Understanding Climate Change: MOZAIC and IAGOS

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Radiative Forcing

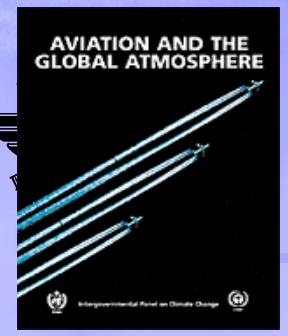
- Additional energy dissipated by GHGs within the troposphere (globally)
  - without GHGs: T_{av} = 255 K
- Primary effect of GHGs is modified by feedback due to:
  - Water vapour
  - albedo (ice cover)
  - cloud cover and structure
  - oceanic circulation, ...
- Impact of Aviation:
  - CO_2 (as other combustion sources)
  - NOx (via O_3 formation and OH => CH_4 reduction)
  - Aerosol => contrails and cirrus

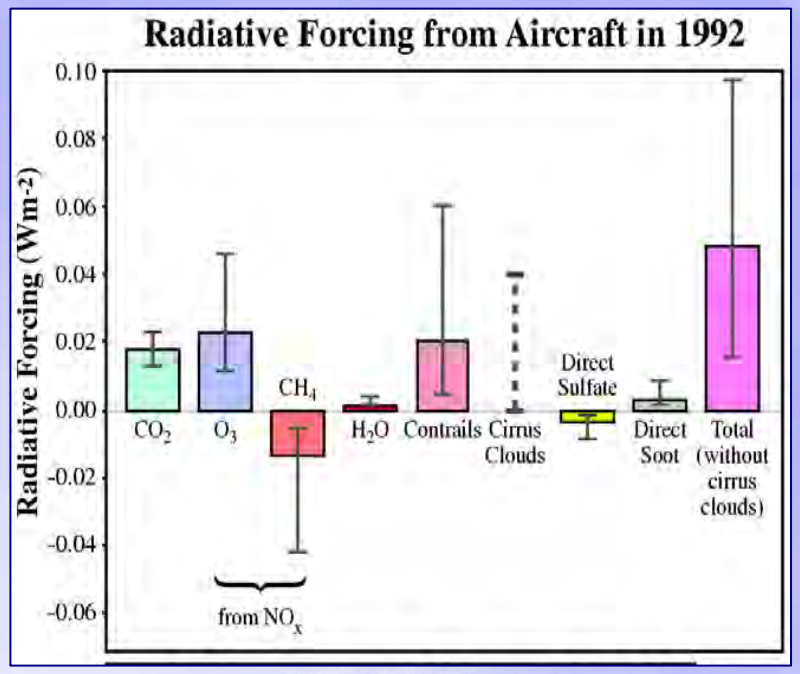
NOx Emissions

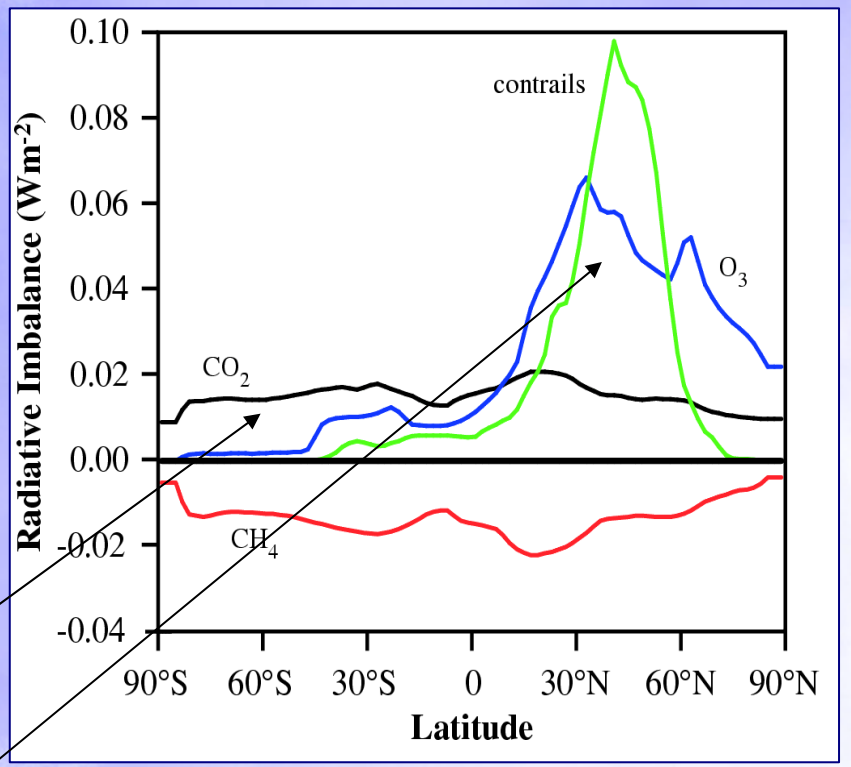
- Aviation emissions (basis 1990):
  - 2% of total global emissions (>90% non-LTO)
  - But mostly in northern mid-latitudes
- Emissions into Lower Atmosphere (LTO)
  - Similar O_3 forming potential as road transport
- Emissions into UTLS
  - Higher O_3 forming potential
  - But influence also CH_4 (via OH)

