Source oriented GW parameterization in WACCM3

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Community Climate System Model

WACCM
Whole Atmosphere Community Climate Model

"If there is a hell, I am sure gravity wave tuning will be one of the main activities there!"

Rolando R. Garcia

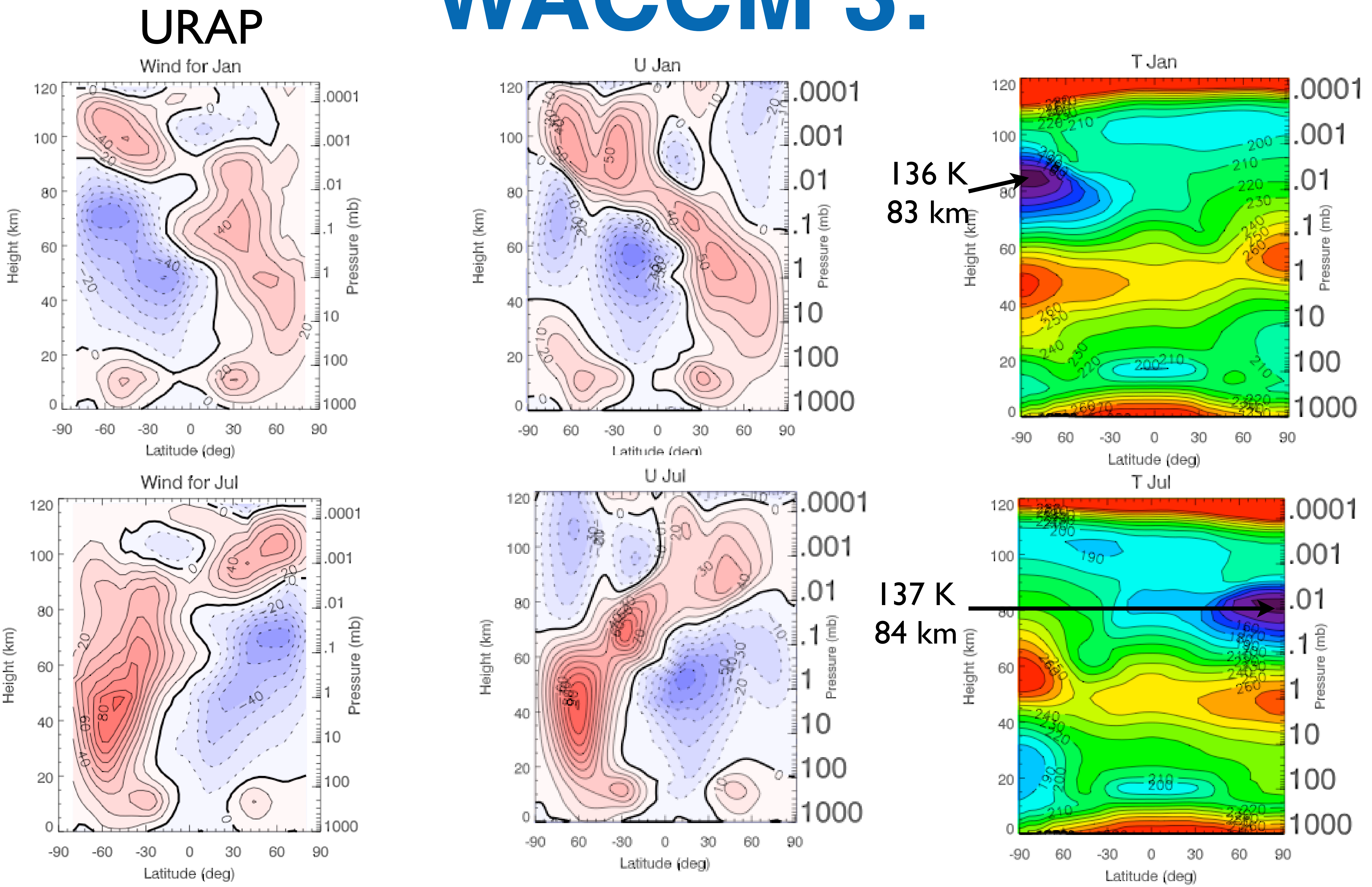
Introduction:

- Gravity waves with horizontal wavelengths 10 - 1000 km have to be parameterized in GCMs
- Typically, a GW parameterization assumes:
    - Spatially uniform GW source
    - Temporally uniform GW source
    - Same GW properties regardless of background conditions or location
    - Arbitrarily prescribed momentum flux phase speed spectrum

WACCM 3:

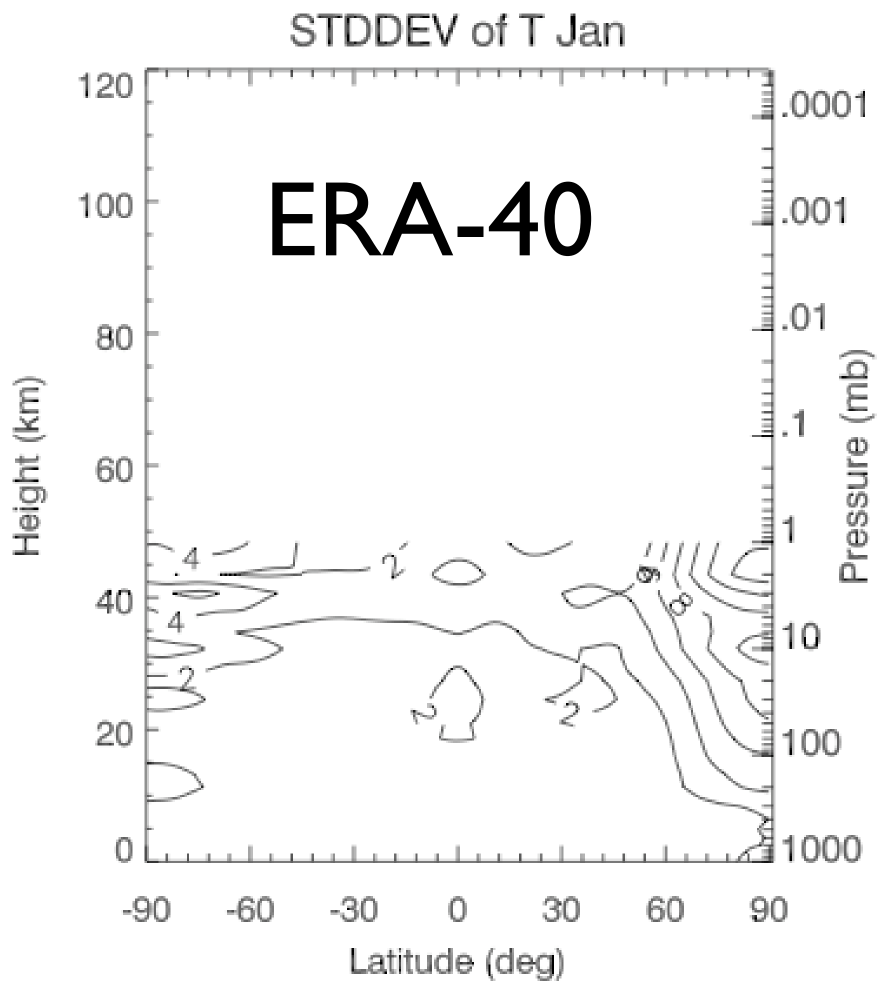
- McFarlane (1987) orographic GW parameterization
- Lindzen (1981) GW propagation parameterization
- Sassi, Boville, and Garcia GW source spectrum:
  - wave amplitude: taubgnd = 7.0 x 10-3 Pa efficiency: 0.125
  - momentum flux distribution: Gaussian in phase speed with width of 30 m/s (centered on source level wind)
  - Tuned latitudinal cycle
  - Tuned seasonal cycle
  - Launching height: 500 mb

