

## A diagnostic tool for the analysis of water, energy and entropy budget in climate models

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We present here a collection of tools for the diagnosis of various aspects of the thermodynamics of the climate system in models and reanalyses. The collection has been implemented as part of the ESMValTool v. 2 community diagnostics. It consists of four independent modules: 1. the energy budgets and meridional energy transports, 2. the water mass and latent energy budgets and respective meridional transports, 3. the Lorenz Energy Cycle (LEC), 4. the material entropy production in climate models. If a land-sea mask is provided, the modules 1 and 2 provide results on land and oceans separately. As an example, we present here results from a subset of the CMIP5 multi-model ensemble, in which three scenarios are compared, one accounting for the pre-industrial conditions, one for nowadays conditions, and one for the business-as-usual greenhouse gas emissions at the end of the 21st Century. We notice that the metrics provided indicate a clear change in the mean state of the climate in occurrence of increased GHG forcing. The hydrological cycle is stronger, and this is signaled by many features: the meridional water mass/latent energy convergence towards the Northern Hemisphere Tropics (about the ITCZ position) is increased, as well as the convergence from oceans towards the continents. The material entropy production is increased, mainly because of an increase in the component attributable to the hydrological cycle, especially tropical convection. Besides that, the LEC changes indicate a sharp decrease in available potential energy and increase in kinetic energy reservoirs. This is attributed to a decrease in the meridional temperature gradient, as also suggested by a decrease in the entropy production related to the heat convergence from low to high latitudes.