ALADIN-HIRLAM Newsletter

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ALADIN Programme, c/o P. Termonia, IRM, Avenue Circulaire 3, 1180 Bruxelles, Belgium

HIRLAM-C Programme, c/o J. Onvlee, KNMI, P.O. Box 201, 3730 AE De Bilt, The Netherlands

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Introduction

Patricia Pottier, Frank Lantsheer

Welcome to the combined 10th edition Newsletter of the HIRLAM and ALADIN consortia.

This first 2018 edition is a **big Tour d'ALADIN & HIRLAM**, as it was presented to our Directors at their last meeting. The ALADIN GA and the HIRLAM Council met in the Polish NMS premises in Krakow (Poland) on November 21-22, 2017 for the 22nd ALADIN GA, the LACE Council, the HIRLAM Council and the 3rd joint ALADIN GA - HIRLAM C meeting.

- Besides the usual items on their agendas, the assemblies approved the Rolling Work Plan 2018 (in a completely renewed format), and committed the resources of their NMS to realise it. The HAC/PAC was asked to further discuss its scope and to follow its realisation.
- The convergence roadmap (towards a single ALADIN/HIRLAM consortium after 2020) was debated and guidelines for the next steps were given to the PMs and the HAC/PAC.

The list of ALADIN/HIRLAM events planned for 2018 and later on as far as now known is also added to the Newsletter (for actual information please check the websites).

We like to thank all those that contributed to this Newsletter with their articles.
We hope you enjoy reading the tenth ALADIN-HIRLAM Newsletter.

Patricia and Frank

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

Edito : ALADIN System paper

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Geoscientific Model Development
Open Access

The ALADIN System and its canonical model configurations AROME CY41T1 and ALARO CY40T1

Piet Termonia[1,2], Claude Fischer[3], Eric Bazile[3], François Bouyssel[3], Radmila Brožková[4], Pierre Bénard[3], Bogdan Bochenek[5], Daan Degrauwe[1,2], Mariá Derková[6], Ryad El Khatib[3], Rafiq Hamdi[1], Ján Mašek[4], Patricia Pottier[3], Neva Pristov[7], Yann Seity[3], Petra Smolíková[4], Oldřich Španiel[6], Martina Tudor[8], Yong Wang[9], Christoph Wittmann[9], and Alain Joly[3]

[1]Royal Meteorological Institute, Brussels, Belgium
[2]Department of Physics and Astronomy, Ghent university, Ghent, Belgium
[3]CNRM/GMAP, Météo-France, Toulouse, France
[4]Czech Hydrometeorological Institute, Prague, Czech Republic
[5]Institute of Meteorology and Water Management – State Research Institute of Poland, Krakow, Poland
[6]Slovak Hydrometeorological Institute, Bratislava, Slovakia
[7]Slovenian Environment Agency, Ljubljana, Slovenia
[8]Meteorological and Hydrological Service, Zagreb, Croatia
[9]Zentralanstalt für Meteorologie und Geodynamik, Vienna, Austria

The ALADIN System paper has finally appeared in the journal Geoscientific Model Development.

The idea of writing this paper came up during an ALADIN Policy Advisory Committee (PAC) meeting in Brussels in May 2016. It was not an easy task to document a system that is the result of more than 25 years of research and development. While most aspects of our model system have been described in various publications in the literature, we made an effort to provide a comprehensive overview of the whole system as it is used today for configuring our forecast models, clarifying the terminology that we are using in our daily practice. We also describe the production of the export versions and the implementations in the partner countries, a crucial aspect that has not been openly documented before.

This paper is dedicated to the memory of Jean-François Geleyn. He was the driving force behind the creation of the ALADIN consortium and he was the leading scientist of the development of the ALADIN System. In this paper we did our best to document the legacy of his exceptional contributions to our community.

Piet Termonia

Events announced for 2018 (and later on)

The Newsletters only give a static (twice a year) overview with upcoming meetings for the future time frame. Actual information (year round) is available through the ALADIN / HIRLAM websites. You might find also events of interest through the LACE website.

1 ALADIN/HIRLAM meetings

- Joint 28th ALADIN Workshop/HIRLAM All Staff Meeting 2018 , 16-20 April 2018, Toulouse, France
- 6th joint HAC/PAC meeting, 23 May 2018, Dublin, Ireland
- 40th EWGLAM and 25th SRNWP meetings, 1-4 October 2018, Salzburg, Austria
- 7th joint HAC/PAC meeting, October 2018, Prague, Czech Republic
- 4th joint ALADIN GA/HIRLAM Council, 20 November 2018, Zagreb, Croatia
- 2019: Joint 29th ALADIN Wk/HIRLAM ASM 2019 will be hosted by AEMET in Madrid, on April 1-4, 2019.

2 ALADIN/HIRLAM Working Weeks / Working Days

- HARP meeting, Brussels
- Data assimilation algorithms
- Use of Observations: May, Spain
- Radiation, clouds, aerosols: March, at ECMWF

3 Regular video meetings

Following the positive outcome of the initiative by Roger Randriamiampianina to organize regular group video meetings (via google hangouts) for Data Assimilation staff (from both ALADIN and HIRLAM), these type of group video meetings were also organized for System and Scalability by Daniel Santos Munoz and for Surface by Patrick Samuelsson.

They will be happy to help you if you plan to set up your own group video meeting.

4 About the past events

Find on-line information about the past ALADIN-HIRLAM common events such as the joint ALADIN Workshops & HIRLAM All Staff Meetings, the minutes of the HMG/CSSI meetings, the joint HAC/PAC meetings, the joint ALADIN General Assemblies and HIRLAM Councils.

Highlights of NWP activities in ALGERIA : Operational status and latest developments

Mohamed MOKHTARI, Abdenour AMBAR, Sofiane KAMECHE, Sofiane MANSOURI, Idir DEHMOUS, Mohand Ouali AIT MEZIANE, Mohamed Siraj Eddine BOUZGHAIA, Oussama DOUBA, Abdelhak BAHLOULI.

1 Introduction

This paper describes the current NWP operational models at the national office of meteorology in Algeria, the implementation of ALARO-V0, the on-going activities on data assimilation and the new weather vigilance product based on ALADIN, ALADIN-DUST and AROME. This new system is an important achievement of our service and offers to our users a handy tool to get the meteorological predictions in real time with the easiest way but more significant, especially for extreme weather situations.

2 Local NWP system status

Operational configurations so far

In 2014, the National Office of Meteorology in Algeria has acquired an IBM-HPC system with 26 nodes and 416 processors. This valuable tool allowed to put into operational a forecasting chain containing ALADIN, AROME and ALADIN_DUST models. See Tab.01 for more technical details about the current configurations running locally.

Table 1: Operational configurations at ONM (ALGERIA).

Model		ALADIN	ALADIN DUST	AROME
Cycle		40T1_bf05	40T1_bf05	40T1_bf05
Resolution		8 km	14 km	3 km
Levels		70	70	41
Grid		350 x 350	250 x 250	400 x 400
Area	Latitude	18.5°N – 46.5°N	18.5°N – 46.5°N	28.0°N – 40.0°N
	Longitude	11.0°W– 17.0°E	11.0°W– 17.0°E	3.0°W– 9.0°E
Initial/Boundaries conditions		ARPEGE	ARPEGE	ALADIN (8km)
Starting time		00h	00h	00h
Cycle interval		01h	01h	01h
Runs per day		2 times (00h, 12h)	2 times (00h, 12h)	2 times (00h, 12h)

ALARO-V0 implementation

The ALARO concept is oriented towards the cost-efficient algorithmic solutions and the use of existing well-proven method, offering a multi-scale solution, with a priority targeting on the so-called grey-zone. All this involves a coherent set of governing equations, specific coding rules and a high level of modularity-flexibility.

The components of the ALARO-0 version concern the governing equations set, the horizontal diffusion (SLHD), turbulent diffusion (a pseudo-prognostic TKE scheme), radiation, the microphysical processes (more sophisticated and efficient parameterization including new prognostic variables - cloud liquid and solid water, rain, snow – all treated through the use of the PDF-based sedimentation method).

ALARO is a hydrostatic model with a semi-Lagrangian advection scheme and a vertical descriptor scheme by finite differences. The configuration implemented in Algeria covers the whole country and the Mediterranean Sea. You can find below the characteristics of this configuration:

Table 1: ALARO-V0 implemented at the ONM (ALGERIA).

Model		ALARO
Version		V0
Resolution		6 km
Levels		60
Grid		600 x 600
Center	Latitude	3,25
	Longitude	32,5

We have made several runs with ALARO-V0 and then we compared the results with the operational configuration ALADIN, in order to have a first idea of ALARO-V0 performances over our domain.

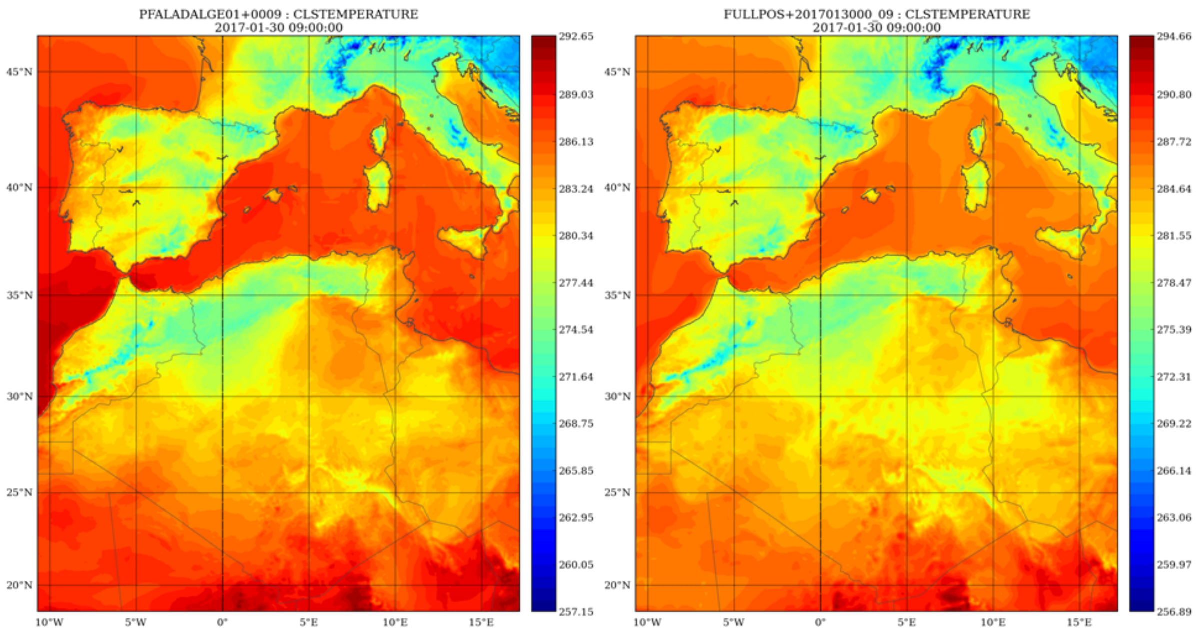


Figure 1: ALARO-V0 (left) and ALADIN (right) temperature at 2meters output on Jan 30 2017 at 09UTC over Algeria.

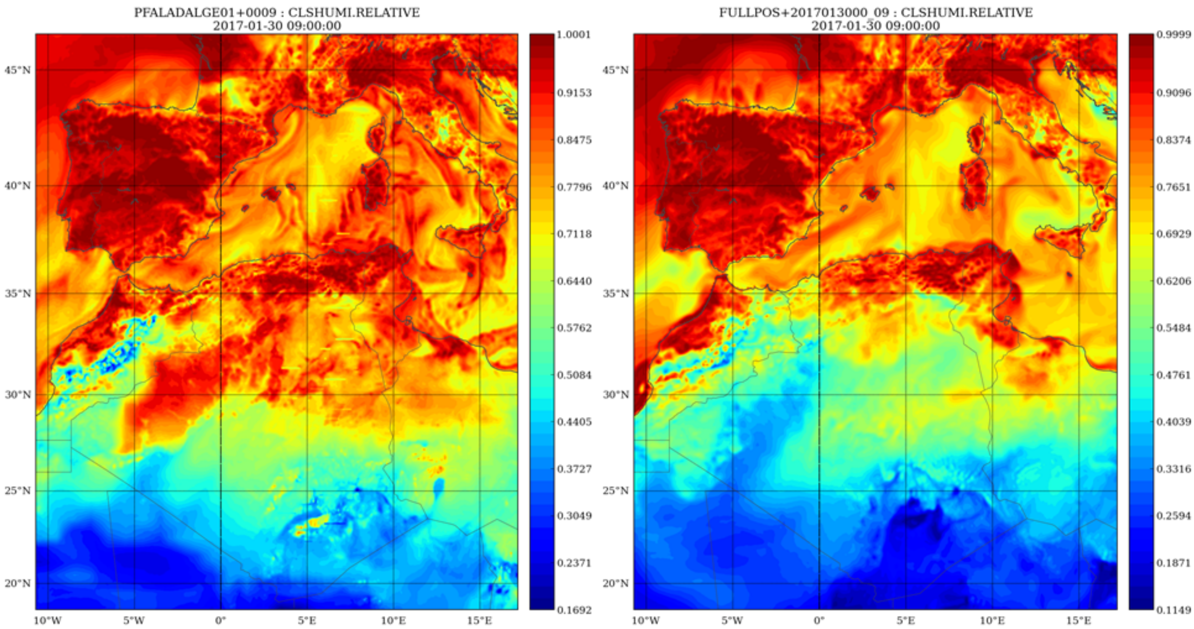


Figure 2: ALARO-V0 (left) and ALADIN (right) relative humidity at 2 meters output on Jan 30 2017 at 09UTC over Algeria.

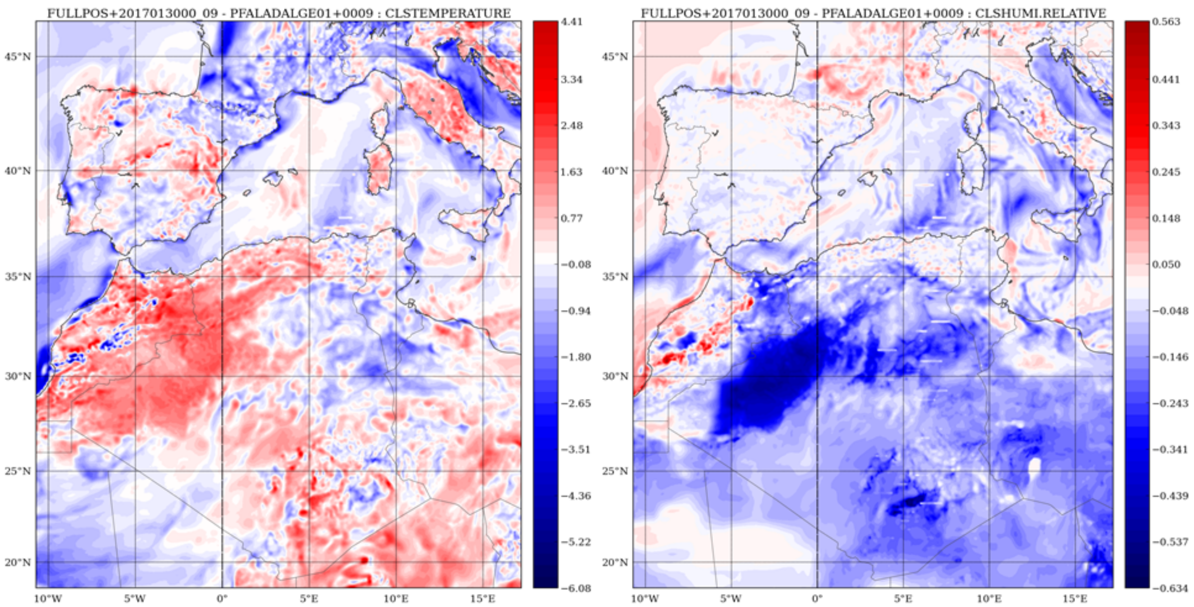


Figure 3: Temperature (lefts) and relative humidity (right) at 2metres differences between ALARO-V0 and ALADIN on Jan 30 2017 at 09UTC over Algeria.

According to figure 3, the temperature differences between ALARO-V0 and the operational configuration ALADIN shows that ALARO had predicted colder temperature than ALADIN. However, for the relative humidity differences, the results show that ALARO-V0 improve the results of relative humidity, which can be explained by the fact that all parameters related to relative humidity were better treated in ALARO-V0.

3 Data assimilation : first experiences with 3DVar

At the ONM, we've just started to use data assimilation configurations on ALADIN. After the implementation of the CANARI configuration for the surface analysis, the next step was to implement the configuration 3DVar to generate an initial state for the operational configuration ALADIN and AROME. In the following section we briefly describe the followed procedure for the realization of 3DVar ALADIN configuration tests.

Preprocessing and Observations

For the moment, the observations used to generate the ODB (Observation Data Base), are SYNOP data, retrieved daily from the GTS server in alphanumeric format and then coded locally in BUFR format. However, the observation network is not dense and only 60 stations on average are used for the generation of ODB after the screening (e002 configuration) step.

Test and Experience

The 3DVar configuration is tested using the ALADIN model cy40t1 with 70 levels and 8km resolution, coupled to the Meteo France ARPEGE model each 3 hours and two productions hour bases 00h and 12h with 72 hours forecast.

The assimilation experiments are usually run on one node IBM machine for the screening and minimization steps and 16 nodes for the integration of the model. Moreover, the assimilation cycle is every 6 hours and the matrix of variances and error covariance of the model (B matrix) used for ALADIN was computed using the NMC method with a period of 15 days between 01 and 15 July.

In order to see the behaviour's differences between model running with dynamical adaptation and by introducing the 3DVAR configuration, a test experiment was prepared over a period of 5 days (01-12-2017 at 05-12- 2017), with range forecast of 24 hours using assimilation cycle and bases hours production corresponding to 00h, 06h, 12h and 18.

Preliminary results

The figures above represent biases of temperature at 2 m forecast for both initialization using the dynamical adaptation setup and 3DVar configuration. The forecasts using 3Dvar initialization at 06h and 18h are compared with 6th terms coming from 00h and 06h base hour respectively (Figure 4 and Figure 5).

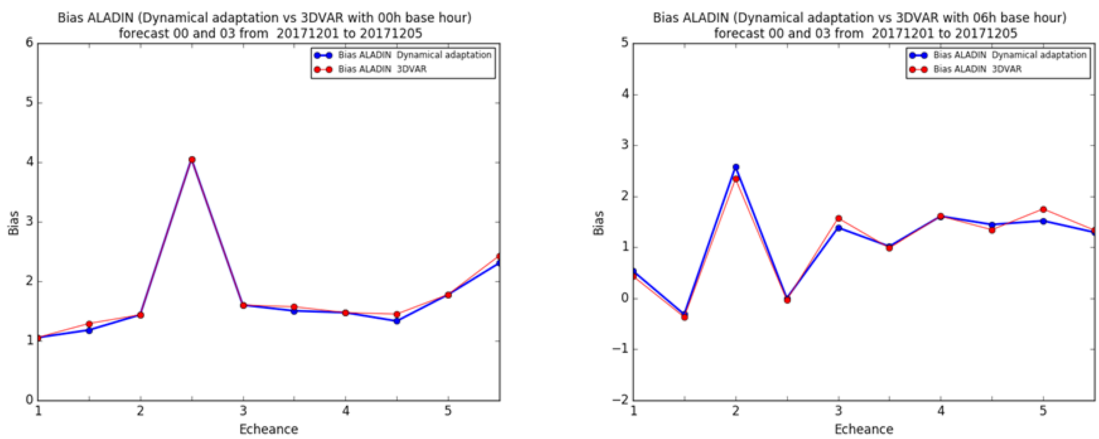
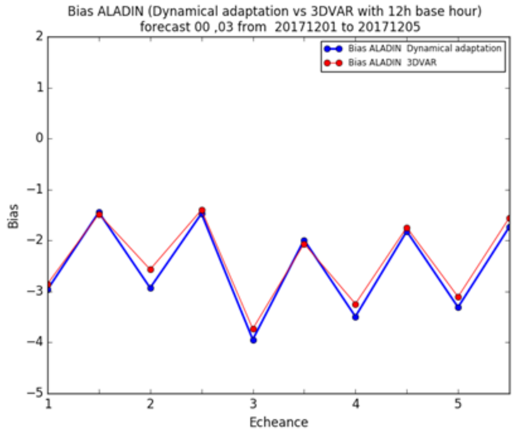


Figure 4: Bias of T2m 00 and 03 forecast of 5 simulations with base hour 00h (left) and 06h (right).



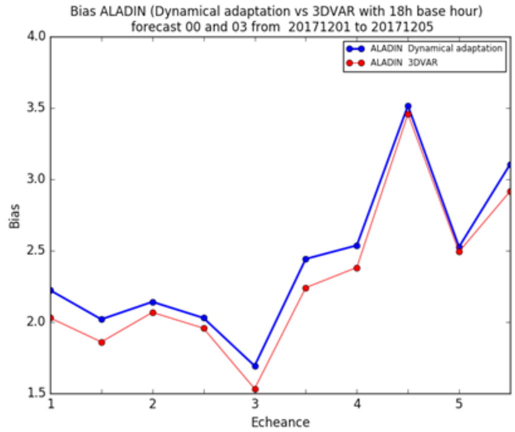


Figure 5: Bias of T2m 00 and 03 forecasts of 5 simulations with base hour 12h (left) and 18h (right).

In general, the bias of the experiments initialized with a 3DVar configuration showed an appreciable improvement for the both 06h and 18h base hour forecasts compared to the results obtained by predictions given by the dynamical adaptation configuration.

On the other hand, the simulations show a slight degradation for forecasts 00h and 12h (Figure 4). This is due to the fact that the forecasts obtained by the dynamical adaptation lose their information in a statistical sense as we move away from the assimilation base hour of the ARPEGE global model used as a coupling model for ALADIN Algeria.

Finally, the use of the ALADIN forecasts as a first guess for an initialization of the intermediate base hour forecast 06h and 18h by using an initial state resulting from the 3Dvar gives better scores in the case of the temperature parameter. As a perspective, a more detailed investigation will be made to see the impact of the minimization on the prediction of the other parameters of the model.

4 New weather warning system based on local operational models

An important advantage of locally running several models is the possibility to run applications adapted to different users' needs. The weather vigilance system and the road vigilance system are the latest applications developed by the NWP team in Algeria.

The weather vigilance system

The meteorological vigilance procedure is a weather warning system based on operational models running locally at ONM Algeria. The main purpose of this new system is to better inform authorities and people, thanks to a simple and condensed message, in case of dangerous weather phenomena, and to improve the early warning system. It was launched officially on 23 March 2017, at the occasion of world meteorology day.

This system is based on AROME predictions for the northern part of the country and on ALADIN system for the rest of the country, and provides warnings when the following parameters exceed the alert thresholds: precipitations, winds, thunderstorms, snow and ice, heat wave, cold wave. ALADIN_DUST is also used for desert dust related phenomena (thunderstorms, blowing sand, etc). The alert thresholds were defined based on statistical studies conducted by the climatological center

In a first step, this map is updated automatically from the operational models outputs, thanks to a verification system of threshold exceeding predefined by the climatological center. In a second step, this map is revised by the forecaster, who can in turn make improvements on the map by using an available interface. Once it finishes, the forecaster validates this map in order to be broadcast then to concerned authorities and large audiance (website, social networks). In case of ORANGE or RED vigilance level (very dangerous phenomena), the map is accompanied by monitoring bulletins (written by the forecaster) that are updated as often as necessary. These bulletins specify the evolution of the phenomenon, its trajectory, its intensity and its end, as well as the possible consequences of this phenomenon.

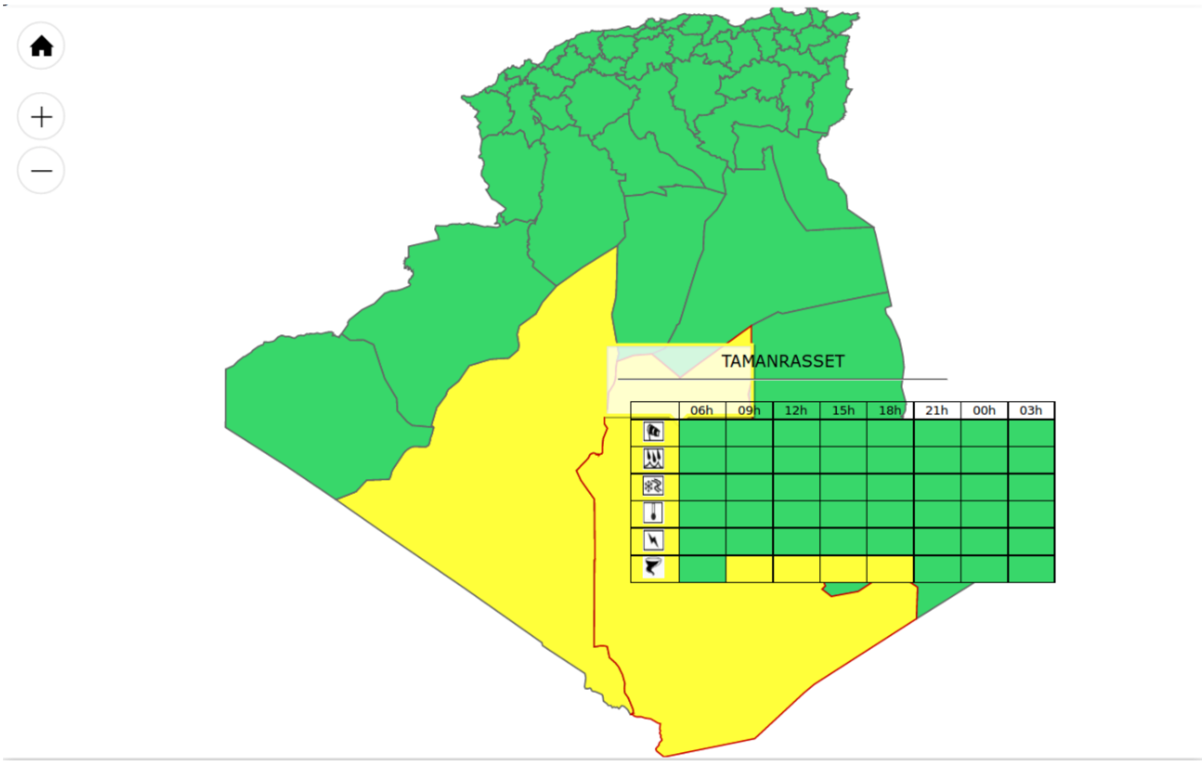


Figure 6: Weather warning map based on operational models outputs.

The vigilance map is published daily on the official website of the national office of meteorology (www.meteo.dz), under the rubric "vigilance", for a 24 hours period. This map is updated twice a day: at 7:00 am and at 7:00 pm.

The road weather vigilance system

The road weather vigilance system was developed on the same principle as the weather vigilance system, based on the outputs of the operational models at the ONM. However, it is still in the pre-operational phase.

This application was created with the aim of improving the safety of the road transport, by specifying the meteorological state of road on the followed track, with the feature to have information on the national roads as well as the secondary roads, thus covering the 1541 communes of the country.

Just like the weather vigilance system, the result of the road vigilance system is a map showing, using color thresholding, the alert levels on the road. By clicking on a place, more secondary roads will be visualized with meteorological information. In case of dangerous phenomena (heavy rain, low visibility, etc) the road will be colorized by RED or ORANGE, depending on vigilance threshold.

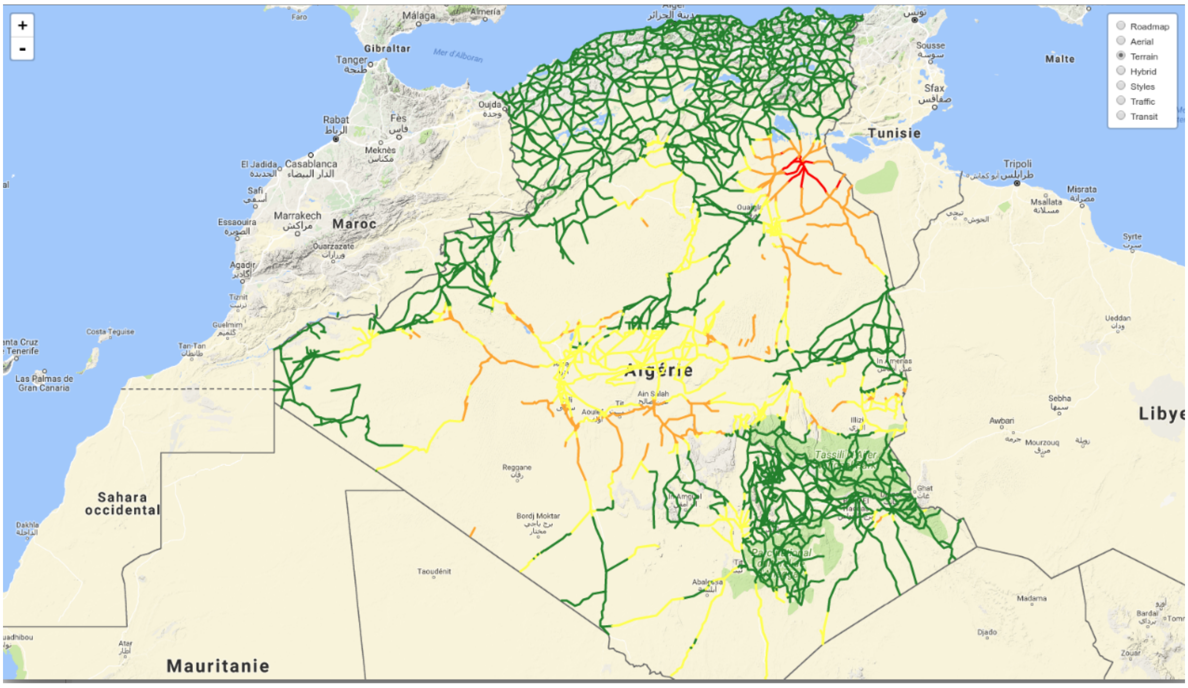


Figure 6: Weather warning map based on operational models outputs.

5 References

Claude FISCHER, T.MONTMERLE, L. BERRE, Pre-operational testing of 3DVar data assimilation in ALADIN France, Newsletter ALADIN 27, 2004.

Doina Banciu, The main outcomes and decisions from the final discussions on the ALARO-0 Training Course 26-30 March 2007, Radostovice, Czech Republic.

Neva Pristov, Radmila Brožková, Ján Mašek, Report from ALARO-1 Working days 2016 Luc Gerard,

Smerkol, P., Debugging and testing Toucans module for Alaro-1, 2016 RC LACE stay report in Prague.

Prediction of visibility using the C-LAEF ensemble system

Magdalena Haselsteiner, Clemens Wastl, Christoph Wittmann

1 Introduction

The development of the C-LAEF system (Convection permitting Limited Area Ensemble Forecasting) based on AROME is currently one of the main research areas at ZAMG. C-LAEF is run with 2.5km/90L resolution on a domain covering the Alpine region. The focus during the last two years was on the extension of the stochastic physics scheme in AROME. In addition to the well known SPPT scheme acting on physics total tendencies, two further schemes have been developed at ZAMG: pSPPT (physics parametrization based SPPT; Wastl et al. 2018) which is acting on partial tendencies and SPP (process based SPPT) (Ollinaho et al. 2017) acting on single processes and parameters.
These newly developed schemes have been tested and refined on a specific forecast problem in the C-LAEF framework - the prediction of visibility. Visibility forecasts are of major importance for many users but existing methods show rather poor performance. The presented work is done in the course of a master's thesis being carried out at ZAMG in cooperation with Freie Universität Berlin/Department of Physics. The following sections give a brief overview about the work and preliminary results.

2 Visibility prediction in AROME

2.1 Definition and Physics of Visibility

The visibility is a measure for sight, which Clark et al. 2008 define as the following:

> 'Visibility represents the shortest horizontal distance visible, considering all directions'

The 'visible distance' means the distance, for which a human observer is still able to see an object. For an object, to be visible, it has to have a contrast above a certain threshold value ε with respect to its background (Horvath 1981). The following formula for the visibility vis was first derived by Koschmieder 1924:

$$vis = -\frac{\ln(\varepsilon)}{\beta_{\mathrm{tot}}} \tag{1}$$

where β_{tot} is the total atmospheric extinction coefficient. The contrast threshold ε was set to a constant value of 2%, and therefore the prediction of visibility relies solely on the prediction of the atmospheric extinction coefficient. Unfortunately the atmospheric extinction coefficient remains to be one of the quantities the hardest to predict.

2.2 Method

Atmospheric extinction is caused by Rayleigh and Mie scattering. Very little spatial and temporal variability can be found in Rayleigh scattering, because it is mainly contributed by scattering on gas molecules. Hence, it is

assumed to be constant and the parametrization resolves only Mie scattering, which (for atmospheric scattering) is scattering on aerosols and hydrometeors. As an example Figure 1 illustrates the scattering of sunlight on a water drop, which is one of the processes that needs to parametrized. A parametrization of visibility including Mie scattering by aerosols has been described by Clark et al. 2008 (implemented in the IFS model at ECMWF and in the UK MetOffice model) and for scattering by hydrometeors (snow, rain, liquid cloud water, cloud ice) by Stoelinga and Warner 1999.
We merged the two parametrizations under the assumption that the total atmospheric extinction is composed of three additive terms:

1. Extinction due to Rayleigh scattering on gases: constant
2. Extinction due to Mie scattering on aerosols: as a function of aerosol concentration (sea salt, mineral dust, organic matter, black carbon, sulphates) and relative humidity, due to hygroscopic growth
3. Extinction due to Mie scattering on hydrometeors: as a function of hydrometeor concentration (snow, rain, liquid cloud water, cloud ice)

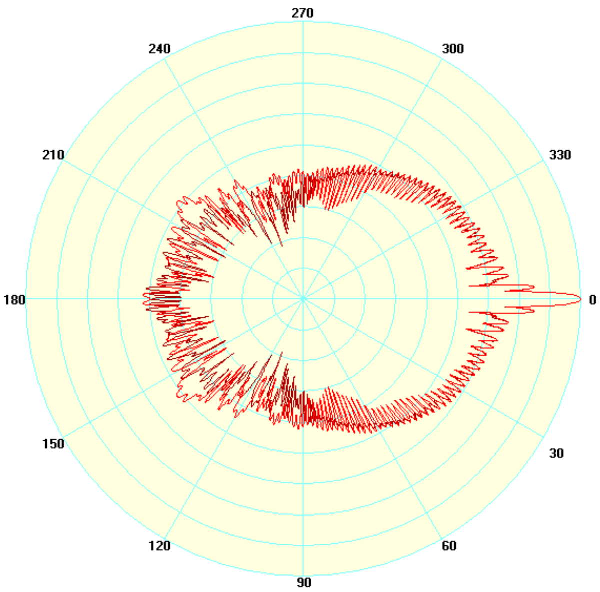


Figure 1: Scatter plot of Mie scattering: Intensity versus scattering angel. Created by the use of MiePlot (A computer program for scattering of light from a sphere using Mie theory & the Debye series).
Scattering of visible red light (λ=650nm) on a water drop.
Used parameters: particle radius: 1.0e-05 m; refractive index: 1.33257 + i1.67e-08; scale: logarithmic, value at outer circle: 2.18e+07, value at inner circle: 2.18e-02.

Because this parametrization of Mie scattering uses many constant parameters and input variables, it suffers from the contribution of uncertainty of all those quantities. To farther examine the uncertainty and thus, the reliability for visibility prediction, a perturbation scheme for visibility was developed by using stochastic physics methods. The perturbation and verification procedure is presented in Figure 2 and shows that aerosol concentration, hydrometeors concentration, specific humidity and the constant parameters in the visibility parametrization are perturbed. The code was implemented in a new routine (visibility.F90) in the AROME physics part called by apl_arome.F90.
To gain better insight of the effect of each single quantity, case studies for five days are done, where only one quantity is perturbed, while the others remain untouched. For the case studies the following dates were selected: 2017-01-8 (northerly flow with large scale snow), 2017-01-21 (high pressure over Central Europe with a lot of

fog), 2017-01-29 (fog in the eastern parts of the domain), 2016-07-14 (cold front from northwest), 2016-07-10 (high pressure ridge with partially fog).
A long term verification of two months (July 2016, January 2017) is done for the visibility prediction, where the total perturbation is applied.
For the experimentation the C-LAEF system was coupled with eight members (plus one control) from the global IFS model. In all C-LAEF experiments (single and total perturbations) different random perturbation produced by the random pattern generator are applied. For each quantity a suitable spatial and temporal correlation is chosen and a range is set.

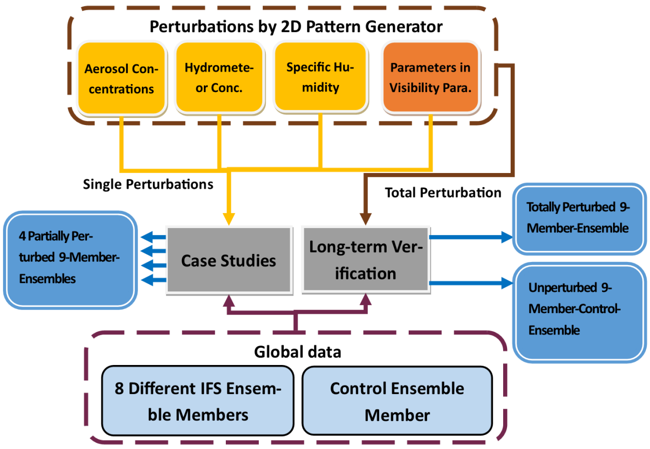


Figure 2: Perturbation scheme and verification strategy of the visibility parametrization: Aerosol concentration, hydrometeor concentration (rain, snow, liquid cloud water, cloud ice), relative humidity and constant parameters are perturbed. For the total perturbations all variables are perturbed by independently sampled random patterns, that are set-up by the AROME pattern generator.

Since so many physical processes contribute to the visibility, most currently used models do not resolve the scattering processes but rely on simpler prediction methods. The simplest and computationally least expensive one is, to find an analytical function of some model variables by fitting to measured data.
Seven other parametrizations of that kind were implemented, which were gained by Gultepe and Milbrandt 2010a and Gultepe, Müller, et al. 2006 to compare the skill of the different methods. All parametrizations were implemented in the new subroutine called ‘visibility.F90’ in AROME physics part, and each parametrizations provides a 2D field of visibility.

2.3 Verification

The visibility forecasts are evaluated against the measured visibility, taken by human observers. The C-LAEF domain and all measurement stations, that provide data for the verification, are shown in Figure 3. At the selected stations visibility measurements are taken at least three times per day.
To evaluate the quality of the visibility prediction, the root mean square of the difference of the logarithm of the forecast and observed value is used. The score, is taken from the logarithmic values, because the badness of the error has to be evaluated with respect to the magnitude of the observed values. The reason being, that for example a forecast value that is off by 20km should be more weighted, when the observed value is 2km than, when it is 70km.
Figure 4 shows data of a C-LAEF forecast of visibility as an example for one day of all implemented methods. The conditions on that day were overcasted with rain, snow and fog were present in the mountainous parts of

the domain. In general the visibility was effected heavily and thus, the measured mean value of 14.83km was rather low.

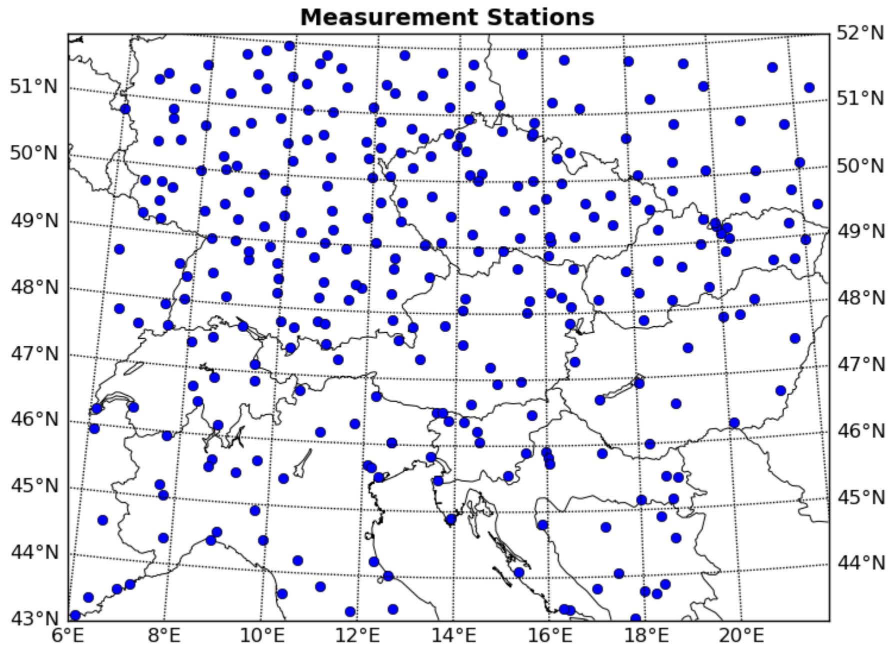


Figure 3: Model domain and all measurement stations where visibility measurements are taken

Our new parameterization, denoted by ‘Clark’ has the mean closest to the measurement data, but shows, that there is a tendency of underestimating visibility values above 45km. One reason for this problem could be, that the climatological aerosols, are weighted too heavily. This possible cause will be subject of farther investigation in the future. The nomenclature of the other parametrizations is in accordance with the work of Gultepe and Milbrandt 2010b, where the description of the fit functions and the corresponding coefficients can be found. The predictions of the different methods vary strongly and some are significantly overestimating the visibility. A weakness of all other parametrizations, but ‘Clark’, is, that they solely depend on relative humidity, or liquid cloud water. Therefore the performance under the presence of precipitation is poor. Another drawback is, that all functions gained by fitting underlie the quality of the used data and the decision of the researchers, which parts of the data set to fit to.
In conclusion, it is hard to pinpoint the best method, because none of them shows an outstanding performance. Depending on the purpose of the prediction and the present conditions, one has to decide which one to use.

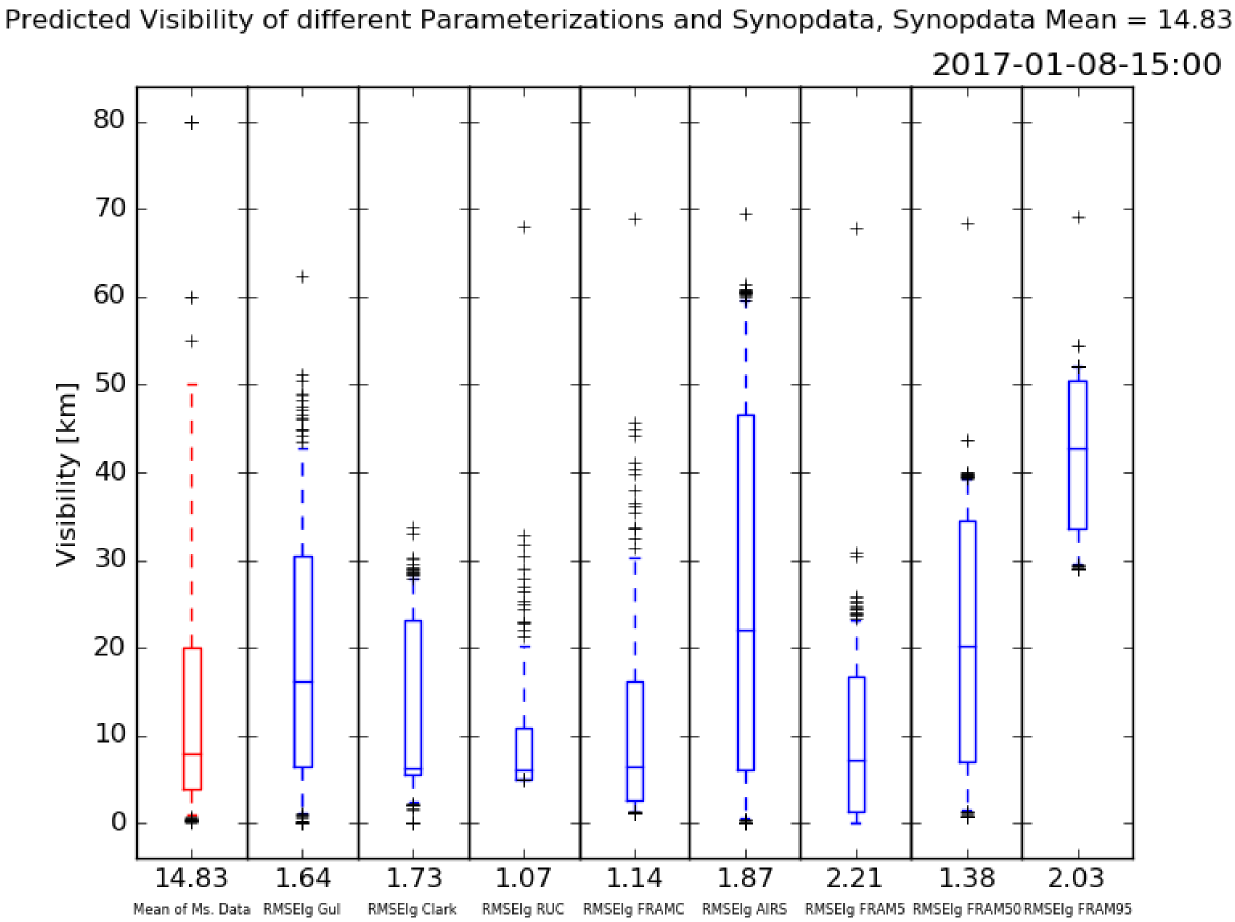


Figure 4: Data of visibility prediction without perturbation: The red box plot shows the measured data and the x-label is the corresponding mean. The eight blue box plots show the forecast data of the different methods, where 'Clark' stands for the new parametrization. For the forecast data the values on the x-axis are the root mean square of the difference of the logarithm of the forecast and observed value. The whiskers of the box plots denote the 5%- and the 95%-quantile. The black markers are the outliers.

3 Conclusion and Outlook

Because of the high uncertainty in the distributions of hydrometeors and aerosols, first tests show, that some parametrizations which use a simple function of relative humidity and/or liquid cloud water can have a better skill than the new visibility parameterization under certain conditions. The main problem is the use of climatological aerosol data. The verification including the applied perturbation has yet to be done, but will provide more details about the gravity of the lack of up-to-date aerosol data. Replacing climatological data by a prognostic aerosol scheme and combing hydrometeor concentration with humidity should help to improve the skill of the new visibility parametrization significantly.

4 References

Clark, P. A. et al.: *Prediction of visibility and aerosol within the operational Met Office Unified Model. I: Model formulation and variational assimilation*. In: *Quarterly Journal of the Royal Meteorological Society* 134.636 (2008), pp. 1801–1816.

Gultepe, I. and J. A. Milbrandt: *Probabilistic Parameterizations of Visibility Using Observations of Rain Precipitation Rate, Relative Humidity, and Visibility*. In: *Journal of Applied Meteorology and Climatology* 49.1 (2010), pp. 36–46. DOI: 10.1175/2009JAMC1927.1.

— *Probabilistic parameterizations of visibility using observations of rain precipitation rate, relative humidity, and visibility*. In: *Journal of Applied Meteorology and Climatology* 49.1 (2010), pp. 36–46.

Gultepe, I., M. D. Müller, and Z. Boybeyi: *A New Visibility Parameterization for Warm-Fog Applications in Numerical Weather Prediction Models*. In: *Journal of Applied Meteorology and Climatology* 45.11 (2006), pp. 1469–1480.

Horvath, H.: *Atmospheric visibility*. In: *Atmospheric Environment (1967)* 15.10-11 (1981), pp. 1785–1796.

Koschmieder, H.: *Theorie der horizontalen Sichtweite. Beifs*. In: *Phys. frei* (1924), pp. 33–53.

Laven, P.: *MiePlot (A computer program for scattering of light from a sphere using Mie theory & the Debye series)*. 2011. URL: http://www.philiplaven.com/mieplot.htm.

Ollinaho, P. et al.: *Towards process-level representation of model uncertainties: stochastically perturbed parametrizations in the ECMWF ensemble*. In: *Quarterly Journal of the Royal Meteorological Society* 143.702 (2017), pp. 408–422.

Stoelinga, M. T. and T. T. Warner: *Nonhydrostatic, mesobeta-scale model simulations of cloud ceiling and visibility for an East Coast winter precipitation event*. In: *Journal of Applied Meteorology* 38.4 (1999), pp. 385–404.

Wastl, C., Y. Wang, and C. Wittmann: *Physical parametrisation based stochastic perturbation of tendencies in a convection permitting ensemble*. In: *submitted to Monthly Weather Review* (2018).

Running ALARO-1 at 1.3km

Alex Deckmyn for ALADIN-Belgium team

1 Introduction

The ALADIN-Belgium team is now running cy40t1 with ALARO-1 at a resolution of 1.3km in a pre-operational setting. The runs are performed 4x per day to +36h. The results are archived and made available to forecasters for evaluation, but external products are not yet produced.

2 Set-up

Our main deterministic model is a locally adapted version of cy38t1 (ALARO-0 + TOUCANS + ACRANEB2 + unsaturated downdraughts) running at 4km resolution, coupled to Arpège. The 1.3km model is a cy40t1 run **nested in the 4km** output, which allows for hourly coupling. Both have **87 vertical levels**.

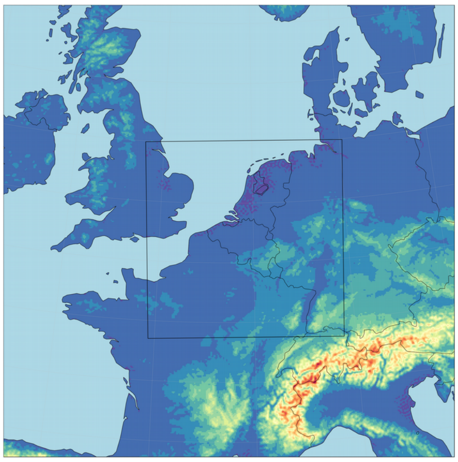


Figure 1: The ALARO-BE domains: 4km and nested 1.3km

There is currently **no data assimilation**, but this is expected to be added in the course of 2018. The results in Duerinckx et al. (2017) show that especially surface assimilation may improve a local high-resolution ALARO run.

Both ALARO versions are running with the ISBA surface physics. In 2018 we will start evaluating model more recent versions running with SURFEX.

3 Example

In Figure 2 below, we compare a precipitation case as forecast by Alaro cy40t1 at 4km and 1.3km with the radar image. Clearly in this case, the 1.3 km shows more detail and gives a good indication of the intensities.

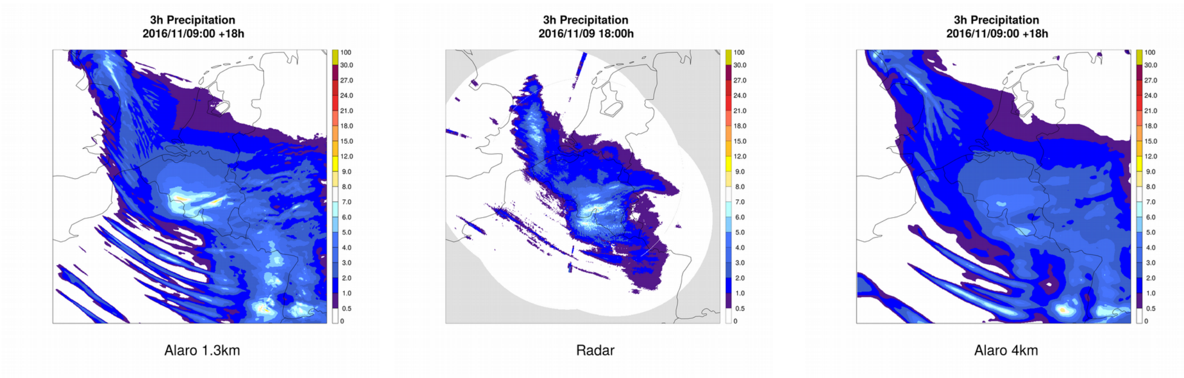


Figure 2: 3h Accumulated precipitation forecasts for 2016110900

4 Evaluation and comparison

We are currently gaining experience and gathering data to evaluate the model over a longer time period. While results are often encouraging, we do also notice some problems in the tuning of the physics (e.g. T2m bias, low clouds).

