ALADIN Activity Report

April 2014

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The range of topics within the ALADIN (and HIRLAM) collaboration is too wide to cover all of them in detail. This report is limited to the most important ones. The strategic points of attention after the 2011 strategy update meeting are briefly repeated here (see the documents of the 2011 General Assembly for more details):

1.investment in code design/development/maintenance;
2.the replacement of the old ISBA scheme by SURFEX;
3.collaboration;
4.external funding;
5.and to launch an effort to "define"our users and to coordinate a project on addressing the end user requirements.

Regarding the organizational aspects, there are renewed activities for the ACNA (ALADIN Coordination and Networking Activities). This has demonstrated its value for the switch to the new machine in Météo France, which took place quite smoothly from the point of view of the involvement of the non-Météo-France partner countries. A first common ALADIN-HIRLAM newsletter was issued, thanks to the efforts of the ALADIN Support Team (ST), elaborating in detail the overview given to the General Assembly (Tour d'ALADIN) and some of the key presentations during the ALADIN workshop. There was also a very efficient meeting of the ALADIN Committee for Scientific/System maintenance Issues (CSSI) in Bucharest, concentrating quite a lot on the code aspects, which becomes increasingly important in view of the large collaboration we are dealing with.

A key action was launched last year related to collaboration and code issues; the so-called physics-dynamics action that was already announced last year. The main deliverables of this action are (a) confidence that the given work practice (communication, planning and follow-up) seems to work and (b) there are some intermediate results that are already worthwhile in itself, independently of the larger goals of addressing the problem of physics-dynamics coupling. Given its importance it will be described in further detail below in this report.

The activities on SURFEX that started with a SURFEX working week organized in Brussels in 2011 have been published in a paper in GMD. It demonstrates what most people expect: there is indeed a considerable potential in using more detailed surface schemes in NWP. Nevertheless, in this study some of the operational constraints (such as, for instance, memory use of the interpolation part of the physiographic data) have not been completely dealt with and may need some extra efforts in the future.

Quite a few discussions took place during several meetings (some SRNWP meetings, the ALADIN workshop and the ECMWF meeting on scalability) where some idea's were put forth for submitting proposals in various funding calls (H2020, COST, ...). It should be noted here that the COST ES0905 was finalized in March this year in a meeting in Toulouse. A book is being written and it is expected that this can become a good reference material for the issues related to deep convection.

The question of the quality of our applications is currently approached from three angles with three different goals: scientific validation, cycle validation and monitoring of the applications in the countries. For the last goal the ALADIN Performance Monitoring Tool (APMT) has been finalized last year. Partners have a need to justify the use of the models in their countries. For this reason it was decided last year to start to build a portfolio of successful cases of the model use within the consortium and to make it available to the participating countries. This is explained in more details further below, two examples of such cases are shown there.

Regarding model development, we limit ourselves here to reporting a few points of note. Météo France is preparing to run AROME at 1.3 km. There are some remarkable examples of so-called "seamless" behavior originating from the WMO WGNE action and a study of long runs carried out in

Brussels. For dynamics, the development on Vertical Finite Elements has been implemented in the most recent cycle (cy40t1). Some evidence was provided that the use of A grids is quite OK. It is also important to highlight some work of our HIRLAM colleagues testing the scalability of the model in so-called MIC's, see below for more details.

We held a working week in Ankara last year (as announced during the common PAC/HAC meeting in Toulouse) to test the HARMONIE system. This was quite a success, as reported further, but there remain a number of important constraints and needs for extra features, that have to be investigated in detail before this system could be fully adopted by the ALADIN consortium. It is also important to stress the activities on OPLACE, which in my opinion, illustrates that within a large collaboration, there is still room and freedom for extra “more downstream” activities on top of the basic transversal ones.

1. ALADIN Coordination and Networking activities

The ALADIN Coordinator for Networking and Applications (ACNA) assists the ALADIN management for the following tasks:

- preparation of the LTM meeting and the coordination of actions to be taken by the LTMs;
- supervising changes in the preparation of coupling files, due to specific changes in the Arpège suite;
- coordination of the tests of the new cycles: supervise the meteorological performance, help on the finalization and installation of the new cycle in partner countries and distribute the needed technical tasks among the ALADIN partners;
- take part in the relevant System coordination.

These activities are the last ones in the line of scientific development – code phasings – cycle porting, and they need special care to ensure proper updates of the national applications in the partner countries.

