Investigations On Gravity Wave Potential Energy Seen By Different Satellites And Ground Based Techniques

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OBJECTIVES

- To propose a uniform method for the retrieval of gravity wave induced fluctuations for the total spectrum from temperature profiles.
- To validate SABER observations of gravity wave potential energy with ground based instruments at specific locations, Gadanki and Thumba.
- To calculate the global potential energy profiles of gravity waves from the Stratosphere to the Mesosphere-Lower Thermosphere using SABER observations.
- To study the gravity wave activity in the Stratosphere using various satellite techniques, indicating the observed spectrum of gravity waves.

To obtain gravity wave induced perturbations…

No	Publication	Methods to extract gravity wave fluctuations
1.	*Wilson et al.,* [1991] *Deepa et al.,* [2006] *G. Ramkumar et al.,*[2006]	Subtraction from a mean profile
2.	*Eckermann D. et al,*[1994] *Tsuda et al.,* [2000] *Alexander et al.,* [2001] *Venkat Ratnam et al.,* [2004] *De la Torre et al.,* [2006] *Frohlich et al.,* [2007] *Namboothiri et al.,* [2008]	Filters of selected vertical wavelength bands (Low pass, Band pass, High pass)
3.	*Allen and Vincent,* [1995] *Wang and Geller,* [2003] *Sivakumar et al.,* [2006]	Polynomial fits of various orders
4.	*Preusse et al.,*[1999,2000,2009] *Krebsbach and Preusse,*[2007] *Schroeder et al.,* [2009]	0-6 zonal wave number Kalman filter

We have used least square fit to remove 0-6 zonal wave numbers

Potential Energy of Gravity waves…

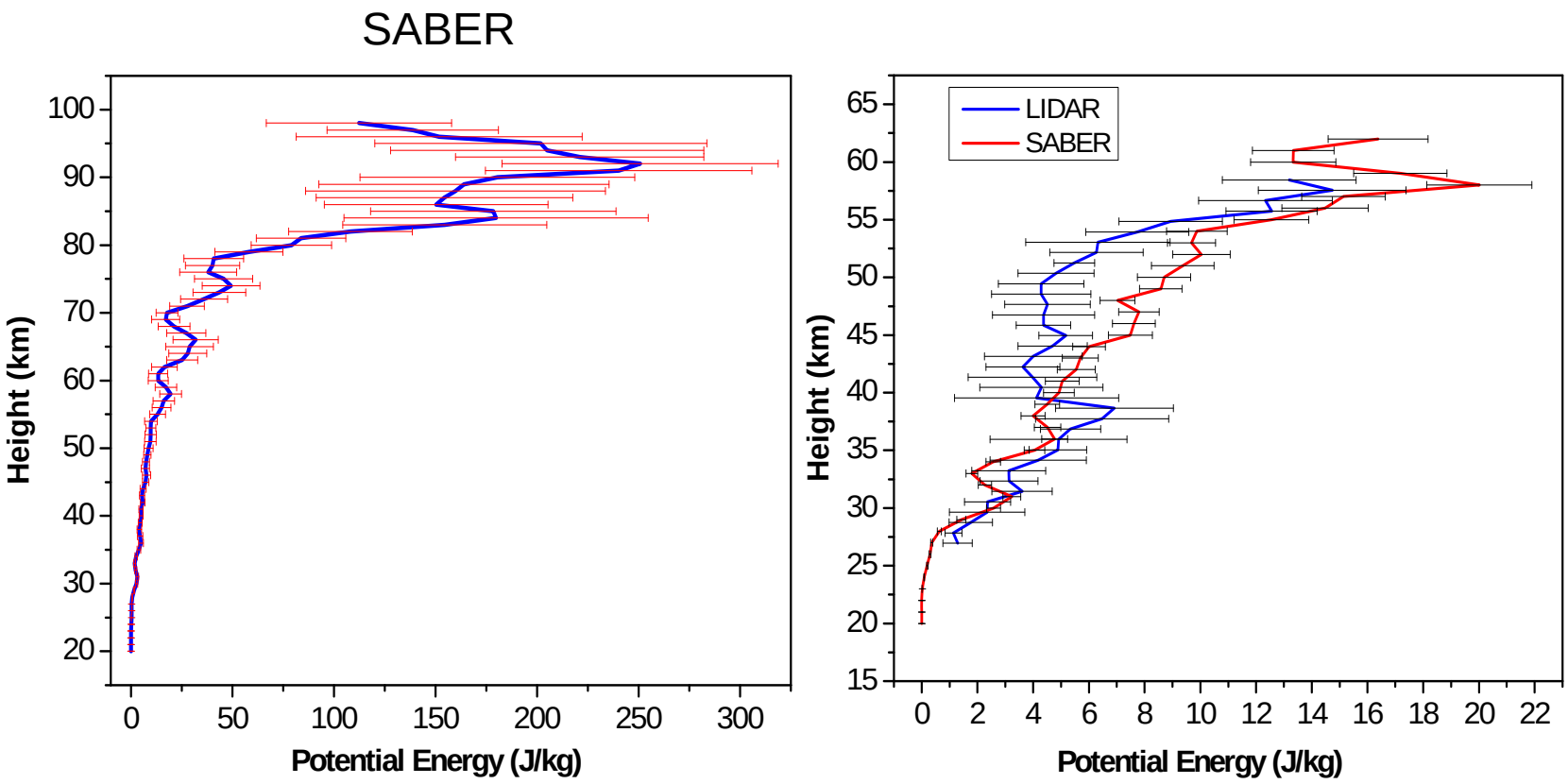
A proxy for wave activity…

$$E_p = \frac{1}{2}\left(\frac{g(z)}{N(z)}\right)^2\left(\frac{T(z)'}{T_0(z)}\right)^2$$

$$N^2(z) = \frac{g(z)}{T_0(z)}\left[\frac{\partial T_0(z)}{\partial z} + \frac{g(z)}{C_p}\right]$$

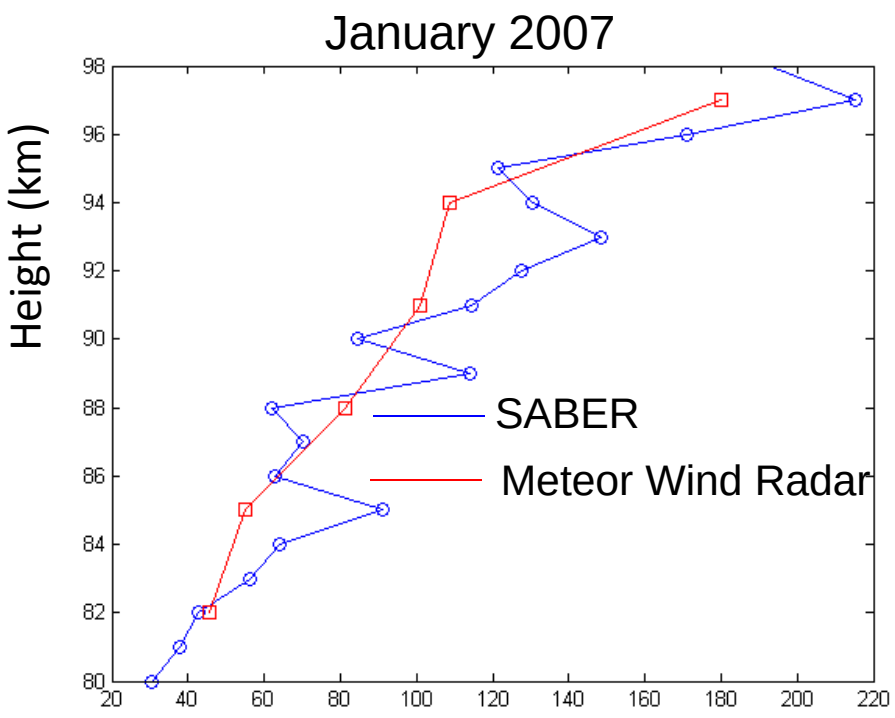
Over GADANKI (13.5^0 N, 79.2^0 E)

