
Global Responses of Gravity Waves to Planetary Wave Anomalies

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Background

- ✓ *Karlsson et al.* [2007] found connections between PWs in the winter polar stratosphere and polar mesospheric clouds (PMCs) at the summer mesopause.
- ✓ Inter-hemispheric occurs not only during SSWs but during non-SSW period.

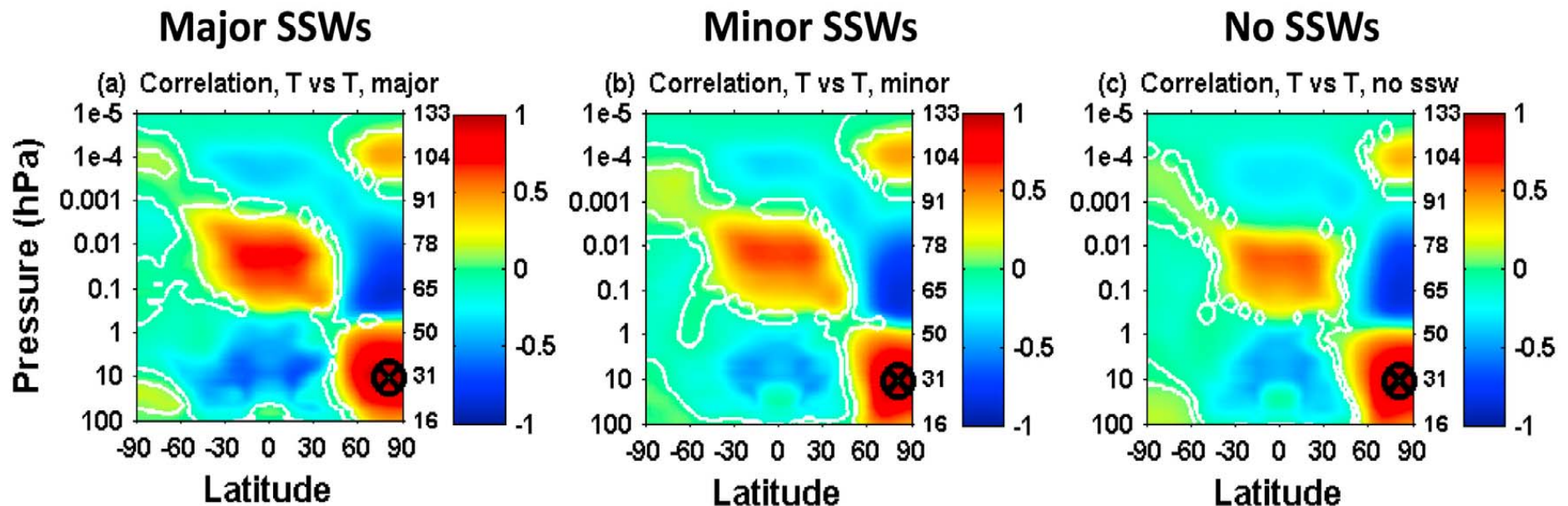


Figure 1. Correlations between winter stratosphere temperature (T) and global temperature from *Tan et al.* [2012].

➔ One of the possible mechanisms of inter-hemispheric coupling is changes in gravity wave forcings in response to planetary wave anomalies according to modeling studies [e.g., Becker and Fritts et al., 2004]

Objective

Problem

There is not enough global gravity wave observations to study changes in gravity waves in the MLT.

Goal

SABER can provide global gravity wave observations [Preusse et al., 2009]

=> study gravity wave responses to planetary wave anomalies and inter-hemispheric coupling

SABER 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)

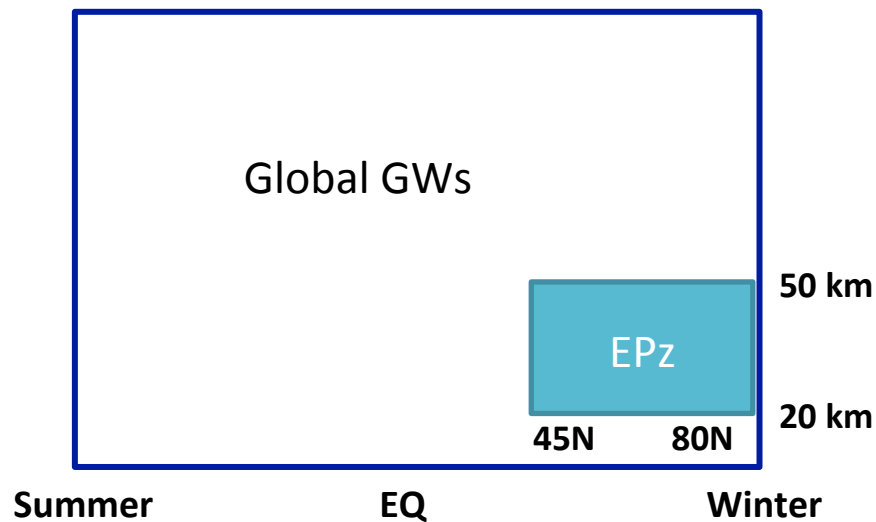
$$T' = T - T_0$$

Background Temperature Estimation Method:

1. Daily temperature data are separated by local time (ascending and descending node) and binned into $24^\circ \times 5^\circ$ (longitude \times 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.

