Screening routines for aerosol- and trace-gas-affected infrared radiances

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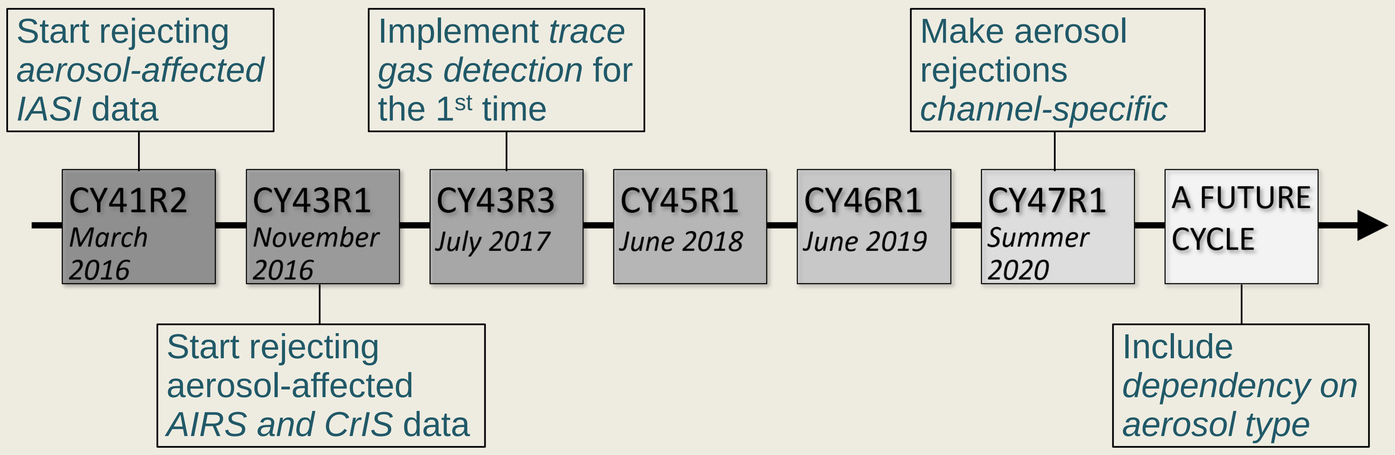
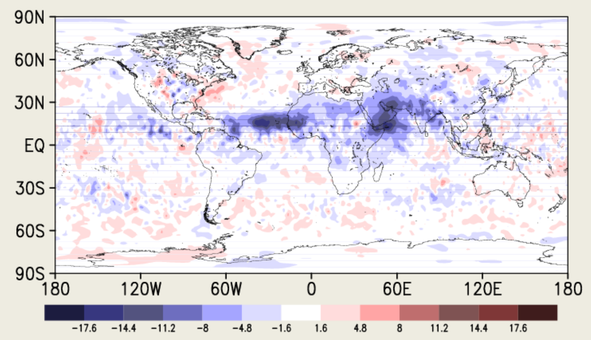
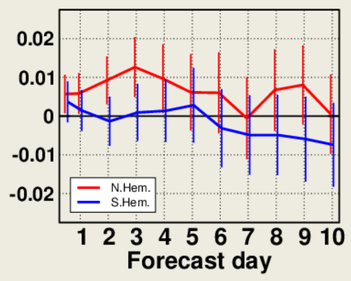
The EUMETSAT Network of Satellite Application Facilities

