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Uncertainty from the choice of microphysics scheme in convection-permitting models significantly exceeds aerosol effects

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1. Impact of microphysics scheme on convective core dynamics

We present here joint histograms for our Congo basin simulations of cloud top height in convective updraughts (columns identified with vertical velocities greater than 1 ms^{-1}) and the radius of the updraughts, as identified by running a connected-components labelling algorithm on the field of identified updraughts. Figure S1 shows that the most significant dynamical difference comes from choice of microphysics scheme: the Morrison scheme has a tendency towards higher frequencies of wider updraught radii with higher cloud tops than the Thompson scheme.

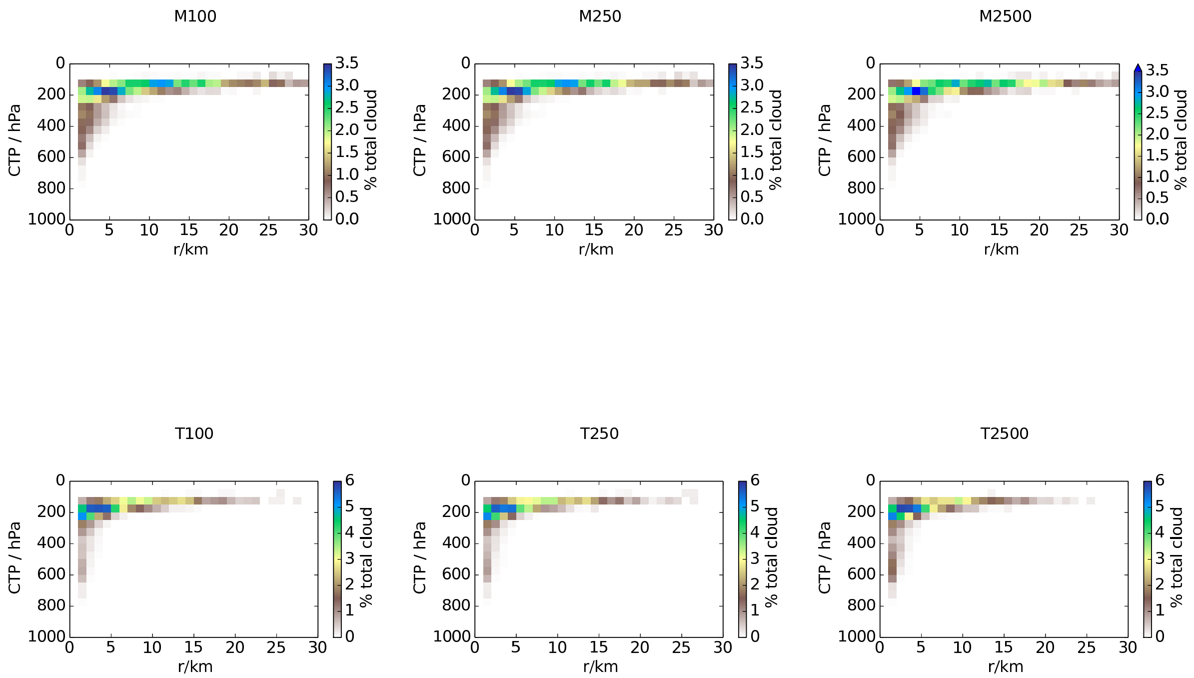

Figure S1: *Congo case: joint histograms of updraught radius and cloud top pressure at the top of the cloudy updraughts. MORR is shown on the top row, THOM on the bottom. CDNC values of 100, 250 and 2500 are shown in the left centre, and right, respectively. Updraughts are identified by masking points where the maximum vertical velocity exceeds 1ms^{-1}, and then applying a connected-components labelling algorithm to identify unique updraught areas*

