Relationship between Stratospheric and Ionospheric Disturbances

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Motivation

• Ionospheric variability affects a variety of communication and navigation systems

• The current deep solar minimum allows for the perfect opportunity to study the coupling of the ionosphere to processes from below
  – Low geomagnetic and solar activity
  – Sudden stratospheric warming (SSW) is the largest meteorological phenomena in the lower atmosphere
Background

• Regions of Interest

- The ionosphere is the electrically-conducting region of the atmosphere
- The primary drivers of ionospheric variation are solar flux and geomagnetic activity
- Incoherent scatter radars (ISR) are used to probe the ionosphere
- Focus is on the daytime ion temperature, Ti, at altitudes of ~200km and above
**Background**

- **Sudden Stratospheric Warming (SSW)**
  - Large-scale meteorological process in the winter hemisphere lasting several days or weeks
  - SSW is thought to be caused by the interaction of planetary waves with zonal mean flow
  - Indication of SSW is rapid, large increase (at least 20K) in temperature at ~30km
Background

• Development of SSW
  – During SSW, warm and cold cells form around the north pole
  – Ion temperature effects observed at higher altitudes depends on the location of the ISR

Consequences of SSW include mesospheric cooling and lower thermospheric warming (Goncharenko and Zhang, 2008, Funke et al, 2010, Kurihara et al, 2010)

• Any effects above ~170km are practically unknown
• Goal is to see if the Millstone Hill ISR observed the SSW in 2010 at higher altitudes
Method

- Ionospheric models (ISRIM, IRI, MSIS) do not capture all of the behavior seen in the data
  - Need to preserve 2-3 hour variations
- Decided to use January 2007 data as a baseline case to determine if the January 2010 SSW event generated any effects over Millstone Hill
Cases Under Study

- Two cases studied: January 2007 and 2010

No SSW (Baseline case)  Minor SSW (Case of interest)
Summary of Cases

- The geomagnetic activity was quiet in both January 2007 and 2010. The solar flux was also low for both campaign periods.
- However, differences in geomagnetic activity and solar flux do exist between the two campaigns.
Ti Differences

- Cooling (~10-25K) is observed in the morning (6-10LT), and warming (~15-30K) is seen in the afternoon.

- Possible reasons for Ti change:
  1. Geomagnetic activity
  2. Solar flux
  3. SSW
F10.7 and Kp

- Changes in geomagnetic activity and solar flux cannot account for all of the Ti differences
- From 7-10LT, the observed Ti in 2010 is cooler than the Ti in 2007 (~5-18K)
- At 11LT, Ti in 2010 is warmer by ~20K than the Ti in 2007
Ti Variation

- Warming begins on January 21 and persists until January 25
- A large warming of 45K is observed on Jan. 21 at 17LT
- A large cooling of ~55K is seen at 9LT on Jan. 29 and 30
Conclusions

• A minor SSW event occurred over Millstone Hill during January 2010

• Ionospheric models do not capture all of the Ti behavior observed
  – ISRIM adequately captures geomagnetic and solar flux activity

• Variations in Ti demonstrate increased wave activity
  – Cooling (~10-25K) was observed in the morning (6-10LT) while warming (~15-30K) was seen in the afternoon
  – Changes in Ti at altitudes below ~285km cannot be explained by geomagnetic activity or solar flux
Future Work

- Investigate the effects of the January 2010 SSW at lower altitudes (100-200km)
- Study how other ionospheric parameters (Ne, Te, ion drift) were impacted by the SSW
- Extend studies into the nighttime hours
- Use other ISR data to see what they observed during the January 2010 campaign period, and compare to the results obtained from Millstone Hill
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