Status of data assimilation in the HARMONIE-AROME model at AEMET

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with contributions from AEMET-NWP team

Reunión Inicial Proyecto TRAMPAS
Palma, 2 y 3 de Diciembre 2021

GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE
AEMet Agencia Estatal de Meteorología

ACCORD

A Consortium for **CO**nvection-scale modelling **R**esearch and **D**evelopment

- Born the 1st of January 2021,
- 26 Euro-Mediterranean National Met Services.
- Built on the ALADIN, LACE and HIRLAM consortia.
- Provide with a state-of-the-art operational short and very short range NWP system

New HPC (cirrus)

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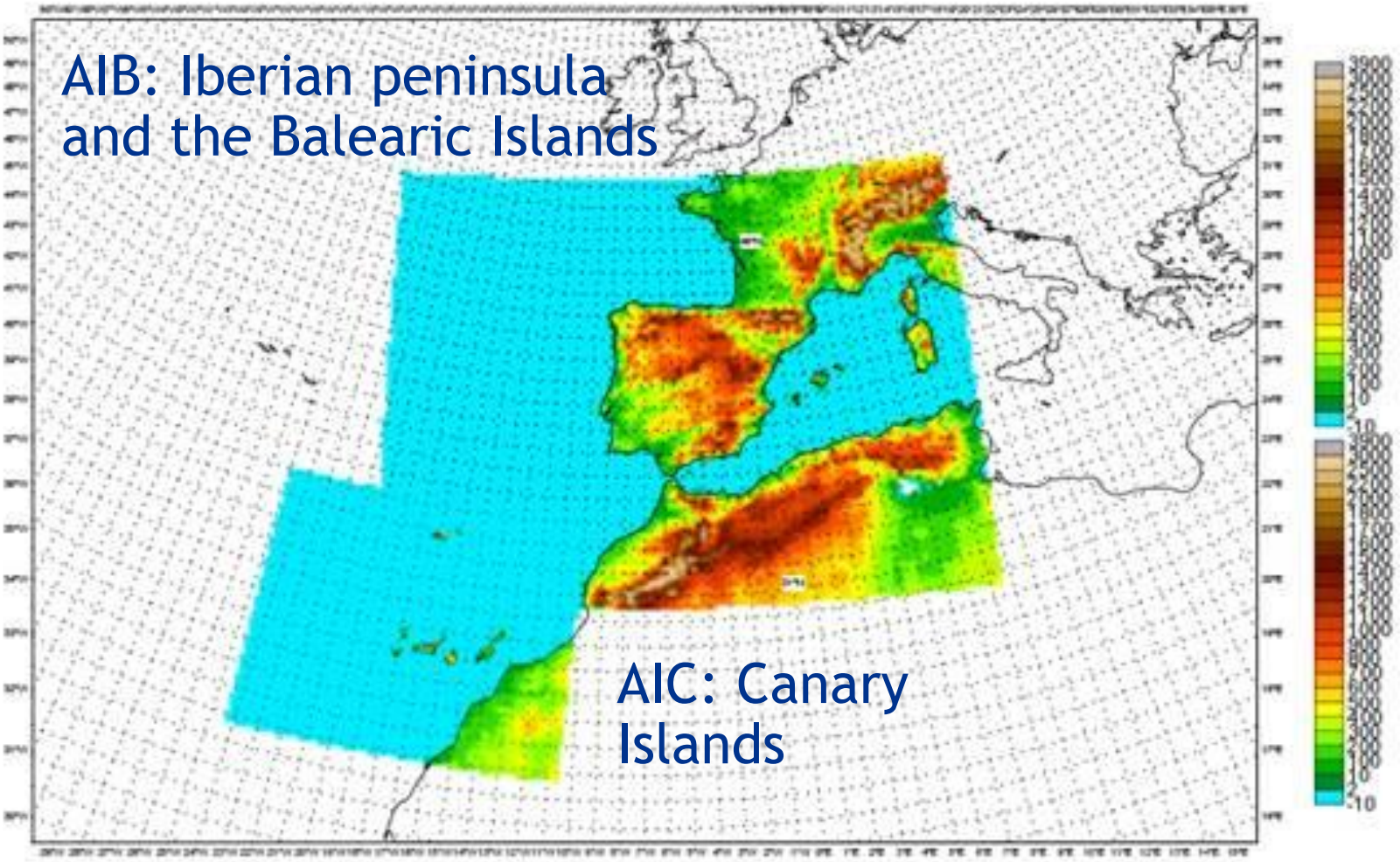
High Performance Computer: **Atos** IT Solutions and Services

Two identical clusters (systems and development) each with:

- 140 compute nodes mounted on Bull Sequana X440 A5 chasis
  - 4 pre/postprocess nodes
- 2 login/control nodes
- 2 I/O nodes
- Each node with 2 AMD EPYC™7742 processors (64 cores)
- Infiniband HDR
- The new HPC provides almost ten times more computing capacity than previous one.