2. Performance of bin versus bulk microphysics in the Congo simulations

We performed the 10-day Congo simulation using the HUJI spectral bin microphysics scheme (SBM, full version) implemented in WRFv3.6.1 (note that this is a newer version of WRF than used in the Morrison and Thompson simulations presented in the paper), and, when we compare the ‘default’ setup in each of the microphysics schemes (cloud droplet number concentration of 250 drops per cc in the Morrison scheme, 100 per cc in the Thompson scheme, and the bin scheme in its default settings) we find that the differences between the bin scheme and either of the bulk schemes are of the same order of magnitude as the differences between the two bulk schemes (Figures S2 and S3). Further, the bin scheme develops both the upper-level anvil ice that is produced in the Morrison scheme, and retains some of the low-level liquid cloud (although some of this rains out) that is persistent in the Thompson scheme but which rains out through autoconversion and subsequent accretion in the Morrison scheme (Figure S2). Therefore, the magnitude of uncertainty introduced by the choice of microphysics scheme remains the same in this particular case whether a bin or bulk scheme is used.

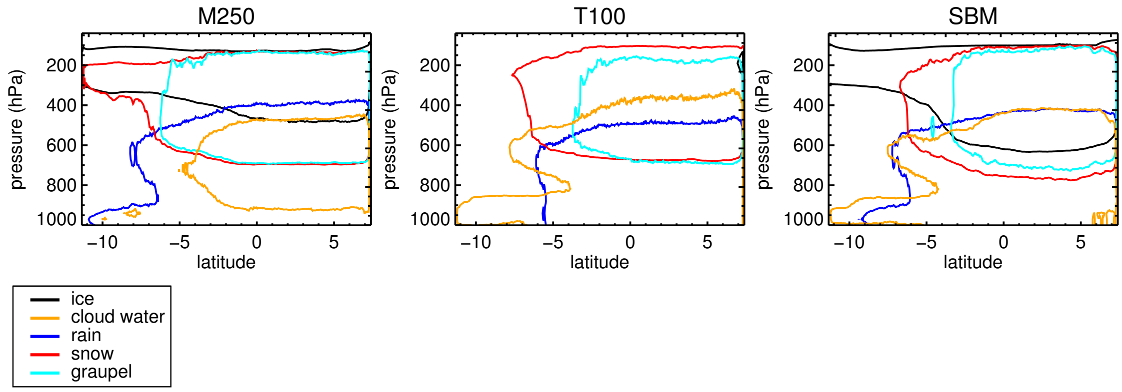

Figure S2: *Congo case: Zonal-mean vertical sections of hydrometeor classes (colour contours) from 01 to 10 August 2007 for the Morrison scheme (left), Thompson scheme (centre) and SBM (right) in their default configurations. Hydrometeor mass mixing ratios are contoured at 10^{-6}kg kg^{-1}. Note that to show the SBM data equivalently to the two bulk schemes, the graupel and hail categories in the SBM have been combined into the 'graupel' contour, and the ice categories (pristine ice, columns, plates and dendrites) have been combined into the 'ice' contour.*

