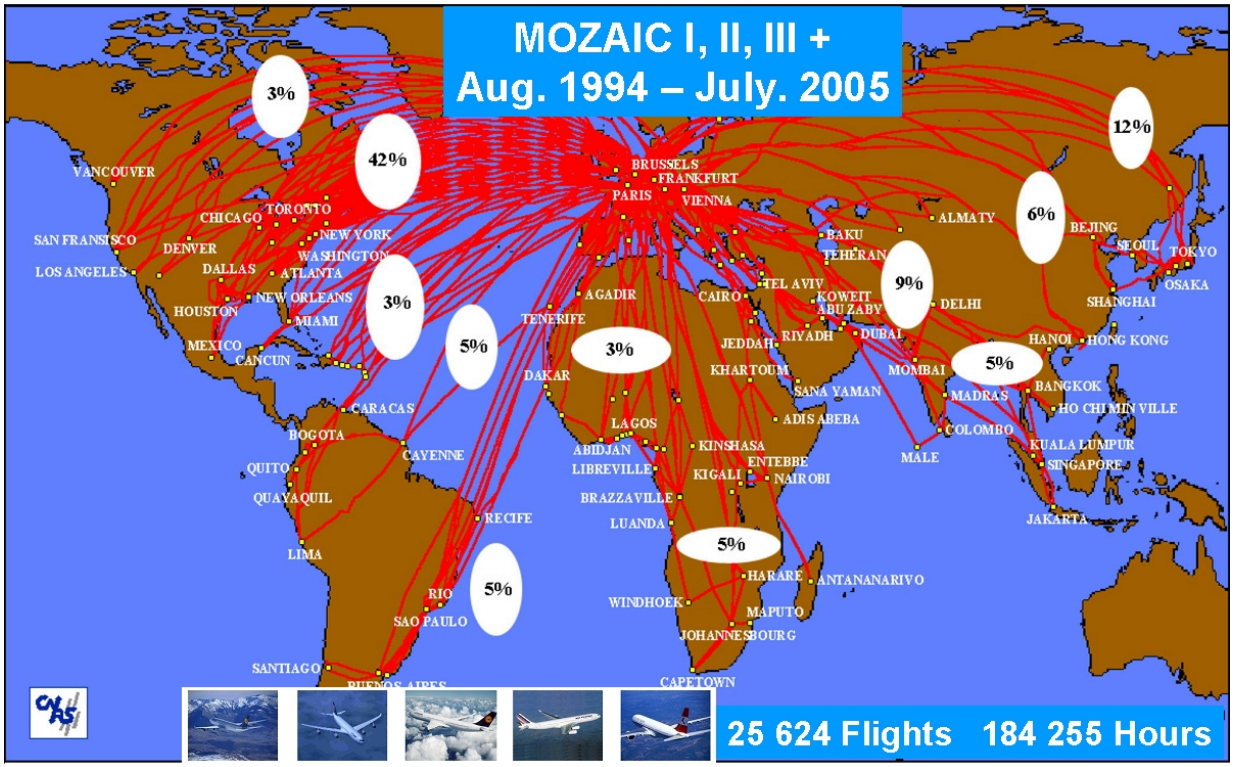
GEMS WP_GRG observational data

MOZAIC Status

MOZAIC I, II & III (1994-2006)



High resolution vertical profiles during take-off and landing (~ 20m)

High resolution horizontal profiles at 9-12 km altitude during inter-continental flight (~ 1 km)

Regularity of measurements with 5 aircraft flying almost every day

- **1994-2002: ≈ 20000 flights with O3/H2O**
- **2002-2006: ≈ 6000 flights with additional CO (4 aircraft) and with additional CO/NOy (1 aircraft)**

Status of MOZAIC

- **MOZAIC aircraft**
  - **Lufthansa 2 aircraft (one with the NOy instrument)**
  - **Air France 1 aircraft (instruments not operational since Dec. 2004)**
  - **Austrian 1 aircraft (will leave Austrian in summer 2006)**
  - **Air Namibia 1 aircraft (transport cost: INSU/CNRS, maintenance: FZJ)**

- **MOZAIC data base**
  - **January 2006: MOZAIC data base completed till 12/2004**
  - **March 2006: MOZAIC data base completed till 07/2005**
  - **June 2006: MOZAIC data base completed to 12/2005**