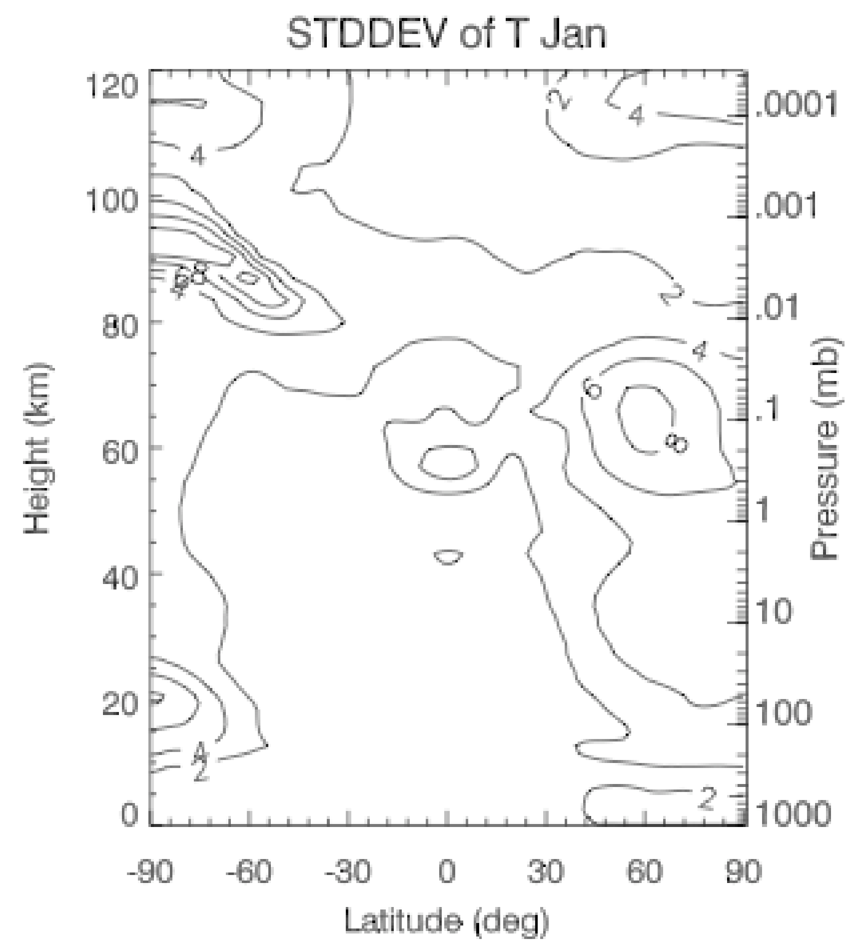
WACCM 3:



URAP
Wind for Jan
Wind for Jul
U Jan
U Jul
T Jan
T Jul
136 K
83 km
137 K
84 km
Height (km)
Pressure (mb)
Latitude (deg)

WACCM 3:





SSW Frequency

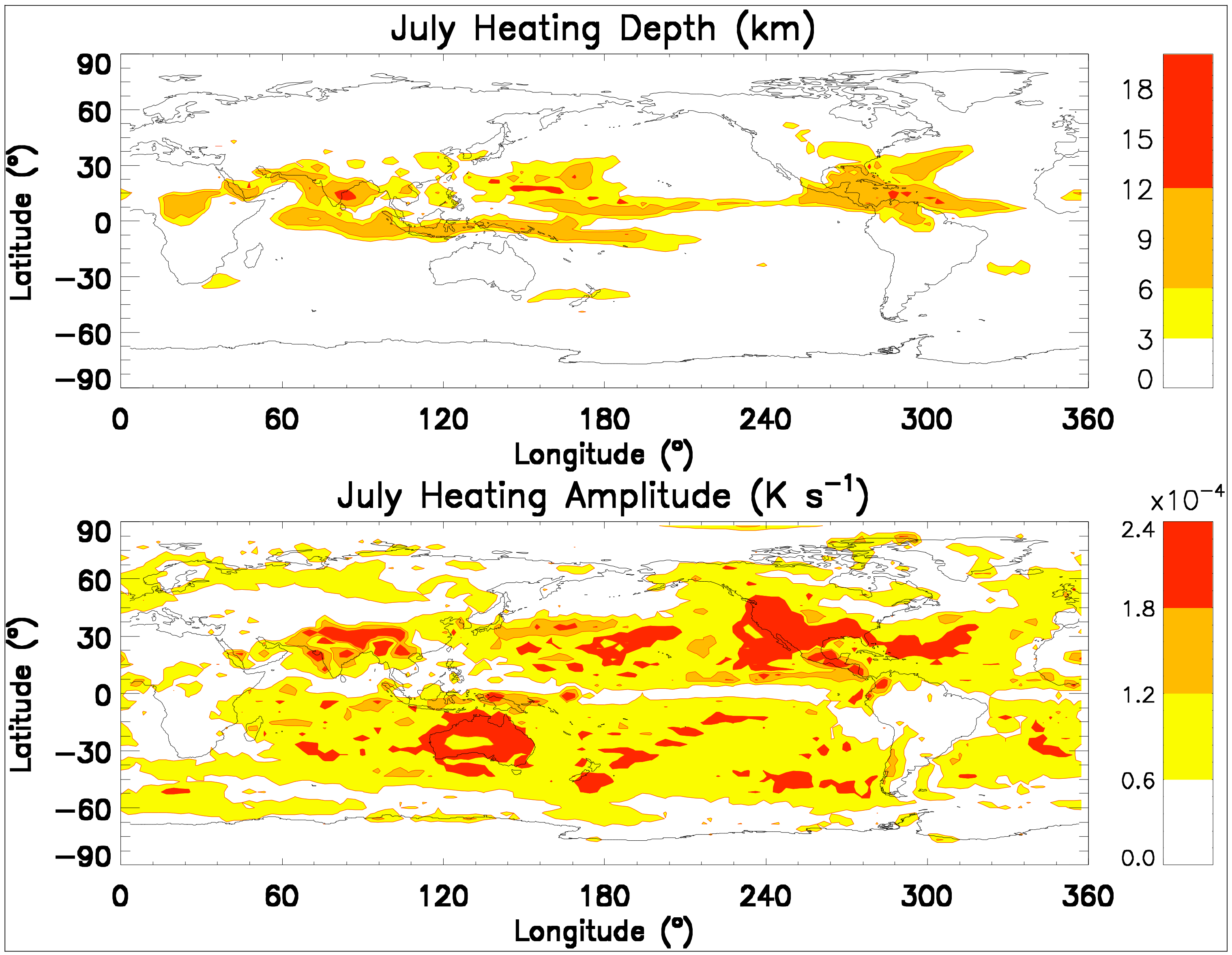
Nov - Feb:	**0.5**	**0.1**
Nov - Mar:	**0.6**	**0.1**

