<u>The major questions to be addressed by TC4 include:</u>

- How can space-based measurements of geophysical parameters, particularly those with small-scale variations (e.g., H_2O, cirrus), be validated?
- How do convective intensity and aerosols affect cirrus anvils?
- How do tropical cirrus evolve? How do they impact the radiation budget and ultimately the circulation?
- What controls the formation and distribution of thin cirrus in the Tropical Tropopause layer (TTL), *and what is the influence of thin cirrus on rates of radiative heating/cooling and vertical transport?*
- **What are the physical mechanisms that control (and cause) long-term changes in the humidity of the upper troposphere in the tropics and subtropics?**
- **What are the fates of short-lived compounds transported from the tropical boundary layer into the TTL (i.e., What is the chemical boundary condition for the stratosphere?)?**
- **What are the mechanisms that control ozone within and below the Tropical Tropopause Transition layer?**

WB-57 Payload

Instrument	Observations	PI
MTP	**T profiler**	Mahoney
MMS	**T, P, Lat, Lon**	Bui
FCAS, NMASS,MACS	**Aerosol size distrib** **Aerosol collector**	Wilson
SP2	**Particle soot counter**	Gao
JLH	**H_2O (1s)**	Herman
FP	**H_2O Frost Point**	Fahey
HWV	**H_2O**	Weinstock
ICOS, HOxITOPE	**H_2O isotopes**	Hanisco
CLH	**Ice Water Content**	Avallone
CSI	**Condensed Water Content**	Gandrud
CDP	**Drop size dist, ice water content**	Gandrud
CPI, 2Ds,CEM	**Cloud particle images, extinction**	Lawson
WAS/flasks	**Halocarbons, HCs, CO, CH_4**	Atlas
PANTHER/GC	**PAN, CO, CH_4, N_2O, SF_6, Cl-F-Cs**	Elkins
Argus	**CO, CH_4 (2s)**	Loewenstein
QCLS	**CO_2, CO, CH_4, N_2O**	Daube
O_3 (2)	**NOAA**	Fahey, Gao
NOx/NOy	**NO, NO_2, NO_y**	Weinhemer
CAFS	**Actinic Flux**	Shetter
REVEAL	**Real time data downlink**	

A Climatology of the Tropical Tropopause Layer

J. Met. Soci. Jap., V80, No. 4B, pp. 911--924, 2002

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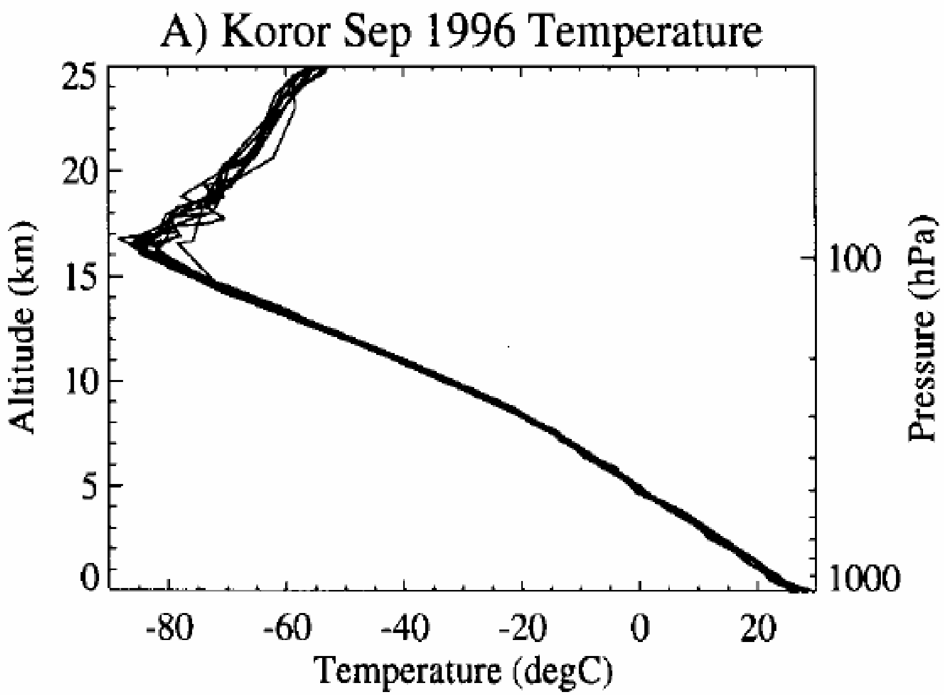


