

An Observing System Simulation Experiment to evaluate the future benefits of MTG-IRS data in a fine-scale weather forecast model

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Meteosat Third Generation – IR Sounder (MTG-IRS)

Onboard GEO platform, scheduled for launch in 2020 ...

1 image / 30 min over Europe

1738 channels

Spec. Res. 0.625 cm^{-1}

(Comparable to IASI)

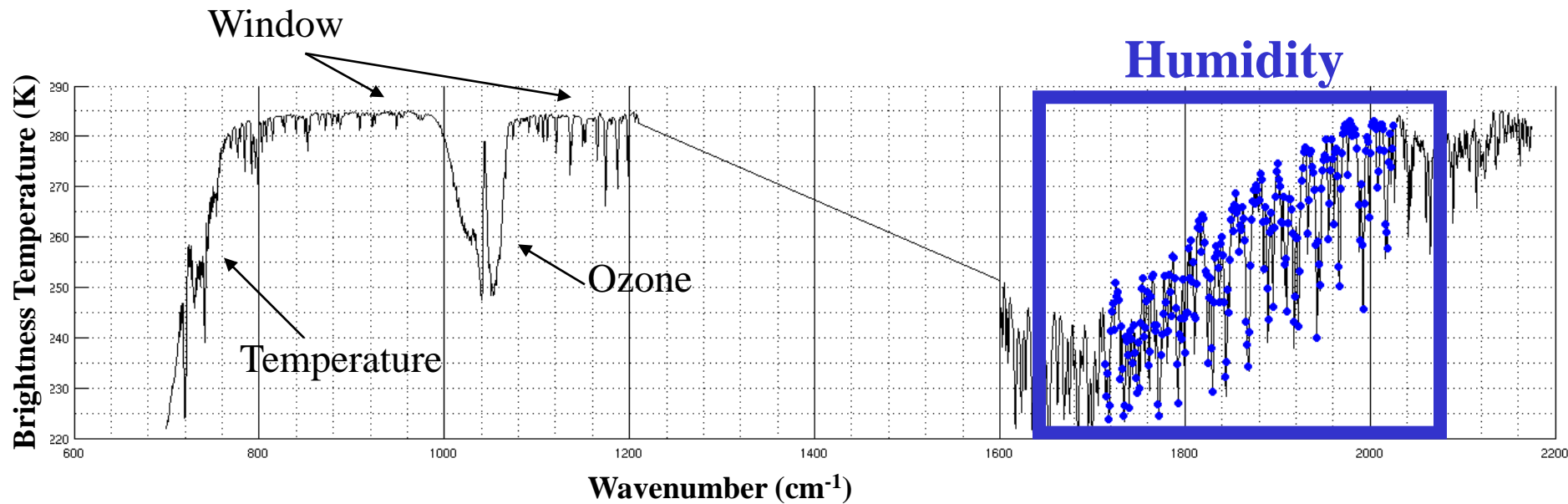
Horiz. Res. 5 km

(Comparable to SEVIRI)



Meteosat Third Generation – IR Sounder (MTG-IRS)

Typical simulated IRS spectrum



OSSE (Observing System Simulation Experiment) is implemented to investigate the potential impact of prospective observing system such as MTG-IRS.

The true atmospheric state is called the **Nature Run** (NR). It is a free-run, long and uninterrupted forecast performed by a **global** NWP model :

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Nature Run : ARPEGE/IFS Free-Run forecast

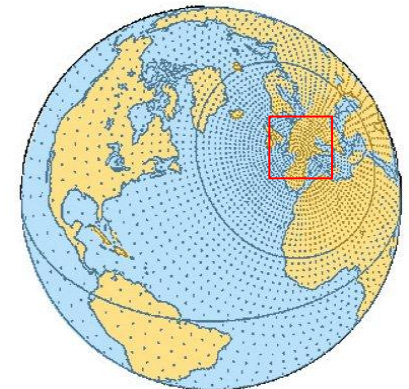
Spectral resolution : T1200

~ 7 km over Europe / 105 levels

Initial conditions : 20/06/2013 – 0h

Model version : cy38op1

No data assimilation !



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OSSE : 3D-Var AROME/France forecast system

~ 2.5 km over France / 60 levels

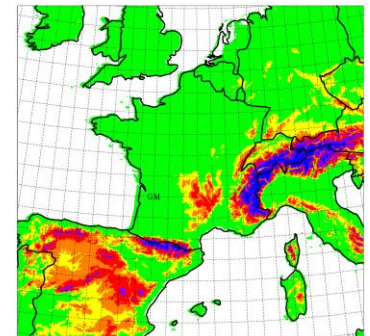
Initial conditions : 15/07/2013 – 0h (**NR**)

3h-assimilation window

Coupling (1h) : Nature Run

Assimilation of the full simulated observing system (+ IRS) :

The AROME domain



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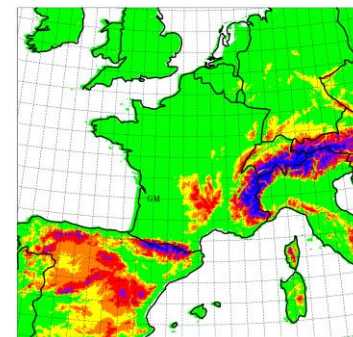
3h-assimilation window

Coupling (1h) : Nature Run

Conv : Radiosondes, Aircraft, Ship/Buoy, Profilers, VAD winds, Surface station

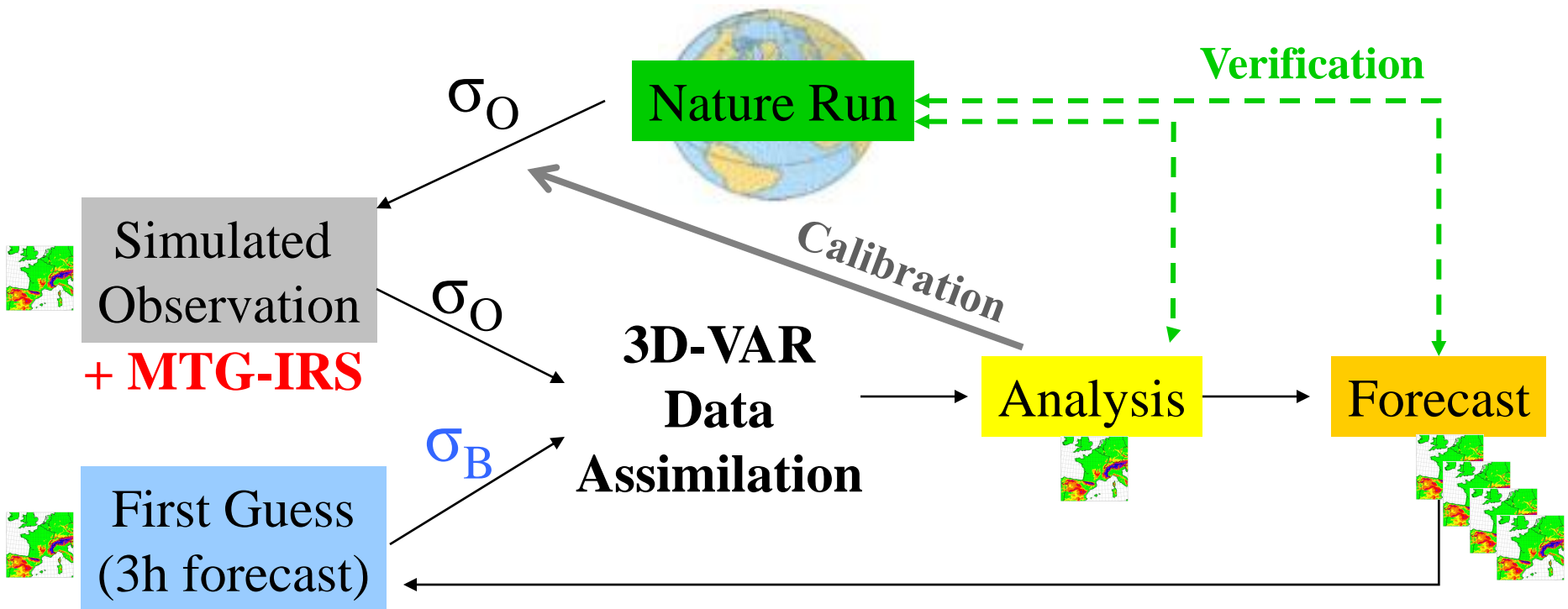
Sat : ATMS, AMSU-A, MHS/AMSU-B, AMVs, GPS-SOL, IASI/ CrIS /AIRS, SEVIRI, HIRS

The AROME domain



Observing System Simulation Experiment (OSSE)

Free-Run forecast simulation, with simulated imperfect “observations”. Truth known.



Challenges :

What is the optimal use of simulated MTG-IRS WV channels that will maximize the positive impact on analysis of Limited Area Models?

⇒ Observation error, thinning distance, channel selection ...

Error sources : Measurement, Forward model, Representativeness, Quality control ...

Problem : We do NOT know the **true observation error** and their **correlations** ...

But we can have some estimates : [Garand et al., 2007](#); [Stewart, 2007](#); [Bormann and Bauer, 2010](#); [Bormann et al., 2010](#); [Miyoshi et al., 2013](#)...

Neglecting error correlations can lead to sub-optimal analyse if the observation are used too densely and errors are correlated ([Liu and Rabier, 2003](#))

⇒ Obs errors are voluntary over-estimated in Operational NWP Systems.

In the OSSE, simulations of observation errors are calibrated using statistic errors provided by the operational system.

Observation error correlations for simulation and assimilation are neglected.