New GW parameterization

- Removed the arbitrary source spectrum
- Going towards a source oriented approach
- Including waves generated by:
  Orography: McFarlane (1987)
  Convection: Beres et al. (2005)
  Fronts: based on Charron and Manzini (2002)
- First attempt in a high-top GCM to go towards a source oriented GW specification

Beres et al. (2004)

- Based on linear theory and mesoscale modeling
- Builds on the Zhang and McFarlane (1995) convective paramterization

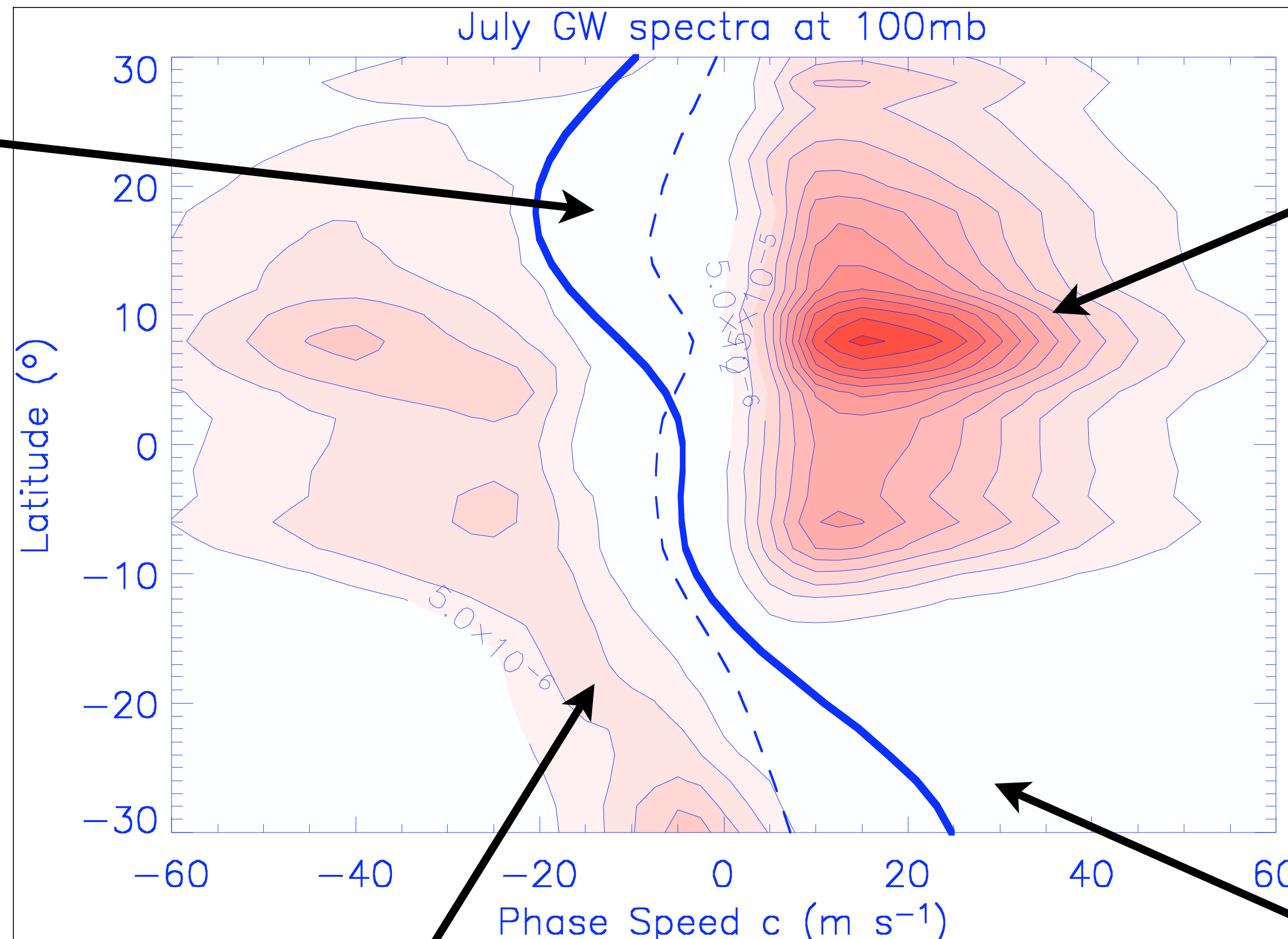


+ U → Determines Shape of Spectrum

→ Determines Wave Amplitudes

Beres et al. (2004)

Filtering by Tropospheric Wind



Broad Spectra due to DEEP convection

Filtering by Tropospheric Wind

Low phase speeds due to SHALLOW convection

Frontal GWs

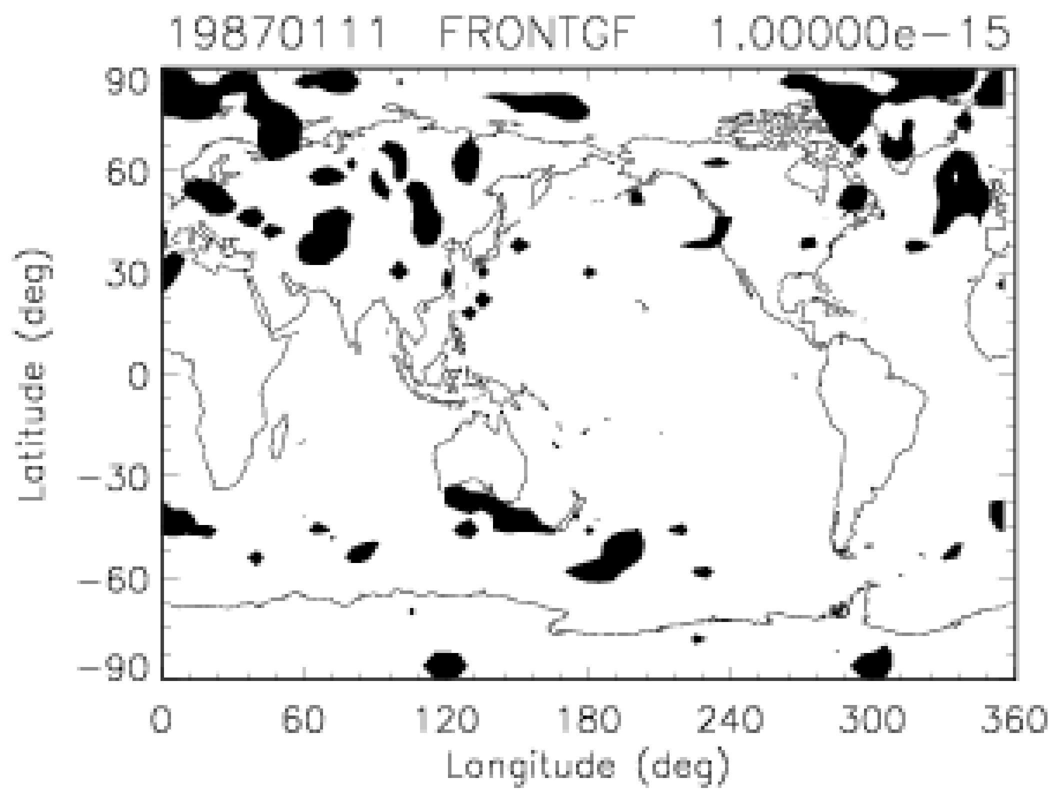
- The Frontogenesis function of Hoskins (1982) is used to determine wave triggering