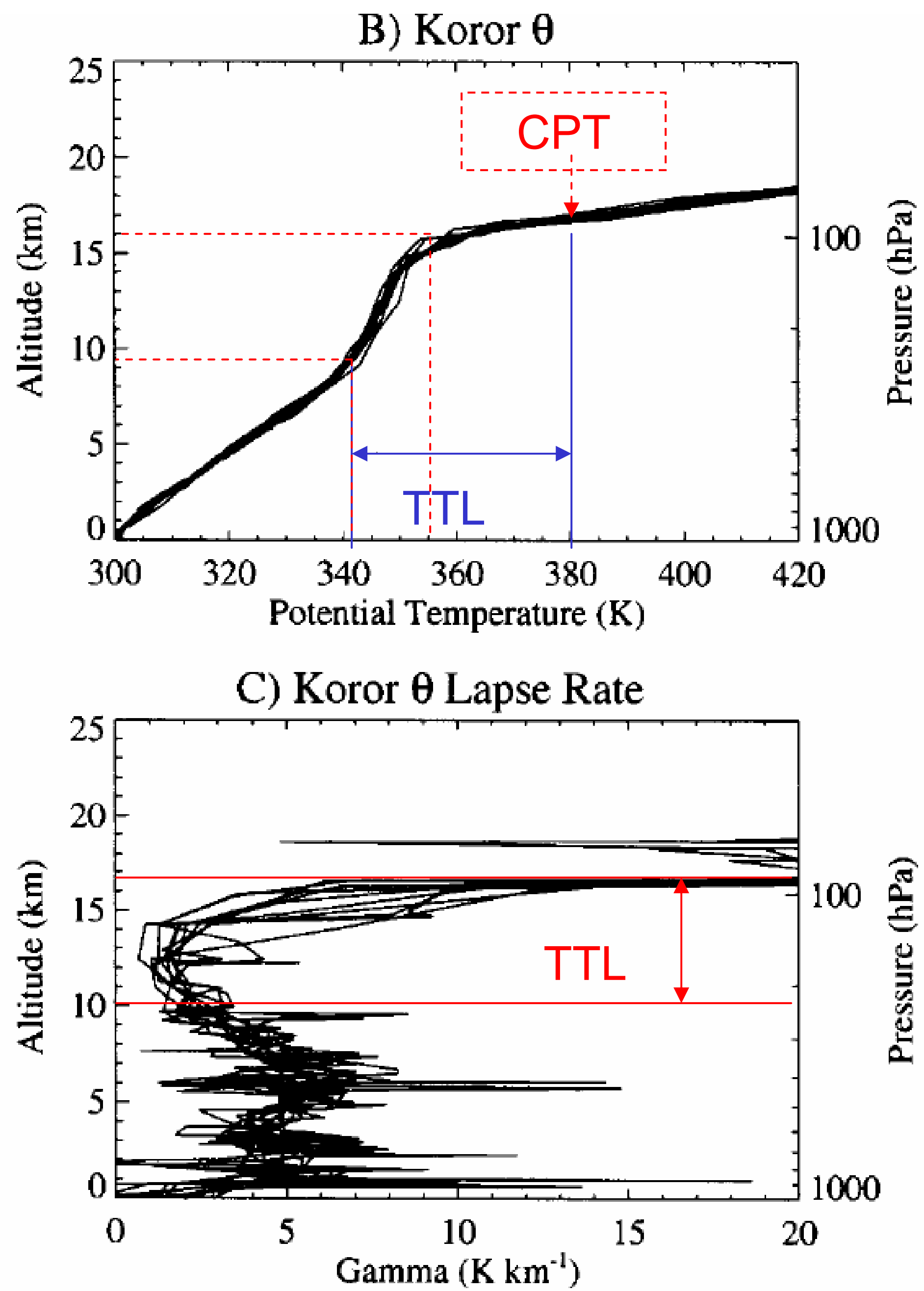
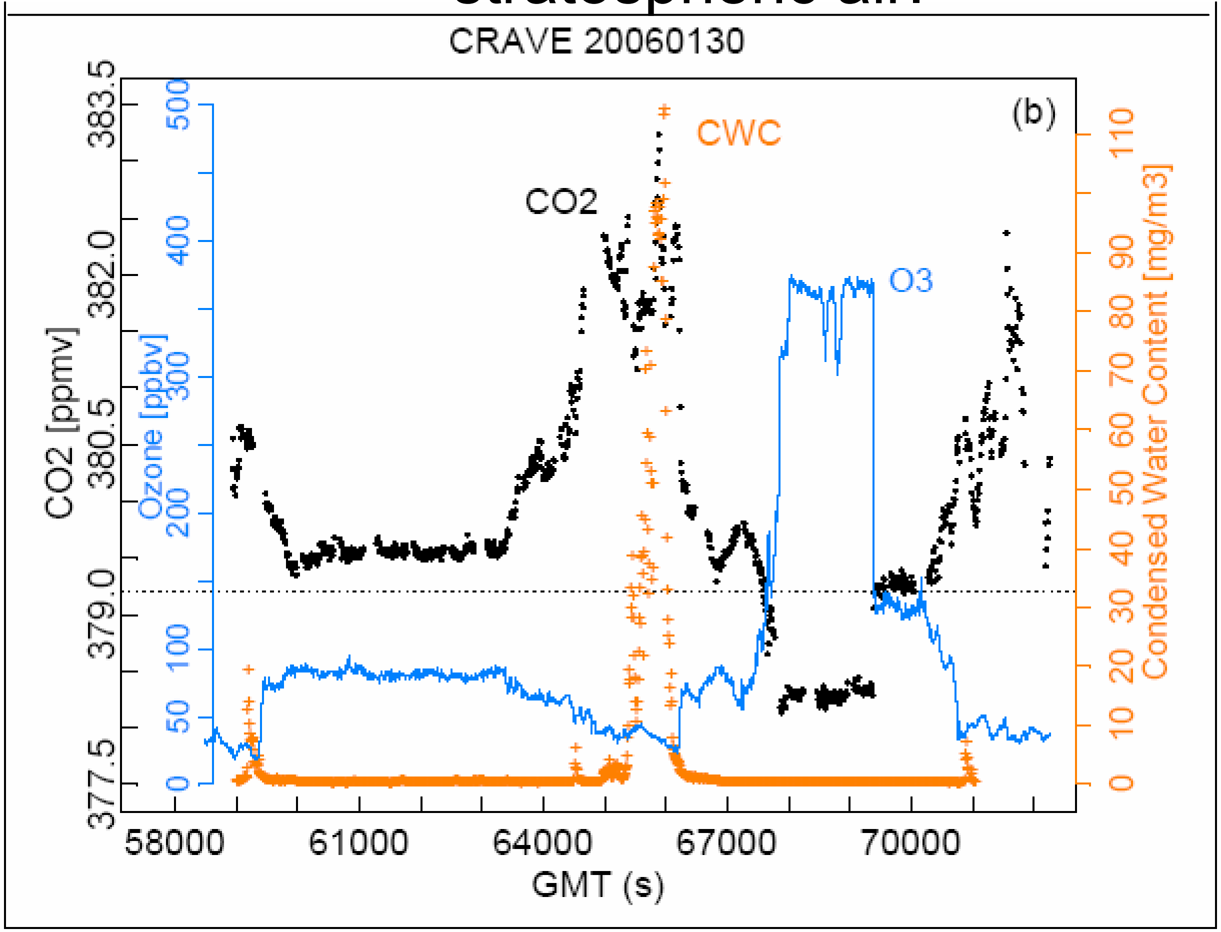


