Satellite perspective on TTL transport

Bill Randel
Atmospheric Chemistry Division
NCAR Boulder, Colorado USA

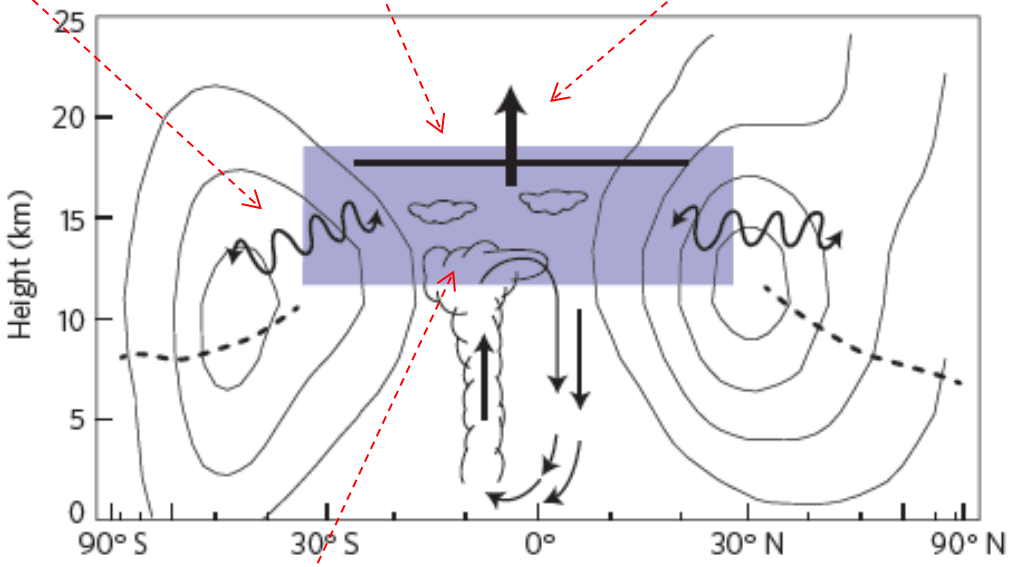
Thanks to: Cameron Hohmeyer, Mijeong Park, Laura Pan

Circulation and transport near the tropical tropopause layer

what processes influence temperature, ozone and other constituents?

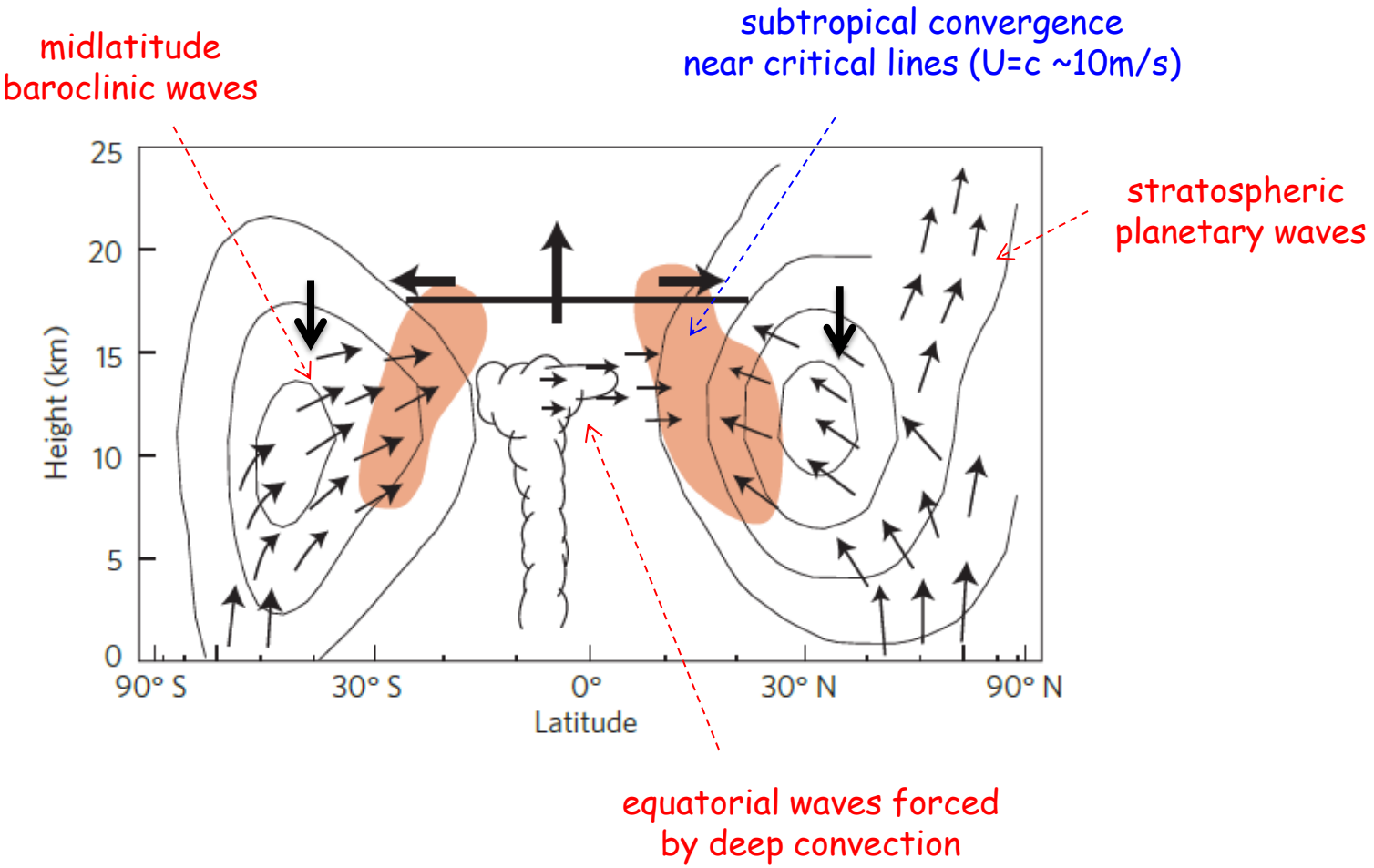
how important is in-mixing?

what controls tropical upwelling?

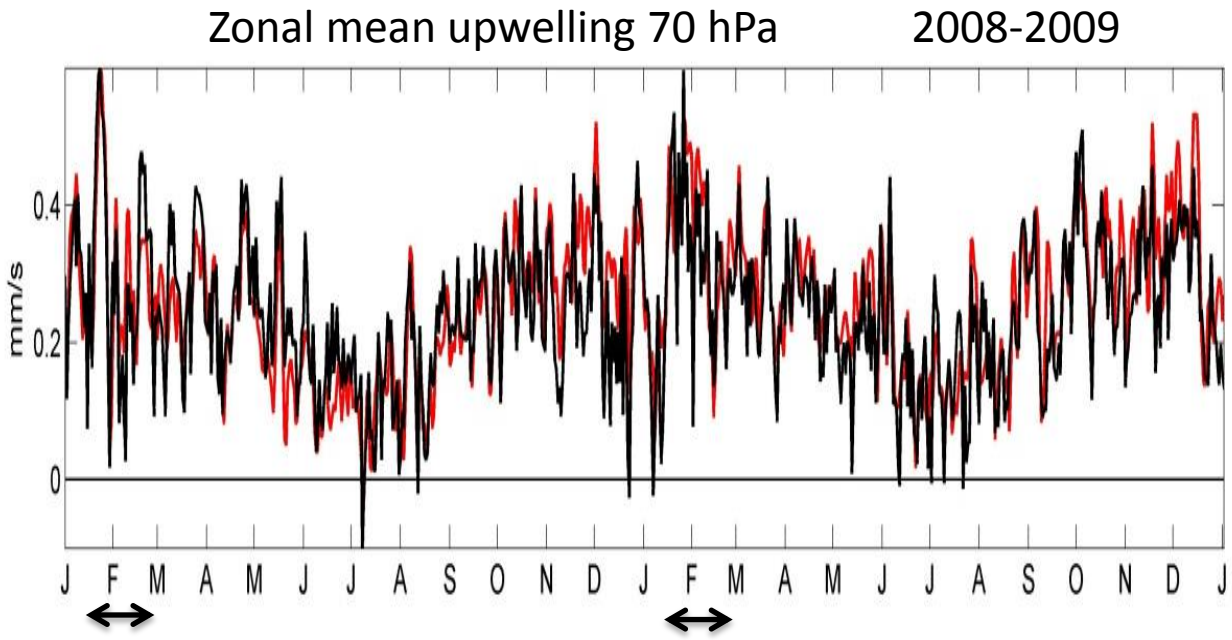


how does deep convection impact composition?

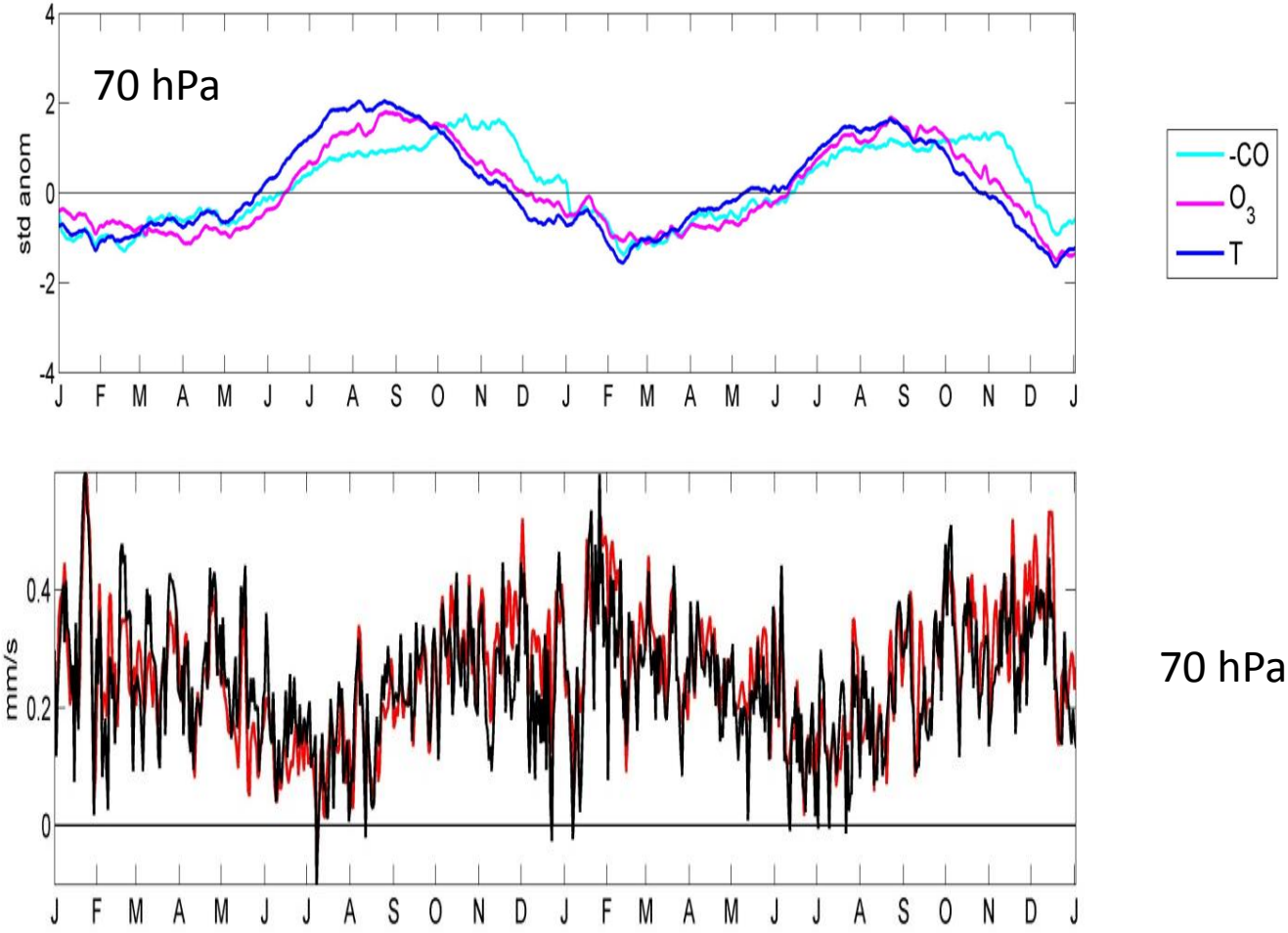
Forcing of tropical upwelling



What drives the variability in tropical upwelling?



