AEMET NWP Activities[1]

## 43rd EWGLAM - 28th SRNWP Meeting, 27 Sep- 1 Oct 2021

Operational Suite

Operational suite based on HARMONIE-AROME cycle 43h2.1.1 updated on 7th September to a new HPC cirrus

- **2.5 km** runs 4 times per day with a forecast length of 72 hours for 2 geographical domains (Iberian Peninsula and Canary Islands).
- SAPP preprocessing for conventional observations
- **3DVar analysis** with **3hr cycle** incl. AMDAR humidity obs, radar reflectivities, ATOVS, GNSS ZTD, ASCAT wind and IASI obs. IFS humidity in the blending process (LSMIX). Assimilation of T2m and rh2m in 3Dvar
- Radar reflectivity using OPERA from BALRAD preprocessing including Spanish, Portuguese and French radars.
- Radar wind assimilated in passive mode.
- New clay and sand database (SOILGRIDS).
- 2 patches for Nature tile and disabling Surface Boundary layer Scheme.
- Modified values of minimum stomatal resistance Rsmin
- Increase Max Richardsson No to 0.2
- Increase roughness increasing heterogeneity of open land patch (FAKETREES)
- Orographic roughness parametrization OROTUR enabled
- HARATU turbulence scheme update mixing top PBL
- EDMF and microphysics optimizations
- Modified increments of soil moisture in the OI assimilation scheme
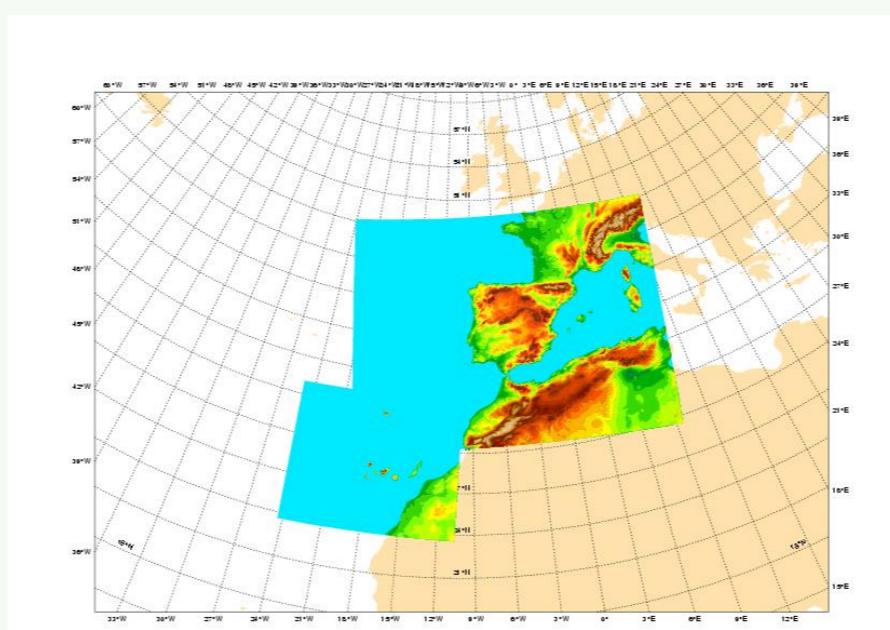
Run in AEMET's BULL-ATOS HPC

New HPC System at AEMET

New High Performance Computer available from April 2021 (1st Phase) compose of two identical clusters each with

