Simulated MSG SEVIRI Imagery from HARMONIE-AROME - Applications

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Thanks to: Olinda Carretero, AEMET NWP group, Alvaro Subías, Alicia Lopez

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Outline

1. HALSSI application – status and plans.
2. Why HA simulated imagery?
3. HALSSI applications:
    1. In weather forecasting.
    2. In satellite product development.
    3. In NWP.
4. Future work.

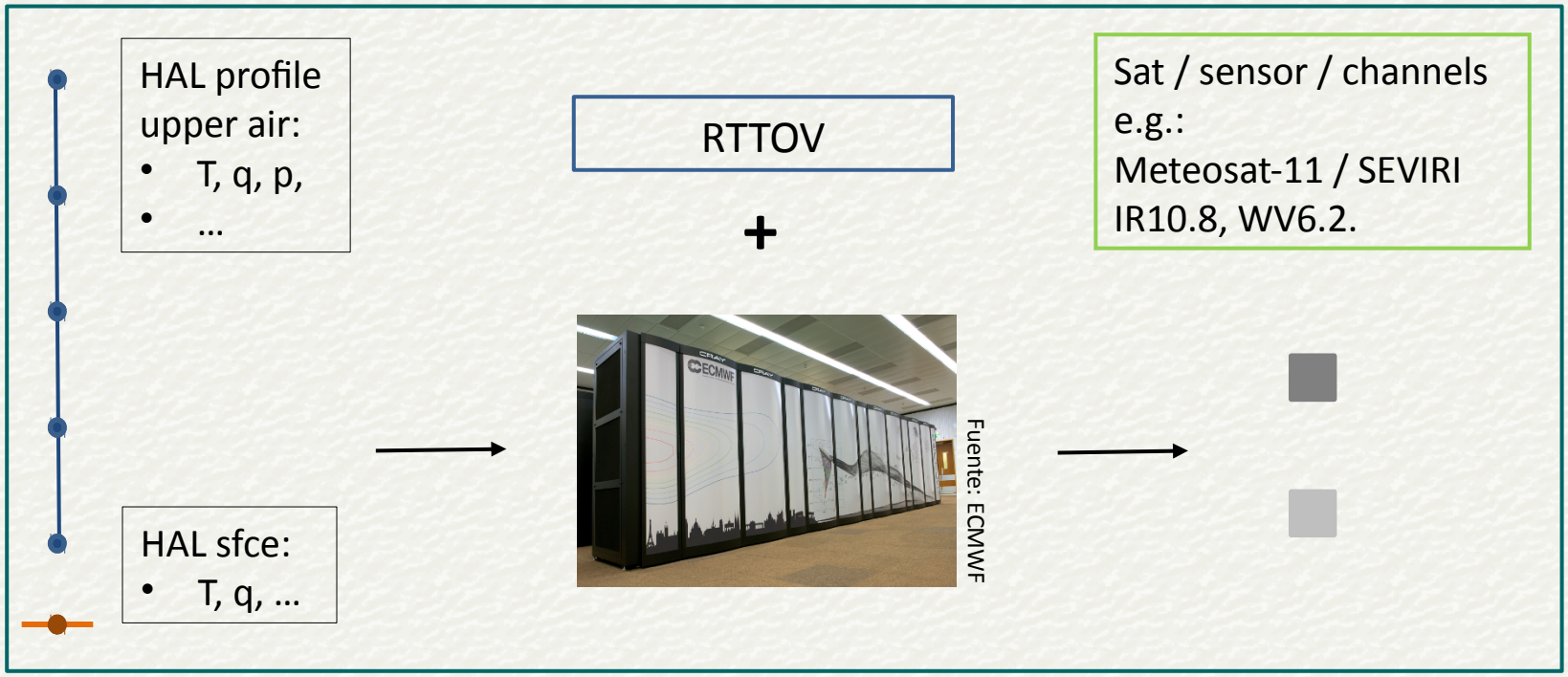
1. HALSSI application

- HAL (HARMONIE-AROME LAM) + SSI (Simulated Satellite Imagery).

