Status of the assimilation of cloudy and rainy microwave observations in the Météo-France global NWP model

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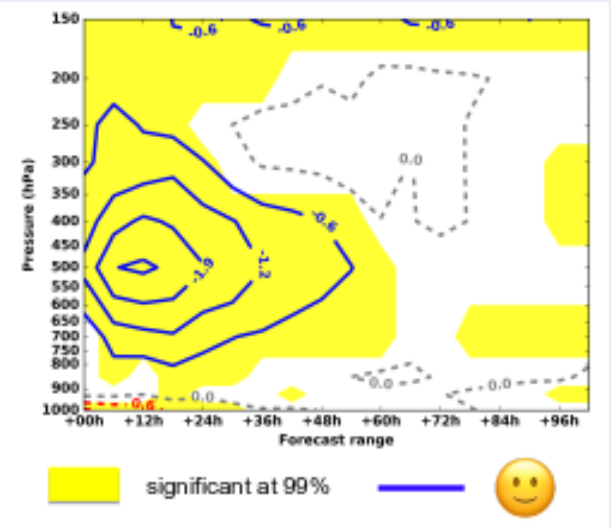
Image : NASA/ESA

The assimilation of microwave observations in the Météo-France global model ARPEGE

- Currently only assimilated in clear-sky conditions.
- Duruisseau et al. (2019) showed the benefit brought by the assimilation of SAPHIR observations in cloudy and rainy areas.
- Allsky assimilation already operational in many NWP centres.



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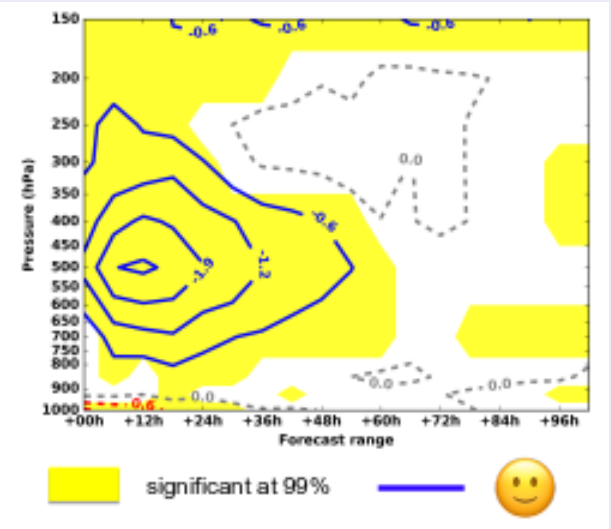


