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Impact of climate change on tropospheric ozone and its global budgets

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Abstract. We present the chemistry-climate model UM_{CAM} in which a relatively detailed tropospheric chemical module has been incorporated into the UK Met Office's Unified Model version 4.5. We obtain good agreements between the modelled ozone/nitrogen species and a range of observations including surface ozone measurements, ozone sonde data, and some aircraft campaigns.

Four 2100 calculations assess model responses to projected changes of anthropogenic emissions (SRES A2), climate change (due to doubling CO_2), and idealised climate change-associated changes in biogenic emissions (i.e. 50% increase of isoprene emission and doubling emissions of soil-NO_x). The global tropospheric ozone burden increases significantly for all the 2100 A2 simulations, with the largest response caused by the increase of anthropogenic emissions. Climate change has diverse impacts on O_3 and its budgets through changes in circulation and meteorological variables. Increased water vapour causes a substantial ozone reduction especially in the tropical lower troposphere (>10 ppbv reduction over the tropical ocean). On the other hand, an enhanced stratosphere-troposphere exchange of ozone, which increases by 80% due to doubling CO_2, contributes to ozone increases in the extratropical free troposphere which subsequently propagate to the surface. Projected higher temperatures favour ozone chemical production and PAN decomposition which lead to high surface ozone levels in certain regions. Enhanced convection transports ozone precursors more rapidly out of the boundary layer resulting in an increase of ozone production in the free troposphere. Lightning-produced NO_x increases by about 22% in the doubled CO_2 climate and contributes to ozone production.

The response to the increase of isoprene emissions shows that the change of ozone is largely determined by background NO_x levels: high NO_x environment increases ozone production; isoprene emitting regions with low NO_x levels see local ozone decreases, and increase of ozone levels in the remote region due to the influence of PAN chemistry. The calculated ozone changes in response to a 50% increase of isoprene emissions are in the range of between −8 ppbv to 6 ppbv. Doubling soil-NO_x emissions will increase tropospheric ozone considerably, with up to 5 ppbv in source regions.

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