Relationship between Stratospheric and Ionospheric Disturbances

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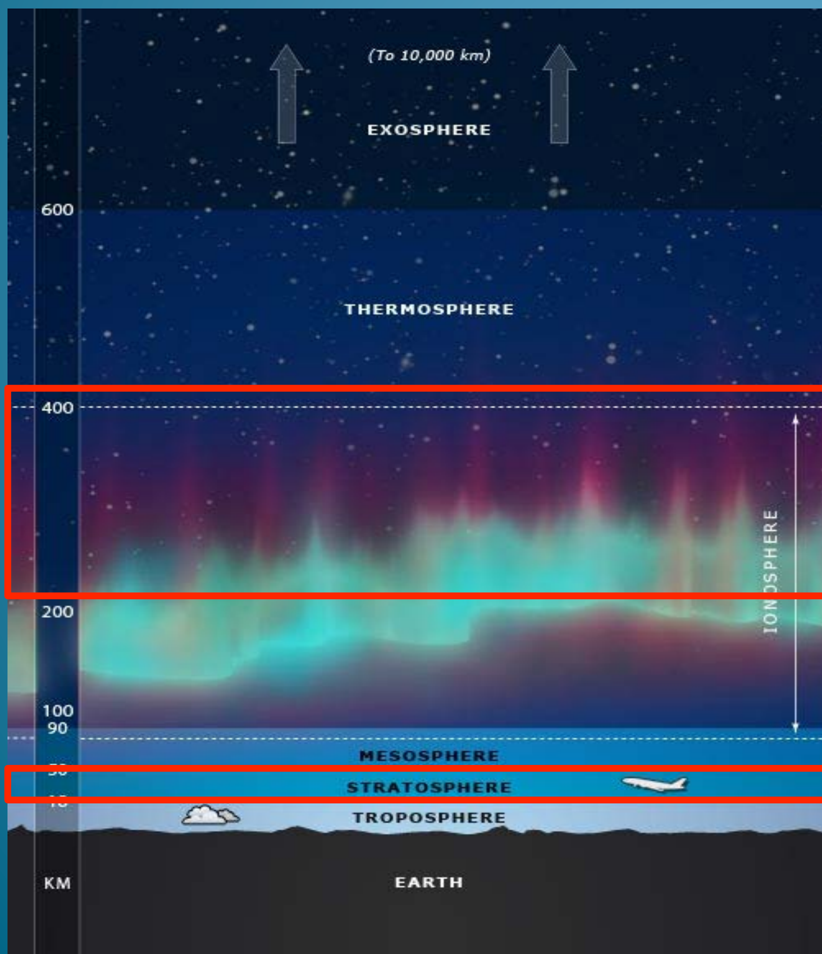
Motivation