Ozone Instrument validation: MOZAIC + ozone sounding at Hohenpeissenberg (48°N, 11°E)

MOZAIC O3 instrument: improved version of commercial dual-beam UV absorption instrument (Thermo-Electron, model 49-103),

Accuracy ± 2 ppbv / precision ± 2% / response time 4 sec

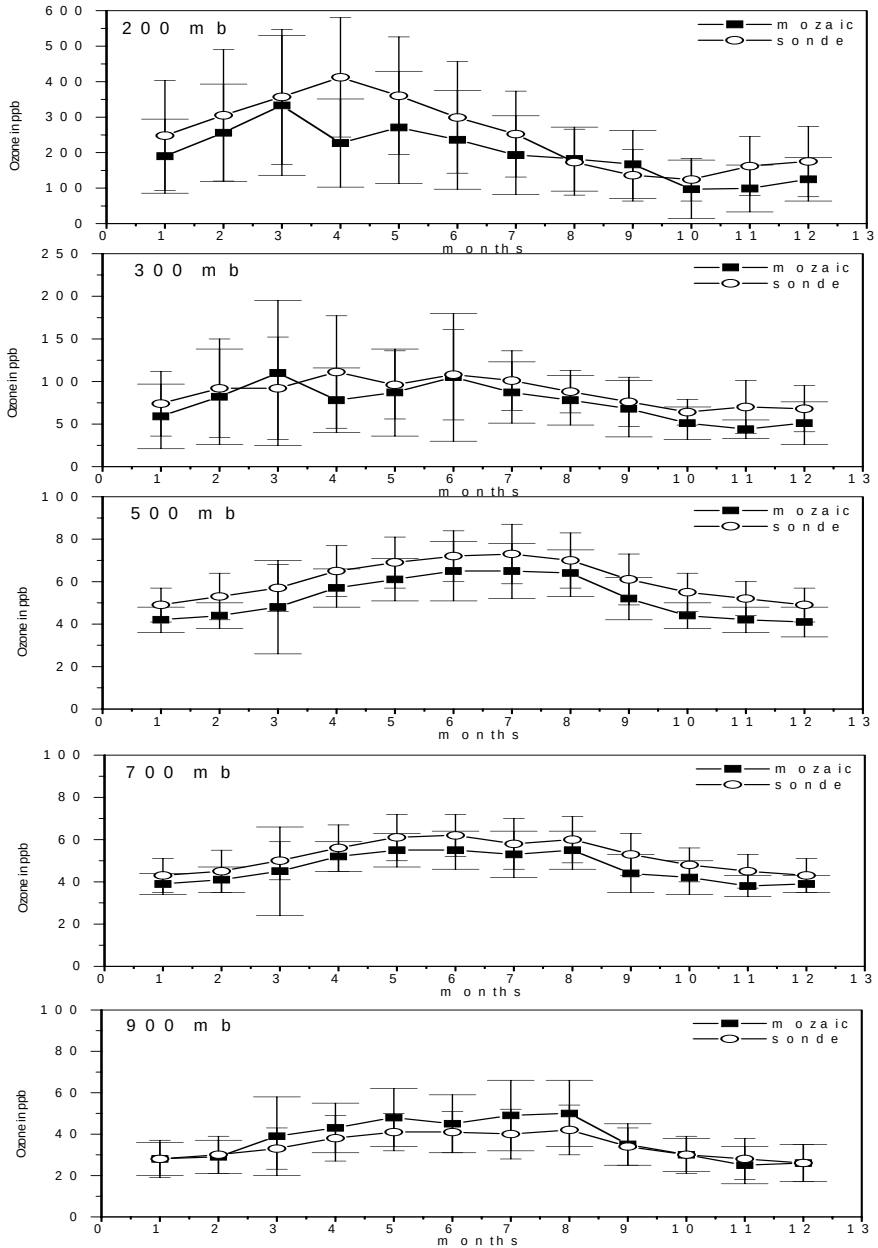
Sensor replacement & pre- and post-calibration in laboratory every C-check of aicraft.

