Daily Variations of Lower Thermospheric Tides at Middle Latitude and Their Association with Sudden Stratospheric Warming Events

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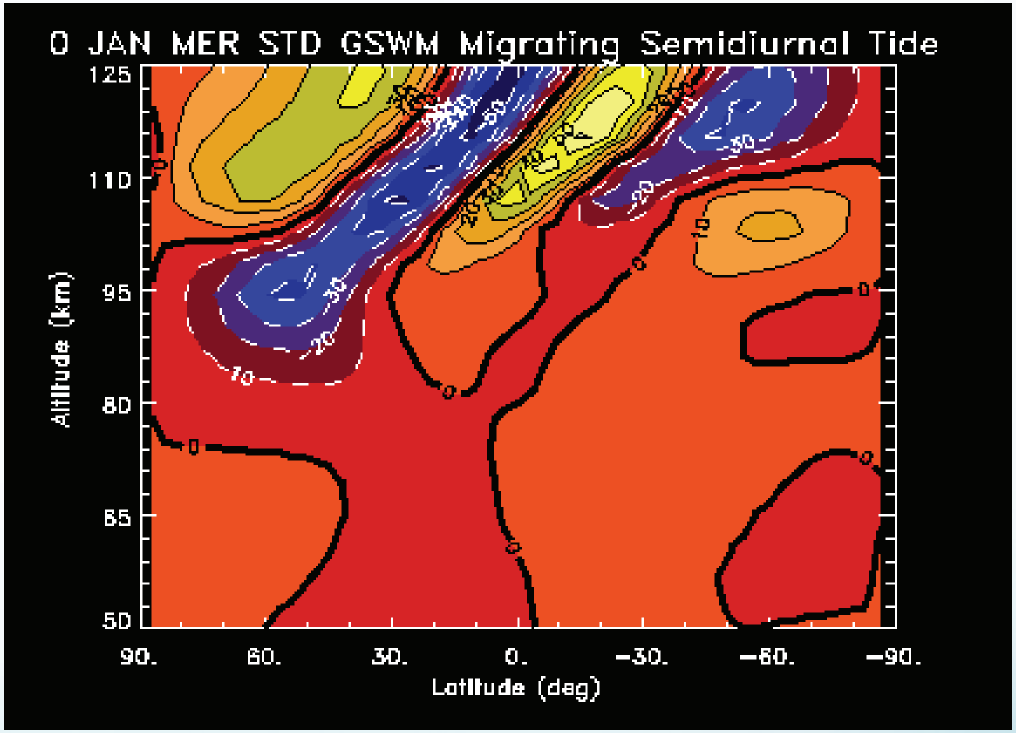
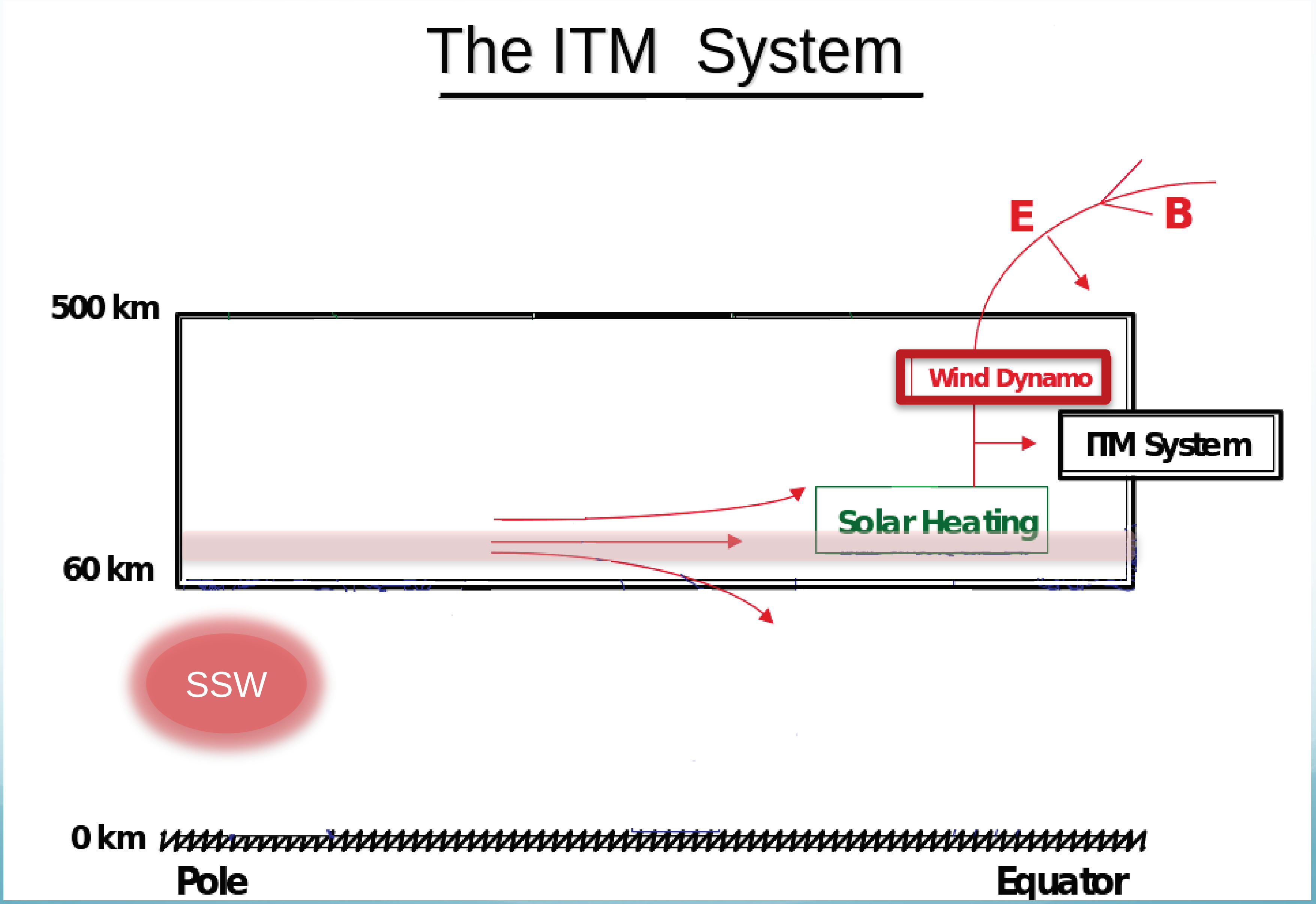
Atmospheric Tides