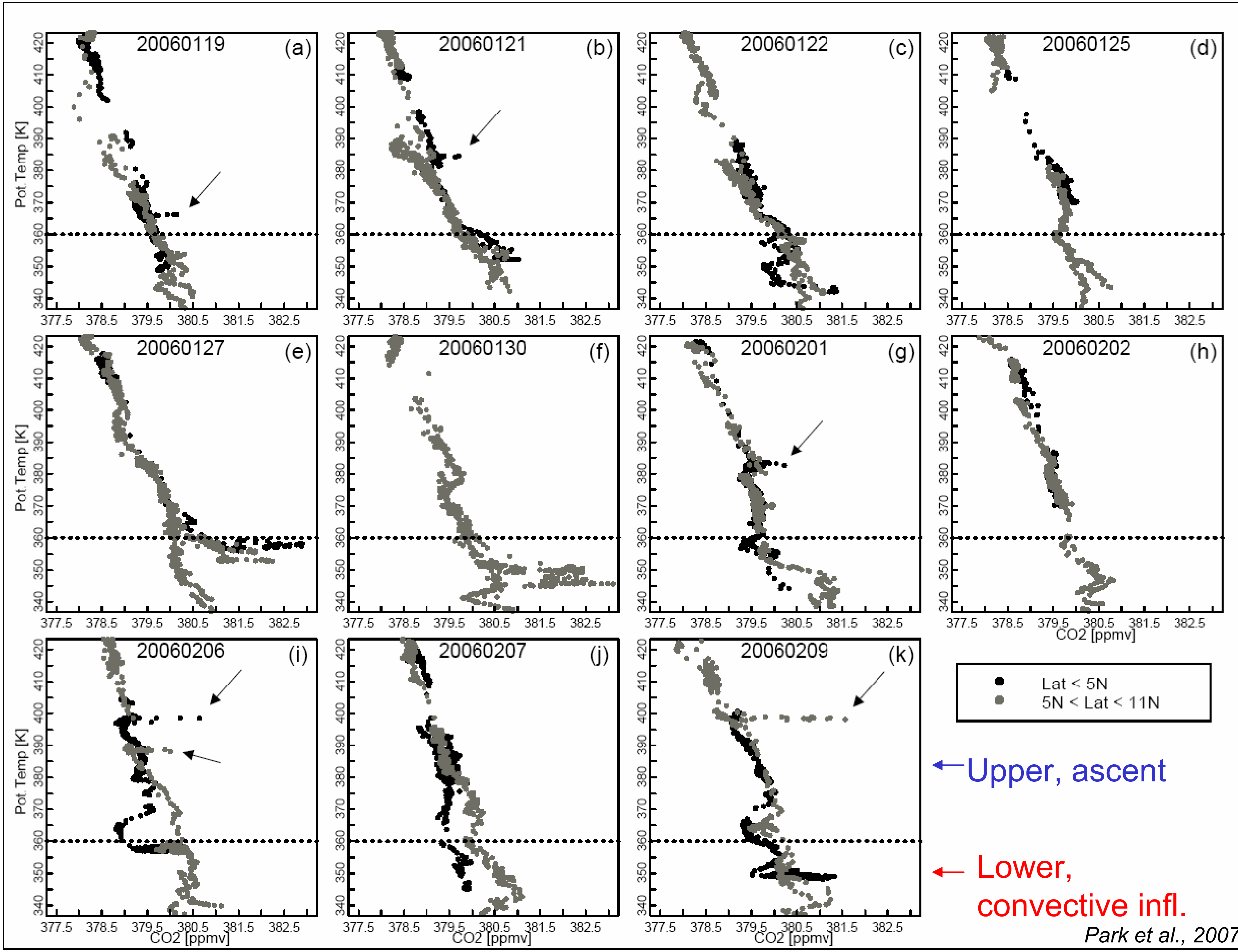
Fig. 2. Radiosonde profiles at Koror (7.3°N, 134.5°E) in September 1996 for A) temperature, B) potential temperature (θ) and C) potential temperature lapse rate. 39 soundings plotted.

Trace gases delineate influence of convection and stratospheric air.

