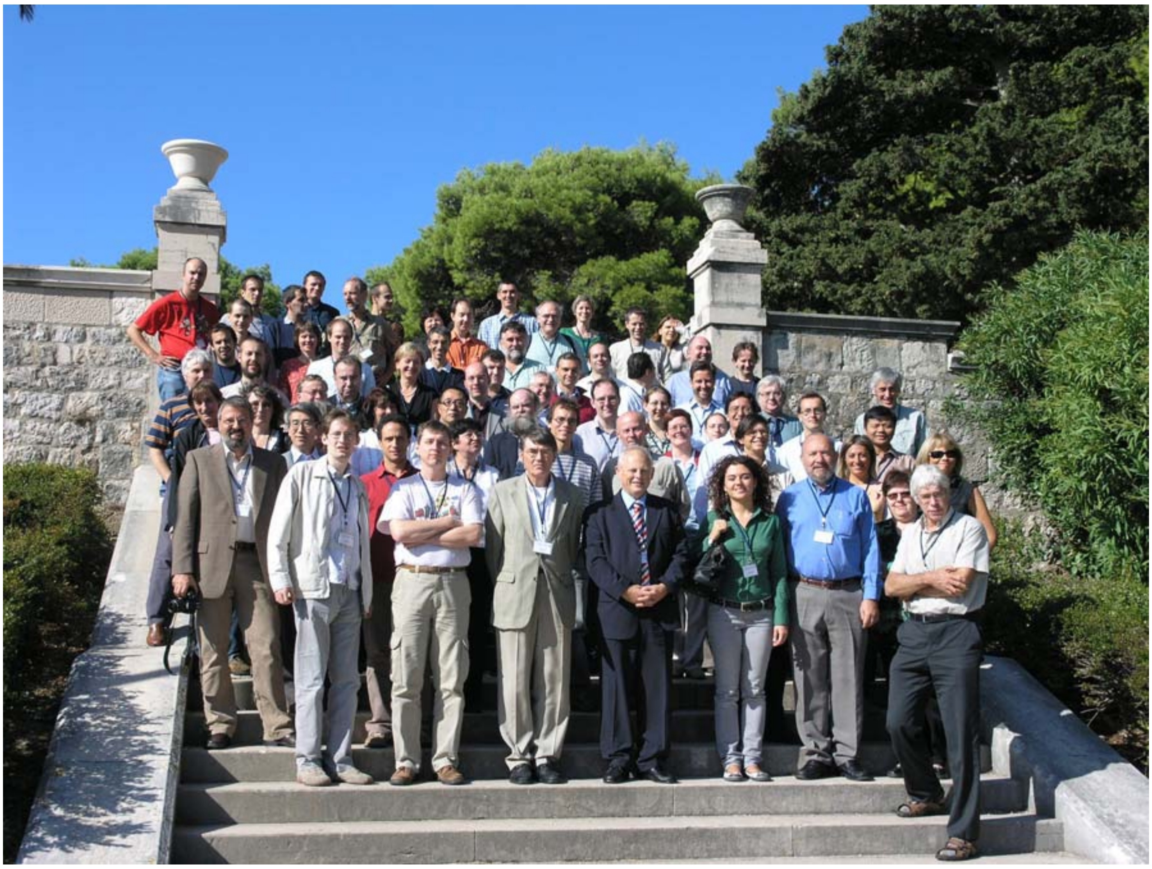
Newsletter of the

29th EWGLAM and 14th SRNWP meetings

8th-11th October 2007, Dubrovnik, Croatia

Croatian Meteorological and Hydrological Service



June 2008

Newsletter of the 29th EWGLAM and 14th SRNWP meetings, 8th-11th October 2007, Dubrovnik, Croatia

Editors: Alica Bajić and Stjepan Ivatek-Šahdan, Croatian Meteorological and Hydrological Service, Grič 3, HR-10000 Zagreb, Croatia

European Working Group on Limited Area Modelling, Meeting 29, Dubrovnik, Croatia

Short-Range Numerical Weather Prediction, Meeting 14, Dubrovnik, Croatia

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Foreword

In 2007, Meteorological and Hydrological Service of Croatia (MHSC) had the pleasure to organise and host the 29th meeting of the European Working Group on Limited Area Modelling (EWGLAM) and the 14th meeting of the EUMETNET Programme Short-Range Numerical Weather Prediction (SRNWP). The meetings took place in Dubrovnik on 9-11 October 2007.

73 participants from 23 countries discussed a wide range of numerical weather prediction and limited area modelling issues in 5 presentations of Consortia, 22 scientific and 20 national poster presentations.

In this Newsletter, you will find the program and the list of participants, the reports of the consortia, the national status reports and the scientific contributions grouped by area received before 1st June 2008. At the end you will find the minutes of the EWGLAM final discussion as well as the report of the SRNWP session.

We want to warmly thank all the colleagues of MHSC involved in the organisation and all the participants; they have so well contributed to the success of the meetings.

Zagreb, June 2008
Alica Bajić and Stjepan Ivatek-Šahdan

METEOROLOGICAL AND HYDROLOGICAL SERVICE

Participants to the 29th EWGLAM and 14th SRNWP meetings

8th – 11th October 2007, Dubrovnik, Croatia

	Name	Institution	Nation	e-mail address
1	Avgoustoglou Euripides	HNMS	Greece	euri(at)hnms.gr
2	Bajić Alica	DHMZ	Croatia	alica.bajic(at)cirus.dhz.hr
3	Baldauf Michael	DWD	Germany	michael.baldauf(at)dwd.de
4	Banciu Doina	National Meteorological Administration	Romania	Doina.banciu(at)inmh.ro
5	Barker Dale	NCAR	USA	dmbarker(at)ucar.edu
6	Beare Sarah	Met Office	United Kingdom	Sarah.Beare(at)metoffice.gov.uk
7	Bélair Stéphane	Enviroment Canada	Canada	Stephane.Belair(at)ec.gc.ca
8	Bölöni Gergely	Hungarian Met. Service	Hungary	boloni.g(at)met.hu
9	Bonavita Massimo	CNMCA	Italy	bonavita(at)meteoam.it
10	Brožková Radmila	CHMI-ONPP	Czech Republic	radmila.brozkova(at)chmi.cz
11	Bush Mike	Met Office	United Kingdom	mike.bush(at)metoffice.gov.uk
12	Catry Bart	University of Gent	Belgium	Bart.Catry(at)Ugent.be
13	Cats Gerard	KNMI	the Netherlands	cats(at)knmi.nl
14	Chalon Jean-Pierre	Météo-France	France	jean-pierre.chalon(at)eumetnet.eu.org
15	Clark Peter	Met Office, JCMM	United Kingdom	peter.clark(at)metoffice.gov.uk
16	Dando Marie	Met Office	United Kingdom	marie.dando(at)metoffice.gov.uk
17	Davies Terry	University of Reading	United Kingdom	terry.davies(at)metoffice.gov.uk
18	Di Giuseppe Francesca	ARPA-SIM	Italy	fdigiuseppe(at)arpa.emr.it
19	Drvar Dunja	DHMZ	Croatia	drvar(at)cirus.dhz.hr
20	El Khatib Ryad	Météo-France	France	ryad.elkhatib(at)meteo.fr
21	Fischer Claude	Météo-France	France	claude.fischer(at)meteo.fr
22	Fortelius Carl	FMI	Finland	carl.fortelius(at)fmi.fi
23	Geleyn Jean-François	CHMI-ONPP	Czech Republic	jean-francois.geleyn(at)chmi.cz
24	Gustafsson Nils	SMHI	Sweden	nils.gustafsson(at)smhi.se
25	Hamilton James	Met Éireann	Ireland	james.hamilton(at)met.ie
26	Horányi András	Hungarian Met. Service	Hungary	horany.a(at)met.hu
27	Hortal Mariano	INM	Spain	mhortal(at)inm.es

	Name	Institution	Nation	e-mail address
28	Horvath Kristian	DHMZ	Croatia	horvath(at)cirus.dhz.hr
29	Ivančan-Picek Branka	DHMZ	Croatia	picek(at)cirus.dhz.hr
30	Ivatek-Šahdan Stjepan	DHMZ	Croatia	ivateks(at)cirus.dhz.hr
31	Iversen Trond	NMI	Norway	trond.iversen(at)met.no
32	Janoušek Martin	CHMI	Czech Republic	martin.janousek(at)chmi.cz
33	Jerczyński Marek	Institue of Meteorology and Water Management	Poland	zijerczy(at)cyfkr.edu.pl
34	Kalin Lovro	DHMZ	Croatia	kalin(at)cirus.dhz.hr
35	Klarić Dijana	DHMZ	Croatia	dijana(at)cirus.dhz.hr
36	Kos Igor	HKZP	Croatia	igor.kos(at)crocontrol.hr
37	Kovačić Tomislav	DHMZ	Croatia	kovacic(at)cirus.dhz.hr
38	Kraljević Lukša	DHMZ	Croatia	kraljevic(at)cirus.dhz.hr
39	Küçükkaraca Ersin	Turkish State Meteorological Service	Turkey	ekucukkaraca(at)meteor.gov.tr
40	Macpherson Bruce	Met Office	United Kingdom	bruce.macpherson(at)metoffice.gov.uk
41	Mahfouf Jean-François	Météo-France	France	jean-francois.mahfouf(at)meteo.fr
42	Majewski Detlev	DWD	Germany	detlev.majewski(at)dwd.de
43	Marsigli Chiara	ARPA-SIM	Italy	cmarsigli(at)arpa.emr.it
44	Mašek Ján	SHMU	Slovak Republic	jan.masek(at)shmu.sk
45	Maziejewski Jean-Antoine	Météo-France	France	jean.maziejewski(at)meteo.fr
46	Meuller Lars	SMHI	Sweden	lars.meuller(at)smhi.se
47	Naylor Mark	Met Office	United Kingdom	mark.naylor(at)metoffice.gov.uk
48	Onvlee Jeanette	KNMI	the Netherlands	Onvlee(at)knmi.nl
49	Orfila Bartolomé	INM	Spain	orfila(at)inm.es
50	Paccagnella Tiziana	ARPA-SIM	Italy	tpaccagnella(at)arpa.emr.it
51	Pottier Patricia	Météo-France	France	patricia.pottier(at)meteo.fr
52	Pristov Neva	Weather Service	Slovenia	neva.pristov(at)gov.si
53	Quiby Jean	Federal Office of Meteorology	Switzerland	jean.quiby(at)meteoswiss.ch
54	Raspanti Adriano	CNMCA	Italy	raspanti(at)meteoam.it
55	Riviere Olivier	Météo-France	France	Olivier.riviere(at)meteo.fr
56	Saito Kazuo	Meteorological Research Institute	Japan	ksaito(at)mri-jma.go.jp
57	Sass Bent	DMI	Denmark	bhs(at)dmi.dk
58	Sasu Monica-Roxana	National Meteorological Administration	Romania	mona_sasu(at)yahoo.com
59	Seity Yann	Météo-France	France	yann.seity(at)meteo.fr
60	Stanešić Antonio	DHMZ	Croatia	stanesic(at)cirus.dhz.hr

	Name	Institution	Nation	e-mail address
61	Stanković Katarina	HKZP	Croatia	katarina.stankovic(at)crocontrol.hr
62	Steiner Philippe	MeteoSwiss	Switzerland	philippe.steiner(at)meteoswiss.ch
63	Tijm Sander	KNMI	the Netherlands	tijm(at)knmi.nl
64	Tudor Martina	DHMZ	Croatia	tudor(at)cirus.dhz.hr
65	Undén Per	SHMI	Sweden	Per.Unden(at)shmi.se
66	Váňa Filip	CHMI-ONPP	Czech Republic	filip.vana(at)chmi.cz
67	Vanderborght Josette	Belgian Met. Service	Belgium	josette.vanderborght(at)oma.be
68	Wang Yong	ZAMG	Austria	wang(at)zamg.ac.at
69	Yang Xiaohua	DMI	Denmark	xiaohua(at)dmi.dk
70	Žagar Mark	Weather Service	Slovenia	mark.zagar(at)gov.si

Programme

Monday, 8th October	
08:00-09:00	*Registration*
09:00-09:15	Opening
09:15-10:30	**Presentations of the Consortia (Chair Per Unden)**
09:15-09:30	Jeanette Onvlee *HIRLAM*
09:30-09:45	Tiziana Paccagnella *COSMO*
09:45-10:00	Mike Bush *UK Met Office*
10:00-10:15	Jean Francois Geleyn *ALADIN*
10:15-10:30	Dijana Klarić *LACE*
10:30-11:00	*Coffee break*
11:00-12:30	**Scientific presentations on numerics and coupling numerics/physics (Chair Detlev Majewki)**
11:00-11:30	Michael Baldauf *COSMO numerics and physics-dynamics coupling*
11:30-11:55	Filip Vana *ALADIN & LACE dynamics & coupling (2006-2007 progress report)*
11:55-12:15	Jan Mašek *Diagnostic tool for ALADIN lateral coupling*
12:15-12:40	Terry Davies *Variable resolution and lateral boundary conditions in the UM*
12:40-12:55	Discussion
12:55-14:30	*Lunch break*
14:30-15:30	**Presentations of national posters (Chair Mark Žagar)** Austria Belgium Croatia Czech Republic Denmark Finland France Germany Hungary Ireland Italy Netherlands
15:30-15:50	*Coffee break*
15:50-16:30	**Presentations of national posters (Chair Mark Žagar)** Norway Poland Romania Slovakia Slovenia Spain Switzerland United Kingdom
16:30-18:00	**Scientific presentations on verification (Chair Gerard Cats)**
16:30-16:45	Adriano Raspanti *Verification strategy in COSMO*
16:45-17:00	Xiaohua Yang *Verification strategy in HIRLAM*
17:00-17:15	Mike Bush *Status report on Met Office verification*
17:15-17:30	Terry Davies *Met Office SRNWP proposal on verification*
17:30-17:50	Discussion

Tuesday, 9th October	
08:30-10:00	**Scientific presentations on data assimilation (Chair Terry Davies)**
08:30-08:55	Bruce MacPherson and Mark Naylor *Developments in regional DA at the Met Office*
08:55-09:25	Claude Fischer and Gergely Boloni *ALADIN 3D-Var Data Assimilation*
09:25-09:40	Nils Gustafsson *HIRLAM 3/4DVar developments*
09:40-09:55	Nils Gustafsson and Claude Fisher *Progress in the joint HIRLAM/ALADIN mesoscale data assimilation activities*
09:55-10:15	Jean-François Mahfouf *Surface Data Assimilation*
10:15-10:30	Massimo Bonavita *Mesoscale Data Assimilation for the Cosmo Model: Status and Perspectives at the IMS*
10:30-11:30	**Poster session** *& coffee break*
11:30-12:30	**Scientific presentations on data assimilation (Chair Terry Davies)**
11:30-11:50	Detlev Majewski *Assimilating radiances from polar-orbiting satellites in the COSMO model by nudging*
11:50-12:10	Francesca di Giuseppe *Assimilating of the SEVIRI data including the use of the Ensemble B matrices and other developments based on the 1DVar approach*
12:10-12:30	Discussion
12:30-14:00	*Lunch break*
14:00-16:00	**Scientific presentations on physics (Chair Bent Sass)**
14:30-14:55	Mike Bush *Physics developments in the Met Office regional NAE model*
14:55-15:20	Peter Clarke *Physics development in the Met Office high resolution model*
15:20-15:50	Yann Seity *Developments at AROME model*
16:00:16:30	*Coffee break*
16:30-16:50	Phillipe Steiner *The COSMO Project "Tackle deficiencies in quantitative precipitation forecasts"*
16:50-17:20	Neva Pristov *ALARO physics development*
17:20-17:40	Sander Tijm *Status of the eddy diffusivity - mass flux (EDMF) scheme*
17:40-18:10	Sander Tijm *In-depth verification/intercomaprison of convection schemes*
18:10-18:25	Discussion

Wednesday, 10th October	
08:30-10:00	**Scientific presentations on predictability and EPS (Chair Tiziana Paccagnella)**
08:30-09:00	Trond Iversen *Overview of GLAMEPS activities*
09:00-09:30	Yong Wang *Status of ALADIN LAM-EPS*
09:30-09:55	Sarah Beare *Performance of the MOGREPS regional ensemble*
09:55-10:15	Chiara Marsigli *EPS activities in COSMO*
10:15-10:30	Discussion
10:30-11:00	*Coffee break*
11:00-11:30	**EWGLAM final discussion (Chair Mariano Hortal)** - preparation of the Newsletter - date and place of the next meeting (2008) - place of the meeting 2009
11:30-12:30	**SRNWP business meeting**
11:30-11:40	Jean Quiby *Opening of the Meeting*
11:40-12:00	**OMSZ proposal (Chair Andras Horanyi)**
11:40-11:55	Andras Horanyi *Main elements of the proposal, contentious issues*
11:55-12:30	Discussion
12:30-14:00	*Lunch break*

Thursday, 11th October	
08:30-13:00	**SRNWP business meeting**
08:30-09:40	**Project proposals – overview (Chair Jeanette Onvlee)**
08:30-08:45	Terry Davies *Interoperability*
08:45-09:05	Discussion
09:05-09:20	Trond Iversen *EUREPS*
09:20-09:40	Discussion
09:40-10:20	**Relation between the C-SRNWP programme and the projects (Chair Andras Horanyi)**
10:20-10:45	*Coffee break*
10:45-11:45	**Establishment of the thematic working groups (Chair Jean-Francois Geleyn)**
10:45-11:45	- selection of topics - main structure of work
11:45-12:30	**Next steps (Chair Andras Horanyi)**
11:45-12:30	- Advisory Committee meetings - finalisation of the already drafted projects
12:30-13:00	**AOB (Chair Andras Horanyi)**
12:30-12:35	Jean Quiby *Presentation of the NWP requirements towards "OPERA"*
12:35-12:45	Discussion
12:45-13:00	Detlev Majewski *Presentation of the THORPEX European plan*
13:00-13:15	Discussion
13:15	**Closure of the meeting (Andras Horanyi)**

HIRLAM-A status and activities in 2007
Jeanette Onvlee

1. Organizational aspects

In January 2006, the HIRLAM cooperation entered a new phase of its existence, with the official start of the HIRLAM-A programme and the entering in force of the cooperation agreement with ALADIN. The main targets of the HIRLAM-A programme, as they have been formulated in the scientific strategy for 2006-2015, are as follows. The most important deliverable of HIRLAM-A is an operational mesoscale analysis and forecast system, at a target horizontal resolution of 2km, by 2008/2009. A second goal is the continued development and maintenance of the synoptic HIRLAM (~10km resolution) system, for as long as necessary. The third major deliverable is the development of a reliable short-range ensemble forecasting system.

The institutes participating in HIRLAM-A from the start are the national meteorological services of Denmark, Finland, Iceland, Ireland, the Netherlands, Norway, Spain and Sweden. On 1 January 2007, the meteorological service of Estonia, EMHI, officially joined the consortium. From 1 January 2008 onwards, the Latvian and Lithuanian meteorological services will also be accepted as acceding members. Météo-France is an associated member, participating in HIRLAM research but not running the model in an operational context. Close cooperation further exists with ECMWF and St. Petersburg university (RSHU).

The HIRLAM programme is led by a programme manager (Jeanette Onvlee), and has been organized into 5 projects: Data assimilation and use of observations (project leader: Nils Gustafsson, SMHI); Model dynamics (Mariano Hortal; INM); Model physics parametrizations (Sander Tijm, KNMI); Probabilistic forecasting (Trond Iversen, met.no); and System and applications (Xiaohua Yang, DMI). The programme manager, project leaders and a scientific secretary (currently vacancy) together form the management group of HIRLAM.

Member institutes contribute to the program by research staff and a yearly financial contribution. Man power contributions to be delivered by each institute depend on the institute's size, and range from 0.5 to 5.5 fte/year. Of this staff contribution, a part has been put explicitly under the full control of the HIRLAM programme management: all but the smallest institutes contribute a so-called core group member to the programme, a researcher who is full-time available for high-priority tasks and under the direct supervision of the management group. This core group concept has proven to be essential for the achievement of critical tasks at the desired time.

The cooperation with ALADIN on mesoscale modelling and short-range ensemble forecasting, which had already been taking shape in earlier years, has continued to intensify. Mid-term planning meetings have been held to establish joint activities in mesoscale data assimilation and surface modelling. A good rhythm has been established of assessment of the common work and coordination of actions in joint meetings of the HIRLAM management group and the ALADIN CSSI twice per year. Interaction between the researchers on both sides has increased through the fact that the yearly HIRLAM All Staff Meeting and ALADIN Workshop have been integrated into a single meeting. Direct research cooperation by means of visits is also on the rise. Finally, the organization of both consortia has now become more symmetric, and cross-representation in each others' steering bodies has now been arranged (figure 1).

2. Mesoscale modelling activities:

In the field of mesoscale modelling, nearly all HIRLAM institutes now are running 1-4 km-scale forecast models on a (semi-)operational basis. Most of these are based on the ALADIN non-hydrostatic dynamics, the AROME physics and SURFEX surface scheme . Denmark additionally is using the non-hydrostatic ALADIN model with partly HIRLAM physics, and EMHI the non-hydrostatic HIRLAM model with HIRLAM physics. Many of these mesoscale suites are being monitored on a daily basis on the HIRLAM extranet.

A mesoscale code and script repository, including a standard system setup and common visualization and verification tools, has been included in the HIRLAM repository. Henceforth, this mesoscale system, containing HIRLAM, ALADIN and AROME components, will be designated the HARMONIE model. Monitoring and diagnostic tools for HARMONIE now include a radar reflectivities simulation module, the budget tool DDH and the 1D-version of AROME, MUSC. The HARMONIE script system has been brought under the HIRLAM job submission and scheduling system mini-SMS. In the coming months, the present forecast system will be extended to a full cycling system including analysis.

The main initial contribution from HIRLAM to the mesoscale physics package has been the development of a coupled eddy diffusivity – mass flux convection scheme (EDMF). This scheme has been implemented at ECMWF and in the 1D-model MUSC. It is presently being validated against Cabauw data. As the physics developments for the synoptic HIRLAM model have practically been brought to a close, all HIRLAM physics staff should now switch their activities to the HARMONIE system. Recently, a training week on the HARMONIE system was held for them as a kick-off for future experimentation and optimization. Key issues for further research will be the tuning and optimization of the EDMF scheme, an investigation how to extend this scheme with a deep convection parametrization, and the search for solutions in presently known problems of the AROME description of convection, such as the over-prediction of severe precipitation and the occasional "fireworks" grid-point storms that sometimes occur. Additionally, the present AROME system contains some highly sophisticated but also computationally expensive physics parametrizations, most notably the microphysics and the radiation scheme; the impact of replacing these complex schemes by simpler and cheaper variations will be investigated.

In the field of dynamics, HIRLAM is contributing to the ALADIN dynamics in a number of ways: the implementation of a Mercator map factor, and the development of a vertical finite element (VFE) method. In addition, research on the construction of transparent lateral boundary conditions will be continued. It now appears possible to extend the transparent lateral boundary approach developed by McDonald to a spectral model (Termonia, 2007), but this will require a considerable effort. For this reason, a complementary approach, reducing the need for highly accurate lateral boundary conditions by means of more frequent boundary coupling, is also under study.

Joint plans for the stepwise development of a mesoscale data assimilation system (initially 3D-VAR, later 4D-VAR) have been formulated after an initial planning meeting in October 2006.
This assimilation system will initially be based on the ALADIN 3D-VAR. The ALADIN 3D-VAR analysis system has been installed in a few HIRLAM institutes and at ECMWF, and an intercomparison with the performance of the HIRLAM 3D-VAR is ongoing. A few concepts which have proven their worth in the HIRLAM 3- and 4D-VAR systems, such as the treatment of the extension zone, will be ported to the ALADIN system; the resulting adapted system will be the HARMONIE 3D-VAR. Work on these adaptations has recently started.
Joint research with Météo-France on the assimilation of radar reflectivities has continued. Additionally, progress has been made in the assimilation of GPS slant delays, SEVIRI radiances, IASI and binary cloud information. In 2008, impact studies are planned involving most of these observation types, and presumably high-resolution BUFR radio sonde and AMDAR data as well. In order to achieve convergence between the ALADIN and HIRLAM observation operator formulations, researchers on both sides have attempted to reach a common formulation. Joint observation operators have now been formulated for radar reflectivities and radial winds, GPS delays, cloud-cleared radiances and conventional radiosonde and PILOT data. This work has also led to recommendations for follow-up research on issues of observation preprocessing; for example, HIRLAM and ALADIN use different ways of handling radar radial winds (superobbing versus filtering and thinning), and it should be studied which approach is the optimal one.

A common plan for surface modelling activities has been drawn up at a workshop in Toulouse in December 2006. All surface developments are to be based on the externalized SURFEX scheme. Surface modeling experts in HIRLAM have started familiarizing themselves with it. HIRLAM will port its new snow and forest scheme to SURFEX, and compare its performance to the two other snow schemes available there. Surface data assimilation activities in cooperation with Météo-France have also very recently taken off . HIRLAM will contribute to the assimilation of sea and sea ice properties, and validation of the lake model, first on synoptic scales, then on mesoscales. For the description of urban characterization, the existing TEB (Town Energy Balance) scheme will be adopted.

3. Synoptic scale developments:

For the synoptic model, the huge past efforts to develop a 4D-VAR system are now bearing fruit, through the operational implementation of 4D-VAR as the default analysis scheme on synoptic scales from December 2007 onwards, and its application to a wide range of remote sensing observations. The testing and optimization of 4D-VAR has been a major area of attention in 2007. New background error statistics therefore have been derived, using a variational quality control approach. A weak constraint for digital filtering initialization has been introduced and successfully tested; this will obviate the need for an explicit initialization scheme. Investigations on the replacement of the present blending mechanism of ECMWF analyses into the HIRLAM analysis by a large scale constraint $J_{k,}$ and on the use of an alternative moisture variable have been concluded successfully, and both these methods will be implemented in the HIRLAM Reference System soon. OpenMP improvements have improved the efficiency of the 4D-VAR code on parallel architectures.

Now that 4D-VAR is available, it has become of prime importance for HIRLAM to start to fully exploit its potential for the assimilation of non-conventional data. The number of remote sensing data which can be assimilated in the model has increased with AMSU-B, AMSU-A over land and sea ice, MODIS AMV's and scatterometer winds. OSI SAF sea ice and SST products can now be used in a new OI SST assimilation module. Research on the assimilation of (clear and cloudy) SEVIRI radiances, (slant) GPS, radar winds and IASI profiles is ongoing.

A set of joint coherent data impact studies has been planned, subdivided into 3 areas for different sets of instruments and with different time horizons:

- Synoptic scale assimilation over mid-latitude (data-sparse) sea areas: Observations include AMSU-A over sea, land and ice areas, AMSU-B over sea, AMV satellite winds, Seawinds scatterometer winds, OSI-SAF SST and sea ice data and radar VAD profiles. Data sets for selected test periods have been collected in the summer. Impact studies for these test periods are ongoing.
- Synoptic scale assimilation over the Arctic, in the context of the International Polar Year: the same observations will be used as above, plus MODIS winds. Data sets for this study have been prepared, and experimentation will begin soon.
- Assimilation studies aimed at improving the description of convection forecasting: Observations will include radar radial wind vectors, SEVIRI radiances and ground-based GPS zenith delay data. As for most of these data some development is still necessary before impact assessments can be done, these coherent assimilation experiments have not started yet.

Updates in the condensation-convection scheme and two bug fixes have led to improvements in the description of fog over sea in spring and summer (fig.2), the dynamical behaviour of the model (less extreme deepening of low pressure system and fewer small scale lows), and the representation of small precipitation amounts. On the basis of GABLS experiments, a few adaptations have been determined by which the description of stable boundary layer conditions in general can probably be further improved.

Presently there are two convection schemes available in HIRLAM, STRACO and Kain-Fritsch (KF). A comprehensive comparison of both schemes has taken place in the past months, on the basis of set of test periods and quantitative evaluation criteria which were set beforehand. On the whole, the KF scheme consistently produced better precipitation and cloud verification scores than STRACO, apart from very low levels of precipitation, where STRACO performed better. STRACO showed a consistent bias in relative humidity, and to a lesser extent geopotential, in mid- and upper tropospheric levels. In view of this outcome it was decided to adopt KF as the reference scheme.

In the surface model, problems with a temperature bias in the new snow and forest scheme during summer unfortunately have not yet been solved. Investigations of the possible causes of this behaviour are still ongoing.
A lake model parametrization has been built into both the new synoptic surface scheme and in SURFEX (the latter by ALADIN staff), and is ready for testing. A new

parametrization for the albedo of snow on (sea) ice has been developed. Initial tests showed positive impact on temperatures close to the coast. An increase in the number of snow and ice layers is expected to yield further improvements; this is being studied now.

Work on coupling HIRLAM to chemistry transport models is ongoing in several HIRLAM countries. In May 2007, HIRLAM staff and chemistry researchers had a kickoff meeting to discuss plans for joint activities. The main goal on the short term is to adapt HIRLAM in ways to make it more useful as input to chemistry transport models. Work on this has started. On a longer time perspective, it is aimed to either couple chemistry models to, or include chemistry components in, HIRLAM to realize a "coupled HIRLAM-CHEM" branch and to study feedback effects, such as the impact of aerosols on clouds. Ideas on this need to be elaborated further.

4. Probabilistic forecasting:

In the area of probabilistic forecasting, several HIRLAM institutes have been active in the past, but these efforts were largely steered at a national level, and not under the control of the programme. The same situation occurred in ALADIN. The intention is to integrate these existing and new efforts into a joint HIRLAM-ALADIN short-range EPS system, GLAMEPS. GLAMEPS is a grand ensemble of limited area EPS systems, which is intended to be produced in a distributed manner, all members being run on the same area and grid, and using a variety of ensemble generation techniques. In a strategic context, the GLAMEPS system is a HIRLAM-ALADIN contribution to the THORPEX/TIGGE-LAM program.

In the past year, a laboratory environment has been created for GLAMEPS at ECMWF. In this laboratory, also known as GLAMEPS version-0, a variety of new short-range EPS generation techniques will be tested. The initial HIRLAM ensemble contributions to GLAMEPS consist of downscaling of an ECMWF TEPS targeted for Europe with HIRLAM, and the introduction of perturbations through model parameters and parametrizations. Soon to be added are initial perturbations by means of HIRLAM singular vectors, which later can be extended to lateral and lower boundary perturbations as well. Fig. 3a shows the model domain of the GLAMEPS system as used in HIRLAM, and fig. 3b the domain for ALADIN; the slight differences are the consequence of the different projections used in both models. Fig. 3c depicts the three targeting areas used for the derivation of a European targeted ECMWF TEPS.
A set of calibration, visualization, assessment and product generation tools has been made available for the GLAMEPS laboratory. Technical and meteorological testing of GLAMEPS is now ongoing. Much attention will be paid to calibration of the ensemble, and optimization of the output products by means of e.g. BMA techniques.

5. Operational suites and HIRLAM Reference System developments and changes:

The focal point of all HIRLAM developments is the HIRLAM Reference System. The Reference model is run at FMI as its operational system. The other reference platform on which HIRLAM is always tested and made available, is ECMWF, as this is the

customary development environment for most HIRLAM researchers. The source code repository is maintained on the HIRLAM server at DMI.
In 2007, the HIRLAM Reference System has been extended with two new components: the HARMONIE mesoscale code, scripts, tools and standard setup; and the scripts and tools used in the GLAMEPS system. The HARMONIE Reference code follows the naming convention of IFS/Arpege, and its present version is Cy32t2.

The operational systems in the HIRLAM institutes remain more or less close to the synoptic scale Reference System (presently version 7.1). Major upgrades to more recent model versions have been made this year by INM, MetEireann and met.no. The model configurations in use at the moment are listed in the table below:

Country	Hor.res. (degrees)	Vert.levels	Nr.points	Version
Denmark	0.15	40	610x568	7.1
	0.05	40	550x378	6.3+
Estonia	0.10	40	114x100	6.1+
	0.03	40	114x100	6.1+
Finland	0.15	60	582x448	7.1
	0.08	40	582x448	6.2.1
Ireland	0.15	60	438x284	7.0
	0.05	60	438x284	7.0
Netherlands	0.10	60	816x650	7.0
Norway	0.10	40	936x756	7.1
	0.036	60	300x500	6.4.2
Spain	0.16	40	582x424	7.1
	0.05	40	606x430	6.1.2
Sweden	0.20	40	306x306	6.3.5+
	0.05	60	294x441	6.3.5+
Lithuania	0.10	40		7.1

During 2007, the following changes have been introduced, or prepared for introduction, in the HIRLAM Reference System:

- HIRLAM version 7.1 (released April 2007):
    - An increase in vertical resolution to 60 layers
    - Introduction of a statistical balance and increased resolution structure functions in the data assimilation system
    - Introduction of 4D-VAR as optional assimilation system
    - Optional assimilation of screen level parameters, AMV and MODIS winds
    - A moist turbulence TKE scheme
    - Introduction of a more extensive package of postprocessing tools.

- HIRLAM version 7.2 (expected release December 2007):
    - 4D-VAR as default assimilation scheme, with retuned (statistical balance) structure functions, weak constraints for large scale (J_k) and DFI (J_{DFI}), a new moisture variable, and variational quality control.
    - RTTOV/ATOVS upgrade, assimilation of AMSU-B, and AMSU-A over land and sea ice.

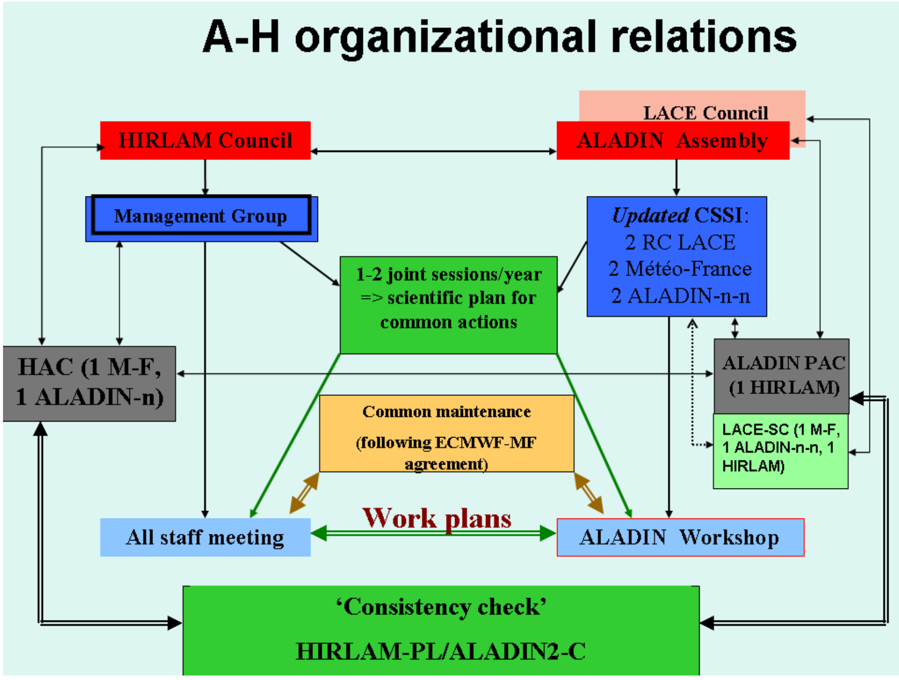
- Assimilation packages for scatterometer winds and MODIS AMV's
- Introduction of OSI SAF sea ice/SST products, SST OI assimilation
- Improved openMP parallellization for 4D-VAR
- Adoption of the Kain-Fritsch Rasch-Kristjansson condensation-convection scheme as default
- Bug fixes and several physics changes resulting in an improved description of temperatures and fog over sea, and in more accurate low precipitation amounts
- A new mean and subgrid scale orography parametrization
- Sloping surface adaptations to the radiation scheme

Figure captions:

Fig.1: Symmetry in organizational relations between HIRLAM and ALADIN.

Fig.2: Example of improved prediction of fog and temperatures over sea. The model used to predict too much fog and too low air temperatures over sea, particularly in spring. This is shown for a +24h forecast for 13 April 2007, where temperatures along the Swedish coast were modelled to be close to freezing, while in fact temperatures were close to 6 degrees Celsius (left panel). After adjustments in several microphysical parameters (droplet fall speed and thin cloud layer emissivity), temperature forecasts over sea were improved markedly (right panel) and the overprediction of fog was reduced.

Fig. 3: Domains to be used for the HIRLAM components of GLAMEPS (upper left panel), and for the ALADIN components (upper right panel). The lower panel shows the HIRLAM integration area of the GLAMEPS laboratory system (black), with the three areas for which targeted EPS singular vectors are derived for Northern (green), central (blue) and Southern (red) Europe.



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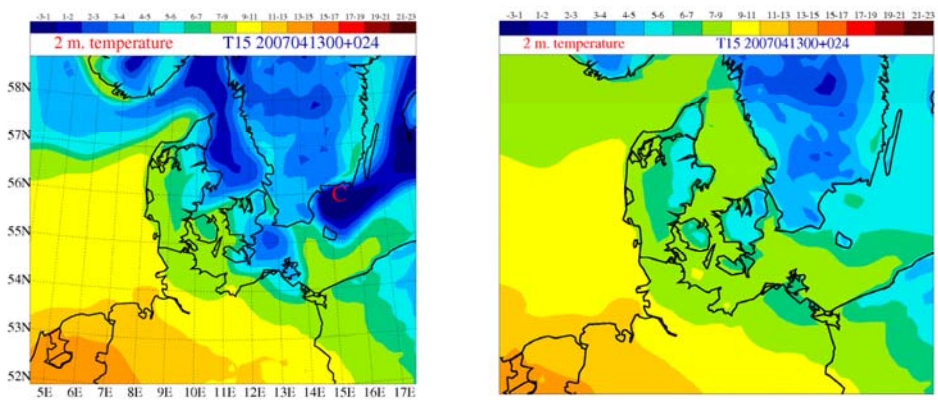

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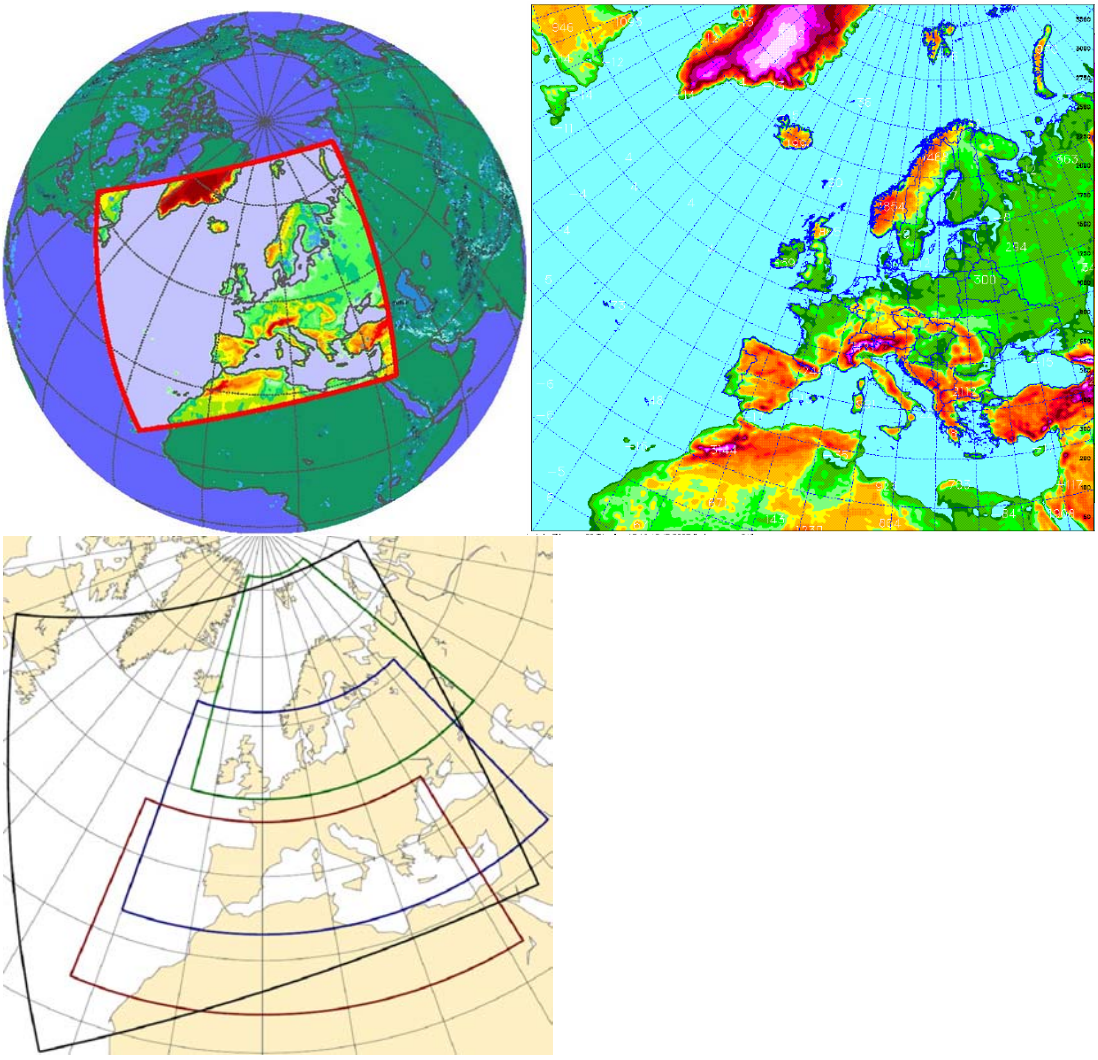

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The COSMO Consortium in 2006-2007

Tiziana Paccagnella

Most of this report is taken from documents written by my COSMO colleagues.

1. Organization and structure of COSMO

The European Consortium for Small-Scale Modelling, COSMO, since the beginning has been cooperating to improve and further develop the non-hydrostatic limited-area model Lokal Modell (LM) originally developed by DWD. LM is used both for operational and for research applications by the members of COSMO.
During the years, the different operational suites of LM were named in very different ways making sometimes difficult, for people external to COSMO, to understand that we were always using and talking of the same model. To improve clearness, and to take on the same philosophy adopted by the other European consortia, the name of the COSMO model was recently changed from Lokal Modell to **COSMO model** and the national operational suites have been renamed accordingly as reported in the following section 4 of this report.

As regards the participation to the consortium, the full membership of the NMA of Romania to COSMO was recently approved and the members of COSMO are now the following national meteorological services:

DWD	Deutscher Wetterdienst, Offenbach, Germany
HNMS	Hellenic National Meteorological Service, Athens, Greece
IMGW	Institute for Meteorology and Water Management, Warsaw, Poland
MeteoSwiss	Meteo-Schweiz, Zurich, Switzerland
USAM	Ufficio Spazio Aereo e Meteorologia, Roma, Italy
NMA	Romanian National Meteorological Administration

Additionally, these other institutions within the member states are also participating:

ARPA-SIM Servizio IdroMeteorologico di ARPA Emilia-Romagna, Bologna, Italy
ARPA-Piemonte Agenzia Regionale per la Protezione Ambientale-Piemonte, Italy
AWGeophys Amt für Wehrgeophysik, Traben-Trarbach, Germany
CIRA Centro Italiano Ricerche Aerospaziali, Italy

Since July 2007, Roshydromet, the Hydrometeorological Centre of Russia, has been accepted as applicant COSMO member.

All internal and external relationships of COSMO are defined in an Agreement among the national weather services. There is no direct financial funding from or to either member. However, the partners have the responsibility to contribute to the model development by providing staff resources and by making use of national research cooperations. A minimum of two Full Time Equivalent (hereafter referred as FTE) scientists, working in COSMO research and development areas is required from each member. After a decision of the STC in 2006, these 2 FTE's must be delivered with the framework of one of the so-called Priority Projects (see Section 5). In general, the group is open for collaboration with other NWP groups, research institutes and universities as well as for new members.

The COSMO's organization consists of a STeering Committee (STC, composed of representatives from each national weather service), a Scientific Project Manager (SPM), the Work-Packages/Working groups Coordinators (WPCs) and scientists from the member institutes performing research and development activities. At present, six working groups covering the following areas are active: Data Assimilation, Numerical Aspects, Physical Aspects, Interpretation and Applications, Verification and Case Studies, Reference Version and Implementation.

During the past year, Michal Ziemianski replaced Ryszard Klejnowski in the STC as representative of Poland and Michael Baldauf replaced Juergen Steppeler as coordinator of the Working Group on Numerics.

The present organisation of COSMO is reported in the following:

Steering Committee Members:

Mathias Rotach **(the Chairman)**	MeteoSwiss	(Switzerland)
Hans-Joachim Koppert	DWD	(Germany)
Massimo Ferri	UGM	(Italy)
Ioannis Papageorgiou	HNMS	(Greece)
Michal Ziemianski	IMGW	(Poland)
Victor Pescaru	NMA	(Romania)

Scientific Project Manager:

Tiziana Paccagnella	ARPA-SIM	(Italy)

Working Groups/Work Packages Coordinators:

Data assimilation	Christoph Schraff	DWD
Numerical aspects	Michael Baldauf	DWD
Physical aspects	Marco Arpagaus	MeteoSwiss
Interpretation and Applications	Pierre Eckert	MeteoSwiss
Verification and case studies	Adriano Raspanti	UGM
Reference Version and Implementation	Ulrich Schättler	DWD

In the near future some other changes will be brought to the management groups. Marco Arpagaus will replace Tiziana Paccagnella as SPM starting January 2008 and, at the same time, Federico Grazzini from ARPA-SIM will take the lead in the working group on Physical aspects.
Hans-Joachim Koppert from DWD will become the chairman of the STC after the 1st half of 2008.

COSMO activities are developed through contacts among scientists, work-package coordinators, the scientific project manager and the steering committee members via electronic mail, special meetings and internal mini-workshops. Twice a year the WPCs, the SPM and the chairman of the STC (forming all together the Scientific Advisory Committee SAC), meet together to discuss ongoing and future activities. The STC also meets twice a year and once a year there is the General COSMO meeting where results are presented and future plans are finalized. Several mini-workshops (at working groups and/or Projects level) are also frequently organized.

Since two years, the “vertical” organization of the activities grouped in the six working groups is complemented by a “transversal” organization in Priority Projects (PPs). In these PPs the most relevant scientific issues to be investigated are clearly defined and all the scientific activities contributing to tackle those issues are grouped together and framed in a real project layout. PPs are proposed by the SAC, finalized during the general meeting after collecting contributions and proposals from all the COSMO scientists. The last step is the final approval by the STC which is also responsible of allocating the required human resources for a minimum of 2 FTEs per Country per year. The other COSMO activities, not included in the Priority Projects, are carried on with extra resources if available.

Every year the COSMO User Seminar is organized to illustrate the activities carried out by groups and people using the COSMO model. The next user seminar will be held in March 2008 in Langen, Germany.

2. Model system overview

The key features of the COSMO model are reported below:

Dynamics

Basic equations: Non-hydrostatic, fully compressible primitive equations; no scale approximations; advection form; subtraction of a stratified dry base state at rest.

Prognostic variables: Horizontal and vertical Cartesian wind components, temperature (or temperature perturbations), pressure perturbation, specific humidity, cloud water content. Options for additional prognostic variables: cloud ice, turbulent kinetic energy, rain, snow and graupel content.

Diagnostic variables: Total air density, precipitation fluxes of rain, snow and graupel.

Coordinates: Rotated geographical coordinates (λ,φ) and a generalized terrain-following coordinate ς. Vertical coordinate system options:

- Hybrid reference pressure based σ-type coordinate (default)
- Hybrid version of the Gal-Chen coordinate
- Hybrid version of the SLEVE coordinate (Schaer et al. 2002)
- Z coordinate system almost available for testing

Numerics

Grid structure: Arakawa C grid in the horizontal; Lorenz vertical staggering

Time integration: Second order horizontal and vertical differencing Leapfrog (horizontally explicit, vertically implicit) time-split integration including extension proposed by Skamarock and Klemp 1992. Additional options for:

- a two time-level Runge-Kutta split-explicit scheme (Wicker and Skamarock, 1998)
- a three time level 3-D semi-implicit scheme (Thomas et al., 2000)
- a two time level 3rd-order Runge-Kutta scheme (regular or TVD) with various options for high-order spatial discretization (Förstner and Doms, 2004, Wicker and Skamarock, 2002)

Numerical smoothing: 4th order linear horizontal diffusion with option for a monotonic version including an orographic limiter (Doms, 2001); Rayleigh-damping in upper layers; quasi-3D divergence damping and off-centering in split steps.

Lateral Boundaries: 1-way nesting using the lateral boundary formulation according to Davies and Turner (1977). Options for:

- boundary data defined on lateral frames only;
- periodic boundary conditions

Driving Models: The GME from DWD, the IFS from ECMWF and COSMO itself.

Thanks to the cooperation with INM, in the framework of the INM-SREPS and COSMO SREPS projects, ICs and BCs can now be extracted also from the NCEP and UK Met Office global models.

Physics

Grid-scale Clouds and Precipitation: Cloud water condensation /evaporation by saturation adjustment. Cloud Ice scheme HYDCI (Doms, 2002). Further options:

- prognostic treatment of rain and snow (Gassman, 2002; Baldauf and Schulz, 2004, for the leapfrog integration scheme)
- a scheme including graupel content as prognostic variable
- the previous HYDOR scheme: precipitation formation by a bulk parameterization including water vapour, cloud water, rain and snow (rain and snow treated diagnostically by assuming column equilibrium)
- a warm rain scheme following Kessler (1969)

In the latest COSMO 4.0 release of the model, a new version of microphysics has been introduced; the major changes will be listed in the next section 3.

Subgrid-scale Clouds: Subgrid-scale cloud scheme based on relative humidity is used in the radiation calculations to diagnose the fractional cloud cover and the amount of cloud condensate. Optionally, statistical subgrid-scale cloud scheme may be used.

Moist Convection: Mass-flux convection scheme (Tiedtke) with closure based on moisture convergence. Further options:

- the Kain-Fritsch convection scheme

Vertical Diffusion: Diagnostic K-closure at hierarchy level 2 by default. Optional:

- a new Mellor-Yamada-type level 2.5 scheme with prognostic treatment of turbulent kinetic energy; the scheme is formulated in terms of quasi-conservative variables (liquid water potential temperature and total water specific humidity); fractional cloud cover and the amount of cloud condensate (need to compute the buoyancy flux) are diagnosed through the use of a statistical subgrid-scale cloud scheme (Sommeria and Deardorff 1977); the effect of the subgrid-scale horizontal inhomogeneity on the structure of the stable boundary-layer turbulence is accounted for to avoid sharp critical-Richardson-number turbulence cut-off.

Surface Layer: Constant flux layer parameterization based on the Louis (1979) scheme (default). Further options:

- A new surface-layer scheme including the effect of a laminar roughness-layer resistance

Radiation: δ-two stream radiation scheme after Ritter and Geleyn (1992) for short and longwave fluxes; full cloud-radiation feedback

Soil Processes:

Two-layer soil model including snow and interception storage; climate values are prescribed as lower boundary conditions; Penman-Monteith plant transpitration. Further options:

- a new multi-layer soil model including melting and freezing (Schrodin and Heise, 2002)

Initial Conditions:

- Interpolated from the driving model.
- Nudging analysis scheme (see below).

Diabatic or adiabatic digital filtering initialization (DFI) scheme (Lynch et al., 1997).

Physiographical data Sets:

Mean orography derived from the GTOPO30 data set (30"x30") from USGS.
Prevailing soil type from the DSM data set (5'x5')of FAO.
Land fraction, vegetation cover, root depth and leaf area index from the CORINE data set.
Roughness length derived from the GTOPO30 and CORINE data sets.

Code:

Standard Fortran-90 constructs.
Parallelization by horizontal domain decomposition.
Use of the MPI library for message passing on distributed memory machines.

Data Assimilation for COSMO

Method: Nudging towards observations
Implementation: Continuous cycle
Analyzed variables: horizontal wind vector, potential temperature, relative humidity, 'near-surface' pressure (i.e. at the lowest model level)
Observations:
SYNOP, SHIP, DRIBU: station pressure, wind (stations below 100m above msl) and humidity
TEMP, PILOT: wind, temperature: all standard levels up to 300 hPa; humidity: all levels up to 300 hPa; geopotential used for one "near-surface" pressure increment.
AIRCRAFT: all wind and temperature data
WIND PROFILER: all wind data (except blacklisted stations)
Quality Control: Comparison with the model fields from the assimilation run itself.
A Latent Heat Nudging scheme is also implemented.

3. Recent developments.

During the last year, four major releases of the COSMO-Model have been distributed. The highlights of the changes are:

- Consolidation of the Runge-Kutta scheme and the very high resolution runs (among others: new treatment of moisture variables for boundary relaxation; added topographical corrections for radiation scheme)
- Consolidation of the climate mode
- Preparations for Ensemble Mode (new Namelist groups)
- New Version of microphysics with major changes in the parameterization of snow: Variable intercept parameter based on Field et al. (2005), temperature -dependent sticking efficiency, changes in geometry and fall speed of snow. Use of Seifert and Beheng (2001) warm rain scheme with a constant cloud droplet number concentration.

Now we have: COSMO-Model Version 4.0 which is also the new official reference version of the model.

4. COSMO operational applications.

The different operational implementations of the COSMO model are shown in Figure 1. The other characteristics are reported in Table 1. For more details please see the National Reports in this Newsletter.

Country/ Institute	Name of the COSMO Implementation	N° of Grid Points	Hor Res. (km)	N° vert Layers	Start Time and Forec. Range	Lateral BCs from	LBCs Upd. Freq	Initial State	HW/ N° Procs
Germany DWD	COSMO-EU	665x657	7	40	00/12 +72h 06/18 +48h	GME	1h	Nudging	IBM SP5 /264
	COSMO-DE	421x461	2.8	50	Every three hours +21 h	COSMO-EU	1h	Nudging	IBM SP5 /256
Switzerland MCH	COSMO-7	380x325	7	45	00/12 +72h	IFS	3h	Nudging	Cray xt3/ 100
	COSMO-2	520x350	2.2	60	6x24h 2x30h	COSMO -7	1h	Nudging	Cray xt4 816
Italy USAM (NMS)	COSMO-ME	641x401	7	40	00/12 +72h	IFS	3h	3D-VAR FGAT	IBM p5-575+ (192)
	COSMO-IT	542x604	2.8	50	00 +36h	COSMO-ME	1h	Nudging	IBM p5-575+ (352)
Italy ARPA-SIM	COSMO -I7	297 x 313	7	40	00/12 +72h	IFS	3h	Nudging	IBM SP5 128/256
	COSMO-I2	447 x 532	2.8	45	00 +48h	COSMO-I7	1h	COSMO-I7 analysis	IBM SP5 128/256
	COSMO-BK	297 x 313	7	40	00/12 +72h	GME	1h	Nudging	Linux cluster-64
Greece HNMS	COSMO-GR	7	649 x 393	35	00,12 +72h	IFS	3h	Nudging	IBM P4 cluster
Poland IMGW	COSMO-PL	193x161	14 -	35	00,12 +72h 06/18 +48h	GME	3h	GME	SGI Origin 3800-88
Romania NMA	COSMO-RO	81x73	14 -	35	00/12 +78h 06/18 +48h	GME	3h	GME	PC Cluster
COSMO-LEPS	COSMO-LEPS	3157920	10	40	132	ECMWF EPS members	3h	Interpolated form ECMWF EPS members	ECMWF IBM SP5 128 procs

Table 1 Operational Implementations of the COSMO model.

As mentioned before, the Hydrometeorological Centre of Russia, Roshydromet, is now Applicant member of COSMO. Since August 2007 they started a pre-operational trial with the COSMO model at 14 km horizontal resolution. They plan to move very soon to an operational suite at 7 km horizontal resolution.

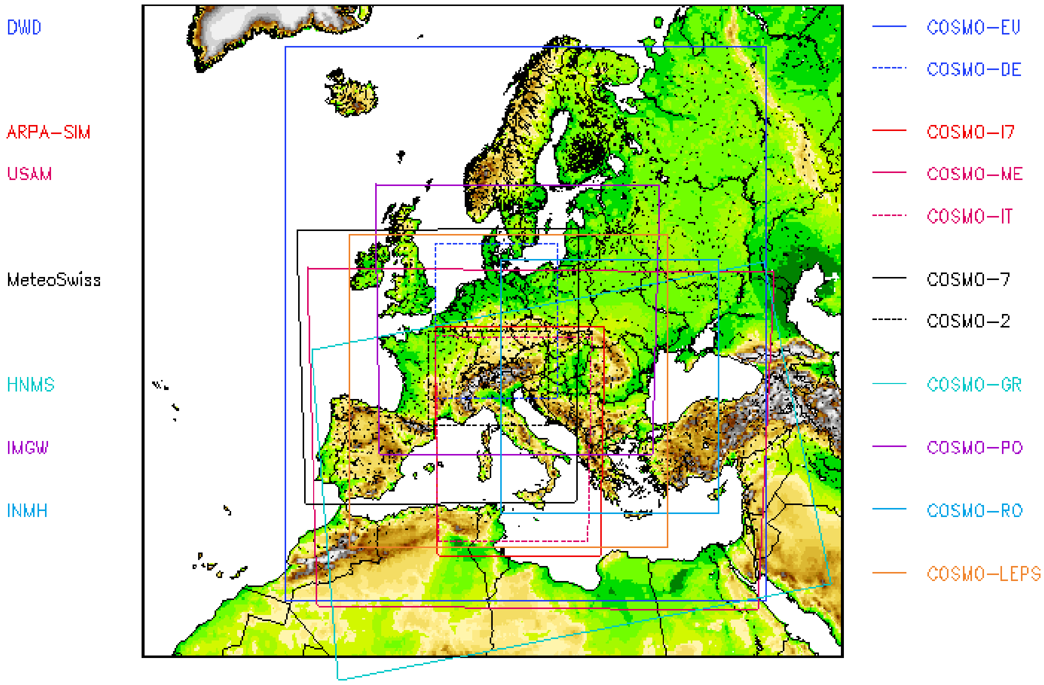

Figure 1: Integration domains of the COSMO model operational implementation

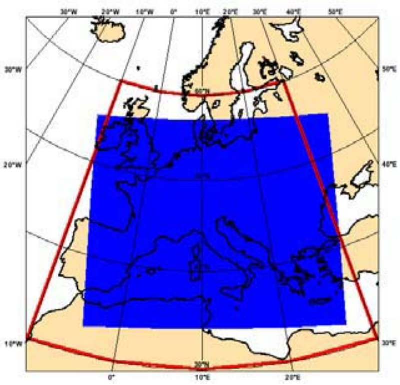

Figure 2 : COSMO-LEPS integration domain

The COSMO-LEPS system is running every day regularly at ECMWF as a Time-Critical Application.
In Figure 2, the integration domain is represented. Since January 2006, COSMO-LEPS is composed of 16 members at 10 km horizontal resolution and 40 vertical levels. The forecast length is 132 hours starting from the 12 UTC analysis time. For more details on COSMO-LEPS see the report by Chiara Marsigli, in this newsletter, about *EPS activities in COSMO*

5. COSMO Priority Projects

5.1. Support Activities -Project Leader: Ulrich Schaettler (DWD)

This project includes all the activities related to the Source Code Administration, the Documentation, the editing of newsletters, tech. reports and the management of the COSMO

WEB site. Actually this project includes many of the activities of WG6 Implementation and Reference Version and, due to the importance of these basic and “vital” activities it has been decided to keep this as a permanent Priority Project.

5.2. SIR: Sequential Importance Resampling filter (renamed to become ‘KENDA’) - Project Leader: Christoph Scraff (DWD):

The SIR project’s take-off has been delayed due to missing experienced resources within COSMO. During this last year the SAC and the STC decided to re-discuss the long-term strategy of COSMO for DA at the convective scale and to reformulate the SIR project accordingly.
Two meetings with external experts, P.J. van Leeuwen from the Institute for Marine and Atmospheric Research of Utrecht and Chris Snyder from NCAR, were organized to better focus the problem and to have some support in the design of the new project.

Following these meetings and the internal discussions, the SIR project is being revised and replaced by the new project KENDA: a - Km-scale ENsemble-based Data Assimilation.

The aim of the project is to develop a novel ensemble-based data assimilation system for the convective scale (i.e., 1 – 3 km model resolution). The system has to be able to provide the initial conditions for ensemble forecasting at the same resolution.
Two approaches are envisaged, that is the Local Ensemble Transform Kalman Filter (LETKF, see Hunt et al., 2007) and the Sequential Importance Resampling (SIR) filter (van Leeuwen, 2003), but SIR will be mainly matter of research in cooperation with some university groups.

5.3. Assimilation of Satellite Radiances into COSMO with 1D-Var and Nudging - Project Leader: Reinhold Hess (DWD):

Data of polar orbiting as well as geostationary satellites (ATOVS, AIRS/IASI, and SEVIRI) will be assimilated into COSMO in two steps: First, profiles of temperature and humidity will be retrieved from the satellite radiances using a 1D-Var analysis scheme. Second, these profiles will be assimilated like conventional data with the nudging scheme of the COSMO.
This project is well on schedule and is going to be completed in few months. An extensive report about this project is given by the following two contributions in this newsletter:

- *Assimilating radiances from polar-orbiting satellites in the COSMO model* by Reinhold Hess and Detlev Majewski"
- *Assimilation of the SEVIRI data including the use of the Ensemble B matrices and other developments based on the 1DVar approach* by Francesca di Giuseppe

5.4. Further development of the Runge Kutta time-integration scheme - Project leader: Michael Baldauf (DWD):

The Runge-Kutta method is implemented in the COSMO as another time integration scheme besides the Leapfrog method. It will be used for high resolution applications with LM-DE and possibly replace the Klemp-Wilhelmson scheme later on. It offers a substantial gain in accuracy at no additional costs. The method is quite new and differs from the Runge-Kutta scheme used in WRF, for example by having less conservation properties and a smaller approximation order in the vertical. Further work is required to investigate the advantages (and possible problems to be solved) thoroughly and to investigate further developments, such as third (or higher) order in the vertical and conservation properties. Within the WRF group possibilities of increasing the efficiency of RK are seen. Such developments should be followed. With an increased order a better interface to physics as well as the observation of other approximation conditions should become more essential. Interactions with fine scale orography should be investigated more thoroughly. For more details please see the report *COSMO numerics and physics-dynamics coupling* by Michael Baldauf in this Newsletter.

5.5. Further development of COSMO_Z - Project leader: Ulrich Schaettler (DWD)

COSMO_Z is a research version of the COSMO model, where the Leapfrog dynamics is not formulated on the vertical terrain-following grid, but on so-called Z-levels. These levels are plain for the whole domain and have a fixed height above sea-level everywhere. Near the surface, these levels really cut into the orography. For the numerical treatment the cut-cells approach is used.
The project produced a prototype which is now under testing. Results will be evaluated at the end of 2007 and the future of COSMO_Z development will be defined also considering the available human resources. Some more about this project is again reported by Michael Baldauf in this newsletter.

5.6. Towards a Unified Turbulence-Shallow Convection Scheme (UTCS) - Project leader: Dmiitri Mironov (DWD).

Representation of shallow convection and boundary-layer turbulence in numerical models of atmospheric circulation is one of the key unresolved issues that slows down progress in numerical weather prediction. Even in high-resolution limited-area NWP models, whose horizontal grid size is of order 1 km, these phenomena remain at sub-grid scales and should be adequately parameterised. The goal of the proposed project is to make a step forward along this line. The project is aimed at:

1.1. parameterising boundary-layer turbulence and shallow non-precipitating convection in a unified framework
1.2. achieving a better coupling between turbulence, convection and radiation. Boundary-layer turbulence and shallow convection will be treated in a unified second-order closure framework. Apart from the transport equation for the sub-grid scale turbulence kinetic energy (TKE), the new scheme will carry at least one transport equation for the sub-grid scale variance of scalar quantities (potential temperature, total water). The second-order equations will be closed through the use of a number of advanced formulations, where the key point is the non-local parameterisation of the third-order turbulence moments. The proposed effort is expected to result in an improved representation of a number of processes and phenomena, including non-local transport of heat, moisture and momentum due to boundary-layer turbulence and shallow convection, triggering of deep cumulus convection, and stratiform cloud cover. This in turn is expected to lead to an improved forecast of several key quantities, such as the rate and timing of precipitation and the 2m temperature.

Unfortunately, even if considered strategic for the application of the COSMO model at the “quasi” convective scale, this project was also delayed due to the lack of available trained resources. The project is being reformulated and, according to the new time schedule, the implementation of UTCS into the COSMO model will be done in 2009 and during 2010 numerical experiments, fine tuning and the evaluation of results will be performed.

5.7. Tackle deficiencies in precipitation forecasts - Project leader: Marco Arpagaus (MeteoSwiss)

This project was aimed at looking into the COSMO deficiencies concerning QPF by running sensitivity experiments on a series of well chosen cases which have verified very poorly. Results present some interesting outcomes and, among them, a clear indication that COSMO Version 4.0 represents a real step forward in the development of the model. This project is now in the concluding phase and a report about the results is under writing. See more about this project in the report by Philippe Steiner entitled *The COSMO Project Tackle deficiencies in quantitative precipitation forecasts*

5.8. Development of Short Range ensemble based on COSMO - Project Leader: Chiara Marsigli (ARPA-SIM)

This COSMO SREPS (Short-Range Ensemble Prediction System) project deals with the development and implementation of a short-range ensemble based on COSMO to fulfil some needs arisen in the COSMO community:

1.3. To have a short-range mesoscale ensemble to improve the support especially in situations of high-impact weather.
1.4. To have a very short-range ensemble for data assimilation purposes (e.g. the KENDA and the evaluation of the flow dependent model error statistics for the 1D-VAR system).

COSMO-SREPS status is described in the report by Chiara Marsigli, in this newsletter, about *EPS activities in COSMO*

5.9. Advanced interpretation and verification of very high resolution models - Project leader: Pierre Eckert (MeteoSwiss, Genève)

The foreseen increase in resolution of the models will lead to a proliferation of grid points and probably also to an increase of the noise in the forecasts. The manifestations of the double penalty effect will increase for events not predicted exactly at the right place at the right time. Valuable information can however be found by composing a statistics on the neighbourhood of a verification point. Various ways to extract the best possible information out of high density precipitation fields have been proposed so far. It can be of deterministic nature (means, quantiles,…) or totally probabilistic. Different “fuzzy” verification methods will be explored and compared in this project. Some results are reported in the report by Adriano Raspanti

5.10. Implementation of a Common Conditional Verification (CV) library - **Project Leader: Adriano Raspanti (CNMCA (USAM)- AM)**

Aim of this project is the development of a common and unified verification library including a Conditional Verification Tool. The main purpose of conditional verification is the systematic evaluation of model performances in order to reveal typical shortcomings and the reasons behind them, in a way different from the usual classical verification tools. This project will continue with the new name *VerSUS - Verification System Unified Survey.*

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Unified Model Developments 2007

Met Office Fitzroy Road Exeter
+44 1392 886098 mike.bush@metoffice.gov.uk

1. Global Model developments

Cycle	Date	Model change
G42	05th December 2006	Increased use of ATOVS Introduction of GPS RO Model Stratospheric stability package Spectral Gravity wave drag Convective cloud decay 10m wind gust
G43	06th March 2007	Introduce METOP data to replace NOAA15 data (early introduction 16th Jan) Retune 10m gust
G44	15th May 2007	Corrections in the representation of convective clouds in the radiation scheme Introduce biogenic aerosols climatology Changes to soil hydrology Seasonal varying leaf area index (LAI) Bare soil albedo based on MODIS Assimilation of COSMIC GPS radio occultation data
G45	14th August 2007	UM 6.4 Improved use of GPSRO, AIRS / ATOVS Update Increased frequency of SYNOPs (hourly) Extra PF model physics (convection) Satellite changes: SSMIS and GPS RO
-	02nd October 2007	OSTIA SST analysis

1.1 Cycle G44

This model change was aimed at tackling poor summer performance, in particular a warm bias over land and a negative PMSL bias. Trialling the individual components of the package showed that the convection changes, the biogenic aerosols and the COSMIC data assimilation changes give the most positive impact.

1.1.1 Corrections in the representation of convective clouds in the radiation scheme.

The first corrects an error whereby the cloud phase is set according to the temperature at the top of the model rather than the top of the cloud. Without this fix all convective cloud is seen as ice cloud within the radiation scheme. The second correction ensures that deep convective clouds are seen as liquid by the radiation scheme below the freezing level.

1.1.2 Adding a climatology of biogenic aerosols.

These aerosols are created by oxidation of hydrocarbon emissions from plants and so are particularly prevalent over the land in the Tropics and over land in the Northern Hemisphere in Summer. These aerosols are also more reflective than the absorbing aerosol in the Cusack et. al (1998) climatology currently used in the model.

