Evaluation of the infrared spectral signature of ARPEGE-Climat in clear-sky conditions using IASI observations

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ABSTRACT

The Earth's radiative budget is key to understand the climate system and predict its evolution. In most scientific studies, this budget is investigated using broadband radiative fluxes, which are standard outputs of climate models and have been measured from space for decades, for instance with the Clouds and the Earth's Radiant Energy System (CERES) instruments. However, spectrally-resolved radiative fluxes, especially in the infrared (IR) range, bear specific features of the climate system, such as the spatial and temporal variability of temperature, water vapour, clouds and atmospheric composition. This makes such observations very relevant for the evaluation and improvement of climate models.

This paper aims at evaluating the climate model ARPEGE-Climat using IASI observations. To this end, the radiative transfer code RTTOV is applied offline to ARPEGE-Climat outputs of an Atmospheric Model Intercomparison Project (AMIP) simulation, where sea surface temperatures and sea ice concentrations are prescribed. A set of synthetic IASI radiances at the temporal and spatial scales of the climate model is thus generated, for the 2008-2014 period. These radiances are statistically compared to the corresponding IASI A L1C spectra. This implies appropriate spatial sampling of the simulated radiances to match the satellite track, and spatial aggregation of the observations at the resolution of the model. The study focuses on clear-sky spectra, so that a recently developed IASI cloud mask is used.

The globally averaged clear-sky spectra are compared, showing brightness temperature differences up to 2 K in the water vapour absorption band and 1 K in the atmospheric window over oceans. Differences reach 5 K over lands. Further investigation of the spatial patterns of BT in various selected channels highlights differences that are attributed to issues with the surface temperature, the representation of surface emissivity, and already known biases in temperature and humidity. When roughly correcting ARPEGE-Climat by subtracting the local mean annual biases in temperature and humidity compared to ERA-5 the match is greatly improved, confirming the origin of the differences in IR radiances. Then the mean simulated and observed annual cycles in the selected channels are compared, showing a general underestimation of the amplitude of the cycles by ARPEGE-Climat, and a slight temporal shift.

This study aims at demonstrating the potential of hyperspectral IR observations for climate model evaluation and tuning. The framework can be applied to other IR sounders, such as the upcoming IASI-NG and FORUM missions. Future work will extend the evaluation to other models and to cloudy situations, and will investigate the added value of far-infrared coverage for such applications.