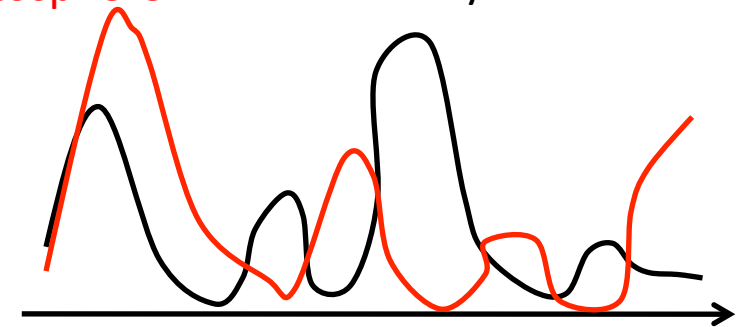
Validations and detailed analysis method => *Preusse et al.* [2009], *Yamashita et al.* [2013, JGR]

Correlation Method



Planetary Waves in the
polar stratosphere

Gravity Waves



Time-Series



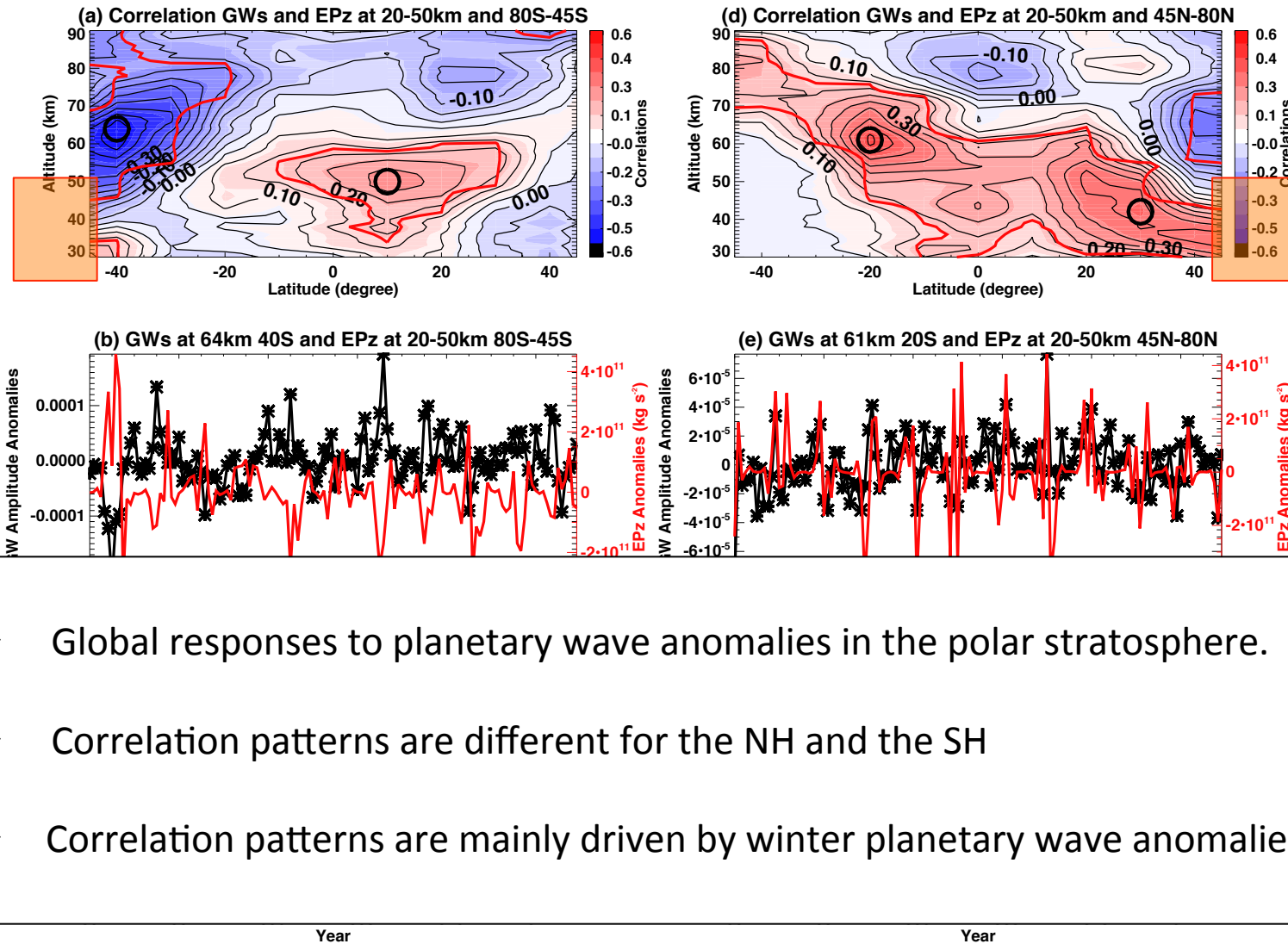