Aeronautical certification: Airbus

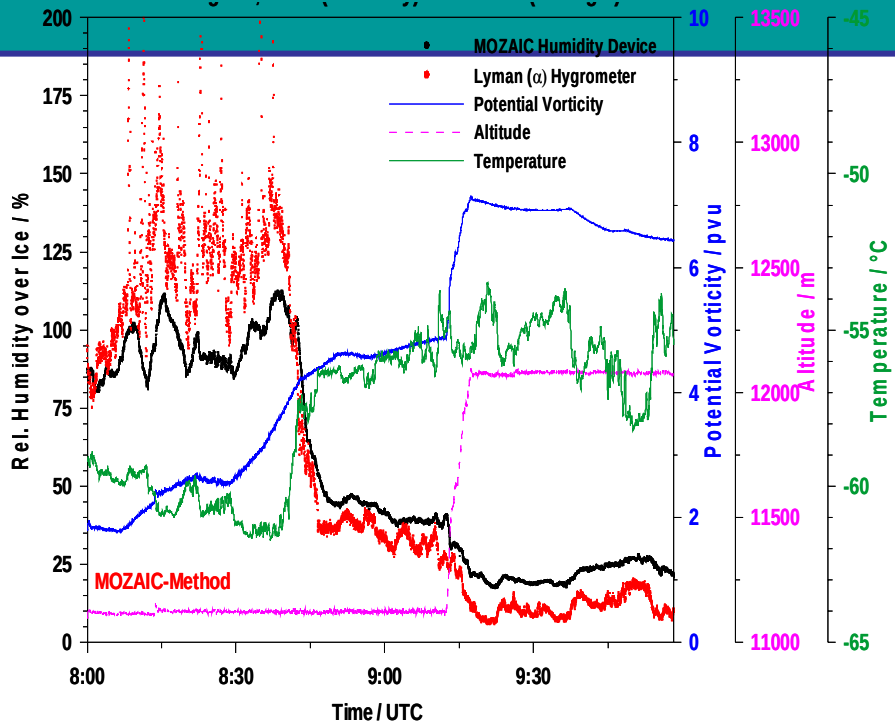
Marenco et al., JGR, 1998

Seasonal variations of ozone monthly averages for the Hohenpeissenberg sounding station [1980-93] compared with MOZAIC data over Frankfurt [Sept 1994-Aug 1996] at 5 standard pressure levels. Standard deviations are plotted as error bars with large cap for MOZAIC and small cap for Hohenpeissenberg.

Thouret et al., JGR, 1998



Instrument validation: MOZAIC H2O measurements



In-flight comparison of relative humidity over ice (RHI) measured by MOZAIC (black curve) and Lyman(α) hygrometer (red curve) at cruise altitude (pink curve) of Learjet research aircraft during SPURT mission at 28 April 2003. Potential vorticity (blue curve) obtained from ECMWF analyses along the flight track.

The comparison provides experimental evidence that the phenomena of ice super saturation observed by MOZAIC are real and not caused by the evaporation of hydrometeors.

MOZAIC RH instrument: capacitive RH sensor (Humicap-H) mounted in a Rosemount Probe system

Accuracy < 10%, precision ± 7%, response time depending on temperature (sec at ground to 2 minutes at cruise altitude)

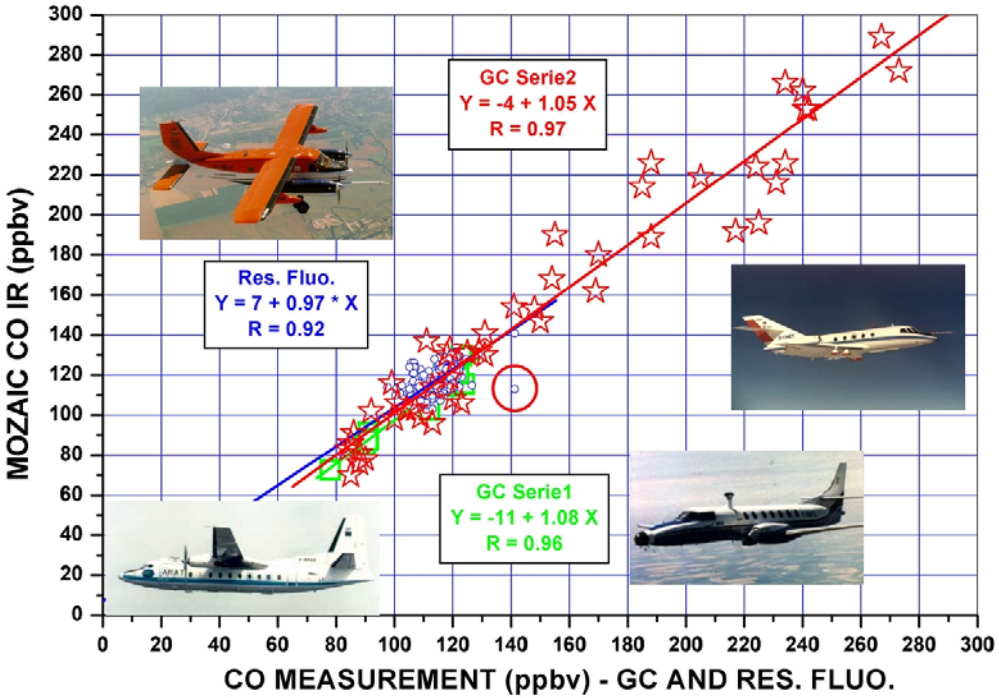
Sensor replacement & pre- and post-calibration in laboratory every C-check of aicraft.

