Gravity Wave Variations during Elevated Stratopause Events using SABER Observations

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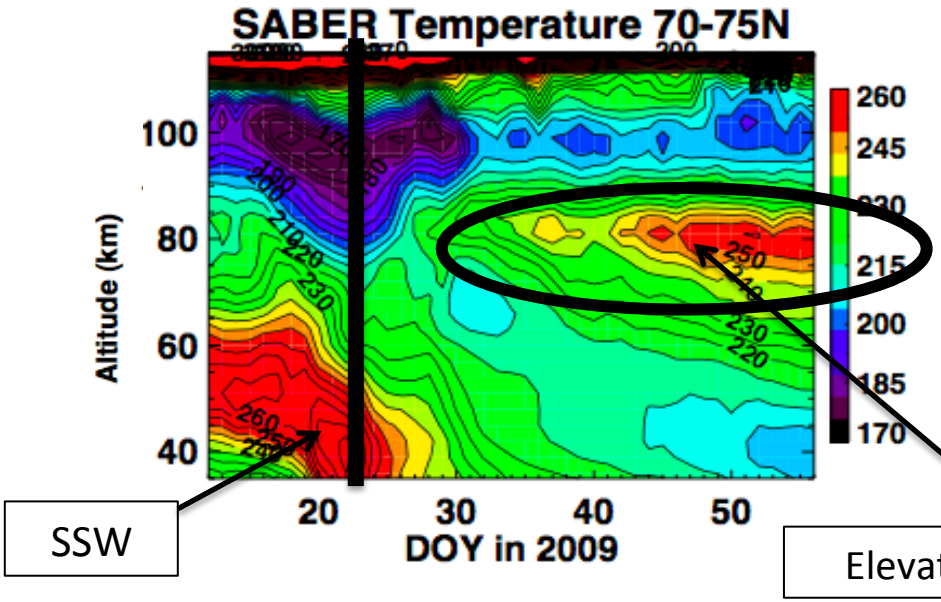
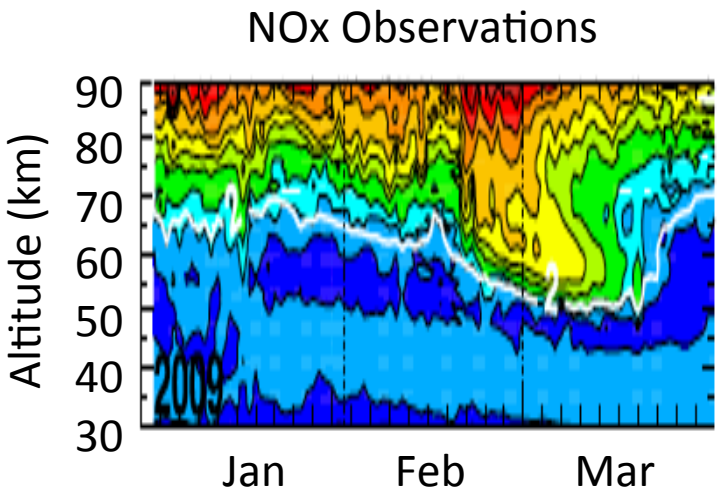
Background





[Randall et al., 2009]

✓ Enhancements of downward flow likely cause the formation of an elevated stratopause and downward transport of chemical species.

Objective

Problem: Global gravity wave observations in the MLT is missing.

=> Physical mechanisms of an elevated stratopause formation and downward movement is still not clear.

Solution: SABER provides global gravity waves from ~30-100 km [Preusse et al., 2009]

Goal: Study gravity wave variations during elevated stratopause events and their mechanisms.

Gravity Wave Analysis Method [*Preusse et al.*, 2009]

T’ = Temperature Perturbation (*T’*) = Gravity Waves

T = SABER temperature profile (*T*)

T_0 = Background temperature (Zonal mean T + planetary waves + tides)

$$T' = T - T_0$$

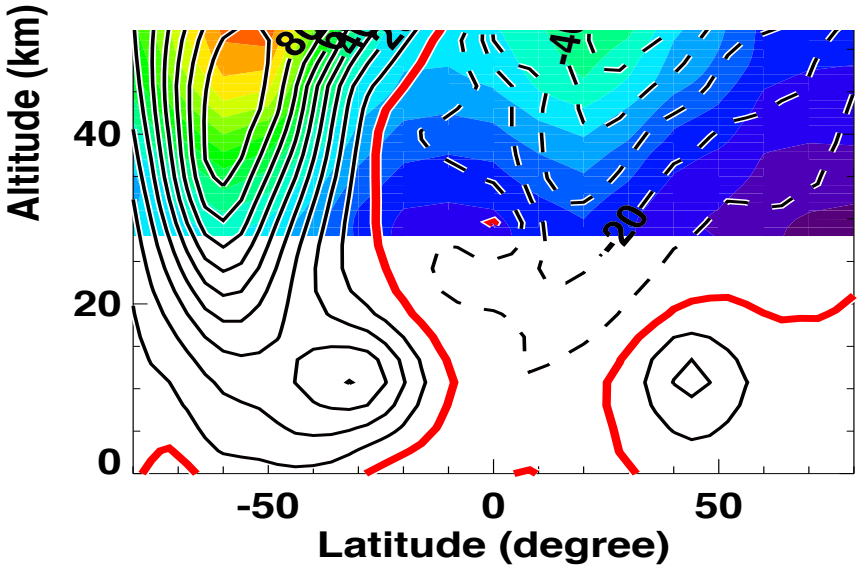
Background Temperature Estimation Method:

1. Daily temperature data are separated by local time (ascending and descending node) and binned into 24°×5° (longitude × latitude) grid
2. Zonal wavenumbers 0-5 components are estimated using least-square fitting.
3. Estimated background temperature contains tides, planetary waves, and zonal mean temperature.