Besides comparing the 1.3km run to the operational 4km run, we can now also compare to the control members of the **RMI-EPS** ensemble that we are running experimentally at ECMWF. This ensemble, based on HARMON-EPS cy38h1.1, has 10+1 members each of Alaro and Arome (cy38h1) running at 2.5km resolution and coupled to ECMWF-ENS. Both these model versions have SURFEX for the surface physics and the control members have surface analysis and 3d-Var (only conventional observations).

A full evaluation is still underway. There are many differences to consider: cycle version, surface physics, data assimilation, coupling model (Arpège, ECMWF), horizontal and vertical resolution differences.

Figures 3 & 4 show a comparison of RMSE for T2m in Ukkel, for September and December 2017.

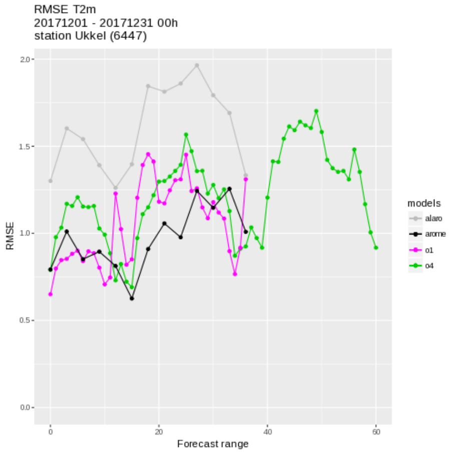


Figure 3: Figure 3: T2m scores December 2017: Operational models at 4 (o4) and 1.3 (o1) km, and RMI-EPS control members (arome and alaro) at 2.5km

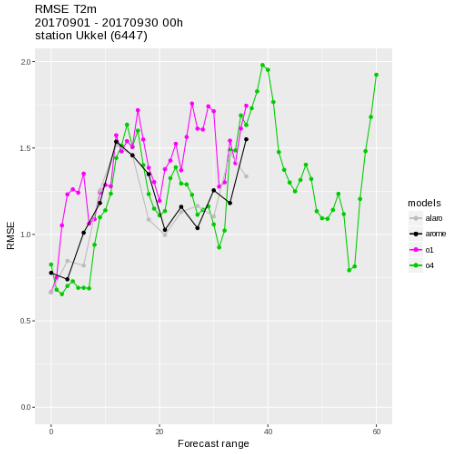


Figure 4: Figure 3: T2m scores September 2017: Operational models at 4 (o4) and 1.3 (o1) km, and RMI-EPS control members (arome and alaro) at 2.5km

5 References

Duerinckx, A., Hamdi, R., Deckmyn, A., Djebbar, A., Mahfouf, J.-F. and Termonia, P. (2017), *Combining an EKF soil analysis with a 3D-Var upper-air assimilation in a limited-area NWP model.* Q.J.R. Meteorol. Soc., 143: 2999–3013. doi:10.1002/qj.3141

The new operational models in Bulgaria

Boryana Tsenova, Andrey Bogatchev

1 Introduction

In the National Institute of Meteorology and Hydrology in Bulgaria we have a new computational server since December 2016. During 2017, new E-suites (for ALADIN and AROME models) were run experimentally on the new machine and became operational at the institute since the end of the year. Here we present the new E-suites that are based on cy41t1, as well some comparisons between them and the old one, that was based on cy38t1.

2 The new operational E-suites

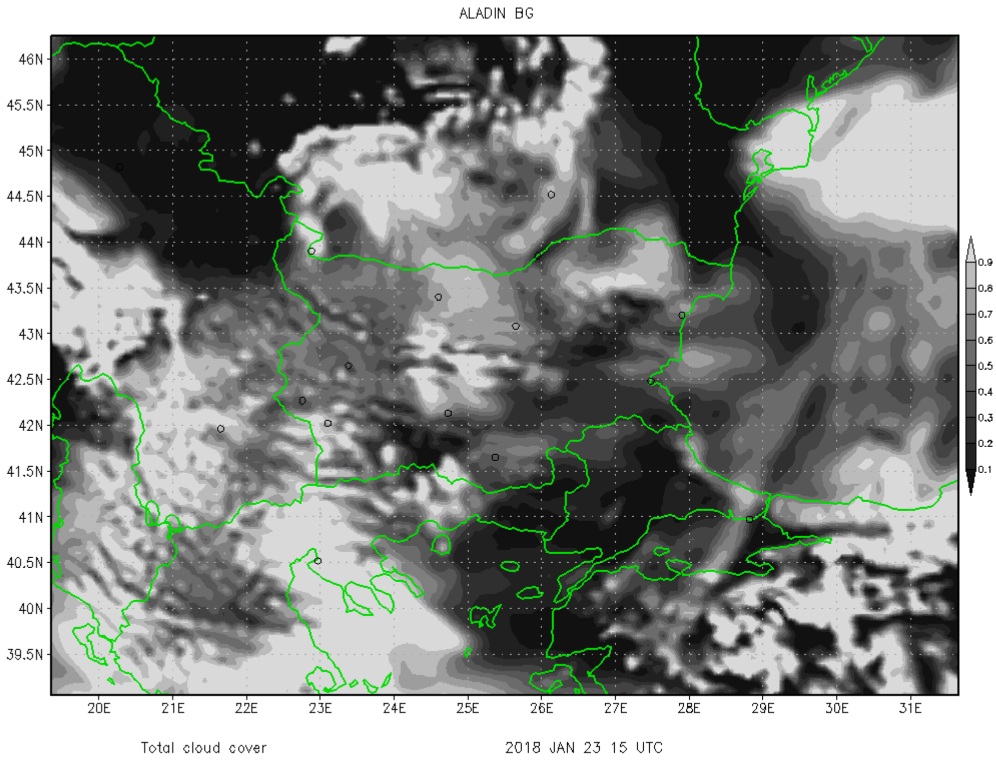
ALADIN BG 5/105

Since the First of November 2017 ALADIN BG 5/105 based on cy41t1 runs operationally twice daily, at 06 and 18 UTC, with a forecast range 72 hours. The model is using ARPEGE boundary conditions from 00 and 12 UTC runs. The main parameters of the new ALADIN BG domain are:
LONC=25.5, LATC=42.75, NDLON=256, NDGLG=200, NDLUX=245, NDGUX=189, NMSMAX=127, NSMAX=99, NFLEV=105, EDELX=5000

AROME BG 2.5/60

The non-hydrostatic model AROME BG, also based on cy41t1, runs operationally twice daily, at 06 and 18 UTC, with a forecast length of 36 hours. The model uses initial and boundary conditions produced by ALADIN BG 5/105. The main parameters of the AROME BG domain are:
LONC=25.5, LATC=42.75, NDLON=320, NDGLG=240, NDLUX=309, NDGUX=229, NMSMAX=159, NSMAX=119, NFLEV=60, EDELX=2500.

The domains of integration of the two new models can be seen in Figure 1, where the total cloud cover forecast for 15 UTC on 23 January 2018 based on new ALADIN BG and AROME BG runs at 06 UTC on 23 January are presented. For the same moment, one can see the two meters temperature forecasts from the two models in Figure 2.



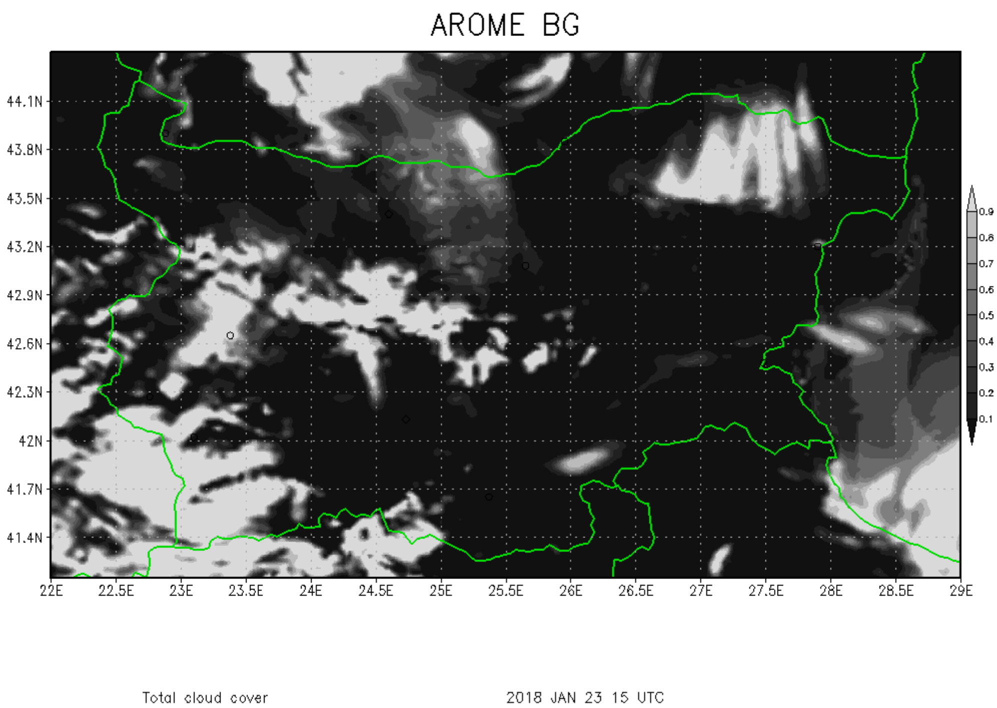


Figure 1: Total cloud cover forecast for 23 January 2018 15 UTC based on ALADIN BG (top) and AROME BG (bottom) runs at 06 UTC on 23 January 2018.

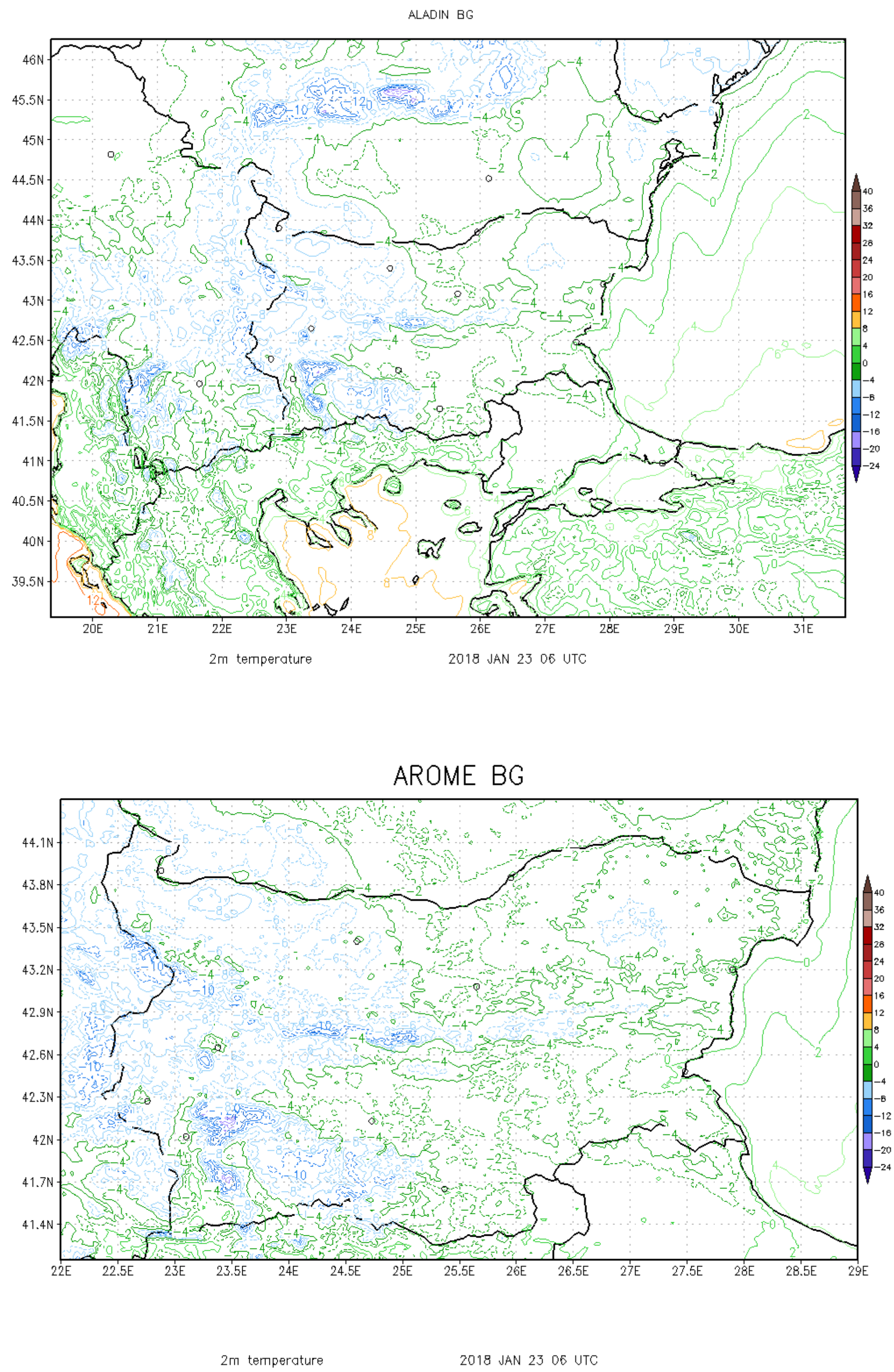


Figure 2: Two meters temperature forecast for 23 January 2018 15 UTC based on ALADIN BG (top) and AROME BG (bottom) runs at 06 UTC on 23 January 2018.

Models verification

Several studies on models performance were made before their launching in operational mode. Here we present the mean monthly BIAS and RMSE for two meters temperature (Fig.3), relative humidity (Fig.4) and wind speed at 10 m (Fig.5) for the month of September 2017 obtained based on synop data stations for the forecasted by the old version of the operational model – ALADIN BG 7/70 (based on cy38t1) and the new ones – ALADIN BG 5/105 and AROME BG 2.5/60. Model data for temperature are interpolated to stations coordinates horizontally using bi-linear interpolation and then vertically using a mean lapse rate of 8.5 K/km. Data for relative humidity and wind speed are interpolated horizontally (bi-linear interpolation).

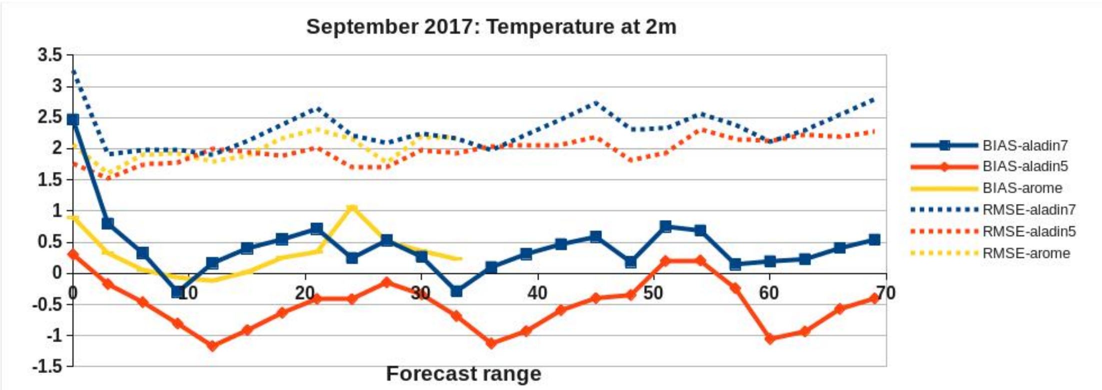


Figure 3: Mean Monthly BIAS and RMSE for September 2017 for two meters temperature forecasted by ALADIN 7/70, ALADIN 5/105 and AROME 2.5/60 for all synoptical stations in Bulgaria

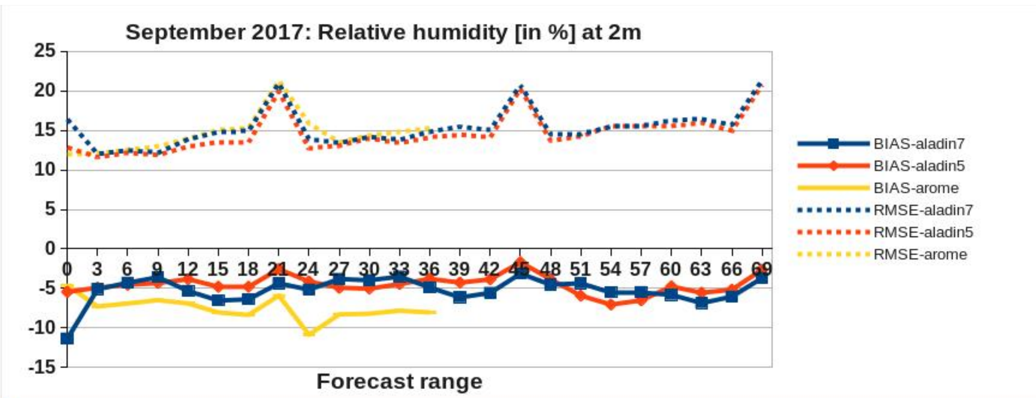


Figure 4: Mean Monthly BIAS and RMSE for September 2017 for two meters relative humidity forecasted by ALADIN 7/70, ALADIN 5/105 and AROME 2.5/60 for all synoptical stations in Bulgaria

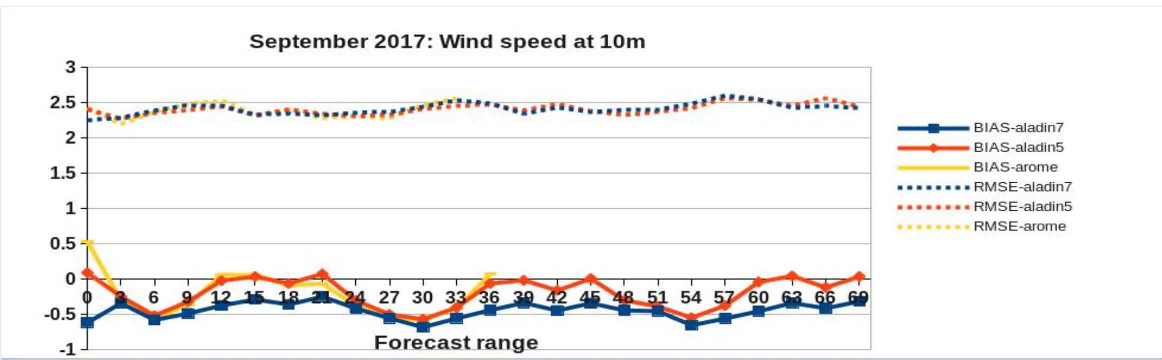


Figure 5: Mean Monthly BIAS and RMSE for September 2017 for wind speed at 10 m forecasted by ALADIN 7/70, ALADIN 5/105 and AROME 2.5/60 for all synoptical stations in Bulgaria

During operational works with some external clients it was established that for some stations locations especially in sub-mountainous regions the bilinear horizontal interpolation of two meters temperature data is not the best manner of evaluating forecasted by ALADIN BG 5/105 data due to the better representation of the orography. Such an example is Sofia, which is surrounded by mountains Vitosha, Lulin, Stara Planina. In Fig. 6 it is visible that if forecasted by ALADIN BG 5/105 temperature data are horizontally interpolated using bilinear interpolation (left panel), results for mean monthly BIAS and RMSE are worst in comparison to if only closest grid point is considered (right panel). For this particular case, if bilinear interpolation is used mean monthly BIAS and RMSE are respectivly -1.07 and 2.53, while if only closest grid point temperature value is taken into account they are -0.29 and 2.38 respectively.

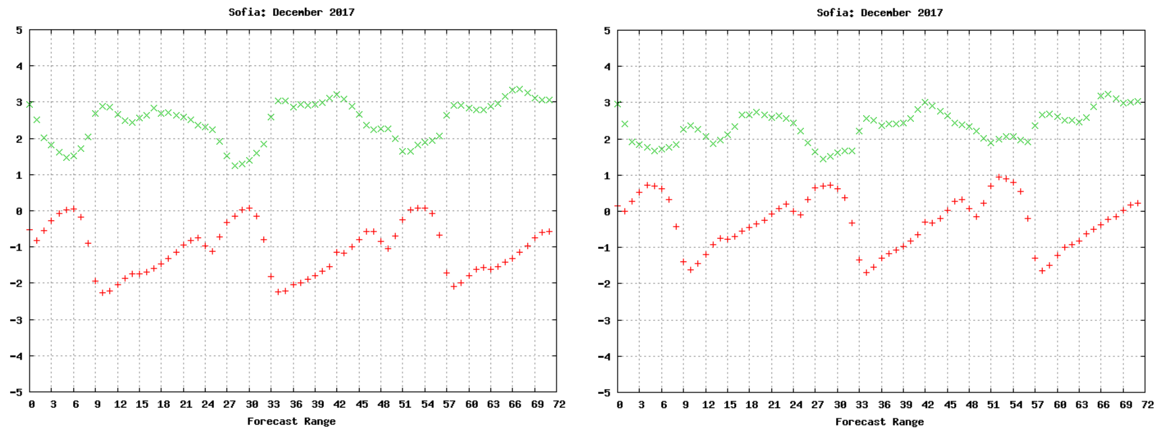


Figure 6: Mean Monthly BIAS and RMSE for December 2017 for two meters temperature forecasted by ALADIN 5/105 for Sofia station: left panel – forecast model data are horizontally interpolated using bilinear interpolation; right panel – only closest model grid point forecast data is taken into account

With the launching of the new operational models ALADIN BG and AROME BG many new studies on their forecast production are planned. As an example, we are working on a new scheme for summer severe weather prediction, as thunderstorm formation, heavy rain/hail precipitation, that will be based as well on different instability indices calculated using ALADIN BG, as on the more precise micro physics scheme included in AROME BG.

Summary of activities in Croatia

Martina Tudor, Stjepan Ivatek-Šahdan and Antonio Stanešić

1 Introduction

Here we briefly describe few activities in the Croatian Meteorological Service.

2 SST studies

During 2017, the impact of SST to the operational forecast using the ALADIN System has been studied on cases of intensive precipitation events (Ivatek-Šahdan et al., 2018) and severe winter conditions (submitted). The studies have shown small changes in the atmospheric forecast fields for weather situations with significant synoptic forcing.

3 LBC evaluation

The operational domain is rather small so rather dependent on the quality of forecast used at the lateral boundaries. Due to complaints from the forecast department, an evaluation of the operational forecast was done. This evaluation also included running verification using VERAL on the coupling files from both IFS and ARPEGE. The evaluation revealed larger RMSE in the coupling files from IFS with respect to the coupling files from ARPEGE (Figure 1). The Figure 1 shows a rather extreme case for January 2017 when the difference was particularly large. We should stress that the differences for other months are not so large and not always in favour of ARPEGE. Also, the domain is small, the verification is computed against TEMPs and IFS coupling files undergo several interpolation steps and are finally pushed to a lower resolution than original IFS HRES run.

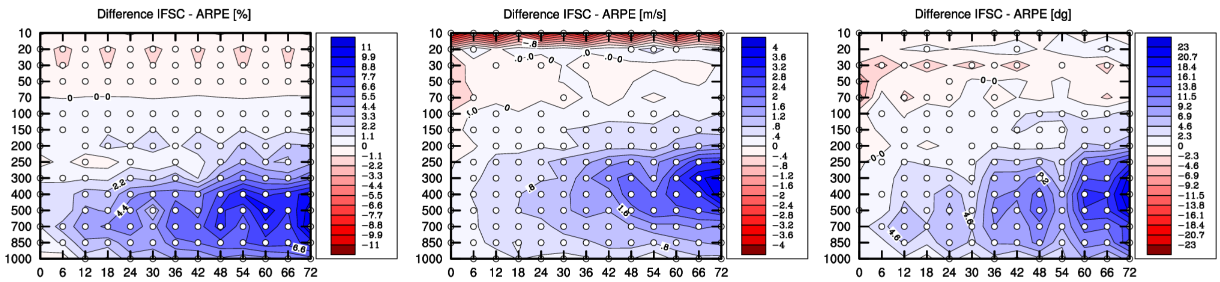


Figure 1: Differences in RMSE fro relative humidity (left), wind speed (centre) and wind direction (right) computed using VERAL for January 2017 between coupling files from IFS and ARPEGE for 00 UTC run.

Operationally, we are using coupling files from the operational IFS in the lagged mode.

4 The project MESSI

Research subject related to a MESSI project was the ability of the operational non-hydrostatic ALARO0 CMC to forecast rapidly propagating pressure disturbances that can cause meteotsunamis (Figure 2). Prediction of the pressure wave has to be precise for propagation speed and direction. It is sensitive to LBCs and dynamics and physics set-up, SST and topography representation (Figure 3).

Definition: A meteotsunami or meteorological tsunami is a tsunami-like wave of meteorological origin (atmospheric gravity waves, pressure jumps, frontal passages, squalls).

Figure 2: Photo of meteotsunami impact - low water levels mean that boats and ships can run into the bottom.

5 New B matrix

New B matrix was calculated and diagnostic comparison of B matrix properties was made. Three B matrices were computed with following methods/characteristics:

- NMC (standard, 12-36h fcst. differences, 4 runs per day) - NMC
- Ensemble (local ALADIN-HR4 ensemble, 6 members, 6h cycle, upper air observation perturbation)
  - Operational ECMWF LBC same for all members - ENS
  - LBC from ECMWF global ensemble - ENS-LBC
- Time period: 20161210 to 20170228
- Number of differences:
  - NMC – 316
  - ENS/ENS-LBC – 972

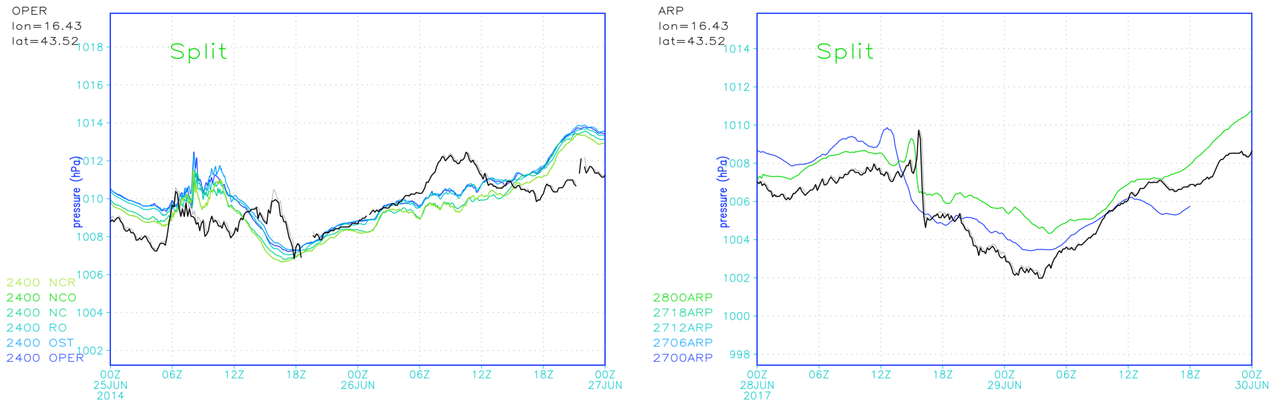


Figure 3: Measured (black) and forecast mean sea level pressure for Split during a meteotsunami episode on 25th June 2014 (left) and 28th June 2017 (right). Different colours represent different experiments. All experiments had model output every timestep (one minute). Left: operational forecast (blue), OSTIA SST (light blue), ROMS SST (aqua), new topography (blue-green), new topography + OSTIA SST (green) and new topography + ROMS SST (green-yellow). Right: experimetns performed using ARPEGE LBCs for different initial times and using TOUCANS turbulence scheme.

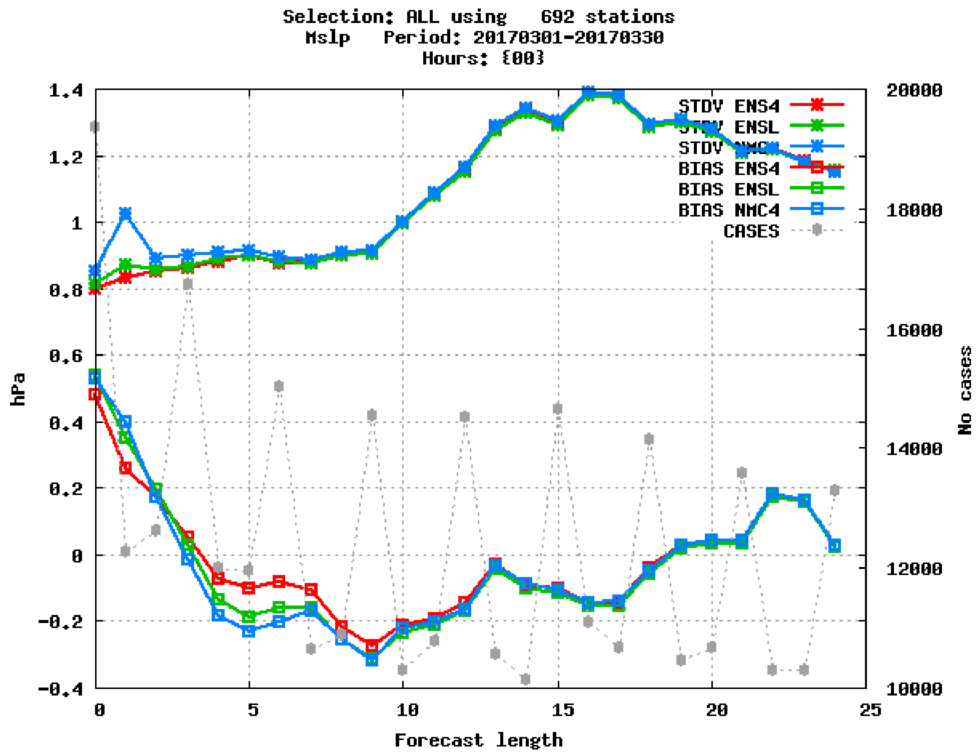


Figure 4: MSLP standard deviation and bias starting from analyses computed using different B matrices.

Goal: compare NMC vs. ENS diagnostics, evaluate influence on forecast scores, evaluate impact of LBC error on ENS statistics

Results:

- Largest horizontally averaged standard deviation for NMC method, smalles for ENS; similar shape
- Shorter length scales for ensemble B matrix than NMC; Shape similar for ENS and ENS-LBC
- Smallest energy for ENS on almost all scales especially on long scales (no LBC perturbations)
- A bit higher contribution of smaller scales for ENS-LBC method compared to NMC
- Narrower vertical correlations for ENS and ENS-LBC compared to NMC

Verification:

- Verification was done for May and June 2017; tuning of B matrix performed over one month period (Desrozier et al; REDNMC: NMC 1.3; ENSLBC 1.4; ENS 1.7)
- Small differences in surface scores, mainly visible in first 24 hour
- Bigger differences for upper-air better visible for June

Ensemble method for estimation of background error covariance matrix was applied. The resulting initial conditions produced small differences in surface scores, mainly visible in first 24 hours.

6 References

Ivatek-Šahdan, S., Stanešić, A., Tudor, M., Odak Plenković, I., Janeković, I., 2018. Impact of SST on heavy rainfall events on eastern Adriatic during SOP1 of HyMeX. Atmospheric Research, 200, 36–59, ISSN 0169-8095, https://doi.org/10.1016/j.atmosres.2017.09.019.

Desroziers, G., L. Berre, V. Chabot, and B. Chapnik, 2009: A Posteriori Diagnostics in an Ensemble of Perturbed Analyses. MWR, 137, 3420–3436.

Tour d'ALADIN: Czech Republic

Radmila Brožková, Patrik Benáček, Antonín Bučánek, Ján Mašek, Petra Smolíková, Alena Trojáková

1 Introduction

Milestones of 2017 activity of the Czech Hydrometeorological Institute NWP team are briefly summarized below. The past year has been mainly devoted to the data assimilation problem at high resolution and to the acquisition of a new powerful supercomputer.

2 Year 2017 Highlights

Background error covariances for the BlendVar System

The Digital Filter Blending (DFB) method has been successfully exploited in the ALADIN operational suite of CHMI since 2001. To recall, ARPEGE 4D-VAR analysis is blended with ALADIN high resolution guess, taking advantage from the sophisticated 4D-VAR scheme, recently enhanced by the ensemble information on the structure functions of the day, and from the high resolution information contained in the ALADIN guess. Since 2015 the DFB method has been completed by a 3D-VAR step at high resolution to still improve the initial conditions; this combination is the so-called BlendVar scheme.

In 2017 we have developed background error covariances adapted to the BlendVar scheme, with the goal to make the ALADIN 3D-VAR step working on finer scales while keeping the larger ones close to the result of the DFB algorithm. Comparison with background error covariances obtained by a more standard approach, including the impact on ensuing forecast has been published in Bučánek and Brožková, 2017. One of main conclusions is that DFB outperforms a classical 3D-VAR assimilation for forecast ranges longer than two hours about. The BlendVar scheme combines successfully DFB and 3D-VAR and yields better results than DFB or 3D-VAR used standalone, as expected. Using the newly proposed background error covariances in the BlendVar leads still to a slight forecast improvement visible also for forecast ranges longer than six hours.

Assimilation of MODE-S MRAR data

High-resolution aircraft observations available by modern air traffic surveillance systems (MODE-S radars) became over past years a very interesting source of information for data assimilation in NWP. MODE-S enhanced surveillance (EHS) protocol contains indirect meteorological information, while MODE-S Meteorological Routine Air Report (MRAR) register can provide direct observation of temperature and wind.

MODE-S aircraft observations have been made available to CHMI by the Air Navigation Services of the Czech Republic since mid 2015. Both MRAR and EHS types are available. In June 2017 the MRAR observations were included into the operational data assimilation. The MRAR data coverage is shown on Fig. 1; although it is limited around the Czech Republic, there is a small positive impact on the forecast. In addition these data are used in the diagnostic analysis application called VarCanPack, leading to a better description of boundary layer, e.g. temperature inversions.

Recently an agreement has been conducted between RC LACE and KNMI for acquisition of more MODE-S data. These are of EHS type only. Work on MODE-S EHS observations monitoring and assimilation experiments has started in 2017 within RC LACE in cooperation with Slovenia.

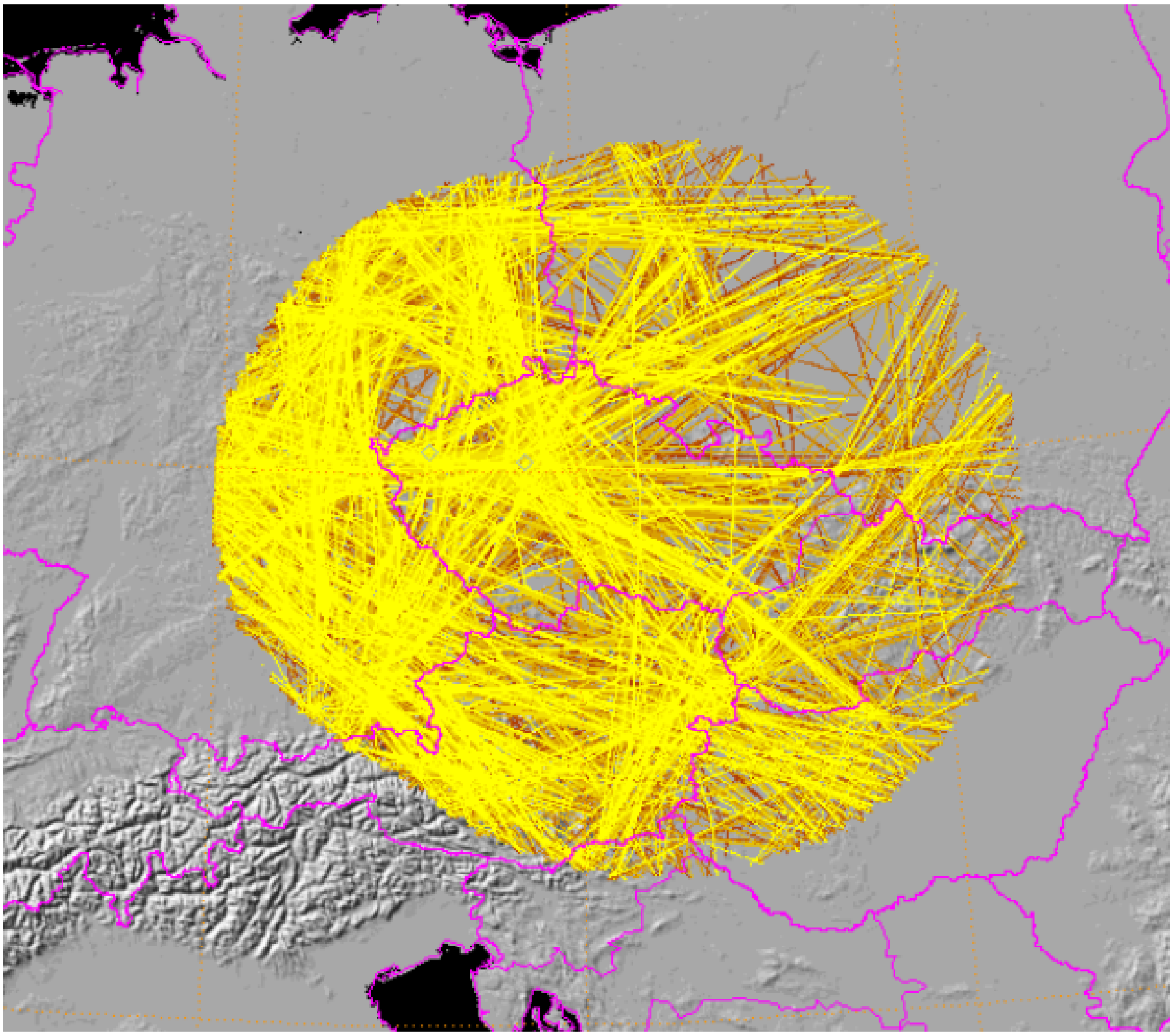


Figure 1: MODE-S MRAR Data Coverage. Source: Air Navigation Services of the Czech Republic

New High Performance Computing System at CHMI

In March 2017 CHMI signed the contract to acquire NEC LX Supercomputer. NEC will deliver the computational power of 320 nodes, connected through a high-speed Mellanox EDR InfiniBand network and containing the new Intel® Xeon® E5-2600 v4 product family dual socket compute nodes, with a total of 7,680 computational cores. This HPC solution also consists of a high-performance storage solution based on the NEC LXFS-z parallel file-system appliance, with more than 1 Petabyte of storage capacity and a bandwidth performance of more than 30 Gigabytes per second.

The first configuration of the HPC System was delivered by the end of June 2017 and till the end of year all the ALADIN operational suite was successfully ported to it. The nominal production on the new HPC System started on 9th January 2018. The full power configuration is planned to be available by the end of March 2018.

Preparation for 2km resolution

New supercomputer will allow to double the resolution over the large Central European (LACE) domain and to switch to the ALADIN Non-Hydrostatic dynamical core. Preparatory works focus not only on the forecast model itself, but also on the proper setup of the BlendVar assimilation cycle, since high resolution information contained in the initial conditions is critical for improving forecast.

Here below is an example on the role of analysis for the case of very heavy rain over Czech Republic on 29th June 2017. The high resolution 2km version of ALARO-1, using the non-hydrostatic dynamical kernel with one predictor-corrector iteration, was tested in the dynamical adaptation. The first experiment was run from ARPEGE analysis, while the second one was run from the ALADIN analysis obtained by the BlendVar cycle. The respective analysis resolutions are 8km for the ARPEGE model over Central Europe and 4,7km for the ALADIN one. A simple eye-ball comparison of precipitation forecast with respect to radar (Fig. 2) is enough to demonstrate the great advantage of the higher resolution ALADIN BlendVar initial condition.

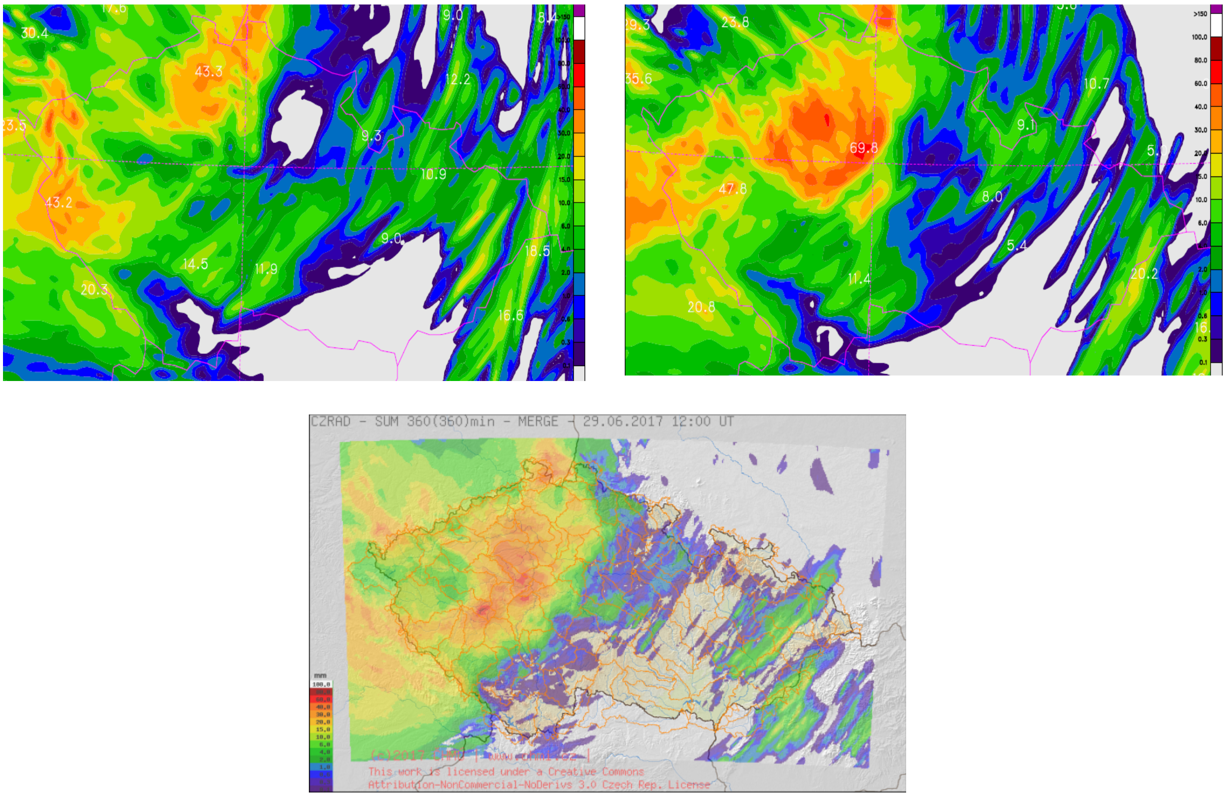


Figure 2: 6h precipitation sum between forecast ranges +6h and +12h by 2km ALARO-1 run from the network time of 29 June 2017 at 00UTC. Upper left: forecast starting from the ARPEGE analysis; upper right: forecast starting from the ALADIN BlendVar analysis; bottom: verifying observations combined from radars and rain gauges.

3 References

Bučánek A., and R. Brožková, 2017: Background error covariances for a BlendVar assimilation system. Tellus A Dynamic Meteorology and Oceanography, volume 69, Issue 1, http://dx.doi.org/10.1080/16000870.2017.1355718.

Sub-km HARMONIE and on-demand setup for storm forecast

Xiaohua Yang

1 Introduction

Coastal Greenland area suffers frequent storms, featuring strong local variability associated with a steep and complex orography. Operational experiences and numerical experiments reveal that high resolution meso-scale model at sub-km grid resolution may be necessary in order to satisfactorily resolve the highly heterogeneous flow situation charactering Greenland storms. This notes discusses operationally feasible approaches to configure Harmonie-Arome forecast system to achieve useful storm forecast for Greenland..

2 Challenges with prediction of storms in complex orography

Forecasting severe weather in Greenland faces many challenges. Almost all Greenland inhabitants live in coastal areas, which features a very steep and complex orography. Especially during winter half year, storms occur frequently in these area in connection with passage of northern Atlantic cyclones. Strong local variability are typically observed within small geographical areas, especially for populated areas such as southernmost Greenland coast and regions around Tasiilaq and Nuuk. Often, while some exposed areas experience extreme wind, other well shielded places just short distances away are hardly affected.

In recent years, operationalization of 2.5 km non-hydrostatic Harmonie-AROME in DMI (Yang et al 2017a, 2017b) has been seen to improve greatly the overall capability for routine weather forecast for Denmark, Greenland and Faroe Islands, the main service areas of DMI, including warning of hazardous winter storms. Figure 1 illustrates, e.g., a comparison of observation verification of wind forecast in Greenland among operational short range forecasts by 9 km ECMWF (1a), the previously operational HIRLAM-K05 at 5.5 km (1b) and the presently operational Harmonie-IGA at 2.5 km(1c).

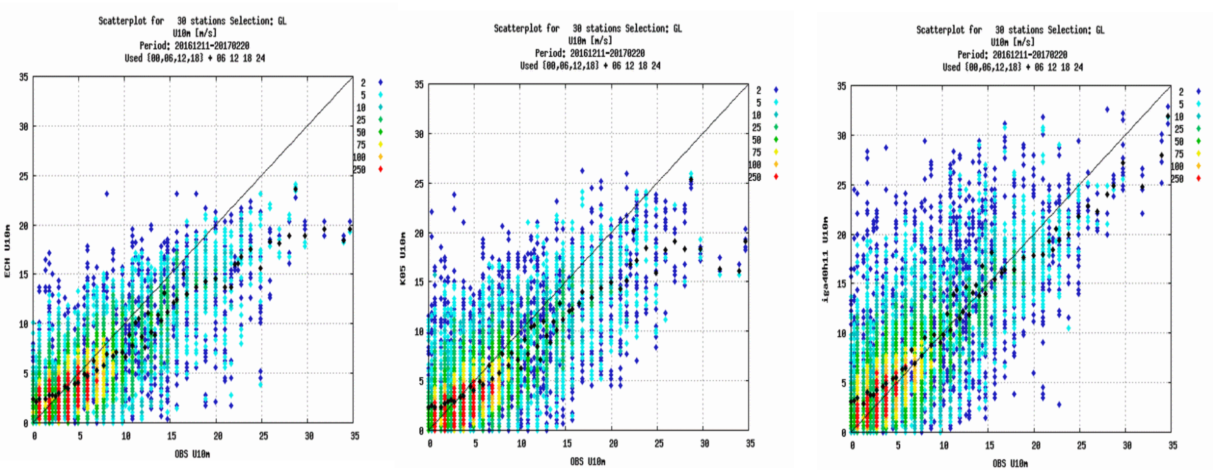


Figure 1. *Scatterplot comparing 10m wind speed forecast (y axis) with lead time of 6, 12, 18 and 24h as compared to observations in Greenland (x-axis) for the winter month of Dec 2016, Jan-Feb 2017 by a) ECMWF (9 km), b) HIRLAM-K05 (5.5 km) and c) Harmonie-IGA (2.5km).*

As shown in Figure 1 on X-axis, numerous events with wind speed above 24.5 m/s have been observed during the 3-month winter period, higher than the thresh-hold for storm class as set by DMI, with many surpassing 31.5 m/s, the thresh-hold for hurricane wind. Interestingly, while the coarse resolution ECMWF forecast failed to predict any storm case throughout this period, and the 5.5 km HIRLAM K05 had only very few predicted, there are numerous successfully forecasted cases about storm to hurricane events by the HARMONIE-IGA-2.5 km, demonstrating a clear advantage of the high resolution, non-hydrostatic meso-scale model HARMONIE in storm warning.

Nevertheless, Fig 1c also reveals strikingly many cases where HARMOINE-IGA appears to have over-forecasted storm conditions. This may be attributed to several factors. First, observation data may be deficient due to instrument failures. Second, phase error tends to punish more heavily finer resolution models than for coarser resolution ones. Third, surface observation network is extremely sparse in Greenland, making it much more prone to forecast error in both phase and intensity for cyclone prediction. Finally, finer resolution model is subjected to representation error of observation data by a higher degree. Fundamentally, both a single point measurement, and a single model grid representation, are inadequate to represent weather features if there exist significant local variability below grid scale.

As an illustration about the last point above, Figure 2 shows two surface wind speed time series by models for southern Greenland stations Narsaq (station 04280) and Qaqortoq (station 04273) starting 20171227 at 00 UTC, both compared to measurement data. For this episode, a storm warning had been issued by DMI for southern Greenland, based on the operational HARMONIE-IGA forecast. As shown in Figure 2, while IGA predicted a strong wind reaching hurricane scale for both of the stations, the forecasts were only up to gale force by HIRLAM-K05 and ECMWF9 km. According to observations, hurricane-scale wind did occur in NARZAQ stations, (Fig 2a) whereas the measurement data for station Qaqortoq (Fig 2b) appeared to be much closer to the coarser resolution forecasts by K05 and HRES.

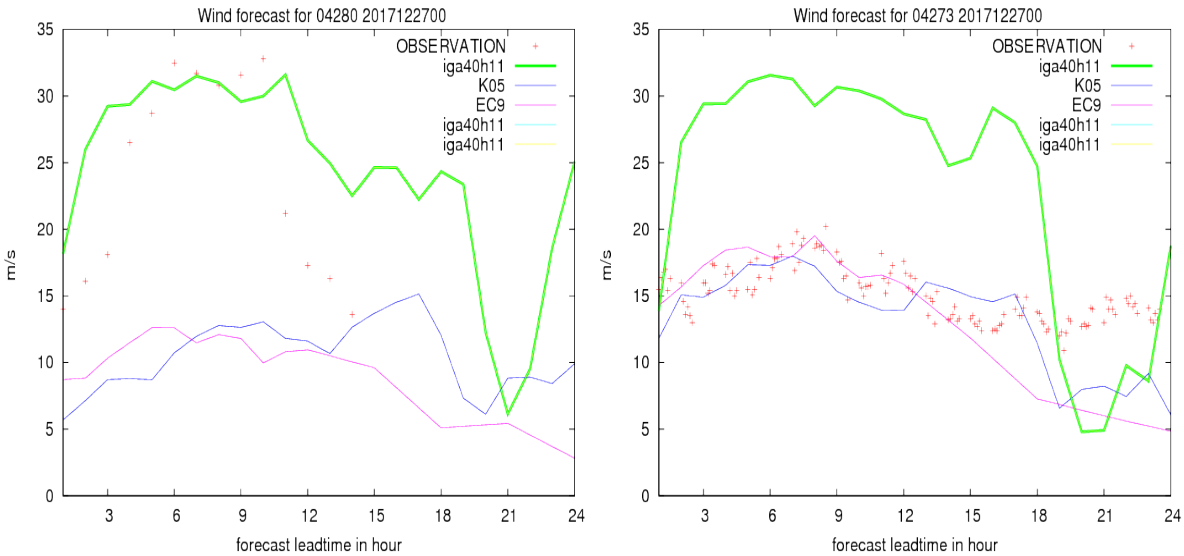
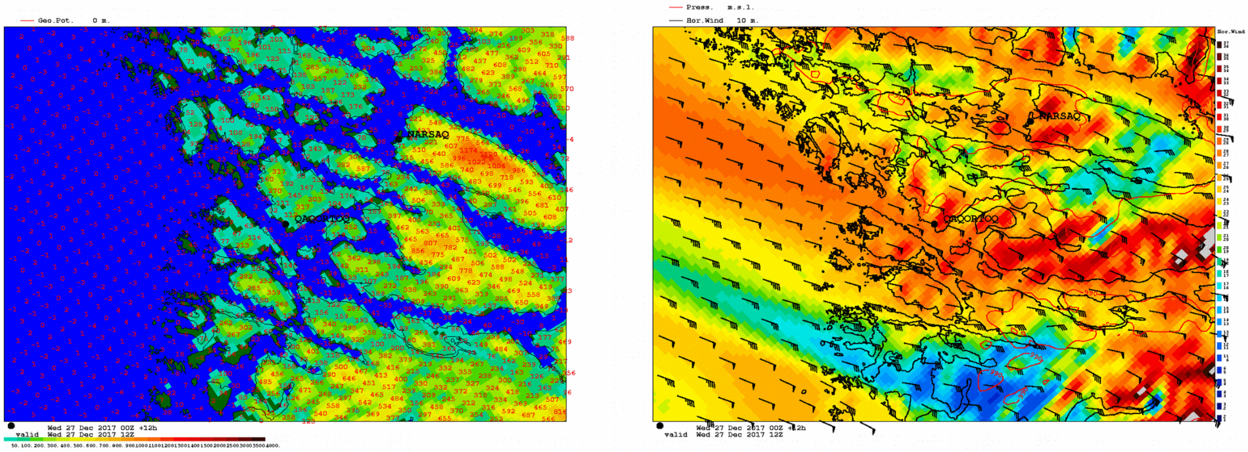


Figure 2. *Meteograms with forecast by HARMONIE-IGA (green), HIRLAM-K05 (blue) and ECMWF -9km (magenda) for 20171227 at 00 UTC compared to measurement (red crosses) for a) NARSAQ (04280) and b) Qaqortoq (04273).*

Interestingly, as one could derive from local Greenland media (not shown here), while the predicted storm did not materialise in the town of Qaqortoq, residents in nearby area a few kilometre away did experience major storms with hurricane force, suffering major material damages. Obviously for this event, it had been fully justifiable to issue storm warning, even though the forecast for the town of Qaqortoq itself turned out to be an over-prediction.

