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

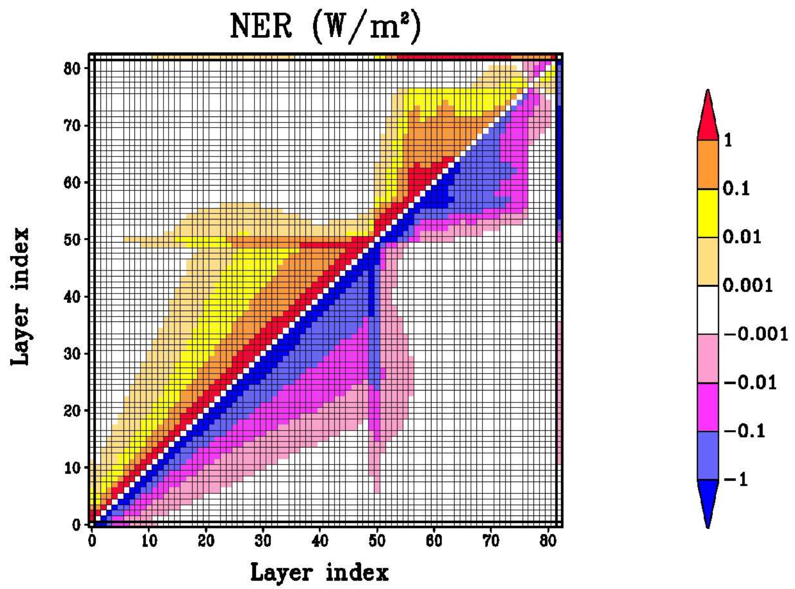
- Specific physics:
  - radiative transfer
  - parameterizations (sub-grid processes, boundary layer, convection, turbulence)
  - topography
  - no clouds microphysics

- 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
  - Surface pressure taken into account (topography)
  - Altitude of clouds variable with latitudes
  - 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

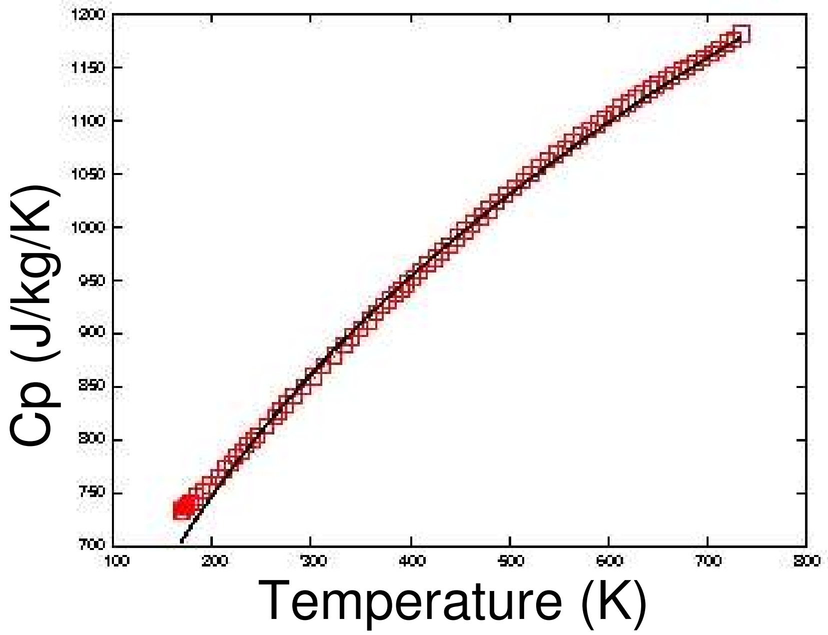
  no diurnal cycle

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

Technical difficulties

- **Computation times :**
  - 24 to 40 h / 10 Venus days
  - Time scales needed: 100 to 200 Vd...

- **Initial conditions :**
  - starting from rest means long simulations
  - starting from previous simulation means possible influence of initial conditions (or long simulations...)

- **Boundary conditions :** sponge layer in upper levels

- **Angular momentum conservation :** it has been checked, and conservation is excellent

Simulations

- **A (topography) / B (no topography)**
  - started from rest
  - Cp(T) ; full radiative transfer

- **C (topo, Cp=1000) / D (Cp=900) / E (no topo, Cp=900)**
  - same as A/B, but with constant Cp

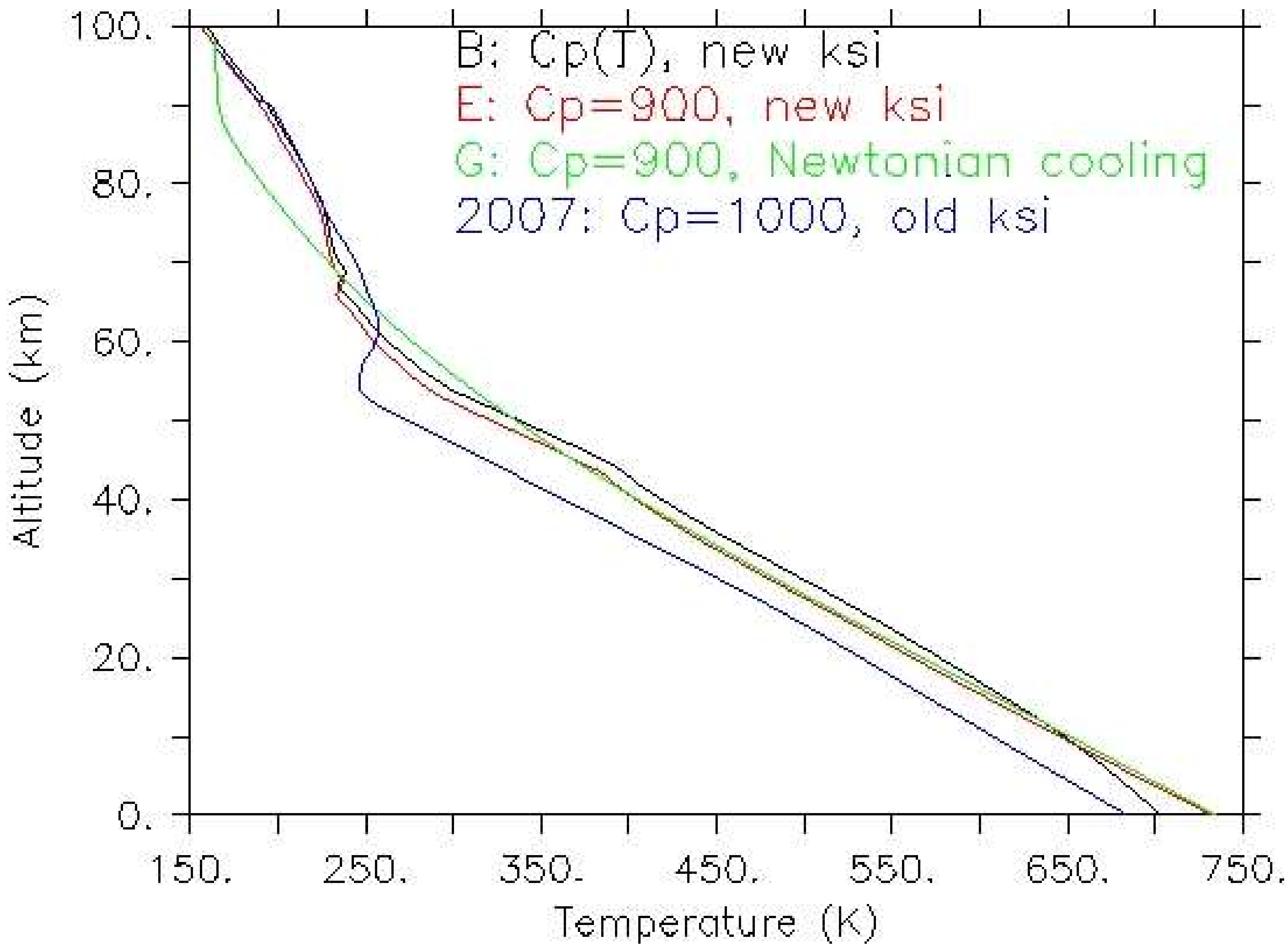
- **F (topography) / G (no topography)**
  - started from rest
  - constant Cp (=900 J/kg/K) ; Newtonian cooling

In **summer 2007**, promising simulations using constant Cp=1000, full radiative transfer, started from rest. These simulations had several problems, including numerical instabilities in the clouds region.

