Perturbations of all-sky microwave radiances forward operator specifications within the Ensemble of Data Assimilation system of Météo-France

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Motivation

Assimilation of microwave radiances in the global NWP models of Météo-France

→ Use of the direct allsky assimilation route of ECMWF (Geer et al. 2014) for MHS, MWHS-2, GMI and AMSR-2

→ Use of a single particle shape (e.g. sector snowflake, Liu 2018) for all meteorological situations and geographical areas

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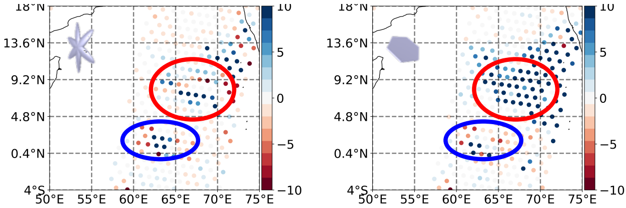
Example of first-guess departure for MHS (channel 5) using two different particle shapes :



→ Larger first guess departure

→ Smaller first guess departure

→ Large single scattering property uncertainties

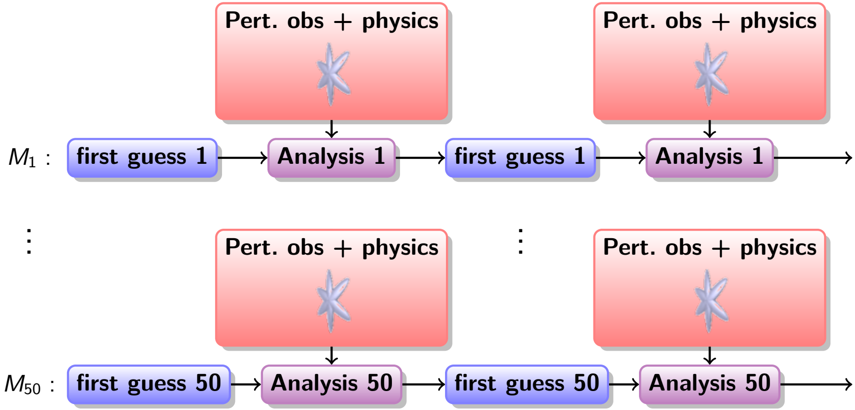
How to account for single scattering property uncertainties in an Ensemble of Data Assimilation (EDA) system ?

- $\rightarrow$ Take into account these uncertainties in a coupled "EDA $\rightleftharpoons$ deterministic model".
- $\rightarrow$ Add perturbations into the EDA, which is known to be under-dispersive.
- $\rightarrow$ *Work initiated by Barreyat (2021) with GMI only, extended here to the full constellation.*

1. The experimental setup
2. Impact on the EDA spread
3. Impact on the deterministic model ARPEGE

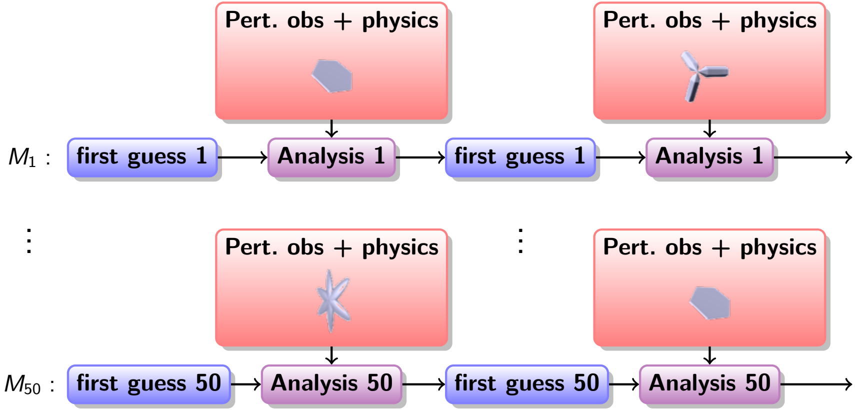
The Ensemble Data Assimilation system of Météo-France (AEARP)

- Ensemble of **50 members** running a **4D-Var at 100 km**.
- Provide flow-dependent background error matrix for the deterministic model
- SSPs specified using the Sector Snowflakes assumption of the Liu (2008) database



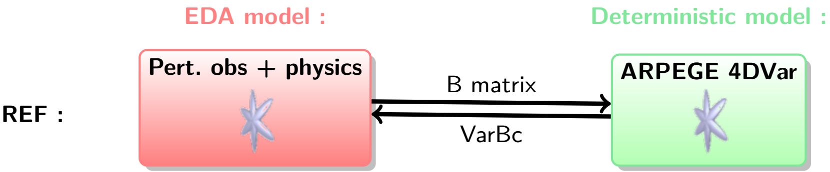
Perturbation of microwave radiances forward operator assumptions in the AEARP

PertH : **Random selection** of the single scattering properties **for snow** in each member between Thin plate, Rosette 3-Bullet and Sector Snowflakes



Experimental setup

Two fully coupled experiments "EDA $\rightleftharpoons$ deterministic model" in which only the EDA is changed