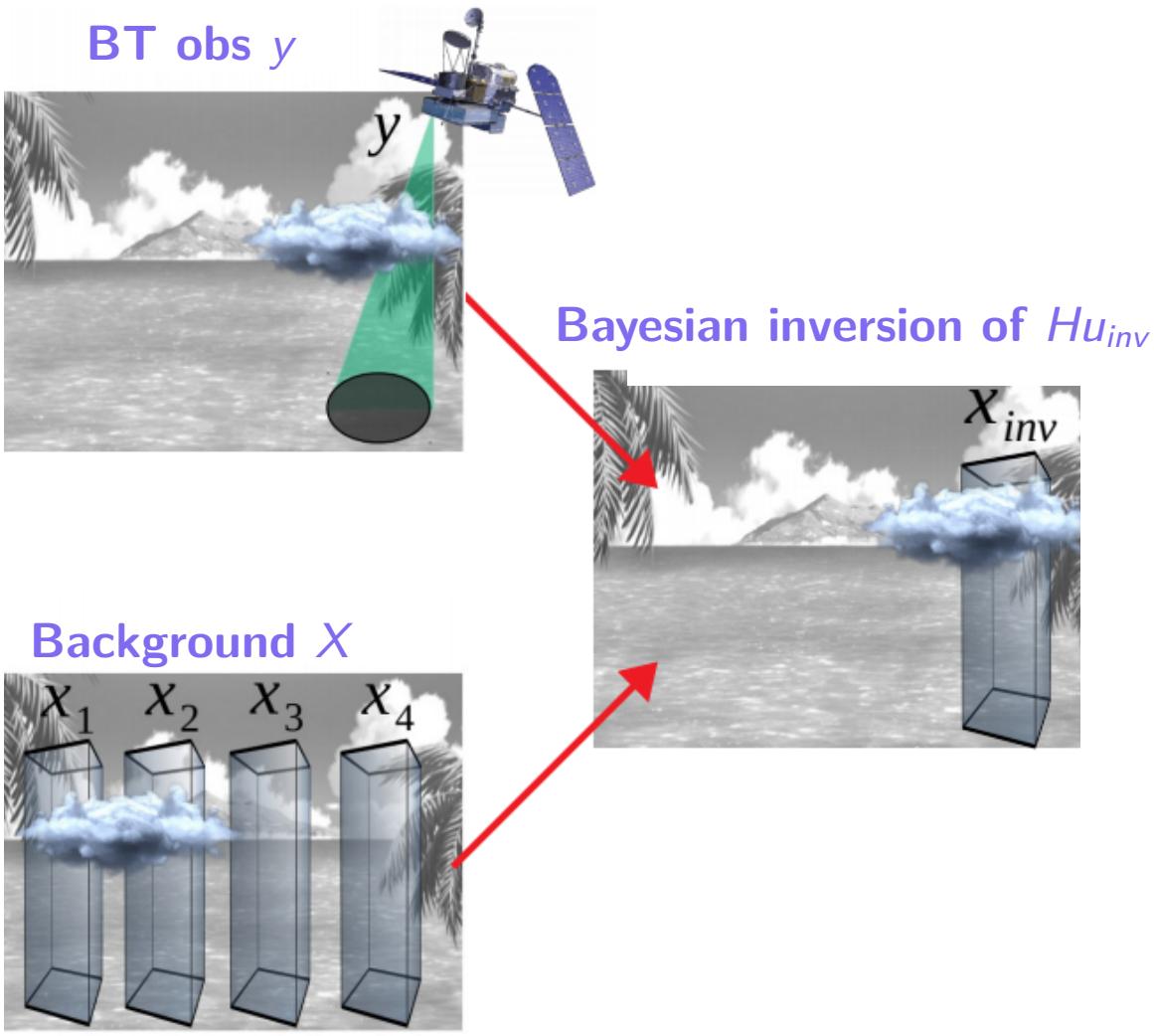
MHS and ATMS are assimilated in the 2021 parallel suite of ARPEGE

- 1D Bayesian + 4DVar assimilation framework
- **ATMS** for channels at 165.5 GHz,183.31±7 GHz and 183.31± 4.1 GHz.
- **MHS** for channels at 157 GHz, 190.31 GHz and 183.31±3 GHz.

Outline

1. 1D + 4DVar cloudy and rainy assimilation framework
2. Impacts of assimilating MHS and ATMS in cloudy and rainy areas over a 5-month period from 09/10/2020 to 02/22/2021
3. On-going research activities

First step : 1D Bayesian retrieval of humidity pseudo-observations Hu_{inv}



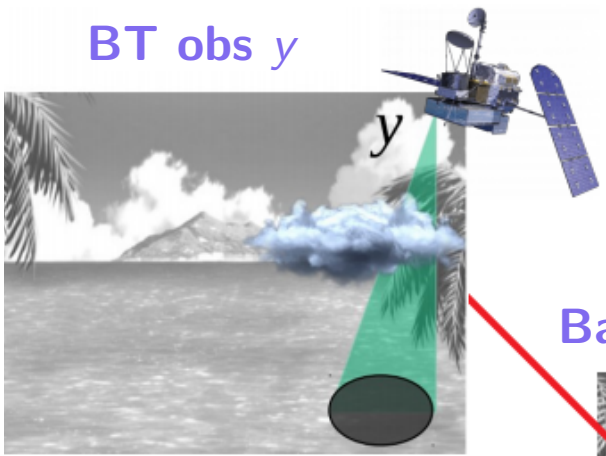
$$Hu_{inv} = \sum_i x_i^{Hu} \frac{W_i}{\sum_j W_j}$$

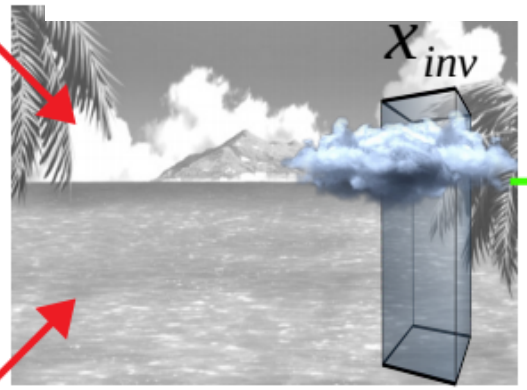
$$W_i = \exp\left(-\frac{1}{2}\frac{||y - H(x_i)||^2}{\sigma_o^2}\right)$$