HARMONIE-AROME is a convection permitting NWP model used for operational short-range forecasting (Bengtsson et al., 2017)

- Limited Area Model (LAM)
- Horizontal resolution: 2.5 km in two geographical domains (AIB: Iberian peninsula and the Balearic Islands and AIC: Canary Islands)
- ALADIN non-hydrostatic dynamics
- Surface data assimilation Canari (Optimal interpolation)
- Vertical resolution: 65 levels (top 10 hPa)
- Boundaries from ECMWF (1 hour)
- Model time step is 75 s
- Run 4 times per day with 72 hours forecast length
- Operational run with **Cy43 from Sep 2021**


AIB: Iberian peninsula and the Balearic Islands
AIC: Canary Islands

- AROME physics:

a) Radiation

b) Clouds and cloud microphysics (ICE3):

Six species: vapor, cloud vapor, rain, cloud ice, snow and graupel

c) Turbulence (HARATU)

d) Convection: explicitly resolved deep convection, but parametrized for shallow convection (EDMFM)

Currently in the operational suite for upper air data assimilation:

- 3D-Var (3h cycling)
- LSMIXBX for T, u, v, and **q**

- Conventional observations: surface synoptic stations (SYNOP and SHIP), buoys (DRIBU), aircraft (AMDAR), and radiosondes (TEMP), and **T2m and Rh2m.**

Non-conventional:

- **Radar reflectivities**

- Satellites:
  - ZTD from GNSS
  - **ASCAT winds**
  - AMSU-A, MHS and **IASI radiances**

Large Scale Mixing (LSMIXBC)

Mixes large scales at host model with small scales of own model. In HARMONIE-AROME this would typically be to take advantage of the high quality ECMWF forecasts in 3D-Var cycling scenario.

$$\hat{\mathbf{x}}_{\mathrm{MIX}}(m,n,l) = w_{\mathrm{BC}}\hat{\mathbf{x}}_{\mathrm{BC}}(m,n,l) + (1 - w_{\mathrm{BC}})\hat{\mathbf{x}}_{\mathrm{OWN}}(m,n,l),$$

where m, n are wavenumbers, l is the level. The total weight on the BC field is a product of a horizontal and vertical weight

$$w_{\mathrm{BC}} = w_h w_v.$$

LSMIXBC for q was introduced (before only for T, u and v) in June 2020.

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Radar reflectivities

(Sánchez-Arriola et al., ALADIN-HIRLAM NL 14, 2020)

The data from Portuguese (2), Spanish (17) and French (23) radars pre-processed by OPERA (Radar program of EUMETNET).

The relationship between the model variables and the reflectivities is non-linear and therefore it is complex, since it takes into account the microphysics parameterization. For these reasons, in the HARMONIE-AROME system, the reflectivity variable is not directly assimilated in the model but is previously transformed into a 1D vertical profile of relative humidity.

Results show that the impact of these observations has been similar to other studies performed in AEMET, which is positive in precipitation forecast mainly by decreasing the false alarm rate of precipitation and being in general more accurate on the place.

Radar reflectivities are assimilated since June 2020.