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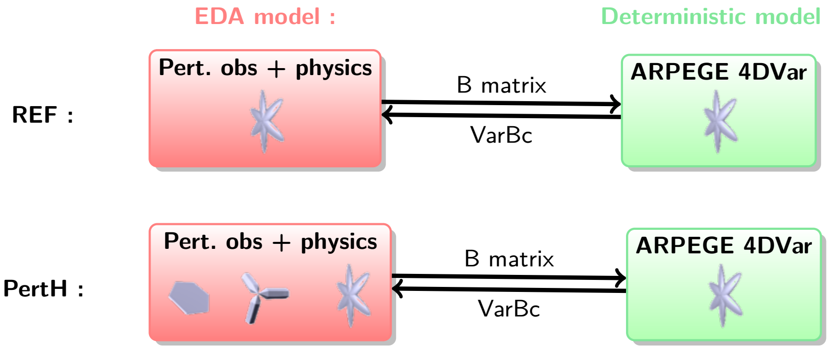
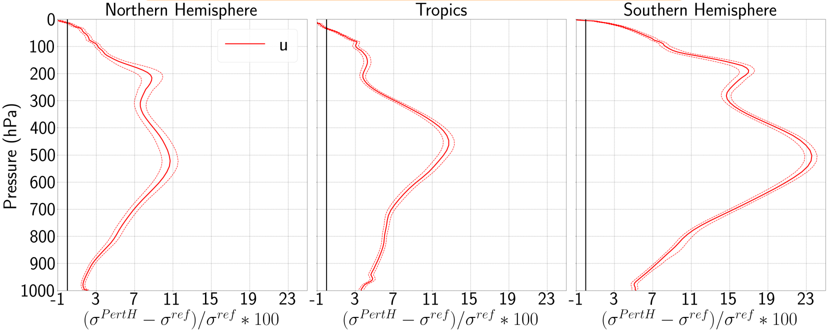


→ Period of study : 2-month period from 1st of January 2023 - 4rd of March 2023

Impact of *pertH* on the EDA spread

$$\text{spread ratio } I = \frac{\sigma_{ens}^{PertH} - \sigma_{ens}^{REF}}{\sigma_{ens}^{REF}} \text{ (2-month period)}$$



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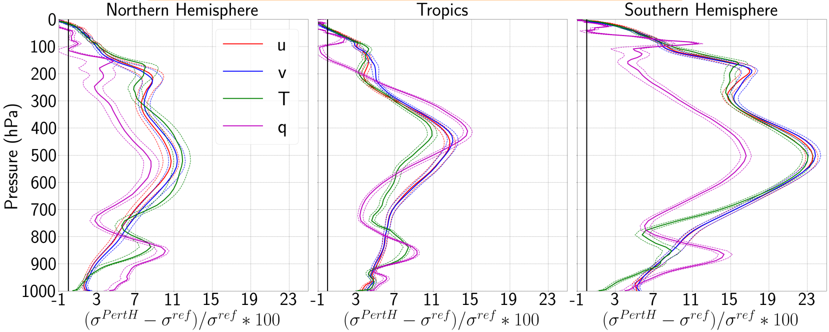

- PertH allows to increase the EDA spread by ≈ 15 % in the Southern hemisphere on the humidity field and by ≈ 23 % on the other variables.
- Larger impact in the southern hemisphere, then in the Tropics, and finally in the northern hemisphere.

Impact on the deterministic model ARPEGE : short range assimilation impact (+6h)

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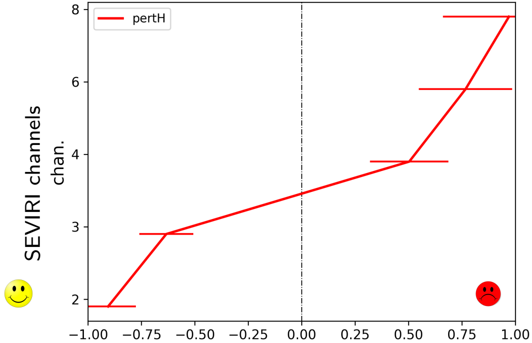
Relative Differences of the standard deviation of first guess departures : **SEVIRI**



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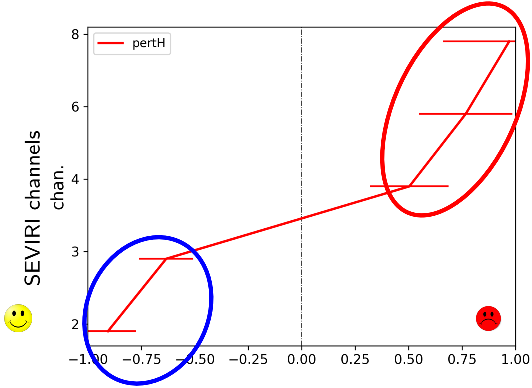


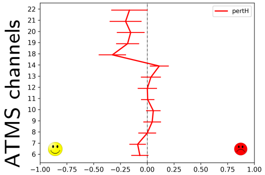
→ Degradation of the fit to temperature channels

