Geo-satellite monitoring and Dust detection with IR measurements in the weather forecast

EUMETSAT Fellow Day
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ECMWF

Plan

- Geo-satellite
  - GOES.
  - Himawari-8.
  - Meteosat-11.
- Dust detection in global data assimilation
  - Aerosol dust specification
  - IR instruments
  - Theory
  - Results

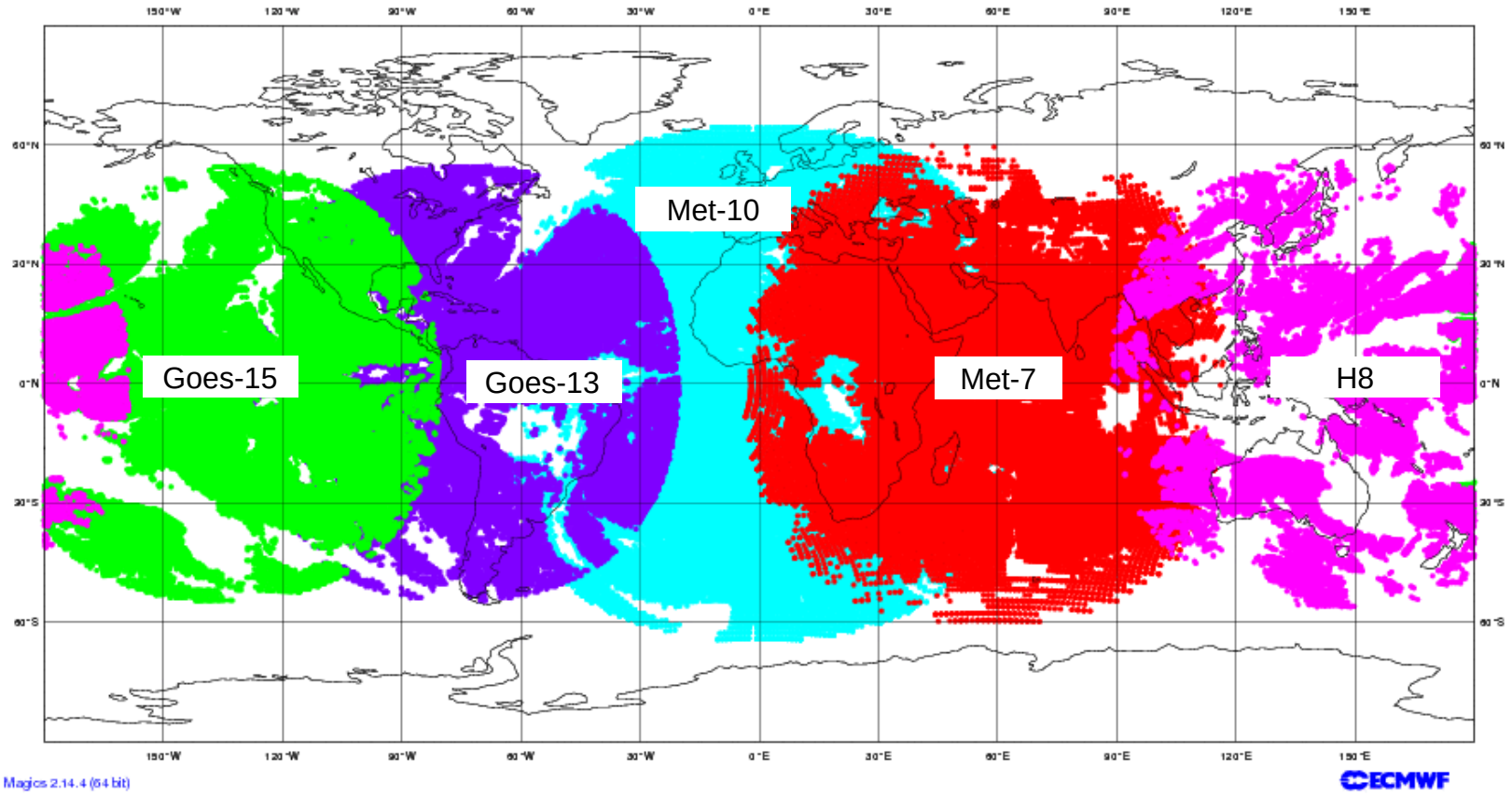
Plan

- Geo-satellite
  - GOES.
  - Himawari-8.
  - Meteosat-11.

- Dust detection in global data assimilation

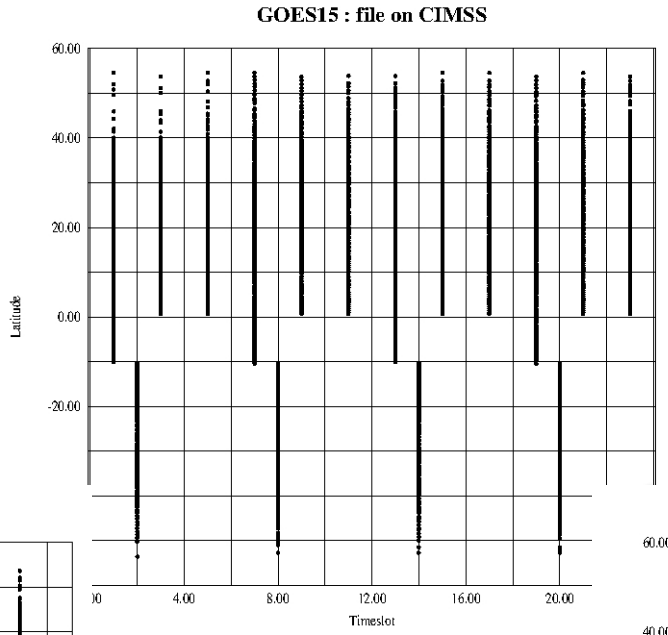
Geo-satellite monitoring

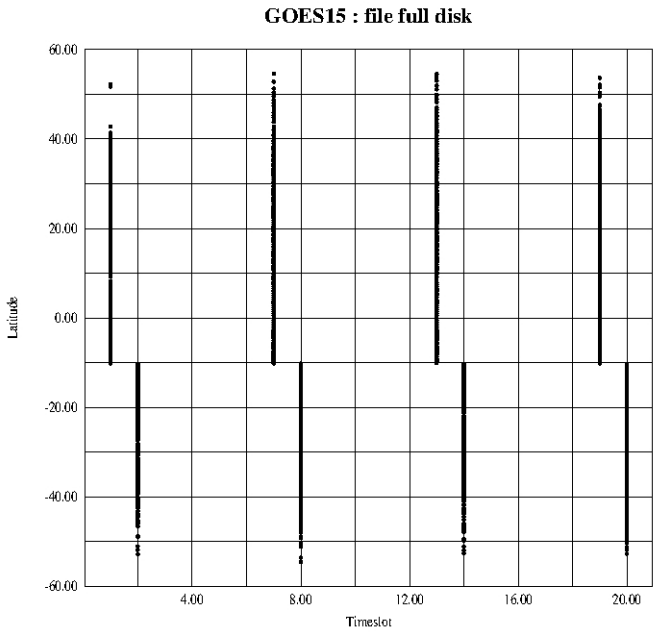
ECMWF Data Coverage (All obs DA) - GRAD
20/Feb/2015; 00 UTC
Total number of obs = 437855



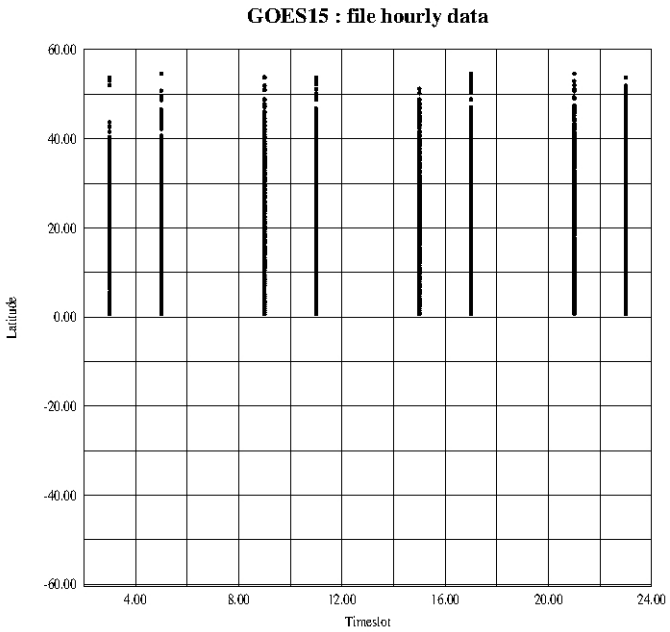
GOES 13 & 15

16th April 2015 : data received from NESDIS (CIMSS before).





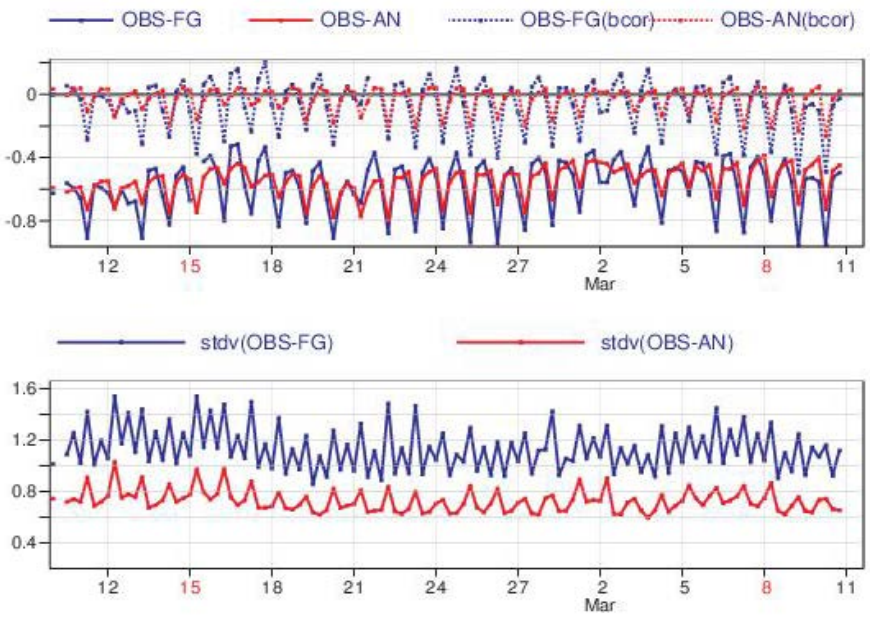
NESDIS



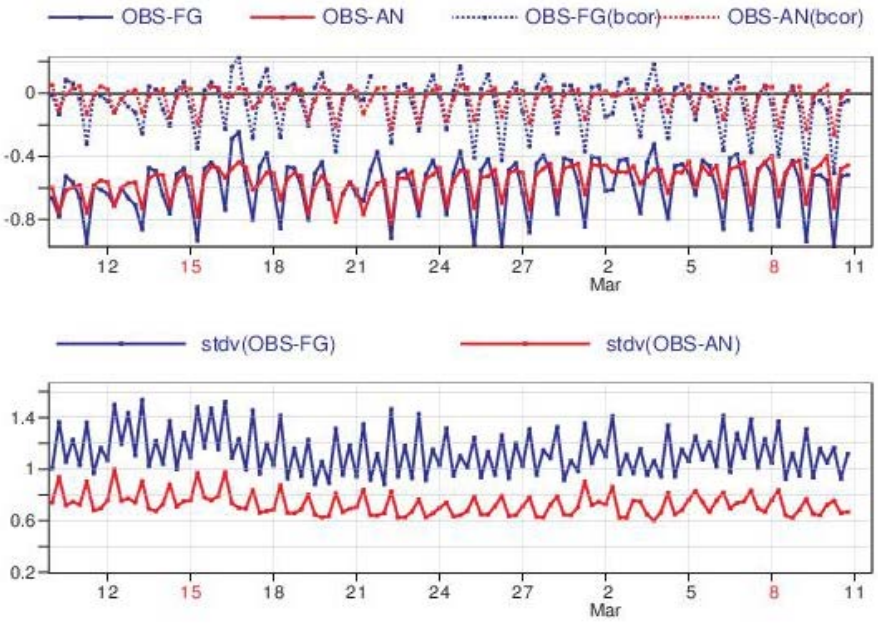
GOES 13 & 15

Transition between CIMSS and NESDIS was done with success.

