EGU25-12720, updated on 14 Jan 2026
https://doi.org/10.5194/egusphere-egu25-12720
EGU General Assembly 2025

Physical understanding of bugs to improve the representation of the climate system

Hans Segura, Cathy Hohenegger, Reiner Schnur, and Bjorn Stevens
Max-Planck-Institute for Meteorology, Atmosphere, Hamburg, Germany (hans.segura@mpimet.mpg.de)

Earth system models are important tools used to understand our climate system and project possible changes in our climate due to anthropogenic and natural forcings. Human errors can occur in the development of Earth System models, i.e., bugs, giving an unphysical representation of our climate. A way to identify and solve bugs is to apply physical concepts. Here, we present an experience that occurred in the development of the ICOsahedral Non-hydrostatic model (ICON) as a kilometer-scale Earth System model, in which physically understanding a bug in the surface energy budget fixed land precipitation.

In a simulation of ICON, referred to as ICON-bug, precipitation over tropical land continuously decreased across the simulation. This led to a ratio of land-ocean precipitation in the tropics of less than 0.7, which, otherwise, should be more than 0.86. As part of the possible explanations, the surface energy budget over land was targeted as a culprit. This idea relies on the influence of the interaction between soil moisture, surface heat fluxes, and winds to generate circulation favoring precipitation over dry land surfaces (Hohenegger and Stevens 2018). Indeed, the surface energy budget over dry surfaces in the ICON-bug showed an error in sensible heat flux. The sensible heat flux transmitted to the atmosphere was 70% of what was calculated for the surface module. Fixing this error closed the surface energy budget and increased land precipitation over the tropics, leading to a ratio of land-ocean precipitation of 0.94, close to observations.