Validations and detailed analysis method => Preusse et al. [2009], Yamashita et al. [2013, JGR]

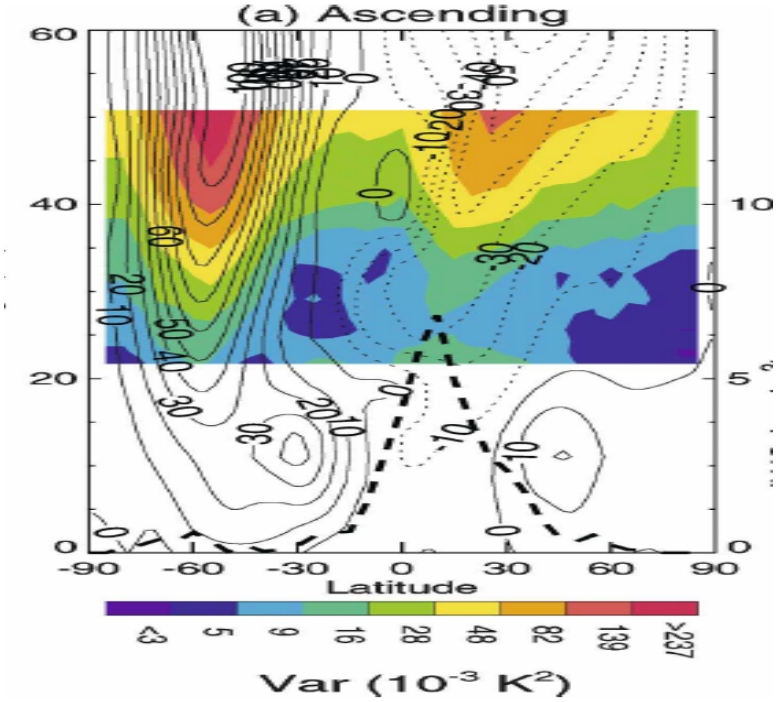
Comparison with MLS

SABER Observations
(d) Total GW July



[*Yamashita et al.*, 2013]

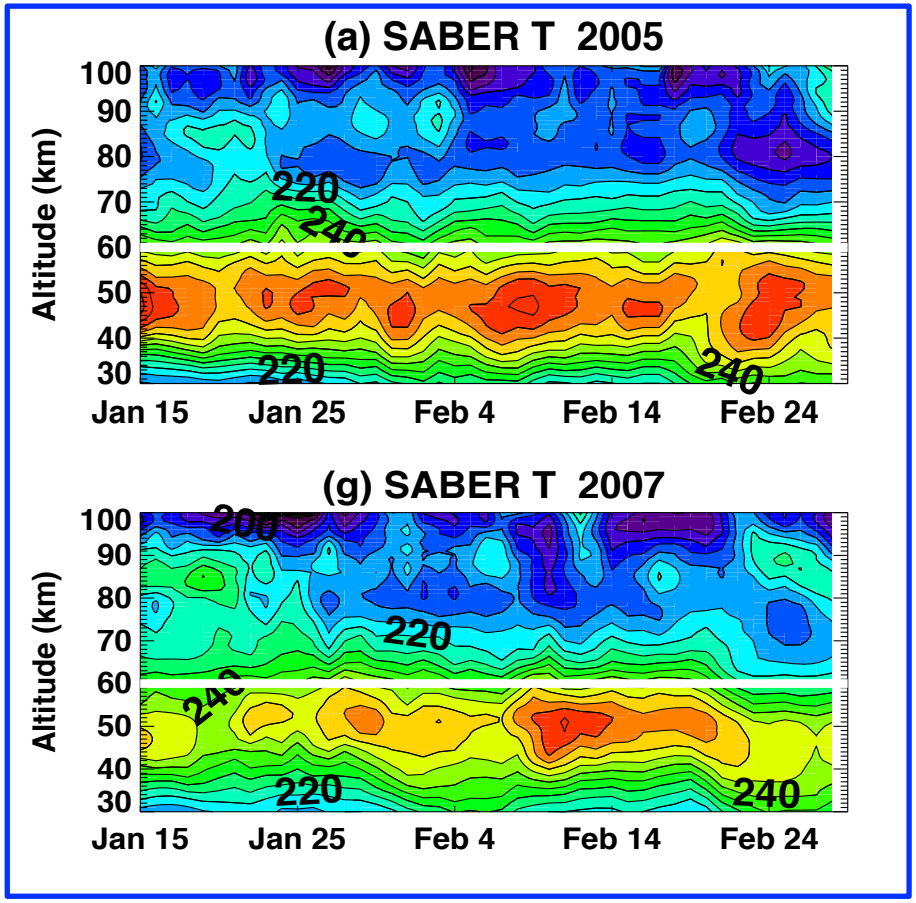
MLS Satellite Observations (Microwave Limb Sounder)



