Review of "A Model Instability Issue in the NCEP Global Forecast System Version 16 and Potential Solutions", by X. Zhou and H.-M. H. Juang.

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Recommendation: publish after minor revisions

General evaluation

The authors discuss a numerical stability issue in the FV3 dycore that appeared several times during the preoperational phase of NCEP's GFS v16, where the transition from the former spectral hydrostatic dycore to the nonhydrostatic FV3 was prepared. The instability was related to extremely small thicknesses of the lowest model layer and could be solved by changing the lower boundary condition for geopotential advection from high-order to zero-gradient. Since the potential occurrence of this type of instability is specific to the numerical implementation of FV3, its solution has probably no relevance for other atmospheric models, but one may argue that the FV3 is sufficiently widely used in the meteorological community to warrant publication in a peer-reviewed journal despite this caveat. I will leave the decision upon the question of sufficient general relevance to the editor. Apart from that, I have only a couple of minor comments.

Specific comments

1. p. 3, ln. 84/85: Is the pressure-gradient discretization in FV3 fourth-order accurate including the metric terms related to the coordinate transformation?

2. p. 4, ln. 121: "but that did not fix the model stability issue for all eight crashed cases": That means, it did help for some of the cases, or for none of them? Please clarify.

3. p. 5, ln. 124/125: As the instability was related to a collapse of the surface layer thickness, did the changes of the Rayleigh damping / sponge layer beneath the model top have any impact at all? If yes, how can this be explained?

4. p. 5, caption of Fig. 1: From which model level are the wind fields taken? And the unit for the reference arrow is missing (hopefully m/s).

5. p. 6, Eq. (1): What is m? I suppose mass, but this should be indicated here.

6. p. 7, ln. 218: "close to 0 200s ..." please write "zero".

7. p. 8, Fig. 4 and corresponding caption: please indicate the unit of virtual potential temperature and explain the meaning of its values. Is it a deviation from a reference state? In addition, it appears quite odd that the height thicknesses in panel (e) are generally negative. This may be a model-internal sign convention, but a thickness is usually a positive-definite quantity, and it would be better to adjust the figure accordingly.

8. p. 8, ln. 234–237: The sentence starting with "Note that the update" is hard to understand and should be formulated more clearly.

9. p. 12, ln. 329: $\frac{dq}{dx} = 0$ – analogous in y-direction? Moreover, I would expect that zero slope means $\frac{dh}{dx} = 0$. Please clarify.

10. p.15, ln. 391: Is replacing upper and lower boundary conditions at the same time needed for consistency, or would it be sufficient to use zero-gradient for the lower bc's?

11. p.15, ln. 392: "forecasting" $\rightarrow$ "forecasts"

12. p. 15, ln. 409: “zerio” → “zero”
13. p. 15, ln. 411: “Planetary Boundary Lateral” → “... Layer”
14. p. 17, ln. 469: “value of 2 to 6 can ...” insert “meters”