- 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

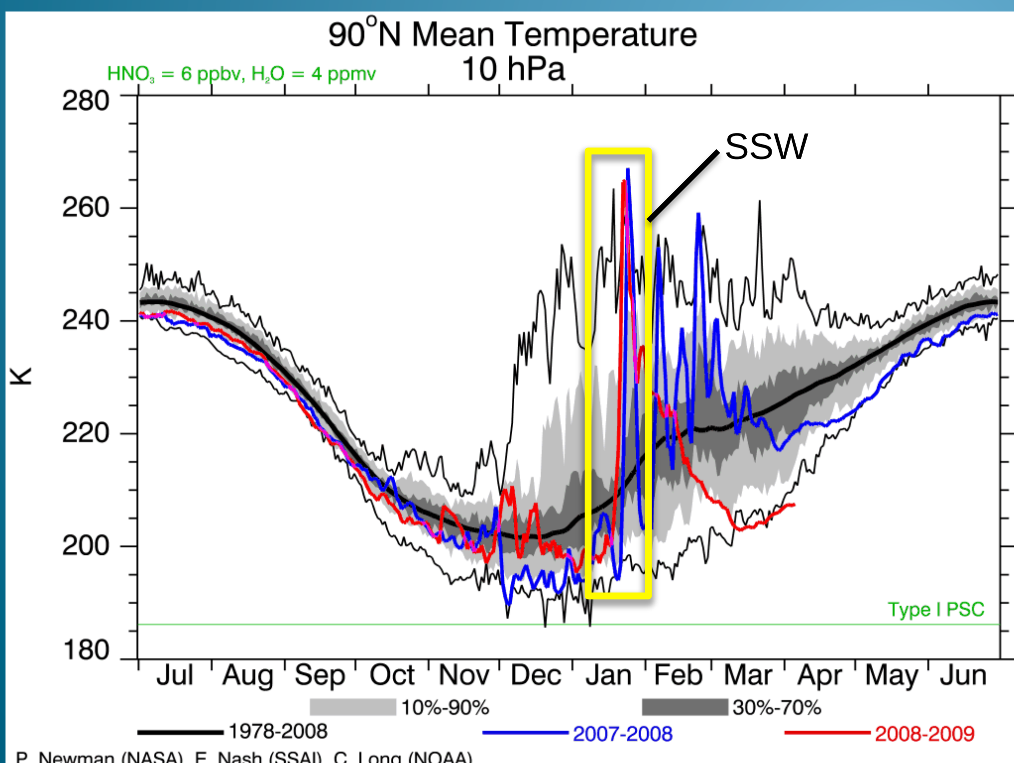
- Regions of Interest



- 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

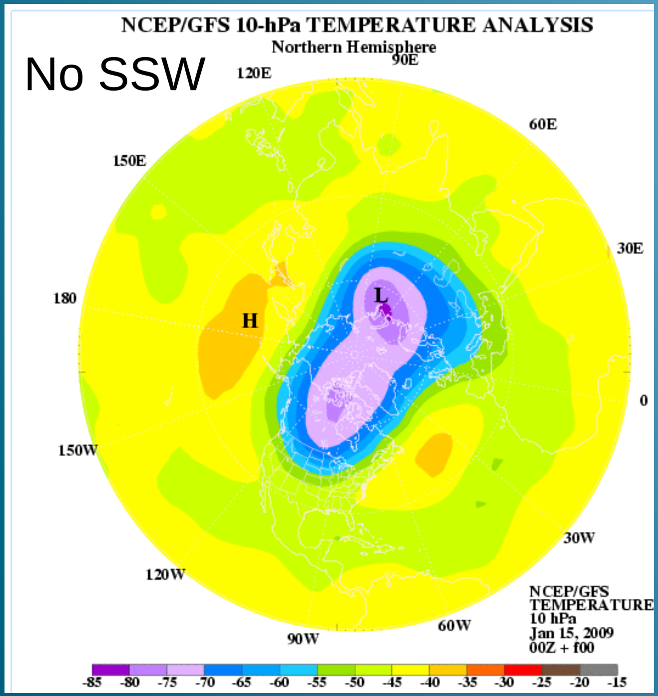


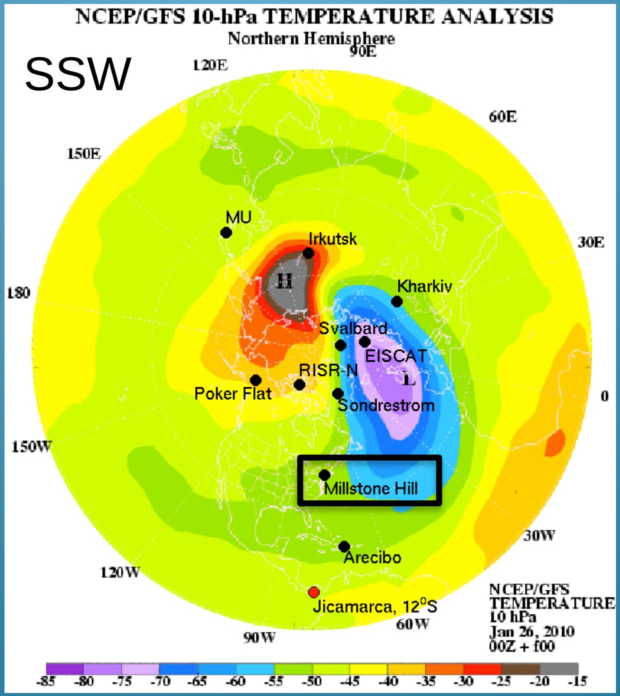
-SSW is thought to be caused by the interaction of planetary waves with zonal mean flow

