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Linear stability analysis of radiatively-driven convection in a lake[1]

TODD CHRISTOPHER, WILFRIED COENEN, STEFAN LLEWELLYN SMITH, University of California, San Diego — Observations of springtime warming of ice-free Lake Superior show that an instability arises each day at the surface and propagates down though the water column on a time scale of hours before restratification occurs at night. This situation is modeled using the Boussinesq approximation, leading to a Rayleigh-Benard-like configuration, except with a periodically-varying forcing term to capture the diurnal heat flux into the system. The forcing term is considered first as either a varying temperature or a varying heat flux at the boundary, but radiative heating in the bulk of the fluid is also investigated. A linear stability analysis of the system leads to a Floquet differential equation eigenvalue problem for the critical Rayleigh number. This problem is solved using a pseudospectral numerical method. The results found agree with the literature where applicable, while extending previous work to cover different boundary conditions and different forms for the forcing term.

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