- Oscillations present in the atmosphere
- Two distinct types
  - Migrating
  - Non-Migrating
- Major periods:
  - 24h, 12h, 8h
- Largely driven by thermal forcing
  - Ozone
  - Water vapor
- Amplitude increases with increasing height

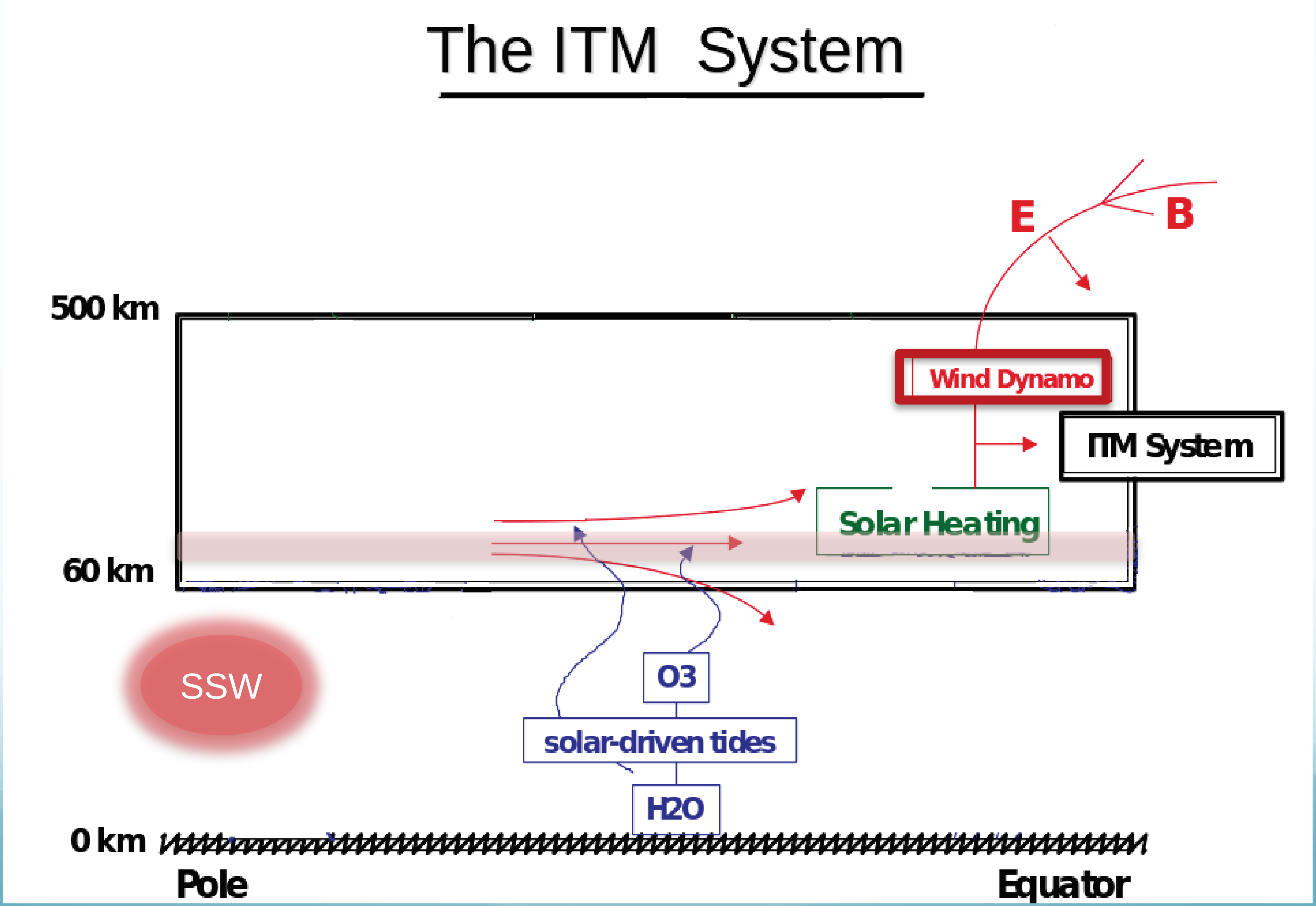


