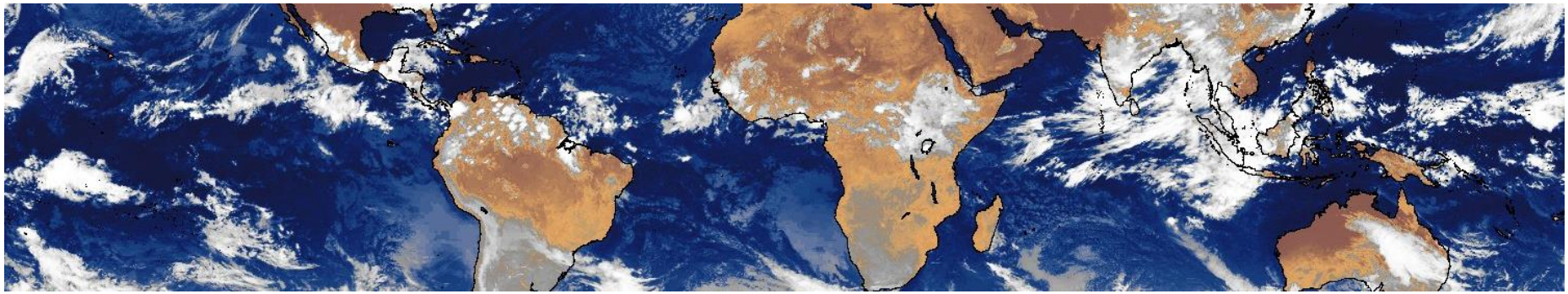
Tropical modelling activities at Météo-France and potential applications of TROPICS data



(Source: satmos.meteo.fr)

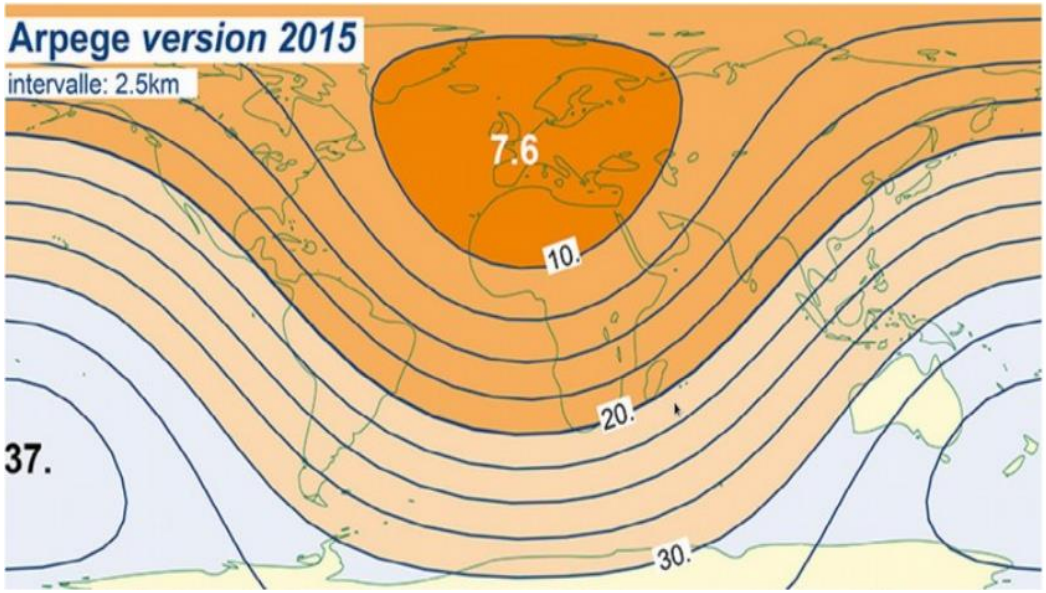
Philippe Chambon, Ghislain Faure and Fabrice Duruisseau

CNRM, Météo-France & CNRS, Toulouse

Numerical Weather Prediction systems operational at Météo-France for tropical regions

Météo-France operates two different atmospheric models which provide forecast products in the Tropics:

- a global model called ARPEGE
- Stretched and tilted grid: 7.5km over Europe and 10 to 30km in the Tropics
- 4D-Var data assimilation system with 6h windows
- Ensemble-based background error co-variances
- Forecasts up to +102h



Numerical Weather Prediction systems operational at Météo-France for tropical regions

Météo-France operates two different atmospheric models which provide forecast products in the Tropics:

- a **non-hydrostatic** model called AROME

Over Western Europe	**Over 5 domains in the Tropics**
- 1.3km resolution/90 vertical levels - Lateral boundary conditions from ARPEGE - 3D-Var including ground radar reflectivities	- 2.5 km resolution / 90 vertical levels - Lateral boundary and initial conditions from the IFS model - Coupling with a 1D ocean model - 3D-Var in research mode

La Réunion – Météo-France
WMO Regional Specialized Meteorological Centre
for the South-West Indian Ocean

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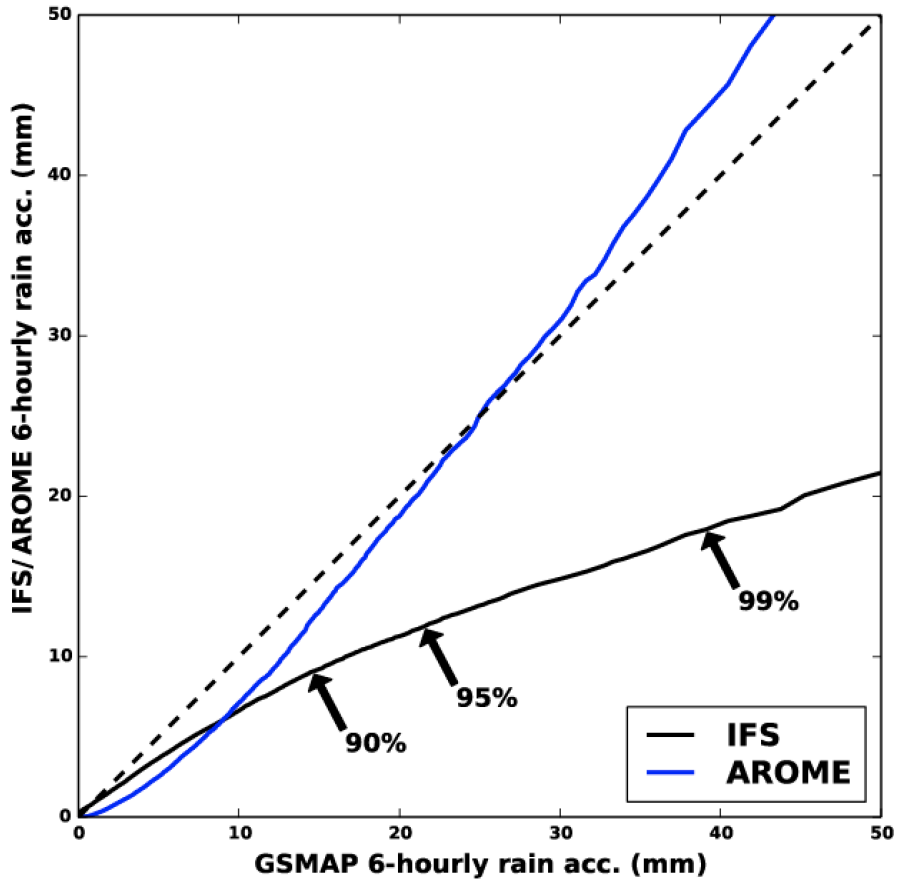
Examples of validation of AROME forecasts

Comparison of rainfall forecasts distributions with a satellite rainfall product over a 2-month period in the Pacific ocean (French Polynesia domain)

