High Latitude Ion Temperature Responses in the Lower and Upper Thermosphere to Sudden Stratospheric Warming Events

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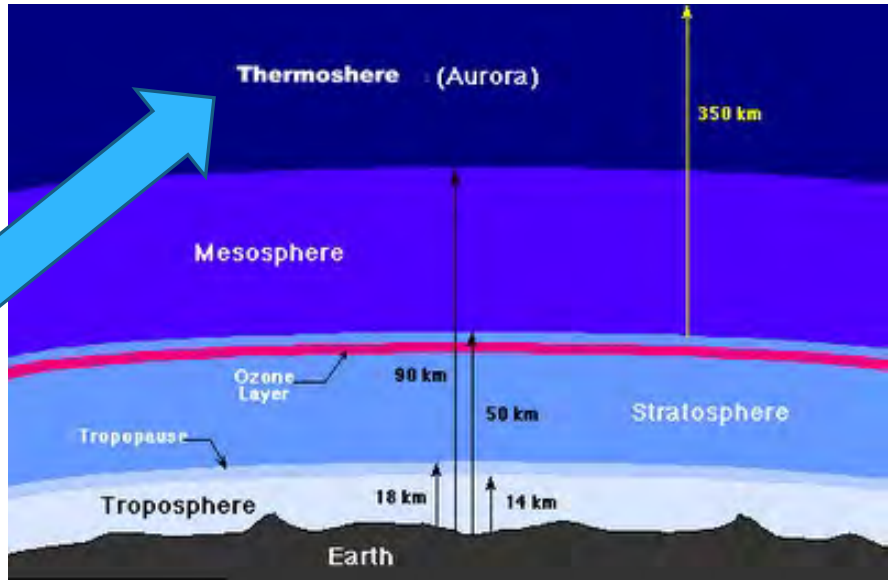
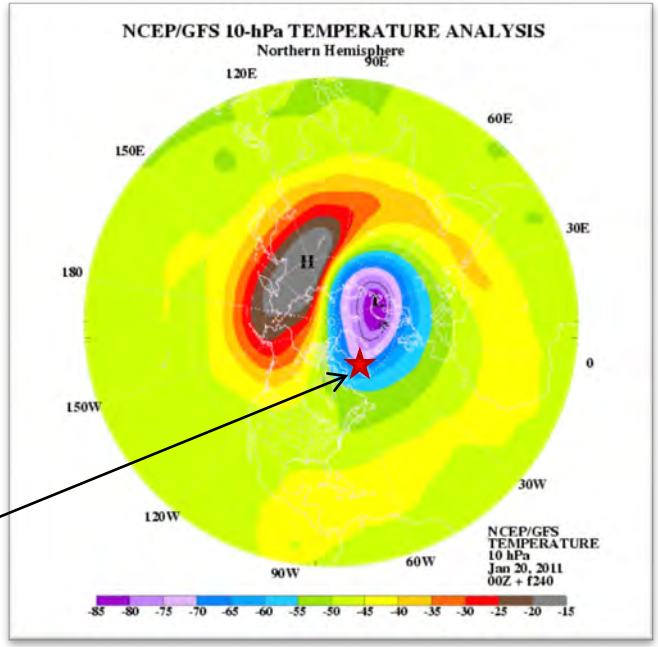
Introduction

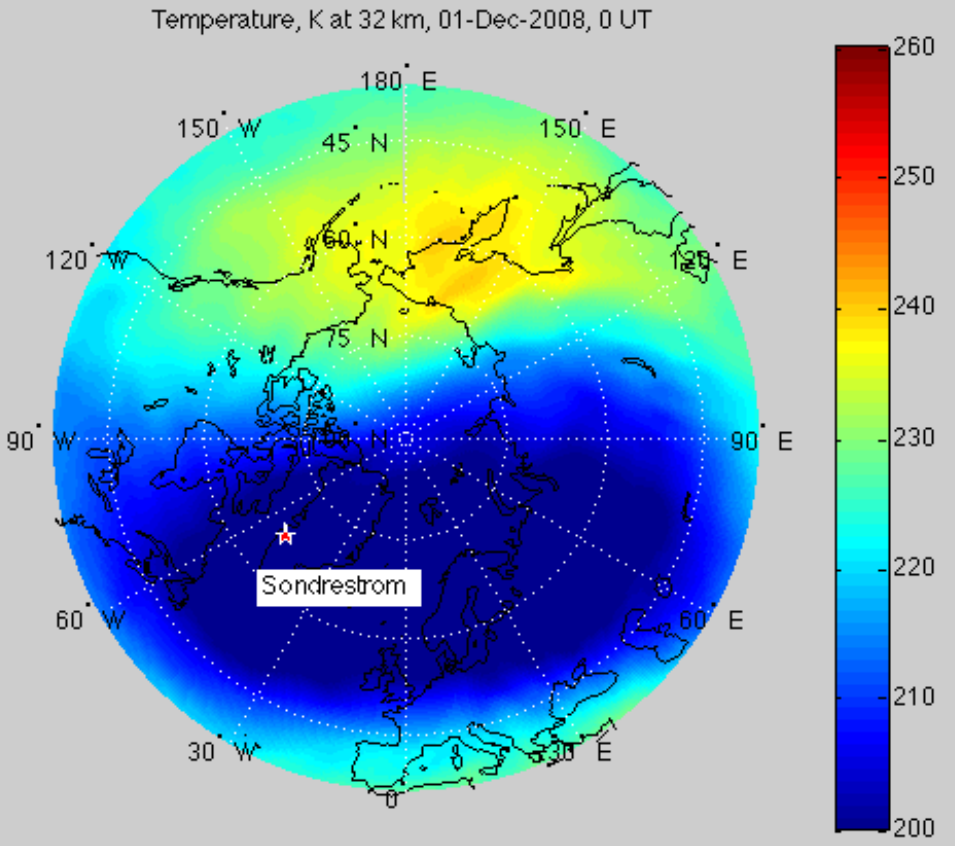
- What are SSWs?
- Why are they worth studying?
- Project focus
  - High latitude ion temperature in thermosphere (150-350km)
- Source of data
  - Sondrestrom ISR (Greenland)
- Events Studied
  - January 2008 and January 2009
- Why those events?
  - Deep solar minimum
  - Data availability

