



ALADIN-HIRLAM Newsletter

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2018 Grand Tour of ALADIN & HIRLAM

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 12th edition Newsletter of the HIRLAM and ALADIN consortia.

This first 2019 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 Zagreb on November 19-20, 2018 for the 23rd ALADIN GA, the LACE Council, the HIRLAM Council and the 4th joint ALADIN GA - HIRLAM C meeting. The three Programme Managers (ALADIN, HIRLAM and LACE PMs tell more in the **Edito**).



The list of ALADIN/HIRLAM events planned for 2019 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 twelfth 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

Jeanette Onvlee, Piet Termonia, Martina Tudor

Over the past few years we are undertaking a number of concrete steps to foster the collaboration within our NWP community.

Last year, thanks to the work of Patricia Pottier, we have introduced a common registration tool for the man power contributions of both consortia. This allowed, for the first time, to assess the progress of the common rolling work plan in numbers. Although such numbers should be interpreted with care, it nevertheless allows to draw a few conclusions. In general, what is committed is executed. In fact in 2018 more man power was reported than committed in the work plan.

A few issues also became visible. We need to pay special attention to our code engineering. We are short in experts on dynamics and model development in general. We will organize a few meetings in 2019 to address these issues: a dynamics workshop, a workshop on code engineering, ALARO workshop and MUSC workshop (if possible). Data assimilation gets a lot of attention but the efforts are a bit fragmented across the different families (HIRLAM, LACE, ALADIN). In 2018, it became nevertheless clear that the interests of the different groups are strongly overlapping. The 2018 LACE data assimilation working days were partially merged with training on data assimilation for non-LACE participants with remote contribution from HIRLAM. This year a common data assimilation training is organized in OMSZ in February. So we are making an effort to coordinate better the various data assimilation workshops that are traditionally organized separately. Predictability work is still concentrated around several operational applications but the scientific results and operational experiences are exchanged regularly.

During the common HIRLAM Council/ALADIN General Assembly last year in Zagreb, for the first time we jointly presented the progress within the whole ALADIN-HIRLAM collaboration. The scope document was discussed. In 2019, a task group consisting of the three PMs, the chairs of HAC, PAC and CSSI will make a first proposal for an MoU for a single consortium. Philippe Bougeault of Météo-France will graciously contribute to this redaction. Many helpful comments were made in Zagreb on the scope document. We will address them in the draft MoU.



The 3 PMs and the GA/C chairs at the Zagreb meeting

Events announced for 2019 (and later on)

The Newsletters present a static overview (twice a year) of upcoming meetings for the (near) future time frame. For actual updates (year round) please check the [ALADIN](#) /[HIRLAM](#) websites and the [LACE](#) website.

1 ALADIN/HIRLAM related meetings

- Surfex User Workshop, 18 to 20 March 2019, Toulouse
- [Joint 29th ALADIN Wk/HIRLAM ASM 2019](#), hosted by AEMET in Madrid, 1-4 April 2019
- [26th LTM meeting](#), Madrid, 2 April 2019
- [Coordination Meeting Hirlam-MGM/Aladin-CSSI](#), Madrid, 5 April 2019, Madrid
- [17th PAC meeting](#), Norrköping, 13 May 2019
- [8th Joint HAC/PAC meeting](#), Norrköping, 14 May 2019
- 7th HIRLAM-C Council, Lisbon, 28 June 2019, with invitation to the ALADIN GA to join for the discussion on the convergence (t.b.c.)
- [41th EWGLAM and 26 th SRNWP meetings](#), 30 September – 3 October, Bulgaria
- [27th LTM meeting](#), Sofia, 1 October 2019
- [18th PAC meeting](#), Toulouse, 4 November 2019
- [9th Joint HAC/PAC meeting](#), Toulouse, 5 November 2019
- [Regular 24th ALADIN GA](#), Istanbul, 16 December 2019
- 8th HIRLAM-C Council, Istanbul, 16 December 2019
- [5th joint ALADIN GA & HIRLAM Council](#), Istanbul, 17 December 2019

29th ALADIN Workshop & HIRLAM All Staff Meeting 2019

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The Spain Meteorological Agency (AEMET) will host the **joint 29th ALADIN Wk & HIRLAM 2019 ASM** in Madrid.

The major meeting will be held at the **Ministry for Ecological Transition** in the *Nuevos Ministerios Building* (Pza San Juan de la Cruz, Madrid) from 1st to 4th April.

2 ALADIN/HIRLAM Working Weeks / Days

Following topics through working weeks/days will be addressed:

- Training/webinair for developers: Jan/Febr. 2019
- Data Assimilation algorithms, 11-15 February 2019, Budapest
- [ALARO-1 Working days](#), 11-13 March 2019, Bratislava (Slovakia)
- Radiation, clouds, aerosols
- EPS, 6-10 May 2019, De Bilt
- Use of Observations : May 2019, Spain
- Dynamic Days, Toulouse, prob. Spring 2019, t.b.c.
- Surface WW : SMHI - Norrköping- Feb 25th - March 1st, 2019
- HARP (meeting, February/March 2019, Brussels – training, June, Copenhagen?)
- Hi-Res modelling + ITER, Tenerife?
- Code training for code developers (not for beginners), prob. Toulouse, autumn or winter 2019, t.b.c.
- [DAsKIT WD](#) : prob. Back-to-back with the LACE DA WD (Prague, Sept.), t.b.c.

3 About the past joint events

During the last semester of 2018

- the Regular 23rd General Assembly, the 6th HIRLAM-C Council and 4th joint ALADIN GA and HIRLAM Council was held in Zagreb, November 19-20, 2018. [The minutes of these meetings have been validated and are on-line.](#)
- the PAC and HAC/PAC met on 22-23 October 2018 in Prague. The minutes of these meetings have been validated and are on-line (16th PAC, 7th HAC/PAC).

On-line information is available through the dedicated ALADIN webpages for past ALADIN/HIRLAM common events such as:

- [report of the joint ALADIN Workshops & HIRLAM All Staff Meetings](#)
- [minutes of the HMG/CSSI meetings](#)
- [minutes of HAC/PAC meetings](#)
- [minutes and presentations for the joint ALADIN General Assemblies and HIRLAM Councils](#)

Highlights of NWP activities in ALGERIA (Tour d'ALADIN)

Mohamed MOKHTARI, Abdenour AMBAR, Idir DEHMOUS, Mohand Ouali AIT MEZIANE, Oussama DOUBA, Sofiane KAMECHE, Sofiane MANSOURI .

Introduction

This paper summarized the NWP activities done in 2018, mainly focused on the implementation locally of the CY43T2 export version and on a pre-operational surface data assimilation using SYNOP.

Implementation of CY43T2 export version

Currently, at the national office of Meteorology in Algeria, three models are running on operational suite: ALADIN, ALADIN_DUST and AROME, one model on experimental suite: ALARO, and one model for research purpose : AROME_DUST, based on CY40T1. By the end of October, all those configurations were tested and ported successfully on CY43T2 export version. Hereafter, you can find few results obtained during the implementation of this export version, compared to our previous operational cycle (CY40T1).

ME: Mean Error / **MAE:** Mean Absolute Error / **RMSE:** Root Mean Square Deviation / **STDV:** Standard Deviation of a Frequency Distribution

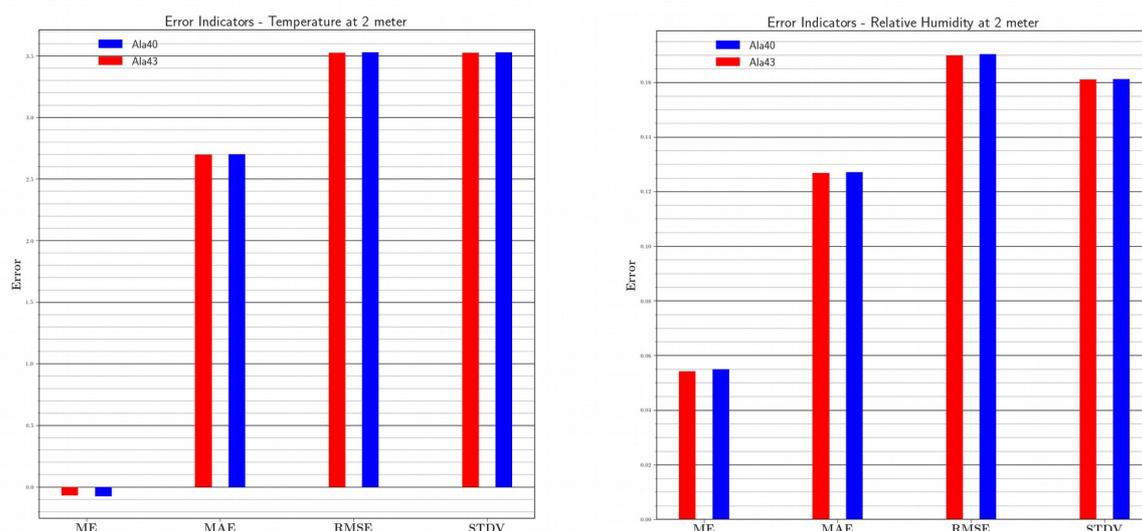


Fig.1: Statistical comparison of the 2meters temperature (left) and relative humidity (right) between ALADIN-ALGERIA CY40t1_bf.05 (bleu) and ALADIN-ALGERIA CY43T2.bf09 (red).

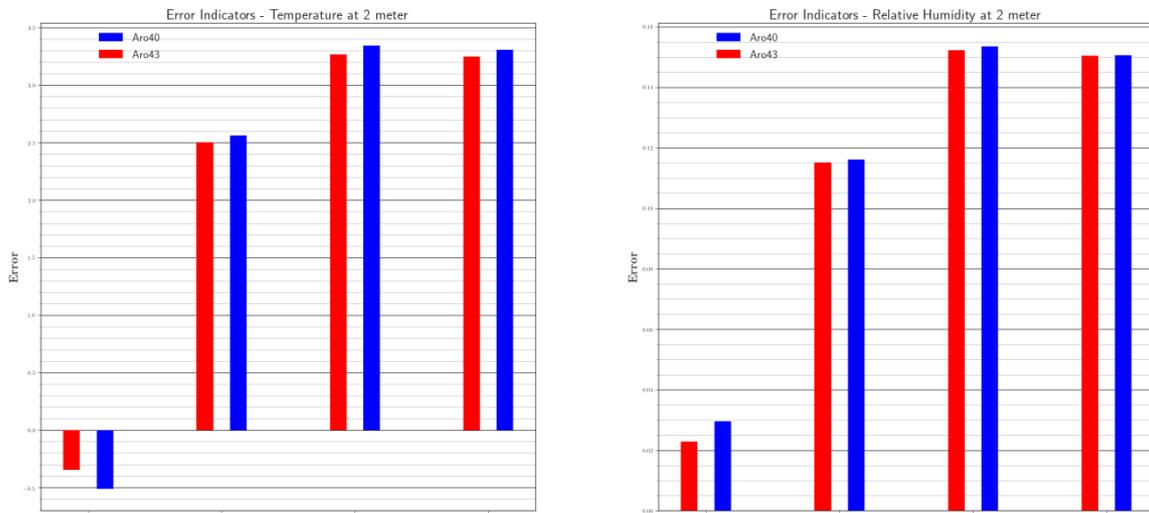


Fig.2: Statistical comparison of the 2meters temperature (left) and relative humidity (right) between AROME-ALGERIA CY40t1_bf.05 (bleu) and AROME-ALGERIA CY43T2.bf09 (red).

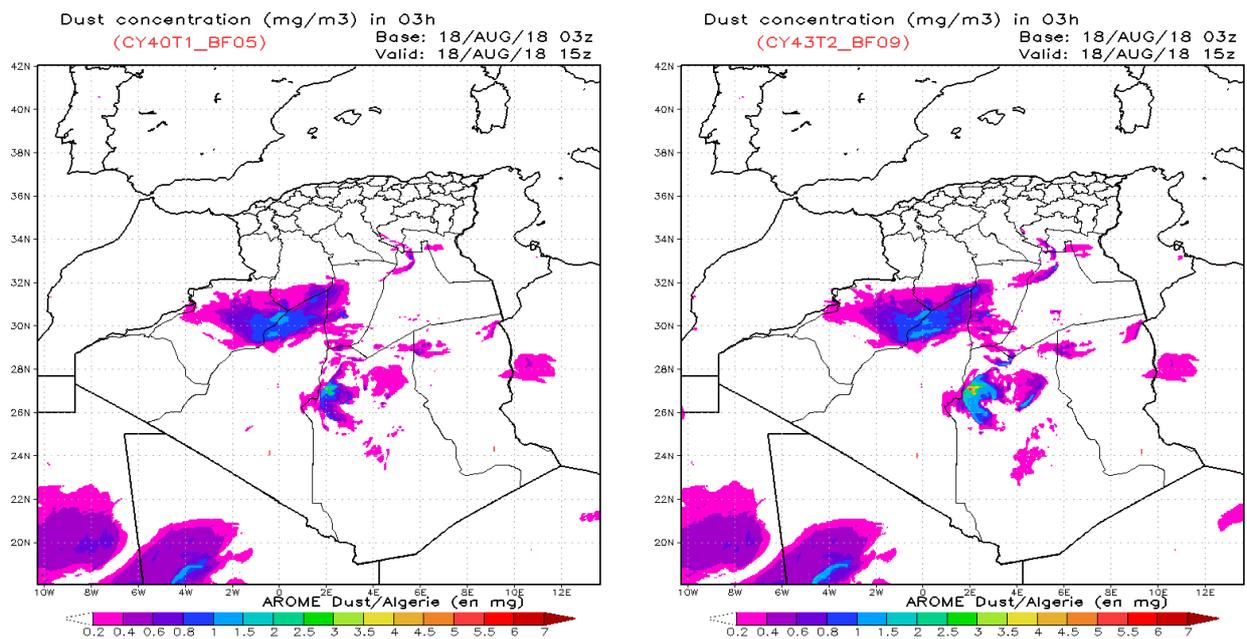


Fig.3: Comparison of Dust concentration output between AROME-DUST CY40t1_bf.05 (left) and AROME-DUST CY43T2.bf09 (right).

Progress in DA at Météo Algérie :

In June 2016 we realized a first pre-processing program of SYNOP and we've installed the binary BATOR for the generation of ODB "Observation Data Bases". Later, in November we've tested CANARI with SYNOP data for ALADIN model.

After, in May 2017 we've calculated the B matrix for the ALADIN model using NMC methods. In august, we've tested 3 Dvar configurations with SYNOP observation for ALADIN model. In October, at Météo France, we've calculated B matrix for AROME model and we've done assimilation of ASCAT wind. After, at Météo Algérie we did the assimilation of ASCAT winds data for ALADIN and AROME models using cy40t1. In February 2018, we built the first version of the 3Dvar assimilation chain for ALADIN using cy40t1. We run the 3DVAR chain for ALADIN in pre-operational. Later in April, we worked in pre-processing of AMDAR data. In July, we built a new scheme of 3DVAR assimilation chain with rapid update cycling. Currently, it's run in pre-operational.

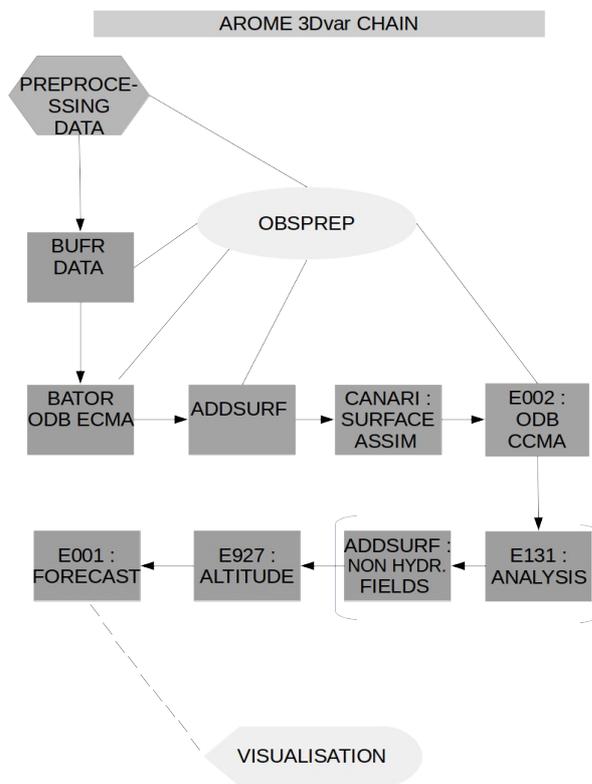


Fig.4: AROME 3DVar Chain of Algeria.

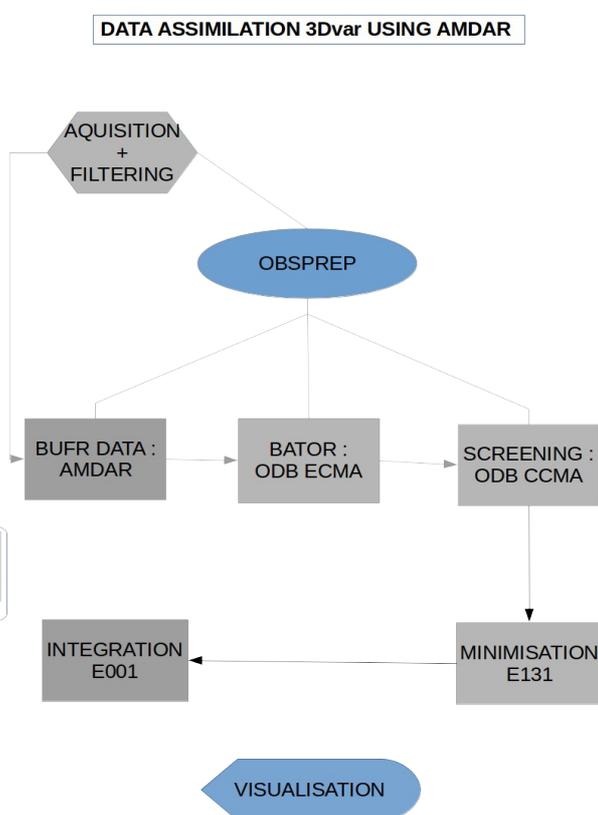


Fig.5: ALADIN 3Dvar Chain of Algeria

Current activities:

- Rapid updates Cycling for AROME using: synop,AMDAR and ASCAT data.
- AROME 3DVAR chain with CANARI OIMAIN.

Data acquisition and preprocessing:

We have developed a pre-processing observations system for ALADIN Algeria domain. It does a real-time processing of SYNOP each 3 hours "Main and intermediate SYNOP" for Algeria and neighbouring countries "Morocco, Tunisia, Italy, France, Spain and Portugal. The first step of programme consists to get data from GTS, the next one is to remove the errors, duplications and add amendments. The last step is to convert the data to BUFR format. For AMDAR data we have built a pre-processing program that consist of getting data from GTS and do filtering of ALADIN Algeria domain. In the end the programme merge BUFR files each hours. The pre-processing of ASCAT it is quiet similar then pre-processing of AMDAR. The program gets ASCAT data from GTS from MetOp-A and MetOp-B and does the filtering of ALADIN Algeria Domain. The data are available in two networks by day: between 9h30 to 11h and 20h to 23h.

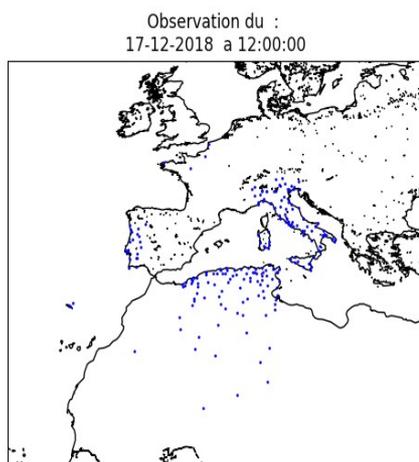


Fig.6: SYNOP Data of ALADIN Algeria Domain.

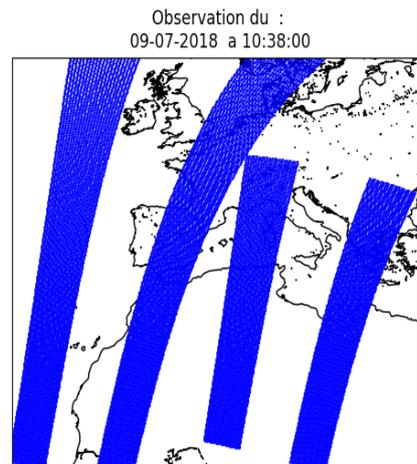


Fig.7: ASCAT Wind Data from MetOp of ALADIN Algeria Domain

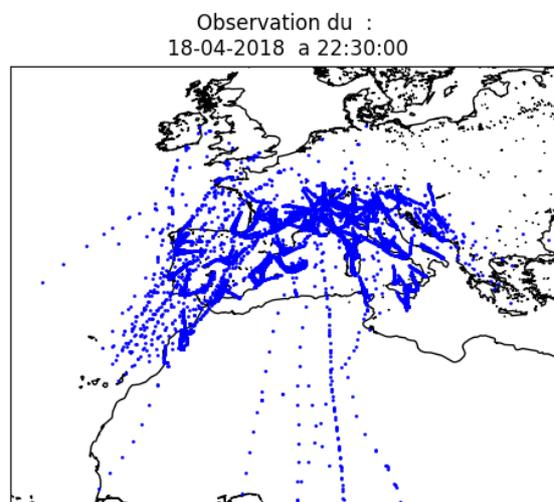


Fig.8: AMDAR Data from GTS of ALADIN.

3Dvar Data Assimilation :

We show an example of outputs of the temperature field at 2 m. The figure 6 is the output of the dynamic adaptation, on the right the output of the assimilation chain for the deadline of 09h from 18-12-2018. The figure 7 represents the difference between the two outputs. The difference of temperature is generally slight over the ALADIN domain except the north west of Algeria, where the difference reaches 4 degrees C.

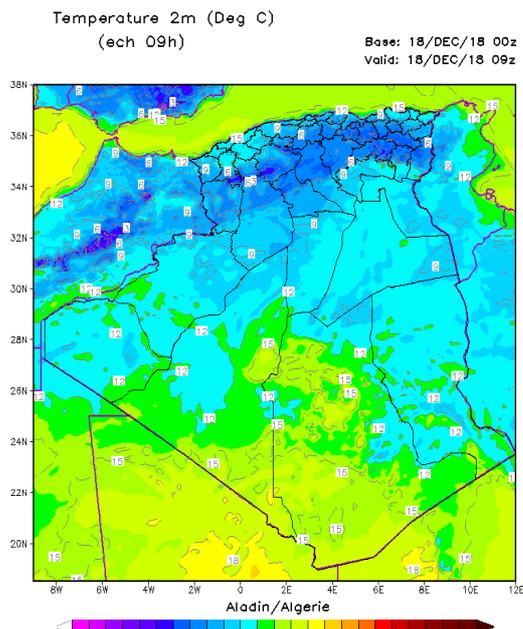


Fig.9: 2m Temperature ALADIN Dynamic Adaptation at 9h.

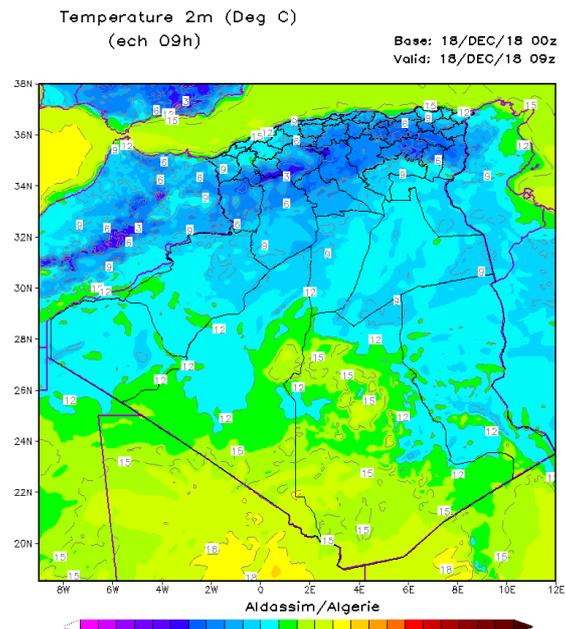


Fig.10: 2m Temperature ALADIN 3 Dvar using SYNOP data.

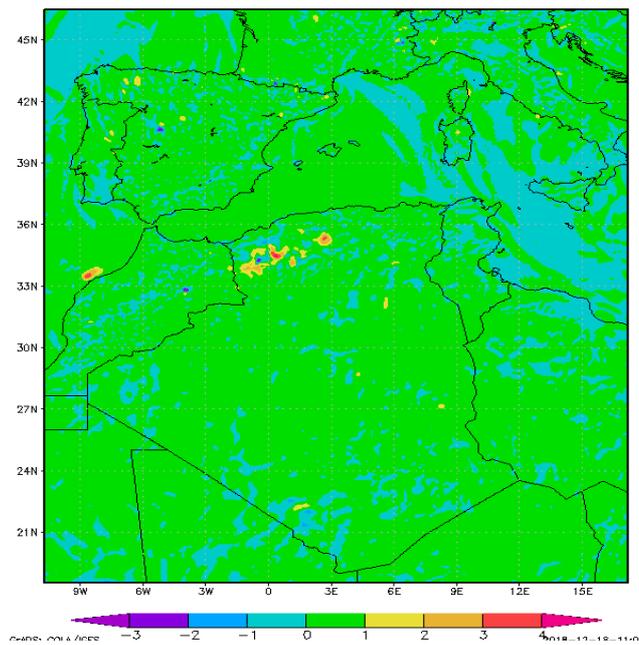


Fig.11: Difference of 2m Temperatures between ALADIN dynamic adaptation and ALADIN 3Dvar.

Improvement of the road weather alarm system

The road weather vigilance system was developed by the NWP team in Algeria during 2017, and had being putted into pre-operational by the end of 2017.

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. This warning system was updated and improved by introducing more significant meteorological phenomena that affects road traffic such as : strong wind, rain, snow, storm, temperature, fog and dust storm.

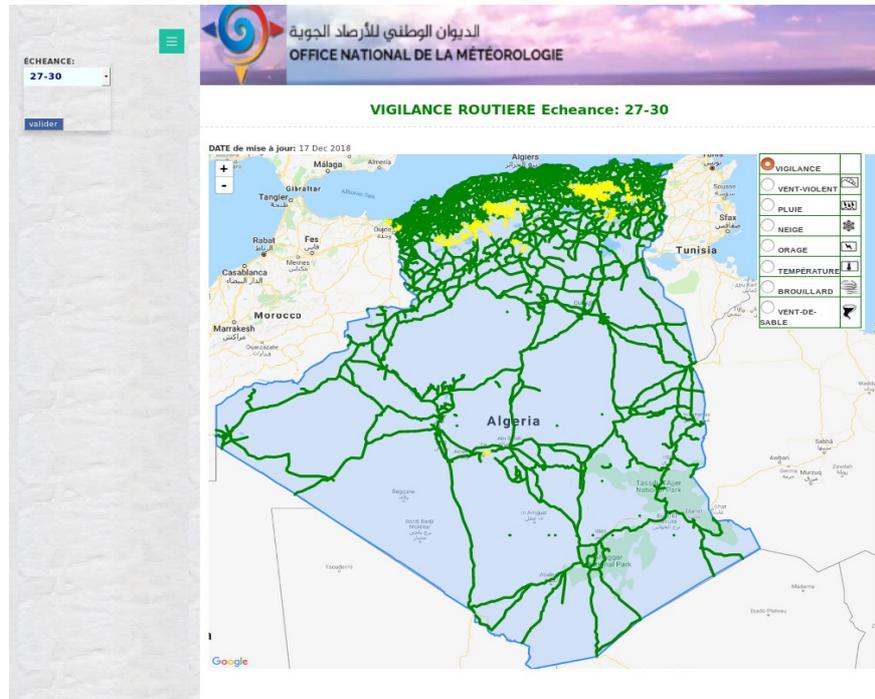


Fig. 12: Weather warning map based on operational models outputs.

ALADIN related activities in Austria in 2018

Florian Meier, Clemens Wastl, Christoph Wittmann

1 Introduction

The following sections briefly describe the major operational and research highlights in Austria in 2018. The upgrade of the HPC system at ZAMG by the end of 2017 brought an effective increase of computing resources by a factor of ca. 3. The old HPC system (SGI ICE-X) was replaced by a new one: HPE Apollo 8600 (= SGI ICE XA). These significantly increased our possibilities to run tests with a nowcasting version of AROME (see section 4).



Figure 1: HPE Apollo 8600 at ZAMG, in operations since 12/2017.

2 Operational upgrade of AROME

The last operational upgrade of the AROME-Aut system has taken place in the beginning of 2018 together with the switch to the new HPC system. Beside slight changes in the numerical diffusion setup and canopy drag tuning the upgrade included a further extension of the model diagnostics (e.g. lightning, icing, low stratus identification).

Table 1: AROME-Aut setup

Model version	Based on Cy40t1_bf07
Resolution	2.5 km
Levels	90
Initial conditions	3DVAR for atmosphere, IO for surface
Boundaries	IFS HRES (time lagged)
Starting times	00 UTC and 12 UTC
Cycle interval	3 hours
Forecast range	+60 hours

In addition to the developments for an AROME based nowcasting system (section 4) and an ensemble system (section 3) the introduction of additional observation data into the AROME 3D-VAR system is currently a focal point. The data sets currently under evaluation include radar data (local + OPERA), GNSS ZTD and Mode-S-data (local, OPLACE, KNMI).

3 C-LAEF

The C-LAEF system has been developed at the Austrian weather service ZAMG and is based on the AROME model. The ensemble comprises 16 members using the first 16 out of a total of 51 members of ECMWF-ENS for the boundary conditions with a coupling frequency of 3 hours. Uncertainties in the initial conditions are represented by

a combination of EDA (ensemble data assimilation), sEDA (surface ensemble data assimilation) and Ensemble-Jk. In Ensemble-Jk small-scale perturbations coming from 3D-Var EDA and large-scale perturbations coming from the driving model are blended. Ensemble-Jk method gives a more skillful and reliable EPS, especially for upper air variables. In addition, a positive impact on surface pressure and precipitation of large-scale perturbations is obtained.

Model error in C-LAEF is represented by an innovative method in stochastic physics called hybrid stochastically perturbed parametrization scheme (HSPP). In HSPP the individual parametrization tendencies of the physical processes radiation, shallow convection and microphysics are perturbed stochastically by a spatially and temporally varying pattern. Uncertainties in the turbulence scheme are considered by perturbing key parameters on the process level. HSPP features several advantages compared to other stochastic schemes: a more physically consistent relationship between different parametrization schemes is considered; uncertainties are especially adapted to the individual physical processes; conservation laws of energy and moisture are respected; the tapering function which has to be introduced to other stochastic schemes because of mainly numerical reasons has become redundant. C-LAEF is running on the ECMWF HPC with 2.5 km resolution in the horizontal and 90 levels in the vertical direction. A 6-hourly assimilation cycle is operated with two long (00 and 12 UTC; +48h) and two short runs (06 and 18 UTC; +6h). C-LAEF is planned to become operational end of 2019.

4 AROME-RUC

Since 2015 an AROME based nowcasting system is developed at ZAMG in Austria, an operational start is foreseen in 2019. The system will run every hour up to +12h lead time. Lateral boundary conditions come from the most recent operational AROME 2.5km. The 2-hourly assimilation cycle with a cutoff time of 30min uses additionally to the operational system radar reflectivity and Doppler wind observations, AMDAR humidity data, national GNSS-ZTD observations and MODE-S aircraft data from OPLACE and KNMI, where especially the latter two were found to be beneficial. It also tries to profit from the classical advection nowcasting system INCA by latent heat nudging of 5min-INCA precipitation analyses up to +35min lead time and uses via FDDA nudging most recent 10min automated weather station wind, temperature and humidity up to +30min. In 2018, the grid space was switched from 2.5 to 1.2km keeping 90 vertical levels and the system was moved to the new ZAMG HPC, which allows running the system in realtime. Two test months (summer 2016 and winter 2016-2017) were run. Several sensitivity studies have been conducted to check the impact of surface assimilation, spin-up, cycling strategy and several observations' impact. Compared to the operational 2.5km system, especially wind forecasts could be improved. In case of precipitation, classical scores degrade very fast showing sometimes even worse results especially at 15UTC and in the morning hours, while Fraction Skill Score clearly favours the new system. In 2019 the system is planned to become operational, further improvement is expected by updating the background error B-Matrix and optimising the radar wind usage by better quality control.

Probabilistic storm forecasts for wind farms in the North Sea

Geert Smet, Joris Van den Bergh, Piet Termonia

1 Introduction

In the last few years there has been a significant increase in Belgian offshore wind energy production, with more capacity being expected by 2020. Storm events over the North Sea can impact many of these wind farms at roughly the same time, because they are situated relatively close together in a narrow band in the North Sea. Each wind turbine has a characteristic cut-out (wind) speed, above which they will shut down as a protection measure. In case of a major storm, many wind turbines could shut down at the same time, creating a so called cut-out event for the wind farm(s). When such cut-out events occur at multiple wind farms at the same time, this can lead to large imbalance risks in the electricity grid. To better understand and predict such events, the Royal Meteorological Institute of Belgium (RMI) is involved in the development of a dedicated storm forecast tool for Elia, the Belgian transmission system operator for high-voltage electricity.

The aim is to forecast storm events, and associated cut-out events, a day ahead and up to two days, making use of weather models that generate wind speed forecasts at turbine height and location. Because there is a substantial uncertainty in the precise location, timing and intensity of a forecasted storm, and cut-out events are moreover very sensitive to whether or not a high wind speed threshold is exceeded or not, a probabilistic forecast approach is logical. Because Elia also required high temporal resolution forecasts (output every 15 minutes), a combination of a high resolution deterministic model and lower resolution ensemble weather prediction model was used. This allows both detailed forecasts and a good estimation of the uncertainty in the forecasts, thereby helping end users in their decision making process.

The storm forecast tool developed at the RMI makes use of the deterministic ALARO model (4 km resolution) combined with the ENS ensemble forecasts (~ 18 km resolution) of the European Centre for Medium Range Weather Forecasting (ECMWF), hereafter referred to as ECEPS. For the ALARO model, wind speed forecasts are calculated at turbine height from the model levels, while for ECEPS we use the 100m wind speed field. The wind speed forecasts are then used to give an ensemble forecast of the wind power in each wind farm. Since November 2018, the storm forecast tool is running operationally at the RMI, in a test phase for Elia. The forecasts are updated six times per day, twice for ECEPS and four times for ALARO, with an hourly timestep for ECEPS and 15 minutes for ALARO, up to a lead time of 60 hours.

2 Forecast examples

Case studies have been performed over a 7 month period from 01 September 2015 until 31 March 2016, which contained several big storm events, leading to cut-out events. We show some forecast examples from this period. Note that we have anonymized the figures by removing the names of the wind farm(s) and by only showing relative wind power, i.e. amount of power is relative to the maximum attainable power of the wind farm.

2.1 Cut-out event of 28 March 2016

All wind farms consisting of wind turbines with a 25 m/s cut-out speed experienced a cut-out event on 28 March 2016, due to wind speeds reaching significantly higher than the cut-out speed, which was forecasted well, see figures 1 and 2. Both ALARO and a significant amount of ECEPS members predicted wind speeds above 25 m/s and even above 30 m/s during the day.

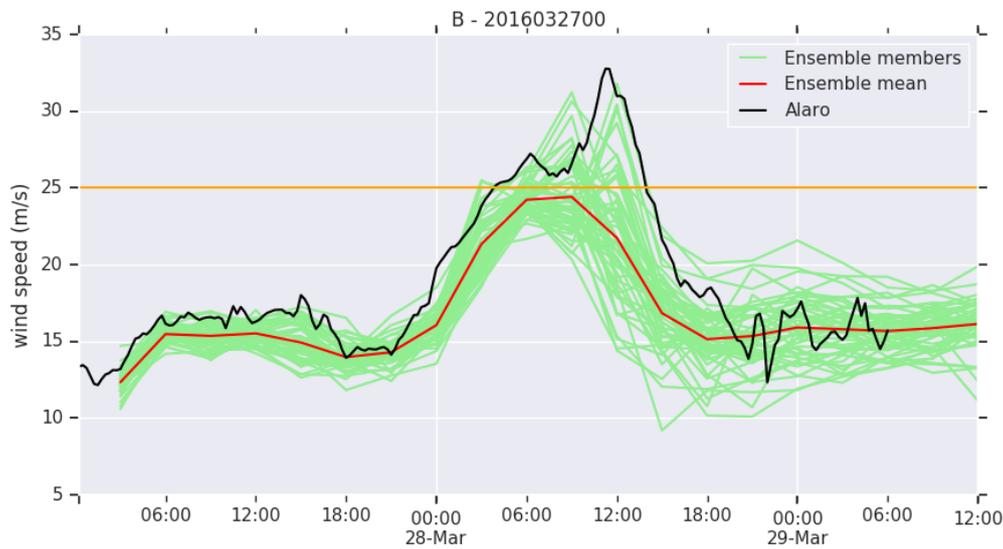


Figure 1: Ensemble wind speed forecasts from 27th of March 2016 (00h UTC) for wind farm B.

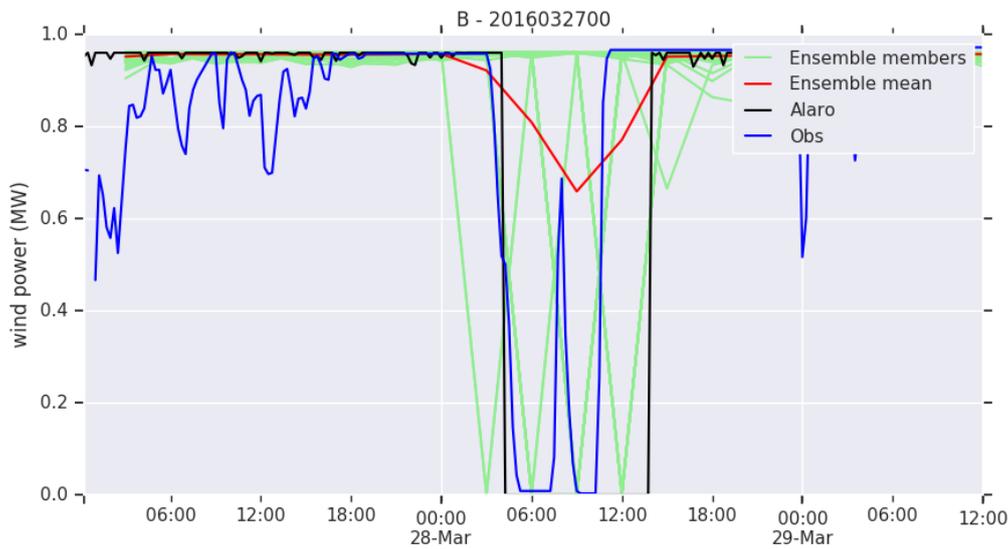


Figure 2: Ensemble wind power forecasts from 27th of March 2016 (00h UTC) for wind farm B.

2.2 False alarm for 28 March 2016

None of the wind farms consisting of wind turbines with a 30 m/s cut-out speed experienced a cut-out event on 28 March 2016, even though some ECEPS members and ALARO predicted wind speeds above the cut-out speed see figures 3 and 4. Whether this should be considered as a false alarm or not, depends on how much risk the forecast user wants to take, i.e. on the probability threshold above which the forecast user will take action.

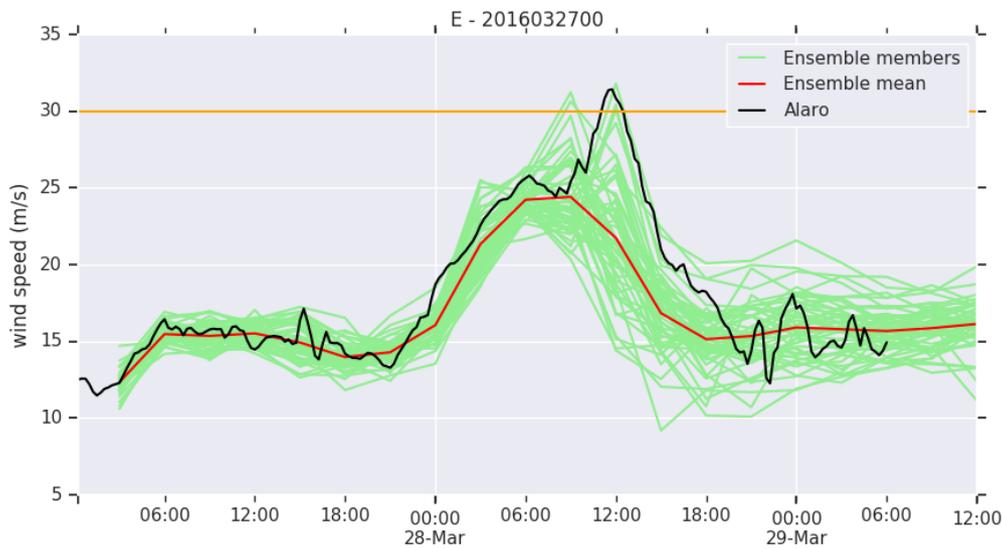


Figure 3: Ensemble wind speed forecasts from 27th of March 2016 (00h UTC) for wind farm E.

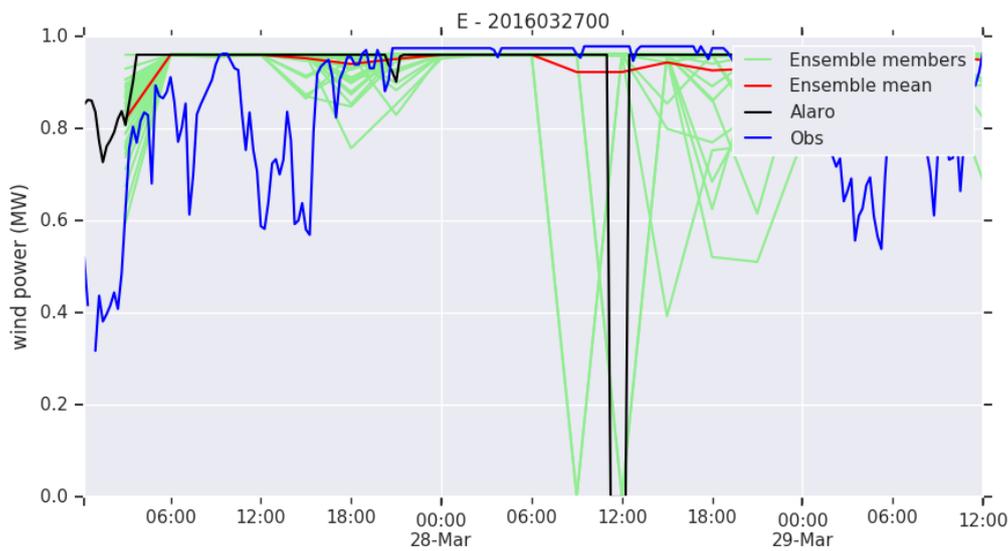


Figure 4: Ensemble wind power forecasts from 27th of March 2016 (00h UTC) for wind farm E.

2.3 Some near misses for 29-30 November 2015

On 29 and 30 November 2015, some small cut-out events occurred that were not predicted by the storm forecast tool (in hindcast mode), see figures 5 and 6. The forecasted wind speed was very close to the cut-out wind speed of 25 m/s, but just below it. As this example, and the previous ‘false alarm’ example shows, these cut-out events are very sensitive on the chosen wind speed threshold(s), which can be tuned in the storm forecast tool (and for each wind farm), depending on whether more false alarms or more misses are preferred.

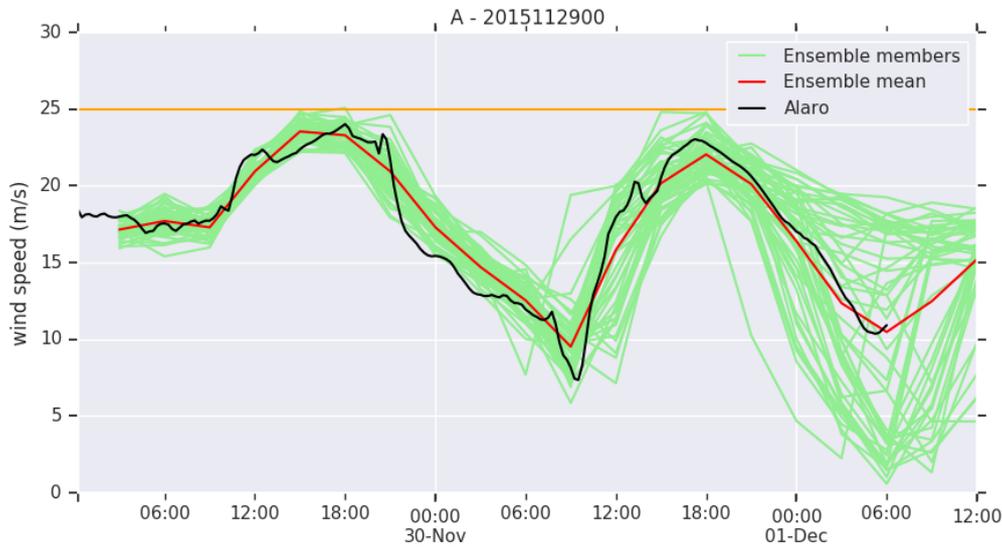


Figure 5: Ensemble wind speed forecasts from 29th of November 2015 (00h UTC) for wind farm A.

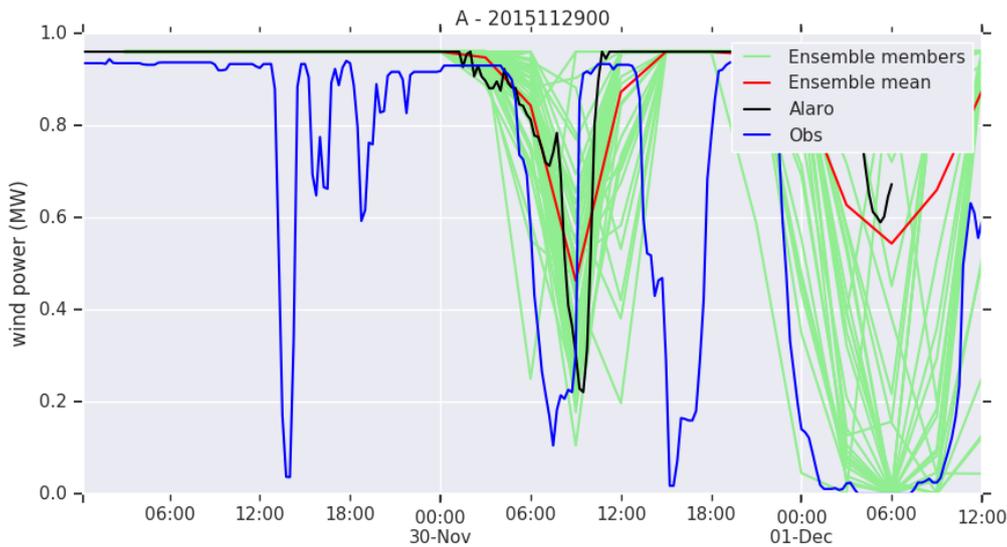


Figure 6: Ensemble wind power forecasts from 29th of November 2015 (00h UTC) for wind farm A.

2.4 Wind drop of 09 February 2016

A cut-out event occurred on 08 February 2016 at the wind farms where the wind turbines had a cut-out speed of 25 m/s, followed by a drop in the wind speed on the next day. As the figures 7 and 8 show, both events had a similar effect on the wind power, and were both forecasted well. Note also that there can be a large uncertainty in the wind power not only close to the cut-out speed, but also in the area between 5 m/s and 15 m/s. This is because the wind power depends on the cube of the wind speed, and because at 15 m/s the turbine will usually already be at its maximum (rated) power, while at 5 m/s it will still be close to its cut-in speed and power. The ECEPS ensemble forecasts capture this uncertainty nicely.

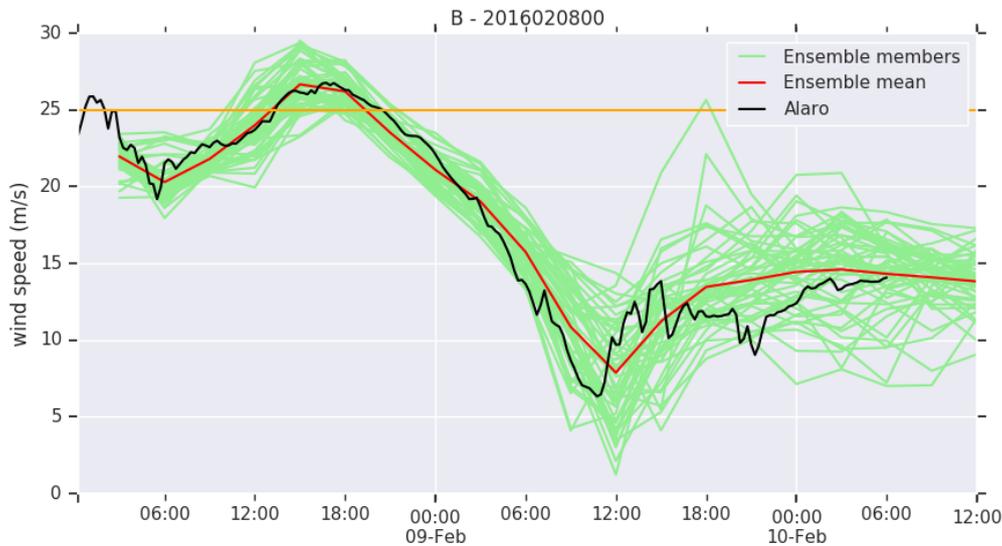


Figure 7: Ensemble wind speed forecasts from 8th of February 2016 (00h UTC) for wind farm B.

