IAGOS in the USA: An opportunity for commercial airlines to monitor air quality and greenhouse gases above the United States

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HIPPO Workshop

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The scarcity of vertical profiles of trace gases in the troposphere and lower stratosphere limits the ability of scientists to fully assess:

- the global distribution of greenhouse gases
- the impact of intercontinental pollution transport on global air quality
- the impacts of aviation on climate

Brasseur G., (2008), ACCRI Report on the Way Forward based on the Review of Research Gaps and Priorities, *Federal Aviation Administration Report*, 53 pp.

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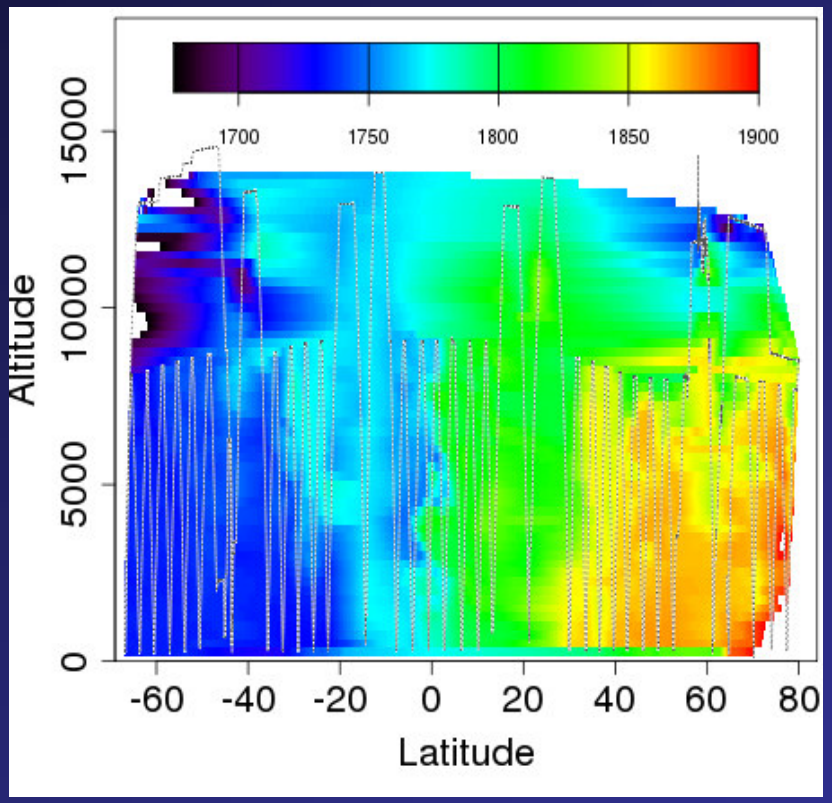
Task Force on Hemispheric Transport of Air Pollution (2011), Hemispheric transport of air pollution, *United Nations Publication, in-press*.



HIPPO methane curtain,
from a presentation by S. Wofsy

When HIPPO ends in 2011, how can we continue to monitor trace gases in the free troposphere around the globe?

