Global Monitoring: CARIBIC Aircraft Data for CO, Greenhouse Gases (GHGs), and Non-methane Hydrocarbons

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The current Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container (CARIBIC) measurement container has been in operation since 2005 with a steadily increasing performance. Installed in the cargo bay of a Lufthansa Airbus A340-600 for 4 long distance flights each month we have covered over 2 million miles (www.caribic-atmospheric.com). Presently we are adding CH_4 to our suite of *in situ* measurements, which already included gases such as CO_2, O_3, CO and water vapor. However, the most information is gained from analysis of monthly whole air samples; comprising 28 glass flasks each month, plus 88 stainless steel flasks since May 2010. In many cases it is an advantage to sample remotely from sources and sinks, which was also a philosophy of the early monitoring sites. In this respect the CARIBIC dataset, and the one from the sister project CONTRAIL (http://www.cger.nies.go.jp/contrail/contrail.html), offer perhaps the largest *in situ* datasets of GHGs in upper tropospheric and free tropospheric air. On the other hand, whenever flight routes pass over regions of strong convection, e.g. tropical Africa (Figure 1), more direct information about sources and sinks is obtained. The clearest example we know in this respect is the Indian monsoon, where a large scale waxing and waning distribution of trace gases is formed spanning thousands of kilometers. With the support of transport models the CARIBIC data can be used to constrain the uptake and release of CO_2 and the production of CH_4. Additionally, using tracer-tracer correlations, for instance between CH_4, CO and C_2H_6, one can even make estimates about sources without calling the help of a model. In addition to GHGs, CARIBIC data show the distribution of non methane hydrocarbons over Europe. For these gases, even in Europe upper troposheric measurements are sparse. From the examples shown, it is evident that passenger aircraft-based systems have a great potential. In Europe, this is leading to the formation of a measurement infrastructure based on equipment in a number of aircraft giving daily measurements, and in the future to be transmitted partly in near real-time. This infrastructure IAGOS will thus encompass the MOZAIC and CONTRAIL approach, namely a number of aircraft in continuous operation, and the CARIBIC system having fewer flights but more species.

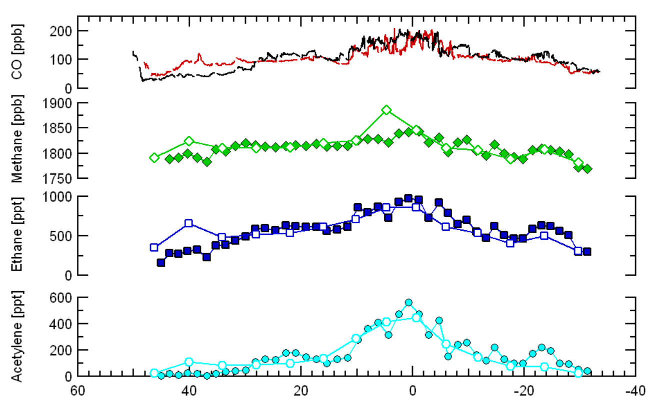

Figure 1. CO, CH_4, C_2H_6 and C_2H_2 at cruise altitude for flights in December 2010 from Frankfurt to Cape Town and back. For CO the flight data to Cape Town are color coded red, and sampling took place with the glass flask system (open symbols). The data for the return flight (closed symbols, many samples) are based on the stainless steel canisters. The profiles show elevated concentrations in the tropics over a large distance. Back-trajectories point to surface air masses that very slowly rose to flight level over a period of 7 days. The profiles for the 2 flights are fairly identical, however the return flight shows low mixing ratios for 30-40 degrees north as the aircraft flew in the lowermost stratosphere.