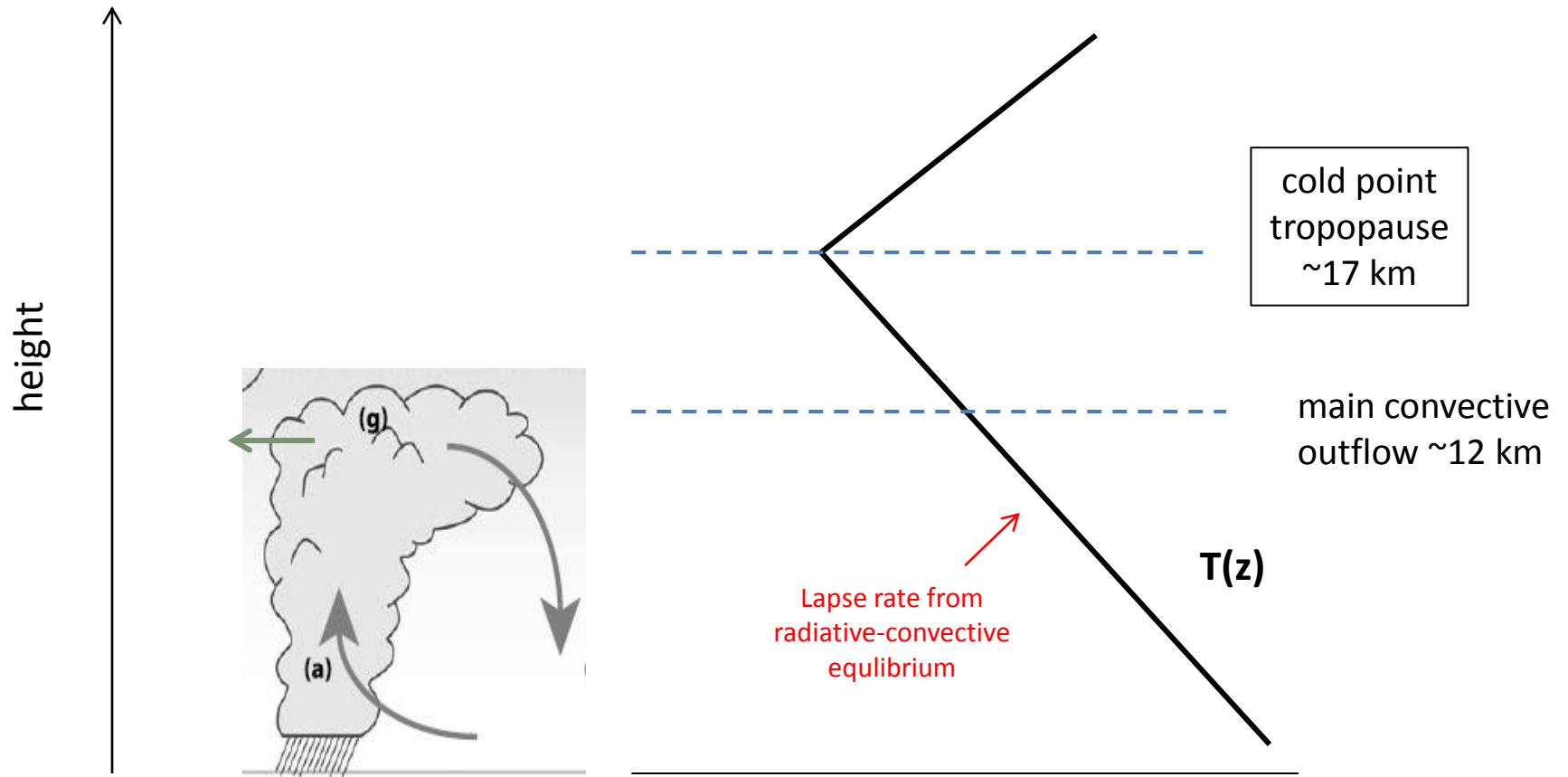


The cold point tropical tropopause observed by GPS

Bill Randel
Atmospheric Chemistry Division, NCAR



Convection and thermal structure in the tropics



EVIDENCE FOR A WORLD CIRCULATION PROVIDED BY MEASUREMENTS OF HELIUM AND WATER VAPOUR DISTRIBUTION IN THE STRATOSPHERE

By A. W. BREWER, M.Sc., A.Inst.P.

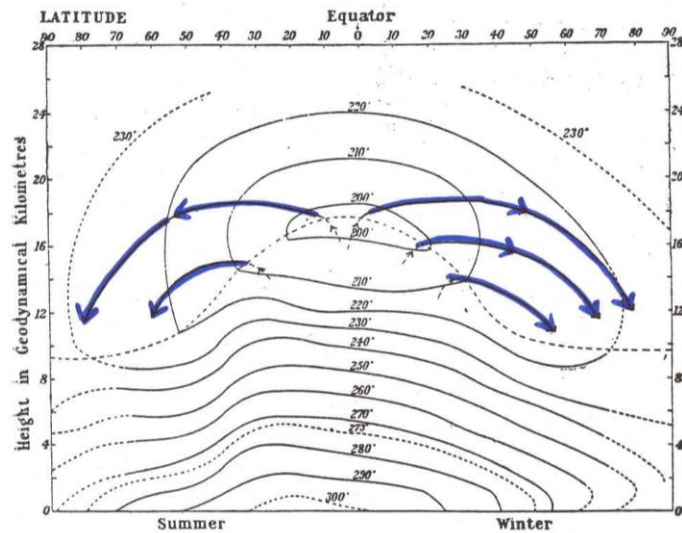
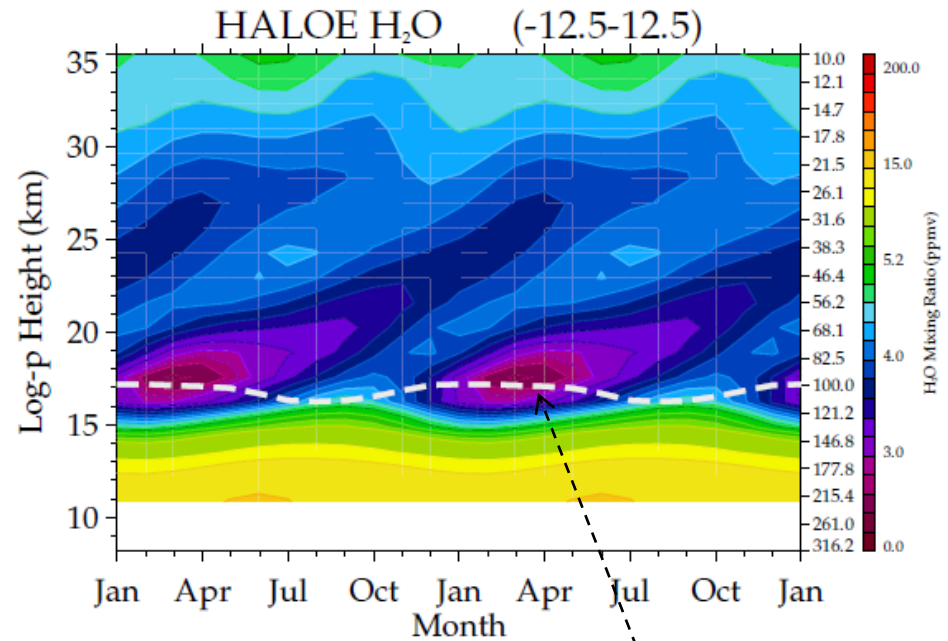


FIG. 5. A supply of dry air is maintained by a slow mean circulation from the equatorial tropopause.