CIMSS



NESDIS



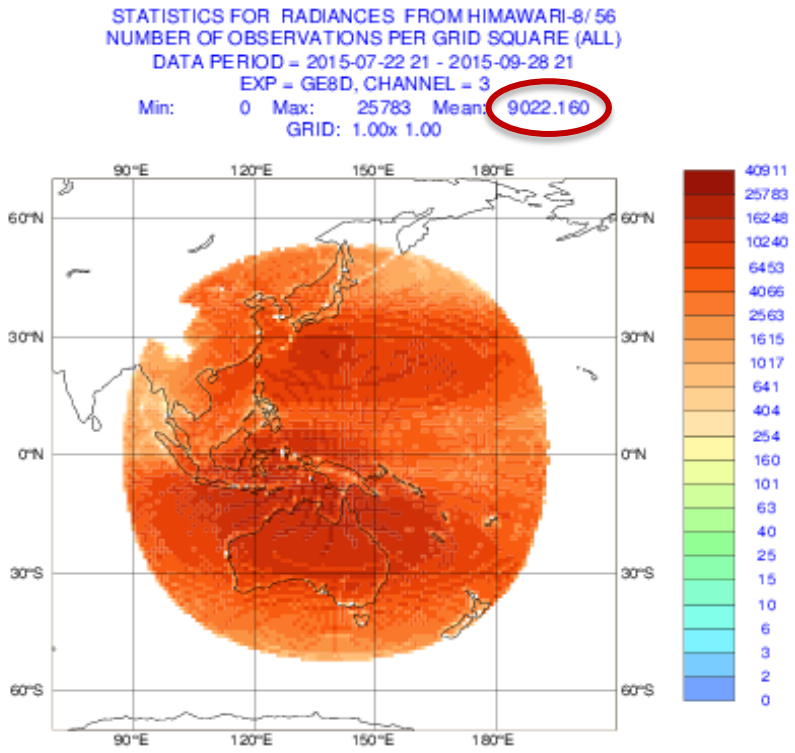
Himawari-8 : Operational assimilation

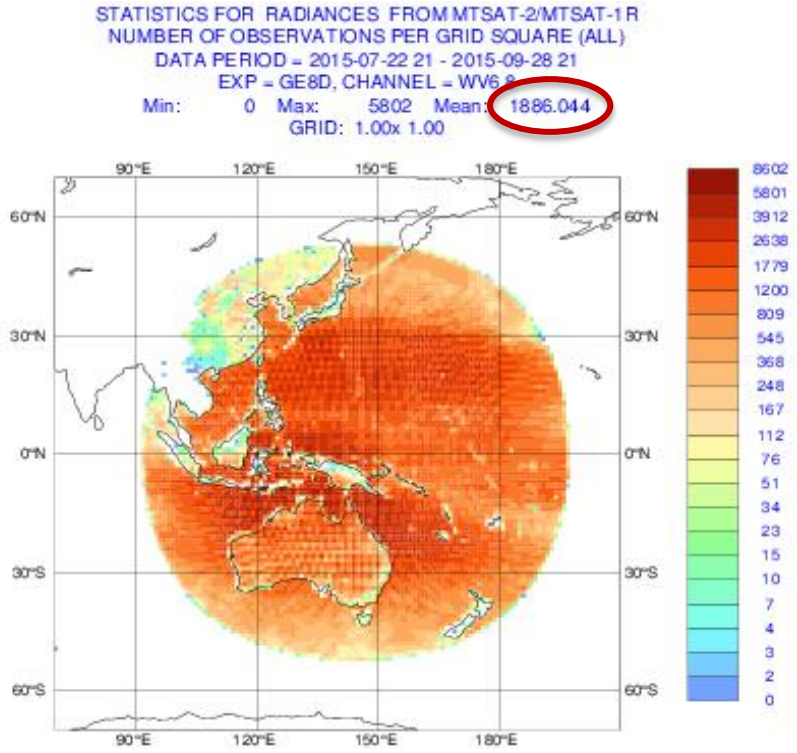
14th December 2015 : operational monitoring for Himawari-8 CSR

12th January 2016 : Assimilation of Himawari-8 CSR / end of MTSAT-2 CSR

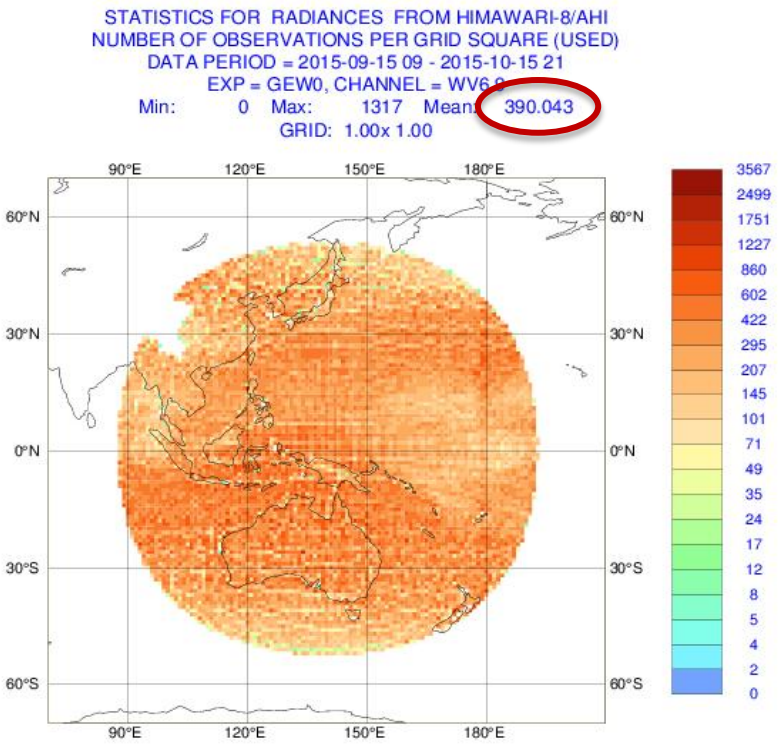
	MTSAT		HIMAWARI	
	Central wavelength (μm)	Spatial Resolution (km)	Central wavelength (μm)	Spatial Resolution (km)
Visible	0.55 – 0.90	1 km	0.43 - 0.48	1 km
			0.50 – 0.52	
			0.63 – 0.66	0.5 km
Near Infrared			0.85 – 0.87	1 km
			1.60 – 1.62	2km
			2.25 – 2.27	
Infrared	3.50 – 4.00	4 km	3.74 – 3.96	2 km
			6.06 – 6.43	
	6.50 – 7.00		6.89 – 7.01	
			7.26 – 7.43	
			8.44 – 8.76	
			9.54 – 9.72	
	10.3 – 11.3		10.3 – 10.6	
			11.1 – 11.3	
	11.5 – 12.5		12.2 – 12.5	
			13.2 – 13.4	

