

Wave Analysis in the Atmosphere of Venus below 100 km Altitude using the LMD Venus GCM

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OUTLINE

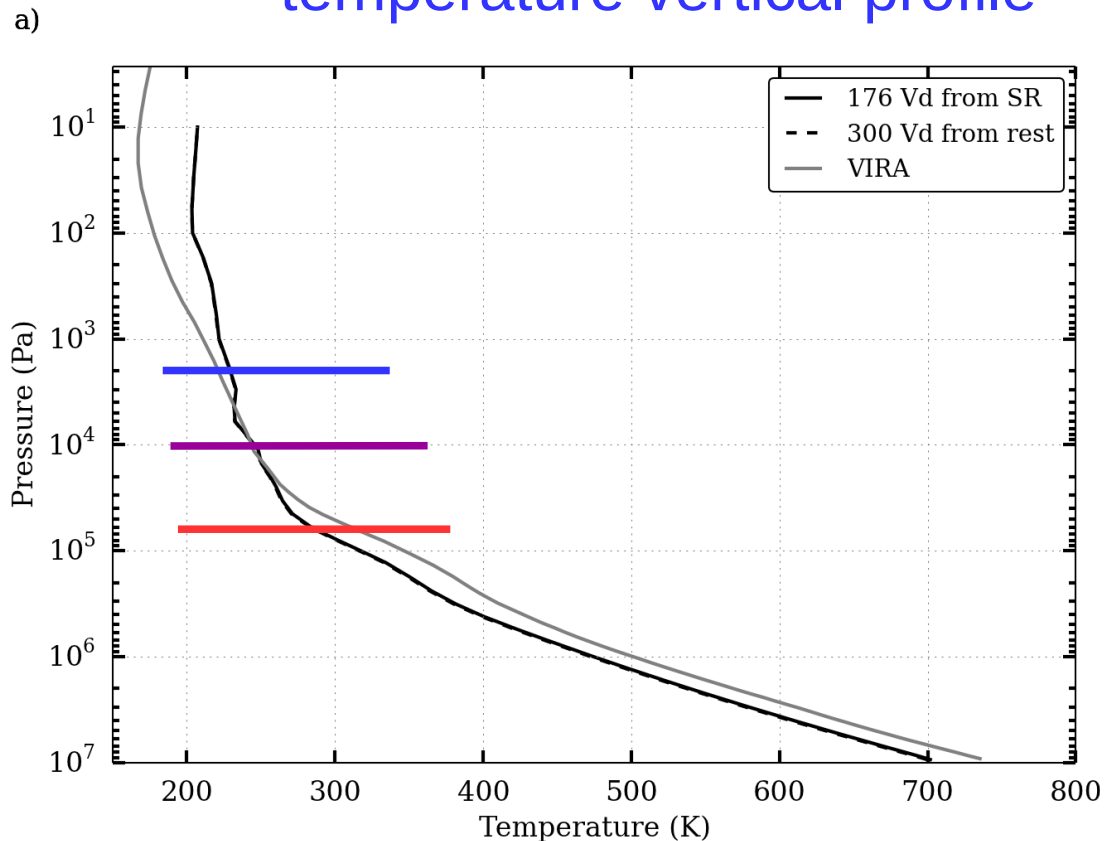
- ◆ The LMD Venus GCM – configuration used here
- ◆ Thermal structure and zonal wind
- ◆ Thermal tides
- ◆ Waves in the clouds and above
- ◆ Waves below the clouds

The LMD Venus GCM

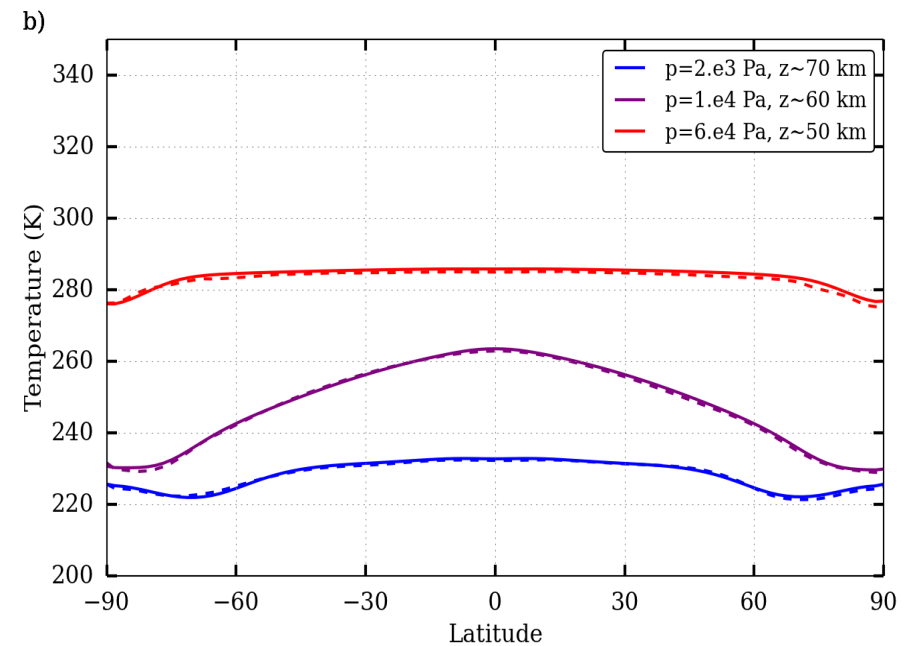
- ◆ 96X96 ($3.75^\circ \times 1.875^\circ$), 50 vertical levels (hybrid) up to ~100 km
- ◆ Radiative transfer : Tabulated solar (Crisp 1986)
 NER matrix for IR (Eymet et al 2009)
- ◆ PBL : Mellor&Yamada 1982
- ◆ Topography
- ◆ 300 Vdays from rest / 200 Vd from superrotation (convergence)