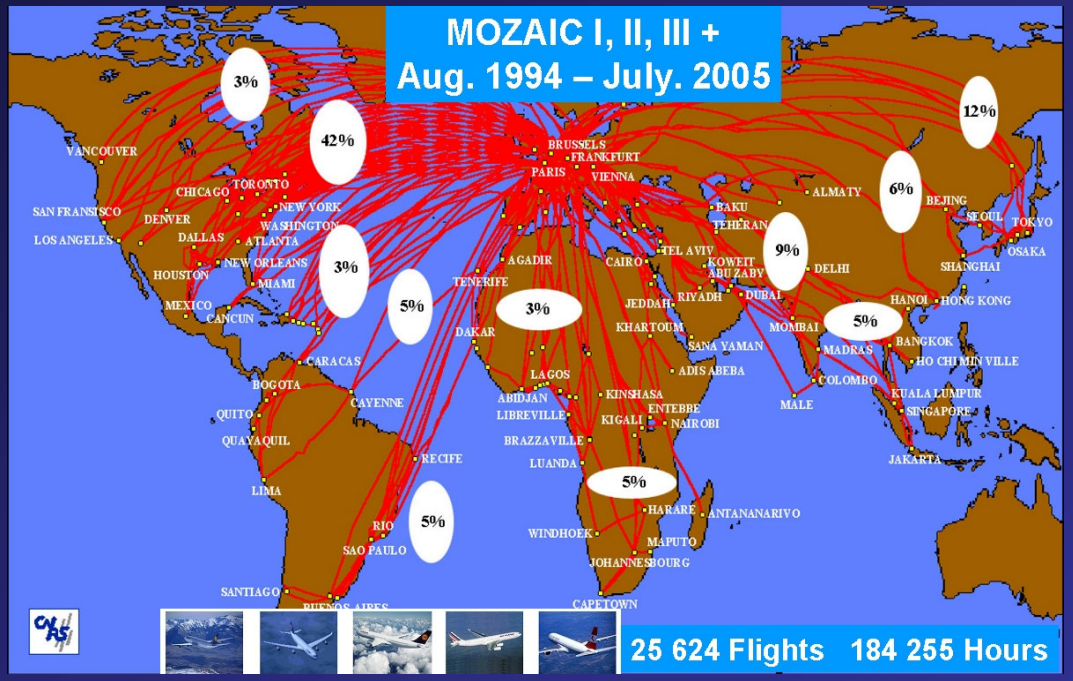
MOZAIC

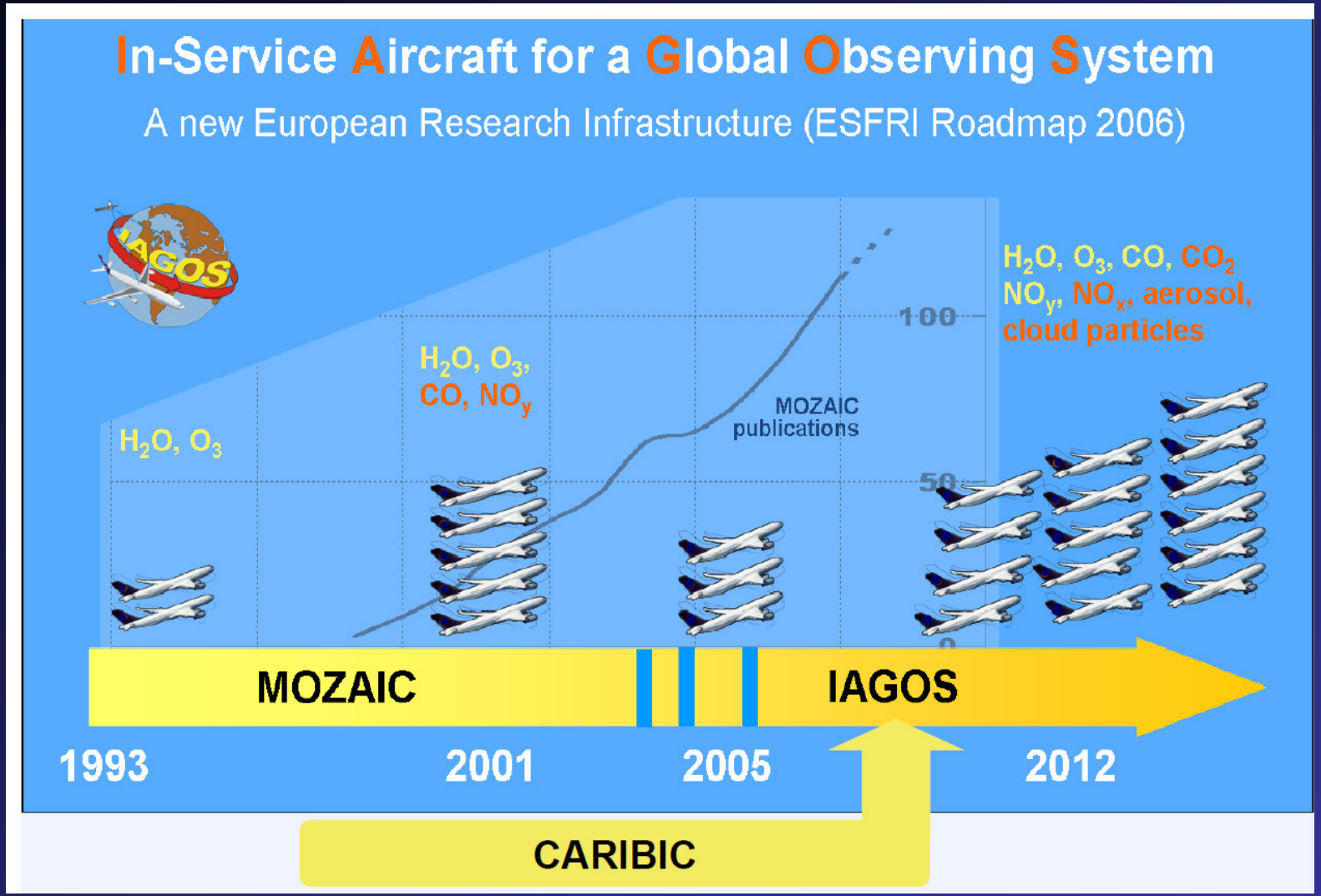
Measurements of **OZ**one and water vapour by in-service **AI**rbus air**C**raft

The most cost-effective method for profiling the troposphere is to make measurements from commercial aircraft.

