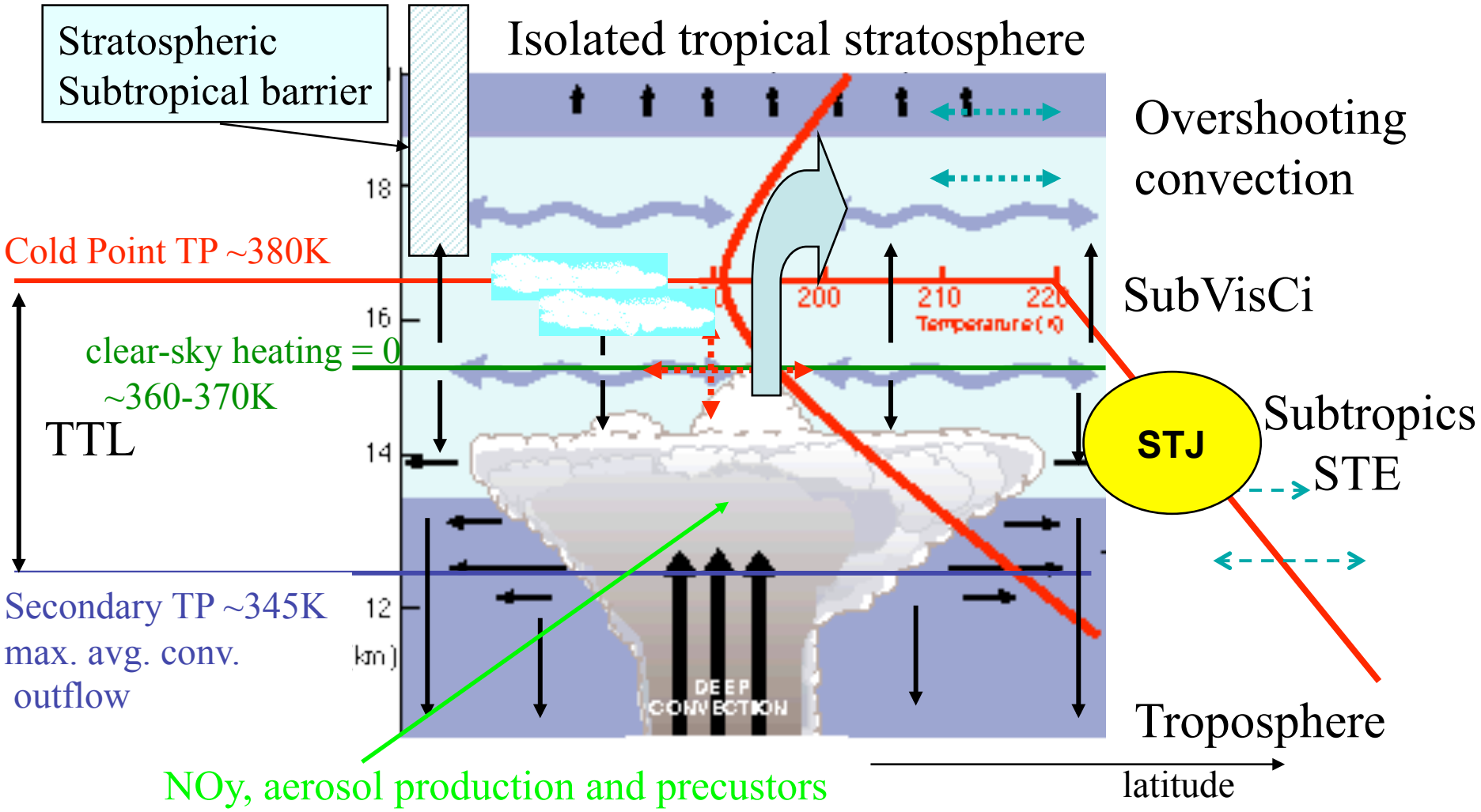
The M55 Geophysica Deployment In West Africa:

An Overview Of Processes Governing TTL Composition Over West Africa

Francesco Cairo

SPARC GA, Bologna 31 Aug – 5 Sept 2008

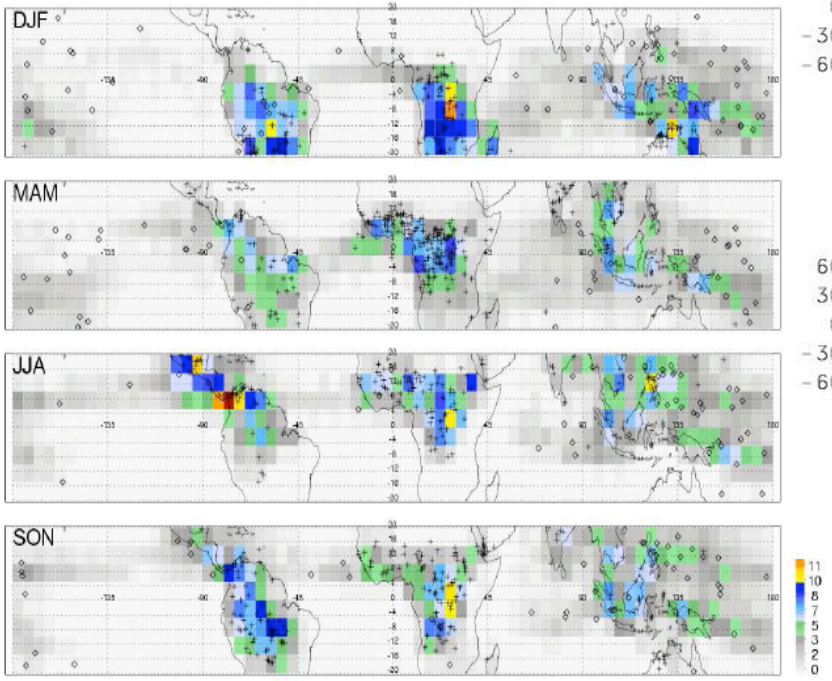
Processes in the Tropical Tropopause Region

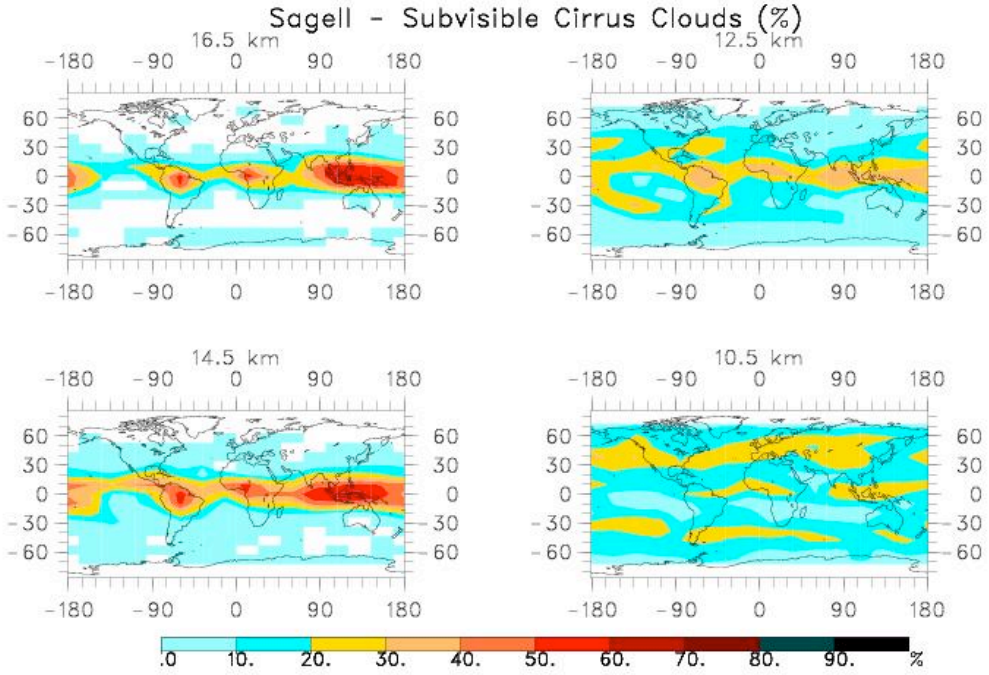


Adapted from M. Volk

TTL sets chemistry of lower stratosphere:
Stratospheric H2O, 'Short lived' species, Aerosols & precursors are set in TTL
Radiation from TTL Clouds affects climate
Changes to TTL over time may affect climate