Thermal structure

Global averaged temperature vertical profile

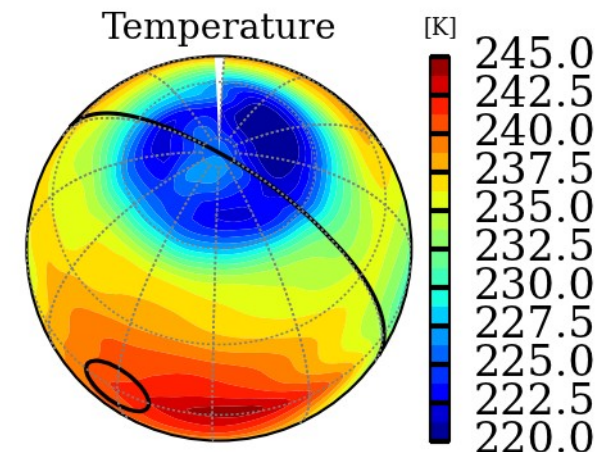
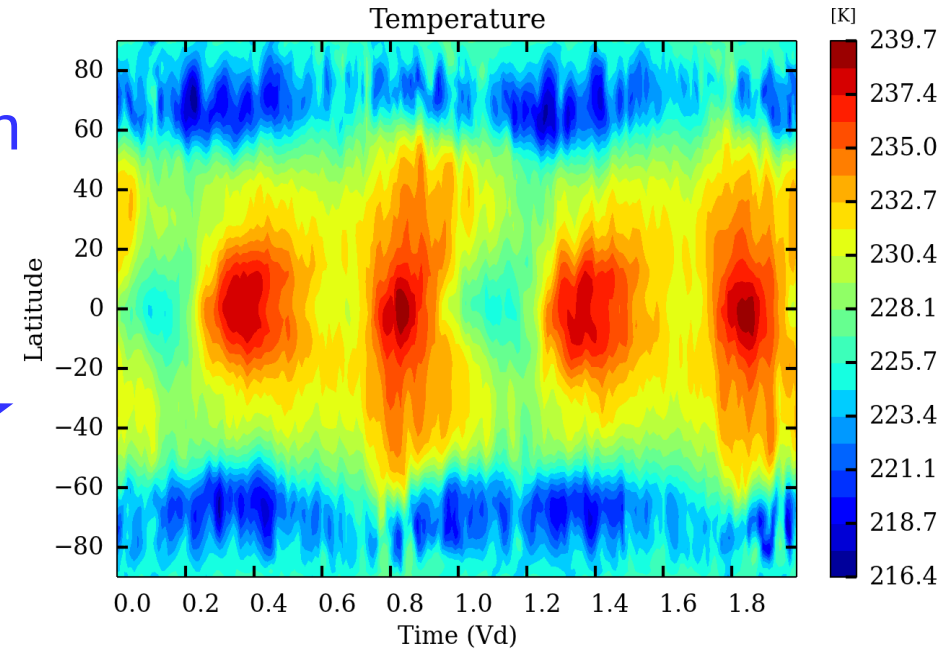
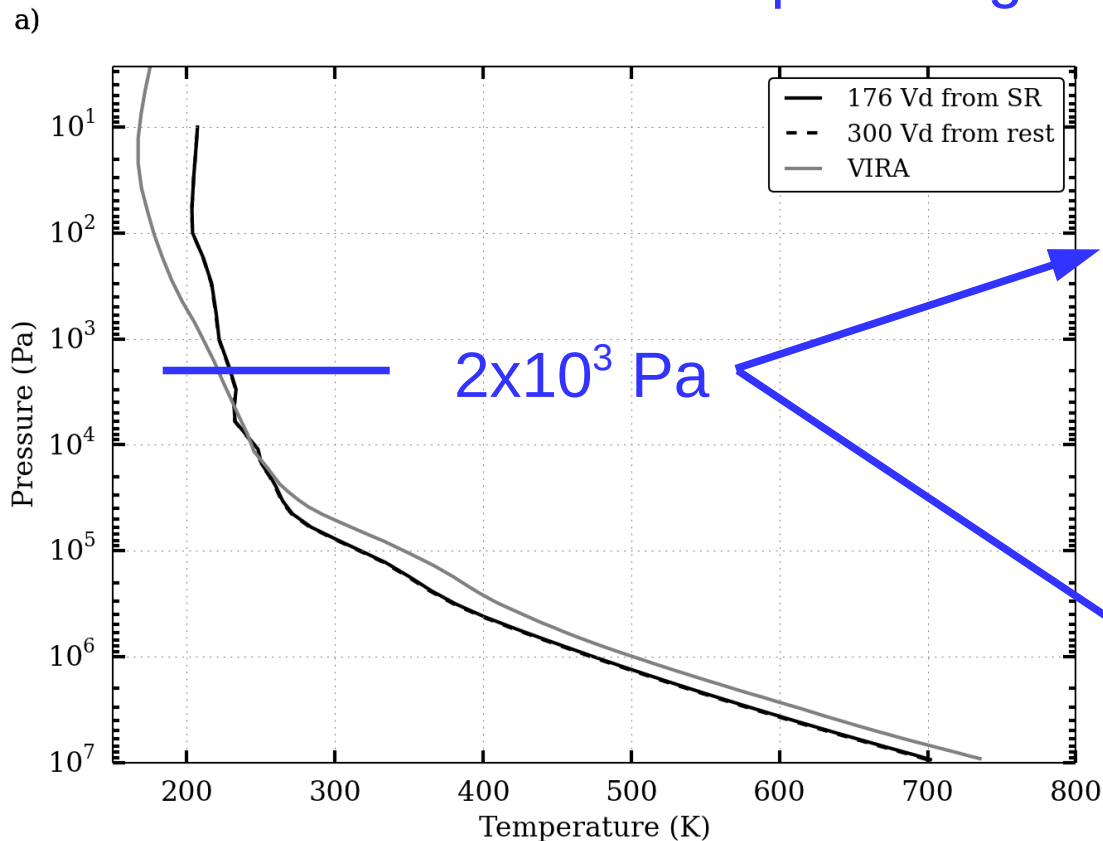