To shed further light on the actual flow situation, a HARMONIE-model with 750 m grid resolution has been run, cold started with initiation time 00 UTC on 20171227. Fig 3a plots the model orography, and Fig 3b shows the 12h wind forecast, which shows a strongly varying wind ranging from calm conditions to hurricane wind within small distances, with apparent correspondence to surface landscape and orographic contrast, and for some lee side locations, the shielding effects. Obviously, in an overall strong wind condition, it is virtually impossible to use single value to describe wind condition over a complex orography. It seems that, to help protecting human life and properties, a finer resolution weather model would be necessary to both warn for storm condition for the area and to provide usable guidance about spatial variability of wind force.



***Figures 3**. Illustration of spatial variability in orographically induced wind flow by sub-km Harmonie model. (a), Orography height in HARMONIE-AROME for southern Greenland at grid resolution of 750 m, (blue for sea level and warmer colours for higher altitudes) and (b), 12h forecast of wind speed valid at 20171227 at 12 UTC. Cold colours for calm condition and warm colours for storm to hurricane wind force.*

3 Sub-km Harmonie-lite and on-demand storm forecast

Greenland is a vast island with a size comparable to West Europe but with very sparse population and also a very sparse observation network. Although it would be ideal to use sub-km model for adequate storm forecast for Greenland area, running such a high resolution model with full area coverage is a formidable task given the available computational resource. Rather, alternative solutions are required to meet the basic forecast needs for the area.

Recently, several sub-km HARMONIE model set-up have been configured at DMI to test forecast for selected areas along coastal Greenland, focusing on an improved forecast for populated areas with frequent storms. To reduce computational cost and ensure robustness, a relatively small domain size (around 400 x 400 points) and a computationally efficient and stable cubic grid have been selected, aiming for a quick delivery and low cost. As these sub-km suites are significantly cheaper than other operational HARMONIE suites at DMI and easily affordable with the computational resource at DMI, they have been referred to as “Harmonie-lite”. Among the tested areas, those that centred around

Tasiilaq, Nuuk, Qaanaq and southern Greenland coast have been run exclusively on real time basis, while the other domains have only been tested technically. Common features for these set-ups include,

- A grid mesh of ca 400x400x65 with 750m, 500m or 1000 m grid resolution
- Internal nesting to the 2.5 km HARMONIE model
- Cubic grid
- Time stepping of 20 to 30s
- 24h forecast every 6h
- Surface assimilation of T2m and RH2m

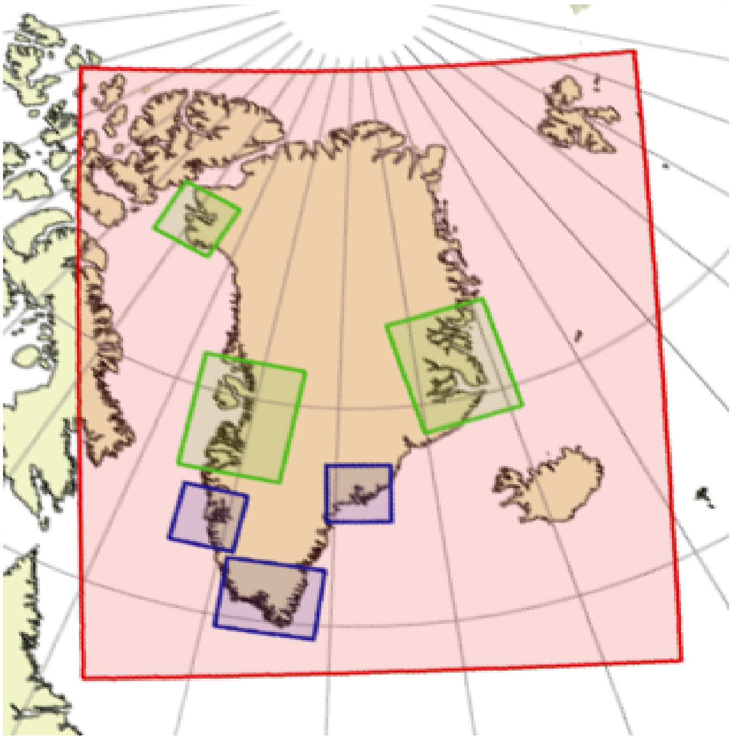


Figure 4, *Domain coverage of Harmonie-Arome suites for Greenland at DMI. Red denotes the operational 2.5 km IGB (2018), rest for sub-km Harmonie-Lite. Blue domains are semi-permanent domains centred around main Greenland towns Nuuk, Tasiilaq and southern Greenland. Green domains are on demand domains centered around Qaanaq, Disk Bugt and Scoresbysund.*

Among the above, real time runs have been made over an extensive period for three of the domains (TASIILAQ, NUUK, QAANAQ), in addition to technical evaluations for all the configured domains. The sub-km models have been found to be computationally efficient and robust, and regular monitoring and verification have confirmed their usefulness and added values in comparison to the 2.5 km operational suite especially for wind forecast. Figure 5 shows, e.g., observation verification of wind speed forecast with the 750-m TASILLAQ model in comparison to that of the operational IGA-2.5 km model for stations around TASILLAQ, the latter has been characterised by a systematic over-prediction of wind. As shown in Fig 5, the 750-m model did produce a significantly improved wind forecast with reduced errors in both STD and BIAS.

In view of the resource constraint, it is further envisaged that for areas with less frequent storm occurrences such as coastal areas in mid- and northern Greenland, (as those denoted by green colours in Figure 4), the sub-km HARMONIE-lite will only be run with on-demand set-up, so that these are only activated when duty forecasters see the need during storm seasons. For the on-demand runs, the model will only be run in cold-start mode without data assimilation cycling. From evaluation test, such has been found feasible given the main focus on forecast of surface wind. For the three southern

Greenland domains (blue regions in Fig 4), the real time runs will be continued in the near future, with decisions to be made about their status to be either permanent or for storm-season only.

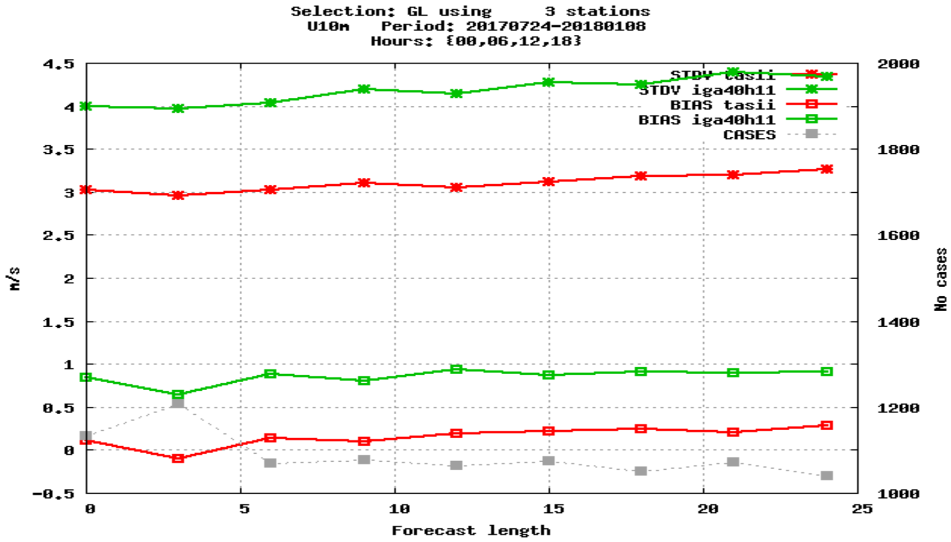


Figure 5, *Averaged standard deviation error and bias in comparison to observations for wind speed predicted by 750 m model (red) and 2.5 km model (green) for the period between July 2017 and beginning of January for areas around Tasiilaq, an area with frequent storm over-prediction with HAMRONIE at 2.5 grid scale. .*

4 References

Yang, X., B S Andersen, M Dahlbom, B H Sass, S Zhuang, B Amstrup, C Petersen, K P Nielsen, N W Nielsen, A Mahura, 2017a: NEA, the Operational Implementation of HARMONIE 40h1.1 at DMI, Joint ALADIN-HIRLAM Newsletter 8, 2017

Yang, X., B. Palmason, B. S. Andersen, B. H. Sass, B. Amstrup, M. Dahlbom, C. Petersen, K. P. Nielsen, R. Mottram, N. W. Nielsen, A. Mahura, S. Thorsteinsson, N. Nawri and G. N. Petersen, 2017b: IGA, Joint Operational HARMONIE by DMI and IMO. Joint ALADIN-HIRLAM Newsletter 8, 2017.

Highlights of NWP activities at FMI

Carl Fortelius, Erik Gregow, Ekaterina Kourzeneva, Laura Rontu, Karoliina Hämäläinen

1 Introduction

In the beginning of 2017, FMI joined the MetCoOp cooperation for short range NWP together with SMHI and MET.Norway. The MetCoOp ensemble MEPS, based on HARMONIE-AROME, became the principal short range forecating system at FMI in September. MEPS is described by Ulf Andrae et al. in this issue. The present article highlights a selection of research activities involving FMI staff. Section 2 describes an effort to improve short range forecasts of clouds and radiation by modifying the initial humidity with the aid of observed cloud information. Section 3 describes the application of the Flake parameterization for lakes in the HARMONIE-AROME system. An assessment of the HLRADIA broad-band radiation scheme, applied in HARMONIE-AROME, is introduced in Section 4. Section 5 briefly outlines down stream modelling of atmospheric icing on structures basead on model output.

2 Assimilation of cloud data

Using observed cloud information to modify the initial state humidity after the analysis step, has been shown to improve short-range cloud forecasts for as long as a day ahead in the HIRLAM NWP system (van der Veen, 2013). At FMI, he method of van der Veen has been applied in HARMONIE-AROME and further developed together with colleagues from SMHI and KNMI (Magnus Lindskog, Tomas Landelius, Siebe van der Veen). To date, four experiments have been completed, based on harmonie cy38h12 on the MetCoOp MEPS domain covering Scandinavia and the Baltic countries. All experiments use 3-hourly cycling, with 48-hour forecasts initiated at 00 and 12 UTC.

Table 1. Data assimilation experiments for ingesting cloud information

Exp.	Cloud mask and cloud top temperature	Cloud base	Humidity increment	Period
1 Ref	None	None	None	July 2016
2 MSG	MSG-NWCSAF	SYNOP	Van der Veen	July 2016
3 MSG-SWE	MSG-NWCSAF	MESAN	Van der Veen	July 2016
4 MSG-SWEw4	MSG-NWCSAF excluding specified classes	MESAN	Modified limits, accounting for supersaturation over ice	25-31 July 2016
5 MSG-SWEw4-CldLay	MSG-NWCSAF excluding specified classes	MESAN	Modified limits, accounting for supersaturation over ice, cloud layer detection	25-31 July 2016

The “MSG” experiment uses the original van der Veen methodology: cloud mask and cloud top temperature are obtained from MSG-NWCSAF, cloud-base height from interpolated SYNOP observations. In “MSG-SWE”, SYNOP cloud base data is replaced by the Swedish MESAN mesoscale analysis. In “MSG-SWEw4”, specific NWCSAF cloud-type classes are excluded, and the humidity-increments are modified by changing the applied limits of relative humidity and by accounting for super-saturation over ice. In “MSG-SWEw4-CldLay”, saturation is precluded in layers that are relatively dry in the base-line analysis.

The experiments have been compared against the reference run (Ref) and observations. WebGraf has been used to verify against surface and upper-air observations. Cloud and radiation parameters have been further verified against Finnish stations.

The results confirm that using MSG cloud information can improve the short range cloud and radiation forecasts. The starting experiment (MSG) gave mainly negative verification scores for surface and upper-air temperatures, and also for the cloud and radiation verification. But with the modifications done to MSG-SWE, and especially the latest version MSG-SWEw4_CldLay, the results are clearly improved and very encouraging. Here results are shown for cloud, temperature, humidity and radiation verification for the 1 week experiments.

The total cloud-cover bias becomes smaller, going from Exp.1 to Exp.5, and in the last experiment Exp.5 (MSG-SWEw4_CldLay: light-blue lines) the scores are better better than the Reference run (see Fig. 2.1). The effect persists out to approxmately +35h forecast step. The verification for 2 meter temperature show that with the most recent Exp. 5 is similar to Reference and the scores are only slightly worse (Fig. 2.2; compare light-blue with red line).

Vertical profiles of bias and standard deviation of humidity (not hown) indicate that Exp.5 is rather close to Reference, and that difference in the bias error is mainly seen for lower levels. The STDV is larger, when compared with Reference. Similar results were found for temperature.

From the histograms in figure 2.3 one can see that the Ref Exp mainly gives too high frequency of high-valued radiation data (i.e. overpredicts the occurenece of clear skies; Fig. 2.3a). Most of the experiments overestimate the cloudiness and reduce the radiation, which can be seen in Figs. 2.3b-d (i.e. the red column values, at the low end of radiation distribution, are too high). But in the last experiment MSG-SWEw4-CldLay there is a clear improvement (Fig. 2.3e). The result is closest to the observations and gives also much better distribution of the values over the radiation ranges (there is a slight overestimation of too much clouds, giving slightly higher frequences at low radiation values).

We validate the total cloudiness and cloud layers from the different experiments against the Reference run (note: here are no oberservations involved). By doing this, we can see at what levels our modifications (e.g. Exp.1-5) have the most impact. It is clear that the impact is strongest for the middle and high clouds and that the low-level clouds are almost untouched (i.e. same as in Reference; results not shown here). Looking at the total cloud fraction (Fig. 2.4) we can see that with the two last experiments (MSG-SWEw4 and MSG-SWEw4-CldLay) have similar frequency distribution as the Reference.

In upcoming experiments we plan to approach the cloud-base corrections and improve the estimates at low levels (low altitudes). In setup MSG , i.e. where the cloud-base is taken from an interpolated field of Synop observations, the most problematic areas are in between sparse Synop stations, especially if there exists a border between different clouds in that area. For example, the Synop observations is placed in an area of low clouds but the nearby area (with no Synop) contains only high Cirrus. Here the low cloud-base information will be transferred to the Cirrus cloud and affect the vertical cloud extension for this area, i.e. creating a much too thick cloud. On the other hand, in setup MSG-SWE Exp the edges/areas of different clouds are mainly well captured, the cloud-base is determined from the NWCSAF cloud-type. As a consequence, if there is a high cloud, the NWCSAF product is not able to detect if there exist a layer of cloud beneath. Therefore, there is a clear risk that setup MSG-SWE

Exp will miss the low-clouds, if there are sheltering high clouds, and the cloud-base is set too high compared to the reality. One can say that both methods have their weakness and strengths.

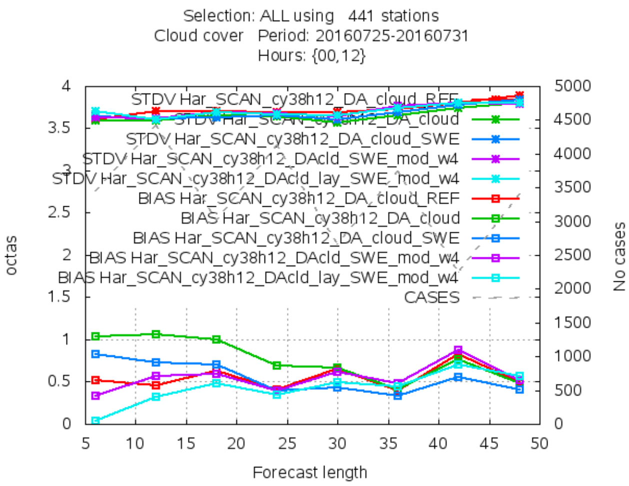


Figure 2.1. Verification of the total cloud cover; Ref Exp (red), MSG Exp (green), MSG-SWE Exp (dark-blue), MSG-SWEw4 (purple) and MSG-SWEw4-CldLay (light-blue), for 1 week in July 2016.

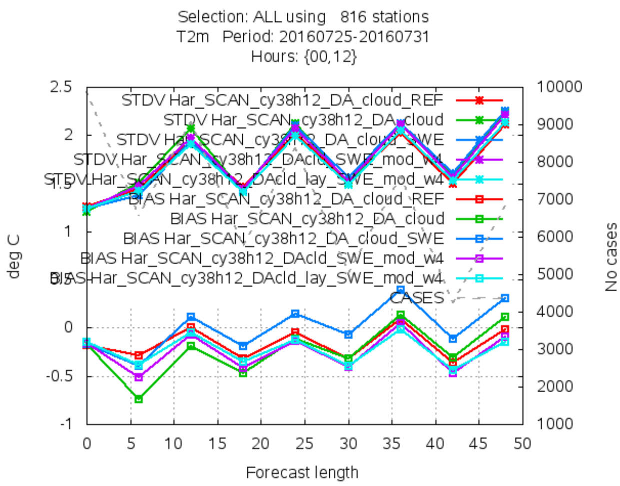


Figure 2.2. Verification of the 2 meter temperature, Ref Exp (red), MSG Exp (green), MSG-SWE Exp (dark-blue), MSG-SWEw4 (purple) and MSG-SWEw4-CldLay (light-blue), for 1 week in July 2016.

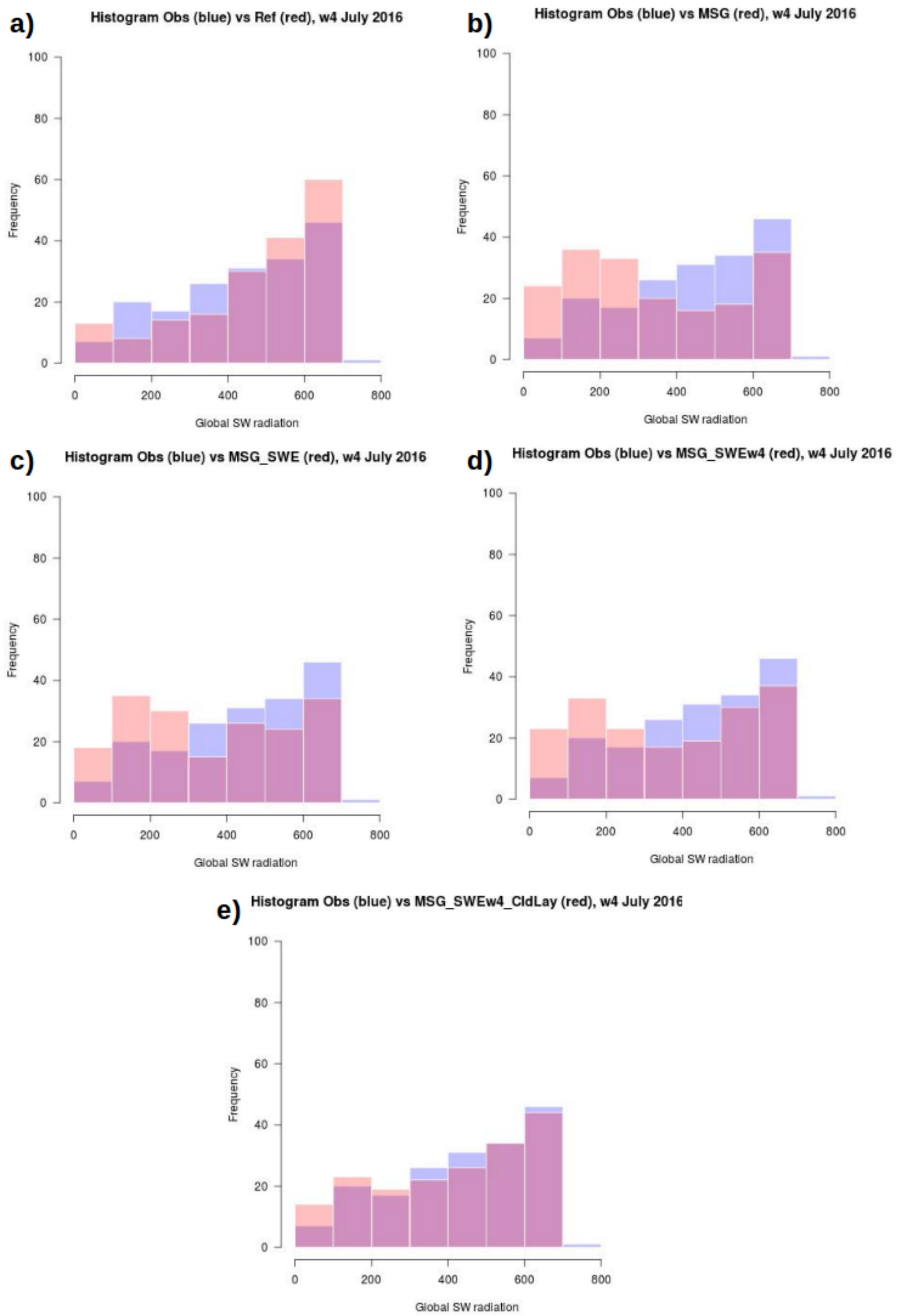


Figure 2.3. Histogram of Global SW radiation, observations (blue color) vs model experiment (red). Note: the dark-red/purple color indicate overlapping areas. Experiments, in red color: a) Ref Exp, b) MSG Exp, c) MSG-SWE and d) MSG-SWEw4 and e) MSG-SWEw4-CldLay, for week 4 (25-31.7) July 2016 at 07Z (+1h fc).

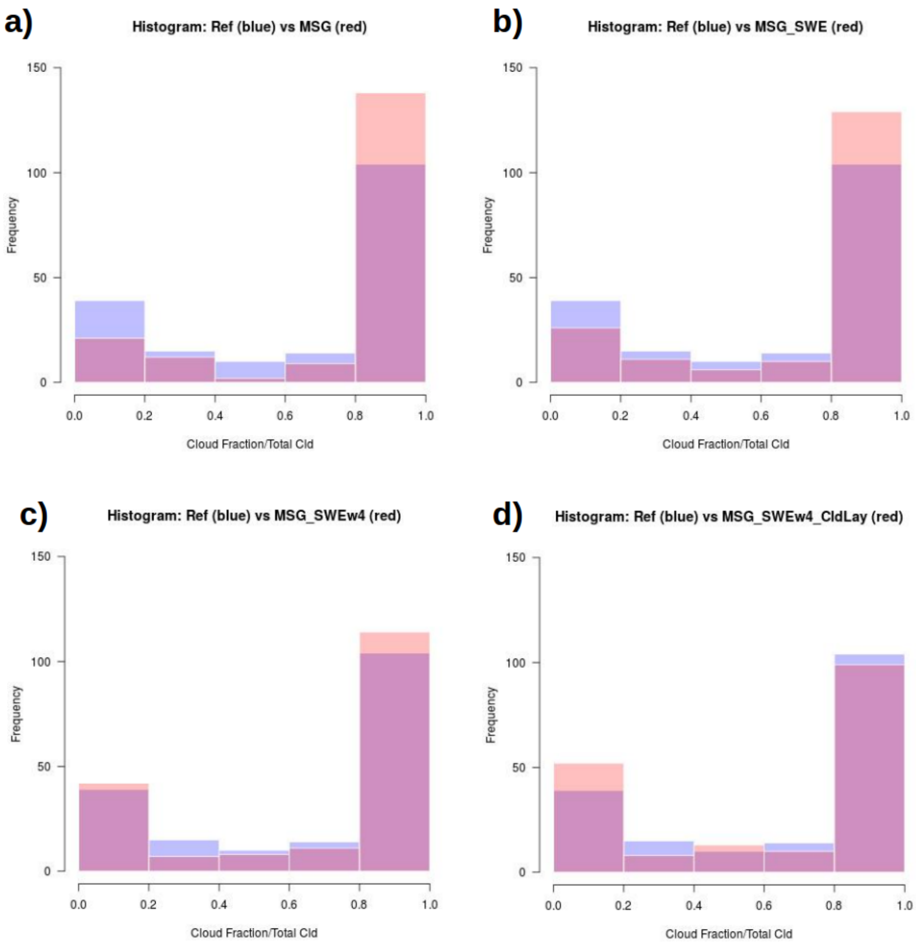


Figure 2.4. Validation of total cloudiness for week 4 (25-31.7) July 2016 at 10Z. In a-c) Ref Exp is shown in blue color and the different experiments is in red color; a) MSG Exp, b) MSG-SWE Exp, c) MSG-SWEw4 Exp and d) MSG-SWEw4-CldLay. Note: overlays between Reference and experiments are in purple color.

3 Lake modelling

Lakes present a type of underlying surface with its specific behavior, which affects the atmospheric boundary layer and the regional and local scale atmospheric processes. Effects of lakes are numerous, depending on a season, lake location and lake properties, and there are a lot of studies devoted to them (for example, Pereira and Muscato, 2013, Eerola et al., 2014). To provide a good forecast, fine resolution NWP models should contain parameterization of lakes in their land-surface parameterization package. In HIRLAM, parameterization of lakes based on the lake model FLake (Mironov, 2008) has been available starting from v.7.3 and run operationally at FMI since year 2010 (Rontu et al., 2012). However in the ALADIN-HIRLAM NWP system within HARMONIE-AROME model configuration (Bengtsson et al., 2017) this parameterization, although being included into the land surface model block SURFEX (Masson et al., 2012), was not activated until recently. The reasons for that where the following:

1. the consistency problem between mapping methods in SURFEX and in the global lake database (GLDB, Choulga et al., 2014);
2. the problem of projection of the lake depth from GLDB onto an atmospheric model grid;
3. bugs in the system;
4. a lack of testing of FLake performance within HARMONIE-AROME .

We present a short summary of the study, which is devoted to solving these problems, with the main focus on the results of testing.

The problem of mapping lakes in SURFEX was that its basic land use map ECOCLIMAP (Faroux et al., 2013) considered as “inland water” not only lakes, but also other land use types, such as different types of wetlands and coastal lagoons. For these land use types, the lake model is not applicable. Moreover, for the grid boxes containing these land use types, it was technically impossible to run FLake because GLDB provides no lake depth for them. To solve this problem, two actions were performed:

1. for some land-use types, the percentage of different tiles in the look-up tables of ECOCLIMAP was corrected, e.g. for coastal lagoons the “inland water” was moved to “sea water”;
2. for the other land use types, where the “inland water”-type on the raster map existed by error, the raster map itself was corrected: erroneous data were replaced by the most dominant land use type in the vicinity.

The problem of projection of the lake depth from GLDB onto an atmospheric model grid reveals when resolutions of the grids of the atmospheric model and ECOCLIMAP/GLDB become close to each other, for example 2.5 km and 1 km, respectively. In this case the lake depth may be projected onto the atmospheric model grid only by the nearest neighbor method. In SURFEX software, this functionality was not provided. It was developed and implemented in this study.

Testing of FLake was performed in HARMONIE-AROME v.40h1, with the model setup close to that of operational MetCoOp, for the large MetCoOpB domain. Prior to using FLake, the WATFLUX scheme was used in HARMONIE-AROME to represent lakes. In the WATFLUX scheme, the lake surface temperature is constant during the whole forecast period. This temperature may be initialized from different sources. For example, in operational MetCoOp setup, this temperature is initialized either from the extrapolated sea surface temperature, or from the deep soil temperature, depending on the grid box location. Thus, in WATFLUX the lake surface temperature may be influenced by the analysis procedure and due to this, does not go far from the screen level temperature value.

Parallel experiments were performed for the autumn-winter-spring period of 2015-1016. It is important to notice, that winter of 2015-1016 was unusually warm. For example, Lake Ladoga was covered by ice for only 8 days during that winter (climatological value for the duration of the ice cover period for Lake Ladoga is 4 months). Two experiments were performed: an autumn experiment, for 15.12.2015-20.01.2016 and a spring experiment, for 15.04.2016-31.05.2016. WATFLUX experiment used operational MetCoOp setup to initialize the lake surface temperature. FLake experiment run freely, without data assimilation for lakes. Both started from the dataset for lake climatology (Kourzeneva et al., 2013). Experiments contained 3-hour cycles with 48 hour forecasts starting from 00 UTC and 12 UTC.

Compared to the MODIS images, FLake shows good performance of the lake ice cover for the autumn period. For example, at 15.01.2016 neither Lake Vännern nor Lake Vättern are frozen according to MODIS and partly frozen according to FLake, Lake Ladoga is partly frozen according to both MODIS and FLake, and Lake Peipsi is fully frozen according to both MODIS and FLake. For the spring period FLake shows too much ice. For example, Lake Ladoga opened up in early February according to MODIS, but only in early May according to FLake. This was due to starting of the model run from the climatology for the non-typical year. Situation improves in 1.5 months.

General verification scores for all SYNOP stations in the domain showed only a slight signal. To study the situation better, a list of SYNOP stations in the vicinity of lakes was compiled. The list contains 122 stations. Even for this full list, only a slight signal was detected. However if we consider lake stations in different climate areas, we see clear changes. For example, for 39 lake stations in South Finland, for January 2016 we may see a clear improvement in both bias and error standard deviation for 2-meter temperature, see Fig. 3.1. The bias for this month for these stations is very high, 3-3.5°C. This is because HARMONIE-AROME can't reproduce the situation of sudden cooling which happened around January, 7. An example of deterioration of the forecast is given by 2 stations around Lake Vännern for January, 2016, see Fig. 3.2. FLake gives the cold bias of -0.5 ºC for the 2 meter temperature for this month. In general, considering different forecast scores for lake stations in different areas for different months, we may conclude more improvement rather than deterioration, and recommend using FLake in operational.

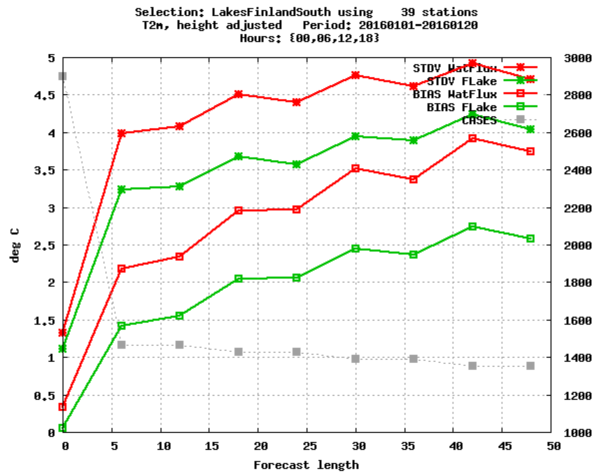


Fig. 3.1. Verification scores for the 2 meter temperature for 39 stations in the vicinity of lakes in Southern Finland for the period of 01.012016-20.01.2016.

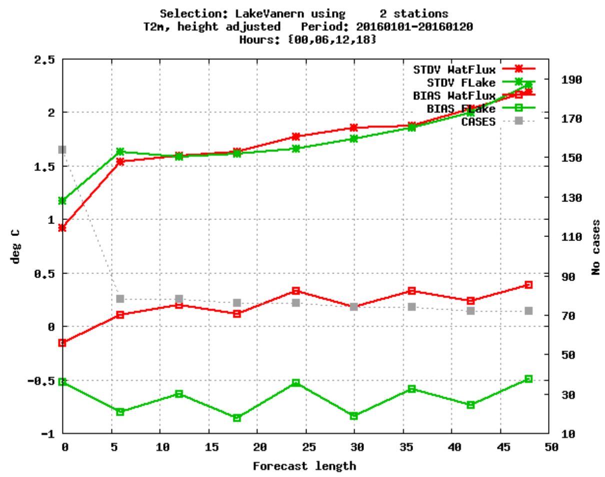


Fig. 3.2. Verification scores for the 2 meter temperature for 2 stations in the vicinity of Lake Vänern for the period of 01.012016-20.01.2016.

4 Assessment of the broadband radiation schemes HLRADIA

A paper describing the HLRADIA shortwave (SW) and longwave (LW) broadband radiation schemes used in the HIRLAM numerical weather prediction (NWP) model and available in the HARMONIE-AROME mesoscale NWP model was published by Rontu et al. (2017a), see also Rontu et al. (2017b). The advantage of broadband, over spectral, schemes is that they can be called more frequently within the model, without compromising on computational efficiency. In mesoscale models fast interactions between clouds and radiation and the surface and radiation can be of greater importance than accounting for the spectral details of clear-sky radiation; thus calling the routines more frequently can be of greater benefit than the deterioration due to loss of spectral details. Fast but physically based radiation parametrizations are expected to be valuable for high-resolution ensemble forecasting, because as well as the speed of their execution, they may provide realistic physical perturbations.

Results from single-column diagnostic experiments based on CIRC benchmark cases and an evaluation of 10 years of radiation output from the FMI operational archive of HIRLAM forecasts indicate that HLRADIA performs sufficiently well with respect to the clear-sky downwelling SW and longwave LW fluxes at the surface. In general, HLRADIA tends to overestimate surface fluxes, with the exception of LW fluxes under cold and dry conditions. The most obvious overestimation of the surface SW flux was seen in the cloudy cases in the 10-year comparison; this bias may be related to using a cloud inhomogeneity correction, which was too large. According to the CIRC comparisons, the outgoing LW and SW fluxes at the top of atmosphere are mostly overestimated by HLRADIA and the net LW flux is underestimated above clouds. The absorption of SW radiation by the atmosphere seems to be underestimated and LW absorption seems to be overestimated. Despite these issues, the overall results are satisfying and work on the improvement of HLRADIA for the use in HARMONIE-AROME NWP system is ongoing.

In a HARMONIE-AROME 3-D forecast experiment we have shown that the frequency of the call for the radiation parametrization and choice of the parametrization scheme makes a difference to the surface radiation fluxes and changes the spatial distribution of the vertically integrated cloud cover and precipitation.

5 Modeling of atmospheric icing on structures

An icing model for atmospheric icing on structures has been combined with deterministic MetCoOp HARMONIE model output. Validation of the icing model has been done by using observations from three sites (Hämäläinen and Niemelä, 2017). The icing model is based on the ISO Standard 12494 (2001). As an input the icing model needs wind speed, temperature and liquid water content. MetCoOp HARMONIE includes a bulk microphysical scheme (Jabouille and Pinty, 1998) with five prognostic hydrometeors for different water species: cloud water, cloud ice, rain, snow, graupel. Only liquid water phases were taken into account when calculating hourly icing rates. The icing forecast is updated four times per day.

The icing model meets the needs of wind power producers and is also under testing for aviation. For the wind power producers the forecast is presented as a point forecast on the wind turbine hub height. For the aviation, vertical profiles of icing are provided for few airports and measurement sites. Vertical profiles of icing are also compared against ceilometer measurement and in-situ mast measurements. The idea is to study if ceilometers can be used for the verification of atmospheric icing (Hirsikko et al., 2017).

6 References

Bengtsson, L., Andrae, U., Aspelien, T., Batrack, Y., Calvo, J., de Rooy, W., Gleeson, E., Hansen-Sass, B., Homleid, M., Hortal, M., Ivarsson, K.-L., Lenderink, G., Niemelä, S., Nielsen, K. P., Onvlee, J., Rontu, L., Samuelsson, P., Muñoz, D. S., Subias, A., Tijm, S., Toll, V., Yang, X., and Køltzow, M. Ø., 2017: The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System, *Monthly Weather Review*, **145**, 1919-1935, http://dx.doi.org/10.1175/MWR-D-16-0417.1

Choulga, M., Kourzeneva, E., Zakharova, E. and Doganovsky, A., 2014: Estimation of the mean depth of boreal lakes for use in numerical weather prediction and climate modeling. *Tellus A* 2014, 66, 21295, http://dx.doi.org/10.3402/tellusa.v66.21295

Eerola, K., Rontu, L., Kourzeneva E., Kheyrollah Pour, H. and Duguay, C., 2014: Impact of partly ice-free Lake Ladoga on temperature and cloudiness in an anticyclonic winter situation - a case study using a limited area model. *Tellus A* 2014, **66**, 23929, http://dx.doi.org/10.3402/tellusa.v66.23929

Faroux, S., Kaptué Tchuenté, A. T., Roujean, J.-L., Masson, V., Martin, E., and Le Moigne, P., 2013: ECOCLIMAP-II/Europe: a twofold database of ecosystems and surface parameters at 1 km resolution based on satellite information for use in land surface, meteorological and climate models, *Geoscientific Model Development*, **6**, 563-582, doi:10.5194/gmd-6-563-2013.

Hirsikko A., Komppula M., Leskinen A., Hämäläinen K., Niemelä S., O'Connor E., 2017: Freezing condition monitoring and FMI's icing forecast model evaluation with observations from ceilometer network in Finland. *EMS Annual Meeting,* 4–8 September 2017, Dublin,Ireland. [http://meetingorganizer.copernicus.org/EMS2017/EMS2017-132.pdf]

Hämäläinen K., and Niemelä S., 2017: Production of a Numerical Icing Atlas for Finland. *Wind Energ.*, 20: 171–189. doi: 10.1002/we.1998.

ISO Standard 12494, 2001: Atmospheric Icing of Structures. *ISO, Geneva: Switzerland*, 2000.

Jabouille P, and Pinty JP, 1998: A mixed-phase cloud parameterization for use in a mesoscale nonhydrostatic model: simulations of a squall line and of orographic precipitation. *Conference on Cloud Physics*. American Meteorological Society, Everett, WA, 1998; 217–220.

Kourzeneva, E., E. Martin, Y. Batrak and P. Le Moigne, 2012: Climate data for parameterisation of lakes in Numerical Weather Prediction models. *Tellus A* 2012, **64**, 17226, DOI: 10.3402/tellusa.v64i0.17226

Masson, V., P. Le Moigne, E. Martin, S. Faroux, A. Allas, R. Alkama, S. Belamari, A. Barbu, A. Boone, F. Bouyssel, P. Brousseau, E. Brun, J.-C. Calvet, D. Carrer, B. Decharme, C. Delire, S. Donier, K. Essaouini, A.-L. Gibelin, H. Giordani, F. Habets, M. Jidane, G. Kerdraon, E. Kourzeneva, M. Lafaysse, S. Lafont, C. Lebeaupin Brossier, A. Lemonsu, J.-F. Mahfouf, P. Marguinaud, M. Mokhtari, S. Morin, G. Pigeon, R. Salgado, Y. Seity, F. Taillefer, G. Tanguy, P. Tulet, B. Vincendon, V. Vionnet and A. Voldoire, 2012: The SURFEX7.2 land and ocean surface platform for coulpled offline simulation of Eath surface variables and fluxes. *Geoscientific Model Development*, 5, 3771-3851, doi:10.5194/gmdd-5-3771-2012

Mironov, D. 2008. *Parameterization of lakes in numerical weather prediction. Description of a lake model.* COSMO Technical Report 11. Deutscher Wetterdienst, Offenbach am Main, Germany.

Pereira, G., and Muscato, M., 2013: Multivariate analysis of lake - effect snowstorms in western New York. *Journal of Operational Meteorology*, **1** (14), 157–167, doi: http://dx.doi.org/10.15191/nwajom.2013.0114

Rontu, L., K. Eerola, E. Kourzeneva, and B. Vehviläinen, 2012: Data assimilation and parametrisation of lakes in HIRLAM. *Tellus A* 2012, **64,** 17611, DOI: 10.3402/tellusa.v64i0.17611

Rontu, L., Gleeson, E., Räisänen, P., Pagh Nielsen, K., Savijärvi, H., and Hansen Sass, B.: The HIRLAM fast radiation scheme for mesoscale numerical weather prediction models, Adv. Sci. Res., 14, 195-215, https://doi.org/10.5194/asr-14-195-2017, 2017a.

Rontu, L., Gleeson E. and Nielsen, K.P.: HIRLAM and HARMONIE-AROME radiation comparisons. 9th ALADIN-HIRLAM Newsletter, 34-36, 2017b.

van der Veen, Siebe, 2013: Improving NWP Model Cloud Forecasts Using Meteosat Second-Generation Imagery. *Monthly Weather Rev.,* **141,** 1545-1557, doi: https://doi.org/10.1175/MWR-D-12-00021.1

Forecasting the tropical cyclones Irma and Maria with Arome-Antilles

Ghislain Faure, Claude Fischer

1 Introduction

The 2017 tropical cyclones (TC) season has been quite exceptional for the North Atlantic, and it is being recorded as the most active one since 2005 (see for instance link to NOAA website in reference). Thus, the Lesser Antilles islands have been hit successively by two Category 5 storms within two weeks :

- Irma, which was maintained for three consecutive days at Category 5 with average maximum wind intensity above 250 km/h, hit several islands in a row (among them, St Barthelemy and St-Martin) ;
- Maria, which was remarkable by its dramatic and unusual deepening and strengthening, with wind intensity increasing from 130 km/h to about 260 km/h in 24h. The sudden intensification occurred in close vicinity of the islands of Martinique, Dominica and Guadeloupe, with a direct landfall effect on Dominica.

2 Results and performance of AROME-Antilles

These repeated outbreaks of intense cyclones allowed to assess the performance of the AROME-Antilles model with respect to TC forecasting. The model is run at 2.5km resolution with fields initialized from the atmospheric state of IFS (10km resolution), sea surface temperature (SST) from OSTIA and surface from Arpège. AROME then performs a dynamical adaptation to higher resolution, and in this process the model is indeed able to forecast storms with significantly stronger gradients, deepening and wind intensity than the IFS global model. The spin up time needed for a strong mature cyclone to be reached in AROME is estimated to about 12h. After the adaptation period, AROME is able to maintain extreme cyclonic conditions, as well as to represent a whole track and life cycle of the storm until boundary conditions are reached. This is illustrated in Fig. 1 for Irma.

When specific TC aspects are considered, experience shows that AROME keeps the usually good track forecast of the coupling model (IFS), thus neither improving nor deteriorating the track despite its much stronger gradients and storm structure. The most visible and effective added value of AROME is with respect to wind forecast, both in terms of maximum intensity and of spatial structure. This finding is illustrated in Figs. 2a and 2b which display forecasts of average maximum wind intensity for both AROME and IFS , for resp. Irma and Maria. For both cases, the much increased wind values better fit observations as reported by the NHC (National Hurricane Center located in Miami, Florida). For Irma, IFS clearly under-estimated the intensity, while for Maria, AROME is able to forecast a rapid strengthening.

On the whole, the performance of AROME-Antilles for these two major TC cases was found to be very satisfactory, and compared very well with other available mesoscale models dedicated to TC forecasts and alerts (like H-WRF, not shown). A new version of AROME-Antilles has been switched to operations since the occurrences of Irma and Maria. This new version uses ocean/atmosphere coupling (the ocean component being a single column model), an enlarged geographical domain and daily updated MERCATOR SST. It is expected that this version will further strengthen the use of AROME-Antilles for North Atlantic TC forecasting and be a useful, if not unavoidable, model in local Forecast Departments.

Acknowledgements : the author is grateful to the Cyclone team of LACy (Laboratoire de l'Atmosphère et des Cyclones, La Réunion), who provided Figs. 2a and 2b.

3 References

NOAA Internet media release about cyclonic season in the Atlantic: http://www.noaa.gov/media-release/extremely-active-2017-atlantic-hurricane-season-finally-ends

4 Figures

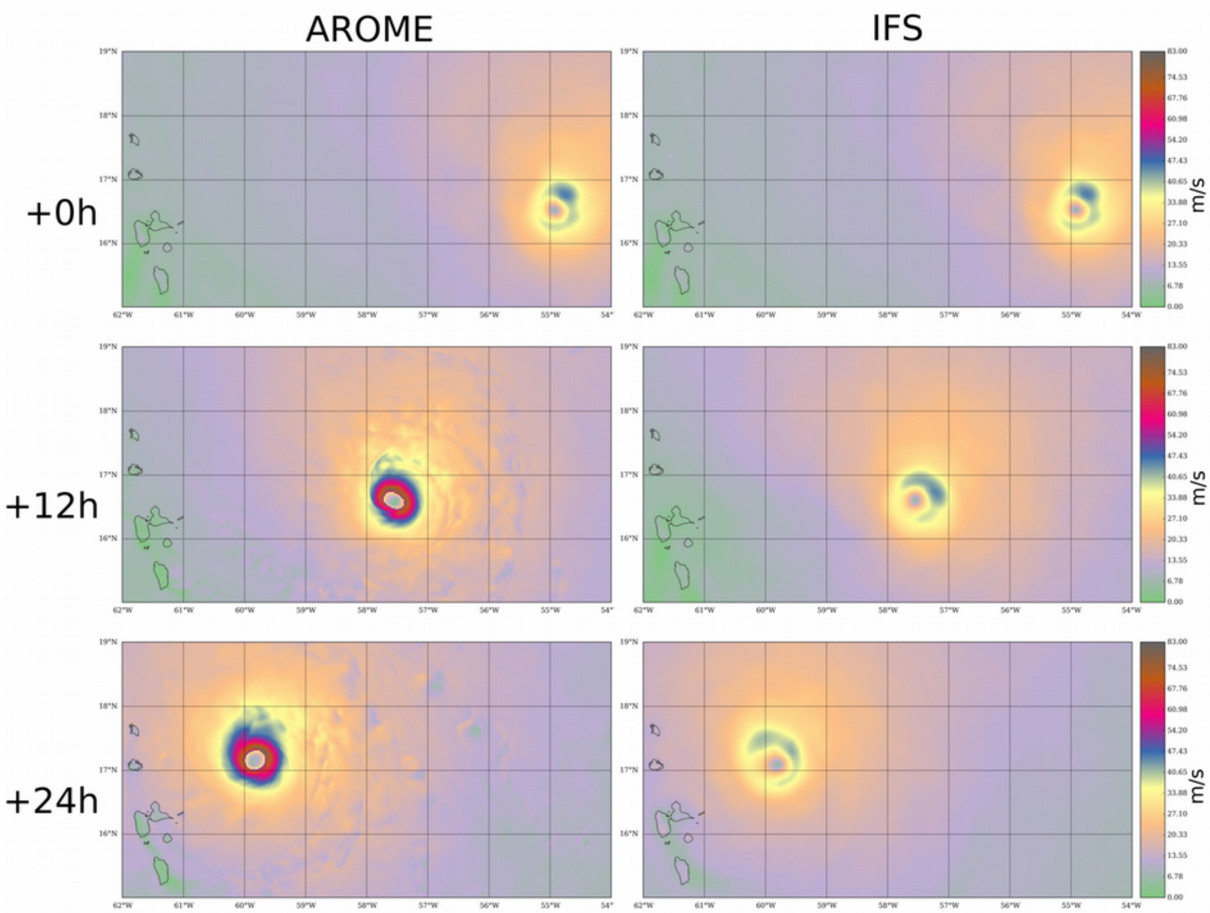


Figure 1: Average wind at about 10m for AROME (left) and IFS (right), for the forecast ranges of +0h (top), +12h (middle) and +24h (bottom); forecasts are from the 5 Sept 2017 00 UTC network.

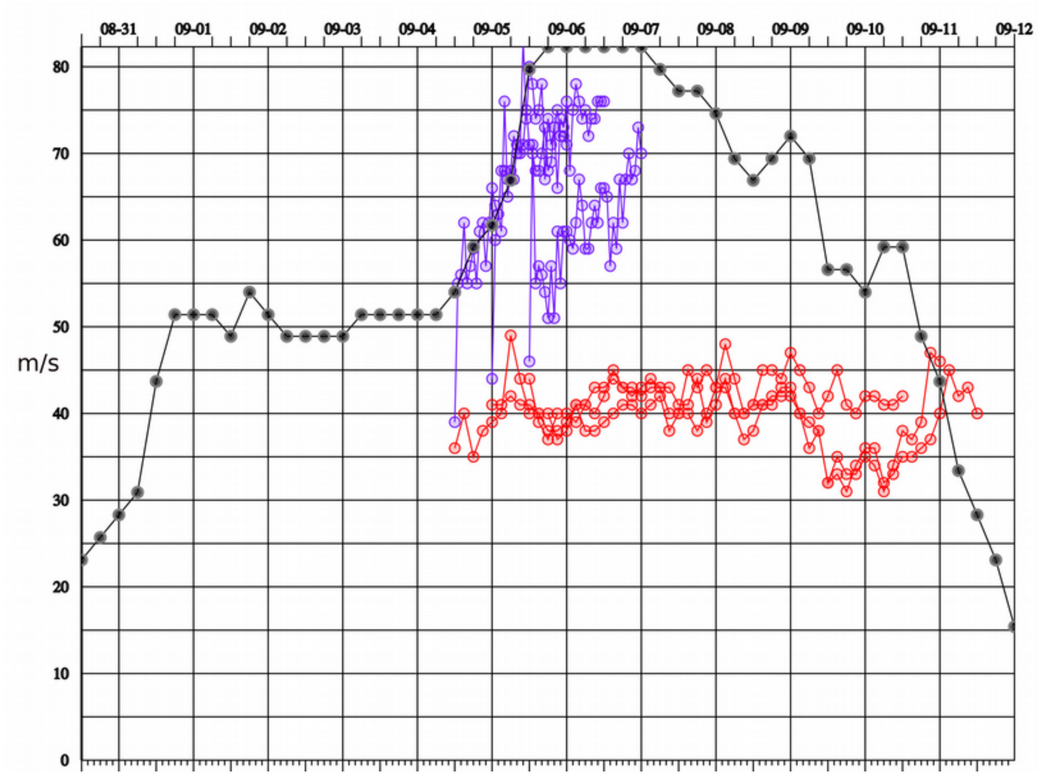


Figure 2a: Average maximum wind intensity from 3 forecast networks of AROME-Antilles (magenta) and IFS (red); the black curve represents estimated wind intensity from the NHC analysis (as a surrogate to observations). (a) Irma case.

