VENUS ATMOSPHERIC DYNAMICS WITH THE LMD VENUS GCM

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LMD VENUS GCM

- Three-dimensional: 48x32x50 (0~95 km)
- Vertical coordinates: hybrid (sigma/pressure)

- Dynamical core, transport of tracers

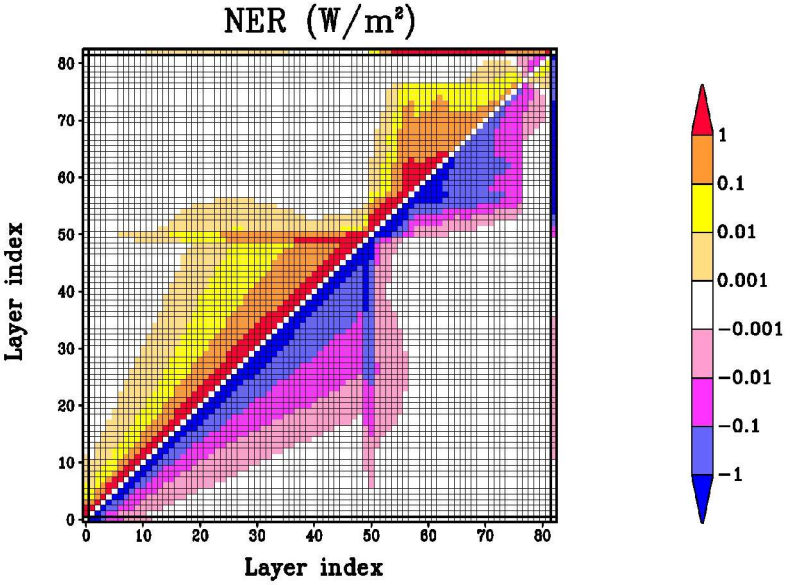
- Specific physics:
  - **radiative transfer**
  - parameterizations (sub-grid processes, boundary layer, convection, turbulence)
  - topography
  - no clouds microphysics

- No photochemistry

Radiation scheme

Full radiative transfer: (diurnal cycle)

- **Solar radiation** : tabulated fluxes and heating rates from D. Crisp, 1986.
- **Thermal radiation** : Monte-Carlo computation of Net Exchange Rates.
  - Radiative properties of atmosphere (gas, clouds) are fixed (uniform in latitudes)
  - Surface pressure taken into account (topography)
  - Net Exchange Rates matrix, T dependent



Newtonian cooling:

- **Simplified T forcing** : similar to Oxford Venus GCM (Lee et al.)

  distribution of heating rates peaking at equator around 70 km altitude

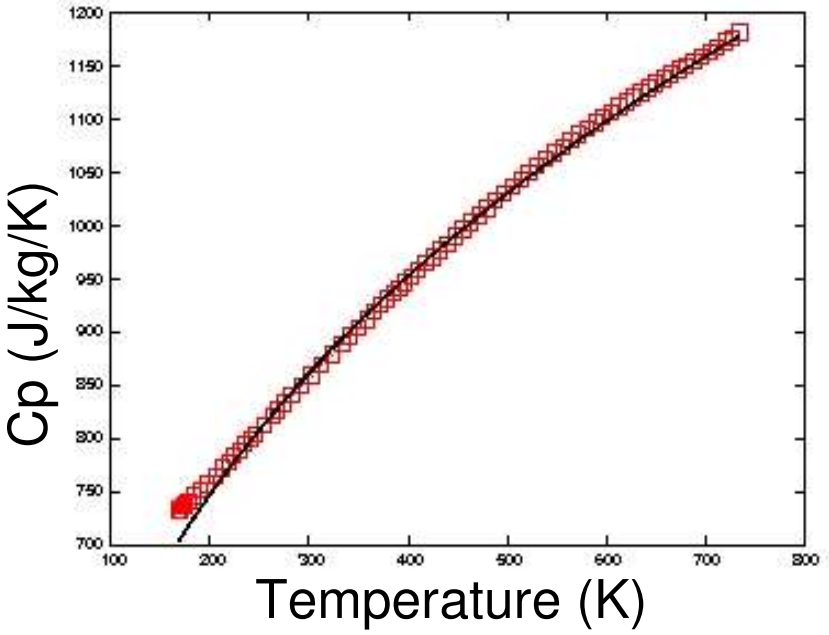
  no diurnal cycle

Specific heat Cp(T)

Taking into account T dependence of Cp :

- **Impacts** : adiabatic lapse rate; definition of potential temperature
- **Formulation** :
  - $Cp(T) = Cp0 \times (T/T0)^A$, with Cp0 = 1000 J/kg/K, T0 = 460 K, A = 0.35
  - New definition of potential temperature used in dynamical core :

$$\theta^A = T^A - A \times T0^A \times (R/Cp0) \ln(p/pref)$$



Options tested:

- **Constant Cp** : 900 and 1000 J/kg/K

NEWTONIAN COOLING

Possible intercomparison with other models

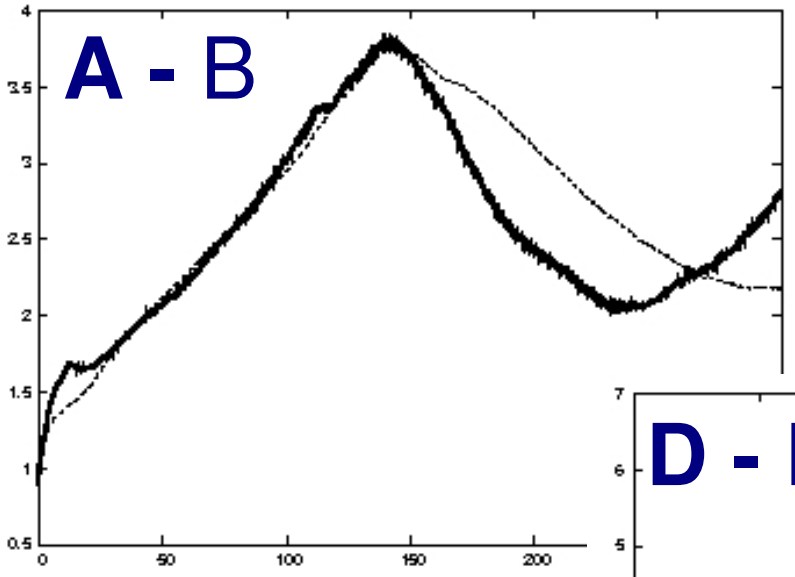
Simulations

- **Summer 2008: A (topography) / B (no topography)**
  - started from rest
  - constant Cp (=900 J/kg/K) ; Newtonian cooling
  - standard boundary layer
  - upper boundary condition: Rayleigh friction in the top three layers

- **November 2008: C (topography) / D (no topography)**
  - started from rest
  - constant Cp (=900 J/kg/K) ; Newtonian cooling
  - simple boundary layer: Rayleigh friction and Kv=0.25 m^2 s^{-1}
  - upper boundary condition: Rayleigh friction in the top three layers

- **Winter 2009: E (topography) / F (no topography)**
  - Same as November 2008, except upper boundary:
  - Dumping only u', v' in the top three layers
  - After 180 Venus days, both upper boundary conditions were run