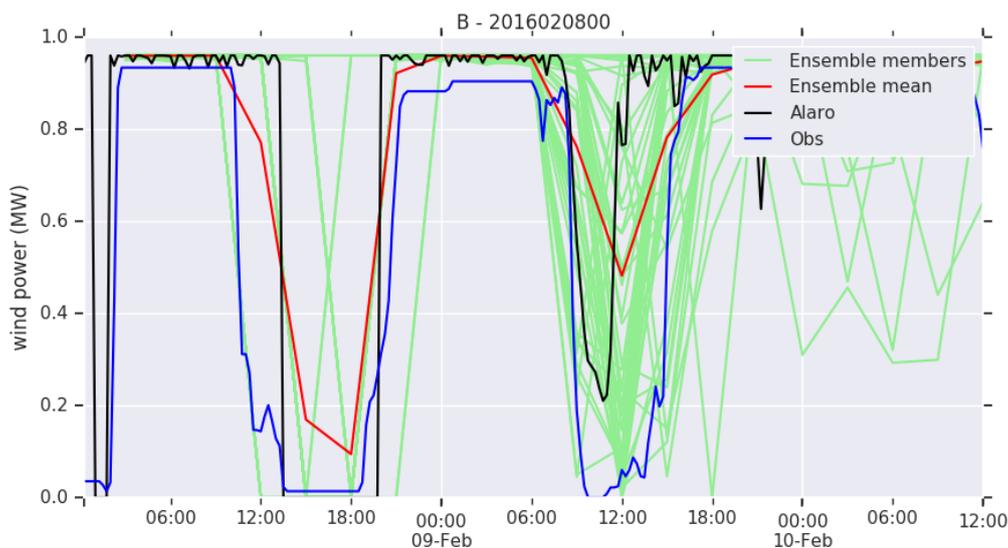


Figure 8: Ensemble wind power forecasts from 8th of February 2016 (00h UTC) for wind farm B.

3 Verification

We verified 100m wind speed of ALARO and ECEPS against 100m wind observations that were made available by one wind farm, for a 5 month period from 01 September 2017 until 31 January 2018. In figures 9 and 10 we show RMSE, spread and bias of the ECEPS ensemble mean and ALARO, all for the 00h UTC runs.

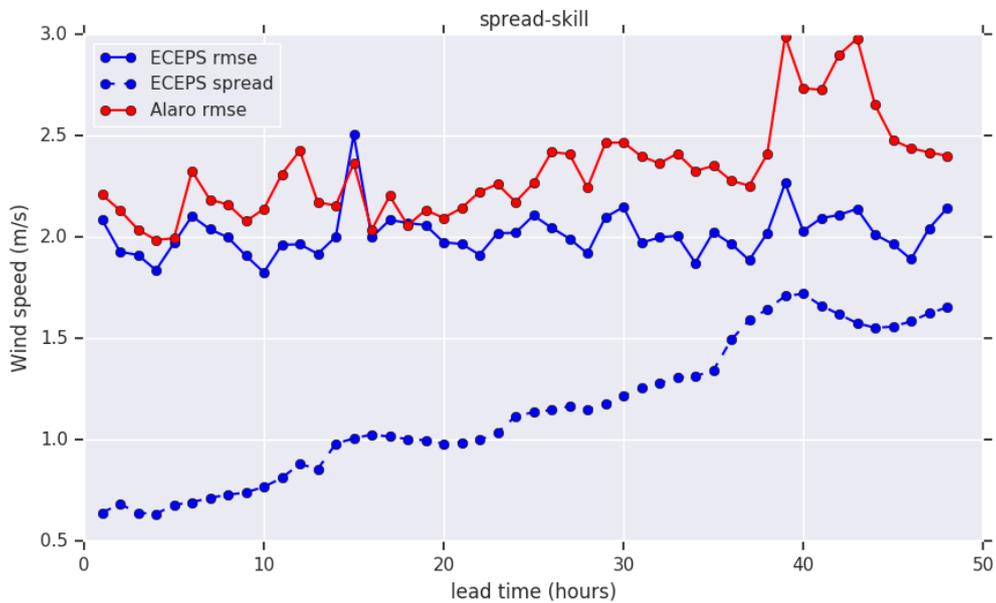


Figure 9: RMSE and spread for the ensemble mean of ECEPS, together with RMSE of ALARO (00h UTC runs).

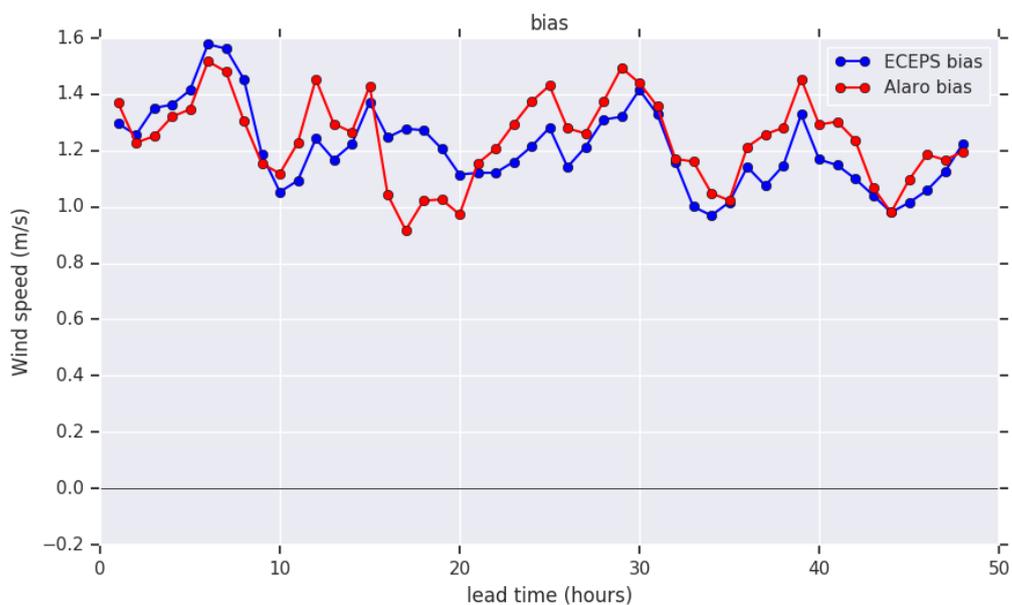


Figure 10: Bias for the ensemble mean of ECEPS and ALARO (00h UTC runs).

As can be expected, the ECEPS ensemble is underdispersive in the first day, but has a good RMSE to spread ratio near the end of the second day. Both ALARO and ECEPS have a similar bias, but ALARO seems to have a somewhat worse RMSE, which is also seen when comparing with the ECEPS control member in figures 11 and 12. However, it's possible that at least in part the ALARO model suffers from a double penalty problem, due to its higher variability, as seen in the forecast examples, as a result of its higher temporal and spatial resolution. This needs to be investigated further. Moreover, the ALARO forecasts are still useful to quantify the gradient of a drop in wind production at temporal scales (15 minutes and 30 minutes) that are not available from the ECEPS members (1-hourly output).

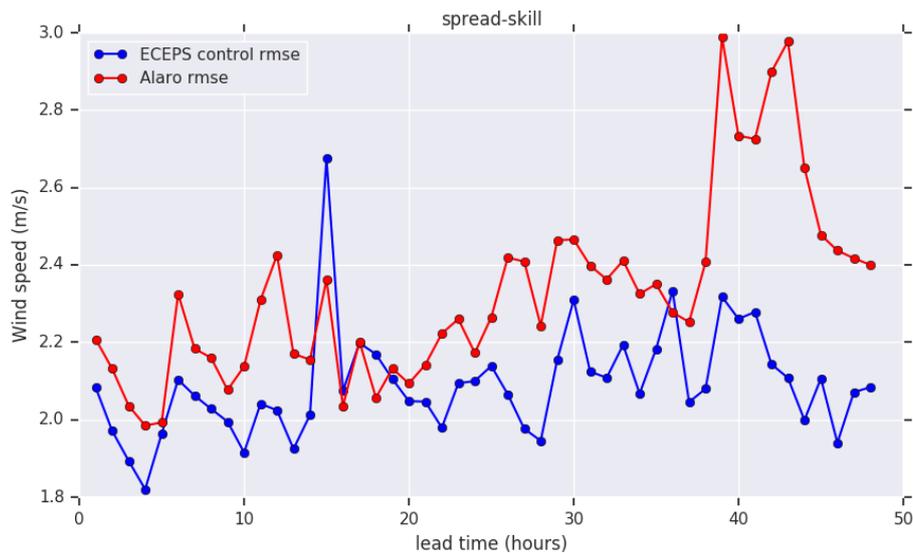


Figure 11: RMSE for the control member of ECEPS and ALARO (00h UTC runs).

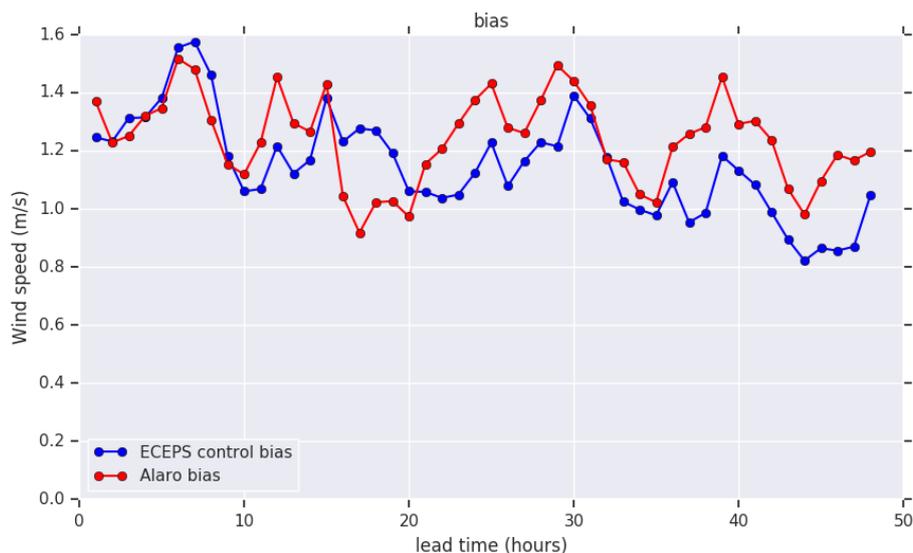


Figure 12: Bias for the control member of ECEPS and ALARO (00h UTC runs).

4 Conclusion and future plans

The wind power forecasts used in the storm forecast tool seem adequate to predict important power losses and gains, with a good indication of the uncertainties involved. During the historical periods studied, no big storm events were missed. However, the cut-out events are very sensitive to which cut-out speed is used as a threshold. Some further tuning to optimize false alarms, hits and misses might therefore still be useful. We also intend to look into some postprocessing methods to improve the bias and spread of the ECEPS wind speed forecasts, and investigate their impact on the wind power forecasts and the prediction of cut-out events.

5 Acknowledgements

The authors would like to thank Alex Deckmyn for help with and development of the Rfa and Rgrib based tools used in this project.

Some general results of the verification of meteorological elements forecasted by ALADIN-BG and AROME-BG versus synoptical measurements in Bulgaria during 2018

Boryana Tsenova, Andrey Bogatchev

1 Operational suites in Bulgaria

Since December, 2017 two new canonical model configurations based on cy41t1 are run operationally twice daily at 06 and 18 UTC: ALADIN-BG (LONC=25.5, LATC=42.75, NDLON=256, NDGLG=200, NDLUX=245, NDGUX=189, NMSMAX=127, NSMAX=99, NFLEV=105, EDELX=5000) and AROME-BG (LONC=25.5, LATC=42.75, NDLON=320, NDGLG=240, NDLUX=309, NDGUX=229, NMSMAX=159, NSMAX=1199, NFLEV=60, EDELX=2500).

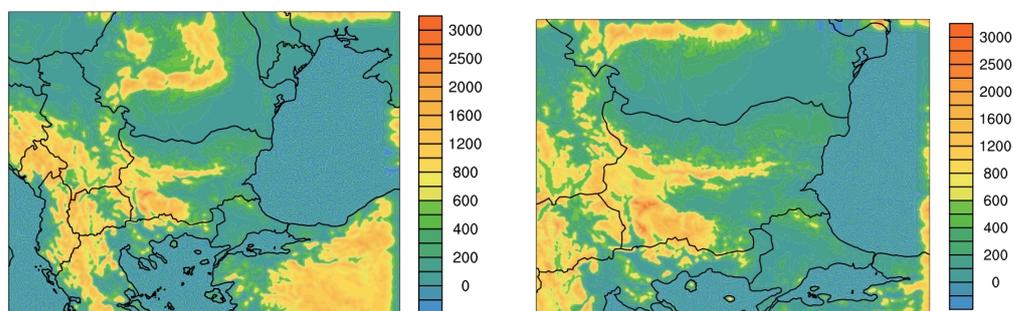


Figure 1: The orography presented by ALADIN-BG (left) and AROME-BG (right) in their corresponding domains of integration (C+I+E zones)

2 Verification of some meteorological elements forecasted by ALADIN-BG

ALADIN-BG uses LBCs from ARPEGE with 3 hours frequency. Here, we present ALADIN-BG verification results based on data from 40 synoptic stations in Bulgaria. For some of the synoptic stations, model data for temperature were interpolated to stations coordinates horizontally using bi-linear interpolation and then vertically using a mean lapse rate of 8.5 K/km. For these stations, model data for relative humidity and wind speed and function were also interpolated using bi-linear interpolation. For other stations analysis showed that verification results were better while using the closest model point.

From Fig. 2 it is visible that generally 2m temperature forecasts from ALADIN-BG during the winter months are with higher mean RMSE (around 3 K), mostly with negative mean BIAS, while 2m temperature forecasts during the summer months are with lower mean values of the RMSE (around 2 K) and mean BIAS close to 0 K. Figure 3 shows that generally the two daily model runs (at 06 and 18 UTC) overlap for the forecast of the 2m temperature. The mean RMSE is around 2.5 K and the mean BIAS – between 0 and -1 K, with worse forecast during night hours in comparison to day hours.

From Fig. 4 it is visible that mean RMSE for the relative humidity forecasted by ALADIN is between 6 and 8%. During the cold half year the ALADIN-BG generally overestimated a bit the 2m relative humidity, while during the warm half year – it underestimated it a bit. There is also a very good overlap for the 2 daily forecasts of the 2m relative humidity (Fig.5) with a slight overestimation during night time and slight underestimation during day time.

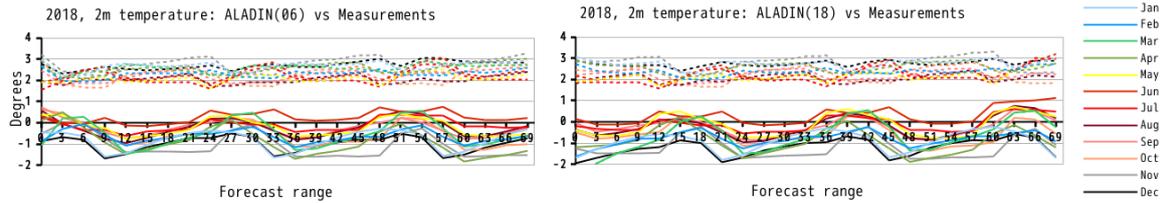


Figure 2: Temperature at 2 m: mean monthly BIAS (solid lines) and RMSE (dashed lines) as a function of forecast range – model runs at 06 UTC (left) and 18 UTC (right)

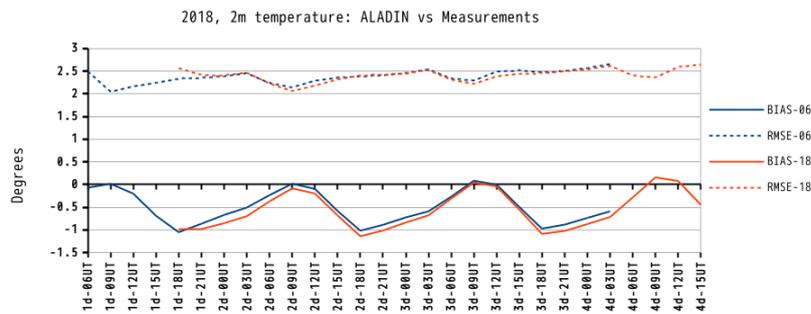


Figure 3: Mean annual BIAS (solid lines) and RMSE (dashed lines) of 2 m temperature as a function of the time of the corresponding forecasts (in UTC) for the runs of the model at 06 UTC (blue) and 18 UTC (red)

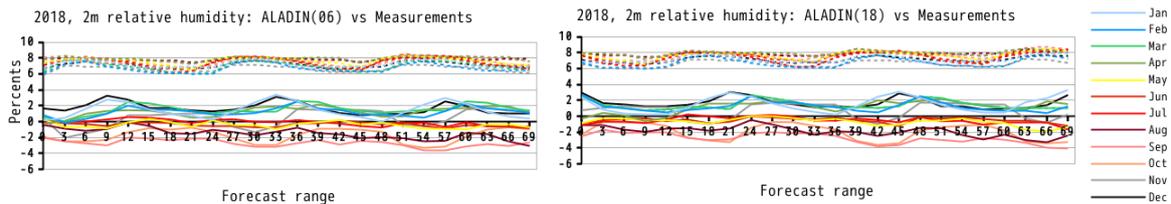


Figure 4: Relative humidity at 2 m: mean monthly BIAS (solid lines) and RMSE (dashed lines) as a function of forecast range – model runs at 06 UTC (left) and 18 UTC (right)

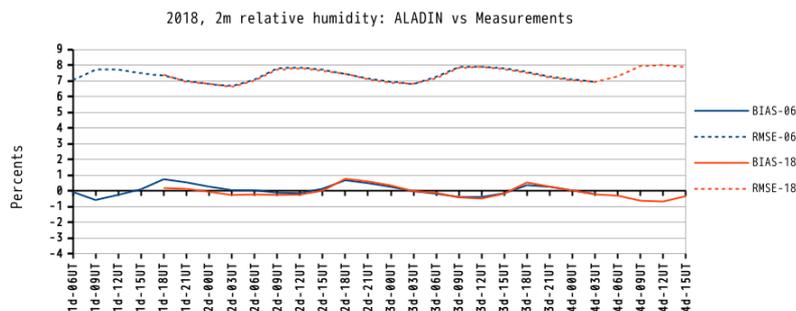
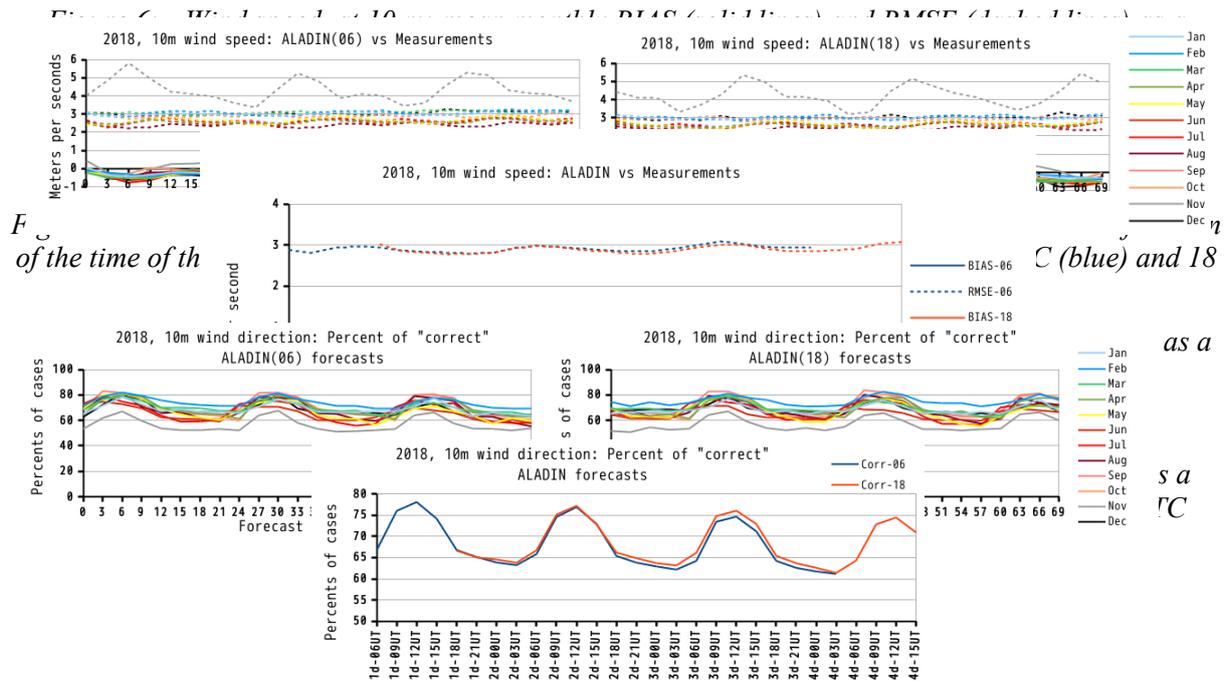


Figure 5: Mean annual BIAS (solid lines) and RMSE (dashed lines) of 2 m relative humidity as a function of the time of the corresponding forecasts (in UTC) for the runs of the model at 06 UTC (blue) and 18 UTC (red)



The mean RMSE for the wind speed at 10m (Fig. 6) is between 2 and 3 m/s for each month except for November (with mean RMSE between 3 and 6 m/s) - the month on average with the worst forecasts for 2018. On average, the mean RMSE (Fig. 7) for the forecasted by ALADIN-BG 10m wind speed is around 3 m/s. The model seems to underestimate a little the wind speed in 2018, especially during the day hours. Generally between 60 and 80 % are the cases of correctly forecasted wind function at 10 m for each month, except of November (Fig.8). The 10m wind function was generally better forecasted for the day hours in comparison to night hours (Fig.9).

3 Verification of some meteoelements forecasted by AROME-BG

AROME-BG LBCs from ALADIN-BG with 1 hour frequency. We present AROME-BG verification results for 2m temperature and relative humidity, as well the 10 m wind speed based on data from 40 synoptic stations in Bulgaria. For all stations closest model points were used for the verification, and temperature data were vertically interpolated using a mean lapse rate of 8.5 K/km.

Contrary to ALADIN-BG, AROME-BG generally overestimated the 2m temperature during all months, except of winter months, when the mean monthly BIAS was close to 0 K (Fig.10). There was a mean mismatch of about 0.5K between the forecasted 2m temperatures from the two daily model runs (Fig.11), with lower mean RMSE during night-time.

Similarly to results with ALADIN-BG forecasts, mean RMSE for the relative humidity forecasted by AROME-BG is between 6 and 8% (Fig.12). However, AROME-BG seems to generally underestimate the relative humidity, especially during the warm half year. There is a good overlap for the 2 daily forecasts of the 2m relative humidity (Fig. 13).

The wind speed forecasts verification results from AROME-BG (Fig.14 and 15) are quite similar to those from ALADIN-BG (Fig.8 and 9).

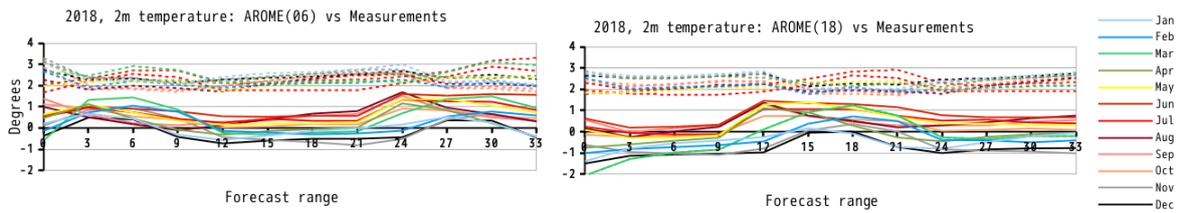


Figure 10: Temperature at 2 m: mean monthly BIAS (solid lines) and RMSE (dashed lines) as a function of forecast range – model runs at 06 UTC (left) and 18 UTC (right)

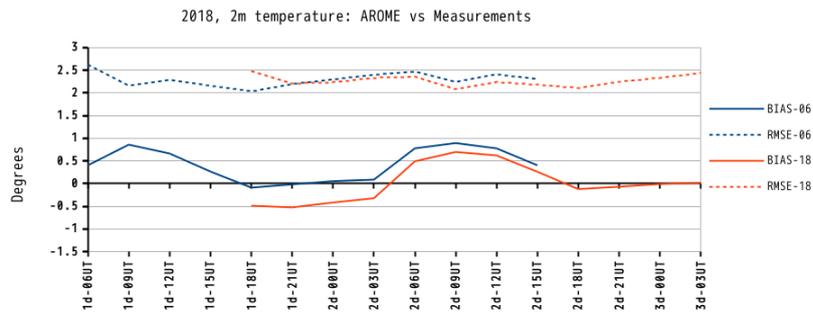


Figure 11: Mean annual BIAS (solid lines) and RMSE (dashed lines) of 2 m temperature as a function of the time of the corresponding forecasts (in UTC) for the runs of the model at 06 UTC (blue) and 18 UTC (red)

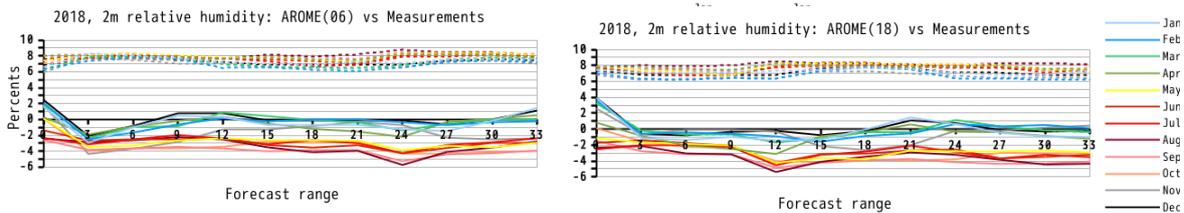


Figure 12: Relative humidity at 2 m: mean monthly BIAS (solid lines) and RMSE (dashed lines) as a function of forecast range – model runs at 06 UTC (left) and 18 UTC (right)

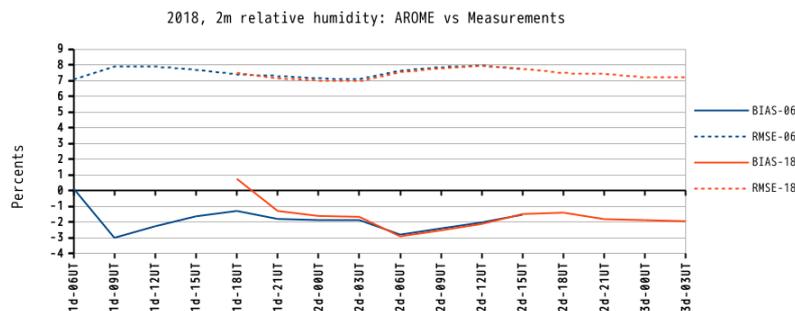


Figure 13: Mean annual BIAS (solid lines) and RMSE (dashed lines) of 2 m relative humidity as a function of the time of the corresponding forecasts (in UTC) for the runs of the model at 06 UTC (blue) and 18 UTC (red)

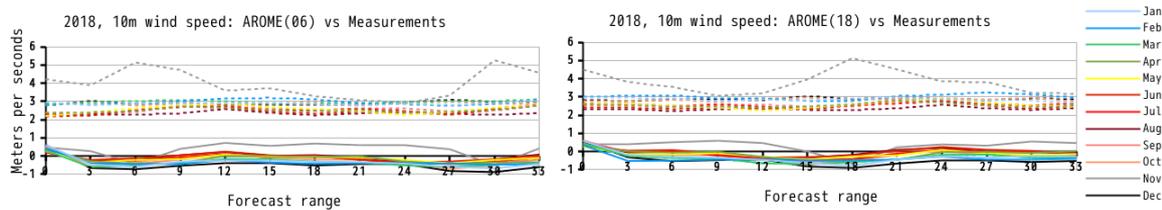


Figure 14: Wind speed at 10 m: mean monthly BIAS (solid lines) and RMSE (dashed lines) as a function of forecast range – model runs at 06 UTC (left) and 18 UTC (right)

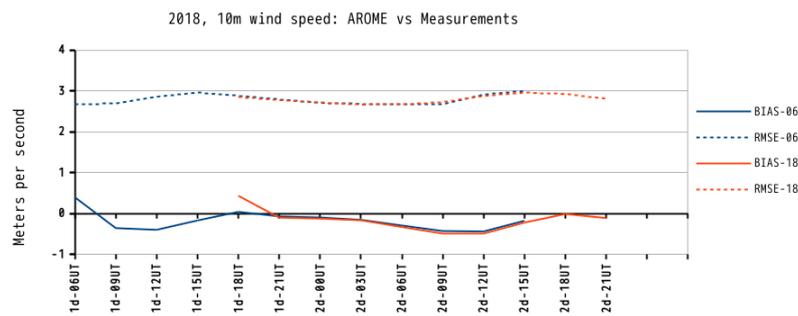


Figure 15: Mean annual BIAS (solid lines) and RMSE (dashed lines) of 10 m wind speed as a function of the time of the corresponding forecasts (in UTC) for the runs of the model at 06 UTC (blue) and 18 UTC (red)

Evaluation of wind forecast for Croatian Transmission System Operator

Endi Keresturi, Kristian Horvath, Iris Odak Plenković and Antonio Stanešić

1 Introduction

As detailed in Horvath et al. (2011) and Tudor et al. (2013), weather in Croatia is largely modified by orography, especially in coastal areas. Thus, improved representation of orography in numerical weather prediction models is expected to vastly improve forecast in those areas. That is mostly true for wind and precipitation as those parameters are heavily influenced by orography (Buizzi et al., 1998; Horvath et al., 2011; Schellander-Gorgas et al., 2017). Accurate wind forecasts are especially important for wind energy utilization as wind power plant production heavily depends on wind speed. In Croatia, almost all wind power plants are located in the mountainous area near Adriatic coast which is well known for its heavy downslope wind – bora (Grisogono and Belušić, 2009).

As global models still do not resolve many of these local weather patterns, high resolution limited area models provide an added value. In Croatian Meteorological and Hydrological Service (DHMZ), one configuration of ALADIN is specifically adopted to high resolution wind forecasting. Configuration of the so-called high resolution dynamical adaptation mode (HRDA) of ALADIN is given in Table 1. Interested reader is referred to Ivantek-Šahdan and Tudor (2004) for more information.

In this work, a wind speed study done for Croatian Transmission System Operator (HOPS) using ALADIN-HRDA is presented.

2 ALADIN performance

Analysis of wind power plant production and wind speed forecast presented here is done for the wind power plant located in mountainous area near Senj, Croatia. This power plant is exposed to heavy bora events and thus frequently switched off. Wind turbine shuts down when wind speed reaches a cut-out speed of 25 m/s. Figure 1 shows absolute error of power production forecast for power plant mentioned above. It can be seen that errors are the largest around the cut-out wind speed. These results indicate that the evaluation of models and wind forecast improvement is needed, especially for higher speeds.

An example of heavy bora event happened on 14 November 2017. A cut-out of zero production of wind power on the analyzed power plant is shown in Figure 2. While there are no measurements of hub-height wind speed, it is clear that only ALADIN-HRDA forecasted 80 m winds over 25 m/s of the four tested models (ALADIN, ECMWF, GFS and UKMET). Additionally, Figure 3. shows histograms of forecasted 80 m wind speeds for the same location for 3-month period (October-December, 2017). Only ALADIN-HRDA is able to forecast wind speeds over 25 m/s.

To further show the advantage of ALADIN-HRDA on wind speed forecast, Table 2 shows RMSE and MAE for a different power plant (where hub-height measurements are available) in mid-Adriatic near town Šibenik and a threshold of 15 m/s. The ALADIN-HRDA outperforms ECMWF by far, in both MAE and RMSE. The results presented here clearly demonstrate the added value of the high-resolution ALADIN-HRDA.

Table 1: ALADIN-HRDA configuration

Resolution	2 km
Levels	15
Initial conditions	ALADINHR 8 km
Boundaries	ALADINHR 8 km
Starting times	00, 06, 12, 18 UTC

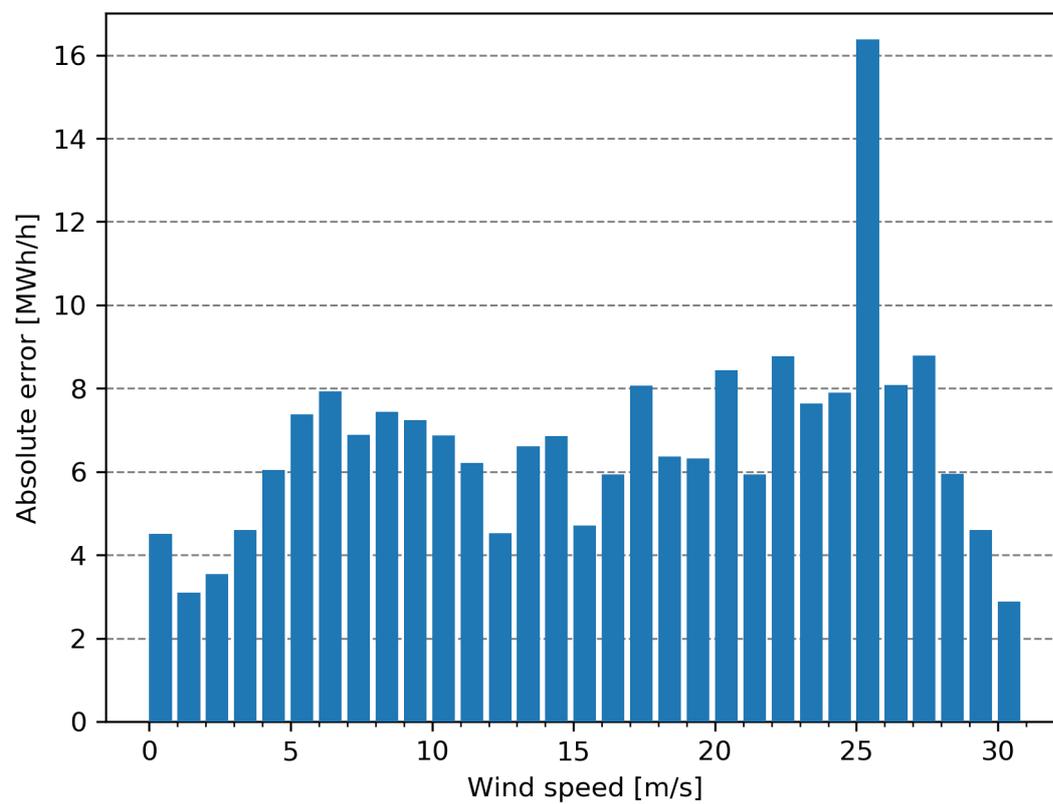


Figure 1: Absolute error of production forecast vs observed wind speed for wind power plant located near Senj.

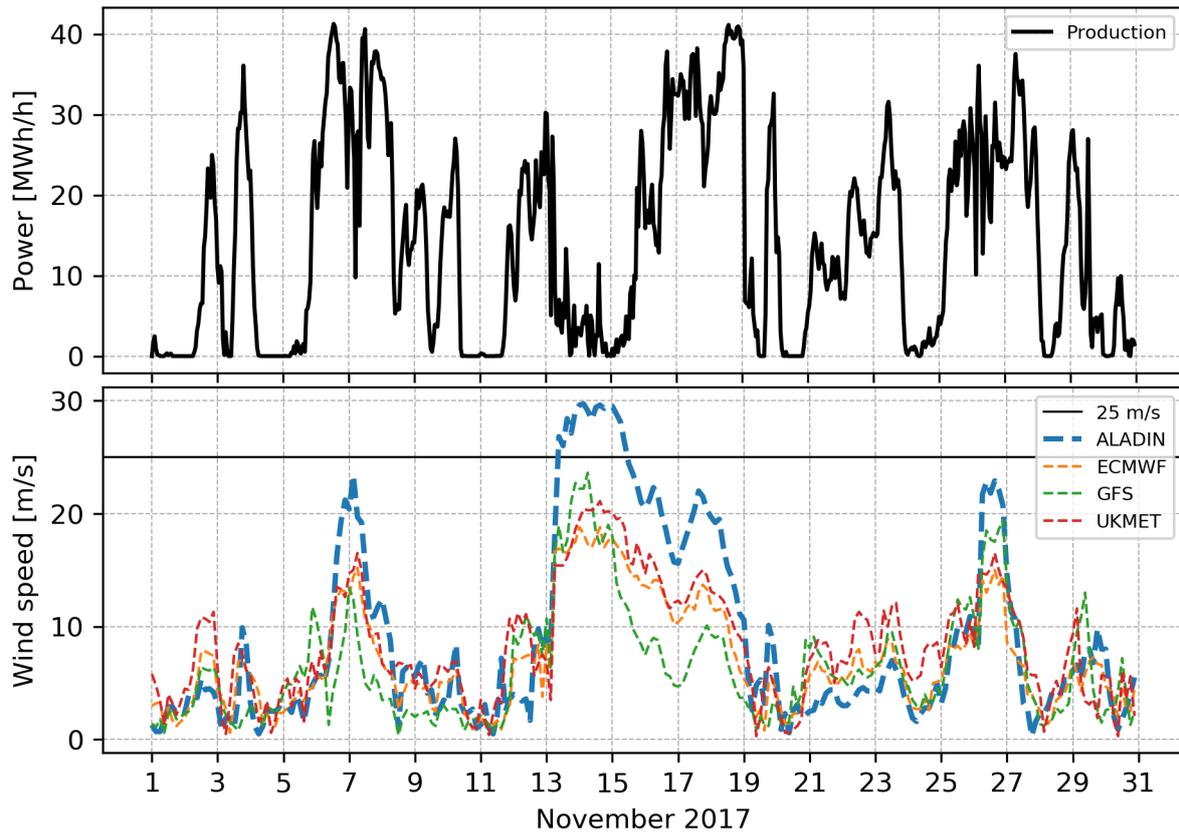


Figure 2: Time series of power plant production (MWh/h) in November 2017 for a power plant near Senj (above) and wind speed (m/s) at 80 m above ground as given by ALADI-HRDA N, ECMWF, GFS and UKMET (below). Horizontal grey line denotes a turbine cut-out wind speed of 25 m/s.

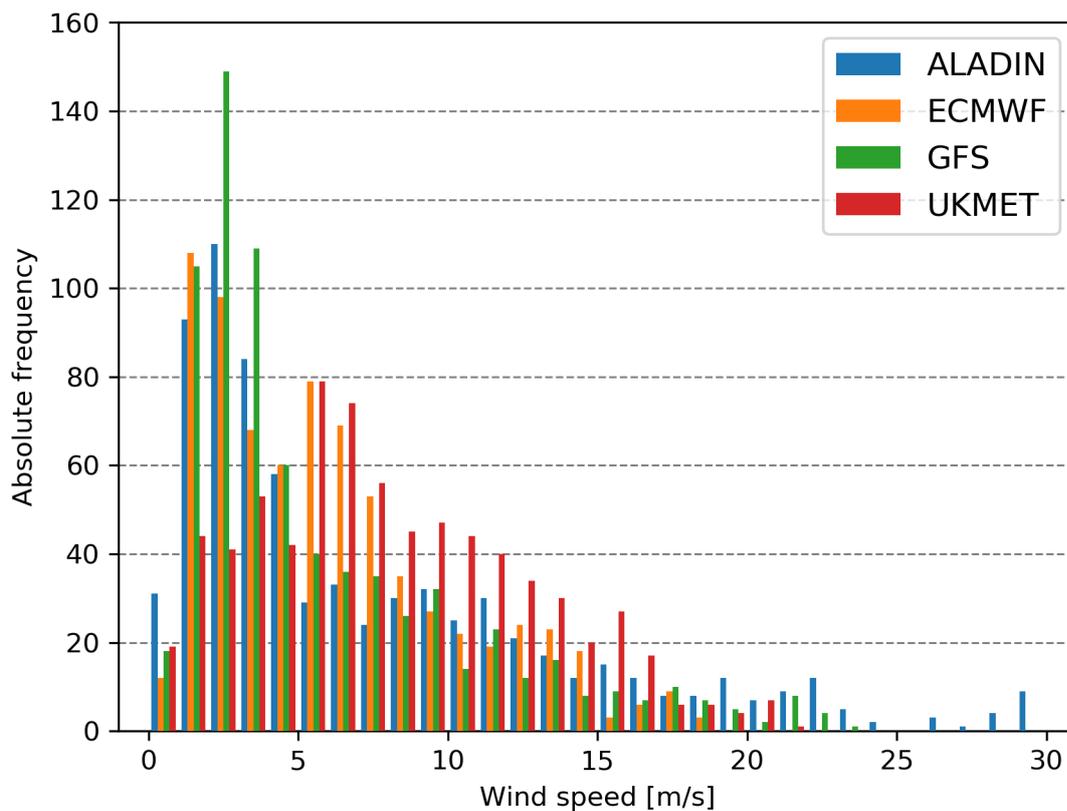


Figure 3: Absolute frequency of 80 m wind speeds in three-month period between October and December 2017 for a power plant near Senj.

Table 2: 80 m wind speed forecasts mean absolute error (MAE) and root mean square error (RMSE) for ALADIN-HRDA and ECMWF for wind speeds exceeding 15 m/s.

Wind forecast ($v > 15$ m/s)	ALADIN-HRDA (m/s)	ECMWF (m/s)
MAE	5.54	7.22 (+30%)
RMSE	6.53	7.66 (+17%)

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Assessment of ECOCLIMAP v2.2 cover types over Croatia

Suzana Panežić

1 Introduction

In preparation for the use of SURFEX at Croatian Meteorological and Hydrological Service, ECOCLIMAP v2.2 cover types over the Croatia were assessed. For the Croatian domain, 600x760 matrix was extracted and analysis showed there were 190 cover types included in the extracted domain.

Each cover type was isolated and highlighted on the drawn domain so the errors could be better perceived. While cover types looked rather realistic at the first glance, once they were isolated, significant unrealistic features came into view.

2 Assessment

2.1 Islands

The most specific feature about Croatia is probably the number of its islands, islets and crags along the coast. Since there is 1244 of them and some are relatively small and densely packed together, this was the first thing to evaluate. While bigger islands were represented nicely, smaller ones were not as can be seen at Figure 1. On the right picture, sea and ocean cover type was highlighted in dark blue color and it can be seen that there is a lot of smaller islands missing and some bigger ones are misshapen when compared to a realistic map of Croatia on the left.

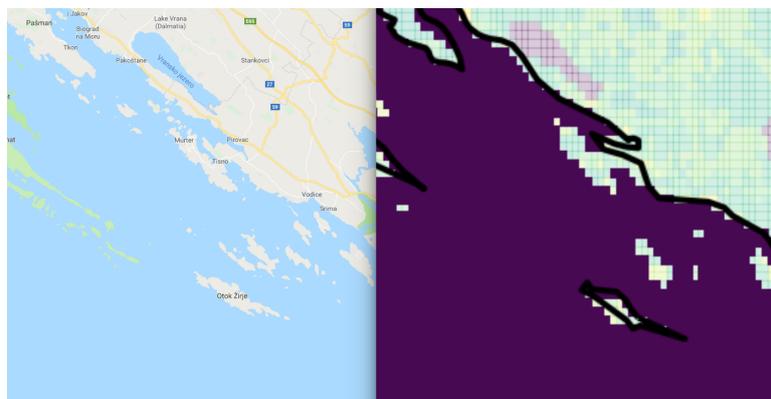


Figure 1: Missing islands

2.2 Lakes and bays

Assesment of inland water cover types showed that some smaller or elongated lakes were missing. Some examples are Plitvička jezera, Modro jezero, Crveno jezero and Ponikve which are represented by cover types expressed mostly through broadleaf trees and grass.

While some lakes were completely missing, some extra appeared as well as shown in Figure 2. Due to a highly complex terrain, a bay at the island of Pag (left picture) became a relatively smaller lake in the ECOCLIMAP database (highlighted in dark blue on the right picture) as well as the bay at the island of Krk.

In Istria, both bays (Limski zaljev and Raški zaljev) are missing from the database. They are represented with the same cover types as the missing lakes.



Figure 2: False representation of sea and ocean as inland waters cover type

2.3 Urban areas

For the assessment of urban areas, all urban and suburban cover types with equal or more than 10% of urban and artificial areas were grouped together and analysed. While larger towns had a relatively good representation, smaller towns were mostly missing, as can be seen in Figure 3. In the left picture, urban areas were highlighted with red circles and in the right the same is done in dark blue color. It can be seen that the town of Crikvenica (upper larger circle) is visible in ECOCLIMAP as an urban area, but towns of Novi Vinodolski (lower larger circle), Selce and Šilo (two smaller circles) are not expressed in the same way.

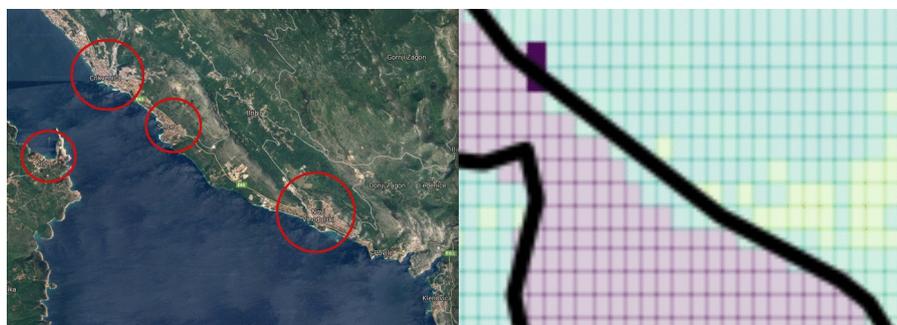


Figure 3: Missing urban areas

It was also noted that most of the airports are not present in the airport cover type. The only visible ones are near Zagreb and Pula, as well as a military airport in Udbina. The missing ones are airports near Zadar, Split, Rijeka, Osijek, Mali Lošinj, Dubrovnik and Brač.

2.4 Cultivated and natural areas

Leaf area index, tile fractions and other parameters used by SURFEX were calculated from the ECOCLIMAP database, analysed and compared to the CORINE 2012 land cover data and the Croatian Agency for Environment and Nature natural habitats database. Analysis showed that the coastal part of the mountain region of Velebit was expressed through C4 crop and grass tiles, even though the same is actually composed mostly of bare land, rocks and low shrubs, resulting in an unrealistically large leaf area index.

Continental part of the Croatia, which is the main C3 crops production area, has low percentage of C3 crop tiles. At the same time, central and southern coastal area have a high percentage of C3 crop tiles (up to 70%), even in some areas mainly covered by either bare land, rocks, low shrubs or coniferous trees.

When rock tiles in ECOCLIMAP were assessed, it was shown that the rock percentage was mostly low (10% and lower) throughout the whole domain, with the exception of towns of Zagreb and Rijeka where rock percentage reaches up to 60%. In reality, a big portion of Croatian coast is largely covered by rocky terrain, as seen in Figure 4, but is expressed as bare soil tile. Due to a difference in surface roughness and thermal parameters, this could potentially be very problematic if used in SURFEX without corrections.

Assessment showed some IR_SCOT_SWAMP_MOORS1 cover types in the Zadar area, where there shouldn't be any swamps. It was shown that the area marked as swamps was the area of Velebit Pumped Storage Power Plant on Zrmanja river.

Due to numerous wildfires in coastal area every year, burnt portion cover type was also specially assessed. This cover type was present only on islands of Brač, Hvar and Lastovo, while in reality there are more present along the coastal area.



Figure 4: Rocky terrain expressed as bare soil tile in ECOCLIMAP

3 Next steps

Due to many errors in the ECOCLIMAP v2.2 database, corrections will be made using the Croatian Agency for Environment and Nature natural habitats database and the new CORINE 2018 database. New cover will be tested and implemented for the SURFEX usage at the Croatian Meteorological and Hydrological Service.

Tour d'ALADIN: Czech Republic

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

1 Introduction

For the CHMI NWP team, the year of 2018 was marked by quite a polyvalent activity, yet with a couple of well-focused targets. New powerful supercomputer, reaching its full configuration in May 2018, considerably helped to increase the productivity in Research and Development works, also it allowed for a relatively smooth implementation of the export cycle CY43T2.bf9 into operations. Most important achievements are summarized here below.

2 Year 2018 Highlights

Assimilation of MODE-S EHS data and improved shallow convection closure

RC LACE has concluded a contract with KNMI on the acquisition of pre-processed MODE-S EHS data, covering area of Benelux countries and Germany. These data are now available in the OP LACE database for RC LACE Members. Thanks to the close cooperation within RC LACE, CHMI could capitalise relatively quickly on the previous research and development works concluded by Slovenian and Czech colleagues. Assimilating MODE-S EHS data lead to a very clear improvement of namely wind scores up to 12 hour forecast range, and of temperature scores, at levels close to aircraft cruise ones.

A parallel suite, the last one on the old library cycle, comprised not only the above mentioned assimilation of MODE-S EHS data, but also modified shallow convection closure. Work on shallow convection in the turbulence scheme TOUCANS has been reported in the previous ALADIN Newsletter N°11 but it is not yet fully published; some ideas can be found in Bašták-Đurán et al., 2018. Besides improved scores brought in by aircraft data in the altitude, bias of temperature and moisture got better close to layers 850-700 hPa owing mostly to the shallow convection modification. The parallel suite was switched in the operational service in July 2018.

Export cycle CY43T2 in operations, new products and R&D contributions to CY46T1

Shortly after the announcement of an already quite consolidated version of the CY43T2, CHMI team ported this new library to the local HPC and commenced with a more in depth validation of various configurations of the forecast model, surface analysis CANARI, screening and 3DVAR minimization, DFI filtering sessions, and FULLPOS. This work helped to reveal a couple of remaining problems and/or bugs; these were rapidly fixed thanks to an excellent cooperation with the Toulouse team. We however ought to mention a repetitive problem of map factor scaling/rescaling of wind, since this is a classical trap, source of errors. We could fix some of them, for sure not all. We plead for removing useless applications of the above mentioned scaling/rescaling by map factor and code cleaning in that sense of course with our help. The CY43T2 export based library (level bugfix #9) including already a list of local developments (e.g. roughness length, shallow convection, FULLPOS products) has entered the operational service in August 2018.

We have profited from the switch to the new cycle to introduce some new products, such as mean radiant temperature for bio-meteorological applications and ensemble meteograms - EPSgrams. The ensemble is the so-called lagged one, created from the consecutive model runs. What is interesting with respect to the traditional presentations, is that these EPSgrams contain also recent past including hourly observations. Like that the model and observations comparison can be seen locally for given weather situation. An example of such an EPSgram is shown below. The local developments were phased into the main library CY46T1; these are about ALARO physics, new products and also there is a considerable code contribution regarding NH VFE discretization realized within the RC LACE cooperation, by Slovak and Czech teams.

