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

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Turbulence is well represented at meshes coarser than 2 km by meso-scale models for which the turbulence is entirely subgrid and at very high resolutions (10 to 100 m) by LES models for which turbulence is mainly resolved. However we do not know which part of the turbulence should be resolved and which part of it should be parameterized when a model runs at kilometric scales, the so-called “gray zone“ of turbulence from Wyngaard (2004). Thanks to increasing computational resources, in a near future, limited area numerical weather prediction models will reach grid sizes on the order of 1 km or even 500 m. The aim of this study is to develop a parameterization which provides adequate turbulence to these new-generation, high-resolution models. At first, this study describes a new diagnostic based on LES, which clarifies which part of turbulence should be parameterized at kilometric scales. The LES reference is a precious tool for quantifying the errors made by atmospheric models when running at kilometric scales. These errors are quantified for a state-of-the-art meso-scale model with several turbulence mixing options : a K-gradient scheme or an EDMF approach (K-gradient with a mass-flux scheme). K-gradient turbulence schemes are unable to reproduce the counter-gradient zone. In the gray-zone, this characteristic has a disastrous effect. As the instability is too large, the boundary layer is mixed by the dynamic of the model and the resolved mixing is too strong. The counter-gradient zone can be reproduced by adding a mass-flux scheme to the K-gradient turbulence scheme (Pergault et al. (2009)). However the mass-flux scheme in its original form only produced wholly subgrid thermals at a grid size for which boundary-layer thermals should be partly resolved. In this case, the subgrid mixing is too strong. The mass-flux scheme is adapted to produce a new parameterization which depends on the grid-size and is valid in the gray zone.