Initial assimilation tests of CrIS short-wave channels at ECMWF

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Motivation for considering SW channels

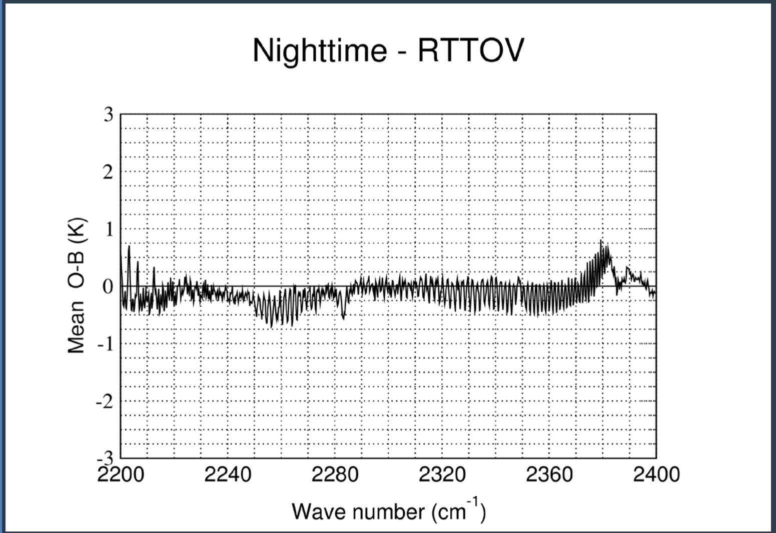
- These are “clean” temperature-sounding channels – very little water vapour contamination.
- Radiative transfer developments have made it possible to assimilate these channels both in daytime and night-time.
- Results from NOAA have shown encouraging impact from these channels in initial experiments.
- Instrument failures could result in loss of the LW band (NWP needs to be robust to this).
- Future opportunities have been proposed to augment our operational satellites with a constellation of SW small satellites (NWP needs to be able to exploit these).

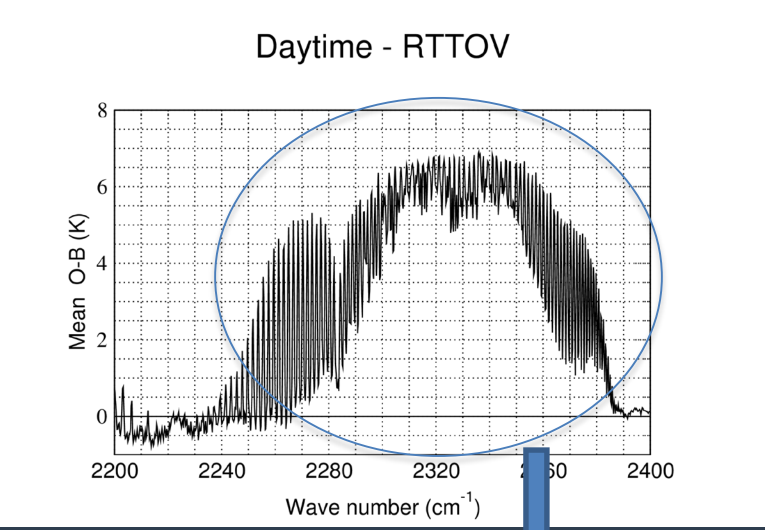
- *How close are we to being able to assimilate these channels effectively?*

Non-LTE effects in radiative transfer (RTTOV)

- The exploitation of short-wave data requires the introduction of Non Local Thermodynamic Equilibrium (NLTE) effects in the simulation of the radiances.
- For IASI-like satellite nadir-sounding applications, NLTE effects occur primarily during daytime above altitudes of ~40 km in the CO_2 spectral region at 4.3 μm where the main mechanism responsible for the population of the excited states is the absorption of the strong solar radiation field.
- If not accounted for, NLTE effects can introduce significant errors in the simulation of daytime top-of-the-atmosphere (TOA) IASI radiances.