Latitudinal profiles



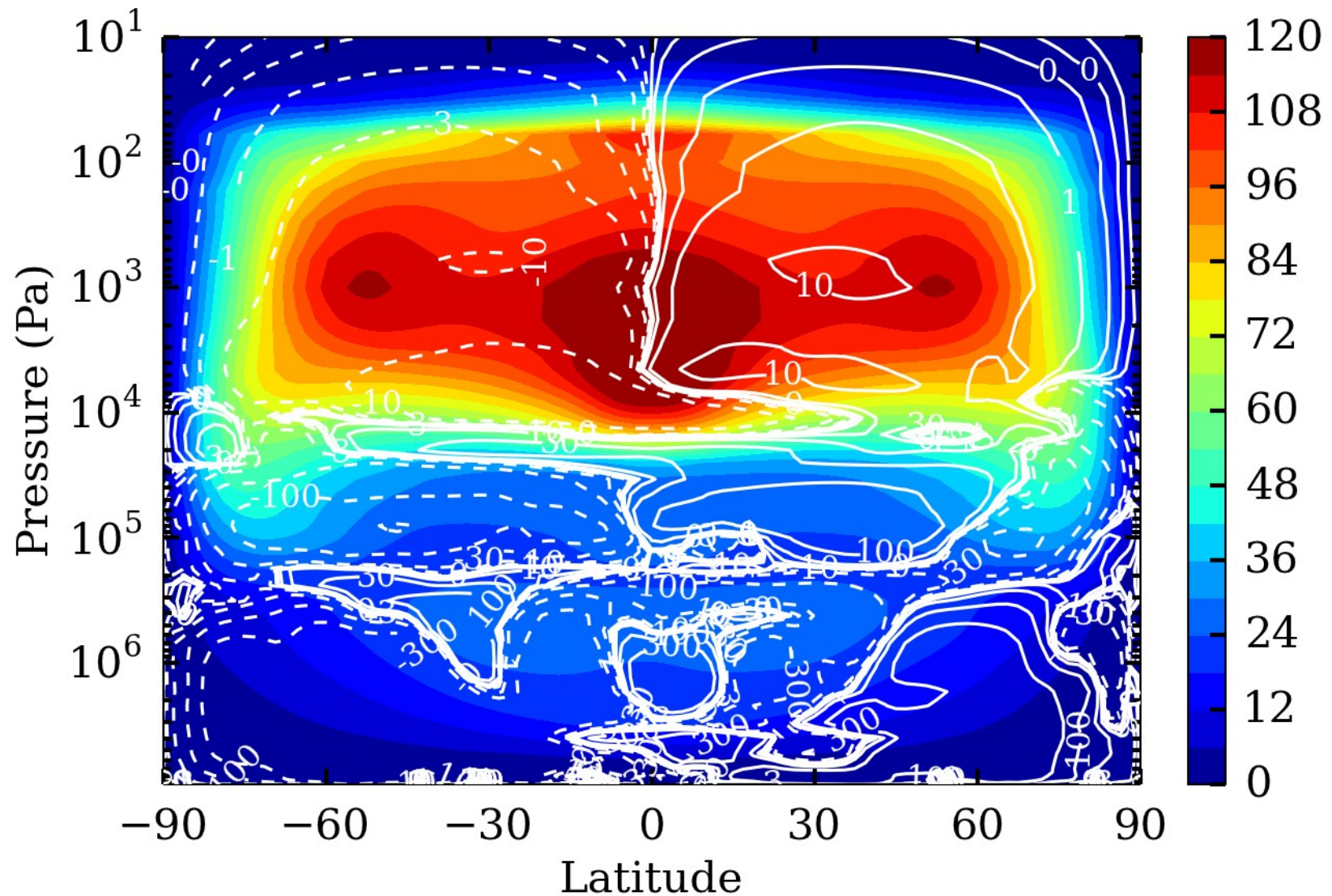
Thermal structure

Cloud-top time variations
and **cold collar** / polar region



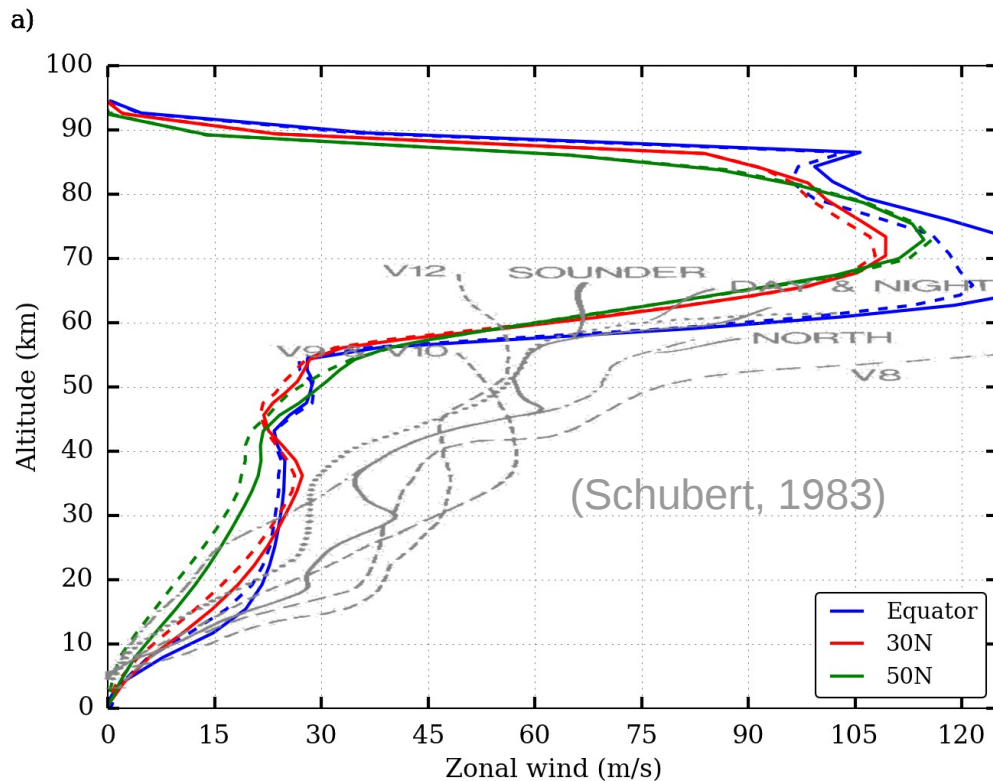
Zonal wind

Longitudinal and time averaged
zonal wind (colors) and stream function (contours)

