

Developments in cloud and aerosol detection for infrared radiance data

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Departure-based cloud detection: the operational implementation at ECMWF

The primary focus in the operational use of advanced infrared sounder radiances is in the assimilation of clear channels (often above clouds)

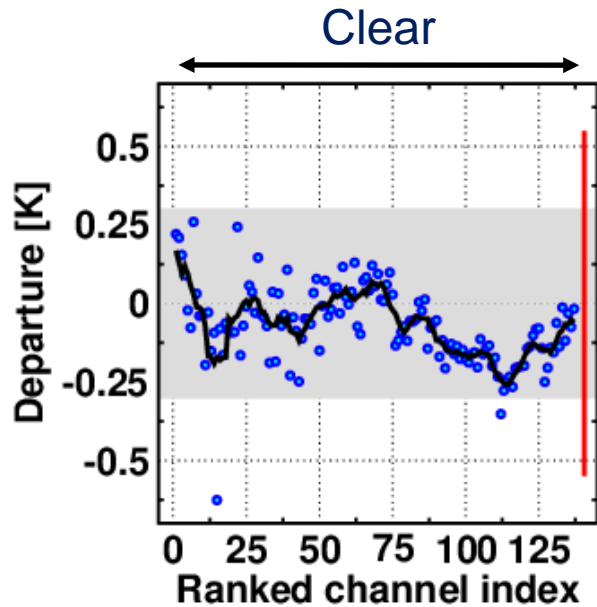
Cloud-contaminated radiances are detected and rejected using a refined version of the scheme of McNally & Watts (2003)

The scheme ranks channels in vertical according to their sensitivity to cloud and looks for a monotonic increase (or decrease) in background departure – if found, it will be interpreted as a signature of cloud

There is a comprehensive and up-to-date description of the implementation in the documentation of the associated NWP SAF deliverable at

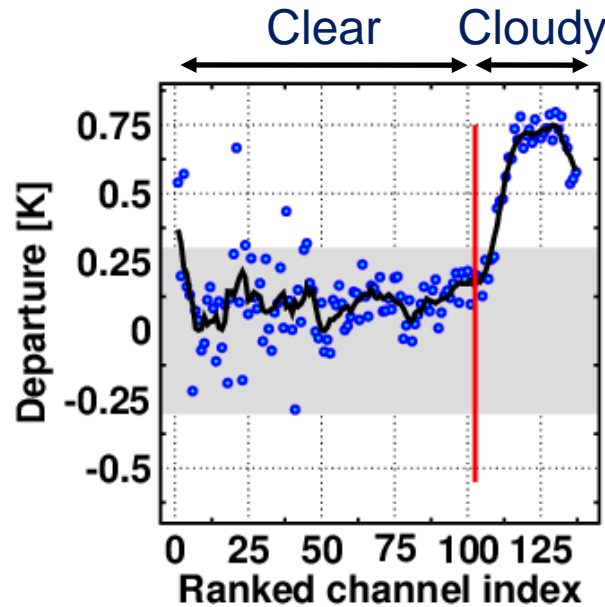
https://nwpsaf.eu/deliverables/IR_aerosol_cloud_detect/index.html