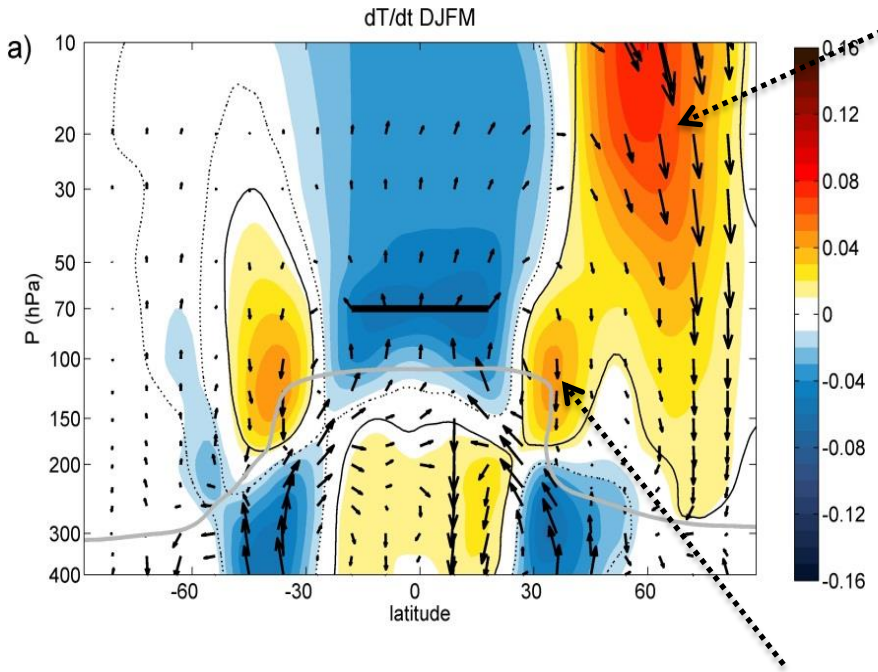
Coupling with temperature, O_3, CO



70 hPa w*

Regressions onto sub-seasonal w^*_m

residual circulation and dT/dt

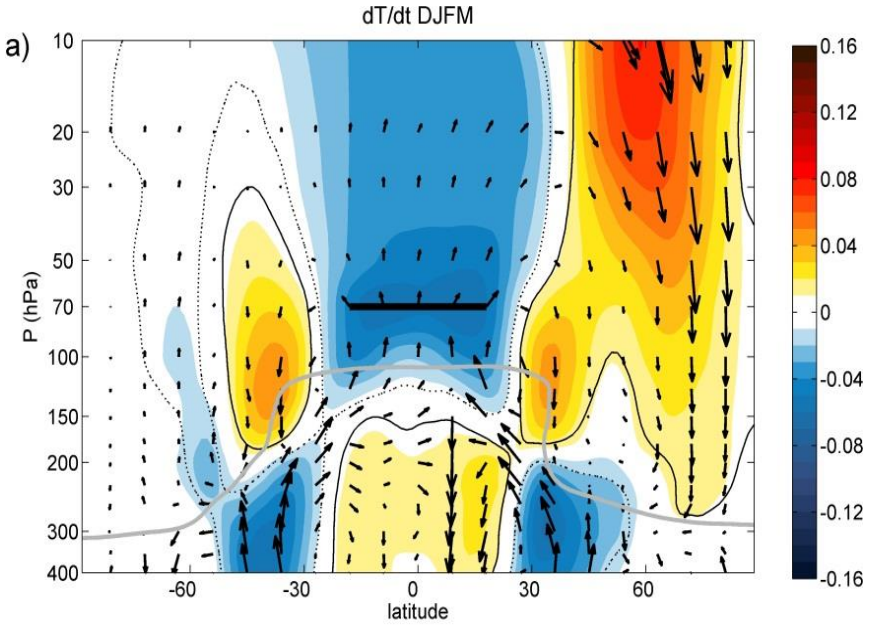


deep branch of
Brewer-Dobson circulation

shallow branch

Regressions onto w^*_m

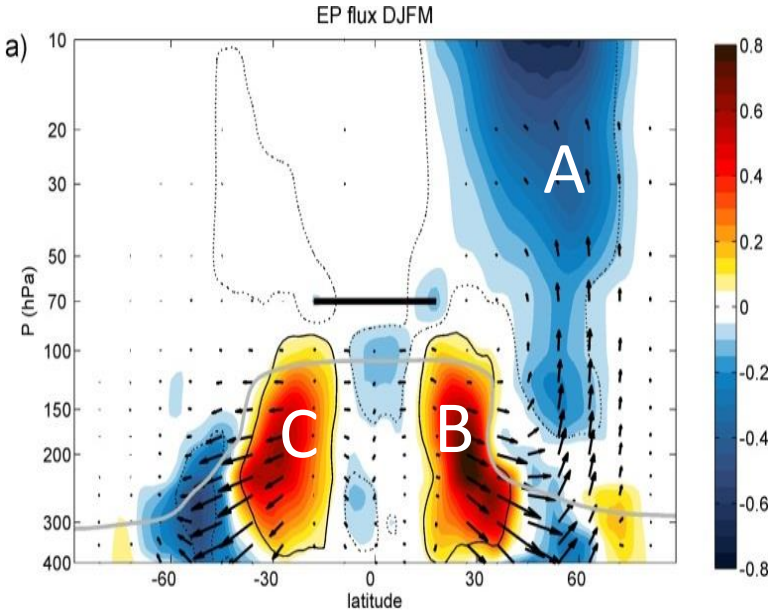
residual circulation and dT/dt



Centers of action:

- Winter stratosphere
- Subtropical upper troposphere (both hemispheres)

EP flux and divergence

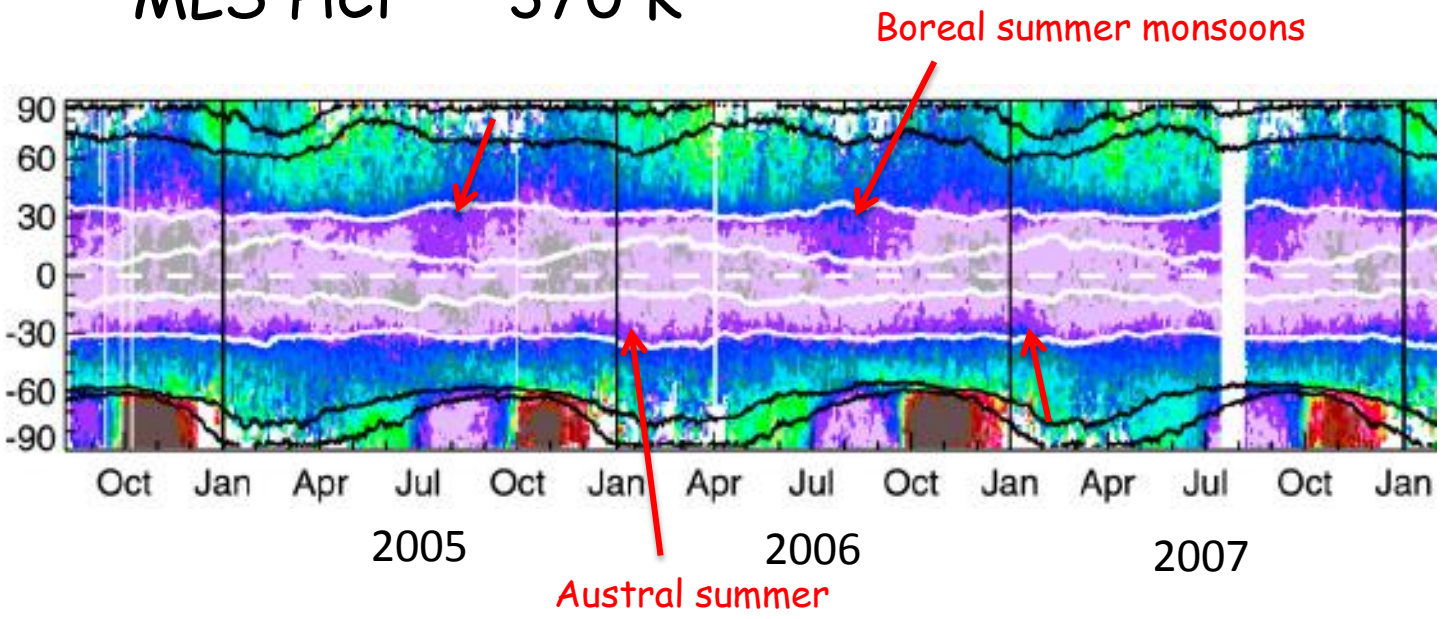


Abalos et al, 2013

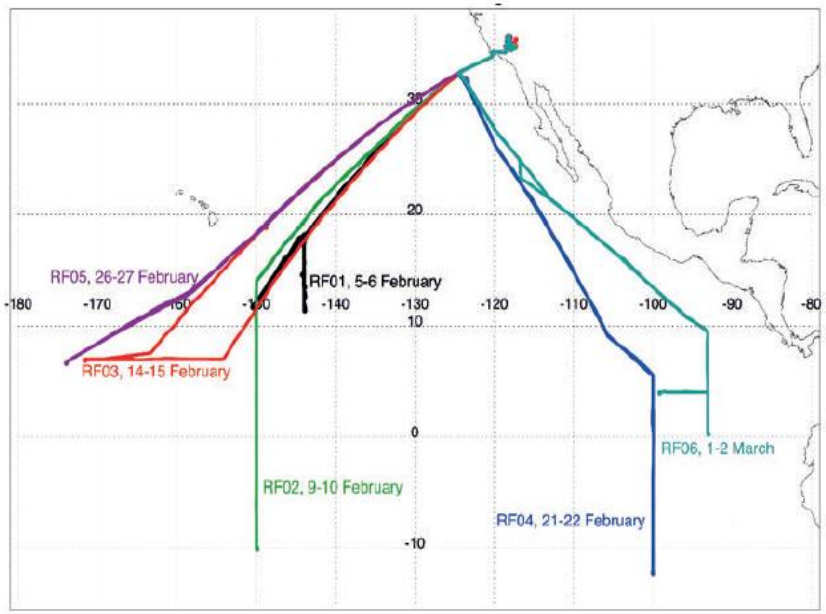
How important is in-mixing in the CONTRAST region?

