Quantifying the Deep Convective Temperature Signal within the Tropical Tropopause Layer (TTL) using co-located measurements from CloudSat and COSMIC

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Paulik & Birner, ACPD 2012
11km, Tropical Atlantic (20N, 65W), August

Stratosphere

Troposphere

Courtesy Andrew Gettelman, NCAR
Tropical Upper Troposphere / Lower Stratosphere ~ Tropical Tropopause Layer (TTL)

- Sets boundary conditions for constituents entering the stratosphere, most importantly water vapor

- Water vapor is crucial for stratospheric radiative budget (and potentially even for surface climate), but also for polar stratospheric cloud formation and therefore ozone depletion

- Temperature variability is governed by unusually large number of processes, e.g. Dynamics on vast range of spatial and temporal scales (convective plumes, small & large scale waves, planetary-scale circulations)
courtesy Diane Pendlebury, see TTL w/s report in SPARC newsletter 2007
Dynamical Controls on TTL Temperatures

- Planetary-scale circulations (e.g. adiabatic cooling by Brewer-Dobson upwelling)
- Convectively coupled equatorial waves (broad spectrum!)
- Convection (large-scale indirect & small-scale direct)

Here: large-scale (hydrostatic) response to tropospheric deep convective diabatic heating – TTL cooling (Johnson & Kriete 1982; Highwood & Hoskins 1998; Sherwood & Wahrlich 1999; Randel et al. 2003; Holloway & Neelin 2007; Gettelman & Birner 2007)
Randel et al. (2003): GPS/MET Observations (Temperature Anomalies, 10S-10N, DJF)

Cold Point

CMAM (DJF)

Gettelman & Birner (2007)
See also longitude-height wave structures in temperature – OLR regressions (Randel et al. 2003)
→ Create temperature anomaly profiles by subtracting monthly means interpolated to position of profile
→ Study temperature associated with deep convective cloud top events
Deep convective cloud top pixels as identified by CloudSat (Stephens et al. 2002, Sassen & Wang 2008), DJF

Diamonds: SHADOZ stations

Yellow: Deep Conv. Cloud Tops > 15 km
Red: Deep Conv. Cloud Tops > 17 km
Temperature Anomaly Profiles as a Function of Deep Convective Cloud Top Height (within +/- 6h & 1000 km)

DJF

<table>
<thead>
<tr>
<th>Altitude (km)</th>
<th>Count</th>
</tr>
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<tbody>
<tr>
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<td>4392</td>
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<tr>
<td>16–17 km</td>
<td>3007</td>
</tr>
<tr>
<td>&gt; 17 km</td>
<td>1235</td>
</tr>
</tbody>
</table>
Temperature Anomalies as a Function of Distance from Deep Convective Cloud > 17km (within +/- 6h)
Temperature Anomalies as a Function of Time Lag from Deep Convective Cloud > 17km (within +/- 1000km)

DJF
Summary & Conclusions

• Large-scale deep convective temperature signal: warming due to latent-heating in mid to upper troposphere, cooling in TTL

• Convective temperature signal from COSMIC / CloudSat for deep convective cloud tops > 15 km

• Signal is large-scale (~1000's km) & long-lived (1-2 weeks)

• Big(!) differences between DJF and JJA (not shown): larger in scale and more persistent signal during DJF