Stratosphere-Troposphere Analyses of Regional Transport Experiment (START08)

Science Objective: Investigate transport processes that impact the chemical-microphysical distribution of the Ex-UTLS

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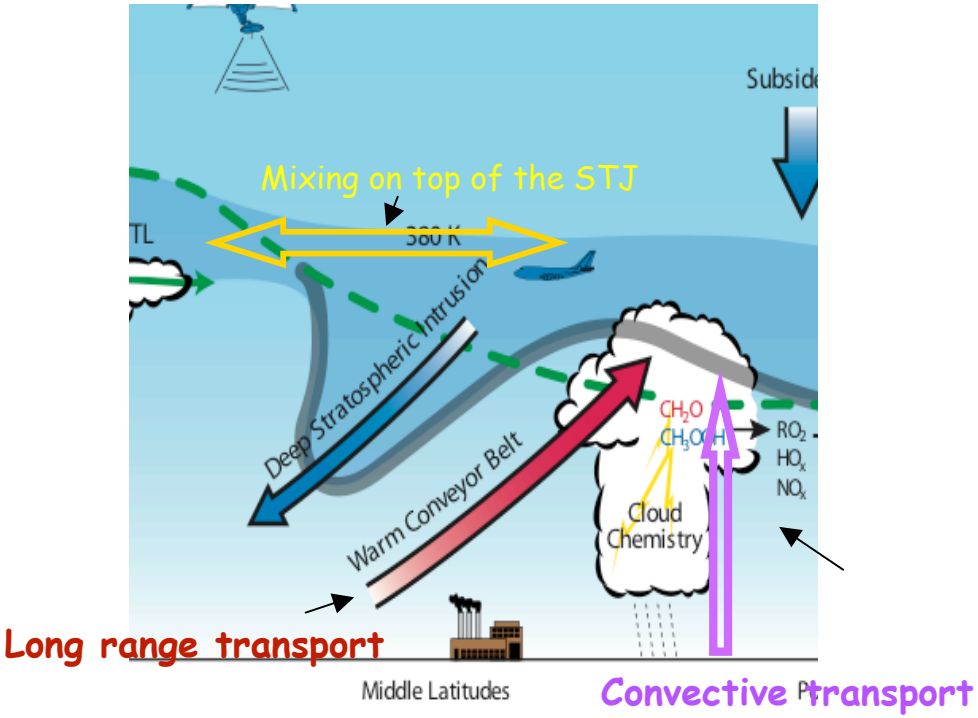
- April-June, 2008
- Flight operation from JeffCo
- Joint with HIPPO (global carbon)



START08 Information

- Motivations, brief history of project development
- Science questions & objectives
- People involved
- Payload & campaign dates
- Modeling effort
- Opportunities of collaboration

Project History

- START was planned by the UTLS initiative at NCAR, in collaboration with a group of university colleagues, for the HIAPER progressive science mission (2005) for test flights
- NSF declined the funding for University co-Is and suggested a full scale campaign proposal in a later date
- A limited payload START was conducted by NCAR scientists (Dec 05)
- A proposal for START08 with a moderate payload developed over the last two years, lead by a joint PI group (Pan, Atlas, Bowman, Zhang…)
- NSF LA program suggested a joint payload/operation with Pre-HIPPO (Wofsy). The PI groups considered the payload overlap and flight pattern consistency and agreed to the joint operation

Motivations and general questions

- In the Ex-UTLS region, multi-scale dynamics (i.e., stratospheric circulation and tropospheric weather systems), coupled with chemistry, controls and redistributes a suite of radiatively significant species (Ozone, Water vapor, particles…)

- How well is the new generation of CCMs representing this region and predicting the coupling of dynamics and chemistry in a changing climate?