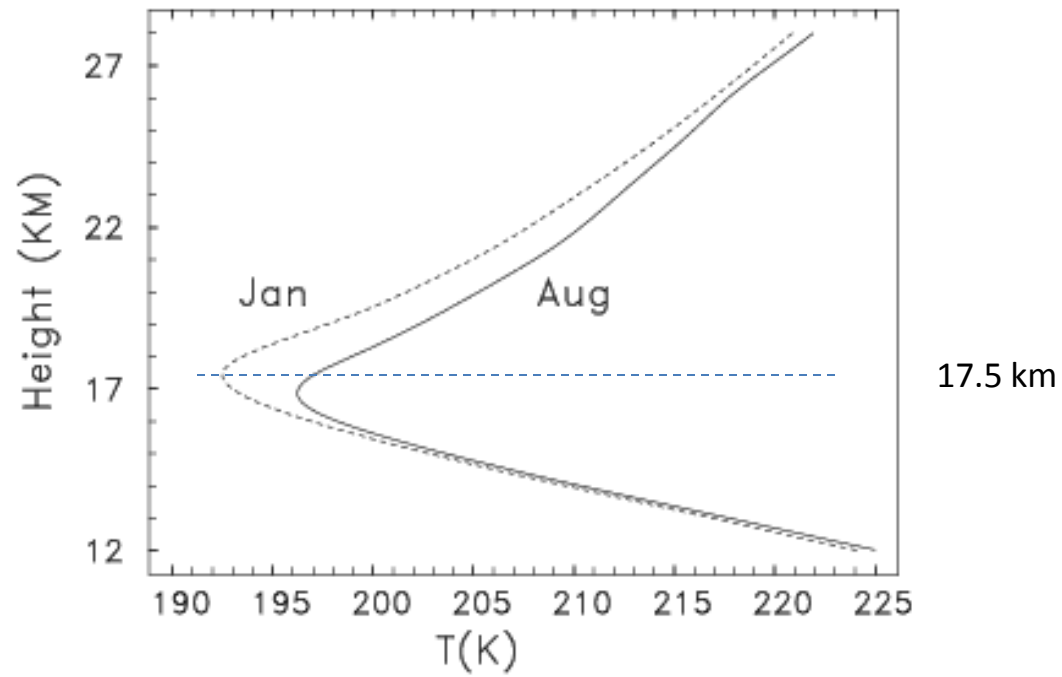
Water vapor 'tape recorder'

Mote et al 1998



Cold tropopause
temperatures produce
enhanced dehydration

Tropical temperature seasonal cycle



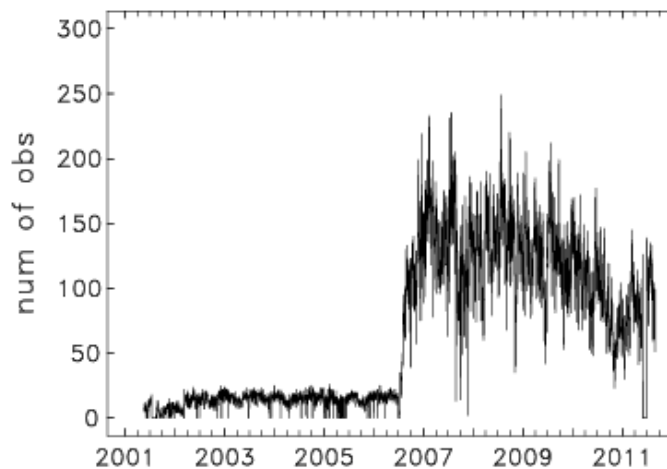
Objective: use GPS data to understand variability of tropical cold point

Zonal average GPS data over 10° N-S from CHAMP + COSMIC

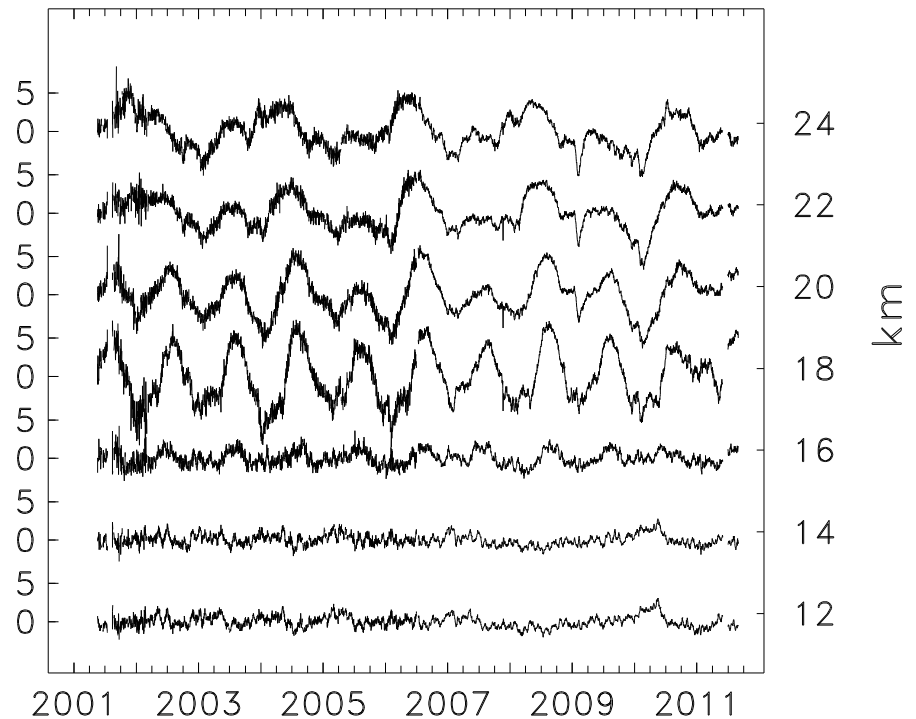
Daily data for 2001-2011 (ten complete years)