Over the past year this function received a new impulse in the ALADIN consortium, thanks to the efforts of Maria Derkova who took up this function since a bit more than a year. There were two highlights. First there was the switch to the new HPC machine in Météo France, which necessitated a re-creation of the climatological files for all the ALADIN domains and which caused a change in the computation of the coupling files. The switch (on 14/1/2014) was very well prepared with well coordinated tests in the countries, and the switch itself took place without any noteworthy problems. Still some differences are found when using the new climatological files and this is still being investigated.

Secondly, CY38T1_bf03 was used to create an export version. Currently this version is compiled and tested in all the countries (except a few who are in the process of the acquisition of a new machine). In one country (Czech Republic) this cycle is already operational. Several countries will make the switch soon.

There were two efficient LTM meetings in Antalya during the EWGLAM meeting (1/10/2014), where the coordination of the above-mentioned switch were planned, and one in Bucharest (8/4/2014), both chaired by ACNA with very useful input from the LTMs. The importance of these meetings and the efforts of the ACNA should be stressed.

2. The physics-dynamics interface and the APL-routines

During the previous workshop in 2013, several issues were raised that relate to the organization of the physics. First there has been some request for clarity on what model(s) we are running; AROME/ALARO/HARMONIE or said differently, “What is Harmonie?”. Work on the physics-dynamics interface was progressing slowly last year and needed to be invigorated. There was a request from HIRLAM to scientifically compare several radiation schemes (IFS, ACRANEB2, hlradia) in the same testbed; in this case the AROME model configuration. The APLPAR routine (the routine that calls the physics routines for ARPEGE/ALADIN/ALARO) has become a long and complex routine and some serious cleaning would help a lot.

Last year a work plan was presented to PAC to start an action on this. This action progressed very well, although, it must be admitted, not entirely as was foreseen in the detailed road map. Regular follow-up and discussion meetings were held (almost every month or even more frequently) between ALADIN, Hirlam, Météo-France, LACE. Reports, presentations and documentation can be found on the HIRLAM wiki page: https://hirlam.org/trac/wiki/phys-dyn. The approach of follow-up meetings, and stepwise planning is working very well for this complex matter: it allows to make concrete steps

forward and it provides a forum to make decisions on the code design involving the concerned scientists.

Most of the technical work presented below was carried out by Daan Degrauwe (coordination, implementation of INTFLEX and code organization), Jan Mašek (implementation of ACRANEB2 and phasing to cy40t1) and Yann Seity (testing in AROME).

2.1 INTFEX

The basis of these developments is the installation of a flexible interface called 'INTFLEX'. It has a number of distinct features: it allows for an arbitrary number of hydrometeors and it is build such that all conversions between hydrometeors are possible. This interface has been tested for AROME already last year during a Working Week in Brussels. It is now available in CY40T1. In fact this interface was already available for ARPEGE, ALADIN and ALARO, but it has turned out to be also useful for AROME. It allows automatic detailed diagnostics at the level of the physics-dynamics interface, which can be used as an extra tool to validate the physics code (in fact it has been used to validate PCMT, eliminating a bug).

2.2 Testing in AROME

The flexible interface allows to perform a few corrections of the approximations that were made in the thermodynamics in the meso-NH physics. First it allows to keep an accounting for heat transport by precipitation in AROME and correcting for it. The behavior of AROME is not neutral with respect to this (and can not expected to be), but tests show that it is in general neutral in terms of scores and, even a small improvement was found for the skill scores of precipitation, as shown in Fig. 1.

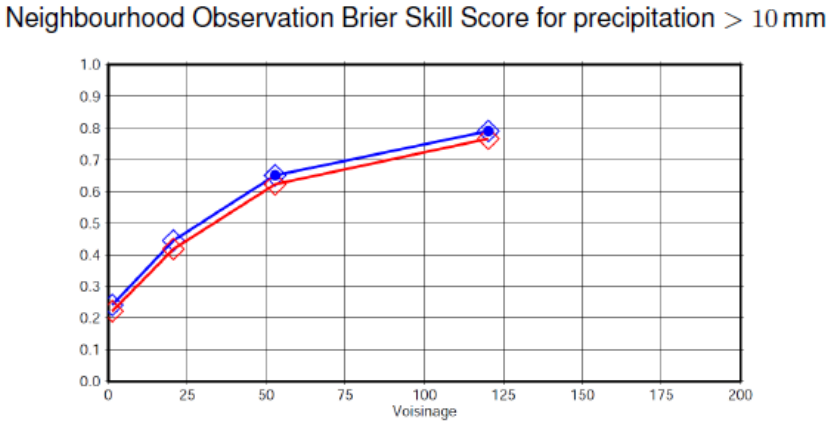

Figure 1: Tests with AROME with the new interface, including a correction to take account of the heat transport due to precipitation. Most found scores are neutral but there is a slight improvement for precipitation as shown here (blue: using the interface; red: old configuration). Courtesy Y. Seity.

