The cold point tropical tropopause observed by GPS

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Convection and thermal structure in the tropics

- Cold point tropopause ~17 km
- Main convective outflow ~12 km
- Lapse rate from radiative-convective equilibrium
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.

Water vapor 'tape recorder'

Mote et al 1998

HALOE H₂O (-12.5-12.5)

Cold tropopause temperatures produce enhanced dehydration
Tropical temperature seasonal cycle

![Graph showing temperature change with height and time (Jan and Aug) with 17.5 km indicated.]
Objective: use GPS data to understand variability of tropical cold point

**Zonal average** GPS data over $10^\circ$ N-S from CHAMP + COSMIC

Daily data for 2001-2011 (ten complete years)
5-day average observations (730 pentads for 2001-2011)
Annual cycle in temperature

![Graph showing annual cycle in temperature with GPS and radiosondes indicated.](image)
'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

\[ T = a \times \text{ENSO} + b_1 \times \text{QBO}_1 + b_2 \times \text{QBO}_2 \]
deseasonalized

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<th>GPS 10–10 12–24km ano</th>
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<td>T(K)</td>
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<td>2001 2003 2005 2007 2009 2011</td>
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Remove QBO and ENSO

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Variance after removing seasonal, QBO, ENSO components

![Residual variance plot with a dashed line at 18 km]
EOF analysis of residuals

COSMIC 10–30km EOF1 75.4%

COSMIC 10–30km EOF2 16.3%

Deep stratosphere signal

Near tropopause signal

EOF1 projection

EOF2 projection
Tropical cooling linked to major stratospheric sudden warmings.

**September 2002**

**January 2009**

**EOF1** projection

SH warming Sept 2002

NH warming Jan 2009

Spatial structure of temp anomalies
Analysis of lapse rate $dT/dz$

What is more fundamental: $T$ or $dT/dz$?
deseasonalized residuals

GPS 10–10 \( \frac{dT}{dz} \) ano

\( \frac{dT}{dz} \) variance

\( \frac{dt}{dz} \) residual variance

17.5 km
EOF analysis of residuals for $dT/dz$

DT/DZ 10–30km  EOF1 51.6%

EOF1 projection
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