GPS 10–10 12–24km

Number of obs / day for 10° N-S

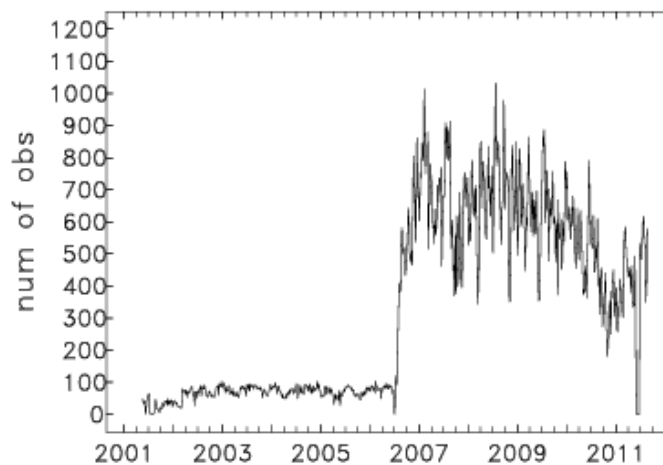


$T(K)$

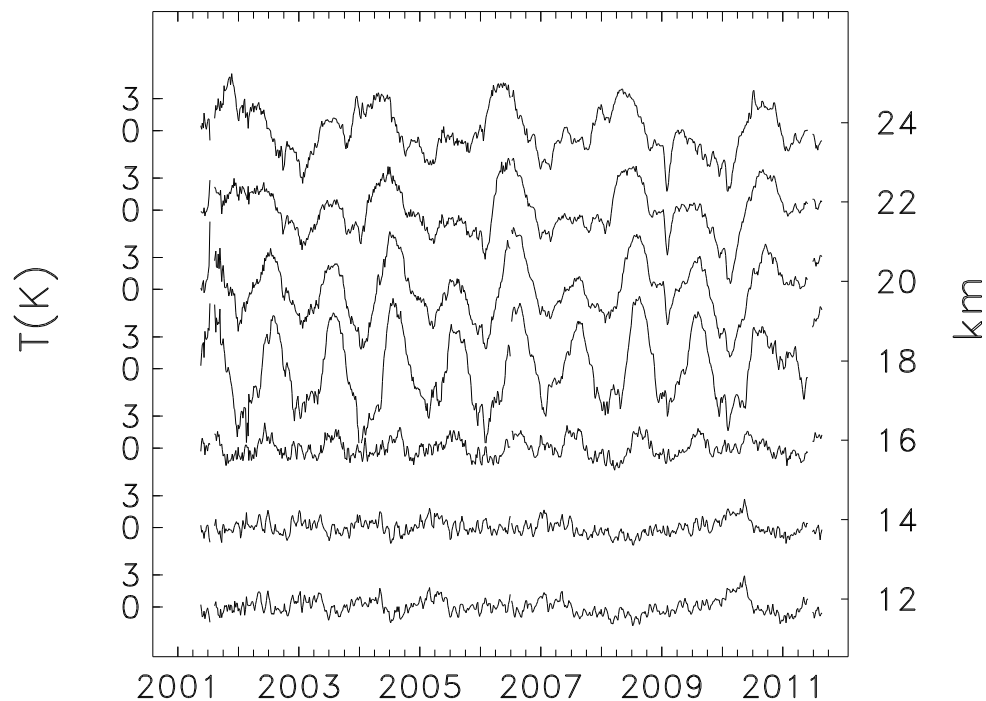


5-day average observations (730 pentads for 2001-2011)