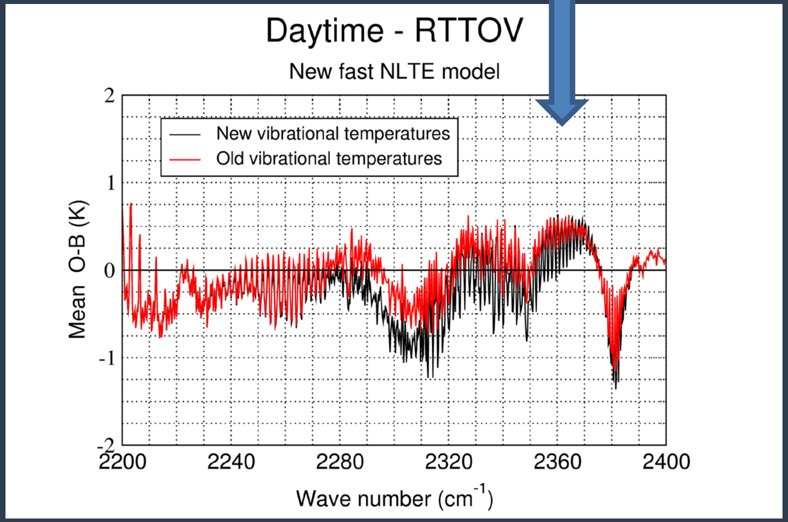
Mean O-B when neglecting NLTE…





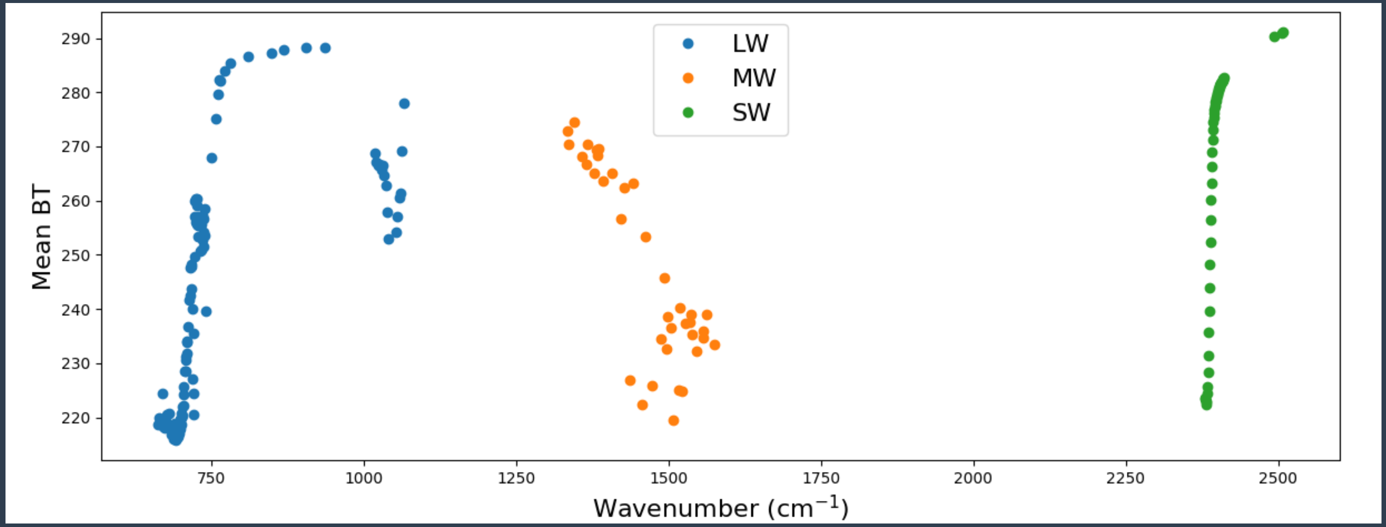
… and when NLTE is accounted for

The introduction of NLTE effects in the RTTOV simulations greatly reduces the daytime biases.