- 140 compute nodes mounted on Bull Sequana X440 A5 chasis. Each node with
  - 2 AMD EPYC™7742 processors (64 cores)
  - 256 GB DDR4-3200 memory
  - SSD Disc with 240
- 4 login/control nodes
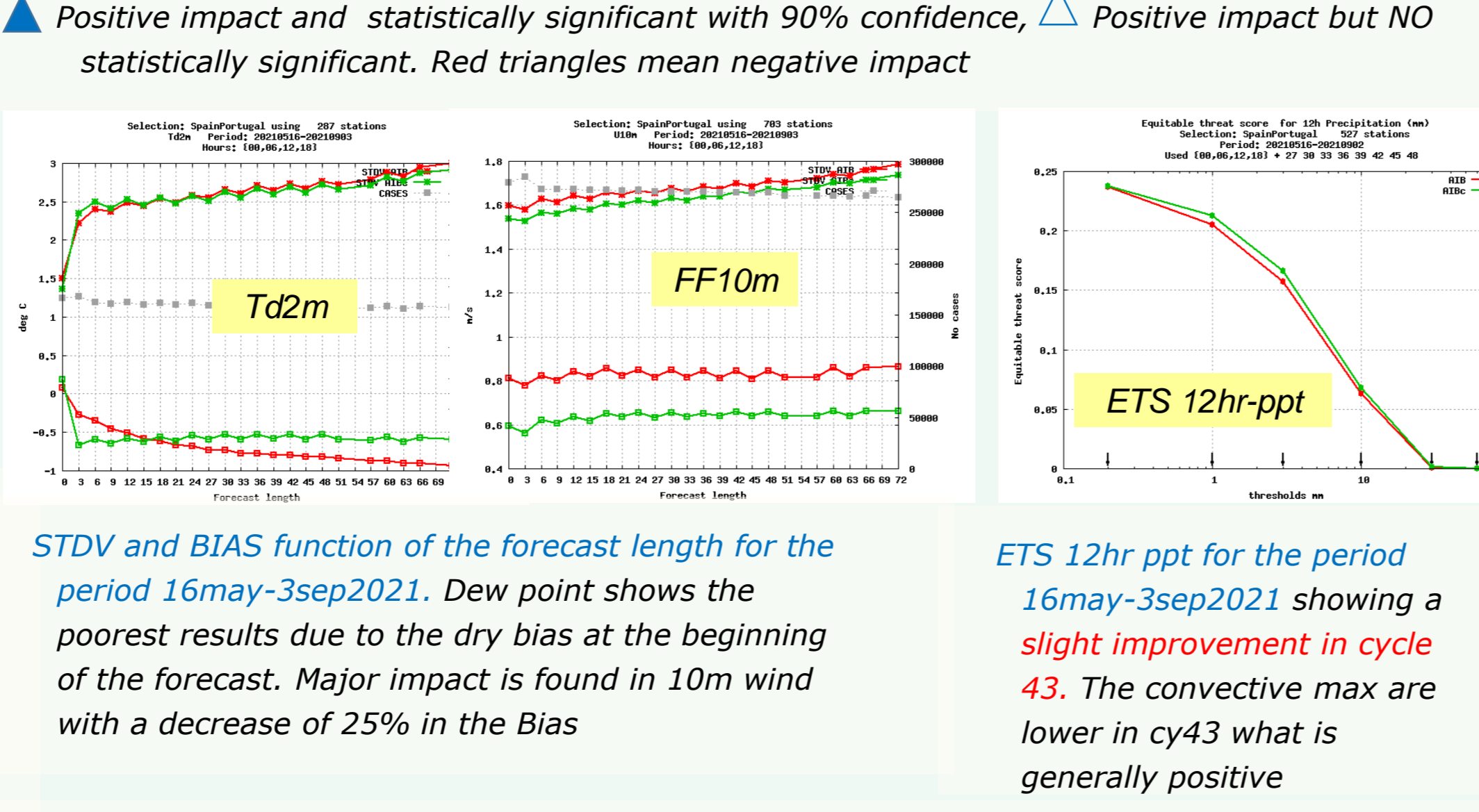- 4 pre/postprocess nodes
- 2 I/O nodes
- 500 TB lustre disc
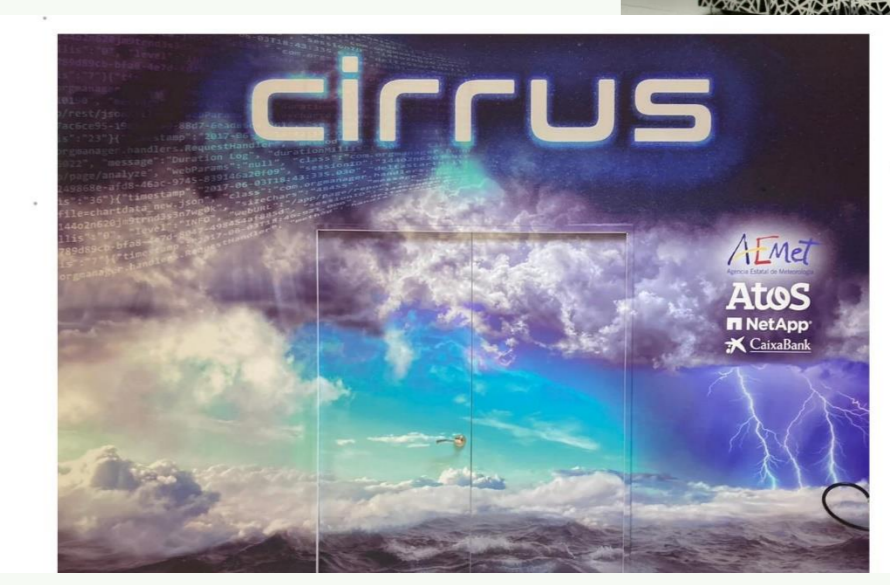
It increases the computer capacity at least 6 times. The system will be enhanced in 2023 with 48 additional compute nodes