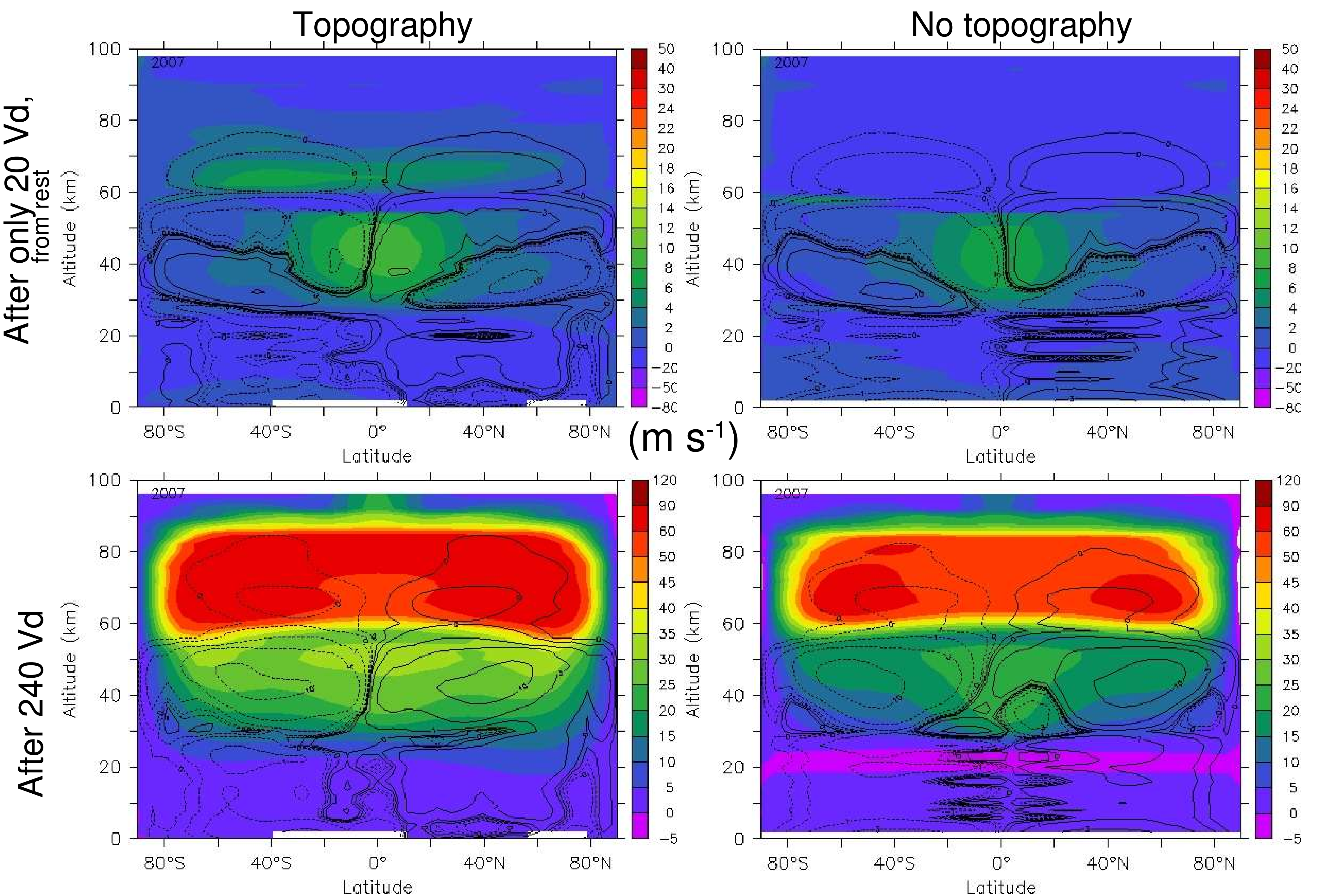
During this **last year**, several bugs were causing troubles in the simulations. We hope they are all taken care of, now.

I will give here some comparisons, and where we are aiming now.