Since 1994 the European MOZAIC program has made over 65,000 vertical profiles from airports around the world.

All profiles measure ozone and water vapor and since 2002, all profiles have CO, and roughly a quarter have NO_y.





European scientists are expanding MOZAIC into the newly developed IAGOS program.

The goal is to have 10-20 instrumented aircraft based around the world to obtain global coverage.

Partnership

Project Partners

- FZJ
- CNRS (LA and INSU)
- Meteo France
- Univ. Cambridge
- Univ. Manchester
- DLR
- Lufthansa
- Airbus UK
- British Airways
- MPG
- enviscope GmbH
- IfT
- WMO
- NERC
- CNES

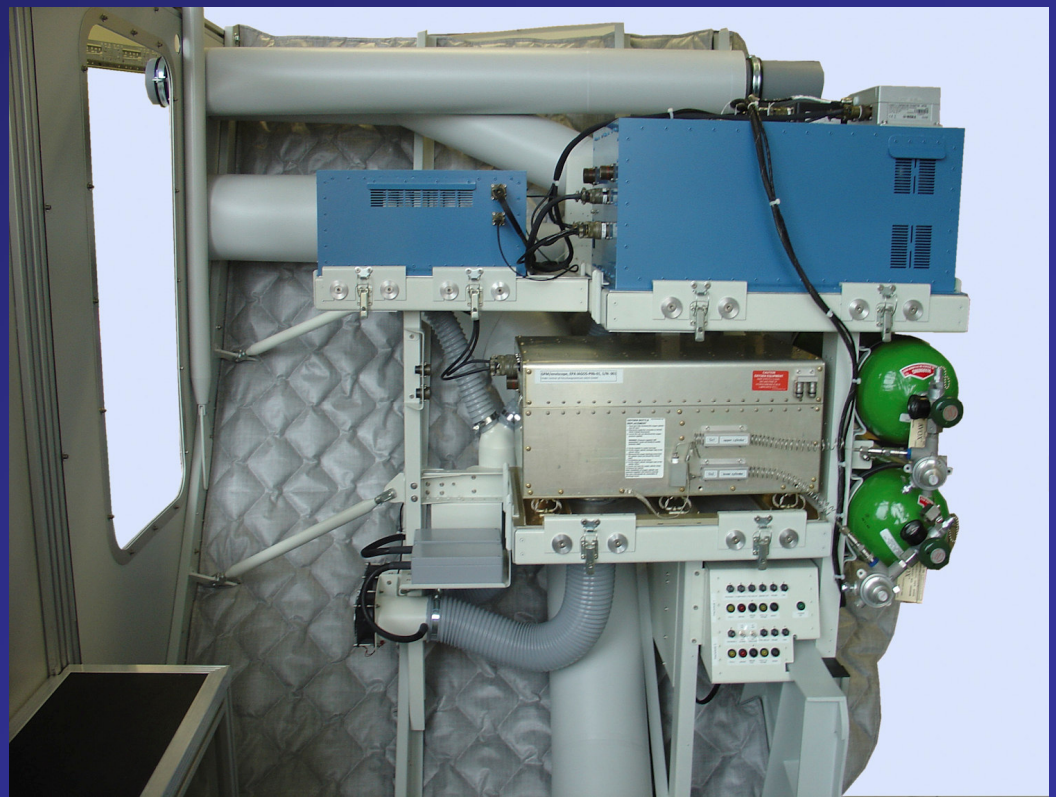
Associated and potential partners

- ECMWF (non-signatory partner)
- NCU Taiwan MoU signed
- China Airlines MoU signed
- Air France MoU in prep.
- Iberia interested
- Cathay Pacific interested
- South African Airlines interested
- Air Namibia MoU for MOZAIC

IAGOS equipment is designed to fly on Airbus A330 aircraft.

Species that can be measured include:

ozone
carbon dioxide
methane
particulate matter
carbon monoxide
nitrogen oxides
total reactive nitrogen
water vapor
cloud droplet backscatter



IAGOS aircraft measurements

- Package I, on all aircraft, measures ozone, carbon monoxide, temperature, water vapor, cloud droplets

