3D Mesocale Modeling of the Venus Atmosphere

Maxence Lefèvre, Sébastien Lebonnois and Aymeric Spiga

maxence.lefevre@lmd.jussieu.fr
Laboratoire de Météorologie Dynamique, Paris, FRANCE

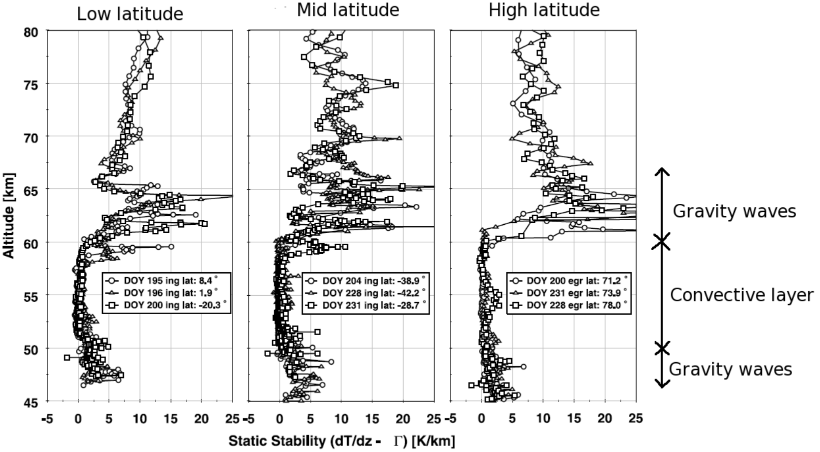
CPS, 29th March 2018

LMD

SORBONNE UNIVERSITÉ
CRÉATEURS DE FUTURS DEPUIS 1257

Introduction : Convective layer

VeRa radio occultation

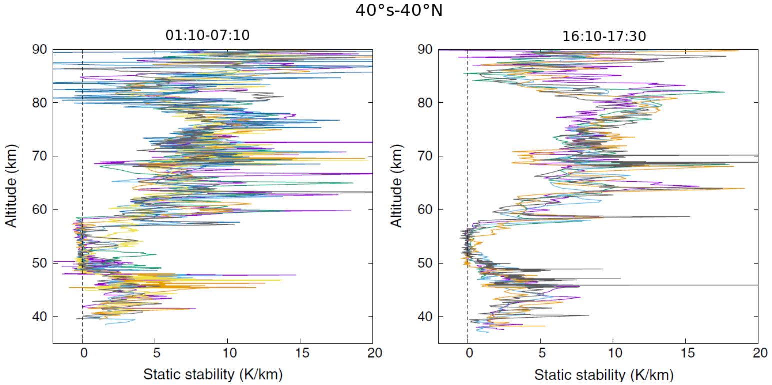


Tellmann et al., 2009

Stronger convective activity at high latitude

Introduction : Convective layer

Akatsuki radio occultation

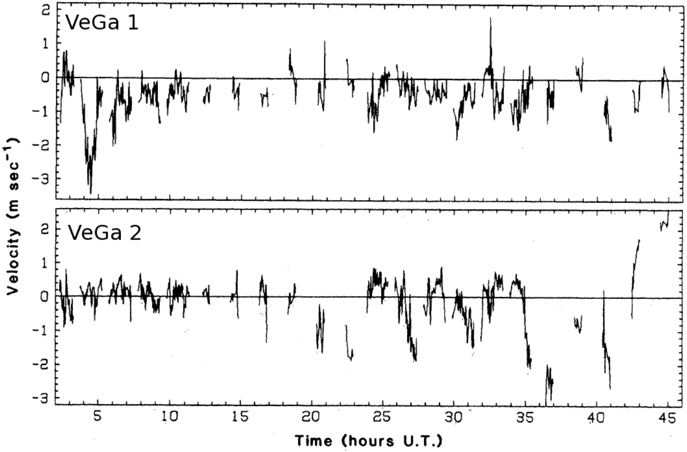


Imamura et al., 2018

Stronger convective activity at night

Introduction : Convective layer

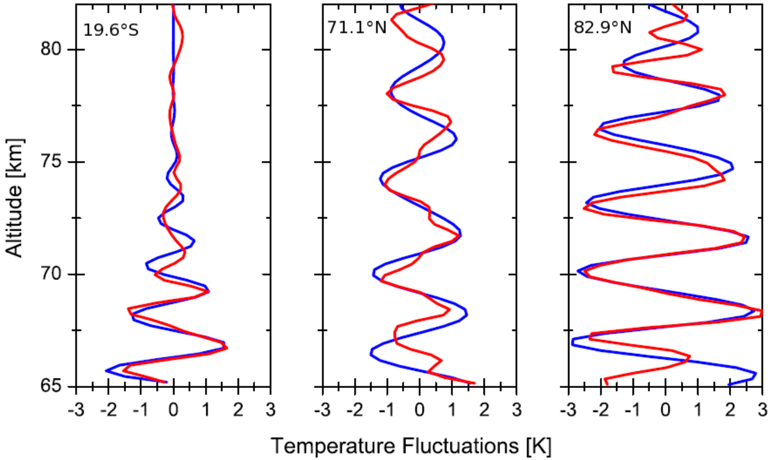
VeGa Balloon vertical wind measurement $\sim \pm$ 3 m/s at $\pm$ 7°



Linkin et al., 1986

Introduction : Gravity waves

VeRa radio occultations

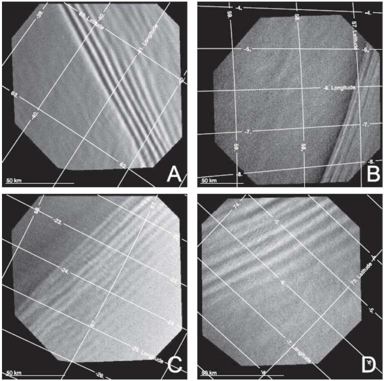


Tellmann et al., 2012

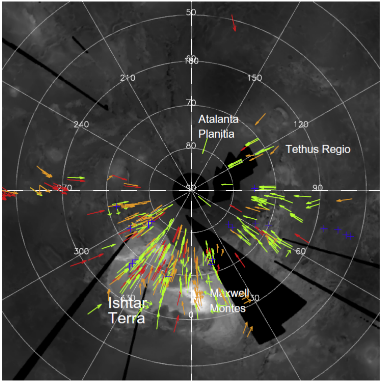
Variability of the convective layer → variabilty of the amplitude of gravity waves

Introduction : Gravity waves

Observations at cloud top ($\sim$ 70 km)



Picciali et al., 2014



Bertaux et al., 2016

Picciali et al., 2014