  => Effects on climate cancel to some extent

Global versus Regional
(IPCC 1999)



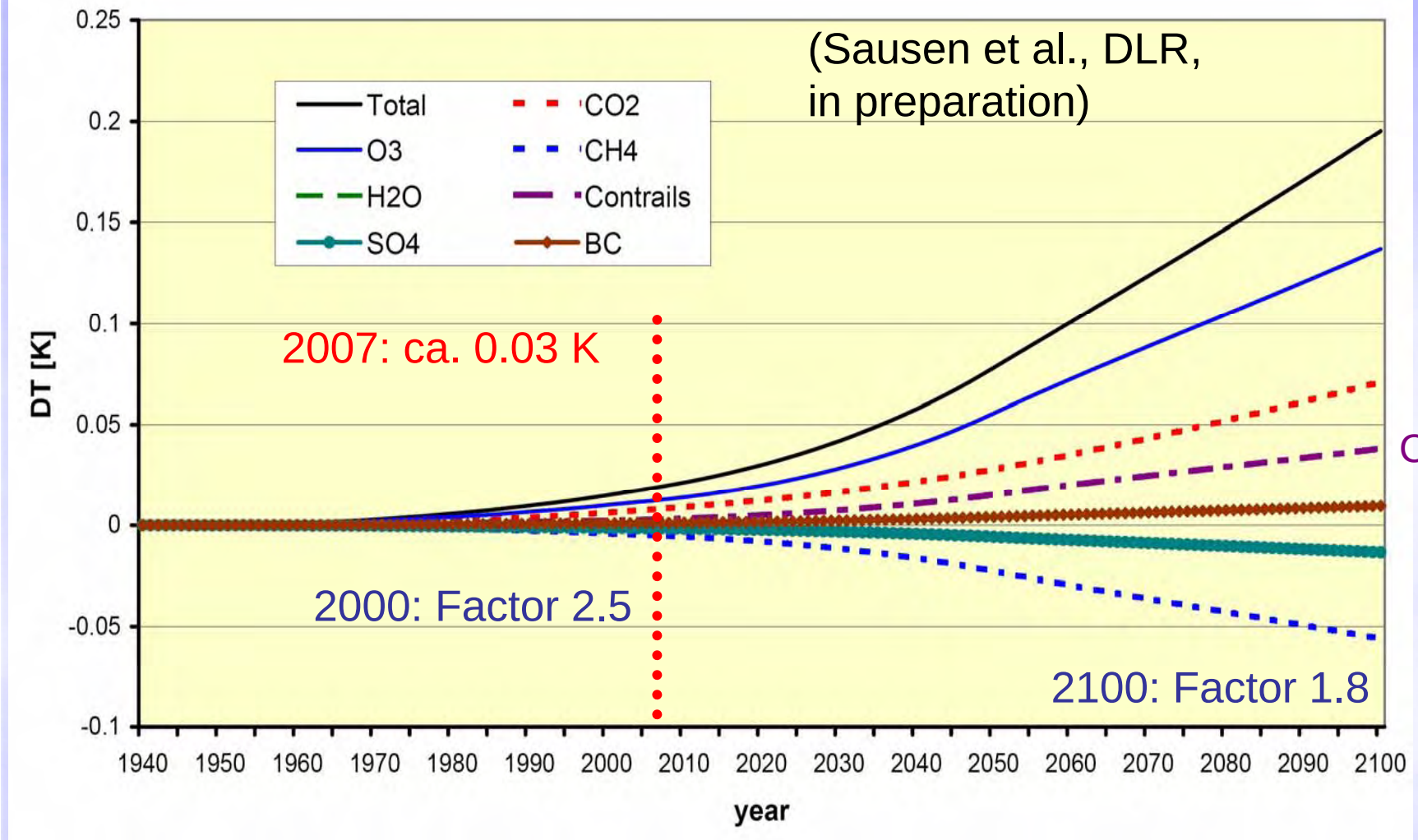




Impact of Aircraft:

- small fraction of total RF
- CO_2 and CH_4 global
- O_3 and contrails regional

Temperature increase caused by aviation in scenario A1



Total

O3

CO2

Contrails

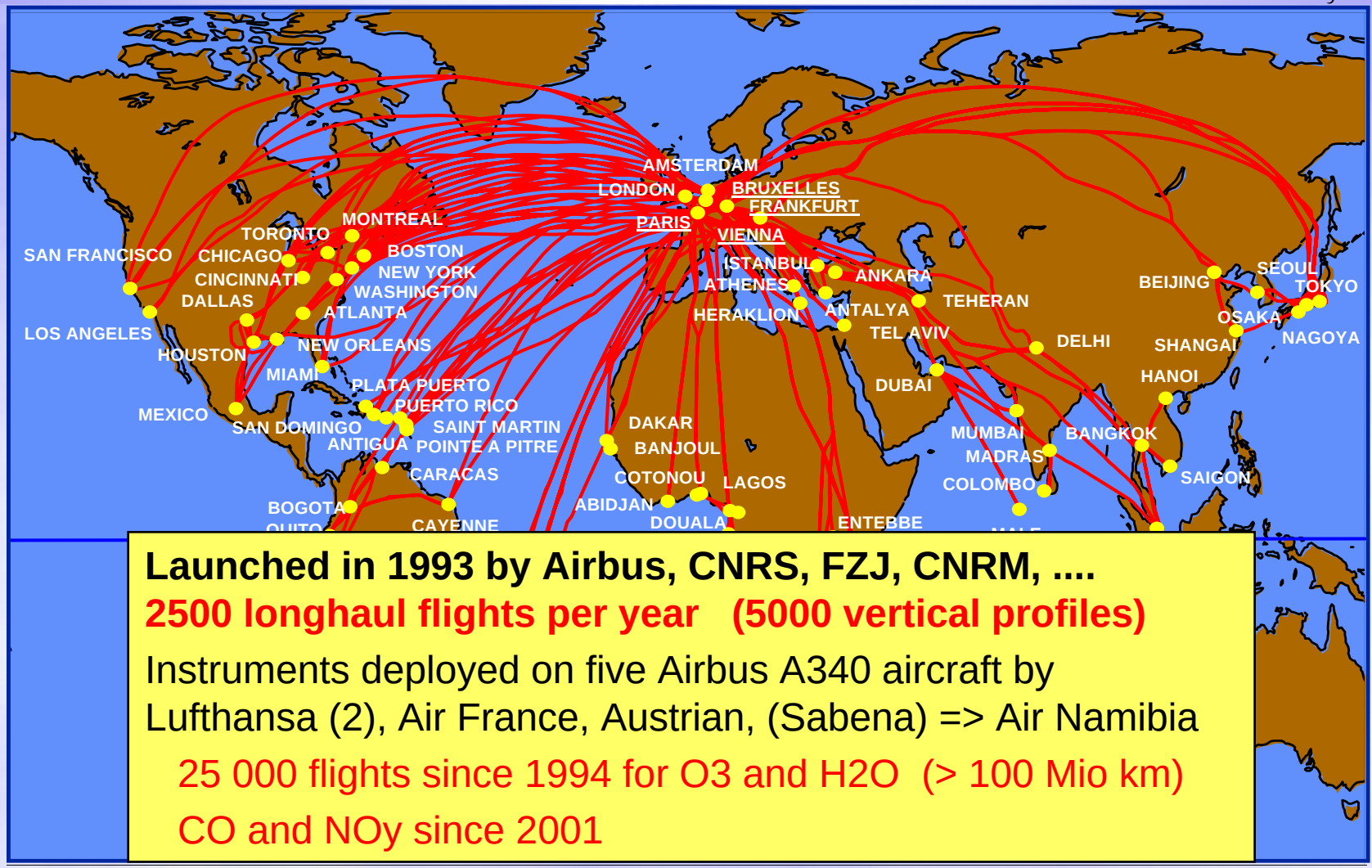
CH4

Uncertainties and Scientific Basis

- Result depends on scenario and RF-values.
  - Both have large uncertainty ranges
- Influence of NO_x on O_3 and CH_4 compensate to some extent
- Model resolution and convective transport