1.1.3 Changes to soil hydrology

The soil hydrology is modified so that over saturated or frozen soils excess soil moisture flows down into the soil level below rather being lost to the hydrological cycle as run-off. This ensures that the soil underneath melting snow is wet rather than the very dry soils that are currently in the model in mountainous regions or the Tundra. It should also allow more moisture into the lower levels of the soil when there are brief periods of intense rainfall.

The leaf area index (LAI), which represents the density of vegetation, uses a seasonally varying climatology rather than a fixed annual mean.

1.1.4 Bare soil albedo based on MODIS

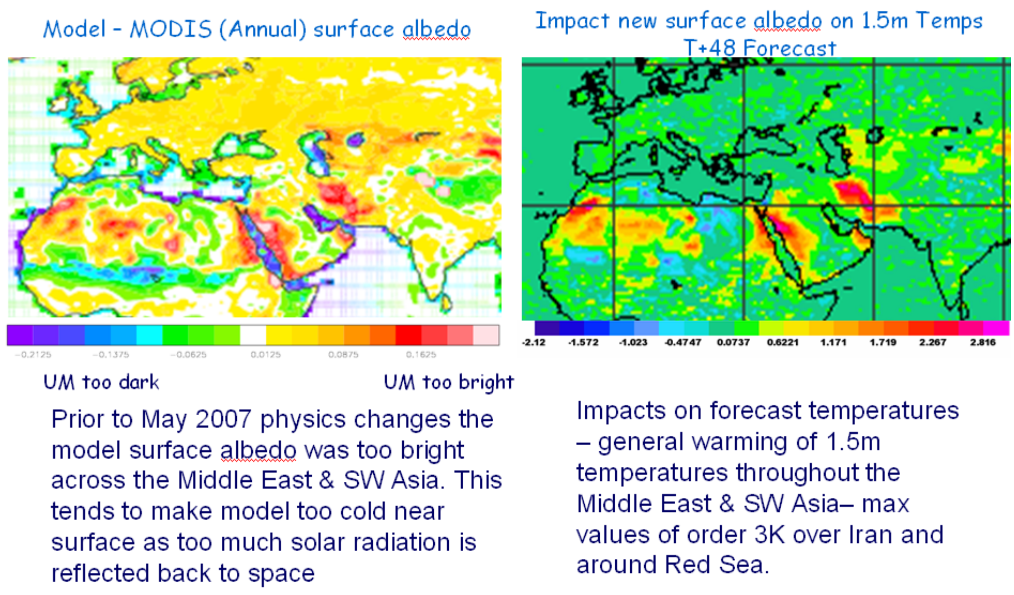


Figure 1: Model –MODIS (Annual) surface albedo (left) and impact of new surface albedo on 1.5m temperatures (right)

1.1.5 COSMIC GPS Radio Occultation data

GPS signals undergo changes in frequency and amplitude when they encounter gradients in atmospheric density and water vapour. These changes can be measured using a process called radio occultation and used to derive the profiles of atmospheric temperature and humidity.

There are now several satellites equipped with GPS receivers to make such measurements. The most extensive of them is the US/Taiwanese COSMIC constellation of 6 micro-satellites, launched in 2006.
NWP trials of COSMIC data show improvements of ~0.5 on the global NWP index. Further improvements are expected when biases between COSMIC and other observations are better understood and addressed.

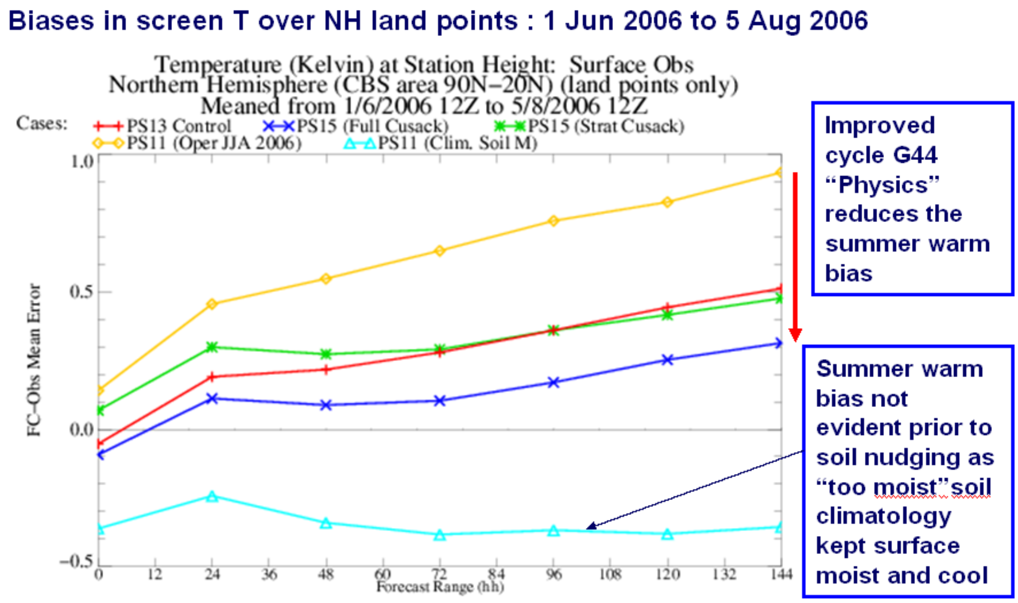


Figure 2: Screen T warm bias over land – Improvements with Cycle G44. JJA 2006 trials

2. MOGREPS-R developments

2.1 Introduction of Regional ETKF

Until recently MOGREPS Perturbations for the NAE were interpolated from the Global model at T+6. These large scale perturbations had too large a spread, especially at upper levels. Therefore a regional ETKF has been introduced in the MOGREPS-R model. The spread at upper levels is now approximately correct but the spread at the surface may be too small.

2.2 Storm surge Ensemble

The CS3 Storm surge model has been coupled to the MOGREPS-R model as part of a contract for the Environment Agency. This system successfully predicted the storm surge event of 08th November 2007, caused by a low pressure system passing to the north of Scotland and associated winds driving a surge down the North Sea. The tide at Felixstowe (on the East Anglian coast) was the highest since January 1983 and was a 1 in 50 year event (Figures 3 and 4).

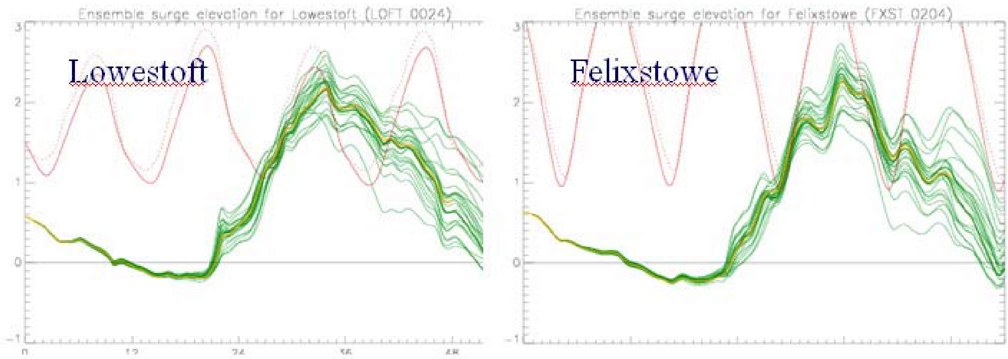


Figure 3: Surge predictions for Lowestoft and Felixstowe. The graphs are timeseries from T+0 to T+48 of model surge elevation. If the model curves go above the red sinusoidal line, then an alert should be considered.

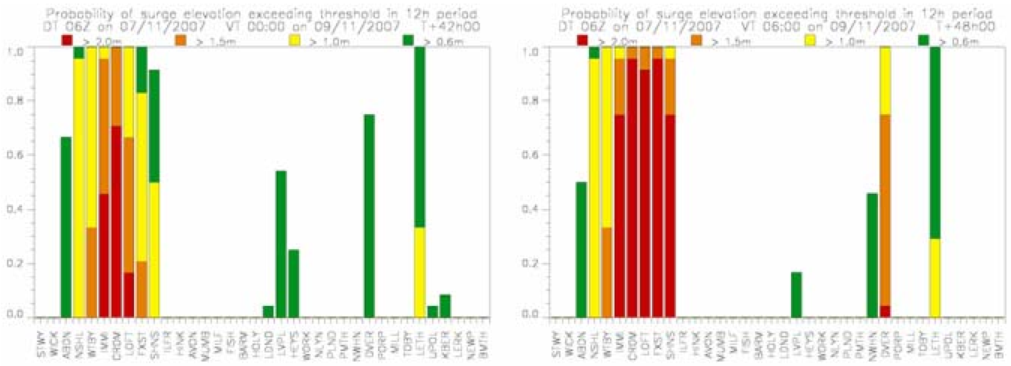


Figure 4: Graphs at T+42 and T+48 showing a bar chart for each port with colour coded probabilities for an elevation greater than a particular threshold (e.g. red is for > 2.0m).

2.3 Eurorisk PREVIEW windstorm warnings

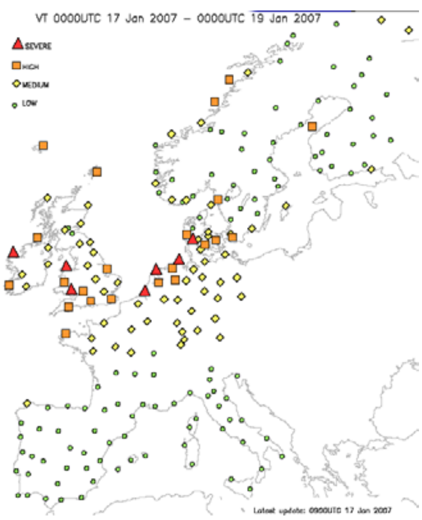


Figure 5: MOGREPS is used in multi-model ensemble for windstorms warnings and forecasts for Europe.

3. NAE Model developments

Cycle	Date	Model change
E14	05th December 2006	Hourly averaged convective ppn rates More efficient microphysics Aerosol max reduced from 1000 to 200micro g/kg New reconfiguration to remove snow over sea when interpolated from land in global model New soil ancillaries - removal of isolated permanent land ice points ATOVS & Satwind changes
E15	06th March 2007	w-based convection instead of RH based New balance for lbcs Revised 10m wind gust Replace murk by climatological aerosol in radiation Switch relaxation to climatological aerosol fixed land/sea values from 2 to 20 days Aerosol - Reduced background error in data assimilation Revised ATOVS/AIRS use & introduction of ground based GPS
E16	15th May 2007	Reduced NAE domain (see Figure 6)
E17	14th August 2007	UM6.4 Add the Equation of time in the astronomy GPSIWV Optimisation, AMSU-B cloud-detection changes, AIRS ozone changes Extra PF model physics (convection only)

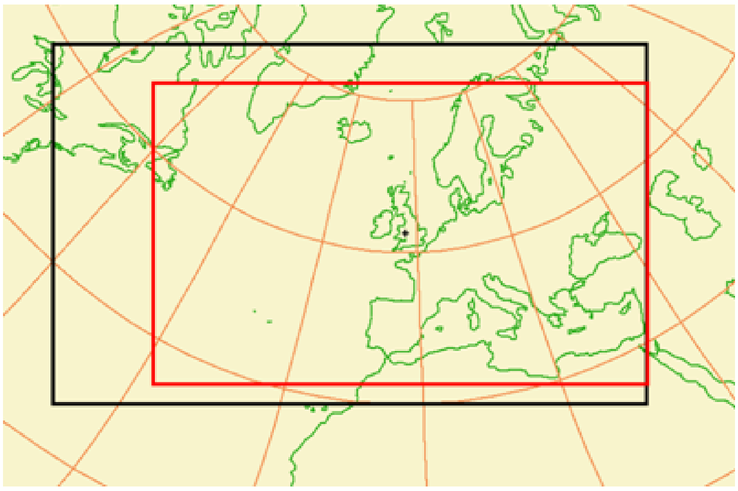


Figure 6: Previous NAE model domain (black) and current NAE domain (red). This change was made in order to afford the planned move from 38 to 70 vertical levels.

3.1 Metop

Metop was made operational (via a Global dataset) in the Global model on 16/01/2007. Metop was then made operational in NAE using the Exeter ground station on 20/03/2007 giving four atovs satellites in the system for the first time. Unfortunately there was a HRPT antenna failure on 06/07/2007. A second antenna may be activated once the failure mode has been understood. It is possible that the NAE may switch to using the global dataset in the meantime.

4. UK4 Model developments

Cycle	Date	Model change
U4.08	06th March 2007	Daily reconfigure of Ozone from climatology Reinstate daily soil moisture update 10m wind gust diagnostic
U4.09	14th August 2007	UM 6.4 Physics changes: Catch up package with NAE. DA changes to LHN settings, visibility Introduction of Ground GPS data Introduce radiation on slopes: including slope aspect and angle in direct solar radiation Extend Q421 run to T+42 for MORST backup

4.1 UK4 model performance – subjective assessment

4.1.1 Precipitation

Variable performance, but generally performs better with strong dynamic forcing. The False alarm rate is high, but forecasts of orographically enhanced rain are good.

4.1.2 Temperature

Cold bias, RMSE and bias worse than the NAE model
Heatwave Summer 2006: Max. temperature ~3 Celsius lower than observations.

4.1.3 Wind

Slight slow bias. Objective verification scores better than the NAE. Good gale forecasts.

4.1.4 Cloud

Slight negative bias, although better than the NAE model.
Small scale structure impacts RMSE.
Better cloud base, particularly for low cloud (<300 m.).

4.1.5 Fog

Underestimated due to dry bias near saturation.

4.1.6 Visibility

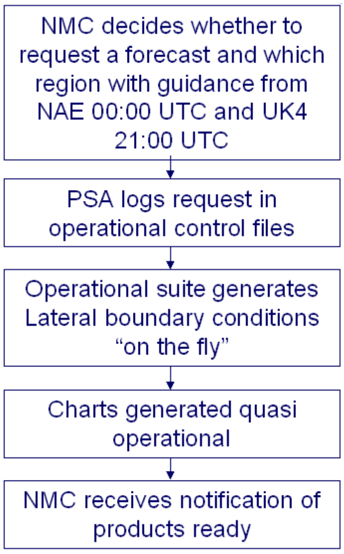
Generally poorer than coarser resolution.

5. 1.5km On-demand model

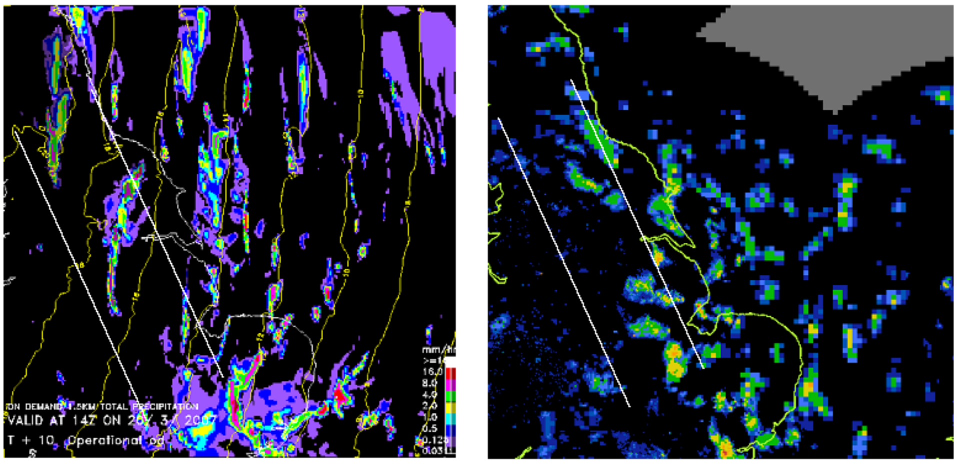
5.1 System set-up

9 Domains

- Nested in UK4.
- 300 x 300 gridboxes, approximately 450 km x 450 km.
- 38 levels.
- Spin-up from UK4 T+1.
- Forecast length 18 hours.
- Available at 03:00 UTC with possibility of a further 15:00 UTC forecast.
- Intended for evaluation of convective scale NWP by forecasters



5.2 Inland penetration of showers



Inland penetration of wintry showers from the North Sea

Deficient in coarser resolution models (die off too quickly) has been well represented by the model in all relevant occasions; however, the way precipitation structures align with the flow does not agree with the radar image. VT 20/03/2007 14:00 UTC; forecast T+14

Figure 7: Inland penetration of showers: 1.5km On-demand model (left) and radar (right). The straight white lines indicate the degree of penetration in the 1.5km model (the line furthest inland) and in the NAE model (the line nearer the coast).

5.3 Subjective Assessment

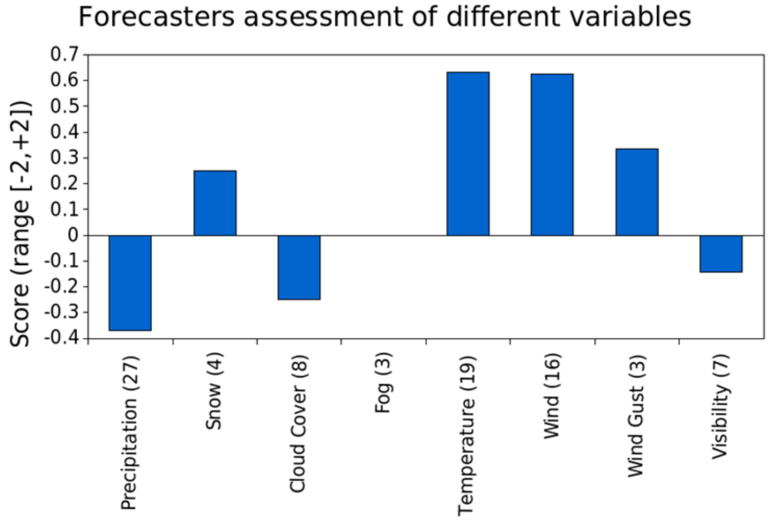
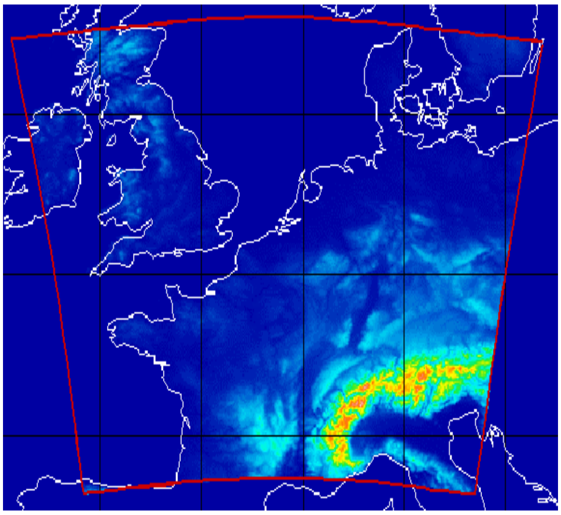


Figure 8: Forecasters subjective assessment of 1.5km model performance. The poor scores for precipitation possibly reflect the high expectations they have.

LIMITED AREA MODELLING ACTIVITIES AT THE ROYAL METEOROLOGICAL INSTITUTE OF BELGIUM

Josette VANDERBORGHT (josette.vanderborght@oma.be)

Operational Aladin Belgium



1. Main features

- Model version: AL29t2.
- 60 hour production forecasts four times a day (0, 6, 12 and 18 UTC).
- Lateral boundary conditions from ALADIN-France and Arpege global model.

2. The computer system

- SGI Altix 3700BX2.
- 56 Itanium2 1.5 GHz 6Mbyte CPU's.
- Peak performance: 4.1 Gflop/processor.
- 104 Gbyte internal memory.

3. Model geometry

- 7 km horizontal resolution (240*240 points).
- 46 vertical model levels.
- Linear spectral truncation.
- Lambert projection.

4. Forecast settings

- Digital filter initialization (DFI).
- time step 300 s (two time level semi-implicit semi-Lagrangian - SISL - advection scheme.
- Lateral boundary condition coupling at every 3 hours.
- Hourly post-processing (latitude-longitude and Lambert).

5. Operational suite/technical aspects

- Transfer of coupling file from Météo-France via Internet (primary channel) and the Regional Meteorological Data Communication Network (RMDCN, backup).
- Model integration on 16 processors.
- Post-processing on 8*1 processors.
- Continuous monitoring supported by a home-made Kornshell/Web interface.
- Monitoring with SMS (Supervisor Monitor Scheduler) will be made by October 2007.

Monitoring the Coupling-Update Frequency (CUF)

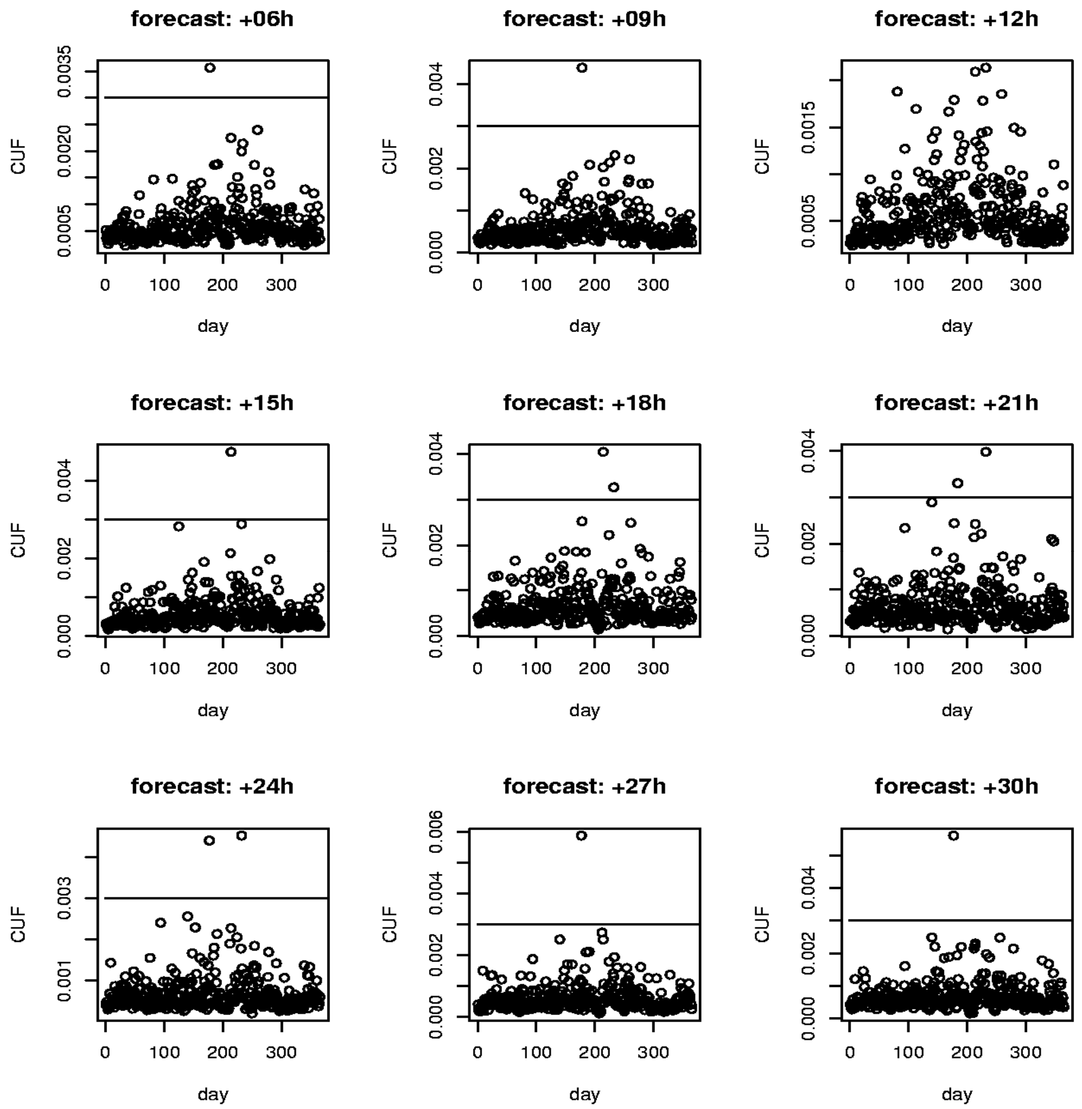
When a fast moving storm system crosses the border of a limited area model, the coupling frequency may be too low to capture this event adequately. Therefore, an index was developed (Termonia, 2004) to monitor the data loss due to the coupling.

The coupling files for ALADIN/Belgium contain the field CUF1PRESSURE since 21/02/2006. A high value for this index indicates that there is a potentially significant difference between the linear interpolation of 2 successive coupling files and the actual value in the original (e.g. global) model.

The figure summarizes the value of the index for the period 21/02/2006-31/08/2007 (only the forecasts at 00h). In this time, the warning threshold value of 0.003 was reached on 5 occasions:

- 24/11/2006: a storm entering the domain
- 25/11/2006: the same
- 01/12/2006: a system that only touched the coupling zone
- 31/12/2006: a system that only touched the coupling zone
- 18/01/2007: a storm system that developed inside the domain, but gives a signal when passing through the coupling zone.

In 4 of these cases, re-initializing the forecast doesn't make a difference. For the storm passing through on 25/11/2006, restarting the forecast with the storm inside the domain increases the wind speeds in the first hours (though only when turning the DFI off).



New approach to Lateral Boundary condition's

Some alternative ideas for the Davies scheme exist where one imposes the characteristic values at the inflow LBC’s and extrapolates (by upstream time differencing) the outgoing characteristics

The work of Aidan McDonald (2000, 2003, 2005, and 2006) has led to a formulation for the semi-implicit semi-lagrangian scheme in the HIRLAM model which leads to a quality that is comparable to the Davies Scheme

This is done by adapting the dynamical equations at the boundaries, i.e. in distinct points only.

In order to have a stable scheme as a net result, this adaptation should be done in the implicit part of the semi-implicit scheme, in practice being the Helmholtz equation.

In spectral models, this equation is solved in spectral space where the value of a field can not be changed in distinct points.
Termonia and Voitus propose an approach where the LBC's are computed with a numerical finite-difference scheme that is different than the SI SL scheme of the dynamical core.
This is called the extrinsic LBC's. This can be applied in a grid point model but much more interestingly, it may allow solving the problem of LBC's in spectral models.

Including atmospheric layers in vegetation and urban offline surface schemes

A formulation to include prognostic atmospheric layers in offline surface schemes is derived from atmospheric equations. While multi-layer surface schemes developed previously need a complex coupling between atmospheric models levels and surface scheme levels, the coupling proposed here remains simple, respecting the ALMA formulation. This is possible because the atmospheric layers interacting with the surface scheme are independent of the atmospheric model that could be coupled above (Masson, 2007). The Surface Boundary Layer (SBL) (both inside and just above the canopy) is resolved prognostically, taking into account large-scale forcing, turbulence and, if any, drag and canopy forces and surfaces fluxes.

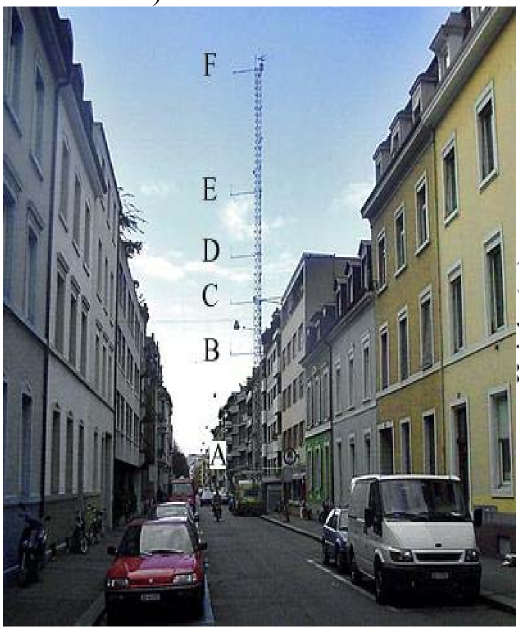
1. Validation with the ISBA scheme:

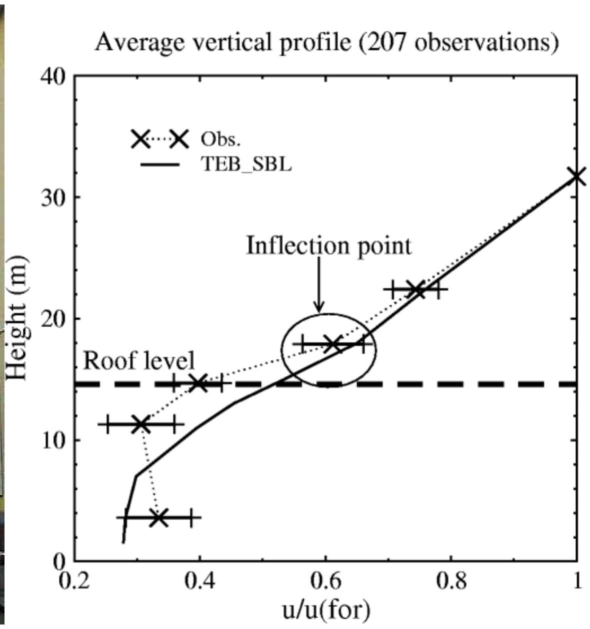
The SBL implemented in the ISBA (Noilhan and Mahfouf, 1989) scheme allows retrieving the logarithmic law in neutral conditions and is able to retrieve the 2m variables accurately, without any use of analytical extrapolation (as the Paulson laws 'REF'). In this Table are displayed the scores (bias and root mean square error -RMS-) on the surface radiative temperature, 2m temperature and 2m specific humidity for a flat terrain, low vegetation site, not far from Roissy airport (France) (Masson, 2007):

	Ts		**T2m**		**q2m**	
	BIAS	**RMS**	**BIAS**	**RMS**	**BIAS**	**RMS**
REF (3 years, overall scores)	-0.39	1.76	0.05	0.69	-0.10	0.59
SBL (3 years, overall scores)	0.09	1.67	-0.36	0.71	0.06	0.62
REF (3 years, daytime scores)	-0.46	2.32	-0.28	0.62	-0.05	0.68
SBL (3 years, daytime scores)	-0.25	2.39	-0.30	0.64	-0.01	0.70
REF (3 years, night time scores)	-0.55	1.58	0.32	0.86	-0.13	0.53
SBL (3 years, night time scores)	0.13	1.26	-0.40	0.78	0.12	0.54

2. Validation with the TEB scheme:

The inclusion of the SBL into the urban Town Energy Balance (TEB) (Masson, 2000) scheme is also presented (Hamdi and Masson, 2007), where the ability of the method to simulate both the profiles of both mean and turbulent quantities from above the building down to the road surface is shown using the BUBBLE experiment data (Basel, Switzerland).





Downscaling of the ERA-40 reanalysis

Belgian activities up to now were focused on the dynamical downscaling of the ERA-40 re-analysis. As a first approach, we opted for a **double nesting** strategy, with domain resolutions at 40 km and 10 km. A third nesting at 2 km was also introduced, but this consisted only of a dynamical adaptation run (30' and limited physics) for a more detailed wind field (Zagar & Rakovec, 1999). This work is part of the ECMWF special project SPFRCOUP.

- The first stage, at 40 km resolution, consists of runs starting at 00h and lasting 48 hours. They are coupled every 6 hours to interpolated ERA-40 data. The first 12 hours are taken as spin-up.
- The second stage consists of 36 hour runs at 10 km resolution, coupled every 3 hours to the 40 km data set. After 12 hour spin-up, this leaves 24 hours of data.
- The 10 km output is used (with constant boundary conditions) for a dynamical adaptation run at 2.1 km.
- Only the interpolation of ERA-40 data to the 40 km domain was run at ECMWF. All other steps were run locally at RMIB.

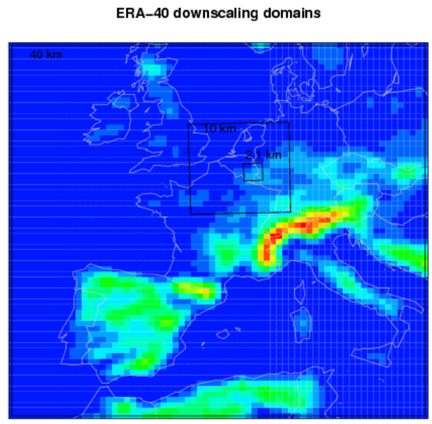


Illustration 1: ERA-40 Downscaling: nested domains for Belgium

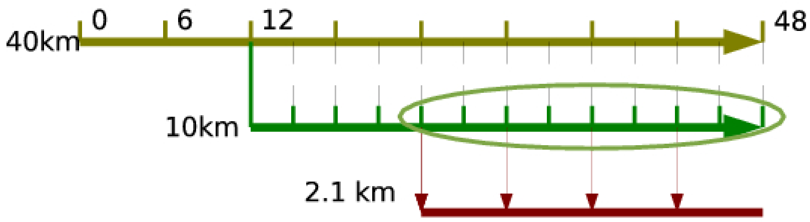
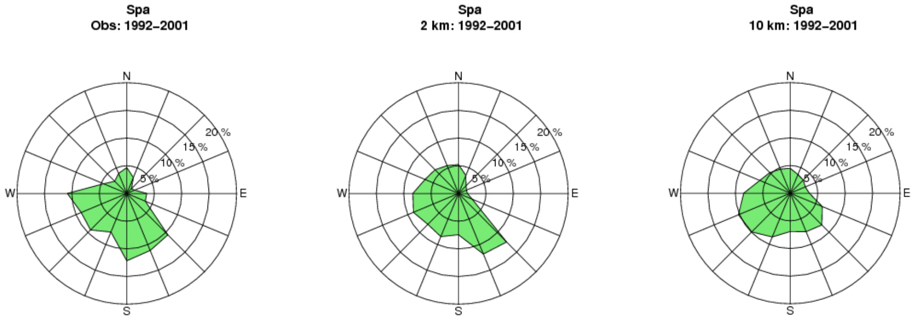


Illustration 2: Nesting strategy

Validation of wind downscaling

The downscaling of the wind field at 10 km and 2.1 km resolution has been compared to observed 10m winds at the station of Spa, which has significant orographic effects. The test period was 1992-2001. At 10km, the downscaled wind field (at the grid point closest to the station) does not accurately reproduce the local orographic effects, but at 2.1 km the SE wind component is very clearly visible.



When comparing the wind speed distribution, it can be seen that the downscaled climatology tends to underestimate wind speed for this location. But it should be noted that this is a very local effect. In the 2.1 km dynamical adaptation the wind speed distribution is much closer to the observations.

Progress with the 3MT scheme in Alaro-0

SEE “Activities in Slovenia”

Alaro-0 was developed for operational forecasts at high resolution, with meshes between 10 and 2 km.
3MT implements in Alaro-0 the package described by Gerard (2007) and ideas of Piriou
Tests have been performed at 9 and 4km resolution
The forecast at 4km, in the so–called grey zone of the convection, is consistent with the other scales

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NWP in Croatian Meteorological and Hydrological Service

Status report prepared by Alica Bajić, Martina Tudor, Stjepan Ivatek-Šahdan,
Lukša Kraljević, Blaženka Matjačić & Čedo Branković

Current status of the operational suite

Computer: SGI Altix LSB-3700 BX2 Server with 24 Intel Itanium2 1.6GHz/6MB, 48 GB standard system memory, 2x146 GB/10Krpm SCSI disk drive, OS SUSE Linux Enterprise Server 9 for IPF with SGI Package, Intel Fortran & C++ compilers version 9.0.031, No queuing system (PBS Pro licence expired)

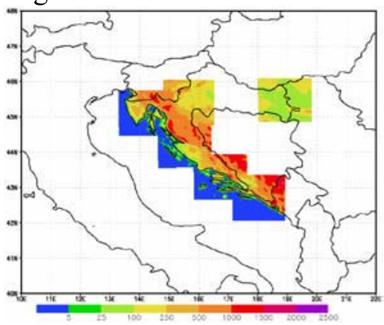
LBC files and lines: global model ARPEGE, coupling frequency 3 hrs, Internet primary and RMDCN through ecgate as backup from July 2006.

Domains, model set-ups and forecast range

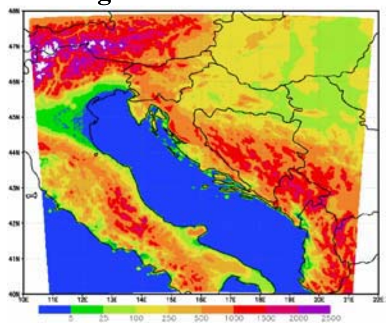
main: 8 km horizontal resolution, 37 levels in the vertical, 229x205 (240x216) grid points, Corners: SW (36.18,3.90), NE (50.68,26.90) two model set-ups are used:
1) AL29T1mxl with SLHD
2) Alaro0 (no prognostic cnv)
Digital Filter Initialisation for both

6 domains for high resolution dynamical adaptation:
- 2 km horizontal resolution,
- 15 levels in the vertical,
- 72x72 (80x80) grid points each.

forecast range: 72 hours for all



Changes in near future only one domain for dynamical adaptation
left-old 6 domains
right-new domain
size: (439x439) (450x450) g.p.
corners: SW(39.94,10.87),
NE(47.80,21.86)



Porting and runtime issues of Alaro0 to SGI Altix

The code was ported using gmkpack. Due to some characteristics of local compiler/computer, several subroutines had to be modified. The errors probably occur since the local compiler is not very forgiving. The cputime per timestep varies during integration, following the same general pattern shown in the figure below (ref).

	LQLSATUR	LRAYPL	LRAY	LCVRA	LADV	LSLHD	LSLONDEM
ref	T	T	T	T	T	T	T
exp1	F	T	T	T	T	T	T
exp2	F	F	T	T	T	T	T
exp3	F	F	F	T	T	T	T
exp4	T	T	T	F	T	T	T
exp7	T	T	T	T	T	F	T
exp8	T	T	T	T	F	F	T
exp9	T	T	T	T	F	F	F

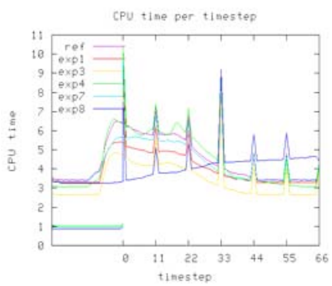
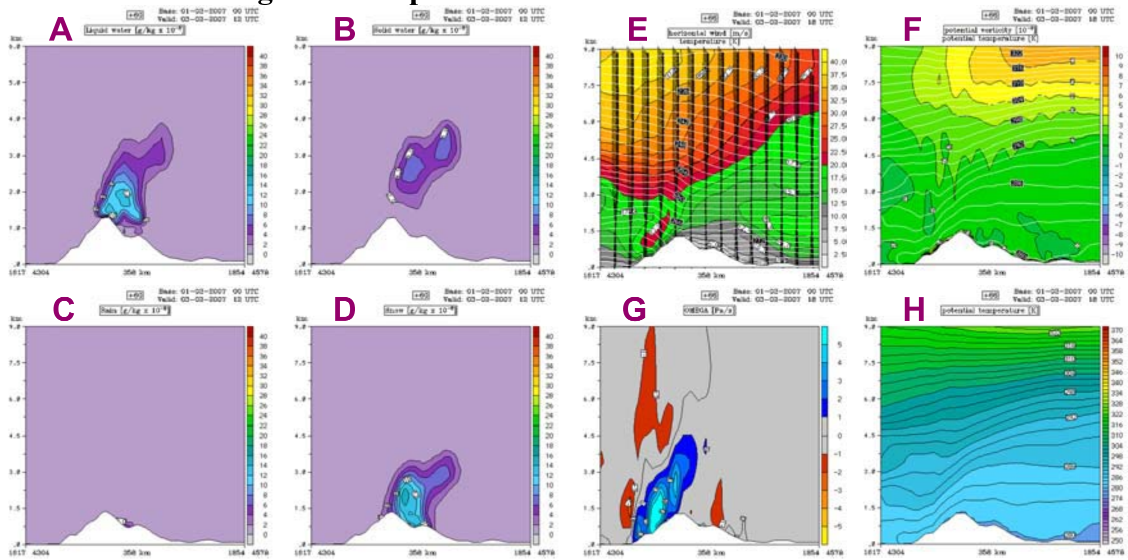


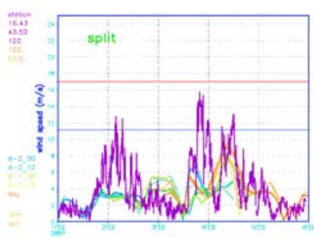
Table shows the experiment properties. LADV shows if the condensed species were advected, LSLHD shows if SLHD was used on condensed species and TKE. Figure shows CPU time per timestep for several experiments from the Table during the first 6 hours, 11 timesteps per hour. When advection of new GFL variables is switched off the increase of CPU per timestep during forward DFI is avoided, but the cputime per timestep grows slowly and continues to do so until 72 hours. Croatian SGI Altix is the only computer with this feature. In the examples, the historical output files are written every hour, while fullpos files are written every 3 hours.

Visualization products for Aladin and Alaro

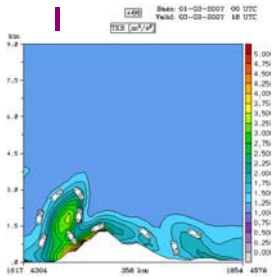
- numerous surface fields (including Alaro-Aladin difference) and fields on pressure levels,
- meteograms, vertical time cross section HRID's and ASCS vertical cross sections,
- hourly comparison of forecasts against SYNOP and automatic meteorological stations.

Not forecasted strong wind in Split



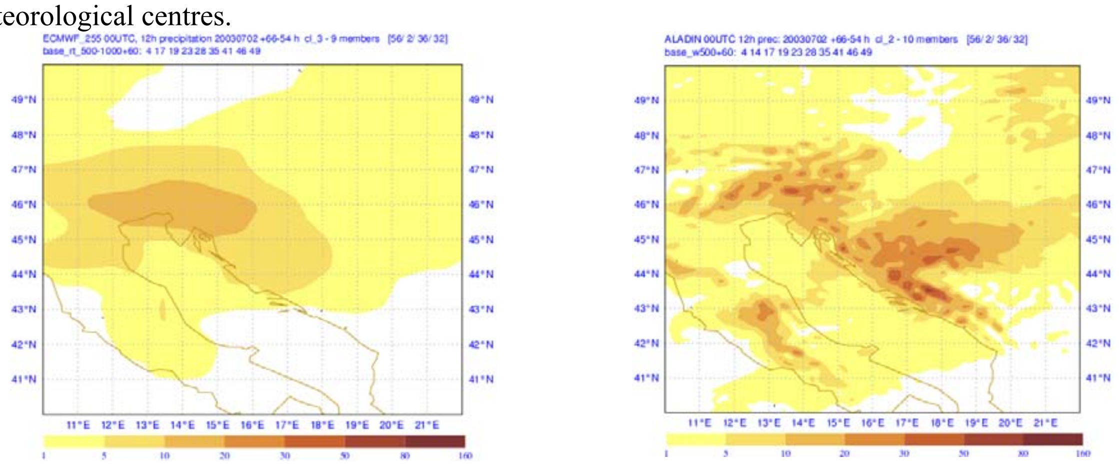


Vertical cross-sections through Split and Osijek for moist variables: cloud water (A) cloud ice (B) rain (C) and snow (D), wind (E), PV (F), potential temperature (H) and vertical velocity (G) and TKE (I).
Left: measured (dark purple) and predicted 10m wind speed using Aladin model with 8km (full lines) Alaro (thin lines) and 2km (dashed) horizontal resolution for Split.



EPS downscaling with ALADIN

Dynamical downscaling, using the ALADIN Limited Area Model (LAM), has been applied to the ECMWF Ensemble Prediction System (EPS) forecasts in order to assess its potential impact during cases of severe weather (precipitation and wind) over various parts of Croatia. Four synoptic cases are considered, for which both global and regional 51-member ensembles were run. The differences in some basic forecast statistics between the two ensembles have been identified. Such statistics is extended to the clusters derived from both ensembles using the same clustering algorithm. The results indicate that, on average, downscaling may yield differing results between global and regional ensembles and can have an important impact on clustering. Because of such potential dissimilarities between global and regional clusters, a careful consideration must be taken when choosing the global representative members for dynamical downscaling, currently the operational practice in some meteorological centres.

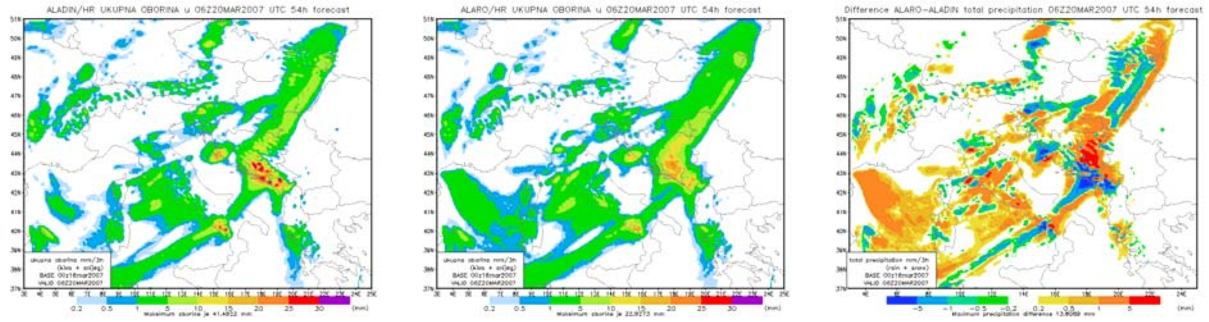


The 12-hour accumulated precipitation between T+54 and T+66 hr for ECEPS cluster no. 3 for the RT 500/1000 clustering base (left) and for ALEPS cluster no. 2 for the omega 500 clustering base (right). Contouring 1, 5, 10, 20, ... mm/12 hr. More in ECMWF Technical Memorandum No. 507.

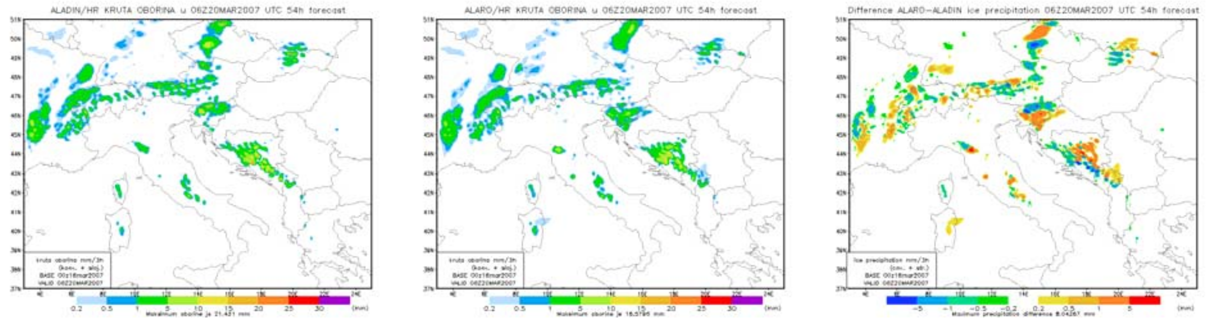
First Alaro operational forecast experiences

Differences between Alaro and Aladin forecasts are plotted operationally for precipitation, cloudiness, 2m temperature and humidity, 10m wind, mean sea level pressure and other prognostic variables. Cold fronts move faster in Alaro than in Aladin. Temperature differences appear due to evaporation of precipitation and cloudiness. Usually, Alaro gives more clouds than Aladin, especially later in the forecast run. Aladin looses much moisture from the atmosphere that is kept in Alaro with moist prognostic variables. Alaro produces less precipitation generally, but more on the lee side of mountains and hills.

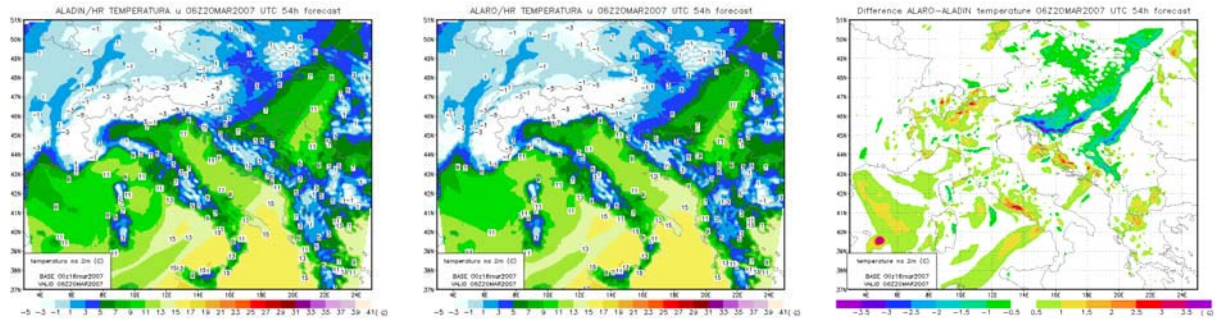
Example of forecast for a 19th March 2007 cold front passage are shown bellow



Precipitation fcsts for a cold front passage with Aladin (left) and Alaro (center) and their diff. (right).



Snow forecasts for a cold front passage with Aladin (left) and Alaro (center) their difference (right).



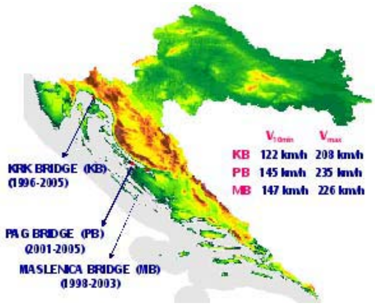
2m temperature fcsts for a cold front passage with Aladin (left) and Alaro (center) their diff (right).

EMEP4HR

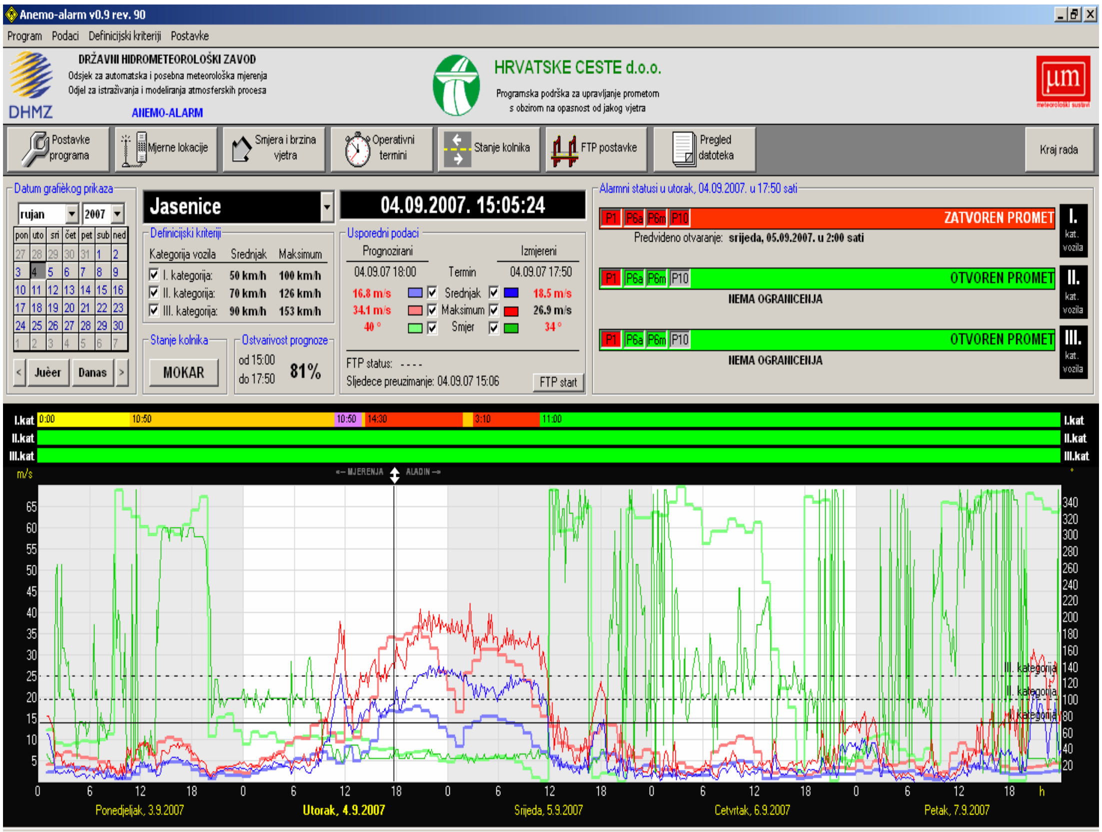
EMEP4HR is a joint MHSC - Met.no project on developing air quality modelling capabilities at MHSC. The project has two main aspects, scientific and operational. Operational aspects include two work packages. First package aims at linking Unified EMEP model - an eulerian chemical transport model, together with ALADIN NWP model as its meteorological driver. In the second package, high resolution emission inventories for Croatia will be made. The project is in the early development stage and first results are expected soon.

ALADIN and road traffic safety in regions with severe bura winds

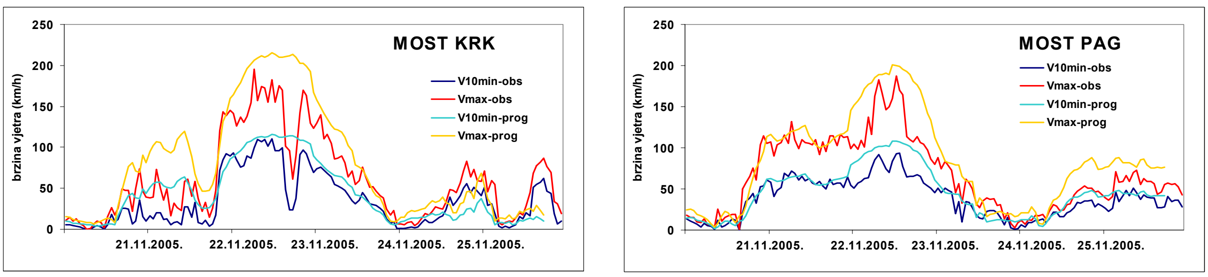
The Numerical modelling department of the Croatian NMS participates in the ANEMO-ALARM project. Its aim is to develop and apply operational warning service for maintaining road traffic safety in regions with severe bora winds. The ANEMO-ALARM is based on the ALADIN forecast products as a main triggering mechanism for assigning different alarm status. The possibility of ALADIN to forecast the strength and onset time of bora wind has been studied on the base of 10 most intense severe bora cases during the period 2003-2006 as the first stage of the program. Obtained results show that ALADIN provides appropriate tool to solve the users demands and maintain road traffic safety.



Locations with the measured maximum bora wind speeds. V10min - 10-minutes wind speed, Vmax - maximum wind gusts



Example of the ANEMO-ALARM warning system screen that will be available for the operational road maintenance service (Prognozirani=forecast Izmjereni=measurements).



Measured and modelled wind speeds during the severe bora cases.

STATUS REPORT OF THE CZECH HYDROMETEOROLOGICAL INSTITUTE (CHMI)

OCTOBER 2006 - SEPTEMBER 2007

Filip Váňa

The core NWP application at CHMI is the ALADIN/CE model. Its main characteristics are to this date (October 2006) as follows:

- LACE domain (309x277 grid points, linear truncation E159x143, Δx=9km),
- 43 vertical levels,
- time step 360 s,
- mean orography,
- OI surface analysis based on SYNOP data,
- digital filter spectral blending of the upper air fields, long cut-off cycle (6h cycle, filtering at truncation E47x42, no DFI in the next +6h guess integration),
- digital filter blending + incremental DFI initialization of short cut-off production analysis of the upper air fields,
- 3h coupling interval,
- ARPEGE/ALADIN cycle 32t1_alr01
- ALARO-0 without 3MT physics package containing:
  - pseudo-prognostic TKE scheme (TKE fully prognostic but use in input of turbulent exchange coefficients computed diagnostically following Louis et al. (1981)) with shallow convection according to Geleyn (1987) and a specific anti-fibrillation scheme (Bénard et al., 2000)
  - modified calculation of vertical diffusion coefficients in stable conditions
  - gravity wave drag parameterisations takes into account anisotropy, the Lott-Miller form-drag effects of blocking and some midtropospheric effects on top of the linear deposition at critical levels, lift effect (Catry et al., 2008)
  - cloud optics takes into account the effect of spectral saturation, globally across the atmosphere
  - prognostic micro-physical scheme of resolved clouds and precipitation: prognostic cloud water, cloud ice, rain and snow; parameterization of autoconversion, WBF process, collection, evaporation, sublimation and melting/freezing; statistical sedimentation scheme (Geleyn et al., 2008); diagnostic graupel effect; vertical geometry of clouds and precipitation areas taken into account
  - simplified radiation scheme called at every time step and derived from Geleyn and Hollingsworth (1979) and Ritter and Geleyn (1992) containing a simplified version of the Voigt-line-broadening effect and revised statistical model for secondary thermal radiation coefficients
  - an improved version of the ISBA including an explicit parameterisation of soil freezing
  - simple parameterization of snow cover
  - constant analyzed sea surface temperature and amount of sea-ice
  - mass flux convection scheme (Bougeault, 1985) modified in many aspects see Gerard and Geleyn (2005)
- generic multi-phasic barycentric equations (Catry et al., 2007)

- semi-Lagrangian horizontal diffusion (Vana et al., 2008)
- OpenMP parallel execution,
- daily 4x per day execution: 00 and 12 UTC forecast to +54h, 06 and 18 UTC forecast to +24h,
- hourly off-line fullpos,
- post-processing of near-surface parameters into selected localities using obs-operators of OI.

The major operational changes during the period October 2006 - September 2007 were:

30 January 2007 ALARO-0 (without 3MT) package, introduction of prognostic snow albedo and density and ozone climatology

11 July 2007 Fix to cloud geometry in microphysics and sublimation of snow

3 September 2007 Switch to CY32T1

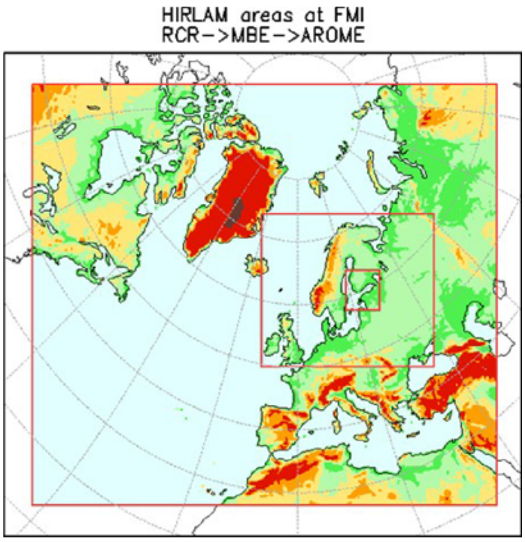
In the close future the main operational point of interest at CHMI is to complete and validate the 3MT prognostic convection. Besides this priority topic pre-operational validations of the 3DVAR assimilation of the upper air fields are planned for the year 2008.

Operational NWP at FMI

Carl Fortelius and the NWP team

Overview

The Finnish national weather service relies on the ECMWF for synoptic-scale medium-range numerical weather forecasts. Deterministic short range forecasts are generated by two suites of the HIRLAM forecasting system (HFS), one for the synoptic scale (RCR) and one mainly for the meso-β scale (MBE). Additionally, dynamic downscaling of the RCR forecast to the meso-γ scale is carried out by using the AROME system.

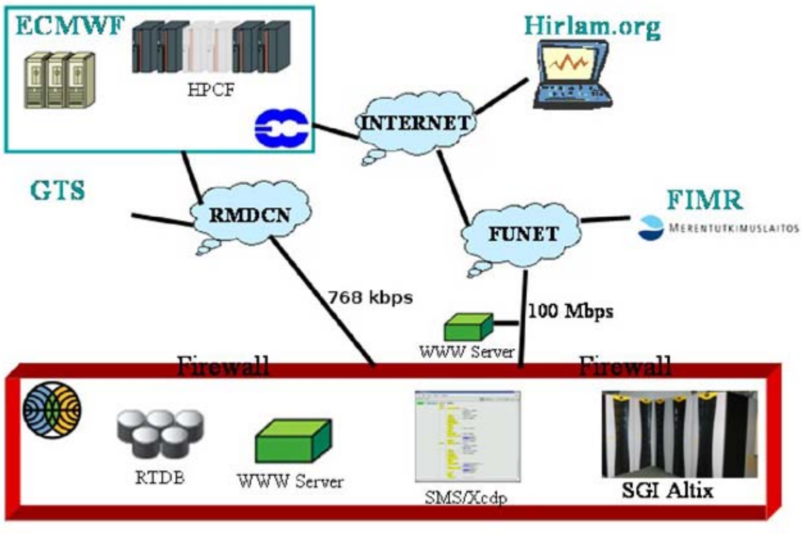


Acting as lead centre for reference runs within the HIRLAM consortium, we always apply the latest reference version of the HFS on the larger domain (RCR). Our on-line monitoring facility is used by scientists throughout the HIRLAM programme for monitoring and assessment. The output from the RCR-suite is stored at ECMWF, and forms a widely used basis for testing new developments.

Computing and data handling

The operational forecasts are produced in-house on a Silicon Graphis Altix 3700 BX2 high performance computer consisting of 304 Intel Itanum 2 1.5 GHz processors with 4 MB of cache, and a total of 304 GB of shared memory. The system is operated by Novell Suse Linux and we use the Platform LSF work load management software. All operational computing and data handling are controlled by the SMS system monitoring and scheduling software, produced and maintained by the ECMWF.

Lateral boundary files for the HIRLAM-suites are received from the ECMWF over the



internet, using the MD5 checksum to ensure a faultless transfer. Two sets of boundary files are needed four times a day, making up a total of 1.5 GB of data per cycle. By using parallell processing, the transfer is accomplished in only 30 minutes.

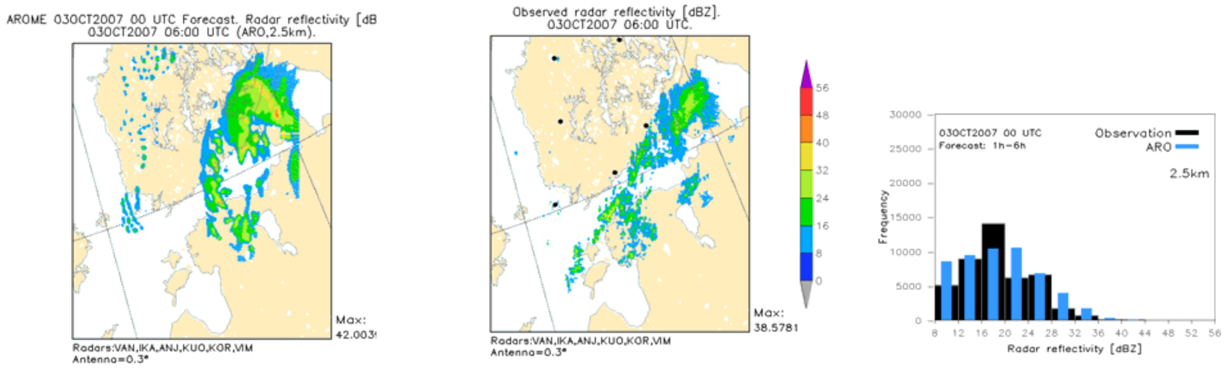
Details

The table summarizes details of the current HFS reference system (HIRLAM 7.1.2) as implemented at FMI on the large domain (RCR). On the smaller domain (MBE) an older version is still in operation but is about to be replaced by new suite, already running parallel to the old one. In the new MBE-suite we run the same HFS version as in the RCR-suite on the same levels but on a denser horizontal grid of 0.068 by 0.068 degrees, without using AMSU-A observations and without the re-analysis step.

Analysis	
Upper air analysis	3-dimensional variatinal data assimilation
Version	HIRVDA 7.1.2, FGAT option
Parameters	surface pressure, wind components, temperature, specific humidity
Surface analysis	Separate analysis, consistent with the mosaic approach of the surface/soil treatment * sea surface temperature, fraction of ice * snow depth * screen level temperature and humidity * soil temperature and moisture in two layers
Horizontal grid length	0.15 degrees on rotated lat-lon grid
Integration domain	582 x 448 grid points
Levels	60 hybrid levels
Observation types	TEMP, PILOT, SYNOP, SHIP, BUOY, AIREP, ATOVS AMSU-A brightness temperatures
Background	3 hour forecast, 3 hour cycle
Initialization	Incremental digital filter (IDFI)
Data cut-off time	2 h for main cycles, 4 h 20 min for intermediate cycles
Assimilation cycle	3 h cycle, reanalysis step every 6 h to blend with large-scale features of the ECMWF analysis.

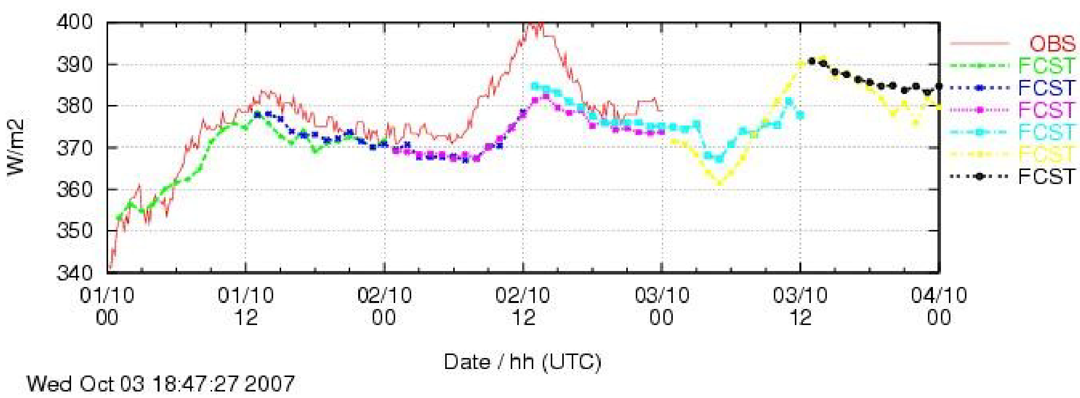
Forecast model	
Forecast model	Limited area grid point model
Version	HIRLAM 7.1.2
Basic equations	Primitive equations
Independent variables	longitude, latitude, hybrid level, time
Dependent variables	log. of surface pressure, temperature, wind components sp. humidity, sp. cloud condensate, turbulent kinetic energy
Discretization	Arakawa-C
Horizontal grid length	0.15 degrees on rotated lat-lon grid
Integration domain	582 x 448 grid points
Levels	60 hybrid levels
Integration scheme	Semi-Lagrangean semi-implicit, time step 360 s.
Orography	Hirlam physiographic data base, filtered
Physics	* Savijärvi radiation scheme * Turbulence based on turbulent kinetic energy * STRACO condensation/convection scheme * Surface fluxes according to drag formulation * Surface and soil processes using mosaic approach
Horizontal diffusion	Implicit fourth order
Forecast length	54 hours
Output frequency	Hourly
Boundaries	* "Frame" boundaries from the ECMWF optional BC runs * Projected onto the HIRLAM grid at ECMWF * Boundary file frequency 3 hours * Updated four times daily

For southern Finland the HIRLAM RCR forecasts are dynamically down-scaled using the AROME model. AROME cy30t1 (to be replaced by cy32t2 within October 2007) is run on 40 levels with a horizontal grid-spacing of 2.5 km. Output is stored every 15 minutes from 24-hour forecasts started on 00 and 12 UTC every day. A special feature of the AROME forecasts are simulated radar reflectivities allowing direct intercomparison with the latest radar observations. An example is shown in the figure below.



On-line forecast monitoring

We maintain an on-line monitoring facility where model output can be compared in real time to measured profile and flux data at meteorological towers. An example showing upwelling longwave radiation at the Cabauw tower is given in the figure below.



Presently the monitoring includes data from Sodankylä in northern Finland and from Cabauw in the Netherlands, as well as forecasts from two Finnish and one Spanish HIRLAM suite and from the French ARPEGE system. Other initerested forecasters and tower operators are welcome to join in the intercomparison by providing data or forecasts, and are encouraged to contact either Markku.Kangas@fmi.fi or Carl.Fortelius@fmi.fi.

LIMITED AREA MODELLING ACTIVITIES AT THE HUNGARIAN METEOROLOGICAL SERVICE (2007)

András Horányi, Edit Hágel, Sándor Kertész, László Kullmann, Roger Randriamampinina
Hungarian Meteorological Service (1525 Budapest, P. O. Box 38.)