Convection/Topography $\rightarrow$ Gravity waves $\rightarrow$ maintaining super-rotation ?

3D turbulent-resolving model

GCM resolution > convective activity / gravity waves → turbulent resolving model.

We use WRF non-hydrostatic and compressible dynamical core :

	Large Eddy Simulation (LES)
horizontal resolution	10-1000s m
turbulence resolved	Yes
horizontal boundary	Periodical
Bottom boundary	Flat
Top boundary	Sponge layer

Physics configuration

Heating rates decomposed in 3 different contributions :

-2 radiative ones

- Dynamics: associated with global dynamics : Hadley cell (Adiabatic warming/cooling)

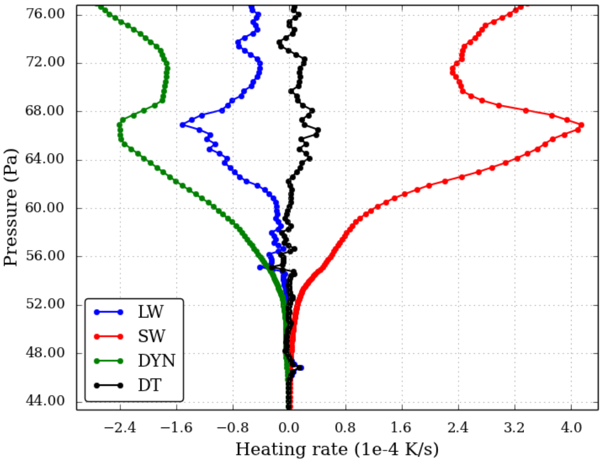
	Off-line (Lefèvre et al., 2017)	On-line (to be submitted)
Solar	Interpolated : LMD Venus GCM (Lebonnois et al., 2016)	short waves radiation fluxes from Haus et al (2016)
IR	Interpolated	Eymet et al (2009) NET matrix latitudinal varying cloud model (Haus et al 2013/2014)
Dynamics	Interpolated	Interpolated, zonally averaged
Resolution	200 m	400 m
horizontal domain	36x36 km	60x60 km
vertical domain	40 to 70 km	300 levels from surface to 100 km

No wind shear is imposed

Input from GMC Simuations (Garate-Lopez and Lebonnois, 2018)