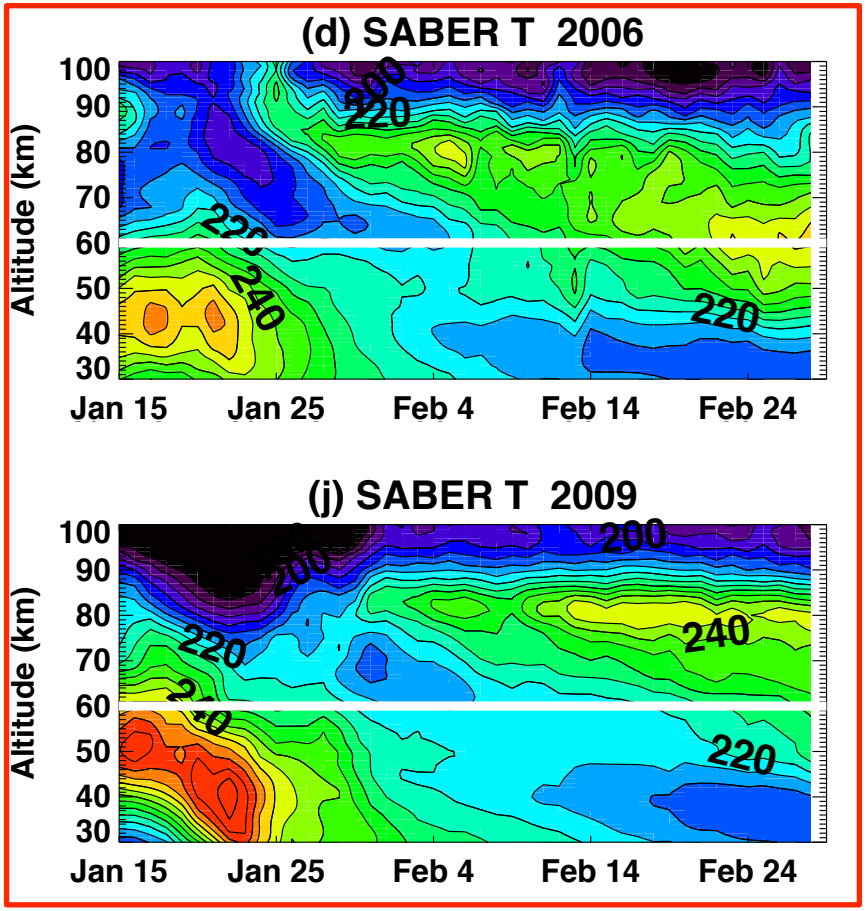
[*Wu and Eckermann*, 2008]

