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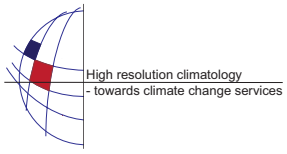

Analysis of tropical cyclone dynamics in a conceptual box-model and the axisymmetric cloud model HURMOD

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Tropical cyclone dynamics is investigated by means of a low order box-model and an axisymmetric high-resolution cloud model. Within the conceptual model the tropical cyclone is divided into three regions, namely the eye, the eyewall and the ambient region. It comprises the processes of surface evaporation, radial entropy advection, convection and radiative cooling. For typical tropical ocean parameter settings the system possesses three steady state solutions when the sea surface temperature (SST) is above a critical minimum value. One steady state is unstable while the two remaining states are stable. One of the stable solutions represents the atmosphere at rest and the other can be identified as a tropical cyclone at its maximum potential intensity (MPI). A saddle node bifurcation appears at a critical minimum temperature where two branches vanish. Below the critical temperature, only the atmosphere at rest represents a steady state solution in the system. A bifurcation diagram provides an explanation why only finite-amplitude perturbations above a critical SST can transform into tropical cyclones. Besides SST, relative humidity of the ambient region forms an important model parameter and the surfaces that describe equilibria as a function of SST and relative humidity reveal a cusp-catastrophe where the two non-trivial equilibria split up into four. Within the model regime of four equilibria, cyclogenesis becomes very unlikely due to the repulsing and attracting effects of the two additional equilibria. The results are in qualitative agreement with observations. Furthermore it is tested, whether the qualitative behaviour observed in the box-model simulations is reproducible in the axisymmetric cloud model HURMOD. It is shown that an attractor associated with a tropical cyclone exists in HURMOD when a simplified cloud physics is applied, so that condensate terminates immediately. By varying SST we find a tropical cyclone branch and a bifurcation in HURMOD similar to those detected in the low order box-model. The results evince the relevance of the simple model approach to the dynamics of tropical cyclone formation and its maximum potential intensity (MPI).