Aeronautical certification: Airbus

Helten et al., JGR, 1998

Smit et al., 2004 (MOZAIC final report, 2004)

Instrument validation: MOZAIC CO measurements

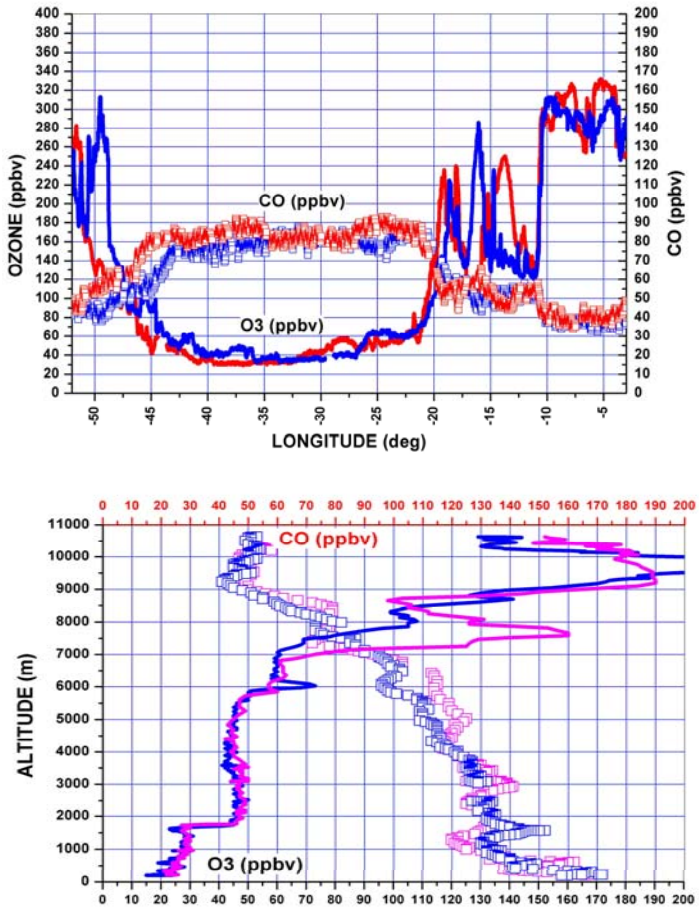


MOZAIC CO instrument: improved version of commercial IR gaz filter correlation model (48CTL, Thermo Environmental Instruments)

Accuracy ± 5 ppbv, precision ± 5%, detection limit 10 ppbv, response time 30 sec. Sensor replacement & pre- and post-calibration in laboratory every C-check of aicraft.

