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Moistening of the stratosphere by deep convection as simulated by Cloud Resolving Models.

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Recent observations reported in the literature have provoked renewed interest in the effects of deep convection on the water content of the stratosphere. Measurements of extraneous abundances of the heavy water vapour isotopologues in the lower stratosphere above N. American vapour plumes, solid particles - most likely ice - over tropical continental regions and frequencies of occurrence of overshooting deep convection suggest that such clouds inject ice into the stratosphere and that the moistening effect is likely to be greater than previously thought.

Here we present 3D Cloud Resolving Model simulations of overshooting tropical convection over Brazil (22.36 S, 49.03 W) performed as part of the HIBISUCS project, for various degrees of overshoot, in an attempt to quantify the stratospheric moistening produced by different clouds. The vigour of the clouds was found to produce a large effect on the amount of moistening with 1250, 197 and 87 tonnes of total water transferred to the stratosphere in the strongest, medium and weakest cases respectively. This suggests that trends in the number of severe overshoots could lead to stratospheric vapour trends if the overall convective effect is globally significant.

Upscaling of the modelled input of water into the stratosphere to the global scale is performed based on satellite observations of overshooting cloud frequencies in order to assess the contribution relative to moisture input across the tropopause by slow uplift from the Brewer Dobson circulation. This will give an idea of whether convective input of moisture is likely to be significant and hence whether it could account for the unexplained portion of the observed stratospheric moisture increases from 1954-2000.

Much more moistening was produced below the tropopause of the model, which could have a very large effect on the stratosphere if some of that extra moisture can ascend past the tropopause and survive freeze drying on the way.

Increases in cloud condensation nuclei (CCN) concentrations were found to increase the amount of moistening above the tropopause by 38.5 % suggesting a possible anthropogenic effect on stratospheric moisture. However, the results indicate that CCN trends are only likely to have a large enough effect on stratospheric moisture levels to explain stratospheric humidity trends if moistening below the tropopause is important since much larger sensitivity to CCN was observed there, comprising a 108 % increase between 15 and 16 km.

Finally, ongoing work considers the modelling of moistening from storms in other regions such as those observed during the SCOUT and AMMA campaigns in Australia and Africa, as well as storms in the mid-latitudes. If, as observations suggest, mid-latitude storms can provide an important stratospheric moistening effect then the combined effect of tropical and mid-latitude storms will make it more likely for deep convection to play a role in determining stratospheric water vapour levels and trends. The effects of vertical and horizontal model resolution on gravity wave breaking at storm top may also prove to be important and these will be considered along with further validation of the simulations using observations.