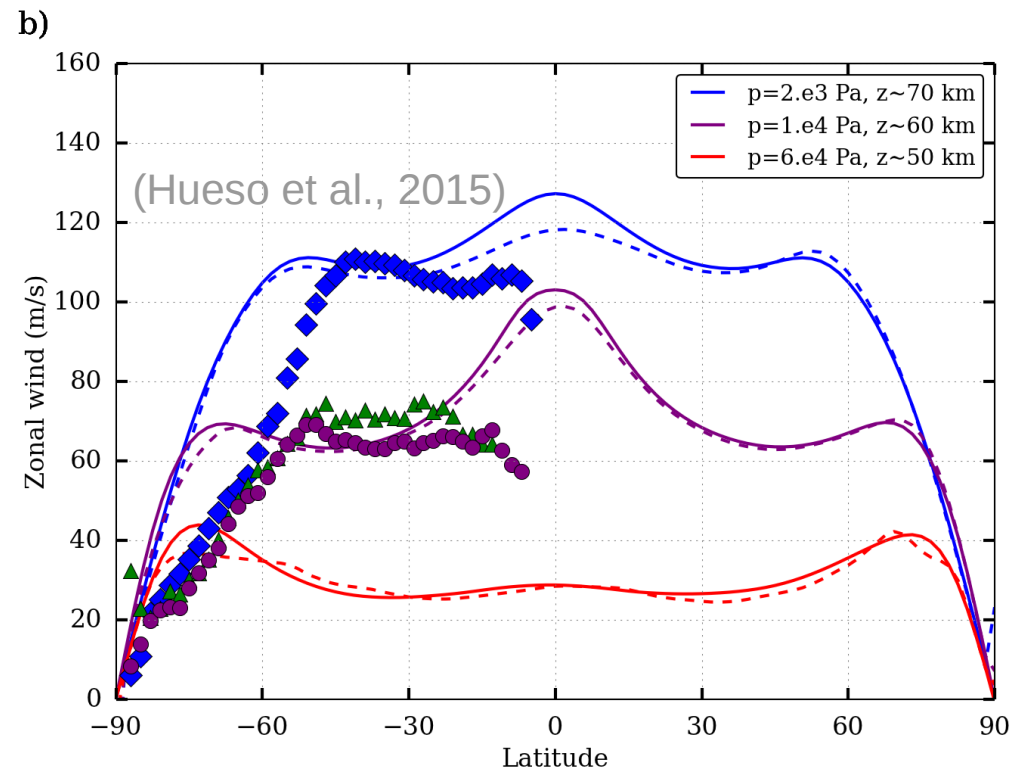


Zonal wind

Vertical profiles



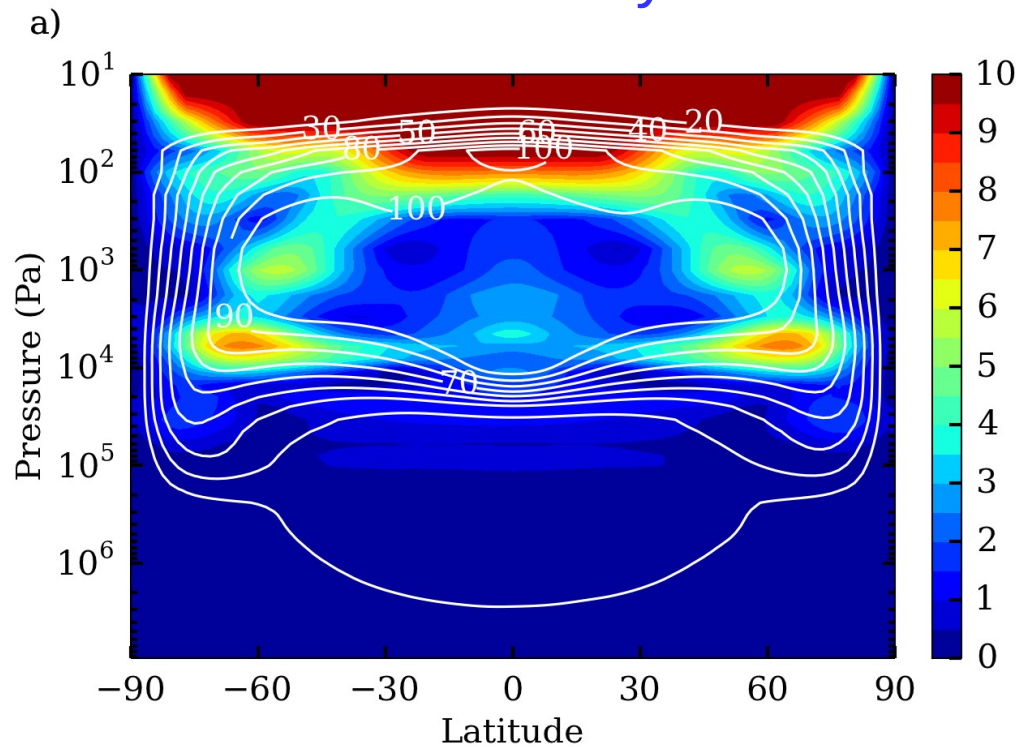
Latitudinal profiles



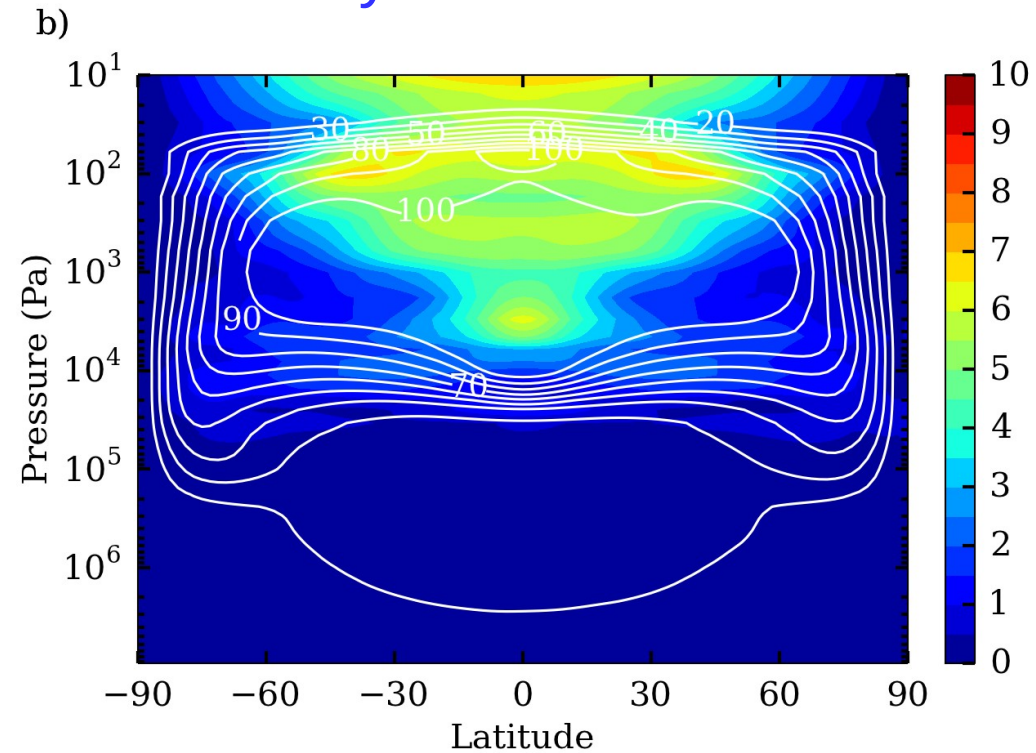
From motionless initial state, with full radiative transfer