15 Nov 2021 12 UTC

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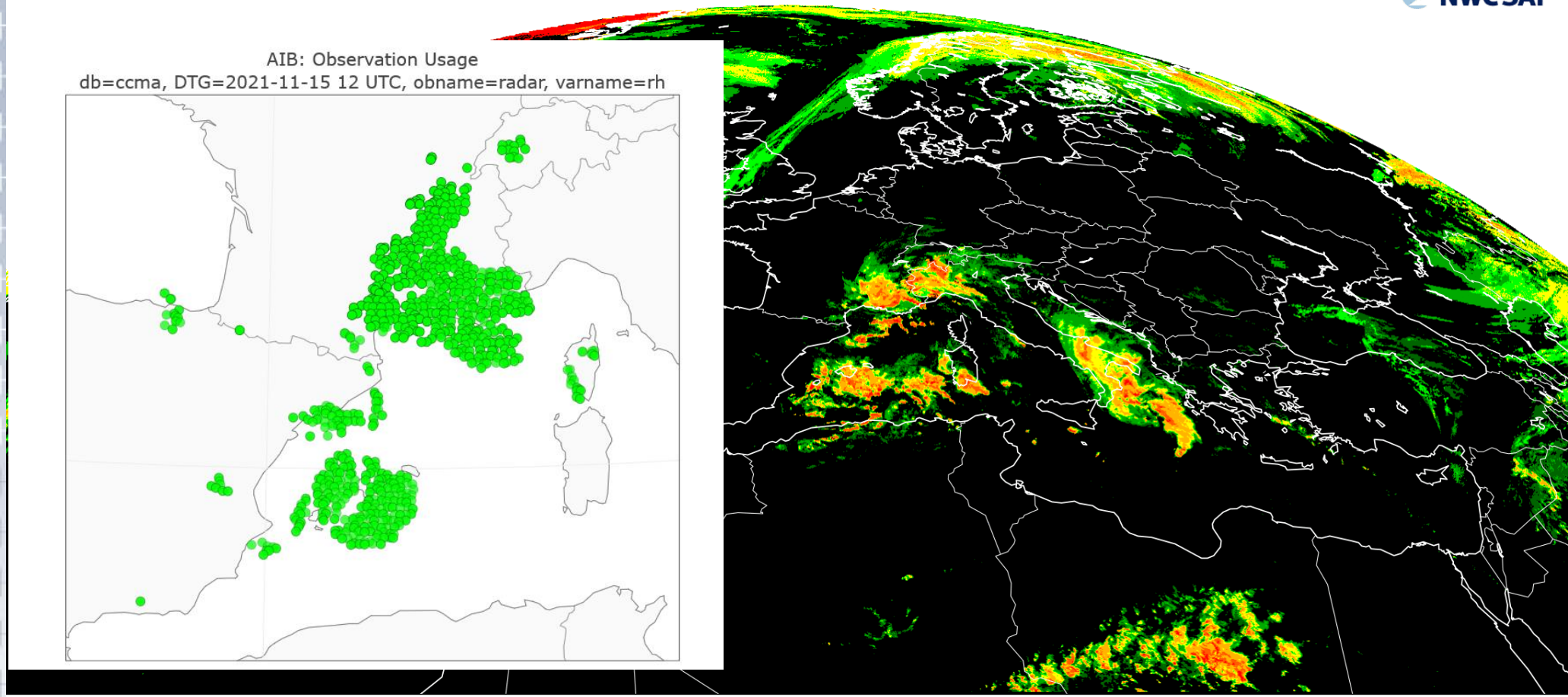
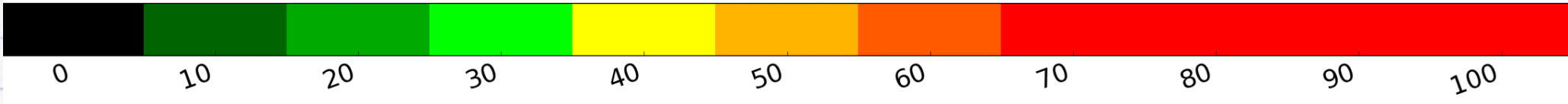
EUMETSAT NWC SAF



NWC GEO v2018 PC Total Precipitation Likelihood Class



ASCAT winds

(Sánchez-Arriola et al., ALADIN-HIRLAM NL 14, 2020)

Scatterometers uses radar to measure the electromagnetic backscatter from the wind-roughened ocean surface, from which data on wind speed and direction can be derived.

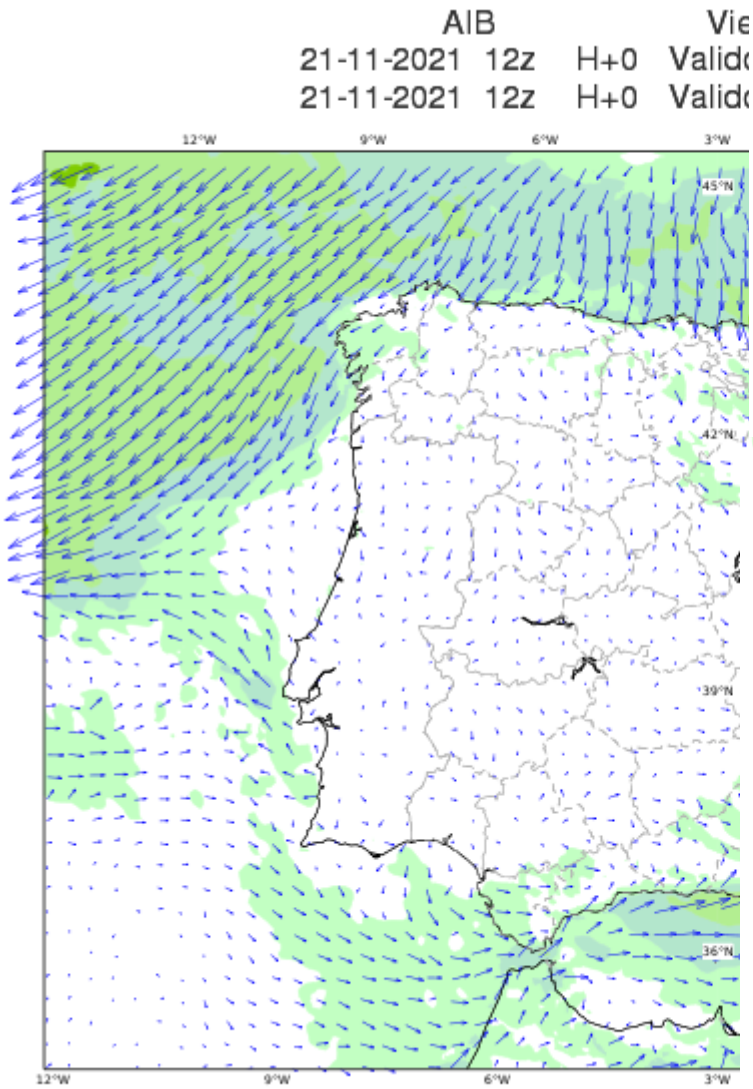
Adcanved **SCAT**terometer (ASCAT), is European C-band (microwave, rain insensitive) scatterometer on-board the Metop's satellites.