Identifying clear and cloudy channels in the ECMWF scheme



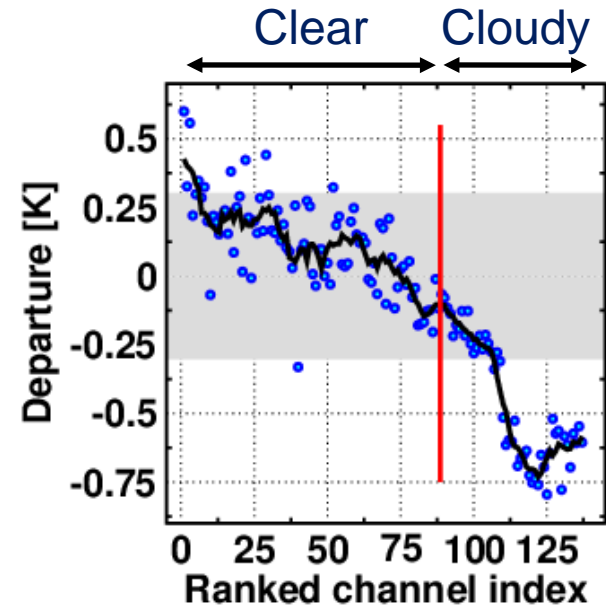
Scenario 1: All channels are clear

Accounts for ~10% of all cases over sea, but only up to 4% over land



Scenario 2: Warm cloud over cold surface

Accounts for polar clouds but is chosen commonly over land everywhere

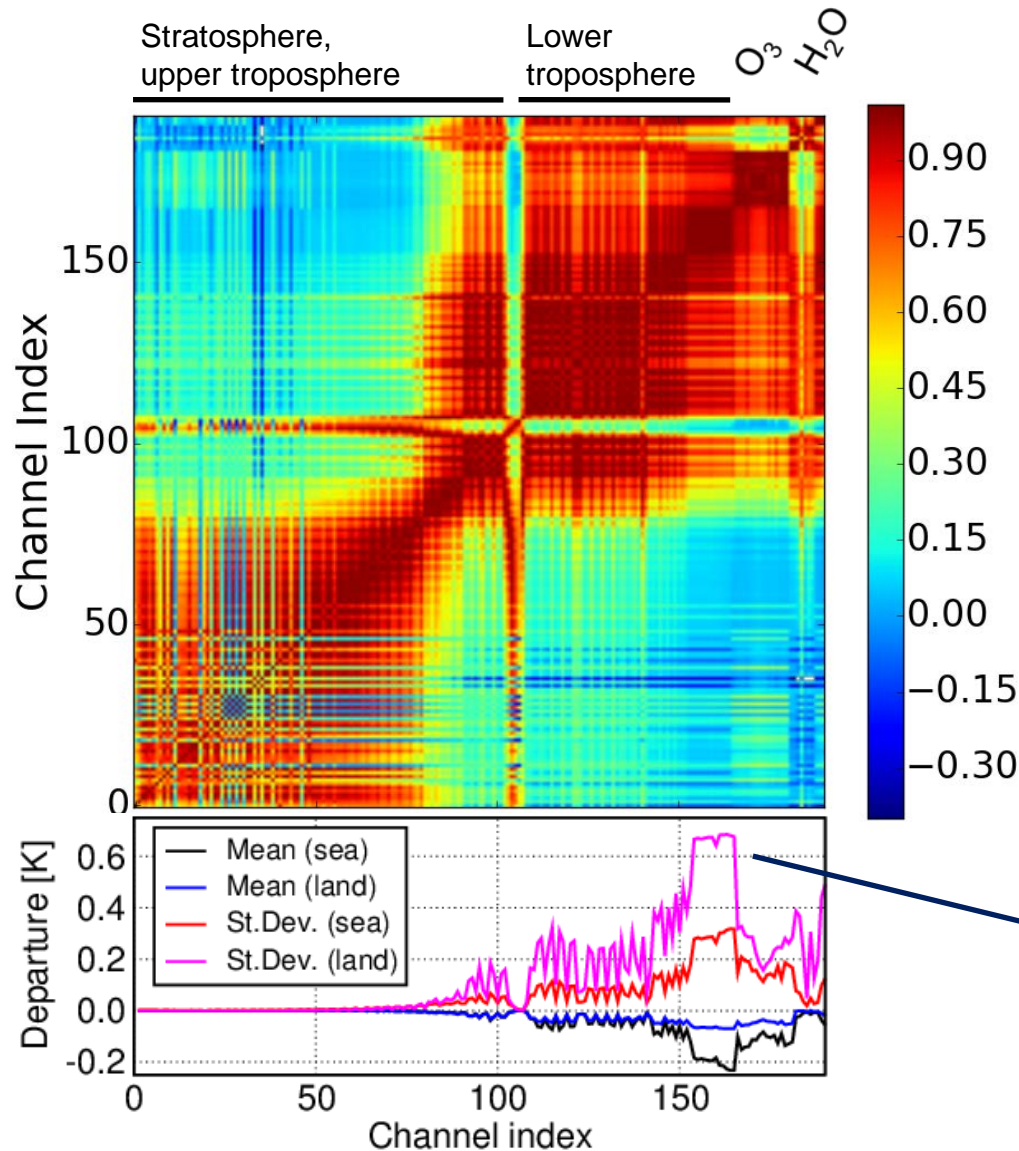


