Effect of Sudden Stratospheric Warming on Low- and Mid-Latitude Ionospheric Parameters as Simulated in the TIME-GCM Model

Allyson Clark
Penn State University
August 6, 2009

Motivation

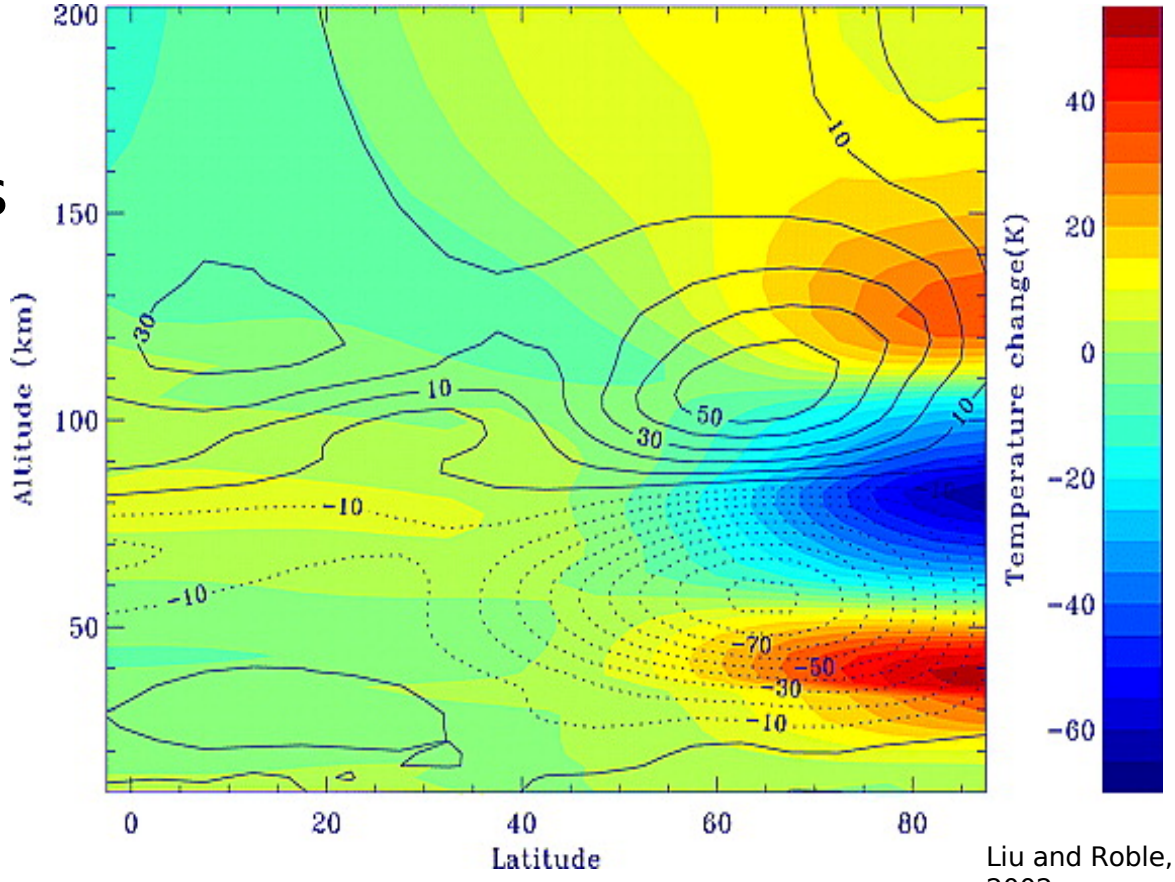
- Observations suggest links between ionosphere and stratosphere
- Plausible mechanisms can be studied with global circulation models
- Does a model realistically reproduce effects in the ionosphere from sudden stratospheric warming events?
- What are the drivers of changes in ionospheric parameters?

TIME-GCM Model

- Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model
- A product of National Center for Atmospheric Research
- Covers altitudes from ~30km to ~500km
- Resolution: 2.5 degree in latitude, 15 degree in longitude, 1 hour in time
- Produced data from December 2007 through February 2008.