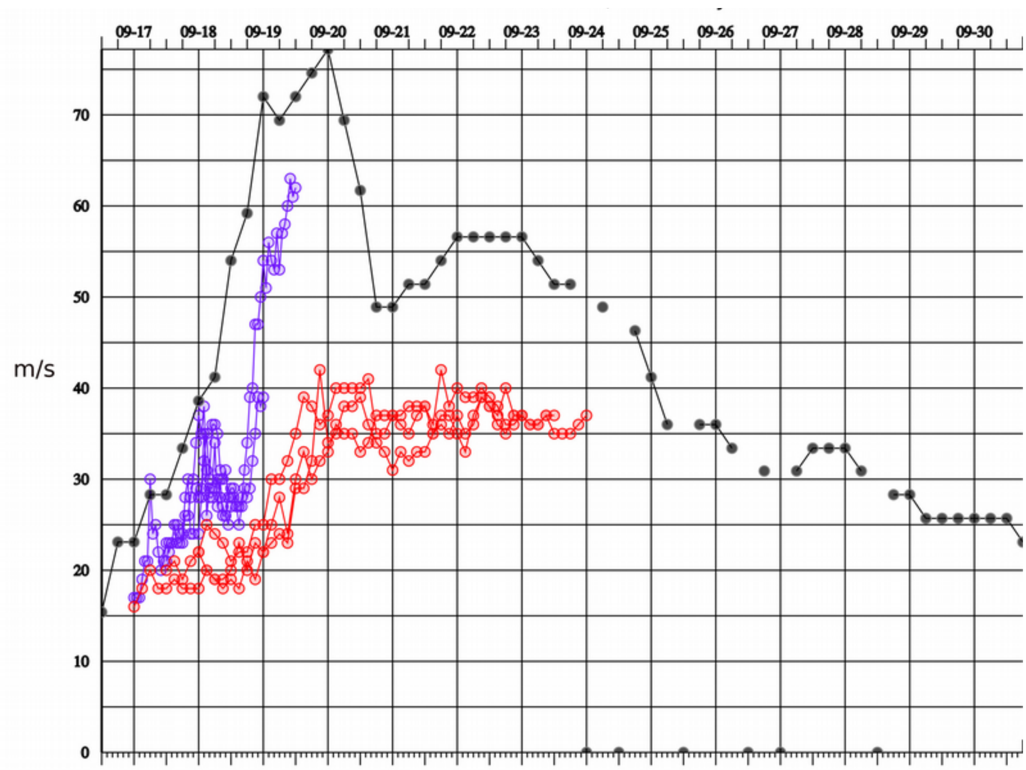


Figure 2b: Same as Fig. 2a. (b) Maria case.

Modelling activities at the Hungarian Meteorological Service

Antal Fischer, Viktória Homonnai, Máté Mester, Máté Mile, Réka Suga, Balázs Szintai, Mihály Szűcs
Hungarian Meteorological Service (OMSZ)

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. In 2017 there were no major upgrade in the operational configurations. Three limited area systems from the ALADIN/AROME model family are run operationally at OMSZ, which are described in Table 1.

Table 1: Operational model configurations at OMSZ.

	AROME	**ALADIN**	**ALADIN-EPS** (11 members)
Resolution	2.5 km	8 km	8km
Levels	60	49	49
Number of points	500x320	360x320	360x320
Boundaries	ECMWF deterministic (1h coupling)	ECMWF deterministic (3h coupling)	ECMWF ENS (3h coupling)
Runs per day	00, 06, 12, 18 (+48h), 03, 09, 15, 21 (+36h),	00 (+54h), 06 (+48h), 12 (+48h), 18 (+36h)	18 (+60h)
Data Assimilation	3 hourly (SYNOP, TEMP, AMDAR, MODE-S)	6 hourly (SYNOP, TEMP, AMDAR, SEVIRI, AMV, ATOVS)	-

This paper describes the developments related to these operational systems.

2 Research and development activities

Assimilation of GNSS ZTD observations in AROME 3DVAR

For the time being, the operational AROME data assimilation system includes only conventional observations. In order to extend the current observation set, the impact of Zenith Total Delay (ZTD) measurements of Global Navigation Satellite System (GNSS) are studied in the three hourly updated AROME 3DVAR system. During the OSEs, ZTD measurements from Hungarian(SGO1), Czech(GOP1) and Polish(WUEL) E-GVAP networks were pre-processed, pre-selected and studied providing dense ZTD observations over AROME/Hungary domain. Before the pre-selection procedure, the optimal thinning distance of ZTD stations was determined and a whitelist was generated according to the pre-selection criterias. During the impact studies both static and variational bias correction approaches were tested and compared on a summer and a winter period. A highlight of verification scores can be seen on figure 1. below.

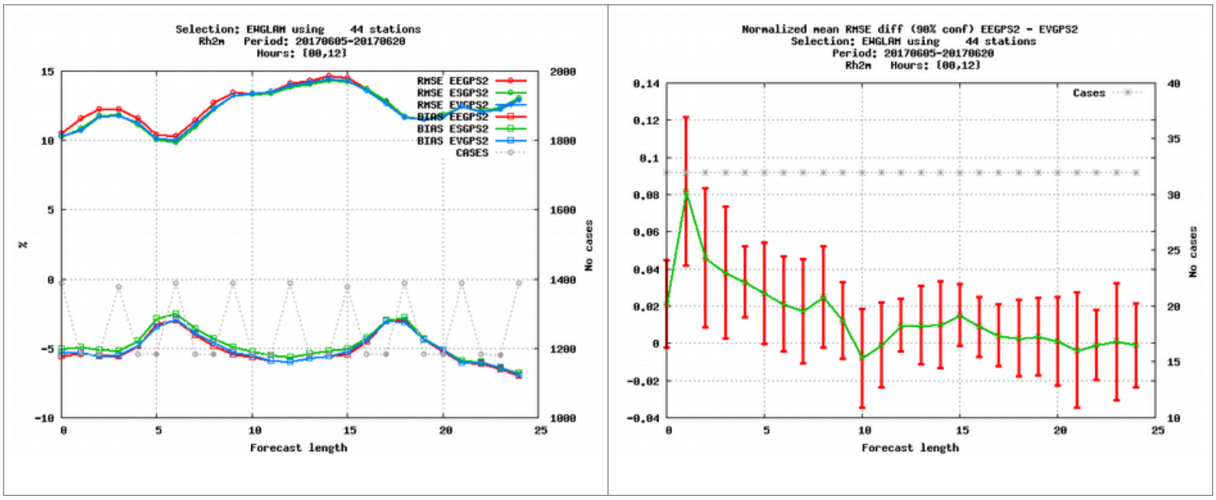


Figure 1. RMSE and BIAS of 2 metre relative humidity (left panel) for AROME operational (red), AROME with ZTD assimilation and static bias correction (green) and AROME with ZTD assimilation and variational bias correction (blue). Normalized RMSE differences of 2m relative humidity between AROME operational and AROME with ZTD assimilation based on variational bias correction for the period 2017-06-05 – 2017-06-20. Verification was made against EWGLAM SYNOP stations.

Implementation of Stochastic Pattern Generator (SPG) and its test with SPPT scheme in an AROME-EPS

The Stochastically Perturbed Parameterized Tendencies (SPPT) scheme was first implemented and successfully applied in ECMWF (Palmer et al., 2009). Its LAM version became also available and tested with AROME model by MeteoFrance (Bouttier et al., 2012). OMSZ started its convection-permitting EPS tests based on AROME in 2012 and SPPT scheme has been also in the focus since then. The first results were relatively poor which motivated further investigations. Finally the random pattern generator was reported as one source of the problems while its LAM version seemed not able to produce fields with the correct standard deviation and correlation values (Szucs, 2015).

The idea of implementing a new spectral pattern generator was examined as a part of a LACE stay in 2016 (Szucs, 2016). The Stochastic Pattern Generator (SPG; Tsyrulnikov and Gayfulin, 2016) looked as a favorable choice to replace the current one because it had some theoretically attractive feature and it was hoped to be easy to apply in ALADIN code. The main part of its implementation under cycle 38 took place in 2017 as a part of a following LACE stay (Szucs, 2017a). As a result, SPG method became available to generate random fields and work together with SPPT scheme. These fields are practically better tunable then with the default pattern generator and they have the “proportionality of scales” feature (Fig. 2).

The SPG based version of SPPT has been tested in an AROME-EPS, as well. The change of the pattern generator can lead to avoiding some strange model behave but at the same time it can not effectively increase the spread of the ensemble system. Its impact can be summarized as the perturbations become more correct but from smaller amplitude. Because of that reason SPG based SPPT's introduction is suggested together with further improvements in the application of random numbers. For instance, at OMSZ it was tested together with allowing perturbations in PBL (by switching-off the tapering function) and modification of the so-called supersaturation check part. This approach led us to promising results (Szucs, 2017b).

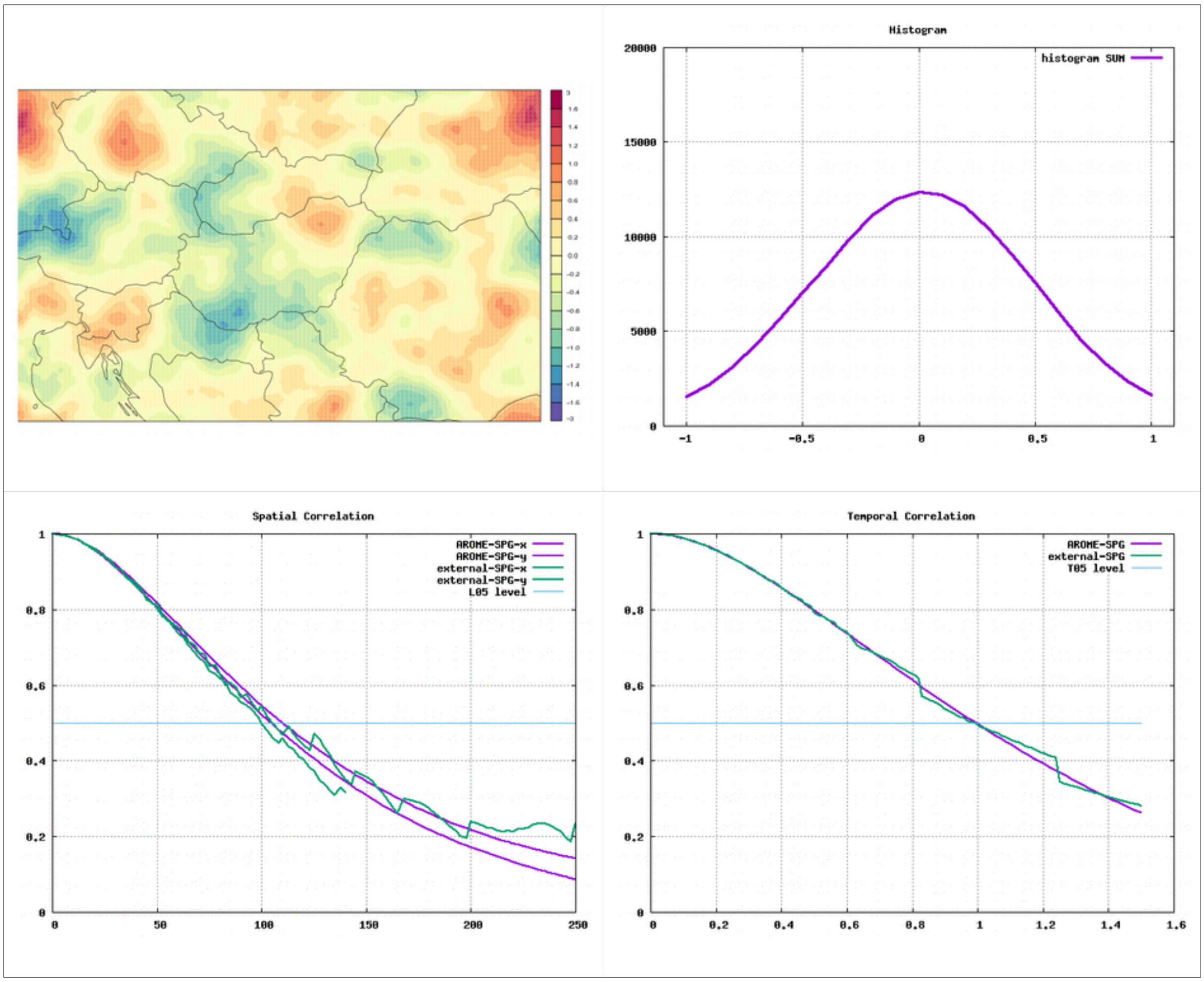


Figure 2. Upper left panel shows the random pattern generated by SPG while on the right side the histogram of the point-wise values can be seen. Bottom left panel shows the spatial correlation function of SPG based fields calculated from ALADIN implementation (two purple lines for two horizontal directions) and external SPG program (green lines). Bottom right figure is the same for temporal correlations.

3 References

Bouttier, F., Vié, B., Nuissier, O., Raynaud, L., 2012: Impact of Stochastic Physics in a Convection-Permitting Ensemble. Mon. Wea. Rev., 140, 3706–3721.

Palmer, T., Buizza, R., Doblas-Reyes, F., Jung, T., Leutbecher, M., Shutts, G., Steinheimer, M., Weisheimer, A., 2009: Stochastic parametrization and model uncertainty. Tech. Rep., ECMWF Tech. Memo. 598, 42 pp. [Available online at http://www.ecmwf.int/publications/.]

Szűcs, M., 2015: Tests of possible SPPT developments , Report on stay at ZAMG 28/09/2015 - 06/11/2015, Vienna, Austria

Szűcs, M., 2016: Stochastic pattern generators , Report on stay at ZAMG 23/05/2016 – 17/06/2016, Vienna, Austria

Szűcs, M., 2017a: Implementation of Stochastic Pattern Generator (SPG) in ALADIN code, Report on stay at ZAMG, 12/06/2017-21/072017, Vienna, Austria

Szűcs, M., 2017b: SPPT in AROME: pattern generator and other issues, SRNWP-EPS II Workshop presentation, 25/10/2017, Madrid, Spain

Tsyrulnikov M. and Gayfulin D. A limited-area spatio-temporal stochastic pattern generator for simulation of uncertainties in ensemble applications. – Meteorol. Zeitschrift, 2017, doi:10.1127/metz/2017/0815, in press.

Met Éireann Updates

Colm Clancy, Rónán Darcy, Sarah Gallagher, Emily Gleeson, Alan Hally, John Hanley, Eoin Whelan

1 Introduction

Met Éireann's operational Numerical Weather Prediction (NWP) activities during 2017 were mainly focussed on the porting of our operational NWP suite to run at ECMWF's High Performance Computing Facility (Section 2) and the testing for a planned upgrade to cycle 40 of the shared ALADIN-HIRLAM NWP System (Section 3). Preliminary work was also carried out on the introduction of a regional ensemble system (Section 4) and the use of ECMWF's SAPP system for observation pre-processing (Section 5). In Section 6 we discuss recent research in the ongoing regional reanalysis project, MÉRA.

2 Operational NWP in 2017

This section provides details of Met Éireann's operational NWP suite. The HARMONIE-AROME configuration of the shared ALADIN-HIRLAM NWP system, hereafter HARMONIE-AROME, is the main model used for operational short-range forecasts and additionally as a research tool for Met Éireann scientists. The HIRLAM model also continues to be run as part of the NWP suite. Table 1 below provides a summary of the configurations of both models.

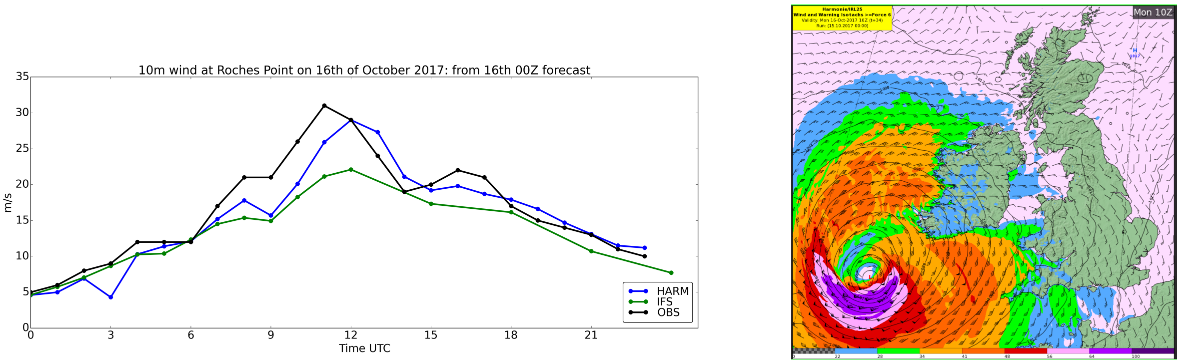
The 1200 UTC cycle on the 15th of August 2017 produced the first set of forecasts at ECMWF used operationally by Met Éireann. This followed the porting work carried out in 2016 and 2017 and an upgrade to the Irish RMDCN connection to ECMWF. The operational suite is monitored and running successfully under the "Framework for Member State time-critical applications - option 2" (ECMWF, 2015) using the ecFlow scheduler.

On the 16th of October, Ireland was hit by the extra-tropical extension of Hurricane Ophelia which resulted in three fatalities. Mean 10 m wind speeds of 31 ms^{-1} were recorded at Roches Point station in the south of the country; see Fig. 1(a). The accuracy of the HARMONIE-AROME forecasts leading up to this event was praised by the operational forecasters, particularly in relation to wind speeds.

Table 1: HARMONIE-AROME and HIRLAM operational configurations

	HARMONIE-AROME	**HIRLAM**
Version	37h1.1	7.2
Horizontal domain	540×500, 2.5 km grid	654×424, 0.1°grid
Vertical levels	65 levels, 12 m up to 10 hPa	60 levels, 31 m up to 10 hPa
Timestep	60 s	240 s
Observations	Conventional only (cut-off 45 mins)	Conventional only (cut-off 2 hrs)
Data assimilation	Surface analysis only	4D-Var
Forecast	54 hour forecasts at 0000, 0600, 1200, 1800 UTC	54 hour forecasts at 0000, 0600, 1200, 1800 UTC
Boundaries	IFS	IFS

Some stability issues arose, however, resulting in two forecast model crashes. Firstly, the 0000 UTC forecast on the 15th of October destabilised at a forecast time of approximately 34 hours, when the storm was due to have entered the southwest of the domain; see Fig. 1(b). The model time-step was reduced from a default of 60 s to 45 s and the subsequent cycles ran without incident at this value. However, the 00 Z forecast on the 16th crashed again, necessitating an unprecedented reduction of the time-step to 30 s.



(a) (b)

Figure 1: Ex-hurricane Ophelia on the 16th of October: (a) shows the operational 10 m wind forecasts from the 0000 UTC forecast on the 16th, at Roches Point station on the southern coast of Ireland; (b) shows the forecast at +34 hours from 0000 UTC on the 15th. HARMONIE-AROME encountered instabilities around this time.

3 Cycle 40 upgrade

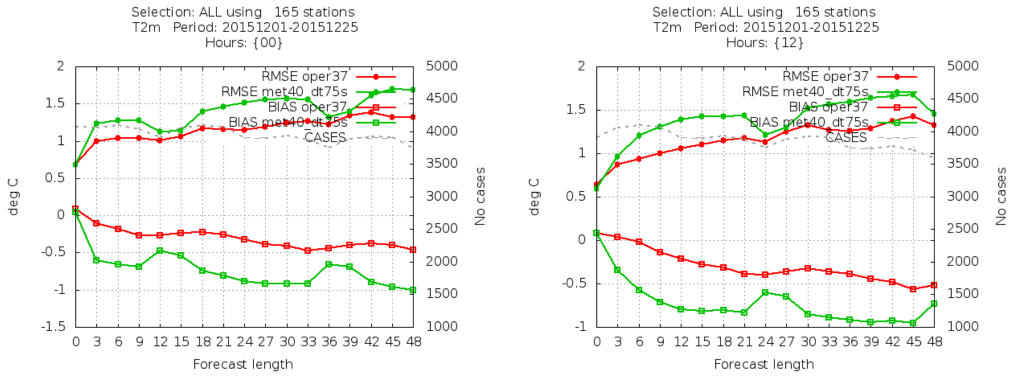
We plan to upgrade from our current operational cycle 37h1.1 to 40h1.2 of HARMONIE-AROME. As part of this upgrade, we intend to increase the domain size and to implement upper-air data assimilation (3D-Var) using conventional observations with a 3-hour cycle. Extensive testing of 40h1.2 was carried out in 2017 and results were compared with past operational cycle 37h1.1 forecasts. Although cycle 40h1.2 shows a general improvement in verification scores, especially for 10 m wind speeds, there was a significant degradation in the 2 m temperature forecasts and this has delayed the implementation of our HARMONIE-AROME upgrade. We have observed a consistent cold bias of up to 1 °C using the default HARMONIE-AROME settings; see Fig. 2.

A number of changes to the physics parametrizations have been investigated; see Fig. 3. Switching off HARATU showed an improvement in the temperature bias, but this degraded the quality of 10 m wind forecasts. We have also experimented with lowering the default value of the heat capacity of vegetation in SURFEX (PCV in the code) and this has improved the temperature biases. However, the physical basis for any such changes needs to be investigated further. This work will continue in 2018.

4 Ensemble System, IREPS

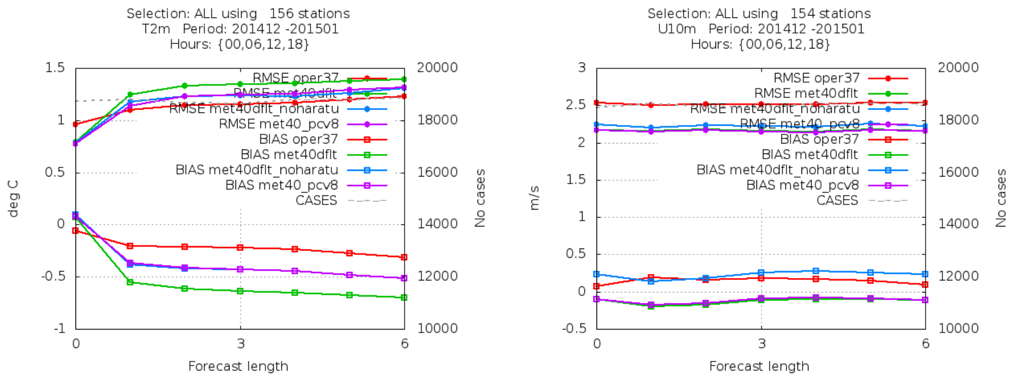
We plan to implement a version of HarmonEPS based on cycle 40h1.2 of HARMONIE-AROME. This implementation will be based on the Scaled Lagged Average Forecasting (SLAF) technique which has already been made operational at a number of other HIRLAM centres. Initial testing has been carried out with the default set-up available in cycle 40h1.2, along with some tests using the official HarmonEPS branch of the code. We plan to have an 11-member ensemble (10+1 control) running twice daily (0600 and 1800 UTC) out to +36 hours.

We aim to improve the short-range forecasting of high-impact weather events over Ireland with the introduction of IREPS (Irish Regional EPS). As such, our initial testing has focused on simulating a number of these types of



(a) (b)

Figure 2: Comparing cycle 40h1.2 with the operational cycle 37h1.1 for December 2015: point verification of 2 m temperature forecasts starting at (a) 0000 UTC and (b) 1200 UTC.



(a) (b)

Figure 3: Comparing cycle 40h1.2 with the operational cycle 37h1.1 for December 2014: point verification of (a) 2 m temperature and (b) 10 m wind forecasts. The cycle 40 experiments run with default physics (met40dflt), HARATU turned off (met40dflt_noharatu) and HARATU on but with a reduced value for the PCV parameter (met40_pcv8).

events which occurred in 2017. The most unprecedented of these was the passing of the extra-tropical extension of Hurricane Ophelia on the 16th of October 2017. At the time, the track was somewhat uncertain. Fig. 4 (a) demonstrates the projected track of the central pressure of Ophelia using our operational HARMONIE-AROME run from 0000 UTC on the 16th of October, while Fig. 4 (b) shows the track simulated by each of the 11 ensemble members in our initial IREPS set-up. The narrow geographical spread of the projected tracks illustrates the high model-confidence in Ophelia's path. Such an ensemble product would have been very useful for our forecasters to have on the morning of the 16th October.

5 SAPP evaluation

SAPP (Scalable Acquisition and Pre-processing) was introduced into operations at ECMWF in 2014, replacing the previous observation pre-processing system which ran for 20 years (Fucile et al., 2014). In Met Éireann we have tested this system as a possible replacement for our current operational pre-processing system called the ADE (Automatic Data Extraction), which has been used to process observational data for assimilation in our NWP models since the 1990s. The function of the SAPP processing chain is to:

- Acquire observations from multiple sources

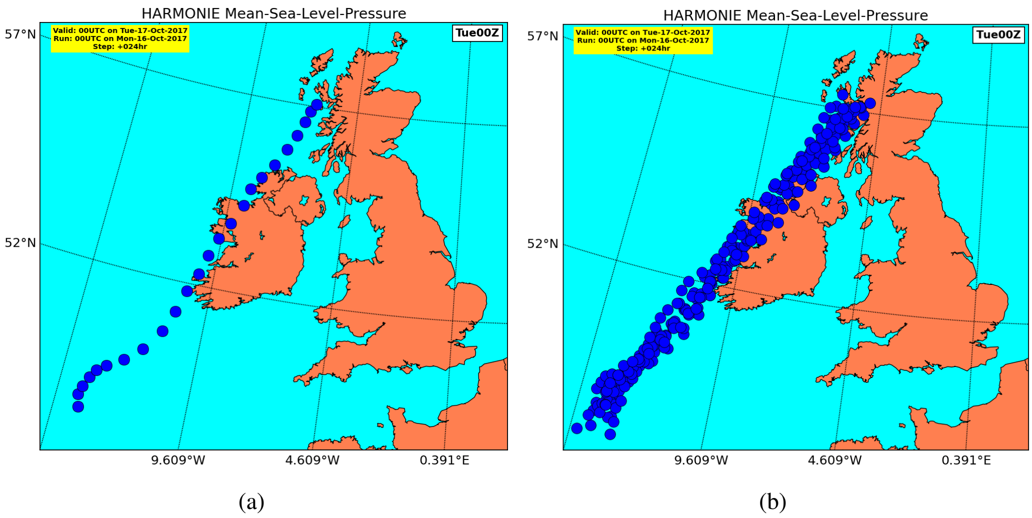


Figure 4: (a) Projected track of the central low pressure of Ophelia over a 24-hour period from the operational run of HARMONIE-AROME at 0000 UTC on the 16th of October. (b) Projected track of the central low pressure of Ophelia over the same period for each of the 11 ensemble members of IREPS.

- Decode these formats (for example, BUFR, GRIB, HDF, netCDF, ASCII)
- Apply QC to the process
- Convert to a consolidated format (ECMWF BUFR), before ingestion in data assimilation

SAPP was provided by ECMWF pre-installed on a virtual machine. The set-up, configuration and familiarisation of the system can be achieved within a short time-frame. A working version can conceivably be installed and begin processing GTS data in a matter of hours. The SAPP system was reliable and robust during the test period of six months. The preliminary evaluation of SAPP for use by Met Éireann would suggest that the SAPP system would be suitable for operational use by any institute.

6 Regional Reanalysis, MÉRA

Met Éireann has completed a regional reanalysis, called MÉRA, in 2017 which spans the period 1981 to 2017 and will be continued in close to real time as ERA-Interim boundaries become available. We used cycle 38h1.2 for this project which covers the same domain as we use operationally. We currently have approximately 100 users in Ireland, the UK, the Netherlands, Germany, the USA and Canada. Details on MÉRA can be found in Gleeson et al., 2017.

Here we focus on the monthly accumulations of precipitation compared to observations and coarser resolution datasets including ERA-Interim (79 km) and HARMONIE-ALARO from UERRA (11 km). Precipitation forecasts produced by these datasets were compared with observations of 24-hour accumulations of precipitation recorded by Met Éireann's network of (approximately 400) voluntary rainfall stations (0900 UTC to 0900 UTC). Fig. 6 shows areal comparisons of monthly precipitation (for winter, DJF) averaged over the period 1981-2015. ERA-Interim mainly underpredicts monthly precipitation, particularly over mountainous areas. Both UERRA and MÉRA also underpredict the precipitation over mountains, due to mismatches in orography; the 2.5 km and 11 km grid spacings cannot resolve all mountain peaks contained within a grid box. UERRA underpredicts precipitation over most of the country whereas MÉRA overpredicts except over high ground. As expected, the higher resolution MÉRA shows an improvement over the coarser resolution ERA-Interim and UERRA, which underestimate precipitation at the Irish rainfall stations. MÉRA shows similar bias patterns for each season (not shown) i.e. negative biases over high ground and positive elsewhere.

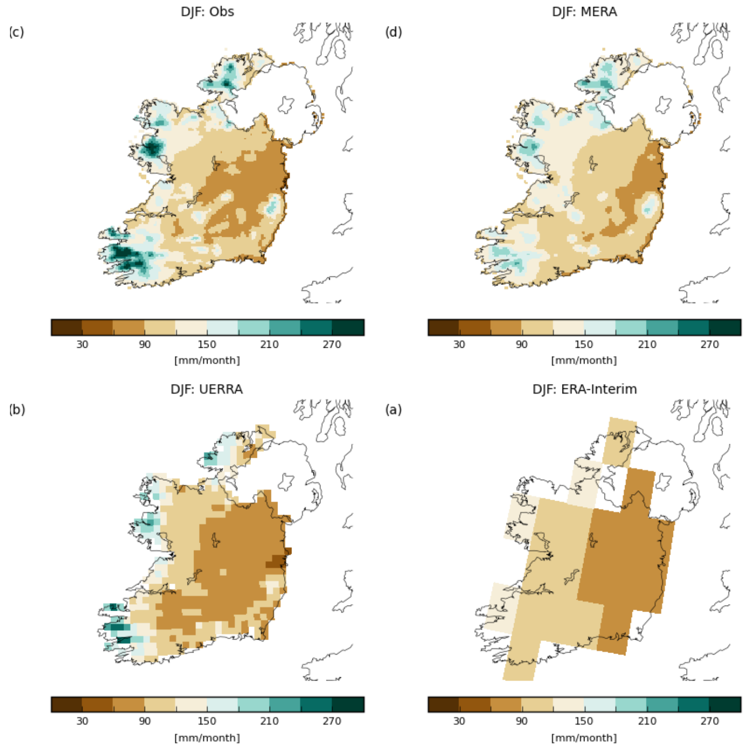


Figure 5: Monthly mean DJF precipitation for the period 1981-2015 (a) Observations projected on to the MÉRA grid, (b) MÉRA (c) UERRA and (d) ERA-Interim

7 Summary and Outlook

The past year has seen some significant NWP developments at Met Éireann. The move of our operational suite to ECMWF followed 11 successful years using ICHEC HPC platforms. Significant work in the area of NWP during 2017, including the preparation for the upgrade to cycle 40, the development of an ensemble prediction system and the evaluation of SAPP, should put Met Éireann on a good footing for the coming years.

The operational version of HARMONIE-AROME will be upgraded from cycle 37h1.1 to 40h1.2 in the second quarter of 2018. The implementation of HarmonEPS for Ireland, IREPS, will be made operational in the second half of the year. Other planned NWP developments include further local development of SAPP, the assimilation of radiance data and the evaluation of locally received Mode-S observations.

8 References

ECMWF: *Framework for time-critical applications*. ECMWF Internal Report, available to download from https://software.ecmwf.int/wiki/display/UDOC/Time+Critical+applications, February 2015.

E. Fucile, Zanna, C., Mallas, I., Crepuljia, M., Suttie, M., and Vasiljevic, D.: *SAPP: a new scalable acquisistion and pre-processing system at ECMWF*. ECMWF Newsletter No. 140, Summer 2014, pp. 37-41.

Gleeson, E., Whelan, E., and Hanley, J.: Met Éireann high resolution reanalysis for Ireland, Adv. Sci. Res., 14, 49-61, https://doi.org/10.5194/asr-14-49-2017, 2017.

Some numerical weather prediction activities in Moroccan Meteorological Service (DMN) related to ALADIN-HIRLAM CONSORTIUM in 2017

1 Quality control and proceeding of local GPS data before assimilation

Hdidou, F.Z . and Sbii, S.

Beside the GPS (Global Positioning System) traditional application for precise geodesy, the GPS system has proved to be a powerful tool in atmospheric studies, such as climatology and meteorology. In fact, the Zenith Tropospheric Delay (ZTD) of the GPS signal induced by the refraction in the troposphere is related to the atmospheric Integrated Water Vapor (IWV).
The GPS network of the Moroccan Meteorological Service comprises ten permanent ground-based GPS stations. The present work describes the developed operational processing of GPS data based on BERNESE software. It presents also the evaluation of the accuracy of ZTD. The accuracy is evaluated by comparison to equivalent values derived from radiosonde profiles. The comparison of GPS ZTD and radiosondes ZTD time series over almost one year (2016) shows a good agreement and a seasonal signal with higher values of ZTD in summer and lower in winter. Furthermore, a negative bias of -2.82 mm and a standard deviation of 14.01 mm are found.

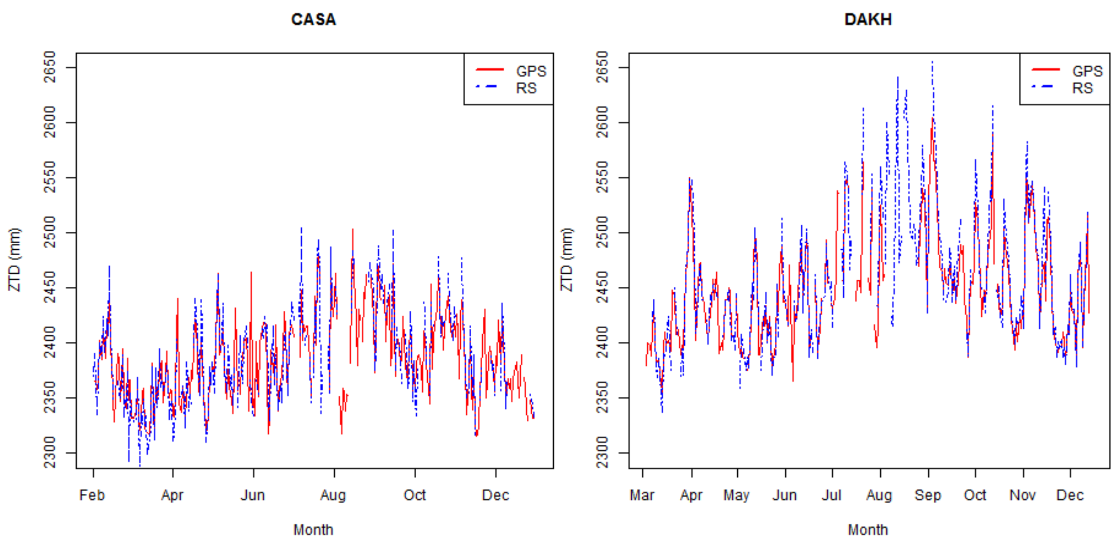


Figure 1. Time series of GPS ZTD and radiosonde ZTD (mm) at CASA station from 1 February to 31 December 2016 (left) and for DAKH station from 19 March to 31 December 2016 (right).

2 A validation of Local Radar Data before assimilation

Sahlaoui, Z.

Precipitation measurement and forecast are from big interest to human safety and many economic activities. Therefore, in one hand, radar QPE (Quantitative Precipitation Estimate) is continuously enhanced to better represent precipitation structure and amounts. In the other hand, many efforts are undertaken in numerical weather prediction to improve the quality of the model forecast in case of heavy rain events, especially by assimilating rainfall measurements (Lopez 2011)[i].

The present work aims to improve QPE from moroccan radar by using rain gauge measurements. Thus the data from a C-band radar located at Khribga is first quality controlled to remove clutters and to correct the signal attenuation. The radar QPE shows an underestimation when compared to the rain gauges. In the next step, radar QPE is merged with 11 rain gauges measurement over an area of about 150km radius. The merge procedure is based on a mixed model assuming that the difference between radar QPE and rain gauges has both additive and multiplicative terms Rradar = A* Rgauge + B. The validation of the adjusted radar QPE against CPC rain (Novella et al, 2012)[ii] shows a clear improvement.

3 Study of the Wind shear predictability in airports using AROME-MAROC

Sbii, S.

The objective of this work is to evaluate the capability of the Moroccan operational version of AROME in modelling the wind in the lower layers of the atmosphere especially in the airport zone. The data used for this assessment are the horizontal wind components observed and transmitted by AMDAR (Aircraft Meteorological DAta Relay). These data are used because of the lack of other wind measurements in the airports domains. We have made comparisons of AROME-MOROCCO Cycle 41t1, the horizontal resolution is 2.5km and the vertical resolution is 90 levels. The series of data used is spread over a year since April 2016. The boundary layer of interest corresponds to the first 1000m, modeled in AROME by more than 20 vertical levels. The comparison between model data and AMDAR data is done in the observation space. To do this, the direct operator of the 3DVAR assimilation system is used to produce the wind values (horizontal components) from the model in the AMDAR observation points. The results for the wind at 00h show an annual zonal wind bias varying between 0.01ms-1 and 0.12ms-1 , and an annual meridional wind bias of 0.05ms-1 and -0.05ms-1 depending on the altitude. The standard deviations vary between 1.74ms-1 and 2.3ms-1 for the zonal wind and between 1.69ms-1 and 2ms-1 for the meridional wind. This work is a preliminary step in modeling studies of wind shear at airports in the region.

4 3DVAR- AROME phasing and introducing local data

Hdidou F.Z and Sahlaoui Z.

To prepare the Benchmark for a new machine in DMN (Direction de la Météorologie Nationale), a test of AROME 3DVAR was performed. It's based on cy41T1 with horizontal resolution of 2.5km and 90 vertical levels. The cycling period is 3 hours and the data used are conventional observations. Boundary conditions are provided by ALADIN-7.5km. An example of model outputs is shown in figure 2. In parallel, some case studies are undertaken to assess the impact of this new AROME version over Morocco.

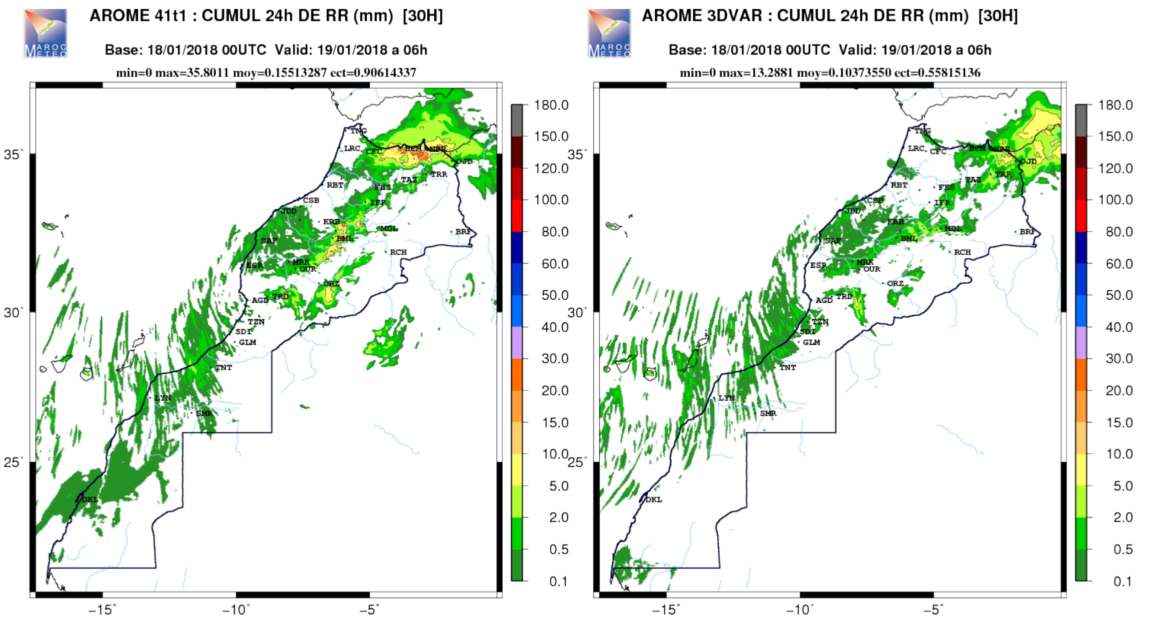
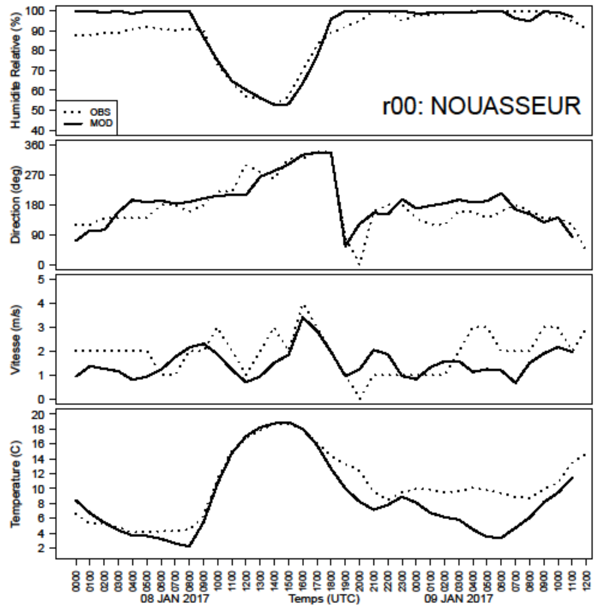


Fig2: 24h cumulated rainfall amounts forecasted by both operational version (left side) and Arome 2.5 km using 3DVAR initialization (right side)

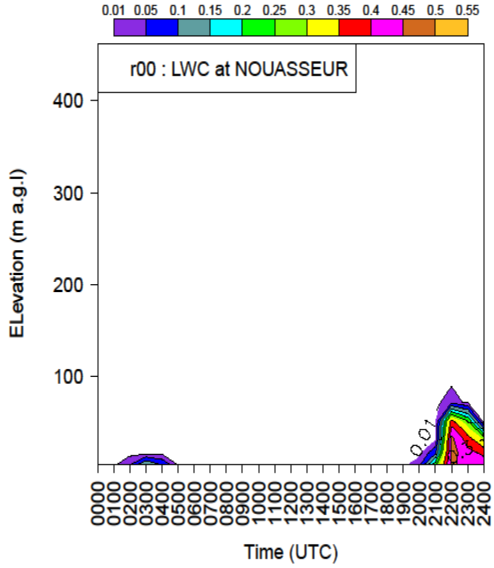
5 Numerical simulation of an advection-radiation fog event over Morocco with AROME Cy41T1 1.3km

BARI, D. and EL KAROUNI, K.

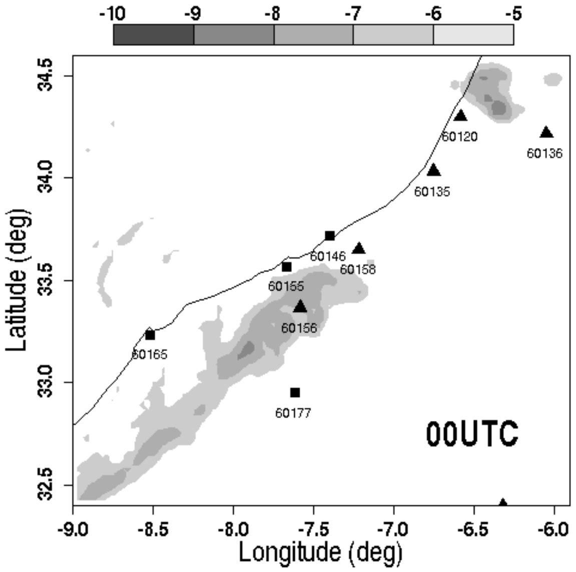
Operational short-term fog forecasting is a real challenge and has safety and economic impacts, especially for airports. To take into account of surface heterogeneities, recent research studies have focused on fog forecasting with 3D mesoscale models. Fog onset is controlled by several physical and dynamical processes that differ according to fog type; thus to forecast the fog events accurately, the numerical model resolution should be fine enough to represent the local circulations and small-scale vertical exchanges occurring during the fog life cycle. In this study, a prototype of nested AROME based-models has been developed. Simulations are performed over a small domain (250 x 250 grid points) and are centered over the northwestern part of Morocco, containing the main national airports with a 1.3-km horizontal resolution and 90 vertical levels with the lowest one at 5m. The lateral boundary conditions are issued from AROME with 2.5-km horizontal resolution and 90 vertical levels. Results show that the developed prototype capture well the occurrence of the fog event but it anticipates the fog onset two hours earlier than in observation at Nouasseur international airport (Fig. 3a and 3b). For the spatial extent over the study domain, it is found that the simulated fog event covers a large area than in observation in comparison with MSG data and local meteorological measurements from synoptic stations (Fig. 3c vs 3d). This shows that predicting fog onset and dissipation with high precision still a challenge for researchers. To evaluate the advantages and drawbacks of the developed prototype, a systematic study will be performed over a winter season.



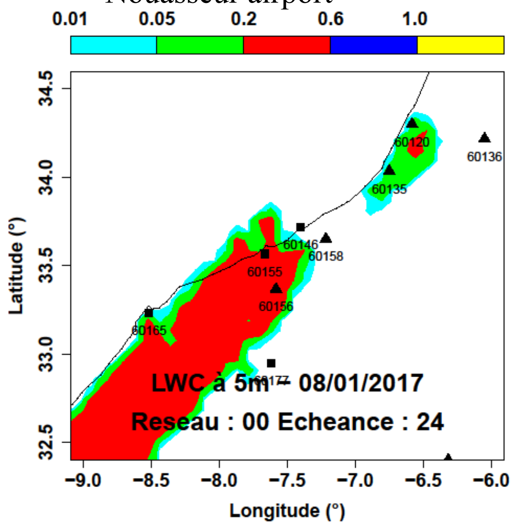
(a) Observed (dashed line) vs simulated (solid line) near-surface meteorological parameters at Nouasseur airport



(b) Liquid water content(g.m-3) as function of time and height at Nouasseur airport



(c) Brightness Temperature Difference product issued from MSG showing the spatial extent of the observed fog / low cloud over the study domain



(d) Spatial extent of the simulated fog event based on LWC at 5m over the study domain.

Fig 3: the observed versus simulated fog event over the studied domain with a zoom on the Nouasseur airport

6 References

i. Lopez P. 2011. Direct 4D-Var Assimilation of NCEP Stage IV Radar and Gauge Precipitation Data at ECMWF, Monthly Weather Review 139 : 2098-2115.

ii. Novella NS, Thiaw WM. 2012. African Rainfall Climatology Version 2 for Famine Early Warning Systems. Journal of Applied Meteorology and Climatology.

An Arctic Dedicated, Convective Permitting Model

Richard Moore, Morten Køltzow, Teresa Valkonen, Eivind Støylen,
Gunnar Noer and Jørn Kristiansen
(Norwegian Meteorological Institute)

1 Introduction

Over the past decades the Arctic has warmed more than any other region in the world with profound socio-economic consequences. Thus, our current weather forecasting systems are challenged by increasing interest in accurate forecasting products. There are many challenges for Arctic weather prediction, e.g. the sparse observation network, atmospheric data assimilation, the representation of sea-ice, and the high-latitude representation of many sub-grid scale parameterizations.

The limited area model AROME-Arctic, employed in the European Arctic, is a particular Norwegian Meteorological Institute (hereafter, MET Norway) configuration of the HARMONIE system (Figure 1 presents the model domain, see Müller et al. for further details). The Arctic forecast and research activities at MET Norway focus on use and further development of this particular system. In addition to the core activities at MET Norway, AROME-Arctic is a part of a variety of research projects.

Herein is presented current developments and recent results of AROME-Arctic.

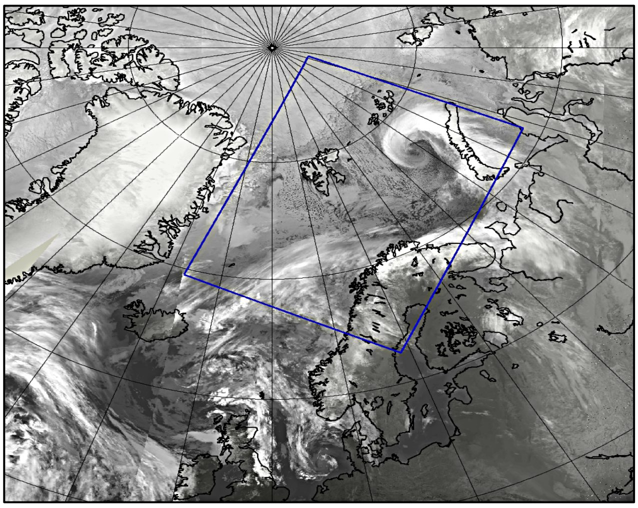


Figure 1: AROME-Arctic domain (blue box)

2 Model Description

AROME-Arctic has been in operational use since autumn 2015. It is a limited area model that provides four daily forecasts up to +66 hr lead time on a 2.5 km horizontal grid and 65 vertical levels. It is currently based on HARMONIE cycle 40h1.1. Data assimilation is comprised of 3D-var including surface analysis with a 3-hour cycling time (using conventional observations, scatterometer data and satellite radiances). The lateral and surface boundary conditions are from the ECMWF IFS high resolution and the EUMETSAT OSTA / OSI-SAF).

The full model output is openly available to the public at thredds.met.no. It is the source of the forecasts on Yr.no in the European Arctic, and is used actively by the on-duty meteorologists, researchers and downstream users.

3 Verification Efforts

It is critical to assess the performance of AROME-Arctic from an IT perspective (running time, crashes, etc. – assessed at weekly meetings) and with respect to current operational benchmarks: global model forecasts from ECMWF (hereafter, IFS HRES) and the MetCoop Ensemble Prediction System (MEPS). These ongoing efforts include long-term verification statistics, operational forecaster feedback (Section 4) and case study analyses (Section 5).

A 'Scorecard' analysis of the comparison of AROME-Arctic and IFS HRES is presented in Figure 2. Each column indicate a stratification of synoptic observation stations. Green (red) indicate AROME-Arctic has better (worse) scores than IFS HRES. Circles indicate small differences in performance while triangles indicate larger differences. Parameters are total cloud cover (NN), 24 hr accumulated precipitation (AccPcp24h), Relative humidity at 2m (RH2m), Mean Sea Level Pressure (Pmsl), 10m wind speed (S10m) and 2m air temperature (t2m). Metrics used are Mean Absolute Error (mae), Equitable Threat Score (ets) for given thresholds of 24hr precipitation [mm] and wind speed [m/s], systematic errors (bias).

To summarize the results:

- AROME-Arctic outperforms IFS HRES with respect to wind speed and 2m air temperature. Most likely this is due to the better resolution of topography and coast lines in AROME-Arctic. The temperature forecasts are not height corrected to observation heights and such an adjustment will decrease the difference for 2m air temperature. However, AROME Arctic will still outperform IFS HRES.
- For Mean Sea Level Pressure there are small differences, but a noticeable advantage for the IFS HRES forecasts.
- For near surface humidity and cloud cover AROME-Arctic is not as skillful as IFS HRES.
- For precipitation, there is a mixed signal. IFS HRES performs better for moderate precipitation amounts. However, AROME-Arctic forecasts are in general better than IFS HRES with respect to precipitation / no-precipitation and large precipitation amounts.

The overarching conclusion is that, in general AROME-Arctic adds value to the global available IFS HRES forecasts, but not necessarily for all variables. Ongoing work is dedicated to further AROME-Arctic improvements.

4 Forecaster Feedback

A determined effort is underway to analyze AROME-Arctic results in the context of weather events. An integral part is to have a synergistic interaction between operational forecasters (whom use the model on a daily basis) and model developers.

A web-based system has been constructed wherein forecasters can present case study results (both for good and poor model performance) and receive feedback from the model development team. A 'sample' is presented in Figure 3.