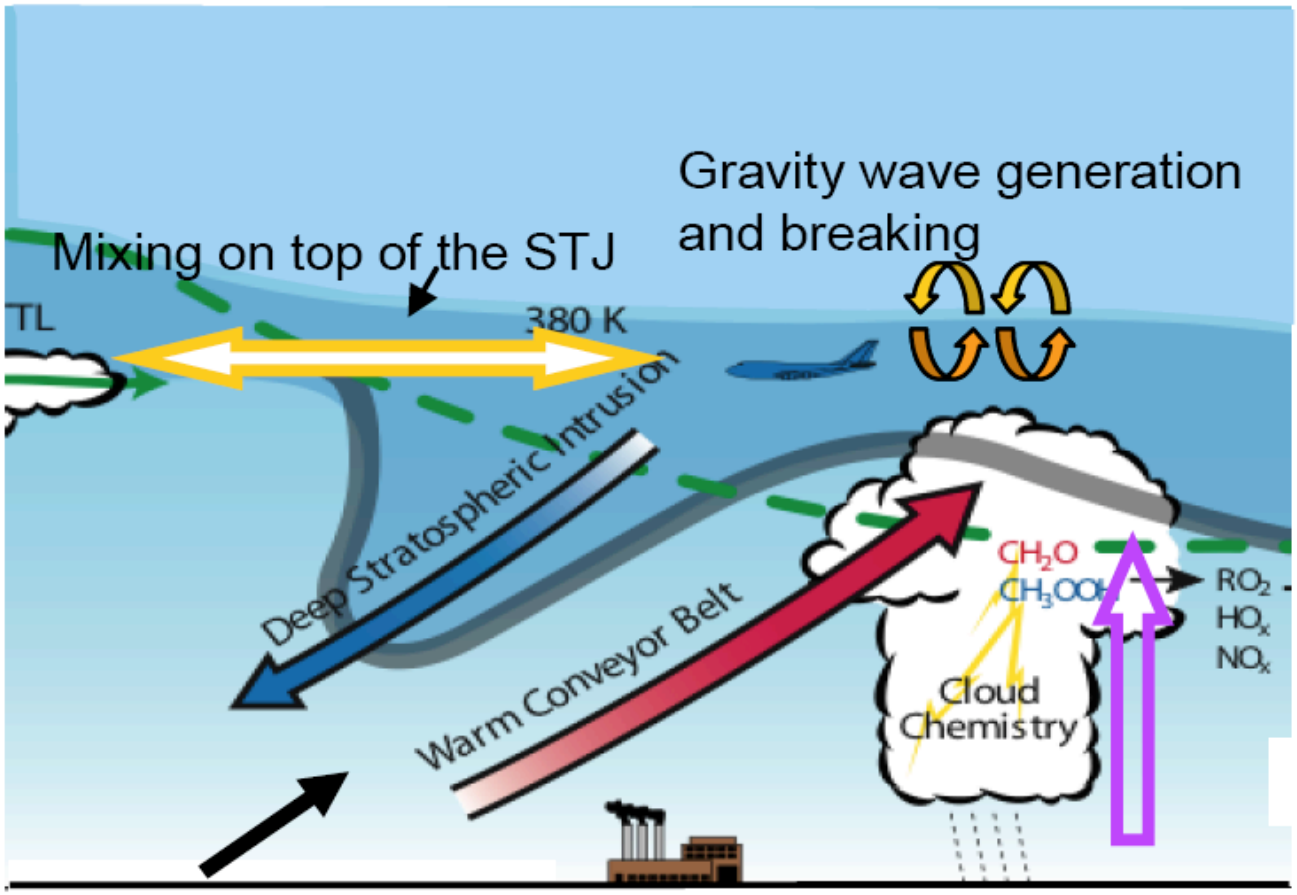
- Process-oriented validation for the CCMs - the need for diagnostics that are observables - flux is not an observable, tracer-tracer correlations are, so is the age spectrum - need for a climatology in the UTLS region, also a theoretical framework

- Need for a new paradigm - what controls and defines the boundary between the stratosphere and troposphere? The perspective of chemical and microphysical behavior of the tropopause

- The need of HIAPER platform/instrumentation development (after the "no-go" for TC4 participation) - we need exercise to put chemistry instruments on the plane

- Also need for experience of challenging flight patterns - can we probe convective anvils?

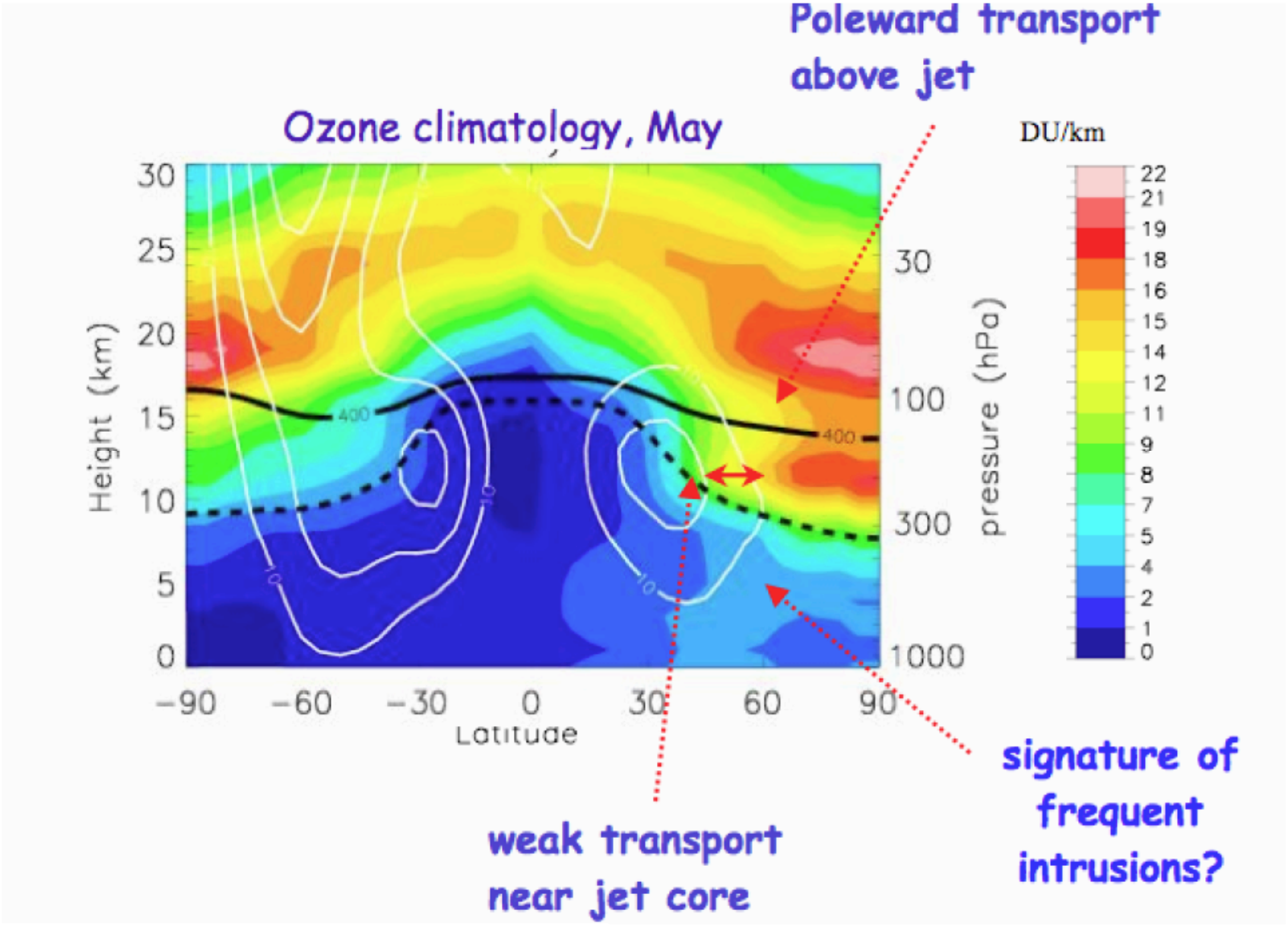
Primary Science Objective: Investigate transport processes that impact the chemical-microphysical distribution of the Ex-UTLS



