

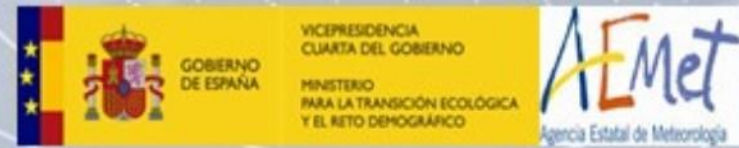
The impact of assimilating satellite radiance observations in the HARMONIE-AROME model at AEMET

Joan Campins
with contributions from AEMET-NWP team

ACCORD

A Consortium for CONvection-scale modelling Research and Development

- 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



ACC RD

A Consortium for CONvection-scale modelling Research and Development

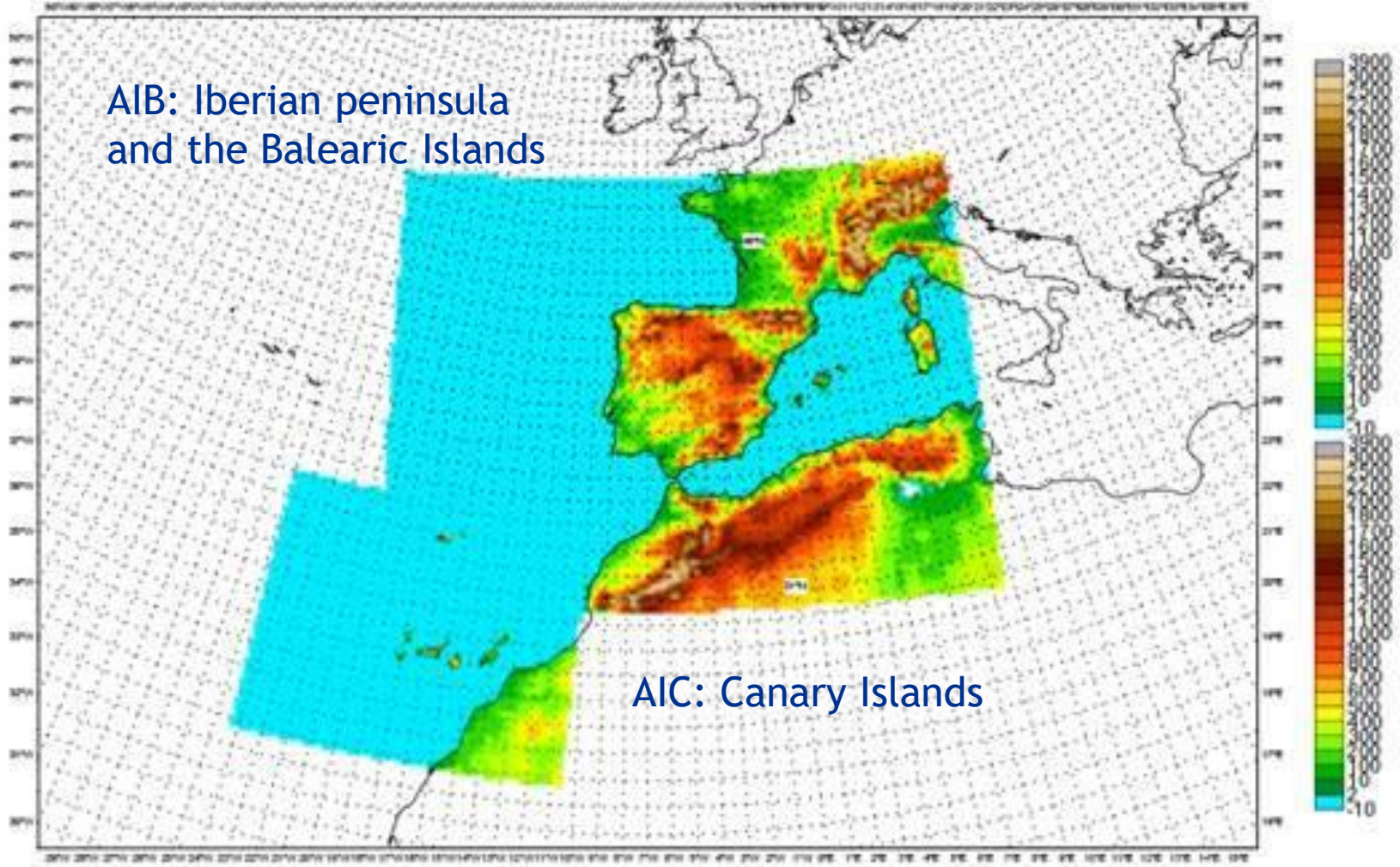


HARMONIE-AROME is a convection permitting NWP model used for operational short-range forecasting (Bengtsson et al., 2017)

- 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**

AlB: Iberian peninsula
and the Balearic Islands

AlC: Canary Islands



Currently in the operational suite for upper air data assimilation:

-3D-Var (3h cycling)-LSMIX 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

Microwave radiances: AMSU-A and MHS

Infrared radiances: IASI and SEVIRI

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
Radiances over land and sea

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

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

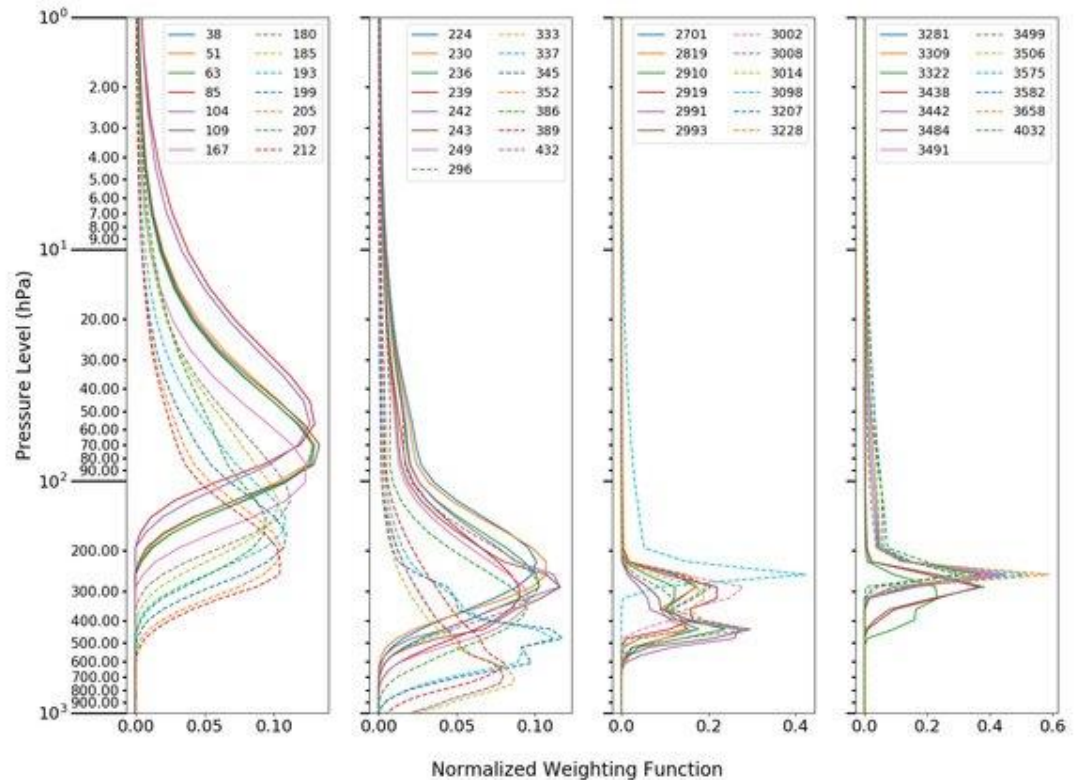
55 channels (land and sea)

CO2 band: 30 channels

H2O band: 25 channels

Clear-sky radiances
(cloud -detection scheme
needed)

Normalized Weighting Function IASI Channels

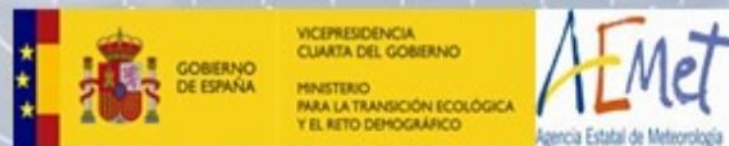


The IASI radiances are assimilated since December 2020.