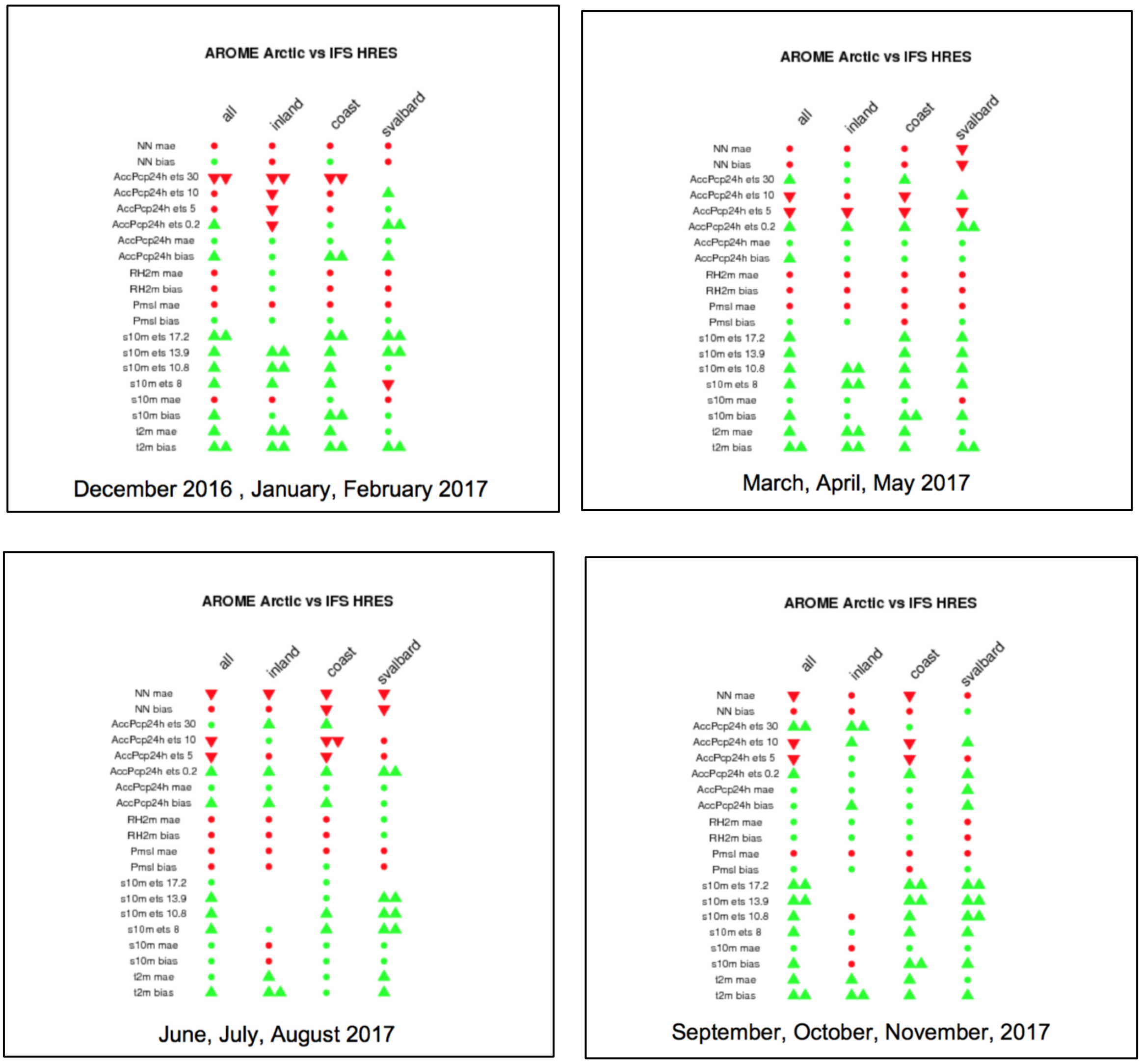


Figure 2: Scorecards AROME Arctic vs IFS HRES, +7 hour - +30 hour forecasts.

5 Case Studies

A number of weather events have been examined in greater detail to assess model performance.

As an illustrative example, a precipitation event that impacted northwestern Norway in December 2017 is presented in Figure 4. A squall line from the northeast resulted in strong showers and gale force winds. The squall line was well captured by AROME-Arctic and the forecast for precipitation amounts were very accurate (13.4 mm / 12h for Tromsø in AROME-Arctic while observed amount was 15.1 mm / 12h).

For this event, both MEPS control and IFS HRES underestimated the precipitation amount in Tromsø. Even though the squall line was well captured, precipitation from shallow convection over the ocean and the coastline (south of the squall line) was underestimated compared to radar observations. This illustrates a typical winter-time problem which regularly occurs both in AROME-Arctic and MEPS.

Dato	Parameter	Erfaringer (hva er bra eller dårlig)	Vedlegg	Brukernavn	Kommentar fra SUV
28.11.2017	PL/SPM	Polart lavtrykk som var bra tatt av AA. Her fra 12-kjøringen fra 27.11. SPM fra hovedsenteret treffer bra. To track lenger vest er mindre i samsvar, og viser til mye svakere utviklinger. Prognosen og satellittbildet fra kl. 15 en 28 viser at SPM klarer å skille mellom et nærliggende hovedsenter og selve PL'et, enten ut fra virvling eller fra diameteren. Dette kan være et bra case siden vi har aktuelle oppstigninger fra Bjørnøya fra tre terminer.		gunnarn	Takk for tilbakemelding, dette er en fin case å se videre på. Eivind
23.10.2017	Sørøst mye vind i Trøndelag/Helgeland	Arome har 1-2 beaufort for lite vind på Sklinna, Nordøyan og Halten fyr. Det handler nok om fjellbølger med fallvind som er vanskelig å løse opp, og at en modell med bedre oppløsning hadde trolig fanget det bedre, men gir ihvertfall tilbakemelding på dette. Ventes enda mer vind i morgen.		Eirik (eiriks)	Takk for tilbakemelding! Dette ble presentert på møte 26. okt., det er vist at høyere oppløsning kan løse denne utfordringen. Eivind
06.10.2017	Instabilitetslavtrykk som har likhetstrekk med PL sørøst for Jan Mayen	Posisjonen til Arctic er veldig dårlig + fullstendig feil oppstigning over Bjørnøya. Over Jan Mayen er forskjellene mindre, men også her utmerker Arctic seg negativt ut. 12 timers prognosen til ECMWF er mye riktigere på plassering av lavtrykk, samt oppstiningen på Bjørnøya. På Jan Mayen er ECMWF + Metcoop bedre enn Arctic, men ingen følger oppstigningen godt nok.		Eirik (eiriks)	Takk for en veldig viktig tilbakemelding! Vi har ikke hatt data assimilasjon i arome-arctic siden 11.september, har identifisert feilen og det skal nå forhåpentligvis være fikset innen en termin eller to (altså innen termin 2017101000). Eivind

Figure 3: Web-based forecaster feedback

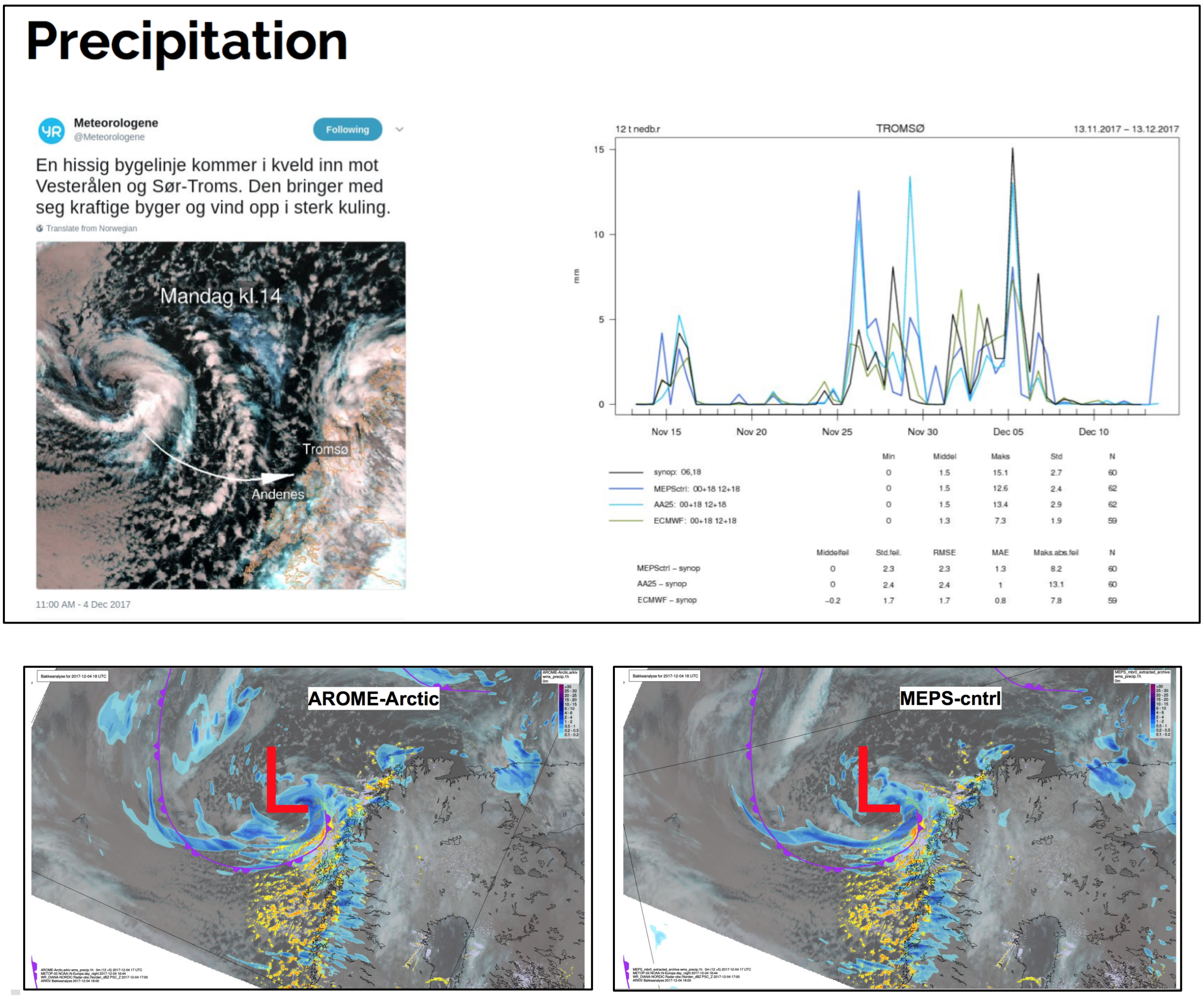


Figure 4: Visual summary of 4 December 2017 precipitation event. Yr.no tweet (top left); 12-hour precipitation for Tromso observation site, IFS HRES, AROME-Arctic and MEPS control (top right); operational forecaster subjective analysis, radar imagery (warm colors) and model predicted precipitation (blue colors) in the bottom panels.

6 Future Work – Research Projects

The effort to improve the performance of AROME-Arctic is ongoing. Weekly meetings discussing salient issues are conducted to aid the process. In conjunction, a number of funded international research programs are currently or will be soon be taking place. They include:

- ALERTNESS (Advanced Models and Weather Prediction in the Arctic: enhanced capacity from observations and polar process representations): primary objective is to develop world leading capacity for the delivery of reliable and accurate Arctic weather forecasts and warnings for the benefit of maritime operations, business and society.
- Nansen Legacy Project – Towards a Coupled Arctic Prediction System
- CARRA (Copernicus Arctic Regional Reanalysis)
- NORDNWP: to identify and use the best physiographic databases in order to get the best forecast.
- APPLICATE (Advanced Prediction in Polar Regions and Beyond): to developo enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on Northern Hemisphere mid-latitudes, for the benefit of policy makers, business, and society.

In addition, MET Norway will play an active role in the upcoming Year of Polar Prediction led by the World Meteorological Organization (see http://www.polarprediction.net). The enhanced observations and international collaborations provide an exciting and unique opportunity for enhanced knowledge and predictability of the Arctic weather.

7 References

Müller, M., Y Batrak, J. Kristiansen, M. Køltzow, and G. Noer, 2017: Characteristics of a Convective-Scale Weather Forecasting System for the European Arctic. *Mon. Wea. Rev*. **145**, 4771-4785.

Recent development in MetCoOp

The MetCoOp team

Corresponding author: Ulf Andrae, SMHI

1 Introduction

In October 2017 a new milestone was reached within MetCoOp when FMI started to use the MetCoOp ensemble (MEPS) in their daily forecasting. The preparations involved not only an extended domain including areas of interest for FMI, it also included Teho, the HPC used at FMI, to the already existing resources Frost and Alvin located at NSC Sweden. The extra resources allows us to maintain the 10 member ensemble although the domain has been extended. In addition the 24/7 monitoring is now performed by FMI operators. In the following we describe the operational improvements during 2017 and the next version targeted for operational implementation.

2 MEPS

The forecast model

The current operational version of the MetCoOp ensemble (MEPS) is based on harmonie-40h1.1 (http://hirlam.org/trac/wiki/Harmonie_40h1) with the forecast model setup as described in Bengtsson et.al. (2017) with local modifications following Andrae (2017). No major changes has been done to the forecast model during the past year but the atmospheric physics has been altered by an improved description of freezing rain (Ivarsson, 2017).
In March 2017 SMHI switched from HIROMB to NEMO as the main operational oceanographic model. SST and ice from the ocean model is used in HARMONIE over the Baltic sea as well as the lakes Vänern and Vättern. The meteorological impact was small but with a small reduced T2M negative bias along the coasts following more realistic SST.

Upper air and surface assimilation

The assimilation setup is based on 3DVAR with large scale mixing within a 3h cycle using a large set of observations as described in Andrae (2017). During 2017 the observations used have been extended to include:

- Finnish, Danish and Estonian radars
- Switch GNSS processing center to NGAA allowing an increase of the number of stations from 28 to 72
- Added assimilation AMSU-A/MHS data from METOP-B

The structure functions used operationally have been updated in two steps. First by a downscaling using four members from the ECMWF ensemble data assimilation (EDA) system for June 2016 and January 2017. Structure functions from a combination of these two months was implemented in operations in April 2017. The new period for the structure functions allows us to benefit from the resolution increase in CY41R2. As a second step a EDA run with HARMONIE has been performed using the same observations as in operations. Running our own EDA system give additional improvements in the analysis by introducing smaller scales for the increments, figure 1.

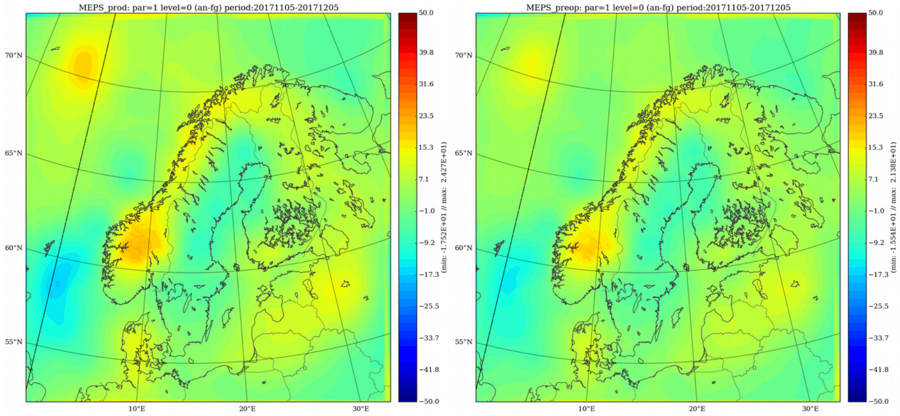


Figure 1: Surface pressure analysis increments for December 2017. Using structure functions derived by downscaling (left). Using EDA derived structure functions (right).

The snow assimilation has been changed from being done twice a day (06Z and 18Z) to once a day since Finnish snow observations are now available at 06Z like most other stations in the domain. Due to an inconsistency in the land sea mask treatment between CANARI and SURFEX we've started to blacklist stations adding snow increments where the model first guess is always zero, figure 2.

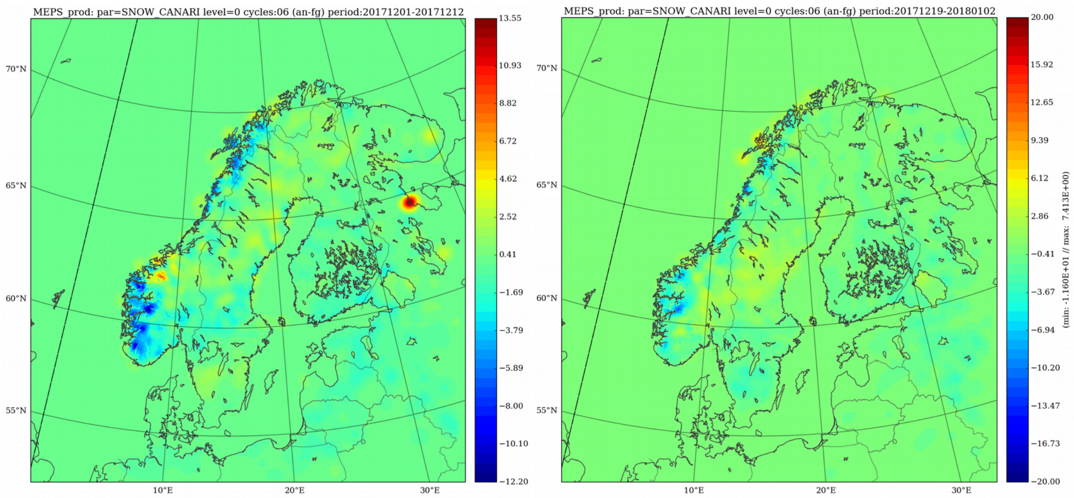


Figure 2: Snow increments in CANARI. Left shows first part of December, Right second part.

Compared to HIRLAM still running e.g. at FMI, HARMONIE-AROME has problems to forecast very cold temperatures. The very warm bias in the first guess in cold cases causes T2M observations with a large departure to be rejected in the surface analysis. Increasing the rejection limit, RCT2SY in NAMCOK from 3.9 to 10, allows the surface assimilation to use more observation and improves the forecast, figure 3.

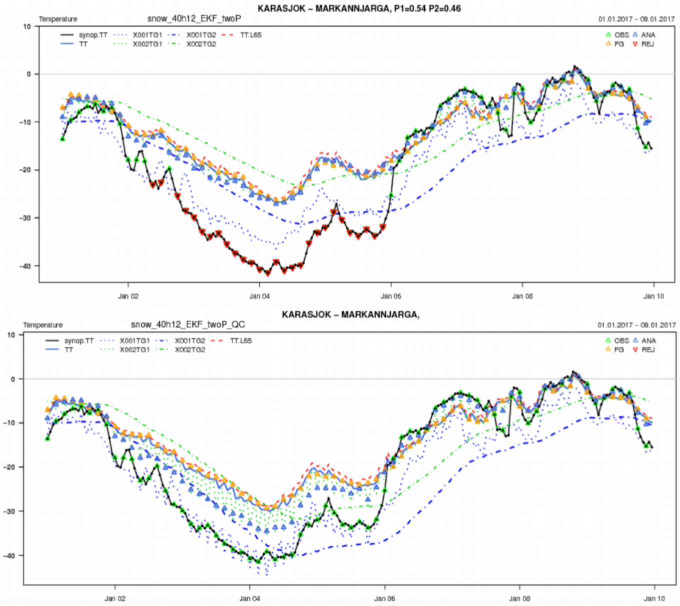


Figure 3: Evolution of T2M for Karasjok, January 2017. In the upper panel RCT2SY=3.9 is used and in the lover RCT2SY=10. The black solid line are the observations. Red triangles shows rejected stations and blue triangles the analysis.

A well working observation diagnostics is cruisal for the daily monitoring and for this purpose Obsmon is a valuable tool. Obsmon has recently been rewritten both in terms of the underlying structure and in the user interface. Figure 4 shows and example of the new stations statistics.

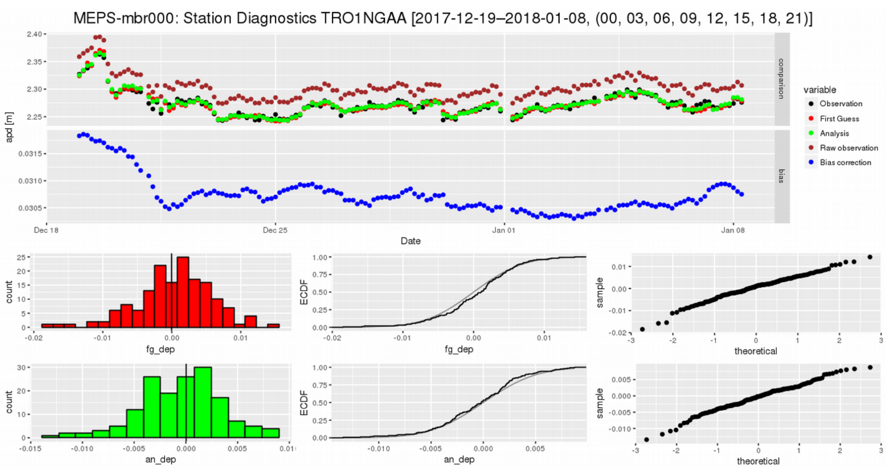


Figure 4: Station statistics for a GNSS observations.

Ensemble settings

The biggest change in the ensemble is the introduction of the surface perturbation scheme following Bouttier et. al. (2016). In the MetCoOp implementation the perturbations have been restricted to roughness, albedo, SST, soil temperature and soil wetness. LAI, vegetation cover, snow and CV have been kept untouched for the time beeing as compared to the implementation described by Bouttier. A more comprehensive study of the impact of the surface perturbation scheme in MEPS has been reported by Singleton et.al. (2017) and will not be repeated here. It's clear however that the increased spread achieved in the experiments is maintained in the operations.

MEPS uses the SLAF method to generate perturbations on the boundaries, see Andrae (2017) for further details. The method require some tuning of the scaling parameter SLAFK to achieve equally sized perturbations for the different members and has been adjusted in operations compared to the initial settings.

Diagnostics from January 2017 indicated unexpected large differences in the surface variables between the control member and the perturbed members. It was speculated that the difference in the surface assimilation cycle, 3h for control vs 6h for the members, could cause this differences and it would be better to apply the surface perturbations directly on the control surface analysis. It turned out however that both for a summer and winter period, figure 5, a combination of surface assimilation and surface perturbations for the members gives the best spread skill relationship.

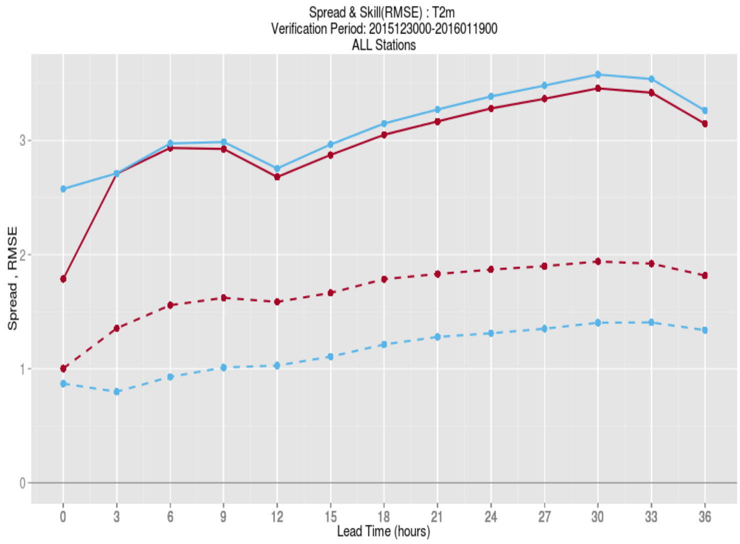
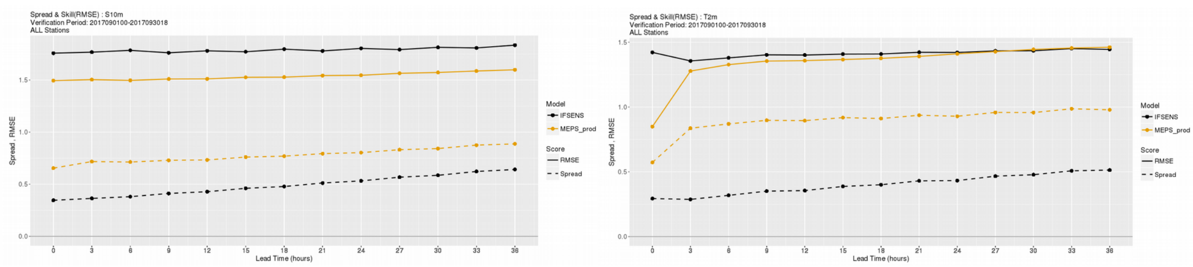


Figure 5: T2M spread/skill scores for a period in January 2017. Solid lines indicate skill and dashed lines spread. The red and blue lines are with/without surface assimilation for the members respectively.

After one year with MEPS operational we can conclude that it is a good support for the forecasters and gives an added value to IFS ENS data. In figure 6 we see that MEPS has a better skill and higher spread for all compared parameters but MSLP compared to IFS ENS. From experiences in the daily forecasting and comments from forecasters we know however that we still lack enough spread in e.g. cloud cover.



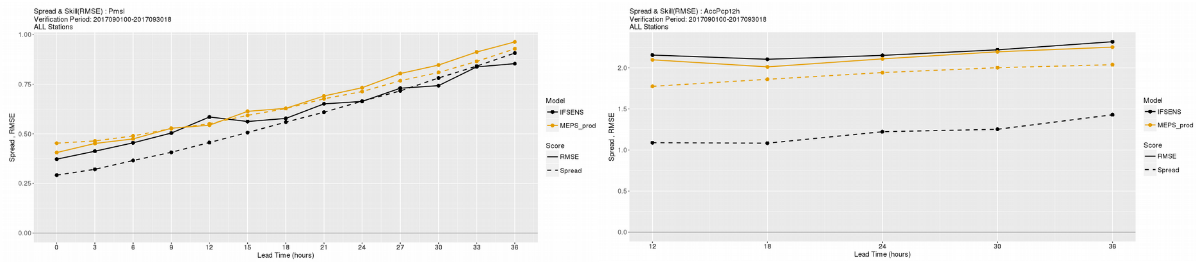


Figure 6: IFS ENS (black) and MEPS (brown) spread/skill scores for September 2017. Solid lines indicate skill and dashed lines spread. Wind speed in upper left panel, T2M in upper right, MSLP in lower left and 12h accumulated precipitation in lower right panel.

3 Implementation of harmonie-40h1.2

The next version of HARMONIE-AROME, harmonie-40h1.2, has been subject for extensive testing during the past year. Some of the changes to be included in harmonie-40h1.2, such as COMAD, SICE and the freezing rain, is already included in MEPS. However the new version also brings a few other important scientific and technical improvements worth mentioning here.

FLAKE

The freshwater model FLAKE is activated in the MetCoOp implementation of harmonie-40h1.2. FLAKE provides prognostic temperatures and ice for inland lakes as compared to the current version, WATFLUX, where the lake surface temperature is diagnosed using the nearby deep soil temperature as a proxy. As can be seen in figure 6 we get met much more realistic temperature patterns in the new version. A comparison of T2M for near lake stations also shows a clear improvement, see figure 7.

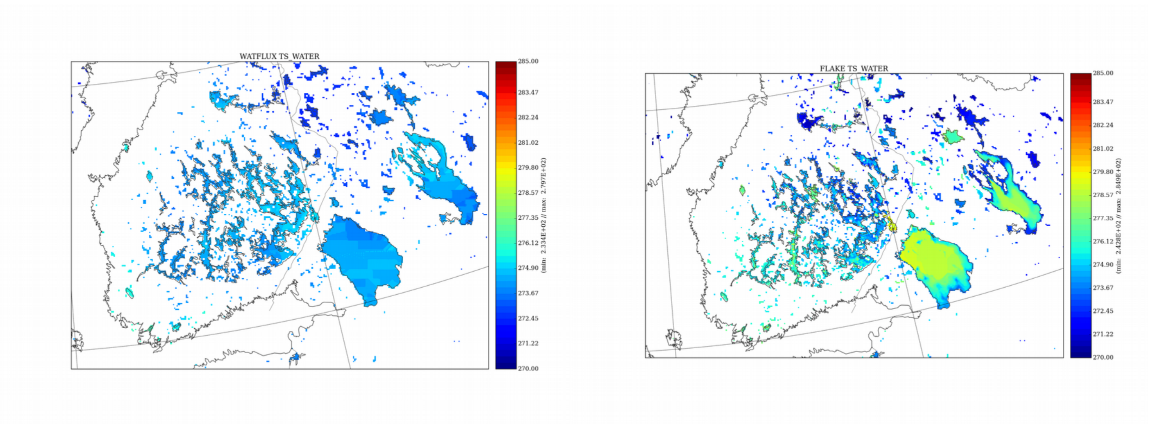


Figure 6: Lake water temperature for 20171202 00Z over Southern Finland. Left: Operational version (WATFLUX), Right: FLAKE.

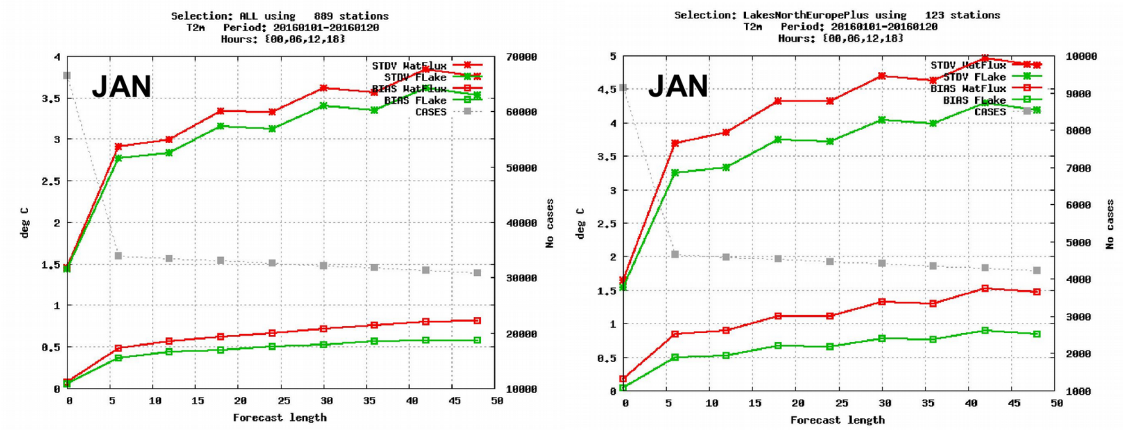


Figure 7: January 2016 T2M STDV and BIAS. Without FLAKE in red and with FLAKE in green. Left full domain and right near lake stations only.

Running with 2-patches

Another important change in the surface part concerns the deactivation of the surface-boundary-layer scheme (SBL) over land and activation of two patches in SURFEX, i.e. separation of forest and open land. In the initial tests it was found that the change effectively reduces the spring time positive bias of RH2M. However it was also found to make the 10 m wind speed scores worse. The wind speed problems has been address by e.g. an introduction of improved tree hight information over Scandinavia, discussed in detail in Samuelsson et. al. (2018).

Deactivate oulan

A more technical change, but not without meteorological impact, is the removal of oulan from the observation preprocessing chain. Following the implementation used by Meteo France and described by Whelan (2017) the bufr files are used directly by BATOR. One clear improvement is an increased number of ship observations, see figure 8. This is due to the fact that the station id where lost in the oulan setup. In the initial tests without oulan station pressure from synop station were used instead of mean sea level pressure. Unfortunately it turned out that for a number of stations the setup suffered from erroneous station heights in the reports leading to unrealistic systematic increments. In the current implementation we use mean sea level pressure when it is reported and reject the stations otherwise. The cause for the erroneous station reports are subject for further investigations. Moving to BATOR also allows us to investigate the usage of the new TEMP data with full position and higher resolution.

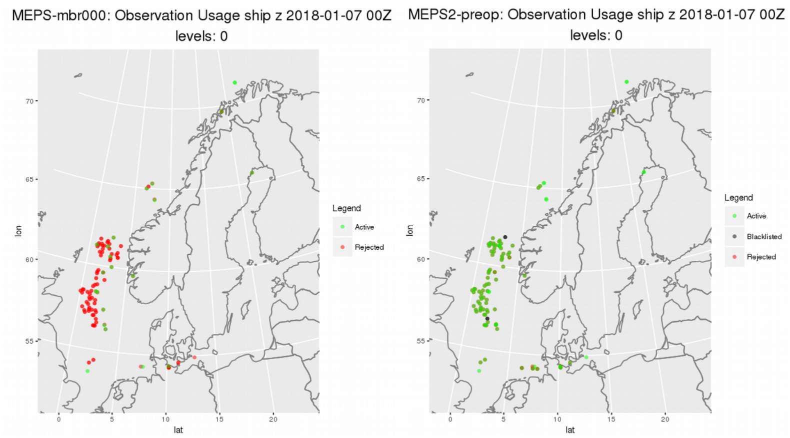


Figure 8: Ship observations entering the screening for a given date. To the left data processed through oulan is shown and to the right BATOR only.

First pre-operational impression

The first MetCoOp implementation of the future harmonie-40h1.2 has been running without problems in real time since June 2017. The new version takes about 3% longer for the forecast model to complete which is acceptable from an operational point of view. The final corrections concerning tree height and BATOR were introduced in mid December 2017 and in figure 9 we see the first impression for a three week winter period. We see clear improvements in wind, small improvements in temperature but also a small degradation of the relative humidity. In general the overall impression, combined with results from Samuelsson et.al. (2018) suggests that the current version is ready for operational implementation.

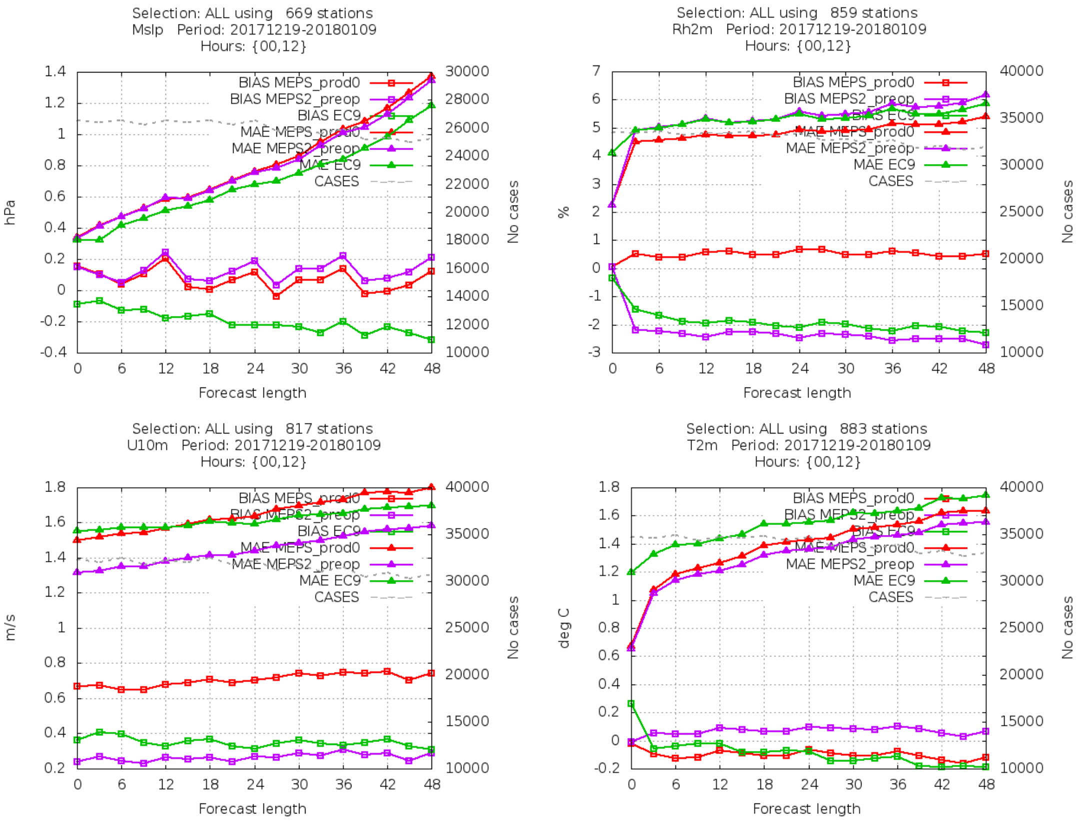


Figure 9: BIAS and MAE for MSLP, RH2M, U10M and T2M from top left to bottom right. The colours denotes the operational MEPS version in red, the MetCoOp implementation of harmonie-40h1.2 in purple and IFS HRES in green.

4 References

Andrae U., The MetCoOp ensemble MEPS, ALADIN-HIRLAM Newsletter No. 7, pp. 98–103, 2017. Available at: http://www.cnrm.meteo.fr/aladin/IMG/pdf/nl7.pdf.

Ivarsson K-I., Recent development of cloud microphysics (ICE3) within MetCoOp,ALADIN-HIRLAM Newsletter No. 9, pp. 30–33, 2017. Available at: http://www.cnrm.meteo.fr/aladin/IMG/pdf/nl9.pdf.

Bengtsson, L., Andrae, U., Aspelien, T., Batrak, Y., Calvo, J., de Rooy, W., Gleeson, E., Hansen-Sass, B., Homleid, M., Hortal, M., et al., 2017. The harmonie–arome model configuration in the aladin–hirlam nwp system. Monthly Weather Review 145 (5), 1919–1935.

Bouttier, F., Raynaud, L., Nuissier, O. and Ménétrier, B. (2016), Sensitivity of the AROME ensemble to initial and surface perturbations during HyMeX. Q.J.R. Meteorol. Soc., 142: 390–403. doi:10.1002/qj.2622

Samuelsson P, et. al., 2018, Two patches in cy40h HARMONIE-AROME and modified tree height and snow roughness length for the MetCoOp domain, ALADIN-HIRLAM Newsletter No. 10, in press.

Singleton, A., 2017, Surface perturbations in HarmonEPS, 27 th ALADIN Wk & HIRLAM 2017 ASM, http://www.umr-cnrm.fr/aladin/IMG/pdf/surfaceperturbationsinharmoneps.pdf

Whelan E., 2017, An update on observation processing, 27 th ALADIN Wk & HIRLAM 2017 ASM, http://www.umr-cnrm.fr/aladin/IMG/pdf/eoinwhelan_obsprocessingwk27asm2017.pdf

ALADIN in Poland - 2017

Marek Jerczyński, Bogdan Bochenek, Marcin Kolonko, Piotr Sekuła, Małgorzata Szczęch-Gajewska, Jadwiga Woyciechowska

1 Introduction

During 2017, members of ALADIN Poland team focused on running CROCUS operationally and its verification, preliminary tests of AROME P005 suite and switching of ALARO-1vA to ALARO-1vB.

2 CROCUS usage and verification

Our main task was to start calculations and visualising of CROCUS system results. On dedicated web page (see screenshot, Figure 1) one might select quantity (field – snow depth or swe - snow water equivalent) and forecast range (up to 24 hours), section of given drainage basin, and region of Poland.

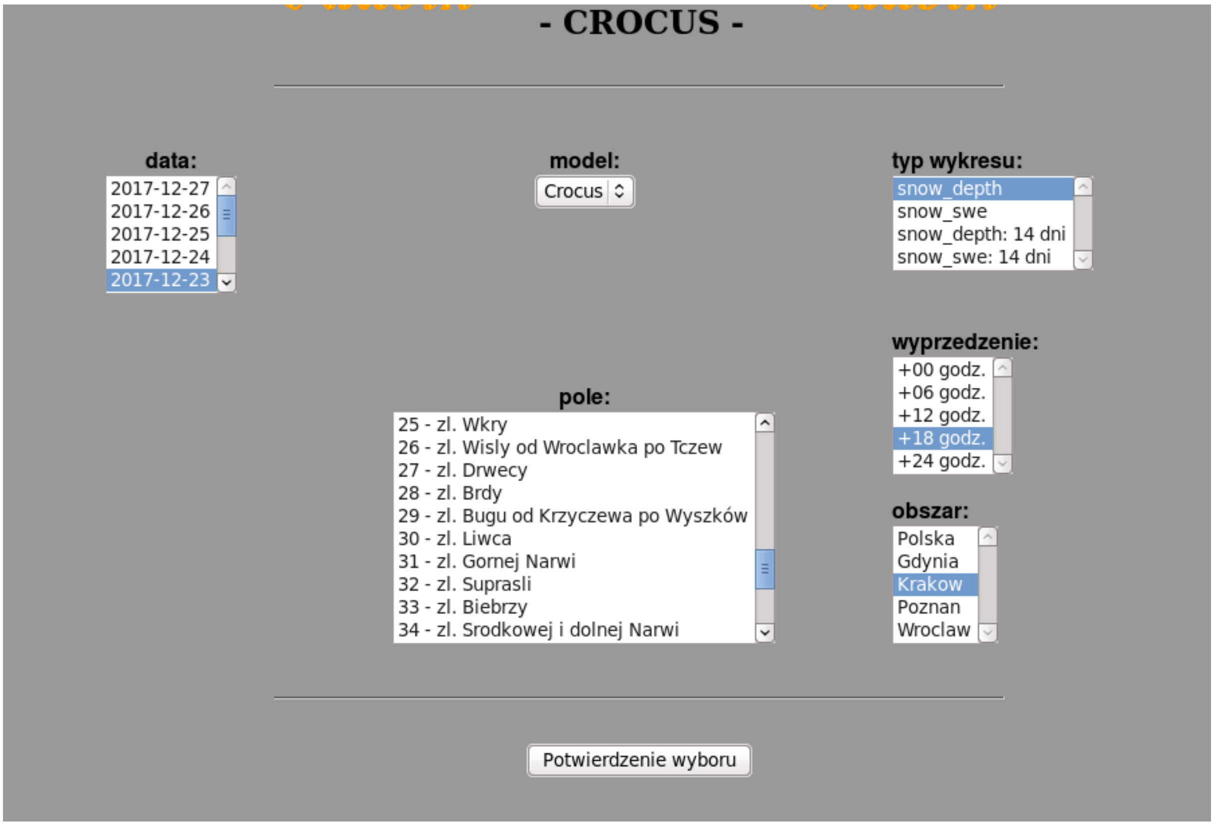


Figure 1: Screenshot of CROCUS forecast web page.

The forecast is computed for 1 day (24 hours). Figure 2 shows the example of mean of snow depth forecast within river Sola drainage basin. Besides the current forecast, one can see the results of weather prediction from previous two weeks.

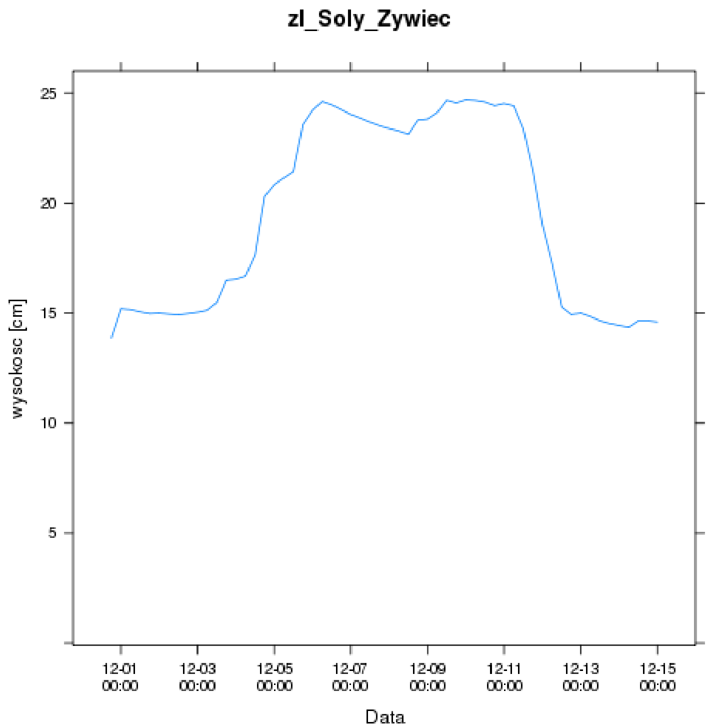


Figure 2: CROCUS forecast for Sola river basin in December, 2017.

And Figure 3 shows the map of snow depth for 24 hours in the domain (the example shown at the picture was taken the same as on Figure 2 for consistency of description). On the map it was marked the border of the drainage basin. The lack of continuity is due to Beskidy Mountains surrounding the basin, while white spots point lack of snow.

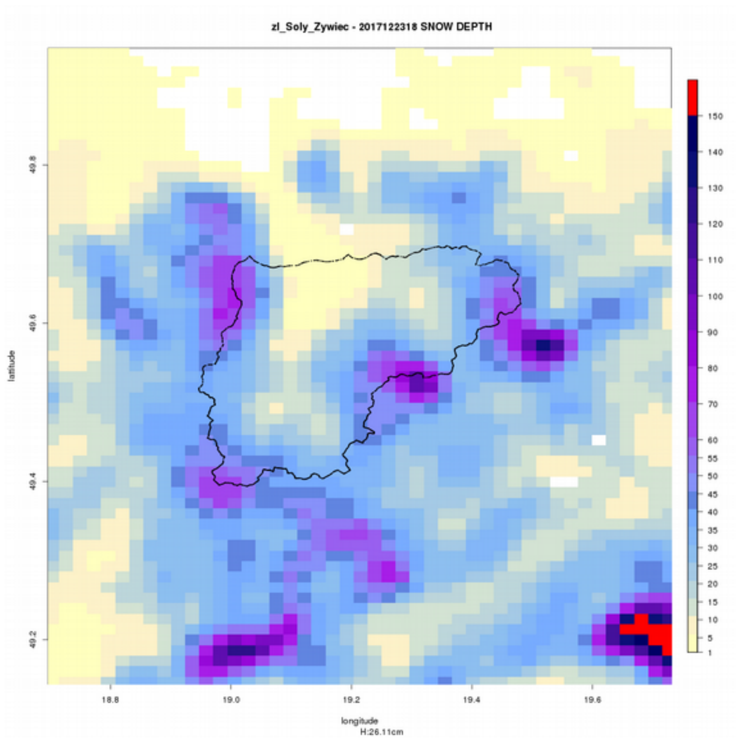


Figure 3: Sola river basin and watersheds with snow depth imposed. The forecast is for 23 Dec 2017, 18 h.

M. Jerczyński, B. Bochenek, M. Kolonko, P. Sekuła,
M. Szczęch-Gajewska, J. Woyciechowska

3 AROME 500m tests

The second activity was running and validation of AROME in the P005 (500m resolution) computational domain using our cluster. The trial calculation domain for AROME P005 covers southern Poland with the top mountain range (Figure 4) with 500 m resolution.

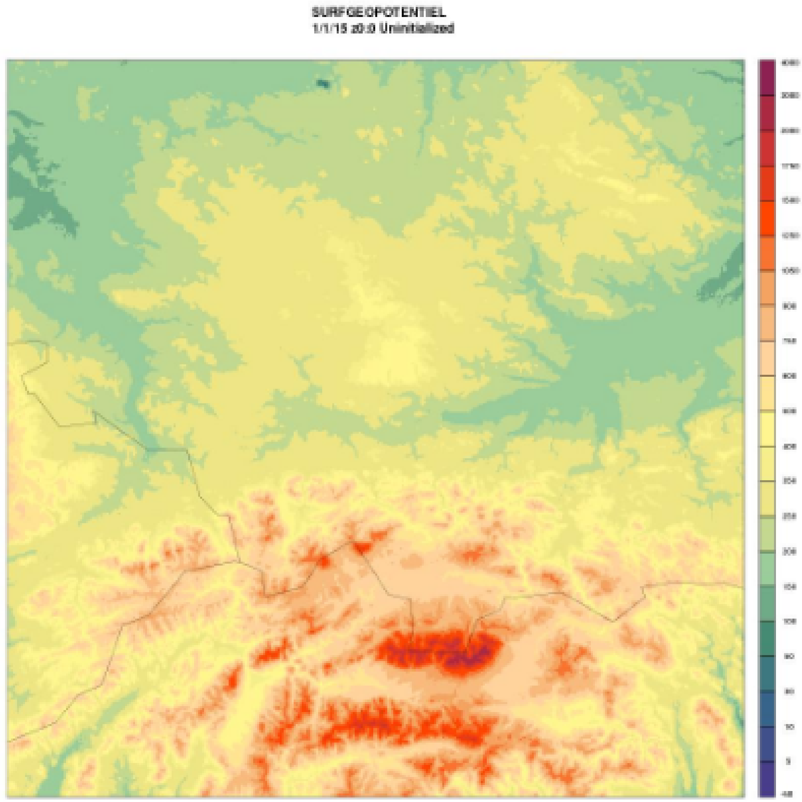
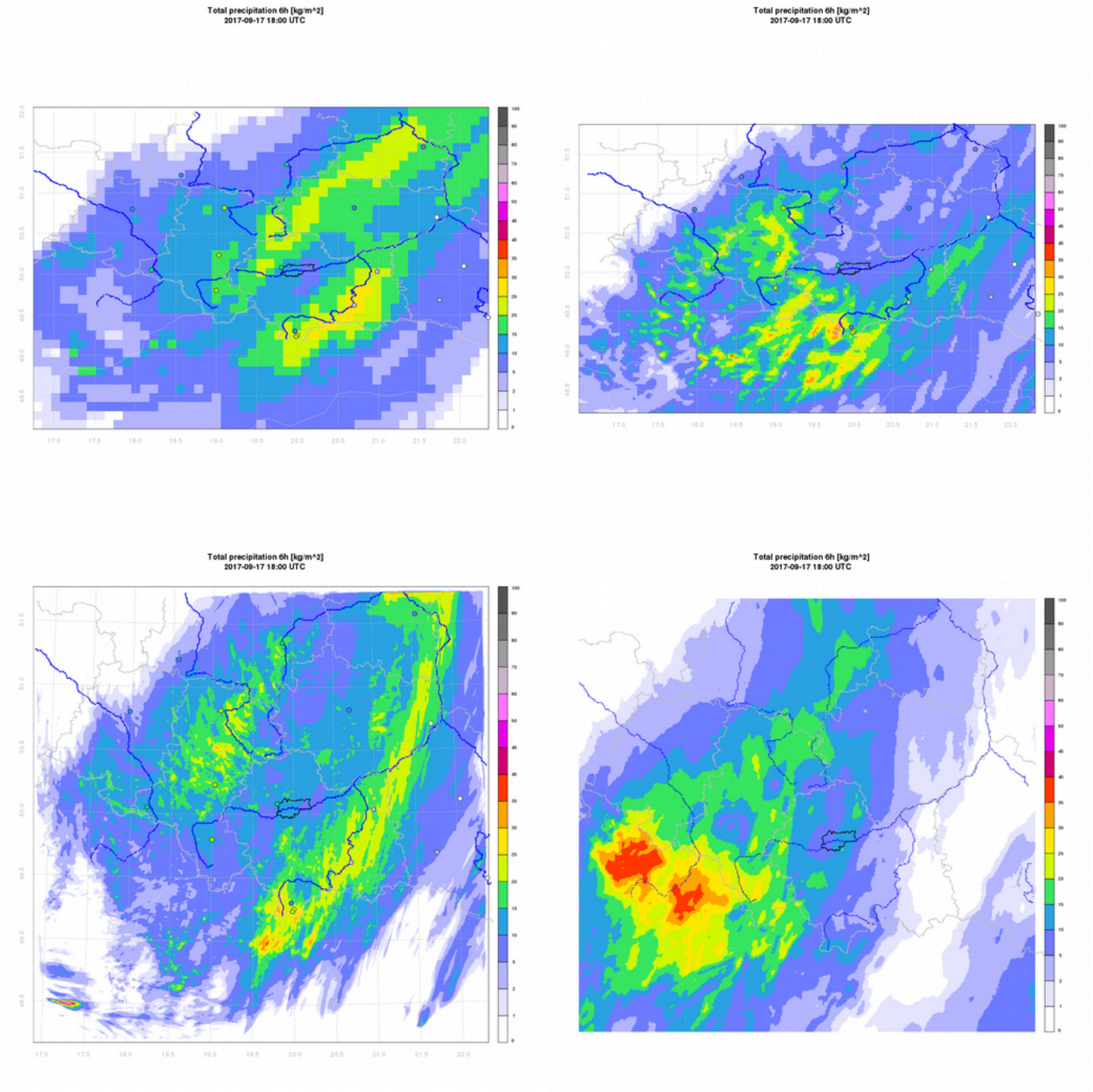


Figure 4: Orography of AROME 500m domain – Carpathia mountains of southern Poland.

The result of such resolution is shown in Table 1, lower left picture. For comparison, at the table are put results of model run for the same domain for resolution 4 km (upper left) and 2 km (upper right). As the reference, radar observations are shown lower right.

