

Identification of the Tropical Tropopause using O_3 - H_2O Tracer Correlation

from the ATTREX experiment

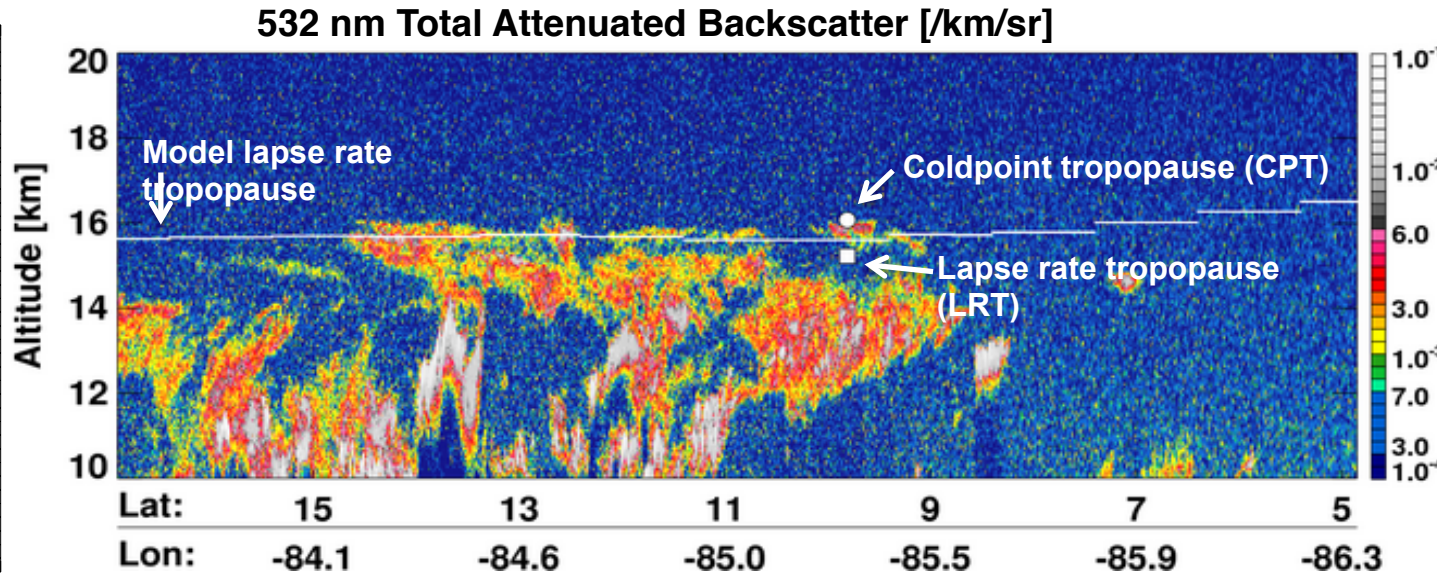
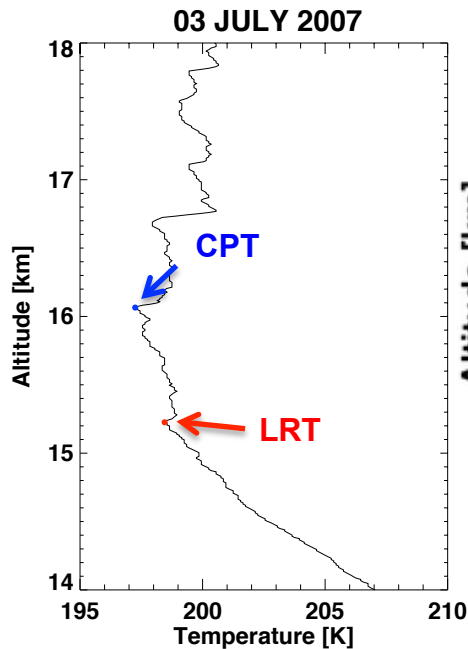
Laura Pan and Shawn Honomichl

With contributions from

**Troy Thornberry, Andrew Rollins, Ru-shan Gao,
David Fahey, and Paul Bui**

In the tropics, the tropopause can be defined by both the lapse rate criteria (WMO, 1957) (**LRT**), or the temperature minimum (the cold point tropopause, **CPT**)

Evidence that both tropopauses can affect cloud structure



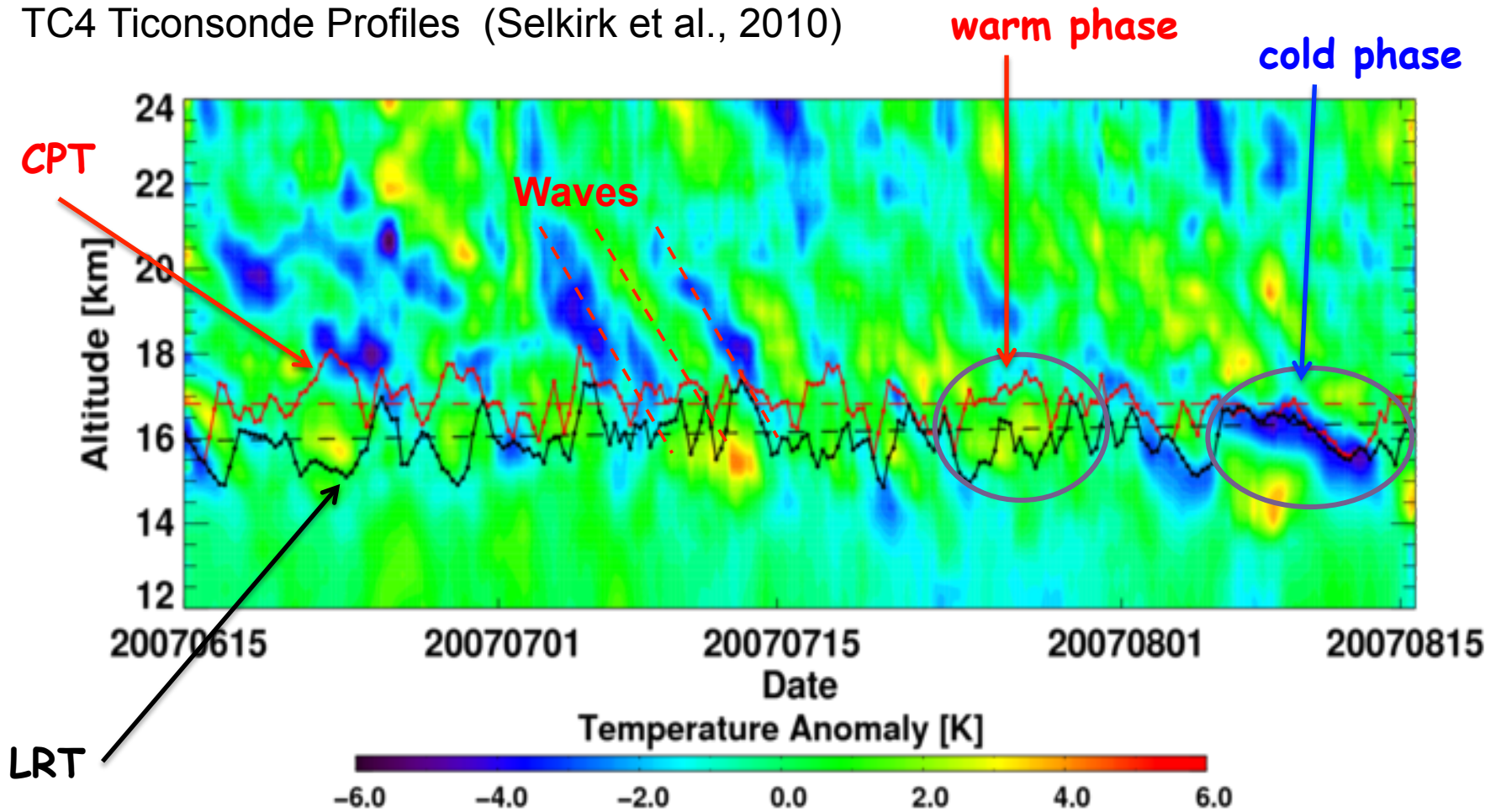
Radiosonde profile during the TC4 campaign, Costa Rica and co-located CALIPSO

Pan and Munchak, 2011

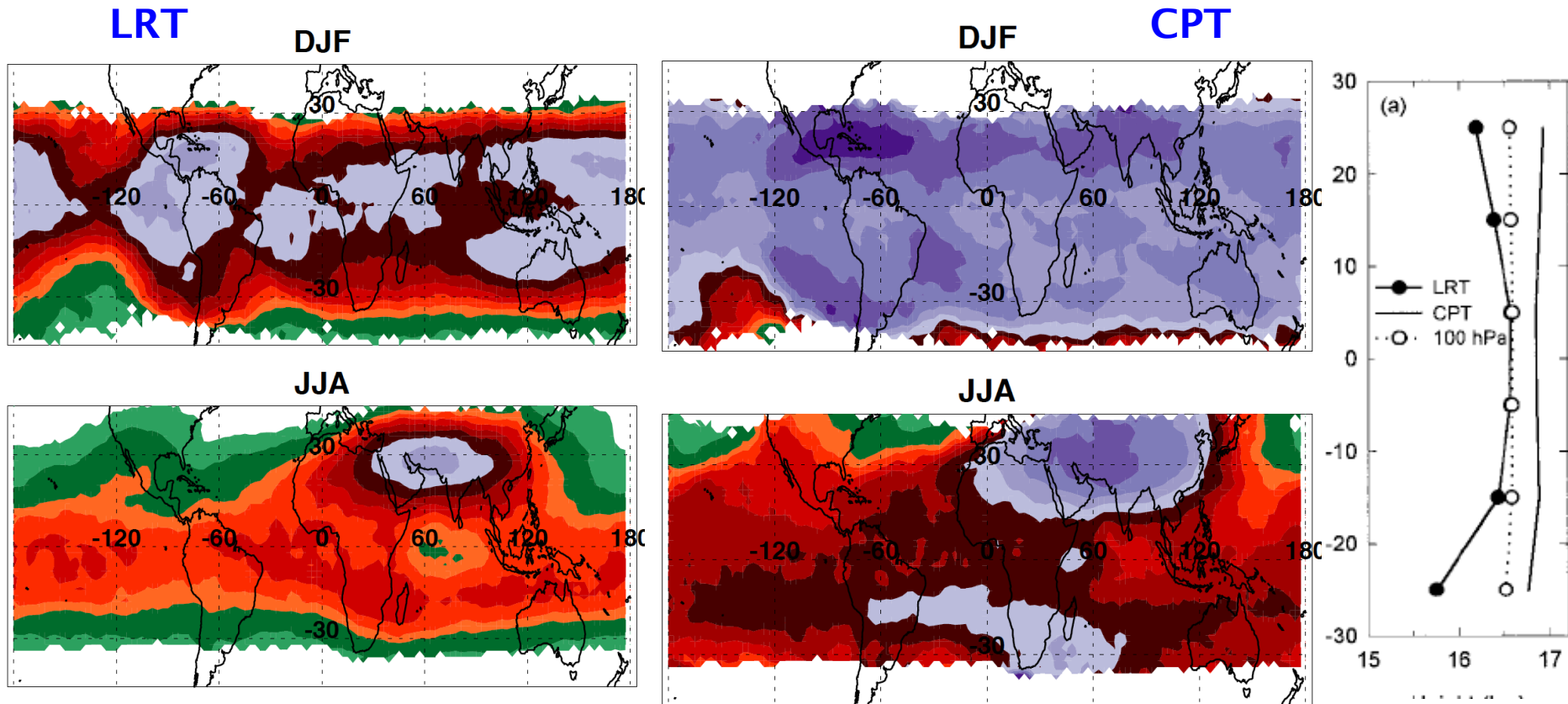
Vertical view of CPT/LRT separations

- Timeseries from Costa Rica during the TC4 campaign

TC4 Ticonsonde Profiles (Selkirk et al., 2010)



