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Posit numbers as an alternative to floating point numbers for weather and climate models

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Weather and climate models are based on computations of real numbers, which are represented with 64 bits on a computer up to a finite numerical precision. The standard are so-called floating point numbers (floats), that decode a real number in terms of sign, exponent and significant bits. Recent research shows that many bits, especially of the significand, do not contain real information, promoting the use of reduced precision floats with less than 64bit. However, floats might not be the best bit-wise representation for numbers in numerical models of weather and climate. Posit numbers are a recently proposed alternative to floating point numbers. By introducing regime bits, posits have a higher numerical precision around one, yet a wide dynamic range of representable numbers. Studying weather and climate models of low and medium complexity (the Lorenz 1963 system and a shallow water model) we present benefits of posits compared to floats at 16bit. Using a shallow water model, forecasts based on 16bit posits are clearly more accurate than 16bit half precision floats and well below the discretisation error. Although this study focuses on idealised simulations, the results show potential for weather and climate modelling with dynamical cores that are largely based on 16bit computations. Especially 16bit posits with 2 exponent bits provide a great potential for many weather and climate models, due to its wide dynamic range of 32 orders of magnitude. Together with a 32bit posit format, a posit processor based on these two formats could greatly support the transition of models that are rewritten to use less than 32 bits to represent real numbers. We believe that high performance computing for Earth System modelling would benefit greatly from a processor that would support both 16 and 32bit posit formats.