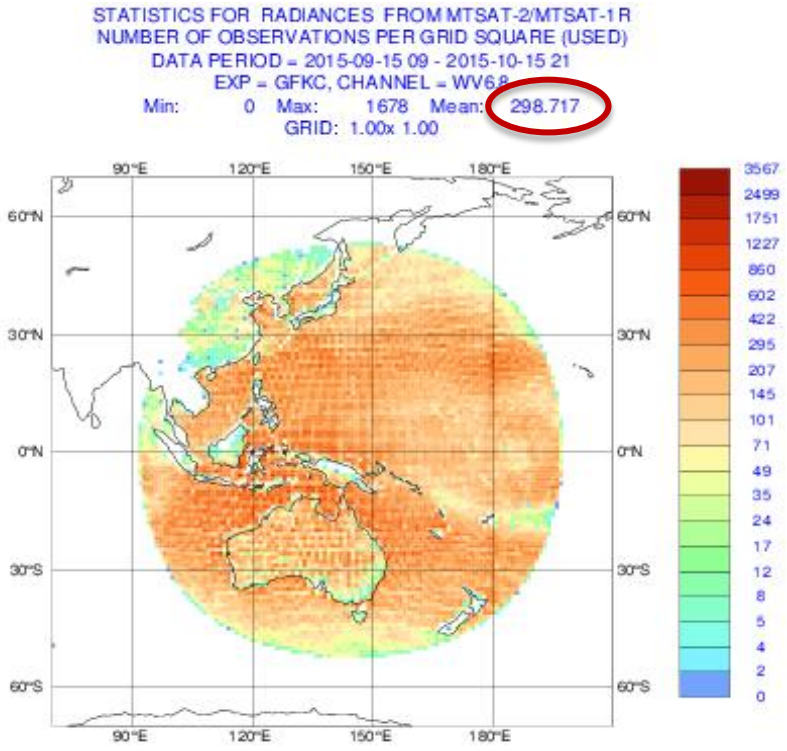
Himawari-8 : Operational assimilation



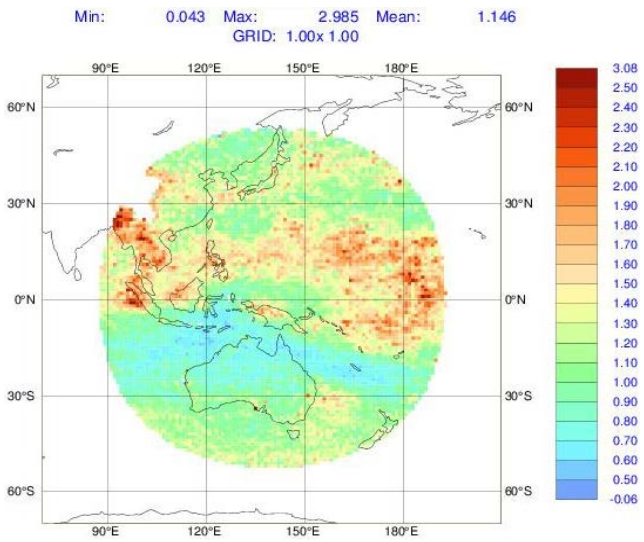


Himawari-8 : Operational assimilation



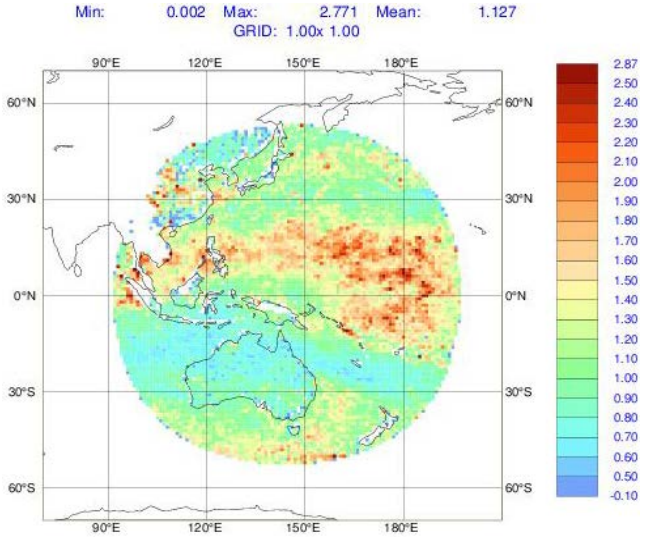


Himawari-8 at 6.8 micron

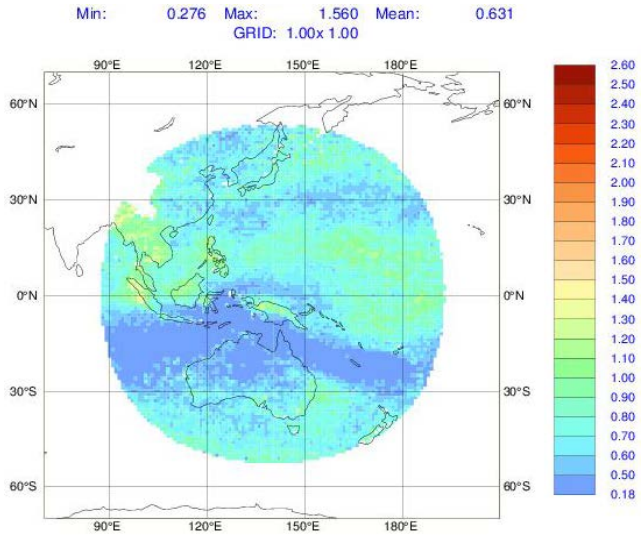


Himawari-8

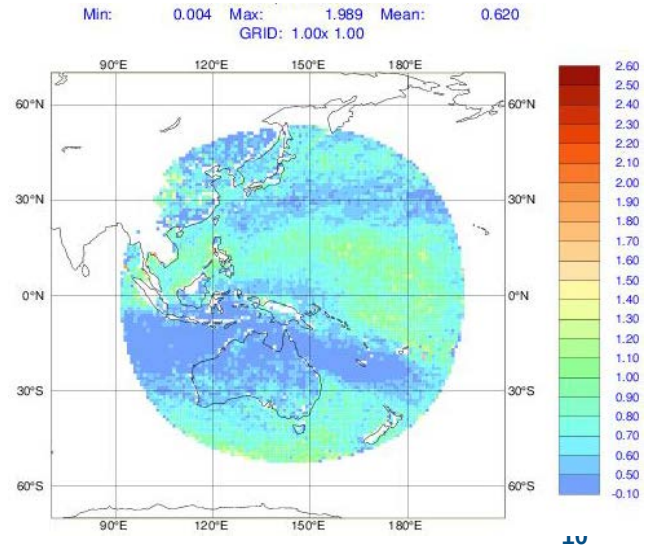
Obs-Fg



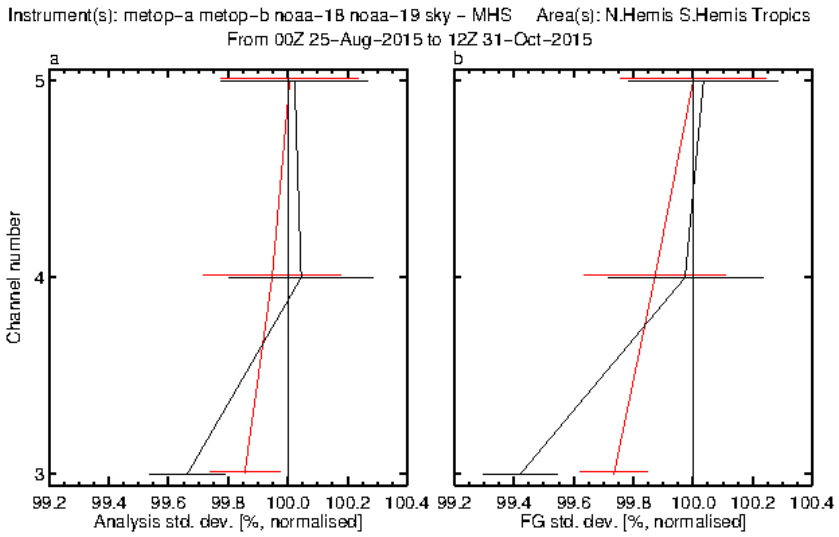
MTSAT-2

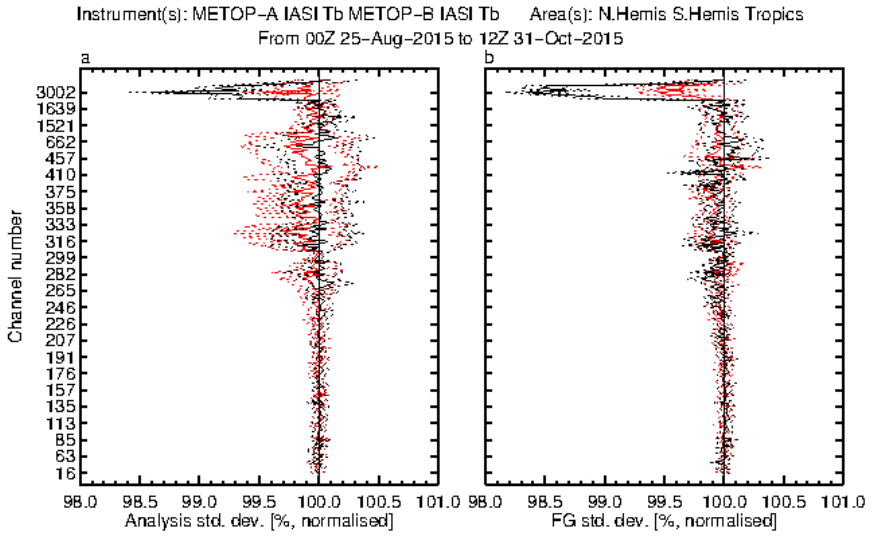


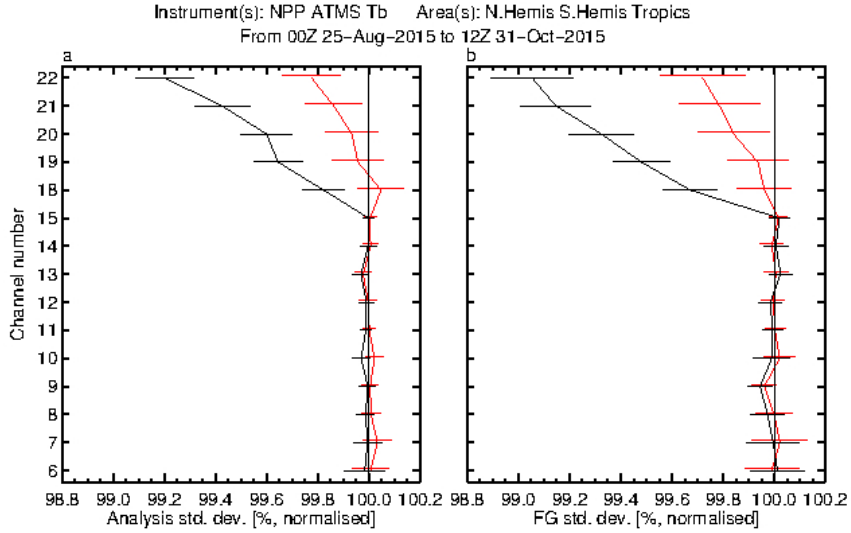
Obs-An

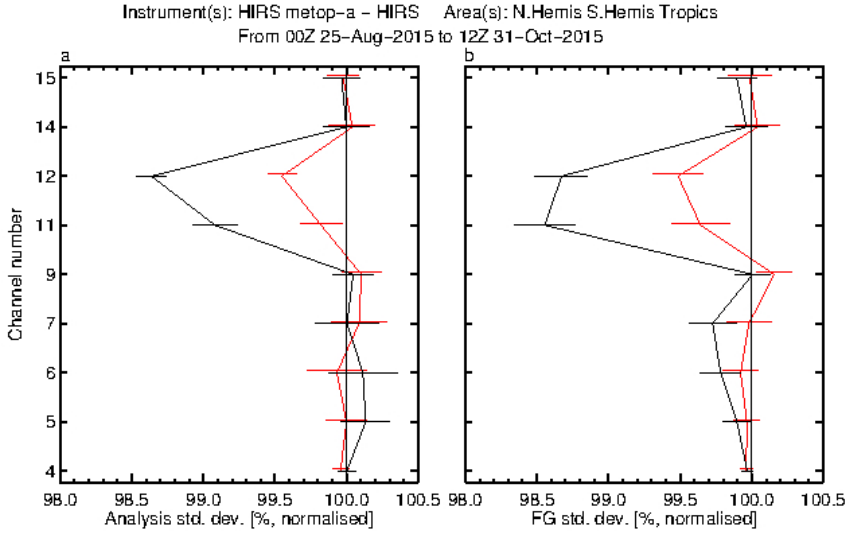


Himawari-8 : Operational assimilation







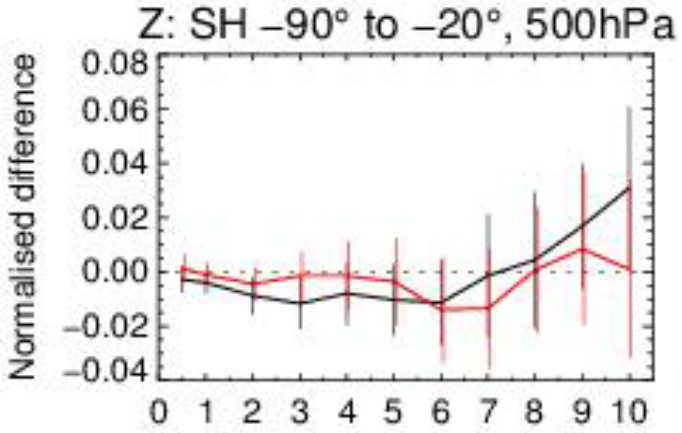


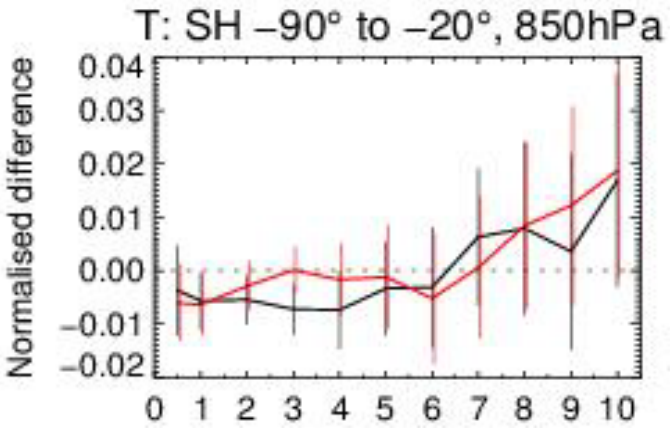
Under 100% : positive impact

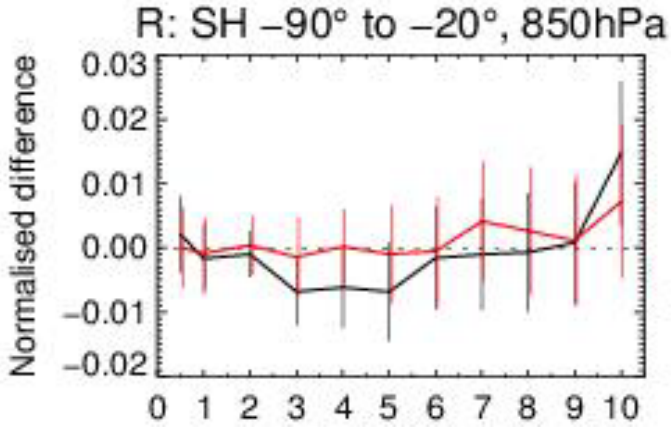
Red : MTSAT-2 assimilation

Black : Himawari-8 assimilation

Himawari-8 : Operational assimilation



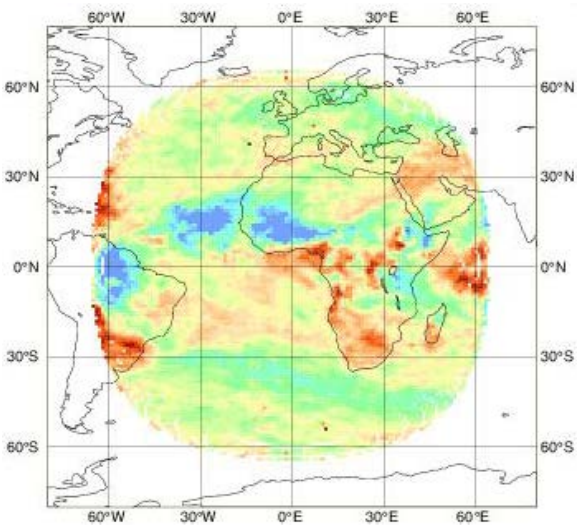


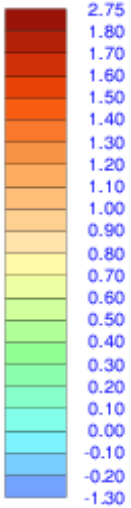


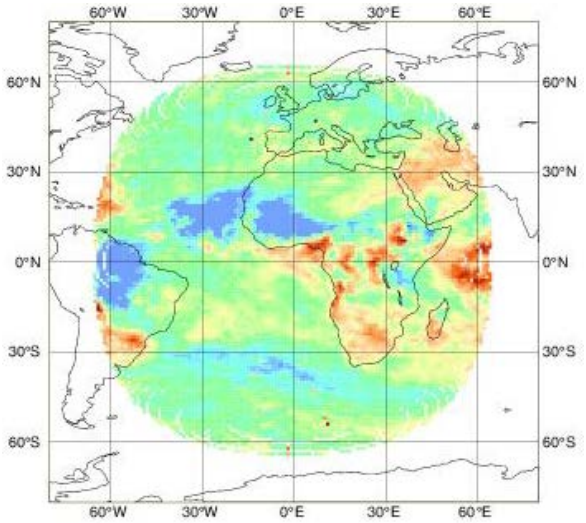
Under 0 : positive impact
Red : MTSAT-2 assimilation
Black : Himawari-8 assimilation