Additionally the interface allows to make corrections to the approximation in the humidity dependence of c_p, making it a time evolving quantity. The effects of this in the AROME runs were noticed, but mostly at the first time steps after the initialization of a run.

2.3 APLPAR cleaning

The idea here, essentially, is (a) to remove all computations from the APLAR and APL_AROME routines (and in parallel the APL_AROME routine) and (b) to structure the arguments. The aim is to make these routines pure "calling" routines and to make them transparent to clearly see the structure of the calls. After finalizing this, one can hope to identify different major blocks. As a first guess one hopes the find one for radiation, one for turbulence and one for the rest (i.e. microphysics and clouds).

The action started with a streamlining of the part of the radiation, taking the request of HIRLAM as an opportunity. All the preparatory calculations (aerosols, cloudiness, ozone, CO2, albedo) were moved to separate subroutines. The choice between different radiation schemes (FMR/RRTM, ACRANEB) is moved to a separate routine. This clarifies dependencies between radiation and other parameterizations. This may provide some guidelines for cleaner physics. From this, a list of guidelines has been put forward to for future implementations of physics in the calling routines. As a result, about 600 lines of code were removed from APLPAR (from the original 4500+ line). Lastly, it was found that both APLPAR and APL_AROME can be organized in a symmetrical manner for radiation, facilitating the transfer of a development in one routine to the other. The cleaning and specifically the organization of the inputs for radiation should become the basis for the planned future activities to include aerosols in the system (cfr. the aerosol workshop that took place last year in September in Toulouse).

2.4 Conclusions regarding the interfacing work

The common flexible physics-dynamics interface has been coded and some first encouraging tests were carried out with AROME (further tests are needed). Future developments (new fluxes, new hydrometeors) can benefit from it due to the possibility of extra diagnostics in the interface. The physics calling routines (APLPAR and APL_AROME) cleaning and reorganization is challenging but necessary. We should aim (at least) at a 'symmetric' organization of these two routines. The feasibility has been proven for radiation. The next 'block' is turbulence and shallow convection. The remaining question to be answered is: "what level of granularity are we aiming at when organizing APLPAR and APL_AROME in blocks?" Or, stated differently, "could we evolve to a HARMONIE Forecasting System (HFS)?" (see illustration 1), i.e. gradually removing the shady area in the HARMONIE box, leaving more options while validating a few baseline versions in expert versions. We also plan to finish work on DDHFLEX and remove old-style diagnostics.

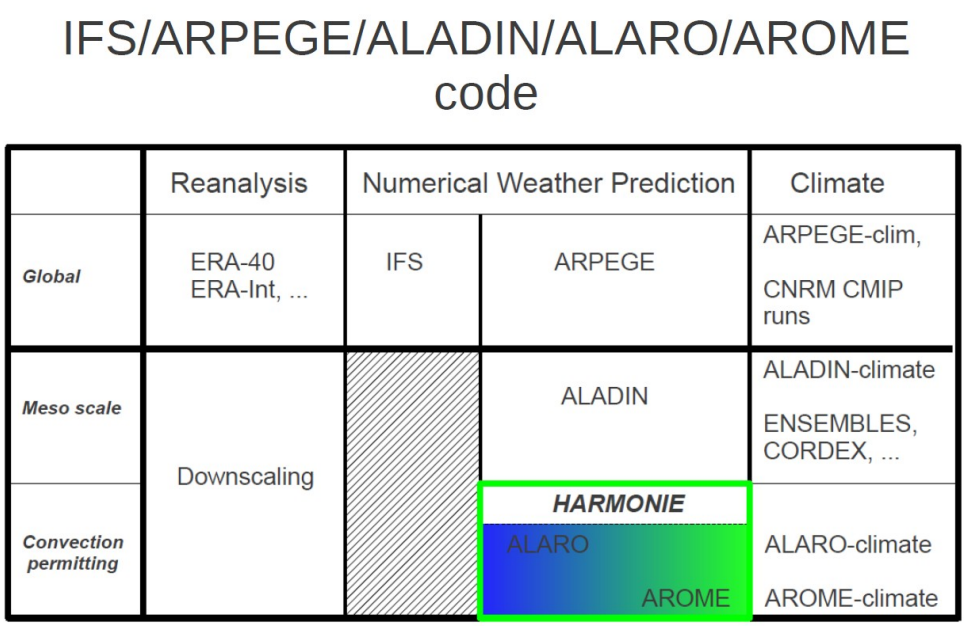

Illustration 1: An synthetic overview of the IFS/ARPEGE/ALADIN/ALARO/AROME code and its different usages.