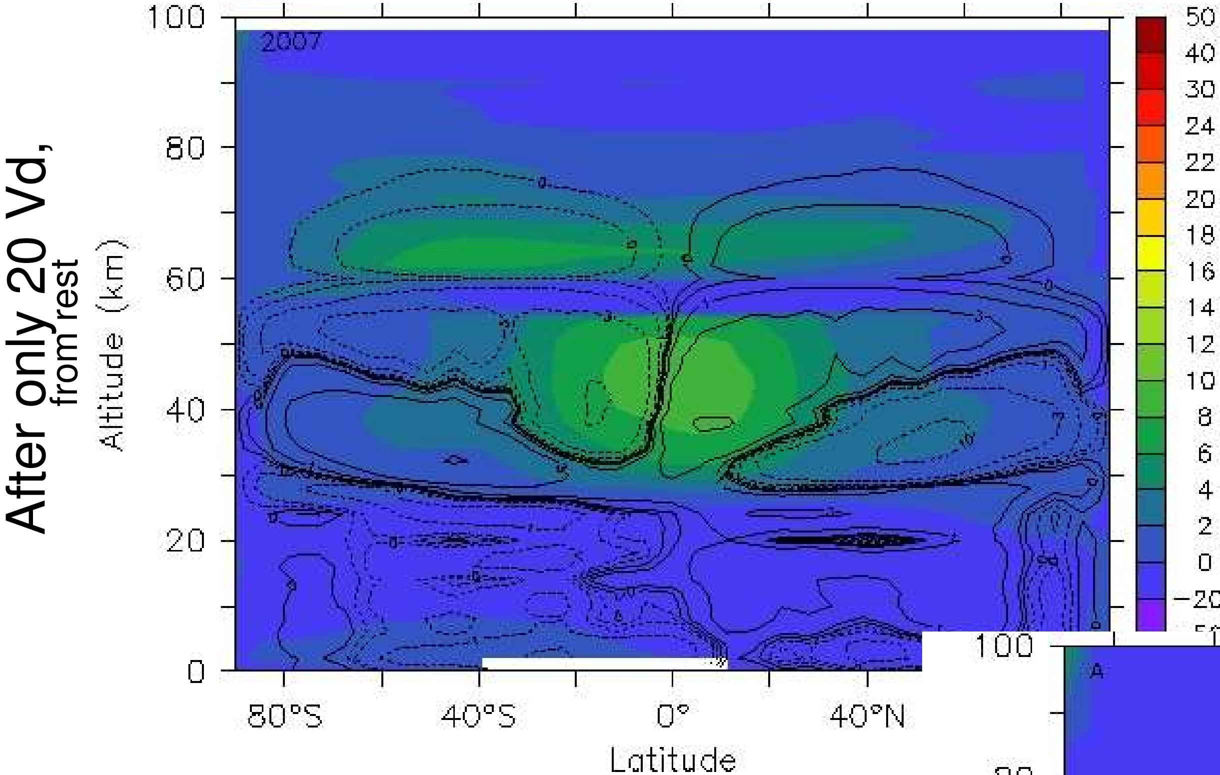
Temperature profiles

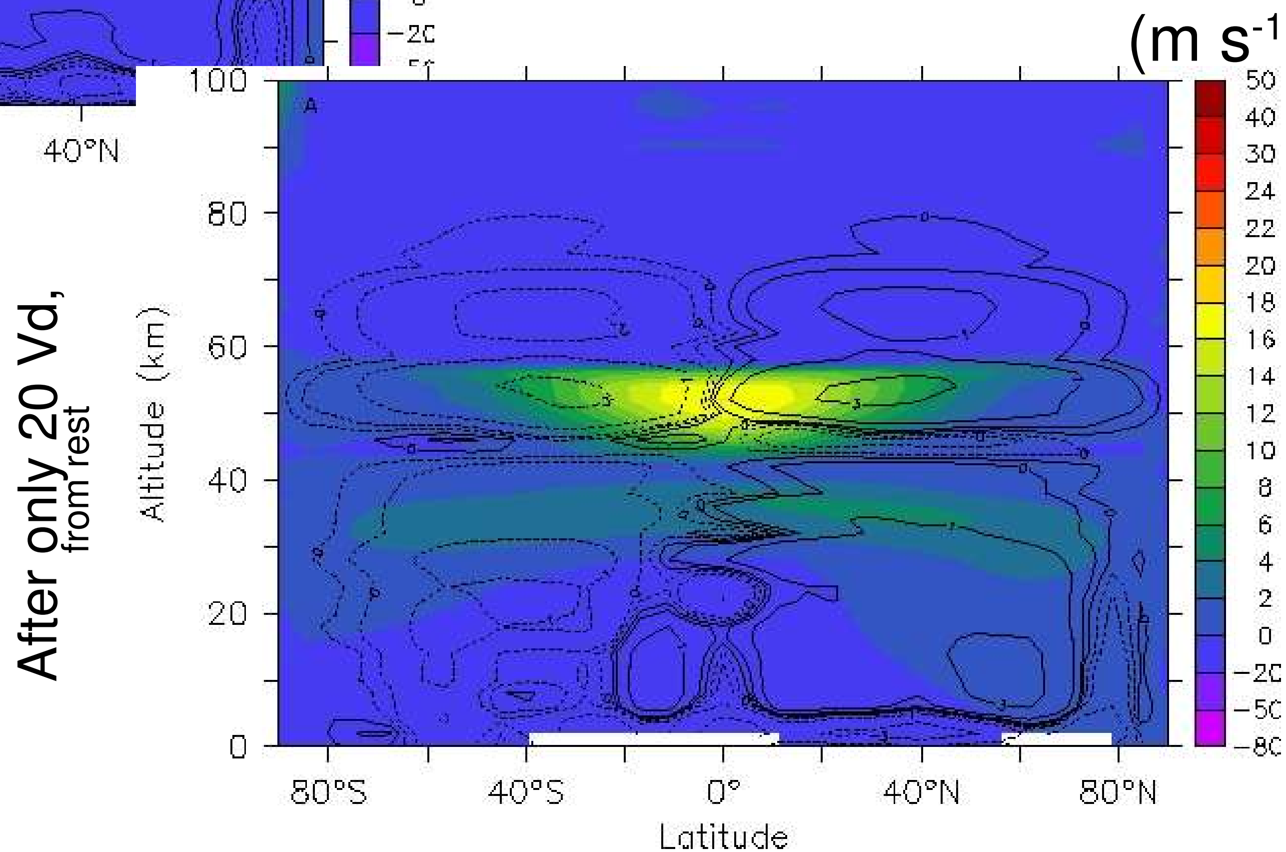


Last year Simulations



Current simulations

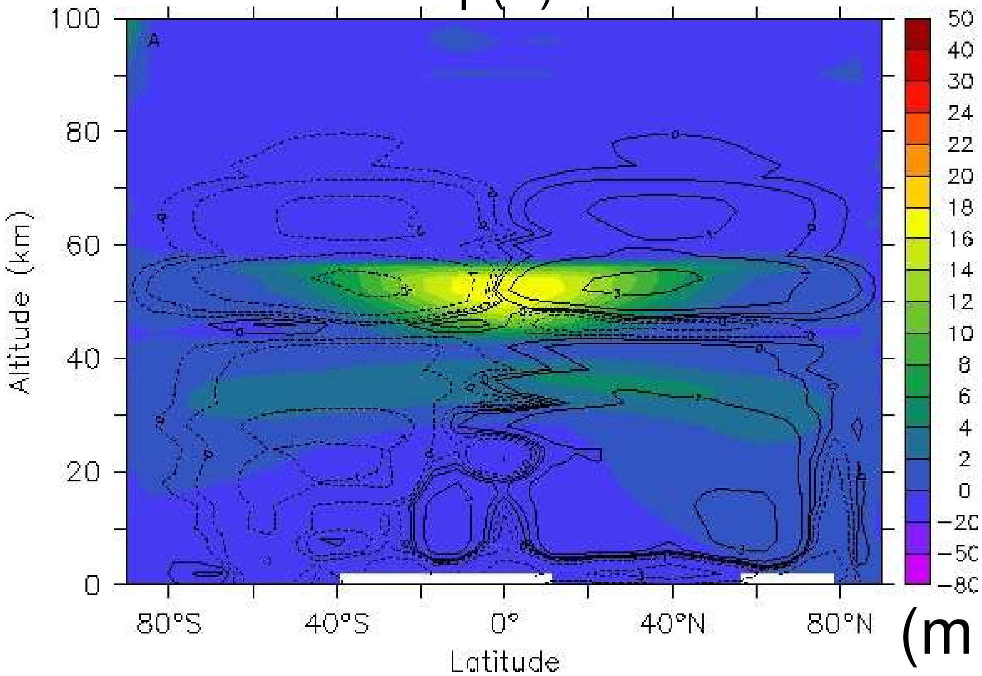




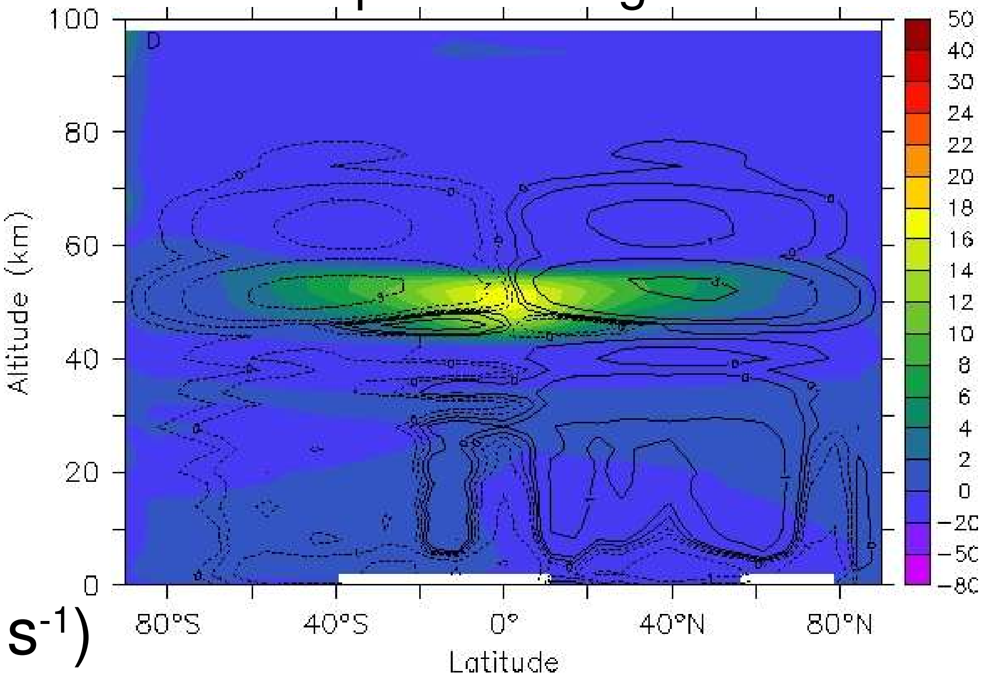
Influence of Cp

After only 20 Vd, from rest

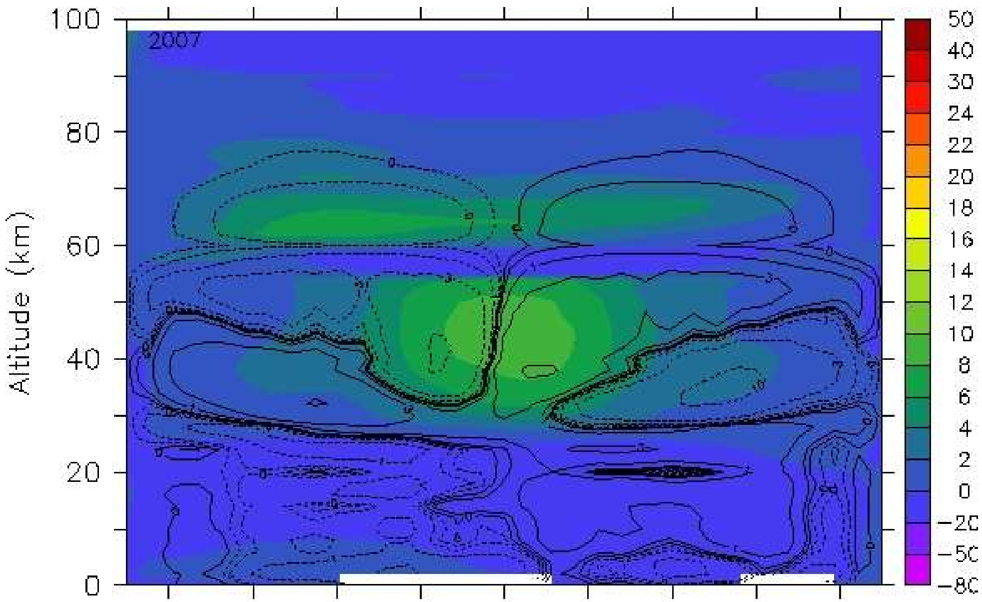
Cp(T)



Cp = 900 J/kg/K



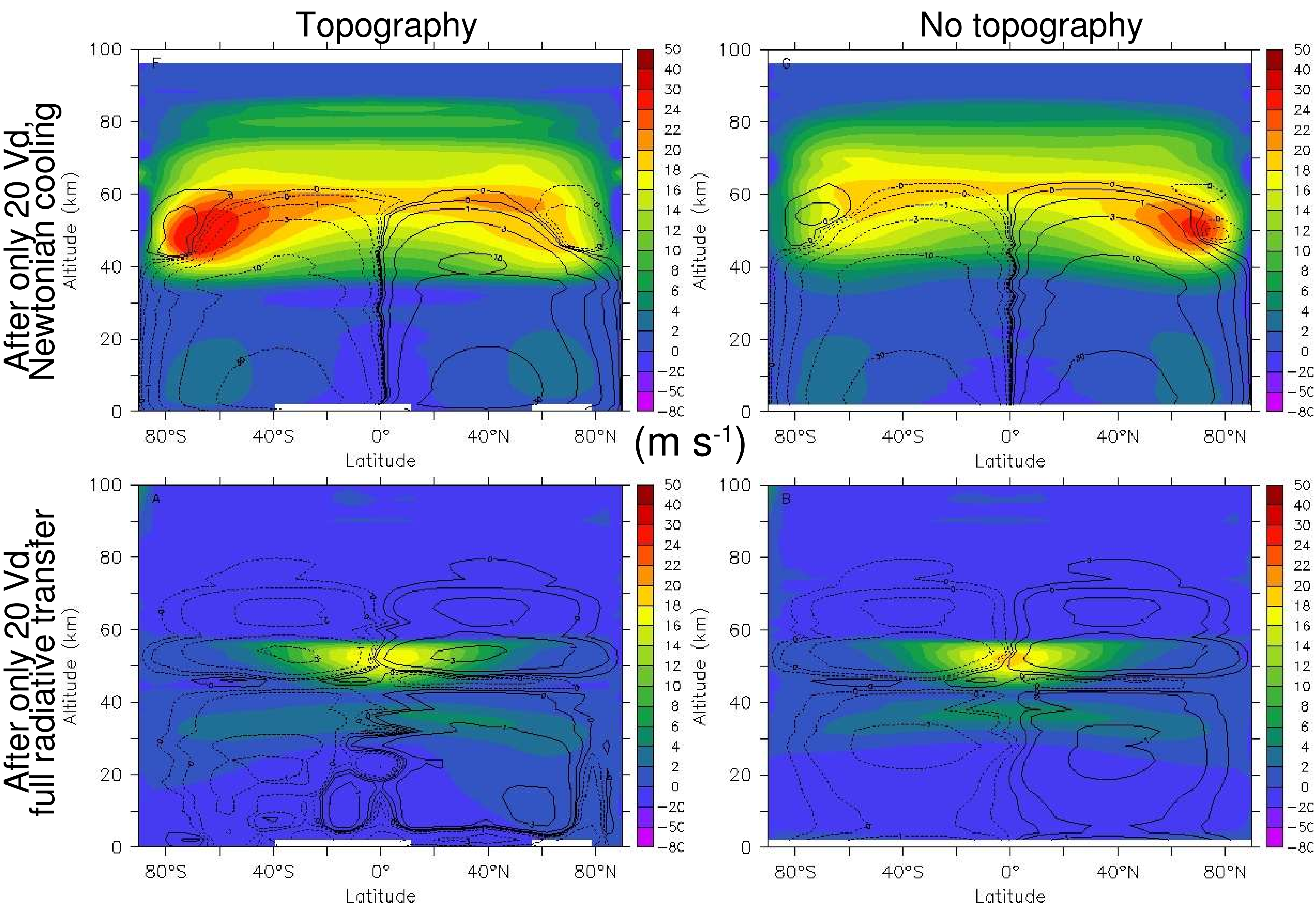
(m s^{-1})