INTRODUCTION

The numerical weather prediction (NWP) group (now it is called as Division for Numerical Modelling and Climate Dynamics, which indicates that regional climate modelling is also part of our activities) of the Hungarian Meteorological Service (HMS) belongs to the Department of Forecasting and Climate. At the moment the team consists of 11 people (we lost 6 people within a year, therefore our recent activities are really in danger). The main NWP activities are concentrating on the work around the ALADIN limited area model. The backbone of the research and development is the operational exploitation of the ALADIN/HU limited area model. The three most important research and development areas of interest are data assimilation, short range ensemble prediction and non-hydrostatic modelling.

ALADIN OPERATIONAL EXPLOITATION: ALADIN/HU

The operational ALADIN/HU suite is realised at the SGI Altix machine with integrations four times a day (54h, 48h, 48h, 36h respectively).

Main features of the operational ALADIN/HU model

- Model version: AL30T1
- Initial conditions: 3d-var data assimilation (see also below)
- Digital filter initialisation (DFI)
- Two-time level semi-implicit semi-Lagrangian advection scheme (timestep: 300s)
- Lateral boundary conditions (LBC) from the ARPEGE French global model with 3h update frequency

Model geometry

- 8 km horizontal resolution (349*309 points)
- 49 vertical model levels
- Linear spectral truncation
- Lambert projection

Assimilation settings

- 6 hour assimilation cycle
- Short cut-off analyses for the production runs
- Ensemble background error co-variances
- Digital filter initialisation (DFI)
- LBC coupling at every 3 hours

Observation usage

- SYNOP (surface pressure)
- TEMP (temperature, wind components and humidity)
- ATOVS/AMSU-A (radiances from NOAA 15 and 16 satellites) with 80 km thinning distance

- ATOVS/AMSU-B (radiances from NOAA 16 and 17) with 80 km thinning distance
- AMDAR (T, u, v) with 25 km thinning distance and 1 hour time-window together with a special filter (that allows only one profile in one thinning-box)
- AMV (GEOWIND) data
- Web-based observation monitoring system

The computer system

- SGI Altix 3700
- CPU: altogether 152 processors from which 72 for NWP (1,5GHz Itanium II)
- 304 Gbyte internal memory
- IBM TotalStorage 3584 Tape Library (capacity ~ 30 Tbyte)
- PBSpro job sheduler

ASSIMILATION OF SEVIRI DATA IN THE ALADIN/HU 3D-VAR SYSTEM

Due to its high spatial and temporal resolution the SEVIRI (MSG) data is considered to be an important ingredient for a data assimilation system, therefore explorations had been started for their optimal inclusion into the ALADIN/HU 3d-var data assimilation system (the work was basically performed during the stay of Alena Trojakova in Budapest).

Regarding the pre-processing of the SEVIRI data a single file in GRIB format is created hourly, which consists of 17 components as follows:

- The SEVIRI brightness temperatures for channels 3.9 μm, 6.2 μm, 7.3 μm, 8.7 μm, 9.7 μm, 10.8 μm, 12.0 μm and 13.4 μm (8 components);
- The associated constant fields: date, longitude and latitude position, azimuth and zenith angles (5 components);
- The cloud type and cloud top pressure with their quality flags (4 components)

Several assimilation and forecast experiments have been carried out using the SEVIRI data including various tunings of the observation and background error variances. The main conclusions of the study can be summarised as follows:

- SEVIRI data are available for an operational use at HMS.
- The impact of the SEVIRI data in our system was found to be similar order of magnitude as that of ATOVS data (AMSU-A or AMSU-B) assimilated in high resolution.
- Both improvements and degradations in RMSE can be found depending on the vertical level and the variable.

Regarding plans for the future the following issues will be considered:

- To perform additional experiments using only the water vapour channels;
- Testing the use of more surface measurements (e. g. 2 m humidity and/or 2 m temperature) with the aim to try to correct the humidity fields near the surface.

INVESTIGATION OF THE ALADIN 3D-FGAT SYSTEM

3D-FGAT is regarded as an intermediate step between 3D-VAR and 4D-VAR. In contrast to 3D-VAR, which cannot handle temporal information and is restricted to the analysis time, 3D-FGAT is even able to take into account the temporal distribution of the observations (though only in a limited way). In the incremental formalism, supposing that there are n time-slots, the cost function of 3D-FGAT takes the following form:

In our the experiments the ALADIN 3D-FGAT system was tested on a 21 day period (with a

$$J(\delta\mathbf{x}) = \delta\mathbf{x}^T\mathbf{B}^{-1}\delta\mathbf{x} + \sum_{i=1}^{n}(\mathbf{d}_i - \mathbf{H}\delta\mathbf{x})^T\mathbf{R}^{-1}(\mathbf{d}_i - \mathbf{H}\delta\mathbf{x})$$

4 days of warm up period) using 6h analysis cycling and 7 one-hour-long time-slots. All the observations were available at the middle point of the observation window except AIREP and satellite radiances. The horizontal model resolution was 12 km.

Because the resulting analysis increment in 3D-FGAT has no temporal information it is not trivial to determine its temporal position i.e. where to add to the background trajectory:

- By default the ALADIN model adds the analysis increment to the background trajectory at the beginning of the assimilation window.
- Regarding the temporal distribution of observations the middle of the observation window seems more reasonable choice.

Both configurations were tested and it turned out that by shifting the increment to the middle of the observation window 3D-FGAT gives significantly better results.

3D-FGAT was compared with 3D-VAR using the same set of observations. Regarding the observation statistics the two systems differed only in AIREP and satellite radiances. The background departures for AIREP were smaller at certain levels in 3D-FGAT. The difference for the satellite radiances was less significant and the mean of the departures was even smaller in 3D-VAR. This may indicate that the applied bias correction coefficients that were derived by 3D-VAR are not suitable for the use in 3D-FGAT. The largest difference in the forecast scores was found in the wind speed near the flight level at 00 UTC using all the AIREP reports. For the 12 UTC runs the two systems performed quite similarly.

COMPUTATION OF ALADIN SINGULAR VECTORS, VERY FIRST EXPERIMENTS

We continued the research with ALADIN singular vectors. After testing the adjoint and tangent linear configurations of ALADIN the real singular vector experiments could start. First, technical issues were addressed as speed of convergence during the singular vector computation, as well as CPU time and memory usage. These are rather important issues, since the number of iterations performed determines the accuracy of the computed singular values/vectors. The more iterations performed, the more precise the results we get. On the other hand more iterations require more CPU time and memory, therefore a compromise solution is needed.

For the computation of singular vectors, several technical and scientific choices have to be done. These include the choice of norms both at initial and final time, the optimisation area(s), the optimisation time and the vertical optimisation as well. For our first tests the following choices were made:

- Norms: total energy norm (both at initial and final time)
- Optimisation area(s): 55.78N/33.67S/1.83W/39.79E (i.e. the so called LACE coupling domain)
- Optimisation time: 12 hours
- Vertical optimisation: between level 1 and 46, i.e. all levels
- Resolution used for SV computations: ~20 km
- Coupling frequency: every 3 hours, coupling files from ARPEGE

The ALADIN singular vectors were compared to those of other models. Comparison to ARPEGE singular vectors is obvious. In addition research has started to compare the ALADIN singular vectors with high resolution IFS (ECMWF model) and with HIRLAM singular vectors as well. The next step is to study the singular vectors in more detail and later we plan to use them to generate perturbations, which will provide initial conditions for the ALADIN ensemble system.

CASE STUDIES WITH THE AROME NON-HYDROSTATIC MODEL

We continued to run case studies with the AROME non-hydrostatic model. The selected cases were heavy precipitation events.

Sensitivity to coupling zone size: Earlier experiments showed that due to the small domain size of AROME the coupling model has too large influence on the forecast, especially near to the border of domain. One way to decrease this influence is to increase the size of the coupling zone. We studied the sensitivity of the forecasts with respect to the coupling zone size. Different values were tried but according to the results the effect is quite neutral. Nevertheless there are cases where some improvement can be seen due to a bigger coupling zone.

Sensitivity to coupling model: In the experiments we did so far we coupled AROME to ALADIN. A case was found when ALADIN was not able at all to predict correctly the precipitation location and AROME coupled to ALADIN performed in a similar way. Neither using bigger AROME domain nor changing the coupling frequency or coupling zone size could help to improve the forecast. We then tried to couple AROME to another AROME model, which had the same resolution (8 km) and dynamics than ALADIN but uses different microphysics. The result shows that by coupling AROME (2.5 km) to AROME (8 km) instead of ALADIN the forecast improved significantly (so the impact of microphysics parameterisation in the coupling model is important!).

Hydrometeor initialisation: AROME microphysics uses 6 prognostic hydrometeors. Since the coupling model (ALADIN) does not contain "condensed" prognostic hydrometeors (only vapour) the initial values of these variables are taken zero for AROME. This results in a poor precipitation forecast in the first few hours of integration (spin-up). To improve the forecast we tried the following initialisation methods:

a) All hydrometeors are taken from the initial condition of the coupling model, i.e. "condensed" hydrometeors (everything except vapour) are zero (reference case).
b) All hydrometeors are taken from the forecast of an earlier AROME run.
c) Specific humidity is taken from the initial condition of the coupling model, "condensed" hydrometeors from the forecast of an earlier AROME run.

In case of method b) there is inconsistency between initial and lateral boundary values of specific humidity. On the other hand in case c) the initial values of condensed phase hydrometeors are inconsistent with the initial values of specific humidity. The three methods were compared. The overall results showed that method c) is superior compared to the other ones.

SUMMARY

The main limited are modelling activities were briefly summarised in this overview. Beside the description of the operational ALADIN/HU system data assimilation, short range ensemble prediction system and non-hydrostatic modelling issues were considered and described. Due to the requirement of brevity, figures are not enclosed to this report, therefore the interested readers are kindly asked to contact the authors, if further details and/or explanations are needed.

ACKNOWLEDGEMENTS

This paper presents results of research programs supported by the Hungarian National Research Foundation (OTKA, Grant N° T049579, T047295), Hungarian National Office for Research and Technology (NKFP, Grant N° 3A/051/2004, 2/007/2005) and the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

NWP at Met Éireann – Ireland – 2007

Introduction

The Hirlam system is used at Met Éireann – the Irish Meteorological Service – to produce operational forecasts out to 48-hours. The model [version 7 with 3DVAR] is run four times per day using 32 dual-CPU nodes of the walton cluster at ICHEC [Irish Centre for High-End Computing].
Met Éireann and ICHEC [www.ichec.ie] signed a collaboration agreement early in 2007. As part of this collaboration ICHEC provides computational facilities and support to Met Éireann to enable it to run its operational high-resolution forecast models on ICHEC's flagship supercomputer, walton [IBM eServer cluster 1350 consisting of 476 IBM e326 compute nodes with 20 TB of tightly integrated high-performance SAN based around an IBM DS3400].

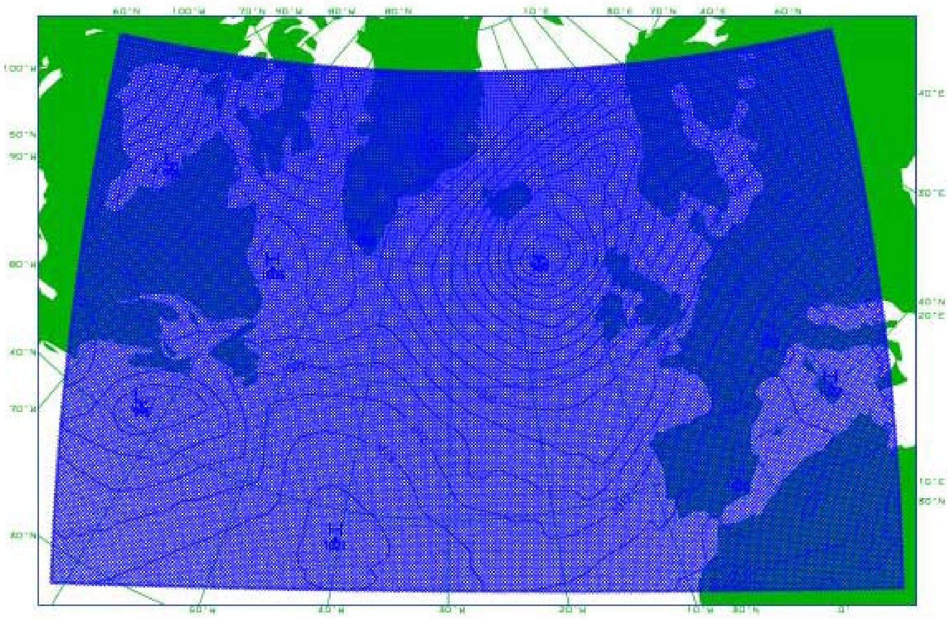
Data Assimilation

Observations: SYNOP, SHIP, BUOY, AIREP, AMDAR, ACARS TEMP, TEMPSHIP, PILOT, SATOB and SATEM observations are used. The data are packed into BUFR format both for storage and for input to Hirlam.
Analysis: Hirlam 3D-Var [3-dimensional variational assimilation]. The analysis runs on 60 hybrid [eta] levels. Upper-air observational data is accepted on all standard and significant levels (10 hPa to 1000 hPa) and interpolated to eta levels.
Assimilation Cycle: Three-hour cycle using the forecast from the previous cycle as a first-guess. [It is also possible to use an ECMWF forecast as a first-guess].
Analysed Variables: Wind components (u,v), geopotential and specific humidity.

Forecast Model

Forecast Model: Hirlam 7 reference system grid point model.
Horizontal grid: A rotated latitude-longitude grid is used with the South-Pole at -30˚ longitude, -30˚ latitude). Fields are based on a 438x284 grid corresponding to 0.15˚ x $0.15˚ horizontal Arakara C-grid [see diagram on next page].
Vertical Grid: Hybrid [eta] coordinate system with 60 levels.
Initialisation: Digital Filter.
Integration Scheme: We use a two time-level three-dimensional semi-Lagrangian semi-implicit scheme with a time-step of 300 seconds.
Filtering: Fourth order implicit horizontal diffusion.
Physics: CBR vertical diffusion scheme; Sundqvist condensation scheme with the 'STRACO' (Soft TRAnsition COndensation scheme) cloud scheme; Savijarvi radiation scheme.
Lateral Boundary Treatment: Davies-Kallberg relaxation scheme using a cosine dependent relaxation function over a boundary zone of 8-lines. The latest available ECMWF 'frame' files are used [based on 4 ECMWF runs per day at 00Z, 06Z, 12Z and 18Z, respectively]. ECMWF data is received on a 0.3˚ x 0.3˚ rotated latitude-longitude grid on a selection of the 60 ECMWF eta levels. The data is interpolated both horizontally and vertically to the Hirlam 0.15˚ x 0.15˚ rotated latitude-longitude grid at [Hirlam] 31 eta levels. [The selected 0.3˚ x 0.3˚ grid corresponds to half the resolution of the 0.15˚ x 0.15˚ grid; we may upgrade to full resolution in the future if the line-speed proves fast enough].
In general the ECMWF boundary files are just provided as 'frame' boundaries where the data is not defined in the central section of the grid. However, the ECMWF

analysis fields are received on a 'full' grid and so can be used as a 'first-guess' in the case of a 'cold-start'.

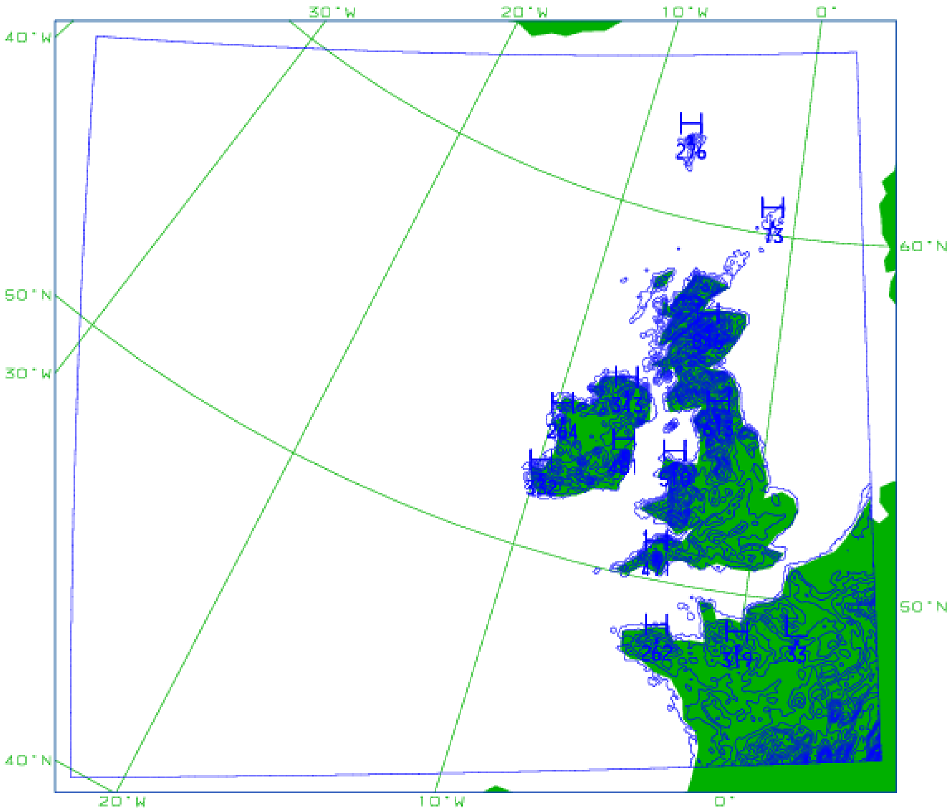


Data Monitoring
The analysis departures/flags are fed back to the original BUFR reports to create 'feedback' files which are used to monitor the quality of the data on an ongoing basis and to identify problems [e.g. station elevation errors].

Operational Usage
General Forecasting: Hirlam forecasts are used for general forecasting in Met Éireann out to 48-hours. [ECMWF forecasts are used beyond that period]. Hirlam output can be displayed using an interactive graphics system called *xcharts* (developed at Met Éireann).
WAM model: Forecast 10-metre winds from Hirlam are use to drive a WAM wave model.
Roadice Prediction System: Forecast surface parameters [temperature, wind, cloud-cover, humidity and rainfall] are used [after forecaster modification] as input to a roadice model.
SATREP: Hirlam output can be overlaid on satellite plots as part of the ZAMG SATREP analysis scheme.

Verification
Verification against Fields: A small number of Hirlam parameters are verified against the corresponding Hirlam analysis fields. [This is to provide continuity with an earlier model which was used before Hirlam became operational].
Verification against Observations: The Hirlam verification system is used to verify forecasts against observations from EGWLAM stations within the area.

Nested Hirlam
A nested version of Hirlam is also run at ICHEC. It runs immediately after the main run has finished and produces 30-hour forecasts. It runs on a 438x395 grid, with 60 levels in the vertical. The grid spacing is 0.05˚ x 0.05˚. The following diagram shows the area:



Nested Hourly Analysis
A separate nested version of Hirlam is run every hour on a high-performance PC running Linux. The run has a cutoff time of 20-minutes and provides an hourly analysis and also a short range [3-hour] local forecast.
Forecast Model: Hirlam 7 forecast model.
Vertical grid: A set of 40 hybrid [eta] levels.
Horizontal grid: A rotated latitude with 166x163 grid points with a resolution of 0.15˚ x 0.15˚.

Experiments with Linux Cluster
Met Éireann started to experiment with running Hirlam on a Linux cluster in early 2004. The experiences have been generally good. The cluster performance is similar to our old IBM RS/6000 SP mainframe [a system with 9 nodes each with 4 processors sharing 2 Gbytes of memory i.e. a total of 36 CPU's and 18 Gbytes of memory]. We use the cluster to run a backup version of the operational Hirlam-7 model but with 31-levels rather than the 60 used at ICHEC.

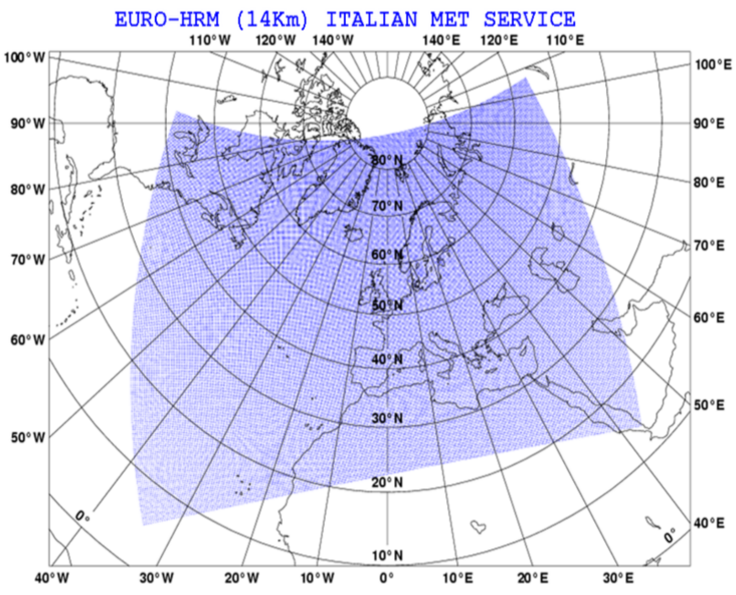
Italian Meteorological Service Status Report

Massimo Bonavita, Lucio Torrisi, Antonio Vocino and Francesca Marcucci

CNMCA Pratica di Mare (ROMA)
bonavita@meteoam.it, torrisi@meteoam.it,
vocino@meteoam.it, marcucci@meteoam.it

Regional Modelling and Data Assimilation

The regional model EURO_HRM, whose main features are summarised in Table 1, is operationally run by the Italian Meteorological Service (IMS) over the domain shown in Fig. 1. Most of the development activities which were started in 2006 have found their way into operations since they were found to be beneficial to the analysis and forecast skill.
Most notable improvements have been:
- 3-hourly analysis update cycle;
- doubling of horizontal resolution of EURO_HRM model (to 0.125 Deg., ~14 Km);
- FGAT treatment of observation increments in 3DVar analysis step;
- NMC evaluation of background error matrix on 0.125 Deg. Grid;
- use of Incremental Digital Filter Initialization (IDFI)
- introduction of Schrodin and Heise multi-layer soil model in EURO_HRM.



Domain size	769x513
Grid spacing	0.125 Deg (~14 km)
Number of layers	40
Time step	150 sec
Forecast range	72 hrs
Initial time of model	00/12 UTC
L.B.C.	IFS
L.B.C. update	3 hrs
Initial state	CNMCA 3DVAR
Initialization	Incremental DFI
External analysis	None
Status	Operational
Hardware	IBM (ECMWF)
N° of processors used	32 (Model), 90 (An.)

Tab. 1 Characteristics of EURO-HRM

Local Area Modelling

There currently are two operational implementations of the COSMO Model running at the Italian Met. Service.: The 7 Km gridsize COSMO-ME (fig.2, Tab. 2) and the 2.8 Km COSMO-IT (fig.3, Tab. 3)

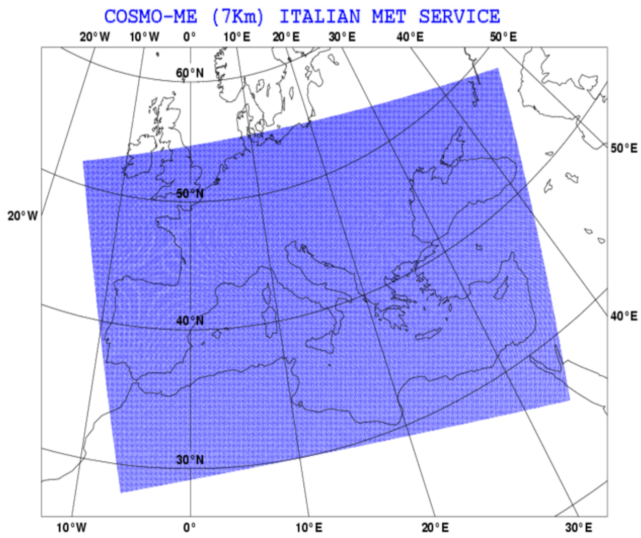


Fig.2 Integration domain of COSMO-ME model

Domain size	641x401
Grid spacing	0.0625 (~7 km)
Number of layers	40
Time step and scheme	40 s LF
Forecast range	72 hrs
Initial time of model run	00/12 UTC
Lateral bound. condit.	IFS
L.B.C. update frequency	3 h
Initial state	interp. 3DVAR
Initialization	Digital Filter
External analysis	None
Special features	Filtered topography
Status	Operational
Hardware	IBM (ECMWF)
N° of processors	192

Table 2 Characteristics of COSMO-ME model

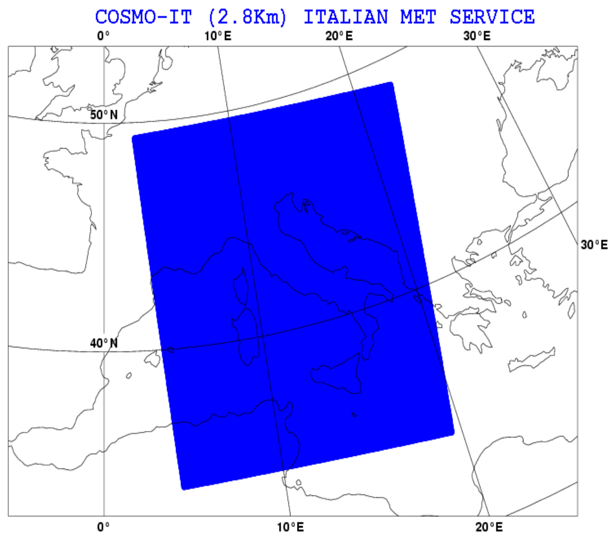


Fig.3 Integration domain for COSMO-IT model

Domain size	542 x 604
Grid spacing	0.025 (~2.8 km)
Number of layers	50
Time step and scheme	25 s RK
Forecast range	48 hrs
Initial time of model run	00 UTC
Lateral bound. condit.	COSMO-ME
L.B.C. update frequency	1 hr
Initial state	Observation Nudging
Initialization	None
Convective paramet.	Only shallow convection
Special features	Filtered topography
Status	Operational
Hardware	IBM (ECMWF)
N° of processors	352

Table 3 Characteristics of COSMO-IT model

The COSMO-IT implementation differs from the COSMO-ME implementation in terms of both horizontal (2.8 vs 7 Km) and vertical resolution (50 vs 40 layers). The COSMO-IT initial conditions

are also specified through an observation nudging analysis step, while the COSMO-ME initial conditions are interpolated from the EURO-HRM 3DVAR objective analysis.
Some of the most significant changes in the local area modelling area have been:
- introduction of Schrodin and Heise multi-layer soil model
- use of semi-lagrangian advection of humidity variables in COSMO-IT

Development Activities

Development activities have been aimed at improving the skill of the analyzed and forecast fields through:

1. Introduction of new observation types in the objective analysis step. Monitoring of METOP instruments (AMSU-A, see fig. 4, ASCAT, IASI) with a view of their use in the operational 3DVAR is well under way;
2. Further tuning of NMC covariances;
3. Enlargement of COSMO-ME domain;
4. Testing RK dynamics in COSMO-ME;
5. Further development of COSMO RK core
6. Implementation of a Wave Model (7km) for Mediterranean Sea

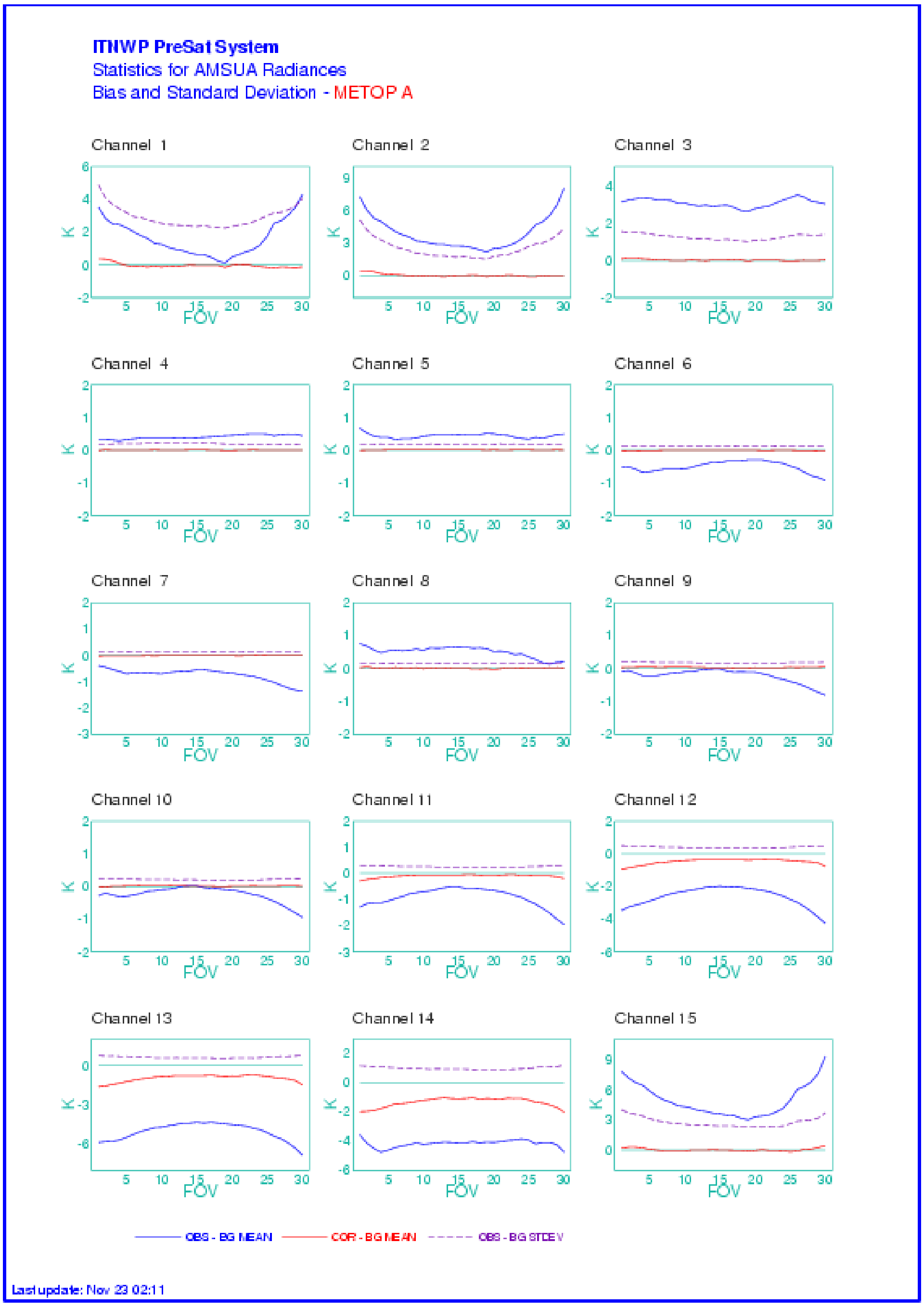


Fig. 4 Monitoring statistics for AMSU-A instrument on board METOP polar orbiter.

LAM ACTIVITIES IN ROMANIA

Doina BANCIU (doina.banciu@meteo.inmh.ro)
National Meteorological Administration, Bucharest ROMANIA

A. ALADIN model (*D. Banciu, M. Caian, R. Radu, S. Stefanescu, C. Soci, S. Tascu*)

A.1 Operational Suite

- Computing platform:
- SUN E4500 server (8-CPU 400GHz, 8*1 GB RAM) for direct integrations and in line post-processing; ALPHA DEC 500 workstation (1CPU, 704 MB RAM) for additional post-processing
- Domains (quadratic grid, Lambert projection)

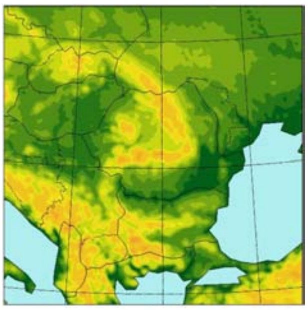


Fig.1.a: ALADIN-Romania
41 levels, 144x144 points, Δx=10 km, Δt= 450

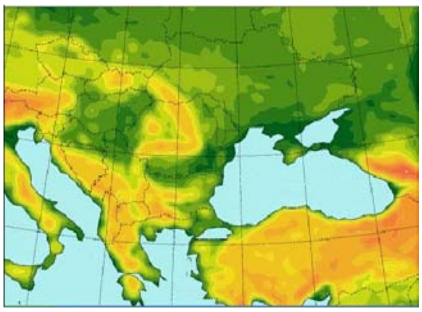


Fig.1.b: ALADIN-Selam
46 levels, 120x90 points, Δx=24 km, Δt= 900

- Model version: Cy28t3 (dynamical adaptation mode, DFI initialization, semilagrangian scheme);
- Arpege LBC; 6hours coupling frequency forecast range: 78h for 00 UTC run, 66h for 12 UTC run, 54h for 06 and 18 UTC run
- in line post-processing on geographical regular grid, (pressure & near surface standard levels output in grib format, routed towards the visualization systems in Bucharest and to the Regional Meteorological Centers) and of line FPOS on model grid
- additional post processing: stability indexes, pseudo-temp, different isotherms height
- Graphical products (standard products, stability indexes, specific isotherms, meteograms, pseudo-satellite images,etc.) available on the intranet ALADIN web page.
- Statistical adaptation
- Operational verification (local and common verification project)
- Input for downstream applications: pollutant diffusion and transport, wave and hydrological models

A.2 Research and development (mainly in the frame of the ALADI, LACE and LIFE projects)

- Data assimilation: J_b formulation Physical parameterization (prognostic convection)
- Scale analysis and tunning of spectral coupling for fine scale process representation
- Case studies (severe weather events)
- Study of the urban boundary layer using an extended database; application for Bucharest region

A.3 ALADIN and hot summer in Romania (S. Stefanescu, S. Tascu)

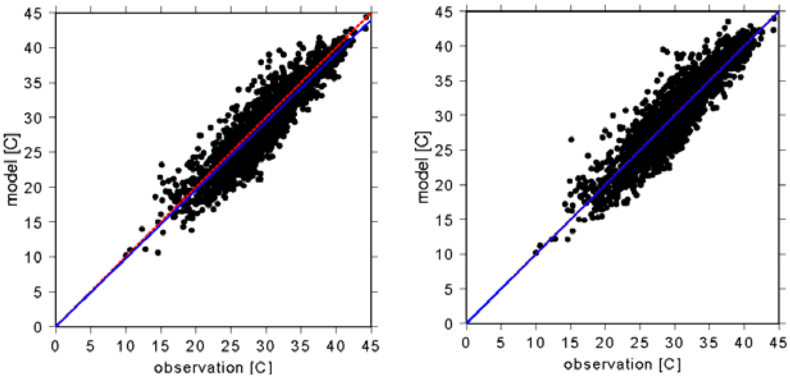


Fig. 2: ALADIN maximum temperature, scatter plot: first (left) and second forecast day (right) of 00 UTC run for June-July 2007 including data for 49 observation stations

Good behaviour !

July 2007, maximum temp. in Romania: 44.3°C (15482)
absolute record: 44.5°C, August 10, 1951

ALADIN model for 15482
00 run : 44.4/44.0,
12 run : 43.6

B. COSMO Model *(I.V. Pescaru, R. Dumitrache, L. Velea, C. Barbu, A. Lupascu, I. Ibanescu)*

B.1 COSMO-RO integration characteristics

- LAM, based on the non-hydrostatic, full compressible equations in advection formΔx= 14km ; 35 levels; Δt=80sIC & LBC: GME 00, every 3h
- Data Assimilation: No
- Operational suite for 4 runs/day (00, 06,12 and 18 UTC) up to 78 hPhysical Parameterizations: clouds and precipitation (grid-scale pp: 2-ice category scheme, prognostic convection scheme-Tiedtke, grid-scale and convective clouds, total cloud cover), radiation, turbulent fluxes, soil processes
- Operational domain and products

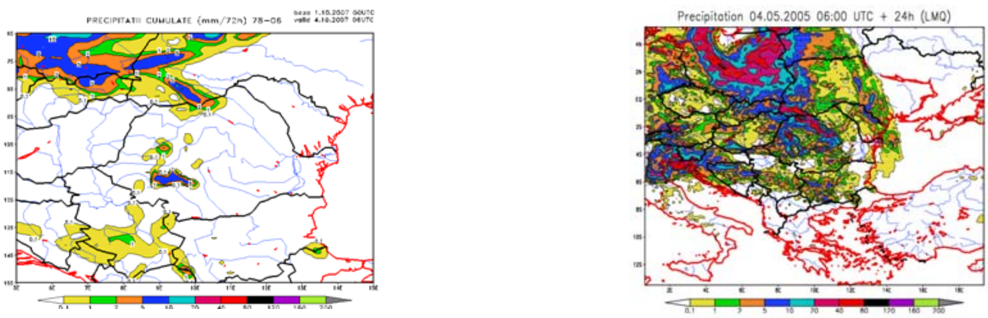


Fig. 3: COSMO-RO – actual operational domain (left) and the future one (right)

- Operational products: T2m, MSLP, 10 m wind speed and direction, total, convective and grid scale precipitation, geopotential (850,700, 500 hPa), cloudiness

B.2 COSMO-RO research and development activities

- Installing of the COSMO_3.19 and the new COSMO_4.0 code on the PC Cluster Testing different convection schemes, soil humidity, initial conditions , microphysical parameterizations and numerical schemes for both COSMO versions over a domain with 301x301 grid points and 7 km resolution (future operational domain)
- Testing the COSMO code for a domain with 81x81 grid points and 2.8 km resolution.
- Implementation of the CVS - Common Verification Suite on the Linux system, and COSMO model evaluation
- Development of the graphic package for scores visualization in GRACE.

B.3 COSMO-RO Future activities

- Local developmentsnew operational domains: a) 301x301, 40 levels, Δx =7 km; b) 81x81, Δx =2.8 km
  - Data assimilation for synop and AMDAR data
  - Improvement of the data visualization
  - Operational verification versus observational data
- Developments in the frame of COSMO consortiumFurther participation on priority projects: *Advanced Interpretation of COSMO model output*, *Towards Unified Turbulence-Shallow Convection Scheme*, *1dVar retrievals of satellite radiances for nudging*
  - Participation on priority projects CV *(Conditional Verification, Extended Common Verification Suite)* on SPRT *(Support Activities)* and to other priority projects, if it is required

C. High resolution Regional Model (*I.V. Pescaru, R. Dumitrache, L. Velea, C. Barbu, A. Lupascu, I. Ibanescu)*

- Workstation version (updated accordingly with DWD version)
- Full operational implementation, 78 hours forecast range, twice per day
- Initial and boundary conditions from GME-DWD
- Rotated geographical grid with 0.25 deg. resolution, 20 vertical levels

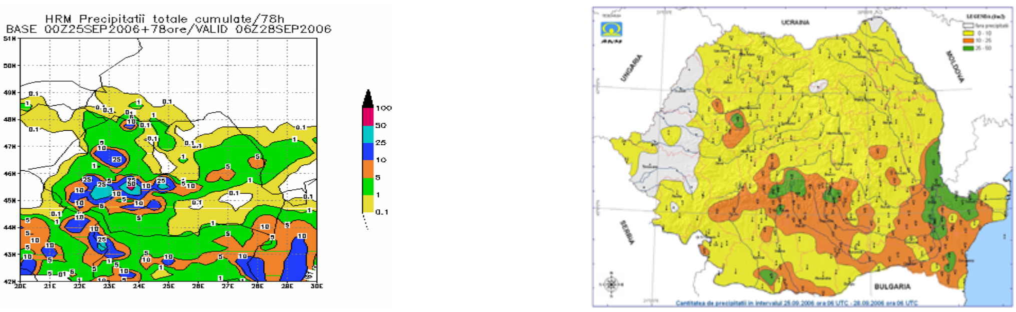


Fig.4: domain, 78 cumulated precipitation forecast

D. MM5 *(I .Ibanescu)*

D.1 Operational characteristics

- non-hydrostatic mm5 v3.4 versioninitial and boundary conditions from global model GFS (Global Forecast System, 1.25º resolution) and the sea-surface temperature from NCEP)
- model domain: 80 x 167 points, Δx=15 km, 25 vertical σ levels4 runs per day, up to 24 hours
- Output: pressure & near surface standard levels output in grib format routed towards the visualization systems in Bucharest and to the Regional Meteorological Centers

E. Regional Climate Modelling (*M. Caian)*

E1.1 Downscaling ability of ALADIN-Climate using spectral nudging (Radu R.)

Radu R., Déqué M., Somot S., 2007: ***Spectral nudging in a spectral regional climate model***, (submitted to Tellus)

-25 years simulations using ARPEGE and ALADIN models at the same resolution (50km), by employing spectral nudging method to nest the large-scales from the driving model (ARPEGE) into LAM (ALADIN).

- ALADIN is able to predict the large scales present in the driving global fields and the small scales as well. For summer season: an important reduction of differences in between the driving global and regional model when using spectral nudging (Fig. 5)

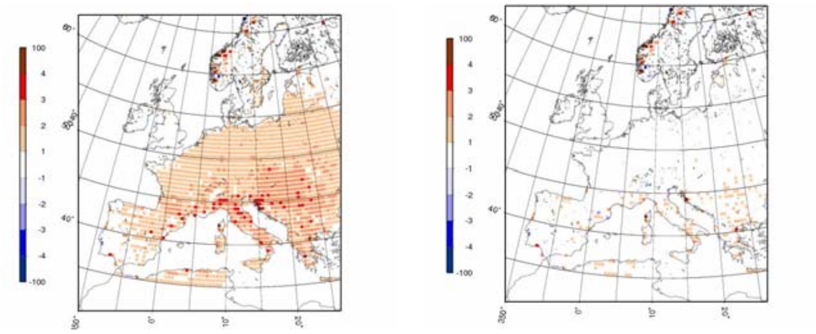


Fig. 5: Differences in 2m temperature between ARPEGE and ALADIN for summer. Seasonal means over 25 years:
a) without spectral nudging (left),
b) with spectral nudging (right).

<u>E2. Regional climate modelling using REGCM3</u> (M. Caian)

REGCM3 (Giorgi, 1993) on Altix 350 - 2 ITANIUM processors

- coupled with the ECMWF
  - For 10 days: Dx=10km, 23 σ - levels
  - For 1 month: Dx=50 km, 15 σ levels, with 10 members ensemble

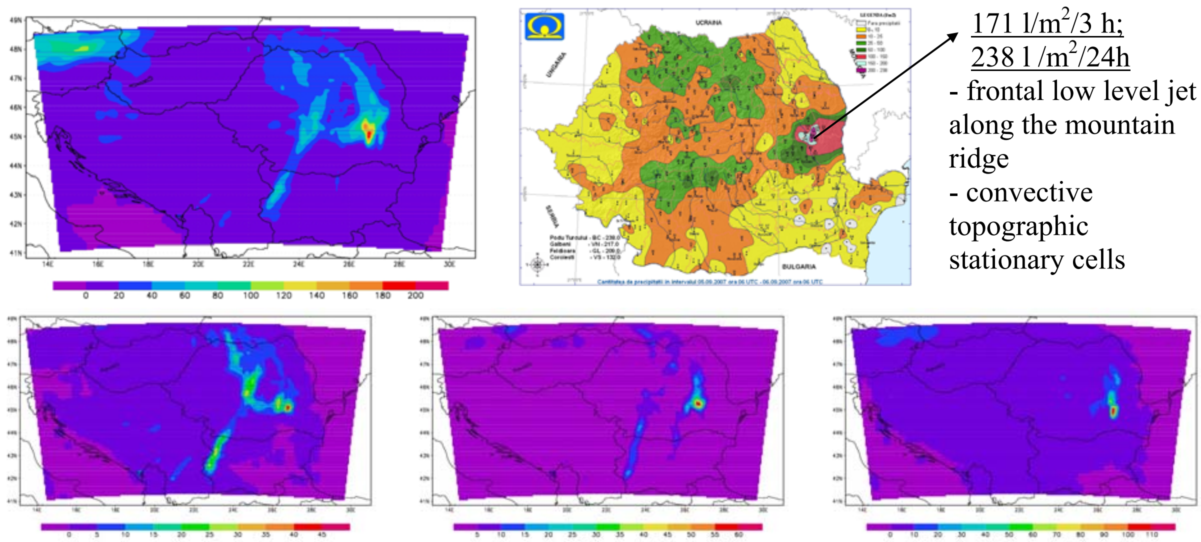


Fig. 6 Observed precipitation (24 h accumulation) – top right, REGCM3 00 run: last 3 h precipitation: September 5.09.2007, 12 UTC (bottom left), 15 UTC (bottom center) and 18UTC (bottom right)

F. NWP models verification *(O. Diaconu)*

- The operational verification procedure was reorganized, including descriptive diagrams (scatter plots, histograms and box plots), confidence intervals for all computed scores (figures 7, 8 and 9)
- Currently the procedure is applied to the ECMWF products but in the future it will be used for all operational LAM in Romania

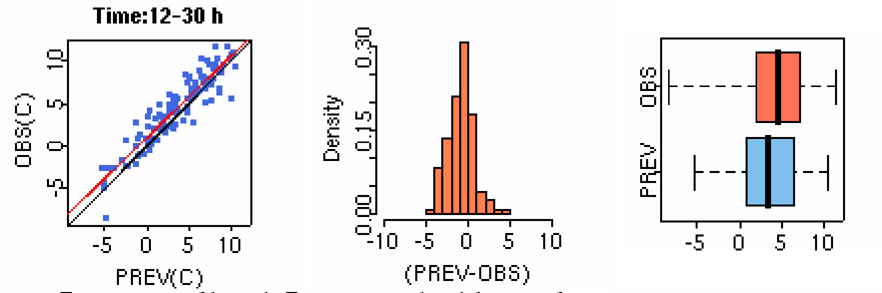


Fig. 7: ECMWF temperature, scatter plot, histogram and box plot for 15080 station (W Romania) for 12-30 h forecast, January 2007

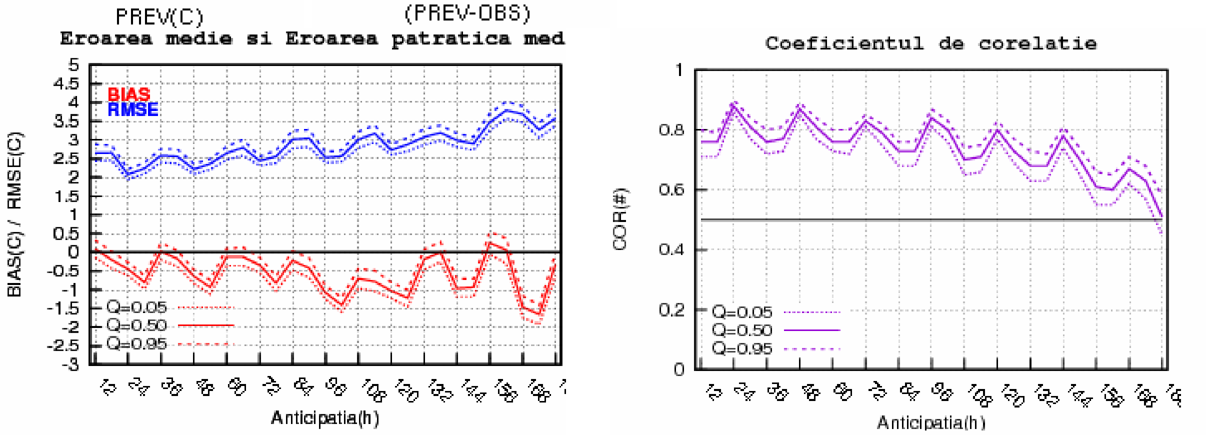


Fig. 8: Temperature Bias and RMS (left) and correlation coefficient (right) with confidence intervals for ECMWF 10 days forecast, SW Romania region for January 2007

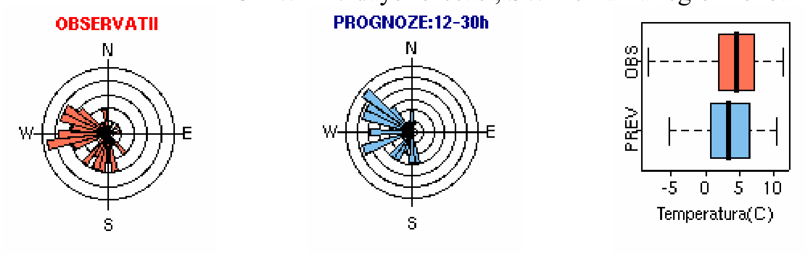


Fig. 9: ECMWF wind direction (observed–left, forecast-center, box plot=right) for the 15247 station (W Romania) for January 2007

NWP activities at Slovak HydroMeteorological Institute in 2007

(compiled by Martin Belluš and Ján Mašek, with contributions from other colleagues)

NWP staff

Year 2007 was quite tough for our NWP team, since three colleagues left (Emeline Larrieu Rosina, André Simon and Michal Májek), while only one newcomer appeared (Michal Neštiak). Current composition of the team is following:

Martin Belluš
Mária Derková (on maternity leave)
Richard Habrovský
Marián Jurašek
Jana Krajčovičová (dispersion modelling)
Ján Mašek
Michal Neštiak
Oldřich Španiel
Jozef Vivoda

ALADIN/SHMU – computer and model characteristics

- **HPC:**

  IBM p690 Regatta, 32 CPUs POWER 4+, 1.7 GHz
  32 GB RAM, 1.5 TB IBM FAST Storage Server
  OS AIX 5.2, LoadLeveler queueing system

- **archive:**

  IBM Total Storage Tape Library 24 TB
  IBM Tivoli Storage Manager

- **model:**

  al28t3_czphys (cloudiness and radiation tuning)
  envelope orography, no SLHD
  LACE domain, $\Delta x = 9.0\,\mathrm{km}$, 37L
  forecast length 72 hours, 3 hour coupling with ARPEGE
  pseudo-assimilation blending cycle (upper air)

Operational suite monitoring – basic features

- application status browser
- application log browser
- automatic alerts via email/SMS
- application finish time charts
- application documentation with search engine
- monitor of data transfers
- monitor of load under operational user
- monitor of LoadLeveler jobs
- full remote control via GSM/GPRS device, monitoring via password protected web page
- diary of operational events with search engine
- online point verification (2 m temperature, 10 m wind speed, cloudiness)

Main operational highlights since last EWGLAM workshop

25.1.2007 – LBC backup via ECMWF and ZAMG updated
7.2.2007 – switch to the new webserver for NWP products
1.3.2007 – ALARO-0 without 3MT in parsuite (only 00 UTC run)
20.3.2007 – upgrade of backup for ZAMG (06 and 18 UTC runs added)
14.5.2007 – download of AVP multigrams for LACE web
16.5.2007 – download of LAEF products for LACE web
6.8.2007 – upper air blending cycle in parsuite
19.9.2007 – upper air blending cycle operational
26.9.2007 – multirun epsgrams on SHMÚ public web page

Research and development stays

- LACE stay in Prague, J. Mašek, 6.11.–9.12.2006: Diagnostic tool for lateral coupling

  Diagnostic tool for evaluating performance of lateral boundary treatment in 3D ALADIN was developed. It is based on perfect model approach, employing two LAM domains – large and small – with the same horizontal resolution and matching gridpoints. Solution obtained on large domain serves as perfect reference. After filtering out small scales it provides imperfect LBC for small domain.

Basic tests of Davies relaxation scheme were performed, demonstrating main limitations of LAM approach. These are lack of predictive skill on higher levels (long forecast lead times), quality of initial state (short forecast lead times) and insufficient coupling frequency. In future, tool can be used to evaluate alternative coupling strategies.

- ALADIN stay in Toulouse, M. Jurašek, 4.6.–30.6.2007: Assimilation of radar reflectivity

  During the stay monitoring of radar reflectivity simulator started. Eight French radars were simulated for period 1.–31.5.2007.

- LACE stay in Vienna, M. Belluš, 4.6.–29.6.2007: Combination of large scale initial conditions uncertainity with small scale initial perturbations obtained by breeding method using blending procedure (part II)

  In the LAEF setup, as applied at ZAMG in Vienna, breeding method is used as one of the options to generate perturbed initial conditions for the limited area ensemble prediction. Downscaled outputs of the global model ensemble system are used for the lateral boundaries. Therefore, LAEF boundary data are inconsistent with LAEF initial state, as different techniques were used for their production. Initial state created as a combination of the small scale uncertainities coming from the LAM and the large scale perturbations of driving model shall be more consistent with the boundary conditions downscaled from the global model ensemble system. To mix both initial states, blending by digital filter application was modified and installed on new HPC NEC in Vienna and new cycle 32t1 was used. This time whole application for breeding cycle was written and installed on new NEC (12 hour ALADIN forecast of a breeding pair is used to create new initial conditions by centering and rescaling perturbations around the global analysis).

- LACE stay in Prague, J. Mašek, 16.7.–18.8.2007: Test implementation of new semi-Lagrangian interpolators in ARPEGE/ALADIN cycle 32t1

  New class of second order accurate interpolators was implemented in semi-Lagrangian horizontal diffusion scheme (SLHD). Basic validations in 3D real case were carried on. Analysis of kinetic energy spectra shows comparable impact on shortest scales as for the old scheme. Due to higher scale selectivity, impact on intermediate scales was reduced. This on one hand improves conservation properties by reducing MSLP bias, on the other hand it is not sure whether the new scheme will be efficient enough in suppressing false cyclogenesis.

Description of the most important operational events

- Operational implementation of spectral blending by digital filter and pseudo-assimilation cycle (since 19.9.2007)

  Spectral blending by digital filter in pseudo-assimilation cycle and production was used while 24 hour forecast was compared to the operational one during 5 weeks of testing in parallel suite. Positive impact on precipitation fields (both positioning and amounts) was observed within whole forecast period.

  Blending was implemented only for model atmospheric fields. To prevent possible surface drift from climatology after some longer cycling period, for the time being surface fields are used from ARPEGE analysis, not from ALADIN guess. In the near future surface blending will be implemented and blending procedure will be used to cycle hydrometeors necessary for ALARO-0 microphysics.

- Parallel suite: ALARO-0 minus 3MT (March–May 2007)

  Impact of ALARO-0 developments on surface scores was mostly neutral. Main improvement could be seen in scores of 24 hour cumulated precipitation (forecast window +6 to +30 hours), which can probably be attributed to microphysics. Verification against 600 rainguages on SK territory showed positive impact in all precipitation scores, the only exception being probability of detection of precipitation amounts 30 mm/24 h and larger. This is not surprising, since microphysics tends to reduce extremes and produces smoother precipitation field.

- INCA precipitation analysis

  Since March 2007 INCA precipitation analysis is produced operationally every 15 minutes. Inputs are meteorological (ASTA) and hydrological (MARS) automatic stations and radars (2 km CAPPI product). Only SK stations/radars are available. Output format is GRIB file with 1 km mesh size. In the near future convective rainfall rate produced by SAF and SAFIR lightnings should be added.

Limited Area Modelling Activities in Slovenia

Mark Žagar, Benedikt Strajnar, Neva Pristov

December 2007

Environmental Agency of Slovenia is a partner in the international projects ALADIN and RC LACE. Our group's operational task is to prepare three times a day a limited area numerical forecast using ALADIN model. We take the leading role in the common ALADIN verification project for the objective verification on the synoptic scale. A web service (http://www.arso.gov.si/verification) is available to the NWP community.

Our main activities regarding the NWP suite were linked to the procurement procedure for the new computing platform so the operational suite did not change. In continued development within ALADIN project we participated to activities mainly connected to data assimilation. Some results are presented in the following sections. Besides, but not included in this report, validation of the newest improvements to the 3MT scheme was performed. Unfortunately a severe flash flood event occurred in September and a preliminary analysis of the NWP performance for this case is also presented in this report.

Operational ALADIN application (neva.pristov@rzs-hm.si)

Our current ALADIN model configuration (started in June 2003 on a Linux cluster system) stayed unchanged also in 2007. For details about configuration and computer system please see the 2005 report.

Main activity was focused to the preparation of the ITT for the new computer system. The selected computer SGI Altix ICE 8200 system was delivered in November. Installation followed and in the beginning of 2008 the migration process of the operational suite will start.

The first results are very promising: we are able to run our current ALADIN/SI model configuration on a single cluster node (8 cores) for around 30% faster than on whole previous operational cluster with 24 processors. Rough computation tells that the new machine is 40-50 times more powerful than the previous one.

Some technical characteristics of the system are: 35 compute nodes installed in a single rack, every compute node has a 8 GB of memory and 2 Quad core Intel Xeon 5355 processors, 300 cores are currently installed, two Infiniband DDR networks, one for IO and the other for MPI communication, additional 7 service nodes are used for login, management, control and IO operations, a dedicated NAS IO node is installed with 15 TB FC disk array.

New machine is running SGI ProPack on top of SLES 10. Scali MPI Connect is used for MPI and Altair PBSPro for a queuing system. Fortran compiler is Intel 10.1.

A comparison between dynamic adaptation and mesoscale analysis methods for initial conditions for ALADIN over Slovenia (benedikt.strajnar@rzs-hm.si)

The performance of dynamic adaptation (used operationally at EARS) and 3DVAR (used at Hungarian Meteorological Service) was tested for a period of one month (June 2006). The purpose was to evaluate both strategies and discover possible benefits of local data assimilation. Fields of major interest were compared to each other and against observations of Slovenian observing network. The inter comparison showed quite small differences on average, except for precipitation amounts, where less overestimation was detected in ALADIN/HU forecasts. The differences occur mostly over complex terrain and intermediate valleys and basins.

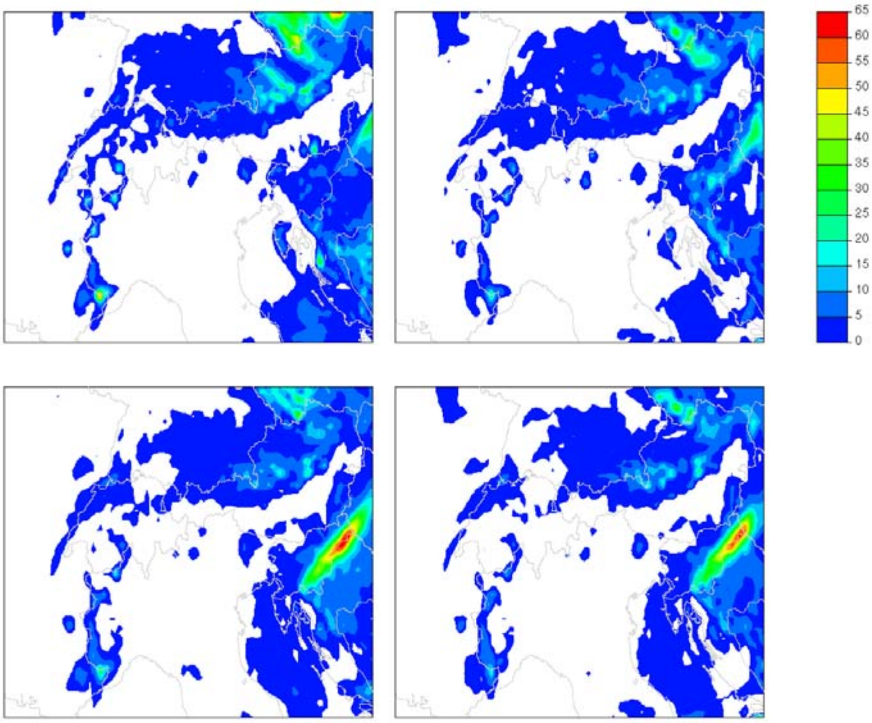


Figure 1: Precipitation accumulations for 30th June 2006: operational ALADIN/HU (upper-left), operational ALADIN/SI (lower-left) and forecasts on a common smaller domain using ALADIN 3DVAR (upper-right) and ARPEGE initial conditions. 3DVAR initialized forecasts (with no precipitation belt) verify much better.

On average, the comparison and verification did not reveal striking improvements of local data assimilation. The reason was partly in having a temperature in humidity bias in Hungarian fields (unfortunately chosen verification period). However, some cases were identified with initial conditions playing an important role in predicting precipitation events. These cases show the advantages of using high resolution wind and moisture initial fields.

Experiments with 3DVAR RUC (benedikt.strajnar@rzs-hm.si)

An experimental rapid update cycle (RUC) was tested using ALADIN/HU 3DVAR operational assimilation system. The main idea is to assimilate either more observations of a certain type (for the cases of short time windows) or use the observations at more appropriate time. The frequency of assimilation cycle was reduced to 3 hours, which increased the number of SYNOP, AMDAR and SATOB observations. At the same time, satellite data were used at more appropriate time. After 14 day testing period it was found that the performance of RUC was not very different (slight improvements for wind, but degradations for humidity) from operational 6 hour cycle. It was afterwards found that the observations in the RUC experiment could be used in more appropriate way in terms of time windows and data selection (an erroneous AMSU-B satellite channel was used). To estimate the impact of that, another experimental 6 hour cycle was carried out, using the same observation setup as for RUC. Geopotential, wind and relative humidity forecasts were clearly improved in this case, but no significant changes for temperature forecasts could be observed. This shows that RUC has a good potential to reduce the forecast errors.

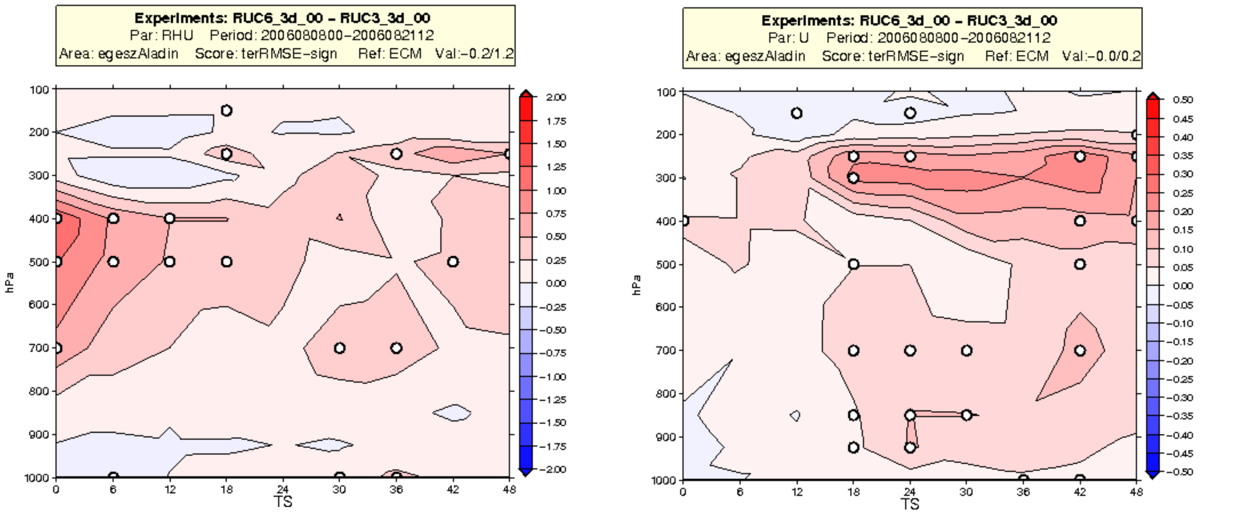


Figure 2: Verification of RUC against radio soundings at 00 UTC: forecast range-vertical cross-section of RMSE score (6-hour reference minus 3-hour RUC) for humidity (left) and zonal wind component (right). Red colors indicate improvements of RUC.

Flash-floods of 18 September 2007 (mark.zagar@gov.si)

Bands of quasi-stationary prefrontal convection were responsible for locally up to 485mm of rain within 12 hours. Mechanisms, leading to these local maxima are under investigation. Preliminary findings point to occurrence of cold pools, pushed against the steep orography, and dynamical low-level wind convergence around complex topography.
Based on the operational ALADIN/SI model (Figure 3), PEPS and other LAM guidance, flash-flood warnings were issued by the Weather service, although the actual amount of rain surpassed the expectations by factor 3-4.

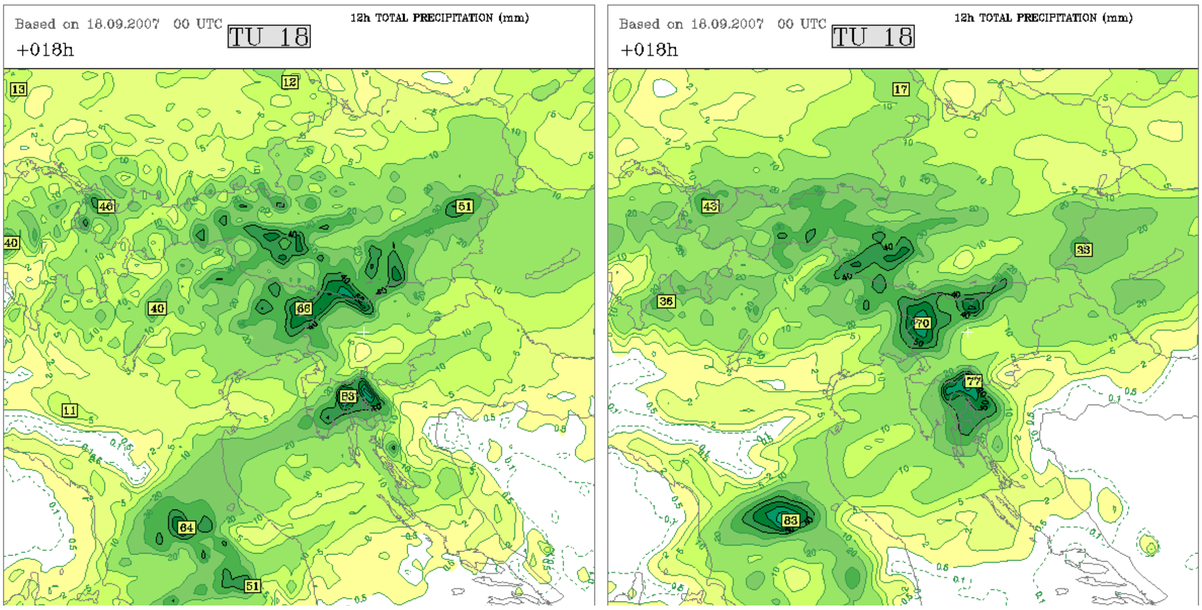


Figure 3: 12-hour accumulation of rain between 06 and 18 UTC of 18 September 2007, predicted by two ALADIN/SI configurations (operational, left, and ALARO-0 with 3MT, right) initialized on 00 UTC of that day.

Large variability of the rainfall characterized this situation. As seen in Figure 4 (left), temporal variability observed at a couple of rain-gauges only 30km apart indicated that many singular storm cells occurred and were then transported in the direction of the mean wind. The spatial distribution of total observed rainfall (Figure 4, right) probably does no justice to the variability due to too few observing stations.

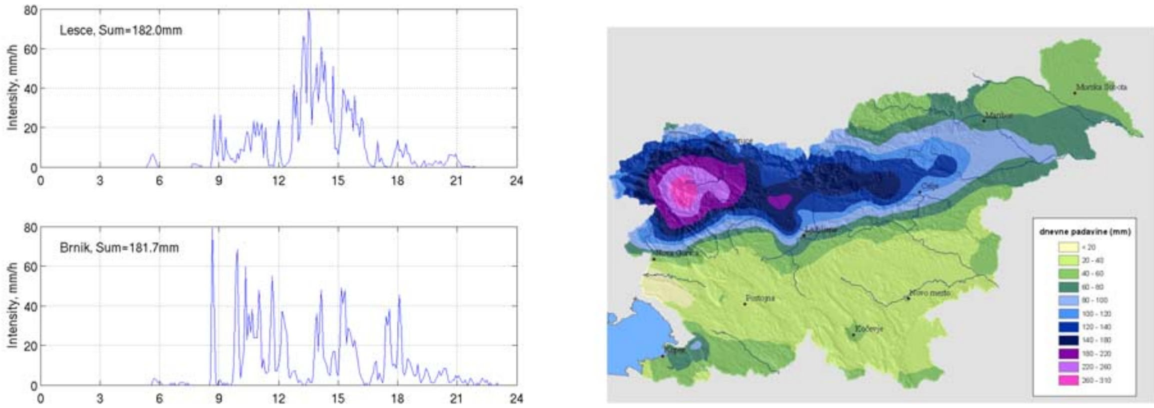


Figure 4: Rain intensity on 18 September 2007 at two stations, less than 30km apart (left) and total accumulation for the day (right).

Besides the regional ALADIN the products of an experimental set-up using dynamically adapted wind (2.5km resolution) for estimating precipitation maxima were consulted, indicating possibility of local deluges of up to 60mm/h (Figure 5).