Seasonal Average of LRT and CPT from COSMIC GPS data



15.0 15.5 16.0 16.2 16.4 16.6 16.8 17.0 17.2 17.4 17.6 17.8 18.0

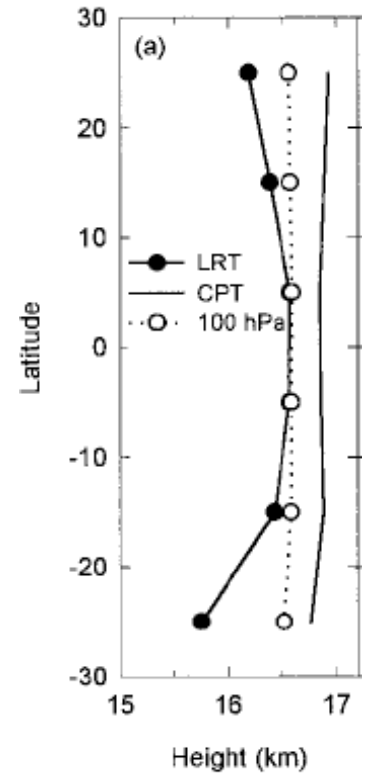
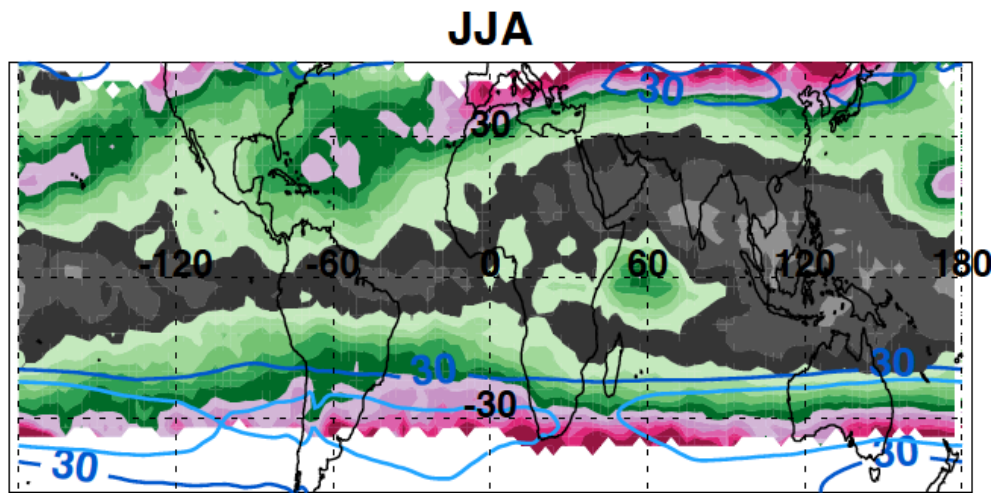
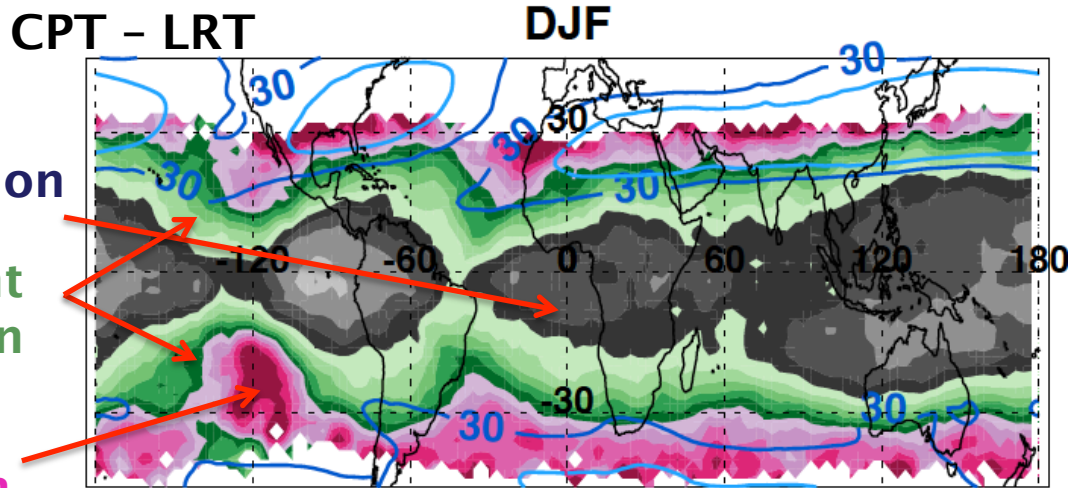
LRT or CPT Height [km]

Seidel et. al.,
2001

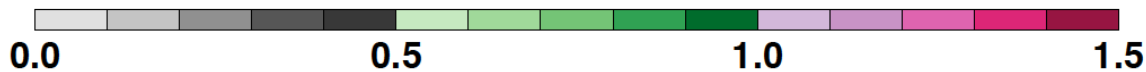
Laura Pan, Joint Pacific Experiment
STM, Oct. 21, 2014

Munchak and Pan, 2014

Seasonal Average of LRT and CPT Separation from GPS data



CPT/LRT Separation [km]



Seidel et. al., 2001

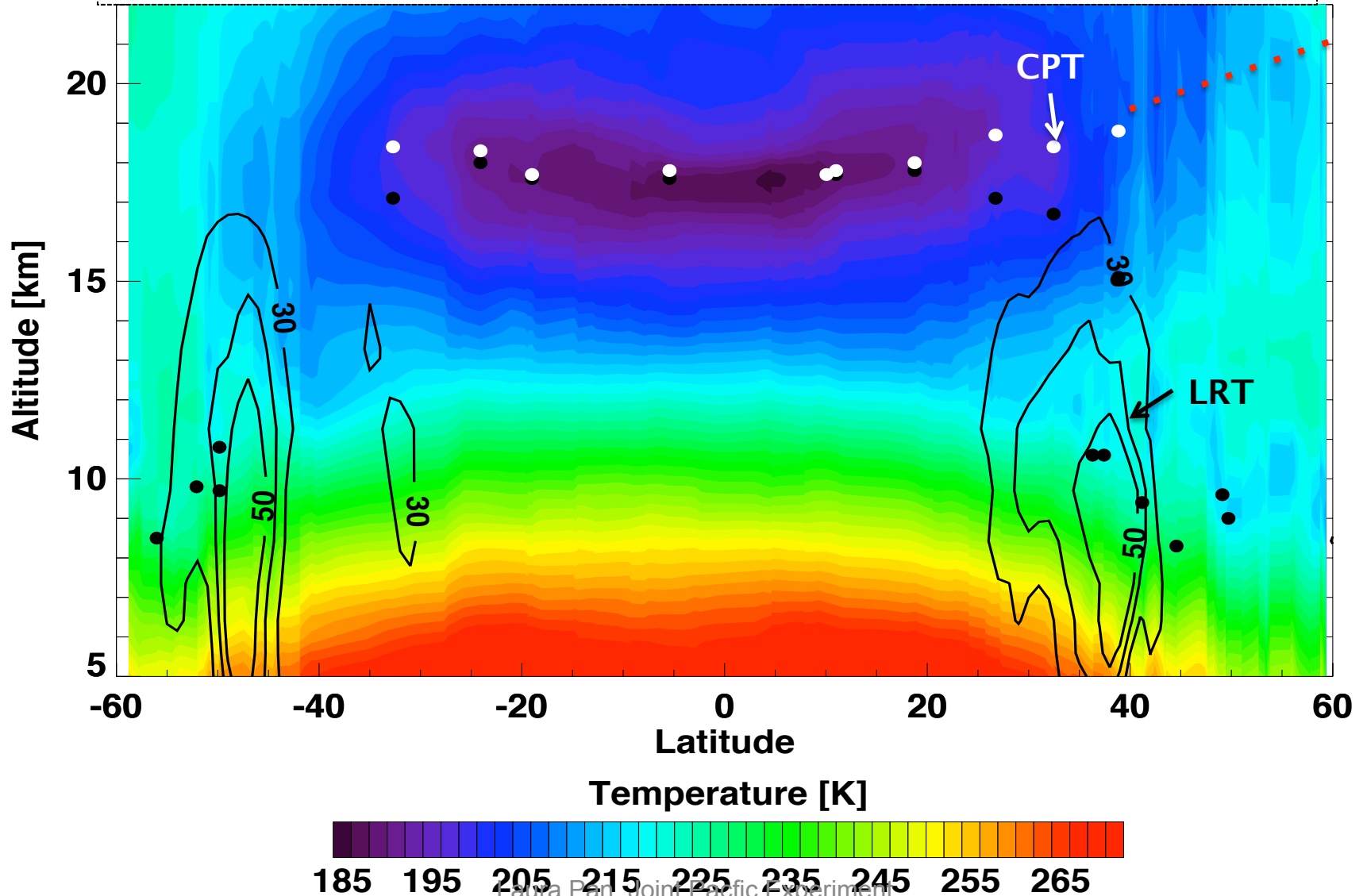
Laura Pan, Joint Pacific Experiment
STM, Oct. 21, 2014

Munchak and Pan, 2014

Issues of the Tropical Tropopause

- **Significant differences exist between the CPT and LRT –**
 - **Which one is a “better physical boundary”?**
- **If CPT, when and where does it stop being a meaningful definition of the tropopause ?**

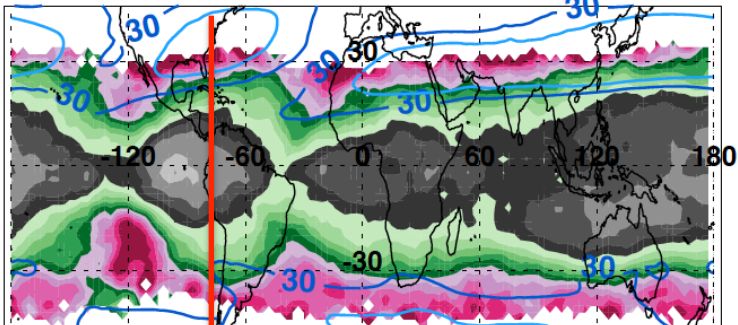
Temperature cross section
GPS profiles $90^{\circ}\text{W} \pm 5^{\circ}$, the week of Feb 09, 2009
LRT/CPT, Feb 12 2009



