Operational use of SEVIRI and other satellite enhancements at AEMET

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Outline

- Aemet Operational suite.

- Seviri data assimilation in Aemet operational suite.

- Ongoing work.

  - Improvements on IASI data assimilation

  - ATMS (Suomi-NPP and NOAA-20)

  - Towards a new domains at AEMET.

  - Low peak channels for Microwave and Infrared radiances.

- Summary and conclusions

Operational suite.

- Two domains that covers Iberia Peninsula and Balearic Islands and Canary Island.
- Harmonie-Arome cycle 43h2.1.1
- 3h cycle, with 72 hours of forecast length for 4 of the cycles.
- SAPP has been operational like preprocesing software of observations since June of 2020.
- Assimilation approach.
  - Canari and 3D-VAR data assimilation:
    - Conventional observations: SYNOP (T2m& RH2m for 3D-VAR), SHIP, BOUY, E-AMDAR (q-sensor), RADIOSONDES.
    - Radar (reflectivity).
    - Satellite obs:
      - ATOVS (Metop-B, Metop-C, NOAA-18, NOAA-19)
      - IASI (Metop-B),
      - Scatterometers (Metop-B and Metop-C)
      - Global Navigation Satellite System (GNSS) Zenith Total Delay (ZTD) data
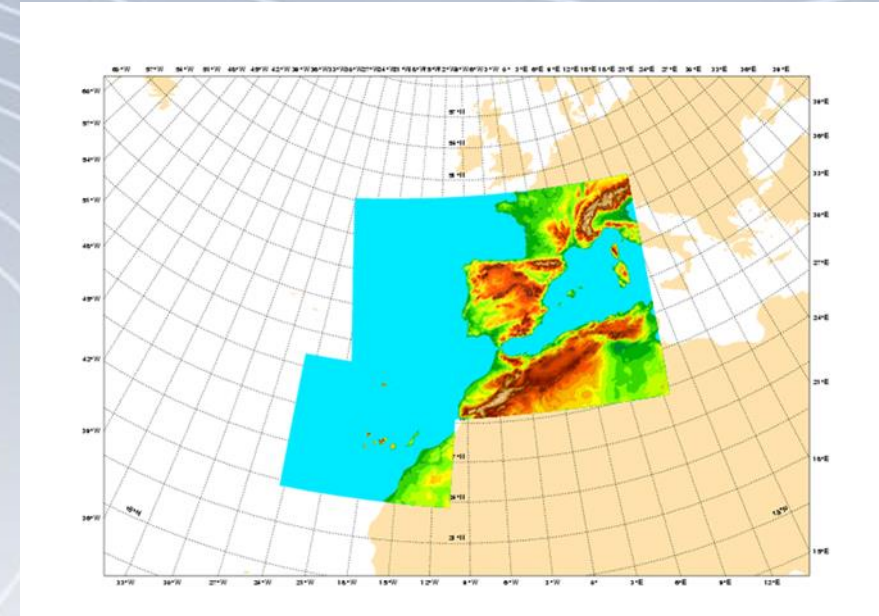   - **SEVIRI Water Vapour Channels.** Operational since December 2022
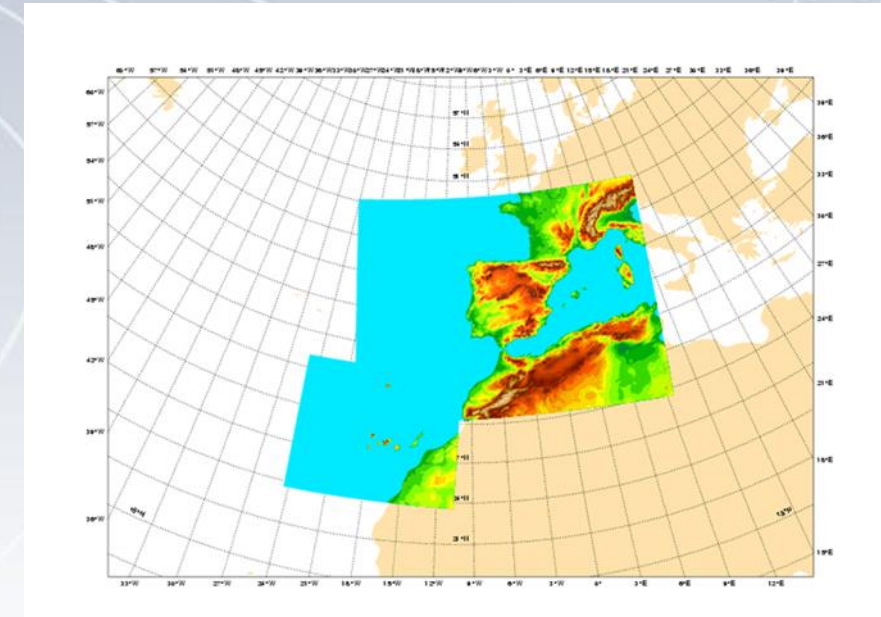
Operational suite. More details.