Santee et al 2011

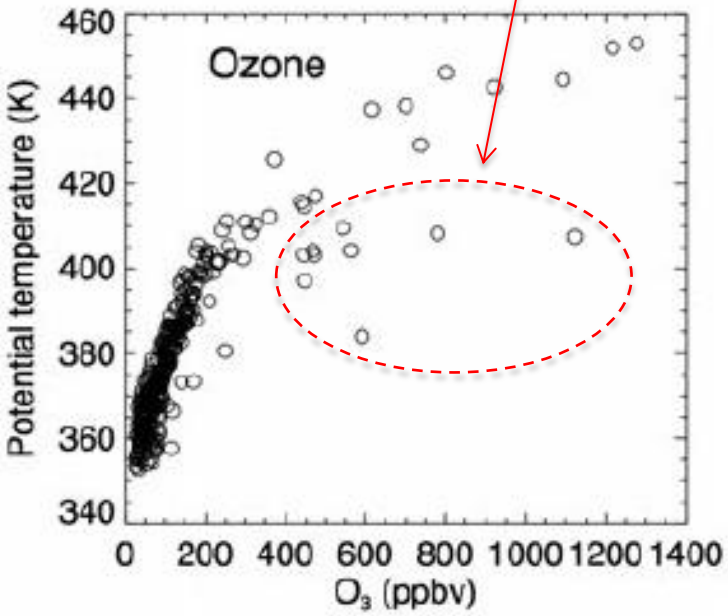
MLS HCl 370 K



ATTREX measurements February-March 2013

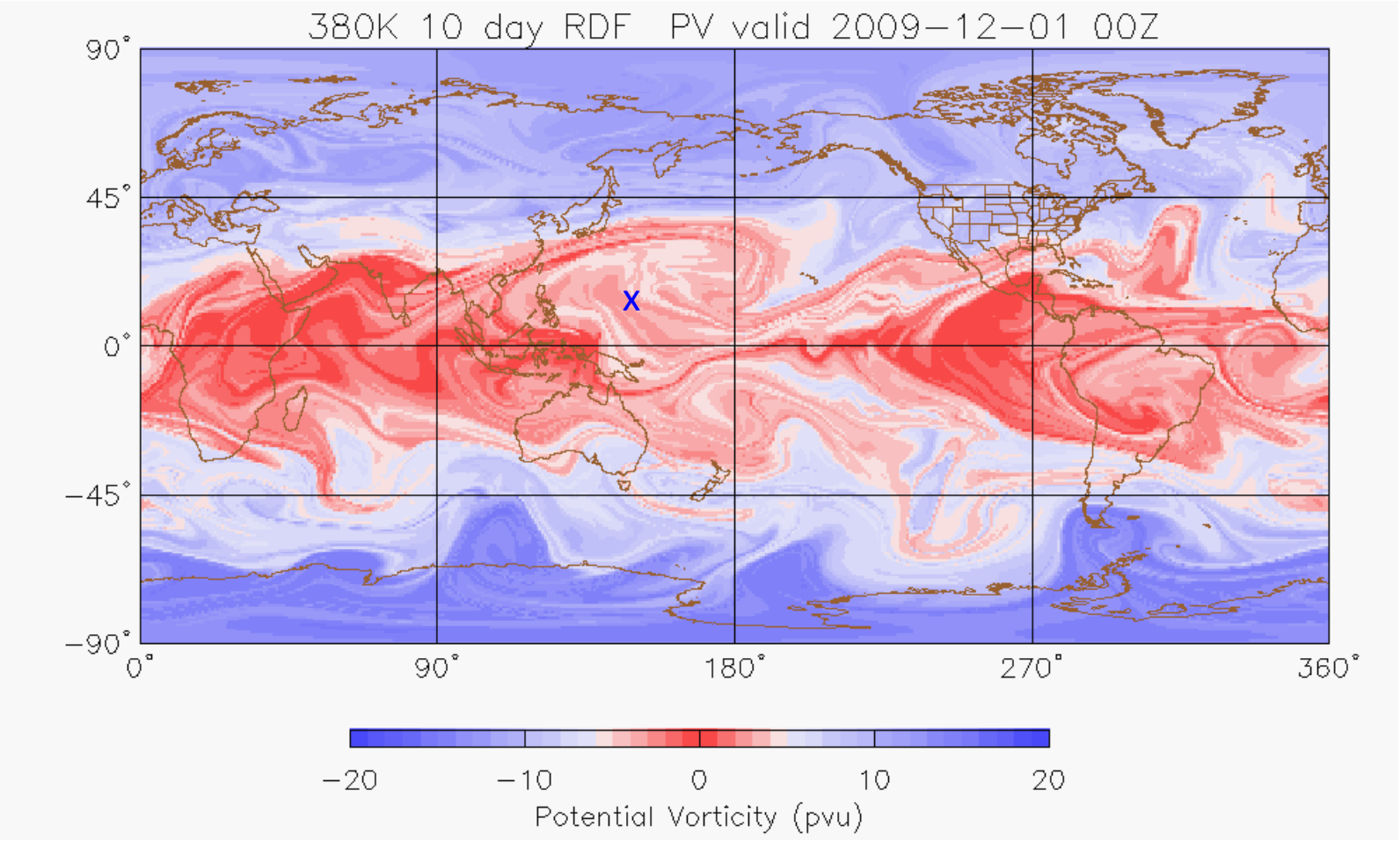


Where did the high O_3 come from?

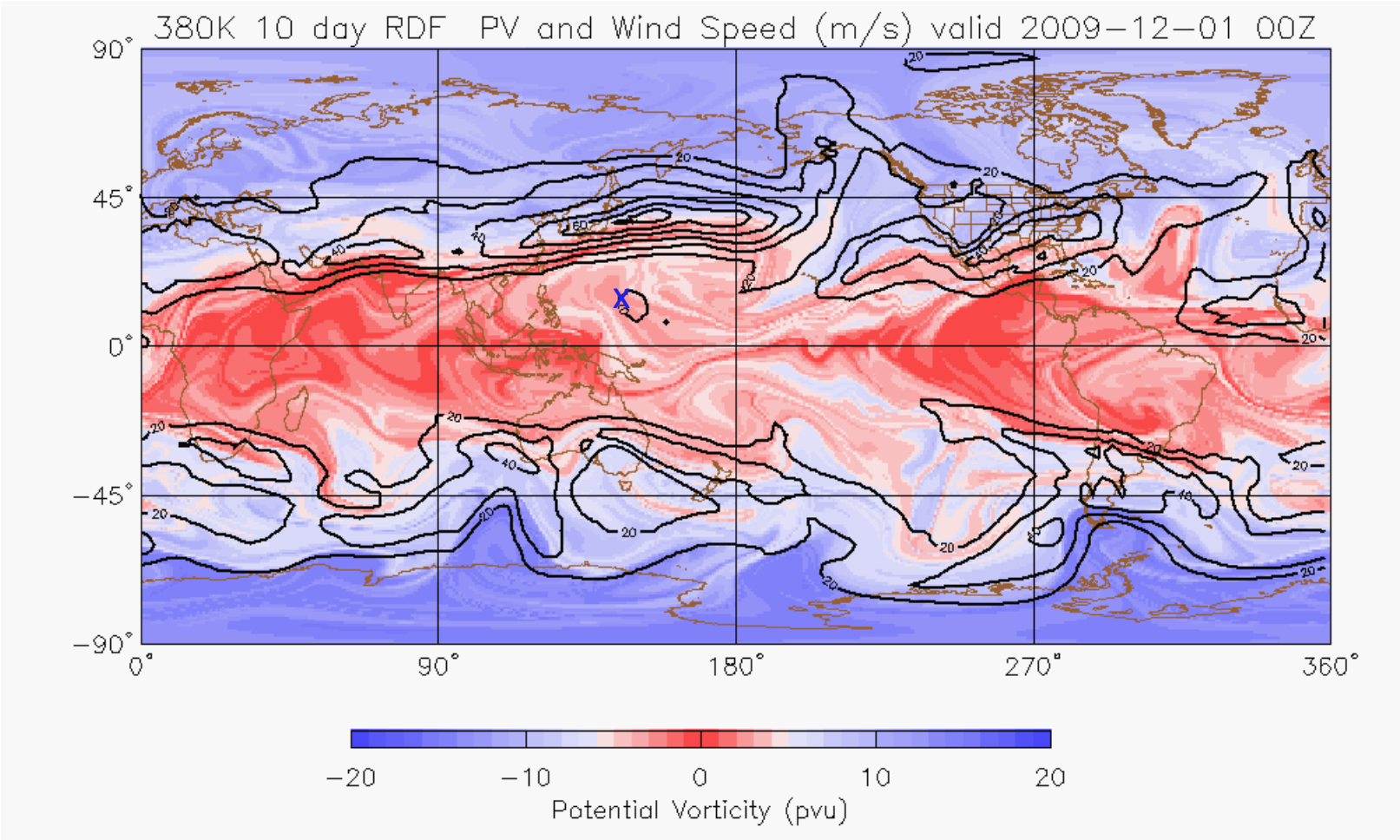


Jensen et al, SPARC Newsletter, 2013

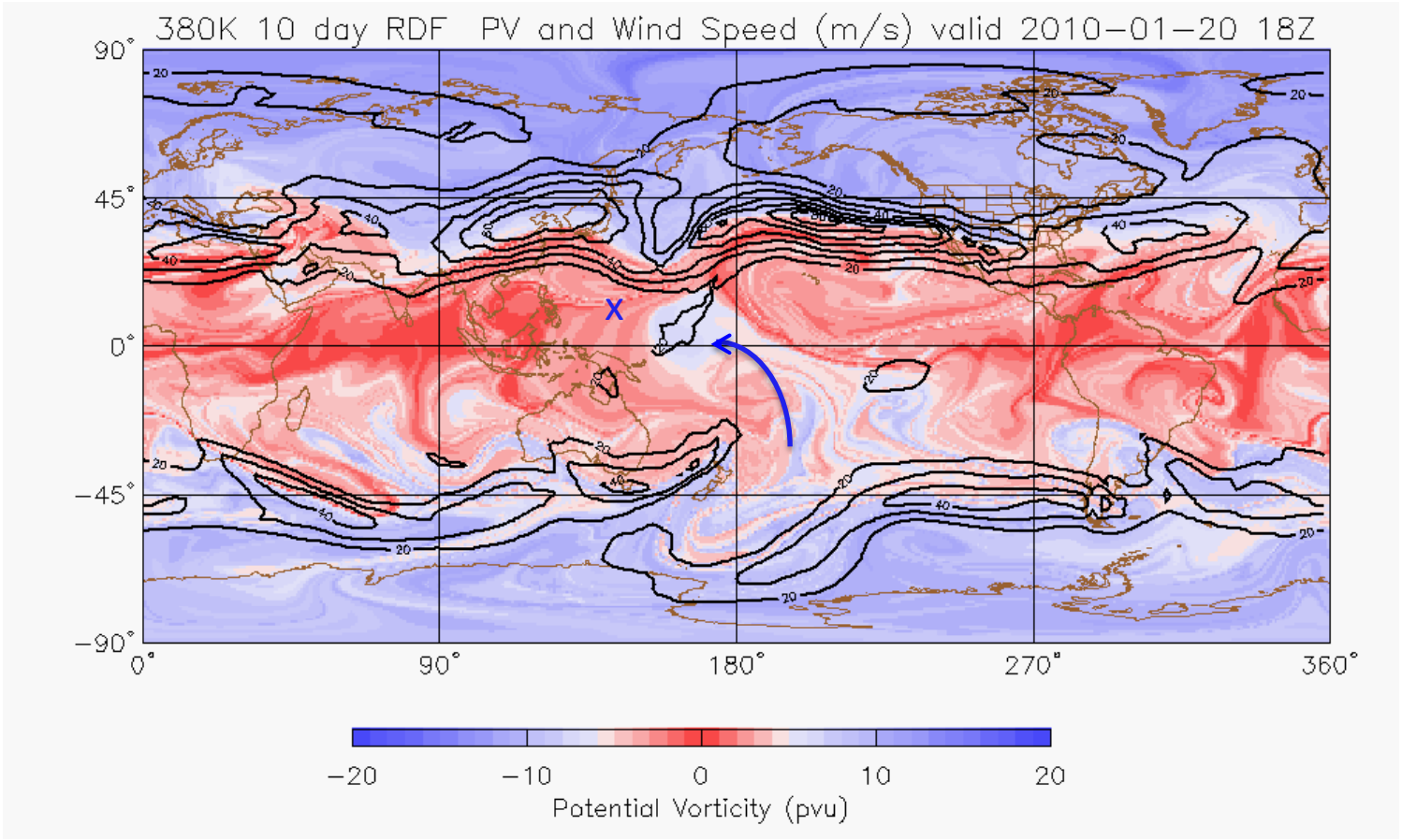
6-hourly PV from RDF calculations (Cameron Homeyer)