I believe this type of work should be officialized in the next ALADIN MoU, with a coordinating and technical function. Similarly as the ACNA function there should be a ALADIN Code Coordinator.

3.OPLACE

OPLACE(Observation Preprocessing for LACE) is a common observation pre-processing system providing operational real-time data to LACE members (Austria, Czech Republic, Croatia, Hungary, Romania, Slovakia and Slovenia) for NWP and verification purposes. This system manipulates observations from conventional (SYNOP, TEMP, AMDAR) and non-conventional (SATOB, SATEM, WINDPROF) sources (see Illustration 2) to generate input data for data assimilation in a readable format. Therefore OPLACE can help to reduce local (NMS) work on observation preprocessing which is an exemplary achievement of the LACE consortium as an extra organization that is embedded within the ALADIN consortium. It demonstrates that a large consortium can provide a background and the necessary freedom for further developments that make possible an exchange of observation data between a geographically confined sub-area within the consortium and even use it and create a background for development on data assimilation, based on an extra "sub"consortium structure.

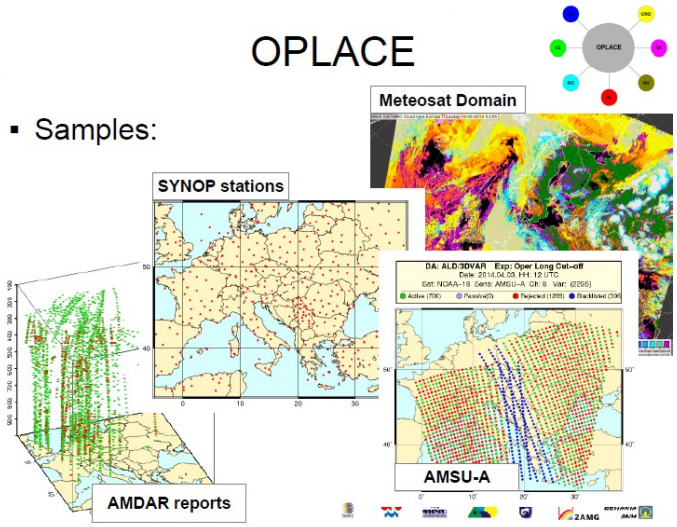

Illustration 2: Typical data distribution and domain examples from OPLACE for SYNOP, AMDAR, AMSU-A and Meteosat observations, taken for M. Mile's presentation during the ALADIN workshop.

4. The ALADIN Performance Monitoring Tool

Last year, the old tool, the ALADIN Performance Monitoring Tool (APMT) for the monitoring of the operational applications in the ALADIN countries took a fresh start. The question of forecast quality is multifaceted and several issues should be addressed, ranging from the validation tool of scientific development, the monitoring of the performance of the models in the operational applications to the question of the quality of information that is sent to the end users. Currently the tools to be used for this are summarized in table 1.

	Compute scores on the fly	Monitoring of the applications in the countries	Validation of new cycles	Science verification	Verify fields or pointwise
ALADIN Performance Monitoring Tool in Ljubljana (APMT)	yes	yes	no	no	pointwise (station data)
HARP	yes	yes (through APMT)	no	yes	both
HIRLAM verification tool: The HARMONIE system	no	no	yes	yes	pointwise

Table 1: Three existing tools for quality control to address different needs

The APMT has been finalized. It produces monthly reports. These reports will be checked during the Forecaster's meeting later this year to provide a report to the next General Assembly. The enquiry of the needs of end users was finished (the details can be found in a report of the Lisbon meeting). It was proposed to the General Assembly last year to build a portfolio of cases of added-value forecasts in our consortium from which the partners could make folders and documents to present their activities to their national stakeholders.

5. Planned steps towards 1-km resolution operational runs with AROME.

Météo France is preparing to run AROME with a resolution of 1.3 km. Currently a configuration has been established and this is being tested. Here one finds an improvement of the counting of the convective cells as compared to radar data, especially in the small scales and an improvement of the diurnal cycle, see Figure 2. An improvement for the scores was found except for the temperature at 2m and the relative humidity at 2 meter. For the last case extra tests are being planned with turbulence schemes addressing the issues of the stable boundary layer.