- Indication of SSW is rapid, large increase (at least 20K) in temperature at ~30km

Background

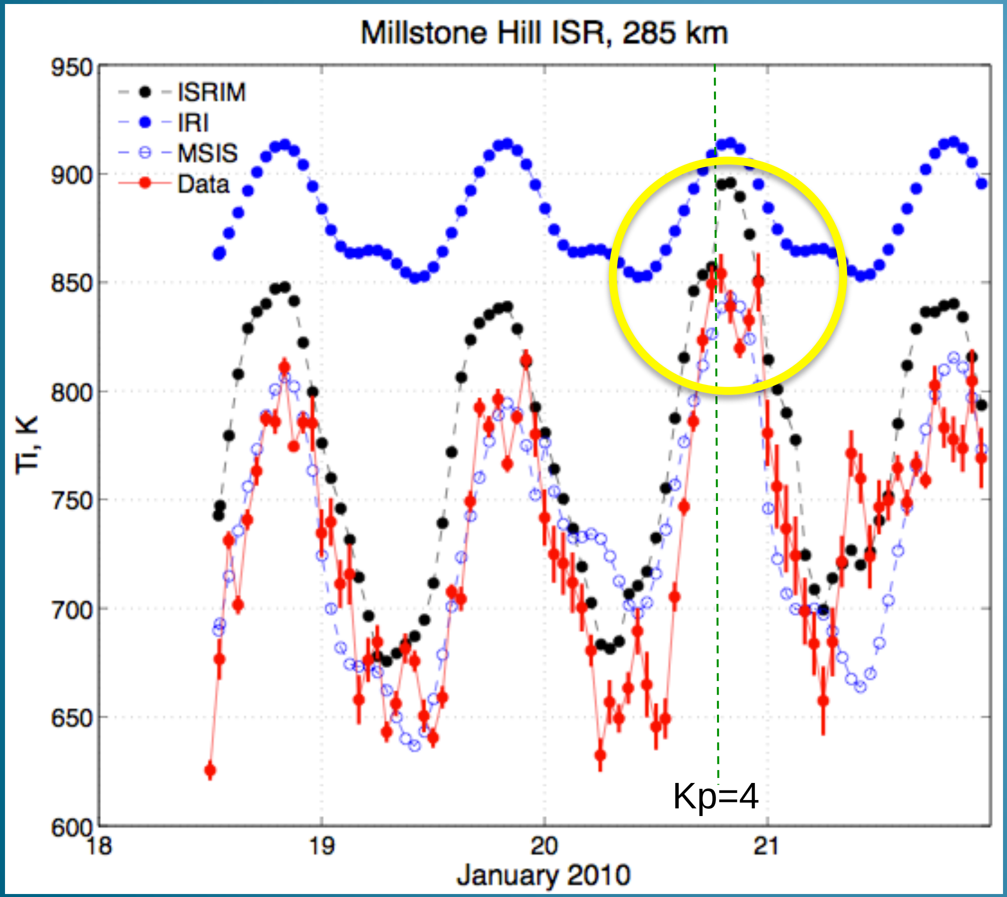
- Development of SSW
  - During SSW, warm and cold cells form around the north pole
  - Ion temperature effects observed at higher altitudes depends on the location of the ISR





