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The IMECC aircraft campaign: validation of total column CO_2, CH_4 and CO measurements over Europe

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Ground-based in-situ measurements of CO_2 and CH_4 are a well-established technique for the estimation of sources and sinks for these major greenhouse gases. In the future, total-column measurements from satellite instruments like GOSAT or ground-based FTIR networks like TCCON should play an increasing role in this field. To make both types of measurements comparable, the total-column measurements need to be linked to the well-established WMO scales for greenhouse gases. For ground-based FTIR instruments this can be achieved through aircraft in-situ measurements above the measurement sites.

To provide this link, the Max Planck Institute for Biogeochemistry (MPI-BGC) organized a flight campaign that covered six FTIR sites in Europe: one in France, one in Poland and four in Germany. The aircraft used was a Learjet 35 which could cover an altitude range from roughly 300 m to 12-13 km above each FTIR site. For continuous measurements, the aircraft was equipped with a Picarro analyzer for CO_2 and CH_4 and an Aerolaser CO instrument. In addition, roughly eight flasks were taken at different altitude levels above each station to assure the quality of the continuous measurements. The flasks were then analyzed post-flight at the MPI-BGC's gas analysis lab. This flight campaign was one of the major efforts of the European infrastructure project IMECC.

The aircraft measurements covered roughly 80% of the total column measured from the ground. Several stations were located directly next to tall tower sites, so extension to the ground was possible through the use of the tower measurements. The remaining stratospheric part was estimated from balloon measurements taken at similar equivalent latitude for CO_2. For CH_4, climatological data from satellites (e.g. UARS) was used to fill the gap. The main goal was to provide realistic values for the total column as well as good estimates for the total column error bars.

The techniques developed for the optimization of flight patterns and the data analysis provide a role model for future aircraft campaigns. These will provide the essential quality-assurance for ground-based or satellite remote sensing measurements as a valuable addition to the established long-term flask records.