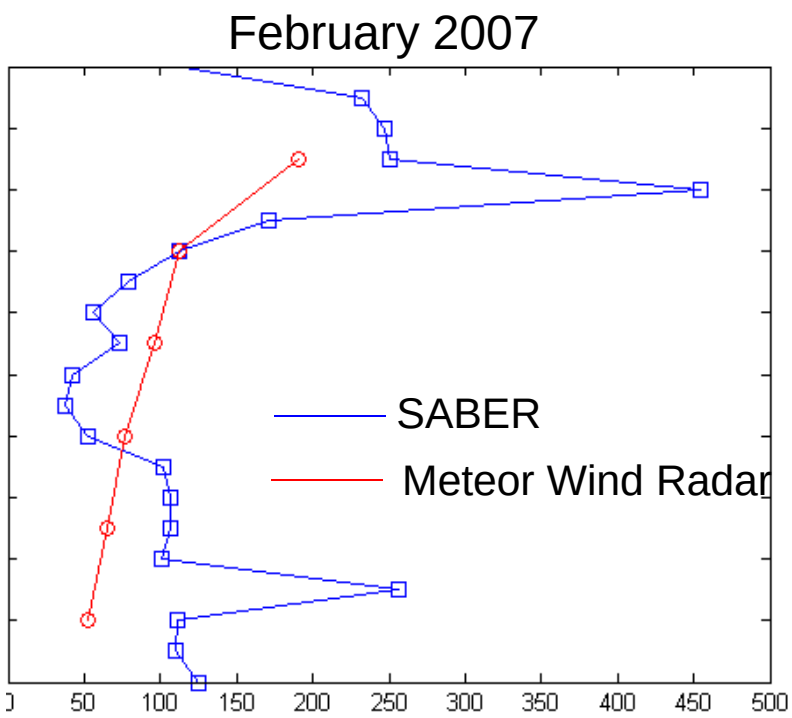
Potential Energy (DJF 2004-05)



Over Thumba (8.5^0 N, 77^0 E)