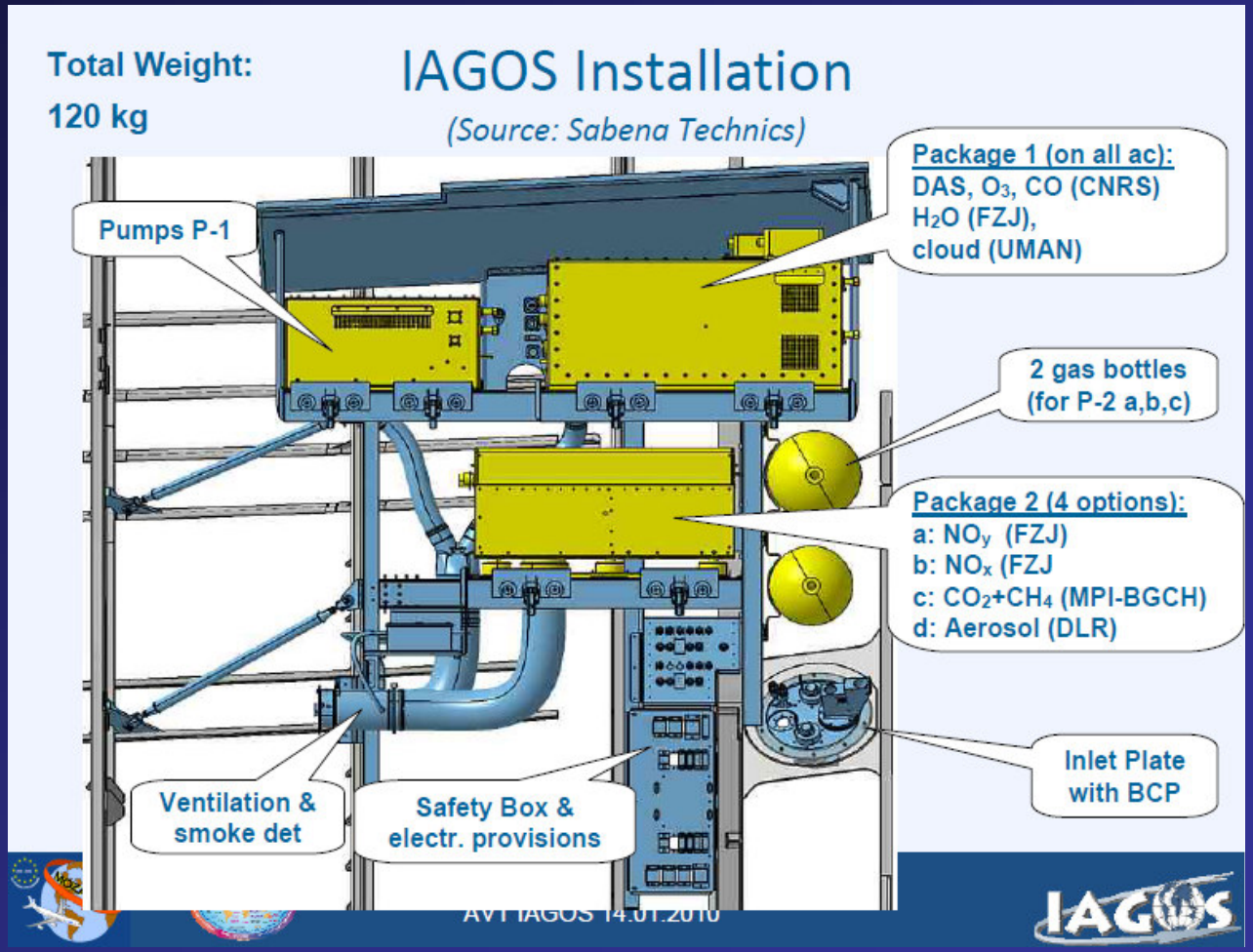
- Package II, optional, measures one of the following:

NO_x or NO_y or CO_2+CH_4

or particulate matter size distribution and composition (can detect soot, volcanic ash and dust)

Sampled air enters the aircraft though specially designed inlets that are installed in an existing port in the hull. No new holes need to be cut into the aircraft.

A newly designed Real Time Transmit Unit will allow the measurements to be transmitted during flight via VHF or Satcom, making them available in near real-time for use in air quality forecast models.



- data will be reported at 4-second intervals, corresponding to a horizontal (vertical) resolution of approximately 1 km (20-30 m)