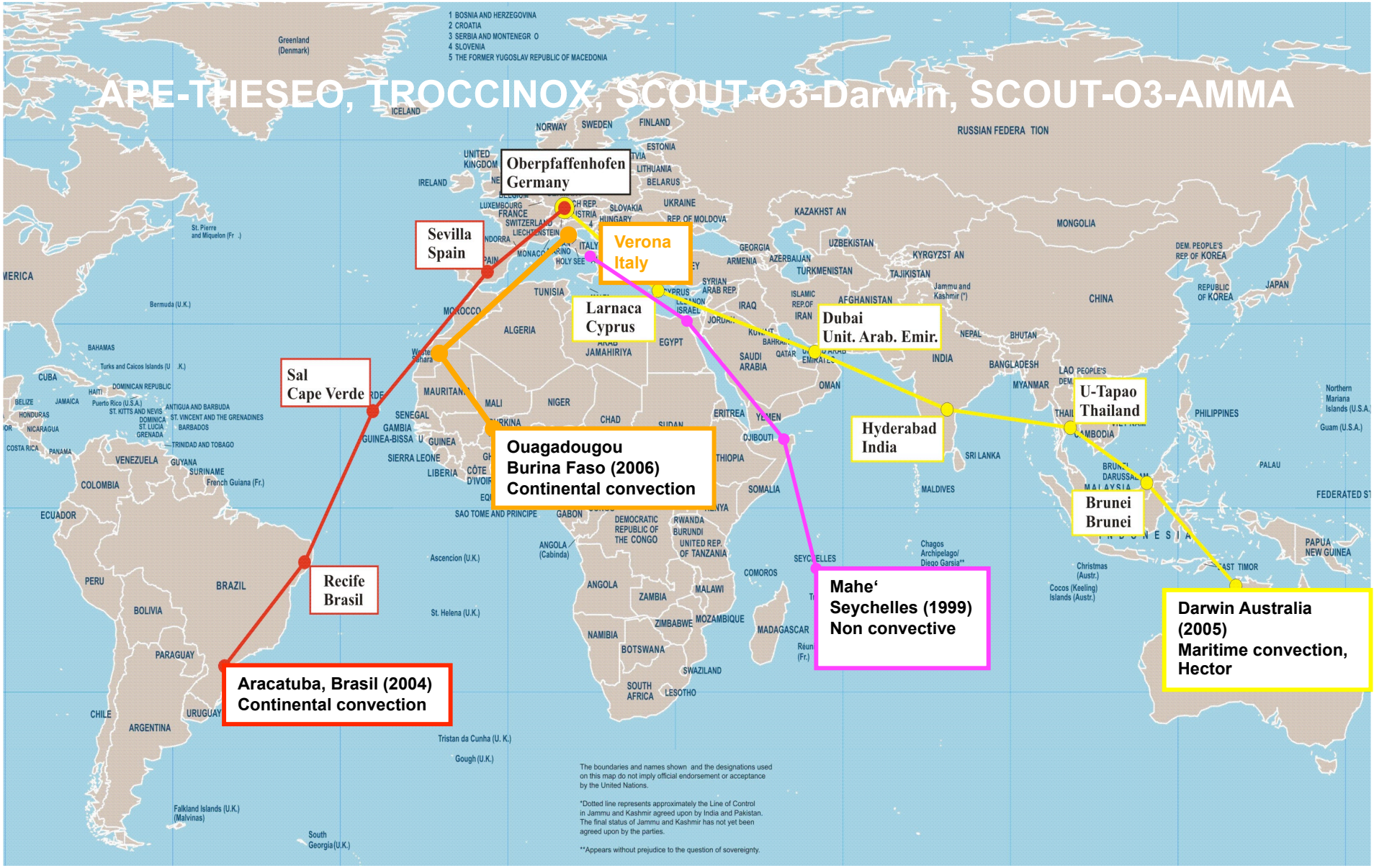
Liu and Zipster, 2003



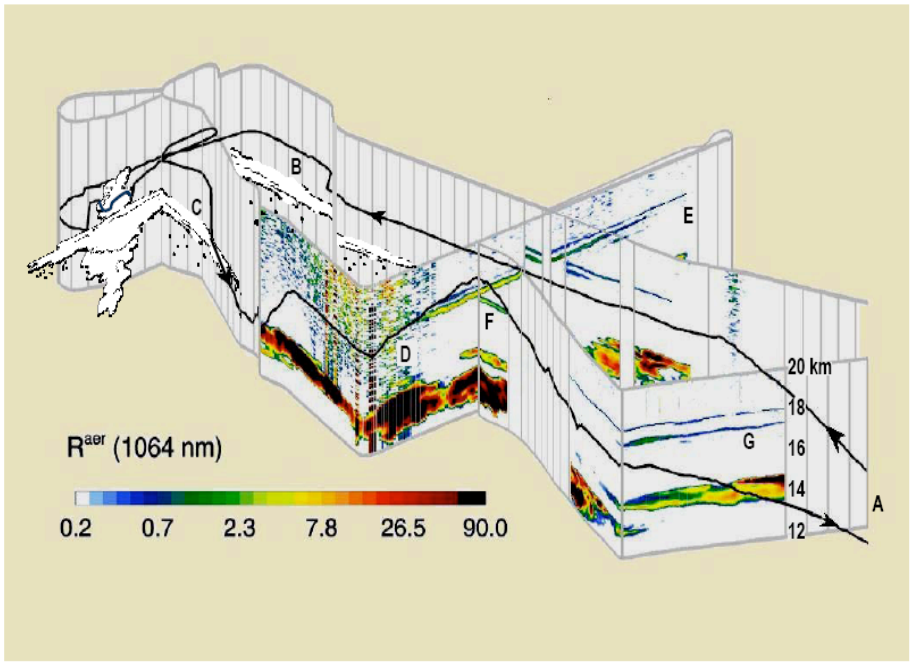


Wang et al. 1996

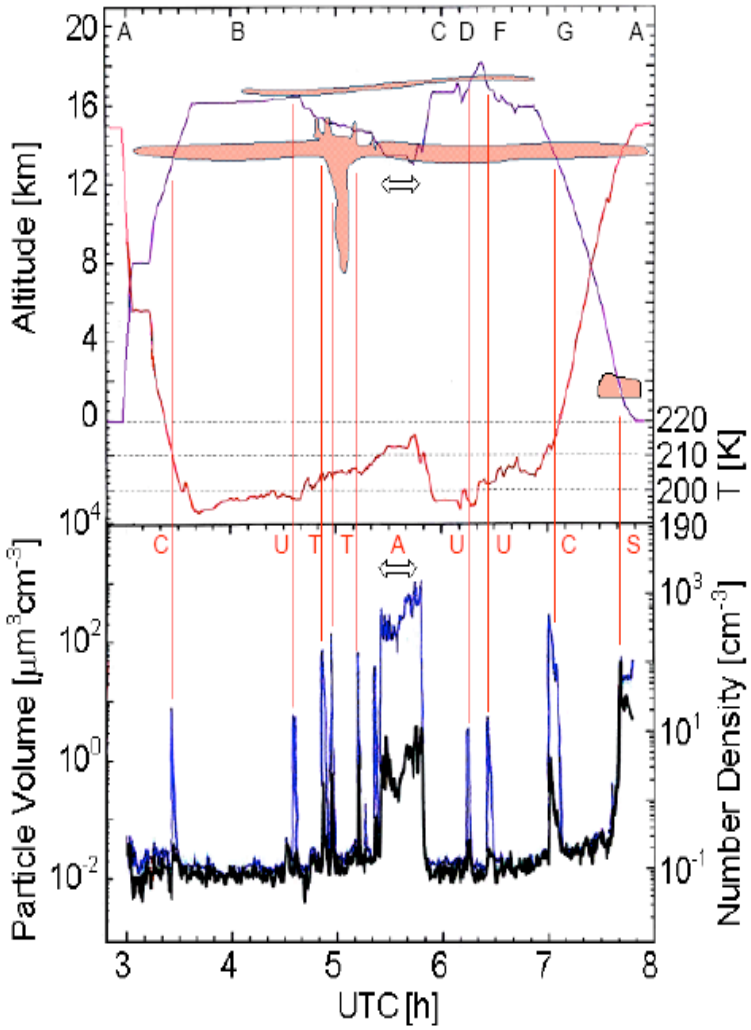
Where deep convection and SVC are.

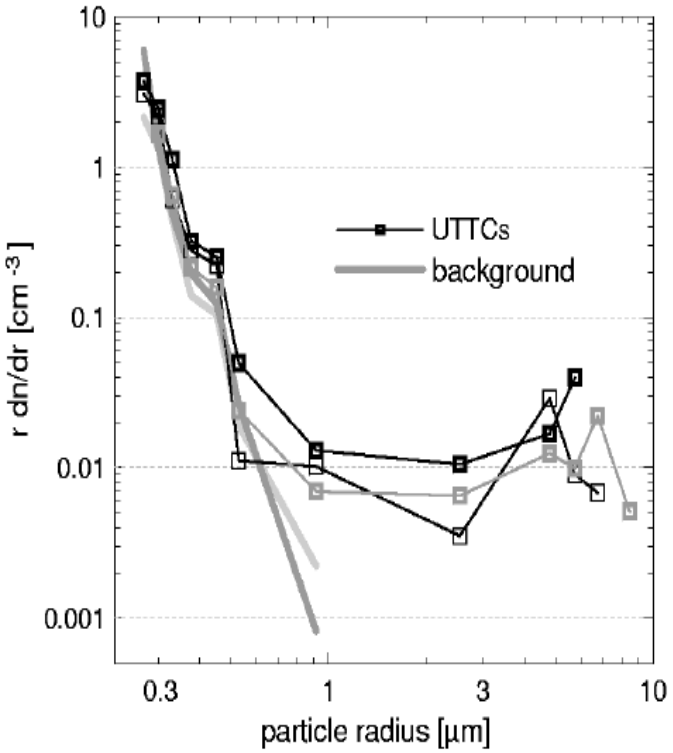

APE-THESEO, TROCCINOX, SCOUT-O3-Darwin, SCOUT-O3-AMMA
Oberpfaffenhofen
Germany
Sevilla
Spain
Verona
Italy
Larnaca
Cyprus
Dubai
Unit. Arab. Emir.
Sal
Cape Verde
Ouagadougou
Burina Faso (2006)
Continental convection
Hyderabad
India
U-Tapao
Thailand
Brunei
Brunei
Recife
Brasil
Aracatuba, Brasil (2004)
Continental convection
Mahe'
Seychelles (1999)
Non convective
Darwin Australia
(2005)
Maritime convection,
Hector

In the Seychelles (1999) the first characterization of the "less than subvisible" cirrus clouds

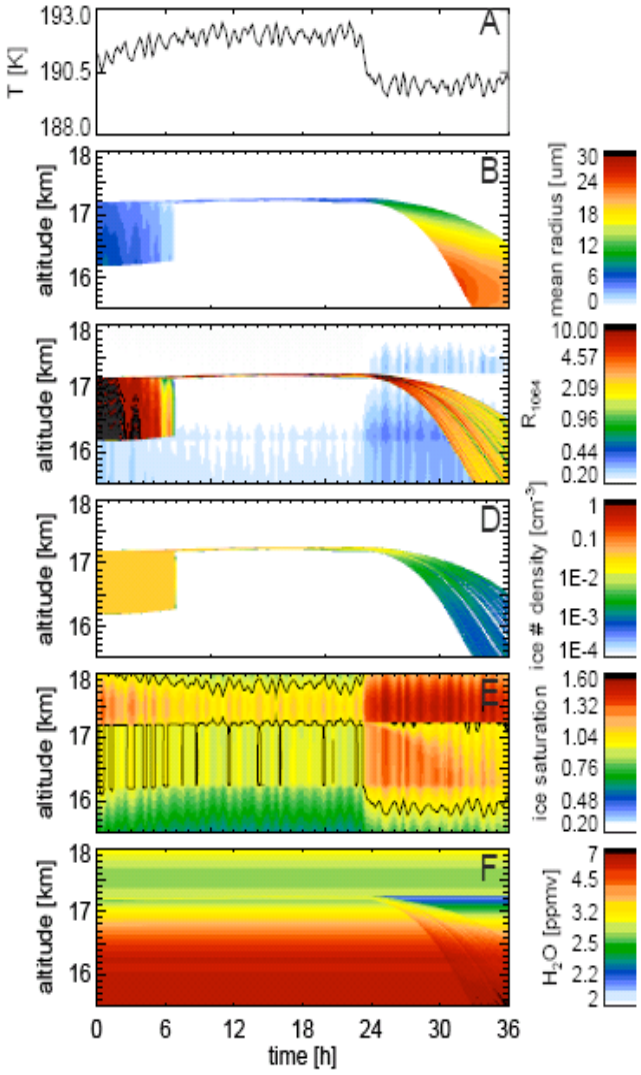


Peter et al. ACP 2003





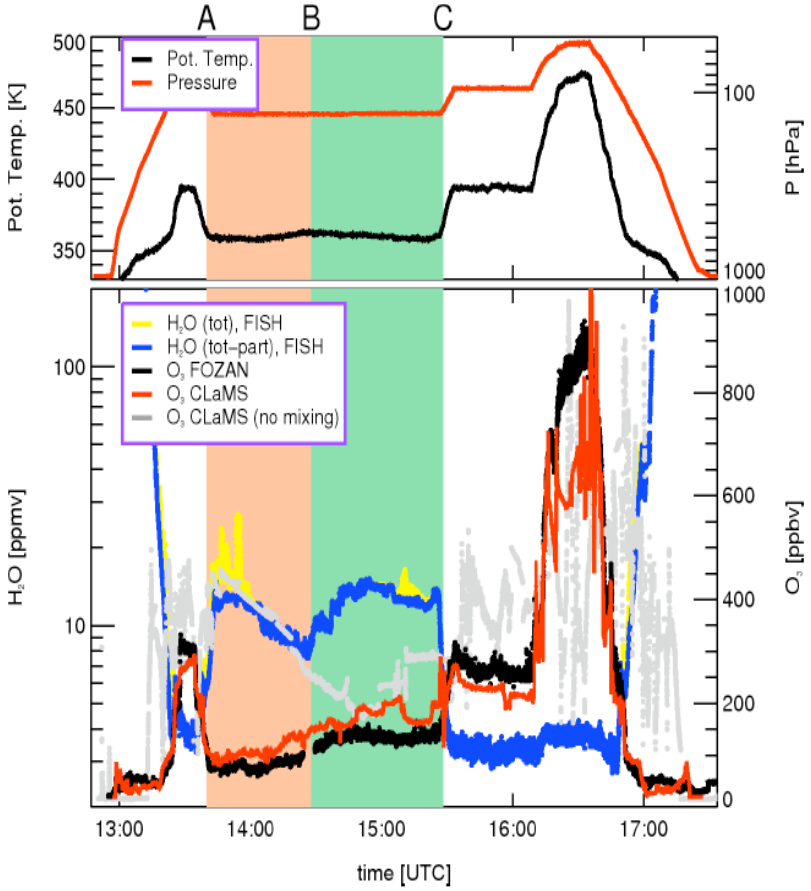
Thomas et al. JGR 2002

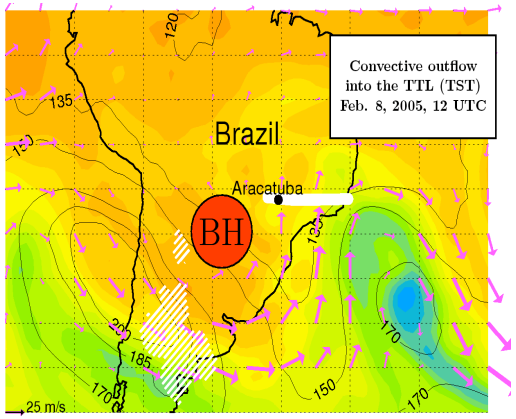


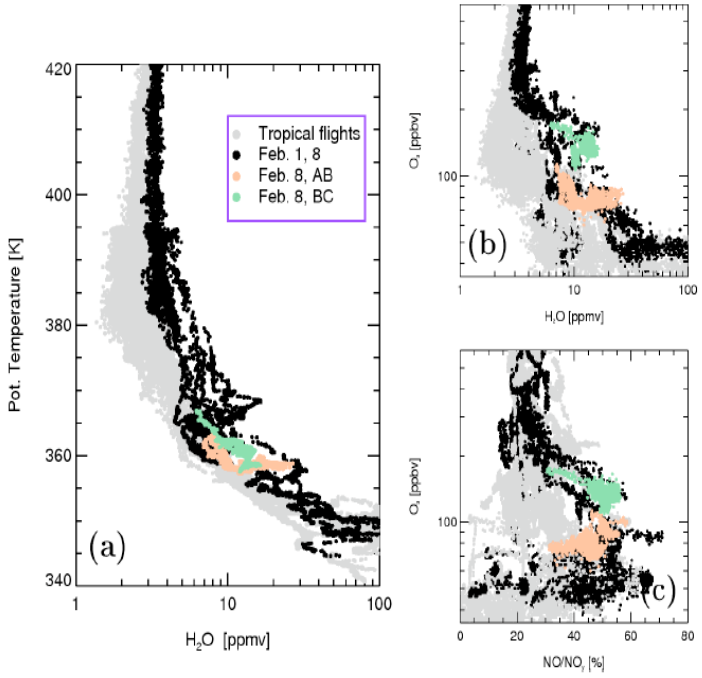
Luo et al. ACP 2003

Stabilization forces the particles into a thin layer: upwelling of the air, supersaturation above and subsaturation below the SVC. Dehydration upon cooling.