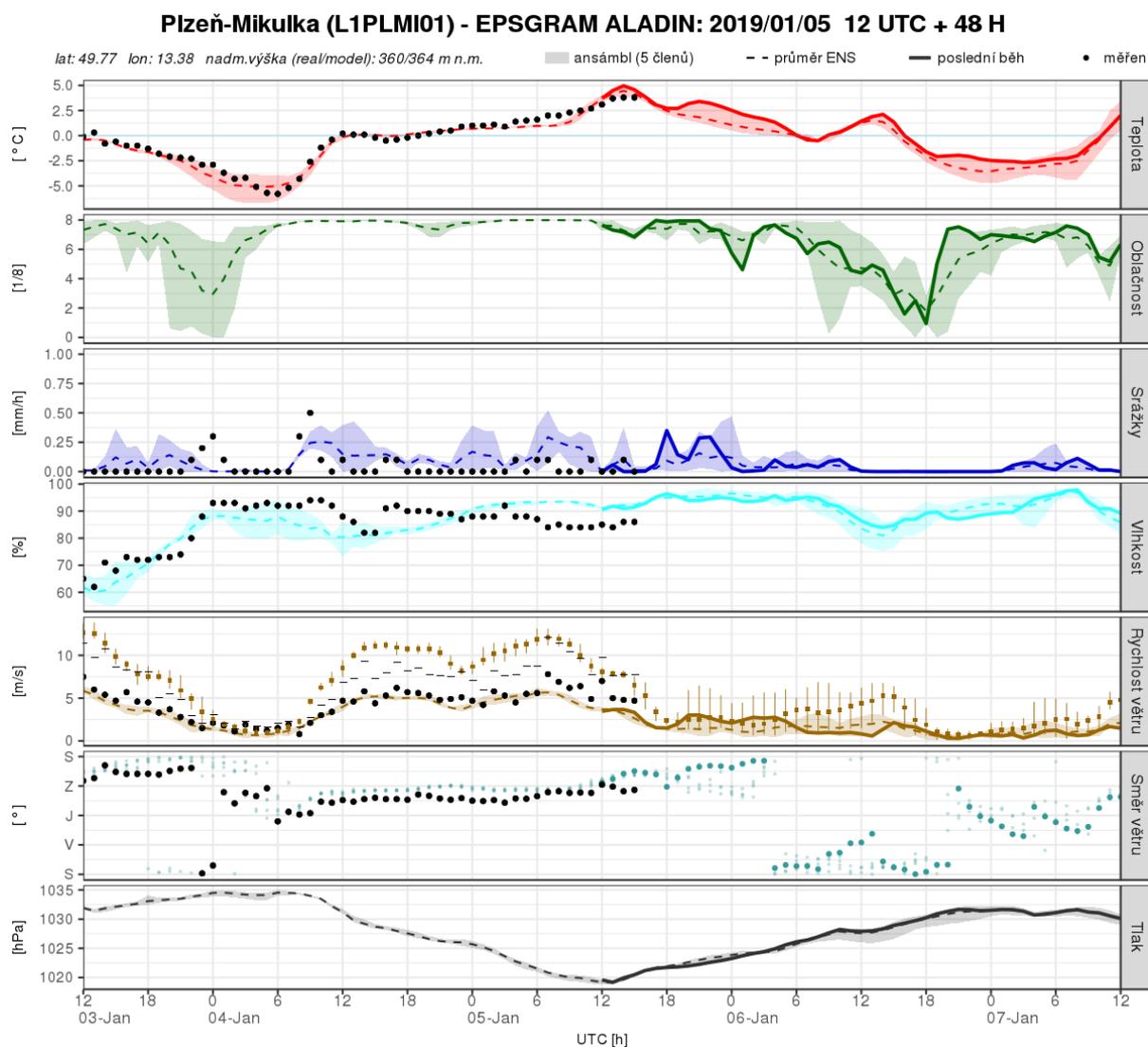


Figure 1: EPSgram for the station Plzeň-Mikulka, base 2019/01/05 at 12UTC. Measured quantities are represented by dots. Ensemble is composed from five members – consecutive model runs. The ensemble mean is plotted as a dashed line and the last run is presented by a full bold line.

Future high resolution

During 2018 works focused on future high resolution of the ALADIN application in CHMI. Some preliminary results were mentioned already in the previous ALADIN Newsletter N°11. New planned configuration will cover the same computational domain like now, i.e. the so-called LACE domain.

The resolution will be 2.3km with linear grid and 87 levels. The forecast model will comprise non-hydrostatic dynamics and ALARO-1 physics, while the assimilation will continue to profit from the digital filter blending followed by 3DVAR and combined with the surface CANARI-OI.

During summer, we concluded on the setup of the dynamical core including the retuning of the spectral horizontal diffusion combined with the SLHD scheme. The non-hydrostatic core will run with one iteration of the PC scheme and the time step of 90 seconds. For the physics only slight tunings were necessary; these were mainly linked to the new computation of surface roughness. An interesting question is about the use or not of gravity wave drag, or better say parameterizations of still unresolved orography, despite a general belief these parameterizations could be dropped for horizontal resolutions higher than 5km about. We shall continue using the 3MT parameterization of still unresolved drafts.

Preliminary validations of the high-resolution setup were done for winter 2017 and late spring 2018, covering various weather regimes. For moist deep convection the specific period of June-July 2009 was used as a complementary test-bed. As expected, higher resolution improves namely scores of screen level parameters. We complete the classical scores by additional validations, such as the verification of global solar radiation, which helps to verify indirectly cloudiness. Here below (Fig. 2) is the validation of downward solar flux hourly sum, where for the high-resolution model version we reduce the bias below 5%.

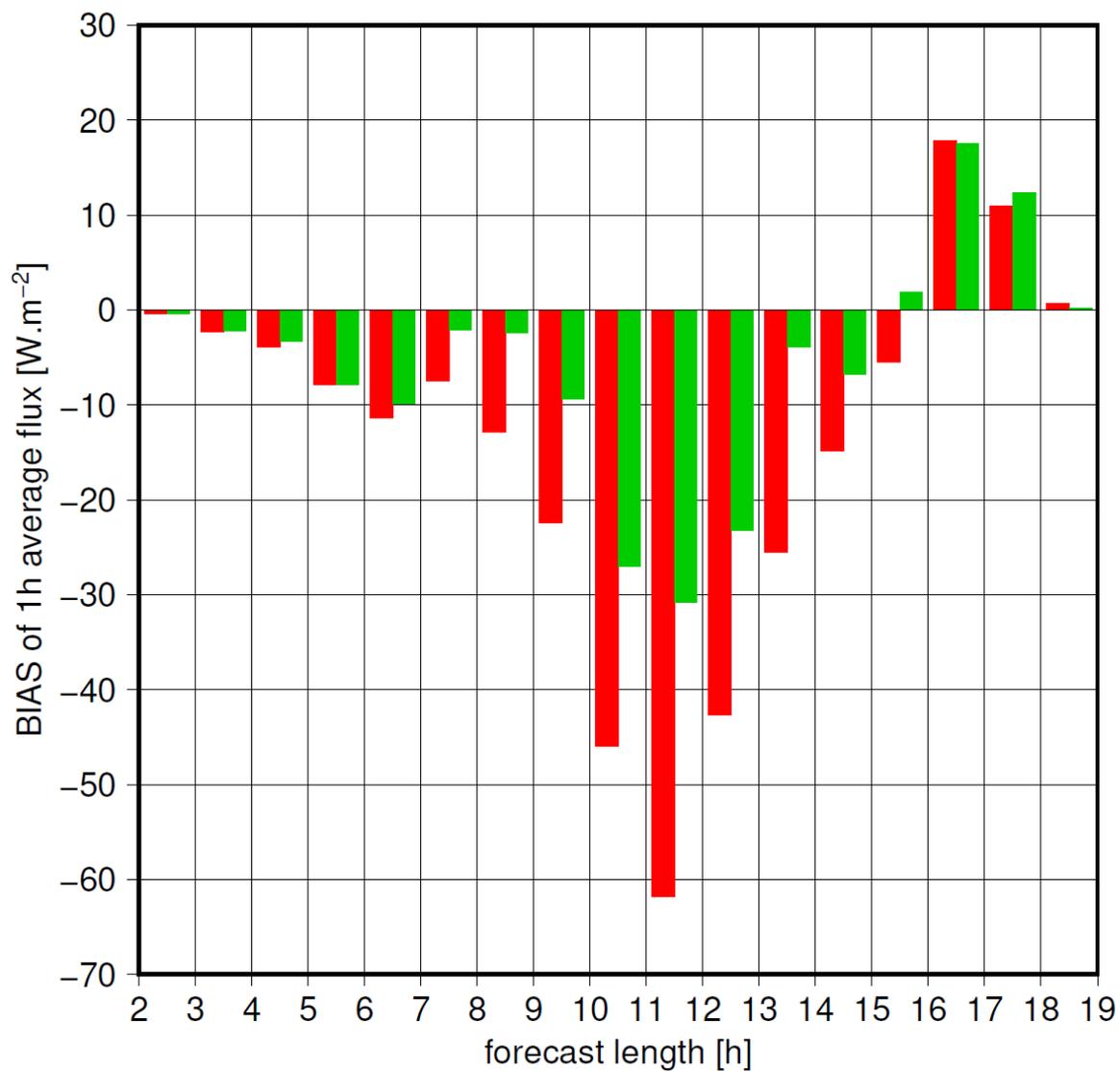


Figure 2: Bias of hourly surface downward solar flux with respect to 19 stations, for the period from 14 May to 31 May 2018. Red bars denote the reference at 4.7km and green bars denote the high-resolution model version at 2.3km.

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TAS, an operational forecast model at hectometric scale

Xiaohua Yang

1 Introduction

Coastal regions in Greenland and Faroe Islands, both parts of Kingdom of Denmark, suffer frequent storms with strong intensity and high variability. In Greenland, transition from high plateau, with permafrost glaciers/ice-sheet and an altitude of ca 3 km, to coastal zones near sea level, often occurs abruptly with sharp gradients in orography and landscape, contributing to triggering of extreme weather. Throughout year, especially during autumn and winter, storms occur in different parts of Greenland. The type of weather phenomena, associated with complex orography with small scales, poses severe challenge to numerical weather prediction (NWP).

In recent years, successful operationalisation of high resolution, nonhydrostatic, 2.5 km Harmonie-Arome forecast system at DMI has advanced significantly its capability to detect and warn storms in Greenland and Faroe Islands, the intensity of which have often suffered severe under prediction in the past due to insufficient model resolution (Yang et al 2017, 2018a). Meanwhile, operational experiences have also revealed that, for some coastal sites, Harmonie model tends to predict storms much too often and too strong. While such tendency could partially be attributed to representation error with in-situ measurement in connection with complex orography, the over-prediction may also be a consequence of insufficient model resolution. For some orographically induced storms with small scales, a grid resolution of 2.5 km, as used in the present operational HARMONIE systems at DMI, is still too coarse.



Figure 1: Domain coverage of the operational TAS (in red), which is nested within the operational DMI-IMO IGB (in blue). TAS runs 54h forecast every 6 hours at 03, 09, 15 and 21 UTC.

Recently, a series of sub-kilometer (hectometric) model suites using Harmonie-Arome has been set up in DMI, with a goal to address challenges in storm forecast for regions with complex orography. These suites are referred to as “Harmonie-lite” (Yang, 2018b), which is a special model configuration mainly for downscaling forecasting with a grid resolution of 500 m to 750m. Typically a domain of “Harmonie-lite” covers only a small area and is nested inside one of the operational Harmonie forecast

suites. In view of the need for substantial computational resources with very high resolution models, priorities have been taken, in configuration of Harmonie-lite, to ensure efficiency, stability and robustness for operational purpose. Based on extensive experiences from episode studies and real time quasi-operational runs, the value and advantage with these high resolution forecast suites in storm prediction has been verified. In Oct 2018, the first Harmonie-lite forecast suite, TAS, with domain centred in Tasiilaq, southeast Greenland (Figure 1), became operational at DMI, with several more to follow in the near future.

2 Small scale orography and associated variability in weather

Tasiilaq is one of the main residential towns in southeast Greenland. It is situated in a complex coastal region with high orography in the surrounding. The town is known to be associated with a special weather phenomena “Piteraqa”, the strong and cold katabatic wind coming down from the Greenland ice-cap. “Piteraqa” means in local language “the wind that attacks”, the strongest of the observed case occurred on Feb 6 1970, in which the wind was estimated to have reached 90 m/s at peak, resulting a severe destruction of the town. On the other hand, wind flows in the area have also shown phenomenal variability due to complex orography. Local residents often experience that, while some exposed areas suffer extreme wind, the nearby places just short distances away would hardly have been affected. In this work, the potential to make storm forecast with a very high resolution model is explored by test of TAS centered around Tasiilaq (Fig 1, red domain). TAS is with a grid resolution of 750 m and based on same forecast system as in the operational DMI-IMO IGB, and nested within the latter domain through hourly coupling (Fig 1, blue domain with 2.5 km resolution).

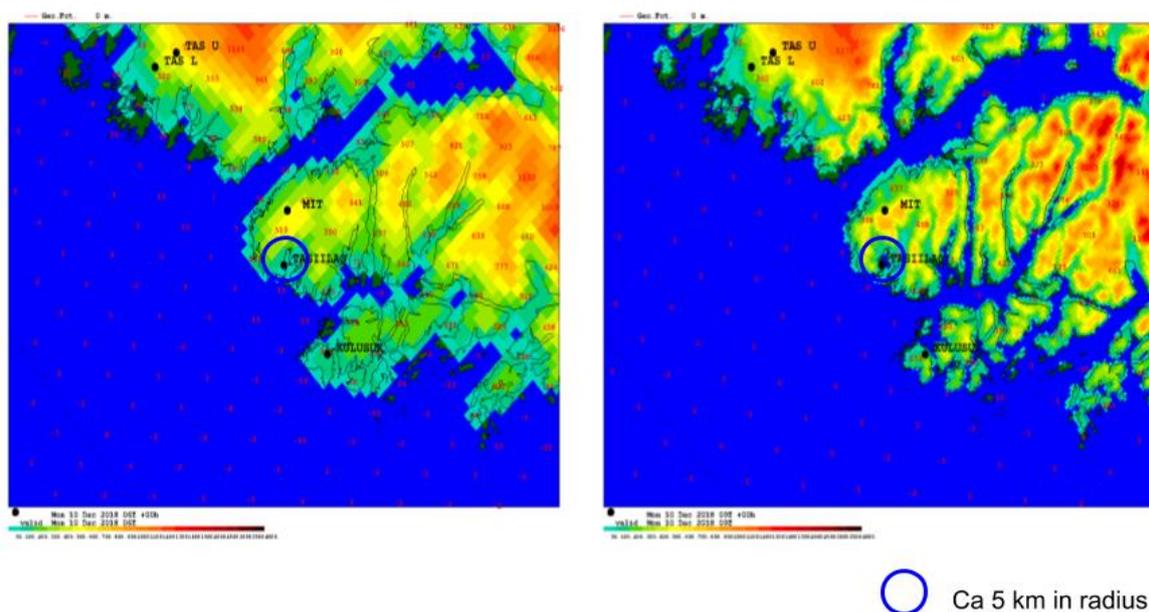


Figure 2: Orographic height as represented with colour in Harmonie-2.5 km (IGB, left) and Harmonie-750 m (TAS, right), the latter is seen to represent more clearly the strong variation of orographic height in the transition from high Greenland plateau to that of sea level at coastal region. The town Tasiilaq lies in the center of the plot. A circle with a radius of 5 km is marked around Tasiilaq to highlight the scale of the landscape.

The orography complex around Tasiilaq, and its representation by NWP models, is illustrated in Fig 2, in which orographic height in IGB at 2.5 km grid resolution (Fig 2a) , and the higher resolution TAS (750m), are shown, respectively, in which the town of Tasiilaq is marked by a blue circle with ca 5 km radius. A remarkably strong variability in orography and landscape is shown in the figure, especially by the higher resolution TAS. Obviously, the 750 m model represents better small scales associated with a strong contrast in landscape and variability.

For given large scale weather regimes, e.g. low pressure and cold air outbreak from Greenland high plateau, spatial scales in flow responses are strongly related to the scales in the underlying surface.

Fig 3 shows a comparison of wind forecasts by IGB and TAS, respectively, for a recent Pitera episode on 9 Jan 2019, with valid time at 18 UTC. At large scale, strong wind up to hurricane scale has been simulated in both models over the Greenland ice sheet (north side of the shown domain) and part of the offshore area, whereas the wind forecast for area along the coast looks rather different between the two. e.g. for Tasiilaq and nearby area as marked by blue circles in the figures. While the IGB-2.5 km forecast shows an extended area with hurricane-scale wind, a much more heterogeneous flow pattern along the region with complex orography is seen in the forecast by TAS-750 m. A comparison to the wind measurement in Tasiilaq indicates that TAS verifies clearly best, with predicted storm evolution better described both in magnitude and phase. Meanwhile, it is worth noting that, under storm situation like this, it is virtually impossible, but also improper, to use a single point value to represent flow condition for a site with complex orography, such as the town of Tasiilaq, as the local variability (as simulated by TAS) is enormously large, with wind speed ranging from light condition to strong storm, as illustrated by the blue circled area on the wind field by TAS in Fig 3. Instead, providing a 2-D wind forecast plot, or at least a meteogram containing interval and uncertainty in wind forecast, shall be more appropriate.

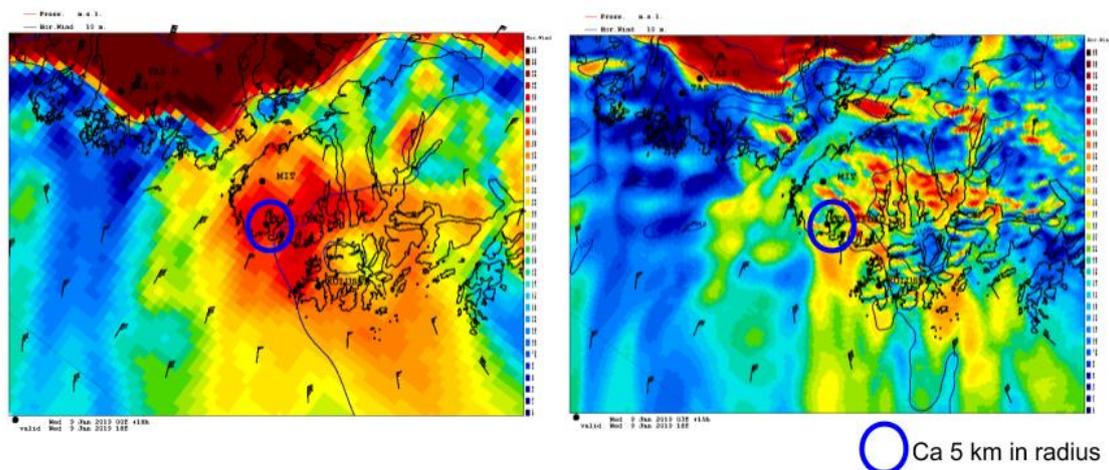


Figure 3: Short range wind forecast at 10 m for area around Tasiilaq (see the blue-circled part with a ca 5 km radius) by Harmonie-2.5 km (IGB, left) and Harmonie-750 m (TAS, right), valid for 9 Jan, 18 UTC. Yellow colours indicate wind above storm scale ($> 24.5\text{m/s}$), red above hurricane scale ($> 31.4\text{m/s}$). As the figures indicate, the simulated wind pattern with 750-m TAS reveals a strongly varying wind situation for larger part of the coastal region in the neighborhood of Tasiilaq, whereas the 2.5 km IGB shows a more uniform wind flow. From in-situ measurement at Tasiilaq, the simulation in the right column fit better both in magnitude and in phase.

3 Configuration of HARMONIE-TAS and its validation

Extreme weather such as PiteraQ in Tasiilaq region as shown in Fig 3 (right plot) reveals strong horizontal variability which is clearly affected by the local complex orography, posing a major challenge to NWP systems, as it requires very high model resolution in order to adequately represent critical scales of surface conditions. Normally, increase in model resolution is generally associated with a significant increase in computation needs, which is not easily affordable unless model domain is kept small. The work with Harmonie-lite here is an attempt on such direction.

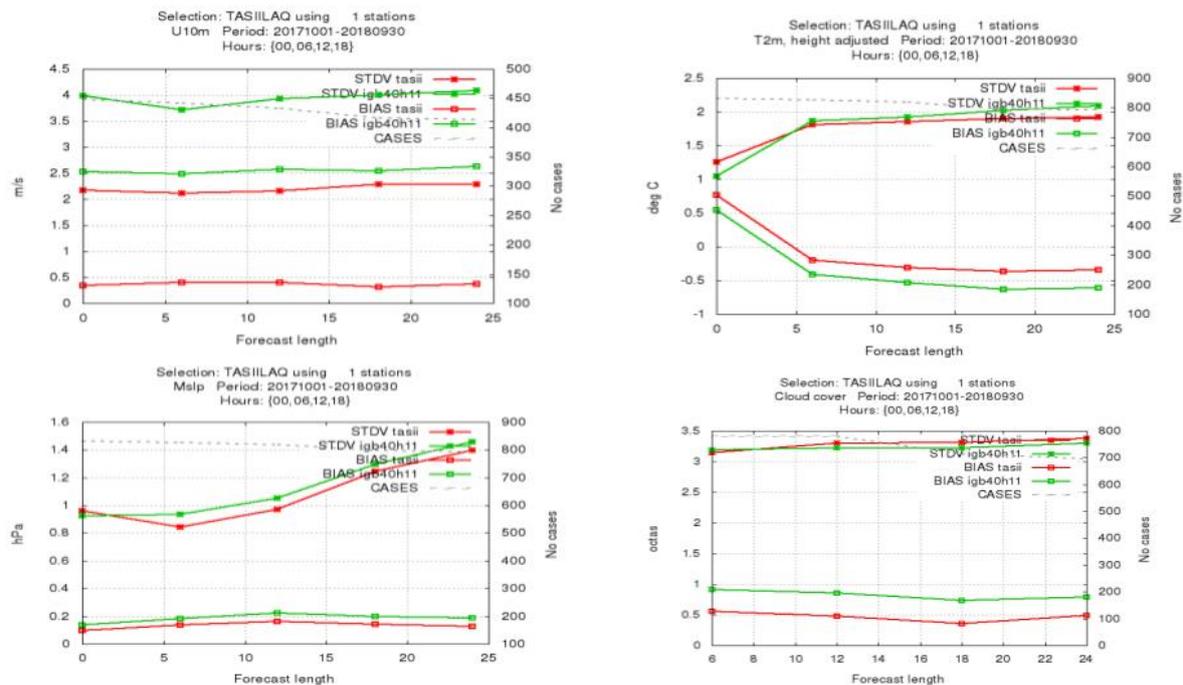


Figure 4: Averaged forecast error along forecast lead-time up to 24 h for the one-year period between Oct 2017 and Sept 2018 as compared to surface measurement for station Tasiilaq in standard deviation (upper curves) and bias (lower curves) for TAS domain with IGB (green) and TAS (red) for screen level parameters: surface wind (upper left), temperature (upper right), mean sea level pressure (lower left) and cloud cover (lower right).

TAS is configured with a relatively small domain with 400x400x65 grid mesh, as shown in Fig 1. Real time TAS suit started in Feb 2017 with a downscale forecast with 24-h lead time, 4 times a day. After an initial period with direct coupling to the ECMWF HRES (9 km), TAS is nested to the operational IGB. From an one year intercomparison of conventional objective verification between pre-operational TAS and IGB against in-situ measurement during Oct 2017 and Sept 2018 (Figure 4), the sub-km TAS looks to have a clearly superior verification results in observation verification, especially in terms of fit in wind forecast, (Fig 4, upper left panel). Advantages with high resolution in TAS for other screen level parameters are also apparent, e.g. for T2m temperature, surface pressure and cloud cover, albeit to a less degree. Obviously, the very high grid resolution setup with TAS has been crucial in description of the complex orography and its impact on screen level parameters especially for wind forecast.

In Fig 5, the corresponding scatter-plots comparing Harmonie forecast to measurement in Tasiilaq for 10m wind (upper panels) and 2m temperature (lower panels) demonstrates further an improved accuracy in high resolution TAS (right) than IGB (left). Especially for wind speed, while no event above storm scale (24.5 m/s) is found from the measurement data for Tasiilaq, IGB has an excessive amount of predicted storms, whereas for TAS, the tendency of over-prediction is much less severe. Note that the measurement in Tasiilaq station has been rather unstable in recent years, resulting a quite frequent and lengthy interruption in the observation data series during the one year period.

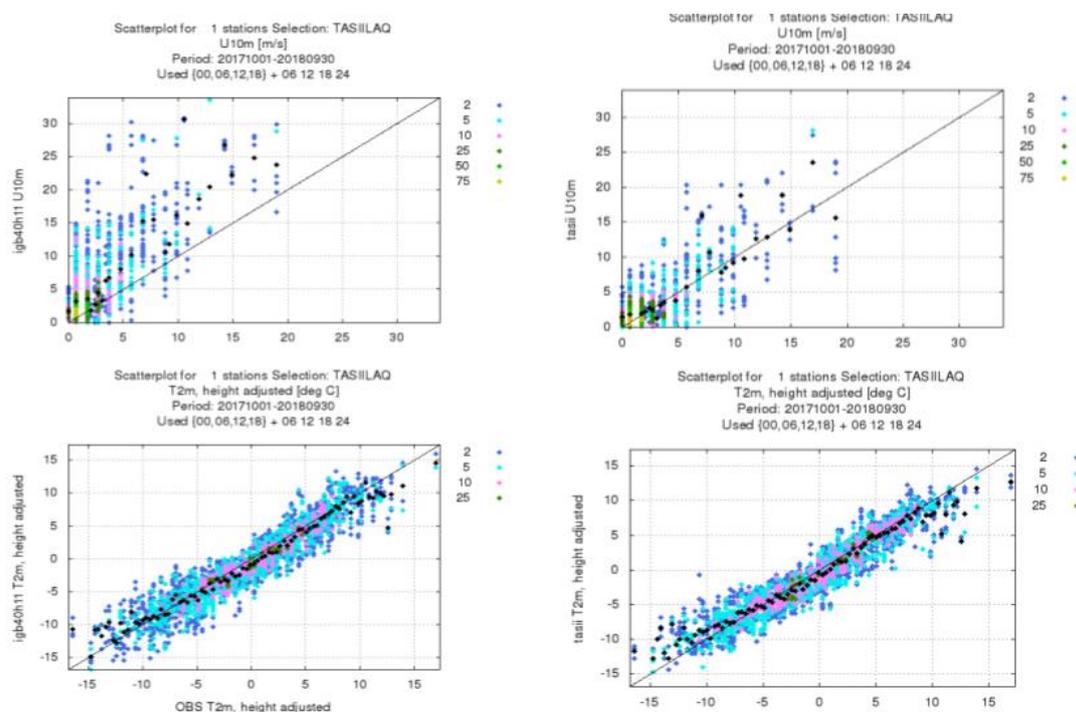


Figure 5: Scatter plots of model forecast (Y-axis) vs measurement (X-axis) for station TASIILAQ during the one year period from Oct 2017 and Sept 2018, by IGB (2.5 km, left columns) and TAS (750m, right column) for 10-m wind (upper panels) and 2-m temperature (lower panels). A significantly reduced scattering can be seen for Harmonie-750m. In particular, especially for surface wind, there is a major reduction in predicted wind speed by Harmonie-750m.

To investigate further the behaviour of TAS in forecast for critical conditions, all episodes with predicted or measured strong storms or hurricanes for Tasiilaq and the nearby coastal site Ikermit, during the one year period prior to operationalisation, have been examined, with modelled wind time series vs matching observation plotted in Fig 6 (Tasiilaq) and Fig 7 (Ikermit). In these comparison, forecast time series by TAS (750 m), the operational IGB (2.5 km), and the previous operational Hirlam-K05/K0T (5.5 km) have been plotted. For Tasiilaq, as shown in Fig 6, numerous strong wind episodes ranging from storm to hurricane strength have been predicted by IGB (in red), with a clear over-prediction about peak winds in almost all cases when compared to the measurement in Tasiilaq (in blue). TAS-750m (in green), on the other hand, looks to offer a much better fit to observations, presumably due to its capability to represent better local variability. Note that from Fig 3, TAS does also predict similarly strong wind conditions as in IGB, but just with strong local variability in response to orographic complexity. Interestingly, while the coarse resolution HIRLAM-K05/K0T at 5.5 km in general tends to forecast weaker wind in average conditions (not shown here), the predicted wind speed in these storm episodes appears to either severely under-predict in some cases (20180205,

20180506, 20180928), or severely over-predict in other episodes (20180206, 20180223, 20181005). All in all, TAS validates best for TASIILAQ for these episodes, showing a clear added value.

It may be worth stressing that, as illustrated by Fig 2 and Fig 3, due to a very strong variability of wind flow in Tasiilaq, the measurement in Tasiilaq mast has very limited representability and hence needs to be used with caution. Contrary to situation for Tasiilaq as shown in Fig 6, the corresponding forecasted meteograms for Ikermit (fig 7) reveal a rather similar forecast between Harmonie models at 2.5 km and 750 m, presumably due to an more open and less heterogeneous coastal landscape in Ikermit. For the latter, 8 windy events have been found during the one year period, 5 of them with measured wind speed peaking above hurricane strength (> 32.6 m/s). Harmonie models appear to be able to forecast the storm situation and evolution of the systems remarkably well, although the model predicted wind strength usually fail to reach the observed peak strength. As a comparison, for none of these episodes, the coarser resolution and hydrostatic model HIRLAM-5.5 km model prediction has been able to reach a wind speed over storm thresh-hold. Finally, it shall be noted that, in-situ weather measurement in Greenland stations is a severe logistic challenge and wind data in both of the places, especially TASIILAQ, suffered frequent interruption during recent years. As such, Fig 6 and 7 show only the forecast fit during windy condition when measurement data are available.

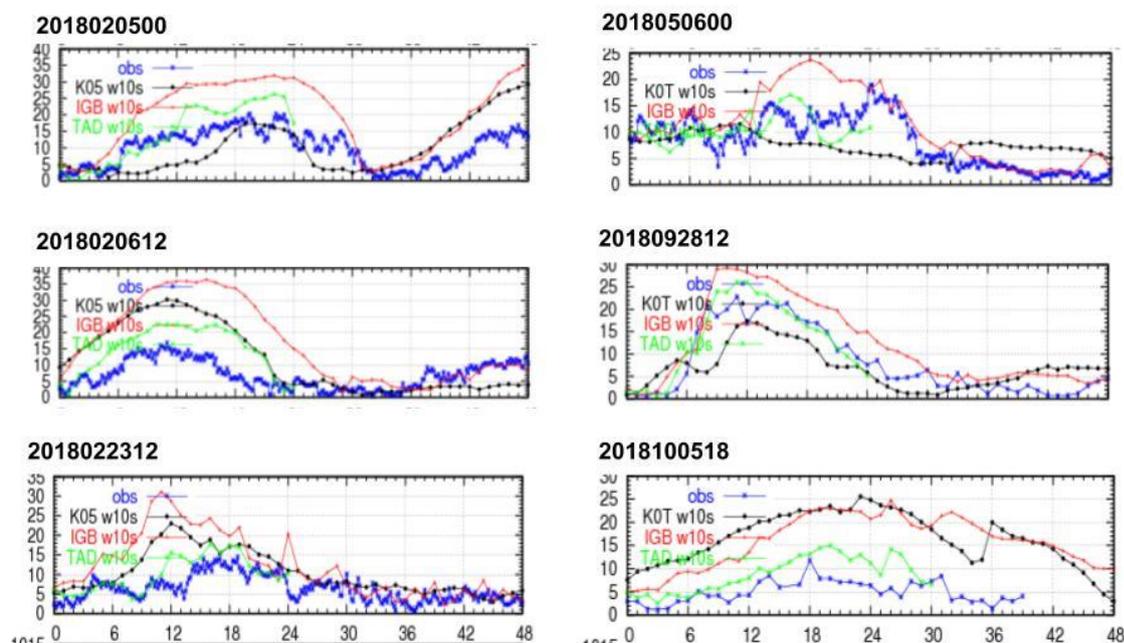


Figure 6: Forecast meteogram for Tasiilaq during 6 windy episode during a recent one year period comparing predicted time series between TAS (noted as TAD, green), IGB (IGB, red) and HIRLAM 5.5 km model (K05/KOT, black). The in-situ measurement is in blue. Only the episodes with strong wind forecast and available measurement data have been selected. Note that TAS runs only to 24 to 30h during pre-operational phase. Contrary to a general over-prediction of IGB (and sometimes also with K05/KOT), the sub-km TAS appears to generally fit much better to the observed wind speed.

Presently, operational TAS runs 4 times a day with 54-h forecast, providing supplementary 2-day forecast for the regions around Tasiilaq, Kulusuk and Ikermit, including a feed to automated city weather forecast in dmi.dk. Systemwise, TAS is built upon a subversion code branch “tas40h11”, adapted from the operational DMI-IMO igb40h11 repository with forecast system based on the reference Harmonie-arome 40h11 released by Hirlam-C programme. TAS is run at 03, 09, 15 and 21 UTC, using 3-h lagged IGB forecasts as lateral boundary condition, supplemented by its own surface assimilation using screen level temperature and humidity. Up to now only limited adaptation in dynamic schemes or physical parameterisation has been done in order to run at sub-km resolution. A

lower spectral resolution quadratic grid has been selected for TAS in dynamic computation in view of its satisfactory stability and efficiency. A time step of 25s is chosen, which has shown to be sufficiently stable. As TAS is used mainly for supplementary forecast, it is scheduled to run on DMI-Cray XC50 during the time windows with least system load. For operational delivery, it is sufficient with 5 to 10 hpc nodes. With 10 nodes, a 54-h forecast takes 47 min. As the main target is to provide high resolution screen level forecast, only surface and single level GRIB data is produced.

4 Summary and discussion

In this work, forecast skills with TAS, Harmonie-Arome model at 750 m grid resolution, for storm situations in Tasiilaq, a coastal town in complex orography, has been examined. Investigation on similar setup for several other regions in Greenland, Faroe islands, with focus on improved storm prediction in complex orography, has also been conducted. These sub-km Harmonie-Arome setup, known as Harmonie-lite, typically has a grid resolution of 500 to 750 m, cover relatively small geographic area. As reported in this work, experiences from episode studies and long term evaluation have shown a clear superiority and added values with the high resolution setup in forecast of storms in Tasiilaq area. At present, results for other Harmonie-lite setup are being investigated, several is likely to be operationalised in near future. As pointed out in Yang 2018b, for the purpose of storm forecast, Harmonie-lite can be configured either for regular operational runs, or for an on-demand use during storm seasons.

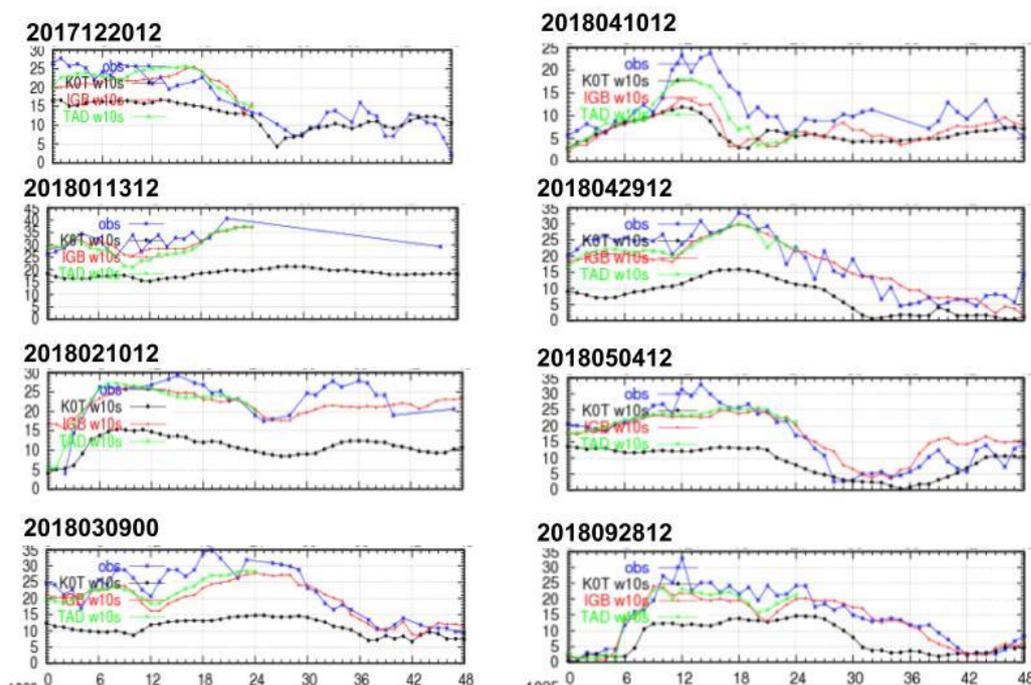


Figure 7: Forecast meteogram for Ikermiit during 8 windy episodes during a recent one year period comparing predicted time series between TAS (labeled TAD in the figure, green), IGB (red) and HIRLAM 5.5 km model (KOT, black). The in-situ measurement is in blue. Only the episodes with strong wind forecast and available measurement data have been selected. Note that TAS runs only to 24 to 30h during pre-operational phase. Contrary to the situation for TASIILAQ, there is no obvious tendency with over-prediction of wind storms with neither IGB km nor TAS, whereas the coarser resolution K05/KOT-5.5 km fail systematically to predict storm condition there.

In operationalizing sub-km model for Tasiilaq region, a relatively long forecast length of 54h has been selected in response to requests from DMI duty forecasters and for use in automated 2-day forecast for the relevant locations. Given a very high grid resolution and a rather limited area coverage, one may argue whether such a long forecast range has really been meaningful. In our view, this may be justified by the following reasoning. For location like Tasiilaq, hazardous storm weather is often associated with synoptic scale lows accompanied with small scale orographic forcing and land sea contrast. These together are the determining factors for predictability in local weather, which tends to be much more extended compared to other small scale weather features at convective scales.

It shall be noted that the work reported here has been done with primary focus on prediction of strong wind. Clearly, raising grid resolution from 2.5 km to 750 m has been beneficial for storm forecast for Tasiilaq, for which 2.5 km model tends to over-predict. On the other hand, added values in wind forecast by sub-km model do not appear universal for all coastal stations, as seen from the station verification for Ikermit, suggesting critical dependence of local variability on scales of the underlying surface such as orography. In other words, a very high resolution model with sub-km grid may not necessarily be universally necessary.

5 Acknowledgement

The work with hectometric models has been inspired by discussion with John Cappe and numerous duty forecasters at DMI. The Harmonie-lite system benefited from the crucial contribution on high resolution orographic database by Bolli Palmasson, Icelandic Meteorological Office (IMO), within framework of the operational DMI-IMO collaboration. Ludovic Auger, Meteo France and Mariano Hortal, AEMET, are acknowledged for inspiring discussions about model dynamics and stability issues. Bent Hansen Sass, DMI, offered enthusiastic support throughout the course of this work. Bjarne Amstrup helped with regular monitoring and verification for real time forecast from Harmonie-lite runs at DMI.

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Highlights of NWP activities at FMI

Erik Gregow, Anniina Korpinen, Ekaterina Kurzeneva, Laura Rontu*,
David Schönach and Pilvi Siljamo

1 Developments for operational forecasting

During 2018, the operational mesoscale NWP at FMI was based on HARMONIE-AROME configuration of the ALADIN-HIRLAM system (Bengtsson et al., 2017; Termonia et al., 2018). Four cycles of the MEPS ensemble predictions of ten members were run daily within the joint MetCoOp system by the Finnish (FMI), Norwegian (METNO) and Swedish (SMHI). HARMONIE cycle cy40h1.2 was used with the horizontal/vertical resolution of 2.5km/65L and the forecast lead time of 66h (Andrae et al., 2018). For the 1+9 ensemble members, perturbations are provided by time-lagged boundary fields together with limited sets of surface and initial perturbations (Andrae, 2017). The upper air analysis applied three-dimensional variational data assimilation while the surface analysis (CANARI) was based on optimal interpolation. Data for the horizontal boundary conditions were obtained from ECMWF.

1.1 MetCoOp-Nowcasting (MNWC) pre-operational model setup at FMI Erik Gregow and David Schönach

As part of the MetCoOp a new HARMONIE-AROME Nowcasting branch (MNWC-preop) has been set up. It is running since May 2018 at FMI supercomputer in a pre-operational manner (branches/MetCoOp/harmonNWC-40h1.2_preop). Different first-guess strategies have been tested and the selected setup is to use first-guess information (both surface and upper-air) from MEPS control member. MNWC-preop does produce 3D output of 15-minute interval, delivered within approximately 45 minutes, and soon there will be output-format in Grib2 available. Several other developments are on-going, as part of the MetCoOp nowcasting goals.

MNWC development: MSG cloud-ingest

FMI has continued to investigate the usage of cloud information (from NWCSAF, as reported earlier) to modify the HARMONIE-model initial-state of the humidity and thereby the 3D cloud-structures. The original method showed improved short-range cloud forecasts in the HIRLAM NWP system (Van der Veen, 2013). The method has been further developed together with colleagues from FMI, SMHI and KNMI and the aim is to introduce these changes into the MNWC-preop suite.

Initial experiments have been run on ECMWF supercomputer facilities, both using harmonie-38h1.2 and harmonie-40h1.1.1 model versions. Results from July 2016 have been validated and an article is under preparation. On top of that the MSG cloud-ingest code has been implemented in a MNWC-development version, which is running in parallel to the MNWC-preop. Continued (days to weeks) experiments show that the analyzed cloud pattern adopts to the situational cloudiness when using the MSG cloud-ingest (Figure 1 right),

*Corresponding author laura.rontu@fmi.fi

validated with satellite image (Figure 1 left). Compared with the original HARMONIE analysis (Figure 1 middle) clouds are added, for example in middle-west of Sweden, but clouds are also removed, as seen in southern Finland areas, and at the end the final cloud-cover analysis has been corrected.

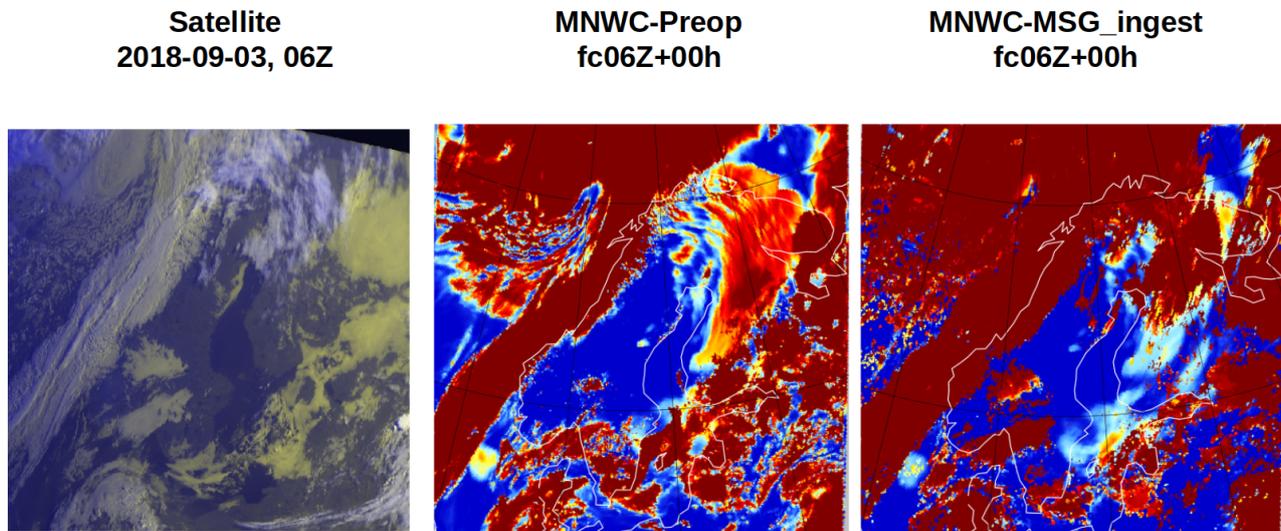


Figure 1: A comparison of cloud-cover for the 3rd of September 2018 at 06Z. Satellite image in left panel, MNWC-preop in middle and experimental run with MSG cloud-ingest in right panel

During 2018 the MSG cloud-ingest method was further developed and now there is a new version combining the NWCSAF cloud information with surface observations and a first-guess field from MEPS (control run). This new method make use of GridPP-system (optimal interpolation) and interpolates the observed cloud-base information to correct the first-guess cloud-base field from MEPS.

Apart from correcting the cloud information, this method also has an impact to the precipitation. So far the investigated summer-time precipitation cases have shown to be positive and the MSG cloud-ingest gives an extra “boost” to introduce convective precipitation. This will be further investigated and validated. There are some side-effects which are not positive, such as the too high (positive) bias in humidity for upper-air, when verifying against radio-soundings. There is only a small impact on the temperature but this does not significantly deviate from the operational MNWC results. Planned developments include a better technique to detect cloud-layers within the 3D-column while using the MSG cloud-ingest method and by that reducing the moisture bias.

Local Analysis and Prediction System (LAPS) at FMI

The operational analysis tool LAPS used at FMI has been running for many years and produces 3D-analysis of both upper-air and surface parameters in near real-time (Albers et al., 1996). FMI is now updating the software to newest LAPS version. A new domain (almost full MEPS-area) and new background-fields from MEPS (control runs) is being configured for this setup. The new LAPS updated analysis, with a horizontal resolution of 2,5 km in Lambert Conformal Conic (LCC) projection, is to become operational during Q1 2019.

1.2 Towards Harmonie between CANARI and SURFEX

Ekaterina Kurzeneva

Motivation

In the analysis fields of the Snow Water Equivalent (SWE) and deep soil temperature of the HARMONIE-AROME forecast and analysis system (Bengtsson et al., 2017), unrealistic features were noticed, first in the operational runs of FMI before it joined the MetCoOp cooperation (2016) and then in the MetCoOp operational and experimental runs. In the examples of SWE analysis (Fig. 2) and deep soil temperature (Fig. 3), the unrealistic features are associated with the coastal areas, both for the sea and lake coasts. The reasons for them might be complex.

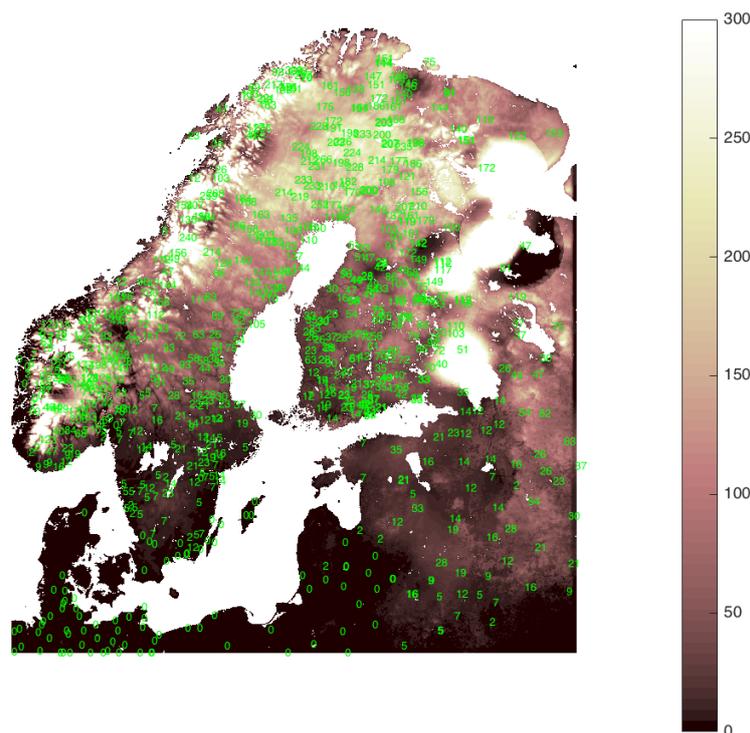


Figure 2: MetCoOp (cy40h1.1) operational SWE analysis field (the background color) and the SWE for the SYNOP stations calculated from the snow depth observations using the climatological values of the snow density (numbers in green), kgm^{-2} , for 19.02.2016, 06 UTC.

Currently, to reduce the problem in the operational snow analysis in the MetCoOp runs, some coastal stations are blacklisted. These are:

22525	RAZNAVOLOK	Russian station on the White sea coast, with wrong geographical coordinates, not captured by the quality control,
22805	VALAAM	Russian station, on the island in Lake Ladoga,
26226	KIHNU	Latvian station, on the island in Gulf of Riga,
02750	HANKO TVARMINNE	Finnish station, of the island in Gulf of Finland
02976	KOTKA RANKKI	Finnish station, on the coast of Gulf of Finland

The land surface analysis in Harmonie uses the CANARI software (Taillefer, 2002) to assimilate the land surface observations with the Optimal Interpolation (OI) method. According to the ALADIN/HIRLAM/LACE Rolling Work Plan, the general development of the land surface analysis with CANARI suggests using of the

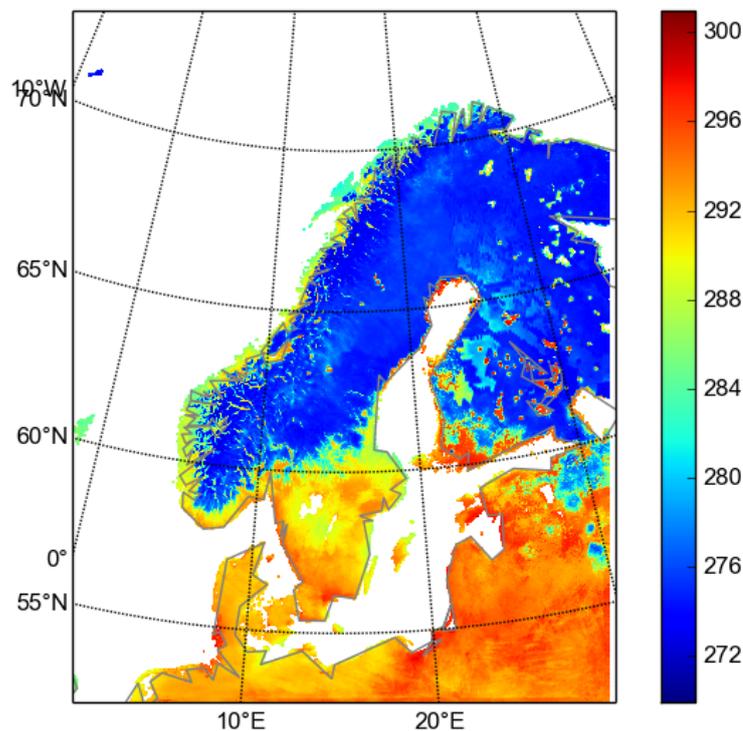


Figure 3: The deep soil temperature analysis field, K, in the research experiment of Harmonie cy40h1.1 over the MetCoOp domain, for 01.06.2016, 00 UTC. The experiment used the standard Harmonie configuration and started at 15.04.2016.

snow observations from remote sensing and the development of the analysis for lakes. Thus, understanding of the current problems, both technical and scientific, is needed.

Objective

Currently in FMI an action is ongoing to find the reasons of the problems in the land surface analysis and to understand better the perspectives of the development of the CANARI code.