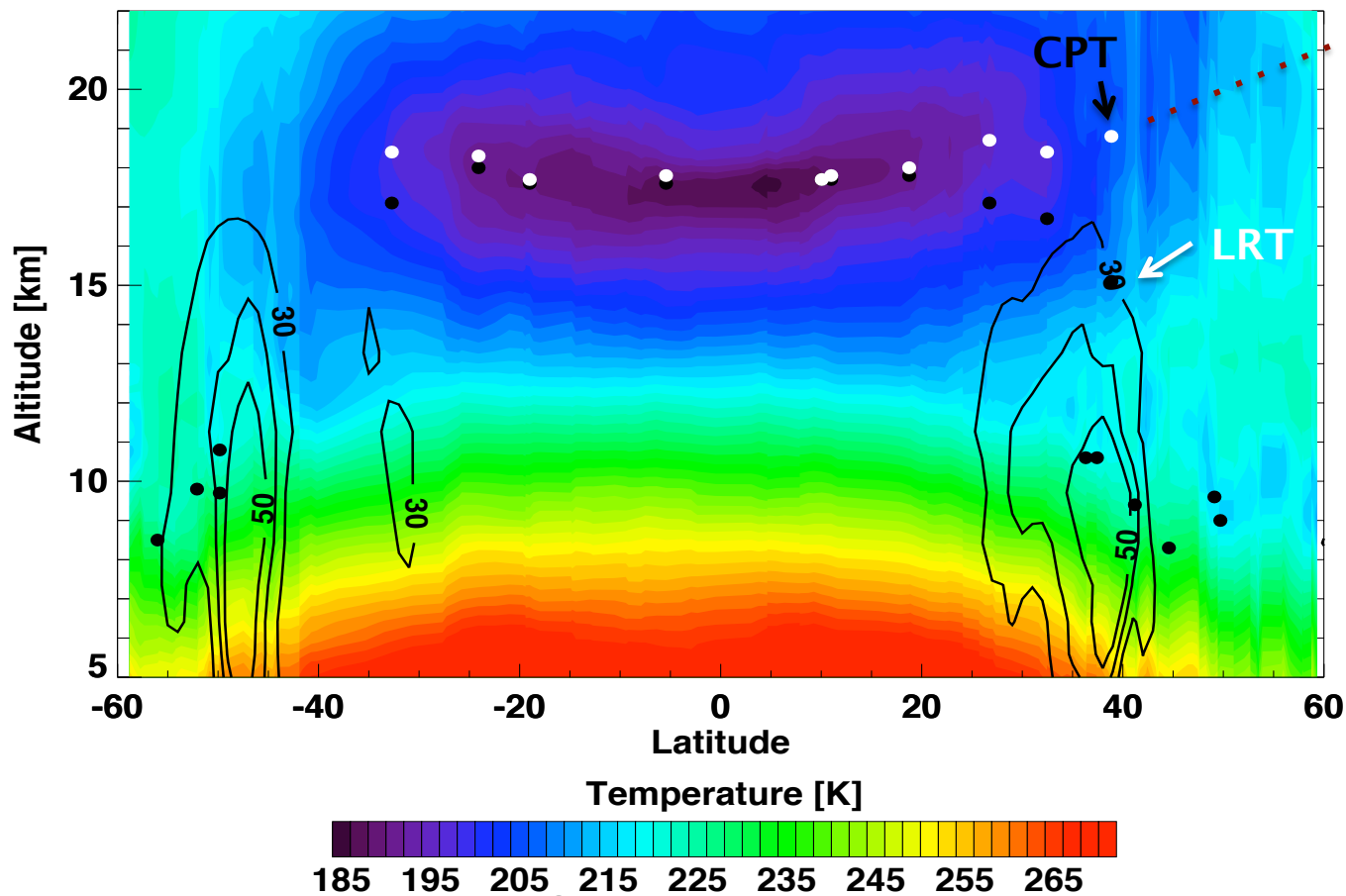
185 195 205 215 225 235 245 255 265

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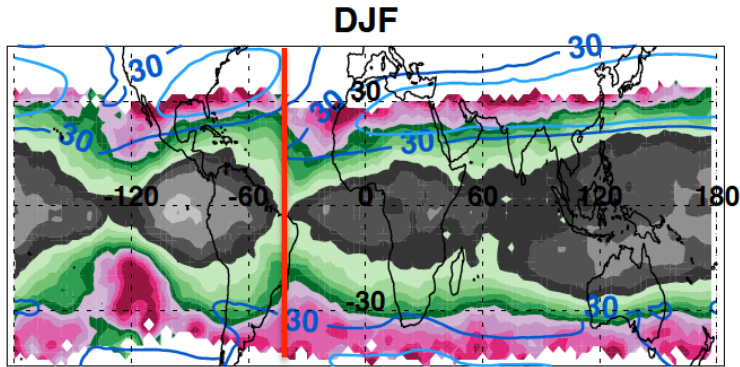
DJF



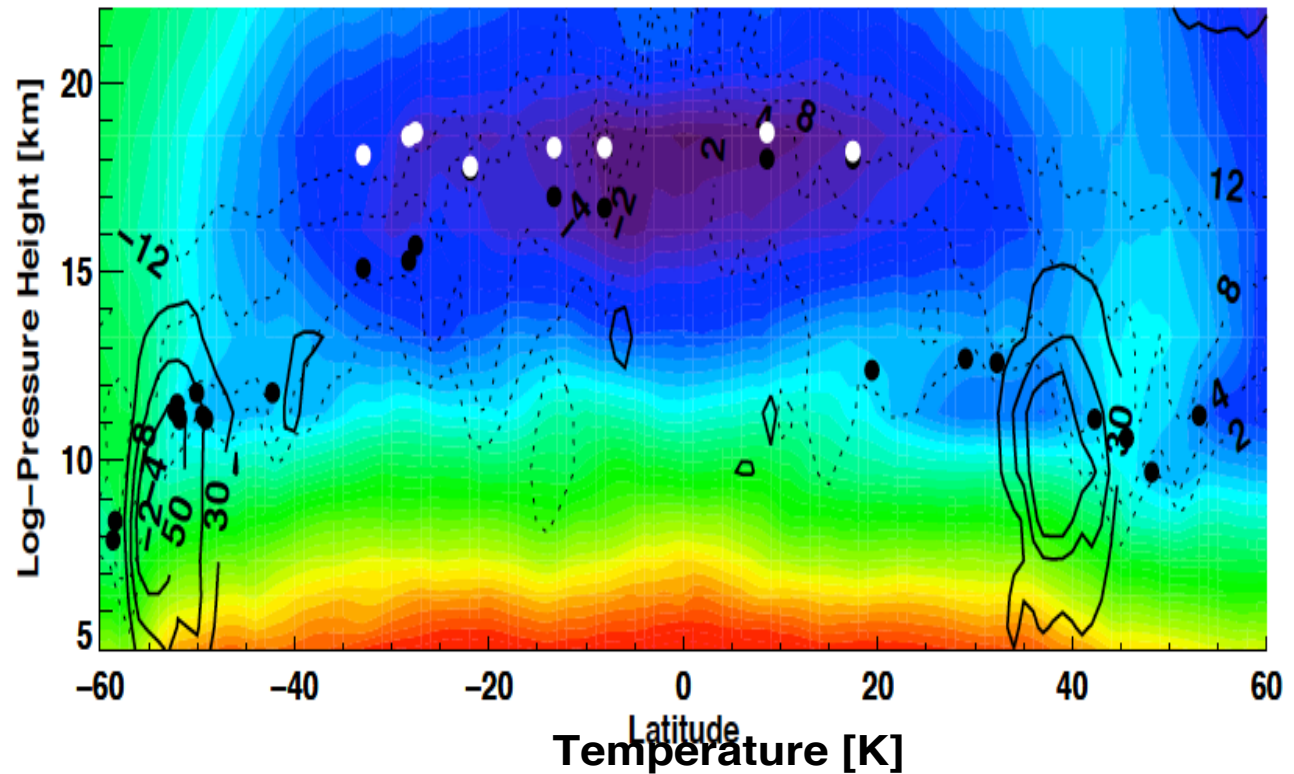
Temp cross section
GPS profiles $90W \pm 5^\circ$, the week of
Feb 09, 2009
LRT/CPT, Feb 12 2009



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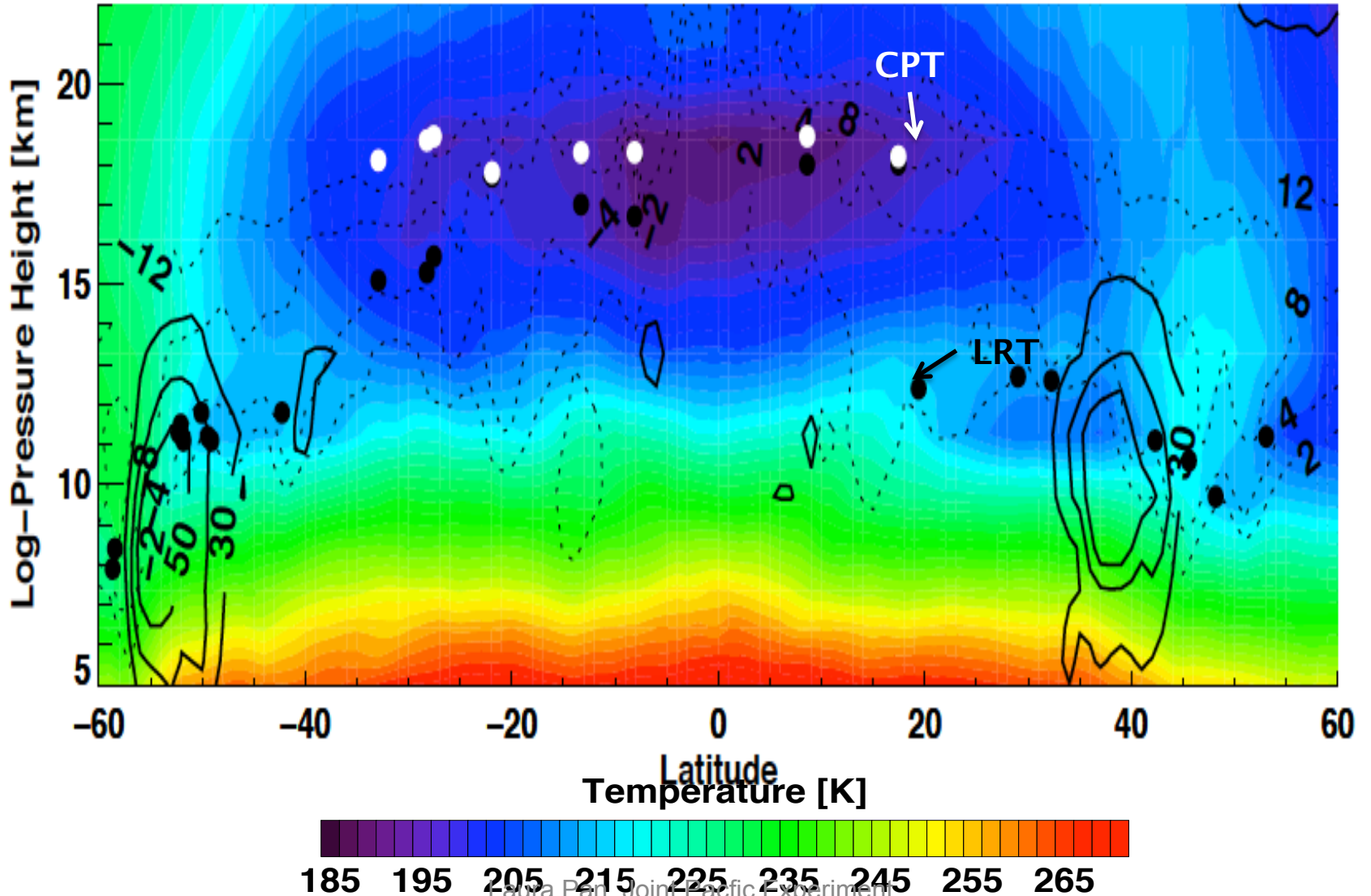
Temperature cross section
GPS profiles $35W \pm 5^\circ$, the week of
Jan 05, 2010