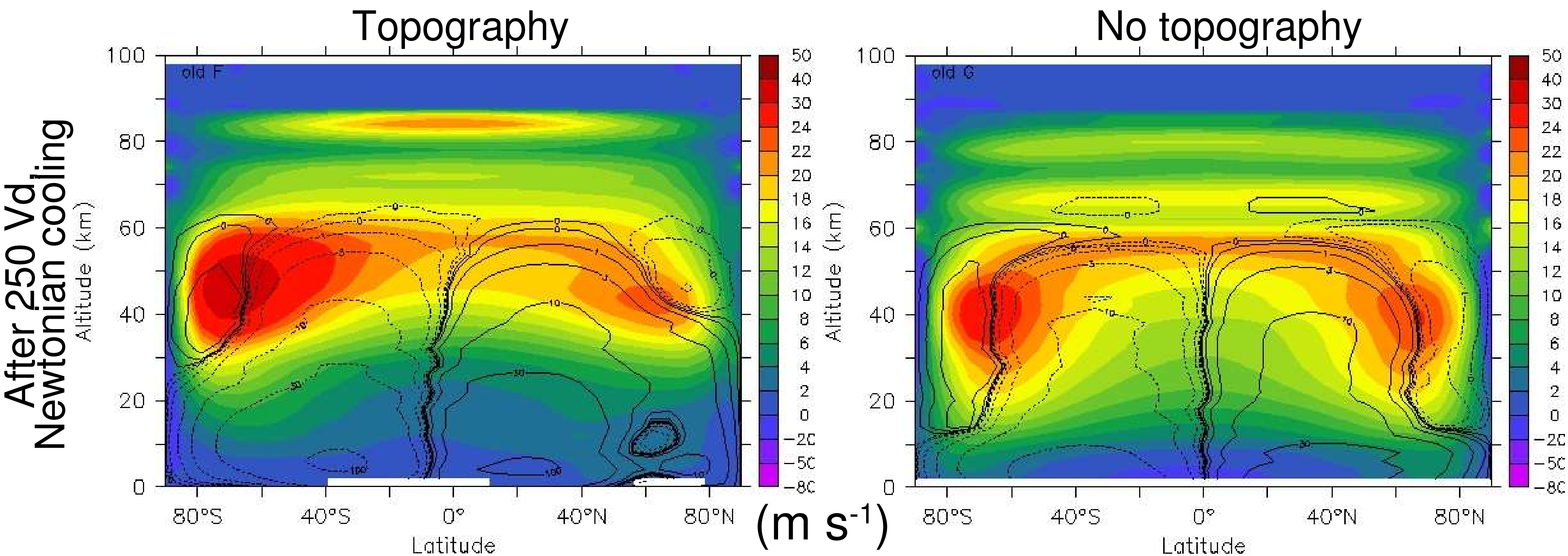
Cp = 1000 J/kg/K, 2007 simulation

similar 2007, new ksi matrix

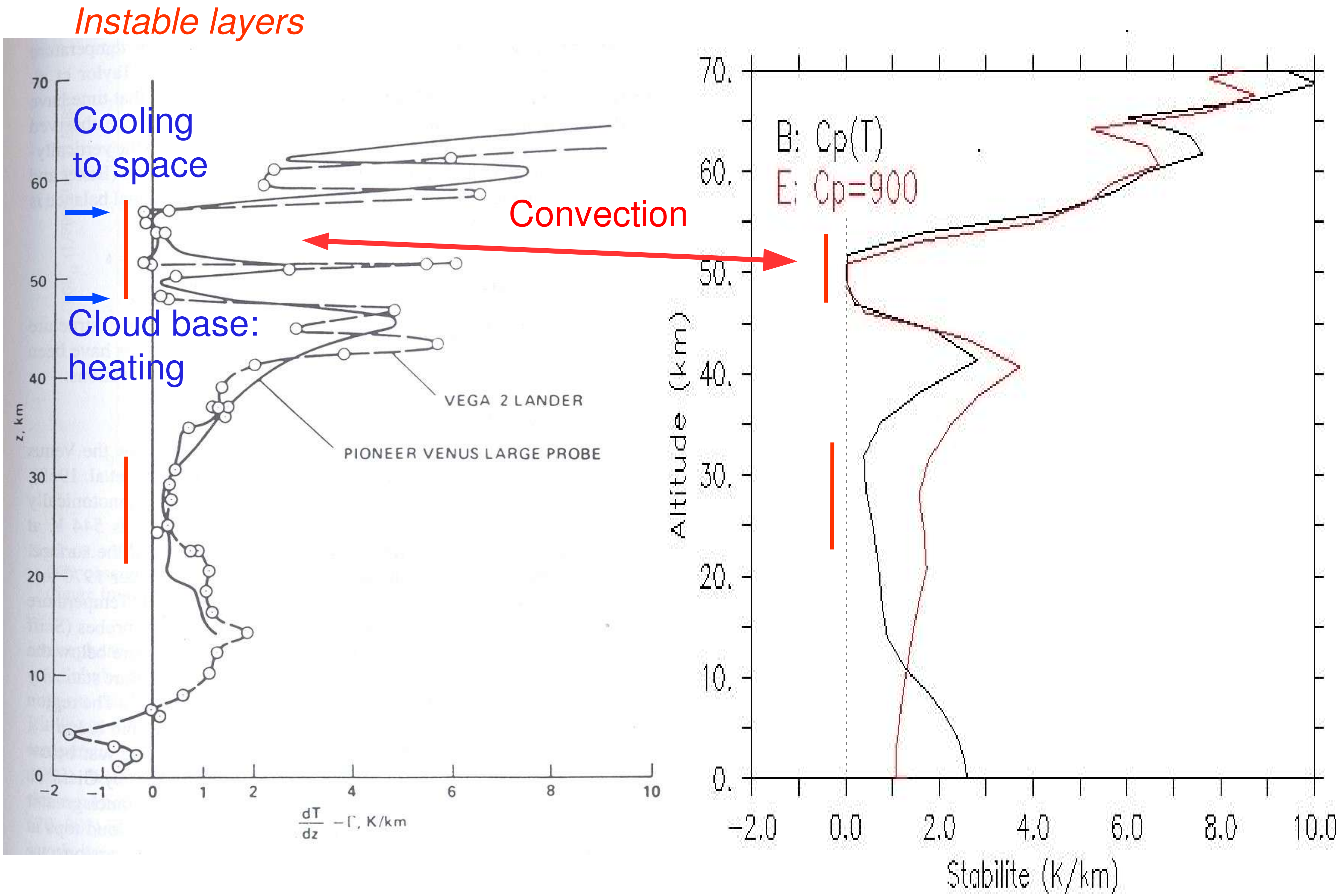
Role of radiative transfer



Role of radiative transfer



Stability



Instable layers
Cooling to space
Cloud base: heating
Convection
VEGA 2 LANDER
PIONEER VENUS LARGE PROBE
z, km
dT/dz − Γ, K/km
B: Cp(T)
E: Cp=900
Altitude (km)
Stabilite (K/km)

CONCLUSION

Simulations we hope to get at last, if no further problems...