TIME-GCM Model

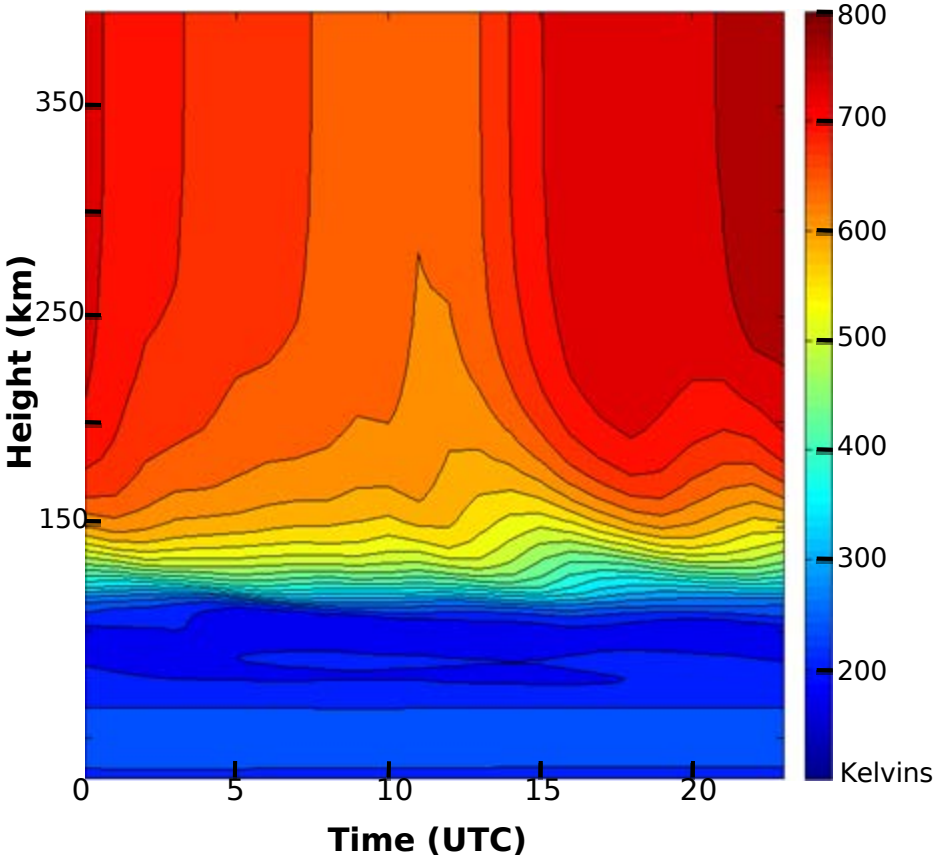
- Uses realistic geomagnetic activity (KP) and solar flux (F10.7) as drivers.
- Lower boundary: Stratospheric data
- Output parameters include:
  - Neutral temperature, electron density, vertical ion drift