Primary Science Objective: Investigate transport processes that impact the chemical-microphysical distribution of the Ex-UTLS

- **Understanding the Ex-Tropopause**
  - Is the extratropical tropopause better characterized as a surface or a layer? ExTL?
  - If a layer, how do we identify/define it? What controls its existence/depth?
- **The behavior of the secondary tropopause**
  - What dynamical processes contribute to the occurrence of 2ndry tropopause?
  - What's the chemical transport processes associated with multiple tropopauses?
  - What are the microphysical behavior of the region of multiple tropopauses?
- **Key transport pathways**
  - Where are the preferred locations of STE and mixing?
  - How do we identify the convective impact to UTLS air mass?
  - What are the key tracer relationships that identifies these pathways?

Signature of the key pathways in ozone climatology



Microphysical implications of the secondary tropopause?

Noel and Haeffelin, 2007

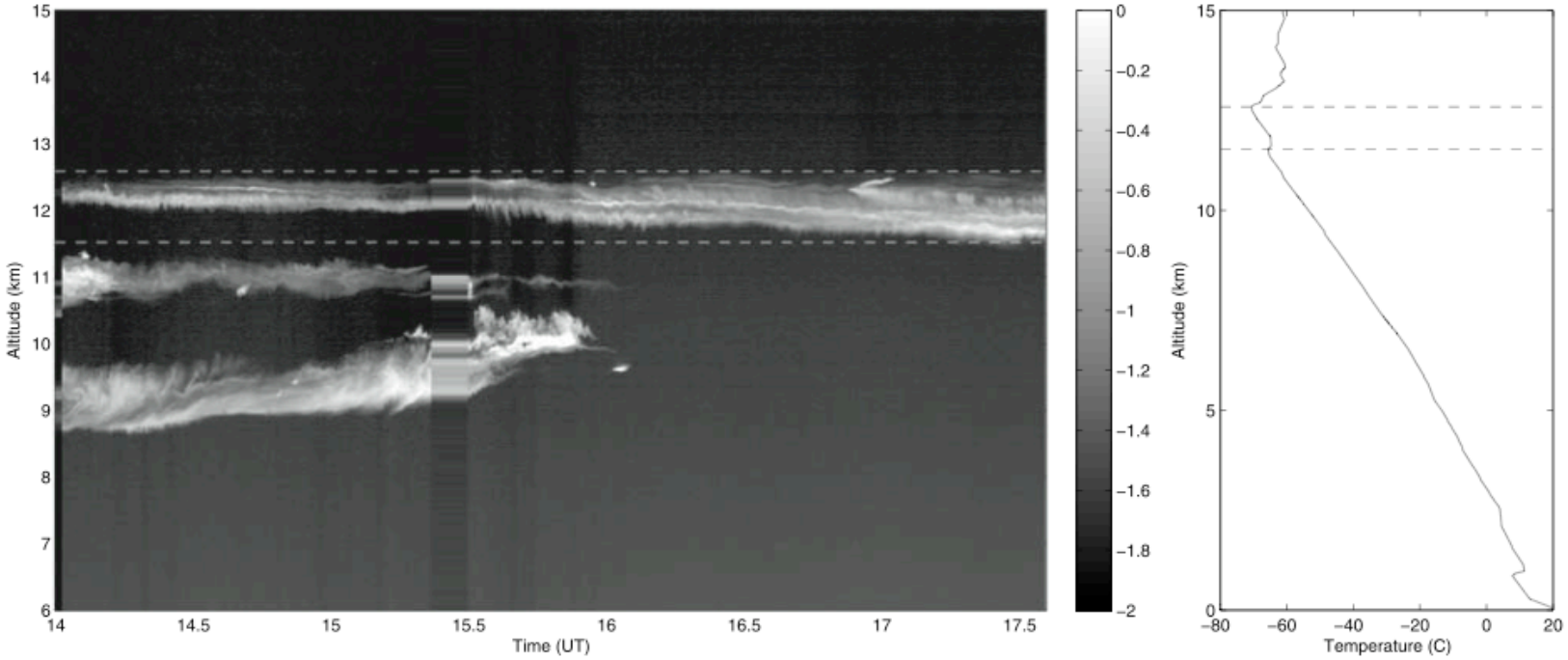
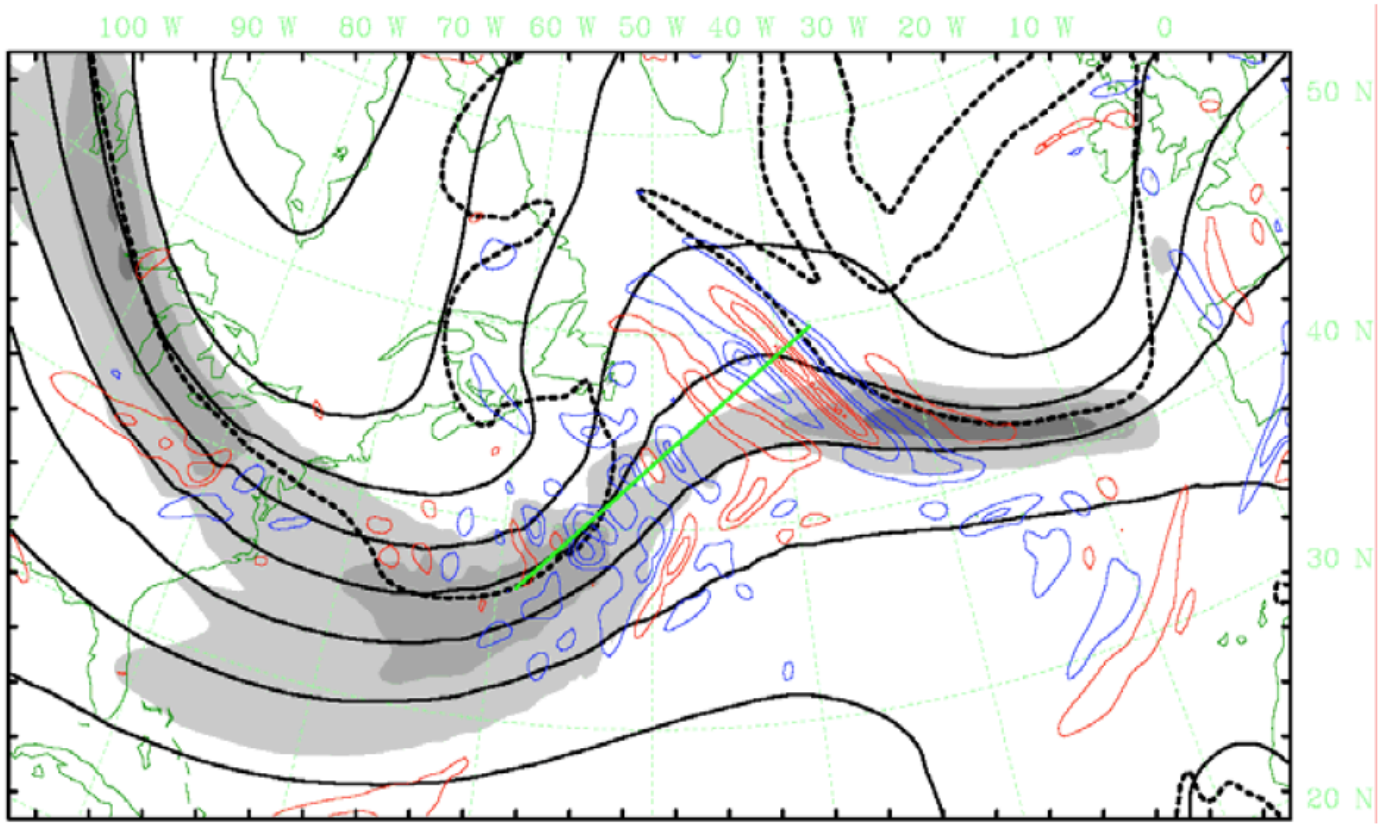


Figure 5. (a) Backscattering coefficients observed by the LNA lidar on 17 March 2005 as a function of time and altitude, using a logarithmic color scale. (b) Temperature profile from radiosoundings on 17 March 2005. On both figures, the first two tropopauses are indicated using dashed lines.

Objectives (con.)

- **Role of gravity waves in the structure and composition of ExUTLS**
  - How well does the current generation of mesoscale models predict the excitation of GW by jet/fronts?
  - How often do GW break in the ExUTLS and what is the evidence in tracer measurements for the contribution of GW breaking to mixing?