Verification of the cy43 vs cy40

Area: Spain-Portugal

	AS20	ON20	DEF21	MAM21
MSLP	▲	▲	▲	▲
T 2m	▲	▲	▲	▲
10m wind	▲	▲	▲	▲
10m gust	▲	▲	▲	▲
FF10> 10m/s	▲	▲	△	△
Td 2m	▽	▽		
CC			△	△
Ppt12>3 mm	△	△	△	△
Ppt12>10 mm	△	▽	△	△

▲ Positive impact and statistically significant with 90% confidence, △ Positive impact but NO statistically significant. Red triangles mean negative impact

Summary of the verification for 4 periods: 1ago-17sep2020, 1-oct-30nov2020, 1dic2020-28feb2020 and 1mar-21jun2021. FF10> and Ppt12> are based on ETS above the thresholds (no significance test applied). An overall improvement of cy43 is found for most vars and periods

STDV and BIAS function of the forecast length for the period 16may-3sep2021. Dew point shows the poorest results due to the dry bias at the beginning of the forecast. Major impact is found in 10m wind with a decrease of 25% in the Bias

ETS 12hr ppt for the period 16may-3sep2021 showing a slight improvement in cycle 43. The convective max are lower in cy43 what is generally positive

Minimum Temperatures under very Stable Conditions

Snow coverage and Minimum temperature in Filomena snowstorm (12/01/2021)
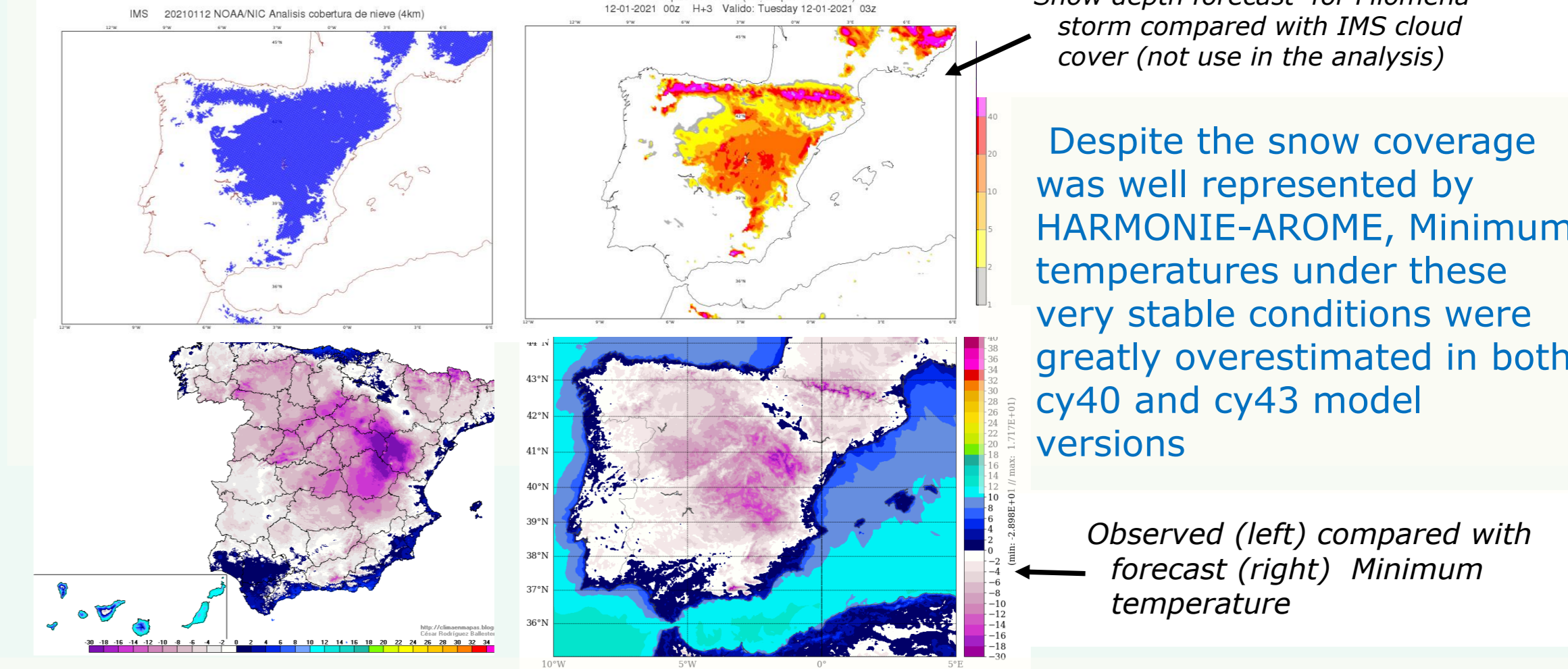
Snow depth forecast for Filomena storm compared with IMS cloud cover (not use in the analysis)
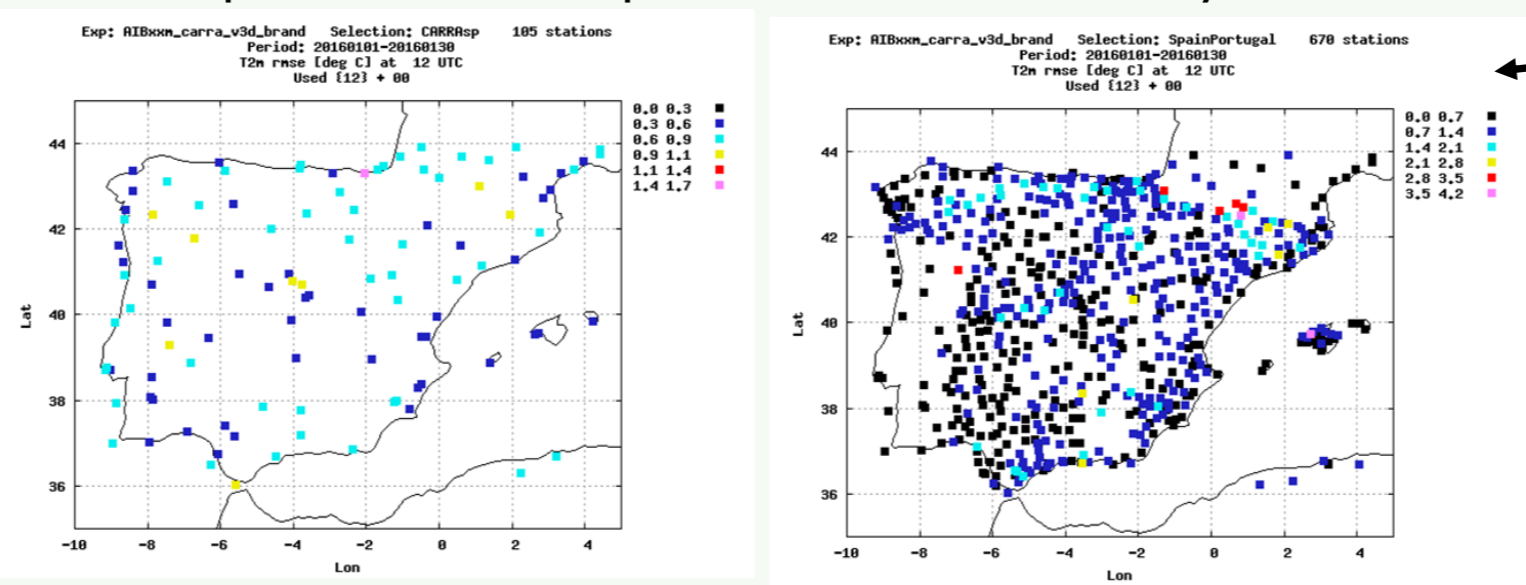
Despite the snow coverage was well represented by HARMONIE-AROME, Minimum temperatures under these very stable conditions were greatly overestimated in both cy40 and cy43 model versions