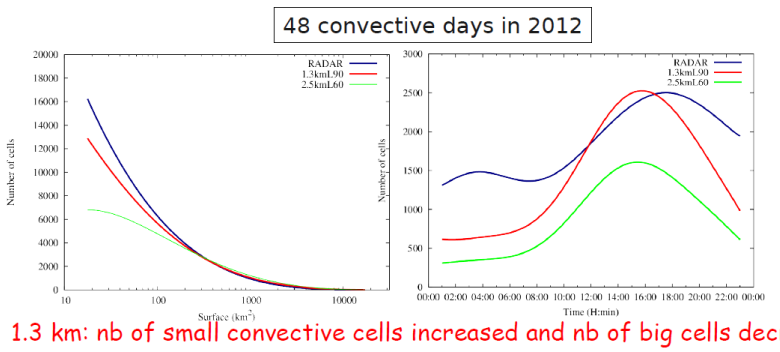

Figure 2: Improvement of the counting of the convective cells with respect to radar data, especially in the small scales, and a better diurnal cycle. Courtesy Y. Seity.

6. “Seamless” behavior of the models

6.1The WGNE Grey Zone Experiment

The ALARO physics was specifically designed to address the issues of the behavior in the so-called gray zone (i.e. resolutions of about 5 km and below, where the dynamics already starts to resolve parts of the deep convection, but not completely and thus parameterization schemes should be constructed to avoid a double counting). ALARO uses the 3MT scheme which has been designed specifically to care for this. WMO launched an experiment to gain insight into the behavior of the models at these resolutions. ALARO has been used in this context, specifically to tests this feature. In this project a cold air outbreak is studied North-West of Scotland for 30 January 2010. The aim is run the model across a range of different resolutions: 16 km, 8km , 4 km, 2 km, and 1 km. ALARO demonstrated good multi-scale performance as demonstrated in figure 3.

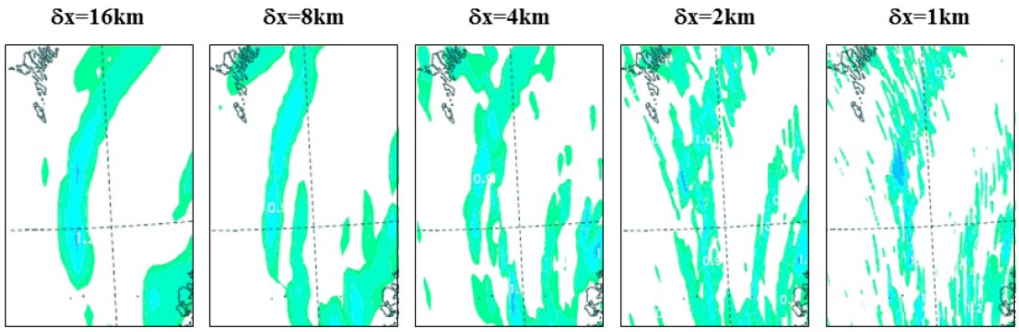

Figure 3: ALARO "seamless" forecast: 1h precipitation sum from +30h to 31h, forecast base 30 January 2010, 12h UTC, area between Faeroe and Orkney islands. Courtesy R. Brožková

Additionally, this occasion has been seen as an opportunity to carry out tests of the sensitivity of the scheme with respect to different aspects of the parameterization. In particular, several tests were carried out by switching on different part of the physics. It was found that the largest sensitivity (and positive impact) was found from taking into account phase changes of the falling species and from the details of the geometry of the cloudiness and the precipitation.

6.2Validation of statistics of precipitation in downscaling long runs (climate).

ALARO has also been tested in a long-run setup, coupled to ERA-Interim. The goal was to test the properties of the statistical relationship between the occurrence and intensity of precipitation and not so much the results of individual variables at

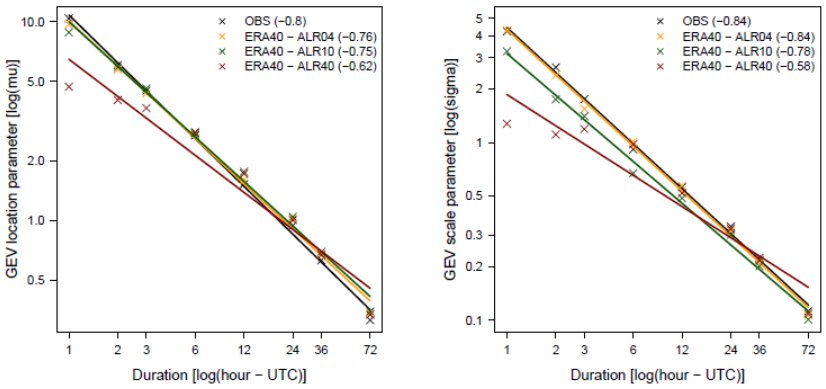

Figure 4: Scaling (per duration) of the estimates of the mu and sigma parameters of the Generalized Extreme Value (GEV) distribution, used for statistics of extreme precipitation. De Troch et al., presented at EGU 2014.

