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Comparison of Semi-Lagrangian Scheme and Eulerian Spectral Element Scheme for the Tracer Transport Problem on Cubed-Sphere Grid

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In order to improve the overall efficiency of the Eulerian type spectral element transport scheme, a semi-Lagrangian scheme at the Gaussian-Legendre-Lobatto (GLL) grid points with equi-distant sub-grid (as cell grid) for each element has been tried to implement in the tracer transport problem on a cubed-sphere grid. In horizontal discretization, the semi-Lagrangian scheme is considered on the 4-by-4 GLL grid points and the 7-by-7 equi-distant sub-grid points. In order to deal with these points values, new piecewise continuous interpolation operators on bi-cubic polynomial space are designed, and the values at the points of GLL grid and equi-distant sub-grid in an element are able to be interchanged. Also, in vertical discretization, we use the vertically Lagrangian coordinate system which reduces the three dimensional governing equation to the two dimensional form. Then, for the application of the semi-Lagrangian scheme in the problem, we use the algorithm to find the departure points on the sub-grid points, which is introduced by Erath et al. in the conservative SPectral-Element Lagrangian Transport (SPELT) scheme and the Conservative Semi-LAgrangian Multi-tracer transport scheme (CSLAM). To assess the accuracy and efficiency of semi-Lagrangian scheme, the solid-body rotational simulation and three-dimensional deformational flow simulation as the ideal tests have been performed. We show that the comparisons of numerical results for the proposed semi-Lagrangian scheme and the current spectral element tracer transport advection scheme in the Korean Integrated Model (KIM) as the Eulerian type scheme. Moreover, the proposed scheme eliminates the most oscillation generated from the numerical calculations in high resolution.