NWP SAF Numerical Weather Prediction

Aerosol and trace-gas screening milestones at ECMWF

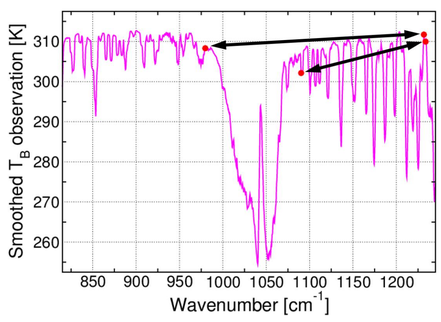






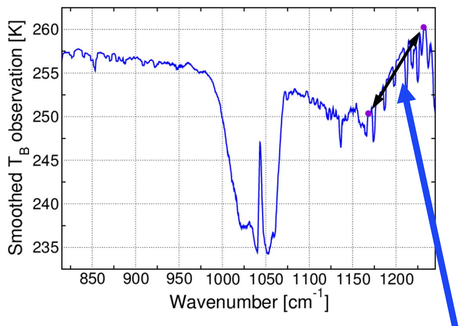
The undesirable impact of aerosol-affected IR radiances on 500 hPa geopotential mean analysis (left; unit m^2s^{-2}; 21—30 June 2018) and control-normalized forecast RMSE (right; 1 May — 30 August 2019).

Three-step aerosol type recognition

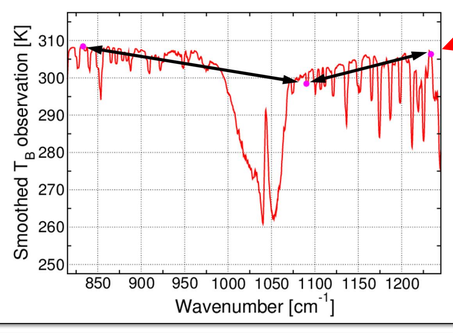


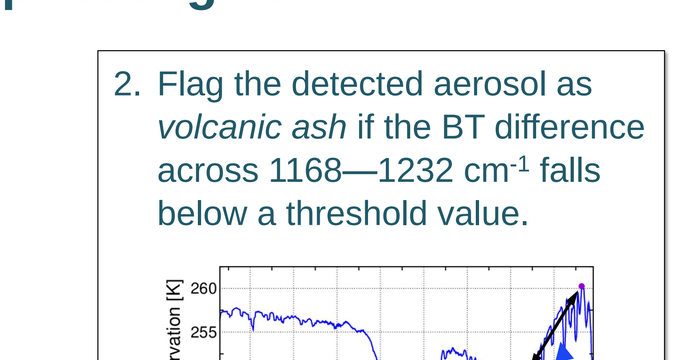
1. Flag the infrared (IR) field-of-view as aerosol-affected if brightness temperature (BT) differences at 980—1232 cm^{-1} and 1090.5—1234 cm^{-1} fall below threshold values.

2. Flag the detected aerosol as *volcanic ash* if the BT difference across 1168—1232 cm^{-1} falls below a threshold value.



3. Otherwise, flag the aerosol as *Saharan dust* if the BT differences at 833—1090.5 cm^{-1} and 1090.5—1232 cm^{-1} fall below thresholds.