Model output from NCAR/HAO for the Global Scale Wave Model

The Missing Piece



The Missing Piece



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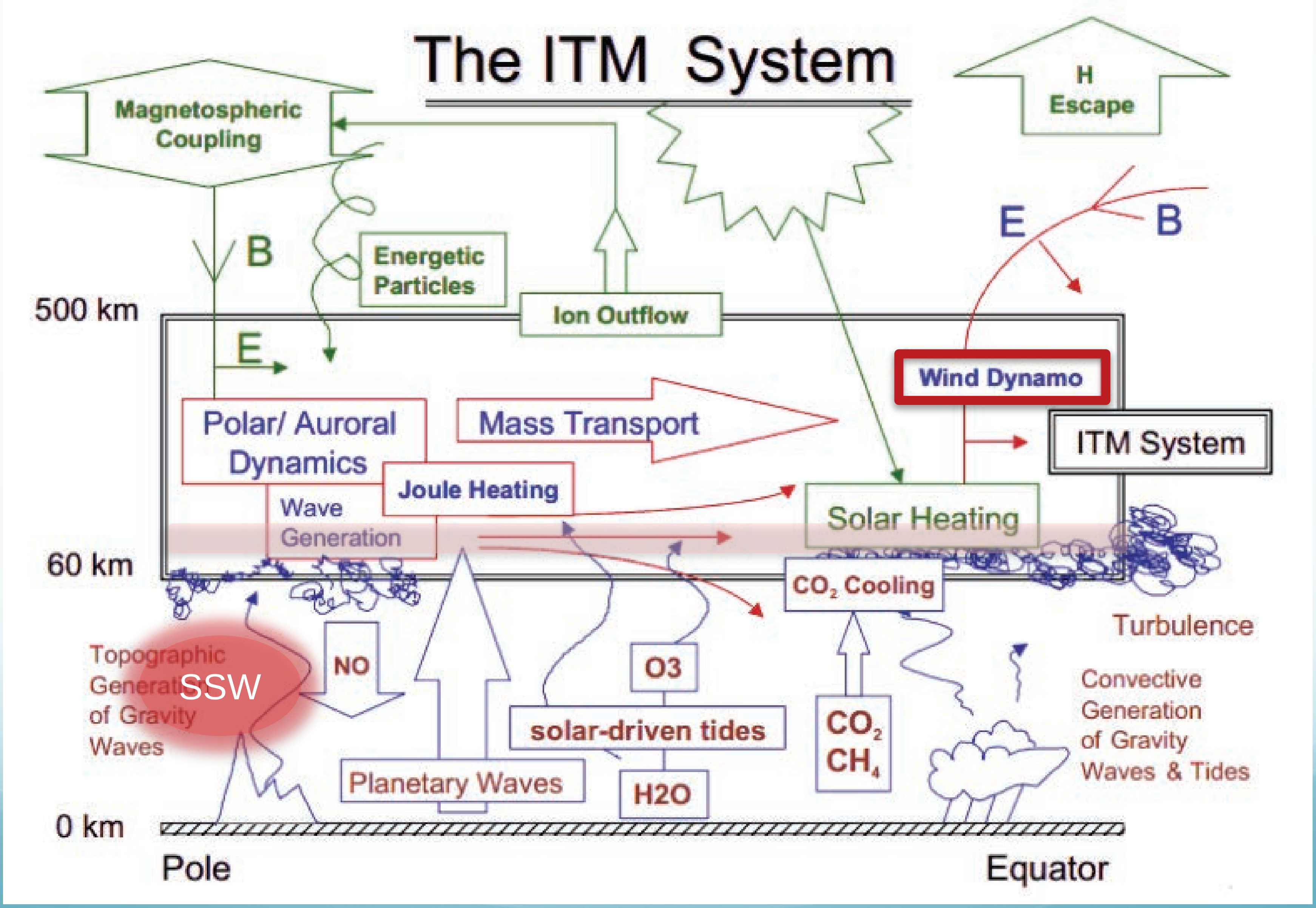
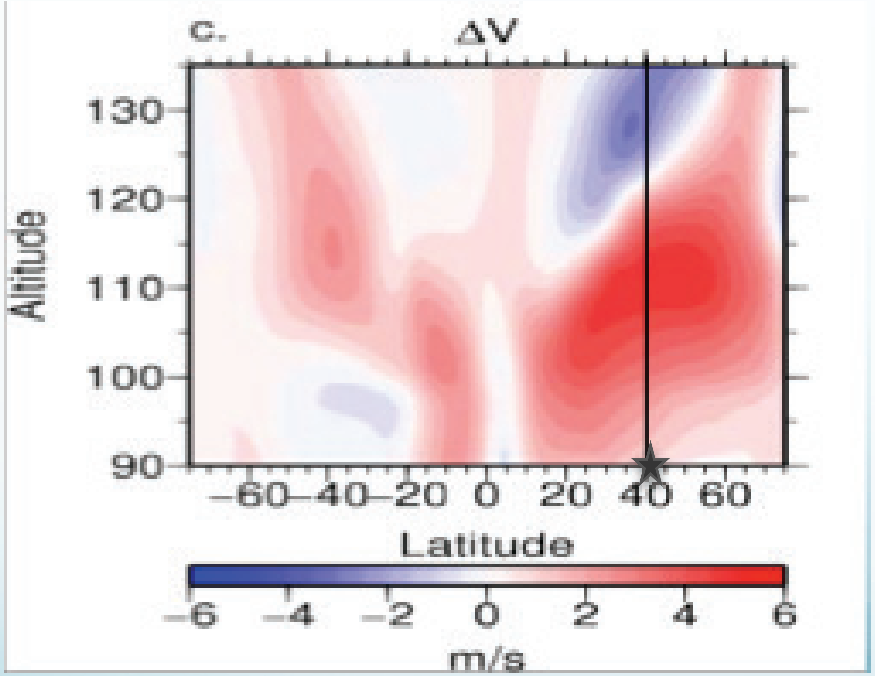