- HALSSI: software tool to produce simulated radiances
  - from HARMONIE-AROME NWP forecasts,
  - using RTTOV radiative transfer model.

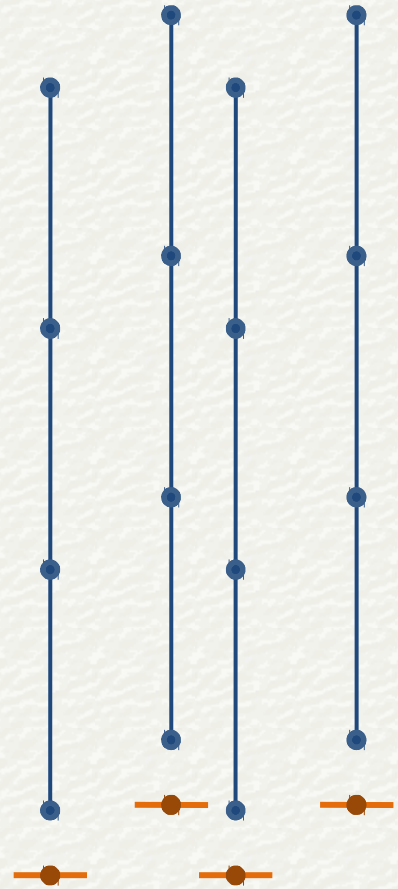
1. HALSSI application.

- At the core: simulation of ToA radiances, using RTTOV,
  - that a satellite instrument would measure, for a specific channel
    - E.g. SEVIRI channel WV6.2 on Meteosat-11.
  - viewing a point on Earth, for a specific position of the satellite (e.g. 0 deg)
  - for a HA atmospheric profile + sfce conditions at that point.



1. HALSSI application.

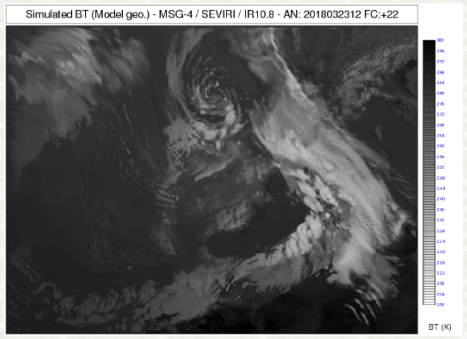
Images model-native geometry.