Scenario 3: Cold cloud over warm surface

The typical case: accounts for 80-85% of all cases over sea and 60-70% over land

Simulated error statistics from missed cloud

Correlation matrix
(over land)



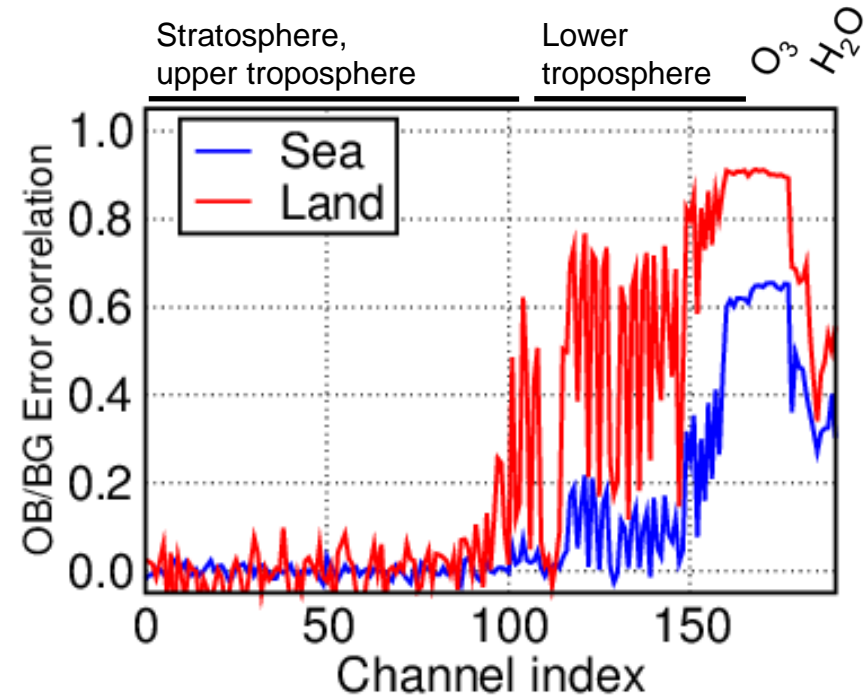
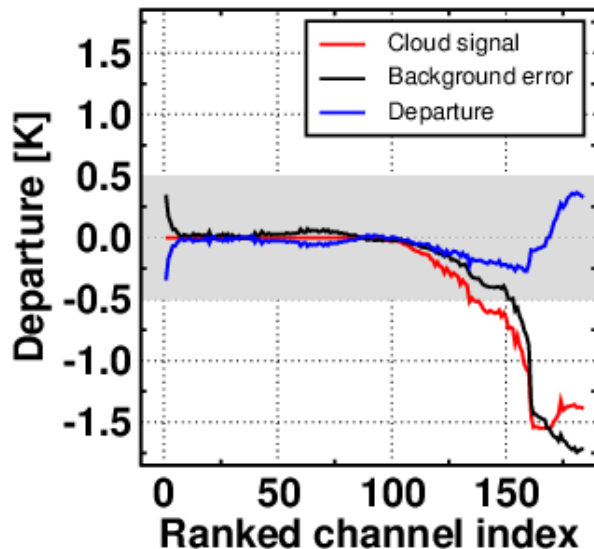
Errors are strongly correlated because of missed cloud!

