Improving WRFs large-eddy simulation capability with new subfilter stress models

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To enhance WRF's large-eddy simulation capability we have implemented improved subfilter-scale stress (SFS) models into the ARW core. These include two improved subgrid stress models, the Nonlinear Backscatter and Anisotropy Model of Kosović (1997), and the Dynamic Eddy Viscosity model of Wong and Lilly (1994), as well as a model for the Resolvable Subfilter-Scale Stresses, which models the portion of the SFS stress term arising from scales of the flow that are filtered by numerical discretization errors (following Chow et al, 2005). Improved LES functionality allows high-resolution simulations with complex terrain; however, the coordinate transformation used in WRF's native terrain-following grid introduces numerical errors which scale with terrain slope. An immersed boundary method (IBM) which avoids grid distortion and the associated truncation errors is introduced.

We examine the behavior of WRF's Smagorinsky and 1.5-order TKE models as well as our new SFS models using data from idealized simulations. We observe improved performance using the new models, including superior agreement with the logarithmic wind profile in neutral flow over flat terrain and enhanced flow separation in the lee of a ridge. Additionally, comparisons are made between simulations using terrain-following coordinates and those using IBM.

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