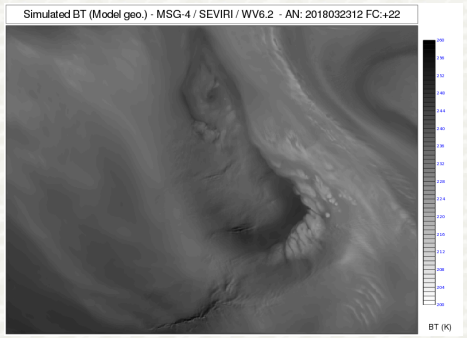


RTTOV

+

Fuente: ECMWF

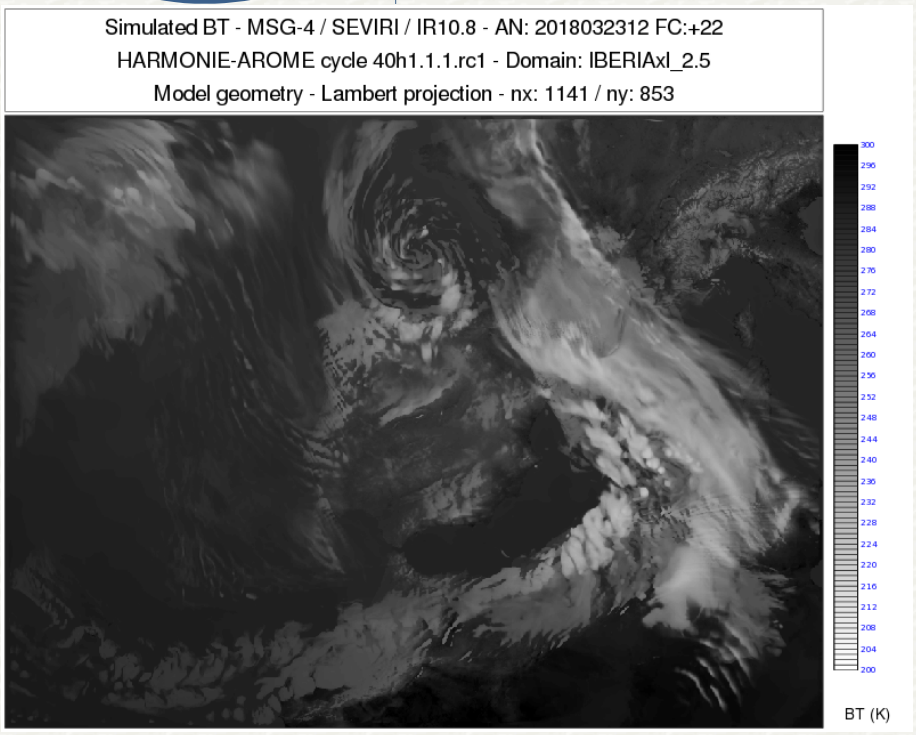


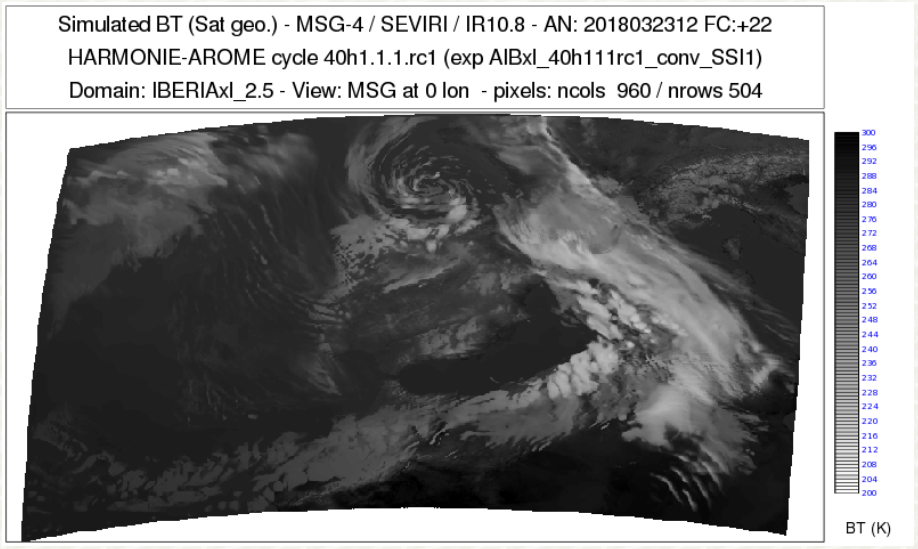


1. HALSSI application.

Model-native geo.

Sat (MSG4) geo.