Errors due to undetected cloud are large over land!

Departure-based cloud detection over land: interaction with skin temperature error

Cloud is often missed because of skin temperature error cancelling the cloud effect

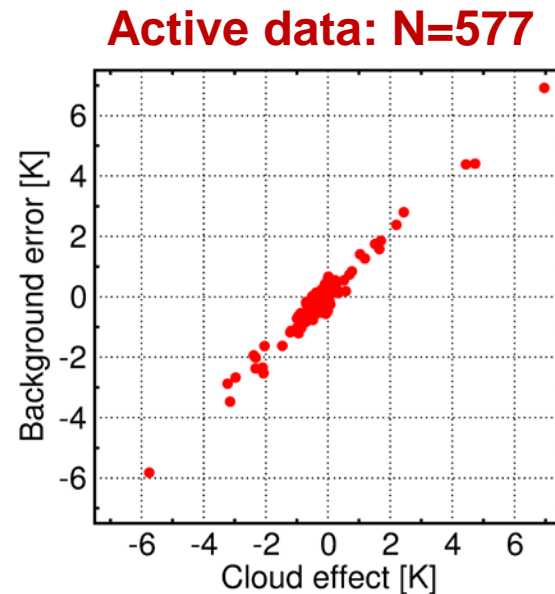
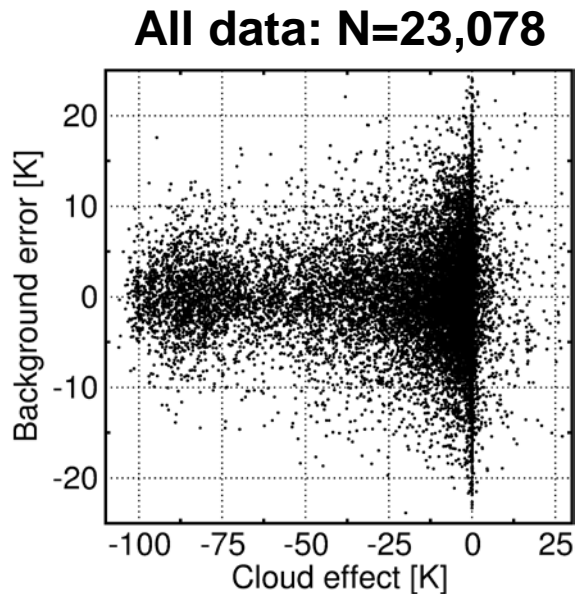
→ “Clear” population contains a large amount of cloudy scenes associated with a background error



Correlation between observation and background errors!

→ A major complication on the use of infrared radiances over land!

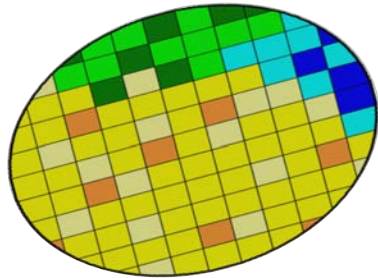
OB/BG error correlation and how to reduce it



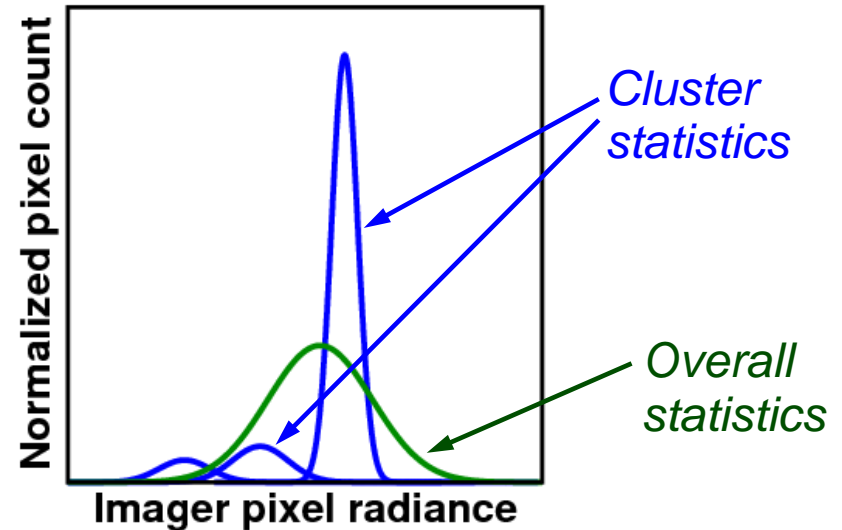
Two approaches are being taken with the aim at reducing the OB/BG error correlation in the active population:

- (1) Using collocated imager statistics as additional input to the cloud detection
- (2) Exploiting inter-channel differences in observed brightness temperature spectra

Imager-assisted cloud detection as we currently do it



*IASI-located
AVHRR data*



Easy access to clustered statistics of AVHRR radiances within each IASI FOV

→ Useful information on scene homogeneity and inter-cluster consistency to assist distinguishing between background errors and cloud

Eresmaa (2014): Imager-assisted cloud detection for assimilation of Infrared Atmospheric Sounding Interferometer radiances. *Q. J. Roy. Meteorol. Soc.*, **140**: 2342—2352.

Imager-assisted cloud detection as we currently do it

(Numbers are for a global sample over sea)

Using departures only

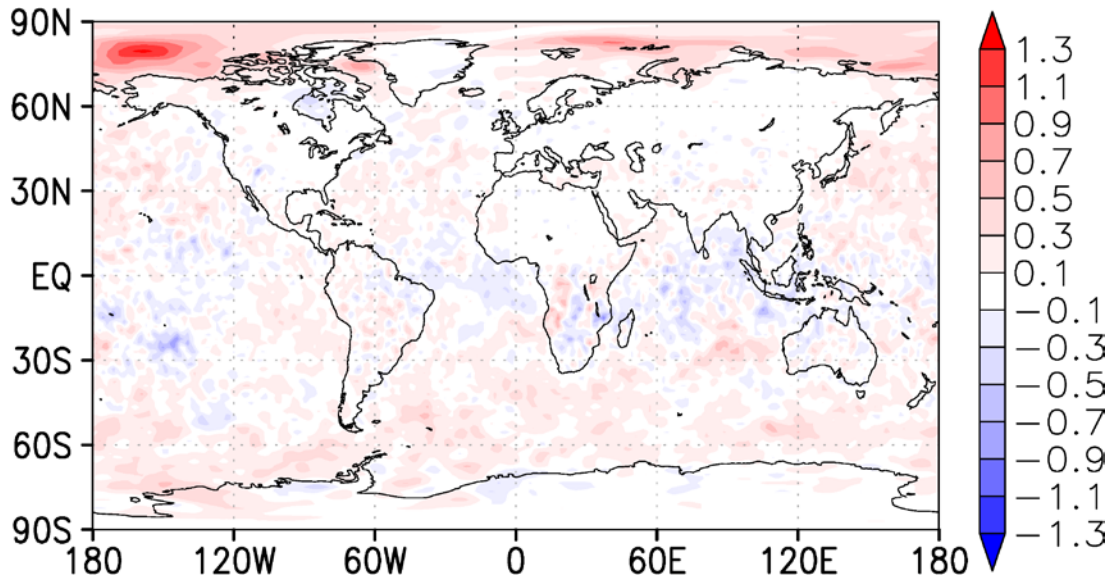
		Clear	Cloudy	Total
<i>Using imager only</i>	Clear	5.2%	3.4%	8.6%
	Cloudy	5.5%	85.9%	91.4%
	Total	10.7%	89.3%	100.0%

An independent imager-based cloud flag is determined from the collocated cluster statistics and used as additional input in the imager-assisted scheme