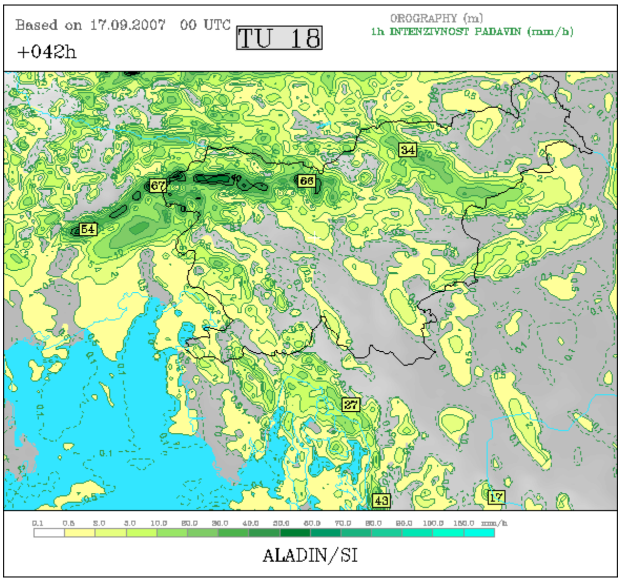


Figure 5: Rain intensity, calculated using the ALADIN physics and dynamically adapted local winds and vertical velocity. Estimates for maximum available guidance for 18 September are shown.

NATIONAL STATUS REPORT
on
Operational NWP at the Swedish Meteorological and Hydrological Institute

EWGLAM 2007 8 – 11 October 2007, Dubrovnik

Lars Meuller, SMHI

Introduction

The Swedish Meteorological and Hydrological Institute (SMHI) is a member of the HIRLAM project. All research and development in the area of numerical weather prediction are done within the HIRLAM project. This report will only describe the operational HIRLAM at SMHI.

Computer system

HIRLAM at SMHI is run on the computer resources at the National Supercomputer Center (NSC) at Linköping University.
SMHI operational models, HIRLAM and an oceanographic model, HIROMB, are run on a dedicated cluster, BLIXT, that consists of:

- Linux operating system.
- 83 nodes.
- dual Intel Xeon processors, 3.2 GHz, 2 GB memory.
- Infiniband Interconnect.
- PCI Express bus.
- Scali MPI connect.
- Intel compilers.
- 5.6 TB disc.

SMHI has for a long time also, for backup reasons, been running a complete model setup also at another computer. If BLIXT is down the production can easily be switched to BRIS by just issuing one operator command.

BRIS is also a Linux cluster:

- home made by NSC.
- 16 nodes.
- dual Intel Xeon processors, 2.2 GHz, 1GB memory.
- Scali interconnect.
- ScaMPI.
- Intel compilers.
- 1 TB disc.

HIRLAM system

SMHI runs a HIRLAM model with version number 6.3.5 which in our case means a system with:

- 3D-VAR analysis
- DFI initialization
- ISBA surface scheme
- CBR turbulence
- Kain-Fritsch convection
- Rasch-Kristjansson large scale

SMHI at present runs 3 operational suites of the HIRLAM analysis and forecast model with different horizontal resolutions, C22, E11 and G05. They all have their own separate 6 hour data assimilation cycle.

Domain:	**C22**:	**E11**	**G05**
Horizontal resolution:	0.2×0.2° (22 km)	0.1×0.1° (11 km)	0.05×0.05° (5.5 km)
N:r of gridpoints:	306x306	256x288	294x441
Vertical levels:	40	60	60
Boundaries:	ECMWF 3 hourly	ECMWF 3 hourly	HIRLAM E11 every hour
S.L time step:	10 min	5 min	2.5 min
Forecast length:	+48 hour	+72 hour	+48 hour

E11 is run to +72 hour to give input to a LEPS (Lagged EPS) system

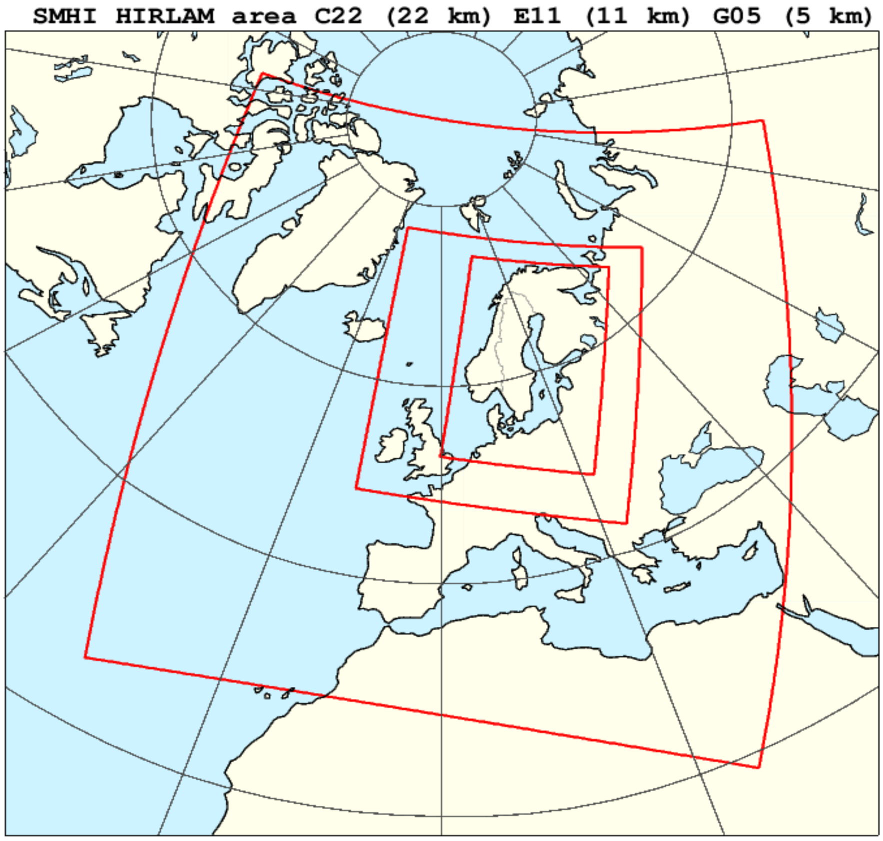


Fig 1. SMHI HIRLAM horizontal domain's

Model input

The observations used for the analysis are SYNOP, SYNOP SHIP, TEMP, PILOT, BUOY, AIREP and AMDAR.
Additional AMDAR in BUFR form from GTS are also used.
ATOVS AMSU-A radiances (EARS) over sea used in HIRLAM C22

A version of ECMWF observational pre processing system is used to convert from WMO alphanumeric code forms to BUFR.

In SMHI version of HIRLAM, the ice-cover and the sea surface temperatures in the Baltic Sea comes from the oceanographic HIROMB model.

Operational schedule

Every 3 hour a preliminary HIRLAM analysis is run with a cut-off time of +0h25m using mainly SYNOPs. The output is mainly used for the automated analysis of weather charts.
Every 6 hour E11 is started with a cut-off time for observations of +1 h 15 min. After E11 have ended G05 is started.
Every 6 hour C22 is started with a cut-off time for observations of +2 hours.

The clock time for all the runs to complete is about 40 – 50 minutes.

Model output files are written every hour and sent to SMHI.

Events

Very small changes to the SMHI operational NWP system has been made the last year. The only major change was that the 5 km runs were extended to + 48 hours 20070424.

Instead much work and extensive testing has been performed on HIRLAM version 7.1.2, with 4DVAR on the C22 domain.

Plans

- Starting operational 4DVAR (on 22 km resolution) with HIRLAM version 7.1.2 beginning of 2008

- The C22 and E11 suites are planned to be replaced by a new suite with 0.1 degree (11 km) horizontal resolution, 60 levels with 4DVAR on roughly the C22 domain, when the new cluster is operational.

- The old BRIS cluster will be replaced by a new, BORE. The new cluster will will consist of 140 quad-core nodes (1120 cores) and are going to be installed 200803.

- HIRLAM has now started a cooperation with the ALADIN group to develop a non-hydrostatic model and a version of that has been tested at SMHI and near-real time runs with ALARO will be started nest year with 5 km resolution on a domain equivalent to HIRLAM G05 domain.

Numerical Weather Prediction at MeteoSwiss

Philippe A.J. Steiner, Felix Fundel, Felix Ament

Federal Office of Meteorology and Climatology MeteoSwiss, Zurich, Switzerland

1. Preoperational chain COSMO

MeteoSwiss is currently setting up a new high-resolution NWP model in order to get an automatic generation of local forecast products in complex topography. These will be used for general short-range forecasting purposes and contribute to the security of the Swiss population by the generation of warnings/alarms e.g. in case of high-impact weather, floods or incidents in nuclear power plants.
MeteoSwiss operates an implementation of the non-hydrostatic COSMO model (of the Consortium for Small-Scale Modelling currently composed of the national weather services of Germany, Switzerland, Italy, Greece and Poland – see www.cosmo-model.org). The model is run in two configurations in the new system: the regional COSMO-7 is driven with the ECMWF IFS and covers most of Western Europe. It provides the lateral boundary conditions for the high-resolution COSMO-2 model calculated on a domain covering the Alpine arch (Figure 1). The primary aim of COSMO-2 is to provide forecasts from nowcasting to very short-range time scale. Therefore the forecasts are organized as a rapid update cycle with forecasts computed every 3h and integrated to 24h. Twice a day, COSMO-7 is integrated to 72h and is used for the short-range time scale.
The system is currently in a pre-operational test phase. It runs in 25 minutes on a Cray XT4 of the Swiss National Supercomputing Centre, CSCS, and reaches 390 Gflops sustained on 816 processors (9% of the peak). It is planned to go operational at the beginning of 2008 and it will replace the actual operational version of COSMO-7, running at a resolution of 7km.

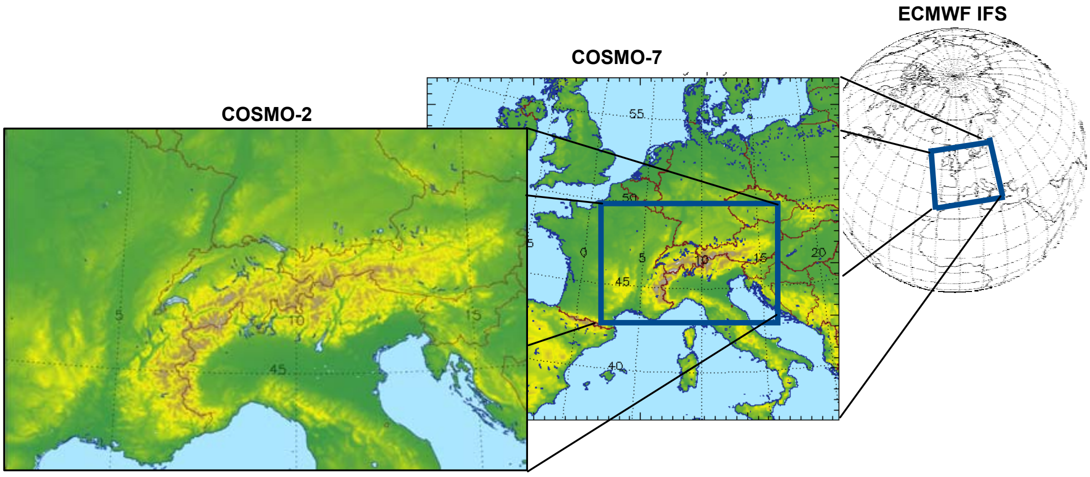


***Figure 1:** Setup of the MeteoSwiss NWP System.*

1.1 Model description

COSMO is a primitive equation model, non-hydrostatic, fully compressible, with no scale approximations. The model equations are formulated on a rotated latitude/longitude Arakawa C-grid, with generalized terrain-following height coordinate and Lorenz vertical staggering. The prognostic variables include the pressure perturbation, the cartesian wind components, the temperature, the specific humidity, cloud liquid water, cloud ice, rain, snow and turbulent kinetic energy. Finite difference third order spatial discretization is applied, and time integration is based on a 2-timelevel Runge-Kutta split explicit method. Fourth order linear horizontal diffusion with an orographic limiter is applied. Rayleigh-damping is applied in the

upper layers. A multi-layer soil model with 8 layers for energy and 6 for moisture is used; moisture is updated every 24h from IFS in the lowest levels.
The parametrizations of COSMO-2 differ from that of COSMO-7 as follows: Convection is parametrized by a shallow convection scheme, the deep convection being explicitly computed, and a prognostic graupel hydrometeor class is used in the microphysical parametrization. The topographic effects on radiation are considered in both versions. Table 1 lists the specifications of COSMO-7 and COSMO-2.

	COSMO-7	COSMO-2
Number of gridpoints and levels	385x325, 60L	520x350, 60L
Horizontal mesh size	3/50° ~ 6.6km	1/50° ~ 2.2km
Time step	72s	20s
Data Assimilation	Conv. Observations	Conv. Observations + Radar

Table 1: *Specification of COSMO-7 and COSMO-2*

1.2 Data assimilation

Data assimilation in COSMO is based on the nudging or Newtonian relaxation method, where the atmospheric fields are forced towards direct observations at the observation time. Currently, conventional observations are assimilated: synop/ship/buoys (surface pressure, 2m humidity for the lowest model level, 10m wind for stations below 100 m above msl), temp/pilot (wind, temperature and humidity profiles) and airep/amdar (wind, temperature) as well as wind profiler data. Typical 24 h assimilation at MeteoSwiss ingests about 120 vertical soundings, about 8000 upper-air observations, about 28000 surface observations and about 1000 wind profilers. A snow analysis derived from MSG satellites combined with dense observations is applied. In COSMO-2 radar-derived rainfall is additionally assimilated by the Latent Heat Nudging scheme, making use of the high spatial and temporal resolution rainfall observations. Radar data is taken from the Swiss Radar Network consisting of three C-Band Radars. The assimilation cycle consists of 3h slices with an observation cut-off time of 45min.

1.3 Further developments

Still, there is a lot of research going on. Planned improvements include a higher vertical resolution in the boundary layer, new terrain following coordinate (SLEVE), the assimilation of humidity information derived from GPS with tomographic methods and radar wind profiles (VAD). A mosaic approach is being integrated in the soil model together with a measurement driven soil moisture analysis.
Additional developments carried out in the COSMO consortium will also be integrated in the new chain.

2. Warning of extreme events (Felix Fundel)

Warnings of unusual or extreme weather events are usually given whenever a certain threshold is exceeded by the forecast. This procedure has several drawbacks that we try to adjust within the PRECLIM project. One drawback is the application of a single threshold to a large domain. As the climate is subject to spatial variability, threshold will not be suitable to the entire domain. An extreme precipitation event in a dry region e.g. might not be extreme in a very humid region. Further on, as the threshold used to give a warning is usually chosen from a climatology of observation data, the warning itself might be flawed by model biases.

We try to solve this by relating the actual forecast to a climatology consisting of hindcasts using the same model setup as the forecast. If we assume that an extreme event in the model forecast is an extreme event in the real atmosphere, such an event should also be extreme within the model climatology. By defining measures that express how unusual a forecast is within the model climatology, it is not necessary anymore to choose a threshold depending on region and season. This information is already contained in the model climatology. Further on, a climatology based warning measure is independent of existing systematic model errors. In a recent study by Wilks and Hamill, 2007, it has been shown that the increase of forecast skill of a climatology calibrated forecast is equivalent to 5-10 years of model system development.

In the framework of this project, warning parameters for rare weather situations are developed, using the limited-area ensemble prediction system COSMO-LEPS. This system consists of 16 representative members with 132 hours forecasts.

To create a reasonable warning index that additionally accounts for systematic model errors, a COSMO-LEPS model climatology is established. As the main focus here is on extreme events, the climatology has to be sufficiently large to achieve a good sample statistics. Therefore, hindcasts over a 30 years period from 1971-2000 are computed. To be consistent with the forecast, the same model version is used. The boundary fields for this set of hindcasts come from the ERA40 reanalysis data set.

In a first approach we use the COSMO-LEPS forecast and climatology to construct an extreme forecast index (EFI). This index basically is the weighted integrated difference between the cumulative distribution functions (CDF) of the model climatology and the ensemble forecast (figure 2) [Lalaurette, 2002; Zsoter, 2006]. As the EFI combines properties of two CDFs in just one number it is not clearly interpretable without the underlying information.

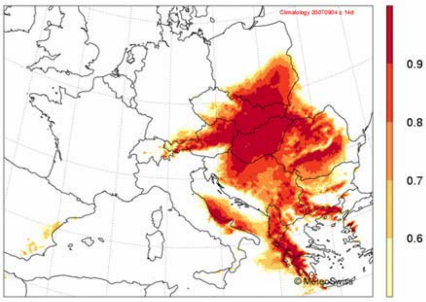
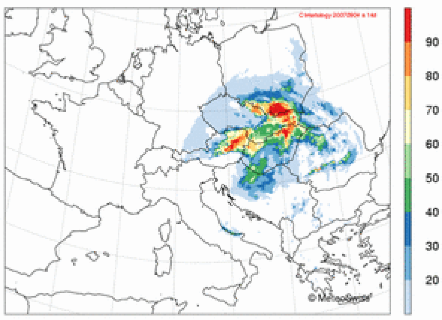


Figure 2: *The EFI is the integrated difference of model climatology and forecast cumulative density function. A special weight is given to the tail of the CDF as the index should be sensitive to extreme events. It varies from -1 to 1 whereas the extrema of the EFI are only reached when all forecast members exceed the extrema of the climatology. For -1>EFI<1 the interpretation is ambiguous, depending on the mean and the spread of the CDFs. The plot shows an example of the EFI for 24h precipitation for the 05.09.2007*

In a second step the ambiguity of the EFI is tried to overcome by using return periods. For each forecast member a return period with respect to the model climatology can be given. All the advantages of relating a forecast to a model climatology remain, however, return periods are straight forward interpretable. Further on, as an ensemble prediction system is used, a probabilistic forecast of return periods can be given. Another advantage of using return periods for the prediction of unusual weather events is the direct transformation into warning levels which often refer to the return periods of events. An example of a probabilistic return period forecast is shown in figure 3.

Figure 3: *Probability to exceed an event occurring in one out of 6 Septembers shown for the COSMO-LEPS 24h precipitation forecast for 05.09.2007.*



It is difficult to estimate the return period of an event that occurs on time scales in the range of the model climatology or even beyond due to the sparse sampling rate of such rare events. We estimate the return period of such events using extreme value statistic. By using the Peak over Threshold method a Generalized Pareto Distribution (GPD) can be fitted to the extreme data of the model climatology [Coles, 2001]. With this theoretical distribution function it is possible to give a reasonable estimate of the return period of extreme events.

Besides plotting the probability of the actual forecast exceeding a return period in 2d plot, the information can also be given in a Warngram for the complete lead time of the forecast. We found a convenient way in presenting the severity of a forecasted event together with the probability of occurrence. An example of a 24h precipitation Warngram is given in Figure 4.

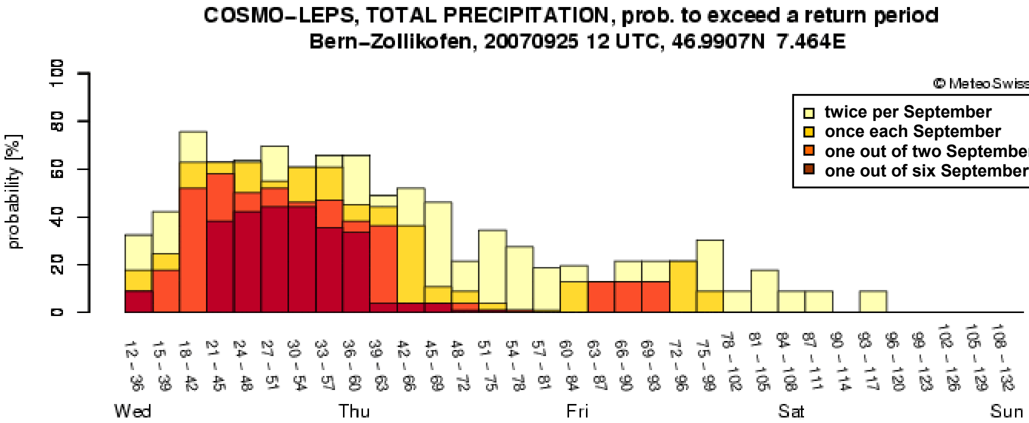


Figure 4: *The Warngram shows a probabilistic forecast for the exceedance of several return periods. It covers the entire forecast length of 132 hours and therefore is given for selected grid points/stations only (Here an example forecast for Bern). Here we show a forecast of 24h precipitation, gliding in intervals of 3 hours. The return periods are indicated by different colors, the height of the bars gives the probability.*

3. Fuzzy Verification (FelixAment)

Traditional verification methods (e.g. equitable threat score at surface stations), evaluate a point wise match between model forecast and observations. These methods a likely affected by the so-called “double penalty effect”: Even if a forecast predicts the overall structure well, but not perfectly at the right placed, these scores are deteriorated both because precipitation is observed where it was not forecast and vice versa. This problem becomes in particular severe for today’s high resolution numerical weather prediction models with a grid spacing in the order of 1 km because they resolve partly convective precipitation structures which are characterized by sharp gradients and limited predictability.

Consequently, various new verification techniques, which relax the strong requirement of a point wise match, have been proposed in recent times. Ebert (2007) has established a theoretical framework called “fuzzy verification” which covers many of these techniques. Calculating a fuzzy score is a two-step procedure: First a spatial of scale of interested is selected by considering the forecast only in terms of moving windows with this size, rather than in terms of grid point values. Secondly, statistics of the forecast within these windows are compared with corresponding observations. Since most scores applied in this second step are categorical, fuzzy scores additional depend on the rain intensity thresholds chosen to distinguish between events and non-events.

The method how to evaluate the statics inside a window is arbitrary and consequently quite a lot of different fuzzy scores have been proposed. This wealth of scores tends to confuse users because fuzzy scores can provide different results which are sometimes even contrasting. It is

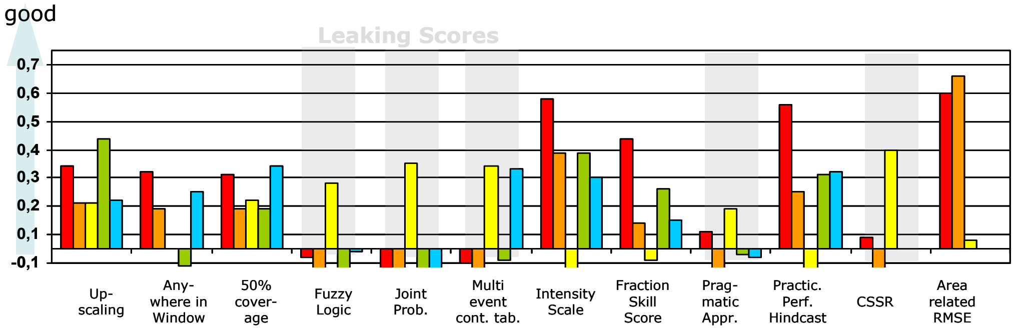


Figure 5*: Contrast of testbed results for twelve fuzzy scores and five perturbations: XSHIFT (red), BROWNIAN (orange), LS_NOIS (yellow), SMOOTH (green) and DRIZZLE (blue). Gray shaded bars indicate leaking scores which do not indicate perfect skill in case of a perfect forecast.*

therefore necessary to gain experience how to interpret fuzzy scores and afterwards to concentrate on the most useful scores in order to avoid an information overload.

To tackle this problem, we propose a testbed approach, which is an inversion of the problems in operational practice. There, the verification scores are known, but it is difficult to infer from this information the unknown, underlying forecast errors. In the testbed approach, the situation is reversed: A well defined forecast error is artificially implemented. This allows to study whether the verification scores respond as expected.

In this study, we explore twelve fuzzy scores which are presented in more detail by Ebert (2007). Rain gauge calibrated radar observations from the August 2005 flood event in Switzerland with a spatial and temporal resolution of 1km and 1h, respectively, are used as virtual truth in the testbed approach. Six types of well defined perturbations have been applied to this reference: doing nothing (PERFECT), horizontal translation (XSHIFT), exchanging randomly neighboring pixels to simulate small scale errors (BROWNIAN), multiplication by a large scale error pattern (LS_NOISE), smoothing of the field (SMOOTH) and broadening low precipitation regions (DRIZZLE).

The first test (PERFECT) is trivial and all scores should reach their maximum value to indicate a perfect forecast. Surprisingly, five fuzzy scores (see Fig. 1, "leaking scores") give imperfect results, because they assume that the model has no skill below the window scale. This response is very misleading and we recommend not to use these scores for model verification.

In the same way, one can define expected responses for the other perturbations. Concerning e.g. XSHIFT, the response should be independent from rain intensity and a deterioration of the score should only occur at scales equal or below the translation distance. To measure the agreement between expected and observed response, we define a "contrast" as the difference between the score values at scales / intensities which should not be affected minus the values at scales / intensities which are perturbed. A contrast of one would indicate a very good agreement and contra-intuitive results are reflected by a negative contrast.

Looking at the contrast for all perturbations and all scores (see Fig. 5), the "Intensity Scale" score, the "Fraction skill Score", the "Practically Perfect Hindcast" method and the "Area Related RMSE" perform pretty well. However, all these methods have problems to detect large scale errors (LS_NOISE); in this respect, "Upscaling" or "50% coverage" is more robust. Also the leaking scores, which fail to indentify a perfect forecast, show a good performance for LS_NOISE, but for a wrong reason: They always give low scores at coarse scales, which is accidently correct for LS_NOISE. For all other perturbations, their response is misleading.

Based on these findings and on additional testbed analyses (not shown), MeteoSwiss has decided to concentrate on the following set of scores: “Intensity Scale” score, the “Fraction skill Score”, the “Practically Perfect Hindcast” method and “Upscaling”. First applications in the framework of MAP D-PHASE give some hint that is feasible with fuzzy methods to quantify the increased ability of high resolution forecasts to represent convective precipitation structures.

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DYNAMICS & COUPLING

ALADIN AND LACE PROGRESS REPORT FOR 2006-2007

Filip Váňa

The research on the field of modelling in the ALADIN consortia and its sub-part RC LACE is traditionally specially focussed to the effects playing important role at high resolution. An effort is also payed to increased computing efficiency of the model.

During the period between October 2006 and September 2007 following major topics were tackled by ALADIN (or LACE) people:

1. **VFE scheme for NH dynamics**
   Work of E. Larrieau Rosina and J. Vivoda
   An ongoing research aiming to extend the existing VFE scheme from hydrostatic dynamics also to the NH core. The first version is already available in research model branch. The results are stable, accurate but affected by a noise originating from the non-linear model discretization boundary conditions.

2. **New interpolation for SL advection**
   Work of J. Mašek and F. Váňa
   New data-flow of the SL interpolation is about to be adapted to the common software. The revised data-flow is mainly expected to bring some improvement to the model efficiency. By introduction of general parametric interpolation an infinite freedom for definition of interpolation properties will be possible. Like that the SLHD (semi-Lagrangian horizontal diffusion) scheme would become integral part of the standard SL data-flow.

3. **TL/AD of LAM SL advection**
   Work of F. Váňa
   The global model TL/AD of SL advection was successfully adopted to ALADIN. The special effort was paid namely to algorithmic issues promoting the existing support to vector platforms and OpenMP parallelization also for the LAM geometry.

4. **Scale selective DFI**
   Work of P. Termonia and A. Deckmyn
   With the existing field monitoring the coupling-update frequency it is possible to detect situations for which the standard operational coupling frequency becomes insufficient. When this is the case, the easiest solution would be to restart integration from such LBC field (the policy for spectral model ALADIN allows to restart integration from any coupling file) having already the fast moving feature inside. It has been however found that in this case such signal is typically filter out by the DFI initialization. The solution is seen in developing a scale selective DFI, acting differently for various scales.

5. **New approach to LBC strategy**
   Work of P. Termonia and F. Voitus
   The central idea of this work is to develop so called extrinsic LBCs approach. This is to propose a finite-difference scheme for LBCs that is different from the SI SL dynamical core of the spectral model. Having such technique would allow to adopt any new approaches to LBC coupling independently to the actual model algorithmics. The first tests from 1D model confirm the optimistic expectations.

Diagnostic tool for ALADIN lateral coupling

Ján Mašek, Slovak HydroMeteorological Institute

1 Introduction

Integration of limited area model (LAM) is initial-boundary value problem. Therefore, success of LAM approach depends not only on accurate initial state, but also on quality and mathematical formulation of lateral boundary conditions (LBC). Ideally, LBC formulation should be well posed, leading to transparent behaviour of coupling scheme. It means that coupling scheme should ensure correct transfer of incoming signals from driving model to nested LAM and at the same time absorb all outgoing signals leaving nested LAM. If LBC formulation fails to ensure any of these two requirements, nested solution becomes contaminated by noise generated at lateral boundaries, which propagates inwards and makes LAM forecast useless after some time.

Numerical weather prediction (NWP) models are based on Euler equations, for lower horizontal resolutions usually combined with hydrostatic approximation leading to so called primitive equations. Unfortunately, formulation of well posed boundary conditions on opened lateral boundaries is extremely difficult for these systems. Common NWP practice is therefore to overdetermine LBC and to use some sort of damping which should reduce boundary noise coming from overdetermination. This approach is best represented by Davies relaxation scheme [1], which was golden standard in NWP field for thirty years.

Nowaday shift towards kilometric resolutions, more vertical levels and sophisticated physical packages together with limited computing resources implies use of small LAM domains. And since in small domain solution becomes dominated by LBC very early, lateral boundary treatment becomes key issue. It is therefore questionable whether Davies relaxation scheme is still satisfactory in the new conditions.

Subjective evaluation of coupling scheme performance in 3D real cases can be problematic. For this reason some objective diagnostic tool is needed. In this article design of such tool developed for model ALADIN is described. In future it can be used to evaluate performance of alternative coupling strategies.

2 Design of diagnostic tool

2.1 Perfect model approach

Design of diagnostic tool was inspired by perfect model approach described in [2]. Basic idea is very simple. Same model is integrated on two LAM domains – large and small – with identical resolutions and matching grid points. Solution on large domain is used as perfect reference. After removing short scales it provides LBC for nested model on small domain. In this way imperfect LBC coming from lower resolution driving model are simulated.

Then it can be examined how successfully is nested LAM able to reconstruct small scales which were not present in LBC.

Perfect model approach in ALADIN environment is illustrated on figure 1. LBC filtering is done in spectral space. Due to elliptical truncation unfiltered LBC are not perfect even with linear grid, since the wavenumbers from the corners of bi-Fourier space are missing.

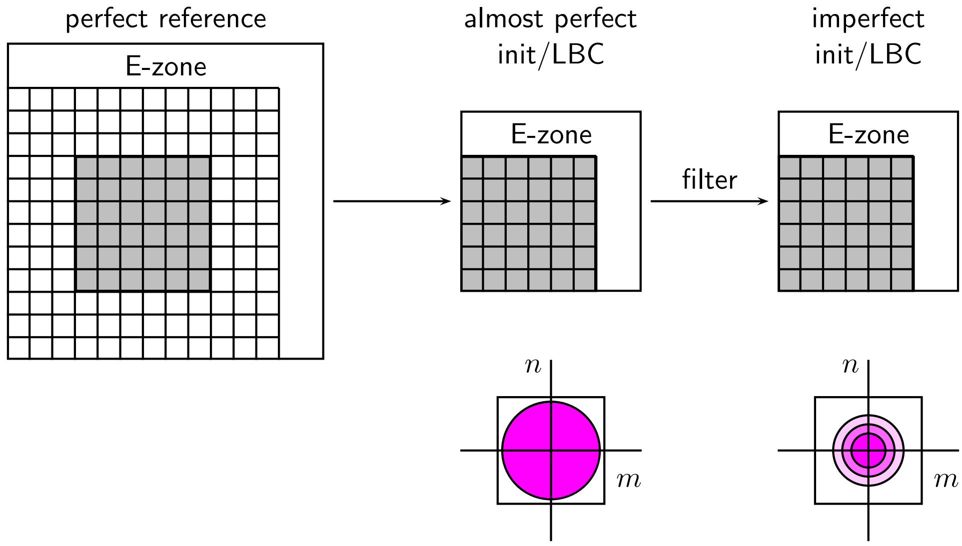

Figure 1: Scheme of perfect model approach in spectral model. Grey area represents geographical domain of nested LAM. E-zone is artificial extension zone needed for biperiodicization of fields. Bottom diagrams show bi-Fourier space with elliptical truncation. Area with non-zero spectral coefficients is indicated by magenta.

2.2 LAM domains and basic model setup

Used LAM domains are shown on figure 2. Large domain MFST was taken from project MFSTEP. It covers large part of Europe, North Africa, North-East Atlantic, Mediterranean Sea and Black Sea. Small domain DOM1 with size approximately 1300×1300 km was placed approximately in the centre of MFST domain. It contains Alps and Apennine Peninsula and was chosen in such way so that its boundary does not cross main mountain ranges.

Resolution of both domains was 9.5 km with 37 vertical levels. Linear grid with quadratically truncated orography was used. Hydrostatic version of model ALADIN was integrated with timestep $\Delta t = 400$ s, employing two time level semi-implicit scheme with semi-Lagrangian advection.

In order to see asymptotic value of error coming from coupling scheme, 10 day integrations starting on 01-Apr-2005, 00 UTC were performed. Coupling frequency was 3 hours. Reference integration on MFST domain was carried on in reanalysis mode, i.e. it was coupled with ARPEGE analyses and 3 hour forecasts. Width of relaxation zone was always 8 points.

2.3 LBC filtering for nested LAM

LBC for nested model were prepared in two steps. First step was done in gridpoint space, where reference solution was extracted for nested domain

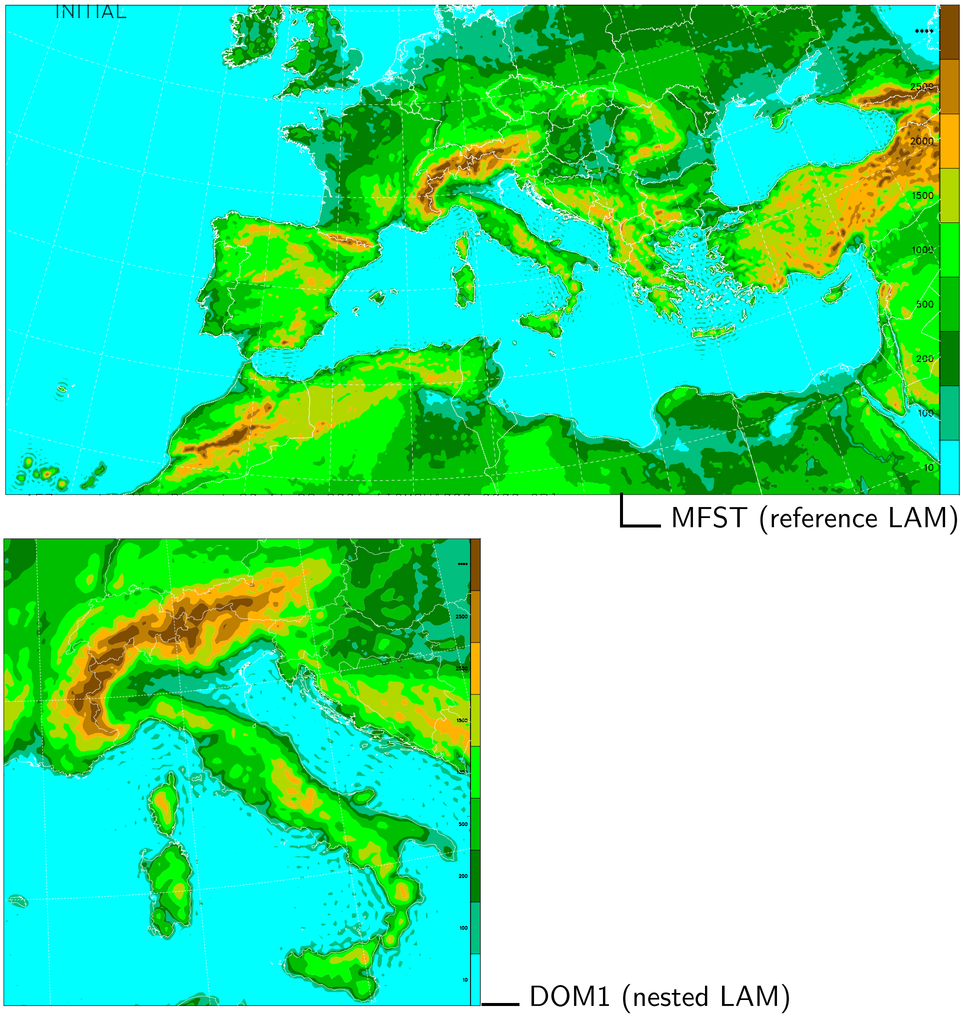

Figure 2: Domains and orography used in reference LAM (top) and nested LAM (bottom).

and biperiodicized. Second step was transformation to spectral space followed by application of cosine filter, acting on spectral coefficients $c_{m,n}$:

$$c_{m,n}^{\text{filt}} = c_{m,n} \cdot f(r_{m,n})$$

$$f(r) = \begin{cases} 1 & ; \quad r \leq r_1^{\text{crit}} \\ \frac{1}{2} + \frac{1}{2}\cos\left[\pi \frac{r - r_1^{\text{crit}}}{r_2^{\text{crit}} - r_1^{\text{crit}}}\right] & ; \; r_1^{\text{crit}} < r \leq r_2^{\text{crit}} \\ 0 & ; \quad r > r_2^{\text{crit}} \end{cases} \tag{1}$$

$$r_{m,n} = \sqrt{\left(\frac{m}{M}\right)^2 + \left(\frac{n}{N}\right)^2} = \frac{k}{k_{\max}}$$

Filtering function (1) is shown on figure 3. It can be tuned by changing critical relative wavenumbers r_1^{crit} and r_2^{crit}. Setting $r_1^{\text{crit}} = r_2^{\text{crit}}$ would correspond to sharp cut-off. In experiments soft filter with $r_1^{\text{crit}} = 0$ and $r_2^{\text{crit}} = \frac{1}{3}$ was used. It removed all wavelengths shorter than $6\Delta x$, simulating driving model with three times coarser resolution (shortest wave represented in nested model was $2\Delta x$). Use of smooth filtering function was necessary in order to supress generation of Gibbs waves.

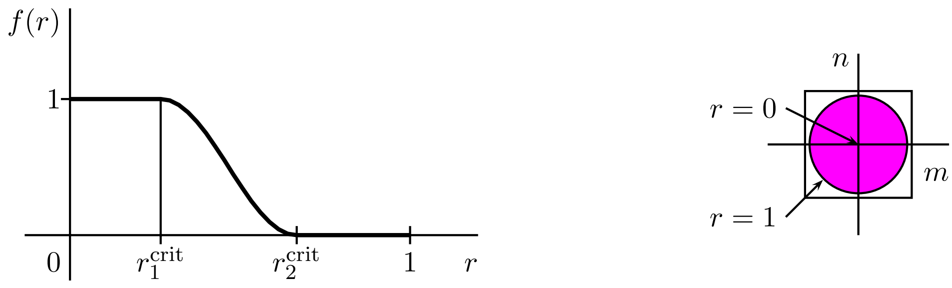

Figure 3: Filtering function. Diagram on the right shows meaning of relative wavenumber $r = k/k_{\max}$.

2.4 Choice of parameter and scores

Performance of coupling scheme was judged from vorticity field ξ at 500 hPa level. Vorticity was chosen mainly because it contains significant energy in small scales. Score measuring forecast accuracy was root mean square error (RMSE) normalized by standard deviation of reference solution $\sigma(\xi_{\text{ref}})$:

$$s = \frac{\sqrt{\overline{(\xi - \xi_{\text{ref}})^2}}}{\sigma(\xi_{\text{ref}})} \tag{2}$$

It has two significant values: $s = 1$ when field ξ is approximated by its mean value $\bar{\xi}$ and $s = \sqrt{2}$ when forecasted field ξ has correct variance but is uncorrelated with reference solution ξ_{ref}. Value $s = \sqrt{2}$ therefore represents usability limit for LAM forecast.

Choice of level is justified by figure 4, which displays evolution of normalized vorticity RMSE for levels 300, 500, 700, 850 and 925 hPa. It can be seen that after approximately 2 day period of initial growth error saturates and fluctuates around asymptotic value. Level 500 hPa was selected as the least favourable case, showing smallest forecast skill.

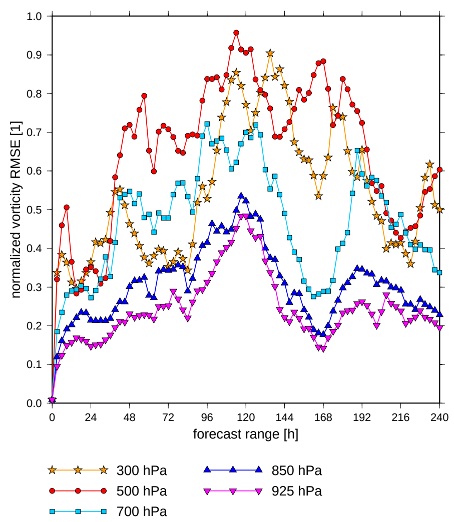

Figure 4: Evolution of normalized vorticity RMSE for 10 day nested integration with perfect initial state and filtered LBC. Scores computed over nested domain DOM1 without 8 point boundary zone.

3 Basic tests of Davies relaxation scheme

3.1 Sensitivity to LBC treatment

Figure 5 shows impact of LBC filtering on forecast quality. In order to reduce spinup, perfect initial state was used. It can be observed that use of filtered LBC deteriorates forecast only slightly, which is good message for LAM approach. Added value of Davies coupling is illustrated by experiment with no relaxation zone, where deterioration of scores is much more pronounced.

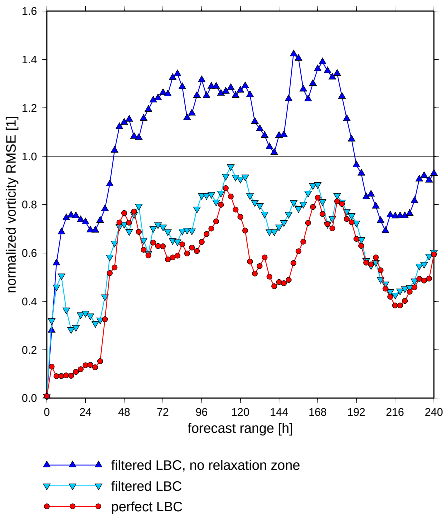

Figure 5: Evolution of normalized vorticity RMSE at 500 hPa level. Nested integrations with perfect initial state: red – perfect LBC; light blue – filtered LBC; dark blue – filtered LBC and zero relaxation zone.

3.2 Sensitivity to initial state

Sensitivity to initial state is demonstrated on figure 6, where filtered LBC were used. With perfect initial state spinup is rather weak. Integration starting from filtered initial state gives much stronger spinup. Additional digital filter initialization (DFI) moves filtered initial state away from perfect one, but spinup is reduced thanks to better balanced fields. After approximately 36 hours all three curves converge, showing negligible impact of initial state for longer forecast lead times.

3.3 Sensitivity to coupling frequency

Figure 7 shows sensitivity to coupling frequency. Left panel displays evolution of scores for nested integrations with perfect initial state and perfect LBC. Coupling frequencies were 3 hours, 1 hour and 400 s ($27\Delta t$, $9\Delta t$ and Δt). It can be seen that after roughly 6 hour spinup period curves for 3 hour and 1 hour coupling frequency separate, but coupling at every timestep brings almost no improvement compared to 1 hour coupling frequency. Right panel displays the same for perfect initial state and filtered LBC. Here the spinup is stronger and takes roughly 15 hours, but the curves for 3 hour and 1 hour coupling frequency separate much later, approximately after 33 hours. Coupling at every timestep was not tested in this case.

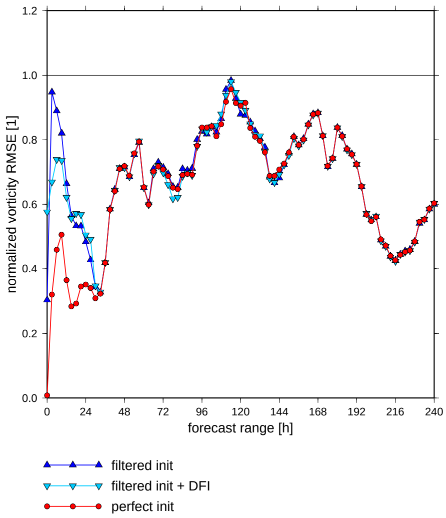

Figure 6: Evolution of normalized vorticity RMSE at 500 hPa level. Nested integrations with filtered LBC: red – perfect initial state; light blue – filtered initial state with DFI; dark blue – filtered initial state without DFI.

Explanation of described behaviour is rather straightforward. Spatially filtered LBC do not contain short scales, which are often connected to high frequencies. These frequencies can be undersampled and aliased due to insufficient coupling frequency, so their removal has beneficial impact on temporal LBC interpolation.

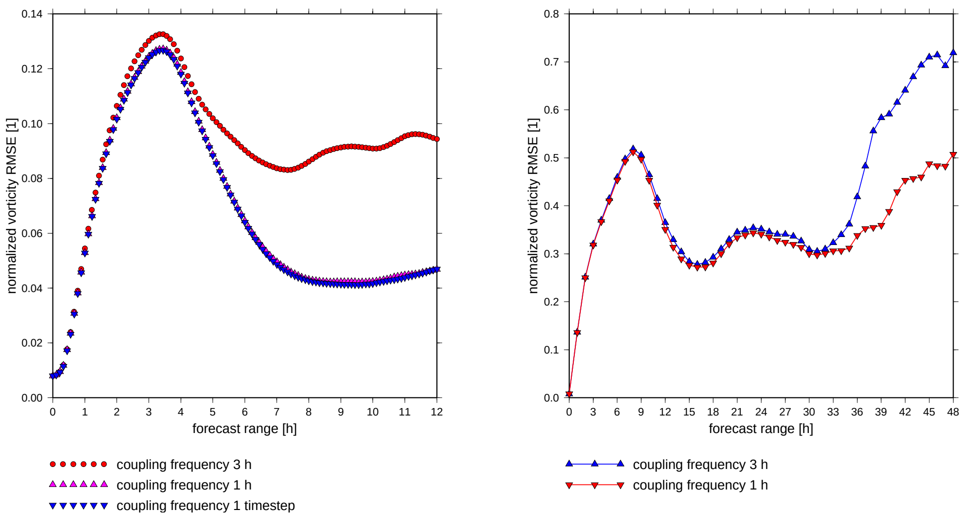

Figure 7: Evolution of normalized vorticity RMSE at 500 hPa level. Nested integrations with perfect initial state and coupling frequencies 3 hours, 1 hour and eventually 1 timestep: left – perfect LBC; right – filtered LBC. Note that scales on the plots are not the same.

3.4 Comparison of two extreme cases

Figure 8 compares nested integration using perfect initial state and perfect LBC with that using flat initial state and filtered LBC. Flat initial state was prepared by replacing 3D prognostic fields by their mean values on each model level. Even if starting from such crude initial state, after period of enormous spinup error is reduced to values comparable with perfect case. This once again illustrates that solution at later stages is fully determined by LBC.

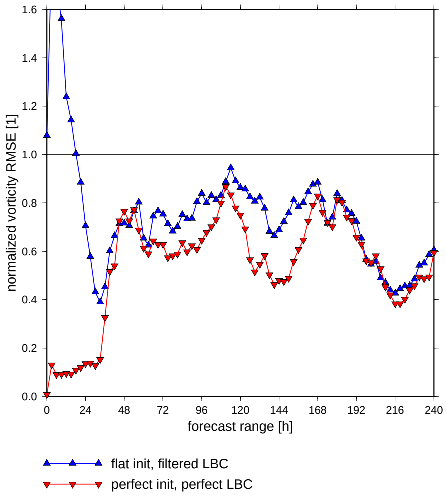

Figure 8: Evolution of normalized vorticity RMSE at 500 hPa level. Two extreme cases of nested integration: red – perfect initial state with perfect LBC; blue – flat initial state with filtered LBC.

Vorticity field after 48 hour integration is shown on figure 9 for both cases. Two solutions are similar, but there are visible differences in finer scale details. However, in terms of RMSE difference from reference solution they are equally good.

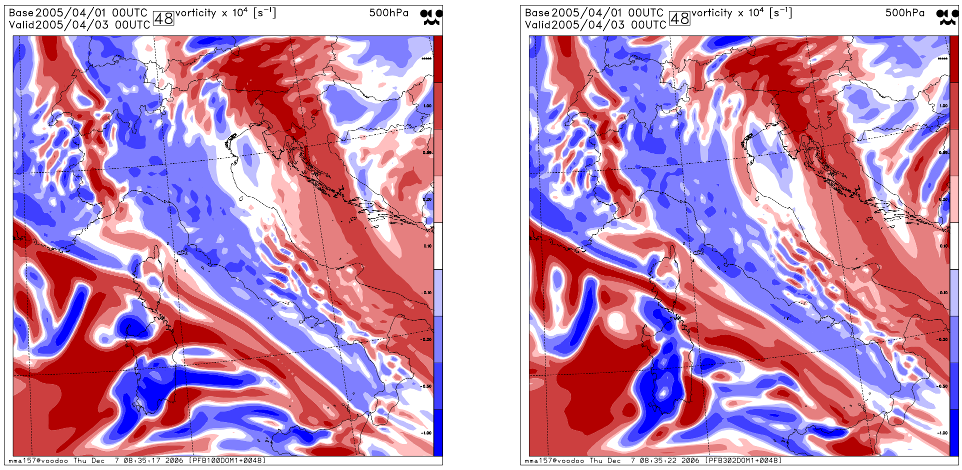

Figure 9: Vorticity field at 500 hPa level after 48 hours of nested integration: left – perfect initial state with perfect LBC; right - flat initial state with filtered LBC.

3.5 Spectral composition of RMSE

Figure 10 shows vorticity RMSE for 5 levels obtained by nested integration with perfect initial state and filtered LBC, relative to RMSE of imperfect driving solution represented by filtered LBC. Scores were computed over integration days 3–10, therefore they correspond to least favourable asymptotic error values. Spectral profile of RMSE was determined by using several values of relative cut-off wavenumber r and by removing all waves shorter than $2\Delta x/r$ from nested solution.

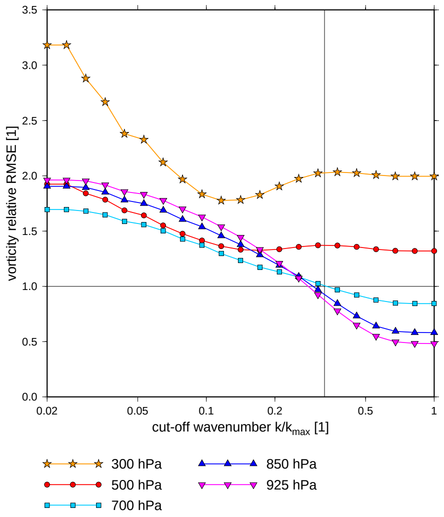

Figure 10: Dependency of relative vorticity RMSE on relative cut-off wavenumber for nested integration with perfect initial state and filtered LBC. Scores computed over nested domain DOM1 without 8 point boundary zone and averaged over integration days 3–10. Vertical line denotes value $r_2^{\text{crit}} = \frac{1}{3}$ which was used for LBC filtering. Horizontal line shows usability limit for LAM approach. Above this line quality of nested solution is worse than quality of filtered LBC.

Decreasing parts of curves on figure 10 indicate useful skill in removed scales (their addition improves score), while stationary or increasing parts indicate no skill. It can be seen that while for levels 925, 850 and 700 hPa there is skill in short scales, higher up in the atmosphere it is lost. Moreover, for levels 500 and 300 hPa values of relative RMSE exceed 1, showing deterioration of imperfect driving forecast by nested LAM. This is not surprising, since the main improvement in LAM approach comes from better resolved orography and surface, having strongest impact on lower atmospheric levels.

3.6 Note on forecast skill

In previous sections, quality of nested LAM forecasts was measured by RMSE score. However, it might be objected that such criterion is too strict in some respects. For example, when the field with high spatial variability has correctly forecasted structure but is slightly shifted, resulting RMSE score can be very poor due to double penalty. As pointed out in [2], in high resolution NWP models meteorologically insignificant phase shift of short waves can lead to considerable deterioration of RMSE score, even if the forecast is still almost perfect from synoptic point of view. This problem is illustrated on figure 11. On the other hand, point interpretation of high resolution forecasts requires fairly good RMSE scores.

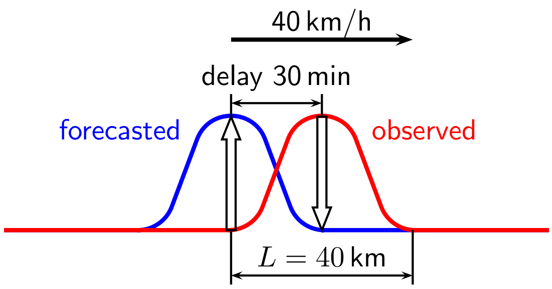

Figure 11: Illustration of double penalty problem for advected meso-synoptic system which is slightly delayed in model: red – observed; blue – forecasted. Thick arrows represent forecast error.

4 Summary and conclusions

Diagnostic tool for ALADIN lateral coupling was developed and is ready for use. It is based on perfect model approach [2], which enables to isolate error caused by coupling scheme from other errors. Main purpose of diagnostic tool is to perform final evaluation of new coupling strategies in 3D ALADIN, after they have passed set of idealized 1D and 2D tests. Alternatively, it can be used to test some quick win solutions.

So far only basic tests of currently used Davies relaxation scheme were carried out, illustrating most important limitations of LAM approach:

- quality of initial state (short forecast lead times)
- lack of predictive skill at higher levels, when measured by relative RMSE (long forecast lead times)
- coupling frequency

With 11 point wide extension zone, no coupling problems specific for spectral LAM could be seen.

It must be remembered that some quantitative conclusions drawn in this article may depend on integration period, resolution, size and placement of integration domains. Therefore, care is needed when applying them in different conditions. It is believed that presented qualitative results should have more general validity.

References

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Aladin consortium activities in data assimilation

G. Bölöni and C. Fischer
30/10/2007

3DVAR installations in the consortium

Presently, there are four Aladin countries running an assimilation suite on a regular basis (Czech Republic, France, Hungary, Morocco). Among these, Czech Republic runs a surface OI for the surface completed with an upper-air digital filter blending. The other three suites are common in using the Aladin 3DVAR code for an upper-air analysis, but they differ in several aspects in the organization of the assimilation cycle and the use of observations. As an example, the main characteristics of the Aladin/France assimilation suite is described below:
Cycle:

- 6 hour cycle
- long and short cut-off assimilation
- coupling with the Arpège analysis
- digital filter initialization (cycle and production)

Observations:

- SHIP: winds
- SYNOP: Ps, T2m, RH2m, V10m
- Aircraft data
- SATOB motion winds
- Drifting buoys
- Soundings: TEMP, PILOT
- Satellite radiances: AMSU-A, MHS, HIRS, Meteosat-9 SEVIRI
- Quickscat winds
- Ground-based GPS zenital total delays

In 2007, a number of other countries took important steps in order to implement a 3DVAR assimilation. Croatia, Romania and Slovenia started to install and use ODB and the related softwares, Czech colleagues installed the 3DVAR configuration of the Aladin code and computed NMC B matrices for their domain. In Slovakia, digital filter blending of the upper-air fields became an operational application.

Cycling aspects

Aladin Rapid Update Cycle (RUC)

A trial of 3 and 1 hourly 3DVAR cycling took place with Aladin in Hungary. The purpose was to take the benefit of SYNOP measurements more frequently and to reduce the timing errors in the innovation vector. Preliminary results show that some skills can be gained when going to the more frequent cycling but also some deficiency is present (Fig.1).

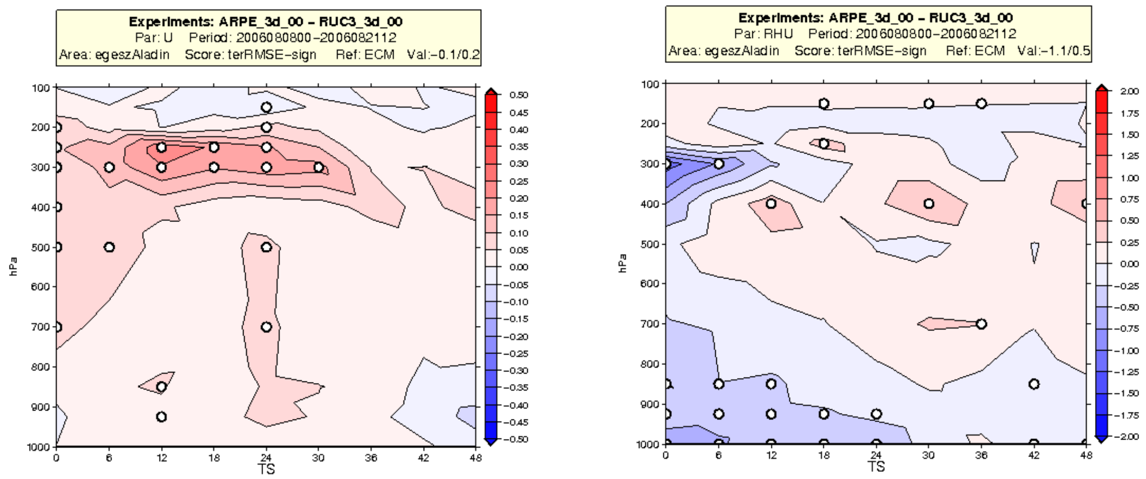

Fig.1: Cross sections of RMSE differences for wind-u (left) and relative humidity (right). Red (blue) colors indicate a smaller (larger) RMSE of the 3 hour cycle compared to the 6 hour cycle. White circles indicate statistical significance in the RMSE differences with 90% confidence. The RMSE is computed against ECMWF analyzes. Sandor Kertesz and Gergely Bölöni (HMS).

The deficiencies are intuitively supposed to come from spin-up problems in the background or from an inappropriate Jb for 3 hour background forecasts. These possible sources of problems should be studied in the future. Also, more screen level observations from SYNOP stations (wind, temperature, humidity) and high frequency satellites (SEVIRI) are planned to be used in later RUC experiments (so far, only surface pressure has been used from SYNOP reports).

Use of ECMWF fields as lateral boundary conditions in Aladin 3DVAR

The use of ECMWF fields as LBCs has been compared with the usual configuration, which is the use of Arpège fields. Two main experiments have been set up according to the availability constraints of ECMWF LBC files. One should explain here that the ECMWF LBC files from the 00 UTC run are available too late for driving an operational 00 UTC LAM run with them. The present practice (in Hirlam for instance) is to use LBCs from the previous 18 UTC run for driving the 00 UTC LAM runs. Note that the Arpège 00 UTC LBCs probably are available earlier due to a shorter data cut-off, which allows to use always the corresponding global fields to drive the LAM models. Taking into account the above availability constraints, a “laboratory” and an “operational” experiment have been run. The laboratory setup showed a very clear improvement if ECMWF LBCs are used (not shown). This improvement is reduced in the operational experiment but still remained significant (Fig 2.)

Background error covariance modeling

A new humidity control variable has been tested in France following the work done at ECMWF. The purpose of the work is to transform specific humidity into a new variable whose errors are more Gaussian and homogeneous. With the introduction of the new humidity variable, it is also possible to avoid supersaturation and negative values of humidity. In Hungary, a major change was the operational use of ensemble background error covariances with a simple a posteriori tuning of the spectral variances.

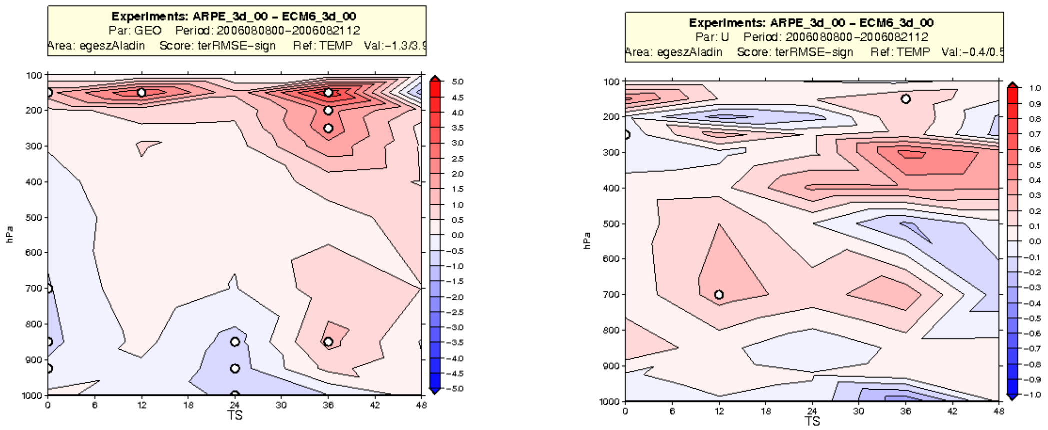

Fig.2: Cross sections of RMSE differences for geopotential (left) and wind-u (right). Red (blue) colors indicate a smaller RMSE using ECMWF (Arpège) LBCs. White circles indicate statistical significance in the RMSE differences with 90% confidence. The RMSE is computed against ECMWF observations. Sandor Kertesz and Gergely Bölöni (HMS).

Development on observation use (OSEs)

Radiances over land (land emissivity estimates)

Microwave channels which receive a contribution from the surface are sensitive to surface emissivity. In order to use these radiances over land, one should estimate the land surface emissivities. Three different estimates have been tried using AMSU-A, AMSU-B (aka MHS) and SSM/I observations:

- Averaged emissivities over 2 weeks prior to the assimilation period; Ts is taken from the model's first guess.
- Dynamically varying emissivities derived at each pixel using only one channel of each instrument; Ts is taken from the model first guess.
- Averaged emissivities + dynamically estimated skin temperature Ts at each pixel using one (or two) channel(s) of each instrument

Experiments have been done in Arpège using the above-mentioned microwave radiances. Scores are neutral to positive for relative humidity, temperature and geopotential. The precipitation forecast is improved over West-Africa. This example is shown on Fig. 3.

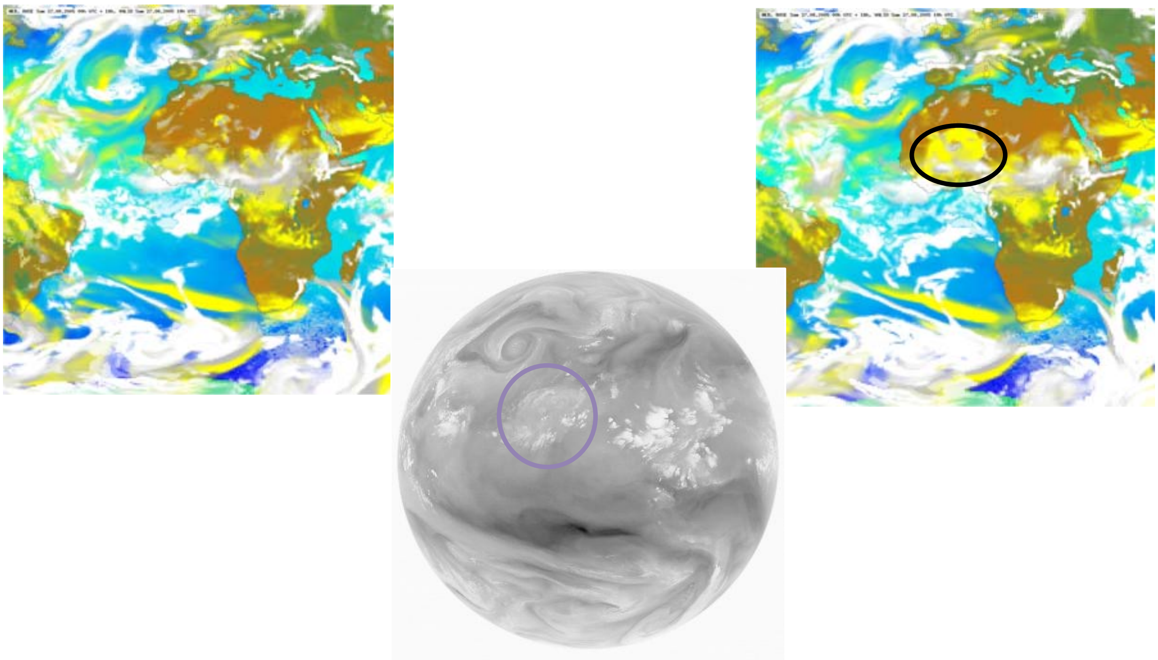

Fig.3: Cloud forecasts of the control run (top left) and the run including radiances over land (top right). In the bottom, the corresponding IR Meteosat image is shown as verification. Fatima Karbou (MF).

The future work will tackle the use of cloudy pixels of microwave radiances both over land and sea.

Radar wind

The preparations for the assimilation of Doppler radar radial winds in Aladin-France and Arome are under progress. This new source of information helps in the initialization of convective systems, especially through a better description of the PBL and low-tropospheric wind field. In the test experiments with Arome, the benefits are visible in terms of relocation of convergence lines and positioning and organization of precipitation fields.

Radar reflectivity

Radar reflectivity assimilation is a major cornerstone of the work on very high resolution, high frequency use of observations for the Arome system. In 2006, a radar reflectivity observation operator has been developed and plugged within the common IFS/Arpège/LAM software. The observation operator allows for mode-to-observation comparison, fine tuning of quality control checks, improvements on the removal of spurious echoes, test cases and verification. However, for the time being, the direct assimilation of reflectivities has not been developed.

Instead, the strategy is to invert the reflectivity information into humidity and temperature profiles via a 1D Bayesian approach (the output profiles are weighted averages of model 1D columns, the weights being expressed in terms of a cost function for reflectivity) and then to assimilate these profiles in 3DVAR. There is ongoing work on the quality control of the data, the removal of spurious clutters (with respect to orography), further tests on assimilation experiments with Arome. A case study is shown on Fig. 4.

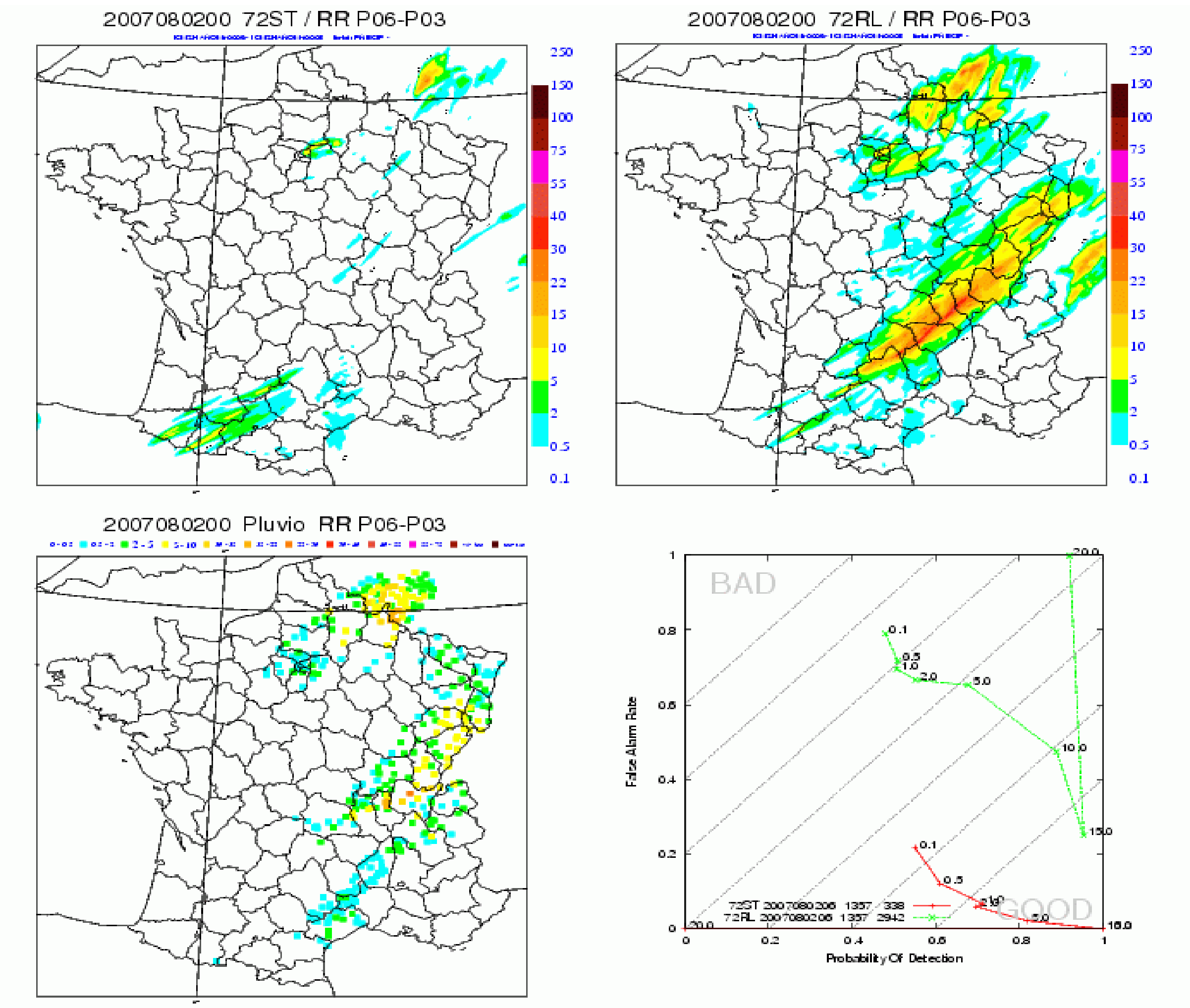

Fig.4: Top left panel: 3 h modelled precipitations (6-3 h lead times) with reflectivity assimilation, Top right panel: the same without reflectivity assimilation, Bottom left panel: 3h raingauge aggregates, Bottom right panel: POD v/s FAR diagram for the run with (red) and without (green) reflectivity assimilation. Eric Wattrelot (MF).