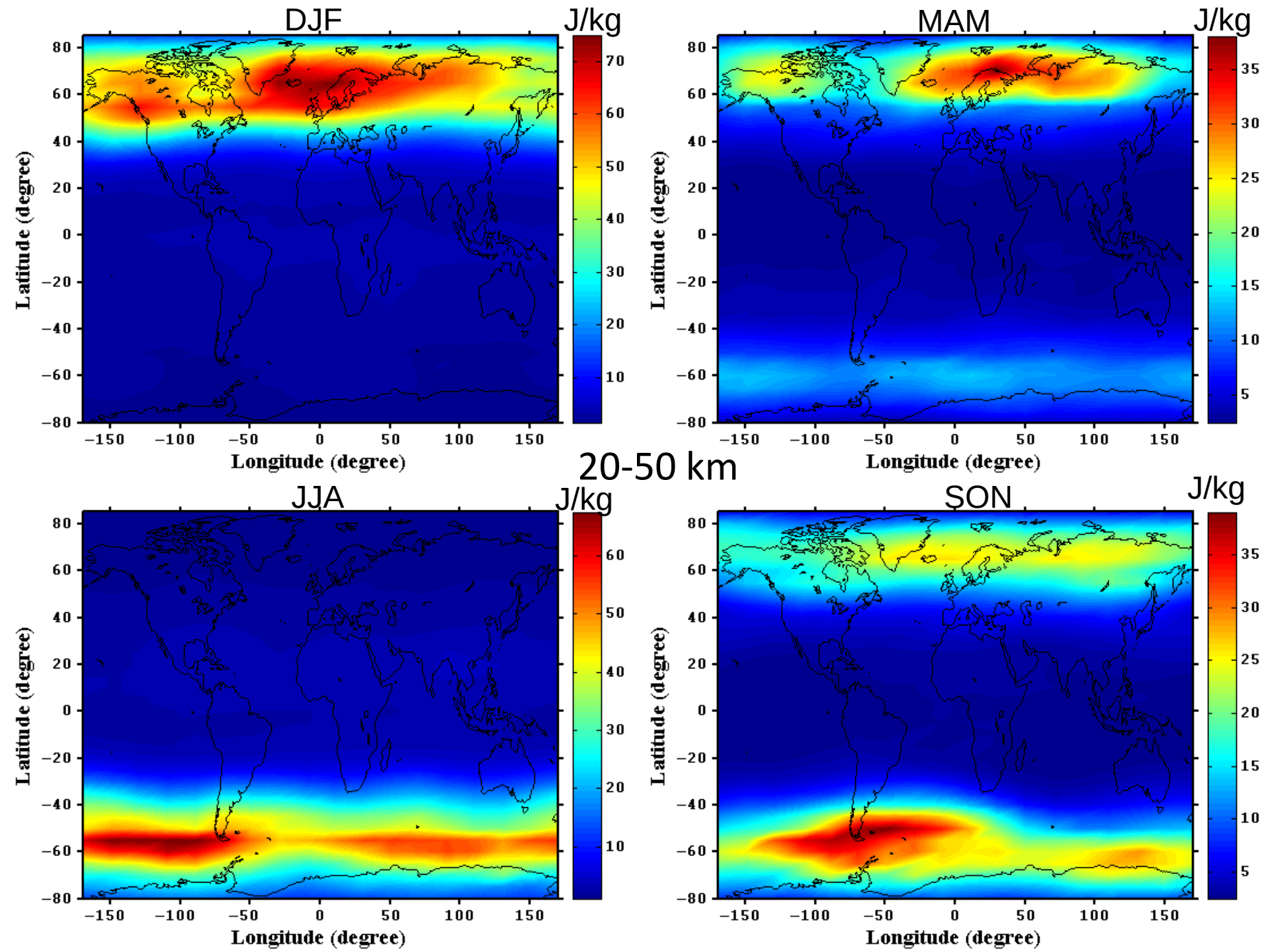
Potential Energy Vs Kinetic Energy

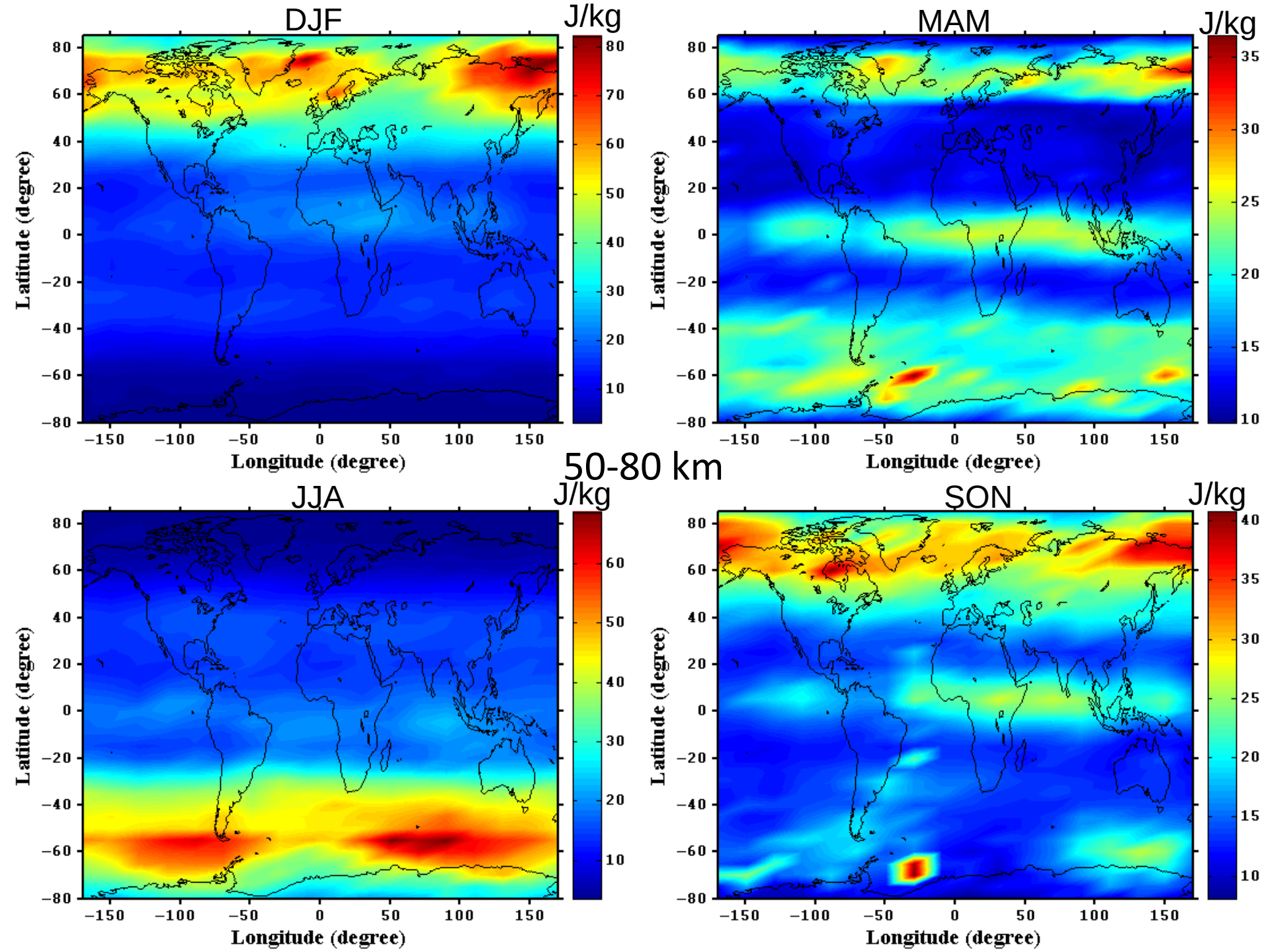


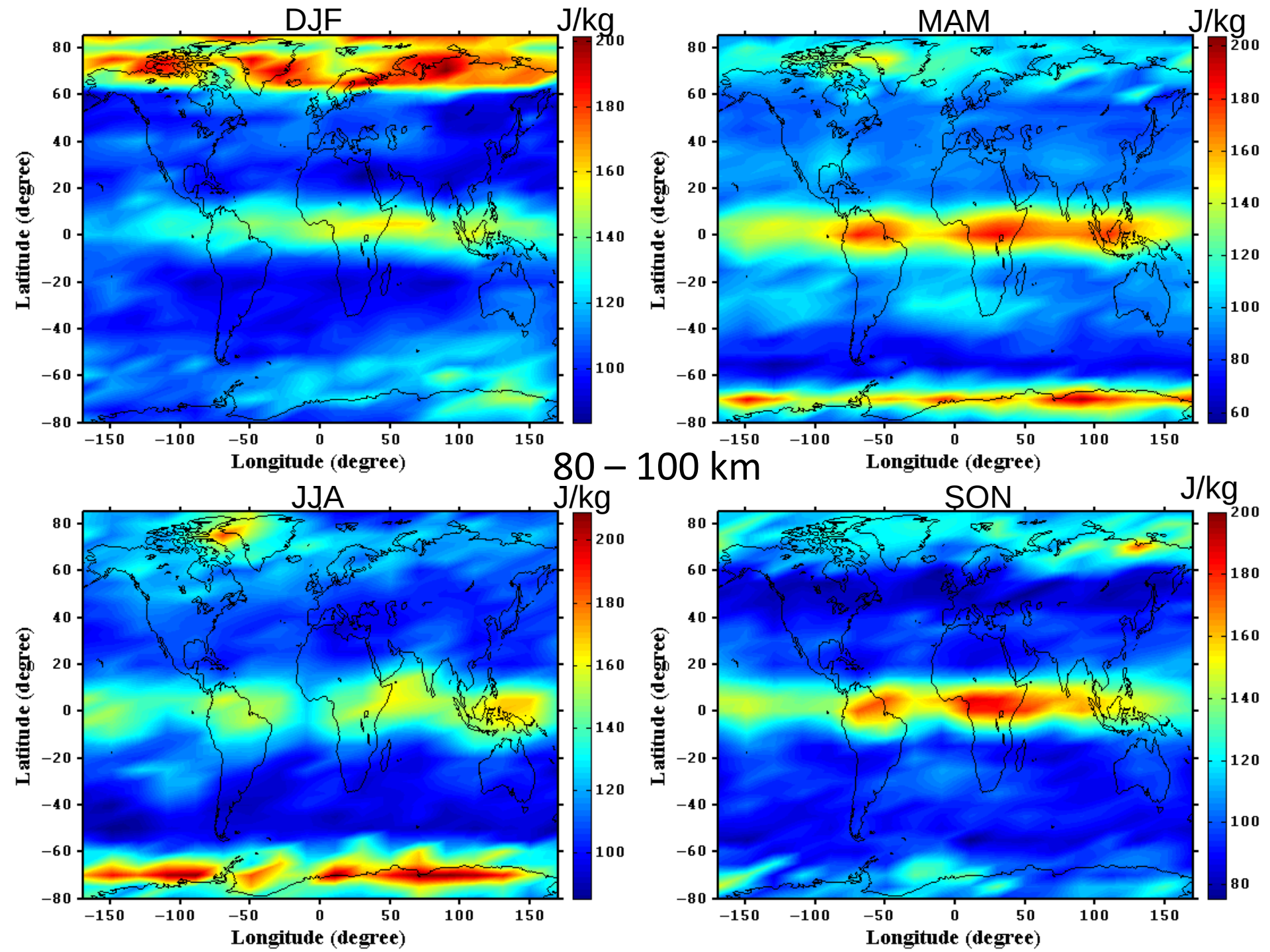


A Global Perspective....