Calculate Correlation Coefficients

Gravity Waves => Temperature variance $(T'/T_0)^2$

Planetary Waves => Vertical components of EP Flux (EPz)

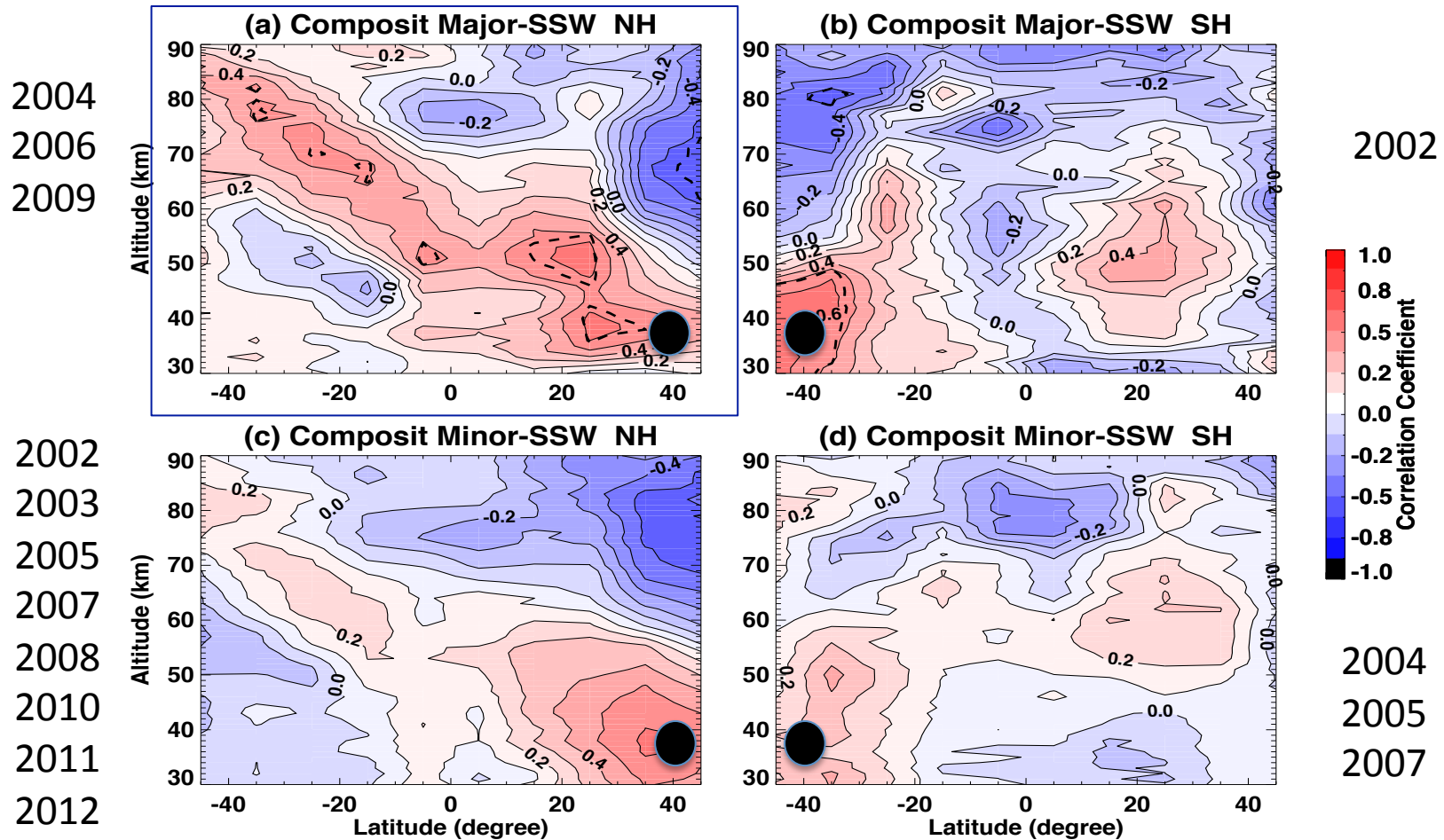
e.g., Positive Correlation => gravity wave enhancements when planetary waves are large.