Initial experimental set-up

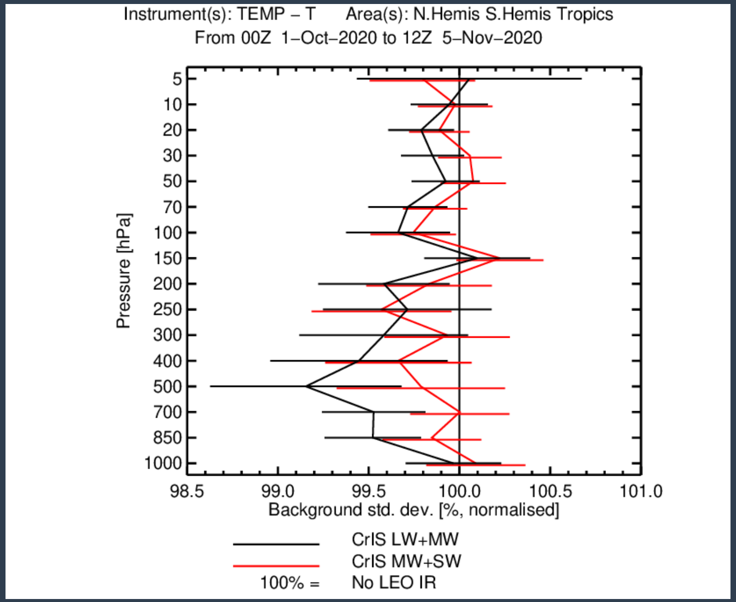
- Two experiments (LW+MW and SW+MW) compared to a no-IR baseline system.
- Solar and non-LTE effects are activated in RTTOV.
- Channel selection for LW and MW matches ECMWF operations, and for SW follows NOAA's selection.

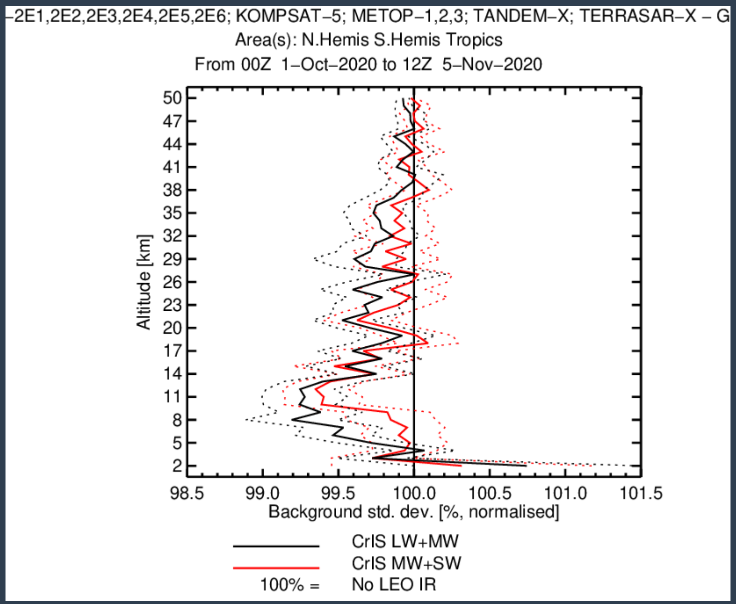


- SW channels used are: 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 2119 2140 2143 (2380-2507.5cm^{-1})
- These are assimilated day and night, but with a sun glint check.
- Ob errors are those provided by NOAA.
- Scene-dependent observation errors are applied to channels 1939-1948 (2380 - 2385.625 cm^{-1}).

Short range forecast fits to independent observations (using NOAA diagonal SW errors)

- Short-range forecast fits to independent obs suggests that the LW+MW experiment is performing better than SW+MW.
- Shown here are the T+12 forecast fits to radiosonde temperatures and GPSRO for the two experiments. Fits to other observation types show similar signals.
- **However**, this is not to be taken as a conclusive statement about the value of LW vs SW because we are comparing a mature (since 2003!) LW assimilation strategy against the first attempt at SW, using untuned observation errors etc.
- Future work will aim towards optimising the SW assimilation methodology.





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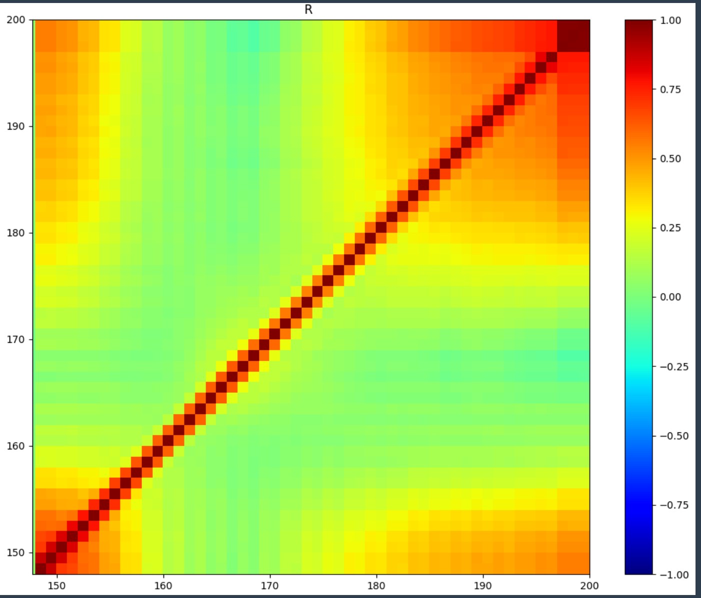
Observation errors

