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Unstable periodic orbits and stationary points of barotropic atmospheric model

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Unstable periodic orbits (UPOs) are an important feature of chaotic dissipative systems(i.e. systems having positive Lyapunov exponents and contracting the phase space). For some of chaotic systems like Anosov or Axiom A systems UPOs are dense on the system attractor so that any trajectory of the system can be approximated by some orbit with any given accuracy. As a result statistical characteristics of a system can be quantified in terms of UPO characteristics.

Atmospheric systems are dissipative and chaotic but likely do not have Axiom A property. In this study we try to understand to what extent UPOs of simple atmospheric system approximate its dynamics and statistics. The system under consideration is a Galerkin approximation for barotropic vorticity equation on a rotating sphere with T12 and T21 truncations.

With the help of damped Newton and Gauss-Newton methods we were able to find a large set of the system UPOs and stationary points. It was shown that average state of the system as well as its second order statistics (variance and leading EOFs) can be calculated by UPOs with very high accuracy. Other system properties like Kaplan-Yorke attractor dimension and number of positive Lyapunov exponents can also be reconstructed using UPOs. These results suggest that UPOs form a skeleton of the system attractor and may be important in understanding model dynamics.