- 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

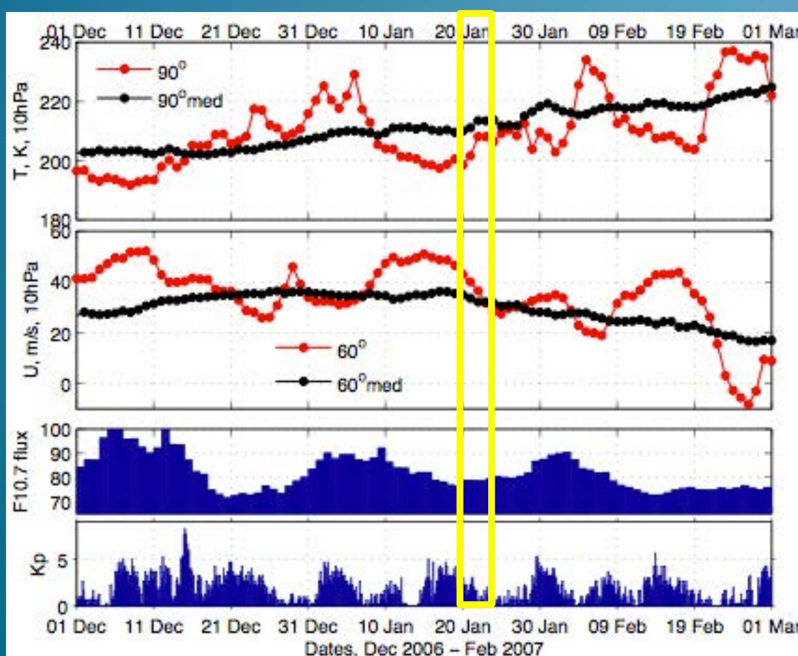
Method



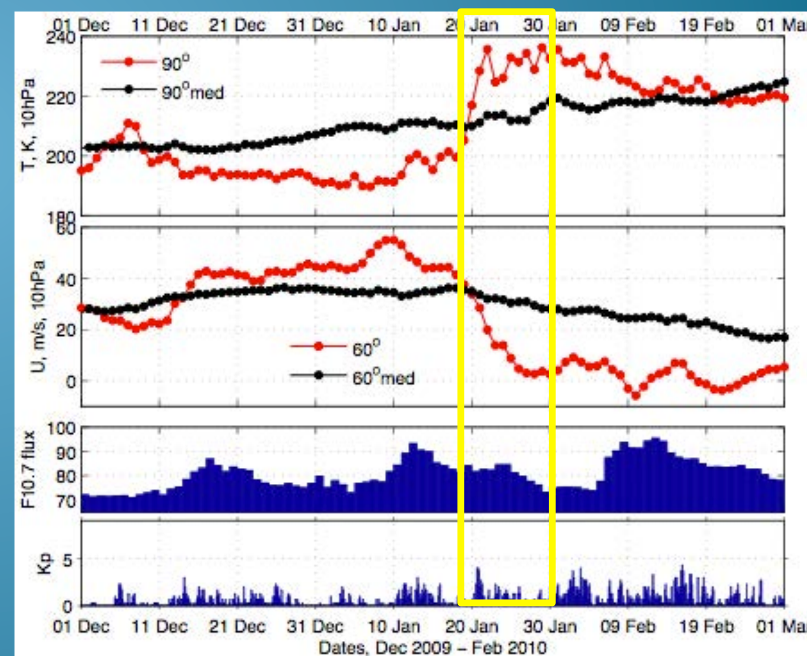
- Ionospheric models (ISRIM, IRI, MSIS) do not capture all of the behavior seen in the data
  - -Need to preserve 2-3 hour variations
- Decided to use January 2007 data as a baseline case to determine if the January 2010 SSW event generated any effects over Millstone Hill

