

Sensitivity of the Quasi-Biennial Oscillation to top boundary condition and model grid



NCAR

ESSL's Climate & Global Dynamics

CGD

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*Jadwiga (Yaga) Richter, Julio Bacmeister & Rolando R. Garcia
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Motivation:

- Quasi-biennial Oscillation (QBO) has been a modeling challenge for CAM/WACCM for many years
- 60 level CAM5 (ne30) produces a very realistic QBO
- However, the QBO is very sensitive to choice of model parameters: **vertical resolution, model lid height, dynamical core, momentum deposition at model top**
- The sensitivity in the above is in addition to the sensitivity in the GW parameterization parameters

Model:

- NCAR Community Atmosphere Model, version 5 (CAM5)
- Dynamical Core: Spectral Element (SE) or Finite Volume (FV)
- Gravity Waves: same as in WACCM:

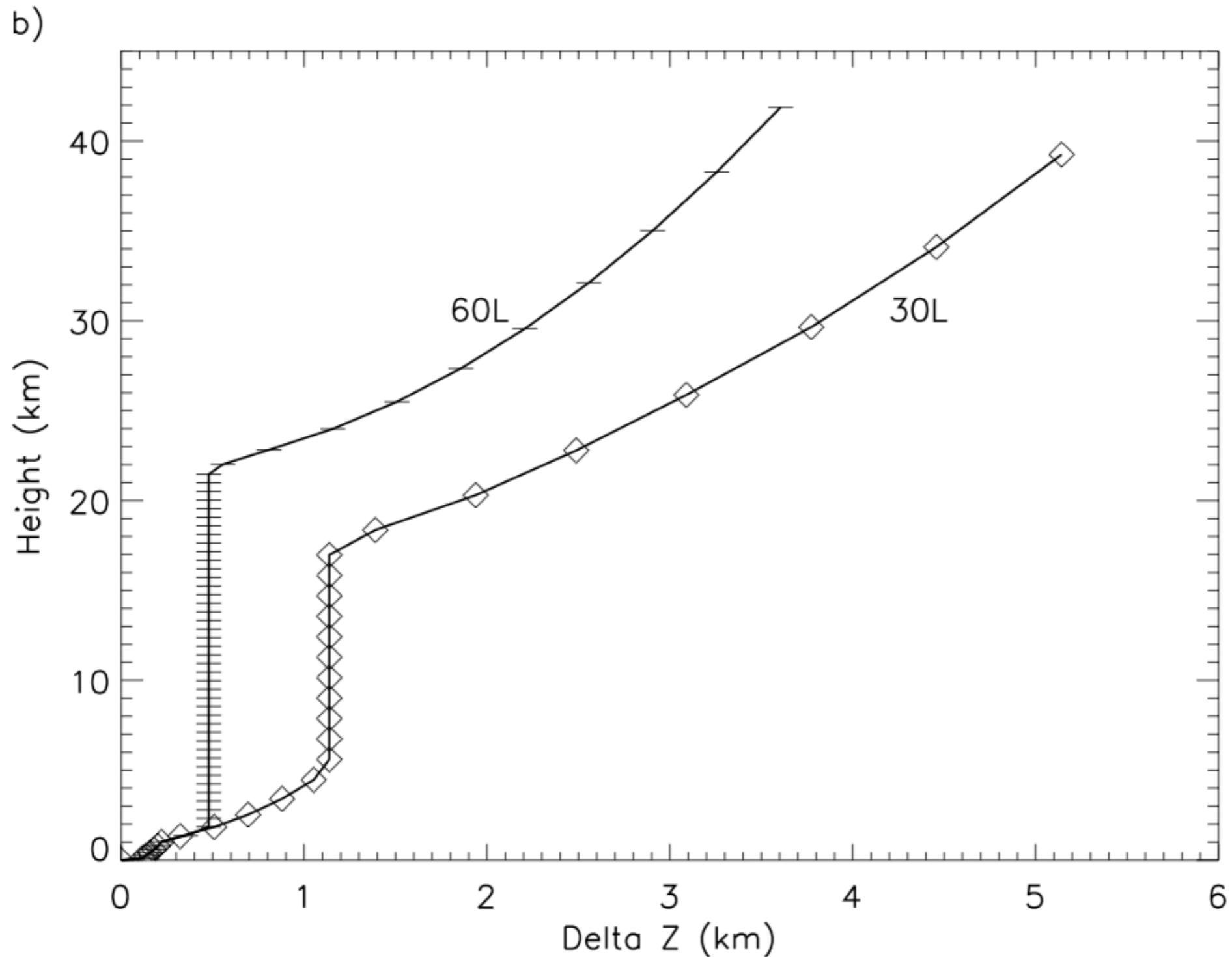
Default: Orographic only

Non-Oro: Frontal and Convective Sources (Richter et al 2010)

Lindzen (1987) propagation scheme

- But, by default we deposit GW momentum at model top (following recommendations of Shaw & Shepherd)
- Default horizontal resolution: ne30 ~ 100 km

Vertical Resolution:

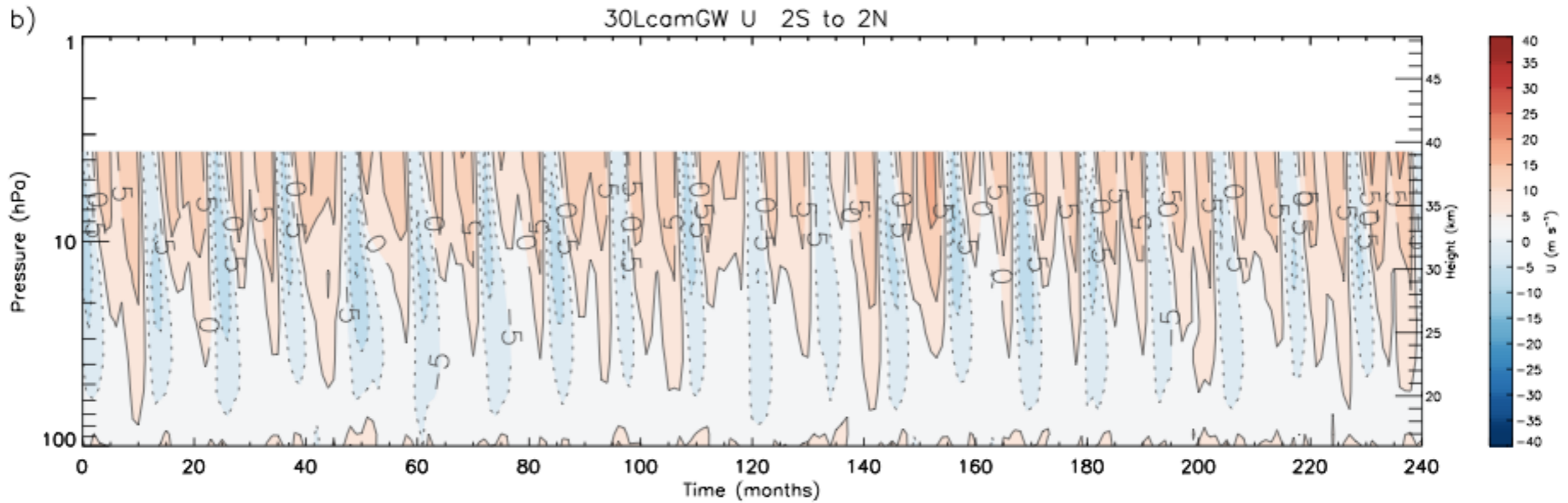


30L model: ~ **1200 m** resolution in troposphere/lower stratosphere

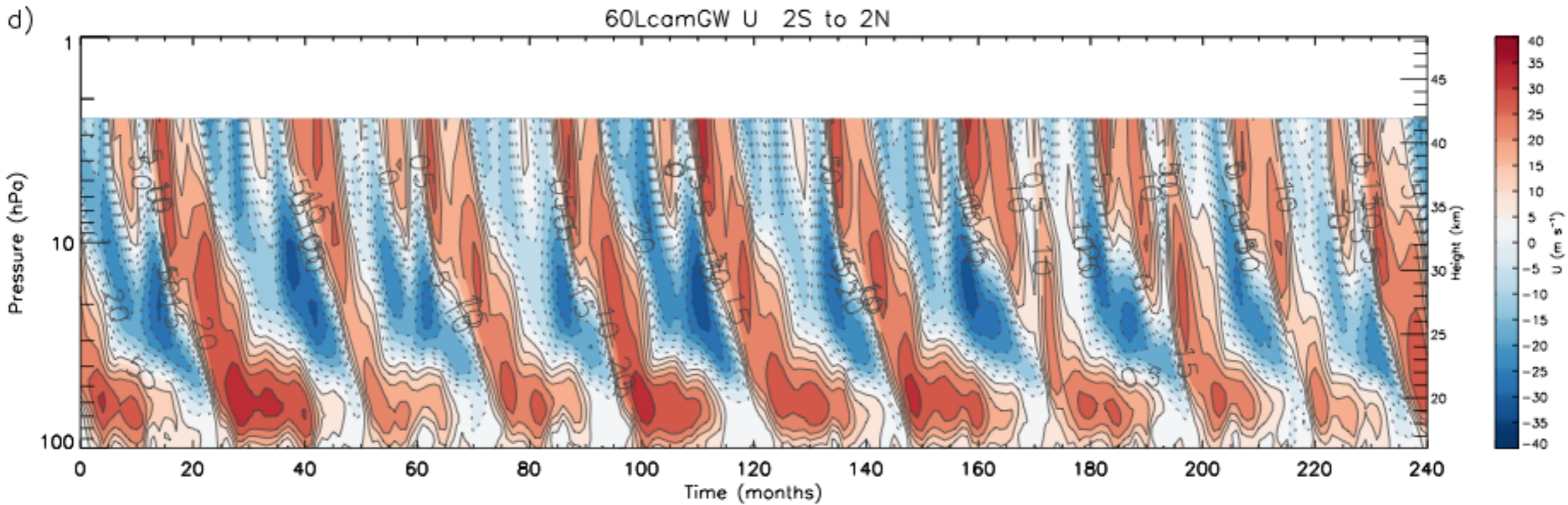
60L model: ~ **500 m** resolution in troposphere/lower stratosphere

Tropical U: 60L model

30L
GW

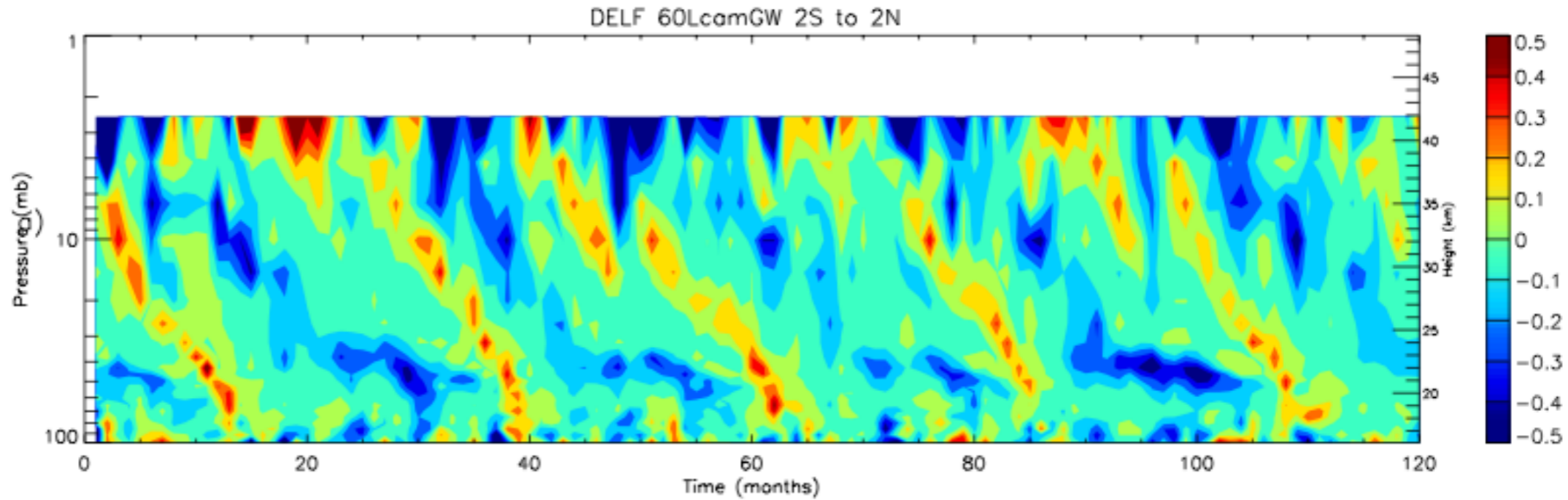


60L
GW

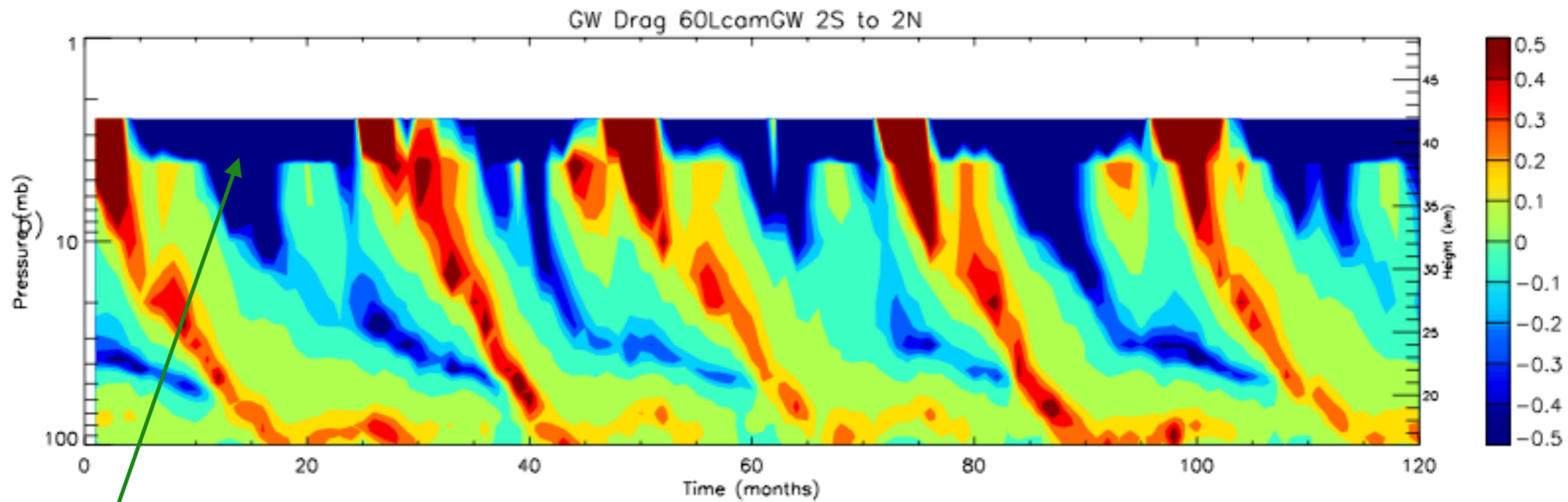


QBO Forcing:

Resolved
EP Flux



GW
Drag

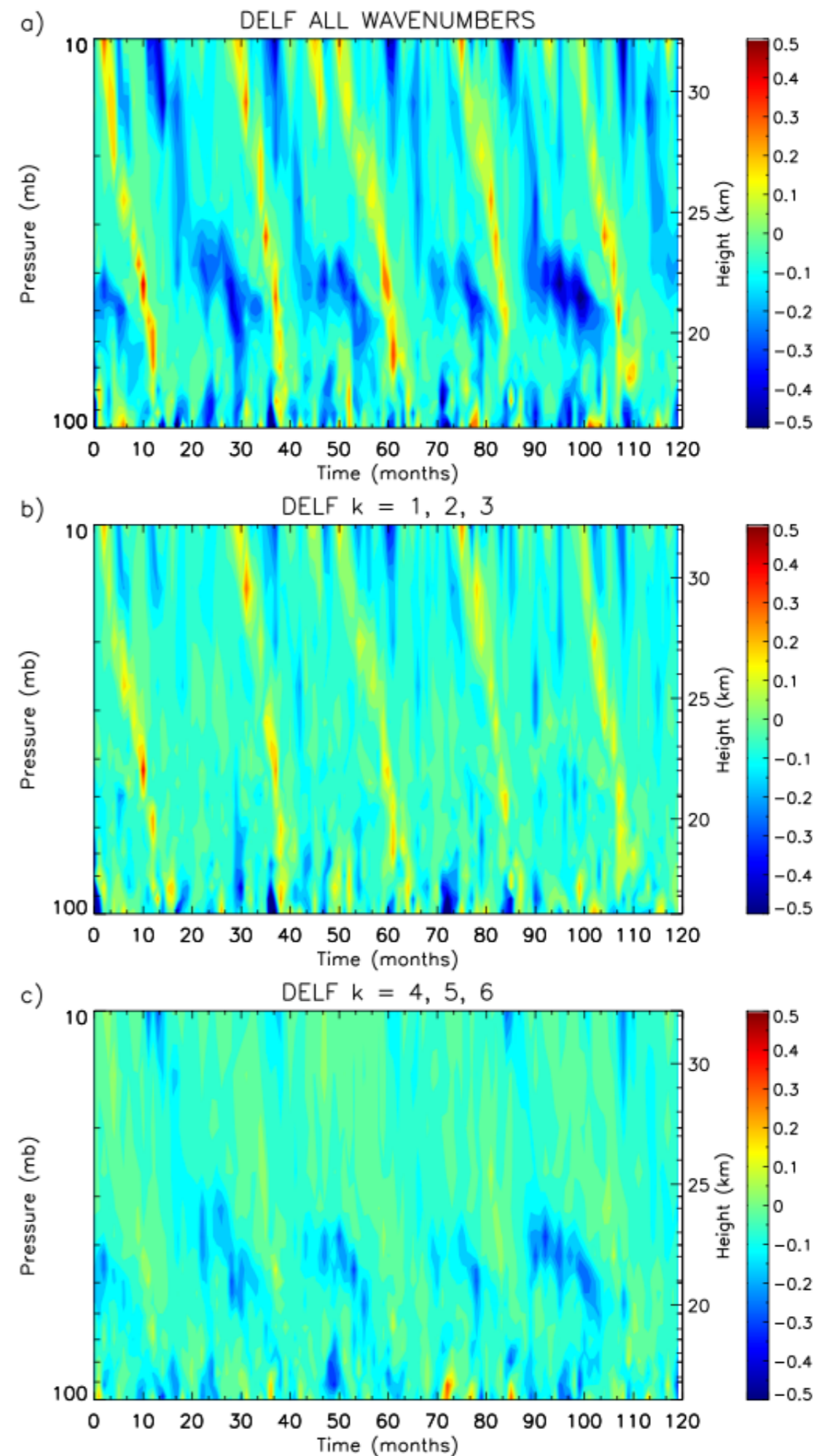


Momentum deposition at model top (Shaw & Shepherd 2007)

EP Flux Components:

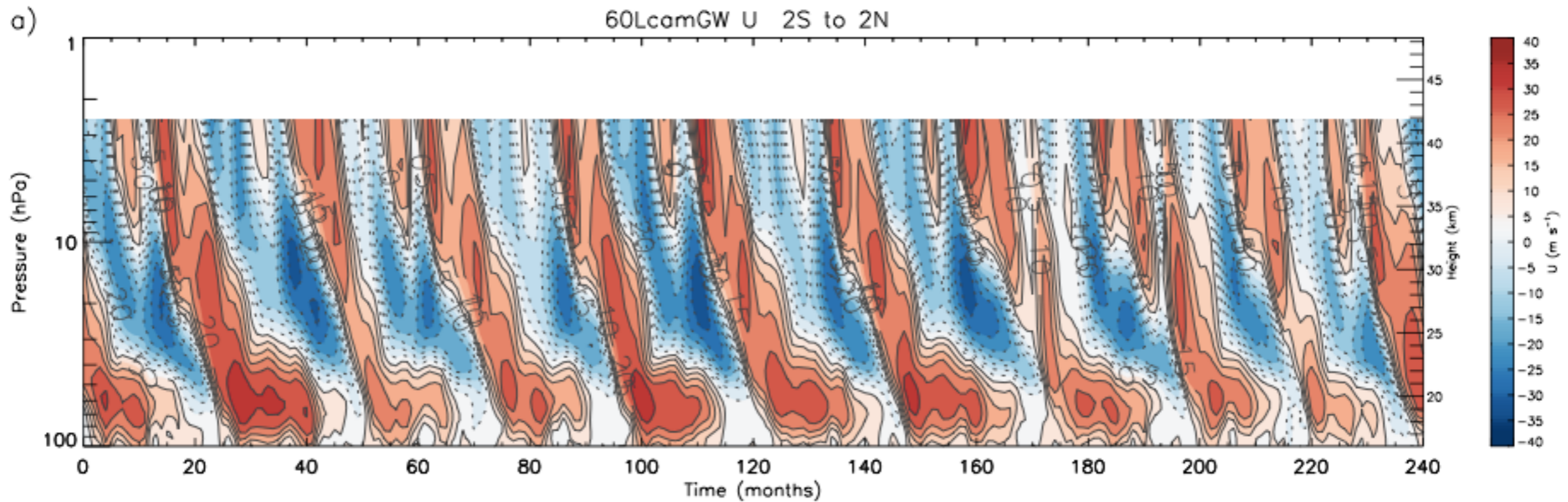
Kelvin Waves

Mixed-Rossby GWs

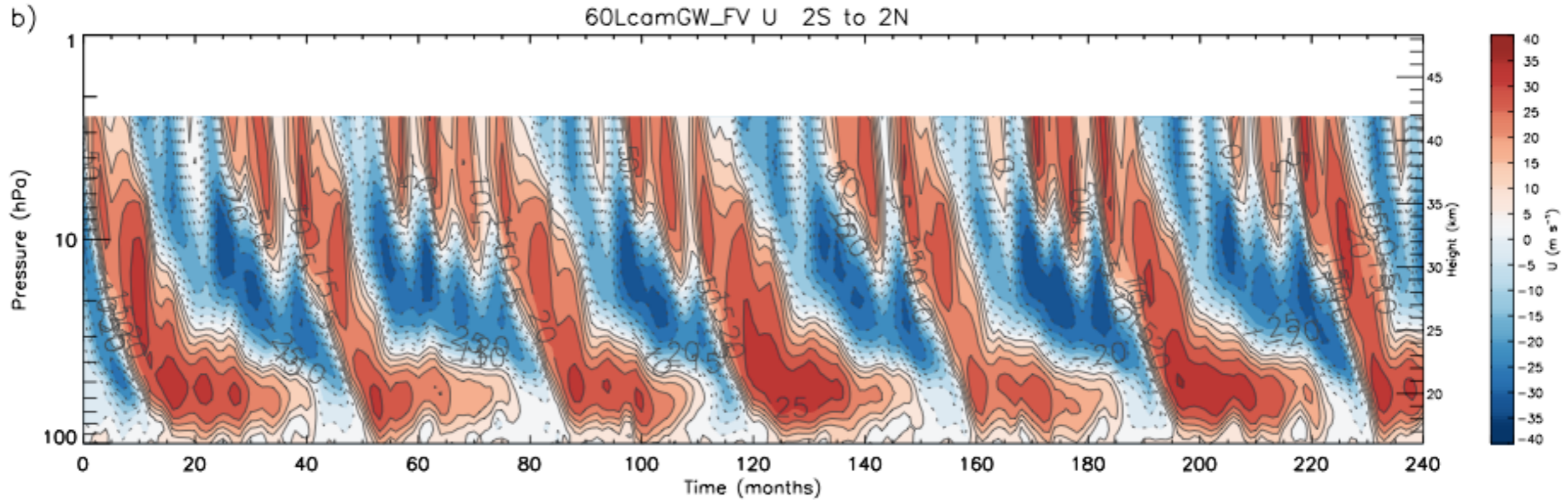


Effects of Dynamical Core:

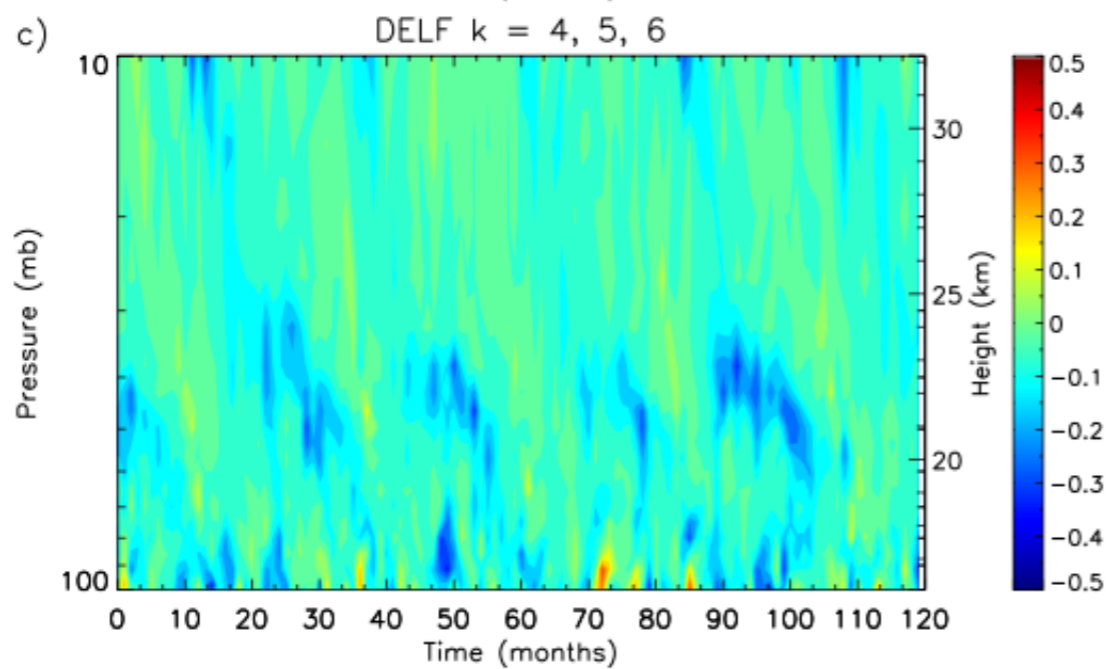
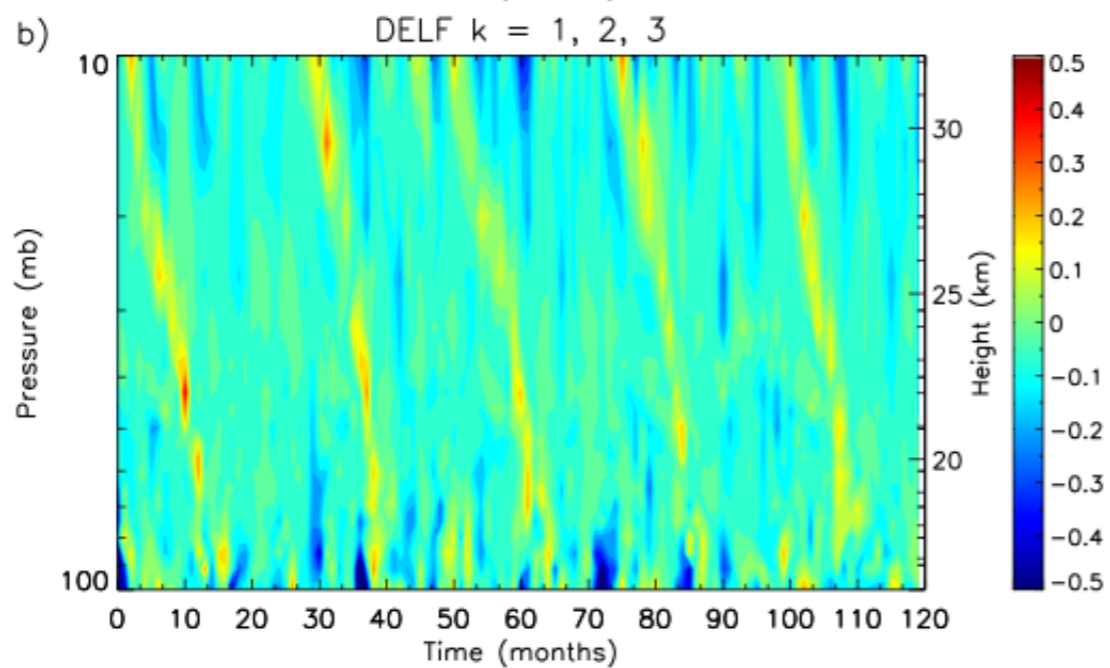
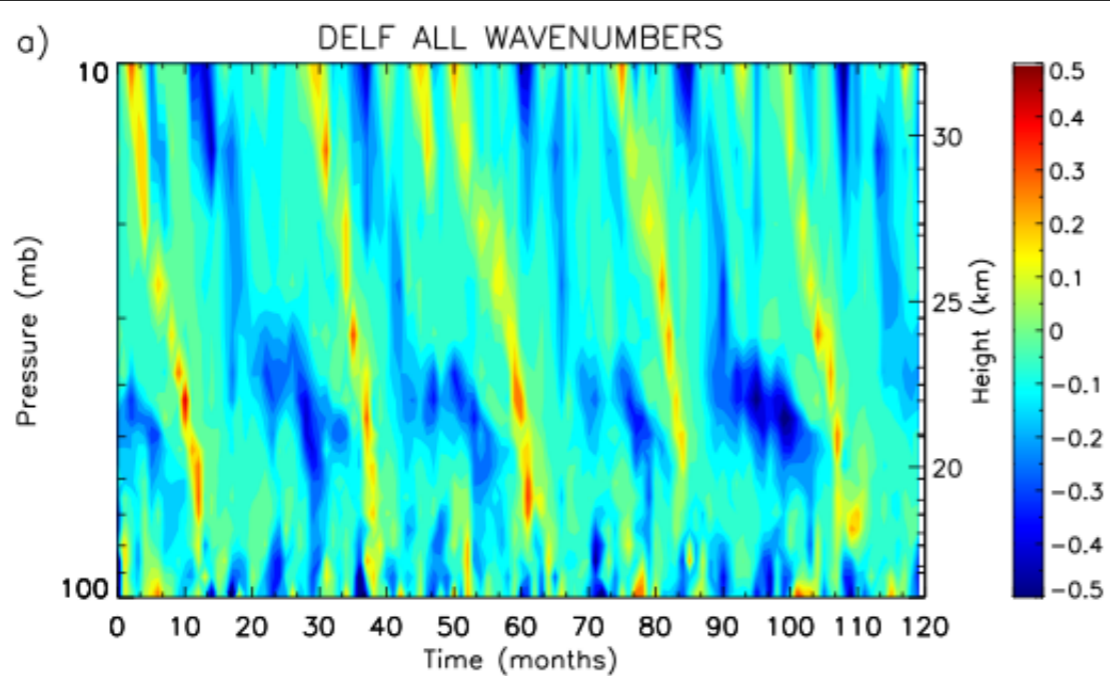
SE



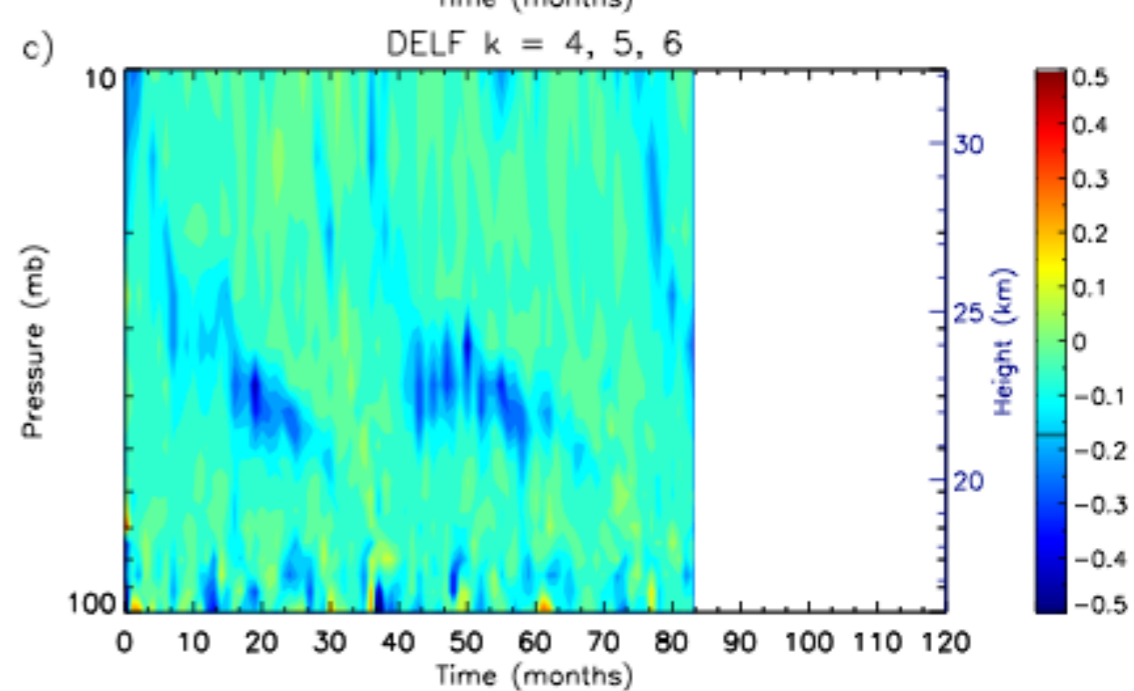
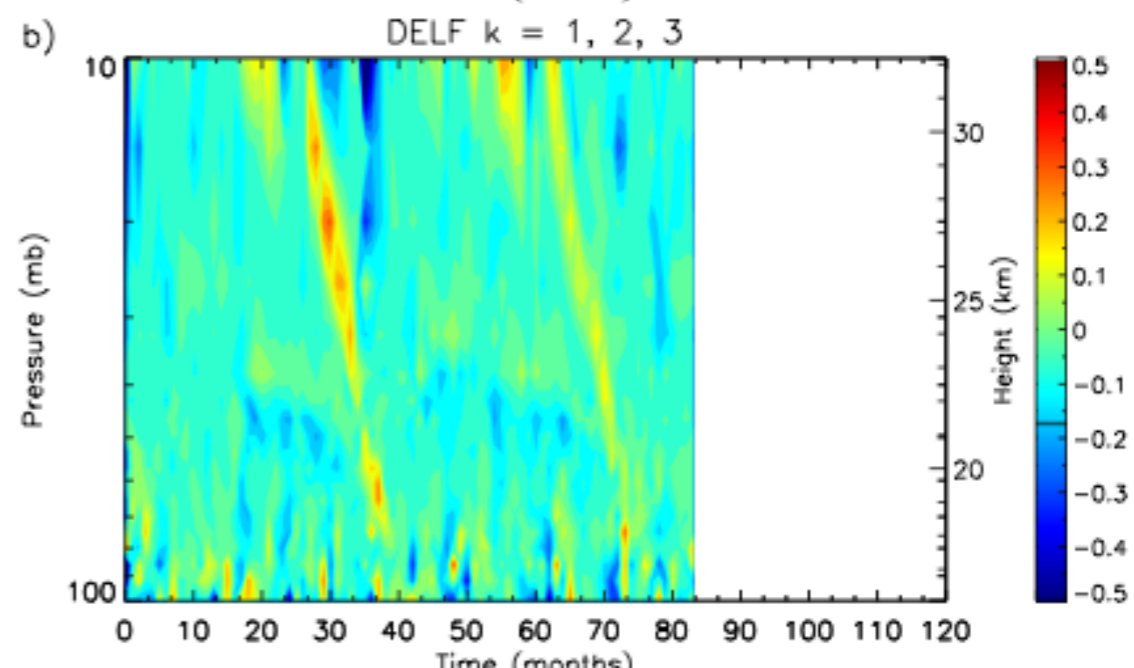
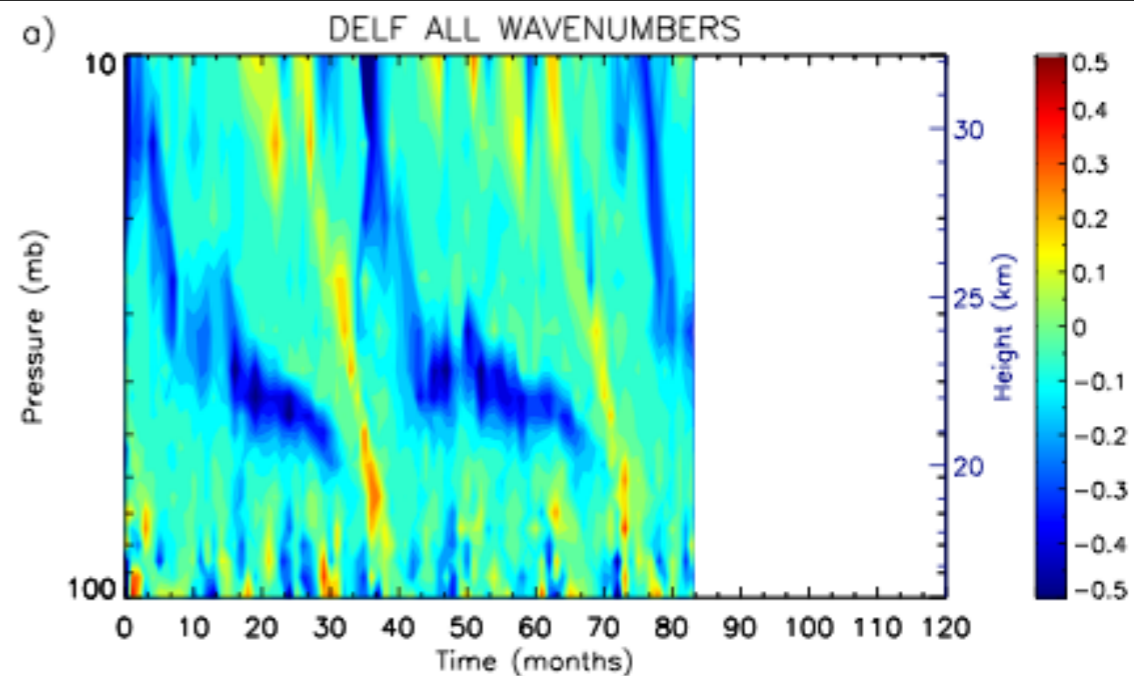
FV



SE



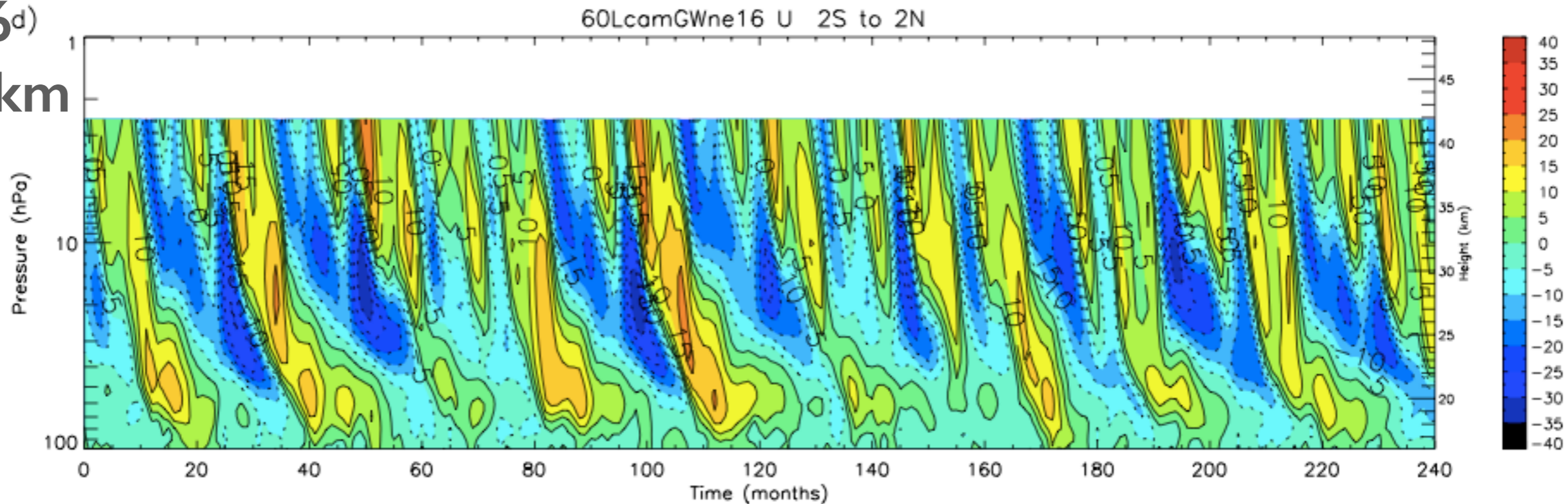
FV



Effects of Horizontal Resolution:

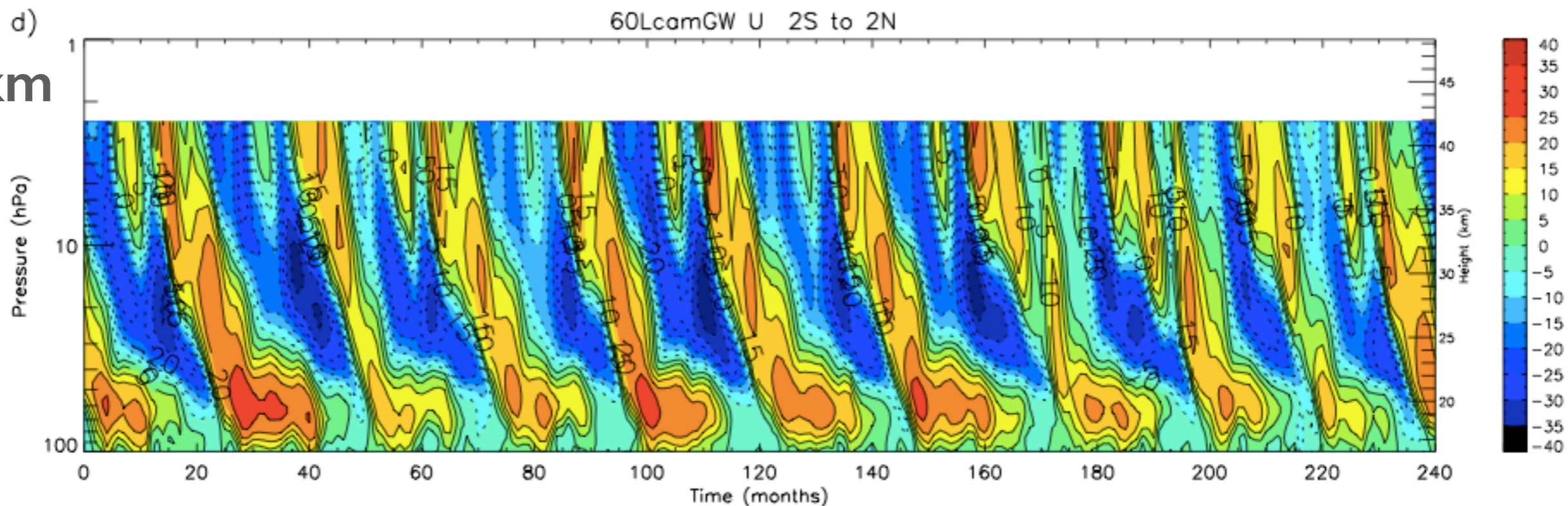
ne16_d)

~ 200 km

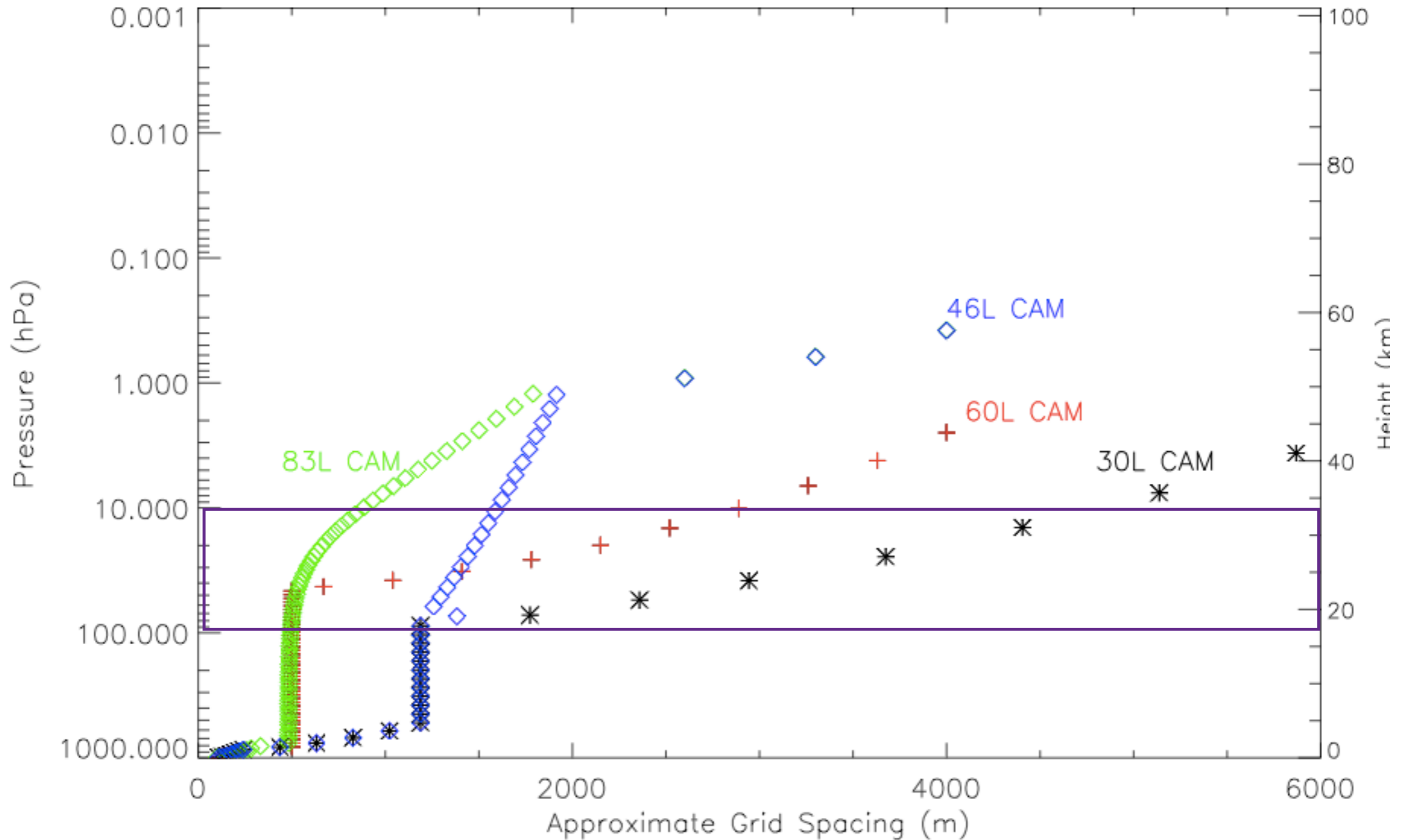


ne30_d)

~ 100 km

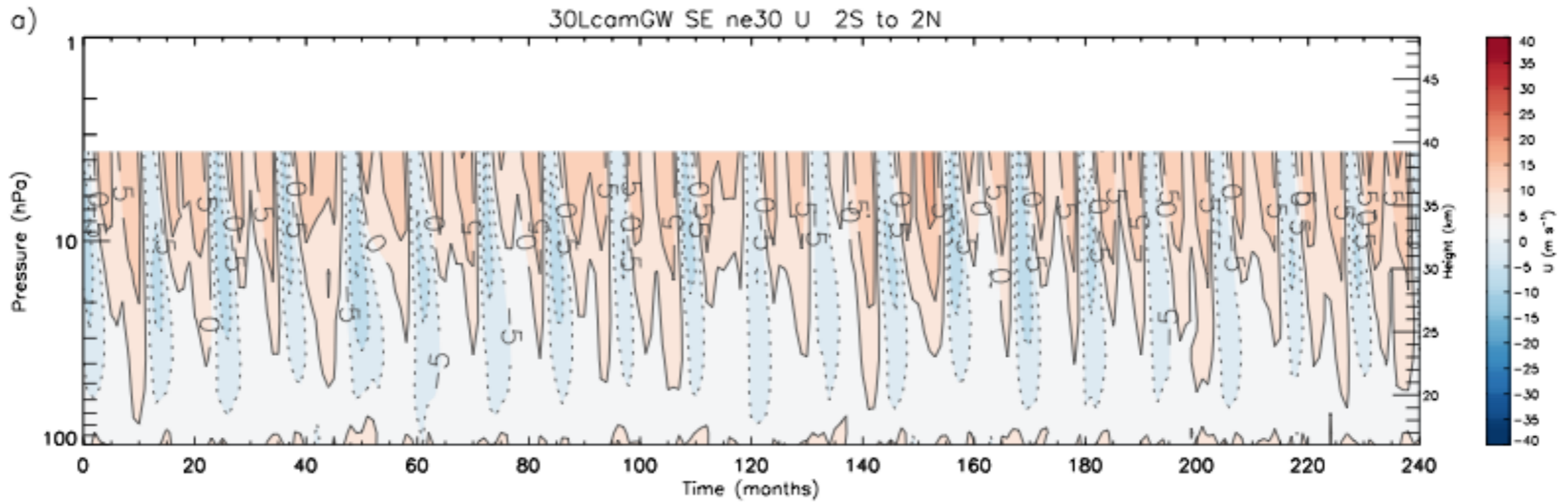


Effects of Increased Model Top:

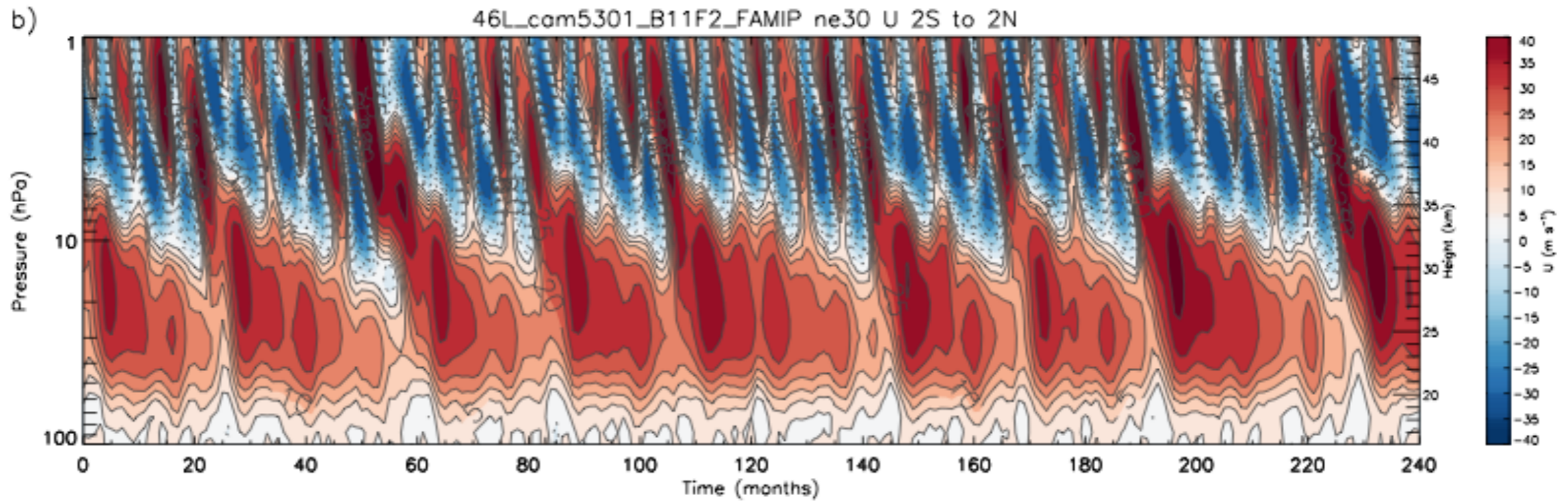


Increased Model Top - Low Res:

30L
GW



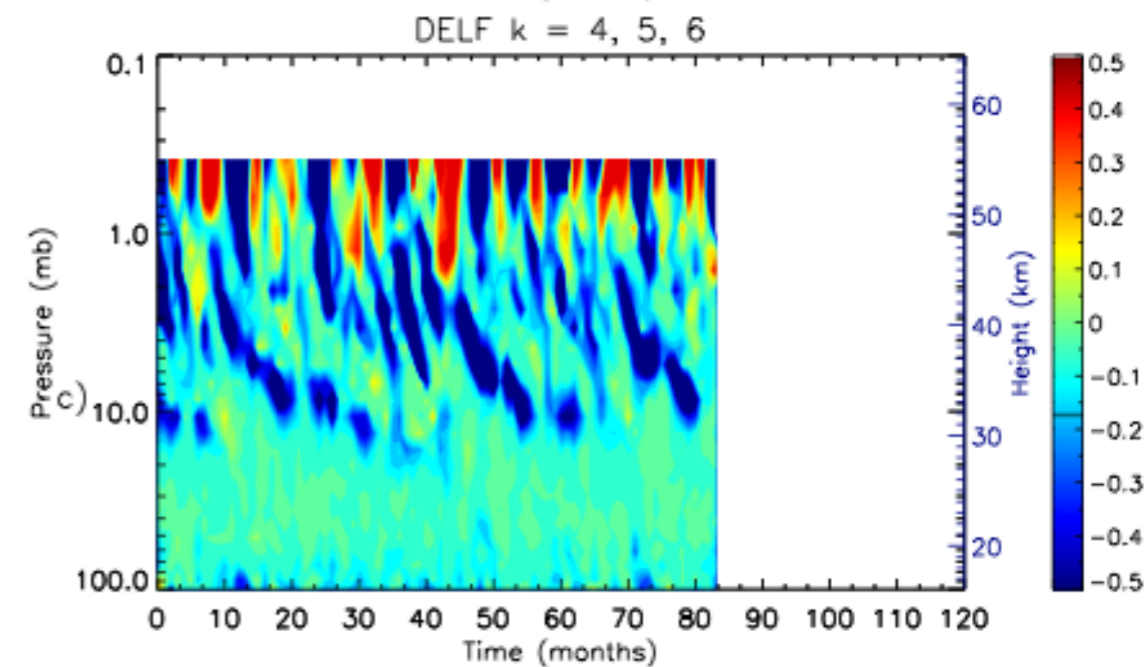
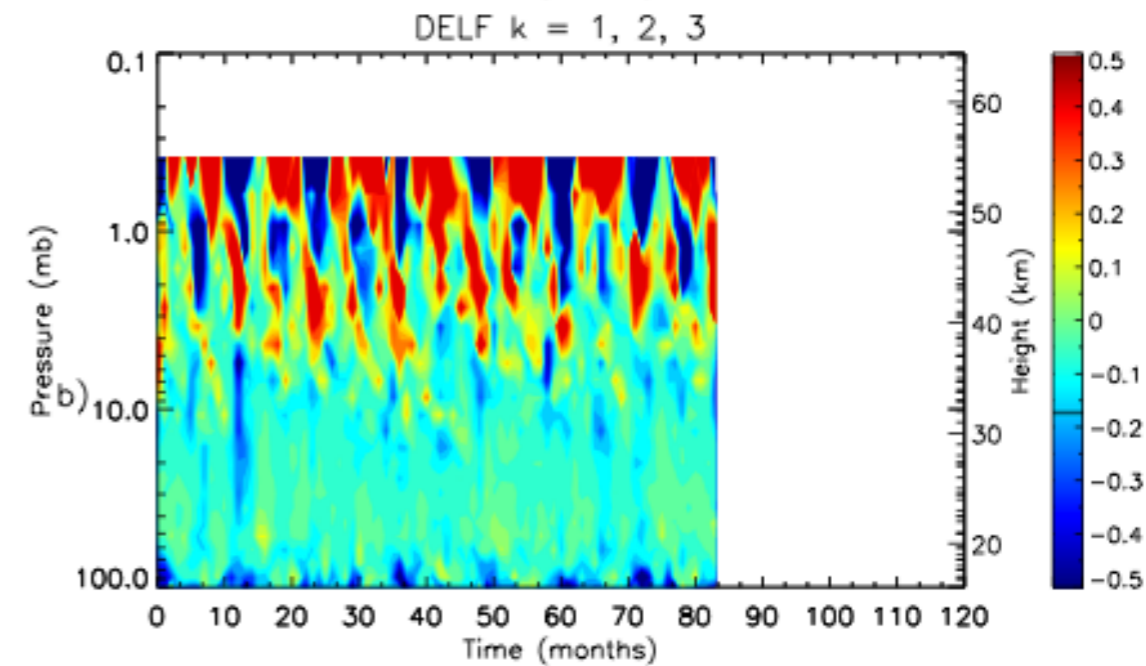
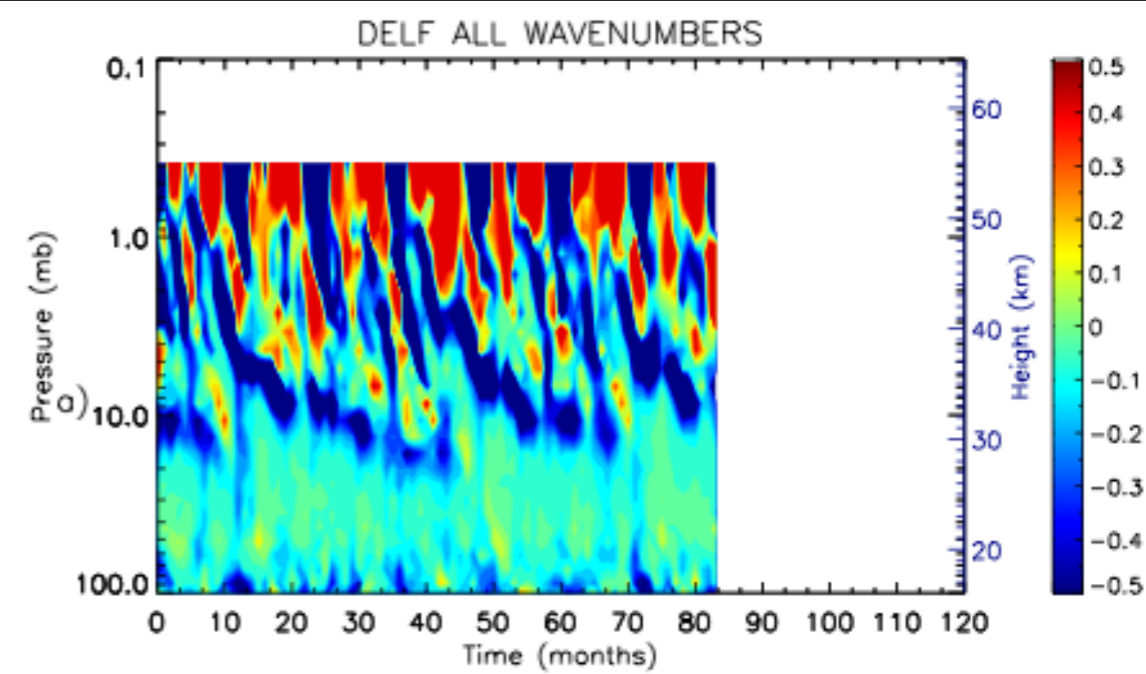
46L
GW



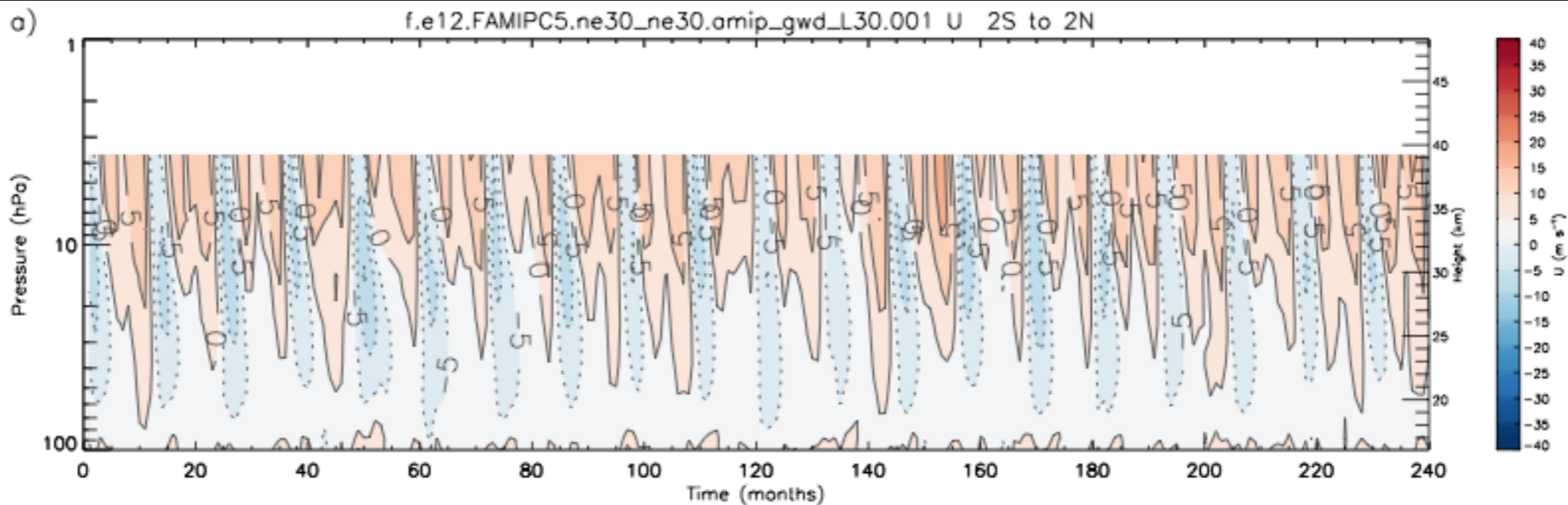
EP Flux Components:

Kelvin Waves

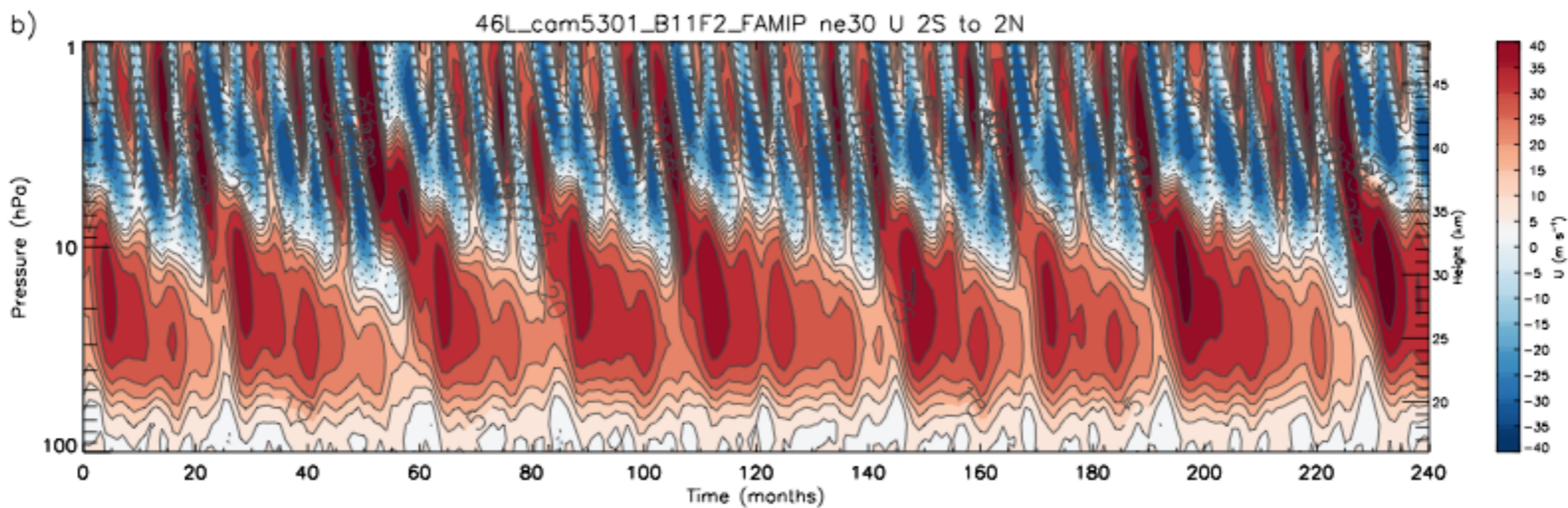
Mixed-Rossby GWs



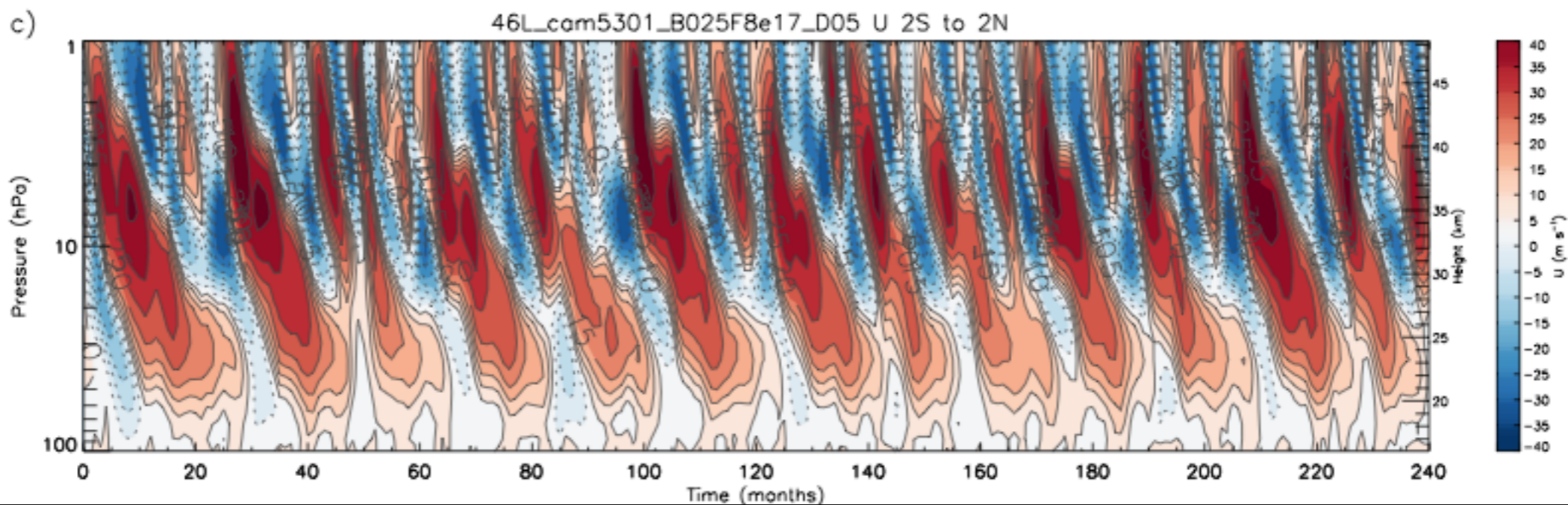
30Lgw



46Lgw



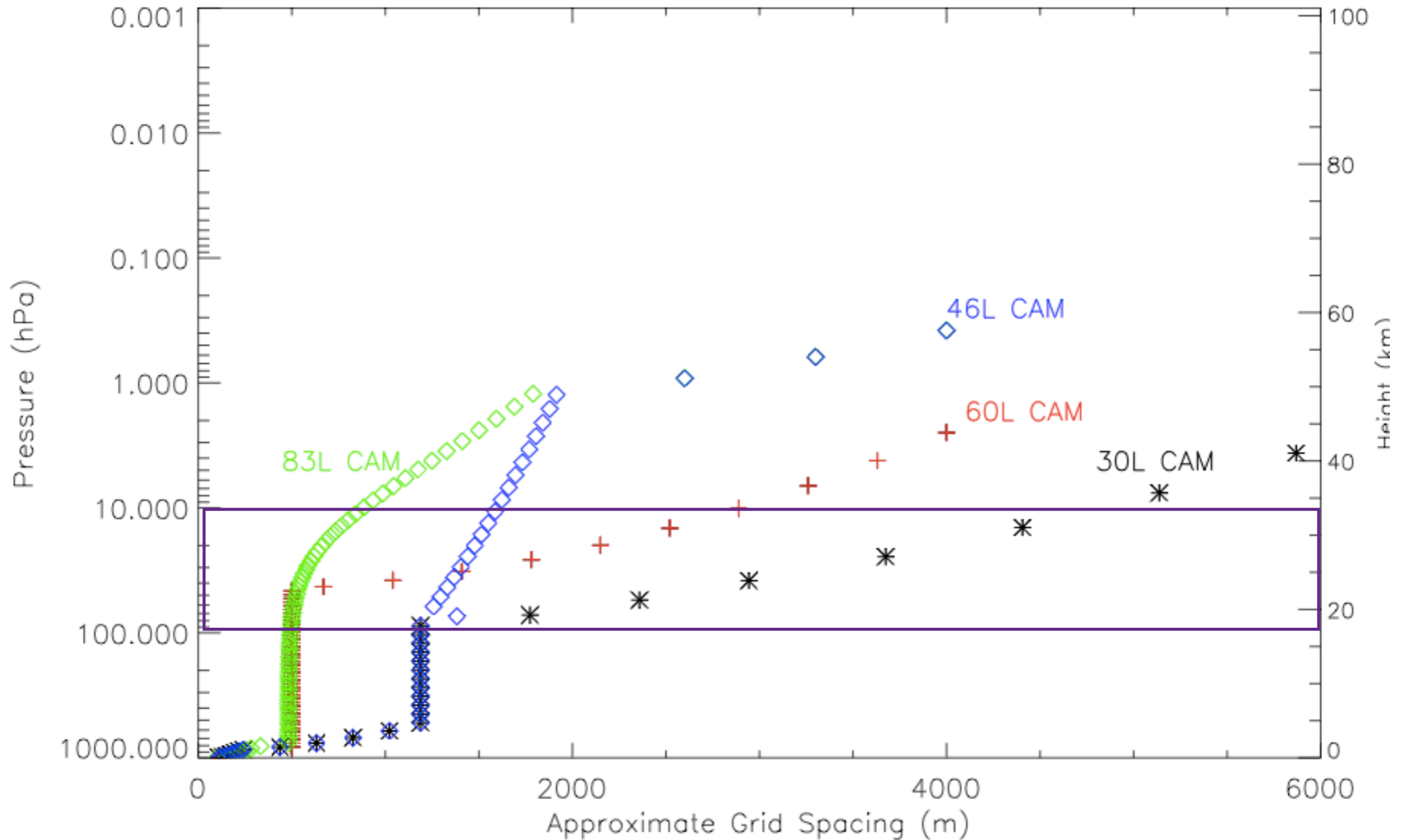
46LgwT



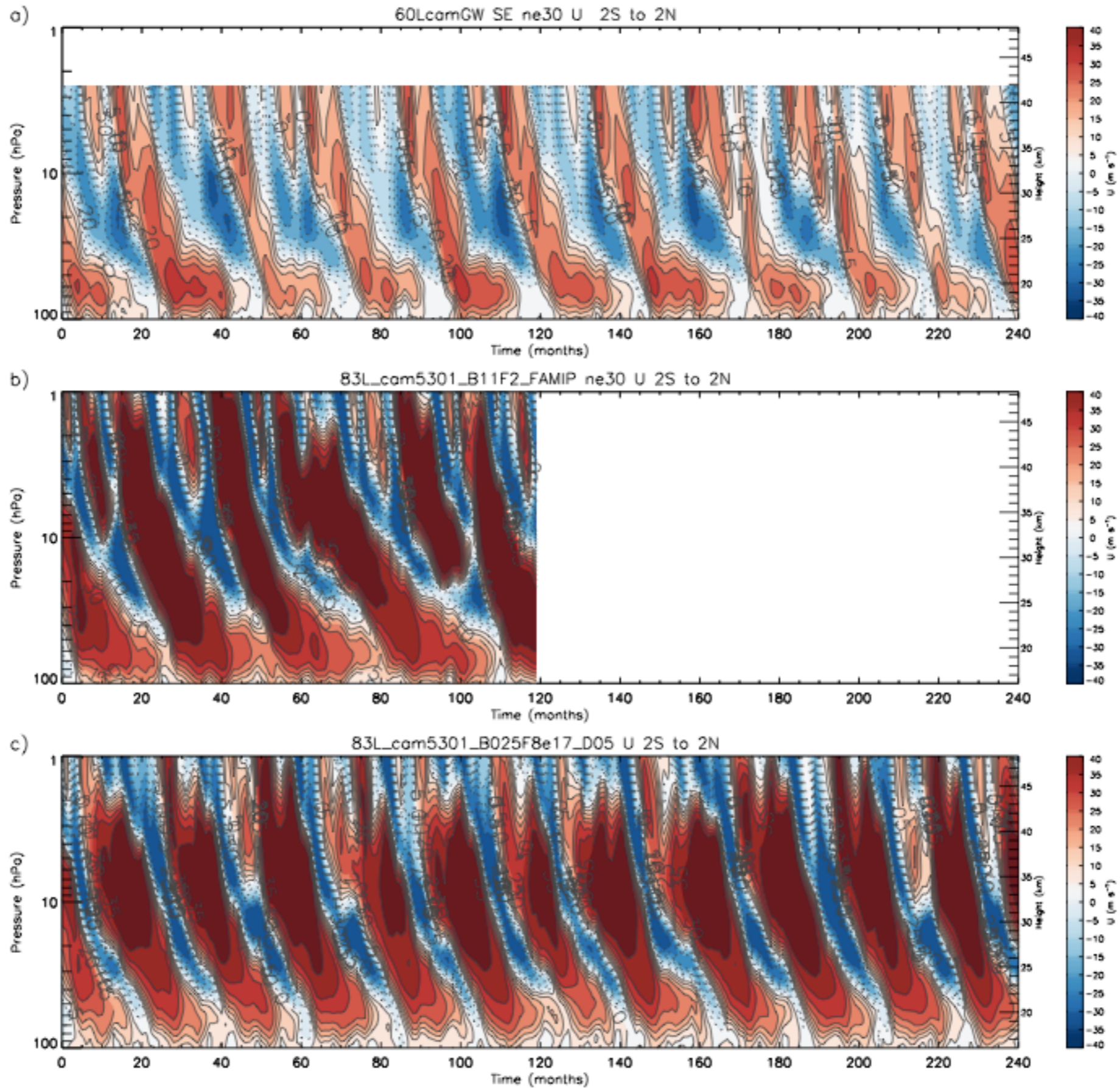
NCAR

ESSL's

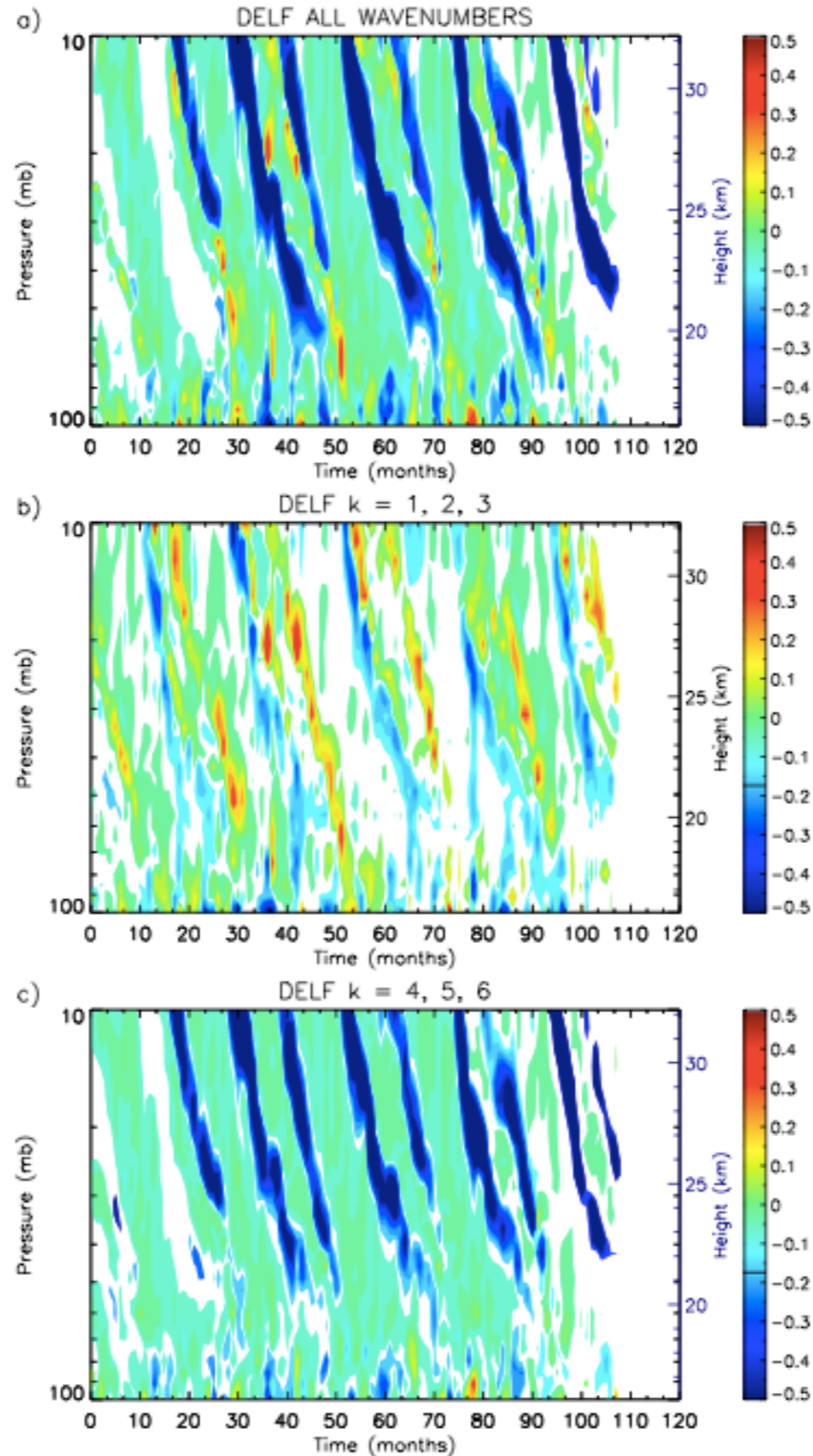
Effects of Increased Model Top:



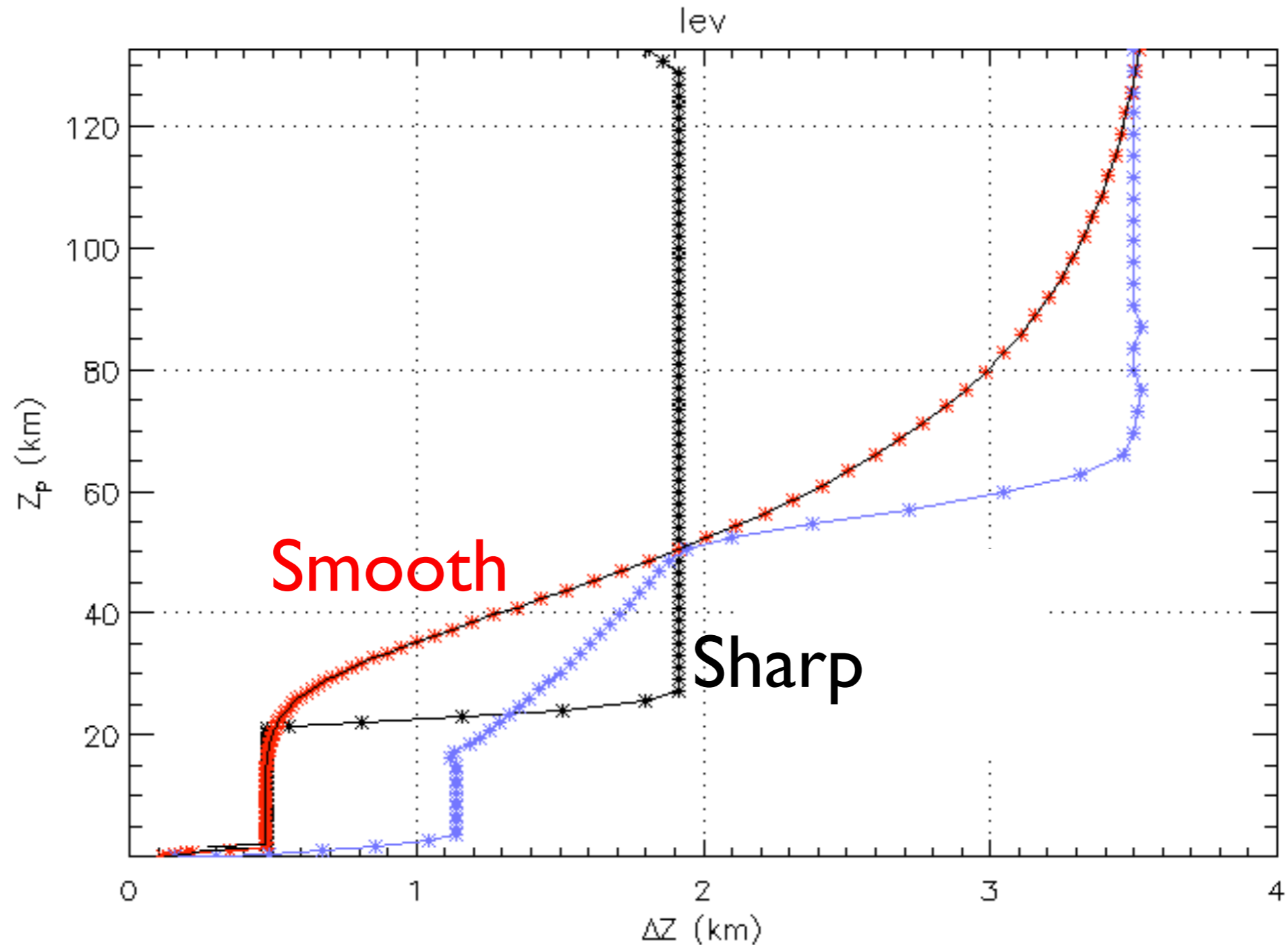
Increased Model Top - High Res:



Increased Model Top - High Res:

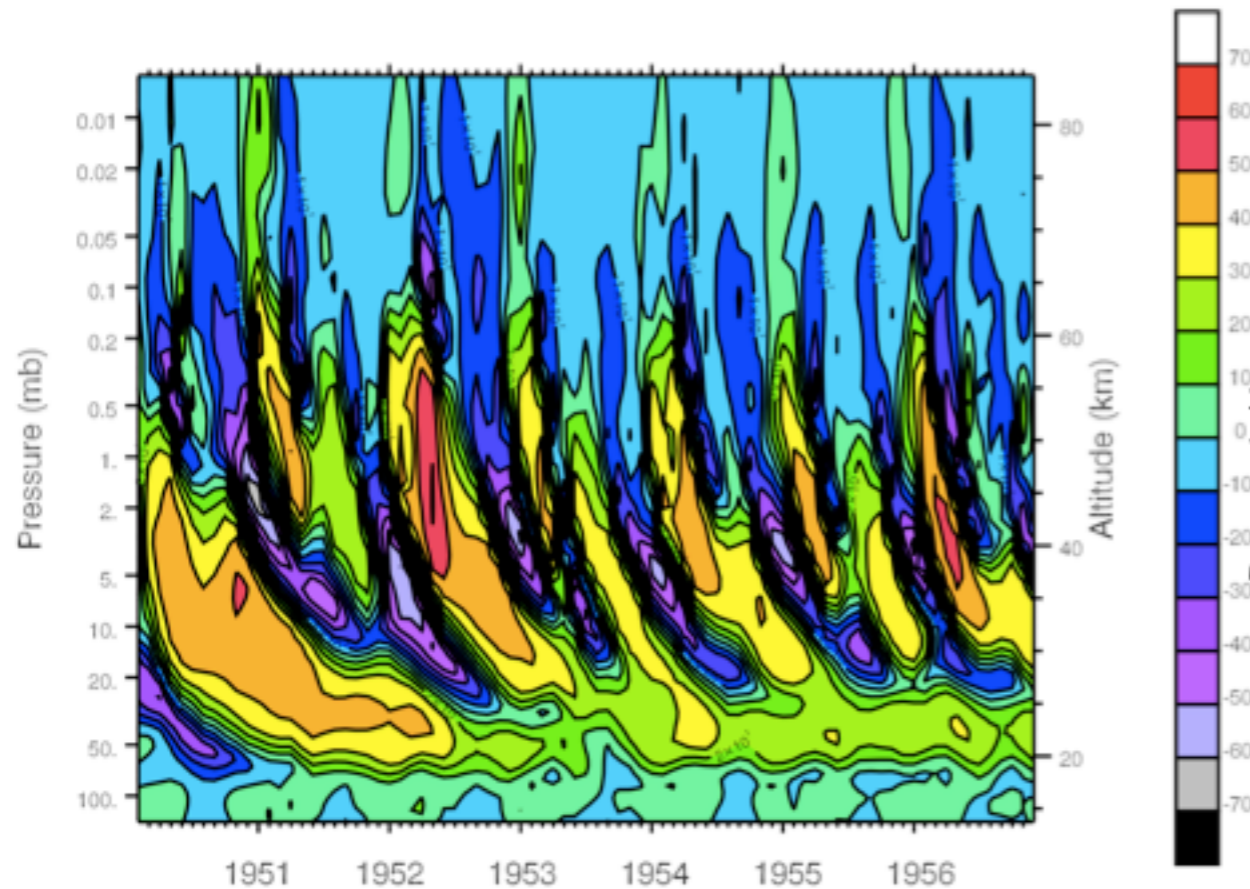


What about WACCM?

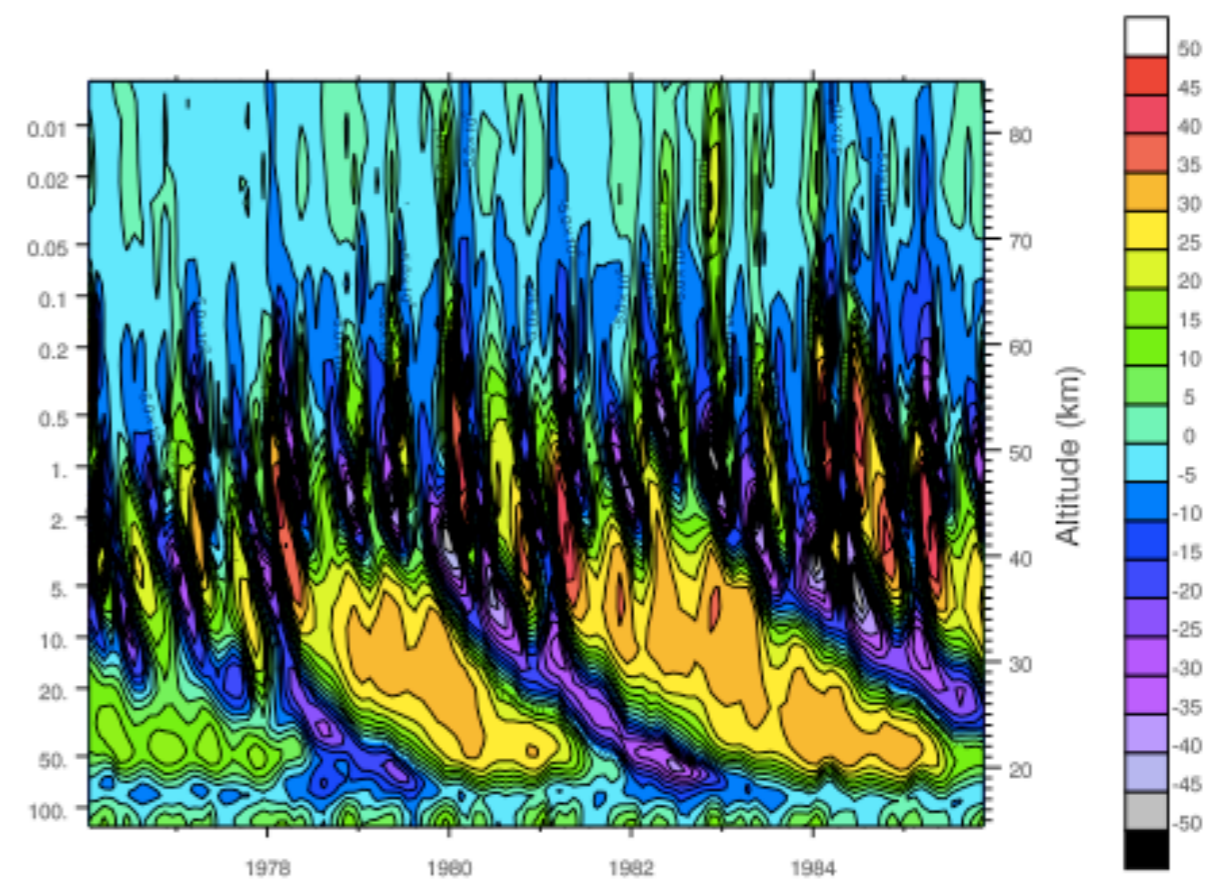


What about WACCM?

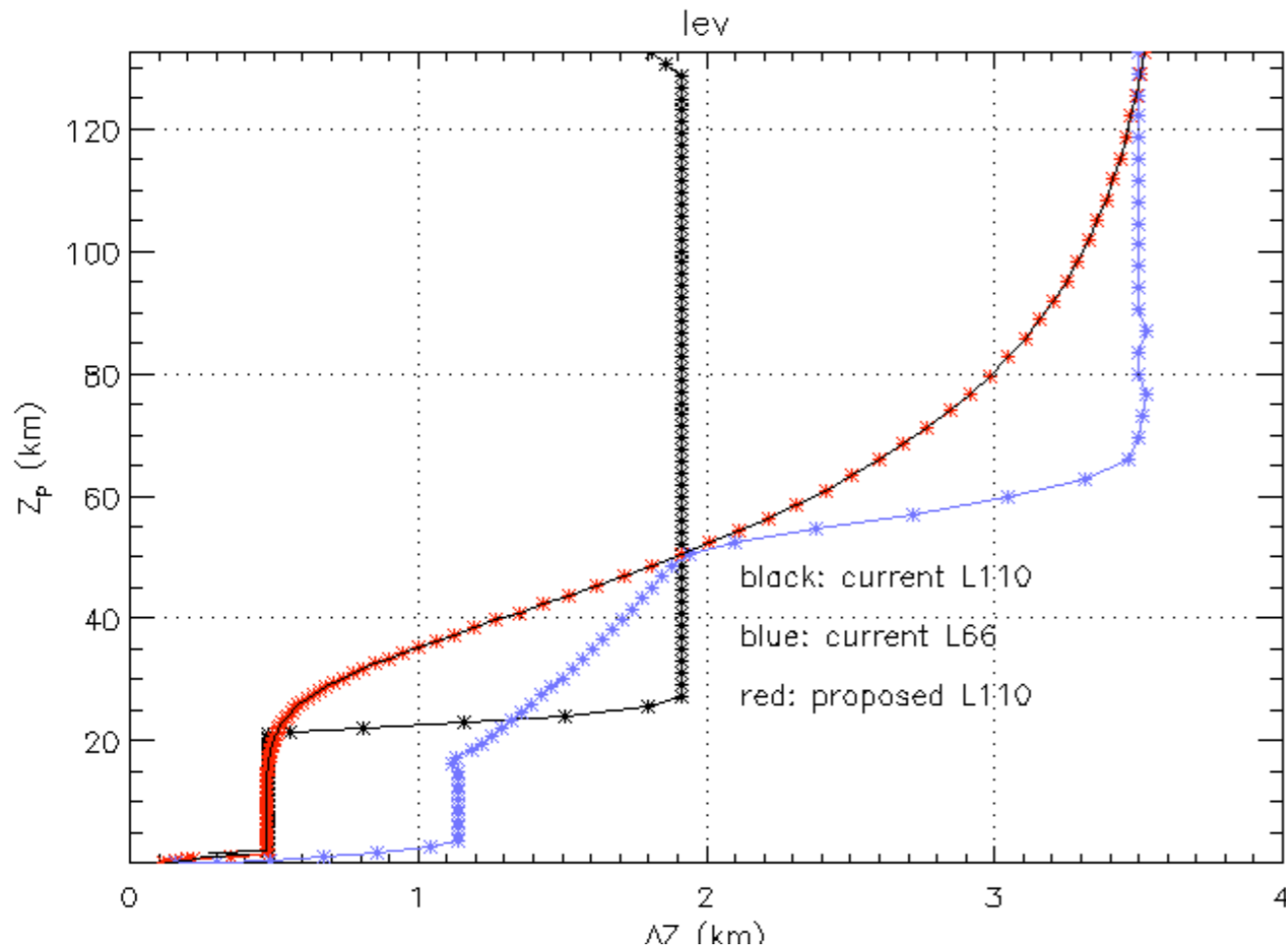
I I 0L Smooth Transition
Higher Strat Res