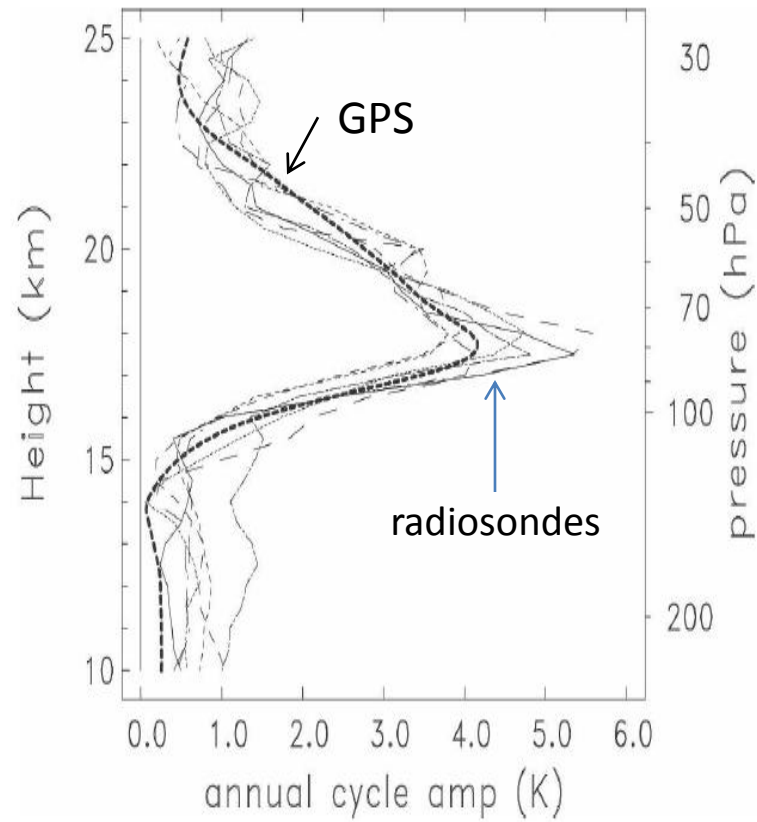
Number of obs / 5 days



GPS 10–10 12–24km

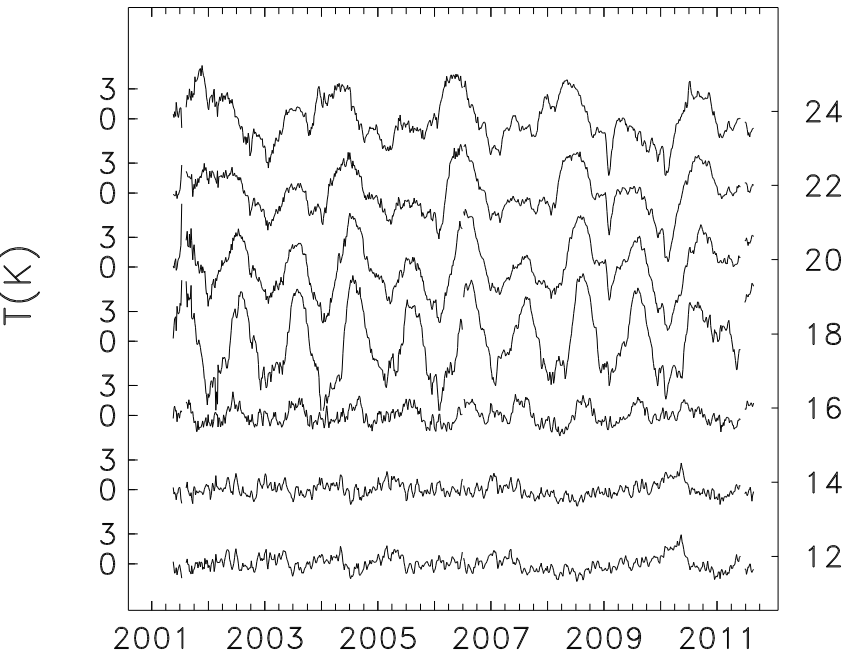


Annual cycle in temperature



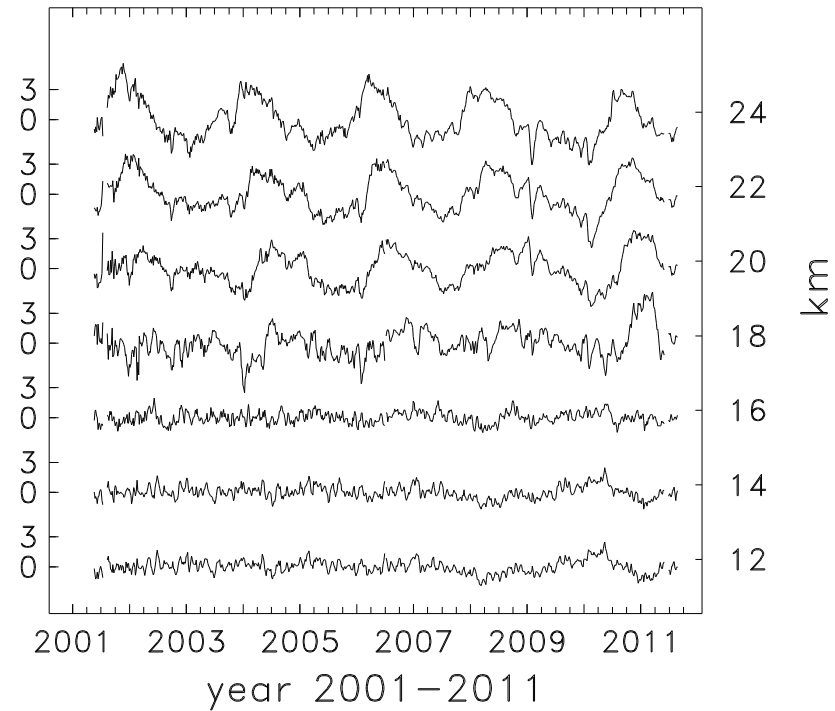
'raw' time series

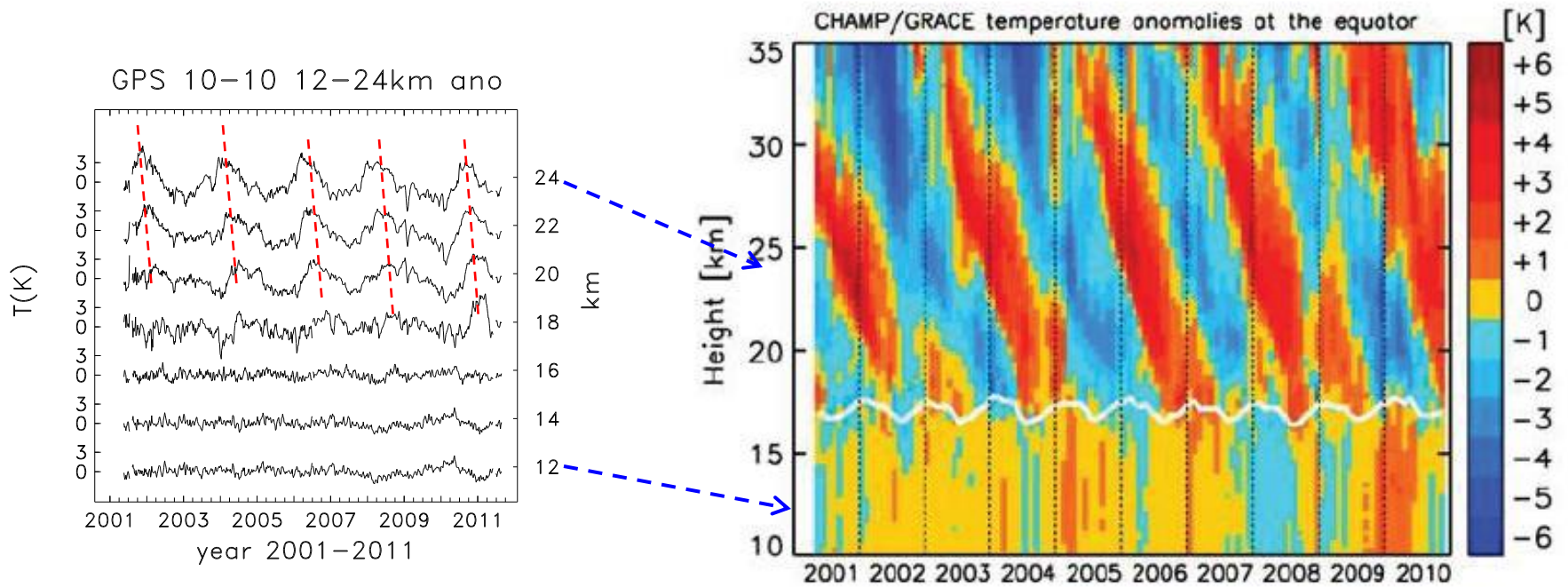
GPS 10–10 12–24km



Remove seasonal cycle

GPS 10–10 12–24km ano



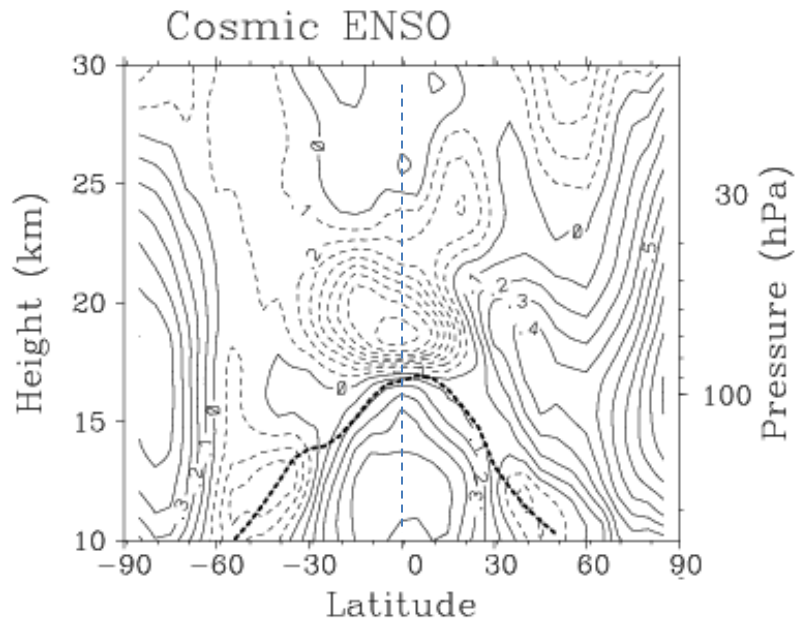
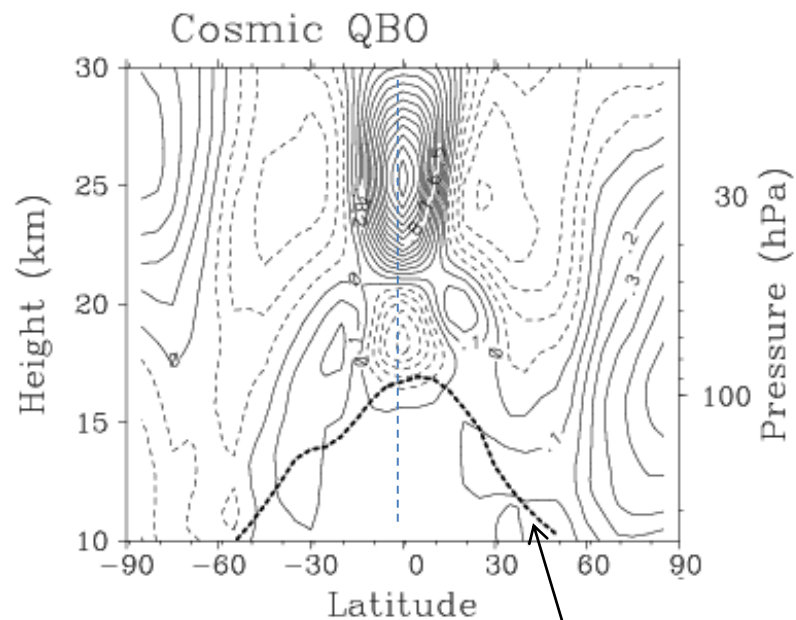


Anthes et al, 2011; from Torsten Schmidt

Regression fits of QBO and ENSO 2001-2011

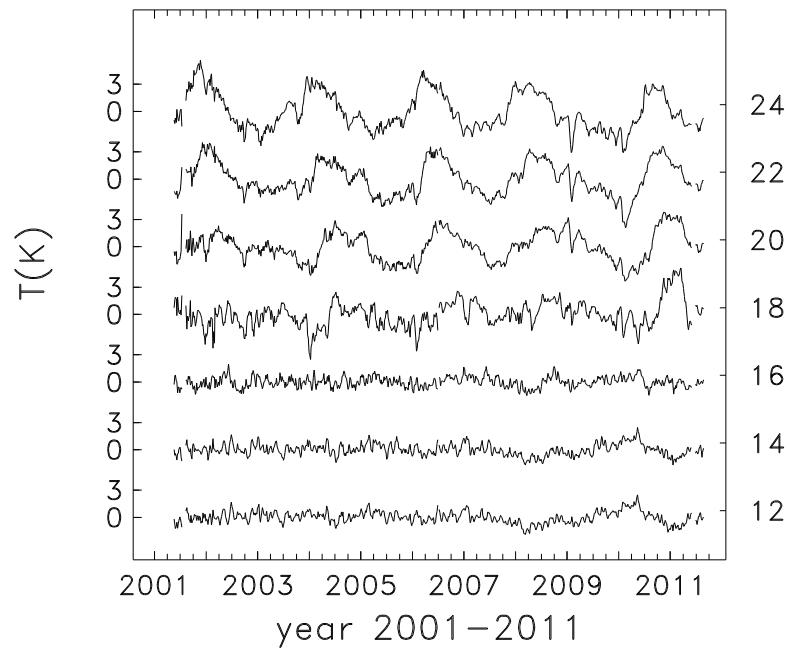
$$T = a * \text{ENSO} + b_1 * \text{QBO}_1 + b_2 * \text{QBO}_2$$