Cases Under Study

- Two cases studied: January 2007 and 2010



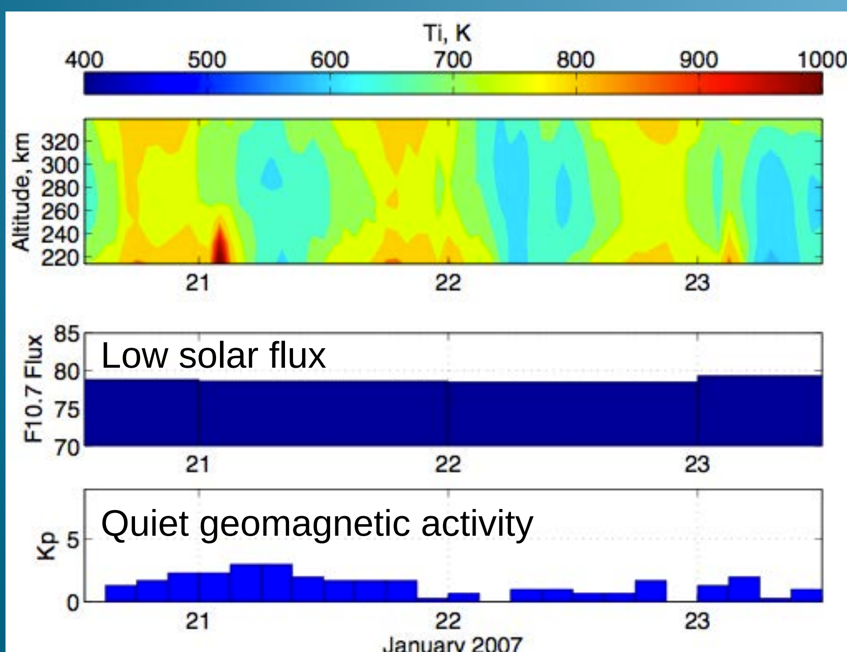
No SSW (Baseline case)

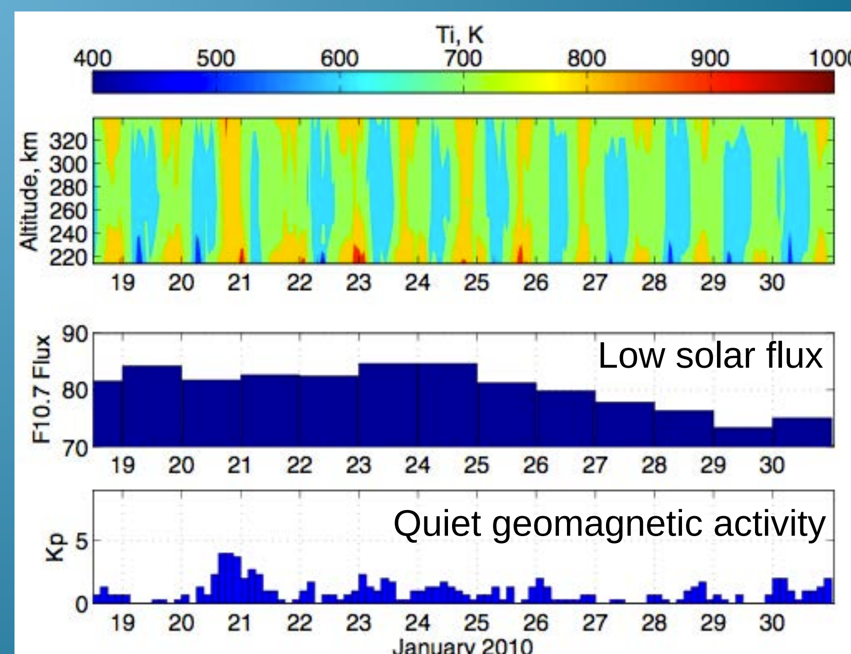


Minor SSW (Case of interest)

