ALADIN Report 2019

This report describes the activities of the ALADIN consortium in 2019. It follows the structure of the work plan as it can be found in http://www.umr-cnrm.fr/aladin/IMG/pdf/rwp2019-approved.pdf. A report on the highlights of the activities in the Institutes of the ALADIN Members will be provided in the next ALADIN-HIRLAM Newsletter that will be published on the ALADIN website in the beginning of 2020.

MGMT1: Management

All tasks have been executed as planned.

The main work during the last year was the work of the convergence working group (CWG). This group consists of the three PMs (ALADIN, LACE, HIRLAM), the chairs of the PAC and HAC, the CSSI chair and a representation of the Météo France (Philippe Bougeault) and the ALADIN Scientific Secretary (Patricia Pottier). The group was tasked during the previous joint ALADIN General Assembly HIRLAM Council (AG/HC) meeting Zagreb to produce a first draft of a MoU for the single consortium. Several meetings took place:

- A kick-off meeting in Toulouse: 11-12-13 February 2019
- A meeting on 24 April 2019 in Brussels where mainly to the scope and the content of the management was a more elaborated. It was also decided that the precise scope of the collaboration will be established during a Strategy meeting planned in February 2020 in Toulouse.
- The joint PAC and HAC meeting on 13-14 May 2019 was used to produce a first draft taking into account their feedback. The draft was sent to the Directors of GA and HC asking to provide their feedback.
- On 28 June the draft was discussed during the HIRLAM Council. There were three main issues to be clarified: (i) the goal of the consortium should be clear, (ii) the expected evolution (of the management) and (iii) it was requested to provide an alternative scheme for the financing. Several other ALADIN countries provided their comments.
- After summer the CWG prepared replies to the comments and a new draft of the MoU, to be discussed by the PAC and HAC on 4-5 November 2019.
- After the PAC-HAC meeting, a new draft was prepared to be discussed by the General Assembly and Council on 16-17 December 2019.

The ALADIN workshop/HIRLAM All Staff meeting was organized this year in Madrid from 1-5 April 2019. Details and the slides of the presentations can be found on the ALADIN website: http://www.umr-cnrm.fr/aladin/spip.php?article322

During 2019 we organized several working days, training days:

- ALARO1 working days in SHMU, Bratislava, 11-13 March 2019
- Code Training, Météo France, Toulouse, 9-13 September 2019: http://www.umr-cnrm.fr/aladin/spip.php?article347
- The Dynamics Days in Toulouse on 28 May 2019 : http://www.umr-cnrm.fr/aladin/spip.php?article343
- the DasKIT meeting and the RC LACE data assimilation working days at CHMI, Prague, on 18-20 September 2019 and several web conferences. See the documents and minutes on the DasKIT pages : http://www.umr-cnrm.fr/aladin/spip.php?rubrique74
- Finally, a training organized by HIRLAM on data assimilation in OMSZ, Budapest, 11-15 February 2019 and it was attended by several ALADIN staff members.

Several ALADIN colleagues attended the EWGLAM workshop, see https://storm.cfd.meteo.bg/ewglam/. A few conclusions from his workshop are:

- A lot of attention was payed to crow-sourced data and machine learning. Some promising results were shown on the use of data from smart phones.
- Regarding EPS it was stressed that developing perturbation methods can not replace model developments. There is an increasing trend to focus more on developing diagnostics for physics than for fundamental developments.
- It was (once again) recognized that we need to spent efforts on the quality of the physiographic datasets. With the ALADIN-LACE-HIRLAM community we plan to switch to ECOCLIMAT-SG. This dataset ha been prepared by Météo France. COSMO is also using data of ESA-CCI. EUMETNET will attempt to organize a common action to the documentation of found errors in the dataset and possibly also try to find funding to hire a person to clean/correct the data.
- The development of the RC LACE consortium on vertical finite element discretization has been implemented in the IFS (https://www.ecmwf.int/en/about/media-centre/news/2019/tests-numerical-scheme-developed-member-states-are-promising). It has

been demonstrated that some temperature biases in the tropopause can be controlled and improved with this model. Based on very encouraging results in first tests, it is anticipated that the new VFE will replace the existing scheme once it has been extended to and carefully tested for all configurations used at ECMWF.

Two Newsletters were published (MGMT1.6):

- "Grand Tour" of ALADIN and HIRLAM and can be found on the ALADIN site: http://www.umr-cnrm.fr/aladin/IMG/pdf/nl12.pdf
- And a second one mostly based on the outcomes of the ALADIN workshop/HIRLAM ASM: http://www.umr-cnrm.fr/aladin/IMG/pdf/nl13.pdf

In 2019 we had for the first time a full comparison between the registered manpower contributions and the committed man power for 2018, see Fig. MGMT(a). A few conclusions:

1. In general, the realized work corresponds quite well to the committed work.
2. Quite a lot of man power is devoted to code implementations and testing as can be seen from COM2 and COM3.1. A lot of work, about 10 FTE, is devoted to the so-called phasing (which is the activity of updating the so-called T cycles with recent code contributions). This is mostly Météo-France work, with well coordinated contributions from the others, thanks to the role of the ALADIN System Coordinator (ASC) that is financed by RC LACE.
3. The CPDY package on dynamical core developments is quite understaffed. It is difficult to find experts who have required skills to work on development of the dynamical core. This is a general difficulty that is felt also in other NWP communities. HIRLAM will start to contribute to this work package in 2020.
4. Most of the efforts are spent on data assimilation, in particular on the handling of the observational data in DA3 (use of existing observations) and DA4 (use of new data). Mind that the main issue of the DasKIT project is to help the DasKIT countries to organize their local data streams in line with this need.

From Fig MGMT(b) is can be concluded that the community, indeed, is composed of four families: MF, LACE, HIRLAM and the Flat Rate countries, that have roughly the same size, although it should be noticed that MF is bigger (40%) and that LACE and HIRLAM are of comparable size, each representing about 30% of the total man power.

Manpower (in F.T.E.) in 2018 & 2019 RWP Work Packages

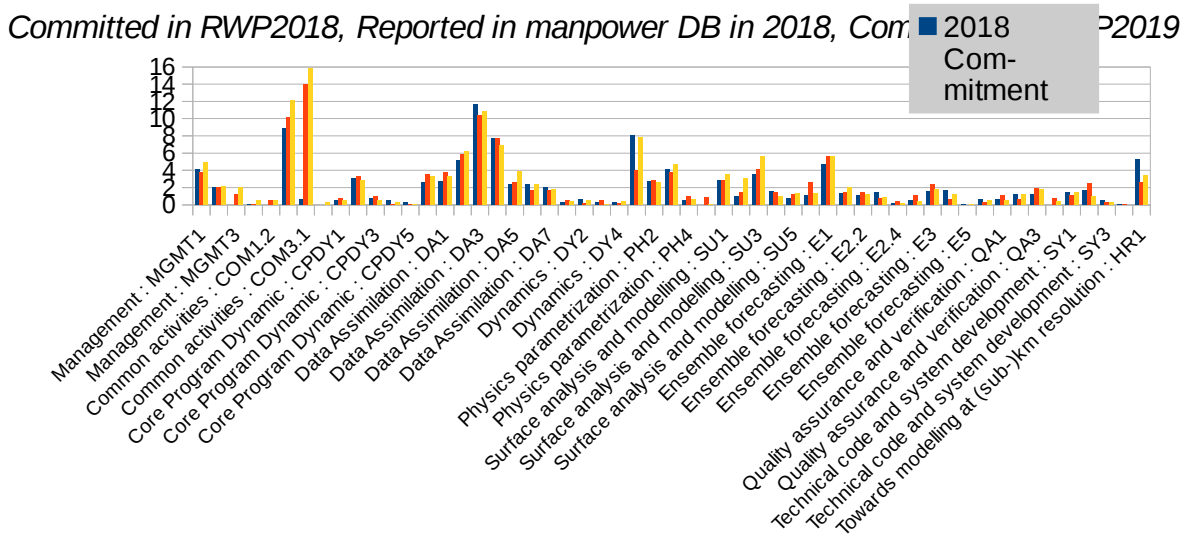

Fig MGMT(a): Committed (blue) and realized (red) manpower for 2018, as well as commitments for 2019 (yellow).