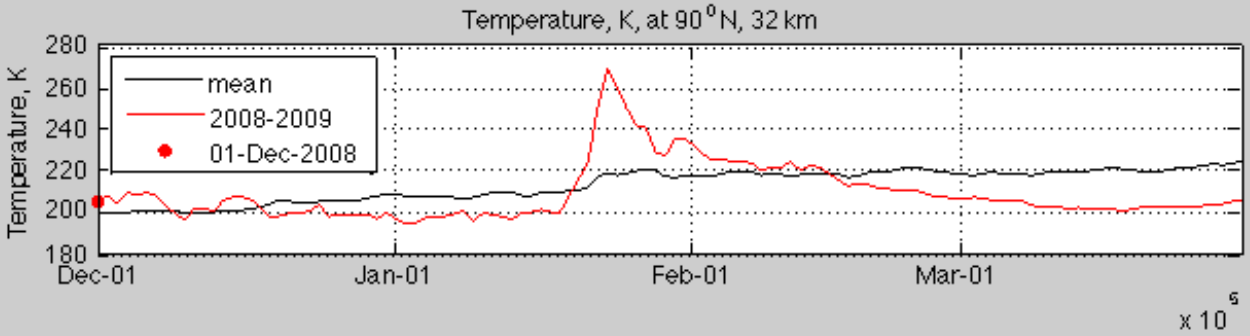




Sondrestrom

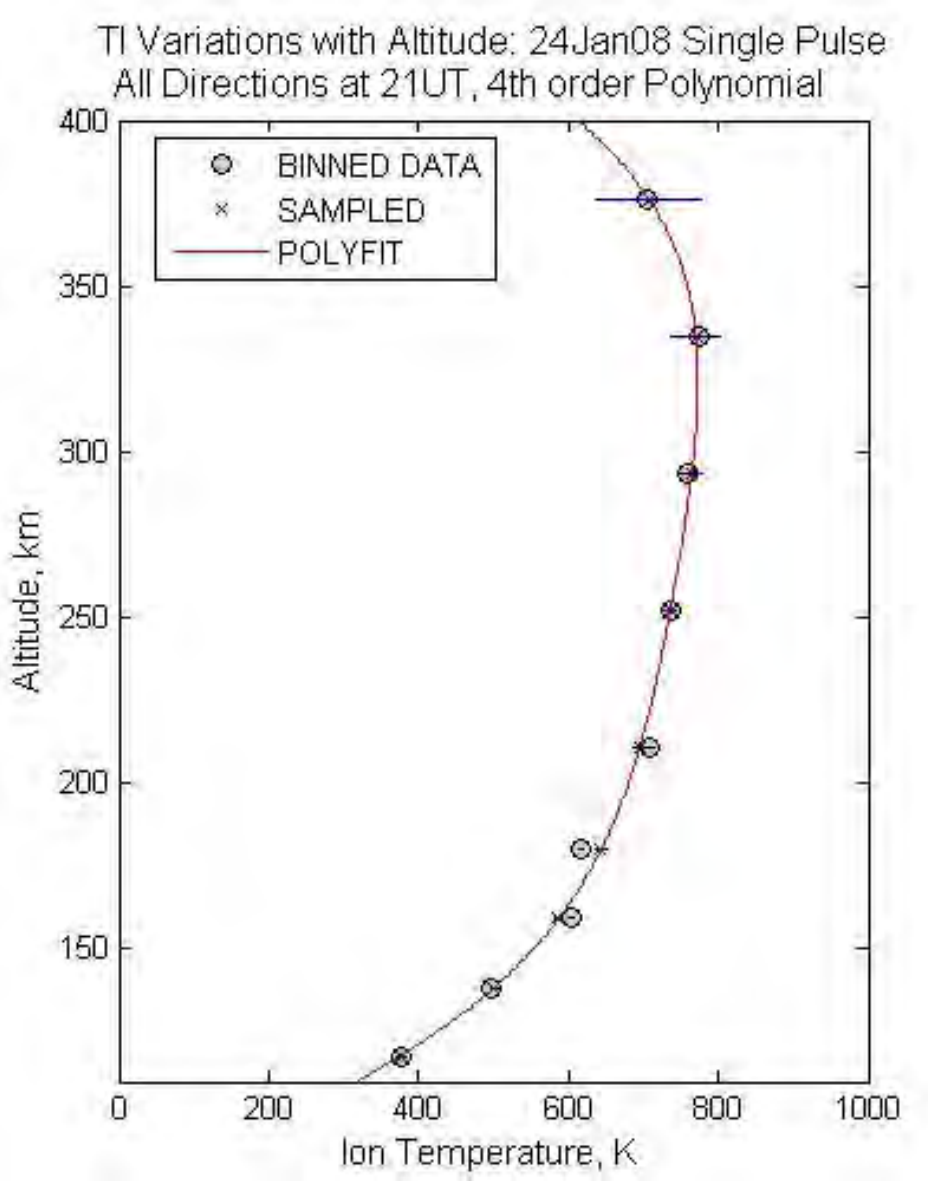
http://albertan1956.blogspot.com/2010/07/nasa-indicates-part-of-earths.html
http://www.boards.ie/vbulletin/showthread.php?t=2056056522&page=3


Temperature, K at 32 km, 01-Dec-2008, 0 UT
180° E
150° W
150° E
45° N
120° W
120° E
60° N
75° N
90° W
90° E
Sondrestrom
60° W
60° E
30° W
30° E
0°
260
250
240
230
220
210
200

