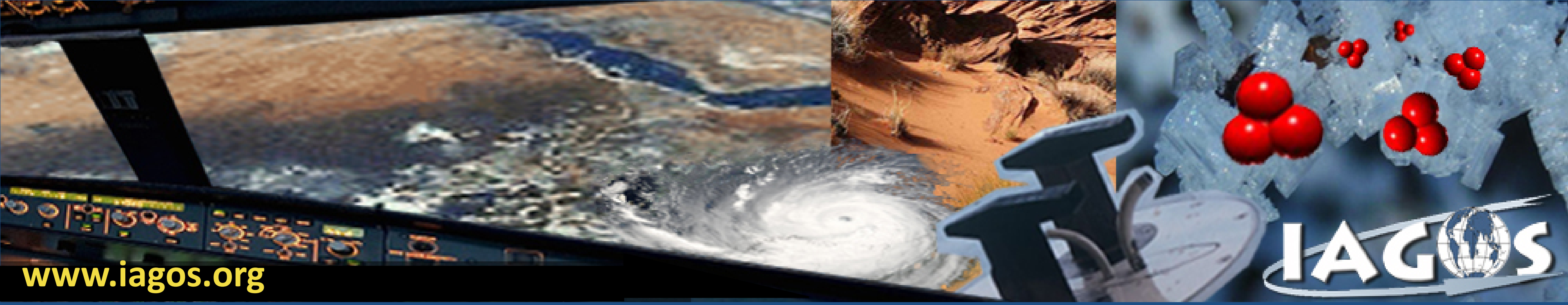
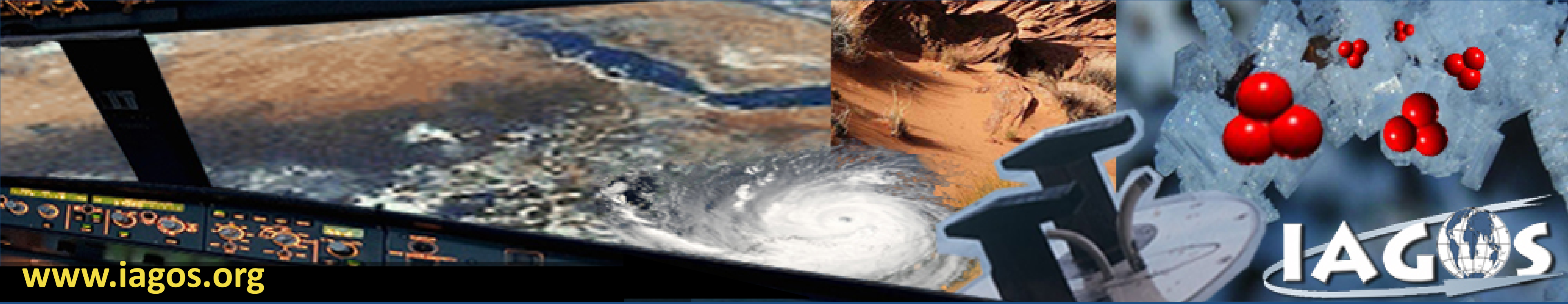


Global Monitoring of Atmospheric Composition by IAGOS-CORE Aircraft:

Current Achievements and Future Developments Including Involvement of US Partners

A. Petzold, A. Volz-Thomas	|	IEK-8 FZ Jülich
V. Thouret	|	CNRS , UPSL, Toulouse
O.R. Cooper	|	CIRES Univ. Colorado, Boulder
J.H. Butler	|	NOAA ESRL, Boulder

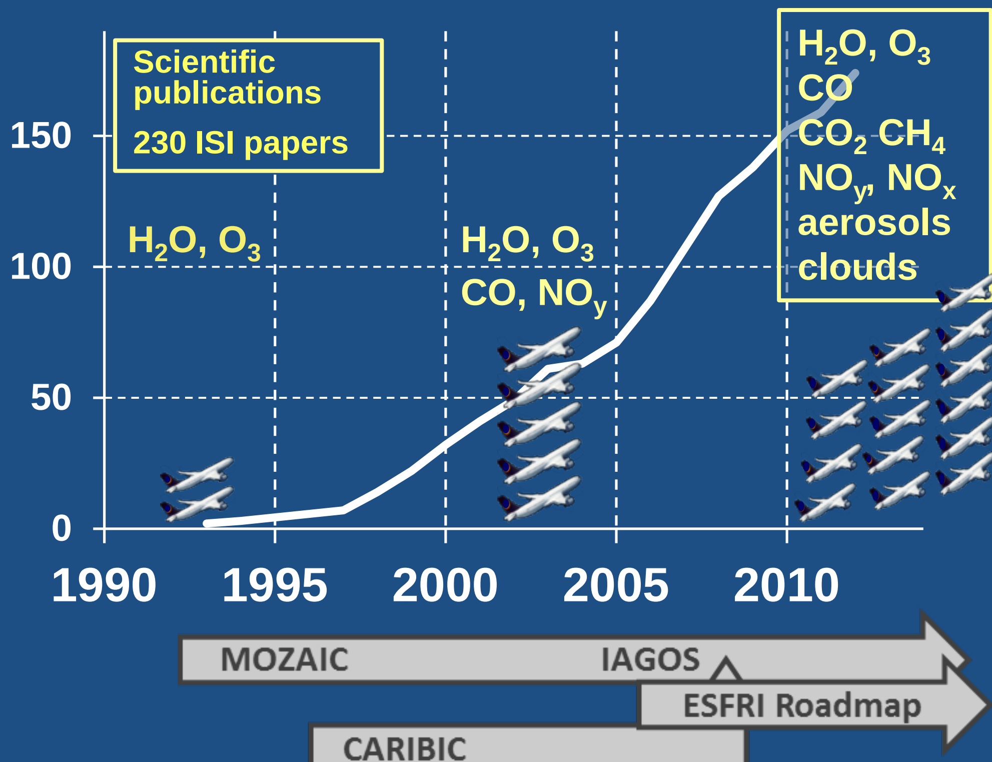
ESRL-GM Annual Conference | Boulder, CO | 21-22 May 2013