Calibration : Verifies the simulated data impact by comparing it to real data impact

Radioonde Q data

104 assim. cycles (13 days, July 2013)

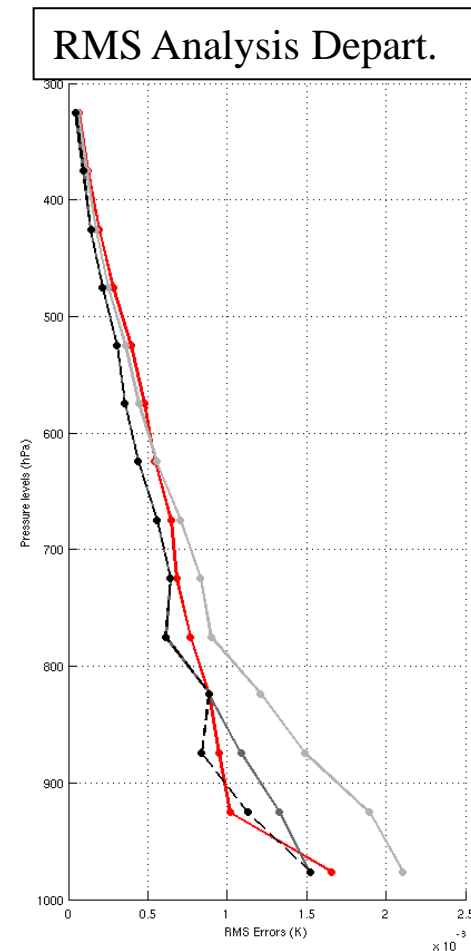
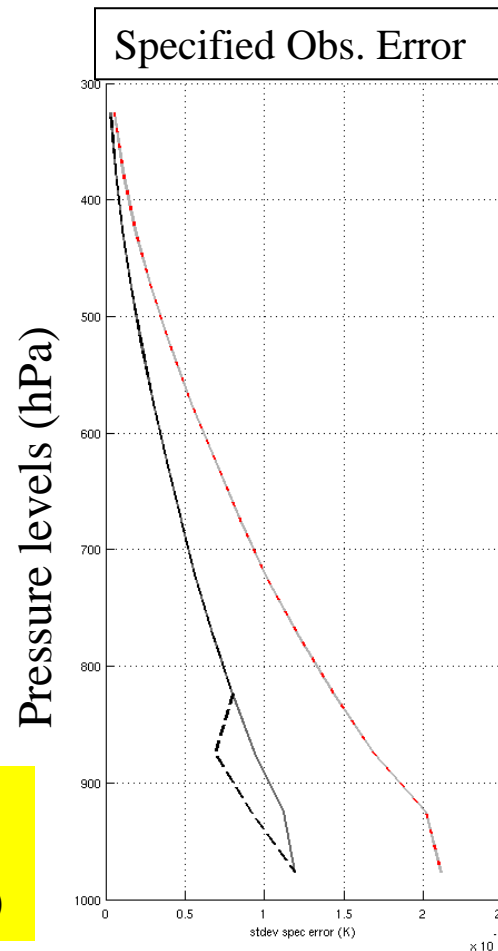
Real Obs DAS

OSSE Cal-0 : σ_O (OSSE) = σ_O (DAS)

OSSE Cal-1 : σ_O (OSSE) = σ_O (DAS) x 0.5

OSSE Cal-2 : σ_O (OSSE) = σ_O (DAS) x 0.5
+ *Manual modifications*

⇒ Same work for the full active observing system (conv, LEO, GEO ...)



Future benefits of MTG-IRS : Assimilation experiments

- **REF** = Nature Run
- **CTL** = OSSE ~ OPER with the full simulated observing system
- **IRS-80km** = CTL + IRS (80 km, 25 Q channels)

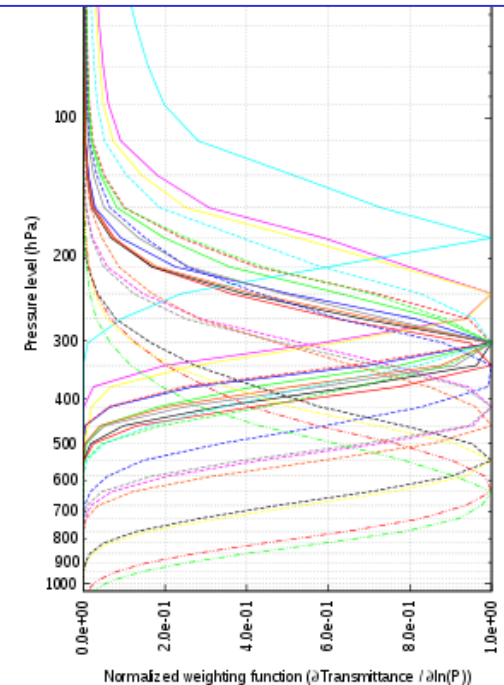
Period : 20/07/2013 (8 assimilation cycles)

Additional experiments

Thinning distance :

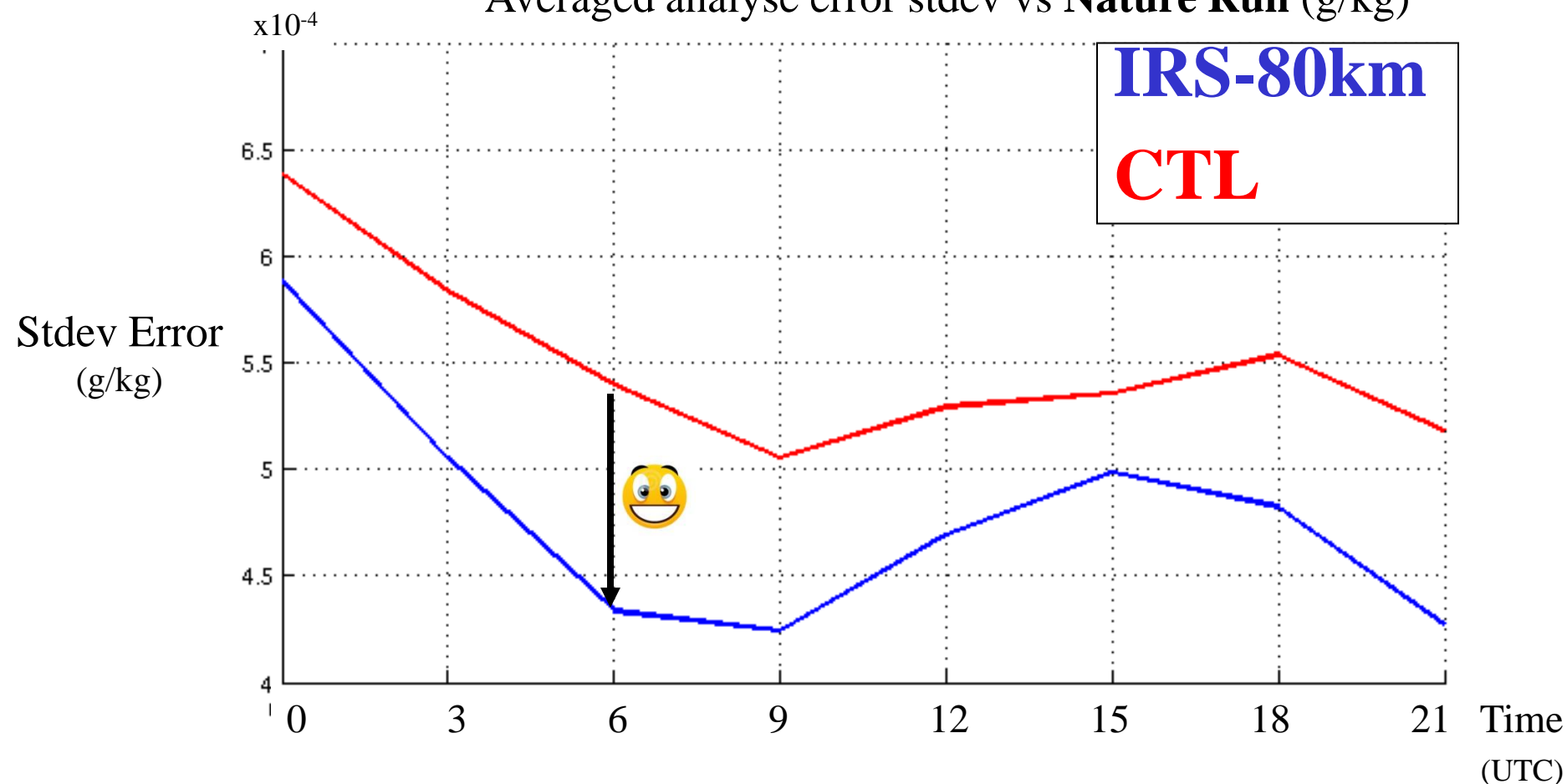
- **IRS-40km** = CTL + IRS (40 km, 25 Q channels)
 - **IRS-20km** = CTL + IRS (20 km, 25 Q channels)
- + Channel selection (not shown)

Normalized Weighing function



SPECIFIC HUMIDITY

Averaged analyse error stdev vs Nature Run (g/kg)