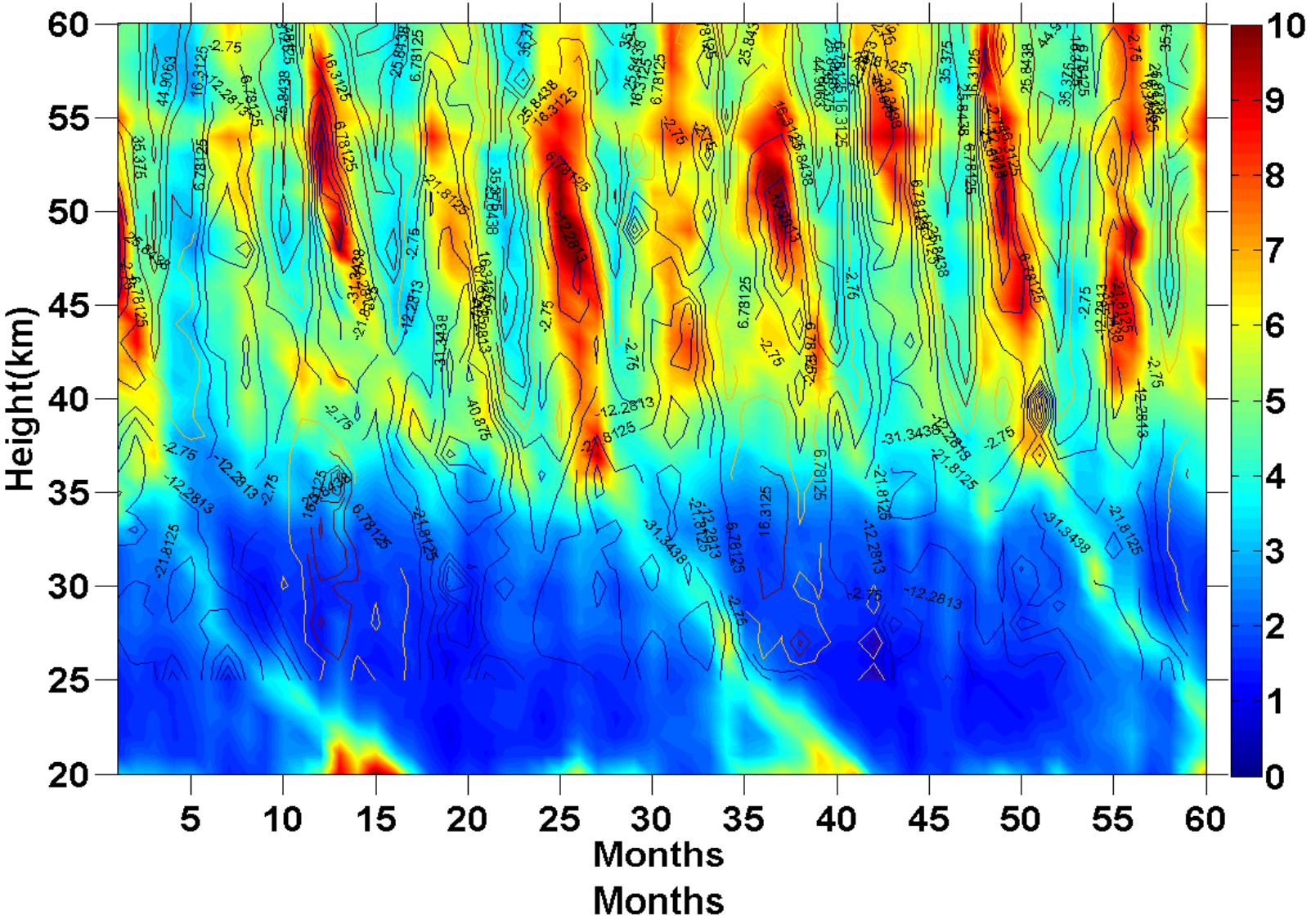
SABER (2003-2007)


DJF
J/kg
MAM
J/kg
20-50 km
JJA
J/kg
SON
J/kg
Latitude (degree)
Longitude (degree)
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
70
60
50
40
30
20
10
35
25
15
5


DJF
J/kg
MAM
J/kg
50-80 km
JJA
J/kg
SON
J/kg
Latitude (degree)
Longitude (degree)


DJF
J/kg
MAM
J/kg
80 – 100 km
JJA
J/kg
SON
J/kg
Latitude (degree)
Longitude (degree)
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
200
180
160
140
120
100
80
60

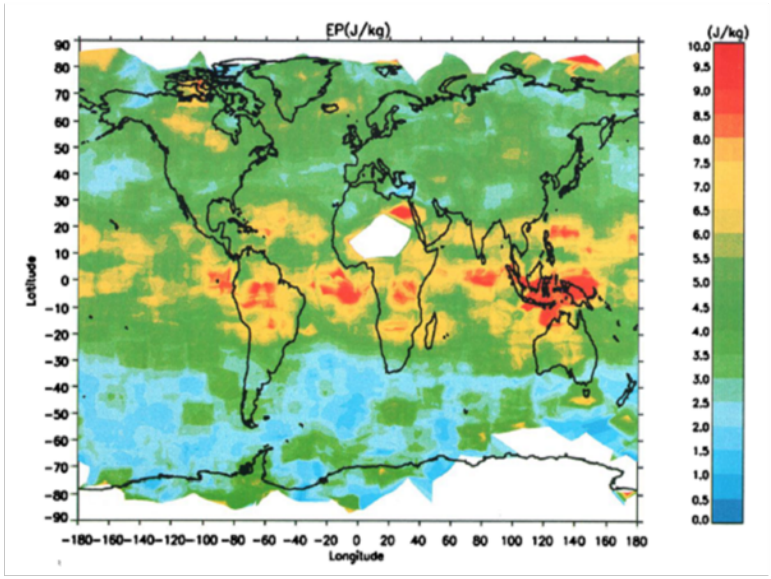
Monthly mean Potential energy over equator (zonally averaged) for 5 years from 2003-2007



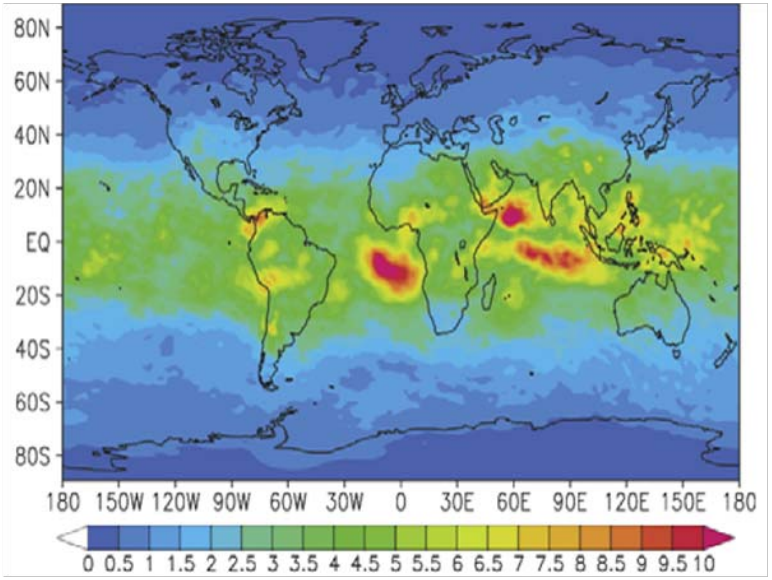
Multi-Satellite Observations...

Alexander, 1998
Alexander and Barnet, 2007

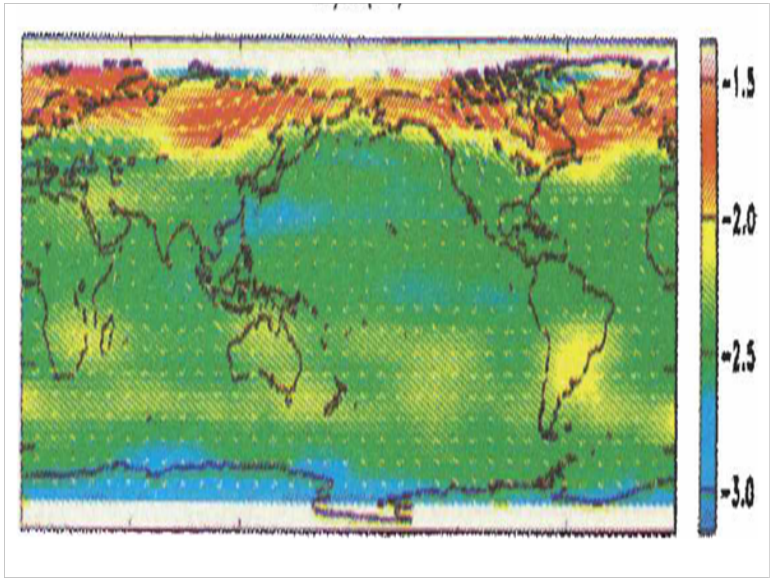
Average **PE** of short vertical-scale gravity waves using **GPS/MET** data for winter from 20–30-km altitude **(Tsuda et al., 2000)**



