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An exploration of ozone changes and their radiative forcing prior to the chlorofluorocarbon era

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Abstract. Using historical observations and model simulations, we investigate ozone trends prior to the mid-1970s onset of halogen-induced ozone depletion. Though measurements are quite limited, an analysis based on multiple, independent data sets (direct and indirect) provides better constraints than any individual set of observations. We find that three data sets support an apparent long-term stratospheric ozone trend of -7.2 ± 2.3 DU during 1957-1975, which modeling attributes primarily to water vapor increases. The results suggest that 20th century stratospheric ozone depletion may have been roughly 50% more than is generally supposed. Similarly, three data sets support tropospheric ozone increases over polluted Northern Hemisphere continental regions of 8.2 ± 2.1 DU during this period, which are mutually consistent with the stratospheric trends. As with paleoclimate data, which is also based on indirect proxies and/or limited spatial coverage, these results must be interpreted with caution. However, they provide the most thorough estimates presently available of ozone changes prior to the coincident onset of satellite data and halogen dominated ozone changes. If these apparent trends were real, the radiative forcing by stratospheric ozone since the 1950s would then have been -0.15 ± 0.05 W/m², and -0.2 W/m² since the preindustrial. For tropospheric ozone, it would have been 0.38 ± 0.10 W/m² since the late 1950s. Combined with even a very conservative estimate of tropospheric ozone forcing prior to that time, this would be larger than current estimates since 1850 which are derived from models that are even less well constrained. These calculations demonstrate the importance of gaining a better understanding of historical ozone changes.

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