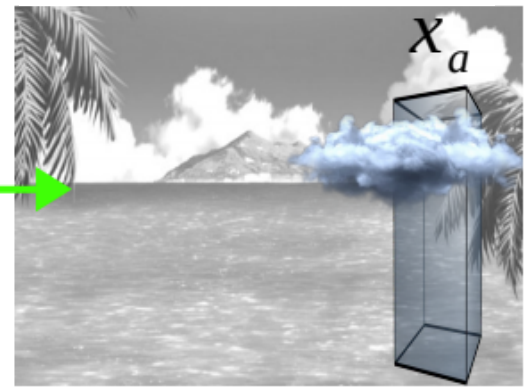
with :

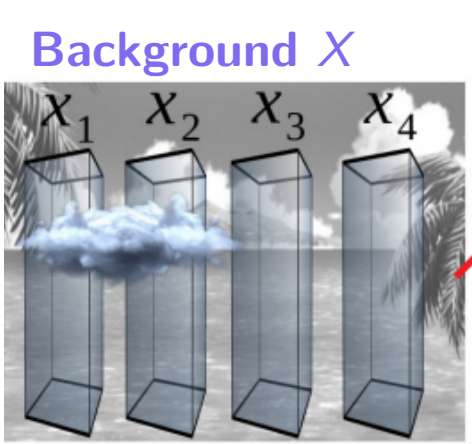
- $\sigma_0 = 1$ K
- H : observation operator rttov-scatt

Second step : 4DVar assimilation of humidity pseudo-observations Hu_{inv}





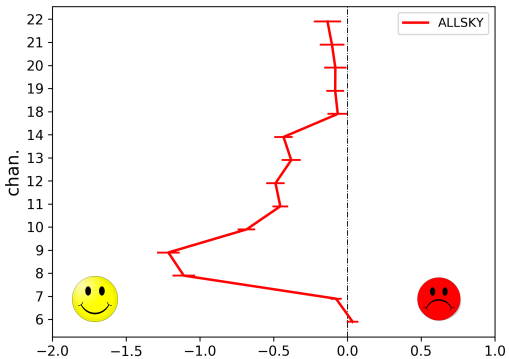




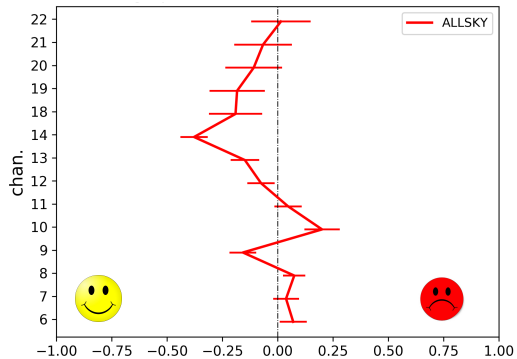
- $\sigma_0 = 20\%$
- Only over ocean

Comparisons against other assimilated observations

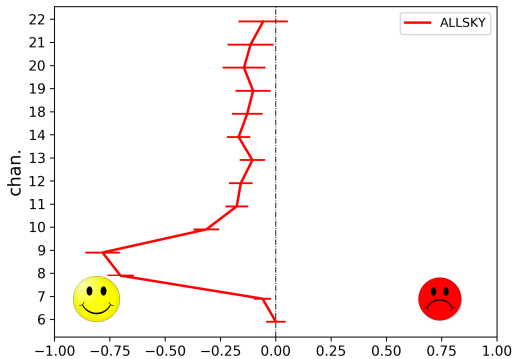
ATMS - N. Hemis



ATMS - TROPICS



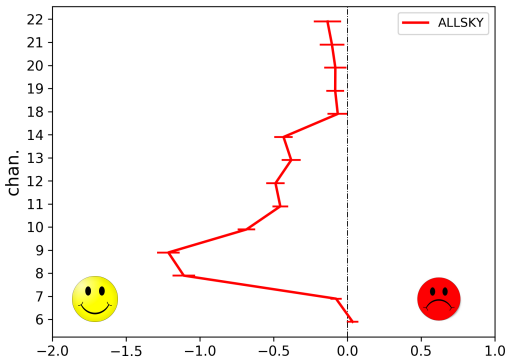
ATMS - S. Hemis



- Positive synergy between clear sky and cloudy assimilation (same for MHS).
- Positive impact on ATMS temperature channels.