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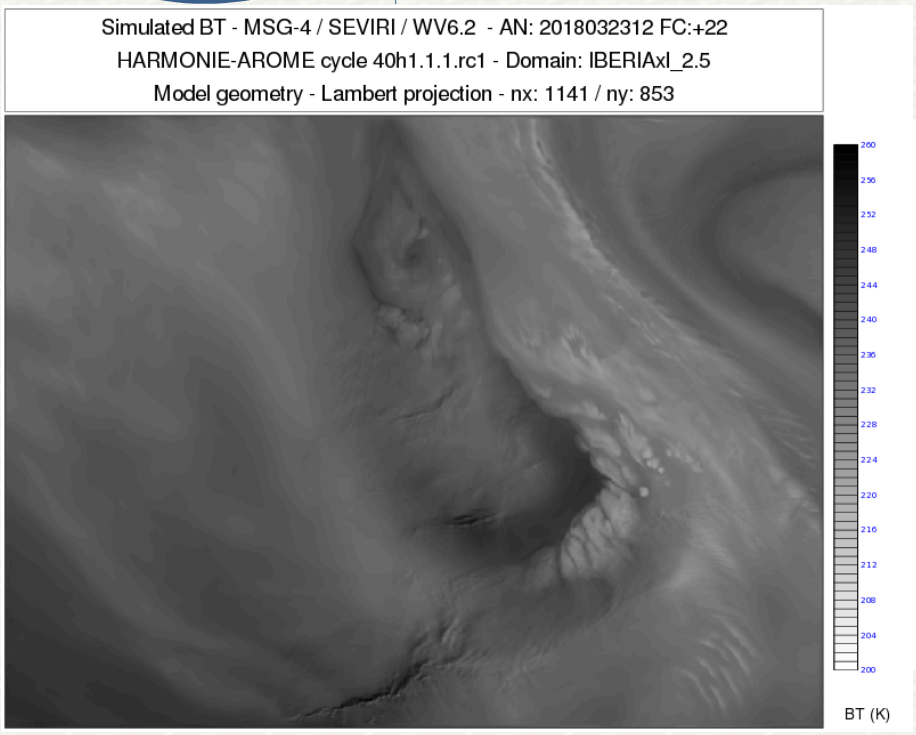
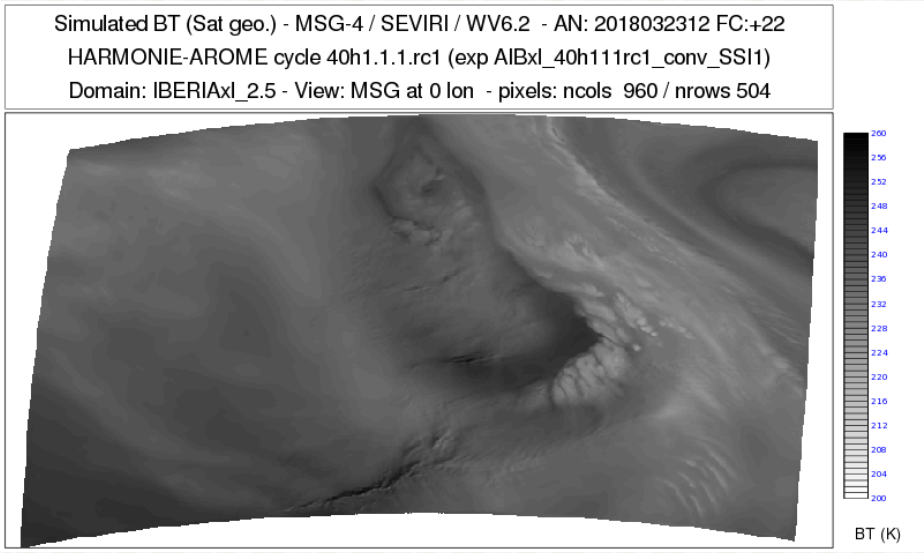




Model-equivalent of the obs, in DA language.

1. HALSSI application – status and plans.

- In HARMONIE-AROME 43h2.x, part of post-process, optional.
  - Using RTTOV v12.2 – or latest available.
  - Format: GRIB2 - ECMWF ecCodes lib used for encoding.
  - Experimental.
- User choices, at least:
  - SEVIRI channels: IR10.8, WV6.2, WV7.3 (Meteosat-11).
  - Model-native geometry.
- Later
  - Meteosat-11, satellite geometry (located at 0 deg lat, 0 deg lon).
  - More SEVIRI channels.
  - Next generation of EUMETSAT geo satellites: MTG sat geo.