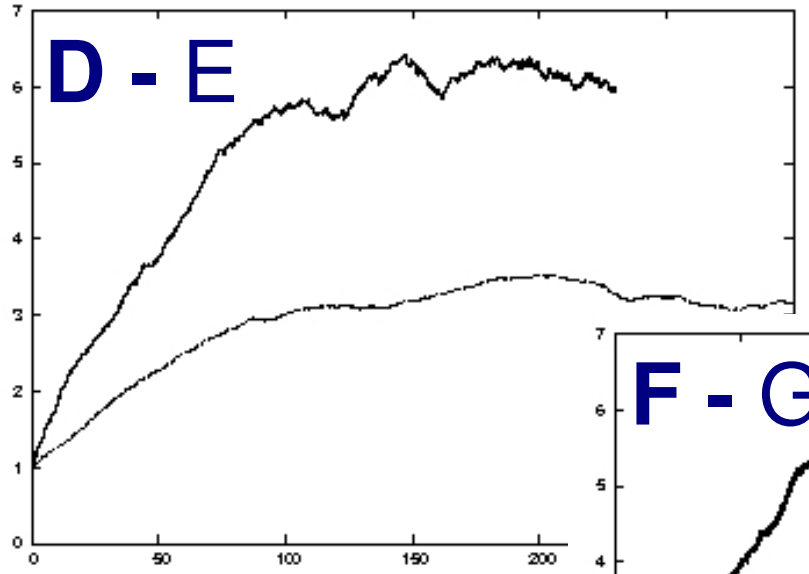
Total angular momentum

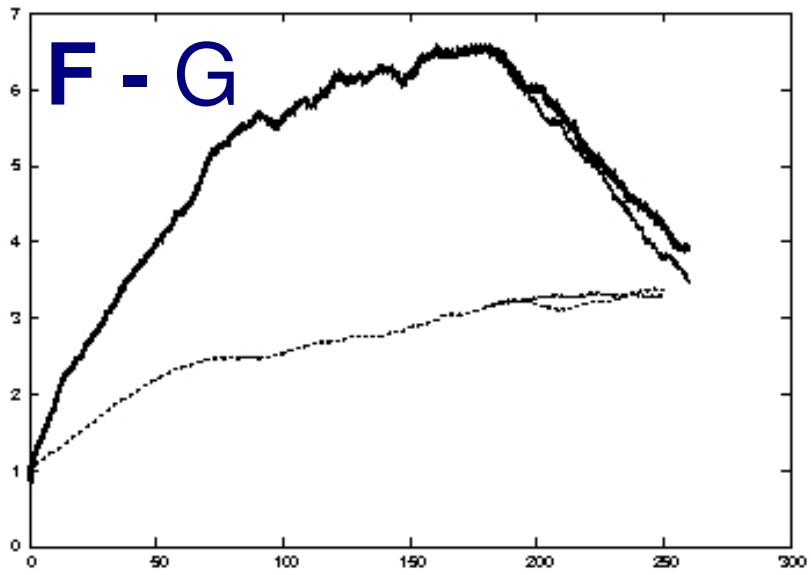


-> two states ?...

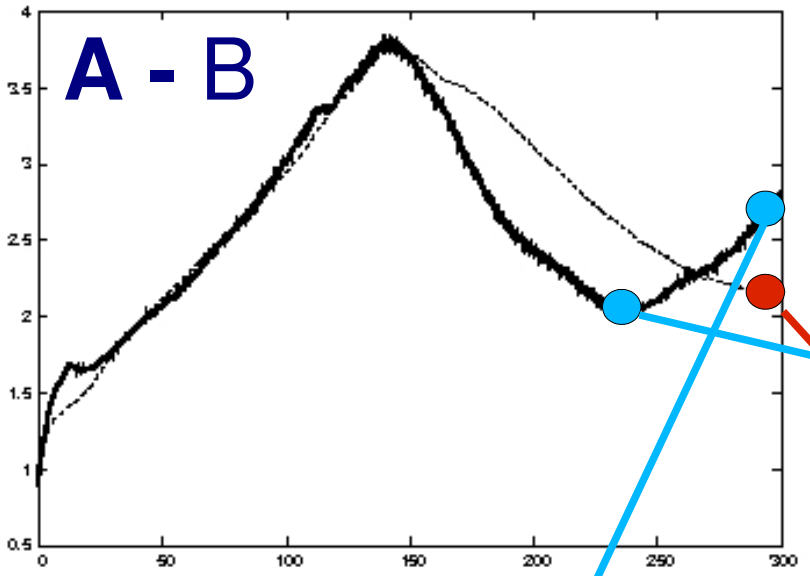
-> influence of lower boundary layer

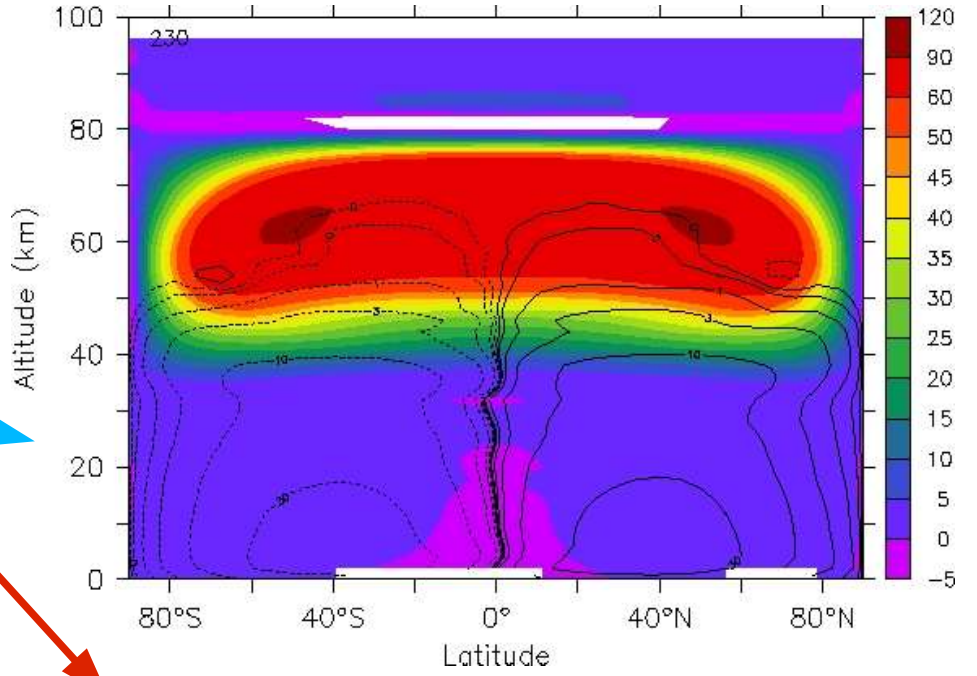
-> influence of topography

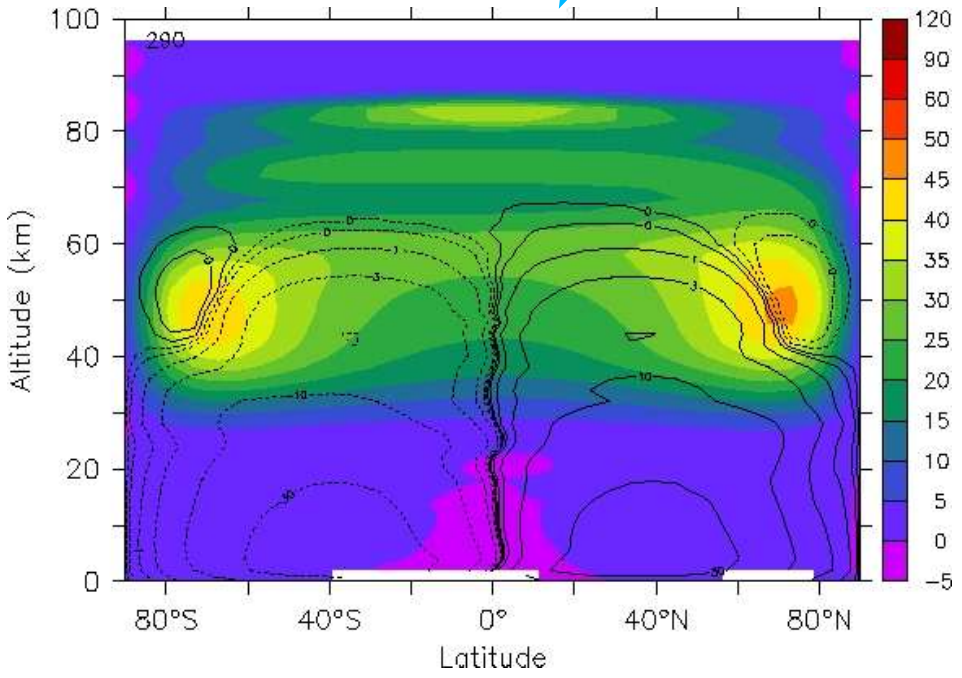




Two states ?