→ Improvement of the fit to water vapour channels

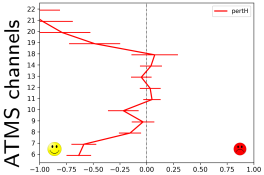
Impact on the deterministic model ARPEGE : short range assimilation impact (+6h)

Relative Differences of the standard deviation of first guess departures : **ATMS**

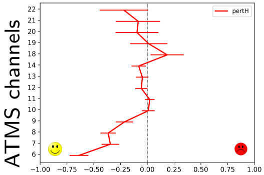
NORTH20



TROPICS



SOUTH20



→ Positive impact on humidity channels

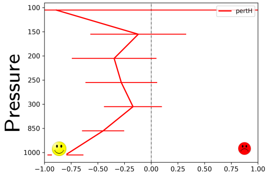
→ Positive impact on the temperature and humidity channels

→ Positive impact on the temperature channels

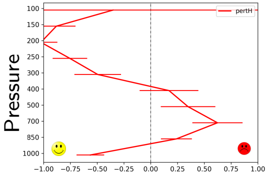
Impact on the deterministic model ARPEGE : short range assimilation impact (+6h)

Relative Differences of the standard deviation of first guess departures : **AMVs**

NORTH20



TROPICS



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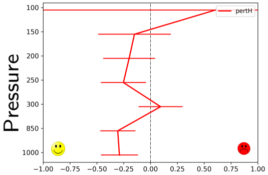


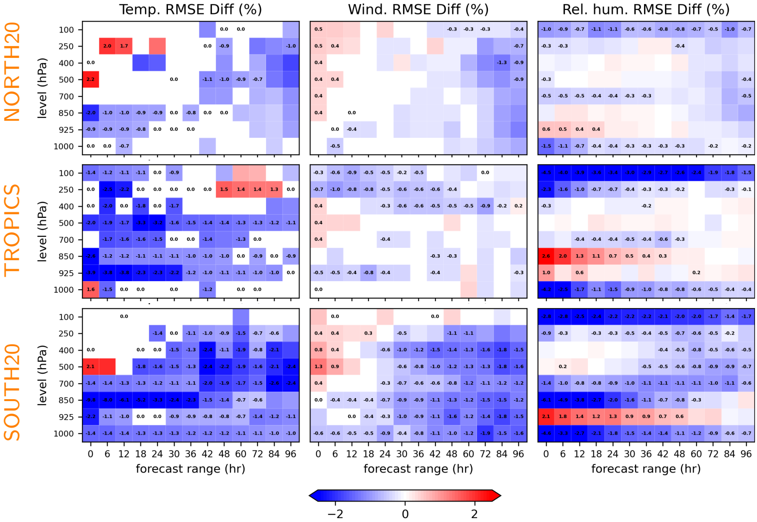
→ Neutral to positive impact in the lower atmosphere

→ Negative impact at ≈ 700 hPa

→ Positive impact below ≈ 300 hPa

→ Neutral to positive impact in the lower atmosphere

Medium-range impact : comparisons against ECMWF analyses



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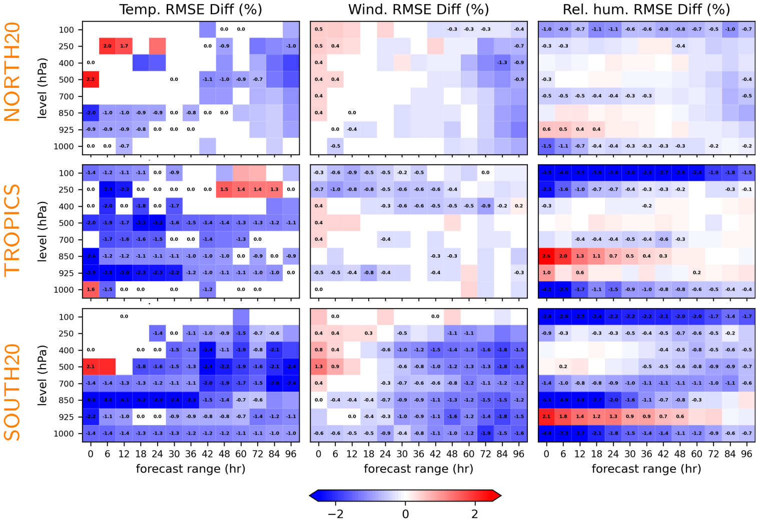

→ Negative impact on the humidity at ≈ 850 hPa

→ Larger impact in the southern hemisphere **up to 4 days ahead**

Conclusions and Perspectives

The perturbation of microwave radiances forward operator assumptions within the EDA system :

→ Allows to **increase the EDA spread.**

→ The comparisons against ATMS and AMVs observations indicate a neutral to a **beneficial impact on the +6h forecasts**.

→ The comparisons against ECMWF analyses indicate **beneficial impact on the medium range forecasts** (similar results against conventional observations)

→ ***PertH has been implemented in our current parallel suite (cy48t1op1)***

Perspectives :

- Apply similar perturbations on other microphysical parameters (e.g. rain PSD, etc..).
- Apply the same methodology to other observing system (on-going work with GNSS-RO forward operator).
- Apply the similar perturbations within the EDA system of the km-scale NWP model AROME.