Planning for 2007, outlook for 2008

Background error modeling

** Errors of the day in screening*

The computation of daily background error standard deviations will be tested in the screening quality control. These standard deviations come from an Arpège ensemble assimilation system in which the observations are randomly perturbed.

** Gridpoint maps of σb's for minimization*

Grid point maps of σb's allow to include inhomogeneity information in the analysis. These maps can be computed based on background forecasts accumulated in time or based on ensembles of backgrounds if an ensemble system is available. The latter solution would introduce also some flow dependency into the analysis.

** Filtering of the ensemble background errors (low-pass)*

R&D work is performed at Météo-France in order to reduce sampling noise within small ensemble background error estimates. In particular, twin experiments and filtering properties of the sampling estimates are investigated, in order to filter sampling noise and retain only the statistically useful signal in the output background error estimation.

** Wavelets*

Triggered by the efforts undertaken at IRM/Belgium, the work on wavelets will continue. A LAM suitable wavelet basis, based on complex (diadic-type) wavelet structure functions, is under investigation. Besides the work on the theoretical properties and geometrical possibilities offered by these functions, work will also start in order to assess the practical implementation of the wavelet approach into the Aladin 3DVAR code.

Algorithms

** 4D-VAR in a nutshell*

Recently, some of the major bricks towards a 4DVAR LAM assimilation system have been made available (eg. TL and AD of the semi-Lagrangian advection scheme). In 2008, we plan to resume sensitivity studies and first 4DVAR tests using a baseline version which would offer a common technological basis for large-domain LAMs (Hirlam) and very high resolution R&D activities (Aladin). The nutshell version would include reduced simplified physics from Arpège, SL advection scheme in TL/AD, possibly Jc-DFI instead of an external DFI, but no multi-incremental nor non-hydrostatic versions.

** Simplified microphysics scheme for the mesoscale*

For an efficient mesoscale 4DVAR, one expects that a simplified microphysics scheme (with its TL and AD version) will be necessary. The development of such physics is on the plan and this will be tackled together with the Hirlam community.

** Towards an integrated « Ensemble/Variational » data assimilation system*

The combination of an ensemble forecasting system with variational data assimilation will be tested, first in the global Arpège context. On the side of data assimilation, the goal is to include flow dependency into the background term of the variational assimilation scheme. Another suitable result would be to make the Ensemble Prediction System initial perturbations consistent with the deterministic data analysis. The attempts will go both in the direction of system simulation experiments (Aladin) and Ensemble Transform Kalman Filtering (Hirlam).

Observations

** SEVIRI radiances in Hungary and Morocco*

The assimilation of SEVIRI data is on the plan in several Aladin countries, such as Czech Rep., Hungary and Morocco.

** Surface emissivity for microwave channels*

Tests of the methods developed for the global Arpège system in the LAM will be undertaken. As further steps, the inclusion of a simple surface emissivity model within the radiative transfer code is also considered.

** Radar radial winds in the Aladin-FR and Arome assimilation*

Developments and further tests will be carried out, with the goal to make the radial wind assimilation operational at least in the Arome system by end of 2008. Inter-comparisons between the Arome-originated and the Hirlam-born observation operators are on the plan.

** Continuation on radar reflectivity obs. op. & retrieval methods*

The retrieval method will be further tested at Météo-France. Work on quality control and spurious clutter detection and removal will also be continued, in a close collaboration between MF, SMHI (Slovakia) and SHMI (Sweden).

Operations

Aladin-France:

- Incremental DFI is to be applied instead of the present non-incremental one
- radar winds to be used in the assimilation
- σb's to be retuned
- increase of the vertical levels from 46 to 60

Arome-France:

- first operational Arome implementation on 2.5km resolution, with 3h frequent continuous 3DVAR assimilation, 4 production runs a day for +30 hours. Radar wind and reflectivity are to be used in the assimilation.

Aladin-Hungary:

- assimilation of T2m+RH2m observations from SYNOP reports is expected
- assimilation of SEVIRI radiances is expected
- implementation of surface OI assimilation is expected

Aladin-Morocco:

- 3D-VAR to be implemented operationally using NOAA and MSG radiances

A new land data assimilation system for ALADIN

Jean-François Mahfouf[1] and Karim Bergaoui[2]

[1] *Météo-France/CNRS, CNRM/GAME, Toulouse, France*
[2] *Institut National de la Météorologie, Tunis, Tunise*

1. Introduction

This paper provides a brief description of a new land data assimilation system (LDAS) currently under development within ALADIN and HIRLAM consortia. The current operational practice for the initialisation of soil variables in most ALADIN models is to start from an interpolation of the global ARPEGE soil analysis. This analysis was developed by Giard and Bazile (2000) following ideas from Mahfouf (1991) and Bouttier et al. (1993). It is based on a local optimal interpolation (OI) technique where analysis increments of temperature ΔT_{2m} and relative humidity ΔRH_{2m} at screen-level are used to correct soil variables (temperatures ΔT_s and water contents Δw_s). The relationship between near-surface increments and soil corrections is linear and uses statistics of forecast and observation errors. Forecast error statistics were derived from Monte-Carlo (ensemble) one-column model runs. This soil analysis is run operationally in HIRLAM models (Rodriguez et al., 2003) and also in some versions of ALADIN (A. Trojakova, 2006; personal communication). Even though this technique is useful in providing a ”reasonable” initial soil state to NWP models, by avoiding potential positive feedback loops and reducing short-range forecast errors in the boundary layer (Drusch and Viterbo, 2007), it has a number of known weaknesses.

The optimal (statistical) coefficients α_i and β_i proposed by Bouttier et al. (1993) where derived in summer clear-sky conditions when the coupling between the surface and the boundary layer is strong. For a general use, Giard and Bazile (2000) defined a number of empirical criteria in order to switch off soil analysis when screen-level forecast errors are not informative about the soil state. The new LDAS will prevent from such arbitrary specifications. Another more important limitation (regarding future applications) is the fact that the Giard and Bazile (2000) technique cannot easily make use of other observations than screen-level temperature and relative humidity and is very much tied to the structure of the two-layer force-restore land surface scheme ISBA (Noilhan and Planton, 1989; Noilhan and Mahfouf, 1996). A number of new satellites have recently been launched with instruments (microwave radiometers and scatterometers) that already provide useful information about surface soil conditions (AMSR-E, ERS, ASCAT, WindSat). In a very near future (2009) a soil moisture dedicated space mission SMOS will be launched by ESA. The ISBA scheme has considerably evolved during the last ten years, with a 3-layer version (Boone et al., 1999), a multi-layer version (Boone, 2000), a dynamical vegetation scheme (Calvet et al., 1998). Such improvements are not yet in operational NWP models, one reason being the lack of appropriate technique to initialize the additional prognostic variables. The new system will be able to accomodate rather easily new observation types (more directly related to soil conditions than T_{2m} and RH_{2m}) and its design will not be limited to a particular version of the ISBA scheme. Finally, it is interesting to mention that despite the relative success of the OI technique currently used in a number of operational NWP centers, another approach has been developed to initialize the soil state of NWP models by forcing the land surface scheme with the best available forcing (analyses) in terms of precipitation and radiative fluxes. This methodology is however limited to areas well covered by high density raingauge or radar networks. The new system will allow the inclusion of such useful additional information on soil state where available.

2. Current status of activities

The new LDAS is based on a simplified Extended Kalman Filter (SEKF) that was first proposed by Hess (2001) but here the land surface scheme is run in an offline system (prescribed atmospheric forcing) within the externalized surface module SURFEX (Le Moigne, 2005). In the SEKF developed by Hess (2001), a coupled atmospheric/land surface model is run twice (one for a reference run and one for a perturbed run with modified initial soil conditions) to compute in finite differences the Jacobian of the observation operator. This method allows to produce ”dynamical” OI coefficients (the elements of the Kalman gain matrix) that depend upon actual meteorological conditions, thereby empirical reductions of the OI coefficients are not needed. This method was tested with success in ALADIN by Balsamo et al. (2004). They considered a SEKF with a 24-h assimilation window where screen-level analyses are available every 6 hours. In consequence the technique was named *simplified 2D-Var*. However, the extra computing cost associated to the additional model run has prevented this method from becoming operational in any ALADIN member state. Recently, Balsamo et al. (2007) have shown that it is possible to develop such LDAS in ”offline mode”, reducing significantly the extra cost associated with the Jacobian computation in finite differences. This approach was unsuccessfully tried ten years ago by Douville et al. (1999) since the atmospheric forcing (ECMWF) was not coherent with the land surface scheme (ISBA, Météo-France). Recently Mahfouf (2007) has shown that, at local scale with similated observations, the offline SEKF assimilation of screen-level temperature and relative humidity behaves similarly to ”analytical” OI approaches (ARPEGE and ECMWF). He also confirmed that such LDAS can assimilate simultaneously L-band brightness temperatures and screen-level observations. Indeed, this demonstration was first done by Seuffert et al. (2004) with a SEKF in fully coupled mode.

3. Experimental set-up

The SEKF LDAS has been coded within the externalized module SURFEX, where all recent versions of ISBA are available. Since SURFEX has been designed to be coupled to a large number of atmospheric NWP models (AROME, ARPEGE, ALADIN, HIRLAM), this new assimilation system could be available to each of them.

We have designed a first experimentation over the ALADIN-France domain for July 2006. The domain covers a large part of western Europe with a 9.5 km grid (273x273 points). To start with, only the analysis of the mean soil moisture reservoir w_2 from the two-layer version of the ISBA scheme (Noilhan and Mahfouf, 1996) is considered. First a screen-level analysis of temperature T_{2m} and relative humidity RH_{2m} has been performed every 6 hours with an optimum interpolation technique (CANARI system) using observations from both the GTS SYNOP and French RADOME surface networks. This is a univariate analysis using isotropic horizontal structure functions with a correlation length of 45 km. The standard deviations of background and observation errors have been set to : σ_T^b=1.6 K, σ_{RH}^b=10%, σ_T^o=1.4 K, σ_{RH}^o=10%. Short-range forecasts have been run with a 46-level version of the ALADIN-France model and hourly outputs have been stored in terms of wind, specific humidity, temperature at the lowest model level (around 17 m), surface pressure, accumulated precipitation and radiative fluxes (downward longwave and shortwave components). These quantities are then used to force a version of the land surface scheme ISBA in the externalized module SURFEX. They are linearly interpolated between two hours at each model time step (taken as 5 minutes) by ensuring that accumulated fluxes are conserved. A number of features of SURFEX have been adapted in order to reproduce a behaviour of ISBA within SURFEX as close as possible to its behaviour within ALADIN. This necessary condition to make the offline assimilation meaningful has been a rather tedious exercise for several reasons. By default, soil and vegetation properties at model resolution are generated by SURFEX using ECOCLIMAP physiographic data bases at 1 km (Masson et al., 2003). It has been necessary to by-pass ECOCLIMAP data bases and to use those described in Giard and Bazile (2000). Moreover, the averaging and interpolation procedures being different between SURFEX and those used for ALADIN (*configuration e923*), already interpolated fields onto the model grid have been used as inputs in SURFEX. As mentioned above, a large number of ISBA options exist within SURFEX, however the one used in the ARPEGE and ALADIN models and described in Giard and Bazile (2000), was not present in the first version. The current SURFEX version (v3) contains most of the ISBA features defined for NWP applications. Differences between ISBA ”offline” and ”online” still persist (for example due to the temporal interpolation of the forcing or to timestep differences) but have reached a level that we considered as acceptable. The initial soil conditions (temperature and moisture contents for two reservoirs) have been taken from the ALADIN analysis on the 1st July 2006 at 00 UTC. Within SURFEX, the use of a ”normalized” soil wetness index (instead of volumetric water contents) to perform grid interpolations induces slight differences with the original soil moisture field that reflect on evapotranspiration in regions close to the wilting point (due to strong non-linearities).

In the current experiments, the SEKF is run completely decoupled from the atmospheric model. This set-up is acceptable for a feasibility study, but for operational applications the offline LDAS will be coupled to the atmospheric model through a cycling described in Figure 1. By considering a 6-h data assimilation cycling, a 6-h forecast of ALADIN will be used as background for a screen-level analysis of temperature and relative humidity. The atmospheric forcing including downward radiative fluxes and surface precipitation produced during this 6-h forecast will be stored at an appropriate frequency (from our experience 1-h is better than 3-h) to be able to run the surface scheme in offline mode within SURFEX over this period. Then, the initial soil conditions at the beginning of the assimilatin window are changed by a small amount and the SURFEX module is run again (once per control variable; in the present set-up we only perturb the mean soil moisture content w_2). The perturbed forecasts of screen-level parameters allow to compute the Jacobian of the observation operator, that is necessary to estimate the ”dynamical” OI coefficients. The computation of the OI coefficients also require the specification of observation and background errors. We have set values of 1K and 10 % for temperature and relative humidity at 2 meters and 10% of the soil wetness index for the background error of w_2. This last value is in agreement with the settings of Douville et al. (2000) for the ECMWF soil analysis and with the ”simplified 2D-Var” of Balsamo et al. (2004). However at ECMWF the soil root zone in shallower (1 m) than that of ISBA in ALADIN (between 2 and 3 m), which means that in terms of actual water corrections (in kg/m^2 instead of volumetric) large amounts can be added or removed with the present set-up. This aspect will have to be revisited and improved in the future. The 2-m analysis increments combined to the OI coefficients provide corrections to the soil variables (Δw) that are used to define the initial conditions of ALADIN model to run the next 6-h period. An important simplification with respect to an Extended Kalman Filter is the fact that the background error covariance matrix is kept constant in time (implicit equilibrium between its decrease through the analysis step and its increase through model error in the forward propagatation step).

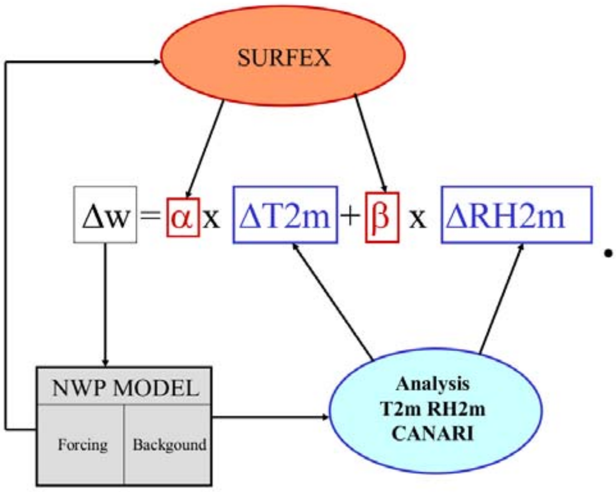

Figure 1: Coupling strategy of the offline LDAS (SURFEX) with atmospheric modelling and analysis systems

4. Results

a. *The optimum interpolation coefficients*

The most important aspect to examine in order to prove the feasibility of using SURFEX for soil analysis is the OI coefficients (or Kalman gain) computed dynamically with respect to those estimated analytically (formulation of Giard and Bazile) that were derived from one-column ensemble simulations. We need to show that, even with only the surface boundary layer, the sensitivity of screen-level parameters to soil variables is kept. It is important to indicate that contrary to the standard method for imposing a prescribed forcing (e.g. the GSWP or PILPS exercises), in the offline LDAS the atmosphere is not forced at screen-level but at a higher level (still in the surface boundary layer) in order to diagnose, by a vertical interpolation procedure (in our specific case using the Geleyn (1988) formulation), the values at screen-level. Figure 2 shows that for a specific date (01 July 2006 at 18 UTC) the size of the OI coefficients are rather comparable between the two approaches but that the ”static” approach displays less spatial contrasts than the ”dynamical” one. This figure also compares favourably with those presented in Balsamo et al. (2004) but obtained with ISBA fully coupled to ALADIN.

b. *Comparisons*

Several comparisons have been performed in order to verify the behavior of the SEKF. The soil variables have been compared to those produced by ALADIN (6-h forecasts followed by an interpolation of the soil analysis from ARPEGE). The comparison is not entirely consistent for three reasons : first ALADIN-France has no specific soil analysis, second the soil analysis in ARPEGE has a non-negligible relaxation towards a climatology that is not considered in the SEKF, third not only the mean volumetric water content is modified in the ARPEGE soil analysis, but also the soil temperatures and the surface volumetric water content. An ”open loop” run has been performed within SURFEX where the land surface evolves according to the ALADIN forcings without performing any

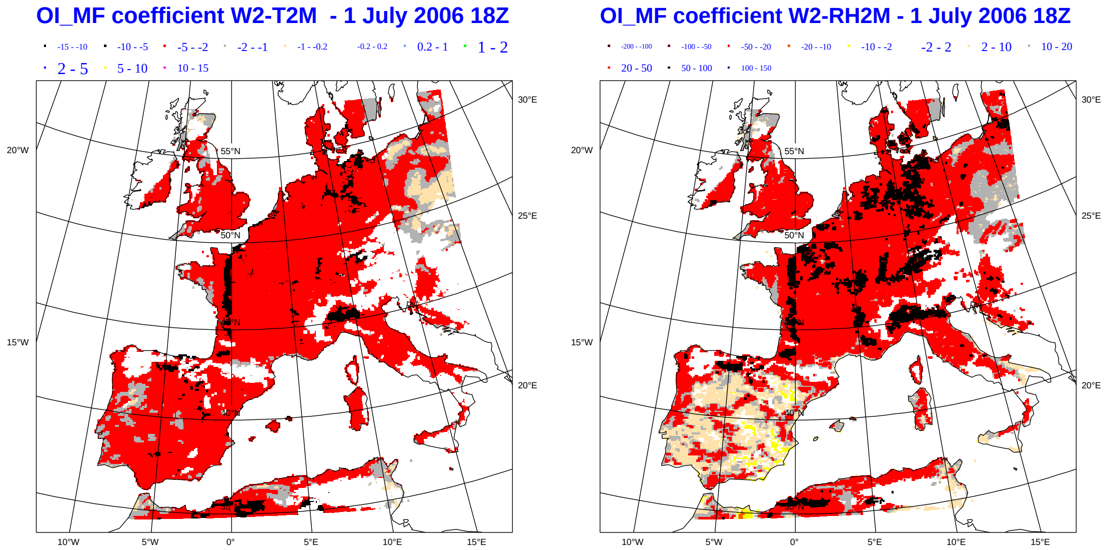

Figure 2: Gain matrix components from the analytical formulation of Giard and Bazile (2000) [static OI coefficients]

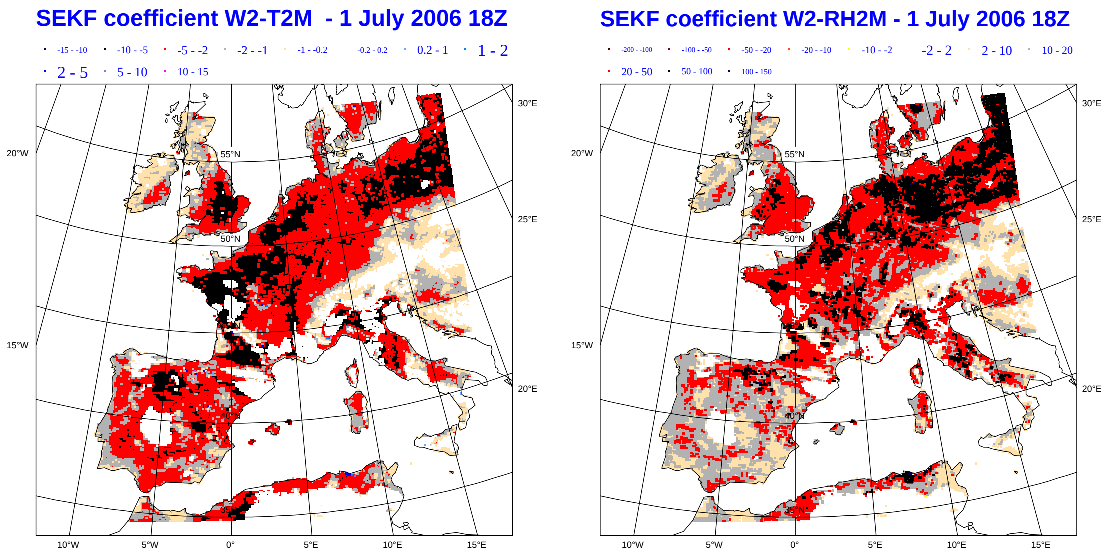

Figure 3: Gain matrix components from the Simplified Extended Kalman Filter (SEKF) [dynamical OI coefficients]

soil analysis. This integration indicates how the water balance is affected by the soil analysis and what are the consequences in terms of screen-level parameter forecasts. Finally, an offline 3-layer version of ISBA forced by analyses of precipitation, radiation and atmospheric parameters is run operationnally at Météo-France (DCLIM/HYDRO) over France at a resolution of 8 km. The outputs from this system (coupled to an hydrological routing model) called SIM (Habets et al., 2008) can be considered as the best estimate of the surface water budget components but limited to the France domain. They have been interpolated onto the ALADIN-France grid for quantitative comparisons.

5. Conclusion

We have presented the first steps in the development of a new land data assimilation system (LDAS) for the ALADIN model. This system based on a Simplified Extended Kalman Filter is available within the externalized land surface module SURFEX designed to be coupled to a number of NWP models (ARPEGE, ALADIN, AROME, HIRLAM). The feasibility of such system was already done by Hess (2001), Balsamo et al. (2004) and Seuffert et al. (2004) but with fully coupled surface-atmosphere models. The present LDAS has a number of advantages with respect to the current soil analysis described by Giard and Bazile (2000) used operationally in ARPEGE, HIRLAM and several ALADIN models, mostly the flexibility to assimilate other observations than screen-level parameters and to initialize new prognostic variables from recent versions of the land surface scheme ISBA. A proof of concept has been done over the ALADIN-France domain for July 2006 where screen-level observations have been assimilated in accordance with the common operational practice, and the results obtained are encouraging. The validation work of this system will continue in collaboration with ALADIN and HIRLAM partners. It will be important to examine winter situations where the combined initialisation of deep soil temperature and water content could lead to some aliasing problems in soil freezing-thawing situations. A number of experiments will be performed to show the ability of this LDAS to assimilate superficial soil moisture contents derived from satellites and from the offline hydrological model SIM, in combination with observations at two-meters. Similarly preliminary experiments from Muñoz-Sabater et al. (2008) on the joint assimilation of soil moisture and leaf area index with the ISBA-Ags scheme will be redone using the SURFEX SEKF. The use of improved radiative and precipitation forcing data will also be examined. The last aspect will be the actual coupling with atmospheric models so that during an assimilation cycle the forcing entering the SURFEX SEKF and the background fields entering the 2D screen-level analysis are affected by the previous soil analyses. This will require a number of improvements to the offline version of SURFEX in terms of input/output file formats, since it was not initially designed for such applications.

Acknowledgements

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data assimilations for both NWP applications and the continental carbon monitoring. Finally encouragement and support of Claude Fischer to integrate this activity within the ALADIN and HIRLAM communities was very much appreciated.

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MESOSCALE DATA ASSIMILATION FOR THE COSMO MODEL: STATUS AND PERSPECTIVES AT THE IMS

Massimo Bonavita, Lucio Torrisi, Antonio Vocino and Francesca Marcucci

CNMCA, Italian Meteorological Service,
Pratica di Mare (ROMA)
bonavita@meteoam.it, torrisi@meteoam.it,
vocino@meteoam.it, marcucci@meteoam.it

Overview

During 2007 a number of changes and upgrades have been performed on the Italian Meteorological Service (IMS) Numerical Weather Prediction System. Many of these changes have stemmed from the need to increase the NWP system spatial resolution and to use a larger amount of observational information which is nowadays available from satellite platforms. These changes have resulted in improvements to both analysis and forecast skill. In the process, some interesting results on the relevance of current and experimental objective analysis techniques have emerged.

The NWP System at the IMS is composed of a regional and a local component.
The regional component, whose integration domain and characteristics are illustrated in Fig.1 and Table 1, is initialized with a 3DVar (Bonavita and Torrisi, 2005) atmospheric objective analysis. This IMS 3DVar makes use of a large and increasing number of asynoptic observations, as reported in Tab.2

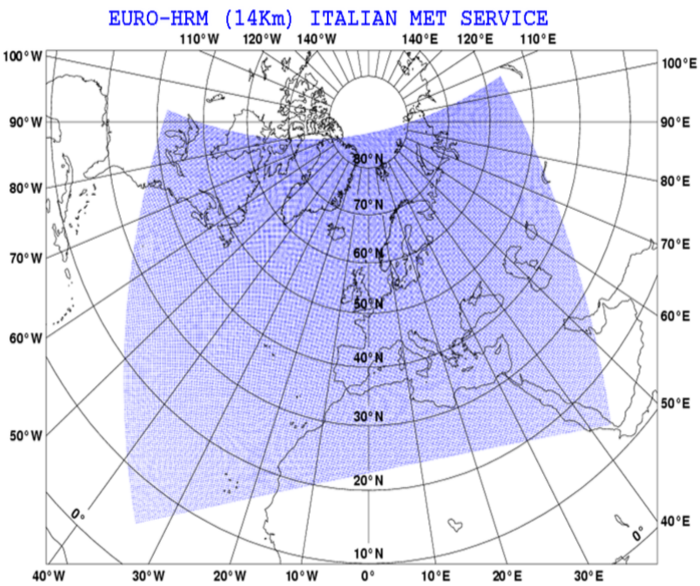


Fig. 1 Integration domain of EURO_HRM model

Domain size	769x513
Grid spacing	0.125 Deg (~14 km)
Number of layers	40
Time step	150 sec
Forecast range	72 hrs
Initial time of model	00/12 UTC
L.B.C.	IFS
L.B.C. update	3 hrs
Initial state	CNMCA 3DVAR
Initialization	Incremental DFI
External analysis	None
Status	Operational
Hardware	IBM (ECMWF)
N. of processors used	32 (Model), 90 (An.)

Tab. 1 Characteristics of EURO-HRM

Daily observation usage stats.

Synoptic	Asynoptic
RAOB ~19000	- AIREP ~5500
PILOT ~250	- AMDAR ~38000
SYNOP ~5500	- ACAR ~8500
SHIP,BUOY ~1200	- WIND PROF ~1200
	- QSCAT/ERS2/ASCAT ~5800
	- AMV (MET9/MET7/MODIS)~14000
	- AMSU-A Rad. (NOAA1X) ~14000
Synoptic Obs ~26000	Asynoptic Obs ~87000

Total ~ 113000 obs/day

Tab. 2 Observation usage statistics in IMS 3DVar

The main changes applied to the analysis system have been:

- move from 6 to 3-hourly analysis update cycle;
- doubling of horizontal resolution of EURO_HRM model (to 0.125 Deg., ~14 Km);
- FGAT treatment of observation increments in 3DVar analysis step;
- NMC evaluation of background error matrix on 0.125 Deg. Grid;
- use of Incremental Digital Filter Initialization (IDFI)
- introduction of Schrodin and Heise multi-layer soil model in EURO_HRM.

The impact of these changes has been positive at all forecast ranges for most variables. Particularly noticeable has been the impact of the increase in horizontal resolution of the prognostic model (EURO_HRM), fig.2, and the switch from 6 to 3-hourly cycle (fig. 3).
The main reason for these results seems to lie in the fact that both changes have improved the first guess quality, thus allowing a better use of available observations.

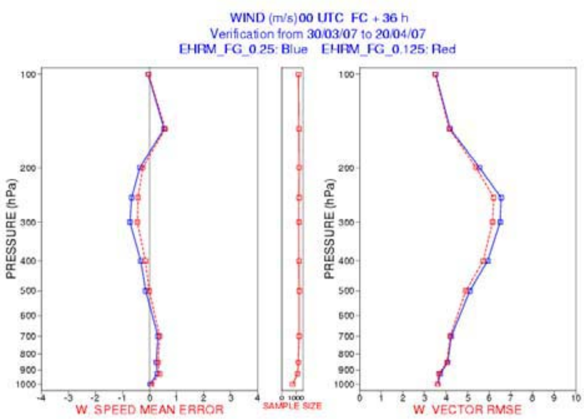


Fig. 2 Impact on wind vector +36h forecast skill of doubling prognostic model spatial resolution

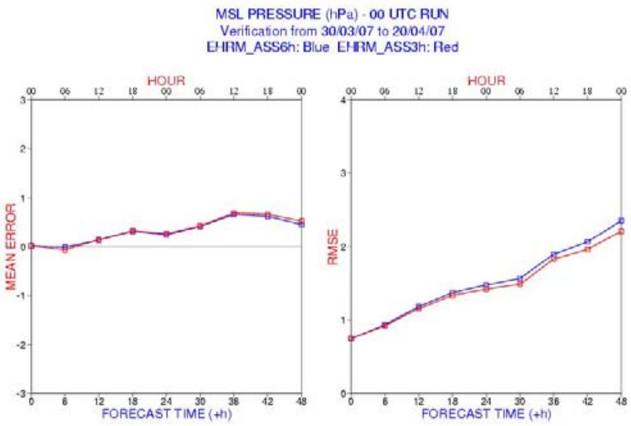


Fig. 3 Impact on Mean Sea Level Pressure forecast skill of doubling data assimilation system refresh time.

The positive impact of these changes has cascaded down to the non-hydrostatic model COSMO-ME which is nested in the EURO_HRM and is initialized with the EURO-HRM interpolated initial conditions (see Fig. 4 and Table 3).

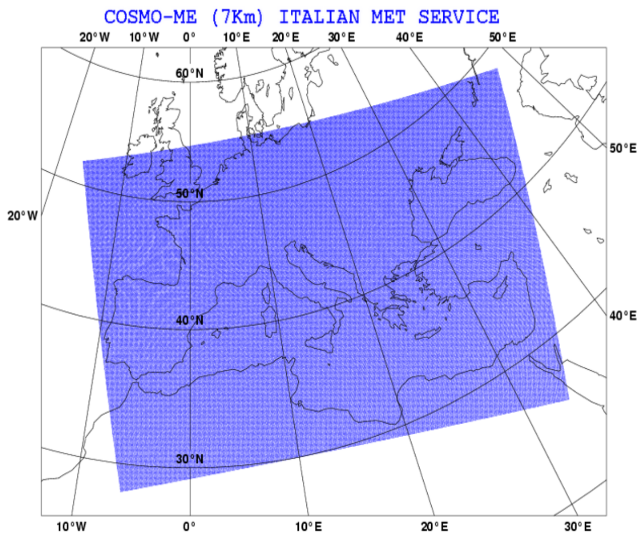


Fig.4 Integration domain of COSMO-ME model

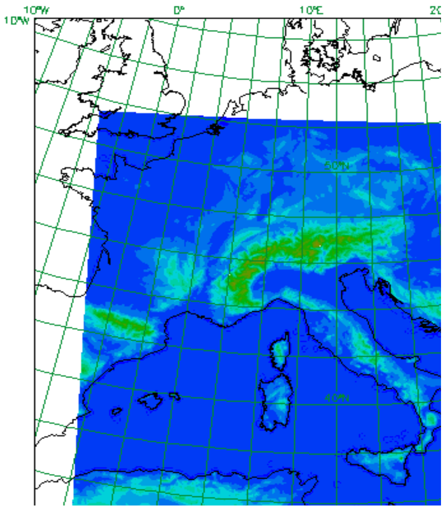
Domain size	641x401
Grid spacing	0.0625 (~7 km)
Number of layers	40
time step and scheme	40 s LF
Forecast range	72 hrs
Initial time of m. run	00/12 UTC
Lateral bound. condit.	IFS
L.B.C. update freq.	3 hrs
Initial state	Interp. 3DVAR
Initialization	Digital Filter
External analysis	None
Special features	Filtered topography
Status	Operational
Hardware	IBM (ECMWF)
N° of processors	192

Table 3 Characteristics of COSMO-ME model

To verify the impact of the improved analysis fields on the 7-Km COSMO Model, an inter-comparison has been performed between the COSMO-ME implementation described above and another implementation of the COSMO Model which is run by the IMS in collaboration with two Italian regional weather services and whose main characteristics are summarized in Fig. 5 (COSMO-IT). Apart from different integration domains, the main difference between the two implementations lies in the different initialization techniques. COSMO-ME initial conditions come from the interpolation of the EURO-HRM 3DVar analysis, while the initialization of COSMO-I7 is performed through a standard Newtonian Nudging algorithm.

Results of this comparison (an example is shown in Fig. 6) point to a clear advantage of using a variational analysis scheme at the model spatial resolution (7 Km). The in-built quasi-geostrophic analytical balance constraints present in the 14 Km 3DVar seem to hold at the 7 Km scale, producing balanced initial conditions of statistically significant better quality than the corresponding fields derived from the nudging scheme. For a fair assessment, it must be stressed that the 3DVar analysis is ingesting a larger number of observations, especially satellite radiances in the microwave part of the spectrum, which the nudging scheme is not able to assimilate directly.

COSMO I7



2 run per day starting at 00 and 12 UTC

Forecast length + 72 hours

Horizontal resolution about 7 km

40 vertical levels

3-hourly boundary conditions from IFS/ECMWF forecast

Initial Conditions through continuous assimilation cycle based on nudging

Fig.5 Characteristics of COSMO-I7 model.

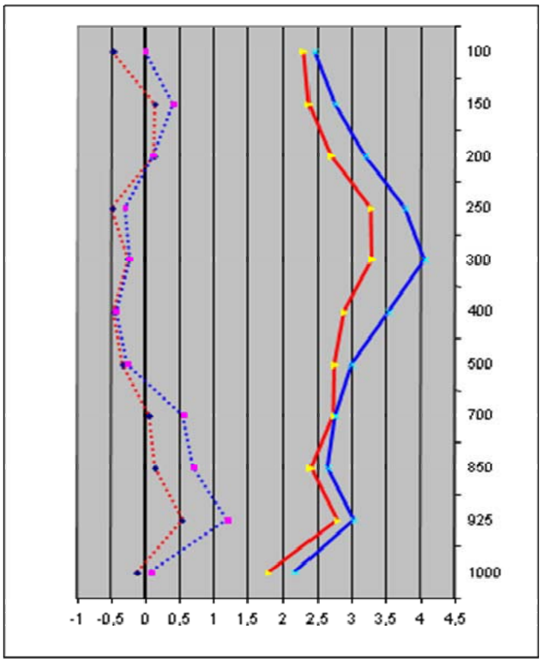


Fig. 6 Wind speed mean error (dashed) and mean absolute error (solid), t+24h forecast, of COSMO-ME (red) and COSMO-I7 (blue) verified against radiosonde network

The initialization of the 2.8 Km COSMO Model implementation operationally run at the IMS (Fig. 7 and Table 4) has also been the subject of some experimentation in order to test which assimilation strategy would work best at this scale.
For a month two parallel cycles have been run, one with initial conditions directly interpolated from the 3DVar 14 Km analyses and the other from the COSMO model nudging scheme.

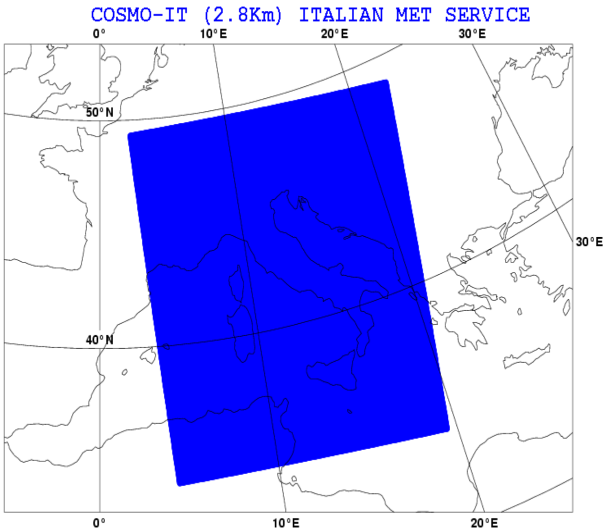


Fig.7 Integration domain for COSMO-IT model

Domain size	542 x 604
Grid spacing	0.025 (~2.8 km)
Number of layers	50
Time step and scheme	25 s RK
Forecast range	48 hrs
Initial time of model run	00 UTC
Lateral bound. condit.	COSMO-ME
L.B.C. update frequency	1 hr
Initial state	Observation Nudging
Initialization	None
Convective paramet.	Only shallow convection
Special features	Filtered topography
Status	Operational
Hardware	IBM (ECMWF)
N° of processors	352

Table 4 Characteristics of COSMO-IT model

Forecast skill for the two systems was found to be comparable (not shown) in a statistical sense, but the forecast initialized from the 3DVar analysis showed clear symptoms of unbalanced initial conditions, with precipitation spin-up in the first 6 hour of forecast (an example is shown in Fig. 8,9). For this reason the initialization of the COSMO-IT is currently performed with the nudging scheme.

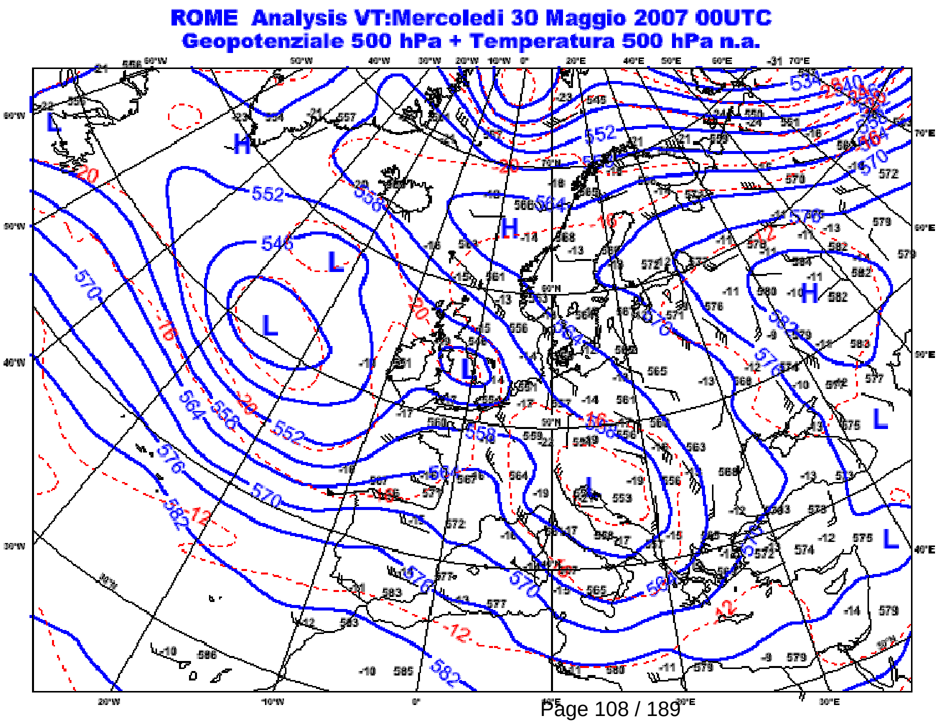


Fig. 8 500 hPa Analysis, 30-05-2007 00UTC

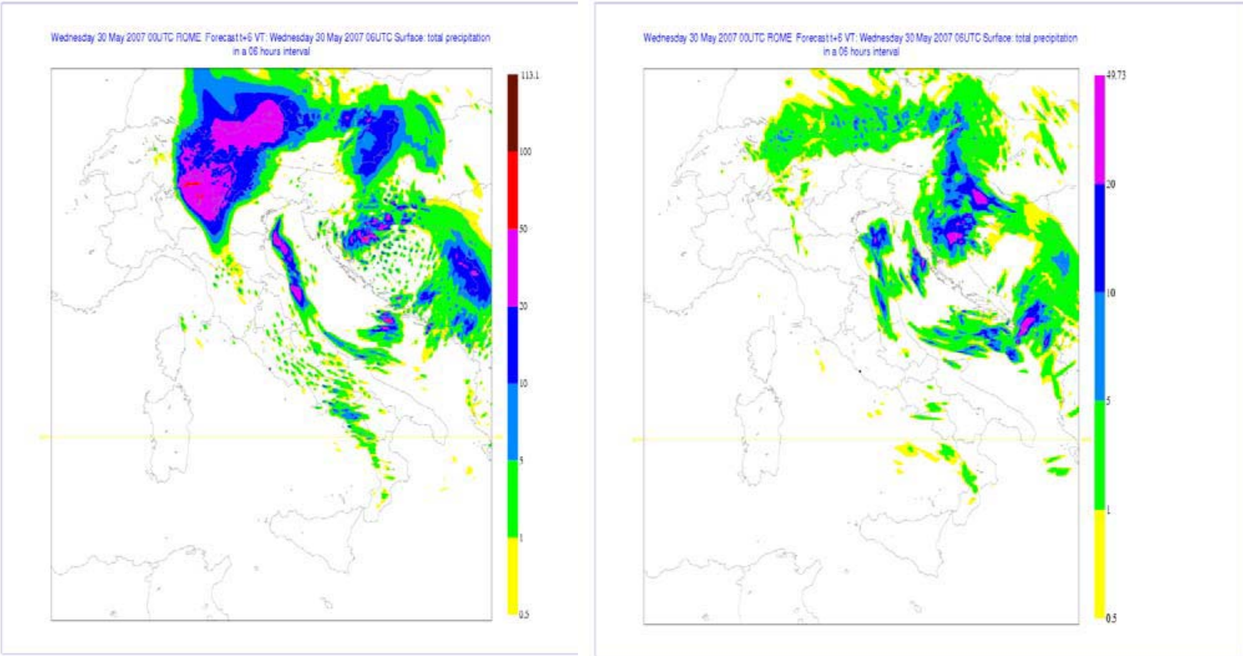


Fig.9 Cumulated precipitation, t+6h COSMO-IT forecast, with 3DVar interpolated Initial conditions (left) and nudging initial conditions (right).

Future Directions

As it has been showed, data assimilation for the high resolution COSMO Model implementations run at the IMS is based on two separate approaches: variational for the 7Km COSMO-ME, nudging for the 2.8Km COSMO-IT. While one would like to use the variational approach for the mesoscale too, given the coherent framework it provides for the ingestion of observations non linearly related to the state variables, the current 14Km implementation is not able to provide balanced initial conditions for the COSMO-IT model. Possible solutions to the problem include the use of digital filter (or incremental digital filter) smoothing of initial conditions and are being investigated.

On a longer time frame, the use of strongly non linear observations (i.e. radar reflectivities), the complex nature of the model (and nature!) balance relationships at the mesoscale and the need to move towards ensemble forecasting at the mesoscale, are all factors which clearly point to the need of migrating towards an ensemble based data assimilation system.

On this path, tests are undergoing at the IMS to test the operational feasibility of using an Ensemble Kalman Filter scheme, both to supersede the current 3DVar system for the deterministic analysis, and to provide optimal initial perturbations for an ensemble forecasting system at the mesoscale.

Assimilating radiances from polar-orbiting satellites in the COSMO model by nudging

Reinhold Hess[1], Christoph Schraff[1], Francesca Di Giuseppe[2], Blazej Krzeminski[3], Detlev Majewski[1]

1: Deutscher Wetterdienst, Offenbach, Germany
2: Servizio Idrometeorologico, Bologna, Italy
3: Instytut Meteorologii i Gospodarki Wodnej, Warsaw, Poland

29th EWGLAM meeting 8-11 October 2007, Dubrovnik

Abstract: *The Newtonian relaxation or Nudging technique (Stauffer and Seaman 1990) has important characteristics in the context of limited area modeling and is operationally applied at DWD for the COSMO model (formerly LM, Schraff and Hess 2002) since the end of 1999. Asynchronous and frequent observations can be assimilated straight forward without restrictions on model physics or steadiness of solutions. The Project* Assimilation of Satellite Radiances with 1D-Var and Nudging *of the Consortium on small scale modeling (COSMO) aims at assimilating ATOVS, AIRS/IASI and also SEVIRI radiances into the COSMO model using the nudging framework. An overview of the project is presented and preliminary results are provided for assimilating AMSU-A radiances from polar orbiting satellites.*

1 Overview

There are currently five AMSU-A instruments in space (on NOAA-15, 16, 18, AQUA, and METOP) providing each two overflights per day and altogether a reasonable data coverage for European scale models like COSMO-EU that is an operational configuration of the COSMO model at DWD and covers Europe, the Mediterranean Sea and parts of the north-eastern Atlantic with a grid resolution of 7 km. For every assimilation cycle of three hours there are some data available. The Nudging technique has several advantages for limited area models, asynchronous observations can be used straight forward and there are no difficulties with complex and sophisticated physics that are more prominent for limited area models and small scales. Neither linear nor adjoint models are required as for variational methods. Nudging has low computational needs and allows for timely forecasts which is important for short range forecasting.

A backdraw of Nudging is that remote sensing observations with nonlinear observation operators cannot be assimilated directly. The COSMO-Project *Assimilation of Satellite Radiances with 1D-Var and Nudging* aims at exploring the use of nonlinear remote sensing data for COSMO-EU and other configurations of the COSMO model with Nudging in general and specifically at assimilating ATOVS, AIRS, IASI and also SEVIRI radiances. Profiles of temperature and humidity are derived from the radiances using a one dimensional variational method (1D-Var, Chevallier 2001) and are subsequently nudged into the model like conventional observations.

Section 2 presents the Nudgevar scheme, the combination of Nudging and 1D-Var, for assimilating nonlinear observation operators, especially satellite radiances. Very preliminary results of trial studies are given in Section 3 . Final remarks are provided in Section 4 .

2 Nudging and 1D-Var: Nudgevar

Figure 1 (left) sketches the idea of Nudging: During Nudging assimilation the model trajectory is nudged at every time step towards the observations by adding special relaxation terms to the model equations. The retrieval of temperature profiles from satellite radiances with 1D-Var requires a first guess which is is obtained from the current model state. As nudging of any individual observation is started already before its observation time, a preliminary 1D-Var retrieval is computed with the currently available model first guess. This preliminary 1D-Var retrieval is updated at regular intervals using the latest available model first guess until the model time reaches the observation time and the final retrieval can be computed. For ATOVS data the first retrieval is computed 1.5 h before observation time and is updated every 0.5 h until the time of observation.

These preliminary computations of the retrievals allow a consistent interaction with conventional observations and other remote sensing data without need for iterations forwards and backwards in time. However, the nudging of the preliminary retrievals leads to correlated errors of satellite radiances and model first guess in later 1D-Var retrievals. The practical implication of this is not clear and has to be taken into account when tuning the background errors and nudging weights.

For the 1D-Var retrieval in general the same methods are applied as for global models: The background errors are derived with the NMC-Method (Parish and Derber 1992) where forecasts of different lead times but for the same valid date are compared. Bias correction is performed after Eyre 1992

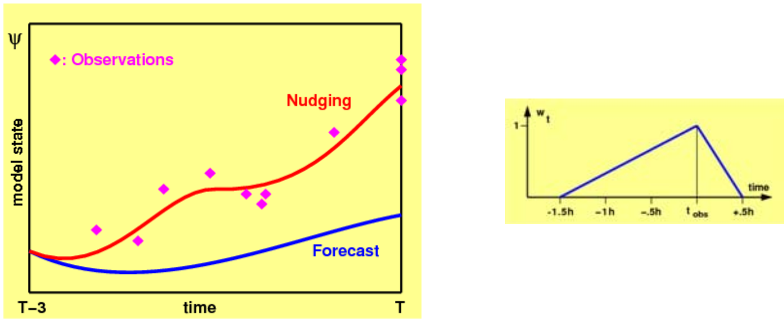


Figure 1: *Left: Sketch of Nudging: Any model variable* Ψ *diverges from the observations during free forecast from time T–3 to the time of analysis* T *. Special nudging terms are added at each time step to the model equations that force the model trajectory towards the observations. The nudged trajectory may follow asynchronous observations with high temporal resolution. Right: The size of these additional terms (Nudging weights) depends among others on the difference between observation time and current model time and on the spatial distance of a grid point to the observation. Observations are assimilated 1.5 h before and 0.5 h after observation time with a linear increase and decrease of nudging weights. Preliminary 1D-Var retrievals are computed at -1.5 h, -1 h, and -0.5 h before observation time, the final retrieval at observation time.*

using scan line and mass dependent corrections. Figure 2 shows observed minus simulated brightness temperatures depending on scan line position for COSMO-EU and for the global model GME of DWD. The shapes of the scan line biases are very similar for both models except for the surface channels including Channel AMSU-A 4. However, due to different model climates, the general level of the biases are different. The scan line biases may be taken from GME for COSMO-EU but the mass dependent bias coefficients have to be computed based on own statistics for COSMO-EU in order to provide optimal corrections (in the following case study scan line biases are nevertheless derived from own COSMO-EU statistics).

Climate profiles from IFS/ERA-40 (Uppala et al. 2005) are used as first guess above model top of COSMO-EU at 30 hPa. Radiances are used over sea only and observations affected by rain and thick clouds are removed using the surface type classification scheme of Kelly and Bauer 2000.

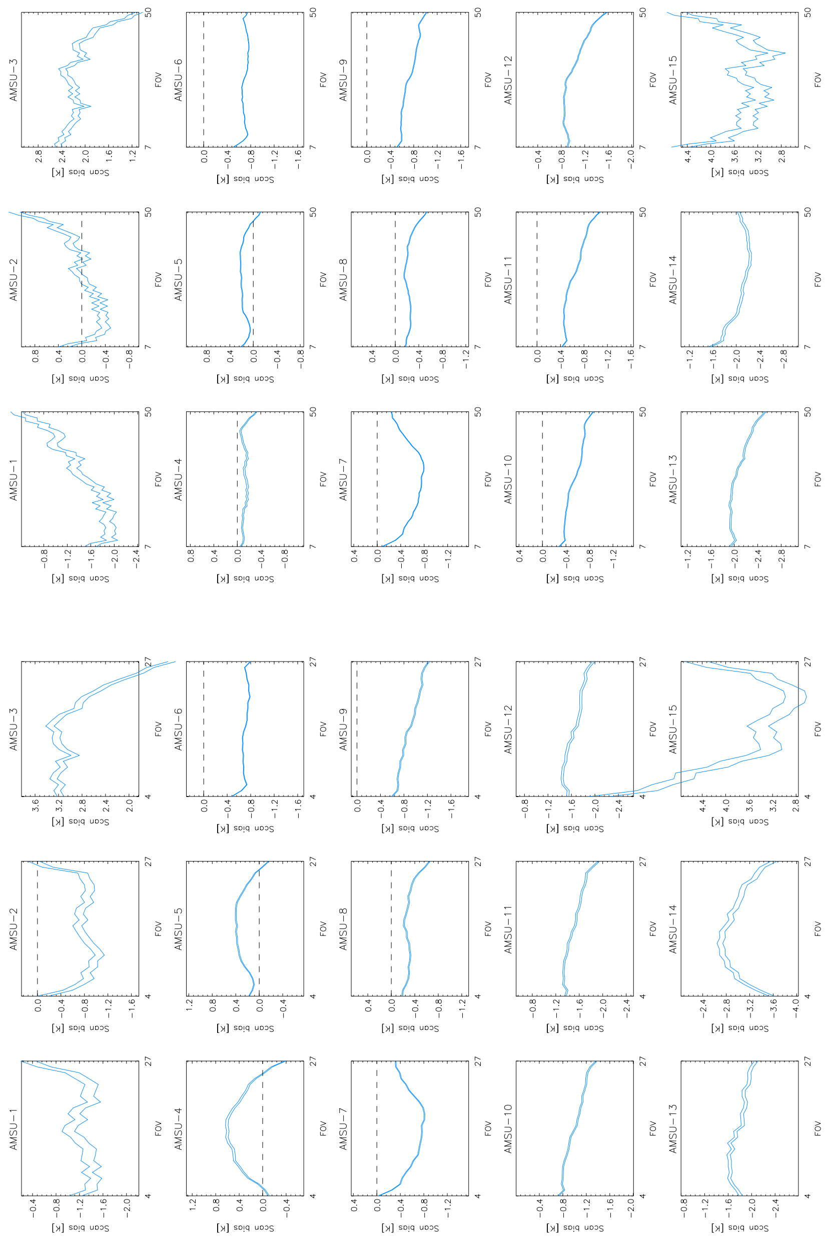


Figure 2: *Differences between observed and simulated brightness temperatures for AMSU-A channels 1 to 15 for NOAA-18 (15 to 25 June 2007) by scan line (scan line biases). Displayed is mean difference plus/minus standard deviation of the mean difference. Left: GME statistics for area from latitude 30º to 60º and longitude -30º to 0º, AMSU-A data has been interpolated on HIRS grid via AAPP. Right: statistics for COSMO-EU on the original instrument grid. For better visual comparison the outer scanlines are left out in both cases so that beginning and end of the displayed scanlines coincide.*

3 Preliminary Results

Very preliminary results are presented for the assimilation of AMSU-A radiances for COSMO-EU in the following. Figure 3 shows observation increments and corresponding analysis increments as derived from 1D-Var using actively Channels 5 to 7 . Because of the vertical resolution of the three

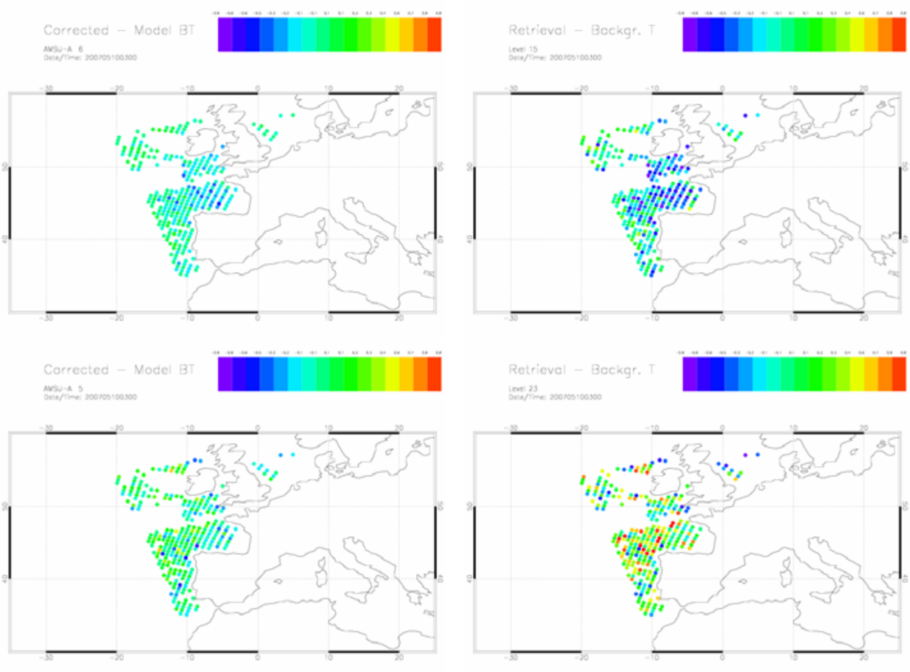


Figure 3: *Left: Observation increments (bias corrected observations minus model simulations) for AMSU-A channels 5 (bottom) and 6 (top) of NOAA-18 within domain of COSMO-EU. Right: Corresponding analysis increments of 1D-Var for temperature at Level 23 (approx. 650 hPa, bottom) and 15 (approx. 400 hPa, top).*

channels and because of vertical background error correlations the analysis increments at a certain level can be larger than the observation increments. The analysis increments are very variable in space, and horizontal thinning has to be tuned carefully in order to exploit AMSU-A information for the 7 km grid resolution of COSMO-EU in an optimal way.

A trial study of COSMO-EU with 1D-Var for AMSU-A and Nudging is presented in Fig. 4 for 20 March 2007, 0 UTC: The reference forecast shows an overpredicted low over the Baltic Sea with strong wind gusts of over 30 m/s in northern Germany. The low was generated within the model domain of COSMO-EU and is not driven by boundary conditions. Two studies with different thinning options show slightly better results if compared subjectively to the analysis. The improvement is small, however encouraging; more

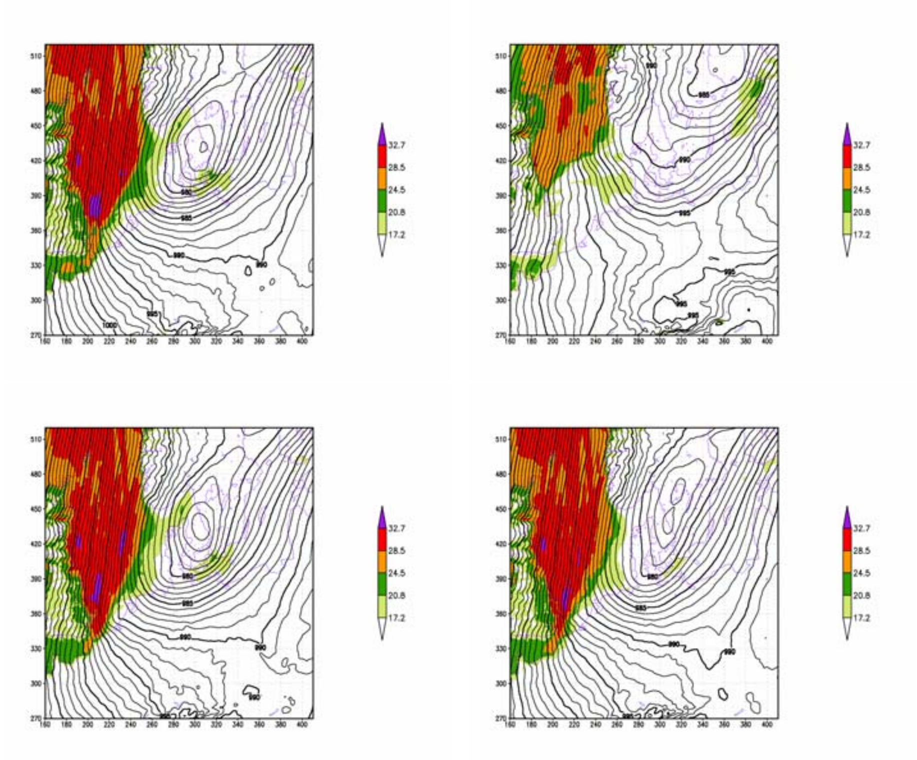


Figure 4: *Trial study of COSMO-EU with two different thinning strategies. Displayed is the mean sea level pressure with lines and maximal 10 m wind gusts in shades. Top: Reference forecast (left), verifying analysis (right). Bottom: Trial forecasts with 1D-Var and Nudging. Every third respectively second observation in each direction is active after thinning (left and right). Valid date of analysis and forecasts is 20 March 2007, 0 UTC with a forecast length of 48 h.*

positive impact is expected with a better tuning of the 1D-Var scheme and the nudging coefficients. However, this special case may be caused by model deficiencies as well and more case studies and longer time series are required.

4 Final Remarks

The Nudging analysis scheme is considered a reasonable approach in the context of limited area models and small scales, its computation is fast and allows for timely short range weather predictions. With Nudgevar, the combination of 1D-Var and Nudging, also remote sensing operators with nonlinear observation operators can be used. Further tuning is required in the context of satellite radiances like AMSU-A to fully assess the possible impact, however. The weakness of Nudging is a missing stringent mathematical framework that guarantees a consistent use of observations and optimal solutions as variational methods have.

The forecast quality of limited area models depends essentially on boundary values and also on the quality of the forecast models itself that include more and more sophisticated physics. In general less improvement can be expected for limited area models when assimilating observations and satellite radiances in comparison to global models. The most prominent challenge for the improved assimilation of radiances for limited area models like COSMO-EU is to enhance data coverage, i. e. the use of microwave data over land and the use of infrared data in case of clouds, as only about 5 % of all infrared data is cloud free. Methods for both enhancements are currently developed intensively for global models and should be applicable for local area models with very similar approaches in the future.

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The added value of prospective spaceborne Doppler wind lidar for extreme weather events

Gert-Jan Marseille[1], Ad Stoffelen, and Jan Barkmeijer

[1] Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
E-mail: *Gert-Jan.Marseille@knmi.nl*

Abstract: Lacking an established methodology to test the potential impact of prospective extensions to the meteorological global observing system (GOS) in real atmospheric cases we developed such a method, called Sensitivity Observing System Experiment (SOSE). For example, since the GOS is non uniform it is of interest to investigate complementary observing systems filling its gaps. Unlike full observing system simulation experiments (OSSE), SOSE can be applied to real extreme events that were badly forecast operationally and only requires the simulation of the new instrument. We apply SOSE to the 2nd 1999 Xmas storm "Martin" over Europe and show that an extended GOS by a tandem of spaceborne Doppler wind lidars would have improved the forecast substantially.

Keywords - *SOSE, Doppler wind lidar, Christmas storm*

1. INTRODUCTION

Many resources are spent on new observation types complementing the GOS or its climate equivalent GCOS. This paper presents a new and relative cheap method to assess the added value of additional observations for Numerical Weather Prediction (NWP), named Sensitivity Observing System Simulation Experiment (SOSE). SOSE requires only the simulation of the new instrument and as such it is relatively easy to test various observation strategies culminating in observation requirements for prospective observing systems for instance to sample meteorologically sensitive areas that are otherwise not measured. These sensitive areas are generally associated with atmospheric structures that tend to grow rapidly in time potentially causing forecast failures already on the short term (up to 2 days).

2. SOSE - Sensitivity Observing System Experiment

Impact assessment of prospective observing systems requires a synthetic true atmospheric state for the simulation of the new instrument. This atmospheric state is denoted pseudo-truth and should fulfil the following requirements: (i) it corrects the incorrect analysis, (ii) it improves the 2-day forecast, (iii) it is compatible with observations from existing observing systems and (iv) its spatial structures must be realistic. The pseudo-truth is subsequently used for the simulation of the future observing system under investigation and when the new observing system is capable of (partly) observing the analysis corrections, it will contribute to improve the 2-day forecast. Figure 1 presents a scheme to determine the pseudo-truth based on adjoint first-guess sensitivity structures and fulfilling the stated requirements above.

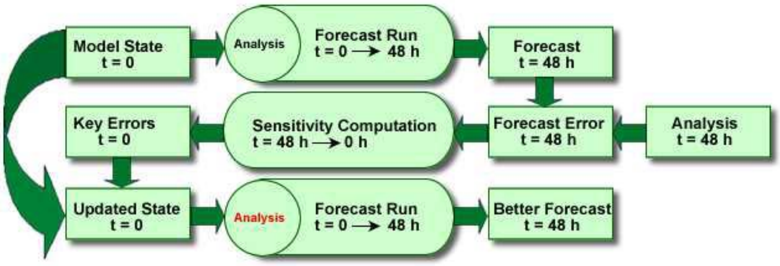

Figure 1: First-guess sensitivity experiment. The updated (red) analysis provides the SOSE pseudo truth.

3. PROSPECTIVE SPACEBORNE DOPPLER WIND LIDAR

The European Space Agency (ESA) is preparing to fly a spaceborne Doppler wind lidar (DWL) for the first time in history within the Atmospheric Dynamics Mission (ADM) named Aeolus (ADM-Aeolus).

The scheduled launch is end of 2008. ADM is a polar orbiting satellite giving a global three-dimensional coverage of single line-of-sight wind components. Anticipating on the success of ADM there is need for wind observation requirements to define an operational network of lidars in the post-ADM era beyond 2011. In a recent study by (Marseille et al., 2006) a number of possible scenarios were considered, including a dual-perspective scenario measuring the full wind vector and a tandem scenario giving double the coverage of ADM, see Fig. 2.

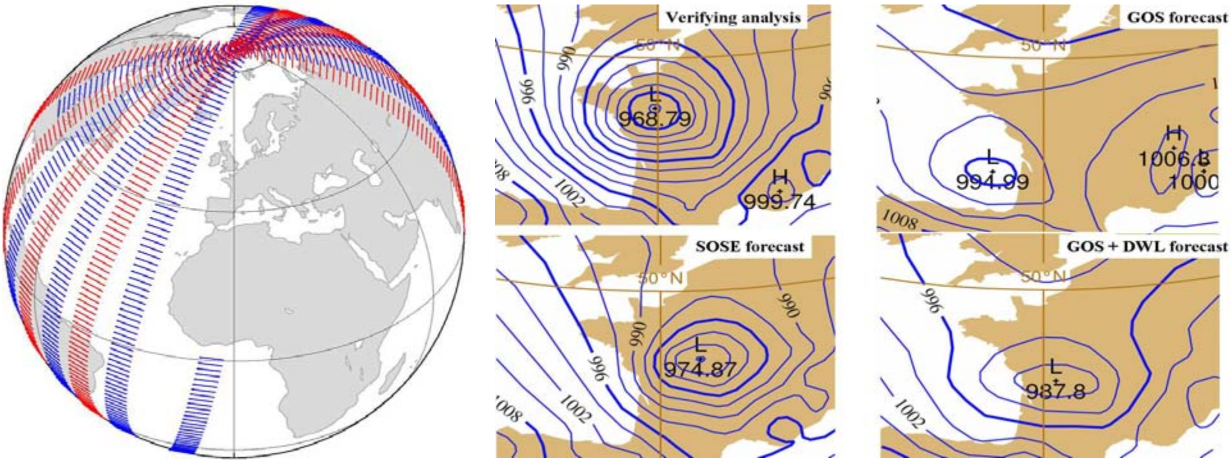

Figure 2: Left, data coverage of a tandem-Aeolus scenario. The arrows show the locations of the measured wind profiles and the direction of the line-of-sight wind components. Blue arrows correspond to ADM, the red arrows show the added coverage in case of flying two Aeolus-type satellites in tandem, separated by half an orbit. Right, ECMWF mean sea level surface pressure at 27/12/1999 18UTC from the verifying analysis (upper left), forecast using the 2003 model version and all available observations (upper right), best achievable forecast from SOSE analysis (lower left), see Fig. 1, and same forecast as upper right panel but now including DWL observations from the tandem-Aeolus scenario (lower right).

4. APPLICATION TO THE XMAS'99 STORM "MARTIN" OVER EUROPE

The SOSE method has been applied to the Xmas'99 storm "Martin" that caused large damage over Europe on 27/28 December 1999. For this purpose, SOSE was run in cycling mode to generate a series of pseudo-truths at 6 hour resolution starting on 23/12 12UTC, i.e. 54 hours before the forecast initiated at 25/12 18UTC. DWL observations were simulated over this 54 hour period and assimilated in the ECMWF operational model in conjunction with real observations from the 1999 operational network. Fig. 2 shows a substantial improvement of the 2-day forecast verifying at 27/12 18UTC by extending the GOS with DWL observations.

Besides a deterministic forecast, an ensemble forecast of 50 members was run for the NoDWL (using the GOS only) and DWL (using GOS+DWL) experiments. For NoDWL 5 out of 50 members included a storm over France against 15 members for DWL, showing a substantial improvement of forecasting the storm in the presence of DWL observations.

5. CONCLUSION

The potential added value of global wind observations from a prospective spaceborne Doppler wind lidar scenario was demonstrated in a Sensitivity Observing System Experiment (SOSE) applied to the Xmas'99 storm "Martin". SOSE is a relatively cheap tool to assess the added value of prospective extensions to the GOS, requiring the simulation of only the new instrument under investigation.

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Application of a potential vorticity modification method to a case of rapid cyclogenesis over the Atlantic Ocean

A.M.M. Manders, W.T.M. Verkley, J.J. Diepeveen and A.R. Moene
Royal Netherlands Meteorological Institute, The Netherlands

Abstract

A method to modify the potential vorticity of a numerical weather analysis is applied to a case of rapid cyclogenesis over the Atlantic Ocean. The development of the cyclone's intensity in terms of mean sea level pressure is underestimated by the Dutch version of the limited area weather prediction model HIRLAM. The analysis shows a rather clear mismatch between the potential vorticity of the analysis and the corresponding water vapour satellite image. A barotropic displacement of potential vorticity, based on a subjective comparison with the water vapour satellite image, improves the forecast in terms of the cyclone's mean sea level pressure eighteen hours after the analysis.