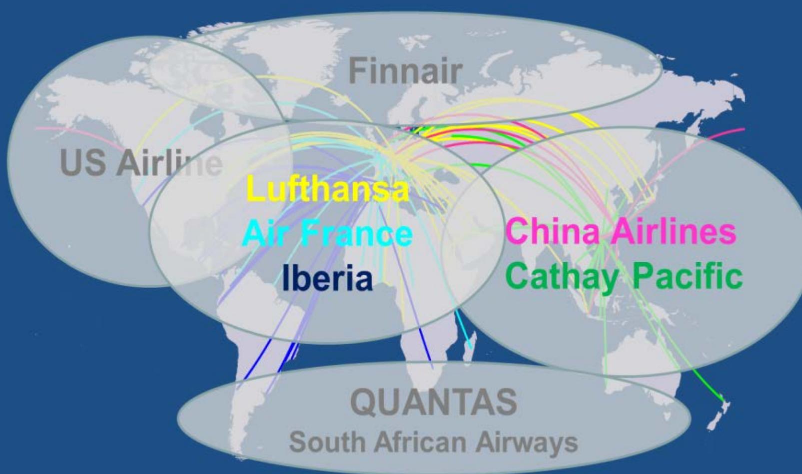
In-service Aircraft for a Global Observing System

European Research Infrastructure

20 equipped long-haul a/c + 1 flying laboratory



Global Dimension



- 16 partners from science, industry and meteorological services
- Long-term deployment (20 years)
- Near real time data provision
- Open data policy (GMES/GEO/GEOSS)

IAGOS-CORE

Permanent installations in the avionic bay of A340/A330

First flight of LH D-AIGT on 8 July 2011

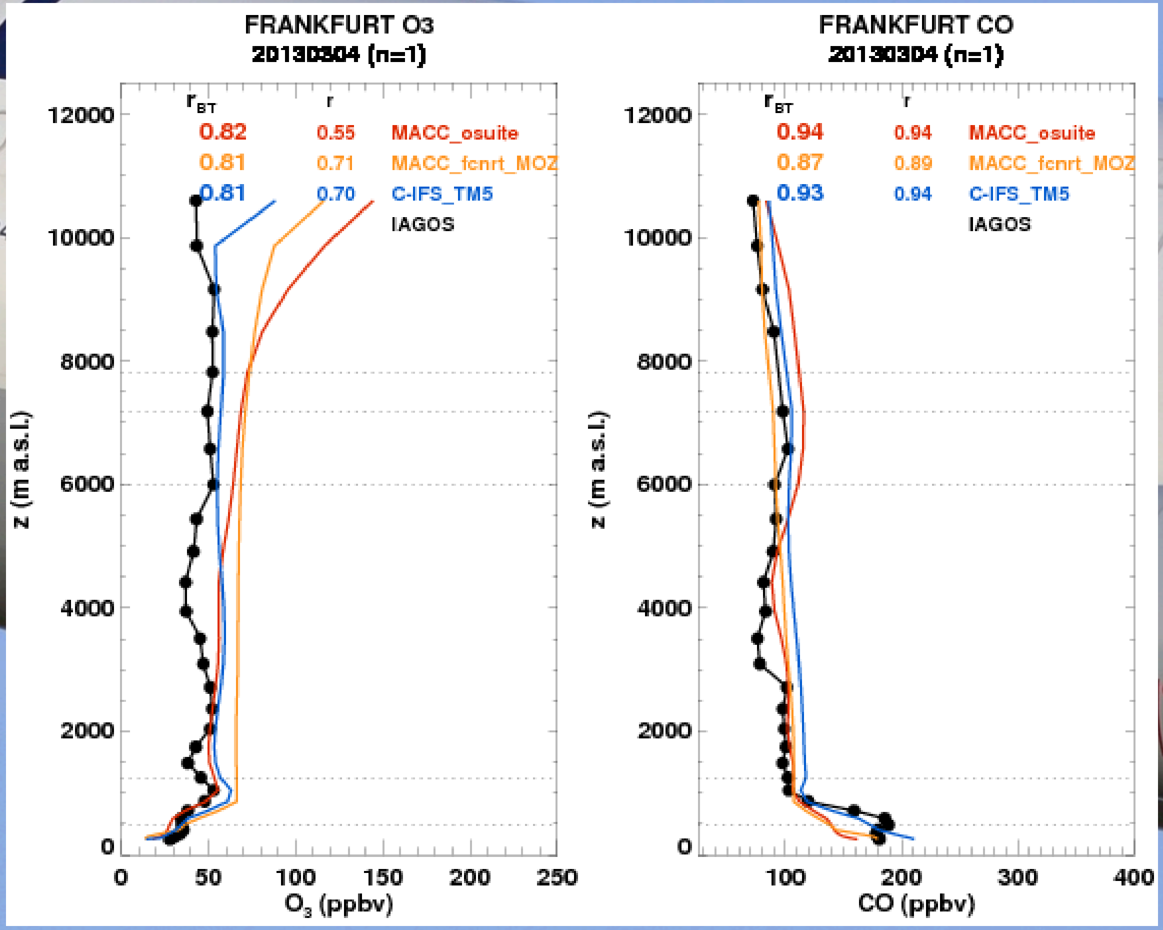
<u>Weight:</u> 120 kg **<u>Operation:</u> Continuous**