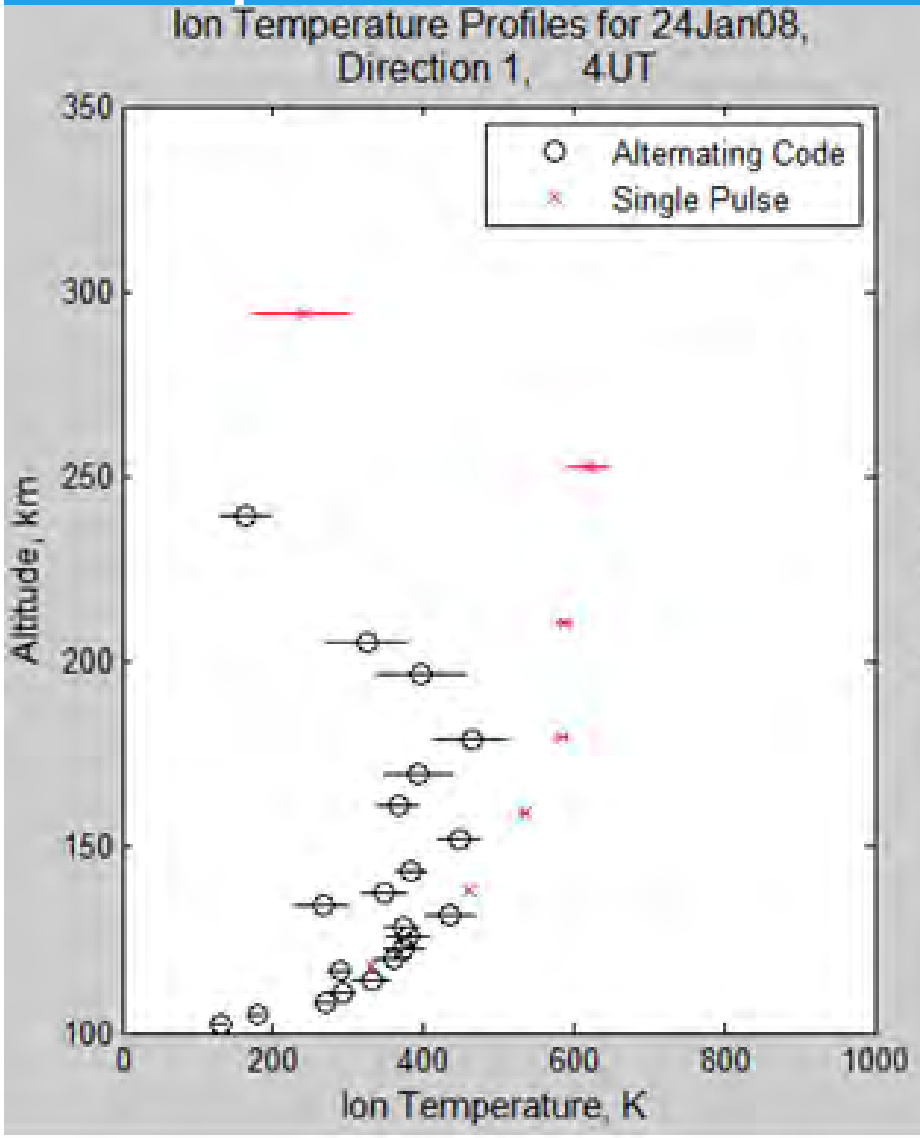

Temperature, K, at 90°N, 32 km
Temperature, K
280
260
240
220
200
180
mean
2008-2009
01-Dec-2008
Dec-01
Jan-01
Feb-01
Mar-01
x 10^6

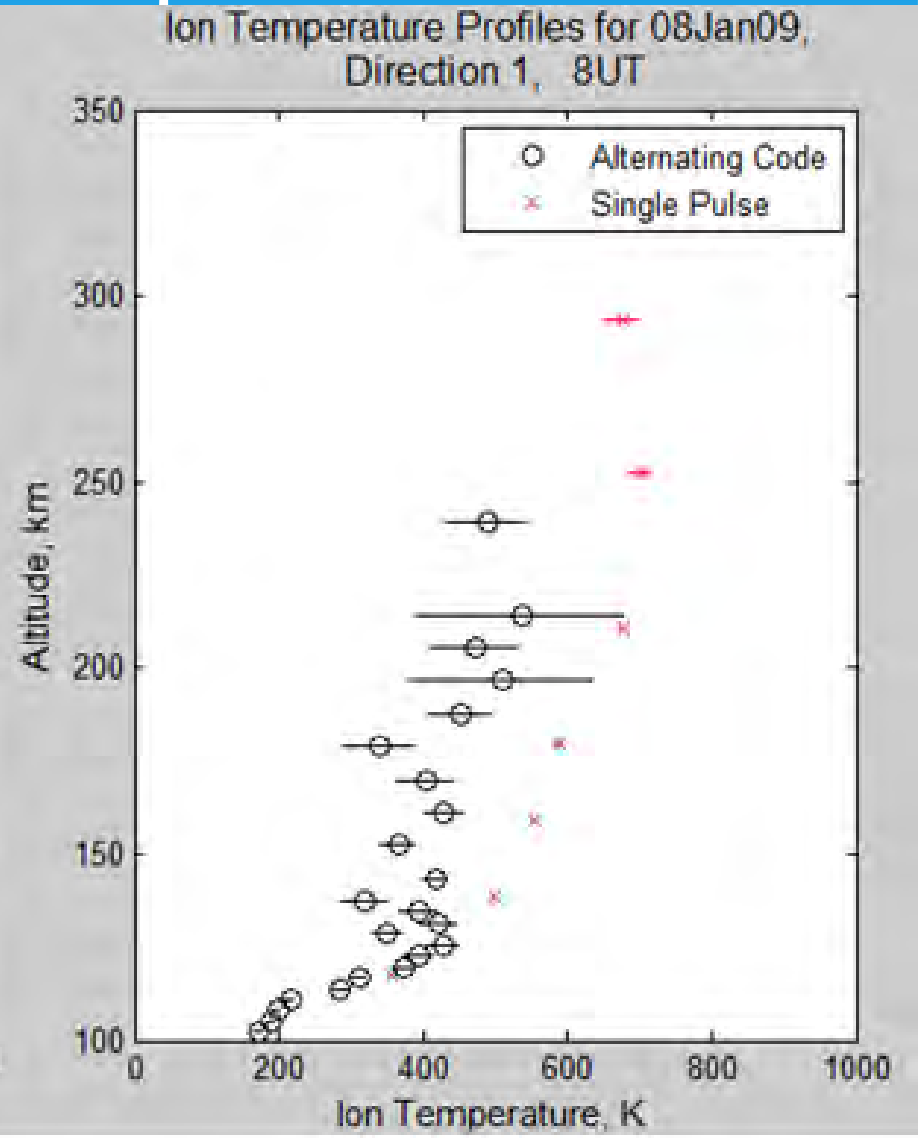
Data Processing Techniques

- Filtering data with high errors (alternating code: $\sigma_{high:}$ 125- 165K single pulse: $\sigma_{high:}$ 100- 150K)
- Fit temperature profile with polynomial to reduce noise in data (TI vs. altitude for each time)
- Combining data from all beam directions (ELM: 60°-80°)
- Averaging data into hourly bins using weighted mean (gives more weight to data points with lower errors)
  - Brings out broader features in ion temperature data



