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Entropy production diagnostics and entropy budget in an atmosphere-ocean general circulation model

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There is increasing interest in entropy production as a diagnostic tool for General Circulation Models, which is motivated in part by the intriguing Maximum Entropy Production conjecture and its possible applications.To that end, a thorough estimate of the material entropy sources by the climate system is required.

These terms are here estimated in the HadCM3 coupled Atmosphere-Ocean General Circulation Model and in FAMOUS, the low-resolution version of HadCM3. The entropy sources are calculated directly using the temperature and the temperature tendencies on every timestep.

The physical processes implemented in the atmosphere model are taken into account:
Temperature diffusion, Large Scale Cloud condensation and evaporation,
Convection, Boundary Layer mixing of latent and sensible heat fluxes, Kinetic Energy dissipation and Radiation. The use in some parts of the code of the cloud conserved variables makes it hard to uniquely separate the latent heat contribution from the sensible heat one. The numerical entropy source of the dynamic core is evaluated as well.
The entropy sources of the ocean are estimated in the same way. The processes represented in the ocean are: Diffusion, Convection, mixed-layer mixing, Gent-McWilliams thickness diffusion, radiation and other surface fluxes.
The entropy balance of the climate is satisfied within a few mW m-2 K-1. The radiative processes dominate the planetary entropy production, of which only a small fraction, the climate material entropy production, is expected to matter with respect to the MEP principle, and hence for climate.
The largest material entropy production term comes from the transport of latent and sensible heat from the surface (including the
ocean) to the atmosphere (nearly 80% of the total climate material entropy production) while the processes internal to the atmosphere
(dissipation, diffusion) contribute around 20-30% and processes internal to the ocean (diffusion, mixing) some percents.
Effects of the increasing model resolution are considered by comparing the entropy production terms in HadCM3 and FAMOUS.
The influence of internally generated variability on time-mean entropy production is taken into account as well.