ALADIN-HIRLAM Newsletter

No 4, February 2015

1st joint ALADIN General Assembly and HIRLAM Council,
Reading, December 2, 2014

ALADIN Programme, c/o P. Termonia, IRM, Avenue Circulaire 3, 1180 Bruxelles, Belgium
HIRLAM-B Programme, c/o J. Onvlee, KNMI, P.O. Box 201, 3730 AE De Bilt, The Netherlands

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Introduction

Patricia Pottier

I am glad to provide you with the forth edition of the combined Newsletter of the HIRLAM and ALADIN consortia. This edition is dedicated to a "***Tour d'ALADIN & d'HIRLAM***", with contributions describing main achievements at our meteorological institutes in 2014. Finally a list of events that are planned for 2015 is added.

At the consortium level, 2014 saw the first joint meeting of the ALADIN General Assembly and the HIRLAM Council (Reading, 2nd of December) where a ***joint declaration*** was unanimously adopted by the Directors. It stresses the ALADIN/HIRLAM commitment to work together with the aim of forming one single consortium by the end of the 2016-2020 MoUs.

At this turning point for our consortia, we lost the one who started the merge between the ALADIN and the HIRLAM consortia, Jean-François Geleyn (see Piet Termonia's tribute). Jean-François created ALADIN in 1991. He acted as ALADIN Program Manager, the main executive officer of the ALADIN Consortium, years before this position was officially defined in the ALADIN Memorandum of Understanding. Until 2010, he led the life of the ALADIN consortium.
On 8 January 2015, the ALADIN community lost its icon and beacon.

I thank the authors for their contributions and hope you enjoy the forth ALADIN-HIRLAM Newsletter ... and bear with me as it is the first combined Newsletter I did on my own. After 7 years as HIRLAM scientific secretary, Tilly said goodbye to us last December to join a new position at CGI (IT and business process services company) in Rotterdam.

Patricia

For additional information, please visit the ALADIN and HIRLAM websites, or just ask the authors.

In memory of Jean-François Geleyn

Piet Termonia

Jean-François left us on 8 January 2015. His struggle with his health was not unknown. He hoped still to come to Ghent for the lectures at the university in spring 2015. But his departure came sudden and unannounced and left no opportunity to properly say farewell, neither to express my deep gratitude for what he did for me, and I can fairly say, for us. So I have to write this down.

Jean-François was a giant. ALADIN is Jean-François' creation. The science was top notch. ALADIN started pratically out of nothing in 1990 and grew to a scientific collaboration in which roughly 150 NWP experts are involved, spread across 16 countries, which formed the basis for the creation of many NWP groups in these countries. Most of it was based on "in-kind" contributions which illustrates his unique ability to recognize competences and to motivate and to steer people. The number of scientists Jean- François in the NWP community has influenced, inspired, guided, trained, extends over a priod of about 25 years and reaches far beyond the ALADIN consortium. While it is impossible to put any numbers on that it must be hunderds. He also (co)supervised 14 PhDs and published papers in top journals, all of them of the highest scientific level. But to make a list of his realizations would be incomplete to give proper credit to his contributions because they reached far beyond track records, impact indices, number of publications and other so-called quantifiable indices.

But Jean-François was fond of using analogies and images to capture the essence of things. So I will use an image here, one that, I am sure, Jean-François would have liked himself.

Plato introduced us to the world of ideas. Ideas can be right or wrong. Even more important than right or wrong, is the relation between the ideas. In some subspaces of Plato's world ideas are structured according to logic, rationality and ordered in a consistent way. If you move along such submanifolds you get the immediate feeling that things make sense.

I have never met someone that could move so fast through Plato's world as Jean-François. No one I know has explored such vast spaces of Plato's space. No one I know, knew so well where the consistent submanifolds of Plato's world are located.

Jean-François also understood that, to make the world better you have to move out of the consistent submanifolds and he understood better than anyone that reality is sometimes merely a shadow of the underlying ideas. He even enjoyed to move out of the consistent submanifolds. Paradoxes, contradictions were an inexhaustible source for humor for him. But, when the situation called for it, he instinctively knew where the consistent manifold was lying and was instantly back on it.

When I started to work in NWP, I was impressed by this and I wanted to learn from him. Many times he was moving too fast. "I don't see it", I sometimes dared to say. In that case he didn't take my hand and take me into the submanifold and offered the answers on plate, but he replied "look there, it is there". If I still didn't see it, he said, to use the image of Plato's world: "don't act as such a blind person, the truth lies there". His style of teaching was atypical, but extremely powerfull, because most of the time he did not provide the answers but rather forced you to discover Plato's consistent spaces yourself. He teached you rather to use your instinct to look in the right direction. If you discussed with him you could not stay untouched by this, and most of the time you had a different view on the world afterwards.

In fact, Jean-François was moving faster than any one I know. He understood the role of gray zone(s) a long time before anyone else. At least a decade ago he started to insist on the fact that the thermodynamics would become the real main issue at the high-resolutions and spared no effort to get the diabatic interactions properly formulated. He understood the issues of deep convection faster than any one else and nailed it down in a few terms such as memory, laterality and stochasticity, giving glimpses of consistent submanifolds of Plato's world, that are there to be uncovered. He also understood that what we do in our models for turbulence are very vague shadows of reality and realized that the answers were spread between different approaches, e.g scale-based methods like QNSE or total turbulent energy, or higher-order closer theories, each of them being mere shadows of a deeper underlying the turbulence consistent subspace of Plato's world. His approach to this was to control them all and to embed them all in the models consistently, in order to try to move deeper in Plato's world. Lately he insisted that entropy needs to get a more prominent role. He was still hoping to have some quiet times to shed his intellect on these issues, away from the shadows of the day-to-day business. Alas, nature did not grant him that.

The above list is far from being exhaustive. Apart from such topics which were “his” topics, he moved equally fast in other domains. Whenever asked advice on subjects like data assimilation, ensemble techniques, predictability issues, code engineering, high-performance computing, or any other topic in or outside of science, he often captured the meanings faster than the experts. He was perhaps not always right, but his answers always made sense and he never wasted time with sloppy reasoning or false statements.

He was often misunderunderstood or, perhaps, should I say “criticized”. But I believe that a lot of that was originating from the fact that people were pointing out the shortcomings of the shadows, while he was in fact inviting them to follow him into Plato's world and not take the shadows as the truth. And I know that his invitations were always genuine, steered by an exceptional enthousiasm, which he expressed in a style that could sometimes be overwhelming. If you had the courage to follow him, he made no prerequisites and took you along. He didn't care how many diplomas you had, where you came from, what your background was, or what your position was. Jean-François took you at face value. Young people, including students at the university, often came with a solution or an idea that sparked his enthousiam. When that happened, his reactions were overly abundant. He would always shout the idea from the highest place he could find and spared no effort to give the person all the credit, even if it was clear that the seed of the idea was provided by Jean-François himself.

It is tough to realise that he is not there anymore. Who will answer the phone to shed his light whenever I am dealing with some shadows of reality? I will miss the beers we drank together and the dinners we had when he came to Ghent. I will miss his sense of humor. I have lost a true friend.

But Plato claimed that ideas are more real than the physical world, more solid than rocks. I agree with that. While physical objects perish, the ideas remain. The beauty in Plato's space is more pure than the ones we often encouter in reality. Jean-François uncovered huge parts of it and that will not perish. He will be still there and I will still meet him there.

Farewell Jean-François.
Piet Termonia

1st Joint Meeting of the ALADIN General Assembly and the HIRLAM Council

Patricia Pottier

The ALADIN General Assembly (GA) and the HIRLAM Council met for the first time on December the 2nd, 2014, in Reading at the premises of ECMWF. This was a good opportunity for the Directors to assess how the ALADIN-HIRLAM cooperation could be improved. The HAC Chair and the ALADIN PM jointly reported on the common rolling work plan and then gave their analysis of the ALADIN/HIRLAM cooperation. They proposed some consistent steps and a time line for the preparation of the next -still separated- ALADIN and HIRLAM MoUs.
This was followed by discussions on various aspects of the existing and future collaboration, in a generally very positive atmosphere. At the end, the French delegation proposed a joint declaration stating the firm intention of both consortia to merge by the end of the next MoU-phase, and this was unanimously accepted:

Recognizing the capabilities and achievements of the NMHS belonging to Aladin and Hirlam consortia:

1. The NMHS present at the joint Aladin-Hirlam meeting (dec 2, 2014) share the same objective to jointly develop and maintain the best possible skilled limited area weather forecasting system, building on the developments of the IFS/Arpege global forecast system and on the Aladin and Hirlam limited area systems. This limited area system is defined as a set of data pre-processing, data assimilation, atmospheric model and postprocessing tools for producing the best possible operational mesoscale weather forecasts.

2. Aladin and Hirlam consortia will work together with the aim of forming one single consortium by the end of the 2016-2020 MoUs. To this aim, the following issues have to be resolved:
- code ownership (software IPR) : current situation and suitable evolutions. In particular advantages vs drawbacks of open source solutions should be assessed;
- data policy (access to model outputs) ; to this aim a map of the various current operational configurations of the limited area system should be produced and scenarios for data dissemination should be assessed;
- global picture of annual contribution of countries to the various types of activities (from fundamental research to code implementation);
- identification of common activities and specific activities (possibility of core and optional programs);
- branding (including suitable evolution of the name of the system).

3. Human resources to support the work will be identified.

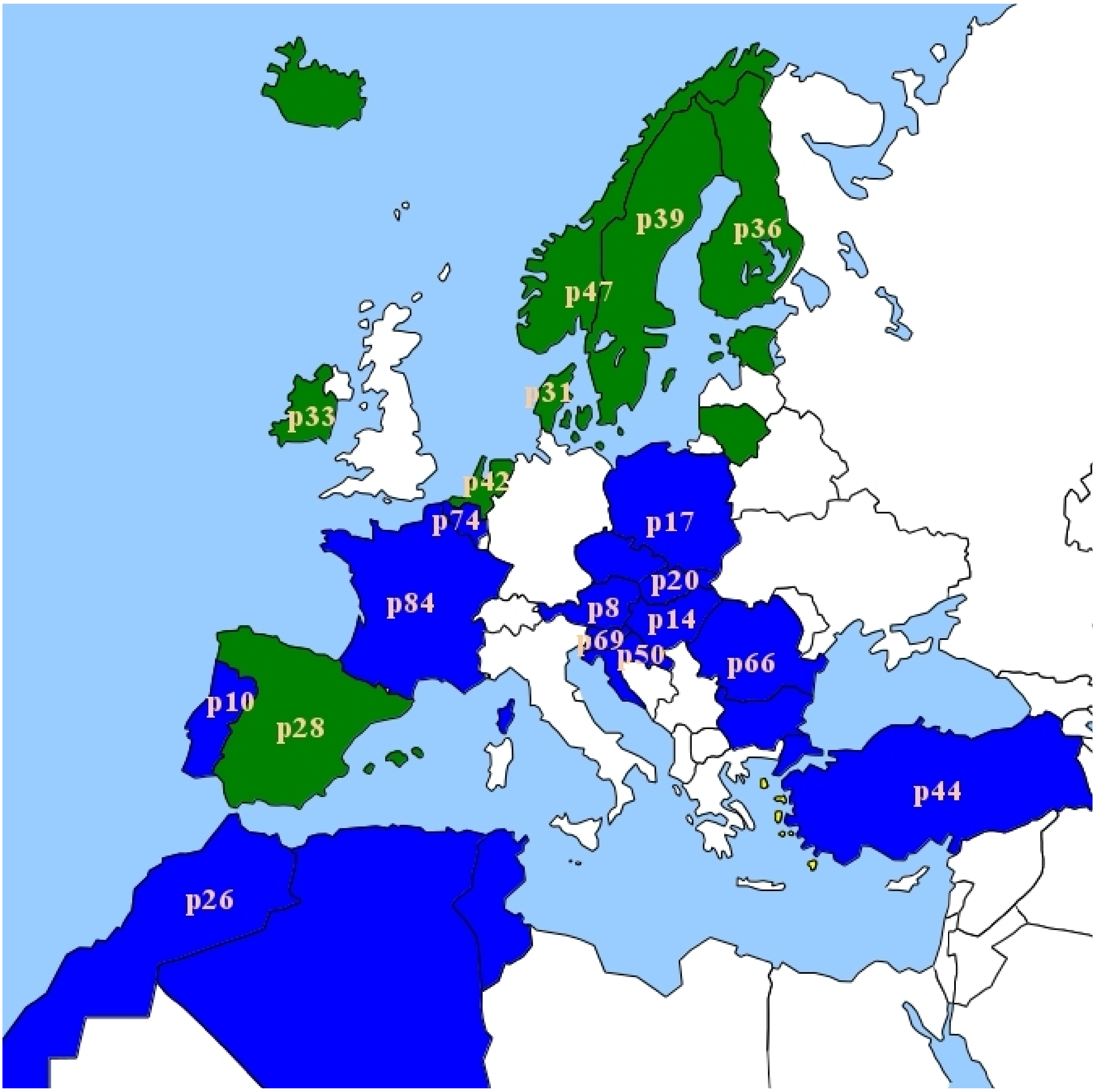
4. Both PM will report every six months on those issues to the consortia governing bodies.

5. Joint meeting of governing bodies of both consortia will be held at least once a year.

The joint declaration, some photos and the documents presented during this 1st Joint GA/Council meeting are available on the ALADIN website:
http://www.cnrm.meteo.fr/aladin/spip.php?article271.

"Tour d'ALADIN & HIRLAM"

Join for a Grand Tour and follow the page numbers on the map ..



Update of operational AROME in Austria

Florian Meier, Christoph Wittmann, Nauman Khurshid Awan, Theresa Schellander-Gorgas, Stefan Schneider, Clemens Wastl, Florian Weidle, Xin Yan

1 Introduction

Since January 2014 AROME 2.5km has been operational at ZAMG. Along with the global IFS data, deterministic ALARO 4.8km and probabilistic ALADIN-LAEF 11km, it completes the Austrian model chain. AROME has been running on ZAMG local high performance computer (SGI ICE-X) 8 times per day. Due to the requirements of forecasters and our customers and free computational resources, a revised version became operational on 18th of August 2014. Besides other changes an extended lead time of 48h, a larger model domain and an increased vertical resolution was implemented in this new version. Furthermore, the range of post-processed (fullpos) fields was increased. The effect of the changes on the forecast quality is mostly neutral, but the extended domain and lead time opened the gate for new applications of the model data.

2 The new AROME version

The new AROME version covers not only the Alpine mountain range, as before, but Serbia, Southern Germany and Poland as well as all LACE countries except Romania are also included (Figure 1). In order to improve numerical stability, model top was lowered from around 8hPa (60 levels) to around 20hPa (90 levels). Therefore we also made slight modifications in the data assimilation system: the high peaking AMSU-A channels 12 and 13 are blacklisted and only channels 5-11 of AMSU-A are still used. Predictors 5 and 6 in the 3D-Var system (thickness 1-10hPa/5-50hPa) were switched off. We also found that NOAA 19 satellite HIRS observations caused several crashes in the data assimilation and hence don't use it any more. However, we did not change the rest of the observation data sets. A short summary of the changes is listed in Table1. Another finding worth mentioning is, that the former version of OIMAIN (cy36t1op2) has led to corrupted soil moisture increments when the lowest CANOPY layer was placed below 10m above ground (as it is in both Austrian AROME versions). Therefore a revised OIMAIN will be used in the new Austrian AROME. Future plans include the usage of new observations in data assimilation, rapid update cycling and consideration of orographic shadowing. After verification and evaluation, it is planned to switch to new AROME version cy38t1 probably with CANARI-OIMAIN inline.

Table 1: Comparison of the operational AROME in Austria before and after 18th August 2014

Model version	AROME old	AROME new
Cycle	cy36t1(assim)/cy37t1op 1	cy36t1(assim)/cy37t1op1
Resolution	2.5km	2.5km
Levels	60	90
Area	432x320 GP	600 x 432 GP
Initial conditions	3D-Var+OIMAIN offline	3D-Var+OIMAIN offline
B-Matrix	Ensemble method LAEF	Ensemble method LAEF
Orography	Mean GTOPO30	Mean GTOPO30
Physiographic data	ECOCLIMAP I/FAO	ECOCLIMAP I/FAO
TEB-Scheme	Yes	Yes
Screen level diag.	CANOPY	CANOPY
Model top	~8hPa	~20hPa
SNOW	Cycled; modified by	Cycled; modified by

	MODIS data	MODIS data
Boundaries	IFS lagged/3hourly	IFS lagged/3hourly
Starting times	0/3/6/9/12/15/18/21UTC	0/3/6/9/12/15/18/21UTC
Cycle interval	3 hours	3 hours
Lead time	+30h	+48h

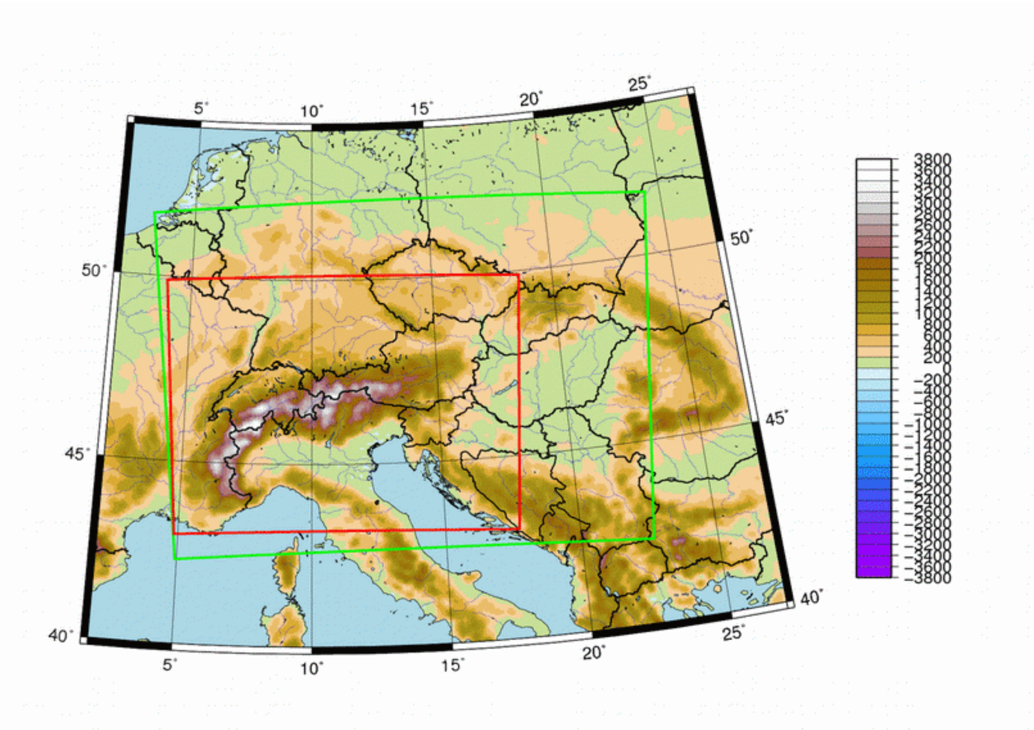


Figure 1: New (green) and old (red) Austrian AROME domain and orography.

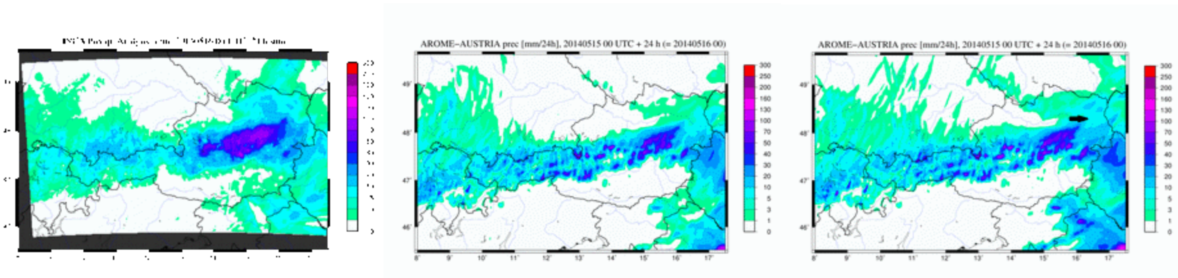


Figure 2: 24h precipitation sums during a heavy precipitation period in May 2014: Reference analysis with the nowcasting system INCA (left) and forecasted amount with AROME "old" (middle) and "new" (right). In Northeastern Austria precipitation is insufficiently simulated (underestimated) by the older AROME version, where this area is close to the lateral boundary, while the result of new version is more realistic (black arrow).

ALADIN Highlights for IPMA, I.P. (Portugal)

Maria Monteiro, João Rio, Vanda Costa, Manuel João Lopes, Nuno Moreira

1 Introduction

Since the last report, efforts have been focused into three main aspects: in the first place, on the upgrade of the Portuguese Numerical Weather Prediction (NWP) operational system; secondly, on the support of internal and external customers of the NWP products; and finally, on the initial steps to the design of a local data assimilation system. In this publication, we summarise the main achievements on these different aspects.

The details on the local system upgrade are given in section 2. They consist on both the migrations of the computing plataform and of the cycle´s version of the numerical system. In section 3 we highlight a new derived product which statistically combines the forecasts of the local models with those disseminated by the European Center Medium-range Weather Forecast (ECMWF), and in section 4 we show the results of a successful time integration of the local AROME-Mainland model (here called, AROME/PTG) with the assimilation of Lisbon's radar data (WMO_ID=08550).

2 The upgrade of the local NWP operational system

During 2014 a new High Performance Computing (HPC) plataform has been acquired and installed - the IBM Pure Flex system. It is composed by 8+1 IBM Power 7+ nodes with 24 cores each of 3.4 GHz and 128 GB (model p260). Moreover, a 1 IBM Total Storage DCS3700 with 50 discs SAS of 300GB (15TB) at 15 Krpm is available. AIX (7.1) is used as OS (Operating System).

As a front-end to the HPC machine, an high-availability virtualization system is used - the IBM Blade Center, where each node is a Xeon X5650 with a 6 cores at 2,67 GHz. This system acts as a server to the operational scripts which submits jobs to the HPC through the Scheduler Monitoring System (SMS/Xcdp) from ECMWF.

In parallel with the migration of the actual operational system to the new computing plataforms, the migration of the numerical system to the new cycle CY38T1_bf03 is taking place. It includes the upgrade of climate files with CY38. Taking advantage of this work, an enlargement of the integration area for the AROME/PTG domain will take place also by pulling the actual eastern boundary to East. In this way, the new model domain should cover a wider geographical area of the Iberian Peninsula. A new pre-operational suite is expected to start during the first quarter of 2015 as well as its meteorological validation using the actual operational system as reference.

Foreseen developments on the local Limited Area Model (LAM) system will consider the direct coupling of AROME/PTG with the ARPEGE model (from Météo-France, M-F).

3 Statistical adaptation of hourly forecasts

The statistical adaptation of forecasts from AROME, ALADIN and ECMWF models was already available locally in order to improve the daily minimum and maximum temperatures forecasts at selected locations up to 5 days. Model Output Statistical (MOS) and KALMAN adjusted temperatures were performed for each NWP model (AROME,ALADIN and ECMWF) and a final forecast was then computed as the average of all available post-processed forecasts. During the current year, this framework has been extended to the 2 m temperature and relative humidity, as well as to the 10 m wind speed, with an hourly frequency, up to 3 days. The daily minimum and maximum temperatures forecasts have also been extended to 10 days.

As an illustration, the panels in Figure 1 show the RMSE of maximum (left) and minimum (right) temperatures, for the summer of 2014 (from 1 June to 10 August). The scores are valid for the 00 UTC run and were computed at 105 weather stations.

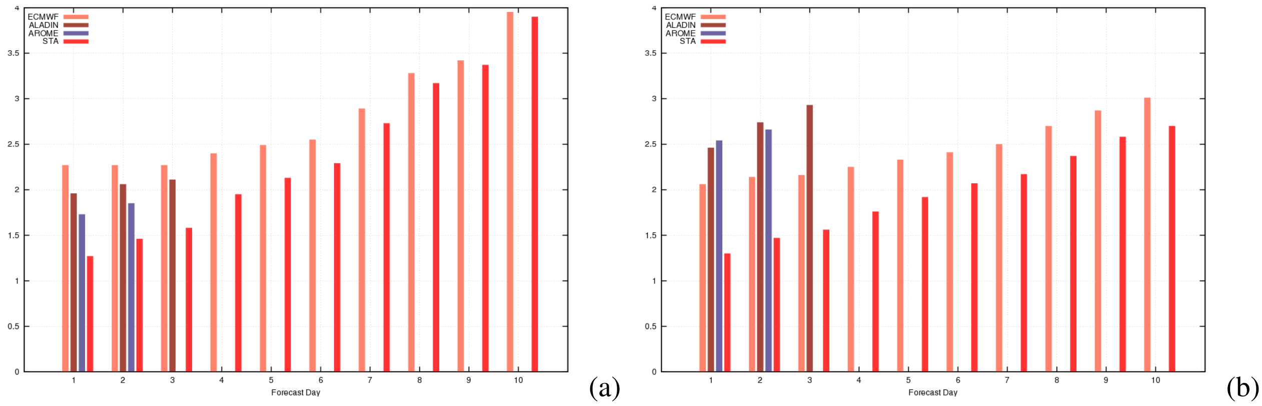


Figure 1: RMSE comparison of the statistical post-processing (STA) and direct model output (DMO) for ECMWF, ALADIN and AROME forecasts, using 105 weather stations over Portugal-Mainland, during the summer period of 2014 (from 1 June to 10 August), for the parameters: (a) 2 m maximum temperature and 2 m minimum temperature.

The plots allow the comparison of the statistical post-processing (STA) and the Direct Model Output (DMO) of ECMWF, ALADIN and AROME forecasts. When assessing DMO forecasts, the lowest RMSE of 2 m maximum temperature is found for AROME and of 2 m minimum temperature for ECMWF. The statistical post-processing has the lowest values of RMSE, regardless of the variable and forecast length.

These products are available through IPMA's website and a mobile app.

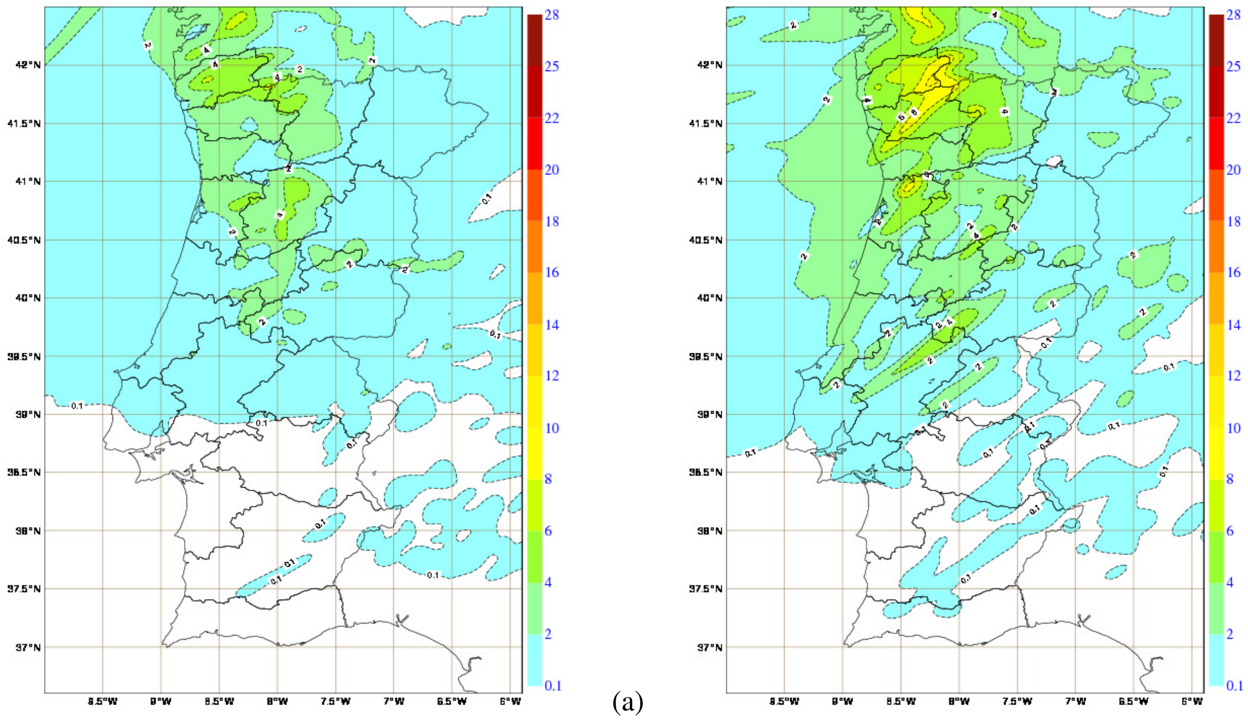
4 Radar data assimilation development activities

The study to the future implementation of a data assimilation system for AROME/PTG, has started by the end of 2013, by setting an experiment with the system HIRLAM-ALADIN Research towards Meso-scale Operational NWP in Euromed (HARMONIE), on version cy37h1.2, at ECMWF plataforms. In this way, it was possible to shortcut some local technical work and just focus the efforts on the design of the system it self.

The experiment setup with HARMONIE at ECMWF comprises the new components (in comparison with the local operational system): a CANARI surface assimilation with conventional data, a 3D-Var upper air assimilation with conventional data as well as Lisbon radar observations; the usage of ECMWF (instead of ARPEGE) as a coupling model; and the increase of 46 (ARPEGE designed) to 60 (HIRLAM designed) levels.

To feed this experiment with BUFR data, a new pre-processing interface to CONvert RADar data (CONRAD) - the CONRAD_RC developped by the LACE sub-consorcium, is being used to convert local IRIS raw data into M-F BUFR format. Once set the experiment, the first step was to evaluate the impact of the assimilation of Portuguese radar observations on the AROME/PTG forecasts and this work is still on going.

The Portuguese radar data has been sucessfully ingested by the HARMONIE system when a reverted version of the BATOR application (cy36t1_bf.04, according to M-F standards) was used in the HARMONIE system. In the Figure 2 it is illustrated the AROME/PTG 3 h forecast of 1000hPa simulated refletivity with initial conditions starting on 4 February 2014 at 12UTC. In the left panel as it is produced by the operational system and the initial conditions are obtained by dynamical adaptation from an ALADIN field; on the right panel as performed with the HARMONIE experiment starting from an analysis obtained from a 6 hour cycling. In the latest, it is a successful minimization of the 3D-var assimilation scheme which is achieved when 20% of Lisbon's 3D radar data at 12UTC remains active after screening.



(a)

(b)

Figure 2: AROME/PTG 3 h forecasts of 1000hPa radar reflectivity, on the 20140204 and valid at 15UTC, obtained by the different systems, over Portugal-Mainland: (a) local operational AROME/PTG (without assimilation) and (b) HARMONIE (with assimilation).

The Figure 3 illustrates the atmospheric conditions on 4 February 2014 at 15UTC. As we can see by comparing the Figures 2 and 3, the reflectivity forecast produced with assimilation looks realistic and promissing. Though from the operational point of view this first result may be still meaningless (it requires the tunning of the system and a systematic validation), it has shown the potential of HARMONIE as a research tool and the potential of the actual radar pre-processing applications onto the implementation of local data assimilation systems.

Meanwhile the HARMONIE system (cy38h1) has been installed locally and the migration of the original experiment to this new cycle is taking place. Foreseen work in order to track the added value of each new design component (initial and lateral conditions, surface and upper air assimilation) from the actual operational system should be resumed and complemented.

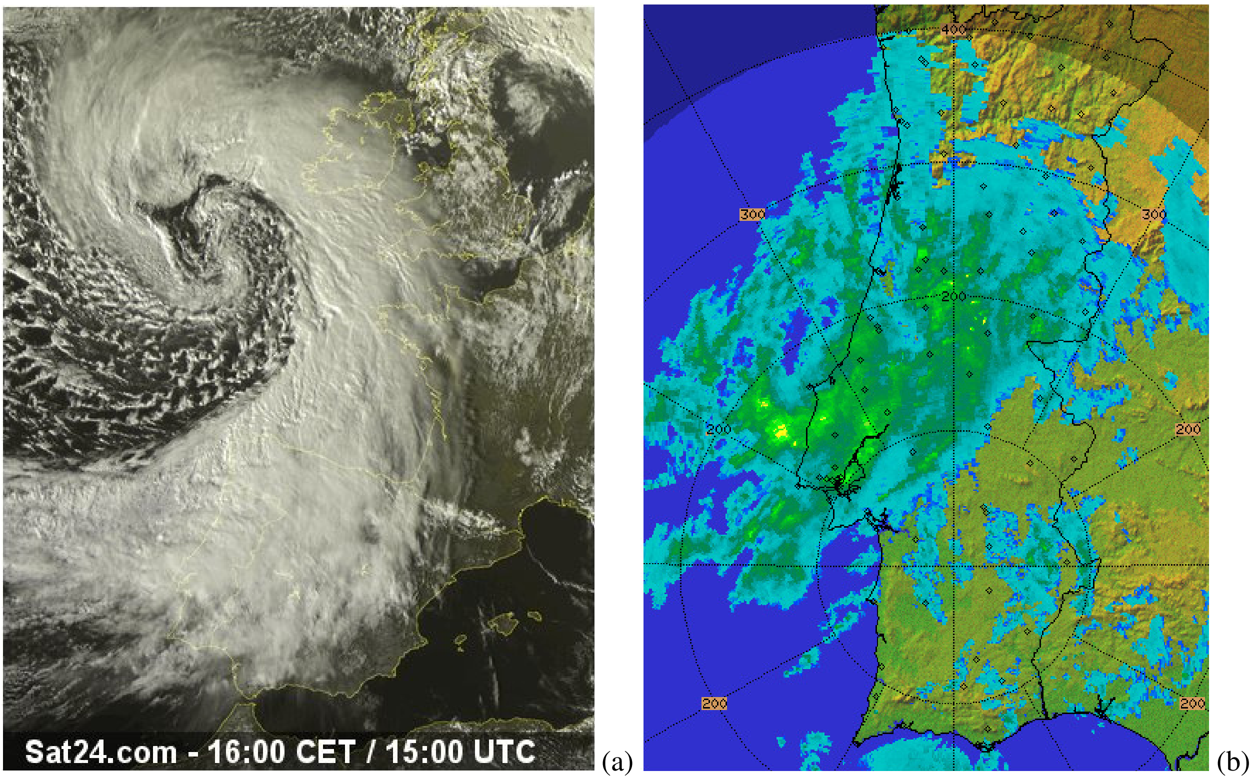


Figure 3: Weather situation on 04 February 2014 at 15UTC, as illustrated by two different ways: (a) a satellite image and (b)a local radar mosaic at 1000m height.