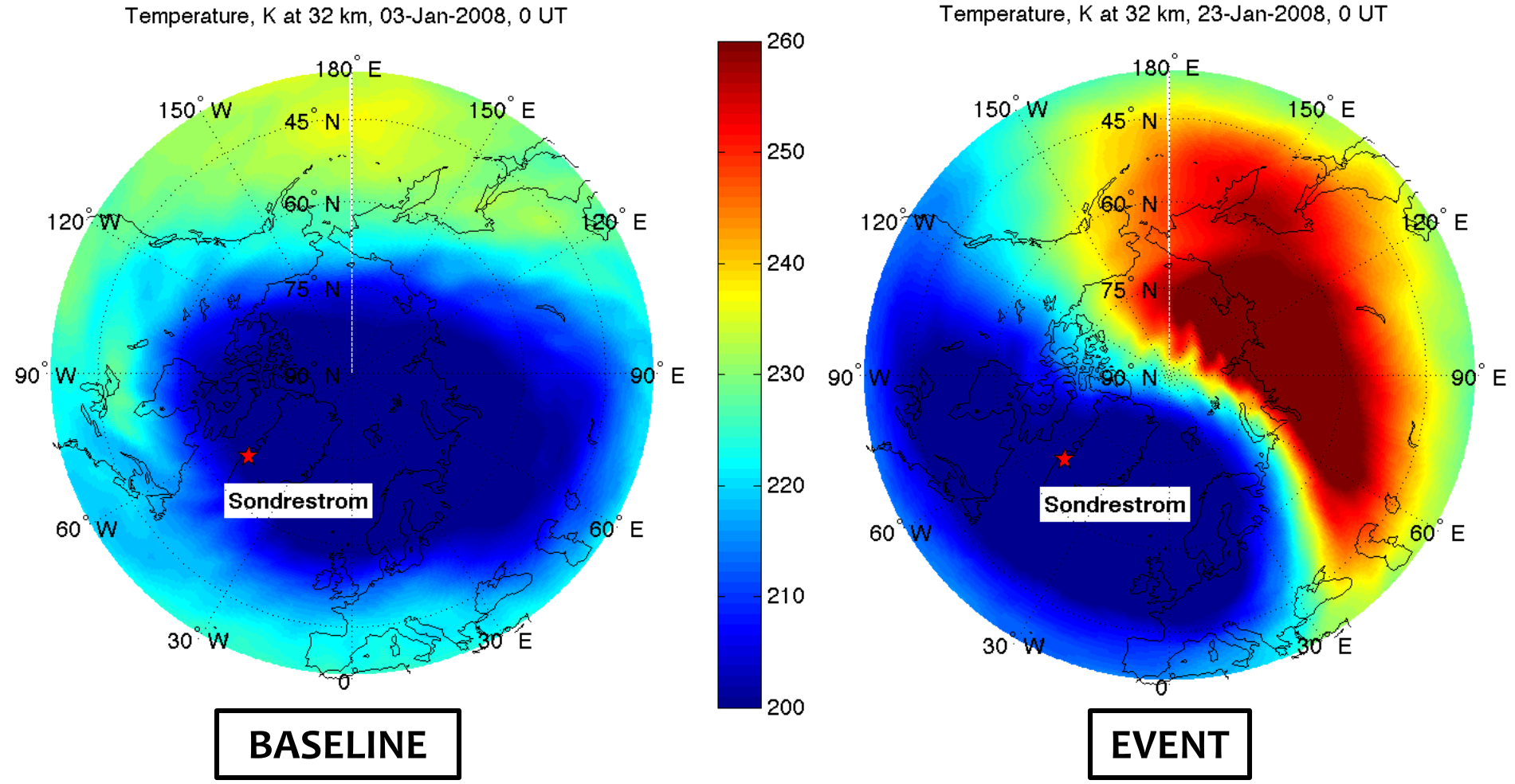
Comparison of Ion Temperature Profiles





* There appear to be differences in alternating code and single pulse ion temperature data (needs to be further investigated)
* Further analysis is based on single pulse data

