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Numerical Error Estimation with UQ

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Ocean models are still in need of means to quantify model errors, which are inevitably made when running numerical experiments. The total model error can formally be decomposed into two parts, the formulation error and the discretization error. The formulation error arises from the continuous formulation of the model not fully describing the studied physical process. The discretization error arises from having to solve a discretized model instead of the continuously formulated model. Our work on error estimation is concerned with the discretization error. Given a solution of a discretized model, our general problem statement is to find a way to quantify the uncertainties due to discretization in physical quantities of interest (diagnostics), which are frequently used in Geophysical Fluid Dynamics.
The approach we use to tackle this problem is called the "Goal Error Ensemble method". The basic idea of the Goal Error Ensemble method is that errors in diagnostics can be translated into a weighted sum of local model errors, which makes it conceptually based on the Dual Weighted Residual method from Computational Fluid Dynamics. In contrast to the Dual Weighted Residual method these local model errors are not considered deterministically but interpreted as local model uncertainty and described stochastically by a random process. The parameters for the random process are tuned with high-resolution near-initial model information. However, the original Goal Error Ensemble method, introduced in [1], was successfully evaluated only in the case of inviscid flows without lateral boundaries in a shallow-water framework and is hence only of limited use in a numerical ocean model. Our work consists in extending the method to bounded, viscous flows in a shallow-water framework. As our numerical model, we use the ICON-Shallow-Water model.
In viscous flows our high-resolution information is dependent on the viscosity parameter, making our uncertainty measures viscosity-dependent. We will show that we can choose a sensible parameter by using the Reynolds-number as a criteria. Another topic, we will discuss is the choice of the underlying distribution of the random process. This is especially of importance in the scope of lateral boundaries.
We will present resulting error estimates for different height- and velocity-based diagnostics applied to the Munk gyre experiment.

References

[1] F. Rauser: Error Estimation in Geophysical Fluid Dynamics through Learning; *PhD Thesis, IMPRS-ESM, Hamburg, 2010*

[2] F. Rauser, J. Marotzke, P. Korn: Ensemble-type numerical uncertainty quantification from single model integrations; *SIAM/ASA Journal on Uncertainty Quantification, submitted*