IAGOS - CARIBIC - Nitrogen oxides measurements

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Radiative Forcing
Nitrogen oxides impact on $O_3$ and $CH_4$

Holmes et al., 2011
Sources that control the NO\textsubscript{y} distribution

(V. Grewe, 2007) for 5 Tg/a LNO\textsubscript{x}
Measurement of NO, (NO$_2$), NO$_y$ since 2002 (CARIBIC-1)

Similar instruments are operated on board of other research aircraft: HALO, Geophysica, D-CMET
Seasonality in the UTLS over Europe

Lowermost stratosphere - maximum in spring
Upper troposphere – maximum in summer
IAGOS-CARIBIC NO$_y$

NO: 0.14/0.19/0.13/0.13 ppbv
NO$_y$: 0.82/1.07/0.70/0.42 ppbv

NO and NO$_y$ in the upper troposphere: Nine years of CARIBIC measurements onboard a passenger aircraft
Atmos. Environ., 133, 2016
MOZAIC - CARIBIC

O3 < 100 ppbv

O3 > 100 ppbv
Structure and seasonality of UTLS NO$_y$
IAGOS and research aircraft – measurements complement each other

Research - aircraft: HALO

IAGOS- CARIBIC: A340-600
IAGOS and research aircraft – measurements complement each other

HALO missions

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53680 Flights from 19940801 to 20171109
ASIAN summer monsoon: Research aircraft – model simulation - IAGOS
Measurement of trace species
e.g. NO, NOy, O3, CO, ...
Research aircraft: HALO, Falcon,
Civil aircraft: IAGOS

ECHAM/MECO(n)
Atmospheric Chemistry model (EMAC). Numerical chemistry and climate simulation system.
Emitted NO\textsubscript{x} per grid cell per hour

**CARIBIC flight: September 2007 Frankfurt - Toronto**
Classification of regions with different burden of aircraft emissions
Analysis of IAGOS-CARIBIC data and model EMAC model simulations

Model sensitivity scenarios

IAGOS vs. EMAC

EMAC2 (REACT4C Scenarien), CARIBIC-2 (Ozon Andreas Zahn, KIT) vs. EMAC2
Contribution of air traffic emissions to atmospheric ozone in the NAFC Model simulation and IAGOS / CARIBIC observations

Analysis of different weather patterns
Summary

• Nitrogen oxides observations since 2002
• One of the longest continuous time series in the UTLS
• Seasonal and regional differences
• Structure and seasonality of the UTLS
• Comparison with MOZAIC

• **IAGOS vs. research aircraft** – mutual supplementation
• **Observation vs. model simulation** – comparison, validation, development