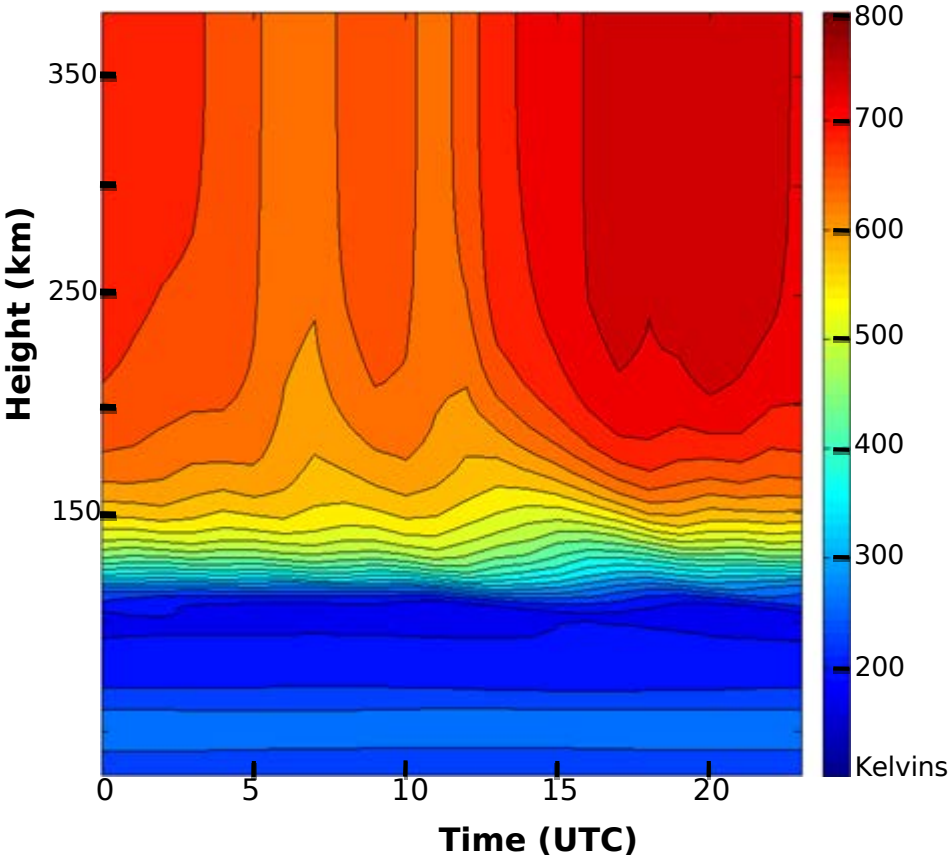
Liu and Roble, 2002

Modeled Neutral Temperature at Millstone Hill

Before SSW Event – 2008-01-19



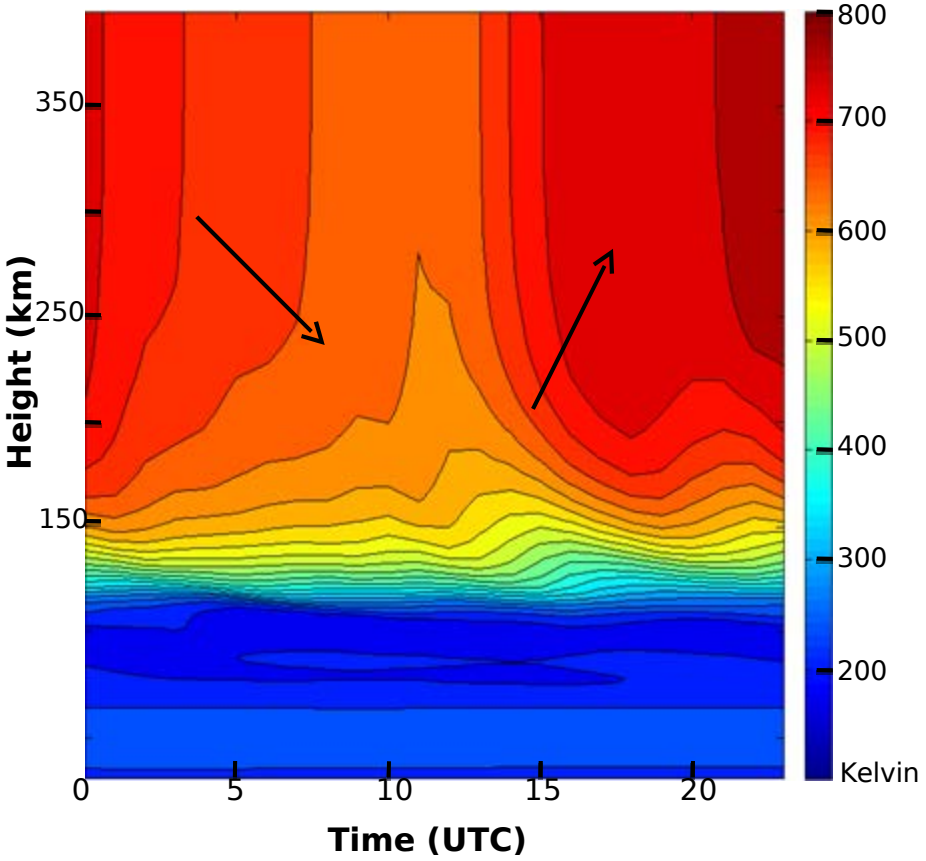
