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Mixed-Precision Arithmetic in Earth-System Modelling

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Earth-System models traditionally use double-precision, 64 bit floating-point numbers to perform arithmetic. According to orthodoxy, we must use such a relatively high level of precision in order to minimise the potential impact of rounding errors on the physical fidelity of the model. However, given the inherently imperfect formulation of our models, and the computational benefits of lower precision arithmetic, we must question this orthodoxy. At ECMWF, a single-precision, 32 bit variant of the atmospheric model IFS has been undergoing rigorous testing in preparation for operations for around 5 years. The single-precision simulations have been found to have effectively the same forecast skill as the double-precision simulations while finishing in 40% less time, thanks to the memory and cache benefits of single-precision numbers. Following these positive results, other modelling groups are now also considering single-precision as a way to accelerate their simulations.

In this talk I will present the rationale behind the move to lower-precision floating-point arithmetic and up-to-date results from the single-precision atmosphere at ECMWF. I will also present the first results from running ECMWF's chosen ocean model, the community model NEMO, with single-precision. Finally I will discuss the feasibility of even lower levels of precision, like half-precision, which are now becoming available through GPU-based and ARM architectures.

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