Modelling activities at the Hungarian Meteorological Service

Gergely Bölöni, Máté Mile, Dávid Lancz, Balázs Szintai, Mihály Szűcs, Helga Tóth
Hungarian Meteorological Service

1 Introduction

This short paper describes the current research and development activities at the Hungarian Meteorological Service (OMSZ) related to the ALADIN/AROME modelling system. At the end of 2014, three limited are systems from the ALADIN/AROME model family are run operationally at OMSZ:

- AROME model at 2.5 km horizontal resolution
- ALADIN model at 8 km horizontal resolution
- Limited area ensemble system based on the ALADIN model at 8 km resolution

This paper describes the developments related to these operational systems as well as research work on the next generation of numerical weather prediction models.

2 Research and development activities

Experimental AROME Data Assimilation with non-conventional observations

RADAR data assimilation activity for a summer period of 2012 with AROME 3DVAR has been tested employing newer cycle (CY38t1) and improved local RADAR (both reflectivity and radial wind) observations in Hungary. The spin-up problem in surface variables - reported last year during preliminary RADAR data assimilation studies - has been solved with corrected Hungarian RADAR data and using CY38t1. The verification of AROME forecasts showed promising impact on surface variables compared to operational configuration (Fig. 1. shows examples from verification scores).

Concerning data assimilation of GNSS Zenith Total Delay (ZTD), a so called SGOB Network has been introduced to the E-GVAP Network bringing more than 50 new ground-based GNSS receiver stations to the E-GVAP. Using this network an assimilation study of GNSS ZTD has been investigated with roughly 67 selected (whitelist selection procedure) ground-based stations inside AROME Hungary domain. These stations provided reliable and good quality of ZTD observations and gave good data coverage over the AROME domain. In conclusion the impact of assimilated ZTD has been mainly neutral and slightly positive especially on AROME humidity forecasts.

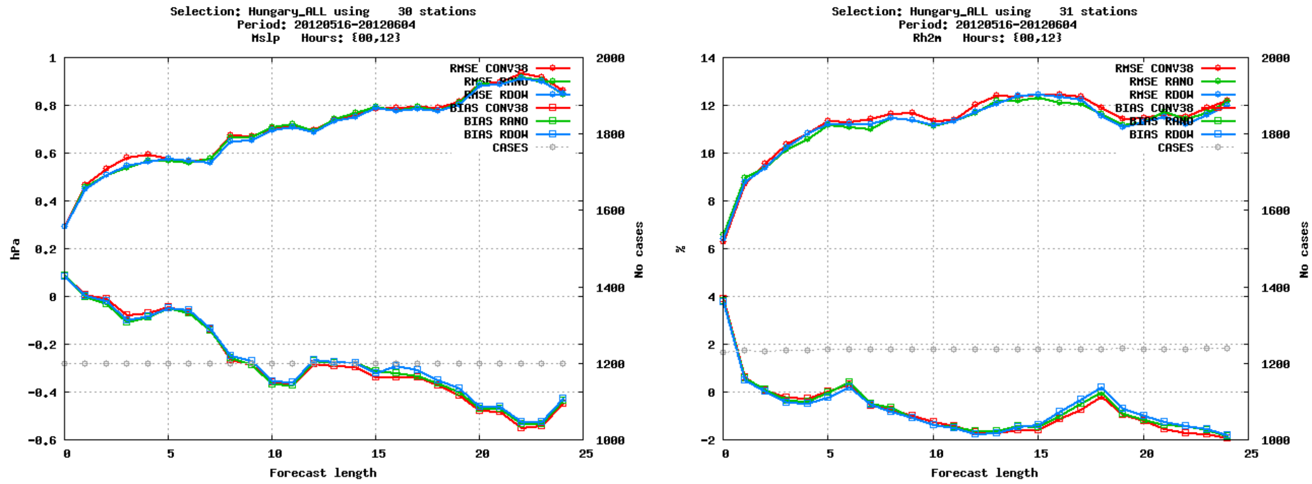


Figure 1: RMSE and BIAS scores for MSLP (left) and 2m Relative Humidity(right). Red curves – AROME CONV: Operational configuration, Green curves – AROME RANO: AROME CONV+ RADAR reflectivity and radial wind, Blue curves – AROME RDOW: AROME CONV + RADAR radial wind

Surface Extended Kalman Filter in AROME

One week FR-LACE stay was executed in Brussels in the topic of surface data assimilation. In the ALADIN-BE model Extended Kalman Filter has been tested recently in the surface assimilation. In Hungary the plan for the future is to use EKF in AROME, not in ALADIN, but the main basics are the same in both models given that SURFEX is the surface model we are both building on at RMI and OMSZ. The aim of the visit was to perceive the procedure of EKF and produce an analysis over the Hungarian domain. After returning home the installation of the AROME EKF system started and is almost ready, but some bugs are under correction.

Microphysics tuning in AROME related for wintertime low cloud events

Wintertime low cloud cases were investigated which are associated with anticyclonic conditions over Central Europe. It was found that most operational numerical weather forecasting models face difficulties when simulating these situations. The most common problem is the underestimation of low cloud cover. Several sensitivity experiments were performed with the AROME model over Hungary, which indicated that the cause of the inadequate low cloud forecast can be traced back to the microphysics parameterization. By increasing the critical threshold of autoconversion, the overestimation of solid drizzle could be decreased and consequently the low cloud cover forecast improves. The modification wast tested on longer time periods (winter and summer) and selected case studies. Operational implementation is planned for the end of 2014.

Research of shallow convection parameterization in the gray zone in AROME

The shallow convection parameterization in AROME is using the Mass-Flux scheme. This means, it is supposed that a thermal, which has far smaller horizontal size than the mesh-size of the simulation, is responsible for the non-local vertical turbulent transport in the planetary boundary layer. Because this thermal is not resolved by the models dynamics, it is parameterized. If we increase the horizontal resolution, the dynamics begins to resolve these thermals, so they are treated twice. These resolutions are in the shallow convection gray zone. The currently used shallow convection parameterization works independently from the resolution. The goal of this work is to upgrade this parameterization to count with the horizontal grid-size. We plan to modify the coefficient in the equation of the initialization of these thermals. In the new version it would be dependent on the horizontal resolution. This new coefficient would be based on the results of large-eddy simulations made by MesoNH.

Model error representation in LAM ensemble systems

Hungarian Meteorological Service is running its operational limited area ensemble system. It is based on ALARO which runs on 8km resolution. This system is the simple downscaling of French PEARP and runs daily once at 18UTC for 60 hours. As convection-permitting ensemble systems were getting more focus in Europe, OMSZ has also started its test with AROME-EPS on 2.5km resolution. We have been focusing mainly on two methods to generate better perturbations, both in ALARO-EPS and in AROME-EPS. Ensemble data assimilation (EDA) system was tested to get more precise initial condition fields and to estimate its uncertainty better. Results were quite promising especially in AROME-EPS where near-surface verification showed a clear improvement if EDA was implemented. Stochastically Perturbed Parameterized Tendencies (SPPT) is a method what we tried to use to give a representation of the model uncertainty. Tests are still in their early stage, but the effectivity of scheme looks highly dependent on the size of the model domain.

ALADIN in Poland - 2014

Marek Jerczynski, Bogdan Bochenek, Marcin Kolonko, Malgorzata Szczech-Gajewska,
Jadwiga Woyciechowska – Institute of Meteorology and Water Management / POLAND

1 Introduction

At IMWM main efforts in 2014 were mainly focused on the following tasks: putting 7.4km ALARO and 2.5km AROME suites into operational service on new 97-node cluster, preparation of new set of NWP products and developments in robust D-MOS statistical adaptation.

2 Description

Several months ago ALADIN team in Poland was equipped with computational cluster capable of peak performance of 30 TFLOPS. After numerous tests all operational production has been moved to this machine.

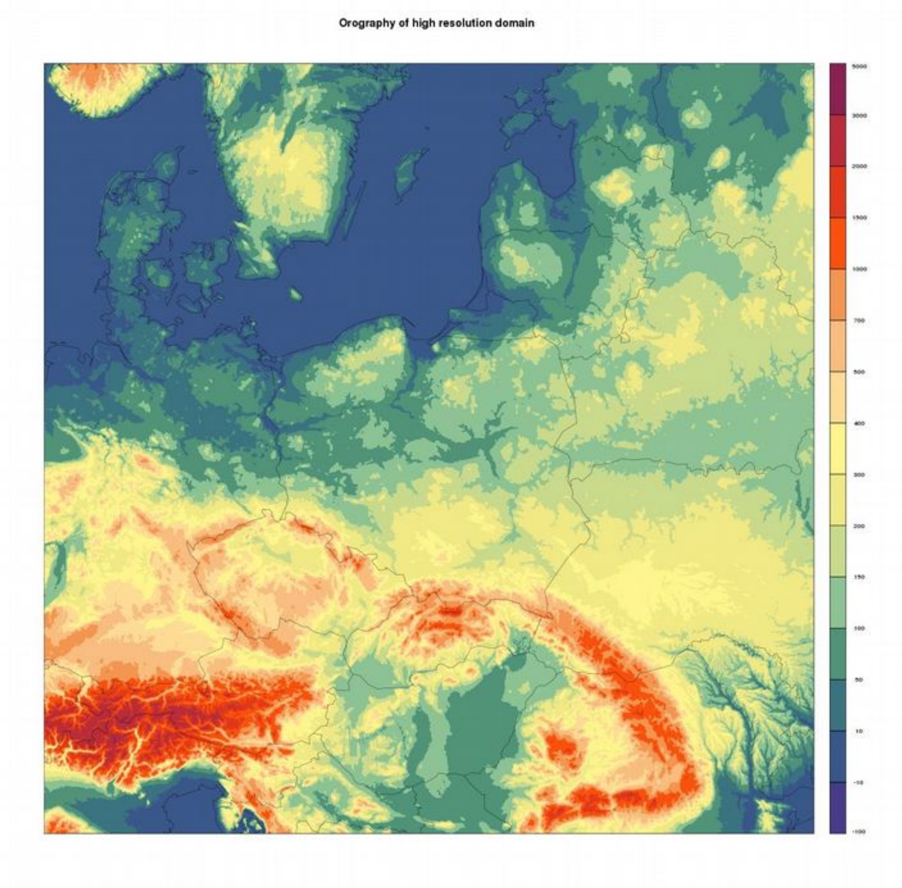


Figure 1: Domain for 2.5 km AROME

Currently two main configurations of ALADIN prediction system are being exploited – their features can be seen in Table 1. Domain for high resolution forecasting is presented at Figure 1.

Table 1: Current operational configurations

Domain	POLs	P025
Model	ALARO	AROME
Resolution	7.4 km	2.5 km
Size	2230 km x 2230 km	1600 km x 1600 km
Grid	320 x 320	648 x 648
Levels	60	60
Range	54h	30h
Coupling	ARPEGE / every 3h	POLs / every 1h
Starting times	00h + 12h	00h + 12h

Significant number of new operational forecast products were prepared and put into operational usage at IMWM. The products are dedicated to support various purposes such as nowcasting, hydrology, air quality and teledetection. Among new products are maps with high resolution forecast - see Figure 2.

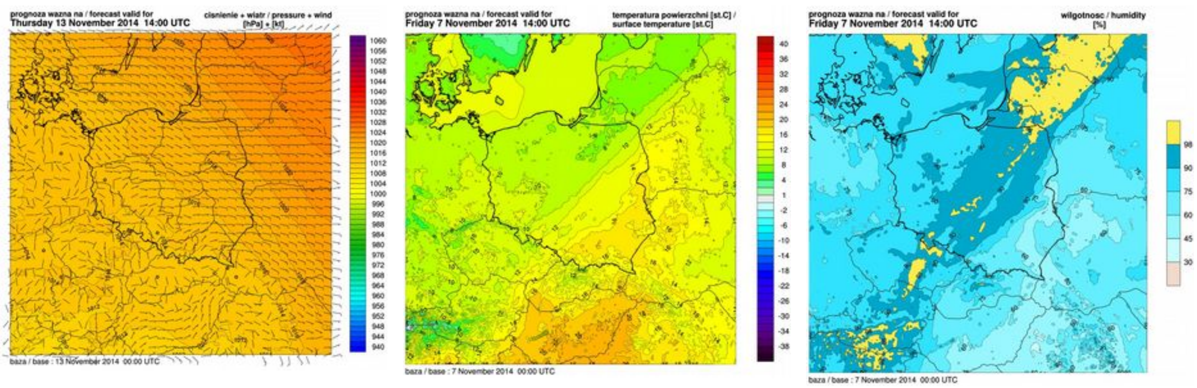


Figure 2: Examples of maps visualizing high resolution forecast

To create method of statistical adaptation that is not affected by outliers and is effective in operational use was motivation of our R&D work. Applicability of various robust attitudes has been analyzed during last months. Finally D-MOS statistical adaptation with robust regression was developed, meliorate and tested. See below example of forecast improvement obtained with it – Figure 3.

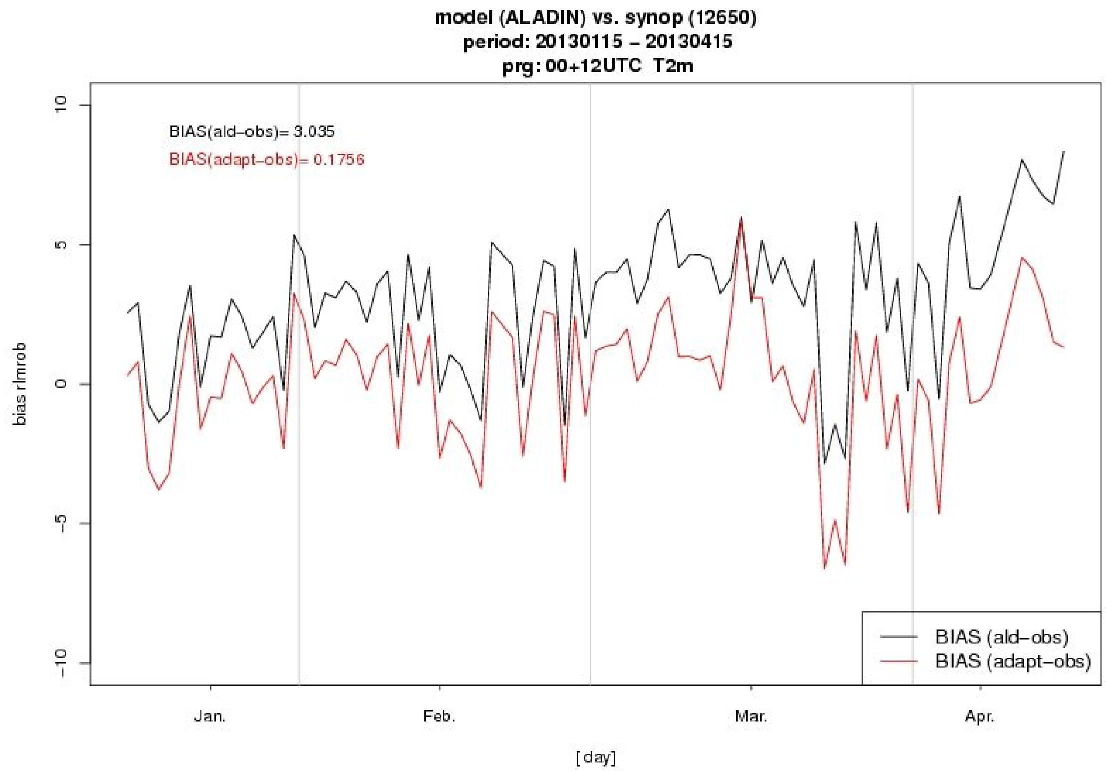


Figure 3: One month time series of RMS scores for temperature (K) at 500 hPa.

ALADIN related activities @SHMU (2014)

Mária Derková, Martin Belluš, Jozef Vivoda, Oldřich Španiel, Michal Neštiak

1 Introduction

The summary of ALADIN related activities at Slovak Hydrometeorological Institute in 2014 is given. The setup of ALADIN operational system and new high resolution e-suite based on CY38T1bf03_export version are described and some research and activities are highlighted.

2 Operational ALADIN/SHMU NWP system

The ALADIN/SHMU system setup

The operational ALADIN/SHMU NWP system covers so-called LACE domain with 9km horizontal resolution and 37 vertical levels. It is operated 4 times per day up to +72h. Current model version is based on CY36T1 with so-called ALARO+3MT physics and ISBA surface scheme, coupled to Arpege global model. The spectral blending by digital filter is applied for the upper-air pseudo-assimilation using Arpege analysis. For surface the CANARI data assimilation scheme using additional local observations is active. More ALADIN/SHMU details are given in Table 1. In addition, the high resolution e-suite was installed since June 1, 2014 with resolution of 4.5km in horizontal and 63 levels in vertical. It is based on CY38T1bf03_export version with ALARO-0 physics setup. The assimilation system is identical with the operational one.

Table 1: ***ALADIN/SHMU - operational & e-suite setup, HPC parameters***

Model version	ALADIN/ALARO, CY36T1_bf10	CY38T1bf03_export, ALARO
Resolution	9.0 km	4.5km
Levels	37	63
Area	2882 x 2594 km (320 x 288 points) [2.19; 33.99 SW, 39.06; 55.63 NE]	2812 x 2594 km (625 x 576 points) [2.31; 33.77 SW, 39.07; 55.88 NE]
Initial conditions	CANARI surface analysis & upper-air spectral blending by DFI 6 hours cycling	
Boundaries	ARPEGE, 3h coupling frequency	
Starting times	00, 06, 12, 18 UTC	00 and 12UTC
Forecast length	+72h (+60h at 18UTC)	+72h
Physics	ALARO+3MT	ALARO-0 (CY38t1bf03)
Surface scheme	ISBA	
Dynamics	2TL SL hydrostatic; SLHD	
HPC	10 nodes of IBM Power 755: 4x Power7 8core CPUs, 256 GB RAM total: 320 CPUs, 2.5 TB RAM	
Management servers	2x IBM Power 750: 1x Power7 6core CPU (3.6 GHz), 64 GB RAM	
Software & file system	AIX 6 SE OS, IBM Load Leveler queueing system, 40 TB GPFS	

Activities in Y2014 and plans for Y2015

New high resolution e-suite based on CY38T1bf03 with ALARO-0 settings was installed since June the 1st, 2014 in full assimilation/production mode. Apart from higher vertical and horizontal resolution and the linear grid replacing the quadratic one, the mean orography was used instead of the envelope one of the operational suite with the old roughness length tuning applied. See Table 1 for specification details and comparison with the operational suite setup and Figure1 for the orography illustration. Concerning the timing, e-suite is about ten times more expensive in CPU consumption: 72h integration needs about 40minutes compared to 4minutes of the operational forecast. The e-suite scores were neutral to slightly positive when compared to the operational scores. A deterioration was noticed for cloudiness that is not understood yet (see Fig.2). The subjective evaluation of the e-suite by the forecasters was mostly neutral. It is difficult to comment on precipitation. This summer many cases with heavy rain occurred thus the assessment of the correctness of timing and location might be misleading (Fig. 3). What was noticed both in operational and e-suite forecast was often the inconsistencies between subsequent forecasts.

It is planned that some further tuning of the e-suite will be made, namely with respect to cloudiness and precipitation forecasts. Its operational implementation will be probably postponed till the upgrade of HPC, which is envisaged in 2015 in frame of the POVAPSYS project (Flooding Warning System).

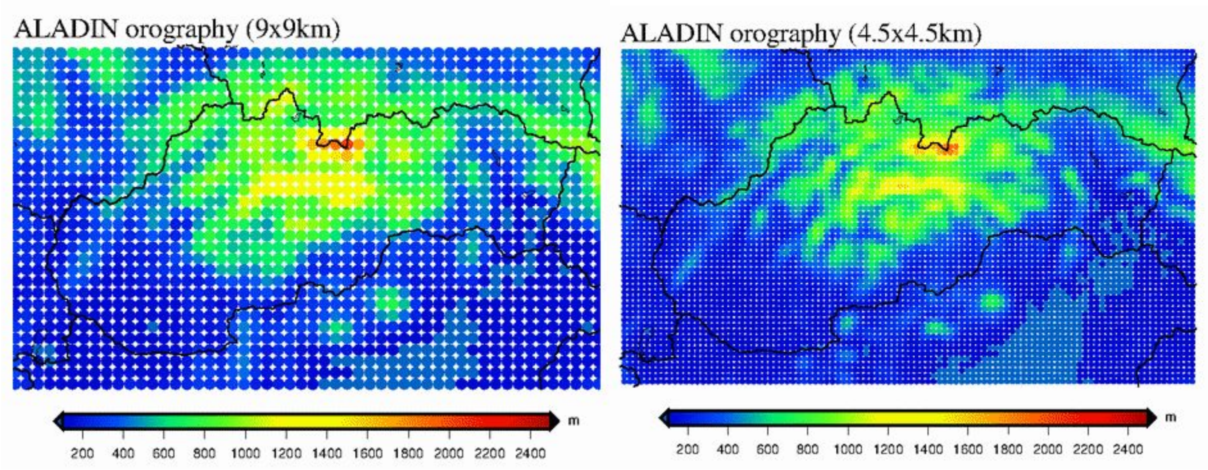


Figure 1: The orography of operational and e-suite zoomed over Slovakia.

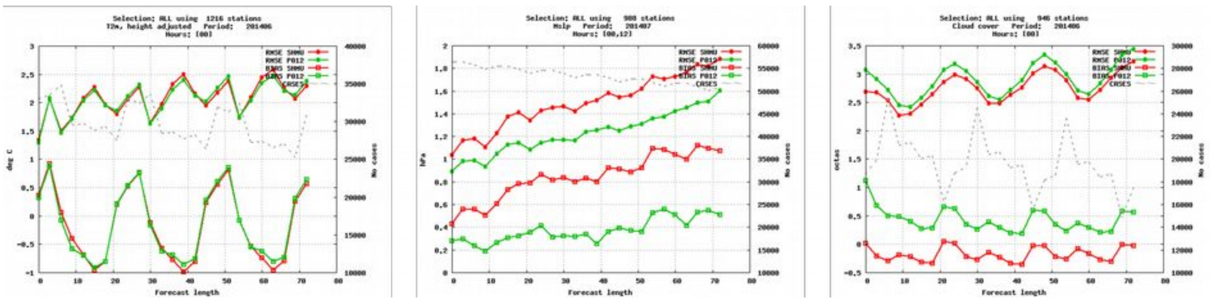


Figure 2: Example of verification results of the high resolution parallel suite (green) versus the operational scores (red).

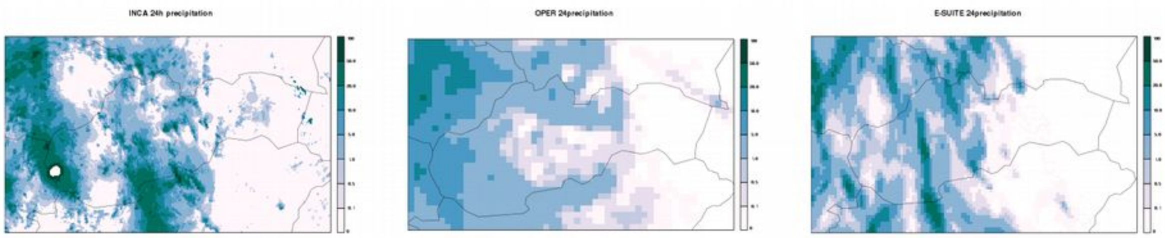


Figure 3: Example the precipitation forecast: 24h cumulated rain as analyzed by INCA (left), the operational forecast (middle) and the e-suite forecast (right) for 2014-08-04 (heavy storm in Bratislava)

3 Research and Development activities

Finite element vertical discretization for ALADIN non-hydrostatic dynamics (Jozef Vivoda)

The work on vertical finite elements discretization has continued within two scientific stays in Prague and Valencia, in collaboration with P. Smolikova (CHMI), A. Subias and J. Simarro (AEMET). The code was debugged, cleaned from obsolete options and phased to CY40T1. The choice of parameters and methods was evaluated, the stability and accuracy properties and the convergence of operators (vertical linear laplacian operator discretized with finite element method) were studied. The methodology of realization of Baldauf's test for the horizontal propagation of the gravity waves was discussed. Remaining problems are C1 constraint (solution proposal of A. Subias is being discussed); sensitivity of the vertical levels distribution to stability; formulation of invertible operators and the problem of remaining noise connected with their application. An article on VFE is under preparation.
A complete report from the stays will be available on the RC LACE web pages (www.rclace.eu).

ALADIN-LAEF (Martin Bellus)

The development of ALADIN-LAEF configuration within RC LACE cooperation has continued. The stochastically perturbed physic tendencies for prognostic surface parameters have been implemented in ALADIN-LAEF system. An article titled "*A New Method for Generating Initial Condition Perturbations in a Regional Ensemble Prediction System: Blending.*" has been written and published in MWR (see references).

Stochastic physics methods are used to asses the model uncertainties in the ensemble prediction systems. The SPPT (Stochastically Perturbed Parameterization Tendencies) method was implemented in the ALADIN-LAEF to perturb the surface prognostic fields with their randomly distributed physics tendencies. Mathematically, the j^{th} ensemble member is given by the sum of two contributions of resolved processes (A) and of perturbed tendency of parametrized processes (P'). P'represents the fluctuation around grid-box averaged physical tendency P and r_j is an uniformly sampled random number for subdomain of size D, constant over time T.:

$$\delta e_j/\delta t = A(e_i,t) + P'(ej,t) = A(e_i,t) + (1 + r_j(\lambda,\varphi,t)_{D,T}) Pj(e_i,t)$$

The random number is defined using Gaussian distribution with zero average and standard deviation σ; using spectral pattern generator with namelist tunable parameters. For more details see report in References.
Behavior of new revised SPPT scheme has been checked against the former BMP (Buizza, Miller, Palmer) scheme. The main difference between the original BMP scheme and revised SPPT is in the random patterns definition and their generation. While the first one approach divides the whole domain into regular, temporally and spatially constant lat-lon rectangles, the second one generates rather chaotic patterns varying smoothly in space and time. Latter technique is more natural and less dangerous in creation of spurious, non-physical horizontal gradients in the perturbed physics fields (Fig. 4).

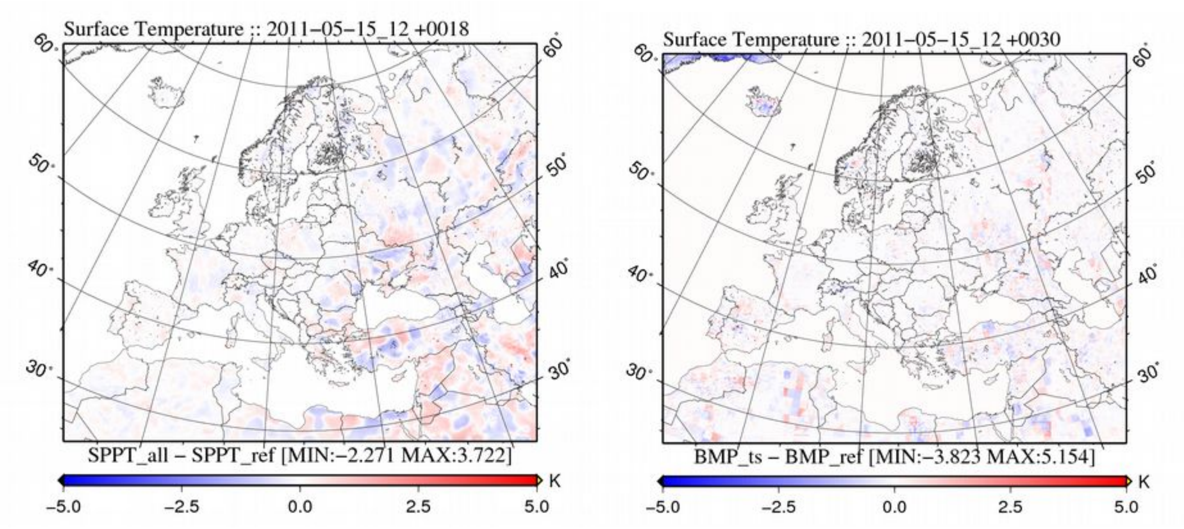
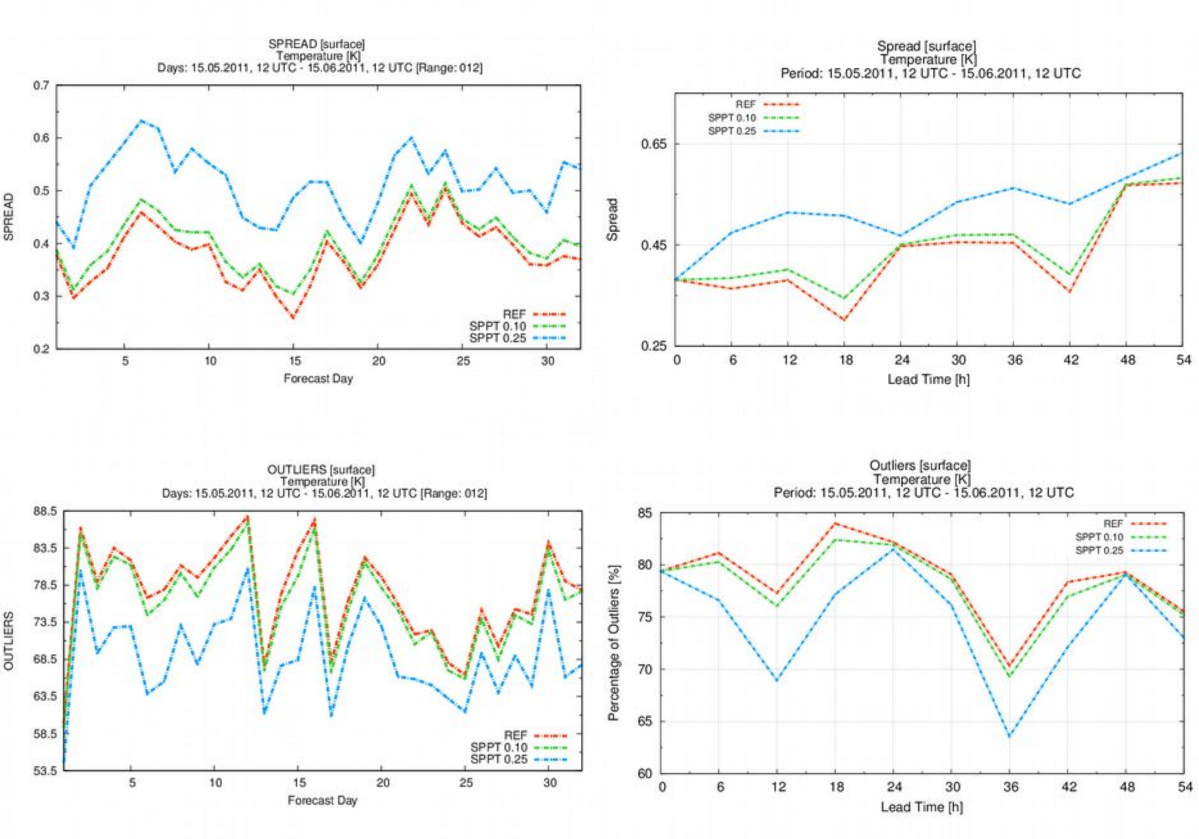


Figure 4: The surface temperature differencies from unperturbed reference as obtained by SPPT method (left) and BMP method (right).

The performance of the stochastically perturbed physics tendencies of the surface prognostic fields has been evaluated over 3 month period with σ=0.1 (small but rather positive impact), and with σ=0.25 for 1month period. In the latter case the scores, namely ensemble mean BIAS and RMSE, are improved while system has bigger spread and less outliers with respect to reference. Figure 5 shows few verification results.



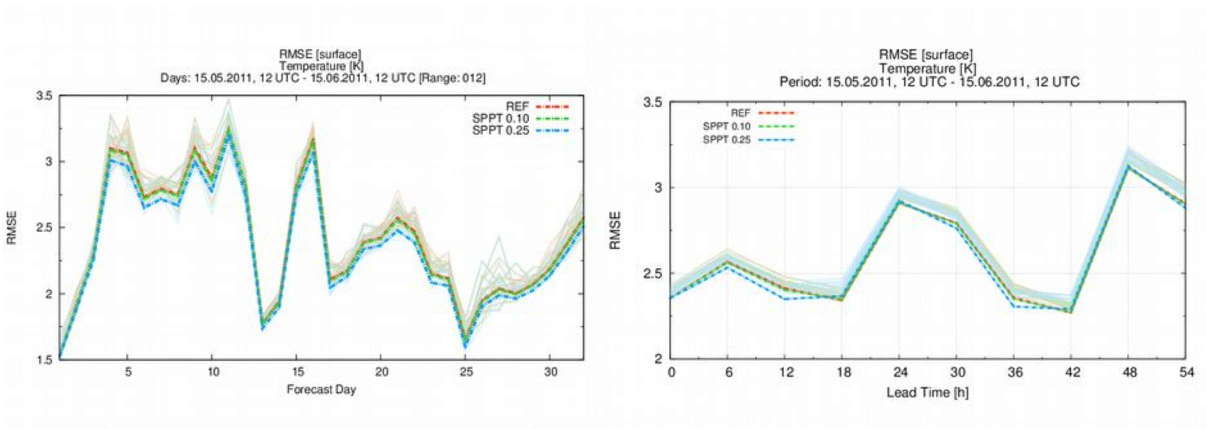


Figure 5: Verification scores for reference and two tunings of perturbed experiments.

Radar quality control and data assimilation for RC LACE (Michal Nestiak)

The work on radar data assimilation has continued. The quality control (QC) algorithms for radar data from the INCA2 precipitation module (outcome of the INCA-CE project) were adapted to be used in CONRAD QI and consequently have been tested on the sample of RC LACE radar data. The 2-months period of May-June 2012 was selected. Volume radar data were collected in HDF5 format together with automatic station data from all LACE countries and processed using the above mentioned QC tool. Data assimilation experiment with those data was performed using AROME/OMSZ. Results are currently under evaluation.

A complete report from the stays will be available on the RC LACE web pages (www.rclace.eu).

HARMONIE system Working Week (Oldrich Spaniel, Maria Derkova)

HARMIONIE system Working Week (WW) has been organized from Oct 13 to 17, 2014 at SHMU, Bratislava with the participation of 15 ALADINers from eight countries, and three HIRLAM lecturers. The WW was kind of continuation and an extension of the Ankara 2013 WW, in frame of further convergence between ALADIN and HIRLAM consortia in the cooperation on the system/code maintenance and validation. The main topics for the WW were:

- installation of CY38T1_bf03 under HARMONIE (with the emphasis on the "T" version);
- installation of HARMONIE system including 3DVAR on local platforms, training of newcomers;
- installation of missing ALADIN system components (e.g. DFI blending) under HARMONIE system.

During the WW several presentations were given (available on HIRLAM wiki page) and the HARMONIE system installations and runs were supervised by HIRLAM and SHMU colleagues. Installations were successful in 3 Partners countries, 2 participants were able to run on laptops, others are supposed to continue at home. DFI blending was incorporated, but not yet fully validated. Other topics as the OPLACE support, HARMONIE verification package, bug fixing etc. were covered. Further continuation of HIRLAM-ALADIN collaboration on the code and system aspect was discussed.