Additionally, on the forecast maps one can see 6-hour sums measured at the synoptic stations in the form of points. The values are marked with color (according to the color scale on the right hand side of the picture) showing amount of precipitation at the point (station). Comparing of ALARO 4 km and AROME 2 km as well as AROME 0.5 km one can notice the complexity of structure of precipitation field. This fine resolution allows us to predict accurate precipitation value in large amount of points at the given map (especially information of large convective precipitation that can be lost for low resolution). In the nearest future it is planned work on high resolution models predictions and their verification with the use of HARP verification package (started in the December of 2017) and tests of AROME model runs with resolution of 1 km.

Table 1: Cumulated precipitation for 17-09-2017 in upper Vistula river according to ALARO 4km (upper left, lower spatial resolution), AROME 2km (upper right), AROME 500m (lower left) forecast and radar observations (lower right). Cracow county border is marked black.



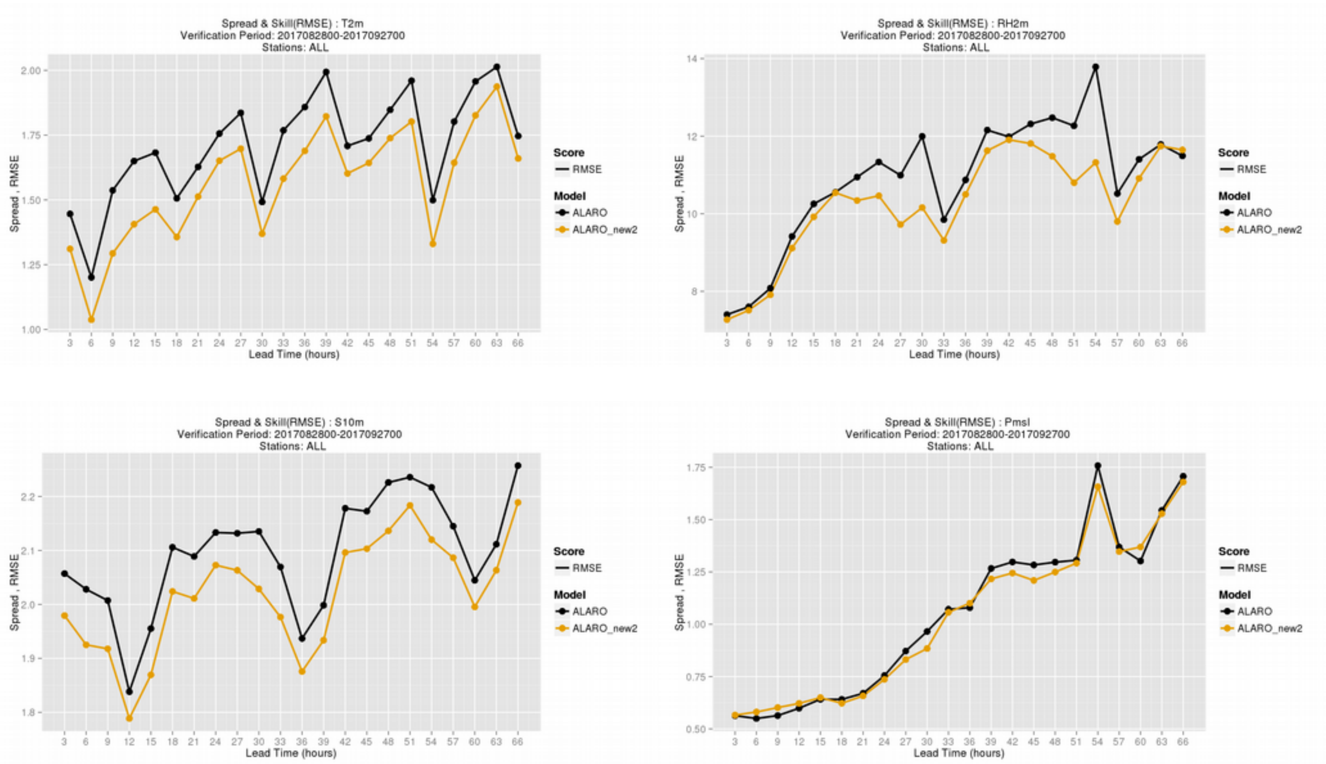
4 ALARO new version

At the end of this report it must be mentioned that we switched from ALARO-1vA to ALARO-1vB. Results of the new version in comparison with old one (with the use of verification package HARP) are depicted in Table 2.

At the Table 2 the HARP RMSE diagrams for ALARO-1vA (black) and ALARO-1vB (brown) for temperature (upper left) and relative humidity (upper right), 10m wind (lower left) and sea level pressure (lower right) in September 2017 are shown.

One may notice substantial improvements of model forecast quality (lower values of root mean square error, RMSE) of AROME-1vB in comparison to AROME-1vA. Temperature and 10m-wind are better-predicted in all forecast hours (0-66 h) whereas realtive humidity is better-predicted in middle hours (18-57 h) and there is only small difference for sea level pressure.

Table 2: HARP RMSE diagrams for ALARO-1vA (black) and ALARO-1vB (brown).



2017 ALADIN Highlights for IPMA, I.P. (Portugal)

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

1 Introduction

During 2017 a few changes have taken place on the local NWP operational systems, in sequence of the new features provided by recent modifications on the ARPEGE dissemination. The first change on the local systems took place in July 2017 with impact on their design and products quality. It consisted on the increase of the daily runs and vertical levels of the AROME model, taking advantage on the 2016 ARPEGE dissemination update. The new features entered into operations in the three local geographical versions of AROME: over the Mainland Portugal (an Iberian sub-domain called PT2), over the Madeira archipelago (a domain called MAD) and over the Azores archipelago (a domain called AZO). A second change took place more recently in December 2017 which did not involved a modification on the systems design and with neutral impact on the quality of the products of the local models ALADIN and AROME. The impact of the new coupling has been monitored shortly over the mainland version (AROME-PT2) of the AROME model.

On the model development side, efforts have been dedicated to surface issues: one point of attention was the implementation and validation of the largest European artificial lake physiography - the Alqueva Lake - in the AROME-PT2 surface; another point of attention was the adequate establishement of the Azores physiography and climatologies for AROME-AZO with CY38T1.

Local progress has been noticeable in data assimilation: the AROME surface data assimilation cycling by the formalism OI_MAIN (Giard and Bazile, 2000) locally implemented according to the description in Monteiro *et al.* (2017), has suffered an upgrade and was re-validated for the Iberian domain with a clear positive impact on the screen level parameters forecasts up to a 24-hour range; these short-range forecasts are now feeding a pre-operational hourly CANARI surface analysis. Moreover, a 3D-Var testbed (the LACE 3D-Var testbed) has been implemented on the actual operational HPC platform of IPMA, the IBM p7+, and a first B-matrix has been computed for an Iberian domain, by the ensemble method as a cold start from the Prevision d' Ensemble ARPege (PEARP). Furthermore, the collaboration with CHMI on pre-processing has progressed onto to the development of procedures for the ingestion of aviation observations under WMO BUFR (E-)AMDAR template 311010v7.

Further local team efforts have been used to support other research projects, internal requests and also ALADIN/SRNWP activities with emphasis on the organization of the "ALADIN Data Assimilation basic kit Working Days", in Lisbon.

Finally, the acquisition of a new HPC platform which should allow new developments, an IBM p8 (9xS822L nodes), has just taken place.

This article is organized as follows: in section 2, an overview is given over the recent operational system changes; in section 3 a brief summary is given on the validation of Alqueva Lake physiography in the AROME-PT2 surface; and, in sections 4 and 5, the recent local achievements on data assimilation are described.

2 Local NWP operational system evolution status

As said in the section 1, during 2017 two main changes occurred in the Portuguese NWP system, both related to modifications on the ARPEGE dissemination. On the first change, the impact of increasing the number of vertical levels, was studied previously and is discussed in Monteiro *et al.* (2017). Therefore, in this article, details are only given in relation to the second change.

The AROME local operational model is run with initial and boundary conditions given by ARPEGE. The operational version of ARPEGE was upgraded on December 5, at the 06 UTC network, to cycle CY42_op2 which included the replacement of its surface scheme from ISBA to SURFEX (hereafter called ARPEGE-SURFEX).

To assess the impact of the ARPEGE upgrade on the local production, a small study over the period 22-30 April 2017 was done for the AROME Mainland Portugal version (AROME-PT2). In particular, the quality of AROME-PT2 forecasts starting at 00UTC was assessed, using the operational verification procedures and taking 18 surface weather stations over Mainland Portugal as reference. The 24-hour forecasts AROME-PT2 produced with the test coupling files (hereafter named AROME_NEW) were then compared with the operational AROME (hereafter named AROME_OPER) forecasts. The following variables have been looked up: 2-meter temperature (T2M) and 2-meter relative humidity (H2M), 10-meter wind speed and direction, 3-hour total precipitation (3HPP) and mean sea level pressure. Table 1 shows some of the main statistical scores obtained. Figure 1 shows examples of hourly time series in Castelo Branco location (left) for T2M and in Porto (right) for 3HPP.

	AROME_NEW	AROME_NEW	AROME_OPER	AROME_OPER
	RMSE	BIAS	RMSE	BIAS
2 m temperature (C)	1.76	0.34	1.78	0.63
2 m relative humidity (%)	11.7	-3.2	12.6	-5.5
10 m wind speed (m/s)	1.60	0.33	1.66	0.55

Table 1: AROME_NEW *vs.* AROME OPER scores over a 9-day April 2017 period.

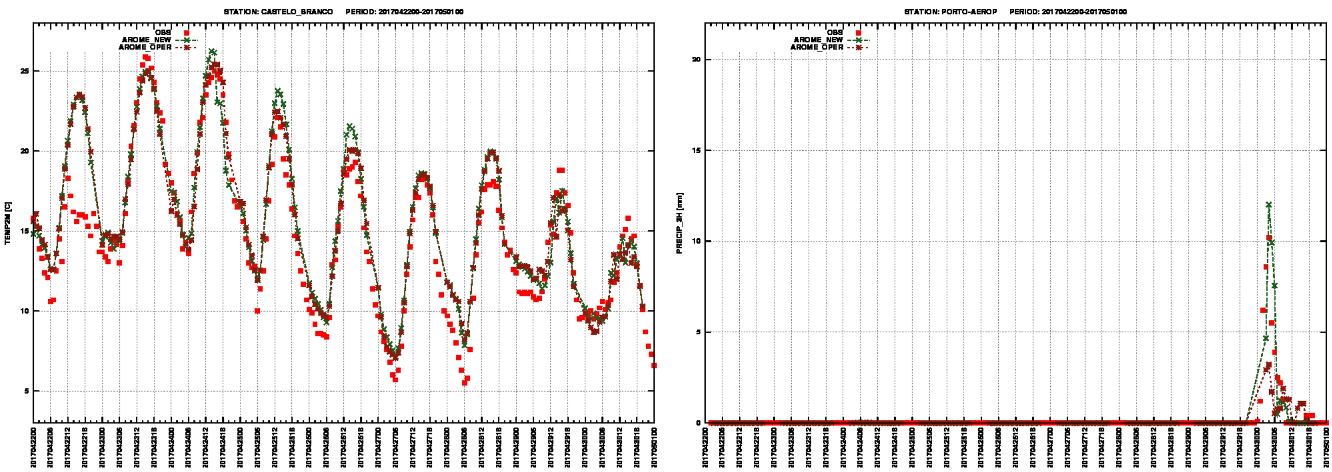


Figure 1: Time series of hourly AROME_OPER and AROME_NEW forecasts vs. observations, for the parameters: T2M (left) and 3HPP (right).

Figure 2 shows the 3-hour total precipitation forecast (3HPP), valid at 09 UTC on April, 30th 2017. These scores show that using the new couplings is either neutral or benefitial for the operational model, as the RMSE is now similar or smaller.

Overall, despite local changes in the forecast which arise from using ARPEGE-SURFEX, the main structures

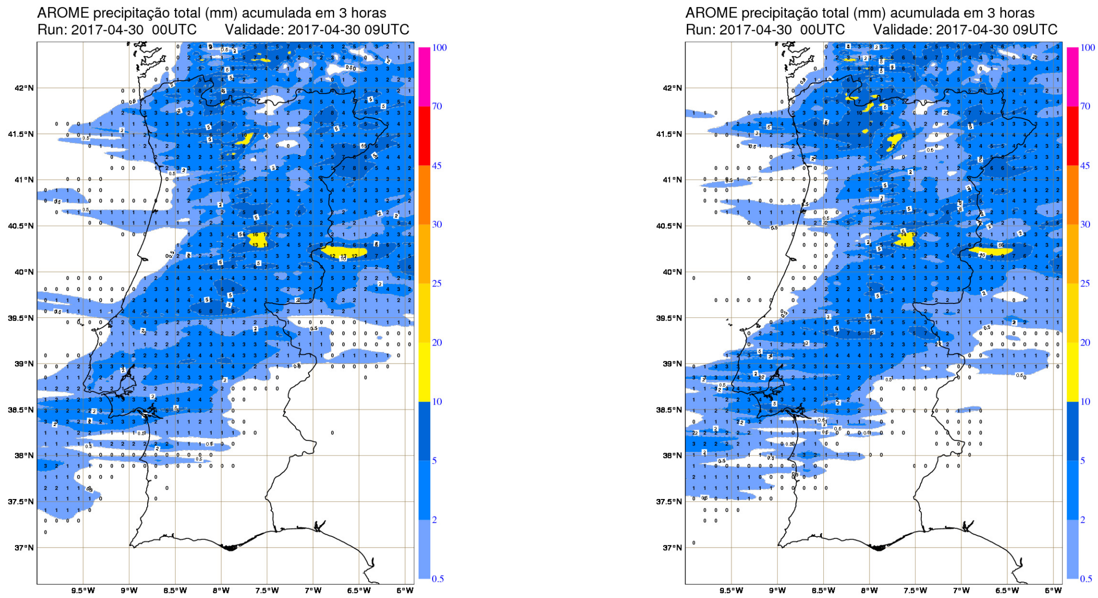


Figure 2: 3-hour accumulated precipitation valid at 09UTC and forecasted by AROME_OPER (left) and AROME_NEW (right).

are kept the same as surface related variables (heat/moisture fluxes, drag) lead to small changes in ARPEGE forecasts.

As the main conclusion, the results show that using ARPEGE-SURFEX is neutral or beneficial, with scores being similar or somewhat smaller than the ones computed with AROME_OPER; moreover, any differences in the forecast fields are limited in amplitude and area.

3 Alqueva Lake physiography validation

Alqueva is the largest artificial lake in Europe, located in Southern Portugal. Although the floodgates of the Alqueva dam were closed in 2002, giving rise to a large reservoir in Western Europe, its possible effects on the weather in Portugal are not taken into account by the operational models maintained at IPMA. However, the representation of this lake can have an impact on the forecast of localized phenomena, has shown recently by Policarpo *et al.* (2017).

In this way, a feasibility and validation study was undertaken in order to provide the local operational model with the new lake representation. For that, it was necessary to introduce the physiography of the lake, shown in Figure 3, in the model under study (AROME-PT2), and validate by analysing both statistically and meteorologically the differences between the model simulations with and without Alqueva. For this study the Summer period 22-24 July 2014 was chosen, for being coincident with an intensive observational field campaign, called ALEX2014 [a].

In order to take advantage of the most recent surface knowledge available, the Alqueva physiography was locally introduced on the latest available version of ECOCLIMAP_II_v2.3 [b] and the lake orography in GMTED2010_30 [c].

To validate these changes, the physical consistency of the model forecasts up to a 48-hour range was analysed. In a first step, it was analysed the impact of different model configurations, on the region of the lake, by changing the characteristics which could leave from the model version operational at the summer 2014 (CY36T1, 46

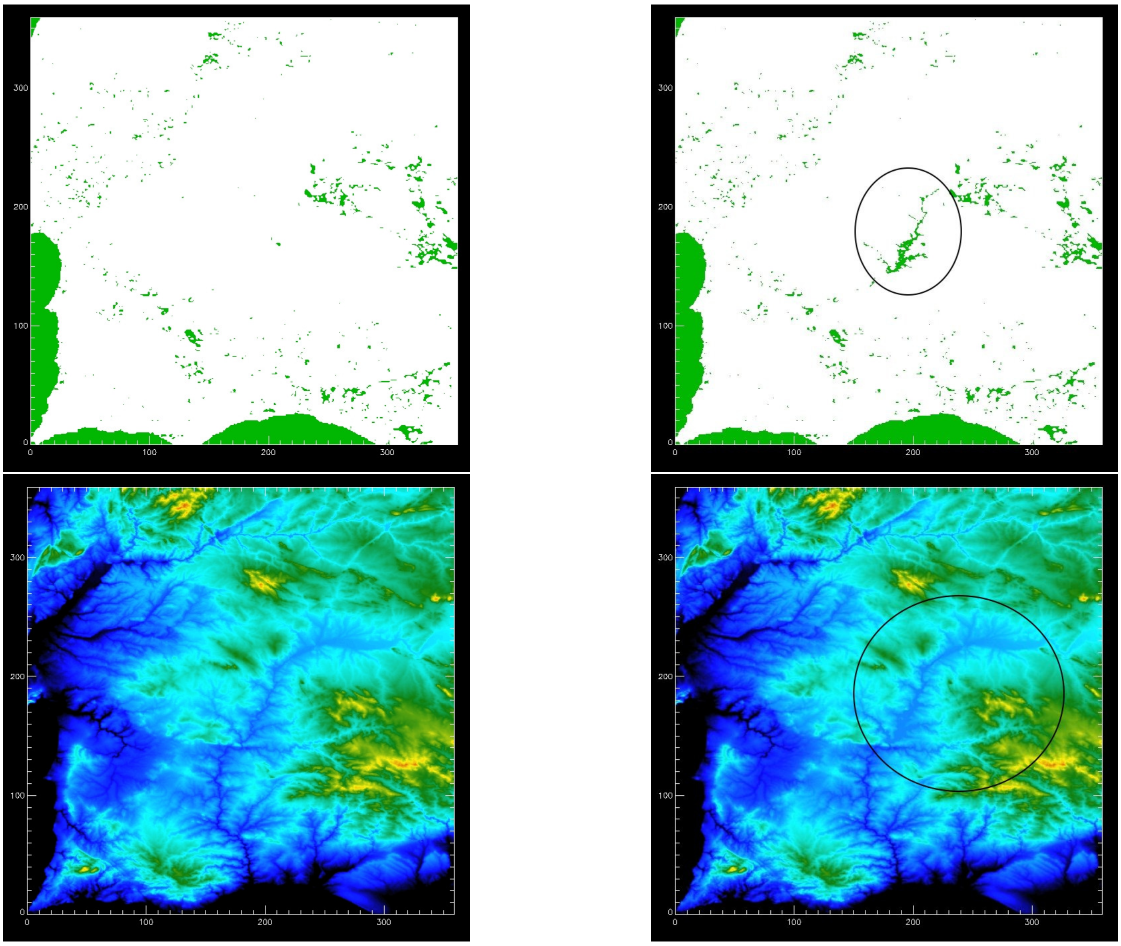


Figure 3: Alqueva Lake physiography (top) and orography (bottom), as represented by ECOCLIMAP_I_GLOBAL_v1.5 (left) and ECOCLIMAP_II_EUROPE_V2.3 (right).

levels, ECOCLIMAP_v1.5, GTOPO30, hereafter named AROME2014) upto the latest locally available in 2017 (CY38T1, 60 levels, ECOCLIMAP_II_V2.3, GMTED2010_30, hereafter named AROME2017); doing so, the main contributions to the model performance variability along these upgrades could be identified. To assess the quality of the forecasts the operational verification procedures were used, taking as reference a small region around Alqueva of IPMA's surface observational network. On a second step, using the last model version, AROME2017, the simulation of well identified weather situations with and without the lake representation was analysed taking as reference the ALEX2014 observations.

From the first part of our study it was possible to conclude that: i) the AROME2017 version provided forecasts more consistent with the observations than any other available; ii) the version of AROME with ECOCLIMAP_I_GLOBAL_v1.5 provided forecasts closer to the observations than with ECOCLIMAP_II _EUROPE_v2.3.

The second part of this study, was done with the AROME2017 version but replacing the ECOCLIMAP_v1.5 by the latest available. In this part of the study, two case-studies have been done: one during a lake breeze and the second one during a low level cloudiness event.

The implementation of the Alqueva Lake in the model surface has shown that all the AROME-PT2 screen level forecasts suffered changes consistent with the two weather conditions at play. For instance, during the lake breeze situation and over the lake, the surface temperature was about 22 degrees smaller (and the relative humidity was around 60% higher) at 18UTC on the simulation with Alqueva than on the simulation without Alqueva. Therefore, it was possible to conclude on the added value of using the Alqueva physiography, since the results looked physically resonable under the presence of a big water mass such Alqueva with a high thermal inertia.

Acknowledgments are due to Rui Salgado and Carlos Policarpo from Évora University for providing the Alqueva physiography.

4 Surface data assimilation

Along 2017, the surface data assimilation cycling setup, previously described in Monteiro *et al.* (2017), suffered two important upgrades giving rise to a positive impact on the screen level parameters forecasts: firstly, the frequency of cycling was increased from a 6- to a 3-hour cycling; and secondly, the Sea Surface Temperature (SST) was made evolve each 6-hour interval using the fields from the ARPEGE coupling files.

The added value of the new surface data assimilation cycling was assessed through the forecasts of a daily 24-hour model run initialized with the 00UTC analysis for a 2016 Summer month. For comparison, the quality of these forecasts was assessed in parallel with those from other two experiments, using the operational verification procedures, where around 110 stations over Portuguese Mainland were taken as reference. The model version used in this study was: CY38T1_bf03, 46 levels on the PT2 domain (hereafter called AROME-PT2). The three different experiments were characterized by different initializations: i) surface and upper-air direct downscaling from ARPEGE (hereafter named AROME_ASSIM); ii) a 6-hour cycling surface analysis and upper-air direct downscaling from ARPEGE (hereafter named AROME_ASSIM_6H; iii) a 3-hour cycling surface analysis and upper-air direct downscaling from ARPEGE (AROME_OPER).

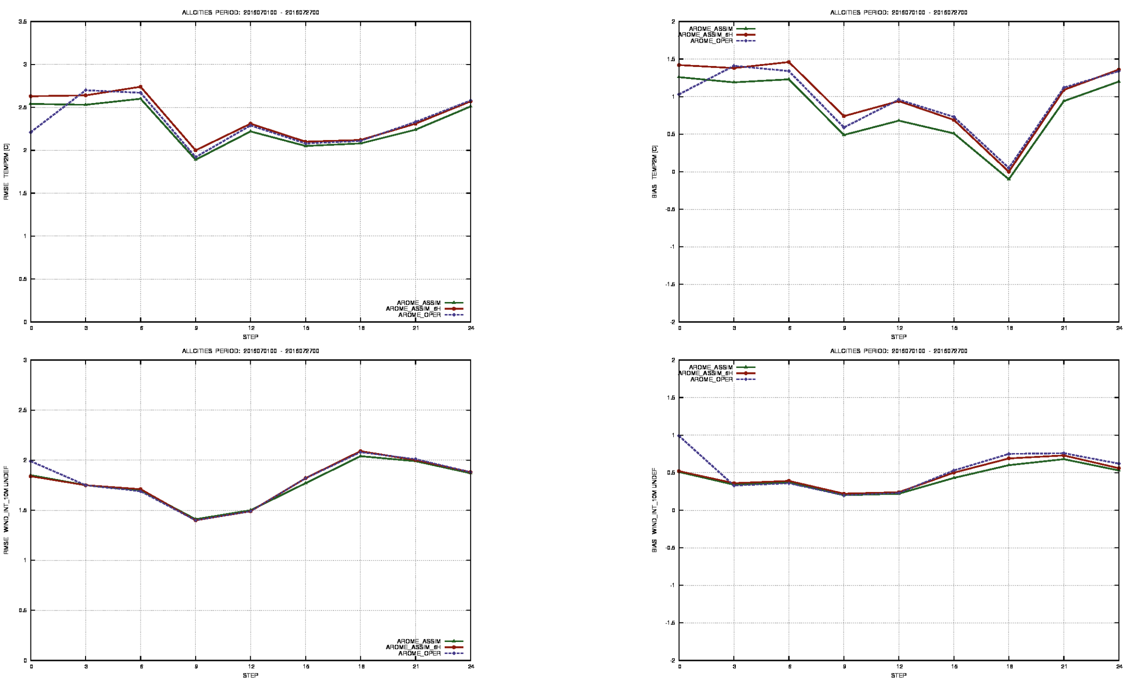


Figure 4: RMSE (left) and Bias (right) of 24-hour forecasts of AROME-PT2 for the period (1 ago 2017 - 15 sept 2017) with different model initializations: for T2M (top) and for V10M (bottom).

The Figure 4 shows the objective scores for the 2-meter temperature (T2M) and for the 10-meter wind (V10M). As it can be seen, the latest changes on the surface cycling (a 3-hour frequency) brought in general a clear positive impact on the model performance, reducing both the RMSE and bias of the 2-meter temperature forecasts of AROME-PT2 on the ranges H+03 to H+24, when compared to the previous cycling setup and also to the operational downscaling setup. Although not so evident, the same conclusions could be taken also for the 2-meter relative humidity. However, for both parameters there is an apparent degradation on the pos-processing of the initial time in the setups with the data assimilation cyclings. The same conclusion is also valid for the

10-meter wind, but now the problem on the initial time is not visible and suggests in opposition that the model spin-up has been much reduced.

The impact on the upper-air fields was not assessed so far. However, these first results have shown an added value on the recent updates of the OI_MAIN cycling Monteiro *et al.* (2017), which is quite cheap computionally. Therefore, its short-range AROME-PT2 forecasts have been used as first guess on a hourly analysis by the CANARI standalone configuration. As input data set, the WMO BUFR SYNOP observations shared regionally with AEMET have been used. The new hourly product has been also validated, both during Summer and Winter. The analysis increments for screen level parameters have been compared for the two periods with the deviations to the observations of the operational AROME-PT2 initialization fields at 00UTC and 12UTC (not shown). Table 2 shows RMSE and bias for CANARI-AROME (CAN-ARO), CANARI-ALADIN (CAN-ALA) and AROME-PT2 initialization ARO-OP.

	T2M		H2M		V10M	
EXP	RMSE (C)	BIAS (C)	RMSE (%)	BIAS (%)	RMSE (m/s)	BIAS (m/s)
CAN-ARO(Summer)	1.52	0.18	8.86	-0.70	1.37	0.18
CAN-ARO(Winter)	1.63	-0.01	8.58	-1.36	1.35	0.03
CAN-ALA(Summer)	1.78	0.43	10.95	-0.76	2.18	0.92
CAN-ALA(Winter)	1.85	-0.09	10.66	-0.72	2.25	0.82
ARO-OP (Summer)	2.07	0.90	11.79	-4.69	2.50	1.63
ARO-OP (Winter)	2.06	0.27	12.69	-5.26	2.16	1.24

Table 2: Analysis increments statistics vs. AROME-PT2 initial fields at 00UTC.

By analysing the results it was possible to conclude that the new CANARI which uses the OI_MAIN surface cycling forecasts as background is the product which generally is closest to the observations.

5 Upper-air data assimilation

As contribution to the project activities, Portugal has hosted at its headquarters in Lisbon, the ”ALADIN Data Assimilation basic kit Working Days” as the kick-off meeting to the ALADIN Core Program ”basic DA kit”, on 22-23 March 2017. It included 19 data assimilation new-comers and experts from many countries of the ALADIN, LACE and HIRLAM consortia. At the same time, the collaboration with CHMI has given rise to a new code source which should be available from CY42T1, the AMDARWMO procedure, which allows the ingestion by the upper-air assimilation of WMO BUFR E-AMDAR data as described by Monteiro (2017). And finally, it was possible to install in the local HPC IBM p7+ the LACE 3D-Var testbed which can now be adapted to the local domain, taking advantage of the first B-Matrix recently computed from a downscaling of PEARP.

Giard, D., & Bazile, E. (2000): Implementation of a new assimilation scheme for soil and surface variables in a global NWP model. Monthly Weather Review, 128, 997-1015.

Monteiro, M. (2017): Upgrade of the source code BATOR to WMO AMDAR template 311010 v7, ALADIN Project Stay report, version 0.2 (January 2017), available from http://www.rclace.eu/.

Monteiro, M., Rio, J.,Costa, V., Lopes, M. J., Moreira, N. (2017): ALADIN Highlights for IPMA, I.P. (Portugal), ALADIN-HIRLAM Newsletter, n.8.

Policarpo, C., Salgado, R. and Costa, M.J. (2017): Numerical Simulations of Fog Events in Southern Portugal, Advances in Meteorology, Volume 2017, Article ID 1276784, 16 pages.

[a] https://www.alex2015.cge.uevora.pt;

[b] https://opensource.um-cnrm.fr/projects/ecoclimap/wiki;

[c] https://topotools.cr.usgs.gov/gmted_viewer/

Revision of the LAEF multiphysics scheme

Christoph Wittmann[1], Simona Taşcu[2], and Raluca Pomaga[2]

[1]Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria
[2]National Meteorological Administration, Bucharest, Romania

1 Introduction

An upgrade of the current LAEF (Limited Area Ensemble Forecasting) system towards finer horizontal and vertical resolution (5 km, 60 levels) is planned. In order to compensate the increasing demand of computing resources, the size of the LAEF 5km test domain had to be reduced compared to the original LAEF 11km domain (Figure 1 - Bellus, 2016).

The current operational LAEF multiphysics scheme is composed of 16 different namelists, including physics options from ALARO-0, ALADIN and HIRLAM (Wang et al., 2011). This fact turns maintenance into a really difficult task as not all used options are supported in recent software cycles. Therefore it was decided to revise the multiphysics scheme for LAEF 5km and increase the maintainability at the same time. This can be just realized through a significant reduction of namelists and a focus on ALARO physics options/tuning parameters. A combination with a stochastic physics scheme is intended to compensate for the loss of variety in terms of physics options, at least up to a certain extent. In the following, the selection method for different physics options and first results are presented.

The work was realized during three LACE stays in Vienna in 2016 and 2017.

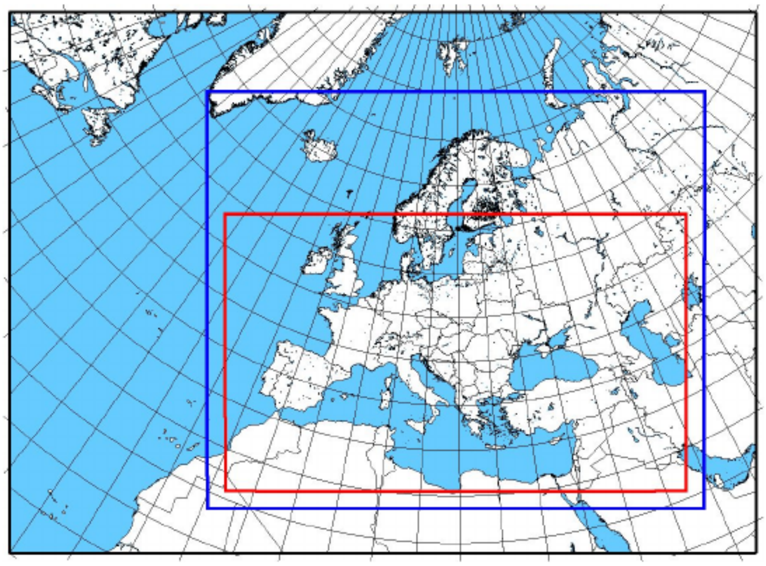


Figure 1: LAEF integration domains: the current one at 11 km horizontal resolution (blue) and the new one at 5 km horizontal resolution (red).

2 Sensitivity tests

The impact of namelist changes (mainly related to deep convection, microphysics and turbulence) was evaluated by applying the MTEN tool (Moist Total Energy Norm - Storto, A. and Randriamampianina, R. (2010)) on forecasts for a convective day in summer. Table 1 summarizes the different options which were tested on top of the ALARO-1 and ALARO-0 export version namelists (EX00 and EX01) using cy40t1.

Finally 5 sets of namelists (version1 − version5) were selected and evaluated for a 2-weeks period. Each set or version is composed of 4 namelists and each namelist is applied to 4 members to create a 16 member ensemble (+ control). The composition of the different versions is shown in Figure 2.

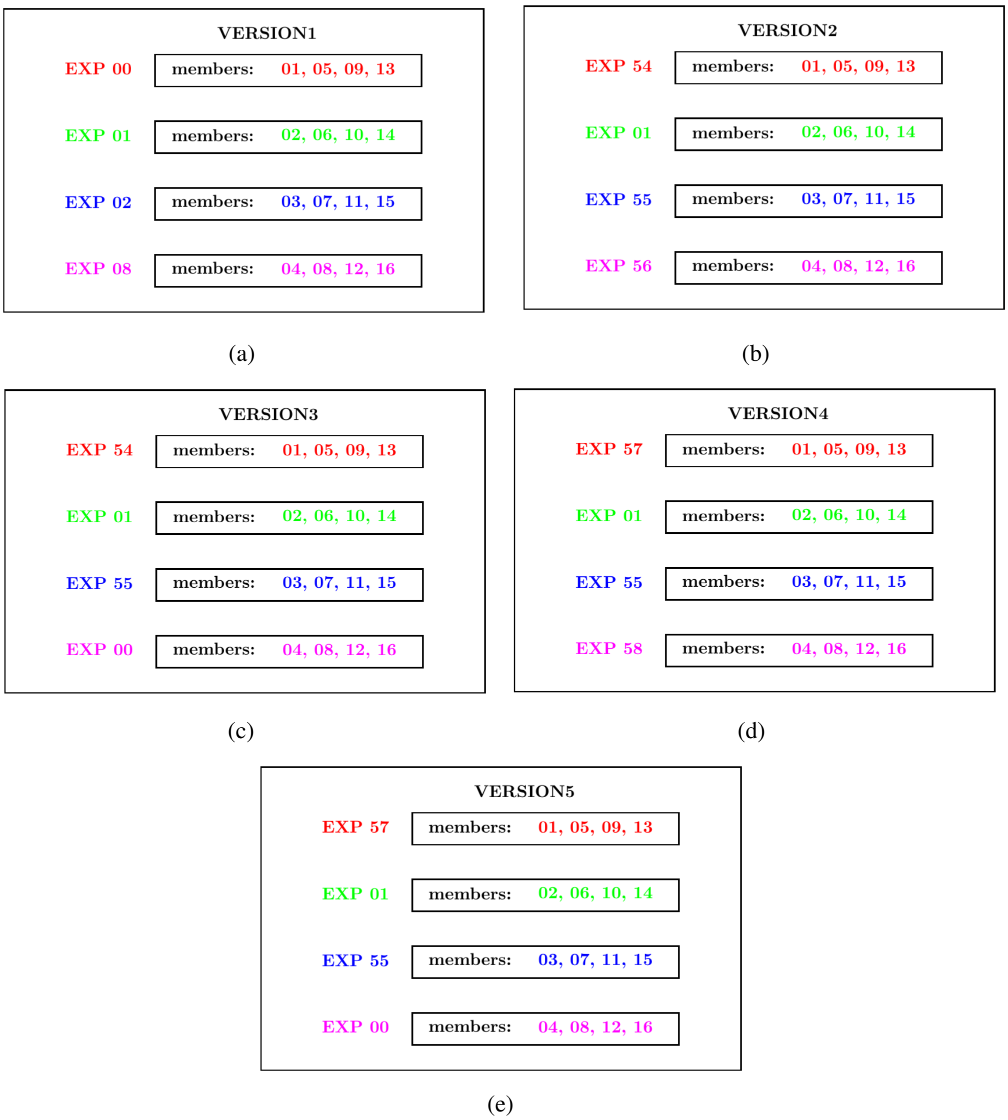


Figure 2: Namelist settings versions. Each set consists of 4 members while each namelist is applied to 4 out of 16 LAEF members.

EX00	ALARO-0
EX01	ALARO-1
EX02	ALARO-1 TOUCANS
EX03	ALARO-1 MIXLEN="EL1"
EX04	ALARO-1 MIXLEN="EL2"
EX05	ALARO-1 MIXLEN="EL3"
EX06	ALARO-1 MIXLEN="EL4"
EX07	ALARO-1 MIXLEN="EL5"
EX08	ALARO-1 ACRANEB2
EX09	LAB12=.F.
EX10	ALARO-0 gravity wave drag computation LGWD=.F.
EX11	ALARO-0 Smith Gerard option in condensation/evap
EX12	ALARO-1 Smith Gerard option in condensation/evap
EX13	ALARO-0 FMR/RRTM radiation scheme
EX14	ALARO-1 FMR/RRTM radiation scheme
EX15	ALARO-0 no LENTCH
EX16	ALARO-0 LSCMF=.FALSE.
EX17	ALARO-0 LCVGQM=F
EX18	ALARO-0 LCVGQM=F,LGVGQD=F
EX19	ALARO-0 prognostic updraft LCVPRO downdraftLCDDPRO → FALSE
EX20	ALARO-0-MIXLEN="Z"
EX21	ALARO-0-MIXLEN="EL1"
EX22	ALARO-0-MIXLEN="EL2"
EX23	ALARO-0-MIXLEN="EL3"
EX24	ALARO-0-MIXLEN="EL4"
EX25	ALARO-0-MIXLEN="EL5"
EX26	ALARO-0-MIXLEN="AYC"
EX27	ALARO-0-MIXLEN="EL0"
EX28	ALARO-0 no LENCHT, LSCMF=.FALSE., LCVGQM=F, LCVQGD=T
EX29	ALARO-0 no LENCHT, LSCMF=.FALSE., LCVGQM=F, LCVQGD=T, Smith Gerard, MIXLEN="Z"
EX30	ALARO-0 LVFULL=T
EX31	ALARO-0 LRNUMX=.FALSE.
EX32	ALARO-0 LPRGML=F
EX33	ALARO-0 no LENTCH, LSCMF=.FALSE., LCVGQM=F, LCVGQD=T, Smith Gerard, MIXLEN="Z"
EX34	ALARO-0 no LENTCH, LSCMF=.FALSE., LCVGQM=F, LCVGQD=T, Smith, Gerard, MIXLEN="Z", LGWD=.FALSE., LNEWD=.FALSE.
EX35	ALARO-0 no LENTCH, LSCMF=.FALSE., LCVGQM=F, LCVGQD=T, Smith/Gerard=.TRUE., MIXLEN="Z", LPRGML=F, LGWD=.FALSE., LNEWD=.FALSE.
EX36	ALARO-0 no LENTCH, LSCMF=.FALSE., LCVGQM=F, LCVGQD=T, Smith/Gerard=.TRUE., MIXLEN="EL5", LPRGML=F, LGWD=.FALSE., LNEWD=.FALSE.
EX37	ALARO-0 no LENTCH, LSCMF=.FALSE., LCVGQM=F, LCVGQD=T, Smith/Gerard=.TRUE., MIXLEN="EL5", LPRGML=F
EX38	ALARO-1 LCVGQM=F, LCVGQD=F
EX39	ALARO-1 LENTCH=.F.
EX40	ALARO-1 LENTCH=.F., LSCMF=.FALSE.
EX41	ALARO-1 LCVGQM=T, LCVGQD=T
EX42	ALARO-1 LGWD=.FALSE., LNEWD=.FALSE.
EX43	ALARO-1 LPRGML=F → NOT STABLE
EX44	ALARO-1 CGTURS=MD1+retune pf parameters → NOT STABLE
EX45	ALARO-1 CGTURS=RMC01+retune pf parameters → NOT STABLE
EX46	ALARO-1 CGTURS=QNSE+retune pf parameters → NOT STABLE
EX47	ALARO-1 CGTURS=EFB+retune pf parameters → NOT STABLE
EX48	ALARO-1 LCOEFK_SCQ=.F.
EX49	ALARO-1 LCOEFK_FLX=.F.
EX50	ALARO-1 LCOEFKTKE=.F. (→ LPTKE)
EX51	ALARO-1 XDAMP=0 (turn off moist antifribrillation)
EX52	ALARO-1 LCOEFK_TOMS=.F. LA
EX53	ALARO-1 CGTURS=MD1=default+retune → not stable
EX54	ALARO-1 modif turbulence: mixing length:EL5, CGTURS=MD2+retune, LPRGML=F
EX55	ALARO-1 modif micro+conv: LAB12=F, LCVGQM=F, LCVGQD=F, LENTCH=F, LSCMF=F,LSMGCDEV=T,LXRCDEV=F
EX56	ALARO-1 modif turbulence: mixing length: EL5, CGTURS=MD2+retune, LPRGML=F, modif micro+conv: LAB12=F, LCVGQM=F, LCVGQD=F, LENGTH=F, LSCMF=F, LSMGCDEV=T, LXRCDEV=F
EX57	ALARO-1 modif turbulence: mixing length: EL3, CGTUR=QNSE+retune, LPRGML=F
EX58	ALARO-1 modif micro+conv: LAB12=F, LCVGQM=F, LCVGQD=F, LENTCH=F, LSCMF=F, LSMGCDEV=T, LXRCDEV=F, modif turbulence mixing length:EL3, CGTUR=QNSE+retune, LPRGML=F

Table 1: Experiment list

3 Validation tests

The evaluation of the five versions was done for a period of two weeks (18th of May to 1st of June 2016) using different verification scores. For surface, the following parameters were analyzed: air temperature at 2m, mean sea level pressure, wind speed at 10m, relative humidity at 2m and 6 hour accumulated precipitation. For the upper levels (500 and 850 hPa), temperature, geopotential and wind speed were evaluated. The surface verification was done against 1355 synop stations over Europe and verification for upper levels was done using IFS analysis.

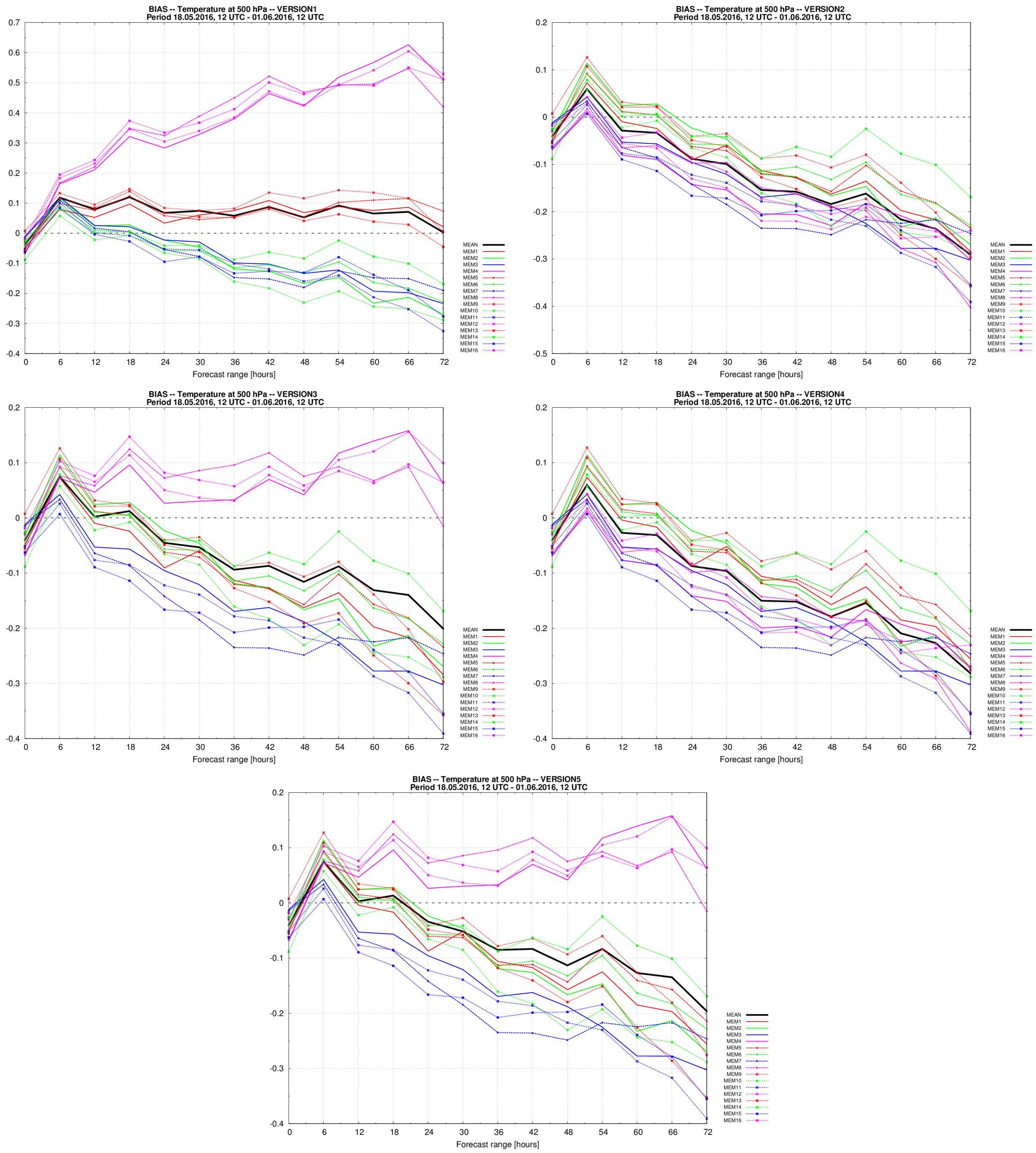


Figure 3: BIAS for temperature at 500 hPa for all five versions.

The verification results for the two weeks period showed similar behaviour for most of the scores, thus making it difficult to choose a final version for further tests. But it was obvious that those versions or sets including both ALARO-0 and ALARO-1 namelists tend to produce clustered results.

In Figure 3 showing the 500 hPa temperature BIAS for all five versions it can be seen that members which are run with ALARO-0 are distant from the others.

Similar results were obtained for other parameters for upper levels and for surface. This led to the decision to exclude any ALARO-0 based namelists and to the choice that version 4 should be further investigated and combined with a stochastic physics scheme:

EX01	ALARO-1	-
EX55	ALARO-1	in microphysics and deep convection: LAB12=F, LCVGQM=F, LCVGQD=F, LENTCH=F, LSCMF=F, LSMGCDEV=T, LXRCDEV=F
EX57	ALARO-1	in turbulence mixing length: EL3, CGTUR=QNSE+retune, LPRGML=F
EX58	ALARO-1	in microphysics and deep convection: LAB12=F, LCVGQM=F, LCVGQD=F, LENTCH=F, LSCMF=F, LSMGCDEV=T, LXRCDEV=F, in turbulence mixing length: EL3, CGTUR=QNSE+retune, LPRGML=F

4 Activation of SPPT scheme

In the next step the SPPT scheme was activated using the following setup:

SPPT settings
LSPSDT=.TRUE., TAU_SDT(1)=7200., XLCOR_SDT(1)=60000., SDEV_SDT(1)=0.5, NSEED_SDT=RANDOM_SEED, XCLIP_RATIO_SDT=2.0, NQSAT_SDT=0, LTAPER_BL0=.TRUE., LTAPER_ST0=.TRUE.,

Figure 4 summarizes BIAS, RMSE and SPREAD for different forecast parameters for the 500 hPa level using the version 4 multiphysics setup with (red curves) and without activation (blue curves) of SPPT. It is obvious that for temperature at 500 hPa and for relative humidity at 850 hPa (not shown) the SPPT scheme provides some slight but hardly significant improvements. For geopotential and relative humidity at 500 hPa (Figure 4), a slight (but again hardly significant) degradation when using a combination of multiphysics and SPPT can be noticed.

Although it is known from other experiments that the impact of SPPT is rather small, it is still surprising that the differences are not really significant. This fact might also indicate a problem in the implementation of SPPT in ALARO-1 as it was used in these experiments.

For surface parameters, the verification results show slight improvements for the combination of multiphysics and SPPT, e.g. for relative humidity at 2m and wind speed at 10m parameters (not shown).

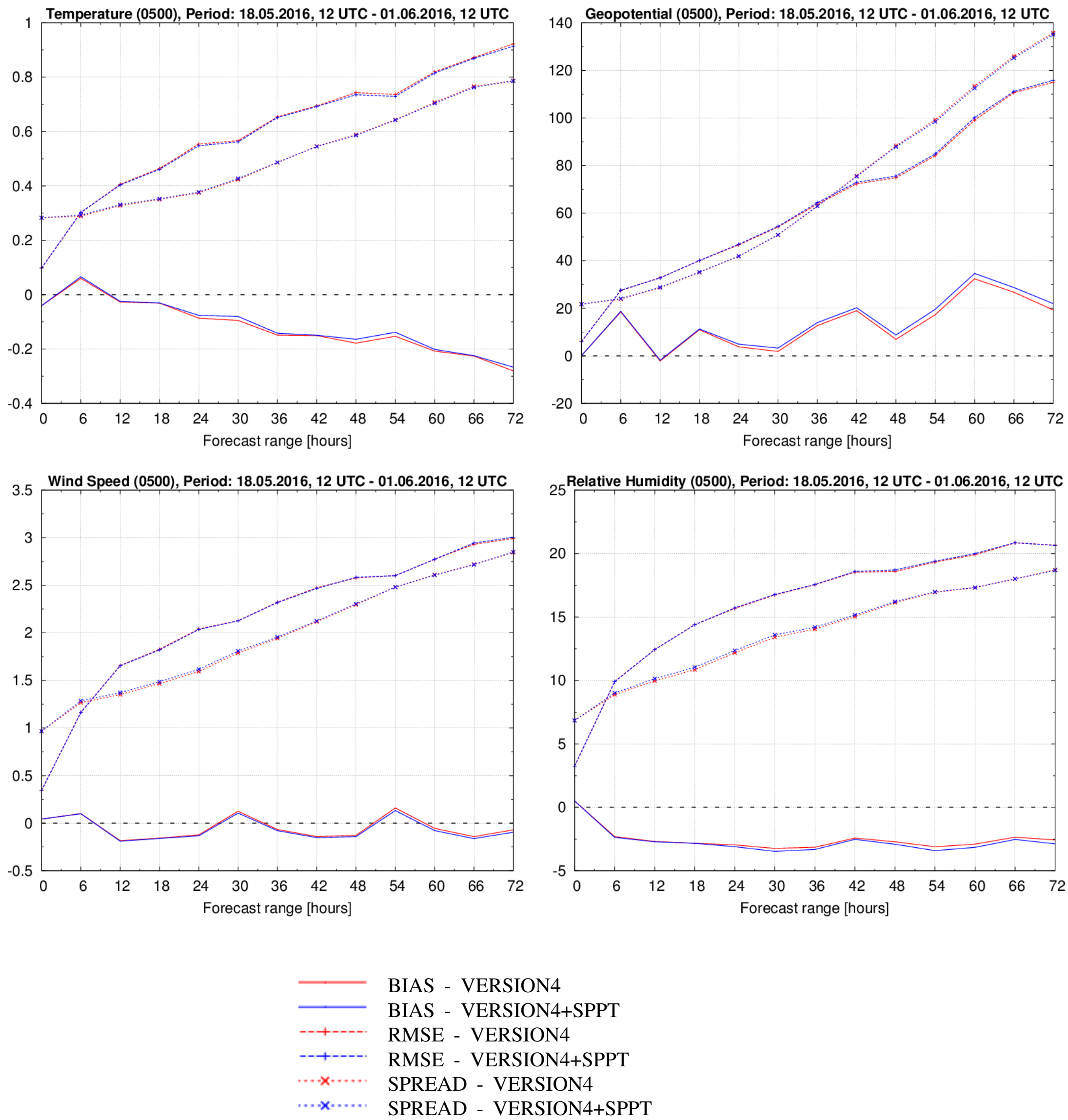


Figure 4: BIAS, RMSE and SPREAD for temperature, relative humidity, geopotential and wind speed at 500 hPa for VERSION4 and VERSION4+SPPT, for 18.05-01.06.2016 period

In conclusion it can be said that a first version for a new multiphysics setup for LAEF 5km based on ALARO-1 was chosen and finally combined with the SPPT scheme. As the choice for multiphysics options and tuning parameter are manifold, the possibilities for testing new versions for multiphysics setups are almost endless. But in order to keep the maintainability as high as possible, a focus on an efficient combination with stochastic physics (or even a complete switch to it) should be targeted for LAEF 5km. But as long as the spread/skill ratios gained with multiphysics setups are convincing it is worth to use it.