Importance of the Mid-Latitudes

Change of Meridional Wind Component for the 12-h Migrating Tide

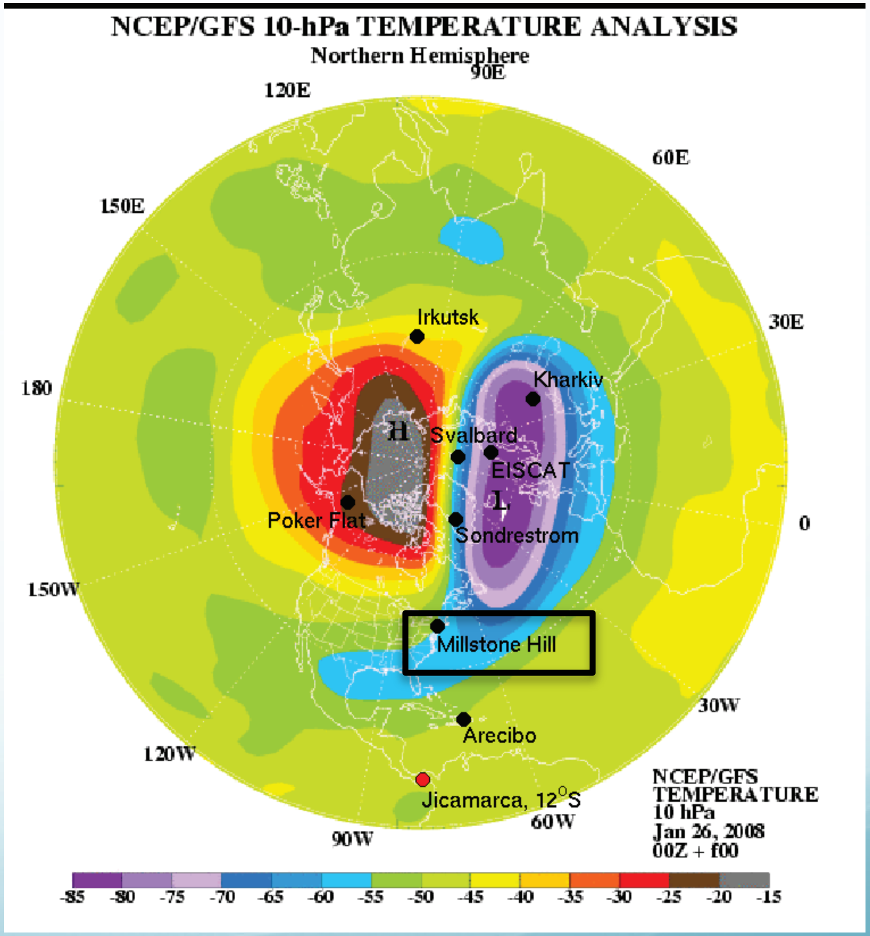


- Modeling efforts show an increase in semi-diurnal (SD) tide globally
  - Maximum Increase at Mid-Latitudes
  - Important altitude range: 100-120km
- Millstone Hill ISR
  - Located at 42^{o}N
  - Ideal altitude range
  - **Only** instrument to provide this type of data