4 References

Belluš, M., 2014: Stochastically perturbed physics tendencies of surface fields in ALADIN-LAEF system, Report on stay at ZAMG, Vienna, Austria, 2014. Available on www.rclace.eu.

Wang, Y., Bellus, M., Geleyn, J.-F., Ma, X., Tian, W., and Weidle, F., 2014: A New Method for Generating Initial Condition Perturbations in a Regional Ensemble Prediction System: Blending. Mon. Wea. Rev., 142, 2043–2059.
doi: http://dx.doi.org/10.1175/MWR-D-12-00354.1

Vivoda, J., 2014: Vertical FE discretization of NH kernel of models ALADIN/AROME. Report on stay at CHMI, Prague, 2014. Soon available on www.rclace.eu.

DIRECTION DE LA METEOROLOGIE NATIONALE MOROCCO

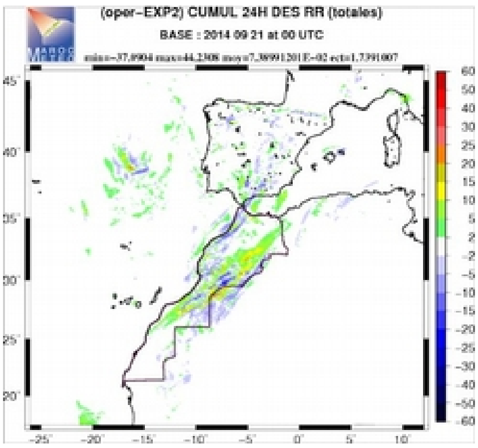
Hassan Haddouch

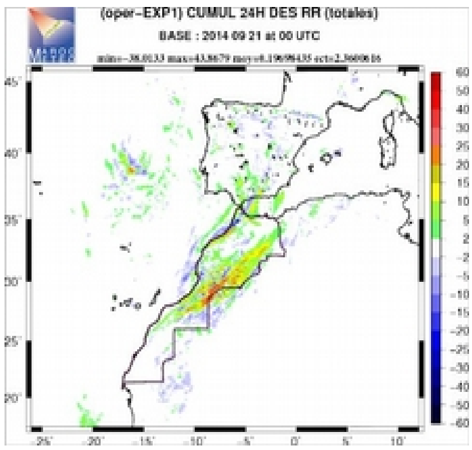
1 Introduction

This short article gives an overview of the most important achievements within the NWP group of the Moroccan Meteorological Service (DMN) during 2014.
AROME 2.5km forecast system was set up at Morocco weather service in addition to the operational ALBACHIR 10km model and NORAF . It is now reaching an operational status.
After that the impacts of surfex test experiment are shown as well. In the end I introduce the work of introducing local automatic weather station in 3DVAR data assimilation.

2 cy38t1bf03 with SURFEX in ALADIN-MAROC

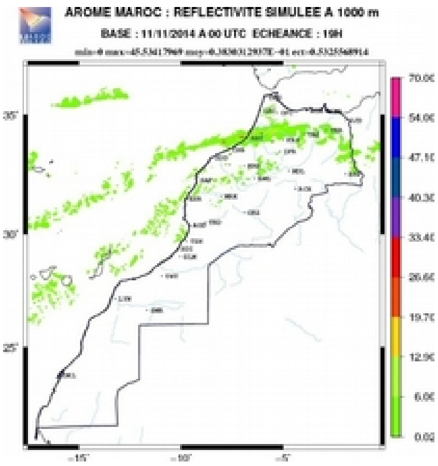
ALADIN-MAROC, NORAF, AROME models are used in the forecasting practice. The cycle 38t1bf03 with surfex in ALADIN-MAROC was implemented locally at the Moroccan Meteorological Service (DMN) on an IBM HPC cluster.
The execution time has been reduced by passing to cy38t1bf03 cycle which shows that the code parallelizing is improved than in cy36t1.
It appeared during the operation of the new cycle for three months, that there was a problem of underestimation of rainfall, with the help of our colleagues in the GMAP team of Meteo-France, the problem was solved

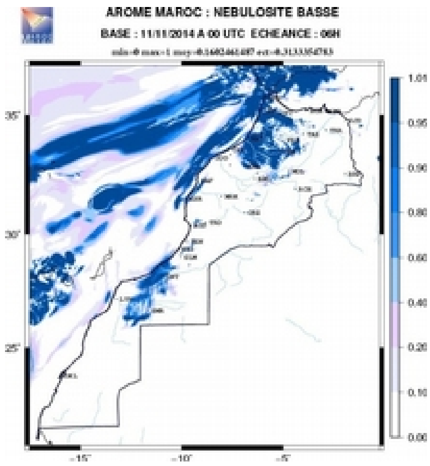




3 Implementation of AROME-MAROC 2.5 km Over Morocco

AROME-MAROC model with the cycle 38t1bf03 was implemented locally in a double suite at the Moroccan Meteorological Service (DMN) on an IBM HPC cluster.
The AROME ultra-short range forecasting model is executed two times a day (at 00, 12 UTC network times) providing 36h forecasts, respectively.
The objective verification and validation are in progress.

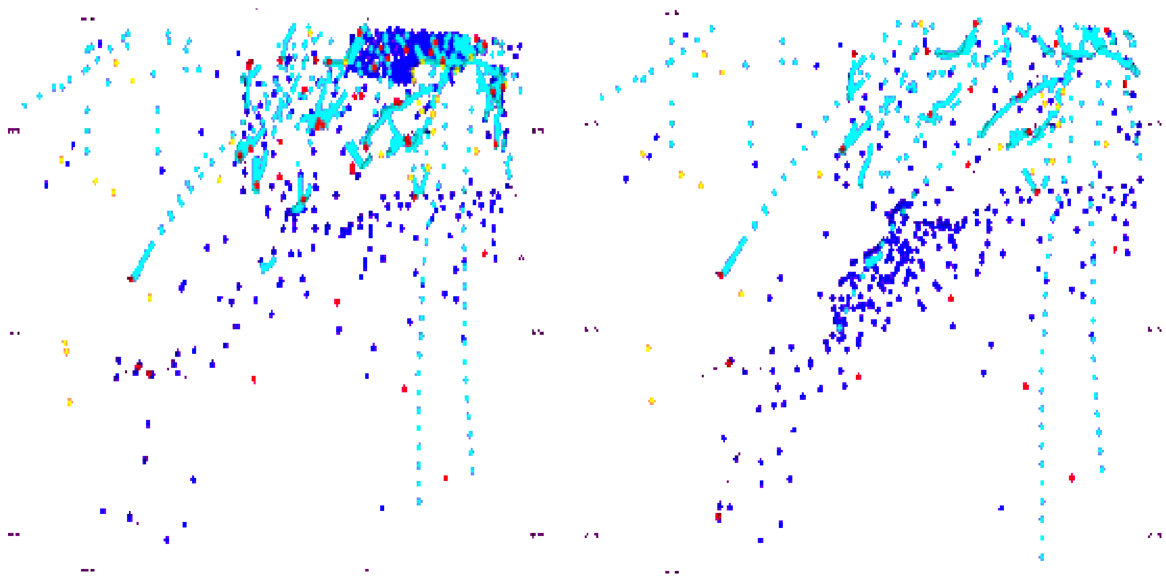




4 Integration of AWSs data in 3Dvar assimilation in ALADIN-MAROC

Recently the DMN have implemented about 156 automatic weather station. In order to take into account this new local data, a system of controlling and extracting data is developed. the AWS provide measurements of 2m temperature, 2m dewpoint, station pressure and accumulated precipitation.

To investigate the sensitivity of the model to the AWSs data several experiments are in progress.



Observation network (left) before the implementation of AWSs (right) after the implementation of AWSs

5 References :

Karam Essaouini 2014 activity report
Hdidou Fatima Zahra “CONVOBS” document

What was important for AEMET of HIRLAM and ALADIN?

Bartolomé Orfila

1 Implementation and use of the HIRLAM System

Research and development activities on NWP at AEMET have evolved significantly since they started more than forty years ago. They have resulted in subsequent limited area models (LAMs) running operationally, producing realistic weather parameters in the short range that complemented ECMWF global model forecasts. A big step forward arrived when INM (former AEMET) joined HIRLAM consortium in 1994. Since then AEMET has significantly contributed to the progress of HIRLAM model. Performance assessments show a continuous improvement in AEMET operational HIRLAM forecast, attributable both to better global ECMWF forecast fields used as boundaries and to successive LAM upgrades. The forecast model has improved through more accurate and efficient dynamical cores, enhanced physical parameterizations, and changes in horizontal and vertical resolutions. A better description of the atmospheric initial state has been achieved with the implementation of 3D-Var data assimilation (DA) method, the evolution of the composite observing system and assimilation of new data from satellite, aircraft and sea surface reports, as well as the blending procedure to incorporate the large scale component of the ECMWF global analysis. The first HIRLAM NWP suite started operations at INM in 1995. Since then, it has undergone several scientific and technical upgrades, but only two changes in geographical domain, grid geometry and vertical and horizontal resolution always associated to the local availability of enhanced computing resources. Until March 2011, the main configuration of AEMET NWP operational suite has consisted in a synoptic scale HIRLAM (ONR) covering Europe and North Atlantic Ocean using ECMWF operational forecasts as boundary conditions, with a higher resolution HIRLAM model (HNR) nested into it covering the Iberian Peninsula and the Balearic Islands. Another mesoscale HIRLAM over Canary Islands has been also operationally run using the synoptic scale HIRLAM as host model. Until 2005, the synoptic and mesoscale HIRLAM versions were run on a regular lat-lon grid at 0.5º and 0.2º horizontal resolutions, respectively, both with 31 hybrid levels in the vertical. From this date onwards, the model has been run on a rotated grid at 0.16º horizontal resolution in the synoptic domain and 0.05º in the two mesoscale geographical areas (Iberian Peninsula and Canary Islands), all of them with 40 vertical levels. Since March 2011 the three HIRLAM models are directly nested into ECMWF global model. The series of upgrades in the operational suite has resulted in a continuous improvement of model forecast performance, assessed by means of several objective verification statistics against observations. Although ECMWF global model has always shown better skill to represent large scale atmospheric flow, the short range forecasts produced by a higher resolution LAM like HIRLAM, provide a clear benefit in some surface variables such as two-meter temperature and ten-meter wind. An example of it is presented in the reference.

An important advantage of locally running a LAM is the possibility to run applications adapted to different users needs. HIRLAM output is widely acknowledged at AEMET as a basic input for forecasters. Specifically, for aeronautical products (flight levels) obtained from model levels and as input to radar nowcasting. An interesting example, where model resolution plays a critical role and LAM added value is straightforward, is the case of tropical cyclone Delta and its associated downslope winds when it crossed Canary Islands. HIRLAM surface parameters are one of the basic components of AEMET Digital Forecast Database from which tailored forecast products are automatically created. A variety of post-processing tasks are applied to direct model output to create additional products required by users. For example gust estimations are used for user warnings and post-mortem analysis of observations. HIRLAM analysis and forecasts are also the basis of many studies, such as those concerning mesocylones and adverse weather phenomena in Western Mediterranean Sea, carried out within the context of the ten-year project MEDEX under the auspices of the World Meteorological

Organisation. A single column version of HIRLAM is used operationally for fog and low clouds forecasting at several airports. HIRLAM surface analysis has been enhanced to analyse more parameters, as mean sea level pressure and ten-meter wind and it is run operationally for weather monitoring and other application. The operational HIRLAM output provides the atmospheric forcing needed by other operational processes daily run at AEMET: the ocean wave forecasting system, the MOCAGE chemical transport model used for air quality forecasting and dispersion of accidental release of pollutants to the atmosphere, the Fire forests Weather Index forecasting module of the Water Balance Model over Spain. Finally, HIRLAM model is also used for seasonal and climate prediction. For these purposes we use a special version of HIRLAM model developed by the Swedish Rossby Center. AEMET performs dynamical downscaling of ECMWF seasonal predictions and produces high resolution climate change projections over Spain and Mediterranean area.

2 Harmonie implementation

With the ECMWF global model approaching 5-10 km resolution in the medium term, an operational LAM can only add value by moving towards cloud permitting-resolving resolutions, especially over areas of complex topography such as Spain. The HARMONIE system, result of collaboration between HIRLAM Consortia and ALADIN –with AROME configuration- is intended for km scale resolutions (currently 2.5 km) and has represented another critical step forward in LAM modelling. Results obtained so far both for the Iberian and Canary Islands regions by a quasi operational suite run at ECMWF facilities four times a day are satisfactory enough to go ahead with the operational replacement of HIRLAM by HARMONIE. This, jointly with the migration of operational applications is taking place and will be completed as soon as the new AEMET HPC system with significantly more computing power is operationally available in the first quarter of 2015.

Probabilistic weather prediction based on regional EPS has undergone a huge development at AEMET over the last decade. AEMET-SREPS and GLAMEPS have demonstrated their ability to provide an accurate estimation of short range forecast uncertainty, an excellent complementary help for early warnings of high impact severe events. Sound experience has been gained on EPS post-processing and verification on top of the design, development and implementation of these systems. Considerable research and experimentation are still needed to fully exploit the potential of the new generation of Non Hydrostatic modelling and DA systems so as to cope with predictability issues at these scales. International cooperation will probably remain essential for such ambitious developments highly demanding of computer power and broad scientific expertise.

A significant part of the dynamics of HARMONIE (Aladin NH Dinamics) is shared with ECMWF model and it is a subject of active research at AEMET. A variable map factor has been included to allow larger domains. Currently under development is the use of a new vertical coordinate system and the possibility to use finite elements for the vertical discretization. Work is on going to introduce a second order accurate physics-dynamics interface and to improve the mass conservation in the semi-Lagrangian scheme to meet the chemistry transport model requirements. Other subjects of active research at AEMET are the treatment of deep convection at km scale resolution, the improvement of fog and low clouds and the use of HARMONIE for wind forecasting at sub-km resolutions. The very relevant problem of convective-scale growth of errors is addressed in two ways: improving of the DA system and developing ensemble systems to assess predictability. The planned analysis enhancements include the assimilation of all kinds of observations as radar data and GNSS, trying Rapid Update Cycles, further develop of DA algorithms with position error correction algorithms, flow dependency testing ensemble/variational hybrid methods, and blending with the large scale component of the host model. The benefit of surface analysis is particularly noticed in the mesoscale. Predictability issues at meso-γ scales are critically different and also need further specific research for ensembles because probably future reliable high resolution forecast must be explicitly probabilistic. AEMET is walking in that direction designing a meso-γ SREPS, coordinating efforts with HIRLAM new generation HARMONIE based HarmonEPS, Local Ensemble Transform Kalman Filter (LETKF) to perturb initial conditions and Stochastic Perturbed Parameterization Tendency (SPPT) to perturb model formulation coordinated research.

3 Reference

Most of the information contained above is taken from the following AEMET 'internal note'. It contains additional relevant references :

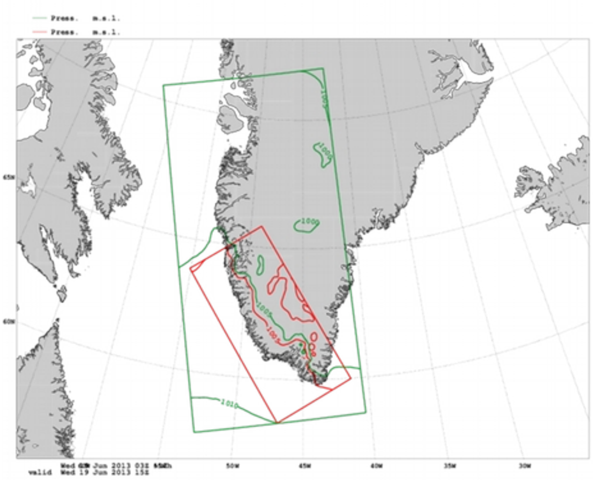
Navascués, B., Calvo, J., Morales, G., Santos, C., Callado, A., Cansado, A., Cuxart, J., Díez, M., del Río, P., Escribà, P., García-Colombo, O., García-Moya, J. A., Geijo, C., Gutiérrez, E., Hortal, M., Martínez, I., Orfila, B., Parodi. J. A., Rodríguez, E., Sánchez-Arriola, J., Santos-Atienza, I., and Simarro, J.: History and perspectives of Numerical Weather Prediction at AEMET, AEMET Technical Report, 2013.

Highlights of HARMONIE and HIRLAM at DMI in 2014

Bent Hansen Sass

A major decision was taken in 2014 to install DMI's coming HPC in Iceland. In this context a collaboration agreement was made with the Icelandic Met-Service (IMO). The HPC procurement process is ongoing. It is expected that an HPC willl be installed in Iceland during Autumn 2015. The process of planning new operational setups based on mainly HARMONIE has started. The future model development at DMI is focused on HARMONIE. However, a nowcasting system based on HIRLAM using a combination of 3D-VAR and nudging has been developed and is now oprational at DMI [1]. Precipitation and clouds have a small spinup in the model due to a modification of model's divergent wind field. The vertical integral of the added divergence becomes zero. Convergence is added in the bottom of the atmosphere and divergence aloft in situations where convective precipitation should be triggered. The feasibility to transfer this idea to HARMONIE will be investigated. HARMONIE got full operational status at DMI in 2014. The related model setups are outlined below. The concept of the DMI HARMONIE setup using 3-hourly cycling at asynoptic times has been described previously [2]. Modelling of aerosol effects in NWP has also been an important topic during 2014, e.g. through the EuMetChem COST action.

Fig. 1



HARMONIE-Greenland has been updated (green area) to a domain with 800x400x65 with 2 km grid-spacing, which covers now better the south western Greenland having over 80% of local population (Fig.1). The forecast has been found to be especially popular for end users due to its superior capability to predict catabatic wind in coastal Greenland.

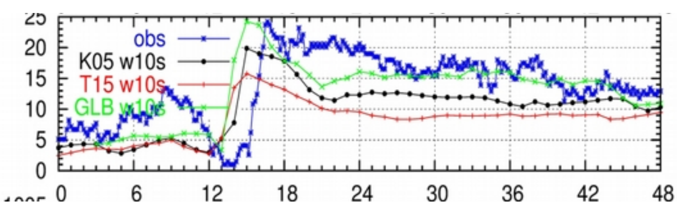


Fig. 2

Fig. 2 illustrates the prediction of sudden storm winds in Nuuk (Capital of Greenland). Prediction is made with different NWP models at DMI. Observations (m/s) in blue, coarse mesh HIRLAM 16 km model in red, HIRLAM K05 (5.5 km grid) in black and HARMONIE GLB (2 km grid in green). It is seen that a sudden increase in wind speed up to 25 m/s was well predicted by the HARMONIE model. The phase error in time of ~2 hours was reduced in the next forecast prior to the event.

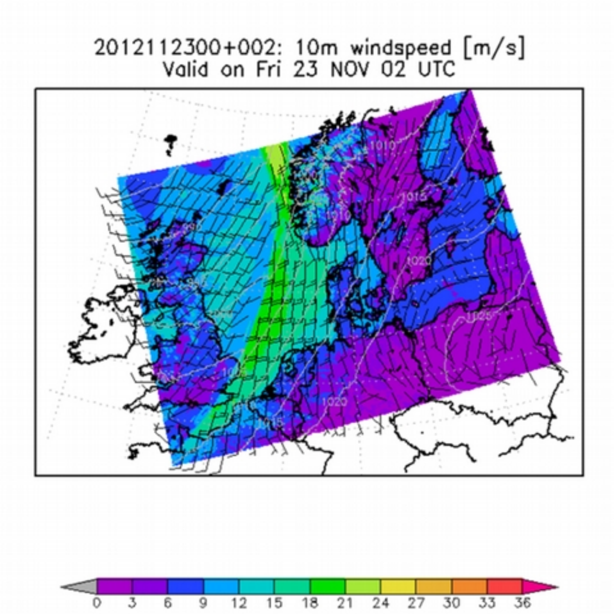


Fig.3

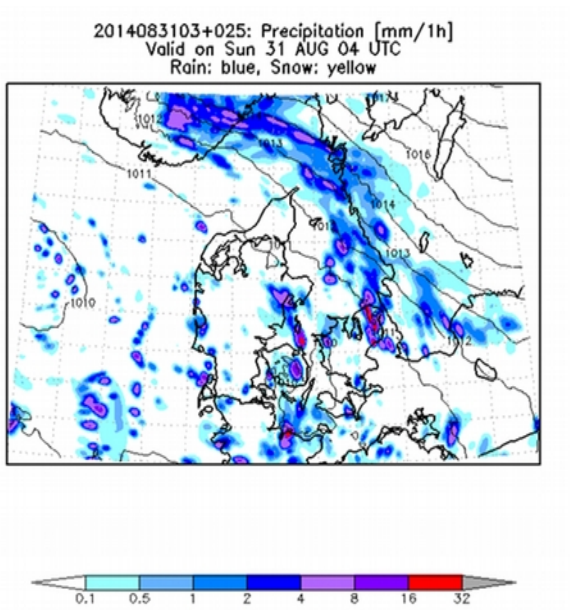


Fig.4

The HARMONIE model area is shown in Fig.3 Currently DKA-38h1 is run with 3h interval at 02, 05, 08, 11, 14, 17, 20 and 23 UTC, each with a 52 h forecast length. Upgrades for new model versions were in preparation in late 2014. A sign of the recent flash flood in Copenhagen occurring in the night between 30 and 31 August 2014 was provided already in the HARMONIE forecast from the early morning hours of 30 August (Fig.4). However later forecasts were suffering from some degradation. This indicates an unresolved challenge related to data-assimilation. In addition, future priority will be given to ensembles in high model resolution providing probabilities of extreme precipitation thresholds.

References :

[1] Korsholm, U. , Claus Petersen, Bent Hansen Sass, N. Woetmann Nielsen, David Jensen, Bjarke Olsen, Rashpal Gill, Henrik Vedel: `A new approach for assimilation of two-dimensional radar precipitation in a high resolution NWP´, Meteorological Appl.,December 2013

[2] Yang, X. , Bjarne Stig Andersen, Mats Dahlbom and Shiyu Zhuang: HARMONIE Upgrade in December 2012: DMI Tech. Rep.12-21.
http://www.dmi.dk/laer-om/generelt/dmi-publikationer/2013/

HIRLAM/HARMONIE forecasts: experience in Met Éireann

Ray Mc Grath, Emily Gleeson, Eoin Whelan

1 Introduction

One of us is old enough to have worked with HIRLAM back in the 1990s and remembers the difficulties in getting the operational forecasters to use the products. It was an uphill struggle; the forecast quality was quite poor by today's standards and HIRLAM had very stiff competition from ECMWF. The advantages of higher resolution (HIgh Resolution was an aspiration!), and the flexibility of quick updates four times per day, did not win the argument; most forecasters would politely tell you that they invariably used ECMWF products as they felt they were more accurate. It was difficult to change this sentiment as ECMWF kept raising the bar in terms of quality and resolution, maintaining its poll position among forecasters.

But the tide has turned in the last few years, particularly since the HIRLAM-B phase and the introduction of the HARMONIE model for operational use (*Ireland was one the first countries to use HARMONIE operationally*). HARMONIE forecasts are now well regarded by the forecasters. True, some will still express a preference for ECMWF forecasts for a particular weather element but the verification scores show that HARMONIE generally has the advantage, especially when resolution matters (e.g. for local precipitation). Forecasters tend to be conservative and a single bad forecast may colour their overall judgement of a model; it is essential that the objective performance scores are regularly advertised and forecasters briefed so that negative views do not become entrenched.

2 Case Study: Storm Tini February 12th 2014

An excellent example of the performance of HARMONIE occurred on 12 February 2014 when storm Tini (also known as storm Darwin marking the 205th anniversary of Darwin's birth) crossed the western and northern regions of Ireland. Valentia Observatory in the south west of the country recorded violent storm force 11 sustained winds, only the fourth occurrence at the station since 1940. The extreme west to northwest gusty winds behind the storm centre caused major damage. Remarkably, there was no reported loss of life even though many houses lost their roofs and building structures collapsed. The forestry industry estimated that up to 7.5 million trees were felled.

HARMONIE did an excellent job in providing advance warning of the severity of the storm.

A striking feature of the weather system was the presence of a relatively narrow band of extreme wind speeds near the tip of the wrapped-around occluded front. A detailed examination of the structure of the storm shows that it shared many features associated with so called 'sting-jet' cyclones (Smart & Brown, 2014): a low level jet in advance of the cloud head, descending to the surface.

The 12 UTC sounding from Valentia Observatory – it was in fact delayed by 45 minutes due to a burst balloon and therefore missed the core of the jet - and the analysed vertical winds from the HARMONIE and ECMWF models, are shown in Figure 1. Based on a subjective analysis of the event, of the two models the HARMONIE profile is probably the more accurate.

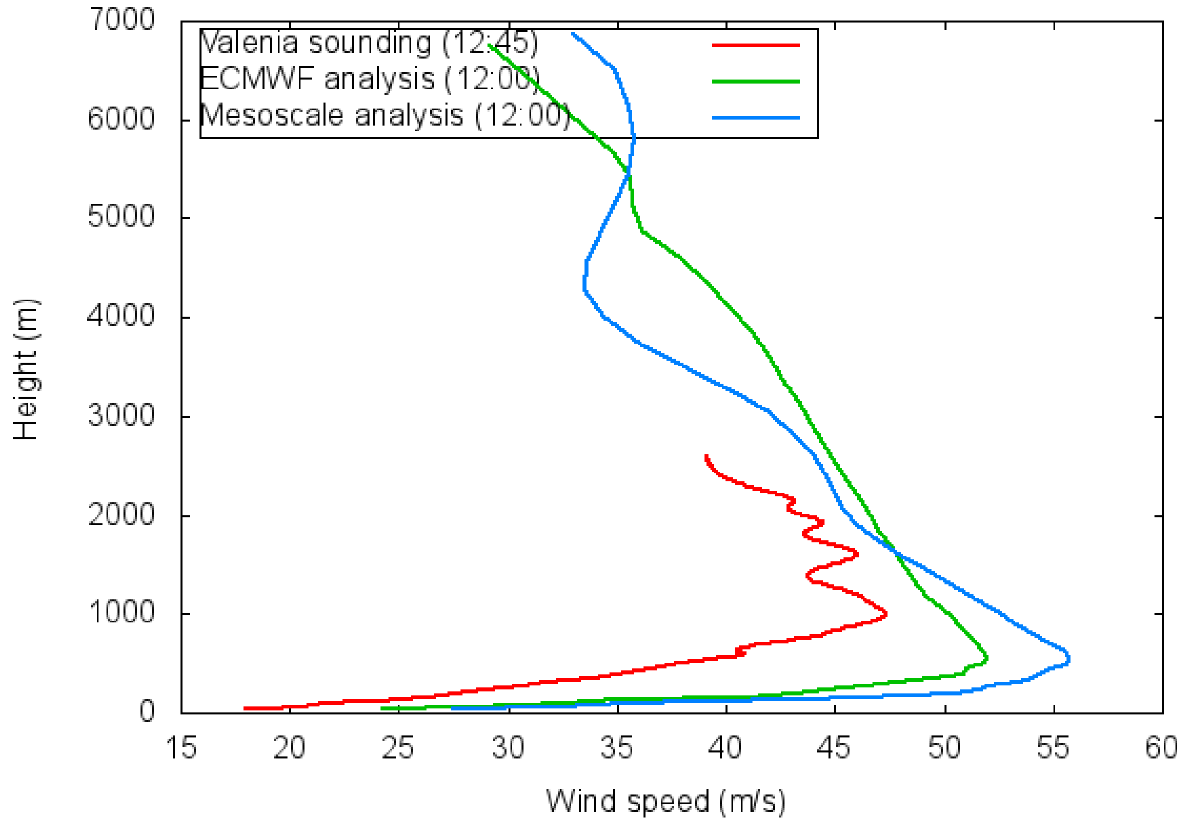


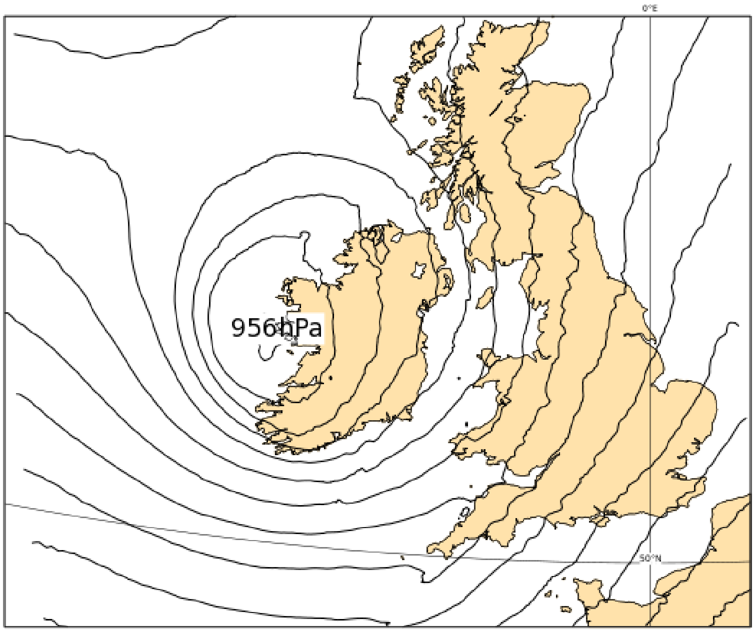
Figure 1: Vertical wind profiles at Valentia Observatory for 12 February 2014. Red (observed; 12.45 UTC); green (ECMWF analysis; 12 UTC) and blue (HARMONIE analysis; 12 UTC) model level wind data.

Figure 2 shows the HARMONIE 24-hour forecast and verifying analysis for 12 UTC. The agreement is remarkable, including the details regarding the storm force surface winds (not shown here).

On the previous day when this forecast became available some of the forecasters felt that the surface winds were 'far too strong'; in reality, the HARMONIE forecast was quite accurate and this was reinforced by later forecasts which led to severe weather warnings being issued.

Wind storms are not uncommon in Ireland and it a challenge to forecast those that are classified climatologically as exceptional; in such cases the dividend from an accurate forecast is far higher. The Darwin storm falls into this category and the climate records suggest that it was a roughly 1 in 20 year occurrence. The last comparable storm occurred in 1998 and a check on the global and regional forecasts for the time shows that it was not well forecast.

Recent performance reflects the impressive progress made in weather forecasting by the NWP community, including HIRLAM/ALADIN.



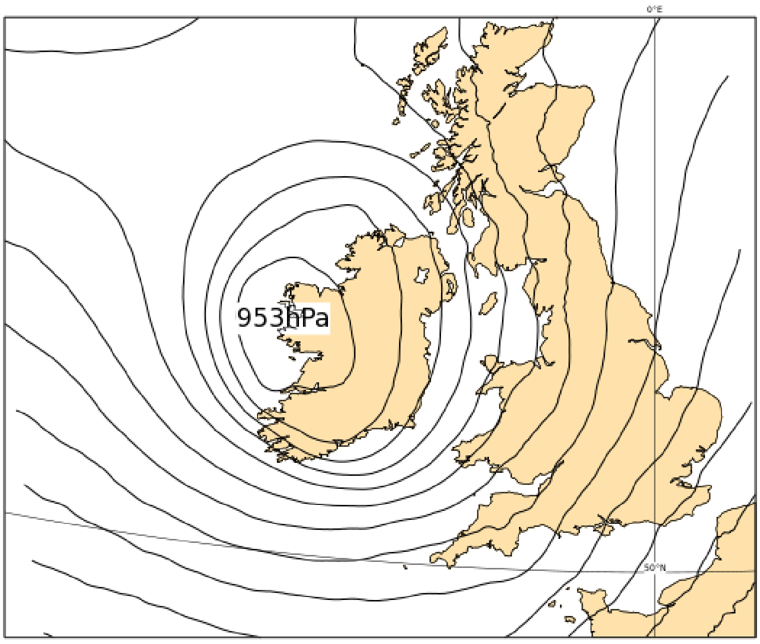


Figure 2: (top) HARMONIE 24-hour MSLP forecast for 12 UTC 12 February 2014; (bottom) the verifying NWP analysis.

3 References

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Highlights of NWP activities at FMI in 2014

Sami Niemelä
Finnish Meteorological Institute

1 Introduction

The Finnish Meteorological Institute (FMI) has been running the Harmonie forecasting system since 2006 starting from version 30t1. The first official operational release was 36h1.4 in 2012. The year 2014 marked again another milestone in both operational NWP and research activities. This paper gives a short review on highlights of FMI's NWP activities during 2014. First, we present the operational activities. Secondly, the new High Performance Computing (HPC) platform is introduced, and finally, research activites are summarized.

2 Operational NWP suites

FMI operates two main operational NWP-suites: the 2.5km grid-size Harmonie for mesoscale applications and the 7.5km grid-size Hirlam for synoptic scale applications. Figure 1 shows the domains of both operational models.

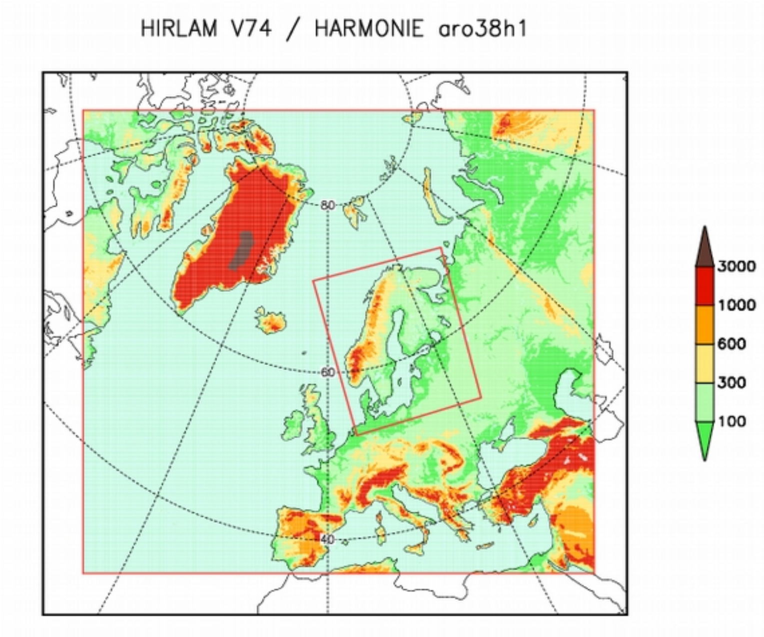

Figure 1: The domains of FMI's operational NWP-suites.

In 2014, FMI-Harmonie was upgraded to version 38h1.1 with a horizontal grid-size of 2.5km and 65 levels in the vertical. Upper air analysis is performed using 3D-Var, whereas optimum interpolation is used for surface analysis. This new version improved the 10m-wind and temperature scores. Earlier Harmonie versions suffered from a too weak temperature diurnal cycle in summer-time. With the new version, the diurnal cycle was greatly improved. However, in winter-time, Harmonie stilldisplays a severe cold bias, especially in the northern part of Scandinavia. This poor performance will be improved a lot along with the next version 38h1.2 to be operationalized at FMI in Feb 2015.