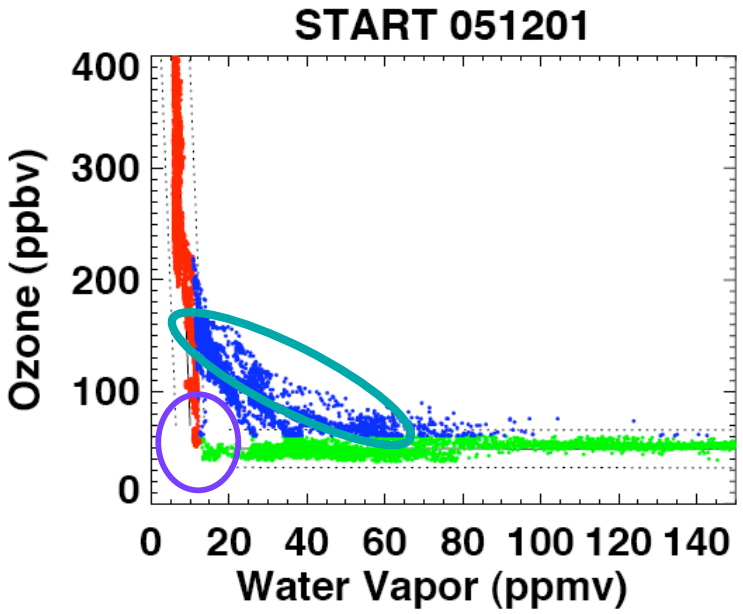


START05

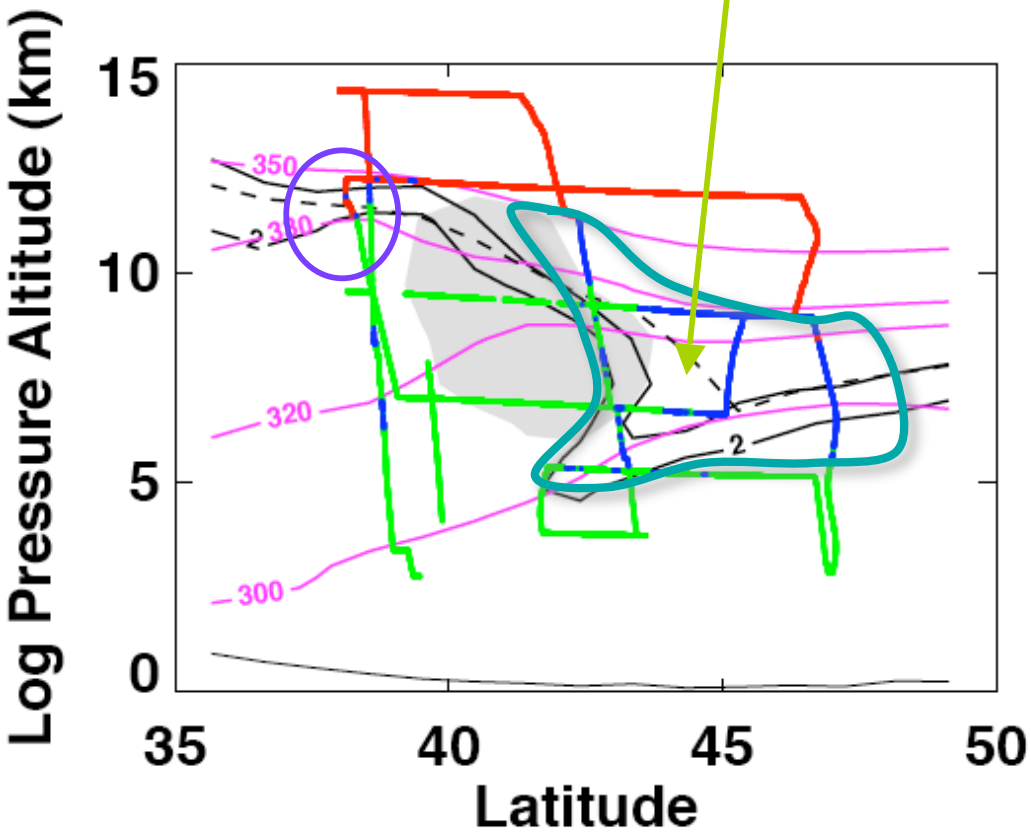
- The concept of START08 was tested during START05
- Three publications up to date, highlights what we can learn with this new aircraft, in the Ex-UTLS region