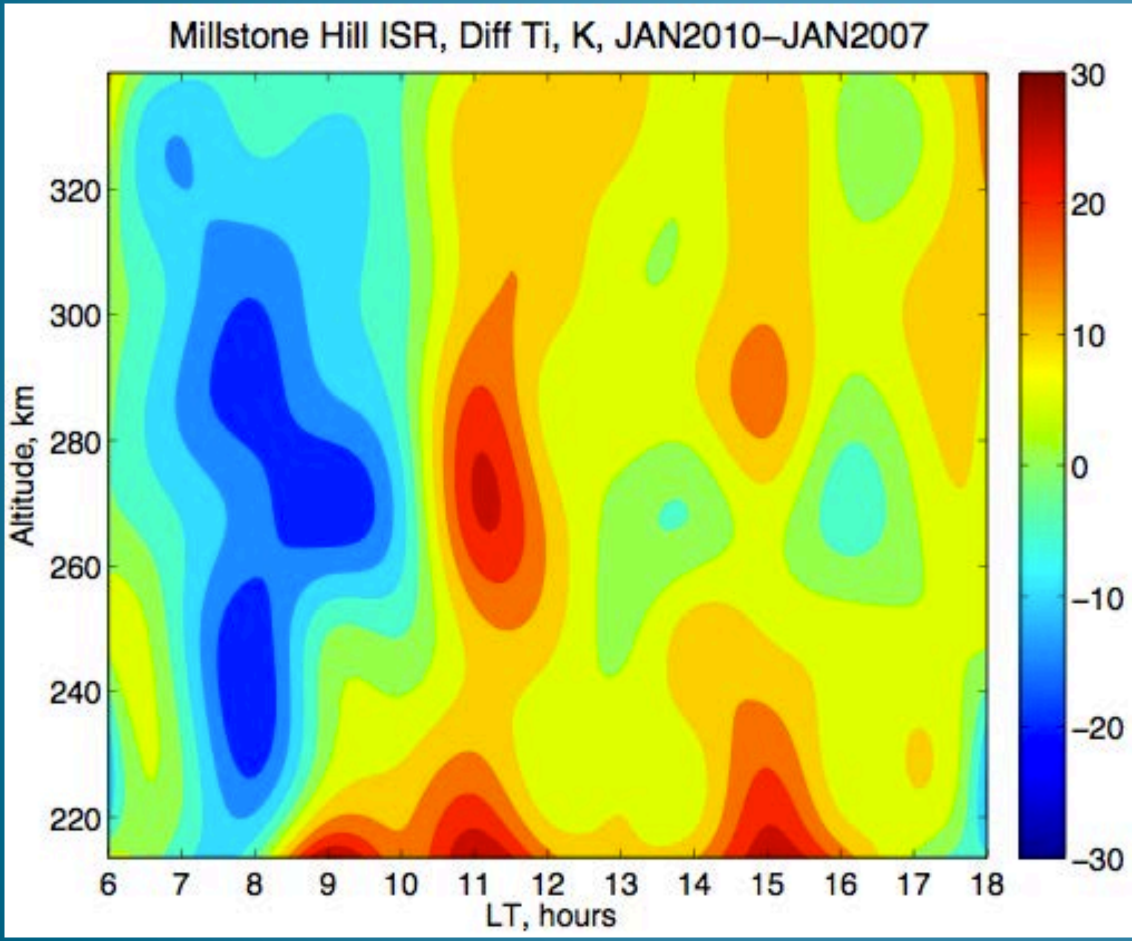
Summary of Cases

- 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





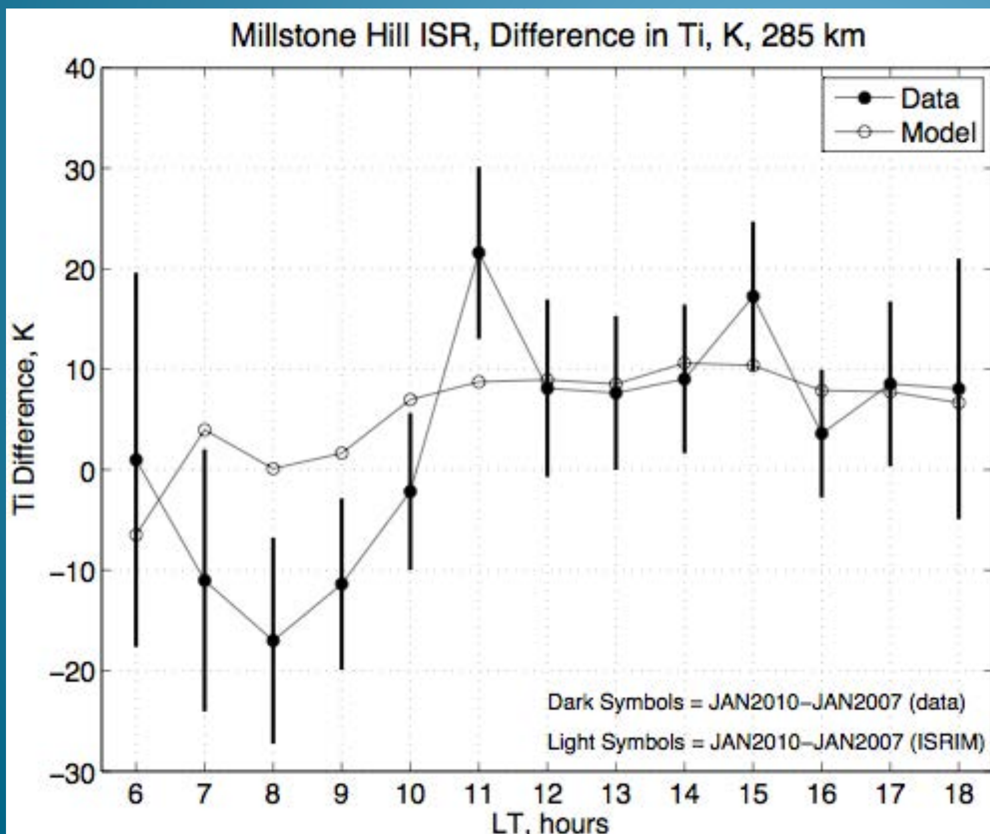
Ti Differences



- •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