The operational model domain for Harmonie 38h1.1 (Fig. 1) was increased to cover the whole Scandinavia, the Baltic countries and the Baltic Sea. Previously, FMI-Harmonie was covering only Finland. The new domain consists of 720x800 points in the horizontal. Furthermore, the new version is operated in Rapid Update Cycle (RUC) mode with 8 runs a day. All forecasts are extended up to 54 hours (previously up to 36 hours only).

3 High Performance Computing

The enlarged Harmonie domain with extended lead time was possible due to our upgraded HPC system at FMI. In early 2014, the new supercomputer Cray XC30 was implemented. Cray XC30 consists of two identical clusters, each including 3420 cores. This enables roughly 70 Tflops/s peak performance for each individual system. Along the new HPC system, the peak performance increased by a factor of four. The current Harmonie forecast run is using about half of the cores from the operational computer. This enables 54h Harmonie forecast run to be completed roughly within 30 minutes.

4 Research activities

FMI participated to the WMO's “Forecast and Research: the Olympic Sochi Testbed”-project (FROST-2014) by running operational Harmonie forecasts before and during the Sochi winter Olympic games during Jan-Mar 2014 (Niemelä et al., 2013; Niemelä et al. 2014). FMI contribution was part of the Forecasting Demonstration Project, where all the participants ran forecasts with their own high resolution forecasting systems and disseminated the results to the local organising committee. The FMI-Harmonie configuration was based on the latest version available at the time: 38h1.beta.3. The grid-size was 1km with 65 levels in the vertical. The model domain covered the eastern parts of the Black Sea and most of the Caucasus mountains. Upper air assimilation was handled with 3D-Var, whereas optimum interpolation was used for surface analysis. Forecasts were provided 4 times a day up to 36 hours. Hourly boundary conditions were taken from ECMWF.

Overall, the verification inter-comparison showed that Harmonie was among the best models in the whole FROST-2014. However, Harmonie had a large cold bias during the dry and calm night-time conditions in the mountains. Later experiments revealed that replacing the CANOPY-scheme by more traditional 2m-temperature diagnostics improved the temperature scores considerably.

FMI scientists have extensively studied the effect of lakes in the NWP-systems and climate models. In 2014, several papers were published from different aspects of this scientific problem. Eerola et al. (2014) showed a clear positive impact of lake parameterization (FLake) on temperature and cloudiness scores. Furthermore, Kourzeneva (2014) developed a new extended Kalman filter algorithm to assimilate lake surface temperature (LST) observations, while Kheyrollah Pour et al. (2014) studied the impact of satellite-based LST observation in the initial condition of the NWP-model. The second enhanced version of the global lake database was created by Choulga et al. (2014). Finally, the effect of lake snow/ice parameterization was studied by Cheng et al. (2014). All the scientific developments presented in the papers pave the way towards the operational implementation of lake modelling and assimilation in the Harmonie system.

The work related to the turbulence closure model accounting for the potential energy associated with thermal fluctuations in stably stratified flows has progressed. This Energy Flux Budget (EFB) closure model has been implemented in the single column version of the AROME-physics package in Harmonie. EFB has been tested in a single column mode to assess its potential in several ways

(Fortelius and Kadantsev, 2014; Kadantsev et al., 2014): i) comparison with idealized GABLS1-case, ii) comparison with realistic GABLS3-case and iii) comparison with LES-simulations. Although the single-column results are very promising, several issues still need to be solved before the 3-dimensional experimentation.

FMI's NWP-group is participating in three new major projects funded by the Academy of Finland. The projects are focusing on different aspects of NWP-related research and development. The TWASE-project will enhance the modelling capability in the Arctic environment by developing satellite-based data assimilation, sea-ice parameterizations, cold environment microphysics and post-processing methods for icing and low visibility. The VaGe-project will develop forecast uncertainty estimations as part of the renewable energy production process. VaGe will focus on short-range ensemble prediction and forecast calibration methods. The CityClim-project will develop nested-domain urban LES linked to the NWP-model. One of the results will be an assessment of the host NWP-model capabilities and recommendations for improving the representation of sub-grid scale processes in the urban environment. The duration of all the projects is 4 years.

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HARMONIE research activities at SMHI

Heiner Körnich, Erik Kjellström, Per Undén, Per Dahlgren, Per Kållberg, Sébastien Villaume, Tomas Landelius, Esbjörn Olsson, Martin Ridal, Ulf Andrae, Lisa Bengtsson, Ralf Döscher, Anna Fitch, Christer Jansson, Marco Kupiainen, Petter Lind, David Lindstedt and Patrick Samuelsson

1 European regional reanalysis with HARMONIE

SMHI prepares an European regional reanalysis based on HARMONIE within the European FP7 (7th Framework Programme) project UERRA – Uncertainties in Ensembles of Regional Re-Analysis, together with 12 institutes from 7 EU countries, Switzerland and ECMWF. UERRA is coordinated by Per Undén at SMHI. As a preparation to the Copernicus Climate Change Service, UERRA will provide long-term datasets of Essential Climate Variables (ECVs) on the European scale.

The project will use HARMONIE to produce a regional reanalysis from 1961 to 2010 with a horizontal grid distance of 11 km and 65 vertical levels. The 3-dimensional variational data assimilation will be extended with a term for the host model error, the so-called Jk-term (Dahlgren and Gustafsson 2012). This allows coupling the regional and global reanalysis as provided by ECMWF. During 2014, SMHI has prepared the configuration of the HARMONIE reanalysis and started the production of a shorter multi-physics mini-ensemble. In order to examine the role of model physics, regional reanalyses will be produced with both ALADIN and ALARO model physics over a time span of 5 years. The design the long-term reanalysis with HARMONIE will be based on the results of this mini ensemble.

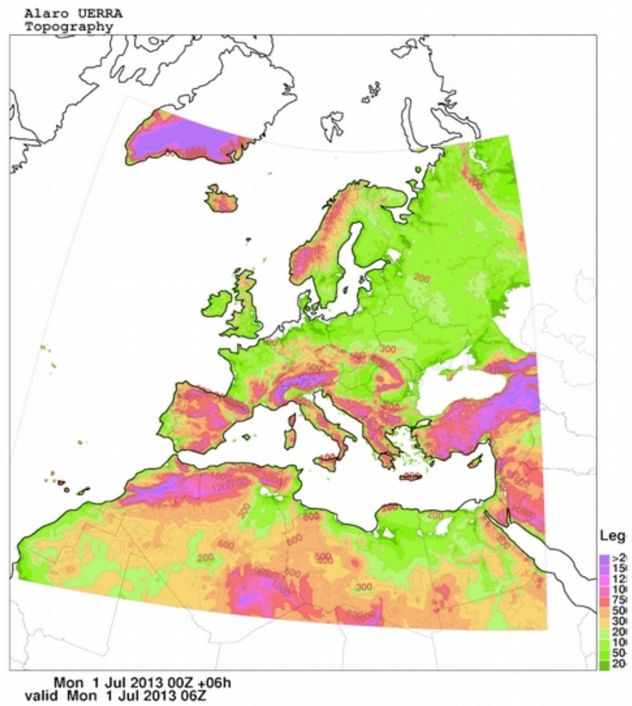

Figure 1: Model domain and topography (shaded) for UERRA.

2 Recent development and application of HARMONIE-Climate

Worldwide, there is a strong demand for high-resolution regional climate information. In Europe the most comprehensive high-resolution data set available is the EURO-CORDEX data set with a large number of pan-European regional climate model simulations performed at 12.5 km grid spacing (Jacob et al., 2013). The regional climate modelling community is now pushing towards even higher resolution, i.e. down to a few kilometres. At such convective-permitting scales better representation of heavy rainfall events have been demonstrated. Also, and highly relevant in a climate change context, is a stronger future increases in intensity of the most severe convective rainfall events (see references in Kjellström et al., 2014).

Over the last few years HARMONIE has been set up at and applied for climate purposes at SMHI. Lindstedt et al. (2015) presents model performance in two long-term ERA-Interim driven simulations at respectively 15 and 6.25 km resolution covering Europe. The hydrostatic option of HARMONIE version 36h1.3 is used with ALARO physics at both resolutions. Results show that this version of HARMONIE-Climate very well represents many aspects of the regional climate for seasonal means and at larger scales. Also higher order climate statistics and smaller scale spatial characteristics of precipitation are in good agreement with observations. They conclude that the main added value going from 15 to 6.25 km resolution lays in a better representation of the frequency and intensity of very rare, high-intensity precipitation events. Lindstedt et al. (2014) identifies a number of problems with the model including the treatment of skin temperatures over open water in winter leading to severe overestimation of winter time temperatures in northern Europe. Also, excessive cloud cover and precipitation in large parts of northern Europe were found, most notably in spring.

In addition to pan-European simulations with HARMONIE at 5-15 km resolution we are also exploring the model system at higher resolution for climate purposes. The first studies with HARMONIE at 2-4 km resolution include simulations of single heavy rainfall events for the island of Crete (Lind et al., 2014a) and a summer sampling exercise for the Alpine region (Lind et al., 2014b). These studies indicate that the model is able to simulate heavy precipitation amounts close to observations and that simulation of heavy rainfall events is significantly improved compared to that in coarser resolution simulations (Figure 2).

Currently, a first "operational" version of HARMONIE-Climate is being finalized. Some of the problems referred to above have been solved by combining HARMONIE c38h1.1 with an updated version of SURFEX7.3. E.g. a thermodynamic sea-ice model is implemented, the lake model FLake is activated and corrections of snow and soil physics are made. In addition to these improvements the model has also been prepared for climate change experiments by allowing for changing greenhouse gas concentrations over time. This includes replacing the radiation scheme in ALARO with ACRANEB2. The first climate change experiments with HARMONIE-Climate will be undertaken in the near future. The development of HARMONIE-Climate can be followed via this HIRLAM wiki page: https://hirlam.org/trac/wiki/HarmonieClimate

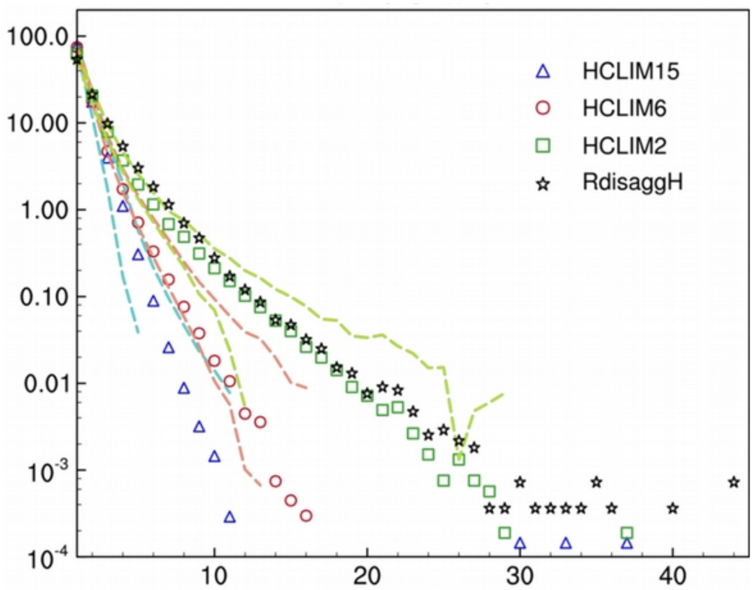

Figure 2. Probability distributions of hourly summertime precipitation in Switzerland from three HARMONIE-Climate runs at different horisontal resolutions (Lind et al., 2014b). These are 15 km (HCLIM15), 6.25 km (HCLIM6) both run with ALARO physics and 2 km (HCLIM2) run with AROME physics. RdisaggH is based on rain gauges and radar data covering Switzerland at a grid of 1 km resolution with 1-hourly data. Symbols are pdf:s while dashed lines represents a 95% confidence interval derived with a bootstrap technique.

3 Forecasting solar and wind power with HARMONIE

Weather conditions play a crucial role for renewable energy such as solar and wind power. Thus, weather forecasts provide relevant input for the expected production, operations, safety, and maintenance. Within the European project DNICast, SMHI provides HARMONIE forecasts with a focus on the Plataforma Solar de Almería in Spain. The forecasts will be combined with different observational nowcasting methods. For wind power in cold climates, ice on the wind turbines causes severe production loss. SMHI uses HARMONIE forecast as an input to icing and production loss models. The research on probabilistic production loss forecasts is currently supported by the Swedish Energy Agency. High-resolution wind power production losses due to icing are forecasted with HARMONIE with a grid distance of 1.2 km. The map in Figure 3 shows an example of 9 hour-forecast for production losses with initial time 30 Jan 2015, 0 UTC.

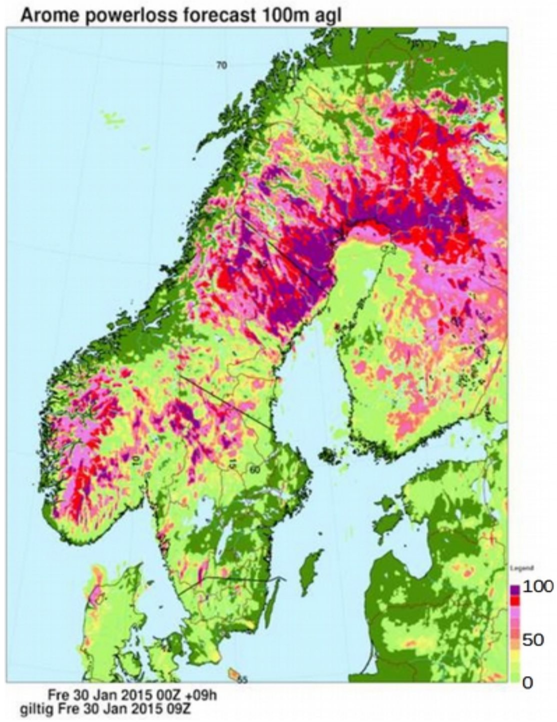

Figure 3: 9-hour forecast of wind power production losses in percent at 100 m above ground, initialized on 30 January 2015, 0 UTC.

4 References:

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HARMONIE at KNMI during 2014

Jan Barkmeijer, Henk van den Brink, Cisco de Bruin, Gertie Geertsema, Siebren de Haan, Frits Koek, Kees Kok, Gert-Jan Marseille, Toon Moene, Emiel van der Plas, Wim de Rooij, Maurice Schmeits, Sander Tijm, Sibbo van der Veen, Hans de Vries, John de Vries, Wim Verkley, Ben Wichers Schreur, Ernst de Vreede, Ine Wijnant

The focus on HARMONIE both in research and operations at KNMI has continued to increase during 2014. Below some highlights are briefly discussed.

1 Operational use

In the KNMI weather room confidence has been gained in using HARMONIE during the last year. Meteorological circumstances where HARMONIE gave excellent guidance are very helpful in this. One of these examples – and there are many- is provided by the occurrence of a narrow band of black ice during the end of January in the North eastern part of the Netherlands. This hazardous situation was captured very nicely by HARMONIE and well in advance, giving the local authorities ample time to take responsive actions.

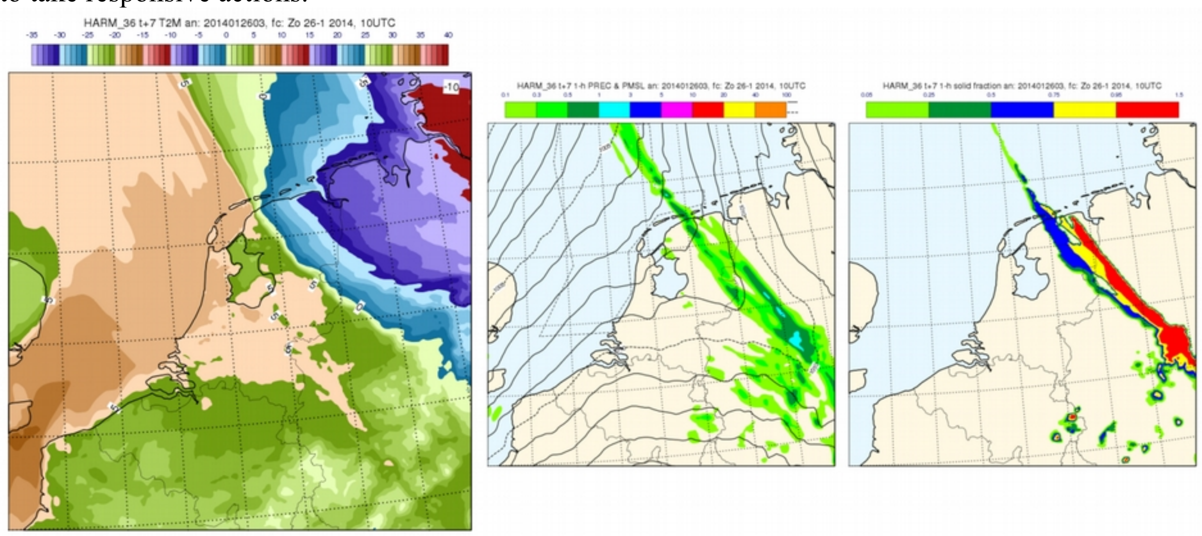

Figure 1: Left panel shows sharp gradient in the 7-hour T2m HARMONIE forecast from 26 January 2014 at 3UTC. Corresponding 1-hour accumulated precipitation for 26 January 2014 at 10 UTC is shown in middle panel, together with solid fraction in right panel.

2 Fog

The occurrence of fog, in particular over sea, is a complex phenomenon to model as it is associated with many physical processes of HARMONIE. Introduction of the turbulence scheme of RACMO, which performs well in the ASTEX case, has revealed that some of the sea fog problems can be solved or strongly improved. Also the too low boundary layer and cloud base height have increased. It is hoped that this step forward combined with a promising cloud masking technique to improve the initial model state will contribute to improved forecasts of sea fog.

3 Data assimilation

Exploiting the use of Mode-S EHS and scatterometer has continued. The development of a HARMONIE 4DVAR version jointly with SHMI and Met Norway provided the opportunity to digest more of the available observations during the analysis step. The use of the abundant Mode-S EHS indicated a positive impact on HARMONIE forecast performance and research will continue to incorporate other data sets like radar, GNSS and scatterometer and to improve the statistics of the background error, possibly by including flow dependency.

4 KNMI North sea Wind (KNW) atlas

In producing the KNW- atlas KNMI has made a detailed wind climatology at 2,5x2,5 km grid resolution for the North Sea; more specifically for the areas designated for offshore wind energy and for heights relevant for wind energy production. The KNW-atlas is based on 35 years of HARMONIE forecasts with boundary conditions provided by ERA interim. KNMI intends to make this wind atlas publicly available in 2015 in an effort to contribute to the government goal of 40% reduction of the cost of offshore wind energy. Currently KNMI is in the process of validating the KNW-atlas against publicly available wind measurements, such as provided by scatterometer and Cabauw.

5 Acoustic forecast

Based on operational HARMONIE data an acoustic model with a grid resolution of 10m is providing an acoustic forecast on a real-time basis for the Netherlands. Validation has started for two locations.

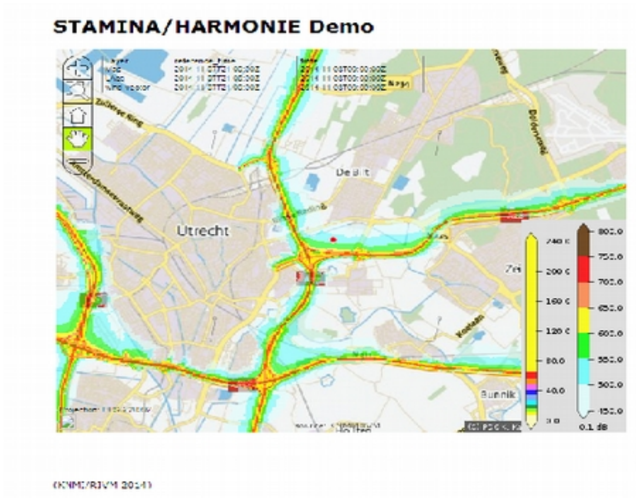

Figure2: Acoustic forecast valid for 8 November 2014 at 0 UTC for the Utrecht area (centre of the Netherlands) and produced by combining the expected traffic intensity with the HARMONIE forecast. Notice the asymmetry in the vicinity of highways. Contour interval is 5d (right bar).

6 Re-forecasting

Currently three years of re-running the operational HARMONIE suite with a fixed model configuration (Cy37h1.2) has completed. Domain comprises 800x800 grid points at a 2,5x2,5 km resolution centered around The Netherlands. Among other things the data set will be used to derive statistical properties required for forecasting lightning.

DDH (**D**iagnostics in **H**orizontal **D**omains)

Thread-Safety

Tayfun Dalkiliç (TMS), Daan Degrauwe (IRM)

Introduction

DDH is a generic tool to generate budget of prognostic variables used in ARPEGE and ALADIN. It provides a budget of prognostic variables, understanding and developing physico-dynamical interactions of the model for researchers and model's developers on user-defined domains.

Due to Phys-Dyn (Arp/Ald/Alr and Arome) interface issues, difficulties for debugging and maintaining because of growing numbers of entries due to evolution of physical parametrizations and fixed data structures, flexible and user-friendly DDH tool is started to develop which is called as DDHFLEX.

OpenMP usage was not possible for DDHFLEX, since it was not a thread-safe. To overcome this, data is transferred by arguments, instead of by global variables.

1 Modifications

1.1 DDH_MIX and Other Modules

1.1.1 Global Variables

- LDDH_OMP in yomlddh: activate threadsafe DDHFLEX.
- CFLDNAMES3D, CFLDTYPES3D, CFLDNAMES2D and CFLDTYPES2D in yomtddh: field names and types. Allocated in sualtdh; deallocated in dealddh.
- NFIELDS3D_OFFSET, NFIELDS3D_AUTO, NFIELDS2D_OFFSET, NFIELDS2D_AUTO in yommddh: information about numbers of fields to be stored between timesteps.

1.1.2 Types

Three new types are introduced: TYP_DDH, TYP_FIELD2D and TYP_FIELD3D.

The TYP_DDH has serves several purposes:

- it contains (constant) information like dimensions, averaging weights, domain info;
- it acts as a container which gets shipped around and filled with fields of type TYP_FIELD2D and TYP_FIELD3D;
- it is used to pass information from one NPROMA block to another (e.g. the number of fields);
- it is used to pass information from the first OpenMP loop (in cpg_drv) to the second OpenMP loop (in cpglag).

TYP_FIELD2D and TYP_FIELD3D contain (pointers to) the numerical data of this field, as well as some metadata (name and type)

1.1.3 Routines

- SETDDH

  Called at the beginning of an NPROMA block. It initializes a TYP_DDH structure with the correct dimensions etc.
- CLEANDDH

  Called at the end of an NPROMA block. It performs deallocations. For one NPROMA block, it also stores some metadata (field names and types) in global variables.
- STOREDDH

  Called after the OpenMP loops. It stores some data (OFFSET, MASK, NTOTFIELD etc.) in global variables
- NEW_ADD_FIELD_3D and NEW_ADD_FIELD_2D

  Called throughout the gridpoint calculations. They add new 3D or 2D fields to a TYP_YDDH structure. They are a threadsafe replacement (under the LDDH_OMP key) for the ADD_FIELD_3D and ADD_FIELD_2D routines. A difference is that the horizontal average is already taken in this routine.

1.2 cpcuddh and cpcuddh_omp

To save memory, the average is taken inside the NEW_ADD_FIELD* routines, so it shouldn't be taken in the cpcuddh routine anymore. A new routine cpcuddh_omp was introduced as a replacement of cpcuddh.

1.3 Organizational Routines: gp_model, cpg, mf_phys, cpglag

For threadsafety, data should be passed by argument, instead of relying on global variables. Therefore, a TYP_YDDDH variable is passed around throughout the gridpoint calculations. An important advantage of this strategy is that further modifications to the TYP_DDH structure don't require any modifications to these routines.

1.4 Physics Routines etc.

All calls to ADD_FIELD* are accompanied by a call to NEW_ADD_FIELD* under the switch LDDH_OMP.

Some additional modifications were necessary to make the BUDGET routine threadsafe:

- An extra dimension (for the thread number) is added to all global arrays (TCON1, TCON2, TCON3, TVARSM) in the MODDB_INTBUDGET module
- The allocations and uses are modified accordingly in ARO_SUINTBUDGET, and BUDGET.
- The OpenMP CRITICAL section is moved from APL_AROME to ARO_SUINTBUDGET for efficiency. The OpenMP barrier is now only active during the first timestep, for the allocation of the global arrays, instead of covering the complete subroutine every NPROMA block.

2 CPU and Memory Usage

Several tests with different domain sizes (40x50 – 512x600 all in 60 levels) were performed on each two overlapping rectangular domains. Arome with 180 timesteps of 60 seconds was run on MF beaufix on a single node, with 1 MPI task.

Table 1: Timings obtained from drhook profiles for a 512x600x60 domain.

	rootpack	**ddhomp pack**		
# threads	no ddh	no ddh	ddhflex	ddhomp
1	811.01	818.52	1028.55	948.52
2	-	465.36	x	581.44
4	-	292.88	x	353.98
6	-	271.95	x	293.19
12	-	268.32	x	292.56

Table 2: Memory monitoring with drhook for multithreaded tests, and with sacct for single-threaded tests

	rootpack	**ddhomp pack**		
# threads	no ddh	no ddh	ddhflex	ddhomp
1	10667	10673	16797	13058
2	-	3159	x	2364
4	-	5430	x	4641
6	-	7707	x	6918
12	-	14535	x	13747

3 Conclusions

- DDHOMP is thread-safe.
- The timings of a run without DDH don't increase with the modifications.
- DDH comes at a cpu cost. This is mainly due to the calculations of the fields themselves, not due to the dataflow. DDHFLEX has a substantial overhead during the first timestep due to the dynamic reallocation of 3D fields. This overhead is avoided with DDHOMP.
- The OpenMP scaling of the run with DDHOMP is the same as the scaling of the run without DDH.
- CPU costs are more or less the same both for small and large domain.
- The runs with 12 threads activates hyperthreading, so these timings may not be entirely representative for the scalability.
- DDH comes at a memory cost however, monitoring with sacct may not be so confident. The additional memory required for DDHFLEX is substantially reduced by DDHOMP.
- With DDHOMP, DDH comes at a negligible memory increase for the multithreaded tests. Required additional memory doesn't increase much when running on more threads.

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[1] O. Rivière, New flexible DDH structures for Arpege/Aladin/Alaro/Arome (Météo-France/GMAP)

Meteorological Co-operation on Operational NWP

Morten A. Ø. Køltzow, Dag Bjørge, Mariken Homleid, Ivar Seierstad (MET-Norway)
Bo Strandberg, Karl Ivar Ivarson, Magnus Lindskog, Anders Wettergren (SMHI)

1 AROME-MetCoOp

In March 2014 the meteorological cooperation (MetCoOp) between SMHI and MET-Norway, became operational. The most important feature of this cooperation is that the forecasts from daily AROME-MetCoOp runs on the Norwegian HPC (Vilje) are distributed both to SMHI and MET-Norway. Similar back-up runs are performed at the Swedish HPC (Byvind). The model system used was Harmonie Cy38h1.1 with AROME physical parameterization, 2,5km horizontal resolution and 65 vertical levels. The model employs 3D-VAR (conventional observations, AMSU-A and AMSU-B/MHS) and surface assimilation with 3-hourly cycling. The lateral boundaries were taken from ECMWF (every hour) and the forecast length was +66hr (only 00, 06, 12 and 18 UTC).

Some model weaknesses were well known, also before MetCoOp became operational. The most important ones were the winter cold bias and several aspects concerning clouds. The increased exposure of the model to forecasters, researchers and the public has revealed/underlined other issues as well. I.e. influence of sea surface temperature, convective precipitation (both winter and summer) and fog. However, it should be emphasized that despite these model deficiencies the model system verifies well compared to other models (i.e. ECMWF, HIRLAM) used operationally at SMHI and MET-Norway.

An important update of the operational model was introduced on 8 December 2014. The new model version was Cy38h1.2, with improved temperature and cloud cover forecasts. Figure 1 shows an example of the improvement in the time series of 2m air temperature for the Norwegian synop station Venabu.

Within the MetCoOp cooperation, there has also been work on including more observational data in the assimilation system (GNSS, radar and IASI). At the moment GNSS is closest to operational implementation as it runs daily in the preop-suite where it shows positive impact on humidity in the lower troposphere.

The next upcoming main event in MetCoOp is the introduction of the new Swedish HPC. With this, MetCoOp aim to run a high resolution ensemble prediction system.

2 The use of AROME-MetCoOp at MET-Norway

At MET-Norway AROME-MetCoOp replaced AROME-Norway (Cy37h1.2, without upper air assimilation, but on the same domain) and is now the main weather forecasting model. The model is used to force several downstream applications (i.e. turbulence forecasts at airports, air quality forecasts and ocean forecasts). AROME-MetCoOp is also the main model for the duty forecasters and the basis for the official weather forecasts on Yr.no (api.met.no). For the latter application the model output is post-processed for several parameters (temperature, wind, precipitation, cloud cover, thunder).

For several severe weather events (precipitation and wind) the last half year AROME-MetCoOp has been offering very good forecast guidance. In Figure 2 we see accumulated precipitation from AROME-MetCoOp and observations for Western Norway during a severe flood event 27-29. October last year (left) and a similar plot for maximum wind speed (not gust) for each observation station during the extreme weather Nina (10. January 2015, called Egon in Sweden).

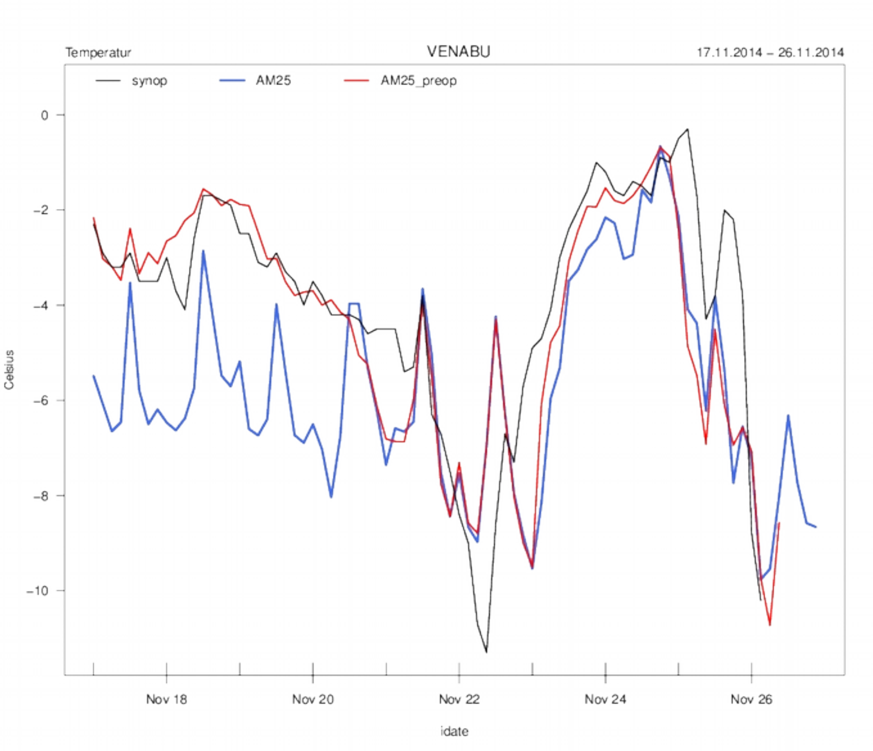

Figure 1: Time series of 2m air temperature for the Norwegian synop station Venabu (61.6513N, 10.1087W 930 masl, observed temperature as black lines, blue lines are Cy38h1.1 and red Cy38h1.2)

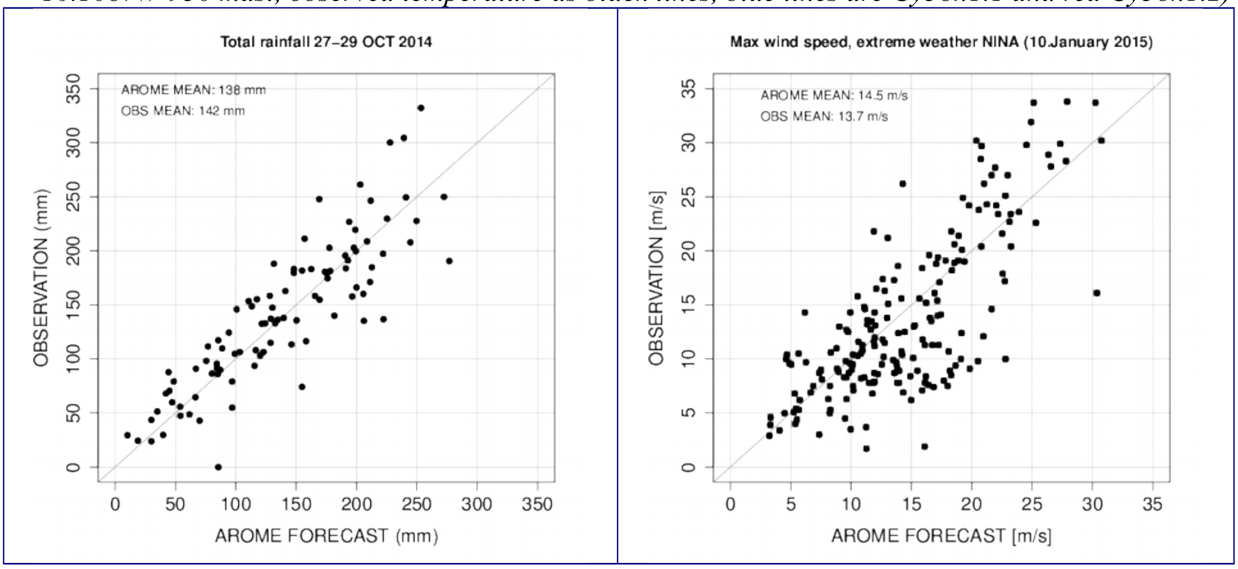

Figure 2: Scatterplot of accumulated precipitation at different stations over three days from AROME-MetCoOp and observations under a severe flood event in west Norway (left) and maximum forecasted- and observed wind speed (not gust) at different stations under the extreme weather Nina (right).

3 The use of AROME-MetCoOp at SMHI

During Spring 2014 AROME-MetCoOp was adopted as one of the models used in the SMHI operational production. Today AROME is used in operations, in addition to the ECMWF model and two different set-ups of the HIRLAM modeling system (C11 and E05. C11 has a 11km grid, and E05 a 5.5km grid). All these models are included in the database, containing the model options available as possible choices for the meteorologists. This database has a great number of users, both commercial ones and ordinary people. Due to the adoption of AROME the spatial resolution of the data base was increased to match the AROME-MetCoOp resolution (2.5 km). Furthermore the data base processing methodology for cloudiness and precipitation has been improved to handle the detailed structures represented by AROME and to enable proper comparison of forecasts made with the available models.