Brasil (2005): Close to the STJ, Troposphere to Stratosphere Transport

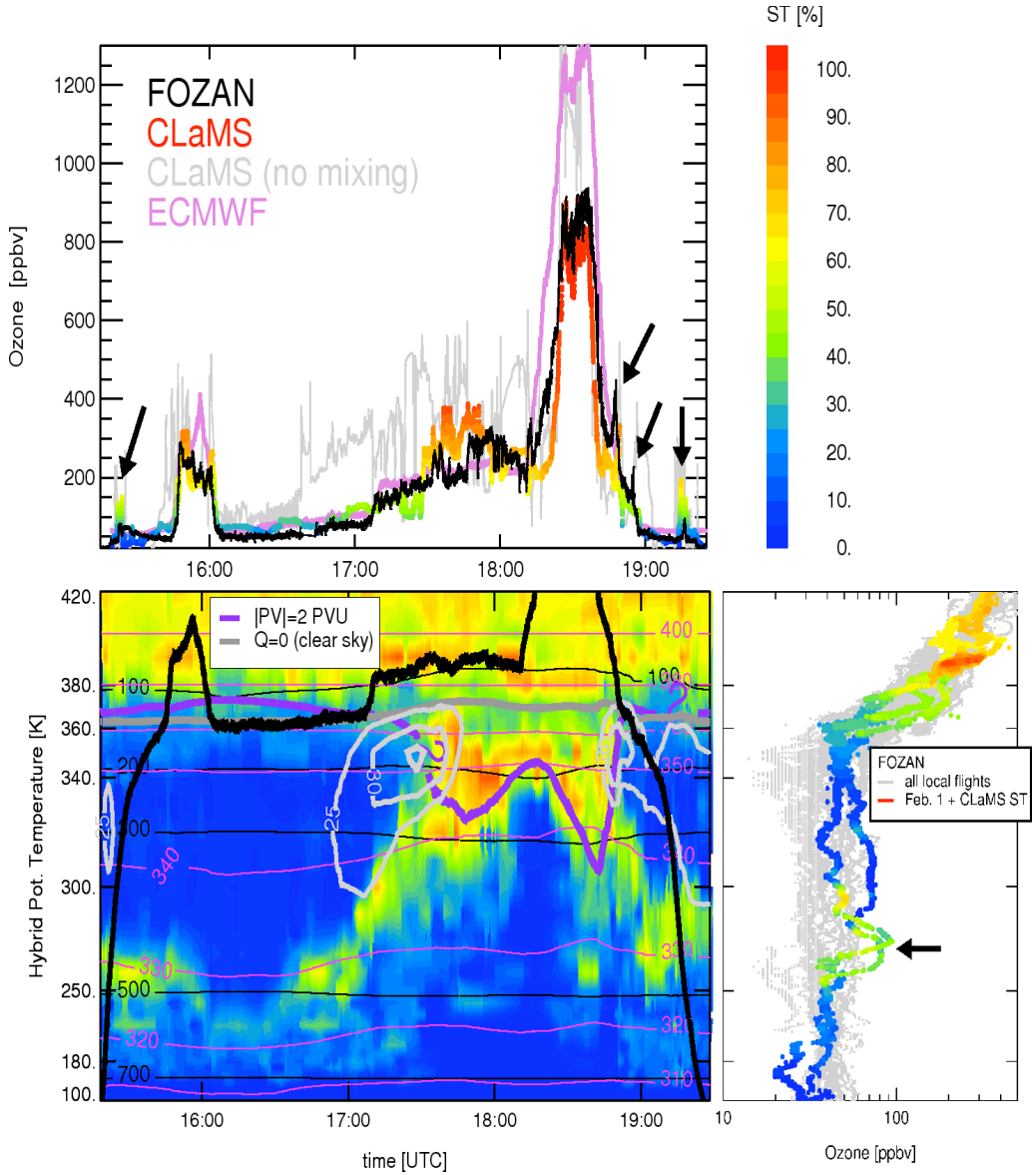


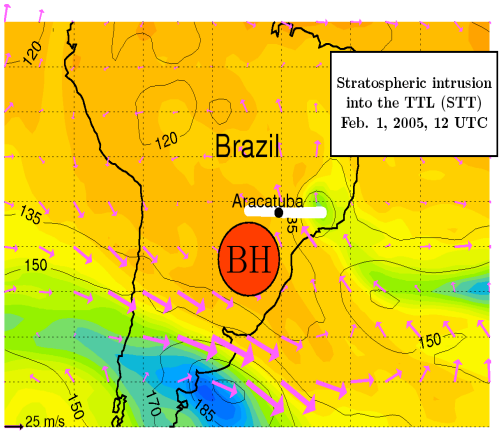




Konoptka et al., ACP 2007

…and stratospheric intrusion into the TTL

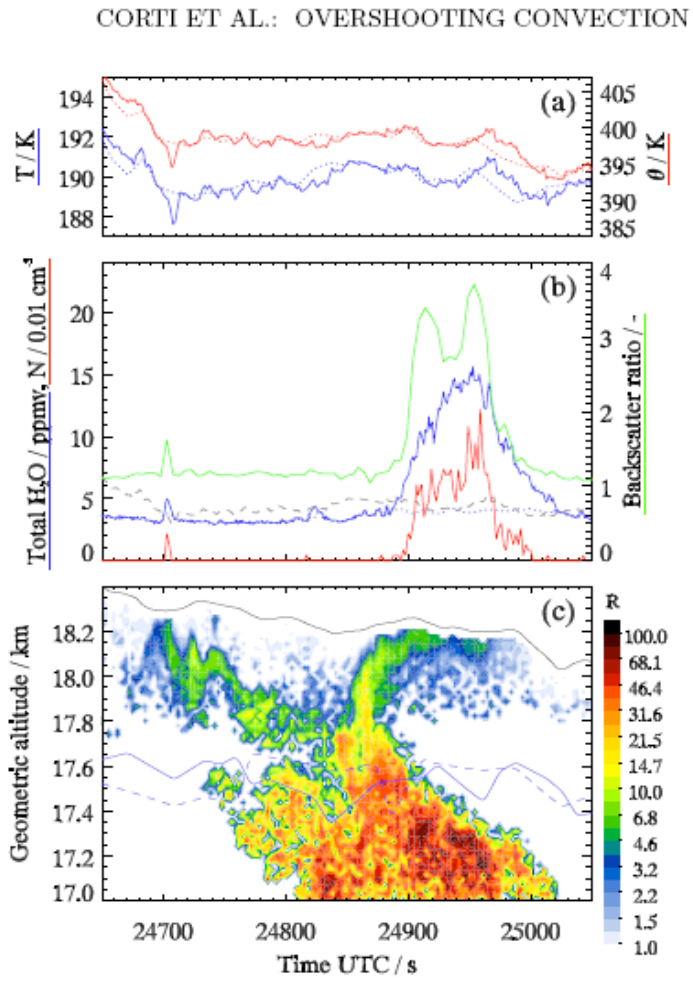


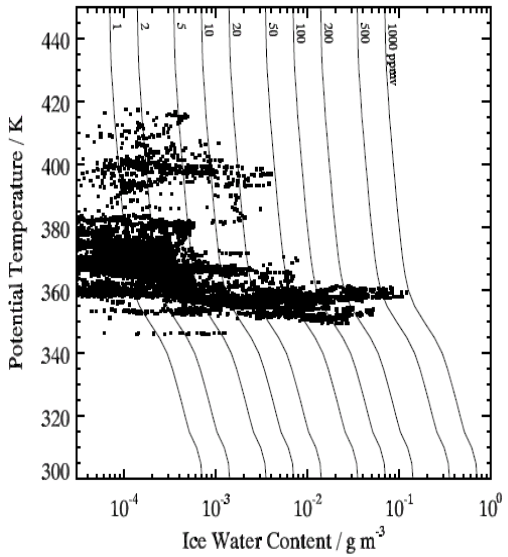


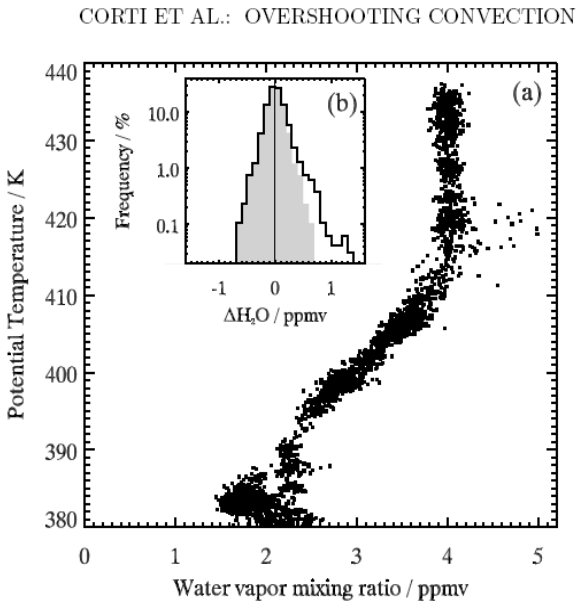
Konoptka et al., ACP 2007

Transport of trace species across the TTL may be achieved by diffusive irreversible mixing induced by enhanced shears/strains close to the STJ

In Darwin (2005) the evidence of overshooting cirrus hydrating the stratosphere







Corti et al. GRL 2008

… where to look for <u>some</u> more convection (experimentalist bias)

Peter Tom
Unprecedented Evidence For Deep Convection Hydrating The Tropical Stratosphere (00186)

Schiller Cornelius
Drying And Moistening At The Tropical Tropopause (00223)

Yushkov Vladimir
Water Vapour In The Polar And Tropical UT/LS From Balloon And Aircraft Observations With FLASH Lyman-Alpha Hygrometer (00307)

Daniel Grosvenor
*Stratospheric Moistening By Overshooting Deep Convection From Cloud Simulations: Towards A Global Estimate (*00445)

Chaboureau Jean-Pierre
Cross-Tropopause Transport By Convective Overshoots In The Tropics (00009)

M-55 „Geophysica“ in West Africa August 2006

ALTO-COLD TDL CO2, N2O, CH4 (INOA)

MARSCHALS Millimetre spectrometer (RAL)

FSSP optical aerosol counter (UniMainz)

HALOX BrO ClO Chemical-Conversion Fluorescence (FZJ)

CIP Cloud Particle Imager (UniMainz)

Rosemounts Pressure, Temperature (CAO)

MIPAS FFTMIRS (FZK)

FOZAN chemoluminescence, O3 (ISAC;CAO)

WAS H2O isotopes sampler (UniGron)

IRIS TDL isotopes of H2O (UniUtrecht)

HAGAR Gas Chromatograph (UniFrank)

MAS Multi-wavelength Aerosol Scatterometer (ISAC)

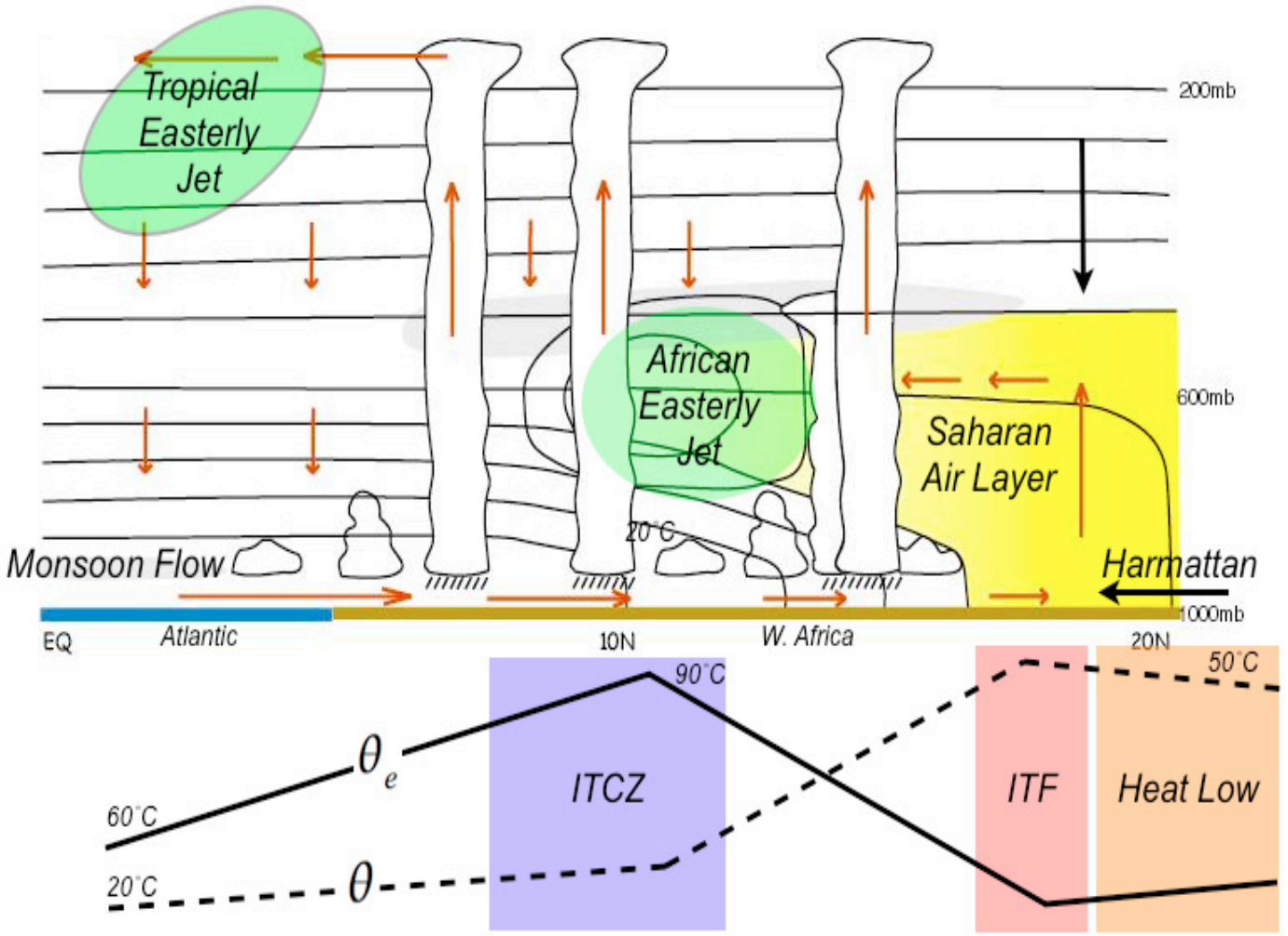
CRISTA Far Infrared Spectrometer (FZJ)

