Analysis of 1970-1995 Trends in Tropospheric Ozone at Northern Hemisphere Midlatitudes with the GEOS-CHEM Model

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Abstract

The causes of trends in tropospheric ozone at Northern Hemisphere midlatitudes from 1970 to 1995 are investigated with the GEOS-CHEM model, a global three-dime nsional model of the troposphere driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS). This model is used to investigate the sensitivity of tropospheric ozone with respect to (1) changes in the anthropogenic emission of nitrogen oxides and non-methane hydrocarbons, (2) increases in methane concentrations, (3) variations in the stratospheric source of ozone, (4) changes in solar radiation resulting from stratospheric ozone depletion, and (5) increases in tropospheric temperatures. Model results indicate that local increases in NOx emissions have caused most of the increases seen in lower tropospheric ozone over Europe and Japan. Increases in methane are responsible for roughly one fifth of the anthropogenically-induced increase in tropospheric ozone at northern midlatitudes. However, changes in ozone precursors do not adequately explain either the spatial differences in observed ozone trends across midlatitudes or the observed decreases in ozone over Canada throughout the troposphere. We argue that ozone depletion in the lowermost stratosphere is likely to have reduced the stratospheric source by as much as 30% from the early 1970s to the mid-1990s. Model simulations that account for such a reduction along with reported changes in anthropogenic emissions show steep declines of ozone in the upper troposphere and variable increases in the lower troposphere that are more consistent with observations. Differential temperature trends in summer between North America and Europe may account for at least some of the remaining spatial variation in tropospheric ozone trends. Increases in ultraviolet (UV) radiation due to strato spheric ozone depletion do not appear to significantly reduce tropospheric ozone, except at midlatitudes in the Southern Hemisphere following the breakup of the ozone hole.

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