A - B


230
Altitude (km)
Latitude
80°S
40°S
0°
40°N
80°N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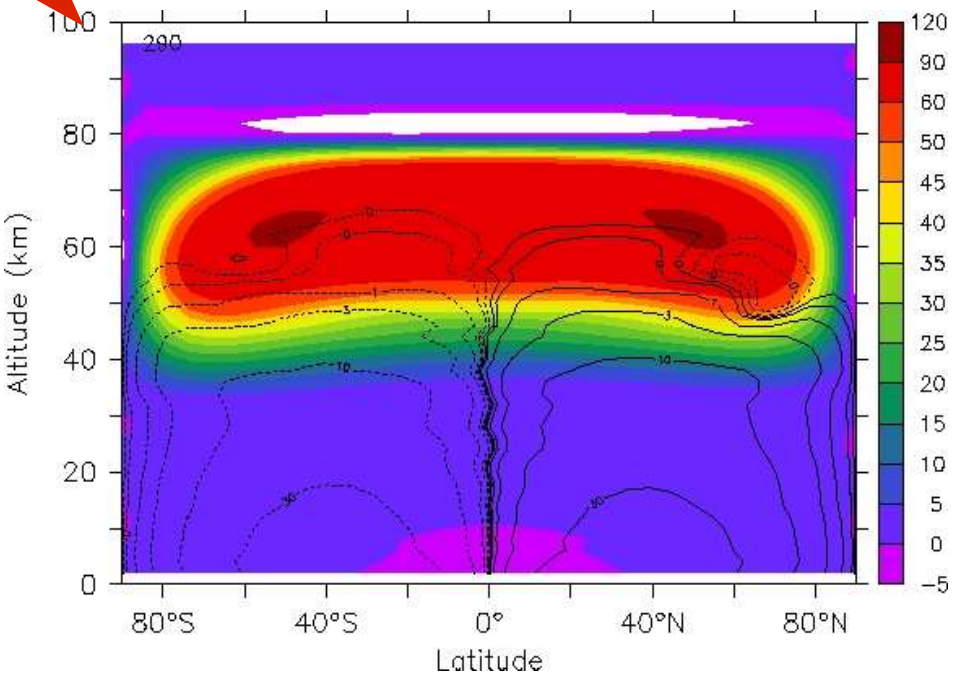
Altitude (km)
Latitude
80°S
40°S
0°
40°N
80°N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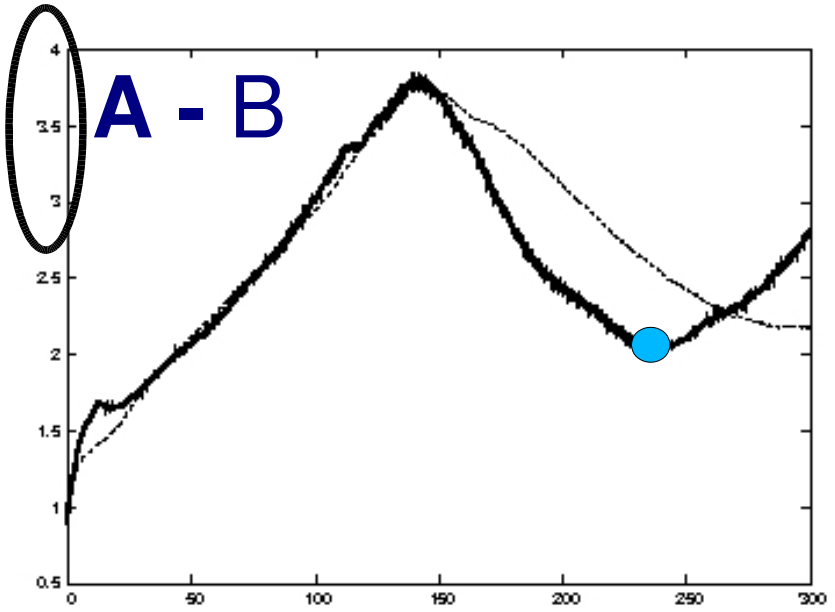
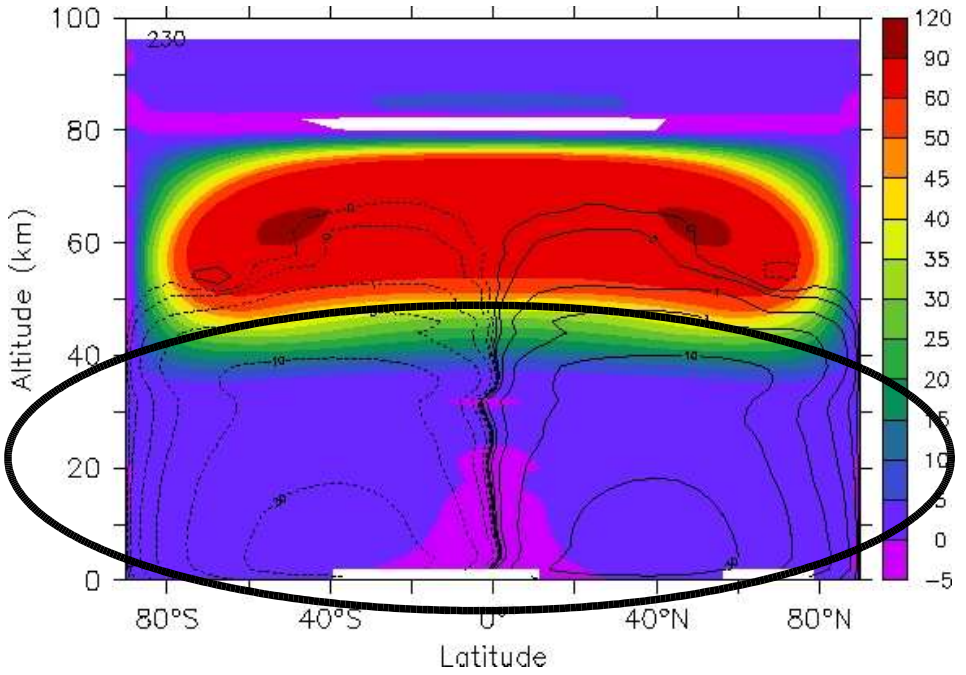
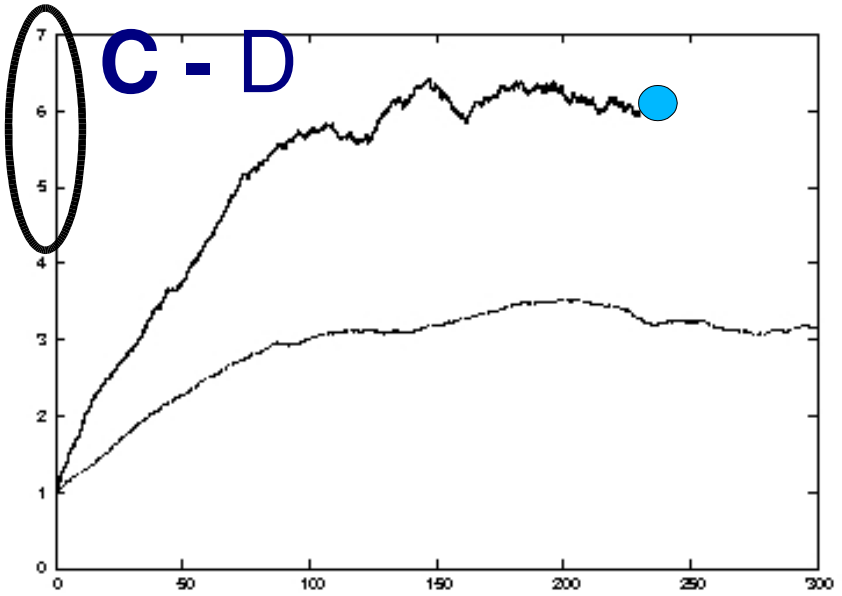
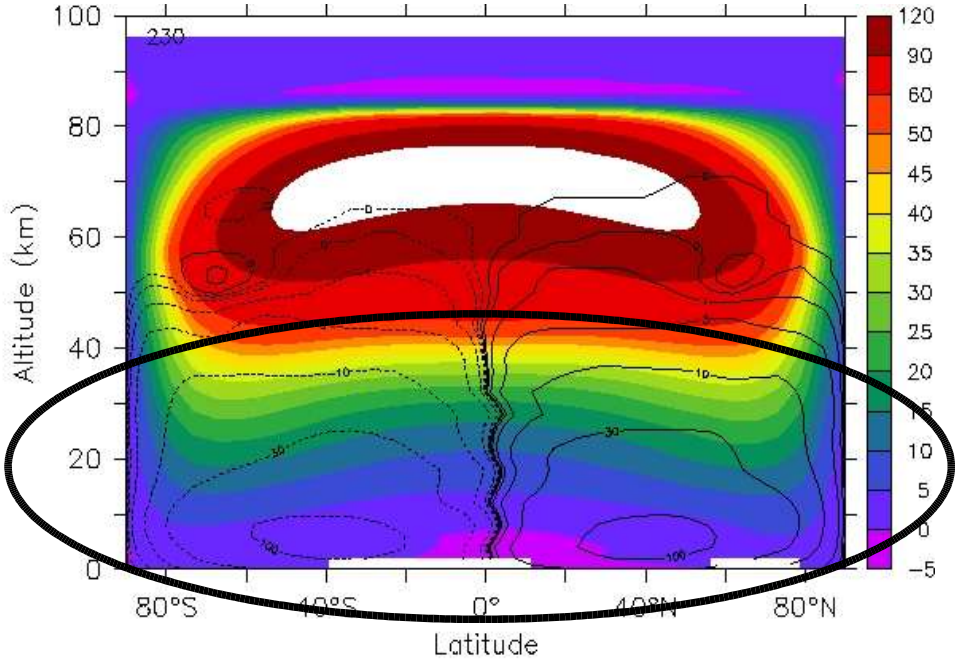
Lower boundary...