6-hourly PV from RDF calculations (Cameron Homeyer)



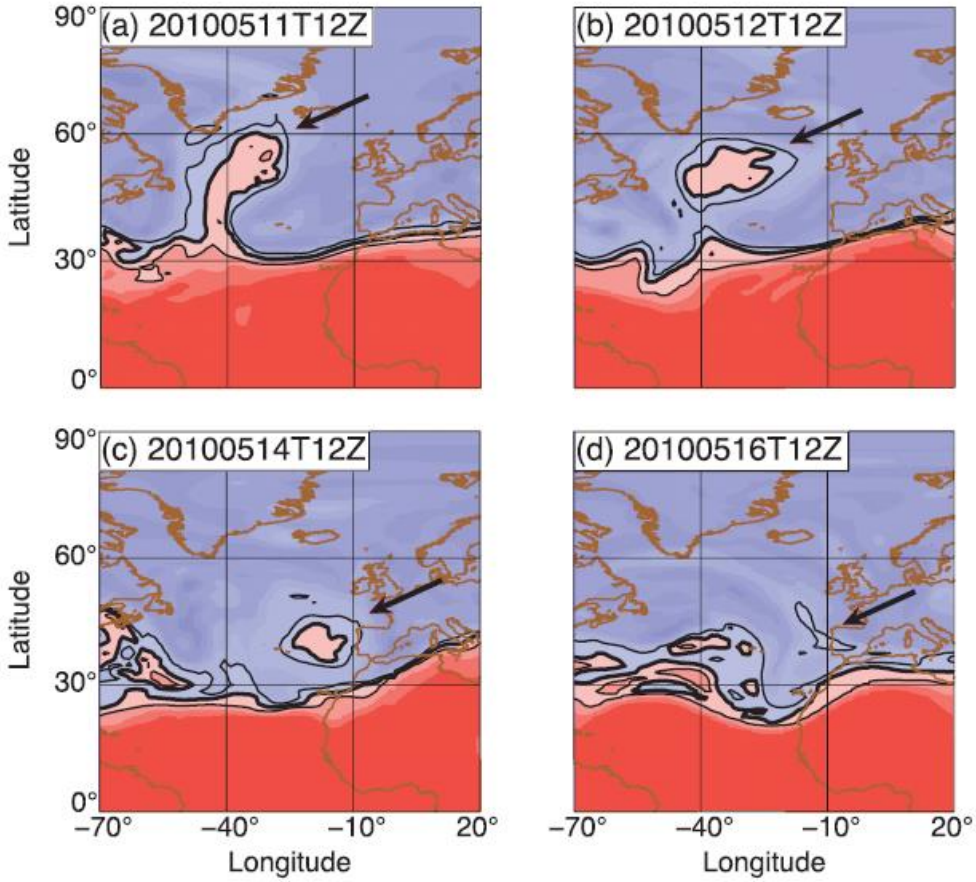
6-hourly PV from RDF calculations (Cameron Homeyer)



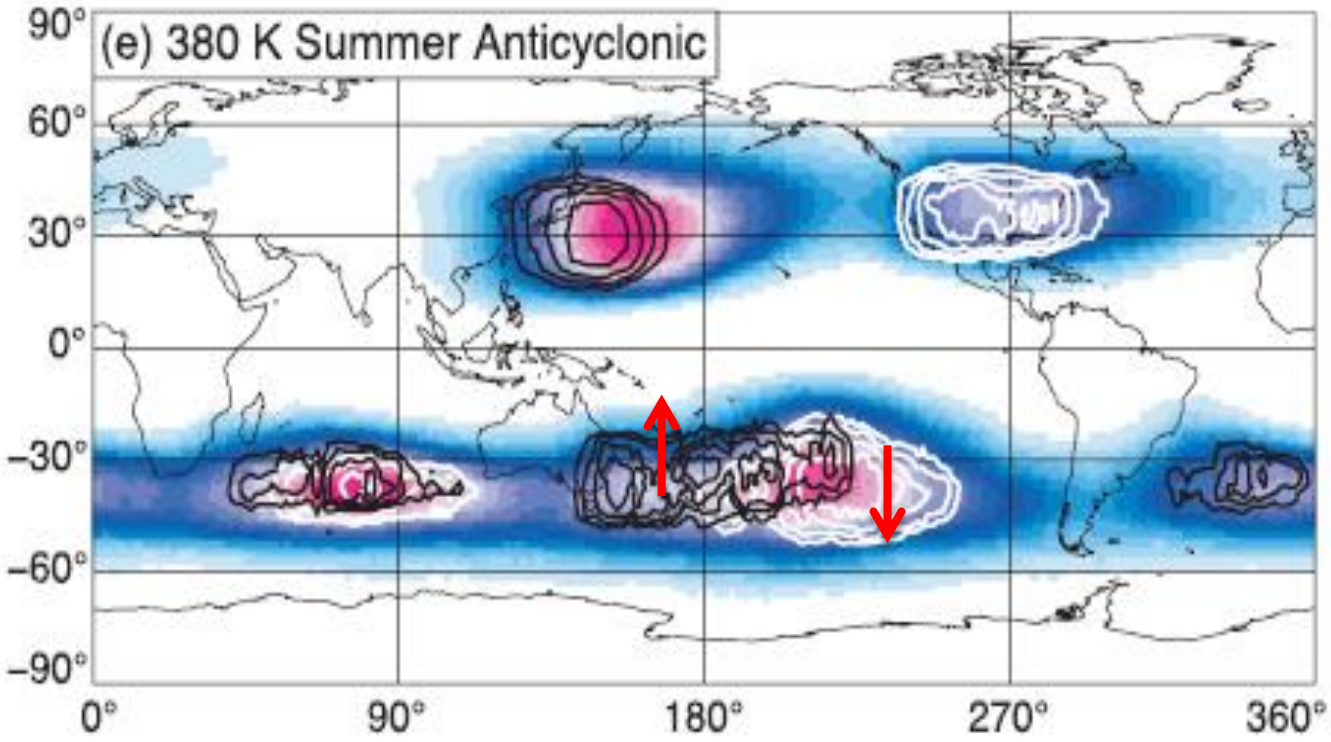
Rossby Wave Breaking and Transport between the Tropics and Extratropics above the Subtropical Jet

CAMERON R. HOMEYER AND KENNETH P. BOWMAN

Department of Atmospheric Sciences, Texas A&M University, College Station, Texas

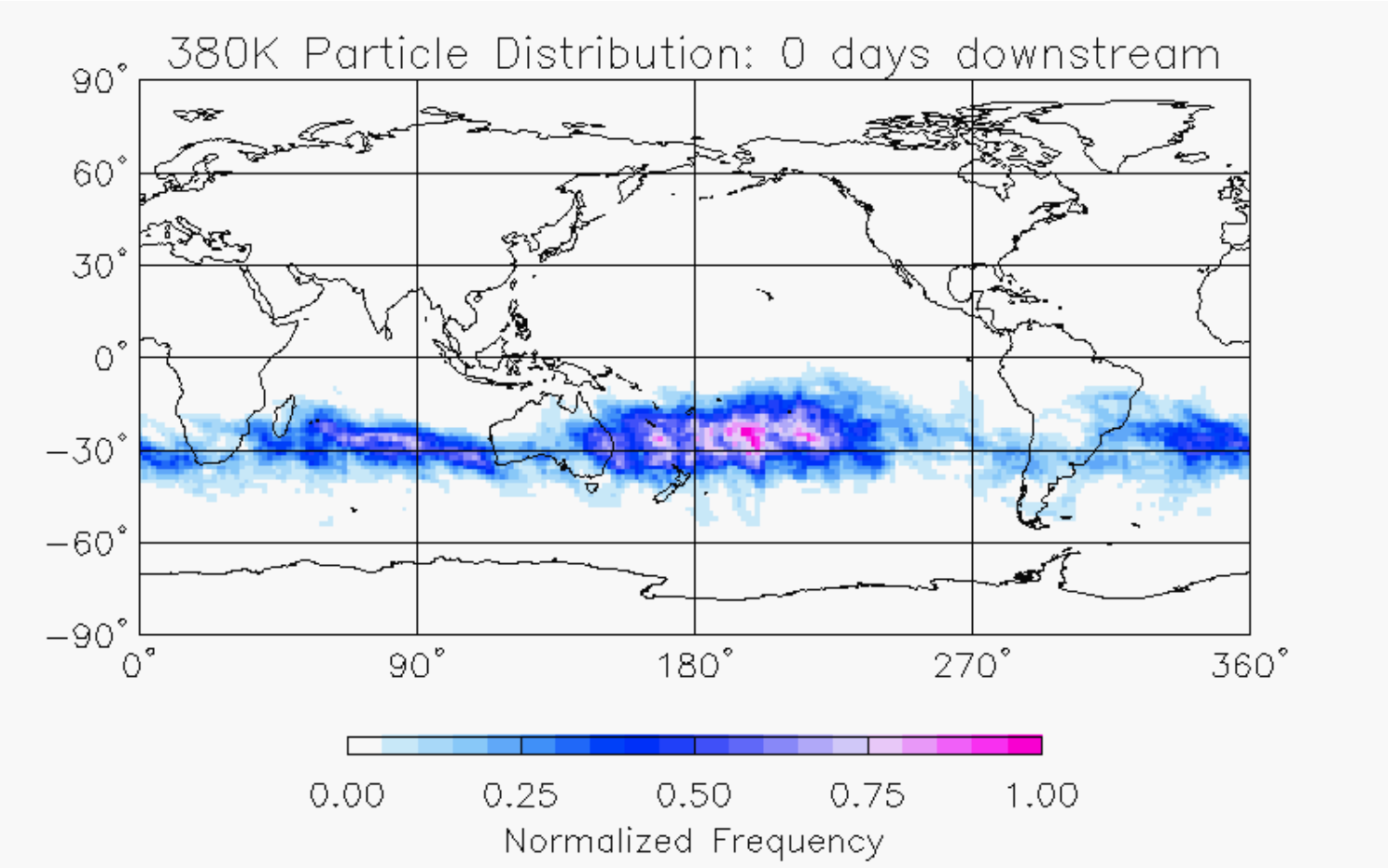


Where does wavebreaking and transport occur?