- a typical Airbus A330 flies 340 days per year

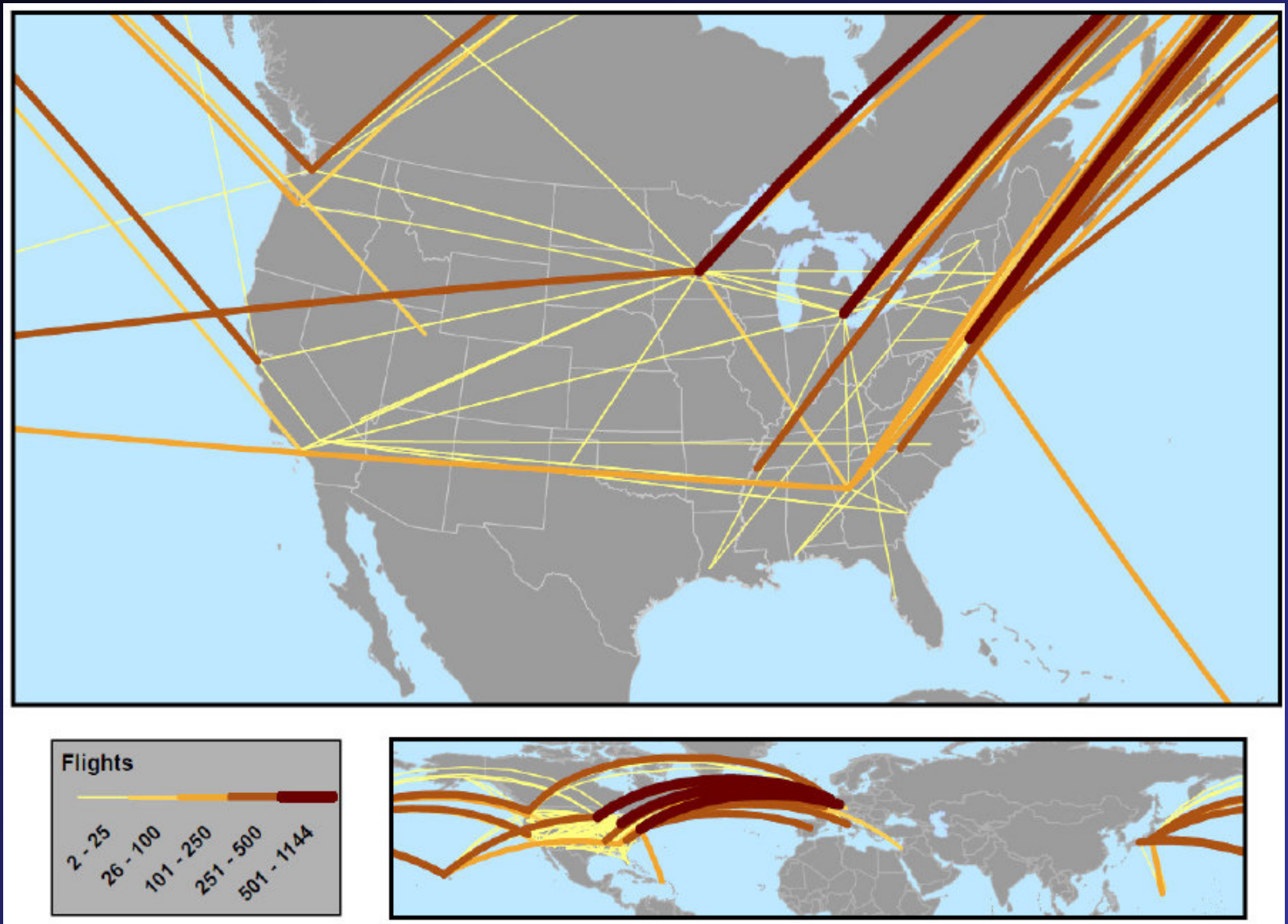
At present IAGOS (and its forerunner, MOZAIC) has no facilities in the United States and has no funding connections to the United States. Regardless, IAGOS will monitor trace gases in US air space when its aircraft fly to the US, and the program will make the data freely available to US researchers.

IAGOS is eager to install its monitoring equipment on US based aircraft (Airbus A330), greatly increasing the profiling frequency within the USA.

To bring IAGOS to the USA, a group of scientists has recently formed the "IAGOS in the USA" working group and written a white paper listing the benefits of the program for air quality monitoring and for climate research.

Formed in August, 2010, the IAGOS in the USA Working Group has representation from a broad range of US government agencies and universities

Institution	Participant
NOAA ESRL CIRES, U. of Colorado	Owen Cooper & Colm Sweeney
FAA	Mohan Gupta, Rangasayi Halthore & S. Daniel Jacob
EPA	Terry Keating, Darrell Winner, Richard Scheffe, S.T. Rao, Jim Szykman
NASA	Jay Al-Saadi & Ken Jucks
National Center for Atmospheric Research	Bill Randel
Harvard University	Jennifer Logan
University of Alabama - Huntsville	Mike Newchurch
Department of Energy	Jared S. Dreicer
Forschungszentrum Jülich, Germany	Andreas Volz-Thomas
Observatoire Midi-Pyrénées, CNRS, Toulouse, France	Jean-Pierre Cammas & Philippe Nédélec



Flight tracks and flight frequency during 2009 of all A330 aircraft based in the United States. *Figure produced by S. Daniel Jacob, FAA.*

IAGOS is not just a routine monitoring program.