Meteosat-11 evaluation

25th September – 25th November 2015 : pre-operational monitoring for Meteosat-11 ASR



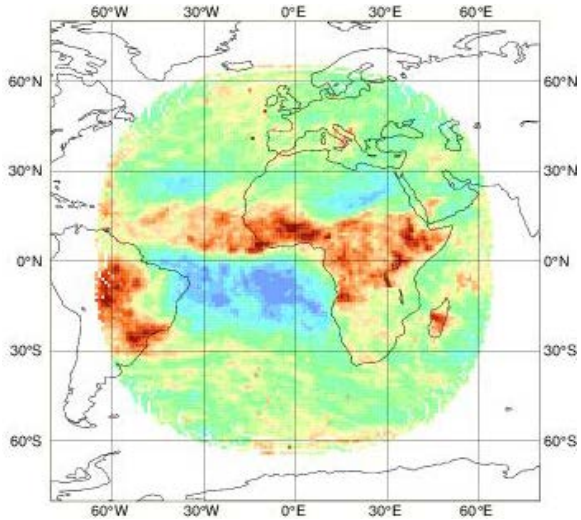


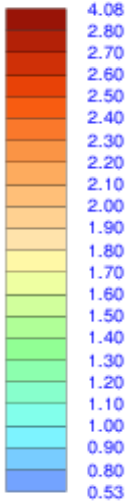


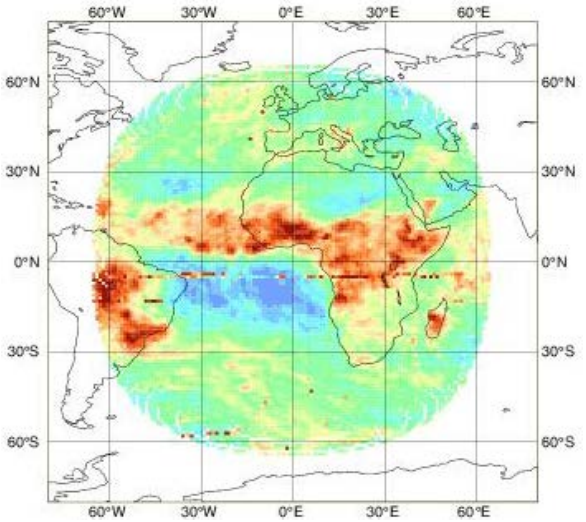
Mean (O-B)

Meteosat-11

Meteosat-10



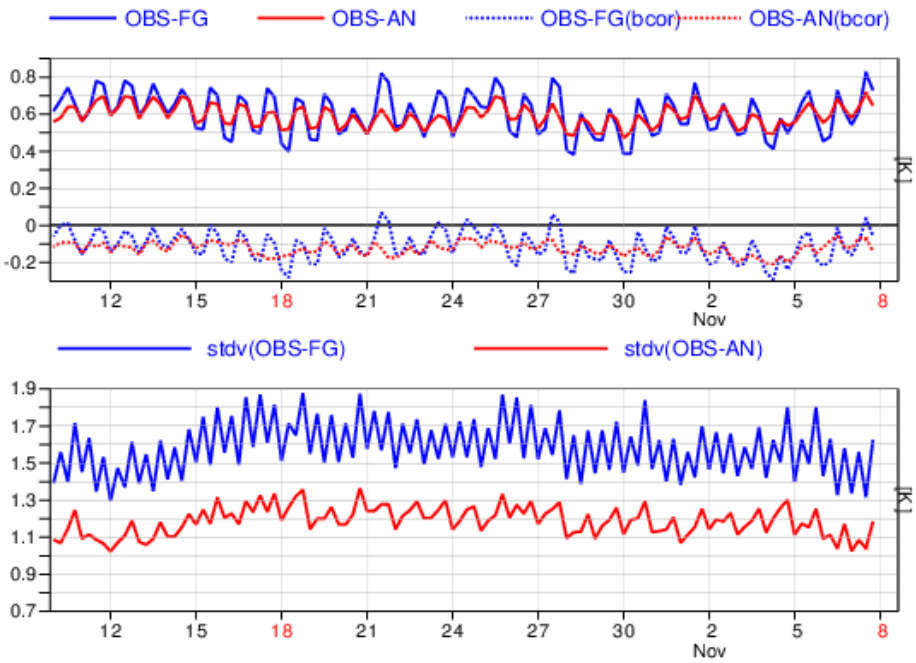




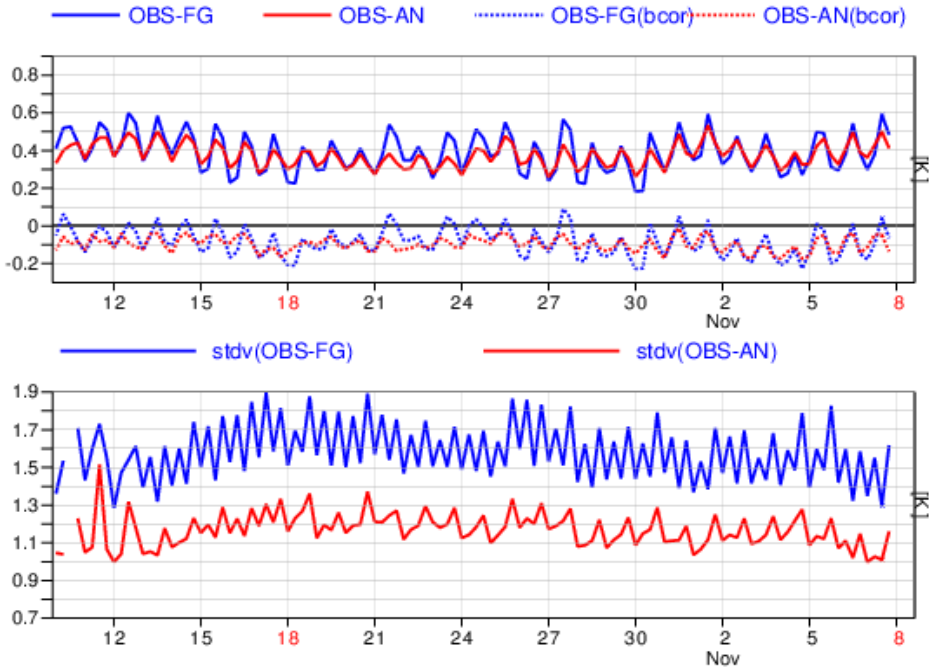
STDV (O-B)

Meteosat-11: Bias evaluation

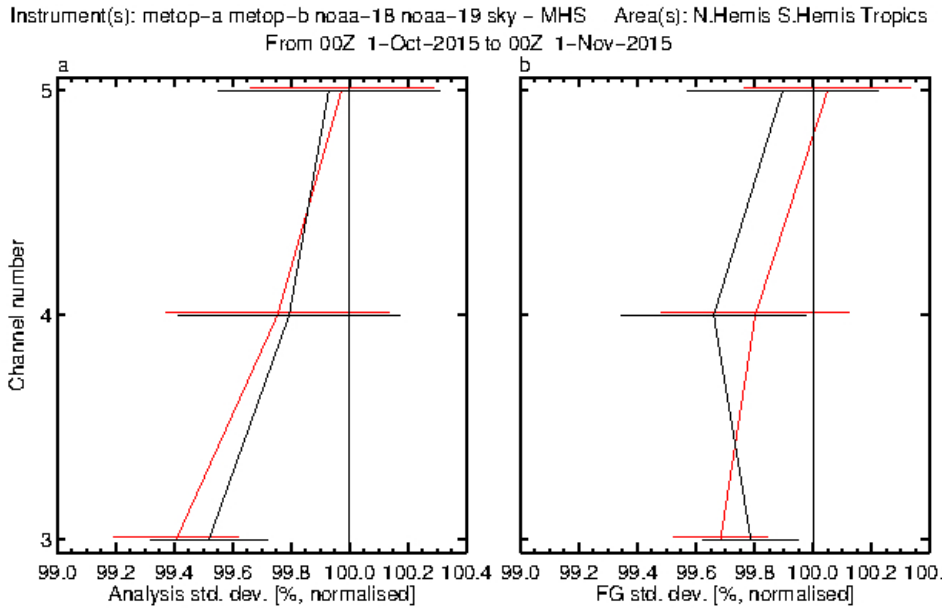
Meteosat-11



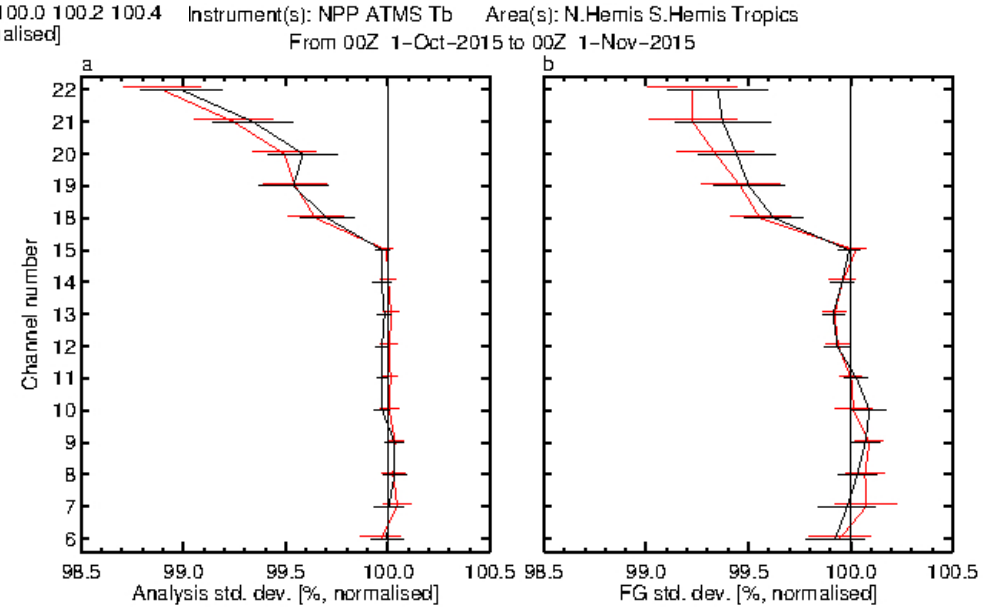
Meteosat-10



Meteosat-11 : assimilation evaluation



MHS



ATMS

Under 100% : positive impact
Red : MET-10 assimilation
Black : MET-11 assimilation

Conclusion

- GOES :
  - Neutral impact after BUFR file change.
- HIMAWARI-8 :
  - 3 water vapour channels assimilated (2 more than MTSAT-2).
  - Improvement of data quality (i.e. better cloud mask).
  - Improvement of analysis and forecast.
- METEOSAT-11 :
  - Good quality of data.
  - Equivalent impact on the system to METEOSAT-10.