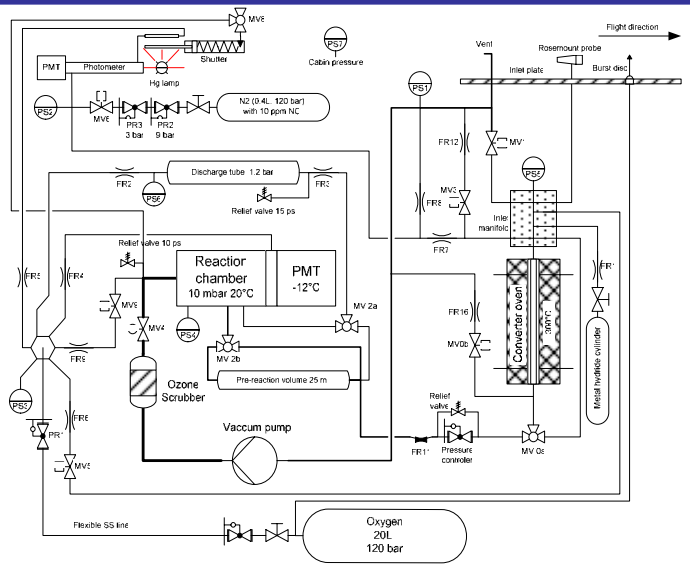
Aeronautical certifcation: Airbus

Nédélec et al., Atmos. Chemistry & Physics, 2003



Comparison of time series of O3 and CO for two co-located MOZAIC aircraft during cruise phase (top) and landing phase (bottom)

Instrument validation: MOZAIC NOy measurements



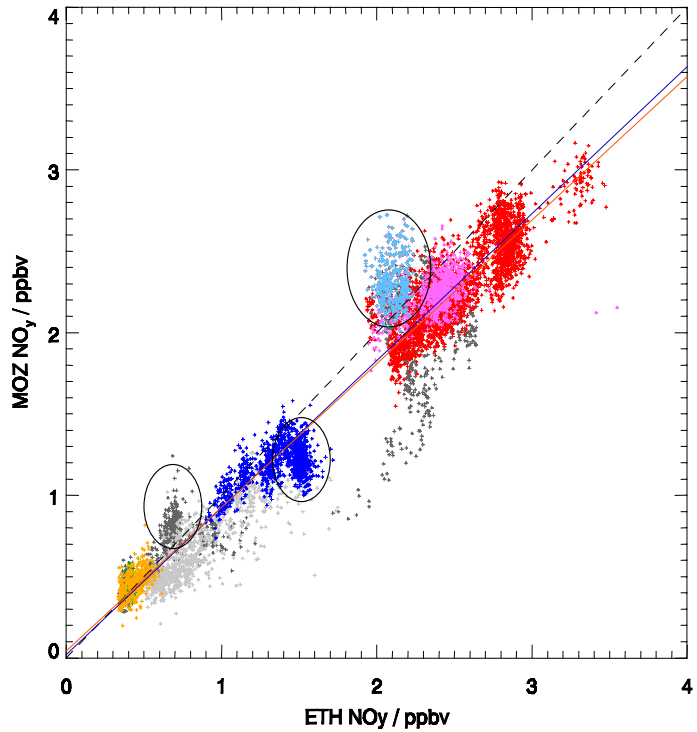
MOZAIC NOy instrument: detection of NO by chemiluminescence with O3 in combination with catalytic conversion of the other NOy compounds to NO at 300°C on a gold surface in the presence of H2.

Sensitivity of 0.3-0.5 cps/ppt gives a detection limit of better than 30-50 ppt for an integration time of 4s, and 150-300 ppt at the maximum resolution of the instrument (10Hz).

Designed for unattended operation during 400-800 flight hours. Total weight 50 kg, including calibration system, compressed gases, mounting, and safety measures.

Aeronautical certification: Lufthansa technics

Volz-Thomas et al., (ACP, 2005)



Quality assurance: Scatter plot of the NOy data from the comparison flight in April 2004 obtained by the MOZAIC and ETHZ instrument. The encircled data are from times after calibrations of the ETHZ (light blue and gray points) and MOZAIC (dark blue points) instrument. ***Pätz et al., (ACPD, 2006)***

Why MOZAIC is important for the future ?

UTLS and the PBL are difficult to probe from space ; high quality and high resolution measurements in these regions are of great value.

MOZAIC contributes nicely to current atmospheric monitoring by providing:

- **high resolution data of key climate constituents in the UTLS**
- **detailed vertical profiles over many cities world-wide**
- **very regular flights along some routes, at least once per day**

MOZAIC is complementary to satellites (global coverage but less quantitative ; plus problems with clouds etc.) and ground based observations (sparse, weekly).

MOZAIC is very cost effective: about 0.5 ME per year (EC funding)

MOZAIC demonstrates a genuine collaboration between scientists, airlines and aircraft manufacturers.