Pedatella et al. 2012

Data Used in This Study

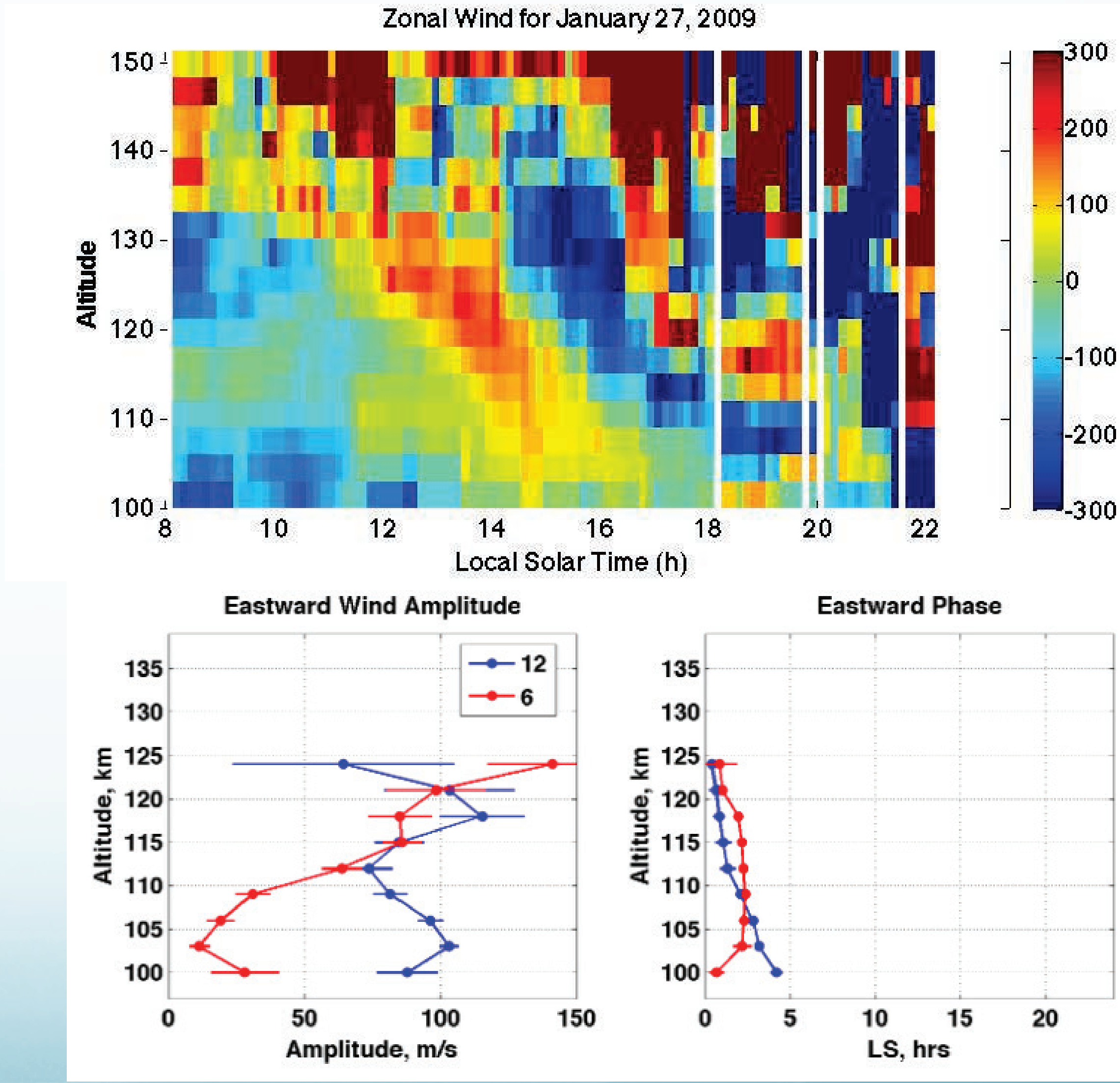
- Data utilized from Millstone Hill ISR (42.6ºN, 288.5ºE) & NCEP
  - Winds
  - Stratospheric Characteristics
- Altitude Range – 100-124km
  - 3km increments
- SSW Events
  - January 17-February 1, 2008
  - January 26-30, 2009
- Non-SSW Events
  - January 20-23, 2007
  - November 8-9, 2007
  - December 11-21, 2007