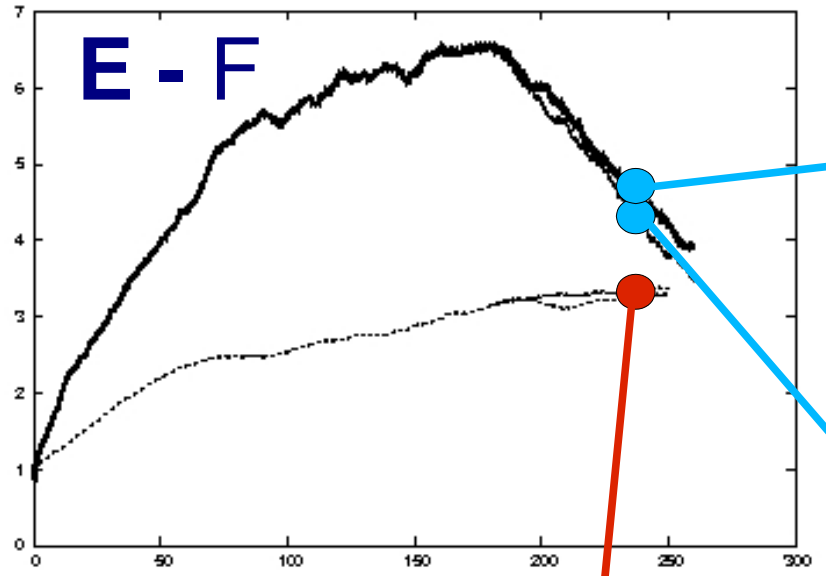


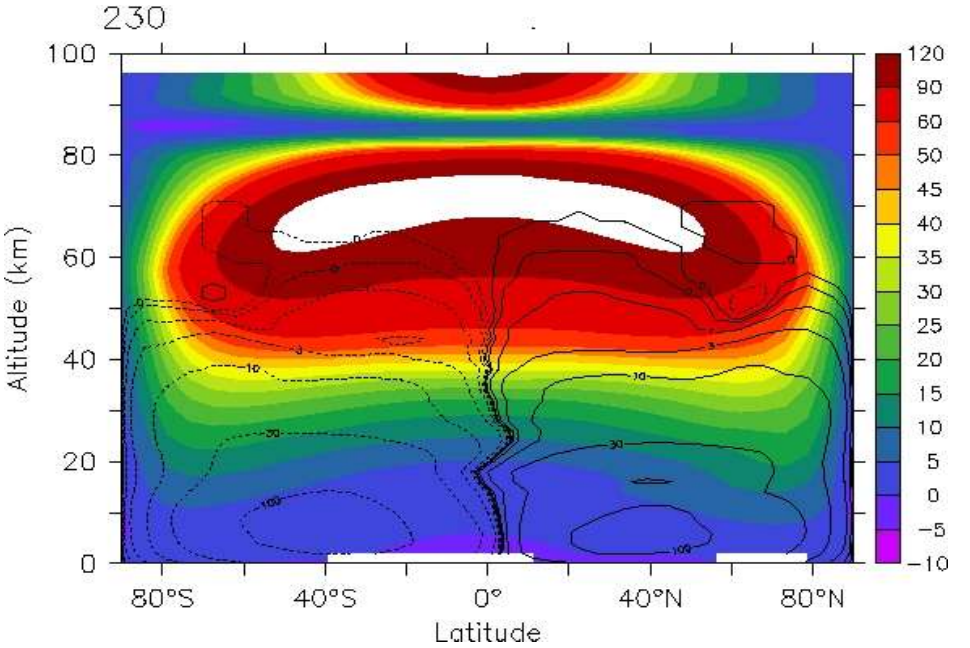






Topography


E - F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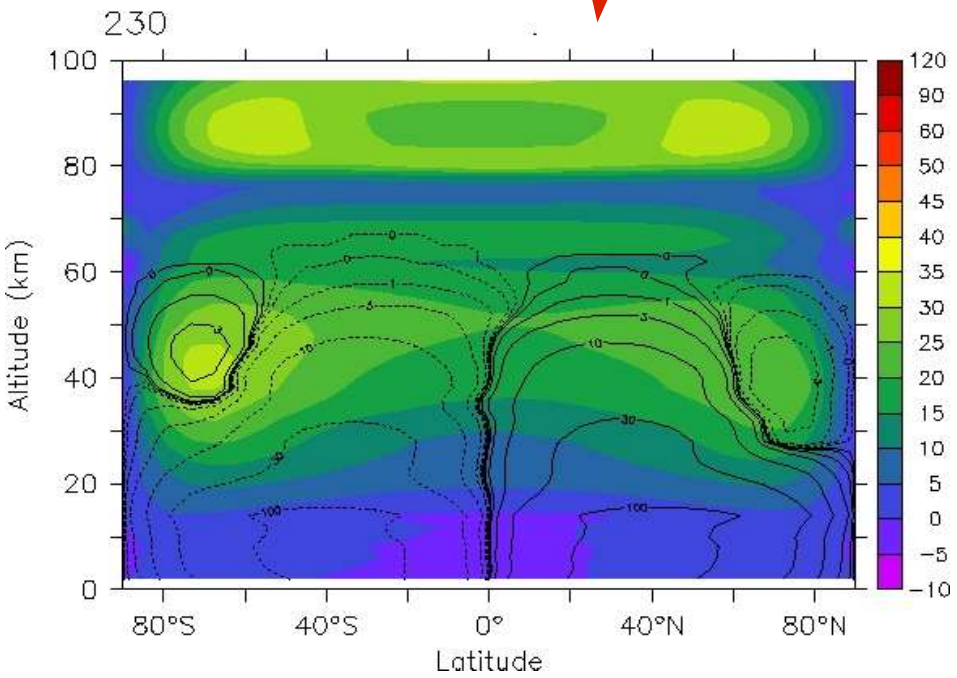
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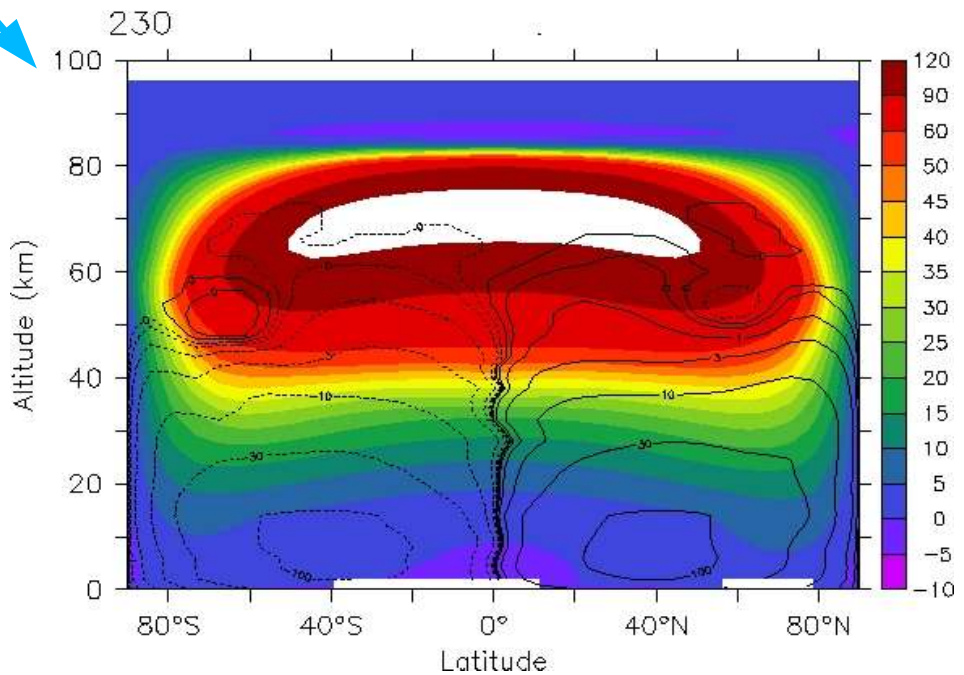
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Altitude (km)
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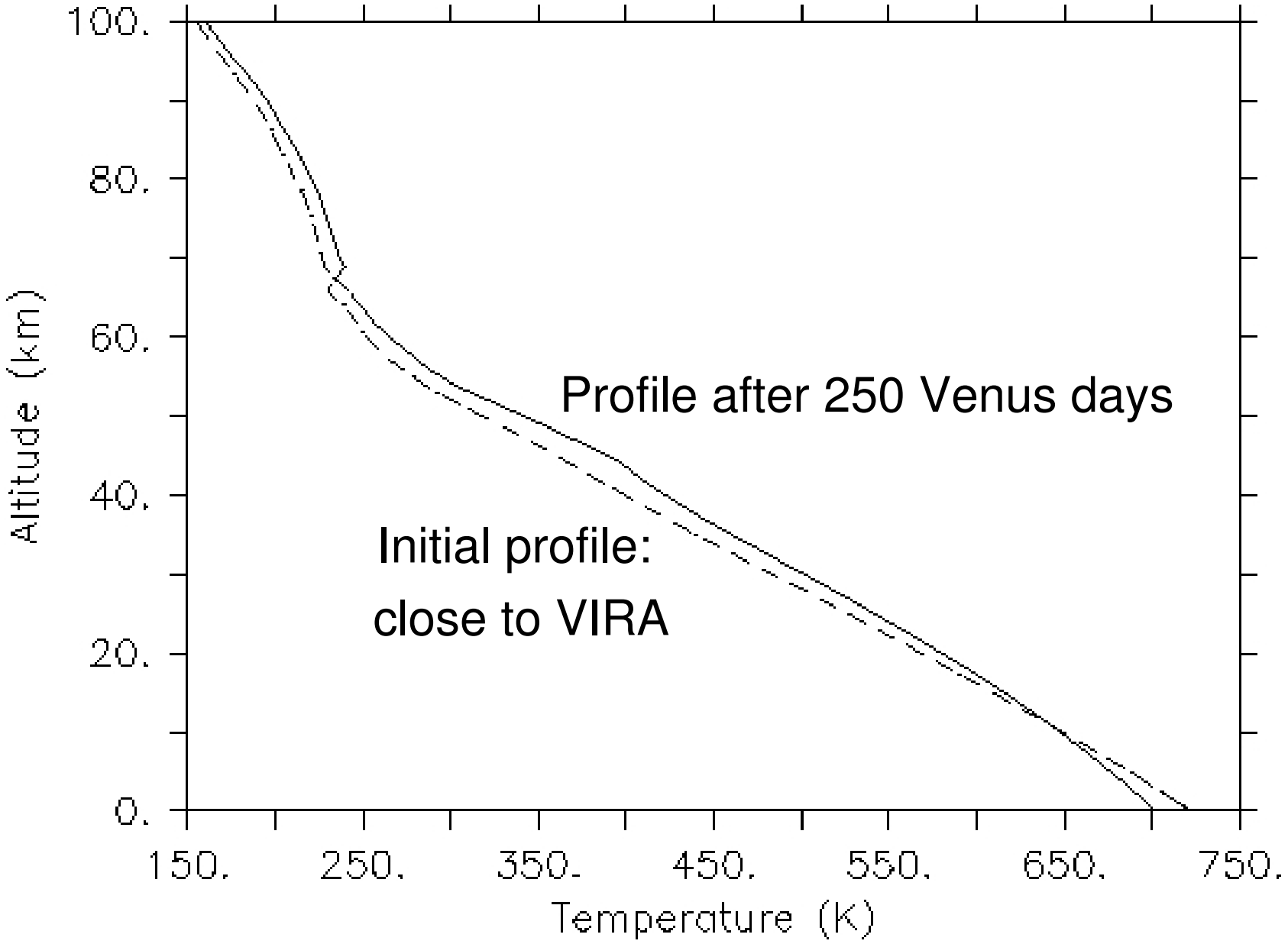
FULL RADIATIVE SCHEME