COPAS COndensation PArticle detection System (UniMainz)

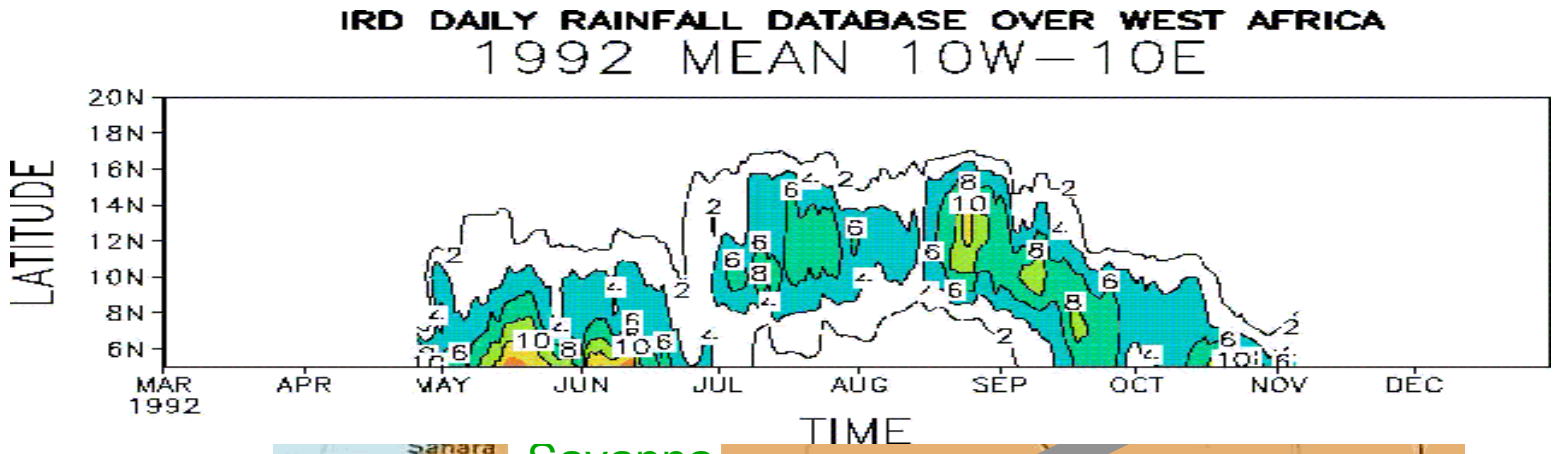
SIOUX resonance fluorescence NO/NOy (DLR)

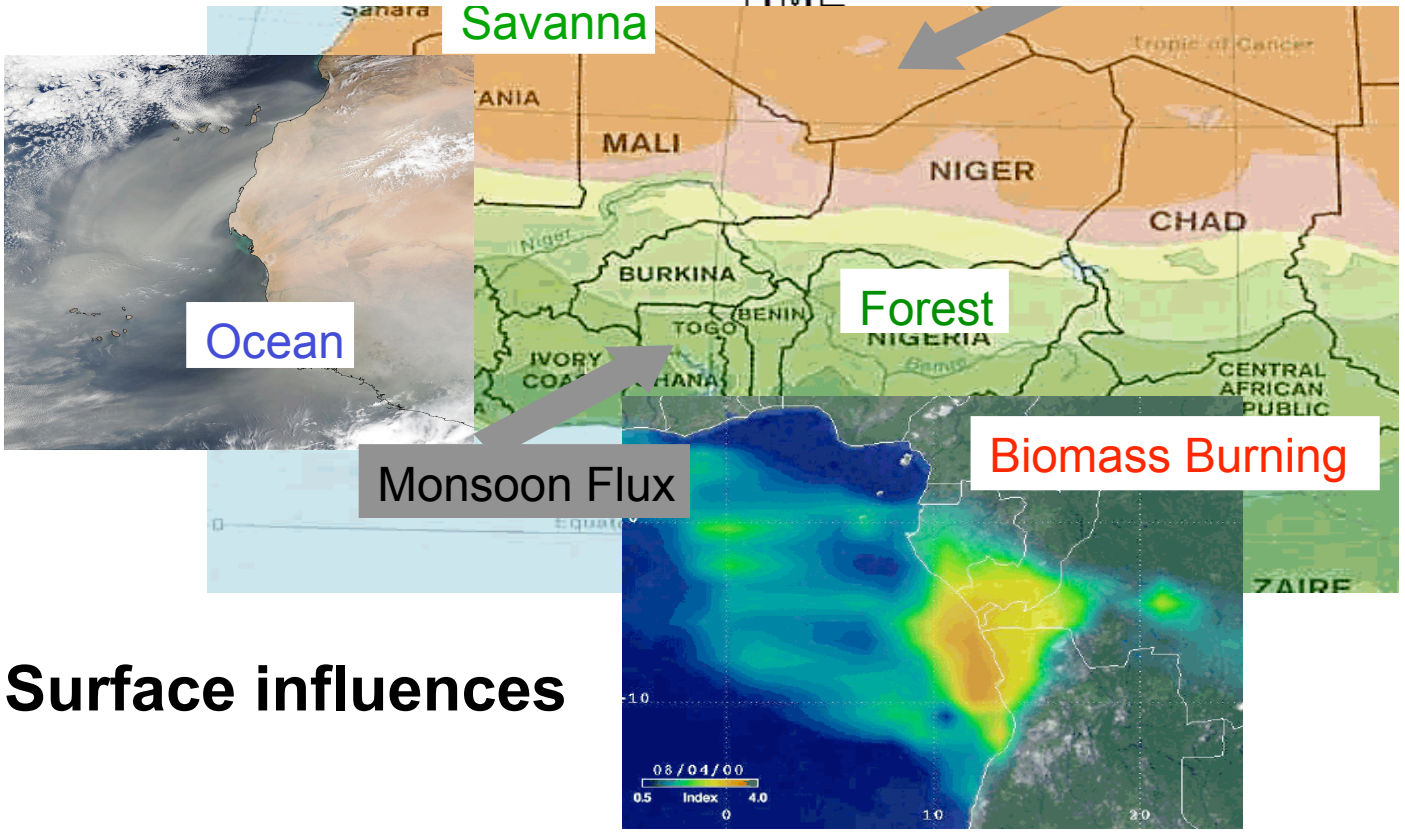
FLASH Fluorescent hygrometer (CAO)

FISH Fluorescent hygrometer (FZJ)



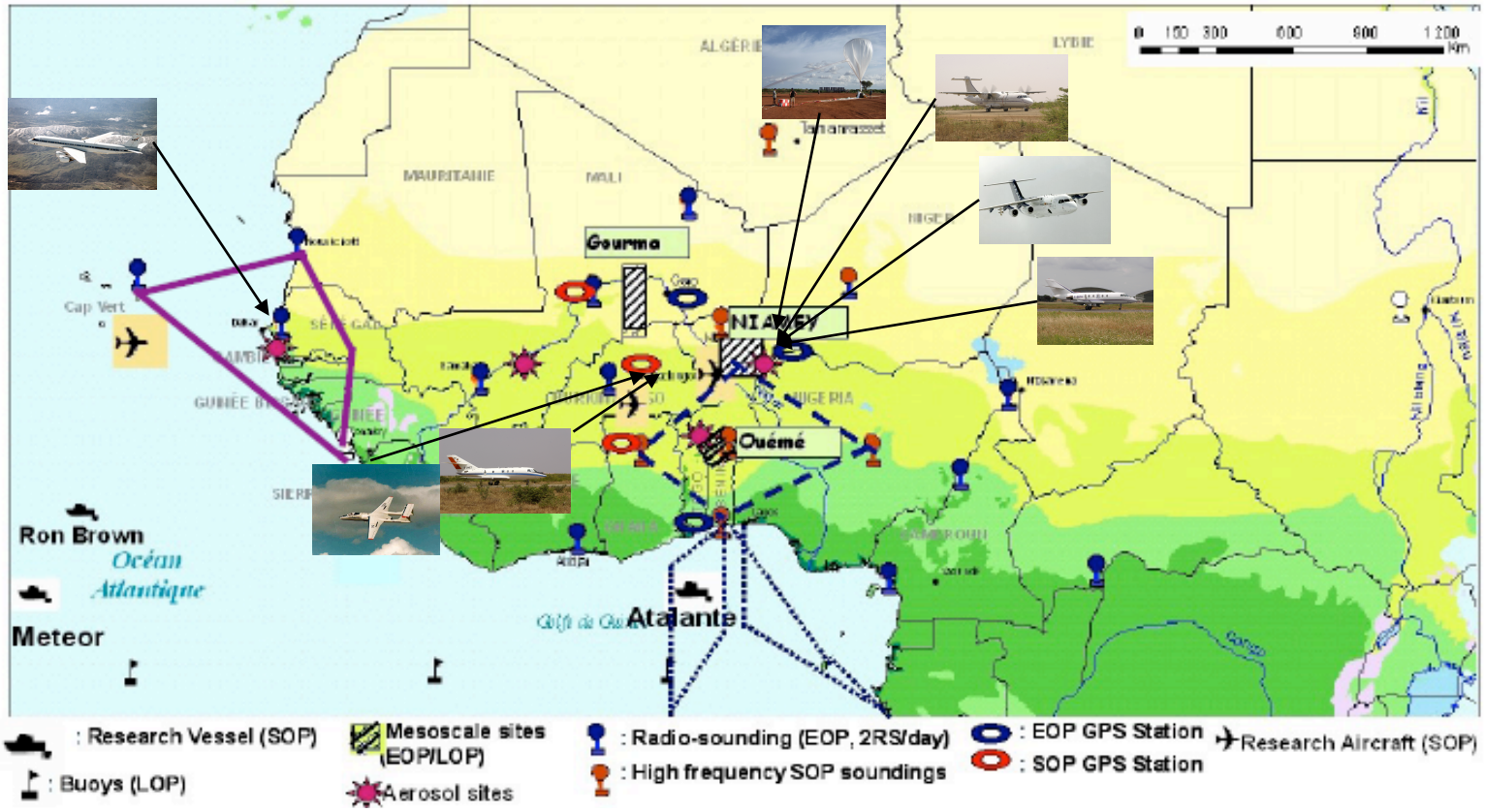
Mohr and Thorncroft, 2006

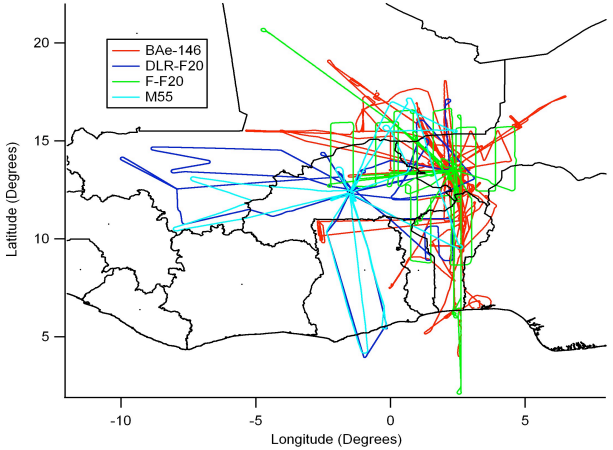


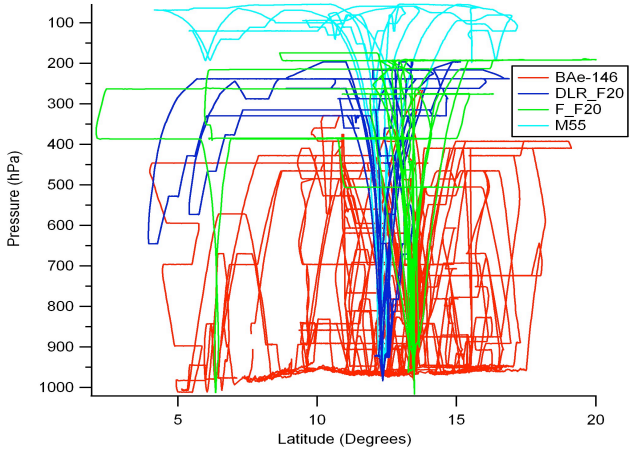


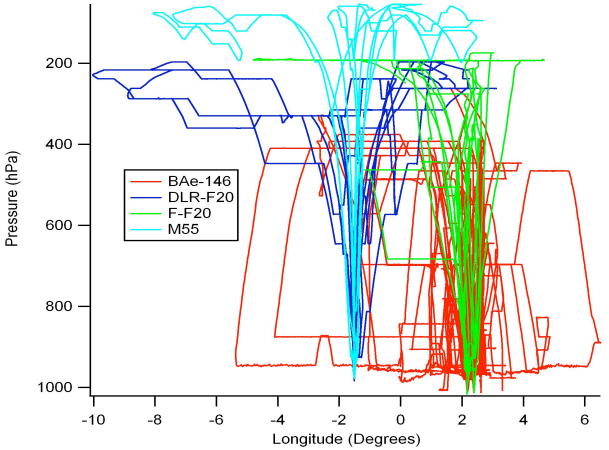
Surface influences

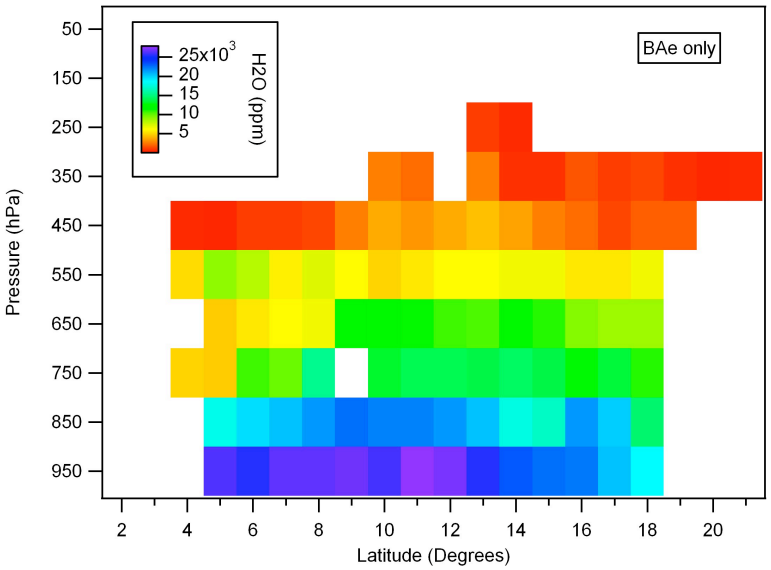
Observational network for the EOP (2005-07)

