EGU22-908
https://doi.org/10.5194/egusphere-egu22-908
EGU General Assembly 2022

Properties and processing of aviation induced aerosol within the UTLS observed from the IAGOS-CARIBIC Flying Laboratory

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The impact of aviation on atmospheric aerosol, its processing, and its effects on climate is still associated with large uncertainties. We identified aircraft exhaust plumes observed during flights of the IAGOS-CARIBIC Flying Laboratory and performed a dedicated analysis of the aviation related atmospheric aerosol properties.

The European Research Infrastructure IAGOS (www.iagos.org) is using in-service aircraft as observation platforms, equipped with instrumentation for measuring gaseous species, aerosols, and cloud particles. From July 2018 to March 2020 the IAGOS-CARIBIC Flying Laboratory (equipped with 15 scientific instruments) conducted 42 operational flights aboard a Lufthansa Airbus A340-600 passenger aircraft. These flights covered routes between Munich (Germany) and destinations in North America, South Africa, and East Asia.

The IAGOS-CARIBIC data set resulting from these flights includes a wide variety of aerosol and trace gas measurements, which could be fully synchronised for a subset of 36 flights. An algorithm was developed and implemented to automatically identify unique aircraft exhaust plumes based on the 1 Hz resolved NO_y and aerosol data sets. For the years 2018 to 2020, the algorithm detected about 1100 unique aircraft exhaust plumes. These exhaust plumes were further categorised as tropospheric (37 %) and stratospheric (63 %) as well as in-cloud (12 %) and clear sky (82 %) conditions, providing a solid statistical bases and global insight into the impact of aviation on aerosol and trace gas properties. For each plume the measured parameters were further divided into their respective background and plume excess values.

The analysis of the plume excess characteristics (e.g., in terms of the fraction of accumulation mode particles or the non-volatile aerosol fraction) shows that the aerosol properties inside the plume are independent from their background environment in the upper troposphere, the tropopause region, and the lowermost stratosphere. This would allow a parameterization of the plume aerosol properties independent of the flight altitude. Furthermore, we discuss the evolution of the aerosols aging/processing for the encountered aircraft exhaust plumes.

Acknowledgments: Part of this study is funded by the ACACIA project (EU Grant Agreement

Number 875036). We thank all members of IAGOS-CARIBIC, in particular Deutsche Lufthansa and Lufthansa Technik for enabling the IAGOS-CARIBIC observatory. The German Federal Ministry of Education and Research (BMBF) is acknowledged for financing the instruments operation and data analysis as part of the joint project IAGOS-D under grants 01LK1301A and 01LK1301C.