(73 peer-reviewed publications with MOZAIC data from 1997 to 2006)

Plans for the future of MOZAIC: A long-term monitoring program

- Until December 2007: Continuation of the measurements with existing equipment and existing 5 aircraft ; internal funds (CNRS & FZJ) ; MOU signed with Airbus & Airlines

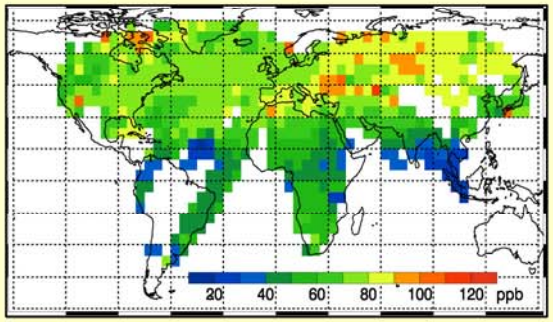
- Integration of MOZAIC into the GMES program *(Global Monitoring for Environment and Security) sustained by the EC & ESA*

  - ✓ 2005 - 2008: IAGOS (Integration of routine Aircraft Measurements into a Global Observing System, Design Study)

  - ✓ 2005 - 2009: GEMS (Global and regional Earth-system Monitoring using Satellite and in-situ data, Integrated Project) in the framework of GMES (Global Monitoring for Environment and Security)

MOZAIC DATA PRODUCTS

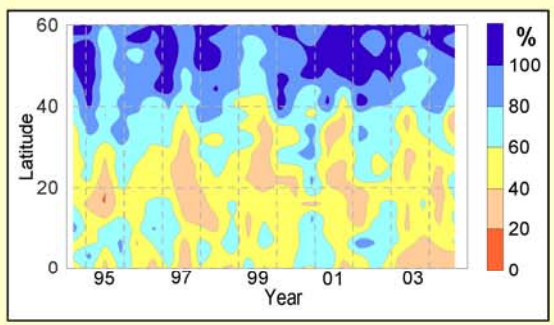
- Maps of O_3, CO, H_2O and NO_y in the upper troposphere and lower stratosphere
- Variability and trends
- Vertical profiles over many cities



Distribution of ozone in the upper troposphere in summer. ppb = parts per billion (one molecule in 10^9 molecules of air).

KEY FINDINGS

- The persistence of horizontal layers in the troposphere, indicating the need for improvements in the representation of transport and mixing in global models.
- The large abundance of ice supersaturation in the upper troposphere, a feature that was not predicted by numerical weather prediction models.
- The extreme CO concentrations at cruise level over East Asia as the result of uncontrolled biomass burning.



Climatology of water vapour (relative humidity over ice) in the upper troposphere over the North Atlantic. The ice supersaturation (dark blue) observed at higher latitudes is important for the understanding of cirrus clouds and persistent contrails.

Forschungszentrum Jülich, Institut für Chemie und Dynamik der Geosphäre

Centre National de la Recherche Scientifique, Laboratoire d'Aérologie, Toulouse

Météo France, Centre National de Recherches Météorologiques, Toulouse

University of Manchester, School of Earth, Atmospheric and Environmental Sciences

University of Cambridge, Departement of Chemistry

Deutsches Zentrum für Luft- und Raumfahrt, Institut für Atmosphären-physik , Oberpfaffenhofen

Max-Planck Institut für Biogeochemie, Jena

Deutsche Lufthansa

British Airways

AIRBUS

CLIMATE RESEARCH BY PASSENGER AIRCRAFT

Past, Present & Future

Understanding the chemistry of our atmosphere and its reaction to human influences is vital in developing global solutions to tackle climate change. Although the link between human activity and climate change has been demonstrated, considerable uncertainties remain that must be addressed urgently.

Dr. Andreas Volz-Thomas
Institut für Chemie und Dynamik der Geosphäre II
Forschungszentrum Jülich
D-52425 Jülich
a.volz-thomas@fz-juelich.de
Tel: +49-2461-616730

I NTEGRATION OF ROUTINE
A IRCRAFT MEASUREMENTS INTO A
G LOBAL
O BSERVING
S YSTEM

PAST

MEASUREMENT OF OZONE AND WATER VAPOUR BY AIRBUS IN-SERVICE AIRCRAFT (MOZAIC)

Passenger aircraft provide a unique platform for directly measuring atmospheric composition. The MOZAIC programme used five AIRBUS A340 aircraft operated by Lufthansa (2), Air France, Sabena and Austrian Airlines to monitor atmospheric gases day by day.