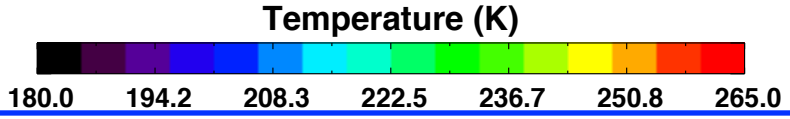
Zonal-Mean SABER Temperature

Non-Elevated Stratopause Years



Elevated Stratopause Years

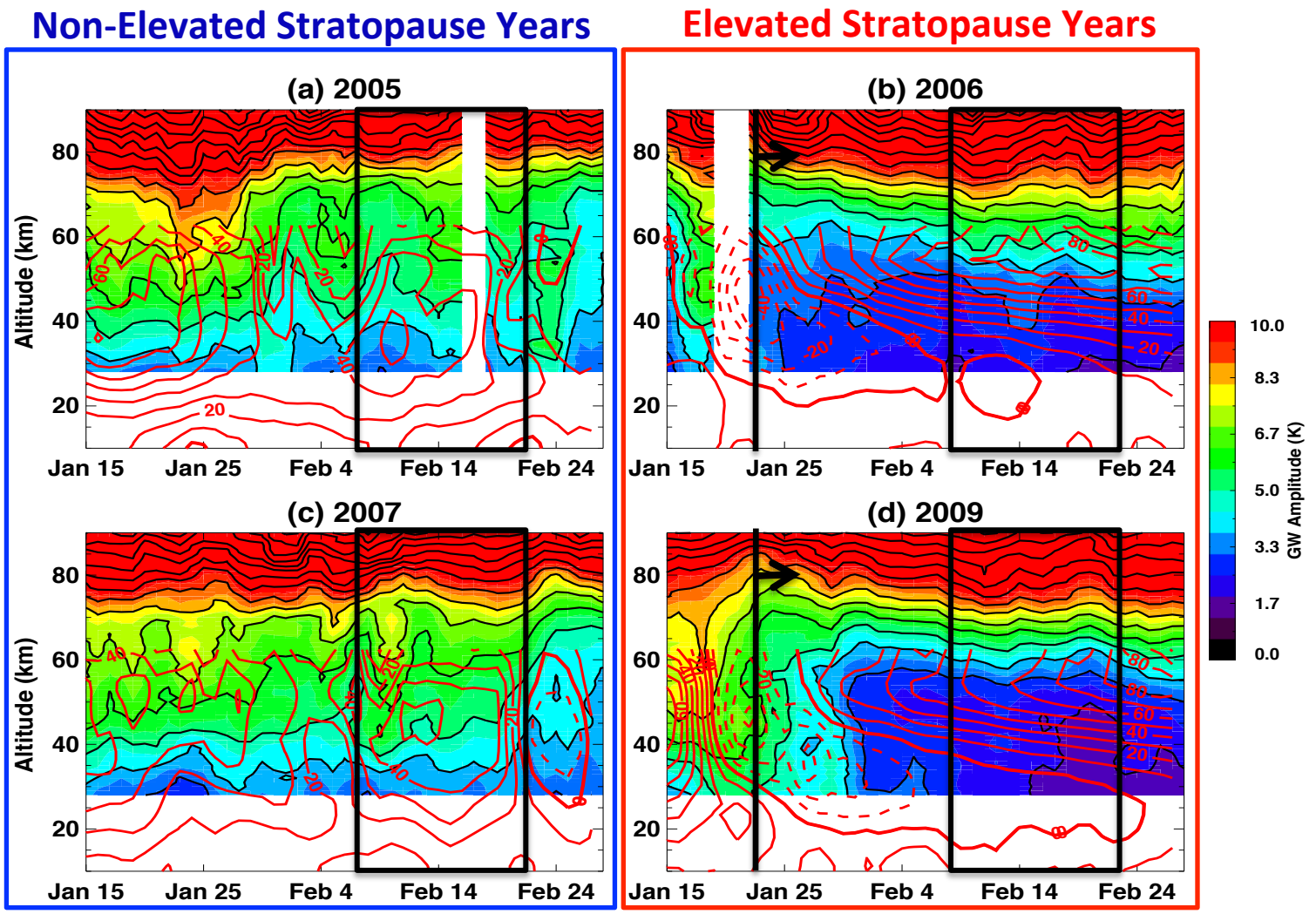




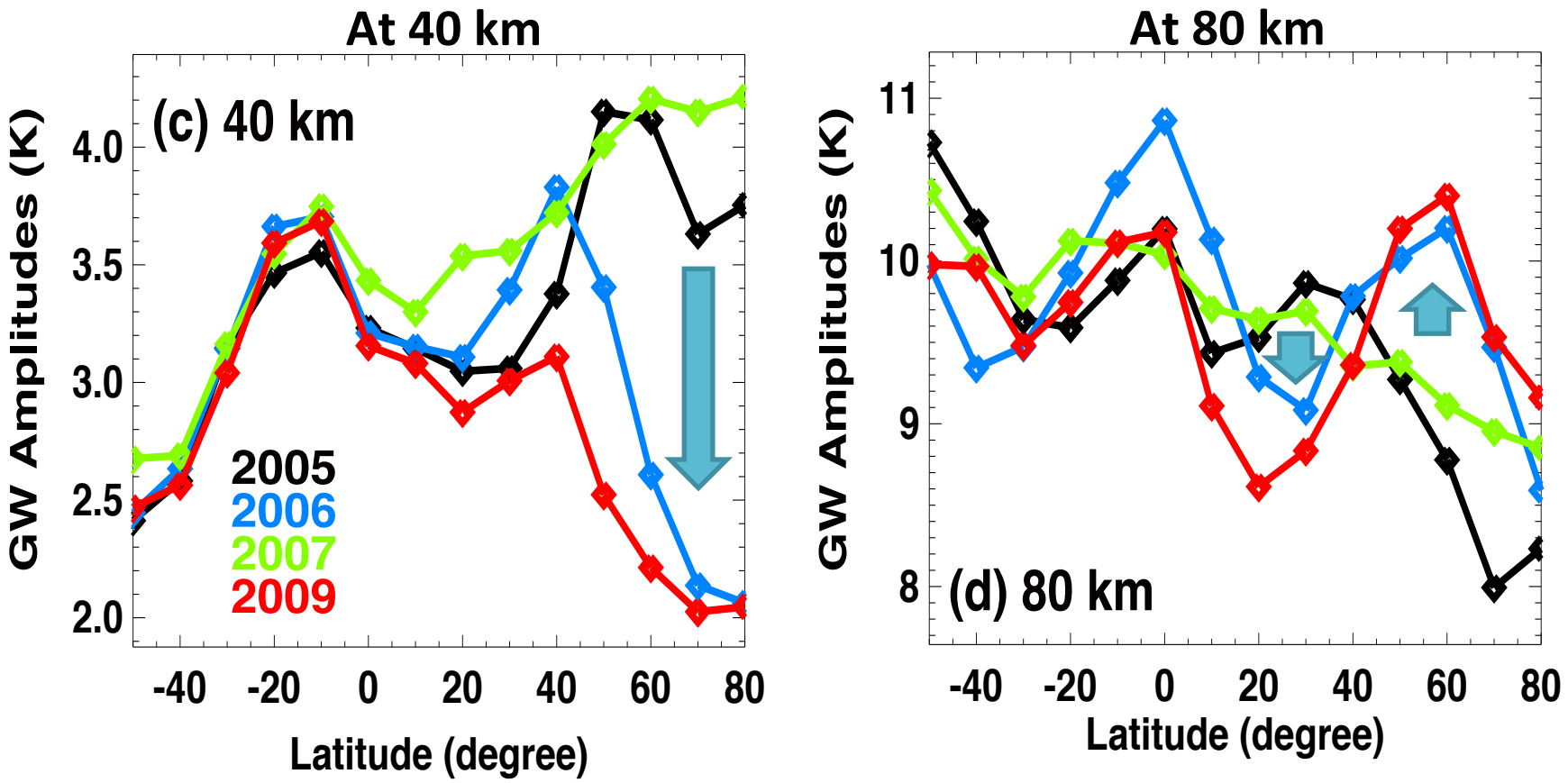
Zonal-Daily Mean Gravity Waves (Latitude 55-75N)

✓ Suppressions of GWs in the stratosphere are comparable with previous studies [e.g., *Thurairajah et al*. 2010; Yamashita et al. 2010]

✓ In contrast to suppressions of GWs in the stratosphere, GWs in the MLT increased during elevated stratopause events.



