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CO2, CH4 and CO measurements by compact cavity ring-down

Annette Filges (1), Christoph Gerbig (1), Harald Franke (2), and Christoph Klaus (2)
(1) Max Planck Institute for Biogeochemistry, Jena (Germany), (2) Enviscope GmbH, Frankfurt a.M. (Germany)

A measurement system for the greenhouse gases CO2, CH4, H2O, and CO was designed and tested for deployment on commercial airliners within the IAGOS-ERI project. The design meets requirements regarding physical dimensions (size, weight), performance (long term stability, low maintenance, robustness, full automation) and safety issues (fire prevention regulations).
The analyzer is based on cavity ring-down spectroscopy (CRDS). The components of a commercially available CRDS instrument (Picarro Inc.) were integrated in a frame, designed within the IAGOS-ERI project, with the compact size of 350mm x 300mm x 530mm. The instrument provides simultaneous measurements of CO2, CH4, CO, and H2O at an acquisition rate of 2.5 seconds and precision of $\sigma < 0.1$ ppmv for CO2, $\sigma < 1$ ppbv for CH4, $\sigma < 20$ ppb for CO and $\sigma < 50$ ppmv for H2O.
Laboratory tests showed that the analyzer can sample the full altitude range from 230-1000 mbar, provided the sample gas flow rate is reduced to about 0.15 L/min. No significant sensitivity to temperature changes has been observed. Furthermore, a correction was derived from laboratory experiments to retrieve the required dry air mixing ratios of CO2, CH4 and CO from wet air measurements, using the simultaneous water vapor measurements. Thus dry air mixing ratios of CO2, CH4 and CO can be measured without a drying system for the measured air, which significantly reduces maintenance effort for unattended operation. These results could be confirmed during test flights with a prototype CRDS instrument (without CO measurements) onboard a Lear Jet during an IMECC (Infrastructure for Measurements of the European Carbon Cycle) campaign in September/October 2009.
To ensure that the measurements are referenced to WMO standards a fully automated in-flight calibration system was designed and laboratory tested. The measurement unit will be integrated in a subset of the IAGOS fleet of commercial airliners. It is foreseen to exchange the unit after six months for maintenance and replenishment of calibration gases. After removal, a functional inspection, followed by replacement of depleted or damaged parts, will be undertaken. Spare instrumentation will be used to provide for year-round GHG measurements onboard each aircraft. The first unit is currently being assembled, and integration and flight testing is foreseen for late 2011. Within the next five years, 7 out of 20 aircraft of the IAGOS fleet are scheduled to be equipped with the GHG measurement package, providing near-real time data via SatCom or VHF to data centres. We expect the IAGOS greenhouse gas data to be useful for example for improved estimation of GHG budgets at regional to continental scales, for assessment of vertical transport in atmospheric models through comparison with observed vertical tracer distributions, and for the validation of remote sensing of GHGs.
The poster will present an overview of the measurement system and results of the laboratory tests.