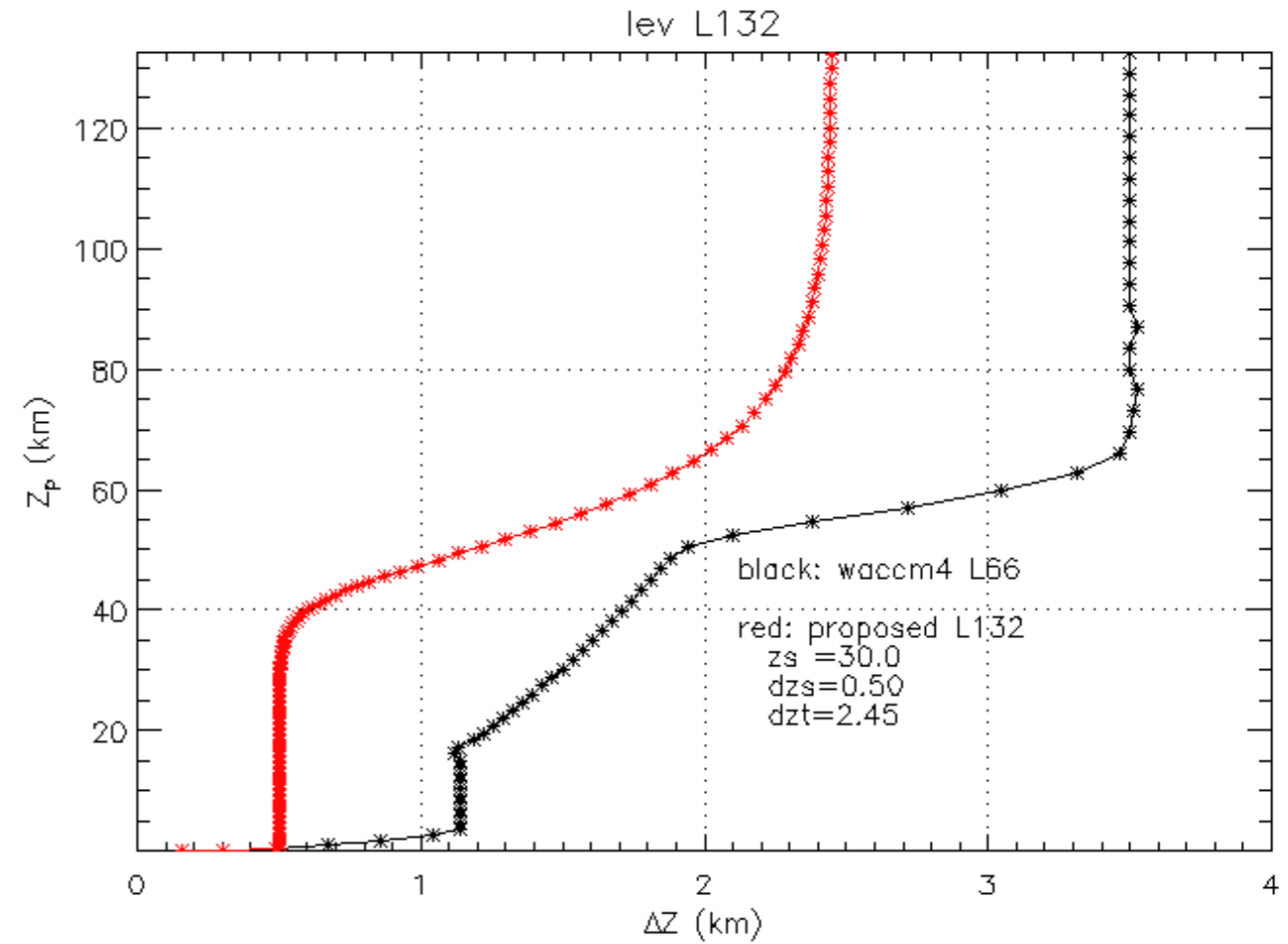
I I 0L Sharp Transition
Lower Strat Res



What about WACCM?



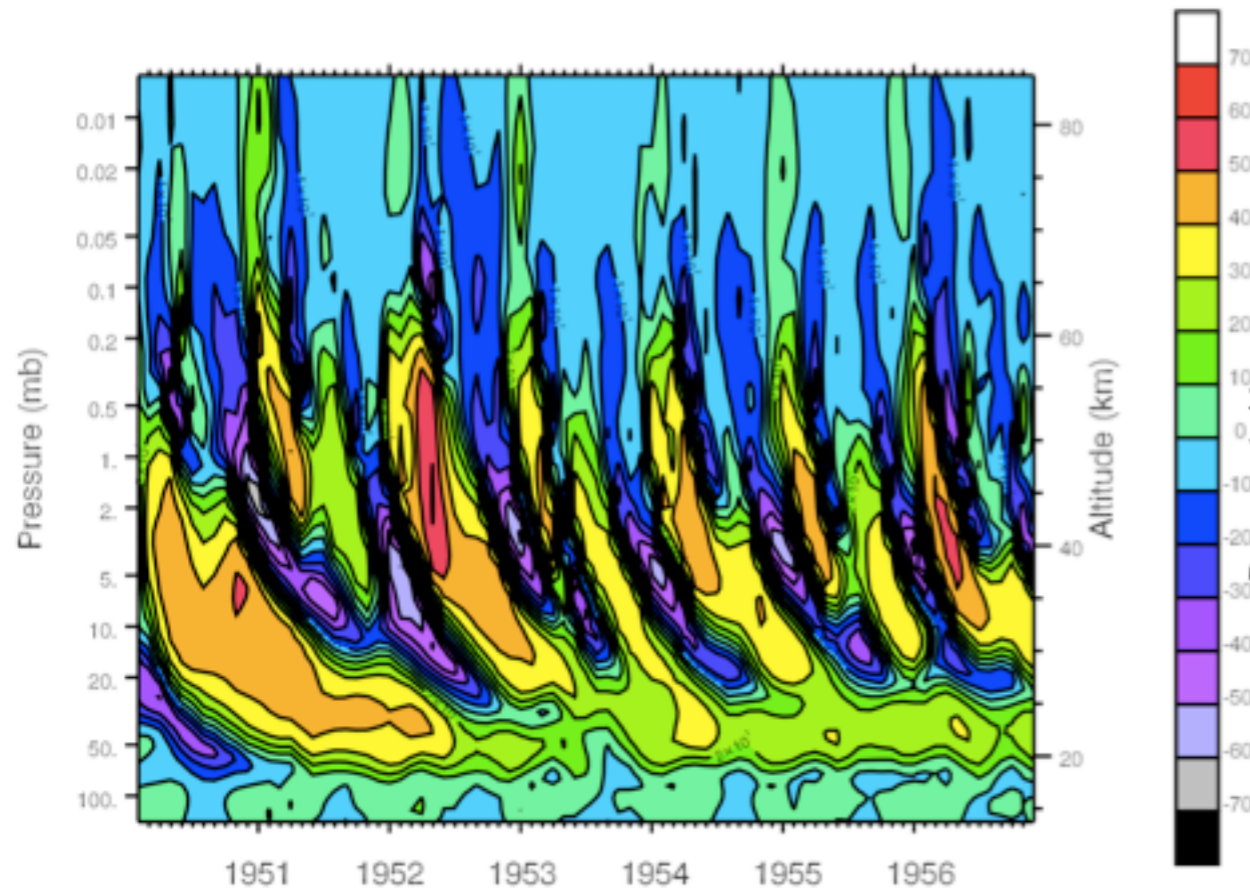
110 Level



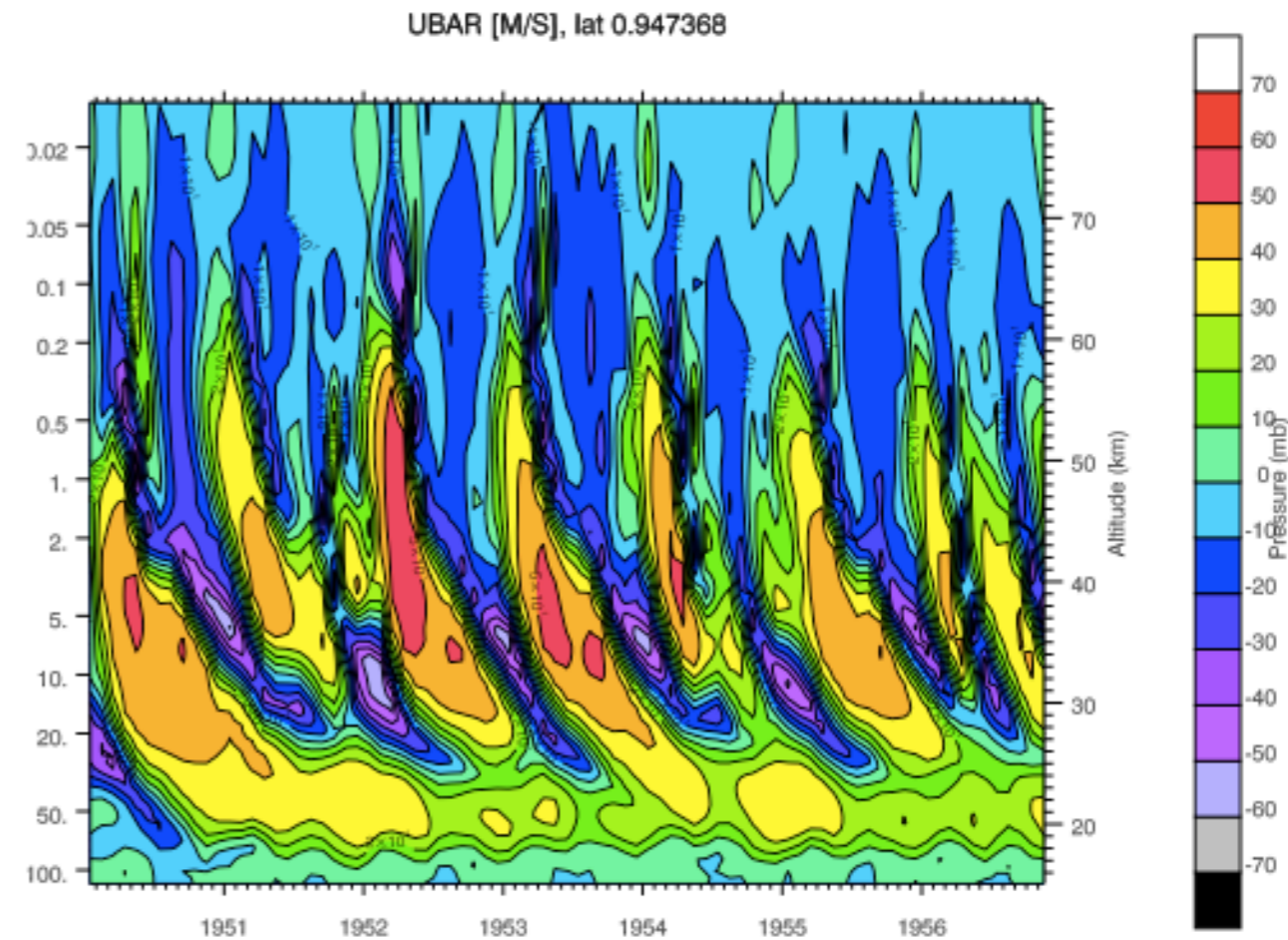
132 Level

What about WACCM?

I 10L



I 32L



Conclusions:

- Vertical resolution is very important to simulating the QBO
- Even small changes in vertical resolution change the nature of the QBO
- Mixed-Rossby gravity waves deposit more momentum in the stratosphere when vertical resolution is increased
- Choice of model lid and way of GW momentum deposition at the model top significantly affects the QBO

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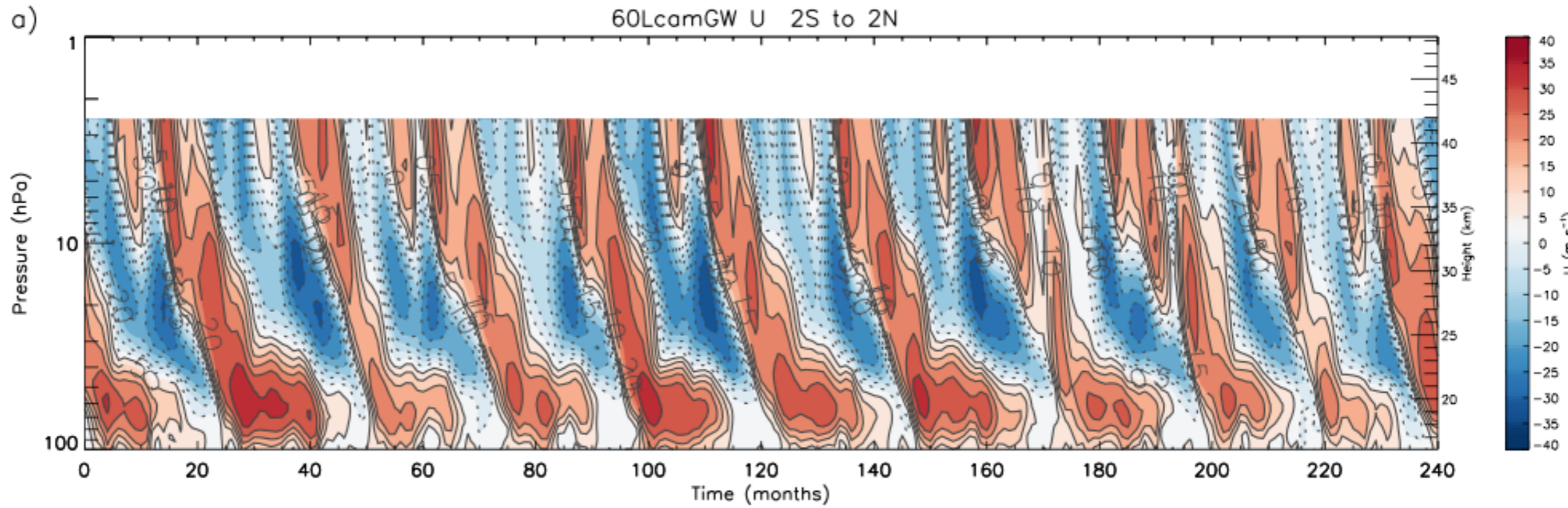
References:

- Richter, J. H., A. Solomon and J. Bacmeister 2014: “*On the Simulation of the Quasi-Biennial Oscillation in the Community Atmosphere Model, Version 5*”, JGR, DOI: 10.1002/2013JD021122
- Richter, J. H., A. Solomon and J. Bacmeister 2014: “*Effects of Vertical Resolution and Non-Orographic Gravity Wave Drag On the Simulated Climate in the Community Atmosphere Model, Version 5*”, JAMES, DOI: 10.1002/2013MS000303

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Effects of tau at model top:

tau=0



tau ≠ 0