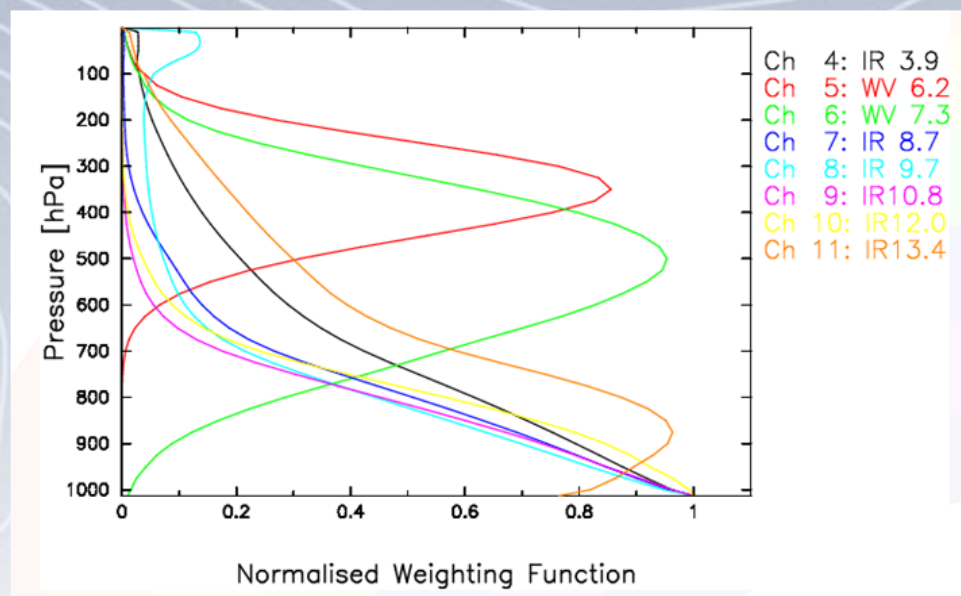
Actually testing IASI from Metop-C.

Assimilation of SEVIRI data

(Campins, Díez, Jiménez and Navascués, ACCORD NL 2, 2022)



- Meteosat-11/Seviri
- Clear-sky radiances
- Cloud detection based on cloud-mask and cloud-top
- Channels 5 and 6 (WV6.2 and WV7.3)
- Only radiances over sea

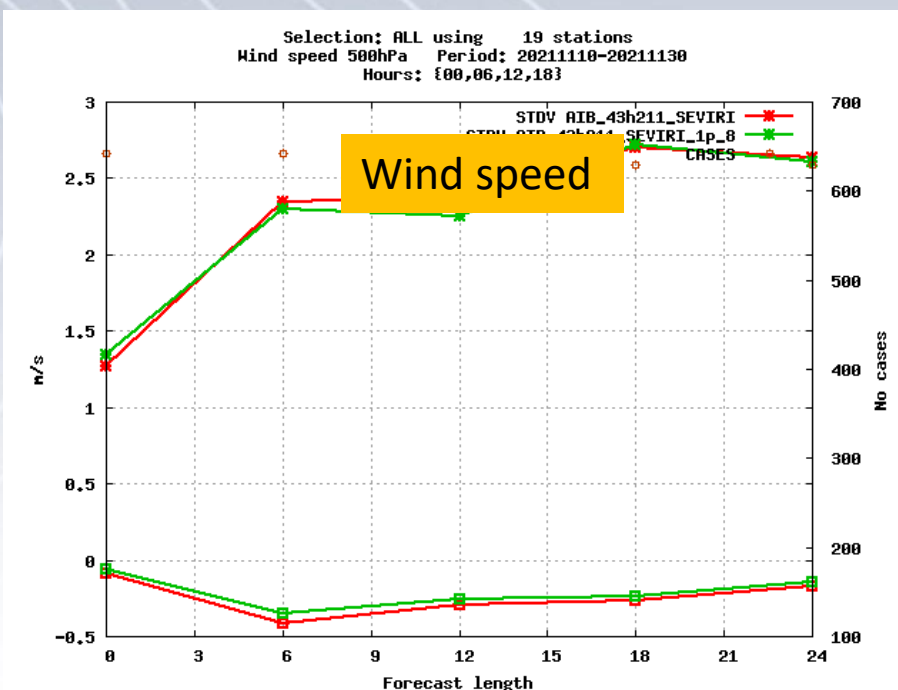
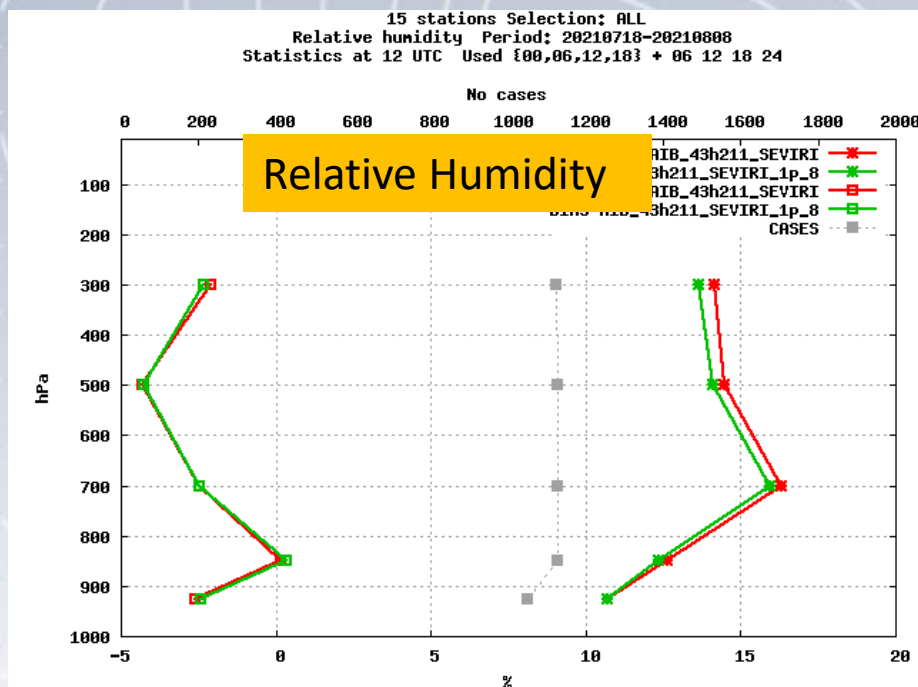


Observations at all analysis cycles (00, 03, 6, 09, 12, 15, 18 and 21 UTC)

Assimilation of SEVIRI data

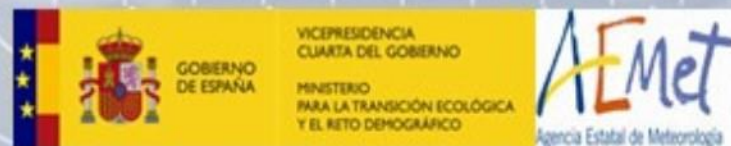
Improvement in the humidity profiles and slight improvement on the wind, and neutral impact on the precipitation.

