Evaluation of HARMONIE-AROME cycle 43h2.1 at AEMET

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1 Introduction

After a thorough evaluation, AEMET's HARMONIE-AROME deterministic suite has been upgraded to Cycle 43h2,1. A description of the main characteristics of the version and of the local changes compared to the HARMONIE-AROME reference version is done. Finally, an objective evaluation is performed compared to cycle 40h1.1 and the main meteorological implications of the new version are outlined.

2 Operational set up

The deterministic operational suite is based on HARMONIE-AROME which is run at 2.5 km 4 times per day with a forecast length of 72 hours over 2 geographical domains (Fig. 1). 3DVar analysis with 3hr cycle includes radar reflectivities, ATOVS, IASI, GNSS ZTD, ASCAT wind and AMDAR humidity observations. IFS humidity enters in the blending process (LSMIX) with the ECMWF forecasts. Upper air analysis includes 2 m temperature and relative humidity.

SAPP preprocessing is used for conventional observations. Radar data comes from OPERA using BALRAD preprocesing and including Spanish, Portuguese and French radars. The control of the HARMONIE-AROME operational suite is based on ecflow.

The operational system has been migrated to a new ATOS computer system composed of two cluster each with 140 computed nodes mounted on Bull Sequana X440 A5 chasis. Each node with 2 AMD EPYC™7742 processors (64 cores). The peak perfrmance of the system is 1350 TFlops.

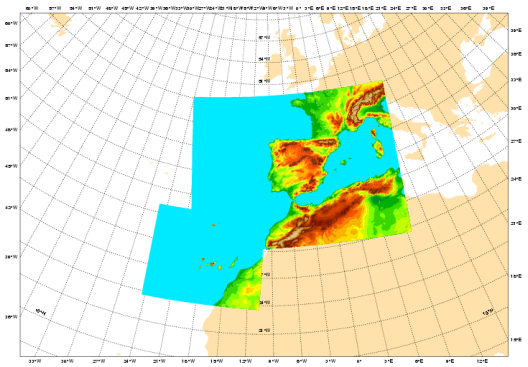


***Figure 1**: AEMET's operational domains*

3 Major changes in cycle 43h2.1

The major changes of cycle 43h2.1 compared to cycle 40h1.1 are

- New physiographic data base: ECOCLIMAP Second Generation
- New clay and sand database (SOILGRIDS)
- SURFEX 8.1 version (Le Moigne *et al*., 2018)
- 2 patches for Nature tile and disabling Surface Boundary Layer Scheme
- Modified values of minimum stomatal resistance Rsmin
- Increase maximum Richardsson number from 0.0 to 0.2
- HARATU turbulence scheme updates mixing at the top of PBL
- EDMF and microphysics optimizations
- Decrease soil moisture increments in the OI assimilation scheme
- New blacklisting procedure based on ECMWF's and redesign of the assimilation scripting system.

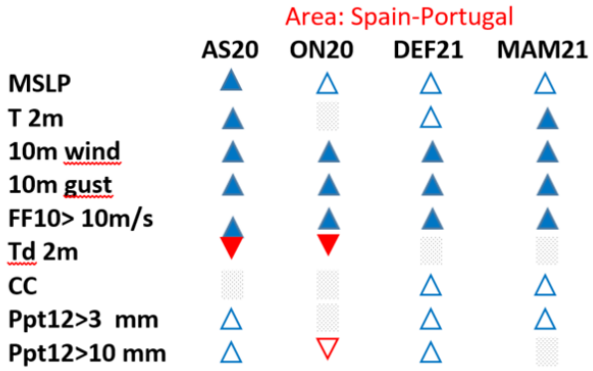
The major local changes compared with the HARMONIE-AROME reference system are

- Increase roughness increasing heterogeneity of open land patch (FAKETREES)
- Orographic roughness parametrization OROTUR enabled (Rontu, 2006)

4 Meteorological impact

Parallel experiments comparing cycle 43h1.2 with cycle 40h1.1 have been conducted for the periods: 1aug/17sep2020(AS20), 1oct/30nov2020(ON20), 1dec2020/28feb2021(DEF21) and 1mar/21jun2021(MAM21). The forecast length for these tests is 24 hr. The overall impact of the model upgrade can be seen in Table 1. There is a general improvement with some concern for de dew point temperature. The impact on the upper level variables is small.