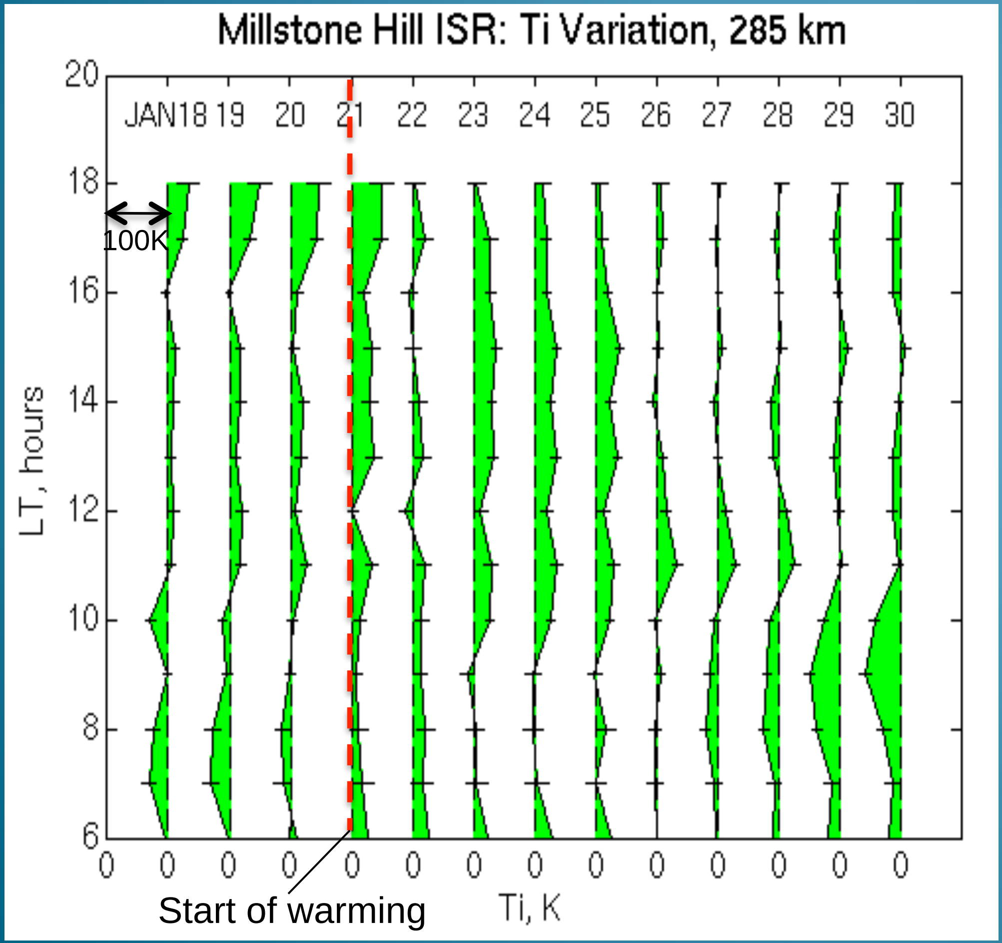
F10.7 and Kp

- 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

Acknowledgements

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