Airliners are perfectly placed to observe the effects of climate change on our atmosphere. **Andreas Volz-Thomas**, of the IAGOS project, describes how profiling technology is now being fitted to 20 long-range aircraft to reliably predict future climate changes

Airliners set for climate and air quality research

Global climate change represents arguably the most serious environmental issue facing mankind today, with implications for global political stability and the global economy.

Reliable predictions of the future climate using climate models are a central and fundamental requirement for determining future mitigation strategies.

IAGOS (In-service Aircraft for a Global Observing System) seeks to establish a sustainable distributed infrastructure for global observations of atmospheric composition from a large fleet of in-service aircraft. This will be achieved by installing autonomous instrument packages aboard between 10 and 20 long-range aircraft operating on international routes.

At the end of the last MOZAIC project it was clear that for a sustainable long-term operation the instrumentation had to be redesigned completely

The initiative originated from the European MOZAIC (Measurement of OZone and Water vapour by Airbus In-service airCraft) project. Close links are already established with several other routine aircraft programmes. CARIBIC has already become a member of IAGOS and it is the hope to establish formal links to other programmes in Japan and North America within the next few years in order to build the aircraft component of the Integrated Global Atmospheric Chemistry Observations (IGACO) system.

IAGOS will provide high quality observation of greenhouse gases and reactive gases, aerosols, and cloud particles in the tropopause region, which lies between the troposphere and the stratosphere. This region is one of the most sensitive for climate change. At the same time, IAGOS will provide detailed vertical profiles in the troposphere, which is of paramount importance for predicting changes in local and regional air quality and its causes. The use of commercial aircraft allows the collection of highly relevant observations on a scale and in numbers impossible to achieve using research aircraft, and where other measurement methods (e.g., satellites) have technical limitations.

MOZAIC data have been used by scientists worldwide and have led to more than 100 publications. Key findings concern the vertical structure of the atmosphere, humidity in the upper troposphere and the strong influence of biomass burning on the pollutant concentrations at the tropopause over some regions.

According to the IPCC and other international assessments, there are various uncertainties, including the influence of water vapour, ozone and aerosol, in assessing climate change. Specifically expressed was the need for continuation and extension of current measurement programmes.

IGACO says routine aircraft measurements are an essential complement to ground-based and satellite observations. The measurements proposed in IAGOS closely match the priorities defined in the IGACO report. Airborne CO_2 profile measurements are essential for accurately modelling the carbon cycle and for Kyoto monitoring.

The technical concept

The technical concept of IAGOS draws on the experience gained in the EC-funded MOZAIC, a series of three EC-funded research projects. At its beginning, airborne systems for ozone and water vapour were installed by Airbus on five A340 aircraft. The MOZAIC rack was modified in 2001 for additional measurements of CO, and an additional NOy-instrument was installed on one of the Lufthansa MOZAIC aircraft.

Several technical deficiencies later became apparent. Maintenance of the equipment was only possible in cooperation with the service departments of the participating airlines. An additional significant problem was that the original MOZAIC rack was heavy (120 kg + 50 kg for the NOy instrument) and space-consuming. After more than 10 years in service, the five MOZAIC aircraft are in danger of being replaced. Presently only three aircraft are still providing measurements, two of which

The MOZAIC NOy instrument in the avionic bay of a Lufthansa A340-300 Photo: Udo Kröner, Deutsche Lufthansa

are operated by Lufthansa and the other by Air Namibia.

At the end of the last MOZAIC project it was clear that for a sustainable long-term operation the instrumentation had to be redesigned completely. This situation was the starting point for IAGOS-DS, a European Design Study for new research infrastructures funded under FP6 between 2005 and 2009 under the coordination of Research Centre Jülich (FZJ). The redesign of the former MOZAIC rack into a compact package of 50kg is being undertaken by the Laboratoire d'Aerologie, CNRS, Toulouse. Meteo France develops an automatic system for near real-time data transmission into the meteorological network.

