

Geosci. Model Dev. Discuss., referee comment RC1
<https://doi.org/10.5194/gmd-2021-84-RC1>, 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.

Comment on gmd-2021-84

Anonymous Referee #1

Referee comment on "BedyMo: a combined quasi-geostrophic and primitive equation model in σ coordinates" by Clemens Spensberger et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-84-RC1>, 2021

The quasi-geostrophic (QG) model has been developed to study the large-scale flow and is one of the most successful models in meteorology. It did not only allow for the first successful numerical weather forecasts but it can be used to explain almost all features we find in large-scale flows (see e.g. Pedlosky 1987). However, more complete models have been developed to describe phenomena beyond the QG scaling, e.g. primitive equation (PE) models. It is important and was done by several earlier studies, to compare the QG and PE dynamics to validate models and to understand better processes consistent or beyond QG dynamics.

The manuscript entitled 'BedyMo: a combined quasi-geostrophic and primitive equation model in sigma coordinates' by Clemens Spensberger, Trond Thorsteinsson, and Thomas Spengler is about the combination of the quasi-geostrophic approximation and the hydrostatic primitive equations in one modelling framework. Different case studies are done: baroclinic life cycles, storm tracks, topographic flow, and equatorial waves. The cases are described well and show the power and quality of the models. I have a number of comments the authors might consider before publication.

Comments:

1. In principle, at least over a certain time period, each model can be run in a "QG mode" by just respecting the QG assumptions. The Rossby number needs to be small, the topography needs to be shallow, etc. Of course, a PE model will develop spatio-temporal ageostrophic dynamics when small scales are not filtered. I wonder, whether this resolution aspect has been considered. When comparing QG and PE, was the size of the time step and the spatial resolution the same? I think this issue is of particular importance for the storm track simulations.

2. The values of the chosen parameters should be given (time step, resolution,...). Also all the values for the coefficients in the models should be given: r , D , α ,.... In particular,

some of the coefficients occur in the QG and the PE model (e.g. r and D). Are they the same in both models?

3. I think Bedyko could be very helpful to study the concept of balance. Recently, interest has increased significantly to better understand the coupling of the slow and the fast dynamics. QG solutions are balanced solutions without any internal gravity waves. Implementing such solutions into a PE model will destroy the balance. Bedyko would be an ideal tool for studying such processes, e.g. so called spontaneous imbalance. This means, however, to resolve the PE model properly. An overview on this issue can be found in a JAS special collection at <https://journals.ametsoc.org/collection/spontaneous-imbalance> .

4. The cases considered test mainly the quality of the QG model and the ability of the PE model to represent the QG solutions. Has the PE model also been tested against typical PE test cases?

5. The color code of Fig. 2, 4, 5 is not easy to read. Using different line styles might make the figures more clear.

6. I think for the baroclinic life cycle and the storm track case the boundaries in the meridional direction are closed ($v=0$). However, for the Rossby wave case these boundaries seem to be open. Could the authors give a short description how the open radiative boundaries have been implemented in both models?

7. What is the reason for the asymmetry in the PE Rossby wave case?

8. For the coupled case a equatorial flow has been chosen that cannot be compared to QG dynamics that covers mid-latitude flows only. Instead the QG comparison, the PE solutions are compared with analytical solutions from linear wave theory. This works only for sufficiently small heating. Was the local heating chosen comparable to the sources used e.g. in the paper by Gill (given in the reference)? For the linear theories, the ocean was passive. Was the motivation to couple an active surface layer ocean to study the differences?

9. Recently, very interesting nonlinear solutions of equatorial waves have been documented (see e.g. Rostami, M., and Zeitlin, V. "Eastward-moving equatorial modons: a missing chain-link in the dynamics of the tropical atmosphere?", *Phys. Fluids*, 31, 021701, 2019). For future work it would be very instructive to try to find such solutions with the PE model.