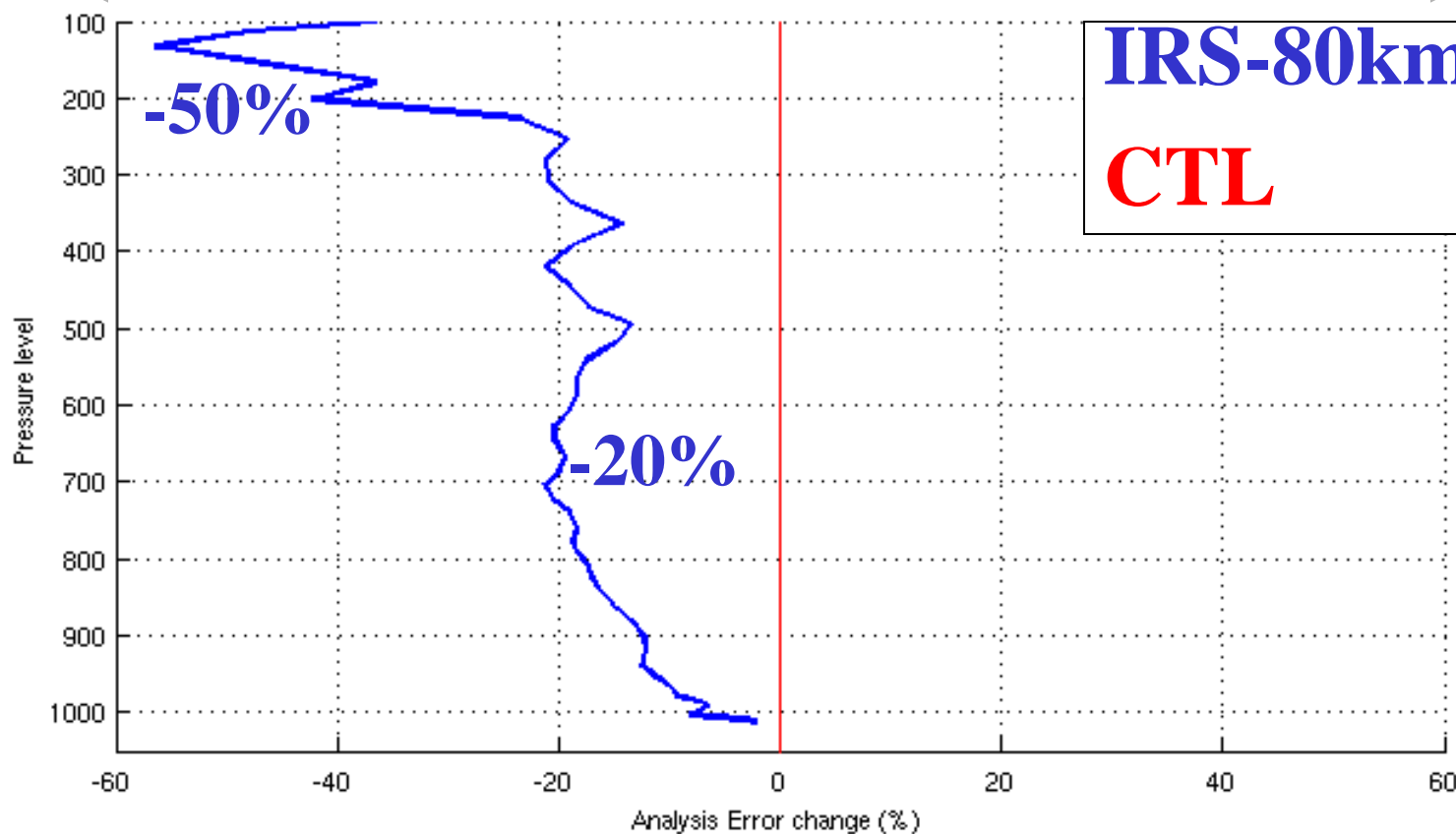
% of change : -7.83 -13.44 **-19.64** -15.97 -11.38 -6.87 -12.86 **-17.54**

SPECIFIC HUMIDITY

Relative analyse error stdev changes (%)

GOOD

BAD

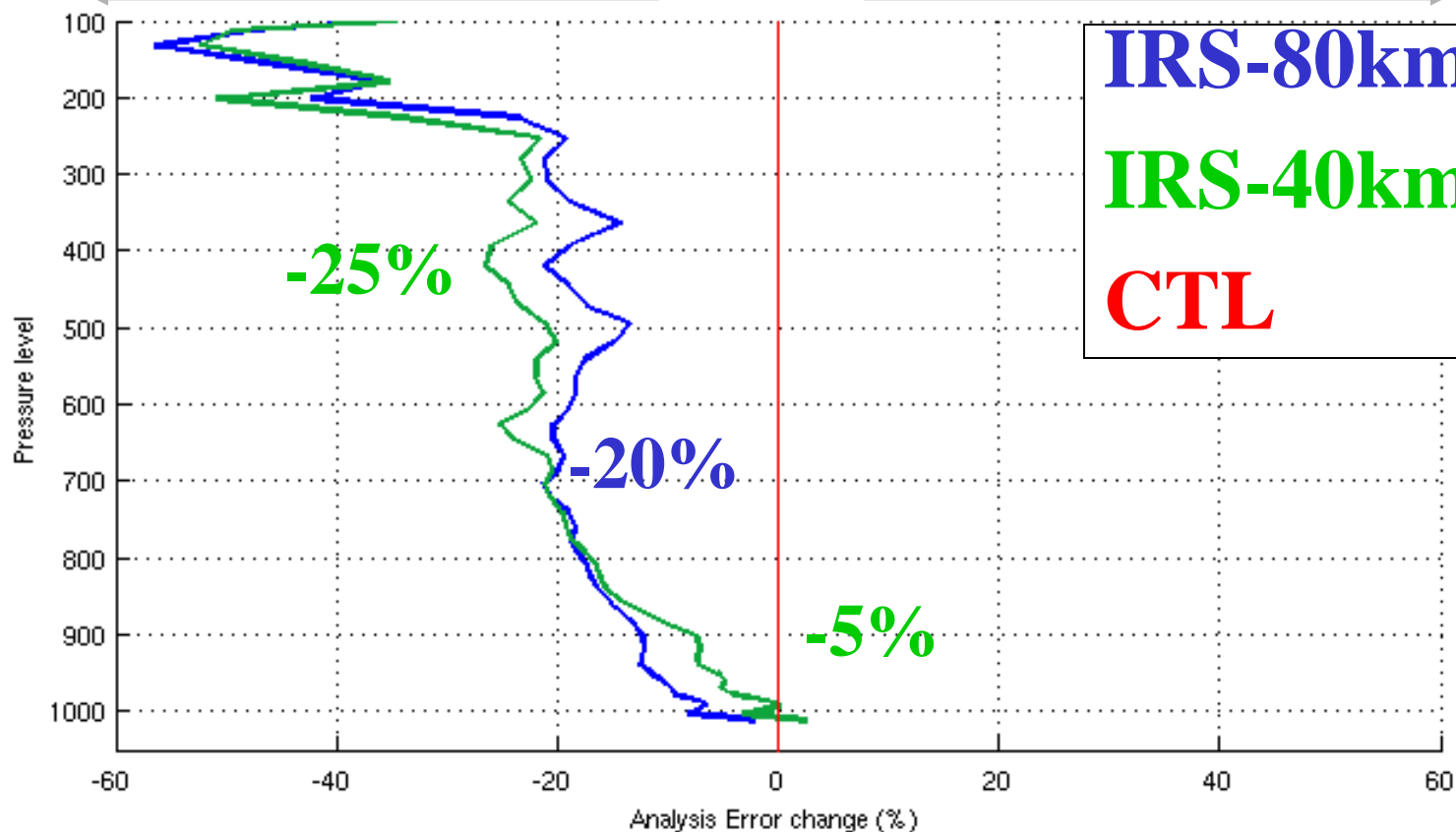


SPECIFIC HUMIDITY

Relative analyse error stdev changes (%)

GOOD

BAD



IRS-80km
IRS-40km
CTL

-25%

-20%

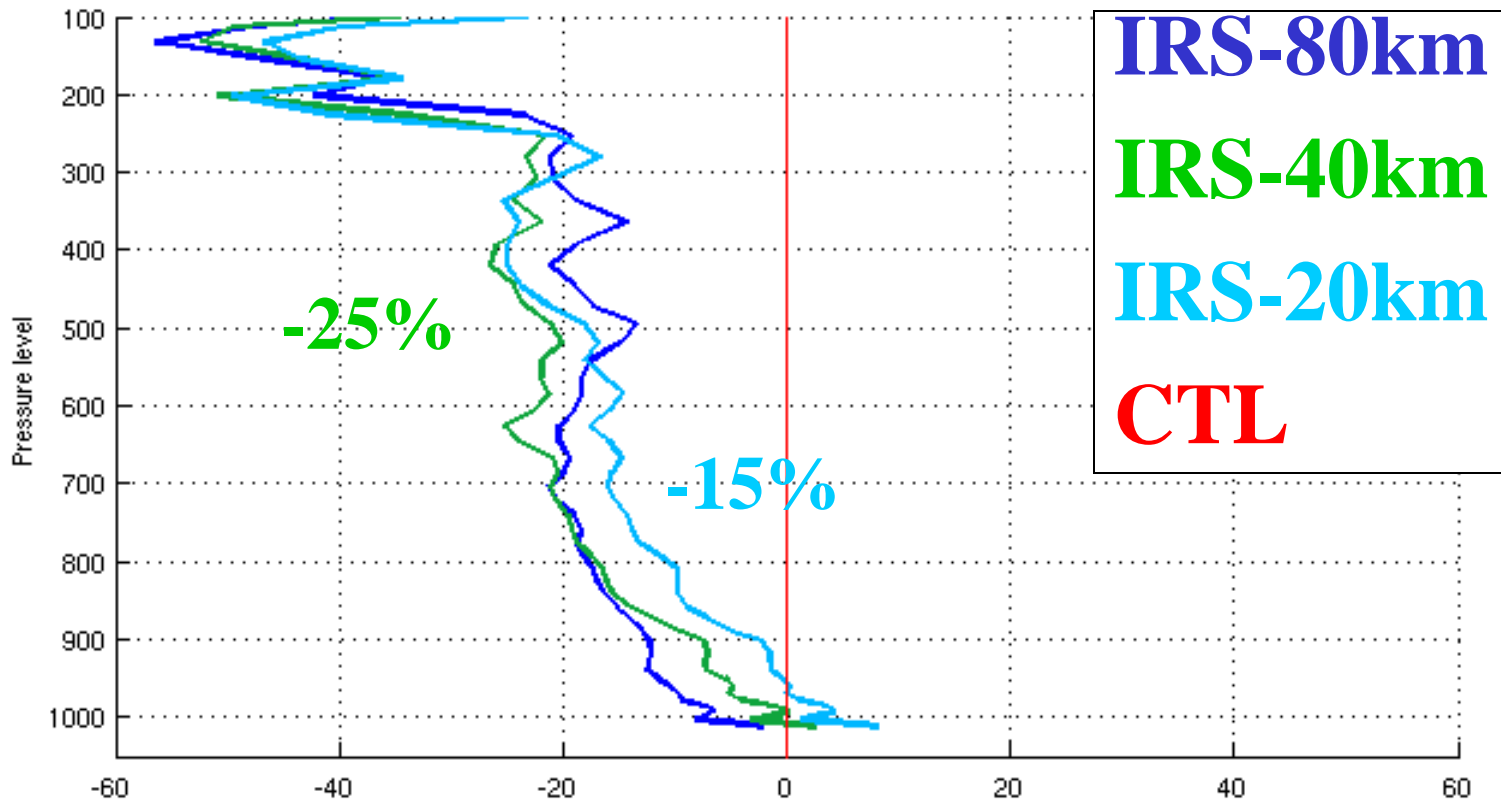
-5%

SPECIFIC HUMIDITY

Relative analyse error stdev changes (%)