Because of the scientific requirements outlined above, the MOZAIC partnership (FZJ, CNRS, MeteoFrance, Airbus, Lufthansa) was expanded in IAGOS-DS in order to enhance the measurement capabilities with new instruments for cloud particles (University of Manchester), aerosols (Institute for Physics of the Atmosphere, DLR), a novel H_2O sensor (University of Cambridge) and CO_2 (MPI-BGC, Jena). The new IAGOS instrumentation comprises two packages:

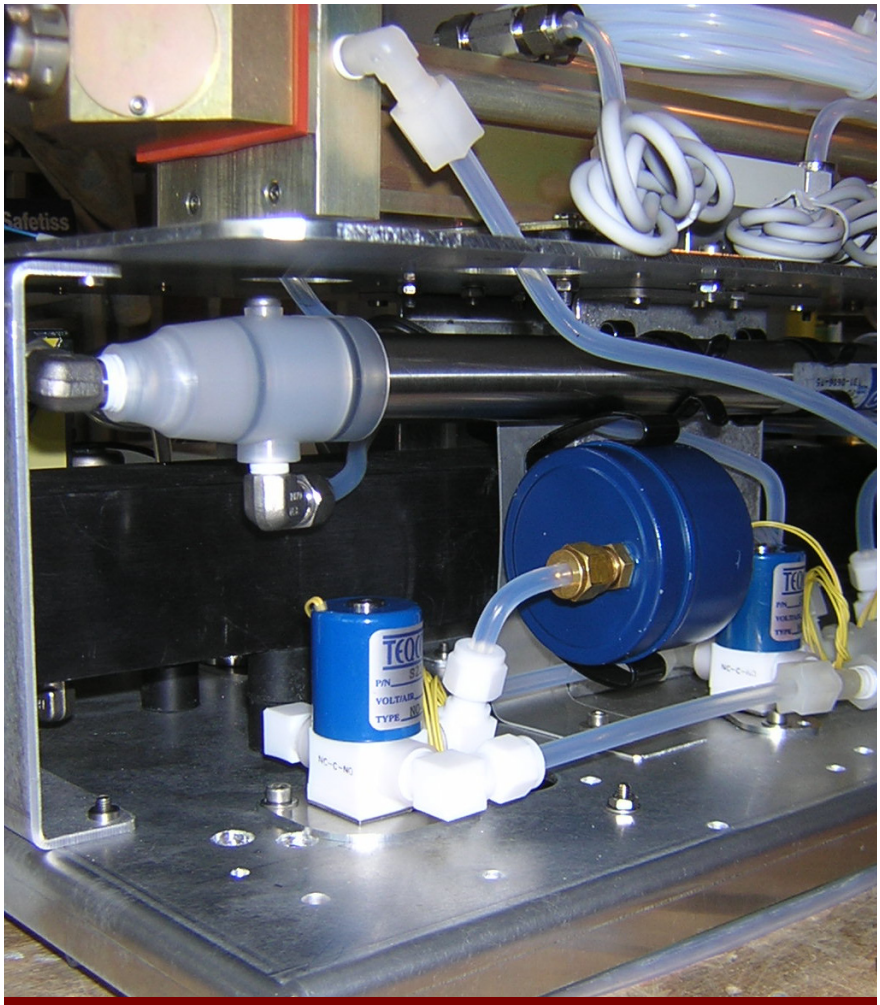
- Package 1: O_3, H_2O, CO, cloud particles, data acquisition, and data transmission (near realtime for selected parameters)
- Package 2a:NOy (the sum of NOx and its atmospheric oxidation products)
- Package 2b:NOx
- Package 2c:Aerosol
- Package 2d:CO_2

Package 1 will be installed on all aircraft, together with one option of Package 2. The instruments will have the full certification for installation and operation on Airbus A340 in-service aircraft, including the EASA Form One for instrument re-installation after maintenance.

