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Lightning-produced NO_x over Brazil during TROCCINOX: airborne measurements in tropical and subtropical thunderstorms and the importance of mesoscale convective systems

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Abstract. During the TROCCINOX field experiments in February–March 2004 and February 2005, airborne in situ measurements of NO, NO_y, CO, and O_3 mixing ratios and the $J(NO_2)$ photolysis rate were carried out in the anvil outflow of thunderstorms over southern Brazil. Both tropical and subtropical thunderstorms were investigated, depending on the location of the South Atlantic convergence zone. Tropical air masses were discriminated from subtropical ones according to the higher equivalent potential temperature (Θ_e) in the lower and mid troposphere, the higher CO mixing ratio in the mid troposphere, and the lower wind velocity in the upper troposphere within the Bolivian High (north of the subtropical jet stream). During thunderstorm anvil penetrations, typically at 20–40 km horizontal scales, NO_x mixing ratios were distinctly enhanced and the absolute mixing ratios varied between 0.2–1.6 nmol mol^{-1} on average. This enhancement was mainly attributed to NO_x production by lightning and partly due to upward transport from the NO_x-richer boundary layer. In addition, CO mixing ratios were occasionally enhanced, indicating upward transport from the boundary layer. For the first time, the composition of the anvil outflow from a large, long-lived mesoscale convective system (MCS) advected from northern Argentina and Uruguay was investigated in more detail. Over a horizontal scale of about 400 km, NO_x, CO and O_3 absolute mixing ratios were significantly enhanced in these air masses in the range of 0.6–1.1, 110–140 and 60–70 nmol mol^{-1}, respectively. Analyses from trace gas correlations and a Lagrangian particle dispersion model indicate that polluted air masses, probably from the Buenos Aires urban area and from biomass burning regions, were uplifted by the MCS. Ozone was distinctly enhanced in the aged MCS outflow, due to photochemical production and entrainment of O_3-rich air masses from the upper troposphere – lower stratosphere region. The aged MCS outflow was transported to the north, ascended and circulated, driven by the Bolivian High over the Amazon basin. In the observed case, the O_3-rich MCS

outflow remained over the continent and did not contribute to the South Atlantic ozone maximum.

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