Photograph by courtesy of A. Karmazin

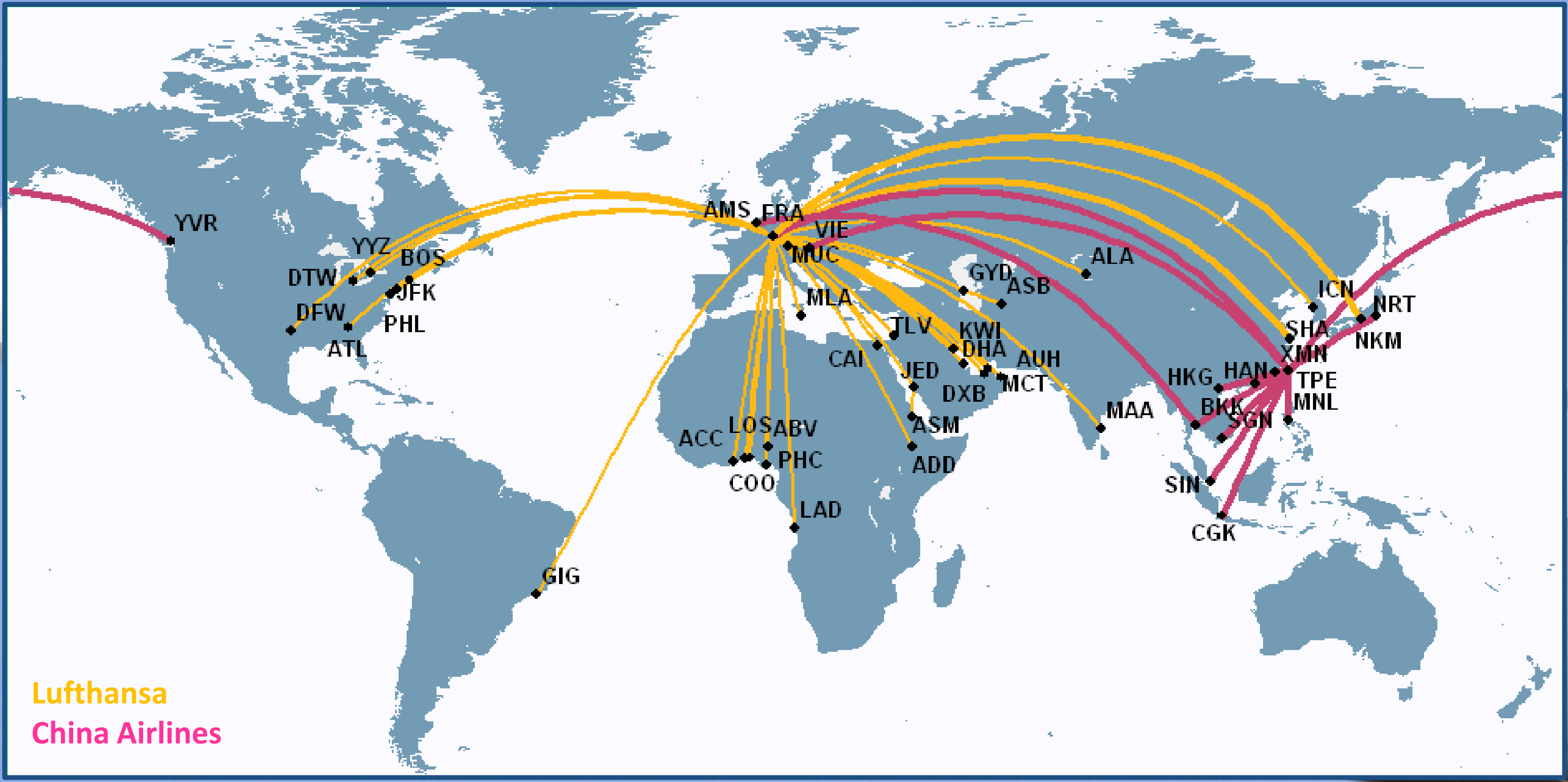
IAGOS-CORE

Photograph by courtesy of A. Karmazin

Near Real Time Evaluation of MACC Results

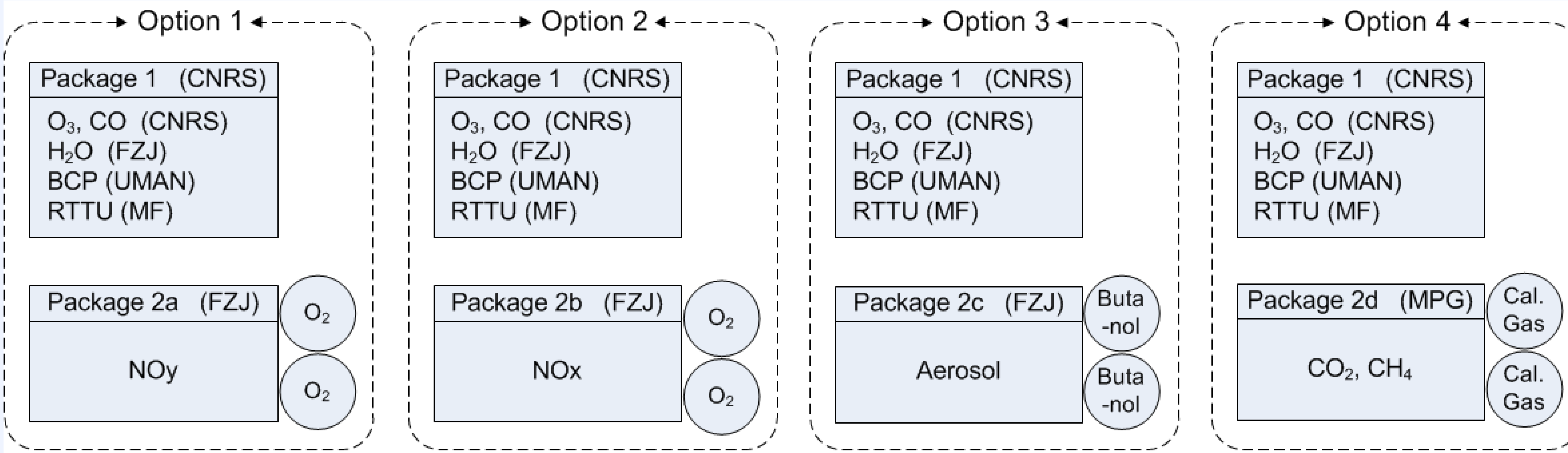


IAGOS-CORE



- > 3000 flights since July 2011
- at least 2 vertical profiles of CO, O_3, and H_2O per day/flight

IAGOS-CORE Instrumentation



NO_y package

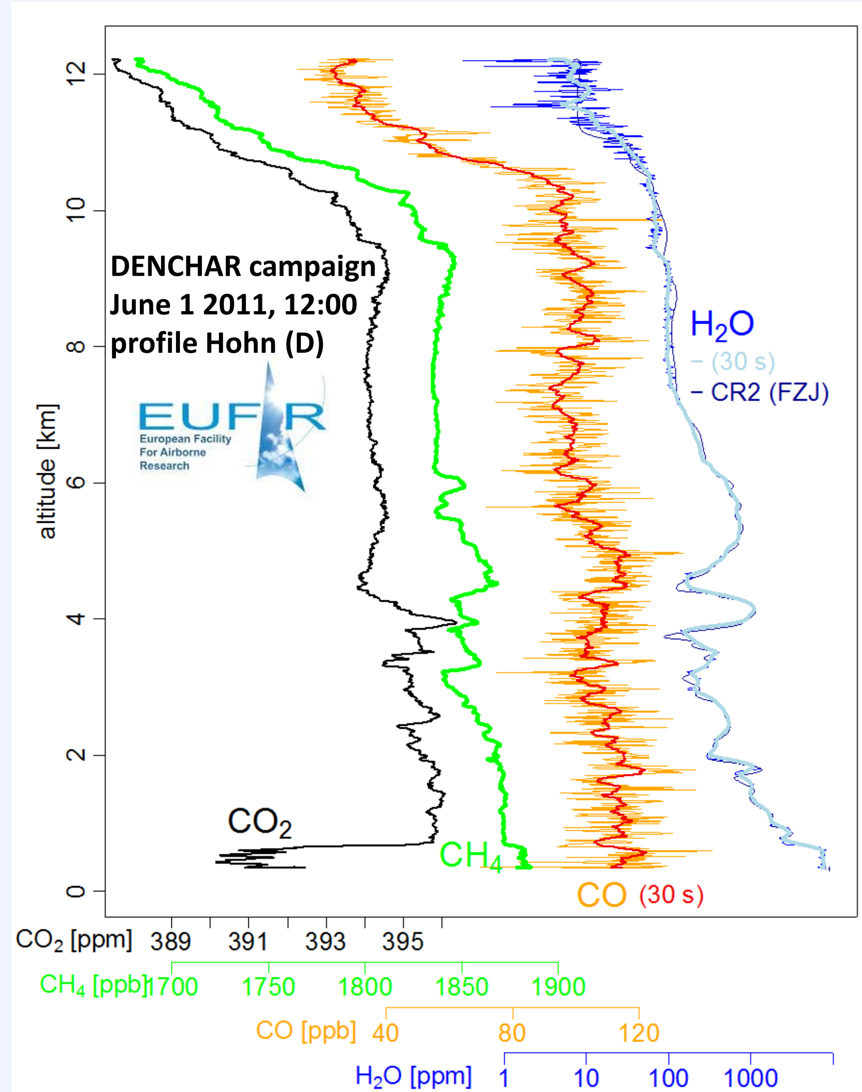
Aerosol package

Parameter	MOZAIC	IAGOS CORE	CARIBIC Phase II
Ozone	1994	2011	2004
Water Vapour	1994	2011	2004
Carbon Monoxide	2002	2011	2004
Odd Nitrogen (NO_y)	2001	2011	2004
Nitrogen Oxides(NO_x)		2011	2004
Carbon dioxide		2013	2004
Methane		2013	2004
Aerosol number concentration and size		2013/2014	2004
Cloud particle number concentration		2011	
~100 trace species			2004