Available polar satellite observations per cycles

IBERIA	00	03	06	09	12	15	18	21
METOP-B				x				x
METOP-C			x	x				x
NOAA-18	x			x				x
NOAA-19				x				x

CANARY	00	03	06	09	12	15	18	21
METOP-B	x				x			x
METOP-C	x				x			x
NOAA-18	x				x			
NOAA-19				x				x

Channel used	AMSU-A	MHS
METOP-B	6,7,8,9	3,4,5
METOP-C	6,7,8,9	3,4,5
NOAA-18	6,7,8	x
NOAA-19	6,9	4,5

SEVIRI

- The Spinning Enhanced Visible and InfraRed Imager (SEVIRI) has on board of Meteosat Second Generation (MSG).
    - We have already used MSG-4.
- It has 12 spectral channels 8 of them in the infrared band.
- The spatial resolution for all channels is 3 km (except the High Resolution Visible that is 1 km).
- Temporal resolution is 15 minutes.

| SEVIRI IR Channels	Main characteristics
IR 3.9	It is used at night to detect fog and very low clouds. Window channel of CO_2
WV 6.2	Water Vapour Channel
WV 7.3	
IR 8.7	Window channel of H_2O
IR 9.7	Ozone absorption channel. Not suitable to data assimilation
IR 10.8	Window channel of H_2O
IR 12.0	
IR 13.4	CO_2 absorption band
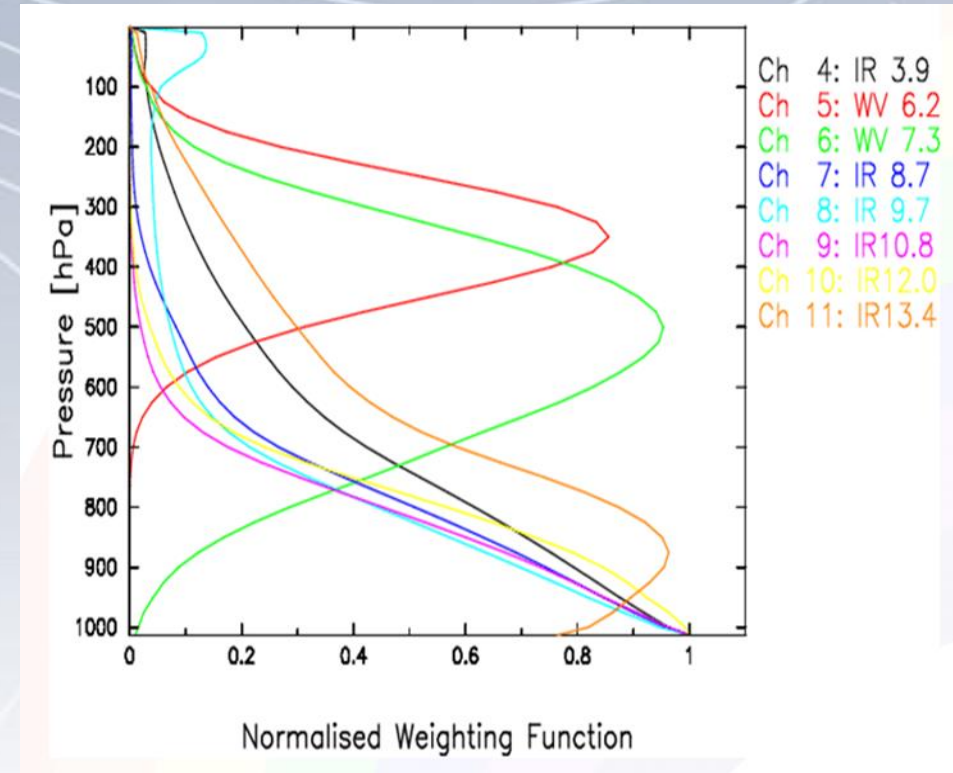
Weighting functions of SEVIRI, for a satellite nadir view for a standard midlatitude summer reference profile.