Comparisons against other assimilated observations

ATMS - N. Hemis



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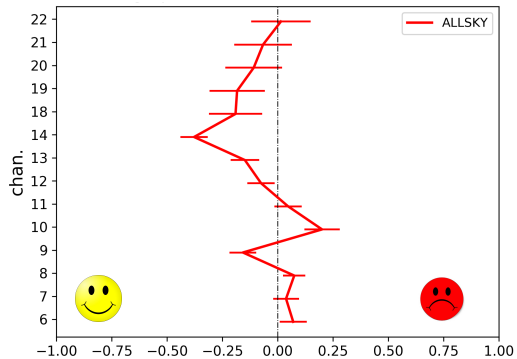
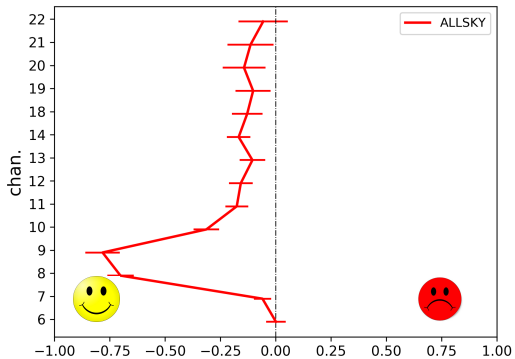


ATMS - S. Hemis



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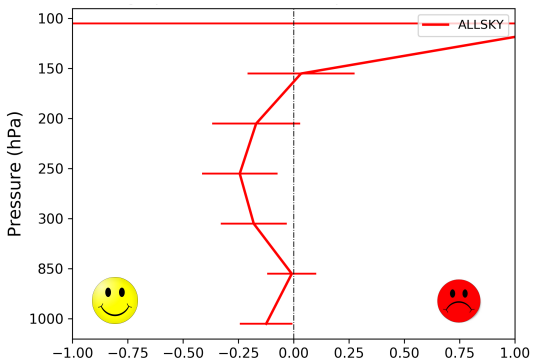
SATOB V - N. Midlat



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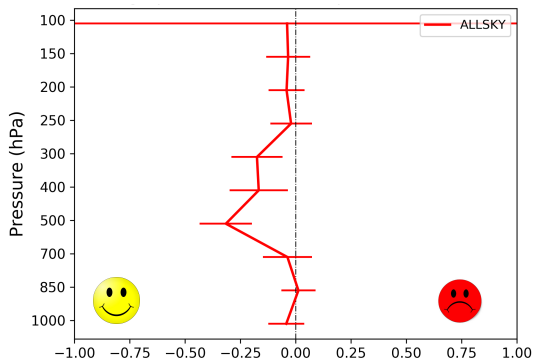

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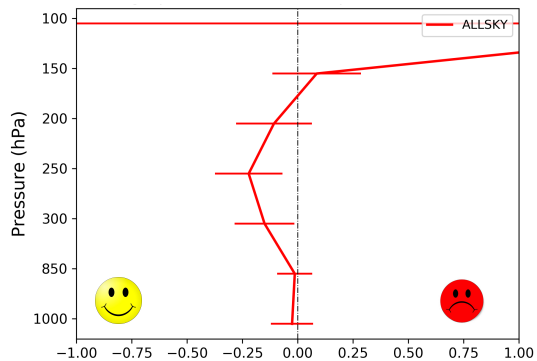
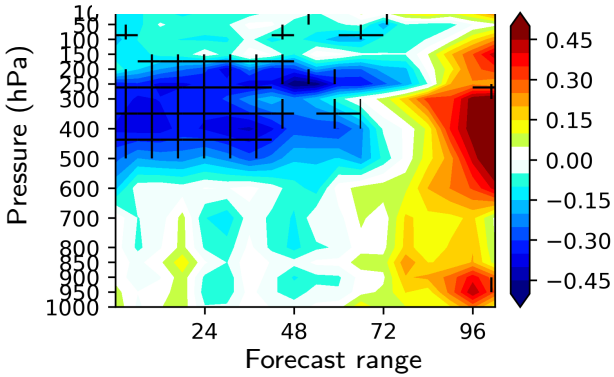