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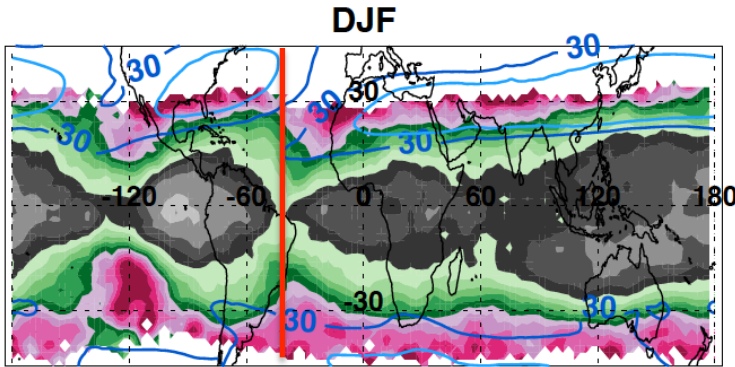
185 195 205 215 225 235 245 255 265

Temperature cross section
GPS profiles $35W \pm 5^\circ$, the week of Jan 05, 2010

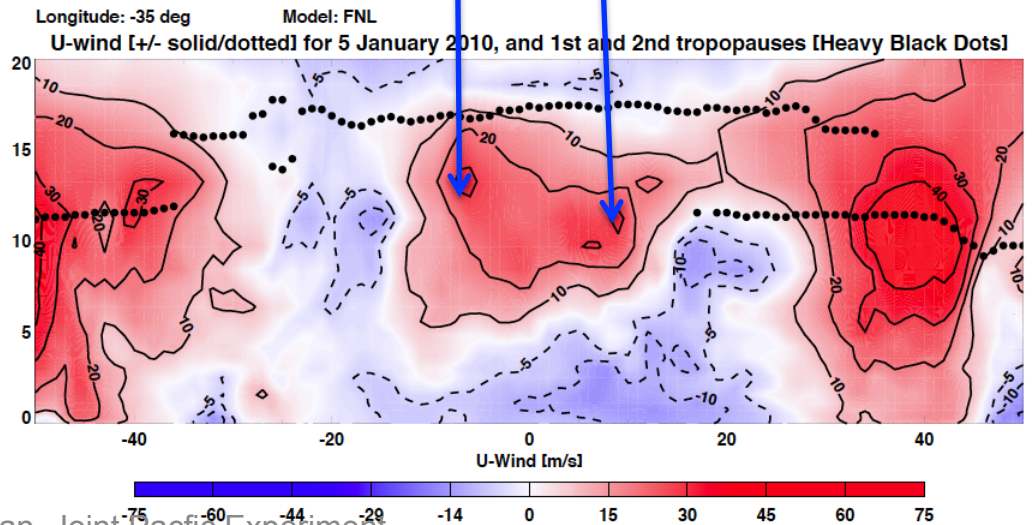
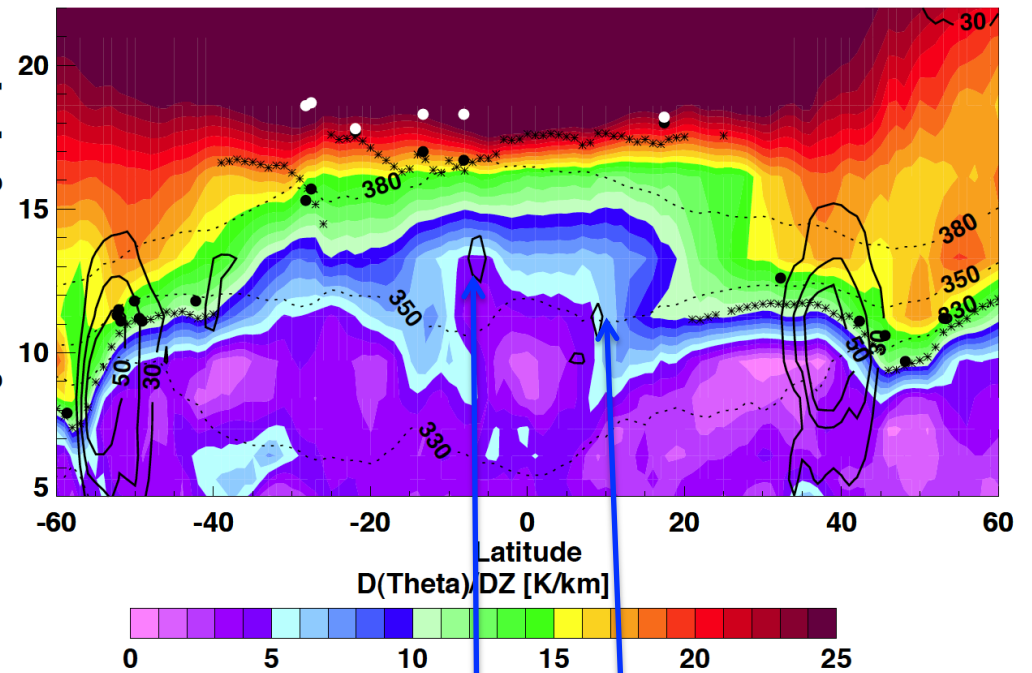


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05 Jan 2010 12:00 UTC, lon = -35



B. Static Stability
C. Zonal wind

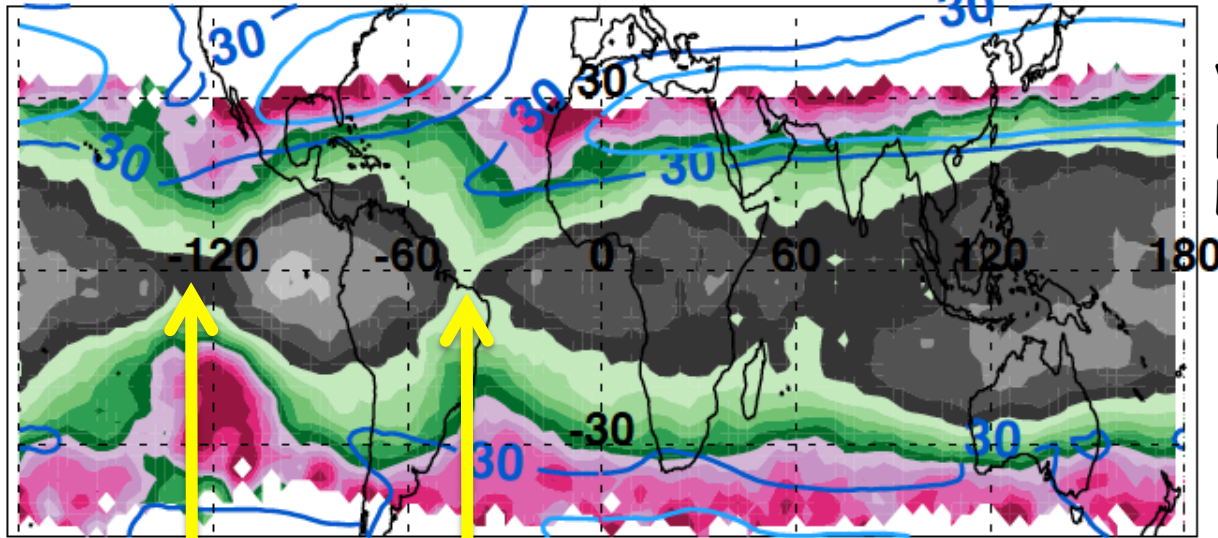


Tropical Westerlies

DJF

Webster & Holton, 1982

"Cross-Equatorial Response to Middle-Latitude Forcing..."

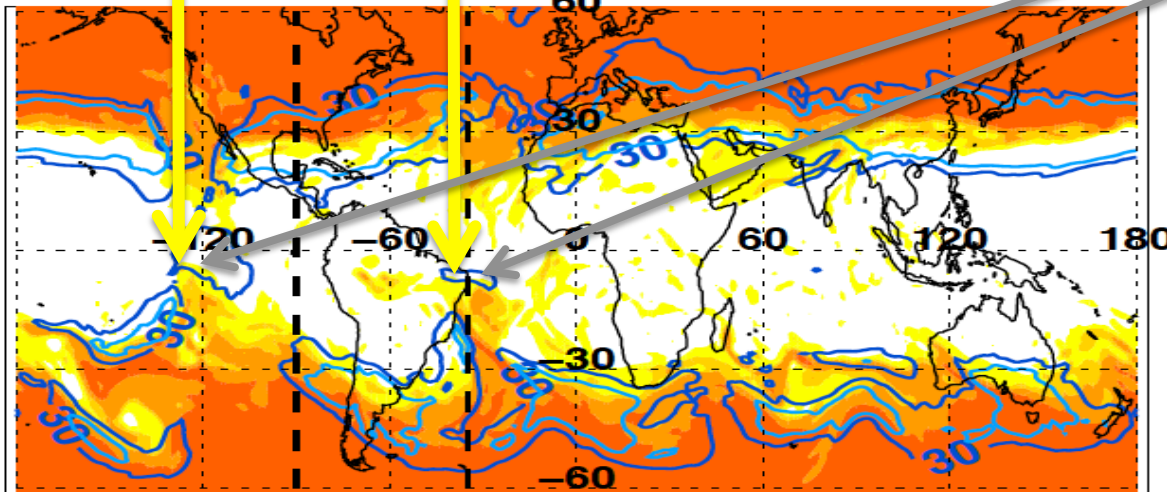


"Westerly Ducts"

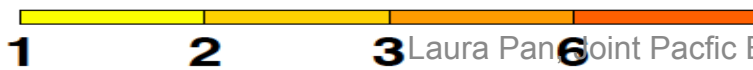
05 January 2010

200 hPa PV
05 Jan 2010

Also see Waugh and Polvani 2000



PV [PVU]