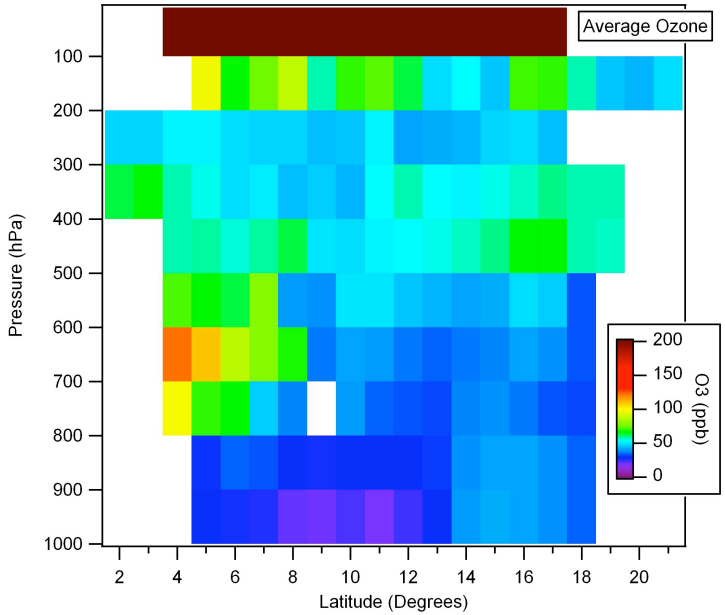


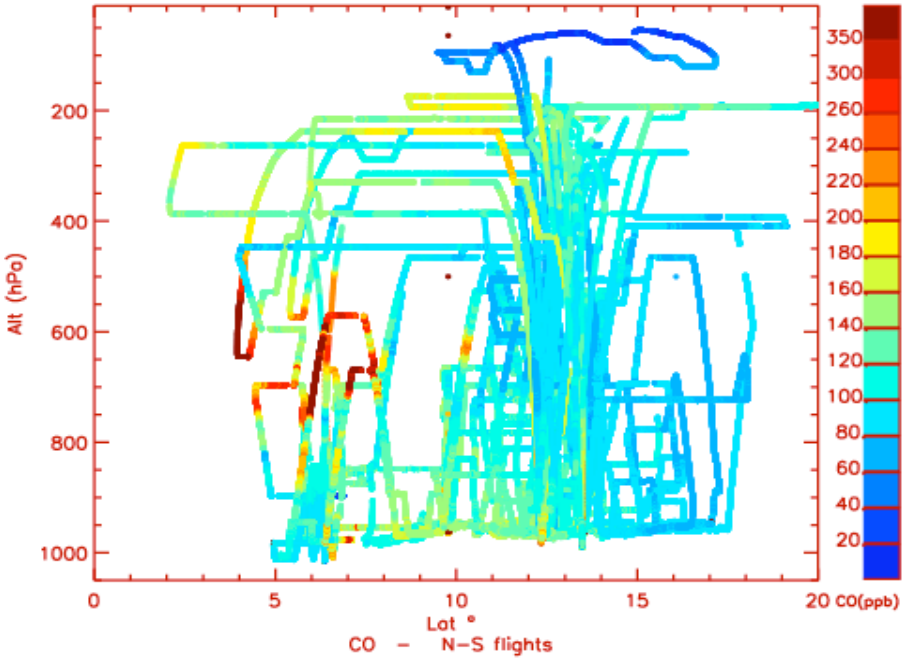




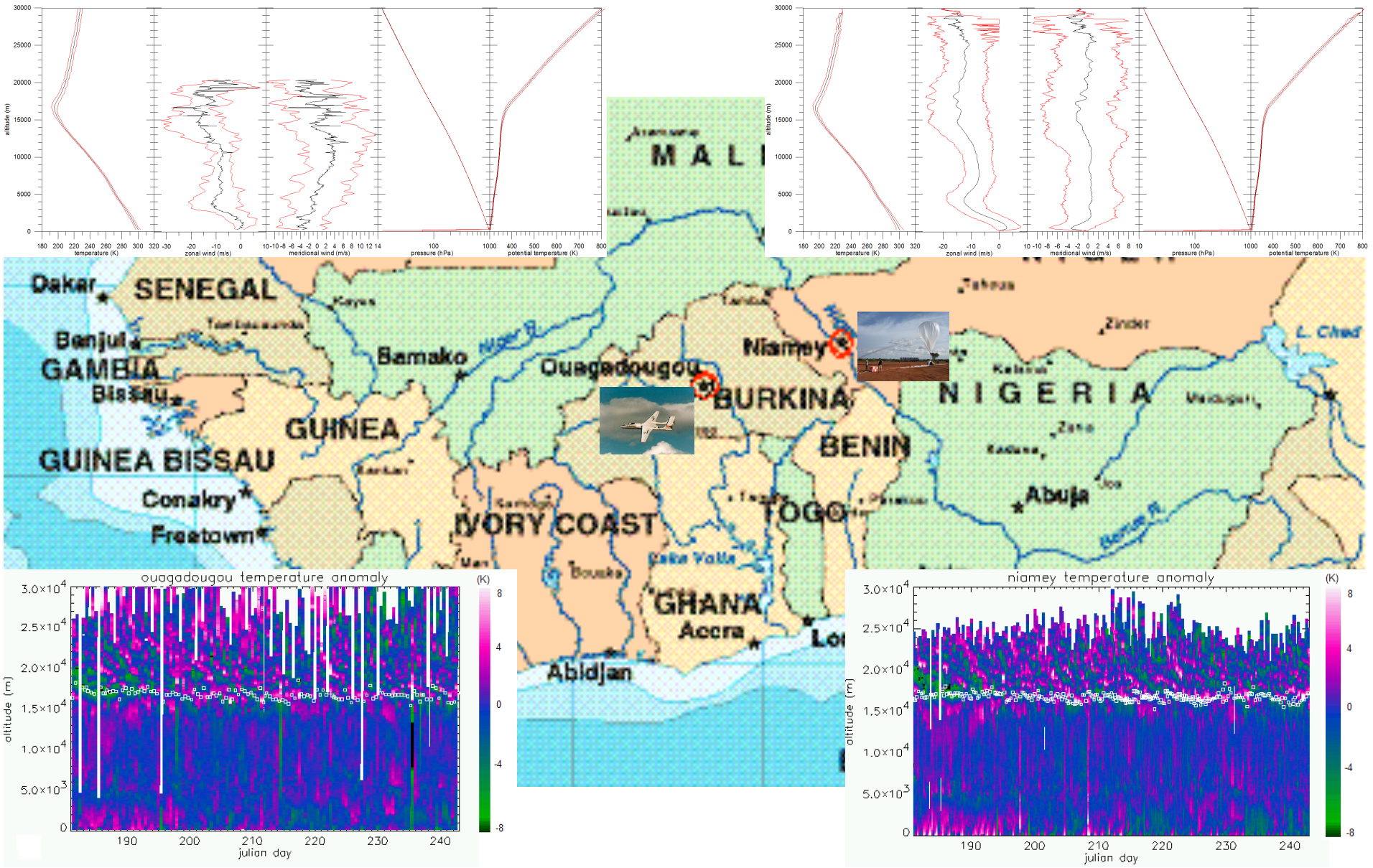






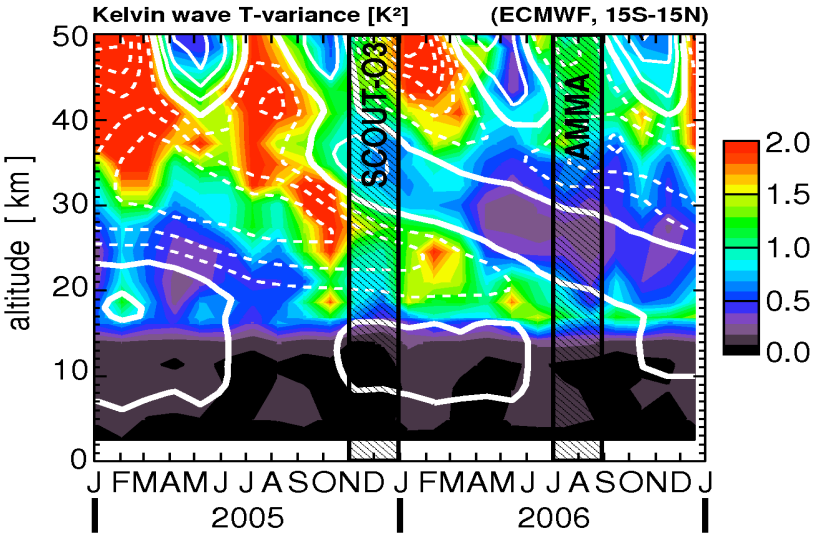


Reeves et al., in preparation



Radiosonde data courtesy D. Parker (UniLeeds)

Stratosphere during SCOUT- AMMA tropical campaign



Global situation during AMMA, lower stratosphere (15S-15N):

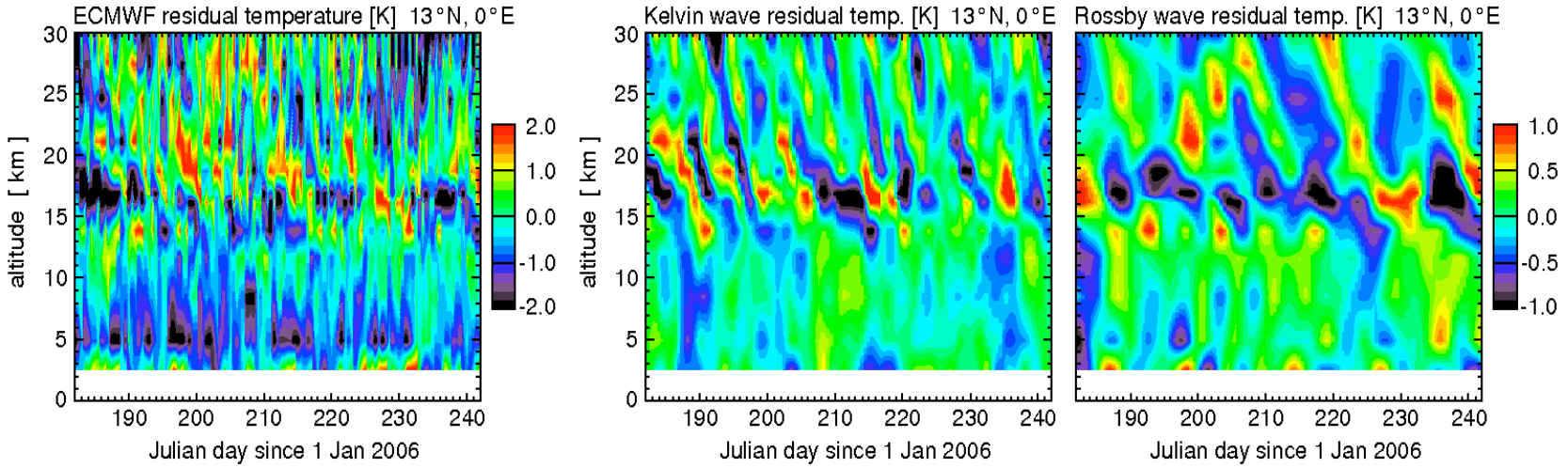
turnaround QBO westward to eastward

Kelvin wave activity decreases with time

westward propagating waves (e.g. Rossby) become more important

ECMWF residual temperature (13N, 0E), 1 July - 30 August 2006:

Space-time Fourier decomposition into dominant wave modes (Kelvin, Rossby)

