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Moist convection and its upscale effects in simulations of the Indian summer monsoon with explicit and parametrised convection

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In common with many global models, the Met Offce Unified Model (MetUM) climate simulations show large errors in Indian summer monsoon rainfall, with a wet bias over the equatorial Indian Ocean, a dry bias over India, and with too weak low-level flow into India. The representation of moist convection is a dominant source of error in global models, where convection must be parametrised, with the errors growing quickly enough to affect both weather and climate simulations. Here we use the first multi-week continental-scale MetUM simulations over India, with grid-spacings that allow explicit convection, to examine how convective parametrisation contributes to model biases in the region.
Some biases are improved in the convection-permitting simulations with more intense rainfall over India, a later peak in the diurnal cycle of convective rainfall over land, and a reduced positive rainfall bias over the Indian Ocean. The simulations suggest that the reduced rainfall over the Indian Ocean leads to an enhanced monsoon circulation and transport of moisture into India. Increases in latent heating associated with increased convection over land deepen the monsoon trough and enhance water vapour transport into the continent. In addition, delayed continental convection allows greater surface insolation and, along with the same rain falling in more intense bursts, generates a drier land surface. This increases land-sea temperature contrasts, and further enhances onshore flow. Changes in the low-level water vapour advection into India are dominated by these changes to the flow, rather than to the moisture content in the flow. The results demonstrate the need to improve the representations of convection over both land and oceans to improve simulations of the monsoon.