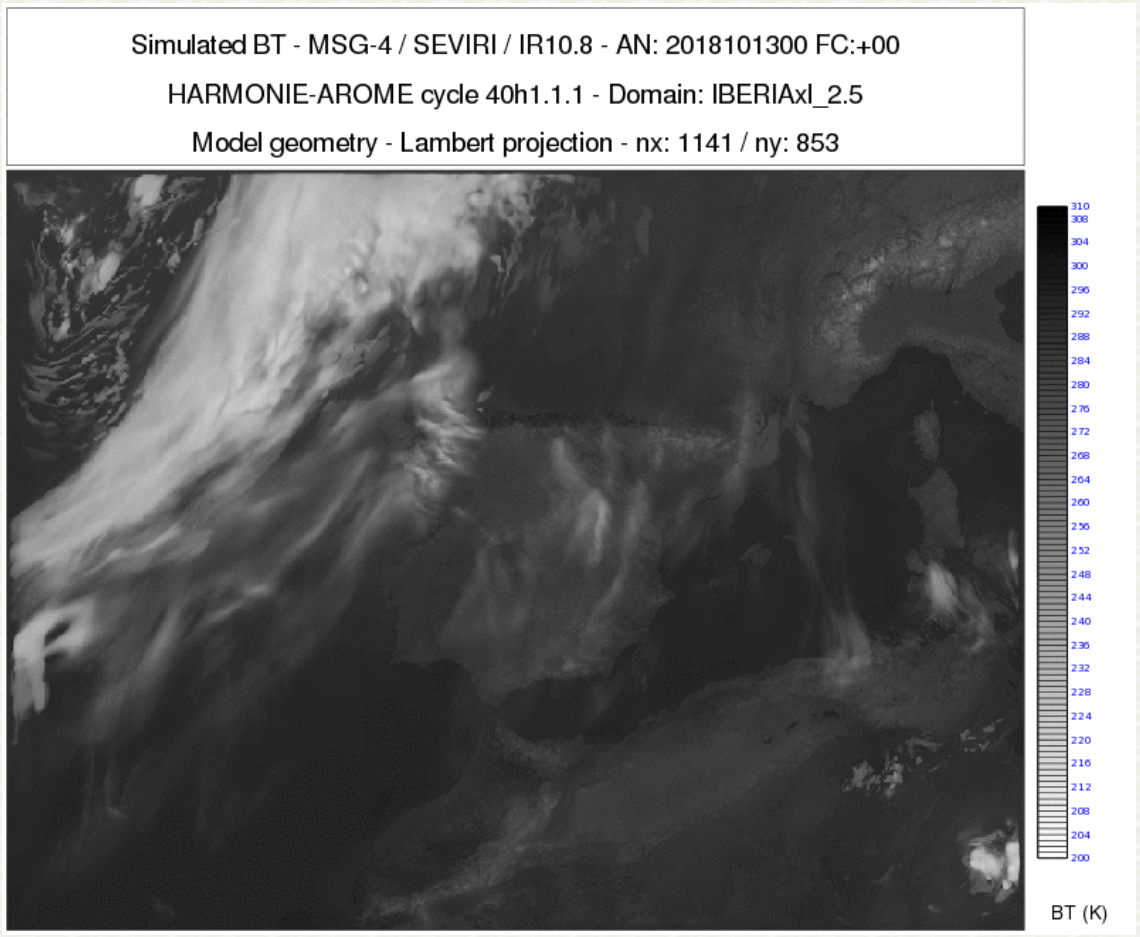
2. Motivation: why HA simulated imagery?

- ECMWF HRES: MSG4 SEVIRI simulated radiances (global) ops.
- Horizontal resolution of HA similar to current geo sats:
  - MSG SEVIRI: 3km at the SSP.
  - ECMWF HRES: current is 9 km (nominal).
  - HARMONIE-AROME: current default is 2.5 km (nominal).
  - Also possible to generate SI from any HA experiments, including sub-km resolution.
- Temporal frequency in the FC loop:
  - 1 hour in HA (or more frequent) vs 3 hour in ECMWF.