10hPa Temperature from January 2008 SSW

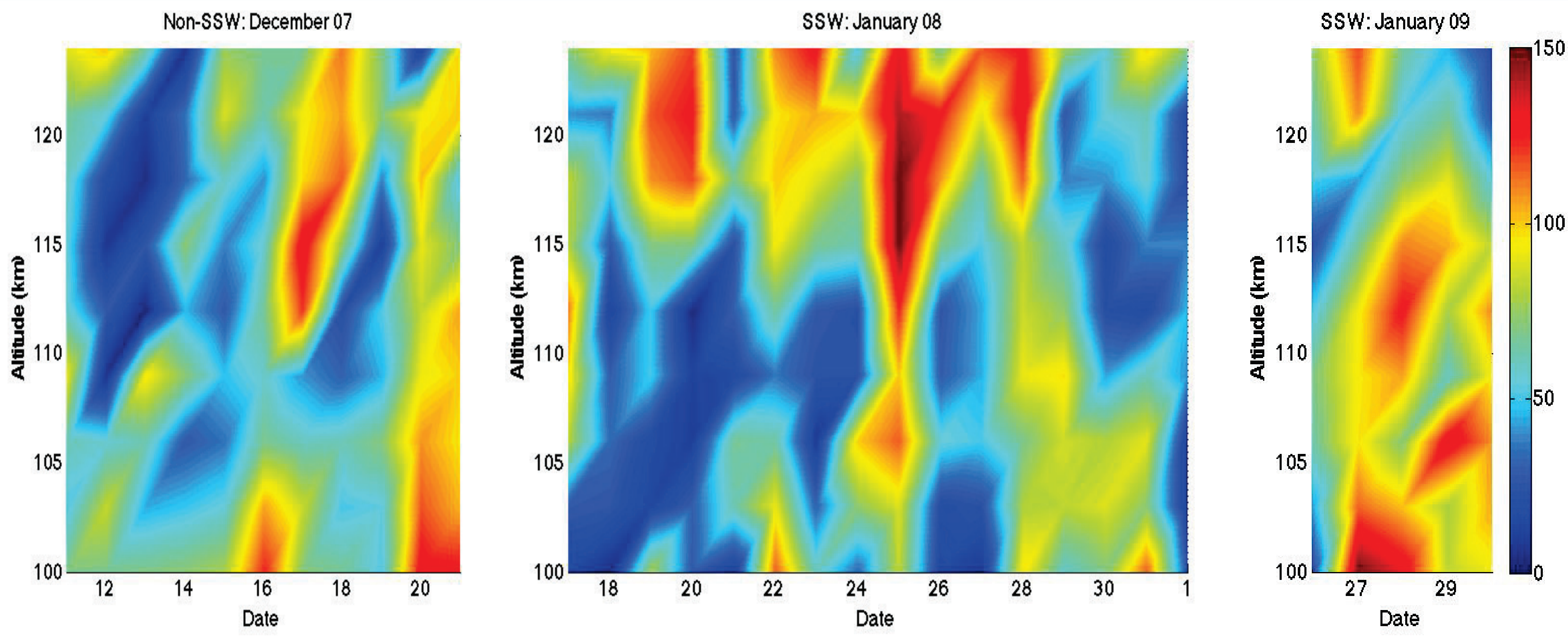
Methodology

- Winds calculated from Millstone ISR data
- Quality Control
  - Large Errors & Wind Speeds
  - Local Sunset times
- Lomb-Scargle Spectral Analysis
  - Time limitation
  - Tides: 12 hour & 6 hour
- Least Squares Fit to determine Amplitude & Phase
- Campaign Comparison



Zonal wind and tidal characteristics for Jan. 27, 2009

Meridional Wind, 12-h Amplitudes



- Comparable in strength & variability
  - December 07: 133 m/s
  - January 08: 152 m/s
  - January 09: 152 m/s

Expectation:

Distinct increase in amplitude

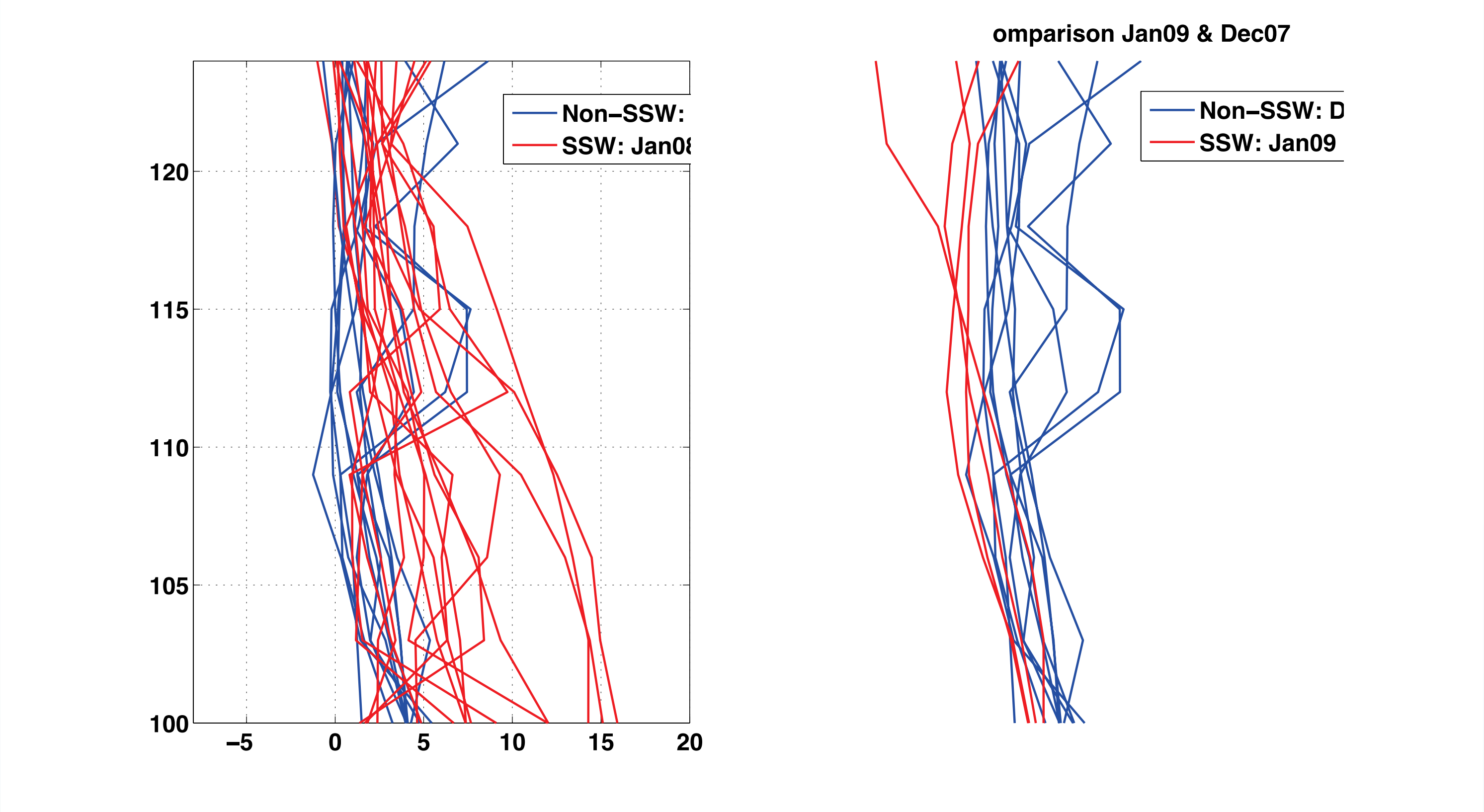
Our Results:

-Both wind components show an increase in max amplitudes

-Increase is case dependent.