Exemple of heating rate

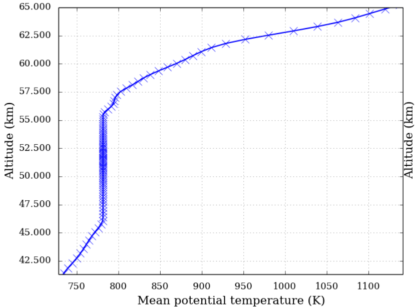
At the Equator at midnight



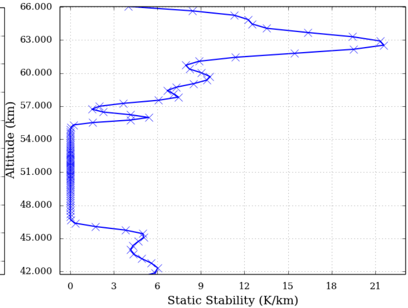
Main convective layer

Equator noon

Potential temperature



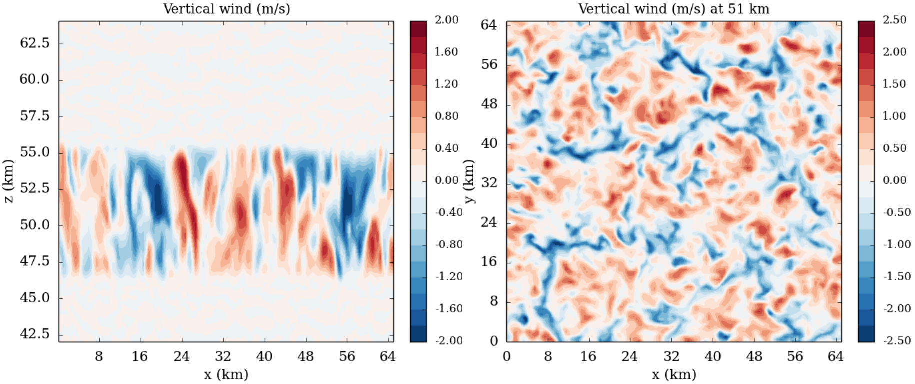
Static stability



On-line convection between 46 and 55 km : 4x the off-line mode.

Fine vertical resolution for radiative transfer needed

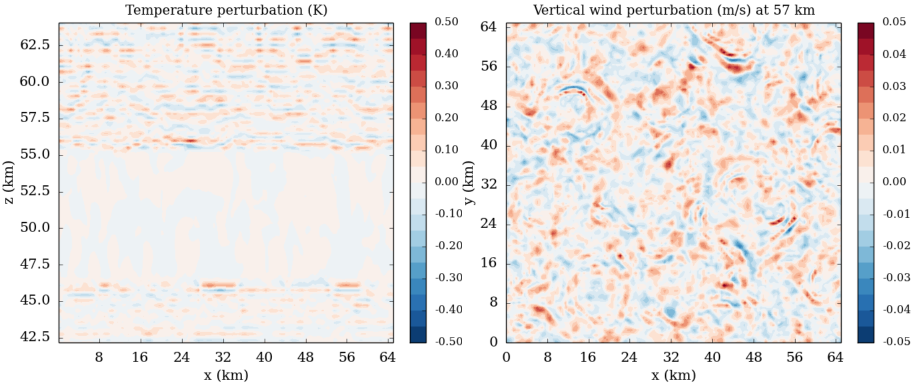
Equator noon: : Convection



Vertical wind between ± 2.5 m/s, consistent with observations

Convective cell of 20 km of diameter.

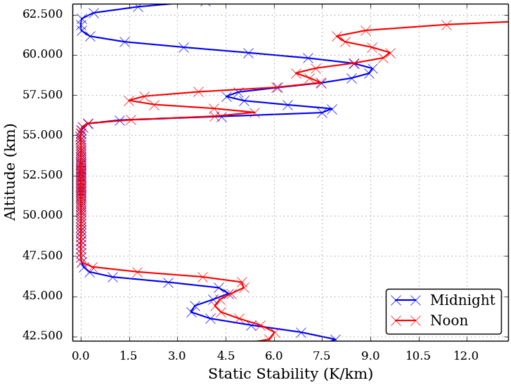
Equator noon: : Gravity waves



Amplitude of GWs ± 0.5 K, smaller than the observations

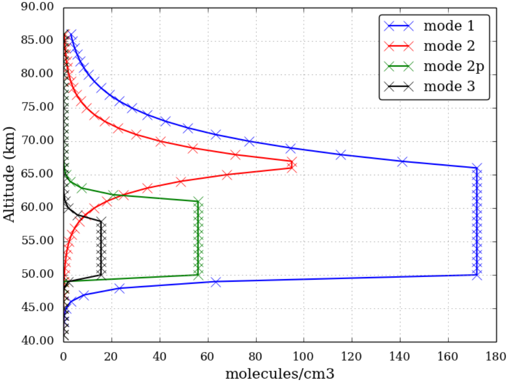
Circular wavefront, not consistent with observations.