Paper on radiative scheme in revision

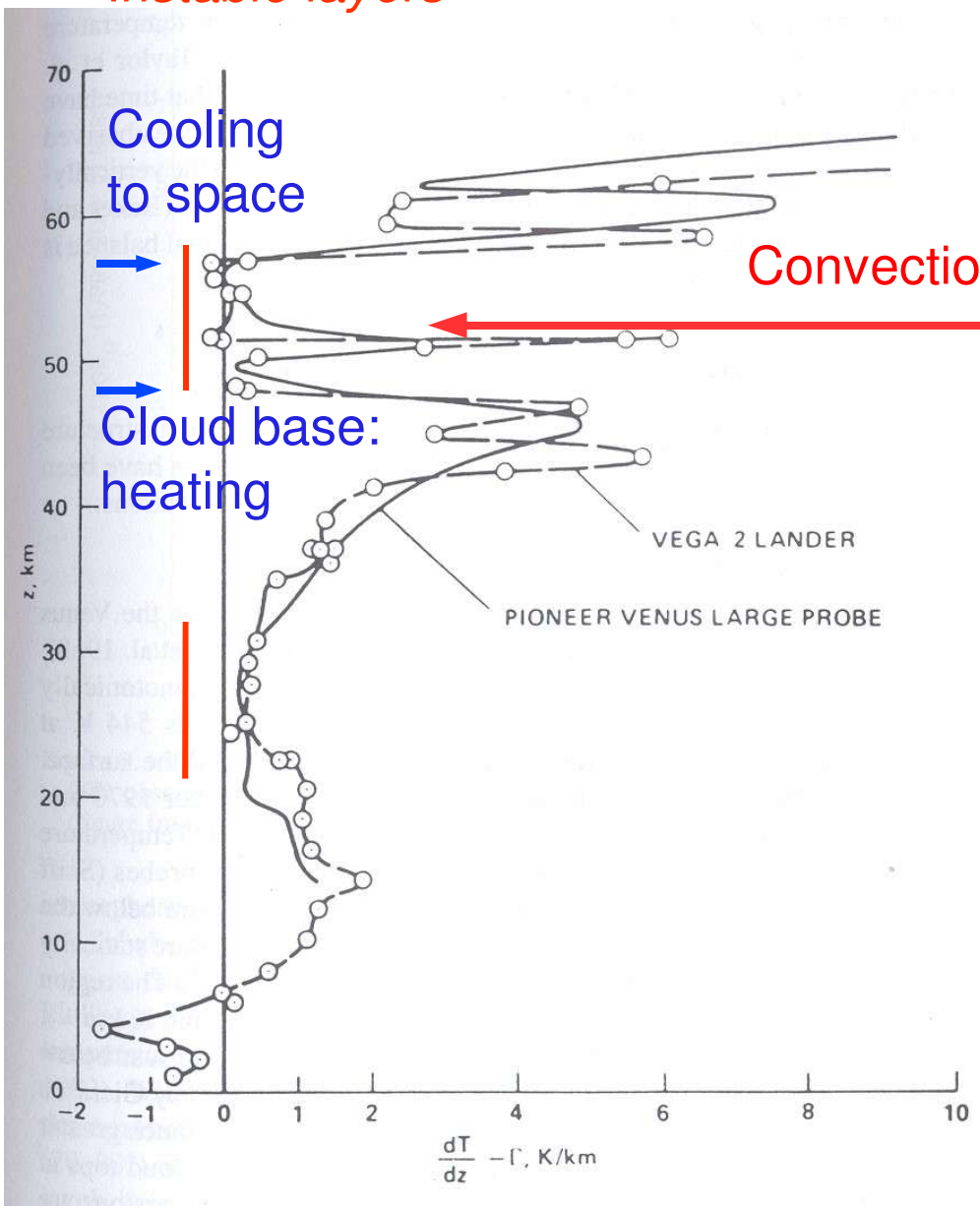
Paper on GCM ready for submission

Temperature profiles

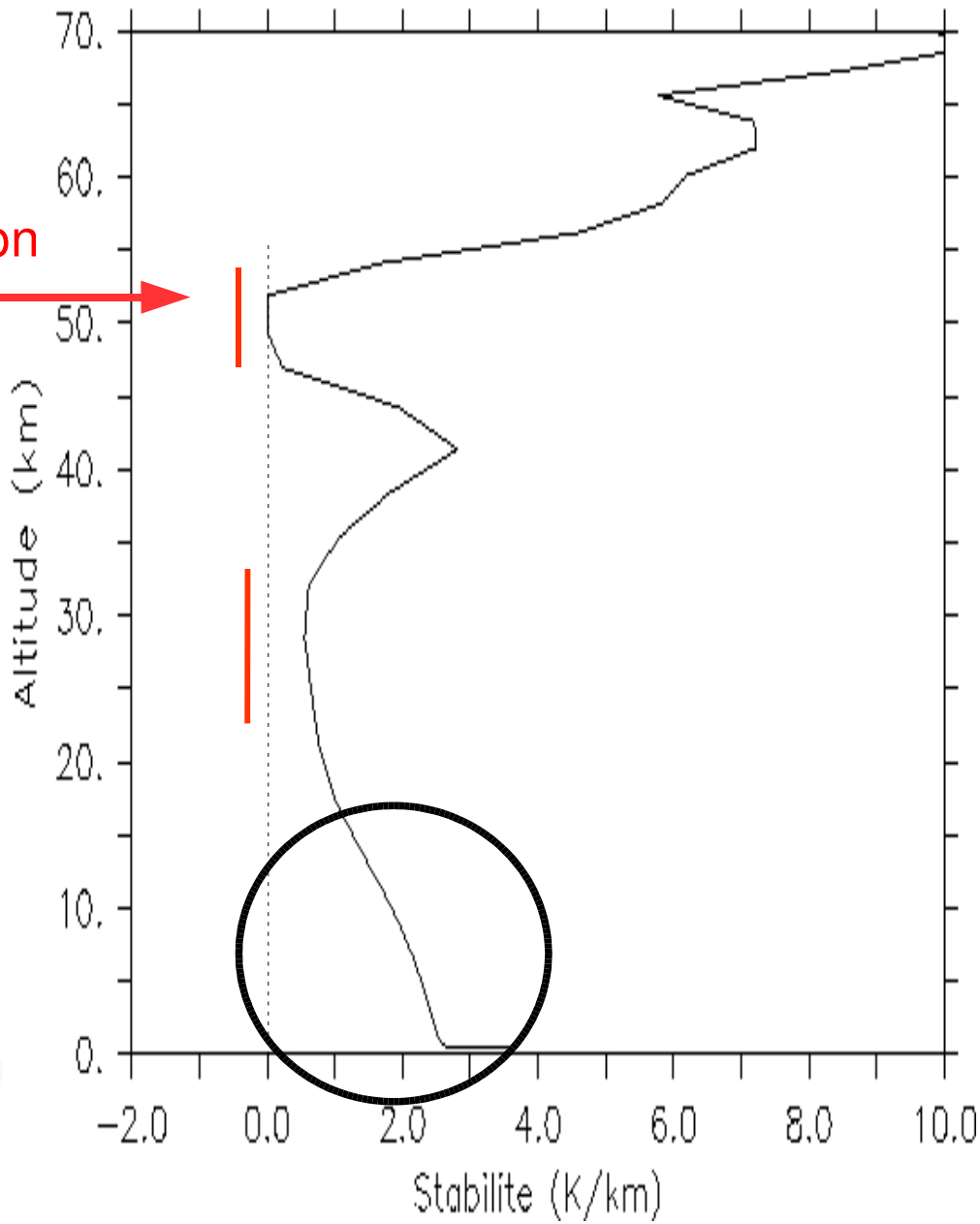


Stability

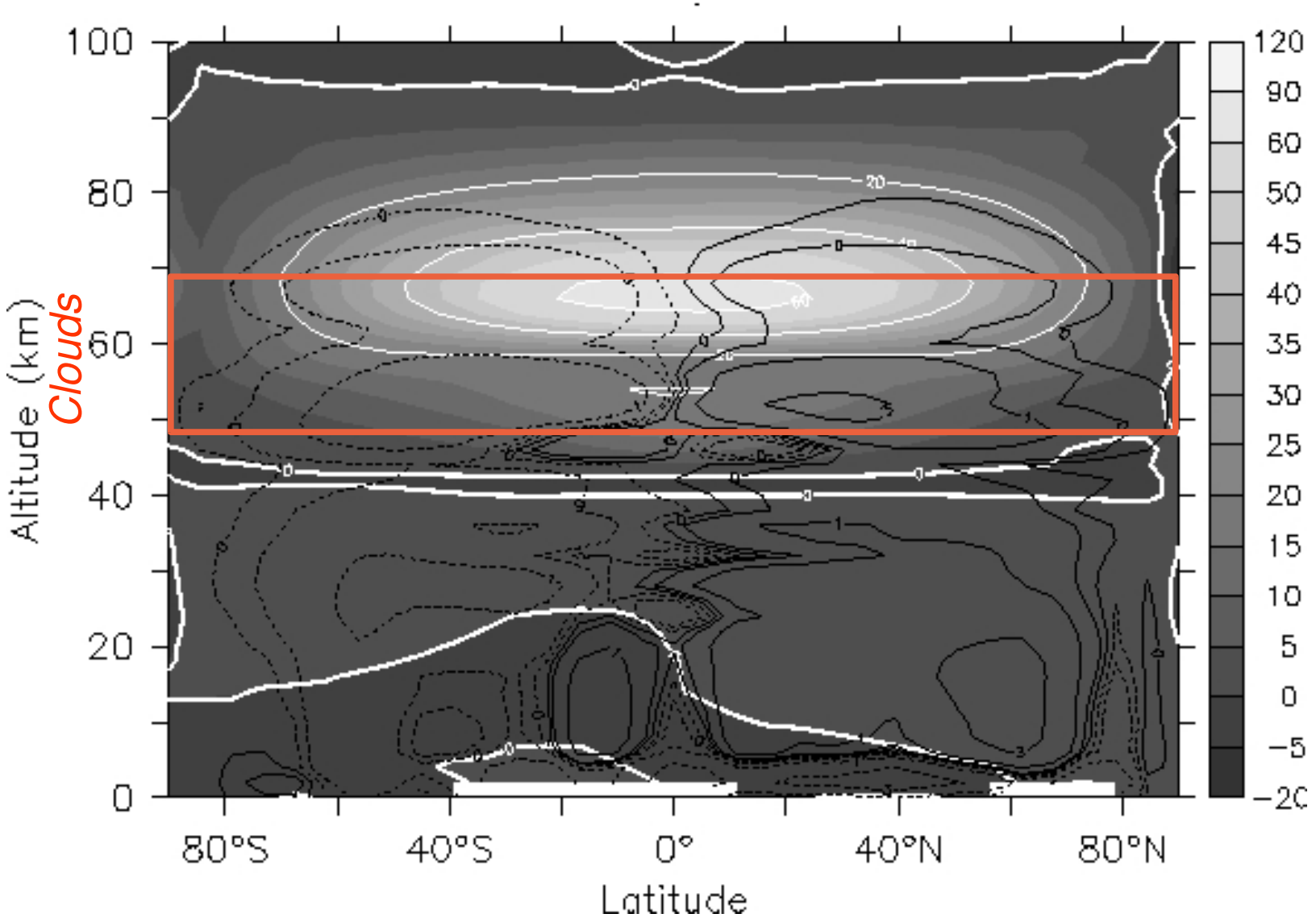
Instable layers