Data Sets for GEOSS

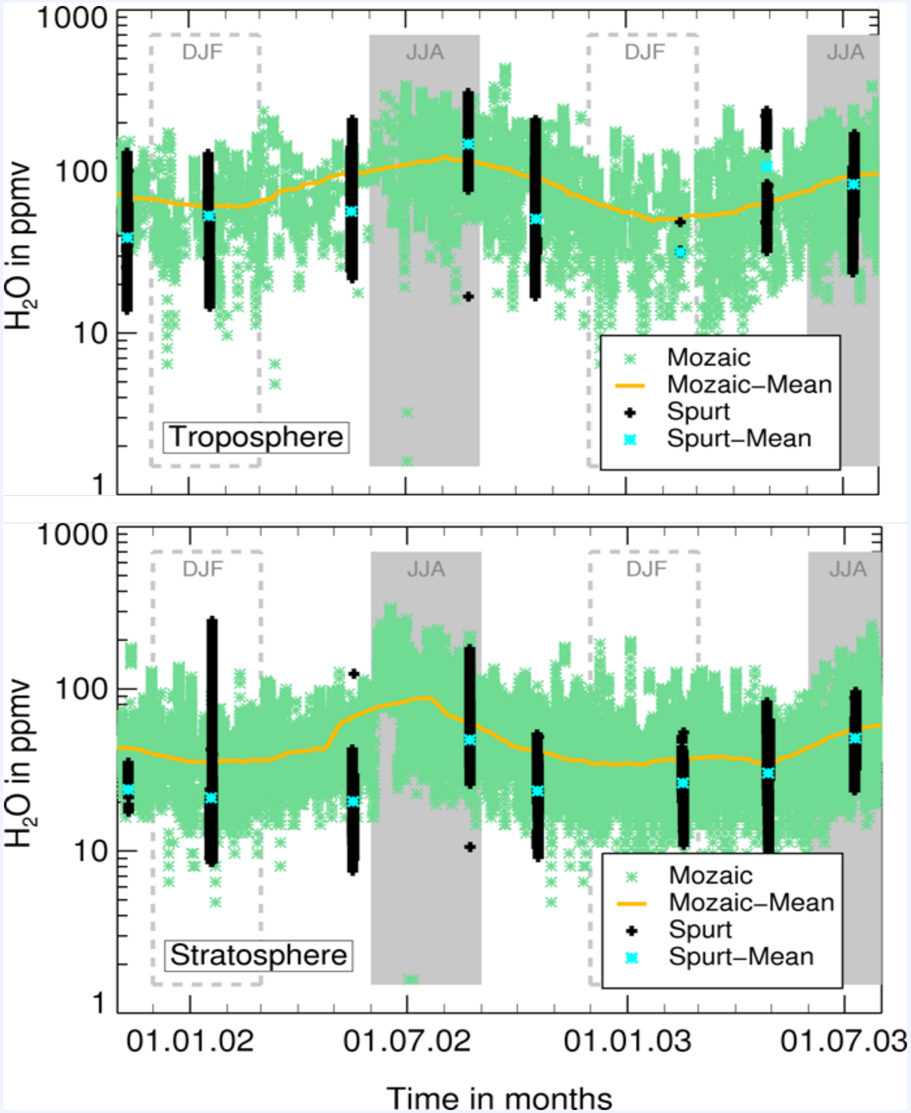
IAGOS-CORE GHG Measurement

C. Gerbig, A. Filges
Max-Planck Institute
for Biogeochemistry
Jena, Germany



- **Picarro G2401-m components (4 species CRDS)**
- **Aircraft-qualified enclosure, wiring/connectors replaced (fire protection)**
- **Rosemount inlet (no aerosols/droplets)**
- **Measurements in humid air, H_2O correction**
- **6-month deployment cycle**
- **In-flight calibration, WMO traceable**
- **Pre- and post-deployment calibration**
- **Ready for deployment (after ground testing and STC)**