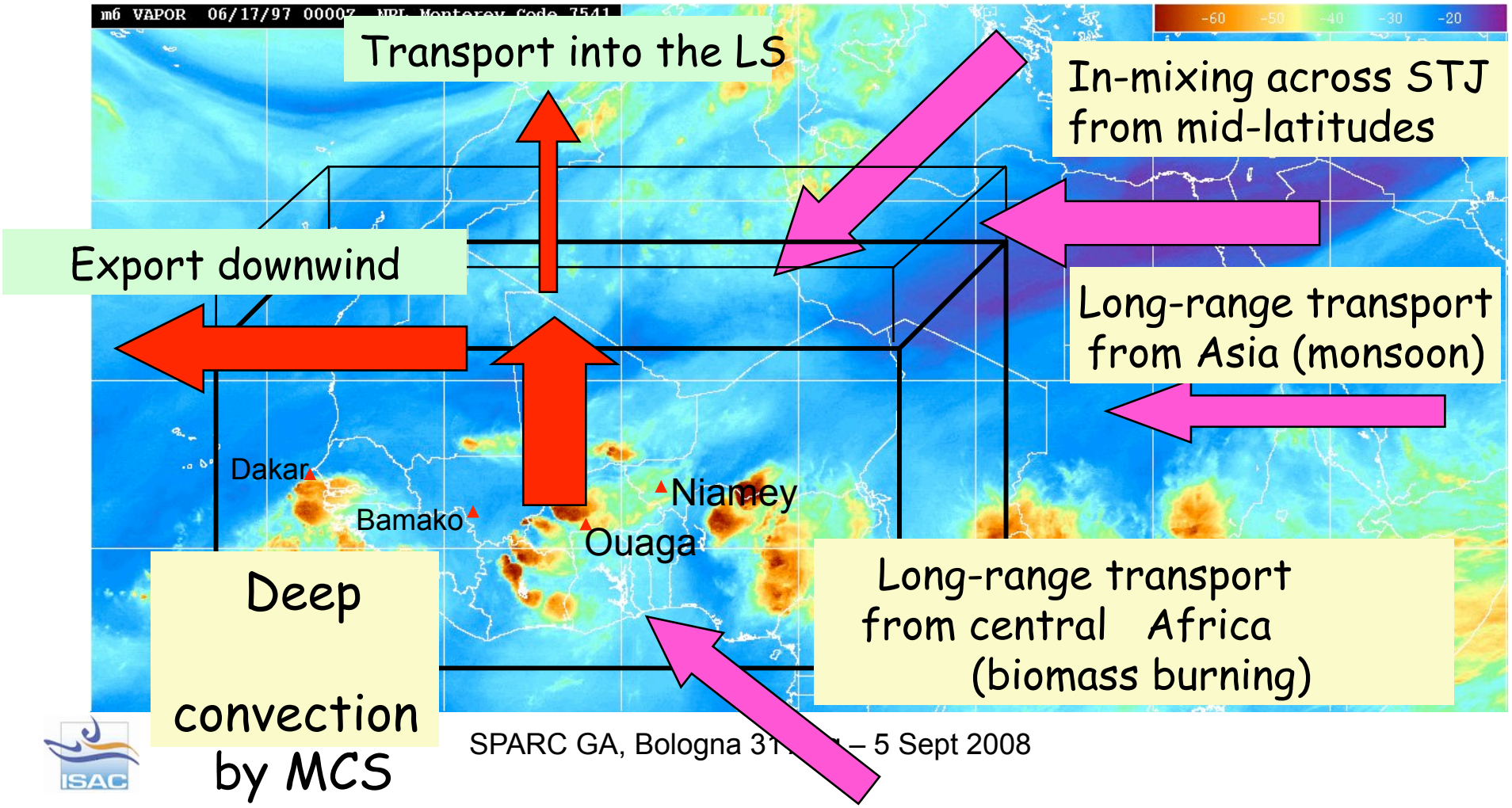


… where to look for more SCOUT-AMMA waves

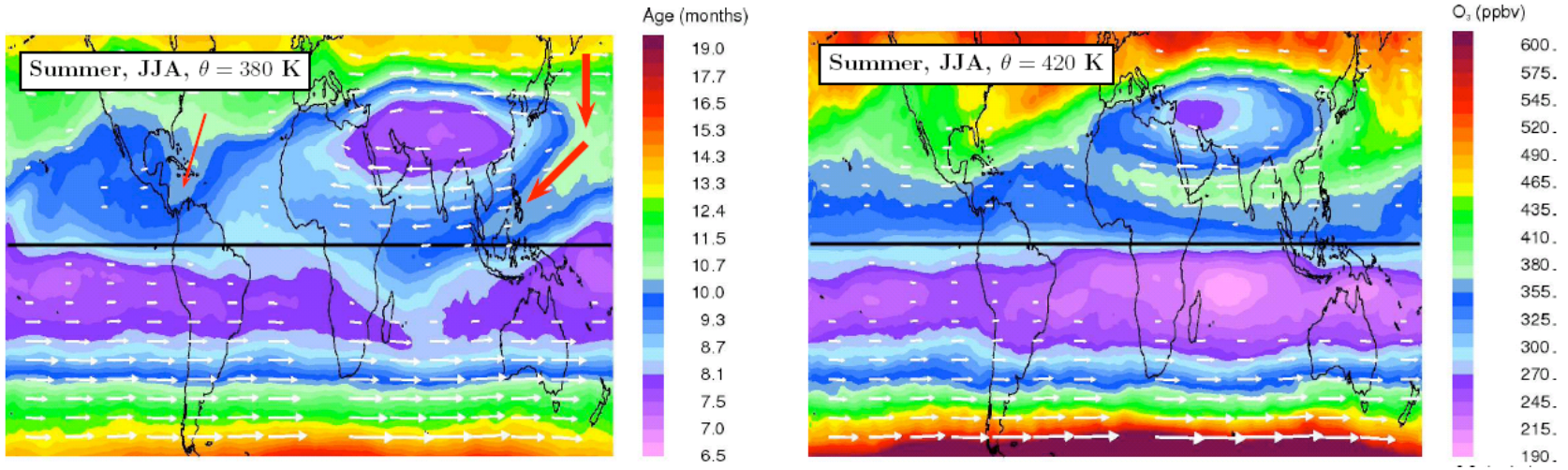
Kafando Petronille
Gravity Waves Induced By The West African Monsoon
(00032)

Ern Manfred
Gravity Waves Resolved In ECMWF And Measured By Current And Future Satellite Instruments (00133)

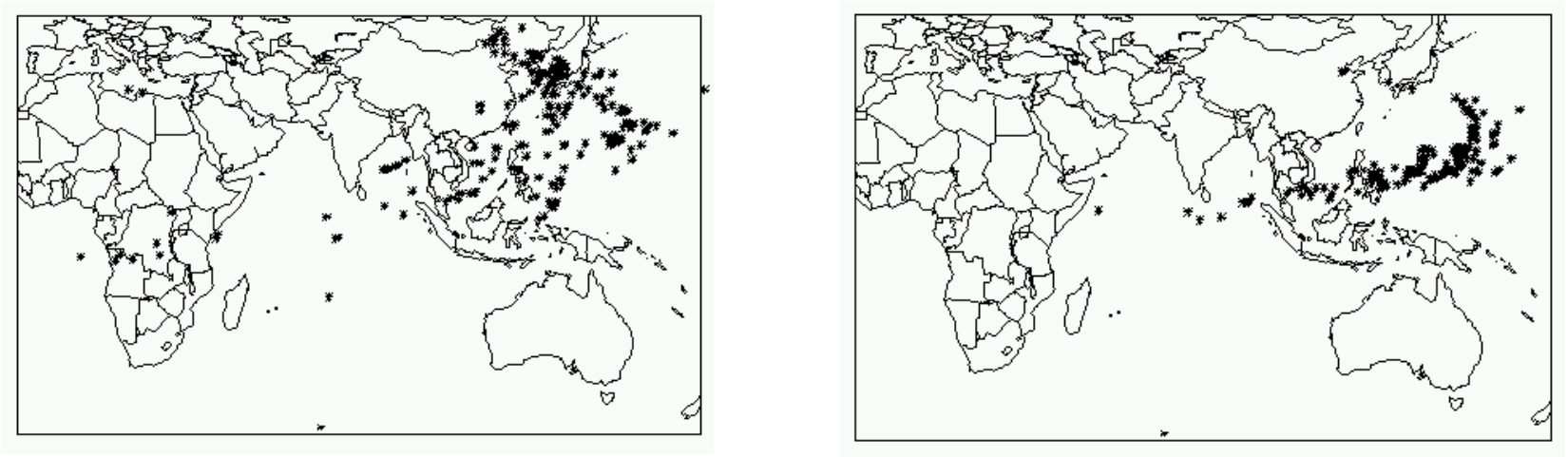
1. **Transport of trace gases, aerosols & water vapour into the upper troposphere and TTL by Mesoscale Convective Systems (MCS)**
2. **Large-scale characterization of chemical composition in the upper troposphere**
3. **Investigation of cirrus cloud formation/water budget in UT/TTL**