  - Lightning and transport of NO_x from surface sources into the upper troposphere
- Data sets for model evaluation needed

MOZAIC 1994-2005

CNRS, FZJ, CNRM, UCAM, UREAD, AIRBUS



Launched in 1993 by Airbus, CNRS, FZJ, CNRM, ...

2500 longhaul flights per year (5000 vertical profiles)

Instruments deployed on five Airbus A340 aircraft by Lufthansa (2), Air France, Austrian, (Sabena) => Air Namibia

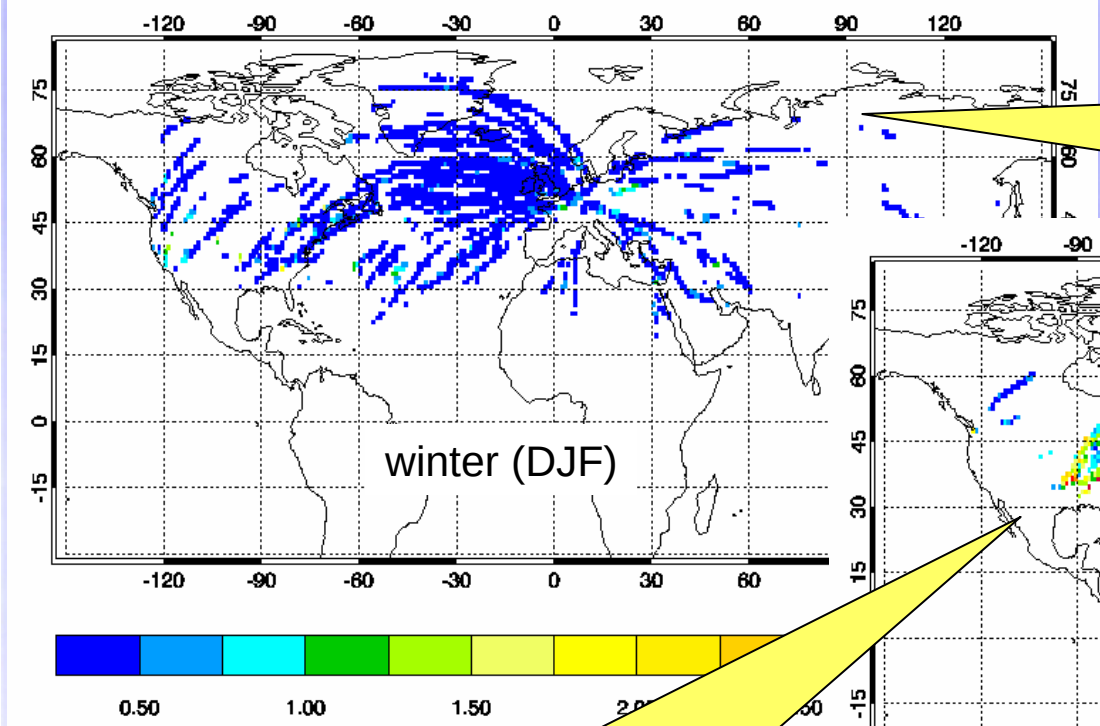
25 000 flights since 1994 for O3 and H2O (> 100 Mio km)