Chemical behavior of the extratropical tropopause

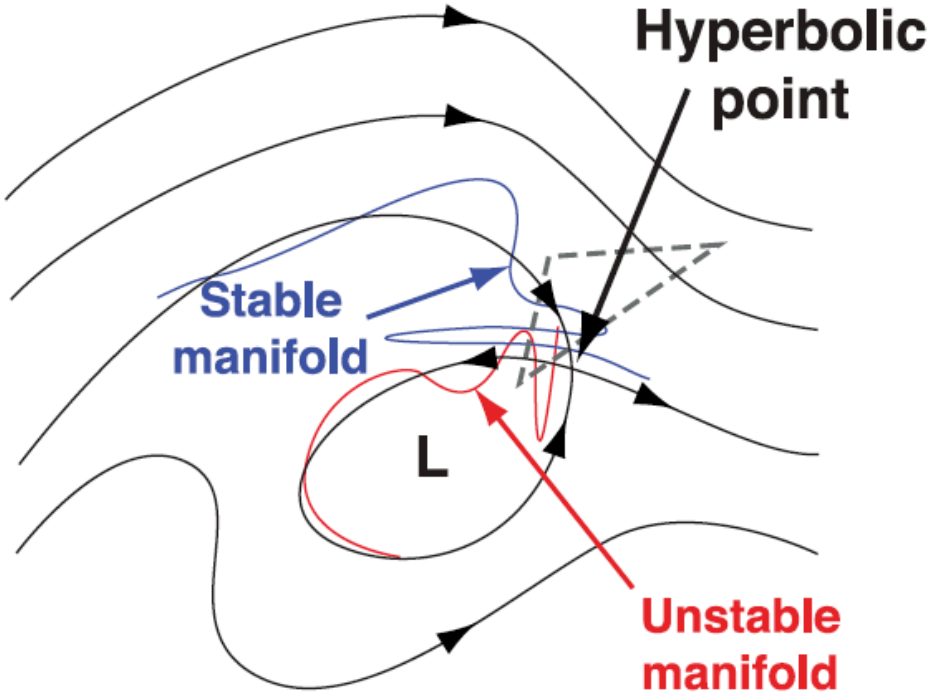
Pan et al., 2007

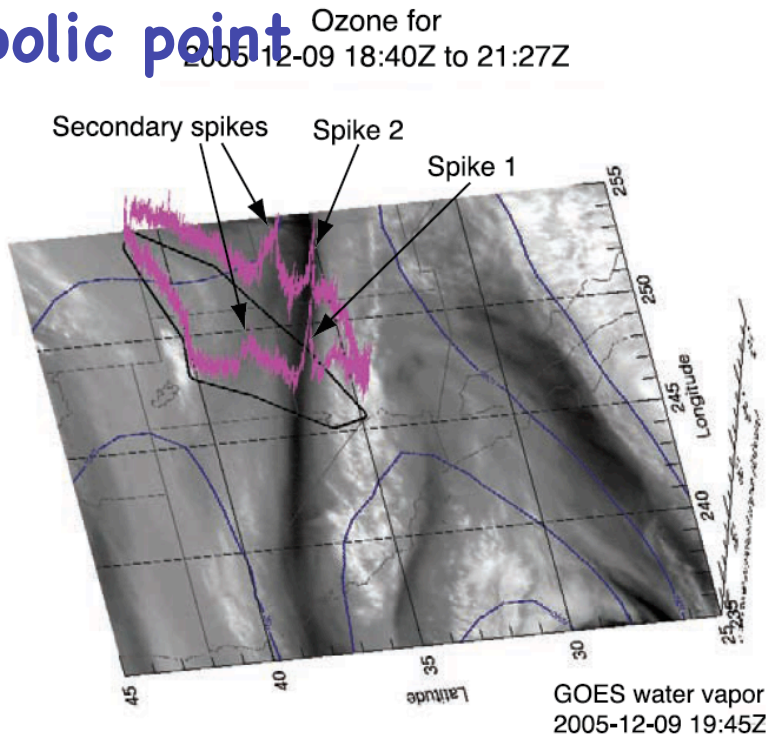


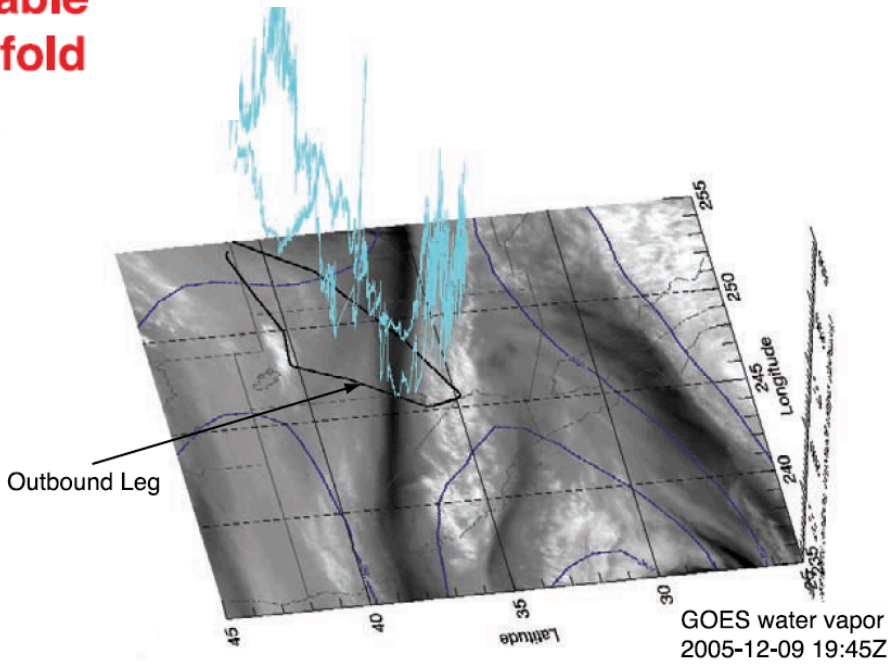
Cyclonic side of the jet