Example: Building UT-LS Climatologies



MOZAIC (green)
Climatological data from routine observation

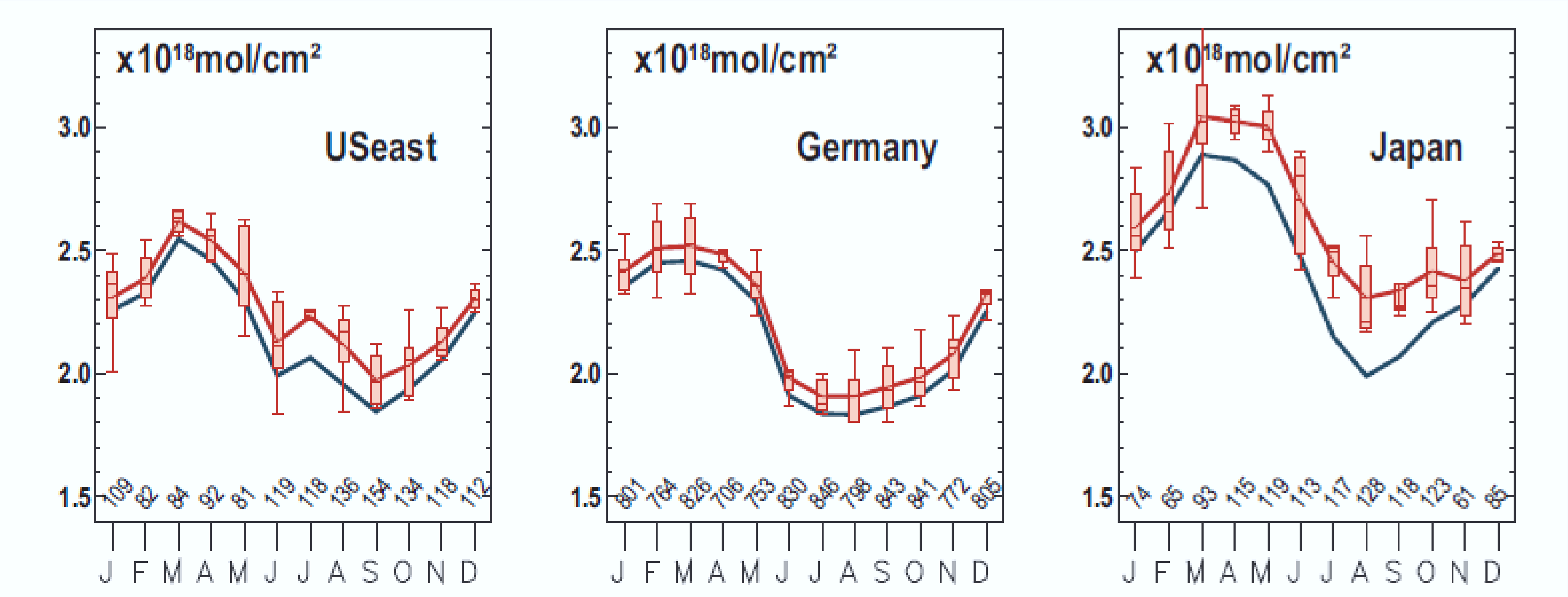
SPURT (black)
Data from dedicated research aircraft campaign

→ **Need for routine in-situ long-term observations**

- **seasonal, interannual variations**
- **data not available from satellite**
- **extremely valuable for model evaluation**

A. Kunz , PhD Thesis, 2010

Example: Climatology of Tropos. Profiles



Annual cycle of tropospheric column CO for 1994 - 2009:

Column data from observation (blue) and completed profiles (red)

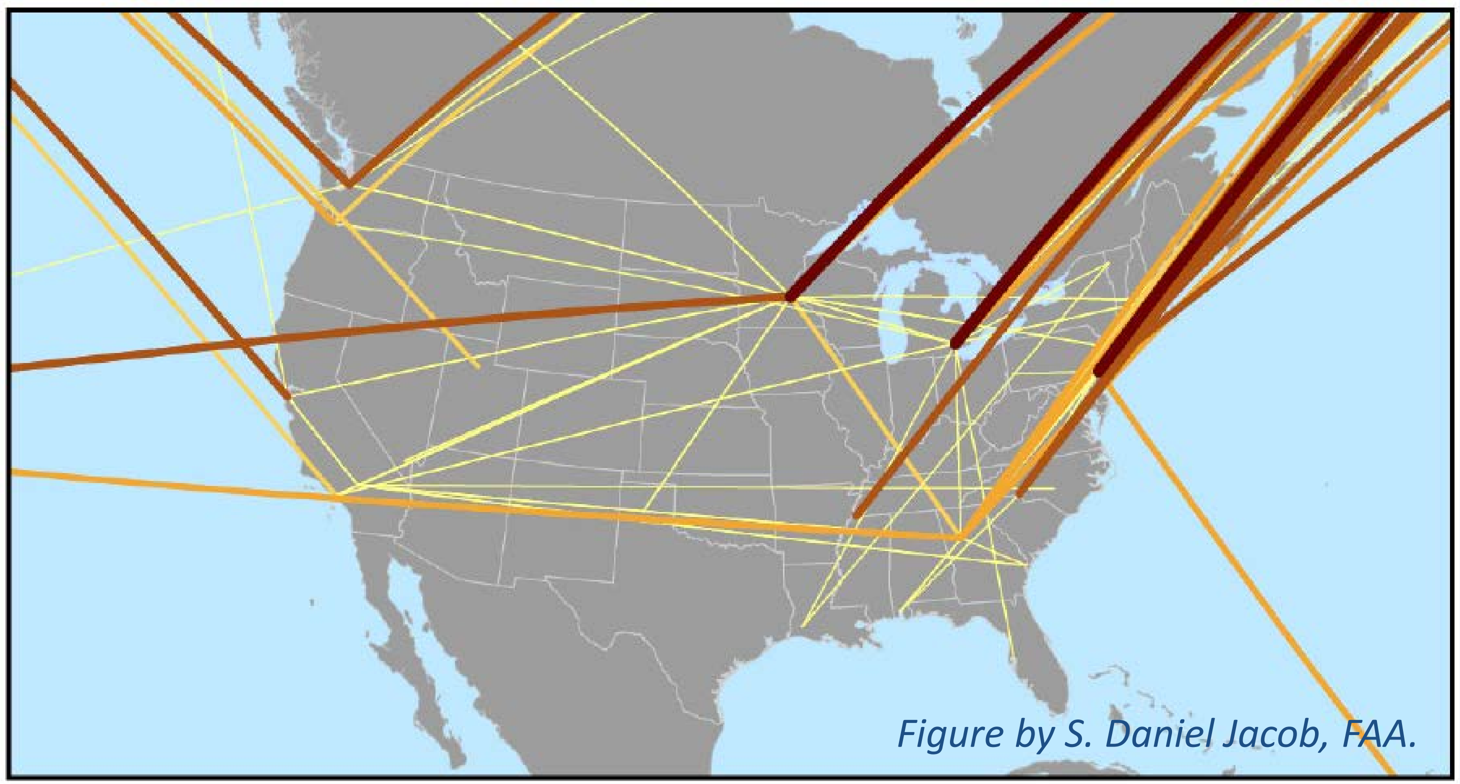
Sampling frequency for US East Coast and Japan << Germany