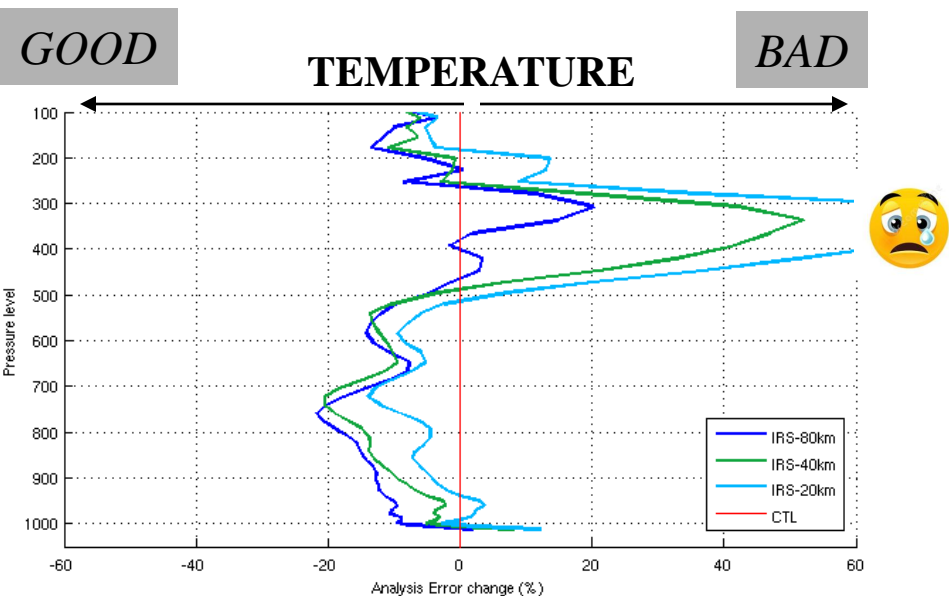
GOOD

BAD



⇒ Even if IRS observations are simulated assuming uncorrelated errors, there is a thinning distance threshold where background errors interact with obs. errors ...

Impacts on the analysis

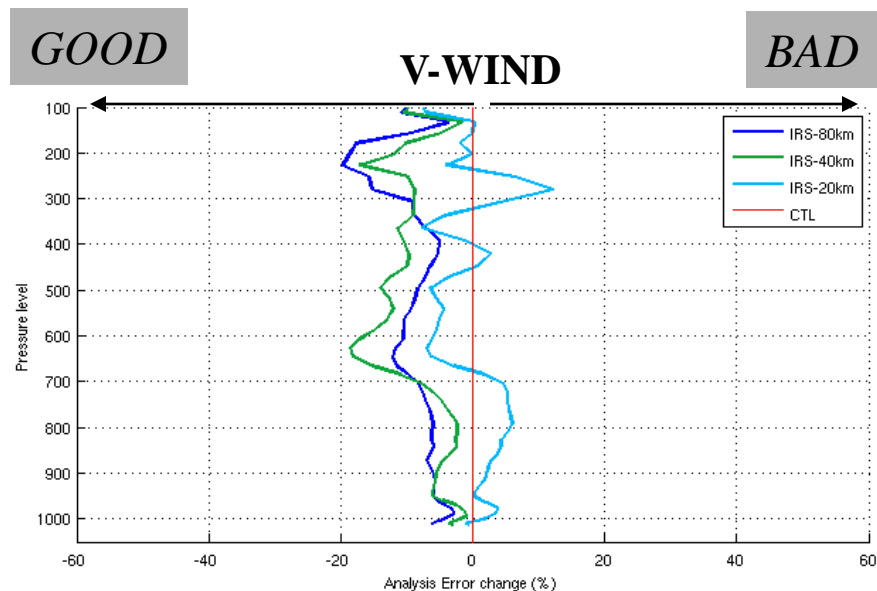
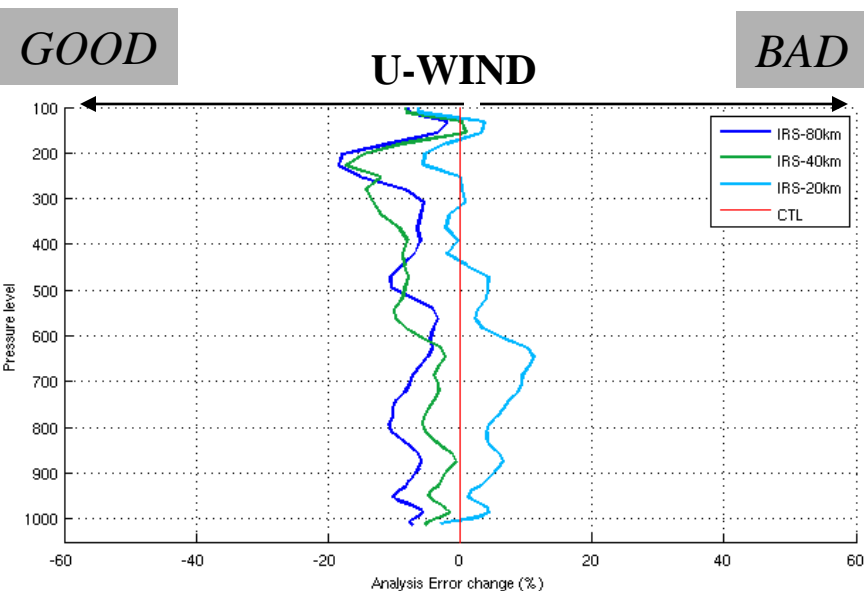


IRS-80km

IRS-40km

IRS-20km

CTL



- An OSSE was implemented at Météo-France to demonstrate the **future benefits of MTG-IRS data in a fine-scale AROME forecast model**
 - The full observing system was simulated from the NR using calibrated observation errors.
 - Several configurations (thinning & channels number) were tested to better understand how background errors interact with observation errors.
- ⇒ **IRS showed strong and systematic positive impacts on the analysis of humidity**
- ⇒ Negative impacts may occur on T and winds fields if the density of IRS is inadequate ...

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Limitations :

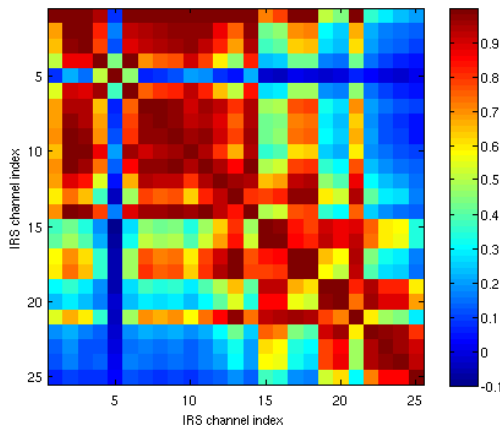
- An **optimal channel selection** for MTG-IRS data (including T channels).
- ⇒ The potential of using PC scores instead of L1 radiance data.
- **Impact of clouds** on simulated Bt and assimilation.
- Make use of **2 different RT models** for simulation and assimilation.

Conclusion, limitations and future work

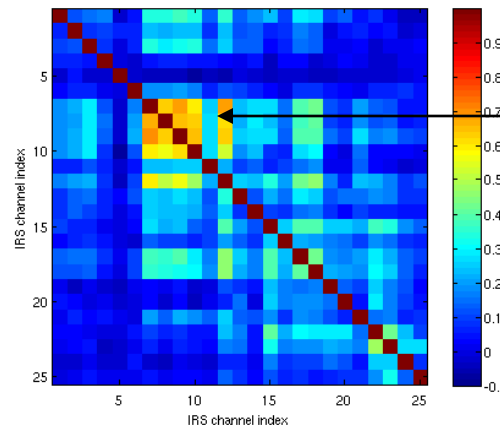
- In this work, the perturbation added to radiances simulations was assumed to be uncorrelated.
- Recently, the a posteriori desroziers diagnostic for **inter-channel error correlation** was run on IRS simulated/assimilated WV data within the framework of this OSSE.

Result : Significant inter-channel error correlation were found even if the perturbation added to the observation was not correlated ...