Comparison of Stratospheric Data: 2008

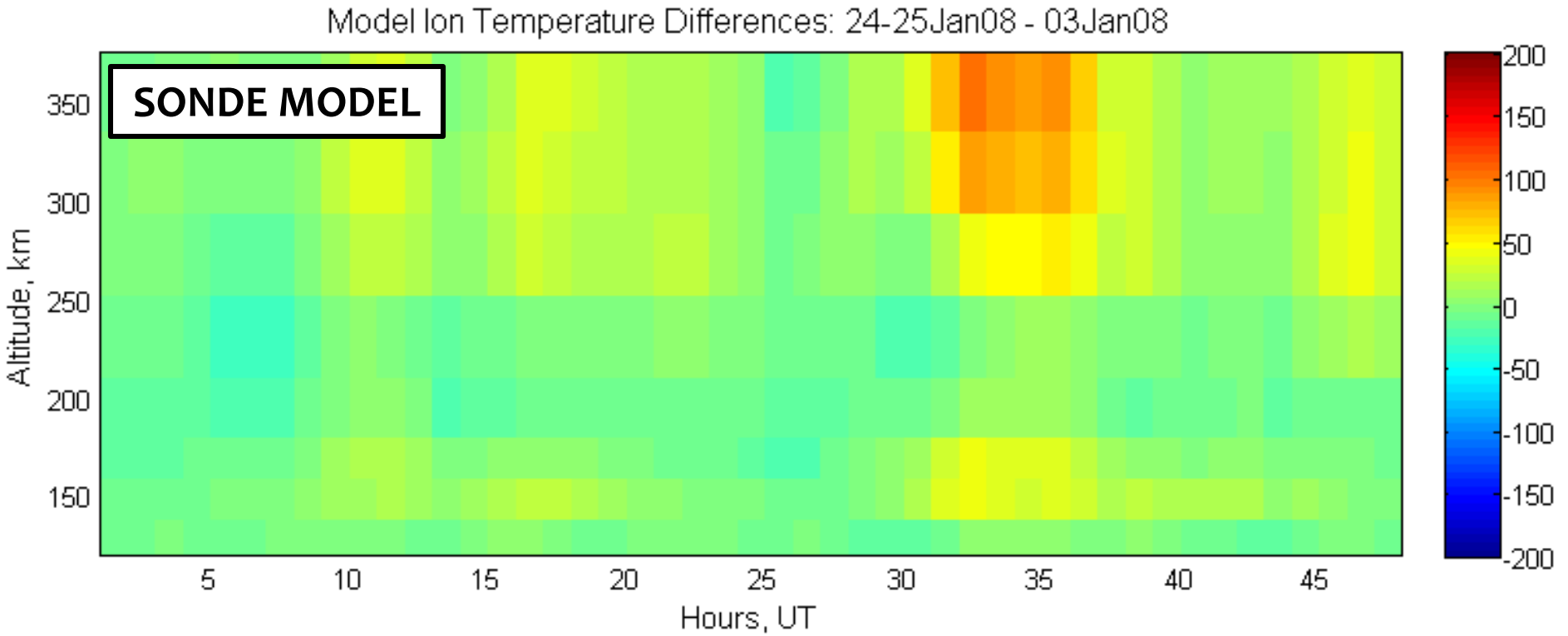


BASELINE

EVENT

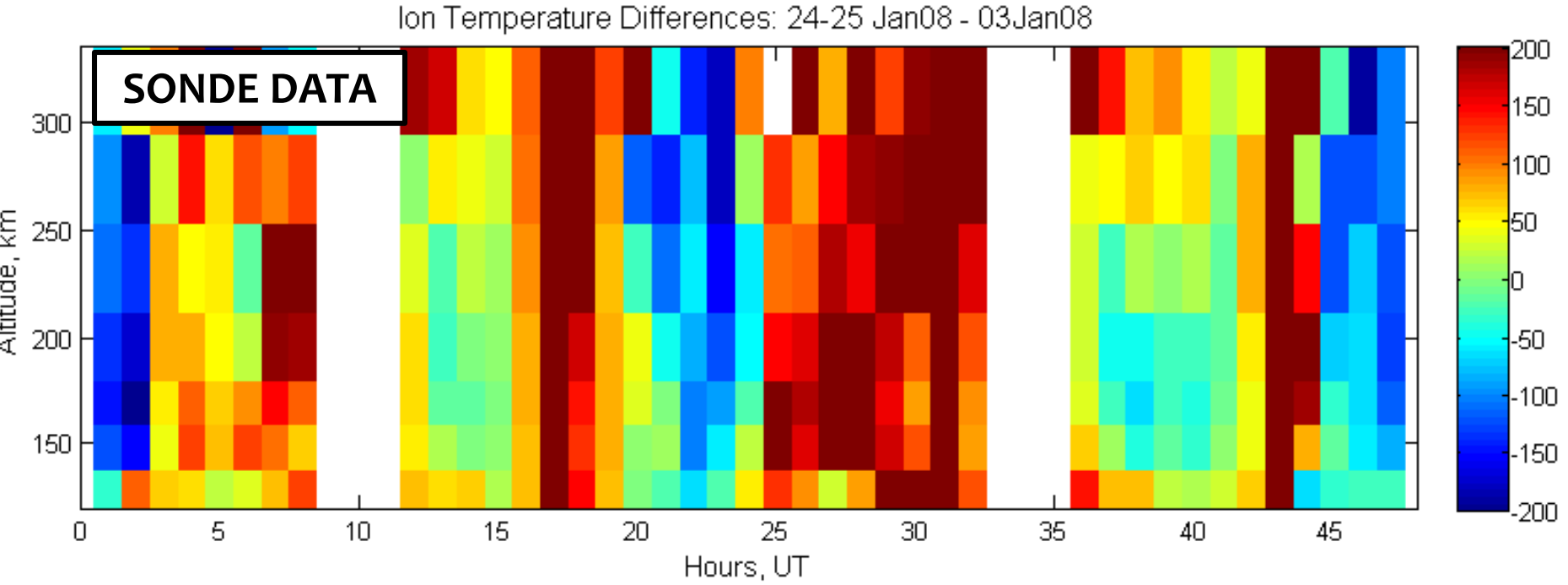
* Baselines have very low geomagnetic activity (Ap3 < 5)
* Ap3 is a measure of geomagnetic activity (Ap3 of 5 corresponds to KP of 1.3)

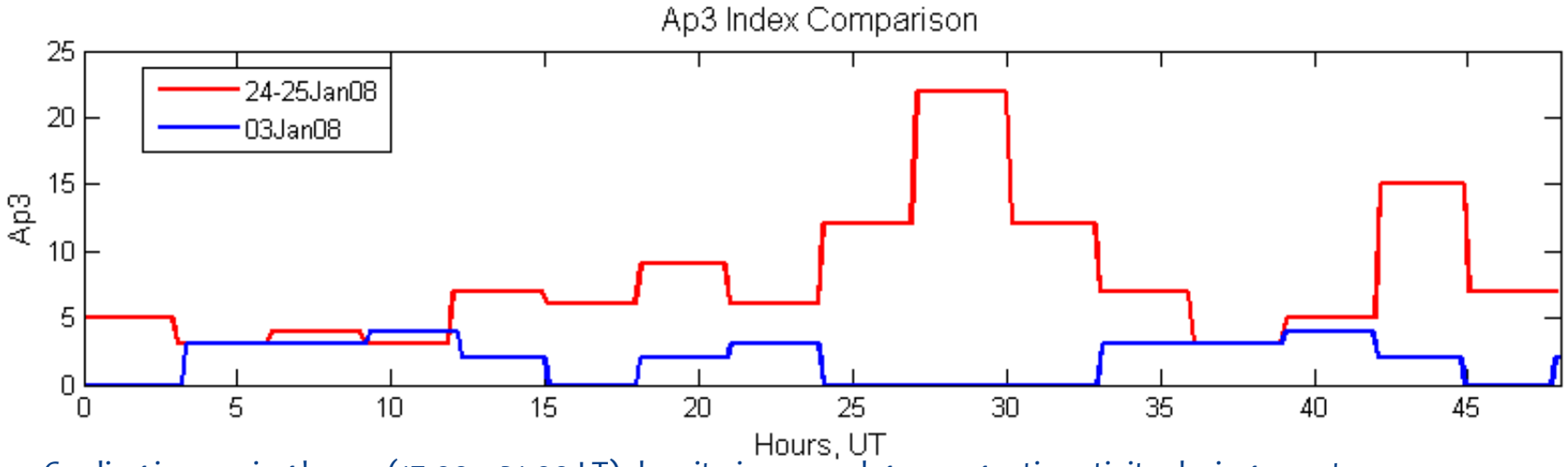
Separating Different Drivers: January 2008 Event



* Based on Sondrestrom local ionospheric model
* Model accounts for seasonal variations and geomagnetic activity
  * Allows for the separation of different drivers of ion temperature variations (differences in solar flux, Ap3, and seasonal variations) from Sudden Stratospheric Warming effects