During SSW Event – 2008-01-26



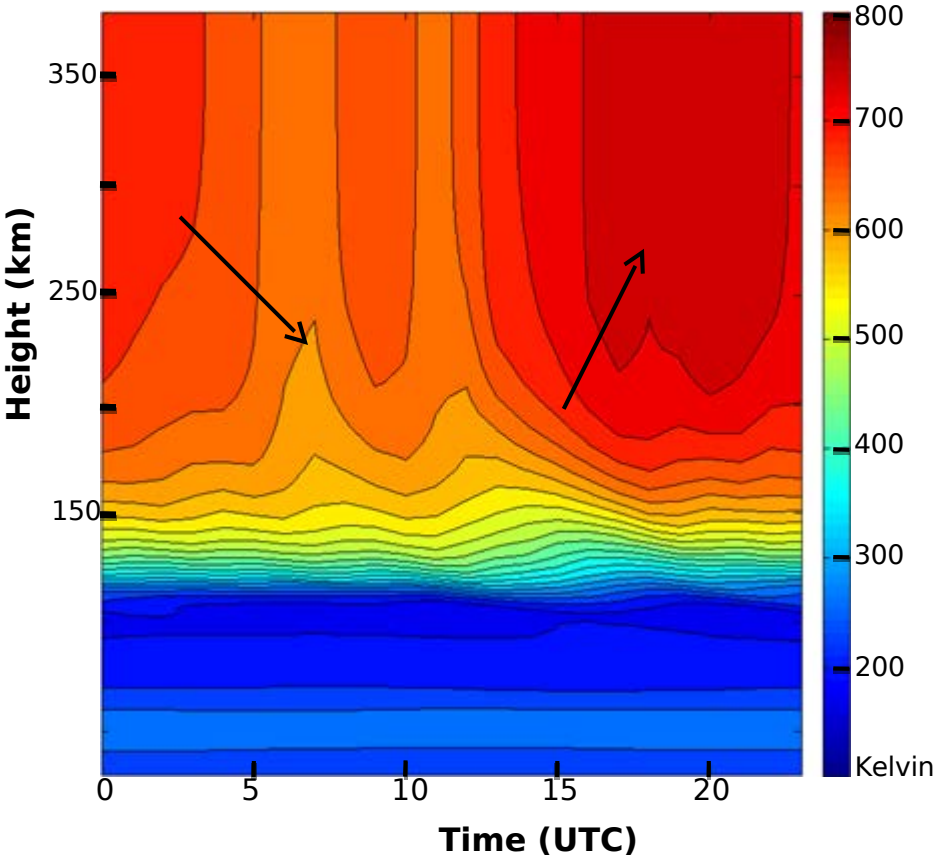
- Increased amplitude in wave structure
- Model shows same changes as observed data but on a smaller scale.

