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Influence of convective transport on tropospheric ozone and its precursors in a chemistry-climate model

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Abstract. The impact of convection on tropospheric O_3 and its precursors has been examined in a coupled chemistry-climate model. There are two ways that convection affects O_3. First, convection affects O_3 by vertical mixing of O_3 itself. Convection lifts lower tropospheric air to regions where the O_3 lifetime is longer, whilst mass-balance subsidence mixes O_3-rich upper tropospheric (UT) air downwards to regions where the O_3 lifetime is shorter. This tends to decrease UT O_3 and the overall tropospheric column of O_3. Secondly, convection affects O_3 by vertical mixing of O_3 precursors. This affects O_3 chemical production and destruction. Convection transports isoprene and its degradation products to the UT where they interact with lightning NO_x to produce PAN, at the expense of NO_x. In our model, we find that convection reduces UT NO_x through this mechanism; convective down-mixing also flattens our imposed profile of lightning emissions, further reducing UT NO_x. Over tropical land, which has large lightning NO_x emissions in the UT, we find convective lofting of NO_x from surface sources appears relatively unimportant. Despite UT NO_x decreases, UT O_3 production increases as a result of UT HO_x increases driven by isoprene oxidation chemistry. However, UT O_3 tends to decrease, as the effect of convective overturning of O_3 itself dominates over changes in O_3 chemistry. Convective transport also reduces UT O_3 in the mid-latitudes resulting in a 13% decrease in the global tropospheric O_3 burden. These results contrast with an earlier study that uses a model of similar chemical complexity. Differences in convection schemes as well as chemistry schemes – in particular isoprene-driven changes are the most likely causes of such discrepancies. Further modelling studies are needed to constrain this uncertainty range.

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