Geophysical Research Abstracts
Vol. 19, EGU2017-6627, 2017
EGU General Assembly 2017

Lyapunov instability properties of a hierarchy of atmospheric models

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The deterministic equations describing the dynamics of the atmosphere (and of the climate system) are known to display the property of sensitivity to initial conditions. In the ergodic theory of chaos this property is usually quantified by computing the Lyapunov exponents. In this work, these quantifiers are computed in a hierarchy of deterministic atmospheric models (coupled or not to an ocean) and the statistical properties of the local Lyapunov exponents are analyzed. It is shown that the variability of the local Lyapunov exponents decreases when the number of variables – or in other words the resolution – is increased.

The implications for the dynamics of (finite-amplitude) initial condition errors in these models are reviewed, and in general found to display a complicated growth far from the asymptotic estimates provided by the Lyapunov exponents. The long-term predictability of the atmospheric dynamics is also discussed.