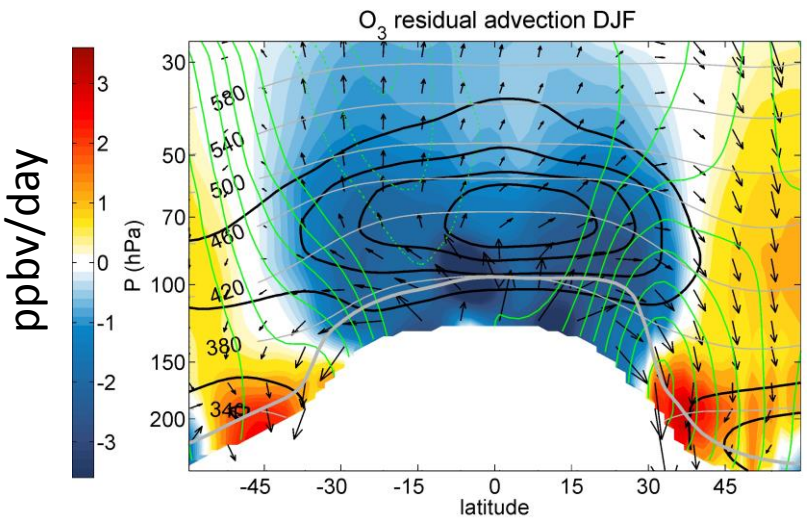
Homeyer and Bowman, 2013

Downstream location of parcels from wavebreaking

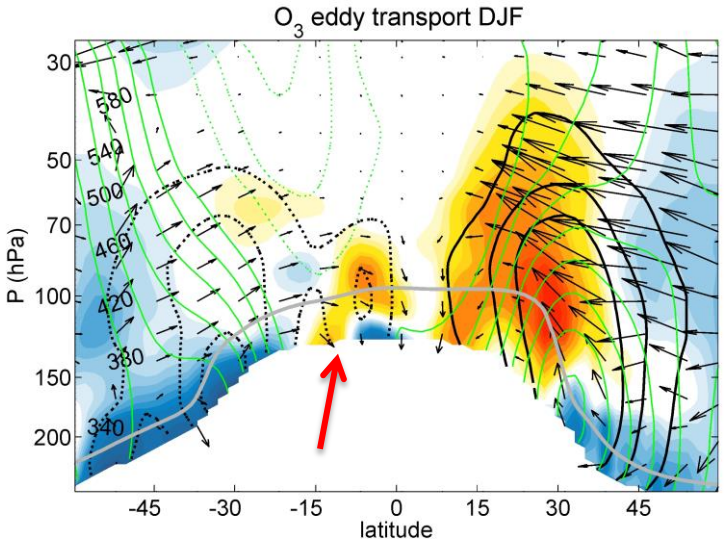


WACCM ozone transport from transformed Eulerian mean calculations:

mean advection



eddy transport



$$\frac{\partial \overline{\chi}}{\partial t} = -\overline{v}^* \frac{1}{a}\frac{\partial \overline{\chi}}{\partial \phi} - \overline{w}^* \frac{\partial \overline{\chi}}{\partial z} + \nabla \cdot \boldsymbol{M} + P - L$$

eddy transport

mean advection

chemistry

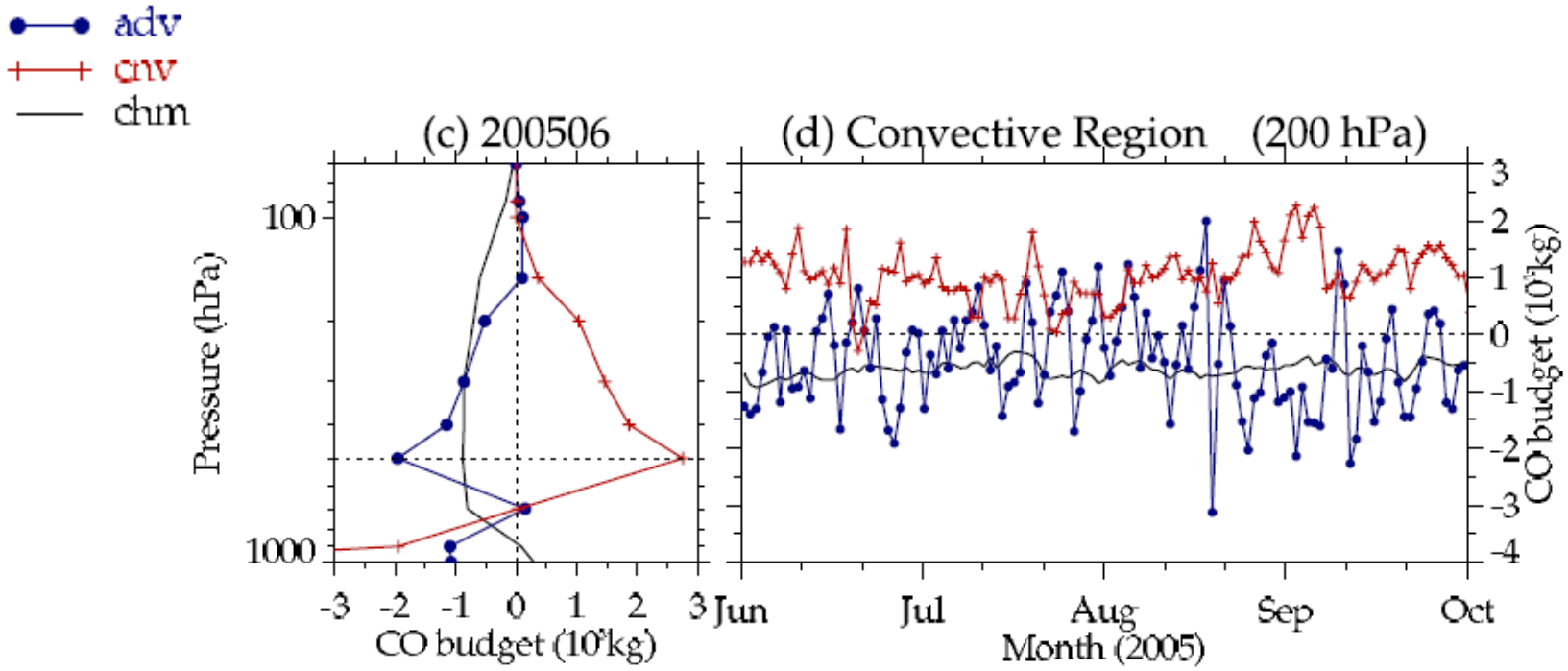
Abalos et al 2013 ACP

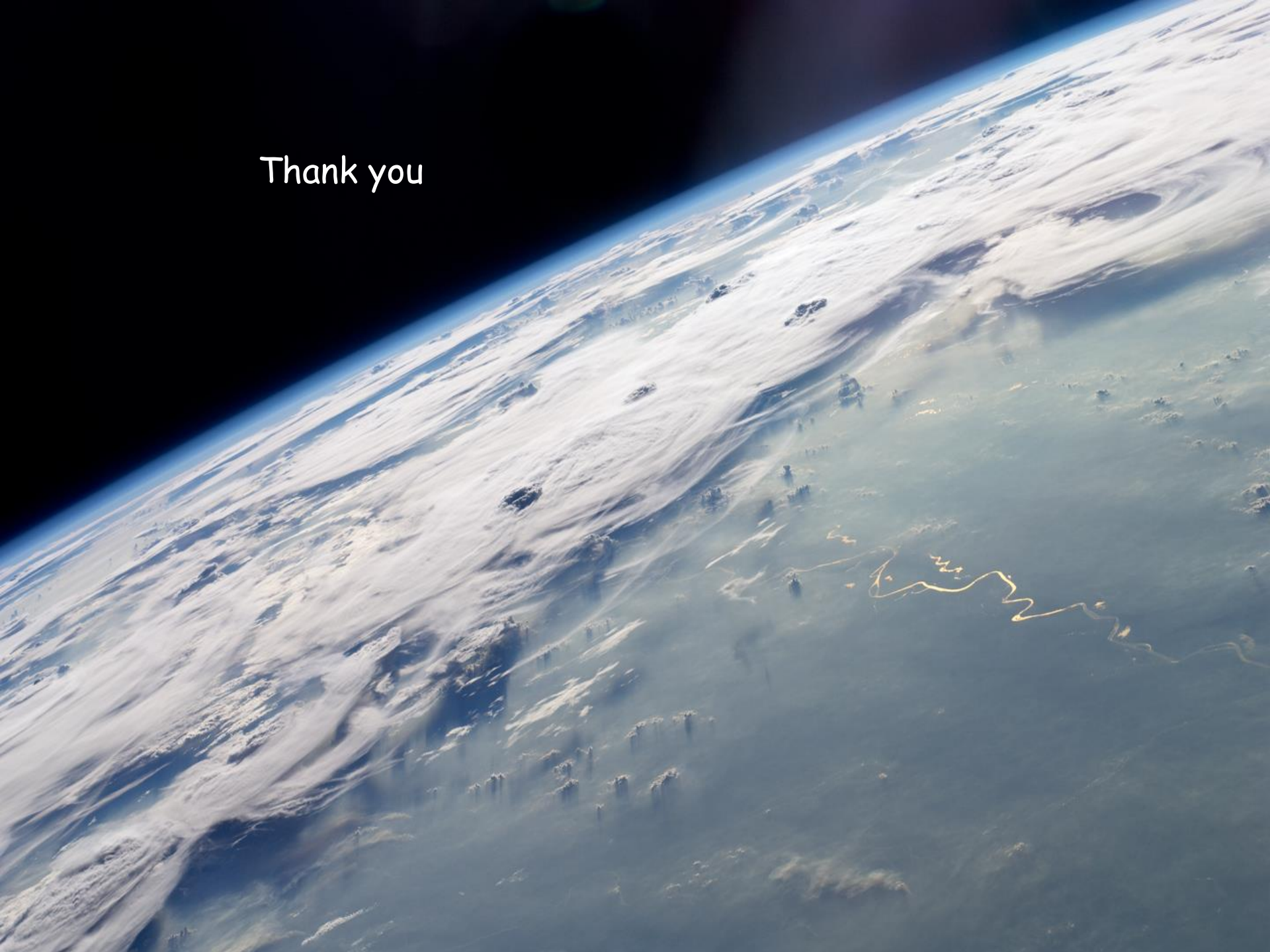
Park et al, JGR, 2009: Transport in Asian monsoon from MOZART

$$\frac{\partial \chi}{\partial t} = \text{advection} + \text{convection} + \text{chemistry}.$$

resolved parameterized

Convective transport is an O(1) process; not resolved in trajectories.