Zonal-Daily Mean Gravity Waves (averaged over February 10-19)

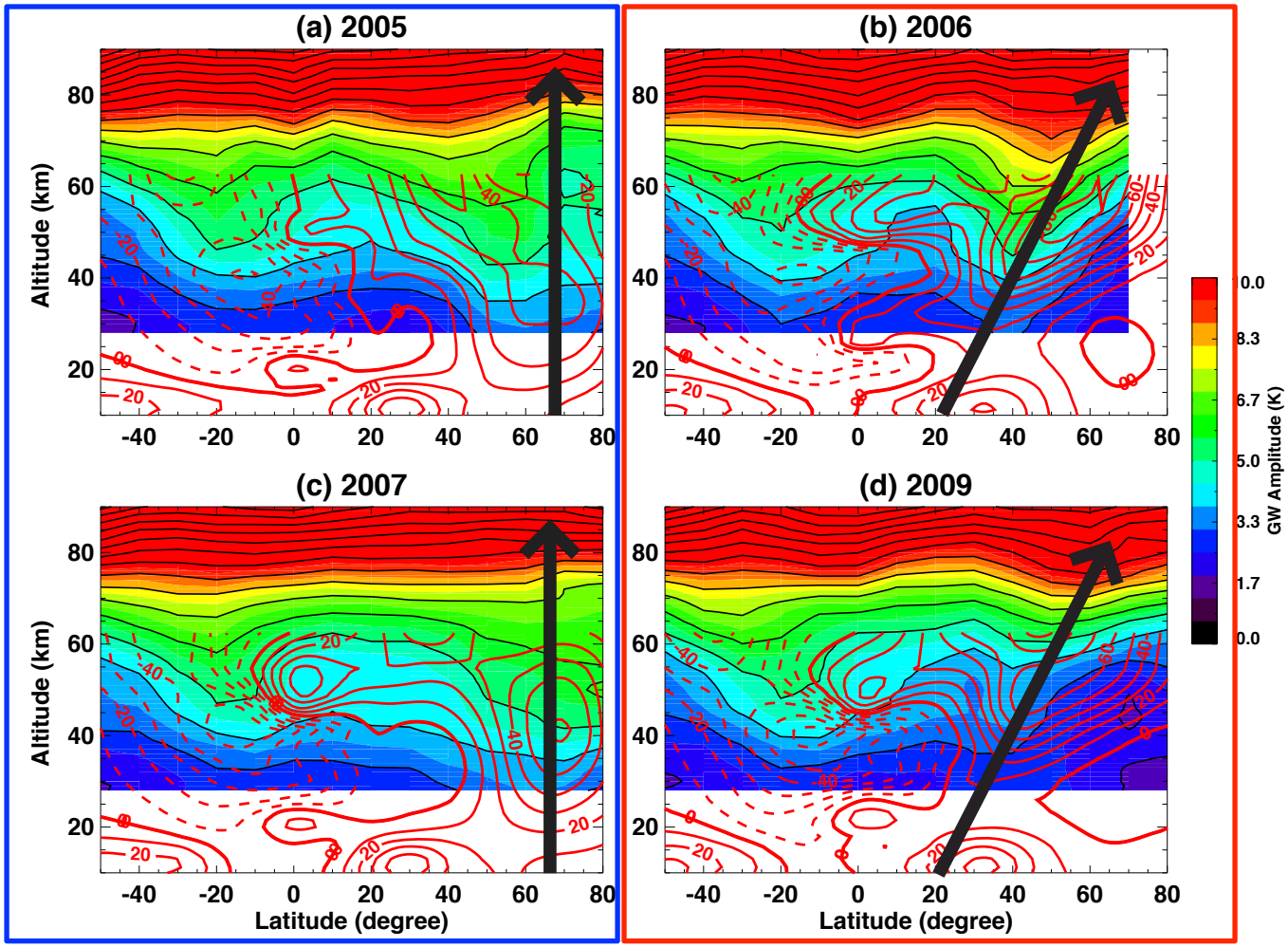


Gravity wave **at 40 km Decrease** during elevated stratopause years (2006, 2009)
at 80 km Increase during elevated stratopause years (2006, 2009)