IAGOS data will have valuable scientific applications, including:

- trend studies of trace gases and PM in the boundary layer, the free troposphere and the lowermost stratosphere

- case studies of regional and intercontinental pollution plume transport

- assessment of chemical transport models and air quality forecast models

- studies of the impacts of aircraft on cirrus cloud formation

- validation of satellite retrievals

Since 1997, MOZAIC data have been used in over 170 peer reviewed scientific publications.

Initial Goal of the Working Group:

Install IAGOS Package I on a single U.S.-based A330 by the end of 2012.

Next steps:

1) Identify a U.S.-based airline to carry the instruments free of charge

2) Obtain FAA approval of the instrument packages

3) Apply for funding

IAGOS in the USA needs your support

In 2012 “IAGOS in the USA” will apply to NSF to seek potential funding

Letters of support from a broad range of university researchers will greatly improve our chances

If you expect to use IAGOS data (all freely available) in your research please consider writing a letter of support.

To learn more please contact Owen Cooper:
owen.r.cooper@noaa.gov

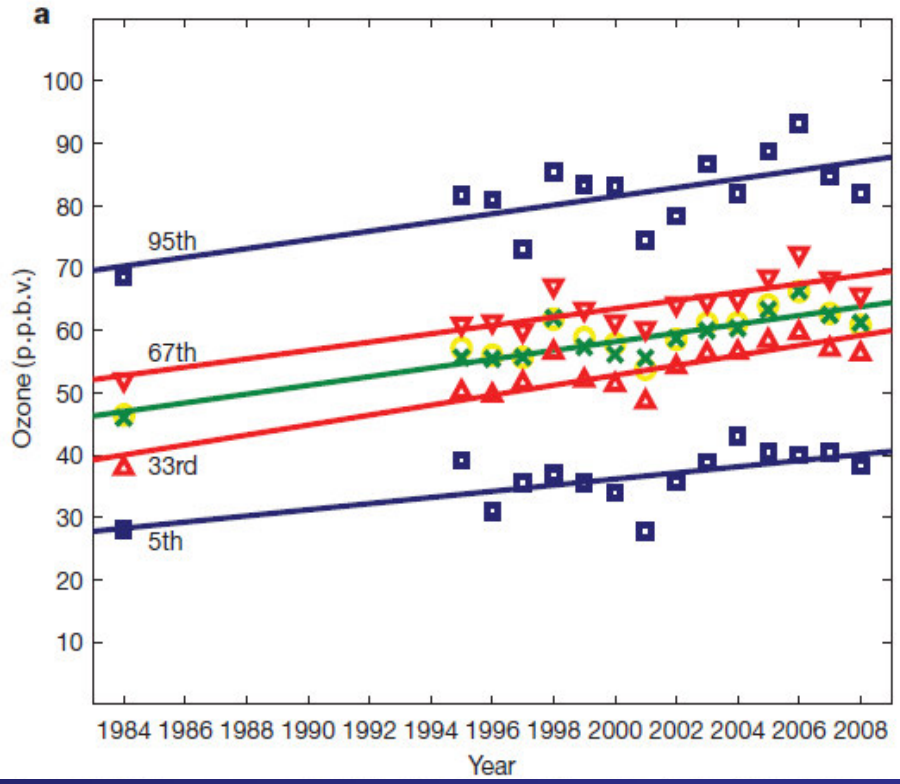
Additional slides

nature Vol 463|21 January 2010|doi:10.1038/nature08708

LETTERS

Increasing springtime ozone mixing ratios in the free troposphere over western North America

O. R. Cooper[1,2], D. D. Parrish[2], A. Stohl[3], M. Trainer[2], P. Nédélec[4], V. Thouret[4], J. P. Cammas[4], S. J. Oltmans[2], B. J. Johnson[2], D. Tarasick[5], T. Leblanc[6], I. S. McDermid[6], D. Jaffe[7], R. Gao[2], J. Stith[8], T. Ryerson[2], K. Aikin[1,2], T. Campos[9], A. Weinheimer[9] & M. A. Avery[10]



Percentile	1995–2008 increase (p.p.b.v. yr^{-1})	*P*
95th	0.56 ± 0.71	0.11
67th	0.62 ± 0.39	0.00
50th	0.63 ± 0.34	0.00
33rd	0.64 ± 0.35	0.00
5th	0.48 ± 0.53	0.07

Percentile	1984–2008 increase (p.p.b.v. yr^{-1})	*P*
95th	0.70 ± 0.45	0.01
67th	0.67 ± 0.25	0.00
50th	0.70 ± 0.22	0.00
33rd	0.80 ± 0.24	0.00
5th	0.49 ± 0.34	0.01

This study depended on all available free tropospheric ozone measurements made above western North America between 1984 and 2008.