***Table 1**: Summary of the verification results comparing cycle 43h1.2 with cycle 40h1.1. Filled triangles mean 90% confidence. For the categorical scores (FF10> and Ppt12>) there is no significance test but a subjective evaluation of the objective scores*



2m dew point temperature

Concerning the degradation seen in de dew point temperature, it is due to the first forecast lengths as can be seen in Fig. 1. This degradation is not seen in relative humidity.

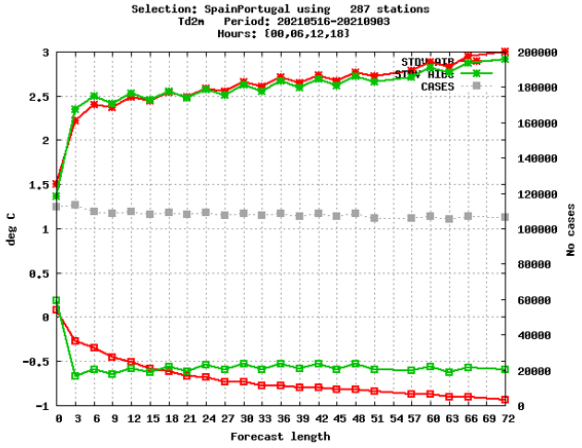


***Figure 2**: STDV and Bias of 2 m dew point temperature function of the forecast length for the period 16may-3sep202. Cy43h2.1 in green and cy40h1.1 in red.*

10m wind

The upgrade to ECOCLIMAP Second Generation and the discontinuation of the canopy scheme produces and increase of the wind bias. The overestimation of 10 m wind was already significant in cycle 40h1.1. This bias is not as clear for other HARMONIE-AROME domains. The wind is improved in the new version mainly due to the increase of roughness on the open land patch (FAKETREES) and activation of an orographic roughness parametrization (OROTUR). The impact on 10 m wind can be seen in Figures 3 and 4.

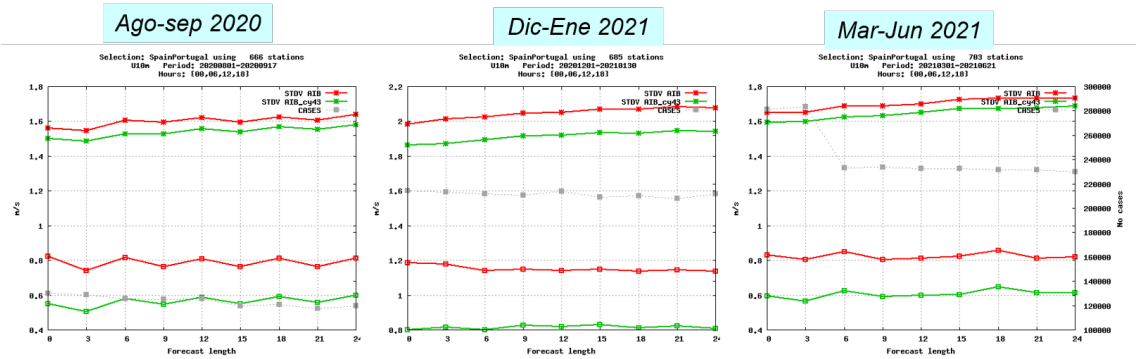


***Figure 3**: STDV and Bias of 10 m wind function of the forecast length for the periods described in the text. Cy43h2.1 in green and cy40h1.1 in red.*