Plan

- Geo-satellite

- Dust detection in global data assimilation
  - Aerosol dust specification
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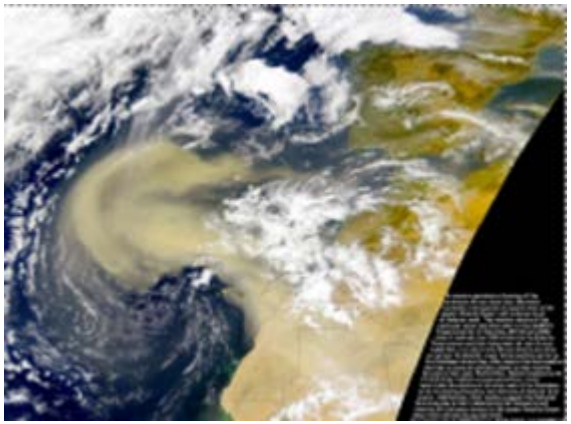
Aerosol specification

- Definition : small particles (solid or liquid) suspended in the atmosphere

Different tropospheric aerosol kind

Natural sources
(radius 1 to 10 µm)
Sea salt
Dust
Volcanic ash

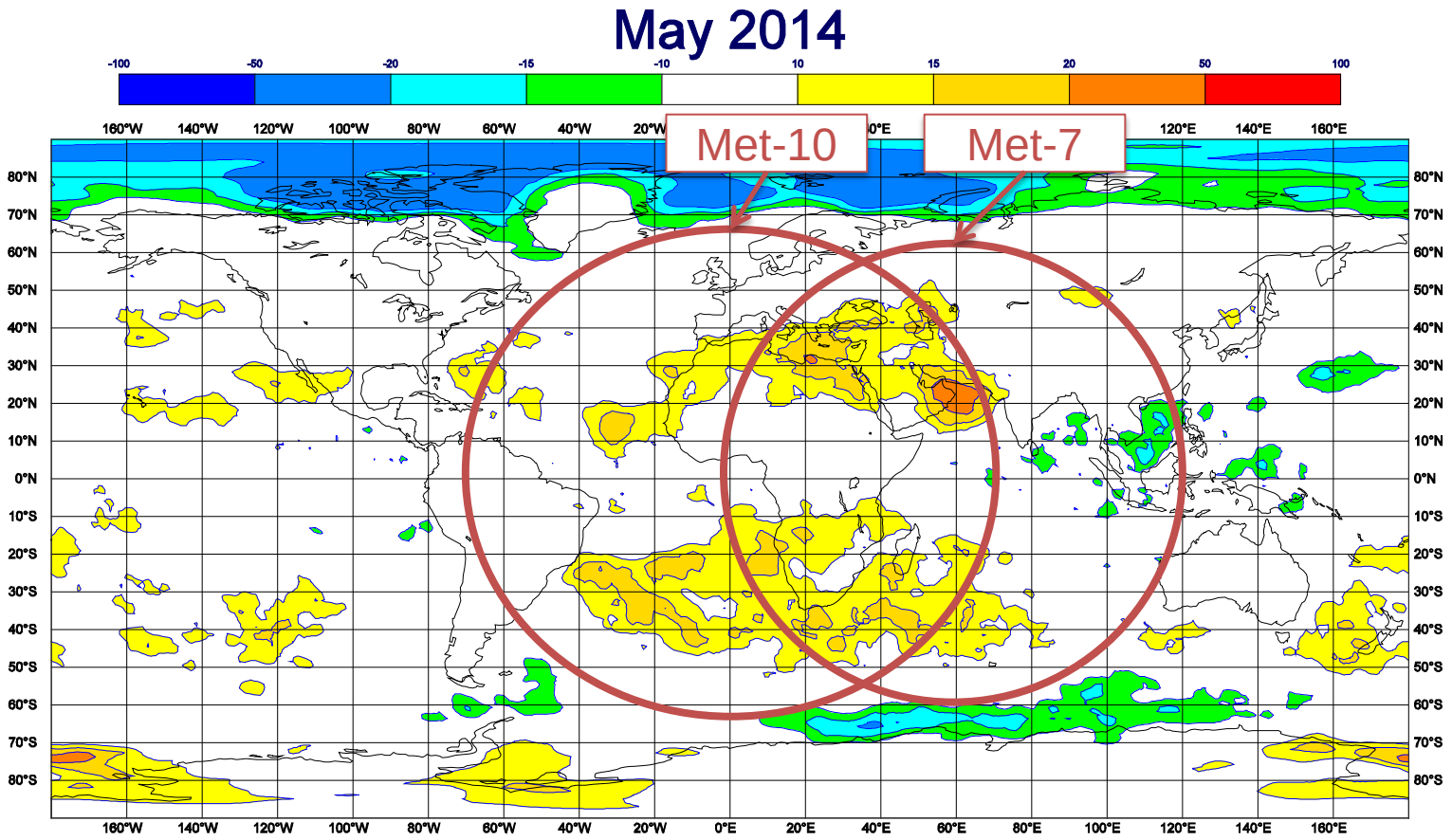


Quantity Desert Dust : 1500 10^9 kg/year

Human sources
Transformation gas-particle
SO – NO
Aitken kernel (nm)
Fin mode
(radius from 0.1 to 1 µm)

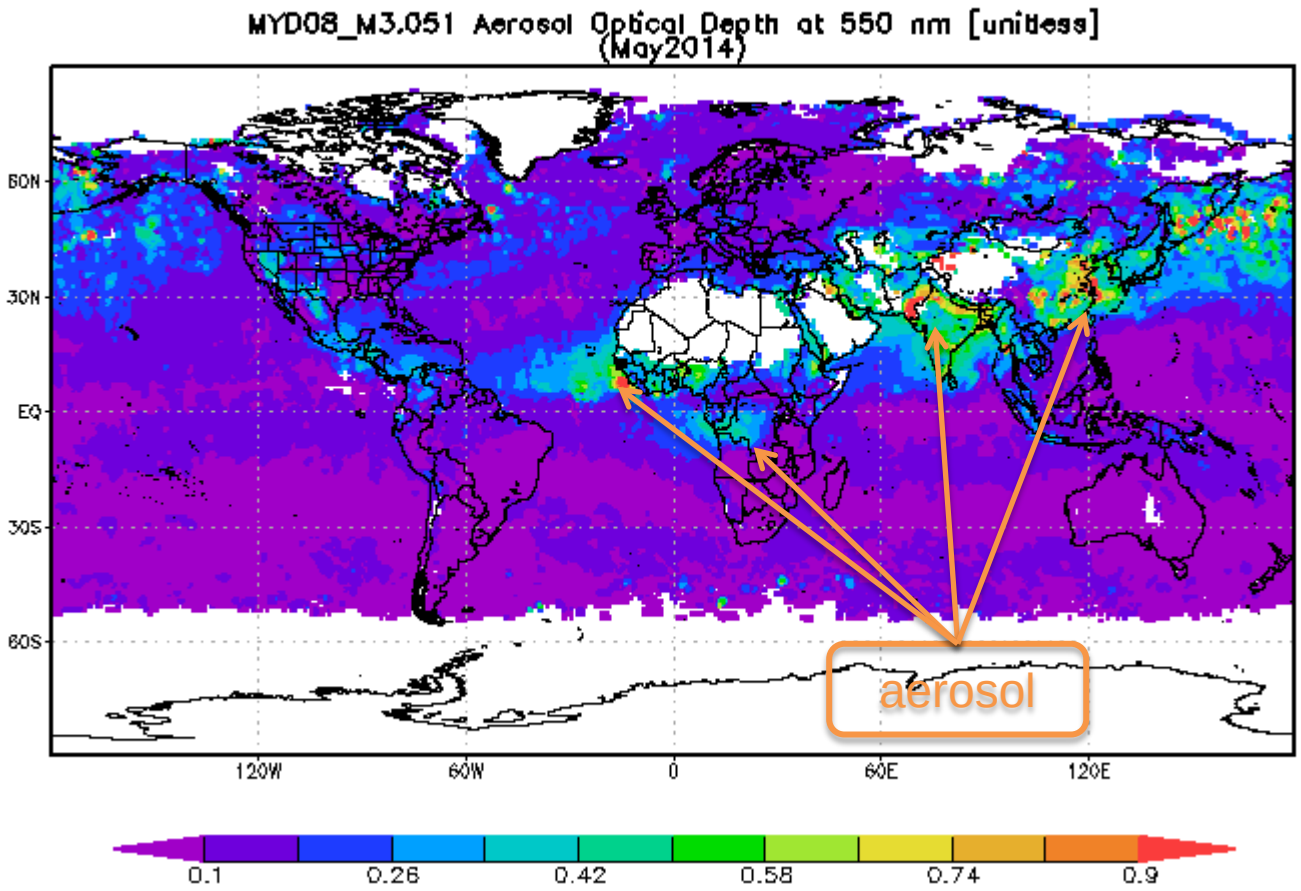
Mean impact from IR instruments on analysis (Z500)

What causing the overestimation of geo-potential at 500hPa under MET-10 and MET-7 track?



Aerosol Optical Depth at 500nm by MODIS

Some of IR impacts on analysis can be explain by dust contamination.



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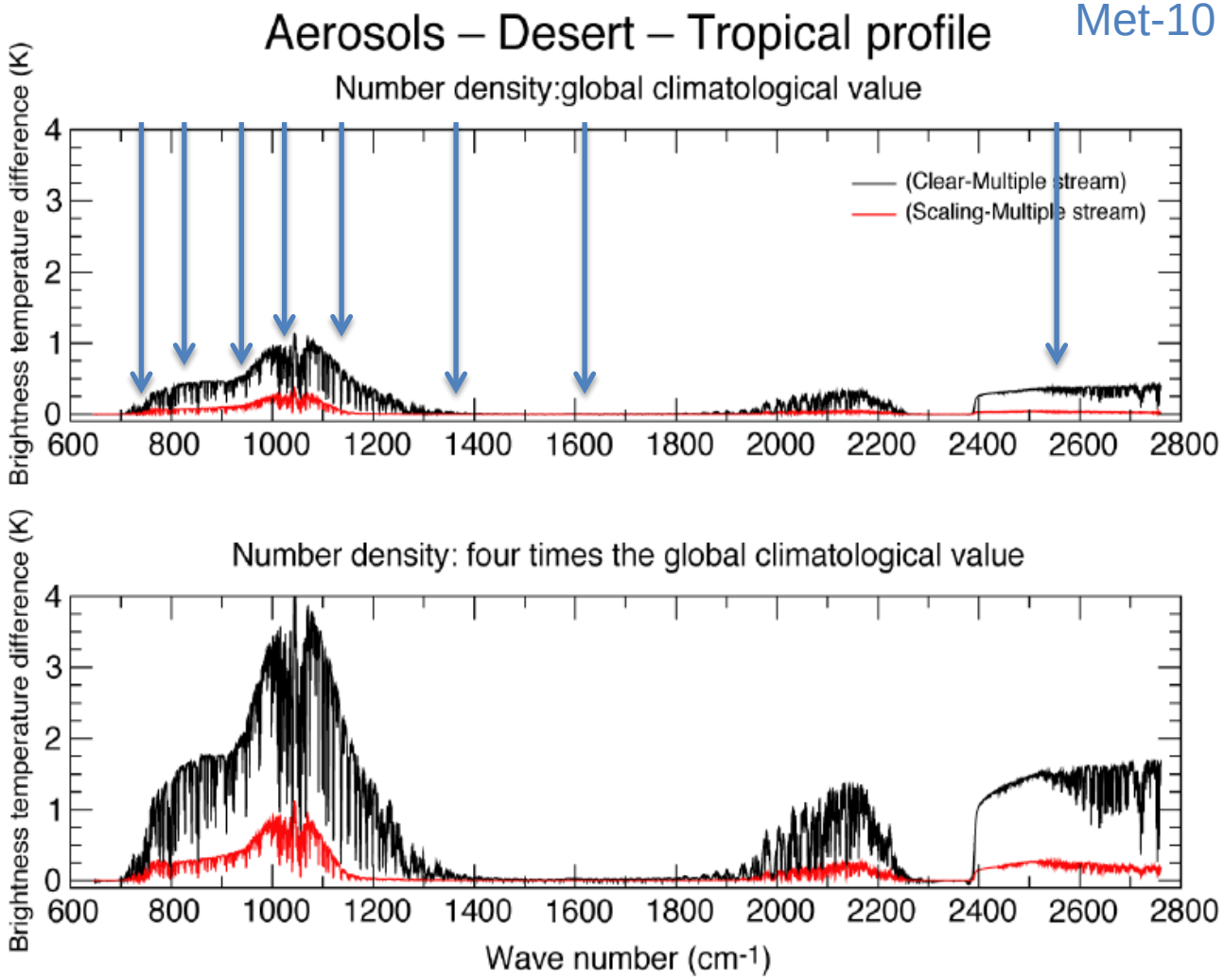
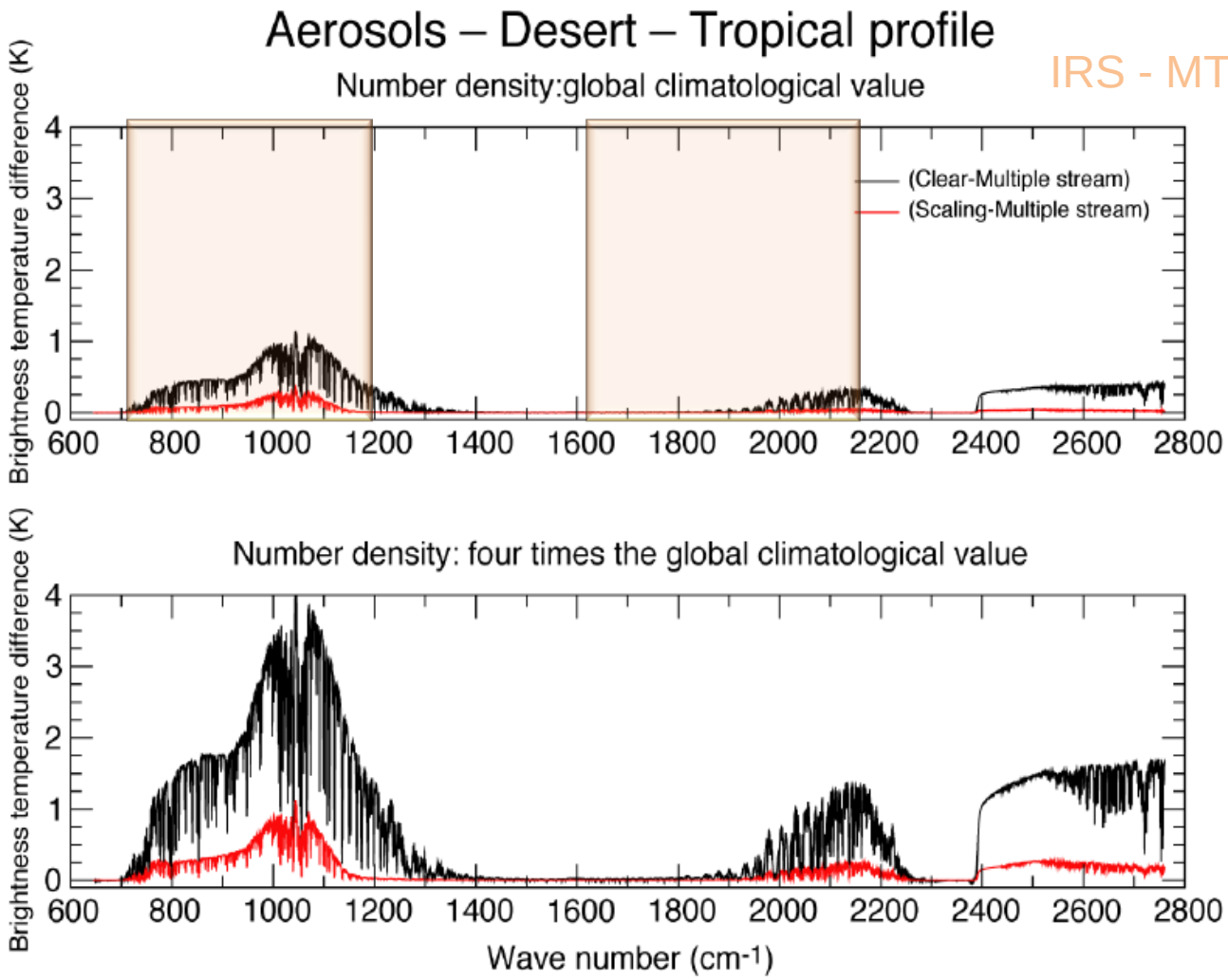
Dust impact on IR spectrum