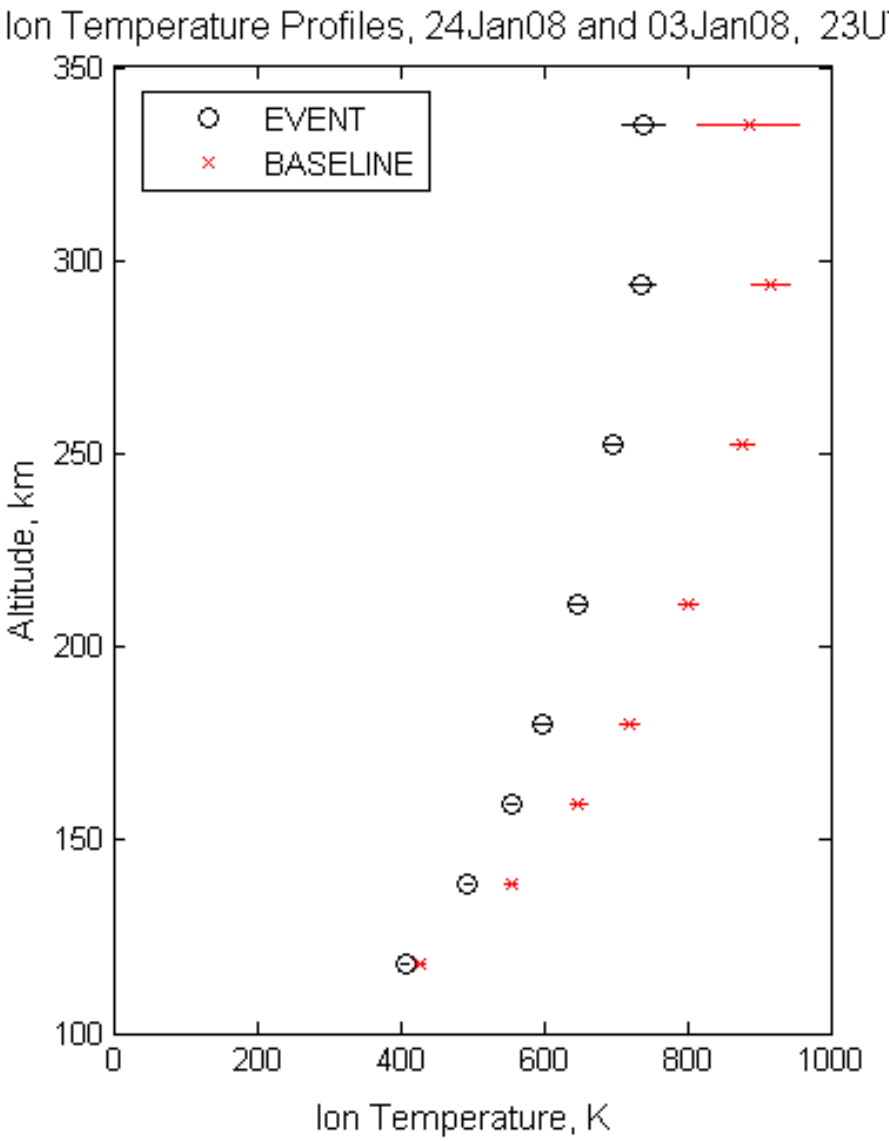
Results: January 2008

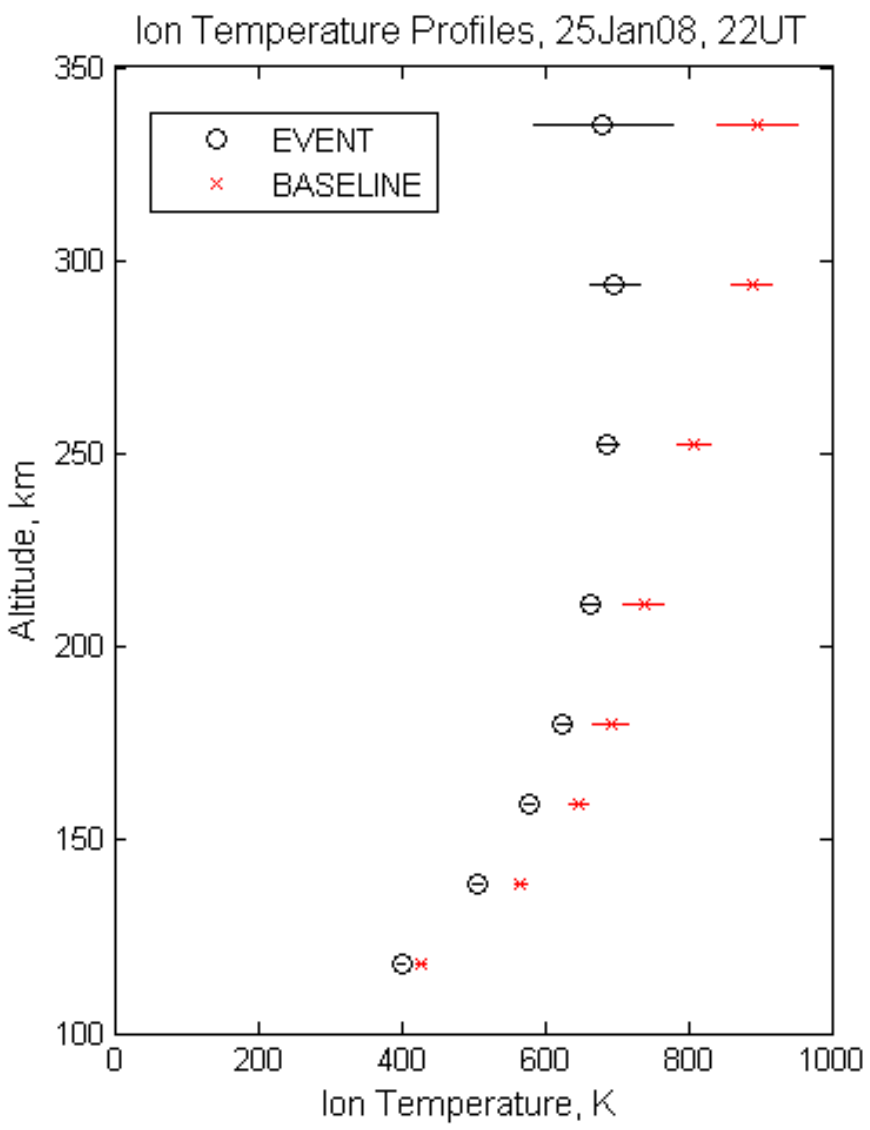




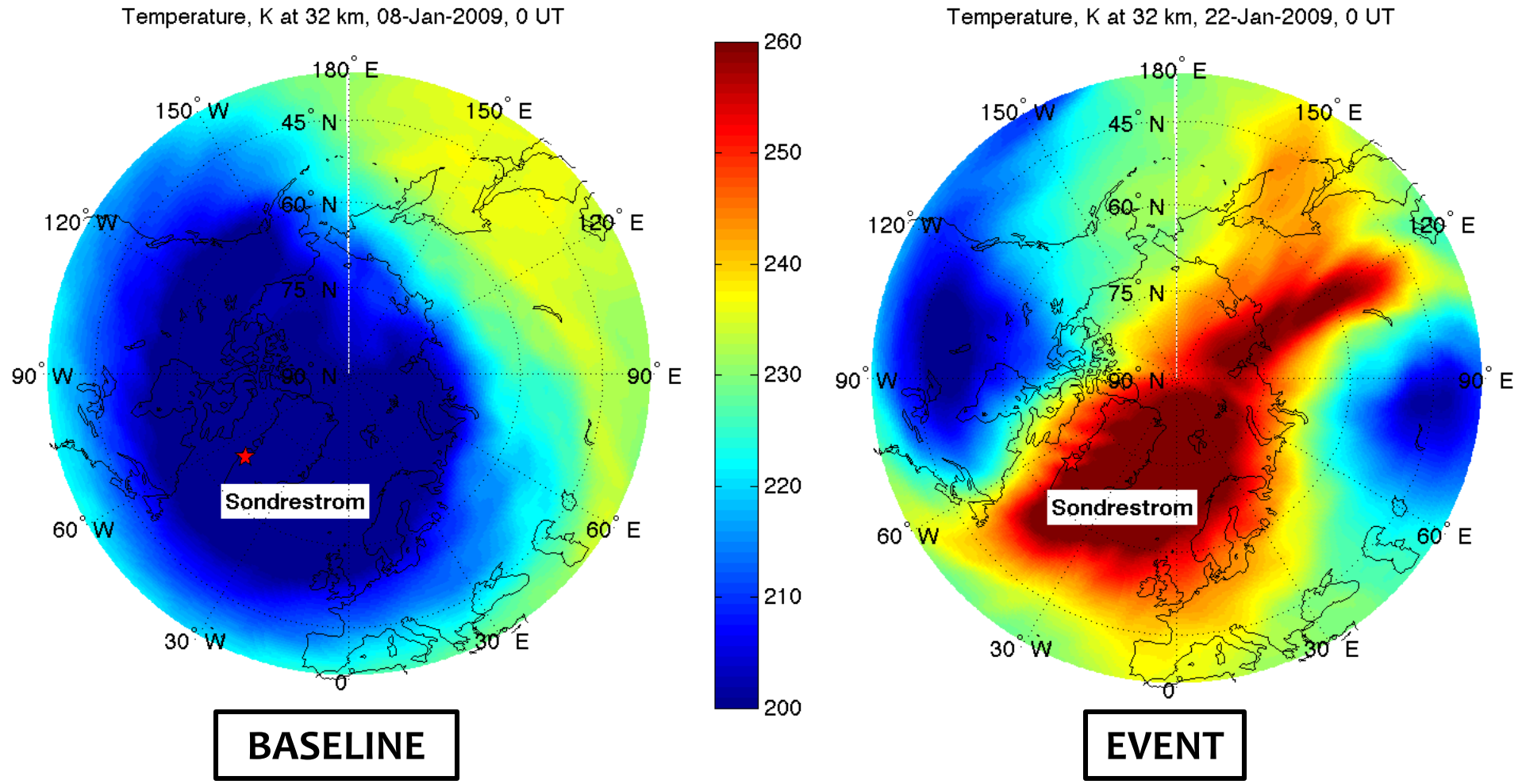
* Cooling in evening hours (17:00 – 21:00 LT) despite increased geomagnetic activity during event
* Peak Ap3 = 22 , KP = 3.7

