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The Climate Impact of Past Changes in Halocarbons and CO2 in the Tropical UTLS Region

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A chemistry–climate model coupled to an ocean model is used to compare the climate impact of past (1960–

2010) changes in concentrations of halocarbons with those ofCO2 in the tropical upper troposphere and lower stratosphere (UTLS). The halocarbon contribution to both upper troposphere warming and the associated increase in lower stratospheric upwelling is about 40% as large as that due to CO2. Trends in cold-point temperature and lower stratosphere water vapor are positive for both halocarbons and CO2, and are of about the same magnitude. Trends in lower stratosphere ozone are negative, due to the increased upwelling. These increases in water vapor and decreases in lower stratosphere ozone feed back onto lower stratosphere temperature through radiative cooling. The radiative cooling from ozone is about a factor of 2 larger than that from water vapor in the vicinity of the cold-point tropopause, while water vapor dominates at heights above 50 hPa. For halocarbons this indirect radiative cooling more than offsets the direct radiative warming, and together with the adiabatic cooling accounts for the lack of a halocarbon-induced warming of the lower stratosphere. For CO2 the indirect cooling from increased water vapor and decreased ozone is of comparable magnitude to the direct warming fromCO2 in the vicinity of the cold-point tropopause, and (together with the increased upwelling) lowers the height at which CO2 increases induce stratospheric cooling, thus explaining the relatively weak increase in cold-point temperature due to the CO2 increases.