CTRL
SEVIRI



The SEVIRI radiances are assimilated since December 2022.

New radiance instruments



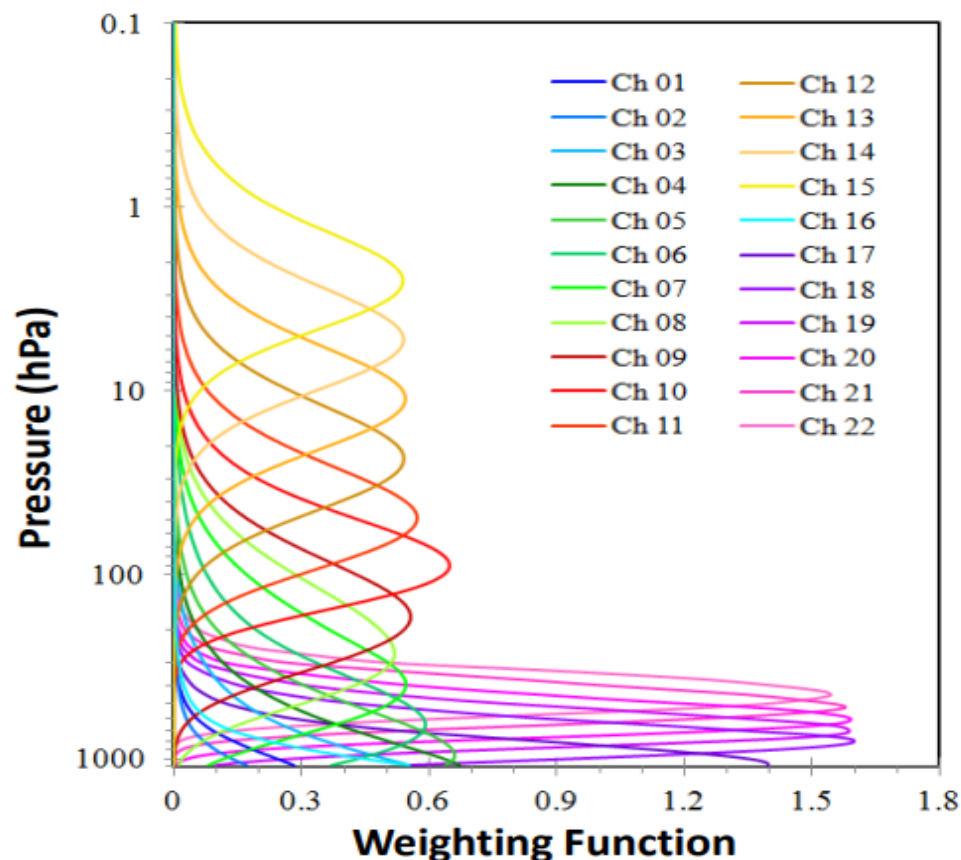
ATMS (Advanced Technology Microwave Sounder)

on board of Suomi NPP, NOAA-20 and NOAA-21

Channels 1-16~AMSUA (~T)

Channels 17-22 ~ MHS (~Q)

Monitoring 5-9 and 17-22
for Suomi-NPP and NOAA-
20

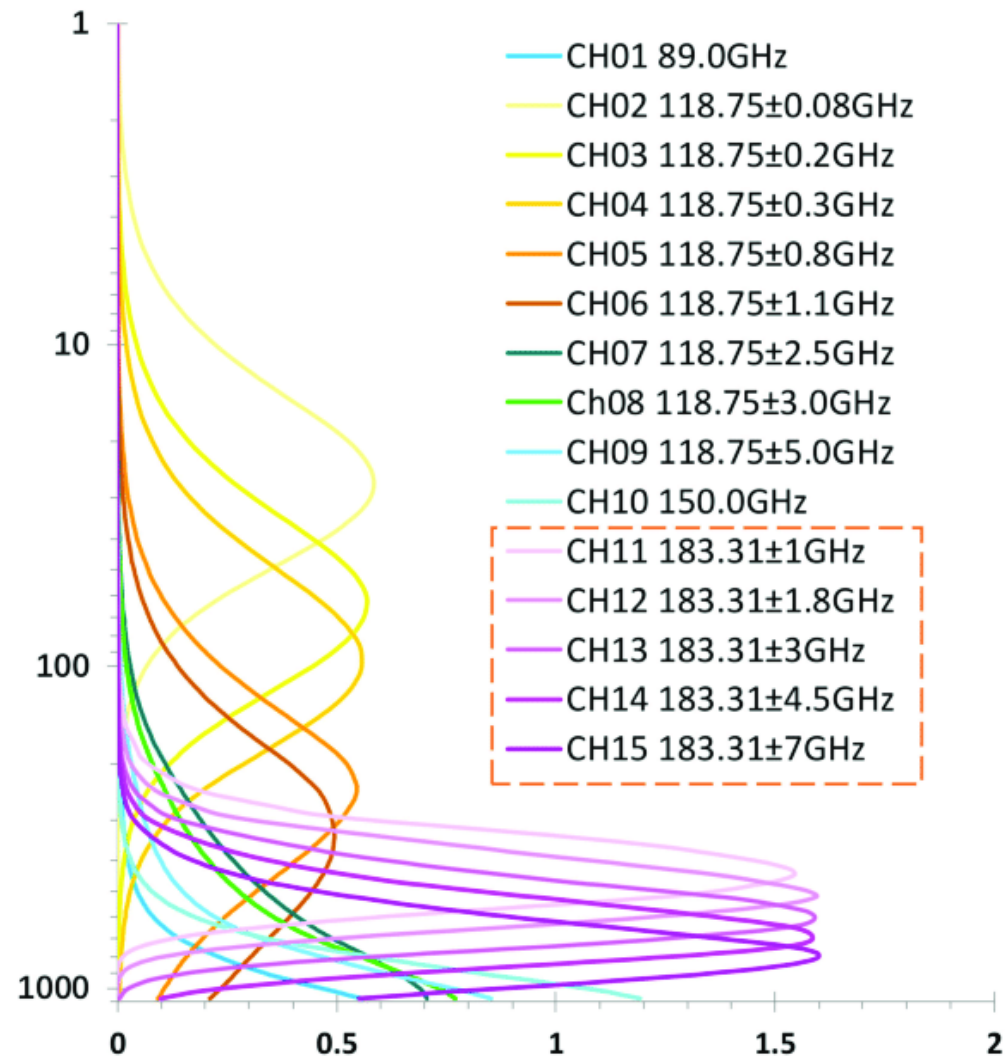


New radiance instruments

MWHS-2 (Microwave Sounder-2)

on board of Feng-Yu (CMA)
satellites (FY-3D and FY-3E)

Monitoring channels 11-15,
similar to MHS (~Q)



SAT	SENSOR	00	03	06	09	12	15	18	21
NOAA-18	AMSUA	X				X			X
NOAA-19	AMSUA MHS				X X			X X	X X
METOP-B	AMSUA MHS IASI				X X X	X X X			X X X
METOP-C	AMSU-A MHS IASI				X X X	X X X			X X X
METOSAT	SEVIRI	X	X	X	X	X	X	X	X
NOAA-20 NPP	ATMS		X X			X X	X X		
FY-3D	MWHS-2		X			X	X		

Actual distribution of assimilated radiances for cycles:
In the operational suite (X) and in development (X)

SAT	SENSOR	Channels
NOAA-18	AMSUA	6,7 and 8
NOAA-19	AMSUA MHS	6 and 9 4 and 5
METOP-B	AMSUA MHS IASI	6, 7, 8 and 9 3, 4 and 5 55 channels
METOP-C	AMSU-A MHS IASI	6, 7, 8 and 9 3, 4 and 5 55 channels
METOSAT	SEVIRI	WV6.2 and WV7.3
NOAA-20 NPP	ATMS	7, 8 and 9; 19, 20, 21 and 22
FY-3D	MWHS-2	11, 12, 13 and 14