2. Motivation: why HA simulated imagery?

- Deep convection:
  - HARMONIE-AROME: convection-permitting.
  - ECMWF: not explicitly represented (it is parameterized).
- ECMWF HRES is global & medium-range.
- SSI from ECMWF HRES & HARMONIE-AROME are complementary
  - as the NWP models they come from.

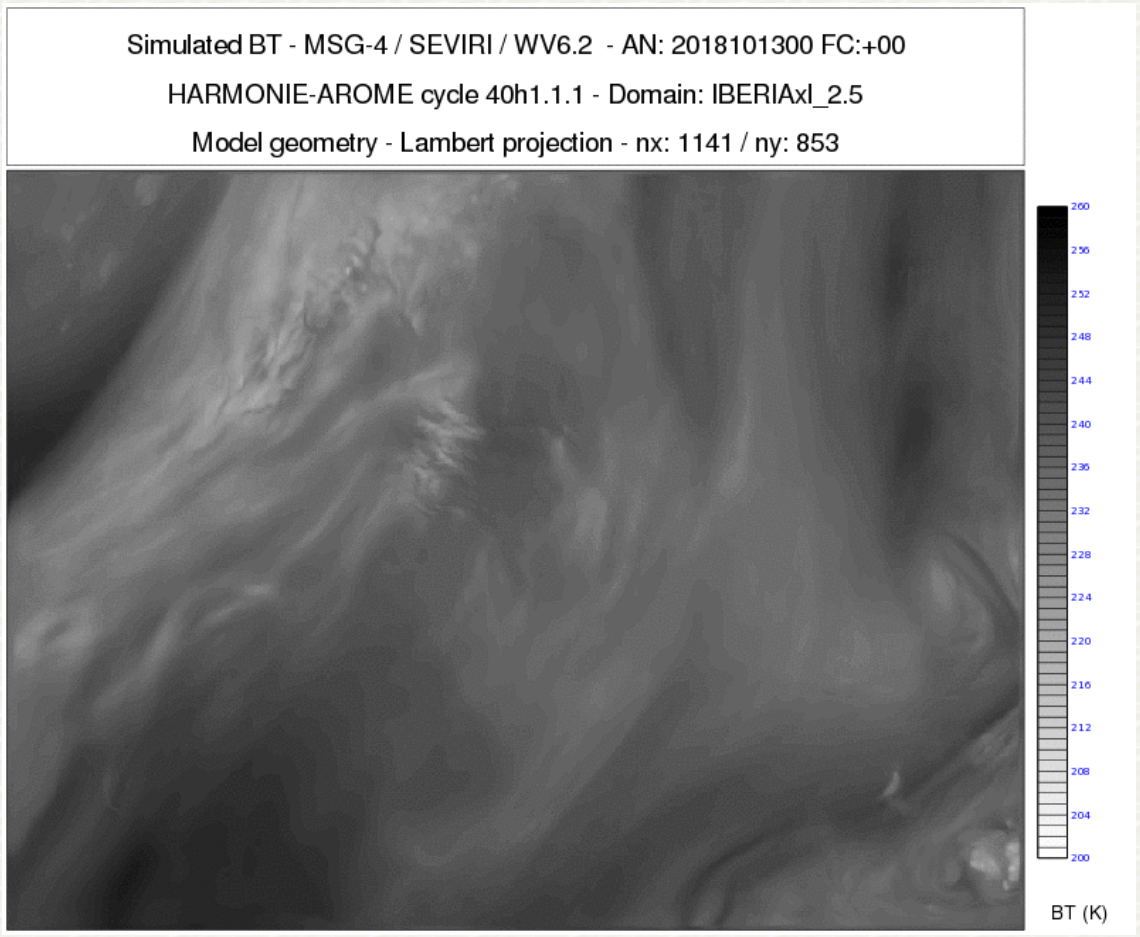
2. Motivation: why HA simulated imagery?