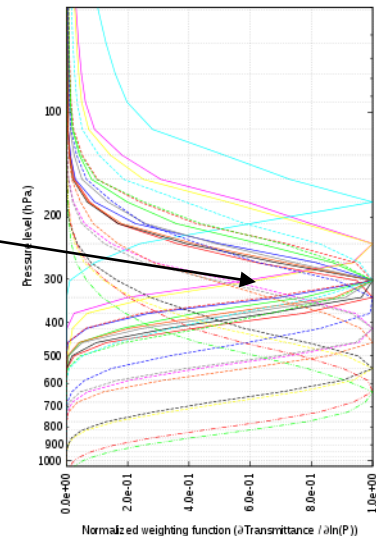
B corr matrix



R corr matrix



$r > 0.7$
?



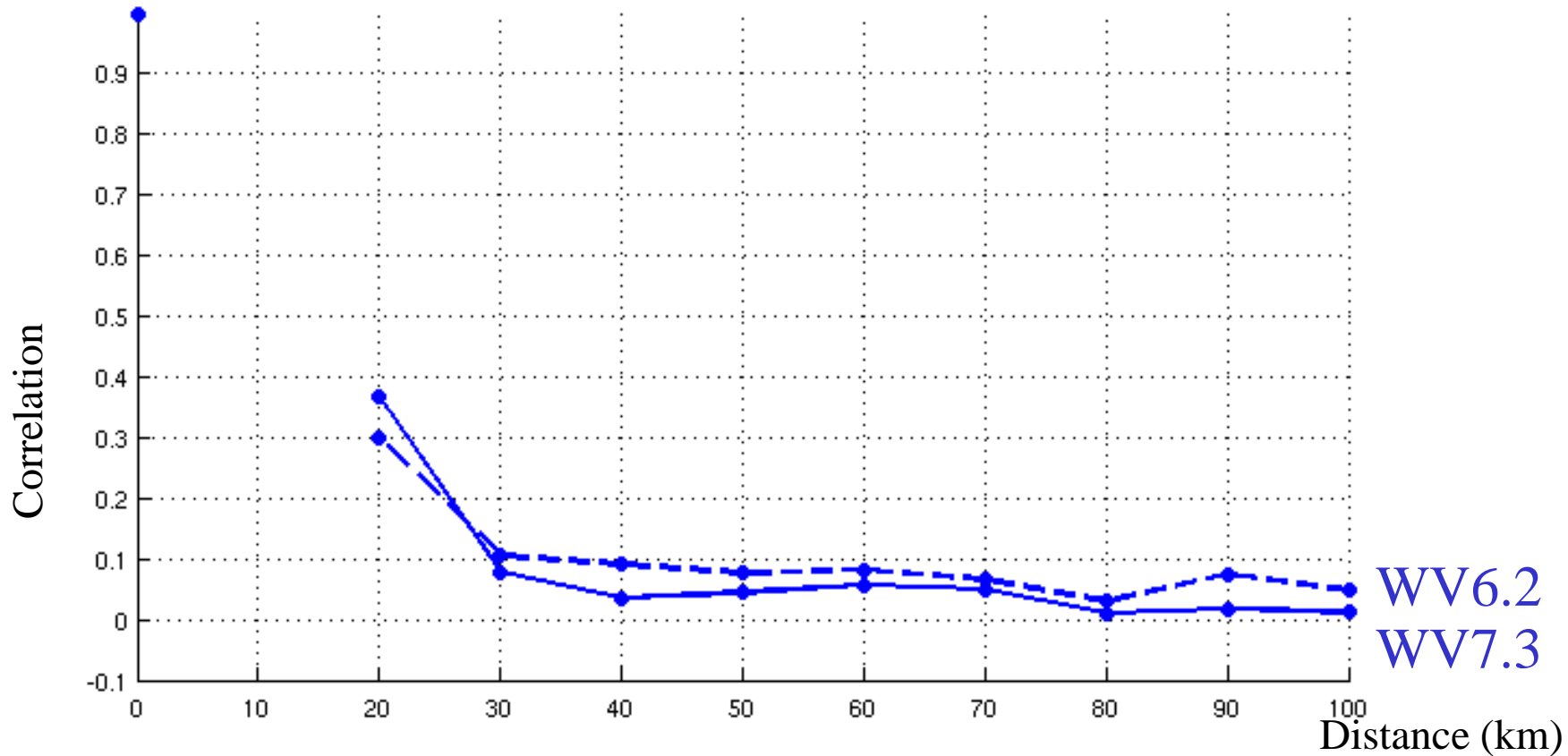
Thank You



Estimate of Observational Errors Correlation

SEVIRI as proxy to MTG-IRS

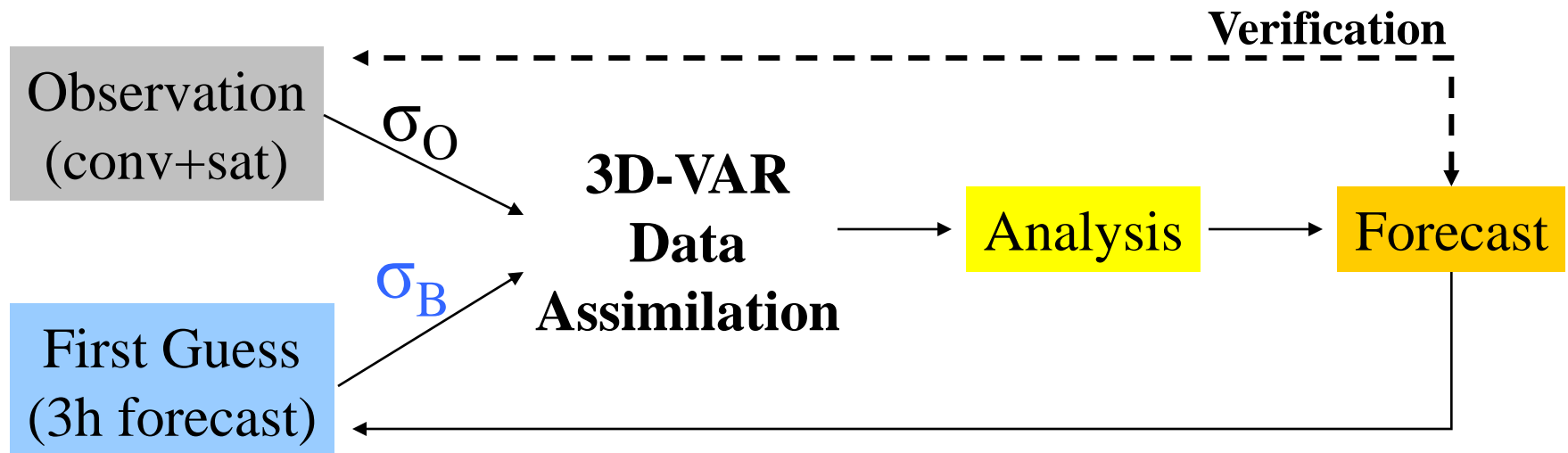
Estimate of **horizontal error correlation** of real SEVIRI WV observations
(Desroziers diagnostic – 15 days, July 2013)



⇒ Even if IRS observations are simulated assuming uncorrelated errors, there is a thinning distance threshold where background errors interact with obs. errors ...

Data Assimilation of Real Observations (DAS)