Assimilated radiance channels for SAT and SENSOR:
In the operational suite (X) and in development (X)

Impact of ATMS and MWHS2



Period study: 25 May to 9 June 2023

Assimilation at 03, 12 and 15 UTC

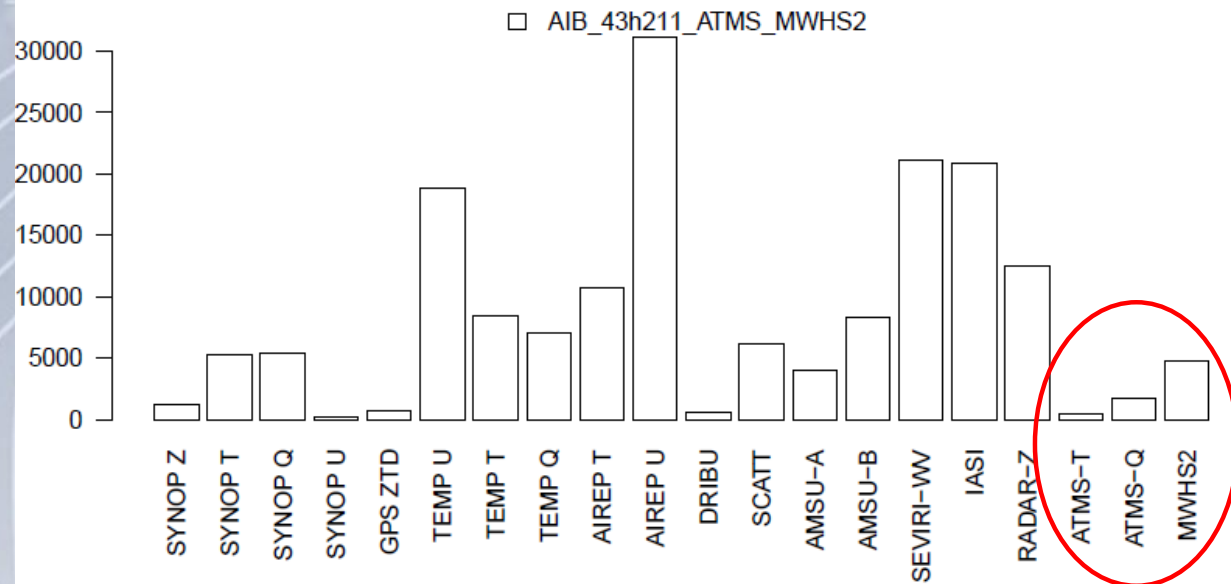
Forecasts: H+24 for cycles 00, 06, 12 and 18 UTC

CTRL ~ operational DA

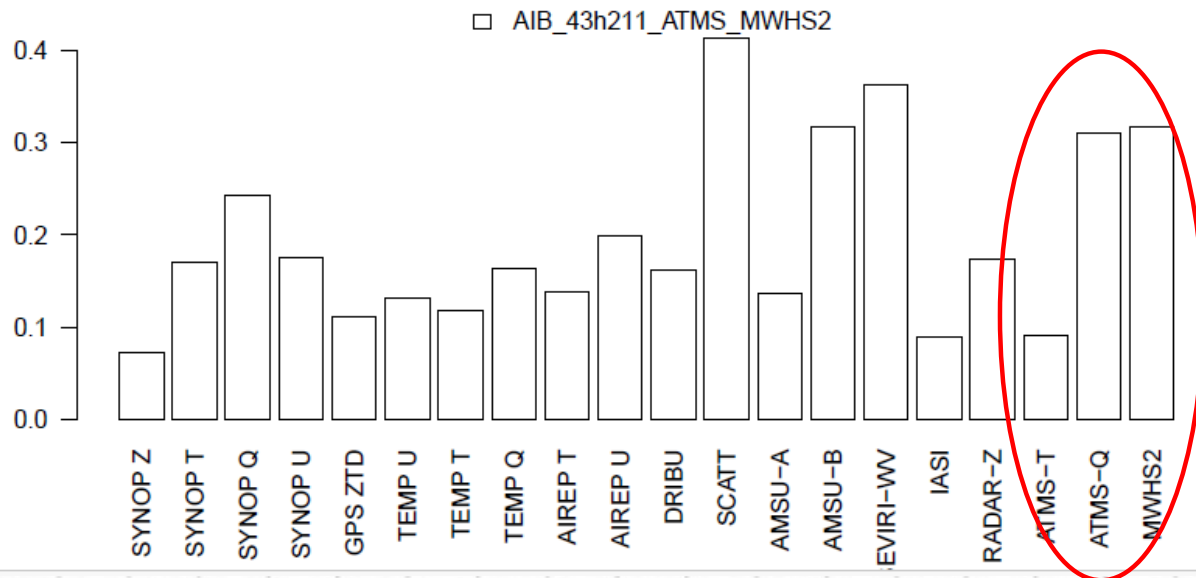
ATMS_MWHS2: CTRL + ATMS and MWHS2

- Observation impact on observations: Degrees of freedom for signal (DFS). DFS is the derivative of the analyses increments with respect to the observations used in the analysis system.
- Observation minus First-guess (ob-fg) on other assimilated observations.
- Forecast impact: verification of forecasts against Synops and Temps

Absolute Degree of Freedom for Signal (DFS)

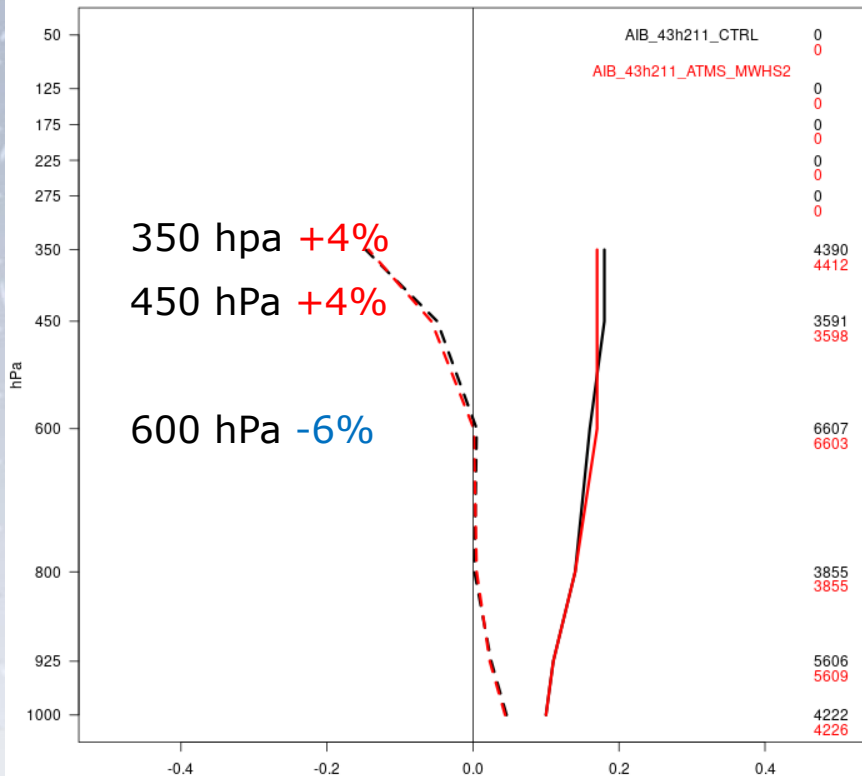


Relative Degree of Freedom for Signal (DFS/observations)