These results were obtained during the RC-LACE stays at ZAMG (Tascu, 2016 and Iordache, 2017). More details can be found on RC-LACE web page.

5 References

Bellus, M., 2016: New high resolution ALADIN-LAEF on CY40T1 with ALARO-1 physics. Report on stay at ZAMG, 25/04 13/05 + 06/06 10/06, 2016, Vienna, Austria (available on www.rclace.eu)

Iordache (Pomaga), R., 2017: Revision of ALADIN-LAEF multiphysics and its combination with SPPT, Report on stay at ZAMG, 10/07 04/08, 2017, Vienna, Austria (available on www.rclace.eu)

Storto, A. and Randriamampianina, R., 2010: The relative impact of meteorological observations in the Norwegian regional model as determined using an energy norm-based approach. Atmosph. Sci. Lett., 11: 51-58. doi:10.1002/asl.257

Taşcu, S., 2016: Revision of LAEF Multiphysics, Report on stay at ZAMG Vienna, Austria 04/07 - 26/8/2016 (available on www.rclace.eu)

Wang, Y. et al, 2011: The Central European limited-area ensemble forecasting system: ALADIN-LAEF. Quarterly Journal of the Royal Meteorological Society, doi=10.1002/qj.751, 137(655): 483-502.

ALADIN related activities @SHMU (2017)

Mária Derková, Martin Belluš, Martin Dian, Martin Imrišek, Michal Neštiak, Oldřich Španiel, Viktor Tarjáni, Jozef Vivoda

1 Introduction

The summary of ALADIN related activities at Slovak Hydrometeorological Institute in 2017 is given. The setup of ALADIN operational system is described and some research and development activities are highlighted.

2 The ALADIN/SHMU NWP system

The ALADIN/SHMU system setup

The ALADIN/SHMU system is running on new HPC (*IBM Flex System p460, 12 nodes, Power 7+ architecture, Red Hat Enterprise linux, gfortran).* It covers so-called LACE domain with 4.5 km horizontal resolution and 63 vertical levels. It is running 4 times per day up to 3 days. Current model version is based on CY40T1bf07 with ALARO-1vB 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.

Activities related to the operational system in 2017

In February 2017 the CY40t1_(pre)bf07 has been installed with activated ALARO-1vB physics. The bug in quadratic coupling was discovered and fixed (see Fig. 1). The operational status has been declared on 20/03/2017 by full access of upgraded ALADIN/SHMU outputs to forecasters and public. The five months verification statistics prove that this version outperforms the previous one (CY36, 9 km/L37) in almost every parameter, as documented on Figure 2. Subjective evaluation and the feedbacks received from the duty forecasters revealed that the extreme weather events are in most cases correctly indicated by this version of ALADIN/SHMU system. However, the timing, intensity and locations of particular severe phenomena are not always as accurate as it would be required.

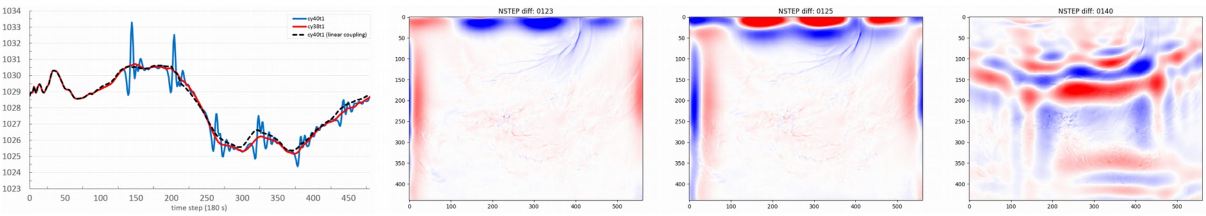


Figure 1: (LEFT) Temporal change of MSLP for one selected case at Bratislava airport with the obvious oscillations in CY40T1 forecast using quadratic coupling interpolation (blue line), while there are no oscillations in the identical forecast of CY38T1 (red line) nor in CY40T1 forecast using solely the linear coupling (black dashed line). All experiments are performed without physics simulation (adiabatic runs) with TSTEP=180 s. Quadratic coupling starts to be active after 120 steps. (RIGHT) Spatial distribution and advection of the artificial signal due to the bug in quadratic coupling interpolation in CY40T1 (differences between the consecutive time-steps) after 123, 125 and 140 steps from left to right respectively (LACE domain).

Table 1: ALADIN/SHMU - operational setup

Model version	CY40T1bf07
Resolution	4.5 km
Levels	63
Area	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 h cycling
Boundaries	ARPEGE, 3 h coupling frequency
Starting times	00, 06, 12, 18 UTC
Forecast length	+78 h/+72 h/+72 h/+60 h
Surface scheme	ISBA
Physics	ALARO-1vB
Dynamics	2TL SL hydrostatic; SLHD

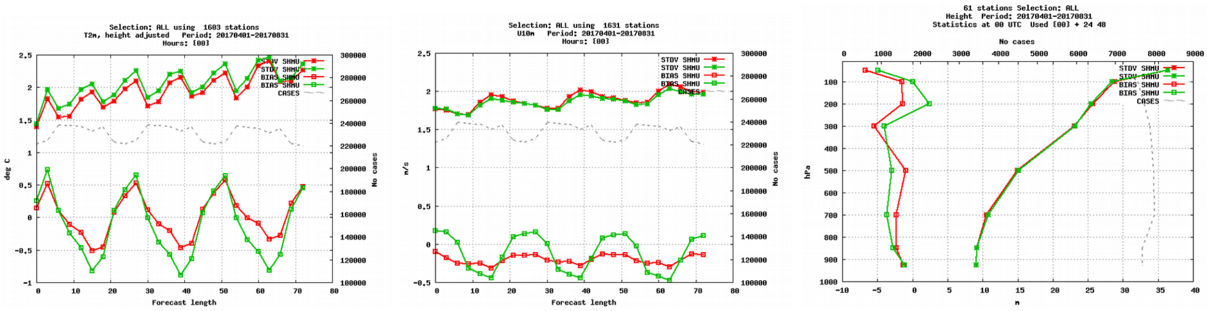


Figure 2: The BIAS and STDEV verification scores of 2 m temperature reduced to station height (left), 10 m wind speed (middle) and vertical profile of +24h and +48h forecast of the geopotential height (right), for 5 months period from 01/04/2017 till 31/08/2017 over whole model domain. The new ALADIN system setup (4.5km/L63) is displayed in red, the old system (9km/L37) in green. The number of cases is depicted by dashed line.

3 Research and Development activities

Tests with IDFI (Martin Bellus)

Incremental digital filter initialization was implemented within the ALADIN/SHMU blending cycle with the aim to filter the noise in the initial conditions. However after a discovery of the bug in quadratic coupling deeper tests were abandoned.

SURFEX (Viktor Tarjani)

Pre-operational implementation of 1-way coupling of SURFEX in offline mode to new (4.5 km/L63) operational model is prepared. It aims for better representation of a surface and surface boundary layer (below lowest model level) that leads to a more accurate analysis and forecast of soil and screen-level variables. Development of application which prepares offline SURFEX forcing consistently from different sources (INCA, AROME) has been started. Validation of offline SURFEX with 1-column configuration on interesting cases is ongoing (PGD testing, forcing with observations, testing different initializations).

ALADIN-LAEF: drying issue with SPPT scheme (Martin Dian, RC LACE stay)

A drying issue in the upper-air when SPPT scheme is applied was investigated. Negative RH bias is observed (Fig. 3 left), invoking an associated T bias (Fig. 3 right), if Q and/or T are perturbed. The only unbiased solution is obtained when solely the wind field is perturbed. The difference between various supersaturation checks in SPPT scheme (see legend) and the reference run averaged over 8 members and over 4 days is plotted. The work is to be continued.

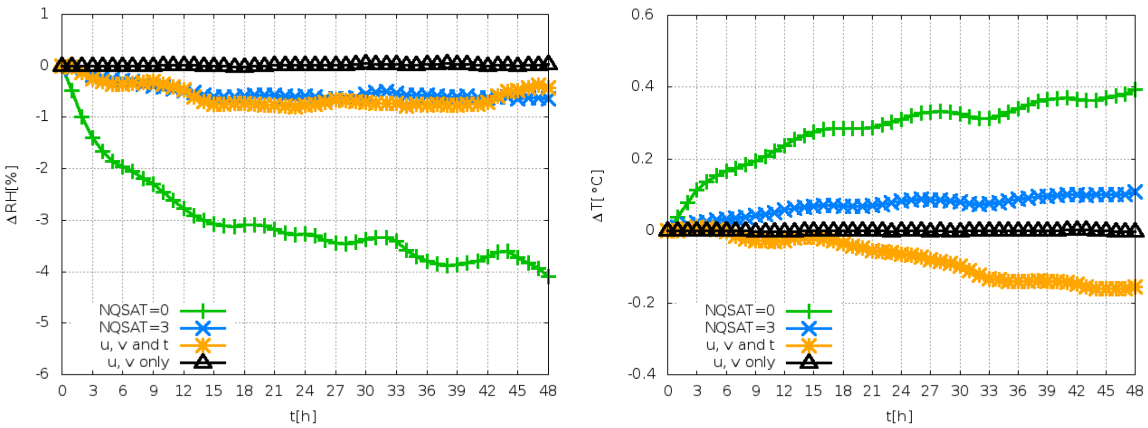


Figure 3: Average from four randomly selected days of April-May 2017 of relative humidity difference (left) and temperature difference (right) between SPPT (8 members) and reference deterministic model run (LSPSDT=.F.) over the whole domain at the 850 hPa level. Green line: 8-member ensemble mean with NQSAT_SDT=0 option. Blue line: 8-member ensemble mean with NQSAT_SDT=3 option. Orange line: 8-member ensemble mean, perturbation of only wind components and temperature without specific humidity. Black line: 8-member ensemble mean, perturbation of wind components only.

ALADIN-LAEF: perturbation methods (Martin Bellus, RC LACE stay)

Different perturbation methods within the new ALADIN-LAEF system were implemented, which was necessary step towards the operational upgrade of spatial resolution to 5 km with the 60 vertical levels. The whole system was upgraded to cycle 40t1 with ALARO-1 physics as well. Ensemble of Surface Data Assimilation (ESDA) was implemented with the two possible ways how to perturb the observations: a) externally; b) by model configuration - screening. Model perturbation was simulated by: a) stochastic physics (surface SPPT); b) reduced set of different physics parameterizations using new ALARO-1 package (1 configuration per 4 ensemble members). The impact of each individual method was clearly positive and in accordance with the expectations and theory, as illustarted on Figure 4.

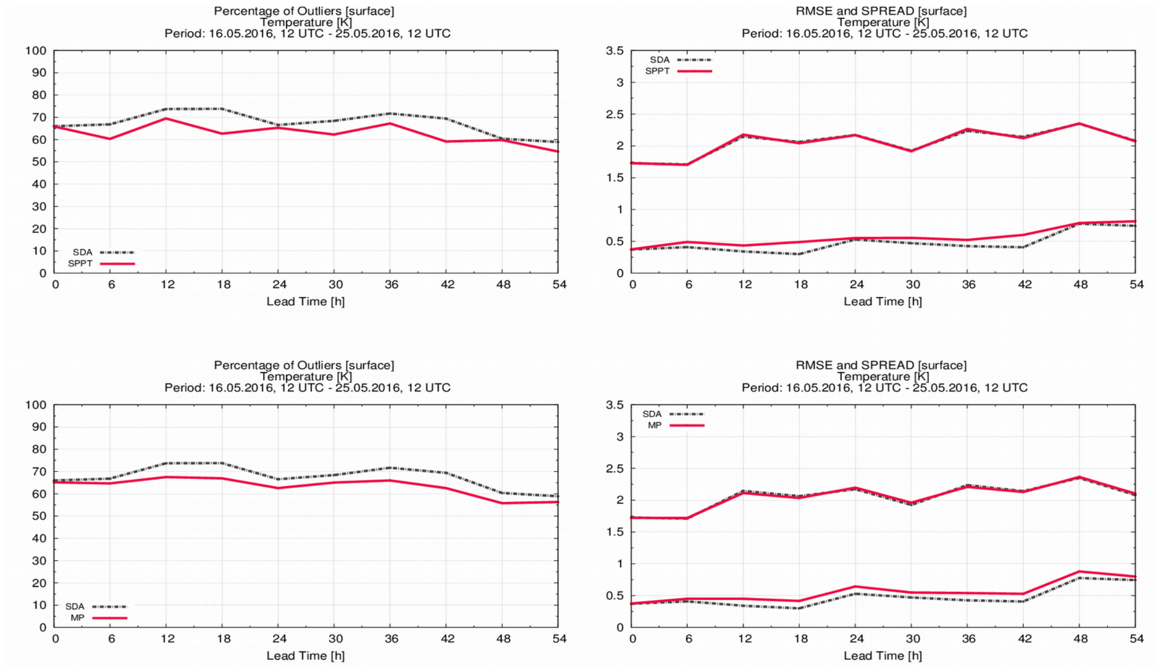


Figure 4: The ALADIN-LAEF statistical scores - percentage of outliers, RMSE and ensemble spread - due to stochastic perturbation of physics tendencies (top) and new ALARO-1 multiphysics (bottom) in red, over the reference (gray dashed lines).

ALADIN-LAEF: new ALADIN-LAEF phase I (Martin Bellus, RC LACE stay)

The problem of land-surface and sea-surface temperature within the conversion and interpolation of global ECMWF files was successfully solved (thanks to Ulf Andrae) and tested (see Figure 5). The boundary conditions for 2-weeks period were recreated and downscaling of ECMWF-EPS was rerun. This was necessary for a proper reference to our LAEF experiments. Furthermore, new ALADIN-LAEF phase I configuration was finally put together, tested and verified against the mentioned reference. It contains ensemble of surface data assimilation (ESDA) with internally perturbed screen-level observations, upper-air spectral blending, stochastic perturbation of physics tendencies (SPPT) for ISBA prognostic fields and new ALARO-1 multiphysics (additionally to the model upgrade from cy36 to cy40, increased horizontal and vertical resolution and redefined domain). The added value of new LAEF over the downscaled ECMWF-EPS is obvious for the surface parameters, while it is rather neutral for the upper-air (not shown, see the correspondig stay report in the References). However, due to the technical aspects (mostly due to enormous increase of consumed SBUs for its integration) we have to admit, that our plan to get it into operations by the end of this year was too ambitious. This is going to be postponed to the next year when it is clear how many resources we have been allocated (Austria) and how many of them could be given by LACE partners.

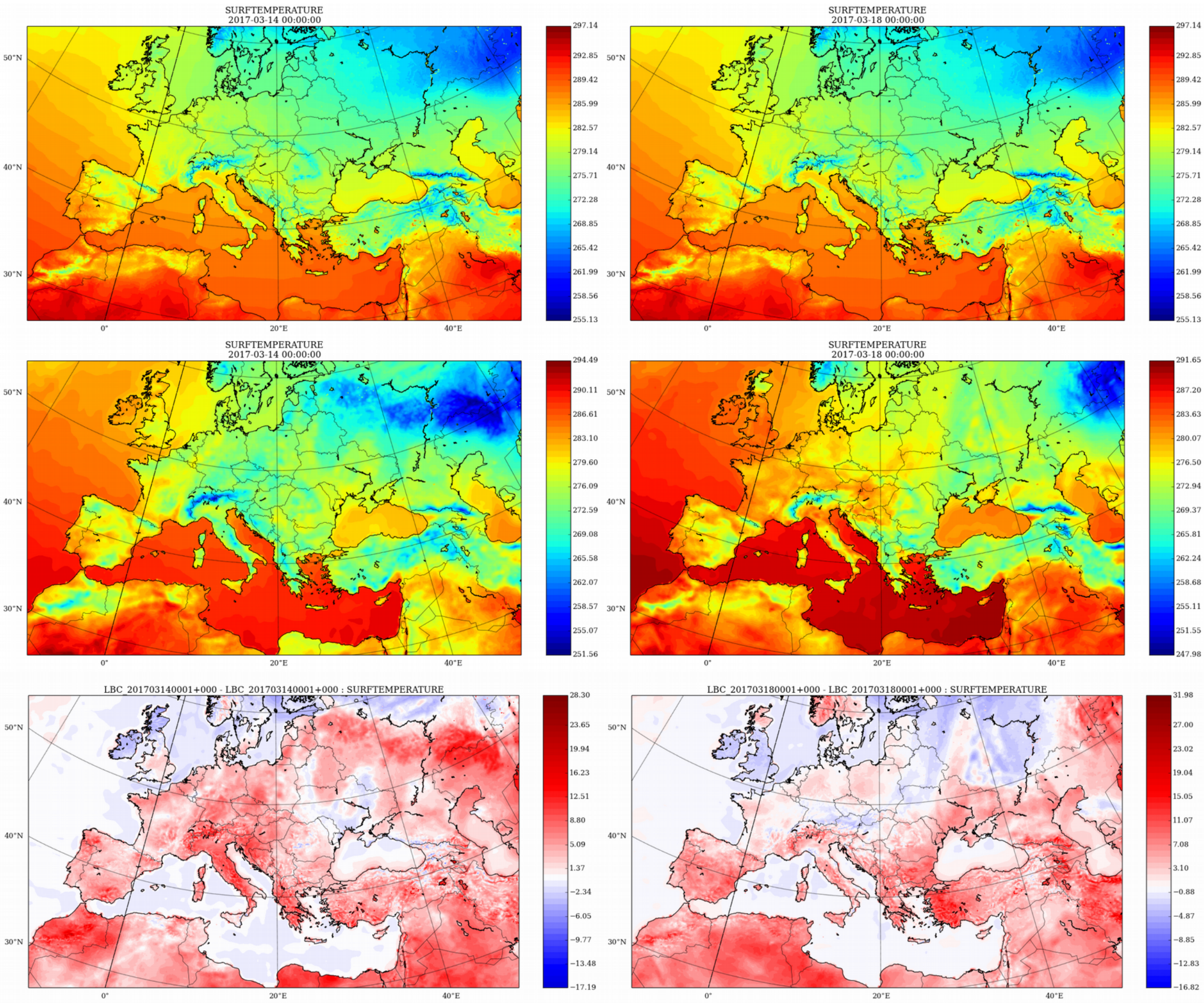


Figure 5: SST/LST initial conditions for 2 different days of March 2017 (left and right) with bugged version of interpolation tool in the first row and fixed one in the second row. The impact to SST/LST field is rather huge (shown in the third row).

NH dynamics (Jozef Vivoda)

Implementation of SETTLS scheme with LPC_CHEAP in NH dynamics has been completed together with the development of mixed scheme with extrapolation and non-extrapolation predictor with dynamical determination of iterations of ICI scheme. An article on new developments in the NH dynamics was drafted that is to be submited to a scientific journal.

Assimilation of ZTD GNSS data (Martin Imrisek)

Local near real-time processing of 59 GNSS stations is performed within a cooperation with the Slovak University of Technology, Department of Theoretical Geodesy (space.vm.stuba/pwvgraph). The station list comprises 40 stations from Euref network, 6 stations from IGS network and 13 from national permanent GNSS stations of AT, CZ, HU and SK. Obtained ZTD are comparable with IGS final PPP product, as illustrated for Ganovce station on Figure 6, left. Technical 3DVAR runs over an AROME/HU domain using locally processed ZTD data look reasonable, as illustrated on Figure 6, right, where a vertical cross-section of the specific humidity analysis increments is plotted. Experiments are to be continued.

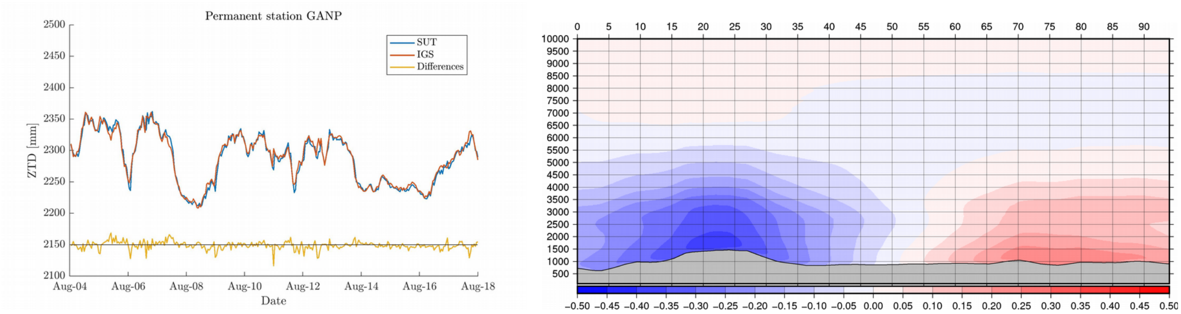


Figure 6. Left: The ZTD values for Ganovce stations obtained by local near real-time processing (denoted SUT, in blue) compared to the final solution computation by the International GNSS Service (IGS, in red); and their difference (yellow). Right: an example of the vertical cross-section of the specific humidity analysis increments using described GNSS data in 3DVAR.

High resolution experiments (M. Dian, M. Nestiak, J. Vivoda, M. Derkova)

The SHMU convection-permitting system is under preparation. Two identical domains for AROME and ALARO CMCs with 2km grid were defined (see Table 2 and Fig. 7), running in a downscaling mode. Generally their performance is comparable, even in the high impact weather situations. Evaluation is ongoing.

Table 2: The experimental setup of two convection-permitting systems currently tested @SHMU

	AROME CMC	ALARO CMC
HPC	IBM Flex System p460 (new HPC)	IBM p755 (old HPC)
model/code version	CY40T1_bf07	
physics	AROME-France CMC	ALARO-1vB CMC
horizontal resolution, no. of grid points	2.0 km, 512x384pts	
number of vertical levels	73	
time-step	144 s	100 s
coupling model	ALARO-1vB (4.5km), 1h coupling frequency	
assimilation, initialization	downscaling, no initialization	
forecast ranges (model output freq.)	+78h at 00 UTC/+72h at 12 UTC (a' 1h)	

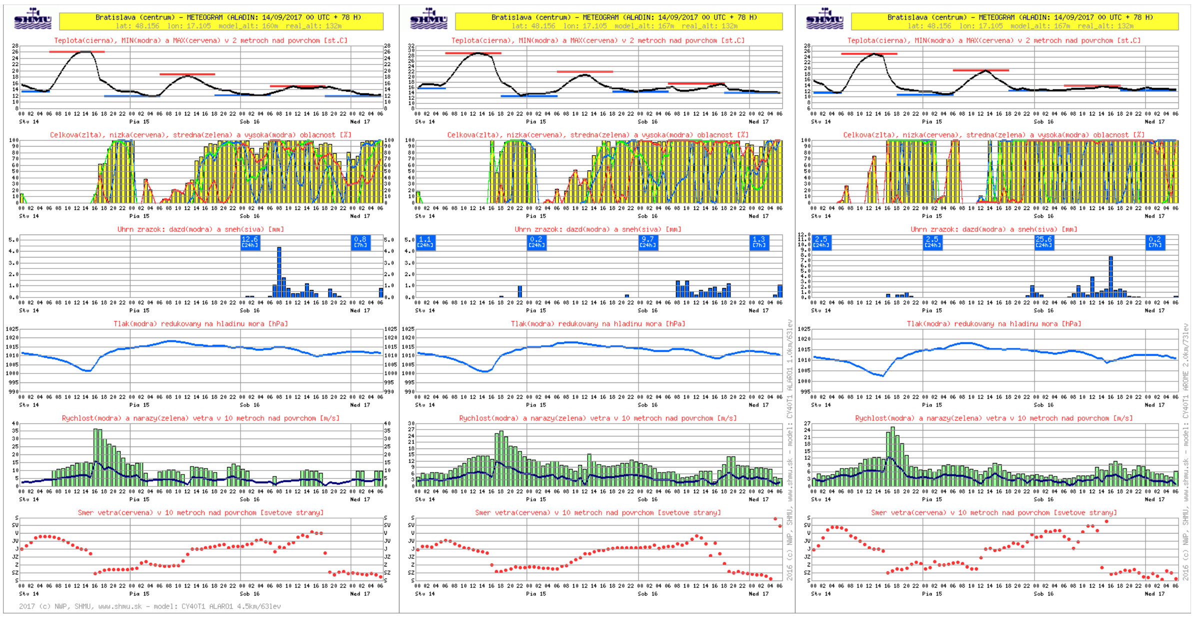
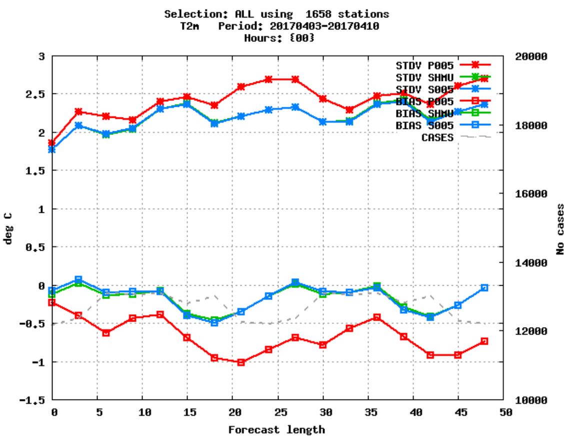


Figure 7: Meteograms for Bratislava airport station from the 14/09/2017 00 UTC integration for ALARO 4.5 km/L63, ALARO 2 km/L73 NH and AROME 2.0km/L73 NH from left to right, respectively. The horizontal axes display days and hours of the forecasts validity (the same for all three meteograms). The vertical axes are from the top to the bottom the corresponding scales for 2 m temperature [° C], total cloudiness [%], hourly precipitation amount [mm/h], mean sea level pressure [hPa], wind speed and wind gust [m/s] and wind direction.

Tests of LBC from Arpege_SURFEX (Maria Derkova)

The usage of the LBC data from the ARPEGE with SURFEX suites has been validated in ALADIN/SHMU environment in the downscaling and in the assimilation (CANARI + blending) modes for various periods and in various setups, in order to prepare the switch for ALADIN Partners. The issue of the SURFEX -> ISBA conversion was addressed. A problem with soil frozen water and snow cover was identified and solved by D. Degrauwe and F. Bouyssel. Figure 8 shows the scores of T2m and geopotential profile for the final solution (S005, in blue) compared to the initial version of the conversion algorithm (P005, in red) and the reference SHMU operational scores (in green). It is shown that the e927 procedure works reasonably well and is ready for operational implementation.



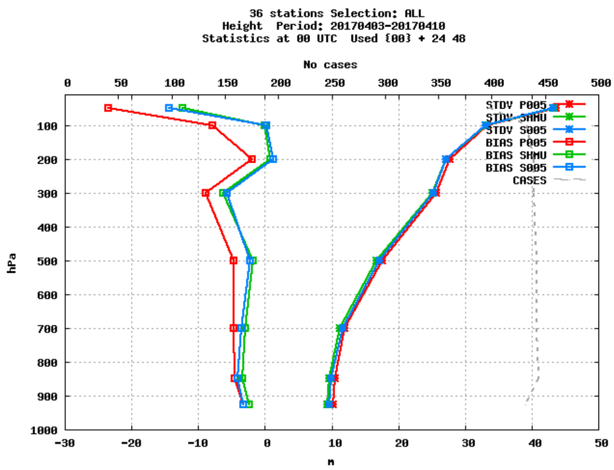


Figure 8: The BIAS and STDEV verification scores of 2 m temperature (left) and vertical profile of +24h and +48h forecast of the geopotential height (right) for 8 days of April 2017. The reference operational suite denoted SHMU is in green, the old setup of SURFEX-> ISBA conversion algorithm denoted P005 in red, the adapted solution denoted S005 in blue.

4 References

Belluš, M., 2017: IC and model perturbations for new ALADIN-LAEF. Report on stay at ZAMG, 24/04~19/05, 2017, Vienna, Austria (available on www.rclace.eu)

Belluš, M., 2017: New ALADIN-LAEF phase I. Report on stay at ZAMG, 16/10~10//11, 2017, Vienna, Austria (soon to be available on www.rclace.eu)

Dian, M., 2017: Supersaturation problem in models with SPPT. Report on stay at ZAMG, 27/03~21/04, 2017, Vienna, Austria (available on www.rclace.eu)

Imrišek, M.: Spracovanie a asimilácia GNSS dát pre účely SHMÚ. Proceeding from the Young scientists' competition, SHMU Bratislava, ISBN 978-80-88907-95-4 (in Slovak)

Tarjani, V., 2017: Validation of EKF surface assimilation scheme. Report on stay at OMSZ, 16/01~17/02, 2017, Budapest, Hungary (available on www.rclace.eu)

Vivoda, J., 2017: Dynamical PC scheme for NH kernel of AAA models. Report on stay at CHMI, 15/05~09/06, 2017, Prague, Czech Rep., (soon to be available on www.rclace.eu)

Vivoda, J., 2017: Vertical finite element scheme in dynamical core of ALADIN. Report on stay at CHMI, 30/10~24/11, 2017, Prague, Czech Rep., (available on www.rclace.eu)

ALADIN highlights in Slovenia in 2017

Benedikt Strajnar, Neva Pristov, Jure Cedilnik, Peter Smerkol, Jure Jerman, Matjaž Ličar

1 Overview

This contribution briefly presents selected development and operational highlights of ALADIN-related activities at Slovenian Environment Agency where a significant progress was reached in 2017. This includes mainly an upgrade of the operational suite to the model cycle cy40t1bf7, physics package ALARO-1vBand developments regarding observational usage in data assimilation. An upgrade of the HPC system increased our computing capabilities for around 30%.

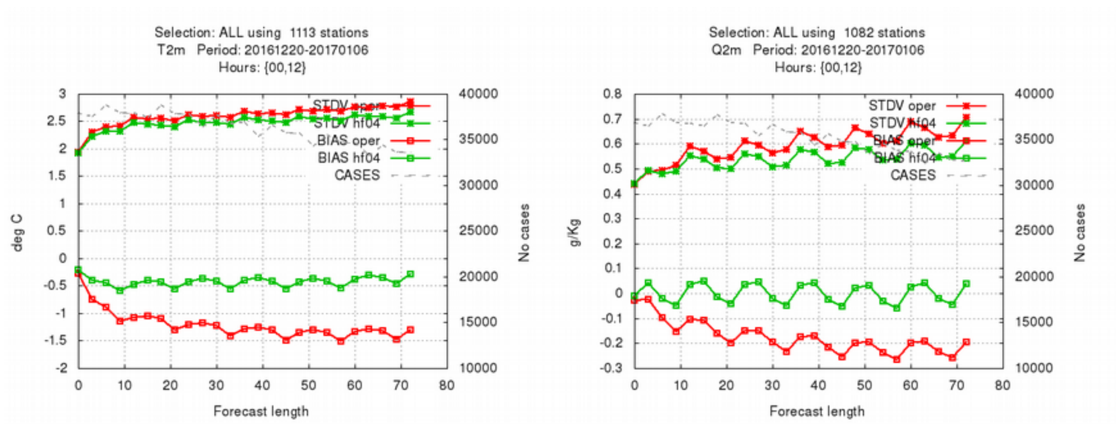
2 Highlighted activities

Upgrade of HPC

An upgrade of HPC took place during summer 2017. Additional 11 Intel Broadwell compute nodes (each with 28 CPUs) were added to the existing 61 Intel Sandy Bridge nodes. At the same time, memory was doubled on existing compute nodes which allows for suspending nonoperational jobs and running off-line FullPos jobs on less processors. Storage capabilities were extended with Data Migration Facility (DMF) which includes 600 TB space on disks and robot tape libraries.

Implementation of cy40t1bf7 and ALARO-1vB in operational suite

The ALADIN cy40, together with assimilation, was put to operations on 4th July 2017 after the validation in full assimilation cycle which showed much improved scores for near surface temperature and humidity, cloudiness and air pressure and neutral impact on other variables (Fig. 1). The forecast improvements however originate mostly from improved model physics ALARO-1vB.



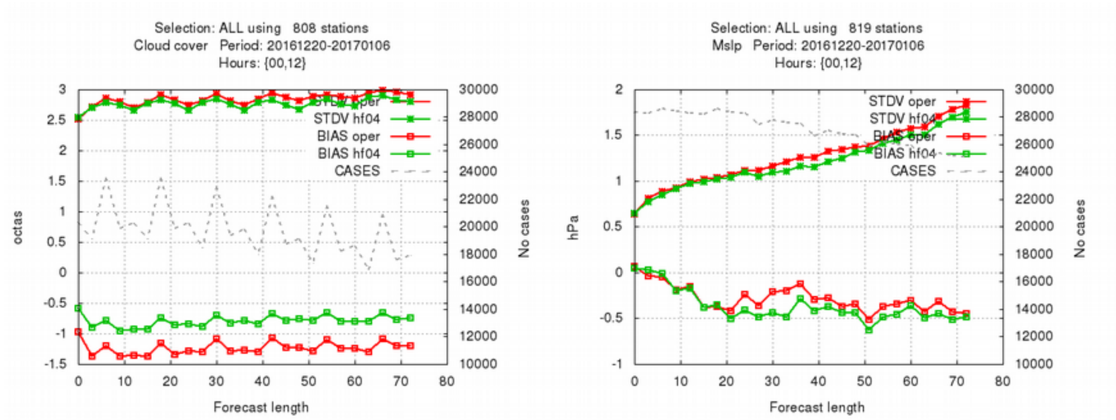


Figure 1: Scores of 2 m temperature and humidity, cloud coverage and pressure which were among the most improved variables in pre-operational cy40 t1bf7 with ALARO-1vB (green) with respect to the previously operational cy38t1bf3 with ALARO-0 baseline (red).

Implementation and validation of new observation types

During the technical implementation of cy40t1bf7, the observational data flow was upgraded to allow processing of additional observations:

- additional AMVs (HRwind),
- scatterometer data (Ascat),
- wind profilers,
- Mode-S EHS aircraft data,
- AMDAR humidity reports,
- IASI clear-sky radiances,
- radar reflectivities and winds.

The impact of those observations (except radar) was separately accessed during a 15 days evaluation period. Mode-S EHS, Ascat and HRwind were considered as most promising and will be implemented into the operational assimilation soon.

Radar DA QC and technical implementation

First experimentation with radar data assimilation started in 2017. Technical steps were taken to read local and/or archived OPERA IOFS radar data in HDF5 format with BATOR decoder. The prepopera Python script was applied to reduce the number of pixels before loading data to ODB. We managed to process numerous European radars except some with missing metadata (e.g. wavelength). A segmentation fault before the reflectivity obs. operator in minimization was encountered and solved. Data assimilation procedure for radar technically works and produces reasonable analysis increments (Fig. 2). Moistening (red) and drying (blue) correspond to areas with cooling and warming, respectively (not shown).

Some efforts were devoted to radar QC as well. The QC modules developed earlier for INCA nowcasting software were applied to OIFS radar files and compared. It was found that QI in OPERA is more detailed as a result of BROPO module (QI1 in OIFS file) where quality depends on the value of reflectivity. Several differences in the two existing radar preprocessing procedures for reflectivity were identified, as explained in Table 1. So far there were no quality assessment tests with Doppler winds. Dealiasing procedures for wind were so far not considered.

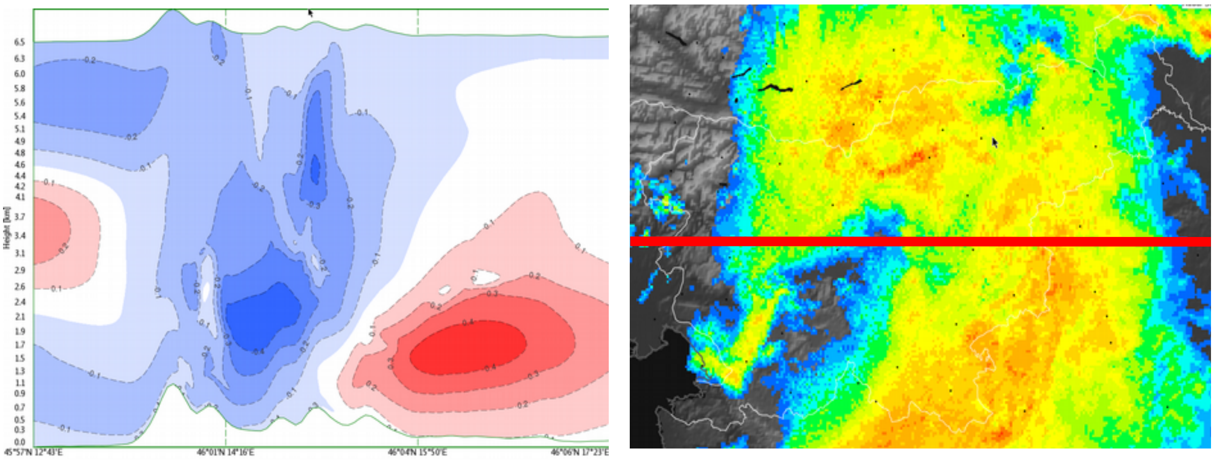


Figure 2: (a) West to east vertical cross section of specific humidity increment over Slovenia due to assimilated radar reflectivities and (b) radar observation on 10 August 2017 0 UTC with indicated cross section line..

Table 1: A comparison of QC filters and corrections applied in Opera OIFS and INCA.

Quality check	Opera OIFS	INCA
attenuation	Implemented within QI1, BROPO assigns smaller QIs to lower dBZs and reduces dBZ based on attenuation	Attenuation stronger than in Opera and computed as a separate QI
Beam blockage	Implemented as QI3	Based on SRTM, more aggressive than in Opera
Laplace test	-	implemented
Satellite cross-check	Implemented as QI2	Implemented using NWC SAF cloud type
WLAN test	Maybe partly in Q1, but some contamination persists (in SI radars)	implemented
Common QI	Minimal value of Q1,Q2,Q3	A product of all QIs

Snow modeling with Crocus model

Performance of snow model Crocus (offline SURFEX) was evaluated over the winter 2016/2017. This included two versions of Crocus, one coupled to ALADIN forecast and another with INCA analysis. In both cases snow analysis and forecast was produced for each grid point of those models. Results are generally encouraging. The model will be used primarily as a snow product for hydrology and as a tool in snow avalanche risk diagnosis and forecasting, but could be later also used as snow analysis for ALADIN. An example of the performance for one mountain station in Slovenia is shown in Fig. 3. It can be seen that the snow melts to fast in the ALADIN assimilation cycle and that Crocus is able to provide a more realistic snow cover.

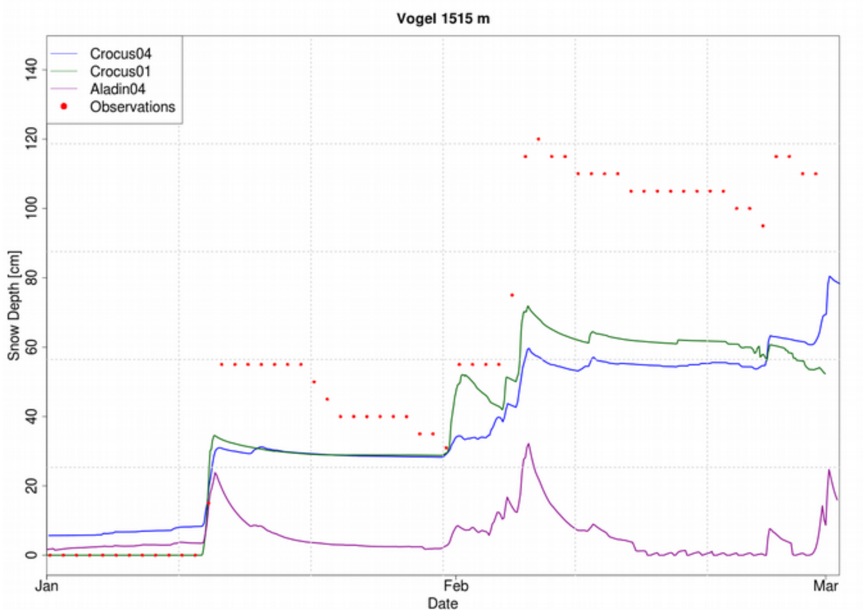


Figure 3: Performance of Crocus snow depth analysis for January-February 2017 on Slovenian mountain station Vogel. Crocus is coupled with ALADIN (Crocus04) or INCA analysis (Crocus01). Estimated snow depth from ALADIN is also shown (Aladin04). Points are snow depth observations.

3 Conclusion

In 2017, ALADIN activities were focused on implementation of newer model cycle with latest ALARO-1 physics package and implementation of additional observations for data assimilation. This ongoing work will continue in 2018 when we foresee operationalization of new observations and further progress in radar data assimilation. We will prepare our modeling system for higher horizontal resolutions.

Two patches in cy40h HARMONIE-AROME and modified tree height and snow roughness length for the MetCoOp domain

Patrick Samuelsson[1], Mariken Homleid[2], Trygve Aspelien[2], Ulf Andrae[1]

[1] Swedish Meteorological and Hydrological Institute (SMHI)
[2] Norwegian Meteorological Institute (MetNorway)

1 Introduction

The semi-long term HIRLAM plan for surface processes and assimilation for the HARMONIE-AROME configuration (Bengtsson et al., 2017) of the ALADIN-HIRLAM NWP system is to activate a number of SURFEX options, e.g. diffusion soil scheme, explicit snow scheme and multi-energy balance (Masson et al., 2013; Decharme et al., 2016; Boone et al., 2017). With respect to number of patches over land this requires at least a separation of forest and open land, i.e. NPATCH=2. These process options are planned to be combined with EKF surface assimilation.

A step in the direction of the semi-long term plan has been taken now with introduction of NPATCH=2. As has been reported at ALADIN Workshops and HIRLAM All Staff Meetings, cy38h and cy40h have suffered from excess spring time evaporation over northern Europe (MetCoOp domain). It has been shown that a separation of forest and open land modifies the Bowen ratio in such a way that spring time evaporation decreases and sensible heat flux increases. Consequently, the spring time positive in $Rh2m$ is reduced. Please note that by SURFEX construction, activation of NPATCH>1 requires a deactivation of the surface-boundary-layer scheme (SBL).

Further tests have shown that NPATCH=2 and SBL off are partly beneficial also for other seasons and HIRLAM domains. Thus, from a land-surface perspective, further development of HARMONIE-AROME beyond cycle 40h1.1 (Bengtsson et al., 2017) towards a new target release, cy40h1.2 target 2 (from hereon simply called tg2), has included these two options.

However, as described in the Result section, although these options have improved a few aspects of the model performance, especially related to $Rh2m$ and $T2m$, they also led to a deterioration of the 10 m wind speed, $U10m$, over northern Europe. Both changes pushed the model towards lower $U10m$. There are mainly two reasons for this; (i) with the SBL scheme the maximum allowed momentum roughness length, z_{0m}, is limited to 0.5 m so when SBL is deactivated z_{0m} is defined by the vegetation based roughness length which is considerable higher in forest dominated areas, (ii) with two patches activated the grid averaged effective roughness length increases which leads to lower wind speed in the lower part of the boundary layer and consequently a lower $U10m$. In the process of investigating what caused the changes in wind speed we started to question the vegetation surface roughness length. For trees the vegetation roughness is directly proportional to the tree height: $z_{0mv} = 0.13 * h_{veg}$. Thus, if the tree height is specified as too tall for ECOCLIMAP covers relevant for the MetCoOp domain it can cause a too large roughness length. Therefore, we investigated alternative data bases for tree height. The result of this investigation is presented in Section 2. Also, there is a seasonal variation in the $U10m$ bias with higher wind speeds in winter. Thus, modified values of snow roughness have been tested as described in Section 3.

All in all, from a surface perspective, the development version of cy40h for MetCoOp described here includes tg2 changes (NPATCH=2 and SBL off) plus modified tree height and modified snow roughness (from hereon simply called tg2mod). This publication describes some details of these modifications and presents results based on test simulations for different seasons.

2 Tree height data

The default physiography database in cycle 40h1.1 is based on ECOCLIMAPv2.2 (Faroux et al., 2013) which is a global database at 1 km resolution. Regional discrepancies between the ECOCLIMAP data base and corresponding physiography information based on national databases are occasionally identified. Here such a discrepancy concerns the tree height. In Figure 1 we compare tree height data from ECOCLIMAP with the global forest canopy height product by Simard et al. (2011) and with corresponding national databases from Sweden (Skogsstyrelsen), Finland (METLA) and Trøndelag, Norway (NIBIO). These national data are based on remotely sensed laser scanned estimated tree heights with a raw resolution at 10 m. The combined national data sets, processed by Matti Horttanainen at FMI, is named “Nordic” national data.

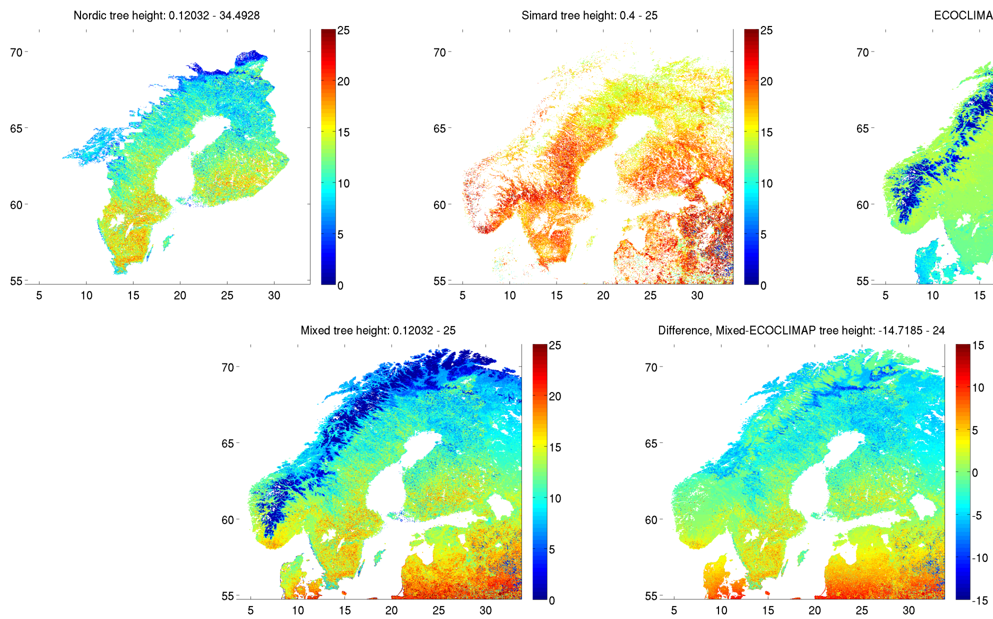


Figure 1: Results visualized for the Nordic area only: Tree heights (m) based on Nordic national data (top left), Simard et al. (2011) (top middle) and ECOCLIMAP (top right). The mixed tree height data set (bottom left) and the difference, Mixed-ECOCLIMAP (bottom right).

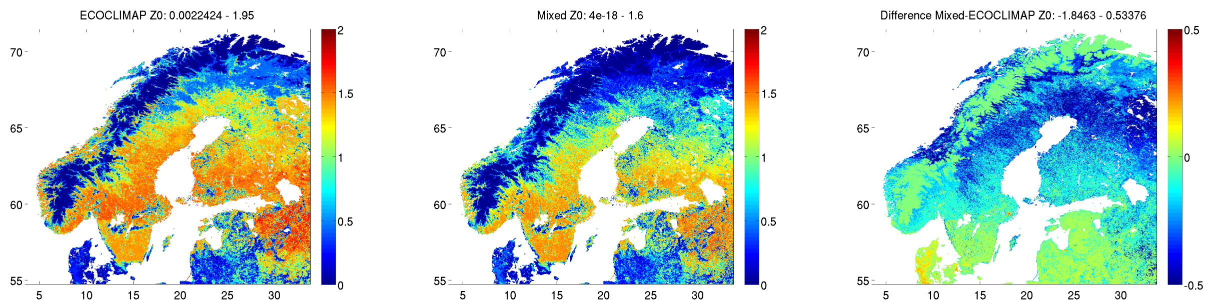


Figure 2: Roughness length (m) based on default ECOCLIMAP (left), mixed tree height (middle) and the difference, mixed - ECOCLIMAP (right).

Figure 1 shows how the ECOCLIMAP default tree height compares with the new data bases and also with the tree height version where all these data bases are mixed together, called the mixed version. This mixed version is created as

- First, the Nordic national data are considered to be the most reliable data and are used as they are where they exist.
- The horizontal variability in the Simard et al. (2011) data is considered to be realistic but the tree height is overestimated compared to the Nordic data. Thus, the Simard et al. (2011) data is used where it exists, in points where Nordic data does not exist, but scaled using a linear fit of the ratio (Nordic data)/(Simard et al., 2011) as a function of latitude where both of them exist. The mean ratio over the common data domain is 1.52.
- For all remaining points, where Nordic and Simard et al. (2011) data do not exist, the default ECOCLIMAP data is used but again scaled with respect to the Nordic data set using a similar linear function between ratio and latitude. The mean ratio over the common data domain is 0.96.

The final mixed version is read into SURFEX as an external tree height field. It remains some artificial borders between data sets but these borders are hardly distinguishable in the final roughness length.

Figure 2 shows the grid-averaged land (ISBA) roughness length where tree heights based on default ECOCLIMAP and mixed version are used, respectively. The maximum value based on the mixed version becomes 2.99 m while the maximum value based on default tree height becomes 1.95 m. Both these values are considered to be too high. Therefore, the maximum value is limited to 1.6 m by modification of the SURFEX subroutine z0v_from_lai.F90.

Details about the tree height data processing are documented at this HIRLAM wiki page:
`https://hirlam.org/trac/wiki/Surface_physis_assimilation/pgd_ecoclimap_work`

3 Snow roughness

For many years we have noticed a seasonal dependence in the $U10m$ bias with higher wind speed during the snowy season. Also, operational forecasters have reported too high forecasted winds in connection to high wind speed events in mountainous regions during winter time. This indicates that snow roughness length may be too low. The snow roughness length is specified by the SURFEX namelist variables XZ0SN (default 0.001 m) and XZ0HSN (default 0.0001 m) for momentum and heat, respectively. From experience only, XZ0SN$= 0.001$ seems a bit too low since a snowy landscape is often disturbed by obstacles and individual tall plants. After a number of tests with different higher roughness values the conclusion is that reasonlble firnal new values are XZ0SN$= 0.003$ and XZ0HSN$= 0.0003$. These are the values used for the winter season as presenetd in the results section.

4 Results

In general the new tree height physiography should lead to higher wind speed since the tree height is in general lower, especially in the northern part of the MetCoOp domain. However, this is partly compensated by slightly increased roughness for snow which should lead to somewhat lower wind speed in snow-dominated areas during winter and spring.

A number of simulations have been performed to evaluate the influence of modified tree height and snow roughness. The setups have their origin in the tg2 specification, i.e. activation of two patches and deactivation

Table 1: Validation simulations. The specified time periods refer to the analysed periods. They are all preceded by at least 10 days spinup. The other specifications concern those where the setups differ.

Season	Time period	Domain	Atmos. analysis	XZ0SN	XZ0HSN
winter	20161215 – 20170110	SNOW_2.5KM	blending	0.003	0.0003
spring	20160301 – 20160409	METCOOP25B	3DVAR	0.01	0.001
summer	20160701 – 20160809	METCOOP25B	3DVAR	0.01	0.0001
autumn	20161001 – 20161107	METCOOP25B	3DVAR	0.01	0.0001

of the SBL scheme. The additional common modifications concern the use of the mixed tree height field and modified snow roughness. For different reasons there are a few details that differ between the setups. These are listed in Table 1. For example, the specified momentum ($XZ0SN$) and heat ($XZ0HSN$) roughness lengths for snow differ somewhat. The reason for this is that preliminary analysis made during the test period indicated that modifications should be beneficial for the results and somewhat different roughness values were tested for different seasons. Consequently, the simulations are not exactly comparable but we argue that this is not critical for the final outcome of this development version of the model. The final values chosen for snow roughness are those used for the winter period, i.e. $XZ0SN = 0.003$ m and $XZ0HSN = 0.0003$ m. Since smaller values were used for the test of the spring period we can expect that $U10m$ should be somewhat lower over snow covered areas during spring in the final development version (tg2mod).

