Enhancing the impact of infrared radiances in the ECMWF system

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IR sounder channels in active use

Hyperspectral radiances from the Atmospheric Infrared Sounder (AIRS), Infrared Atmospheric Sounding Interferometer (IASI) and Cross-track Infrared Sounder (CrIS) are assimilated at ECMWF assuming no significant contamination from cloud or aerosol, and use of data over land is limited to channels with primary sensitivity in the stratosphere. Channels strongly sensitive to surface for reliable cloud detection scheme for land emissivity atlases, as well as looking surface skin temperature and use of IR description of background errors for include improving upon the current down to the surface over land. This Work is continued to improve the land

Observation error covariance

AIRS radiances are assimilated without explicit treatment for error correlations, while IASI and CrIS observation error covariance were updated with the IFS Cy43r1 (Nov. 2016) to include error standard deviations and inter-channel error correlations, as determined from innovation statistics using established diagnostic methods and an empirical inflation and conditioning to optimize performance in the assimilation system:

- The diagnosed error standard deviations are multiplied by a scaling factor of 1.75 for IASI (Bormann et al., 2016) and 2.75 for CrIS (Eresmaa et al., 2017). The same scaling factor is applied at all channels and does not affect error correlations.
- The observation error specification is global and it does not contain any situation dependency. The same error standard deviations and correlations are used at all times and everywhere in the globe. At the same time, the number of active CrIS channels was increased from 77 to 117 (adding more CO2-sensitive sounding channels in the long-wave IR band), which considerably added to the positive impact of CrIS in NWP.

Activated non-surface-sensitive IR channels over land

Mid-tropospheric IR channels from AIRS, CrIS and IASI will be operationally assimilated over land surfaces from IFS Cy45r1 onwards (early 2018). This has significantly improved the quality of analyses over land and resulted in better time-line medium-range forecasts (e.g. Fig. 5a). Surface-sensitive channels are determined on a case-by-case basis, taking atmospheric state and local orography into consideration and are removed from the cloud detection and assimilation.

High-peaking channels show a very homogeneous coverage except for areas of either high orography (surface-sensitivity through elevated surface), high tropopause (tropical convection strong especially over land), or high aerosol content. Figure 3 (bottom) shows that activation of lower-tropospheric channels over land is in practice limited to the Tropics region. IASI humidity-sensitive channel 515 (774cm^-1) would usually be strongly sensitive to surface emission, but may lose this sensitivity if the humidity content is high.

Data impact with the adjoint sensitivity tool

FSOI approach is used to simultaneous estimate of forecast impact for any and all observations operationally assimilated at ECMWF. The “Infrared T” category provides observation error covariance for

OSSEs experiments were carried out to evaluate the impact of hyper-spectral IR, as follows:

- Default 43r3: the same as the operational 4D-Var system IFS Cy43r3, including data from four hyper-spectral IR instruments; 43r3+: As ‘Default 43r3’, but from an upgraded system in which we additionally assimilate non-surface-sensitive IR channels over land.
- Control: As ‘Default 43r3’, but omitting the use of all four hyper-spectral IR sounders;

Summary

- Fully correlated error covariance estimates are used at ECMWF for hyper-spectral IASI and CrIS observations.
- Explicit treatment for correlated error made it possible to use a large number of CrIS channels in the important spectral region around 700 cm^-1.
- Progress has been made in using hyper-spectral infrared data (from IASI, CrIS and AIRS) over land surfaces.
- The use of hyper-spectral infrared radiances is demonstrated to have a very positive impact on short- and medium-range forecasts.
- Effort will continue to maximise their impact by assimilating surface sensitive channels over land and by assimilating new observations (e.g., CrIS on NOAA-20).

References


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