Correlations between anomalies of Gravity Waves and EP Flux (Epz)



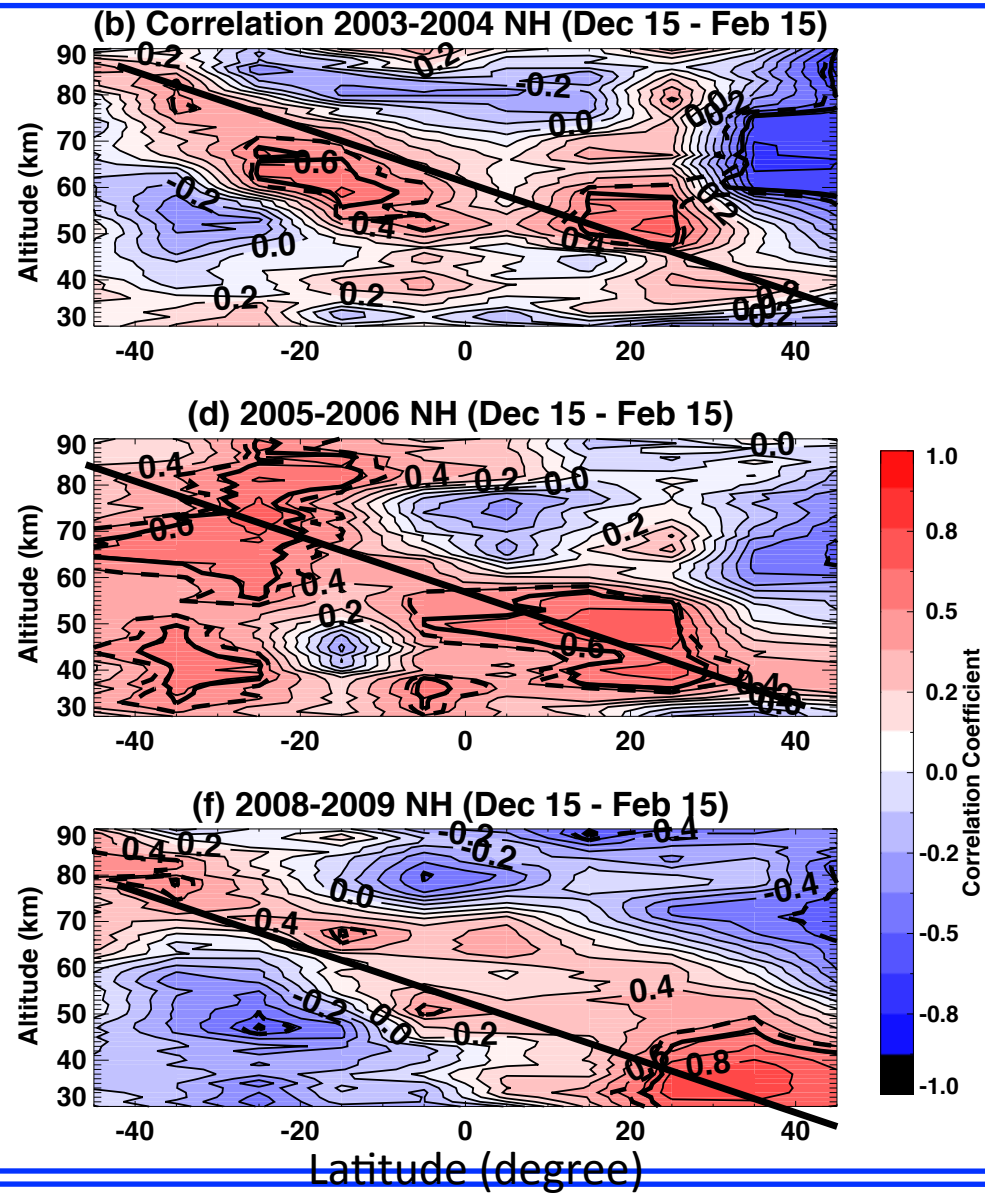
- ➔ Global responses to planetary wave anomalies in the polar stratosphere.
- ➔ Correlation patterns are different for the NH and the SH
- ➔ Correlation patterns are mainly driven by winter planetary wave anomalies