Real Evolving Atmosphere, with imperfect observations. Truth unknown

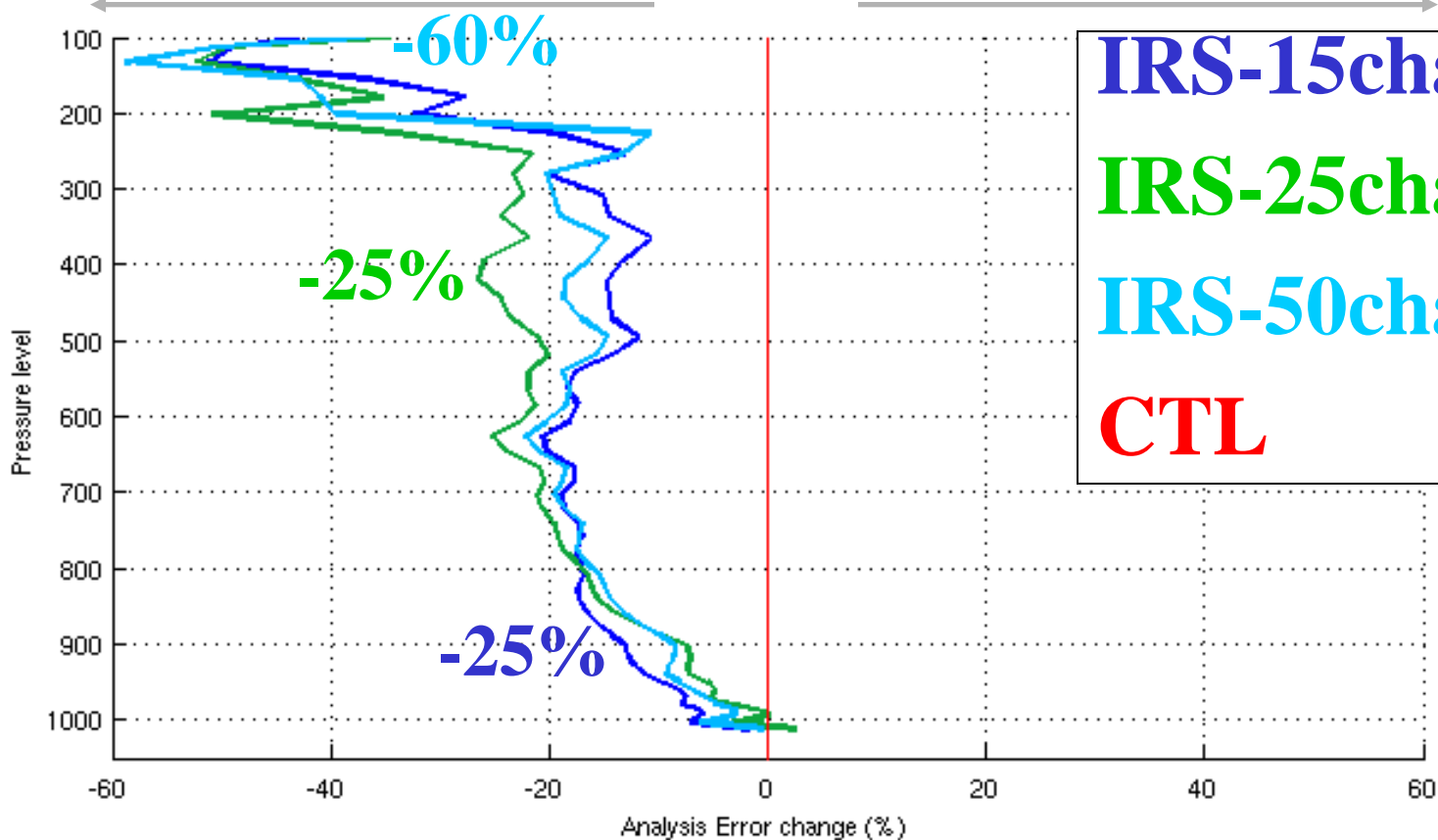


SPECIFIC HUMIDITY

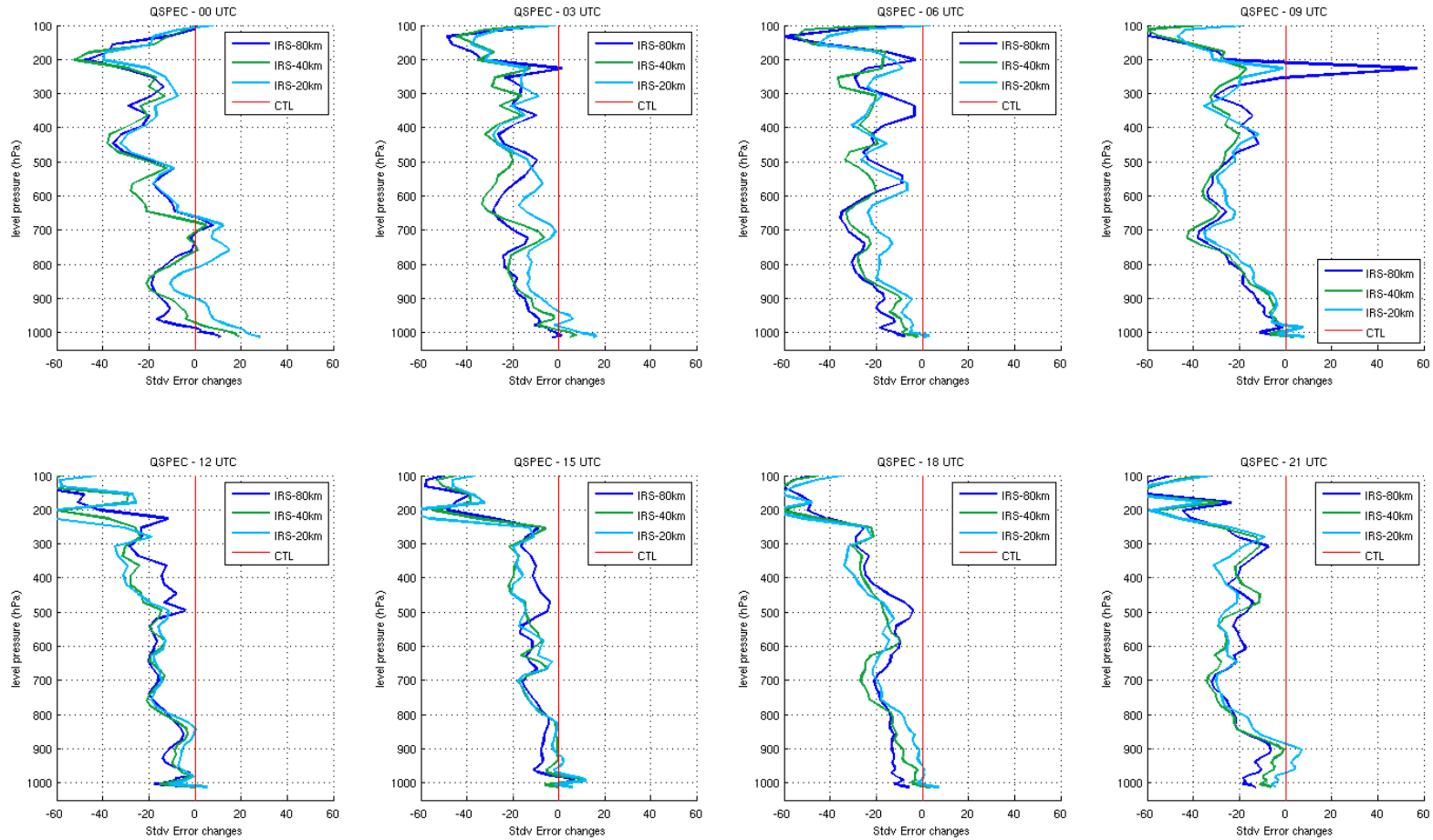
Relative analyse error stdev changes (%)

GOOD

BAD



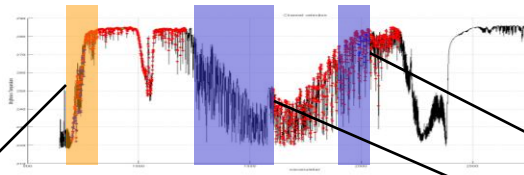
Impact on the analysis



Simulation of Observational Errors : MTG-IRS

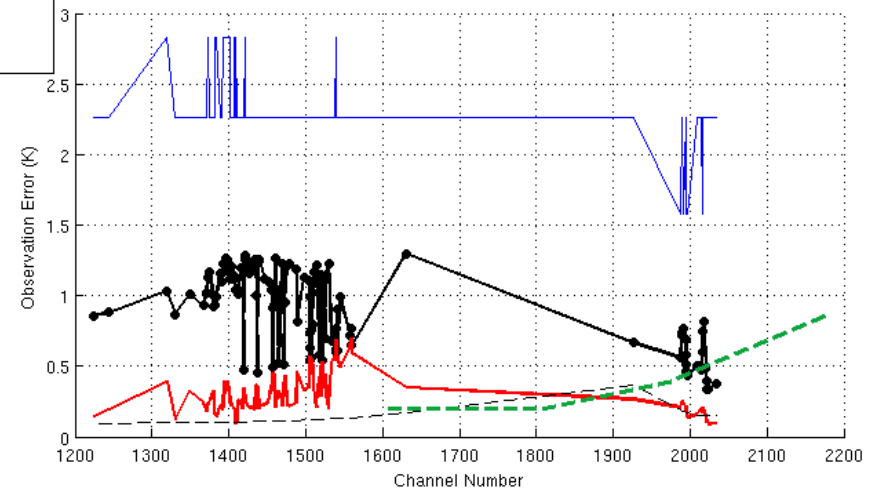
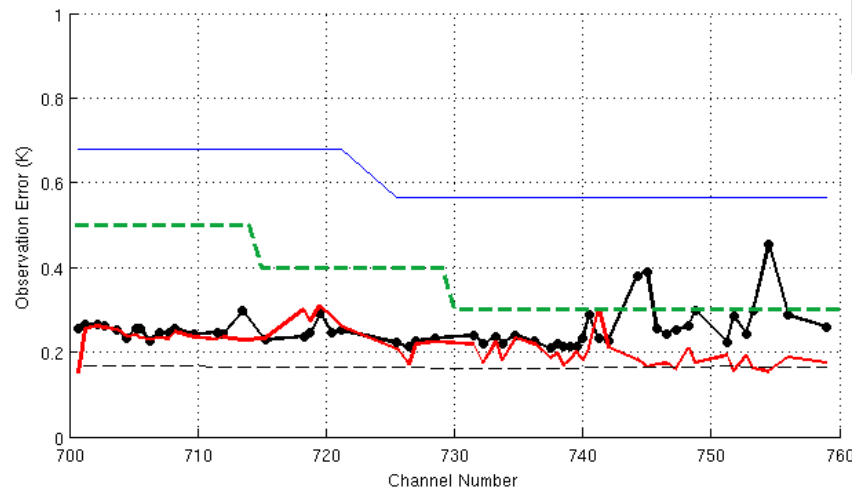
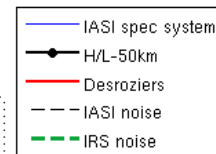
Estimate of observation error amplitude using IASI real data as proxy for IRS