$$\frac{1}{2}\frac{D|\nabla\theta|^2}{Dt} = F$$

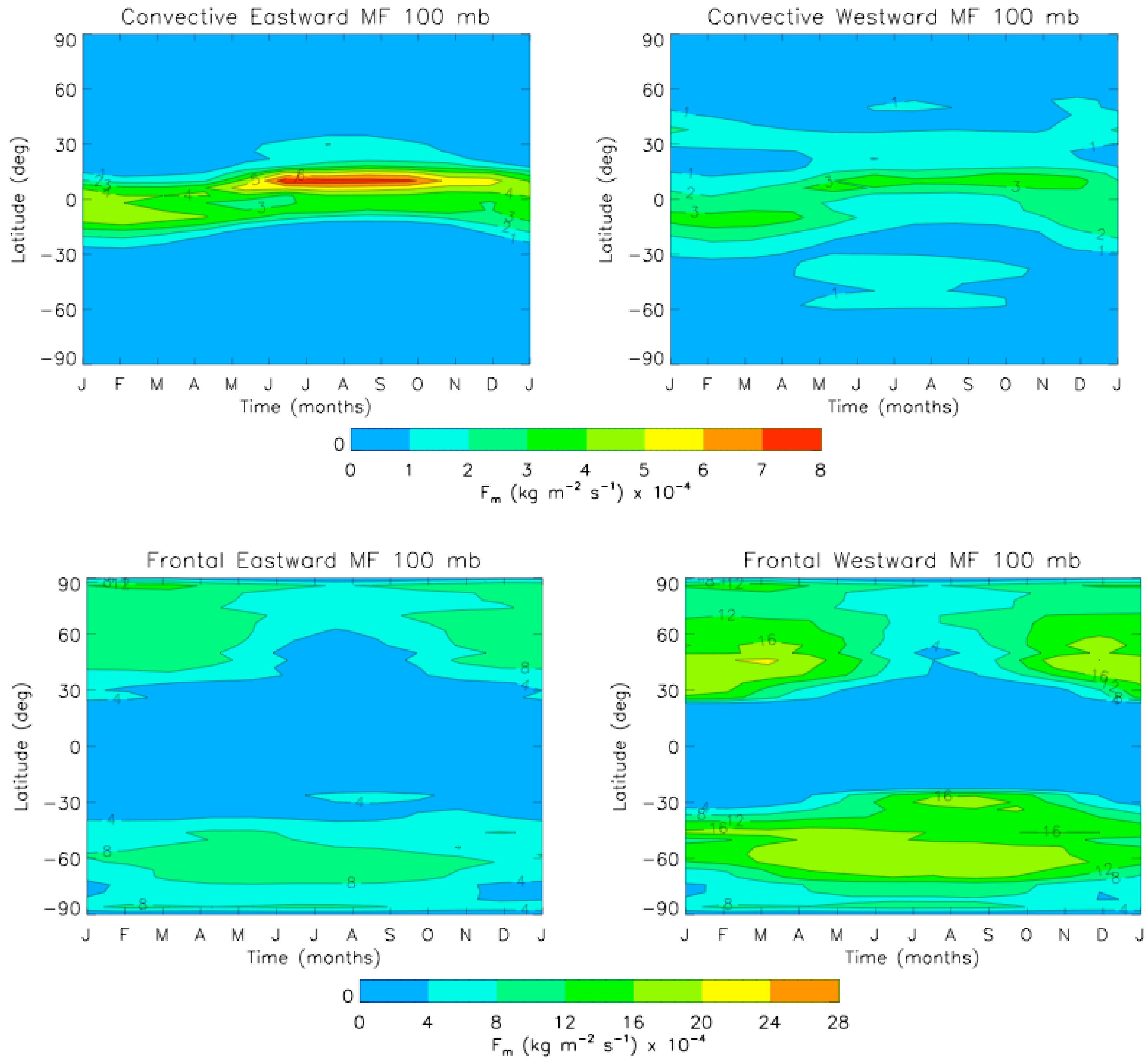
- When a critical threshold of 'F' is exceeded, GWs are launched
- Right now using F_critical = 0.75e-15
- Waves are launched at 600 mb - approximately frontal speed
- Waves are launched with fixed amplitude of 1.0x10-3 Pa
- Momentum flux phase speed spectrum is Gaussian

Frontal GWs

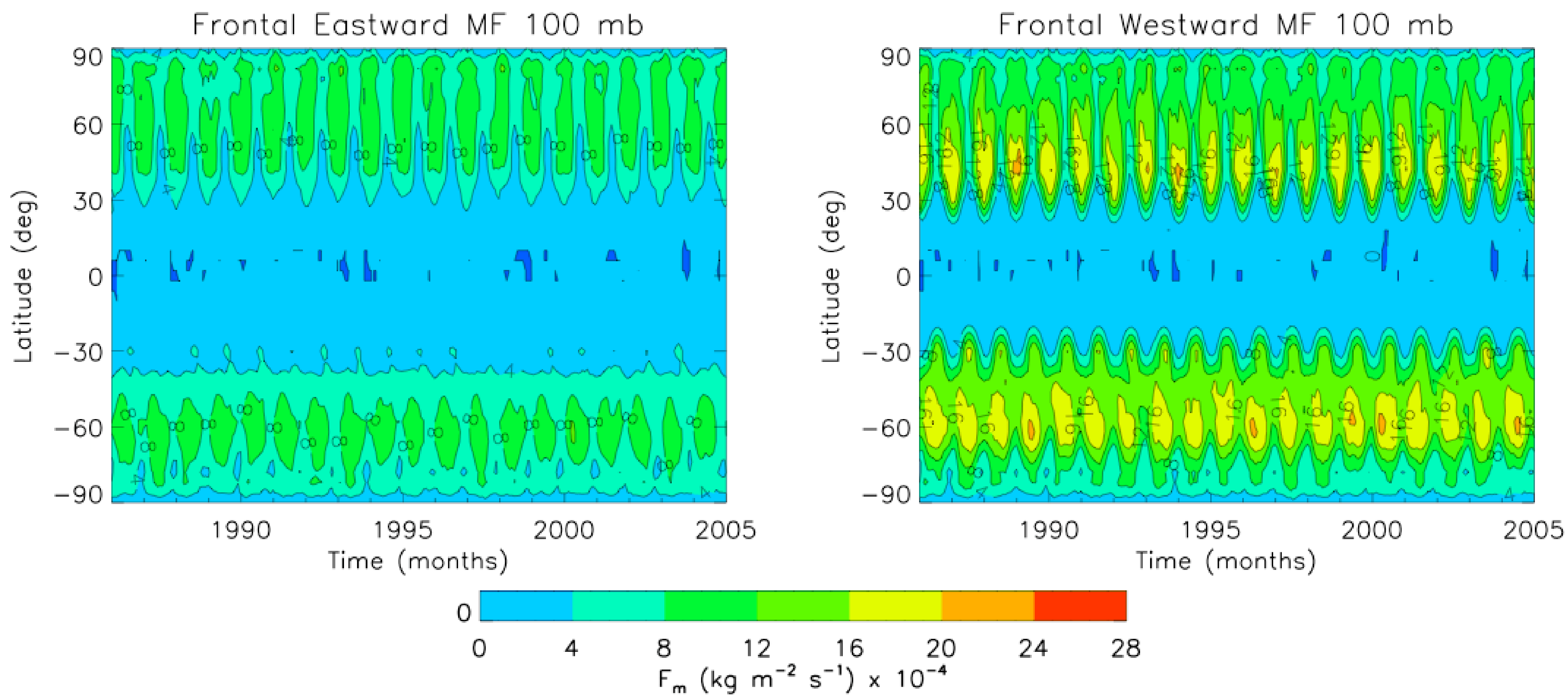
- Typical January region of Frontal wave launching



