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Some optimisation experiments in MITgcm using a reduced-precision adjoint

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In recent years, it has been convincingly shown that weather models can be run in single-precision arithmetic with only relatively minor modifications. Previous work has largely focused on the main nonlinear 'forward' model. A nonlinear model, in weather forecasting or otherwise, has corresponding tangent linear and adjoint models. Within weather forecasting, these are used in data assimilation; more generally, they can be used in sensitivity studies and for gradient-based optimisation. The linearised models are plausibly far more sensitive to reductions in numerical precision since unbounded error growth can occur with no possibility of nonlinear saturation.

Here, we present several geophysical experiments within MITgcm, albeit in an oceanic rather than atmospheric context, and with a coarse resolution. Some experiments make use of an adjoint model to calculate sensitivities, while others perform optimisation using the quasi-Newton method M1QN3. Using software emulation, we investigate the effect of degrading the numerical precision of the adjoint model on the resulting sensitivities and the convergence of the optimisation procedure. We find that reasonable results are obtained with as few as 10–12 significand bits, which is comparable to the significand precision in the IEEE half-precision standard.