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Explicit convection studies in a global climate model

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Most global climate models typically have a diurnal cycle of precipitation peaking near midday in the tropics, which is primarily attributed to the formulation of the parameterisation of convection. Recent advances in supercomputing have made it possible to follow the lead of regional modelling (such as the CASCADE project), and a few global modelling groups, to push global model resolutions far enough into the convective “grey zone” to consider removing or reducing the impact of such parameterisation. Although the explicit representation of convection at such coarse resolutions may be questionable, it does enable an investigation (in a global modelling context) of how a change in the diurnal cycle of precipitation might feed back on the large-scale mean state.

Several multi-year simulations using a global atmospheric model at 12km resolution (based on the Met Office Unified Model with Global Atmosphere GA3.0 configuration) have been completed, using either parameterised convection or an explicit representation of either all or just deep convection in combination with a Smagorinsky-type turbulence scheme. The diurnal cycle of precipitation over tropical land is shown to be greatly improved when no parameterisation of deep convection is used: it is revealed both in the timing and magnitude of precipitation events, with much improved propagation of convective systems over Africa, albeit not over the Great Plains of the US.

The impact that the changed diurnal cycle has on aspects of the mean state, such as surface fluxes, soil moisture and surface winds has also been investigated. There are interesting differences in the diurnal cycle of surface winds between the models, with changes to both sea breeze-type circulations as well as to very large-scale wind direction between morning and evening, which are also seen in satellite-derived observations from QuikScat. The former has important implications for the formation of intense thunderstorms and associated precipitation.

The representation of convection and its role in the coupling between the atmosphere and land surface in such processes as African Easterly Waves will also be examined, as this has important consequences for the formation of some tropical cyclones in the Atlantic.

Some future implications for why it might be important to properly represent the diurnal cycle in global climate models will also be discussed.