The results of the test simulations are shown in Figures 3–5 as diurnal cycles of $T2m$, $Rh2m$ and $U10m$. The simulations shown represent the latest official relase, cy40h1.1, tg2 of the development version (i.e. NPATCH=2 and SBL off) and tg2mod, i.e. tg2 plus modified tree height and snow roughness.

Except for during winter time, tg2mod suffers from a more or less big cold bias, especially during day time. Although the cold bias is actually slightly less than in cy40h1.1 where it also exists. In spring time, almost independent on area, the bias is -0.5 – -1 degC during the whole diurnal cycle, only slightly decreased for the highest altitude area. In summer and autumn a half of a degree cold bias is seen during the daytime period of the diurnal cycle. Only for high altitude areas during autumn tg2mod shows any significant improvement. In winter time the diurnal cycle is in general very weak. The general cold bias in cy40h1.1 is reduced and varies between small (0.15 degC) cold to warm bias depending on altitude range.

The greatest improvement in tg2mod compared to cy40h1.1 is related to a reduced humid bias in $Rh2m$ during spring time. In cy40h1.1 this bias is around 10% during day time while in tg2mod the bias is around 4The bias is even smaller in tg2. Thus, a compromise between wind speed and humidity biases over snow leads to a somewhat larger humidity bias in the final version compared to tg2.

At daytime during winter the $Rh2m$ bias goes from a humid bias of 2-3% in cy40h1.1 to a dry bias of 2% in tg2mod. Partly this change in $Rh2m$ is related to a decreased cold bias in $T2m$ but in some cases the humidity is lower for other reasons. This winter time negative bias in $Rh2m$ is honestly disturbing but not easy to solve without affecting other aspects of the model performance.

During summer we see a very slight improvement of $Rh2m$ during daytime but a humid bias of 1-5% still exist, depending on altitude range. During autumn the daytime $Rh2m$ moist bias in cy40h1.1 is considerable reduced and this specific validation shows a very small $Rh2m$ bias at noon for tg2mod, $< 1\%$. However, during night time we go from a slight humid bias in cy40h1.1 to a dry bias of 2% in tg2mod.

For many area and season combinations we see a positive wind bias in cy40h1.1. This bias was reduced or was turned into a negative bias in the tg2 version. This negative bias became a concern for some areas since $U10m$ is an important variable with respect to extreme events and warnings. So, as already described, this initiated the work to identify means to increase the wind speed. The outcome of this work is seen in Figure 5 where tg2mod shows higher wind speed than tg2 for most areas and seasons in the altitude range 0-600 m. However, during winter-autumn, above 600 m, we see the effect of increased roughness length for snow which to some

Table 2: Areas within the MetCoOp domain used for the validation and order of magnitude of combined cases (observations and model diagnostics) available per area and season. The areas are here specified as cases within a certain altitude interval.

		No of cases	
Area selection	Area description	winter	all other seasons
0-200m	Most land area except the inner parts of Norway and mid-north Sweden	300	670
200-600m	Inner parts of Norway, Sweden and northern Finland, except mountainous areas	110	130
600-1000m	Mountainous areas of Norway and Sweden	30	35

degree compensates the decreased roughness length for forest. In general tg2mod shows better agreement with observed wind speed than cy40h1.1. Although a few exceptions do exist which include the high altitude range during spring and autumn and the mid altitude range during autumn.

5 Summary

This publication describes the performance of a new development version of HARMONIE-AROME, beyond cy40h1.1, as validated over the MetCoOp domain. The focus is changes related to surface physiography and processes. The HIRLAM long term surface plan includes a separation of of the land tile into at least two patches, i.e. forest and open land. By SURFEX construction this also requires a deactivation of the SBL scheme. It is shown here that introduction of two patches do improve some aspects of the model performance, especially via a reduction of a quite strong humid bias in $Rh2m$ over northern Europe during spring time. Not shown here, but introduction of two patches has also been beneficial for some other HIRLAM domains, e.g. $T2m$ is improved over the Iberian peninsula. However, the Nordic HIRLAM partners were not happy with the performance related to $U10m$ and winter time $T2m$. Further investigations of the $U10m$ problem led to the introduction of new tree height data for the MetCoOp domain, replacing the default ECOCLIMAP tree height, and a modification of the snow roughness length. These changes have now led to satisfactory $U10m$ results for the MetCoOp domain. The slight warm bias in $T2m$ during winter has not been solved by any further modifications but is has been concluded that, although not presented here, $T2m$ for the open land only patch compares better with observed $T2m$ during winter time. In principle one would expect that the open land variables would always give better performance with respect to observations since the observations represent open land conditions. However, this is not the case in these validations.

Currently, the described new version runs in pre-operational mode in the MetCoOp NWP suite. If it will be operational as is or after some further extra modifications is not yet decided. The concern is a remaining dry bias during winter time.

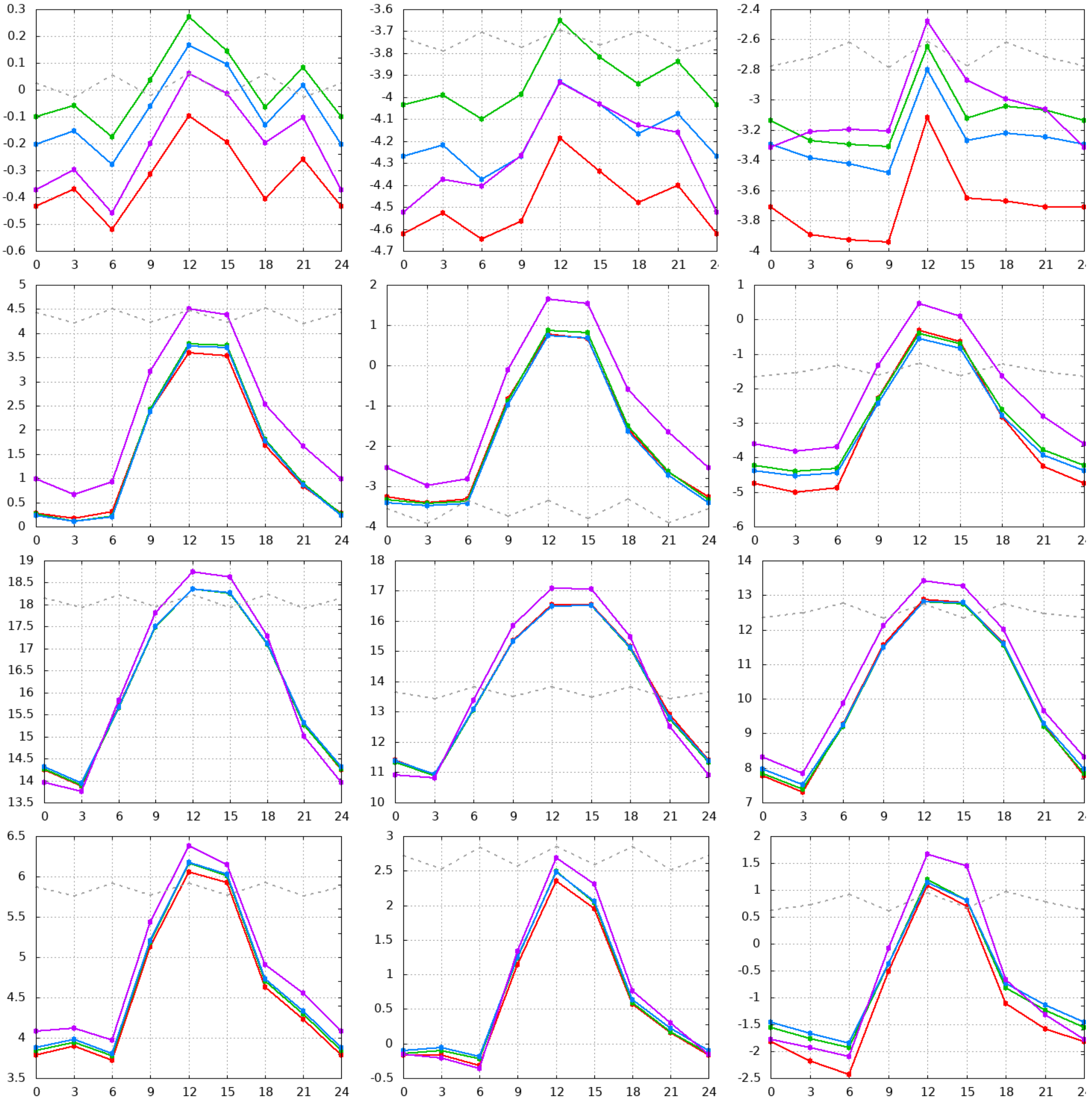


Figure 3: Diurnal cycles (00,12 + 3-24 hours) of $T2m$ (degC) for the areas in Table 2: 0-200m (left column), 200-600m (middle column), 600-1000m (right column). The rows represent the four seasons, winter, spring, summer and autumn, from top to bottom. The lines represent cy40h1.1 (red), tg2 (green), tg2mod (blue) and observations (magenta).

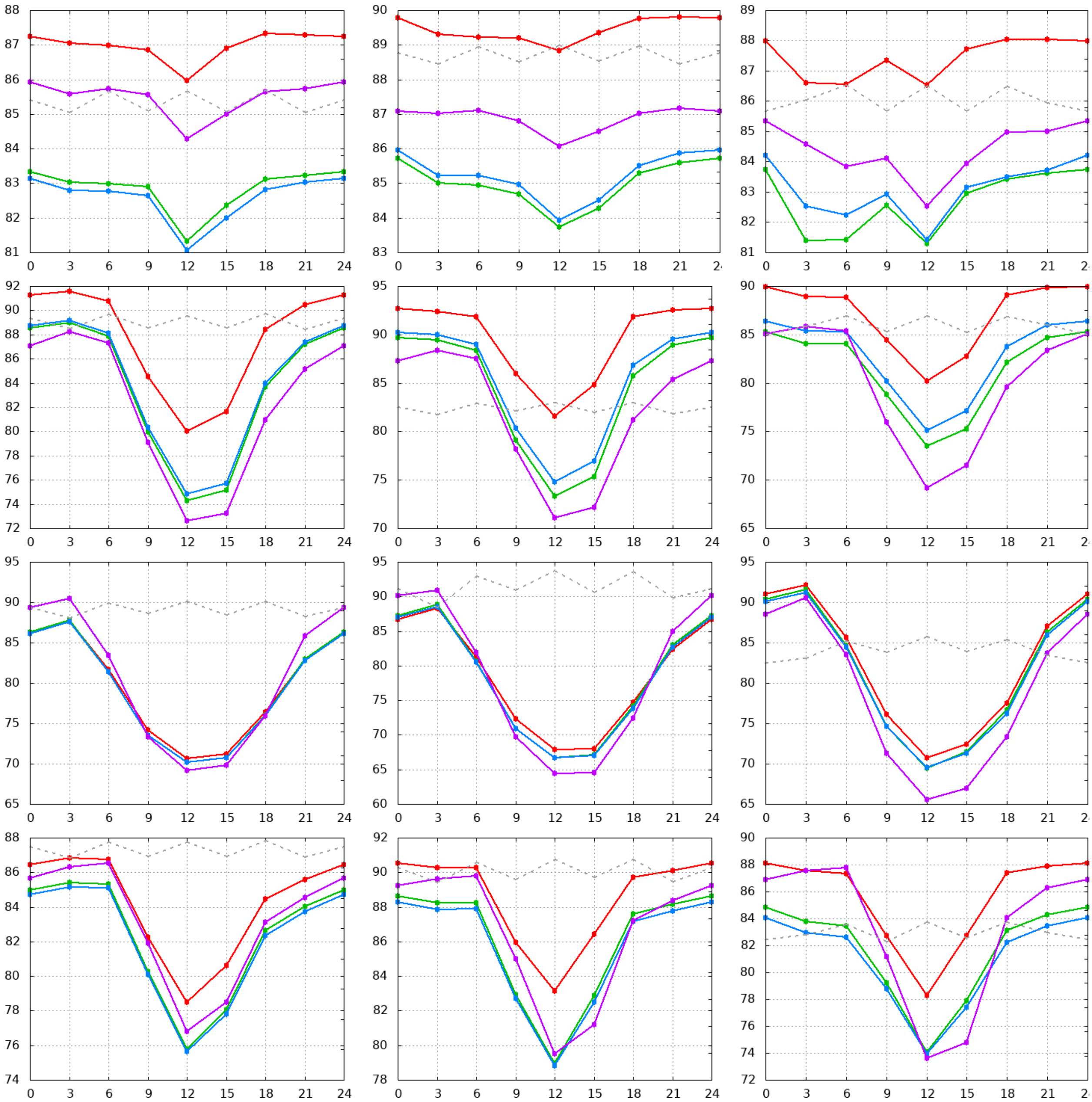


Figure 4: Same as Figure 3 but for $Rh2m$ (%)

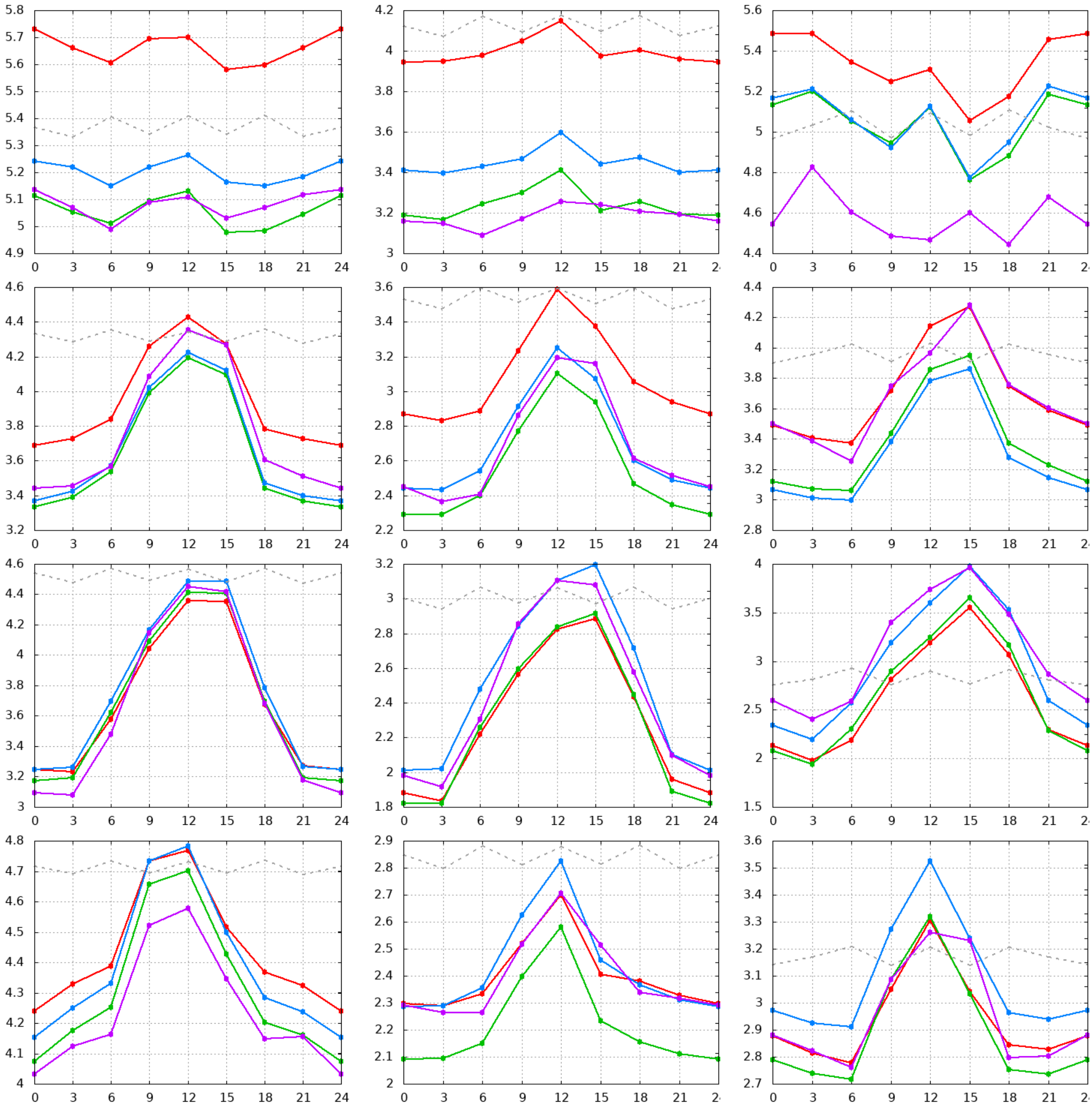


Figure 5: Same as Figure 3 but for $U10m$ (ms^{-1})

References

Bengtsson, L., Andrae, U., Aspelien, T., Batrak, Y., Calvo, J., de Rooy, W., Gleeson, E., Hansen-Sass, B., Homleid, M., Hortal, M., et al., 2017. The harmonie–arome model configuration in the aladin–hirlam nwp system. Monthly Weather Review 145 (5), 1919–1935.

Boone, A., Samuelsson, P., Gollvik, S., Napoly, A., Jarlan, L., Brun, E., , Decharme, B., 2017. The interactions between soil-biosphere-atmosphere land surface model with a multi-energy balance (ISBA-MEB) option in SURFEXv8 - Part 1: Model description. Geosci. Model Dev. 10, 843–872.

Decharme, B., Brun, E., Boone, A., Delire, C., Moigne, P. L., Morin, S., 2016. Impacts of snowpack properties and soil organic carbon content on characteristics and soil temperature profiles simulated by the isba land surface model. Cryosphere 10, 853–877.

Faroux, S., Tchuenté, A. T. K., Roujean, J.-L., Masson, V., Martin, E., Moigne, P. L., 2013. ECOCLIMAP-II/Europe: a twofold database of ecosystems and surface parameters at 1 km resolution based on satellite information for use in land surface, meteorological and climate models. Geosci. Model Dev. 6, 563–582.

Masson, V., Moigne, P. L., Martin, E., Faroux, S., Alias, A., Alkama, R., Belamari, S., Barbu, A., Boone, A., Bouyssel, F., Brousseau, P., Brun, E., Calvet, J.-C., Carrer, D., Decharme, B., Delire, C., Donier, S., Khatib, R. E., Essaouini2, K., Gibelin, A.-L., Giordani, H., Habets, F., Jidane, M., Kerdraon, G., Kourzeneva, E., Lafont, S., Lebeaupin, C., Lemonsu, A., Mahfouf, J.-F., Marguinaud, P., Moktari, M., Morin, S., Pigeon, G., Salgado, R., Seity, Y., Taillefer, F., Tanguy, G., Tulet, P., Vincendon, B., Vionnet, V., Voldoire, A., 2013. The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes. Geosci. Model Dev. 6, 929–960.

METLA, . The Finnish Forest Research Institute. `http://www.metla.fi/index-en.html`.

NIBIO, . Norwegian National Forest Inventory. `http://www.nibio.no/en/info/forest-and-forest-resou`

Simard, M., Pinto, N., Fisher, J. B., Baccini, A., 2011. Mapping forest canopy height globally with spaceborne lidar. Journal of Geophysical Research: Biogeosciences 116 (G4).

Skogsstyrelsen, . The Swedish Forest Agency, Skogliga grunddata. `https://skogskartan.skogsstyrelsen.se/Skogskartan`.

NWP Related Activities in TUNISIA

Anis Satouri, Hajer Dhouioui, Wafa Khalfaoui

1 Operational & Parallel suites

The operational suite and the configurations that are running on the local machine (HP Proliant DI560 Gen8) are summarized on the tables 1 and 2 below.

Table 1: ALADIN operational suite

Model version	**ALADIN-TUNISIE**
Resolution	7.5km
Levels	70
Boundaries & Initial conditions	ARPEGE
Surface scheme	Surfex
Starting times	00 UTC

Table 2: Configuration tested on local machine

Model version	**AROME-TUNISIE 2.5 km**	**AROME-TUNISIE 1.3 km**	**HARMONIE-TUNISIE**
Resolution	2.5 km	1.3 km	2.5km
Levels	60	90	65
Boundaries & Initial conditions	ARPEGE	ARPEGE	ALADIN
Surface scheme	Surfex	Surfex	Surfex

2 Research & development Activities

2.1 AROME-Medjerda: A Tool for a Better Decision Making

The catchement of Medjerda, located in the north-western region of Tunisia, is an area at risk that suffers from severe flooding every year. As it holds the biggest river in Tunisia and several dams around it, Medjerda watershed represents an important hydrometeorological study area.
The need of a better forecast over this area leaded to configure a new AROME domain with a 1.3 km resolution.

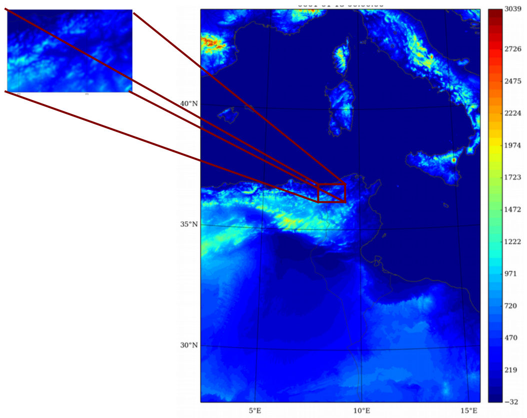


Figure1: AROME-Medjerda Domain

Case Studies of February 25th and 26th 2015

These case studies showed AROME-Medjerda's ability to well localize the nucleus of heavy rainfall (red circles in Figure 2 and Figure 3) with more realistic simulations of the convective cloud structure. In addition, the localization was improved compared to the results of the ALADIN model which shifted the core of rainfall to the coast at Tabarka .Other intense nuclei have been predicted by AROME-Medjerda, notably on February 26th 2015 but have not been validated due to lack of observations.

Thus, AROME-Medjerda gives more occurred and detailed information for the decision makers in terms of the meso-scale phenomenon localization and intensity.

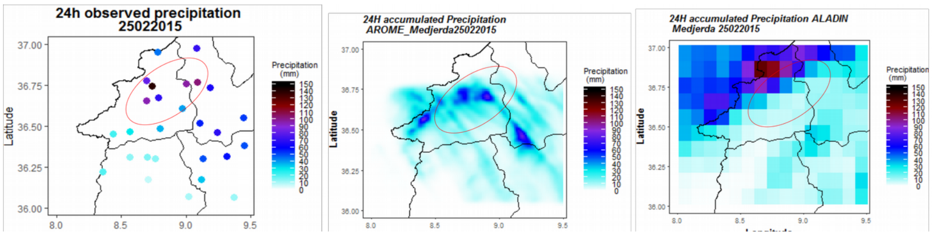


Figure 2: 24H Accumulated precipitations of 25/02/2015 - from left to right: Observation, AROME-Medjerda 1,3km and ALADIN 12.5 km

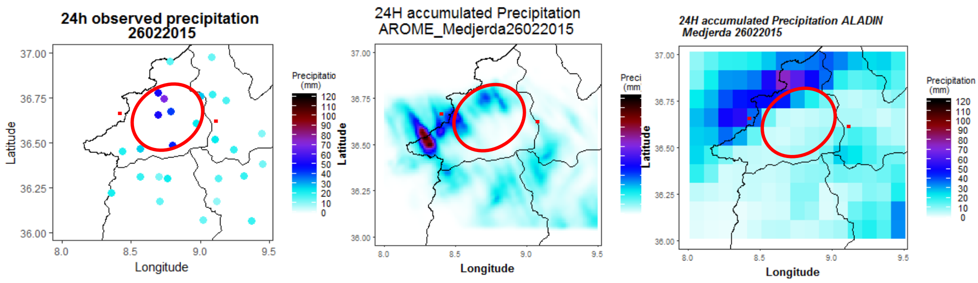


Figure 3: 24H Accumulated precipitations of 26/02/2015 - from left to right: Observation, AROME-Medjerda 1,3km and ALADIN 12.5 km

2.2 3DVAR Data Assimilation Implementation

A 3DVAR data assimilation configuration is being implemented on the local machine.
The case study below shows the data assimilation impact on the forecast of the precipitations. On the 23rd of September 2016, a flood event, on the Tunisian eastern cost near Sousse, was caused by an intense convective system where we recorded more than 120mm of precipitations in 24H.. Although both AROME-3DVAR and AROME Spin-up configurations predicted well the situation, AROME-3DVAR gave more accurate forecasts for the precipitation amount and the convective cell localization.

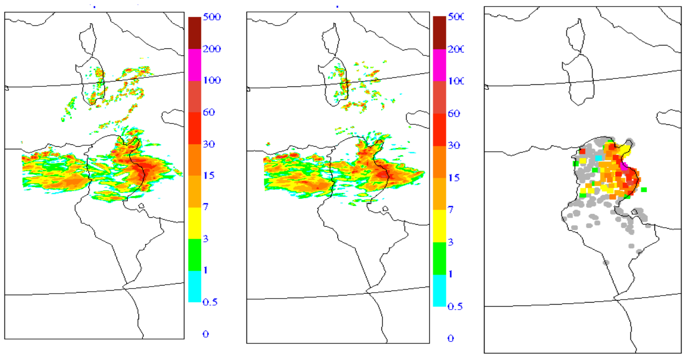


Figure 4: 24H accumulative rainfall for September 23rd 2016 - From left to right: AROME 3DVAR, AROME Spin-up and Observation

2.3 Model Inter-comparison: Motivation of migrating from Aladin 7.5km to Arome 1.3 on the new Calculator

A sample of case studies comparing AROME 1.3 km and ALADIN 7.5 km was made in order to justify the cost of the new HPC as AROME 1.3 is much more expensive in term of computational cost. Figures 5 and 6 represent two atmospheric systems that characterize the main perturbations over Tunisia: North-West and East systems. The figures below show that, regarding the localization and the intensity, AROME 1.3 km is much more accurate than ALADIN 7.5 km.

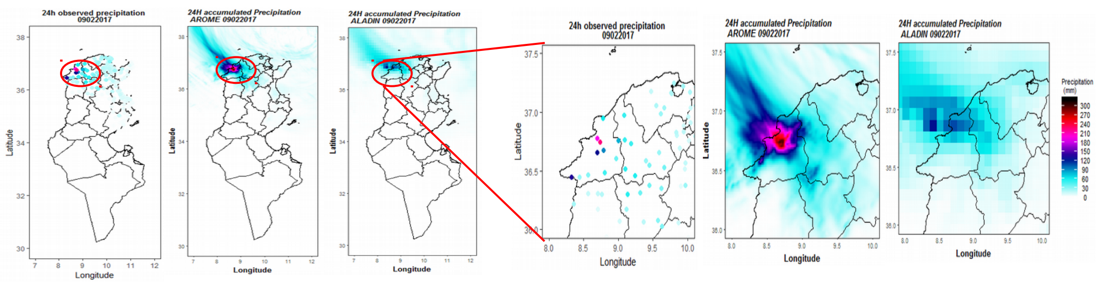


Figure 5: 24H accumulative rainfall for 09/02/2017 North-West system: From left to right: Observation, AROME 1,3km and ALADIN 7.5 km

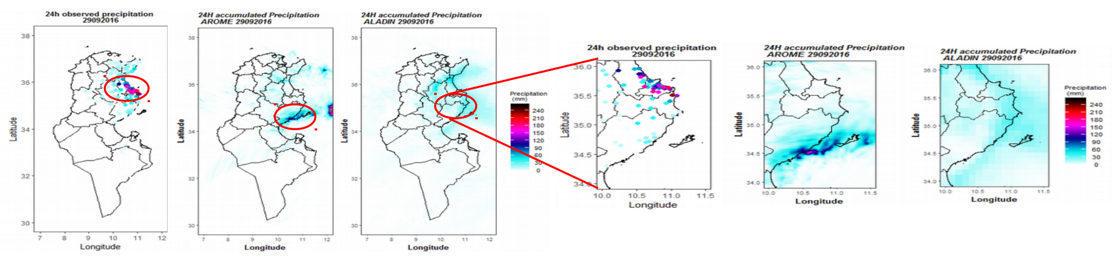


Figure 6: 24H accumulative rainfall for 29/09/2016 East system: From left to right : Observation, AROME 1,3km and ALADIN 7.5 km

Assimilation of SEVIRI Radiance and Conventional Observation Data in the ALARO Model

Yelis CENGIZ, Tayfun DALKILIC

1 Introduction

This article represents the implementation of assimilation system in ALARO model. Currently the system is running in the test suite for four times (00, 06, 12 and 18 UTC) a day. To evaluate the impact of SEVIRI radiance and conventional observations on forecast, three experiments namely CONV, SEV35 and SEV70 were prepared for the period of 20170718-20170801.

The assimilation system is run with 6 hour cycle. While 3DVAR method was applied for the upper air analysis, CANARI OI was used for the surface analysis. The first experiment (CONV) includes only conventional data: synop, amdar and temp observation. The second one (SEV70) includes conventional and SEVIRI data with 70 km thinning distance and the last one (SEV35) uses conventional and SEVIRI data with 35 km thinning distance. The current operational ALARO Turkey with no assimilation was used as a control experiment.

In order to eliminate the negative effect of systematic errors on analysis in radiance data, the adaptive variational bias correction technique VarBC (Dee, 2005; Auligne et al. 2007) embedded within the system was utilized. And finally Harmonie verification package was used to assess the results of the assimilation. In this context, model outputs from short cut off times (00, 12 UTC) of the assimilation cycle were used for verification.

2 Experiments

Control Experiment-Operational ALARO Turkey

Operational ALARO Turkey cycle 40t1 has 4.5 km horizontal resolution and 60 vertical layers. Boundary conditions are applied at 3 hr intervals from global model ARPEGE. The model is run for four times (00, 06, 12 and 18 UTC) and forecasts up to 72 hours are produced and dfi is applied before the integration. In Figure 1 , the operational ALARO Turkey domain is represented.

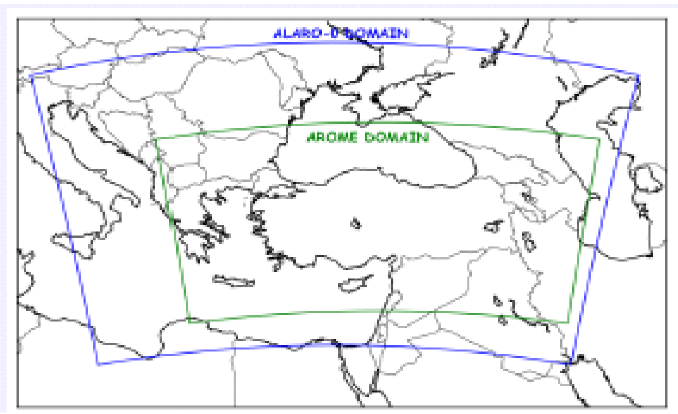


Figure 1: *Operational ALARO Turkey domain.*

Experiments CONV, SEV70, SEV35

In the experiment CONV, synop, amdar and temp observations are included in the assimilation system. The conventional observation data was in BUFR format. From synop observations 2 m relative humidity, 2 m temperature and geopotential data; from amdar u and v components of wind, temperature and from temp observations u and v components of wind, temperature, geopotential and specific humidity data were assimilated. The distribution of the observations (both conventional and seviri radiance) are indicated in the Figure 2.

In the experiments SEV35 and SEV70, seviri radiance observations were assimilated on the top of conventional observations. To eliminate the excess data and to reduce the error correlation between the satellite observations, a horizontal thinning was applied to the radiance data. In this sense, firstly the default thinning value 70 km was applied in SEV70 experiment and then the thinning distance was reduced to 35 km in SEV35 experiment keeping everything else the same.

SEVIRI scans the atmosphere from 12 spectral channels. However in the current study, only the water vapor channels (WV6.2, WV7.3) were used since these channels of SEVIRI provide more information about tropospheric temperature and water vapor and are less affected by the surface emissivity. Radiance data only from these channels were assimilated while others were blacklisted via LISTE_LOC file.

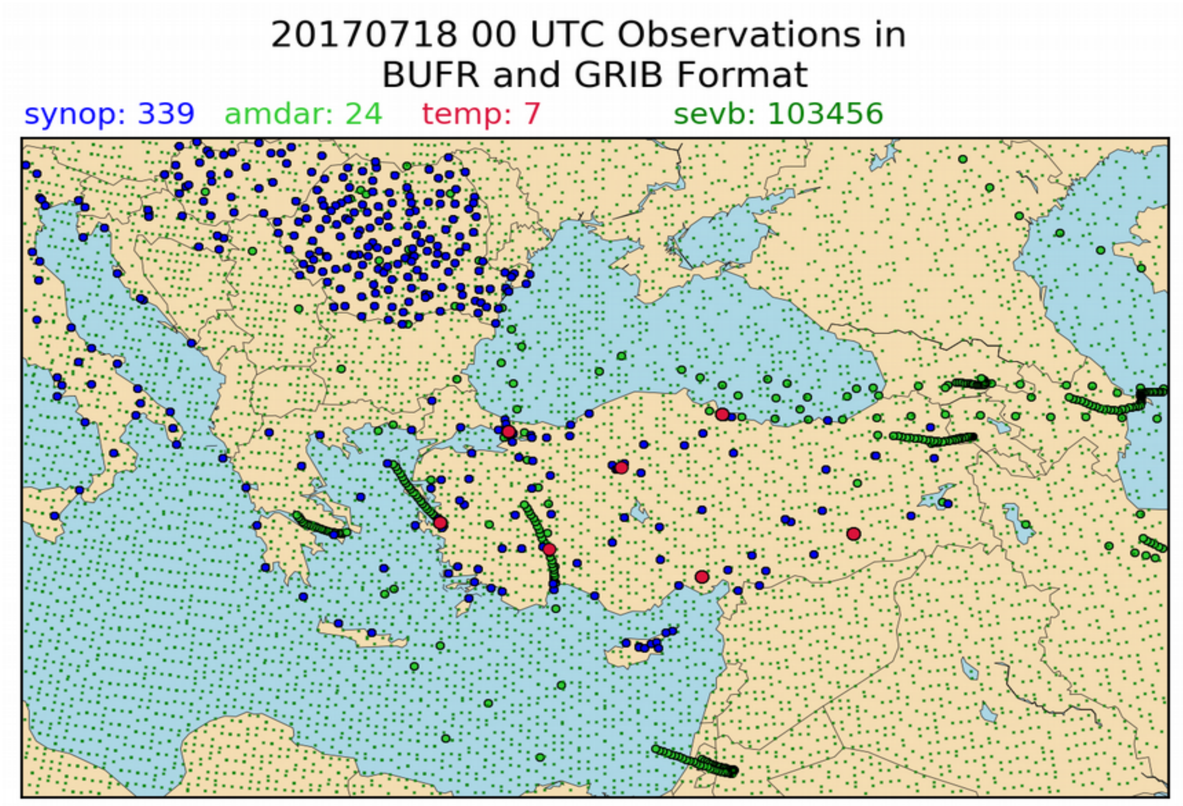


Figure 2: *The locations of the observations used in the assimilation system.*

Variational Bias Correction

The systematic errors in radiance data have to be eliminated since these errors damage the analysis. In this study, variational bias correction method (VarBC) was chosen to remove the biases in the satellite data. The predictors used in the study were: 1000-300 hpa thickness, 200-50 hpa thickness, skin temperature and total column water. Through the VarBC method the values of the predictors are updated in every assimilation cycle.

Results

For the verification, Harmonie verification tool was utilized. In the following figures, red indicates the operational ALARO model (with no assimilation), green indicates experiment CONV, blue reflects experiment SEV70 and purple indicates experiment SEV35. It is shown in the verification results that the most accurate results were obtained when the SEVIRI radiance data is assimilated on the top of the conventional data. It is also represented in the following figures that the forecast of the surface humidity was mostly improved as a result of assimilation.

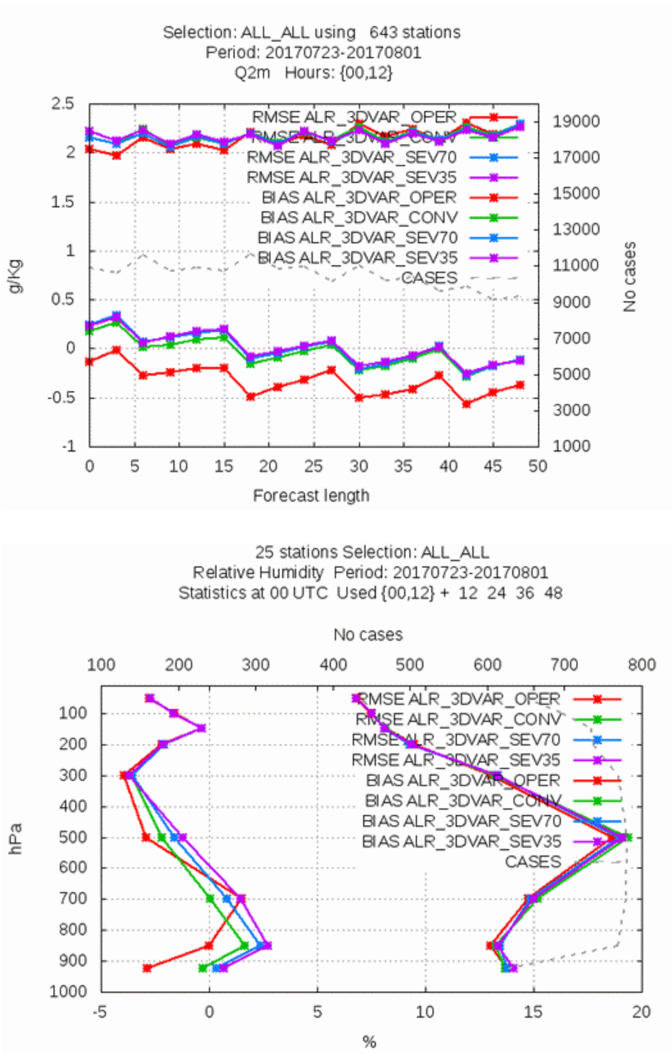


Figure 3: *RMSE and BIAS for specific humidity (top) and relative humidity (bottom).*

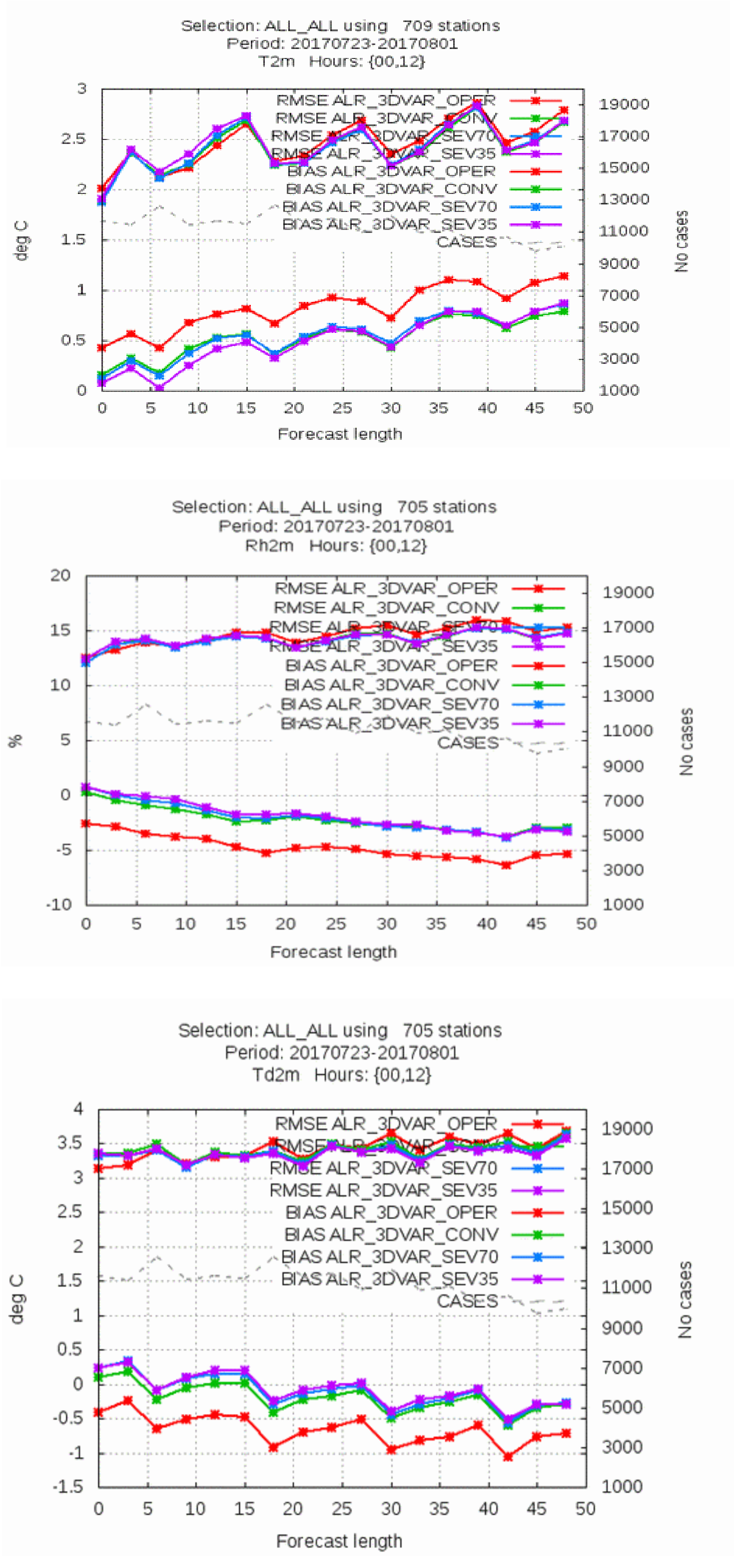


Figure 4: *RMSE and BIAS for 2m temperature (top), 2 m relative humidity (middle) and 2 m dew point (bottom).*

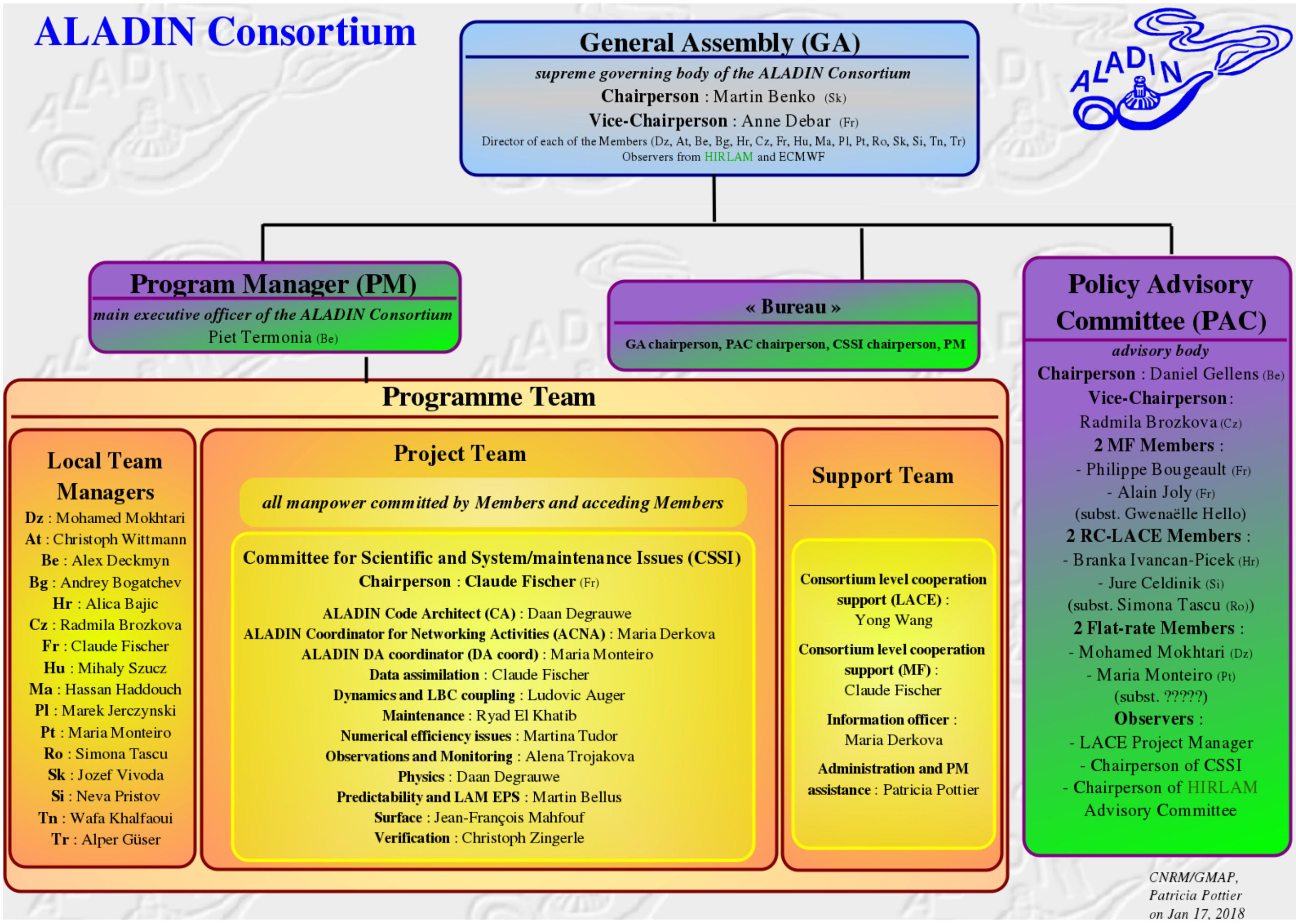
3 References

Aulігné T., McNally A.P., Dee D.P., 2007: Adaptive bias correction for satellite data in a numerical weather prediction system. *Q. J. R. Meteorol. Soc.,* 133: 631-642.

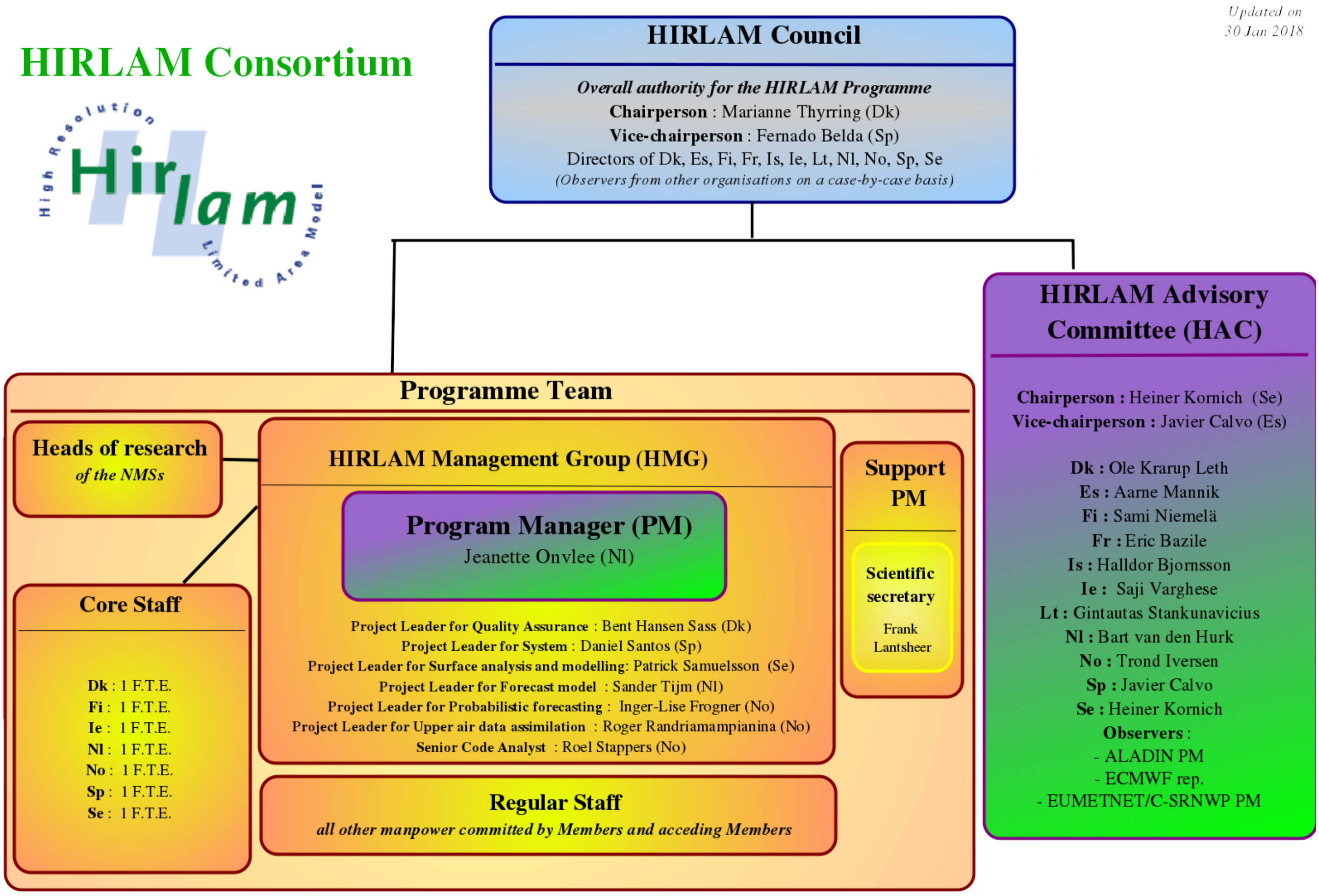
Dee D. 2005: Bias and Data assimilation. *Q. J. R. Meteorol. Soc.* 131: 3323-3343.

ALADIN and HIRLAM organisational charts

Below is the ALADIN governance map as defined in the ALADIN MoU5 and with the current positions after the dicision of the 22nd ALADIN General Assembly. [More information and contacts on-line](#).



Below is the HIRLAM governance map as defined in the HIRLAM-C MoU. More information and contacts on-line.



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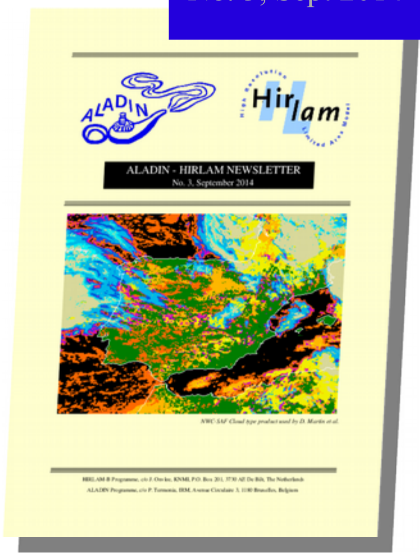

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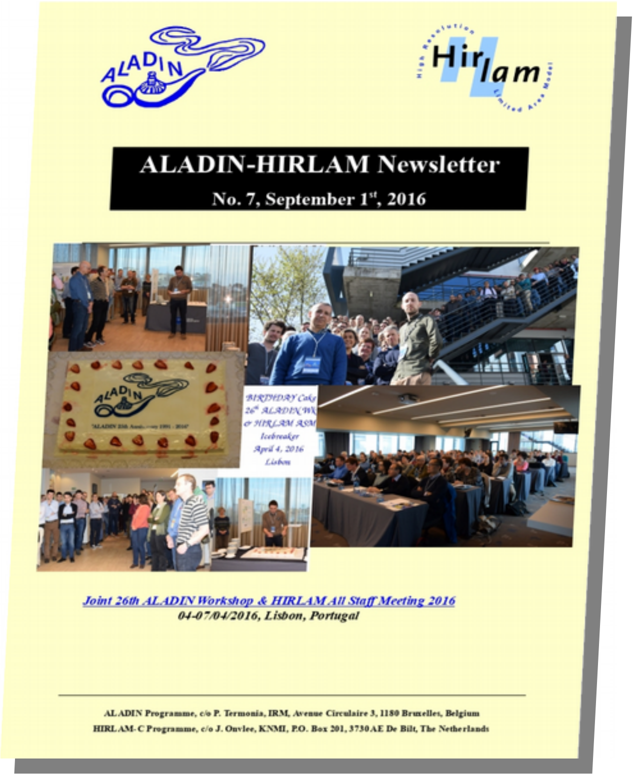

No. 8, Jan 2017

No. 9, Sep 2017