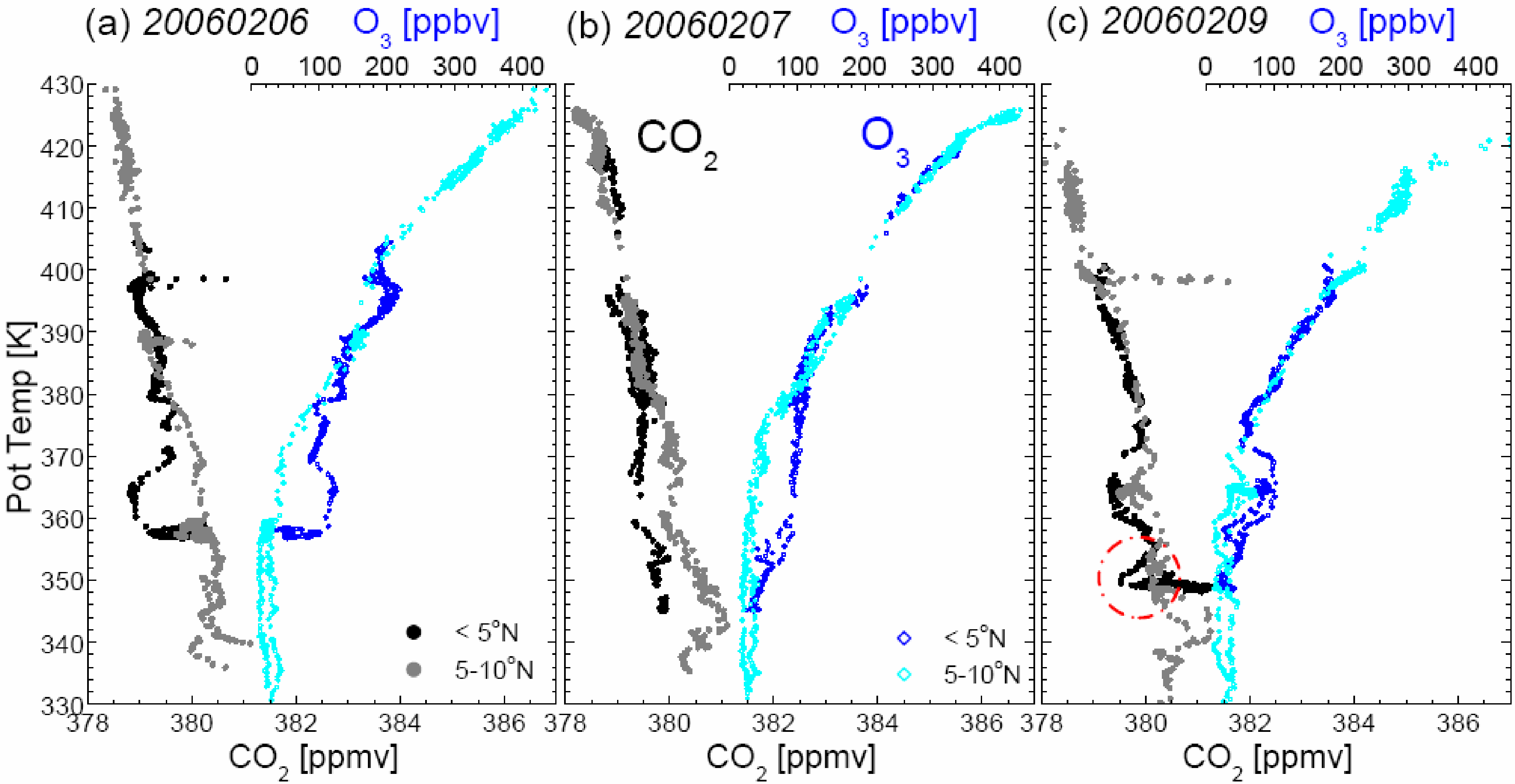


Flight segments for CO_2, O_3 and condensed water content (CWC) **(a)** on January 27th and **(b)** on the 30th. The CO_2 peaks that correspond to CO_2 spikes in the vertical profiles (Figs. 2(e) and 2(f)), are clearly responding to enhanced condensed water content in the outflow of convective clouds. Note high O_3 and low CO_2 mixing ratios on the stratospheric side. Horizontal dotted line represents a CO_2 level at the tropopause. Black, solid dots give CO_2, blue lines for O_3, and orange, cross symbols for CWC.

Park et al., 2007



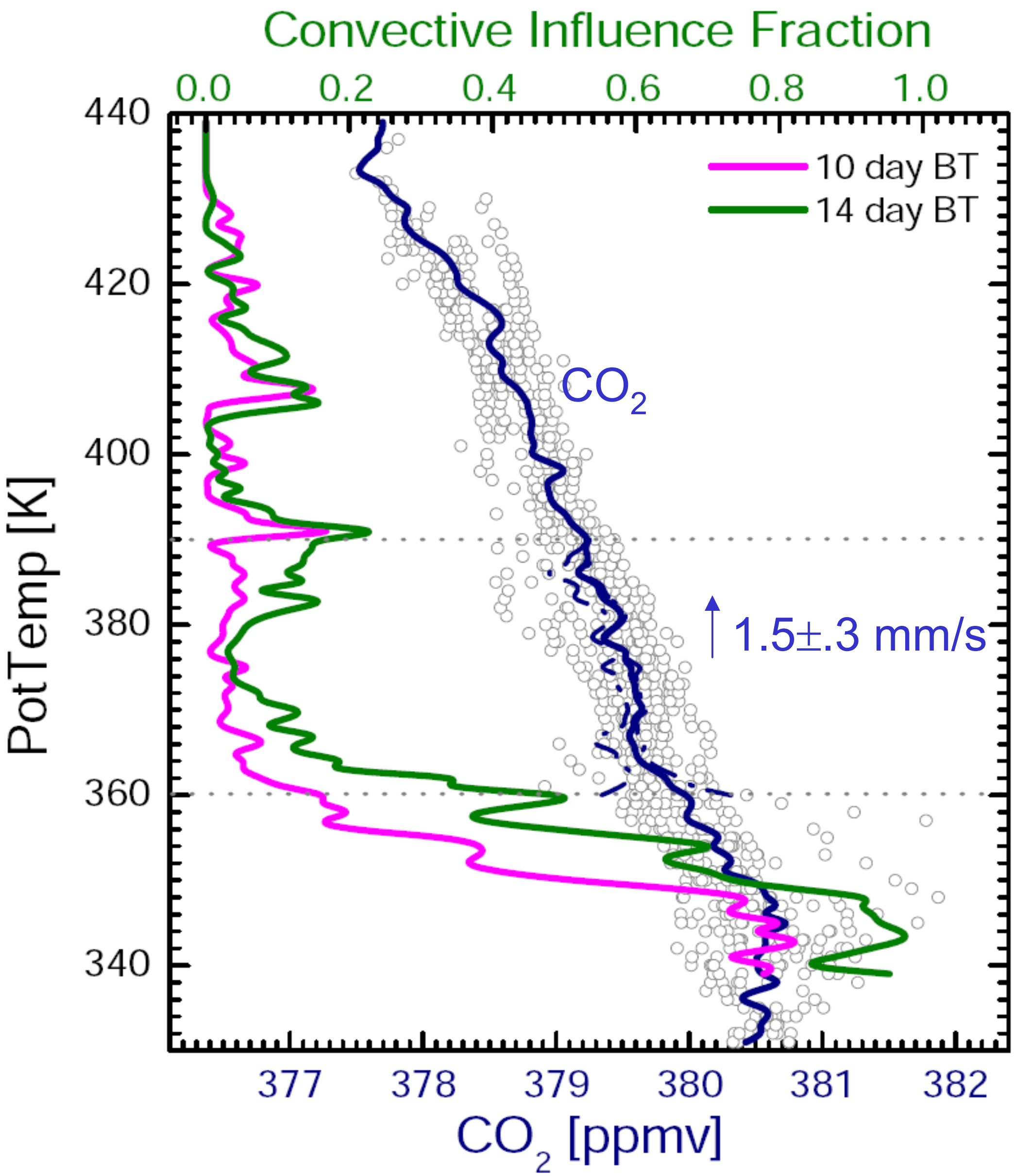
20060119 (a)
20060121 (b)
20060122 (c)
20060125 (d)
20060127 (e)
20060130 (f)
20060201 (g)
20060202 (h)
20060206 (i)
20060207 (j)
20060209 (k)
Pot.Temp [K]
CO2 [ppmv]
Lat < 5N
5N < Lat < 11N
Upper, ascent
Lower, convective infl.
Park et al., 2007

