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An ESMF unified model for a broad range of spatial and temporal scales

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A unified model (UMO) for a broad range of spatial and temporal scales is being developed within the Earth System Modeling Framework (ESMF) at the National Centers for Environmental Prediction (NCEP). The UMO follows the general modeling philosophy of the NCEP's WRF NMM grid-point dynamical core. However, the unified model has been reformulated for the Arakawa B grid in the (rotated) longitude-latitude coordinate system.

The unified model is nonhydrostatic, and the nonhydrostatic component of the model dynamics is introduced through an add–on module that can be turned on or off. The extra computational cost of the nonhydrostatic dynamics is low, or nonexistent if the nonhydrostatic extension is switched off at coarser resolutions.

The "isotropic" horizontal differencing employed in the model conserves a variety of basic and derived dynamical and quadratic quantities and preserves some important properties of differential operators. Among these, the conservation of energy and enstrophy improves the accuracy of the nonlinear dynamics of the model on all scales. "Across the pole" polar boundary conditions are specified in the global limit. The polar filter selectively reduces tendencies of the wave components of the basic dynamical variables that would otherwise propagate faster in the zonal direction than the fastest wave propagating in the meridional direction. In regional applications the rotated longitude-latitude system is used. With the Equator of the rotated system running through the middle of the integration domain, more uniform grid distances are obtained. In the vertical, the hybrid pressure-sigma coordinate is used. The forward-backward scheme is used for horizontally propagating fast waves, and an implicit scheme is applied for vertically propagating sound waves. The Adams-Bashforth

scheme is employed for non-split horizontal advection of the basic dynamical variables and for the Coriolis force. In order to eliminate stability problems due to thin vertical layers, the Crank-Nicholson scheme is used to compute the contributions of vertical advection.

A variety of WRF physical parameterizations have been coupled to the model. This variety is expected to be extended even further in the future.

The model code has been parallelized and it scales well. Estimates indicate that the model can be competitive in computational efficiency with other global and regional models. The results of the preliminary testing and evaluation of the model have been encouraging. The high computational efficiency of the model promises the possibility of application of nonhydrostatic dynamics on the global scale when single digit resolutions become affordable.