Geophysical Research Abstracts
Vol. 20, EGU2018-13696, 2018
EGU General Assembly 2018

Entropy versus Available Potential Energy: What is the right way to define the thermodynamic efficiency of the climate system?

Remi Tailleux
University of Reading, Meteorology, Reading, United Kingdom (r.g.j.tailleux@reading.ac.uk)

The climate system is a natural heat engine that produces work in the form of kinetic energy and available potential energy (APE) from the differential heating/cooling pattern imparted by the incoming solar radiation. Only a fraction of the incoming solar energy — called the thermodynamic efficiency — can be converted into work, however, with the remaining part of the energy going into 'heat' or background potential energy. The thermodynamic efficiency is widely regarded as a key parameter of the climate system, which it is therefore fundamental to understand theoretically in order to predict it correctly. To estimate the thermodynamic efficiency of the climate system, two main approaches have been developed in practice, one relying on the entropy budget, the other on the available potential energy (APE) budget. While both approaches predict thermodynamic efficiencies that are comparable in the atmospheric case, this is not so in the oceanic case for which the entropy-based thermodynamic efficiency is about two orders of magnitude larger than the APE-based value. Such a large discrepancy in the oceanic case clearly demonstrates that the APE and entropy based thermodynamic efficiencies are fundamentally non-equivalent and hence that one must be superior to the other. The main aim of this talk is to elucidate the precise link between the two kinds of thermodynamic efficiency, and demonstrate that the APE-based thermodynamic efficiency is always a better predictor of the effective thermodynamic efficiency of natural heat engines. Other fundamental limitations of the entropy-based approach to estimating the thermodynamic efficiency of the climate system will also be highlighted.