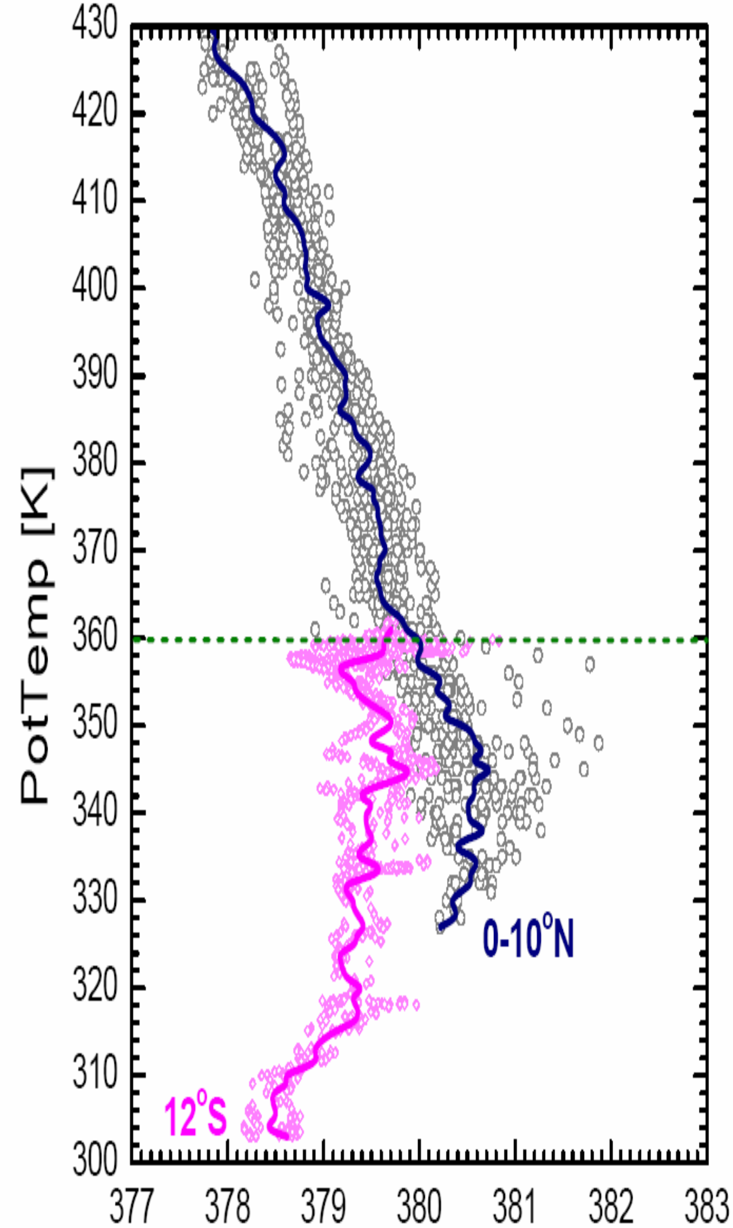


Structure and Morphology of the TTL

Fig. 3. Vertical profiles of CO_2 (denoted by solid dots) and O_3 (by blue diamonds) on February 6**(a)**, 7**(b)**, and 9**(c)**. *Low CO_2 bulges* from < 5°N are responding to high ozone signals, suggesting stratospheric air input. Note dotted circle on Feb. 9 marks the air mass influenced from deep convection over Amazon basin, discussed in section 3.2.2.