Observed (left) compared with forecast (right) Minimum temperature

Iberian Reanalysis at 2.5 km resolution

AEMET has developed a prototype to produce a regional reanalysis at 2.5 km resolution for the Iberian Peninsula and Balearic Islands (IBERA). The goal is to test its added value compared to other reanalysis. The system benefits from local tuning to reduce the model biases, from an increase number of surface observations and from a better representation of regional effects in error statistics used by the analysis systems. The system is based on the HARMONIE configuration developed for the Copernicus Artic Reanalysis CARRA which is based on HARMONIE-AROME cy40h1.1. The main modifications introduced for Iberian Peninsula reanalysis are:

1. Linear grid at 2.5 km resolution and 65 vertical levels.
2. IBERA is driven by ERA5 analysis fields as boundaries every hour.
3. SURFEX with 1 patch and Stable Boundary Layer disabled and Orographic parameterization OROTUR included
4. Large Scale Mixing of humidity from the host model in the Fg

ERA5 surface observations compared with the obs used in the IBERA prototype

t2m	Default settings	Tuned parameters
L (km)	80	60
Eb(K)	1,6	1,6
EO(K)	1,4	1,2

rh2m	Default settings	Tuned parameters
L (km)	85	60
Eb(%)	18	9
EO(%)	10	6

Tuned structure functions for CANARI are sharper than the default ones. The first guess to observation errors ratio has been also modified.

5. 3DVAR background error covariances have been calculated using two different methods: ERA5ENDA method uses a four member ensemble obtained with a dynamical downscaling of 4 ERA5 global ensemble data assimilation members. BRAND method uses a 10 member ensemble whose control member is a high resolution 3DVAR and the rest of members are constructed by stochastic perturbation of the analysis control variables in state space. Boundary conditions for this ensemble come also from ERA5 global ensemble.
6. Canari structure functions have been tuned and 10m wind analysis has been activated in this surface analysis. Hollingsworth and Lönnberg method is used to calculate structure functions from time series of innovations (ob-fg).

	V 10m (m/s)		T 2m (K)		RH 2m (%)	
	BIAS	STDV	BIAS	STDV	BIAS	STDV
ERA5	0,37	1,00	0,04	1,75	-0,18	9,48
UERRA	0,09	1,97	-0,35	1,58	-0,47	9,94
IBERA	-0,16	0,91	-0,01	0,70	-0,56	3,82

Performance compared to other Reanalysis. Test period: January 2026. HARMONIE-AROME IBERA seems to have a clear added value compared to other reanalysis. Note that the obs used in the verification also entered in all the reanalysis.

The HARMONIE system is complemented by an offline modified HIRLAM SPAN surface analysis to analyse tmax/tmin and 24-hr precipitation. The standard deviation and the bias decrease compared to other reanalysis.

	SPAN analysis		Validation against independent obs		
Param	Resol km	Fg	R (ob,an)	STD	Bias
6-6h ppt	5.5	clim	0.85	3.6mm	0.3mm
6-6h ppt	5.5	MESCAN rean	0.87	3.2mm	0.3mm
6-6h ppt	2.5	IBERA	0.88	3.2mm	0.2mm
Tmax	5.5	clim	0.94	1.4K	0.1K
Tmax	2.5	IBERA	0.97	1.1K	0.1K
Tmin	5.5	clim	0.89	2.1K	0.9K
Tmin	2.5	IBERA	0.92	1.8K	0.8K

Assessment of the SPAN analyses using 1200/500 rain/temperature independent observations from AEMET external networks

Radar Doppler Winds DA

Radar Doppler wind (DOW) assimilation (J. Sanchez-Arriola & B. Navascués)
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HARMONIE-AROME cy43 experiments including conv+ATOVS+GNSS+SCATT+IASI+radar REFL DA
1) **DOWp** : Control (no DOW obs are actively assimilated)
2) **DOW16** : DOW DA with increased oberr, longer innova dist , tighter FG check limit
3) **DOW19** : As DOW16, but radial winds from higher elevation angles are not assimilated