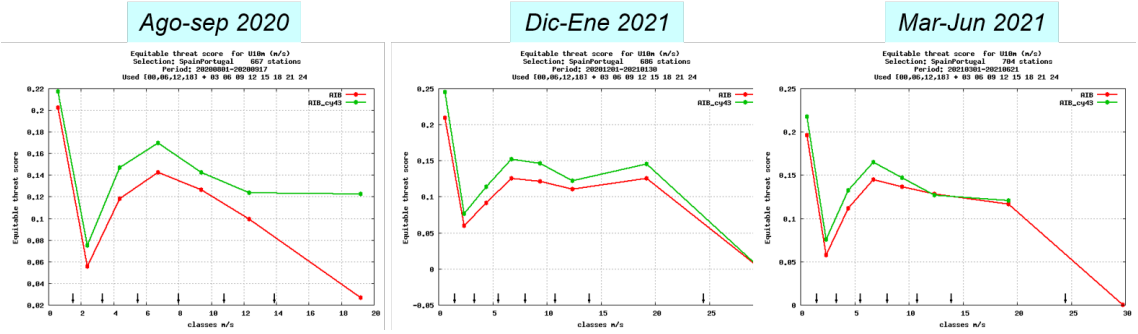


***Figure 4**: Categorical verification of 10 m wind: Equitable Thread Score function of the observed velocity. Cy43h2.1 in green and cy40h1.1 in red.*

It is interesting to note that the impact of the activation of the orographic parameterization is seen not only in mountain regions (Fig. 5). The improvement on the Canary Islands domain is not so clear with

a reduction of the wind bias but with a deterioration of the winds above 10 m/s (not shown). Probably, a revision of the use of OROTUR for this region is need.

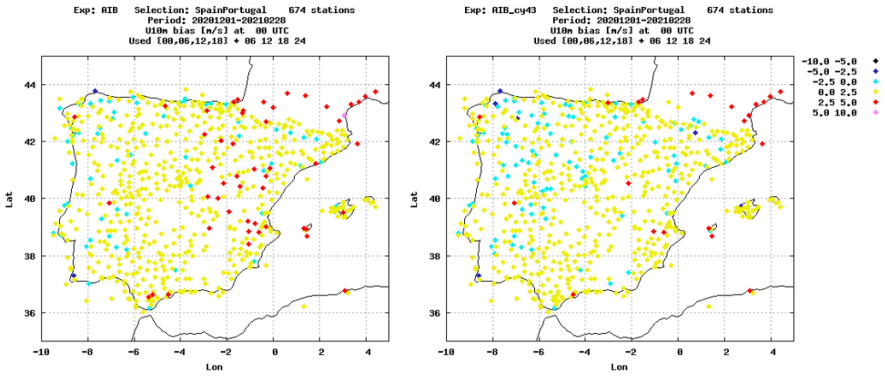


***Figure 5**: Spatial distribution of the 10 m wind bias for the period 1dec2020-28feb2021. Blue colors indicate underestimation and yellow and red colors overestimation. Cy43h2.1 (right) and cy40h1.1 (left).*

10m wind gusts

There is an improvement of the 10 m wind gusts with a bias close to zero (Fig. 6). Note that we use a rafagosity factor of 2.5 instead of the reference 3.5 in both Cy43h2.1 and cy40h1.1. This reduction in the rafagosity factor produces an underestimation of the gusts for the strongest large scale wind events as can be seen in the categorical verification of the winter period (Fig. 7).