Source Level Momentum Flux



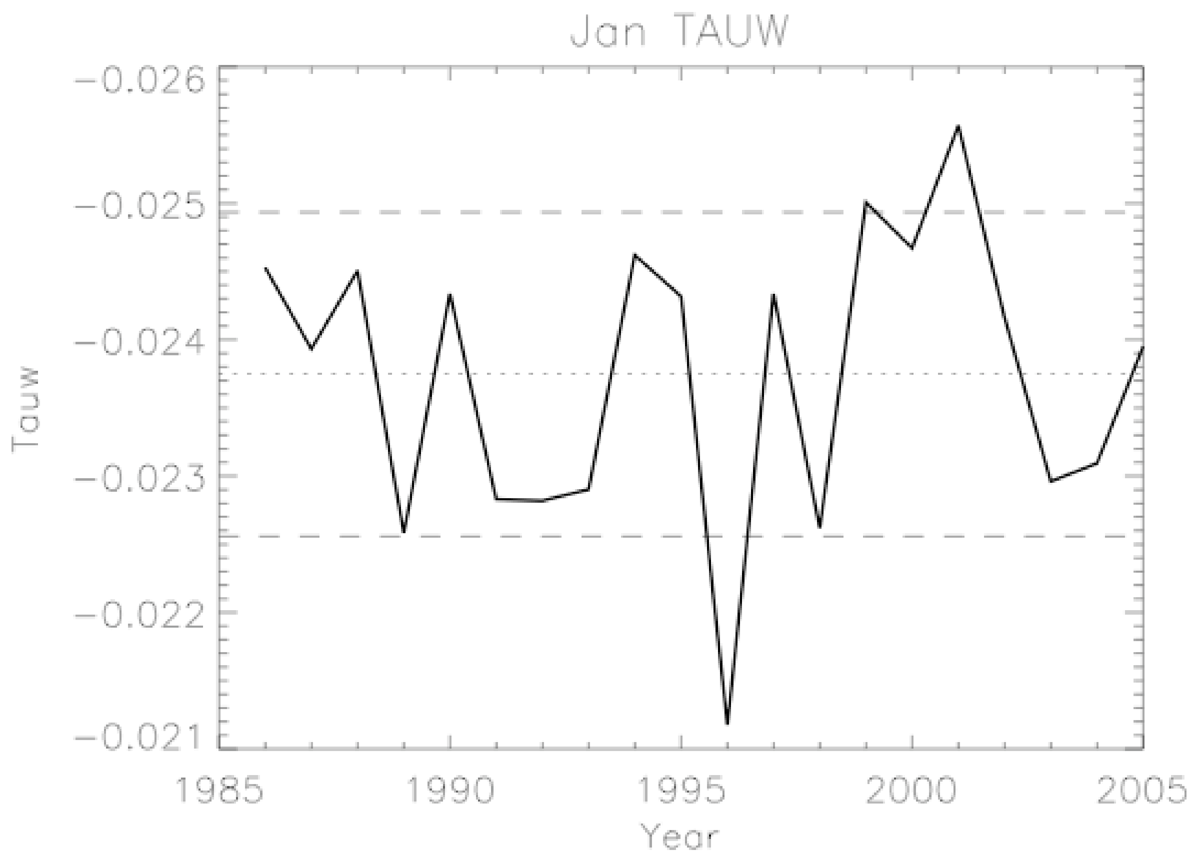
Interannual Variability



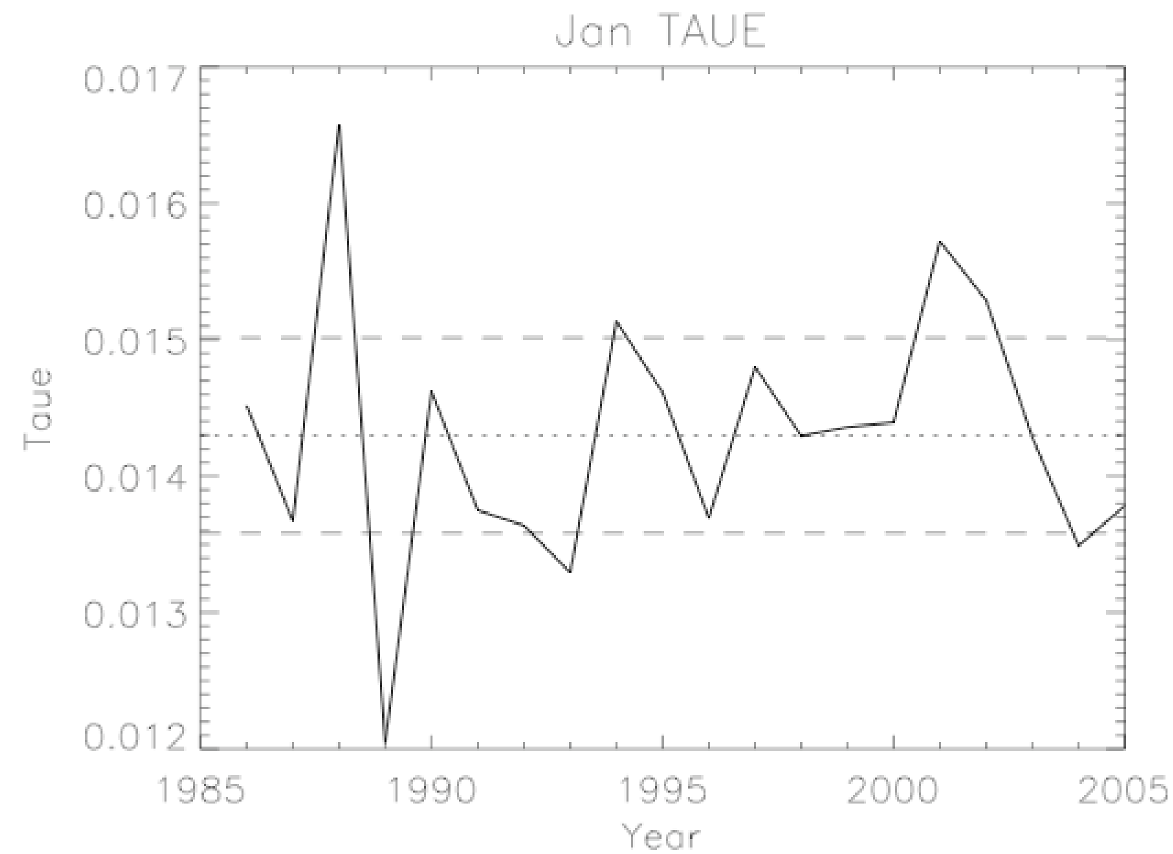
Interannual Variability

Northern Hemisphere Total at 100 mb