Current status

CANARI performs the data assimilation procedure based on the multi-variate OI method. CANARI was originally developed for the upper air data assimilation, but currently it is used for the land surface analysis only. Thus, it contains much unused code. Only part of CANARI is the surface analysis. For the surface analysis, OI is uni-variate. CANARI is effectively parallelized.

In the Harmonie system, the main meteorological part of the CANARI code is located in the arpifs/canari directory. OI analysis is performed variable by variable and point by point. The global variables are declared in the modules located in the arpifs/module directory. The background fields are described in the arpifs/setup directory. The observation operators, including horizontal interpolation and calculation of post-processed variables are located in the arpifs/ob_ops and arpifs/pp_obs directories. Interpolations are located in arpifs/interpol and

aladin/interpol directories. Removing the obsolete code (for the the upper analysis) from CANARI is possible, although not easy.

CANARI uses ODB to work effectively with different types of observations. CANARI (as well as the upper air analysis) uses its own physiography (Pristov, 2002). This is the old physiography, which was used in the ALADIN consortium before the development and implementation of the externalized land surface model SURFEX (Masson et al., 2016) and ECOCLIMAP physiographic dataset (Faroux et al., 2013) and implementation. It has a coarse resolution (depending on the field) and is inconsistent with the SURFEX physiography, which is used in the forecasting part of Harmonie. CANARI does not support the tiling approach, which is used in SURFEX.

For the land surface observations, the observation operator in CANARI is based on the bi-linear interpolation (Yessad, 2018) and assumed to depend only on the grid geometry. It is not variable-specific: the T2m, RH2m and snow depth are always interpolated in the same way by the observation operator. CANARI does not provide an opportunity of using different interpolation methods for them. In the observation operator, CANARI uses only the land-sea mask (values 1 or 0). Although the land fraction field is available during the run, it is used mainly as a land-sea mask. Interpolation weights are first calculated depending on the distances but then modified according to the land-sea mask. For example, for the SYNOP observation, the weight of the influencing background grid-box value with the fraction of land less than 50% is set to zero. If all the influencing grid boxes have the land fraction less than 50%, all the weights should be zero and the observation should be rejected. However currently this is not implemented. The reasons are technical, to avoid a crash in calculation of the T2m and RH2m. Instead, weights remain unmodified in this case. For the snow analysis, this is a serious caveat, because over the pure sea/lake grid boxes, the background SWE value is always zero.

Possible reasons of the current problems

- Inconsistencies between the physiography of CANARI and SURFEX. This may lead also to problems in the quality control (and not recognizing the problem with the station Raznovolok).
- Observation operators in CANARI, which are dedicated mainly to the continuous fields (e.g. for the T2m field, but not for the SWE field). In the observation operator, CANARI uses the separation of observations based on the land-sea mask, sometimes with slight modifications. This separation is applied to all observation reports and in the same way for all observed meteorological variables. Interpolations are also variable-independent. Thus, the snow depth is treated in the same way as the T2m and RH2m. If around a land observation point there are only sea points in the background, the problem is just ignored. The number of SYNOP reports of this kind was calculated, to understand how serious the problem is. This was done by printing from `slint_canari.F90`. It was found that e. g. for the MetCoOpC domain for 15.12.2017, 03 UTC, there were 137 land reports (SYNOPs) for which all the influencing background grid boxes have the land fraction less than 50% and 10 water reports (SHIPs), for which all the influencing background grid boxes have the water fraction less than 50%. In other words, there are 137 meteorological stations over the sea and 10 ship observations over the land in this run. Instead of setting all the interpolation weights in the observation operator to zero for these reports (or rejecting them), CANARI leaves the weights unmodified. In principle, all these reports are potentially dangerous at least in the case of snow analysis.

Proposed steps for a quick solution of the observation operator problem

- To improve the weights of calculation as simple as possible, but still leave the weights for the very problematic stations unchanged. This will reduce the problem, but not solve it. Also, it will affect calculations of T2m and RH2m.

Proposed steps for the nearest future perspective

- To replace the CANARI physiography by the SURFEX physiography. For that, the technical solutions about file formats and data flow are needed.

For the medium-range perspective - implementation of the tiling approach in CANARI

- Theoretical understanding is needed. The experience from HIRLAM (span) may be used.
- Elaboration of the observation operators.
- Elaboration of quality control: to implement the first very rough checks depending on physiography.
- Cleaning of CANARI.

2 Research and experiments

2.1 Fine-resolution experiments over the coast of Gulf of Finland Anniina Korpinen

This study is a part of the Master thesis of Anniina Korpinen published at University of Helsinki, work done in Finnish Meteorological Institute. The subject of the thesis was to study simulated effects of boundary layer over the coastline of Southern Finland in spring 2015 by using NWP model HARMONIE-AROME (Bengtsson et al., 2017) with a horizontal resolution of 500 m. The main goal was to study the capability of HARMONIE to simulate the boundary layer over a heterogeneous surface in a realistic way.

The computational domain comprised 576 x 576 and studied area comprised 121 x 101 grid points. Data at the lateral boundaries were specified from analyses of the European Centre for Medium-range Weather Forecasts (ECMWF). The hindcasts were performed as a sequence of consecutive cycles initiated every six hours by combining near-surface observations and the analysis of ECMWF with a forecast from the previous cycle. Output from forecast hours one to six were used in the study, thus creating a continuous stream of output data with a temporal resolution of one hour.

A case study from 17 of May 2015 is presented where the sea breeze circulation phenomena was simulated. In Figure 4 is presented wind speed at the height of 100 m at 3, 9, 15 and 21 UTC. Strong wind breeze occurred at 9 o'clock directed from sea to inland where the wind speed was almost zero. Wind breeze from sea continued at the afternoon but by the evening the situation changed. In the sea breeze phenomena there is always backward flow at higher levels so there must also be vertical movement in the circulation. The vertical movements should be located in the area of the weakest wind speed over land. The vertical wind speed is depicted in Figure 5 which illustrates the development of convective cells during the day. At 3 o'clock both updraft and downdraft are weak and no convective behaviour is observed. But while strong wind breeze from sea is pushing air to inland also an area of strong convective cells was developing. Convective cells moved more inland during the day but by evening all vertical movement was near zero again.

This case study shows clearly a realistic behaviour of the boundary layer over the coastline: there is hardly any vertical movement over sea but in daytime an area of convective cells is developing over land. In this case study the sea breeze is acting as assumed, by advecting stronger wind over land and causing vertical movements when facing weaker winds on land. However, without good wind observations at several locations it is hard to tell how realistic the simulated magnitude of the sea breeze is. The horizontal wind speed seems realistic with a maximum of 8 ms^{-1} but the maximum vertical wind speed of 1.2 ms^{-1} seems quite strong. From the

simulations' point of view an important outcome was that the area of convective cells was developing in a realistic way.

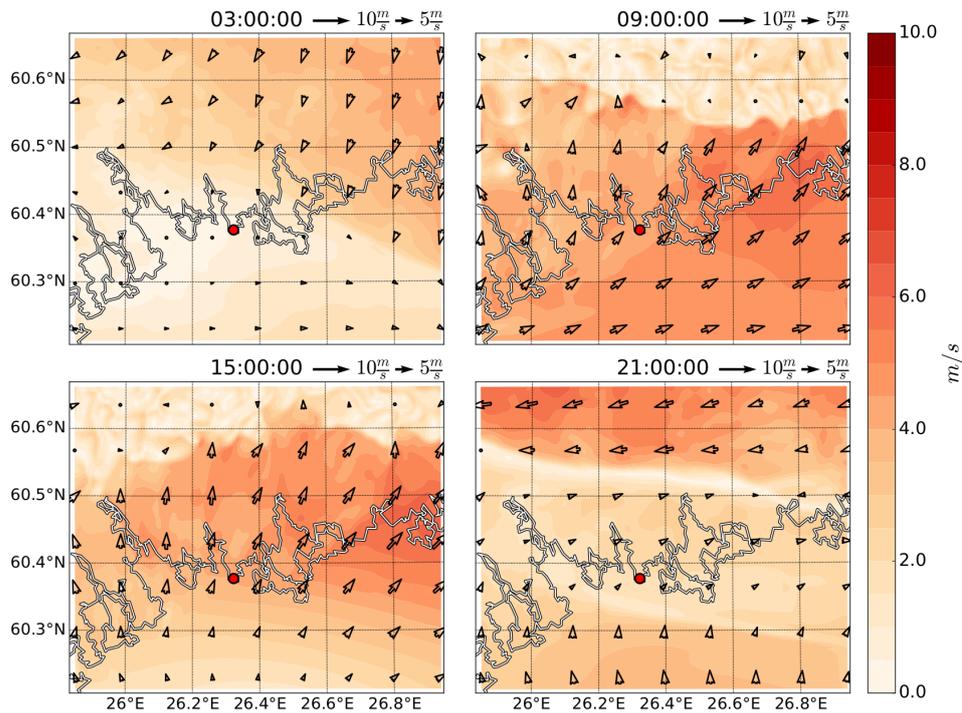


Figure 4: Wind speed at 100-m height at 3, 9, 15 and 21 UTC at 17.05.2015 in Southern Finland. Red dot represents the location of Loviisa nuclear power plant.

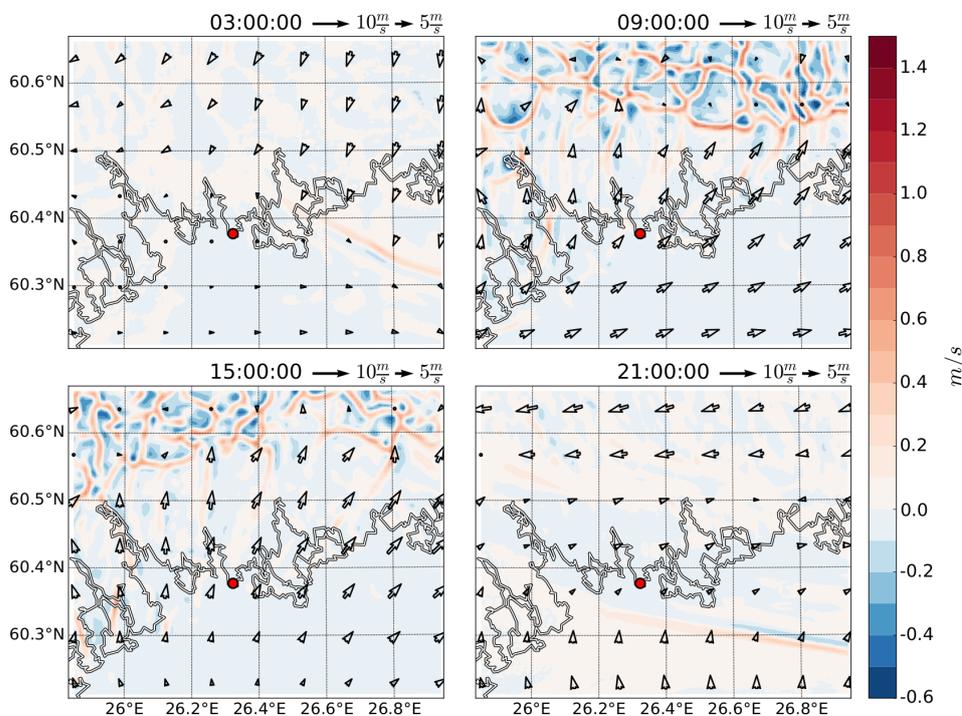


Figure 5: Vertical wind speed at 100-m height at 3, 9, 15 and 21 UTC at 17.05.2015 in Southern Finland. Red dot represents the location Loviisa nuclear power plant.

2.2 Radiation comparisons

Laura Rontu

Downwelling shortwave radiation at the surface (SWDS, global solar radiation flux), given by three different parametrization schemes was compared to observations in the HARMONIE–AROME NWP experiments over Finland in spring 2017 and reported by Rontu and Lindfors (2018). The schemes were the default IFS radiation scheme, ACRANEB2 and HLRADIA. The period March–April–May (MAM) 2017 over Finland was chosen for the model–observation intercomparison. Especially in May, the weather in Scandinavia was dominated by a cold Arctic airflow. Convective clouds formed over the land areas heated by the Sun and light snowfall was frequent until the end of May in Finland. Over the cold sea and lake areas, clear skies prevailed.

Global radiation (SWDS) fluxes due to three radiation schemes – IFSRADIA, ACRANEB and HLRADIA – showed similar results and the time series at observation stations agreed generally well with the measurements. Typically, +24h averaged model results were overestimated as compared to the daily mean observations. The relative difference was the largest when the flux was small. According to the hourly observations, the agreement between the model and observations was better than in the comparison of daily averages. A slight underestimation of SWDS, based on comparison of +3–+6 h HARMONIE forecasts to hourly observations, occurred only in very clear, clean cases. The cloud-related uncertainties influenced the results, perhaps affecting the shorter forecasts less than the longer ones.

Although systematic differences between the observed and predicted daily global radiation by the three schemes were found, all schemes showed up equally reliable. Local and temporal variations between the schemes and observations, related to cloudiness and cloud–radiation interactions were significant. Dedicated experiments should be set up to study whether these variations would give sufficient spread for an ensemble system, influencing the important output variables like solar energy potential or the near-surface weather characteristics.

Regular global radiation observations from the FMI solar radiation measurement network were used. A simple comparison of time series turned out to be useful for the model–observation comparisons. Inclusion of SWDS observations in the operational NWP verification system would allow systematic comparisons and application of more advanced verification scores on a regular basis.

2.3 NWP, atmospheric dispersion models and biological organisms

Pilvi Siljamo

The SAPID project of the Academy of Finland develops a warning system for pest insects and plant pathogens using atmospheric models (i.e. numerical weather prediction models (NWP) and atmospheric dispersion models (ADM)) in regional and continental scales. Timely warning system could help to time precautions and especially when using biological control agents. This would save both costs and the environment.

Pest insect problems caused by migratory pests are occasional, but they may cause locally severe damages. Especially bird cherry-oat aphid (*Rhopalosiphum padi*) is important migrative species in Finland and also the most important cereal pest insect in Finland. The loss of yield can be as high as 20-30%. It acts also as a vector for Barley Yellow Dwarf Virus (BYVD).

Alternaria species are known as major plant pathogens. At least 20% of agricultural spoilage is caused by *Alternaria* spores and the most severe losses may reach up to 80% of yield. *Alternaria* is also common allergens in humans.

Both pest and spore forecasts are based on the SILAM pollen forecasting system (Siljamo et al., 2013; Sofiev et al., 2013). A key tool is the SILAM atmospheric dispersion model (Sofiev et al., 2015), which includes both Lagrangian and Eulerian advection/diffusion formulations and wet and dry depositions. Spores transport in the air like small particles, but also small insects - like aphids - are quite involuntary in the air (Chapman et al., 2012). So far we have used ECMWF's IFS as a source of meteorological information, but SILAM could use HIRLAM and many other NWP data as well.

The SILAM ADM for biological organisms includes habitat maps for host plants as well as maps of emission/uplift parameters, e.g., temperature sums, which control the start of the insects' uplift. These together with the emission model in SILAM constitute spore emissions/insects' uplift. After emissions/uplift, the pests transport and spores disperse in the air and removal processes remove them from the atmosphere. As a result, the model gives spore concentrations in the air (Figure 6) or a risk for pests.

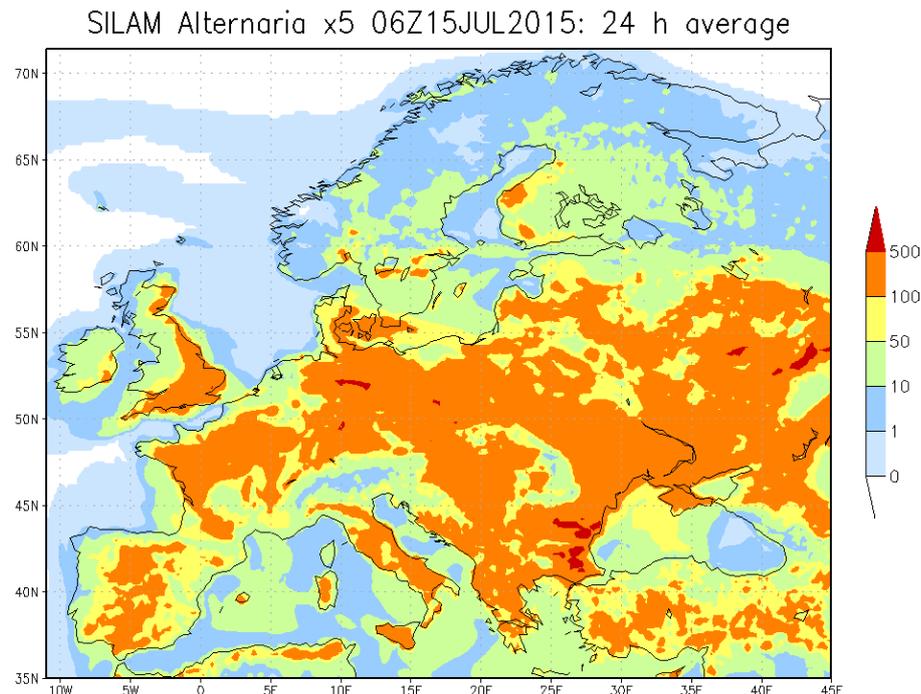


Figure 6: An example of the SILAM *Alternaria* spore concentrations ($\#m^{-3}$) in Europe for July 15, 2015.

Cumulative temperature sum is important for insect's uplift and thus unbiased 2m temperature (T2m) is essential for successful migration warnings. In case of *Alternaria* spores, calendar dates are used for the start of emissions, but T2m is still important for the intensity of spore emissions. Other important weather parameters for the intensity of emissions/uplift are relative humidity, rain and wind speed. Naturally, 4D-flow field in a NWP model plays a key role in timing and dispersion pattern.

Despite many simplifications, the SILAM pest model can simulate aphid's migration to Finland well. *Alternaria* spore forecast are more challenging in Finland, because concentrations used to be low, but the forecasts are more successful e.g., in the UK, where concentrations are higher and thus not that sensitive to random effects like human behavior (harvesting).

Acknowledgements:

Fig. 2 is by courtesy of M. Quenon. The experiment for Fig. 2 was arranged by P. Samuelsson. Thanks to C. Fortelius for useful discussions concerning Section 1.2.

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Towards an operational implementation of a snow analysis in AROME-France

Camille Birman, Claude Fischer

1 Introduction

Snow analysis has been identified as an important, missing feature of the AROME-France operational system since quite a few years. Since 2017, efforts have resumed in order to assess the impact and the detailed tuning of a snow analysis scheme, based on the existing codes in CANARI. This article provides a brief overview of recent results, along with the plans towards an e-suite testing in 2019.

2 Incentive and results from 2018 winter cases

The implementation of a snow analysis scheme in AROME is triggered both by the possibility to provide an operational snow analysis product to Operations and by the ability to correct a snow-related quantity from background to analysis within the data assimilation process. The main snow-related quantity considered here is the snow cover expressed as a surface-averaged water equivalent content (SWE), in $\text{kg}\cdot\text{m}^{-2}$. The analysis step uses observations of snow height from the French surface stations which are converted into SWE using the snow density information from the model. The calculation of the analysis increment is performed using the CANARI 2D Optimal Interpolation code (routine CASNAS). The SWE field can routinely be written out to FA file and be post-processed. In addition, the SWE increment is passed to SURFEX in order to update the soil variables that are impacted by the presence of snow and for use in the surface budget calculations.

One expected beneficial impact of the snow analysis implementation is to correct AROME for insufficient snow melt over plains. This model error leads to too long lasting snow coverage in AROME-France, a model deficiency that is problematic in winter when AROME outputs are being fed into downstream products of winter-type hazards and alerts. It also is a serious source of deterioration of 2 metre fields. AROME-France outputs might occasionally indicate snow cover when actually all snow already had melt away days before. Figure 1 provides an illustration of the impact of the snow analysis on the field of SWE for a February case in 2018. SWE in the snow analysis experiment is significantly reduced over many flat areas in the Northern half of France, as well as wide areas in Germany and in Central England.

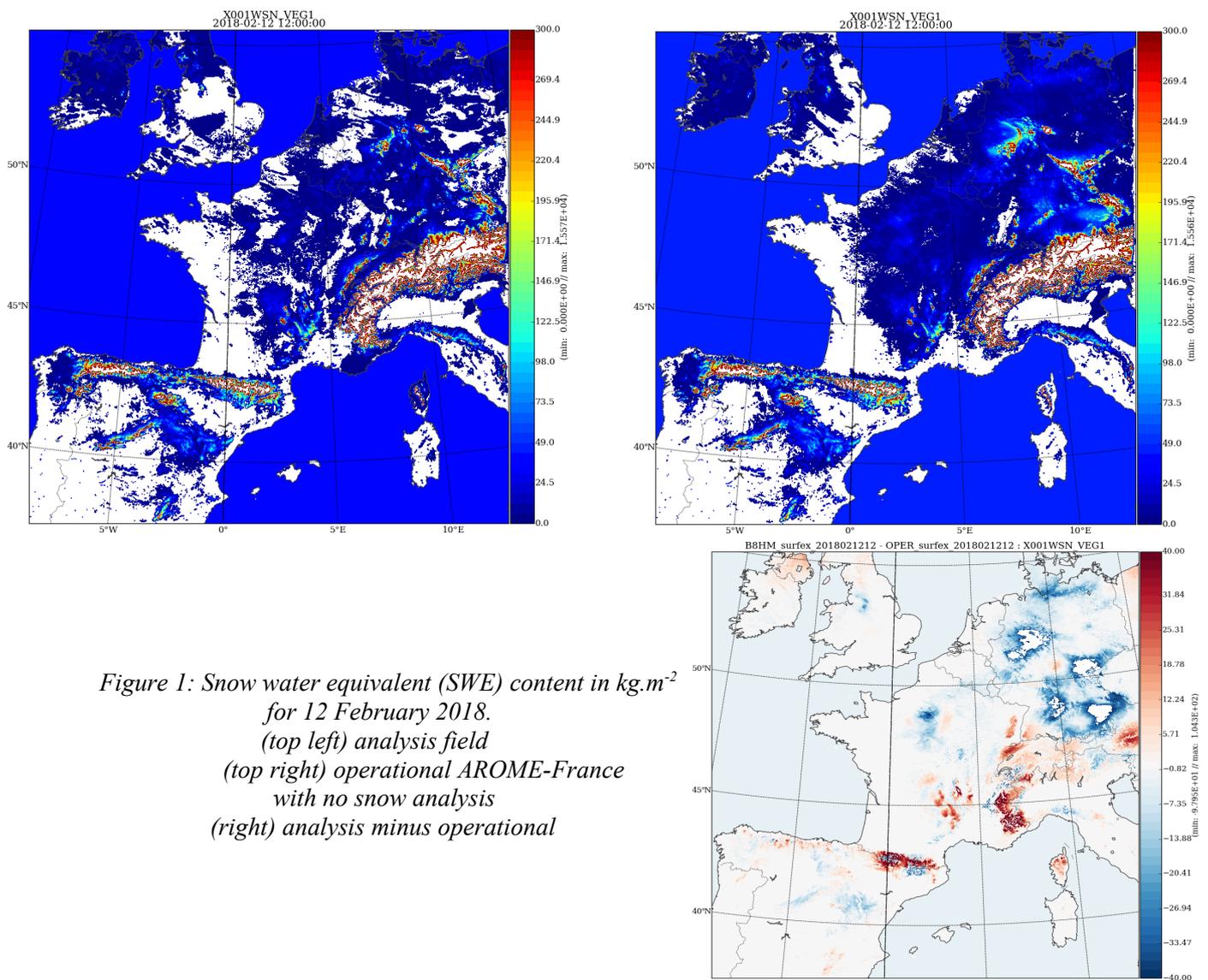


Figure 1: Snow water equivalent (SWE) content in kg.m^2 for 12 February 2018.
 (top left) analysis field
 (top right) operational AROME-France with no snow analysis
 (right) analysis minus operational

3 Next steps, towards an operational use

Ongoing and future work will address the following aspects:

- tuning of the background and observational standard deviations, as well as of the correlation length scales of the structure functions
- activate the snow analysis in the global model ARPEGE
- integrate the snow analysis facility within the other ingredients of the 2019 AROME e-suite definition. This e-suite is scheduled to be handed over to Operations between June and September 2019, for an operational switch probably in the very first months of 2020. It is open for the time being whether it also can be implemented in ARPEGE in 2019, or only later.
- use of satellite products of snow cover

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Modelling Activities at the Hungarian Meteorological Service

Mihály Szűcs, Viktória Homonnai, Dávid Lancz, Máté Mester, Jávorné Radnóczy Katalin,
Réka Suga, Balázs Szintai, Anikó Várkonyi
Hungarian Meteorological Service (OMSZ)

1 Introduction

This short paper describes the current status and recent changes of the operational model runs at the Hungarian Meteorological Service. Additionally a SURFEX related research activity is highlighted which aims to give a better simulation of vegetation properties by assimilating satellite data.

2 Operational overview

Operational suite

Table 1: Operational model configurations at OMSZ. The changes from 2018 are highlighted

	AROME	ALADIN	ALADIN-EPS (11 members)
Resolution	2.5 km	8 km	8km
Levels	60	49	49
Number of points	500x320	360x320	360x320
Cycle	CY40	CY38	CY38
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, GNSS-ZTD)	6 hourly (SYNOP, TEMP, AMDAR, SEVIRI, AMV, ATOVS)	-
Supervision	SMS	SMS	SMS

In 2018 there were two upgrade in our operational model configurations, both related to the AROME suite.

First one was realized on 5th of September and contained two things. The first one is that finally cy38 was introduced. The second one is that the assimilation of GNSS-ZTD data was operationally implemented. This data type had been investigated for a long-time and its positive impact was already reported in the last year's ALADIN-HIRLAM Newsletter (Szűcs et. al., 2018). Basically GNSS-ZTD is retrieved from three networks via E-GVAP: Polish (WUEL) is the most reliable while Hungarian (SGO1) and Czech (GOP1) sometimes faces with data unavailability. In June-July there were a longer parallel run dedicated to these changes when forecasters and developers were able to monitor their impact.

The second operation change (11th of October) was quite big but rather technical. Previously AROME was supervised via a robust script system which maintenance became harder and harder with the growing number of assimilated data and the requested user products. This script system has been revised and migrated under SMS (which has been already done for ALADIN and ALADIN-EPS long ago). As a result the operational system became easier to supervise and maintain.

New supercomputer

In the previous years the main bottleneck of a major upgrade in our operational system was the limited computer resource. At the beginning of 2018 a new SGI supercomputer was delivered to OMSZ which is used mainly to run climate projections. Meanwhile OMSZ got as an extra duty to support a national hail prevention system with short-term forecasts. To satisfy this request an enlargement of the new supercomputer has been also arrived which contains 800 extra cores.

At the end of 2018 the migration to this new somputer has been started. In very-short-term it will modify our ALADIN configuration because together with the migration a cycle switch (from 38 to 40) and a physics upgrade (to ALARO-1vB) are planned.



Figure 1: New supercomputer at OMSZ.

Of course in the future we hope that the new machine will help us not just run our current suite faster and more reliable but it will make possible to operationally introduce some resource dependent developments. The most remarkable of them is AROME-EPS.

3 Simulation and Assimilation of vegetation properties with SURFEX

OMSZ has been involved in the simulation and assimilation of vegetation properties since 2008. During two EU-funded projects (Geoland2 and ImagineS) a Land Data Assimilation System (LDAS) was applied to monitor the above-ground biomass, surface fluxes (carbon and water) and the associated root-zone soil moisture at the regional scale (spatial resolution of 8km x 8km) in quasi real time. In this system the Surfex model is used (in offline mode), which applies the ISBA-A-gs photosynthesis scheme to describe the evolution of vegetation. An Extended Kalman Filter (EKF) method is used to assimilate Leaf Area Index (LAI, from SPOT/Vegetation and Proba-V) and Soil Wetness Index (SWI, from ASCAT/Metop) satellite measurements. Simulations were compared to observations (LAI and soil moisture satellite measurements) over the whole country and also at a selected site in West Hungary (Hegyhátsál), results show that the LDAS system is capable to simulate the evolution of vegetation with an acceptable accuracy (Tóth et al., 2016).

In current state-of-the-art NWP models LAI is considered as an external parameter where monthly values are derived from long-term averages. Such an approach is not capable of describing vegetation anomalies e.g. during severe droughts, when LAI values (especially over non-irrigated grasslands and croplands) could be considerably lower than long-year averages of the selected month. A solution for this inaccuracy could be to implement satellite observed vegetation parameters in the NWP model. The main difficulty with such an approach is that high resolution (e.g. that of Proba-V) satellite vegetation products have a time lag of 10 days. To overcome this the following is planned: satellite vegetation observations are assimilated in the offline land data assimilation system (ImagineS system) which is capable to deliver a soil and vegetation state analysis 10 days prior the actual date (T-10d). From T-10d we integrate the offline surface model with prognostic vegetation until the current date; and the resulting vegetation state (at time T) could be merged with the operational analyses of AROME (Fig. 1).

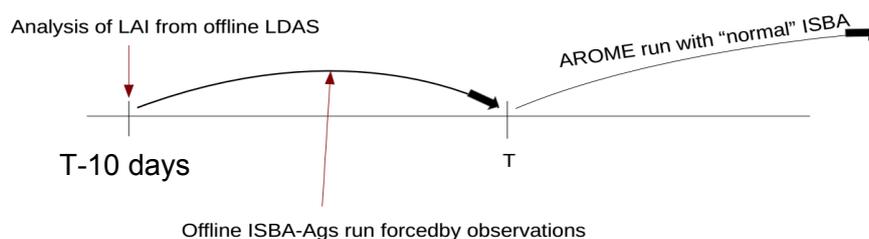


Figure 2: Schematic of the planned system to implement a daily updated LAI in the operational AROME model.

The development work on this daily updated LAI started recently at OMSZ. First, the LDAS system based on ISBA-A-gs had to be updated to run on the AROME grid at 2.5 km resolution (formerly it was running on a much smaller 8x8 km regular lat/lon grid). Then a first case study was investigated. The selected time interval was February until May 2018. This period was characterized by a wet and cold March followed by dry and very hot April and May. This resulted in a very quick growth of the vegetation during April and May, producing LAI values well above the long term mean (Fig. 2).

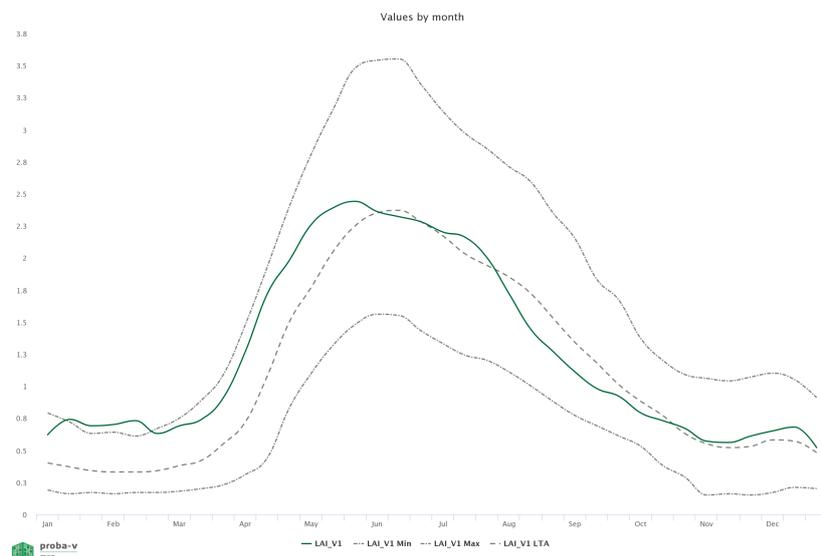


Figure 3: Yearly evolution of the observed Leaf Area Index (LAI) over non-irrigated croplands in Hungary. Data derived from the Proba-V satellite (visualization with Proba-V MEP). Grey lines: minimum, maximum and mean over the period 1999-2013; green line: year 2018.

Surfex offline was first run in “open loop” mode, i.e. without data assimilation using atmospheric forcings derived from AROME forecasts. The run was started in February using climatological LAI values and then vegetation was computed prognostically until the end of May. Results are shown on Fig. 3. Over non-irrigated croplands (mainly the middle and Eastern part of Hungary) ISBA-A-gs gives higher LAI values than the climatology file, which is realistic for the selected period. For areas covered with forests (mainly the North-Eastern part of Hungary and the Carpathian mountains) LAI values from ISBA-A-gs are considerably lower than in the climatology. This behaviour is rather unrealistic as confirmed by observations (not shown).

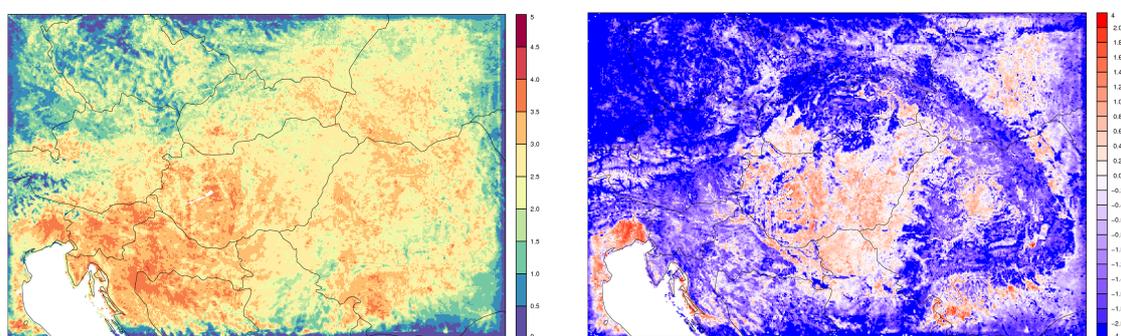


Figure 4: LAI values on 30 May 2018 computed by the Open-loop run of Surfex ISBA-A-gs (left) and the difference from the LAI from the climatology file (right; red colours indicate when ISBA-A-gs values are larger than climatology).

In near future the following steps are planned with the aim of introducing a daily updated LAI in the operational AROME model at OMSZ: (1) assimilating LAI and SWI satellite observations in Surfex offline (as was done in the ImagineS project); (2) using atmospheric forcings in Surfex offline

computed from interpolated measurements (synop and Radar); (3) running longer time periods with AROME with the daily updated LAI obtained from Surfex offline.

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Met Éireann Updates

Colm Clancy, Conor Daly, Rónán Darcy, Emily Gleeson, Alan Hally, Eoin Whelan

1 Introduction

Significant upgrades were made to the operational NWP suite at Met Éireann during 2018. Cycle 37h1.1 of HARMONIE-AROME had been in use since 2013. On the 1st of May 2018, Cycle 40h1 was made operational. This upgrade is detailed in Section 2. On the 15th of October, the new short-range high-resolution Irish Regional Ensemble Prediction System (IREPS) was implemented. Details are given in Section 3. ASCAT wind observations were added to the operational data assimilation. This is described in Section 4, while in Section 5 we discuss some of the new post-processing systems in use.

A new initiative in 2018 was the introduction of regular meetings between the model developers and the operational forecasters for the purposes of discussion and feedback on the performance of the HARMONIE-AROME model. This has proved successful and beneficial, and is discussed in more detail in Section 6.

Finally, an update on the Met Éireann Reanalysis project, MÉRA, is provided in Section 7.

2 Upgrade to Cycle 40

The HARMONIE-AROME configuration of the shared ALADIN-HIRLAM NWP system, hereafter HARMONIE-AROME, is the primary model used at Met Éireann for operational short-range forecasting and additionally as a research tool. Work on upgrading from cycle 37h1.1 to 40h1 began in 2017 and the new cycle was made operational for the 1200 UTC forecast on the 1st of May 2018. The major changes with the upgrade include the use of an enlarged domain (see Figure 1) and the introduction of 3D-Var data assimilation with 3-hour cycling. The background error covariances (structure functions) were estimated using downscaled IFS EDA forecasts and only conventional observations are assimilated. Table 1 outlines the changes in the new Met Éireann operational suite.

Table 1: HARMONIE-AROME operational configurations

	Previous 37h1.1	New 40h1.1
Horizontal domain	540×500, 2.5 km grid	1000×900, 2.5 km grid
Vertical levels	65 levels, 12 m up to 10 hPa	65 levels, 12 m up to 10 hPa
Timestep	60 s	75 s
Observations	SYNOP	SYNOP, SHIP, AIREP, BUOY & TEMP
Cut-off	45 min	45 min
Data assimilation	Surface OI analysis	Surface OI & 3D-Var
Forecast	54 hour forecasts at 0000, 0600, 1200, 1800 UTC	54 hour forecasts at 0000, 0600, 1200, 1800 UTC;
Boundaries	IFS	IFS

Figure 2 shows verification scores for a month-long period during the initial testing phase using cycle 40h1 with its default settings. This showed promising improvements in wind-speed forecasts (left). However, a significant

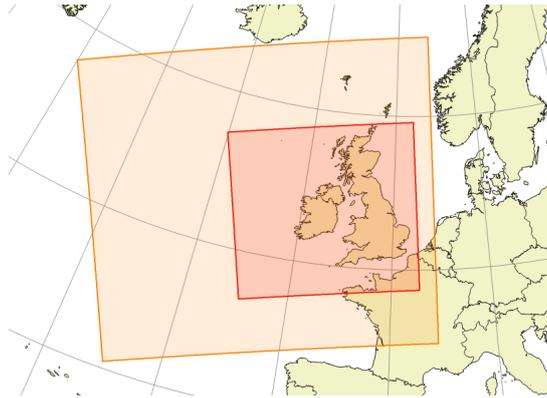


Figure 1: Previous operational (red) and new enlarged domain orange).

cold bias was noted in the 2 m temperatures (right), particularly during the night.

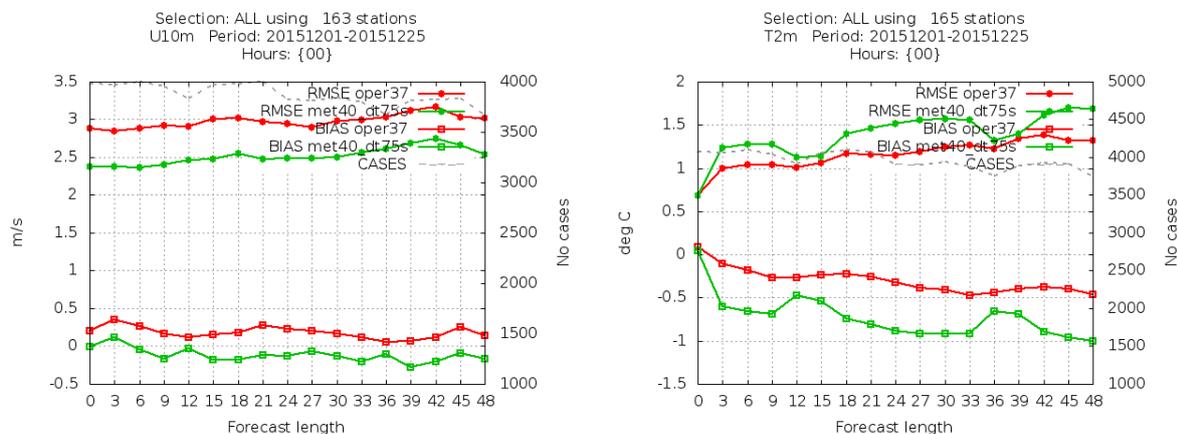


Figure 2: Point verification for December 2015 forecasts during the initial test phase of cycle 40h1.1, comparing the operational cycle 37h1.1 (oper37, red) and cycle 40h1.1 with default settings (met40_dt75, green) for 10 m wind-speed (left) and 2 m temperature (right).

Extensive testing was carried out in an attempt to improve the performance of the near-surface temperature forecasts. Eventually we found that the cold bias could be reduced by switching off the HARATU turbulence scheme and adjusting the temperature increment (ZTINER) in the surface analysis. Unfortunately, this then led to a degradation in 10 m wind forecasts. Further changes related to surface drag were needed in order to compensate. The changes made to create our ‘optimal’ pre-operational configuration are described in Table 2. Full details and results from the testing may be found in the Technical Note of Clancy et al., 2018.

Month-long tests on the new domain with 3D-Var data assimilation were then carried out. Five months in 2014 were chosen: February, April, June, September and November. Verification scores for the five months combined are shown in Figure 3. In addition to long-term statistics such as these, a number of case studies were examined. Again, full details are available in the Clancy et al., 2018. In general, the testing showed neutral to slightly better results from the cycle 40 configuration.

3 Operational Implementation of IREPS

At 1200 UTC on the 15th of October 2018, Met Éireann implemented the Irish Regional Ensemble Prediction System (IREPS), Met Éireann’s short-range high-resolution ensemble prediction system (EPS). IREPS is based

Table 2: Changes made to default cycle 40h1.1 for pre-operational testing

Change	Affected file	Description
HARATU=no	sms/config_exp.h	Turbulence scheme, i.e. use default instead of HARATU
ZTINER=2.0	src/surfex/ASSIM/oi_cacsts.F90	Temperature increment in surface analysis
ZH ← ZLAI/4 for grassland	src/surfex/SURFEX/z0v_from_lai.F90	Increased drag from grassland by increasing height ZH (default is ZLAI/6)
XCDRAG=0.05	nam/surfex_namelist.pm	Canopy drag coefficient (value used in oper37)

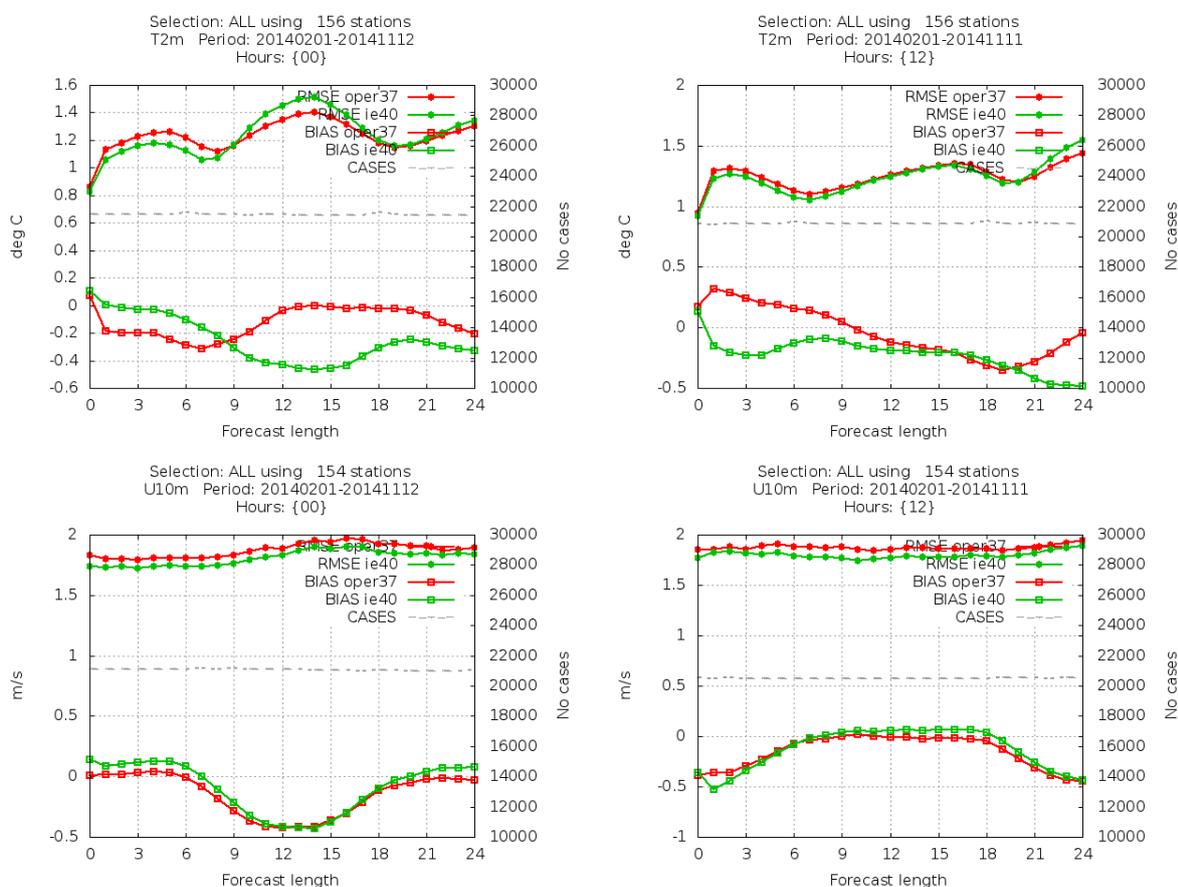


Figure 3: Point verification of 0000 UTC (left) and 1200 UTC (right) forecasts for all month-long tests combined, comparing the operational cycle 37h1.1 (oper37, red) and the new cycle 40 configuration (ie40, green). Parameters shown are 2 m temperature (top row) and 10 m wind-speed (bottom row).

on the MetCoOp setup of the HARMONIE-AROME-EPS branch of cycle 40h1.1. See Section 2 for details, and in particular Table 2 for local changes from the default configuration.

IREPS is composed of 10 perturbed members plus one control member and is run twice daily at 0000 UTC and 1200 UTC with a forecast length of 36 hours. The EPS members are constructed using the scaled lagged average forecasting (SLAF) method. This method uses Integrated Forecasting System (IFS) forecasts from previous runs, valid at the initialisation time, to provide initial and boundary conditions. The forecasts are

tuned using a coefficient or scaling factor, with the size of the coefficient dependent on the age of the forecasts with respect to the initialisation time. More details can be found in Ebisuzaki and Kalnay, 1991. Perturbations are also applied to a number of surface parameters including sea surface temperature, the temperatures of the top two soil layers, surface moisture, vegetation fraction, leaf area index, soil thermal coefficient, roughness length over land, fluxes over the sea, albedo and snow depth. The perturbation strategy follows the method outlined in Bouttier et al., 2015.

Objective verification of IREPS versus the IFS ensemble (IFSSENS) demonstrates the increased skill in the high-resolution limited-area-model EPS (IREPS) compared to the coarser resolution global EPS. Examples of this can be seen in Figure 4. The spread/skill ratios for 10 m wind speed and 2 m relative humidity are significantly improved. IFSSENS continues to have an advantage in terms of MSLP for forecast lengths greater than 18 hours, but this is not an unexpected result as global EPSs generally capture larger-scale structures more accurately.

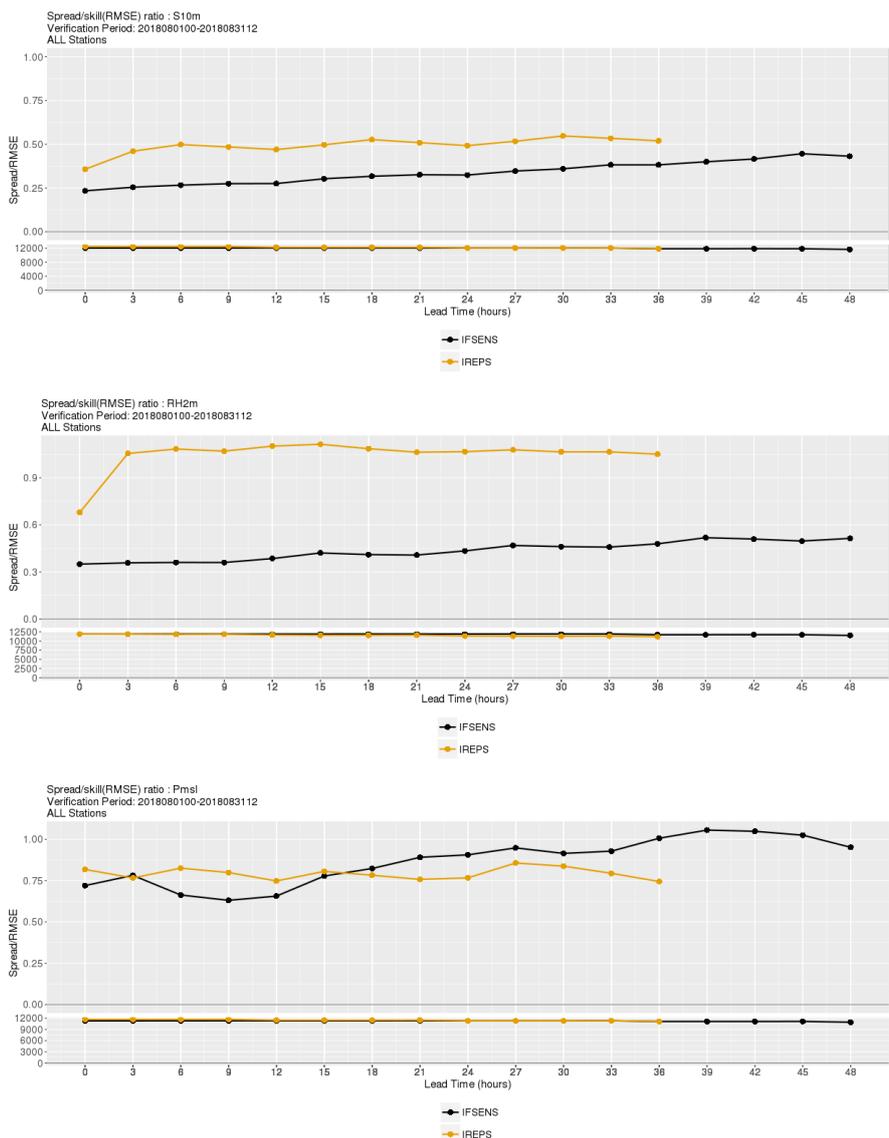


Figure 4: Spread-skill ratios for August 2018 for IREPS (orange) and IFSSENS (black) for 10 m wind speed, 2 m relative humidity and Mean-Sea-Level-Pressure (MSLP).

Since IREPS became operational, and even during its pre-operational phase, it has been an important tool for forecasters at Met Éireann especially during high-impact weather events. One example of its usage was during the first significant wind storm of the 2018/2019 season, Storm Ali, which occurred on the 19th of September

2018.

4 Assimilation of ASCAT winds

The assimilation of ASCAT wind observations from the Metop-A and Metop-B satellites was evaluated for the Irish domain. Typical data coverage plots for ASCAT observations are shown in Figure 5. A three-week period in April 2018 was used to validate the usefulness of these observations. No changes were made to the default settings relating to the assimilation of these observations.