Modeled Neutral Temperature at Millstone Hill

Before SSW Event – 2008-01-19



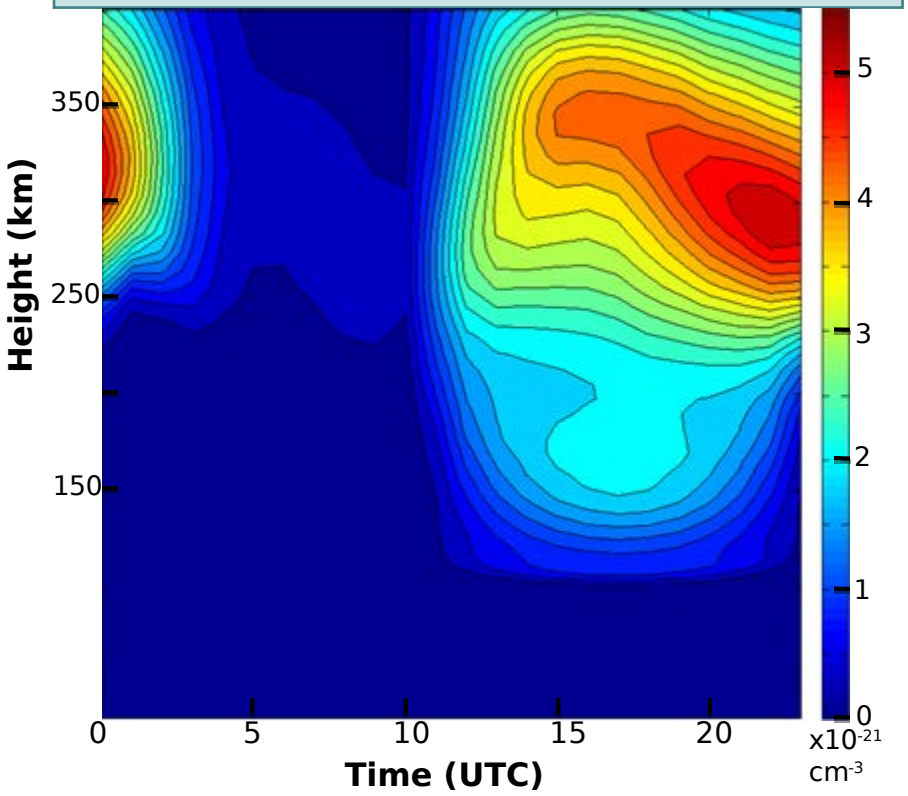
During SSW Event – 2008-01-26



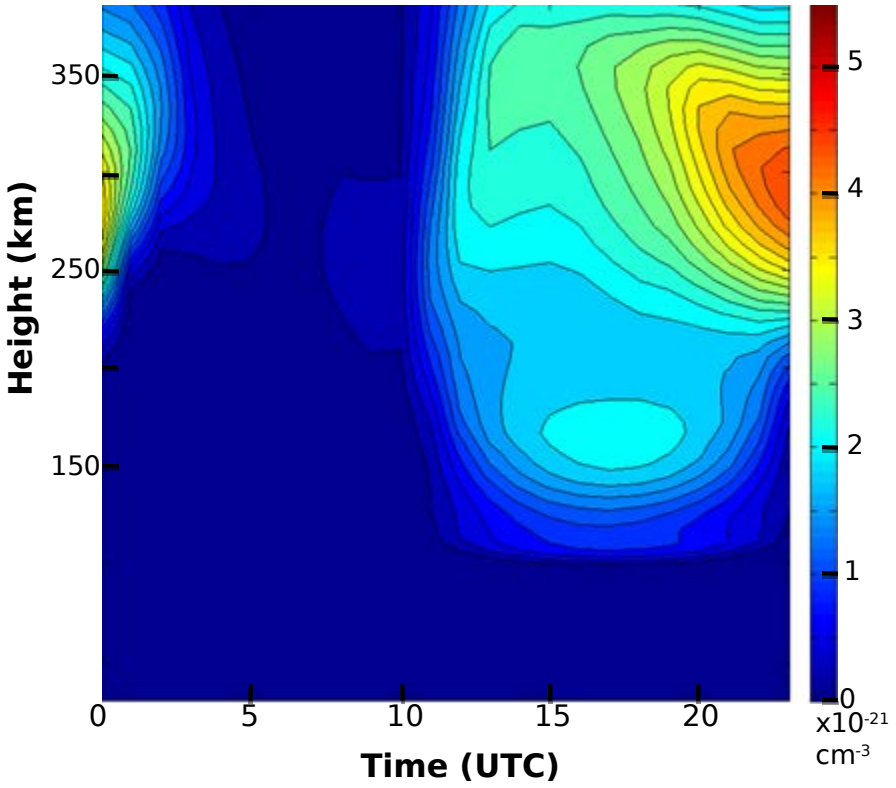
- Increased amplitude in wave structure
- Model shows same changes as observed data but on a smaller scale.