The data are being used by researchers worldwide for the evaluation of satellite observations, the improvement of global chemistry, climate and air quality models, and aircraft environmental impact assessment studies.

Major flight routes of the five MOZAIC aircraft.

The MOZAIC database contains data from more than 100 million flight kilometres in the tropopause region and 40,000 vertical profiles: ozone and water vapour since 1994, nitrogen oxides since 2001 and carbon monoxide since 2002. Meteorological metadata include potential vorticity, back trajectories, and satellite images. The scientific use is free of charge.

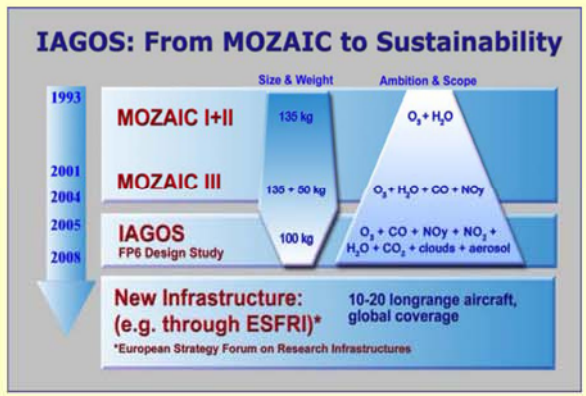
http://www.aero.obs-mip.fr/mozaic/

MOZAIC was co-funded by the European Commission from 1993 to 2004

PRESENT

INTEGRATION OF ROUTINE AIRCRAFT MEASUREMENTS INTO A GLOBAL OBSERVING SYSTEM (IAGOS)

IAGOS prepares the transition from a scheme of individual research projects into a sustainable infrastructure with enhanced measurement capabilities, global coverage, and realtime data transmission. This will not only benefit longterm climate and air quality research, but also will provide timely data for weather forecasting.



To achieve these goals, IAGOS will

- develop lighter, smaller and low maintenance instrument packages, based on the former MOZAIC instrumentation,
- develop new instrumentation for carbon dioxide, aerosol, clouds - key unknowns in climate modelling,
- obtain worldwide aeronautical certification for installation and deployment on in-service aircraft,
- study realtime data transmission to meteorological services,
- evaluate the logistic and financial boundary conditions for operation of the new infrastructure and identify new partner airlines.

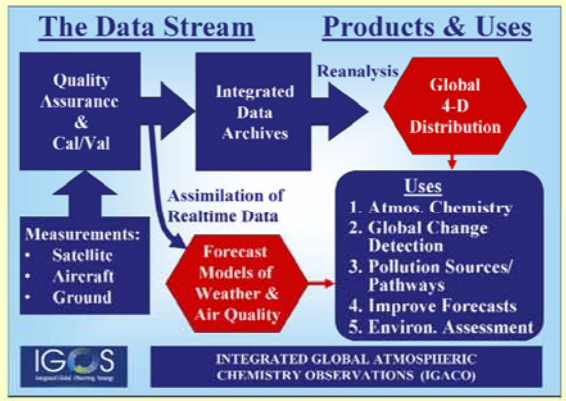
http://www.fz-juelich.de/icg/icg-ii/iagos

IAGOS is a Design Study for New Infrastructures in FP6, co-funded by the European Commission

FUTURE

INTEGRATED GLOBAL ATMOSPHERIC CHEMISTRY OBSERVATIONS (IGACO)

Routine observations from passenger aircraft are a key component of IGACO, itself a key element of a new multi-governmental initiative on Global Earth Observations (GEO) with its secretariat at the World Meteorological Organization (WMO).



The IGACO system and its links to societal needs. (Source: L. Barrie, WMO)
Cal/Val = Calibration & Validation of satellite data

IGACO will merge groundbased observations of atmospheric composition with routine aircraft and satellite measurements through computer models, which serve as smart interpolators for data assimilation.

With IGACO, a next generation Global Atmosphere Watch (GAW) programme will evolve to meet the observational needs and challenges of climate change, ozone depletion, air quality and longrange transport of air pollution.

http://www.wmo.ch/web/arep/gaw/publications2.html

How can I access to MOZAIC data ?

1) Send one page of description of the work you intend to do with MOZAIC data to MOZAIC PIs and sign the data protocol
(available at http://www.aero.obs-mip.fr/mozaic/)

2) Access to the data: ftp / CDroms

Join us in future MOZAIC meetings