Convection

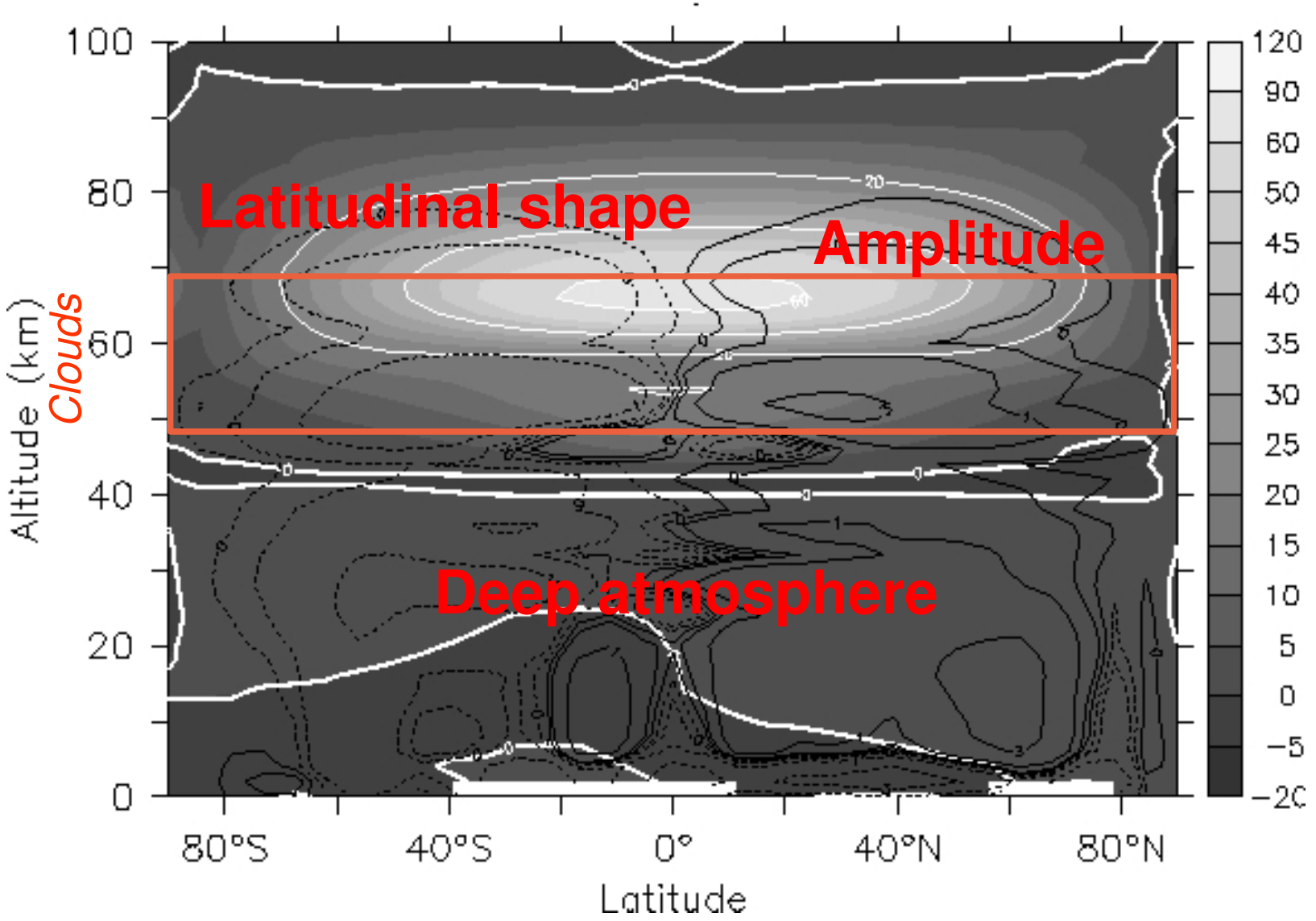


Venus Superrotation



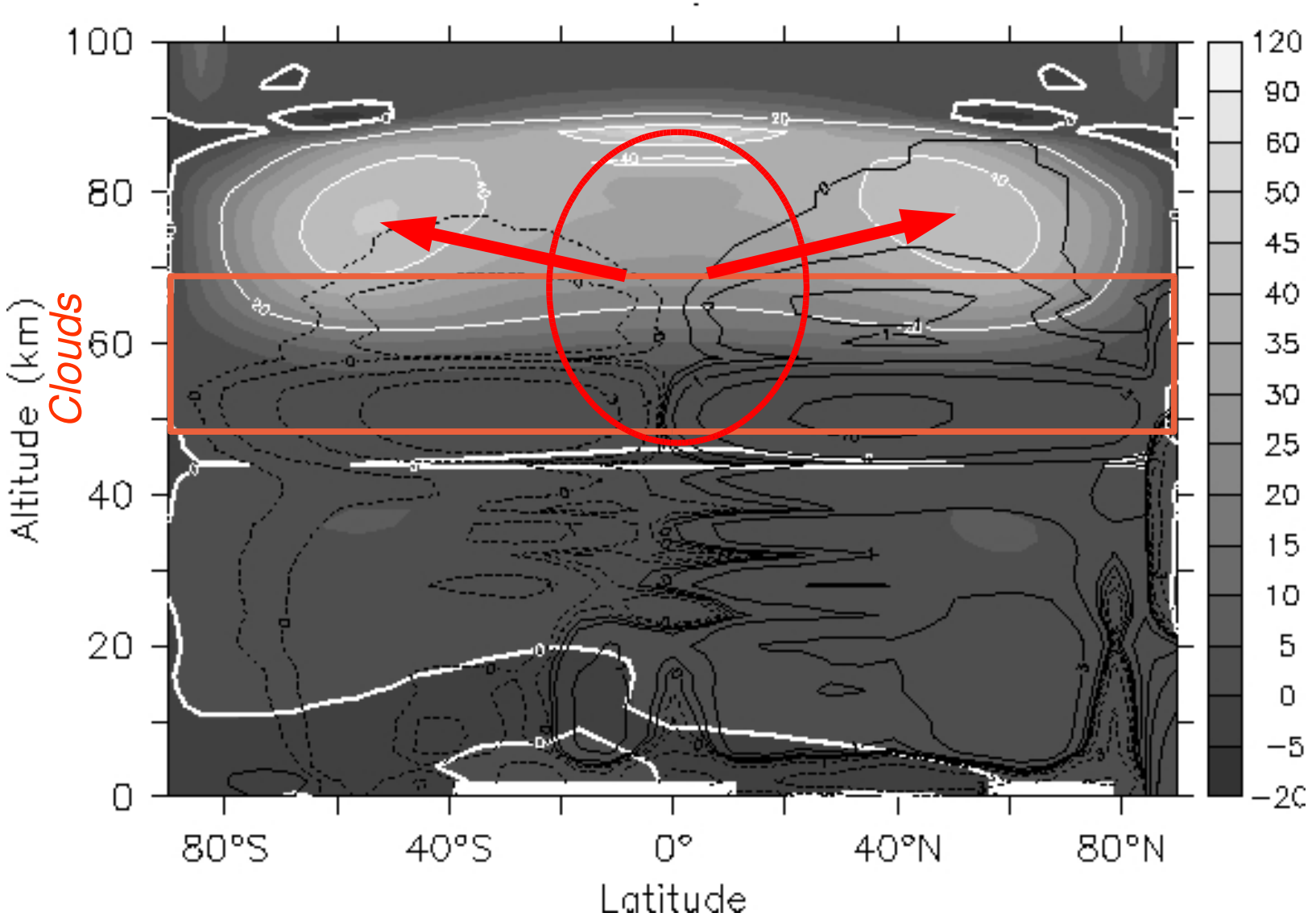
Mean zonal wind and stream function after 250 Vdays
(Topography, diurnal cycle)

Venus Superrotation