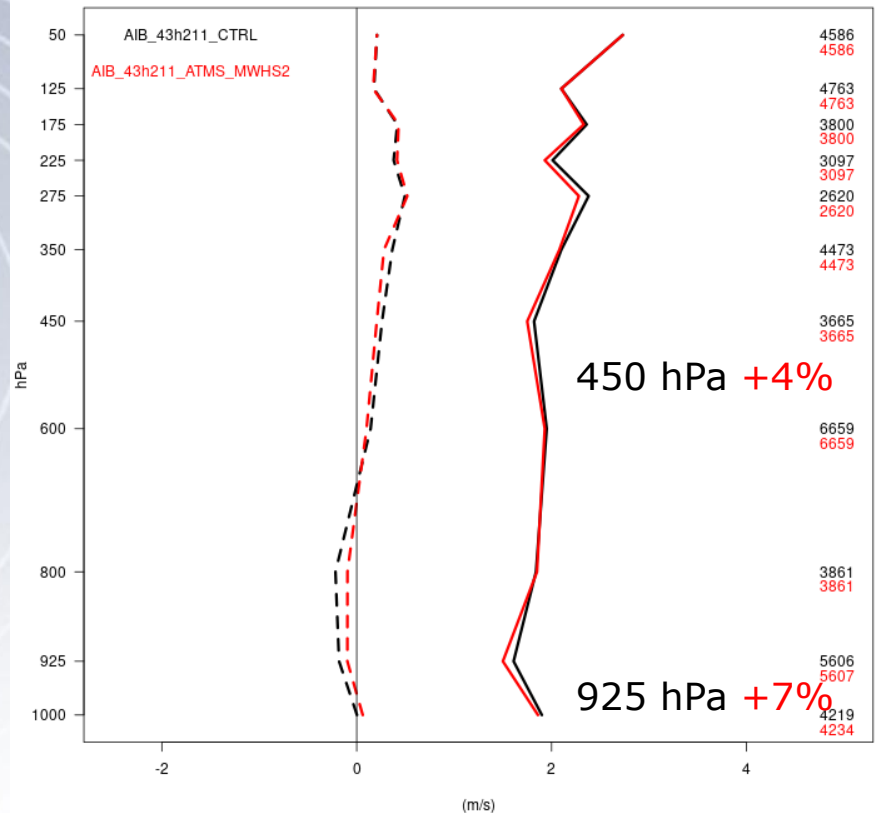


ob-fg Radiosondes at 12 UTC

rh - Bias and standard deviation of ob-fg



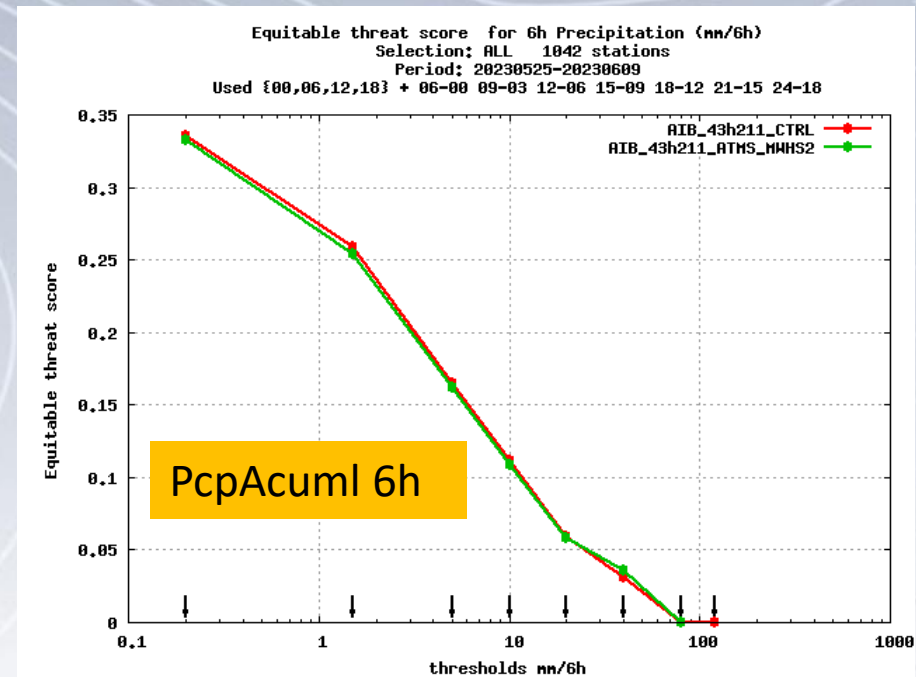
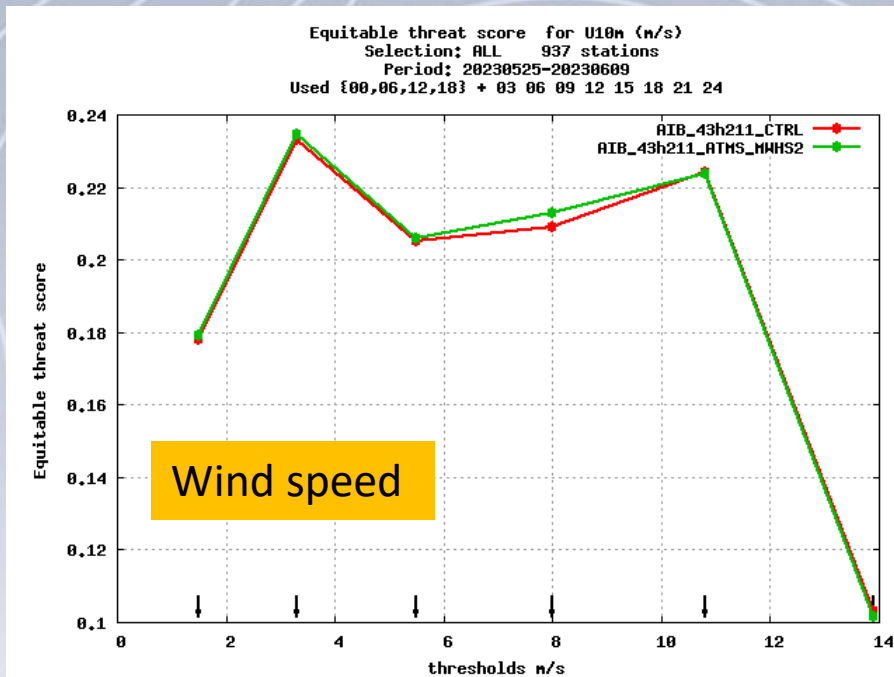
u - Bias and standard deviation of ob-fg



