

QOS2016-297, 2016

Quadrennial Ozone Symposium of the International Ozone Commission

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How ozone affects precipitation

W.J. Collins, C.R. MacIntosh, K.P. Shine, and L.H. Baker

University of Reading, Meteorology, Reading, United Kingdom (w.collins@reading.ac.uk)

Increases in CO₂ since the pre-industrial period have warmed the globe and increased global precipitation totals. Ozone changes over the same time may also have caused an increase in precipitation more than 50% compared to that due to CO₂ even though the top-of-atmosphere (TOA) forcing is only 20% compared to CO₂. We show how increases in ozone affect the radiation balance of the atmosphere, both TOA and the difference in flux between the TOA and the surface (atmospheric forcing). The TOA forcing acts to warm the surface with long-term consequences for precipitation, the atmospheric forcing acts to rapidly suppress or enhance precipitation depending on the sign. We use a combination of a global climate model (HadGEM3) and an offline radiative transfer model to understand and quantify the TOA and atmospheric forcing for idealised ozone changes at different levels in the atmosphere in both the longwave and shortwave. Simulations using realistic historical ozone changes from ACCMIP show that tropospheric ozone production and stratospheric ozone depletion have both contributed to historical increases in global precipitation.