Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2016-247-AC1, 2017
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Geoscientific Model Development Discussions
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Interactive comment on "rpe v5: An emulator for reduced floating-point precision in large numerical simulations" *by* Andrew Dawson and Peter Düben

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Received and published: 13 March 2017

We thank the reviewer for their feedback and we are happy to address the comments in a revised version of the paper, and discuss the reviewer's comments in a detailed reply. In particular, we are happy to add:

- A more discussion on other tools that investigate the propagation of rounding errors through numerical integrations such as the tools named in the review.
- More details on the impact of rounding to plus or minus infinity on conservation properties.
- A more intuitive discussion of the results in Figure 4.

- More details and discussion on the performance overhead, including measurements.

However, we would like to stress already in this very short reply that rpe was designed particularly for fluid dynamical simulations that show chaotic dynamics in a complex model setup. Tools such as CADNA, Precimonious etc. work well for problems where there is a precise exact solution to be obtained. However, they are not as useful to investigate models for geophysical flows. For these models there is typically considerable uncertainty in both the formulation of the model and the initial conditions. Due to the chaotic nature model simulations that are only slightly perturbed, for example by the use of lower or higher precision, will quickly diverge from each other (with the rate of divergence proportional to the leading Lyapunov exponent that will depend on the weather regime of the initial conditions and vary with time). To perform reliable forecasts we need to perform ensembles of simulations that can show good predictive skill even if rounding errors have reached the most significant digits for some of the ensemble members and model outputs. Tools such as CADNA fail to provide satisfying results in a chaotic regime for which a rounding errors in one direction can result in a response of the system in the exact opposite direction. It was these intricacies of analysing precision in chaotic geophysical models that motivated the development of *rpe*.

It is true that *rpe* will not provide information on the validity of results and that the user will need to compare against double precision results. However, this is intentional since a quantification of rounding errors does not provide the required insight in our model framework. Take the paper *Düben et al.* (2017) as an example, where a study of reduced precision arithmetic for a cloud resolving model coupled to a global model is made. To identify model quality by looking at the impact of rounding errors on the output parameters of the cloud resolving model would not provide sufficient insight; model results may differ up to the most significant digit for some of the output parameters of the cloud resolving model due to exponential growth of error in the initial conditions.

However, the cloud resolving model at reduced precision may still provide physically meaningful results that provide sufficient feedback to the global model simulations. This can only be tested with explicit simulations using a tool such as *rpe*, and evaluation by a domain scientist who understands the physical behaviour of the model.

References

Düben, P. D., A. Subramanian, A. Dawson, T. N. Palmer (2017), A study of reduced numerical precision to make superparameterization more competitive using a hardware emulator in the OpenIFS model, *J. Adv. Model. Earth Syst.*, doi: 10.1002/2016MS000862.

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