6-hour rainfall accumulations / +30h forecast range



=> Fine scale non-hydrostatic models have the capability to forecast strong rainfall accumulations, more in agreement with observations/retrievals

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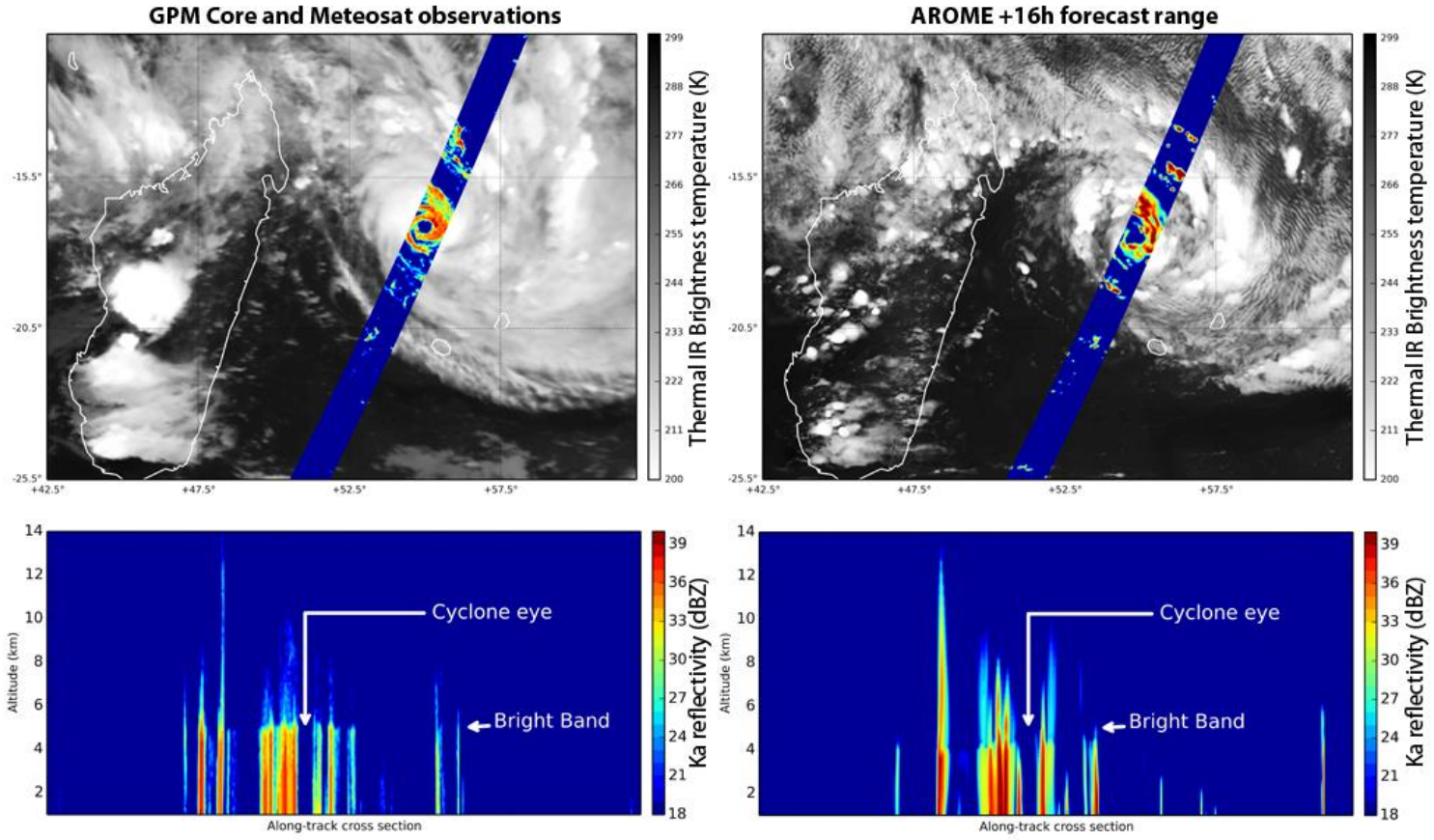
Examples of validation of AROME forecasts

Comparison of hydrometeor profiles from AROME forecasts
with GPM DPR observations

Hurricane Bansi, January 2015 - Ku band / AROME +16h forecast range

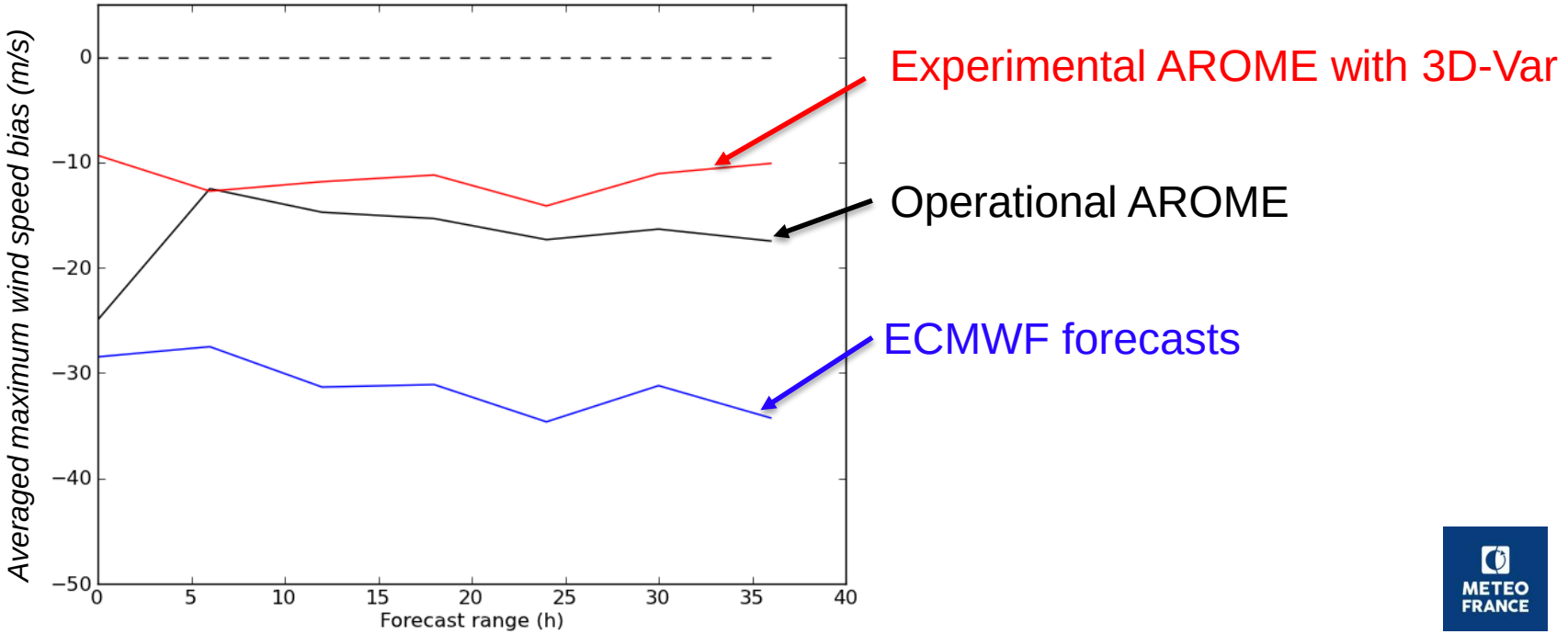


Behavior of AROME forecasts during the 2017 hurricane seasons over the Caribbean's

AROME provides information of a complementary nature to the IFS

- Forecast of hurricane's tracks not degraded with respect to the coupling model
- More realistic hurricane structures associated to stronger winds ; more realistic intensification