Ion Temperature Profiles: 2008





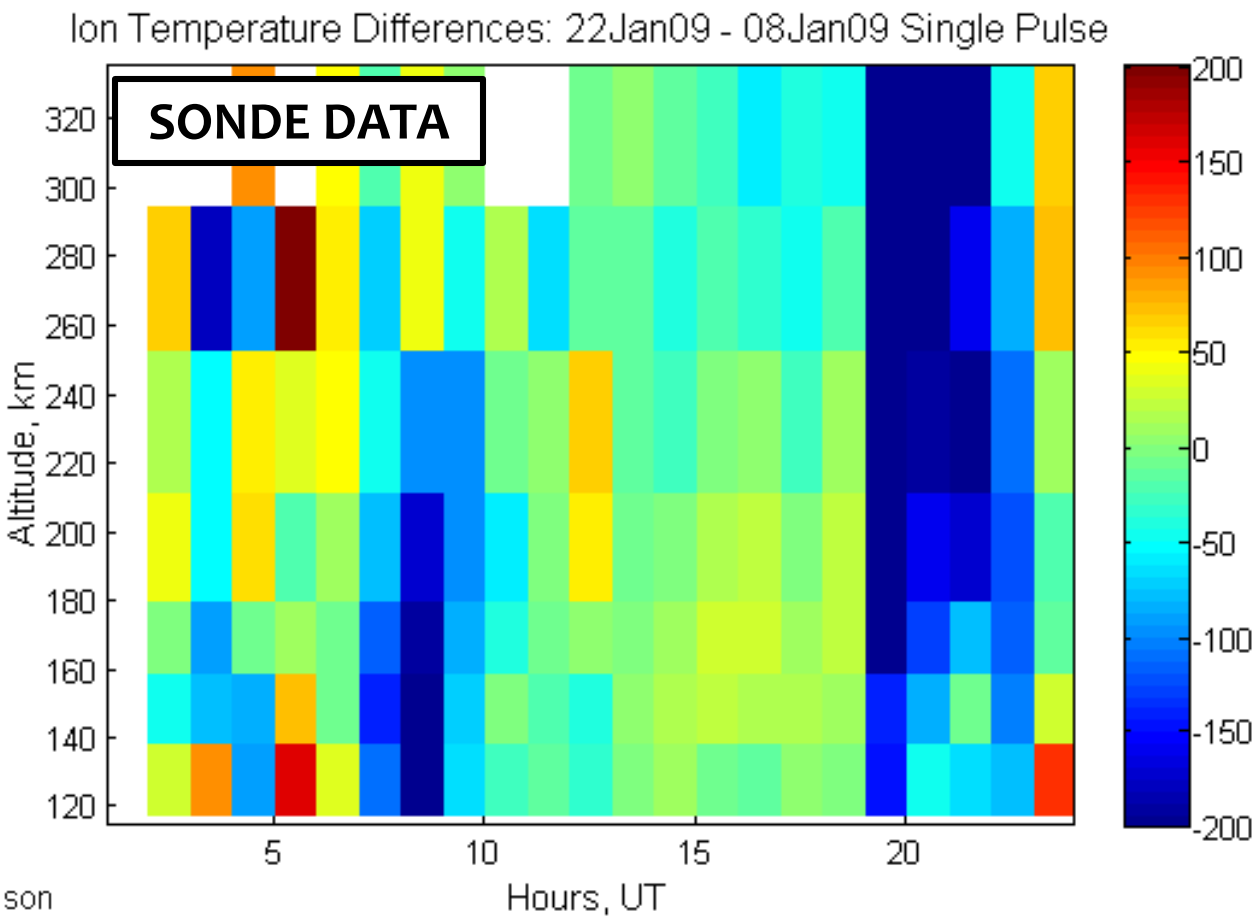
Comparison of Stratospheric Data: 2009

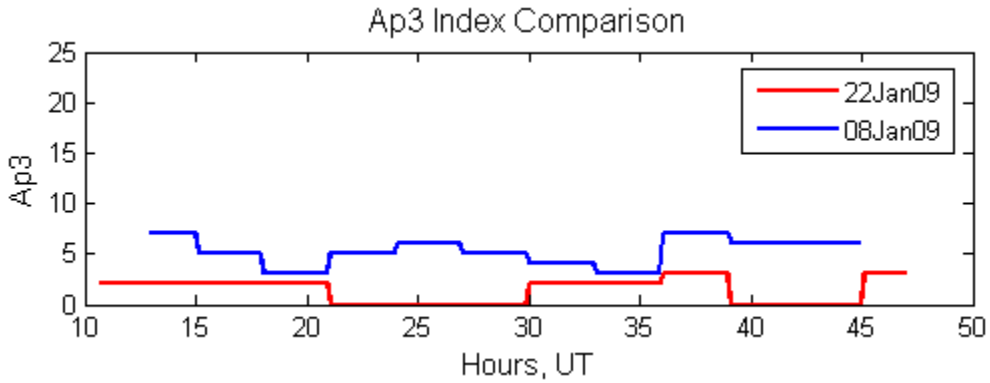


* Baselines have very low geomagnetic activity (Ap3 < 5)