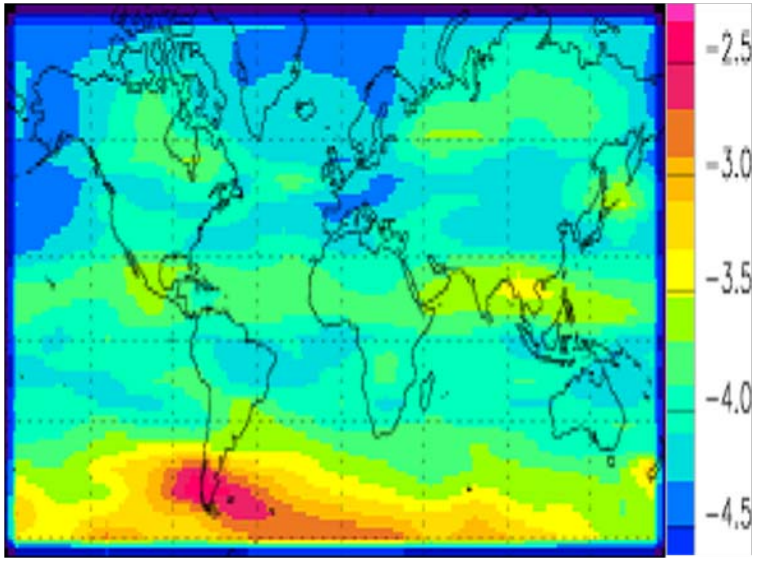
Modeled average **PE** of short period gravity waves using **GPS/MET** data for June in 20–30-km altitude **(Kawatani et al., 2003)**



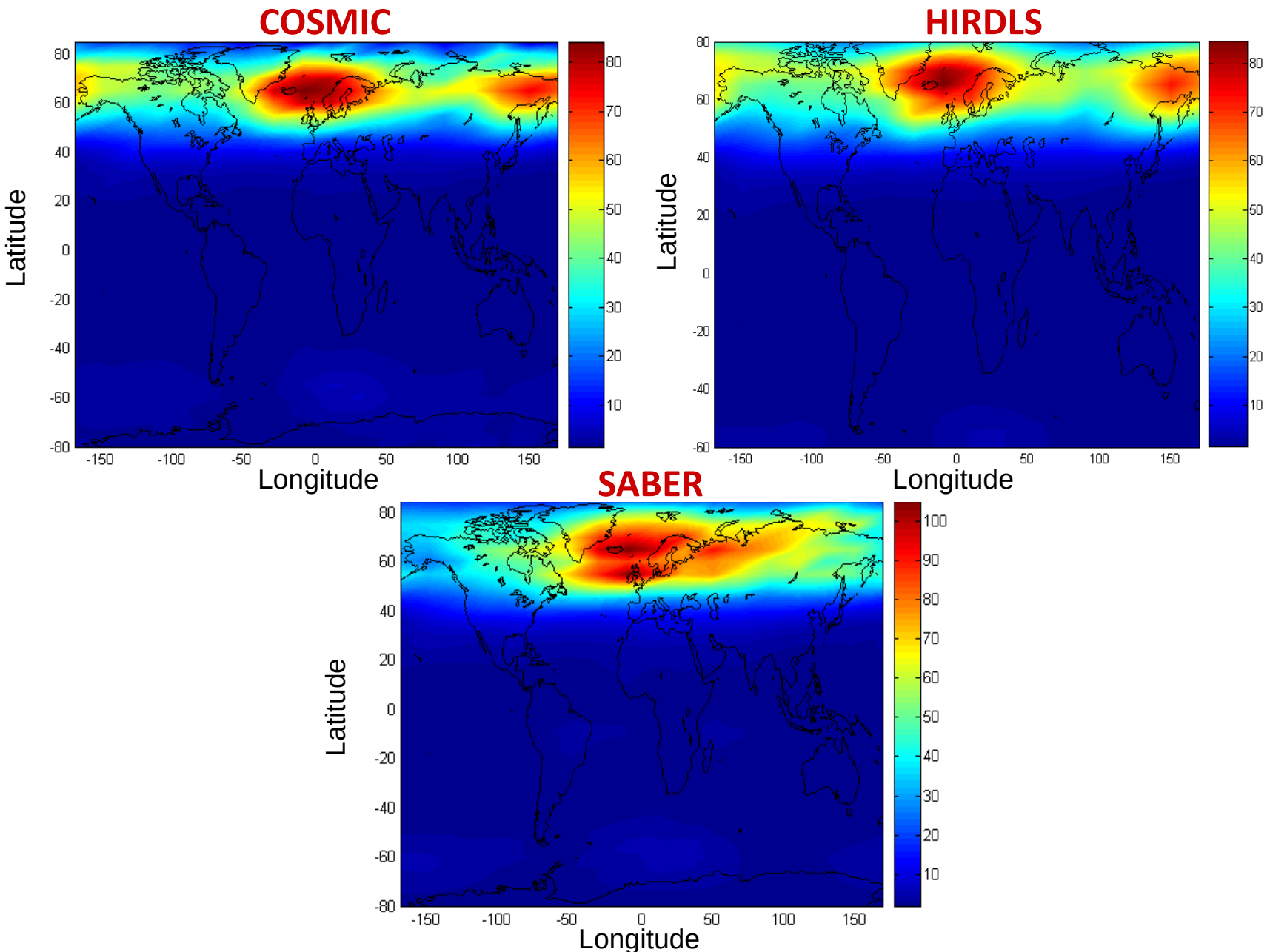
Short-scale gravity wave **variance** from **MLS** data for winter at 33-km altitude **(Wu and Waters, 1996)**



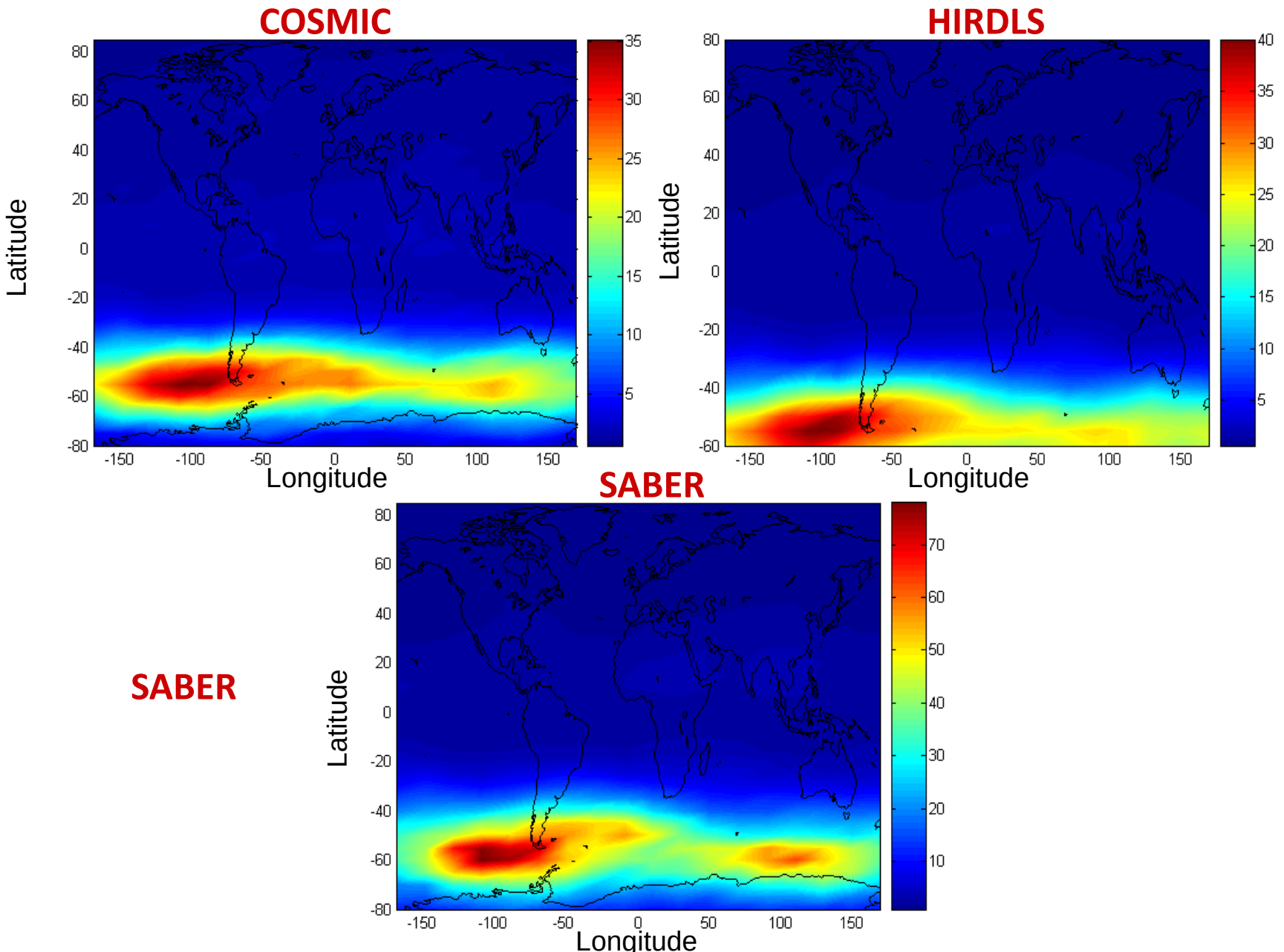
Gravity wave **momentum flux** in **HIRDLS** in May from 20-30 km altitude **(Alexander et al., 2008)**