bias and stdv

CTRL
 ATMS_MWHS2

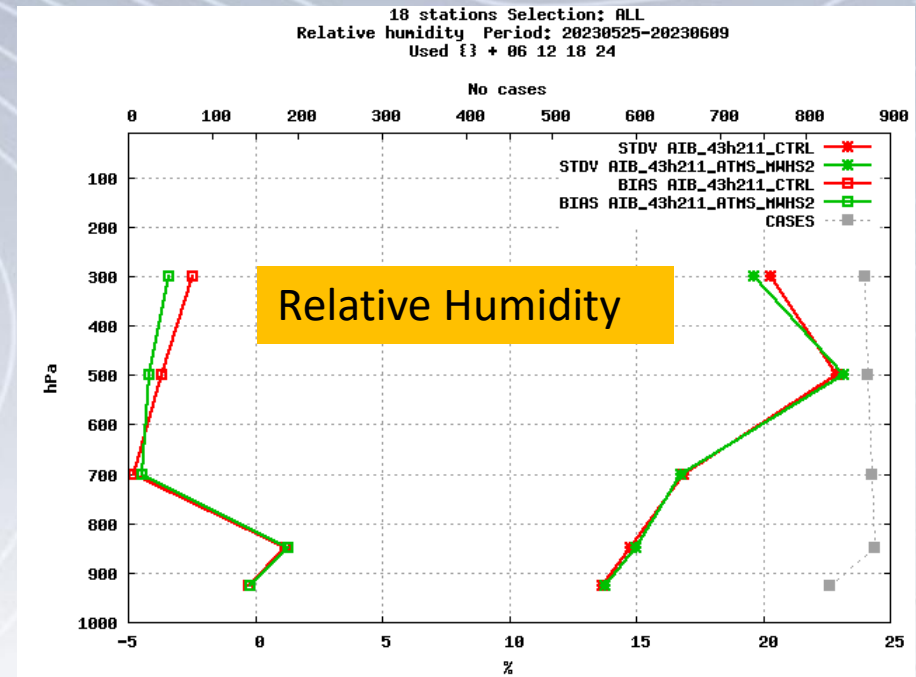
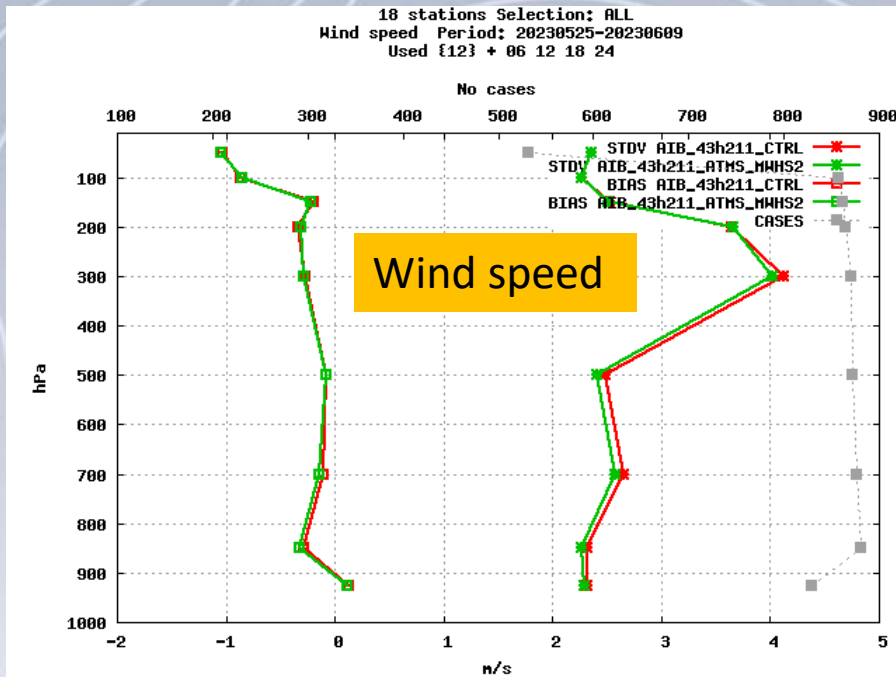
Impact on forecasts



Equitable threat score

CTRL
ATMS_MWHS2

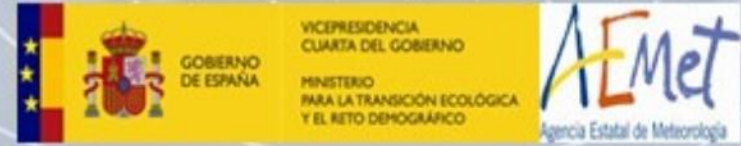
Impact on forecasts



Analysis time at 12 UTC

CTRL
ATMS_MWHS2

Impact of IASI/Metop-C



Period study: 25 May to 9 June 2023

Assimilation at 09, 12 and 21 UTC

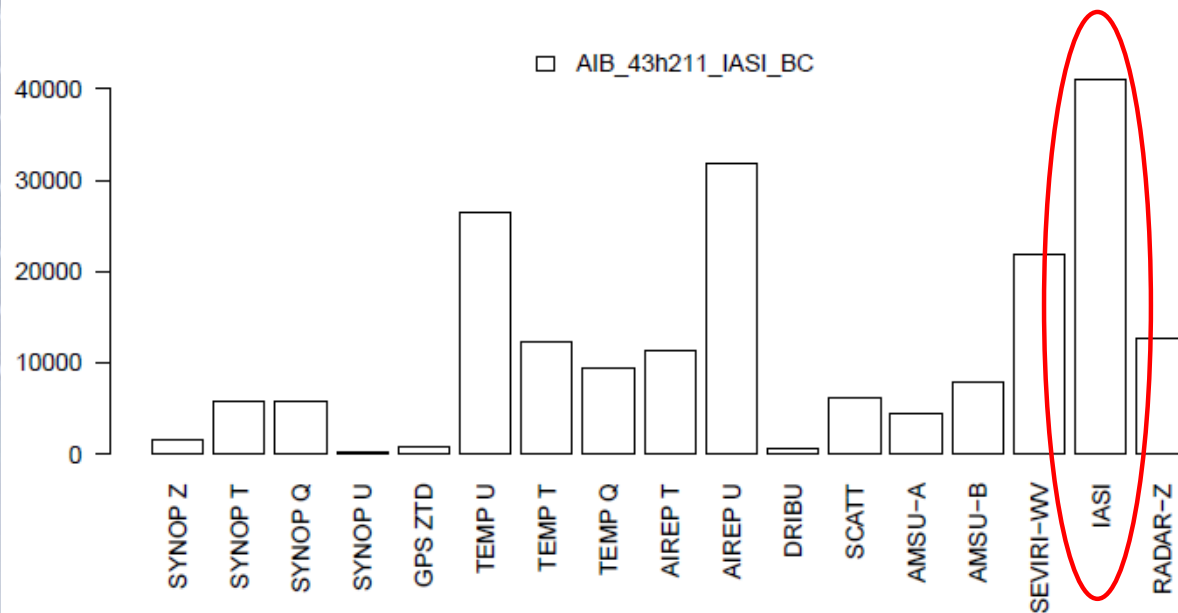
Forecasts: H+24 for cycles 00, 06, 12 and 18 UTC

CTRL ~ operational DA

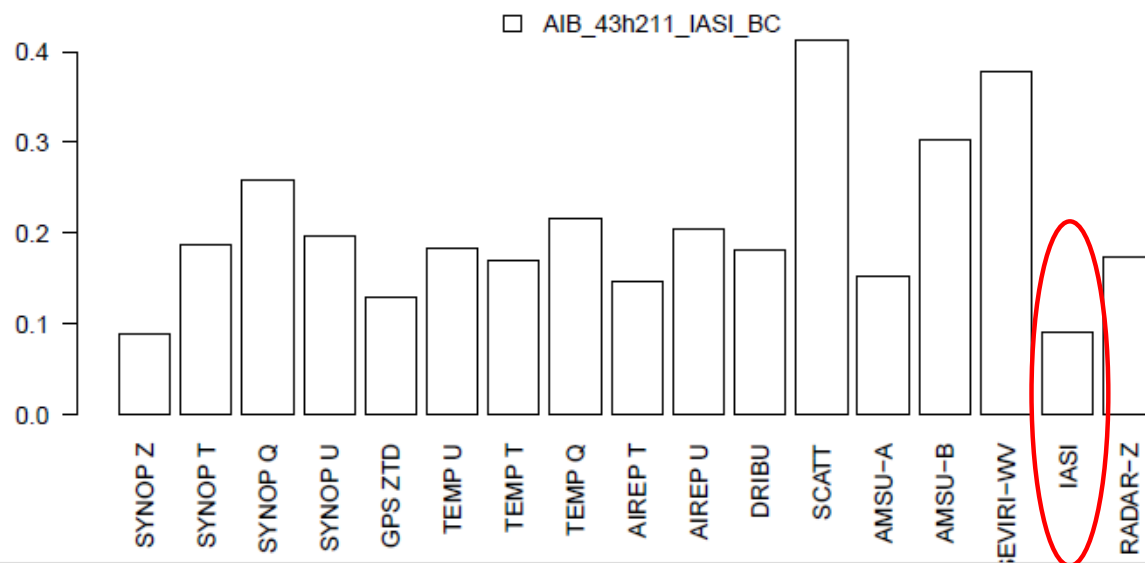
IASI_BC: CTRL + IASI/Metop-C (also IASI/Metop-B in CTRL)