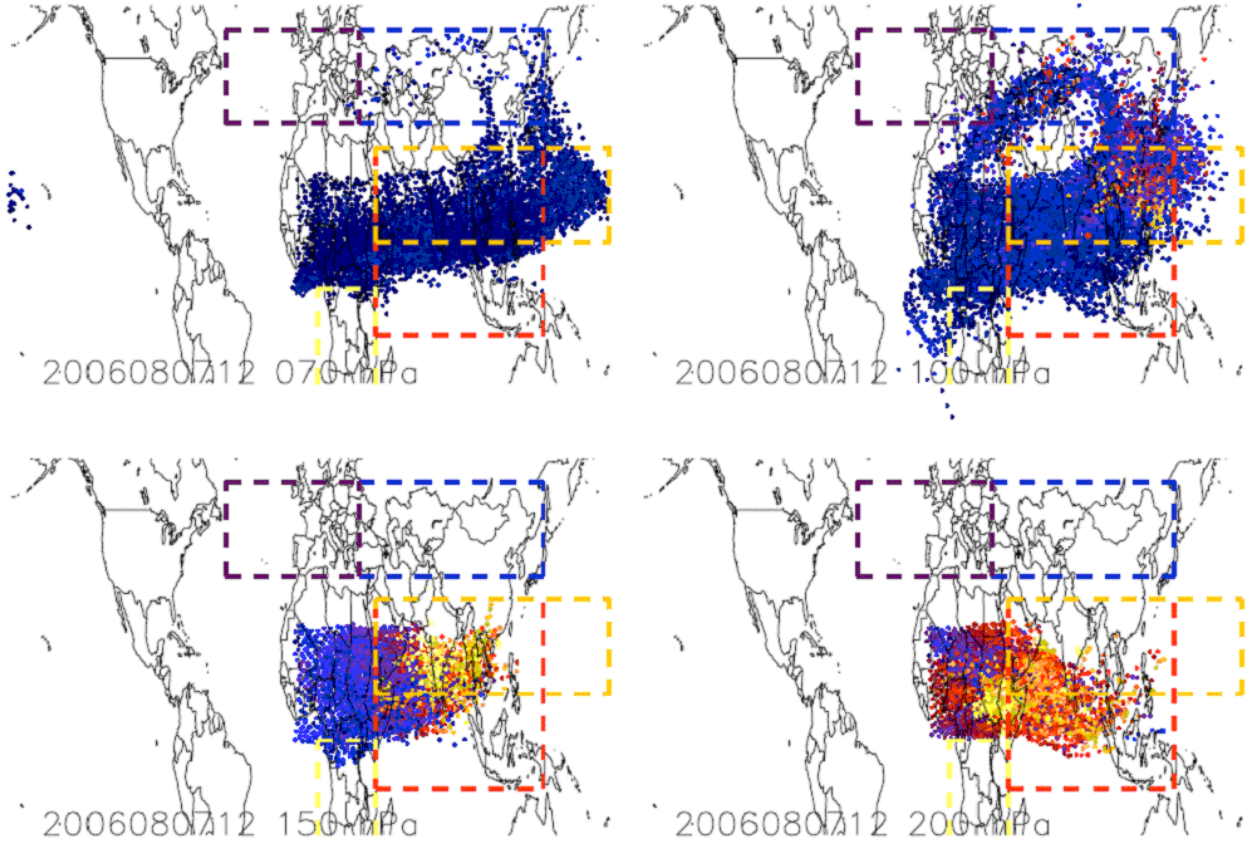
The influence of the Asian monsoon

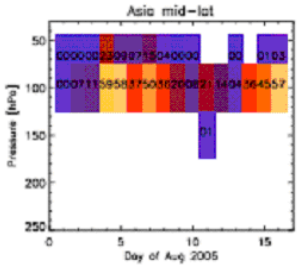


Konoptka et al., paper in preparation

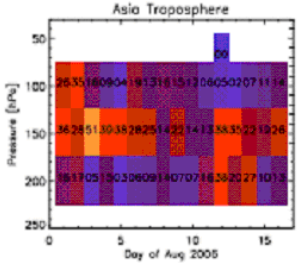


ECMWF 10-d backtrajectories endpoints, 380 K and 420 K

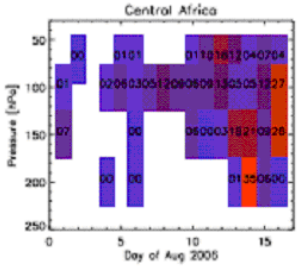




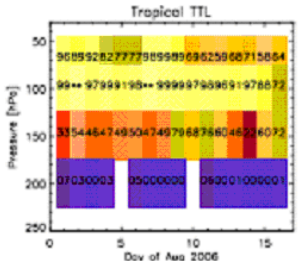
Asia UTLS midlat



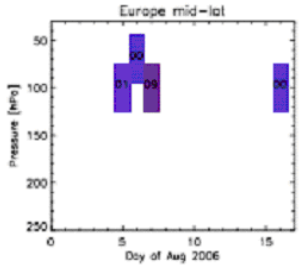
Asia T tropical



c. Africa UTLS Sub-tropical



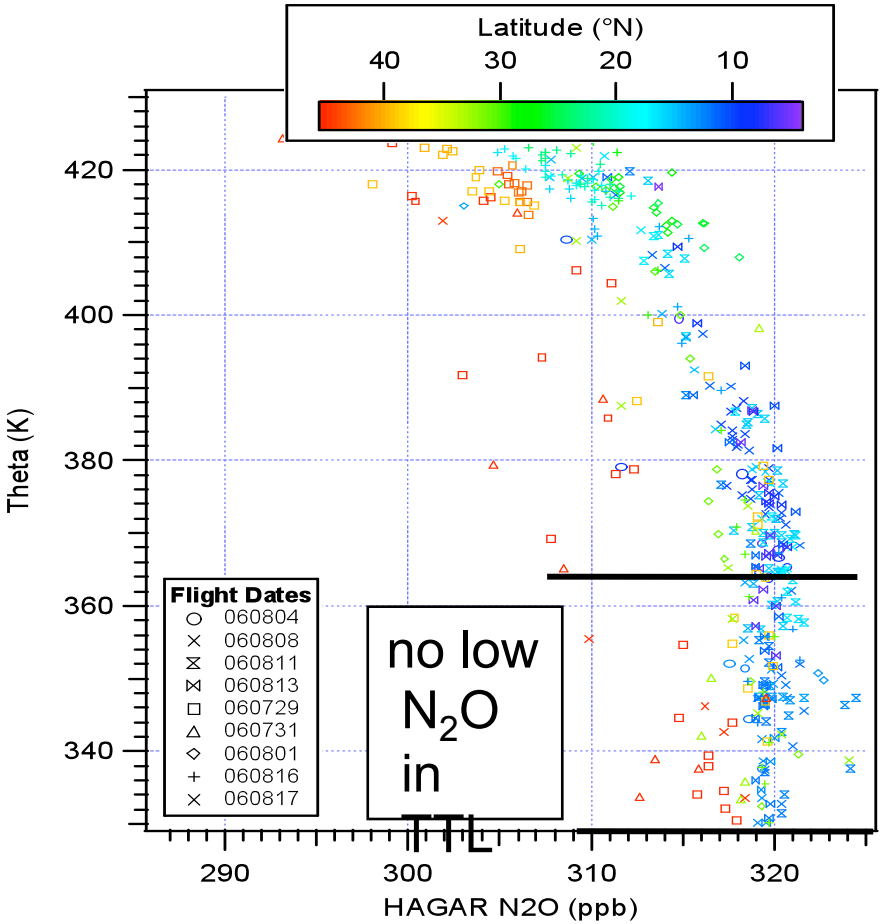
Tropical UTLS



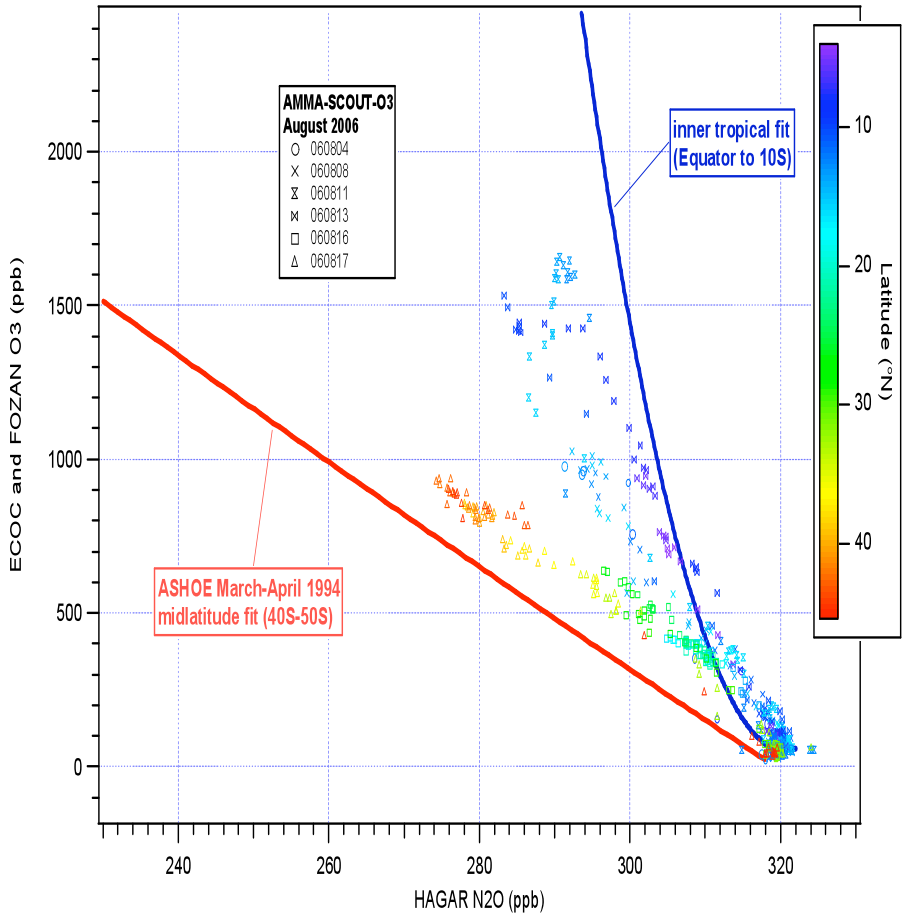
Europe UTLS

RDF backtrajectories:
Most of the UTLS air over Africa was already residing in tropical UTLS.

Stratospheric in-mixing into TTL

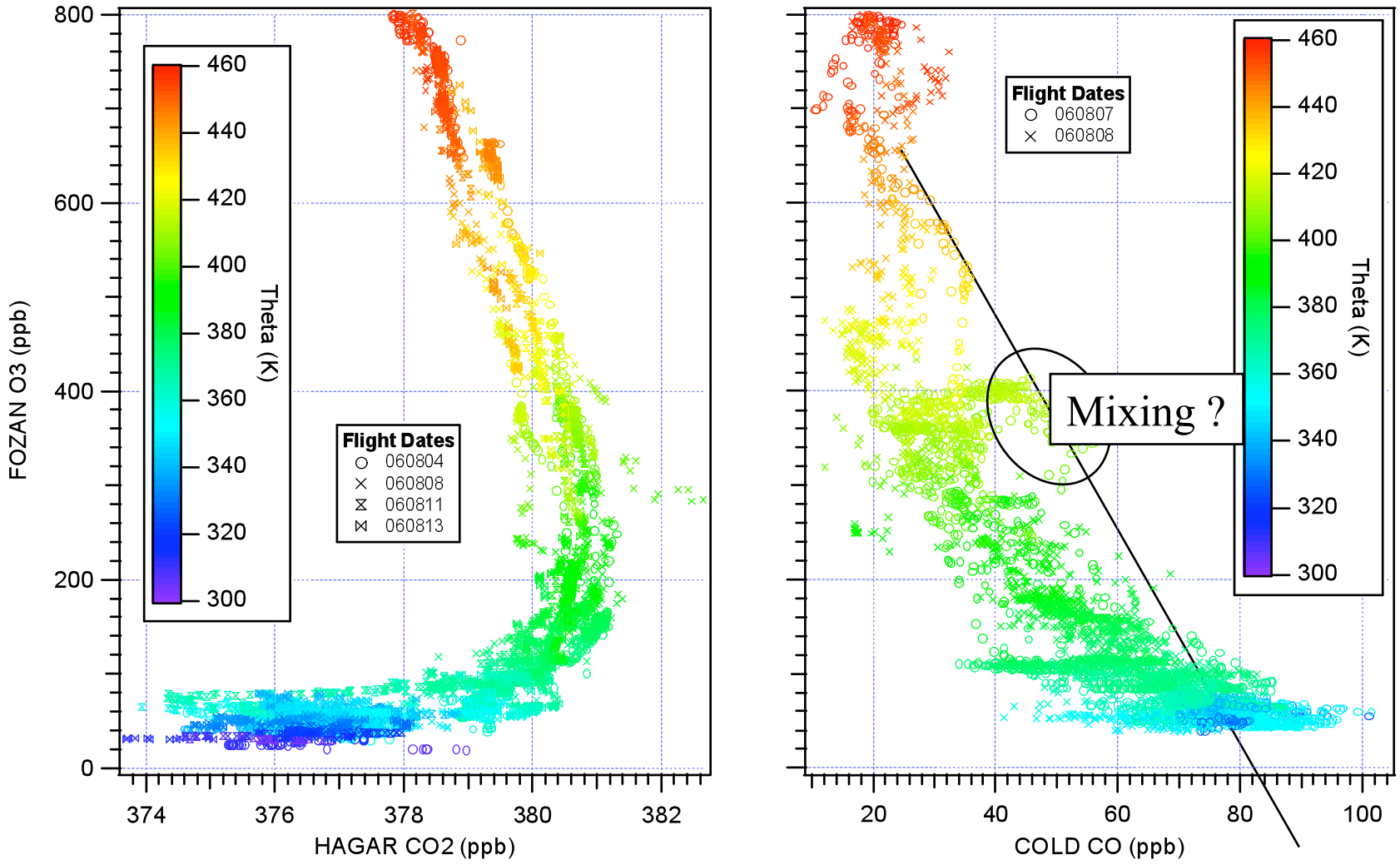


Inner-outer tropical stratosphere signatures



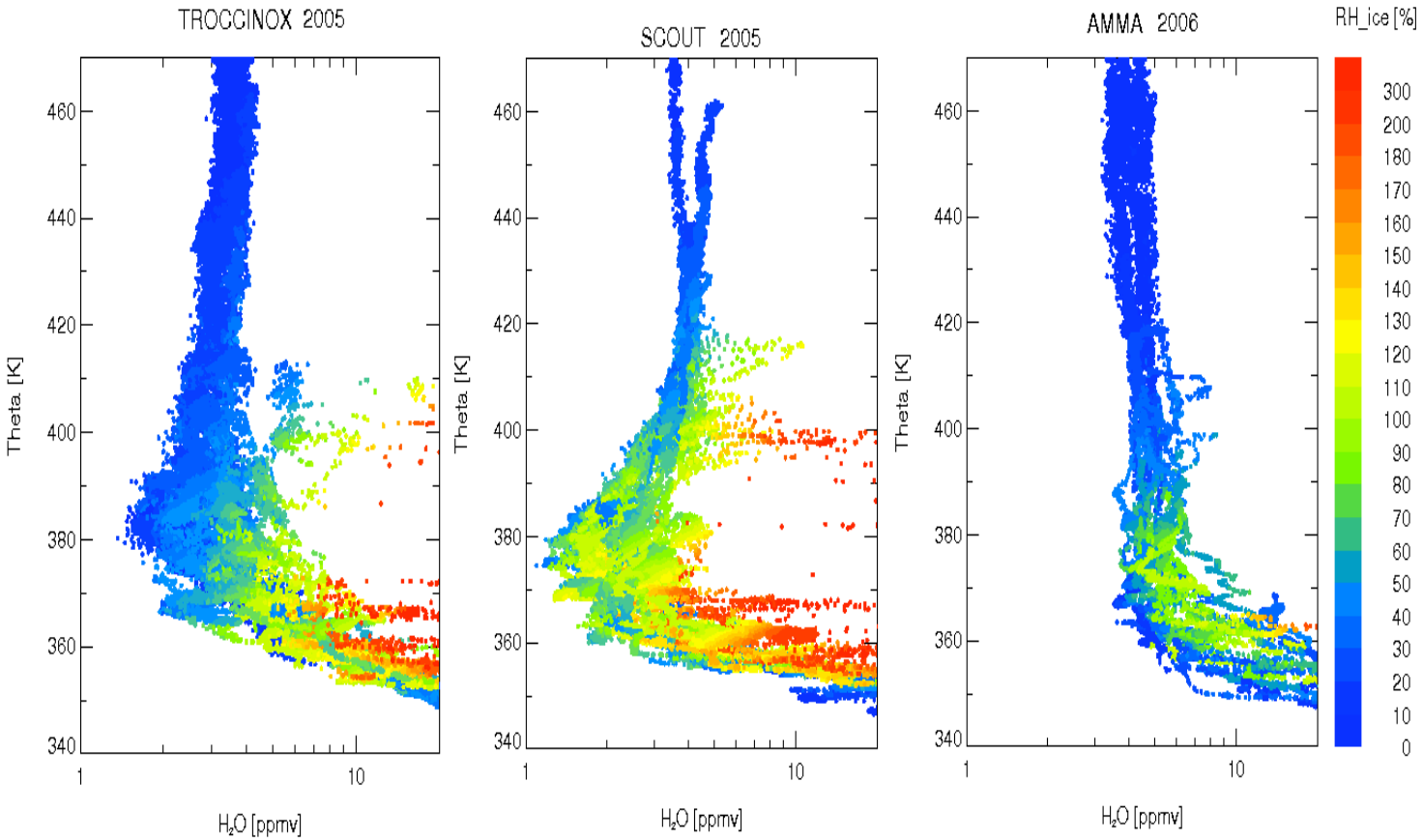
See M. Volk talk on 4 sept. 11:00: *Transport Across The Tropical Tropopause By Convection, Mixing, And Slow Upwelling: Insights From Recent In Situ Observations With The Geophysica Aircraft*