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Munchak and Pan, 2014

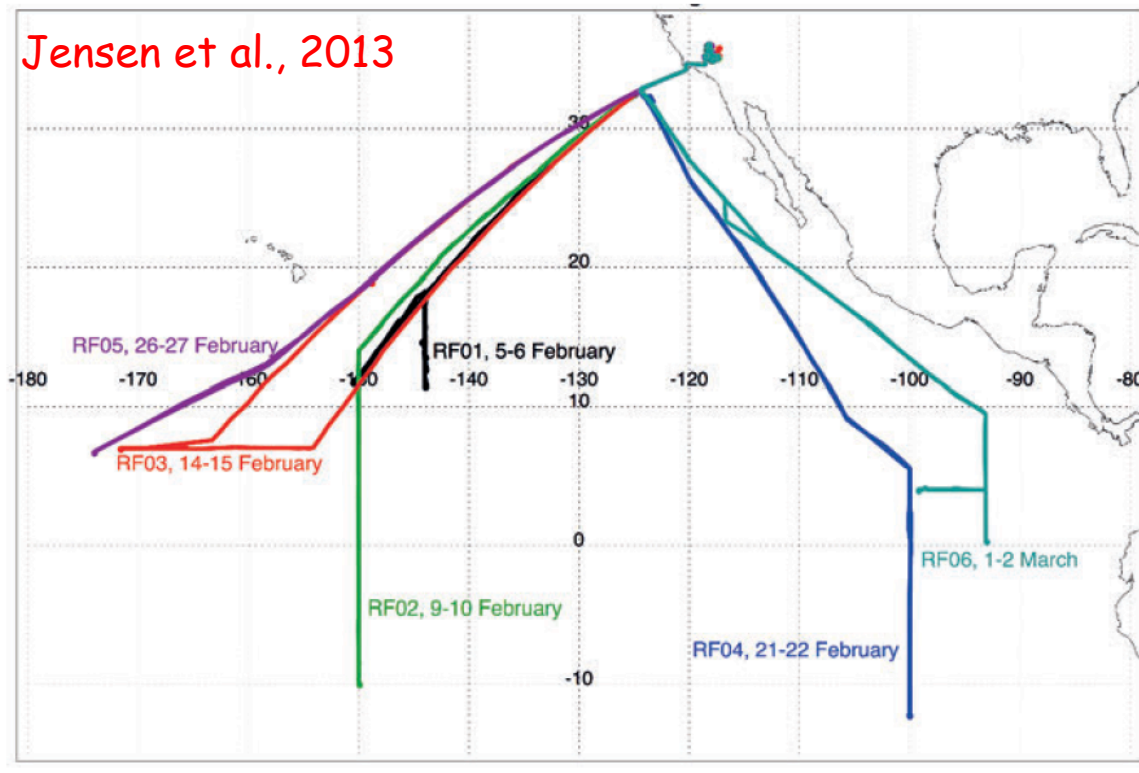
Hypotheses: (Munchak & Pan, 2014)

“The large CPT/LRT separation on the seasonal scale indicates the region of strong extratropical driven dynamics in the tropics.

“In these regions, the CPT is no-longer an effective tropopause”

ATTREX 2013 provided the first opportunity to verify the hypothesis using chemical tracer measurements

Jensen et al., 2013



ATTREX Campaign

Feb 2013

NASA Global Hawk

Dryden RFC, Edwards AFB



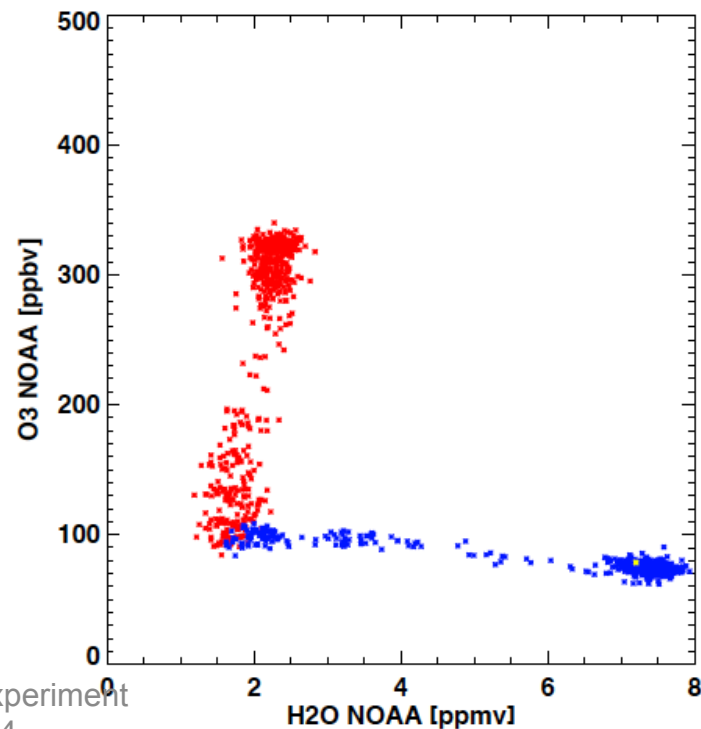
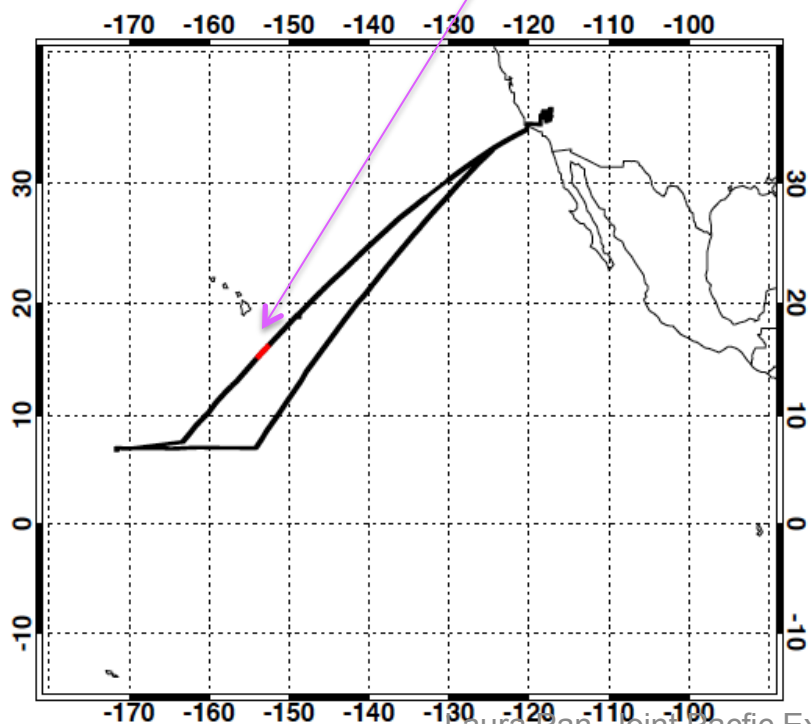
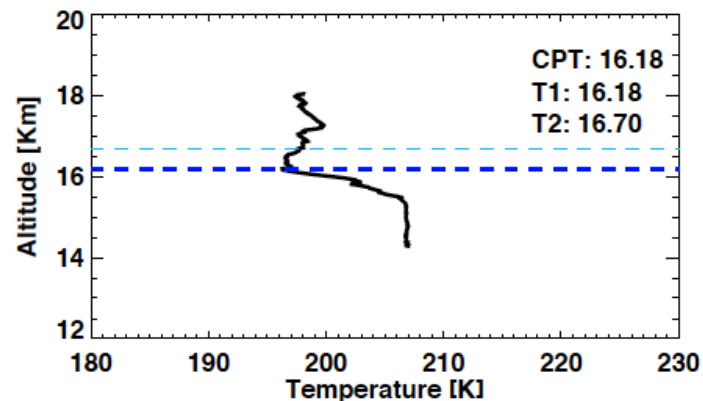
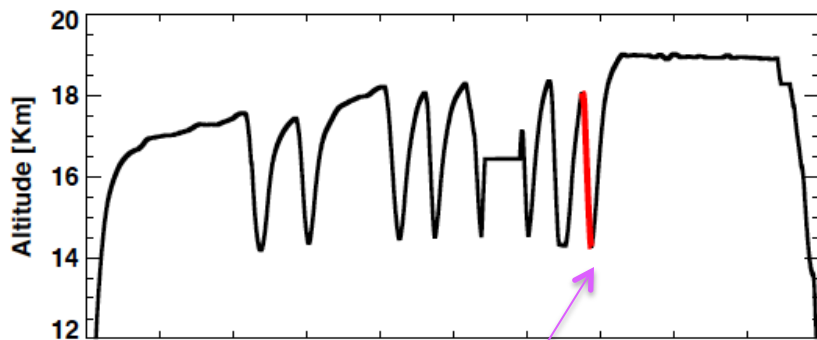
The NASA Global Hawk being towed into the NASA Dryden Flight Research Center hanger, Edwards, California. See results from the recent ATTREX campaigns using the aircraft this issue. Photo courtesy: Tom Tschida, NASA Dryden Flight Research Center.

