# Validation and sensitivity studies

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## 1. Objective

The forecasting of the onset, development and dissipation of fog remains today as one of the biggest challenges in the field of weather forecasting. One of the least explored areas, but with a high potential, is the study of the influence of turbulence and stability in the lower atmosphere over fog cycle.

The Iberian Peninsula has very complex terrain, which means fog develops locally at every place. The study presented here is focused in the Spanish Northern Plateau. This is a fairly homogeneous terrain where fog usually appears during winter. The ability of quasi-operational HARMONIE forecast to reproduce the onset and evolution of fog events will be evaluated. Also several tests will be performed to assess the sensitivity of the model to different settings: Horizontal and vertical resolution, turbulence and shallow convection parameterization, diffusion of hydrometeors and initial analysis.

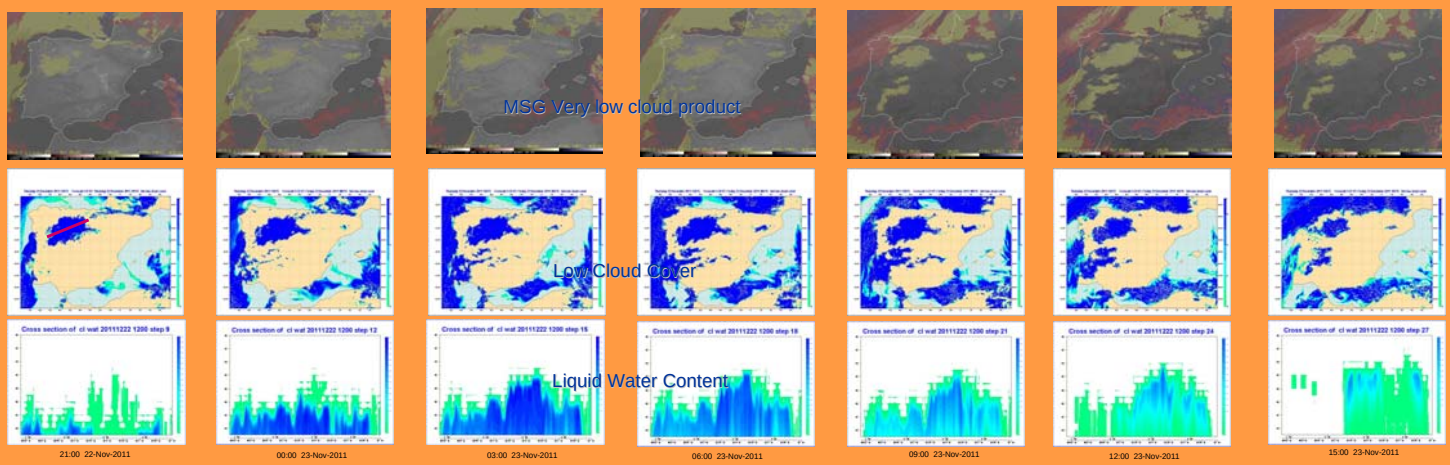
## 2. HARMONIE set up

HARMONIE v36h1.4 with AROME configuration is run quasi-operationally at AEMET since October 2011. The horizontal resolution is 2.5 km and it uses 65 vertical levels. It has a 6-hr cycle for surface fields and the upper air fields are taken from the ECMWF H+6 forecasts. It uses EDMFM for the shallow convection and the reference SLHD scheme for diffusion of hydrometeors.

This model version is also used in the sensitivity tests presented below.

## 3. Evaluation of HARMONIE fog and low cloud forecasts

It was tracked all fog episodes since late November, 2011 until middle of January, 2012 and around 36 days of fog were identified in the northwest part of the Iberian Peninsula. There, fog usually develops during night hours but there were several episodes of persistent fogs which lasted several days, even during the light time hours. Satellite images ( visible and MSG cloud products from EUMETSAT NWC-SAF) were compared with the model output of low cloud cover. Only the 5% of foggy days identified were not represented by the model at all. The most part of the episodes were developed by the model with a spatial coverage close to the observation. However, the daylight fog seems not to be well simulated, specially when fog lasts several days continuously. In these cases, the model dissipates the fog during the light hours more than observed.
The vertical cross sections of the water content along a line going through the area of interest show the evolution of the fog depth during the episode.

