# Towards the operational use of HARMONIE at AEMET

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## Objective

Currently AEMET uses ECMWF and HIRLAM models for weather prediction. The HIRLAM deterministic forecasts have resolutions of 16 and 5km. ECMWF has already gone to 16km and plans to go to 10 Km in 2015. In this context, LAMs are moving towards scales where convective clouds are explicitly resolved and where NH effects may be important. This is a major challenge for NWP groups and has stimulated the collaboration between different NWP consortia.

The HARMONIE system is a coordinated effort of the ALADIN and HIRLAM European consortia. This new system includes non-hydrostatic dynamics and different options for the physical parameterizations: the sophisticated physics of the Meteo-France research model Meso-NH ("AROME configuration"), the "ALADIN physics" and the "ALARO physics" that has been developed for the "grey zone" resolutions. The aim is to improve local forecasts and specially the prediction of severe weather such as heavy precipitation, strong winds, extreme temperatures and fog.

HARMONIE is active as well in meso-scale Data Assimilation. Many different ideas have been and are being tested in this area within the HARMONIE framework. Presently the main efforts are directed towards an operational DA system able to use effectively high spatial and temporal resolution observations.

## The HARMONIE model

ALADIN configuration

• Hydrostatic semi-lagrangian dynamics. ALADIN physics

AROME configuration

• Non- Hydrostatic semi-lagrangian dynamics.

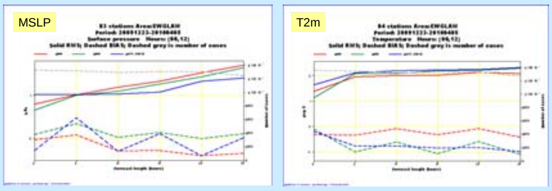
• 5-species "ICE-3" microphysics, KFB shallow convection, ECMWF radiation, TKE-l 1D turbulence, exterrnalized surface "SURFEX" based on ISBA with tiles for soil/vegetaion, sea, lake and town.

Data assimilation for the ALADIN configuration

• 3DVAR scheme for upper levels and OI for screen level variables. Background error statistics can be computed using the NMC method or from ensemble perturbations. A statistical balance formulation of the background constraint is used.

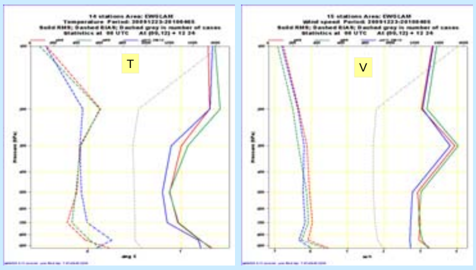
## Synoptic model: Verification against observations and comparison with the operational HIRLAM model

- HARMONIE 35h1.2 (60L) was installed in December 2009 when it replaced the older 32h2 (40L) version. As its predecessor, it runs at a horizontal resolution of 11Km with hydrostatic dynamics and ALADIN physics. The forecasts are initialized from HIRLAM 7.2 with 3DVar 16 Km and 40L analyses. Verification parameters shown below indicate that this new setup performs well compared with the current operational HIRLAM 7.2 system. The verification period is last winter (December2009 - March 2010). Blue lines correspond to HARMONIE 35h1.2, while operational HIRLAM 7.2 at 16Km is displayed in red and HIRLAM 5Km resolution configuration is in green.



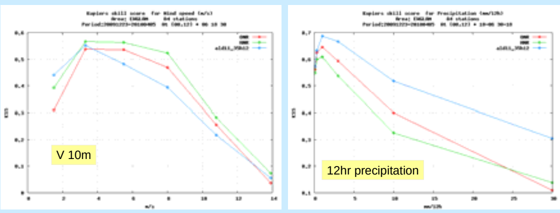

***RMSE and Bias of MSLP and T2m***

- MSLP verifies better in spite of the worse initial fit to observations (initial conditions are interpolated from host model fields). The same can be seen in T 2 m but in this case, the verification does not improve with time. Note the -1 K bias.




***Vertical profiles of RMSE and Bias for temperature and wind speed.***

- The scores for some upper-level variables compare favorably to HARMONIE.

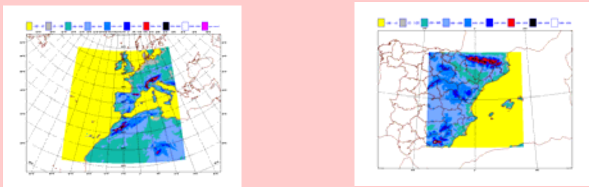



***Kuiper skill score function of the category for 10m wind speed and ppt. .***

Above 5 m/s HARMONIE shows bigger errors even than HIRLAM 16km. For precipitation it's difficult to draw conclusions due to the different resolutions but HARMONIE shows improvement.