specific time in specific locations. A paper has been published (De Troch et al. 2013, J. Clim.) where is it was shown that ALARO gives, unlike the predecessor ALADIN, consistent frequency curves for precipitation across varying resolutions from 40 km up to 4 km, for return frequencies of one day and more. Lately this work has been extended with a time series in Ukkel, Belgium, of very high temporal resolution. Interestingly, in a recent study, it was found that the statistics of a Generalized Extreme Value (GEV) are increasingly better represented when going to higher resolutions (from 40 km to 4 km), as shown in figure 4. This represents a kind of seamlessness that is of interest for climate applications: the statistics are comparable in the temporal scales where there is overlap with the low resolution, but they improve in the short time scales, shorter than 1 day.

7.Dynamics

7.1 The developments of the Vertical Finite Elements (VFE)

There is now a working implementation of the FE method in the vertical discretization of the NH model in the cycle CY40T1. This version leaves open a number of choices of freedom to configure it such the choice of boundary conditions for vertical operators; the fulfillment of numerical constraints for vertical operators; the choice of vertical levels in connection to the choice of knots for spline definitions; the sufficient and necessary conditions posed on eigenvalues of vertical Laplacian operator for stability of the scheme. A few concrete next steps are planned, the most important further testing in real 3D cases. This work is carried out jointly with two experts from HIRLAM (A.Subias and J.Simarro).

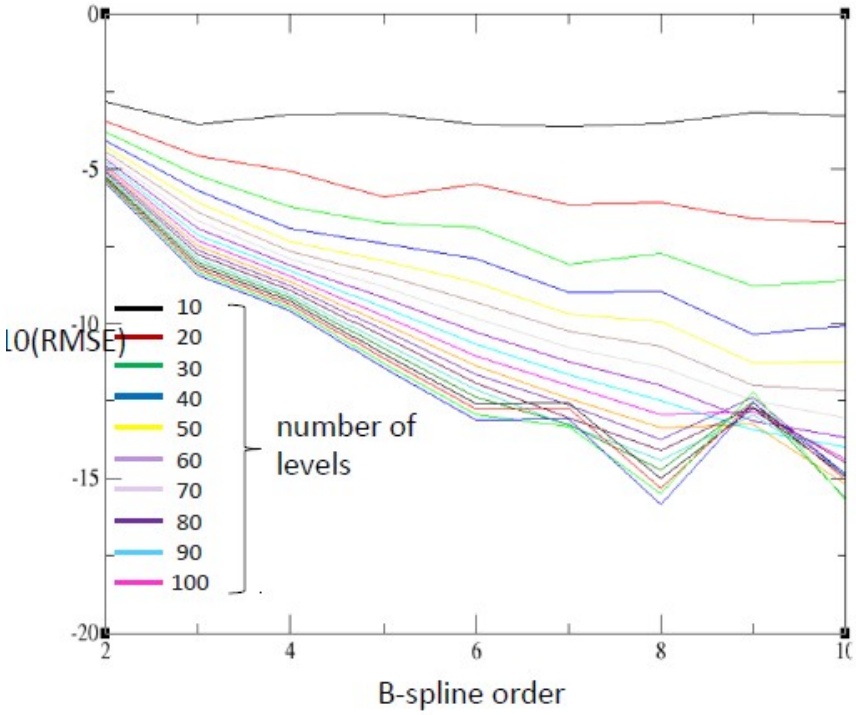

Figure 5: Impact of the vertical resolution and the B-splines on the Root Mean Square Error (RMSE), i.e. the log(RMSE) as a function of the order. Courtesy J.Vivoda, A.Subias, J.Simarro

7.2 Some evidence that A-grid (or its Z-grid counterparts) is fine for the medium term planning of the dynamical core

In the modeling community the choice for C grids is often justified by the argument that it provides better dispersion relation for the gravity waves when used with local horizontal discretization methods (finite elements, finite differences). It sometimes claimed that this is only true for the gravity-wave part, but that for the advection A grids are, in fact, better. P. Bénard elaborated this and computed the equivalent for dispersion relations for the so-called advective vortical mixing, which represents a more meteorological relevant dynamical transport than gravity-wave transport of energy. In the mean time an alternative has been investigated of a hybrid way of using and (u,v) A-grid discretization for the semi-Lagrangian part of the dynamics and a (vorticity, divergence) formulation with A-grid for the implicit part of the semi-implicit scheme, the so-called Z grid, which would allow to keep the best of both worlds.

