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Improving Computational Efficiency in a Spectral Element Cubed-Sphere Model

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This presentation introduces an effort to improve the computational efficiency whilst maintaining forecast performance of a non-hydrostatic numerical weather prediction model named KIM (Korean Integrated Model). It was achieved through several strategies which are 1) vectorization with reducing calculation grid-point, 2) optimization of iteration number and time-step size, and 3) using a low-order basis function.

The vectorization means that each state-variable is to be stored in a column shape, and that derivative operators are to be formed as matrix. Because procedure related to DSS and derivative is based on linear calculation, we can use number of grid-points for model calculation to be the same as DOF (in case of serial mode). In conventional method, the grid-points are based on element-wise including the points on edges which are redundantly included. The speed-up in the advection equation was, as we expected, almost same as the ratio of grid-point reduction. Meanwhile, it was studied about the eigenvalue structures in advection-diffusion equation model, which gives information for optimizing the maximum allowable time-step size and the iteration number of the time-split 6th order horizontal diffusion for stable time integration. Through the study, we found that the number in use is over-tuned, and now fix those. Finally, the current configuration of NP=4 (3rd order basis polynomial) introduce irregular grid-distance so that results in shortening the allowable time-step size. Despite the possibility of reducing accuracy in dynamical core, the time-step size can extended by 25% if NP=3 is used. In comparison between NP=4 and NP=3 for non-hydrostatic gravity-wave experiment, the difference of accuracy seems to be quite small. As results of three strategies, we achieve total $\sim$32% reduction of wall-clock time (in case of 12kmL90 and 2160 cores) and the relative burden of the dynamics package to the physics package is reduced from 7.05 times to 3.58 times.