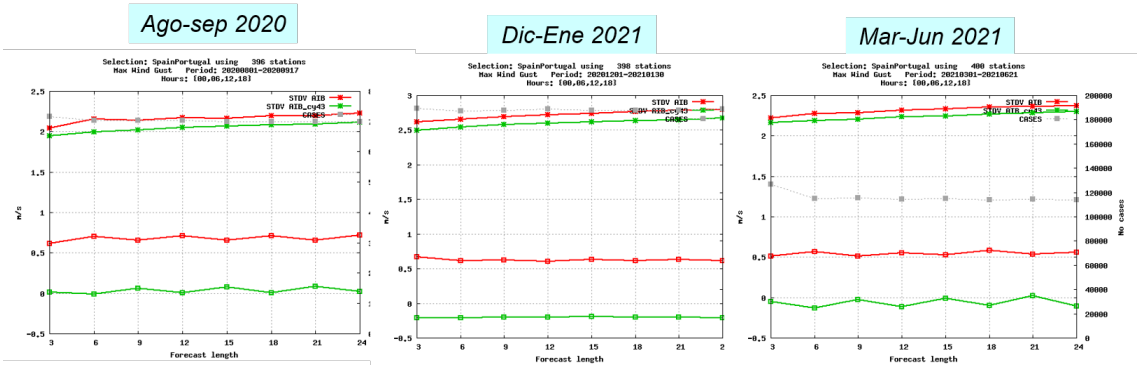


***Figure 6**: STDV and Bias of 10 m wind gusts function of the forecast length for the periods described in the text. Cy43h2.1 in green and cy40h1.1 in red.*

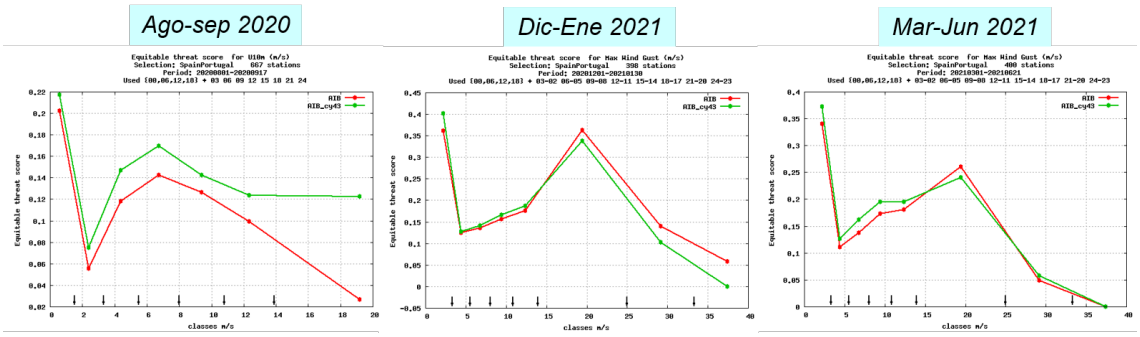


***Figure 7**: Categorical verification of 10 m wind gusts: Equitable Thread Score function of the observed velocity Cy43h2.1 in green and cy40h1.1 in red.*

The problem of overestimation of wind gusts in convection events is still present in the new version as can be seen in the scatterplots of the summer period (Fig. 8)

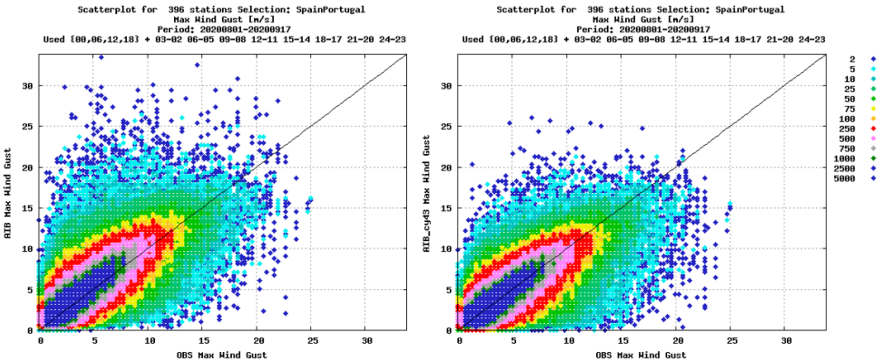


***Figure 8**: Forecast-observation plot of 10 m wind gusts for the period 1ago-17sep2020. Cy43h2.1 (right) and cy40h1.1 (left).*

Low clouds/Fog over sea

The new version increases low clouds and fog over sea (Fig. 9). This is a serious problem for other HARMONIE-AROME domains but not so much over Spain because we also have cases with clear underestimation of low clouds and fog especially over the Mediterranean sea.