Mean zonal wind and stream function after 250 Vdays
(Topography, diurnal cycle)

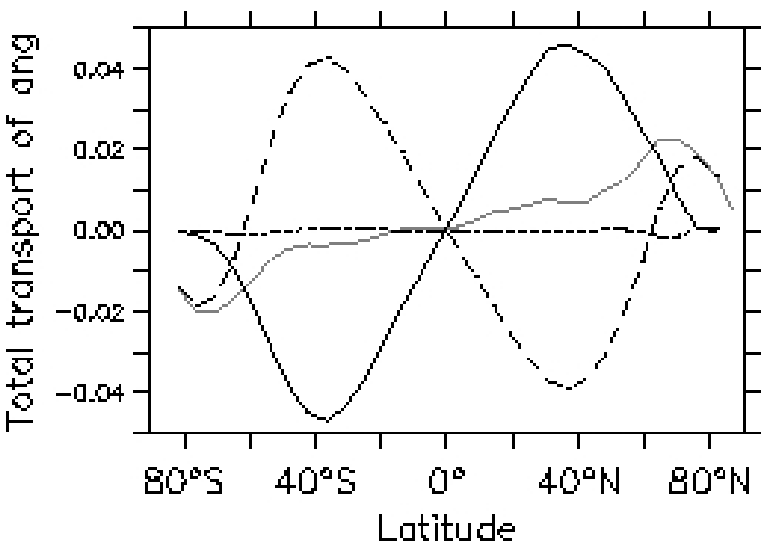
Role of the diurnal cycle



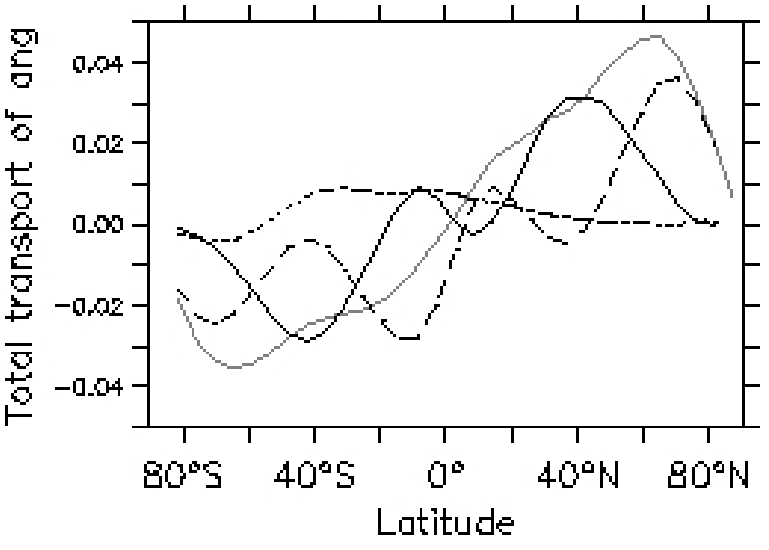
Mean zonal wind and stream function after +50 Vdays
(Topography, no diurnal cycle)

