The use of short-wave channels to improve the cloud detection of high-spectral-resolution radiance observations at ECMWF

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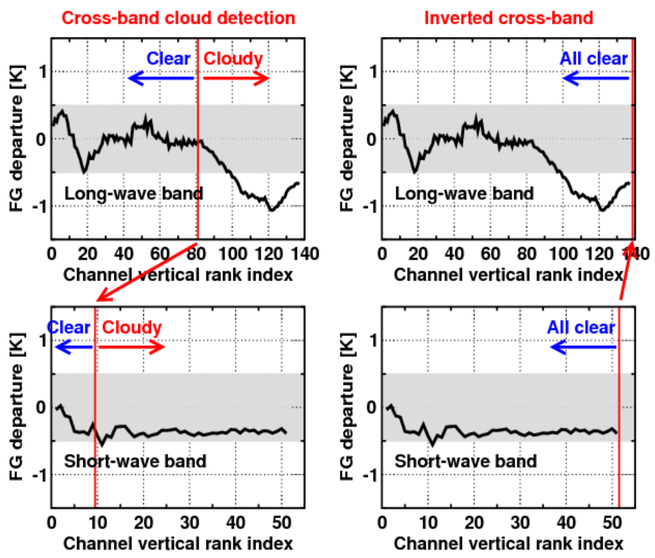
Motivation

Undetected cloud contamination has a considerable potential to degrade performance of radiance data assimilation. Cloud detection methods relying on first guess departure (FGD) data are therefore tuned such that the undetected cloud contamination is unlikely to result in large analysis increments. Disadvantage of such a conservative tuning is that false alarms of cloud contamination are common, particularly in regions affected by first guess humidity errors.

Currently under-exploited channels in the short-wave (SW) part of the observing spectrum of Advanced Infrared Sounder (AIRS) and Infrared Atmospheric Sounding Interferometer (IASI) are mostly insensitive to water vapour absorption. Making additional use of SW channels can lead a way towards improved separation between clear and cloud-contaminated data.

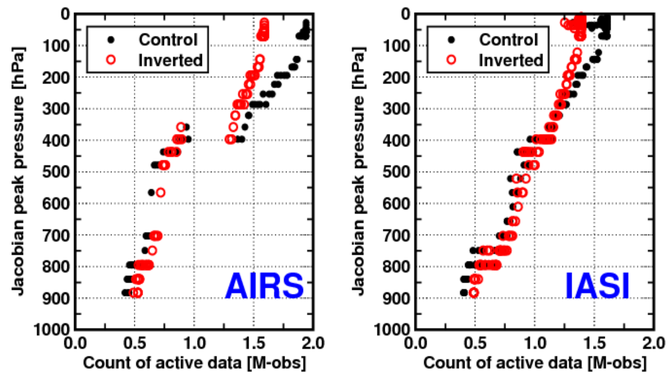
The inverted cross-band option in cloud detection

Cloud contamination in radiance data of advanced infrared sounders is detected from FGD characteristics. A digital filter is applied on FGD of vertically-ranked channels to produce a smoothed curve. Highest point, where cloud radiative effect exceeds a given threshold, is identified from the curve to distinguish between clear and cloud-contaminated channels.



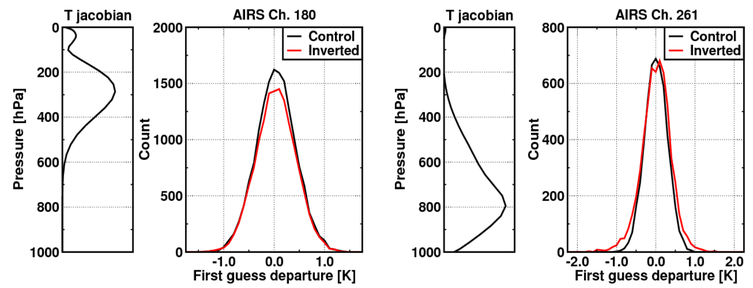
The operational setup of the Integrated Forecast System (IFS) at ECMWF applies a cross-band option in cloud detection. This means that channel-specific cloud flags for the whole of infrared spectrum are assigned on the basis of FGD data on long-wave (LW) channels only.

In this work, we apply the cross-band option of cloud detection in an inverted mode, such that cloud flags are determined from FGD data on SW channels only. The inverted cross-band option is used only at night.