Thermal tides

Amplitude of the FFT spectrum of the temperature
at 1 cy/Vd and 2 cy/Vd

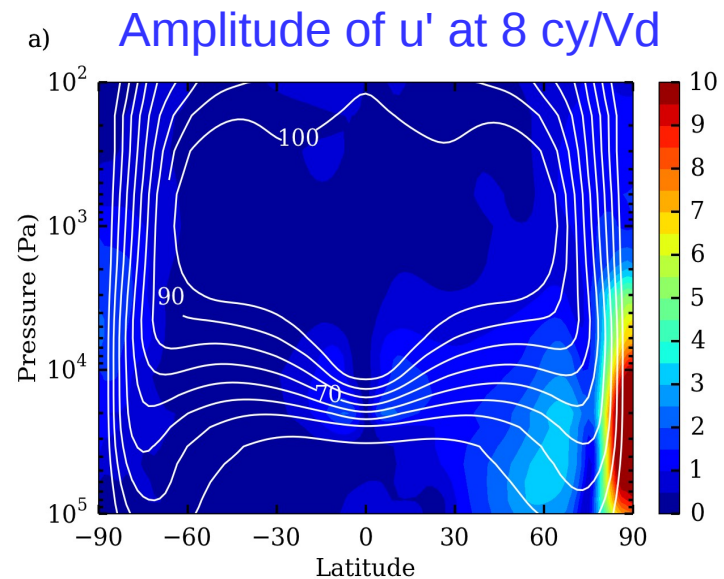
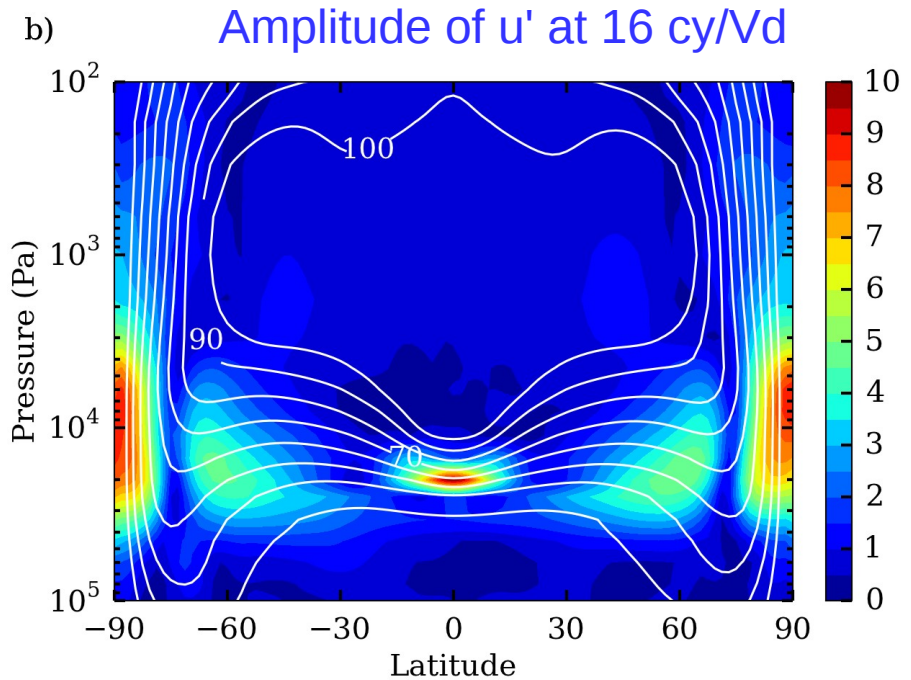
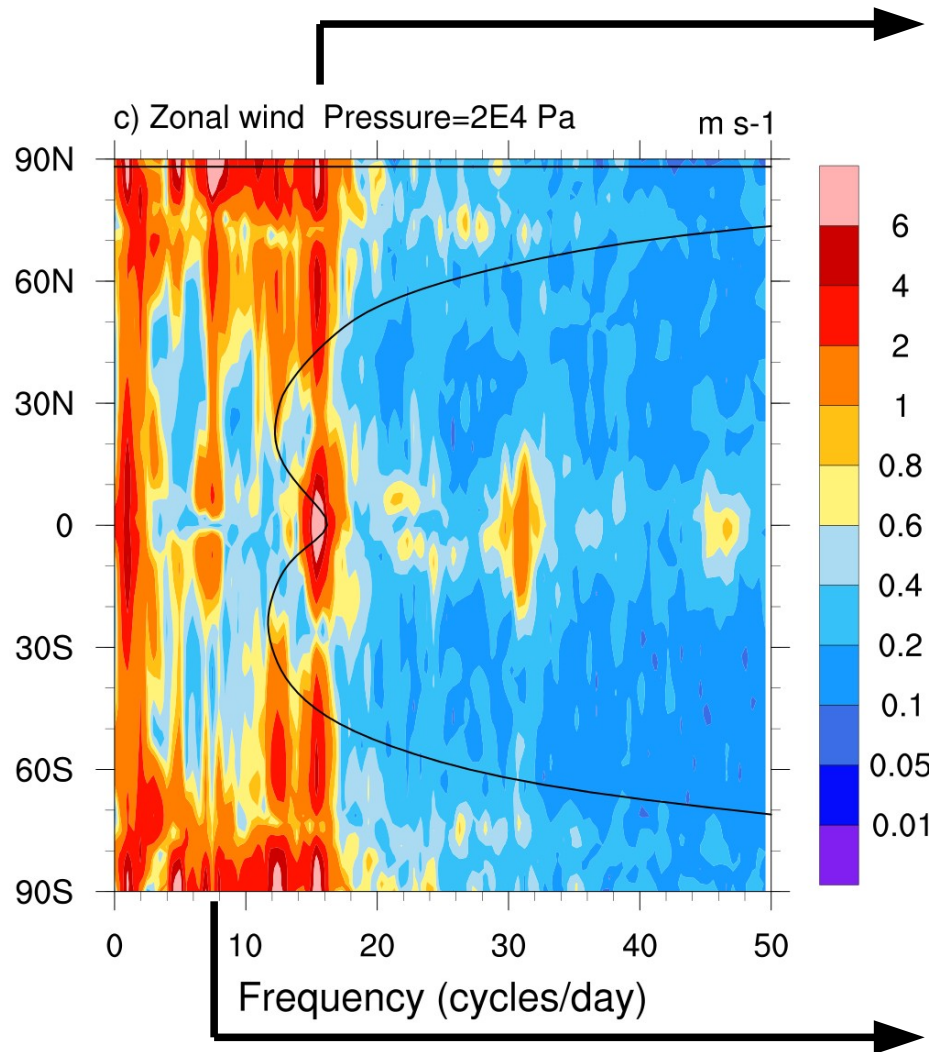


