Diagnosing Vertical Transport Through the Tropical Tropopause Layer

Tropical tropopause

Radiative heating ~ ascent cooling

Clouds are important

Typical convection (~13 km)

E. Jensen, L. Pfister, Q. Yang, Q. Fu, and M. Schoeberl
Clear sky view of TTL transport

- Slow ascent
- Extreme convection (>15 km)
- Typical convection (~13 km)
- Subsidence

15.5 km

Radiative Heating

Radiative Cooling
CALIPSO cloud frequencies (DJF)

Yang et al. [2009]
Clear sky view of TTL transport

- Slow ascent
- Extreme convection (>15 km)
- Typical convection (~13 km)
- Subsidence

15.5 km

Radiative Heating

Radiative Cooling
TTL transport with clouds

- **Radiative Heating**
- **Subsidence**
- **Ascent**
- **Typical convection (~13 km)**

Radiative Heating

13 km

Subsidence

Ascent

Typical convection (~13 km)
Q. Yang and Q. Fu heating rate calculations

![Graph showing heating rate calculations]

- Net (cloudy+clear) heating rate (K/day)
- Height (km)
- Cloud-top frequency
- CALIPSO
- Heating rate

The graph illustrates the heating rate calculations for cloudy and clear conditions, showing the frequency of cloud-top occurrences as a function of height and heating rate.
Q. Yang and Q. Fu heating rate calculations

P = 225 hPa
Science questions:

• What convective outflow altitudes contribute most to air entering the stratosphere?

• In what geographic regions do these convective events occur?

• What is the fate of parcels detrained at the peak detrainment level (12-13 km)?
Back trajectories from tropical tropopause

Jan. 20, 2007 - 2 days
Back trajectories from tropical tropopause

Jan. 20, 2007 - 4 days
Back trajectories from tropical tropopause

Jan. 20, 2007 -10 days
Pfister convective influence analysis

ISCCP IR Image at 199512220600
Pfister convective influence analysis

ISCCP IR Image at 199512220900

- Tuned to match CloudSat/CALIPSO convective cloud-top statistics
Where do back trajectories hit convection?
Age since most recent convective influence

![Chart showing the relationship between age since convection and potential temperature of convection.](chart.png)
Where do trajectories hit convection?

Locations of convective influence

Potential temperature at convective encounter (K)
GEOS-5 forward trajectories from convection

Potential temperature at convective detrainment (K)

Potential temperature after 40 days (K)
• GEOS-5 TTL transport seems to match clear-sky radiation.
Summary

• TTL cirrus have a large impact on radiative heating rates ⇒ they are important for diagnosing transport.

• Detrainment from a broad range of convective outflow levels (including the main convective outflow level (12–13 km)) may affect stratospheric composition

Next steps...

• Directly compare heating rates in models with Yang and Fu calculations

• Repeat for Boreal summer