Correlations during SSWs



NH => Time-series from Dec 15 to Feb 15 for the NH SSWs, Aug 15 to Oct 15 for the SH SSWs

Correlations between anomalies GWs and EPz during major SSWs in the NH

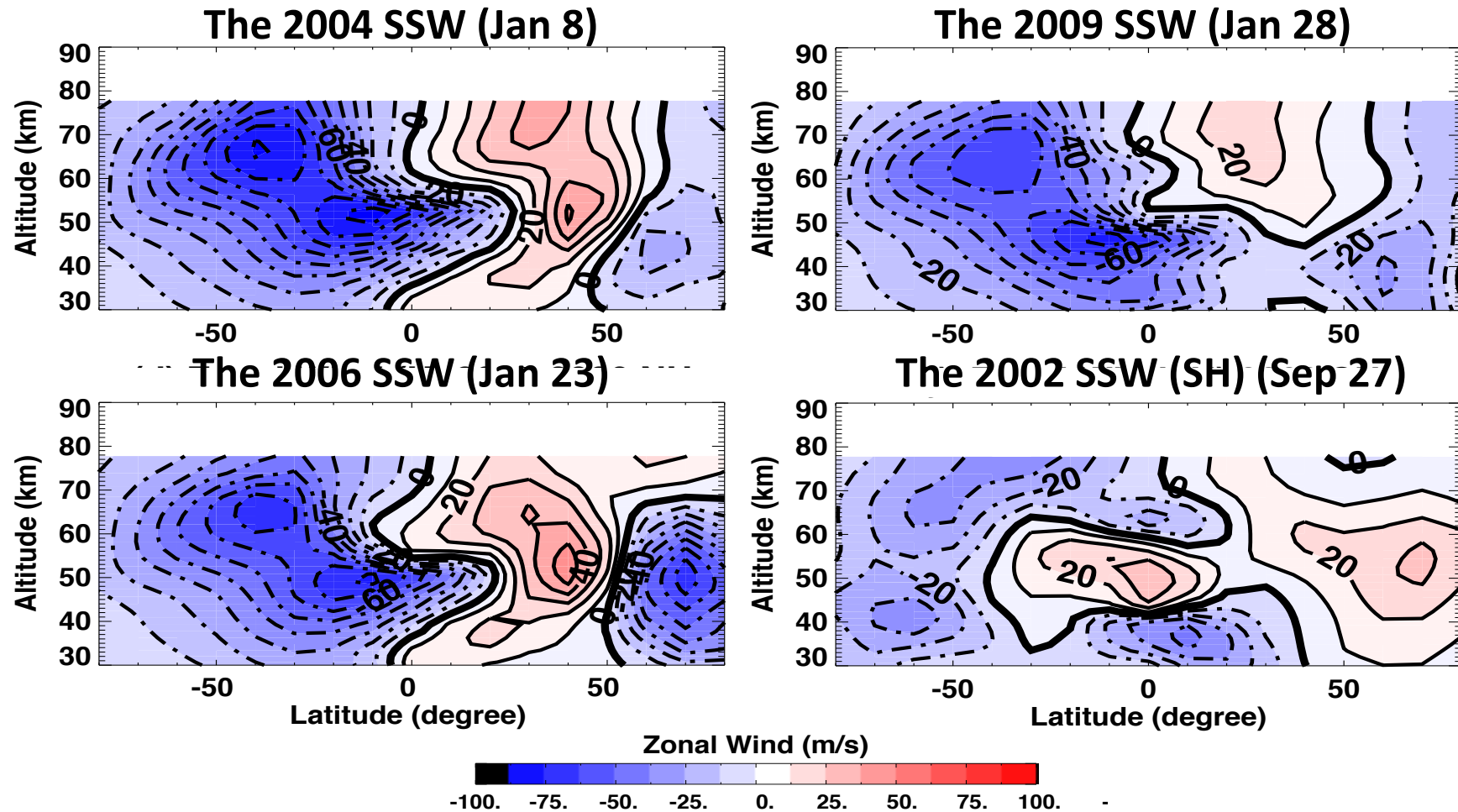


SABER Observations

Two Questions:

- 1) Why are GW responses in the NH and SH different ?
⇒ **difference in wind structure in the NH and SH**
- 2) Why do the region of positive correlations extend from the winter stratosphere to the summer mesosphere?
⇒ **Changes in GW propagation (filtering, directions) ?**
⇒ **Still not clear...**

Causes of Difference in Correlation Patterns (NH and SH)