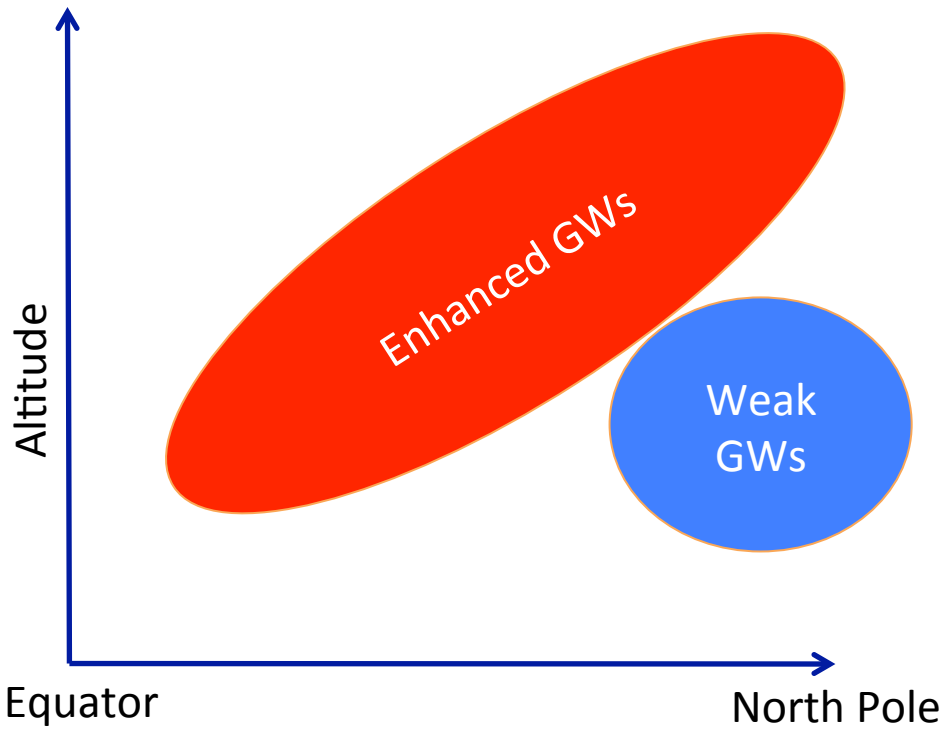
Zonal-Mean Gravity Wave Amplitudes

Gravity Waves are averaged over Feb 10-19

Non-Elevated Stratopause Years **Elevated Stratopause Years**



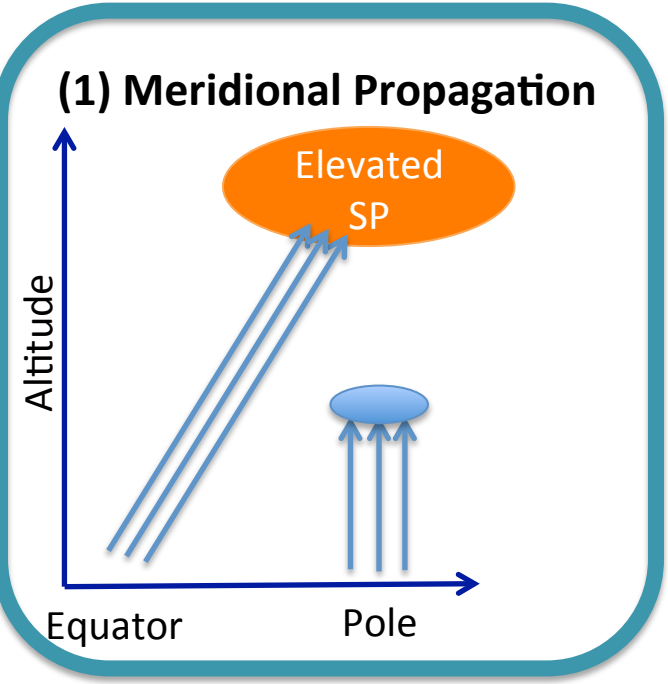
SABER Observations

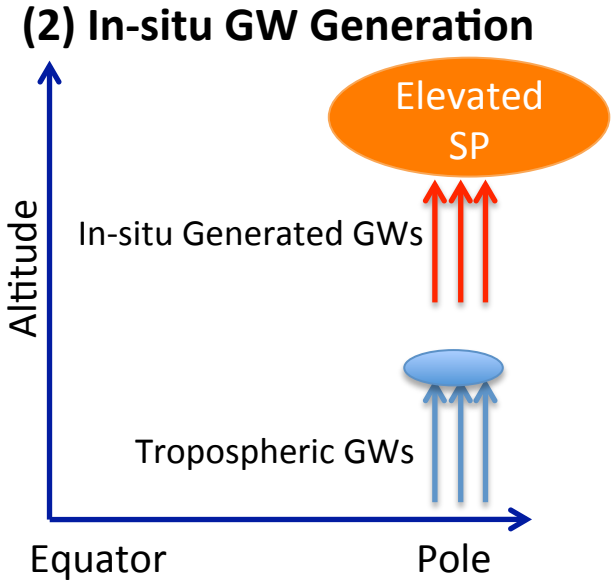


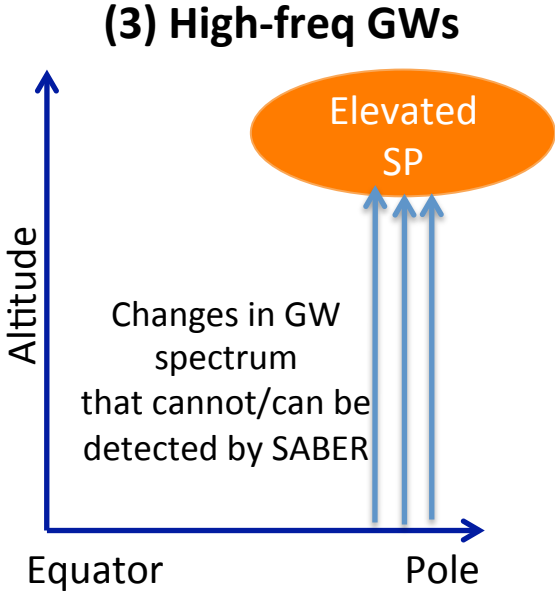
What is the causes of gravity wave changes?