Averaged maximum wind speed bias for IRMA, JOSE and MARIA forecasts (~20 forecasts compared every 12 hours)



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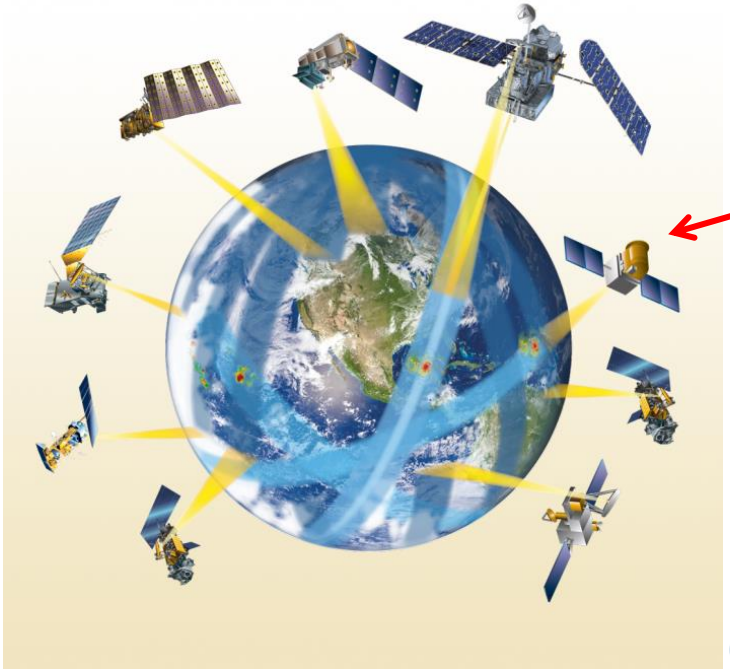
Ongoing research to improve these Tropical forecasts

Data assimilation project ongoing with the French Megha-Tropiques science team



(pmm.nasa.gov)

- Indo-French Mission built by ISRO and CNES launched in October 2011
- Dedicated to the monitoring of the water and energy cycle in the tropics
- Orbit with 20° inclination on the equator
- Nominal life: 3 years + 2 years extension up to end 2016

=> now extended from 2017 to 2021 (some overlap with TROPICS?)

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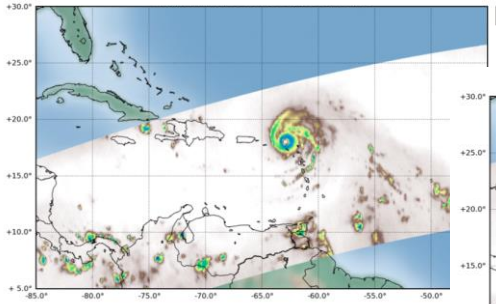
Ongoing research to improve these Tropical forecasts

In ARPEGE and AROME, microwave observations are assimilation in clear sky only in operations.

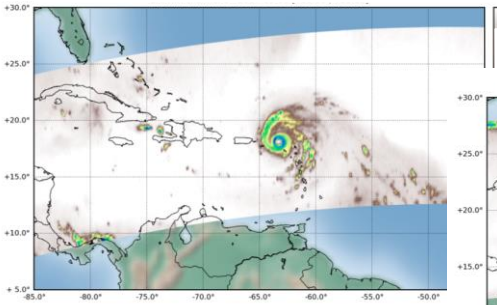
=>Project on data assimilation of SAPHIR observations in cloudy and rainy sky

Channel	Frequency	Bandwidth	Horizontal resolution
1	183.31 +/− 0.2 GHz	200 MHz	10km at nadir
2	183.31 +/− 1.1 GHz	350 MHz	10km at nadir
3	183.31 +/− 2.8 GHz	500 MHz	10km at nadir
4	183.31 +/− 4.2 GHz	700 MHz	10km at nadir
5	183.31 +/− 6.8 GHz	1200 MHz	10km at nadir
6	183.31 +/− 11 GHz	2000 MHz	10km at nadir

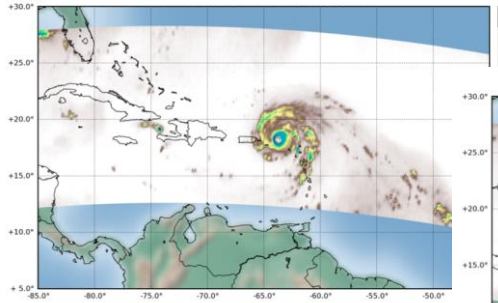
Ch6 - 9h10 to 9h23UTC



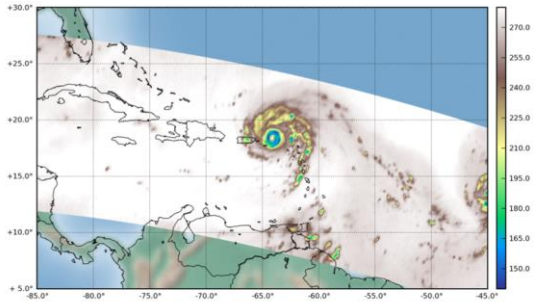
Ch6 - 11h00 to 11h12UTC



Ch6 - 12h50 to 13h02UTC



Ch6 - 14h39 to 14h52UTC



September 6th

Hurricane Irma

Ongoing research to improve these Tropical forecasts

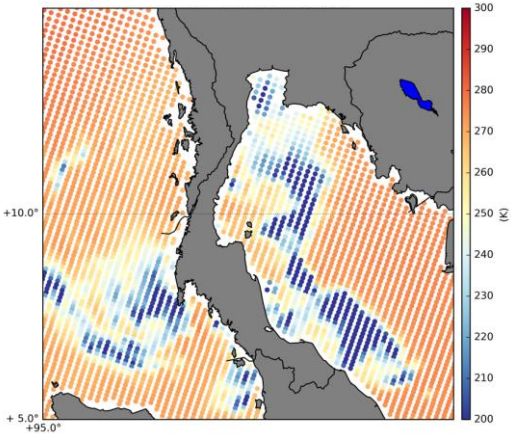
Data assimilation of SAPHIR observations in cloudy and rainy sky

Methodology: original 1D-Bayesian + 4D-Var framework which allow to:

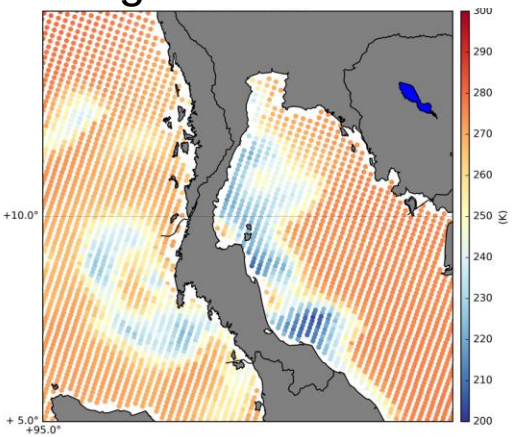
- Retrieve atmospheric profiles (RH, q, T, hydrometeors) and assimilate the retrievals (=> would benefit from 118GHz channels in addition to 183GHz)
- Can include some interesting features in the radiative transfer usage like multiple microphysical assumptions within the retrieval process
- Main idea: making use of the first guess in the neighborhood of an observations