Variability with local time

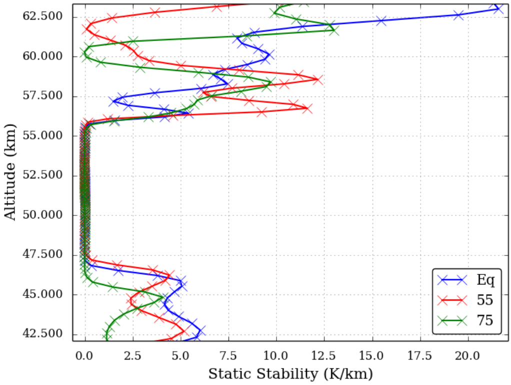


Convective layer slithly thicker at midnight, consistent with Imamura 2014.
Low-static stability layer linked to the end of the mode 2p.

Cloud particle size distribution : The Equator



Variability with latitude

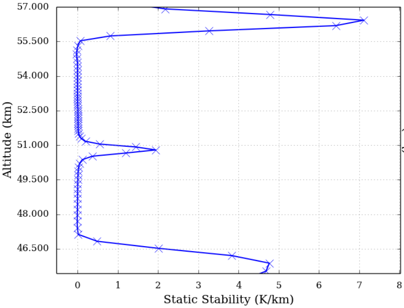


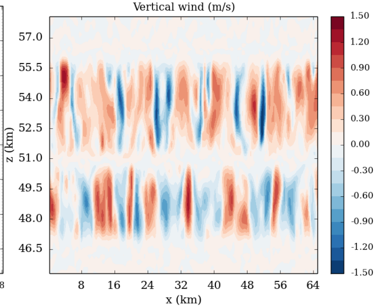
75° thicker than the Equator and 55°, consistent with observations
But 55° and the Equator very similar.