MOZAIC provided 55% of the data used in this study, free of charge.

The study would not have succeeded without MOZAIC.

Advantages of Routine Aircraft Measurements

- Satellites provide global coverage but little vertical information in the troposphere (air quality, carbon cycle, climate modelling)
- Longhaul aircraft sample the tropopause region at high spatial resolution
  - Very sensitive region for climate change
  - Important for intercontinental transport and STE
- Only source of regular tropospheric profiles of CO, CO_2, NO_x, NO_y, aerosol.
- Same instruments for measurements everywhere
  - Excellent comparability
  - Global harmonization standard

IAGOS Development phase

2010

- CARIBIC container improved and re-certified
- funding for 3 additional sets of equipment

2011

- Certification for A340 by EASA
- 1st IAGOS A340 operational (Lufthansa)
- 2nd IAGOS A340 operational (China Airlines)
- 3rd IAGOS A340 operational (Air France)
- new instruments for CO_2/CH_4 and aerosol certified
- Certification for A330 by EASA

IAGOS Operational Phase

2012 and beyond

- IAGOS-ERI Legal form established
- Operation established
- Funding stream established

IAGOS Measurements

Package 1: (on each aircraft)

Ozone	UV absorption (CNRS, Thermo Instruments)
CO	NDIR with enhanced sensitivity (CNRS, TE)
H_2O	Humicap (FZJ, Vaisala)
Cloud particles	Backscatter Probe (UNIMAN, DMT)

Data acquisition (CNRS)

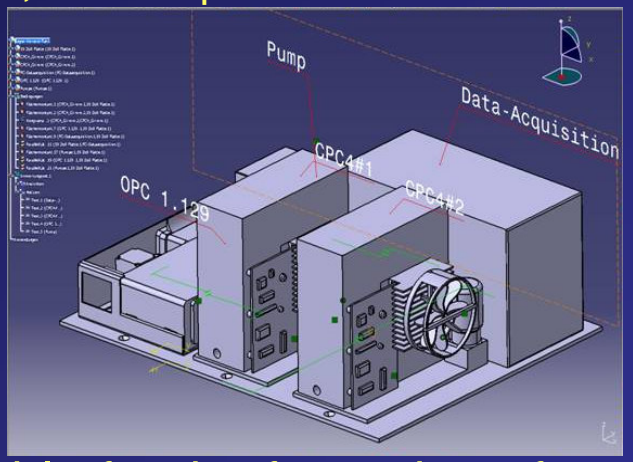
Realtime data provision (Meteo-France)

Package 2: (only one of the following 4 options per aircraft)

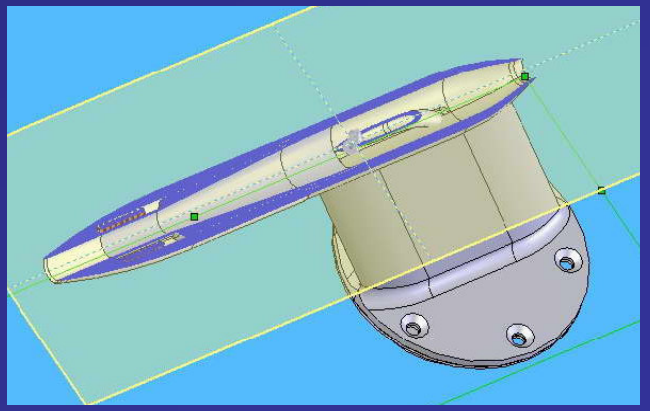
NOx	Chemiluminescence, Photolytic converter (FZJ)
NOy	Chemiluminescence, Catalytic converter (FZJ)
Aerosol	1 OPC, 2 CPC, Themrodenuder (DLR, Grimm)
CO_2/CH_4	Cavity Ringdown (MPI-Jena, Picarro)

IAGOS Aerosol Package

A. Petzold, DLR-IPA; M. Hermann, IfT; H. Franke, enviscope



- Robust instrument for routine measurements from in-service aircraft
  - particle size distribution
  - integral number of particles
  - non-volatile particle cores.
- Optical Particle Counter (> 100 nm): Particles available for the formation of water and ice clouds
- and two Condensation Particle Counters (> 5nm):
  - Information on gas-to-particle conversion and nucleation
- Thermo denuder:
  - Information on non-volatile particles, e.g.:
  - Soot particles emitted by aircraft
  - Volcanic ash
  - Sand and dust
- Special inlet for particle sampling
  - Rosemount footprint