DATA: IASI clear radiances
15 days (01/09-15/09)
Domain: AROME



55 T channels

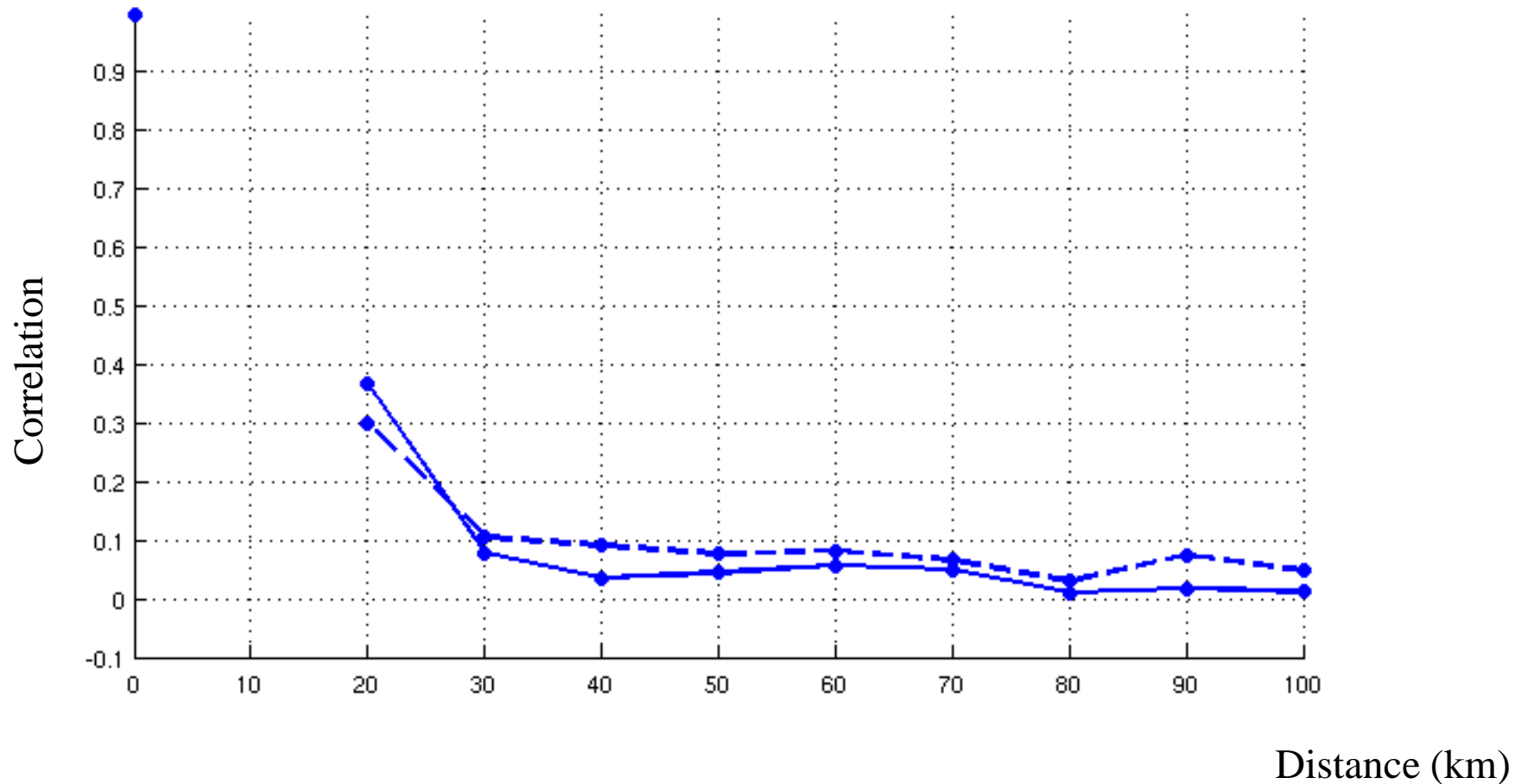
96 + 20 Q channels



⇒ IRS stdev error estimate : $\sim 0.4\text{K}$ for T channels and $\sim 0.5/1\text{K}$ for Q channels

Simulation of Observational Errors : MTG-IRS

Estimate of **horizontal correlation** of real SEVIRI WV observation errors



Simulation of Observational Errors : Calibration experiments

Configuration of assimilation experiments using simulated observations :
sigma O scaling

	First Guess	Assim. OBS	Boundary condition	Stdev error
REF_OPER	AROME OPER	Real	ARPEGE OPER	AROME OPER * fact_oper
EXP_sig0.8	ARPEGE NR	Simulation	ARPEGE NR	AROME OPER * fact_0.8
EXP_sig0.5	ARPEGE NR	Simulation	ARPEGE NR	AROME OPER * fact_0.5
EXP_sig0.2	ARPEGE NR	Simulation	ARPEGE NR	AROME OPER * fact_0.2

METHOD :

- ⇒ Analysis increments (not shown)
- ⇒ comparison of obs-guess & obs-analyse statistics
- + specified stdev modifications if needed

Note :

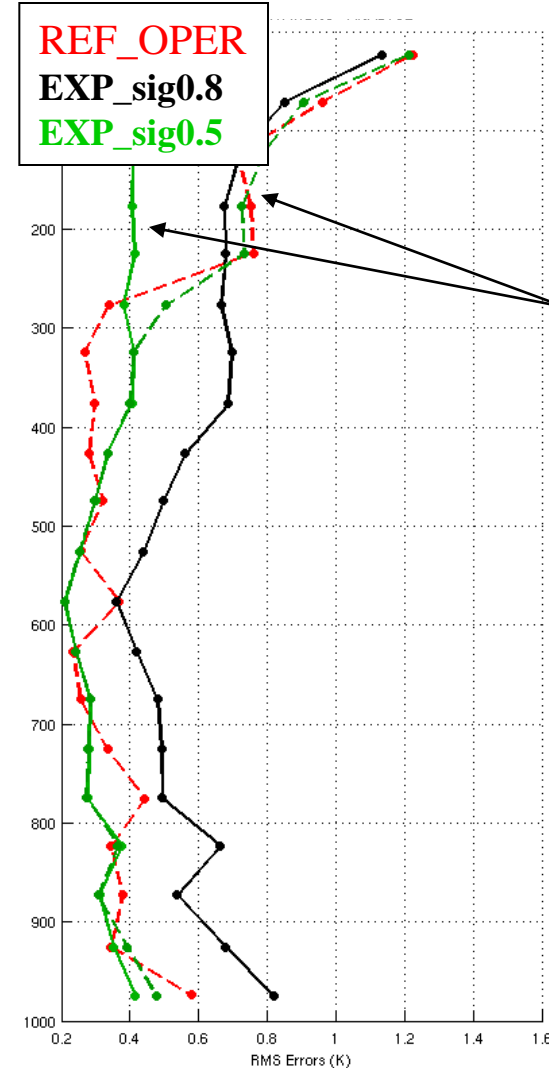
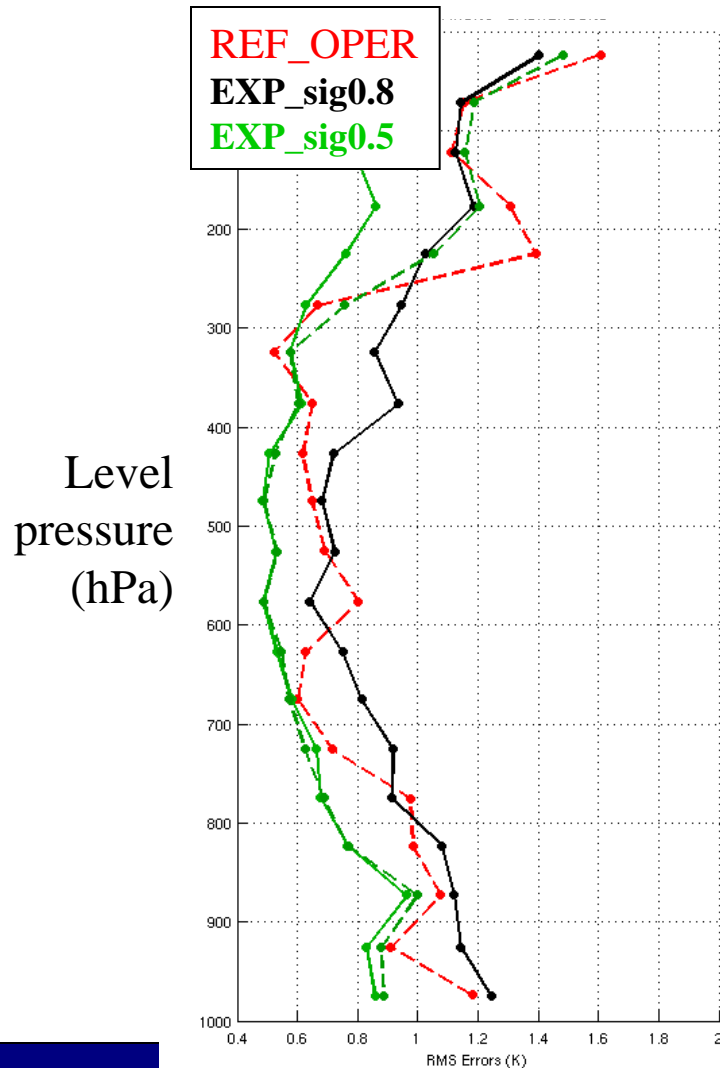
- conventional data
fact_oper = 0.8
- satellite data
fact_oper = 1.15