Hypothesis


Altitude
Enhanced GWs
Weak GWs
Equator
North Pole


(1) Meridional Propagation
Elevated SP
Altitude
Equator
Pole

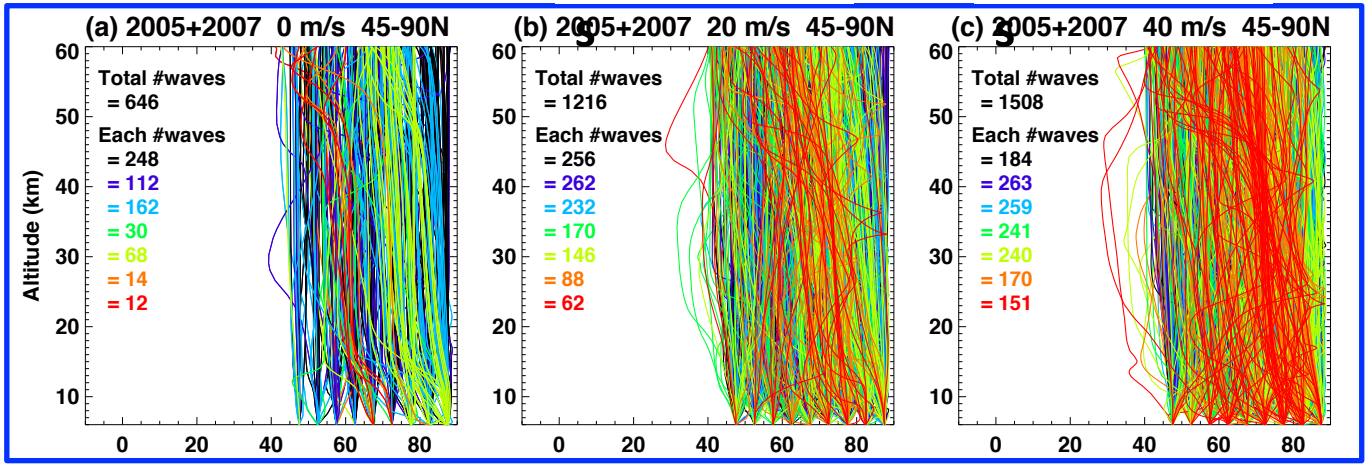

(2) In-situ GW Generation
Elevated SP
In-situ Generated GWs
Altitude
Tropospheric GWs
Equator
Pole


(3) High-freq GWs
Elevated SP
Altitude
Changes in GW spectrum that cannot/can be detected by SABER
Equator
Pole

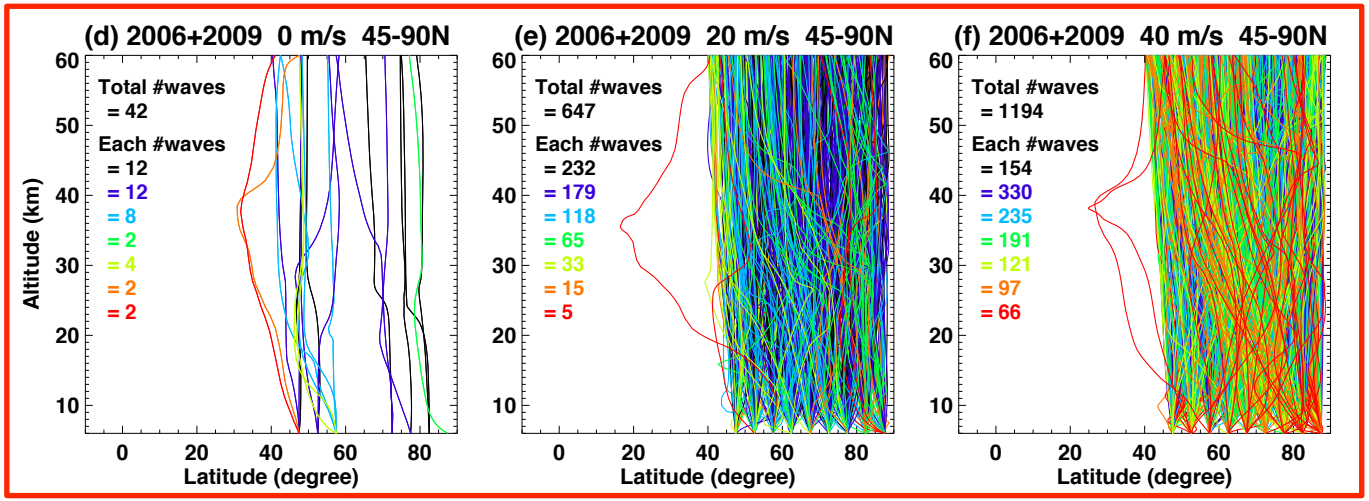
GROGRAT Ray-Path (GW from 40-80°N and reached high-latitude 60 km)