Source EUMETSAT

SEVIRI

- We have started using channels with lower surface influence, so only trying to assimilate **Radiance** for:
  - Channels 5 and 6. (**Water Vapour channels 6.2 μm and 7.3 μm**).
  - Channel 11. (**Infrared channel 13.4 μm**).
- In the pre-processing we make an initial thinning, using only one pixel out of 5.
  - Spatial thinning 65 km
- We use the products **Cloud Type (CT) and Cloud Top Temperature and Height (CTTH) SAF GEO Products (v2018) of Nowcasting SAF** in order to avoid cloud contamination.
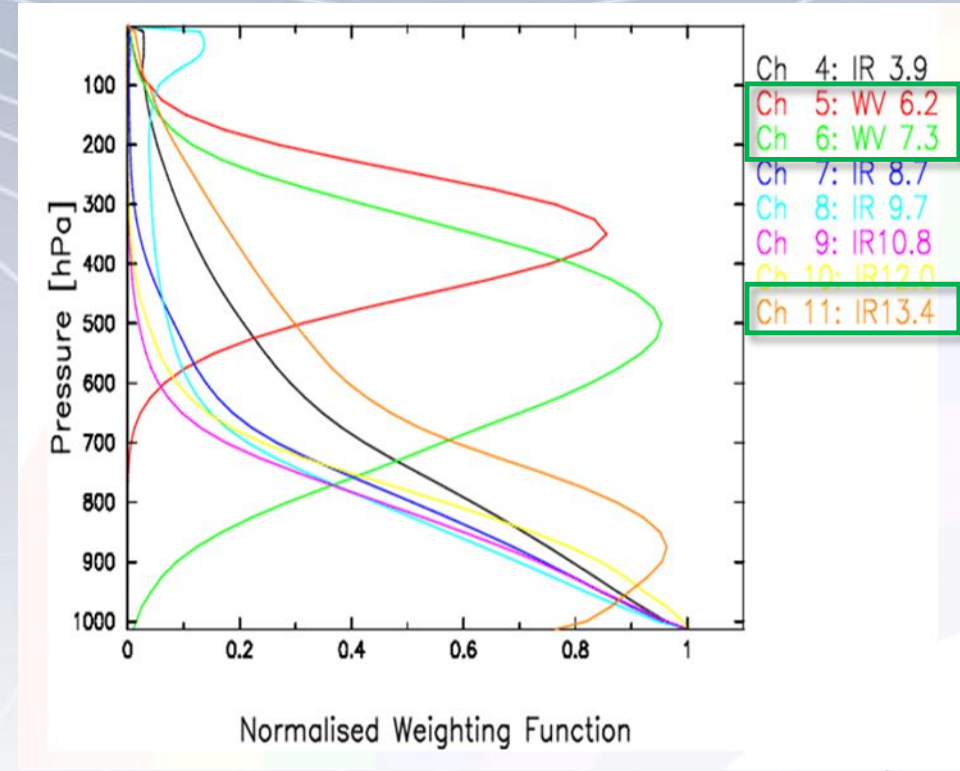
Ch 4: IR 3.9
Ch 5: WV 6.2
Ch 6: WV 7.3
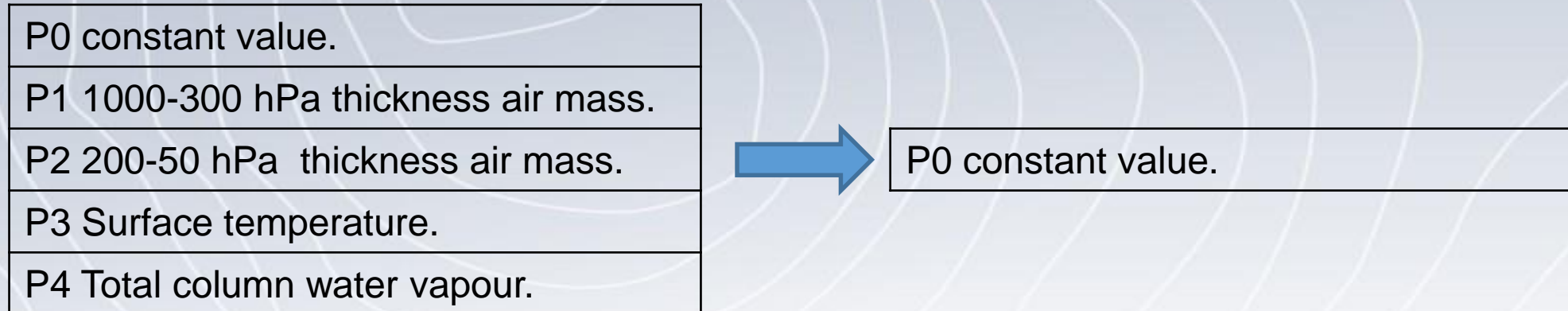Ch 7: IR 8.7
Ch 8: IR 9.7
Ch 9: IR10.8
Ch 11: IR13.4

Weighting functions of SEVIRI, for a satellite nadir view for a standard midlatitude summer reference profile.

Source EUMETSAT
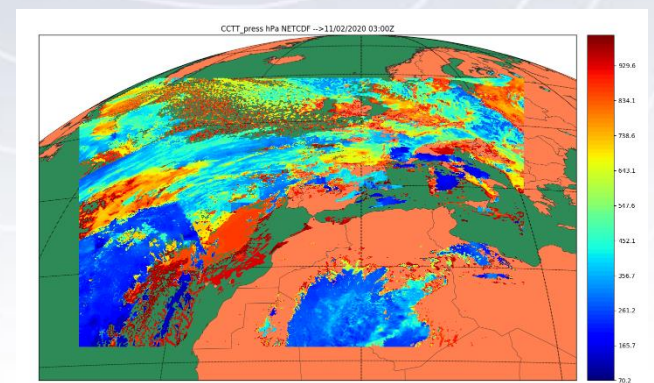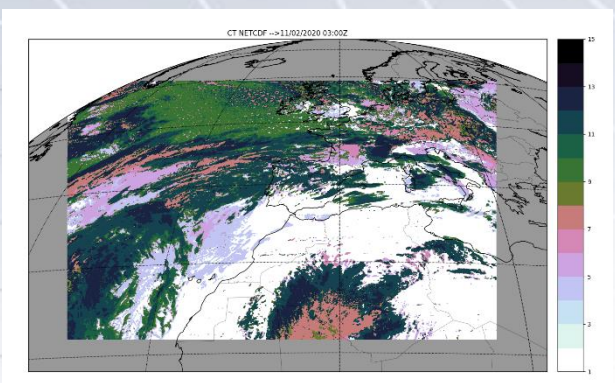
SEVIRI. Variational Bias Correction

- Initial tests have shown a strong diurnal cycle for first guess departures even for Water Vapour channels and forecasts scores aren't good.
  - We decided to apply **the simplest approach**.
    - Blacklist data over land. Not a big deal for our domain.
    - Reduce the number of predictors for the Variational Bias Correction

P0 constant value.
P1 1000-300 hPa thickness air mass.
P2 200-50 hPa thickness air mass.
P3 Surface temperature.
P4 Total column water vapour.