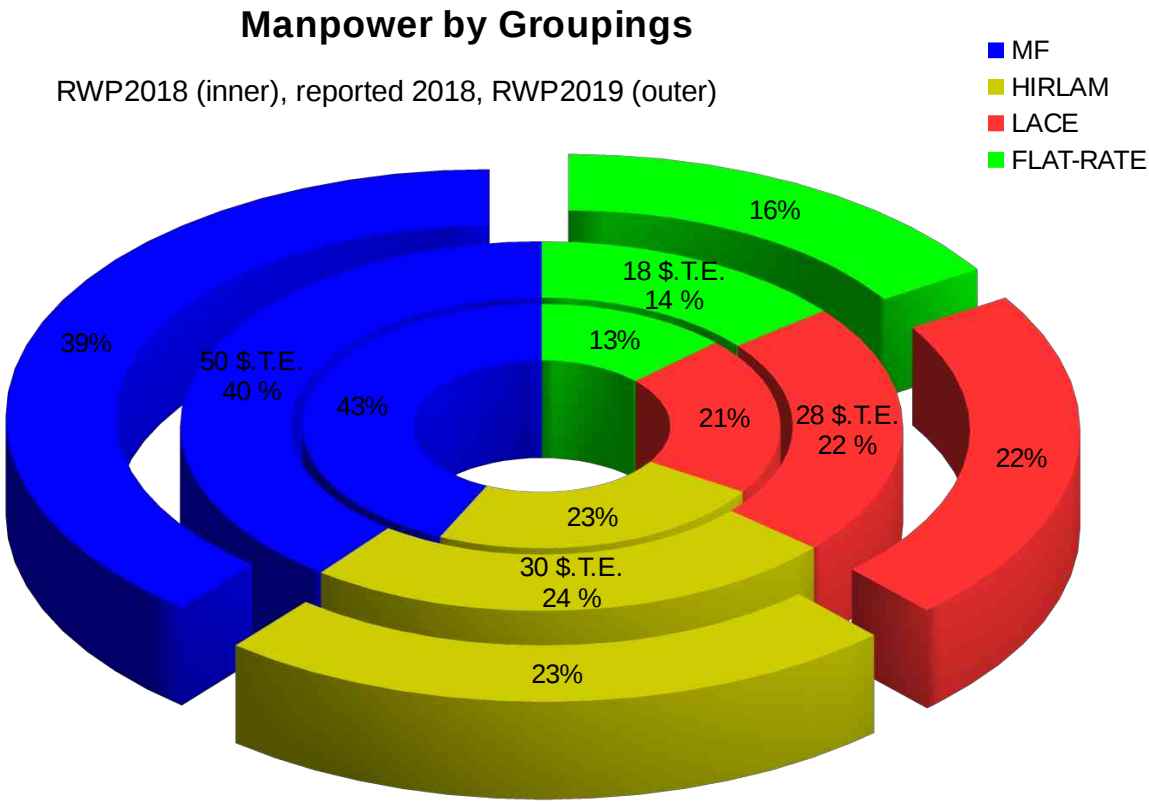

Fig. MGMT(b): Commited manpower 2018 (inner), realized 2018 (2018) and committed manpower for 2019 (outer circle) per "family" MF, HIRLAM, LACE, Flat rate countries.

COM1.1 ALADIN Code architect coordination activities

COM1.1.1 Development of LAM features in the Atlas library (see also SPDY5)

The Atlas library is a software library being developed at ECMWF, to prepare for massive parallelism and heterogeneous hardware platforms. Given the close relation between ECMWF's IFS model and the ALADIN-HIRLAM models, it is necessary that the Atlas library also supports limited area configurations. In 2019, this work has been continued. Concretely, an interface to the LAM spectral transforms ("etrans") was implemented in Atlas, support was added for interpolations between LAM grids, and features were introduced for the multigrid solver of SPDY2.2 (see below).

COM1.1.2 Testing of the HARMONIE-AROME canonical model configuration

To ensure the different canonical model configurations (CMC's) are mutually compatible, a uniform testing platform is necessary. To this goal, the "mitraillette" testing suite was ported to ECMWF, and tests were prepared for cycle 46. After this, HIRLAM staff took over to introduce a mitraillette test for the HARMONIE-AROME CMC.

COM1.1.3 Working out of a procedure for SURFEX contributions

SURFEX is the surface scheme that is used in the AROME and HARMONIE-AROME CMC's, and preparations are under way to also use SURFEX in the ALARO CMC. Since SURFEX is an "external" code, i.e. it is not maintained by the ALADIN-HIRLAM consortium, a well-defined procedure is required to determine how contributions from the ALADIN-HIRLAM consortium can enter SURFEX.

The procedure that was proposed is based on a so-called "double commit": first, a new contribution is phased into the ALADIN-HIRLAM code, and at a later stage, it is also submitted to the main SURFEX branch. The second stage ensures that the contributions don't get lost when a new SURFEX version is imported into the NWP codes. The code architect takes on the coordination of the second stage for non-Météo-France contributions. This procedure was already followed to introduce stability functions from ALARO's TOUCANS turbulence scheme in SURFEX v9.

Development of a scalable solver for the ALADIN-HIRLAM dynamics (SPDY2.2)

The scalability of the current spectral dynamical core of ALADIN-HIRLAM may become problematic on future massively-parallel machines. To anticipate for this, the viability of a non-spectral iterative solver is investigated.

It was found that specific properties of the ALADIN-HIRLAM dynamical core can be used to improve the robustness and efficiency of an iterative solver with a multigrid preconditioner. Concretely, the convergence speed of this iterative solver is known beforehand, which is of great importance for a model that is used in an operational context. Experiments show excellent scalability of this iterative solver up to at least 50’000 cores, outperforming the current spectral solver already on existing HPC machines. Further details will be given under task SPDY2.2.

COM2 Code generation and maintenance

Below is the status of the production of the cycles as prepared by Claude Fischer on 16/10/2019.

Cycles, code releases and a few comments:

CY46T1_main has been complemented by wrap-ups from the late source code changes from the CY43T2 e-suite (CY43T2_op1/op2 version from November 2018 onwards), including fixes for GRIB2 or new model output diagnostics (visibility, types of precipitation at ground etc.). This increased version has been tagged as **CY46T1_bf** in MF's GIT. CY46T1_bf.02 is the almost completed version with respect to the wrap-up of MF's CY43T2_op2, and was declared on 9 July 2019.

Validation of data assimilation (Arpège 4D-VAR, Arome 3D-VAR) is ongoing based on this CY46T1_bf. CY46T1_bf could be considered for an export version (to be confirmed yet).

CY47: the main build process took place over March-May 2019. CY47_main was declared on 19 August 2019. MF has run the mitraillette validation tool on that version, and EC has technically run an IFS 4D-VAR suite. Content:

- OOPS re-factoring in IFS FORTRAN codes:
  - VarBC works
  - final work for Full-POS as PostProcessor object (MF/REK)
  - other required fixes in order to run OOPS-IFS in a full PrepIFS experiment (CY46R1). Note: recent code adaptations in order to run screening in OOPS-IFS are still missing in CY47, and will enter CY47R1.
- Scientific contents of CY46R1 and CY46T1

CY47T0: this is a technical quick cycle built in the end of August 2019. The goal was to enable the first early prototypes of tests based on the "davaï" concept and tools (for technical validation). Another goal was to enable to run the Fortran binary executable files using array bound check options throughout the code (this actually required a number of corrections and adaptations of

interfaces, following a proposal made by Ryad El Khatib, see his presentation during the workshop mentioned above). Content:

- code changes enabling array bound check options throughout the code, for a number of Arpège and LAM configurations (R. El Khatib)
- Fortran/C++ interface codes adapted in order to enable OOPS unitary tests in the “davaï” framework for CY47 (E. Arbogast with A. Mary)
- bator change to enable the use of “one obs out of two” (useful for creating smaller obs databases for testing) (F. Guillaume following an idea by F. Suzat)
- miscellaneous other bug-fixes found in CY47_main or reported from earlier cycles, excluding those linked with reporting codes from CY43T2 (this is planned for CY47T1)

Declaration of CY47T0_main occurred on 3 September 2019.