AROME-MetCoOp is operationally used when it is considered suitable by the meteorologist as the “model of the day”. The use of AROME-MetCoOp varies from day to day and is dependent on weather situation, but it is more and more frequently used. A limiting factor for the use of AROME-MetCoOp is the too high amounts of forecasted cloudiness and fog, during winter. On the other hand, during summer there is an under-prediction of convective clouds. A Strength of AROME-MetCoOp as compared to the other available models is that it is usually able to handle summer-time convective precipitation very well. However, the feeling is that high-intensity showers occur a bit too often. In many cases it is difficult to judge whether these high intensity showers are realistic. AROME-MetCoOp is found to be rather heavily influenced by the ECMWF model (close lateral boundaries) and therefore the developments associated with low-pressure systems are rather similar between the two models. Therefore the AROME model is frequently used in these situations. For example, AROME forecasts capture very well windy situations, like the storm Egon (called Nina in Norway) that hit Scandinavia 10 January 2015 (see the figure below).

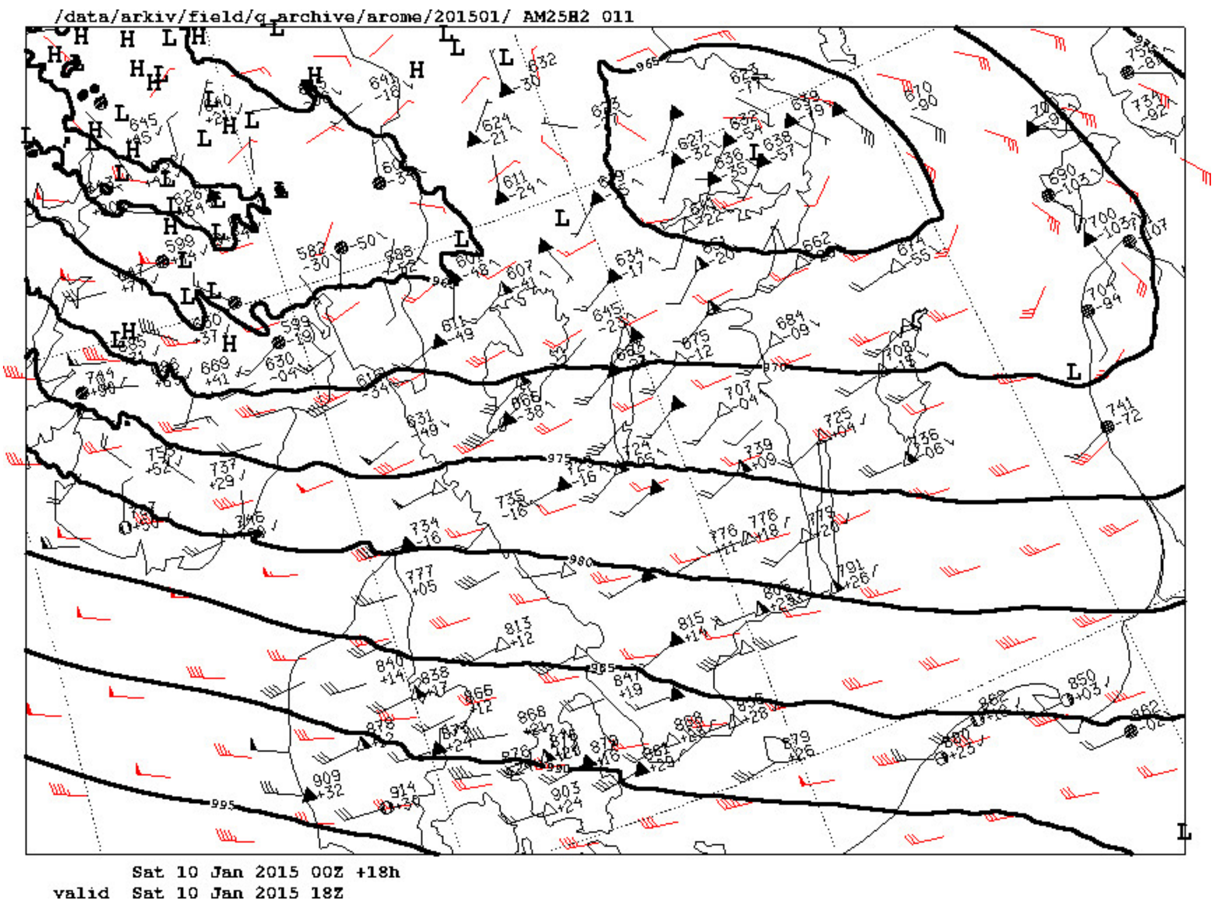

Figure 3: AROME forecast issued Janury 10 at 00 UTC , valid at 18 UTC. (18 hours forecast). Forecast wind as red arrows, observed wind as black arrows. A triangle at the end of the arrow indicate storm, 25 m/s or more. Forecast mean sea level pressure as solid black lines, observed as numbers. (707 means 970.7 hPa etc) Also the observed pressure tendecy is included (-12 means -1.2 hPa tendency in 3 hours etc)

Weather Intelligence For Wind Energy – EU Project WILL4WIND

Kristian Horvath, Alica Bajić, Stjepan Ivatek-Šahdan, Mario Hrastinski, Iris Odak, Antonio Stanešić, Martina Tudor, Tomislav Kovačić

As a response to the real needs of the Croatia economy, a consortium led by Meteorological and Hydrological Service (DHMZ) comprising Faculty of Electrical Engineering and Computing University of Zagreb (FER), Croatian Transmission System Operator Ltd. (HOPS), Energy Institute Hrvoje Požar (EIHP) and RP Global Projekti Ltd. conducts an EU-IPA (Instrument for Pre-Accesssion) project entitled “Weather intelligence for wind energy – WILL4WIND” (www.will4wind.hr) through Science and Innovation Investment Fund (IPA2007/HR/161PO/001-040507) . The overall goal of the project is to reduce the uncertainties in short-term wind forecasting over the coastal and complex terrain of Croatia for the purpose of integration of wind energy in the national electric system and to develop solutions to support wind energy sector based on recent research results and long-standing experience in analyzing specific wind conditions in Croatia (Fig. 1).

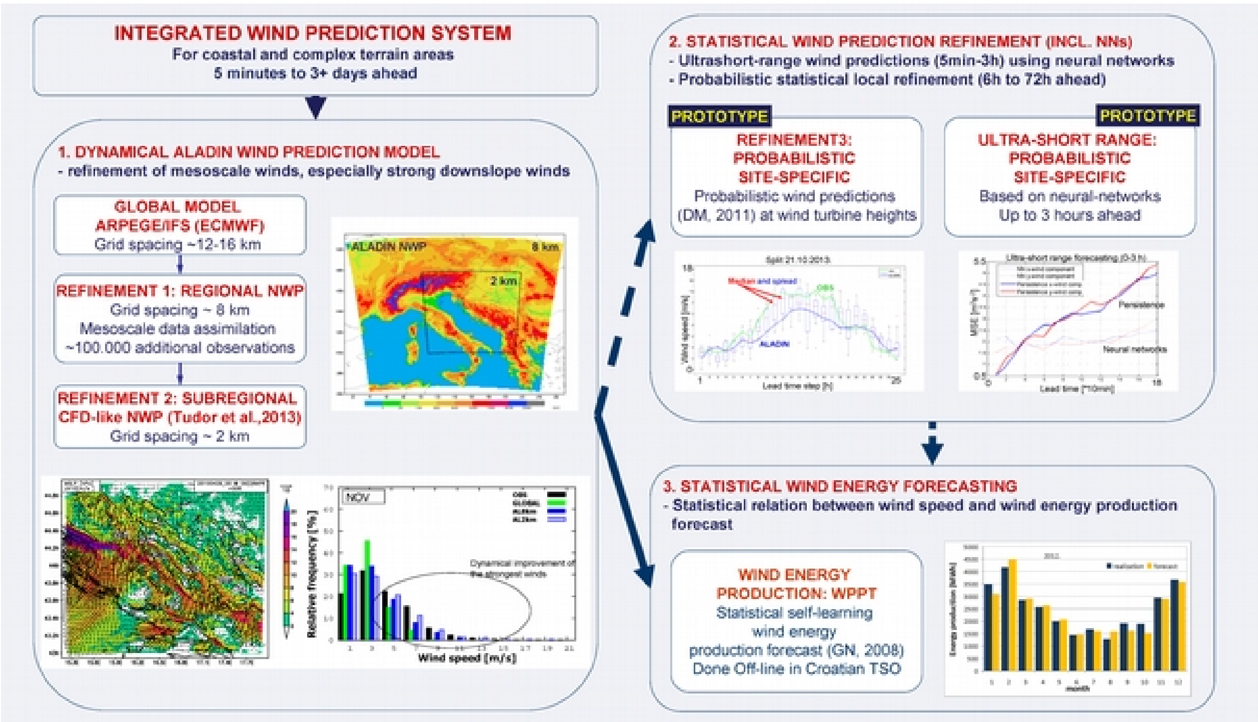

Fig 1: A design of development of prediction technologies in the project Weather Intelligence for Wind Energy – WILL4WIND

Prediction technologies developed in the project WILL4WIND may be divided in two groups:

1. *Short-range forecasts* (from 3-72 h lead time) performed using NWP models and statistical probabilistic post-processing methods
2. *Ultrashort-range forecasts* (up to 3 h lead time, with 10-min output interval) performed based on neural networks usingobservations and NWP models outputs

The goal of this contribution is to describe development of above prediction technologies. .

1 METHODS

1.1 Numerical weather prediction

Operational model ALADIN (ALADIN International Team, 1997) uses Lambert projection on a domain with horizontal grid spacing of 8 km (Fig. 3). The model was driven with ARPEGE LBC data, while initial conditions are derived using 3DVar data assimilation. After model integration, wind speed and direction forecast fields in the planetary boundary layer are dynamically adapted to a grid spacing of 2 km on a smaller domain using lower number of vertical levels and only a PBL parametrization (Ivatek-Šahdan and Tudor, 2004). Additionally, a non-hydrostatic version of the model is run in parallel model at the grid spacing of 2 km using full-physics set of physical parametrizations. More information on the Croatian implementation of the ALADIN model may be found in Tudor, 2013.

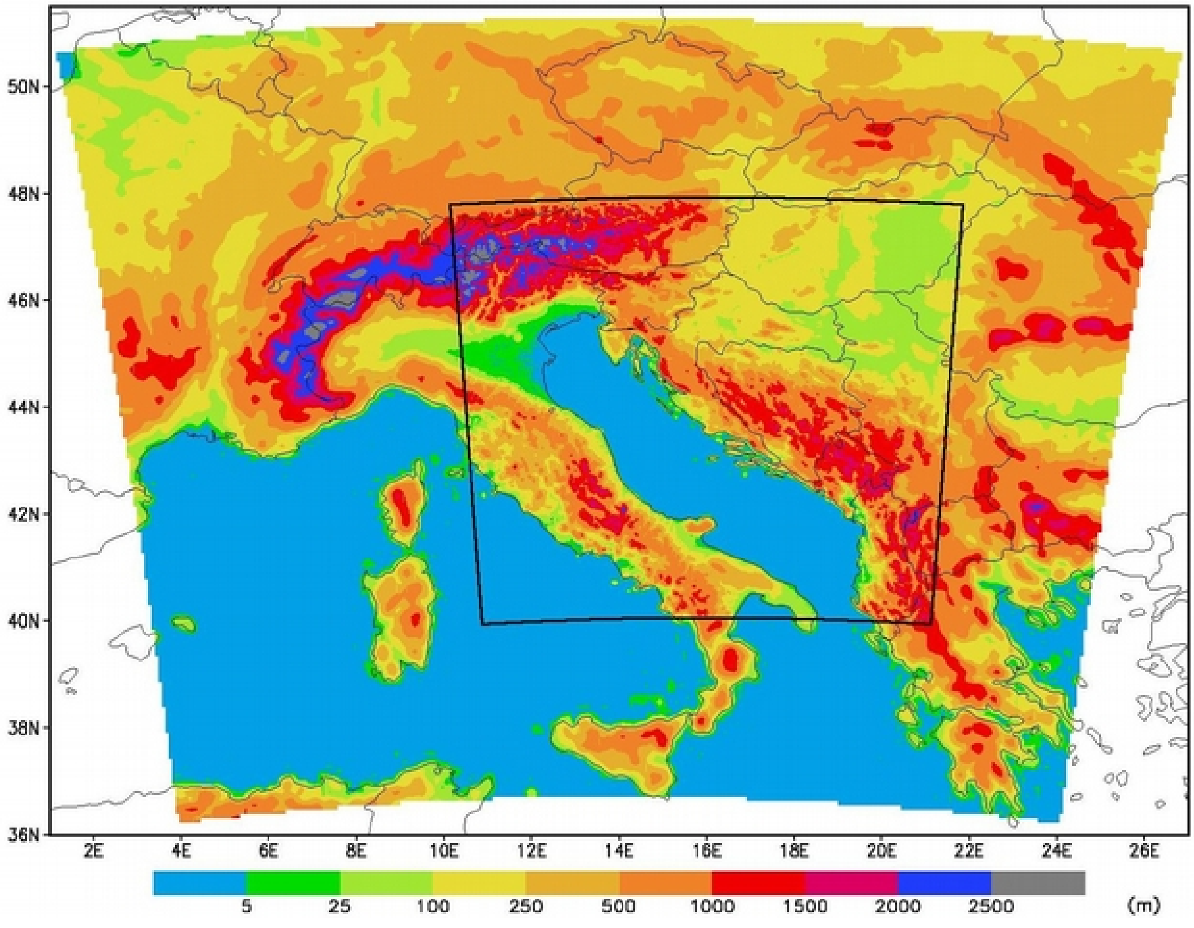

Fig. 2: Model domains in the DHMZ's ALADIN model setup. Outer domain corresponds to 8 km grid spacing model, and inner domain corresponds to 2 km grid spacing models (both dynamical adaptation and non-hydrostatic model).

1.2 Statistical post-processing

Statistical post-processing is used for i) improvement of forecast accuracy at sites with wind speed measurements, and ii) for estimation of the forecast uncertainty. Two groups of methods are tested for improving local wind forecasts:

1. A method based on Kalman filter (Kalman, 1960);

2. A method based on analogues (Delle Monache et al., 2011).
The benefit of the analogue method is that it can be used to provide probabilistic predictions for locations where both forecasts and observations are available (Delle Monache et al., 2013).

2 Results

For the evaluation of developed dynamical and statistical methods, modeled time series from ALADIN forecasts and measurements from 13 locations in Croatia were prepared in period 2010-2012. During the process we have evaluated three different versions of ALADIN numerical model:

1. ALADIN/ALARO8 with 8 km horizontal resolution, 72 h forecasting range and 3 hours interval of forecasting fields availability, model version 32T3 with ALARO0-3MT set-up , old radiation scheme, DFI, Initialization from Assimilation suite from mid November 2011;
2. ALADIN/ALARO2 with 2 km horizontal resolution, 24 h forecasting range (starting from 6-hourly forecast of ALADIN/ALARO8 model), model version AL36T1 with the ALARO0 set-up of the physics parametrizations NH dynamics, initialization scale selective digital filter, 1 hour interval of forecasting fields availability, in parallel mode since 1st July 2011 for period 2010-Jun 2011 model were run afterward;
3. ALADIN/DADA2 with 2 km horizontal resolution, 72 h forecasting range and 3 hours interval of forecasting fields availability;

The difference between the ALADIN/ALARO2 and ALADIN/DADA2 models used at the same horizontal resolution, except Hyd/NH dynamics, primarily occurs due to the complexity in describing the dynamical processes over complex terrain, in particular thermal circulations and the processes of formation of clouds and precipitation.

In everyday practice at DHMZ forecasts were updated every 12 hours, at the moment every 6 hours. However, in this contribution we have used modeled data produced every 24 hours (forecast initialization time was 00 UTC).

The stations used for the analysis were classified into three different winds regimes: coastal (1), mountain (2) and continental (3), and additionally a coastal regime heavily exposed to the bora wind.

2.1 Model ALADIN

Using the forecasts and measurements at stations during the period 2010-2012., we have performed the statistical and spectral evaluation of three tested versions of ALADIN mesoscale NWP model. Statistical verification included several statistical measures, such as systematic error, mean squared error, mean absolute error and others. The analysis of monthly values of the mean square error from three tested versions of ALADIN mesoscale NWP model on the example of Šibenik station (Fig. 3) has shown that its value for the ALADIN/DADA2 and ALADIN/ALARO2 varies between 1.5ms-1 and 2.5ms-1, depending on the considered month.

The decomposition of the mean squared error on its integral components: the bias of the mean (BM), the bias of the standard deviation (BS) and dispersion or phase error (PHE) shows that the dispersion errors, i.e. phase errors are the main reason for the model error, especially in models of higher resolution. In other words, the analysis indicates that errors in the time of start or end of a certain process, including the creation or disappearance of wind flow, are the main reason for the error in the ALADIN model.

Spectral verification is performed by spectral decomposition in wave-number and frequency domains. In this paper the example of the spectral verification in frequency domain will be shown. Such spectral decomposition provides an information on the performance of the model in simulating the processes of certain time scales or a certain range of time scales at specific location and it is useful for the physical interpretation of the results.

Power spectral density functions depending on frequency (period) are shown on Fig. 4. Results of the ALADIN/ALARO8 model show the largest departures from the measurements for all scales of motions, other than daily. The total variability of wind energy is undervalued for longer mesoscale, synoptic motions, as well as for subdiurnal motions.

Results of the ALADIN/DADA2 model have been improved primarily for the NE-SW cross-mountain wind component in the direction of bora wind, while for the NW-SE along-mountain component there are no major differences in comparison to the performance of ALADIN/ALARO8 model. The smallest deviations from the measurements are given by the ALADIN/ALARO2 model which accurately simulates the spectral energy density at all time scales, other than those of a few hours. Therefore, these results suggest that the use of ALADIN/ALARO2 model has a potential to improve the results and accuracy of the weather or wind forecasts in the area.

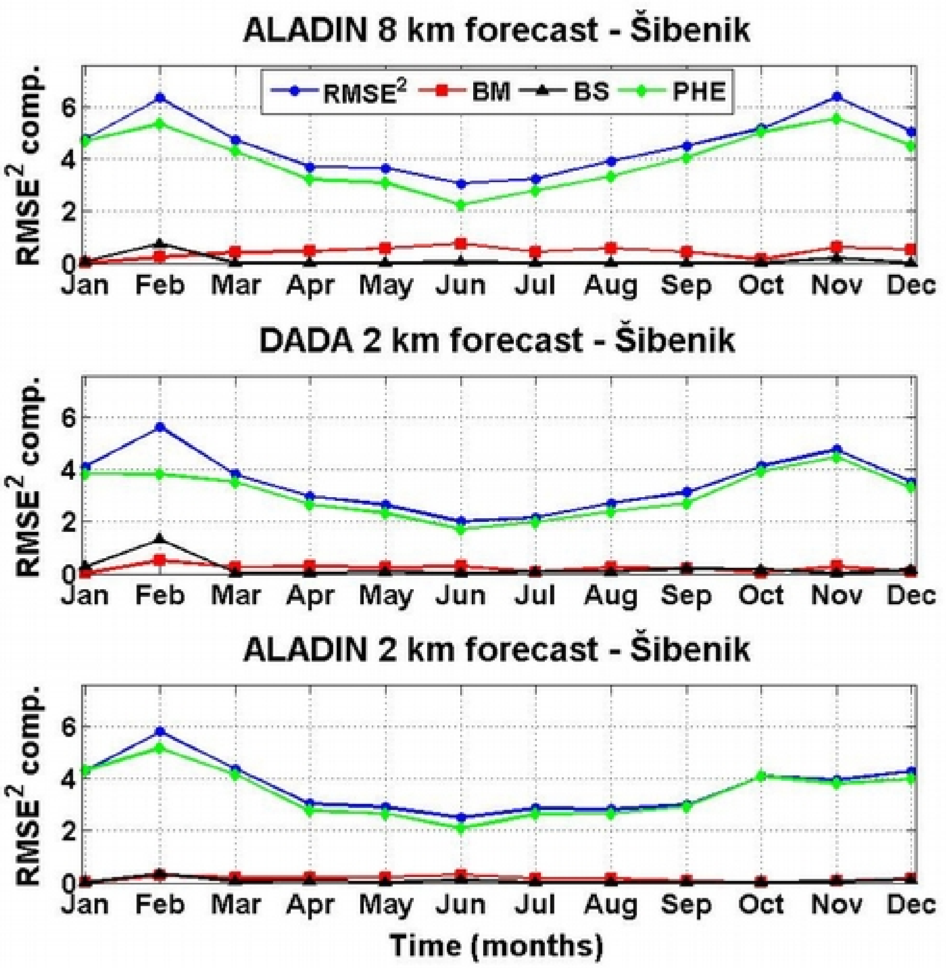

Fig. 3: Decomposition of the mean squared error (MSE) of ALADIN mesoscale NWP model: ALADIN/ALARO8 (upper panel), ALADIN/DADA2 (middle panel) i ALADIN/ALARO2 (lower panel), bias of the mean (BM), bias of the standard deviation (BS) and dispersion error or phase error (PHE). The figure shows squared values of MSE components.

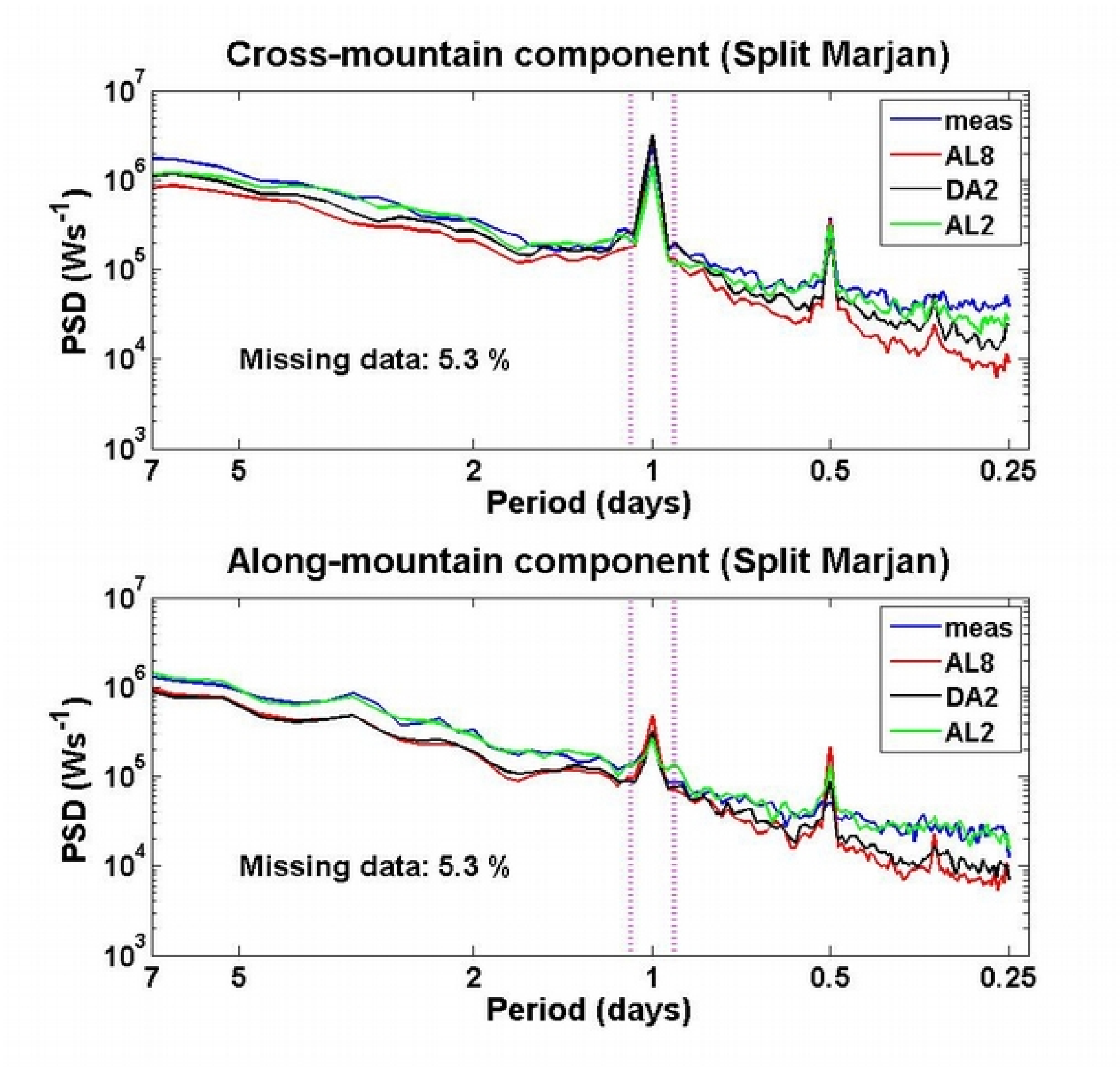

Fig. 4: Spectral decomposition of ALADIN/ALARO8, ALADIN/DADA2 and ALADIN/ALARO2 models and measurements at Split station in the period 2010-2012. for the components in the NE-SW (upper panel) and NW-SE (lower panel) directions.

2.2 Statistical methods

Using the historical prognostic data from ALADIN mesoscale NWP model and measurements, the following deterministic statistical forecasts were developed:

1. Kalman filter – KF;
2. Analogue ensemble (mean value) – AE mean;
3. Kalman filter of analogue ensemble (mean value) – AE mean KF;
4. Analogue ensemble (weighted average) – AE w. mean;
5. Analogue ensemble (median) – AE median;
6. Kalman filter sorted analogue ensemble metrics – KFSM.

The training period for the deterministic analogues ensemble forecast are years 2010 and 2011, while the verification is performed for the year 2012. Prognostic values used in the statistical modeling were taken from the most representative of four models points surrounding the specific station.

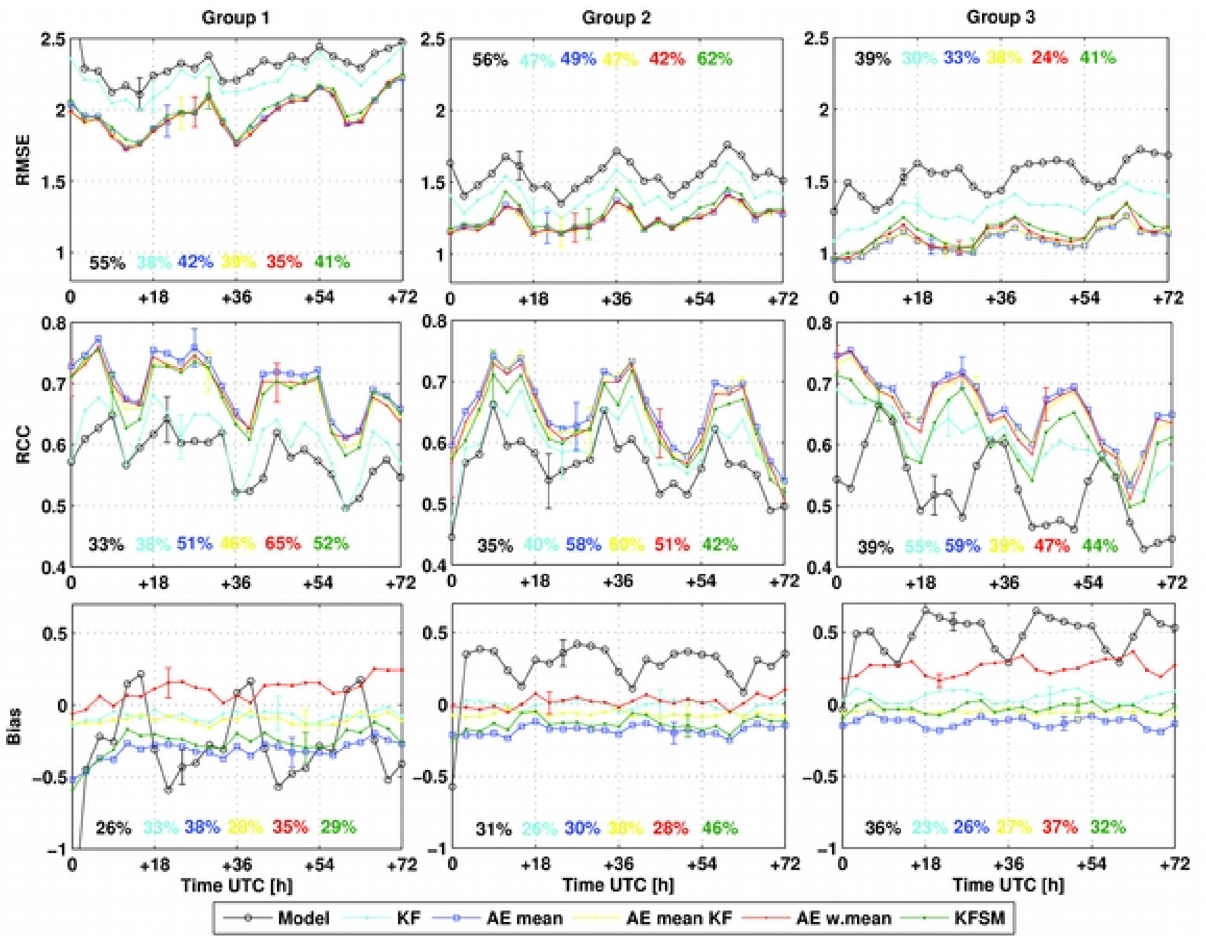

Fig. 5: Mean squared error, rank correlation coefficient and systematic error for 6 different deterministic statistic forecasts compared to the direct ALADIN mesoscale NWP model output for three groups of stations: coastal (left), mountain (middle) and continental (right) during the year 2012. Mean value of the confidence interval of statistical measure is shown for each measure and for each forecast, while its variability is shown numerically as a percentage in the corresponding color.

The performance of various statistical methods was tested with several statistical measures: systematic error, mean squared error, mean absolute error, rank correlation coefficient, and other specialized measures (Stable and Equitable Error Probability Space, Critical Success Index, Frequency Bias, Polyhoric Correlation Coefficient, etc. not shown here). The accuracy of prognostic values obtained as direct output from ALADIN mesoscale NWP model and different statistical models applied to the results of the ALADIN model are shown in Fig. 5. All statistical methods reduce the mean squared error of the direct model output, wherein the methods based on analogues are slightly more successful than the methods based exclusively on the Kalman filter. The amplitude of the error reduction is dependent on the location, i.e. the group of stations and on the forecasting period as well.

Furthermore, all statistical methods almost completely remove a relatively small systematic error which exists in the ALADIN mesoscale NWP model. Additionally is removed its significant daily cycle, which is particularly pronounced at coastal stations. Finally, the rank correlation coefficient is significantly increased for all methods, particularly for those based on analogues.

Finally, the analogues ensemble method was used for producing the probabilistic forecasting information. In other words, using this method can be the computationally undemanding way to assess confidence intervals of wind speed and direction forecast (as well as the energy produced from the wind) for the locations where the measurements exist, i.e. the location of wind farms. This method is not equivalent to the ensemble forecasts which generated using different initial conditions and ensemble simulations for the evaluation of uncertainty of the three-dimensional state of the atmosphere at a future time.

An example of such forecast is given on Fig. 6, which shows single 72-hour forecast for the location of Split Marjan. The figure clearly indicates that the mean value of analogues ensemble improves the wind forecast obtained by ALADIN model, but also gives the corresponding distribution of reliability. From this type of forecasts it is possible to e.g. calculate the probability of wind speed to exceed certain value at particular location.

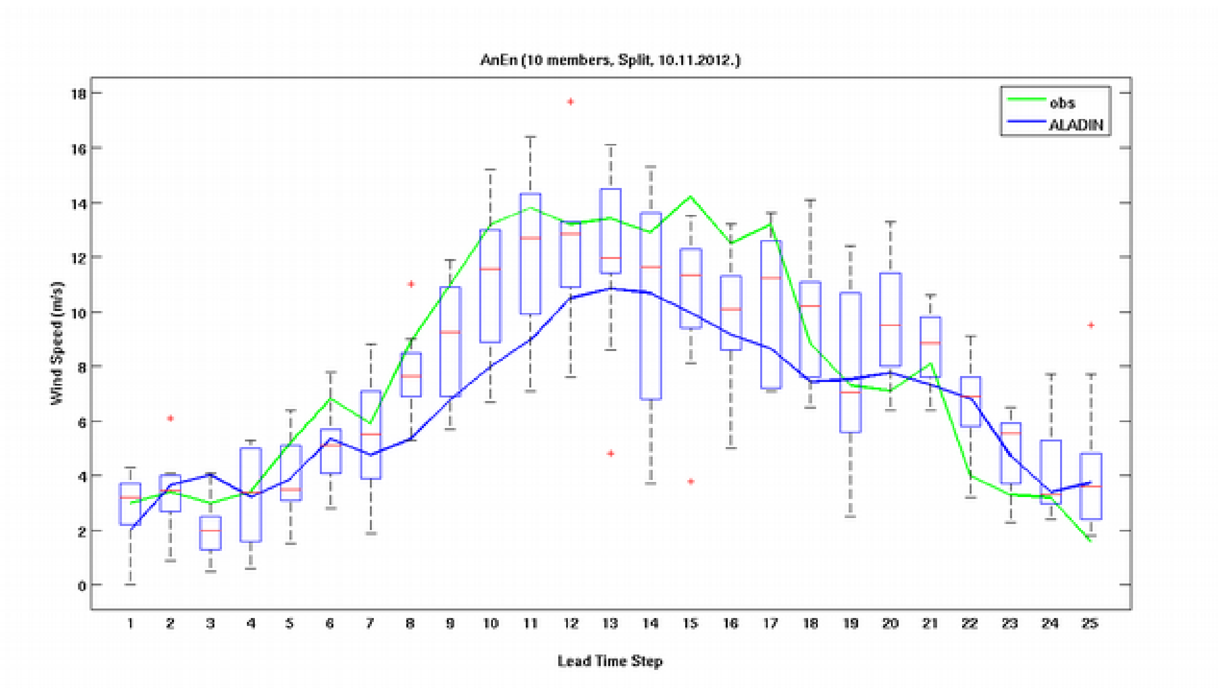

Fig. 6: Example of probabilistic forecast for Split Marjan station using the ALADIN mesoscale NWP model and analogues ensemble. Forecasting lead time is shown on the x-axis (each step corresponds to 3 hours interval), while wind speed is on the y-axis. The blue line denotes ALADIN mesoscale NWP model forecasts, green lines stand for measurements, while red lines correspond to deterministic estimates of wind speed using analogues ensemble. Corresponding distributions provide probabilistic information about the reliability of forecast.