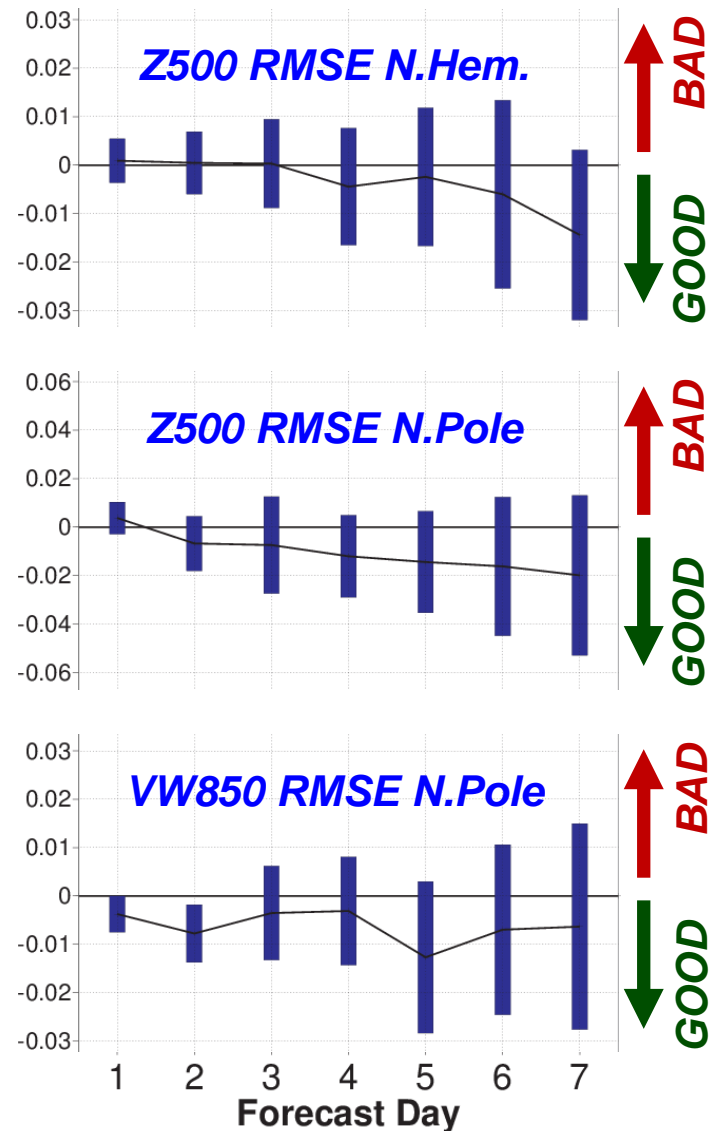
→ Instead of using the departure-based scheme and having ~11% of FOVs completely clear, we use the imager-assisted scheme and reduce the fraction of completely clear FOVs to ~5%