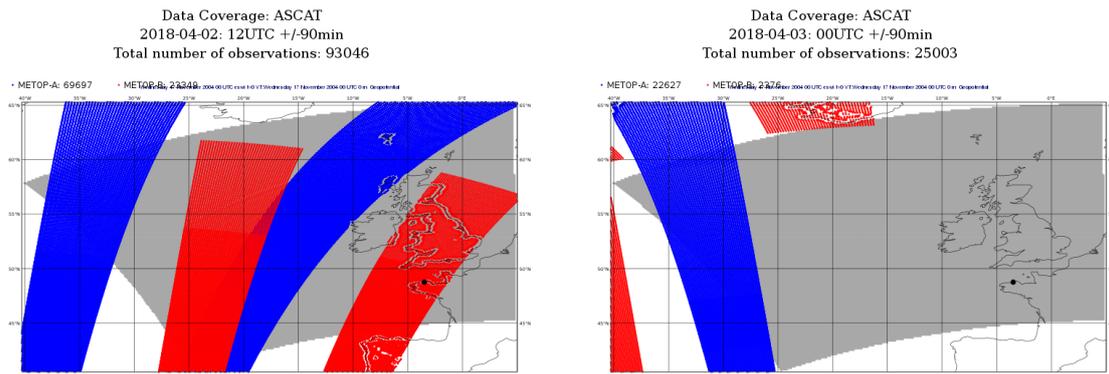


Figure 5: ASCAT data coverage for 1200 UTC April 2nd 2018 (left) and 0000 UTC April 3rd right. The operational HARMONIE-AROME domain is shown in dark grey.

Forecasts produced (April 1st - April 19th) at 0000 UTC and 1200 UTC each day were verified against SYNOP and TEMP observations. Verification scores (mean bias and RMSE) for the period indicated a neutral impact on forecast quality when averaged over the test period. Figure 6 shows average scores for forecasts of MSLP compared with SYNOP observations and forecasts of geopotential compared with 1200 UTC TEMP observations.

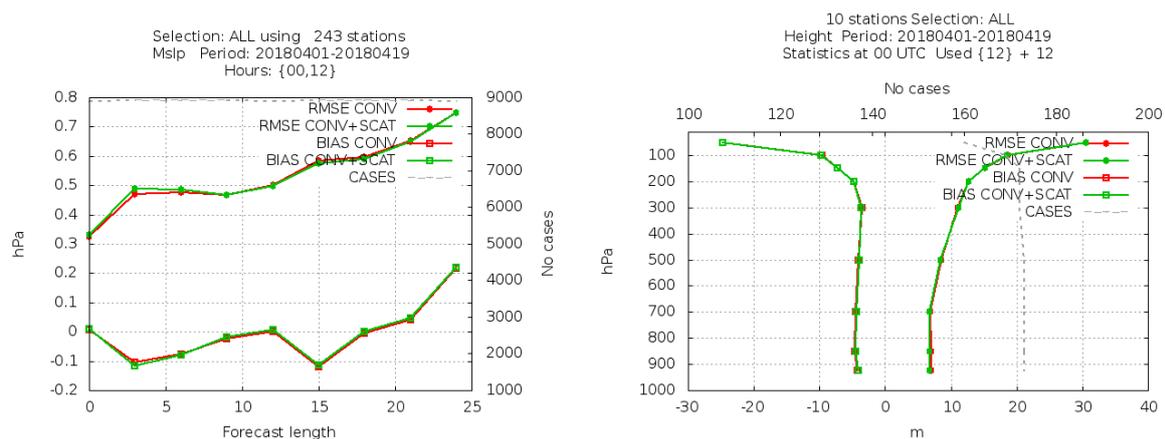


Figure 6: Verification scores comparing conventional only (CONV, red) and conventional plus ASCAT (CONV+SCAT, green) experiments. MSLP forecasts from both experiment (left) are verified against SYNOP (no SHIP) observations. Forecasts of geopotential (right) are verified against TEMP (land only) observations.

The relative usefulness of ASCAT observations was further evaluated using the moist total energy norm approach, MTEN, as described in Stort & Randriamampianina, 2010. Data denial experiments were executed for two typical cycles (20180402 1200 UTC and 20180404 0000 UTC). The forecast sensitivity to the assimilation

of different observation types (SYNOP including SHIP, AIREP, BUOY, TEMP and SCATT) is measured using the MTEN norm. Assuming forecasts produced by the control with all observations assimilated, MTEN values provide a measure of the negative impact of the denial of each observation type. For 1200 UTC (Figure 7 left) MTEN values suggest that ASCAT observations are as important as AIREP observations. For 0000 UTC, with fewer ASCAT (and AIREP) observations, forecasts are less sensitive to the denial of these observations. The assimilation of ASCAT observations was implemented operationally with the introduction of IREPS.

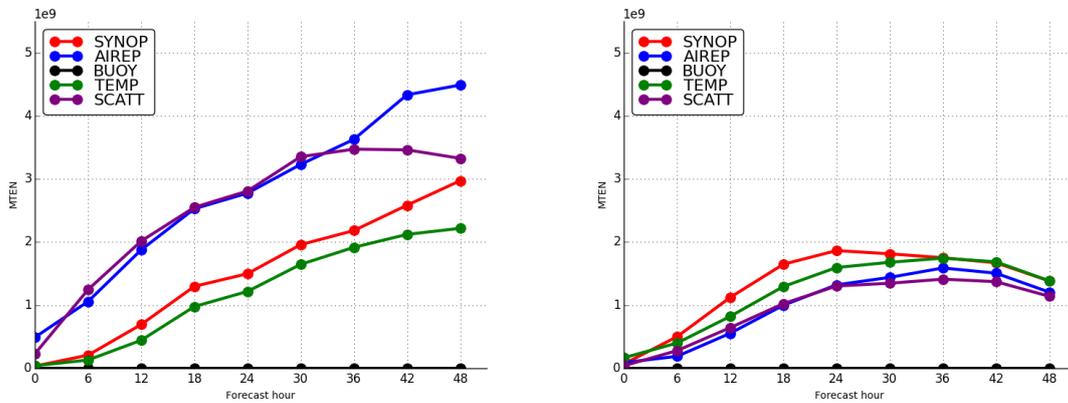


Figure 7: MTEN for forecasts based on data denial experiments for 20180402 1200 UTC (left) and 20180403 0000 UTC (right). SYNOP (red) indicates SYNOP observations have not been assimilated, AIREP (blue) and so on.

5 Postprocessing

Postprocessing of 2 m air temperature is done by downscaling the HARMONIE-AROME data to a 500 m grid with orographic correction from HARMONIE-AROME orography to a 60 m DEM over the island of Ireland. Further adjustment is then done by use of a Kalman filter on observed temperatures followed by kriging with a 30 km influence radius. These data are made available for verification with some measure of success seen. Figure 8 shows the effect of Kalman filtering on points which contributed to the adjustment (right) and the effect of orographic correction on points which did not contribute to the Kalman filter (left).

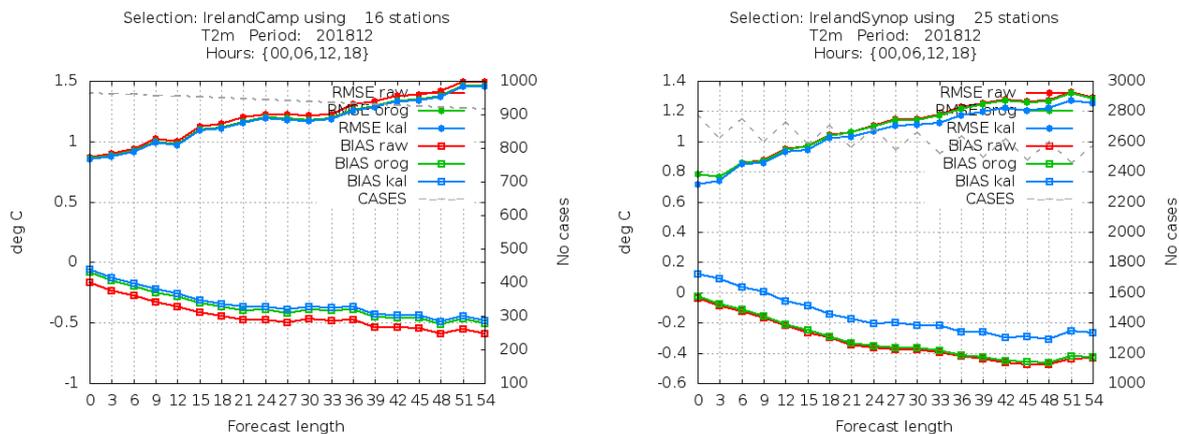


Figure 8: Point verification of orographic correction (left) and Kalman filtering (right). Parameter shown is 2 m temperature. Raw forecast is shown in red, orographic correction in green and Kalman filter in blue.

Rainfall is upscaled by statistical analysis of a 7x7 gridbox producing 20, 50 and 80th percentile figures.

Postprocessed data is used to drive a point forecast system accessible at <https://www.met.ie>.

6 NWP developer/user Working Group at Met Éireann.

In March 2018 we held a workshop to exchange knowledge and enhance communication between users and developers of NWP at Met Éireann. Since then we have held monthly meetings which involve discussions on successful and unsuccessful HARMONIE-AROME forecasts, known issues in the model, model evaluation and verification, what is required to make a model operational, physical parametrizations, the IREPS ensemble and many other topics. Feedback from NWP users (i.e. forecasters at Met Éireann) has been very positive and overall the meetings have vastly improved the flow of information and feedback between the two groups.

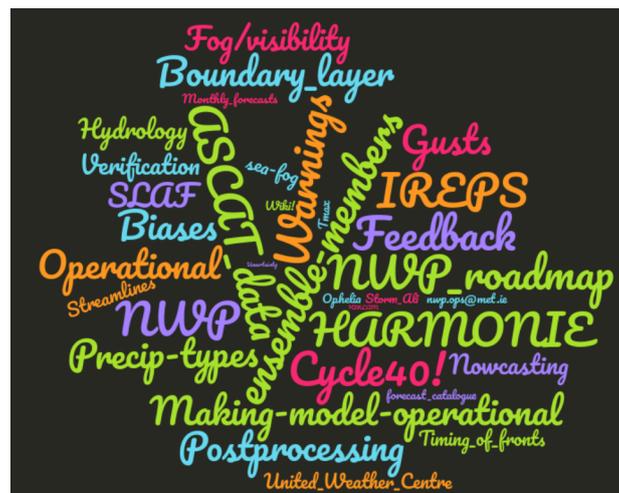


Figure 9: Some of the topics discussed at the NWP user/developer monthly meetings at Met Éireann!

7 MÉRA - Met Éireann Reanalysis

The production of the Met Éireann regional reanalysis (MÉRA, Whelan et al., 2018) is still ongoing. We currently have output spanning 1981 to February 2018. MÉRA production will cease later in 2019 when ERA5 supercedes ERA-Interim and ECMWF stop the production of ERA-Interim.

A successful workshop for users and stakeholders of the MÉRA dataset was held in May 2018 (<https://www.met.ie/science/events/mera-workshop>) and consisted of 15 talks on topics ranging from wind/solar energy to potato and tomato blight to air quality monitoring. The workshop attracted speakers from Canada, the UK and the Netherlands. Extended abstracts have been published in Gleeson and Whelan, 2018. A second workshop will be held on May 2nd 2019.

An analysis of the global radiation outputs from MÉRA is included in Nielsen and Gleeson, 2018 and an analysis of extremes of winds and precipitation is presented in Whelan et al., 2018. There are currently over 200 known users of the dataset across Europe and North America. Some preparations will be made this year regarding the production of an updated reanalysis for Ireland. Ideas include the use of ERA-5 boundaries, improved use of observations similar to the CARRA (Copernicus Arctic Regional Re-Analysis) project, coupling to ocean and wave models, a greater focus on surface processes.



Figure 10: First MÉRA Workshop held in May 2018.

8 Summary and Outlook

The past year has seen many operational NWP developments that have put Met Éireann in a better position to provide the best short-range forecasts of high impact weather for the Ireland. The use of 3D-Var and the assimilation of non-conventional observations coupled with the implementation of a high resolution EPS would not have been possible without the scientific and technical developments undertaken by HIRLAM-C, ALADIN and Météo France. Met Éireann's operational NWP capabilities will be enhanced further with future collaboration and cooperation. In 2018 Met Éireann signed a memorandum of understanding, along with 9 other European countries, regarding joining forces for operational weather forecasting. The new collaboration is known as United Weather Centres (UWC). Ireland will initially join Denmark, Iceland and the Netherlands to form UWC-West in 2022 and will merge with UWC-East (MetCoOp, Estonia, Latvia and Lithuania) in 2027. Further information on UWC is available in the following article by Dick Blaauboer and Jørn Kristiansen: <https://www.emetsoc.org/uwc-short-range-weather-forecasts/>.

A minor suite upgrade is planned in spring 2019. There will be an update to IREPS to introduce initial condition perturbations using the PertAna approach. This approach involves adding perturbations to the analysis of each ensemble member. The assimilation of AMSU-A, MHS and IASI radiance observations will be enabled. Tests have also been carried out with a quadratic spectral grid. No significant reduction in accuracy has been found, and so it is planned to implement this for the benefit of computational efficiency.

The assimilation of Mode-S aircraft derived observations retrieved from locally installed receivers and GNSS observations produced by E-GVAP will also be evaluated in the coming year. Nowcasting activities in Met Éireann have started with the recruitment of a dedicated Nowcasting scientist. Nowcasting techniques and the use of crowd-source observations will be investigated. The operational implementation of CY43 is planned for later in 2019. Following the decision by ECMWF Council to make the SAPP (Scalable Acquisition and Pre-Processing) system available by means of an Optional Programme, Met Éireann plan to make the system operational during 2019.

The coming year will bring many exciting challenges for the Irish NWP team!

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Recent Numerical Weather Prediction activities in Morocco

Moroccan NWP team

1 Abstract

During 2018, several activities were undertaken in Morocco in the field of NWP both from operational side or development side, including phasing, case and impact studies, but also trying to better use the local observations. Some uses of the model outputs in services were also developed.

The local team also worked on the procedure of the acquisition of the next new machine. So several suites are developed and will be ported on the new machine, the configurations are called pre-operational suites.

In term of data assimilation, the team is working in the framework of data kit, and is developing local suite and conducting impact studies.

2 Pre-operational suites in Morocco

The pre-operational suites are listed in the table below:

	Model	Horizontal resolution	Number of vertical levels	Initial Conditions	Lateral boundary conditions	Number of Points
Pre-operational suite N°1	AROME	1.3 km	90	ALADIN-Morocco (Dynamical Adaptation)	ALADIN-Morocco	1800x1800
Pre-operational suite N°2	AROME	2.5km	90	3DVAR	ALADIN-Morocco	800x800
Pre-operational suite N°3	ALARO	5km	70	ALADIN-Morocco (Dynamical Adaptation)	ALADIN-Morocco	600x600
Pre-operational suite N°4	ALADIN	7.5km	70	ARPEGE (Dynamical Adaptation)	ARPEGE	450x450
Pre-operational suite N°5	ALADIN	10km	70	ARPEGE (Dynamical Adaptation)	ARPEGE	600x1200

The operationalization of these configurations will be effective with the acquisition of the new machine, the latter was sized to pass multiple instances of AROME 2.5km at the same time. Currently the acquisition procedure is in its administrative phase.

The verification outputs of model configurations:

The figure below shows the scores from some model configurations: ALADIN 7.5 Km, ALARO 5Km and AROME 1.3Km computed in two periods in winter and in summer.

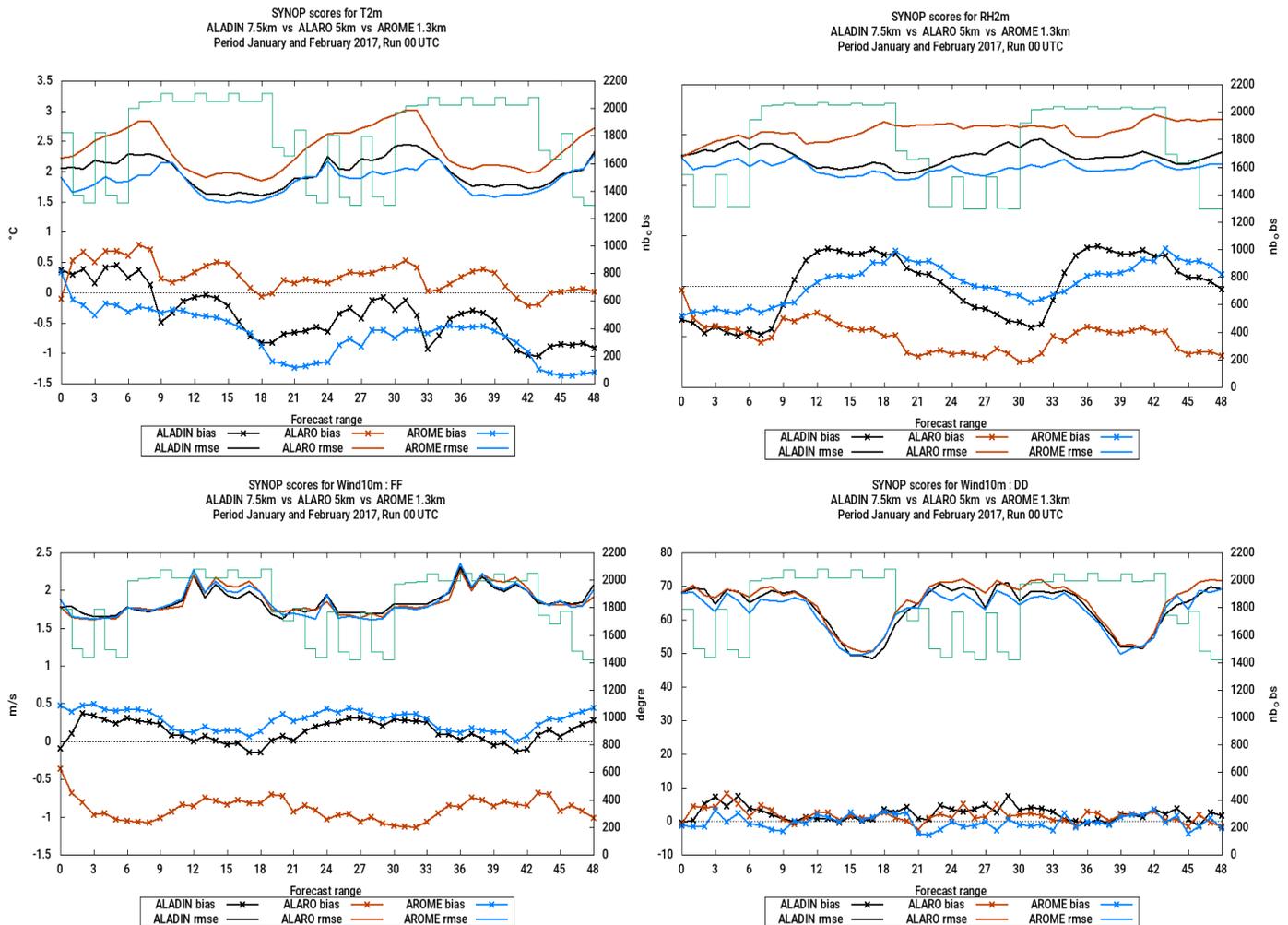


Figure 1: Scores : Aladin 7.5 vs Alaro 5 vs Arome 1.3

3 Data assimilation status

Concept

In harmony with the work undertaken in the Daskit, special focus was done locally on the surface data assimilation. Also, the observation monitoring tool OBSMON was installed and tested. In parallel, some case studies were undertaken with AROME 2.5 km using 3DVAR, developed with cycle 40 and cycle 41, using an ensemble B matrix. A special focus is done on the impact of GPS ZTD on the precipitation forecast.

Some case studies also are undertaken especially using the local Radar observations. In fact, an overall process of studying the ability of the local model configurations to predict high precipitation events using local radars in data assimilation and in verification is in progress. The figure below shows an example of using the radar precipitation quantities adjusted with rain gauges in the validation of the precipitation forecasts.

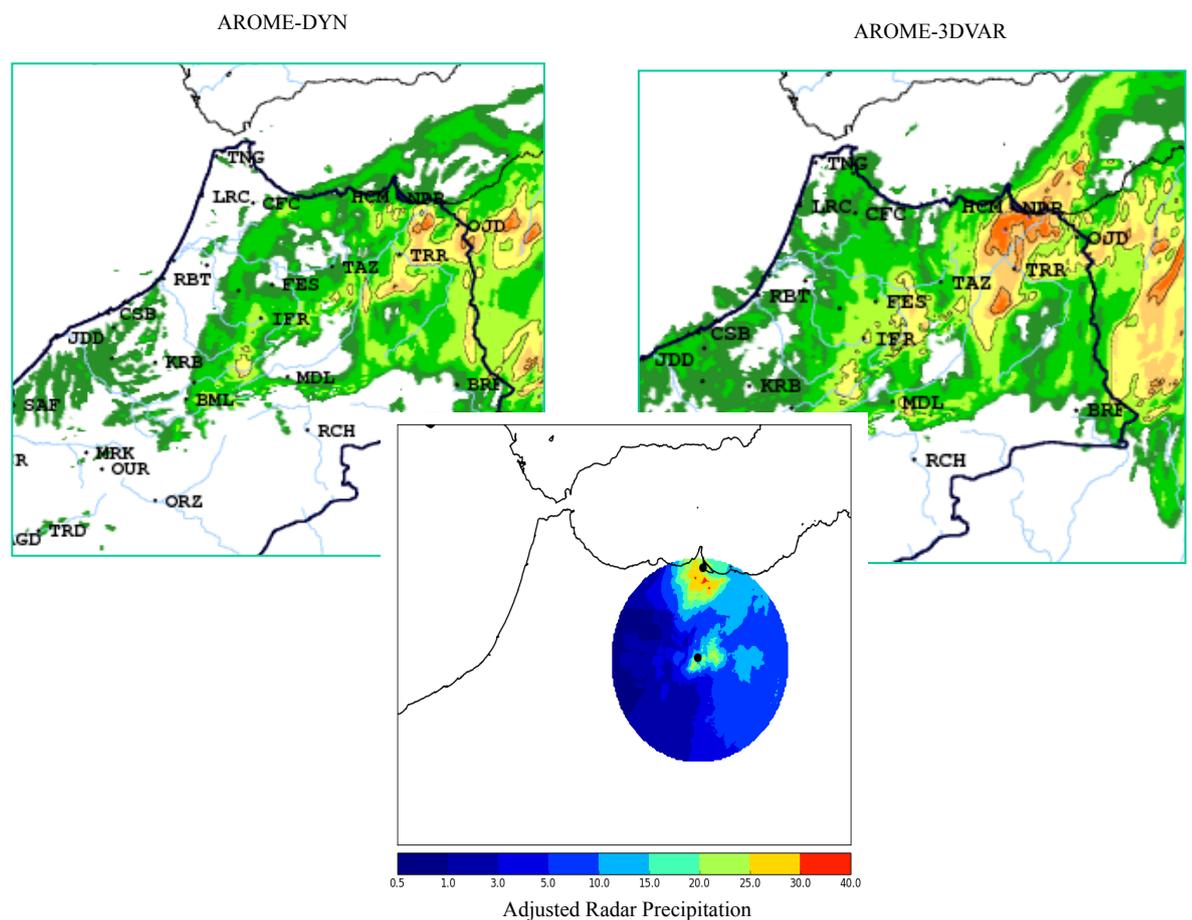


Figure 2: Case study 19/01/2018: 24h precipitation forecast

Aladin in Poland - 2018

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

1 Introduction

On 2018, Aladin Poland group dealt with the following issues: data assimilation, research on inversions in atmospheric boundary layer and SAL verification score.

2 Data assimilation – progress report

Configuration

Thanks to DasKIT meetings and the help of their staff, DA activities in Kraków recorded progress. Currently for operational purposes we use CY40T1, but CY43T2 is installed and it runs in parallel. Initial and boundary conditions are taken from the global model ARPÉGE. To obtain better initial conditions, we started data assimilation for ALARO. Currently, there is just surface CANARI performed once per day (already for few months), but there is set of scripts already prepared to run it within 6 hour cycling. It's going to be implemented very soon. For this assimilation cycle, observations are downloaded from the OPLACE database. Example of innovations for model initial state in our ALARO domain is presented on Fig.1. Except for 6h cycling we work on installing of OBSMON tool and introducing more local surface data. Quality of forecast with single CANARI run mentioned above is simultaneously checked with HARP tool. It seems that introducing even moderate changes in model processing (by data assimilation) improves the forecast score (RMSE at Fig.2).

Results

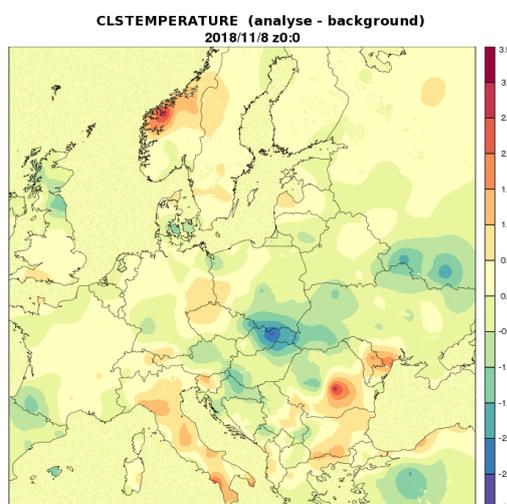


Figure 1: ALARO domain analyse-background differences for 2m temperature.

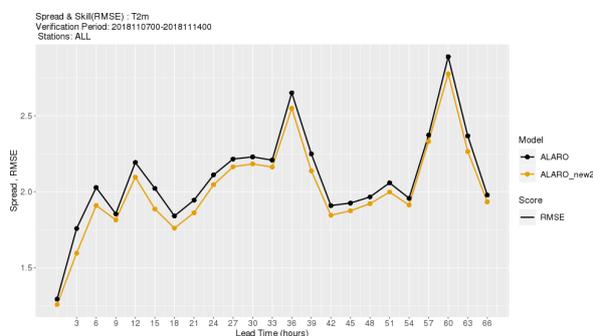


Figure 2: One week 2m temperature rms for whole domain. Black line is operational run, yellow – forecast with CANARI.

3 Temperature inversion in the West Carpathian Mts

Concept

The aim of this subtask was to compare temperature gradient for model and observations for various ensembles of valley-and-peak (or valley-and-highlands) stations for model and to confront them with measurements for these stations (that demanded observation from both valley and peak locations). It is also an interesting verification tool for different models – namely: ALARO-NH and AROME with 1 km grid (and 18 h forecast range and 105 vertical levels) and AROME operational and AROME-HARMONIE with 2 km grid (and for 30 h forecast range and 60 vertical levels). Indexes derived and visualised were BIAS and RMSE. Seasons taken into account were I-IV 2017, IX-XII 2017 and I-IV 2018.

Next step was to test ALARO CY43 CMC in comparison with ALARO-NH at the resolutions of 2 km and 4 km. This is last part of work and the results presented are introductory. They refer to temperature, humidity and wind direction/speed for all 60 Polish synoptic stations and all forecast ranges from 6 to 29 hours (to avoid spin-up).

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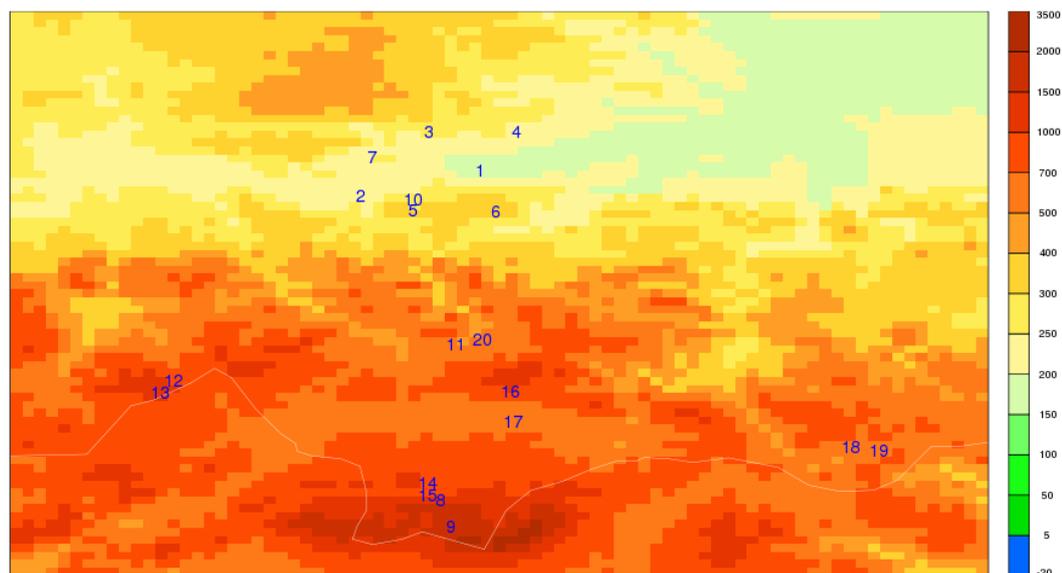


Figure 3: Orography of southern Poland highlands and the Carpathian Mts region with Tatras in red and with pairs of valley-and-peak stations for RMSE studies of temperature inversion.

Results

3 pairs of valley-and-peak stations were selected and relative altitudes for all pairs was higher for map topography than for model orography. Data from 3 rawinsondes (Wrocław, Prostejov and Poprad) for 8 pressure levels were used as a cross-check. It was found that for the wind speed maximum RMSE value is for 200 m above ground level, and for smaller heights (as well as for the larger ones) it decreases. For temperature RMSE decreases with increasing height and contrarily for relative

humidity. Also, the RMSE values for the valleys are higher values than for the peaks for each pair and the autumn season has less RMSE value than both winter/spring seasons.

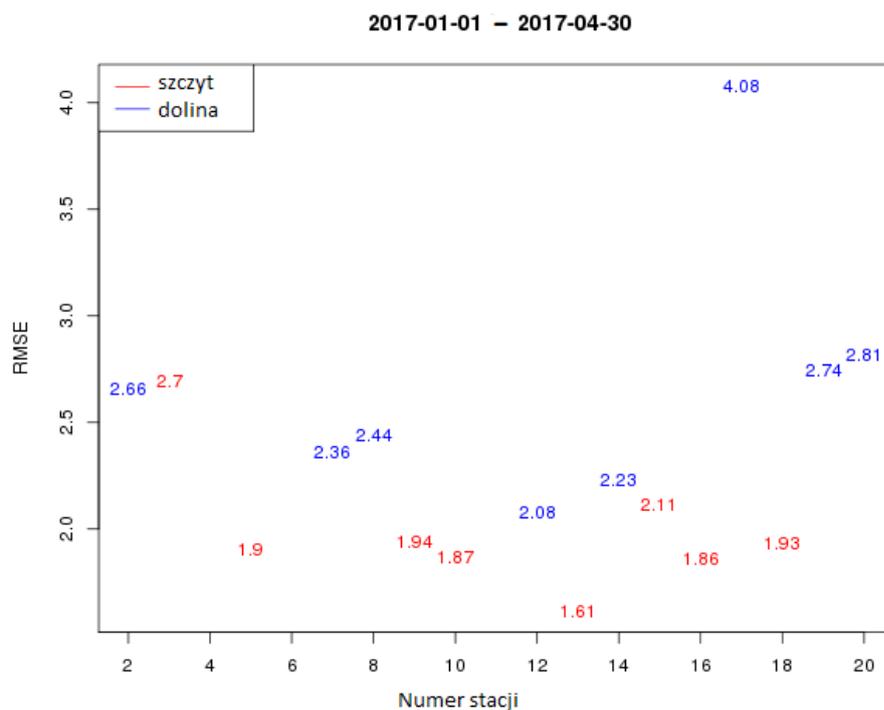


Figure 4: RMSE score for the winter/spring season of the peak (red) and valley (blue) stations according to observations. On the horizontal axis is the station number.

On the diagrams below, there are two examples of RMSE for temperature and relative humidity and for the ALARO CY43 CMC, ALARO CY40 as well as ALARO CY43 NH for 2 km and 4 km resolution, respectively. According to these results, ALARO NH 2 km seems to be valuable member of the future operational suite in IMWM-NRI.

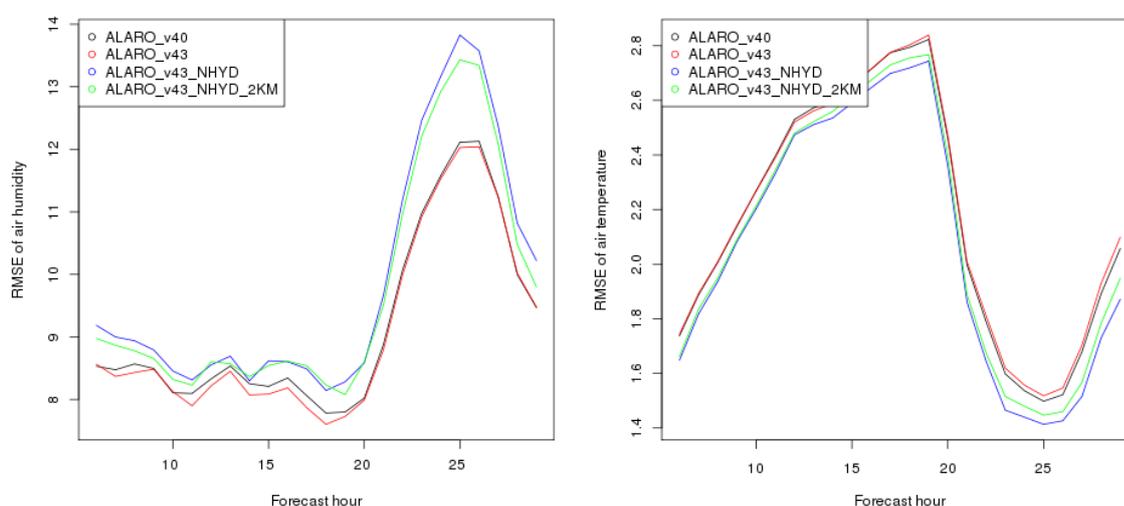


Figure 5: RMSE of temperature (left) and humidity (right) for the sequence of four models and 60 synoptic stations. There is forecast range in hours on horizontal axis.

4 SAL index as a verification tool

Aim

This year aim of flatrate stay in Ljubljana was continuation of previous year task. Tests of fuzzy verification scores and SAL measure (the close to a subjective visual judgment of precipitation forecast score) for verification of precipitation were run with the HARP package.

The task consists on two parts. The goal of first one was to run spatial verification of precipitation and to test the fuzzy method verification as well as calculate SAL measure with HARP. Then to show the result using shiny package. Shiny included in HARP package has two based components put in two R scripts: ui.R for user interface and server.R for server functions.

The second part was to analyze the results.

Results

To run Harp for verification in case of fuzzy method the modification of harp_spatial_verification script was done.

To see results: plots of scores and numbers in table form and make easy switch between methods changes into ui.R and server.R scripts were introduced as well as small modification of plot_functions.R and set_parameters.R were done. Now after putting set of input parameters (sql file with data, verification method, period with further details: month, season, recent or custom, run time, lead time, model and, in case when fuzzy was put — score) the plot of score or data can be seen at the screen according to set of chosen parameters and checkbox (Score or Data) (see Fig. 6, Fig. 7).

HARP spatial verification

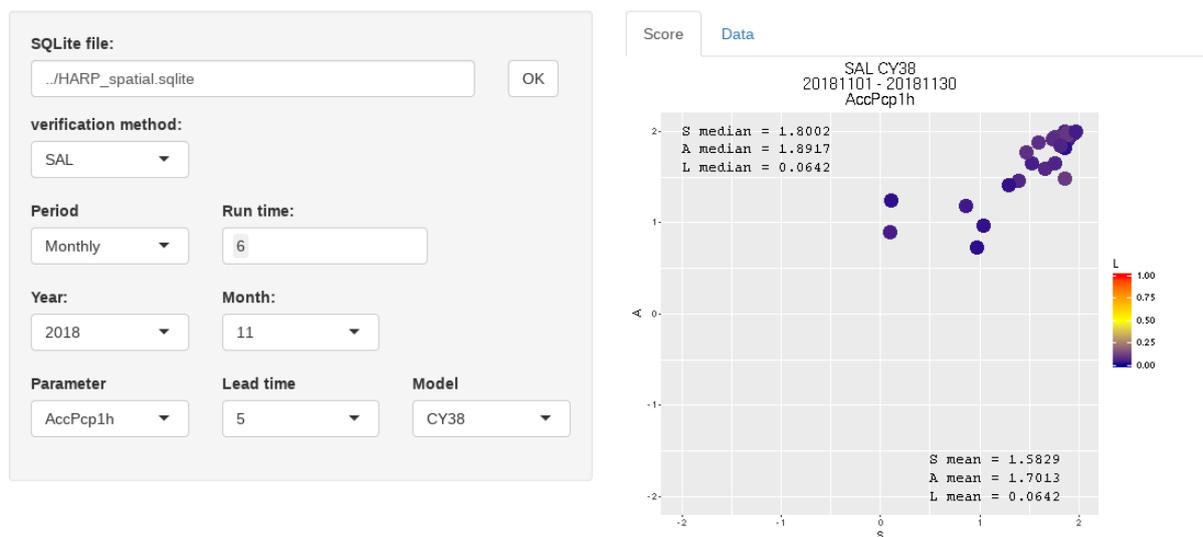


Figure 6: SAL score plot as example of result of HARP spatial verification in application of shiny package

HARP spatial verification

The screenshot displays the HARP spatial verification interface. On the left is a configuration panel with the following settings:

- SQLite file: `./HARP_spatial.sqlite`
- Verification method: `fuzzy`
- Period: `Monthly`
- Run time: `0`
- Year: `2018`
- Month: `11`
- Parameter: `AccPcp1h`
- Lead time: `1`
- Model: `AR`
- Score: `FSS`

On the right is a data table with columns: `model`, `prm`, `fcdate`, `fctime`, `leadtime`, `scale`, `threshold`, `ets`, `fss`, and `hk`. The table shows 600 entries, with the first 25 displayed. The data is organized into two groups based on the forecast date (`fcdate`): 20181101 and 20181102. Each group contains 12 rows for different scale and threshold combinations.

model	prm	fcdate	fctime	leadtime	scale	threshold	ets	fss	hk
AR	AccPcp1h	20181101	0	1	0.1	1	3.749810e-06	2.220446e-16	-2.631787e-05
AR	AccPcp1h	20181101	0	1	0.1	3	2.462315e-05	0.000000e+00	-2.716782e-05
AR	AccPcp1h	20181101	0	1	0.1	5	6.335048e-05	4.276448e-07	-2.794057e-05
AR	AccPcp1h	20181101	0	1	0.1	11	2.022622e-04	1.220459e-05	-5.138291e-08
AR	AccPcp1h	20181101	0	1	0.1	21	6.978771e-04	1.262500e-05	6.681589e-05
AR	AccPcp1h	20181101	0	1	1.0	1	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	1.0	3	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	1.0	5	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	1.0	11	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	1.0	21	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	5.0	1	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	5.0	3	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	5.0	5	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	5.0	11	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	5.0	21	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	10.0	1	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	10.0	3	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	10.0	5	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	10.0	11	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181101	0	1	10.0	21	0.000000e+00	0.000000e+00	0.000000e+00
AR	AccPcp1h	20181102	0	1	0.1	1	-1.619285e-03	2.229204e-02	1.088099e-02
AR	AccPcp1h	20181102	0	1	0.1	3	-2.629438e-03	2.476556e-02	9.215389e-03
AR	AccPcp1h	20181102	0	1	0.1	5	-2.930969e-03	2.607990e-02	7.935335e-03
AR	AccPcp1h	20181102	0	1	0.1	11	-2.144423e-03	2.806585e-02	5.931939e-03
AR	AccPcp1h	20181102	0	1	0.1	21	-1.214905e-03	2.799267e-02	4.162295e-03

Showing 1 to 25 of 600 entries

Figure 7: fuzzy score table as example of result of HARP spatial verification in application of shiny package

As it was mentioned the second part of task was to analyze the results. For purpose of the second part it was assumed to run HARP to verify 2018 numerical weather prediction obtained by models: labeled AR for as04ar model working with coupling files from Arpege, EC for as04ec model working with coupling files from ECMWF and IF for operational at ARSO model working with coupling files from ECMWF. The SAL and fuzzy methods of verification were taking into consideration and the INCA data as reference.

In experiment the case of 1hour accumulation of precipitation of 72hour forecast range was taken into account. It was assumed that tests would involve four models run (00UTC, 06UTC, 12UTC and 18UTC). However HARP needs pretty long time to calculate values for all mentioned cases. Therefore, because of time limitation, the decision was taken to run HARP only for 00UTC models run.

Results show that values of SAL score are comparable in case of EC and AR models whereas values of SAL of IF model vary markedly (Fig. 8).

Results of EC and AR models verification (shown as points picture SAL measure) are:

- grouped in right upper corner of the picture with some nearby at diagonal that points widespread forecast precipitation and small convective events as well as overestimation of domain-averaged precipitation obtain by the model
- scattered points mainly in right half of the picture indicating widespread forecast precipitation and small convective events sometimes over- and sometimes underestimation of predicted precipitation and sometimes correct values
- scattered points mainly below diagonal point

Results of IF model in almost all cases points widespread forecast precipitation and small convective events (similar to EC and AR models) but negative values of A component of SAL show underestimation of domain-averaged precipitation obtain by the IF model. But nearly the same picture for all (taken into account) months and lead time cases is strikingly. The question appeared if the problem is caused by results of model prediction or if there is another source of it.

The explanation of the differences (solution of problem) can be found at the maps showing IF, EC, AR and INCA precipitation fields (prepared by Peter Smerkol).

Next to be done:

- tests fuzzy verification to defined right scales and thresholds in respect of different accumulation periods of precipitation,
- tests of different thresholds in respect of different accumulation periods of precipitation while SAL method of verification is run,
- more flexible shiny to show results of HARP work,
- analyze values of scores in cases with precipitation above the given thresholds only.

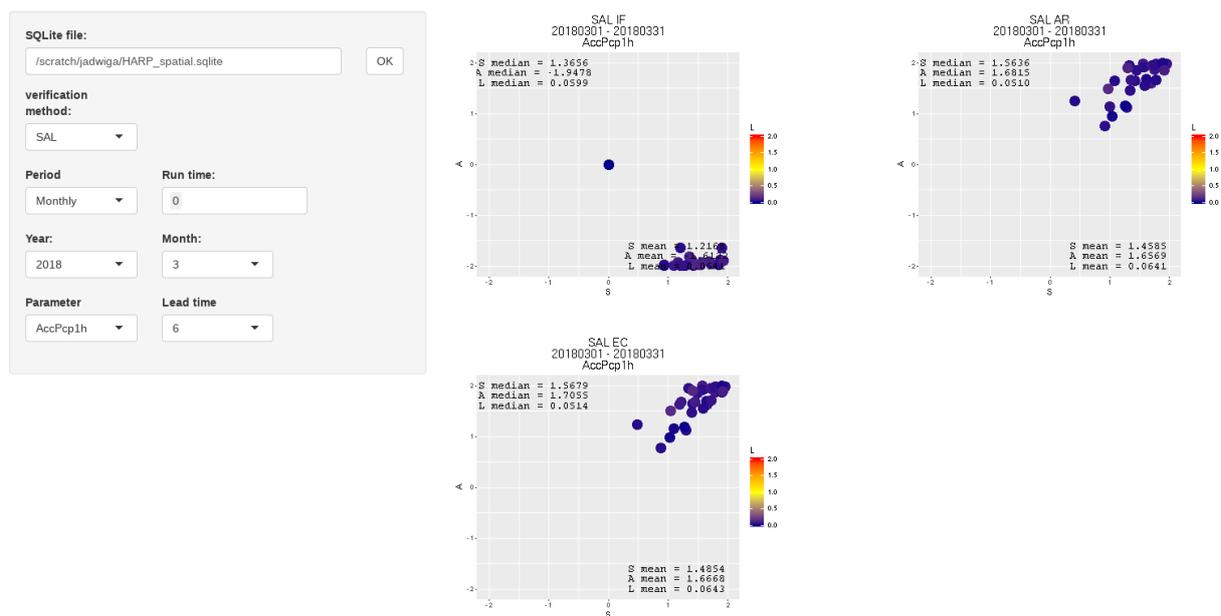


Figure 8: Example of SAL for models: IF (left up) AR (right up) and EC (left down) for March2018, 6h lead time, 00UTC model run

2018 ALADIN Highlights for IPMA, I.P. (Portugal)

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

1 Introduction

During 2018 no changes have taken place on the local NWP operational systems, besides those which occurred on the surface Data Assimilation (DA). Main efforts have been put on the coordination of the new ALADIN Data Assimilation strategic Core Programme (hereafter named “DAsKIT” for simplicity). Furthermore, local efforts have been applied onto the submission of locally funded scientific projects, in order to start the activities on new specific topics which will use the ALADIN-HIRLAM system. More recently, parallel activities have been started in order to enhance the collaboration with the Spanish Meteorological Service (AEMET) on several different aspects, although those will not be described here.

This article is organised as follows: in section 2, an overview is given over the recently added surface operational system; and in section 3, a brief summary is given on the DAsKIT coordination activities.

2 Local NWP operational system status

As mentioned in section 1, no changes were made in the local NWP operational systems during 2018. However, a tailor-made hourly analysis scheme of near-surface parameters by the Optimal Interpolation (OI) method was recently introduced into operations, after a one year of quality assessment and monitoring. One component of this analysis scheme is the DA cycling system described in Monteiro et al. (Jan 2018), which provides the initialization of short-term forecasts used as the first estimates to the hourly analysis (a detailed description of the scheme is done in Monteiro et al., Jun 2018).

In the version CY38T1 of the ALADIN system locally available, the OI method is implemented on the Code d’Analyse Necessaire à ARPEGE pour ses Rejets et son Initialisation (CANARI, Taillefer (2002)), therefore it was possible to use it to perform this hourly analysis: at each analysis time, Iberian surface conventional observations regionally shared under WMO BUFR format (see Figure 1) provide screen-level parameters information to correct the AROME model short-term forecasts (2,5 km horizontal resolution).

For illustration, Figure 1 shows different aspects of the analysis of relative humidity at 06UTC on 15 November 2017: the hourly analysis is shown on the top right panel; the background, a 3-hour forecast, is shown at the top left panel; and the analysis increments at its bottom. It is easy to recognise that the final analysis is more realistic than the background since it adds moisture in the south part of Portugal and northern part of the Pyrenees and removes it around Barcelona region, at the south-eastern part of the Iberian Peninsula, which is in accordance with the observations.

The hourly analysis surface system was implemented in operations after a deep validation process: increments analysis was done, as well as single observation experiments diagnosis (not shown). Besides, the basic scores of the short-term forecasts initialised by the DA cycling, and used as first estimates to the hourly analysis, were performed. They have shown an added value over the actual AROME operational forecast.

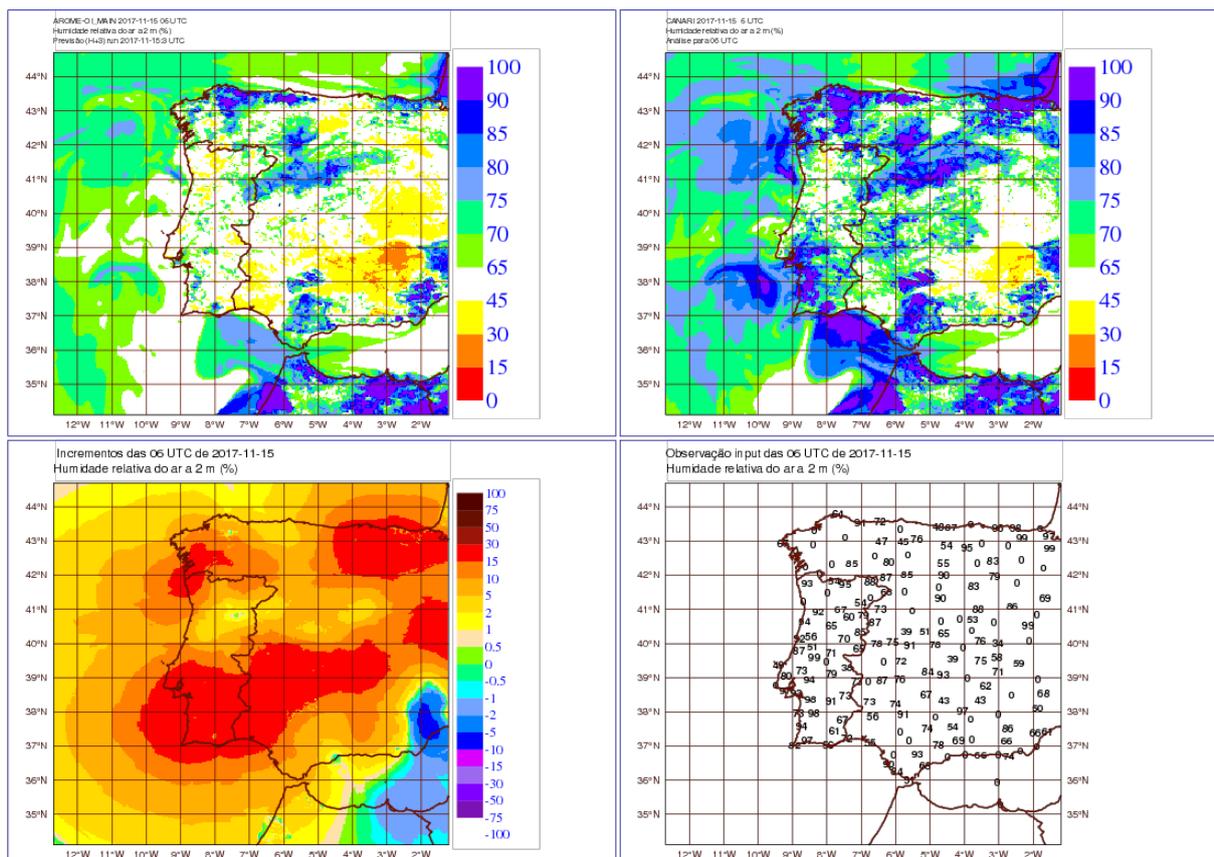


Figure 1: 2-metre relative humidity at 06UTC of 15 November 2017: CANARI analysis (top right panel); AROME (2.5km) background (top left panel); analysis increments (bottom left panel); and the available observations (bottom right panel; “0” stand for missing information).

As future plans, it is expected to port this scheme to CY40T1 together with the actual operational AROME model system.

3 Local NWP operational system status

The ALADIN Core Programme on Data Assimilation (CPDA) took its initial steps during the first quarter of 2018, after a progress survey on the DA activities done among the 8 participant countries. Several actions have taken place in sequence:

- i) regular video-conferences were established, typically on a quarterly basis;
- ii) working days were organised, on an annual basis;
- iii) a forum topic at LACE forum was reserved to DAsKIT issues; and
- iv) a dedicated page on the ALAIN web site was created to announce and report the main achievements and activities.

