Diagnosing the radiative and chemical contributions to future changes in tropical column ozone with the UM-UKCA chemistry–climate model

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Chemical and dynamical drivers of trends in tropical total-column ozone (TCO3) for the recent past and future periods are explored using the UM-UKCA chemistry–climate model. A transient 1960–2100 simulation is analysed which follows the representative concentration pathway 6.0 (RCP6.0) emissions scenario for the future. Tropical averaged (10° S–10° N) TCO3 values decrease from the 1970s, reach a minimum around 2000 and return to their 1980 values around 2040, consistent with the use and emission of halogenated ozone-depleting substances (ODSs), and their later controls under the Montreal Protocol. However, when the ozone column is subdivided into three partial columns (PCO3) that cover the upper stratosphere ($PCO3_{US}$), lower stratosphere ($PCO3_{LS}$) and troposphere ($PCO3_{T}$), significant differences in the temporal behaviour of the partial columns are seen. Modelled $PCO3_{T}$ values under the RCP6.0 emissions scenario increase from 1960 to 2000 before remaining approximately constant throughout the 21st century. $PCO3_{LS}$ values decrease rapidly from 1960 to 2000 and remain constant from 2000 to 2050, before gradually decreasing further from 2050 to 2100 and never returning to their 1980s values. In contrast, $PCO3_{US}$ values decrease from 1960 to 2000, before increasing rapidly throughout the 21st century and returning to 1980s values by ~2020, and reach significantly higher values by 2100. Using a series of idealised UM-UKCA time-slice simulations with concentrations of well-mixed greenhouse gases (GHGs) and halogenated ODS species set to either year 2000 or 2100 levels, we examine the main processes that drive the PCO3 responses in the three regions and assess how these processes change under different emission scenarios. Finally, we present a simple, linearised model to describe the future evolution of tropical stratospheric column ozone values based on terms representing time-dependent abundances of GHG and halogenated ODS.

Key words: Ozone, tropics, chemistry-climate model, UM-UKCA