Diurnal tide



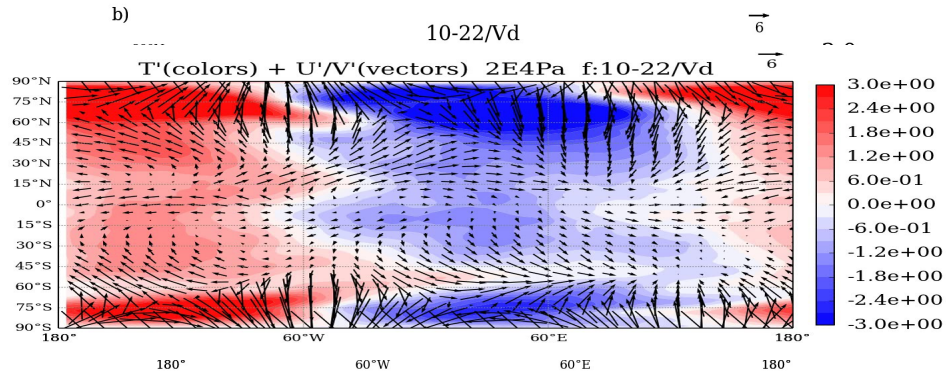
Semi-diurnal tide

Waves in the clouds

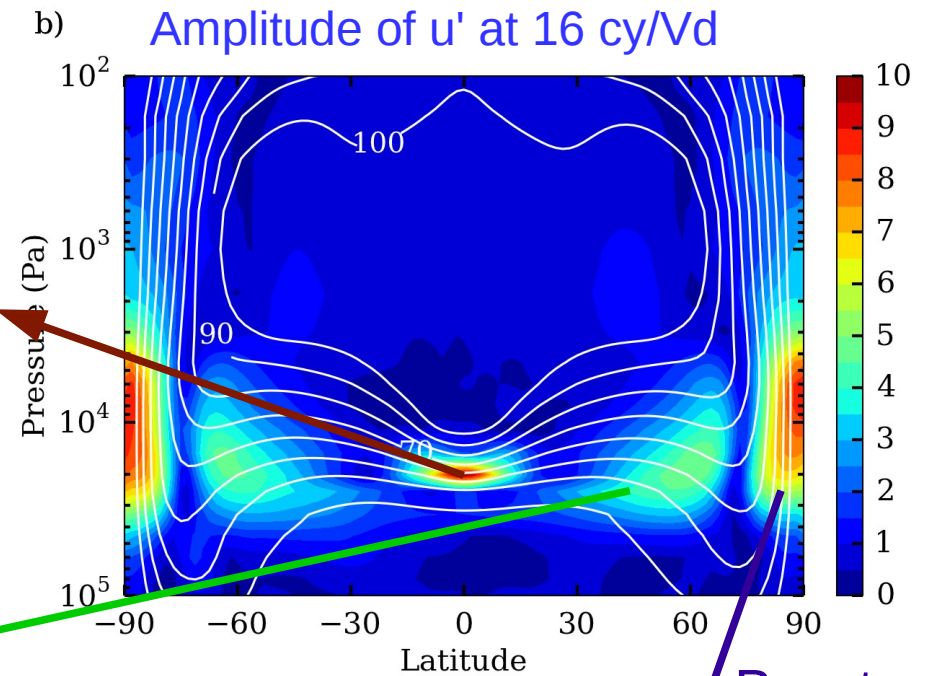


Waves in the clouds

Kelvin-type

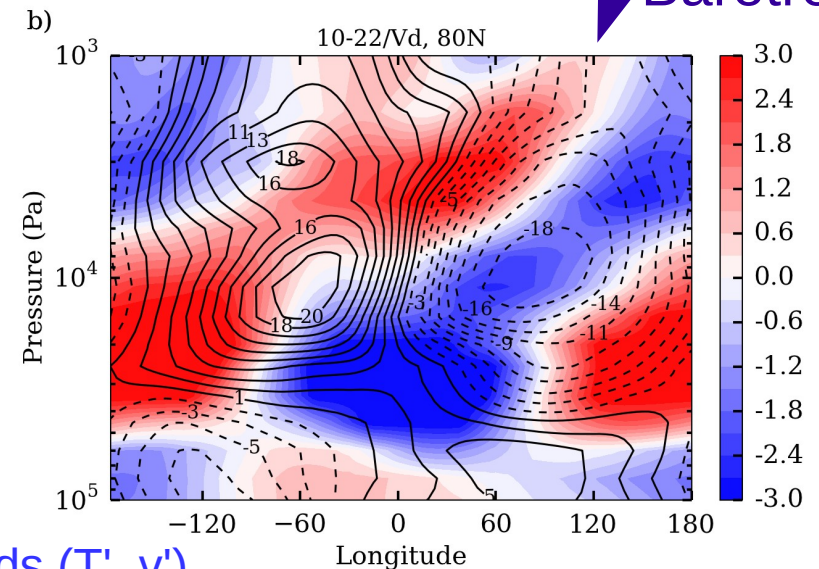
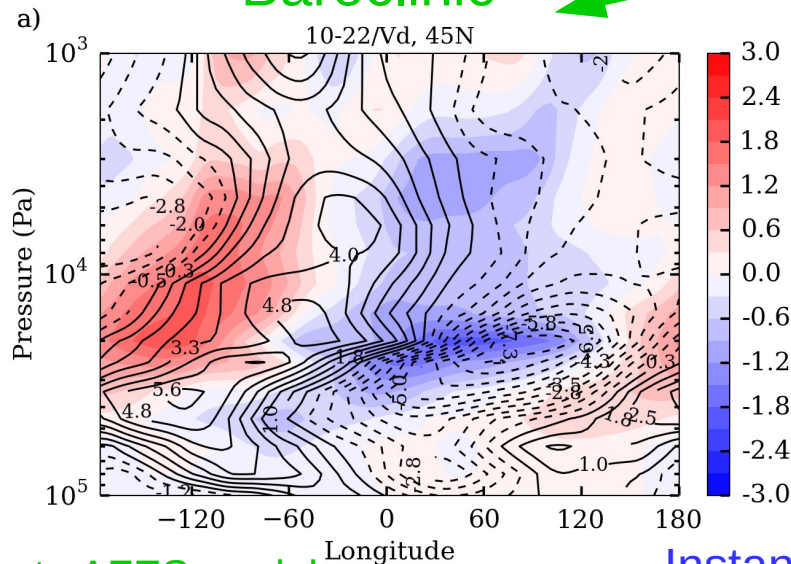