During 2017, a first joint effort to initiate DA at DAsKIT countries during the first ALADIN Data Assimilation Working Days, in Lisbon: an exercise on pre-processing of conventional data, prepared by Alena Trojakova (AT), LACE Data Manager, was prepared and proposed; countries should be able to use the exercise as a reference in order to start implementation procedures in-doors. Then, at the beginning of 2018, the core programme was approved and its coordinator, Maria Monteiro, was

pointed out. The progress survey done in the first quarter of 2018 showed that the DAsKIT countries were already able to pre-process GTS BUFR SYNOP data in-doors (or were able to manipulate OPLACE preprocessed data files for this type of observations); it showed also there was a concern on local surface DA. Therefore the second Data Assimilation Working Days, already in 2018, were organized taking into account these aspects: tools have been prepared to allow DAsKIT countries to implement a surface cycling system in-doors. In particular, a set of scripts to solve the basic surface DA steps on a particular cycling network were prepared. The usage of tools for local data monitoring (standalone OBSMON and MANDALAY) and data validation (HARP) was demonstrated and the experience with its local installation was exchanged.

The 2018 ALADIN Data Assimilation Working Days (2018DAsKIT WD) were planned with support of LACE (AT) and HIRLAM (Roger Randriamampianina, RR) DA experts trying to fulfill the needs and expectations shown in the survey. Rafiq Hamdi (RH) and Alex Deckmyn (AD) expertises, on surface and validation topics respectively, were also supporting these WD and two video-conferences, one with Eoin Whelan on ECMWF pre-processing system SAPP and another with Météo-France (Claude Fischer and Camille Birman) on surface issues have also taken place. In order to optimise efforts, the 2018DAsKIT WD was jointly organised with LACE DA Working Days (DAWD) and Romania team took charge of the local organization.

During these WD it was possible to see that surface DA has a crucial impact on the model performance. It was confirmed during the discussions that one can already gain a lot from surface DA before moving to 3D-Var. The cycling is important to keep the memory of surface conditions at the small scales in our models. In fact, deep soil moisture is the memory for convection and keeping this memory in our models is crucial. Surface DA is a trackable tool, but the frequency of cycling as well as the density of surface observations (in addition to the information assimilated in the global model) are really important for the success of this tool.

In the last quarter of 2018, during December video-conference, DAsKIT countries have shown good progress in their local DA settings (Belgium in particular) and almost all are now able to cycle them. Concerning local implementation of the surface DA settings provided during the 2018DAsKIT WD, all the countries besides those running ALARO (Poland and Turkey), have declared to have started its local implementation. MANDALAY has been implemented and tested in almost all the countries and no issues have been found, while OBSMON has been implemented in many countries and some compilation issues have been found. At the same time, although most of the countries are still working in CY40T1, they plan to start working on CY43T2 in 2019.

Further steps, foreseen for 2019, should be focused on the following main aspects: pre-processing of upper-air conventional observations, validation of local surface data assimilation cycling and on setting the basic 3D-Var procedures.

4 References

Monteiro, M. et al., 2017 ALADIN Highlights for IPMA, I.P. (Portugal), 10th Aladin-Hirlam Newsletter, Jan 2018.

Monteiro, M. et al., An Iberian tailor-made operational high-resolution hourly near-surface analysis using the ALADIN system, Joint Surface Working Group and Satellite Applications Facility on Land Surface Analysis, IPMA, Lisboa, Jun 2018.

Taillefer, F., CANARI (based on ARPEGE cycle CY25T1 for ALADIN), GMAP/CNRM Technical Documentation, Météo France, Toulouse, France, 2002.

Testing SURFEX coupled to ALARO-0 over Romania

Raluca Pomaga, Simona Taşcu, Mirela Pietrişi

1 Introduction

The SURFEX scheme [1], developed within the ALADIN Consortium was coupled to ALARO-0 over Romania and the impact of this surface scheme was analysed. This study was carried out taking into account the Romanian operational setup of ALARO (which includes ISBA as the current model surface scheme) with a finer horizontal resolution for the testing domain.

2 Setup

- LBC from ECMWF global reanalysis ERA-Interim CORDEX at 50 km horizontal resolution
- ALARO - cy36t1-op2 - coupled with SURFEX scheme (with TEB module activated)
- $\Delta x=4$ km, L46, 36 hours forecast range
- evaluation period: March – May 2017 and September – October 2017
- 3 WMO stations and 6 urban stations in Bucharest metropolitan area

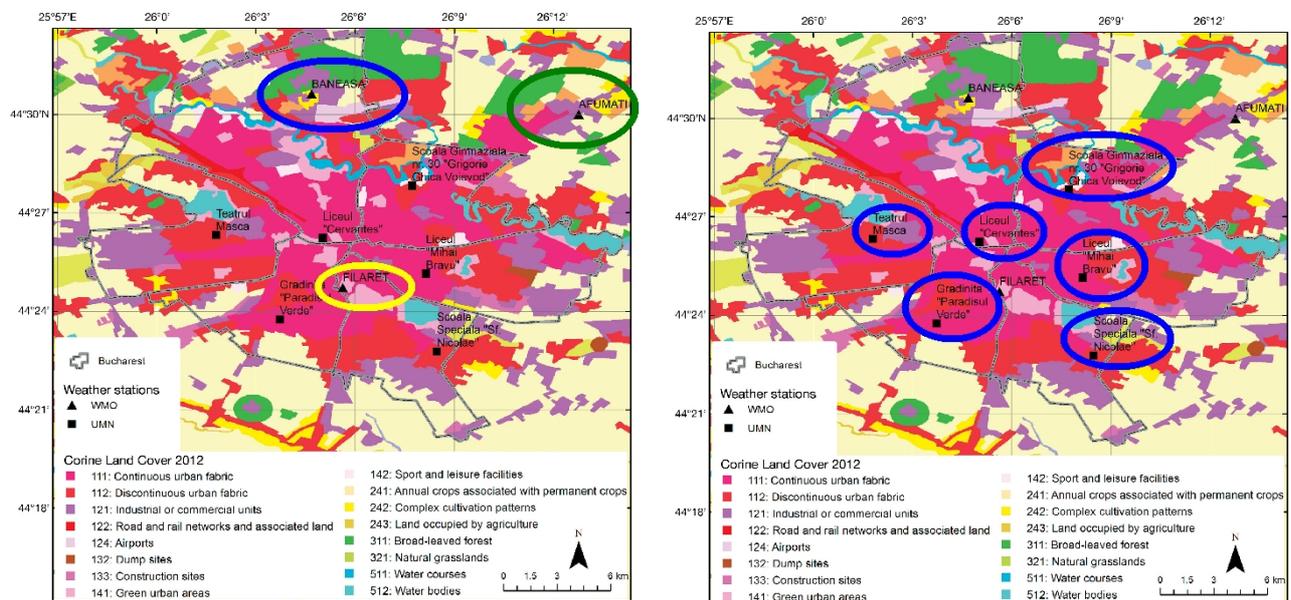


Figure 1: Weather stations, WMO – left and UMN (Urban Meteorological Network) - right.

The integration procedure can be split in two steps: first – ALARO coupled with SURFEX inline using ERA-Interim CORDEX LBC at $\Delta x=50$ km (forecast range up to 48 hours, 00 UTC) and second – the 3h output representing the input for ALARO runs at 4 km resolution. To avoid spin-up problems, the first 12 hours have been eliminated, meaning the 4 km runs start at 12 UTC (forecast range up to 36 hours).

3 Results

The evaluation was done against 9 synop/urban stations in Bucharest metropolitan area (Figure 1). Figures 2 and 3 show the mean 2m temperature for spring and autumn seasons of the year 2017.

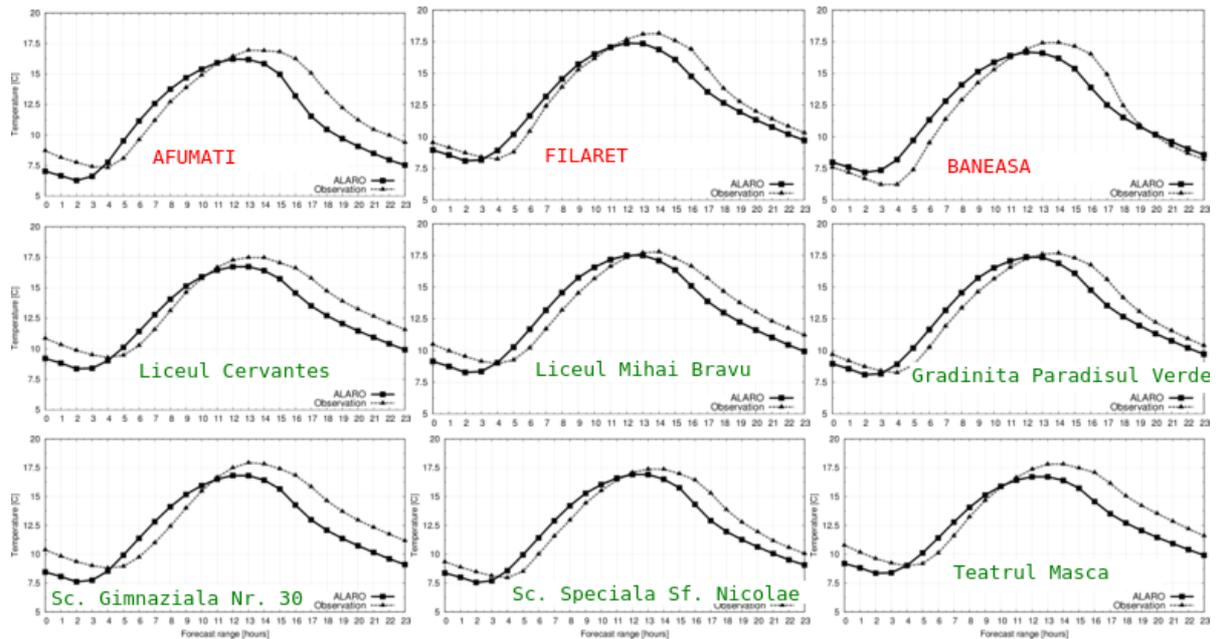


Figure 2: Mean 2m temperature - spring 2017, for WMO stations (first row - in red) and UMN (second and third rows - in green).

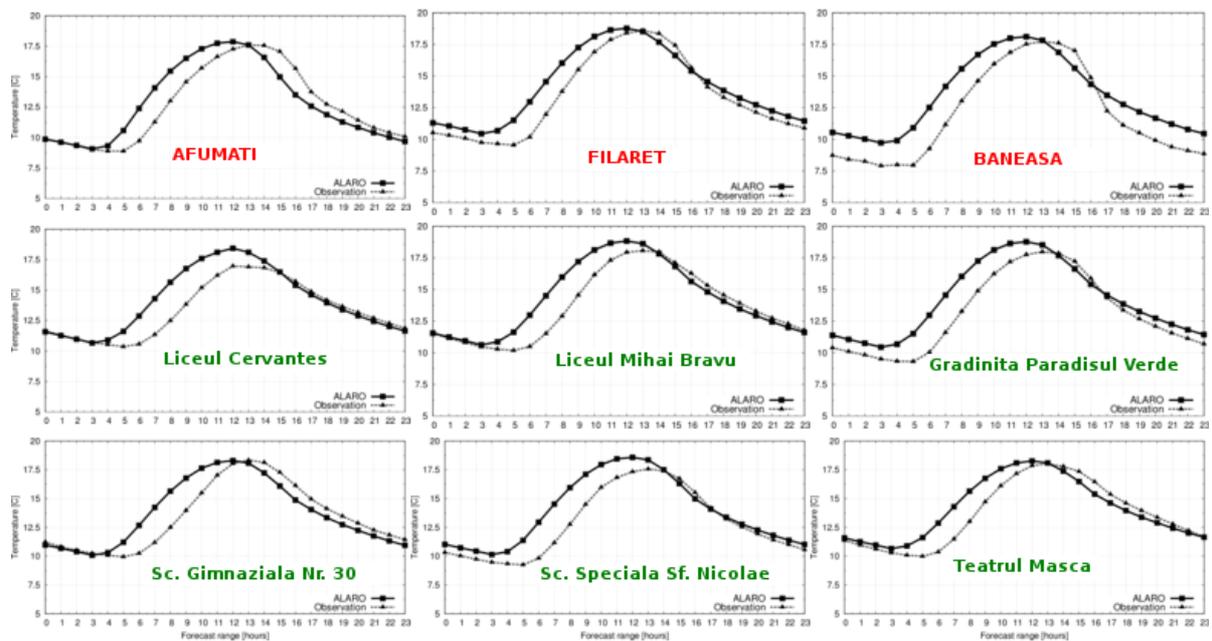


Figure 3: Mean 2m temperature - autumn 2017, for WMO stations (first row - in red) and UMN (second and third rows - in green).

For autumn season (Figure 3), it can be noticed that ALARO forecast has a good performance, for all stations (WMO and urban) over nighttime. Also, it can be observed that for most stations (Afumati, Liceul Cervantes, Liceul Mihai Bravu, Sc. Gimnaziala Nr. 30, Teatrul Masca), the ALARO forecast is very similar to observations in the first interval. Over daytime, ALARO forecast overestimates the temperature. This conclusion cannot be drawn for the spring season (Figure 2), when the model forecast underestimates the temperature over nighttime.

The results are obtained in the framework of the URCLIM project, part of ERA4CS, an ERA-NET initiated by JPI Climate with co-funding of the European Union (Grant n°690462).

4 References

[1] Hamdi, Rafiq, Daan Degrauwe, Annelies Duerinckx, J Cedilnik, V Costa, T Dalkilic, K Essaouini, et al. 2014. "Evaluating the Performance of SURFEXv5 as a New Land Surface Scheme for the ALADINcy36 and ALARO-0 Models." *Geoscientific Model Development* 7 (1): 23–39.

ALADIN related activities @SHMU (2018)

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

1 Introduction

A summary of ALADIN related activities at Slovak Hydrometeorological Institute in 2018 is presented below. 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 HPC IBM Flex System p460, 8 nodes, Power 7+ architecture, Red Hat Enterprise linux, gfortran. Its area covers so-called LACE domain with 4.5 km horizontal resolution and 63 vertical levels (see Figure 1, left panel). 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 including additional local observations is active. More ALADIN/SHMU details are given in Table 1. The ALADIN/SHMU domain is displayed on Figure 1 on the left.

Activities related to the operational system in 2018

There were no changes in the operational setup of ALADIN/SHMU system. We had to deal with serious hardware problems in 2018: in total 6 out of 12 nodes crashed, and only 3 were replaced. During Q2/2018 5 nodes from old HPC (IBM Power755) were configured and plugged in to a cluster with new HPC. The jobs can be submitted there under unified load leveller queueing system.

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

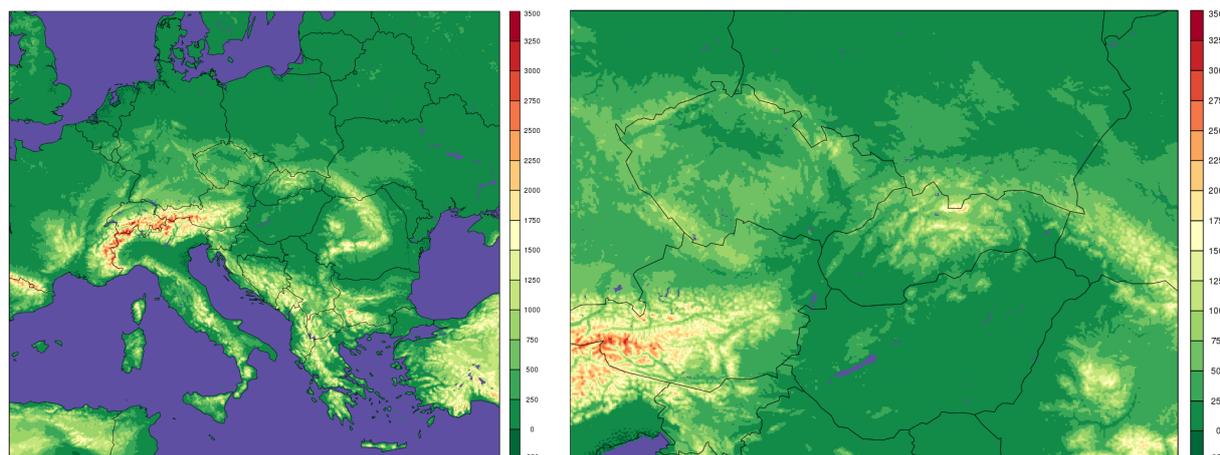


Figure 1: The domains and topography of ALADIN/SHMU operational system 4.5 km/L63 (left) and experimental convection permitting scale setup 2.0 km/L73 used for AROME and ALADIN (right).

3 Research and development activities

Most of research and development activities were ongoing within the RC LACE stays. Local R&D work has been concentrating on the data assimilation at high resolution.

ALADIN-LAEF upgrade (M. Belluš, RC LACE stay)

The ALADIN-LAEF suite is operationally running under obsolete SMS system on ECMWF HPCF. In preparation of new ALADIN-LAEF setup, the environment for the PHASE I was rewritten from scratch under ecFlow, using Perl and Python code. Therefore, recently developed ALADIN-LAEF components like SPPT and ensemble Blending+3DVAR can be easily plugged in. The ecFlow suite is ready for testing in the Time Critical application environment.

Validation of ALADIN-LAEF 3DVAR assimilation (M. Imrišek, M. Belluš, RC LACE stay)

In Phase II of new ALADIN-LAEF setup (4.8 km/L60, 16 members) the handling of initial conditions perturbations of the upper air fields will be based on ensemble blendvar (combination of Blending by digital filter and 3DVAR data assimilation) approach. The 3DVAR DA was technically implemented into ALADIN-LAEF in 2016. Its technical validation started with gradual implementation of various observation types: SYNOP, TEMP, AMDAR, GEOWIND – all OPLACE, and GNSS ZTD (Slovak University of Technology) data. The whitelist for GNSS ZTD data was generated using the “best day” (all members and lowest amount of rejected stations) and “best member” (all days and lowest amount of rejected stations) criteria together. Then, for initial conditions the Gaussian perturbation to all data was applied within screening. The proposed configuration with 3DVAR step inserted between CANARI surface analysis and Blending by DFI blocks (VARBLEND) was run for 2 weeks period of 16.-30.5.2016. The forecast verification scores were slightly positive to neutral in the beginning of integration for all parameters when compared with LAEF Phase I (with only deterioration of geopotential), as it is illustrated on the examples of verification results on Figure 2.

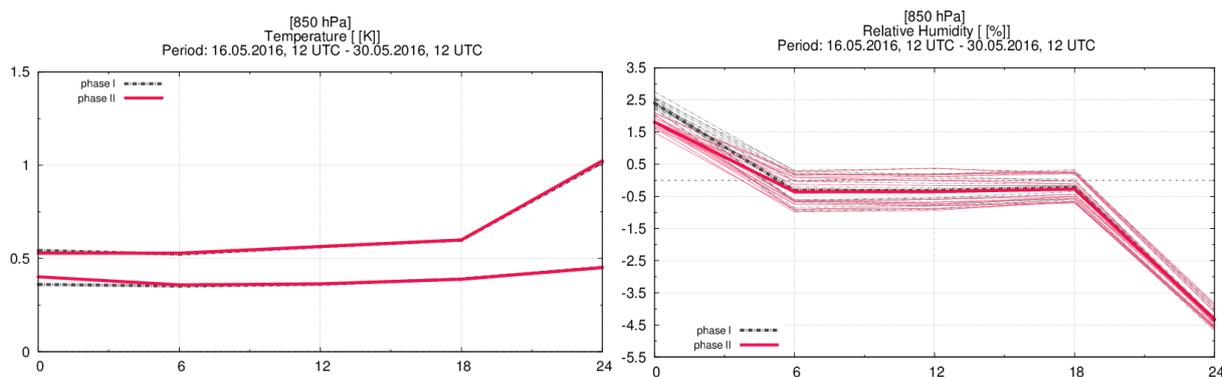


Figure 2: Verification scores of ALADIN-LAEF Phase I and Phase II at 850 hPa: RMSE and spread for T (left) and BIAS for RH (right).

Building of new SODA-EKF based assimilation suite (V. Tarjáni)

A SODA-EKF based assimilation suite is being built over the INCA-SK domain of 501x301 pts with 1 km grid, using CY40T1. INCA analyses of 2m T and 2m RH are used as high resolution gridded observations. To illustrate the quality of adopted input data the example of T2m analyses from CANARI and INCA are displayed on the Figure 3 in the left column, top and middle panel respectively. SURFEX forcing (~20 m above the surface) is provided by ALARO/SHMU 4.5 km model. The preliminary results are shown on Figure 3 as well, displaying analysis increments of the temperature control variables (TG1, TG2 reservoirs) in the right column, top and middle panels respectively. The corresponding 2m parameters innovations are on the bottom line of Figure 3 for temperature (left) and relative humidity (right). Introduction of INCA precipitation analysis and radiation analysis based on NWCSAF as forcing is planned as well as thorough validation, upgrade to SURFEX v8.1 and addition of snow cover analysis.

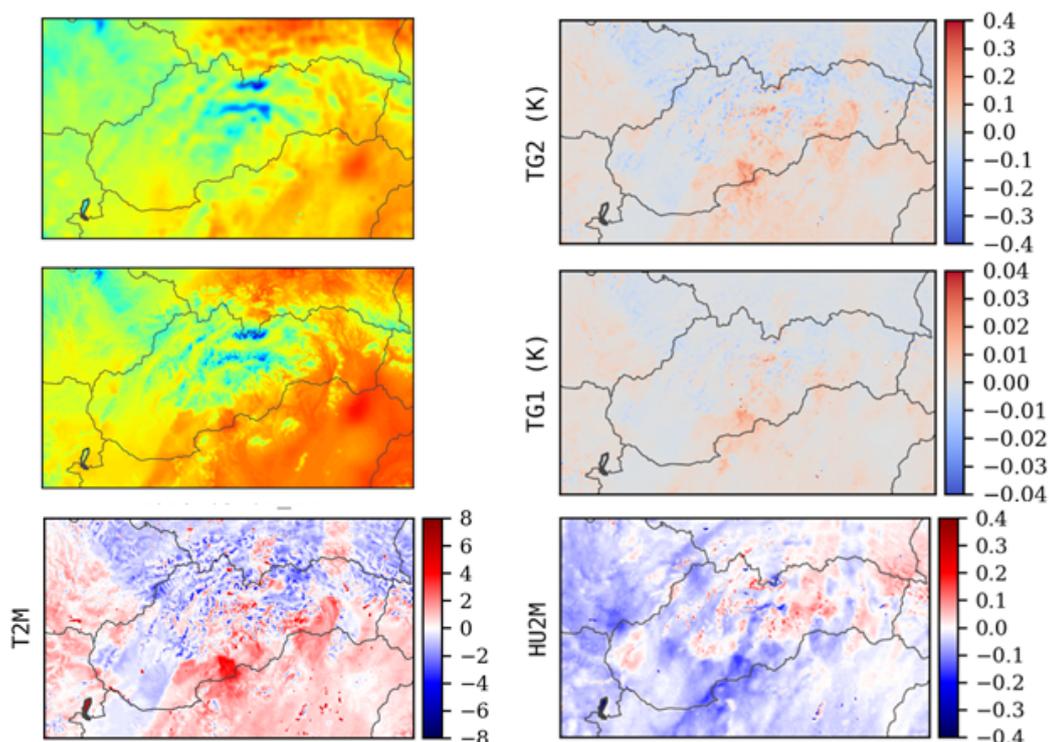


Figure 3: Top left 2mT CANARI analysis, top middle 2mT INCA Top right and top middle corresponding TG1 and TG2 innovations. Bottom line: analysis increments of 2m T (left) and 2mRH (right).

New vertical motion variables in the non-hydrostatic dynamical core of the ALADIN system (J. Vivoda, RC LACE stay)

VFE schemes are implemented in both HY and NH dynamics. However, vertical integral operator in NH model version is not the same as in HY model version. NH operator uses assumption that derivatives of integrated function are zero at model top and surface and B-splines of any order can be used.

We tested operator (CY46) on summer convection case in Alpine territory from 8th of June 2016 with 4.7km resolution and 87 vertical levels (CHMI oper configuration). We performed 24h integration with original HY VFE operator (HFB0) and with new ones (splines of 3rd order– HFB3, 5th order– HFB5, 7th order- HFB7). The results zoomed over Alpine region are shown on Figure 4.

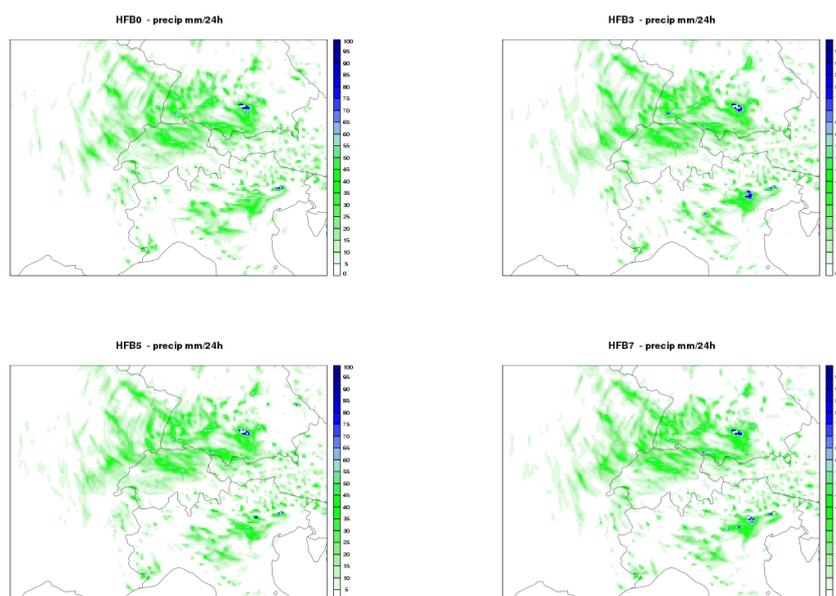


Figure 4: Case 8th of June 2016. 24h precipitation computed with various versions of VFE integral operator using HY dynamics.

We continue in development of new vertical prognostic variable “gW” used in grid points space (idea proposed by Voitus). We implemented 3 versions $gW5 = gw - \vec{v}\vec{\nabla}\phi$, $gW6 = gw - \vec{v}\vec{\nabla}\phi_s$ and $gW7 = gw - \vec{v}_s\vec{\nabla}\phi_s$. We tested properties of NH dynamical core with new variables on case from 4th of January 2017, when severe wind appear almost in the whole troposphere. We compute results with model with resolution 2km, time step 90s. The cross section of wind speed are shown on Figure 5 (W000 – reference with gw prognostic, W001- gW5, W003 – gW6, W005 – gW7). In our experiments the quantity related to BBC was advected using finite difference approximation along SL trajectory.

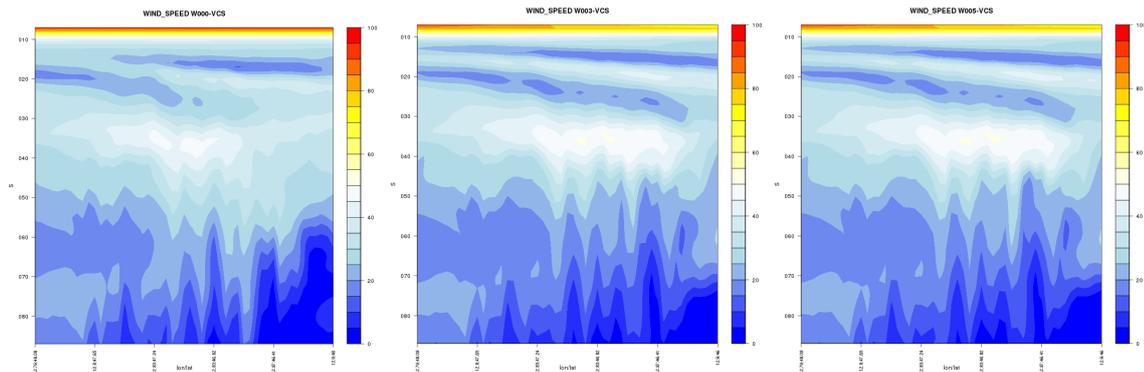


Figure 6. The horizontal wind speed cross section above Alps where the largest variation of precipitation between experiments was observed.

Mode-S data assimilation (K. Čatlošová)

In frame of diploma thesis the work on Mode-S data processing and assimilation has started. A 2 months data sample was obtained from the Slovak Air traffic control authority. These data were processed and technically tested using AROME/SHMU experimental configuration. An illustration of wind speed analysis at model level 70 (around 80m) is plotted on Figure 7, left panel, and corresponding analysis increment on the right one. In the near future the data quality evaluation and MRAR vs EHS data comparison is planned. The full 3DVAR suite and case studies will follow.

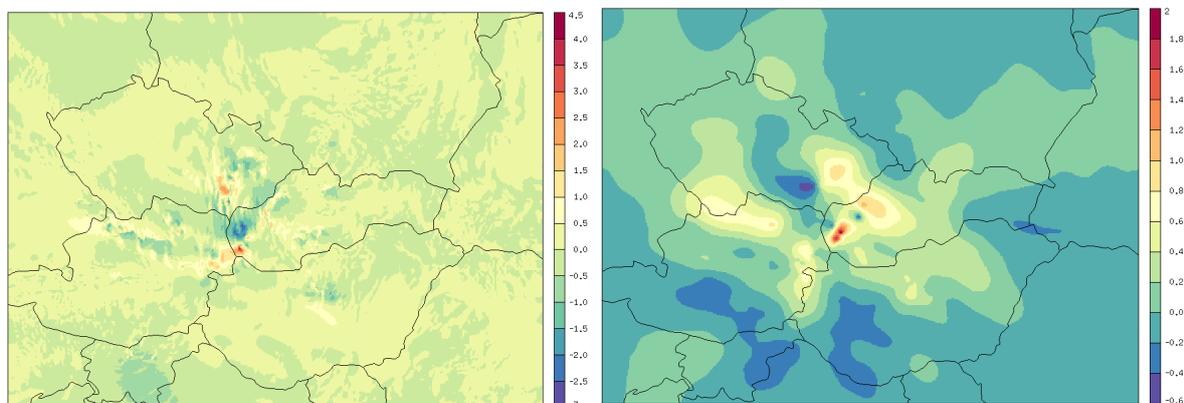


Figure 7: The analysis experiment with Mode-S data: wind speed at model level 70 (left) and corresponding analysis increment (right) is plotted.

GNSS data assimilation (M. Imrišek)

An experimental 3DVAR assimilation suite has been implemented for AROME/SHMU [2 km/L73] domain (see Figure 1, right panel) with 6 h cycling. Locally processed GNSS stations (space.vm.stuba/pwvgraph) are used together with SYNOP, TEMP, AMDAR and HRWIND observations from OPLACE. The analysis and first guess departures were extracted to perform an a posteriori validation of the static GNSS whitelist over the period of 27.06.-11.09.2018. Upon the Jarque-Bera tests (normal distribution of residuals – see statistics for all stations on the Figure 8) 6 stations had to be excluded from the assimilation. A VarBC approach will be tested to generate the station whitelist in the near future.

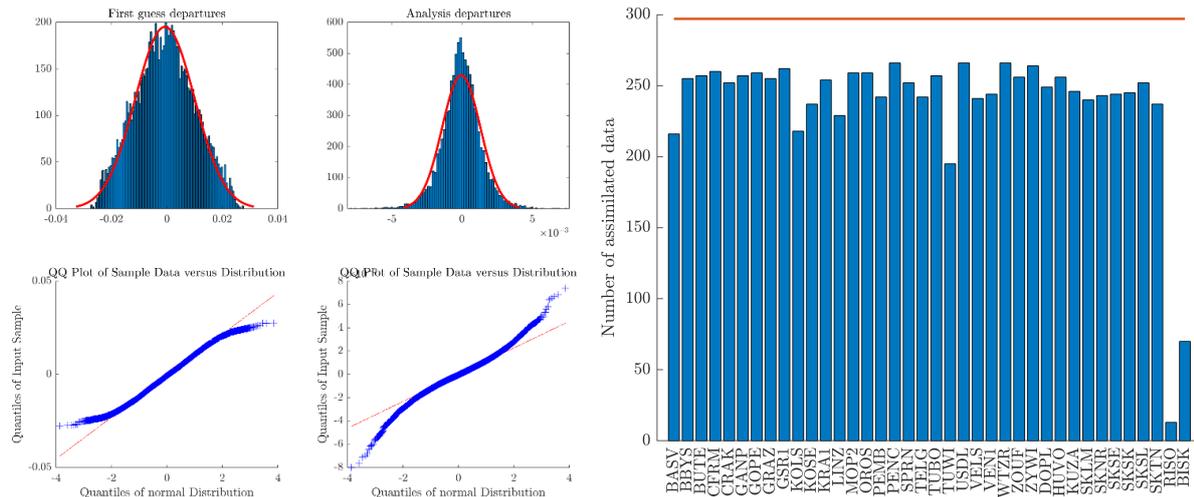


Figure 8: The statistical analysis of the analysis and the first guess departures of GNSS stations assimilated during 12 weeks period with AROME/SHMU experimental suite is plotted on the left. Overall numbers of assimilated data per station is shown on the right.

High resolution experiments (Martin Dian)

Two possible configurations of the convection-permitting non-hydrostatic model are being tested: the ALARO and the AROME CMCs applied over identical domains (see Figure 1, right panel) with 2 km horizontal grid and 73 vertical levels. The model domains are covering Slovakia and close neighborhood, having size of 768 km x 1024 km (see Table 2). These models are coupled to the ALADIN/SHMU system (4.5 km/L63) with hourly coupling frequency. Longer periods of runs are performed as well as individual case studies for testing. Both systems are tested mostly in the downscaling mode, and AROME is also used for standalone data assimilation experiments with GNSS and Mode-S data (see above).

Table 2: The experimental setup of two possible convection-permitting systems tested at SHMU.

	AROME CMC	ALARO CMC
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	144s	100s
coupling model	ALARO-1vB (4.5km), 1h coupling frequency	
forecast ranges (model output frequency)	+78h at 00 UTC/+72h at 12 UTC (a' 1h)	

Radar data assimilation (M. Neštiak, RC LACE stay)

Recently, within the joint effort towards RUC radar data assimilation all RC LACE radars from OIFS (in ODIM/HDF5 format restructured by HOOF tool) were tested in BATOR (CY40T1bf09). This was preceded by technical work on investigations of OPERA OIFS quality indices, BATOR backphasing and radar data processing. An example of radial velocity from Maly Javornik for 24/09/2018 03 UTC is shown on Figure 9 with thinning distances of 5 km (left) and 1 km (right). It is important to notice that with 5 km thinning (pure spatial separation) important local features were ignored.

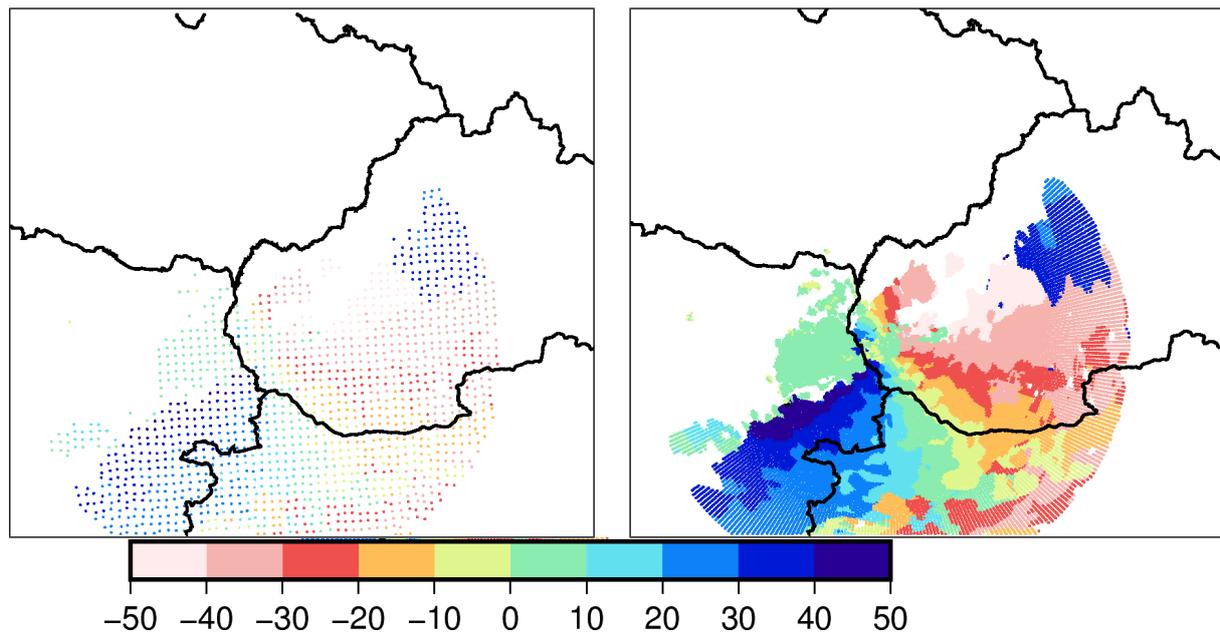


Figure 9: One month time series of RMS scores for temperature (K) at 500 hPa.

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Implementation of visibility and convective diagnostics

Further work was invested into improved diagnostic model fields required by users. ARSO hosted a stay on visibility computation. The method which includes effects of cloud particles and hydrometeors prepared and validated in AROME/ARPEGE was tested with ALARO. A stay at CHMI was devoted to implementation of convective diagnostics in cy43t2. Lightning diagnostics was moved from instantaneous to accumulated values which assures better time representation over the forecast.

Research on two-way atmosphere-ocean coupling

Research on the impact of SST information in Adriatic Sea on forecast along its eastern coast was continued by performing further verification analysis and comparisons with satellite data. Experiments included different SST products (ECMWF, MFS, operational POM) and two-way real time coupling between ALADIN and POM (either in production cycle only, assimilation cycle or both). It is concluded from satellite verification that for the ocean model POM, the two-way coupling always improves SST. However, in ALADIN, high-resolution SST from POM (which has no ocean data assimilation) degrades the forecast with respect to ECMWF (daily analysis) and MFS (weekly analysis). Although the two-way coupling improves the forecast, it is not able to outperform the low resolution ECMWF product which benefits from frequent update with observations. The main conclusion of this recently published work is that the development of local data assimilation for the ocean component is necessary.

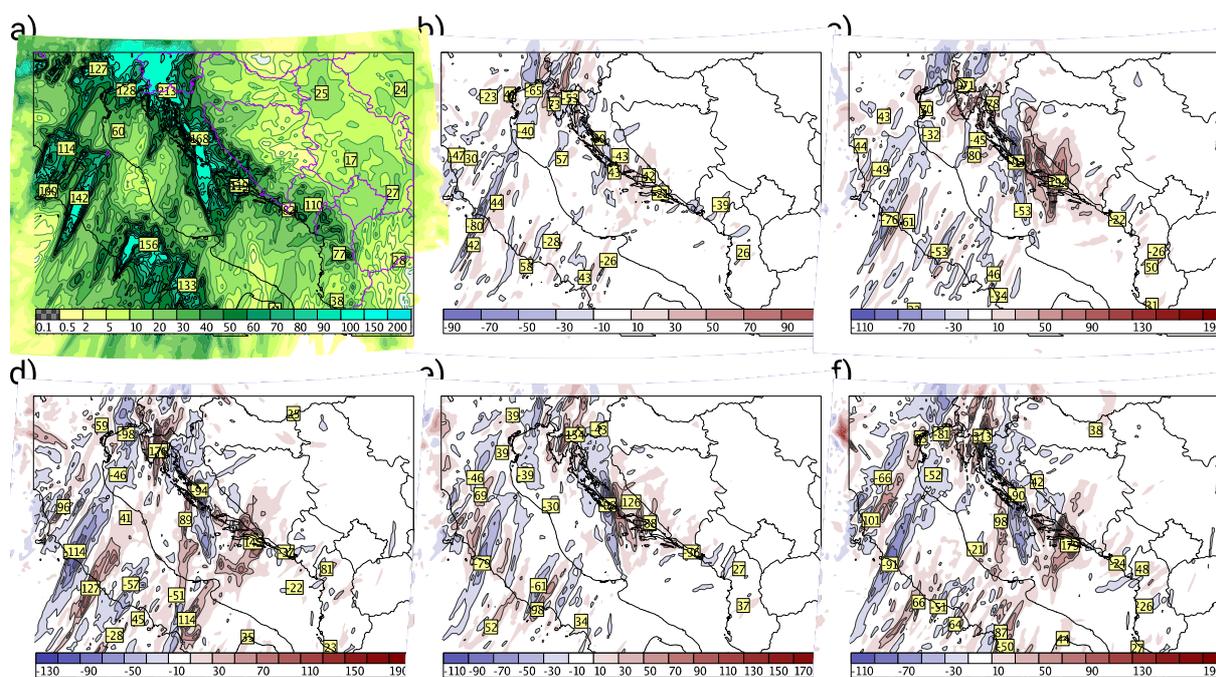


Figure 2: (a) 72-hour precipitation [mm] over the Adriatic Sea on 10 September 2017 as simulated by the operational ALADIN. (b-f) Differences between operational run and several experiments using different static SST and various level of the two-way coupling.

Operational implementations of NEMO

The operational implementation of NEMO ocean model (as replacement for POM) continued by replacing sigma with z-levels. Operational ALADIN is used as meteorological forcing. Additionally, a separate NEMO-based storm surge ensemble modeling system has been set up, employing TPX08 tides at the lateral boundary and ECMWF ensemble as meteorological surface forcing.

Experiments with offline SURFEX: snow cover modeling

Snow simulations were performed during the 2017/18 winter season using the Crocus snow pack model. Crocus is integrated as a snow scheme in the ISBA land surface model, which is part of the SURFEX surface modeling platform. The SURFEX simulations were performed in offline mode, where meteorological forcing at the surface level is provided. The meteorological forcing was based on 1 km INCA analysis. SURFEX also requires the longwave downward radiation (DLW) to be provided as meteorological forcing. Since this data is not available in INCA analysis it is obtained from ALADIN forecast. The DLW data is then corrected using the insolation fraction from INCA analysis. The system runs in an operational mode since the beginning of the 2018/19 winter season, where simulation of the last 24 h is performed on a daily basis. A restart file containing the model state is generated after each day of simulation and is used as an initial condition for the subsequent simulation.

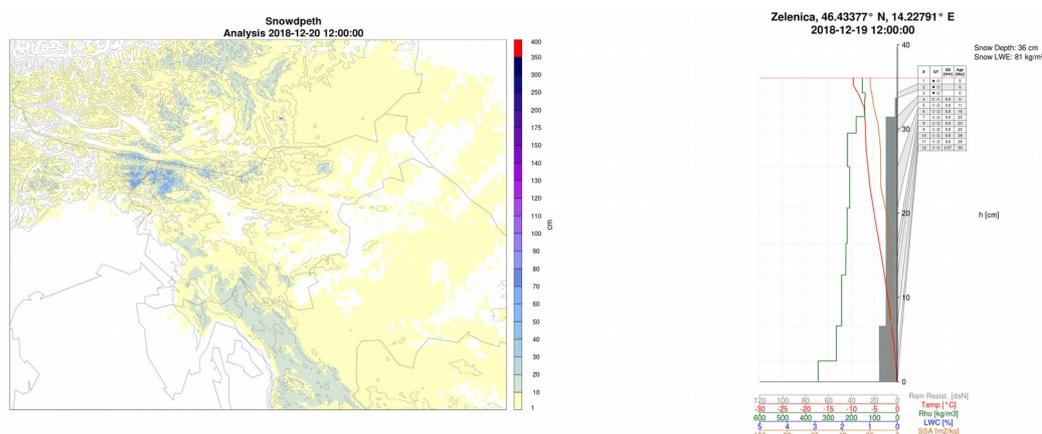


Figure 3: Simulated snowdepth on INCA domain (left) and simulated snow profile at mountain station Zelenica (right).

Singularity container environment

In the scope of cooperation between ARSO and Slovenian national HPC grid initiative, ALADIN code was installed within a Singularity container. The container was stripped of model source code and moved to a freshly installed remote cluster where the code executed successfully. There were only minor problems related to MPI environment and compatibility between cluster MPI and MPI environment in the container.

Singularity container environment is definitely a promising technology for future HPC resources sharing and operational joint ventures.

3 Conclusion

In 2018, ALADIN activities were focused into implementation of radar data, finalization of a two-way ocean – atmosphere study, snow modeling as well as improving model diagnostics fields. As part of preparation for possible future cooperation with national HPC grid, container approach to using remote computing facilities was tested. Work on radar data assimilation will continue in 2019 when we foresee switch in the operations to cy43t1 and also high-resolution (1.3 km) suite to be run in hourly nowcasting mode. The two-way coupling between ALADIN and NEMO ocean model will be implemented and NEMO-based storm surge ensemble modeling system will be tested with LAEF ensemble as meteorological surface forcing

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Highlights of the NWP activities at the Spanish Meteorological Agency

J. Calvo, C. Calvo, A. Callado, J. Campins, M- Díez, P. Escribà, C. Geijo, A. Hernández, A. Jiménez, D. Martín, G. Morales, S. Viana and J. Sánchez

1 Introduction

The purpose of this paper is to summarize the main features of the AEMET operational integrations and its characteristics and to give a broad overview of the ongoing research activities.

2 Operations

Operations at AEMET are based on HARMONIE-AROME cycle 40h1.1 (Bengtsson et al., 2017) with the configuration shown in Table 1. Indeed AEMET is Regular Cycle with the Reference (RCR) for this HARMONIE cycle. Besides, we maintain a parallel run as a *Time Critical Facility* at ECMWF based on cycle 38h1.1 which is described in Table 1. The main purpose of this run was to serve as backup integration but it has shown to have a benefit especially for convection representation.

	AEMET operational setup	<i>Time Critical</i> at ECMWF computers
Model version	40h1.1	38h1.1
Resolution	2.5 km	2.5 km
Levels	65	65
Domains	IBERIAxl (1152x864) CANARIAS (576x480)	IBERIAxxm (800x648) CANARIAS (576x480)
Boundaries	ECMWF BC program every 1 hr	ECMWF BC program every 1 hr
Surface scheme	SURFEX 7.2	SURFEX 7.2
Cycle	3 hours	6 hours
DA upper levels	3DVar incl GNSS and ATOVS	3DVar Iberia, Blending CANARIAS
DA surface	CANARI + OI_MAIN	CANARI + OI_MAIN
Forecast length	48 hours with 15 min output for selected variables	48 hours with hourly output

Table 1: Operational configurations

The main issues found in these integrations are a positive bias in 10m wind speed not found in other operational domains running HARMONIE-AROME, a negative bias in 2m temperature in winter months (Fig. 1) and an overestimation of wind gust with intense deep convection.

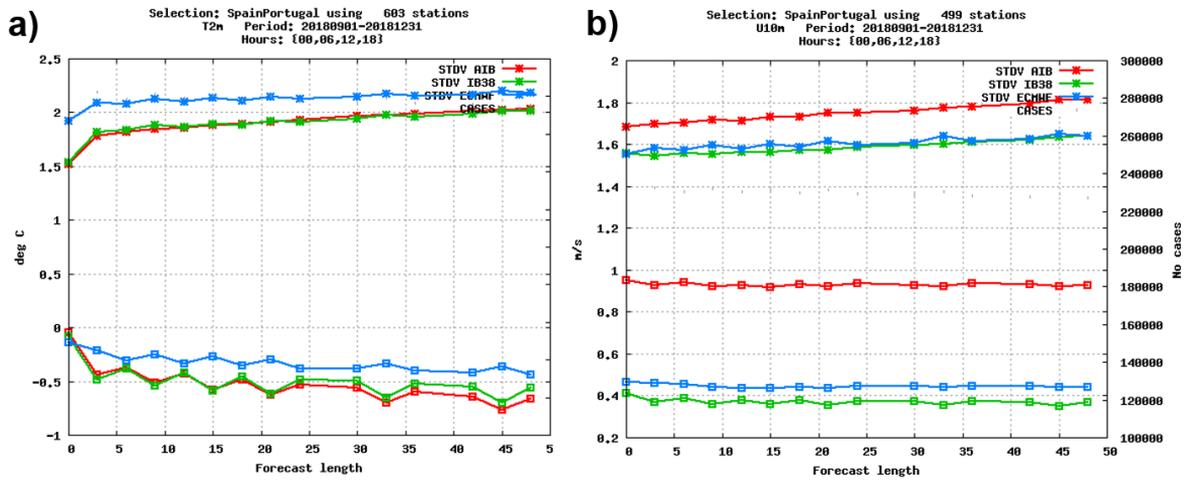


Figure 1: STDV and BIAS for ECMWF (blue), HARMONIE-AROME cycle 38 (green) and cycle 40 (red), (a) 2m temperature and (b) 10 m wind speed

GNSS and ATOVS Data Assimilation

Although the positive impact of including GNSS zenith total delay and ATOVS data was demonstrated independently (Campins et al, 2017) it took some effort to tune the system to obtain benefit including both together, especially for the Canary Islands domain where the lack of anchor observations makes the convergence of the Variational Bias Correction Coefficients difficult. Recent updates for these observations are the generation of a new white list for GNSS, the correction of the format for one GNSS Analysis Center, and a new blacklist for ATOVS data. The ATOVS data come from AMSU-A and MHS instruments for NOAA-19, METOP-A and METOP-B and only from AMSU-A for NOAA-18. The ATOVS channels assimilated are shown in Table 2. The relative weight of the different observations on the analysis is shown in Fig. 2 by means of the Degrees of Freedom for Signal (DFS), and it can be seen that ATOVS and AMDAR observations have a big impact on the analysis.