STM, Oct 21, 2014

Physical boundaries in the tropics: TTL vs. tropopause

Example 1

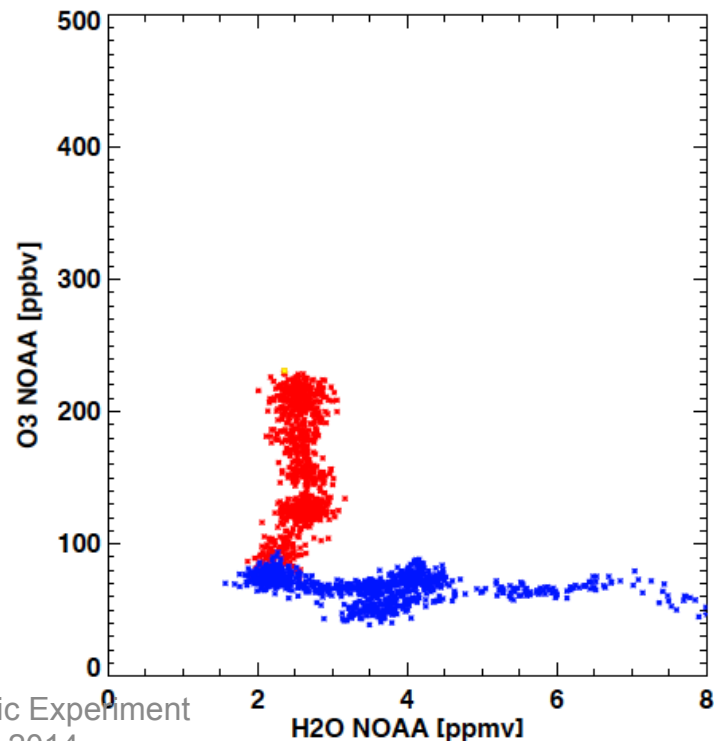
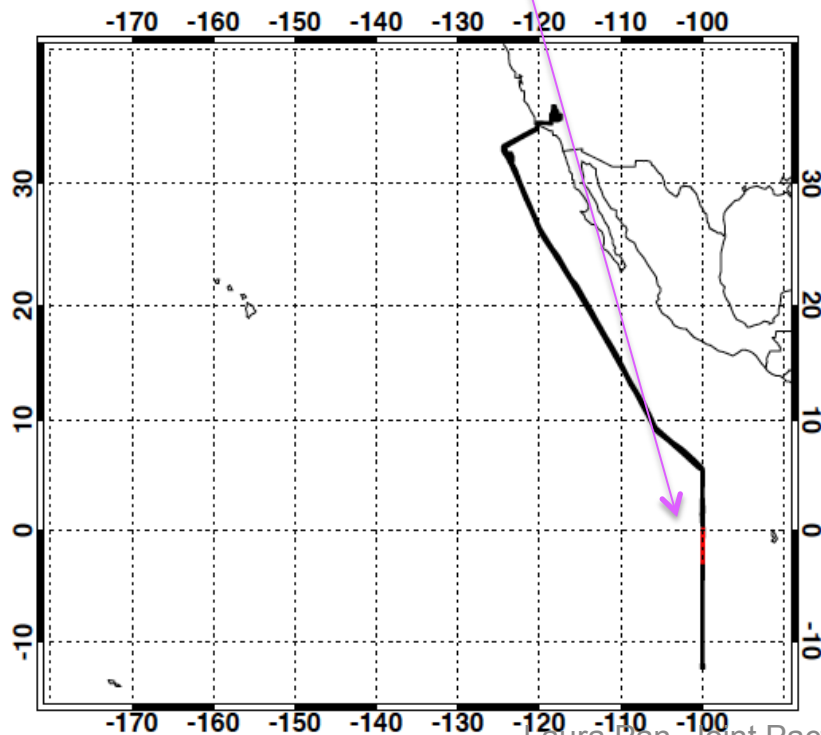
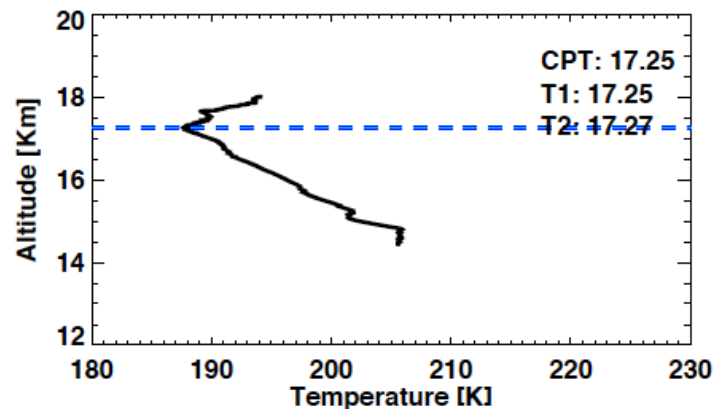
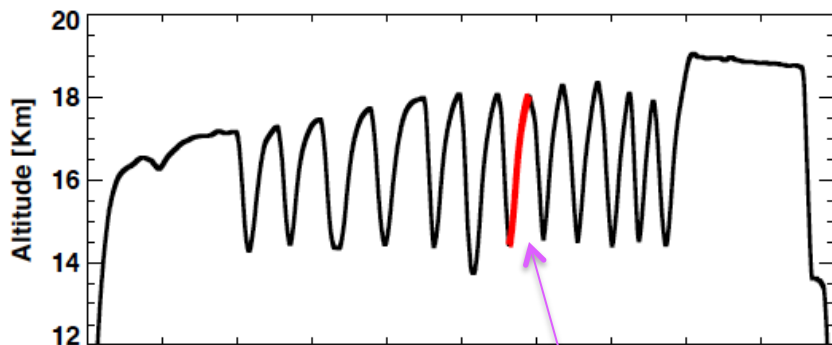
ATTREX Flight RF3 02/14/2013, Profile #16



Physical boundaries in the tropics: TTL vs. tropopause

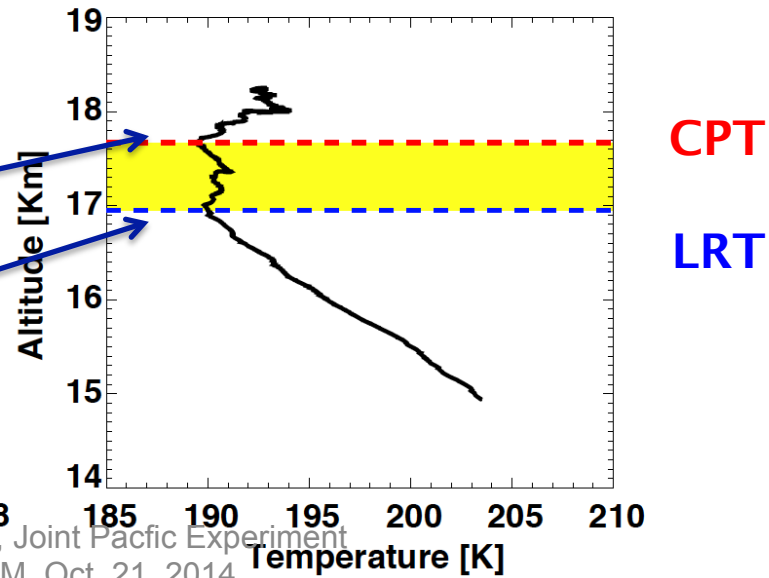
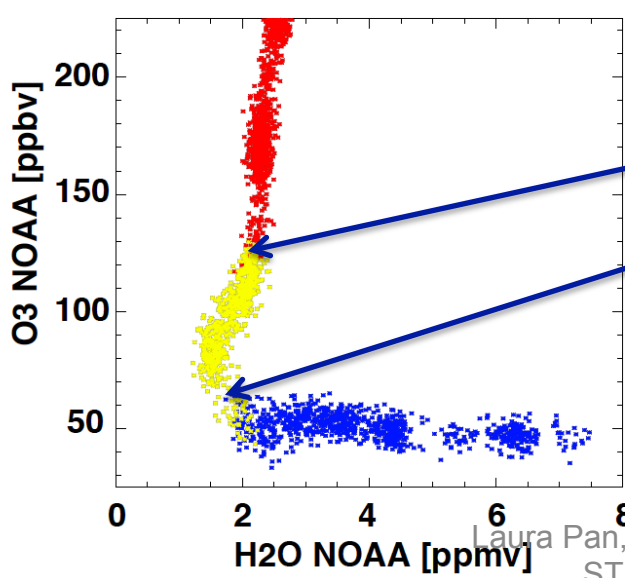
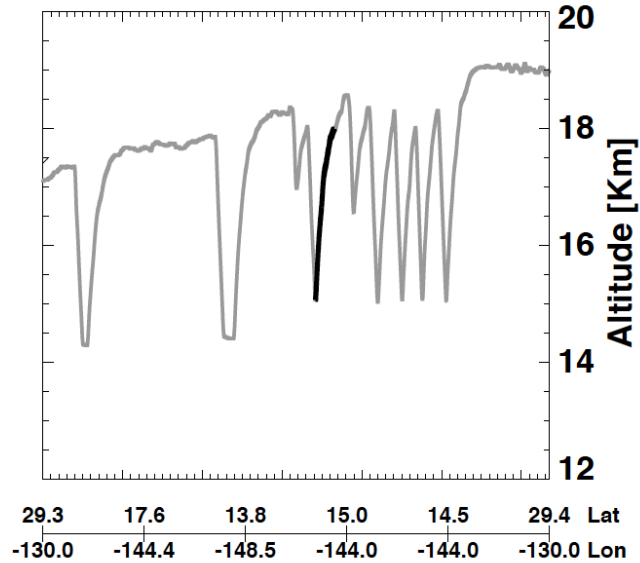
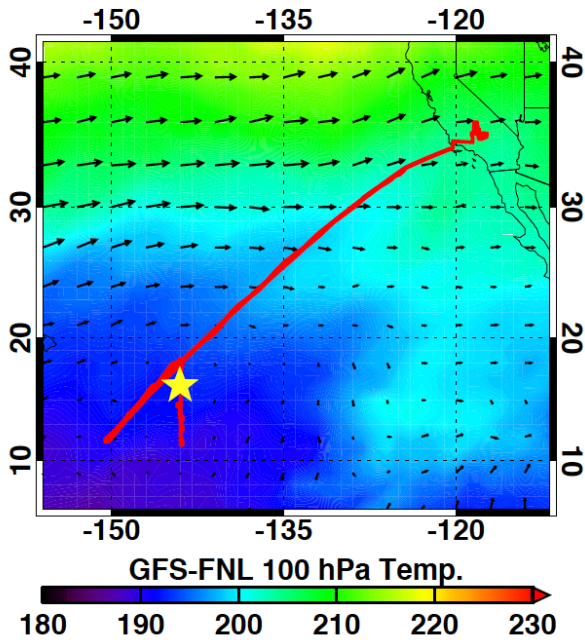
Example 2

ATTREX Flight RF4 02/21/2013, Profile #15

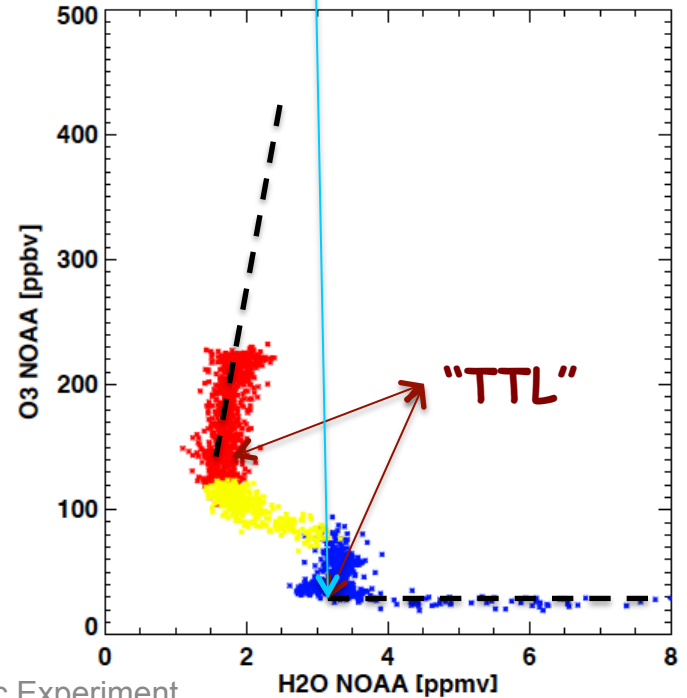
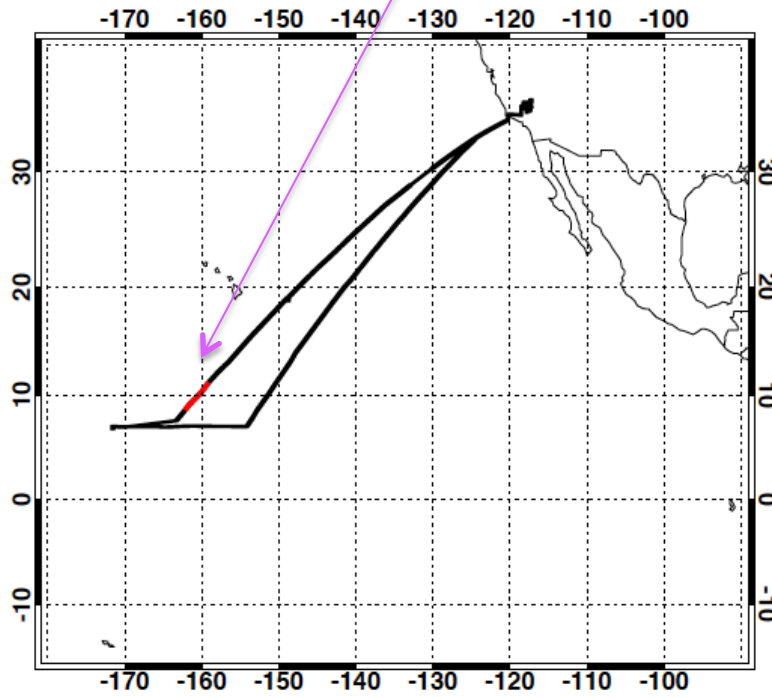
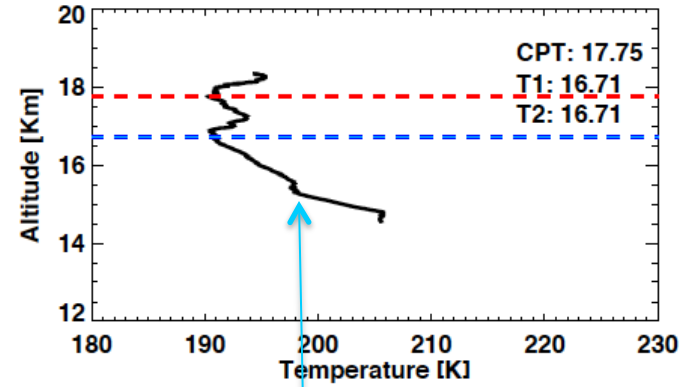
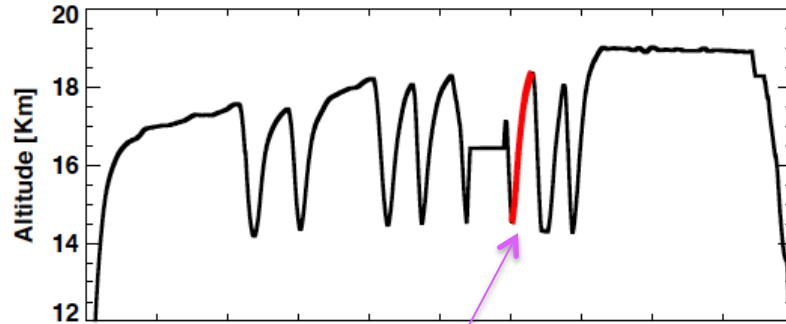