⇒ Since 2012 China Airlines operation covers Far East Region

⇒ Need for US Airline participation in IAGOS

R. Zbinden et al., in prep. for ACP

Benefit of US Airline Participation



Flight tracks and flight frequency during 2009 of all A330 aircraft based in the US.

At present there are two large US airlines with A330s in their fleets:

- Delta Airlines operates 32 A330's, currently the largest A330 fleet in the USA.

- US Airways operates 16 A330s, with delivery of 8 more in 2013-2014.

Scientific Value

- **Changes in the Tropopause Region**
  - high spatial and temporal resolution of in-situ observations
  - ozone background and trend
  - water vapour background and trend
- **Validation of Atmospheric Models and Satellite Retrievals**
  - tropospheric profiles of H_2O, O_3, CO, NO_x, aerosol, CO_2, CH_4
- **Global Air Quality**
  - influence of developing regions
  - long-range transport of air pollutants
  - biomass burning, climate change, ...
- **International Transfer Standards**
  - same systems everywhere
  - regular Quality Assurance

Impact

IAGOS provides essential information for:

- **Climate Change (IPCC)**
- **Air Quality (UNECE-CLRTAP)**
- **Carbon Cycle (Kyoto Protocol)**
- **Ozone layer (Montreal Protocol)**
- **Atmospheric Impact of Aviation**
  - emission trading
  - climate-optimized routing
- **Support to Aviation Industry**
  - hazardous weather including volcanic ash and mineral dust
  - optimized fuel consumption

Acknowledgments

IAGOS gratefully acknowledges financial support during its preparation, implementation and operation phase over more than 10 years from

- the European Commission in FP6 and FP7 programmes,
- national research programmes in Germany (BMBF), France (INSU-CNRS, MESR, CNES) and UK (NERC), and
- institutional resources in Germany (Helmholtz Association, Max-Planck-Society, Leibniz Association), France (Université de Toulouse, Météo-France) and UK (University of Manchester, University of Cambridge).

Thank You For Your Attention!!

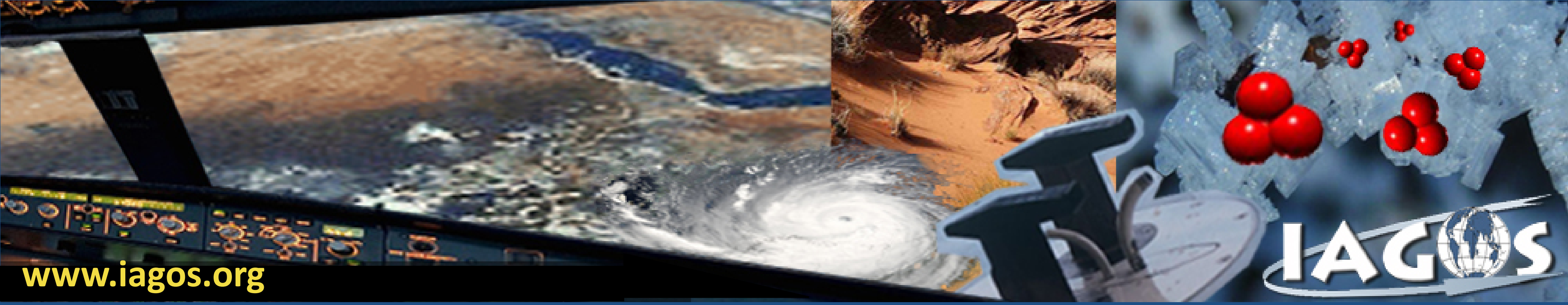
JÜLICH FORSCHUNGSZENTRUM
UNIVERSITY OF CAMBRIDGE
TROPOS
Lufthansa
AIRBUS
METEO FRANCE
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
DLR
MANCHESTER 1824
KIT
BRITISH AIRWAYS
enviscope GmbH
WMO

IAGOS Partners

- Forschungszentrum Jülich, D
  Coordination
- Laboratoire d'Aérologie, CNRS, Toulouse, F
- University of Cambridge, U.K.
- Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, D
- University of Manchester, U.K.
- Max-Planck-Gesellschaft, D
- Karlsruhe Institute of Technology, D
- Leibniz-Institut für Troposphären-forschung, Leipzig, D
- Deutsche Lufthansa AG, D
- AIRBUS, Bristol, UK and Toulouse, F
- British Airways plc, U.K.
- *enviscope* GmbH, Frankfurt, D
- Météo France, Toulouse, F
- World Meteorological Organization, Geneva, CH

