Rapid convective outflow from the U.S. to the upper troposphere over the North Atlantic during the NASA INTEX-NA airborne campaign: flight 13 case study

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Abstract

A case study of convective outflow from the United States (U.S.) was examined using airborne measurements from NASA DC-8 flight 13 during the Intercontinental Chemical Transport Experiment – North America (INTEX-NA). Mixing ratios of methane (CH_4) and carbon monoxide (CO) at 8–11 km altitude over the North Atlantic were elevated to 1843 ppbv and 134 ppbv respectively, while those of carbon dioxide (CO_2) and carbonyl sulfide (COS) were reduced to 372.4 ppmv and 411 pptv respectively. In this region, urban and industrial influence was evidenced by elevated mixing ratios and good linear relationships between urban and industrial tracers compared to North Atlantic background air. Moreover, low mixing ratios and a good correlation between COS and CO_2 showed a fingerprint of terrestrial uptake and minimal dilution during rapid transport over a 1–2 day time period. Analysis of synoptic conditions, backward trajectories, and photochemical aging estimates based on C_3H_8/C_2H_6 strongly suggested that elevated anthropogenic tracers in the upper troposphere of the flight region were the result of fast transport via convective uplifting of boundary layer air over the southeastern U.S. This mechanism is supported by the similar slopes values of linear correlations between long-lived (months) anthropogenic tracers (e.g., C_2Cl_4 and $CHCl_3$) from the flight region and the planetary boundary layer in the southeastern U.S. In addition, the aircraft measurements suggest that outflow from the U.S. augmented the entire tropospheric column at mid-latitudes over the North Atlantic. Overall, the flight 13 data demonstrate a pervasive impact of U.S. anthropogenic emissions on the troposphere over the North Atlantic.

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