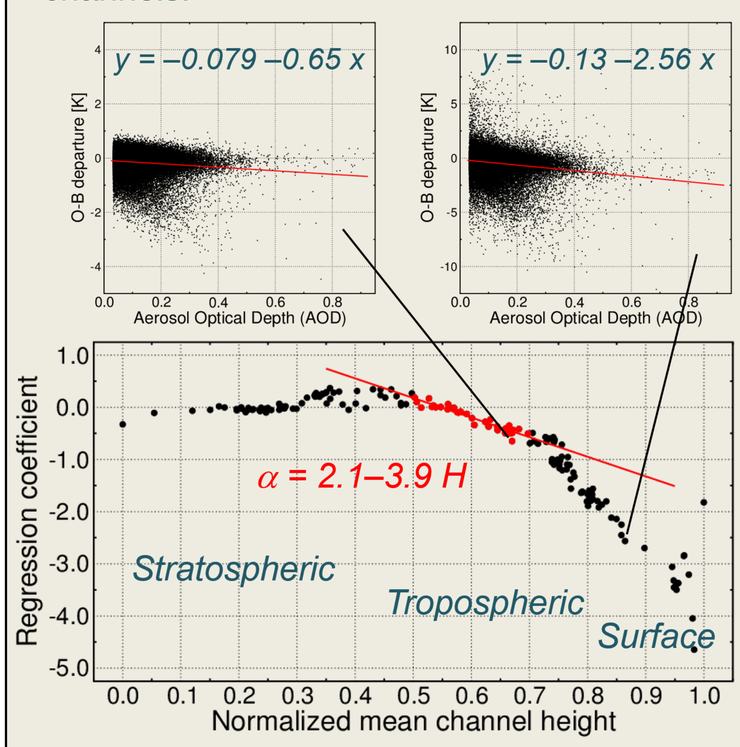




Aerosol type recognitions for Metop-B IASI data on 23rd June 2019. Red, blue, and black indicate Saharan dust, volcanic ash, and unclassified aerosol, respectively.

Channel-specific Saharan dust rejections

We estimate Aerosol Optical Depth (AOD) using the BT difference at 1090.5—1234 cm^{-1} as a proxy. On average, larger AOD means larger negative O-B departure: this dependence is strongest on low-peaking channels.



Linear regression for dust radiative effect as a function of AOD. Situation-dependent rejection threshold follows from parameterizing the regression slope using normalized channel height assignment as a predictor.

Let us assume that the dust radiative effect δ is directly proportional to AOD:

$$\delta = \alpha\ AOD$$

Based on a global sample of Saharan-dust-affected data, we predict the regression slope α using normalized height assignment H as a predictor

$$\alpha = \beta + \gamma H$$

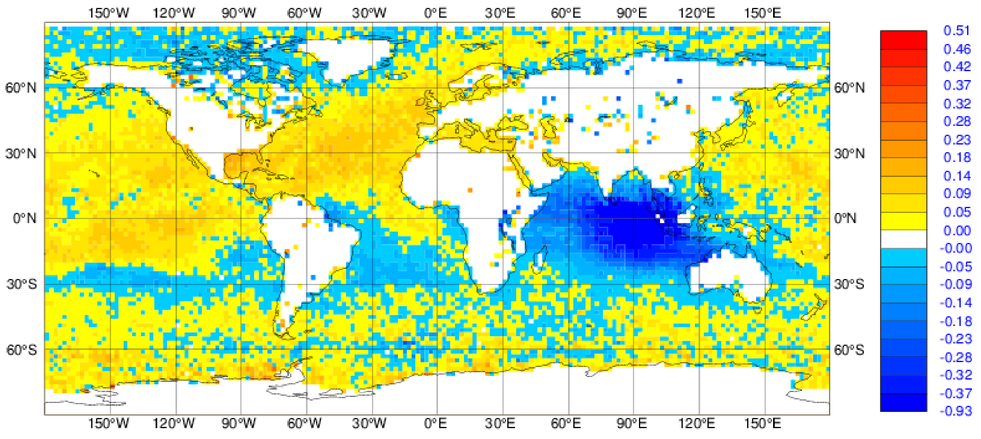
where β = 2.1K and γ = -3.9K.

Combining the two equations, solving for H, and setting the maximum allowed dust radiative effect δ_{max} = -0.1K, we obtain the rejection threshold

$$H_r = \frac{1}{\gamma}\left(\frac{\delta_{max}}{AOD} - \beta\right)$$

Channels are rejected if their heights are assigned lower than H_r.

