Simulating turbulence in the atmospheric boundary layer

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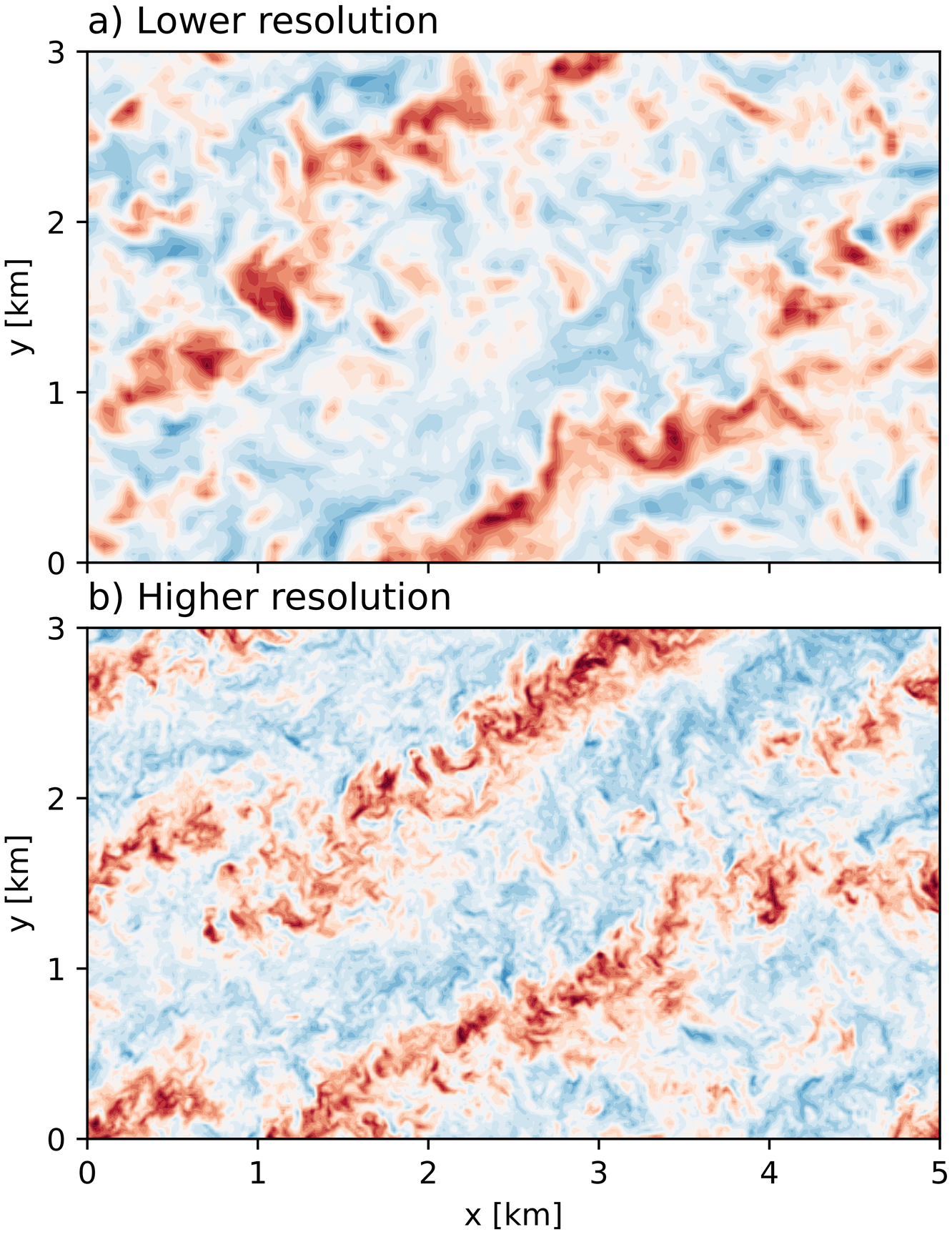
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High resolution simulations

– *the future of atmospheric turbulence modelling*



Turbulence in the atmosphere has eddies with sizes ranging from kilometers down to centimeters (or even smaller!)

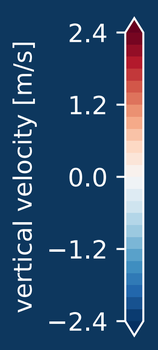
To simulate the turbulent flow we need a large domain but a fine resolution, which is difficult even on a supercomputer

We are developing a new model designed to effectively utilise the computational power that is available today

Our goal is to run simulations at a very high resolution and accurately represent interactions between small and large scales

Atmospheric turbulence

The atmospheric boundary layer, the part of the atmosphere closest to the surface, is distinguished by its turbulent state. The turbulence transports quantities like heat, water, particles, and momentum between the surface and the atmosphere, and therefore plays an important role in the climate system.



The turbulence involves motion at a large range of scales. What happens at the small scales affects the larger scales, but capturing the smallest eddies with a model is challenging. The large figure above shows the same turbulent flow at two different resolutions: aside from the level of detail there are also some differences in the large-scale structures.

Modelling turbulence

Our aim is to develop a Large Eddy Simulation (LES) model that can leverage a highly parallelizable algorithm and the coputational power in graphics processing units (GPUs) to achieve very high resolutions. We can then reduce the uncertainties that are normally introduced through parameterisation choices in turbulence modelling.

Our LES model is based on an established turbulence code called Nek5000, which uses an algorithm called the spectral element method. We will soon start working on a modernised version of the code: Neko.

This work is supported by the Swedish e-Science Centre (SeRC) and the Bolin Centre for Climate Research.The computations were enabled by resources provided by the National Academic Infrastructure for Supercomputing in Sweden (NAISS).

Model verification

We are currently comparing our model results with an established LES model to verify that our model, Nek5000, performs as expected. An example is shown in the figure below.