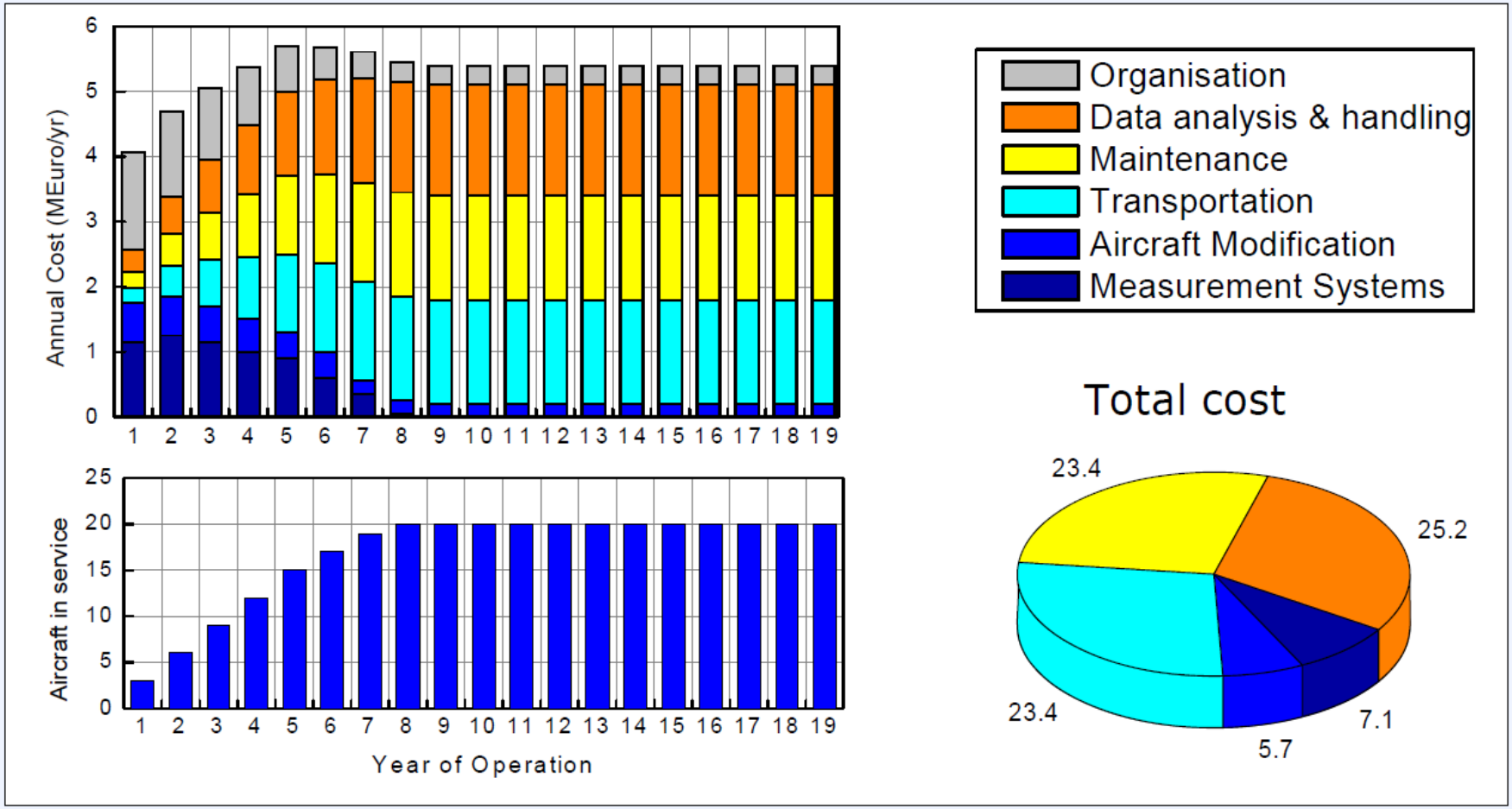


Estimated Development and Cost

(from ESFRI Proposal)

5 MEuro/a => 100 MEuro over 20 years

50 % committed by partner institutions



Benefits of IAGOS measurements for US Air Quality and Climate Monitoring

- IAGOS will provide cost effective multiple profiles per day from the surface to 12 km of ozone, CO water vapor, and cloud properties (at least), plus options for NO_x, NO_y, aerosols, CO_2 and CH_4.

- these data can be applied to the monitoring of air quality and greenhouse gases in the boundary layer, free troposphere and lowermost stratosphere.

- profiles along the west and east coasts will reveal any trends in trace gases imported to and exported from the USA.

- IAGOS data will be available in near real-time for assimilation into air quality forecast models. Efforts are already underway at NOAA and EPA to demonstrate the value of MOZAIC profiles in improving air quality forecasts.

- The profiles can also be used by NOAA's CarbonTracker system, which keeps track of CO_2 uptake and release at the Earth's surface.