High-order Spectral Filter for the Spherical-surface Limited Area

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A high-order spectral filter for the spherical-surface limited-area domain, either window or sector type, is presented, where the window domain is finite both in longitude and latitude and the sector domain is finite in longitude but is ranged from pole to pole in latitude. Discrete data, defined in the physical domain, are extended to either extended window domain or sector domain by padding artificial data that were deliberately chosen to adopt half-ranged Fourier series for spectral decomposition. The high-order filter equation of Laplacian operator type, used for filtering or smoothing, was split into first or second order spherical elliptic-equations with complex coefficients as in the global-domain high-order spectral filter [1]. Each low-order elliptic equation is discretized using half-ranged Fourier series both in longitudinal and latitudinal direction. Due to the spherical geometry of the domain, the window-domain spectral filter consists of full matrices for each zonal wave-number and thus performs filtering with $O(N^3)$operation for $N \times N$ grids. On the other hand, the sector domain filter performs with efficient $O(N^2 \log N)$ operation for the same grids, because the matrices can be constructed in tridiagonal form.

The limited-area domain filters were applied to the mid-latitude observed data of surface pressure, geopotential height, and humidity, and the results were compared to those of global domain filter. Accuracies of window and sector domain filters were found to be almost the same, which turned out to vary with the filter parameters and the location and size of the domain. To test the scale decomposition, the filters were applied to tropical cyclone initialization incorporating the scale adjustable bogus vortex [2]. The results were compared with that of the global filer and three results are close to one another with only small variation among them, being indicative of insignificance of the difference in high-order filters.

References

[1] H.-B. Cheong, I.-H. Kwon, and T.-Y. Goo, *J. Comput. Phys.* **193**, 180-197 (2004).
[2] I.-H. Kwon and H.-B. Cheong, *Mon. Wea. Rev.* in press (2009).

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