Comparison of the advection errors in two kinds of terrain-following coordinates using the idealized advection experiments

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The basic terrain-following coordinate (BTF coordinate) are widely used in numerical models and the orthogonal terrain-following coordinate (OTF coordinate) are proposed to create the orthogonal and terrain-following vertical grids over orography. The reduction of advection errors by the OTF coordinate compared to the BTF coordinate are validated by the idealized advection experiments using horizontal velocity fields. In contrast, here, idealized advection experiments using terrain-following velocity fields are carried out to further compare the advection errors in BTF and OTF coordinates. In addition, three kinds of idealized orography are used, which are the wavelike terrain, linear terrain, and arch terrain. The experimental results show that skewness is the primary index, on reducing the advection errors among the criteria of grid quality. Moreover, the angle between the velocity and the vertical layers (\(\theta\)) has smaller effect than the grid quality on reducing the advection errors. The variation of the advection errors in the OTF coordinate consistently decrease and then increase according to the increasing \(\theta\) regardless of the terrain slope. However, the time-step restrictions at the peak of the terrain and the lack of resolution in valleys appear to be the most serious flaws in OTF coordinate which may be tackled by the unstructured reduced OTF grid.

\[\text{Advection Errors and Mesh Qualities in Different Coordinates}\]

\[\text{Advection Errors in Two Coordinates}\]

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