➡️

P0 constant value.

- Initial NBG (stiffness parameter) was 5000, but the number of data assimilated let us to reduce until 2000.
- 24h cycling.

SEVIRI Impact studies.

- For both areas we studied the assimilation of WV channels and WV channels + IR13.4.

- Two different periods have been taken for this studies.
  - Dry period **Summer 2021** for each domain
    - Not conclusive results.

  - A different wet period has been selected for each domain:
    - Iberian Peninsula **Nov 2021**.
    - Canary Islands **March 2022**.

- VarBC calibration period (aprox 1 month, a bit more for Canary Island Domain).
  - First days of active assimilation are not taking in account in the verification.

SEVIRI Impact studies. Analysis impact DFS
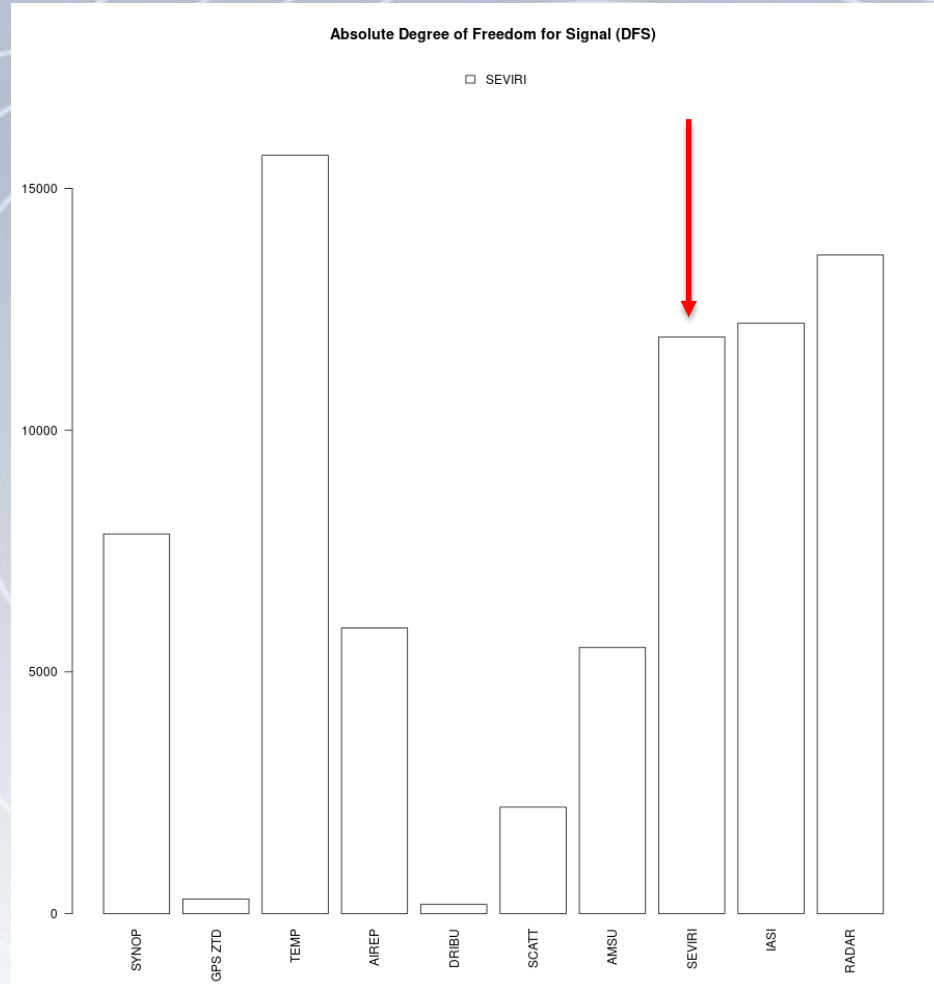
Absolute DFS (degrees of freedom for signal) subdivided for various observation types.

Absolute DFS value for SEVIRI data includes the contribution of WV6.2, WV7.3, and IR13.4 channels.

A separated absolute DFS analysis (not shown) demonstrates that for SEVIRI type, almost all the contribution come from the WV6.2 and WV7.3 (96.7 %), and IR13.4 slightly contributes to the impact (3.3 %).

SEVIRI Impact studies. Analysis impact

Bias and standard deviation of first guess departures for other observations (as for MHS and IASI humidity channels) were improved when SEVIRI radiances were assimilated.