The sun synchronous reference orbit ensures that the local solar time of observations for a geographic location is the same time (at night on ascending orbits and during the morning for descending orbits). In our domain at 21, and at 09-12 UTC.

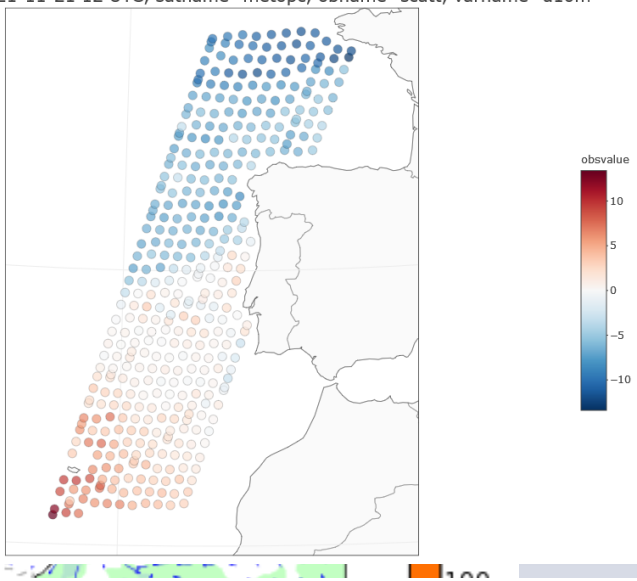
ASCAT data used at both AEMET and IPMA, are on a 12.5 km grid provided by the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF).

ASCAT winds are assimilated since June 2020.

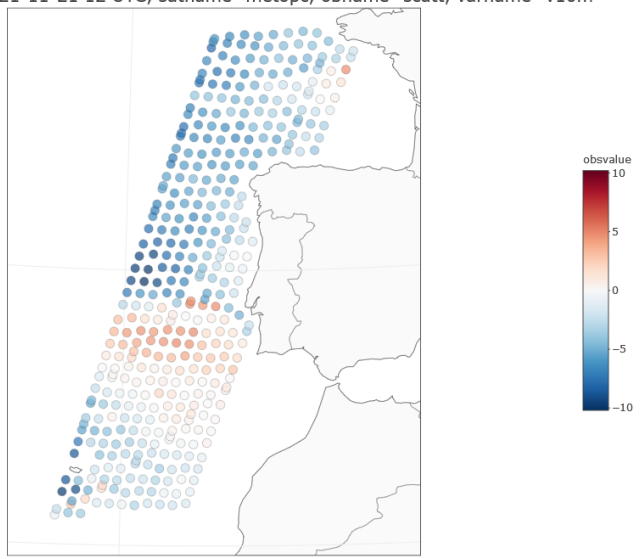
ASCAT winds



u10m



v10m



AMSUA-A and MHS radiances

Since early 2017, the operational run of HARMONIE-AROME assimilates **microwave radiance** from the so-called Advanced TIROS Operational Vertical Sounders (ATOVS) on board of several polar orbiting satellites.

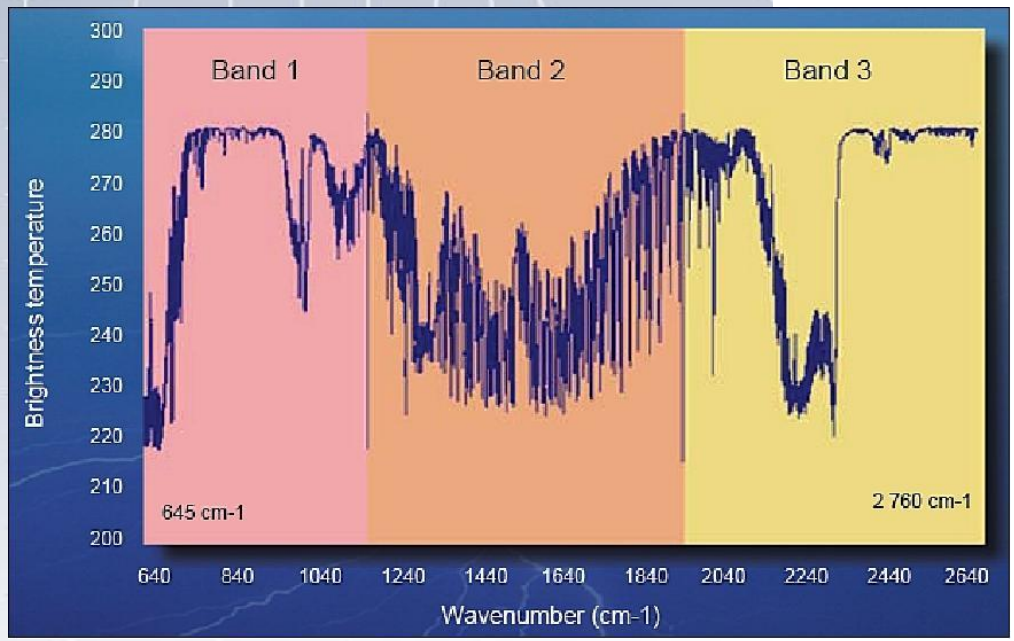
AMSU-A (Advanced Microwave Sounding Unit AMSU): 6,7, 8, and 9
MHS (Microwave Humidity Sounder: 3, 4, and 5