20170108 r00h UTC

SAPHIR Ch.6



ARPEGE First Guess
using RTTOV SCATT



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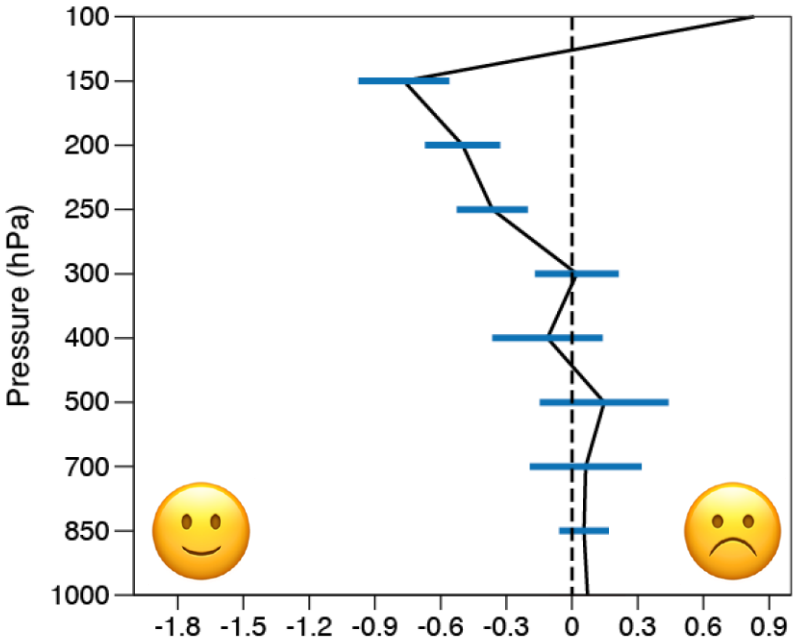
Ongoing research to improve these Tropical forecasts

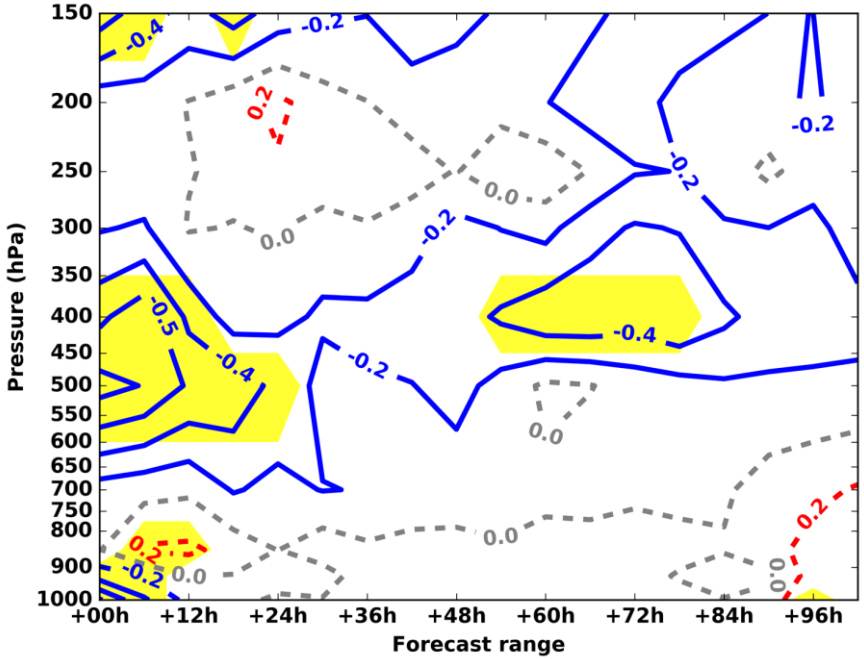
Impacts of assimilating SAPHIR in cloudy and rainy areas with the 1D-Bayesian + 4D-Var technique within ARPEGE over a 3-month period:

Score on 6h forecasts with SATOB geo winds as reference



Relative difference (%) of first guess fits to SATOB data in the Tropics

Relative difference of Std. Dev. on winds forecasts with respect to ECMWF analysis

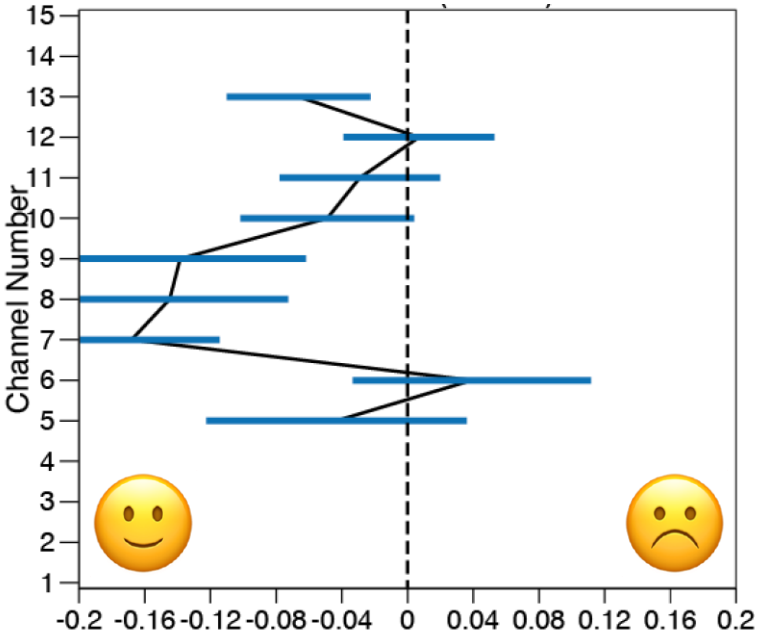


significant at 99%

Ongoing research to improve these Tropical forecasts

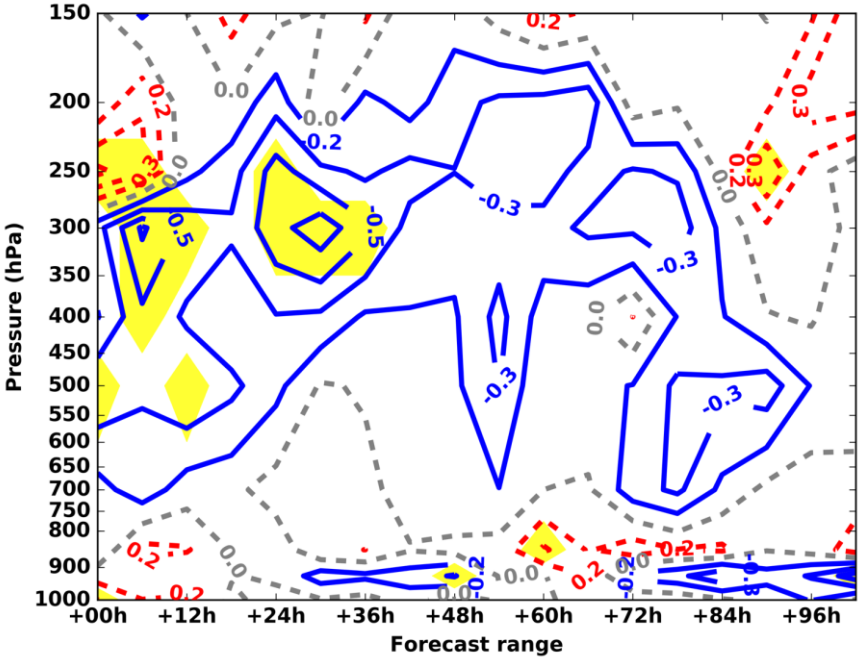
Impacts of assimilating SAPHIR in cloudy and rainy areas with the 1D-Bayesian + 4D-Var technique within ARPEGE over a 3-month period:

Score on 6h forecasts with AMSU-A NOAA15 as reference



Relative difference (%) of first guess fits to SATOB data in the Tropics

Relative diff. of Std. Dev. on T forecasts errors with respect to ECMWF analysis



significant at 99%

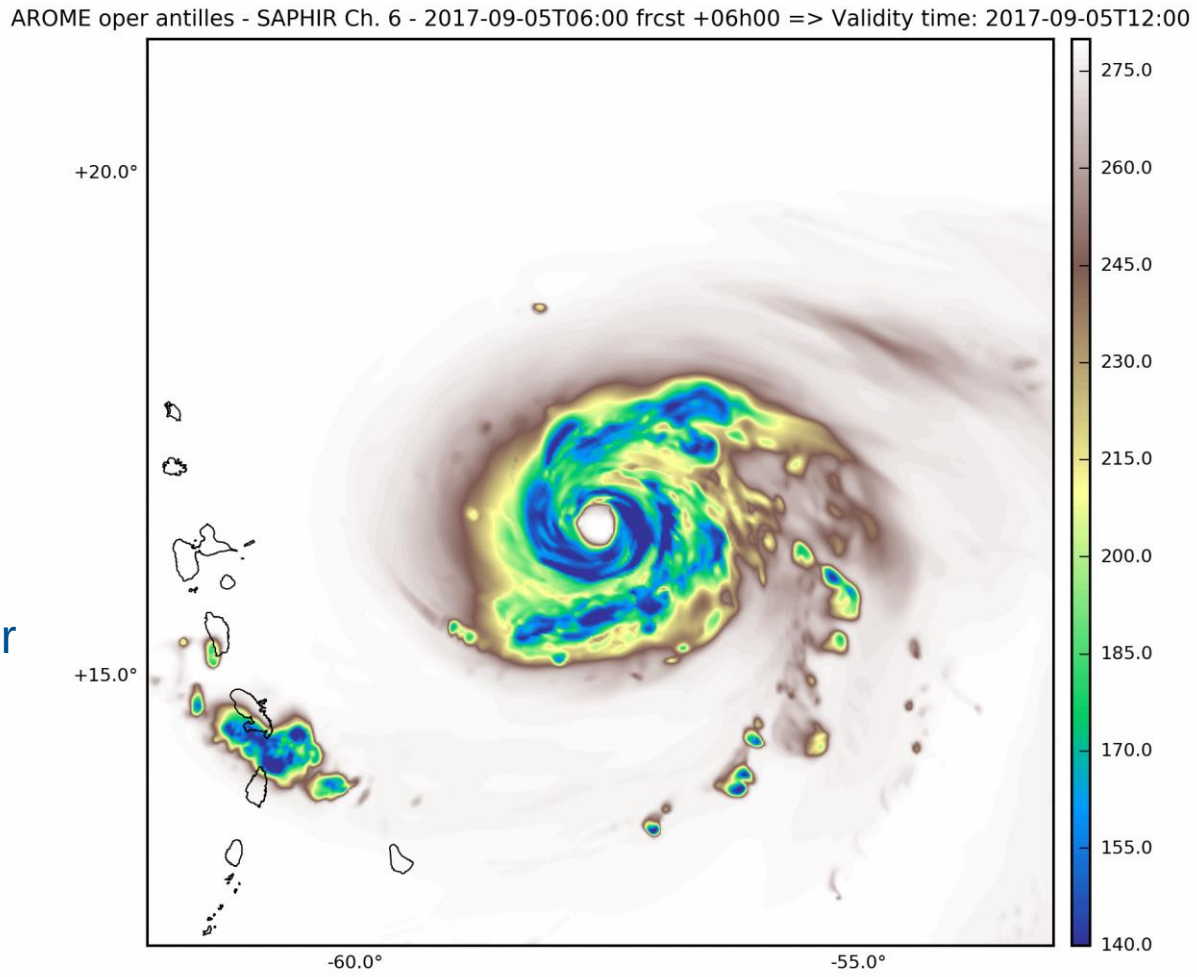
Ongoing research to improve these Tropical forecasts

First tests of this framework ongoing on the hurricane forecasts which occurred in September 2017 in the Caribbean's

Hurricane Irma

AROME forecast initialized on September 5th at 06hUTC

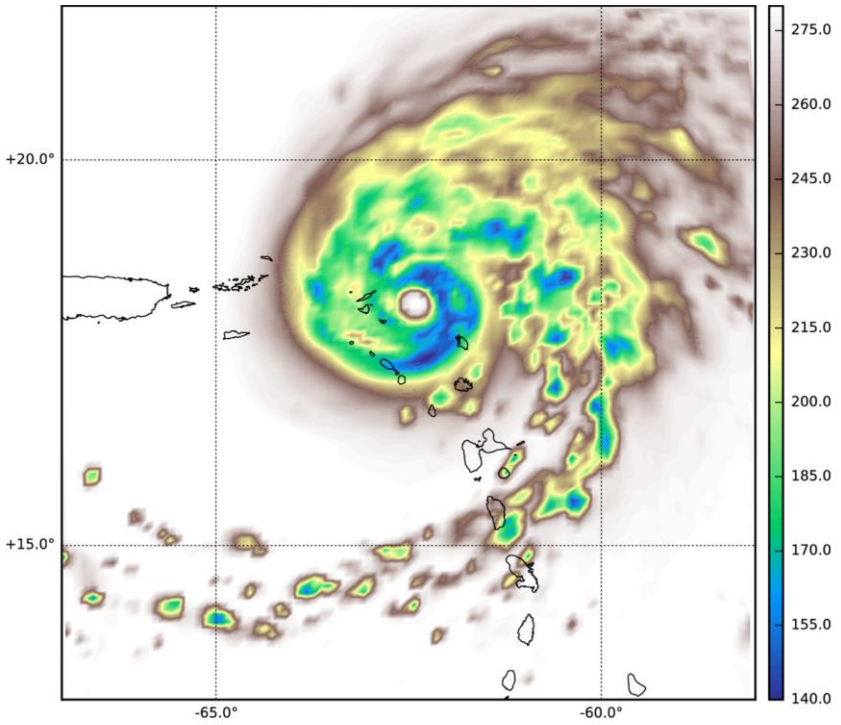
Simulated TBs for SAPHIR Ch6



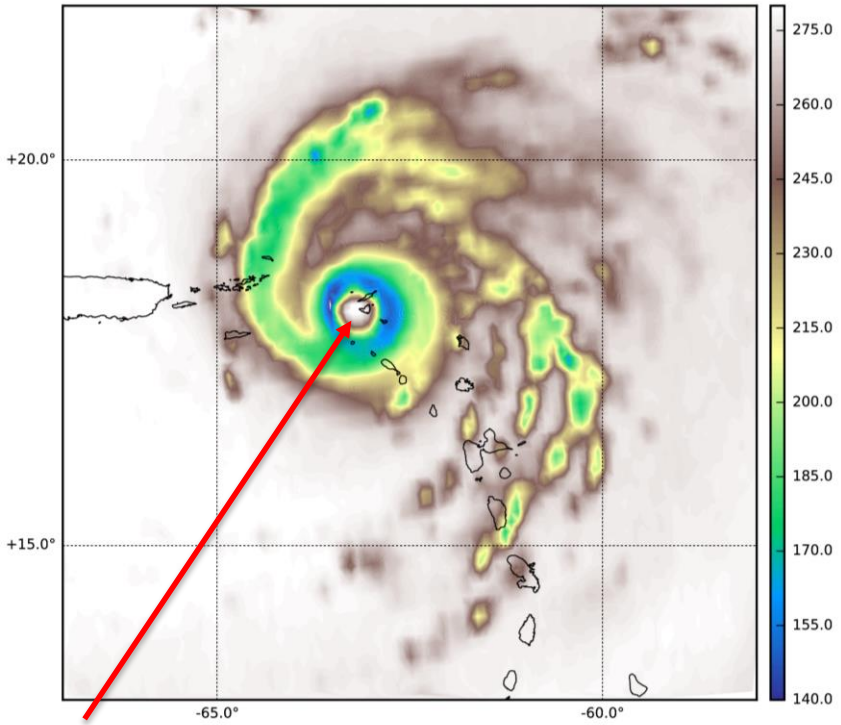
Ongoing research to improve these Tropical forecasts

