Spectral Analysis of Lower Thermospheric Neutral Winds

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DATA
- September 1-30, 2005
- 100-130 km
- Zonal and Meridional
- ~8 min between pts
- Daily 10-hour gaps
- Quiet-time data

Typical Time Series of Neutral Wind

Millstone Hill ISR, Sep 2005 EASTWARD Wind
WHAT ARE TIDES?

- Continuity, Momentum and Heat Equations:
  Periodic solutions
  Driven by solar forcing

- Propagate Through Space
  Amplitude increases with altitude

- Dissipation:
  Planetary rotation
  Molecular viscosity
  Thermal conductivity
  Ion-Neutral Collisions

- Expectations:
  12, 24, 8-hr tides, multi-day planetary waves
  *We know they could exist, but when and where?*
Neutral Wind Calculation

- Motions of neutrals and ions are coupled

- ISR measures:
  - Electric field
  - Ion drift

- ISR Wind Equation:

\[
U_n = V_i - \left[ \frac{w_i}{v_{in}} \cdot (E + V_i/B) \right] / |B|
\]

- \(U_n\) = Neutral Wind
- \(V_i\) = Ion Velocity
- \(w_i\) = Gyro-Frequency
- \(v_{in}\) = Ion-Neutral Collision Frequency
- \(E\) = Electric Field
- \(B\) = Magnetic Field
SPECTRAL ANALYSIS OF NEUTRAL WINDS

- Unevenly-spaced data

- Use Lomb-Scargle (LSP) instead of Fourier analysis

- Issues Associated With Spectral Analysis:
  Aliasing- not a problem in this case
  Spectral Leakage- big problem
SPECTRAL LEAKAGE

4. **Product of sines → sum and difference frequencies:**
\[
\sin(f_1)\sin(f_2) = \frac{1}{2} [\cos(f_1 - f_2) - \cos(f_1 + f_2)]
\]
RESULTS
Zonal Components from First Run of LSP

8-hr
12-hr
2-day
10-day
5-day
24-hr
METHODS TO VALIDATE SPECTRAL PEAKS:
Which ones are real?

- Ones-and-Zeros
- Segmenting the data
- Subtraction of Semidiurnal Wave
- Localization of Waves
- Run Tests on Average Data
RESULTS OF ONES-ZEROS TEST

Also Statistically Significant:
3-hr, 4-hr, 2-day, 4-day, 7-day
RESULTS OF TESTS

Zonal Components After Subtraction of 12-hr Fit

24-hr

8-hr
RESULTS OF TESTS

Meridional 8-Hr Component from 14-Hr Segment Test

8-hr period is detected on 15 out of 25 days
...MORE RESULTS...

- Spectrum of data gaps detected artifacts:
  24, 12, 8, 6, 4, 3-hour-periods
  quasi-7, quasi-4 and quasi-2-day-periods

- 12-hr tide is dominant

- 24-hr tide is detected
  Shows up after subtraction of 12-hr fit
  Shows up in 14-hr segments and average data
  Varies with altitude

- 8-hr period:
  Detected 60% of the time in 14-hr segments
  Contained in average data

- quasi-2, quasi-5, and quasi-10-day-periods
  Picked up in 13-day and 5-day segments
CONCLUSION

- Very likely that **semidiurnal, diurnal, quasi-5-day** and **quasi-10-day** tides exist

- Strong possibility that **8-hr** tide exists but amplitude is overestimated

- Possibility that **quasi-2-day** tide exists

- Spectrum of data gaps complicates most amplitudes
  - General agreement with Kevin Reed's results

- **Future Work:**
  - Compare amplitudes from the different tests
  - Compare to March 2006 data
  - Look at days that contained 8-hr wave
  - Electric field, TEC
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