↑
proxy
time
series



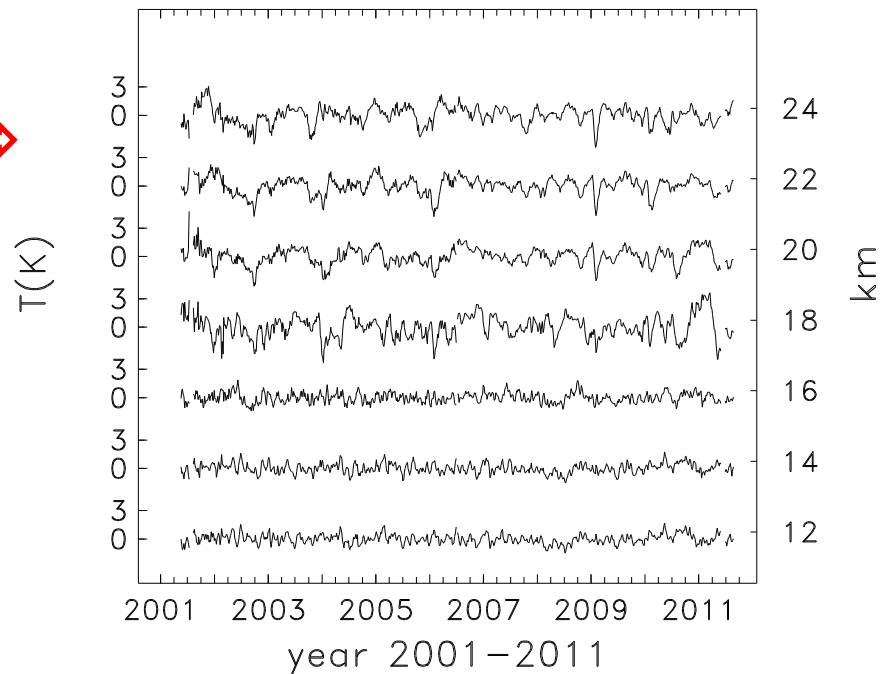
deseasonalized

GPS 10–10 12–24km ano

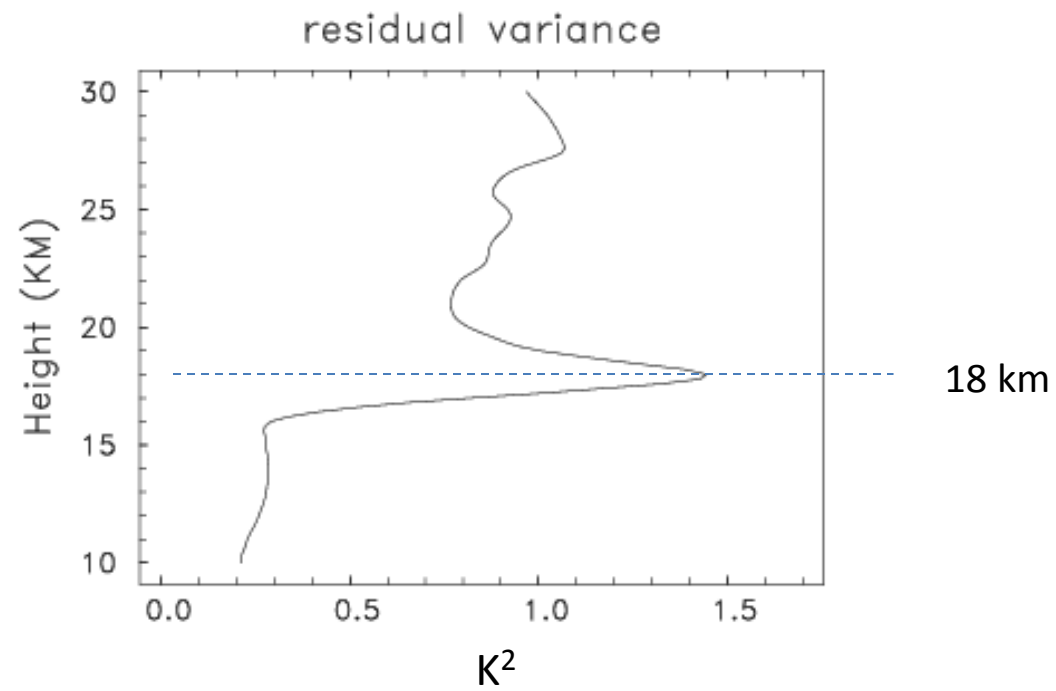


Remove QBO and ENSO

GPS 10–10 12–24km resi

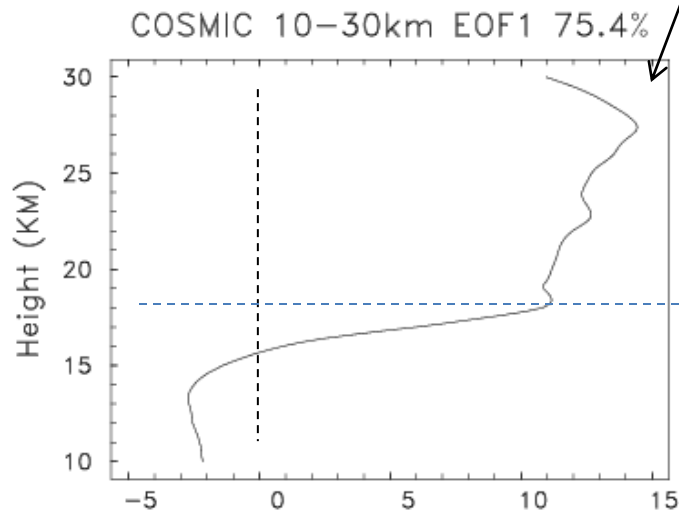


Variance after removing seasonal, QBO, ENSO components

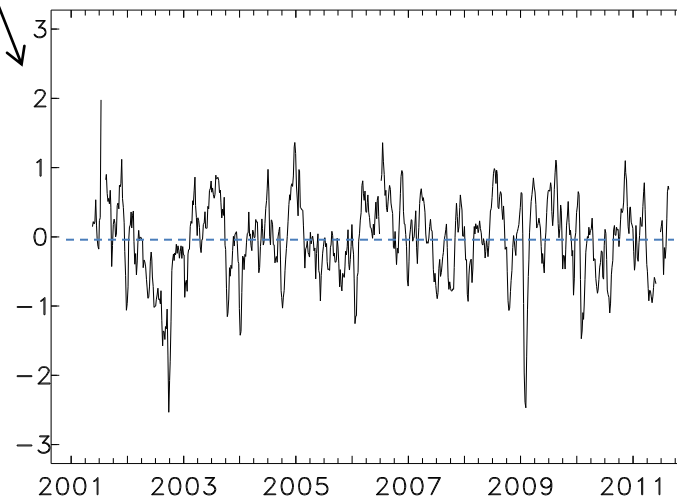


EOF analysis of residuals

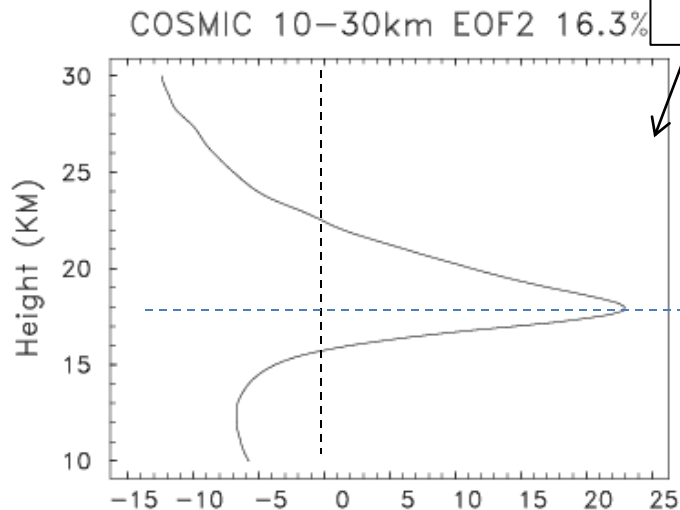
