

Radiation balance of the tropical transition region

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Introduction

Aerosols and trace gases are transported effectively within the tropical troposphere by deep convection. The tropical convection reaches the stratosphere only in rare cases. In fact most of it ends distinctly below the stratosphere. Nevertheless the major part of mass exchange between troposphere and stratosphere takes place in the tropics. Hence processes, which influence the disposition of air in the tropical transition layer (TTL), are of crucial importance for exchange between troposphere and stratosphere. **Radiative heating can enable a further ascend of air into the stratosphere. Thus the level $Q=0$, where the radiation budget is balanced, is a borderline for tropospheric/stratospheric exchange.**

Both the solar and the thermal radiation budget determine the heating rate in the TTL. In the clear sky case the heating rate is effected by absorption and emission of radiation mainly by water vapour, CO_2 , and O_3 . For cloudy sky also thermal heating of the cloud base, thermal cooling of the cloud top of optically thick clouds or thermal heating of thin cirrus clouds, as well as solar heating of the cloud top are of particular interest.

Levels in the TTL

| θ | | p | z |
|----------|----------------------------------|--------|------|
| 400K | Cold Point Tropopause | 80hPa | 18km |
| 375K | Lapse Rate Tropopause | 100hPa | 16km |
| 365K | Radiation Balance $Q=0$ | 125hPa | 15km |
| 360K | Top of Convective Outflow | 145hPa | 14km |
| 350K | Equivalent Potential Temperature | 160hPa | 13km |

Main Convective Outflow



Deep Convection

Modelling

Input parameters

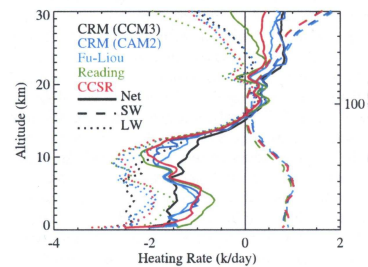
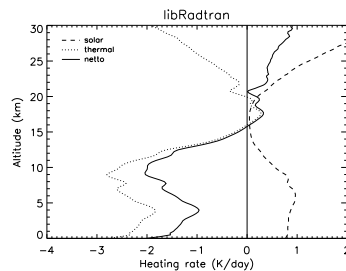
- Clouds
- Trace gas densities
- Surface albedo, temperature
- Solar zenith angle

Radiative transfer models

- libRadtran
- MYSTIC

(see also <http://www.libradtran.org>)

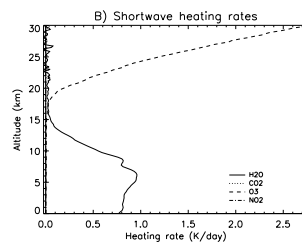
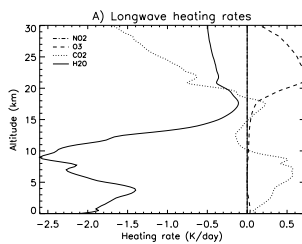
Heating rate in troposphere and stratosphere



(Left) Heating rate calculation by libRadtran

(Right) Heating rate calculations by various models, from Gettelman et al, 2004

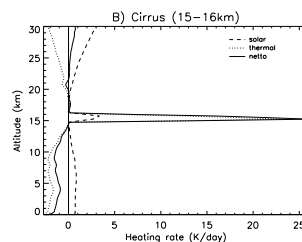
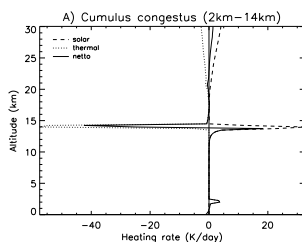
Contribution of single trace gases



(Left) The effect in thermal transfer is a combination of cooling by emission mainly due to water vapour and CO_2 and heating by absorption e. g. due to ozone above 20 km.

(Right) The troposphere is heated mainly due to water vapour, the stratosphere mainly due to ozone.

Influence of clouds



(Left) Heating profile for a water cloud with 1 g/m^3 liquid water content and effective cloud droplet radius of $10\ \mu\text{m}$.

(Right) Heating profile for an ice cloud with 0.01 g/m^3 ice water content and effective particle radius of $20\ \mu\text{m}$.

Goals

This project is a dissertation work at the DLR Oberpfaffenhofen. Following tasks will be addressed:

- Effects of 1D and 3D clouds on the $Q=0$ level
- Comparison of radiative heating rates with climate models
- Influence of radiative heating on Troposphere/Stratosphere exchange

References

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