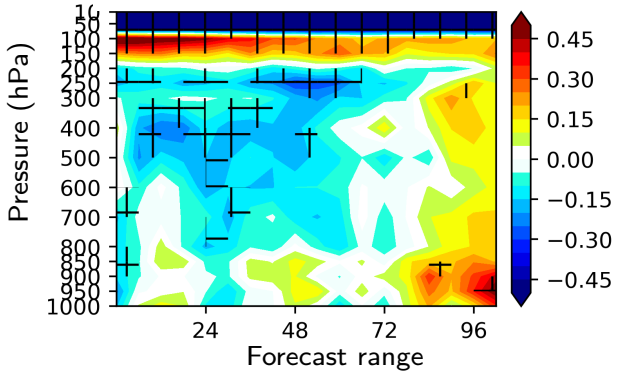
- Neutral to positive impact on the wind field (tracing effect of the 4DVar).

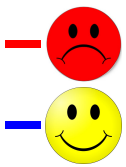
Global relative difference of standard deviation errors against ECMWF analysis

Temperature forecasts

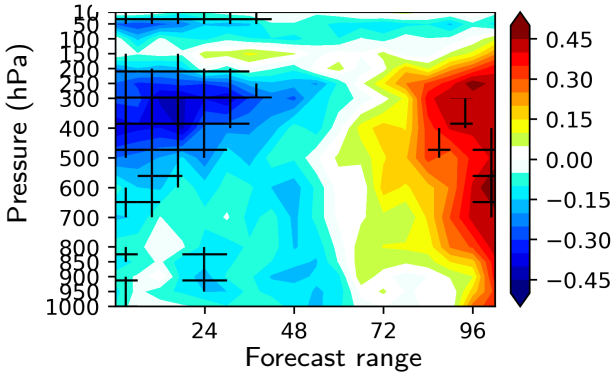


Humidity forecasts

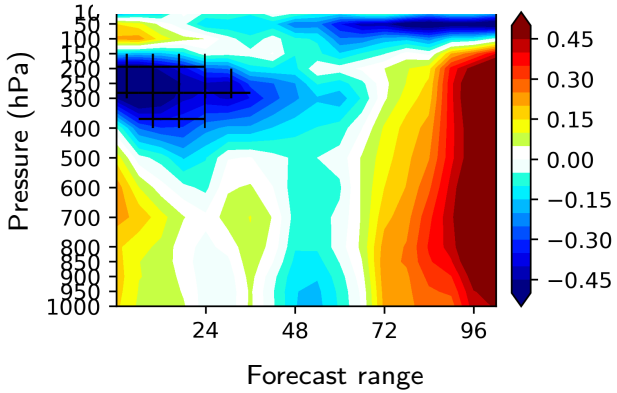




Wind forecasts



Geopotential forecasts

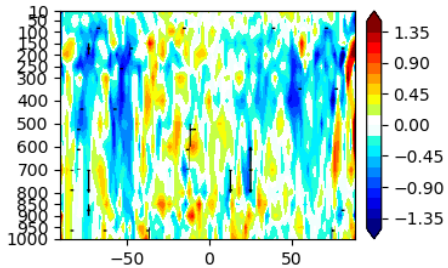


- Global significant positive impact for forecast ranges $\leq +$ 72 h, some degradations above at +72h to be investigated.

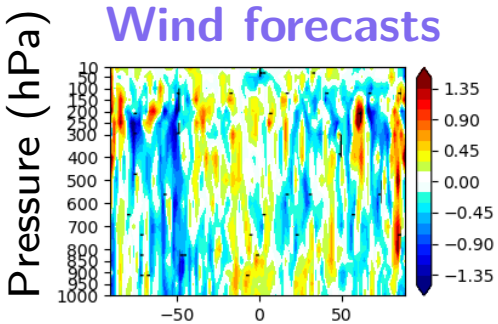
Zonal impacts at different forecast ranges against ECMWF analysis

