Review of paper

Does the envelope of Rossby wave packets exhibit higher predictability than the underlying wave pattern?

by M. Riemer and L. Gölz

submitted to *Weather Clim. Dynam.*

This is in principle an interesting study, which investigates with a sophisticated methodological approach whether Rossby wave packets (RWPs) are better predicted than the underlying Rossby waves. The topic is of great interest to readers of WCD, and I think that after major revisions this can become a valuable contribution. The authors apply a complex set of diagnostics and honestly, I got lost several times in understanding what is done, and why, and how the results were actually obtained. Some analyses appear overly complicated and difficult to understand and should be considered to be removed from the paper or much better explained. In short, this is important work, but the paper requires major restructuring to better guide the reader.

Major comments

A) I found it challenging to understand the structure of the paper and in particular in Sect. 2 and 3 why certain concepts are introduced and how they help addressing the main question of the paper. Section 2 first led me into the climatology of RWPs … then you introduce the envelope concept, then MSE and the idea of a saturation level, and then it felt like an abrupt jump in Sect. 3 to look at PV tendencies … (and in L181 I wondered why this decomposition is needed – how does this contribute to answering the main questions was not clear to me!) … before in Sect. 3.2.2 you go back to envelope errors. Could this be streamlined somehow? Maybe first discussing the envelope and envelope errors in general, and then discussing how this concept looks like in the PV framework? And explain why you need so much detail in the PV error analysis. In the end you are not specifically interested in PV errors, right, but rather in envelope errors? To summarize this point, in Sect. 3.2.2 I felt rather lost. I tried to understand the Fourier notation and the different PV terms but had no clue how this will be related to the theme of the paper.

B) Figure 6 and L253: it is not clear to me how this was done: for all curves in Fig. 6, do you always consider the same grid points? And do you consider them only at times when there is a

RWP or at all times? How do the curves relate to the mathematical terms introduced in the previous section? I am rather lost here how these curves were calculated. Maybe an example for one of the cases shown in Fig. 1 and 3 would help? Figure 6 leads to one of the main conclusions of the paper (L281) and therefore it is very important that the reader clearly understands how the different MSE curves were calculated. Related to this, I was completely confused in L283 (Fig. 7) because I thought that all the analysis before (Fig. 6) was done specifically for RWPs, but obviously not …

C) I could not understand what is shown in Fig. 8. What is the unit along the y-axis? Do these curves relate somehow to the results shown previously in Fig. 6 or 7? I assume yes, but it is not clear to me how. Most likely references to some of the equations introduced in Sect. 2 and 3 could help. A related specific question: if the error growth curves in Fig. 8a and 8b are so similar (L308), why then are the blue and orange curves in Fig. 7a different?

Minor comments

1) L1: "long-standing hypothesis": I was not aware of the quote by Lee and Held (1993), which indeed is a remarkably clear statement. However, to call something a "long-standing" hypothesis, I would expect it to appear more frequently in the literature. Maybe "a hypothesis postulated in the 1990s" would be more appropriate?
2) L4: try to simplify the abstract, e.g., "envelope" has not been introduced and is not clear here.
3) L8: I struggle with "the envelope is the wave". I understand that both have similar error dynamics but still the envelope is a reduced concept of the entire wave.
4) L9: sounds obvious to me – what should have been the "large-scale dynamics" that determines the evolution of the RWP independent from its "underlying wavenumbers"?
5) L11: why are your results rendering the concept of large-scale RWPs a "misconception"?
6) Fig. 1 caption and elsewhere: write dates in the form "at 12 UTC on 6-9 August YEAR".
7) Fig. 1 caption and elsewhere: refer to panels simply as, e.g., "a" not "a)".
8) Fig. 1 caption: not clear where these wind speed values are valid; at a certain pressure level?
9) L42: should read "indicated".
10) L42: I don't find this entirely convincing, changing the amplitude and/or shape of troughs and ridges in most cases directly modifies the shape of the diagnosed RWP – the existence and overall size might not be strongly sensitive to individual troughs and ridges, but the detailed shape (as shown in Fig. 1) should be. In other words, I am not too surprised that the hypothesis

did not verify – but of course this does not downplay the value of this study (which is the first to quantitatively test the hypothesis), it just reduces my "degree of surprise".

11) L53: should read "their Fig. 2".
12) L56: what do you mean by "negates"?
13) L59: incorrect grammar, maybe "signify"?
14) L63: should read "… and Baumgart" instead of "…; Baumgart".
15) L65: what are "piecewise PV tendencies"? (your 2016 paper does not use this term)
16) L81/82: should read "reanalyses".
17) Fig. 3: I suggest including the symbol "E" in the caption, and to overlay the 20 m s^{-1} contour from Fig. 1 (this would help the comparison).
18) Fig. 4: which latitude band is considered here? And are grid point values weighted with latitude?
19) Fig. 4: do you understand why values of E are larger in summer than in winter, both inside and outside of RWPs?
20) L178: I don't understand the logic here. You make the point that advection dominates the growth of PV errors, but what is the connection then to initial condition errors? And does this mean that you totally ignore the potential diabatic contributions to PV error growth, or do you capture some of them indirectly via advection?
21) L179: relative to what?
22) L239: I don't understand the SUM+/–k notation.
23) L249: can you make this more explicit / intuitive to the reader: how will you apply these equations and what exactly can be learned from them?
24) L322: I could not really follow why this is the appropriate interpretation of the results shown. If the envelope was the wave, the whole question of the paper would not make much sense(?). Do you rather mean "errors in the wave directly affect errors in the envelope"?
25) L330: should read "These authors found …" and "presented" in L333
26) L337: I don't understand "outside of identified RWP objects where the envelope field still exceeds its median value"
27) L340: are you comparing here predictability inside and outside of RWP objects on the same days, or do you compare predictability on days with vs. without RWP?
28) L345-L358: here I was again lost with understanding what you are doing

29) L360: I assume that large amplitude PV anomalies occur in preferred regions (since PV variability is not the same everywhere) and I therefore wonder whether your result about predictability and the amplitude of PV anomalies says something about having higher predictability in some regions (where PV variability is larger) and smaller predictability in other regions (where no large amplitude PV anomalies occur) or do make a statement about predictability in a specific region for flow situations with small vs. large anomalies? If the latter is true, then you would say that flow situations close to climatology have the lowest predictability?
30) L371: should read “suggested”
31) L385: I wonder whether some of the conclusions here were not clear already before doing this study. For instance, “phase errors in the underlying wave pattern thereby translate into envelope errors”, isn’t this clear from basic considerations as shown in Fig. 9? Isn’t the main result that this “effect” is so strong that you get the same error growth for the envelope and the wave pattern? Similarly, “the envelope is a direct function of its underlying wavenumbers”: of course!
32) L401: These conclusions should be reformulated such that the reader understands the inside-outside concept (see comments above).