CY47T1: this is the major scientific interim cycle of the shared NWP codes, built in Météo-France this year. It does contain a number of scientific contributions from the ALADIN partners (updates to ALARO-1, new diagnostic model output fields in Full-POS), from the GMAP team and specific items agreed upon with the Météo-France climate group. Another essential target of CY47T1 was to complete the official updating of the operational code versions from Météo-France (which are based on a CY43T2 code version, CY43T2_op3). This goal has been achieved. The technical validation is in progress, including components of the data assimilation using prototypes based on OOPS objects. Declaration of CY47T1 will occur in December 2019.

COM3.1 Maintenance and Partners' implementations of ALADIN system

The main activities of ACNA (Aladin Coordinator for Networking Aspects) in 2019 were:

1. Preparation and chairmanship of the LTM meetings (Madrid, Sofia)
2. Other networking aspect within the ALADIN consortium
3. Collaboration on various issues related to the LBC files from ARPEGE

1. Preparation and chairmanship of the LTM meetings (Madrid, Sofia)

ACNA has prepared and chaired the LTMs meetings in Madrid, 02/Apr 2019 along the ALADIN/HIRLAM workshop; and in Sofia, 01/Oct 2019, along the EWGLAM/SRNWP meetings. Agendas and minutes are available on the ALADIN web page http://www.umr-cnrm.fr/aladin/spip.php?article108&lang=en .

2. Other networking aspect within the ALADIN consortium

Apart from the participation at the video conferences with PM, TTS, CA, DA coordinator (held when necessary) ACNA networking activities comprise:

2.1. Participation at the CSSI/HMG meeting, evaluation of RWP2018-9 fulfillment, redaction of RWP2020

ACNA participated at the HMG/CSSI meeting along the ALADIN-HIRLAM workshop (see http://www.umr-cnrm.fr/aladin/spip.php?article115). ACNA was involved in the RWP2018 and RWP2019 status evaluation and RWP2020 preparation (COM3.1, PH5)

2.2 CY43t2bf10_export preparation

ACNA has collaborated (in liaison with LACE ASC) on the preparation of the incremental bugfix (denoted bf10) of the CY43T2 code version, that was released in February 2019.

2.3 Supervision of the CY43t2 code version installation at the Partners' NMS

ACNA follows the installation of the CY43t2bf10_export versions at the Partners' NMS, collects the reported problems and their fixes once available. ACNA reports on the progress of the installation if relevant (GA, LTM meetings). No major problem with porting of CY43t2bf10_export was noted. For particular progress reports check the links:
https://docs.google.com/spreadsheets/d/1_lQMFDaRRDNEng21asHKQ42Hx_-llOnRG3EX3BtfzVo/edit#gid=2011676472
https://docs.google.com/spreadsheets/d/1_lQMFDaRRDNEng21asHKQ42Hx_-llOnRG3EX3BtfzVo/edit#gid=1870788186
https://docs.google.com/spreadsheets/d/1_lQMFDaRRDNEng21asHKQ42Hx_-llOnRG3EX3BtfzVo/edit#gid=1673101714
For the status as of September 2019 see the attached table.

3. Collaboration on various issues related to the LBC files from ARPEGE

ACNA coordinates the work and information exchange on the generation and distribution of the LBC (Lateral Boundary Conditions) files for Partners from the Arpege global model. Three main actions were followed in 2019:

3.1 Tests of the LBC files produced from the Arpege high-resolution e-suite

ACNA has collaborated on the evaluation of the impact of the Arpege e-suite on the LBC files generated from it. ACNA has tested the standalone files and also evaluated the local e-suite based on these new LBC data (both downscaling and assimilation mode). ACNA has communicated with Partners and MF during the switch of Arpege e-suite into operations. The consecutive debriefing note was compiled and discussed to evaluate this process. The Arpege e-suite switch occurred on 02/July 2019.

3.2 Coordination of the planned upgrade of the LBC files from interested Partners

Due to heavy workload of MF Operations department the changes in the LBC files generated from Arpege are allowed only during dedicated time windows that are planned scheduled well in

advance. Such window was planned for June/July 2019, recently postponed to October 2019. ACNA has collected the “wishes” of ALADIN Partners concerning the changes in their so-called “telecom” domains (domain extent, vertical or horizontal resolution, LBC frequency or range increase) that were consolidated in the table together with the estimation of the total data volume increase. The table was handed over to MF for further discussions with relevant Dpts.:
https://docs.google.com/spreadsheets/d/1AR7behptUUatm6qyH-upo35iWIKCKdPP83enb4Bi1FU/edit?usp=sharing

Exceptionally (due to short time constraint) new telecom climate files and corresponding LBC files for new domains that Partners requested were computed by GMAP people, using new CLIMAKE tool (for climate files, see below) and OLIVE. Those files were handed over to Partners for checking. The retention period of the LBC data in BDPE will be uniformly set to 1 day. All LBC telecom domains from ARPEGE are computed using e903 instead of e927 since last operational switch to CY43T2.

5 out of 6 involved telecom domains and other changes requested by Partners were switched into operations on 14 November 2019. The new common IPMA-AEMET domain was introduced on 20 November 2019. All operational changes went smoothly.

3.3 Testing and validation of CLIMAKE

CLIMAKE is a new tool developed in GMAP/Meteo-France to generate so-called climate files (that contain the physiographic characteristics of the ALADIN domains). ACNA was heavily involved in the testing and validation of this tool, in collaboration with MF and few ALADIN colleagues. The CLIMAKE tool was introduced to ALADIN Partners during the LTM meeting in Sofia (Oct. 2019)

Porting of CY43t2bf10_export version in the ALADIN NMS.

No major problem with porting of CY43t2bf10_export was reported. Status on 04/10/2019:

- 7 Partners are running this cycle operationally (at least for part of their applications)
- 6 Partners do have this code version ported or at least compiled
- 3 Partners did not succeed yet (either due to other priorities or waiting for new HPC)

		porting of CY43T2	
Partners	September2019	March2019	September2018

Algeria	operational	operational	ported
Austria	compiled	compiled	not yet
Belgium	operational	?	compiled
Bulgaria	ported	?	not yet
Croatia	ported	ported	not yet
Czech R.	operational	operational	operational
France	operational	e-suite	exported
Hungary	not yet	?	not yet
Morocco	?	compiled	compiled
Poland	operational (ALARO)	ported	ported
Portugal	not yet	not yet	started
Romania	not yet	not yet	not yet
Slovakia	ported	ported	ported
Slovenia	operational	e-suite	ported
Tunisia	ported	ongoing	not yet
Turkey	operational (AROME)	ported	not yet

SPDY Strategic Program on Dynamics

Most activities in this work package were focused in 2019 on SPDY2, *Development of methods for solving the implicit equation in gridpoint space.* We also report here on SPDY5*, Development of LAM components in Atlas*.

Spectral solvers may have problems with scalability and the accuracy of the flow over steep slopes on massively parallel machines and at high resolutions. For that reason we are investigating alternatives for the spectral solver.

This issue was approached in two ways: (i) give a first estimated of the gains one can get in terms of scalability when replacing the spectral solver by a gridpoint solver, and (ii) to get an idea of the accuracy one can obtain if one uses discrete derivatives of a finite order in comparison to the exact derivatives computed in Fourier space.

For the scalability problem, the solver of the Helmholtz equation was extracted from the code and was converted in a stand-alone tool, following the concept of the Weather and Climate Dwarves of the ESCAPE project. A gridpoint solver was developed that solves exactly the same system, but relying on a gridpoint Krylov solver instead of the spectral solver. This allows for a clean intercomparison between the two methods. Scalability tests were performed on the ECMWF HPC infrastructure, three different solvers were run with up to 50000 cores. Fig. SPDY(a) shows the results of these test. This demonstrates that the gridpoint solvers indeed scale in an excellent way (almost perfectly) as compared to the spectral solver.

At the same time a gridpoint solver was coded in the full model to test the meteorological performance. No attention was payed to the parallellization of the code. Fig. SPDY(b) shows results from an AROME run with the spectral solver (left) compared to the run with the gridpoint solver (right). The differences are hardly noticable. Mind that for these tests the derivatives were approximated with 8^{th} order finite differences in order to approach the accuracy of the (perfect) spectral operators. This is in agreement with earlier test performed with pseudo derivative computed with the spectral ALADIN model.