- Observation impact on observations: Degrees of freedom for signal (DFS). DFS is the derivative of the analyses increments with respect to the observations used in the analysis system.
- Observation minus First-guess (ob-fg) on other assimilated observations.
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Absolute Degree of Freedom for Signal (DFS)

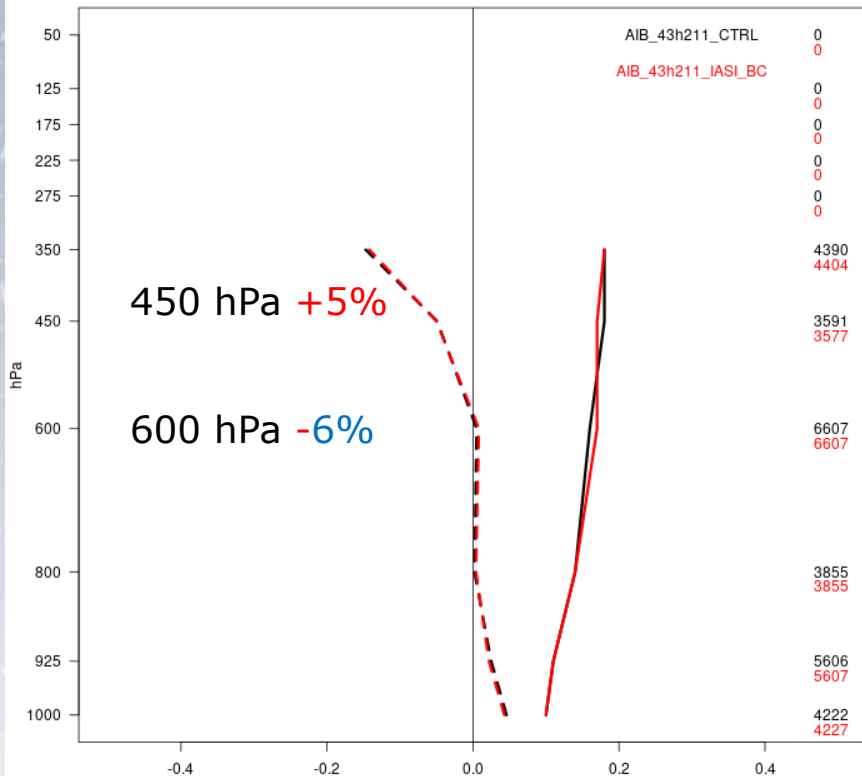


Relative Degree of Freedom for Signal (DFS/observations)