	AMSU-A	MHS
NOAA-18	6, 7, 8, 9	
NOAA-19	6, 9	4,5
METOP-A	6, 9	3, 4, 5
METOP-B	6, 7, 8, 9	3, 4, 5

Table 2: ATOVS channels

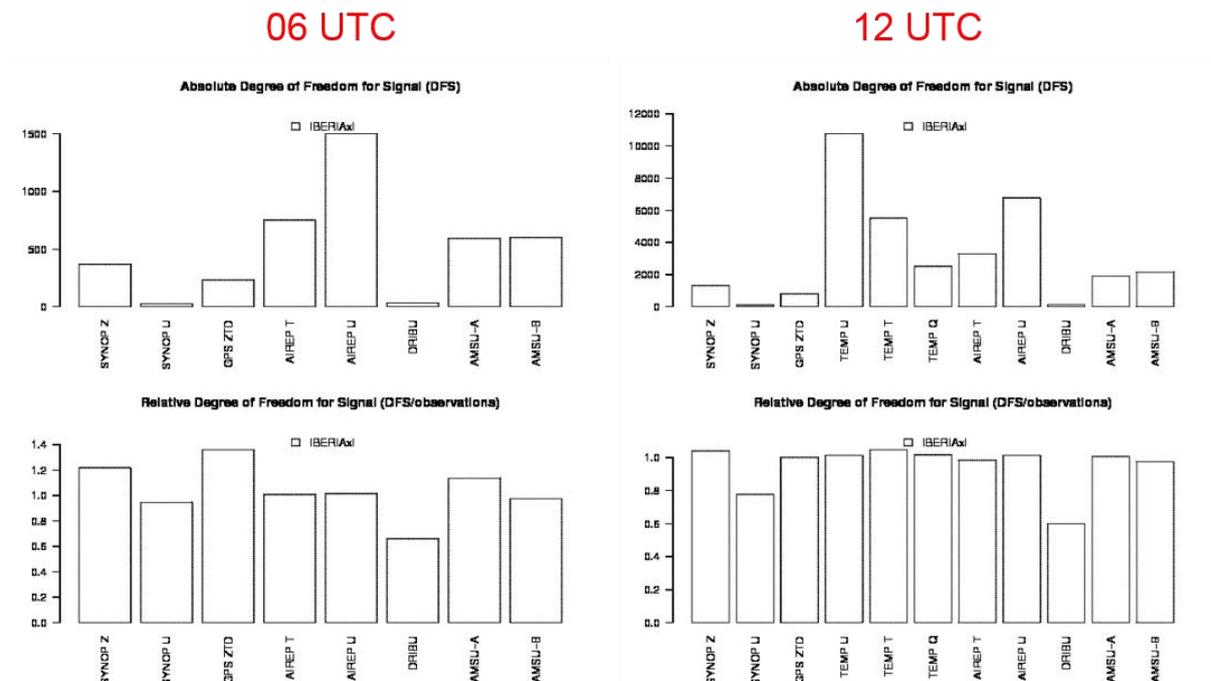


Figure 2: Weight of the different observations on the analysis measured by means of the DFS statistic. Upper plots show Absolute DFS and bottom plots the Relative DFS.

Hydrological Cycle

In order to monitor the model hydrological cycle the Soil Wetness Index and similar indexes for dry and saturated soils are routinely plot for ECMWF model and for HARMONIE-AROME operational runs following ECMWF method. These relative indexes are more independent of the soil scheme definition, making possible the comparison between models. HARMONIE is significantly drier than ECMWF as seen in Fig. 3 but we have not seen any significant correlation of the soil moisture distribution and convection strength.

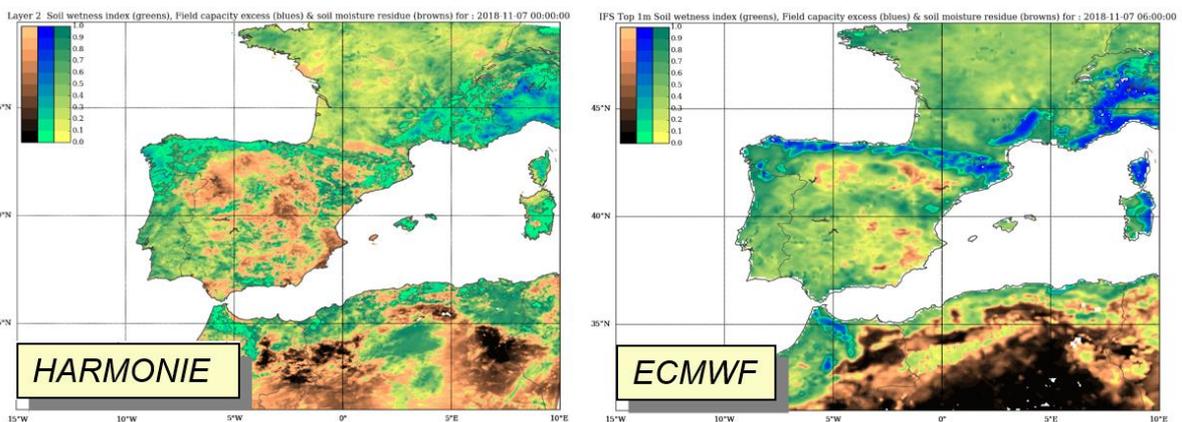


Figure 3: Comparison of soil moisture for HARMONIE-AROME (left) and IFS (right) on 7th November 2018.

Snow Prediction

The snow assimilation follows an OI scheme using only SYNOP observations and these observations are scarce over the Iberian Peninsula. The snow prediction is based on Douville (1995) with a single layer and two forecast variables (snow water content and snow density). Despite the simple approaches, the schemes do a reasonable job as can be seen in Fig. 4.

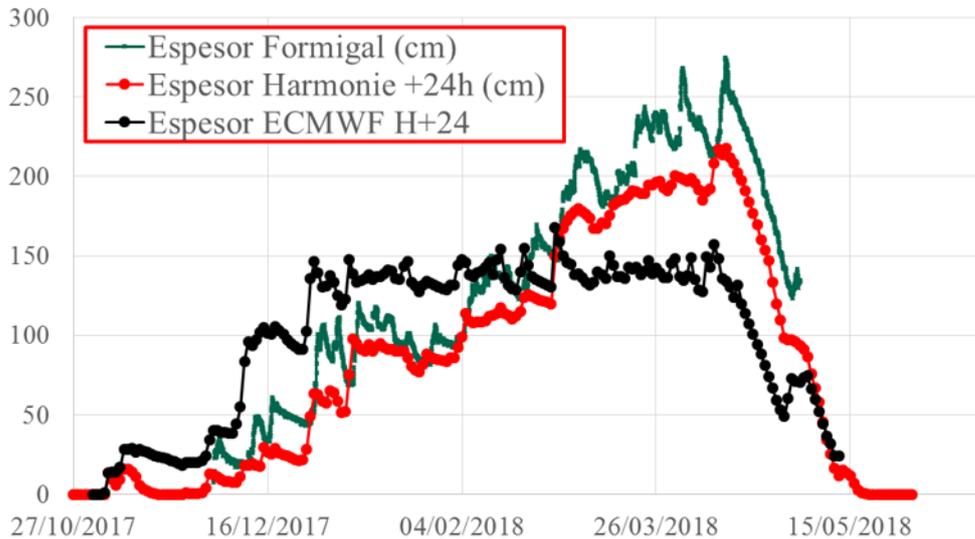


Figure 4: Snow depth evolution of HARMONIE-AROME (red) and IFS (black) for 2017/18 season compared with observation at Formigal (Pyrenees, 1800 m) a reference WMO station (turquoise)

Convection Forecasting

One of the main complains from operational forecasters is an apparent underestimation of deep convection by cycle 40. Subjective comparison with cycle 38 confirms that the latter tends to produce more convection in general what favours convection detection but increases the false alarms. From a statistical evaluation, cycle 40 clearly improves cycle 38 as can be seen in Fig. 5.

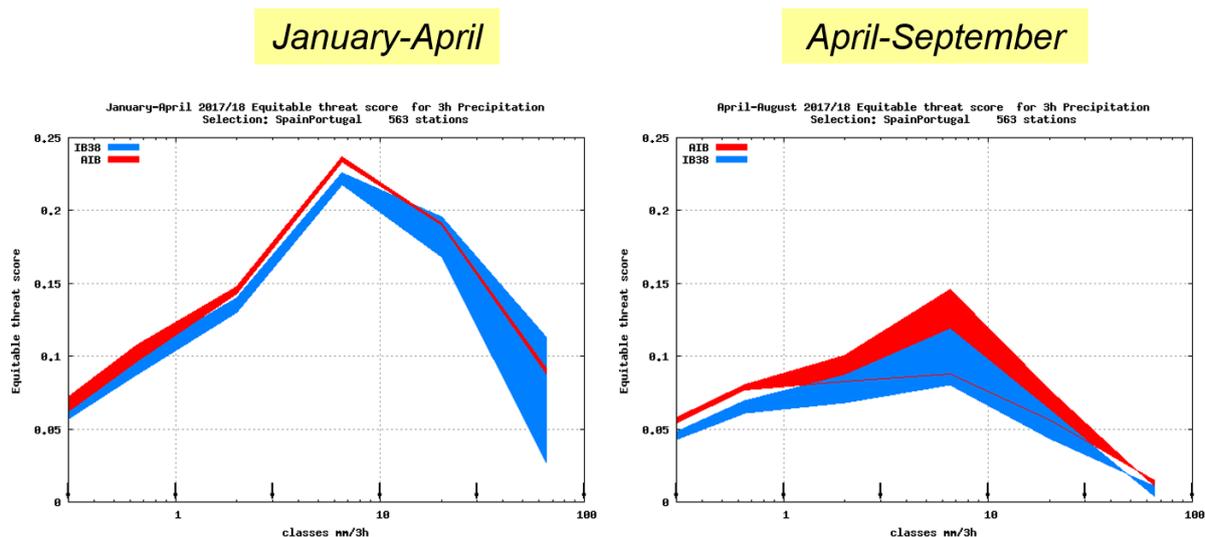


Figure 5: ETS of 3 hr precipitation for cycle 38 (blue) and cycle 40 (red), and 2 seasons Jan/Apr (left) and Apr/Sep (right). Forecasts are compared with rain gauge obs. The shading is plot between the curves corresponding to 2017 and 2018, two very different hydrological years.

3 Radar Data Assimilation

Currently 15 radars from Spain and 3 from Portugal are assimilated in an e-suite run. The data comes from OPERA and so far only reflectivity is assimilated. Following Caumont et al (2010) the reflectivity is transformed to a 1D Relative Humidity profile. A positive impact is seen up to 9 hr in precipitation forecasts and in the humidity profiles (Sánchez-Arriola et al, 2019 in this NL).

4 AMDAR humidity Assimilation

A detailed EUMETNET study (Campins and Navascués, 2018) has shown that E-AMDAR humidity data from Lufthansa aircrafts have good quality and a clear positive impact on the IFS forecasts. The drawback is that only 9 planes include the humidity instruments. Evaluation of the impact of these data on HARMONIE-AROME has shown also a positive impact (Fig. 6) although the weight of AMDAR-humidity observations in the analysis is relatively small due to the low data coverage. Nevertheless, further tests are needed to improve the performance of this data.

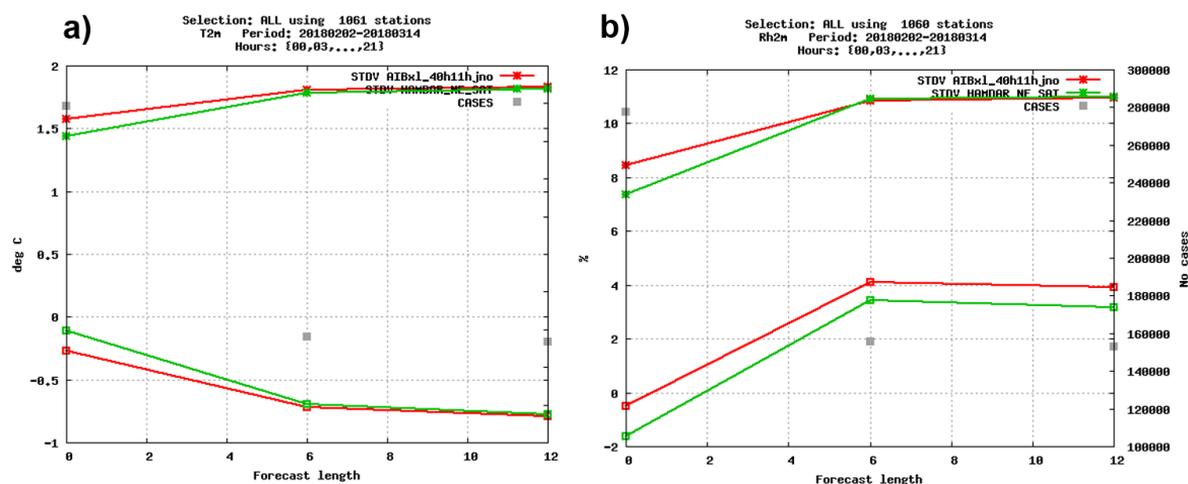


Figure 6: STDV and BIAS for reference (red) and AMDAR-q (green) of (a) 2m temperature and (b) 2m relative humidity

5 Development of new DA techniques

A problem of the 3DVar assimilation is that the model tends to remove rapidly the observation signal included in the analysis due to the lack of proper balances in the initial state. This can be seen for instance when using the Field Alignment technique (Geijo, 2013) that is able to correct for position errors but can create unbalances that have a detrimental impact on short-range forecasts. To overcome this problem, a *Variational Constraints* technique has been developed (Geijo and Escribà, 2018). An interesting feature of this method is the integration in the analysis algorithm of the vertical velocity field, which clearly is important in convection permitting NWP (Fig. 7). Another important characteristic of this technique is its nudging-like functionality making it well suited for DA continuous-in-time, also an indispensable feature for NWP of intrinsically short-time predictability weather. Fig. 7 illustrates the capacity of this method to produce balanced vertical and horizontal dynamics in the analysis.

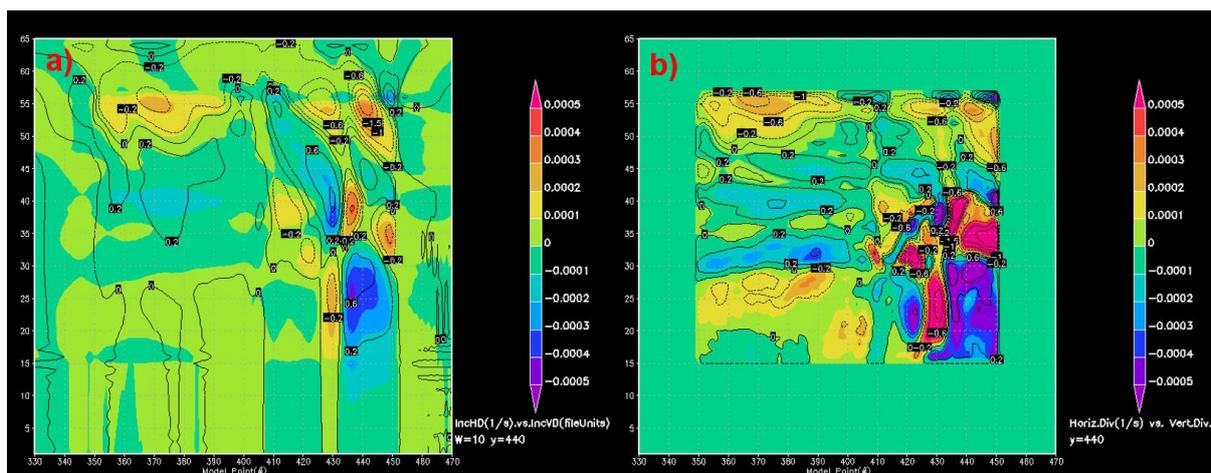


Figure 7: (a) Analysed fields of Vertical Divergence (VD, shading) and Horizontal Divergence (HD, contour). (b) VD and HD fields in mature forecasts. Both VD and HD, display a clear out-of-phase balance in the analysis as they do in the forecasts

Another promising approach under evaluation is the *Local Ensemble Transform Kalman Filter (LETKF)* (Hunt et al., 2007) which belongs to the family of *Ensemble Kalman Filters*. These algorithms are an alternative to variational methods (3DVAR or 4DVAR) to perform DA. LETKF incorporates in a natural manner flow-dependency in estimation of background error, which has become a leading feature in the development of DA algorithms in the recent years and for example produces more realistic analysis increments. LETKF is more expensive than 3DVAR in terms of computing cost (less if compared to 4DVAR), because it incorporates an EPS system in the algorithm itself. First tests with HARMONIE-AROME model show that LETKF in general has better performance than 3DVAR for some surface parameters like Rh2m and T2m, and for humidity parameters in the vertical. For the rest of parameters the impact seems neutral. A study using all the observations used in operations is carried out at the moment.

6 Ingestion of real time aerosols in microphysics and radiation

Aerosols have a big impact over the Iberian Peninsula and especially over the Canary Islands due to the proximity of the Sahara desert. Although the major impact is on the radiation, the influence on the microphysical processes has been the first issue treated. Reference HARMONIE-AROME model uses climatological aerosols with simple land-sea distributions. There is an ongoing work to use real time aerosols from CAMS on model forecasts. On Martin (2018) the impact of using 4 aerosol species to infer Cloud Condensation Nuclei can be seen. The impact is not big but it improves cloud representation. Besides, the impact of CAMS aerosols on the radiation is under study (Rontu et al, 2018)

7 Simulation of MSG SEVIRI images from HARMONIE-AROME

HALSSI (HARMONIE-AROME LAM Simulated Satellite Imagery) is an application (Hernandez et al., 2018), currently in an advanced stage of development, to generate simulated satellite images from the output of HARMONIE-AROME. HALSSI is based on RTTOV, a very fast radiative transfer model developed by EUMETSAT NWP SAF (Saunders et al., 2018). Results of tests to simulate Meteosat-11 SEVIRI channels WV6.2 and IR10.8 over AEMET's operational domain are encouraging, as the simulated images are considerably realistic (Fig. 8) with both model-native and

satellite geometries. HALSSI images are expected to be useful in areas such as operational weather forecasting and for diagnostic purposes, and also for verification in the future.

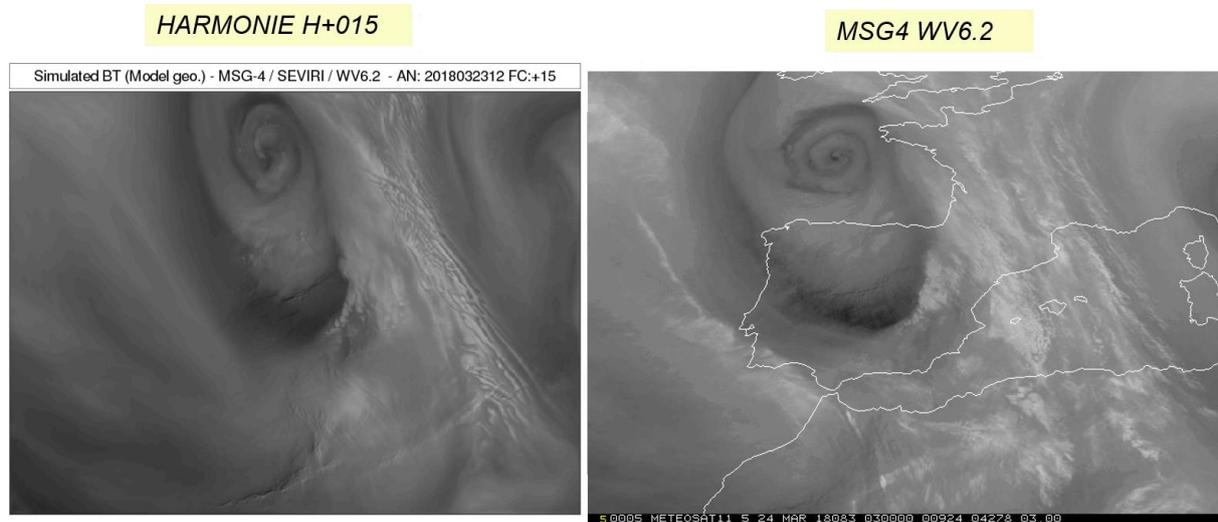


Figure 8: MSG4 WV6.2 simulated image from an H+15 HARMONIE-AROME forecast compared with the corresponding observed MSG4 WV6.2 image during the passage of cyclone Hugo near the Iberian Peninsula.

8 Spatial verification of precipitation

The high-resolution models developed in the last years have been able to come out with a better description of the smaller processes in the atmosphere. Finer grids in addition to a convection-permitting model result in a more realistic precipitation patterns as it is confirmed by comparing the forecasts with the radar observations. However, errors concerning timing and spatial accuracy do still exist due to different reasons: double penalty, coarser grids from boundary conditions, poor representation of the phenomena or just predictability limits.

Traditional objective verification is a complex issue due to the spatial variability and the different scales involved in precipitation, which generally are not well captured by observation networks. Point to point verification might result in poorer scores for high-resolution models due to the double penalty issue. For these models and especially for precipitation, spatial verification can be more appropriate. Instead of relying on located observations, this approach is based on gridded forecasts and observations. Different techniques are possible for spatial verification:

- Object based methods as SAL that try to identify structures in forecast and observation fields and come up with some metrics that offer a global overview of the model behaviour regarding the spatial distribution and intensity of the objects found.
- Neighbourhood methods as FSS where the forecast and observed patterns are compared at different spatial scales. In this methodology, it is not required an exact match between forecasts and observations. Different skill scores can be calculated at the scales of interest, being able to identify the one the model add value to the forecast.

A study has been carried out in AEMET using SAL and FSS spatial verification from HARP tool to assess HARMONIE-AROME and to compare different model versions. In fig. 8 the *Fractional Skill Score* (FSS) is computed for 2 model versions at different scales. It can be seen that scores improve

with the length scale and seem to saturate around 40-50 km. Cycle 40 verifies better than cycle 38 for all the thresholds. The drawback of this study is that the observations come from an analysis of the rain gauge stations that has only a resolution around 30 km.

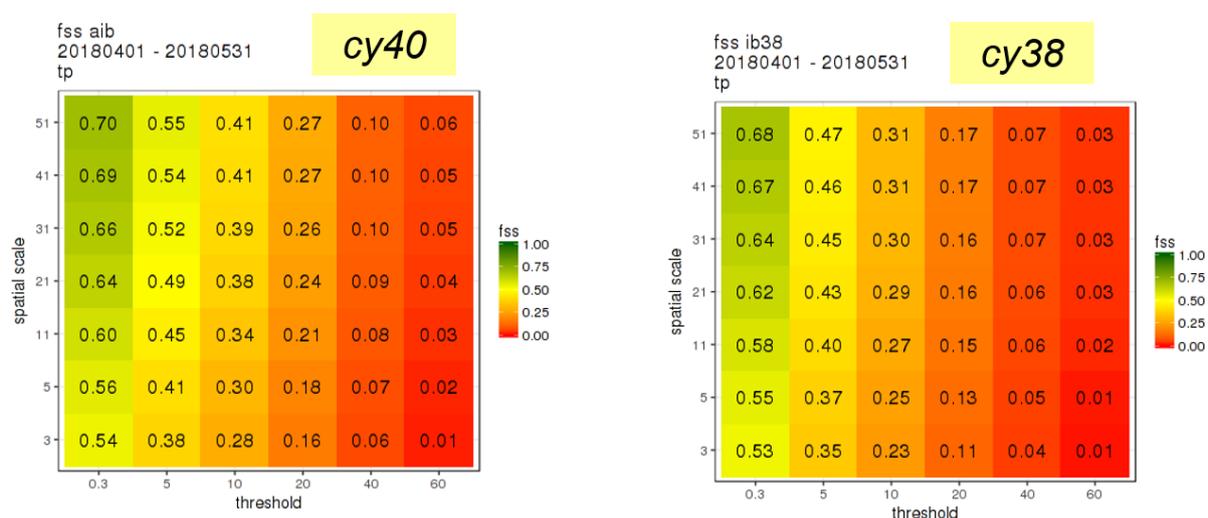


Figure 9: Fractional Skill Score function of the grid scale and the threshold (ppt/24hr) for cycle 40 (left) and cycle 38 (right).

9 AEMET- γ SREPS: convection-permitting Ensemble Prediction System

A 20 members 2.5 km convection-permitting LAM-EPS system called AEMET- γ SREPS (Fig. 10) runs at the ECMWF computers in ecFlow-suite with a 48 hours forecast length. At 00UTC is integrated over three domains: Iberian Peninsula, Canary Islands and Antarctica-Livingston Island (only from 1st December to 31st March); at 12UTC is integrated only over Iberian Peninsula domain. The system is under evaluation by operational forecasters and it is expected to be operational in April 2019. It is a multi-model (HARMONIE-AROME, ALARO, WRF-ARW and NMMB) and multi-boundaries (ECMWF/IFS, MétéoFrance/ARPÈGE, NCEP/GFS, JMA/GSM and CMC/GEM) system. The ensemble is able to reproduce better the boundary and the model uncertainties than systems with single global EPS boundaries and uni-model approaches. The cost is that the system is more difficult to maintain.

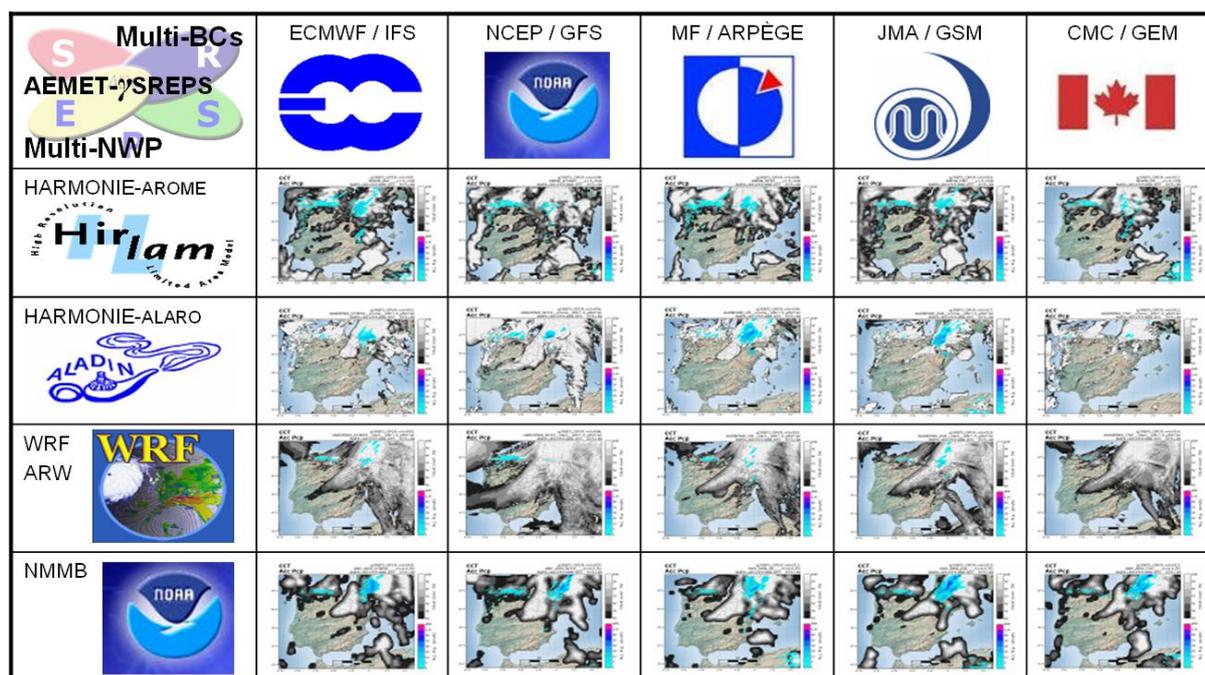


Figure 10: Boundaries and models used in the 20 member γ SREPS LAM-EPS system used in AEMET.

Conclusions and outlook

AEMET operational system is based on HARMONIE 40h1.1 and it is used as RCR together with the METCOOP integrations in order to monitor the quality of the system. The strategy to have North and South domains as reference has turned out to be very positive as model behaviour is different and we have found biases of different signs for the different climatic areas. In this sense, the big positive bias in wind speed is not seen in the METCOOP domain and it points to the need of an enhanced roughness and probably to the need of an orographic parameterization in AEMET domains. The behaviour of convection is similar in both RCRs but the impact is much bigger in the southern domain.

AEMET is doing a significant effort to include new observations in the operational analysis and this is improving the forecast especially during the first hours. We hope to increase the impact of these observations by the Variational Constraints developments and by including the LETKF ensemble DA.

We expect to benefit also from the work on SURFEX in the new model versions, probably by implementing cycle 43. We plan to have an export version of the HALSSI tool to generate simulated images in the near future. On the other hand, we intend to improve the spatial verification by including the radar data.

Concerning the EPS system, there are plans to enlarge the Iberian Peninsula domain because is currently relatively small, include 3DVAR or LETKF assimilation in the system and move Canary Islands domain integration to the AEMET computers

Another area of active research will be the configuration of the model for km and sub-km resolution and there are plans to have a high-resolution model version over the Canary Islands.

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Radar Reflectivity Impact study with HARMONIE-AROME in AEMET

J. Sánchez-Arriola, B. Navascués and J. Calvo

1 Introduction

The current HARMONIE-AROME (Bengtsson et al., 2017) operational suite in AEMET that runs on the Nimbus supercomputer is based on a 3DVar data assimilation with a 3h cycle. It assimilates conventional observations from SYNOP, SHIP, DRIBU, AMDAR, and TEMP reports, GNSS ZTD data, and ATOVS satellite radiances from AMSUA and AMSUB/MHS instruments.

The least observed variable is humidity, because it is just contained in GNSS ZTD and ATOVS AMSUB/MHS observations, apart from in radiosonde profiles available only at 00 and 12UTC. Both the GNSS ZTD and the ATOVS radiances have biases that must be corrected prior to their assimilation. In this sense, the radar reflectivities are a very good additional observation that completes the information of the humidity, due to their wide spatial and temporal distribution and their absence of bias.

The data from the AEMET radar network contribute in real time to the EUMETNET OPERA program. These data are processed and pass a quality filter common to all the other radars of the European National Meteorological Services, so to be harmonized. As a result, homogeneous files are produced and disseminated at European level in conditions to be assimilated by NWP models.

This document describes the impact of the assimilation of radar reflectivity from Spanish and Portuguese radar networks processed and disseminated by OPERA, with respect to the current AEMET operational NWP run configuration.

2 Humidity observations assimilated in the AEMET operational run

As it has been mentioned previously, the humidity observations assimilated in the current AEMET operational HARMONIE-AROME run over the Iberian Peninsula domain are:

- 1) **GNSS Zenith Total Delay (ZTD):** the operational run just assimilates one from each station every three hours, the observation closest to the analysis time. In addition, due to the spatial correlation of their errors, a horizontal thinning of 50 km is applied to these observations.
- 2) **AMSUB/MHS ATOVS satellite radiances:** As they are measured by instruments on board of polar orbiting satellites and the model geographical domain is small, there are analysis times with no available humidity information from ATOVS, as 00, 06 or 18UTC for example. As in the case of GNSS ZTD a data thinning is applied to avoid the effect of correlated observation errors.
- 3) **Radiosondes:** TEMP observations are routinely assimilated at 00 and 12UTC from six places over the Iberian Peninsula (five in Spain and one in Portugal), one in Balearic islands, one in Madeira, and also some others from Italy, France and Switzerland included in the model domain. These observations are not available for other analysis cycles.

On the other hand, from of all these observations only radiosonde data do not contain systematic errors, since the GNSS ZTD data and ATOVS radiances have them. In the AEMET HARMONIE-AROME suite, this bias is corrected by a variational bias correction (VARBC) scheme within the analysis every 3 hours in case on GNSS ZTD, and every 24 hours in case of ATOVS. The radiosonde humidity data, due to the lack of biases, becomes an "anchor observation" at 00 and 12UTC that serves to identify and correct the bias of GNSS ZTD, and ATOVS in these assimilation cycles.

3 Assimilation of radar reflectivities

The OPERA radar observations files received in AEMET contain filtered data of both reflectivity and Doppler winds. OPERA performs a pre-process of the raw data sent by the countries contributing to the project and adds some "metadata" that are useful for data assimilation. Although radar data are available for all Portuguese, Spanish and French radars, only reflectivities from the first two have been used in this study (18 radars). Reflectivities from French radars and Doppler winds will be included in later studies.

Some minor changes have been implemented in the reference code of cycle 40 of the HARMONIE-AROME model to adapt the system locally to the operational context in AEMET.

With respect to the pre-processing and data selection of radar reflectivities, only the observations with an elevation angle higher than 1 degree have been selected. With the ones whose quality "flag" assigned in the OPERA pre-processing exceeded a fixed threshold, a reduction of resolution is performed. Therefore, superobservations are generated, avoiding the effects of spatially correlated observation errors (Ridal et al., 2017).

The relationship between the model variables and the reflectivities is non-linear and therefore it is complex, since it takes into account the microphysics parameterization. Furthermore, reflectivity errors show non-Gaussian distributions. For these reasons, in the HARMONIE-AROME system, the reflectivity variable is not directly assimilated in the model but is previously transformed into a 1D vertical profile of relative humidity as described in Caumont et al (2010). This procedure includes the comparison between the simulated reflectivity by the model and the observation. The humidity profiles assimilated may contribute then to wet or dry the first guess.

4 Experiments description

The study is performed for the Iberian Peninsula domain. First, the model is run over a "spin-up" period in order to calibrate the GNSS ZTD observations in the presence of the new humidity data from the radar reflectivities, and then, for the period of study, two experiments are defined, one as control identical to the operational run (CTRL) and another just adding the radar reflectivity data (REFL).

In order to calibrate the bias coefficients of the GNSS ZTD observations, a parallel experiment (with conventional observations + GNSS ZTD + ATOVS radiances) has been performed assimilating the GNSS ZTD data passively (i.e. without influence the analysis), and radar reflectivity actively. This experiment was run for 16 days, from 1 to 16 February, 2018.

The reflectivities impact study was conducted over a six weeks long period from February 16 to March 31, 2018. This period was very rainy over the Iberian Peninsula. Once the bias coefficients of the ZTD GNSS were calibrated, the two HARMONIE-AROME cycle 40h11 control and experimental runs were started.

5 Results: data assimilation performance

To check the data assimilation performance when introducing the observations of radar reflectivity, we have monitored the fit of observations to the first guess and to the analysis, for the set of assimilated data containing humidity information.

Monitoring of REFL experiment indicates that indeed the change produced in the analysis due to the assimilation of the different observation types is consistent. For radar relative humidity the analysis is closer to the observations than to the first guess (see Figure 1), and it is also so for the GNSS ZTD observations (Figure 2), for ATOVS MHS (Figure 3) and for radiosonde specific humidity (Figure 4).

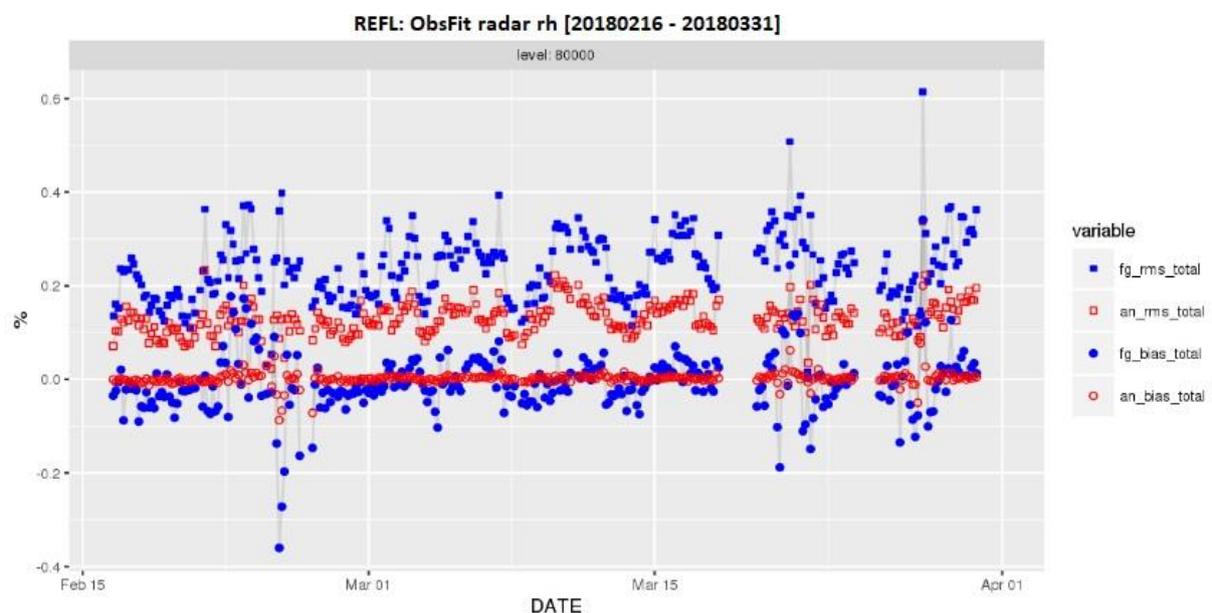


Figure 1
Temporal evolution of the RMS and bias of first guess departure (in blue) and analysis departure (in red) of the radar relative humidity at 800hPa from REFL experiment.

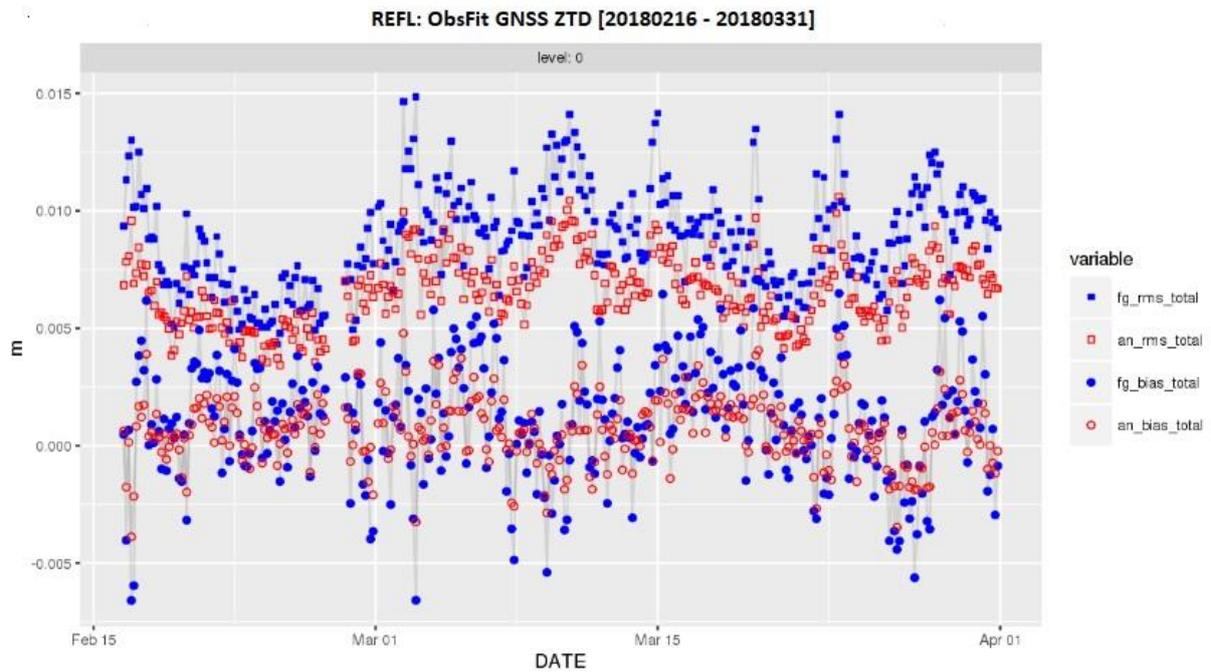


Figure 2
As Figure 1 for GNSS ZTD observations.

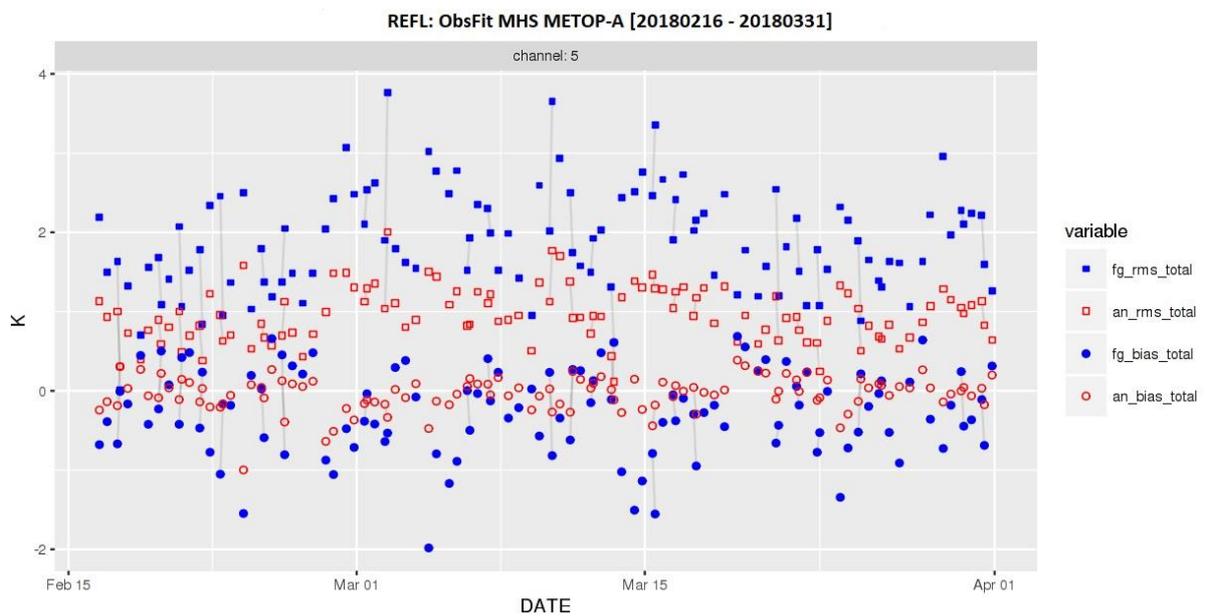


Figure 3
As Figure 1 for METOP-AMHS channel 5.

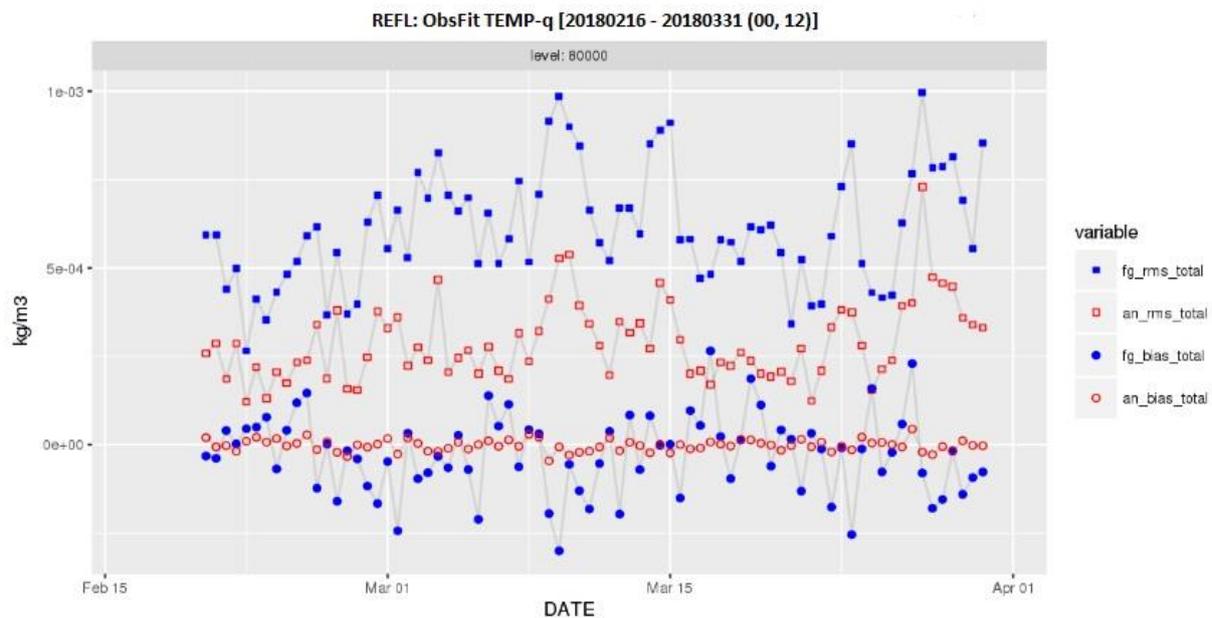


Figure 4

As Figure 1 for radiosonde specific humidity at 800hPa.

Comparing the RMS of first guess and analysis departures for CTRL and REFL experiments, it is observed that the difference between the two is rather small. This is due to the blending with ECMWF forecasts to build the first guess at each assimilation cycle that makes that the progressive effect that an observation can do in the first guess to be rather smooth.

6 Results: forecasts verification

The impact of the assimilation of radar reflectivities has been assessed by means of the objective verification of model forecasts against SYNOP and TEMP observations over this six weeks period. Additionally, some case studies have been evaluated subjectively.

The objective verification against observations indicates that the overall influence of the assimilation of radar reflectivities over the period of study is neutral for most variables, slightly positive for MSLP and humidity and positive for precipitation (Figure 5). On the other hand, the impact is observed mainly in the very short range (up to 12h). The improvement in precipitation skill seems to be related mainly with the reduction of the False Alarm Ratio when assimilating radar reflectivity observations, as it can be seen in Figure 5.

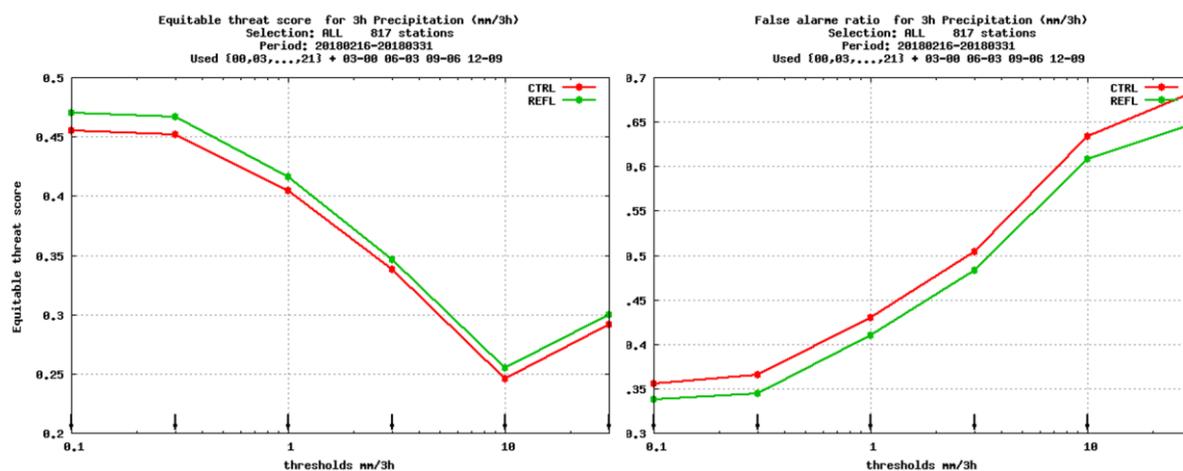


Figure 5:

Equitable Threat score (ETS) and False Alarm Rate for different thresholds of 3h accumulated precipitation by CTRL (red) and REFL (green) experiments. Only forecasts lengths up to 12h are used to calculate the score shown.

Visual inspection of maps of reflectivity simulated by both experiments for different case studies within the period reveals that they are very similar, even those days when objective verification scores indicate the largest differences in precipitation errors. Only the decrease of False Alarms Rate due to radar reflectivities assimilation can be appreciated in some cases, as it happens in a small area over Extremadura in the example shown in Figure 6.

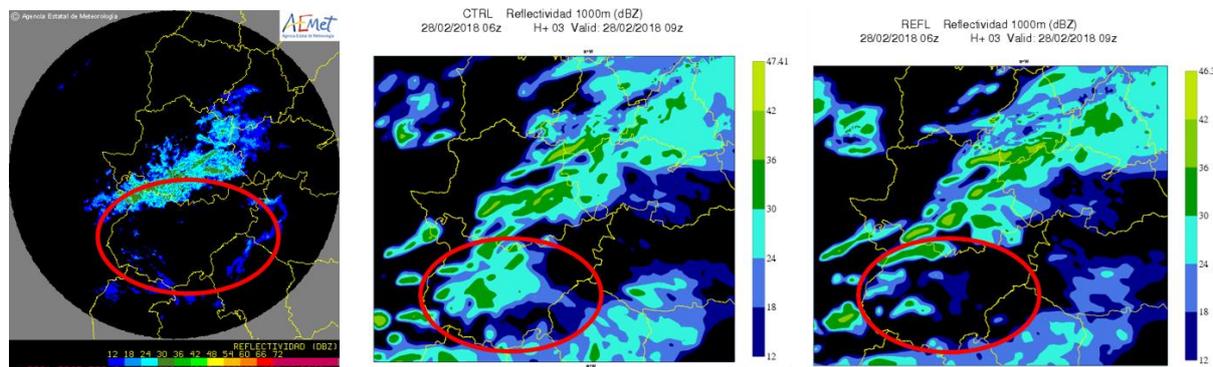


Figure 6

Case study of February 28th, 2018, at 09UTC (a) Observed radar reflectivity, (b) CTRL simulated reflectivity (c) REFL simulated reflectivity. The scale is in dBZ.

Conclusions and further work

The impact of the radar reflectivity assimilation in the operational HARMONIE-AROME run in AEMET has been studied for a period of six weeks between February and March 2018. A positive impact has been obtained, especially on precipitation. This improvement is mainly due to a decrease of the False Alarms rate. The improvement occurs mainly in the first forecast ranges (up 12h), being this result relevant for a HARMONIE-AROME run in support of Nowcasting.

French radars will be included next. On the other hand, the combination of reflectivities with the Doppler winds, also available in the OPERA files, will be studied.

Acknowledgements

The authors would like to acknowledge Martin Ridal from SMHI, and Mats Dahlbom from DMI, for helping in the pre-processing and assimilation of the radar data in Cy40h11, and to Daniel Martin Perez and Angel Alvarez Garcia-Botija for their help in the local installation in AEMET's supercomputer.