Angular momentum transport

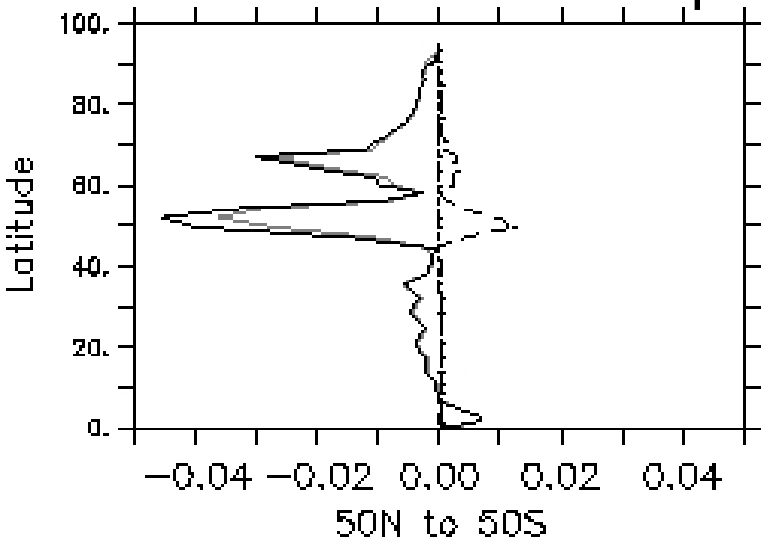
Without diurnal cycle

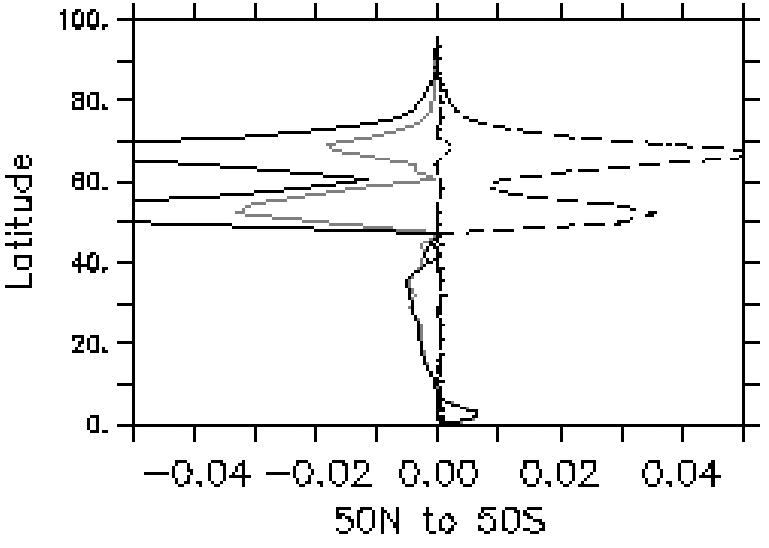


With diurnal cycle



Vertical transport between 50°N and 50°S

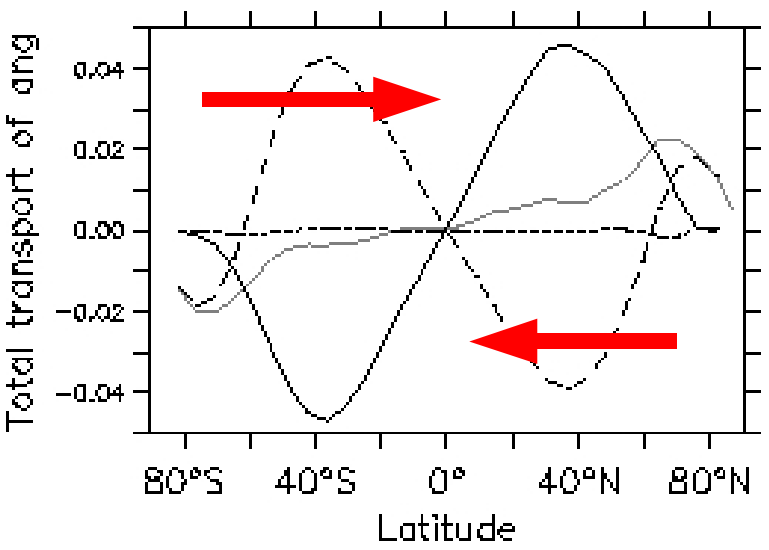




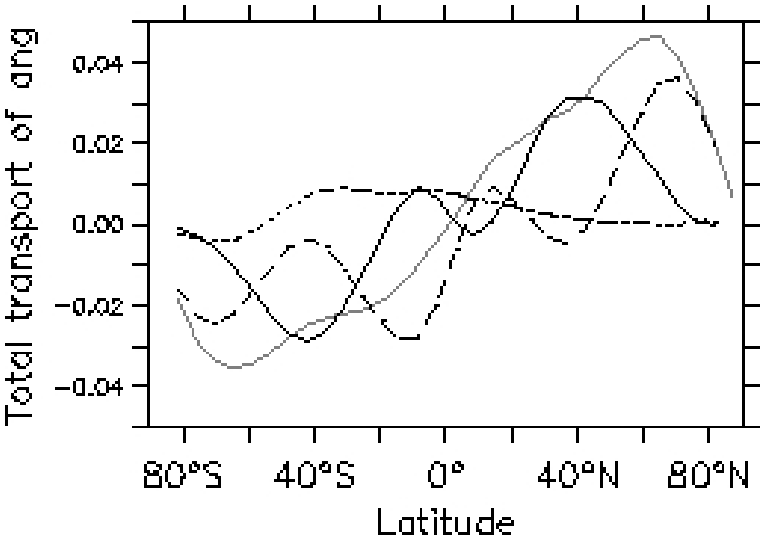
Angular momentum transport

Role of waves

Without diurnal cycle



With diurnal cycle



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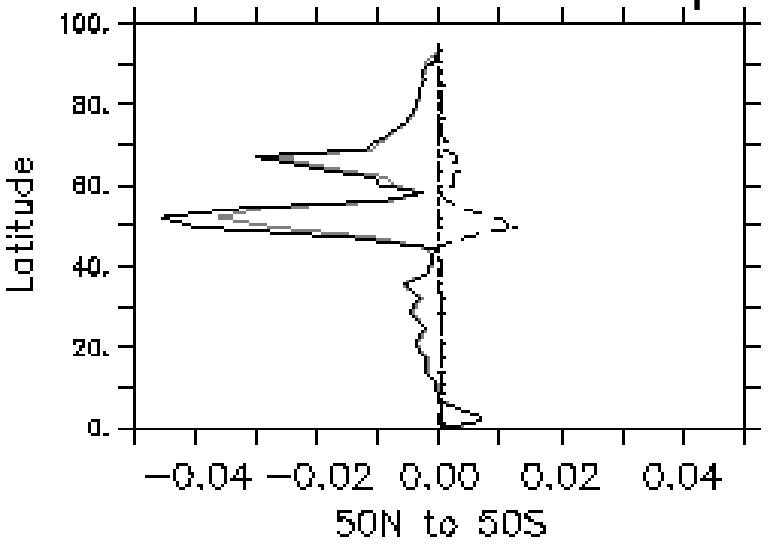

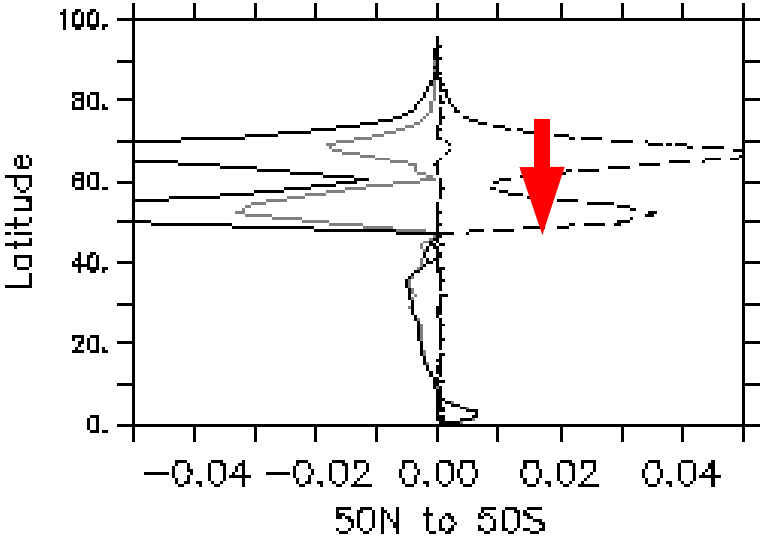

Technical aspects

- **Computation times :**
  - 24 to 40 h / 10 Venus days
  - Time scales needed: 100 to 200 Vd...
- **Boundary conditions :**
  - possible influence of lower boundary layer scheme... How to constrain it ?
  - sponge layer in upper levels
- **Angular momentum conservation :** it has been checked, and conservation is very good
- **To be implemented :** orographic and non-orographic gravity waves parameterization