Instantaneous T' and (u',v') vectors



Barotropic

Baroclinic



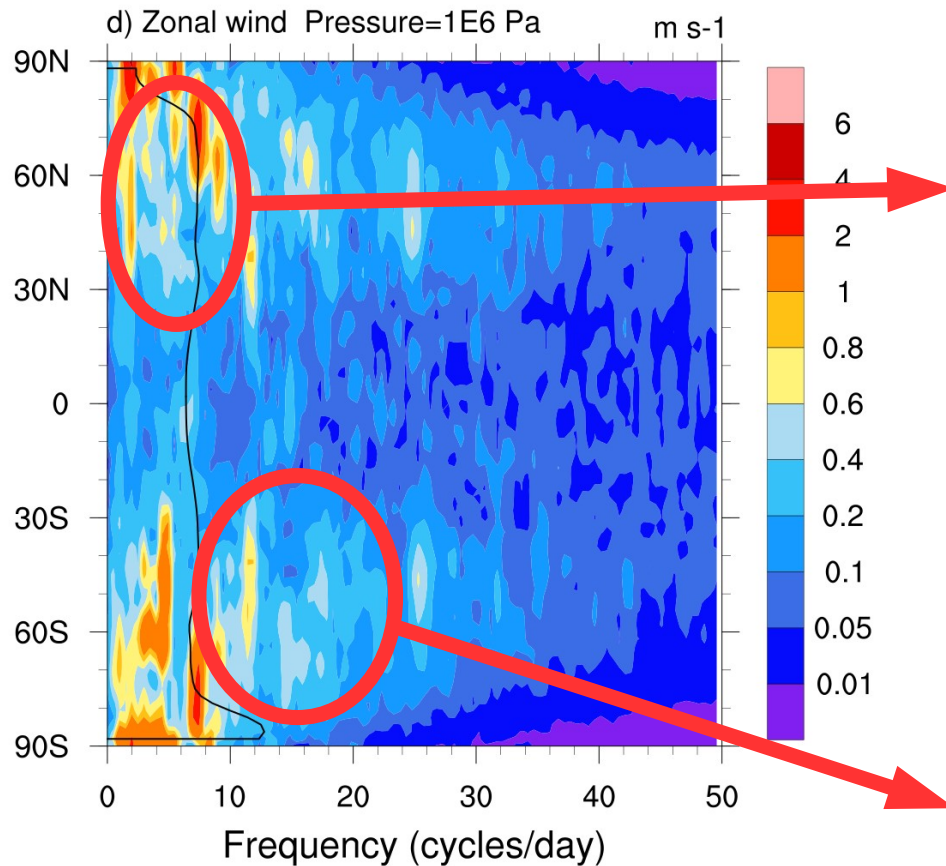
Instantaneous fields (T' , v')

Similar to AFES model
(Sugimoto et al 2014a,b ; Ando et al, 2016)

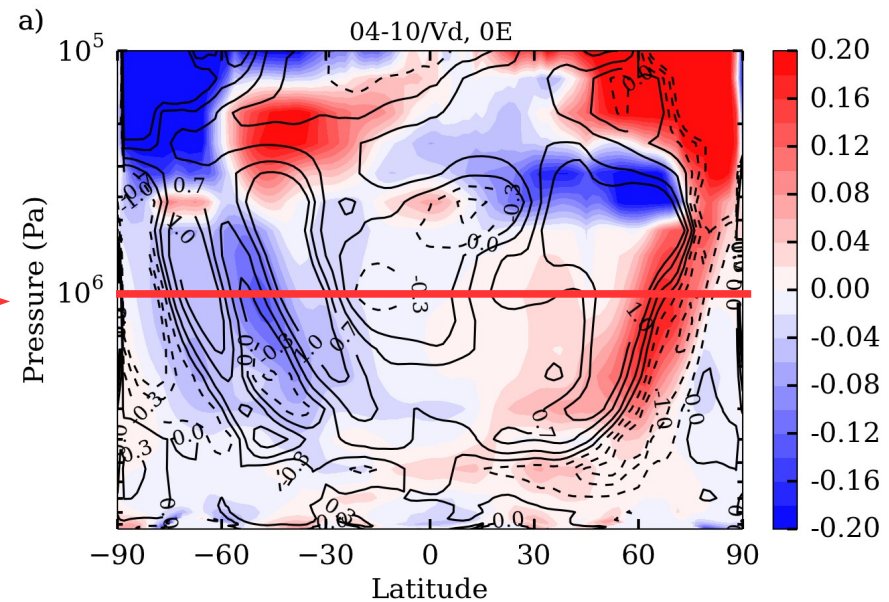
Oxford International Venus Conference – April 2016