3 Conclusions

Despite the growing use of wind energy in Croatia, the management of produced electric energy from wind is not fully adapted to our wind climate regime and local meteorological and energy-related specifics. This also applies to the wind and wind energy forecasting system in very complex wind regime that prevails in the coastal complex terrain areas suitable for intensive use of wind energy. Accurate, reliable and timely weather forecast for several days in advance is the basis for more accurate forecasting of wind farm output, which than serves for efficient technical planning of the electricity system and reduces the costs of electric power system balancing as a whole as well as social well-being in the form of increasing the security of energy supply for the of end consumers.

The improvement of accuracy of mesoscale model predictions can be achieved by improving the dynamical model itself and by using different statistical methods, which can significantly increase some elements of forecast accuracy. Therefore, the optimal prognostic chain model may be ideally achieved by using the forecast system comprised of both dynamical and statistical models. This includes probabilistic forecasting methods such as analogue ensemble, which may be seen as complementarity to classical ensemble prediction systems.

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Operational ALADIN forecast in Croatia: current status and plans

Stjepan Ivatek-Šahdan, Antonio Stanešić, Martina Tudor, Alica Bajić, Mario Hrastinski, Tomislav Kovačić, Kristian Horvath and Iris Odak Plenković

This article describes the operational forecast suite using ALADIN model in Croatian Meteorological and Hydrological Service in January 2015. ALARO0 baseline has been tested using cycle AL38T1 on the domain for operational forecast with 8 km resolution on 37 levels in the vertical. Tests different options for tuning parameters in physics and dynamics on 37 and 73 levels were also performed running 72 hour forecasts for the two whole months, for January and May 2014. Results of the pre-operational testing of Alaro0 in 8 km resolution using AL38T1 reveal that the assumption of cloud overlap plays the most important role in scores for the forecast in 2m temperature. Random overlap performs better than random maximum in winter when the weather is characterized by low stratus and fog, but not in spring and summer with characteristic cumulus clouds. It is intended to replace the 8km operational domain with one in 4 km resolution, ALARO0 baseline was applied and tested on 37 and 73 levels in the vertical with hydrostatic and non-hydrostatic dynamics. The 4 km resolution run on 73 levels is in its pre-operational phase but the difficulties associated with its operational implementation and testing are associated to the computer memory and properties of the scheduler. The standard scores show that the forecast in 4 km resolution are superior to the 8 km forecast.

1 INTRODUCTION

1.1 Computer hardware

Available mainframe computer hardware consists of SGI UV 2000 (shared memory system) with Numalink 6 interconnect consisting of 28 Intel Xeon E5 processors with 6core 2,9GHz and 15MB cache CPUs, total 608 GB RAM with total 228 cores. These cores are pre-defined so that 6 are dedicated to the operational system, 6 are for interactive work, 24 are for mono jobs (both operational and research) and the remaining 192 cores are for multi-processor jobs (both operational and research).
Working disks are 6.6TB, installed are Intel compilers version 13.1.0 20130121 and scheduler PBSPro, SGI management software, Fibre Channel, Gigabit ethernet.

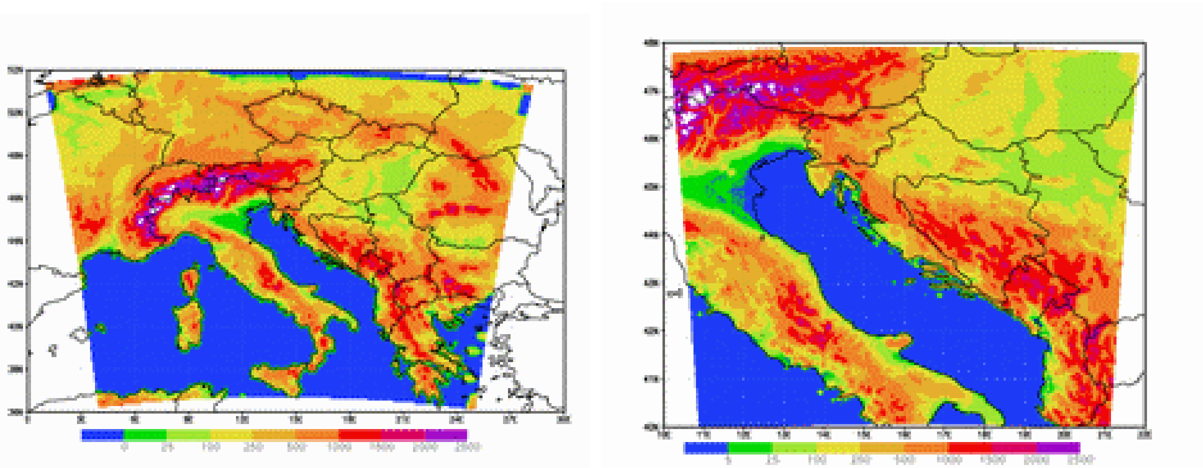

Fig. 1: Terrain height in 8 km resolution operational domain (left) and 2km resolution operational domain (right). The 2km resolution domain is used for dynamical adaptation of wind up to 72 hours and non-hydrostatic forecast.

1.2 The operational forecast suite

The operational forecast suite consists of forecast in 8km resolution on 37 levels (domain shown in Figure 1) 4 times a day up to 72 hours initialized with 3Dvar. On 27th January 2015 the operational executable has been replaced with AL38T1 and the complete Alaro physics package is used for operational forecast (but still on 37 levels only). It is planned to replace the 8 km resolution domain with a 4 km resolution one on 73 levels and this is currently in pre-operational testing.

The wind field is further dynamically downscaled to 2 km resolution (domain also shown in Figure 1) on 15 levels in the vertical (but the lowest 8 are as for 37 level run). It uses each output file of the 8 km resolution forecast and runs the model for 30 minutes to adapt the wind to high resolution topography. The hydrostatic dynamics is used with turbulence parametrization from physics, other parametrisations are switched off.

Once a day full non-hydrostatic forecast using AL36T1 with Alaro physics is run in 2 km resolution on 37 levels on the same domain up to 24 hours. This run uses interpolated fields from the 6 hourly forecast of the 8km resolution 00 UTC run as initial conditions.

On 1st January 2014 the operational ALADIN forecast in DHMZ has switched to using IFS coupling files in the place of ARPEGE ones. The forecast is run up to 72 hours four times a day, it is starting from 00, 06, 12 and 18 UTC analyses, and coupled to LBC fields from IFS in delayed mode. This means that LBC for 6 hour forecast from 18 UTC run of IFS is used for initial LBC for 00 run of the next day, 9 hour forecast from 18 UTC run of IFS is used for 3 hour forecast LBC for 00 run of the next day, and so on.

2 Alaro0 in 8km resolution

ALARO0 baseline has been tested using cycle AL38T1 and namelist parameters as recommended in the ALARO0 baseline namelist documentation (cf. Radmila Brozkova) on the domain used for operational forecast in the Croatian Meteorological and Hydrological Service. Horizontal resolution in the domain is 8 km on 37 levels in the vertical. The contributions of various processes and assumptions were tested by varying namelist parameters and running 72 hour forecasts for 00 UTC run each day, for January and May 2014. The results were evaluated using Veral verification package (Harmonie verification package was installed in October 2014).

Tests with higher vertical resolution on 73 levels in the vertical and non-hydrostatic dynamics were also performed in 8 km resolution. The contribution of cycling through the assimilation cycle of prognostic TKE, cloud liquid water and ice, rain, snow, updraft, downdraft vertical velocities and mesh fractions, and prognostic detrainment was computed for January and May 2014. The results were not very encouraging and since the procedure requires storage of many additional 3D fields this approach was abandoned at least until the upgrade in the storage facilities (which should happen already next month but one never knows).

The first reference is the operational forecast. It is run using AL32T3 but it differs with some of the ALARO switches due to complaints from the forecast office regarding cloudiness and temperature forecast in cases with low stratus and fog during the cold part of the year. The main difference arrives from the switch LRNUMX=F that uses random overlap assumption for cloudiness (random maximum overlap if TRUE). As will be described further in more detail, the switch enables better forecast of temperature at 2m and cloudiness during winter, especially in situations with low stratus and fog. Consequently, significant portion of improvements in the radiation scheme was switched off too, since it had little or no contribution.

The operational suite uses prognostic schemes for TKE, cloud water and ice, rain and snow, but uses diagnostic convection scheme. The cycling of variables in the data assimilation suite with 3Dvar does not include TKE and prognostic condensates. On 1st January 2014, the operational suite switched from coupling files of ARPEGE produced in Meteo France to the files of IFS produced in ECMWF. Finally, on 27th January 2015 the operational suite has switched to AL38T1 that uses Alaro0 physics package with recommended radiation and prognostic convection parameters, the only thing different is the cloud overlap that will change value between winter and summer (from F to T).

ALARO0 forecast was run up to 72 hours starting from 00 UTC operational analysis for each day in the period from 1st July 2013 until 30th June 2014 and coupled to the coupling files used in the operational suite (the ARPEGE one for 2013 and the IFS files for 2014). The forecasts were compared to the operational forecasts by computing bias (BIAS), root mean square (RMS) error and standard deviations (SD) for each month in the period using VERAL verification package (Figures 2-4).

The operational suite has large positive bias of moisture in the upper troposphere and close to surface and a negative bias for the layer 850 to 700 hPa (Figure 4). There is a significant improvement in ALARO0 baseline forecasts of the scores for relative humidity in the upper troposphere for each month in the whole period.

The ALARO0 baseline scores for temperature and humidity at 2 meters are significantly worse in late autumn and winter (Figure 2), better in spring (Figure 3) and early autumn and slightly better in summer. It was important to find if there is a model set-up that could reduce the deterioration of the ALARO0 baseline forecast of RH and temperature at 2 meters in winter.

A number of tests has been performed to estimate the impact of various parameters that can be controlled via namelist by running 72 hour forecasts starting from operational analyses for 00 UTC run for each day in January and May 2014.

A document with more detailed analysis of the testing results is downloadable from http://radar.dhz.hr/~tudor/alaro/cro_exp_wd.pdf and most brave and curios of the readers could be interested in the complete set of Veral outputs for almost all of the experiments at http://radar.dhz.hr/~tudor/alaro/.

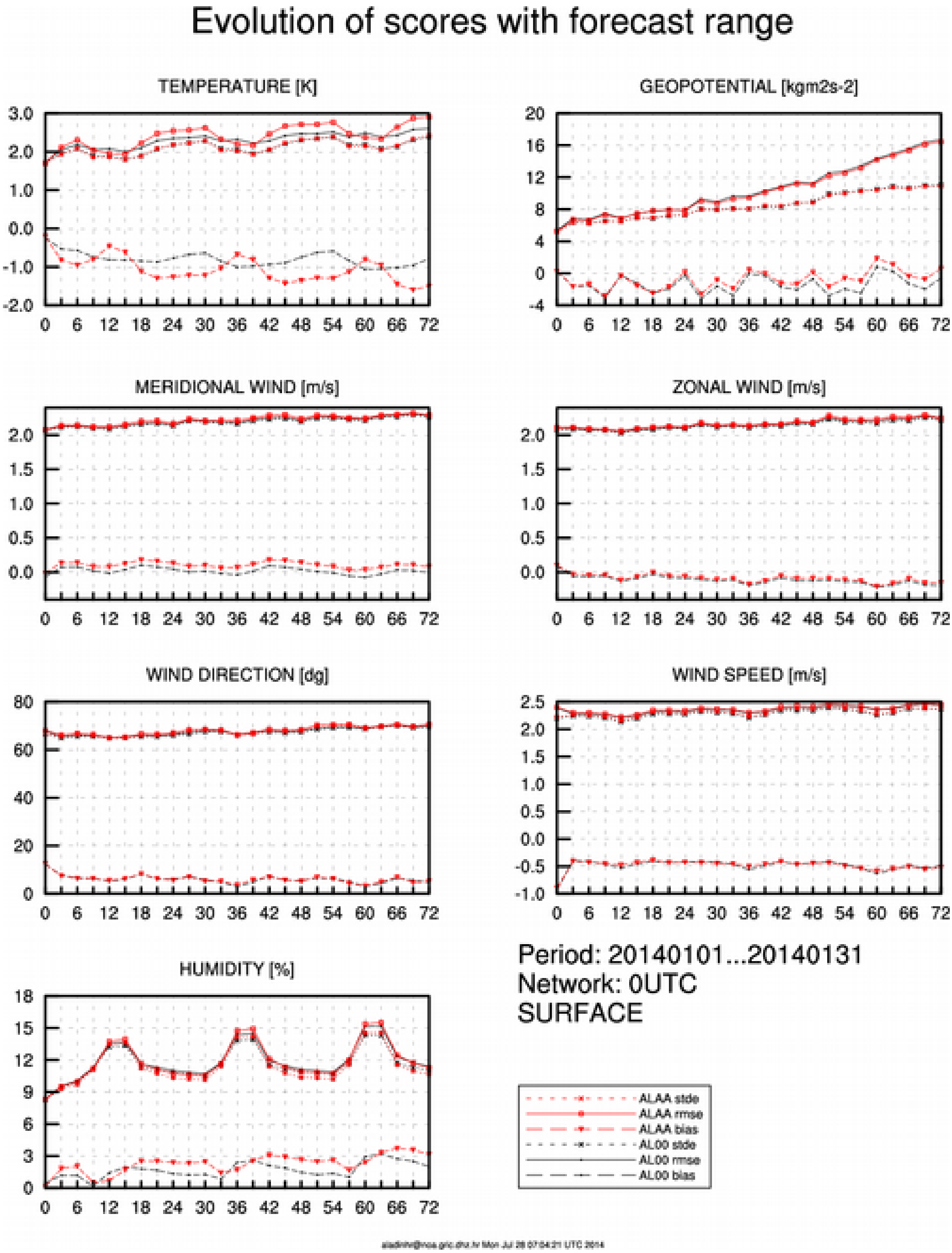

Fig. 2: Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALARO0 baseline forecast (red) for January 2014.

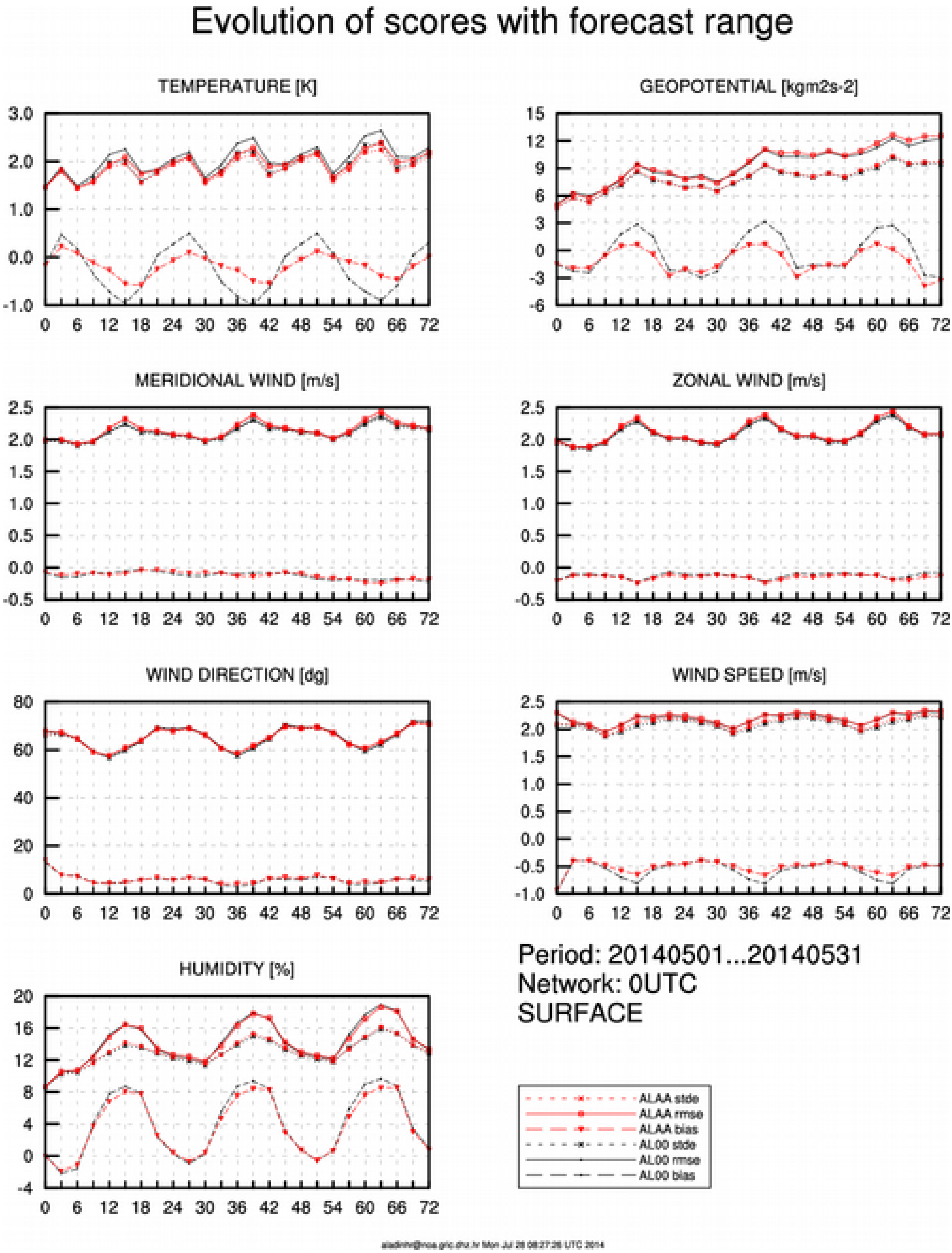

Fig. 3: Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALARO0 baseline forecast (red) for May 2014.

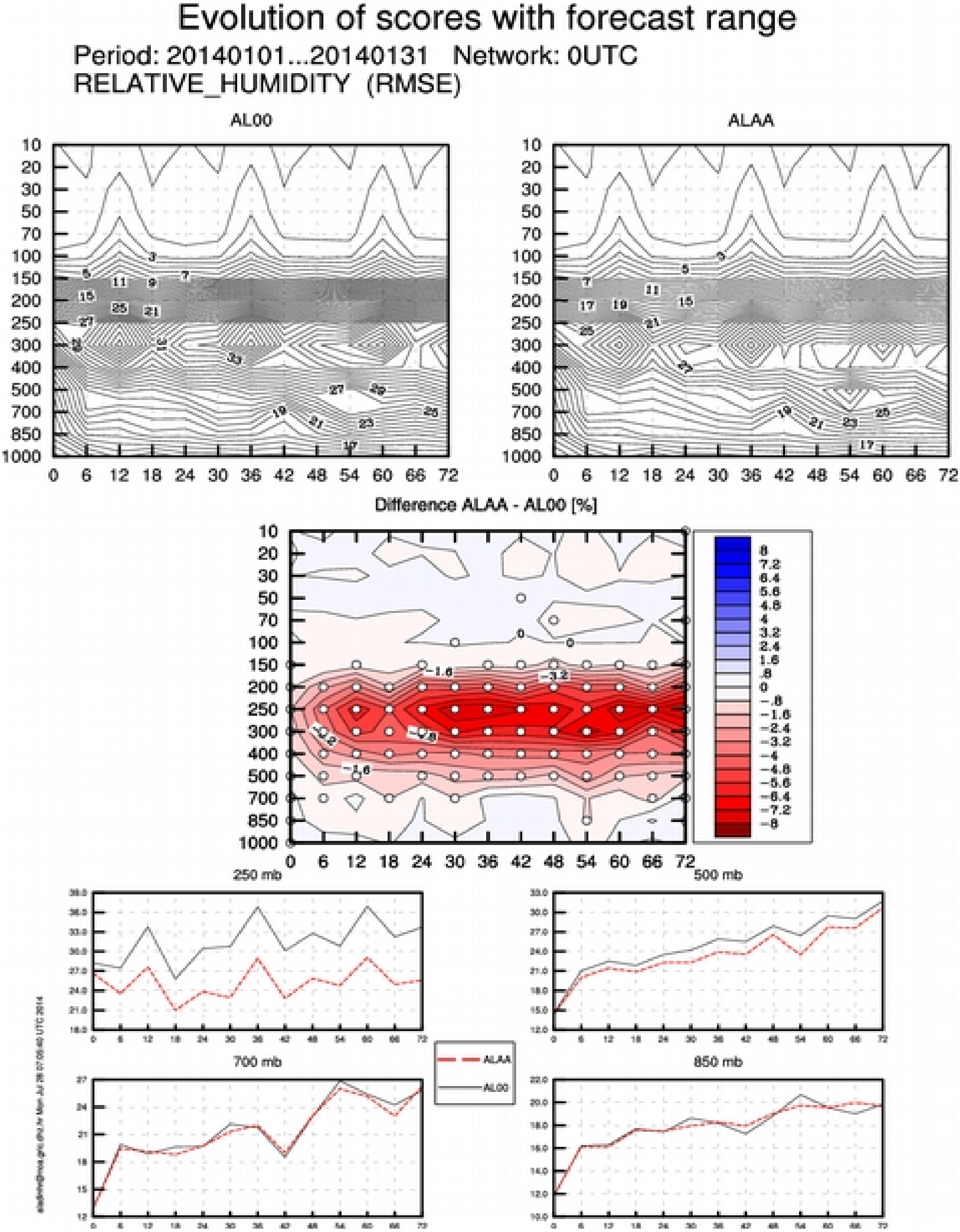

Fig. 4: Root mean square error for operational forecast (top left panel and black lines in bottom panels) and ALARO0 baseline forecast (top right panel and red lines in bottom panels) for January 2014.

3 The problem of initial conditions for the 4km resolution run

Operationally, we have two sources of lateral boundary conditions, one is from IFS run in ECMWF (and currently used for operational forecast in 8 km resolution) and the alternative is from ARPEGE run in Meteo-France (these were operational until the end of 2013). Additionally, the initial conditions can be taken from the operational suite, which uses cycling and 3Dvar (and 6 hourly IFS forecast from the previous run), or we can use the initial file of IFS or ARPEGE and interpolate the fields to the model grid.

The operational forecast in the 8 km resolution is coupled to IFS and the initial file is obtained through the data assimilation cycle using 3Dvar. It was possible to create initial file for the 8km resolution model on 73 levels directly from the initial file on 37 levels by spectral full-pos. But this was not possible for the initial fields on domain in 4 km resolution since these required horizontal interpolation and data from areas not covered by the operational initial files.

It is not wise to use interpolated fields of IFS as initial fields without any data assimilation since the error created in the procedure is significantly larger than any error due to change in the model version. The first problem was to establish a reference in 8km resolution for the tests in 4 km resolution.

Consequently, there were two types of references tested. In both of them the initial file contained the interpolated fields from the initial file of ARPEGE, but in the first reference, the coupling files were the ARPEGE coupling files and in the second reference the coupling files were from IFS. Since the future operational suite is to continue to be coupled to the IFS and use assimilation cycle with 3Dvar, the latter experiment is used for more extensive testing. There is a more extensive report on this testing on http://radar.dhz.hr/~tudor/alaro/alaro0hr4km.pdf (at the time of writing this report it was not containing the most recent data, but the document is to be updated).

The 4km resolution run entered operational suite, currently for the 00 run, on 2nd February 2015.

4 Problems with e927 and RAM

During testing of 4km resolution run on 73 levels a problem appeared. The mainframe computer would become not-responsive. It was not possible to log in. The shells where the users were logged in did not response to anything typed in.

Mono jobs (that require only one core for execution) have 4 reserved nodes (6 cores each, total 24 cores) with 15Gb of RAM per core. One node is for the operational system and one for interactive work. The rest 32 nodes (192 cores) are for multi jobs. Currently all nodes have the same amount of memory.

It was possible to run one e927 (as mono job on one core) and one 001 (on 48 cores) without problems when the machine was mostly free. But when testing for parallel tests (31 e927s and 31 forecasts launched, about 4 of them ran simultaneously, the other were in queue), the machine would stop responding.

The scratch disk (the one where the system writes some temporary stuff) was moved from the system disk (root) to another disk (the work one) and the computer does not develop autism (at least not in its most severe case). The e927 jobs are in queue, appear to be running (according to the output of the scheduler) but do not progress (do not produce output files), but since the move of scratch it is possible to log onto the computer and remove the job that is stalled.

The output of the scheduler does not give a reliable information on how much memory the job has used. Apparently, it did not matter how much memory was asked for in the instructions for the scheduler. The job would run anyway. Actually if little memory was asked for in the e927 job, many jobs would run simultaneously and, well, not really produce output. Somehow, we expected from a scheduler to terminate the job if it would try to use more memory than asked for in the header of the script.

An experiment was performed in which 4 multi processors were switched off, the memory plugged from them into the nodes for mono jobs. With more RAM it took more e927 jobs to stall. Tuning of NPROMA and other options that could reduce memory requirements does not help much since every attempt eventually leads to phoning the SGI to re-start the computer (or scheduler, depends how severe it got).

Also, there were several experiments where a series of jobs was sent to the computer and SGI person was supervising what was going on. The conclusion is that during operational forecast, the scheduler does stop execution of the non-operational tasks, but it does not free the memory. When one operational task finishes, the scheduler lets one non-operational job to run, it should be the one that was stopped, but often it is not the job that was stopped, it is a new task. The old one is still sitting in the queue, the memory is not free but a new non-operational job is running using more memory (and sometimes swap). Then another operational tasks starts running and stops the second non-operational job without releasing the memory … with many operational post-processing mono jobs this can be a nuisance.

It is possible to set-up running e927 on more than one core, it is also possible to ask for a lot of RAM for a mono job. So now we run e927 on many cores to occupy more RAM and find some configuration that could coexist with many other jobs (that we have in operational suite) and not stall. Asking for 28Gb of ram in e927 helped, so now only two mono jobs can run simultaneously using all the memory from the 4 nodes but only two cores. Running e927 as multi is faster but it takes the nodes from other multi tasks such as forecast, and the total number of nodes is, well, not really large. More economical ways are being developed and tested.

Impact of the data assimilation on ALARO precipitation forecast over Romania. Case study: 15th of May 2014

Mirela Pietrişi, Otilia Diaconu, Simona Taşcu

Introduction

Previous results for an episode of cold weather in February 2012 obtained by conventional data assimilation were encouraging. It has been also proved the beneficial impact of local data assimilation surface leading to an increased performance of the model forecast in the 2m temperature field.

As well it is recognized that high-density observational data assimilation, especially radar or satellite data can lead to a substantial improvement in forecasting having an important role in reducing the uncertainties inherent in the initial conditions of the numerical model. Observations from polar and geostationary satellites provide essential information on the vertical structure of the atmosphere (temperature, water vapour content of the atmosphere).

Several experiments were carried out to analyse the impact of satellite data assimilation on the ALARO model precipitation forecast. The results for a case of heavy rainfall, 15 May 2014 are presented in the comparison with the operational forecast (without data assimilation). The model performance was evaluated by using the MODE method (Method for Object - based Diagnostic Evaluation) which provides diagnostics difficult to be obtained by using traditional verification scores, i.e. information about errors in precipitation location, size and intensity.

Experiment set up

The data assimilation was performed for one month, May 2014, using the following settings:

- Model version : cycle 36t1op2
- 6h assimilation cycle
- 3D VAR and CANARI/OI
- B matrix was computed using the Ensemble method (March – August 2009)
- IDFI, ARPEGE LBC files at every 3 hours
- Observation from the common LACE date base (OPLACE): conventional data (including local surface observation) and satellite data: ATOVS / AMSU-A (Advanced Microwave sounding Unit-A), ATOVS / AMSU-B (Microwave sounding Unit-B) from METEOSAT-NOAA19, SEVIRI (Spinning Enhanced Visible and Infrared Imager)

Using the initial state obtained throughout data assimilation and the set up described in Table 1, the ALARO model was integrated in parallel with the operational chain up to 30 hour forecast range.

Table 1: Experiment set up

Model version	ALARO-0 baseline (cy 36t1)
Resolution	6.5 km
Levels	49
Area	ALARO-Romania (240 x240 points)
Initial conditions	ARPEGE
Boundaries	ARPEGE
Surface scheme	ISBA
Starting times	00 UTC
Verification times	Precipitation 6-18, 18-30 UTC

Case of 15th of May 2014

The date of 15th of May 2014, when Romania area was affected by heavy precipitation, was chosen as an example for the evaluation of data assimilation impact. A strong perturbation initially developed in the Genoa Gulf advanced towards Balkans Peninsula, getting a northeast trajectory crossing Romania.

The precipitation forecast was evaluated using the MODE method. MODE defines objects in both forecast and observation precipitation fields which are matched and compared one to another. The evaluation was carried out for day (06-18 UTC) and night (18-30 UTC) and for several precipitation amount thresholds.

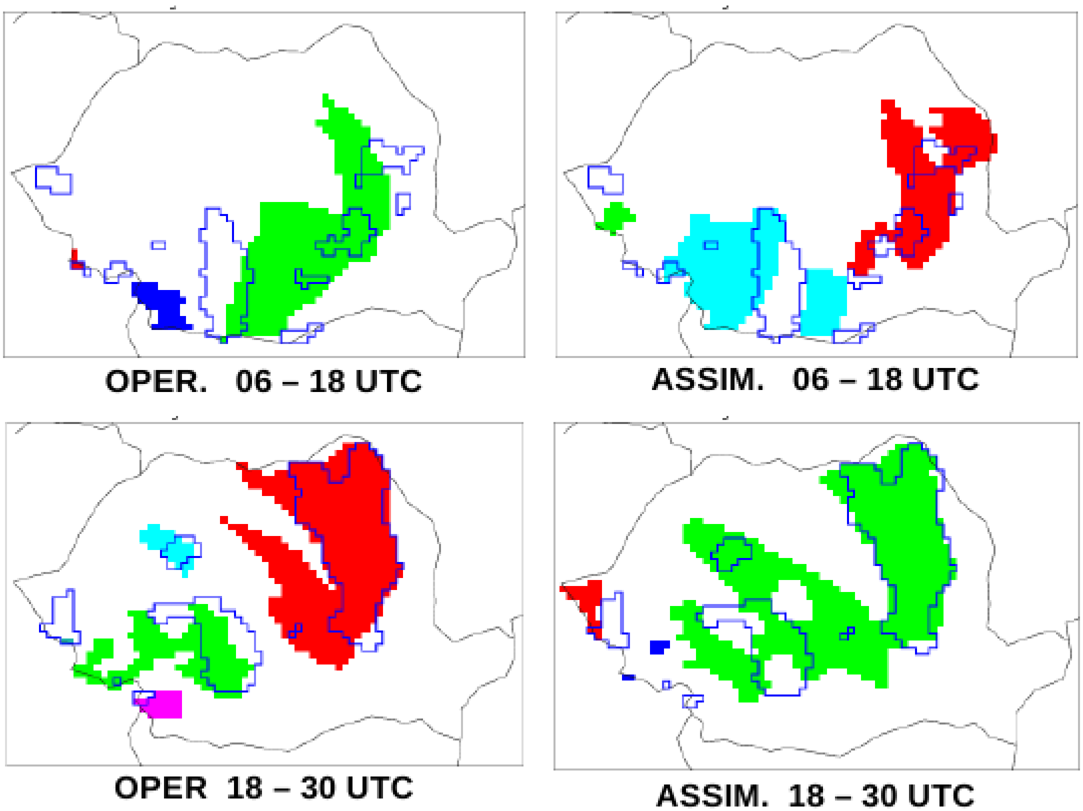

Figure 1 . Forecast Objects with Observation Outlines for precipitation>=20 mm for May 15, 2014: precipitation accumulated during the day – first row, and during night – second row. Operational ALARO –left column, ALARO with data assimilation –right column

Figure 1 shows the forecast objects with observation outlines for a threshold greater than 20 mm/12hours.

One can notice that:

- Both forecasts (with and without data assimilation) overestimate the amount of precipitation in the mountain area (especially on the Carpathians Curvature);
- During day, the impact of ALARO with assimilation is quite visible in the western part of the country; the precipitation amount is increased with respect to the operational forecast and closer to observations;
- During night, both forecasts failed to simulate correctly the precipitation in the eastern area.

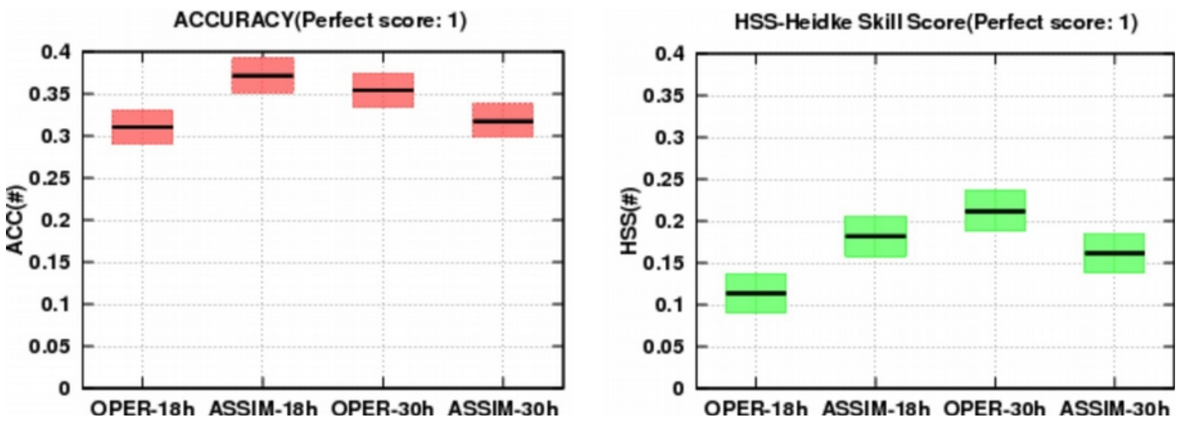

Figure 2: Multi-category scores and confidence limits for May 15, 2014, day and night: accuracy –left and Heidke skill score- right

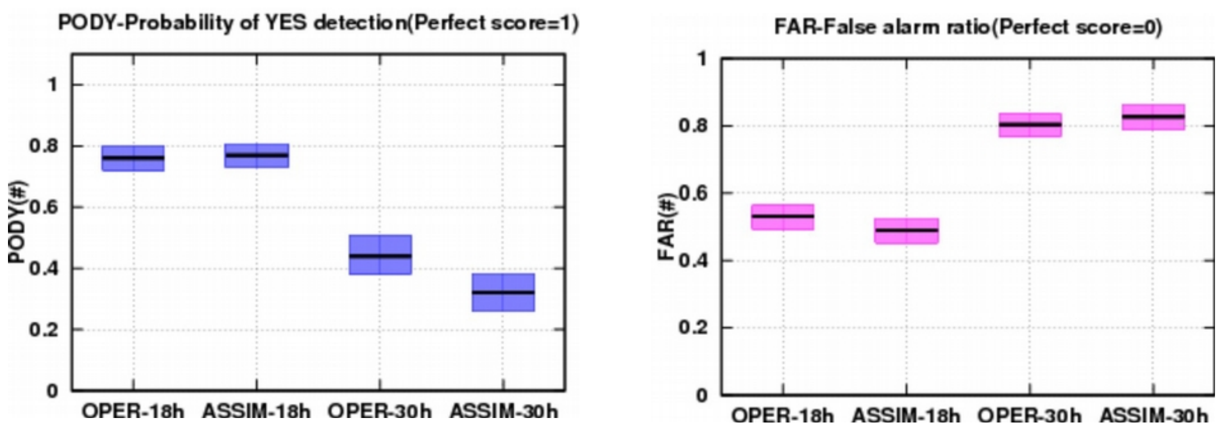

Figure 3 Categorical scores and confidence limits, for precipitation >=20 mm for May 15, 2014, day and night: probability of detection – left and false alarm ratio - right

Figures 2 and 3 show the overall performance of the ALARO model with data assimilation. They indicate a more accurate forecast, with higher degree of correct forecasts (discriminates better between "yes"/ "no") during day.