Met-10



Matricardi, 2005

Dust impact on IR spectrum



IRS - MTG

Matricardi, 2005

IR Instrument

- IASI Instruments
  - Metop-A, launched 19th October 2006.
  - Metop-B, launched 17th September 2012.
  - Metop-C, will launch October 2018.
- AIRS Instrument
- CrIS Instrument(s)

Plan

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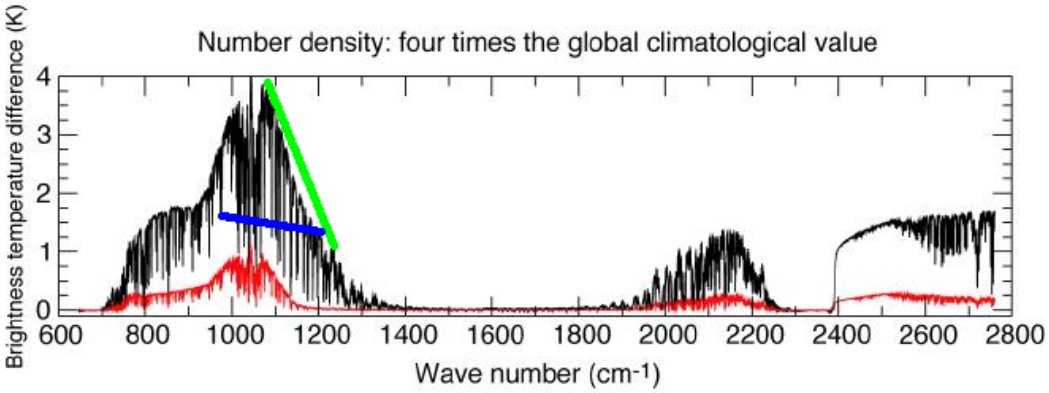
Theory

Peyridieux 2010: aerosol can be detect in infrared by Brightness Difference Temperature (BTD).

ECMWF : new dust detection on all pixels:

- ✓ 2 Brightness Temperature Differences (BTDs):
  - ➢ TB(10.2 µm) - TB(8.12 µm) = BTD1
  - ➢ TB(9.17 µm) - TB(8.10 µm) = BTD2
- ✓ TB(X µm) =mean[TB(643.5+0.25X µm);TB(646+0.25X µm)] (Y measurements)

IF BTD1 < Th1 AND BTD2 < Th2, PIXEL DECLEARS DUST



(Met-10 : 7.3, 8.7, 9.7, 10.8, 12 µm could be used)

Plan

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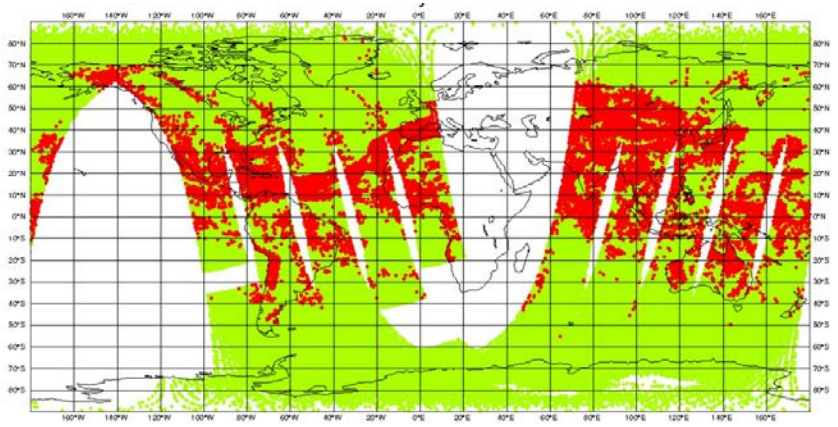
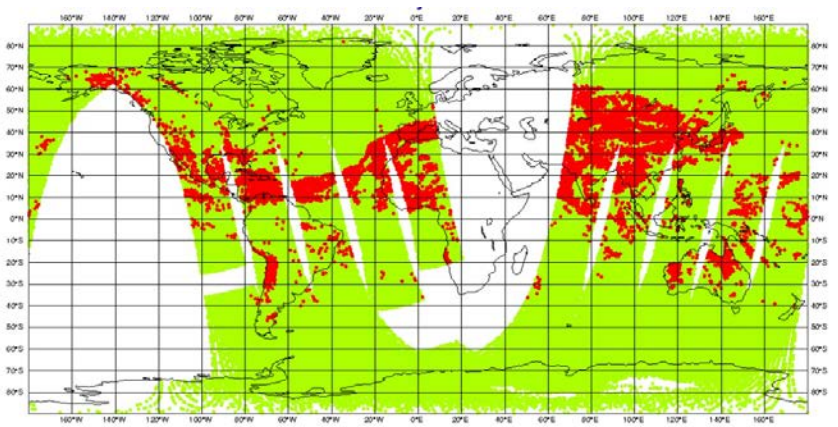
Evolution of aerosol detection at ECMWF