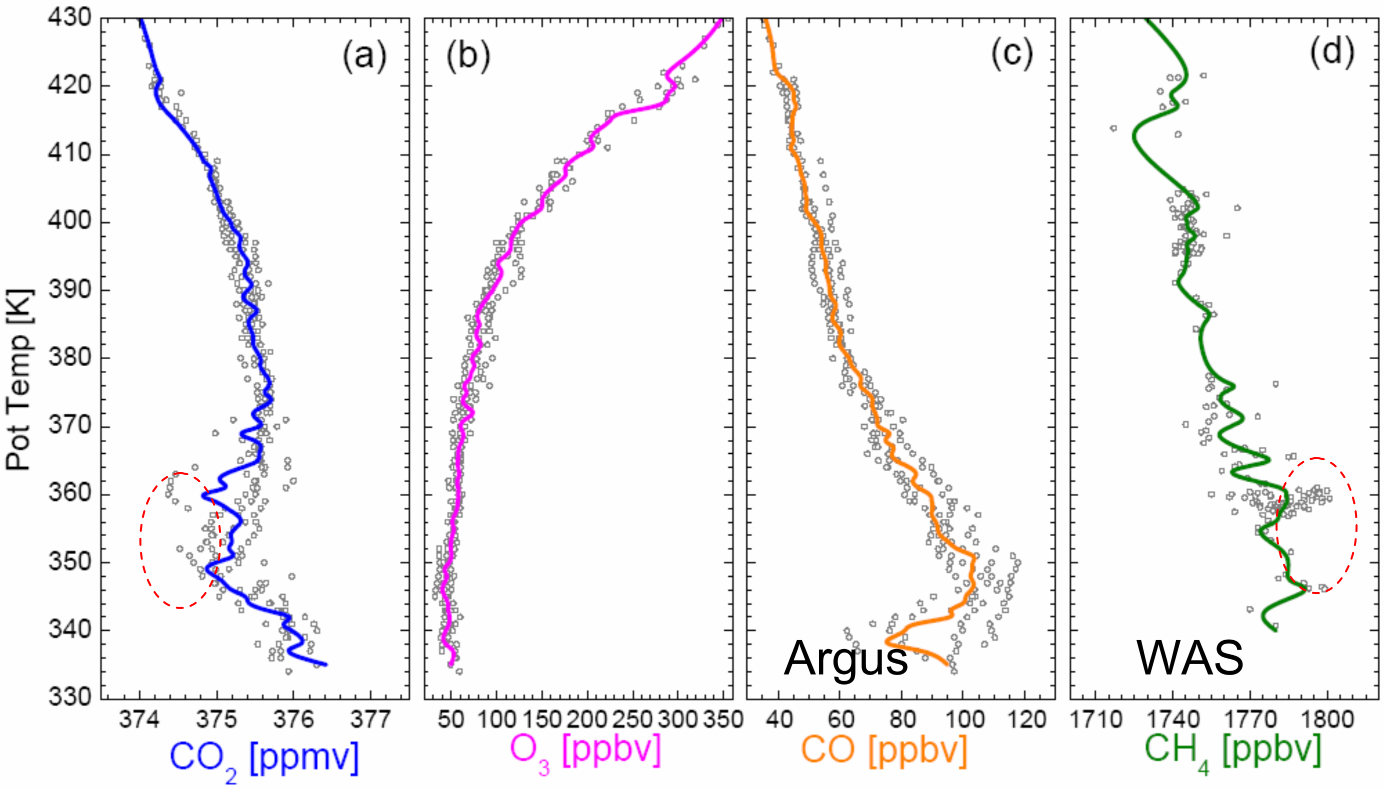
N/S Difference in the TTL



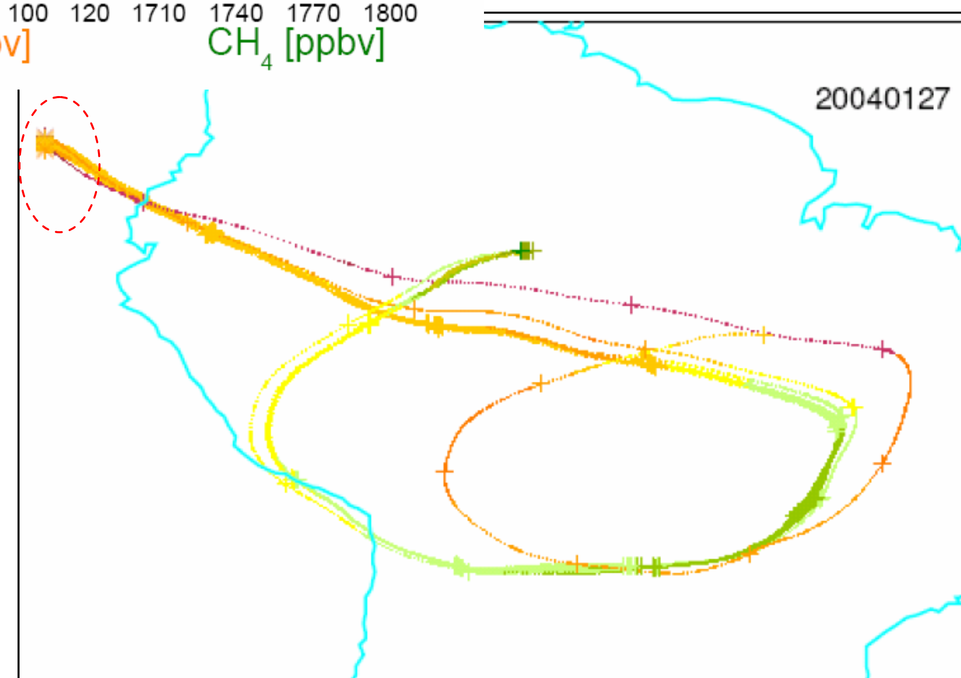


Ascent rates, convective influence, Jan-Feb (CRAVE, Pre-AVE

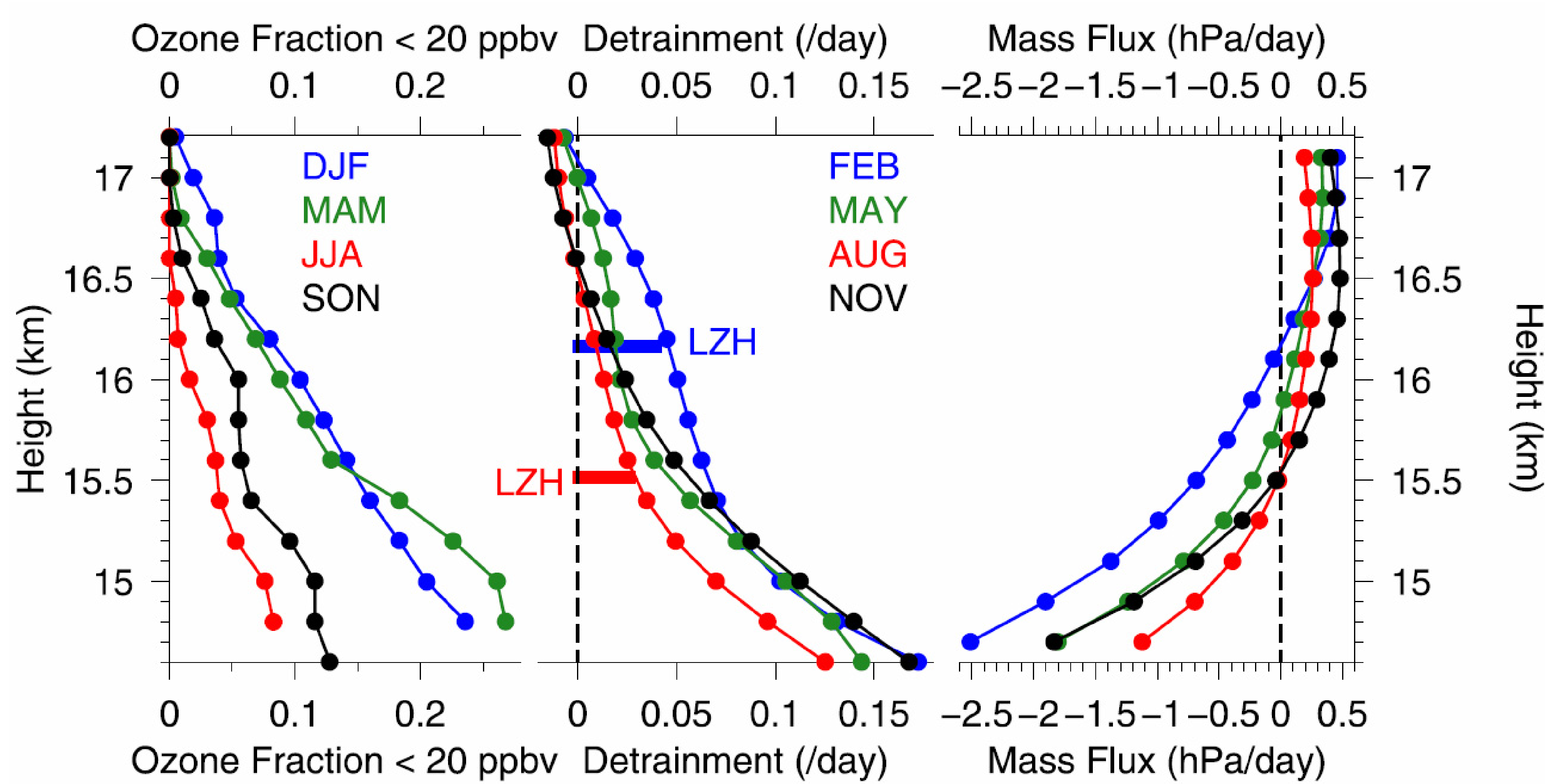
Park et al., 2007



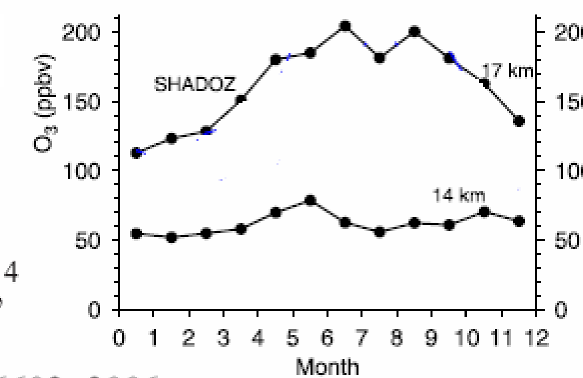
Influence of deep convection over Amazonia, delineated by back trajectories and trace gases



Level of Zero radiative Heating (LZH)



Lower tropopause, less convective infl, in July ??



Seasonal cycles of O_3, CO, and convective outflow at the tropical tropopause

Ian Folkins,[1] P. Bernath,[2] C. Boone,[2] G. Lesins,[1] N. Livesey,[3] A. M. Thompson,[4] K. Walker,[2] and J. C. Witte[5]

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L16802, doi:10.1029/2006GL026602, 2006