Fine scale structure near a hyperbolic point



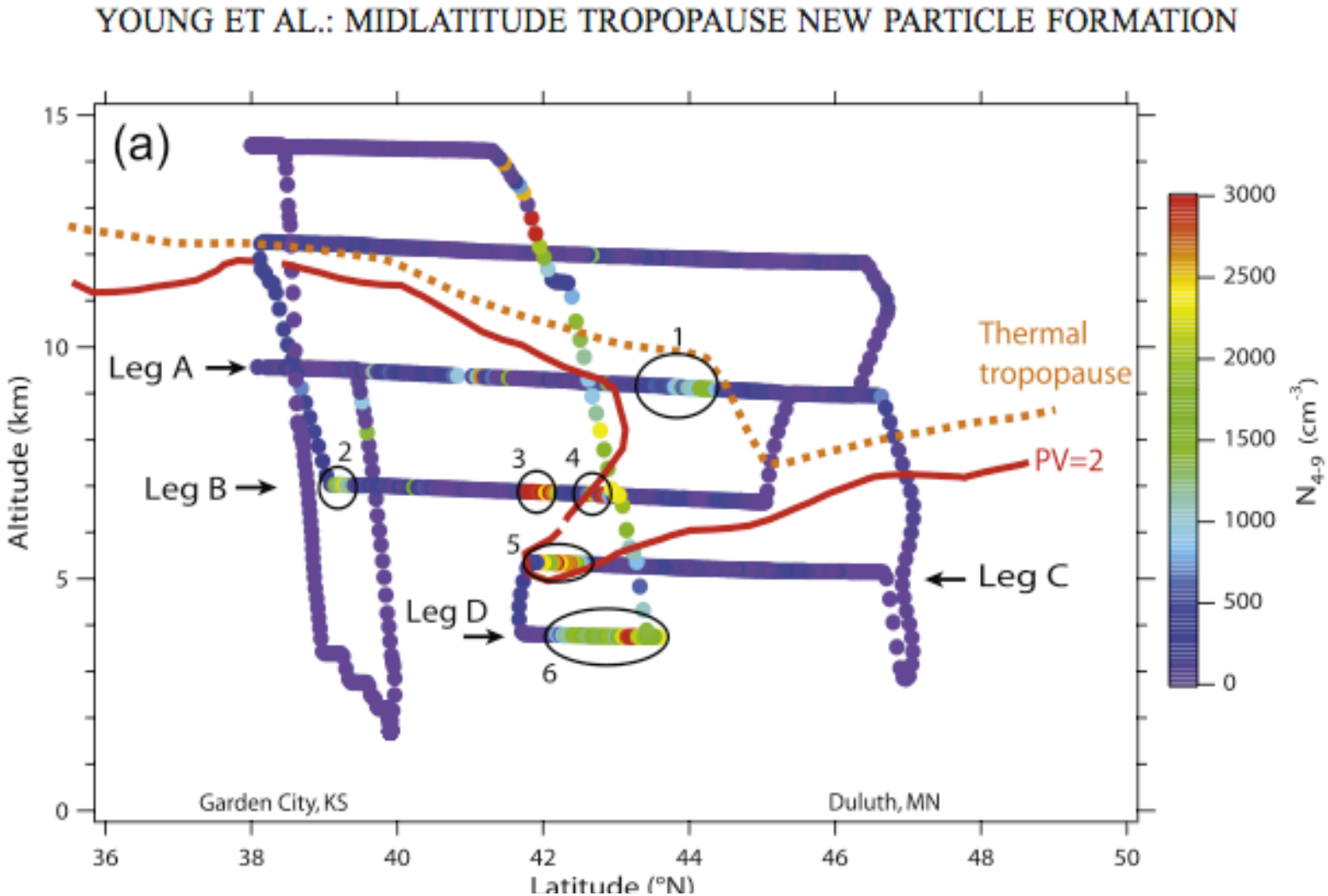




Bowman et al., 2007

New particle formation in the tropopause fold

Young et al., 2007



What more do we expect for START08?

