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Improving Weather Forecasts Through Reduced Precision Data Assimilation

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We present a new approach for improving the efficiency of data assimilation, by trading numerical precision for computational speed. Future supercomputers will allow a greater choice of precision, so that models can use a level of precision that is commensurate with the model uncertainty. Previous studies have already indicated that the quality of climate and weather forecasts is not significantly degraded when using a precision less than double precision [1,2], but so far these studies have not considered data assimilation.

Data assimilation is inherently uncertain due to the use of relatively long assimilation windows, noisy observations and imperfect models. Thus, the larger rounding errors incurred from reducing precision may be within the tolerance of the system. Lower precision arithmetic is cheaper, and so by reducing precision in ensemble data assimilation, we can redistribute computational resources towards, for example, a larger ensemble size. Because larger ensembles provide a better estimate of the underlying distribution and are less reliant on covariance inflation and localisation, lowering precision could actually allow us to improve the accuracy of weather forecasts.

We will present results on how lowering numerical precision affects the performance of an ensemble data assimilation system, consisting of the Lorenz '96 toy atmospheric model and the ensemble square root filter. We run the system at half precision (using an emulation tool), and compare the results with simulations at single and double precision. We estimate that half precision assimilation with a larger ensemble can reduce assimilation error by 30%, with respect to double precision assimilation with a smaller ensemble, for no extra computational cost. This results in around half a day extra of skillful weather forecasts, if the error-doubling characteristics of the Lorenz '96 model are mapped to those of the real atmosphere. Additionally, we investigate the sensitivity of these results to observational error and assimilation window length.

Half precision hardware will become available very shortly, with the introduction of Nvidia's Pascal GPU architecture and the Intel Knights Mill coprocessor. We hope that the results presented here will encourage the uptake of this hardware.

References

[1] Peter D. Düben and T. N. Palmer, 2014: Benchmark Tests for Numerical Weather Forecasts on Inexact Hardware, *Mon. Weather Rev.*, **142**, 3809-3829

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