During the dynamics days meeting in Toulouse it was concluded that this gives sufficient confidence to implement a scalable solver with the ALADIN code. It was decided to benefit from Atlas for this implementation. For the next year it has been decided that HIRLAM will contribute to this work.

Concerning the status of the developments of Atlas in SPDY5, The LAM configuration has been implemented. The following Atlas features have not been adapted to the LAM configuration yet:

1. the map factors and the effect of geographic projection on differential operator
2. the semi-Lagrangian advection dwarf and interpolation schemes
3. the finite-volume function space

However, whether ‘we are ready for Atlas’ depends on our ambitions and on how our dynamics will evolve. If we keep a semi-implicit semi-Lagrangian spectral model, Atlas contains most of what we need. Going to ALADIN-FVM will require much more work. Implementing a non-spectral Helmholtz solver in Atlas, as mentioned above, would be a useful exercise. Additional questions to be adressed in the next phases are:

- Should the Davies relaxation be dealt with in Atlas?
- What about VFE and FullPos?

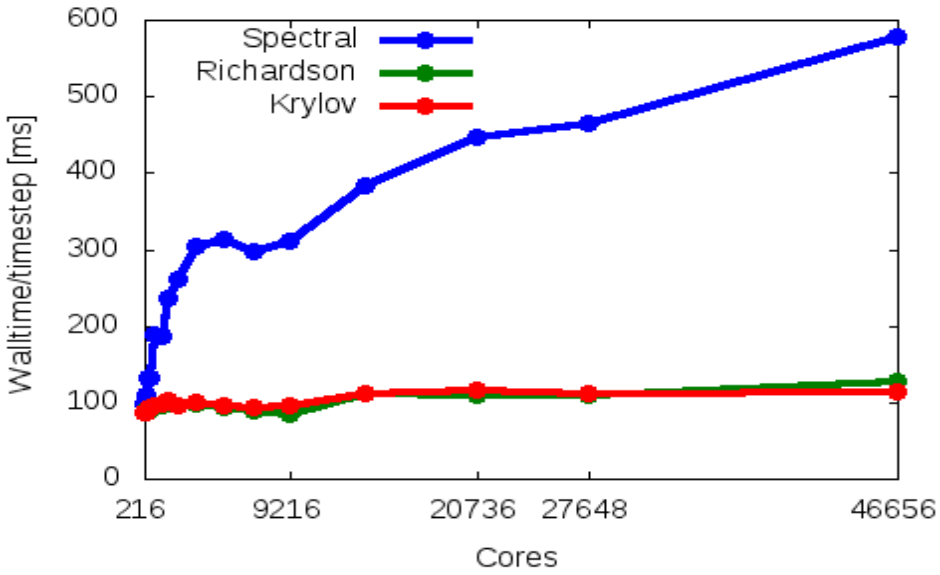

Figure SPDY(a): Scalability test of two gridpoint solvers compared to the spectral solver, up to about 50000 cores. It is a weak scalability test; constant lines represent perfect scalability. One notices that the gridpoint solver exhibits an excellent scaling which is not the case for the spectral solver.

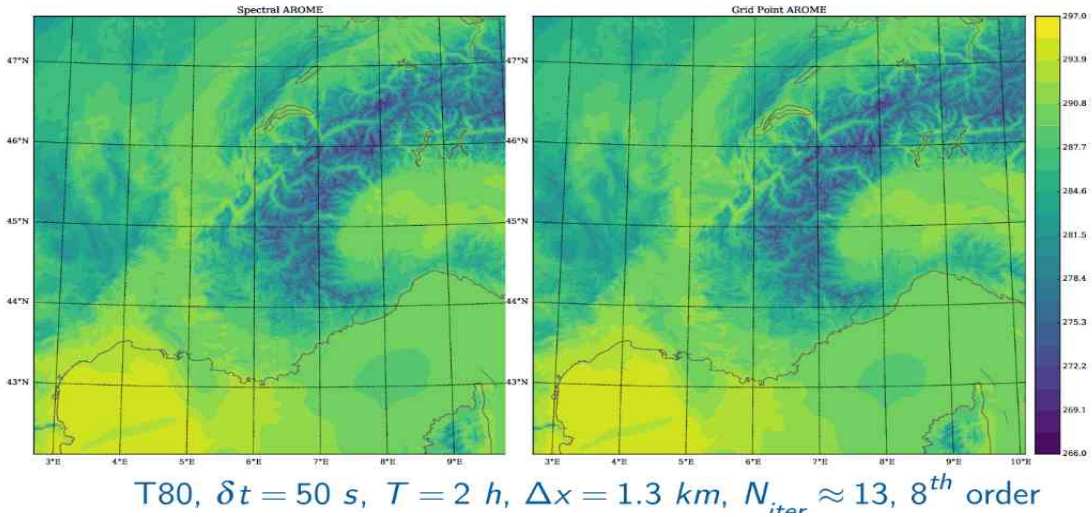

Figure SPDY(b): Intercomparison between a spectal AROME run (left) an AROME run where the Helmholtz equation was solved with a gridpoint solver. The differences are hardly noticable. Closer inspection (not shown) reveils that that differences are not more than 1 degree Celsius and mostly located in mountainous regions (the Alps).

SPDA the DasKIT project

Summary report on the 2019 DAsKIT activities
By Maria Monteiro (DA coordinator), Oct 2019

The main goal of the ALADIN strategic core program on Data Assimilation (here named as DAsKIT) is to develop a cross-consortia coordination to set up a basic 3D-Var Data Assimilation (DA) cycle with a limited set of observations suitable for operational implementation. The countries involved more directly in DAsKIT are: Algeria, Belgium, Bulgaria, Morocco, Poland, Portugal and Turkey.

The DAsKIT program working packages (WP), which simultaneously reflect the local steps to implement DA capacities, encompass: data acquisition; data pre-processing; BATOR pre-processing; surface DA; and combined surface+upper-air (3D-Var) DA.

This progress report provides the status of the program after the recent 2019 Joint RC LACE DAWD & DAsKIT DA WD, hosted by CHMI in Prague during 18-20 September (also supported by HIRLAM and Météo-France (MF)).

1. Data Acquisition

   The object of this WP is the local acquisition of WMO BUFR SYNOP, TEMP and (E-)AMDAR data. With the exception of Poland and Tunisia which receive pre-processed data from OPLACE – the RC LACE common initiative on pre-processing – all countries have now local access to WMO BUFR SYNOP and TEMP observations. In some cases, procedures had to be created or implemented to allow the conversion from other data formats to WMO BUFR standards. Regarding (E-)AMDAR data, the conclusion is similar: besides Bulgaria which is expecting to finish the procedures to the acquisition of this type of data in the very short-term, all countries have access to this type of data. In the meantime,

it was possible to see also that countries have long-term plans to access other data types, like: GPS, OIFS radar, ATOVS and ASCAT.

2. Data pre-processing

This WP aims at the pre-processing of WMO BUFR SYNOP, TEMP and (E-)AMDAR data. For SYNOP and TEMP in particular, duplications between GTS original messages and 'retards' have to be removed; for (E-)AMDAR, no duplications are found but the filtering of different BUFR templates to assure its adequate ingestion by DA systems has to be done (in particular when dealing with the Bristish Airlines AMDAR data with the BUFR template 311001, not yet handled by BATOR at version 40T1). ***As a summary, it is possible to state all countries are now able to pre-process WMO BUFR SYNOP (Poland and Tunisia through OPLACE***; Turkey trough the ECMWF Scalable Acquisition and Pre-Processing tool (SAPP)); the pre-processing of WMO BUFR TEMP has to be done in the short-term, but should be similar to the one used with SYNOP. Besides, short-term plans include the migration, from MF computing platforms, of the procedures provided by Algeria and Morocco during the recent WD to handle (E-)AMDAR data, and to confirm MF plans for handling other templates of this type of observation. As long-term plans, countries start to pay attention to the possibility to use SAPP. At this moment, four out of eight countries from DAsKIT have considered the move to SAPP: Belgium; Bulgaria; Portugal and Turkey. Meanwhile, there is still an issue which has to be clarify in case related to the participation conditions on the SAPP Optional Project, for ECMWF non-cooperating or non-member states (as is the case of some DAsKIT countries).

