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Climate evolution in the spectral signatures of simulated and observed radiances

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Since the mid-2000s, stable hyperspectral observations of the mid-infrared (MIR) region (667 to 2750 cm^{-1}) of the Earth's emitted radiance have been provided by different space-based sensors (IASI, AIRS, etc.) producing a long-term dataset that has proven to be crucial for climatological studies. In addition, the FORUM mission, whose launch is planned for 2027, will provide unique spectrally resolved measurements extending down to the far-infrared (FIR) region (100 to 667 cm^{-1}), thus filling the current observational gap of the Earth's emission spectrum measured from space. Since these measurements contain the spectral signatures of temperature, water vapour, clouds and gases concentration, they can be exploited to strictly test General Circulation Models (GCMs), to constrain the parametrizations of sub-grid-process and to monitor the evolution of the climate system.

In this work, 12 years (2008-2019) of IASI Metop-A measurements are compared to simulated spectral radiances provided by the EC-Earth GCM (ECE, version 3.3.3) based on the atmospheric and surface fields predicted in all-sky conditions by the model. An innovative strategy is adopted to consider the cloud variability within the large model grid cell (roughly 80-km grid spacing near the equator) and to optimally compare the climate model outputs with the higher spatial resolution (about 15 km of diameter) observations performed by the instrument. The spectral radiances are simulated online every 3 hours by the σ-IASI radiative transfer model, that has been previously embedded in the climate model through the Cloud Feedback Model Intercomparison Project (COSP) module. The comparison is performed on both low-resolution bands, between 190

to 2500 cm−1, and on selected high-resolution channels, that mimic IASI and FORUM observation in the MIR and in the FIR regions.

Furthermore, spectral radiances are simulated by the EC-Earth climate models for two RCP climate scenarios (RCP 4.5 and RCP 8.5) spanning the time period from 2015 to 2035.

The comparison between simulated and observed spectral radiances and the study of spectral trends within climate scenarios featuring distinct radiative forcing aids in elucidating the link with the evolution of key climate variables, to characterize relevant driving mechanisms and to determine how these observations can potentially help to identify biases in climate model simulations.

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