Difference in correlation patterns

SSWs in the SH mostly occur during the transition from winter to spring

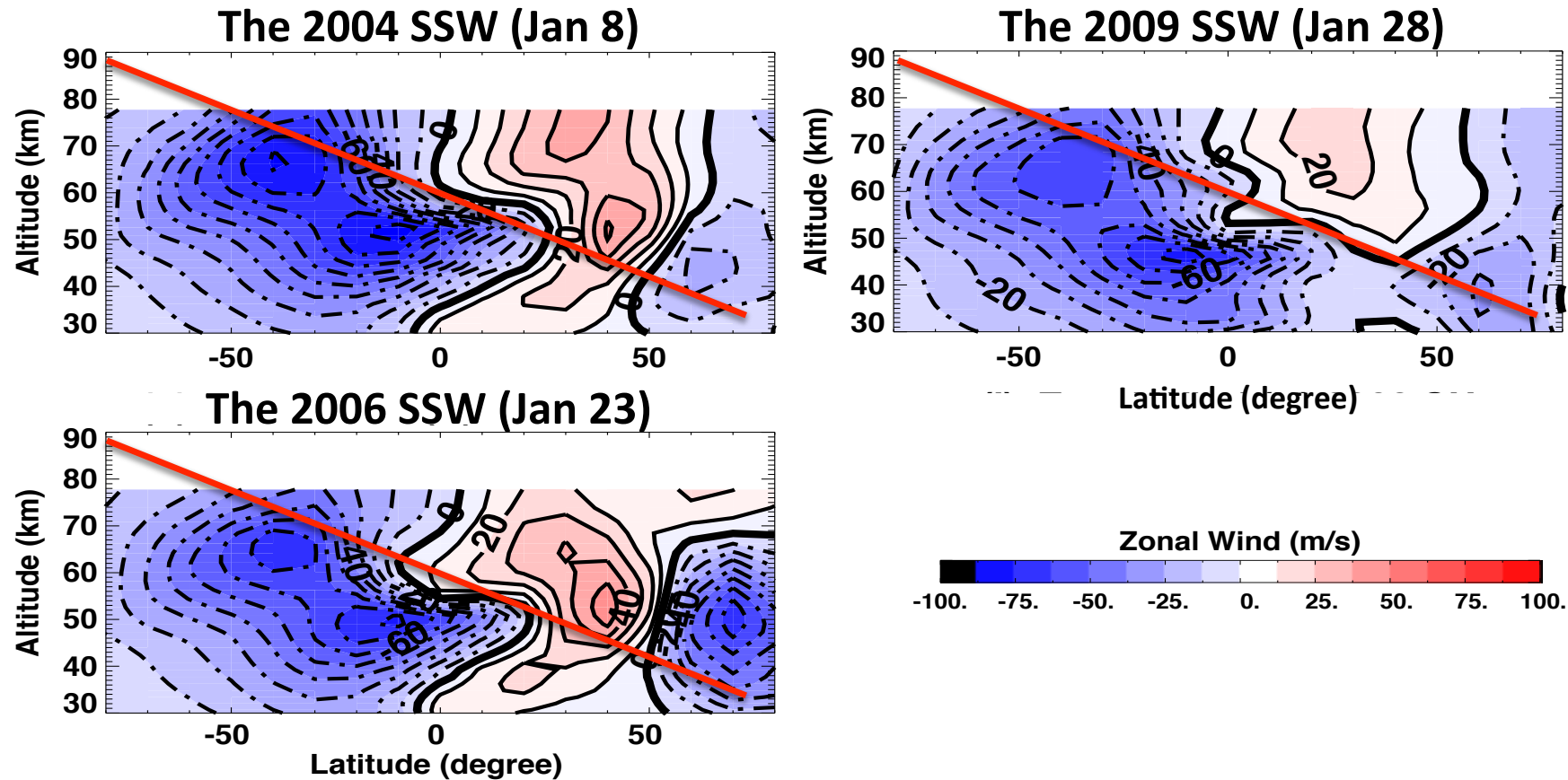


Background wind structure is different compared to SSWs in the NH (major SSWs)