- Newtonian cooling for comparison
- Full radiative transfer

- Cp constant vs Cp(T)
- With/without orography

- To be implemented: orographic and non-orographic gravity waves parameterization

KARINE Monte Carlo radiative transfer code

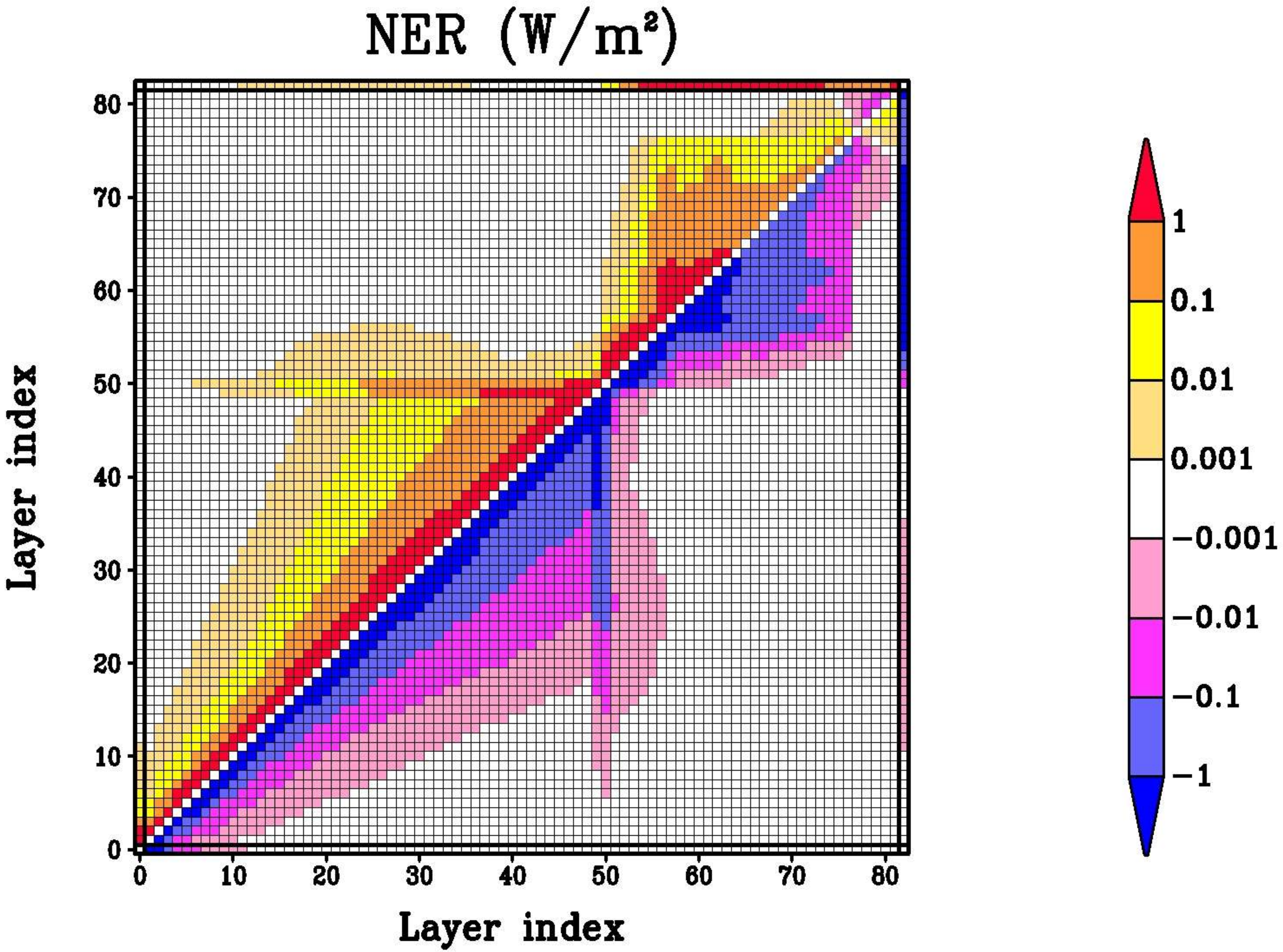
Monte Carlo computations optimized for absorbing and scattering thick media.

Inputs:

- VIRA temperature profile
- Opacity distributions for 68 narrow bands, between 1.7 and 250 microns (40 to 5700 cm^{-1})

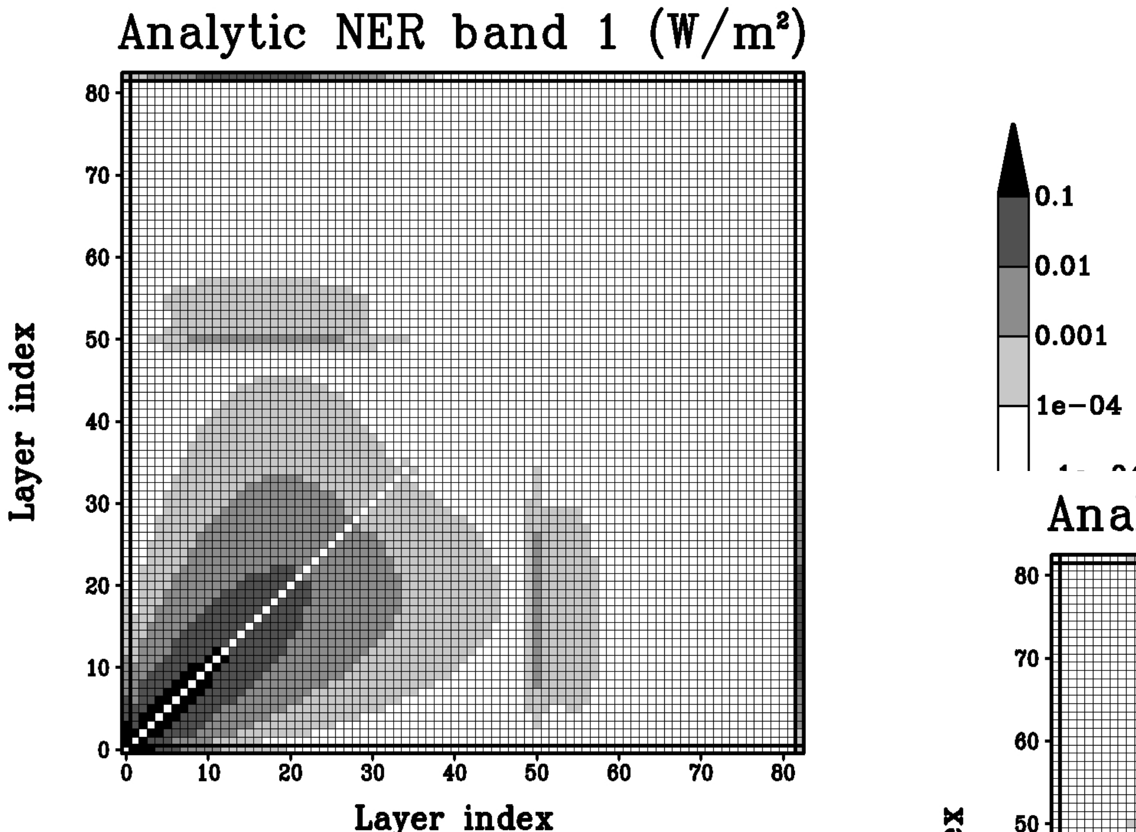
- Gaseous absorption: correlated k coefficients
- Clouds and haze opacities
- Continuum absorption (collision-induced, CO_2 far wings)
- H_2O continuum, CO_2 and N_2 Rayleigh scattering