"In the tropics, very high clouds with cloud top temperatures less than 200 K are observed more frequently during Northern Hemisphere (NH) winter than summer [Zhang, 1993]. One would expect an increased incidence of very high clouds to be associated with an increased incidence of high altitude convective outflow."

"The age of air at 17 km varies from 40 days during NH winter to 70 days during NH summer."

Seasonal cycles of O_3, CO, and convective outflow at the tropical tropopause

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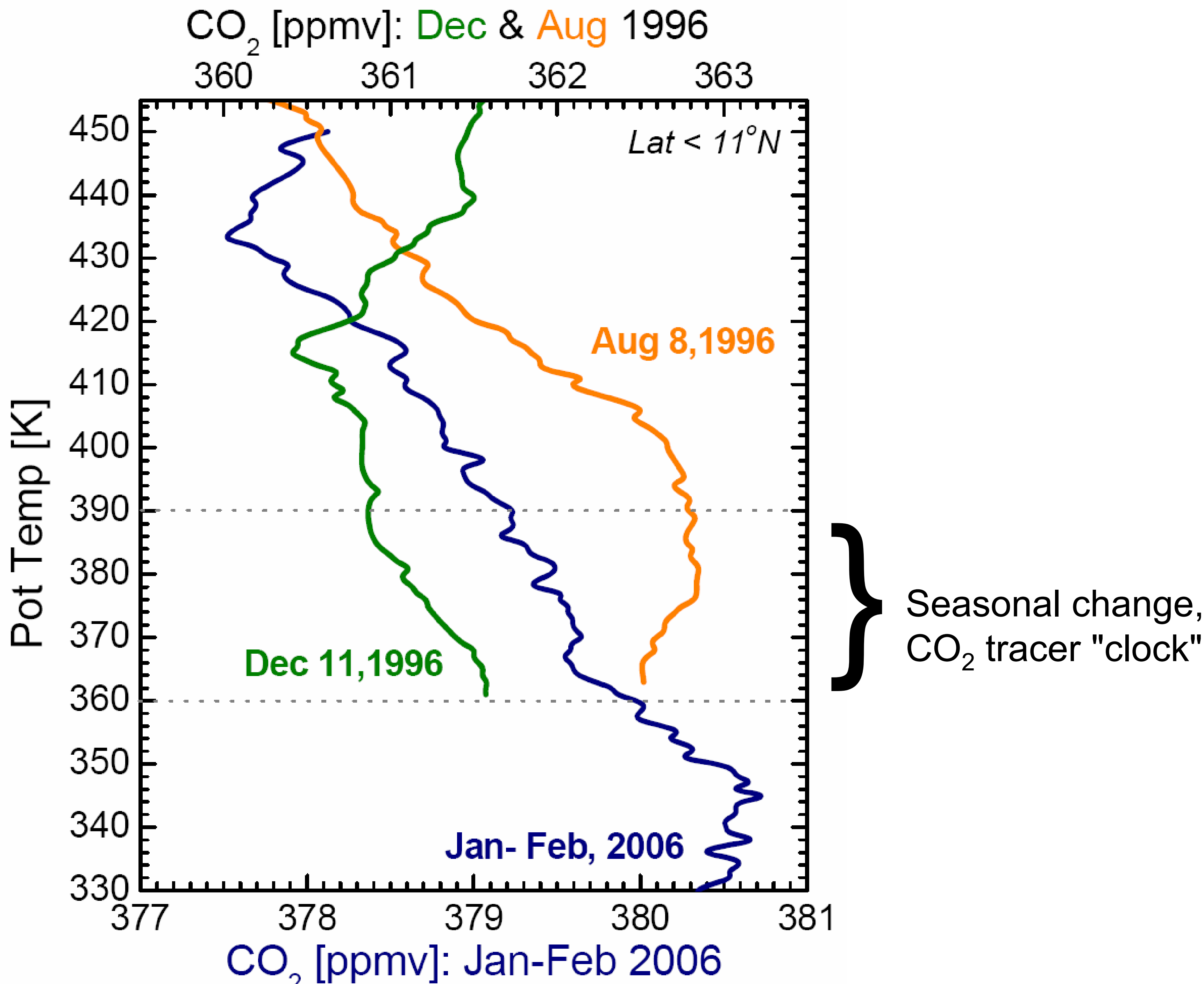
CO2 [ppmv]: Dec & Aug 1996
360
361
362
363
Lat < 11°N
Aug 8,1996
Dec 11,1996
Jan- Feb, 2006
Pot Temp [K]
450
440
430
420
410
400
390
380
370
360
350
340
330
377
378
379
380
381
CO2 [ppmv]: Jan-Feb 2006
Seasonal change,
CO2 tracer "clock"