In figure we can see vertical profile of the bias (dashed line) and the standard deviation (solid line) for H_2O IASI channels. (Dry period)

For MHS the impact is similar (not shown)

Bias and standard deviation of ob-fg (IASI H2O)
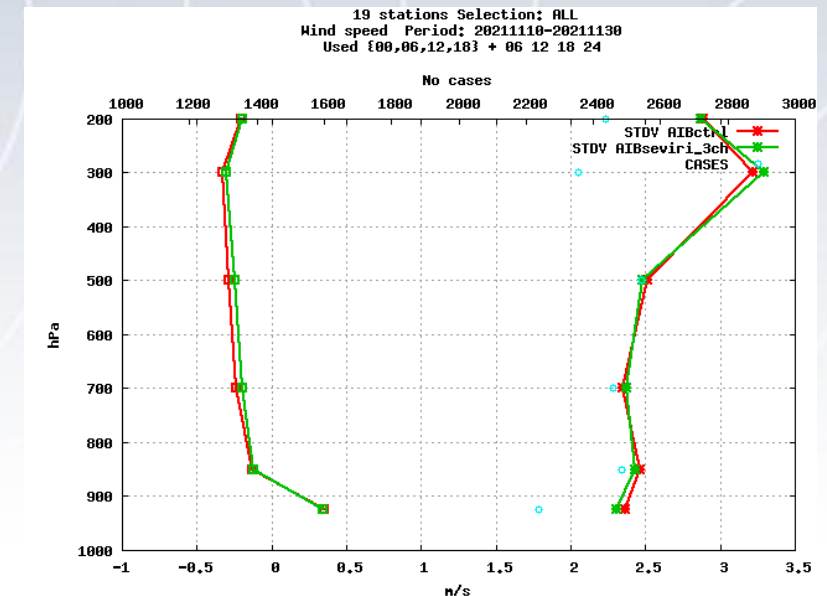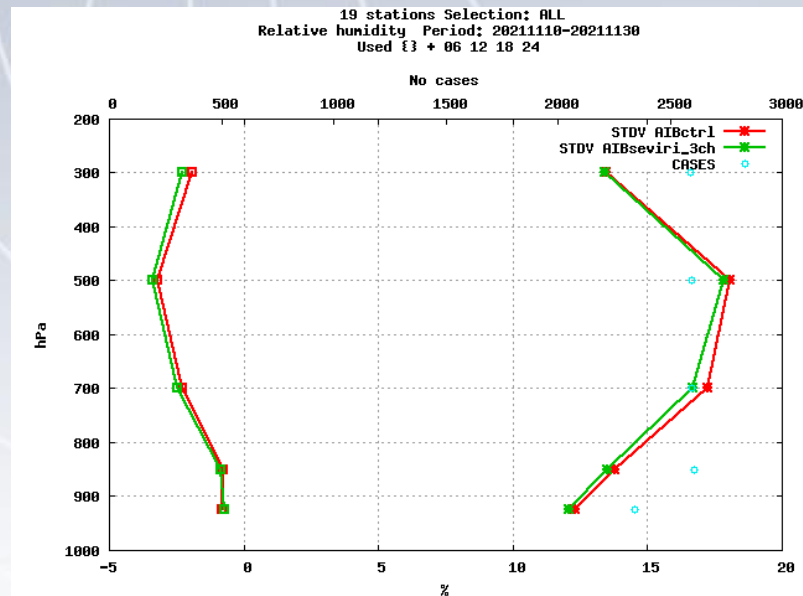
CTRL
WV6.2 + WV7.3
WV6.2 + WV7.3 + IR13.4
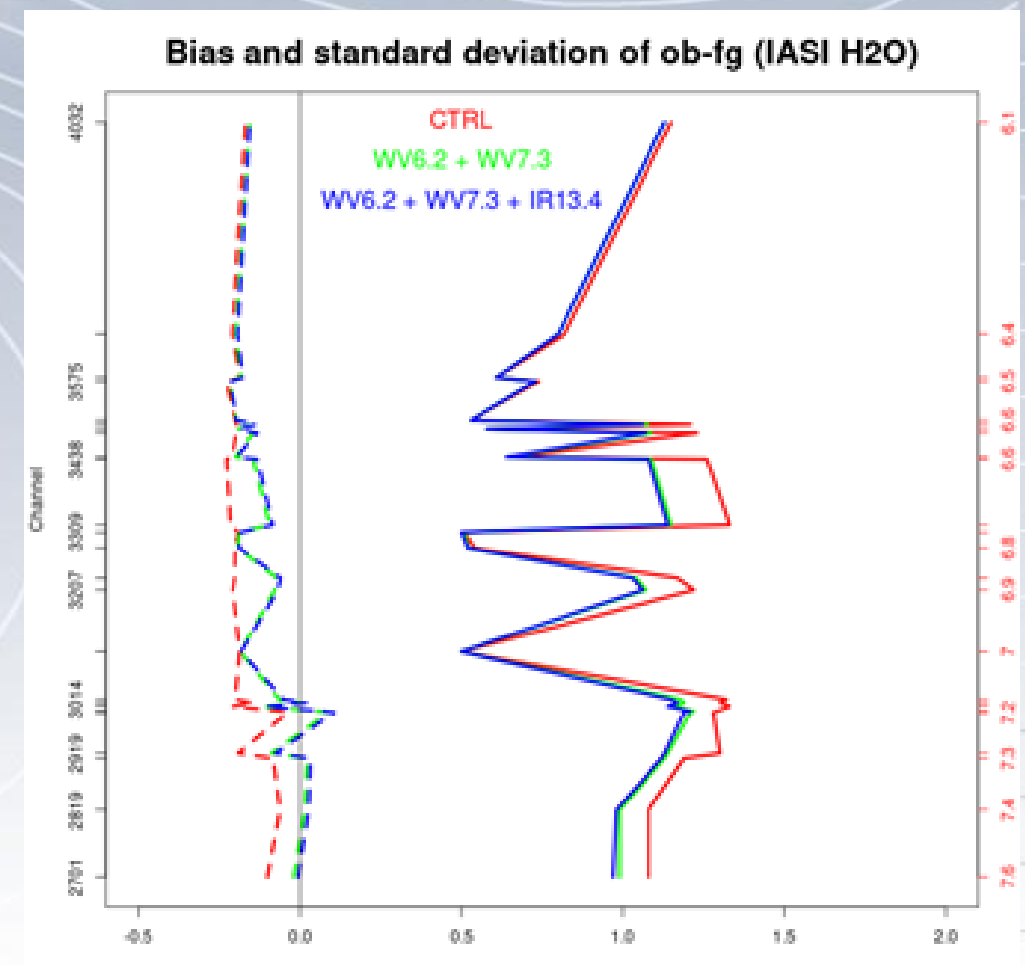
SEVIRI Impact studies. Forecast impact – Iberian Peninsula