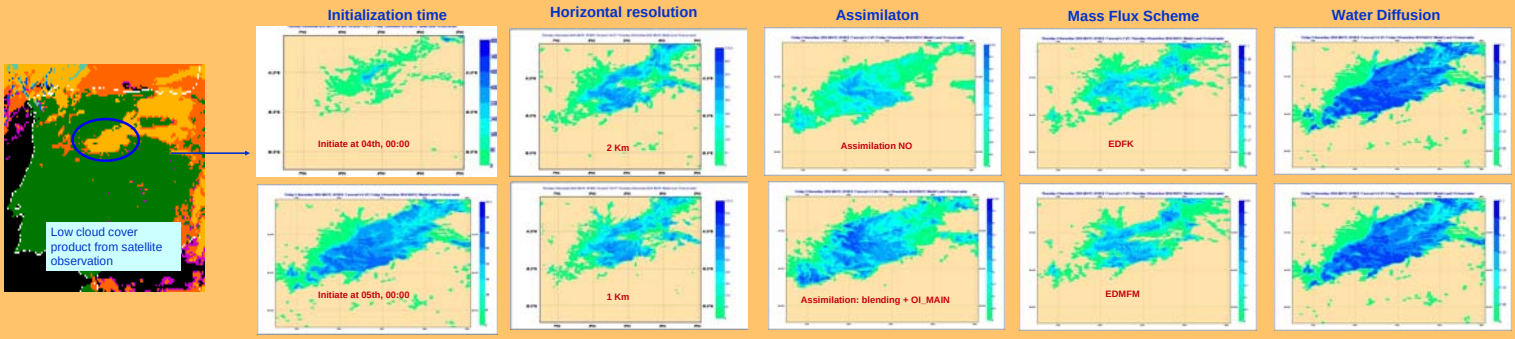



## 4. Sensitivity to different model settings

A three day fog episode (4-6, Nov, 2011) over Spanish Northern Plateau is studied to assess the sensibility to different model settings. Here, we compare the liquid water content at model level closest to the surface from different model configurations:

- Different initial times
- Horizontal resolution: 2 Km .vs. 1 Km
- Vertical resolution: 65 .vs. 74 levels
- With or without Semi Lagrangian Horizontal Diffusion
- EDMFM or EDKF shallow convection
- With or without surface assimilation
- Mixing-length: B&L, Deardoff, Delta mixing length

Horizontal and vertical (not shown) resolution and water diffusion resulted to be the least determining factors in this particular case. Changing the mixing lenght did not mean much differences either. However, the time when the experiment is initialized turns out to be the most decisive element, maybe as a kind of spin-up needed to develop the fog. The assimilation (OI_MAIN + blending) brings out some differences as well.
Below there are some examples of these parallel experiments to be compared at the same valid time.




## 4. Conclusions and future work

- HARMONIE in AROME configuration is run quasi-operationally at AEMET. In general, fog episodes occurring in the north part of Spain are well represented by the model. Nonetheless, the model seems to dissipate the fog during light hours more than it is observed, specially when several days of continuous fog take place. The evaluation will be extended to other parts of Spain to asses model representation of fog in complex terrain.

- Sensitivity tests have confirmed the already known idea that initialization of the simulations is essential for a successful representation of the fog. This suggests two ways to improve fog forecasts: Improving assimilation, specially of humidity, and providing some model ensemble to assess predictability. Even though we haven't seen a big impact of the resolution increase (vertical and horizontal) more work needs to be done in this aspect specially over complex terrain.

- It is planned to develop a procedure to compare satellite products and model output to validate results from a more objective and quantitative point of view. Also possible improvements in the turbulence parameterization will be studied in Single Column Model and complete model configurations.