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A new cavity ring-down instrument for airborne monitoring of N_2O_5, NO_3, NO_2 and O_3 in the upper troposphere lower stratosphere

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The chemistry of NO_3 and N_2O_5 is important to the regulation of both tropospheric and stratospheric ozone. In situ detection of NO_3 and N_2O_5 in the upper troposphere lower stratosphere (UTLS) represents a new scientific direction as the only previous measurements of these species in this region of the atmosphere has been via remote sensing techniques. Because both the sources and the sinks for NO_3 and N_2O_5 are potentially stratified spatially, their mixing ratios, and their influence on nitrogen oxide and ozone transport and loss at night can show large variability as a function of altitude. Aircraft-based measurements of heterogeneous N_2O_5 uptake in the lower troposphere have uncovered a surprising degree of variability in the uptake coefficient [1], but there are no corresponding high altitude measurements.The UTLS is routinely sampled by the IAGOS-CARIBIC program (Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container, www.caribic-atmospheric.com), a European infrastructural program with the aim of studying the chemistry and transport across this part of the atmosphere. An airfreight container with 15 different automated instruments from 8 European research partners is utilized on board a commercial Lufthansa airbus 340-600 to monitor ~ 100 atmospheric species (trace gases and aerosol parameters) in the UTLS. The instrumentation in the CARIBIC container is now to be supplemented by a new cavity ring-down device for monitoring nitrogen oxides, jointly developed by researchers from Cork (Ireland), Boulder (USA) and Karlsruhe (Germany). The compact and light-weight instrument is designed to monitor not only NO_3 and N_2O_5, but also NO_2 and O_3. The detection is based on 4 high-finesse optical cavities (cavity length ~ 44 cm). Two cavities are operated at 662 nm (maximum absorption of NO_3), the other two at 405 nm (maximum absorption of NO_2). The inlet to one of the (662)-cavities is heated in order to thermally decompose N_2O_5 entirely to provide the sum of NO_3 and N_2O_5, with N_2O_5 provided by difference to a direct NO_3 measurement in a separate, unheated channel. One of the (405)-cavities is flushed continuously with NO in order to measure O_3 concentrations via quantitative conversion to NO_2. The air sampled underneath the cargo bay of the aircraft is distributed inside the instrument through a dedicated inlet system distributing the flow over all four cavities. Flow control, data collection, analysis, and zeroing procedures are fully automated and controlled by dedicated electronics and software within the device. On the poster the new instrument, its design and application within the CARIBIC program, will be outlined.

[1] S.S. Brown, T.B. Ryerson, A.G. Wollny, C.A. Brock, R. Peltier, A.P. Sullivan, R.J. Weber, J.S. Holloway, W.P. Dubé, M. Trainer, J.F. Meagher, F.C. Fehsenfeld, A. R. Ravishankara, Variability in nocturnal nitrogen oxide processing and its role in regional air quality, Science, 311 (2006) 67-70.