The case

On 7 November 2005, 00 UTC, a wave at upper levels developed in the left exit region of the jet stream over the North Atlantic Ocean, around 46° N 30° W. The water vapour images at 00, 06 and 18 UTC are displayed in Fig. 1 and show a

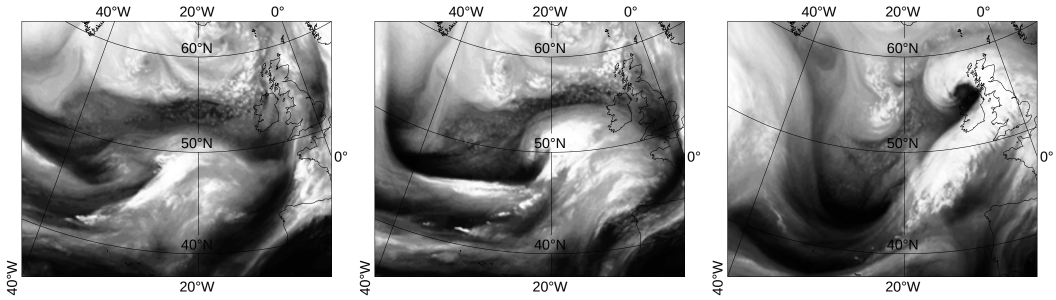


Figure 1: Water vapour satellite images, in the 6.2 μm channel from METEOSAT-8, for 7 November 2005 at 00 UTC (left), 06 UTC (middle) and 18 UTC (right). The sequence displays a typical case of rapid cyclogenesis.

sequence which is typical for rapid cyclogenesis. At 00 UTC, the potential vorticity field on the 315 K isentrope shows a clear mismatch with the corresponding water vapour image, as can be seen from Fig. 2, left panel. The mismatch was corrected

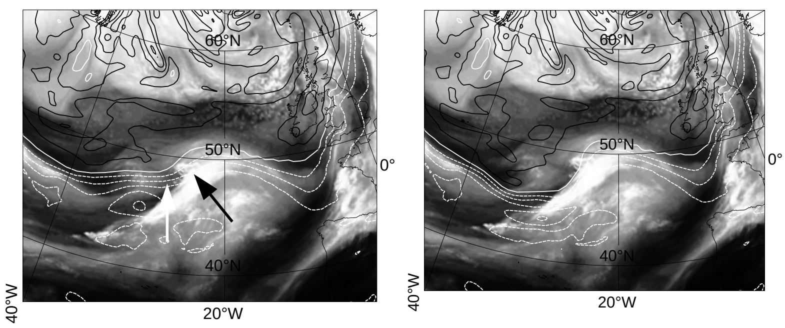


Figure 2: Contours of potential vorticity on the 315 K isentropic surface of the HIRLAM analysis of 7 November 00 UTC and the corresponding water vapour image. Left panel: the original HIRLAM analysis, right panel: the analysis resulting from a barotropic shift of the potential vorticity. The white arrow in the left panel indicates the dry intrusion, the black arrow the cloud head.

by moving the jet stream locally to the south, resulting in a trough that matches better with the corresponding feature in the water vapour image, as shown in the right panel of Fig. 2.

The runs

HIRLAM analyses at the same moments in time as the water vapour images, i.e. at 00, 06 and 18 UTC, are shown (from left to right) in the first row of Fig. 3. At 00 UTC, close to the position of the mismatch, the minimum mean sea level pressure is, according to the HIRLAM analysis, 1003.8 hPa. The operational run, depicted in the second row of Fig. 3, predicts a developing low with a mean sea level pressure of 984.3 hPa after 18 hours (7 November 18 UTC) to the North-West of Ireland. However, as the analyses show, the actual development is more dramatic, with a mean sea level pressure of 974.9 hPa after 18 hours. The modification, as shown in

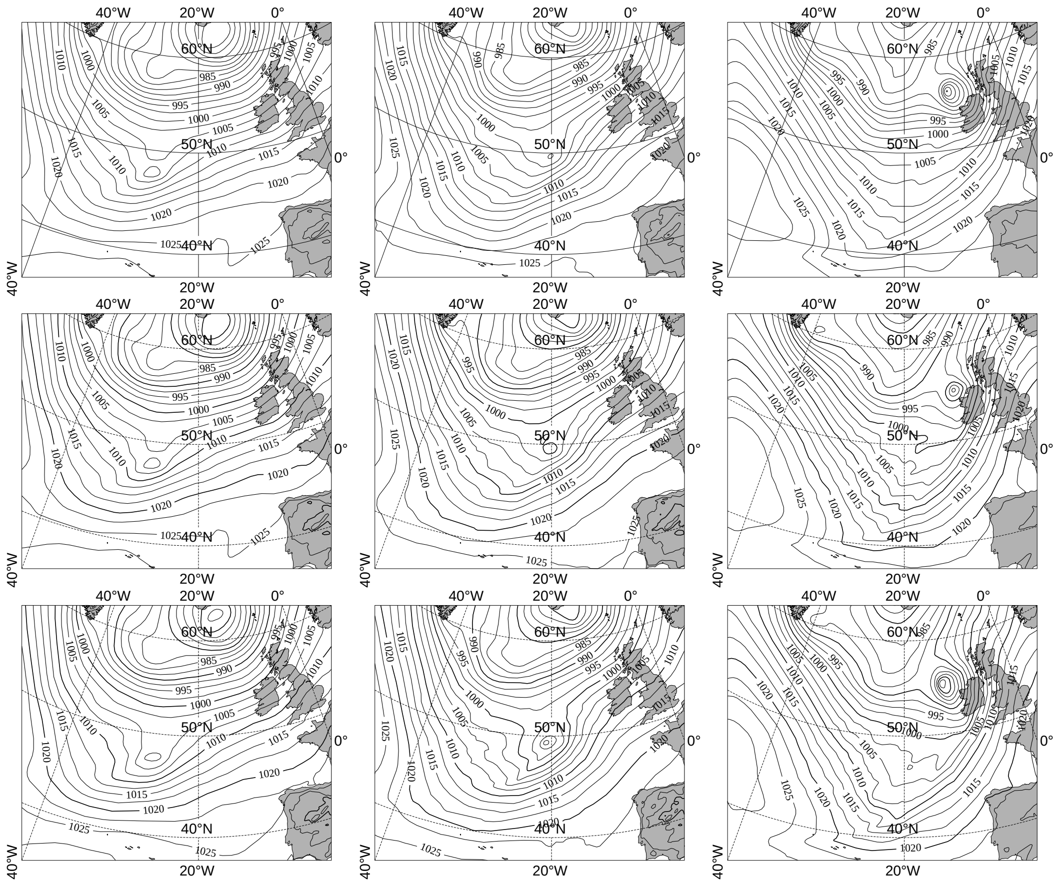


Figure 3: First row, from left to right: HIRLAM analyses of mean sea level pressure for 7 November 2005 at 00 UTC (left), 06 UTC (middle) and 18 UTC (right), second row: HIRLAM analysis and ensuing forecasts, third row: modified HIRLAM analysis and ensuing forecasts. The unit is hPa.

the previous figure, has resulted in a somewhat deeper low at 00 UTC. The resulting pressure development ensuing from the modified analysis is shown in the third row of Fig. 3 and is a considerable improvement over the original run.

Future development of the method will involve the use of singular vectors to facilitate finding modifications that are both realistic and dynamically effective.

Reference

This is a short summary of a paper with the same title that has been published in *Q. J. R. Meteorol. Soc.*, **133**, 1755–1770 (2007). Reprints can be obtained from: W.T.M. Verkley, Royal Netherlands Meteorological Institute, PO Box 201, 3730 AE De Bilt, The Netherlands. e-mail: verkley@knmi.nl.

Physics developments in the Met Office regional NAE model

Met Office Fitzroy Road Exeter
+44 1392 886098 mike.bush@metoffice.gov.uk

1. Progress towards a vertical resolution increase to 70 levels

The NAE model currently has 38 levels in the vertical (L38) while the Global model currently has 50 levels (L50). Work is ongoing to develop a 70 level version (L70) of both NAE and Global models with the expectation that one would see improved BL structures (e.g. inversions), BL clouds and aviation winds. Other expected benefits are improved numerical accuracy and an improved fit to observations. More information from a given sonde will be used and the raised lid is anticipated to give a better fit to satellite channels.

The L70 has 21 levels in the boundary layer (bottom 3 km) compared to 13 levels in the L50 configuration with a reduction in layer thicknesses that is greater towards the top of the boundary layer. The greatest reduction in layer thicknesses of 70L over 50L is at 10km where the resolution goes from 1km (L50) to 500m (L70).

The L70 layer thicknesses are smaller throughout the troposphere and lower stratosphere up to 22km. Above 22km the L50 model has improved resolution over L70, but has its lid at 65km compared to 80km for the L70 (the L38 lid is at 40km).

It is generally accepted that vertical resolution upgrades are more difficult to implement operationally than increases to horizontal resolution, in part due to level dependencies in the physics. This has certainly been the case in this project and an improved physics package for the L70 model has included:

(i) Removal of level dependencies in UM physical parametrizations

(ii) Improved tuning of cloud, convective momentum and gravity wave drag, and removal of errors in parametrization code highlighted by L70 testing (convective cloud and its interaction with the radiation scheme).

The numerical stability of the L70 version has been improved (compared to initial L70 tests) by implementing a new BL solver, removing Gravity Wave Drag above 40km, and improving the diagnosis of convection.

However before the L70 version of the model can become operational, further work is required to investigate a cooling of the troposphere (particularly at freezing level) at L70 which may be due to evaporation from convective downdraughts. This has lead to increased geopotential height biases and RMS errors. There has also been a slight weakening of the tropospheric winds and this has been partially addressed by tuning of gravity wave drag and convective momentum transports.
Finally, further tuning of covariance statistics and satellite biases is required as is further diagnostic work to demonstrate improved BL structure and cloud prediction.

2. Lateral boundary conditions (LBCs)

Up until December 2005, the vertical levels used in the Global UM and Limited Area Models (LAMs) driven from it, were identical (38 levels). However, this changed with the introduction of the 50 level Global model (cycle G38) which provided extra levels in the stratosphere to benefit medium-range forecasts.

Unfortunately, this mismatch between the levels in the Global and those in the LAMs led to problems near the top of the LAM domain with large vertical velocity increments and a failure of the Helmholtz solver to converge. The problem was caused by vertical interpolation destroying the delicately balanced model state.

Interpolation error is determined by the amount of vertical staggering of levels and the non-linearity of the variable being interpolated. The imbalance generated tends to be worse if the levels differences occur higher up in the model where the levels are more spaced out. When the model top of the LAM is different to the global model, but there is no staggering, then there is little impact.

This problem was partially solved by imposing hydrostatic balance in the LBCs to reduce vertical accelerations there (NAE cycle E10, December 2005). However an unsatisfactory side-effect of this was the introduction of a PMSL bias of around 1hPa to 2hPa (Figure 2, right hand panel).

The hydrostatic balance sets the vertical velocity to zero in the LBCs at the beginning of each timestep. However the observed vertical velocity at the end of the timestep indicates vertical acceleration. It is thought that this vertical acceleration is responsible for reducing the pressure at the surface.

This bias has been reproduced in an idealised configuration of the UM which has provided clues as to the cause of the problem. The idealised case study consisted of a steady-state cosine jet centred about the equator in geostrophic and hydrostatic balance. A global model was used to drive a LAM which used exactly the same grid points with the same grid length.

Vertical velocity [ms-1] cross-section at the equator in the idealised case study. The LBCs are seen at each side of the domain. Ascent in the LBC region is clearly visible.

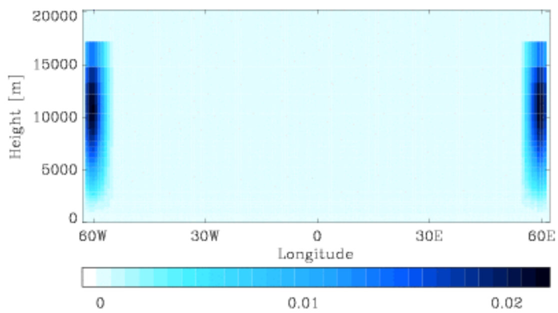


Figure 1: Vertical velocity cross-section at the equator in the idealised case study

This simple situation, free from the complexities of real case studies, showed a clear signal of ascent in the LBCs (Figure 1).

The waves responsible for transporting the boundary effects are thought to be shallow water gravity waves. They take 250 minutes to travel half way across the domain, making their speed around 300 ms-1.

$$c = U \pm (gH)^{\frac{1}{2}}$$

This suggests that the depth over which they are acting is on the order of 10km, i.e. they are confined to the troposphere.

It is interesting that vertical accelerations are occuring in the LBCs given that hydrostatic balance has been imposed. However, it must be remembered that the vertical momentum equation contains more terms than just the gravity and the vertical pressure gradient terms which are balanced in hydrostatic balance.

$$\underbrace{\frac{Dw}{Dt}}_{termA} = \underbrace{\frac{(u^2+v^2)}{r}}_{termB} + \underbrace{2\Omega u cos\phi}_{termC} - \underbrace{g}_{termD} - \underbrace{c_{pd}\theta_v\frac{\partial\Pi}{\partial r}}_{termE} + \underbrace{S^w}_{termF}$$

The vertical momentum equation in the New Dynamics of the Unified Model predicts the vertical accelerations (term A) which occur as a result of the imbalance of gravity (term D), vertical pressure gradient force (term E), vertical component of the coriolis force (term C), a pseudo force (term B) and parameterised tendencies (term F).

Hydrostatic balance occurs if the two largest terms (gravity and the vertical pressure gradient force) are equal. However, small vertical accelerations will still occur in the presence of non-zero horizontal wind. To obtain zero vertical acceleration, the sum of all the terms on the right hand side of the equation must equal zero.

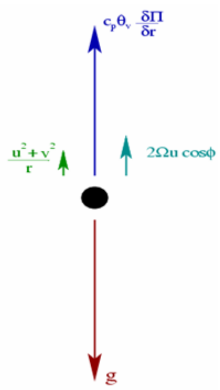
Note that here u is the west-east component of the wind and v is the south-north component, i.e. this equation applies for an unrotated co-ordinate system. Writing this in terms of the urot and vrot wind components on a rotated LAM grid (with pole at φ0), and balancing the terms so as to remove vertical accelerations (neglected any parameterised tendencies), this becomes:

$$c_{pd}\theta_v\frac{\partial\Pi}{\partial r} = \frac{(u_{rot}^2 + v_{rot}^2)}{r} - f_1 v_{rot} + f_2 u_{rot} - g$$

where

$$f_1 = -2\Omega sin\lambda cos\phi_0$$

$$f_2 = 2\Omega\left(cos\phi sin\phi_0 - sin\phi cos\lambda cos\phi_0\right)$$



Starting at the 2nd model level, the pressures are changed at each level such that the vertical pressure gradient term balances the acceleration due to gravity, the vertical coriolis force and the pseudo force:

$$\Pi_{k+1} = \Pi_k + \frac{\Delta r}{c_{pd}\theta_v}\left(\frac{(\hat{u}_{rot}^2 + \hat{v}_{rot}^2)}{r} - f_1\hat{v}_{rot} + f_2\hat{u}_{rot} - g\right)$$

(hats indicate values interpolated onto θ points).

The PMSL bias with the new balance mod (Figure 2 left hand panel) is much reduced compared to the original hydrostatic balance mod (Figure 2 right hand panel). The new balance mod was implemented in NAE model cycle E15 (March 2007).

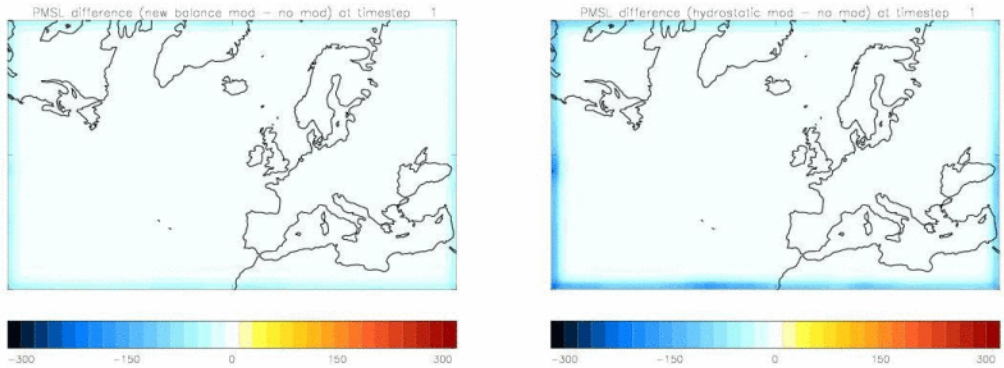


Figure 2: Left hand panel: PMSL difference (new balance mod – no mod)
Right hand panel: PMSL difference (hydrostatic mod – no mod)

3. OSTIA SST Analysis

This is a 1/20° (~5.6km) global SST analysis which is now running operationally on a daily basis. It uses a blend of data sources including satellite (microwave & IR) and in situ data. The analysis is persistence based and uses optimal interpolation. It also uses a sea ice analysis performed by EUMETSAT OSI-SAF (met.no / DMI).

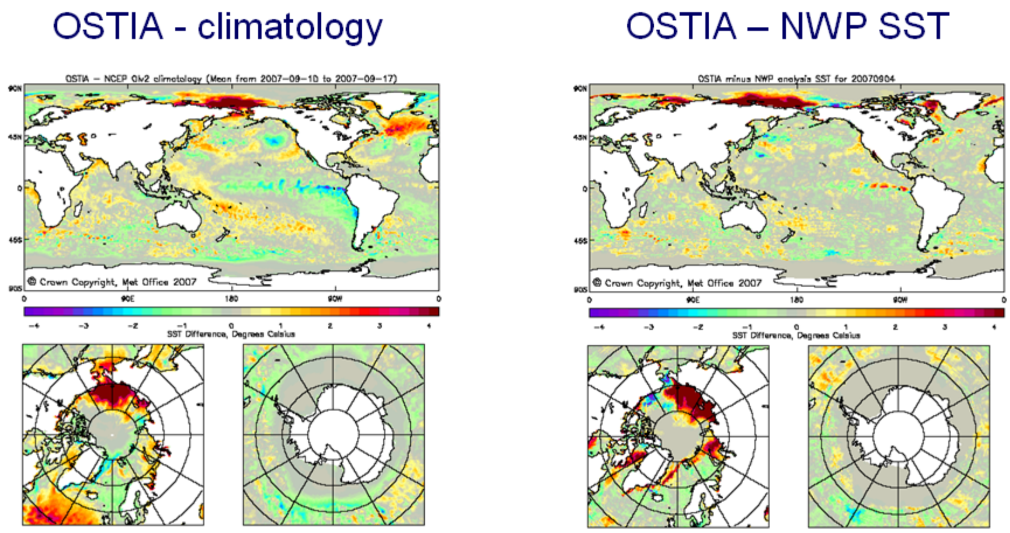


Figure 3: OSTIA – climatology (left hand panel) and OSTIA – old SST scheme (right hand panel).

The old SST scheme was unable to capture the exceptionally warm Arctic SSTs seen in 2007 caused by calm, clear sky conditions (Figure 3). The higher resolution and greater density of observations offered by OSTIA also improves the representation of key SST gradients, such as the Gulf Stream (Figure 4) and the use of microwave data and more satellite data allows changes in SST to be rapidly detected (Figure 5).

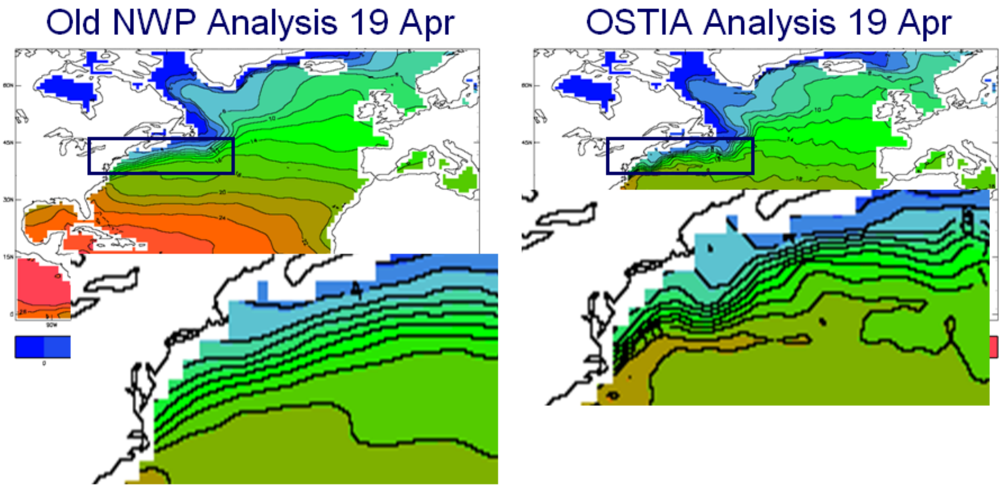


Figure 4: Impact on key SST gradients. Old SST analysis (left hand panel) and OSTIA analysis (right hand panel)

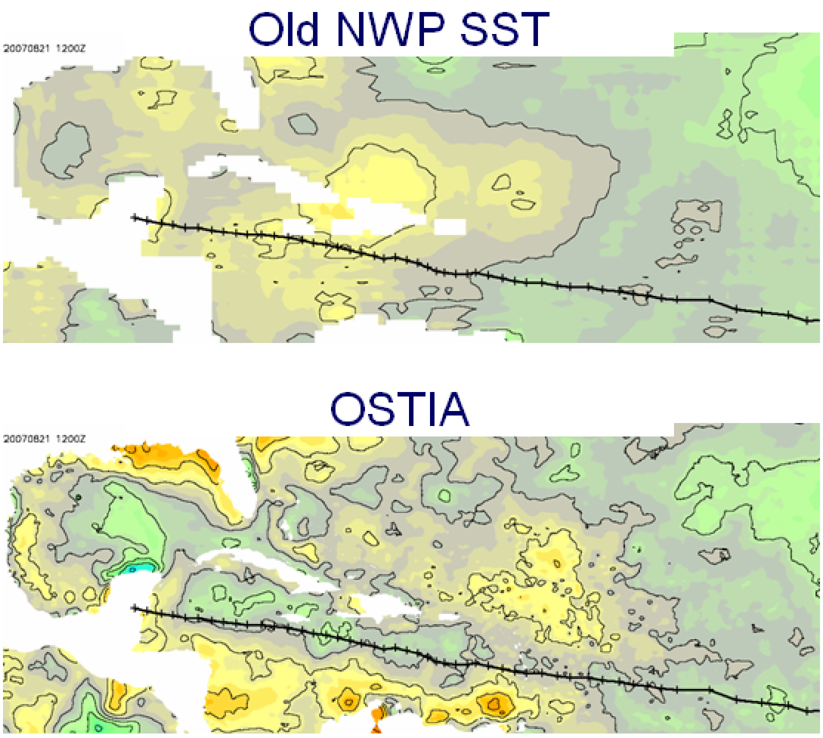


Figure 5: Hurricane Dean - **21st August 2007**. Old SST analysis (top panel) and OSTIA analysis (bottom panel). SST minus Climatology: Contours at 0.5° intervals

4. Snow analysis

Global snow depth and extent are very important parameters in NWP models, significantly affecting the surface radiation and water budgets.
Variability in snow cover causes dramatic changes in surface albedo, affecting the land surface energy budget and surface air temperatures. Snow cover will also affect the surface hydrology, such as soil moisture, and snowmelt is an important source of surface water.

There is currently no observational snow information used in the global NWP. The surface snow variable in the UM is snow amount in units of kgm^{-2}. This is a prognostic variable in the model, but is entirely internal to the UM, generated by UM snow precipitation.

UM surface snow tends to form slightly earlier than observations suggest, and to melt far too rapidly in the spring. There are also regional anomalies, in particular an excess of snow in the model on the Tibetan Plateau.

Observational snow cover data for the Northern Hemisphere are now received daily in the MetDB. These are NESDIS Interactive Snow and Ice Mapping System (IMS) data consisting of a daily map of Northern Hemisphere snow cover at 4 km resolution. This data is drawn from a variety of sources – mainly visible imagery from polar orbiting and geostationary satellites, but also ground weather observations, satellite microwave products, and snow and ice charts.

By virtue of their higher spatial resolution, the full resolution snow cover observations are able to be converted to a fractional snow cover product, on the UM grid.
A system to perform daily snow analyses, at 06Z, using these data has been developed and is now undergoing trials in the global NWP model.

The snow analysis combines information from both the fractional cover observational product and the UM T+6 snow amount field from the previous model cycle to produce an analysis of snow amount. A relation between snow water equivalent, which is in turn related to snow amount, and fractional cover allows direct comparison of modelled and observed snow amounts.

Observations	**Model**	**Analysis**
Zero fractional cover	Any value	Zero fractional cover
Snow present	Snow Present	Model snow amount
Non-zero fractional cover	Zero fractional cover	relations between snow amount and fractional cover are applied up to a maximum of 10 kgm-2

The snow cover data are produced just before midnight, and so data from the previous day must be used in the analysis. Figure 6 shows the NESDIS IMS product for 01/10/07, from which snow cover data were used for the 02/10/07 analysis (Figure 7).

Figure 8 shows the modifications that will be made to the model snow amount field by the analysis. Positive values denote addition of snow and negative values show snow removal. The scheme will be implemented in both Global and regional models.

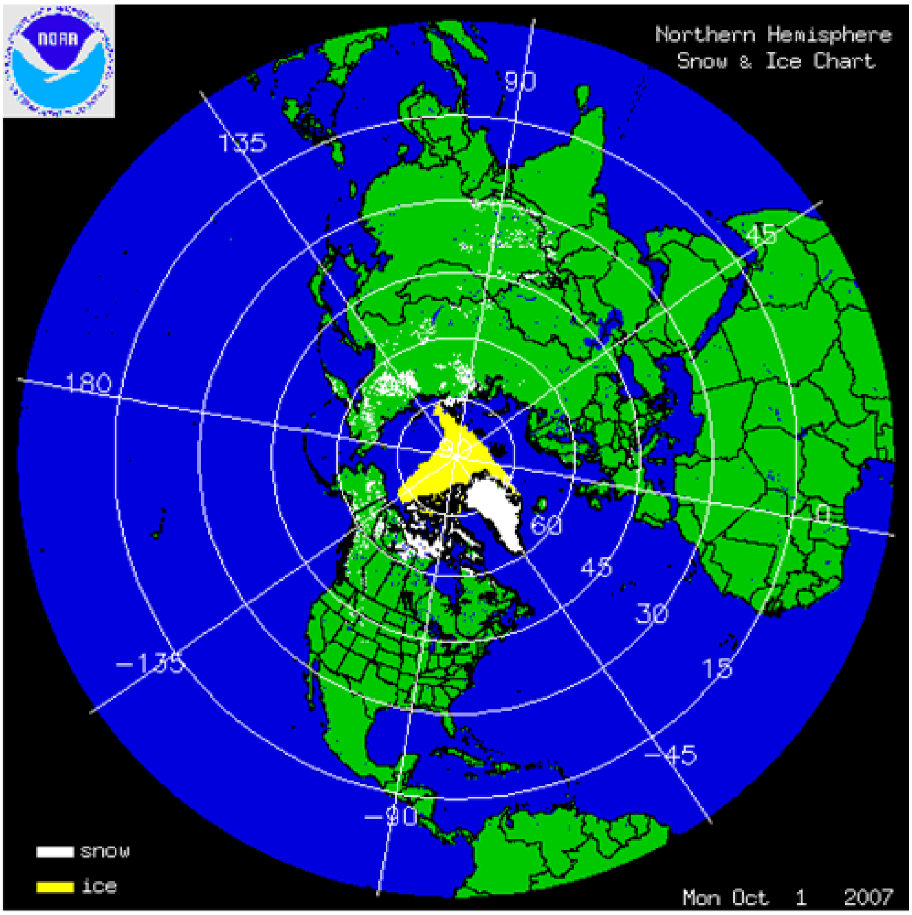


Figure 6: NESDIS IMS product for 01/10/07

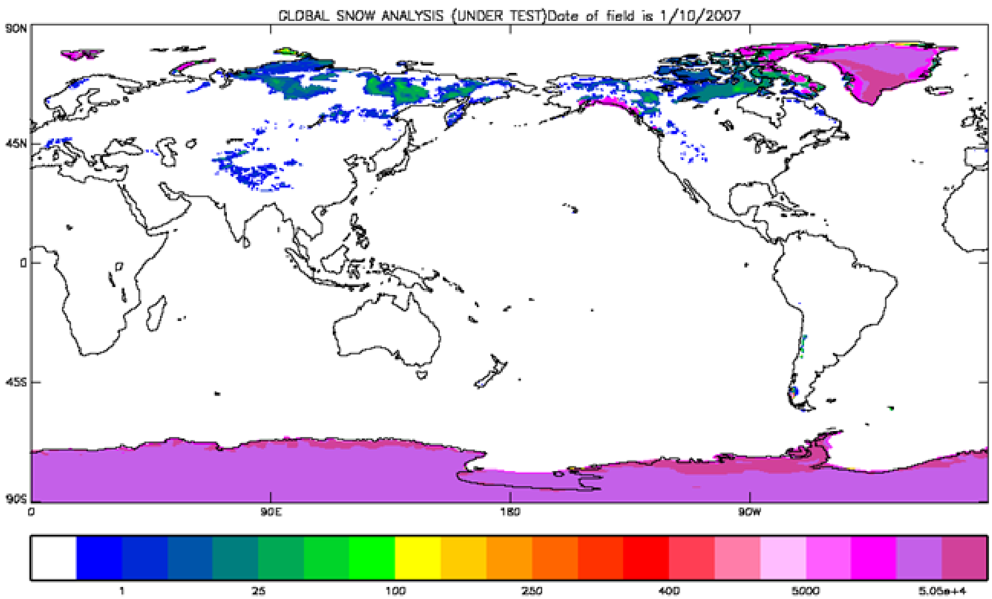


Figure 7: Analysed snow amount (kgm-2) from an analysis performed using global model 00Z snow amount field for 2/10/07 and the observational snow cover data from 1/10/07.

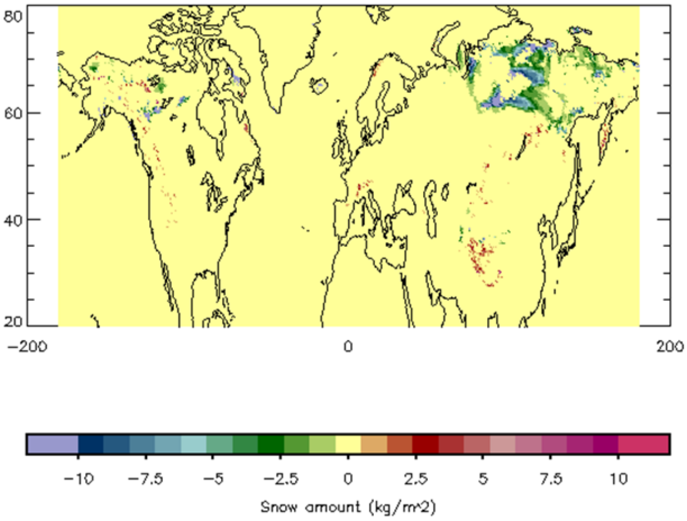


Figure 8: Modifications that will be made to the model snow amount field by the analysis.

5. CAPE closure change to convection

Until cycle E15 the NAE and Global models shared the same RH dependent CAPE closure to the convection scheme.

The RH based closure was introduced to target grid point storms (GPS) by shortening the 30 minute CAPE timescale when RH>80%. However the higher resolution of the NAE model compared to the Global model means that fronts are better resolved. The higher associated RH along the fronts leads to CAPE timescales as small as 5-10 minutes even though there are no GPS along the front. The effect of this short timescale is to produce noisy (both spatially and temporally) convective precipitation rates.

The new vertical velocity based CAPE closure also targets GPS, but does not speed up convection where GPS are not occurring. The CAPE closure is timescale is fixed at 30 minutes and does not reduce unless the vertical velocity exceeds 1m/s (Figure 9).

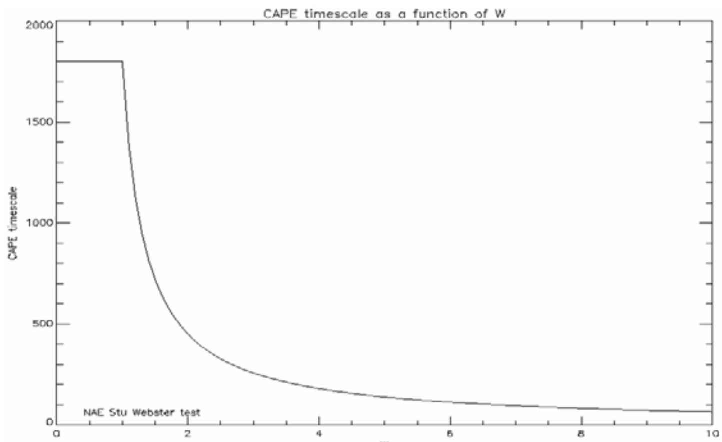


Figure 9: CAPE timescale as a function of vertical velocity

This produces smoother convective precipitation patterns and a re-distribution between large scale and convective precipitation. Case study and then parallel suite testing has shown the w-CAPE scheme to improve precipitation and cloud scores.

Figure 10 shows the forecast of a snow event that happened while the w-CAPE scheme was being tested as part of the Parallel suite. The operational NAE had the snow band moving too slowly northwards whilst the Parallel suite which included the w-based CAPE correctly had the snow extending further into Wales.

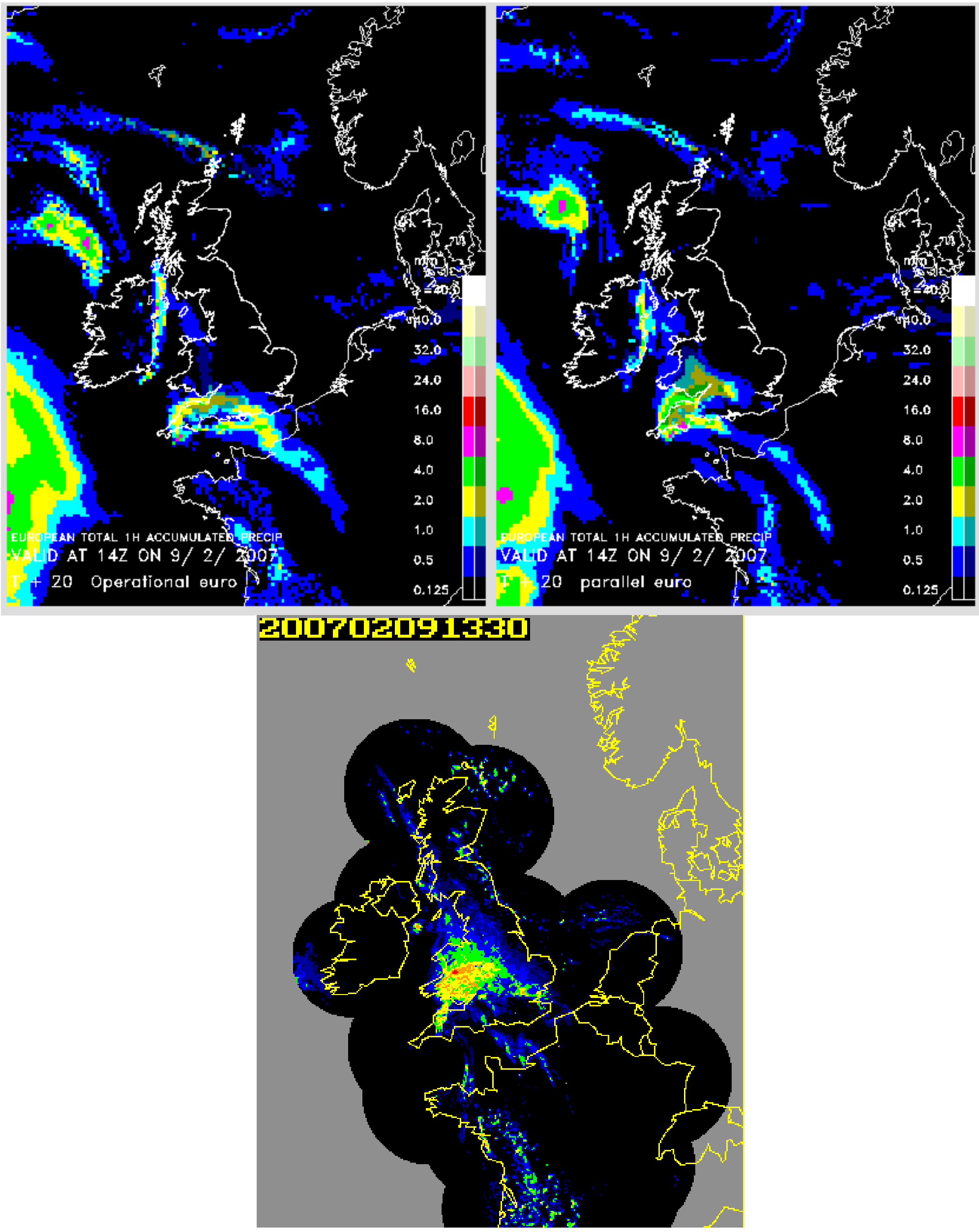


Figure 10: 1 hour accumulated precipitation fields for the snow event of 09/02/07. Operational NAE (left hand panel), Parallel suite (right hand panel) and radar validation (bottom).

6. Wind gust diagnostic

The Met Office has had an operational 'shear-generated' gust diagnostic in the Site Specific Forecast Model since 1998. The diagnostic based on the theory of Panofsky et al. (1977) and observational data from Cardington.

A very similar diagnostic was implemented in the Global and NAE models at the end of 2006. The diagnostic follows the ‘ECMWF method’ and has a large tunable parameter, C, which gives the number of standard deviations from the mean a gust represents.

At ECMWF, C is set to 7.71. However following evaluation in the UM, it was found necessary to retune C to 4.0. In the storm of 31/12/06 (Figure 11), a run with C=7.71 gave a 115 knot gust at Malin head (northern tip of Northern Ireland) while C=4.0 gave a 74 knot gust. The observed gust was 80 knots.

Forecasters are now being persuaded to use this diagnostic as they still like to use “Level 6 stability adjusted” winds. This is not a good practice with a change in vertical levels due in 2008!

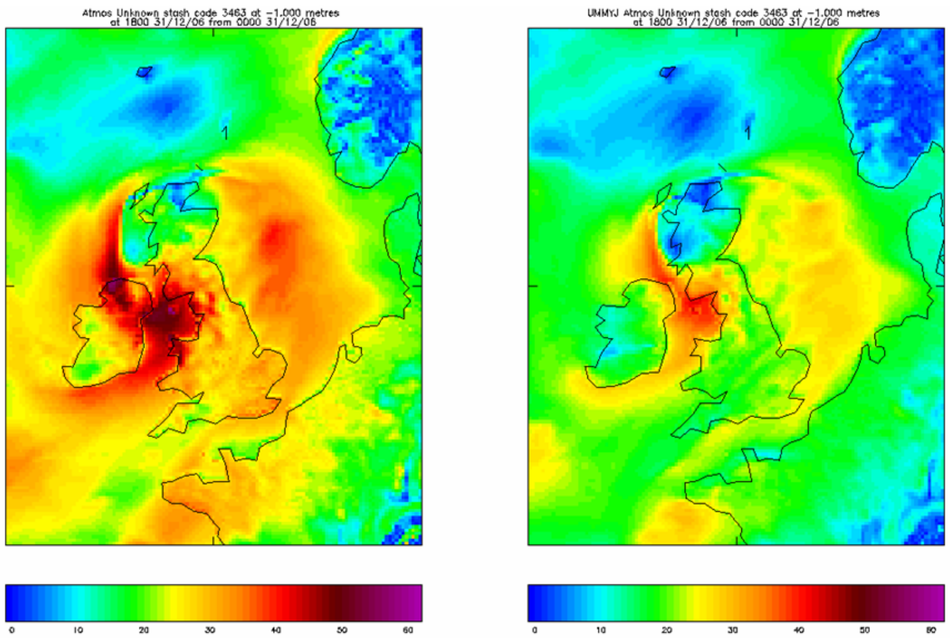


Figure 11: Wind gust forecast for 1800 on 31/12/2006. ECMWF value for C (left hand panel) and retuned value for C (right hand panel).

7. 20th July 2007 case

This case represented one of the best Met Office forecasts in many years. Pershore College of Agriculture recorded 120.8 mm of rainfall on the day (157.4 mm in the period 19-20th) with several other sites from west Berkshire into Gloucestershire and Worcestershire recording in excess of 100 mm. Amounts exceeded 25 mm in an hour in many places.

The Met Office successfully predicted that the major risk of disruption would be across the counties of Herefordshire, Worcestershire and Gloucester. Timely advice was given to the emergency services and other government and commercial customers. The Government's Emergency Committee (COBR) met several times and a representative from the Met Office was invited to attend. In the end there were 3 deaths, £50m spent in clean-up operations, £2bn worth of insurance claims, 4.000 homes affected and major of disruption of traffic, water and electricity supplies.

The models gave good guidance with the skill depending somewhat on the exact region and the time. The Forecast- Analysis Fractional Skill scores for the NAE and UK4 models (Figure 12) for example show the UK4 having greater skill than the NAE for the period 0600 to 1200 over the Thames Valley whilst the NAE shows greater skill than the UK4 for Gloucestershire from 1200 to 1800.

The 1.5km On-demand model was also run at the request of forecasters and the agreement with radar is very good overall (Figure 13). There are inevitably some differences in the detail that are not well captured e.g. a spurious rain band over Kent, too little convection over Lyme bay and a dry slot in South Wales.

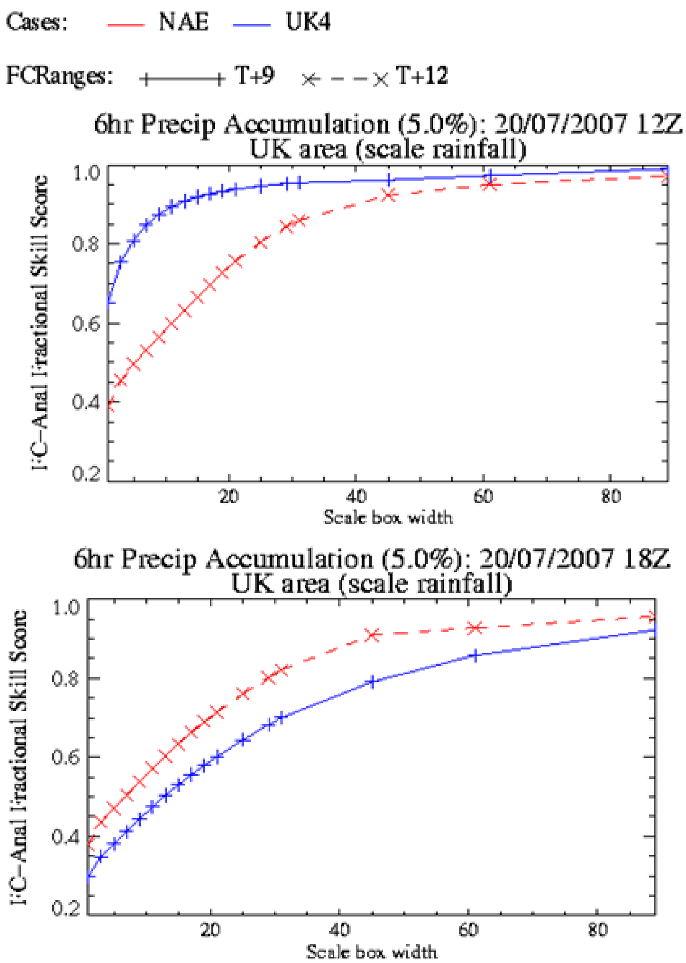


Figure 12: Fractional skill scores for Thames Valley (0600 to 1200) (top panel) and Gloucestershire for 1200 to 1800 (bottom panel).

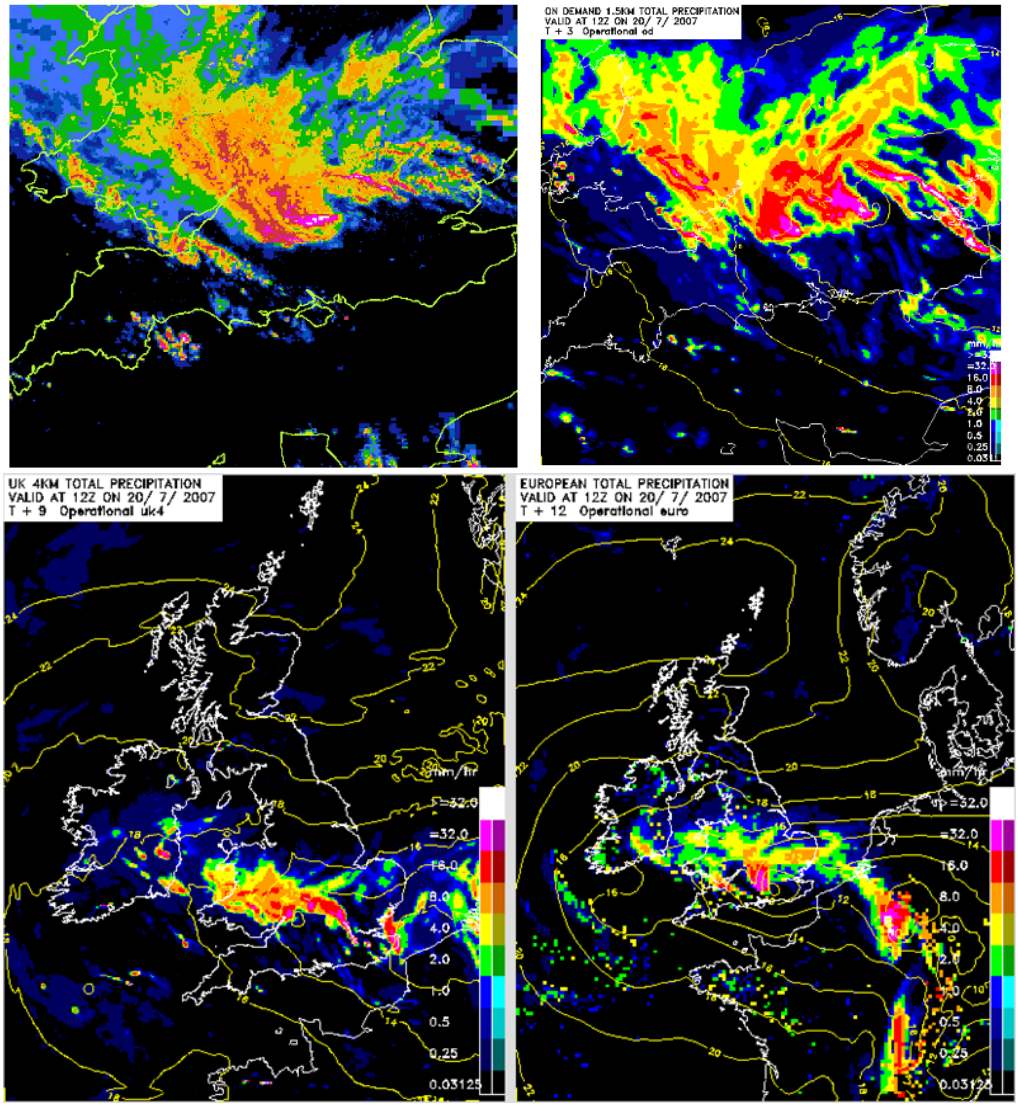


Figure 13: Radar composite (top left hand panel) and three hour spin-up 1.5km model forecast from interpolated 4km model (top right hand panel) valid at 1200.UK4 model T+9 (bottom left panel) and NAE T+12 (bottom right panel).

STATUS OF AROME MODEL DEVELOPMENTS

Y. Seity [1], P. Brousseau [1], G. Hello [1], S. Malardel [1]
[1] Météo-France CNRM/GAME 42, av. G. Coriolis 31057 Toulouse Cedex France
E-mail: *yann.seity@meteo.fr*

Abstract : We present the recent developments in the new Non-Hydrostatic 2.5 km resolution model AROME. This model is planned to be operational over mainland France by October 2008. Three aspects are presented here, a new algorithm to save computer time in precipitation sedimentation, a new surface boundary layer scheme, and a new setup of the numerical diffusion.

1. INTRODUCTION

The AROME model is a new Numerical Weather Prediction system built in order to improve the forecast of mesoscale phenomena and extreme weather events such as thunderstorms, mountain forecasts, coastal winds, immediate forercasts ... The first prototype version saw the day in 2004. Daily experimentations over a quarter of the France territory started in June 2005, to encompass the whole of France in January 2007, thanks to a new supercomputer. Météo-France plans to run operationally AROME in October 2008 over the domain presented in Figure 1. With a 2.5 km horizontal grid mesh and a time step of 60 seconds, this model is designed for short range forecasts. It merges research outcomes and operational progress : the physical package used is extracted from the Meso-NH research model and has been interfaced into the Non-Hydrostactic version of the ALADIN software (Bubnova et al. 1995 ; Benard 2004). AROME mesoscale data assimilation system has been developed in 2006 and 2007 based on the ALADIN 3D-Var system.

In the following sections, we will present the status of the AROME model as used at Météo-France by the end of 2007.

2. Design of the 'pre-operational' suit

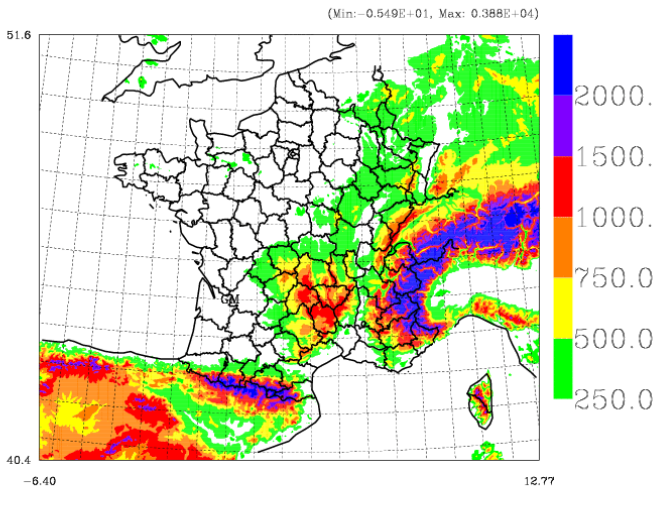


Figure 1 : AROME-France Domain.

The physical parameterizations used in AROME are the follow :

- the ICE3 Meso-NH microphysical scheme with five prognostic species of condensed water (Pinty and Jabouille 1998). It contains three precipitating species (rain, snow and graupel) and 2 non precipitating ones (ice crystals and cloud droplets)
- the Meso-NH 1D turbulence parameterization (Cuxart et al., 2000) with Bougeault Lacarrère mixing lengths (Bougeault and Lacarrere 1998)
- the externalized version of the Meso-NH detailed surface scheme (Noilhan and Planton 1989, Masson 2000)
- the operational ECMWF radiation code which is called every 15 minutes.
- the Meso-NH shallow convection scheme (Bechtold et al. 2001).

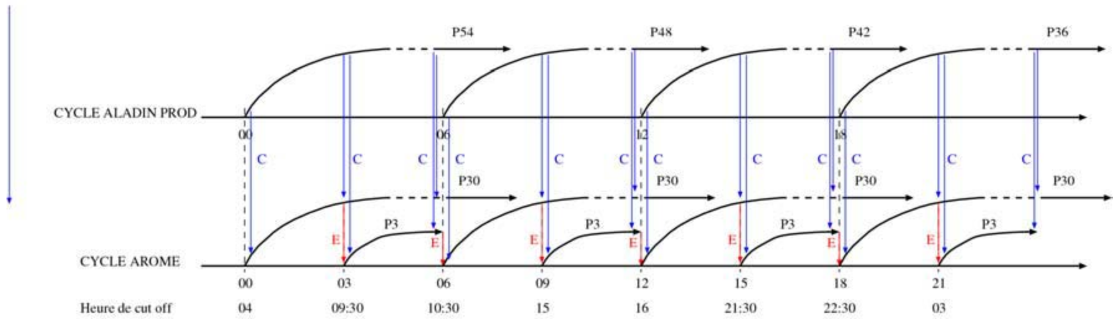


Figure 2 : Technical overview of the AROME suit.

The data assimilation system uses high temporal and spatial frequency observations (RADAR measurements for example) to the best possible advantage, using a rapid forward intermittent assimilation cycle in order to compensate the lack of temporal dimension in the 3D-Var scheme. A first prototype of such a system is presented in Figure 2, with a 3-hourly data analysis frequency. Four times a day (at 00, 06, 12, 18), we performed 30 hours forecasts over a 600x512 domain (Figure 1), with 41 vertical levels. On 64 processors, with a time step of 60 seconds, it needs about 30 minutes of elapse time to produce a 24 hour forecast. AROME is coupled every hour with ALADIN-France.

3. RESULTS

AROME prototype has already showed improvements in forecasts quality in different kind of meteorological situations.

(a) (b) (c)

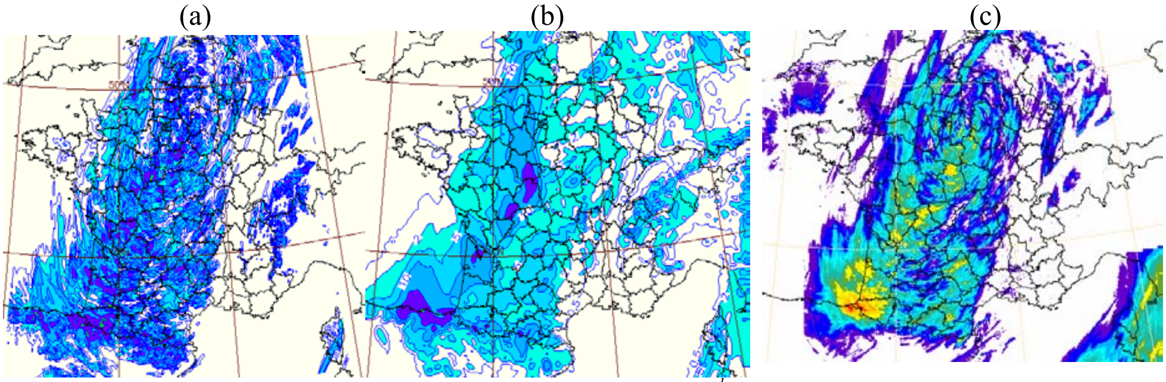


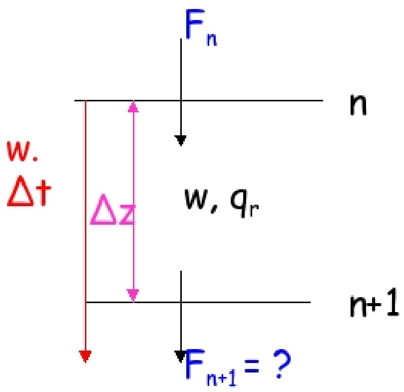
Figure 3 : 24 hour cumulative rainfalls for 23rd August 2007
a) AROME-France b) ALADIN-France c) Radar network.

For example, orographic effects are better represented than in ALADIN-France, thanks to the 4 time smaller grid mesh. Urban effects are well captured by the model thanks to the town scheme TEB (Town Energy Budget). The structure of precipitating patterns is often more realistic in AROME, as shown in Figure 3, even if the model has a tendency to overestimate the maxima of cumulated rainfall.

4. RECENT DEVELOPMENTS

1) Statistical sedimentation scheme

In the first version of the AROME prototype, the sedimentation of precipitating species (rain, snow and graupel) was performed with an Eulerian scheme which used a time-splitting algorithm (with an effective time step of around 4 seconds). Following ideas from Geleyn et al. (2007), we have implemented a so called 'statistical sedimentation scheme' in AROME. It runs with the model time step and it reduces by 15% the cost of the model physics. Its principle is relatively simple. For each column, starting from the model highest level in which there are no precipitating species (it is located in the stratosphere), fluxes are computed according to the algorithm presented in Figure 4. P_1 is the proportion of the layer content falling during one time step. P_2 is the proportion of the incoming flux F_n falling through the layer in one time step. F_{n+1} is the sum of P_1 multiplied by the mass of rain in the layer divided by the time step, and of P_2 multiplied by the incoming flux.



$$P_1 = \min\left(1, \frac{w\,\Delta t}{\Delta z}\right)$$

$$P_2 = \max\left(0, 1 - \frac{\Delta z}{w\Delta t}\right)$$

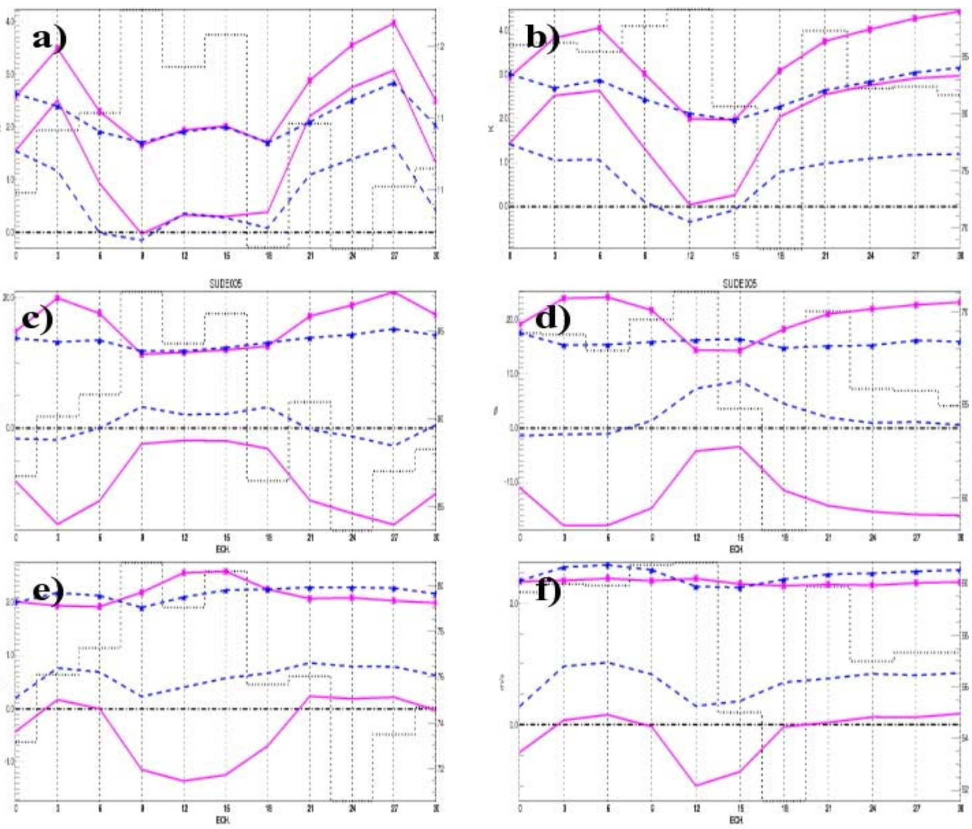
$$F_{n+1} = P_1 \cdot \frac{\rho . q_r . \Delta z}{\Delta t} + P_2 . F_n$$

Figure 4 : algorithm of the statistical sedimentation scheme used in AROME

2) boundary layer diagnostics

When comparing AROME diagnosed 2 meters temperature with surface observations, we observed a systematic positive bias in stable situations. These situations are more frequent during the night. The diagnostic used in AROME to compute 2 meters temperature starts from the model lowest level temperature (which is at 17.5 meters in AROME) and uses surface boundary layer laws to compute temperature at 2 meters. A new scheme named CANOPY has been developed by Masson (2007) inside the surface code. It consists in adding 6 vertical levels between the soil and the model lowest level. Two of these added levels are 2 and 10 meters height. A turbulence scheme is used to compute the evolution of prognostic variables such as temperature, humidity and wind on these 6 added levels. The numerical cost of this new scheme is negligible. The scheme has been evaluated for 2 months over South-Eastern

France : in January and in July 2007. The comparison with surface observations is improved as shown in Figure 5 : 2 meters temperature and humidity bias and root mean square errors are reduced. Concerning the wind, results are improved during the day, but are slightly worst during the night. Contrary to previous surface boundary layer diagnostics, the CANOPY scheme affects all the results of the numerical simulation. Indeed, fluxes send by the surface to the atmosphere are changed.



<u>Figure 5</u> : Evaluation of CANOPY scheme over South-East France domain : AROME-reference in full line, AROME-Canopy in dotted line. Root mean square errors are on the top , bias on the bottom. a) Temperature at 2m during July 2007, b) Temperature at 2m during January 2007, c) 2m relative humidity (%) in July 2007, d) 2m relative humidity (%) in January 2007, e) strength of 10m wind in July 2007, f) strength of 10m wind in January 2007

3) Setup of numerical diffusion

In some convective situations, AROME had a trend to over-estimate convective downdrafts. As shown in Figure 6a, AROME forecasted a strong isolated thundercell, whereas the equivalent Meso-NH simulation (Figure 6d) forecasted smaller individual cells. This AROME behaviour is the same if we switch from Non-Hydrostatic to Hydrostatic mode (Figure 6b). One possible explanation is the strength of numerical diffusion which was four time stronger in AROME than in Meso-NH. In Figure 6c, we can see that the AROME simulation with reduced numerical diffusion is more similar to the Meso-NH one. The evaluation of this new setup over a longer period with classical scores shows a neutral impact. It has been implemented in the daily runs of AROME since November, 16^{th} 2007.

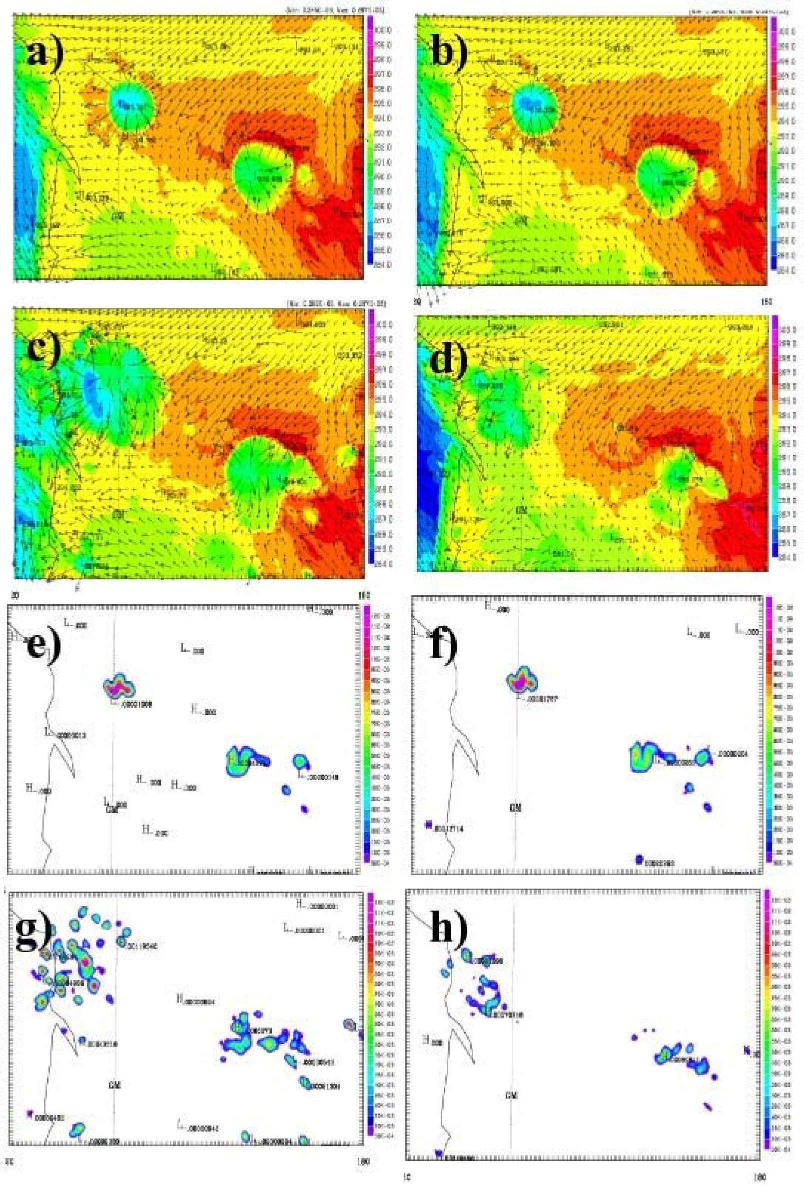


Figure 6 : 10m wind strength, direction and instantaneous rainfalls on 11th April 2007 at 15TU. a-e) AROME-Reference, b-f) AROME Hydrostatique, c-g) AROME with reduced numerical diffusion, d-h) Meso-NH equivalent simulation.

5.CONCLUSION AND OUTLOOK

AROME is on the way to be operational at Météo-France. The first pre-operational suit with data assimilation scheme had been built. AROME has already shown a correct behaviour in most situations. Some improvements in the code efficiency has been performed, as the use of a statistical sedimentation scheme for precipitating species. A new surface boundary layer scheme (CANOPY) has been implemented in the surface scheme SURFEX. It improves comparison with surface observations. The strength of numerical diffusion has been reduced. It corrects some problems of over-estimated downdrafts under convective cells and is more similar to the strength used in Meso-NH.

Daily evaluation of the model will continue with more and more interaction with forecasters. Data assimilation will be expanded by the use of Doppler radar winds which has already shown positive impacts. Results from the MAP-DPHASE campaign will be used to compare our results with other similar models. We are also starting to evaluate the AROME behaviour at 1km resolution to for future plans.

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An assessment of deficiencies and sensitivities of operational quantitative precipitation forecasts using the COSMO model

Philippe A.J. Steiner[1], S. Dierer[1], M. Arpagaus[1], U. Damrath[2], A. Seifert[2], J. Achimowicz[8], E. Avgoustoglou[7], T. Andreadis[7], M. Baldauf[2], R. Dumitrache[9], V. Fragkouli[7], F. Grazzini[3], P. Louka[7], P. Mercogliano[6], P. Mezzasalma[3], M. Milelli[4], D. Mironov[2], A. Morgillo[4], E. Oberto[4], A. Parodi[5], I. V. Pescaru[9], U. Pflüger[2], A. Sanna[4], F. Schubiger[1], K. Starosta[8], M. S. Tesini[3]

[1]MeteoSwiss (CH), [2]DWD (D), [3]ARPA-ER (IT), [4]ARPA-P (IT), [5]Uni Genova (IT), [6]CIRA-CMCC (IT), [7]HNMS (GR), [8]IMGW (PO), [9]NMA (RO)

1 Introduction

Quantitative precipitation forecast (QPF) is an important purpose of limited-area numerical weather prediction models - for forecasters and customers. Indications from verification and forecasters suggest that the operational implementations of the COSMO model (7-14 km horizontal grid spacing) – like other numerical weather prediction models - have deficiencies in forecasting precipitation. This was the motivation to launch the COSMO Priority Project 'Tackle deficiencies in quantitative precipitation forecasts'. The aim of the present study is to investigate which parts of the modelling system have a significant impact on QPF. Investigations are focussing on numerical methods and physical parameterizations, while the effect of inaccurate boundary conditions is disregarded in this study. Identifying the most important and weakest parts of the model will not only, or maybe not at all, lead to direct improvements, but can provide guidance for future research and development.

2 Test cases and sensitivity studies

The first step of the project is the selection of test cases reflecting typical forecast errors of the COSMO model at 7 km grid spacing. The cases are selected in a way that the forecast error is probably not caused by wrong synoptic conditions in the initial or boundary data. A final list of 25 test cases is selected for the QPF sensitivity studies. The selected test cases divide into two main groups of forecast errors: 9 cases of overestimated stratiform precipitation (mainly in Germany, Switzerland and Poland) and 6 cases of underestimated convective precipitation (mainly in Italy and Greece).

The second step is the preparation of a set of sensitivity studies concerning initial conditions, numerical methods and physical parameterizations. The sensitivity studies, the expected changes and the kind of study are described in Table 1–3. The list defines about 20 sensitivity runs with the COSMO model that are performed for all test cases. The evaluation of sensitivity experiments is based on the 24h area average precipitation. Evaluation regions are selected with a minimum size of 100kmx100km. By this method, the focus is on larger scale over- or underestimations. Problems of wrong localization or wrong temporal simulation are not captured.

No.	Sensitivity study	Expected effect	Kind of study
1	Reduction of soil moisture 20%	Homogenous reduction of precipitation	idealized
2	Increase of soil moisture 20%	Homogenous increase of precipitation	idealized
3	Reduction of initial humidity 10%	Homogenous reduction of precipitation	idealized
4	Increase of initial humidity 10%	Homogenous increase of precipitation	Idealized

Table 1: Sensitivity studies regarding initial values.