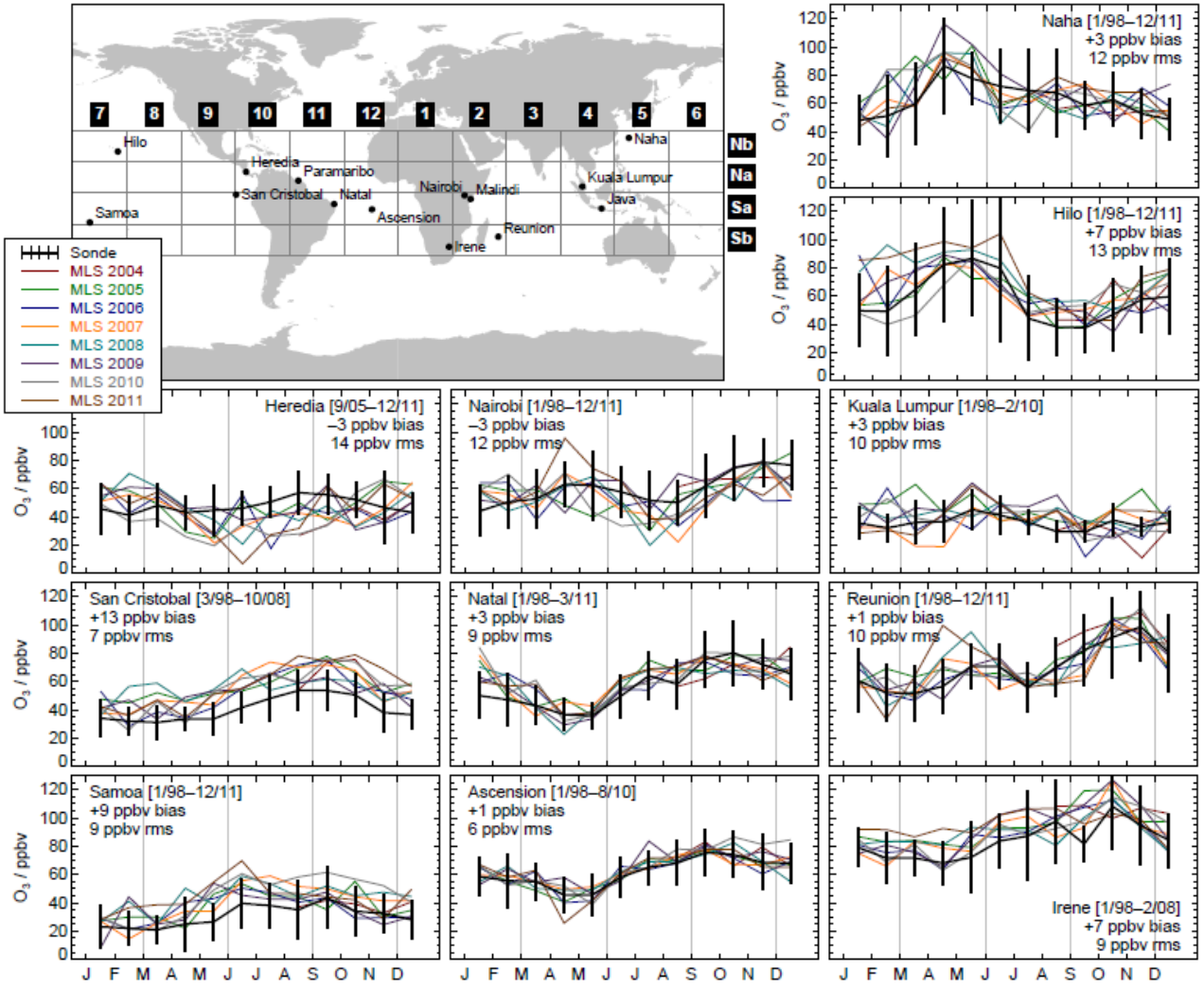



Thank you

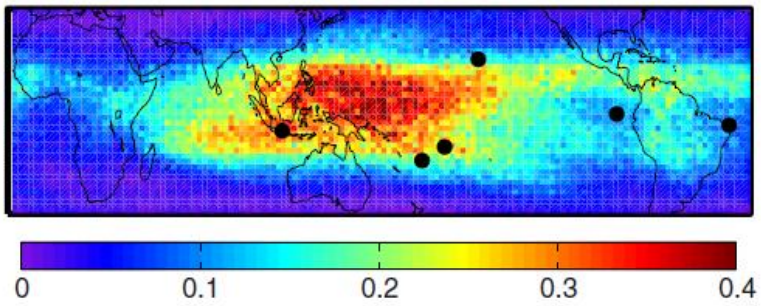
Extra slides

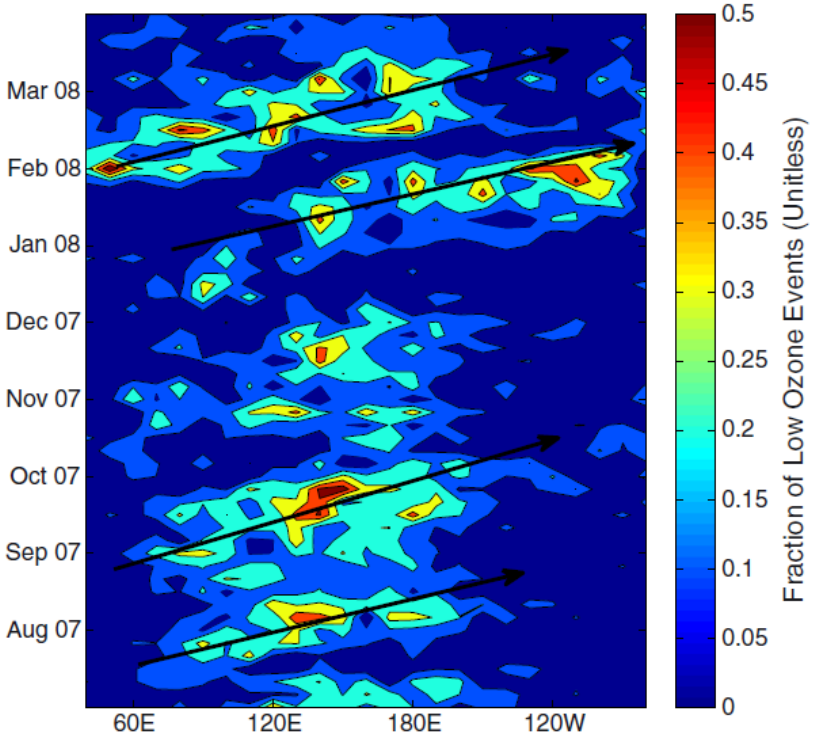
MLS ozone at 215 hPa

Livesey et al 2012



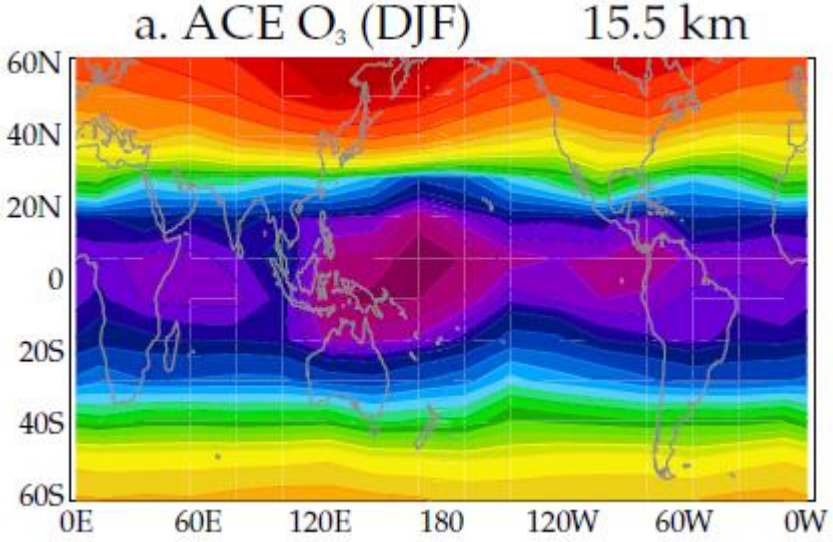
MLS observations: frequency of low ozone events at 215 hPa



