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Low-Frequency Variability in a Low-Order Shallow Water Atmospheric Model

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Low-frequency behaviour is investigated in a low-order atmospheric model derived from the 2-layer shallow water equations on a β-plane channel with bottom topography. The low-order model has a 46-dimensional state space and is obtained from the shallow water equations by a Galerkin projection retaining only the Fourier modes with lowest wave numbers.

The low-order model possesses rich dynamical features, which are investigated using techniques and concepts from Dynamical Systems theory. Bifurcations of equilibria and periodic orbits are studied by varying the height of the bottom topography and the magnitude of the zonal wind forcing. Several Hopf and saddle-node bifurcations of equilibria occur, organised by a number of codimension 2 Hopf-saddle-node bifurcation points. Chaotic attractors are often formed after the breakdown of 2-torus attractors: this gives a particular signature to the low-frequency behaviour, which is remarkably persistent in the parameter plane. Shilnikov-like strange attractors are also detected and related low-frequency behaviour is discussed.

The present study is a first step in the coherent analysis of the (infinite-dimensional) shallow water model. The main open question is which dynamical features of the low-order model persist as the number of retained Fourier modes is increased in the Galerkin projection.