No.	Sensitivity study	Expected effect	Kind of study
5	Halved time step	Optimal case: nothing	idealized
6	Leapfrog, tri-cubic semi-Lagrange advection of QR and QS	Less diffusive advection of precipitation	option
7	Runge-Kutta, tri-cubic semi-Lagrange advection of QV, QC, QI, QR and QS	Less diffusive, improved flow over terrain, improved advection of all moisture variables	option
8	Runge-Kutta, flux-form advection of QV, QC, QI, QR and QS	Less diffusive, improved flow over terrain, improve advection and mass conservation of all moisture variables	option
9	Runge-Kutta, flux form advection and T'-p' dynamics	Less diffusive, improved flow over terrain, improved advection and mass conservation and a better treatment of buoyancy terms	option
10	increased orography filtering	Slightly decreased orographic precipitation	Idealized

Table 2: Sensitivity studies regarding numerical methods.

No.	Sensitivity study	Expected effect	Kind of study
Microphysics			
11	New warm rain scheme (Seifert and Beheng; 2001)	Reduced drizzle	option
12	Strong changes of ice microphysics and new warm rain scheme	Reduced drizzle and precipitation amount and increased transport of precipitation to mountain lee side	idealized
13	Moderate changes of ice microphysics and new warm rain scheme	Reduced drizzle and precipitation amount and increased transport of precipitation to mountain lee side	development
Convection			
14	Modified Tiedtke scheme	Weaker convection	development
15	Kain-Fritsch/Bechtold scheme	Modified convection	development
16	No parameterization of deep convection	Unrealistic up-scaling of convection, deteriorated forecast	idealized
Planetary boundary layer			
17/18	Decreased/increased scaling factor of height of laminar boundary layer for heat	Increased/decreased vertical exchange of heat and moisture	idealized
19/20	Decreased/increased stomatal resistance	Increased/decreased vertical exchange of moisture	idealized
21/22	Decreased/increased laminar scaling factor for heat over sea	Increased/decreased vertical exchange of heat and moisture	idealized

Table 3: Sensitivity studies regarding physical parameterizations.

3 Results

3.1 Effect on area average precipitation

The sensitivity experiments show that the strongest effect on QPF is caused by changes of initial humidity and of convection schemes. Both cause changes of the area average precipitation values in the range of 40% (Figure 2). Increasing (decreasing) initial humidity increases (decreases) the precipitation. There are indications from verification that there are deficiencies in the humidity simulation motivating a closer look at atmospheric humidity in order to approve or disprove its influence on QPF deficiencies. Using the Kain-Fritsch/Bechtold scheme causes increase as well as decrease of precipitation.

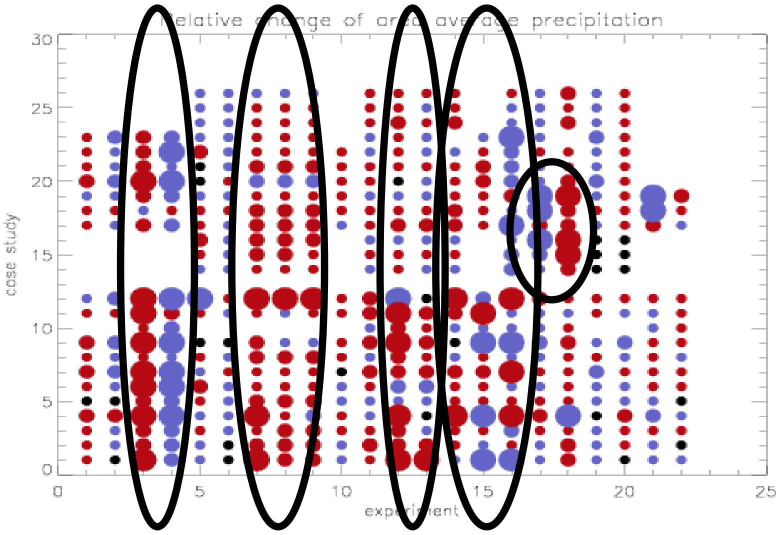

Figure 1: Blue (red) circles indicate an increase (decrease) of 24h area average precipitation relative to the basic simulation (Δrel = rrsens-rrref / rrref). The big circles indicate changes bigger than 30%, medium ones between 10% and 30% and small ones between 0% and 10%, black circles indicate no change. Experiment numbers are the ones in Table 1-3. Marked are changes of initial humidity, Runge-Kutta runs, microphysics and convection changes and changed vertical exchange.

Using the Runge-Kutta time integration scheme instead of Leapfrog and a modified warm rain and snow physics scheme change the area average precipitation by about 10% (Figure 2). Using the Runge-Kutta scheme reduces the area average precipitation for most of the cases, convective as well as stratiform. The reason has not yet been investigated, but might be related to using centered differences. For the Roman and Greece test cases, both regions affected by the sea, the heat and moisture exchange between surface and atmosphere is of great importance causing changes in the range of about 25%. Changes of orography filtering and time step have a negligible effect on the area average precipitation.

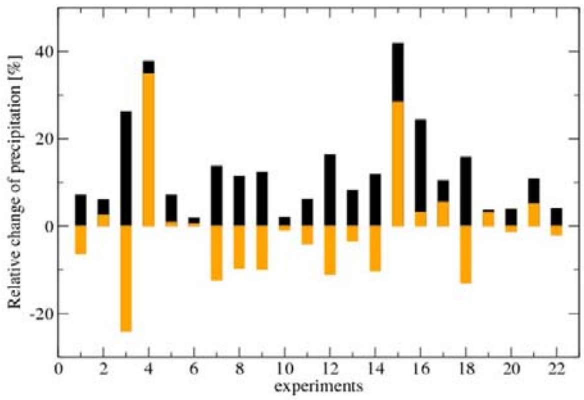

Figure 2: The sum of relative changes of area averaged precipitation ∑Δrel is given as yellow bars. The sum of the absolute values of the relative changes of area average precipitation ∑| Δrel | is given as black bars. The relation between yelllow and black bars indicates if changes have predominantly one direction.

3.2 Improvement of QPF?

For overestimation cases, reducing initial humidity and using the Runge-Kutta scheme have a positive effect. Convective overestimations are additionally reduced by using the modified Tiedtke or the Kain-Fritsch/Bechtold (KFB) convection scheme. Using the Runge-Kutta scheme improves also cases of underestimation. Thus, the Runge-Kutta scheme has an overall positive effect on QPF.

Most underestimation cases are improved by increasing the initial humidity. The change of microphysics (exp. 13) and the modified Tiedtke scheme have a predominantly negative effect. Using the KFB scheme has a neutral impact, improving some and worsening other cases. At last, there is no clear positive impact on cases of convective underestimation.

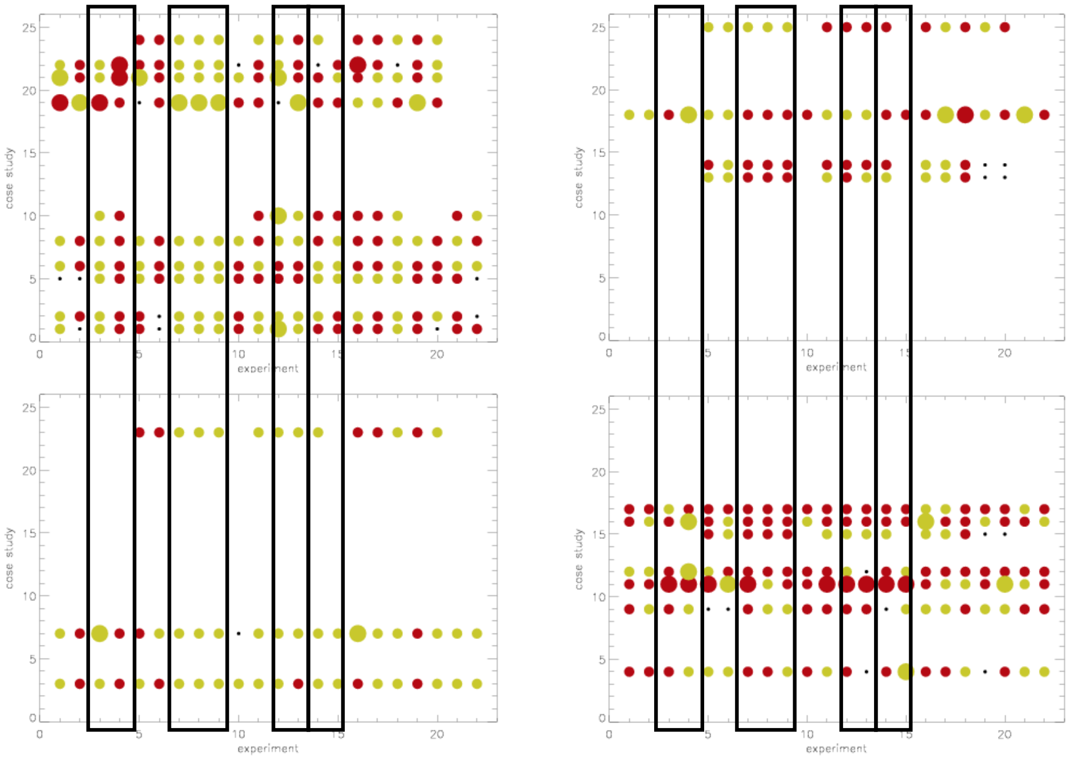

Figure 3: Ratio of the bias of the reference version and of the sensitivity study *biasexp/biasref* *for cases with overestimation of stratiform (upper panel, left) and convective (lower panel, left) precipitation and with underestimation of stratiform (upper panel, right) and convective (lower panel, right) precipitation. Green circles indicate a smaller bias, while red circles indicate a higher bias in the sensitivity study. Big circles show a more than halved (doubled) bias, small circles show an up to halved (doubled) bias. Points indicate no change.Black frames like in Figure 1.*

3.3 Cross experiments

The cross experiments combine those changes that have a positive effect on overestimated stratiform precipitation. The simulations are performed with a model version including microphysics changes similar to exp. 13 (Table 1). Runs are performed using this version (exp. 25), with KFB (exp. 27) and modified Tiedtke scheme (exp. 29) and additionally with Runge-Kutta and reduced initial humidity (exp. 26, 28, 30, respectively). The results show a positive effect on QPF of cases with overestimated stratiform precipitation for most cross experiments.

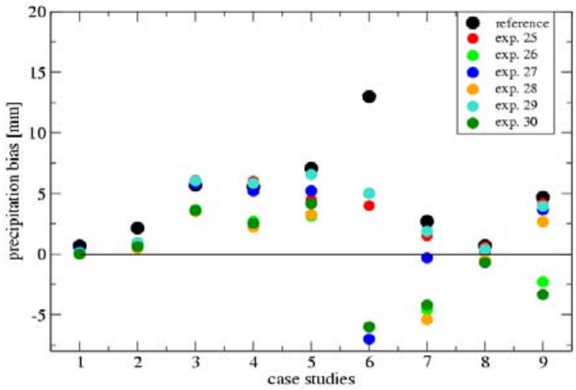

Figure 4: Bias of the reference simulation and cross experiments (see text) for cases with overestimated of stratiform precipitation.

4 Conclusions

The strongest effect on area average precipitation are achieved by changed

- initial humidity
- time integration scheme (Runge-Kutta instead of Leapfrog)
- parameterization of convection and microphysics.

Runge-Kutta, changed microphysics and convection improve the cases of stratiform overestimation.

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ALARO-0 Physics developments in 2007

summarized by Neva Pristov, RC LACE working group leader for physics

In this paper the short overview of the developments on physics parameterization inside ALARO-0 is presented. The main emphasize is put to the new moist processes description.

The ALARO-0 model was developed for operational forecast at high resolution, especially at scales between 10 and 3 km of mesh-size. It includes more elaborated physical parametrisations: prognostic pseudo-TKE for turbulent diffusion, an enhanced radiation scheme, a microphysics with 4 prognostic condensed phases (2 precipitating species) and the moist processes parameterizations so called "3MT" scheme (Modular Multi-scale Microphysics and Transport).

In some meteorological services in RC LACE validation and testing of a simplified version (new microphysics, unchanged convection scheme) was done and in two centers is in the operational use.
The training course was organized in March 2007 (Radostovice, Czech Republic). Information can be found on http://www.rclace.eu/?page=74.

Progress with the 3MT scheme in ALARO-0
(team work Luc Gerard, Radmila Brozkova, J.-F. Geleyn, Doina Banciu)

The 3MT scheme allows a consistent treatment of the subgrid deep convective processes and their combination with the resolved cloud and precipitation schemes. 3MT implements in ALARO-0 the package described by Gerard (2007), including ideas of Piriou et al. (2007). Its main components are prognostic mass-flux schemes for deep convection, an interface of the latter through transport and condensation fluxes, a cascading approach to combine the resolved and subgrid moist processes.

For comparison and tests, a simplified version ("LSTRAPRO") of ALARO-0 was used, applying the microphysics to resolved clouds and precipitation but keeping the old diagnostic deep convection scheme instead of using the 3MT package. In this case, the prognostic microphysics is fed by the sole resolved condensation, while the deep convection scheme only produces precipitation reaching the ground within a single time-step, plus a diagnostic contribution to the cloudiness.

This LSTRAPRO scheme was found to give satisfying scores compared to the operational ALADIN, when running at 9km (however the inconsistency of maintaining two separate precipitation schemes would compromise the higher resolution results). This was taken as a reference to test the full 3MT package. At the beginning of 2007, the tests of the 3MT at 9km showed it produced insufficient precipitation, while the scores over a 10-days period were quite deceiving. There was an unacceptable positive bias of the mean sea-level pressure, an excess moisture at high levels, a cold bias at the lower level. The geopotential presented a "dipole" bias, positive below 500 hPa and negative higher. An excessive moistening and heating around 600hPa by the deep convective transport was observed. This is linked to the local reduction of the updraught mass flux around the triple point level, where precipitation melting cools the environment.

The intensive research effort performed from April revealed several sources for these problems, including : bugs in the coding; unexpected behaviour, such as the evaporation by the resolved scheme of the convective cloud generated at the previous time step, because after advection it was assumed to mix with the entire grid-box; problems of numerical consistency; approximations in the formulation which together appeared more harmful than expected.

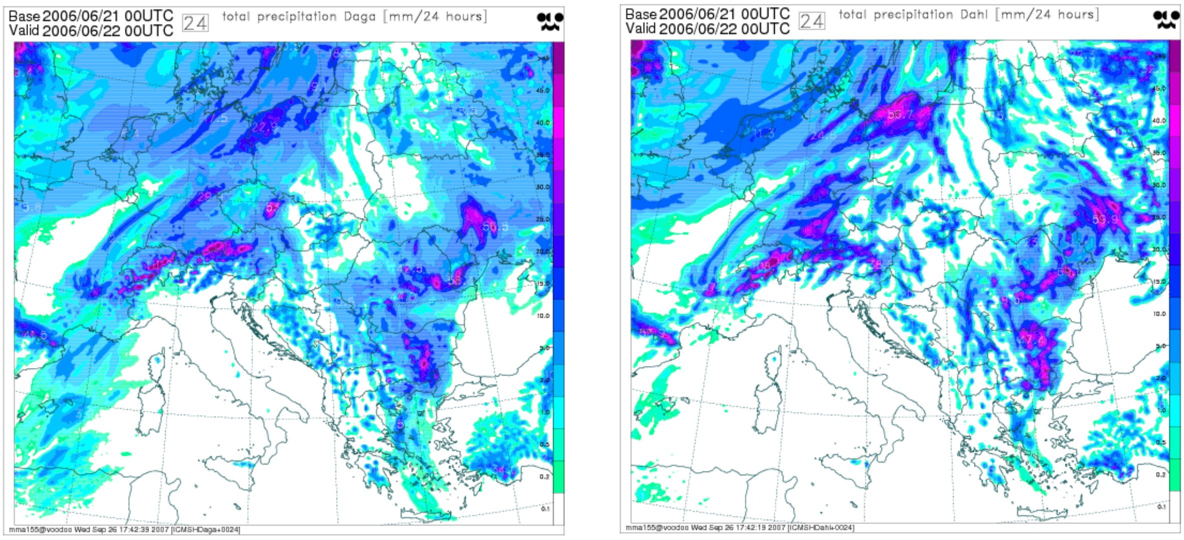

Figure 1: Precipitation fields (accumulated in 24h) with LSTRAPRO (left) vs 3MT (right).

The scores of the present of ALARO-0+3MT at 9km are at least as good as those of the LSTRAPRO version, while the precipitation forecasts appear quite better.
Figure 1 shows that the excessive clouds and precipitation over Baleares and Western Mediterranean Sea produced by the LSTRAPRO (and the operational Aladin) schemes are no longer there with the 3MT scheme. The structure is more realistic, even though there is still a grid-point storm above Moldavia.

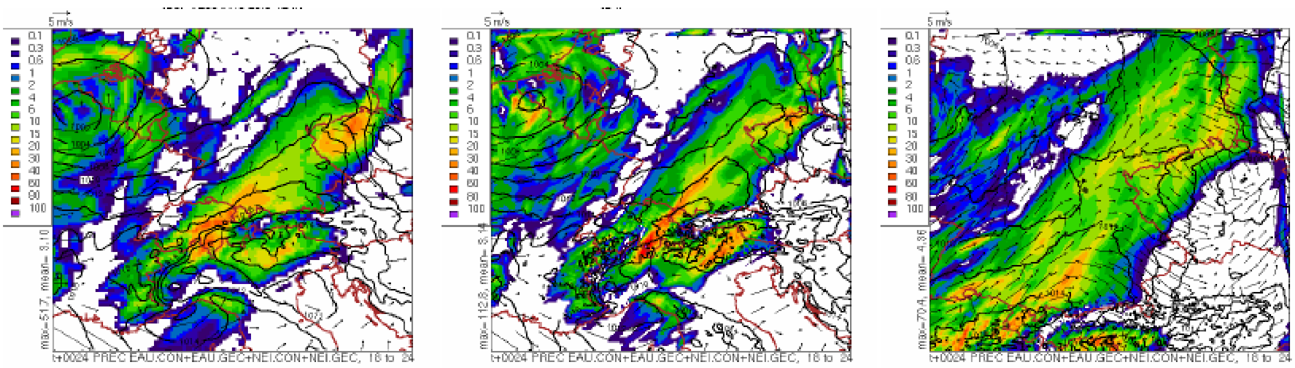

Figure 2: Precipitation (accumulated in 6 hours) forecast at 9km (left), 4km (center) and 2km (right, smaller area). Cold front over Bohemia/Bavaria.

Tests at finer resolution have been started (Figure 2). The forecast at 4km, in the so-called grey-zone of the convection, stays consistent with the other scales and no bogus phenomenon appears at this resolution.

Progress in the turbulent scheme
(Filip Váňa, Ivan Bašták Duran)

Present turbulent scheme (pTKE) in ALARO-0 can be further extended to the full TKE formalism. The convergence from the existing Louis scheme towards the scheme scientifically similar to CBR scheme in AROME is continuing. First step was already implemented pseudo-prognostic TKE scheme (pTKE) with the introduction of new prognostic quantity – an advected and auto-diffused diagnostic TKE. The pTKE equation is simplified form of full (1D) TKE equation where source terms (buoyant and mechanical production/destruction plus dissipation) are represented by relaxation towards Louis scheme.
Numerical stability test of pTKE scheme was done by verifying the existence of fibrillations (T(t-dt)+T(t+dt)-2*T(t) where T is temperature and t is a particular forecast time) at the lowest model level. Some instabilities were detected. This confirms that an improvement of scheme is needed.
Theoretical study how to compute TKE from TKE equation instead of using diagnosed one was done. The description of source terms (buoyant, mechanical production/destruction and dissipation) can be the same as in CBR, while the exchange coefficient are derived from the prognostic TKE equation being in stationary state (without advection and auto-diffusion terms). With this approach the terms of the full TKE equation which are diagnosed from an equivalent of the Louis scheme in pTKE can be computed and substituted into pTKE scheme, that becomes an e-TKE scheme, with 'e' for emulation (of CBR).
First the mixing length computation which is a merge of the previous empirical formula and of Bougeault-Lacarrere parameterization (BL89) was proposed but after additional studies it was found out that original BL89 can be also implemented.
Both these development are going to be implemented and tested in 2008.

Grawity wave drag
(Tomas Kral)

The detailed analysis of the effects of envelope suppression was performed. The envelope removal has a negative impact on the scores of surface quantities and deteriorates the geopotential field due to mass redistribution as the directional forcing of a new parameterization is not equivalent to that of envelope. Consequently, the associated geostrophically balanced circulation induces temperature anomalies at higher levels. Based on this results, it was concluded that present scheme is exerting too much drag.
To improve the scheme many modifications has been tried: implementation of integration of turbulent drag into lift mechanism to obtain a more realistic representation of the lift effect; a new tuning which reduces the form-drag part of the total drag; multi-directional modification approach. All these attempts has not improved satisfactory the verification scores. But the gained knowledge on sensitivity and response of the scheme to new tunings and modifications is valuable base for further developments.

Outlook for 2008

A simplified version ("LSTRAPRO") of ALARO-0 is going to be used in the operational production in more services.
Main focus of developments will be put to stabilisation of 3MT, to solving already diagnosed weaknesses (there are to much high clouds, too weak wind strength bellow 600hPa, slightly too high

extreme precipitation amounts) and to study its performance at 'grey zone'.
Validation of the turbulent scheme (eTKE) is going to be in process. In the radiation scheme improvements are planed with better description of transmission functions and aerosol's optical properties. Cloudiness description should be revised and unified in various processes (radiation, turbulent vertical diffusion, evaporation/condensation, microphysical processes), new methods can profit from new prognostic water condensates.
Performance of ALARO configuration at scales around 5 km of mesh-size are going to be studied and we plan to have operationally ready configuration in two years time.

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Ivan Bašták, 2008: ”New” ACCOEFK subroutine in pTKE parametrisation scheme, upgraded report from stay 4 June - 29 June in Prague

Progress with the 3MT scheme in Alaro-0

Luc Gerard (luc.gerard@oma.be), teamwork implying
Radmila Brožkova, Jean-François Geleyn, Doina Banciu
RMIB – CHMI – INMH

The Alaro-0 model was developed for operational forecast at high resolution, especially with grid-box lengths between 10 and 2km. It includes more elaborated physical parametrisations than the operational Aladin, e.g. prognostic pseudo-TKE for turbulent diffusion, an enhanced radiation scheme, a microphysics with 4 prognostic condensed phases (2 precipitating species) or the "3MT" scheme allowing a consistent treatment of the subgrid deep convective processes and their combination with the resolved cloud and precipitation schemes. 3MT implements in Alaro-0 the package described by Gerard (2007), including ideas of Piriou et al. (2007). Its main components are prognostic mass-flux schemes for deep convection, an interface of the latter through transport and condensation fluxes, a cascading approach to combine the resolved and subgrid moist processes.

For comparison and tests, a simplified version ("LSTRAPRO") of Alaro-0 was used, applying the microphysics to resolved clouds and precipitations but keeping the old diagnostic deep convection scheme instead of using the 3MT package. In this case, the prognostic microphysics is fed by the sole resolved condensation, while the deep convection scheme only produces precipitation reaching the ground within a single timestep, plus a diagnostic contribution to the cloudiness.

This LSTRAPRO scheme was found to give satisfying scores compared to the operational Aladin, when running at 9km (however the inconsistency of maintaining two separate precipitation schemes would compromise the higher resolution results). This was taken as a reference to test the full 3MT package. At the beginning of 2007, the tests of the 3MT at 9km showed it produced insufficient precipitation, while the scores over a 10-days period were quite deceiving. There was an unacceptable positive bias of the mean sea-level pressure, an excess moisture at high levels, a cold bias at the lower level. The geopotential presented a "dipole" bias, positive below 500 hPa and negative higher.

The intensive research effort performed from April to September revealed several sources for these problems, including:

• bugs in the coding,
• unexpected behaviour, such as the evaporation by the resolved scheme of the convective cloud generated at the previous time step, because after advection it was assumed to mix with the entire grid-box,
• problems of numerical consistency,
• approximations in the formulation which together appeared more nocive than expected.

Various tools helped in this work, such as the verification chain (VERAL), the Single Column Unified Model (SCUM) or the DDH (Horizontal Domain Diagnostics) – all of which having been adapted to the new context of Alaro-0. Solutions have been developed to address all the above-mentioned weaknesses.

The scores of the present of Alaro-0+3MT at 9km are at least as good as those of the LSTRAPRO version, while the precipitation forecasts appear quite better.

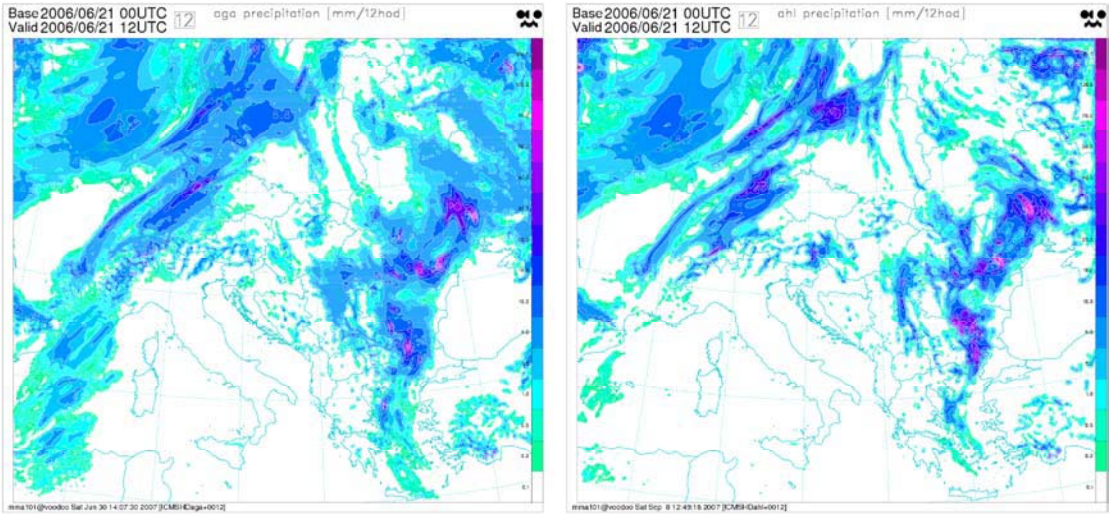


Figure 1: Precipitation maps with LSTRAPRO (left) vs 3MT (right). The structure of precipitation in operational Aladin was quite similar to the LSTRAPRO simulation.

Figure 1 shows that the excessive clouds and precipitation over Baleares and Western Mediterranean Sea produced by the LSTRAPRO (and the operational Aladin) schemes are no longer there with the 3MT scheme. The structure is more realistic, even though there is still a grid-point storm above Moldavia.

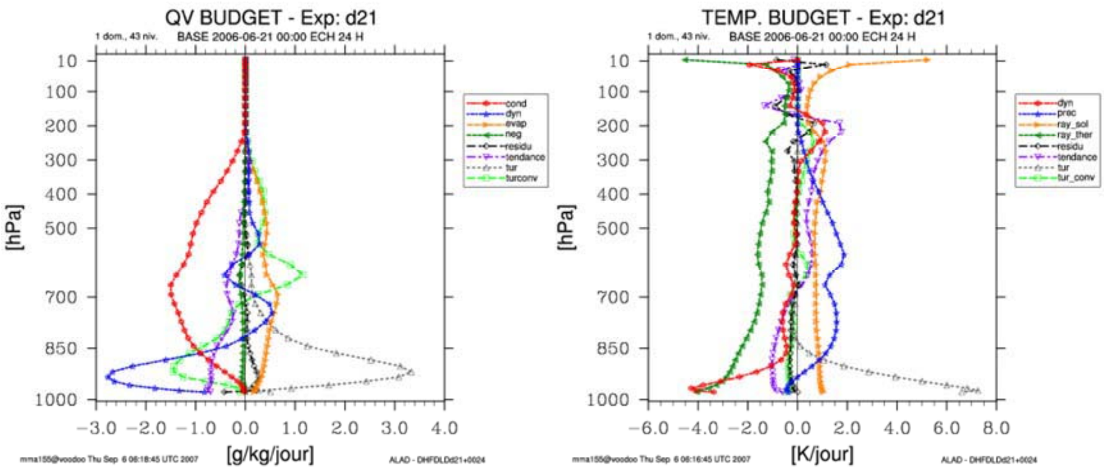
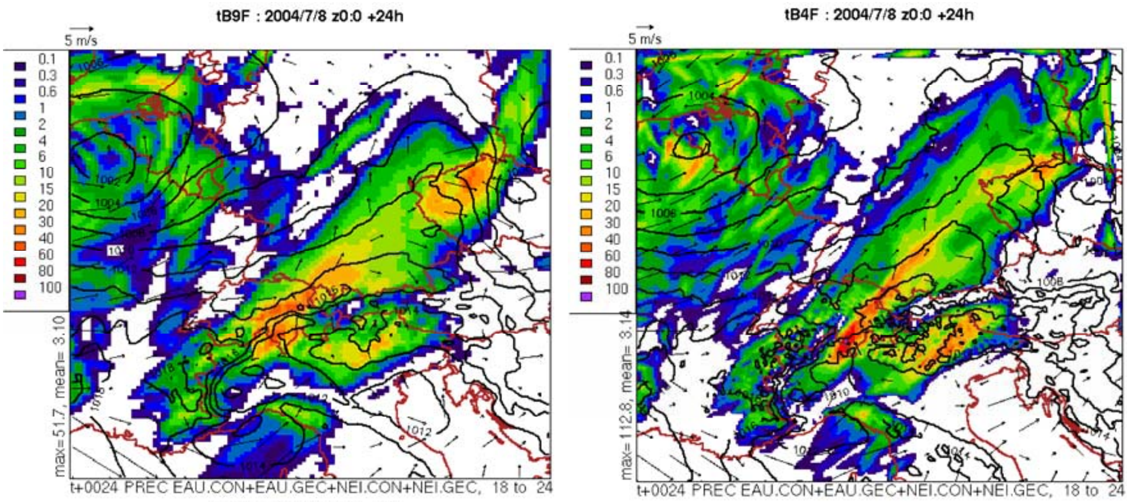


Figure 2: The DDH tool produces mean verticals budget over a chosen area, showing the components of the physical tendency. Left: components of the water vapour tendency (condensation, dynamical, precipitation evaporation, correction against negative water species, turbulent transport, convective transport). Right: components of the temperature tendency (dynamics, condensation/evaporation, radiation, turbulent transport, convective transport).

A few problems are still under investigation. On Figure 2, one observes an excessive moistening and heating around 600hPa by the deep convective transport. This is linked to the local reduction of the updraught mass flux around the triple point level, where precipitation melting cools the environment.

Tests at finer resolution have been started (Figure 3). The forecast at 4km, in the so-called grey-zone of the convection, stays consistent with the other scales and no bogus phenomenon appears at this resolution.



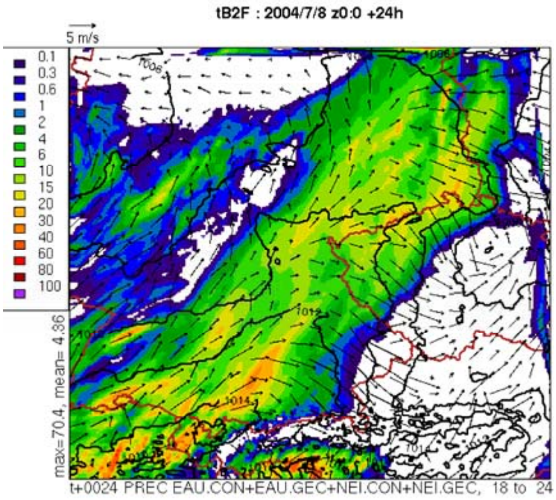


Figure 3: 6-hour precipitation forecast at 9km (top-left), 4km (top-right) and 2km (left, smaller area). Cold front over Bohemia/Bavaria.

References

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J.-M. Piriou, J.-L. Redelsperger, J.-F. Geleyn, J.-P. Lafore and F. Guichard, 2007. An approach for convective parameterization with memory, in separating microphysics and transport in grid-scale equations. accepted in J. Atmos. Sci.

ALADIN &LACE recent and ongoing Development on LAMEPS

Y. Wang, ZAMG, Austria
With contibution from Bellus, Hagel, Horanyi, Ivatek-Sahdan,
Kann, Kertesz, Mladek, Radu, Tascu, Wittmann, Wimmer

1. Overview of LAMEPS research activities in ALADIN countries

Within the ALADIN & LACE countries, there are some research activities on LAMEPS in the last year, which are summarised in the following:

- Austria: ETKF/ET, Breeding, Blending, downscaling, post-processing, LBC and physics perturbation
- Blegium: downscaling
- Croatia: downscaling
- Czech: downscaling, ALADIN Singular Vector
- Portugal: downscaling
- Romania: multi-model EPS, downscaling, LBC and physics uncertainties

2. LAMEPS operations in ALADIN&LACE

Since March 2007, the Limited Area Ensemble System **ALADIN – LAEF** (Fig. 1) runs in (pre-) operational mode . In the following, a description of the complete system will be given.

The main methodological ingredients of the ensemble generation are:
Initial perturbation: Downscaling of ECMWF Singular Vector Perturbation.
Lateral boundary perturbation: Coupling with the ECMWF EPS system.

The model – related part of the system is implemented as a quasi time-critical application on hpce at ECMWF and consists of the following steps (Tascu, 2006; Stjepan Ivatek-Šahdan, 2007):

a) Getting the relevant ECMWF EPS data from MARS archive
b) Conversion from ECMWF to ARPEGE File format (configuration e901)
c) Interpolation from ARPEGE to LAEF domain (configuration e927)
d) Dynamical downscaling (configuration e001)

Dynamical downscaling is performed for the first 16 EPS members, for the control run (T399) and for the high-resolution deterministic model (T799) (altogether 18 members).

e) Transfer of the output FA Files to ZAMG using ectrans
f) FA to GRIB-I conversion
g) Generation of products (EPSgrams, probability plots, poststamp charts, etc…)

The model version of Aladin used for downscaling is cycle31T1. It runs in hydrostatic mode with a horizontal resolution of 18 km and 37 vertical levels using Lopez-microphysics. The forecast covers the time range up to +54 hours and the operational procedure is performed twice a day (00 and 12 UTC model runs).

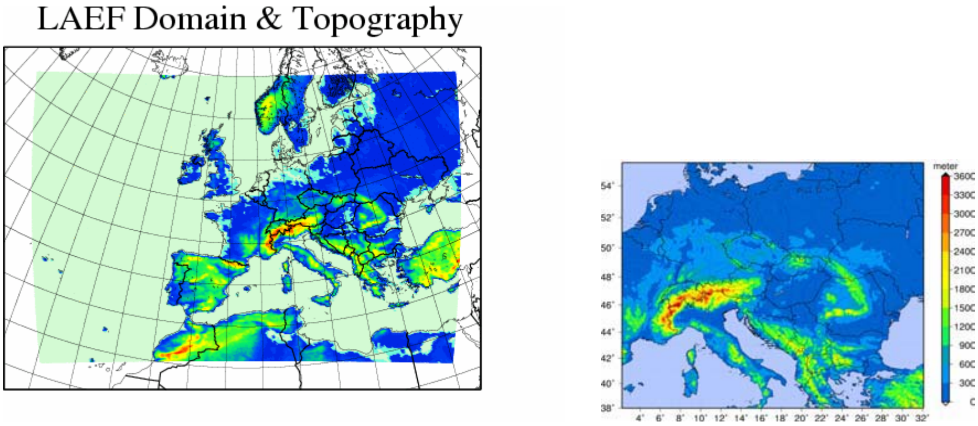


Figure 1: ALADIN–LAEF model domain and topography (left), post-processing domain (right) for products is identical to the LACE telecom domain.

The post-processing domain (Fig.1) covers the area 38.53N to 54.98N in latitude and 2.55E to 31.8E in longitude with 0.15 degrees grid spacing in both directions (regular lat-lon grid). The temporal resolution of post-processing is 3 hours from +6 to +54 hours.

The following types of plots are generated in operational mode:
EPSgrams, Probability plots, Poststamp charts, Ensemble Mean & Spread charts, Spaghetti plots

The elaborated parameters are:
500hPa Geopotential Height, 850hPa Temperature, 2m-Temperature, 2m-Maximum Temperature, 2m-Minimum Temperature, Precipitation, 10m Wind – Speed, 10m Wind – Gusts, CAPE, Mean Sea Level Pressure, 2m – Relative Humidity

EPSGRAMS

2 EPSgrams are produced for a variety of stations within Europe, reflecting the frequency distribution of the main weather parameters. Total Cloudiness, Total Precipitation, Wind speed and 2m – Temperature are shown in EPSgram-1, Convective Cloudiness, CAPE, Gust Speed and 2m – Relative Humidity in EPSgram-2 (Figure 2).

As generally applied in this type of plots, the box-and-whisker diagrams represent the minimum, 25%-percentile, median, 75%-percentile and the maximum of the ensemble distribution.

The temporal evolution of the downscaled control forecast (blue solid line), the downscaled high-resolution deterministic forecast (red solid line) and the operational ALADIN – AUSTRIA forecast (black solid line) are added to the distribution of the ensemble system.

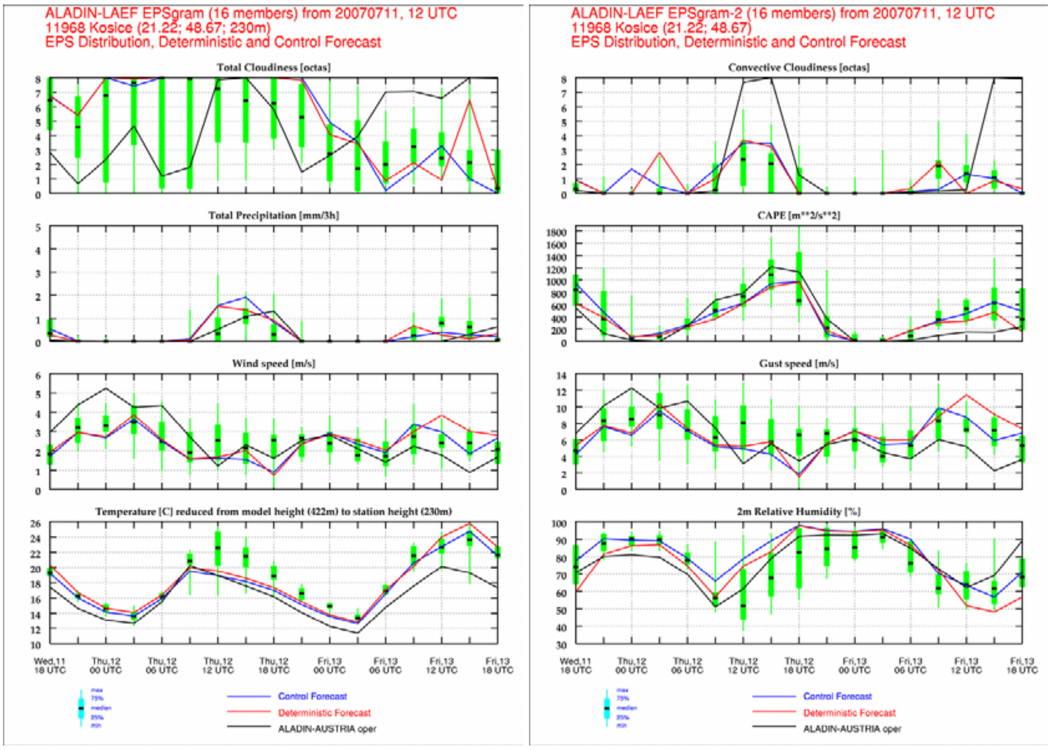


Figure 2: Example of EPSgram-1 and EPSgram-2 for Kosice (SK).

Ensemble Mean & Spread

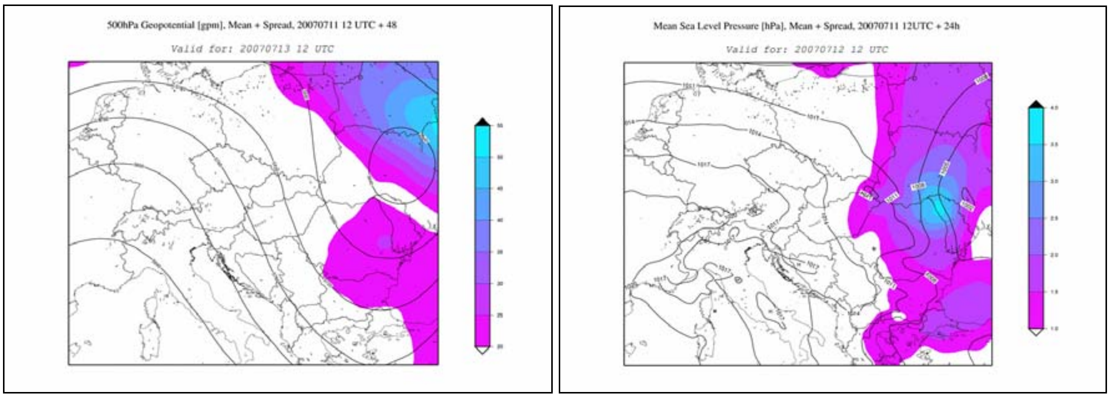


Figure 3: Example of Ensemble Mean & Spread: Left: 500hPa Geopotential Height, right: Mean Sea Level Pressure. The solid contour lines denote the ensemble mean, the coloured areas indicate the spread.

Spaghetti plots

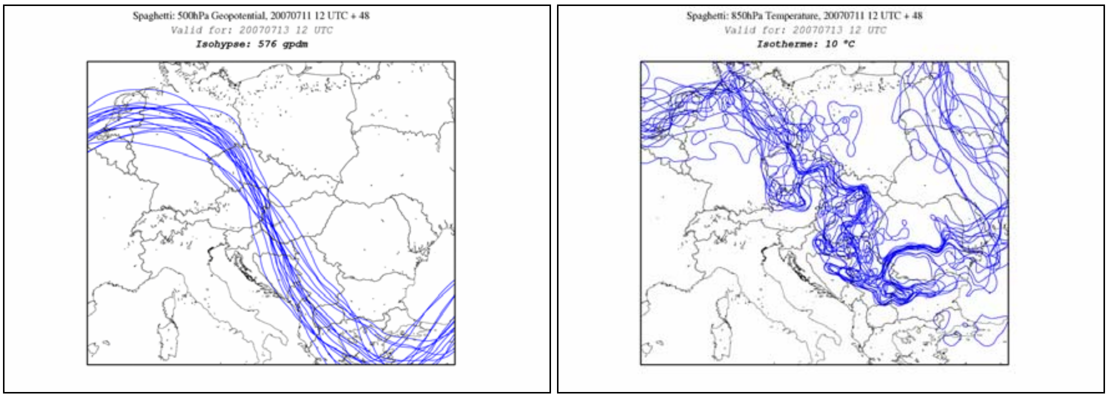


Figure 4: Examples of Spaghetti plots: Left: 500hPa Geopotential showing the Isohypses 576 gpdm of all ensemble members. Right: 850hPa Temperature showing the 10 degC isotherme of all ensemble members.

Poststamp charts

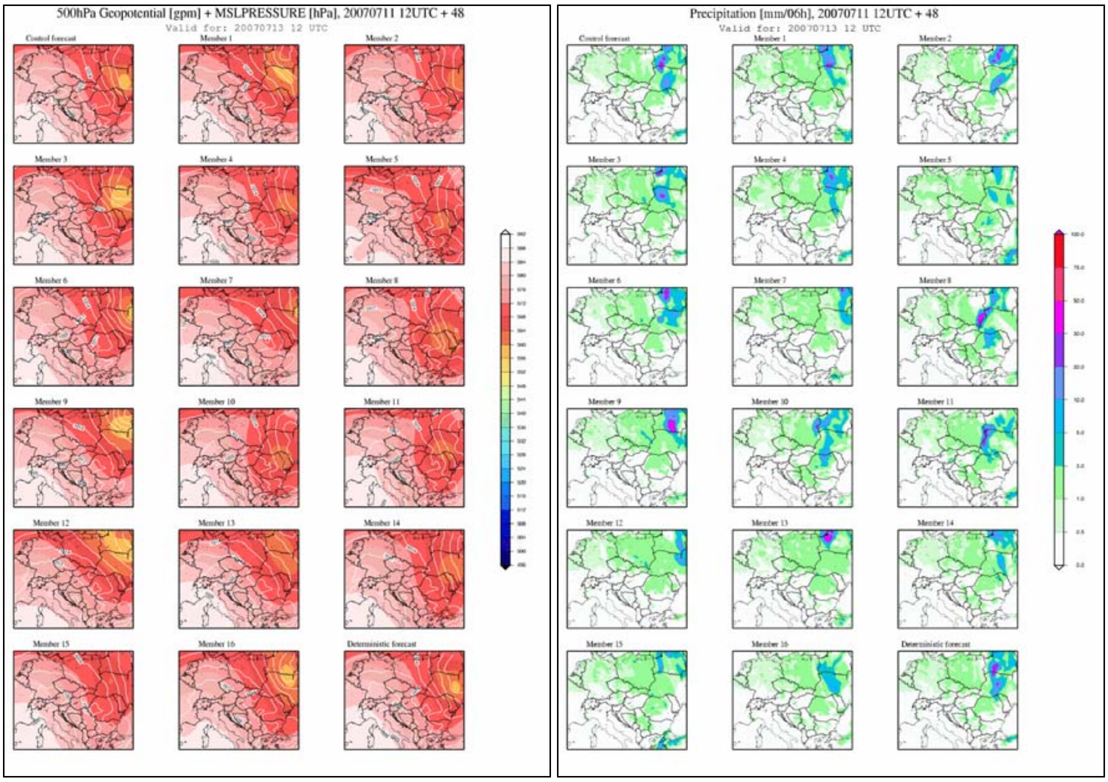


Figure 5: Examples of pststamp charts: Left: Forecast for 500hPa Geopotential Height (coloured areas) and Mean Sea Level Pressure (contour lines) for all ensemble members + control forecast + (downscaled) high resolution deterministic forecast. Right: 6 hours accumulated precipitation forecast for all ensemble members + control forecast + (downscaled) high resolution deterministic forecast.

Probability plots

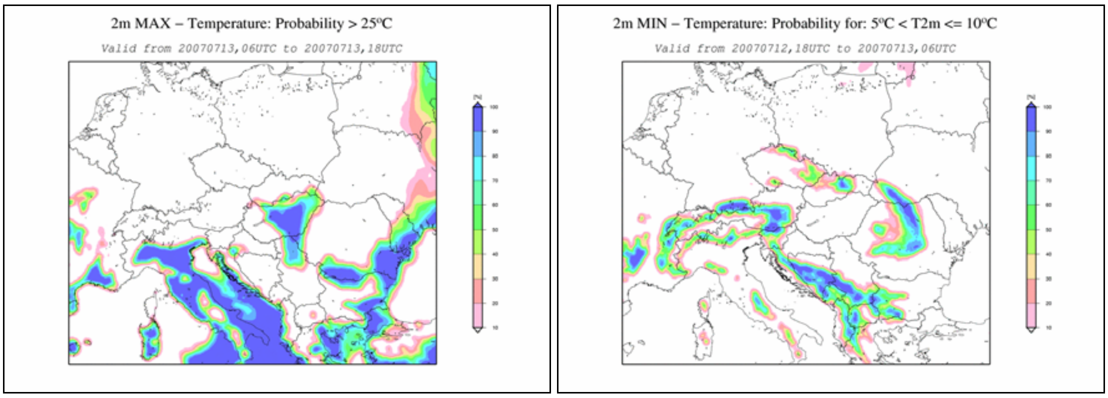


Figure 6: Examples of Probability plots: 2m Maximum Temperature exceeding 25°C (left) and 2m Minimum Temperature between 5°C and 10°C (right) within a certain time range.

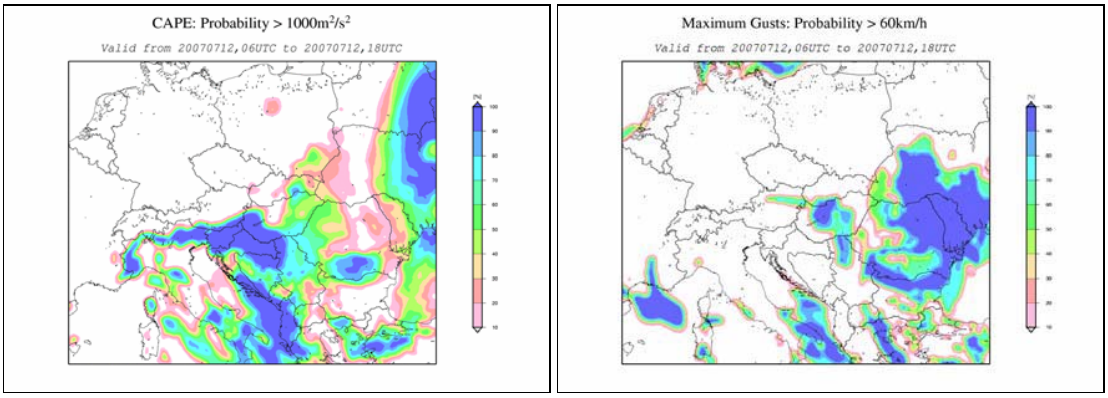


Figure 7: Examples of Probability plots: CAPE exceeding 1000m²/s² (left) and Gusts exceeding 60 km/h (right) within a certain time range.

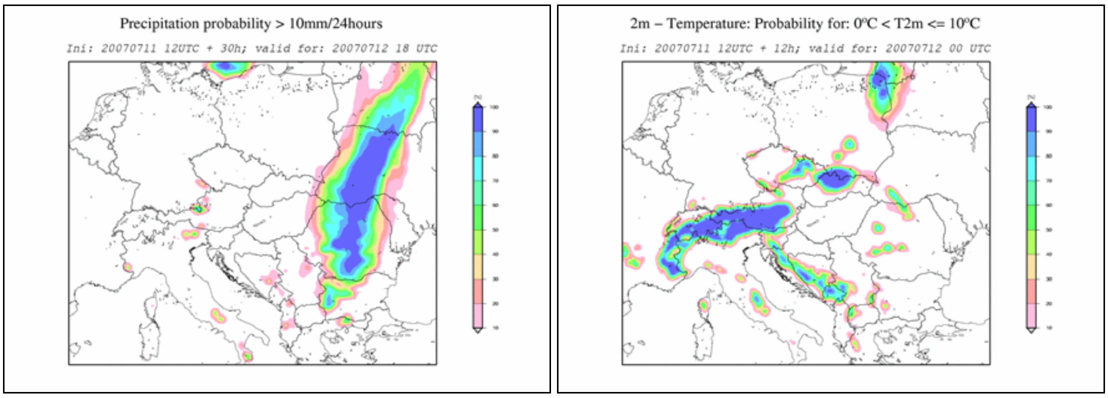


Figure 8: Examples of Probability plots: 24 hours accumulated precipitation forecast exceeding 10mm within a certain time range (left) and 2m Temperature between 0°C and +10°C at a certain verification time (right).

The products shown above are available on RC LACE Homepage in real time.

3. LAMEPS research and development in ALADIN&LACE

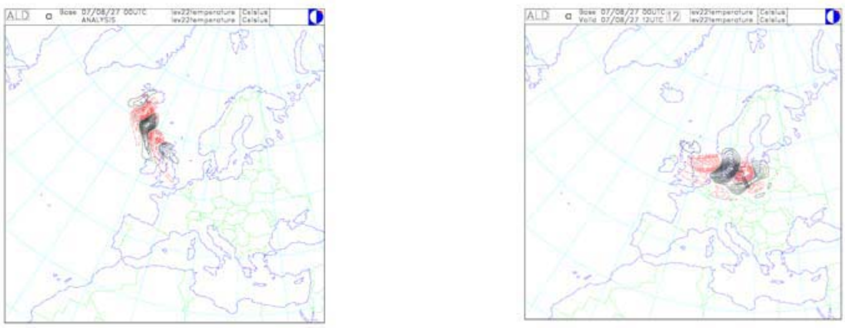
The efforts for research and development on predictability are focused on dealing with the uncertainties in analysis. Other works related LAMEPS, like dynamical downscaling, post-processing and common verification have been also started.

3.1 Dealing with uncertainties in initial condition

- **ALADIN Singular Vector (** by Mladek, A. Horanyi and E. Hagel**)**

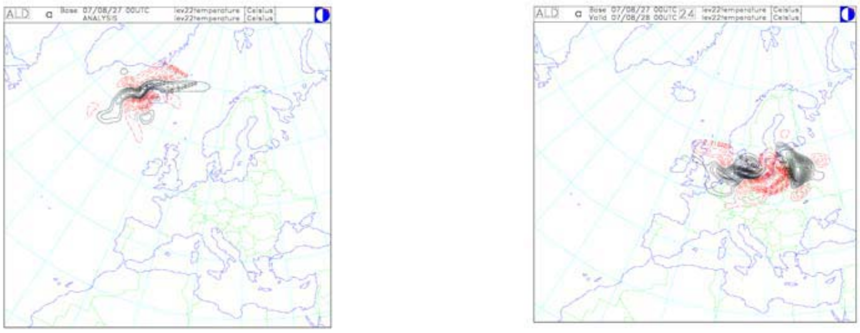
Work has continued with the ALADIN singular vectors. On the one hand the experiments concentrated on technical issues (e.g. CPU and memory usage were analysed). In the laboratory phase of the GLAMEPS (Grand Limited Area Model Ensemble Prediction System) project everything will run at ECMWF (on the supercomputer *HPCE*) therefore all the necessary components of running the singular vector configuration had to be installed and tested there. (At the same time the configuration was tested on the new supercomputer of Météo-France.)

On the other hand experiments were made to test the sensitivity with respect to the choice of optimization time (12 and 24 hours were tried) and also with respect to the resolution (22 and 44 km were tested) used during the singular vector computations. All the necessary files were created on the GLAMEPS domain, but due to the high computational costs, the (smaller) LACE domain was used as optimization area.



a.) ***b.)***

Figure 9: Example of ALADIN singular vectors. Date of the experiment: 27 August 2007, 00UTC. All the files were created for the GLAMEPS domain but the optimization area was the LACE domain. The optimization time was 12 hours. Resolution used for the computations was 44 km. The parameter visualized is temperature on model level 22 with a contour interval of 0.01 degrees. Fig. a.) Singular vector at time T+0 hours. Fig. b.) Singular vector at time T+12 hours (evolved singular vector).

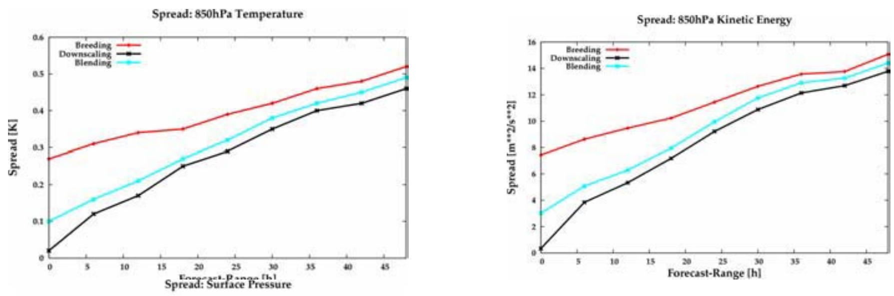


a.) *b.)*

Figure 10: Example of ALADIN singular vectors. Date of the experiment: 27 August 2007, 00UTC. All the files were created for the GLAMEPS domain but the optimization area was the LACE domain. The optimization time was 24 hours. Resolution used for the computations was 44 km. The parameter visualized is temperature on model level 22 with a contour interval of 0.01 degrees. Fig. a.) Singular vector at time T+0 hours. Fig. b.) Singular vector at time T+24 hours (evolved singular vector).

- **Blending ARPEGE PEARP and ALADIN LAEF (**by M. Bellus**)**

Spectral blending on ARPEGE singular vector members and ALADIN Breeding members has been tested. The first blending results are quite satisfactory (shown in Fig. 4), since the blended initial states inherited the large scale perturbations from ARPEGE singular vectors (which were not present in ALADIN breeding files), while still kept the small scale perturbations generated by breeding. The main profit from the blending procedure is, that the blended initial conditions (needed for further limited area ensemble forecast integration) suppose to be now more compatible with the appropriate APREGE PEARP coupling files. The Fig. 11 show the comparison of the spread of blending, breeding and downscaling. It is quite clear that blending has more spread than the downscaling, and the over-diversity with breeding at the first forecast hours has been reduced.



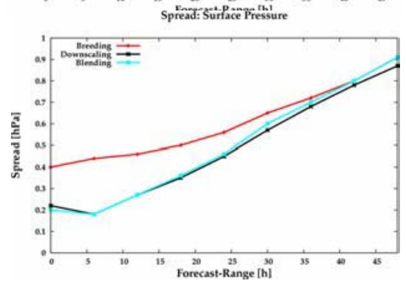


Figure 11. Spread of 850hPa Temperature Kinetic energy and surface pressure for Breeding, downscaling and Blending.

3.2 **Dynamical downscaling of ARPEGE EPS** (by Mladek)

In the recent studies there was found generally no real improvement when using direct downscaling of the global ensemble system (PEARP) by the local area model with high resolution ALADIN. Mainly 500 hPa geopotential, 850 hPa temperature, mean sea level pressure and 10 meter wind speed were examined in detail in those studies. In our work we are trying to evaluate the influence of the same downscaling on the specific situations where our local model had the biggest problems with precipitation forecast for Czech republic during last three years. The probabilistic verification of 6 and 24 hour cumulated precipitation for 17 chosen cases is presented. The aim of the study is to find out if the downscaling of the global ensemble forecasts by the local model can improve precipitation forecast for those difficult situations and to compare resulting probabilistic forecasts of ALADIN model to the global ones provided by ARPEGE model. It is shown that the direct downscaling in our test cases made worse most of the computed probabilistic scores. It can be said further that there is prevailingly no real improvement neither quantitative nor qualitative when exploring each case individually. The best results are obtained with the combination of both model ensembles global and local. (Fig. 12)

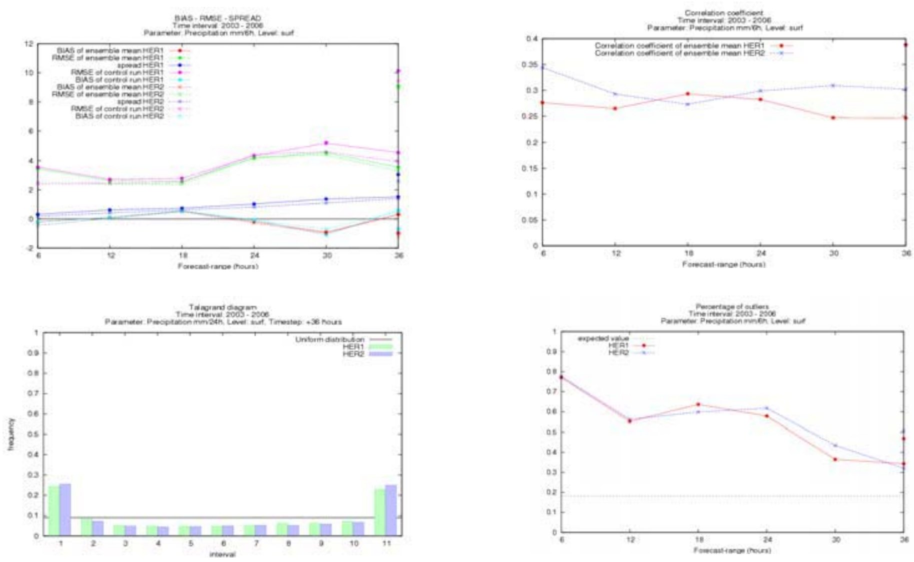


Fig. 12 Verfication results of downscaling ARPEGE EPS. (Mladek 2007)

3.3 **Common verification package** (Kann, Mladek and Hagel)

A common verification package for the EPS forecast has been developed in frame of LACE cooperation. It is designed for the simple, stand-alone and easy use. Table 1 shows the main feature of this common verification package.

Software	verification: FORTRAN 90 graphics: gnuplot
Question of „TRUTH“	surface fields: SYNOP upper air fields: analyses (e.g. ECMWF or ARPEGE)
Data format of forecasts	GRIB I
Data format of analyes	GRIB I
Data format of SYNOP observations	ASCII
Expected surface parameters to be verified	2 meter temperature, 10 meter u-,v- wind components and wind speed, 6, 12 and 24 hours accumulated total precipitation, 2 meter relative humidity or 2 meter dewpoint temperature, mean sea level pressure
Expected upper level parameters to be verified	temperature, u-,v- wind components, wind speed, geopotential, relative humidity
Matching forecasts and observations	When using observations, verification should be performed at the observation location. Forecasted values should be interpolated to the observation point for every variable, except for precipitation and 2 meter dewpoint temperature. In these two cases it is preferable to use the value of the nearest grid point.

Table 1. Main features of the LACE common verification package.

The verification methods, respectively scores, implemented in the package are:

- RMSE and BIAS of the ensemble mean, the control forecast and individual members
- Standard deviation of the ensemble members (spread)
- Talagrand diagram and percentage of outliers
- Ranked Probability Score (PRS), Ranked Probability Skill Score (RPSS)
- Continuous Ranked Probability Score (CPRS), Continuous Ranked Probability Skill Score (CRPSS)
- Brier score (BS), Brier Skill Score (BSS), Reliability
- ROC curve and the area under the ROC.

3.4 Participation on GLAMEPS

Works within ALADIN &LACE countries have been done for the implementation on GLAMEPS. The details can be found in the contribution of T. Iverson in this Newsletter.

4. Conclusions and future plan

Within ALADIN & LACE works have been done for developing ALADIN-LAEF, ALADIN SV and Blenidng techniques. Focuses have been put on dealing with uncertainties in initial conditions, Also the dynamical downscaling of global EPS system, like ECMWF and ARPEG has been investigated. A common verification package has been also developed. The results can be summarized as follows:

a. ALADIN LAEF has been put into pre-operational, and provides the products to all the LACE partners.

b. Blending method seems to be promising. It is more compatible with the appropriate APREGE EPS coupling files.

c. ALADIN SV has been computed. More experiments on the use of it on LAMEPS needs to be done..

d. A common verification package on EPS has been developed.

More works are planned for the next years, the focuses will be on the ALADIN-LAEF, ALADIN SV, and blending method, ECMWF EPS downscaling etc. Post-processing, like bias correction will be also carried out.

Acknowledgements

The work is part of the LACE development on predictability of 2006. I gratefully acknowledge all the LACE colleagues who has involved the LACE LAMEPS development in the last years.

Reference

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Ivatek-Šahdan, S. 2007: Downscaling ECMWF EPS for ALADIN. ***LACE Report***, available by autor and LACE.

R Mladek, 2006: The common verification package for evaluating of ensemble forecast. ***LACE Report***. available by autor and LACE.

R Mladek, 2007: Singular vectors in ALADIN model. ***LACE Report***. available by autor and LACE.

R Mladek, 2007: Downscaling of ARPEGE global ensembles (PEARP) by ALADIN model-Heavy rain case study. ***ALADIN Newsletter 32***.

The Performance of the MOGREPS Regional Ensemble

Sarah Beare[1], Neill Bowler[1], Marie Dando[1]

[1]*Met Office, Fitzroy Road, Exeter, Devon, EX1 3PB, United Kingdom*

Sarah.Beare@metoffice.gov.uk

1. Introduction

MOGREPS (Met Office Global and Regional Ensemble Prediction System) is an ensemble prediction system (EPS) designed specifically for short-range weather forecasting. As the name implies, MOGREPS provides both a global and a regional ensemble capability, but the main interest in MOGREPS is in performance of the higher resolution regional ensemble for high impact events. The global ensemble exists mainly to provide the lateral boundary conditions for the regional ensemble, but it also provides initial condition perturbations for the MOGREPS-15 day ensemble which runs at ECMWF as part of the THORPEX TIGGE research project.

The regional ensemble covers the North Atlantic and Europe (NAE) domain shown in Figure 1. The resolution of both ensemble systems has been chosen to be approximately half the resolution of the corresponding deterministic models in the Met Office operational suite. The global ensemble runs at N144 (~90km) resolution with 38 vertical levels which compares with the deterministic global model which is run at N320 (~40km) with 50 vertical levels. The regional ensemble is run at 24km resolution and 38 vertical levels, which compares with 12km resolution and 38 vertical levels for the deterministic model. Both ensembles are run with 24 members (an unperturbed low-resolution control plus 23 perturbed members).

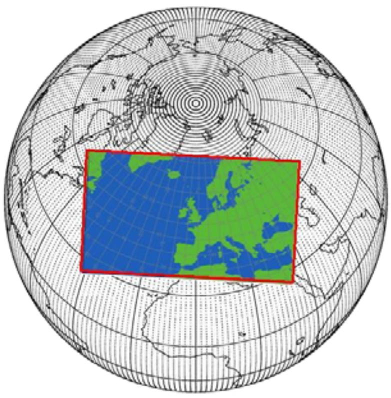

Figure 1: Map showing the domain of the Met Office's models. The NAE model covers much of the north Atlantic and Europe, and is bounded by the red box.

The run times of the ensembles are offset by 6 hours to distribute the computing burden evenly through the day. The global ensemble runs at 00 and 12UTC and the regional ensemble at 06 and 18UTC. Thus the regional ensemble takes its

LBCs from a 6-hour forecast of the global ensemble. For a short-range ensemble to be useful in an operational framework it is critical that the forecasts are available as early as possible after data-time, and this arrangement allows the regional ensemble to be run immediately after the new NAE analysis becomes available (rather than having to wait for the global ensemble to run first). MOGREPS-G (global) forecasts are run to 72 hours ahead and MOGREPS-R (regional) forecasts are run to 54 hours to fully encompass Day 2.

The initial condition perturbations applied in the global ensemble system are calculated using the Ensemble Transform Kalman Filter (ETKF) (Bishop *et al.,* 2001). The perturbations are rescaled to ensure they are consistent with forecast errors using a variable inflation factor. The ETKF provides a set of perturbations which are added to the Met Office 4D-Var analysis to provide the initial states for ensemble members. Further details regarding the implementation of the ETKF in MOGREPS-G can be found in (Bowler et al., 2007a). An important consideration in the design of the MOGREPS system was the issue of consistent perturbations across the lateral boundary between the global and regional ensembles. Until the end of May 2007 initial condition perturbations to the regional ensemble were interpolated from the global ensemble at T+6. However, the perturbations were large scale, and unrealistically large spread was observed at upper levels. The initial condition perturbations for the regional ensemble are now generated using a regional ETKF. The perturbations for the regional ensemble now provide a better representation of shorter length scales and the spread at upper levels is now approximately correct. Unfortunately a lack of spread in surface parameters is now evident.

Uncertainty due to model error is addressed in MOGREPS through stochastic perturbations to the model, mainly to the parameterised model physics. Three schemes are implemented in the global ensemble, but only the random parameters (RP) scheme is currently used in the regional ensemble. The RP scheme targets uncertainty due to the choice of tuneable parameters in a number of parameterisation schemes within the Met Office Unified Model (UM) (for example, the gravity wave drag, convection, large scale precipitation and boundary layer schemes). Nine parameters are used in the RP scheme, their standard values are based on empirical results but are subject to uncertainty. In the standard UM implementation parameter values are held constant at a chosen value, but under the RP scheme they are allowed to vary smoothly within the error bounds of the empirical estimation of the parameter values as specified by experts in the field. The parameter values are updated every 3 hours using a lag-1 autocorrelation process. It is important to emphasise that uncertainties in initial condition and model are not independent, as the impact of stochastic physics perturbations is propagated into the initial condition perturbations of the next cycle through the ETKF. Further details regarding the design of the MOGREPS ensembles can be found in Bowler et al. (2007a,b).

2. MOGREPS Verification

The MOGREPS ensembles have been run in semi-operational mode since August 2005 and products have been available to forecasters via a comprehensive web display system. The aim of the verification presented here is to objectively assess the quality of the products that are generated from the MOGREPS system. The results are focussed on forecasts of surface parameters from MOGREPS-R - further results are presented in Bowler et al., (2007c). Section 2.1 presents an analysis of the spread and skill of MOGREPS-R forecasts of screen level temperature and 10m wind. Sections 2.2 and 2.3 consider the performance of probabilistic forecasts of screen level and precipitation forecasts respectively.

2.1 Spread and skill

One of the key aims of an ensemble from a forecaster's perspective is to predict the skill of the deterministic forecast. Ideally, when the spread of the ensemble is small then the forecaster can have confidence that the deterministic forecast will be reliable, whereas when the spread is large it is more important to express uncertainty and make allowance for errors. There are two aspects to spread and skill. Firstly the spread of the ensemble should match the error in the ensemble mean forecast on average. This is a common assessment, based on finding the average spread and error of the ensemble forecast for a particular lead time. The second type of assessment looks at whether the spread of the ensemble provides an accurate prediction of the error in the ensemble mean on any given instant by looking at the correlation between the spread and error.