Behaviour of the convective layer

Static stability

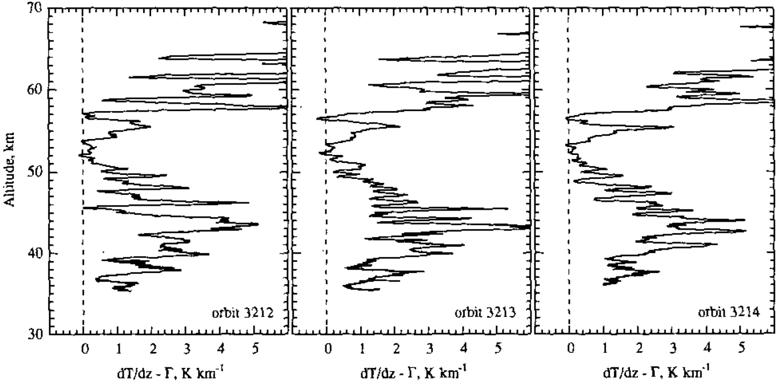
vertical wind





Observations

Magellan radio occultation

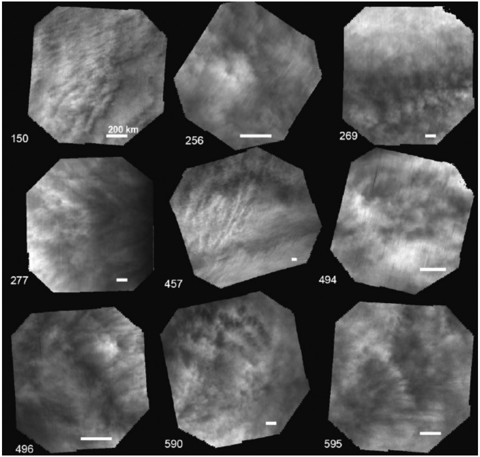


Hinson and Jenkins 1995

Cloud top convective activity

Observations

VMC observations

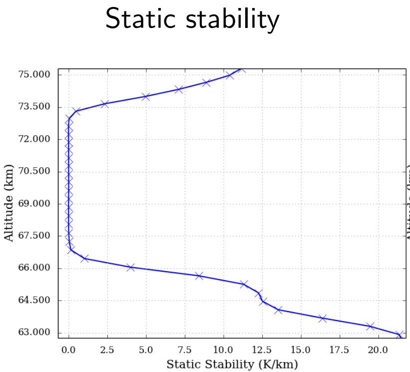


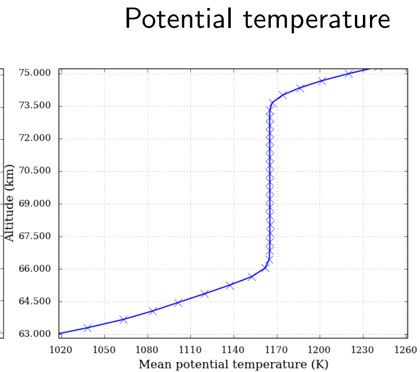
Titov et al., 2012

Subsollar convective activity at low latitude

But no mixed layer observed

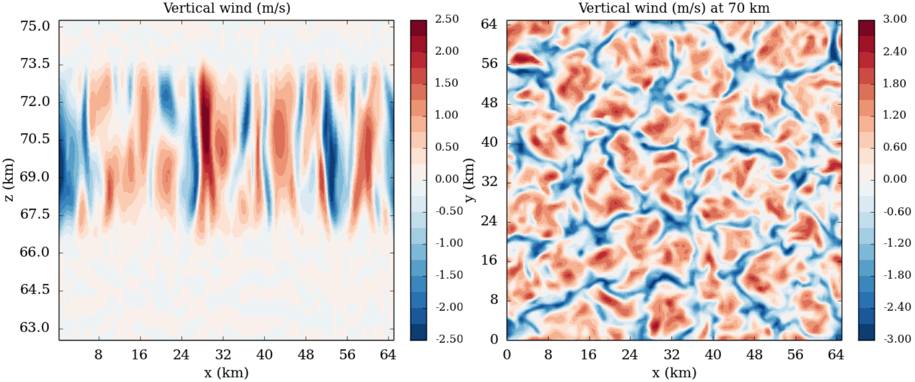
Equator noon





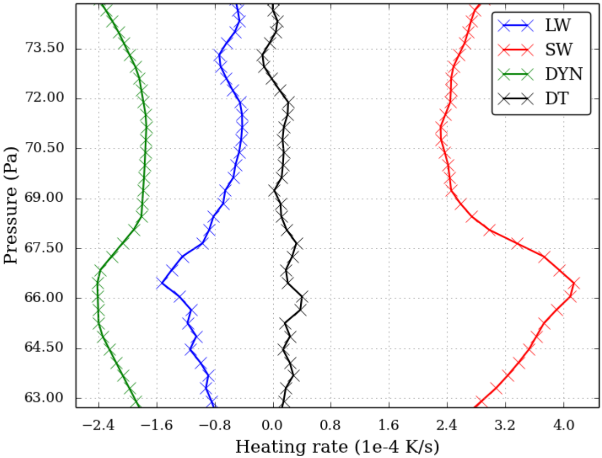
Convection between 67 and 73km but stable atmosphere observed.

Equator noon



Vertical wind between ±3 m/s Convective cell of diameter of 10 km

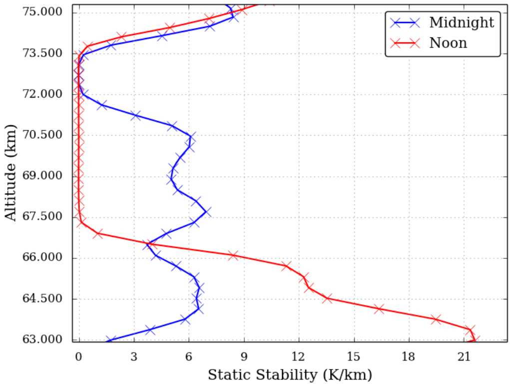
Why ?



Strong heating from unknow UV aborber → destabilization.

