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Comparison of several high-order advection schemes for vertex-based triangular discretization

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We seek to improve the accuracy of the standard 3rd/4th order vertex-centered advection schemes used in ocean models formulated on unstructured meshes. With this aim, we compare them to two high-order transport algorithms formulated for finite-volume vertex-based discretizations (used in the Finite volumE Sea ice-Ocean circulation Model (FESOM)). We show that in simple test configuration increasing the order of advection algorithms based on gradient estimates to 5th or 6th leads to a substantial reduction in simulated errors against the conventional 3rd or 4th order algorithms. We also propose a finite-volume analog of the P1 finite-element advection scheme with consistent mass-matrix, called the compact scheme, and show that its errors are as low as those of the 6th-order algorithm based on gradient estimates in the simple test case. The performance of these schemes in fully nonlinear 3D simulations is judged by the level of simulated mean eddy kinetic energy in a well-developed baroclinically unstable flow. In this metric, using the higher order schemes leads to only very moderate change in eddy kinetic energy. The schemes also differ substantially in the required computational effort, and as the result we recommend the compact scheme which is the fastest.