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An Overview of Numerical Weather Prediction on Various Scales

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The increasing public need for detailed weather forecasts, along with the advances in computer technology, has motivated many research institutes and national weather forecasting centers to develop and run global as well as regional numerical weather prediction (NWP) models at high resolutions (i.e., with horizontal resolutions of ∼10 km or higher for global models and 1 km or higher for regional models, and with ∼60 vertical levels or higher).

The need for running NWP models at high horizontal and vertical resolutions requires the implementation of non-hydrostatic dynamic core with a choice of horizontal grid configurations and vertical coordinates that are appropriate for high resolutions. Development of advanced numerics will also be needed for high resolution global and regional models, in particular, when the models are applied to transport problems and air quality applications.

In addition to the challenges in numerics, the NWP community is also facing the challenges of developing physics parameterizations that are well suited for high-resolution NWP models. For example, when NWP models are run at resolutions of ∼5 km or higher, the use of much more detailed microphysics parameterizations than those currently used in NWP model will become important. Another example is that regional NWP models at ∼1 km or higher only partially resolve convective energy containing eddies in the lower troposphere. Parameterizations to account for the subgrid diffusion associated with unresolved turbulence still need to be developed. Further, physically sound parameterizations for air-sea interaction will be a critical component for tropical NWP models, particularly for hurricane predictions models.

In this review presentation, the above issues will be elaborated on and the approaches to address them will be discussed.