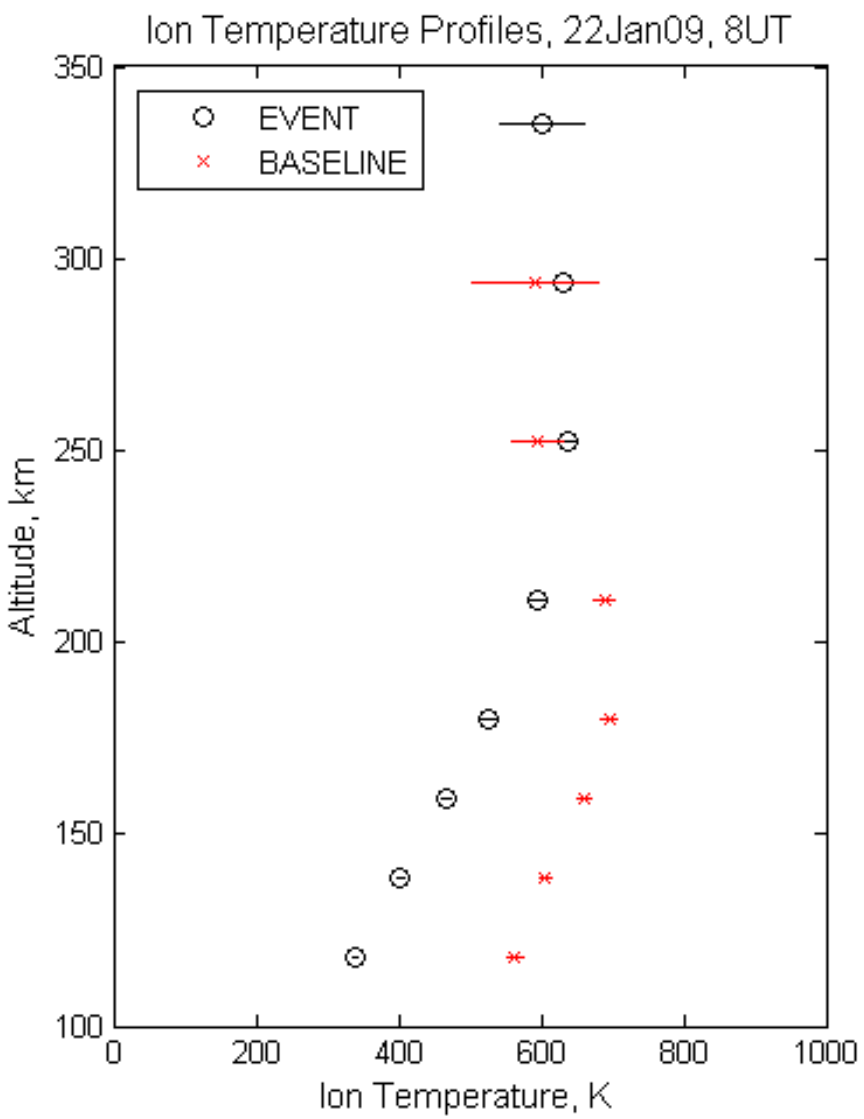
Results: January 2009

- Strong cooling during evening hours
  - 16:00-20:00 local time
  - Magnitude: 100-150K
- Model ion temperature variations are no greater than ± 50 K

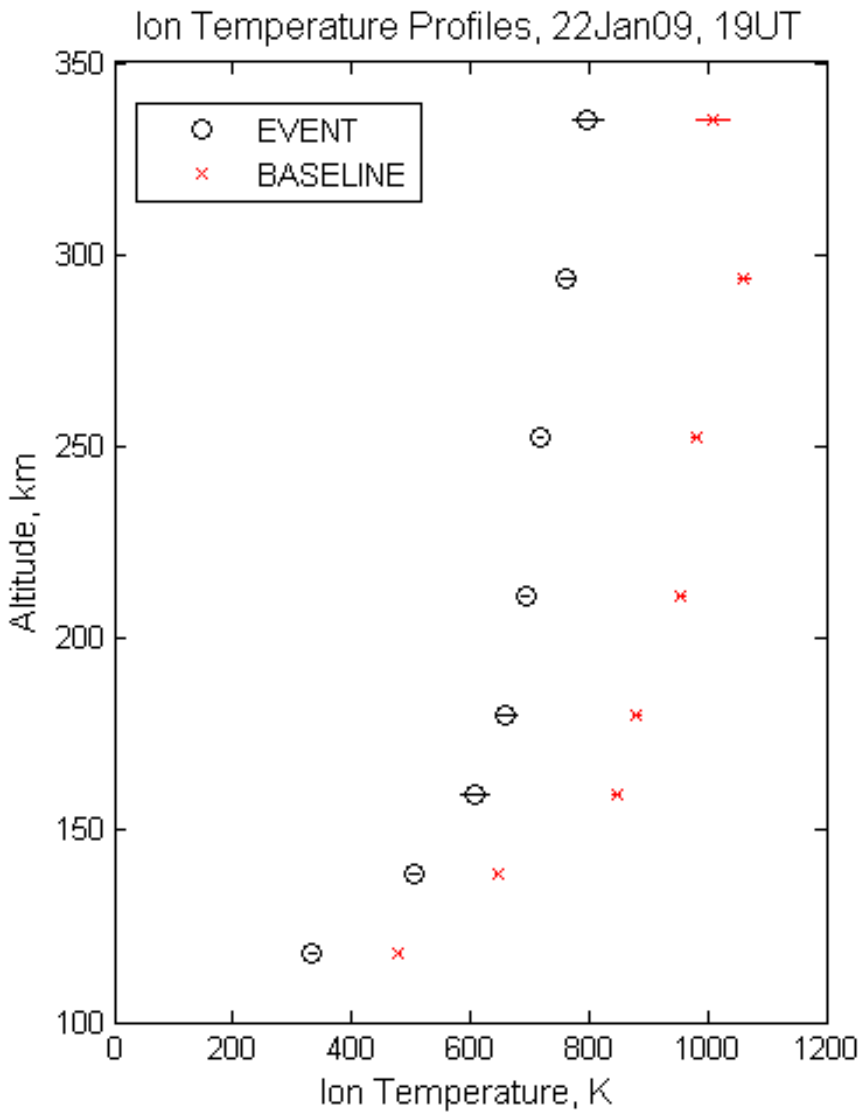




Ion Temperature Profiles: 2009



MORNING



NIGHT

Conclusions

- Cooling (100K) during evening hours (16:00-21:00 local time)
  - Is observed on January 22nd - 25th during January 2008 event, and on January 22nd of January 2009 event
  - Found in both cases despite:
    - Large differences in characteristics of the two events
    - Large differences in stratospheric conditions above Sondrestrom (cold cell in 2008, hot cell in 2009)
- Cooling (~100K) during early morning hours (2:00-7:00 local time)
  - Is only observed on January 22nd of January 2009 event
- Warming (50 – 150K) during daytime hours
  - Increased geomagnetic activity makes it difficult to conclude that warming is caused exclusively by SSW

Future Work

* Need to create a more robust baseline (combine more than one geomagnetically quiet date)
* More cases need to be analyzed
  * Other events in 2008
  * Events in 2010 and 2011
* Further investigation of differences between single pulse and alternating code data is necessary

* Thank you to Larisa for being such a great mentor!
* Thank you to Shun-Rong Zhang for help with the Sondrestrom local Ionospheric model!
* Thank you to the Haystack staff, especially K.T. and Ching!