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Evaluation of the K-scale model hierarchy across MetOffice models.

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Models resolving km-scale processes, such as deep convection, improve the representation of precipitation associated to several processes at sub-synoptic scales, e.g. diurnal cycle, mesoscale convective systems or tropical cyclones. These models generally improve extremes and add value to hazard forecasting, in particular over the tropics. However, these models have been unaffordable to run on a pseudo-global scale until recently and thus their impact in large scale processes is not well known.

Aiming to develop the next generation of Met Office weather and climate prediction systems, the UK K-scale project has been established to evaluate the technical challenges, the scientific improvements and the predictability benefits of km-scale models. The first step of the program is the development of a K-scale “model hierarchy”, a family of simulations across several resolutions and two scientific configurations under the same MetOffice Unified Modelling framework (MetUM). Such hierarchy comprises a generic global model at 12km resolution, realizations at different resolutions of the Cyclic Tropical Channel (CTC), which is a global model in the zonal with north and south boundaries at 26N and 44S respectively, and limited area models (LAMS) over several locations at 2.2km. The two scientific configurations are (i) a global-like aimed at global resolutions above 10km, which includes a parametrization of shallow and mid-level convection, and (ii) a regional-like aimed to km- and sub-km-scale LAM which does not parametrize convection at any level.

Our results from simulations of the 40-day DYAMOND summer and winter periods show than differences between global-like and regional-like configurations at the same resolution can be as large as differences between models at 12km and 4.4km resolution with the same configuration. When all convective processes are not parametrized in the whole tropics at km-scale resolution, the PDF of precipitation shift towards higher intensities, the diurnal cycle improves in several regions, and the wet and dry biases around the E-W boundaries of LAMs are reduced.

The African tropical easterly jet is represented differently across the simulations; with a stronger jet in global-like configurations with convective parametrization. A significant change in mean-state upper wind over the Indian Ocean has potential implications on both subsidence over East Africa, and wind shear over West Africa. These are both tied to widespread rainfall patterns over Africa.

Regional-like configurations at km-scale resolution capture the kinetic energy spectra slope -5/3, poorly represented by the global-like model at 12km. The uncertainty growth across the kscale hierarchy is explored with the use of a twin experiment methodology, and in particular the role of equatorial waves in the error growth across resolutions and science configurations.