Cyclone Leslie

- MSG4 IR10.8.
- Model geometry.
- AN: 20181013 00
- HH+00, 01, …, 36

2. Motivation: why HA simulated imagery?



Cyclone Leslie

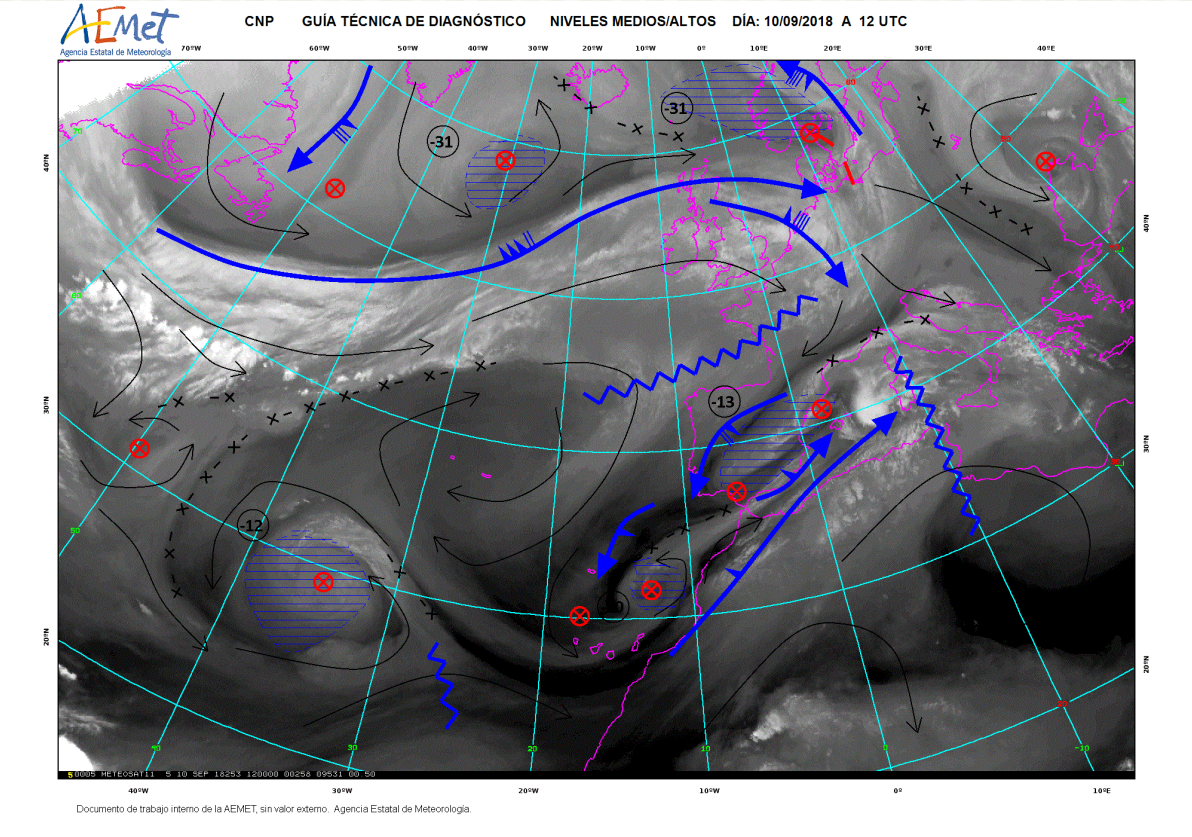
- MSG4 WV6.2.
- Model geometry.
- AN: 20181013 00
- HH+00, 01, …, 36

3.1. HALSSI applications in weather forecasting.

- Intuitive summary of a forecast – e.g. Leslie loops.
- MSG SEVIRI images:
  - IR10.8 window: clouds.
  - WV6.2 and WV7.3: summary of middle and upper tropospheric dynamics.
- Case studies.
- Sidetrack - so this was a tropical cyclone in a HIRLAM domain:
  - How well was it located and represented?
  - Would we need a larger domain for case studies?