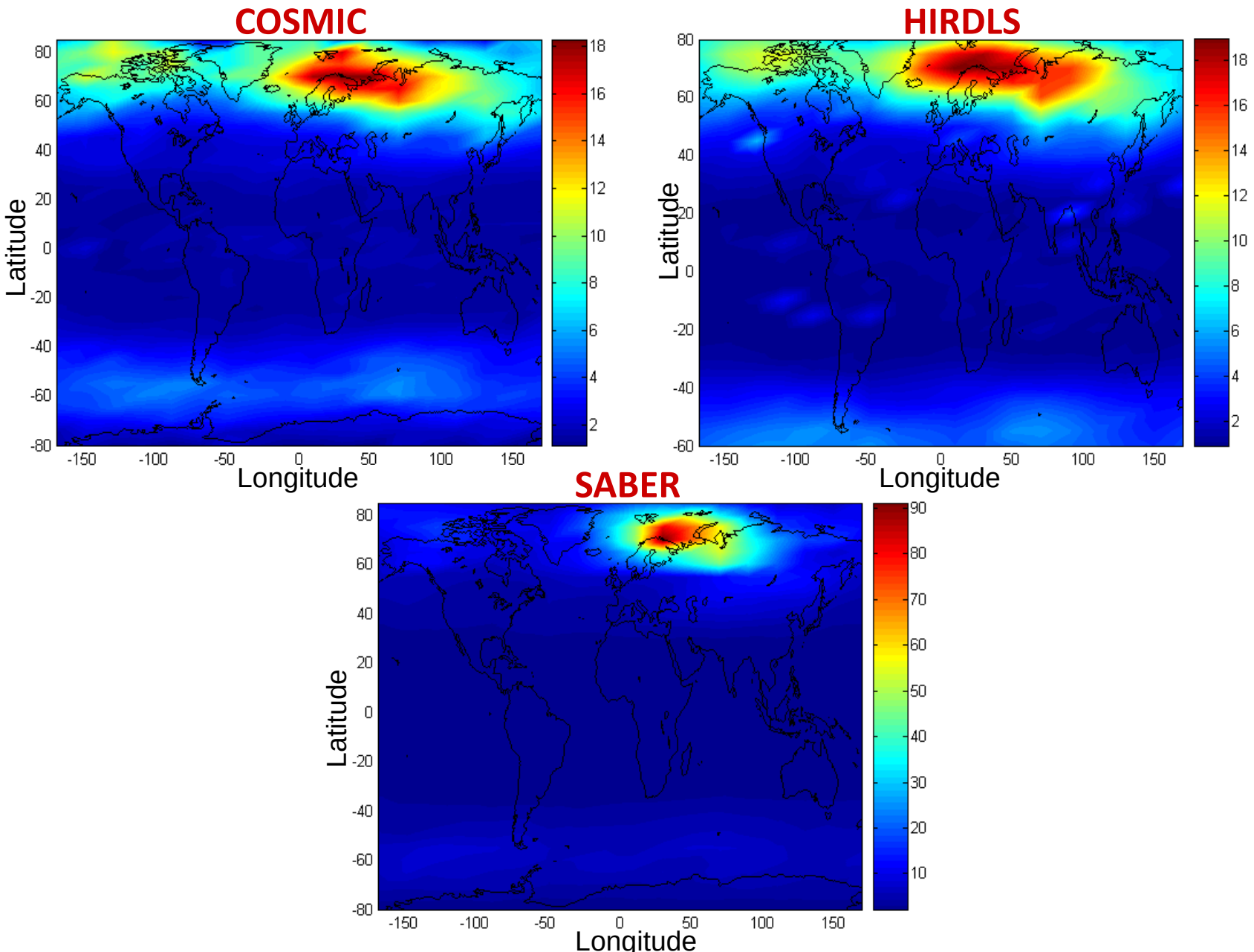
Boreal WINTER (DJF)