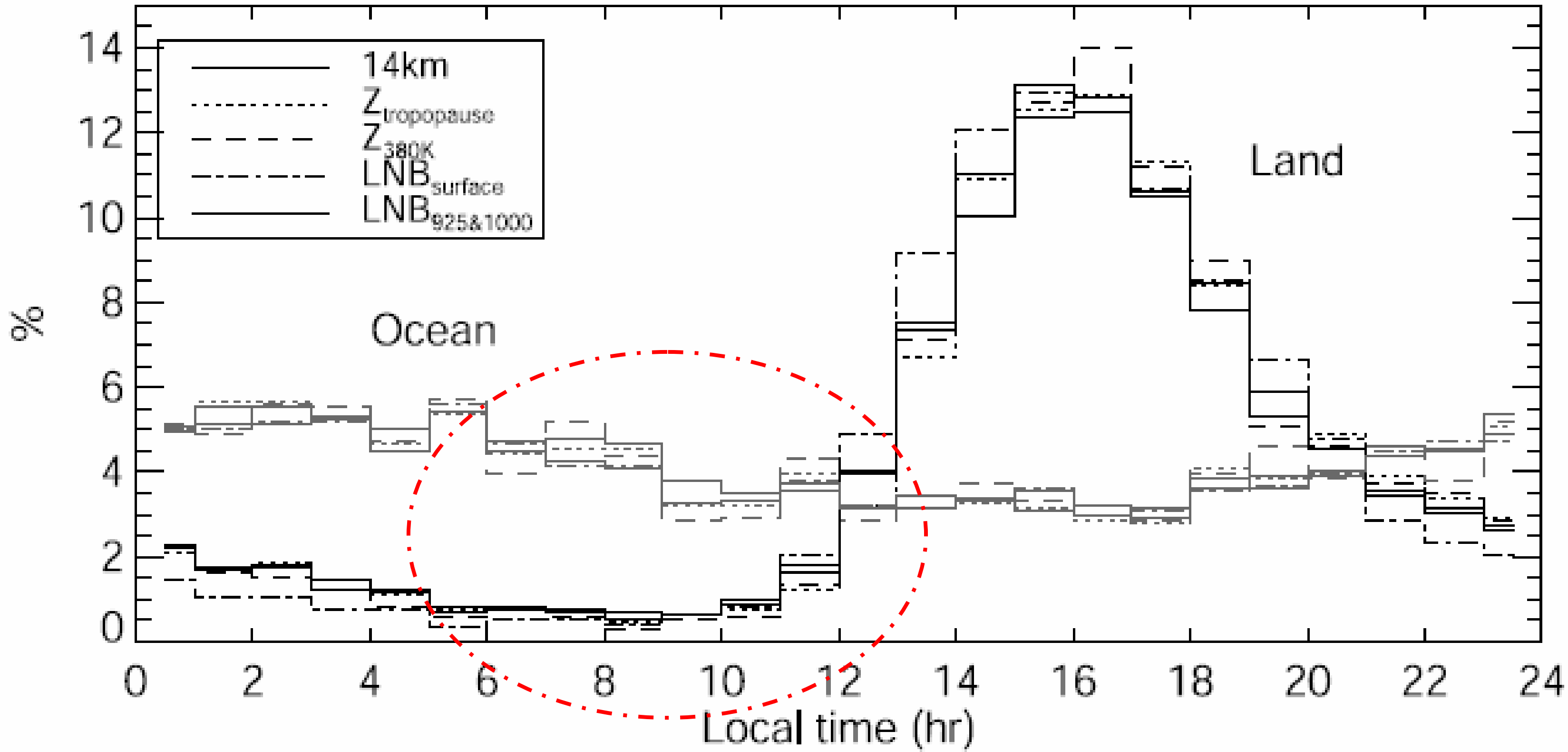

Figure 3. Diurnal variation of population of 20°N–20°S OPFs identified with five reference heights over land (solid) and ocean (shaded).

We will not be able to sample deep convection outflows over land!

Mission strategies *for these objectives…*:

•Determine Convective influence on H_2O and Composition

•Define Chemical Boundary Condition and TTL composition.
Where does the air come from, where does it end up?

•Measure *Large Scale* Transport (Advection, Mixing) Rates

…will focus on:

Clear-sky flying: sample the full range of latitudes and altitudes in the TTL and LS.

Clouds and outflows: measure *both* near and far field outflows and anvils from active and decaying convection.

Sampling of lower altitudes (source air) included as possible.