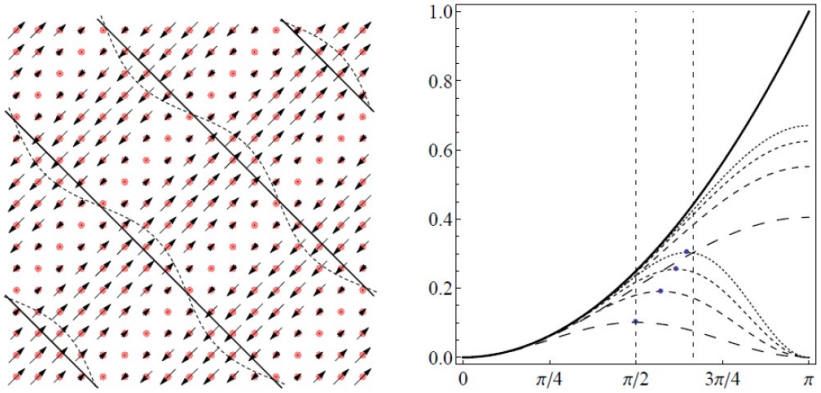

Figure 5: Bottom curves: C-grid; Middle curves : A-grid. Top curve: exact response. The four curves for A and C grids are for accuracy orders 2, 4, 6, 8 in decreasing order of dashing length. Courtesy P. Bénard

7.3 Scalability: MIC's; instructive results from our HIRLAM colleagues

One of the concerns for GP-CPU is a certain need for a recoding of some CUDA solutions to transform FORTRAN code to some specific programming language fit for the GPCPUs (General-Purpose Graphical Processing Unit). During the joint ALADIN workshop/HIRLAM All Staff Meeting (ASM) in Bucharest, Enda O'Brien from the HIRLAM consortium raised the following question " Which provides more value: an extra compute node, or an accelerator?" and executed very instructive tests of the HARMONIE code on architectures with Xeon processors testing MICs (Many Integrated Core) compared to classical processors. The idea of MICs is that they allow the code to be run with more threads, but with a lower clock frequency. Also, the MIC systems had less memory per core than the classical Interestingly his tests included tests with MICs without any code modifications (only a change in the compiler command-line options; and relying on the already existing structures of open-MP application). Considerable speedups were obtained using MICs without any recoding and this lets us conclude that MICs should be taken seriously.

8. Testing of the HARMONIE system

HIRLAM developed the so-called HARMONIE system, which includes the forecast model, but also a scripting system to set up experiments them and also a package for verification. The latter is extensively used by HIRLAM to validate new cycles. In view of a closer collaboration, it is needed that the two consortia try to validate new cycles together in the future. For this it would be beneficial to have a common platform. It was agreed last year to organize a working week in Ankara to use the HARMONIE system to install cycle 38 in an ALADIN country (in this case Turkey) as if it was done commonly with HIRLAM and to analyze what has to be added as features to the system to address the

needs and the work practices in the ALADIN consortium. This action was already announced during the common PAC/HAC meeting last year in Toulouse (see "Prospects for further HIRLAM-ALADIN convergence: Governance and other aspects", Report of the Task Force presented to the ALADIN Assembly last year). The conclusions of this working week were:

- indeed, the HARMONIE system has demonstrated its functionality. The Turkish team was able to install the model in a most efficient way, including a 3Dvar data assimilation, but
- some extra developments are needed to extend it, to make it suitable for use for a validation of the export cycles in the ALADIN countries.

More details can be found in the report of that meeting,

9. SURFEX

The SURFEX action to test a version of SURFEX model for it its performance aimed at running it in an operational version combined with ALARO has been finalized in 2013 and the results are published.[1] This study only investigated the performance but did not address the computational issues. For instance in the past some problems were found with the memory in the setup part of a downscaling run with SURFEX, to prepare the coupling data from the global model to the LAM. In that case the interpolations took too much time for the Turkish application. This has been reported before. Last year there was a flat-rate stay in Brussels of Tayfun Dalcilic addressing this problem and the necessary code modifications were proposed and reported last year. It should be stated here that an extra effort to address this issues is still needed and should be planned.

