

Title: Emergence of chaos in the tropical atmosphere: Study of the weak temperature gradient system

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The predictability of the atmospheric tropical belt is investigated by exploring the emergence of chaos in reduced-order model off the vorticity equation under the weak temperature gradient hypothesis. It is shown that the emergence of chaos depends on the aspect ratio (the length scale of the forcing), the forcing amplitude and its symmetry properties. There is an unusual increase in the number of positive Lyapunov exponents that should be the core of the paper; unfortunately, this is postponed for future works.

I am left with a taste of “so, what”? The authors have an interesting model, come with interesting questions but postpone the core of the work for future works... So, let see what they will do with this. They did not explain sufficiently the key aspect (for instance, when $n = 20$, what is the corresponding length scale?, the role of the dissipation rate r , the implication of the two components of the forcing, etc.). Consequently, this manuscript appears as a preproject... This should be matured to become a paper to quote...

Other comments

Abstract

“This result contrasts with the idea of a predictable tropical atmosphere, and opens important questions on the effective origin of predictability in the Tropics.” This sentence opposes two features that appear contradictory. Please, clarify.

Introduction

The introduction is a little bit short... I don't understand why the problem of the atmospheric predictability can be resumed in knowing “whether the tropical atmosphere is essentially slaved to its boundary conditions.” Indeed, it is now well-known that very simple systems are not long-term predictable. Please, explain. I am rather surprised to read that the unpredictability results from “the uncertainty at the interface between the ocean and the atmosphere”. What is exhibited, particularly by Lorenz, is that the unpredictability is inherent from the dynamics itself and does not result from uncertainties, and this is what quantify the Lyapunov exponents... Please, clarify.

According to the authors, the question is therefore to know “whether the tropical atmosphere is essentially slaved to its boundary conditions”. It is therefore surprising to use simplified equations for investigating this. How are preserved the boundary conditions in the simplified model here investigated? This is a key question to address the problem posed by the authors but it seems to be forgotten from the beginning... So, what? In the other hand, how inserting stochastic forcing can help in answering this problem? Please explain.

Section 2.3

If I well understand this manuscript, the authors use an integration of the model over 30 s to assess Lyapunov exponents leading a horizon prediction of 1 day... It seems strange to me...

Section 3.1

How is selected $n = 20$? What is its influence on the results?

Figure 1 shows that the Lyapunov dimension becomes greater than 3 very quickly. It would be interesting to investigate how is the transition from periodic to chaotic. It appears that the hyperchaos arises also very quickly after the first chaotic solution, a feature quite expected with large dimensional model.

For regimes associated with a Lyapunov dimension greater than 9, how many Lyapunov exponents are null? This is indeed puzzling and this should be checked and explained since all the manuscript is devoted to Lyapunov exponents without further analysis. This cannot be postponed for future works because this could come from a mistake in computing Lyapunov exponents. Otherwise, what would be the interest of such a work? I had a look on the video, it seems rather surprising that these not so turbulent dynamics lead to so large Lyapunov dimension... A clear link could be made between these videos and the figures of the manuscript... This would help the reader...

When only X_{i_2} or X_{i_5} is reported, does it means that the second X_{i_j} is null ? Please, clarify.

Since there is no state portrait, it is rather difficult to figure out which type of (hyper) chaos is actually observed. The influence of symmetric and asymmetric forcing is therefore difficult to assess. The Lyapunov exponents being a poor marker for the type of chaos actually observed.