Impact of the imager-assisted cloud detection

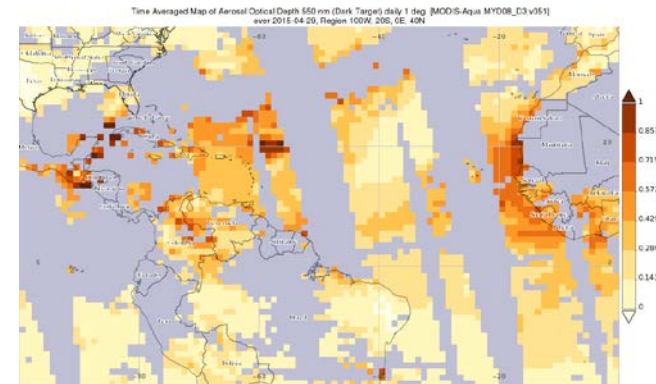
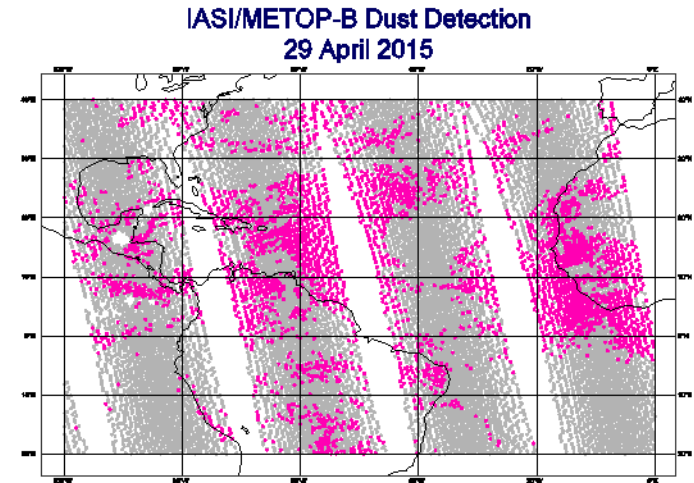
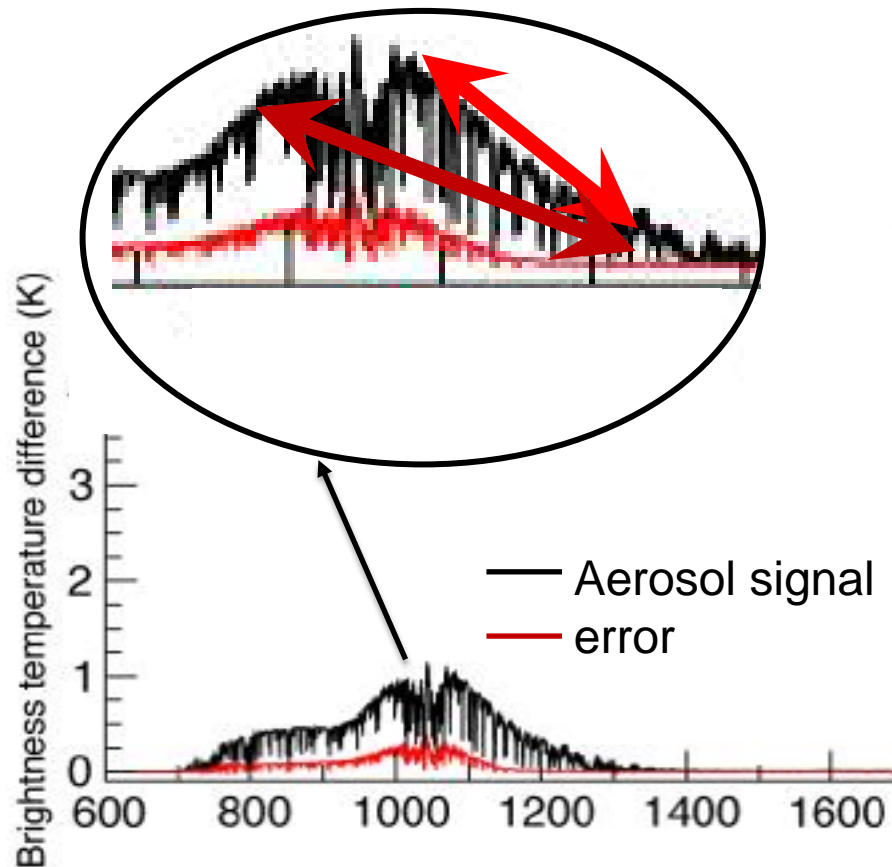
Impact on mean 700-1000 hPa thickness



→ Lower-tropospheric warming over sea ice and a beneficial forecast impact



Inter-channel differences in observed T_B spectra as we are just about to start exploiting them



MODIS aerosol product

See poster 8p.04 by Letertre-Danczak & McNally: Dust detection with IASI measurements in the weather forecast.

Summary

Applying a departure-based cloud detection over land introduces correlation between observation and background errors – these cannot be handled properly by any data assimilation scheme

Recent and near-future developments to the cloud detection aim at reducing the dependency on background information

- Using collocated imager information
- Exploiting inter-channel differences in observed spectra

The future use of infrared radiances over land will rely on fundamentally different cloud detection and observation error covariance as compared with the use of radiances over sea