-Large variability in all campaigns

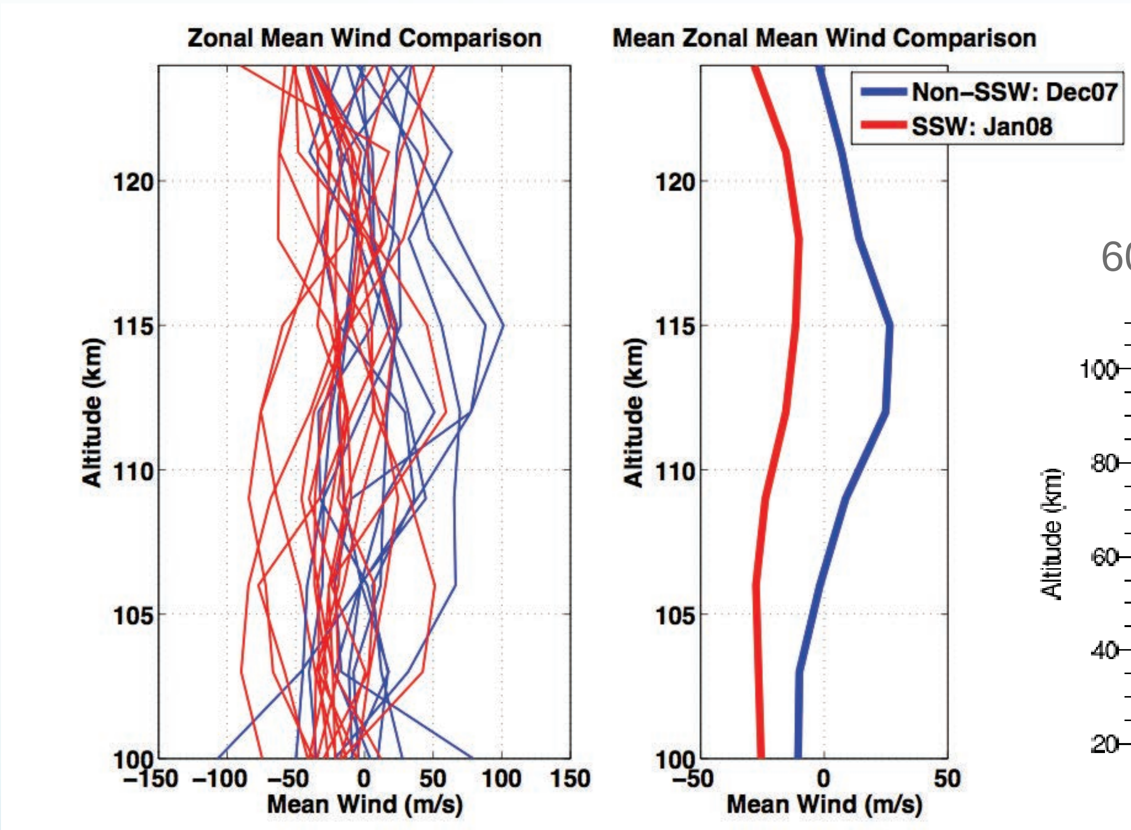
Meridional Phases



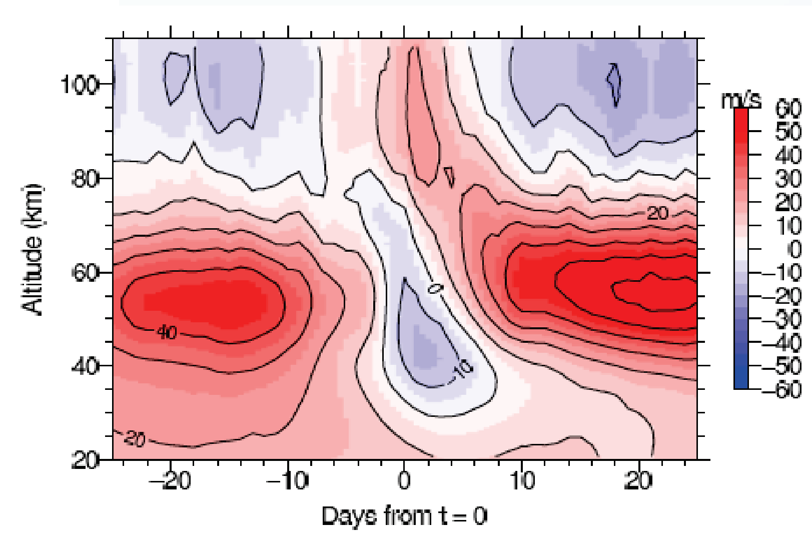
- Large distinction between phases:
  - Non-SSW, Dec 2007: phases consistent
  - SSW, Jan08: difference of 10 hrs
  - SSW, Jan09: difference of 5 hrs
- Oscillating structure of shorter vertical wavelength of about 4/5 days

Difference in phase indicates tides with different vertical wavelength (different tidal modes)