Detection done after bias correction

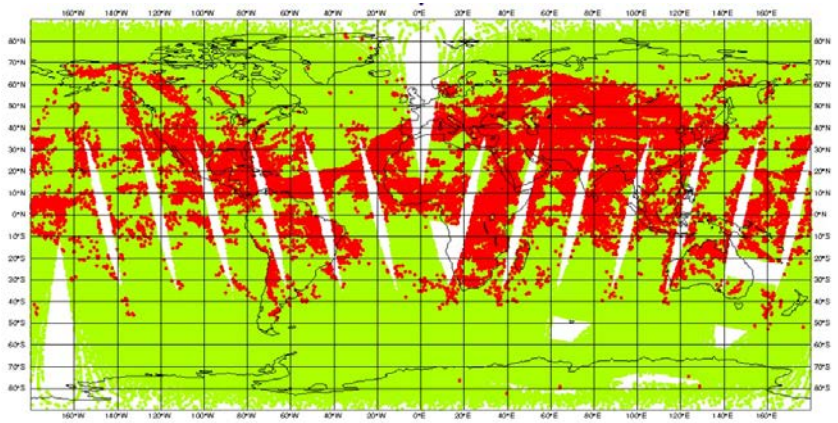
Detection done before bias correction

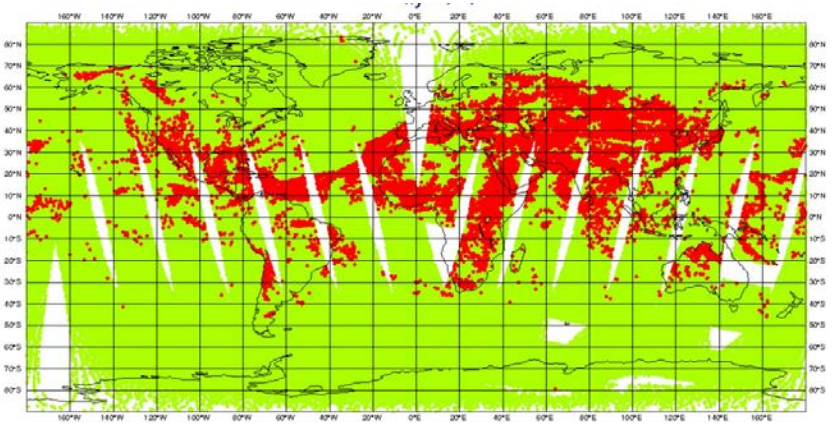
Metop-A





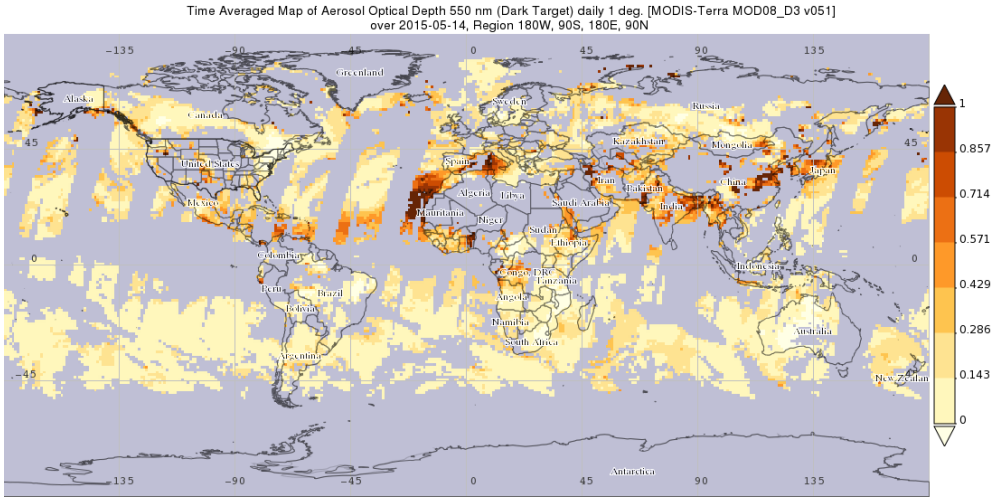
Metop-B



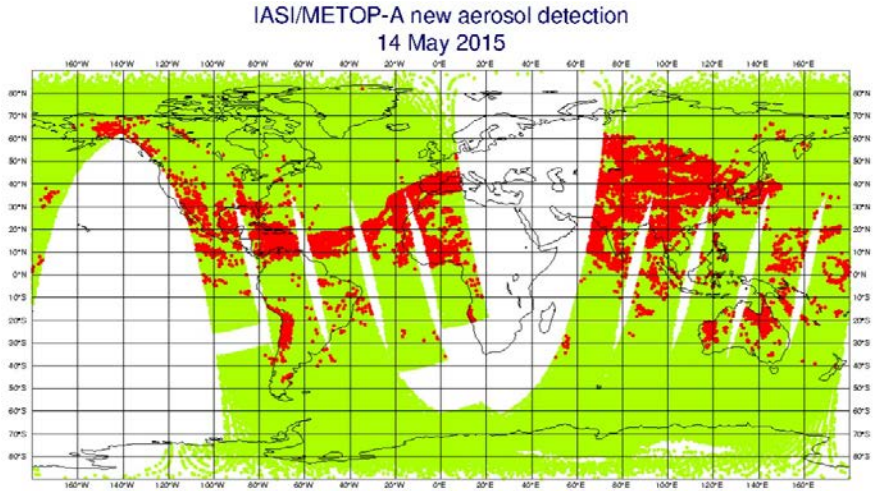


Red dots : aerosol detection

Agreement between IASI detection and MODIS AOD

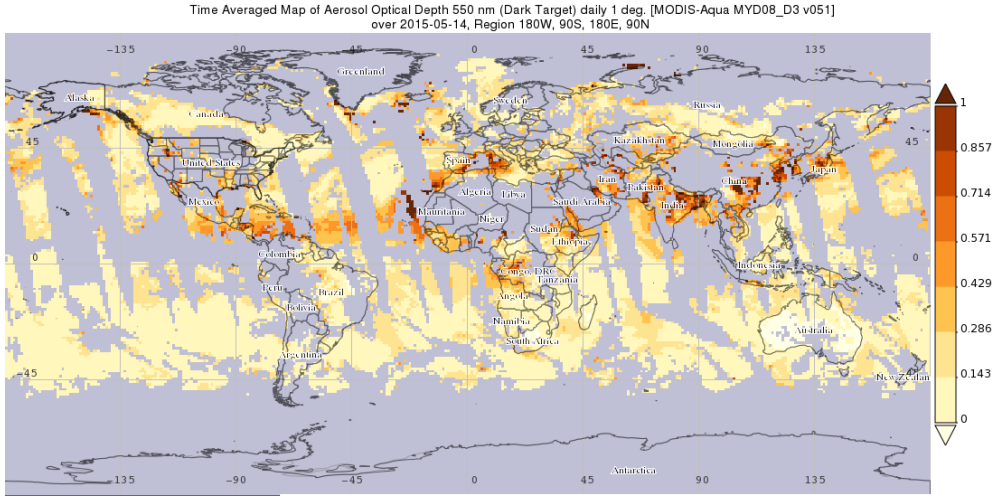


MODIS TERRA



IASI METOP-A

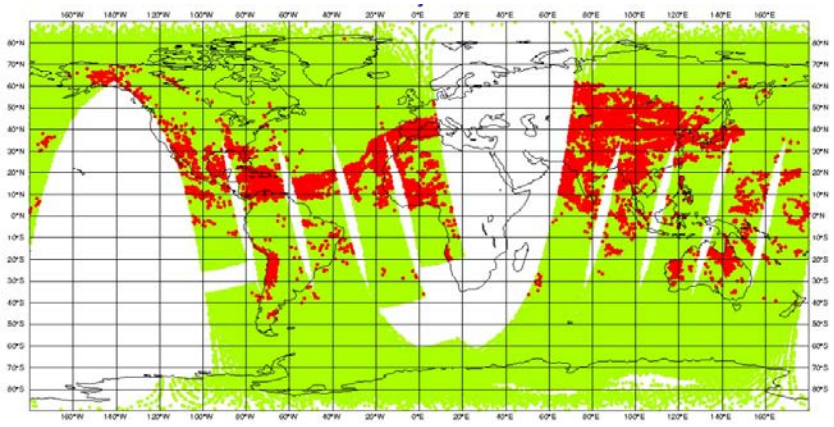
Red dots : aerosol detection



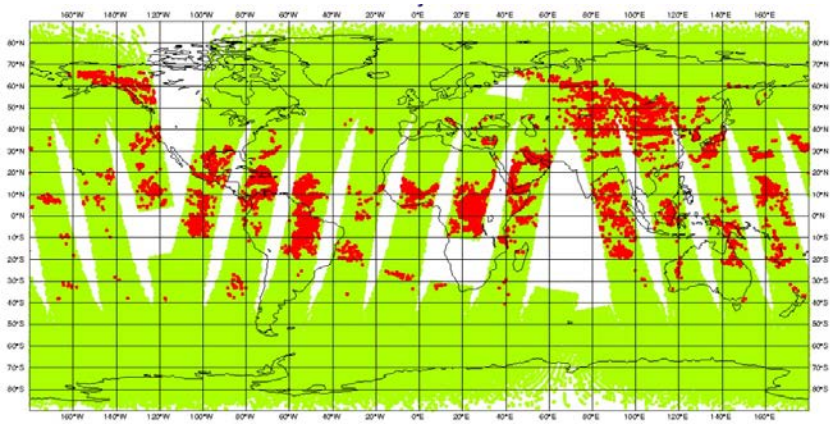
MODIS AQUA

Aerosol detection on all IR instruments

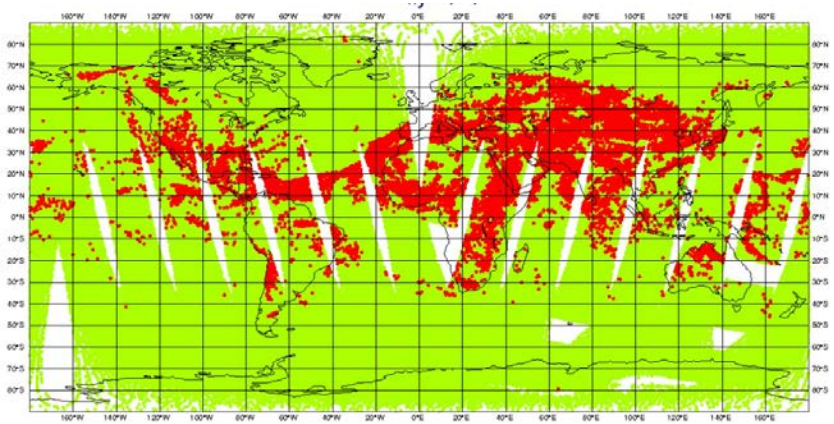
IASI METOP-A



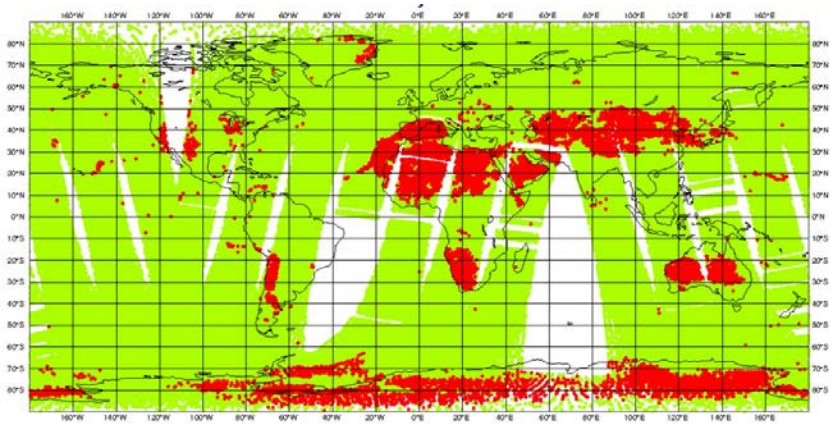
AIRS



IASI METOP-B



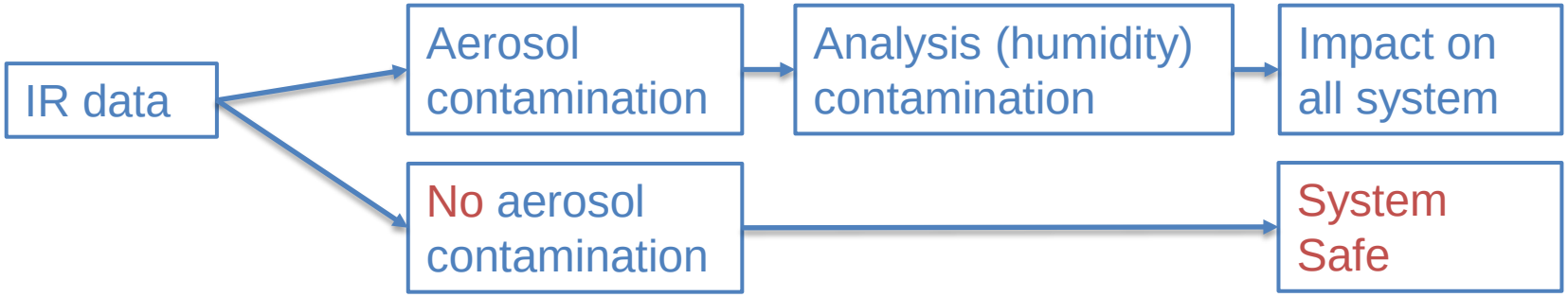
CrIS



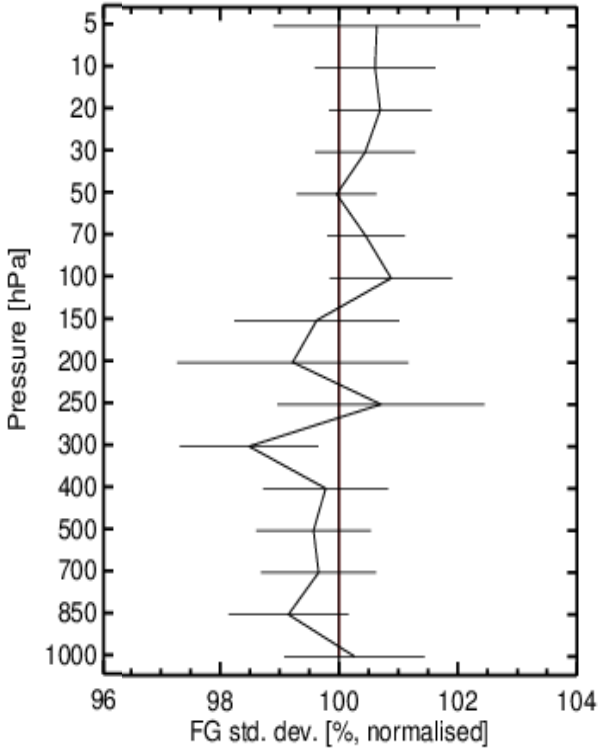
Red dots : aerosol detection

AIRS and CrIS are still in optimisation phase.