Example:
Age spectrum based on
Tracers of different lifetimes

Ehhalt et al., 2007

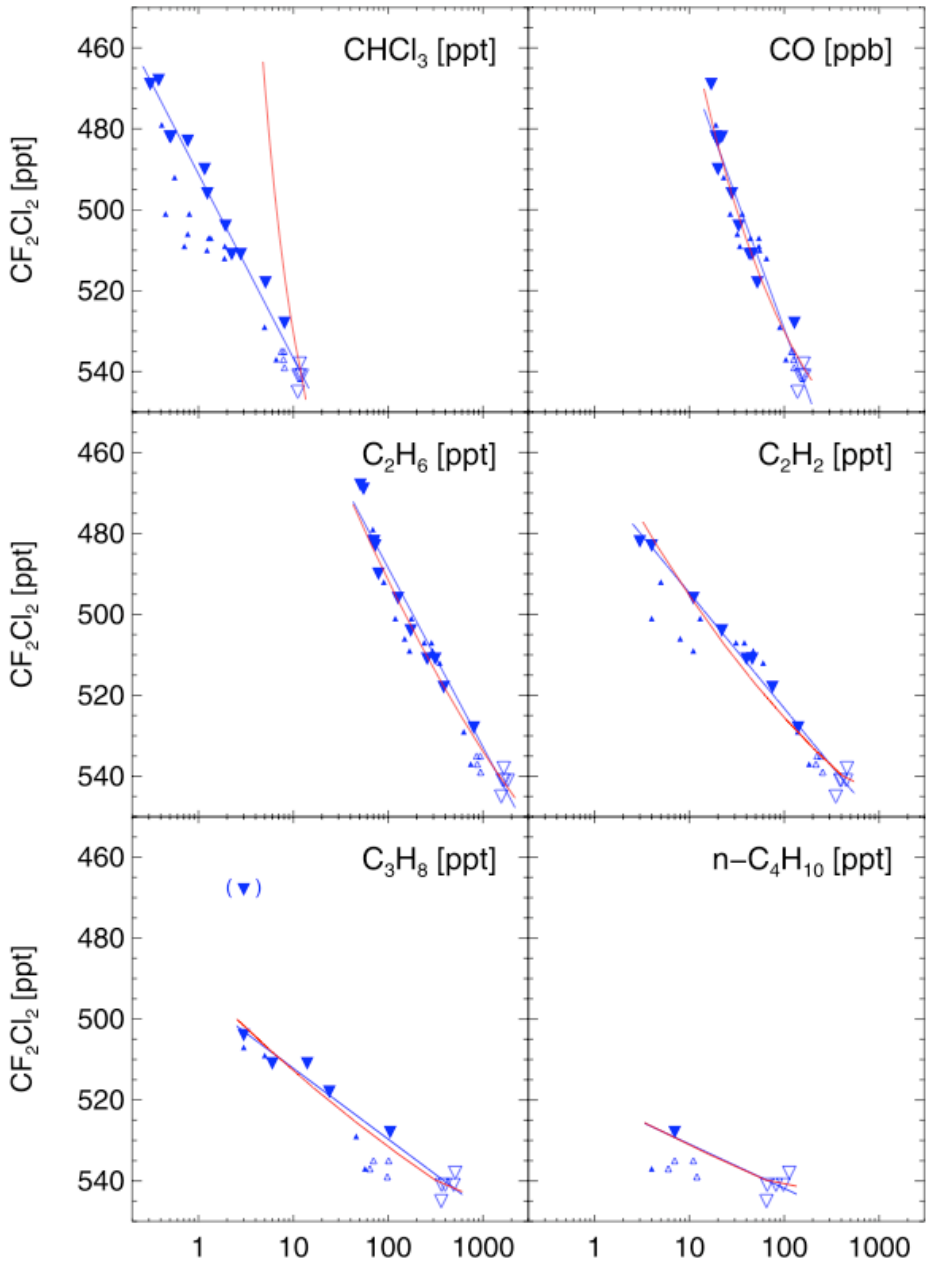


Figure 3. Vertical profiles of $CHCl_3$, CO, C_2H_6, C_2H_2, C_3H_8, and n-C_4H_{10} in the lower stratosphere with CF_2Cl_2 as the height scale from flight 20. The definition of the symbols is the same as in Figure 1. Samples collected during descent are represented by larger symbols. The straight lines represent fits of exponential functions to the data collected during descent. The respective scale heights are given in Table 1. The red

Modeling and Satellite Data Effort

- Global - MOZART-3/WACCM (Simone Tilmes, Doug Kinnison, Andrew Gettelman …)
- High res - CLaMS (Paul Konopka and colleagues, Bill Hall)
- Theoretical/idealized (GCM with baroclinic life cycle study, Lorenzo Polvani)
- MM5/WRF (Fuqing Zhang)
- WRF-Chem (ACD, …)
- Trajectory model (Ken Bowman)

- Satellite data (AIRS ozone and water vapor, AURA data? HIRDLS group?)

Instrument	*Data product*
HAIS Twin QCL	High resolution CO, CO_2, CH_4, N_2O
HAIS AWAS	Grab sampling: NMHC, HCFC, $RONO_2$, etc., etc.
PANTHER GC/MS	Medium resolution: selected trace gases (OCS, MeI, etc.)
UCATS	GC analysis:$N_2O/SF_6/H_2/CO/CH_4$; continuous O_3 & H_2O
HAIS UV O_3	1 Hz ozone measurement
NCAR NO/NO_y	High resolution NO, NO_y
RAF TDL H_2O	High resolution H_2O
HAIS SID-2	Small ice particle detector
HAIS MTP	Atmospheric temperature structure
CU-CLH	Total water measurement; thin cloud detection
NCAR O_2:N_2	Measure of O_2:N_2 ratio
RAF CN	Condensation nuclei count
RAF Particle Probes	FCAS, FSSP, 2D-C
HAIS VCSEL (optional)	High resolution, fast H_2O
RAF Fast O_3 (optional)	High resolution O_3
VUV-CO (Harvard) (optional)	High resolution CO

START08: Measurements

Instrument/Model	*Data product*	*Mission Objective*
HAIS Twin QCL	High resolution CO, CO2, CH4, N2O	Tracer studies
HAIS AWAS	Grab sampling: NMHC, HCFC, RONO2, etc., etc.	Tracer studies
PANTHER GC/MS	Medium resolution: selected trace gases	Tracer studies
