Aerosol detection with IASI, AIRS and CrIS measurements in the weather forecast

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Project Objectives

Brightness temperatures measurements from Infrared Sounders (IASI, AIRS, CrIS) are a valuable source of information on atmospheric temperature, clouds, gas composition and aerosols.

At ECMWF, brightness temperatures from IR sounders are assimilated operationally and are known to improve the quality of numerical weather forecasts. To increase the quality of the forecast, we have to identify the radiances contaminated by the presence of aerosol and remove them from our system.

Theory

The detection of aerosol in hyper-spectral radiance observations from three infrared sounders is important. Even if the magnitude of the contamination is less than for the cloud, the signals are significant compared to those of temperature and humidity in the data. It is thus important to detect and reject radiances displaying significant aerosol contamination because the assimilation system doesn't content information about aerosol.

A new aerosol detection test has been developed at ECMWF. The study of the IASI aerosol infrared spectrum permit to identify some key channels which can be used to detect aerosol contamination over ocean.

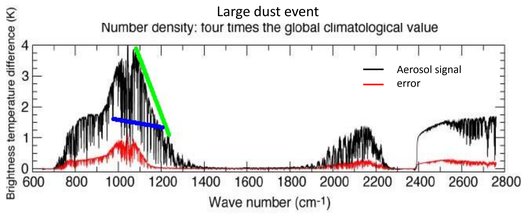
The new test involves applied to the two following brightness temperature differences:

BTD_1 = BT(~10 µm) – BT(~8 µm)

BTD_2 = BT(~9 µm) – BT(~8 µm)

If BTD_1 and BTD_2 are less than the two empirically determined thresholds (instruments dependant), the pixel is declared contaminated by dust.

To make the test more robust against instrument noise in individual channels, X channels are averaged around the central wavelength before the brightness temperature differences are computed (the number of channels used is dependant of the instrument noise).



Summary and future work

Preliminary experience with the new IASI dust detection is very positive and it has been implemented in ECMWF operations (CY41R2). The improvement of IASI detection and the extension to AIRS and CrIS is almost complete and preliminary testing showing similar positive results and it has been implement in ECMWF next operations (CY43R1).

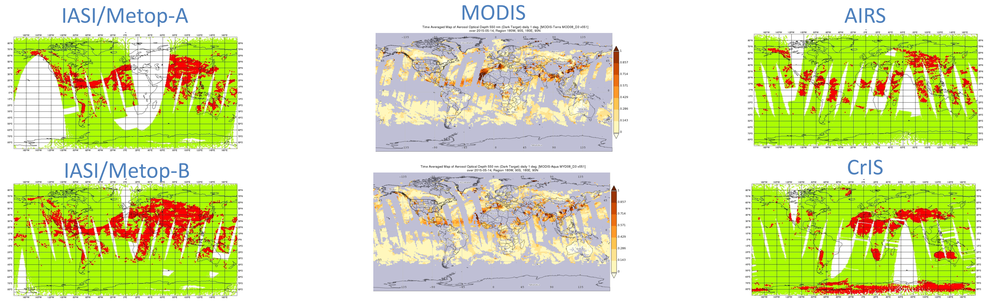
Longer term new test for other important aerosol types will be developed - as well as an ability to identify the altitude of the aerosol so that only the channels actually contaminated will be rejected (not the full spectrum).

It is hoped that this work will evolve to a stage that by when IASI-NG or MTG-IRS are launched we have a tried and tested mature facility to detect aerosol contamination. This is vitally important as MTG will observe some of the most frequently aerosol contaminated regions of the world.

Verification results

The new aerosol detection applied to IASI data from METOP-A and METOP-B is illustrated for one cases with a high Aerosol Optical Depth (AOD) over the Caribbean Sea, this detection is also applied to AIRS and CrIS but need some optimisation.

On the 14th May 2015 a Saharan dust plume extended over Caribbean Sea, when we compare the extent of the detected aerosol dust plume with the MODIS estimate, we see much a good agreement with the test applied on IASI.

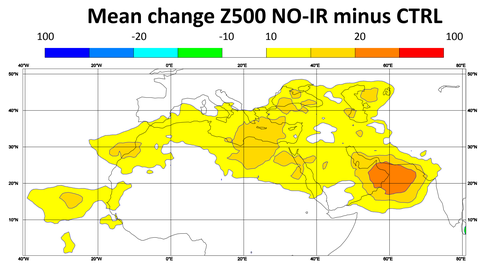


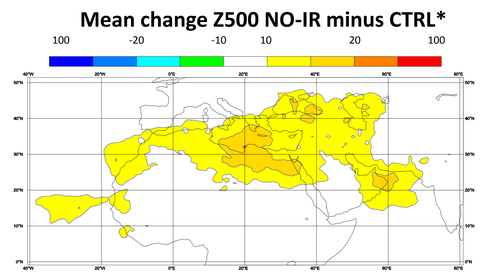
Red dots : aerosol detection

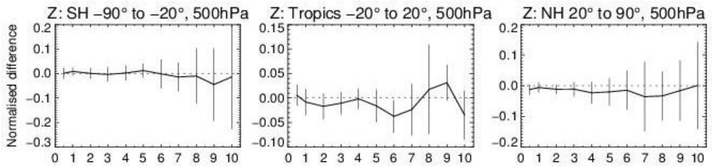
One month of assimilation testing has been performed (May 2014) where a control system (essentially ECMWF operations) is compared to test system that additionally rejects IASI and AIRS spectra if they fail the new aerosol detection test. For reference and assimilation is also ran with IASI data.

The new test leads to more rejections compared to the control (as expected). These additional rejections tend to be concentrated over areas known to be systematically affected by aerosol at this time of year.

If the operational system fails to detect aerosol in a particular area it will assimilate brightness temperatures that are anomalously cold. This in turn should lead to erroneous cooling increments and in areas where this happens systematically analysis will be biased. This is confirmed when we examine the monthly mean differences of the geopotential at 500hPa for the control and test systems (e.g. over the Arabian sea).







Impact of aerosol detection on the forecast:

- South hemisphere is not contaminated by dust : no impact.
- North hemisphere is contaminated by aerosol (Mediterranean and Japan areas) : slight positive impact.
- Tropics are strongly contaminated by dust (Atlantic and Indian oceans) : positive impact.

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