3. BATOR pre-processing

BATOR is the interface of observations information to ALADIN-HIRLAM DA systems and the goal of this WP is to assure that local implementation of BATOR is able to ingest WMO BUFR SYNOP, TEMP and (E-)AMDAR. Along the DAsKIT program, ***all the countries got capacities to handle their conventional data through BATOR, even if different code cycles are in use in accordance with the on-going country plans***. As a short-term plan, countries agreed on a parallel porting of its local BATOR procedures to CY43T2 during 1Q2020. This step should allow simultaneously the BATOR pre-processing of WMO BUFR TEMP. On the long-term, it is overseen the need to make local DA implementations (BATOR) compatible with BUFR templates provided by SAPP; to blacklist local observations through BATOR; and to start handling non conventional data types.

4. Surface Data Assimilation & Data Monitoring

The main goal of this WP is to set a local cycling on surface DA for AROME by the named OI_MAIN method (Giard and Bazile, 2000), after the exercise done during the 2018 Joint RC LACE DAWD & DAsKIT DA WD in Romania. So far, all countries managed to run the 2018 exercise in MF computing platforms and to adapt it to its geographic domains of interest. All countries, except Morocco and Tunisia that were updating their machines in 2019, were able to cycle a surface DA algorithm for their local model configurations. Hence, last September, four out of eight DAsKIT countries (Algeria, Belgium, Poland, Portugal) have shown their preliminary validation diagnostics and scores. It was possible to see surface DA has an impact over 2-metre temperature (T2M) and 2-metre relative humidity (H2M) forecasts (and 10-metre wind, depending on the model lowest level). At the same time, some issues have been found which have to be solved soon. Details are available from the ALADIN website dedicated to DAsKIT, at http://www.umr-cnrm.fr/aladin/spip.php?article348. As short-term plans, countries expect to finish the validation of its local cycling at the different code versions actually in use: 40T1 (Algeria, Bulgaria, Poland, Portugal, Morocco and Turkey) and 43T2 (Belgium, Bulgaria, Tunisia). As a sequence of the

establishment of a local surface DA cycling, regular DA monitoring procedures should be started in order to adequately tune the usage of observations. During 2018 DAsKIT DA WD, a standalone version of the OBSMON tool was provided by HIRLAM and installed locally by the countries. However during 2019 the tool was not yet in use by the teams which means some action or training should take place in the near future in order to boost the usage of the tool locally. In fact, this topic is a candidate for a common action during 2020.

5. Combined surface+upper-air (3D-Var) Data Assimilation

This WP corresponds to the main goal of the DAsKIT program. So far, only two out of eight countries have set a combined DA cycling to their local model configurations: Belgium and Turkey. However, it was clear from the joint discussions that this is a major achievement which obliges a common capacity building. Therefore, DAsKIT agreed on a common step-by-step approach to the local full basic kit implementation: in order to optimise efforts and maximise the available expertise (and eventual support), all countries should install CY32T2 locally and start, in the short-term, by BATOR pre-processing of WMO BUFR SYNOP, TEMP and (E-)AMDAR data (in 1Q2020). Further steps will be taken in common agreement. Meanwhile, a set of scripts will be created and shared on MF computing platforms, also taking into account the expertise of RC LACE and Belgium.

6. Conclusions and Outlook

During 2019, half of the DAsKIT program countries were already able to show validation scores by local cycling surface DA systems, built for the initialisation of their model's configurations, and using a basic set of WMO BUFR SYNOP data. This cycling was possible after the basic pre-processing exercises done during the 2017 WD in Lisbon (prepared by RC LACE) and the surface basic kit shared during 2018 DAsKIT WD in Prague (prepared by DA coordinator in collaboration with MF). It was possible to see the impact over T2M and H2M forecasts (when compared with dynamical adaptation), but some issues have been discussed and have to be sorted out. A step-by-step approach has been agreed upon the countries to tackle the combined surface+upper-air (3D-Var) solution for the local model configurations, using WMO BUFR SYNOP, TEMP and (E-)AMDAR data. At the same time topics which may be of interest to the countries at present and near future will continue to be jointly discussed. Many DA material is already available from MF computing platforms and detailed information is available from the ALADIN website and the RC LACE forum. Meanwhile, it was announced the RWP2020 was revisited: focus will be put on pre-processing of TEMP (WMO BUFR); on the parallel porting of BATOR to CY43T2; to finish the validation of the local surface DA cycling; and to the initial steps onto the combined DA solution. There is an interest to have regular DA users' training (eventually under a remote sessions format) since it was not possible to send many DAsKIT attendants to the Common ALADIN-HIRLAM DA training recently held in Budapest; moreover, there is also some interest on the DA coding training, conditioned to man power issues. Finally, DAsKIT coming events were also agreed: the last 2019 video-conference that will take place in December 2019; and the 2020 Joint RC LACE DAWD and DAsKIT DA WD that will be hosted by ZAMG in Austria and which structure will become more and more merged and include practical sessions.

PROSPECTIVE R&D WORK PACKAGES

DA Data Assimilation

A lot of efforts are spent on the handling of the data streams of the observations. Within ALADIN, RC LACE is well organized and managed to have all of their members running data assimilation cycles, as can be seen from Fig. DA(a), that was taken from the RC LACE report written by B. Strajnar. The status in the flat-rate countries is presented in the SPDA work package. For a specific status of the DasKIT countries see report in SPDA above.

DA	AUSTRIA ALARO	AUSTRIA AROME	AUSTRIA AROME-RUC	CROATIA ALARO	CZECH ALARO	HUNGARY ALARO	HUNGARY AROME	SLOVAKIA ALARO	SLOVENIA ALARO	ROMANIA ALARO (prep.)
Resol.	4.8L60	2.5L90, 600 x 432	1.2L90 900 x 576	4.0L73 480 x 432	2.3L87 (NH) 1069 x 853	8L49	2.5L60	4.5L63	4.4L87 432 x 432	6.5L60
Cycle	40t1	40t1	40t1	38t1_bf8	43t2_bf10	40t1	40t1	40t1	43t2_bf10	40t1
LBC	IFS 3h (lagged)	IFS 1h (lagged)	AROME 1h	IFS 3h (lagged)	ARP 3h	IFS 3h (lagged)	IFS 1h (lagged)	ARP 3h	IFS 1h/3h (lagged)	ARP 3h
Method	OI + dyn. adapt	OI_main MESCAN + 3d-Var	OI_main MESCAN + 3d-Var + LHN + FDDA + IAU	OI + 3D-Var	OI + BlendVar	OI + 3D-Var	OI_main + 3D-Var	OI + DF Blending	OI + 3D-Var	OI + 3D-Var
Cycling	6h	3h	1h	3h	6h	6h	3h	6h	3h	6h
B matrix	-	Downscaled LAEF 11 km	Static ENS from AROME-RUC EDA	NMC method	Downscaled AEARP	ALARO EDA	AROME EDA	-	Downscaled ECMWF ENS	Downscaled AEARP
Initialization	DFI	No (SCC)	No	No (SCC)	IDFI in production, SCC	DFI		No	No (SCC)	No (SCC)
Obs.	Synop + AS	Synop + AS Amdar Geowind Temp Pilot Seviri AMSUA/ MHS/HIRS ASCAT Snowgrid/ MODIS snowmask.	Synop + AS Amdar/MRAR/ EHS Geowind Temp Pilot Seviri AMSUA/MHS/ HIRS/ATMS ASCAT Radar RH/Dow INCA + AS at hig.freq. MODIS snowmask.	Synop Amdar/ MRAR Geowind Temp Seviri	Synop Amdar/MRAR/ EHS Geowind Temp Seviri	Synop + AS Amdar Geowind Temp Seviri AMSUA/ MHS ASCAT	Synop + AS GNSS ZTD Amdar/ MRAR/EHS Geowind Temp Seviri AMSUA/ MHS/IASI ASCAT	Synop + AS Amdar/ MRAR/EHS Geowind Temp Seviri AMSUA/ MHS/IASI ASCAT	Synop + AS Amdar/ MRAR/EHS Geowind Temp Seviri AMSUA/ MHS/IASI ASCAT	Synop Temp AMSUA/ MHS Seviri

Fig. DA(a): Operational status of data assimilation within the LACE countries.