deep stratosphere
signal



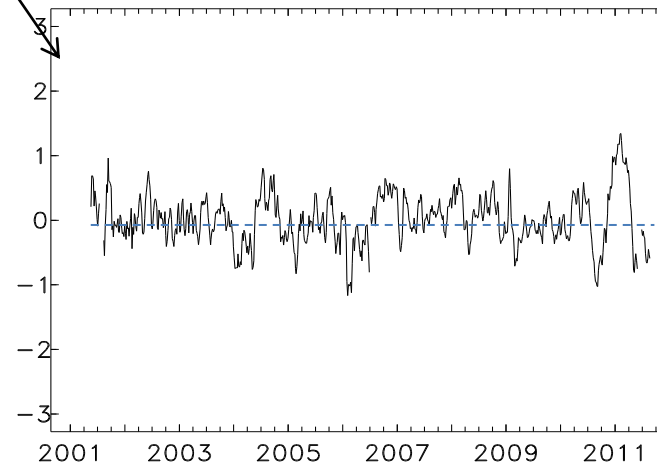
EOF1 projection



near tropopause
signal

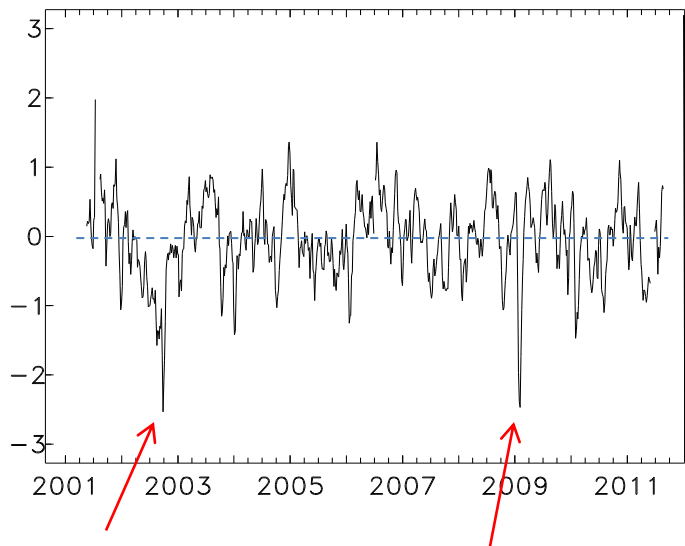


EOF2 projection



Tropical cooling linked to
major stratospheric
sudden warmings

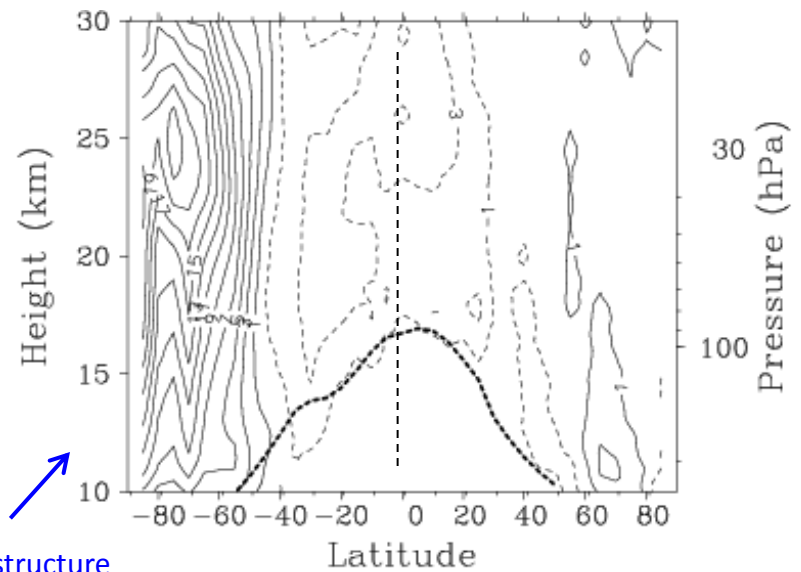
EOF1 projection



SH warming
Sept 2002

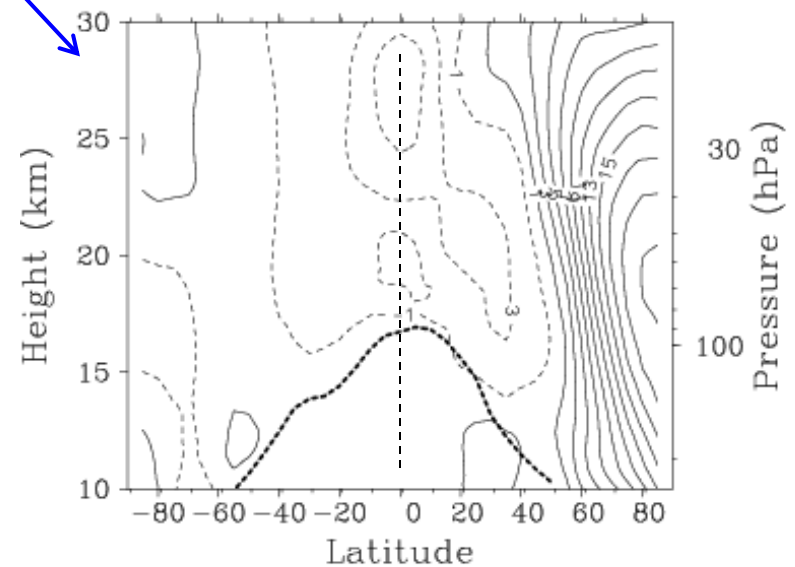
NH warming
