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

EUMETSAT Fellow Day
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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).
GOES 13 & 15

Transition between CIMSS and NESDIS was done with success.
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

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<th>MTSAT</th>
<th>HIMAWARI</th>
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<td>Central wavelength (μm)</td>
<td>Spatial Resolution (km)</td>
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<tr>
<td>Visible</td>
<td>0.55 – 0.90</td>
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<td>Infrared</td>
<td>3.50 – 4.00</td>
<td>4 km</td>
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<td>11.5 – 12.5</td>
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Himawari-8 : Operational assimilation
Himawari-8 : Operational assimilation
Himawari-8 at 6.8 micron

Himawari-8

MTSAT-2

Obs-Fg

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

![Meteosat-11 Mean (O-B)](image1)

![Meteosat-10 Mean (O-B)](image2)

![Meteosat-11 STDV (O-B)](image3)

![Meteosat-10 STDV (O-B)](image4)
Meteosat-11: Bias evaluation

Meteosat-11

Meteosat-10

[Graphs showing bias evaluation for Meteosat-11 and Meteosat-10, with lines representing different datasets and error bars indicating standard deviation.]
Meteosat-11 : assimilation evaluation

Instrument(s): metop-a metop-b nosa-18 nosa-19 sky - MHS
Area(s): N.Hemis S.Hemis Tropics
From 00Z 1-Oct-2015 to 00Z 1-Nov-2015

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

MHS

ATMS
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

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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: $1500 \times 10^9$ 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?

May 2014
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

Aerosols – Desert – Tropical profile

Number density: global climatological value

Number density: four times the global climatological value

Matricardi, 2005
Dust impact on IR spectrum

**Aerosols – Desert – Tropical profile**

Number density: global climatological value

![Graph showing IR spectrum impact of desert aerosols](chart1)

- Brightness temperature difference (K)
- Wave number (cm⁻¹)

Number density: four times the global climatological value

![Graph showing IR spectrum impact of increased aerosols](chart2)

- Brightness temperature difference (K)
- Wave number (cm⁻¹)

IRS - MTG

Matricardi, 2005
IR Instrument

• IASI Instruments
  – 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 DECLARES DUST

(Met-10: 7.3, 8.7, 9.7, 10.8, 12 μm could be used)
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Evolution of aerosol detection at ECMWF

Detection done after bias correction

Detection done before bias correction

Red dots: aerosol detection
Agreement between IASI detection and MODIS AOD
Aerosol detection on all IR instruments

AIRS and CrIS are still in optimisation phase.

Red dots: aerosol detection
Results: Positive impact on other instruments (TROPICS)

IR data

Aerosol contamination

Analysis (humidity) contamination

Impact on all system

No aerosol contamination

System Safe

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

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

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

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 ?