First tests of this framework ongoing on the hurricane forecasts which occurred in September 2017 in the Caribbean's

AROME +29h forecast
SAPHIR Ch6 simulated with
RTTOV-SCATT, averaged at 10km



SAPHIR observation on
September 6th at 11UTC

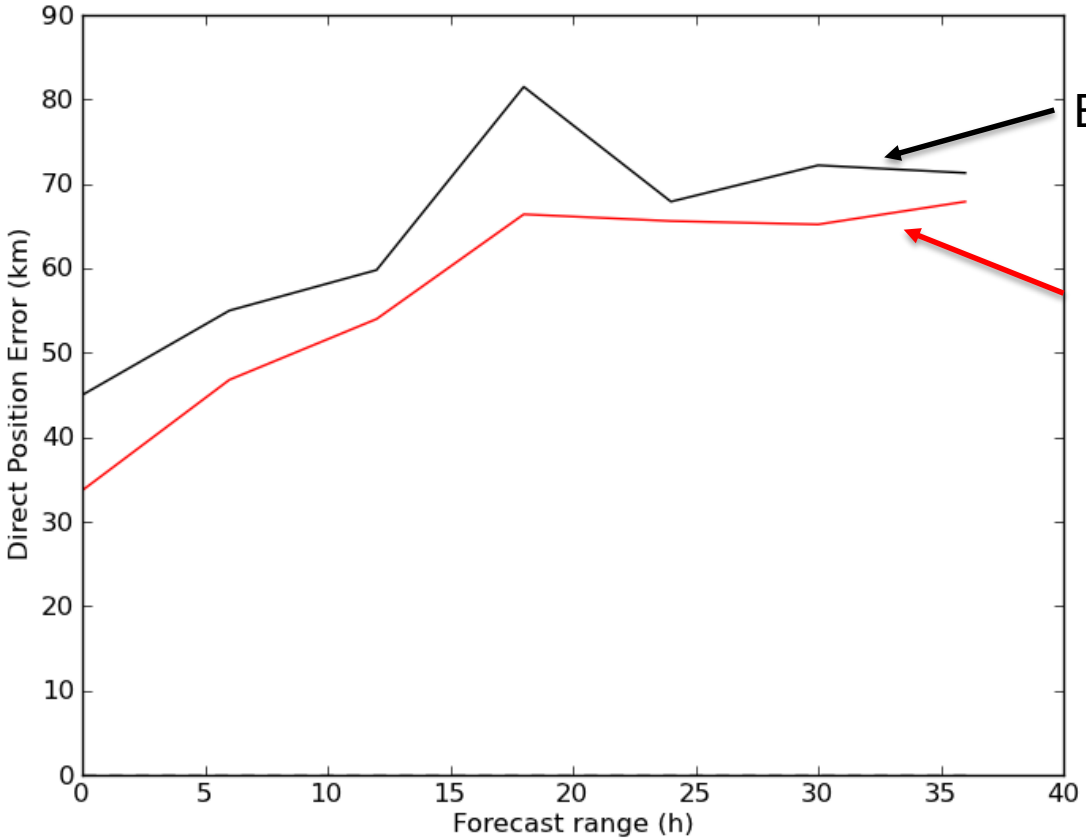


Saint Martin island

Ongoing research to improve these Tropical forecasts

First tests of this framework ongoing on the hurricane forecasts which occurred in September 2017 in the Caribbean's

Direct Position Error with respect to the Best Track for IRMA forecasts
(~15 forecasts compared every 6 hours)



Experimental AROME with 3D-Var

Same + SAPHIR cloudy and rainy radiances assimilated

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Our interest in the TROPICS mission

- Gain experience with the data assimilation of small satellite data
- Improve our Tropical ARPEGE and AROME forecasts with this new observations (an OSSE was already performed at Météo-France in 2016 to examine the impact of a microwave GEOsounder in AROME over Western Europe) => need for NRT data for operational applications?
- One could perform some first comparisons with our model if some data of the first satellite are made available to the community => fully opened or for an international science team?
- Since the meeting in May, the NWP SAF computed clear sky RTTOV coefficients for TROPICS; for the scattering coefficients the current RTTOV SCATT V12 cannot simulate the 205GHz channel (Liu tables missing at the freq.)
- Other activities within the Megha-Tropiques science team, in particular on rainfall retrievals would have some interest in TROPICS data as well

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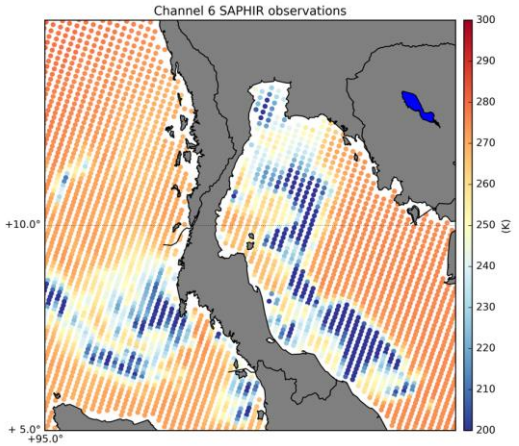
Thanks !
© cnes - labo Photon/M Regy

Back up slides

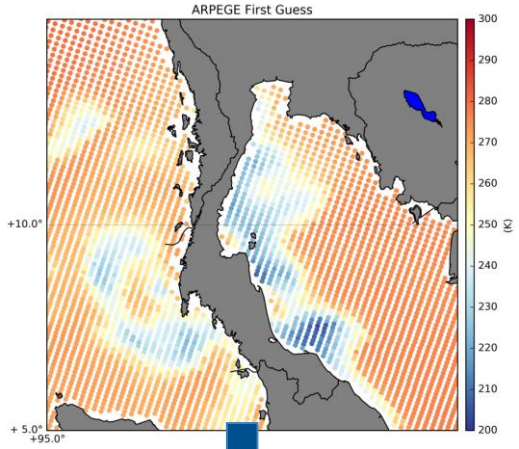
Data assimilation methodology

20170108 r00h UTC

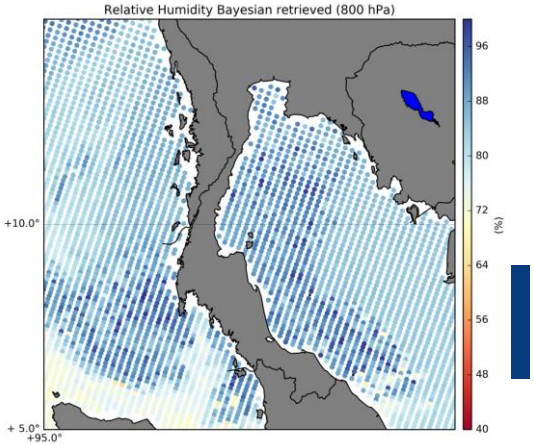
Observations SAPHIR S6



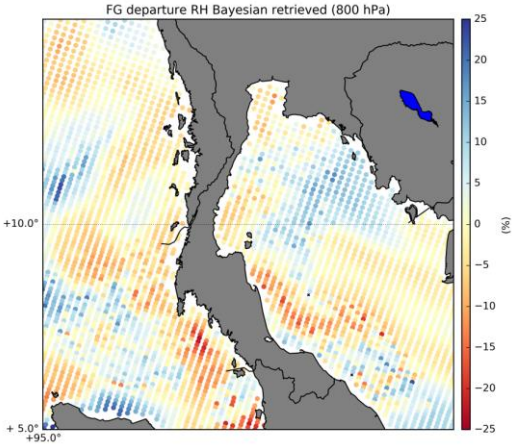
First Guess from ARPEGE simulated with RTTOV SCATT