The Net Exchange Rate matrix



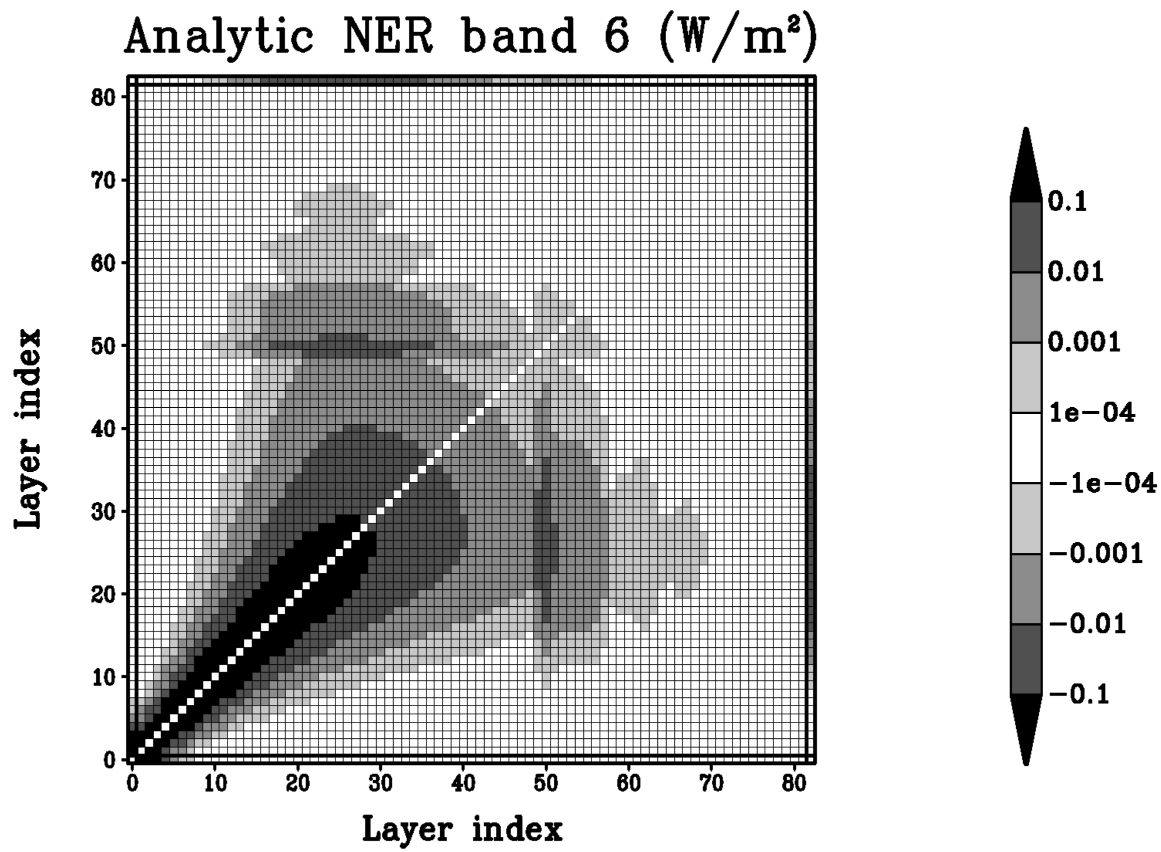
The Net Exchange Rate matrix

Atmospheric windows

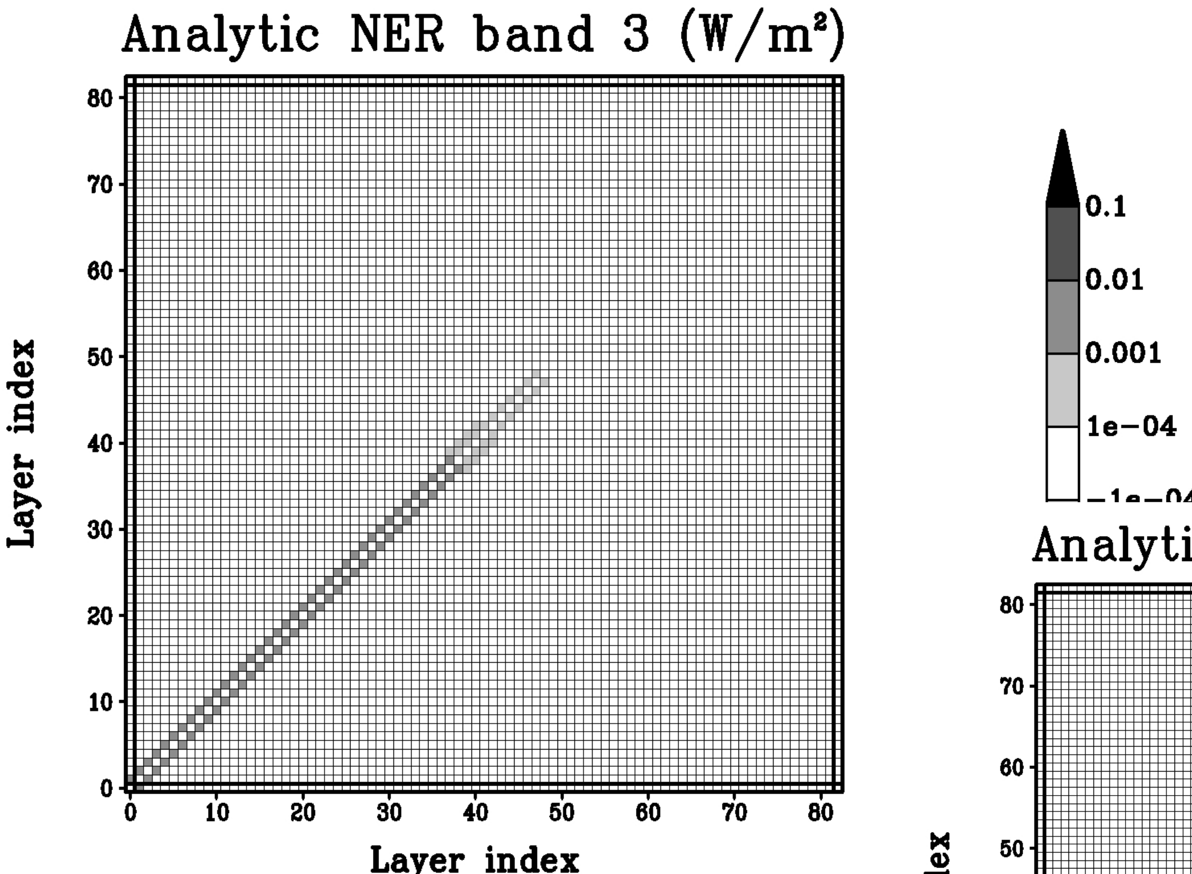


1.7 microns

2.3 microns



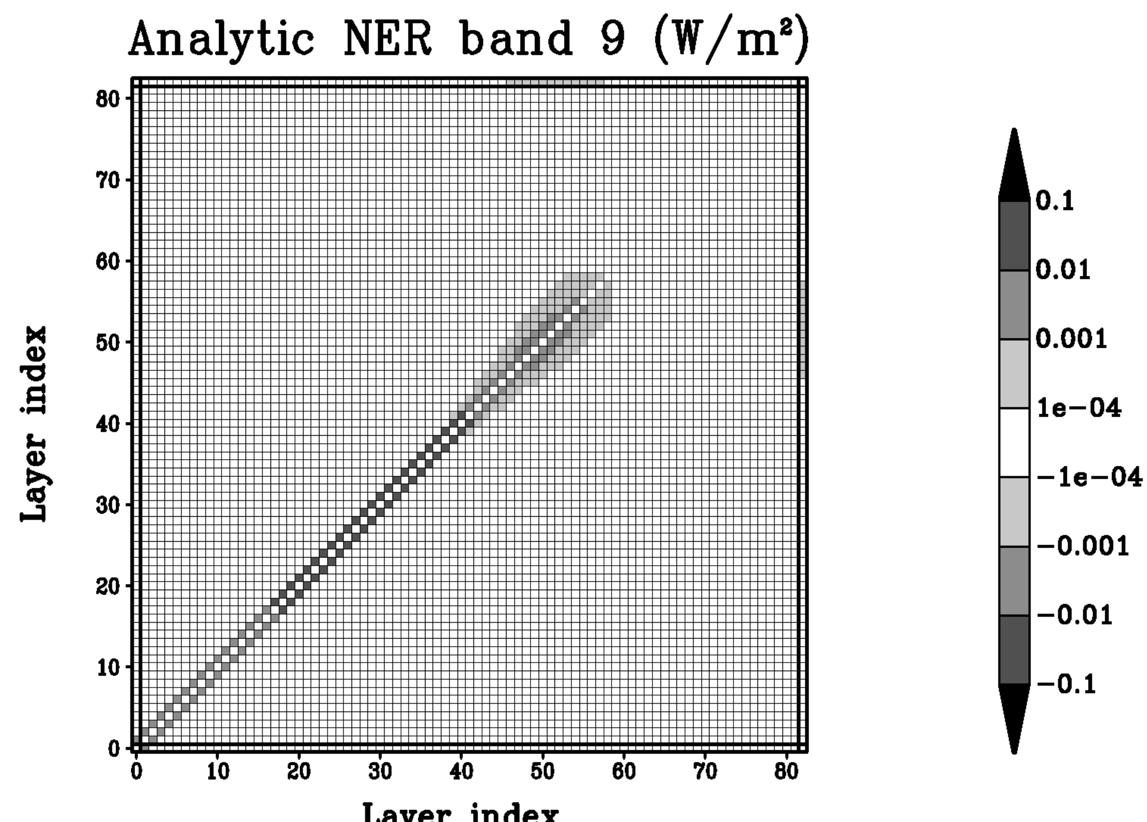
The Net Exchange Rate matrix