DA1 Further development of 3D-Var

DA1.2 *Background error statistics: Evaluate the impact of different formulations of the background error statistics (e.g. downscaled, EDA, Brand, large scale mixing or not) on the balance between control variables and on spinup.*

Here mostly the countries are recalculating their B matrices based on Ensemble Data Assimilation (EDA) techniques.

- In Austria a new B-matrix was designed for the AROME-RUC 1.2 km system. The ensemble data assimilation (EDA) was applied to the hourly RUC forecasts to produce a total of 178 differences. The LBCs for this experiment came from CLAEF 2.5 km ensemble system.
- The B-matrix was recalculated in Hungary. A downscaled EDA forecast data set was constructed, and this comprises 15 days in each of the four seasons. A comparison of the new result with the previously computed B-matrix at 60 levels (both spin-up and full EDA) was also made. The new B-matrix was validated by single observations experiments.
- In Slovenia, an experimental EDA system was developed at a current horizontal resolution of 4.4 km, with 20 ensemble members. Ensemble members are generated by random perturbations of assimilated observations. The ensemble is used to compute background error covariances on daily basis. A first evaluation of the system has just started. Preliminary results show that the daily profiles are much different from the operational (climatological) ones, and that variation from day to day is significant.
- In Romania, the assimilation suite stays in a pre-operational state. Since July, experiment on a new 4.4 km domain are ongoing, and B-matrix is also already available. The new setup provided some encouraging results on a convective case.
- In Tunesia the B matrices for their AROME implementation has been computed based on EDA and it has been validated. They are now in the stage of installing a new HPC machine. The B matrix will then be used for their AROME data assimilation cycle. Even if Tunesia is a DAsKIT country, for this issue, they are technically in phase with the RC LACE developments.

DA2 Development of flow dependent algorithms

DA2.3 *EnVar in OOPS*

Within ALADIN, these developments mostly take place within Météo-France. The goal is to improve scientific options (localization, advection), test cases, update as feasible for using operational-like observations and with respect to refactored IFS Cycles, assess scalability and optimization; assess the performance of the statistical balance constraint in the minimisation, design the hybrid gain environment.

DA2.4 *EDA: AEARP and AEARO: scientific improvements in both EDA systems, increase of horizontal resolutions in AEARP, AEARO oper at MF.*

The new operational suite of Météo-France has new horizontal resolutions for global systems (deterministic, EDA, EPS):

- ARPEGE: ~5km over France (Tl1798c2.2L105)
- 4D-VAR: 2 minimisations in Tl224c1L105 (90km) and Tl499c1L105 (40km)
- EPS: 35 members (unchanged) at ~7.5km over France (~Tl1198c2.2L90)
- EDA: 50 members in Tl499c1L105 => will sample B-matrix from 3*50 instead of 6*25 as now

PEARO, the EPS system for AROME has an increase of the ensemble size to 16 members planned for mid-2019.

DA3 Use of existing observations

DA3.1 *Assist local implementation of radar data assimilation*

- Currently Météo France assimilates 30 French radars in terms of Doppler wind velocities & reflectivities. Monitoring of 62 European radars through OPERA (since 2 July 2019). Some neutral scores (to very slight improvements) were obtained when including these radars in the AROME data assimilation.
- In Slovenia efforts were made on Doppler wind processing with focus also on NWP requirements. An overview of existing methods for dealiasing wind fields for radars with low Nyquist velocity was made, and a few of the relevant methods were implemented and tested on synthetic and real cases. A first evaluation of impact OPERA reflectivity data was carried out, with data from 40 radars in Europe assimilated over 14 days. The setting of preprocessing and assimilation followed choices made by Meteo France. Verification showed improvements of surface scores (bias of temperature, humidity) due to assimilated reflectivities. Impact on upper-air scores was mixed: temperature was somewhat improved while humidity at around 700 hPa was notably degraded. The experimentation needs to be extended to more cases and weather regimes.
- Radar assimilation is becoming operational in Austria with their AROME-RUC by the end of 2019. The national data and data received through bilateral exchange (D, SI, AT, CH) is combined with OPERA data (CZ, SK, HR, CH, F). The non-OPERA data are subject to wind dealiasing procedure while Doppler winds from OPERA are not used if the Nyquist velocity is low. Var-QC was applied this year to the Doppler winds and pseudo humidity profiles. It was found that the observation error assumed in the model for Doppler winds might be too low by a factor of 2 for AROME-RUC. The first guess rejection limit of 20 m/s also seems to be inappropriate.

DA3.2 *Aircraft-derived data (ADD): assist implement Mode-S (EHS and MRAR) pre-processing*

- In Austria, data from OPLACE (EHS, MRAR) are used in the AROME-RUC system. National Mode-S EHS data were further studied and it was found that wrong coordinates of foreign ATS radar stations were provided.

- In Croatia, local Mode-S MRAR data were obtained from ATC (Croatia Control), so far on daily basis only.
- In Czech Republic, the local Mode-S MRAR observations were made available to all RC LACE Members from June 2019.
- Since 2017, Météo-France has Installed a set of 7 ADS-B mode-S antennas over France to receive signals from commercial aircrafts and started collaborations with the French Civil Aviation to set-up an operational link to transfer MODE-S EHS reports in our database from a set of 12 radars (planned by the end of 2020). Feasibility studies have started to monitor and assimilate derived winds from ADS-B signals in AROME-France. First tests in AROME data assimilation show neutral scores. Future activities are planned on mode-S: (1) develop an improved thinning methodology and (2) the use of MODE-S/EHS from French ATC SSR radars.
- In Hungary, an evaluation of Czech Mode-S MRAR data is ongoing, as well as efforts to obtain the national data and start its evaluation.
- In Slovakia, there is ongoing negotiation with Slovak Air Traffic service to provide local Mode-S data. Efforts were made on the analysis of Mode-S EHS and MRAR from four radars in CZ, SK and AT, and the impact of white listing on the quality of observations for assimilation. The results were comparable to previous studies in CZ and SI, except that the quality of MRAR from Vienna airport is reported to be worse than in the earlier studies.
- In Slovenia, the observational use was extended with Mode-S MRAR observations from Czech Republic.In Hungary, the operational use of aircraft observations was modified by extending the time window from +/- 60 min to +/- 90. An attempt was made to recalculate the white list for the Slovenian MRAR data, also shared through OPLACE. A 3-month passive monitoring with respect to operational model was carried out.

DA3.3 *Ground-based GNSS ZTD*

- In Austria, GNSS-based data is evaluated. GPS-RO observations were not available in satisfying numbers in time, an OSSE experiment was continued. Artificial observations were generated from observational data base (ODB) by using real Metop GPS-RO observations at other times and regions and compute first guess departures, which are in turn used to get simulated observations from AROME nature run. All runs are verified

against the nature run. The experiment was run using 3-hourly cycling over two days in August 2018. Results show a positive impact of GPS-RO on CRPS score above 500hPa and especially near the tropopause mainly on temperature and wind, while the results were mixed at lower levels.

- Météo France uses the following new GPSRO observation: GNOS/FY3-C, ROSA/MEGHA-T.
- In Slovenia, an impact study of E-GVAP and local GPS observations confirmed earlier results of biased local data. It was agreed with data provider to verify its observations by comparison to E-GVAP data.
- In Slovakia, the impact of ZTD observations is evaluated during long term (6 months) assimilation in AROME and validated against ECMWF analysis. Performance of ZTD is studied especially during heavy precipitation events, where positive impact was detected.

DA3.4 *Scatterometer winds*

- In Austria, HR-AMVs from OPLACE are now applied within AROME-RUC. Compared to GEOWIND-only the number of assimilated observations increased drastically. However, no validation of the impact was done so far.
- In Czech Republic, a monitoring study was carried out with aim to extend the use of existing observations. High-resolution winds (HRW), wind profiler and scatterometer data are evaluated. This work is still in progress.
- Météo France uses the following scatterometer observations: OSCAT on ScatSat-1 and AMV wind : Goes-16, Goes-17, Metop-C.