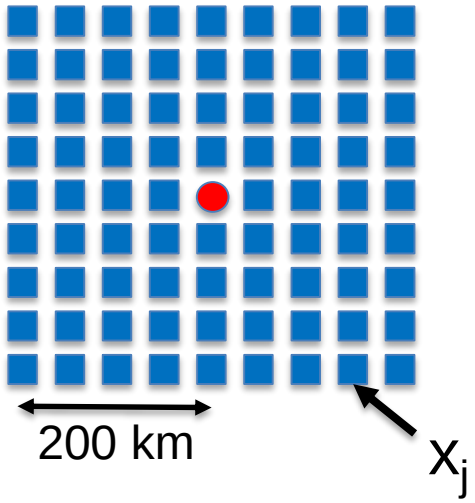
Retrieved Relative Humidity at 800hPa



First Guess departure of Relative Humidity at 800hPa



Assimilation of retrievals



Observations SAPHIR
Model first guess in the suroundings of an observation

Cost Function

$$J_o^j = \frac{1}{2} \cdot \sum_{channels=1}^{6} \left(\frac{H(x_j) - TB_{OBS}}{\sigma_o} \right)^2$$

All SAPHIR channels?

Accuracy wanted for the retrieval

Weights of each Neighbors

$$w_j = e^{-J_o^j}$$

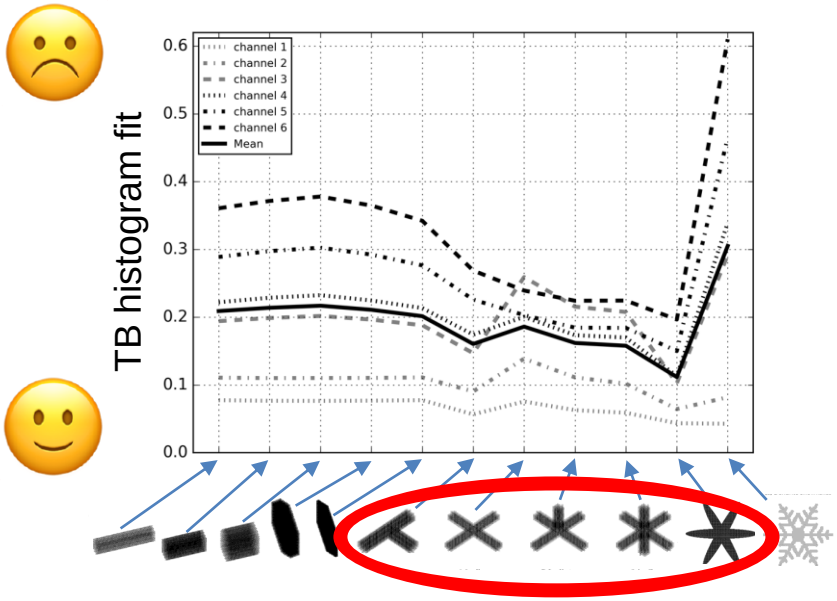
Computation of the retrieved profile

$$x_{retr} = \frac{\sum_{j=1}^{80} x_j \cdot w_j}{\sum_{j=1}^{80} w_j}$$

Comparisons between observations and first guess over 1 month with two different methods:

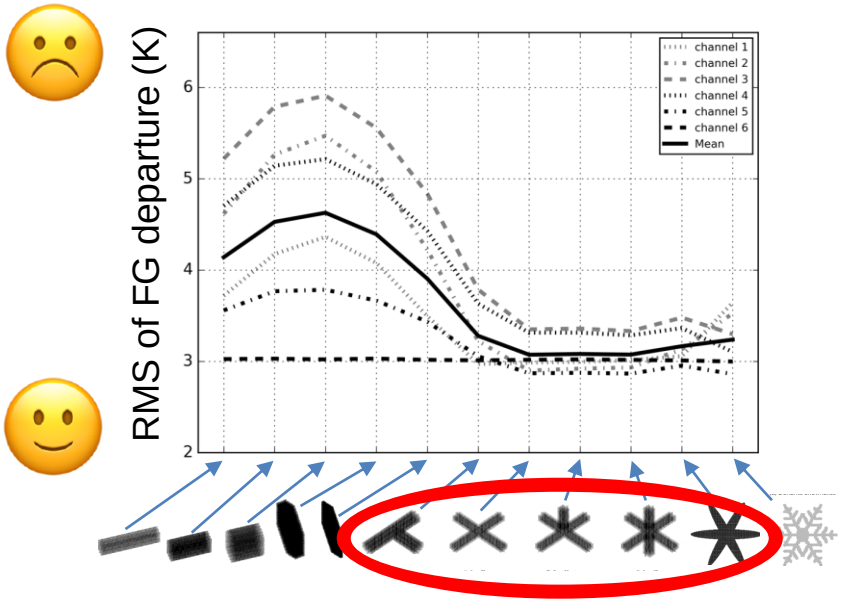
Comparisons of TB histograms with a dedicated metric

(Geer and Baordo, 2014)



First guess departure statistics with a selection of meteorological scenes

(Chambon et al, 2014)



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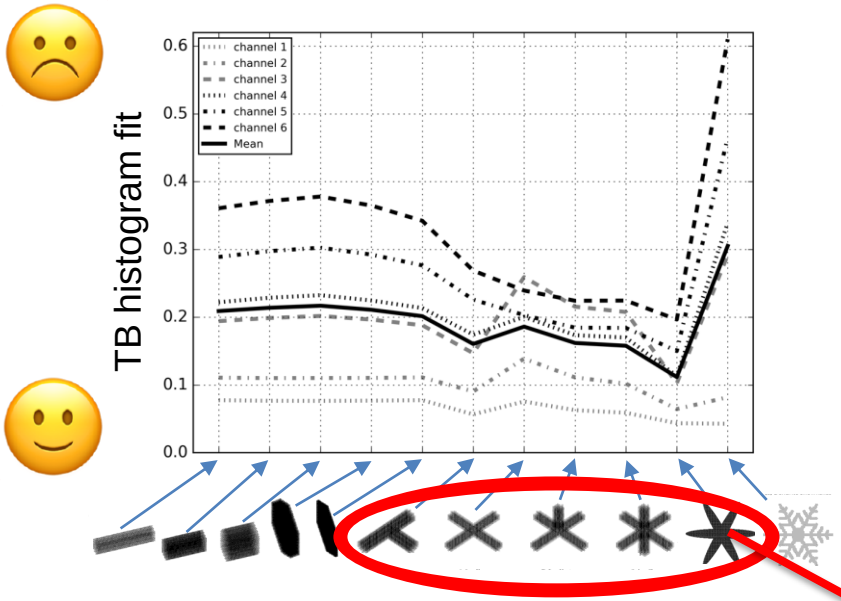