Westward MF

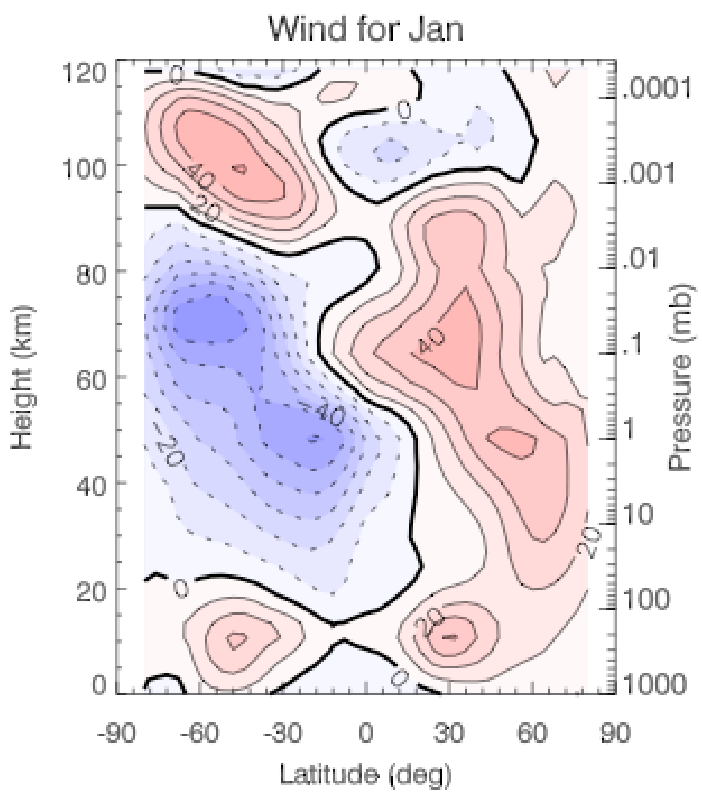


Eastward MF

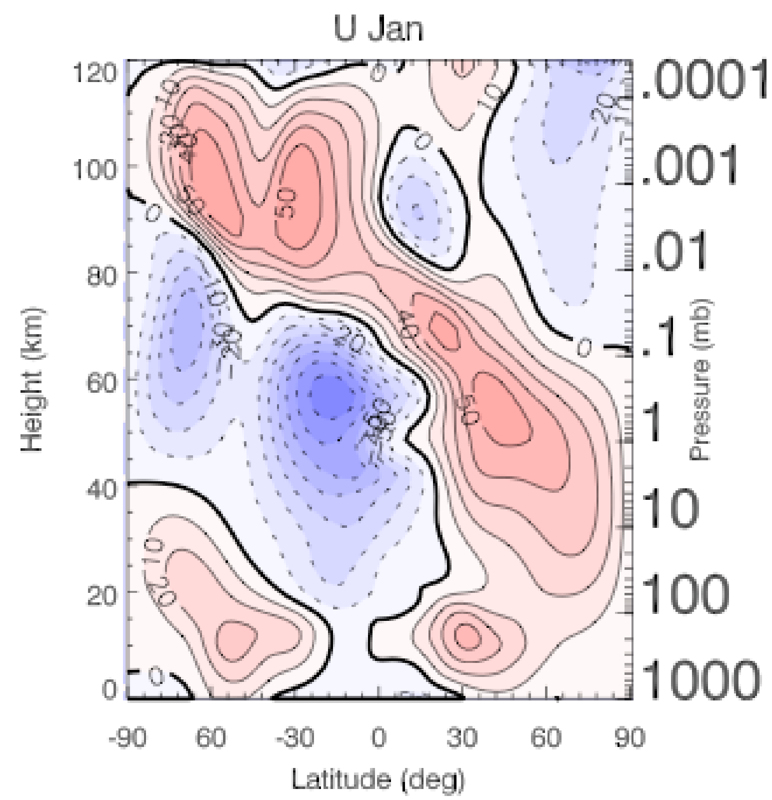


WACCM3.5 January

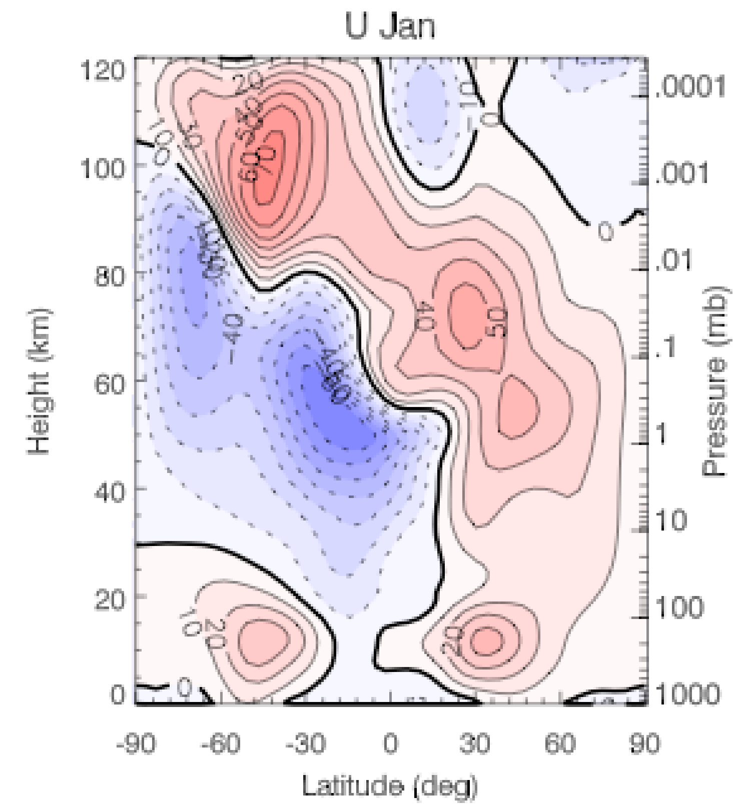
OBS:



WACCM3:



WACCM3.5:

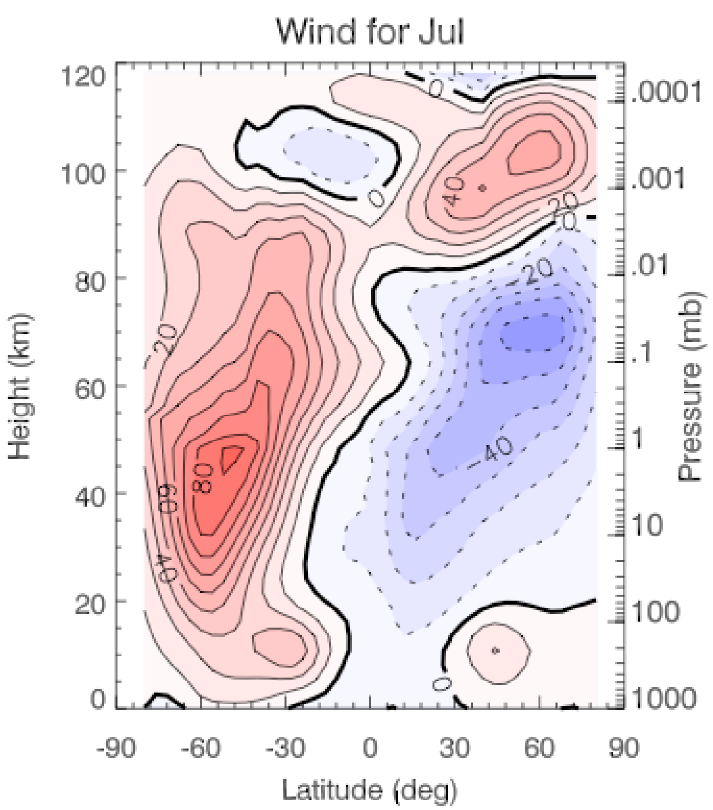


Mesopause:

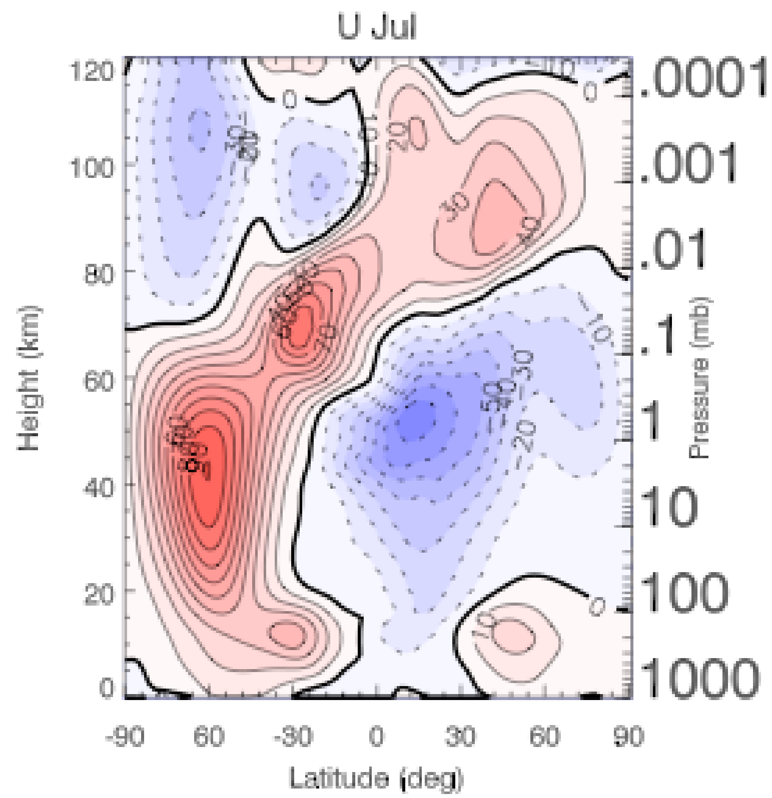
OBS	WACCM3	WACCM3.5
136 K	130 K	130 K
83 km	91 km	91 km

WACCM3.5 July

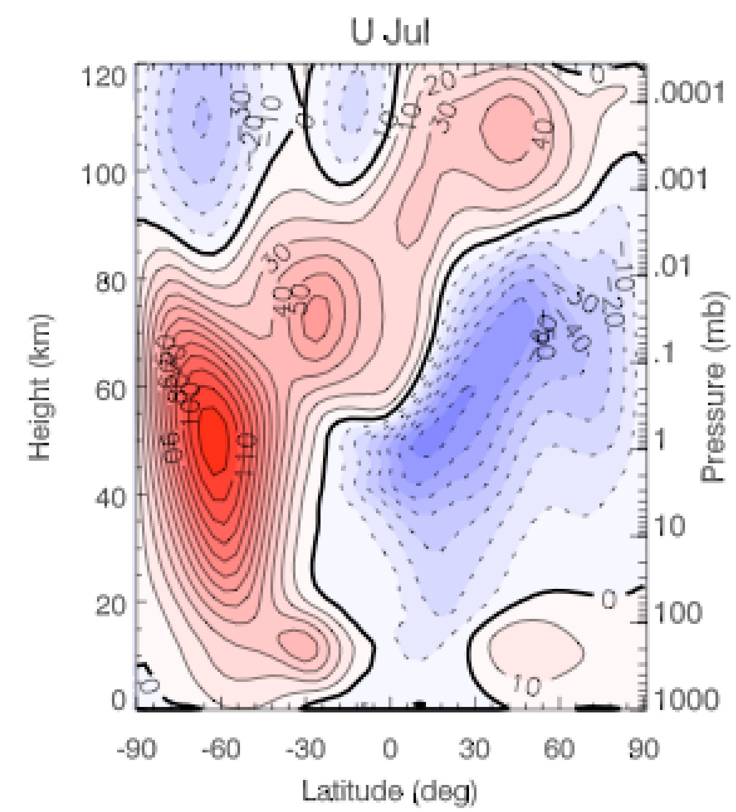
OBS:



WACCM3:



WACCM3.5:



Mesopause:

OBS	WACCM3	WACCM3.5
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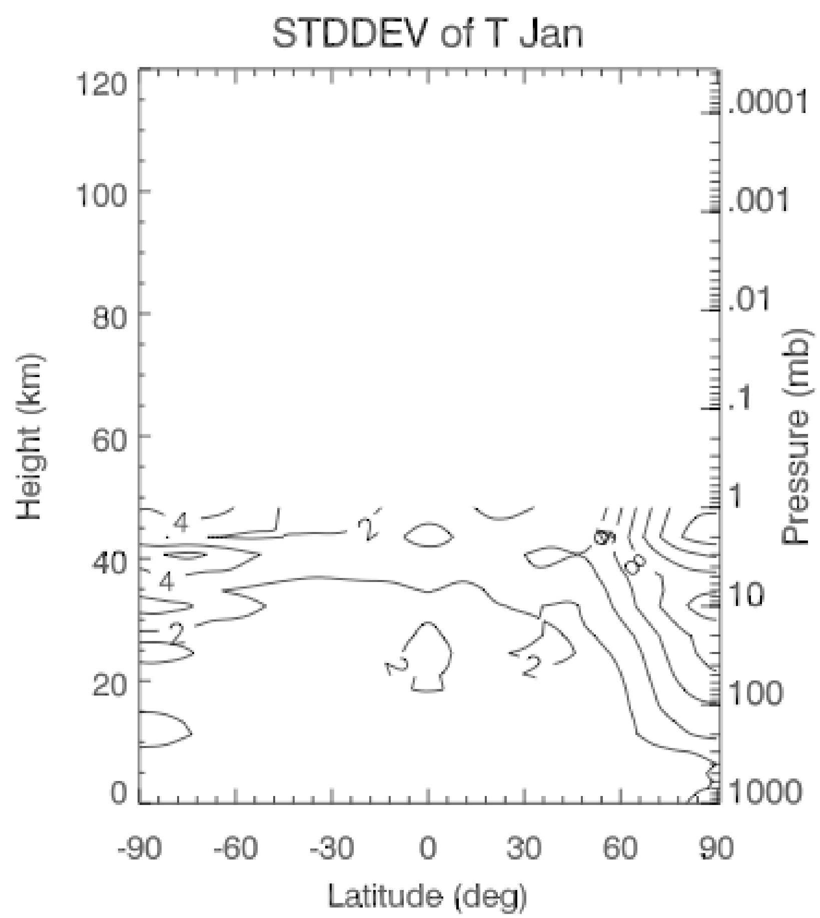
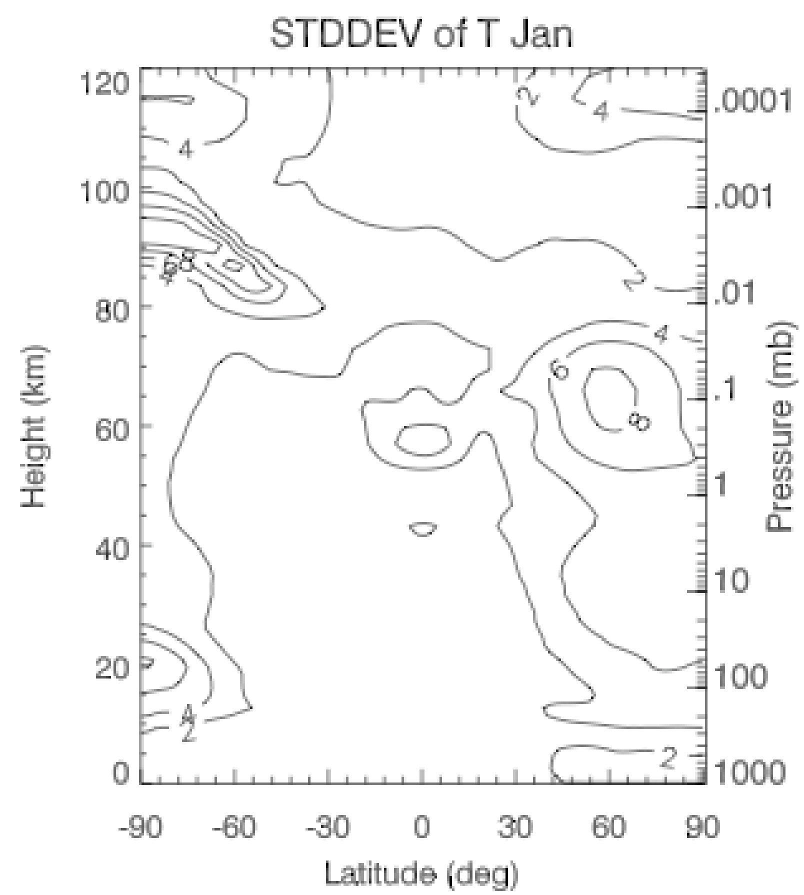
WACCM 3.5:

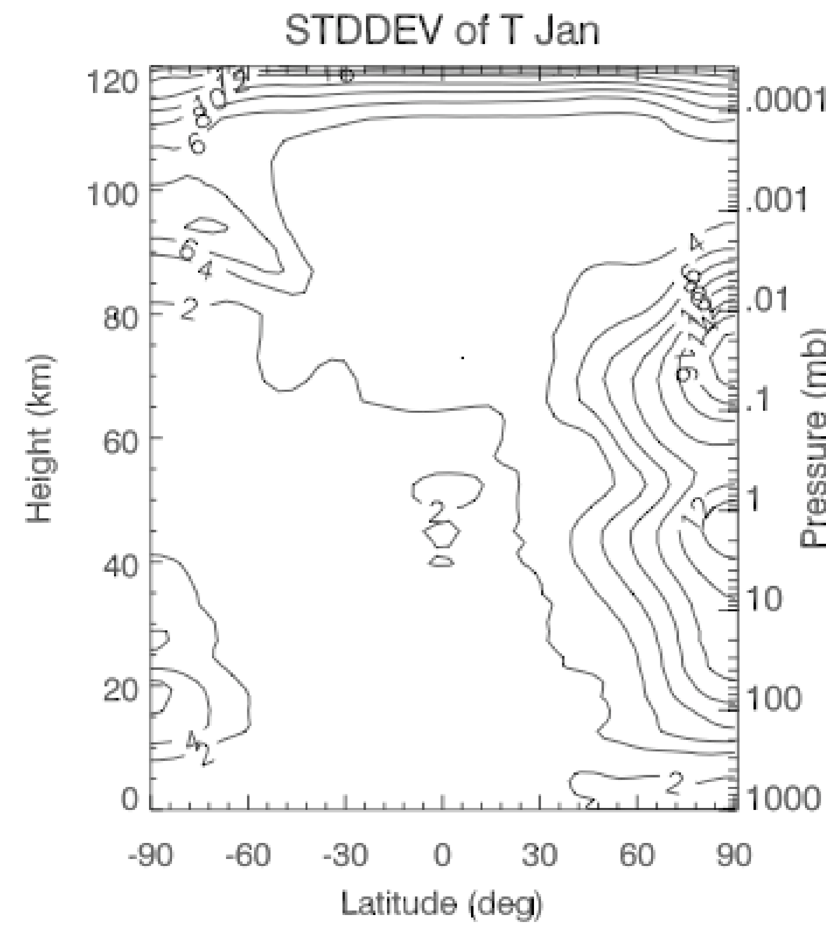
OBS:



WACCM3:



WACCM3.5:



SSW Frequency

	OBS	WACCM3	WACCM3.5
Nov - Feb:	0.5	0.1	0.35
Nov - Mar:	0.6	0.1	0.5

Conclusions:

- We have successfully gone towards a source oriented GW parameterization in WACCM3.5
- We have removed the arbitrarily specified non-orographic wave source and replaced it with convectively and frontally triggered waves.
- There are still uncertainties (tuning knobs)in the parameterization, mainly related to characteristics of frontally generated waves
- The resulting middle atmospheric simulation is better in several regards than that of WACCM3.