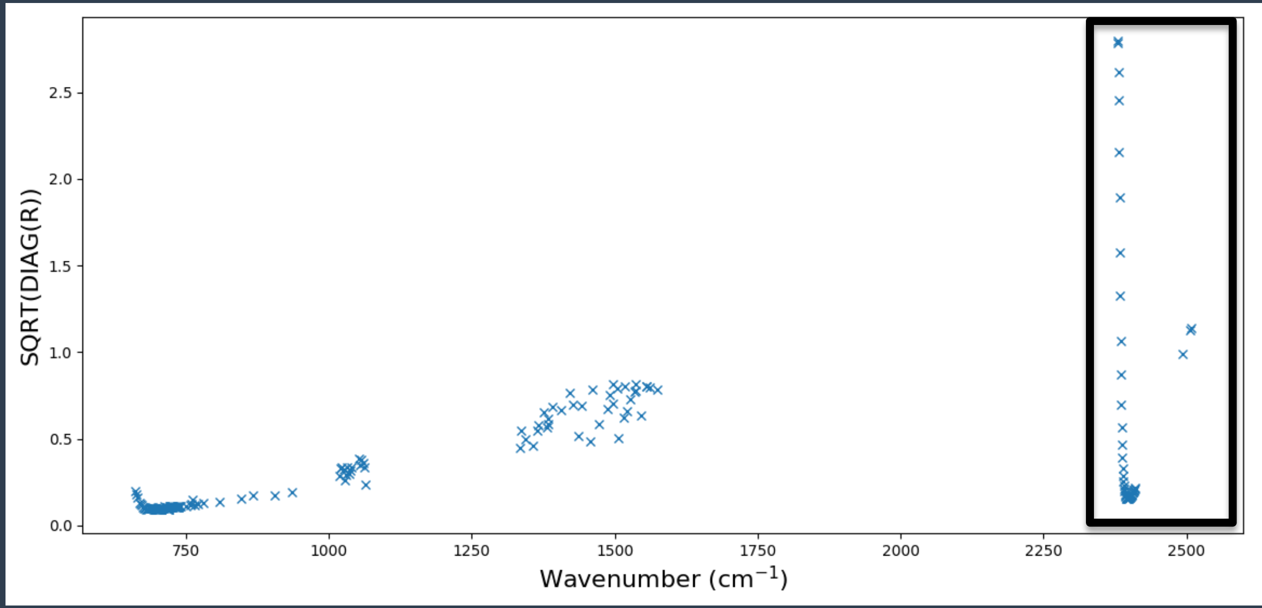
- Following Yingtao and Erin's approach, scene-dependent observation error scaling is applied due to the nonlinearity of the Planck function at these wavelengths.

$$\sigma_{Tscene} = \sigma_{T_B 280} \left.\frac{dB}{dT_B}\right|_{280K} \left.\frac{dT_B}{dB}\right|_{Bscene}$$

- Recently, we have derived full inter-channel covariances using the Desroziers method. SW channels are indicated.

Zoom into SW





- Preparing (and using) a covariance matrix for use with scene-dependent observation error scaling needs more consideration.

Summary

- We have shown that recent developments in radiative transfer modelling have enabled to SW channels to be successfully assimilated during day and night.

- Compared to the established methodology of assimilating LW channels, New complexities for data assimilation have been encountered for SW, such as the necessity of scene-dependent observation errors and how to correctly diagnose R matrices for use with scene-dependent scaling.

- To add SW to a system already assimilating LW+MW is only likely to provide modest additional impact, but as we have seen recently, bands can fail, so the ability to switch from LW to SW (even just for cloud detection) makes SWIR an important topic for future assimilation developments.

- It is vital that we are in a position to exploit any future augmentations to the operational satellite network offered (e.g. constellations of SW sensors providing rapid time refresh).