24h acc pcp

Z 500 hPa

NOW working on :
1) Additional DA diagnostics
2) Superobservation optimal sizes
3) Innovations dependence on elevation angles and radar range

- **DOW19** shows a positive impact with respect to **DOWp** and **DOW16** in rh2m and precipitation
- Assimilation of DOW from higher radar elevation angles (**DOW16**) produce a slightly detrimental impact for upper air Z and wind speed forecasts

Mesoscale EPS → γSREPS
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AEMET-γSREPS towards Data Assimilation in the system

The Plan is to run assimilation for all members operationally by 2022
- AEMET-γSREPS initial states are made by downscaling each of the 5 state-of-the-art global models. Introduction of Data Assimilation cycling in the system is a main goal for the future development of the system.

Recent developments on SFC DA.
- First tests show how surface Data Assimilation corrects surface forecast errors. The figure in the right shows errors for T2m in member 5 (AROME+NCEP) when SFC DA is done (blue line) compared to not doing SFC DA (green and red lines).
- Tuning of SFC background and observation errors and correlation lengths of structure functions has been done following the Hollinsworth and Lonnberg method. This tuning shows coherence between parameters and the characteristics of global and local models used, as expected.

Future developments
- Assimilation: computation of B matrices for Upper Air DA, ongoing. As we does not have a global EPS, we must create the local ensemble for each member playing with global lagged BCs.
- Products:
  - AERONAUTIC products, nearly ready (right Figure).
  - EPSgrams
- γSREPS system: several improvements due to new HPC resources in AEMET and ECMWF:
  - Increase Iberia domain size by 2022 (right Figure). We expect to improve forecasts in boundary zones like Galicia and Balearic Islands.
  - Including 12UTC cycle in Canary Islands and Antarctic-Livingston domains.
  - Extend all simulations up to 72 hours (currently 60/48).

Currently | By 2022

Impact of Cloud Droplet Disdtribution
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Impact of cloud droplet size distribution on fogs

- The formation of anomalous fogs over the sea that are not observed is a known issue in cy43 over several domains. The diminution in the CCN number concentration helps to reduce the extension of these fogs but the modification of the cloud droplet size distribution have also a big impact on the development of the fog through the sedimentation processes.

Cloud droplet distribution.

$\alpha=1.0, \nu=3.0$
$\alpha=3.0, \nu=1.0$

Case study of fog over sea on 18/12/2020. In this case the fog is very much reduced using $\alpha=1.0$ and $\nu=3.0$ compared with the default $\alpha=3.0$ and $\nu=1.0$ values over sea of the Generalized gamma distribution. HARMONIE-AROME cy43 is used including CAMS aerosols. In the plots H+24 cloud fraction of first level is compared with NWCSAF cloud type

Default $\alpha=3,0, \nu=1,0$ | ($\alpha=1,0, \nu=3$) | Cloud type NWCSAF 202012180000

Highlights

➢ New HPC system available since April 2021
  - In its 1st phase increases the computer capacity about 6 times
  - Big effort has been devoted to the migration to the new syste
  - HARMONIE-AROME 2.5 km resolution operational deterministic suite updated to cy43h2.1
  - General improvement for most variables and seasons
  - 10m wind improved by means or enhancing roughness through a orographic parameterization (OROTUR) and increasing heterogeneity of open land patch (FAKETREES).
  - Slightly increase of low level clouds
  - Decrease of fogs occurrence (prediction of radiative fogs is still poor in the Ebro valley and South Meseta)
  - Slight improvement of precipitation including a reduction of convective maxima

➢ Set up of a prototype for a regional reanalysis at 2.5 km resolution
  - It includes a significant increase of surface observations and specific tunings of HARMONIE-AROME analysis and forecast system
  - The system is enhanced with an offline analysis applied to extreame temperaturas and precipitation
  - The results show a clear added value compared with other reanalyis systems available for the Iberian Peninsula an d Balleareic Islands

➢ AEMET-γSREPSs
  - Positive impact including Surface Data Assimilation

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