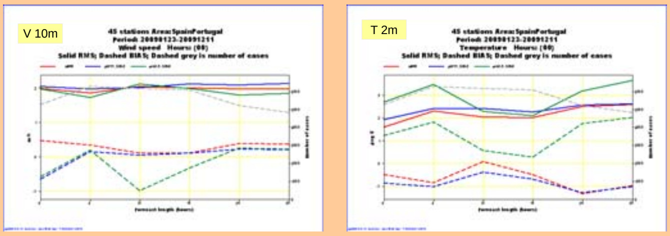
## Configurations of HARMONIE daily runs at AEMET

- Hydrostatic model: 11 Km horizontal resolution (384x400, including extension zone), 40 and 60 levels, boundaries from HIRLAM 16 Km every 3 hr, started at 00 and 12 UTC, forecast length of 36hr.
- 3D-Var upper-air assimilation and surface OI assimilation are run in test mode.
- Mesoscale model : 2.5 Km horizontal resolution (300x300, incl. extension zone), 40 levels, boundaries from synoptic model every 1 hr started at 00 UTC forecast length 30hr.
- No assimilation



## High resolution model: Verification against observations and comparison with the synoptic models .

The NH runs are at the moment generated with HARMONIE 32h2. Deep convection is not parameterized. The initial conditions are taken from HARMONIE 32h2 11Km (40L). The domain extends over a small eastern Iberian Peninsula and Baleares Islands (see up right), an area where severe weather situations are more frequent. The verification uses the observations from AEMET's SYNOP stations network for the period January-December 2009. AROME 2.5Km results are compared with its nestor model HARMONIE/ALD 11km and the operational HIRLAM at 16 Km.

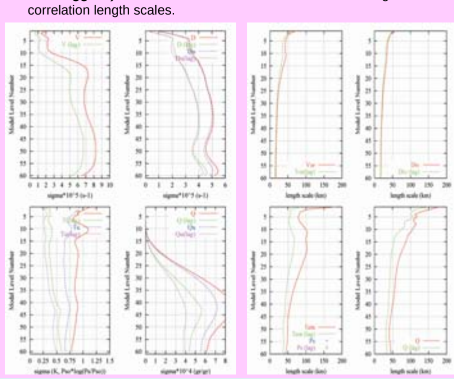



At 2.5km resolution there is a slightly improvement on 10m wind and MSLP (not shown) scores but on cloud cover (not shown) there is deterioration. Errors are slightly worst for 2m temp. where we expected an improvement due to the better orography. Note the -1K bias at 11km and the +1K bias at 2.5km. t resolution but it seems that HARMONIE 2.5 tends to produce very intense, small scale precipitation too often. It is also noteworthy that HARMONIE 2.5 tends to produce very intense, small scale precipitation too often (not shown).

## Tests with the analysis algorithms and DA

- AEMET is currently testing the HARMONIE 3DVar algorithm on a CRAY X1 vector machine. A first step was the installation (September 2009) of the 32h2 version at 11Km resolution and 40 levels for a spatial domain centered over Spain. Recently (April 2010) we have completed the installation of the 35h1.2 version at the same horizontal resolution but with increased number of vertical levels (60 levels).
- The version 32h2 was running in test mode for some months with a six-hour cycle. During this time, several aspects of system exploitation and system performance have been investigated: use of observations (including satellite AMV and radar VAD data), observation and model error calibration (see on the right of these lines the model error estimates for the different analysis control variables), minimization of border effects and forecast verification parameters.
- The results (not shown) indicate that forecasts initialized from these 32h2 analysis verify somewhat worse than those initialized from interpolated HIRLAM 7.2 analyses. The difference is bigger in the middle and upper troposphere. The HIRLAM 7.2 analyses are generated over a wider domain, at coarser horizontal resolution (16Km), increased vertical resolution (60L) and, for the larger scales, are blended with ECMWF fields. The verification however compared much better when the dynamical initialization utilized HIRLAM 6.4 analyses which did not include this blending.
- The testing mode was extended to the surface analysis optimal interpolation algorithm "CANARI". The results indicated that the impact of these surface analyses is retained not long in the forecast. After a few hours of integration the verification parameters reach values similar to those from forecasts initialized with interpolated fields.
- During the next few months comprehensive tests with 35h1.2 HAMONIE DA will be carried out. We expect to obtain better verification results due to the thinner vertical resolution, better tuned data screening and data assimilation, more intensive use of observations, and, in general, a better knowledge of the system. The working plan includes the experimentation with structure functions calculated with the so-called "NMC lagged method" (Široká et al. 2002) (see preliminary results on the right). We are interested too in large-scale constraints that we believe will improve the performance of the algorithm.
- Last but not least we plan to move steadily towards shorter assimilation cycles (Rapid Update Cycle). To this end, we will have to handle and assimilate data of increasing quantity and complexity like radar reflectivities and doppler shifts and RSS AMVs. These two data types have generation cycles of about 15 minutes.

***HARMONIE hydrostatic 11Km and 60L model error for the analysis controls estimated with the NMC method ("standard" and "lagged").*** On the left standard deviations and on the right correlation length scales.



## Conclusions and future work

• We have implemented daily runs of HARMONIE at 11Km 60L (**v35h12**) and 2.5km 40L (**v32h2**) .

- The Non-hydrostatic 2.5km integrations are very demanding from the computer point of view. So far a great part of our efforts have been devoted to implement and optimize the performance of the model in our Cray computer.
- The ALADIN model shows a very good quality at 11Km except in 2m variables. We have to improve the initialization of the near-surface variables and probably there is room for improvement in 10 m wind.
- Currently we are calibrating the assimilation system at the 11Km scale. Data assimilation in the non-hydrostatic runs will follow.

• The non-hydrostatic runs show a tendency to produce too intense and noisy precipitation. This problem also has negative effects on the quality of the wind forecasts.

• Much effort has to be dedicated to find an optimal nesting strategy. To this end, a comprehensive set of tests has recently been defined and will be carried out in the near future.

• Verification at these scales is a complex task. We use only synoptic stations and traditional verification scores, which is known is not optimal for the scales of interest here.

- We are trying to use more types of observations like high resolution climatological networks and radar data.
- We are testing new verification algorithms such as the SAL method to account for the weather system's structure.