Jan 2009

September 2002



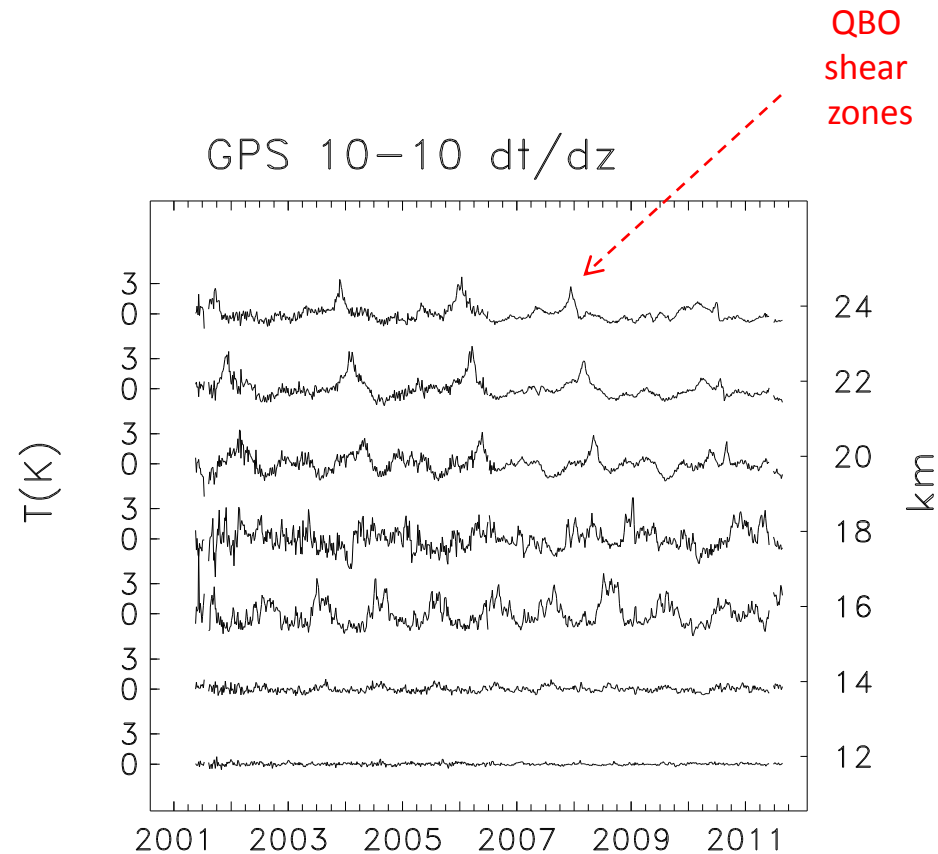
spatial structure
of temp anomalies

January 2009

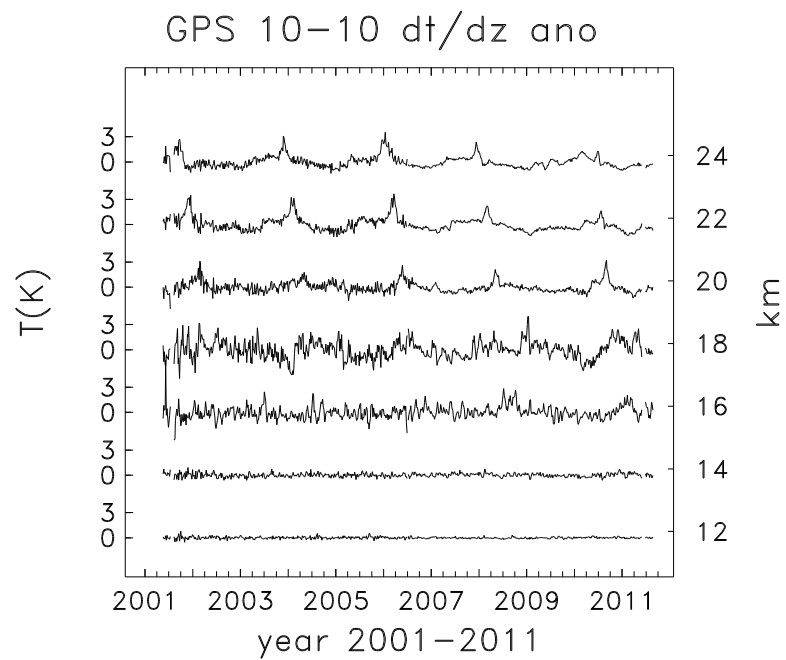


Analysis of lapse rate dT/dz

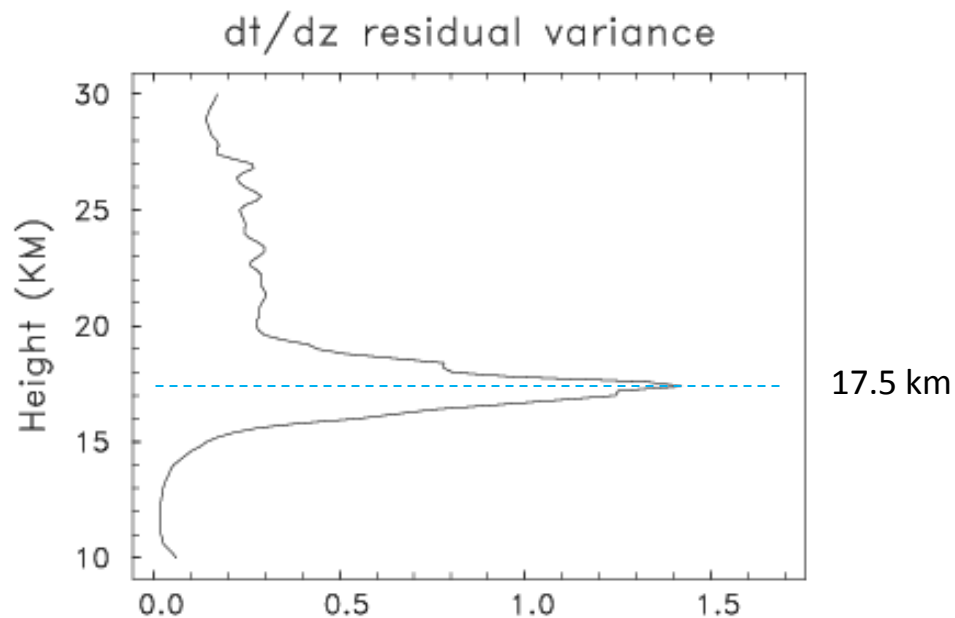
What is more fundamental: T or dT/dz ?



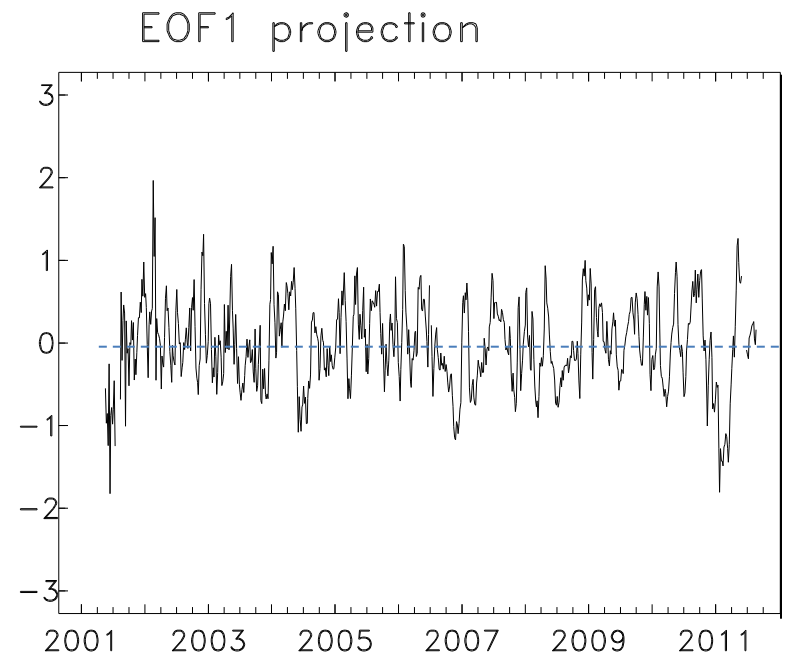
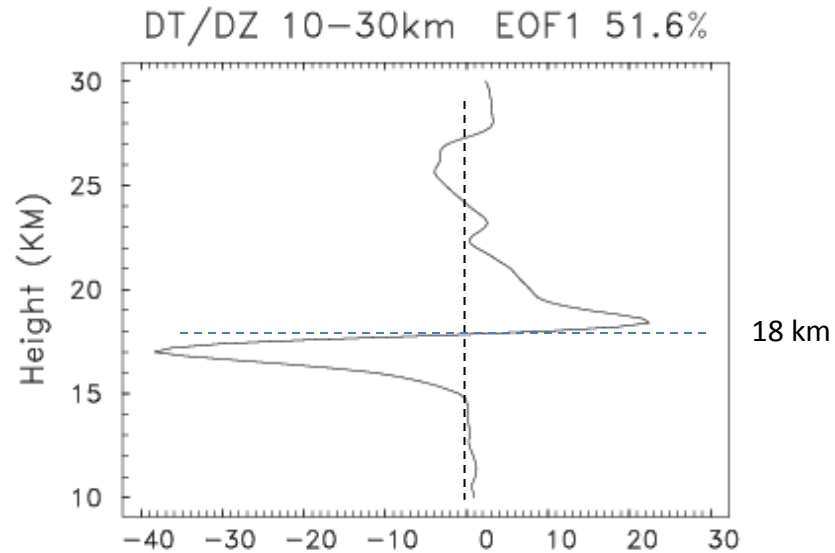
deseasonalized residuals