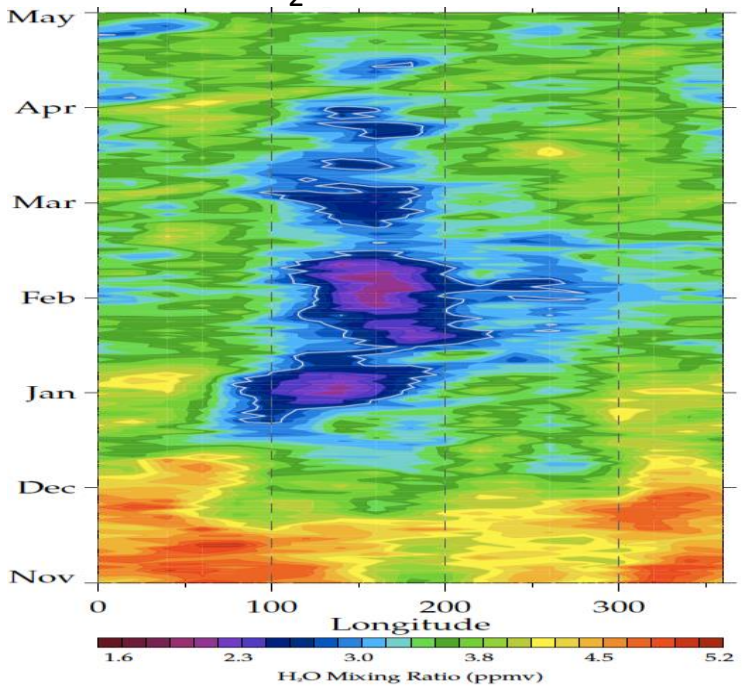


Cooper et al 2013

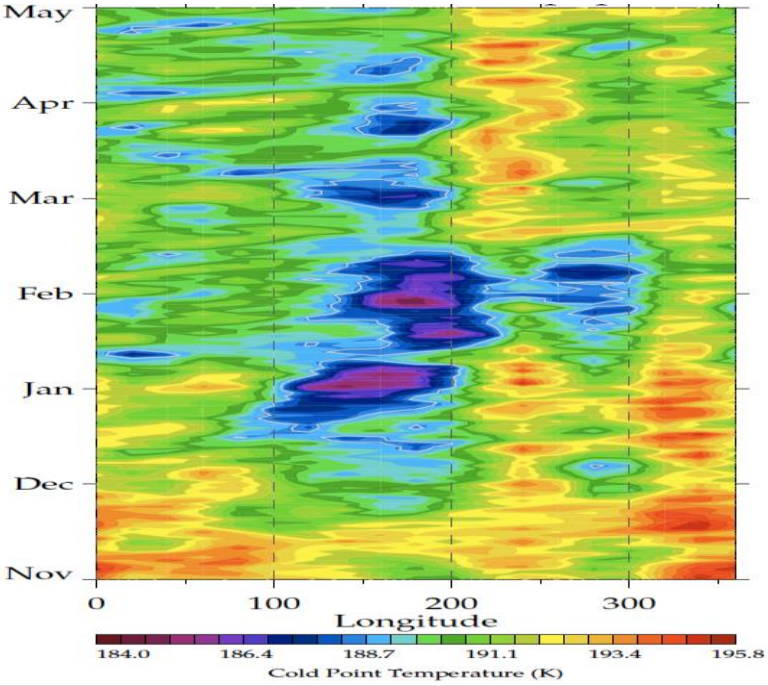
ACE-FTS ozone climatology



MLS H_2O 100 hPa



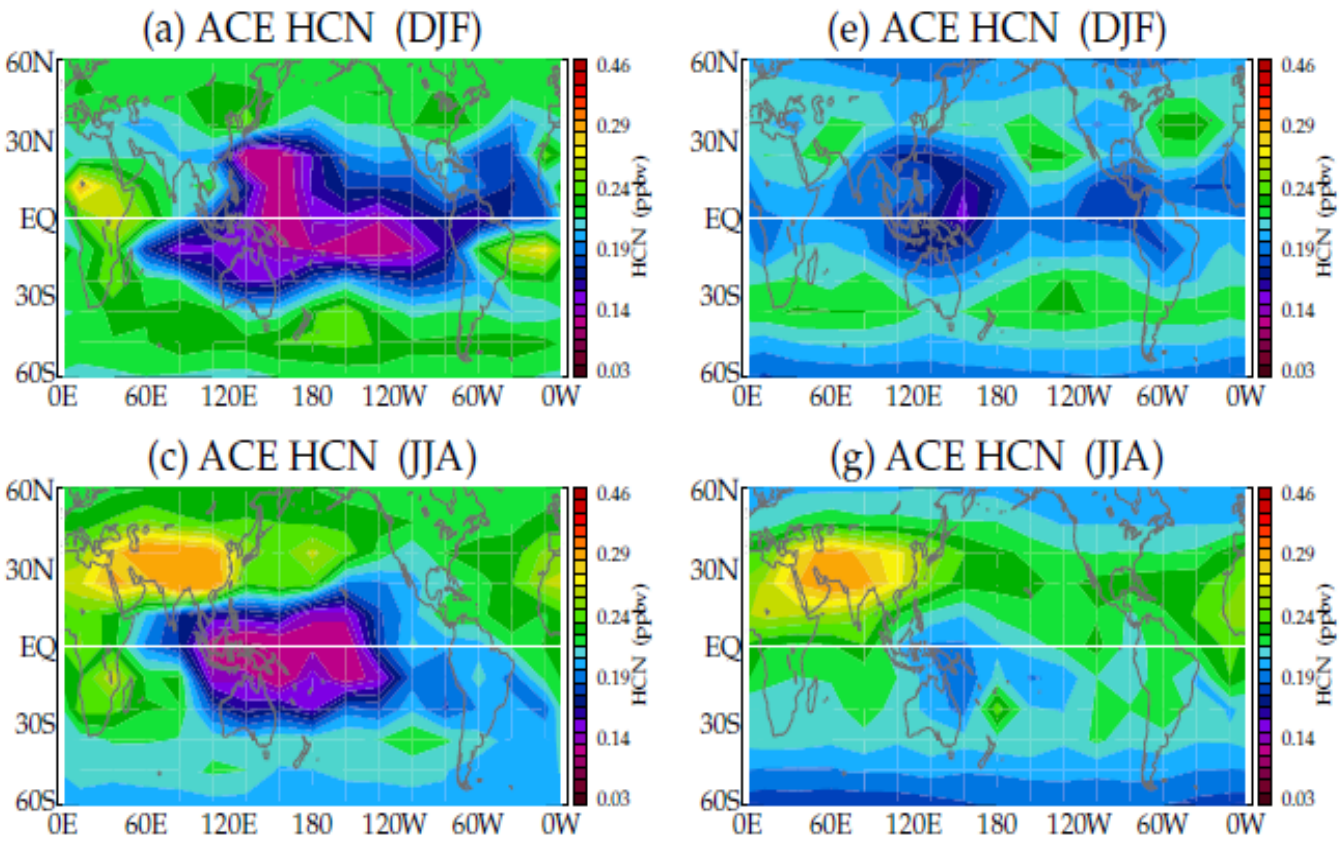
GPS Cold Point Tropopause



HCN as indicator of recent contact with ocean

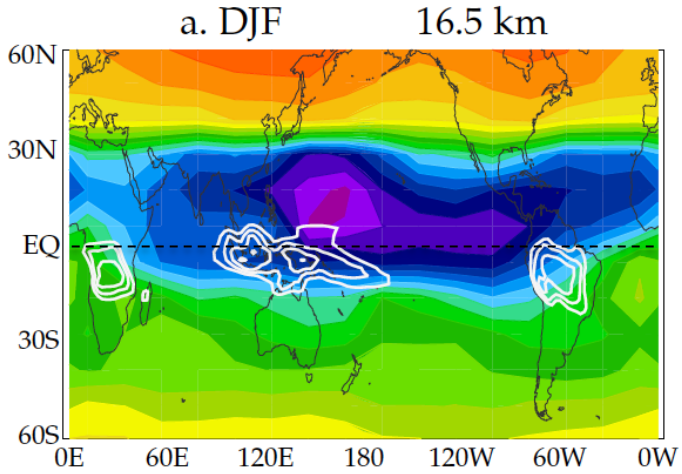
13.5 km

17.5 km

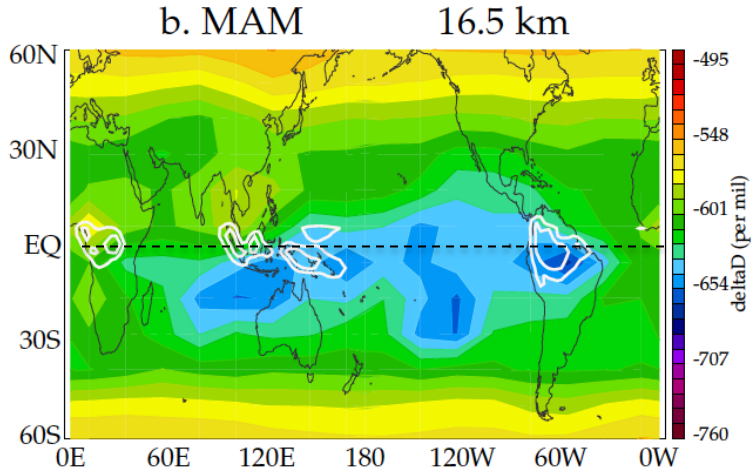


δD at 16.5 km

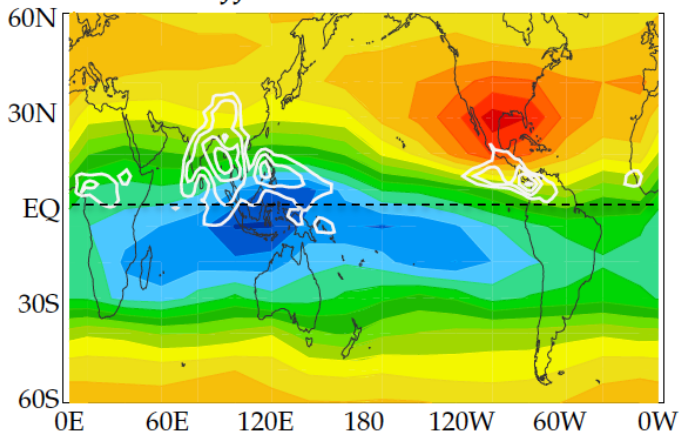
DJF



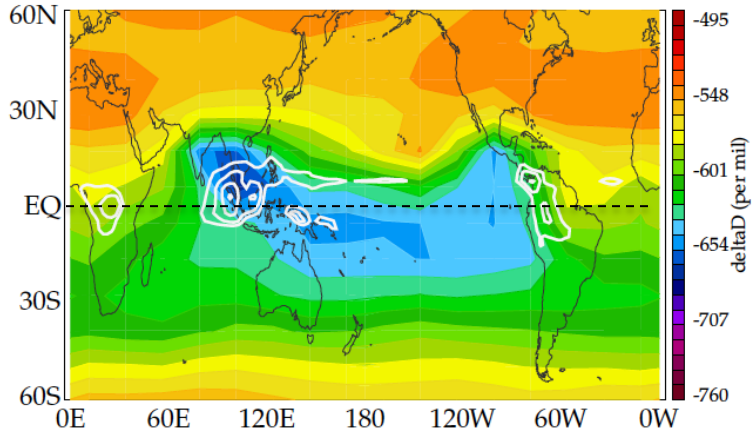
MAM



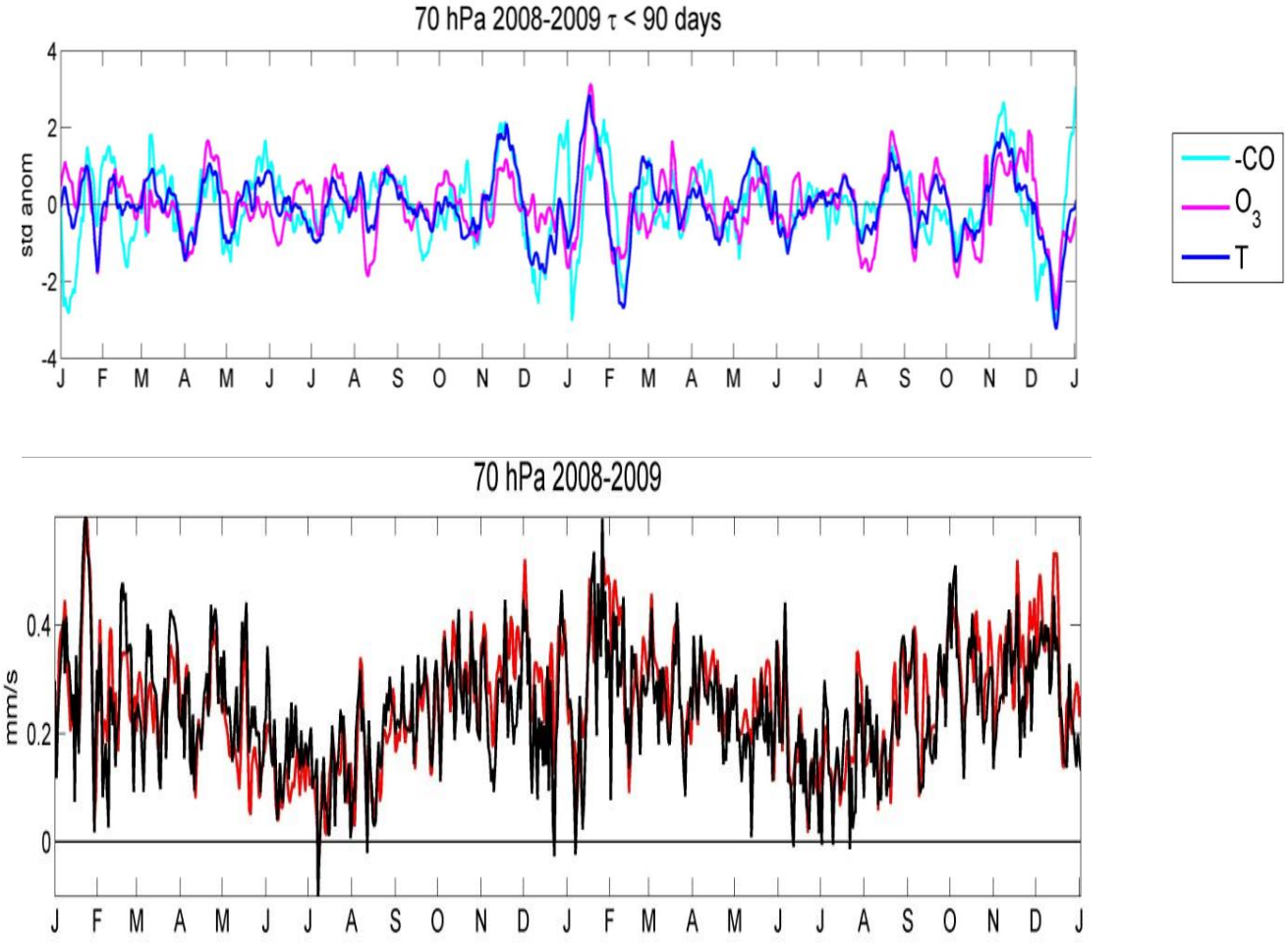
JJA



SON