at +48h

Temperature forecasts



Wind forecasts



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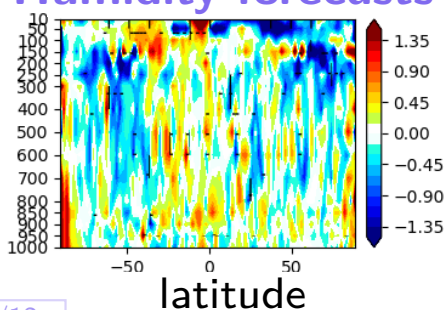
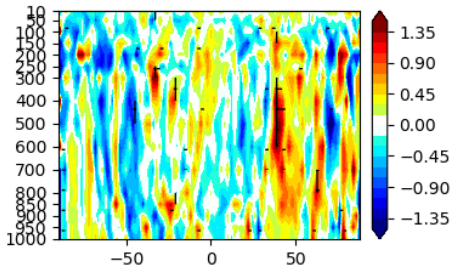


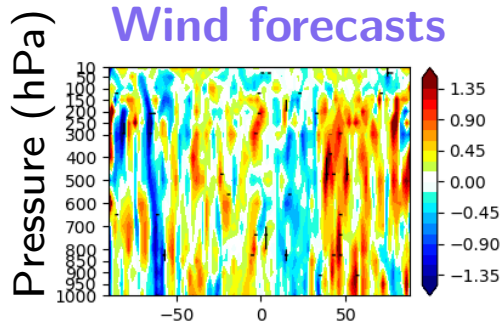
- Positive impact in the mid latitudes, especially in the S. Hemis.
- Neutral in the tropics.
- Negative impact in the N. Hemis at +72h

at +72h

Temperature forecasts



Wind forecasts



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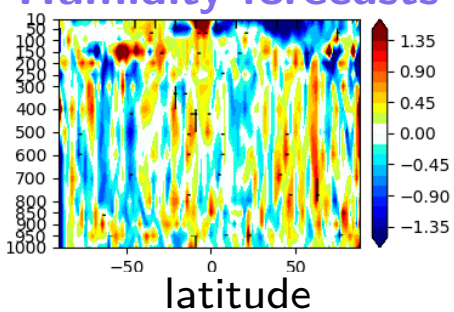
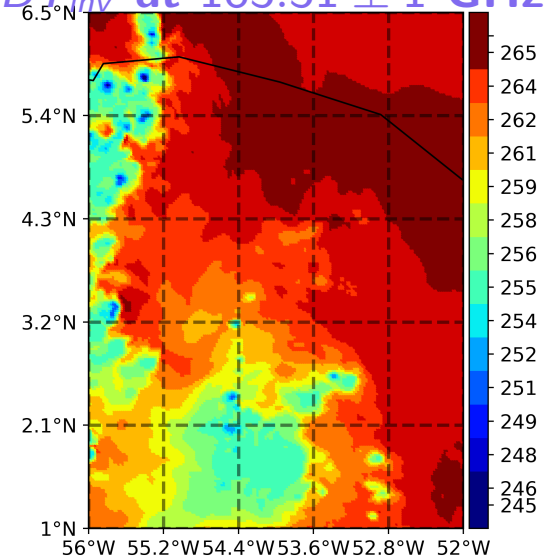


A dynamic method based on weighting function calculations to better localize the impacts

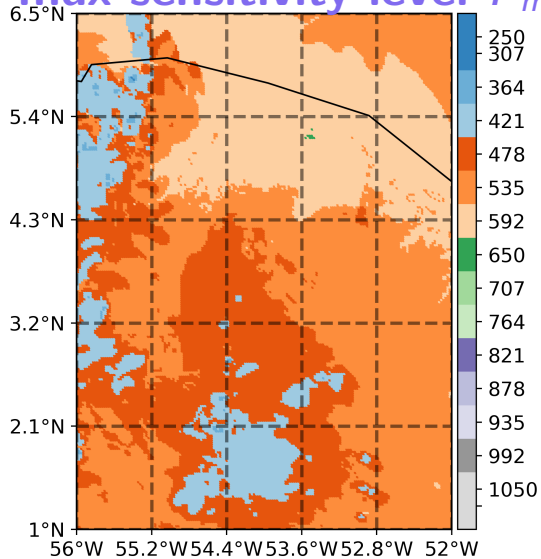
- **Current static method** : the retrieved humidity pseudo-observations Hu_{inv} are assimilated in the 4DVar at fixed pressure levels (400, 500 and 600 hPa) for all meteorological situations.
- **Dynamic selection :** Hu^{PO} are assimilated where the weighting function is max.

