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# A new diagnostic tool for water, energy and entropy budgets in climate models

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This work presents a novel diagnostic tool for studying the thermodynamics of the climate systems with a wide range of applications, from climate models to Reanalyses. It includes a number of modules for assessing the hydrological cycle, the internal energy budget, the Lorenz Energy Cycle and the material entropy production, respectively. The program receives as input radiative, latent and sensible heat energy fluxes for the computation of energy budgets at Top-of-Atmosphere (TOA), at the surface and in the atmosphere as a residual. Meridional heat transports are also computed from the divergence of the zonal mean energy budget fluxes and location and intensity of peaks in the two hemispheres are provided as outputs. Rainfall, snowfall precipitation and evaporation fluxes (or alternatively latent heat fluxes) are received as inputs for computation of the water mass and latent energy budgets. If a land-sea mask is provided, the required quantities are separately computed over continents and oceans. The diagnostic tool also addresses the strength of the Lorenz Energy Cycle (LEC) and its storage/conversion terms as annual mean global and hemispheric values. Two methods have been implemented for the computation of the material entropy production, one relying on the convergence of radiative heat fluxes at TOA and at the surface (indirect method), one combining the irreversible processes occurring in the climate system, particularly heat fluxes in the boundary layer, the hydrological cycle and the kinetic energy dissipation as retrieved from the residuals of the LEC. A version of the diagnostic tool has been adapted to be included in the Earth System Model eValuation Tool (ESMValTool) community diagnostics, in order to assess the performances of soon available CMIP6 model simulations. The aim is to provide a comprehensive picture of the thermodynamics of the climate system as reproduced in the most updated coupled general circulation models.