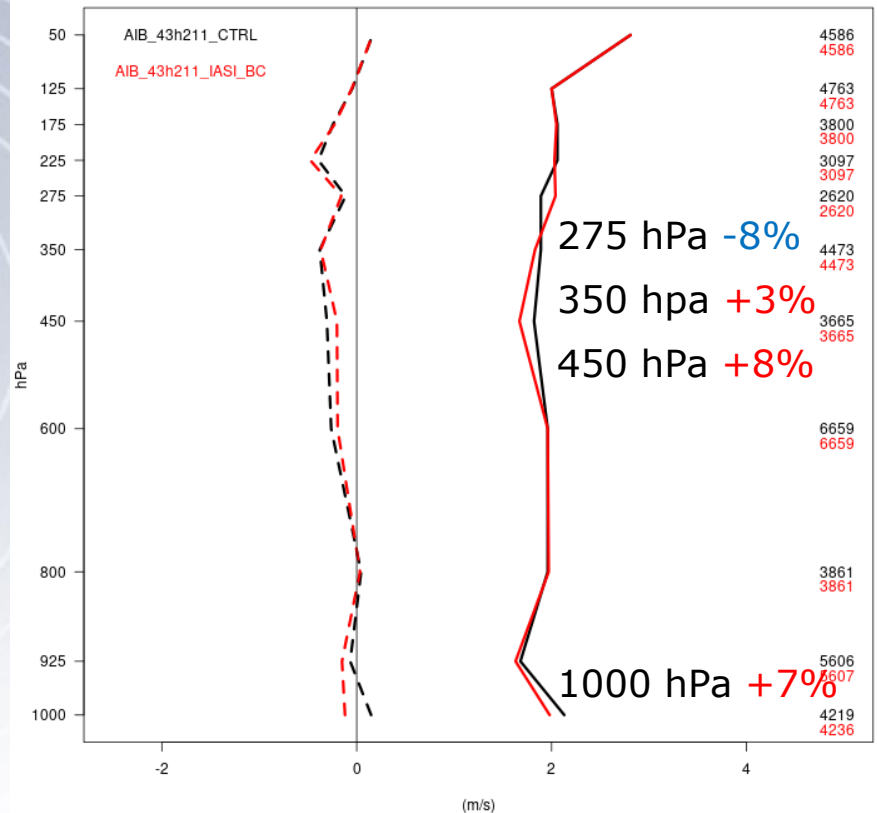


ob-fg Radiosondes at 12 UTC

rh - Bias and standard deviation of ob-fg



v - Bias and standard deviation of ob-fg

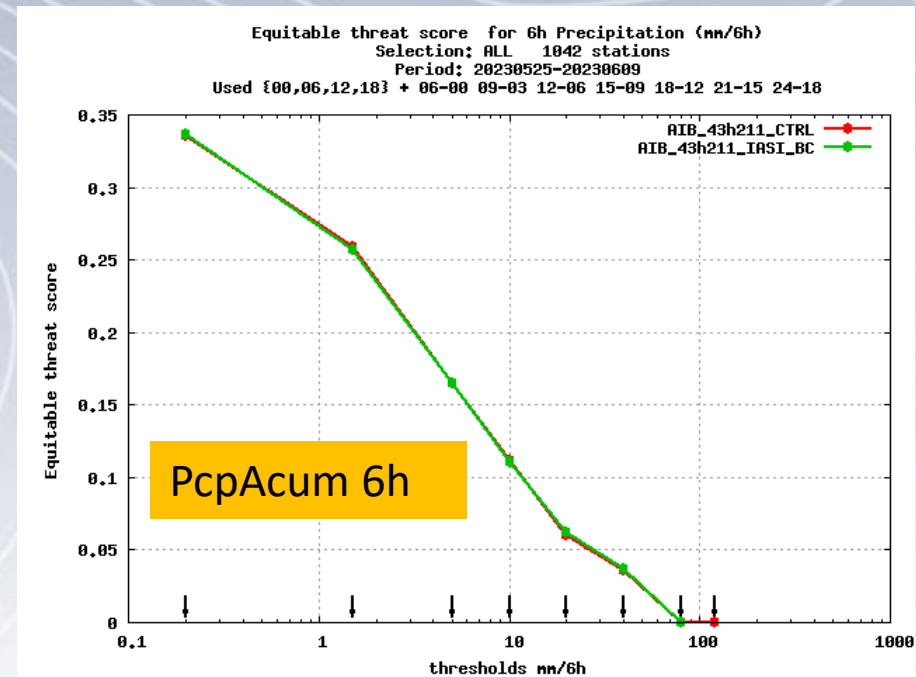
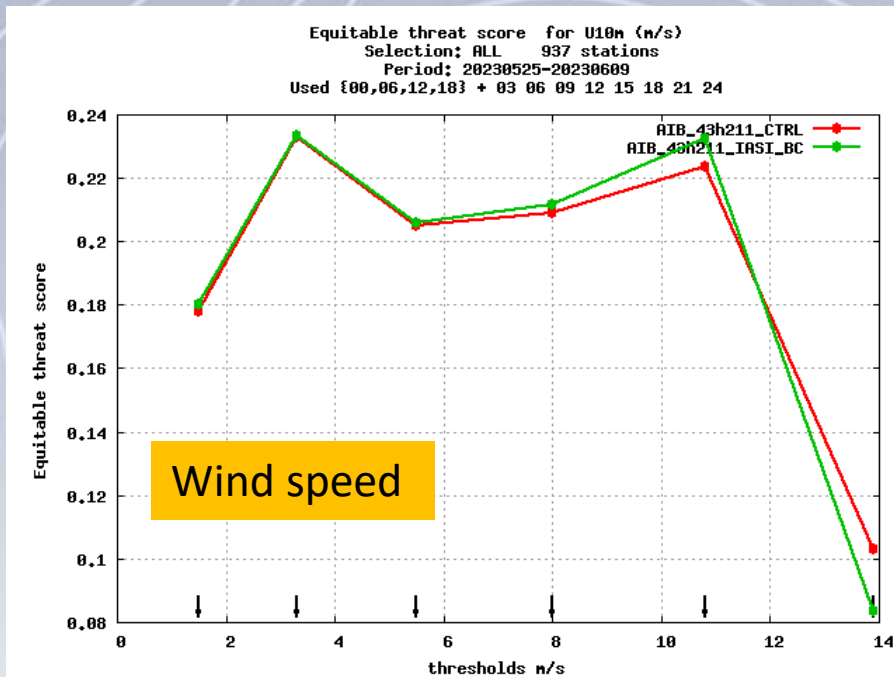


bias and stdv

CTRL

IASI_BC

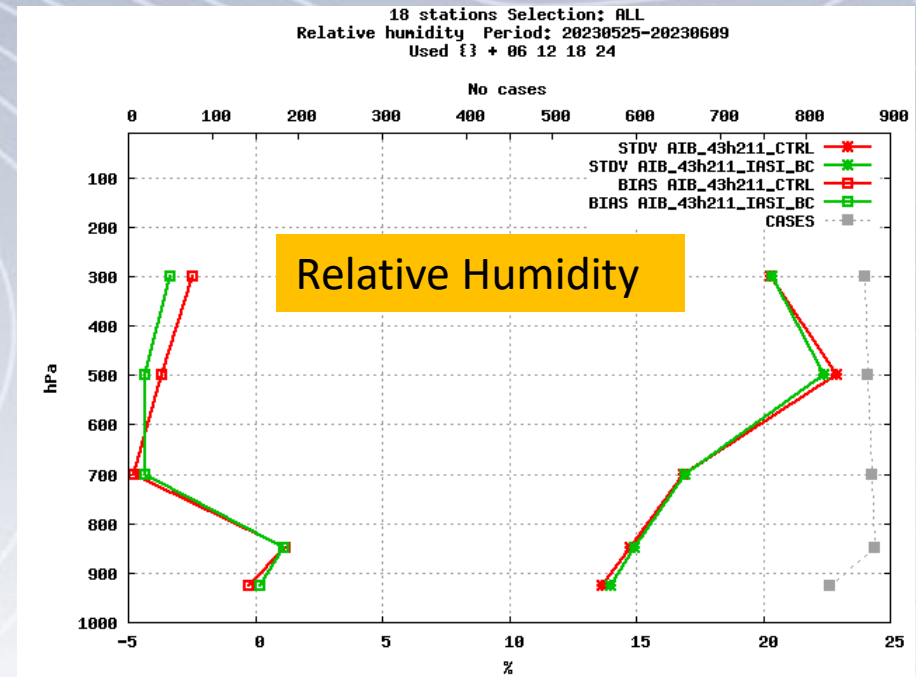
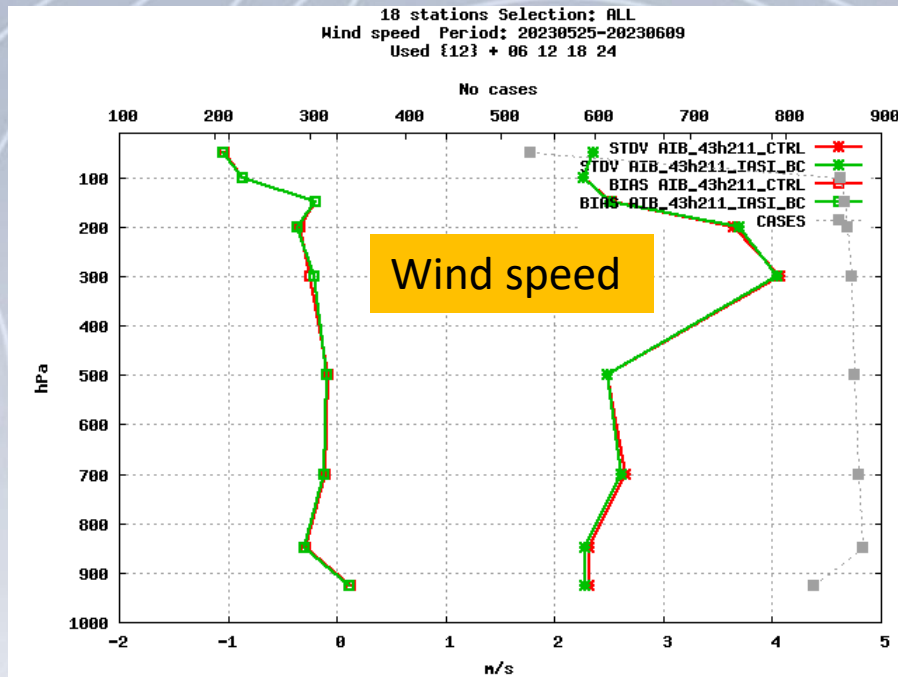
Impact on forecasts



Equitable threat score

CTRL
IASI_BC

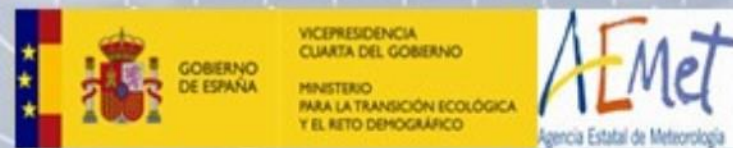
Impact on forecasts



Analysis time at 12 UTC

CTRL
IASI_BC

Next steps

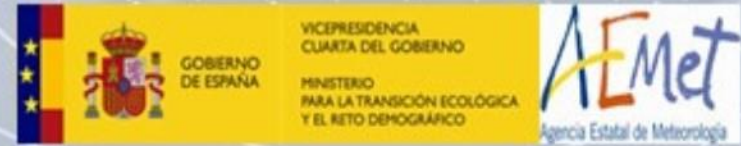


- New experiment including ATMS, MWHS2 and IASI/Metop-C for the same study period
- The same experiments for another study period
- If positive impact, include into to pre-operational and operational suite

Ongoing developments

- cy43/cy46 data assimilation and forecast experiments
- 3dvar/4dvar data assimilation experiments

Future



- Assimilation of SEVIRI channels boarding on MTG.
- Low-levels peaking channels for MW and IR instruments.
- Other instruments/satellites (ATMS on NOAA-21, MWHS2 on FY-3E, ...)