Thermospheric Neutral Density Variation

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Background
Analysis
Fourier Harmonic Function:

\[ \rho = A_1 + A_2 \sin(\omega) + A_3 \cos(\omega) + A_4 \sin(2\omega) + A_5 \cos(2\omega) + A_6 \sin(3\omega) + A_7 \cos(3\omega) + A_8 \sin(4\omega) + A_9 \cos(4\omega) \]
Possible Mechanisms

• Annual Component
  - sun-earth distance

• Semiannual Component
  - Semiannual variation in Ap
  - Semiannual variation of large-scale circulation: “thermospheric spoon”, Fuller-Rowell, 1998

• Additional annual/semiannual variation
  - Annual/semiannul variation of eddy diffusion near mesopause, Qian et al., 2009
Correlation with Solar Activity (F10.7)

Neutral Density Annual Component (400km)

Neutral Density Semi-Annual Component (400km)

F10.7
Correlation With Geomagnetic Activity (Ap)
Correlation with Solar Activity (F10.7) and Geomagnetic Activity (Ap)

### Linear Pearson Correlation Coefficients

<table>
<thead>
<tr>
<th>Height (km)</th>
<th>Yearly Averaged F10.7 vs:</th>
<th>Yearly Averaged Ap Indices vs:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual Amplitude</td>
<td>Semi-annual Amplitude</td>
</tr>
<tr>
<td>250 km</td>
<td>0.4301800</td>
<td>0.7139140</td>
</tr>
<tr>
<td>400 km</td>
<td>0.6931010</td>
<td>0.8229120</td>
</tr>
<tr>
<td>550 km</td>
<td>0.7683370</td>
<td>0.8072910</td>
</tr>
</tbody>
</table>
Lower Atmospheric Forcing?

![Graph showing relative density amplitude over years from 1970 to 2000 for different altitudes (250km, 400km, 550km).]
Lower Atmospheric Forcing?

FFT Analysis

250km Relative Density Amplitude Data

400km Relative Density Amplitude Data

550km Relative Density Amplitude Data
Conclusions
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- The main components of density variations are annual and semiannual variation,
- Both the annual and semiannual components clearly correlate to solar activity,
- Density amplitudes show a weak correlation with geomagnetic activity,
- Density amplitudes increase with altitude in the altitude range 250-550km,
- Density amplitudes also show variation in the range from 2-5 years that suggest lower atmospheric forcing.
Future Steps
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- Investigate correlations with lower atmospheric forcing, e.g., Quasi Biannual Oscillation (QBO) using wind data.
- Analyze phase variations.