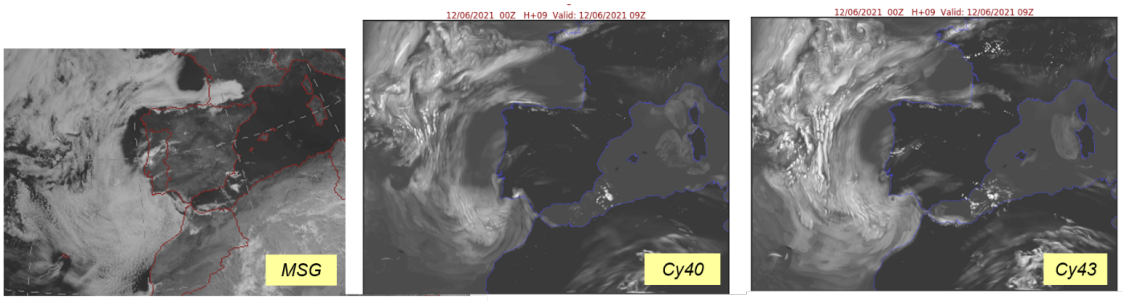


***Figure 9**: Simulated satellite images on 12/06/2021 at 09 utc compared with Meteosat Visible Image.*

Fog over land

The new version decreases the frequency of fog as can be seen from the categorical verification of visibility on Fig. 10 for the winter period, the season when radiation fog usually occurs over the Iberian Peninsula. Although from the subjective evaluation of the forecasts it seems that the model gives a good indication of the spatial distribution of the fogs, from the point verification we can see that the errors are still big and only for the North Meseta reasonable ETS values are obtained (Fig. 11). Overall conclusion is that the cycle change implies some degradation on the fog forecasts. This seems mainly due to the change of the maximum Richardson number because the use of the RISHIFT parameterization (Homleid, 2022) produces results close to the cycle 40h1.1 ones.

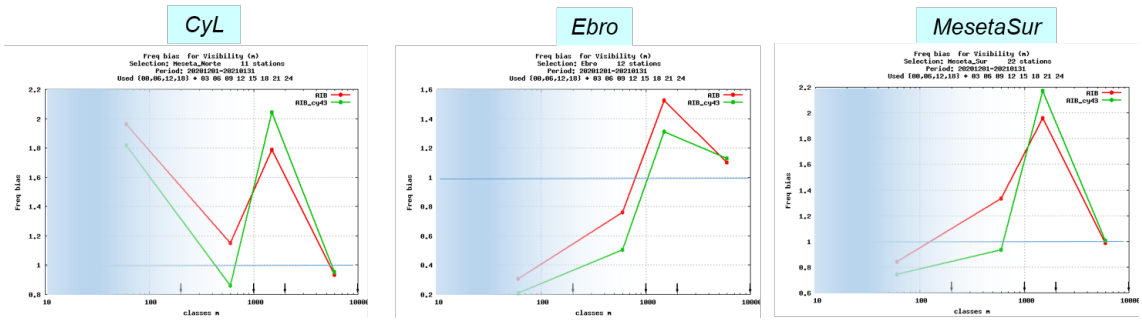


***Figure 10**: Categorical verification of visibility for the winter period for three climatological regions: North Meseta (CyL), South Meseta and Ebro valley. Frequency bias function of observed visibility. Cy43h2.1 in green and cy40h1.1 in red.*

