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Global circulation in an axially symmetric Shallow Water Model forced by Equinoctial differential heating

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Solutions of an axially symmetric Shallow-Water-Model (SWM) on Earth forced by equinoctial differential heating are constructed using numerical integration of the time-dependent equations and analysis of the steady-states. By employing the (absolute) angular-momentum as a dynamical variable, it is shown that the only steady states are a radiative-equilibrium state with vanishing meridional velocity and a uniform angular-momentum state. Each of these states is stable but exists globally only for special parameter values and initial conditions. Numerical integration of the time-dependent equations initiated by physically acceptable conditions shows that the system approaches a discontinuous solution consisting of a uniform angular-momentum state in the Tropics, a radiative-equilibrium state in high latitudes and an unsteady transition region. The settling to the steady states outside this region occurs in finite time, after which the evolution is primarily the ever narrowing of the transition region. The analysis maps the physical initial conditions and parameter values that approach the steady state at long times. The asymptotic properties of the subtropical jets and tropical fluxes are explicitly calculated and it is shown that all solutions of the previously studied nearly-inviscid theory are particular solutions of the present truly inviscid theory. In contrast to non-SWE theories that prohibited westerly flows on the equator, our solutions show that for easterly/westerly equatorial flows, the subtropical jetstream strengthens/weakens and shifts poleward/equatorward. The strength of the tropical circulation increases with the ratio between the Equator-to-poles temperature difference and the mean temperature of the atmosphere and decreases with the thermal Rossby number.