Satellites: NOAA-18, NOAA-19, Metop-A, Metop-B, and Metop-C

Metop-C was introduced in June 2020
Metop-A was switched off in November 2021

IASI radiances

Infrared Atmospheric **Sounding** Interferometer (IASI) measures the radiance emitted from the Earth in **8461** channels covering the spectral interval from 645-2760 cm-1 at a resolution of 0.5 cm-1.



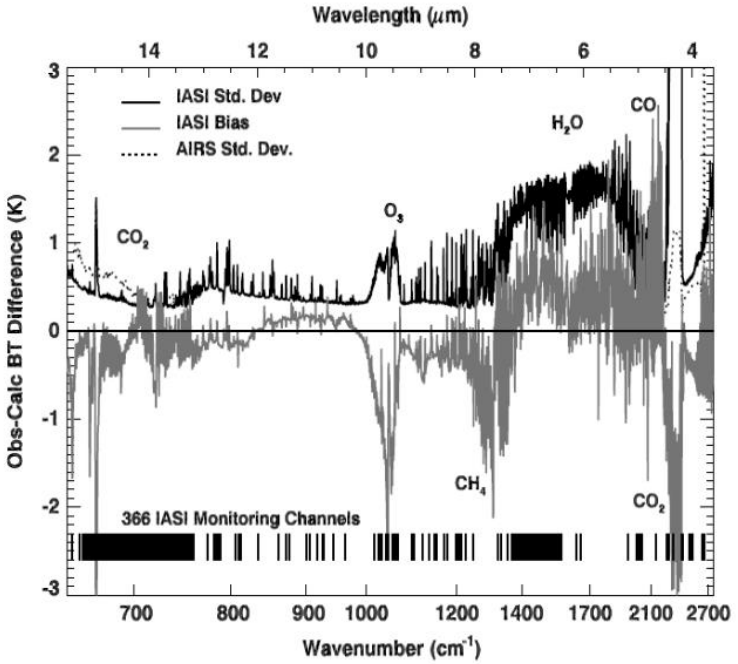


Figure 1. The mean and standard deviation of the difference between observed and calculated IASI radiances. The statistics are for clear channels over sea and the profiles used in the calculation are derived from short-range forecasts (3–15 hours). Also shown is the standard deviation of the equivalent AIRS differences for the 15 μm and short-wave bands.

366 IASI Monitoring channels , ECMWF (Collard and McNally, 2009)

Assimilation of clear-sky IASI radiances in AEMET HARMONIE-AROME

(Campins and Navascués, ALADIN-HIRLAM NL 16, 2021)

Metop-B: 09, 12, and 21 UTC

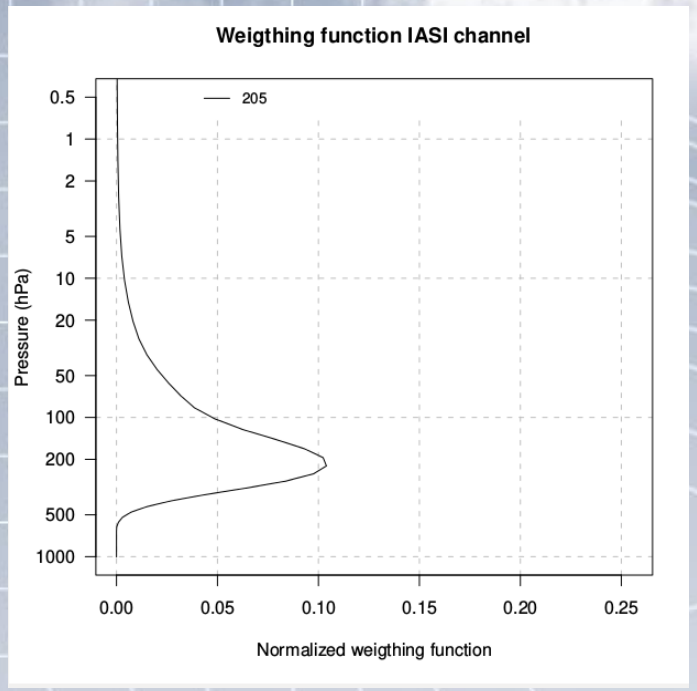
55 channels (land and sea)

