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Spectral signatures of Earth's climate variability as observed from space and diagnosed from reanalyses

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Measurements of the Earth's spectrally resolved outgoing longwave radiation have the intrinsic information content and link to the overall energy budget that implies that they are ideal candidates to monitor the climate and detect and attribute change. Theoretical studies have shown how distinct longwave spectral signals from different climate forcing and feedback mechanisms may be derived and appear to combine with a high degree of linearity. However, an open, important question which has not yet been fully addressed concerns the exact level of short-term variability seen in observed longwave spectra.

We investigate this here by exploiting the emerging radiance record available from the Infrared Atmospheric Sounding Interferometer (IASI) on the Metop-A satellite. We use five years of IASI data to assess the level of interannual variability seen in all-sky spectra at different spatial scales. Maximum variability is seen at the smallest scales investigated (10° zonal means) at northern and southern high latitudes across the centre of the 15 μm CO_2 band. As spatial scale increases, the overall magnitude of interannual variability reduces across the spectrum and the spectral shape of the variability changes. We show that the interannual variability manifested across the IASI spectra is less than 0.17 K in brightness temperature in the all-sky global annual mean, collapsing to a value of less than 0.05 K in the atmospheric window, a spectral region whose variability is dominated by fluctuations in surface and cloud properties. Spectrally integrating the IASI measurements to create pseudo broadband and window channels indicates a variation about the mean that is higher for the broadband than the window channel at the global and quasi-global scale and over the Southern Hemisphere. These findings are in agreement with observations from CERES *Terra* over the same period and imply that at the largest spatial scales, over the period considered here, fluctuations in mid-upper tropospheric temperatures and water vapour, and not cloud or surface temperature, play the dominant role in determining the level of interannual variability in all-sky outgoing longwave radiation.

This pattern of behavior is not seen in spectra simulated using reanalysis fields that have been sub-sampled to match the Metop-A satellite track. Possible reasons for this discrepancy will be discussed in this paper.