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Interactive comment on "A Dynamical Systems Characterisation of Atmospheric Jet Regimes" *by* Gabriele Messori et al.

Anonymous Referee #2

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Summary: This paper uses dynamical systems theory to illustrate and diagnose different jet regimes in a simple idealized atmospheric model, and in reanlaysis. The authors argue that this approach helps distinguish between different jet regimes in a clean and straightforward way, with improved computational efficiency. I found the methods introduced by this paper to be interesting and novel, and the results made sense to me. I think this paper is certainly appropriate for publication in Earth System Dynamics. The paper is overall well-organized and largely well-written, though I think there are a couple of areas where the authors should expand their discussion. My suggestions are primarily related to making the manuscript more approachable and easy to understand by a larger audience. I think that with some expansion of the discussion of the methodology, and some small changes to make the figures easier to interpret, this paper is

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Discussion paper

ready for publication in Earth System Dynamics.

Review:

–Section 2.3 (discussion of dynamical systems metrics): This framework is not familiar to a large number of people. If you have the space I think it is worth it to expand this discussion and explanation in the manuscript, especially since one of the stated goals of this manuscript is for it to be a proof of concept for using this kind of analysis in atmospheric dynamics. I must confess that, from a reader's perspective, I don't know that I'd be particularly inclined to consult several additional references just to understand the basic framework. I think leaving, for example, the detailed derivation of d and θ out is fine, but I'd appreciate a little bit more background information, especially since at least some of the authors on this paper are likely comfortable with this framework and certainly capable of more in-depth explanations. A few areas that I think could benefit from an expanded discussion: –Freitas-Freitas-Todd theorem, and the physical meaning of d. I think that I followed the part where d represents a trajectory (and thus, both space and time). However, the link between d and predictability was not at all obvious to me. Since Messori et al. (2017) has discussed this, I urge the authors to reiterate some of this discussion in this paper to make this easier to follow for the readers. Furthermore, I found physically interpreting d a bit challenging–is a smaller d related to a weaker jet? A jet with less meridional variability? Both? What does an "active degree of freedom" actually mean in this context? –Predictability of d vs predictability of θ. Lines 132-135 made me think that d and θ are related to different kinds of predictability–if this is the case, please elaborate on this (this was not obvious to me). Again, the authors reference Scher and Messori (2018), which makes me think that perhaps they could reprise some of these ideas in more detail in this manuscript.

–L149: "very weak latitudinal variability". In this case, "weak" to me kind of implies a weak jet, which one would sort of expect to be more variable? Maybe switch your wording to "low latitudinal variability"? –Line 215: Where do the low d, high θ jets fit in? (e.g. merged jets in Figure 3?)

–Line 255: Change "one main" to "one might".

–Section 5 (Discussion): I realize the point of this approach is to avoid using the conventional and complex physics-based analysis in place of this phase-space analysis, but I think that extending your results a bit farther to results gained from conventional physics-based studies would be helpful. If the long-term goal of this work is to encourage people to consider adopting this kind of analytical approach, giving them an example of how they can connect these phase-space results to more physically intuitive dynamics would be a useful guide. You touch on this a little but I think a slightly expanded discussion would strengthen this paper. For example, in section 2.3, you link both d and θ to predictability. In Line 255, you state that "one might expect a low d, high θ state to be more predictable than a high d, low θ state"–can you elaborate on this? Do the variability/persistence of the low d, low θ states match what you'd expect of a subtropical jet? And so on. I think that this paper touches on these ideas very briefly but I'd encourage the authors to draw more explicit and clear connections so as to really emphasize the utility of this approach.

–Figure 2a: Include the "x" symbol in the legend.

–Figure 3: I would suggest not using abbreviations in the legend. Furthermore, since persistence is related to θ-1, I would suggest reiterating in the caption that smaller θ corresponds to larger persistence. Alternatively, you could label the y-axes with "less predictability – more predictability" (similarly to what you did in Figure 4).

–Figure 4: Please reproduce the legend from Figure 2, and include a colorbar. Again, I'd suggest reiterating in the caption that persistence is related to θ-1.

–Figure 5: Since the main point of Figure 5 is to point out a detail in Figures 3 and 4, I think it could be moved to the Appendix (if the authors are looking to streamline or shorten the manuscript).

–Figures 6/7: It might be helpful to combine these figures–personally, I would find it

helpful to look at the vertical and horizontal structures together. This is just a suggestion, and very much up to the authors' preferences.

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