Further plans concern: the selection of more satellite channels, the reduction of the assimilation window (3 hours instead of 6 hours) and the increase of the vertical level number in PBL.

ALADIN operational system in Slovenia

Benedikt Strajnar, Neva Pristov, Jure Cedilnik, Jure Jerman

1 Introduction

During spring and summer 2014 the operational ALADIN system was significantly upgraded. The new suite with rapid update cycle (RUC) officially become operational on 20 June 2014. This contribution gives an overview of its current characteristics.

2 Model setup

The operational ALADIN/SI is run on 432 x 432 horizontal grid with 4.4 km resolution (slightly smaller LACE domain) and 87 vertical levels with the model top at 1 hPa. It is based on the model cycle CY38t1_bf3 export version with ALARO-0 baseline physics setup.

The assimilation suite provides analyses and first guesses for the production cycle every 3 hours. The production suite includes four 72-hourly runs per day initialized with analysis at 0, 6, 12, 18 UTC and four additional 36-hourly runs at 3, 9, 15, 21 UTC.

ECMWF Boundary Conditions Optional project is used for lateral boundary conditions. Lateral boundary fields are applied with 1-hour frequency in the assimilation cycle and 3-hour frequency in the production cycle. The coupling in the production runs is in the so called “lagged mode”, which means that 6 hours old ECMWF forecasts are used as LBCs. This allows rapid availability of ALADIN production runs (production starts one hour and 45 minutes after analysis time). The assimilation cycle is coupled to ECMWF without time lag except for 3,9,15,21 UTC runs, where 3 hour lagged ECMWF fields are applied.

No special initialization procedure is used neither in assimilation nor in production forecasts. At the initial time, the analysis is also applied as a first LBC to improve the balance at model boundaries (the so-called “space-consistent” coupling).

3 Data assimilation characteristics

Atmospheric analysis is provided by 3-hourly three-dimensional variational assimilation (3D-Var). Observational data set includes Synop and (national) automatic surface observations, radiosondes, Meteosat Second Generation (MSG) atmospheric motion vectors, AMDAR aircraft observations, and satellite radiances (MSG SEVIRI, NOAA, Metop). On top of these observations available from OPLACE observation preprocessing system, the locally received Mode-S MRAR aircraft observations are assimilated. Mode-S MRAR is a novel aircraft data (sub)type that utilizes modern air traffic control radars to collect aircraft observations with the quality similar to AMDAR (Strajnar 2012). Due to its limited coverage it currently affects mostly very short forecast ranges (Strajnar, 2014).

4 Operational environment

The SGI ICE-X computer system with 62 compute nodes has been used since 2013. Each of the compute nodes has 32 GB of memory and 2 eight-core Sandy Bridge processors (E5-2670 @ 2.6 GHz). Software includes Intel Compiler, Altair PBS Pro queuing system and TotalView debugger.

The current ALADIN integration run is using one third of available cores which enables computation of 72-hour forecast in 30 minutes.

Ecflow (ECMWF) system is used as a workload manager. The computer system and operational suite are controlled by NAGIOS supervision system.

5 References:

- Strajnar, B. (2012), Validation of Mode-S Meteorological Routine Air Report aircraft observations, J. Geophys. Res., 117, D23110, doi:10.1029/2012JD018315.
- Strajnar B. (2014), Collection and assimilation of Mode-S MRAR aircraft observations in Slovenia, ALADIN - HIRLAM Newsletter no. 3, September 2014.

Two-way coupling in the atmosphere-ocean modelling system

Peter Smerkol, Matjaz Licer, Anja Fettich, Jure Cedilnik, Benedikt Strajnar, Jure Jerman
Neva Pristov, Anneta Mantziafou, Michalis Ravdas,
Alexandros Papapostolou, Maja Jeromel, Sarantis Sofianos

1 Introduction

In recent years Slovenia has been facing an increasing trend of severe flooding. To improve forecasting scores of the ALADIN-SI model in such and similar situations the ALADIN-SI model was bi-directionally coupled to a wave and an ocean model. The wave model used was the cycle 4 code of WAM (ECMWF). The ocean model is the Adriatic sea setup of Princeton Ocean Model, ADRIPOM [2]. Coupling was implemented using OASIS3-MCT model coupling toolbox [3] and is now under preliminary verification.

Two different coupling setups are currently being implemented:

- Atmosphere-ocean coupling (implemented). ALADIN-SI model is exchanging fields (winds, fluxes, SST) with ADRIPOM ocean model during every integration timestep. Sea surface temperature field outside the ADRIPOM domain, which nevertheless required by the ALADIN-SI, is provided using Mediterranean Forecasting System MFS (run by INGV Bologna). Model domains are depicted on figure 2. This is the setup that we present briefly below.
- Atmosphere-wave-ocean coupling (under development). ALADIN-SI model is exchanging fields with ADRIPOM ocean model (winds, fluxes, SST) and with the WAM wave model (winds, friction velocity, significant wave height, drag coefficient) during every integration timestep. This setup will be presented at a later time.

2 Two-Way Atmosphere-Ocean Coupling

The atmosphere-ocean coupling is implemented using the scheme shown in figure 2. In the figure, the green boxes represent the distinct OASIS coupling models, white boxes represent additional data fed into the models without OASIS and the arrows show the fields exchanged. The main purpose of the MERGER model is to merge high resolution (1/30°) ADRIPOM sea surface temperature (SST) with the Mediterranean MFS model SST of lower resolution (1/16°) [4]. On the boundary between ADRIPOM and MFS domains a 5-cell buffer zone is implemented in which we linearly interpolate over the MFS/ADRIPOM temperature step.

The coupling scheme uses four OASIS domains shown in figure 1 :

- ALADIN - receives SST field from the MERGER model and sends the computed mean sea-level pressure, air temperature, precipitation, wind speed (u and v directions), humidity, solar and longwave downward radiation fields to the POM model.
- POM - receives mean sea-level pressure, air temperature, precipitation, wind speed (u and v directions), humidity, solar and longwave downward radiation fields from the ALADIN model and sends the computed SST field to the MERGER model.

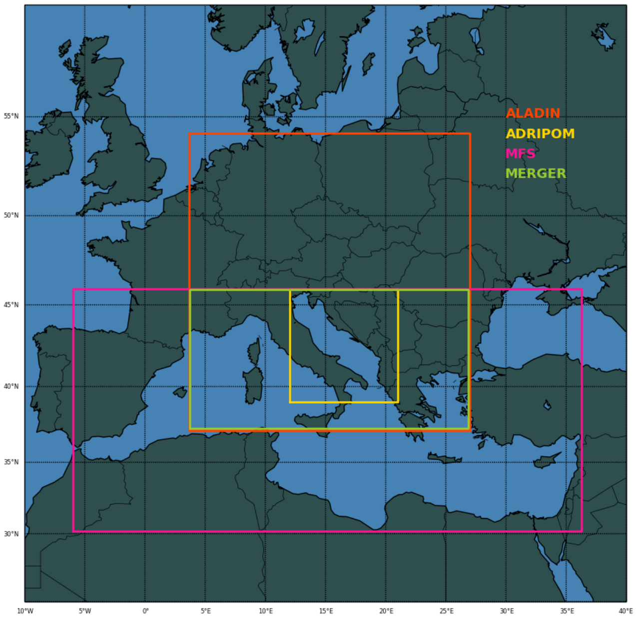

Figure 1: Domains of all OASIS coupled models used in the atmosphere-ocean coupling scheme.

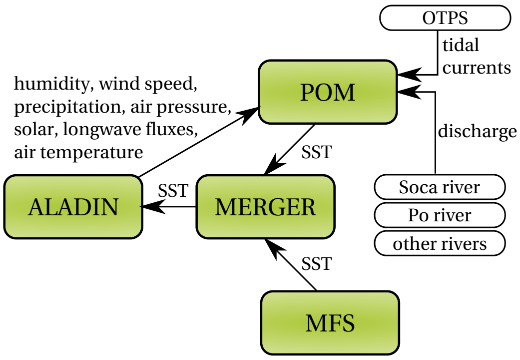

Figure 2: The atmosphere-ocean coupling scheme used in Oasis.

- MFS - a pseudo model, which reads the daily average of the SST field in the interval $[-12h, 12h]$ around 00 UTC, produced by the INGV MFS model [4] from a file, and sends it to the MERGER model.
- MERGER - a pseudo model, which receives the SST fields from POM and MFS models, merges them on a common mask and sends the merged SST field to the ALADIN model.

In figure 3 we present the sea surface temperature difference between the coupled and uncoupled ocean model during an extreme Adriatic Bora (cold northeasterly wind) event. This was a nearly unprecedented event in the Adriatic as Bora was blowing with hurricane force for weeks, leading to intense air-sea interactions. The sea temperatures in the Gulf of Trieste dropped to 4 degrees Celsius, while seawater density anomaly reached 30.5 kg/m^3. This event was thus a perfect candidate to test the coupled system behaviour. Net negative SST differences between the two setups mean that the ocean surface is cooling more efficiently in the coupled mode than in the uncoupled mode, which might also be expected. It is also clear that the differences are most profound in the northern part of the Adriatic, partly because of pronounced Bora jets in that region and partly because of the shallow bathymetry in the area (South Adriatic basin is 1200 m deep while the North Adriatic shelf is about 100 m deep). Shallow northern shelf has a lower heat capacity per unit area and is therefore more exposed to cooling during such extreme conditions.

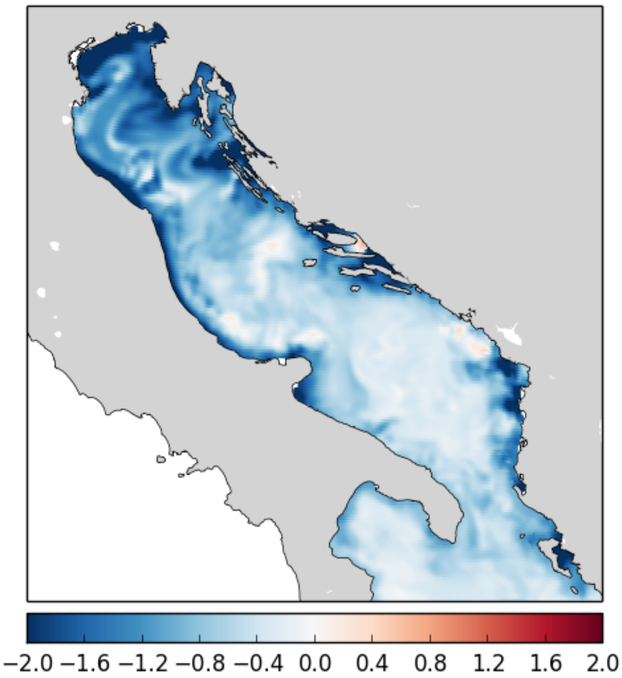

Figure 3: The SST difference of the coupled - uncoupled system during an extreme Adriatic Bora event in February 2012.

3 Conclusions and Future Plans

We plan to further develop two-way coupled atmosphere-wave-ocean modelling system and perform extensive verifications and comparisons to the uncoupled systems. We will assess under which conditions two-way coupling makes a difference and which parameters are most influenced by these implementations. We plan to estimate the impact this new implementation may have on the hydrological parameters (river discharge) and how the flood forecasting skill is influenced (and hopefully improved) by these efforts.

References

[1] *http://www.cnrm.meteo.fr/gmapdoc/*

[2] *http://www.ccpo.odu.edu/POMWEB/*

[3] *https://verc.enes.org/oasis*

[4] *http://medforecast.bo.ingv.it/*

ALARO-0 used to perform EURO-CORDEX simulations

Olivier Giot, Piet Termonia, Rozemien De Troch, Steven Caluwaerts, Geert Smet, Alex Deckmyn, Luc Gerard, Michiel Van Ginderachter, Pieter De Meutter, Daan Degrauwe, Lesley De Cruz, Rafiq Hamdi, Annelies Duerinck, Julie Berckmans, Joris Van den Bergh, Bert Van Schaeybroeck

1 Introduction

The Coordinated Regional Climate Downscaling Experiment (CORDEX) aims to evaluate and compare Regional Climate Models (RCMs). More specifically, the CORDEX community specifies a set of domains all over the globe on which climate simulations forced by either ERA-Interim or a Global Climate Model (GCM) are performed. Within this framework, the Royal Meteorological Institute of Belgium (RMI) has used ALARO-0 to simulate the period 1979-2010 on the EURO-CORDEX domain (see Figure 1) using ERA-Interim as lateral boundary conditions.

In their 2014 paper, Kotlarski et al. evaluated the ERA-Interim forced RCMs that were present at the time in the EURO-CORDEX ensemble for the period 1989-2008 by calculating different metrics for both near-surface air temperature and precipitation on the seasonal scale. The same metrics are now computed for the ALARO-0 simulations and are compared to the existing ensemble.

2 CORDEX and ALARO-0

2.1 K14 ensemble

The CORDEX community defines the integration area and resolution for the EURO-CORDEX domain. The inner orange box in Figure 1 shows the boundaries of the domain which is defined as a rotated pole lon-lat grid with a resolution of .44 degrees ('low-resolution' EUR-44 grid, 106x103 grid boxes) or .11 degrees ('high-resolution' EUR-11 grid, 424x412 grid boxes). Each grid box of the low-resolution grid is divided into 16 four-by-four grid boxes to obtain the high resolution grid.

In Kotlarski et al., 2014 (K14) an ensemble of 17 simulations performed by nine different research groups is analyzed. Eight groups performed a simulation with the same model on both the high- and low resolution grid. One group only performed the high resolution simulation. Three groups used the WRF model, but with different physics schemes. The other models are ARPEGE 5.1, CCLM 4.8.17, HIRHAM5, REMO 2009, RACMO 2.2 and RCA 4. All groups and models used the classical Davies coupling to ERA-Interim, as does ALARO-0. An exception is CNRM, which used the global ARPEGE 5.1 model nudged strongly towards ERA-Interim outside of the EURO-CORDEX domain.

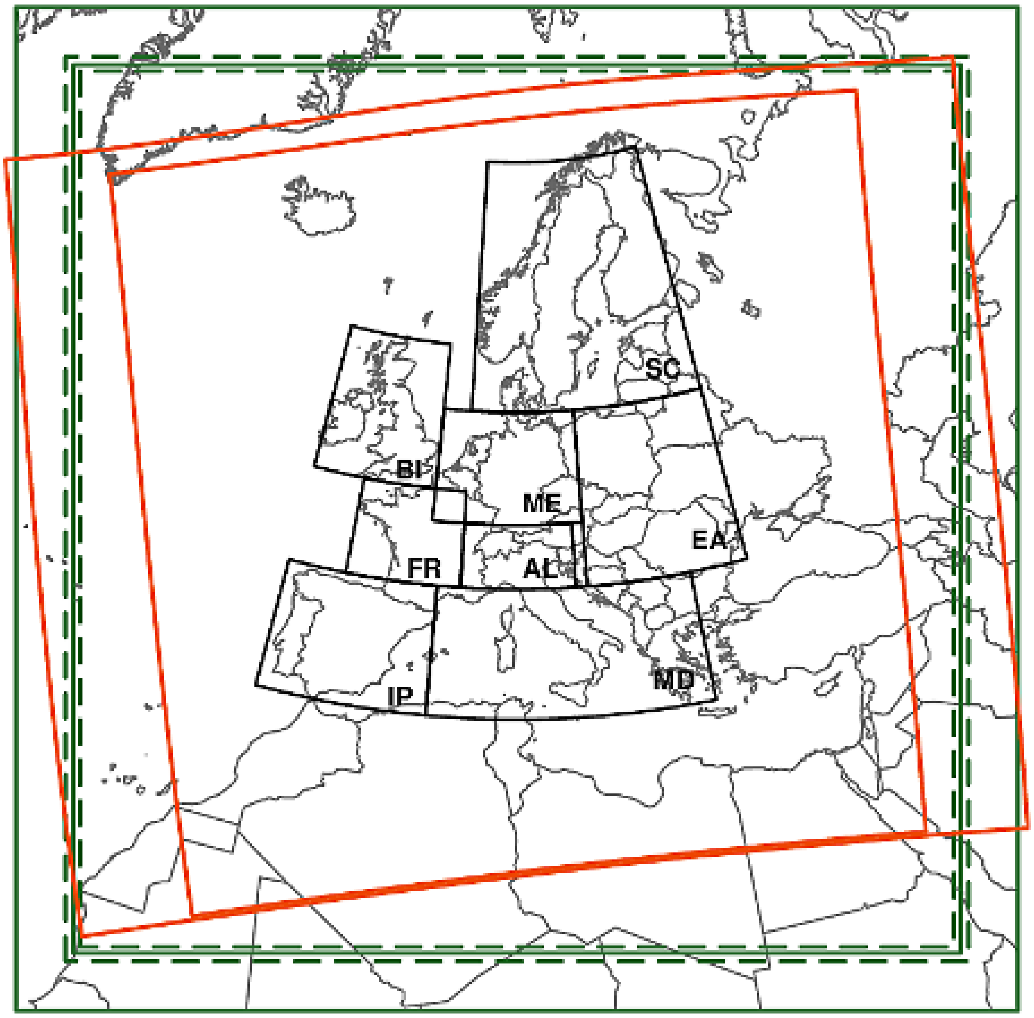

Figure 1: Different domains for the ALARO-0 EURO-CORDEX runs. Green boxes show the boundaries of the ALARO-0 integration high-resolution (dashed lines) and low-resolution (full lines) domains, of which the inner/outer box shows the domain without/with the Davies zone. The outer orange box shows the E-OBS domain, while the inner orange box shows the EURO-CORDEX domain. In black, the eight subregions used for the analysis are shown.

2.2 ALARO-0

The model version used is cycle 36t1 and is discussed in detail in De Troch et al., 2013. As ALARO-0 does not run on rotated lon-lat grids, the prescribed CORDEX domain could not be used to perform the simulations. Two overlapping Lambert grids were defined with a 12.5 km and a 50 km resolution (see green boxes in Figure 1) for ALARO-0. The low-resolution Lambert domain consists of 139-by-139 grid points, while the high resolution domain consists of 501-by-501 grid points (both including an 8 grid boxes wide sponge zone). In both simulations the number of vertical levels was 46. In order to analyze the results, values of the low- and high-resolution grids of ALARO-0 were mapped onto their corresponding EURO-CORDEX grids by chosing the closest grid point. The model was initialized on the 1st of January 1979 from ERA-Interim and was run in continuous mode until the end of 2010. However, runs were interrupted monthly and the necessary climatological fields, such as SSTs, were updated after which a new one-month run is started.

3 Analysis

The analysis in K14 focused on monthly and seasonal mean values of near-surface air temperature and precipitation. Modeled values were compared to observed values, which were given by the E-OBS dataset (Haylock et al., 2008). The domain boundaries of the E-OBS grid are shown in Figure 1 by the outer orange box. In the overlapping area with the EURO-CORDEX domains, the E-OBS grid has one grid box for every two-by-two EUR-11 grid boxes, and thus by definition, the EUR-44 has one grid box for every two-by-two E-OBS grid boxes. In order to compare the EUR-11 simulation with observed values, the model values are therefore aggregated over two-by-two boxes. For the EUR-44 simulation the values of the E-OBS dataset were aggregated over two-by-two boxes.

For every region in the domain (see Figure 1) K14 calculated several metrics based on model output for the 20-year period 1989-2008. Here, we will focus on the metrics

- BIAS: the mean bias of all grid points in a specific region for a specific season.
- RSV (Ratio of Spatial Variability): the ratio of modeled spatial variability and observed spatial variability. Values larger than one indicate that the model overestimates spatial variability.
- RIAV (Ratio of Interannual Variability): the ratio of modeled interannual variability and observed interannual variability of the spatial mean for a specific region. Values larger than one indicate that the model overestimates interannual variability.

The same scores were calculated for ALARO-0 based on the same set of years 1989-2008. In addition, the 95% confidence intervals of these scores were calculated using a so-called jackknife analysis: since ALARO-0 was run for the 32-year period 1979-2010 such an analysis is possible by sampling randomly 20 years from this set and calculating the score for this set of years and repeating this a 1000 times for different random sets of years. The 95 % intervals of the found distribution of scores are calculated and the robustness of the score can be assessed.

4 Results

Figure 2 shows the spatial near-surface temperature BIAS in kelvin for winter (DJF, left) and summer (JJA, right) of the high-resolution ALARO-0 simulation for the period 1989-2008. Comparison to the other models in the K14 ensemble (not shown, see Kotlarski et al., 2014) shows that ALARO-0 shares some features with ARPEGE 5.1. In winter, the large bias gradient in Scandinavia, the large positive bias in the North-Eastern part of the domain, and the general cold bias throughout the rest of the domain are common to both models. In summer, both models have a cold bias in Northern Europe, while in the South a positive bias is present. On the other hand, the spatial variability of the bias is lower in ALARO-0, especially for regions with strong orographic features in summer.

Figure 3 shows the spatial precipitation BIAS relative to the observations (in %, (modeled-observed)/observed) for winter (DJF, left) and summer (JJA, right) of the high-resolution ALARO-0 simulation for the period 1989-2008. Contrary to the temperature bias, the precipiation bias shares no clear features with ARPEGE 5.1. In both seasons, ALARO-0 generally suffers from a wet bias. Although Scandinavia and North-Eastern Europe show considerable temperature biases, the precipitation bias is more moderate. In summer, however, the wet bias in the Mediterranean is rather large. But other models also seem to suffer from this deficiency.

Figure 4 shows the selected metrics in separate columns for all different domains and seasons for temperature (first three columns) and precipiation (last three columns). The scale is shown on the bottom of each column, the full grey line shows the ‘optimal’ value of the metric. The grey circles show the values for the high-resolution

K14 ensemble (9 models). Superimposed are two opaque red bands, which show the jackknife 95%-interval for the high-resolution (top band) and low-resolution (bottom band) simulations with ALARO-0. The vertical red dashes in the bands show the value of the scores based on the period 1989-2008, which can be directly compared to the grey circles. When the background is neutral white, the ALARO-0 value of lies within the K14 ensemble spread. If the background is light orange, this value is outside and worse than the other members of the K14 ensemble. Worse here means that the absolute distance to the optimal value of ALARO-0 is larger than that of any other ensemble member. For example, the BIAS for the Iberian Peninsula in Winter (noted as BIAS-IP-DJF) is more negative than any other model, and it is in absolute value the furthest from the optimal 0 K of all models. If instead the background color is light green, this indicates again the value is outside of the K14 ensemble but either outperforms all other models (e.g. RSV-AL-DJF) or is not per se the worst model (e.g. RSV-EA-DJF, outside of the K14 ensemble, but not as bad as the models at the other end of the ensemble).

At first glance, some features stand out. First, the predominating white background shows that ALARO-0 mostly is within the K14 ensemble. Second, the jackknife confidence intervals are much smaller than the total spread of the K14 ensemble, except for RIAV where the intervals often cover half of the ensemble spread. Third, the difference between the EUR-11 and EUR-44 scores is very small considering the total range of the ensemble and the calculated jackknife confidence intervals.

The relatively large amount of orange colors in the temperature BIAS column stands out. Generally, ALARO-0 is on the cold side of the ensemble and often the coldest model. The low-resolution simulation is often slightly colder than the high-resolution simulation. Spatial variability of temperature is mostly overestimated (RSV > 1) and on the high-end side of the ensemble. However, it is always within the K14 ensemble or does better. For interannual variability ALARO-0 performs very well, with scores almost always close to 1. For two cases ALARO-0 is the worst model, but only just. Generally, ALARO-0 is able to produce both the spatial and temporal variability, but is severely biased towards the cold side. A further study learns that this behaviour is shared with the ARPEGE 5.1 simulation.

For precipitation, the BIAS is generally on the wet side (BIAS > 0%) but for all seasons and regions lies within the K14 ensemble or is better. Remarkably, ALARO-0 outperforms all other models for Scandinavia in MAM, while for temperature this region and season was by far the worst of all models. For both RSV and RIAV precipitation scores are almost always within the K14 ensemble range and therefore satisfactory.

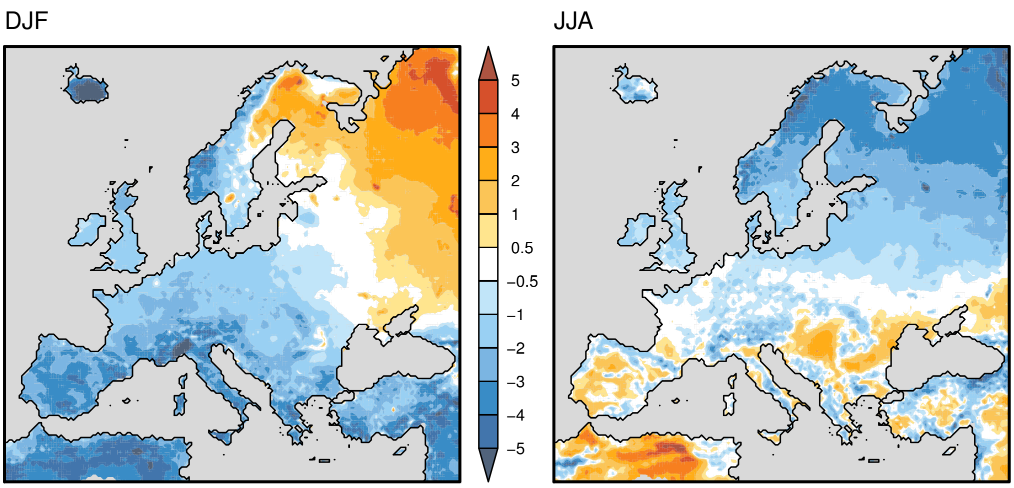

Figure 2: The spatial bias for near-surface air temperature in degrees kelvin for winter (left) and summer (right).

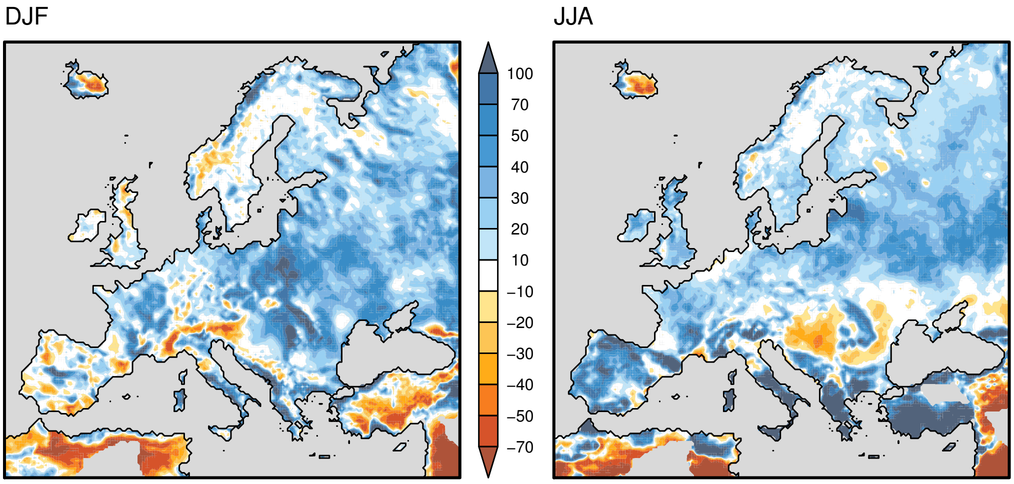

Figure 3: The spatial relative bias for precipitation ((modeled-observed)/observed) for winter (left) and summer (right).

5 Conclusions

For the first time ever ALARO-0 was used as a part of a Regional Climate Model Intercomparison Project. Within the CORDEX framework, the performance of ALARO-0 was compared to an existing ensemble of models analyzed by Kotlarski et al, 2014 and the robustness of the analysis was assessed by using a jackknife procedure. The main results are

- For near surface air temperature, ALARO-0 suffers from some large biases, which are in common with the ARPEGE 5.1 model simulation.
- For precipitation, ALARO-0 performs satisfactory since almost all scores for all regions, domains and metrics are within the K14 ensemble. In addition, no clear shared features with ARPEGE 5.1 are found.
- Most scores seem robust, since the calculated jackknife intervals are much smaller than the total spread of the ensemble. This indicates that the specific rather short period of 20 years used in K14 does not hinder an analysis of the scores. For RIAV, this statement holds less strictly, as for some regions and seasons the jackknife interval covers a considerable part of the ensemble range.
- As also found for the K14 ensemble, no clear difference between the two resolutions is shown for the considered metrics.

In conclusion, ALARO-0 shows some deficiencies for temperature, which are also found in the ARPEGE 5.1 simulations. However, for precipitation, ALARO-0 clearly diverges from ARPEGE 5.1 and performs very well compared to the complete K14 ensemble.

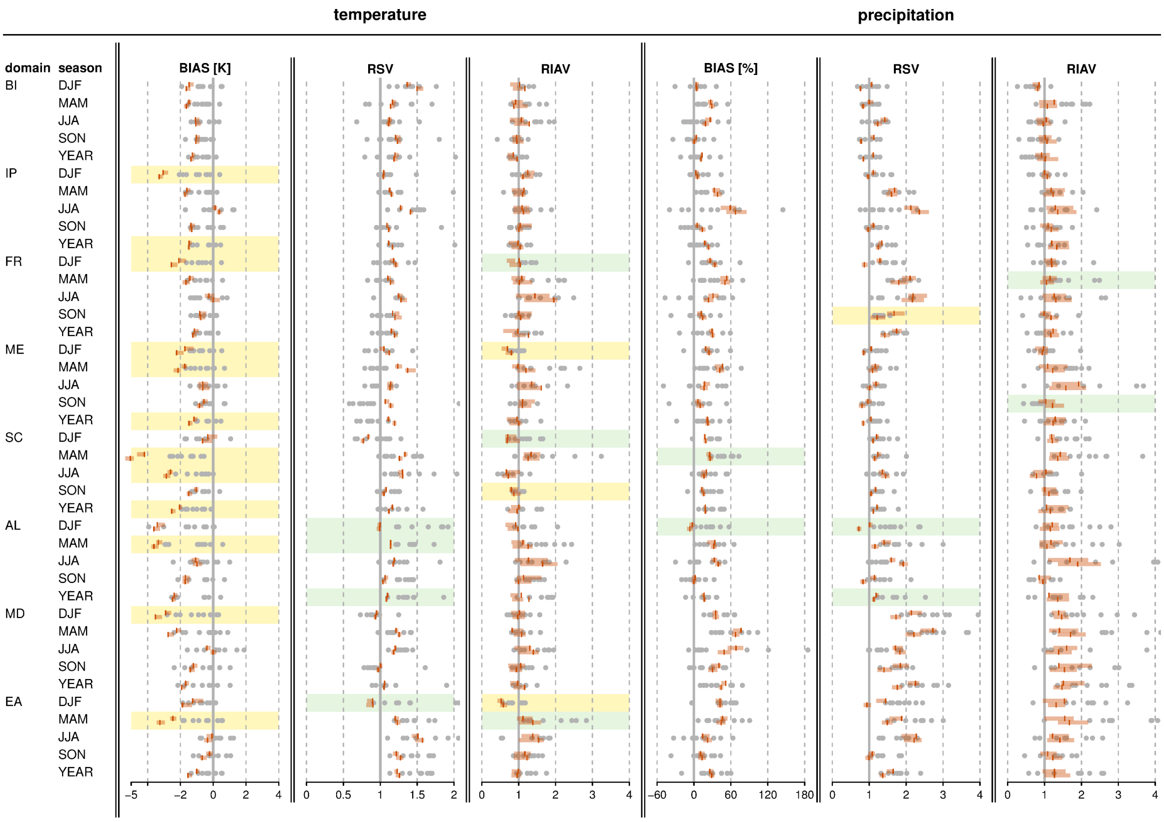

Figure 4: Scores for different domains, seasons and metrics for both temperature (first three columns) and precipitation (last three columns). See text for further details.

6 References

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Deep Convection Diurnal Cycle in ALARO-1

Radmila Brožková

1 Introduction

Parameterizing moist deep convection in NWP models brings a difficulty to describe a correct timing of the convection onset and decay. Most of the schemes suffer from the time shift with respect to the real diurnal cycle, starting the convection too early in the morning by a couple of hours and consequently stopping its activity too early in the evening. The 3MT (Modular Multiscale Microphysics and Transport) moist deep convection scheme developed within the ALARO concept was improved by the end of 2012 to reduce the time shift, yet the early evening decay has been still present. Finally, the interaction of 3MT with new radiation scheme ACRANEB2, introduced in the first version of ALARO-1 within 2014, allowed to significantly reduce this last deficiency with respect to the diurnal cycle timing.

2 Latest improvements of the 3MT scheme

Entrainment, adaptive Detrainment, and Closure

The entrainment parameterization in the 3MT scheme follows the same principles and has the same tuning parameters as developed for the diagnostic convection scheme previously used in the family of ALADIN and ARPEGE models. Among other, entrainment rate depends also on buoyancy, given as an integral of moist static energy difference between non diluted ascent and environment. We enhanced the entrainment scheme by introducing a modulation of the parameter of the buoyancy term, which takes into account relative humidity representing the grid cell. More the state of model cells along the ascent is closer to saturation, the entrainment rate gets lower.

Second improvement of the scheme consists in the introduction of more memory, via the evaporation of precipitations in the previous time-step of the model. Here the evaporation rate influences the cloud profiles, their shape and height. More evaporation leads to getting higher and less entraining clouds in the next time-step. It is a kind of a positive feedback, which allows for maintaining the convective activity longer. Nevertheless, the amplitude of the feedback is here controlled by the time relaxation and by the combination with the entrainment parameter to avoid excessive behaviour.

Finally, computation of the updraft area fraction, resulting from the scheme closure, is modulated with respect to the mesh size of the model. Arriving moisture to the considered grid column may be either immediately consumed in the convective condensation or used to charge the reservoir of the moist static energy. The fact to make the moisture consumption rate modulated and varying with the mesh-size has a twofold impact. First, it helps to improve the scheme performance for resolutions across the moist deep convection gray zone. Second, it helps to delay the convection onset in general, also for the coarser resolutions of the model.

The improvement of capturing the convection diurnal cycle in mid latitudes was demonstrated for the period of the end of June and beginning of July 2009, with an important convection event in Central Europe. Fig. 1 shows the diurnal cycle of precipitation along the model forecast, as an average of eleven realisations from 24 June to 4 July 2009. Introduction of the three above mentioned ingredients greatly improved the timing of the parametrised convection compared to measurements. These became a part of the so-called ALARO-0 baseline version.