CO and NOy since 2001

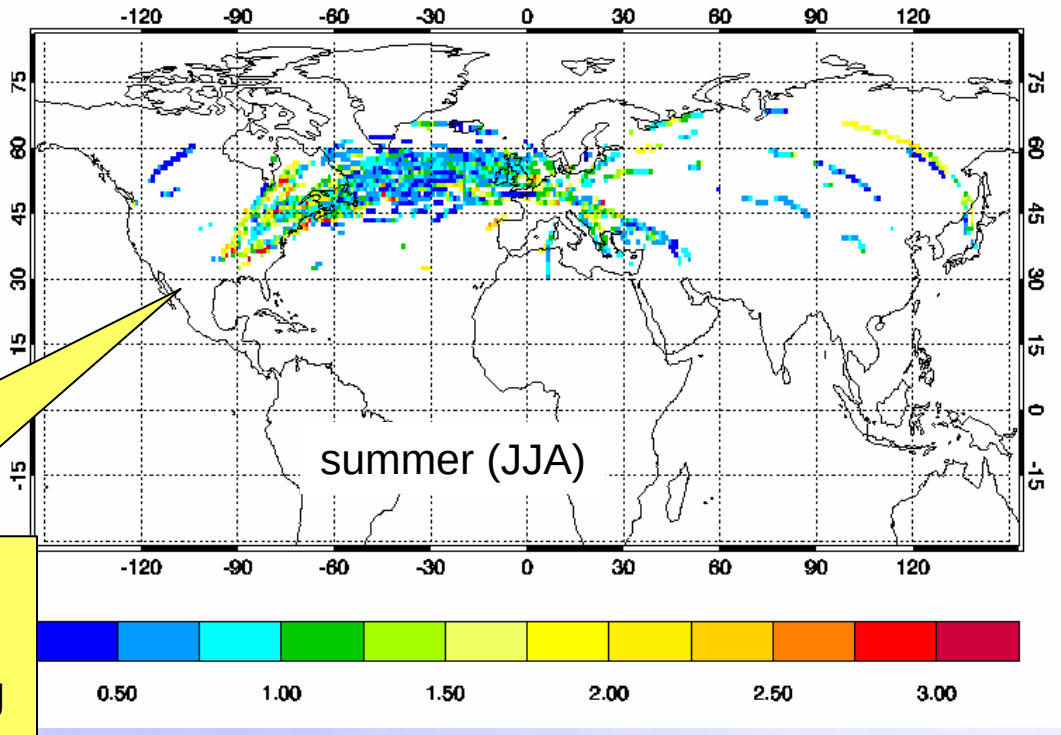
Routine Aircraft Projects

Project	period	a/c	fl/yr	species measured	Future
GASP	1975-1979	5	1500	H_2O, O_3, CO, aerosol	terminated
MOZAIC	1994-2007	5	2500	H_2O, O_3, CO, NO_y	**=> IAGOS** + CO2, NOx, aerosol, cloud part.
NOXAR	1995-1996	1	500	NO, NO_x, O_3	Terminated, plans for reactivation
JAL	Since 1993	1	26	CH_4, CO, CO_2 (12 grab samples/flight)	ongoing with in situ CO2, more aircraft
CARIBIC	Since 1997	1	15	H_2O, O_3, CO, aerosol, grab samples for VOC, N_2O CFCs, isotopes,	**=> IAGOS**

NOy in the Upper Troposphere (MOZAIC 2001-2005)



No significant enhancement in flight corridor during winter
< 0.5 ppb NOy



Enhanced NOy over USA and Europe in summer is due to convective transport and lightning
Up to 3 ppb NOy (average!)