Difference in gravity wave responses to planetary wave anomalies

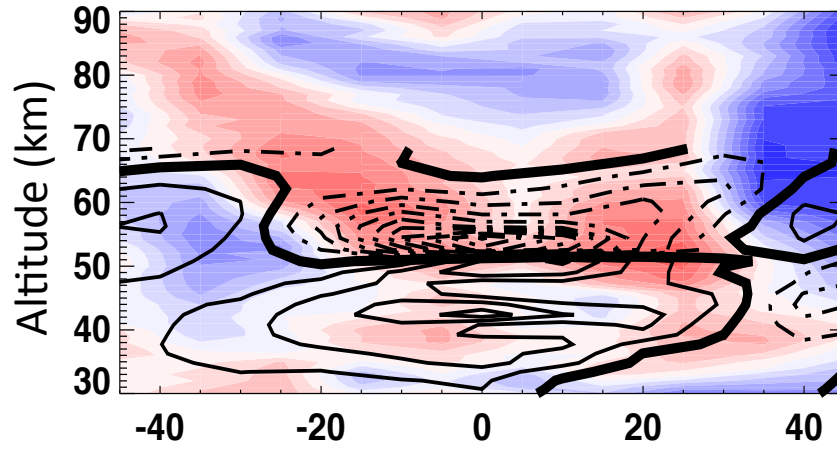
Causes of Diagonally Extended Positive Correlations



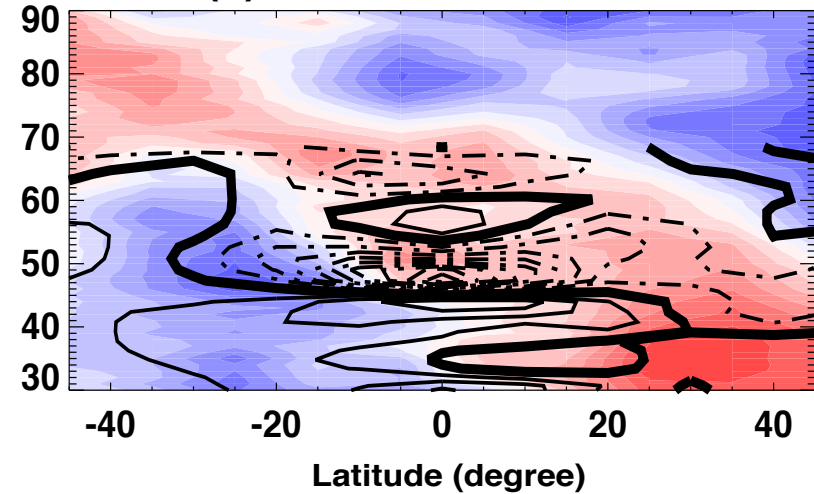
- ✓ Positive correlation regions locate above the westward jet in the equator and in the summer hemisphere.

Correlation and du/dz Anomalies

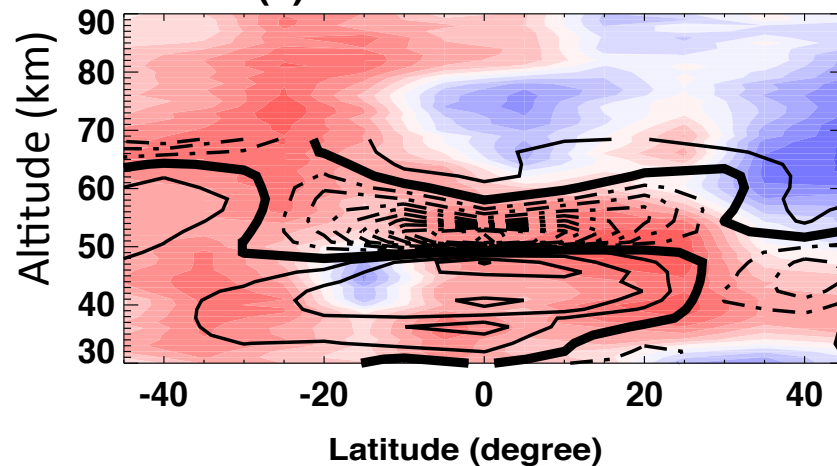
The 2004 SSW (Jan 8)



The 2009 SSW (Jan 28)

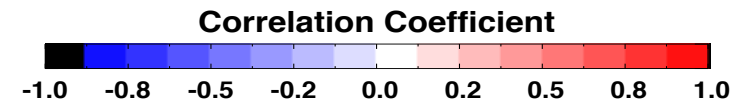


The 2006 SSW (Jan 23)