To investigate the spread-skill relationship of the MOGREPS regional ensemble, two periods were investigated, winter 2006/7 (DJF) and summer 2007 (JJA). For both of the three month periods 30 hour forecasts of 1.5m temperature and 10m wind speed were considered for the 55 UK sites stored in the station-based verification system.

A bias correction was applied to each ensemble member prior to calculating spread-skill results to ensure that there was no bias in the ensemble mean forecast. The standard deviation of the bias-corrected ensemble members for each location on each day, were calculated. A strong correlation would not necessarily be expected when comparing the standard deviation of each individual event against the value of the ensemble mean error and it can be misleading, discussed in Houtekamer (1993). Therefore the events are binned according to the value of their forecast standard deviation. Each standard deviation bin contained an equal number of events so the spread of the standard deviation contained in each bin varied. This avoided the bins containing the largest standard deviation values being determined by a small number of events. The average value of the standard deviation in each bin was then compared to the root mean square error (RMSE) for the events in the bin, providing a robust measure of the spread-skill relationship.

To help evaluate the spread-skill relationship of MOGREPS-R, these results were compared to results from two other, artificially generated ensembles. The first was an ensemble which had no spread-skill relationship and is referred to as the 'no skill' ensemble. The second was an ensemble which had 'perfect spread' which means the observation was always contained within the ensemble distribution. Comparing the MOGREPS-R results with the results from these other two ensembles illustrates the quality of its spread-skill relationship.

In the 'perfect spread' ensemble observation error is not a component of the RMSE because the pseudo-observation is the forecast from one of the ensemble members. Therefore, to allow a fair comparison the RMSE of the MOGREPS-R the observation error was estimated for temperature and wind speed and the RMSE value in each bin was then corrected ($RMSE_c$) by removing the observation error contribution:

$$RMSE_c = \sqrt{RMSE^2 - ObsErr^2}$$

Finally, to remove the effect of MOGREPS-R being under or over-spread the RMS of the standard deviations (RMSS) of all the events was calculated. This was then compared to the $RMSE_c$ for all the events. For a correctly spread ensemble RMSS should be equivalent to $RMSE_c$, so using this information a correction factor was applied to the standard deviation of each event.

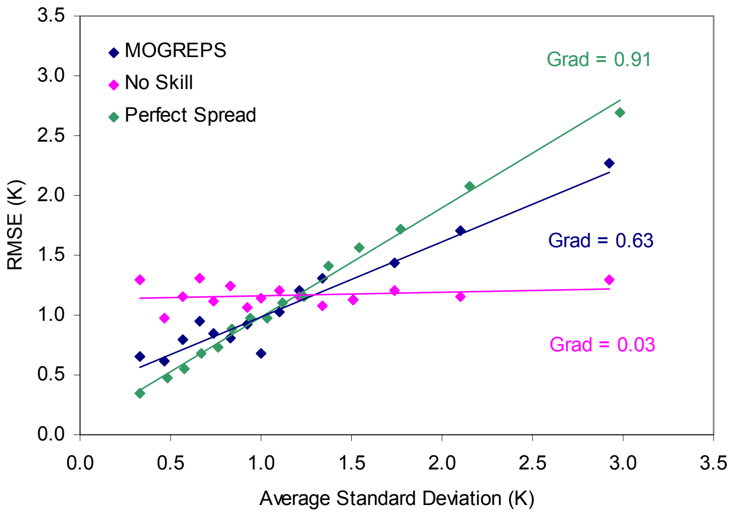

Figure 2. The average standard deviation in each bin plotted against the RMSE in each bin, corrected for observation error. Values for temperature (K) in DJF at T+30.

The results for the DJF 06/07 screen level temperature and wind speed are shown in figures 2 and 3 respectively. Whilst the MOGREPS-R results (blue) do not follow the perfect ensemble (green), the results indicate that there was indeed a spread skill relationship during DJF 06/07; the results for JJA 2007 (not shown) are less encouraging and do not show a spread-skill relationship for temperature or wind speed. This may be related to the change in season or to recent changes applied to the forecast system, for example the introduction of the ETKF in the regional ensemble. The differences between the MOGREPS-R and the 'perfect spread' ensemble reflect the fact that the MOGREPS-R ensemble has limited members and that the perturbation strategies do not adequately sample the uncertainty in surface variables.

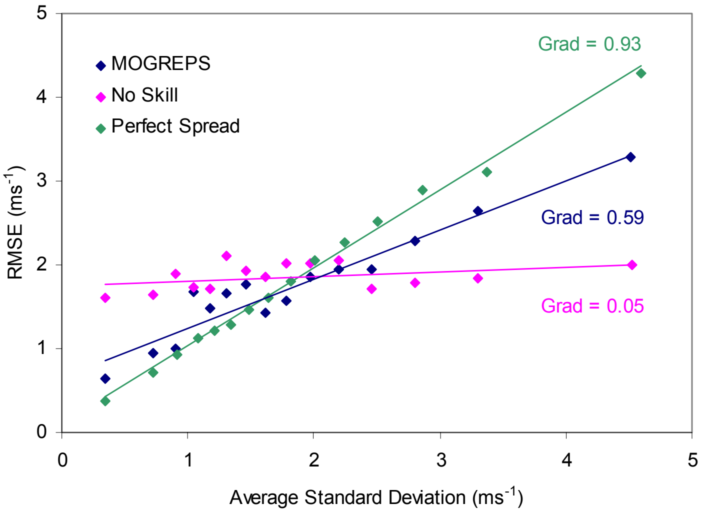

Figure 3. The average standard deviation in each bin plotted against the RMSE in each bin, corrected for observation error. Values for wind speed (ms^{-1}) in DJF at T+30.

2.2 Temperature verification

The results presented here are calculated within the station-based verification system which verifies the ensemble forecast data (which has been interpolated to the station location) against the observations at each site. The station-based system provides a capability to compare the performance of MOGREPS-G and MOGREPS-R forecasts with forecasts from the ECMWF EPS as well as comparing the performance of raw and post-processed forecast data. MOGREPS Verification is performed for a set of 79 sites across the UK and Europe, these have been chosen to ensure that forecast data can be compared against ECMWF forecasts. It should be noted that the ECMWF forecasts that are presented to forecasters and used for verification purposes are disseminated to the Met Office at 1.5 degree resolution. Therefore the results will not reflect the performance of the ECMWF model at its full resolution and the results should be viewed in this context. All results presented are for the validity times of 0Z and 12Z combined. If, on any given occasion forecasts are not available from any one of the forecasting systems, then the verification is not calculated for any system. The Brier skill score and its decomposition into reliability and resolution components, as detailed by Bowler et al., (2007b), are calculated from reliability tables that have been generated for each day of the verification period. The reliability tables were bootstrap re-sampled, using the percentile method, to provide 90% confidence intervals on the statistics calculated.

Figure 4 shows the Brier Skill score and its decomposition for screen level temperature greater than 10^{o}C respectively, for the period 6 November 2006 – 28 February 2007. The MOGREPS-R ensemble (green) is the most skilful, and the MOGREPS-G ensemble (red) the next most skilful. The differences are significant at the 0.05 level for all distinctions, except for the difference between the global and ECMWF ensembles. After post-processing via KFMOS, the forecasts from all three ensembles are improved (see figure 5). The ECMWF ensemble benefits most from the post-processing, as would be expected. None of the differences between the ensemble systems are significant in this case.

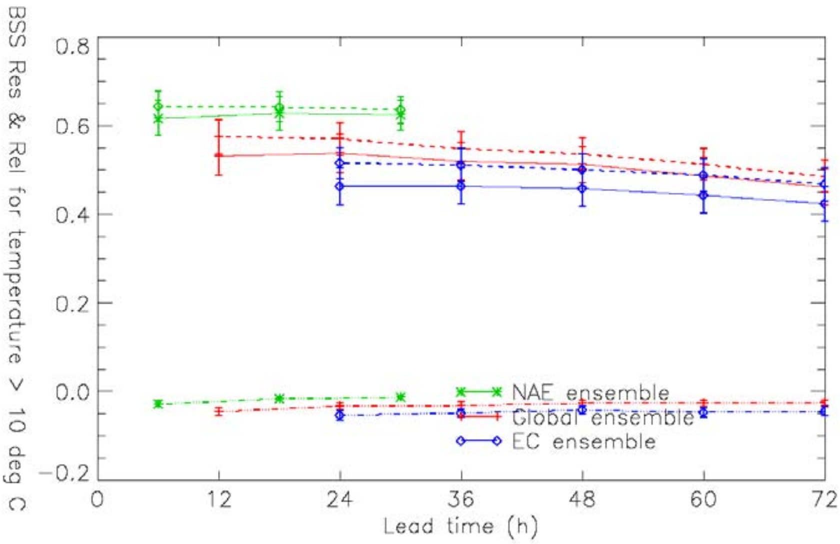

Figure 4. Brier skill score (solid), and reliability (dash-dot) and resolution (dashed) components for the MOGREPS-R (NAE), MOGREPS-G and ECMWF ensembles for forecasts of screen level temperature greater than 10°C. The verification period is from 6 November 2006 to 28 February 2007.

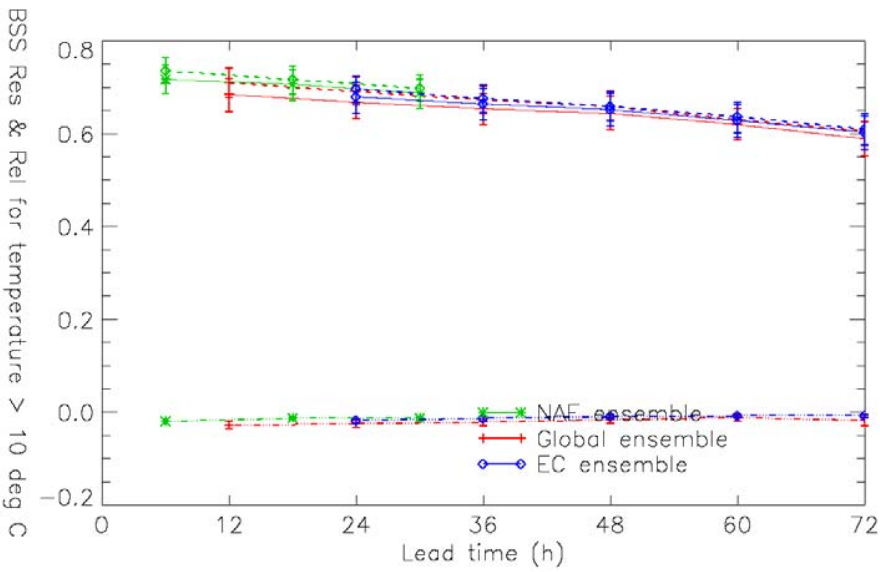

Figure 5. Brier skill score (solid), and reliability (dash-dot) and resolution (dashed) components for the MOGREPS-R(NAE), MOGREPS-G and ECMWF ensembles for forecasts of screen level temperature greater than 10°C. The verification period is from 6 November 2006 to 28 February 2007. All the forecasts have been post-processed using the KFMOS bias correction.

2.3 Precipitation performance

Figures 6 and 7 show the Brier skill score, reliability and resolution for the three ensemble forecasts. The results are for probability forecasts of 12h accumulated precipitation greater than 0.5 and 5 mm respectively. For accumulations of 0.5 mm (figure 6) the MOGREPS-R ensemble (green) has a similar resolution (dashed line) to the ECMWF ensemble (blue), which is better than MOGREPS-G, though not significantly. MOGREPS-R is significantly more reliable (dash-dot line) than MOGREPS-G (red), which is significantly more reliable than the ECMWF ensemble. Overall, this means that MOGREPS-R is significantly more skilful (solid line) than MOGREPS-G and ECMWF ensembles, which have approximately equal skill.

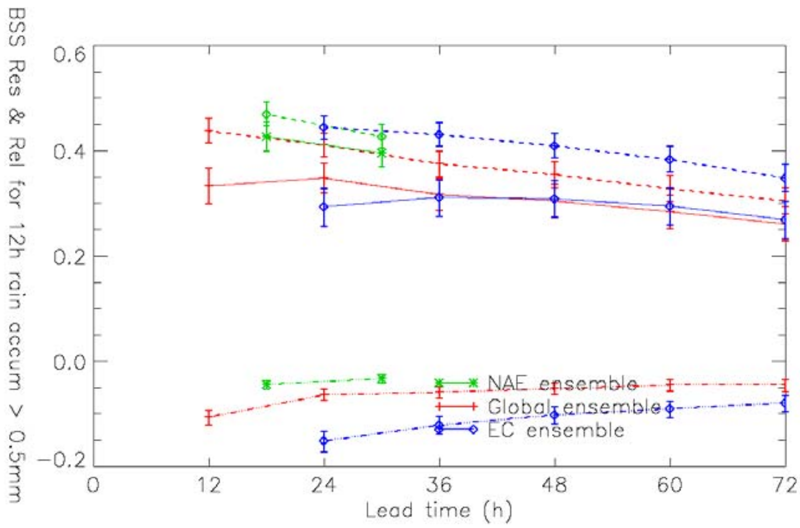

Figure 6. Brier skill score (solid), and reliability (dash-dot) and resolution (dashed) components as defined in equations 3.5 and 3.6 for the regional (NAE), global and ECMWF ensembles for forecasts of 12h accumulated precipitation greater than 0.5 mm. The verification period is 1 July 2006 to 31 March 2007.

The results for higher precipitation thresholds are similar to those for 0.5 mm accumulation. As the threshold moves to higher precipitation values the ECMWF ensemble becomes more reliable. At a threshold of 5mm (figure 7) the regional and ECMWF ensembles perform similarly and both are significantly more skilful than the global ensemble.

The reliability and sharpness diagrams for 12h accumulated precipitation greater than 0.5 mm for forecast lead times of T+30 (NAE) and T+36 (global and ECMWF) are shown in figure 8. All three ensemble systems are over-forecasting the occurrence of light precipitation – the regional and global ensembles having similar levels of bias, and the ECMWF having a worse bias. Since the verification is performed against a series of stations, some over-forecasting of light rain may be expected (since the precipitation would need to be down-scaled to a specific site). Thus, the bias seen in the global ensemble would be expected to be greater than for the regional ensemble (since it is lower resolution) and the ECMWF ensemble would be worst affected (since it is transferred to the Met Office at 1.5 degree resolution). In fact, results from the area-based verification system against Nimrod analyses (not shown) indicate that the regional ensemble is not over-forecasting light rain, when the observations are averaged over grid-boxes of similar size to the model grid.

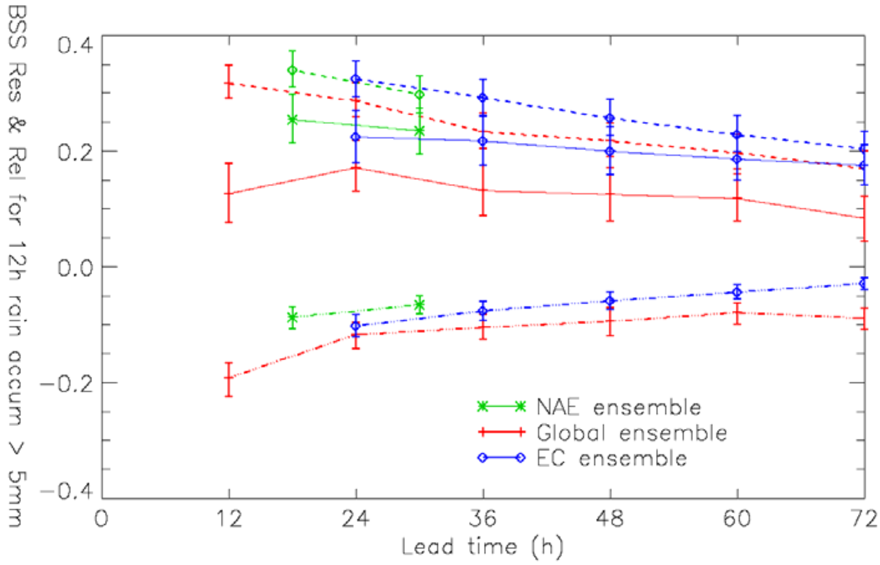

Figure 7. Brier skill score (solid), and reliability (dash-dot) and resolution (dashed) components for the regional (NAE), global and ECMWF ensembles for forecasts of 12h accumulated precipitation greater than 5 mm. The verification period is 1 July 2006 to 31 March 2007.

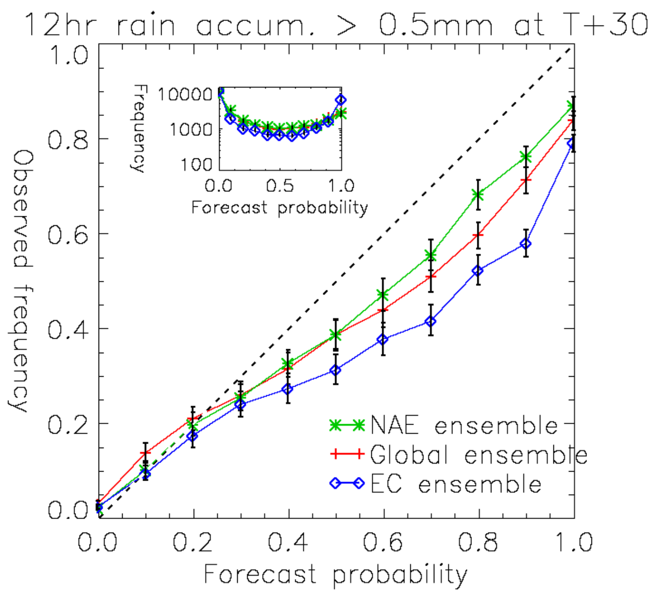

Figure 8. Reliability and sharpness diagrams for forecasts of 12h accumulated precipitation greater than 0.5 mm over the months of July 2006 to March 2007. The lead time of the forecasts is T+36 (global and ECMWF) and T+30 (NAE).

3. Summary

The MOGREPS ensemble system has been running in pre-operational trial mode since September 2005. The performance of MOGREPS has been assessed using a number of different methods. Overall, these results show that the MOGREPS ensembles are providing a useful contribution to Met Office forecasts and the ensemble is expected to become fully operational in Summer 2008. The regional ensemble is at least competitive with the ECMWF ensemble, and on many occasions its performance is superior. This is a remarkable achievement for such a new system, and justifies the decision to implement MOGREPS operationally to meet customers' needs. Furthermore, there is a strong relationship between the spread and the skill of the ensemble for some variables during the winter season. There still remain a number of areas where the MOGREPS ensembles can be improved, such as the lack of spread in the ensemble at the surface, leading us to expect that the skill of the MOGREPS ensembles will increase in future. Future plans include vertical localisation in the ETKF to improve perturbation scale with height and perturbations to the lower boundary of the model through perturbations to soil moisture. Following the next super-computer upgrade in 2009 it is planned to run the global ensemble at 60km and the regional ensemble at 16km resolution, both with 70 levels in the vertical. A further increase in the resolution of the regional ensemble to 12km is planned for 2011.

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EPS activities in COSMO

C. Marsigli, A. Montani, T. Paccagnella

ARPA–SIM, Bologna, Italy

1 Introduction

In recent years the COSMO Consortium has carried out a significant amount of activity on Ensemble Prediction Systems. A part from the projects on this subject that have been developed by single COSMO countries, a big common effort has been made in order to provide the Consortium with shared ensemble systems at the mesoscale.

Since November 2002, the COSMO-LEPS mesoscale ensemble is being daily running at ECMWF, developed and maintained by ARPA-SIM. The Billing Units needed to run the system are made available by the COSMO countries which are ECMWF members, which have benefited in turns of COSMO probabilistic forecasts on their areas at an early medium range (up to 5 days). Furthermore, a continuous evaluation of the system performance by the COSMO partners (Marsigli et al., 2005) and interesting discussions during the COSMO General Meetings have greatly contributed to the system development and improvement.

In 2006 a new COSMO project on ensemble is started, the COSMO-SREPS Priority Project, aiming at developing within the Consortium a COSMO ensemble system for the short-range, to be used both for short-range forecasts and for data assimilation purposes (Marsigli et al., 2006). Different sources of forecast errors have been considered, trying to describe the uncertainties affecting the scales of interest in the high-resolution quantitative precipitation forecast at the considered time range. To take into account the error in the initial and boundary conditions, the Multi-Analysis Multi–Boundary SREPS system of INM has been chosen as driving ensemble. To take into account smaller-scale uncertainties and errors within the model formulation, the values of the parameters included in the schemes for the parameterisation of the sub-grid processes are randomly modified from run to run within their range of variability.

Some results from the COSMO-LEPS operational verification and some analysis of the COSMO-SREPS behaviour are here presented.

2 COSMO–LEPS

The COSMO–LEPS system (Montani et al., 2003) can be considered downscaling ensemble, the perturbations being ingested mainly through the boundary conditions, which are provided by some selected members of the operational ECMWF EPS (Molteni et al., 2001; Marsigli et al., 2001). The EPS spread comes from two main contributions: perturbations to the initial conditions, generated using the Singular Vector technique, designed to guarantee the maximum spread in the medium-range on a global scale (Molteni et al., 1996), and perturbations

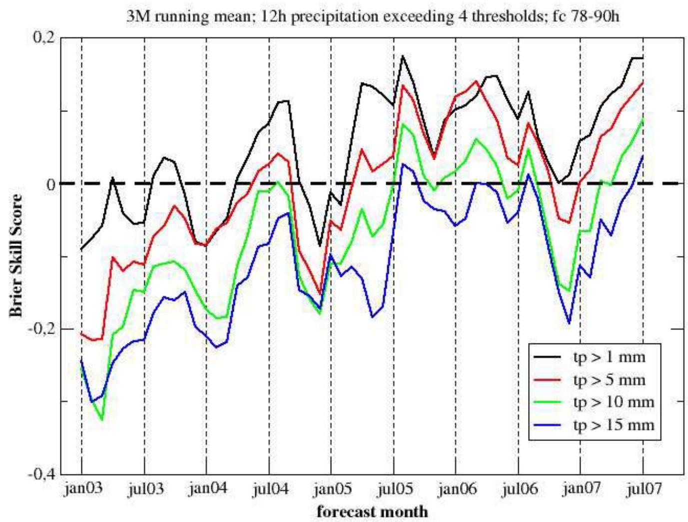

Figure 1: Brier Skill Score of COSMO–LEPS 12-h precipitation forecasts. The BSS has been computed for each month, from January 2003 to July 2007. A 3-monthly running mean has been applied to the results to improve the readability.

to the model, generated by a random perturbation of the physical tendencies (Buizza et al., 1999), which are more local in nature. In order to ensure a smaller scale variability to the mesoscale ensemble, another kind of perturbations is added to the system, by allowing a random choice of the scheme to be used for the parameterisation of the deep convection (either Tiedtke or Kain–Fritsch) in the runs. A preliminary study (Marsigli et al., 2005) suggested that the perturbations applied in this way play a minor role with respect to the perturbations at the boundaries, which explain the major amount of the spread.

Being the system based on the EPS, COSMO–LEPS is useful especially for the early medium range (day 3-5).

COSMO–LEPS is reaching in these days (November 2007) its 5 year milestone, hence a big verification effort has recently been made in order to assess objectively how the system has changed in these years and the extent of its improvements in precipitation forecasts. In order to carry on this evaluation, a fix set of SYNOP stations (about 470) have been selected, covering an area covering the Alps (43-50 N, 2-18 E). Precipitation accumulated over 12 hours (18-06 UTC and 06-18 UTC) has been verified, comparing the values forecasted on the grid-point nearest to each station with values observed on that station. Results in terms of Brier Skill Score are shown in Fig. 1, for 4 thresholds (1, 5, 10, 15 mm/12h). The score is computed monthly and the 3-month running mean has been applied.

At the beginning (2003) the BSS was always negative, increasing to positive values at least for the smaller thresholds starting from summer 2004. The BSS is steadily positive from Spring 2005, for all the thresholds except the highest (15mm/12h). A different behaviour is exhibited in Autumn 2006, which was a very dry season. In 2007 the score is performing well, indicating that the system is skillful. A pronounced seasonal variability is evident, the system often performing better in the Summer season. The year-to-year variability is also quite large, making difficult to draw general conclusions as to the seasonal dependence. The major changes of the system in the considered period are:

- June 2004: the ensemble members have been increased from 5 to 10 and just two EPS instead of three are considered to select the members to drive the ensemble;
- February 2006: the ensemble members have been increased from 10 to 16 and COSMO vertical levels have been increased from 32 to 40.

The first change seems to have lead to better scores, since an improvement is evident after Spring 2004, while the impact of the second change is difficult to judge, due to the already underlined problem in Autumn 2006.

A high–resolution verification is also being carried out in these years, evaluating daily COSMO–LEPS precipitation (06-06 UTC) against observations on a very dense raingauge network, covering Northern Italy, Switzerland and Germany. The difficulty of collecting such a dense network implies that this kind of verification has been done only on selected periods and on sets of stations varying from a period to another, according to data availability.

The importance of this kind of evaluation relies on the fact that the contribution to the ensemble skill due to the high-resolution of the mesoscale model can be shown, by comparing COSMO–LEPS against EPS forecasts. In order to properly evaluate the ensembles at high resolution, a “distributional method” is applied: the distribution of the forecasted values falling within a box of fixed size is compared against the distribution of observed values falling within the same box, by comparing different parameters of the two distributions (average, maximum, percentiles). This is done over a number of boxes covering the verification domain, big enough to contain a sufficient number of both forecasted and observed values. The comparison of ensembles with different horizontal resolution is thus easily allowed, by choosing boxes which size is larger than both resolutions. COSMO–LEPS (cleps, 16 members, 10 km of horizontal resolution) is compared against both the full size EPS (eps51, 51 members, 50 km of horizontal resolution) and the 16-RM reduced size EPS (epsrm, 51 members, 50 km of horizontal resolution).

Results for Spring 2006 are presented in Fig. 2, when a dense network of about 1400 stations was available over Northern Italy and Switzerland. The boxes are 1.0 x 1.0 degrees large. A more complete evaluation can be found in Marsigli et al, 2007.

Results are presented in terms of Ranked Probability Skill Score. A significance test has been applied, using the resampling technique with 1000 repetition, the error bars including the 95% of the values obtained by resampling. In terms of average values (top left panel), eps51 gets the best scores for all the forecast ranges, while COSMO–LEPS is worse or indistinguishable from epsrm at the chosen confidence level. Results are quite different when other parameters of the distribution are considered. In terms of maximum values (bottom panel), COSMO–LEPS has the best scores for all the forecast ranges, outperforming both epsrm and eps51. As for the 95th percentile, the situation is intermediate, the RPSS being higher than both epsrm and eps51 values but the difference being not significant. This indicates that, while EPS is performing better in forecasting the average precipitation amount over a large area, COSMO–LEPS is more skillful in reproducing the tail of the precipitation distribution, being useful in forecasting the occurrence of high precipitation values occurring within an area.

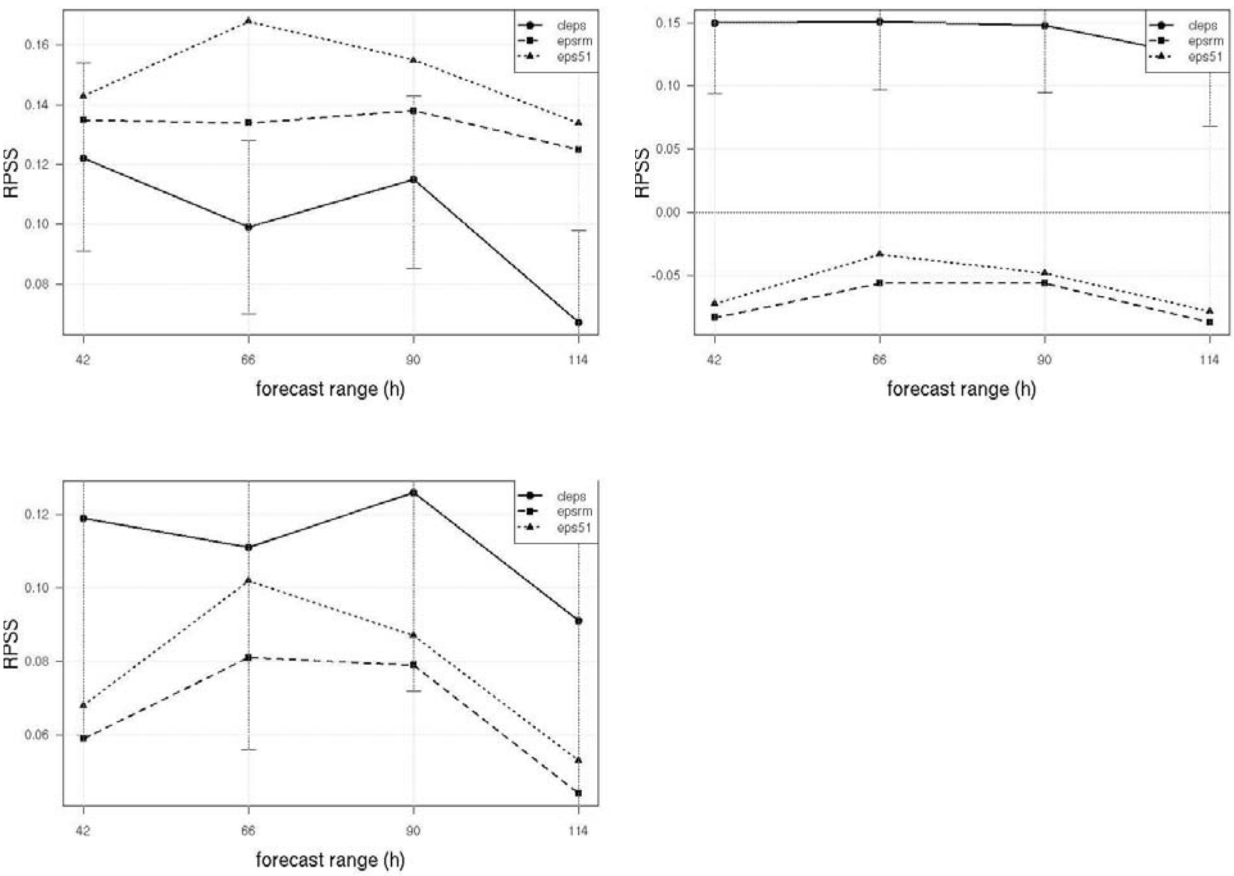

Figure 2: Ranked Probability Skill Score of COSMO–LEPS (solid line), EPS (dotted line) and reduced-size EPS (16 members, dashed lines) daily precipitation for different forecast ranges (18-42, 42-66, 66-90, 90-114 hours. In the top left panel the average values have been considered, while 95th percentile values are shown in the top right panel and maximum values in the bottom panel.

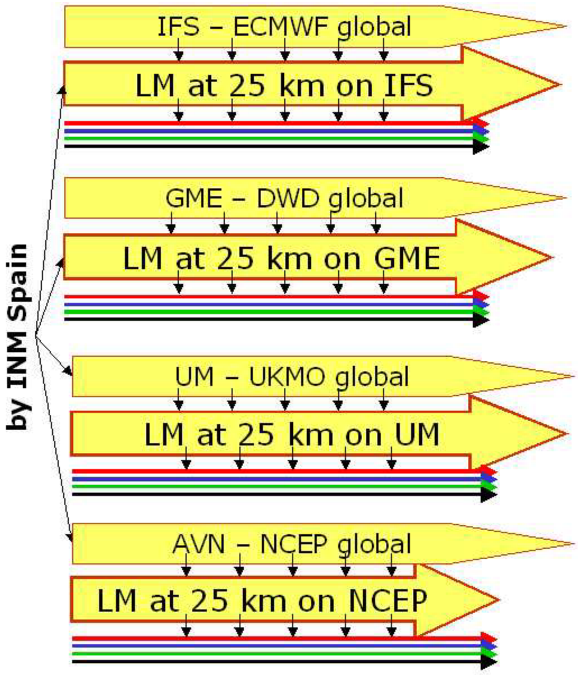

Figure 3: Scheme describing the COSMO–SREPS set–up.

3 COSMO–SREPS

The development of COSMO–SREPS (Short-Range Ensemble Prediction System) is carried out within a Priority Project of the COSMO Consortium by ARPA–SIM, with the external support of a number of COSMO scientists. COSMO–SREPS is built to fulfil some needs that have recently arisen in the COSMO community:

- to have a short–range mesoscale ensemble to improve the support to the forecasters, especially in situations of high impact weather;
- to have a very short-range ensemble for variational data assimilation purposes (1D-Var), to estimate a flow–dependent error covariance matrix;
- to provide initial and boundary conditions to the very high resolution ensemble COSMO-DE-EPS of DWD.

In order to accomplish these purposes, perturbations have to generate a reasonable spread in the short-range and have to act on a more local scale. The strategy to generate the mesoscale ensemble members proposed by this project tries to take into account several possible sources of uncertainty and then to model many of the possible causes of forecast error.

In order to take into account the error of the global model that comes from the boundaries, a multi–model approach is adopted. The MUlti-Model MUlti-Boundaries (MUM-MUB) ensemble system currently run by INM, where five different limited–area models (UM, HIRLAM, HRM, MM5, COSMO) are driven by four global models (IFS, GME, UM, NCEP), is used to provide both initial and boundary conditions: the four 25-km COSMO runs nested on the four different global models are provided to the COSMO partners by INM.

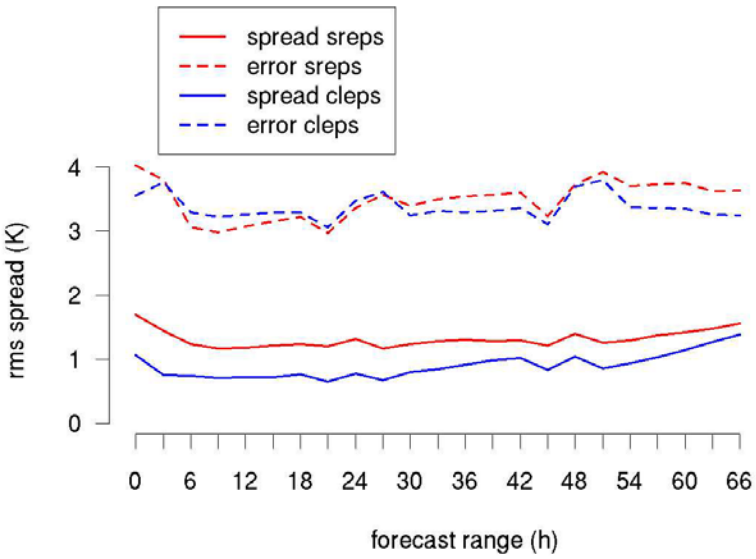

Figure 4: Root–mean–square error (dashed lines) and Root–mean–square spread (solid lines) relative to COSMO–SREPS (red lines) and COSMO–LEPS (blue lines) in terms of 2m temperature with increasing forecast range.

The four INM–COSMO runs are then used to drive 16 COSMO runs at higher resolution (10 km). Each of the 25 km COSMO runs provides initial and boundary conditions to 4 10-km COSMO runs, differentiated by the use of 4 different model perturbations (Fig. 3).

This methodology ends up in a 16–member ensemble, run over the same area of the COSMO–LEPS system, at a horizontal resolution of about 10 km and with 40 vertical levels. The considered forecast range is 72 hours.

COSMO–SREPS has been run in the described configuration over 21 cases of moderate and intense precipitate either over Italy or over Germany occurred during Autumn 2006. The runs have started either at 00 or at 12 UTC, depending on the boundary conditions availability.

In Fig. 4 the COSMO–SREPS spread and error, computed in terms of 2m temperature over a set of about 900 stations covering northern Italy, are compared with COSMO–LEPS one, for the forecast range for which COSMO–SREPS is designed.

It appears from the plot that COSMO–SREPS spread is greater than COSMO–LEPS one for the considered forecast range, being almost double during the first 24 hours and then getting closer to the other one with increasing forecast range. This indicates that the short-range ensemble can really benefit of a source of uncertainty playing a role in the short range. Furthermore, the errors of the two systems are quite close, suggesting that this greater amount of spread within COSMO–SREPS is not worsening the forecast, but permits to describe part of the uncertainty affecting the forecast, at least for the first two days. It has to be pointed out that the error is, for both system, higher than the spread, suggesting that both system are underdispersive for all the forecast ranges. This is probably indicative of the fact that the COSMO model systematic error plays a significant role, the model perturbations applied to COSMO–SREPS being probably not enough, in terms of processes described, to take it into account.

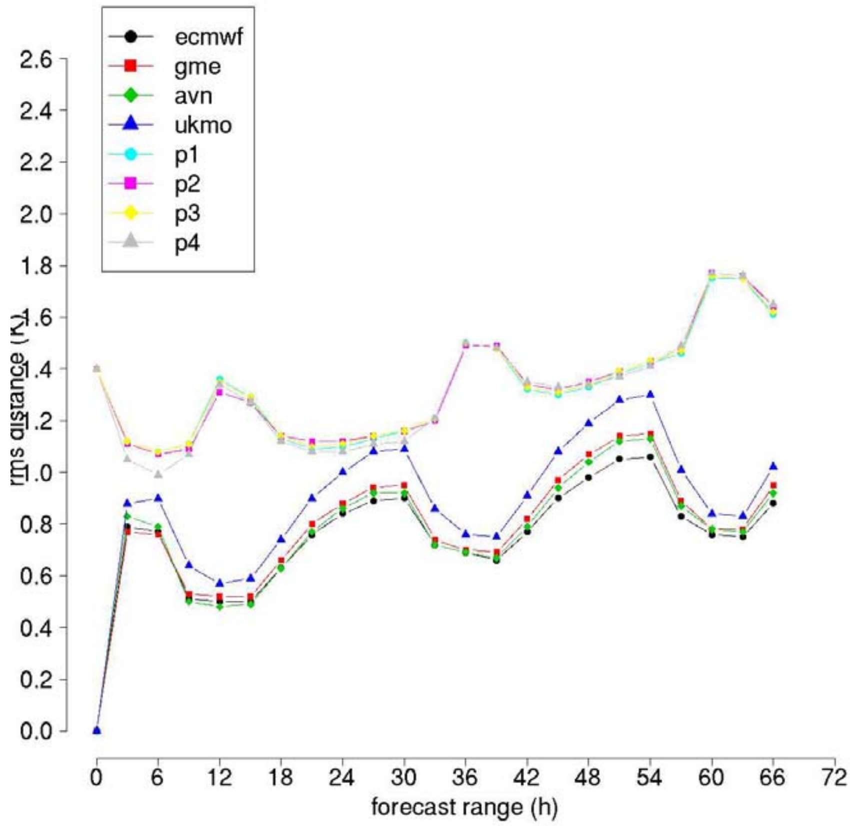

Figure 5: Root–mean–square distance, in terms of 2m temperature, among 8 different groups of ensemble members: the 4 members with the same ECMWF father in black, the 4 members with the same GME father in red, the 4 members with the same NCEP father in green, the 4 members with the same UKMO father in blue, the 4 members with the same p1 model perturbation in violet, the 4 members with the same p2 model perturbation in orange, the 4 members with the same p3 model perturbation in magenta and the 4 members with the same p4 model perturbation in cyan.

In order to address the problem of understanding how the different perturbations applied to COSMO–SREPS contribute to determine its spread, the spread has been computed also for eight different grouping of the 16 ensemble members, containing 4 members each. The members can in fact be distinguished either on the basis of the driving run, which permit to create 4 groups labelled with the name of the driving model (ecmwf, gme, avn, ukmo), or on the basis of the COSMO model perturbation, which permit to create 4 groups labelled simply with p1, p2, p3 and p4. The so–obtained spread are plotted in Fig. 5.

In this plot, the black line is relative to the root–mean square distance among the 4 ensemble members which have received initial and boundary conditions from the ECMWF–COSMO run. Then, the differences among these 4 members come only from the perturbations applied to 4 model parameters. On the other hand, the violet line is relative to the root–mean square distance among the 4 ensemble members which have the same model formulation, the parameter p1 having been changed in the same way in all the 4 runs. It is clear that the spread among members having different values of physics parameters but the same driving model is always lower (almost a half) than the spread among members having different driving models but the equal COSMO formulation. Therefore, the major contribution to the spread is given by the different initial and boundary conditions, as expected, on average over the whole sample. Over specific point of the domain and for specific days, the situation can be quite different and even reversed (not shown).

Within the COSMO cooperation, objective verification of the COSMO–SREPS system is being carried on at HNMS (Greek National Meteorological Service), evaluating the system performance in terms of surface variables (2m temperature, precipitation, mean sea level pressure, 10m wind) over Greece. This aims also at assessing the extent to which the 16 members have different skill, depending on the driving model or on the parameter set up.

The COSMO–SREPS system has been run during the whole DOP (June to November 2007) of the MAP D-PHASE project, in order to allow an extensive evaluation of the system over a six month period.

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Status report on Met Office verification 2007

Met Office Fitzroy Road Exeter
+44 1392 886098 mike.bush@metoffice.gov.uk

1. Area based (ABV) and Station based (SBV) verification

The Met Office has two verification systems – the ABV and the SBV. Both systems can calculate continuous and categorical statistics and skill scores.

1.1 ABV

The ABV only stores area averaged statistics and scores. It caters for verification against Observations e.g. surface, upper air, satellite winds, aircraft, radar precipitation etc. and verification against Analyses. Verification of trials is done in the same way as operational verification (Figure 1).

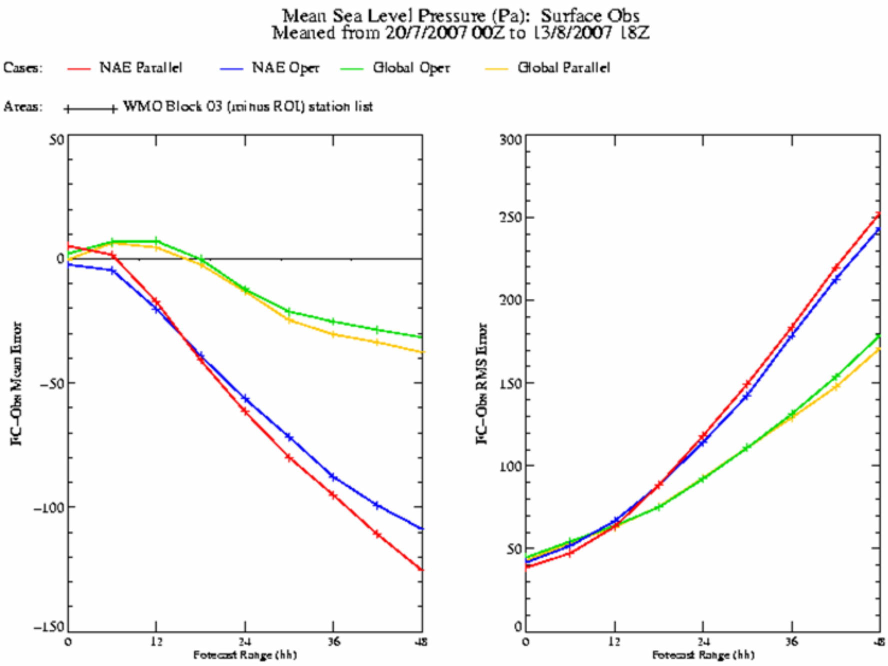


Figure 1: Verification of Mean Sea level Pressure bias and RMSE against surface observations. Both Parallel Trial and Operational model results are plotted.

1.2 SBV

The SBV is a station based relational Oracle database. It enables greater flexibility and allows conditional verification. It is widely used to verify operational and research forecasts and enables the spatial distribution of error to be displayed (Figure 2).

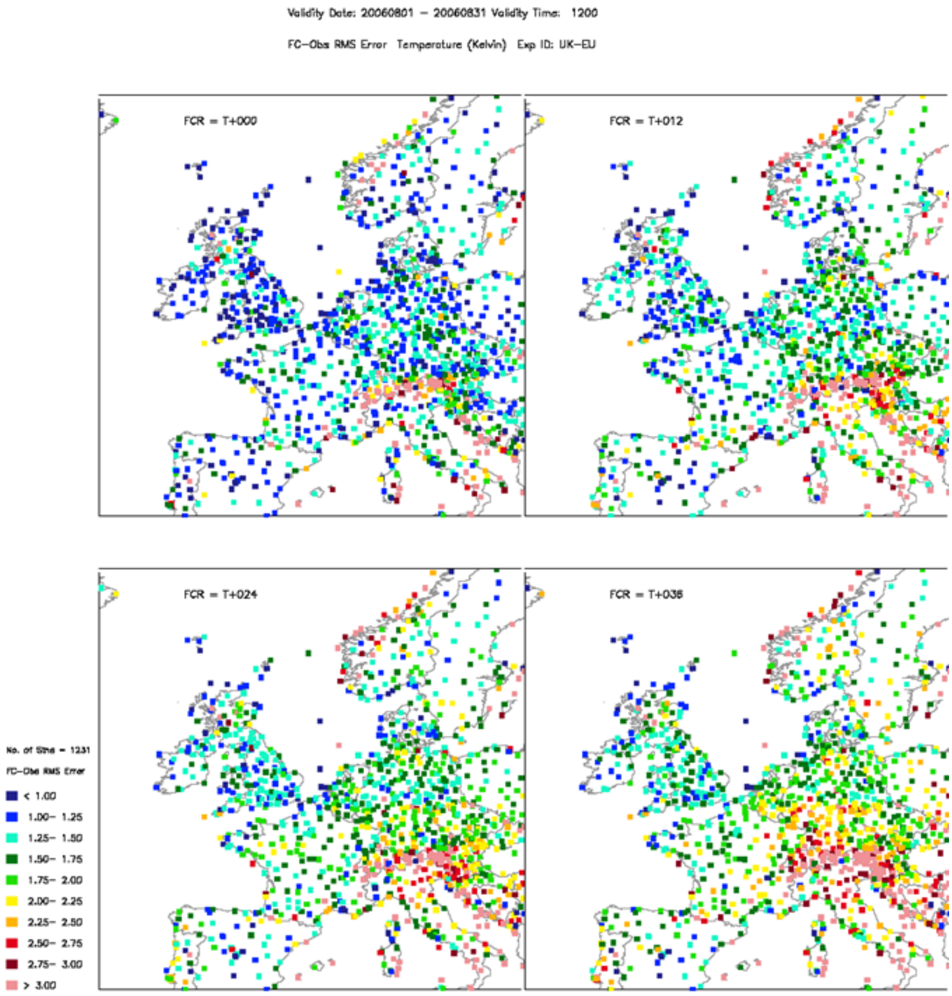


Figure 2: SBV error maps (in this case temperature RMSE at 1200 from the NAE model for August 2006 at different forecast ranges).

2. U.K Index

The UK NWP Index is a measure of the forecasting skill of limited area NWP models over the UK.

It is currently based on North Atlantic European (NAE) model forecasts (but includes Mesoscale (MES) model forecasts for the months before the NAE model became operational); however, other model forecasts might replace the NAE forecasts in the Index in future.

It is based on forecasts of selected parameters currently out to 48 hours ahead for a selected set of positions verified by comparison with station observations and is based on 36 months of data. A score is calculated for each parameter included in the Index. The individual scores are then combined in a weighted average to form a single value.

The Index is compiled from the following parameters

* Near-surface (1.5m) temperature
* Near-surface (10m) wind speed & direction
* Precipitation yes/no (equal to or greater than 0.2, 1.0 and 4.0 mm over the preceding 6 hours)
* Total cloud amount yes/no (equal to or greater than 2.5, 4.5 and 6.5 oktas)
* Cloud base height given at least 2.5 oktas yes/no (equal to or less than 100, 500 and 1000 m above ground)
* Near-surface visibility yes/no (equal to or less than 200, 1000 and 4000 m)

verified at quality controlled station positions across the UK and at the following forecast ranges

* T+6, T+12, T+18, T+24, T+30, T+36, T+42 and T+48

Observations and forecasts are used at all WMO block 03 station positions across the UK including the Channel Islands and the Isle of Man. This includes Northern Ireland, but excludes the Republic of Ireland.

Calculation of skill scores for temperature and wind

Once the forecast and persistence rms errors have been determined for a particular forecast range, the monthly skill score may be calculated. This is defined in terms of Reduction of Variance, i.e.

$$SS = 1 - \frac{mse_f}{mse_p}$$

where:
msef is the mean squared forecast error
msep is the mean squared persistence error.

The smaller the ratio between forecast and persistence errors, the closer the skill score will be to 1 (perfection). If the forecast error is greater (worse) than the persistence error, then the skill score will be negative and is in fact unbounded.

The 36-month skill scores for both parameters, calculated as simple means of the monthly values, are used as components of the final Index.

Calculation of equitable threat score for precipitation, total cloud amount, cloud base height and visibility

The Equitable Threat Score is used as the basis for the precipitation, total cloud amount, cloud base height and visibility components of the Index, the definition being:

$$\text{ETS} = \frac{\text{R} - \text{"chance"}}{\text{T} - \text{"chance"}}$$

where:
R is the number of observed events which were correctly forecast
T is the total number of events which were either observed or forecast.

Subtraction of "chance" from the numerator and denominator removes those observed events which are expected to be correctly forecast by chance. It is given by:

$$\text{"chance"} = \frac{F*O}{N}$$

where:
F is the number of events forecast
O is the number of events observed
N is the total number of events plus non-events.

This score has properties similar to the rms-based score, i.e. it takes the value of 1 for a perfect forecast, and is negative if the forecast is worse than chance, although in this case there is a lower limit of -1/3.

Compilation of the Index

A simple weighted average, S, of all the individual scores (eight forecast ranges and six variables (four of which have three thresholds) is calculated. The weighting factors are chosen to give equal overall weighting to each of the 5 components (wind, temperature, precipitation, cloud and visibility), so total cloud amount and cloud base height get lower individual weighting than precipitation and visibility (Figure 3).

Parameter	Threshold		
	1st	2nd	3rd
Precipitation / mm in 6h	>=0.2	>=1.0	>=4.0
Total Cloud Amount /oktas	>=2.5	>=4.5	>=6.5
Cloud Base Height for TCA>=2.5oktas /m	=<100	=<500	=<1000
Visibility /km	=<0.2	=<1.00	=<4.00

Parameter	Threshold			
	No	1st	2nd	3rd
Temperature	6			
Wind	6			
Precipitation		2	2	2
Total Cloud Amount		1	1	1
Cloud Base Height		1	1	1
Visibility		2	2	2

$$S = \frac{1}{\sum_i w_i}\left(\sum_i (w_i SS_i)\right)$$

Figure 3: UK index Thresholds and weights. wi is the weight for the i-th parameter and SSi is the 36-month score for the i-th parameter.

The Index, I, is normalised so that the value is equal to 114.45960 on 31st March 2007; this is to provide continuity with the old UK NWP Index used up to that date.

Thus, the Index is defined as:

I = {S/S0}*Iold

Where S0 is the value of S on 31st March 2007 and Iold is the value of the old Index on 31st March 2007.

3.0 Precipitation verification

A number of techniques are used to verify precipitation forecasts. Validation of monthly precipitation from the models (Figure 4) can reveal systematic errors in rainfall prediction over orography for example.

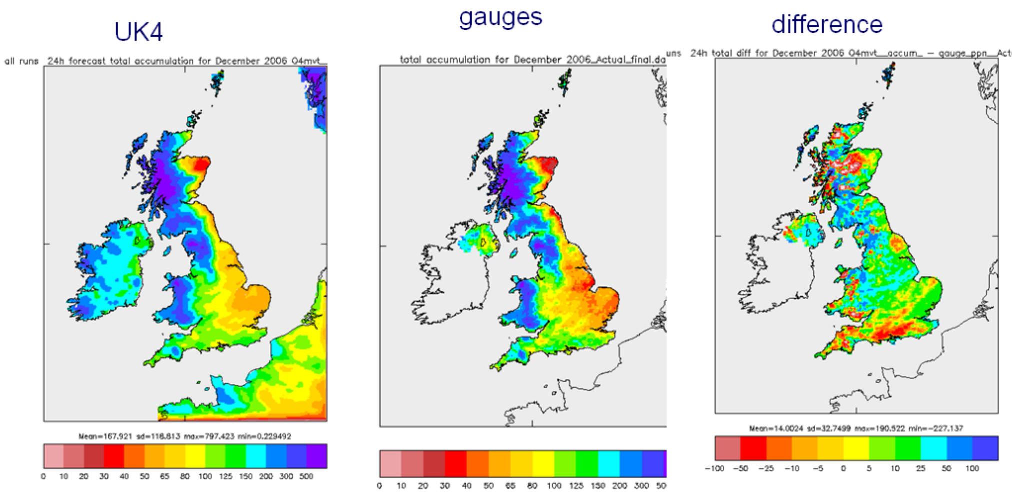


Figure 4: Validation of monthly precipitation (UK4, left hand panel) against gauge analysis (centre) and difference (right hand panel).

Intensity –scale techniques can provide insight into the spatial scales and thresholds at which the models have forecast skill (Figure 5).

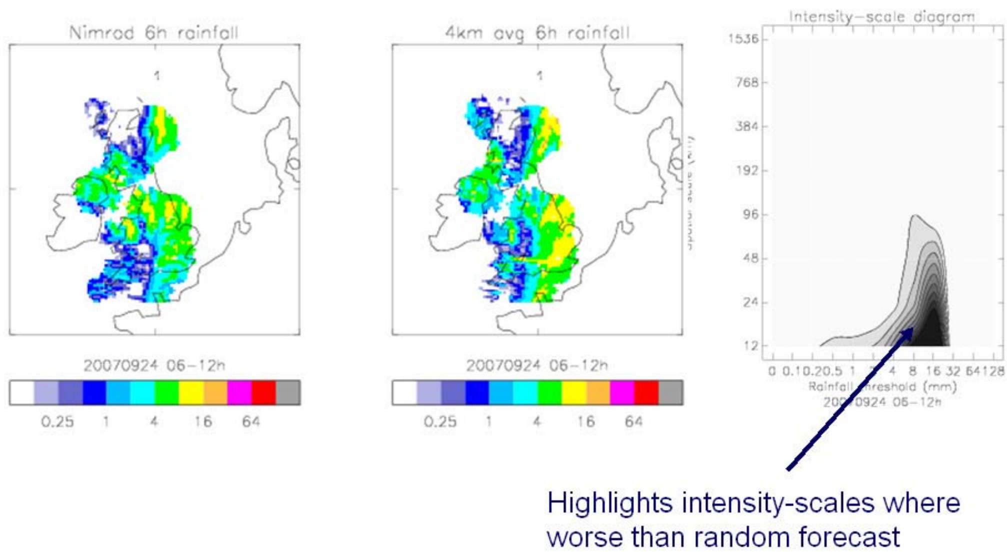


Figure 5: Intensity-scale 4km model precipitation.

Fractional skill scores are another way of assessing the skill of high resolution model forecasts of precipitation. This score does not suffer from the “double penalty” associated with traditional verification measures e.g. RMSE where a small feature displacement in time or space can lead to poor scores (Figure 6).

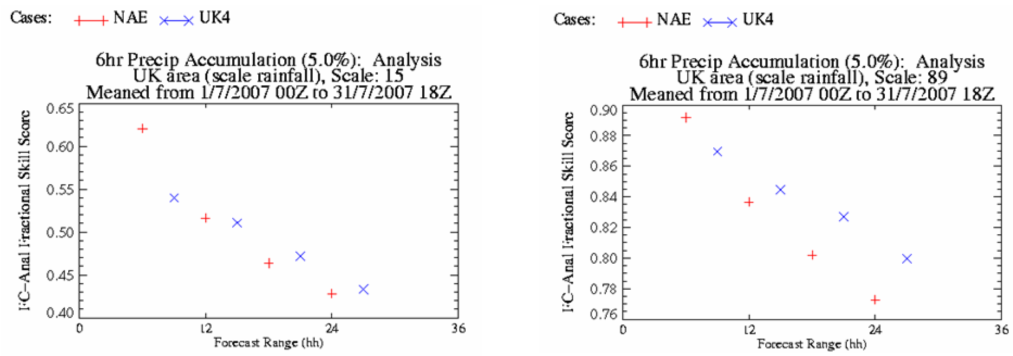


Figure 6: Fractional skill score for precipitation during July 2007. The two plots are for different spatial scales, but both show the skill of the models decreasing with forecast range and the UK4 having more skill than the NAE in this instance.

Valuing information from mesoscale forecasts

Kees Kok, Ben Wichers Schreur and Daan Vogelezang

(submitted to Meteorological Applications)

Traditional objective verification of deterministic model output fails to demonstrate the added value of high-resolution models. It is generally accepted from subjective verification that these models nevertheless have a predictive potential for small-scale weather phenomena and extreme weather events.

In this article we argue that the evaluation of the information in mesoscale forecasts should be essentially connected to the method that is used to extract this information from the direct model output. This could be an evaluation by a forecaster, but, given the probabilistic nature of small-scale weather, is more likely a form of statistical postprocessing. Using Model Output Statistics (MOS) we demonstrate the potential of this approach on a real world example. Our MOS approach incorporates concepts from fuzzy verification. It objectively weighs different forecast quality measures and as such it is an essential extension of fuzzy methods.

MOS predictions are routinely used to post-process and enhance the results of NWP forecasts. An important feature of statistical forecasting methods is the capacity to produce probability forecasts providing explicit expressions of the inherent uncertainty that is present in weather forecasts. It seems an obvious technique, therefore, to assess and objectively quantify the probabilistic information present in deterministic model output. Due to the intrinsically probabilistic nature of the smaller length and time scales it seems even more appropriate in high-resolution forecasting.

We looked at the numerical output of two models whose grid distances differ by a factor of two. We investigated the predictive potential of predicted total precipitation fields for observed precipitation in a single station, in particular for the probability of exceeding certain amounts of precipitation. The models we used are the operational ECMWF model and the control model of the ensemble prediction system (EPS) of ECMWF on which since February 2006 precipitation is calculated on a N400 and N200 reduced Gaussian grid, respectively. The data set ranges from February 2006 until July 2007 and only 1200UTC forecasts are used. No stratification into seasons is performed. A large number of quantities resembling those that are used in fuzzy verification are used as predictors in our example. The MOS method objectively weighs and combines the effect of general features of the forecast field, the size of neighbourhoods and the effect of distortion errors on forecast quality.

In Fig. 1 the direct model output of the control and operational forecasts are compared against station observations at De Bilt. This is done in terms of the root mean square error but other metrics show the same behaviour. The smaller scale operational model (oper) performs much less than the control forecasts even at the earlier forecast ranges.

The apparent smaller skill for the high resolution DMO completely vanishes after we have extracted as much information as possible from the precipitation forecast fields by means of statistical postprocessing. This is shown in Fig. 2 in which the Brier score is presented for the probabilities of exceeding 0.1 mm and 2.5 mm in 3 hours. The operational model seems to contain at the least the same amount of skilful information over most of the lead-times for both thresholds.

Ebert, E. E. 2007. Fuzzy verification of high resolution gridded forecasts: a review and proposed framework. Submitted to *Meteorological Applications*.

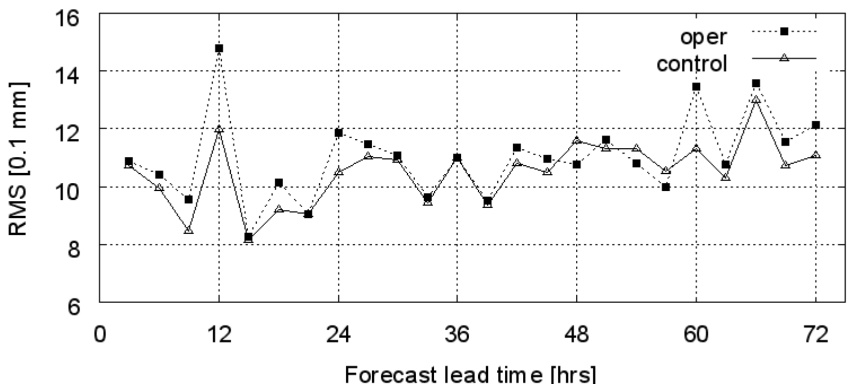
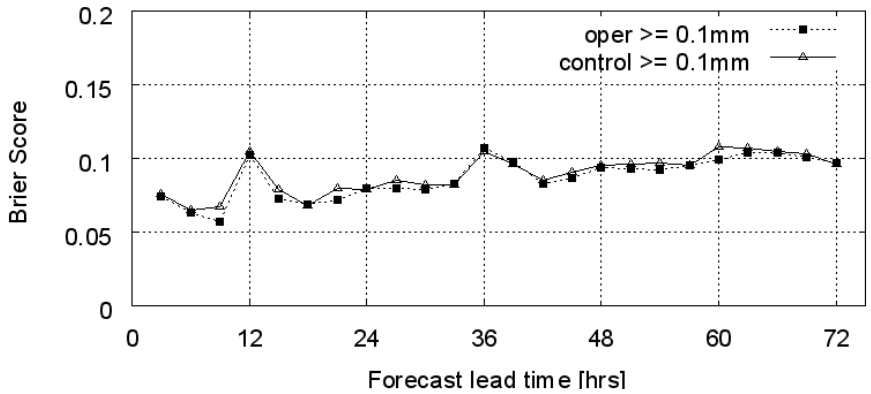


Fig. 1. Root mean square difference as a function of lead-time between the observed precipitation at De Bilt and the direct model output (appropriate gridbox value) of the operational (dashed line) and control forecast (full line).



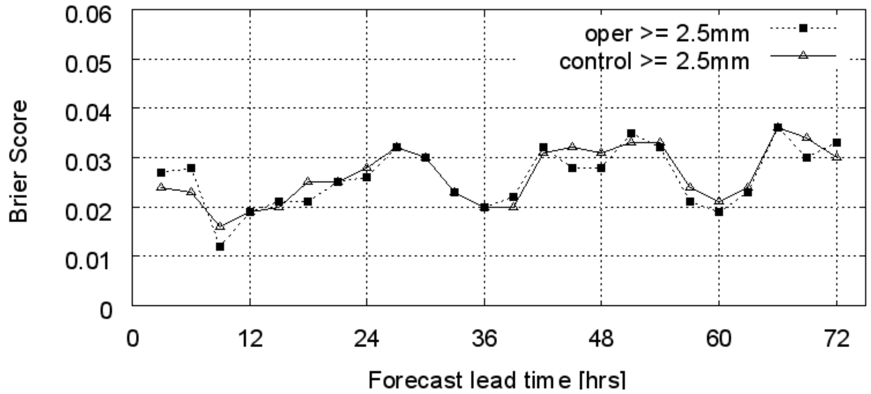


Fig. 2. Brier score as a function of lead time for the postprocessed forecasts of the operational and control model for 2 dichotomous events with thresholds >0mm (top) and ≥2.5mm (bottom) in 3 hours at station De Bilt.

Verification Session: Final Discussion

Monday 8th of October 2007, 17h30-17h50
Chair: Gerard Cats

The Local Organizer has had the very good idea to put in the programme of the EWGLAM Meeting a session devoted to Verification.
The aim was that each Consortium should present its strategy for verification.
The Consortia, with the exception of Aladin, have done this.

The main point of this session has nevertheless been the presentation by Terry Davies - on behalf of Clive Wilson - of a revised Proposal for a EUMETNET Programme on Verification.
To read the first version of this new Proposal,
http://srnwp.cscs.ch/Documents/Revised_Verif_Proposal.htm.
We recall that the first proposal has eventually not been presented to Council, as - among other reasons - it has been judged by its main authors (Joël Stein and Clive Wilson) too ambitious. Moreover, the necessity of a common verification package (as specified in the Proposal) could not be assessed.

<u>Differences between the new and the old (non-submitted) Proposal</u>
1. The main difference is that in the new Proposal the Programme Verification is no longer foreseen as a large and single programme, but will develop as a succession of smaller programmes, each programme complementing the previous one.
2. The old Proposal had two main aims: Development of a common verification package and realization of an operational model intercomparison.
For the first stage in the new Proposal, the development of a common verification package will not be considered. The aim of the first stage will only be to operate an intercomparison of the main European forecasting systems: Aladin, Cosmo, Hirlam and Unified Model.

<u>Characteristics of the first Programme stage</u>
It must be cheap, therefore practical and pragmatic. There is presently no chance to bring through the EUMETNET Council a second (after Interoperability) expensive NWP Programme.
The models foreseen for the intercomparison are:
- The Met Office NAE - 12km (integrated at the Met Office)
- The Hirlam reference - 22km (integrated at the FMI)
- The Aladin France - 9km (integrated at Meteo-France)
- The COSMO-EU - 7km (integrated at the DWD)
The verification will be done on the common area of these 4 models.
It has been proposed to use as verification package an extension of the package used at the Met Office for the European Precipitation comparison.

<u>Ideas for later Programme stages</u>
- Addition of higher resolution forecasts up to the km-scale to the intercomparison
- Investigation of new verification methods (e.g. fuzzy logic, scale intensities, ...)

- Creation of a hub for non-GTS data, particularly for the precipitations (at ECMWF or at a NMS).

The discussion that took place at the end of the session concentrated almost exclusively on the new Verification Proposal.

Some points had to be explained as the size of the common area, the format to be used for the output fields, etc. It is clear that several points remain to be specified.

The main points of discussion have been:

<u>Intrinsic difficulties of the verification.</u>
- It has been made clear that what the verification results show are the performance of a numerical forecast *system* and not the quality of a particular *model*. All the components of a NWP system matter, as, for example, the cut-off time.
- Even on the same integration domain, it is a problem to compare models of different resolutions. The best strategy seems to remain to downgrade by averaging the model resolutions towards the coarsest resolution of the models involved and to verify over this resolution (and to hope that the models computed with higher resolutions will show better results!)

<u>Relation with the ECMWF</u>
It has been asked whether the ECMWF forecasts should also be included in the intercomparison.
Nobody opposed a participation of the ECMWF. However, our intercomparison should be limited to the very short and short-range, where we can take advantage of the use of fresh analyses. We should concentrate our verification on the boundary layer and on the precipitations. As our LAMs have a higher resolution than the ECMWF global model, the better representation of orography should give us better precipitations.

<u>Next steps</u>
The Met Office is asked to complete the revised Proposal.
Then the Proposal will be reviewed by the SRNWP Expert Team for "Diagnostics, Validation and Verification". The aim remains that the Met Office presents the Proposal at the spring meeting of the EUMETNET Council.

For the minutes:
Jean Quiby
SRNWP Programme Manager

EWGLAM Final Discussion

Wednesday 10th of October 2007, 11h00-11h30
Chair: Mariano Hortal

The 2007 EWGLAM/SRNWP Meetings

The Local Organiser (the Croatian Meteorological Service) will prepare a Newsletter under electronic form only. Participants and NMS will be able to download this Newsletter from the web site of the Croatian Meteorological Service (http://meteo.hr/EWGLAM07/).

All the participants of the EWGLAM/SRNWP Meetings are requested to send their contributions in electronic form to Alica Bajic (alica.bajic@cirus.dhz.hr) **until November the 30th** under any of the usual formats.
A maximum number of pages has not been fixed, but based on the experience of the last years it should not exceed 8 pages.

The 2008 EWGLAM/SRNWP Meeting

It has been decided to keep the new meeting format, which has been successfully used for this meeting as well as for the first time last year in Zurich.
However, from next year onwards, the SRNWP Programme will have a new governance with, among other novelties, 7 Expert Teams.
Should the Expert Teams be considered in the Programme? The answer was yes, but it remained unclear how this should be done.
Statements have expressed that it would be too much to have 7 review talks given by the Expert Team chairpersons.
The Local Organiser together with the Programme Manager will have to clear up this point.

Detlev's Proposition

Detlev Majewski (DWD) would like to hear at the beginning of each thematic session (DA, Physics, Verif, etc) a short talk summarising the state of the art in each of these fields. These reviews should not be restricted to the situation in Europe but should also inform about developments and problems in extra-European groups.
This proposition has clearly found a genuine interest among the participants.
The 2008 Local Organizer, with the help of the Expert Teams and of the Programme Manager, will consider the possibility of organising such reviews.

Place and Date of the next Meetings

2008
According to the rotation of our meeting places (List of the Past Meeting Places: http://srnwp.cscs.ch/Annual_Meetings/ListAnnualMeetings.htm), the 2008 EWGLAM/SRNWP Meetings should be organised by the INM.

Bartolome Orfila has invited the EWGLAM/SRNWP Meetings to Spain. The Meetings will be hold in Central Spain from the 6th to the 9th of October.
Thanks to Bartolome and to the INM!

2009

According to our rule, the 2009 Meetings should be organised by a "new" SRNWP Member. We have two new Members:

- the NMS of Latvia, which has joint the SRNWP Programme last year
- the NMS of Estonia, which is now a HIRLAM Member.

However, the 2009 Meetings could also be organized by an "old" SRNWP Member that has not yet organised these Meetings: Greece, Iceland, Luxembourg and Bulgaria.
The Programme Manager will contact next years these NMS.

For the minutes:
Jean Quiby
SRNWP Programme Manager