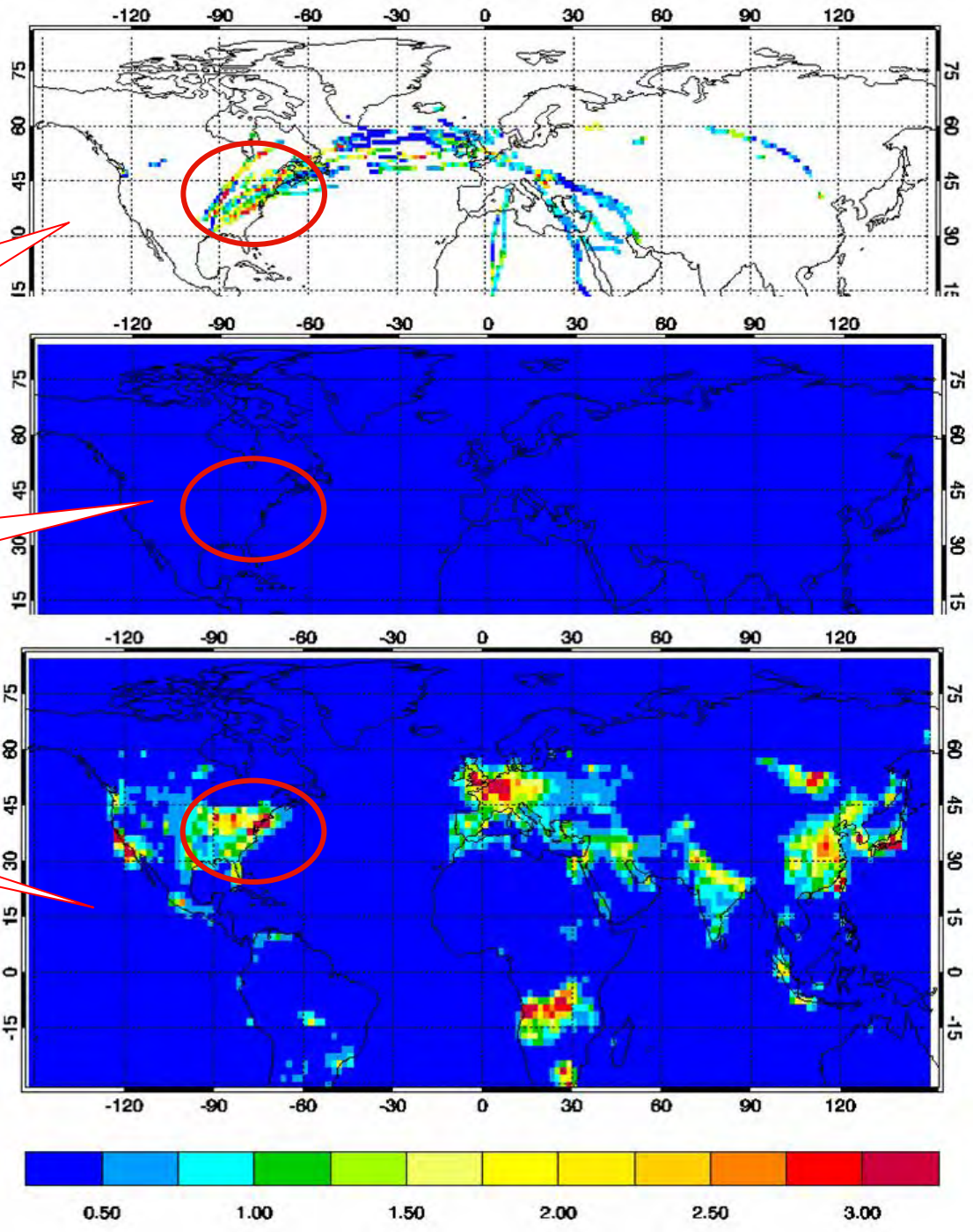
NOy

MOZAIC NOy
Upper Troposphere
Summer 2003

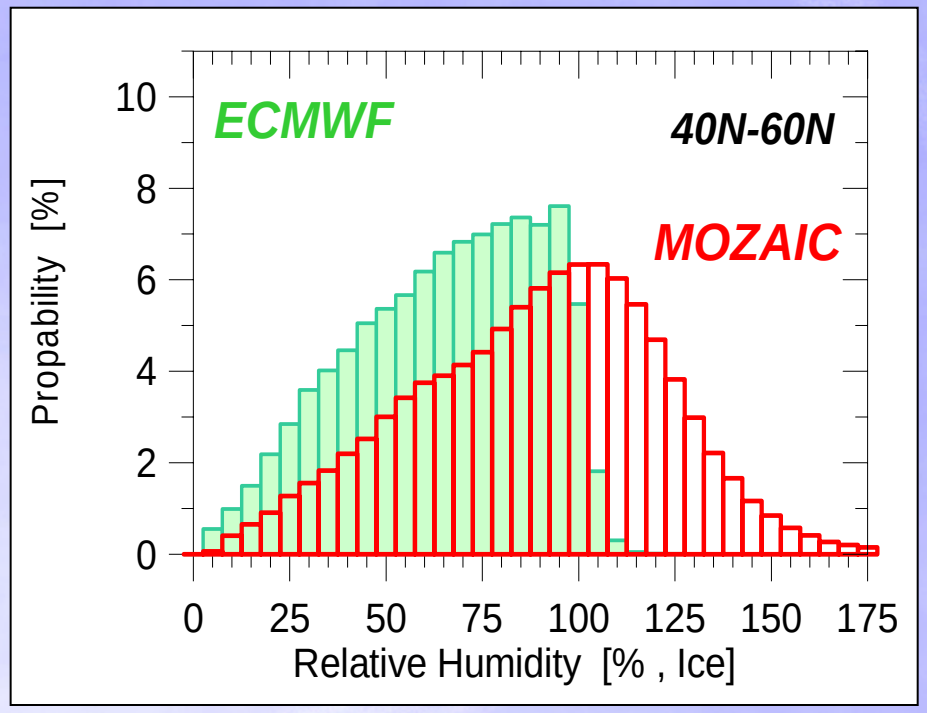
MOZART-3 NOy
above 610 hPa

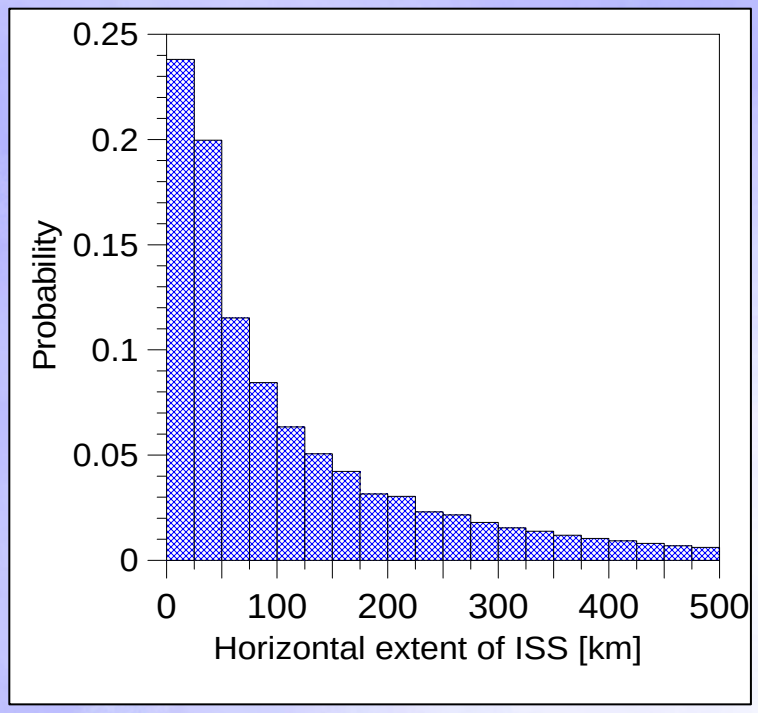
MOZART-3 NOy
Surface (977 hPa)

Models have difficulties to lift surface emissions into the UTLS.



MOZAIC Water Vapour





Ice superaturation (ISS) encountered in 30% of MOZAIC observations.

Not included in current NWP models (now implemented at ECMWF).

Ice supersaturation is a small-scale feature.

Avoidance of such regions would decrease formation of persistent contrails.

Summary

- New results emerging from European projects (TRADEOFF, QUANTIFY)
- Aviation factor likely < 3 and decreasing with time
- Still large uncertainties in scenarios and models
- Recommendation
  - Optimise fuel consumption (CO_2)
  - Avoid areas with ice supersaturation (contrails)
- New datasets now available from MOZAIC for model testing and improvement
- IAGOS will provide an even larger suite of data
  - from the regions where aircraft fly
  - reduce uncertainties in assessments
  - help in flight management (realtime data)

IAGOS-ERI

A new European Research Infrastructure

In-service Aircraft for a Global Observing System:

- IAGOS-ERI is on the ESFRI* Roadmap 2006
- The plan is to equip 20 longhaul aircraft with instruments for O_3, CO, H_2O, NO_y, NO_x, CO_2, aerosol, and cloud particles
- Near-realtime data transmission (AMDAR)
- Operation is foreseen for >10 years
- Implementation in GEOSS-IGACO (WMO)
- We hope for support by Airlines

** European Strategy Forum on Research Infrastructures*