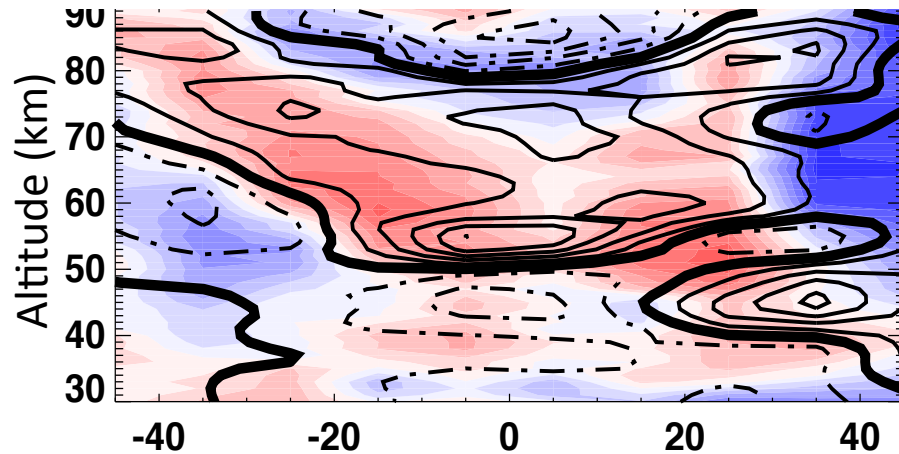
Line contours: du/dz

Color contours: Correlations between anomalies of GWs and EPz.

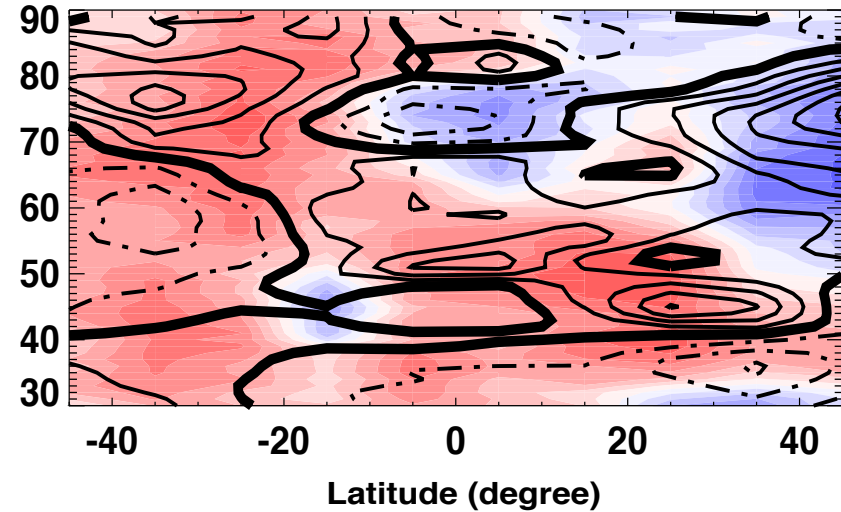


Correlation and Temperature Anomalies

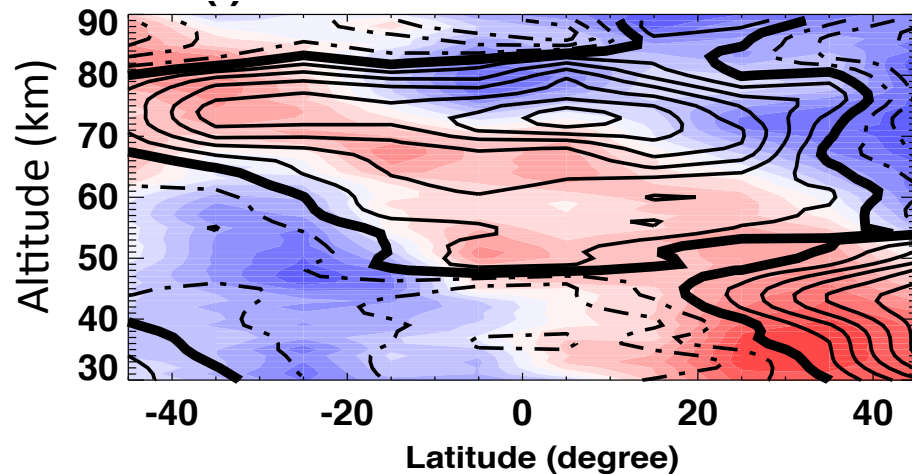
The 2004 SSW (Jan 8)



The 2006 SSW (Jan 25)



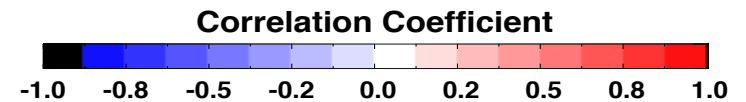
The 2009 SSW (Jan 28)



Line contours: Temperature anomalies

$$T' = T_{\text{during SSW}} - T_{\text{before SSW}}$$

Color contours: Correlations between anomalies of GWs and EPz.



Conclusions

- Gravity wave anomalies have statistically significant correlations with the winter planetary wave activities (EPz) not only in the winter stratosphere but also in the summer hemisphere.
- Positive correlation regions extend from the winter stratosphere to the summer mesosphere.
- Difference in GW responses to PWs in the SH and in the NH can be related to the different wind structure.
- Any comments and suggestions are welcome!