Ozone miniholes over northwestern Europe in the 1950s and 1990s

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Ozone miniholes are substantial reductions of total ozone over an area of several thousand km^2 for a short period (days). They occur mainly at midlatitudes, typically in autumn and winter [*Hood et al., JGR* 106 (2001), 20925]. The main processes leading to ozone miniholes are advection of warm, ozone-poor subtropical air in the tropopause region and upwelling in the context of wave-breaking events. Concurrent advection of cold polar air in the middle stratosphere further reduces the ozone column. The contribution of *in-situ* chemical ozone distruction is very small. Recent work suggests that the frequency of ozone miniholes over the Euro-Atlantic sector increased during the last two decades [*Hood et al., JGR* 104 (1999), 24321; *Reid et al., JGR, 105 (2000),* 12169; *Orsolini & Limpasuvan, GRL* 20 (2001), 4099]. If ozone miniholes are defined based on absolute values, there are two possible explanations for an increase in frequency: a change in atmospheric circulation over Europe or a decreasing mean ozone column. The increase in minihole frequency over Europe has been attributed to more frequent subtropical intrusions related to an increasing North Atlantic Oscillation index. The effect of a change in the mean ozone column, such that caused by chemical ozone depletion or changes in the global meridional transport of ozone in the stratosphere, has rarely been addressed. In this paper we investigate changes in the frequency of low-ozone events over northwestern Europe on interdecadal scales by comparing recent data from 1990–2000 to a past period that can be considered "chemically unperturbed", namely 1952–1963. Total ozone and meteorological data from eight sites are used. Observational data and a statistical model are used to characterize whether and how the frequency of low total ozone events has changed and to separate the two effects outlined above.

The frequency of days with very low total ozone (<225 Dobson Units) was similar in both periods in autumn. However, in winter, low-ozone days were much more frequent in 1990–2000 than in 1952–1963. The analysis of the observational data as well as statistical model results show that the changing atmospheric circulation strongly contributed to the increased frequency of low-ozone days in winter. The model also suggests a strong effect of a different mean ozone column, but the uncertainty is larger. Because both total ozone and atmospheric dynamics changed little between the two periods in autumn, no large differences in frequency of low-ozone days were found during this season.