Physical boundaries in the tropics: CPT vs. LRT

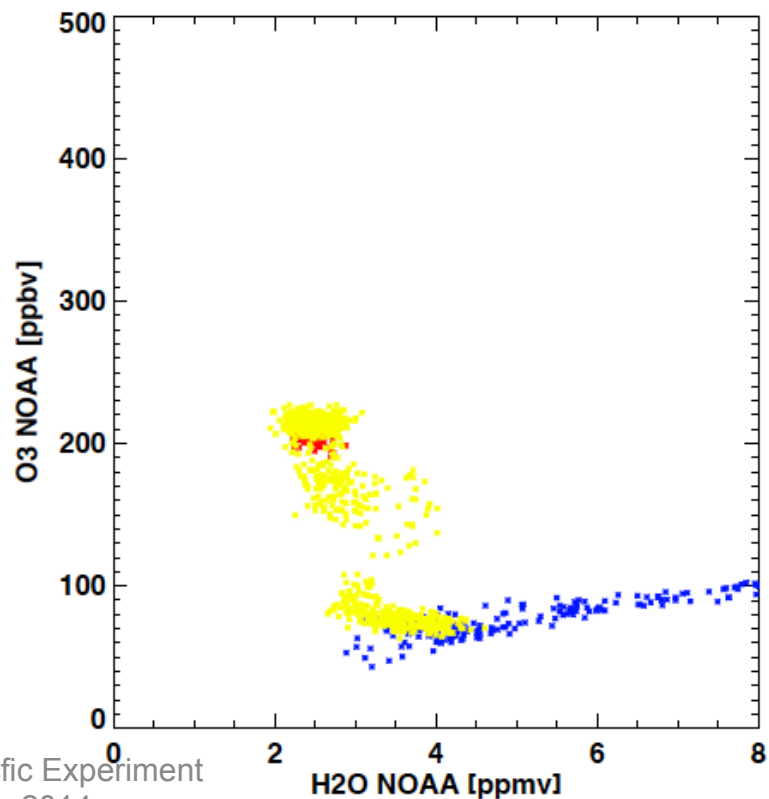
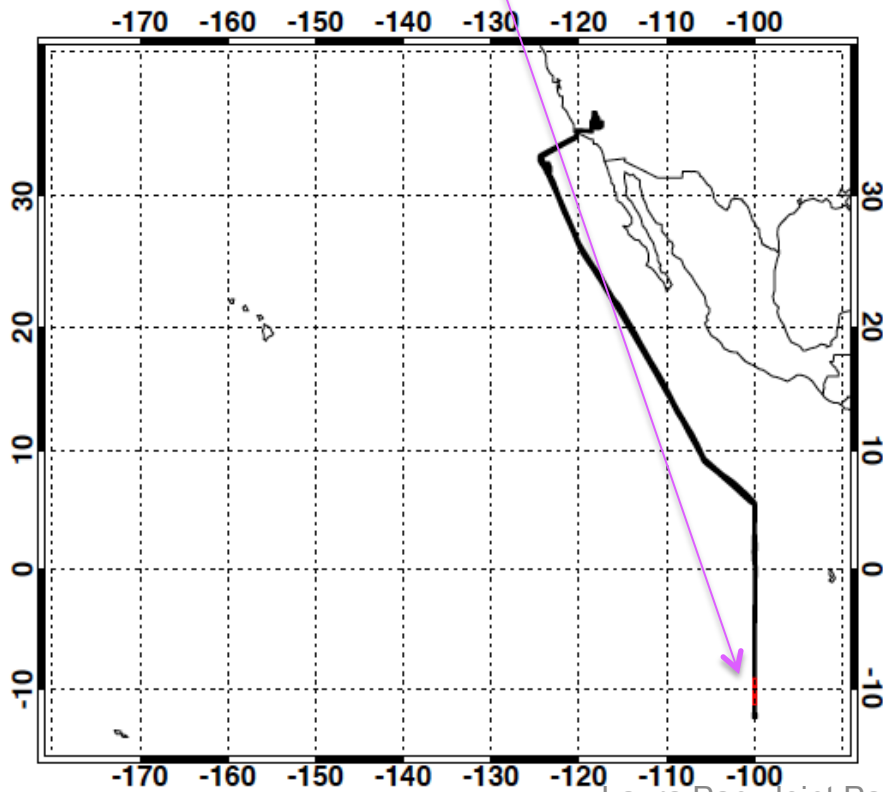
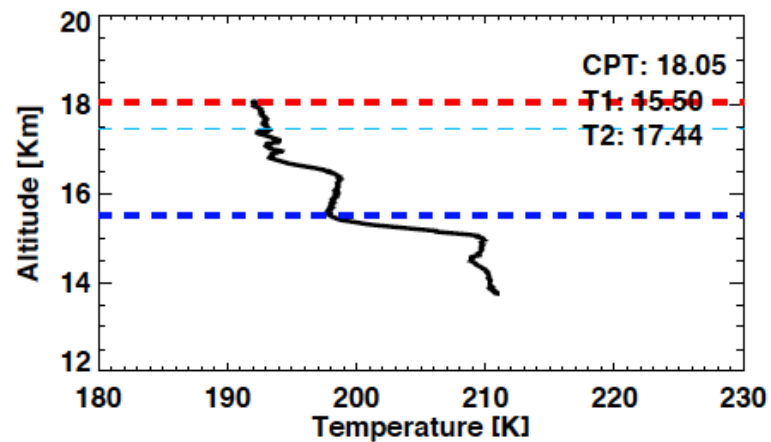
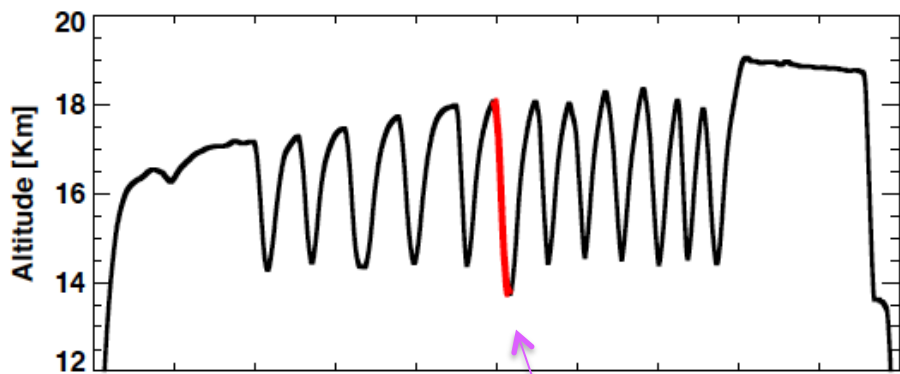
ATTREX RF01 Profile #6



