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Quantifying the diurnal variability of deep convection in the Congo basin using satellite observations, global and regional models.

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Convection transports moisture, momentum, heat and aerosols through the troposphere, and so the temporal variability of convection is a major driver of global weather and climate. The diurnal cycle of convection is associated with large variations in solar forcing and the ability of models to represent this cycle shows how well they represent radiative transfer and surface heat exchanges, as well as boundary layer, convective and cloud processes. Global models and some numerical weather prediction (NWP) models fail to capture the observed diurnal cycle of convection (Yang and Slingo, 2001; Stratton and Stirling, 2012), while the ability of cloud-resolving models (CRMs) to represent the diurnal cycle is strongly dependent on horizontal resolution.

The Congo basin is home to some of the most intense convective activity on the planet, yet has been the focus of very few previous studies, especially when compared to the neighbouring, relatively well-understood West African climate system. Ground-based observations of convection and precipitation in the Congo region are sparse, and there has been a sharp decline in the number of rain gauges in the region over the past few decades (Washington, 2013).

In this study we use a variety of tools to quantify the diurnal cycle of deep convection over the Congo including satellite observations, a global model both with and without a new convective parameterisation, and a regional convection-permitting model. This approach allows us to evaluate our simulations despite the lack of in-situ observational data.

In contrast to the static picture provided by polar-orbiting satellites, the geostationary SEVIRI instrument provides continuous, high time resolution observations of cloud properties over a large area. It has the additional advantage of providing coverage of the Congo Basin, at a spatial resolution of between 3 and 5km. The CLAAS (Cloud Property Dataset Using SEVIRI) product is used to quantify the diurnal cycle of convective cloud top temperatures across the region.

In global models, the mass-flux convection parameterisations commonly used limit our ability to represent the microphysics of convective clouds. We use ECHAM both with and without a new parameterisation (CCFM, the Convective Cloud Field Model), which represents a spectrum of convective updraughts in each grid box, allowing the microphysics to take account of the explicitly-simulated distributions of cloud area, cloud height and vertical velocity.

High-resolution convection-permitting simulations are performed with the WRF model using a 2-moment bulk microphysics scheme. We quantify the diurnal cycle of convection and precipitation in the region on timescales much longer than those usually studied with high-resolution models. In addition, the use of CCFM in the global model allows us to compare the frequency distribution of convective precipitation rates in ECHAM with those from WRF.

Comparing data from satellite observations, global and high-resolution models enables us to quantify the diurnal variability of deep convection in the Congo basin and evaluate our results against observations, providing a more comprehensive analysis of the diurnal cycle than has previously been shown, and also giving new insight into a region that has previously seen little investigation.