Variability with local time

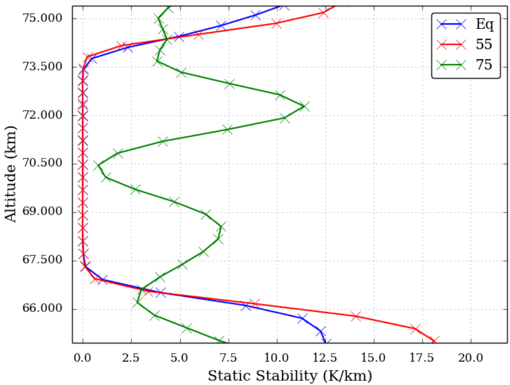
The Equator



Weaker convective activity at midnight
Destabilization at midnight due to the dynamics

Variability with latitude

At noon



convective activity also present at 55° .

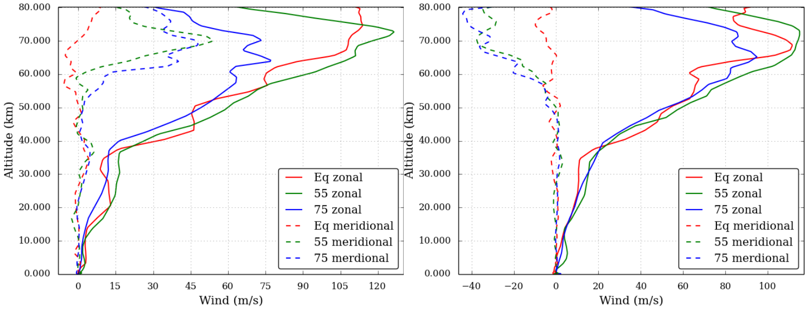
in the GCM mid-latitude jets are too close to the pole.

Impact of the wind shear

Variability with latitude

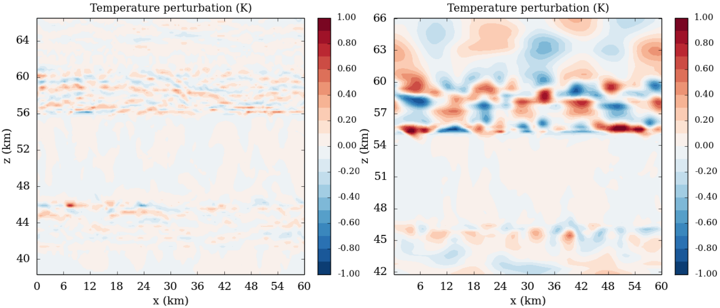
Prescribed wind from the GCM

Noon | Midnight



Impact on the GWs

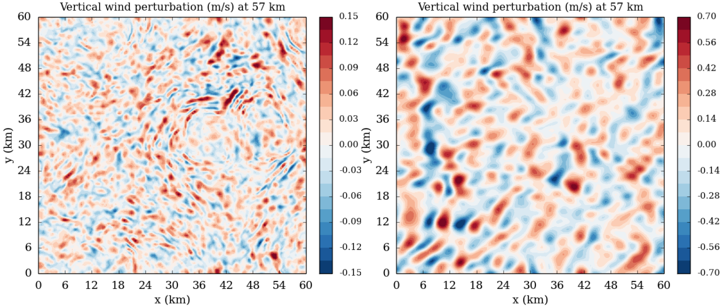
Few impact on convection but strong on GWs



Stronger amplitude with the wind shear : obstacle effect

GWs wavelength

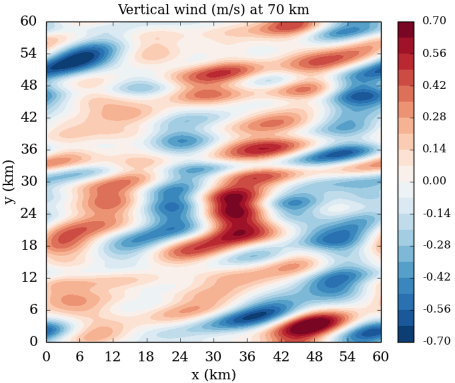
At 57 km



Linear wave front

GWs wavelength

At cloud top



Wavelength up to 20 km. Very close to VMC observations.

Conclusion LES

- Fine vertical resolution radiative transfer to resolve convective layer.
- Latitudinal variabilty of the convective layer.
- Convection activity at cloud top.
- With the wind shear : realistic GWs.

Improvement :

- New dynamical for the GCM.
- Dynamics heating interpolated from fine GCM grid.
- Solar heating rate from tables.

To come :

- PBL study.

Next Step

JSPS project :

- Photochemistry (A. Stolzenbach and F. Lefèvre), already implemented in LES.
- Microphysics (S. Guilbon and A.Määttänen).
- To improve F.Lott parametrization of orographic (T. Navarro) and non-orographic (G.Gilli) GWs into the GCM.