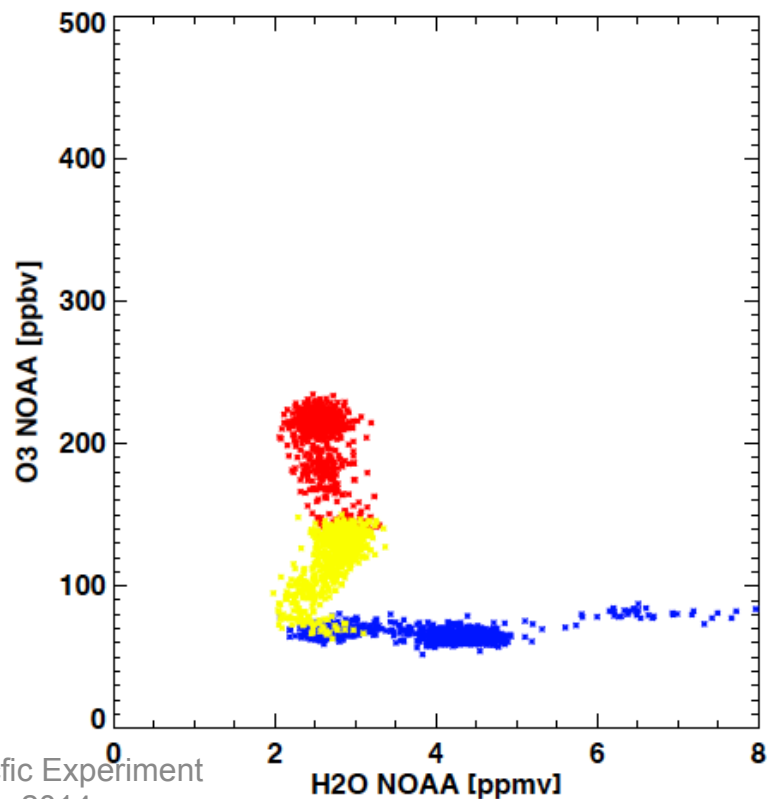
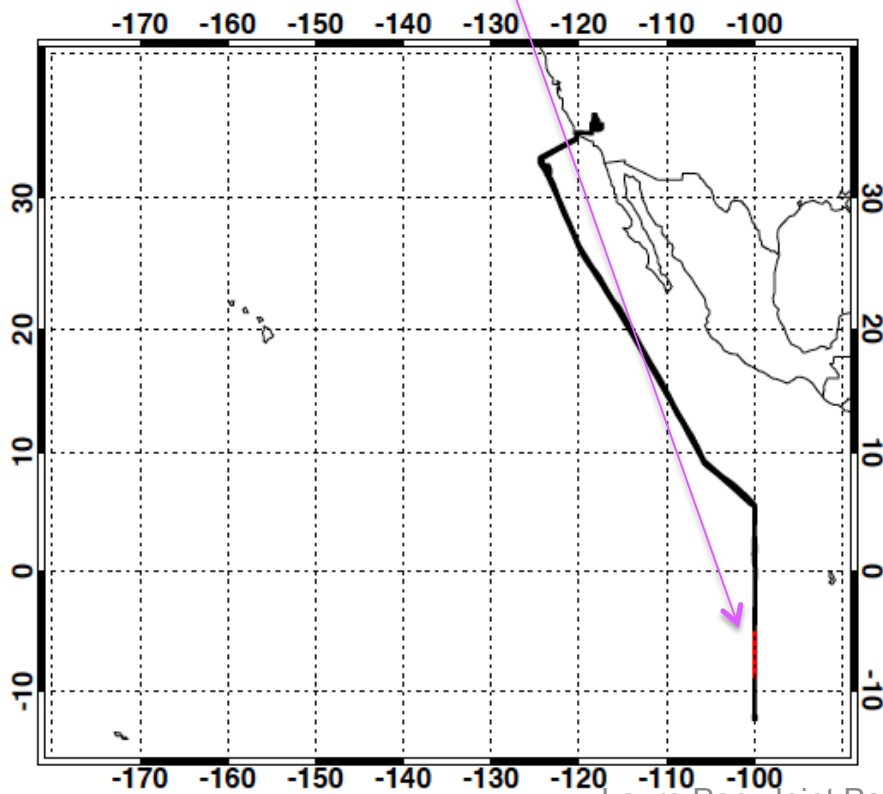
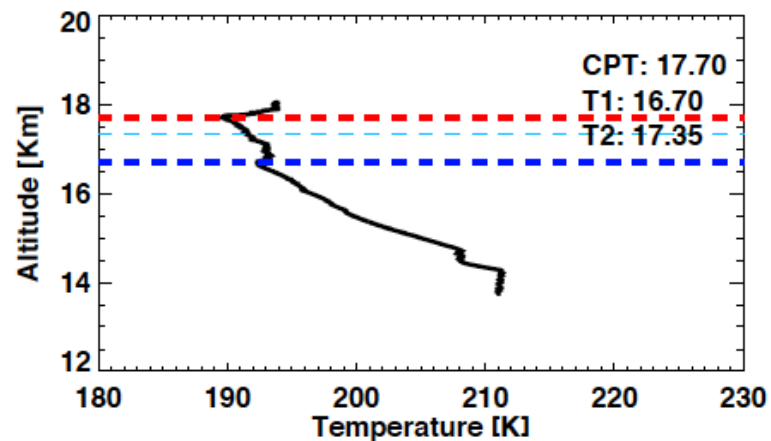
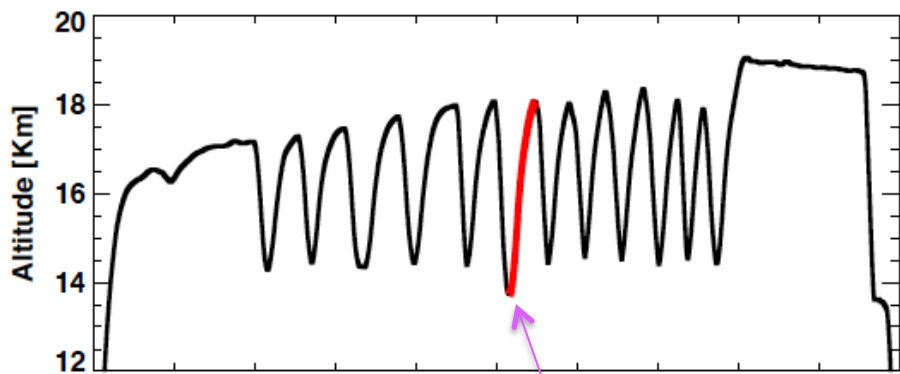
ATTREX Flight RF3 02/14/2013, Profile #13



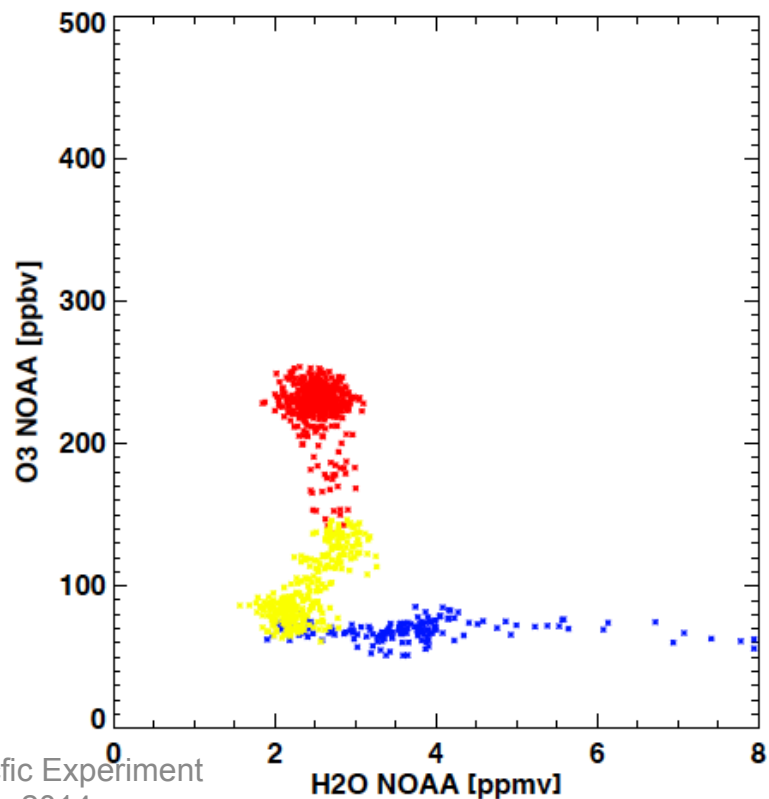
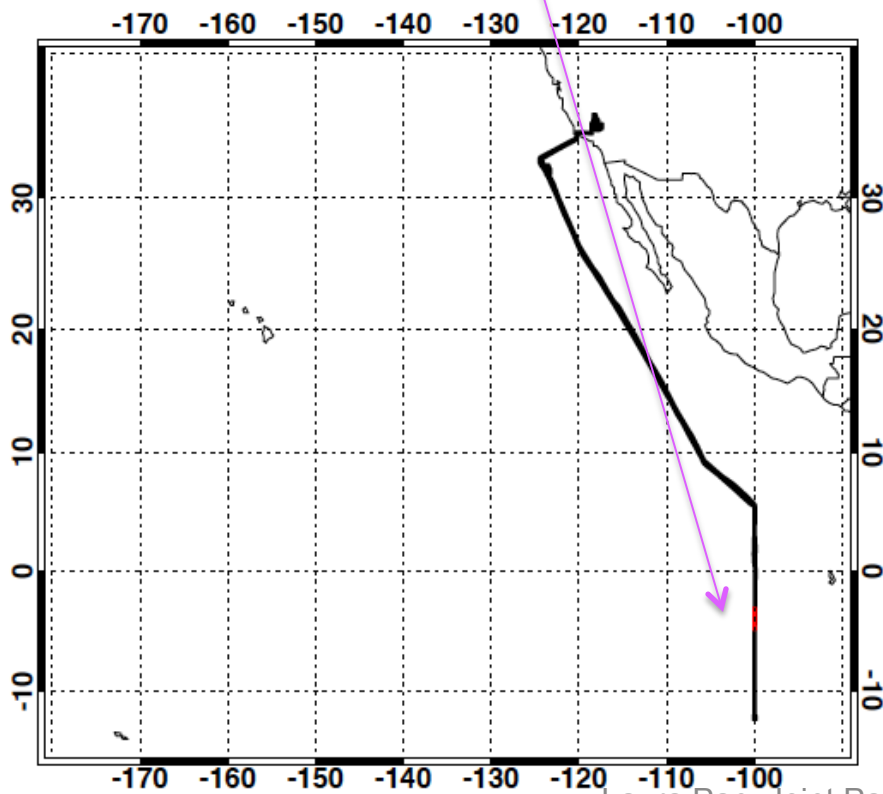
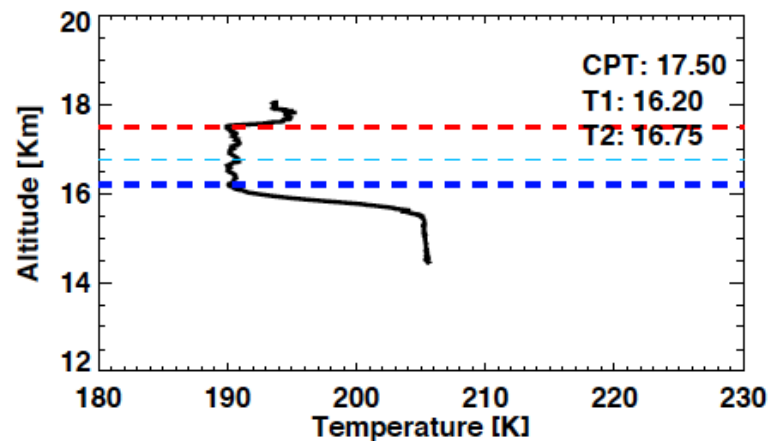
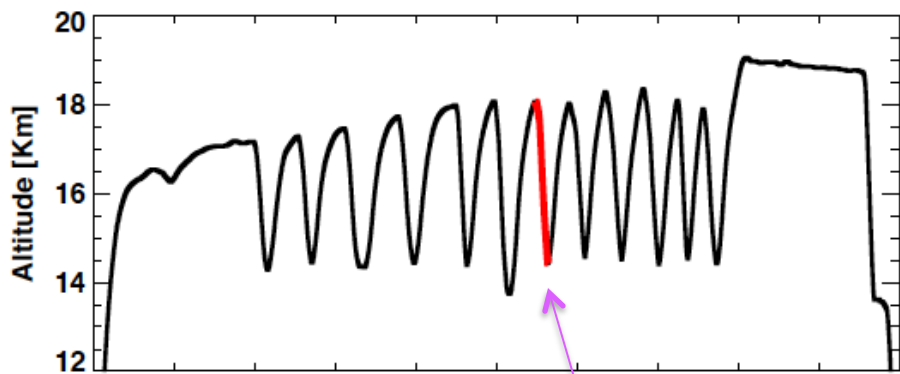
ATTREX Flight RF4 02/21/2013, Profile #12



ATTREX Flight RF4 02/21/2013, Profile #13



ATTREX Flight RF4 02/21/2013, Profile #14



This work is in progress...

My favorite E/O photo: 3 A/Cs are together at last!



Thank You!

Laura Pan, Joint Pacific Experiment
STM, Oct. 21, 2014