UCATS*	GC analysis:CO/CH4; continuous O3 – H2O	Tracer studies
HAIS O3	1 Hz ozone measurement	Strat-trop mixing
NCAR NO/NOy	High resolution NO, NOy	Strat-trop mixing, convective NO sources
RAF TDL H2O	High resolution H2O	Microphysics, strat-trop processes
HAIS SID-2	Small ice particle detector	Cirrus microphysics
HAIS MTP	Atmospheric temperature structure	Strat-trop processes; tropopause location
CU-CLH	Total water measurement; thin cloud detection	Microphysics, strat-trop processes
NCAR O2:N2	Measure of O2:N2 ratio	Strat-trop exchange; carbon cycle objective

Optional: NCAR Fast O_3 and CO

START08: Satellite data and Modeling

Model	*Data product*	*Mission Objective*
MOZART3/WACCM	Global scale model	Flight planning/post mission analyses
MM5/WRF	High resolution regional model	Flight planning/post mission analyses
WRF-Chem	High resolution regional model with chemistry	
CLaMS	Lagrangian chemical transport model	Tropopause mixing processes
Trajectory Model TRAJ3D	Air mass trajectories	Source characterization/ transport pathways
Satellite Data	AIRS High Resolution Ozone&Water	Flight planning/post mission analyses
Satellite Data	AURA/HIRDLS	Trace gas distributions
Satellite Data	CALIPSO	cirrus cloud

Flight Resources/Operation

- 120 flight hours, 15 x 8 hr flights
- April 21-May 16, June 16-June 28
- Based at JeffCo airport

A few actions planned…

- We plan to have a workshop at NCAR Jan 2008
- A mailing list will be created for all who are interested
- A website will be created to update the information

Opportunities of collaboration

Thought starters…

- From the point of future campaign - June flights are planned to probe convective anvil - Forecast experiment for DC3 campaign?
- Expanding the impact of the in situ observations by satellite data- what would HIRDLS see?
- Model diagnostics - how well our multi-scale models at NCAR represents these dynamical, chemical and microphysical processes ?
- …


Thank You !
Shadows of Monument Valley - Flight 051209