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 ITM System

SSW

Solar Heating

Wind Dynamo

ITM System

0 km

Pole

Equator

500 km

60 km
The Missing Piece

The ITM System

- Wind Dynamo
- Solar Heating
- O3
- solar-driven tides
- H2O

- E
- B

500 km

60 km

SSW

0 km

Pole

Equator
The Missing Piece

The ITM System

Magnetospheric Coupling
Energetic Particles
Ion Outflow

500 km

E

Polar/Auroral Dynamics
Mass Transport
Joule Heating
Solar Heating

Wind Dynamo

ITM System

E
B

Turbulence
Convective Generation of Gravity Waves & Tides

SSW

NO
O3
CO2
CH4

Planetary Waves
H2O

0 km

Pole
Equator

Wave Generation

CO2 Cooling

500 km
Importance of the Mid-Latitudes

- 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°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 (42.6°N, 288.5°E) & 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

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
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)!
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Any Questions?