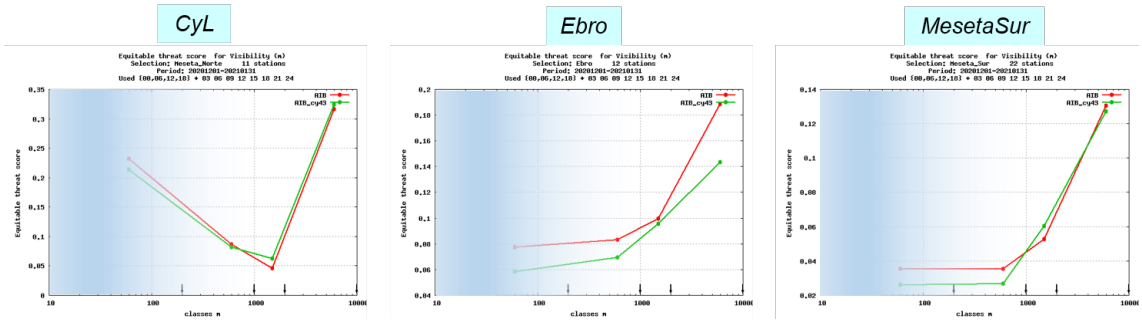


***Figure 11**: As Fig 10, Equitable Thread Score function of observed visibility*

Precipitation

The model upgrade implies an improvement of the precipitation forecasts as can be seen in Fig.12 but without big changes in model climatology (Figs. 13 and 14).

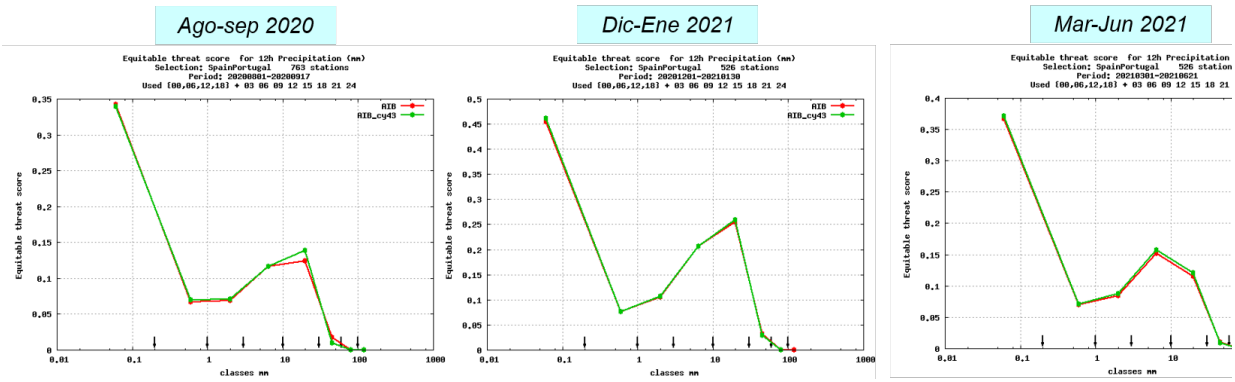


***Figure 12**: Categorical verification of precipitation accumulated in 12 hr. Equitable Thread Score function of the observed rain gauges precipitation. Cy43h2.1 in green and cy40h1.1 in red.*

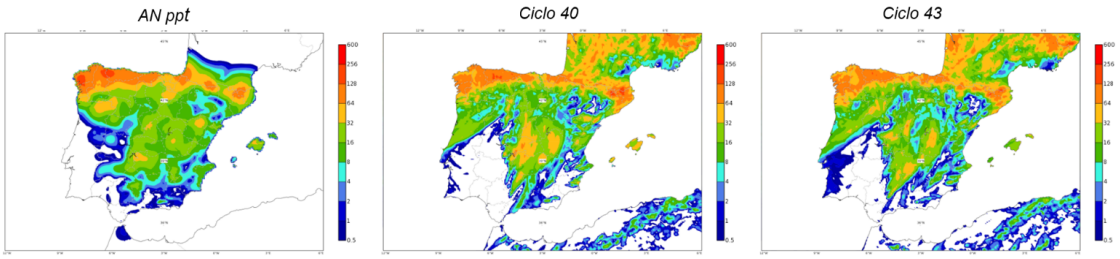


***Figure 13**: Precipitation accumulated in one month (august 2020). Analysis of precipitation (left), cy40h1.1 (center) and Cy43h2.1 (right). Note that the analysis is based only in rain gauges with much lower resolution, very few data over Portugal and no data over France.*