Simulation of Observational Errors : MTG-IRS

TEMP

Stdev Observation - Guess

Stdev Observation - Analyse

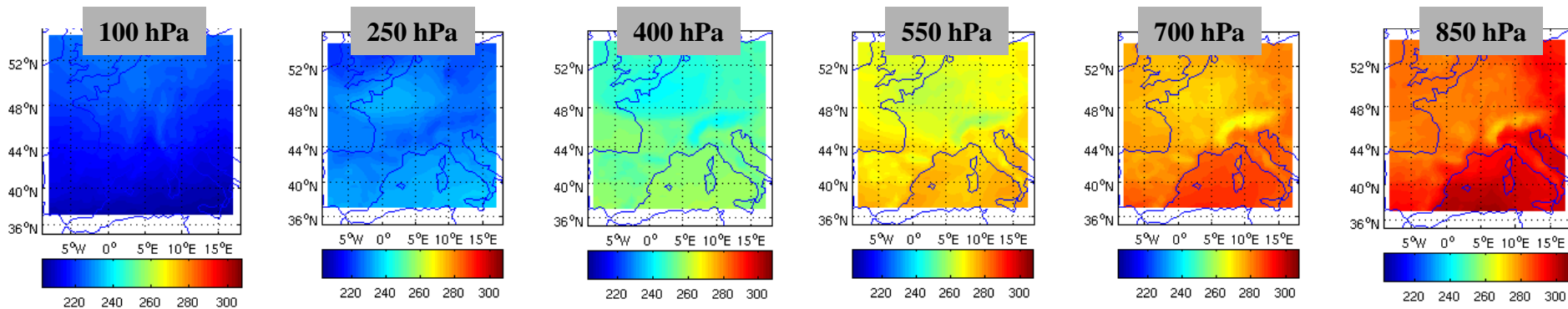


13 days : July 2013
(104 assimilation)
~ 2000 obs/levels
AROME domain

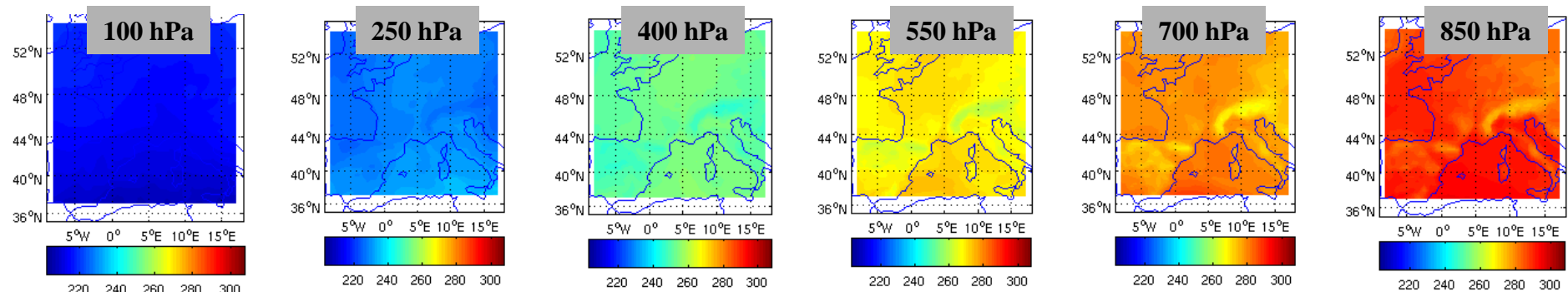
Evaluation of the Nature Run

Maps of averaged temperature fields produced by the Nature Run vs the ARPEGE OPER forecast model over 1 month (July 2013)

Nature Run :

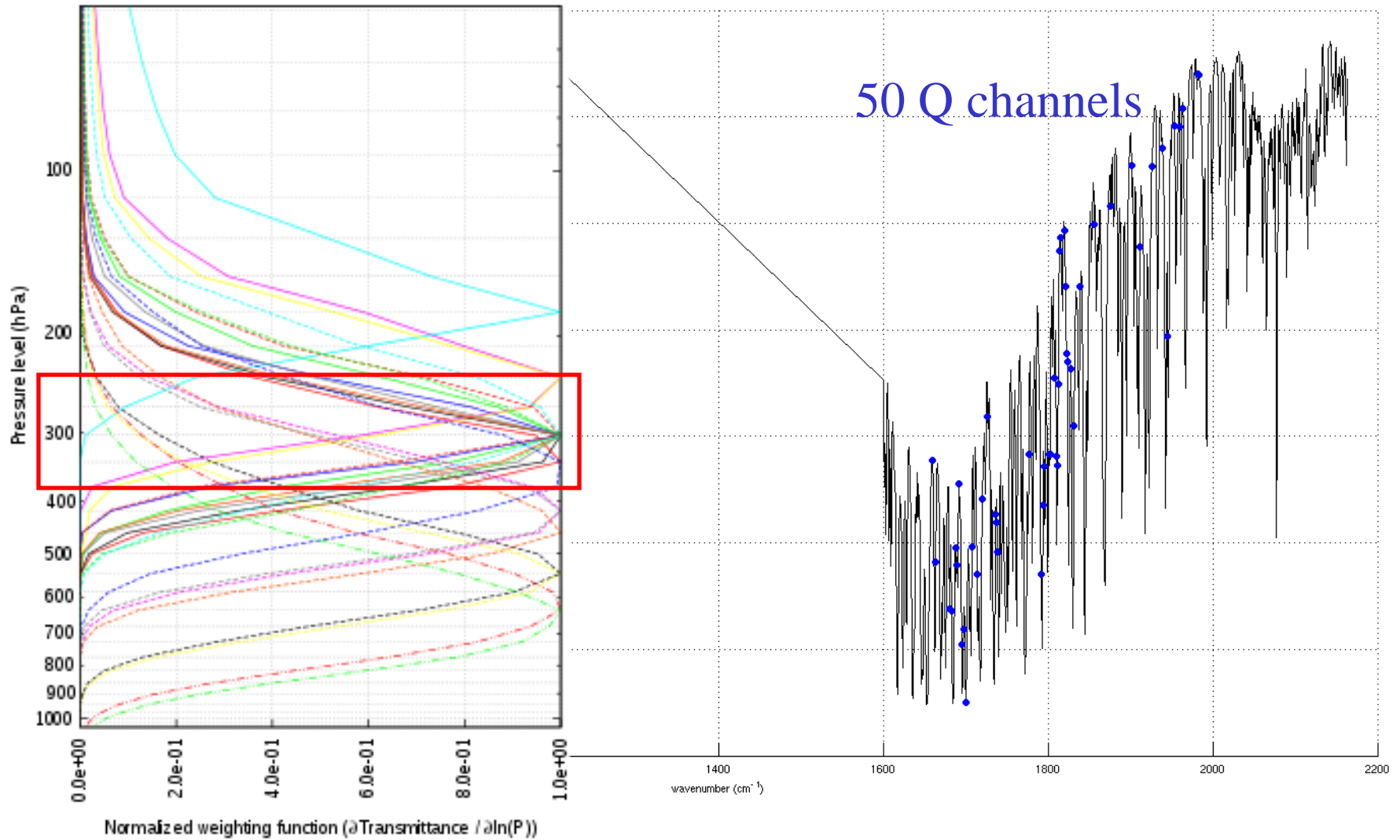


ARPEGE OPER forecast model :



Preparation for IRS : channel selection

Averaged IRS Bt simulated spectrum over the AROME domain

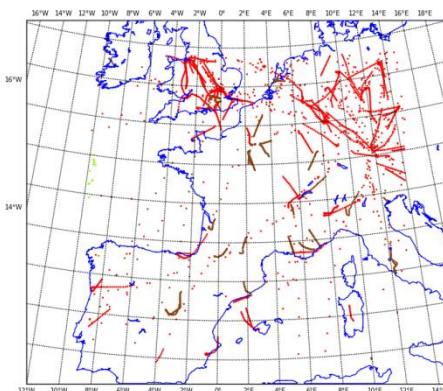


The observing system

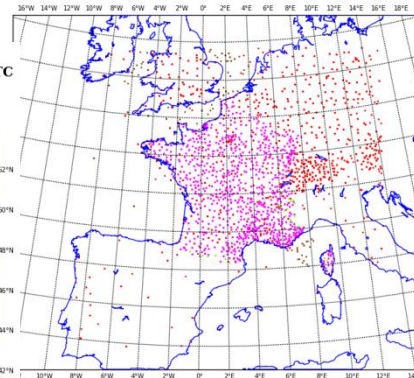
Conventional :

- Radiosondes
- Aircraft
- Ship / Buoy
- Profilers
- VAD winds
- Surface station
- ~~Reflectivities~~

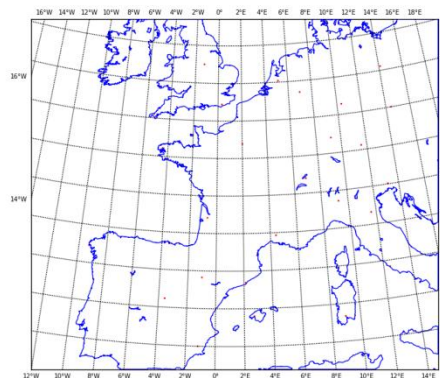
METEO-FRANCE couverture de donnees - AVIONS - 2014/03/03 12H UTC
Nombre total d'observations avant screening : 3685



METEO-FRANCE couverture de donnees - SYNOP/SHIP - 2014/03/04 00H UTC
Nombre total d'observations avant screening : 4823



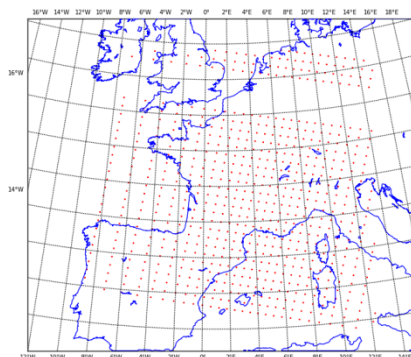
-FRANCE couverture de donnees - TEMP - 2014/03/04 00H UTC
Nombre total d'observations avant screening : 28



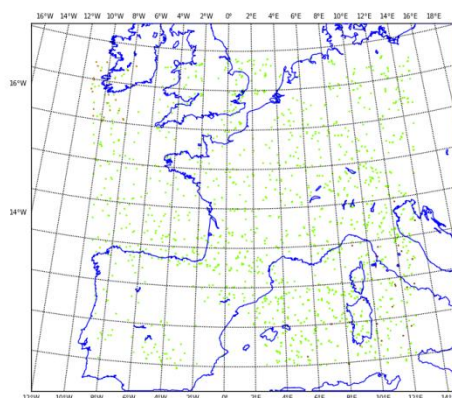
Satellite :

- ATMS
- AMSU-A
- MHS / AMSU-B
- AMVs
- GPS-SOL
- IASI / CrIS / AIRS
- SEVIRI
- HIRS

METEO-FRANCE couverture de donnees - CRIS - 2014/03/02 03H UTC
Nombre total d'observations avant screening : 707



METEO-FRANCE couverture de donnees - SATOB - 2014/03/04 00H UTC
Nombre total d'observations avant screening : 1571



FRANCE couverture de donnees - GPS - 2014/03/04 00H UTC
Nombre total d'observations avant screening : 11642