BT_{inv} **at** 183.31 ± 1 **GHz**



For each PO
$P_{max} = argmax(\frac{\partial \tau}{\partial z})$

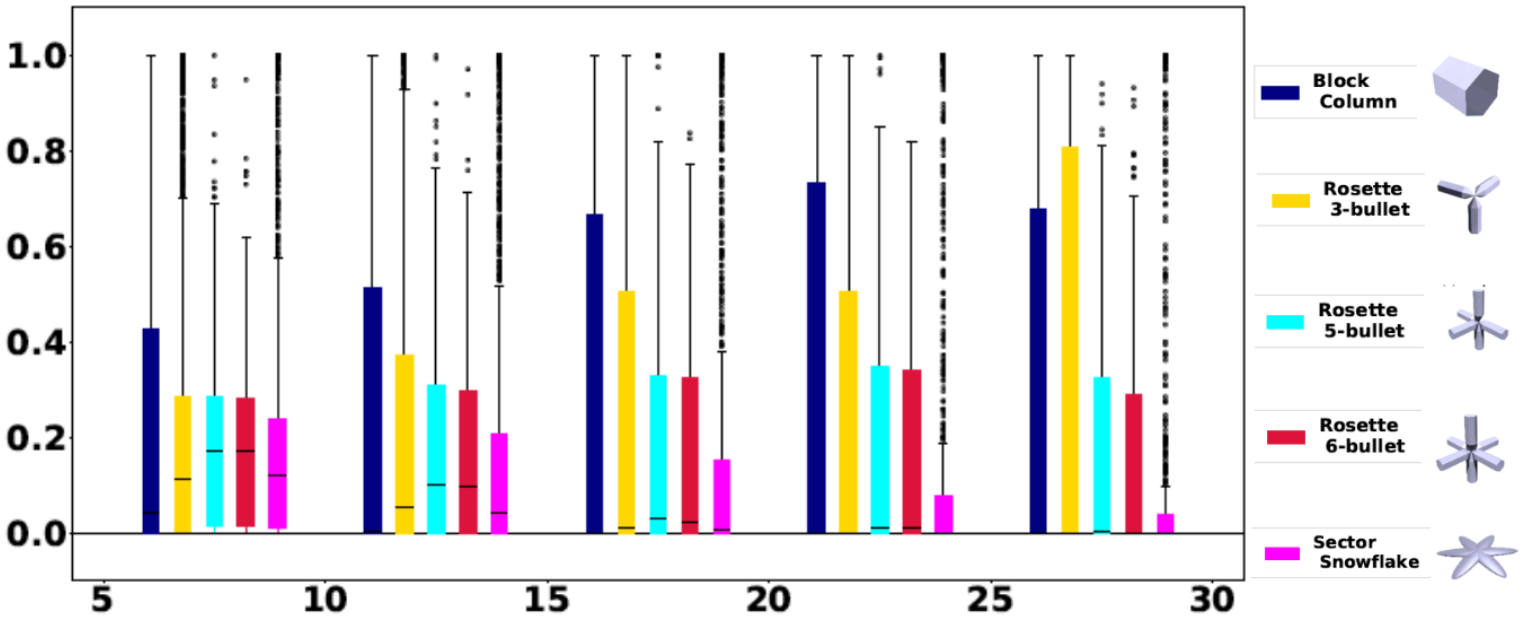
Press. of max sensitivity level P_{max}



- DA experiments over a 5-month period indicate a neutral impact with MHS/ATMS ;
- Larger impact expected with GMI observations.

Adapt the radiative properties to the current meteorological situation

Weight of each particle within the Bayesian inversion



Index characterizing the diffusion of the meteorological situation

- Observations : GMI ;
- Background : AROME-OM in the caribbean ;
- Period : 2 months.

Conclusions and perspectives

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- Assimilation of ATMS and MHS observations activated in the 2021 ARPEGE parallel suit.
- Significant positive impact for forecast ranges $\leq +$ 72 h.

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Short term perspectives

- Include more microwave instruments, including imagers ;
- Dynamic levels selection ;
- Multiple microphysical assumptions within the inversion.

Long term perspectives

- Direct assimilation within 4D-EnVar.

Thank you for your attention

Image : NASA/ESA