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## Operational Single-Precision Earth-System Modelling at ECMWF

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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 presentation I will present the rationale behind the move to lower-precision floating-point arithmetic and up-to-date results from the single-precision atmospheric model at ECMWF, which will be operational imminently. I will then provide an update on the development of the single-precision ocean component at ECMWF, based on the NEMO ocean model, including a verification of quarter-degree simulations. I will also present new results from running ECMWF's coupled atmosphere-ocean-sea-ice-wave forecasting system entirely 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- and ARM-based systems such as Summit and Fugaku, respectively. The use of reduced-precision floating-point arithmetic will be an essential consideration for developing high-resolution, storm-resolving Earth-System models.