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Impact of transatlantic transport episodes on summertime ozone in Europe

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Abstract. This paper reports on the transport of ozone (O_3) and related species over the North Atlantic ocean and its impact on Europe. Measurements of nitrogen dioxide (NO_2) and carbon monoxide (CO) columns from the GOME and MOPITT satellite instruments, respectively, are used in conjunction with the GEOS-CHEM global model of transport and tropospheric chemistry to identify the major events of long range transport that reach Europe over the course of summer 2000. Sensitivity model simulations are used to analyse observed O_3 distributions with respect to the impact of long range transport events. For that purpose, we used in-situ O_3 observations taken at the mountain site of Jungfraujoch as well as O_3 vertical profiles taken in the vicinity of central European cities. Over the course of summer 2000, we identified 9 major episodes of transatlantic pollution transport; 7 events are associated with transient cyclones while 2 events occur through zonal transport (e.g. by advection in the strong low-level westerly winds established in summer between the Azores anticyclone and transient cyclones). We find that on average three episodes occur per month with the strongest ones being in June. The number and frequency of long range transport events that reach Europe are driven by the position and strength of the Azores anticyclone. Model sensitivity simulations indicate that the summer mean North American O_3 contribution ranges from 3 to 5 ppb (7–11%) in the planetary boundary layer and 10 to 13 ppb (18–23%) in the middle and upper troposphere. During particular episodes, North American sources can result in O_3 enhancements up to 25–28 ppb in the layer between 800–600 hPa and 10–12 ppb in the boundary layer. The impact of the zonal transport events on O_3 distribution over Europe is more clearly seen below 700 hPa as they tend to transport pollution at lower levels while the events associated with transient cyclones are more likely to have an impact on the middle and upper troposphere (i.e. above 600 hPa). The air mass origins found in the GEOS-CHEM model are clearly confirmed by back trajectory analyses. During most of the 9 events, a strong contribution in North American O_3 is in general associated with only little European O_3 and vice-versa (in particular at the Jungfraujoch). A substantial North American contribution

(e.g., 30% or higher) to O_3 over Europe does not always result in pronounced O_3 enhancements in the observations during our period of study.

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