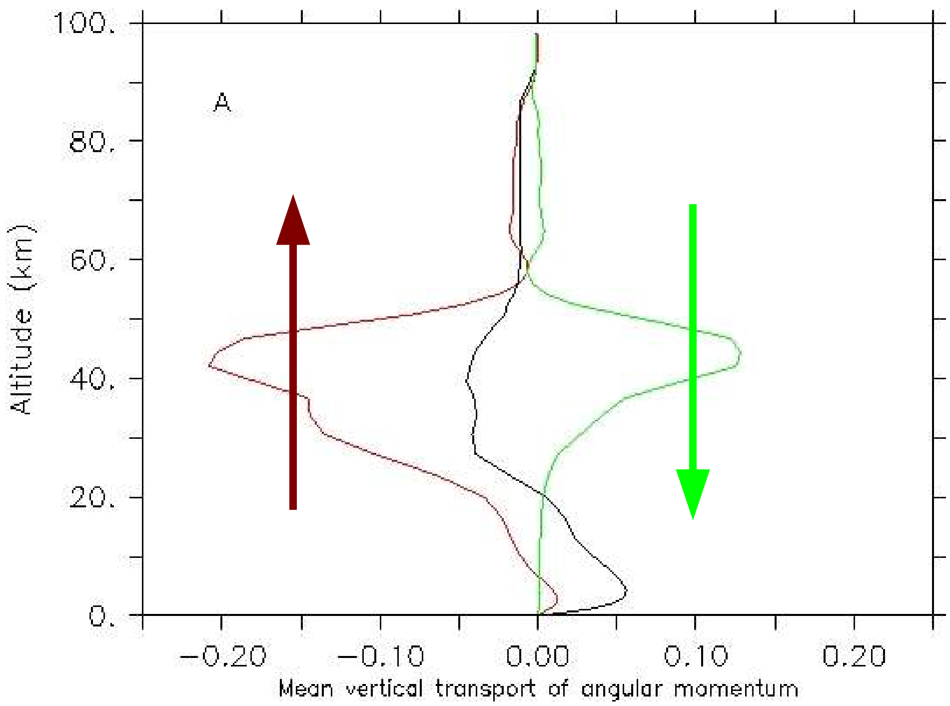
Opaque bands

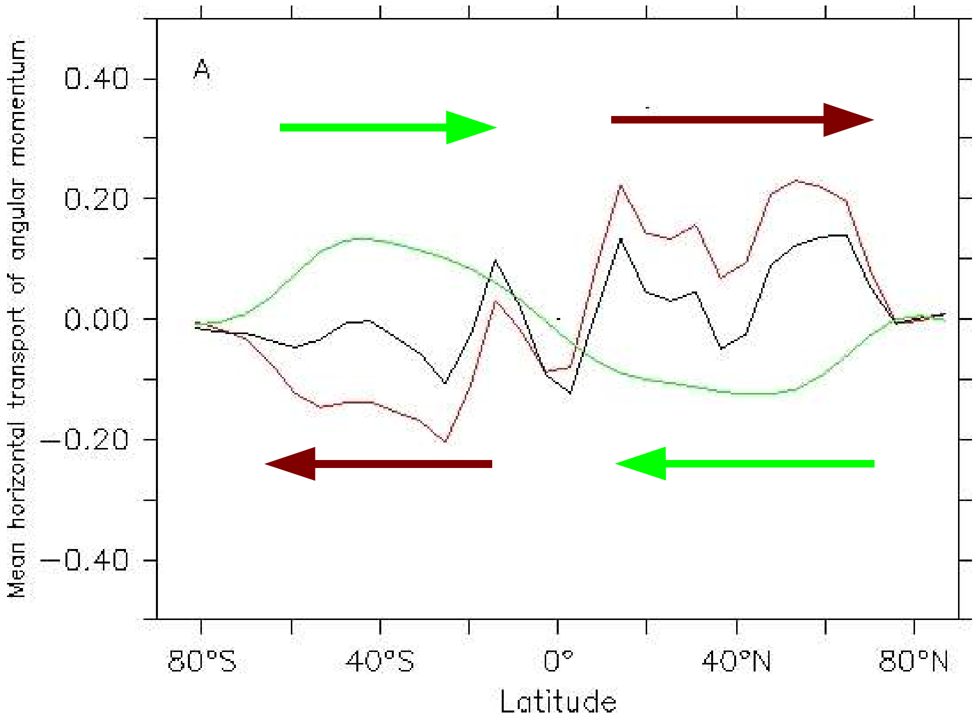
2.0 microns

2.6 microns



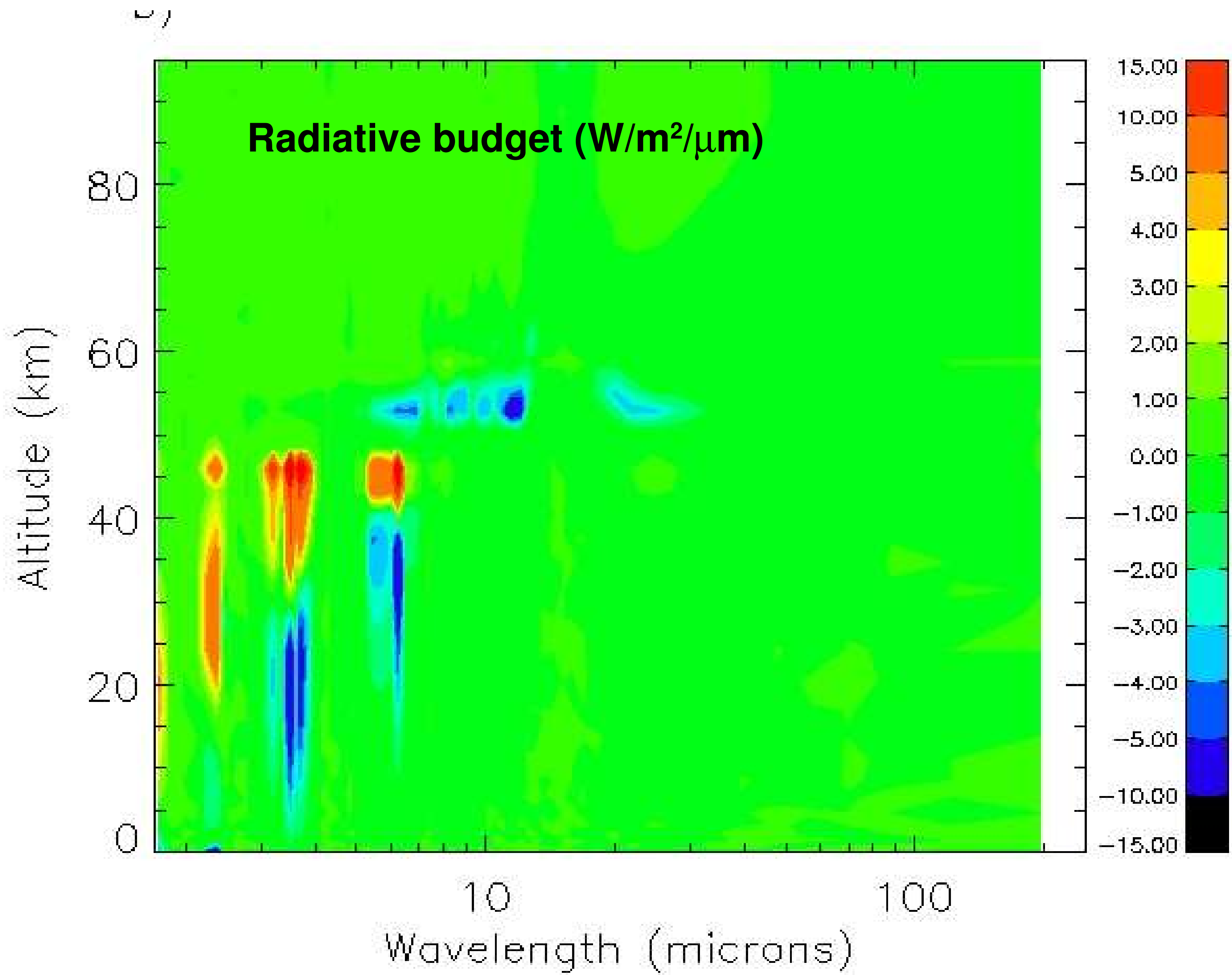
Angular momentum transport



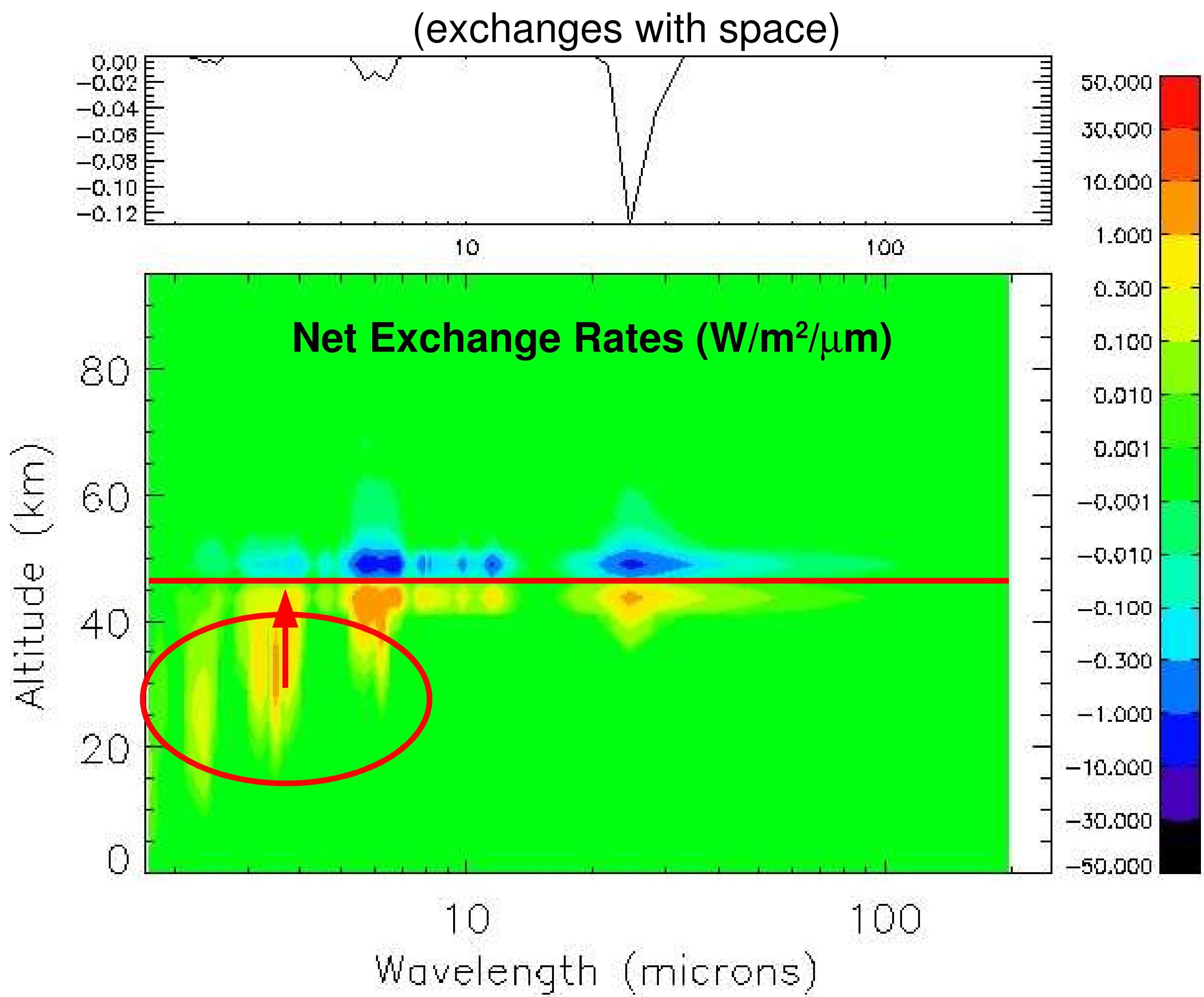


Mean meridional circulation vs transients momentum transport

