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Multistability in a Coupled Ocean-AtmosphereReduced Order Model: Non-linear TemperatureEquations

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Reduced order quasi-geostrophic ocean-atmosphere coupled models provide a platform that preserve key atmosphere behaviours, while still being simple enough to allow for analysis of the system dynamics. These models produce typical atmospheric dynamical features like atmospheric blocking and other low-frequency variability, while having a low number of degrees of freedom. For this reason, these models are well suited to investigating tipping points or bifurcations in the Earth's climate due to their simplified but insightful dynamics.

In our present work we compare the dynamics of an ocean-atmosphere coupled model, previously implemented with linearised temperature equations (Vannitsem et al., 2015), but here we solve the equations including the non-linear Stefan-Boltzmann law in the radiative temperature term. When compared with the original version of the model with linearised temperature equations, the modified version of the model is found to produce multiple stable flows in the coupled ocean-atmosphere system. We find, for increasing atmospheric emissivity, there is an increase in the number of stable attractors, and these stable attractors present distinct flows in the ocean and atmosphere and distinct Lyapunov stability properties.

Vannitsem, S., Demaeyer, J., De Cruz, L., & Ghil, M. (2015). Low-frequency variability and heat transport in a low-order nonlinear coupled ocean–atmosphere model. Physica D: Nonlinear Phenomena, 309, 71-85.