Associated Airlines

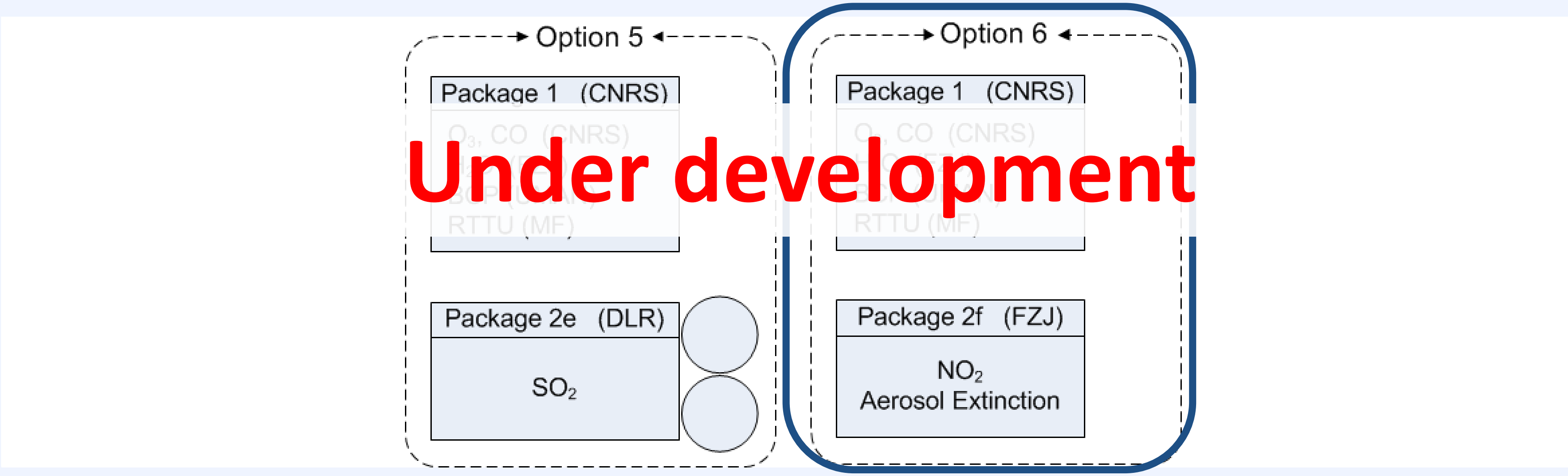
- Lufthansa: 1st IAGOS-CORE 2011; IAGOS-CARIBIC; 2 MOZAIC since 1994
- China Airlines: MoU signed 2008; 2nd IAGOS-CORE 2012
- Air France: MoU signed 2012; 3rd IAGOS-CORE, 2013; 1 MOZAIC -2008
- British Airways: Partner
- Iberia: MoU signed 2012; 5th IAGOS-CORE, 2013
- Cathay Pacific: MoU signed 2012; 4th IAGOS-CORE, 2013
- Air Namibia: MOZAIC since 2005
- Austrian: MOZAIC -2006
- South African Airways: Interest in collaboration
- Qantas: Interest in collaboration
- Philippine Airlines: Interest in collaboration



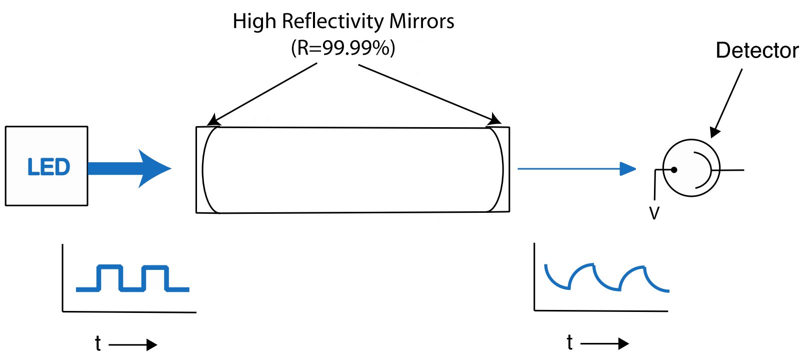
- IPCC ranks in-situ measurements of the vertical structure of the troposphere and tropopause region (UT-LS) of paramount importance to the development of the scientific basis for mitigation of climate change and global air quality issues.

- Long-term, frequent, regular, accurate, and spatially resolved in-situ observations of atmospheric chemical composition in the UT-LS are very sparse compared to the surface.

IAGOS-CORE Aerosol Package



Cavity Attenuated Phase Shift CAPS



Kebabian and Freedman, Rev. Sci. Instrum. 2007

Simple and robust sensor design.

Convincing evaluation of light extinction and NO_2 detectors.

Responds to requests from IAGOS Steering Committee on providing an AQ package.

Close collaboration with Aerodyne Res.

At work : Lufthansa Technik, Sabena Technik, CNRS, FZJ …

Special thanks to : Stefan Hübner (LHT), Thomas Dauer (LHT)
and François Reveillere (SNT)

Summary

IAGOS complements the global observing systems by using the existing air transport infrastructure

IAGOS can't replace other observing systems, because it can't:

- sample the marine boundary layer $\Rightarrow$ ships
- sample the remote continental boundary layer $\Rightarrow$ surface networks
- probe the austral polar region
  $\Rightarrow$ research aircraft, ships, surface stations
- probe the middle and upper stratosphere except over the arctic
  $\Rightarrow$ satellites, balloons, research aircraft

IAGOS is currently the only way to:

- provide regular in-situ observations in the UTLS over mid-latitudes at high spatial resolution
- provide regular profiles of greenhouse gases, reactive gases and aerosol concentration in the troposphere over continental sites