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CC1: 'Comment on egusphere-2026-2981', Nima Zafarmomen, 04 Jul 2026 reply

The manuscript provides a broad and interesting review of catastrophe theory and its possible relevance to physics-based numerical weather prediction. The topic is timely and potentially valuable, but the manuscript would benefit from several minor revisions to improve clarity, structure, and balance.

1. The manuscript discusses catastrophe theory, tipping points, NWP limitations, AI-weather models, and thermodynamic constraints. The authors should state more clearly whether the main aim is to provide a literature review, a conceptual critique of current NWP, or a proposal for a future NWP methodology.
2. Terms such as “catastrophe,” “tipping point,” “bifurcation,” “multiple equilibria,” “multiple solutions,” and “physical solution” are central to the argument. A short definition table or concise explanatory paragraph would help readers from outside nonlinear dynamics.
3. Several sentences are long and difficult to follow. Careful language editing is recommended to improve grammar, sentence structure, and overall readability.
4. The argument that physics-based NWP may be approaching a development limit is interesting, but some statements are quite strong. The authors should either provide stronger quantitative support or present these points more cautiously as hypotheses.
5. Since Figure 1 is used to support the claim that forecast-score improvement is slowing, the authors should explain more clearly how the metrics were selected, how they should be compared, and what limitations exist in drawing this conclusion from the figure.
6. The review summarizes many catastrophe-theory applications, but the practical pathway for using catastrophe theory in NWP remains unclear. The authors should briefly explain how CT could inform model development, data assimilation, ensemble forecasting, or forecast interpretation.
7. The authors are strongly recommended to cite recent work on the use of large language models for adverse weather reasoning. In particular, Zafarmomen, N. and Samadi, V.: *Can large language models effectively reason about adverse weather conditions?*, Environmental Modelling & Software, 188, 106421, 2025, directly addresses whether LLMs can effectively reason about adverse weather conditions using U.S. National Weather Service flood-report data and several transformer-based models, including BART, BERT, LLaMA-2, LLaMA-3, and LLaMA-3.1. This reference is highly relevant to the manuscript’s discussion of AI-weather models and

would strengthen the coverage of recent AI/LLM applications in weather and hazard-related contexts.

Dear Nima Zafarmomen,

Many thanks for your valuable comments that will significantly improve our manuscript (MS).

1. The main content of our MS might be summarized as the following: **The numerical weather prediction (NWP) is facing the challenge of development bottleneck, and this article, via a comprehensive review on application of catastrophe theory to the atmospheric science for revealing the fundamental logic why the physics-based NWP methodology would be about to approach its end with some remedial measures suggested for avoiding its finality to occur, might be helpful to promote the enhancement of NWP forecasting accuracy so as to break its development bottleneck.** It covers largely all of these: literature review, conceptual critique of the current NWP methodology and, a proposal for a future NWP innovation strategy.
2. Thank you for your suggestion. We will do it during the final response phase.
3. Yes, we will revise some long sentences. Thank you!
4. Good suggestions! We will replace some relevant expressions in a more tactful way. Thank you again!
5. In Fig. 1 The time series of the miscellaneous forecasting scores, the ACC, RMS, and CRPSS etc. are conventionally used as forecasting scores. As an example, ACC (see e.g. Fig. 1 (j) in our MS from Haiden and Chevallie (2025)) as a measure of the effectiveness of the model in forecasting 500 hPa heights at several forecast lead times evolved over the past decades shown, tend obviously to keep unchanged with minor fluctuation during the recent period (2020-2025). In other words, by limitation we mean that a further improvement in forecasting accuracy by the physics-based NWP methodology is increasingly difficult.
6. Good questions! From an application perspective, it is highly noteworthy and, partially we have specifically discussed several issues concerned (see the subsections 4.2 and 4.3 in the preprint for further details). Thank you!
7. We are so happy to have the chance to share your article. Especially, your work involves reasoning about adverse weather conditions employing the LLMs. In the revising phase for our MS we will try to add it into the corresponding section. Thank you very much!