Zonal Mean Winds



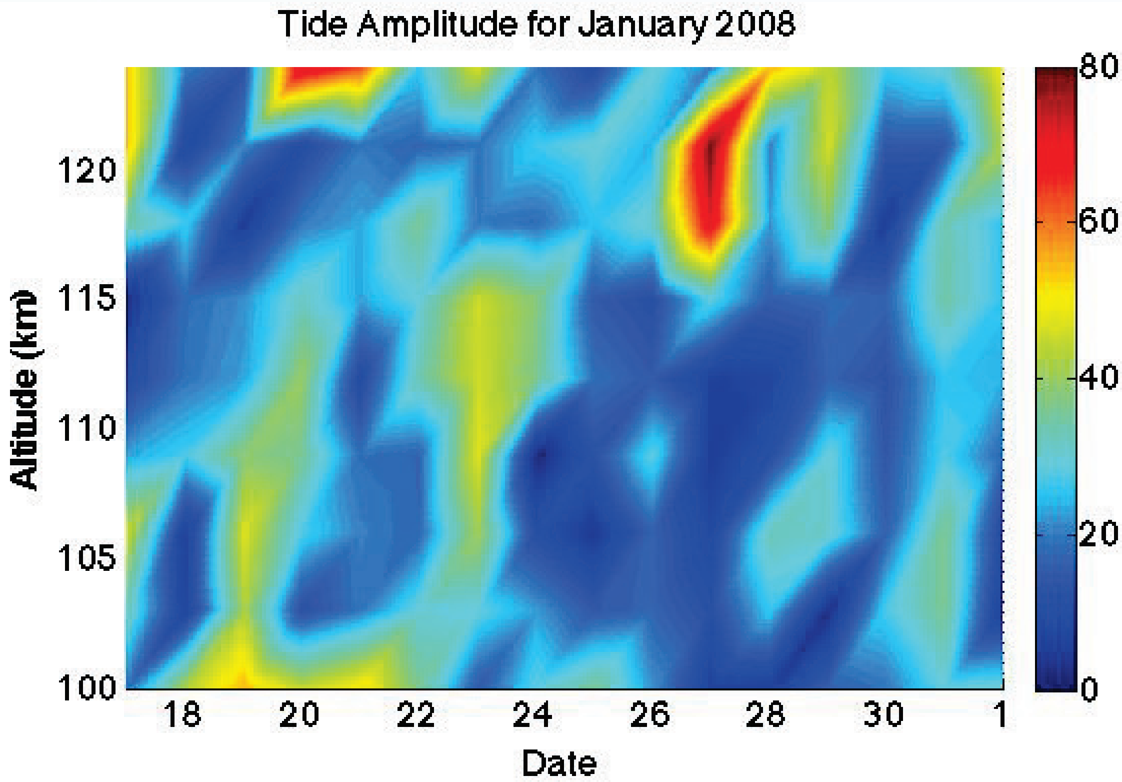
60°N Mean Zonal Winds During SSW

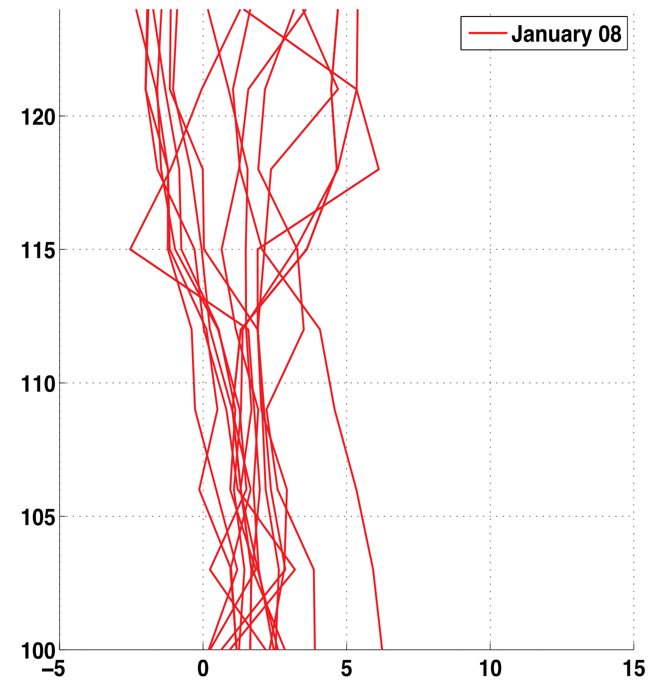


- The SSW zonal mean winds show a westward shift overall when compared to non-SSW events.
- Disagreement with model predictions

Padetella et al 2013; In Press

6 Hour Tide, Zonal Wind for January 2008





- No large difference between zonal and meridional wind
- Day-to-day variability
- 2/3 day oscillation

Quadiurnal tide shows significant presence in all the campaigns.

Summary

- Winds were derived from ISR Data at Millstone Hill and fit with dominant tidal modes to determine lower thermospheric tidal characteristics.
- Large day-to-day variability is present for all campaigns.
- Dominant tides are the semidiurnal (12-h) and quadiurnal (6-h) tides.
- **Major differences between non-SSW and SSW data:**
  - Maximum 12-h amplitudes may show increase (stronger in 2009), but large variability proves too large of a factor.
  - Phase variability larger in the SSW campaigns.
  - SSW zonal mean winds show westward shift overall.
- Future Work
  - Expand to include more campaigns
  - Analyze possible teleconnection
  - More Data (both non-SSW and SSW)!

Acknowledgements

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Any Questions?