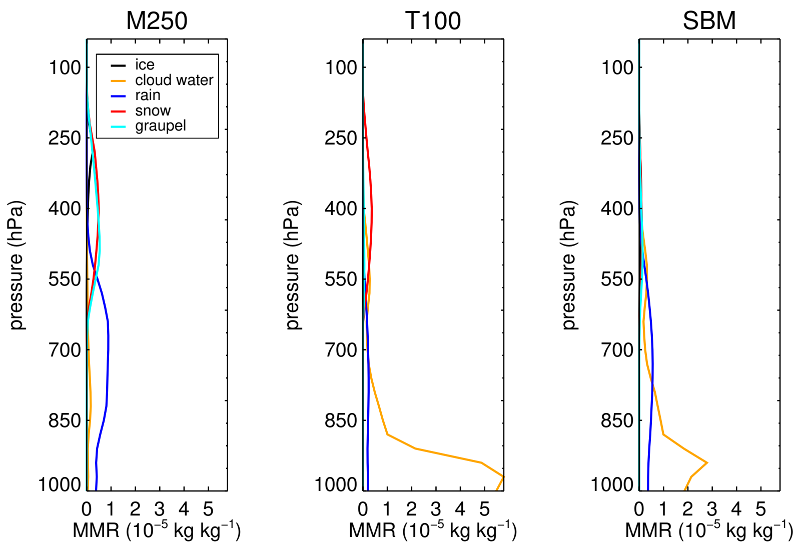

Figure S3: *Congo case: Domain-mean vertical profiles of hydrometeor mass mixing ratios averaged over the period 01 to 10 August 2007 for the Morrison scheme (left), Thompson scheme (centre) and SBM (right) in their default configurations. Note that to show the SBM data equivalently to the two bulk schemes, the graupel and hail categories in the SBM have been combined into the 'graupel' contour, and the ice categories (pristine ice, columns, plates and dendrites) have been combined into the 'ice' contour.*

2. Aerosol response in bin versus bulk microphysics in the idealised supercell simulations

We could not afford the time or computational cost to run our Congo simulation with three different CCN profiles with the full SBM. Neither is the focus of this study to perform a bulk-vs-bin microphysics comparison . However, we also ran the idealised supercell case with the WRF-SBM in its default mode of continental CCN parameters, and also with maritime CCN parameters for comparison against the bulk schemes (Figure S4). We find a similar magnitude of aerosol effect whether a bin or bulk scheme is used in this particular idealised configuration, which itself is between the same order and one order of magnitude smaller than the difference due to choice of microphysics scheme in the supercell case (Figure 8 in our paper).

We note here again the finding of Kalina et al. 2014 that CCN responses are nonmonotonic. By comparing response to the same CDNC values in MORR and THOM to response to continental and maritime CCN profiles in the SBM, we enter a territory where this nonmonotonicity may introduce uncertainty to our comparison. However, we nevertheless find that even when comparing results using a bin scheme against our bulk scheme results, it is the choice of scheme which dominates the differences in the model configurations.

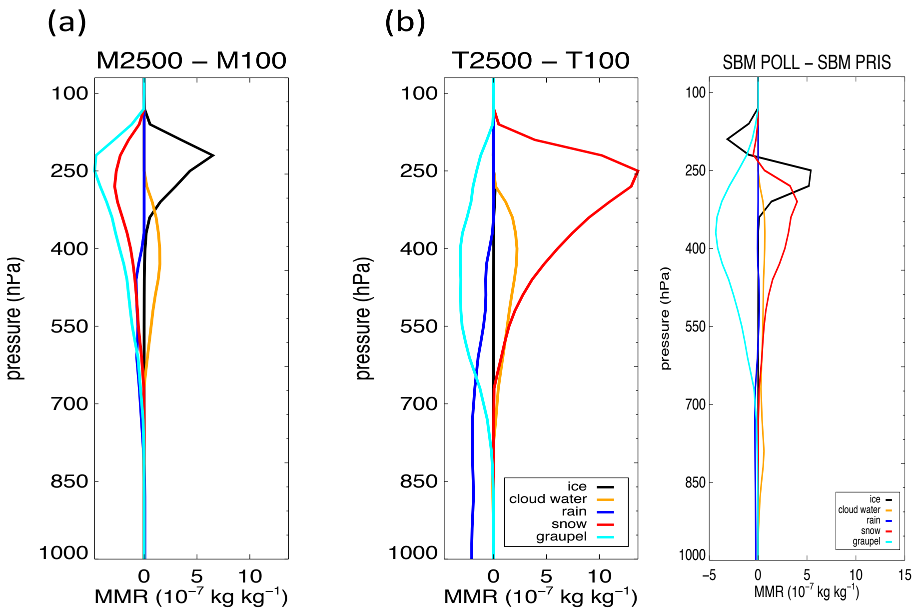

Figure S4: *Domain-mean vertical profiles of difference in hydrometeor mass mixing ratios between the polluted and pristine cases, averaged over the 2 hours of the supercell simulation for the Morrison scheme (left), Thompson scheme (centre) and WRF-SBM (right).*