

## Research on the application of an improved terrain-following vertical coordinates on GRAPES model

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Errors caused by topographic features of the coordinate planes can be reduced with the Smoothed-level terrain-following coordinate (T-F coordinate for short). On higher layers, coordinate planes of T-F coordinate based on trigonometric function of cos (COS coordinate for short) are horizontal with almost none errors. However, on the lower layers, thickness between planes is too small to keep the model stability. At the same time, it will bring larger calculating errors which result in bad performance of the model. Considering all above, an improved COS coordinate is designed to average the thickness of COS coordinate planes.

Ideal and real case tests are conducted with the GRAPES\_Meso model using the improved COS coordinate. The results of the tests indicate that: compared with the COS coordinate, the improved COS coordinate, on one hand, keep the planes horizontal on the higher layers, on the other hand, lead the distribute of the coordinate planes more uniformity, which greatly reduced the errors on the lower layers; The coordinate can reproduce in general the mountain induced gravity waves in comparison to the analytic solution. However, the shapes, vertical structures and intensity of the waves are better simulated by the improved COS coordinate, in the lower levels where the COS coordinate didn't behave so better. In the one-month real case tests, the improved COS coordinate gives the better results in terms of smaller forecast bias and root mean square error, and higher anomaly correlation coefficients than the COS coordinate. In conclusion, the improved COS coordinate solves the calculation problems of the COS coordinate, and improves the prediction ability.

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