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How Turbulence should be represented in Atmospheric Models at the kilometric Scale.

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Turbulence is well-represented by atmospheric models for very fine meshes, from 10 to 100 m, for which turbulent movements are mainly resolved, and for very large meshes, greater than 2 km, for which they are entirely parametrized. But what happens at intermediate scales, the so-called "Terra Incognita" from Wyngaard (2004) ?

Here an original method is presented which makes it possible to calculate the subgrid and resolved parts of five parameters at different scales : Turbulent Kinetic Energy (TKE), heat and moisture fluxes, as well as potential temperature and mixing ratio variances. They are established at intermediate scales in the case of shear-free convective boundary layers. The Theorem of Similarity allows the determination of the dimensionless variables of the problem. It is determined that a new dimensionless variable needs to be added to the Deardorff free convective scaling variables : the scaled mesh size, $\frac{\Delta x}{h}$. Similarity functions for the subgrid and resolved parts are assumed to be the product of the similarity function of the total (subgrid plus resolved) parameters and a "partial" similarity function that depends only on $\frac{\Delta x}{h}$. In order to determine this "partial" similarity function form, Large Eddies Simulations (LES) of boundary layers have been performed. They are based on experimental data from field-experiments. The resolved and subgrid parts of the parameters at coarser resolutions are then derived from means of the LES fields.

The evolution of the subgrid and resolved parts with $\frac{\Delta x}{h}$ is as follows : at high resolutions, parameters are mainly resolved. Then the more coarse the mesh, more eddies are subgrid. Finally, for very large meshes, turbulence is entirely subgrid. A scale therefore exists for which the subgrid and resolved parts are equal. This is obtained for $\frac{\Delta x}{h} = 0.2$ in the case of TKE, 0.4 for the potential temperature variance and 0.8 for the mixing ratio variance. This means that the vertical wind structures are smaller than those for the potential temperature which are smaller than those for the mixing ratio (De Roode *et al.* (2004)).

The defaults of a mesoscale model at intermediate scales are succinctly described. In the case of free convective boundary layer, the model produces too many resolved movements, as the turbulence scheme does not sufficiently represent the impact of the subgrid thermal. This is not true when a mass-flux scheme is introduced. However in this case, a completely subgrid thermal is modeled leading to an overestimation of the subgrid part.