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Global modelling of climate processes at high resolution – from one model towards multi-model

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A traceable hierarchy of global climate models, with atmosphere resolutions (using the Met Office Unified Model) ranging from 130km to 12km, with a subset of these coupled to $\frac{1}{4}^\circ$ ocean (NEMO), have been developed in order to study the impact of improved representation of small scale processes on the mean climate, its variability and extremes. An ensemble of 25km atmosphere integrations, using time on the European PrACE supercomputer HERMIT, and integrations with the 12km atmosphere model in which the convective parameterization has been switched off, have also been completed. In addition, a 10 year global coupled simulation with an eddy-resolving 1/12˚ ocean has recently been completed.

The UPSCALE project completed an ensemble of 25km atmosphere integrations for both present day and idealised future climate, together with lower resolution models for comparison. For an increasing range of processes, we are attempting to assess the resolution at which the process and their impact on the mean climate are adequately represented. Example processes include tropical cyclones, large-scale hydrological transports and tropical precipitation.

Building on this work, several 12km simulations have been performed in which the convective parameterization has been either reduced in effect or switched off and replaced by a sub-grid scale turbulence model. The impact on aspects of the simulation, such as the diurnal cycle and propagation of convective systems, will be discussed.

The recently completed coupled simulation with an eddy-resolving ocean is being analysed to understand aspects of coupling and flux exchanges, in particular whether the ocean has a stronger driving influence on the atmosphere once it is able to reasonably resolve its fundamental dynamical processes.

The above work is primarily based on analysis from one model, whereas robust understanding comes from analysis of multi-model ensembles. The proposed HighResMIP inter-comparison as part of CMIP6 (led by Rein Haarsma) aims to address this, by having multiple groups use a common experimental protocol designed to reduce extraneous model divergence and hence discover processes that are robustly changed by model resolution. Consortia of European climate groups also have several proposals currently being evaluated for funding to further our understanding of both global and regional climate variability, risk and impacts. Some of these proposals will be briefly described.