Role of radiative transfer



PNE analysis



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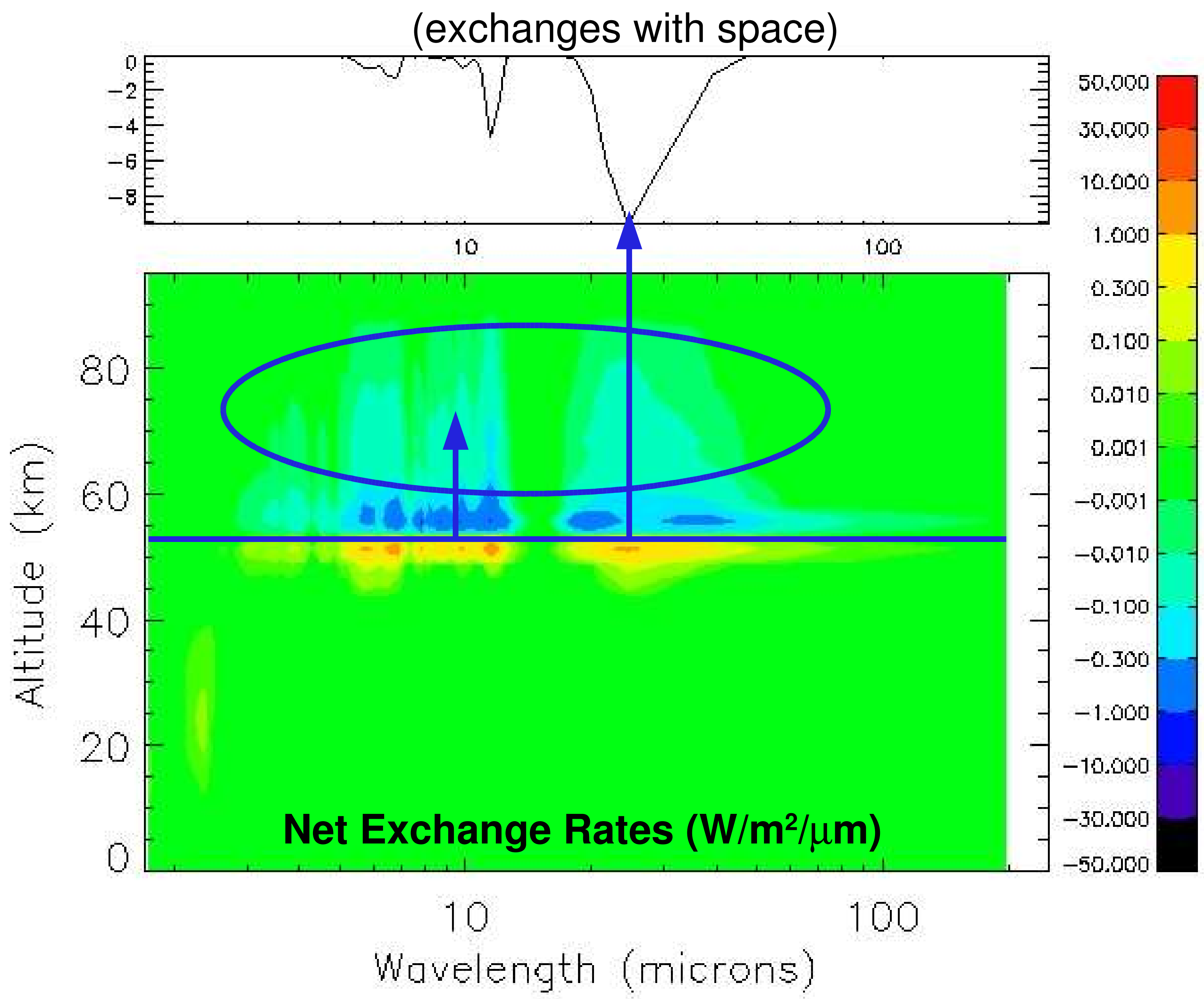

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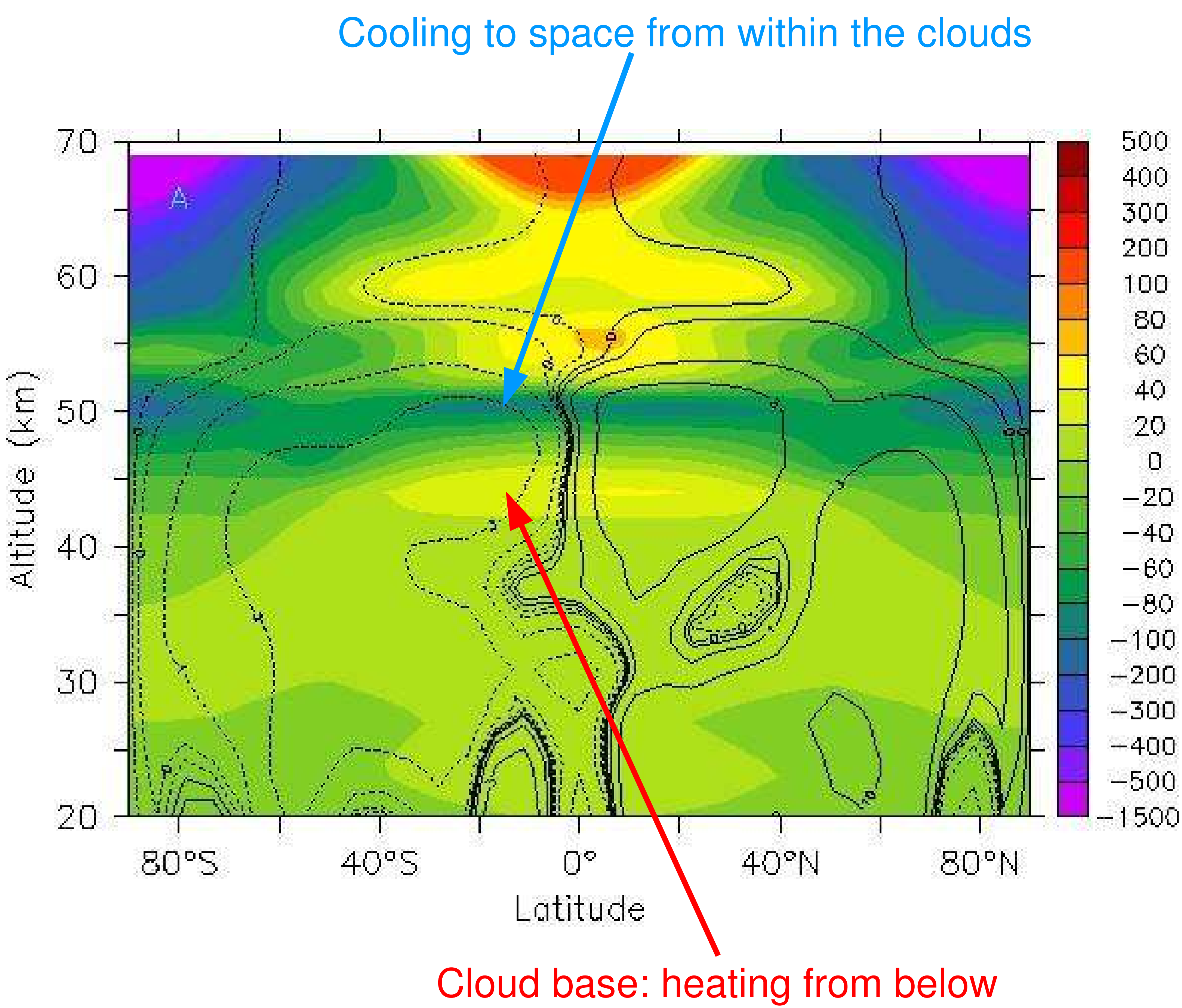

Role of radiative transfer