3.1. HALSSI applications in weather forecasting.

- Experts in interpretation of satellite images can provide a very valuable feedback.



Courtesy of
Olinda Carretero

3.1. HALSSI applications in weather forecasting.

- NRT assessment of the AN and first few hours in the FC loop:
  - Comparison with observed Meteosat-11 imagery.

- Sidetrack: what about the spin-up?
  - What is the spin-up for simulated radiances?
  - I.e. from which step in the FC loop can we use truly use the SI?
  - Would an initialization help?

3.2. HALSSI in satellite product development.

- It is feasible to generate SSI for the next generation of European geostationary satellites:
  - HALSSI could help in preparations for future MTG-I (launch 2021?) with SI for the instrument FCI, e.g. channels IR10.5 / WV6.3.

- AMV studies from SSI.
  - In general for any satellite retrievals.

3.3. HALSSI applications in NWP.

- SI - intuitive summary of a FC (as in weather forecasting).
  - E.g. in case studies.
- SI can help assess the quality of a cycle, specific aspects,
  - Mainly related to clouds, but also dynamics – e.g. jet location.
- Paves the way for objective comparison between simulated and observed SI:
  - Radiance / BT frequency distributions.
  - Effective horizontal resolutions.

3.3. HALSSI applications in NWP.

- Objective comparison between SSI and observed SI - several groups of metrics available for stats:
  - Pixel to pixel comparison statistics, e.g. MAE = Mean Absolute Error.
  - Neighbourhood-based statistics, e.g. FSS = Fractions Skill Score (Roberts and Lean, 2008).
  - Object-based statistics, e.g. MODE (Davis et al. 2006).
- Each metric type has different strengths:
  - Is it easy to implement?
  - Is it sensitive to spatial errors?
  - Is it possible to compare shapes?
- Perhaps the best choice depends on channel / feature type?
  - Semantic segmentation? How?

4. Future work.

- First, HALSSI v1 as part of HA cycle 43h2.X, experimental.
- HALSSI validation study – effective resolution, spin-up, …
  - Essentially to become aware of the limitations.
- Improvements / extensions:
  - Optimization – SI is computationally expensive.
  - Satellite geometry (gridpoint to pixel: nearest neighbour, average).
  - Extension at other SEVIRI channels.
- Continue collaboration with experts in the interpretation of satellite images.
- Evolution shaped by user´s feedback - and management decisions.

Thank you for your attention

Any questions?

Alternatively:

- Contact me during coffee breaks.
- Or email ahernandezc@aemet.es

Acronyms

- BT - Brightness Temperature.
- FCI – Flexible Combined Imager (instrument on MTG satellites).
- HA – HARMONIE-AROME
- HAL – HAROMINE-AROME LAM
- IR – Infra-Red.
- MSG - Meteosat Second Generation. MSG4 = Meteosat-11 = current EUMETSAT geo. sat. at 0 lon.
- MTG-I – Meteosat Third Generation Imager
- RT - Radiative Transfer.
- RTTOV - Radiative transfer model (Radiative Transfer for TOVS, originally).
- SEVIRI - Spinning Enhanced Visible and Infrared Imager (instrument on MSG satellites).
- SI – Simulated Imagery
- SSI – Simulated Satellite Imagery
- SSP – Sub-Satellite point.
- ToA - Top of Atmosphere.
- WV – Water Vapour.

References

- Bengtsson et al. (2017). The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System. Mon. Wea. Rev., 145, 1919-1935.
- Davis et al. (2006). Object-based verification of precipitation forecasts. Part I: Methodology and application to mesoscale rain areas. Mon. Wea. Rev., 134, 1772-1784.
- Hocking et al. (2018). RTTOV v12 Users Guide. Available from www.nwpsaf.eu.
- Roberts and Lean (2008). Scale-selective verification of rainfall accumulations from high-resolution forecasts of convective events. Mon. Wea. Rev., 136, 78-97.