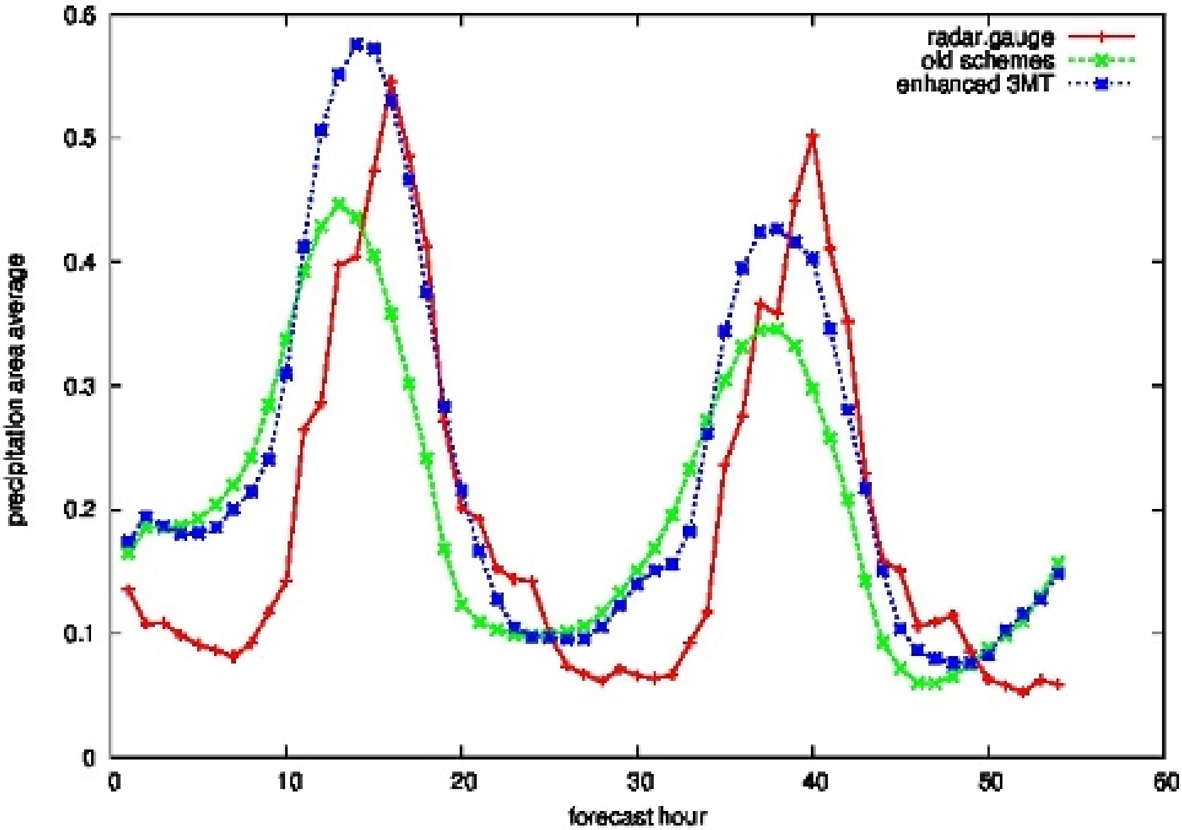

Figure 1: Domain average of hourly precipitation summations, mean of eleven realisations starting at 00 UTC from 24 June to 4 July 2009. Red – combined radar estimates with rain gauges measurements; green – reference model simulations, blue – model simulations with improved 3MT scheme and ALARO-0 baseline.

3 New radiation scheme ACRANEB2 and convection diurnal cycle

ALARO-1 first setup of the new radiation scheme

The radiation scheme of the ALARO concept underwent a major change and improvement. ACRANEB2 remains a broad band scheme, where higher precision in thermal band is reached by the improved gaseous transmissions combined with an appropriate choice of intermittency computations within the Net Exchange Rate algorithm. Indeed, the new radiation scheme is developed including the system of double intermittency in the thermal band, allowing for cloud-radiation interaction computation at every time-step of the model, while more expensive gaseous transmissions terms are divided to two categories requiring more or less frequent refreshment to keep the sufficient precision of the whole scheme. In solar band the intermittency is introduced as well. As already mentioned, gaseous transmission functions have now much better fit, and also cloud optical properties are handled more precisely and are retuned. In addition, parameterization of gas-cloud short wave overlap was introduced and a retuning of geometry factors in effective cloud optical depth computation was done.

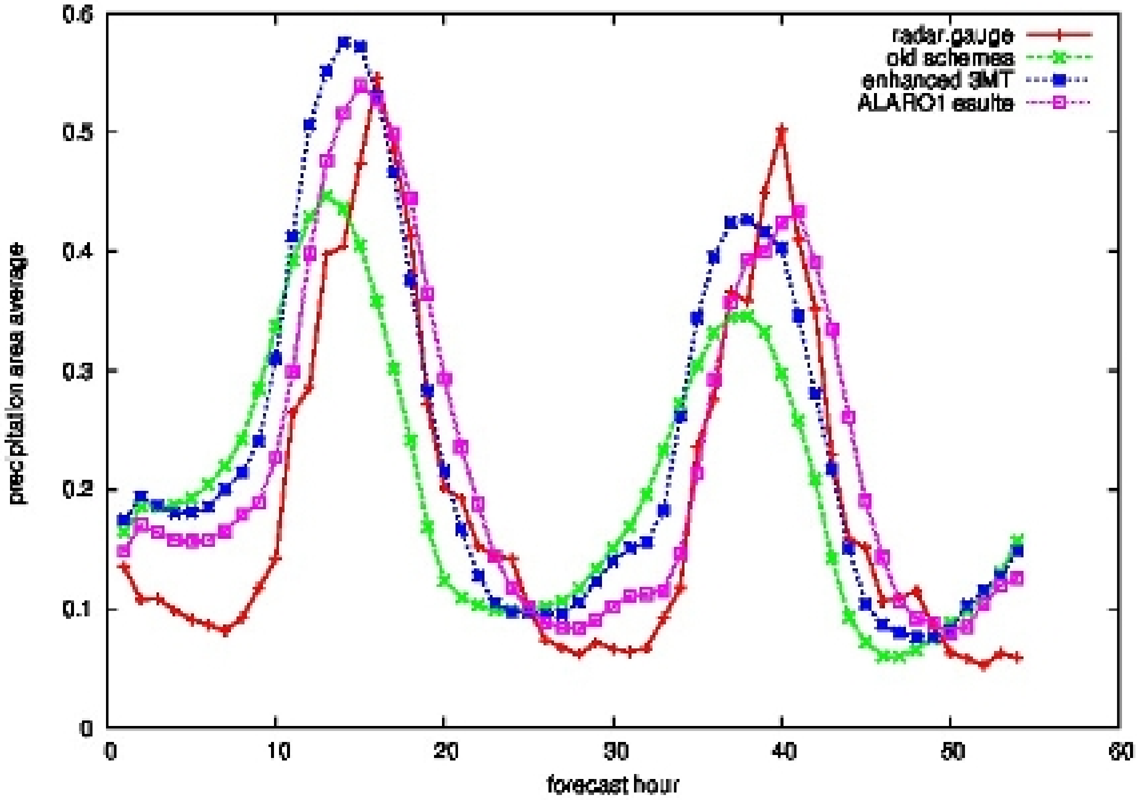

Figure 2: Domain average of hourly precipitation summations, mean of eleven realisations starting at 00 UTC from 24 June to 4 July 2009. Red – combined radar estimates with rain gauges measurements; green – reference model simulations, blue – model simulations with improved 3MT scheme and ALARO-0 baseline, violet – model simulations with improved 3MT scheme and ALARO-1.

Better performance of the radiation scheme and its interaction with cloudiness has got a positive impact on the modeling of moist deep convection. Especially more precise thermal band computations, profiting from better gaseous transmissions fit, lead to the improvement of the “night part” of the daily convection cycle, but not only, as demonstrated on Fig. 2. The results are confirmed also by the quantitative precipitation scores computed for the 6h summations. On Fig.3 we see the reduction of precipitation bias, namely for the evening period from 18h to 0h UTC.

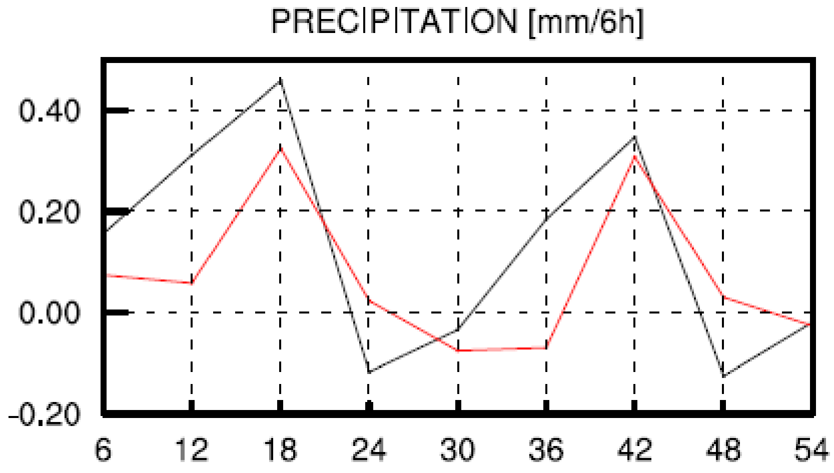

Figure 3: 6h precipitation summations bias with respect to SYNOP, domain LACE, network 00 UTC, period from 24 June to 4 July 2009. Black – enhanced 3MT and ALARO-0 baseline, red – enhanced 3MT and ALARO-1.

4 Conclusion

As demonstrated above, a correct description of moist deep convection diurnal cycle does not depend on the parameterization of convection only, but also on the feedback coming from the interaction of radiation and clouds schemes. In the framework of the ALARO concept, where consistency of parameterizations and their proper interface is taken as a basis for developments, we could profit from a better radiation scheme in a rather straightforward manner to further improve the timing of moist deep convection in the model. ACRANEB2, together with new turbulence scheme TOUCANS and enhancements in the microphysics, are included in the first version of ALARO-1. It became operational at CHMI on 22 January 2015.

Guidance provided by the AROME model for the situation of the 9-10 October 2014

Joël Stein, Philippe Alber

1 Introduction

The aim of this paper is to present the help provided by the operational version of AROME to the forecasters for an extreme situation encountered during last summer in the south of France. This case corresponds to strong convection forced by the complex orography of the Cévennes and the southern part Alps. The AROME model is a non-hydrostatic model with a horizontal mesh of 2,5 km, these characteristics permit not to use a parametrization for the deep convection but instead, to simulate explicitly the convective clouds.

2 9-10 October 2014

Description of the situation

The synoptic situation was characterized by the PV anomalies present over the Gulf of Lion and a strong jet extending from Portugal to France (Figure 1).

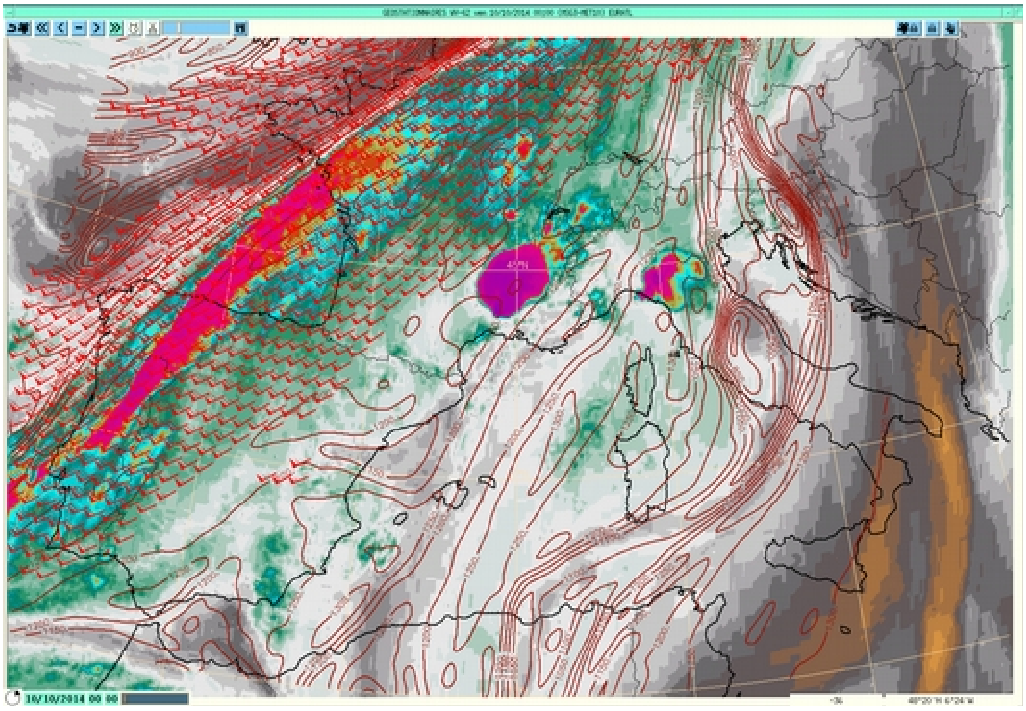

Figure 1: Water vapor METEOSAT 10 picture and height of the surface PV=1,5 PVU analyzed by the global ARPEGE model.

A mesoscale low was located in the lee of the Pyrénées over the Mediterranean Sea. The resulting moist flux feeds convection over France. The resulting rainfall accumulated during 24 hours shows two maxima with amounts exceeding 300 mm over a wide area.

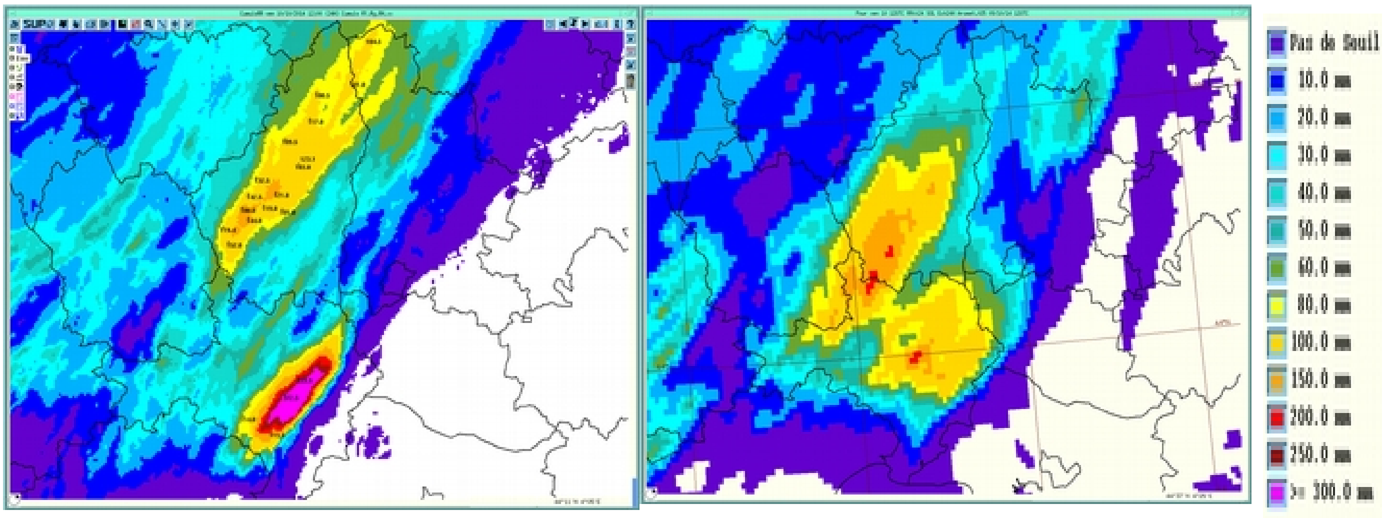

Figure 2: Radar observation of accumulated rain from 09 October 12 UTC to 10 October 12 UTC (left) and simulated counterpart by the model AROME

AROME forecasts

The AROME forecasts located the maximum of convection in the right place but it was largely underestimated by a factor 2 (Figure 2) but the forecast amount is strong enough to warn the Météo-France forecaster on the risk of heavy rain near the coast where most people live. Moreover, the mechanism of the convective storms which occurs in this region was well reproduced by AROME : the line of convective cells moves from West to East and it becomes quasi-stationnary during some hours over the region where the rain was maximum before moving back northwards (Figure3). This evolution was due to the comparison of the cells' generation processes and the south advection coming from the Mediterranean Sea. The chronology of the movements is not exactly reproduced by AROME and this leads to reduced period where the convection remains stationnary and therefore to a reduced amount of rain.

Figure 3 : Radar reflectivity the 10 October at 10 UTC and simulated reflectivity at 1500 m by the AROME model.

3 Conclusion

During the 9 and 10 October 2015, strong convection occured in the south of France. The main mechanism of equilibrium between cells generation and moist advection and the complex movement of convective cells were reproduced by the non hydrostatic model AROME in its operational configuration. Because the chronology was not perfect, the resulting rain amount was finally underestimated by a factor 2 for this extreme case. The AROME model was also very informative on most of the numerous similar cases of strong convection which occurred during summer 2014.

PEARP - ARPEGE - AROME high resolution e-suite

Joël Stein and François Bouyssel

1 Introduction

The aim of this paper is to present the current e-suite which is an important upgrade of the operational numerical weather prediction systems at Météo-France. The main changes include an increase of the spatial resolutions and some improvements in data assimilations of Arpege (ensemble data assimilation and new observations) and Arome (one hour cycle), and in the initialisation and multi-physics of the global ensemble prediction system PEARP. This evolution becomes possible because of the change of the supercomputer in 2014: a vector machine NEC SX 9 has been replaced by a scalar machine BULL. In order to adapt to this new architecture, the input/output (IO) subsystem of operational numerical weather prediction models has been rewritten and now relies on distributed and asynchronous techniques. This “IO server” proved to be necessary in order to fulfil operational time constraints on AROME running at a resolution of 1.3km. This e-suite is based on cycle 40_op2 including Surfex v7.2 and Fullpos II.

2 ARPEGE e-suite

Description of the changes

The resolution of the hydrostatic global model ARPEGE will become 7.5 km over France and 34 km over New Zealand. The stretching factor has been reduced from 2,4 to 2,2 and the truncature is now equal to T_l1198. The vertical resolution has also been increased to 105 levels from 10 m AGL until 10 Pa. The incremental 4DVAR assimilation scheme has been modified to take into account the increased resolution of the two minimisations T149 and T399 with 40 iterations each. The Jc DFI term in 4D-Var cost function is penalizing temporal oscillations on wind divergence and surface pressure. The use of the variational bias correction algorithm has been revised. The background error statistics of the assimilation are extracted from a new version of the ARPEGE ensemble data assimilation, based now on 25 members (instead of 6), a temporal average reduced to one day and a half (instead of 4 days), and an update of correlations every 6 hours (instead of 24 hours). The filtering and the scaling of the variances has been adjusted. A lot of new observations are now assimilated: increase of radiances density as input data in the screening, use of the edge swath for ATMS data, new tropospheric channels for CrIS, 6 sounding channels for SSMI/S on DMSP F17 and F18, 6 humidity channels of SAPHIR on Megha-Tropiques, clear sky radiances of METEOSAT-7 and MTSAT-2, GPS ground stations collected by new centres, vertical extension of GPS Radio Occultation data associated with reduced observation errors, EARS ASCAT Metop-B, radio-soundings in BUFR format (at low and high resolutions). The width of assimilation time-slots changes from 60' to 30' contributing to assimilate more observations. The radiation scheme is now called every hours.

The global ensemble prediction system PEARP based on ARPEGE has also been modified and uses now the previous horizontal resolution of ARPEGE (T_l798C2.4 : 10 km over France and 60 km over New Zealand). The vertical resolution has been increased from 65 to 90 levels. The system is based on 35 members with a production twice a day (at 6 and 18 UTC). The initial perturbations are a combination of singular vectors computed over 7 geographical areas and of 17 members chosen randomly among the 25 members of the ensemble data assimilation. A new set of 10 physical packages is used to take into account model errors. The new physical schemes for thermals “PMMC09” and for convection “PCMT” are used in some physics.

Comparison of the operational and e-suites

The comparison of the operational and e-suites has been performed during more than 8 months. The e-suite presents better scores than the operational counterparts as can be checked on Figure 1 for the geopotential height. The improvement is very important for extratropical area during winter or summer. The statistical test based on bootstrap technics shows that the differences between both versions of ARPEGE are significant at the 1% level over the whole troposphere and the lower part of the stratosphere. These improvements are also present when the reference is changed from the radio-soundings measurements to the analysis of the ECMWF model. The new version also presents reduced errors for temperature and wind (not shown). The surface parameters are also improved : temperature, wind and rain.

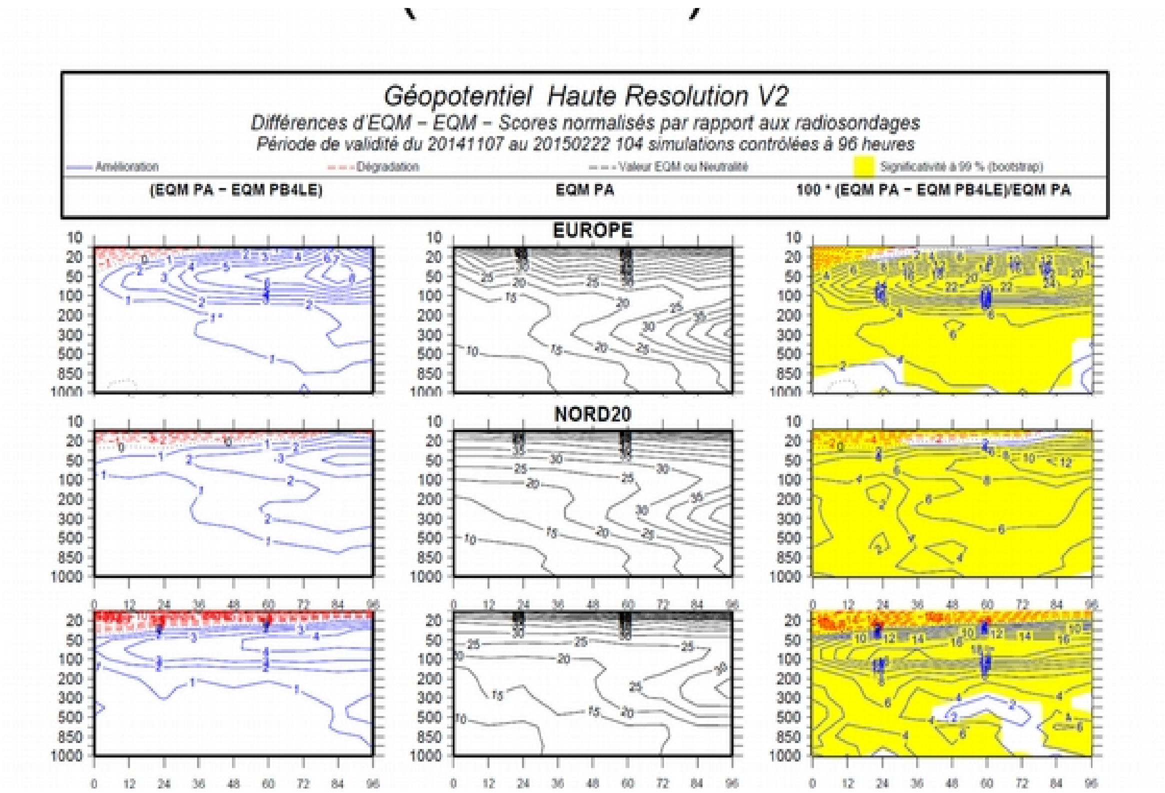

Figure 1: Isolines of RMSE in function of the lead time (in h) and the altitude (in Pa). The reference is provided by the radiosoundings of the area. The first line corresponds to Europe, the second to the extratropical part of the northern hemisphere and the third to the extratropical part of the southern hemisphere. The left columns correspond to the mean difference between both RMSE in metres (isolines every m, blue if the e-suite performs better, red in the opposite situation), the central panels show the RMSE of the operational version (isolines every 5 m) and the right panels represent the variation of RMSE normalized by the operational value (isolines every 2 %), the yellow colour is added when the difference between both versions is statistically significant according to a bootstrap test at the 1 % level.

3 AROME e-suite

Description of the changes

The resolution of AROME model becomes 1,3 km and its domain of simulation has been extended northwards by 10 % until the borderline between Denmark and Germany. The vertical stretched grid extends from 5 m AGL to 10 hPa with 90 levels. The Helmoltz equation is solved following a predictor corrector scheme and new semi-lagrangian weights are used to better take into account the air volume variation. The orography database GMTED at 250m resolution is used. The numerical spectral diffusion is applied on non-hydrostatic variables. The gridpoint diffusion "SLHD" has been tuned, as well as the spectral relaxation towards the host model for the uppermost levels. The snow autoconversion threshold has been changed and the SBL CANOPY parameterization used to computed the screen level parameters has been switched off because of the lowering of the first model level. The surface drag over orography has been adapted to the height of the lowest model level.

The period of the 3DVAR assimilation cycle changes from 3 hours to 1 hour. This increases the number of assimilated data for fixed instruments like radars, SEVIRI, classical and GPS surface stations data (by a factor of 3). An incremental analysis update (IAU) technique is used in the production forecast. New observations are also assimilated such as channel 8 of SEVIRI and radiosoundings in BUFR format. A new observation operator and a new white list are used for the assimilation of GPS ground data.

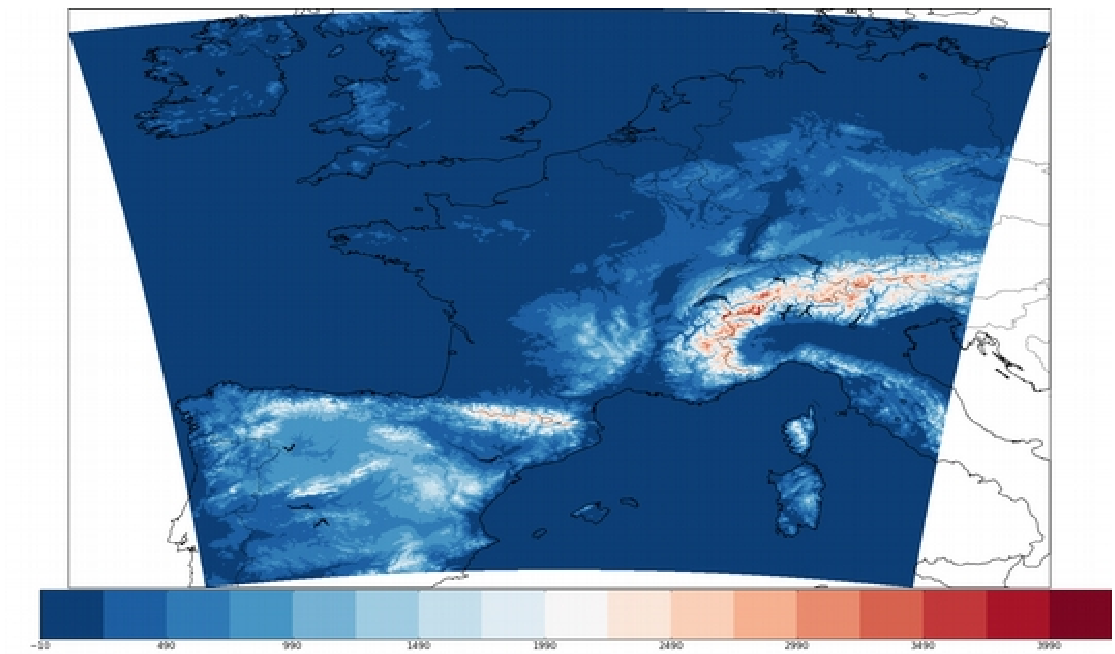

Figure 2: Arome-France 1.3km domain

Comparison of the operational and e-suites

The main differences between the operational and the e-suites were encountered during summer and fall 2014, which were very convective in 2014. The surface parameters like, temperature, humidity at 2m AGL and wind at 10 m AGL were slightly improved. The main change was found for the rain for convective situations : the positive frequency bias of the model at 18 UTC was removed (Figure 3a) and the quality of the heavy rain forecast (10mm/6 h) is proved by the significant increase of the Brier skill score against the persistence forecast also shown in Figure 3b and 3c. The impact is weaker when the neighbourhood is increased from one grid point (in this case, BSS=HSS) to 50 km.

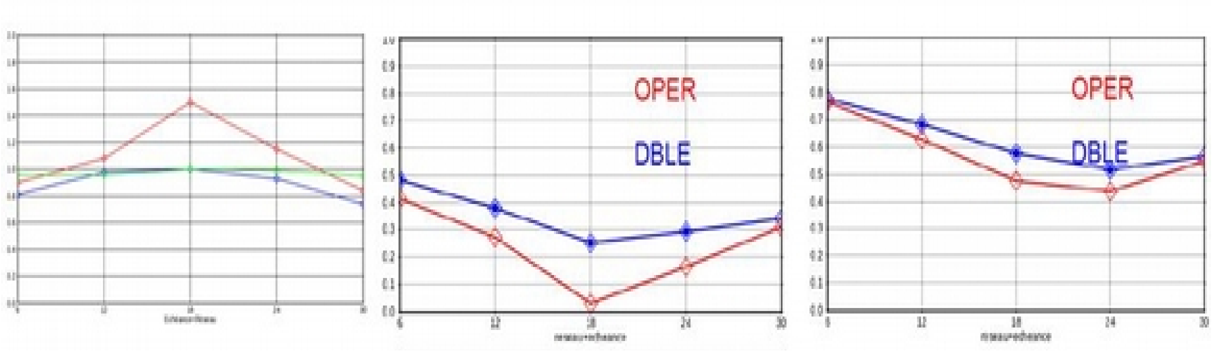

Figure 3: Frequency bias (left panel) for accumulated rain during 6 hours in function of the lead time for the persistence forecast (green line), the operational version (red line) and the e-suite (blue line) computed from table of contingency for the threshold 10 mm/6h. The reference is provided by the measurements of the 1800 rain-gauges of the French real time network. The Brier Skill Scores against the persistence forecast are presented on the central panel for a neighbourhood size equal to one grid point and the right panel for a size equal to 50 km.

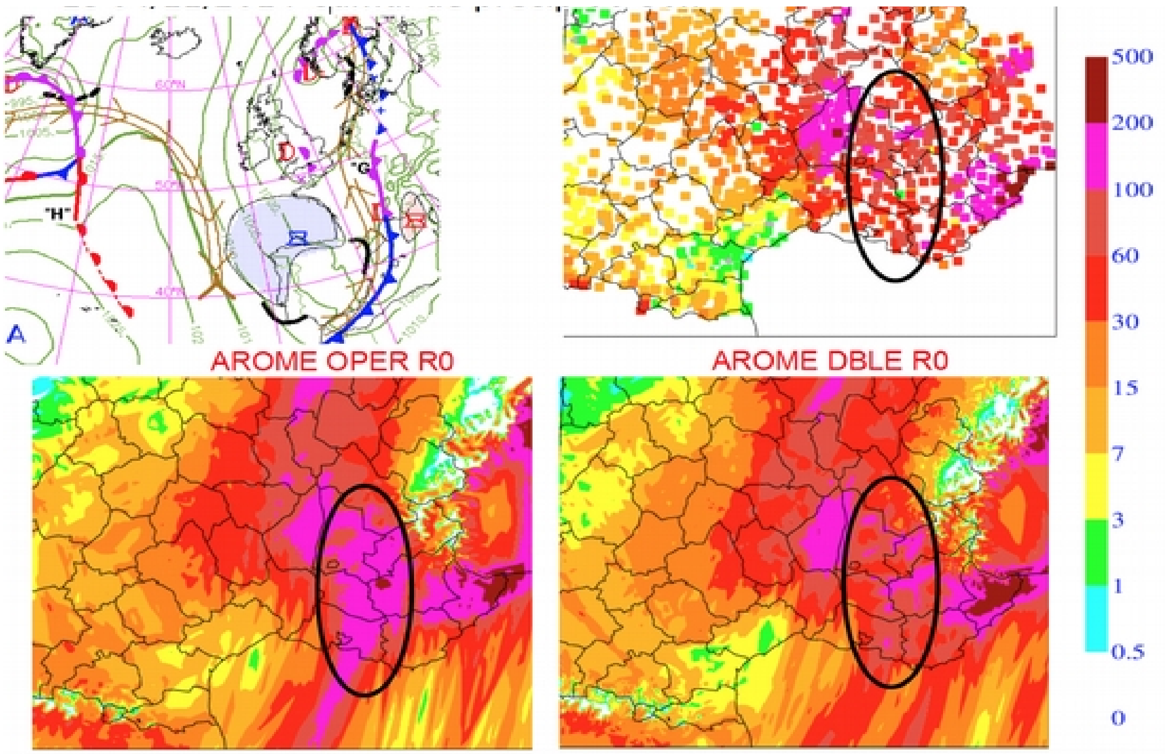

Figure 4: High precipitation event on South-East of France (04/11/2014): 30h accumulated precipitations for Arome Oper (bottom left), Arome Dble (bottom right) and rain-gauges observations (upper right panel)

The operational switch to the new version of the NWP systems is planned for the end of March 2015.

List of planned events for 2015

1 Meetings

- 20th ALADIN Workshop & HIRLAM All Staff Meeting 2015 (& 18th ALADIN LTM meeting), **13-16 April** 2015, **Elsinore** (Dk)
- Coordination meeting between ALADIN CSSI and HIRLAM MG, **17 April** 2015, **Copenhagen** (Dk)
- 12th ALADIN PAC meeting, **21 May** 2015 morning, **Helsinki** (Fi)
- 3rd joint HAC/PAC meeting, **21 May** 2015 afternoon, **Helsinki** (Fi)
- HAC meeting, **22 May** 2015, **Helsinki** (Fi)
- 37th EWGLAM & 22 SRNWP (&19th ALADIN LTM meeting), **5-8 October** 2015, **Serbia**
- 25th ALADIN GA & 2nd joint ALADIN GA & HIRLAM Council, last week of **November** 2015, **Alger** (Dz), with new MoUs signature

2 Working Weeks / Working Days

- ALADIN LBC change WW, 9-13 March 2015 (2 times 2.5 days), Toulouse (Fr)
- Forecasters meeting, after mid-September, Lisbon (Pt)
- HARP/HarmonEPS/GLAMEPS WW, 16-20 March, Brussels (Be)
- LACE DA Working Days, first half of September, Bratislava (Sk)
- SURFEX validation WW, date t.b.d., Brussels (Be)
- 2 HARMONIE working weeks on system aspects, in spring and autumn
- HIRLAM working week on data assimilation algorithms
- HIRLAM working week on use of observations
- HARMONIE working week on predictability in autumn
- more information on-line

36th EWGLAM & 21st SRNWP meeting, Offenbach, 29 Sept – 2 October 2014