Uncertainty of summer convection over land using LES ensemble

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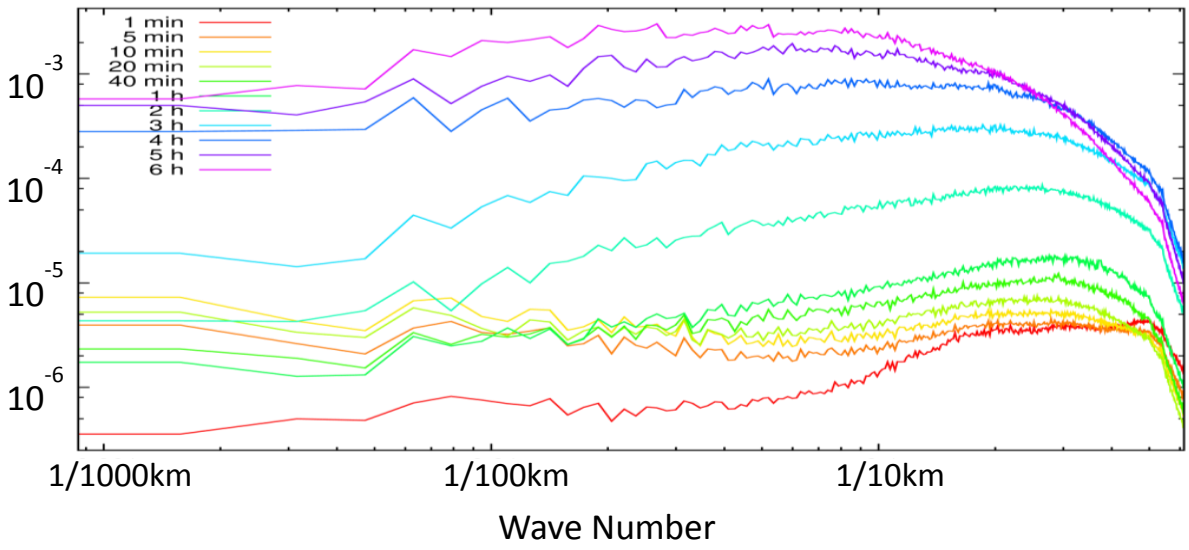
The instability arising from buoyancy – convection – has been discussed extensively since Lorenz (1969, Tellus) as a source of forecasting uncertainty. Yet, a few related fundamental questions are still actively discussed. This work aims to understand and quantify the uncertainty of moist convection on time scales of minutes to hours where the non-linearity of condensation plays a key role.

To answer this question a two-member ensemble of LES are performed using the ICON model as developed in the project HD(CP)^2 (High Definition Cloud and Precipitation for Climate Prediction, Dipankar et al, 2015, JAMES) at 312m resolution over a region encompassing Germany. A day of scattered cumulus is selected (25. Apr. 2013). ICON LES is run from COSMO 2.8km resolution initial and boundary conditions starting at 0UTC. At 12UTC a second ICON LES is started with a temperature noise perturbation of amplitude 0.01K located in the boundary layer up to 1500m. Both ensemble members continue to run in parallel for 6 hours until 18UTC.

The first key result is that the convective growth rate decreases substantially when running at lower so-called convective permitting resolution (e.g. by a factor of 3 at 1200m) used in earlier studies of predictability.

Second, the error growth from convective instability and latent heat releases can be divided in three phases (see figure below): (i) 0-5min, fast upscale cascade of initial grid-scale uncertainty by sound waves; (ii) 5min-1hour, convective growth at scales of 1-10km; (iii) 1-6hours, upward error growth to scale of 100km by gravity waves.

A third question of curiosity was to quantify the uncertainty the location of convection with time. To answer this, a tracking algorithm was used to identify 260 convective cells common to both ensemble members at initial time 12UTC and follow them over time. A median separation of cells of 0.7km/h was calculated.



Vertical mean of temperature difference spectra between two LES ensemble members over Germany on 25. April 2013 at various times after the perturbation of one member at 12 UTC.