dT/dz variance



EOF analysis of residuals for dT/dz



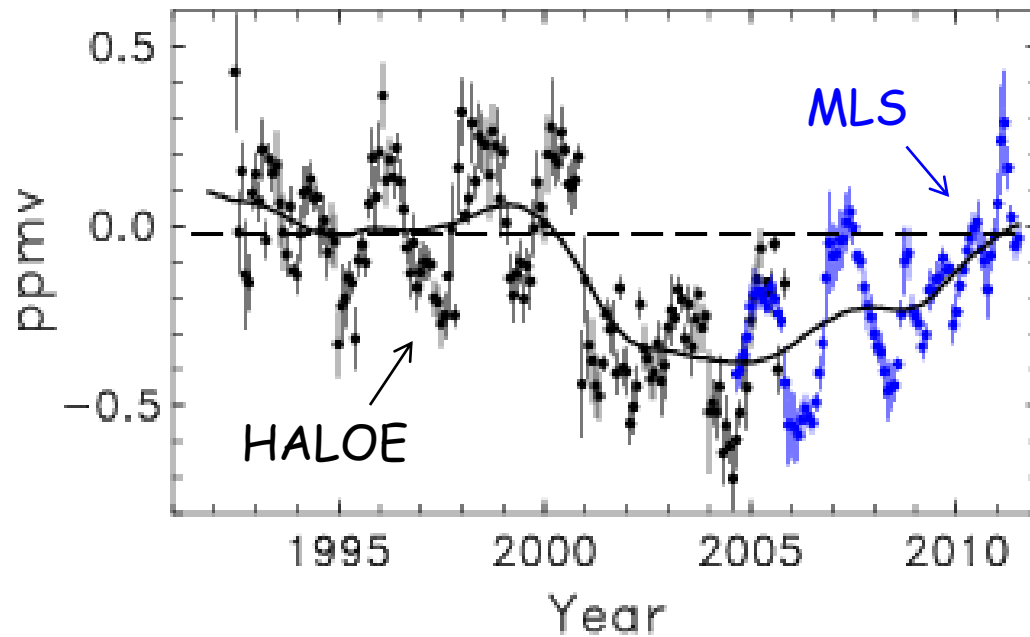
Key points:

- Novel high vertical resolution record of zonal mean tropical atmosphere
- Strong, coherent QBO and ENSO signals in GPS data
- Residual variance maximum near cold point tropopause (~18 km)
- Enhanced variability linked to stratospheric sudden warmings
- 'Climate noise' near cold point tropopause poorly understood

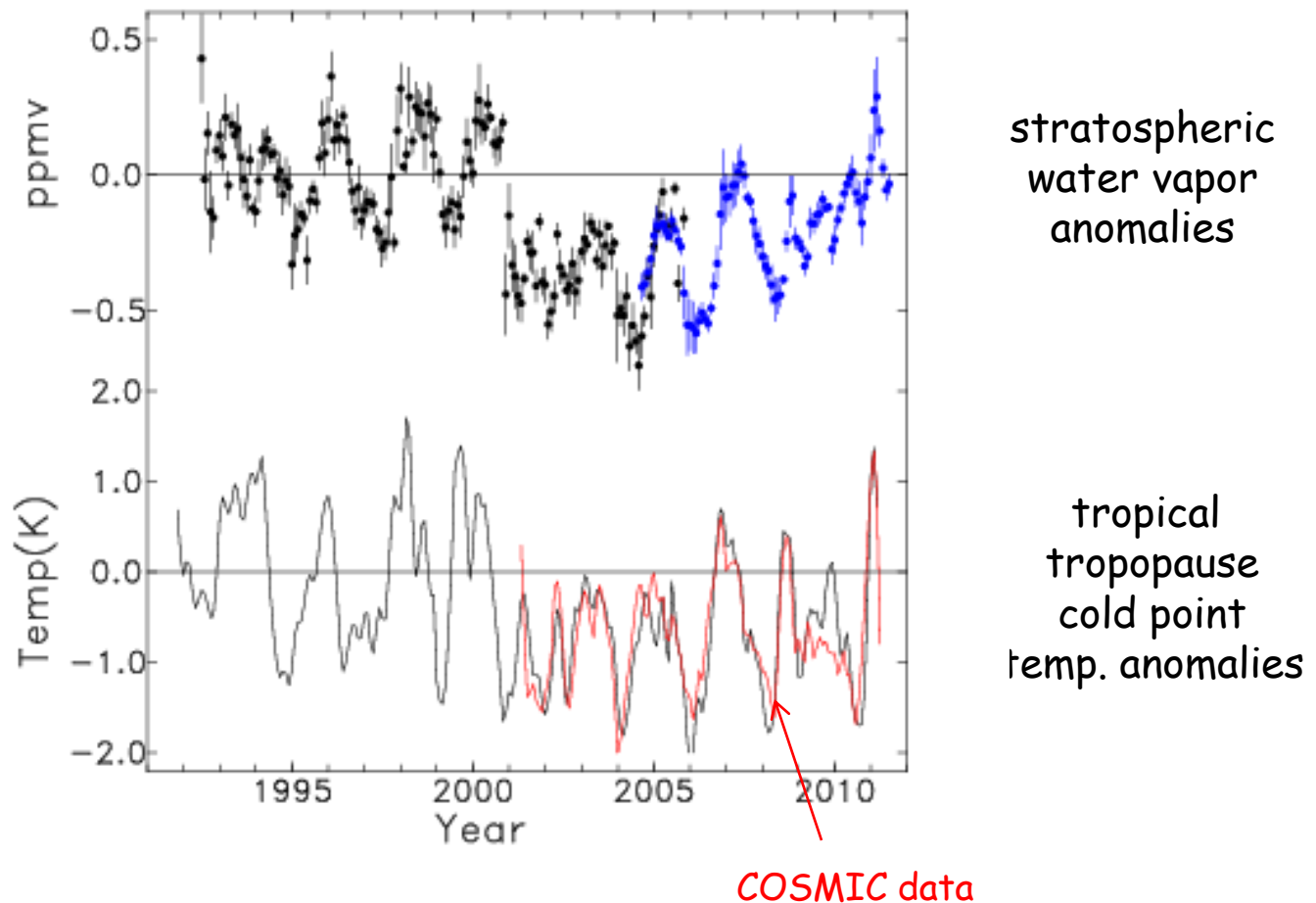
Thank you



Interannual changes in stratospheric water vapor



Changes in stratospheric H_2O are tied to tropopause temperatures



What controls variations of the tropical cold point?

Temperature annual and semi-annual harmonics