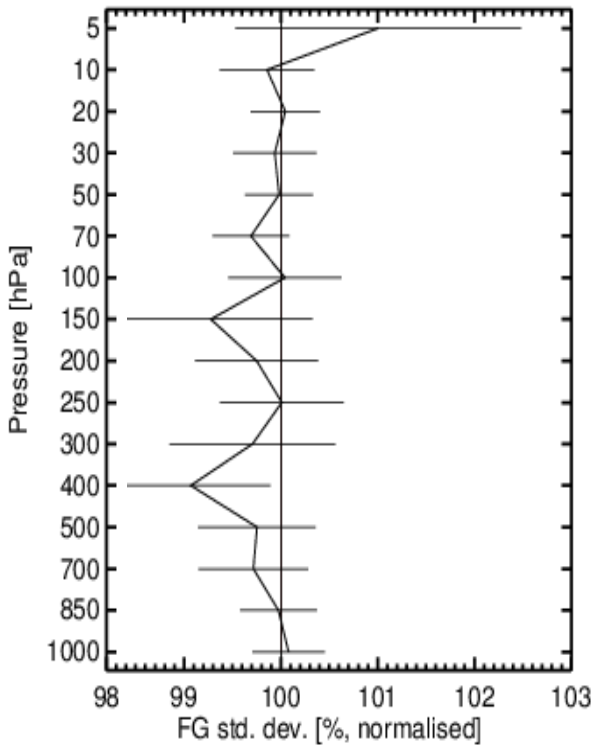
Results : Positive impact on other instruments (TROPICS)



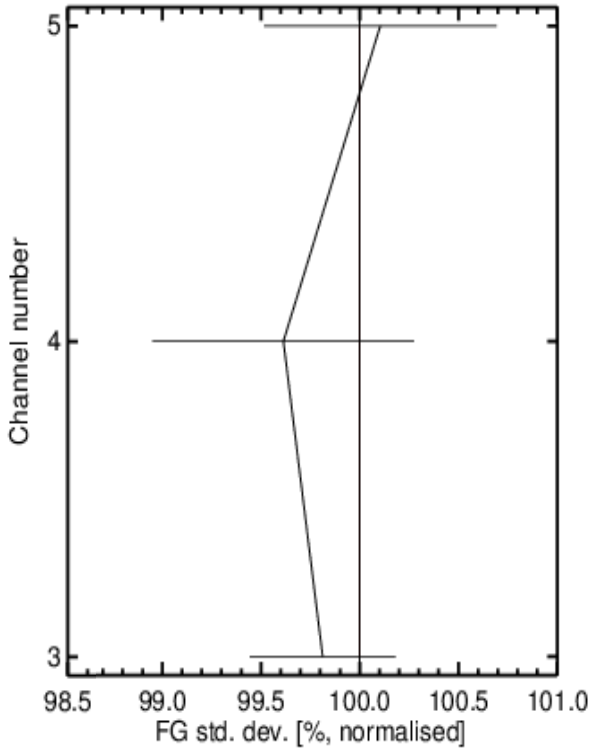
TEMP-T



Uwind-Vwind



MHS

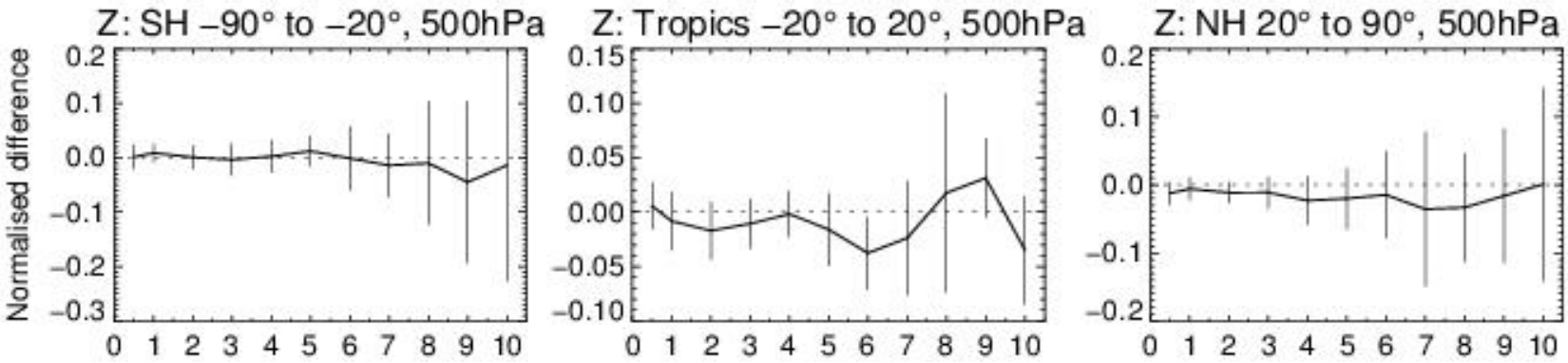


Under 100% : positive impact

Results : positive impact on forecast

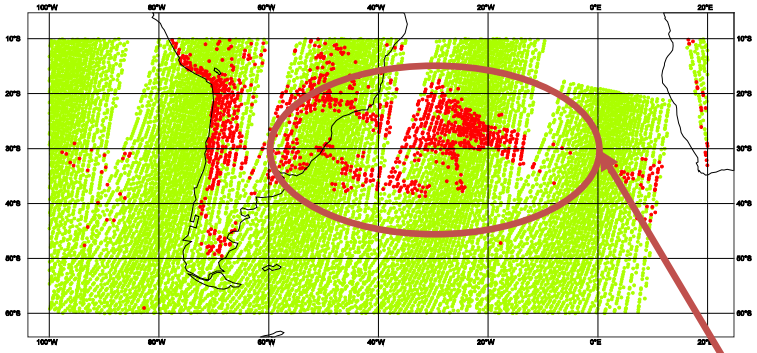
Impact of aerosol detection on the forecast:

- South hemisphere is not contaminated by dust.
- North hemisphere is contaminated by aerosol (Mediterranean and Japan areas)
- Tropics are strongly contaminated by dust (Atlantic and Indian oceans)

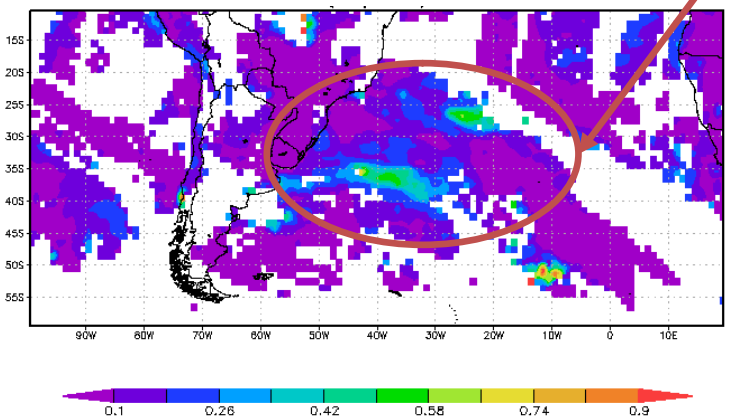


Extension to volcanic ash

Volcanic eruption Chile 23rd April 2015 : 4 days later

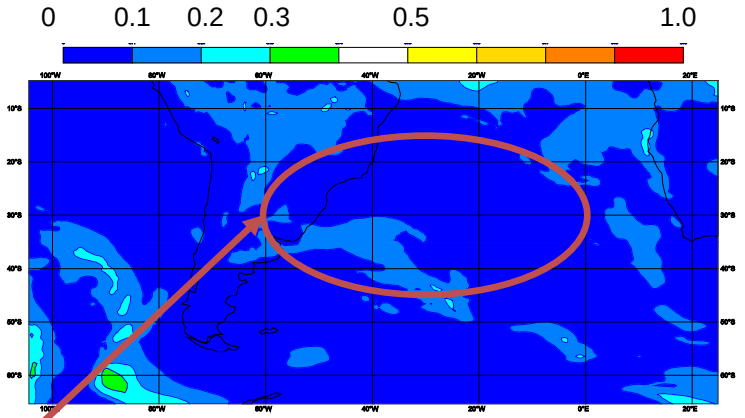


Locations (red dots) where IASI spectra are rejected in 41R2 due to excessive aerosol contamination

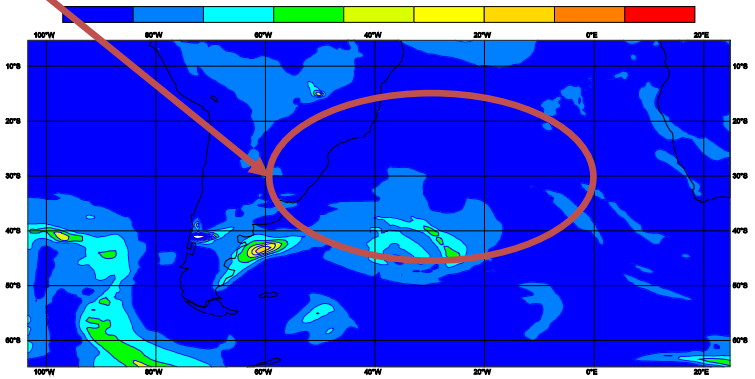


Aerosol Optical Depth (AOD) at 550 nm estimated from MODIS

Plume migration and extension



AOD at 550 nm estimated from the MACC real time product (i.e without emission)



AOD at 550 nm estimated from the MACC with source

Conclusion

- Aerosol detection on IASI improved
- Extension on other high spectral resolution Infrared instruments (AIRS and CrIS).
- Positive impact on analysis and forecast.
- Protection from volcanic ash too

Summary

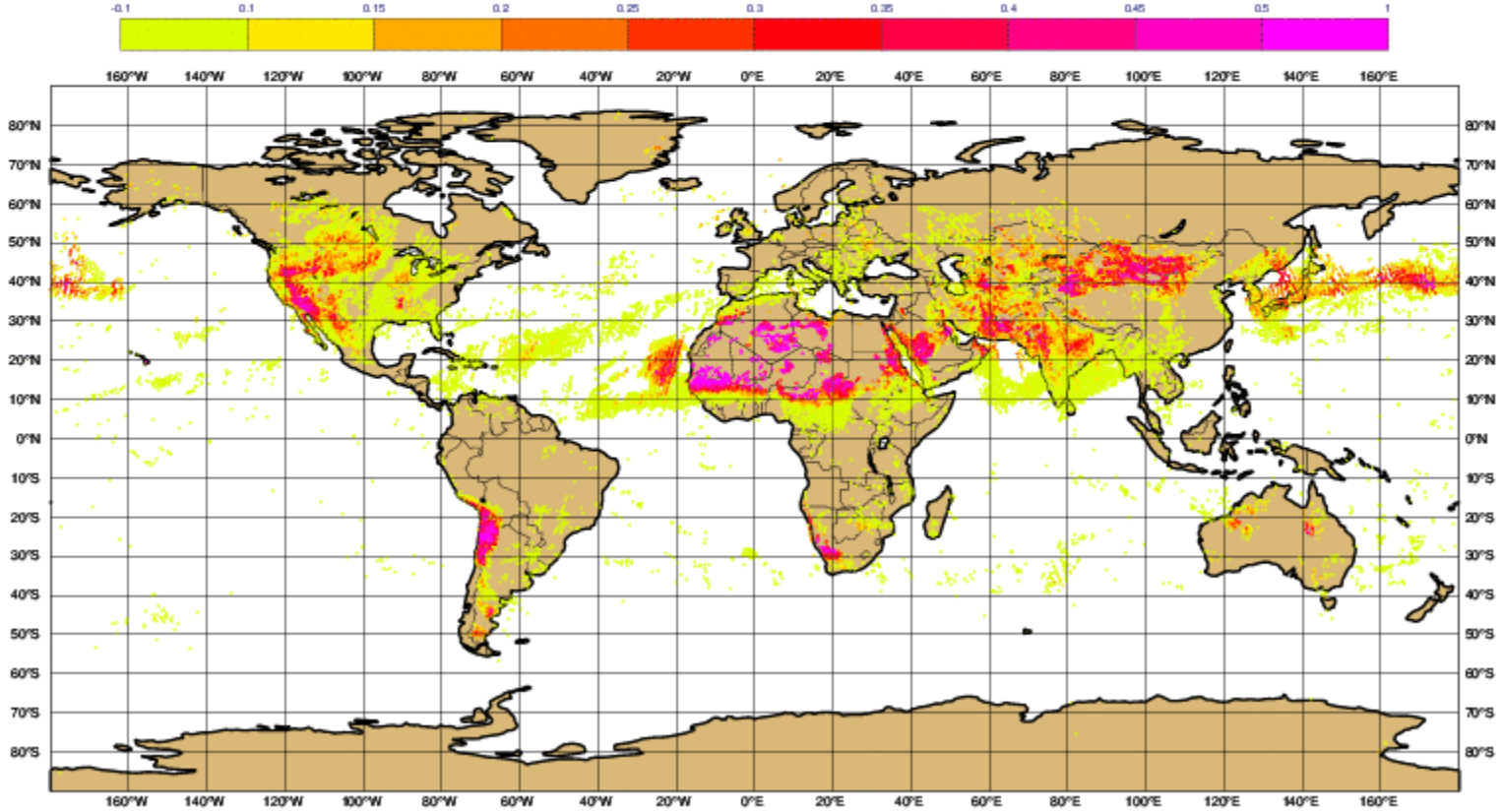
- Geostationary satellite :
  - Improvement of NWP system by HIMAWARI-8
  - METEOSAT-11 as good as METEOSAT-10

- Aerosol detection :
  - Improvement and Extension on all high spectral resolution infrared instruments

Future

- Continuing monitoring for geostationary satellite
- Integrate new satellites as GOES-R.
- Preparation for IRS.
- Investigate more on aerosol detection to :
  - Reject only the part of spectrum affected by aerosol.
  - Extract the aerosol concentration and other characterization.

Total Aerosol Optical Depth (ECMWF OPS) METOP-A/B IASI)
date=2015-05-01 00:00:00 00z and 12z



I would like to thank EUMETSAT for the support on this work

Questions ?