Over the Iberian Peninsula domain we can appreciate the improve in middle levels of relative humidity and wind speed in the case of SEVIRI Assimilation compared with NO SEVIRI Assimilation.

For the rest of the variables (surface and upper air) the impact is rather neutral for both periods.
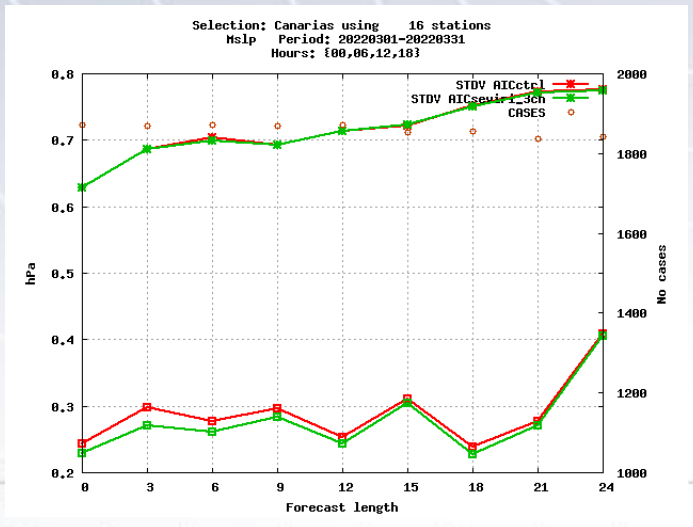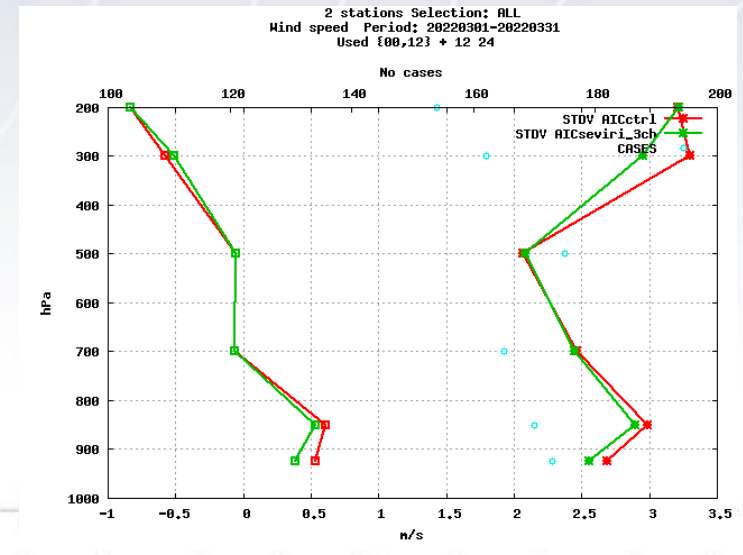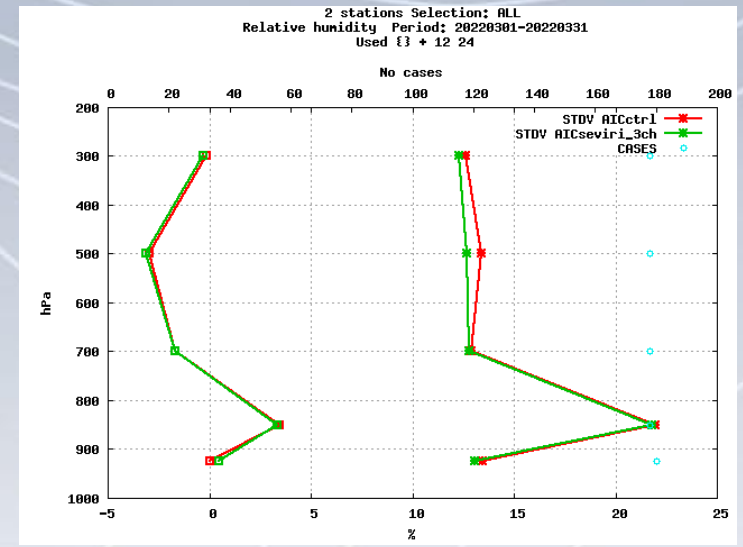
SEVIRI Impact studies. Forecast impact – Canary Islands

Like the Iberian Peninsula domain we can appreciate an improvement in middle levels of relative humidity and wind speed in the case of SEVIRI Assimilation compared with NO SEVIRI Assimilation.