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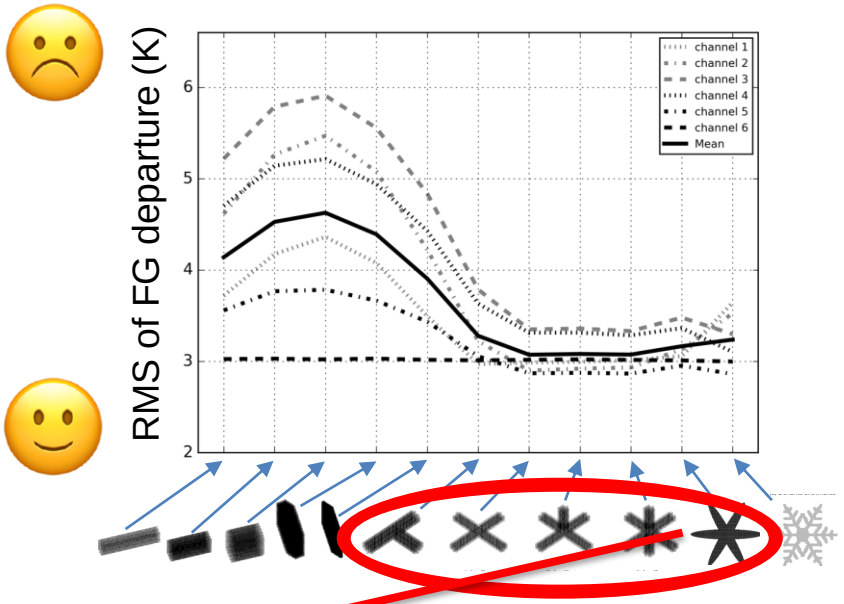
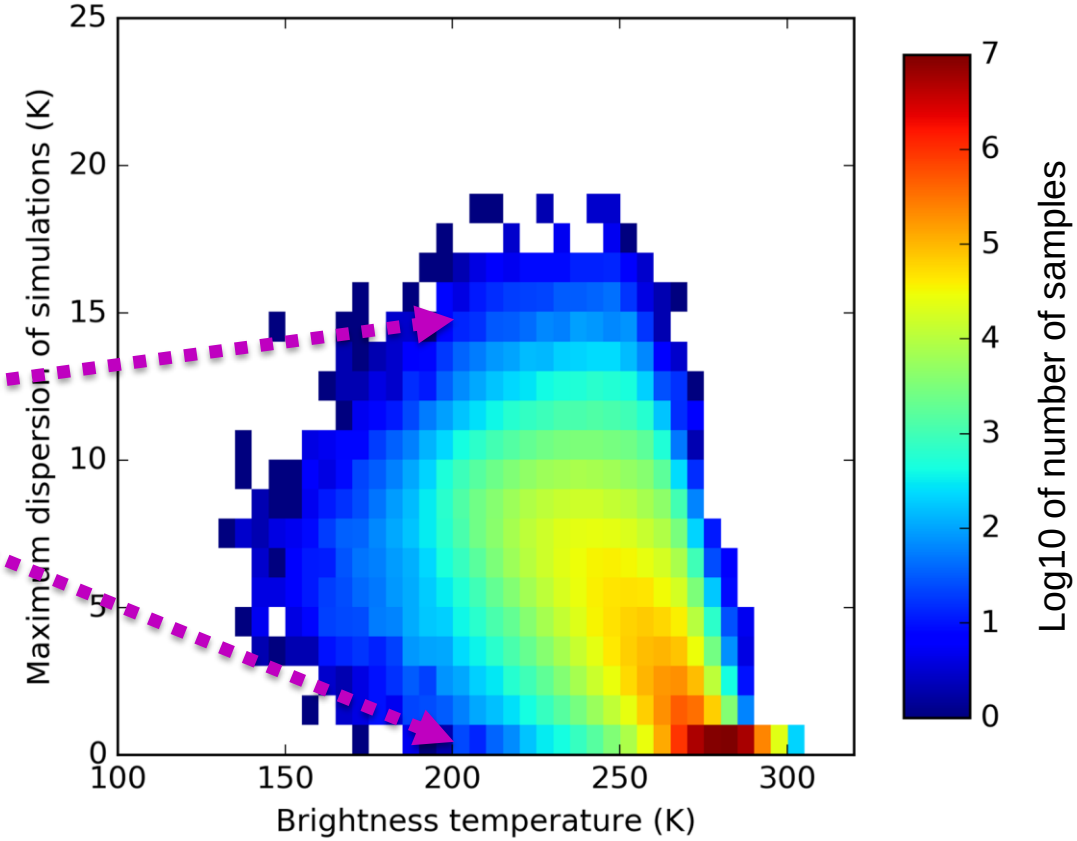


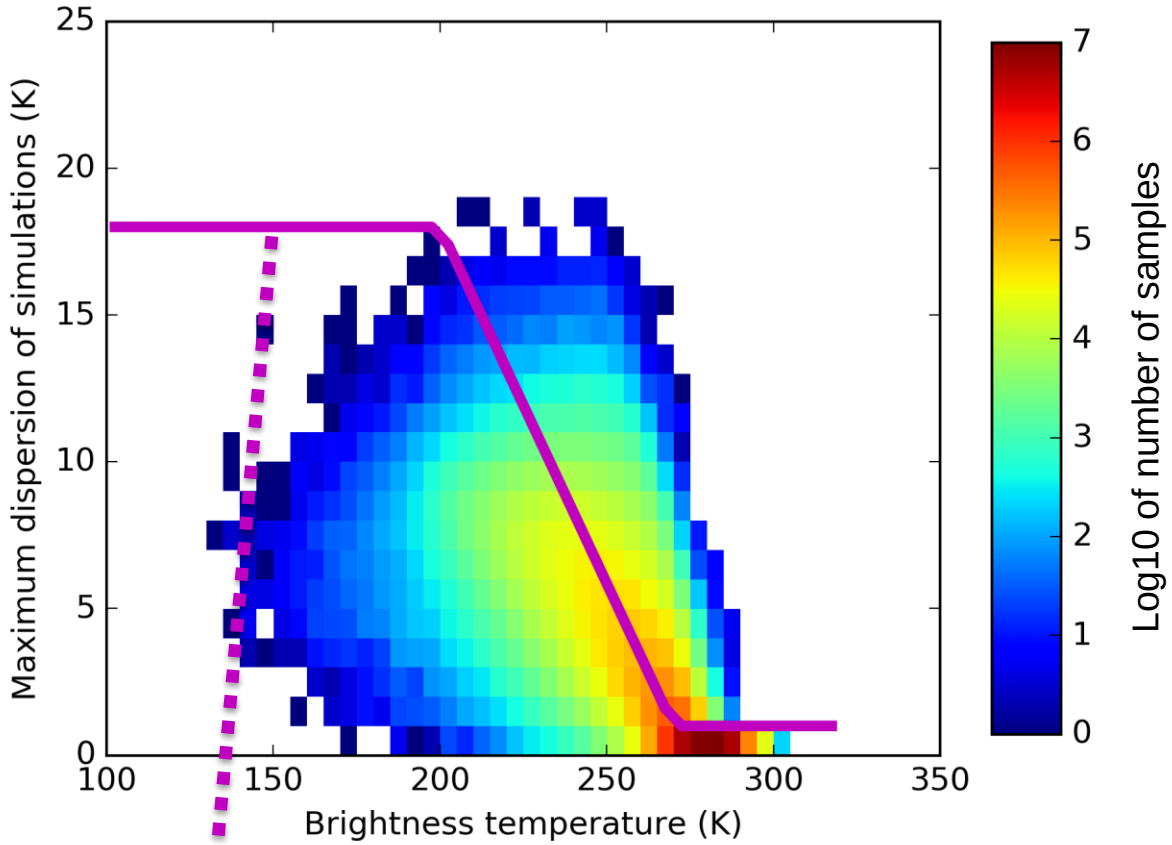
=> Selection of « sector snowflake »

Spread of RTTOV-SCATT simulations for SAPHIR channel 6 between the 5 good candidates for assimilation over 1 month

For a given TB, non linearities can be either weak or quite strong with 15K of differtences between runs



Simplified modeling of the spread between the 5 good particle shape candidates



$$J_o^j = \frac{1}{2} \cdot \sum_{channels=1}^{6} \left(\frac{H(x_j) - TB_{OBS}}{\sigma_o} \right)^2$$

=> Model used to define a realistic accuracy that can be demanded for the Bayesian retrieval