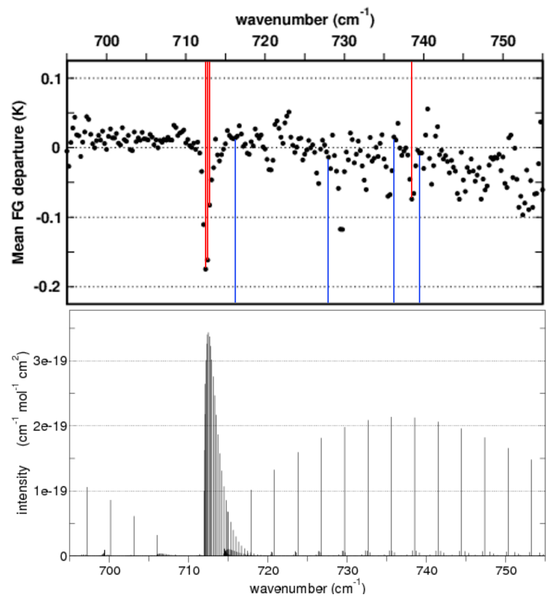
The trace-gas detection scheme



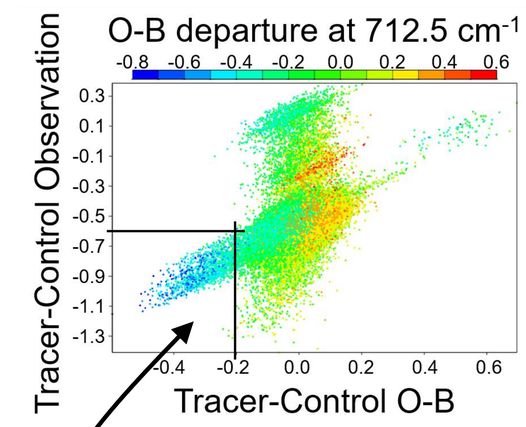
Mean active O-B departure on channel 101 (712.5 cm^{-1}) of NPP CrIS in the Autumn 2015.

In 2015, the ECMWF satellite data monitoring system alerted from excessive Observation minus Background (O-B) departures over tropical Indian Ocean region. The anomaly was attributed to Indonesian forest fires, very intense at the time, and it showed a spectral shape matching the absorption lines of Hydrogen Cyanide (HCN).

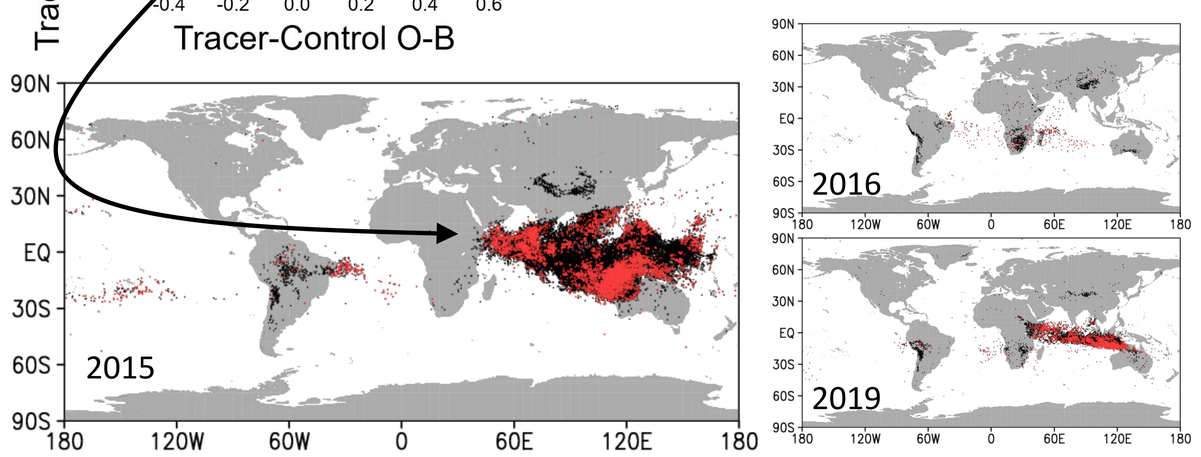
High levels of atmospheric HCN were observed again during the fire season of 2019.



Mean IASI O-B departure at the peak of the 2015 anomaly (top) against HCN absorption spectrum (bottom). Red and blue sticks indicate the tracer and control channels used in the detection scheme.



The scheme compares observations and O-B departures in two distinct channel groups that consist of tracer and control channels, respectively. Tracer minus control differences falling below threshold values lead to rejection of affected channels.



Locations of HCN detections in two-day samples of CrIS data in 2015, 2016 and 2019. Red (black) indicates presence of HCN in the absence (presence) of cloud.

Acknowledgements

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