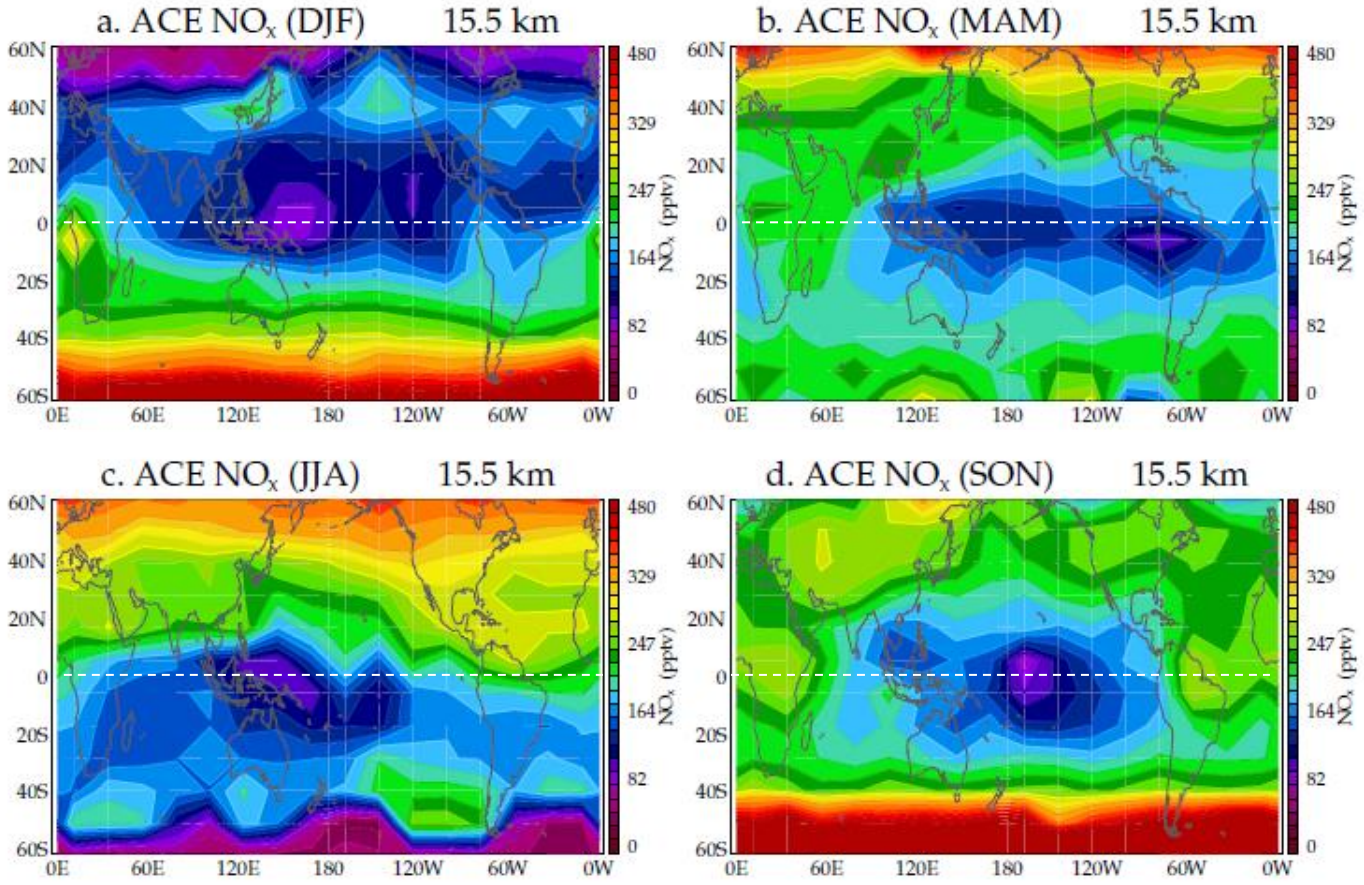


Strong coupling with temperature, O_3, CO

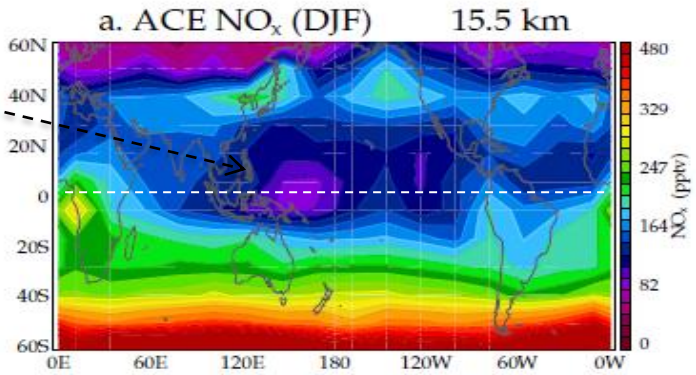


What is the NOx climatology in TTL?

ACE-FTS data

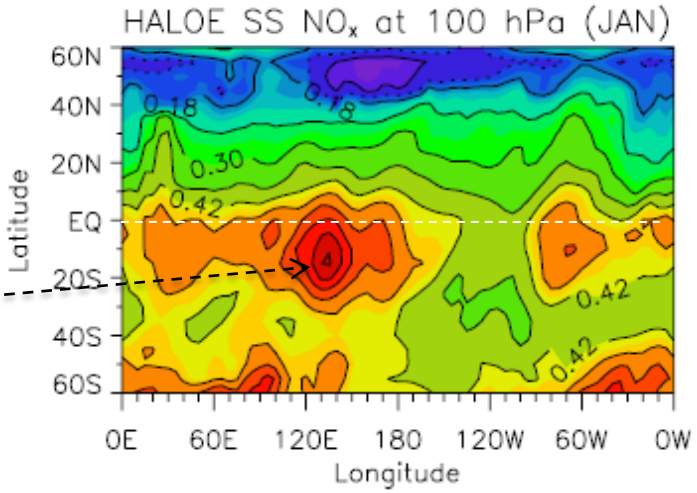


Different NOx results from different satellite data:



minimum

ACE-FTS

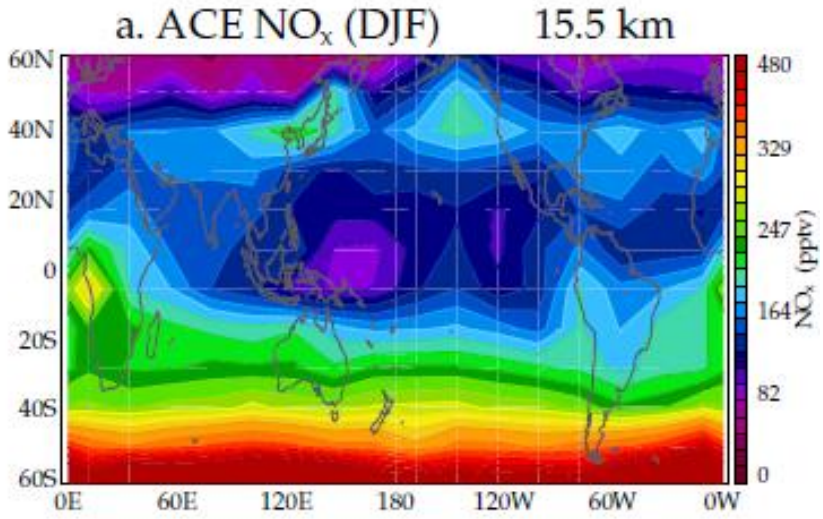


maximum

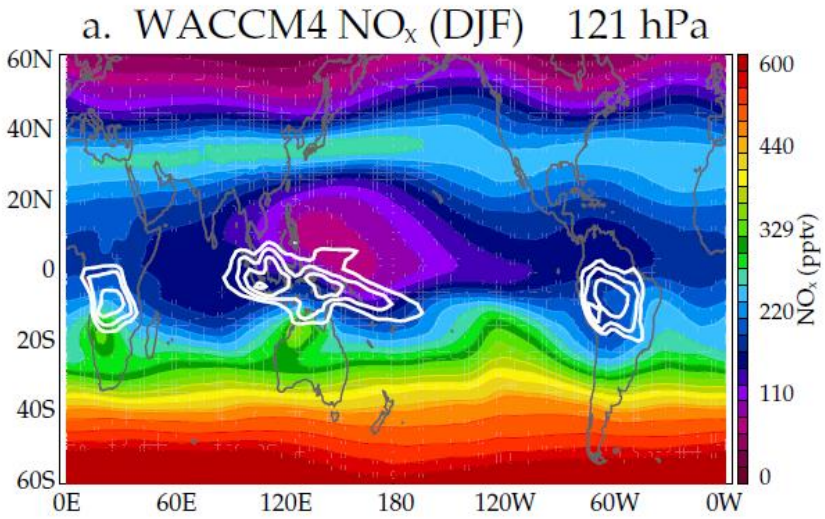
HALOE (Park et al, 2004)

Boreal winter

ACE-FTS

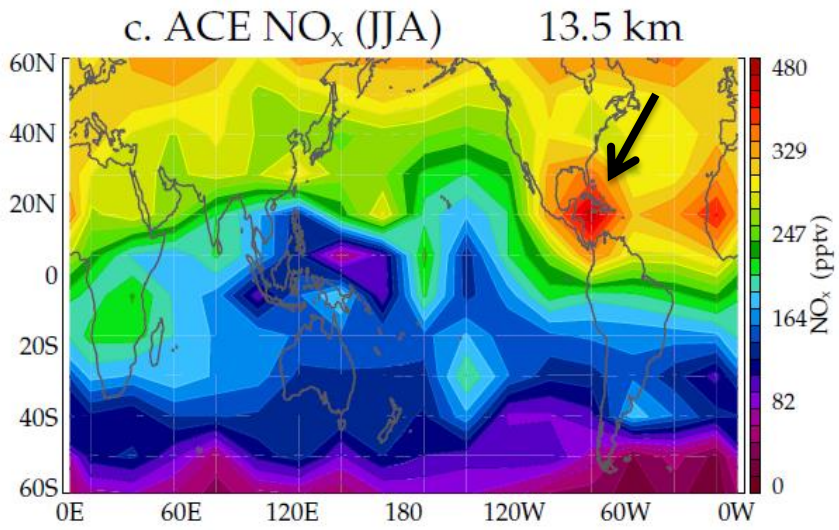


WACCM model result



Boreal summer

ACE-FTS



WACCM