Laboratoire : Centre National de Recherches Météorologiques

Titre du stage : Using infrared spectral signature as an overarching metric to characterize general circulation models

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Sujet du stage :

Context :

The climate of the Earth is controlled by the balance of radiative fluxes at the top-of-atmosphere (TOA), where the sum of reflected solar radiation and infrared (IR) emission from the Earth has to balance incoming solar radiation (Trenberth et al., 2009). Such broadband balance is key in the elaboration of stable and reliable General Circulation Models (GCMs), which would otherwise quickly derive to unrealistically cool or warm worlds. The spectrally detailed radiative balance is on the contrary less constrained in these models. As a consequence, GCM parameterizations are tuned to ensure broadband balance, but such balance can result from the combination of compensating errors in the representation of atmospheric processes, which are generally hard to disentangle (Huang et al., 2008). For instance, an underestimation of cirrus clouds can be compensated by overestimated water vapour in the upper troposphere, although both components have spectrally distinct signatures. Spectrally resolved observations in the IR, which have been routinely performed in the mid-IR for more than a decade and are likely to extend to the far-IR in the next decade, could put a strong constraint on GCMs. They could be valuable for GCM evaluation and calibration, and might help reducing the sustained uncertainty range of climate projections.

Objectives :

This internship aims at investigating the spatio-temporal spectral signature of GCMs in the IR. To this end a global set of synthetic observations of spectrally resolved IR radiance at TOA will be built from atmospheric profiles output by GCMs. These radiative transfer simulations will be performed with RTTOV (Saunders et al., 2018) because it optimally combines computational efficiency and high spectral resolution. A detailed statistical analysis will then enable to identify the main features of the spatio-temporal variations of these spectral radiances, from which metrics will be proposed to compare GCMs among each others or against relevant satellite observations. This analysis will be split up between clear-sky and all-sky conditions. The method will be applied to various GCMs participating in the CMIP6 intercomparison exercise, starting with those of the French community : CNRM-CM and LMDZ. Based on the defined metric, the similarity between GCMs in present-day conditions will be compared to the similarity in warming experiments. This will help assess whether current observations of the IR spectral radiative budget of the Earth can help ranking GCMs and reducing the range of climate predictions.

References :

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