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Bridging the Meso-gamma and Micro-scales using a modified version of the AR-WRF atmospheric model

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As horizontal model resolution (Δ) of numerical models approaches the scale, l, of energy containing turbulent eddies, current one-dimensional planetary boundary layer (PBL) schemes may fail. This numerical region in which 1-D PBL schemes fail is termed “Terra Incognita” by Wyngaard (2004), and it is this region we now fast approach as the need for even higher horizontal resolution and more detailed model results is emerging.

The AR-WRF model includes a number of formulations for parameterizing sub-grid turbulent mixing. Among these is the so-called 1.5 order Turbulent Kinetic Energy scheme where the horizontal and vertical eddy viscosities are computed using

$\mathrm{K}_{v,h} = C_k \times l_{v,h} \times \sqrt{e},$

where e is the turbulent kinetic energy, C_k is an empirical parameter and l is the length scale of energy containing turbulent eddies (Skamarock et al., 2008). This Large Eddy Simulation (LES) scheme for sub-grid mixing is however numerically unstable when used at horizontal resolutions on the Meso-gamma scale. As the standard version of AR-WRF does not support mixing PBL schemes (intended for use on the Meso-gamma scale) with LES schemes (intended for use on the Micro-scale) it has been necessary to use intermediate steps to bridge the gap between the two length scales (see e.g. Rögnvaldsson et al., 2011).

A novel solution to this problem has been developed by offering the potential of adjusting the length scales l in order to gain numerical stability of the 1.5 order Turbulent Kinetic Energy scheme at horizontal resolutions between 1 and 10 km. Initial results show that the AR-WRF model, when run using this solution, produces results that are comparable to simulations using the MYJ and YSU PBL schemes, when the mixing length is scaled appropriately.

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