In this case also can reduce the bias on surface pressure.

Work ongoing. IASI improvements.

Clear sky IASI radiance assimilation is operational since December 2020.

Two tasks are ongoing right now:

1. Introduce IASI from METOP-C.
   - Both satellite METOP-B and METOP-C give observations in the same runs.

2. Improve cloud detection scheme (R. Eresmaa, FMI)

Work ongoing. ATMS

- More microwave instruments from Polar Satellite are ready to be used.

- For the moment we have begun with ATMS that will improve our MW radiances coverage.
  - (Right now we are in calibration phase of VarBC, for both domain)
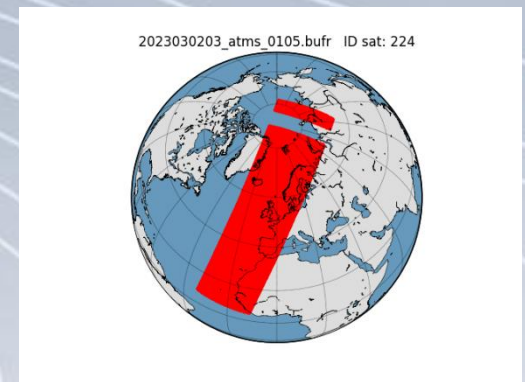
Suomi-NPP
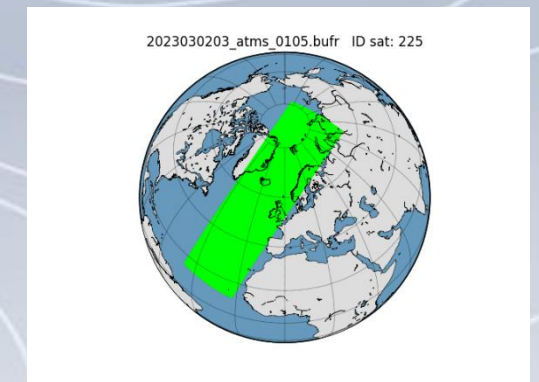
NOAA-20

ATOVS
 AMSU-A & MHS

ATMS.

IBERIA	00	03	06	09	12	15	18	21
METOP-B				x				x
METOP-C			x	x				x
NOAA-18	x				x			x
NOAA-19				x				x
NOAA-20		x				x		
Suomi-NPP		x				x		

| CANARY	00	03	06	09	12	15	18	21
METOP-B	x				x			x
METOP-C	x				x			x
NOAA-18	x				x			
NOAA-19				x				x
NOAA-20		x				x		
Suomi-NPP		x				x		

Work ongoing. New domains.

At present we are redefining the operational domains. In both of them **SEVIRI** must be used

- Big domain that cover Iberian Peninsula and Canary Island.
- Another two high resolution domains 1.3 km of resolution over the Iberia Peninsula and Canary Islands.
  - 3D-VAR With an hourly cycle.
    SEVIRI observations have very low latency time.
    Make the suitable for nowcasting proposes.

The verification scores for surface variables of these new suites 🙂 are better that the operational runs. Happy about that.

More information is shown in the Aemet National Poster.

AIBC_43h221: Observation Usage
db=ccma, DTG=2022-06-06 00 UTC, obname=sevb, satname=Meteosat11
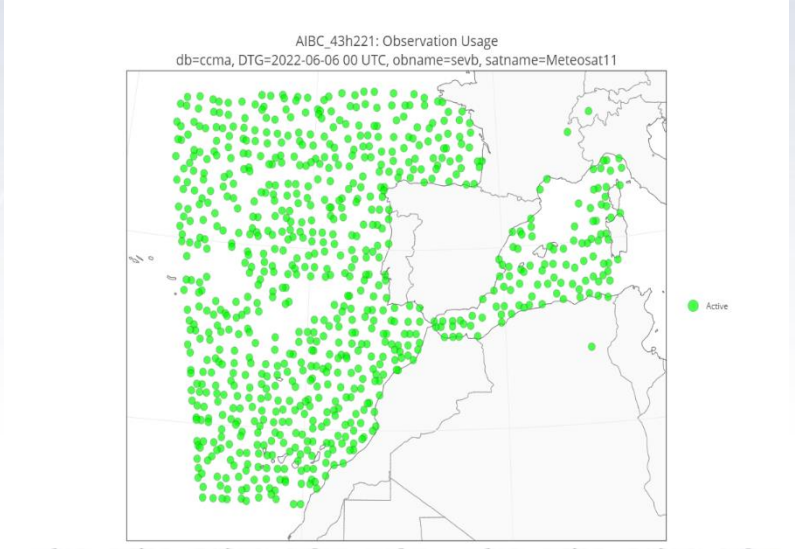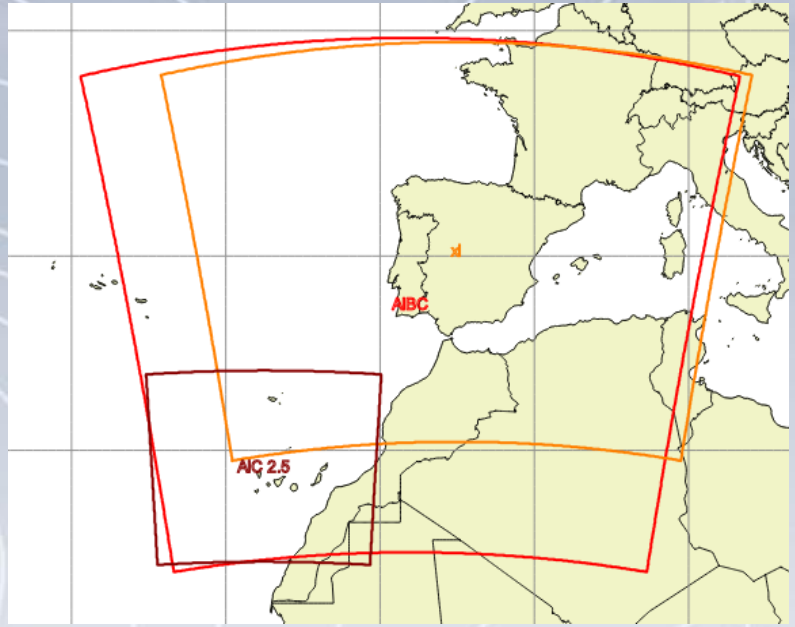
Work ongoing. Emissivity approach