CO2 band: 30 channels
- High-peaking: 38 to 167
- Middle peaking: 173 to 296, and 386
- Low peaking: 333 to 432

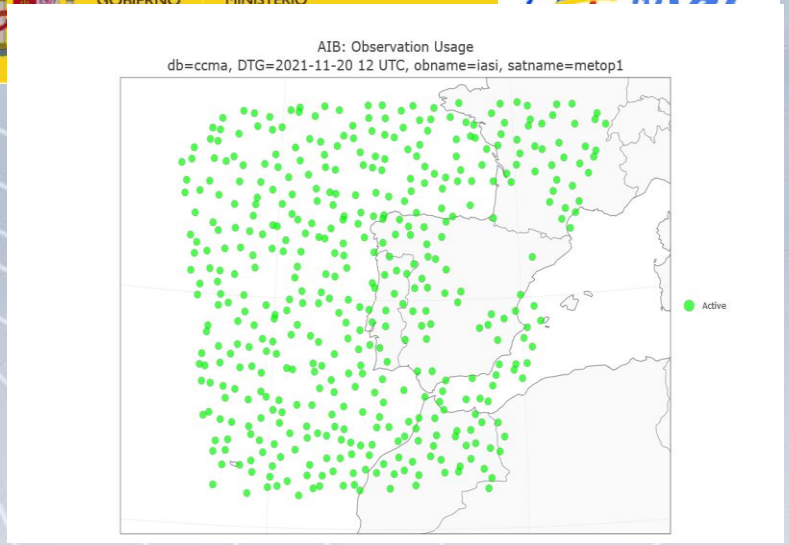
H2O band: 25 channels from 2701 to 4032

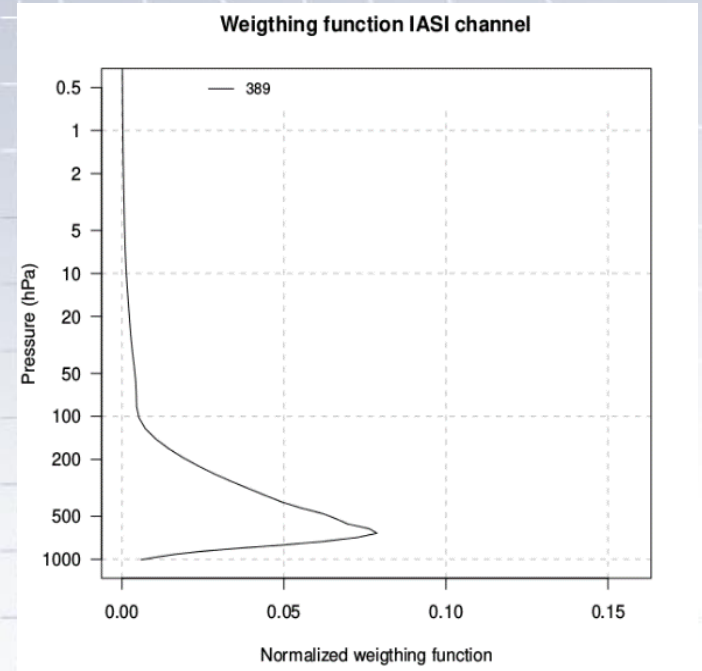
The different peaking level makes necessary a cloud-detection scheme to filter those channels affected by clouds.

The IASI radiances are assimilated since December 2020.