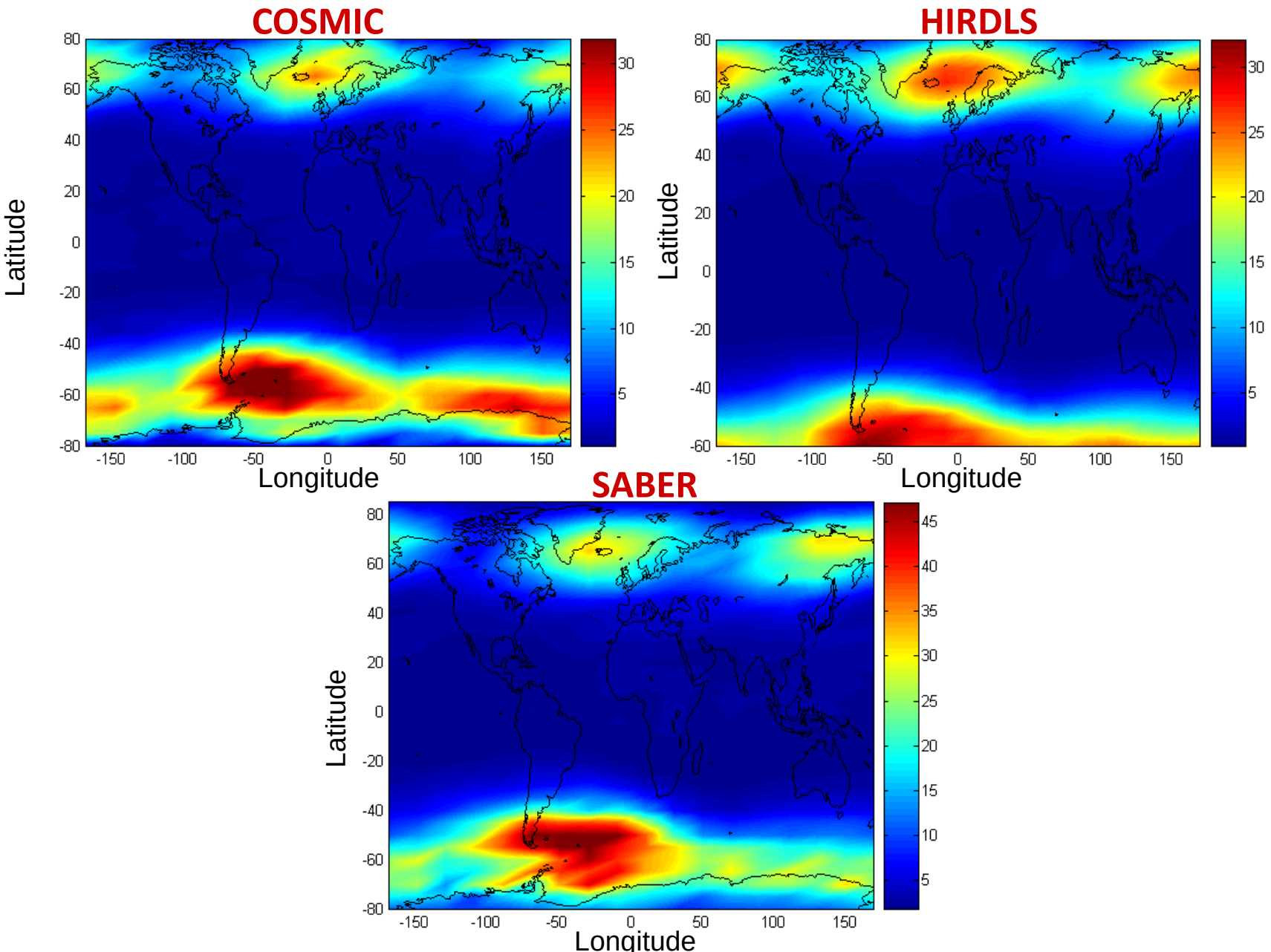
Boreal SUMMER (JJA)



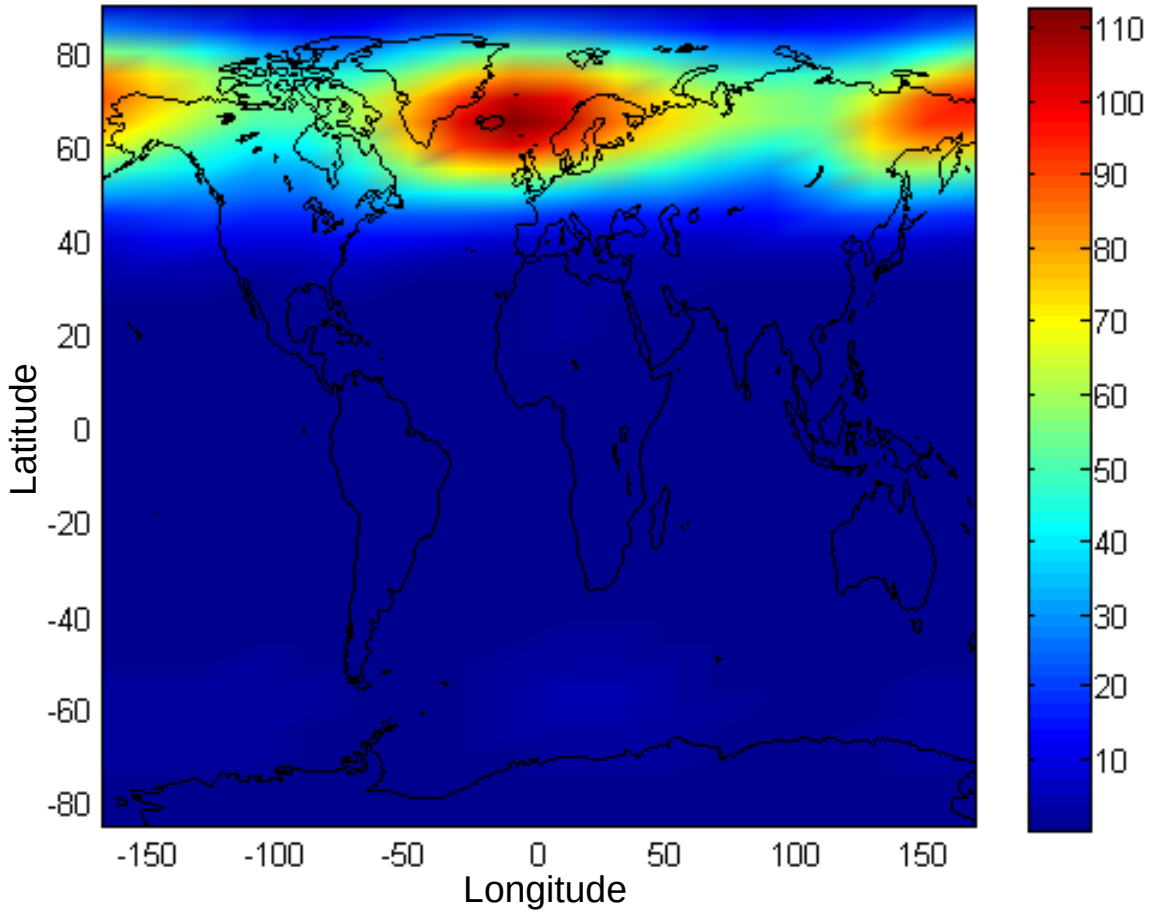
Vernal Equinox (MAM)



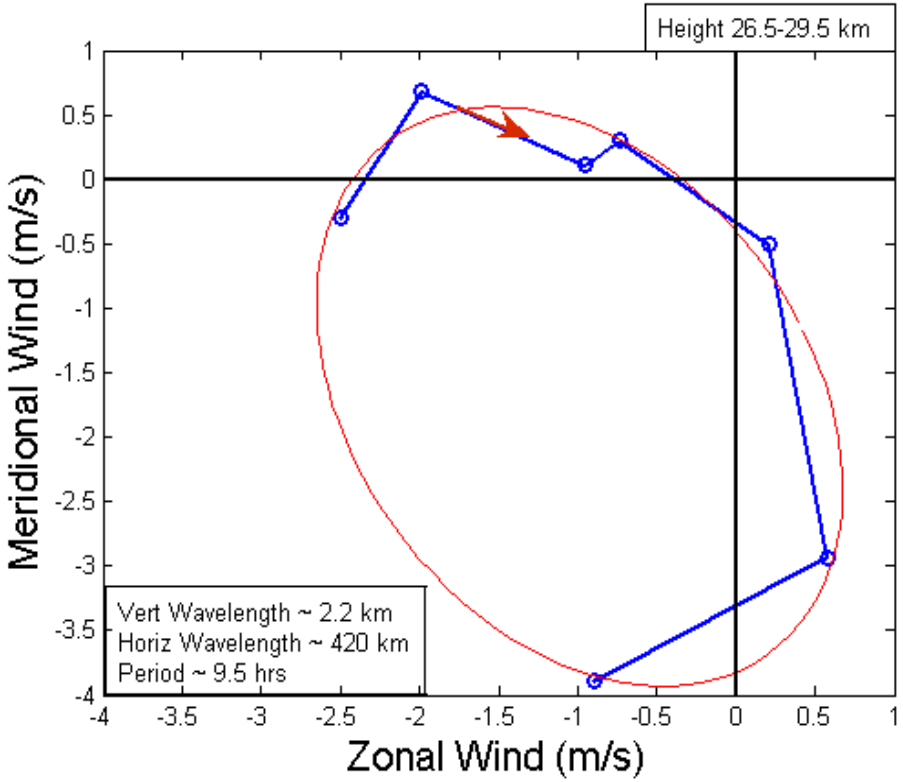
Autumnal Equinox (SON)