The aircraft modification (Supplementary Type Certificate) is being achieved by CNRS together with an industrial partner, allowed to perform modifications on Airbus aircraft. The required aircraft modification for installation of the systems will be performed during scheduled layovers of the aircraft, without immobilisation costs for the airlines. The second component of the IAGOS project is provided by the CARIBIC initiative, which has joined the partnership for the new infrastructure. The CARIBIC aircraft (an A340-600 operated by Lufthansa) is equipped with an instrumented cargo container and an especially designed inlet system. It provides a large suite of measurements, including those measured on all aircraft but also methane, N_2O, a suite of hydrocarbons and fluorocarbons, as well as detailed information on aerosol, and a MAX-DOAS system for remote sensing of atmospheric species.

Where are we?

The aeronautic certification for the revised MOZAIC instruments and the new technical development for aerosol, CO_2 and cloud particles are completed in IAGOS-DS. The next phase (IAGOS) will start in 2008 under FP7 for a duration of four years and serves to prepare the legal and logistical boundary conditions for operation of the new infrastructure.



The prototype of IAGOS-Package 1 Photo: Philippe Nedelec, Laboratoire d'Aerologie

Several airlines operating long-range Airbus aircraft have already expressed their interest in participating in the project, ensuring global data coverage, including the Southern Hemisphere and the Pacific.

Major efforts are still required in order to secure the financial support for the initial investments and the operation of the systems. The initial investment for new instruments, certification and aircraft modification are around €5 million.

Operation of the systems, including maintenance work, quality assurance and data base development/maintenance, as well as fuel costs for transportation of the additional weight, are estimated to approximately €250,000 per aircraft per year.

The vision

Thirty years after the termination of the US Global Atmospheric Sampling Programme (GASP), the first programme using in-service aircraft, IAGOS opens the vision for routine monitoring of the atmosphere, where atmospheric observation systems, built and certified by aeronautical manufacturers, can be installed on a range of aircraft models.

If this became true, IAGOS-ERI would enable the atmospheric community to capitalise on 10 years of investment into a number of research projects. In this context, a very small instrument package (~20kg) is being developed in IAGOS under the lead of the University of Cambridge and with the support of British Airways.

This would allow an even wider distribution at relatively moderate cost and access to smaller aircraft. Near real-time data transmission will fulfil an important requirement for utilising the data in the Global Atmospheric Service (GAS) of the European initiative for Global Monitoring for Environment and Security (GMES). ★

At a glance

Integration of routine Aircraft measurements into a Global Observing System (IAGOS)

The Vision

IAGOS aims at establishing a distributed infrastructure for regular observations of atmospheric composition, aerosols, and cloud particles at the global scale from commercial in-service aircraft.

Project partners

Forschungszentrum Jülich GmbH; Laboratoire d'Aerologie, CNRS, Toulouse; Meteo-France, Toulouse; University of Cambridge; University of Manchester; Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen; Airbus UK, Bristol; British Airways plc, Hammondsworth; Deutsche Lufthansa, Köln; Max-Planck-Institut für Biogeochemie, Jena.

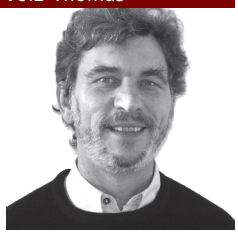
Funding: FP-6 infrastructures, €2,577,000

Cost: €4,528,611

Contact:

e: a.volz-thomas@fz-juelich.de
t: +49-2461-616730
f: +49-2461-615346
m: +49-160-7028943
http://www.fz-juelich.de/icg/icg-2/iagos

Andreas Volz-Thomas



Coordinator
IAGOS

Andreas Volz-Thomas obtained a PhD in physical chemistry from the University of Bonn in 1979. He has since been working in atmospheric sciences, with major interests in radical chemistry, photooxdidants and global trace gas distributions. He leads the research group on global observations at FZJ.