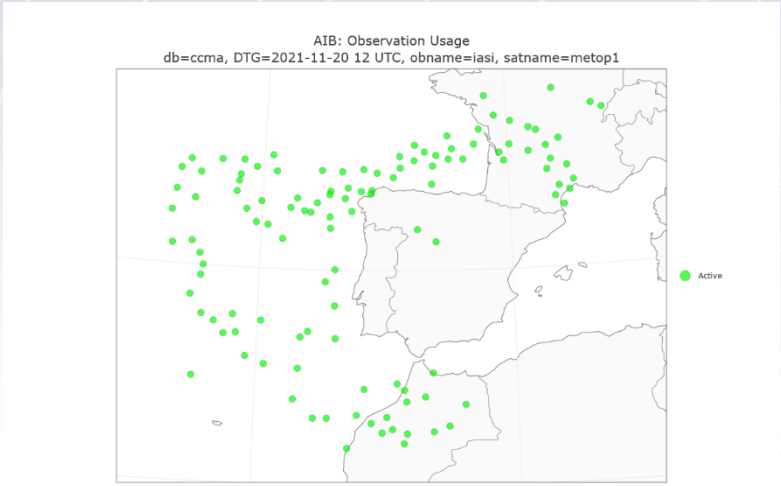


Cha 205





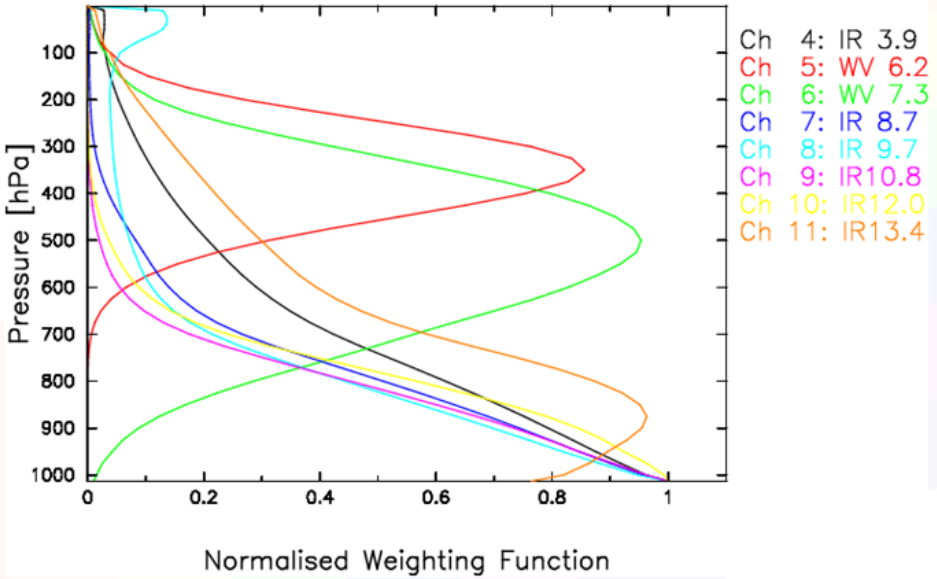
Cha 386



Ongoing:
Assimilation of SEVIRI data
Default configuration

- Meteosat-11/Seviri: Channels
- Clear-sky radiances (CSR)
- Cloud detection based on cloud-mask and cloud-top from NWC SAF

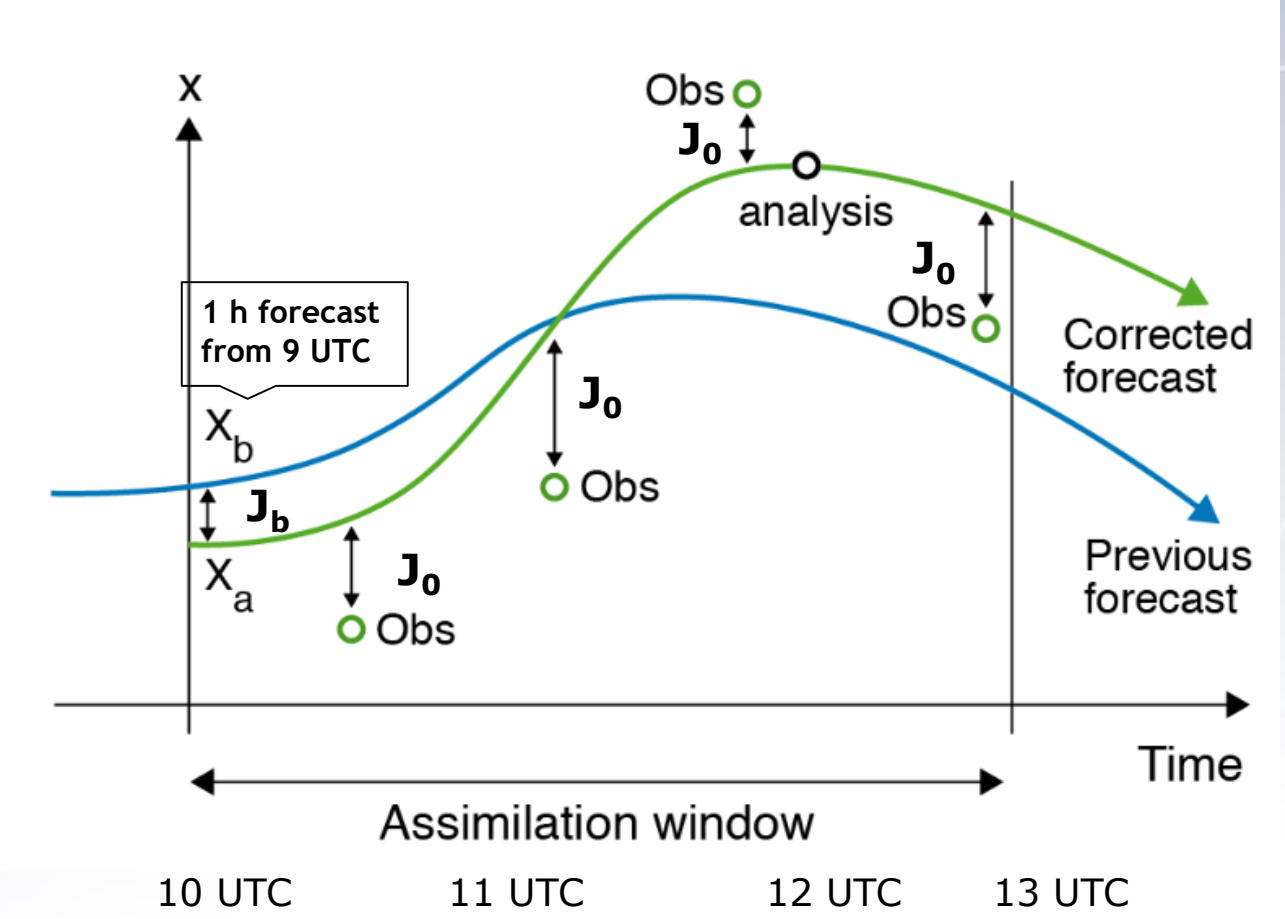
Cha	Spectral band	Use in DA
2	WV6.2	CSR and mid-level clouds
3	WV7.3	CSR and mid-level clouds
4	IR8.7	CSR, no land
6	IR10.8	CSR, no land
7	IR12.0	CSR, no land
8	IR13.2	CSR, no land



