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Sensitivity of model formulation to resolution: an example focusing on the global energy budget in three atmospheric GCMs with various horizontal resolutions

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Changes in the global energy budget of the Earth come from changes in the net solar radiation or in the outgoing longwave radiation and can have profound impacts on global-scale features, such as the global hydrological cycle. These fluxes strongly depend on clouds, aerosols and greenhouse gases, whose interactions with the climate system are mainly parameterised in General Circulation Models (GCM). As more and more GCMs are being developed at higher horizontal resolutions, the sensitivity of processes of the climate system to resolution are being explored, over different timescales and spatial scales.

In this study, we assess the sensitivity of the simulated global annual energy budget to horizontal resolution in three different atmospheric GCMs that have a hierarchy of similar formulations with different resolutions: the UK Met Office Hadley Centre's HadGEM1-A and HadGEM3-A models, and the Japanese Meteorological Research Institute's MRI-AGCM3.2 model. We will show that, in present-day climate, the global energy budget is well simulated by the three models considered, compared to recently published estimates of the Earth's global energy budget. We will also show that the global energy budget is insensitive to horizontal resolution in both HadGEM1-A and HadGEM3-A, but is sensitive to resolution in MRI-AGCM3.2. These findings emphasise that the sensitivity of the simulated global energy budget to horizontal resolution may depend on model formulation, and we will also present primarily results on the cause of this dependency, whether it depends on tuning, on different resolution adjustments in the parameterisation schemes or on the dynamics of the models.

These results show further evidence that the diversity of models' behaviour can simply depend on their resolution, a result that is well known for weather-like features (cyclones, precipitation extremes, blockings), and that this difference in behaviour can also start in the primary driver of the Earth's climate system: the global energy budget.