DA3.6-3.7 *Clear-sky radiances: 1) Seviri, 2) IASI and CrIS, and 3) ATOVS and ATMS and cloud-affected radiances: IASI and CrIS radiances*

- Radiance observations from NOAA and METOP satellites are already in operational use at many LACE centre's DA systems. No significant manpower was put to new developments on this item in 2019. In Austria, ATMS data from OPLACE (NOAA-20 and SUOMI-SNPP) are passively assimilated within AROME-RUC.

- Météo France added more IASI channels over land, improved the inter-channels observation error correlation for IASI and CRIS and added new channels assimilated for geostationnary CSR in their operational suites. Within its new operational suite Météo France improved the monitoring of new microwave observations: AMSR2/GCOM-W1, MWRI/FY3-C, ATOVS, ATMS, MWHS-2 Flux DbNet, AMSUA et MHS on METOP-C, ATMS on NOAA20.

The long-term work by P. Benáček (CZ) on variational bias correction (Var-BC) approaches in LAM was consolidated by improving and publishing a scientific paper and defending a PhD thesis on non-conventional observations in LAM. Extensive underlying research showed that the VarBC-LAM methods outperform the use of global coefficients from ARPEGE providing the better quality of the model first guess (3-h forecast), in the assimilation cycle with the largest normalized impact of 2%–3% for temperature and wind components in the mid troposphere. Compared to the global coefficients, there was little forecast impact between 24 and 48h from using the VarBC-LAM coefficients.

DA4 Use of new observations

DA4.2 *GNSS slant delay*

A study of slant total delay observations (STD) continued in Austria with adaptation of model code from KNMI to the ZAMG's 40t1 model version. Tests with artificial observations and real observations (Austrian national data) were carried out. A simple static bias correction based on the ODB statistics was applied for the STD data. Based on 24 AROME-RUC runs the DFS of STD data was calculated which indicated a slightly larger impact on the analysis than the ZTD data. A validation of one month test data is ongoing.

DA5 Development of assimilation setups suited for nowcasting

- In Austria, the new AROME-RUC system is now run in real time pre-operational mode and is expected to become fully operational by the end of 2019. The final setup of the pre-operational AROME-RUC is at 1.2 km. The spin-up is reduced by applying the incremental analysis update (IAU) to the main assimilation cycle in the time interval between -1h and -15 min relative to analysis time, applied to an earlier first guess forecast. For the 12h production run, IAU is also applied in a small, 7.5 min time frame, and realism of forecast is further enhanced by latent heat nudging (LHN) and four dimensional data assimilation (FDDA) nudging of recent surface observations and rapid INCA analysis and nowcasting. Assimilation of soil is kept consistent with AROME 2.5 km by replacement of soil and SST fields once per day from this model. The system is expected to become operational by the end of 2019.
- Earlier in 2018, investigation of hourly cycling in Hungary indicated that combining the 3- and 6-hourly OI in the hourly system improved 2 m temperature and relative humidity and well as precipitation scores compared to 1-hourly surface data assimilation. This unexpected issue was further investigated in 2019 on two rather long time periods (one month in winter and summer), and earlier results were confirmed.
- In Czech Republic, the Rapid refresh (RAP) system using hourly VarCanPack analysis on the operational ALARO domain was extended with the RUP system (up to 12-hour

forecast). The RUP is evaluated in terms of spin-up and the impact is evaluated especially for surface variables such as wind gusts and precipitation.

- In Slovakia, as preparation for RUC, an automatic QC for automatic weather stations based on weather station data, radar data and NWP is under development. It is planned that such a procedure would run every 1h to control previous 1h data.

DA7 Observation pre-processing and diagnostic tools

In Slovakia, the BATOR cy46 was back-phased to be used with ALARO model. This work is to be consolidated with the work of the rest of the group.

Several LACE members started to test OPERA data (BATOR cy40, cy43). A preprocessing step was is found to be necessary Homogenization of OPERA OIFS Files (HOOF). HOOF has the following properties. It splits 15-min aggregates to single measurements. It rearranges incoming data. It creates one data set for each elevation. All measurements have the same quality flags. It fills in the (specific) metadata from the namelist if missing. It keeps only what is needed/requested, e.g. reflectivity, wind. HOOF enables joint processing of data from ~150 radars in Europe.

DY2 *Time stepping algorithms*

Within RC LACE work was carried out research on formulating the non-hydrostatic formulation as a departure from the hydrostatic one expressed through a departure parameter ε. While values $0 < \varepsilon < 1$ do not have a physical meaning in the full model, we may use them in linear model for the semi-implicit time scheme and investigate the stability of the proposed solution. We may also envisage values $0 < \varepsilon < 1$ for example in dependence on the vertical coordinate η, allowing for smooth transition from fully elastic nonhydrostatic Euler equations to hydrostatic primitive equations near the model top where we care about stability more than accuracy (at least in the LAM).

DY3 *Vertical discretization*

The work on the VFE new formulation for HPE continued [Jozef Vivoda]. VFE was implemented in hydrostatic IFS in 2002 (Untch and Hortal). An extension of VFE to NH dynamics was formulated in 2013 (Vivoda and Smolíková) with a new formulation of vertical integral and derivative operators with prescribed boundary conditions. In the hydrostatic dynamics only the vertical integral is needed. The new formulation of vertical integral together with a revised definition of explicit vertical coordinate may be beneficial for hydrostatic IFS, implemented in 2019. Fig. DY3(a) shows benefits for the implementation within the IFS.

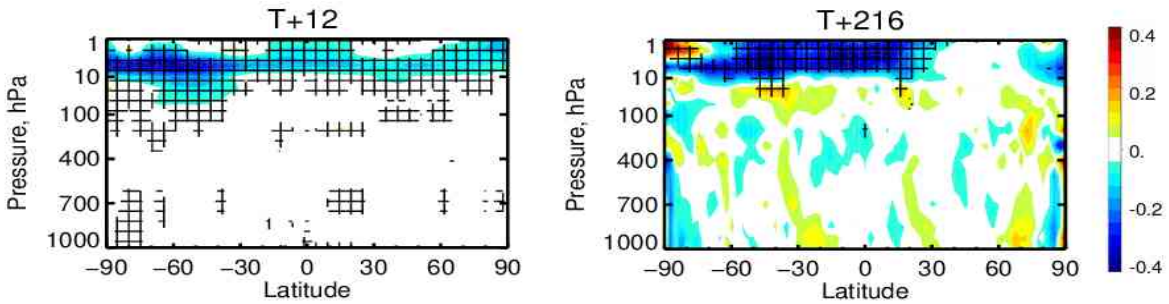

Fig. DY3(a): RMSE for T in IFS, Nov 2018 - Feb 2019, Tco1279: new VFE compared to the reference VFE. [improved, deteriorated, ++ statistically signif.]

PH1 Developments of AROME (and ARPEGE) physics

The new operation suite of Météo-France contains a number of new model features. There was a retuning in the dynamics in the horizontal diffusion and SL iterations number. Some tunings were performed of the convection scheme in ARPEGE. The were efforts to Improve the AROME microphysics scheme. Some work from RC LACE was done on the activation of the aerosols in the LIMA scheme was performed and intercomparison tests were carried out to compared them to the ICE3 scheme performance. The main step was the introduction of news diagnostics: visibility, type of precipitations, etc. Work was carried out to update the roughness and the emissivity for snow. In SC(a) shows the score card of the improvements of AROME in the first half of 2019.

Test du bootstrap sur les REQM
AROME Double par rapport à AROME Opér.