- Spatial thinning ~ 65 km
- Land and Sea ?
- Variational Bias Correction (VarBC)
- Obs. at all analysis cycles (00, 03, 6, 09, 12, 15, 18 and 21 UTC)

Ongoing:

- Pre-operational 4D-Var suite



Future:

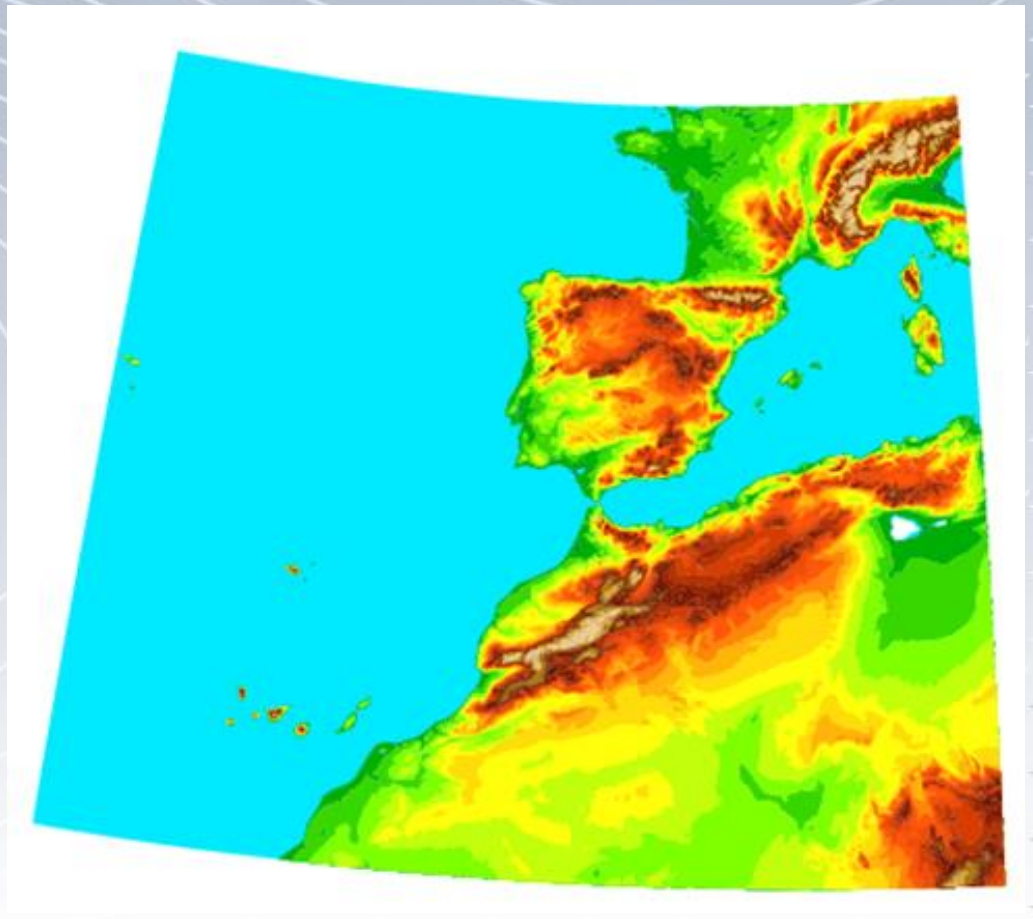
- New bigger domain

New B matrix need

- Radar Doppler wind

- Mode-S

- Nowcasting suite:



1.25 km resolution, observations, cycling, etc…