Distribution of hydrogen peroxide over Europe during the BLUESKY aircraft campaign

Zaneta Hamryszczak¹, Andrea Pozzer¹, Florian Obersteiner², Birger Bohn³, Benedikt Steil¹, Jos Lelieveld¹,⁴ and Horst Fischer¹

¹MaxPlanck Institute for Chemistry, Airchemistry, Mainz, Germany
²Karlsruhe Institute of Technology, Karlsruhe, Germany
³Institute of Energy and Climate Research, IEK-8: Troposphere, Forschungszentrum Jülich GmbH, Jülich, Germany
⁴Climate and Atmosphere Research Center, The Cyprus Institute, Nicosia, Cyprus

Hydrogen peroxide and higher organic hydroperoxides form an important reservoir for peroxy radicals (HOₓ), which are key contributors to the self-cleaning processes of the atmosphere. The work gives an overview of airborne in-situ trace gas observations of hydrogen peroxide (H₂O₂), and methyl hydroperoxide (MHP) over Europe during the Chemistry of the Atmosphere – Field Experiments in Europe (CAFE-EU, also BLUESKY) aircraft campaign. The purpose of the campaign was to obtain an overview of the trace gas and aerosol distribution over Europe to analyze atmospheric chemistry under the conditions of the COVID-19 lock-down. The campaign anticipated to investigate the impact of reduced emissions from anthropogenic sources due to the COVID-19 pandemic on the chemistry and physics of the atmosphere. The rapid decrease of anthropogenic emissions established a unique opportunity for analysis of the changes in the atmosphere. The campaign took place in May/June 2020 over Central and Southern Europe and within the North Atlantic Flight Corridor. Airborne measurements were performed on the High Altitude and Long-range (HALO) research aircraft out of the base of operation in Oberpfaffenhofen (Germany). Average mixing ratios for H₂O₂ of 0.32 ± 0.25 ppbv, 0.39 ± 0.23 ppbv and 0.38 ± 0.21 ppbv within the upper and middle troposphere and the boundary layer were measured over Europe, respectively. Vertical distribution of H₂O₂ reveals a significant decrease above the boundary layer in comparison with previous airborne observations, most likely due to cloud scavenging and subsequent rainout. The expected maximum hydrogen peroxide mixing ratios at 3 – 7 km were not found during BLUESKY in contrast to observations during previous studies over Europe, during the campaigns HOOVER and UTOPIHAN-ACT II/III. Simulations with the global chemistry-transport model EMAC reproduce partly the impact of cloud uptake and rainout loss of H₂O₂. A comparison of calculated deposition loss rates based on EMAC reveals an underestimation relative to the observations. A performed sensitivity study without H₂O₂ scavenging underlines the major impact of cloud processing and precipitation on the hydrogen peroxide budget. Differences between simulations and observations are most likely due to difficulties in the simulation of wet scavenging.