Période de validité du 20190124 au 20190701

La signification des symbôles utilisés dans les tableaux ci-après est :

- ▲ : le double est significativement meilleur que l'opérationnel avec 99,5% de confiance;
- ▯ : significatif à 95%;
- = : pas de signal significatif au seuil 95% ;
- ▯ : le double est significativement moins bon que l'opérationnel au seuil 95% ;
- ▼ : significatif à 99.5% ;
- | : donnée manquante

Domaine FRANGP (entre 152 et 156 cas)

	Réf.	Radiosondages	Propres analyses	Analyses CEP	SYNOPs
	Grille	EURW1S40	EURW1S40	FRANGP05	EURW1S40
	Éch.	0H à 48H pas de 12H	0H à 48H pas de 6H	0H à 48H pas de 6H	0H à 48H pas de 6H
Géopotentiel	100hPa	= ▯ ▼ ▯ ▯	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▼ ▼ ▼ ▼ ▼ ▼ ▯ = =	
	500hPa	= = = ▲ ▯	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▼ ▼ ▼ ▼ ▼ ▼ = = =	
	850hPa	▲ ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▼ ▼ = = = ▼ ▯ = =	
	1000hPa	= ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▼ ▼ = = = ▼ ▯ = =	
Pression	Mer				▯ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲
Température	100hPa	= = = ▯ ▼	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	= ▲ ▲ = = ▼ = ▼ ▼	
	500hPa	= ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	= ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	850hPa	= = = = ▯	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	= = ▯ ▼ = = = =	
	1000hPa	= = = = =	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	= ▼ = = = = ▯ = =	
Température corrigée	2m				▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲
Vent	250hPa	= ▯ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▯ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	500hPa	= ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	850hPa	= ▯ = = ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	= ▯ ▲ ▯ ▲ ▲ ▲ ▲ ▲	
FF	10m				▼ ▼ ▲ = = = ▯ = =
Humidité	400hPa	▲ = ▲ ▯ ▯	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	700hPa	▲ = ▯ ▲ ▯	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	850hPa	= ▯ = ▯ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲	
	2m				▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲

Fig. SC(a): Score card for the double suite of AROME-France.

In Morocco a new tool is being developed to estimate visibility from the output of the AROME model using data mining and machine learning techniques. Several, frequently used open-source data mining tools with open-source algorithms implementations are selected and compared against user groups, data structures, algorithms included, visualization capabilities, programming languages, and import and export options.

Two types of algorithms are used: those based on the ensemble based methods, and those based on neural network, deep learning. In addition, a database covering 3-year of hourly data, and resulting from pre-processing of raw outputs of AROME-Morocco and observed data, were used in this work. The study domain covers the north part of Morocco. The tested methods yield MAEs between 1000 km and 2000 km with the best result for an open source package called Gradient Boosting Machine, see the ALADIN-HIRLAM Newsletter 13 for more details..

PH3 Development of ALARO Physics

The ALARO community organized its bi-annual ALARO working days in SHMU, Bratislava, Slovakia, 11-13 March 2019, see http://www.rclace.eu/?page=197. There were presentations from

- operational applications (Belgium, Croatia, Czech Republic, Poland, Slovakia, Slovenia, Spain, Turkey) and climate simulations (Belgium)
- EPS with ALARO(1): A-LAEF, Belgium RMI-EPS, Spain AEMET-gSREPS Used operationally at 2-11 km resolutions
- Radiation (Ján Mašek: ACRANEB2, 3D radiation)
- Turbulence-Difusion TOUCANS (Ivan Bašták Ďurán: A two-energies turbulence scheme, Radmila Brožková:
- Shallow convection closure using mass-fux type approach, Mario Hrastinski: TKE-based mixing length in TOUCANS,
- Peter Smerkol: TOUCANS: Issues with computations in TOMs)
- Precipitations aspects (microphysics) (Bogdan Bochanek: Prognostic graupel in ALARO)
- Clouds (Radmila Brožková, Ján Mašek: Cloudiness: status, unifcation attempts and perspectives, Luc Gerard: Cloud reunification in the CSD context)
- Deep convection: complementary subgrid drafts; stochastic components (Luc Gerard: Status overview of the CSD adaptive convection scheme)
- ISBA, SURFEX (Martina Tudor: The quality of physiography data in clim fles, Ján Mašek: New roughness treatment in ISBA scheme, Martin Dian: ALARO-1 with SURFEX - current status and plan, Ján Mašek(Rafq Hamdi): ALARO-1 with SURFEX - some interfacing issues)

See the website to get a detailed overview of the status of the physics developments within the ALARO community.

In Czech Republic the resolution of ALARO was increased from 4.7 km to 2.3 km, running it on the same domain (thus more gridpoints) and with 87 vertical levels. The new database GMTED2010 is used and implemented in configuration e923. The thermal roughness is not anymore put together with the mechanical one. The non-hydrostatic dynamics is used instead of the hydrostatic one. The number of iterations in the semi-Lagrangian scheme was increased up to 4. The combination of the

spectral and SHLD horizontal diffusion was retuned. Some parts of the physics in the deep convection and the cloud treatment were retuned.

The ALARO community started to prepare contribution to CY47T1 following the T code QA assurance procedures. The first modset is prepared by Bogdan Bochenek, containing prognostic graupel code.

The second modset is prepared by Jan Mašek, containing several contributions:

1. DDH budgets for prognostic TKE and TTE (in TOUCANS) added by Mario Hrastinski.
2. New cloudiness treatment in vertical difusion by Radmila (introducing new options NDIFFNEB=4 and 5).
3. Fixes in adjustment and microphysics by Luc Gerard. These will be deactivated by a local key, since they require more extensive validation.
4. TOMs (3rd order moments in TOUCANS) fxes by Peter Smerkol. These will be deactivated by local key as well.
5. Further modularization and optimization of ACRANEB2.
6. Fixes of blend utility (new FA date structure, split of ECHIEN to ERIEN, reintroduction of Z_NSIGN, making ofcial version working).

A highlight is the work on TOUCANS – Third Order moments (TOMs) Unifed Condensation Accounting and N- dependent Solver (for turbulence and diffusion). A paper was published: "A Turbulence Scheme with Two Prognostic Turbulence Energies" Bašták Ďurán et al., https://doi.org/10.1175/JAS-D-18-0026.1. The basic data flow from TKE/TTE solver to DDH input structure is completed and successfully tested with uniform input fields. The ddh postprocessing of TKE/TTE budget felds is completed phasing this development within the next common cycle.

Some diagnostics in line with the developments in AROME were developed for visibility within ALARO.

SU1 Algorithms of surface data assimilation

- In Slovakia, work was done on the analysis of soil water content and temperature with SURFEX and SODA-EKF. A gridded observations, the CANARI analysis is replaced by hi-res analysis of T2M & RH2M from INCA-SK. A forcing at ~20m above surface of the INCA-SK precipitation analysis + global radiation analysis and other fields from ALARO-SK 4.5km. The next steps are:
  - Test and optimize current setup.
  - Compare the EKF with OI_MAIN.
  - switch to SURFEX v8.1.
  - Add snow cover analysis.
- Meteo France developed a hybrid method to correct for insufficient snow melt over plains in the AROME model. There were 2 such periods studied, in the winter 2018 (February-March) and 2019 (January-April). In this method the snow analysis performed using CANARI 2D OI. The prognostic variable is Snow Water Equivalent; it uses a model density to transform snow depth observations into snow water equivalent for the assimilation, observed in a heterogeneous observation network over the AROME-France domain. Some tuning of observation and background errors and length scales have been done.
- Both France and Hungary study the use of a Land data assimilation system to assimilate LAI and SSM.

SU3 SURFEX: validation of existing options for NWP

The ALARO community started to implement SURFEX within ALARO, although his task was not planned in the 2019 RWP. The goal is to switch ALARO-1 to SURFEX scheme, offering several more advanced options relevant for NWP. A few steps were made:

- Several issues identified: dynamical roughness length, setup issues, misusing of antifibrillation, inconsistency in the evaluation of TOUCANS stability functions.
- Solutions were developed: to account for the effect of orography on roughness length, to harmonize surface and atmospheric setup, to implement TOUCANS stability functions in SURFEX and remove the antifibrillation scheme.

SU5 SURFEX: development of model components

SU5.1 *ECOCLIMAP activities*

Within the ALARO community efforts are being make to couple SURFEX to ALARO, In order to increase the quality of the physiographic data the differences in results corresponding to physiography differences were computed. A procedure is created to compute variance, orientation anisotropy and topography roughness from GMTED2010 was applied. The code with correct averaging of thermal and mechanical roughness was developed.

SU5.5 *ECOCLIMAP SG activities.*

ECOCLIMAP Second Generation is being tests in Meteo France with, specifically with AROME-500m tests in fog conditions in France.