Waves below the clouds

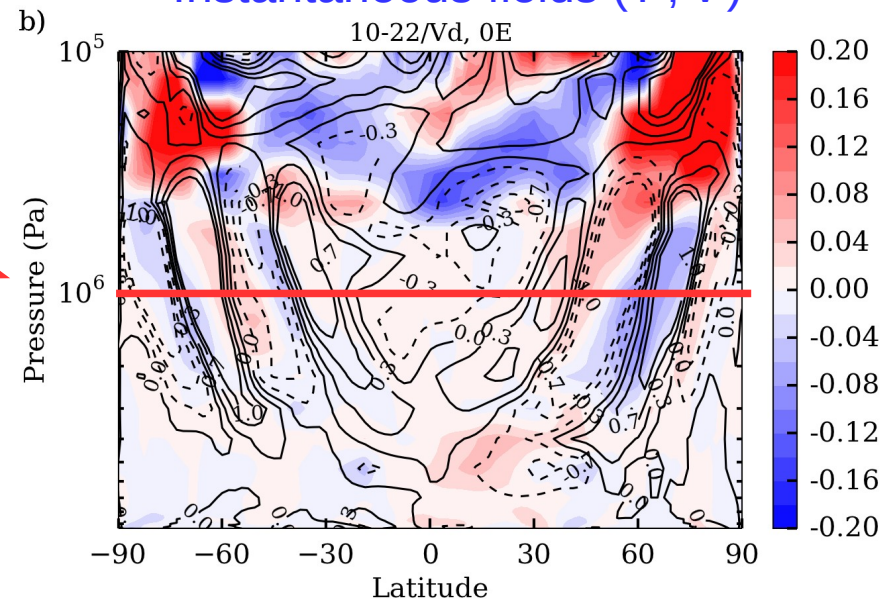
Large-scale gravity waves



Amplitude of u' at 1×10^6 Pa

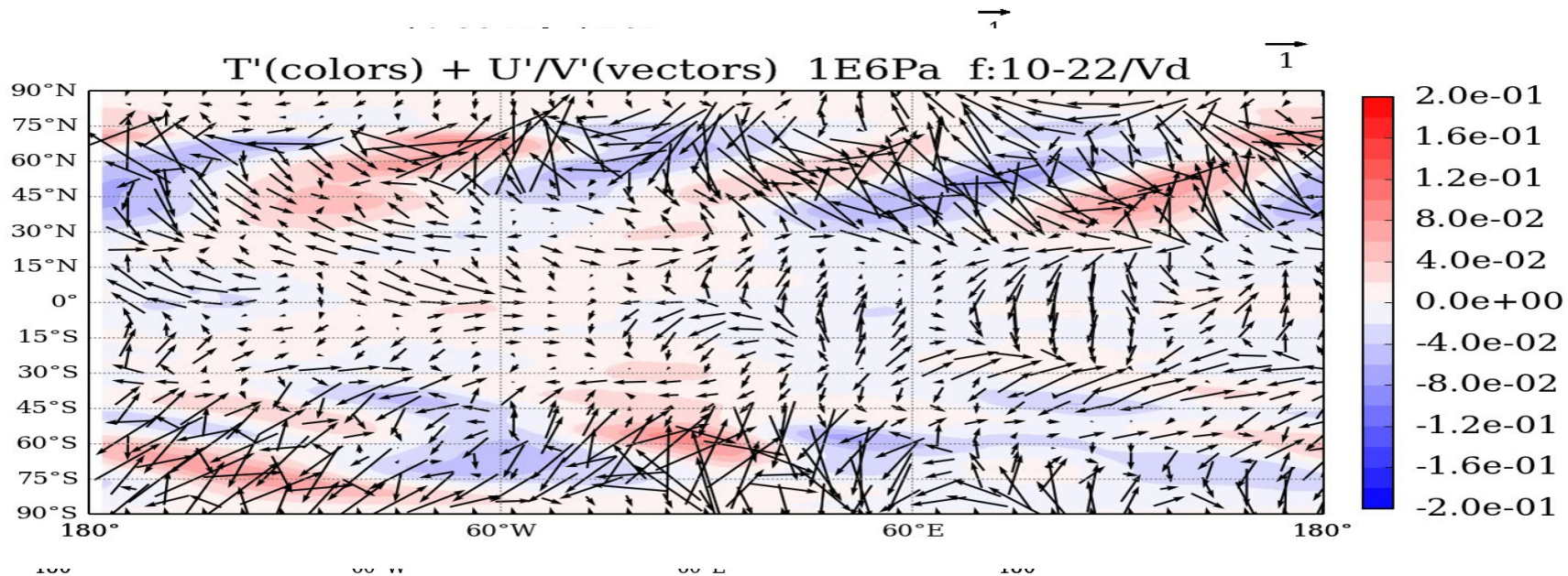


Instantaneous fields (T' , v')



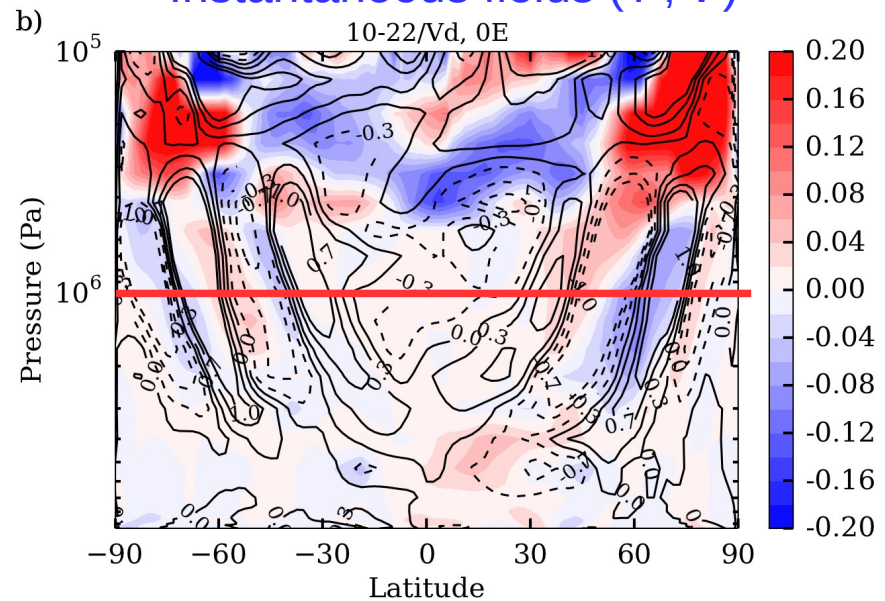
Waves below the clouds

b)



Instantaneous T' and (u',v') vectors

Instantaneous fields (T' , v')



Conclusions

♦ Thermal and wind structure :

- ♦ improved agreement with observations
- ♦ remaining difficulties in the wind profile and equatorial balance

♦ Thermal tides :

- ♦ dominant waves in the upper cloud and above
- ♦ semi-diurnal dominant in the low latitudes

♦ Cloud region :

- ♦ barotropic activity in the polar region
- ♦ baroclinic activity at mid latitudes
- ♦ Kelvin-type wave in equatorial region, but not at cloud top...

♦ Below the clouds :

- ♦ mid- to high-latitude large-scale gravity waves