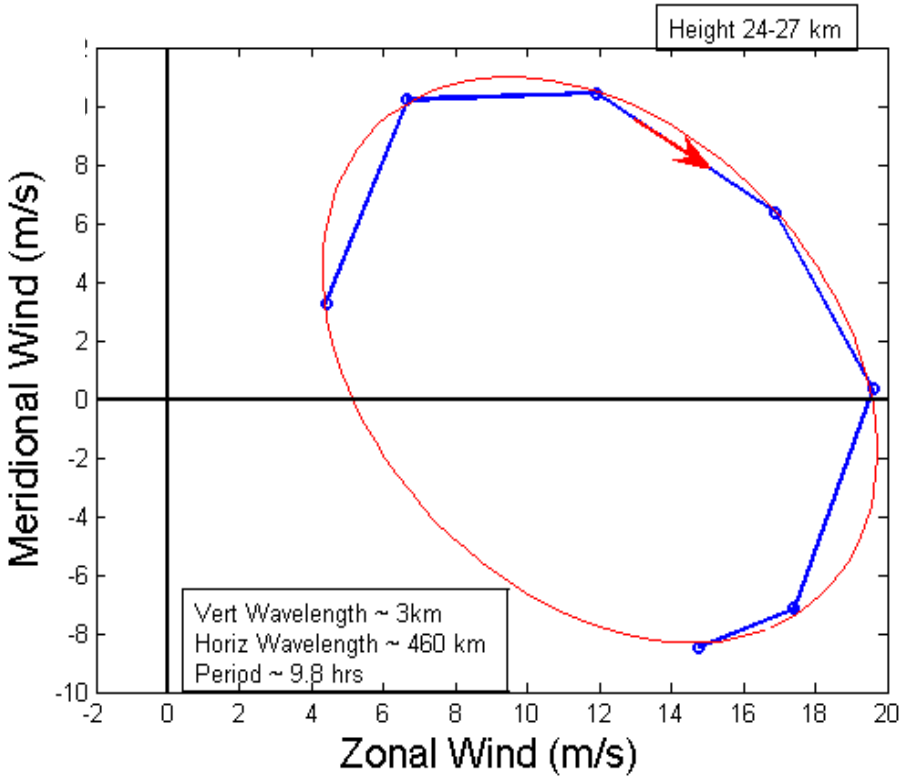
AIRS (Boreal Winter)



PE Map of a Nadir viewing Satellite is stunningly similar to the limb viewers!!!

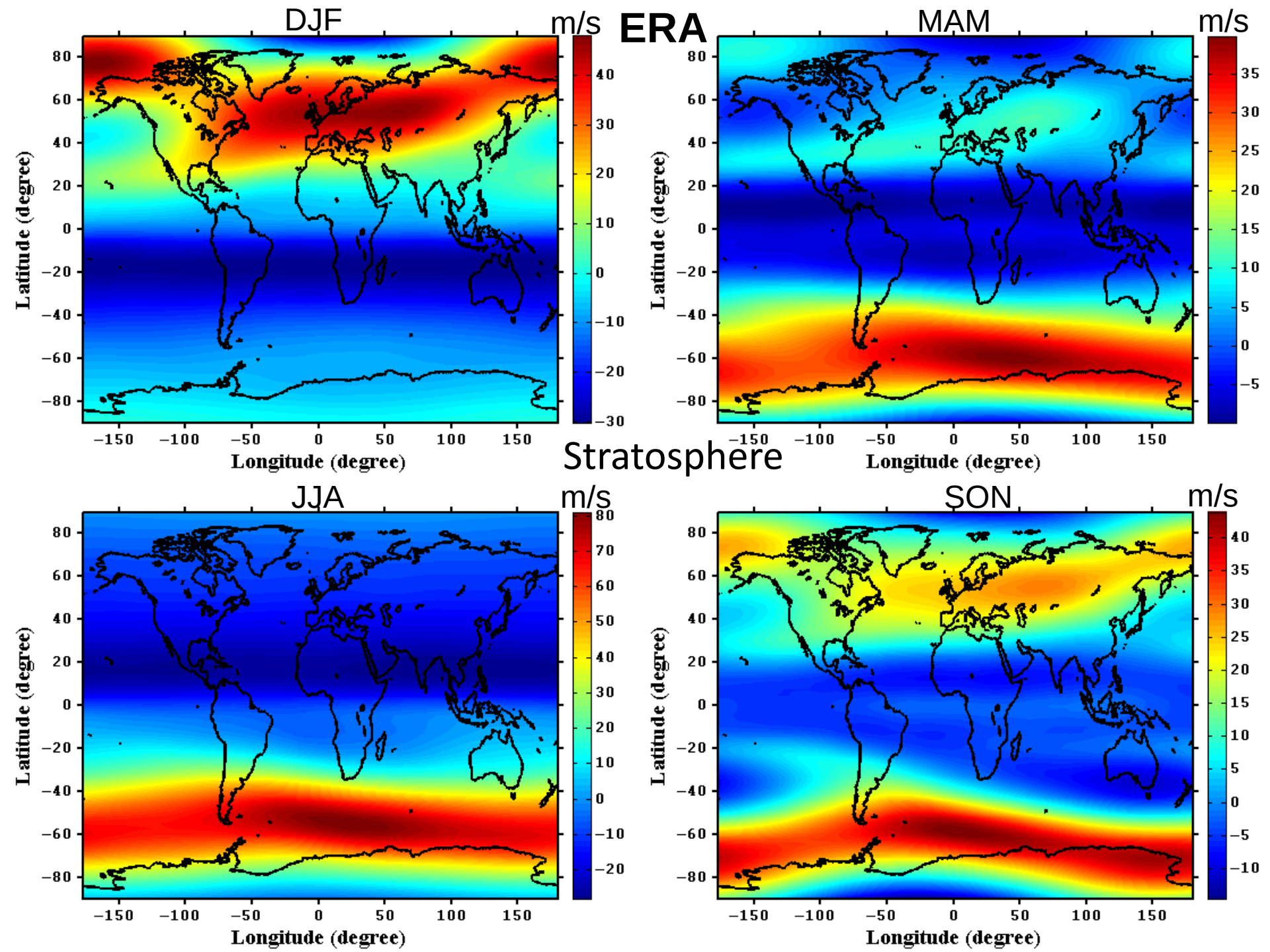


Wyoming University
Radiosonde Data



A look into the Sources....

Sato, 2000


ERA
Stratosphere
DJF
m/s
MAM
m/s
JJA
m/s
SON
m/s
Latitude (degree)
Longitude (degree)

Summary

- ✓ We propose a uniform method for the removal of planetary wave components in obtaining fluctuations due to gravity waves alone. Many of the other methods employed may mask a particular part of the wave spectrum.
- ✓ Comparison between satellite and ground based techniques elucidate the use of satellite observations for gravity wave studies.
- ✓ Global maps from SABER show prominent wave activity in the winter hemisphere high latitudes/poles during all seasons. During equinoxes, the hemisphere transitioning from winter to summer has higher values.
- ✓ A clear shift is observed to lower latitudes with height and tropical enhancement is seen in the Lower Thermosphere.
- ✓ Longer horizontal wavelengths are prominent at the poles and all maps show polar high values in the stratosphere. One major source is the polar stratospheric jets.
- ✓ Multi satellite studies show similarity in the pattern observed by limb viewing, occultation and nadir viewing techniques (SABER, HIRDLS, COSMIC, AIRS). Do they observe almost the same region of the wave spectrum????
- ✓ We are working on momentum flux calculations using multiple satellites…

Thank you…