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Some highlights of NWP and climate research at SMHI

Jelena Bojarova, Heiner Körnich, Tomas Landelius, Martin Ridal, Danijel Belušić and the NWP and climate research team at SMHI

1 Randomization of B-matrix covariance with taking into account uncertainties of lateral boundary conditions

BRAND perturbation is an alternative scheme available in the HARMONIE-AROME forecasting system for generation of initial conditions perturbations. A similar approach to perturb initial conditions has been tried in Raynaud and Bouttier (2016). BRAND ensemble perturbations are sampled randomly in the entire control vector space and are transformed to the physical model space using the square-root of the climatological background error covariance. The model for the climatological background error covariance is the same as the one used in variational data assimilation to form the analysis increments from observations (Berre, 2000). In the HARMONIE-AROME system the control vector space consists of vorticity, unbalanced divergence, unbalanced mass field (temperature and surface pressure) and unbalanced humidity. The homogeneous and isotropic structure functions are assumed for control variables in physical space. The spectral components of different wavelengths are assumed to be statistically uncorrelated and the horizontal auto-correlation functions for control variables are represented through 1D covariance spectra. The balance operator that projects the control variables to the model space (horizontal winds, temperature, humidity and surface pressure) is defined in spectral space separately for each wavelength through a stepwise multivariate linear regression approach. The elliptic truncation is employed to relate spectral space to 1D waves in the framework of LAM. A BRAND perturbation is generated as follows: A random vector of the size of the entire control vector space is sampled. Then random spectral components corresponding to a particular 1D wavelength are first transformed to impose vertical and horizontal correlation structures and then a separate per wavelength balance operators is applied. Finally an inverse 2D Fourier transform projects the perturbations to the grid-point space. A tunable parameter determines the amplitude of the perturbation. The obtained perturbation is relaxed towards a large-scale perturbation on the lateral boundaries. BRAND perturbations can be created in two different modes, the control mode and the EPS mode. In the control mode the perturbations are added to the first guess of the control. In the EPS mode the perturbations are added to the own ensemble member either before or after upper air data assimilation procedure dependent on the configuration. In the EPS mode the spread of ensemble is constrained assimilating the same observations by all ensemble members. There is a possibility to control how strongly the ensemble members are drawn to observations. Figure 1 shows the control member and a randomly chosen ensemble members, in this case number 11 from 20 members BRAND ensemble in the EPS mode (configuration “after DA”), for the specific humidity model field at approximately 850hPa (model level 47 in the HARMONIE-AROME configuration). The fields are +03h forecasts from HARMONIE-AROME 2.5 configuration valid at 2012 06 19 12 UTC. In Figure 2 the mean and the standard deviation computed from the BRAND ensemble are shown for the same field. One can clearly see a much smoother structure of the mean field (Figure 2, left) in comparison to the control field (Figure 1, left), and a similarities in structures between control field and the ensemble members, even if the fields have obvious differences (Figure 1, left and right plots). The standard deviation is an inhomogeneous and anisotropic field with large amplitude in the areas of dynamically active areas. One may notice also smaller amplitude of the standard deviation in the areas over land where dense observations network is available. This is an attractive feature of BRAND initial condition perturbations that makes them sensitive both to the dynamically unstable areas and the density and quality of observing network.

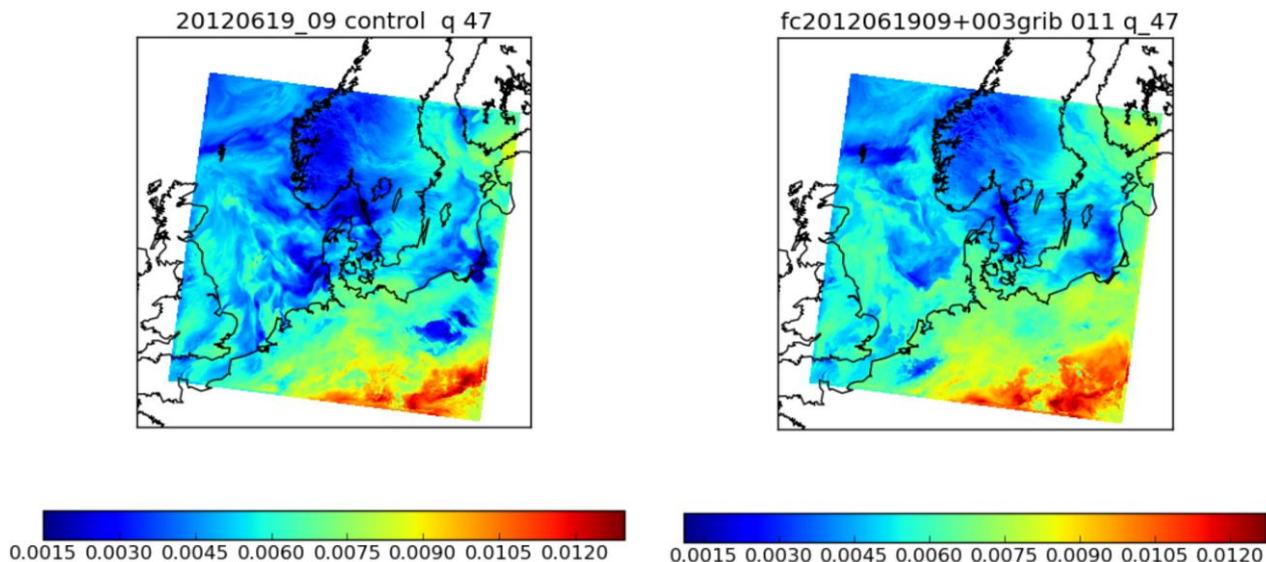


Figure 1: Control (to the left) +03h forecast and the BRAND ensemble member (to the right) for the specific humidity model field at approximately 850hPa valid at 2012 06 19 12 UTC.

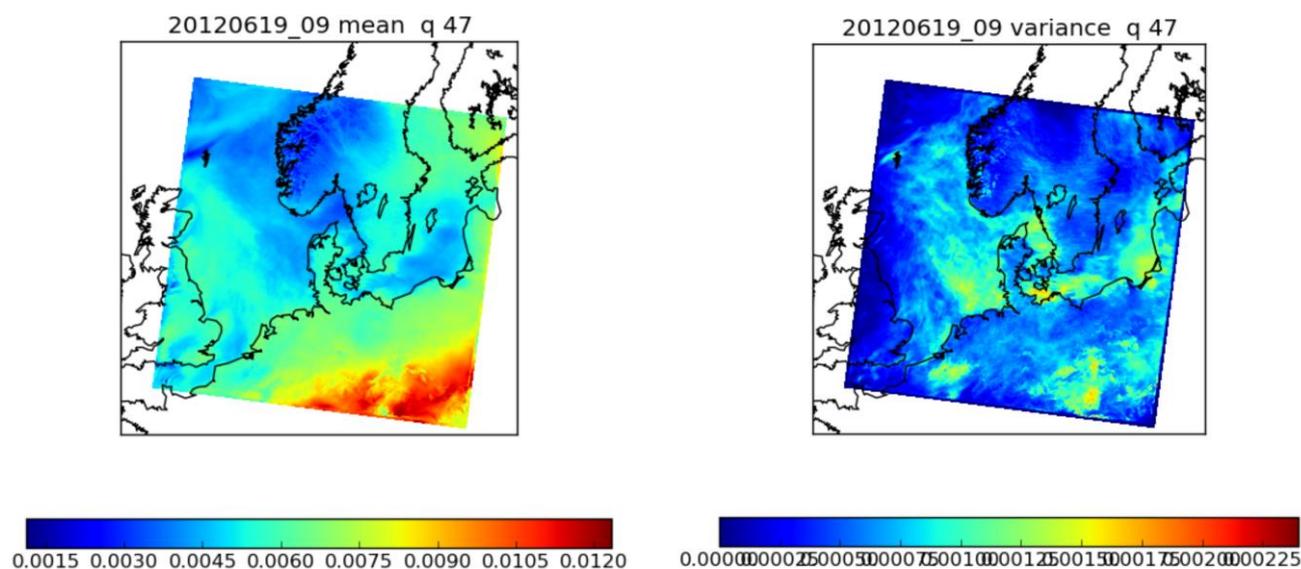


Figure 2: The mean (to the left) and the standard deviation (to the left) of the +03h forecasts of specific humidity model field at approximately 850 hPa computed from the 20 members BRAND ensemble in the EPS mode (configuration “after DA”). The fields are valid on 2012 06 19 12 UTC.

2 Probabilistic forecasting of icing on wind turbines

We examine a probabilistic forecasting chain for icing on wind turbines and the impact of icing-related power loss predictions. This forecasting chain at SMHI consists of a high resolution NWP model, namely HARMONIE-AROME, a physical icing model based on the so-called Makkonen-model, and an empirical power production model. The chain and the related uncertainties are shown in Figure 3.

In the first article (Molinder et al. 2018), we introduced HarmonEPS into this modelling chain and, thus, included uncertainties from initial conditions and representation applying a neighbourhood method. We found that the best forecast skill and forecast uncertainty was provided when both NWP

ensemble and neighbourhood method was combined. Here it was especially important to run the icing-production model for each ensemble forecast and gridpoint of the neighbourhood separately.

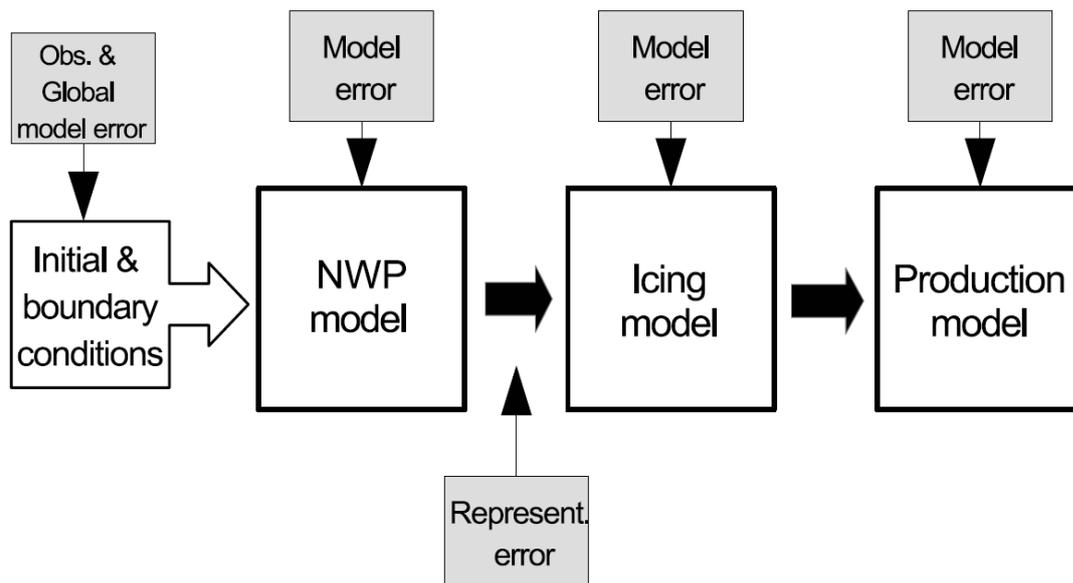


Figure 3: The modelling chain for forecasting icing-related production losses. Uncertain parts are pointed out (reproduced after Molinder et al. (2018a), their Fig.1, CC BY 4.0).

In the second article (Molinder et al. 2018b), we have employed an uncertainty quantification method called deterministic sampling in order to capture the uncertainty of the icing model. In a literature study, we have identified the 5 most uncertain parameters of the icing model with an estimate of their mean and standard deviation. Then, we construct an ensemble with deterministic sampling consisting of 9 members that exactly describes the estimated statistical moments of the uncertain parameters. The results from this ensemble are compared to a random sampling ensemble with 10,000 members. The two ensembles deliver comparable results, but with a fraction of computational costs for the deterministic sampling compared to the random sampling.

3 A 55 year regional re-analysis over Europe

The demands for high resolution regional re-analyses are becoming more common as the interest in local climate variations increases. To meet these requests a regional re-analysis with a horizontal resolution of 11 km has been produced for an area covering Europe over a time period of 55 years, from 1961-2015. The regional re-analysis includes upper air observations introduced by a variational data assimilation scheme as well as surface observations assimilated by an optimal interpolation algorithm. As the available observations increase over time in number (Fig. 4) and, at the same time, improve in quality and distribution, there is an improvement in forecast skill over the time period. The increased quality of the boundary conditions, for the same reasons, also contributes to the improved forecast quality. With a re-analysis over such a long period it is also possible to study climatological changes and consistency over time for different variables. For example, a clear temperature increase has been seen through the 55 years of the re-analysis. Verification against observations has been made for the regional re-analysis as well as to the global re-analysis for comparison. In general the regional re-analysis show good results compared to global re-analyses. This is most clear at the surface where the small scales are most important. There are a few problematic areas though such as moisture and precipitation, especially in complex terrain. An article that describes the reanalysis is planned to be submitted to Tellus (Ridal et al. 2019).

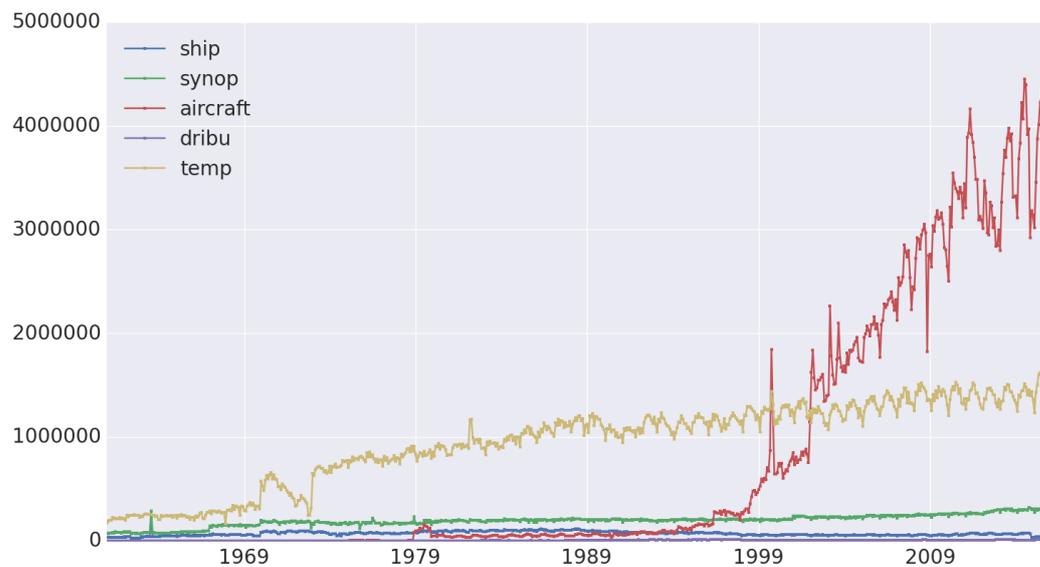


Figure 4: Monthly mean of number of observations used in the upper air analysis from 1961 to 2015. Both the total number of observations (blue) as well as for the different observation types are shown.

4 Modelling and forecasting of PV power production

In a series of articles, we have examined the application of HARMONIE-AROME for solar energy forecasts over Sweden (Landelius et al., 2018a; Landelius et al., 2018b; Landelius et al. 2018c). In the first article (Landelius et al., 2018a) the performance for short-range solar radiation forecasts by the global deterministic and ensemble models from the European Centre for Medium-Range Weather Forecasts (ECMWF) was compared with an ensemble of the regional mesoscale model HARMONIE-AROME used by the national meteorological services in Sweden, Norway and Finland. Note however that only the control members and the ensemble means were included in the comparison. The models resolution differs considerably with 18 km for the ECMWF ensemble, 9 km for the ECMWF deterministic model, and 2.5 km for the HARMONIE-AROME ensemble. It turned out that they both underestimate systematically the Direct Normal Irradiance (DNI) for clear-sky conditions. Except for this shortcoming, the HARMONIE-AROME ensemble model showed the best agreement with the distribution of observed Global Horizontal Irradiance (GHI) and DNI values. During mid-day the HARMONIE-AROME ensemble mean performed best. The control member of the HARMONIE-AROME ensemble also scored better than the global deterministic ECMWF model. This is an interesting result since mesoscale models have so far not shown good results when compared to the ECMWF models.

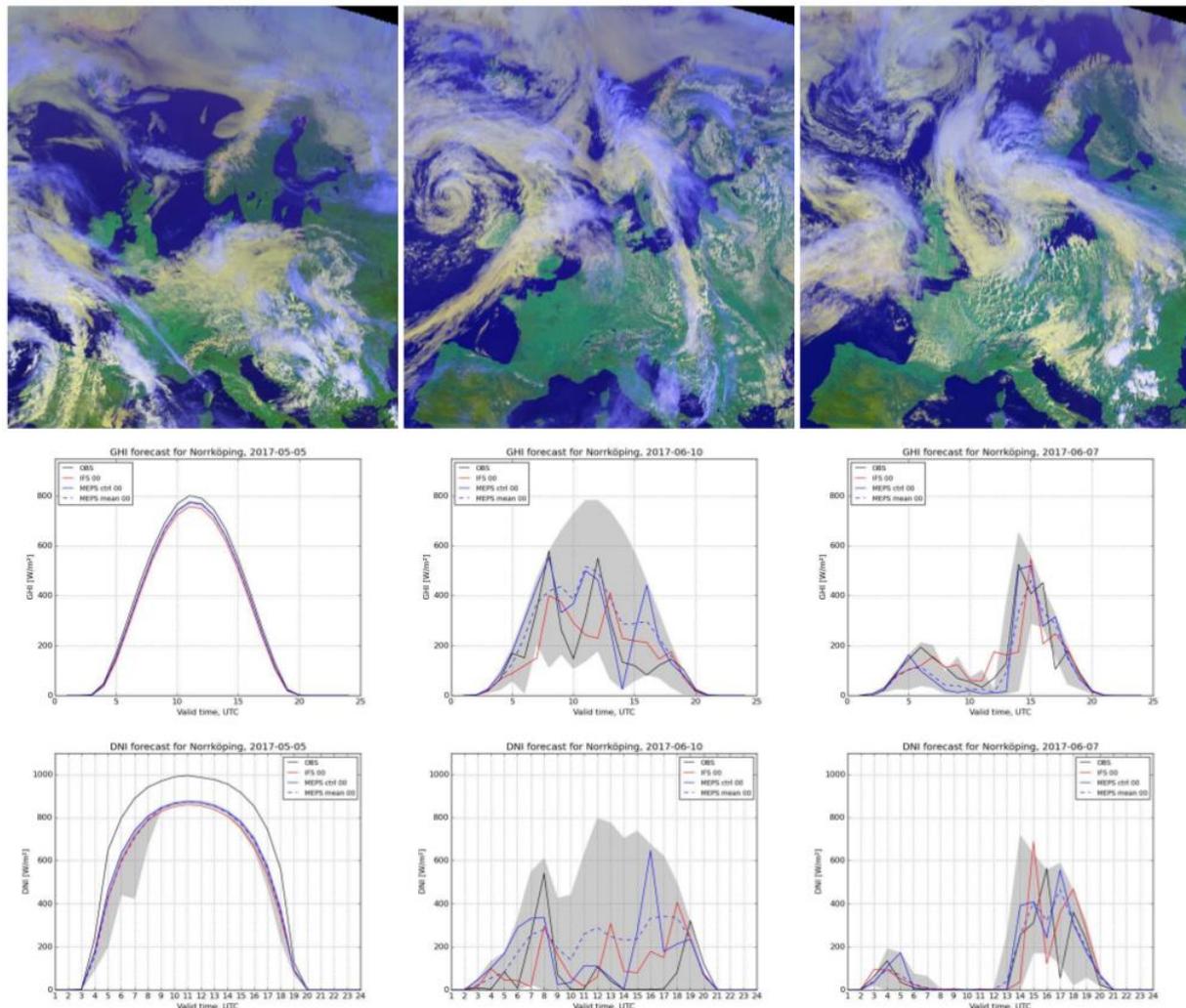


Figure 5: Three cases illustrating forecasts for different cloud conditions: clear (left), mixed (middle) and overcast (right). Top row: cloud images from Meteosat. Middle row: GHI forecasts. Bottom row: DNI forecasts.

In the second paper (Landelius et al., 2018b) we used data from HARMONIE-AROME for hourly day-ahead prediction of the net electricity load at nine photovoltaic installations in a Swedish regional electricity network. The objective of the study was to develop, test and evaluate a set of methods to predict the contribution of PV power to the grid without knowing the production and consumption “behind-the-meter”. An indirect and a direct approach for prediction of the net load were evaluated. For the indirect approach a model of the gross production was first estimated based on the open source software PVLIB. The model was then used to predict the net load given a forecast of the gross consumption. Since we lacked a model of the latter, we used a “perfect forecast”, in terms of measured gross consumption, to estimate the performance of this approach. In the direct approach a model of the net load was estimated using either linear regression or an artificial neural network. Here the model was used for prediction of the net load without any information about the gross consumption. Both approaches rely on information from a numerical weather prediction model together with net load measurements from the previous day. Forecasts using the indirect approach with perfect information about the gross consumption resulted in a normalized (with installed nominal power) RMSEn of 11 %. The direct approach with the artificial neural network also resulted in an RMSEn of 11 %, even though it did not have any information from behind the meter. Linear regression had an RMSEn of 12 %

Finally, the third paper (Landelius et al., 2018c) shows the value of ensemble prediction for trading solar power on the electricity market. The aim of this paper was to study how the use of an advanced

trading method, like the optimal quantile strategy, may affect the balance between generation and consumption at the power system level when trading solar PV power on the Nordic Power Exchange. In order to do this we first developed a set of PV power forecast models. Numerical weather prediction data together with power measurements at 210 PV installations, in the regional network operated by Tekniska Verken Linköping Nät AB, were used for estimation and evaluation. Linear and non-linear regression, the latter in terms of an artificial neural network, both resulted in an RMSE, normalized with installed power, of about 6 %. Second we used the neural network to perform a three month simulation experiment on the Nord Pool Elspot day-ahead market. Strategies based on deterministic forecasts were compared with the use of the optimal quantile, based on ensemble forecasts of the power probability distribution. The optimal quantile strategy resulted in an increased revenue of around 2 % but also in an increased imbalance between contracted and produced energy of almost 20 %. The imbalanced part of the power production for the optimal quantile strategy was about one third. A similar study, on trading wind power with the same strategy from a hypothetical plant on the Nord pool market, showed that about half of the traded energy became imbalanced. This paper was presented at the 8th Solar Integration Workshop and published in the workshop's proceedings.

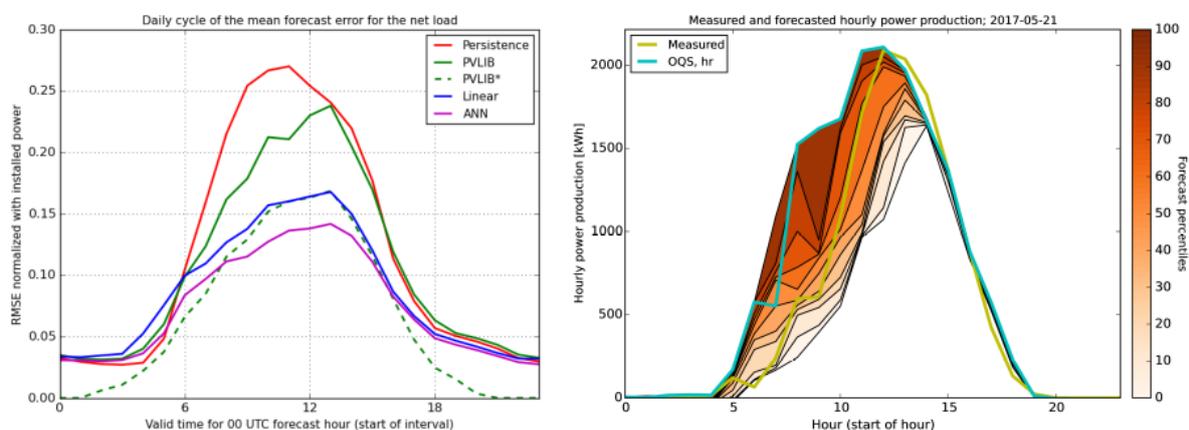


Figure 6: Left: Daily mean RMSEn cycle for net PV predictions using persistence, PVLIB without and with (*) forecasts of the gross consumption, linear regression and an artificial neural network. Right: measured power production (yellow) and bid based on the optimal quantile strategy using actual hourly values of the ratio (cyan) along with forecasted quantiles for the power production from the NWP ensemble system. All forecasts are issued at 00 UTC.

5 HARMONIE-CLIMATE

A stable version of HARMONIE-Climate cycle 38 (HCLIM38) is now available for regional climate downscaling, particularly at convection-permitting scales. The model development is done within the HCLIM consortium in collaboration with other HCLIM participating institutes (currently active participants are: AEMET, DMI, FMI, MET Norway, and SMHI, while KNMI contributed considerably to the model development but are currently not participating actively in the consortium). HCLIM38 is used in a number of projects and currently the majority of simulations with SMHI involvement are performed collaboratively with DMI, FMI, and MET Norway using exactly the same modelling setup. The simulations are performed over 10 or 20 year time slices for typically four such time slices per project: evaluation run (downscaling ERA-Interim), and historical and scenario mid and end of century runs (downscaling GCMs). These simulations at convection-permitting scales require a large amount of resources, and are to a great extent achievable only because of the collaboration with other institutes. One such project is Nordic Convection Permitting climate projections (NorCP), where simulations are performed over a domain similar to the operational MetCoOp domain (Fig. 7). Another project is CORDEX-FPS on convection, aiming at creating an

ensemble of convection permitting climate simulations using different models. The project and preliminary results are described in Coppola et al. (2018). HCLIM38 was also used in the UrbanSIS project (Amorim et al, 2018). Figure 8 summarizes the current collaborative projects and simulations with SMHI involvement.



Figure 7: Domains used in NorCP project. The red box depicts the HCLIM-AROME 3 km grid

HCLIM-COM	Nordic 3km (4 x 20 years)	Nordic 12km (4 x 20 years)	Alps 3km (4 x 10 years)	Alps 12km (4 x 10 years)	CE-EUR 3km (3 x 10 years)	CE-EUR 12km (3 x 10 years)
Evaluation ERA-Interim	NorCP: 1998-2017	NorCP: 1998-2017	-	-		
	EUCP: 2000-2009	EUCP: 2000-2009	EUCP: 2000-2009	EUCP: 2000-2009	EUCP: 2000-2009	EUCP: 2000-2009
	CORDEX: [10yr] 2000-14	CORDEX: [10yr] 2000-14	CORDEX: [10yr] 2000-14	CORDEX: [10yr] 2000-14		
Historical EC-Earth	NorCP: 1986-2005	NorCP: 1986-2005	-	-		
	EUCP: 1996-2005	EUCP: 1996-2005	EUCP: 1996-2005	EUCP: 1996-2005	EUCP: 1996-2005	EUCP: 1996-2005
	CORDEX: 1996-2005	CORDEX: 1996-2005	CORDEX: 1996-2005	CORDEX: 1996-2005		
Mid-century EC-Earth RCP8.5	NorCP: 2041-2060	NorCP: 2041-2060	-	-		
	EUCP: 2041-2050	EUCP: 2041-2050	EUCP: 2041-2050	EUCP: 2041-2050	EUCP: 2041-2050	EUCP: 2041-2050
	CORDEX: 2041-2050	CORDEX: 2041-2050	*CORDEX: 2041-50	*CORDEX: 2041-50		
Late-century EC-Earth RCP8.5	NorCP: 2081-2100	NorCP: 2081-2100	-	-		
	EUCP: [opt] 2090-99	EUCP: [opt] 2090-99	EUCP: [opt] 2090-99	EUCP: [opt] 2090-99		
	CORDEX: 2090-2099	CORDEX: 2090-2099	CORDEX: 2090-2099	CORDEX: 2090-2099		

■ DMI
■ SMHI
■ METNo
■ FMI

NorCP: DMI, SMHI, FMI, METNo ; CORDEX: DMI, SMHI, METNo ; EUCP: DMI, SMHI
 Simulation periods are not including spin-up
 *CORDEX: Mid-century are included, but not prioritized for April 2019 deadline

Figure 8: List of projects and simulations performed collaboratively with DMI, FMI and METNo. HCLIM-COM stands for the HCLIM community (courtesy of Rasmus A. Pedersen, DMI). Nordic, Alps and CE-EUR are model domains. EUCP, NorCP and CORDEX are project acronyms.

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NWP Related Activities in TUNISIA

National Institute of Meteorology of Tunisia

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, 12 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 3DVAR Data Assimilation Implementation

Convective meteorological systems, which cause heavy rainfall over Tunisia, can cause major floods especially during autumn. In order to improve precipitations prediction, the impact of variational data assimilation during intense rain events in convective situations with AROME model over Tunisia was studied. This study was conducted to better understand and predict convective mesoscale phenomena that remain one of the major concerns of National Institute of Meteorology.

The case study below (Figure 2) shows the data assimilation impact on the forecast of the precipitations. On the 3rd of October 2017, 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.

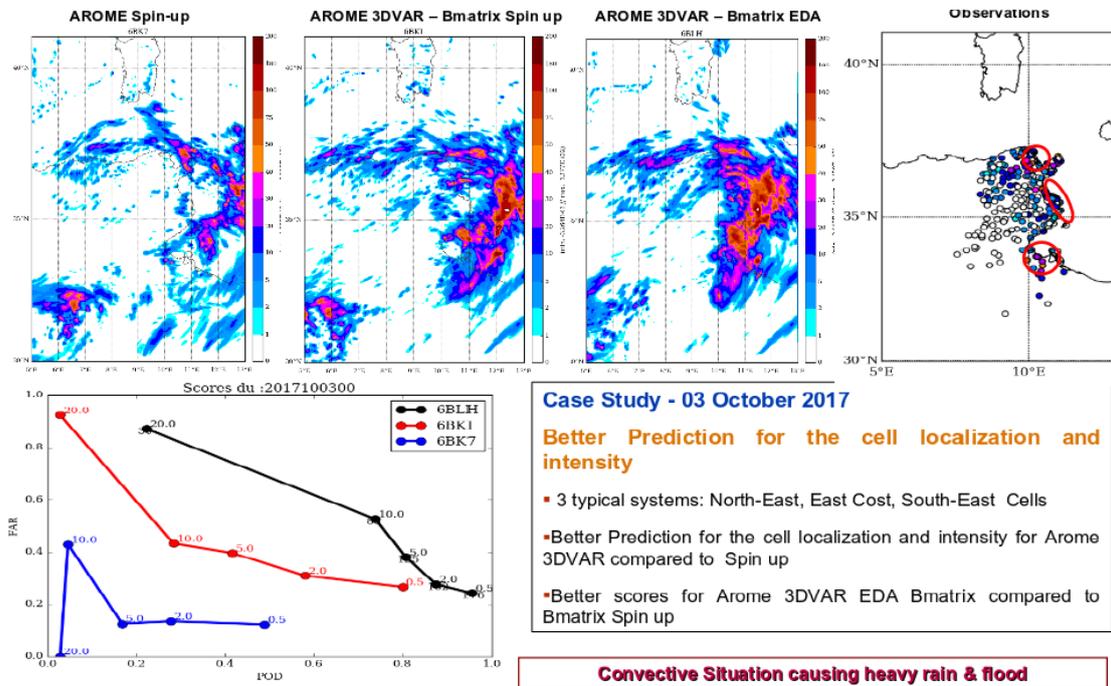


Figure 1: Case Study 3rd October 2017 - 24H accumulative rainfall- from left to right: AROME 3DVAR, AROME Spin-up and Observation

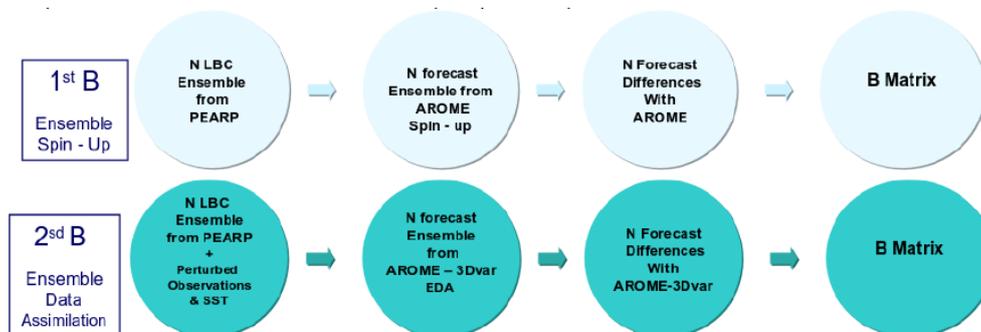
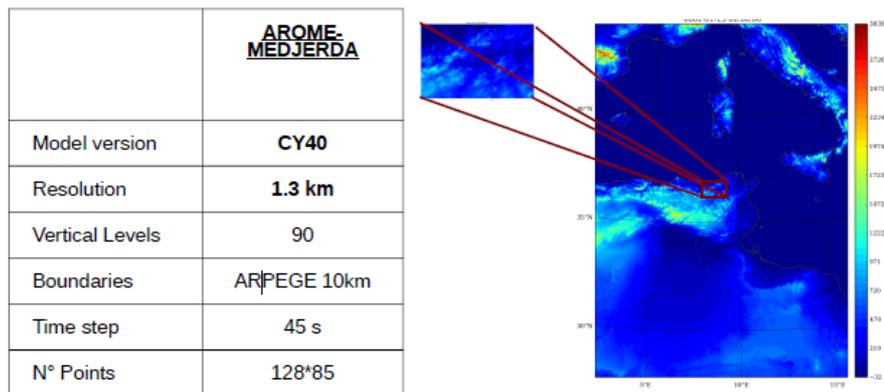


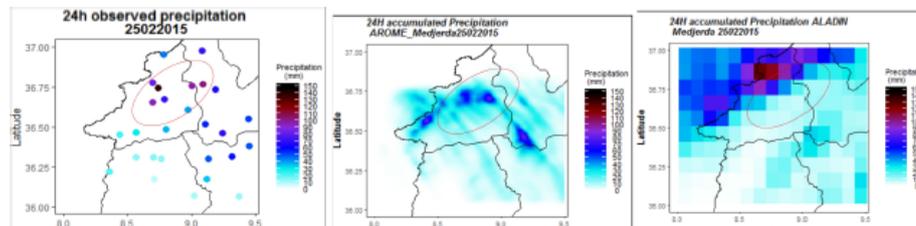
Figure 1: B matrix Computation for the AROME 3DVAR

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

In the frame work of a collaboration with the Department of Water Resources Management, we prepared a configuration of AROME over the catchment of Medjerda (one of the most important watershed that suffers from severe flooding and contains several dams) in order to provide better and more suited forecast products for a hydrological application.



The catchment 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.



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

Figure3: AROME-Medjerda Configuration

Calculation of Background Error Statistics for ALARO Turkey

Yelis CENGIZ, Meral SEZER

1 Introduction

ALARO-Turkey has been running with 3D-Var assimilation system since end of 2017 in quasi-operational mode. ALARO-Turkey has 4.5 km horizontal resolution and 60 levels. The assimilation cycle is using 6h cycling. Previously background error statistics (B matrix) of ALARO-Turkey were computed with NMC method (in cycle 38) (Parrish and Derber, 1992). To represent the uncertainty of background state more precisely, new B matrix was calculated with ensemble method (Fisher, 2003; Belo Pereira and Berre, 2006; Stefanescu et al., 2006).

2 Computation Method of B-Matrix

The B matrix was calculated by ensemble approach using 4 members of ARPEGE ensemble. The calculation was done for the period of February 1-14 2018. 4 runs (00, 06, 12, 18) a day were included. All members were downscaled to ALARO Turkey resolution (4.5 km). Since the length of the assimilation cycle is 6 hours, +6h forecasts were produced. Totally, 112 forecast differences (14 days and 4 runs a day) were obtained from 4 members (RUN2-RUN1, RUN4-RUN3) and used as inputs of B matrix calculation. The B matrix and related diagnostics were calculated by programs FESTAT and FEDIACOV.

The namelist switch **LFEMARSD** was set .T. to obtain differences of prognostic variables in grib format and **LSPRT** was set .F. to calculate temperature differences.

Afterwards the diagnostics obtained from ensemble method were cross checked with those computed with NMC method. The horizontal and the vertical resolutions in cycle 38 were same as in cycle 40 (4.5 km, 60 levels).

Vertical profiles of standard deviations of vorticity, temperature, specific humidity and divergence are shown in Figure 1 and 2. For temperature, vorticity and divergence vertical profile of ensemble standard deviation is greater. For specific humidity of the ensemble, standard deviation is reduced.

Vertical profiles of correlation lengthscales are plotted in Figure 3 and 4. For vorticity, temperature and divergence, ensemble length scale is shorter than nmc. However for specific humidity in the higher levels, ensemble length scale is longer.

In the following figures the diagnostics are shown.

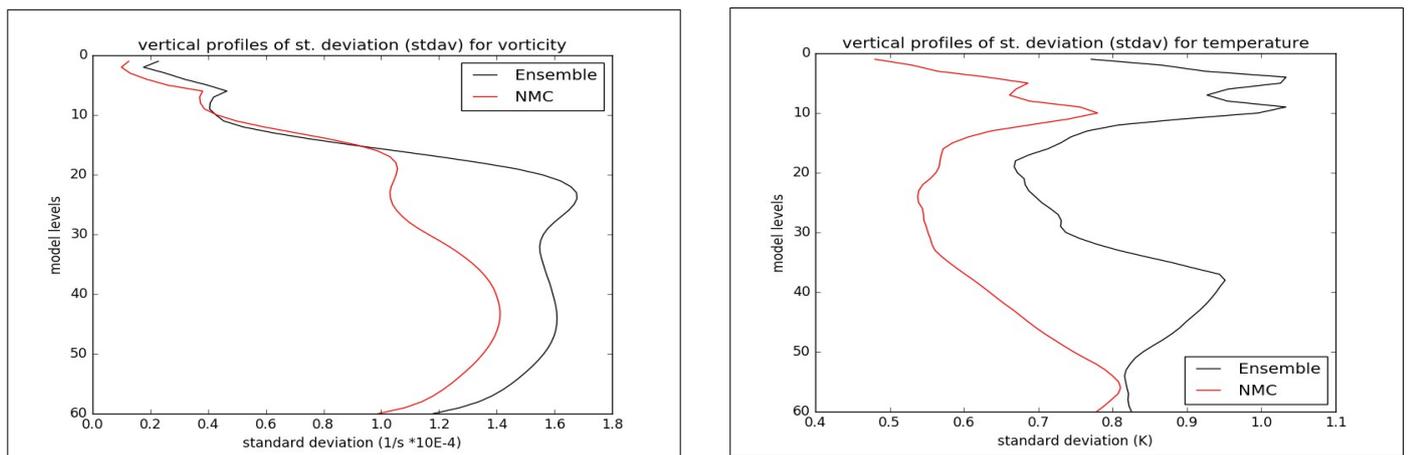


Figure 1: Vertical profiles of st. dev. for vorticity and temperature.

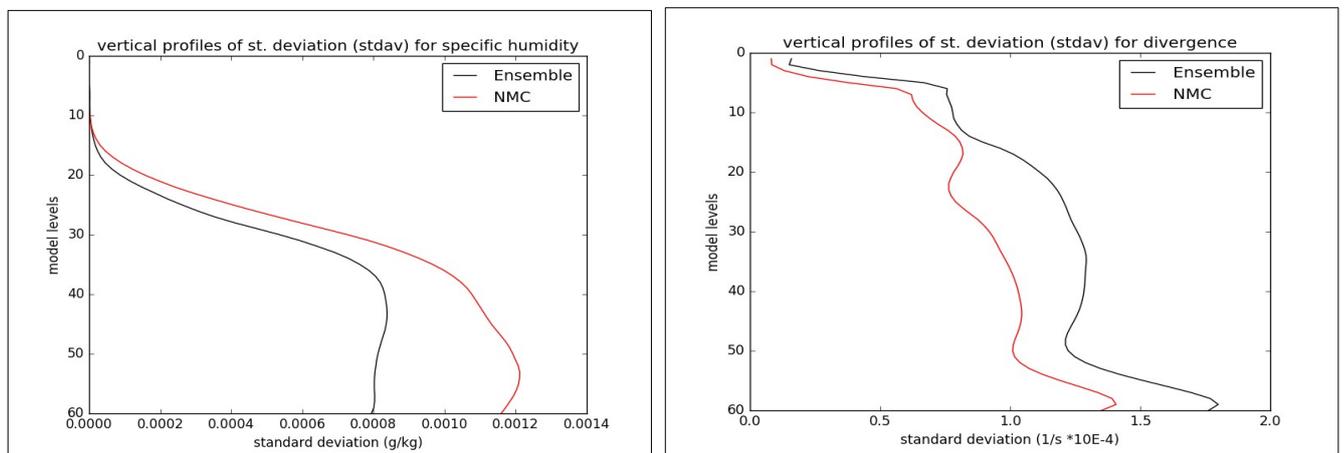


Figure 2: Vertical profiles of st. dev. for specific humidity and divergence.

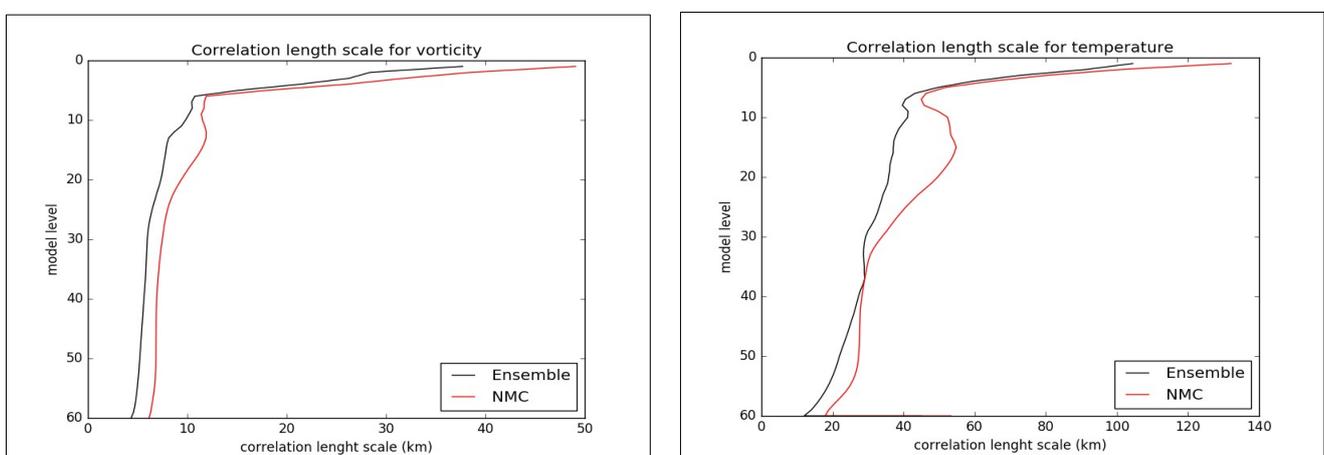


Figure 3: Vertical profiles of the correlation length-scales for vorticity and temperature.

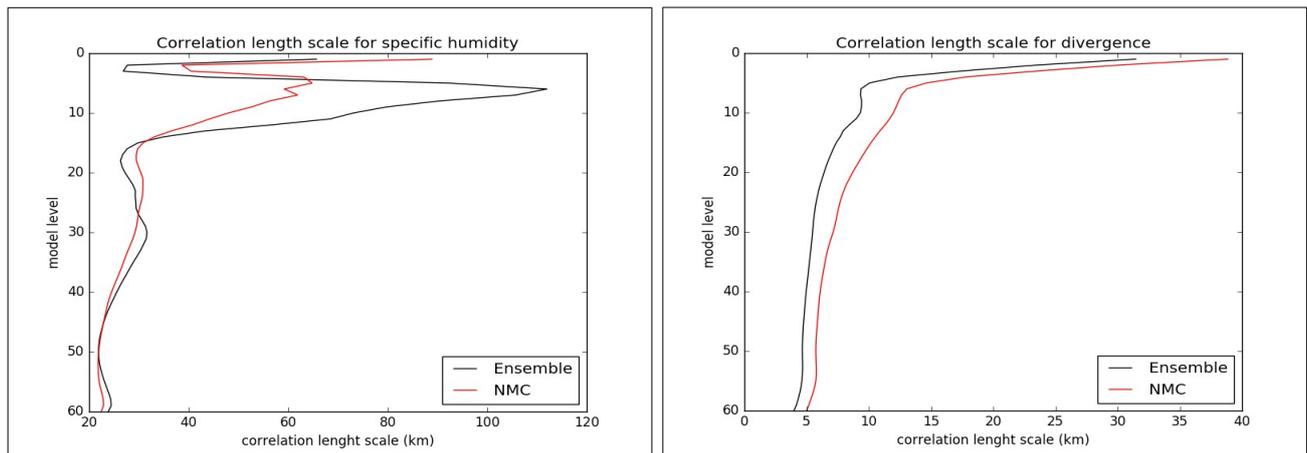


Figure 4: Vertical profiles of the correlation length-scales for specific humidity and divergence.

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Martina TUDOR
University of Zagreb, Croatia.*

More information on the previous ALADIN PhDs on the aladin website :
<http://www.cnrm-game-meteo.fr/aladin/spip.php?article88>

Improvements in the operational forecast of detrimental weather conditions in the numerical limited area model ALADIN

Martina Tudor, University of Zagreb, Faculty of Science

Supervisors: prof. dr. sc. Piet Termonia and doc. dr. sc. Nataša Strelec Mahović

1 Abstract

Severe weather represents storms, cyclones, fronts, severe wind or thick fog and other phenomena. Limited area models (LAM) can simulate or forecast such phenomena in higher resolution and using dedicated model set-up. This thesis explores the ALADIN (Aire Limitée Adaptation dynamique Développement InterNational) model capabilities to forecast threatening weather conditions for wider area of the Republic of Croatia. The research focuses on the consequences of a fast cyclone entering LAM domain through lateral boundary too quickly to be detected, frequency of such events, mechanism for automatic detection of such events and methods to treat the problem in the operational forecast. The solution will be applied to events with severe weather such as windstorms and/or intensive precipitation.

This thesis deals with problems of temporal interpolation of the lateral boundary conditions (LBC) for a limited area model (LAM). The LBCs are taken from a large scale model and usually available with an interval of several hours. However, these data are used at the lateral boundaries every model timestep, which is usually several minutes. Therefore, the LBCs are interpolated in time.

In practice, the LBCs are usually interpolated with a 3 h temporal resolution. This can be too infrequent to resolve rapidly moving storms. This problem is expected to be worse with increasing horizontal resolution. In order to detect intensive disturbances in surface pressure moving rapidly through the model domain, a filtered surface pressure field (MCUF - monitoring of the coupling update frequency) is computed operationally in the ARPEGE global model of Météo France. The field is distributed in the coupling files along with conventional meteorological fields used for LBCs for the operational forecast using ALADIN LAM in the Meteorological and Hydrological Service of Croatia (DHMZ). Here an analysis is performed of the MCUF field for the LACE coupling domain for the period since 23rd of January 2006, when it became available, until 15th of November 2014. The MCUF field is a good indicator of rapidly moving pressure disturbances (RMPDs). Its spatial and temporal distribution can be associated to the usual cyclone tracks and areas known to be supporting cyclogenesis. Alternative set of coupling files from IFS operational run in ECMWF is also available operationally in DHMZ with 3 h temporal resolution but the MCUF field is not available. Here, several methods are tested that detect RMPDs in surface pressure a posteriori from the IFS model fields provided in the coupling files. MCUF is computed by running ALADIN on the coupling files from IFS. The coupling error function¹ (that shows when the temporal interpolation misses the storm) is computed using one time step integration of ALADIN on the coupling files without initialization, initialized with digital filter initialization (DFI) or scale selective DFI (SSDFI). Finally, the amplitude of changes in the mean sea level pressure is computed from the fields in the coupling files. The results are compared to the MCUF field of ARPEGE and the results of same methods applied to the coupling files from ARPEGE. Most methods give a signal for the RMPDs, but DFI reduces the storms too much to be detected. The coupling error function without filtering and amplitude have more noise,

¹There are many functions called *error function* in the literature, this work focuses on the *coupling error function*.

but the signal of a RMPD is also stronger. The methods are tested for NWP LAM ALADIN, but could be applied to other LAMs and benefit the performance of climate LAMs.

Usually, LAMs use higher resolutions and more advanced parameterizations of physical processes than global numerical weather prediction models, but suffer from one additional source of error - the LBCs. The large scale model passes the information on its fields to LAM only over the narrow coupling zone at discrete times separated by a coupling interval of several hours. The LBC temporal resolution can be lower than the time necessary for a particular meteorological feature to cross the boundary. A LAM user who depends on LBC data acquired from an independent prior analysis or parent model run can find that usual schemes for temporal interpolation of large scale data provide LBC data of inadequate quality. The problem of a quickly moving depression that is not recognized by the operationally used gridpoint coupling scheme is examined using a simple one-dimensional model. A spectral method for nesting a LAM in a larger scale model is implemented and tested. Results for a traditional flow-relaxation scheme combined with temporal interpolation in spectral space are also presented.

The work presented here shows that more frequent LBCs are important for forecasting small storms even when they develop inside the domain. Missing a storm in a LAM forecast due to infrequent LBCs has led to a model tuning that enhances storm development. Unfortunately, the same tuning is not very supportive for the fog development.

Key words: Limited area model; Lateral boundary conditions; Coupling; Storms; Temporal interpolation ; Interpolation error; Fourier transform; Spectral coefficients; Phase; Amplitude

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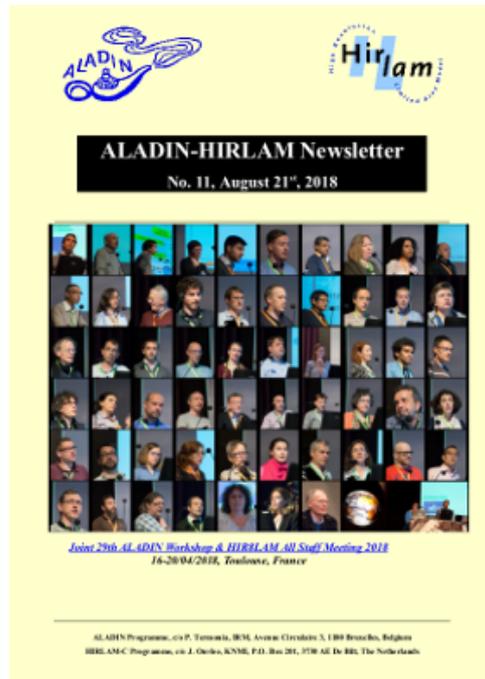
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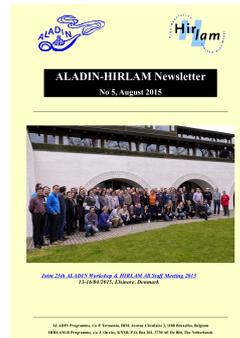
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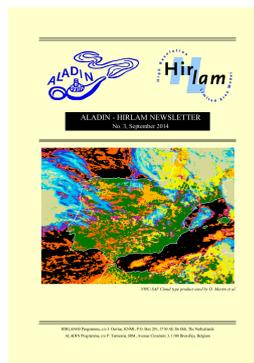
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