Ch = 0 m/s | **Ch = 20 m/** | **Ch = 40 m/**

Non-Elevated Stratopause Years



Elevated Stratopause Years



Wavelength
100 km
200 km
400 km
600 km
800 km
1000 km
1200 km

Changes in GW propagation

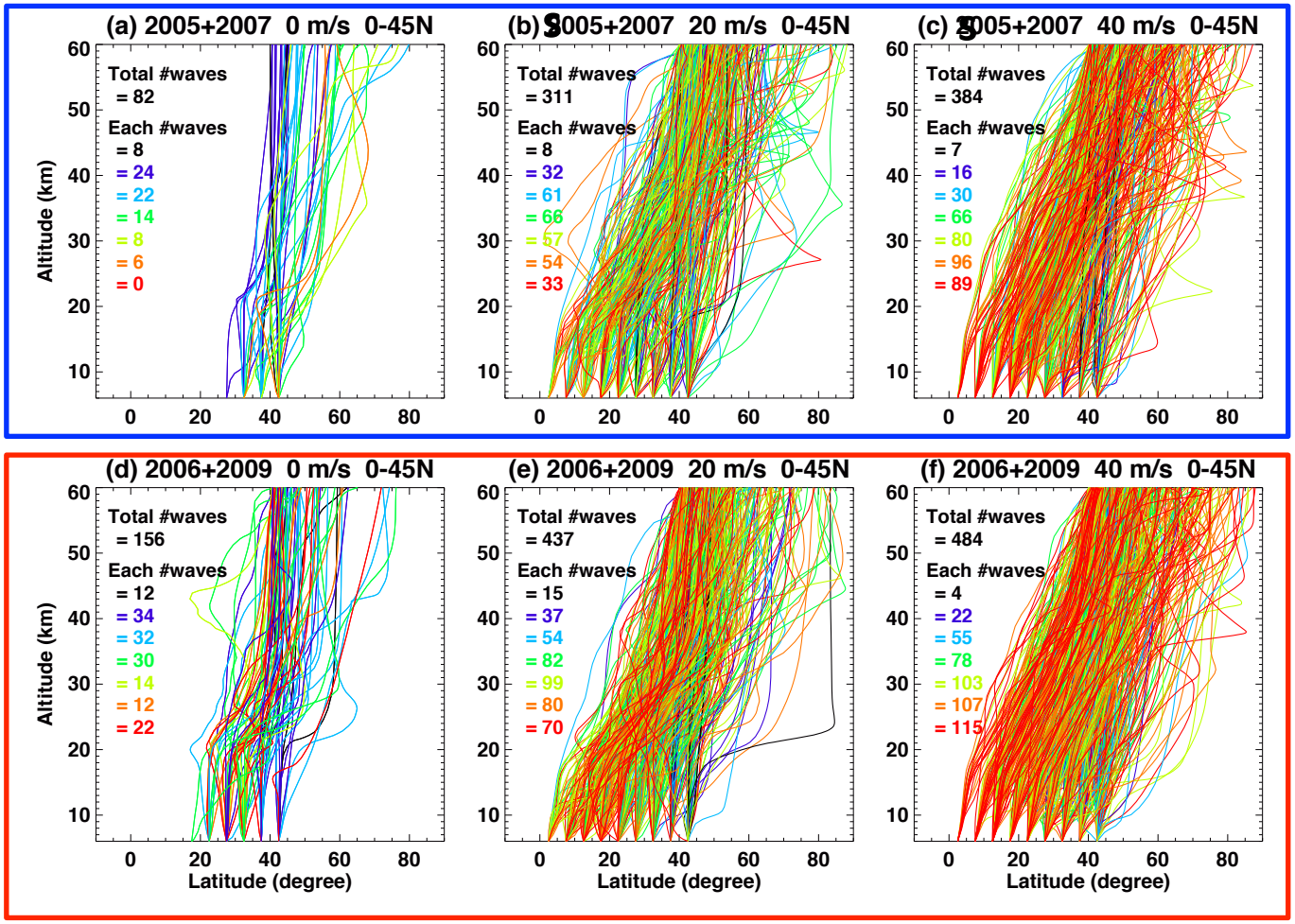
−93% | −47% | −21%

GROGRAT Ray-Path (GW from 0-40°N and reached high-latitude 60 km)

Ch = 0 m/s | **Ch = 20 m/** | **Ch = 40 m/**

Non-Elevated Stratopause Years

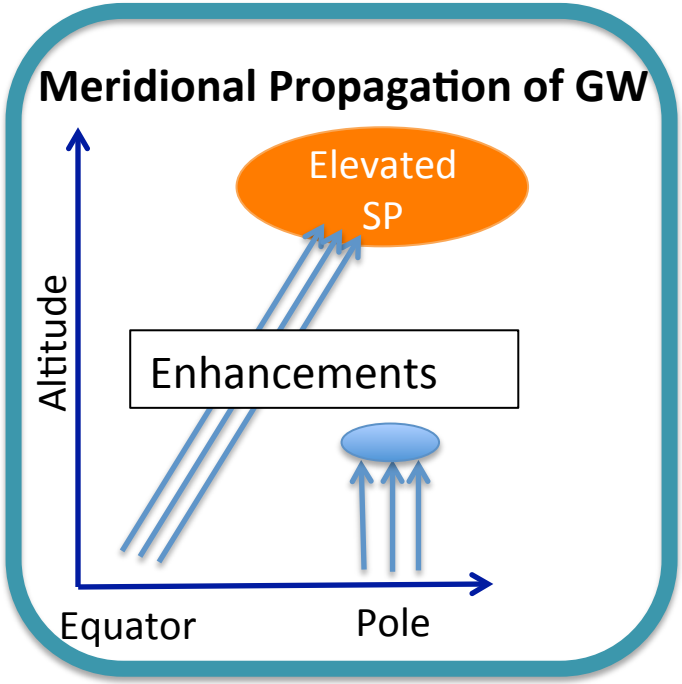
Elevated Stratopause Years



Wavelength
- 100 km
- 200 km
- 400 km
- 600 km
- 800 km
- 1000 km
- 1200 km

Changes in GW propagation: +47% | +41% | +21%

Possible Mechanisms



Our results suggest that enhancements of meridional propagation of gravity waves can contribute to sustain elevated stratopauses.

Conclusions

1. SABER gravity waves are validated with COSMIC/GPS and SABER observations
2. Gravity waves are enhanced above ~60 km but decreased below ~60 km during the downward movement of elevated stratopauses.
3. GROGRAT ray-tracing results suggest that the increase of meridional propagation of gravity wave might contribute to the enhancements of gravity waves in the polar mesosphere.

Yamashita, C., S. L. England, T. J. Immel, and L. C. Chang (2013), Gravity wave variations during elevated stratopause events using SABER observations, *J. Geophys. Res. Atmos*., 118, doi:10.1002/jgrd.50474.