10. Demonstration cases

Last year a few interesting cases happened where the high resolution runs with our model(s) demonstrated added value with respect to the IFS of ECMWF (which is taken in most countries as the reference). A first case was the one of 27 September 2013 of a flooding in Portugal, where ECMWF did not show a significant signal whereas ALADIN and AROME did. Even more, AROME running at higher resolution also showed the best signal compared to ALADIN, see figure 6. Another case of great

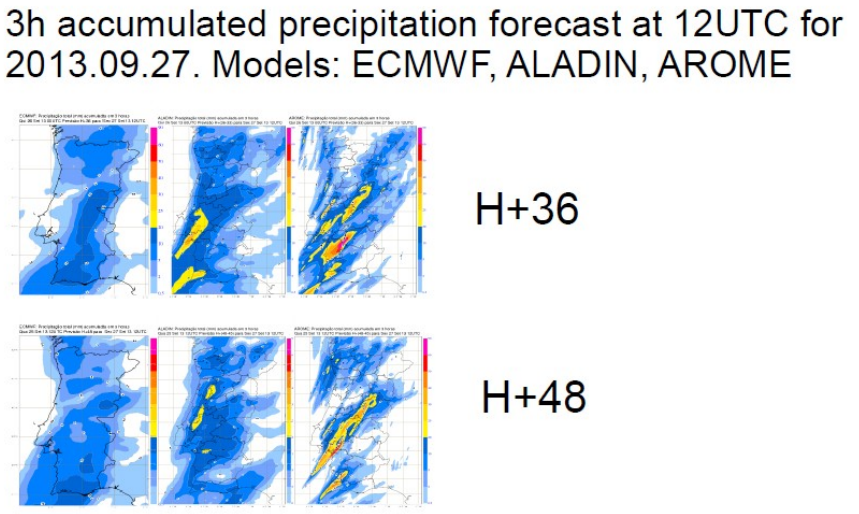

Figure 6: a flooding case in IPMA, Portugal where the high resolution model AROME (right) better captured the extreme precipitation, where ECMWF (left) did not.

1 R. Hamdi, D. Degrauwe, A. Duerinckx, J. Cedilnik, V. Costa, T. Dalkilic, K. Essaouini, M. Jerczynki,F. Kocaman, L. Kullmann, J.-F. Mahfouf, F. Meier, M. Sassi, S. Schneider, F. Váňa, and P. Termonia, 2014: Evaluating the performance of SURFEXv5 as a new land surface scheme for the ALADINcy36 and ALARO-0 models, Geosci. Model Dev., 7, 23–39.

interest was the flooding in Central Europe in the beginning of Jun 2014, see figure 7 for an output at ZAMG, comparing the output of the precipitation of ALARO to ECMWF.

In September this year a forecasters meeting will be planned in Turkey to collect such cases. The plan is then to make a portfolio of such cases within the consortium, from which each partner could then select material that can serve to address the question of the added values of the ALADIN-consortium activities in each country nationally.

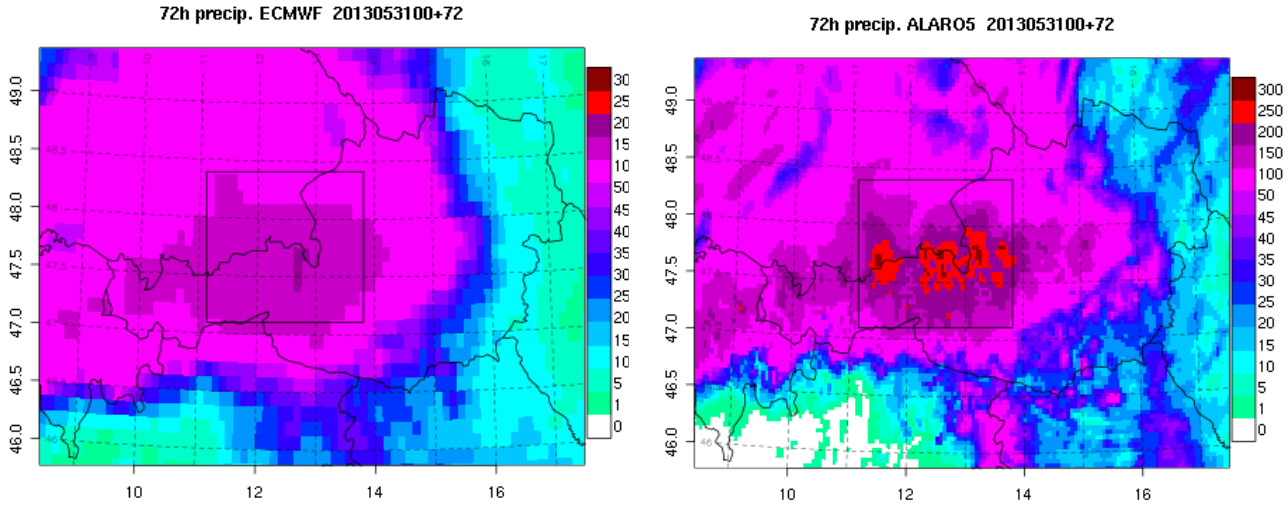

Figure 7: The 2013 central European flooding case: ECMWF and ALARO .