Assimilation of Cross-track Infrared Sounder radiances at ECMWF
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Approach
We aim at operational assimilation of Cross-track Infrared Sounder (CrIS) radiances in the global IFS system of ECMWF. Experience gathered from earlier hyper-spectral radiances, including those from the Atmospheric Infrared Sounder (AIRS) and Infrared Atmospheric Sounder Interferometer (IASI), is applied where possible: the experimental assimilation of new radiances is limited to cloud-free channels over sea and sea ice, and the emphasis is put on the efficient use of temperature sounding channels in the 15 μm CO₂ absorption band.

In contrast to the operational use of AIRS radiances, a large number of spectrally-adjacent CrIS channels are assimilated using a relatively aggressive specification for observation error standard deviation. This is hoped to compensate for the poorer spectral resolution of CrIS instrument. A non-diagonal observation error covariance matrix is applied to account for the effect of the signal apodization.

Baseline configuration
Used in experiments with the previously operational IFS version (Cy40r1) in resolution T511/L91:

- Pre-select the middle FOV (pixel 5) from each Field-of-Regard
- Assimilate 122 channels from the long wave CO₂ absorption band
- Set observation error standard deviations to 0.4 / 0.2 / 0.6 K
- Assume signal apodization to be the only source of observation error correlation
- Assimilate data over sea and sea ice only
- Use RTD-V10 for radiative transfer modelling
- Use variational bias correction with air mass- and scan-angle-dependent predictors
- Assimilate one FOV per thinning box (1.25° by 1.25°) only

A consistently positive medium-range forecast impact extending over the whole of troposphere is found in the extratropics, while a negative impact is seen in the tropical upper troposphere.

Cloud detection
Cloud-contaminated channels are rejected from the assimilation. Cloud contamination is diagnosed using a detection scheme of McNally & Watts (2003) and it is based on brightness temperature background departures in a set of vertically-ranked channels in the 15 μm CO₂ absorption band. Because of cloud contamination, typical count of usable data on a window channel is only 20% of that on a high-peaking stratrophic channel.

The low noise level of CrIS results in increased sensitivity to contamination by undetected clouds. Therefore, parameters of cloud detection need to be tuned more stringently for CrIS than for earlier hyper-spectral sounders. In an appropriately-tuned detection scheme cloud-free background departures constitute a nearly symmetrical and Gaussian histogram.

The following approaches will be considered when designing future experiments to improve the assimilation of CrIS radiances:

- Account for inter-channel error correlations other than those introduced during the signal apodization
- Use calibrated imagery/temperature to aid the cloud detection. VIRS-based estimates of cloud parameters are available for doing this
- Assimilate stratospheric-peak channels over land
- Study the impact of CrIS in a degraded assimilation system, where no AIRS radiances data is available

The effect of spectral resolution
In comparison with earlier hyper-spectral infrared sounders, lower instrument noise levels of CrIS compensate for the effect of the relatively poor spectral resolution. While past experience from the assimilation of AIRS and IASI radiances provides a natural starting point for the use of CrIS radiances, modifications are required to properly account for the different trade-off between noise and spectral purity.

Conclusions
As compared with earlier hyper-spectral sounders, CrIS radiances are affected by a unique trade-off between noise characteristics and spectral resolution. Therefore, experience from the operational assimilation of AIRS and IASI radiances is insufficient to facilitate successful assimilation of CrIS radiances.

We have put emphasis on strong exploitation of cloud-free sounding channels in the 15 μm CO₂ absorption band. We demonstrate a positive medium-range forecast impact in the extratropics from assimilating CrIS radiances into the previously-operational IFS version at ECMWF.

However, similar level of performance has not yet been produced in the currently-operational IFS version. Work is in progress to fully understand the nature and impact of CrIS radiance data in the ECMWF 4D-Var system.