Geophysical Research Abstracts
Vol. 20, EGU2018-14163, 2018
EGU General Assembly 2018

Sensitivity of the Hydrological Cycle to Global Climate Models' Resolution

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Demory et al (2014) have demonstrated that the global water cycle is sensitive to global climate model (GCM)'s horizontal resolution, up to about 60 km, where the results converge. While ocean precipitation decreases at higher resolution, land precipitation increases due to larger moisture convergence over land. The contribution of moisture transport to land precipitation also increases, whereas moisture recycling, a quantity that is known to be overestimated by state-of-the-art GCMs, tends to decrease.

One question that came out of this study is whether such mechanisms are model dependent. The six GCMs involved in the EU-PRIMAVERA project (HadGEM3-GC31, EC-Earth3, MPI-ESM, CNRM-CM6-1, CMCC-CM2, ECMWF-IFS), complemented with three other GCMs (CAM5.1, MRI3.2 and GFDL-HIRAM), spanning a range of resolutions from 200 km to 20 km, offers an unprecedented opportunity to look at the systematic sensitivity of the hydrological cycle and moisture transport to resolution. Whenever possible, depending on high-frequency data availability, the total moisture transport is further decomposed into the contributions of mean circulation and transient eddies. The sensitivity of these different terms to resolution and their contribution to the mean precipitation are assessed at the global scale, in the Tropics and mid-latitudes. A decomposition into orographic and non orographic precipitation is also carried out.

Our results show that: (1) in all models, there is an increase of moisture transport to land when the resolution of the atmospheric model is increased, but the increase in grid-point models is more than twice that of spectral models; (2) the response is largely dominated by the tropics and the advection of moisture by the mean circulation; (3) at the global scale, the increased moisture transport balances the increase of orographic precipitation (which amount is larger in grid-point models with better resolved reliefs); (4) at the regional scale, several systematic improvements are found which can be linked to a better simulated seasonal mean circulation.