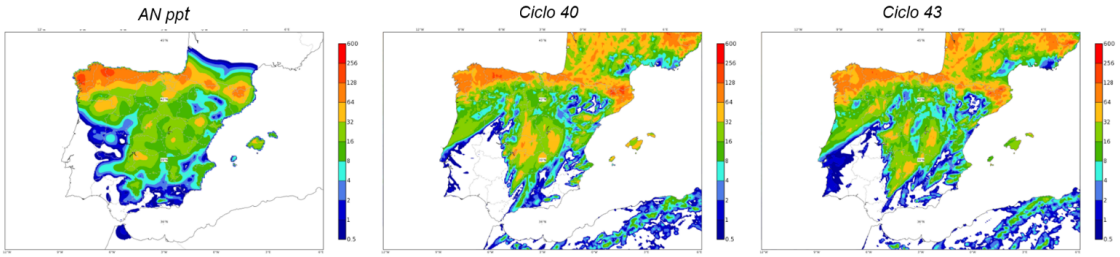


***Figure 14**: As Fig. 13 for December 2020*

Lightning intensity

The density of electrical discharges is estimated from the vertically integrated graupel. The HARMONIE-AROME reference computation is not used but a particular tuning to try to simulate the cloud-earth discharges observed from the AEMET observation network. Due to the changes in the microphysics that imply a reduction of the proportion of graupel, a reduction of the discharge density is seen in the new version (Fig. 15). We think that the modifications on the hydrometeors partition come from updates on cycle 40h1.2 (Ivarsson, 2017). Besides, there has been an update of the AEMET observational network, so a new tuning in the algorithm for the discharges estimation seems to be needed.

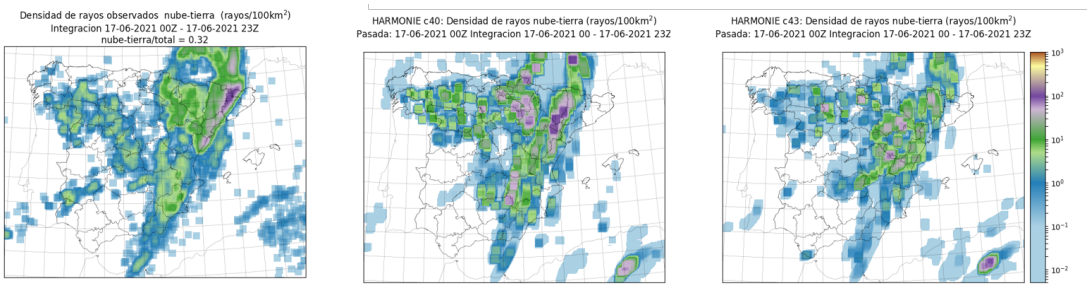


***Figure 15**: Comparison of discharge density in 24 hr on 17/06/2021. Observation (left), cy40h1.1 (center) and Cy43h2.1 (right). Thanks to José A. Sosa*

5 Conclusions

The deterministic operational suite was upgraded to cycle 43h2.1 on 7th September 2021. The operations have been moved to a new computer system that increases AEMET's computing power at least 6 times.

The upgrade from cycle 40h1.1 to cycle 43h2.1 implies a general improvement in most forecast variables. Bigger improvement is found in 10 m wind that comes mainly from the activation of the orographic roughness parameterization OROTUR and enhancement of roughness on open land by FAKETREES. Wind gusts also improved but there is some concern about the underestimation of the gusts for the more intense events associated with large scale lows. There is some increase in the cloud cover amount, especially for low clouds over sea. Nevertheless, there is some decrease on the frequency of radiative fogs over land which implies a slight degradation of its prediction. Finally, there is an improvement on precipitation forecasts and there is a decrease on the maxima of the density of electrical discharges.

6 References

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