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Dynamical system properties of an axisymmetric convective tropical cyclone model

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The dynamical system behaviour of tropical cyclones and their potential intensity with view to sea surface temperature, tropospheric temperature stratification, and tropospheric moisture content is investigated in the axisymmetric convective model HURMOD. The model results exhibit the existence of a fixed point attractor associated with a strong tropical cyclone. Moreover, the initial vortex strength forms an amplitude threshold to cyclogenesis. Above this threshold, the size of the tropical cyclone and its intensity are independent of the initial vortex strength and its horizontal extent. Below the amplitude threshold, cyclogenesis does not occur and the system approaches an atmospheric state of rest. In case one allows for a deviation of the tropospheric stratification from moist-neutral conditions, the modelling results reveal the existence of bifurcations with the sea surface temperature representing the bifurcation parameter: As the sea surface temperature decreases and the storm weakens, the fixed point attractor turns first into a limit cycle indicating a Hopf-bifurcation, and then gives way to a steady state of lower intensity, before the intensity oscillation becomes chaotic, and finally the tropical storm dies. The amplitude threshold and the sea surface temperature range, within which the system exhibits bifurcation points, are sensitive to the reference value of relative humidity and the reference tropospheric temperature stratification. These findings indicate that the observed sea surface temperature threshold for cyclogenesis depends on the climate state, and thus can be expected to shift in response to global and regional climate change.