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A measurement system for continuous observations of CO_2, CH4, H_2O and CO onboard passenger aircraft

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Improved quantification and understanding of surface-atmosphere exchange fluxes of greenhouse gases (GHGs) caused by natural as well as anthropogenic processes is of paramount importance in a world of a changing climate and ever increasing emissions. Top-down estimation of GHG fluxes is traditionally done by inverse transport modeling, using GHG observations from a global network of stations. Uncertainties in modeled vertical transport rates (moist convection, turbulent mixing, stratosphere-troposphere exchange) however greatly affect the quality of flux estimates. More recently, remote sensing of vertical column mole fractions of GHGs have become available for inverse modeling, reducing the impact of vertical transport uncertainties to first order. However, those need validation against in-situ observations. A strategy for regular, global in-situ atmospheric profiling of GHGs, covering at least the troposphere, is thus needed to provide validation of remote sensing and of forward transport modeling of GHGs, to serve as input for inverse modeling, and to reduce the impact of transport uncertainties.

IAGOS-ERI (In-service Aircraft for a Global Observing System – European Research Infrastructure) exploits the synergy between globally operating civil aviation and the need for long-term monitoring of atmospheric composition. Within the framework of IAGOS-ERI a cavity ring-down spectroscopy (CRDS) based measurement system for greenhouse gases was designed, tested, and qualified for deployment on commercial airliners. The design meets requirements regarding physical dimensions (size, weight), performance (long-term stability, low maintenance, robustness, full automation) and safety issues (fire prevention regulations, airworthiness). The system uses components of a commercially available CRDS instrument (G2401-m, Picarro Inc.) mounted into a frame suitable for integration in the avionics bay of the Airbus A-340. The first of the IAGOS GHG packages is scheduled for integration in mid 2013. The aim is to have seven systems operational within four years, providing for long-term GHG observations with near-global coverage.

To enable robust and automated operation of the IAGOS GHG package over six-month deployment periods, numerous technical issues had to be addressed. An inlet system, designed as virtual impactor to eliminate sampling of larger aerosols, ice particles, and water droplets, provides additional positive ram-pressure to ensure operation without an upstream sampling pump. Furthermore, no sample drying is required, as the simultaneously measured water vapor mole fraction is used to correct for dilution and spectroscopic effects. This also enables the collection of science-quality water vapor measurements throughout the atmosphere. To allow for trace gas measurements to be fully traceable to WMO scales, a two-standard calibration system has been designed and tested that periodically provides calibration gas to the instrument during flight and on ground for each six-month deployment period.

We present results from recent test flights and laboratory tests that document the performance for GHG and water vapor measurements. Furthermore, future applications of the IAGOS-GHG data stream, provided in near-real-time via SatCom to the weather prediction centres, will be discussed.