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Parametric Smoothness and Self- Scaling of the Statistical Properties of a Minimal Climate Model: what beyond mean field theories?

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A quasi-geostrophic intermediate complexity model of the mid-latitude atmospheric circulation is considered, featuring simplified baroclinic conversion and barotropic convergence processes. The model undergoes baroclinic forcing towards a given latitudinal temperature profile controlled by the forced equator-to-pole temperature difference Te. When Te increases, a transition takes place from a stationary regime–Hadley equilibrium–to a periodic regime, and eventually to a chaotic regime where evolution takes place on a strange attractor. The attractor dimension, metric entropy, and bounding box volume in phase space have a smooth dependence on Te which results in power-law scaling properties. Power-law scalings are detected also for the statistical properties of global physical observables — the total energy of the system and the averaged zonal wind. The scaling laws, which constitute the main novel result of the present work, can be thought to result from the presence of a statistical process of baroclinic adjustment, which tends to decrease the equator-to-pole temperature difference and determines the properties of the attractor of the system. The self-similarity could be of great help in setting up a theory for the overall statistical properties of the general circulation of the atmosphere and in guiding–on a heuristic basis–both data analysis and realistic simulations, going beyond the unsatisfactory mean field theories and /brute force/ approaches. A leading example for this would be the possibility of estimating the sensitivity of the output of the system with respect to changes in the parameters.

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