- We need do a better treatment for emissivity for radiance assimilation of microwave instruments as well the infrared ones.

- Will be beneficial for:
  - Low peak channels of ATOVS.
  - Infrared channels of SEVIRI.
  - We also think that will be an improvement in the assimilation of Water Vapour channels of SEVIRI.
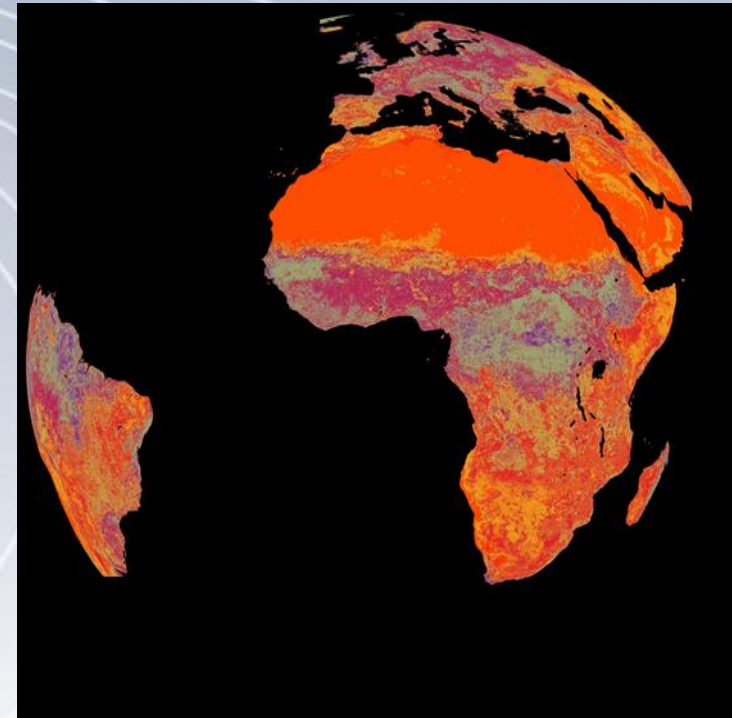
Emissivity for channel IR 10.8

Summary and conclusions

- Assimilation of **WV SEVIRI channels** has been proved to be **beneficial** for improving **forecast** scores as well for the **analysis** quality.
- Different Variational Bias Correction strategies have been tested and we decided due the results to use the simplest approach.
  - Only the constant predictor.
- Assimilation of **IR13.4 SEVIRI hasn't shown any effect** in analysis or forecast over our domains.

- More work need to be done in order to use SEVIRI radiances over land and infrared low peak channels.
  - Use dynamical emissivity values or read of emissivity retrievals.
  - Update for MTG that is expected to provide test files after summer 2023.
- Other instruments have to be added to our operational assimilation system.
  - Microwave sounder like ATMS, MWHS-2 and MWTS-2.
  - Infrared sounder like CriS.

Acknowledgements

We would like to thank you NWC SAF and Land SAF staff for giving us their support and understand our needs

Gema Morales for their support and their fruitful conversations. Miguel Ángel Martínez for helping us to understand RTTOV.

References:

Campins et al. (2017) Assimilation of ATOVS and GNSS ZTD data in the HARMONIE-AROME model configuration run at AEMET. ALADIN-HIRLAM Newsletter, 8.

Campins, J. and Navascues, B. (2021): Assimilation of IASI radiances in AEMET operational suite. ALADIN-HIRLAM Newsletter, 16.

Campins et al. (2022): Assimilation of clear-sky SEVIRI radiances in AEMET HARMONIE-AROME model. ACCORD Newsletter, 3

Thank you for your attention