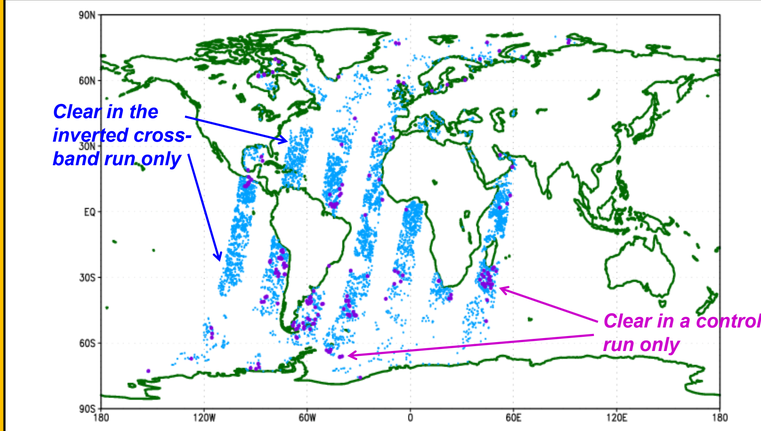


Effect of the inverted cross-band on observation statistics

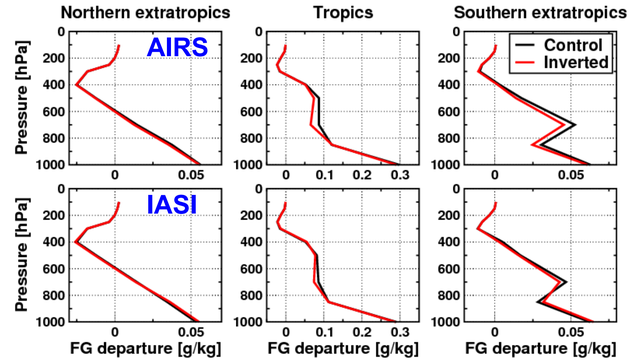
Using all available SW channels in cloud detection results in excessive false alarms because of strong sensitivity to stratospheric non-LTE effects and surface emission. SW channels used here cover primarily wavenumbers 2180—2265 and 2386—2401 cm^{-1}. Counts of active data on upper-tropospheric-sensitive channels are decreased because of this restriction.



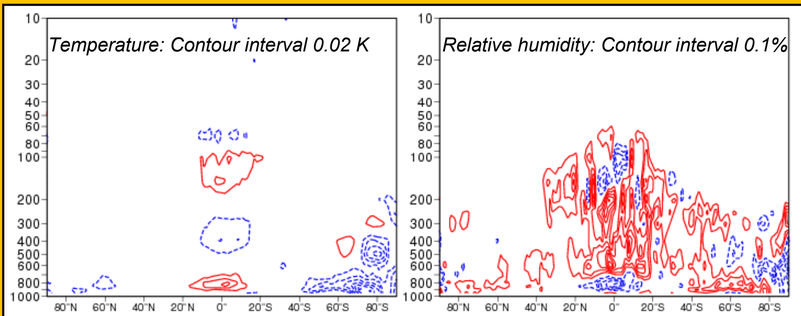
Using the inverted cross-band makes histogram of assimilated FGD wider on lower-tropospheric sensitive channels (right panel) with little effect on the shape of histogram on higher channels (left panel).



Impact from the inverted cross-band on cloud flags is the largest in low latitudes, where large first guess errors in humidity are most typical. Cases where cloud contamination is diagnosed by the inverted cross-band option only are mostly false alarms due to strong sensitivity to surface emission.



The inverted cross-band is found to improve fit of first guess to radiosonde specific humidity in tropics and southern extratropics both in experimental runs with AIRS (top) and IASI (bottom).



Analysis impact from applying the inverted cross-band on AIRS data is dominated by moistening (right) in tropical mid-troposphere and warming/cooling patterns (left) in tropics and southern hemisphere.

Summary of analysis and forecast impact in IFS-Cy37r2

The inverted cross-band method is applied to assimilation of radiance data from AIRS and IASI. A 52-day T511-experiment suggests the following:

Tropical mid-troposphere and southern hemispheric lower troposphere are cooled and moistened. Impact in tropics is associated with a lower-tropospheric warming, that is most extensive over continents. Only a weak impact on temperature and humidity fields is found in northern hemisphere.

When applied to AIRS, a positive forecast impact is found on geopotential and temperature in lead times 3—10 days. The impact is confined to lower- and mid-troposphere in northern hemisphere. However, similar positive effect cannot be identified when the modification is restricted to IASI data.