Mixing of overshooting air in the TTL during AMMA



Ulanowsky, CAO; Ravegnani, ISAC-CNR; Volk, UNI-Frankfurt; Viciani, INOA-CNR

RHi during tropical aircraft experiments

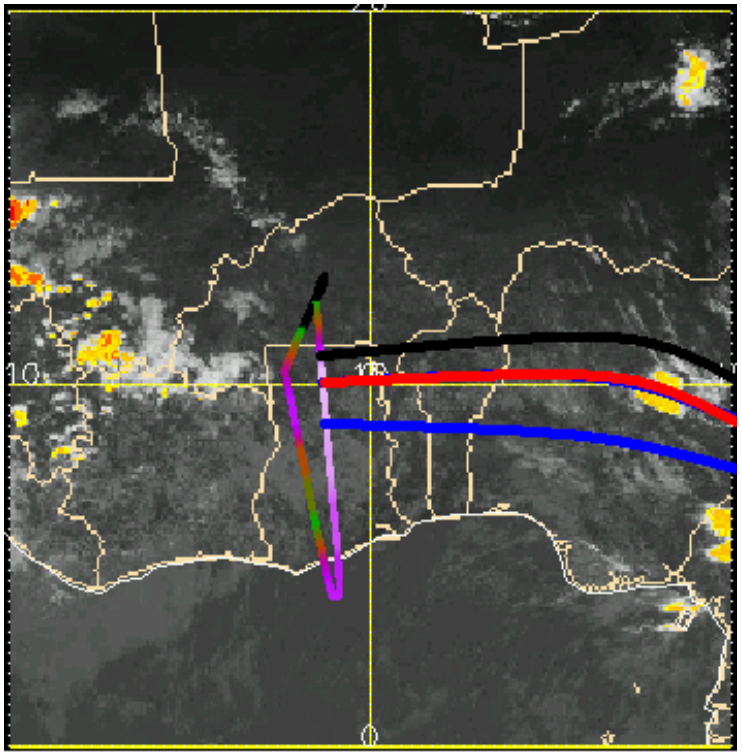


layers sporadically observed covering small areas traceable to recent overshooting convection

lowest H_2O m.r. (< 2 ppmv), high RHi during SCOUT-Darwin (and APE-THESEO) convection above TP: injection of particles in low RHi environment

only few cases of saturation at TP during SCOOUT-AMMA (and TROCCINOX)

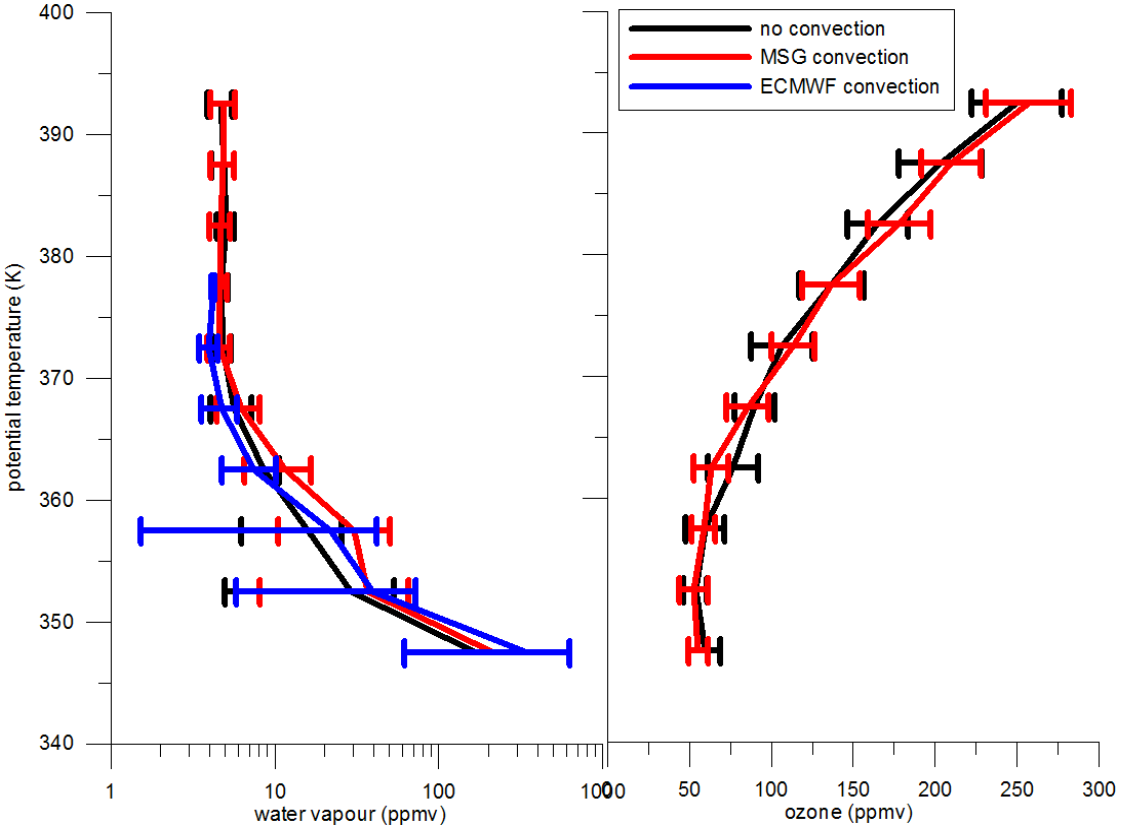
The mean effect of local convection



Backtrajectories that experienced high pressure changes

Backtrajectories that crossed high clouds nearby

Backtrajectories likely unaffected by convection



Effect of convection up to 370 K:

“convective” airmasses are wetter

What we learned:

- Highest “bulk” convective outflow level according to CO and
- CO2 ~ 375 K
- Highly variable H2O above cold point (100-80 hPa), high peaks in the stratosphere traceable to recent (10 hrs) convection. Their geographical extent seems limited.
- Increased H2O below 375 K connected to recent convection
- Flights with and without saturation/cirrus at cold point
- Hygropause at maximum flight levels (tape recorder)
- Cirrus in TTL 350-380 K observed
- Stratospheric profiles not fully inner tropical
- No evidence for significant stratospheric in-mixing into TTL

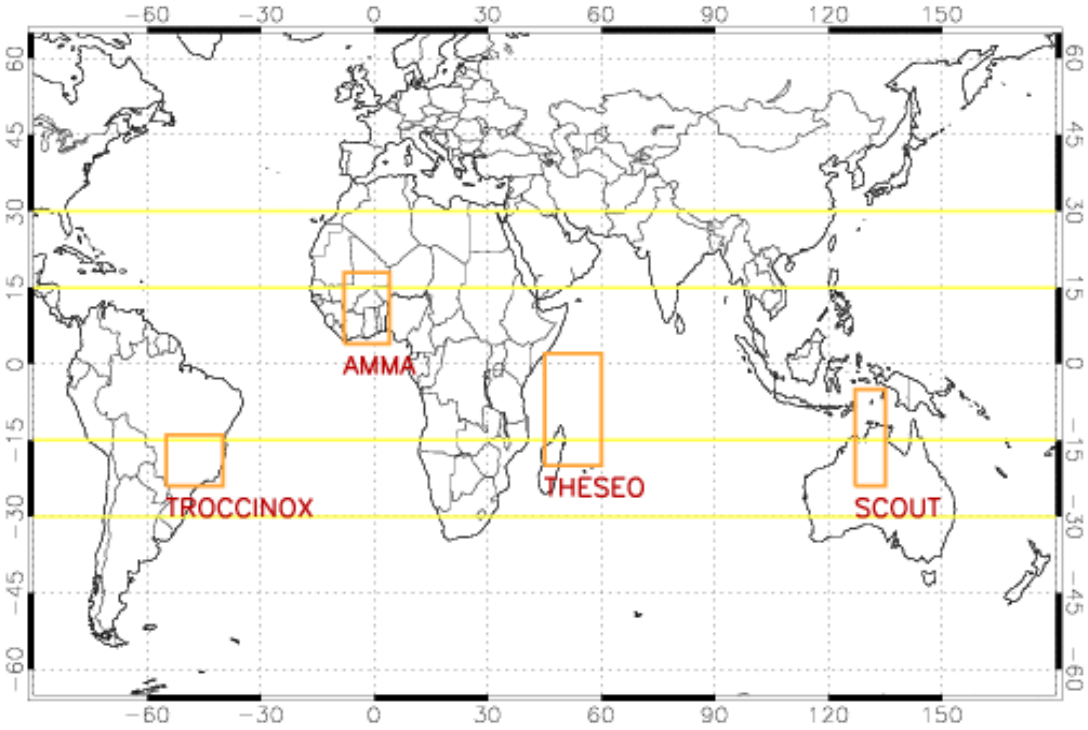
And…

- Enhancement of ultrafine particles in the LS (effect of La Soufriere Hills eruption)
- Favorable condition for particle nucleation in MCS (events frequently observed)

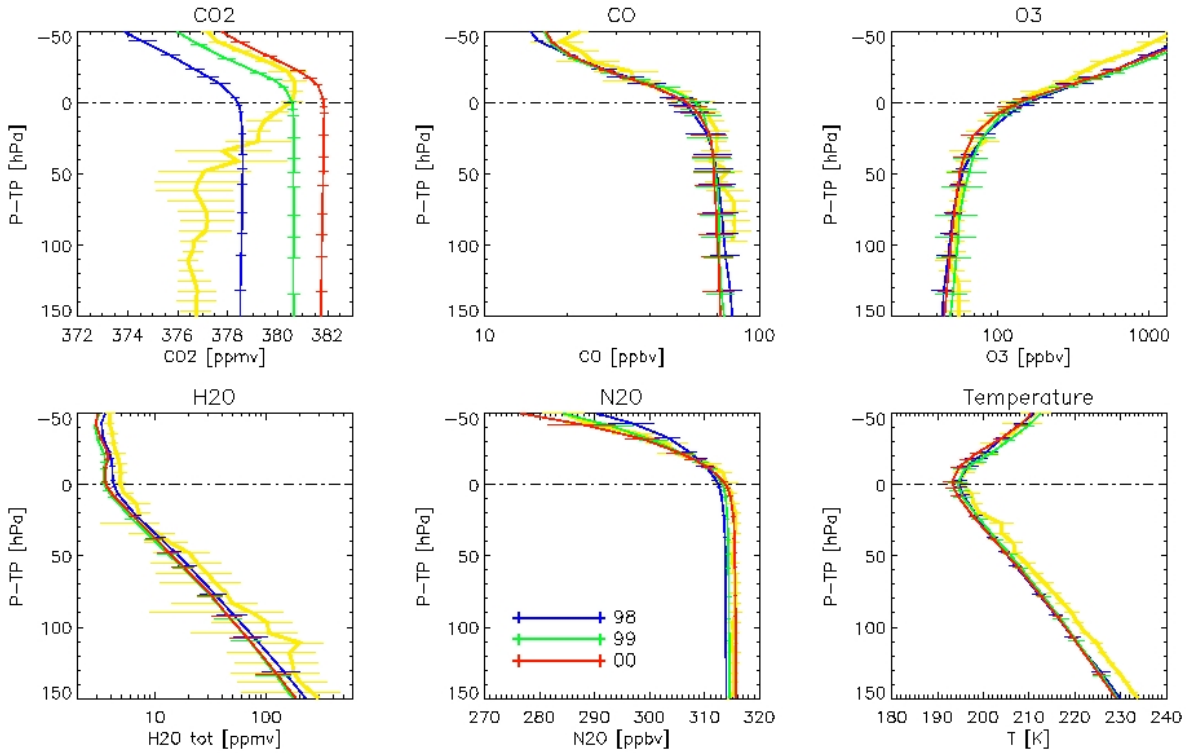
Use of aircraft data, from process studies to evaluation of models; CCMs in the TTL

Diagnostics

- comparison between the measured and modelled **vertical profiles** of the chemical species in a tropopause referenced coordinate (example: next slide)
- analysis of the **tracer – tracer relationships** in the model data and observations : morphology of the scatter plots and construction of the probability distribution functions



ECHAM5/MESSy vs M55 - AMMA Campaign, West Africa, August 2006



Model : ECHAM5/MESSy:
- T42 (2.8°x2.8°), 90 levels
- **climatological SSTs**
- **realistic chemistry**
- **QBO** spontaneously generated
- simulation time: April, 1998 to 2001.

- **Model data sub-sampled according to each campaign time period and location.**
- yellow are observations (mean and standard deviation)
- blue, green, red lines are the model (1998, 1999, 2000)

… where to look for more

Konopka Paul
Composition Of Air And Its Seasonality Within The TTL: Impact Of Asian Monsoon.
(00051)
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