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DYNAMIC TURBULENCE CLOSURES FOR HIGH-RESOLUTION NUMERICAL WEATHER PREDICTION

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https://meteo.webex.com/meteo-fr/j.php?MTID=mea25aeb96bed75ceaa5bb8468d11cda2

As computational power continuous to increase, the spatial resolution of operational Numerical Weather Prediction (NWP) models is advancing towards the sub-kilometre scale, in order to improve the representation of local-scale phenomena and severe weather. In this emerging resolution regime, where turbulent motions in the atmospheric boundary layer and convective clouds are comparable to the grid spacing, the fundamental assumptions underlying conventional turbulence and convection schemes are no longer valid.

A key challenge in this so called 'grey zone' is the specification of turbulence closure parameters. While these can be derived when the grid-resolution is sufficient to resolve the inertial subrange of turbulence, or when turbulent flow is fully parameterised, they remain poorly constrained when turbulent transport is only partially resolved. Moreover, these parameters directly control the evolution of the partially resolved flow, which itself exhibits strong spatial and temporal variability, limiting the validity of ad hoc parameter choices irrespective of the closure scheme used.

Here, we introduce a dynamic, scale-dependent, three-dimensional turbulence closure that adapts to the evolving flow. Closure parameters are optimised using information from the smallest resolved scales, assuming scale similarity between resolved and unresolved motions. This approach enables improved representation of partially resolved turbulence in the grey zone and leads to a more realistic simulation of both shallow and deep convection, as demonstrated in a set of idealised experiments across a range of sub-kilometre resolutions.

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