Modeled Electron Density at Jicamarca Observatory

Before SSW Event – 2008-01-19



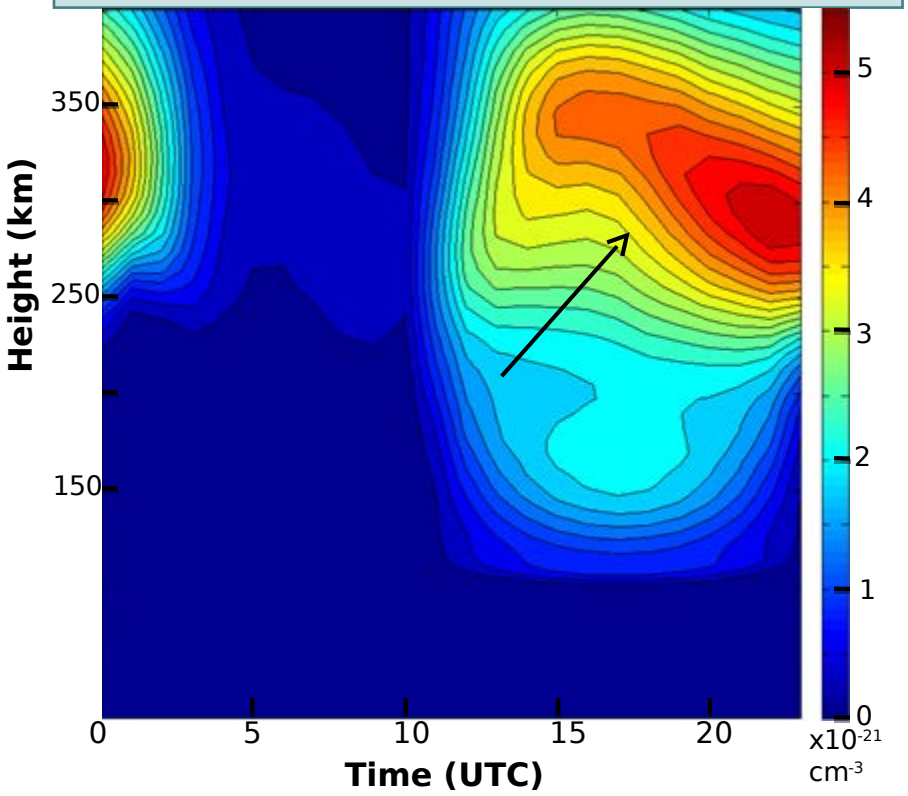
During SSW Event – 2008-01-26



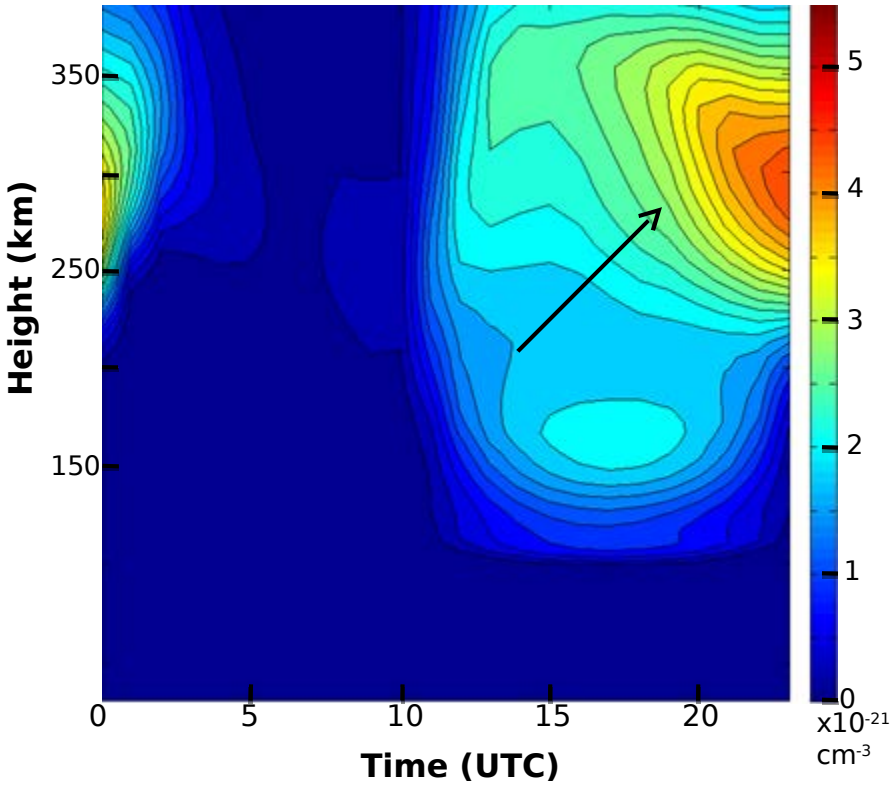
- There is a decrease in modeled electron density during the SSW event.
- Similar effects were seen in observational data.

Modeled Electron Density at Jicamarca Observatory

Before SSW Event – 2008-01-19



During SSW Event – 2008-01-26

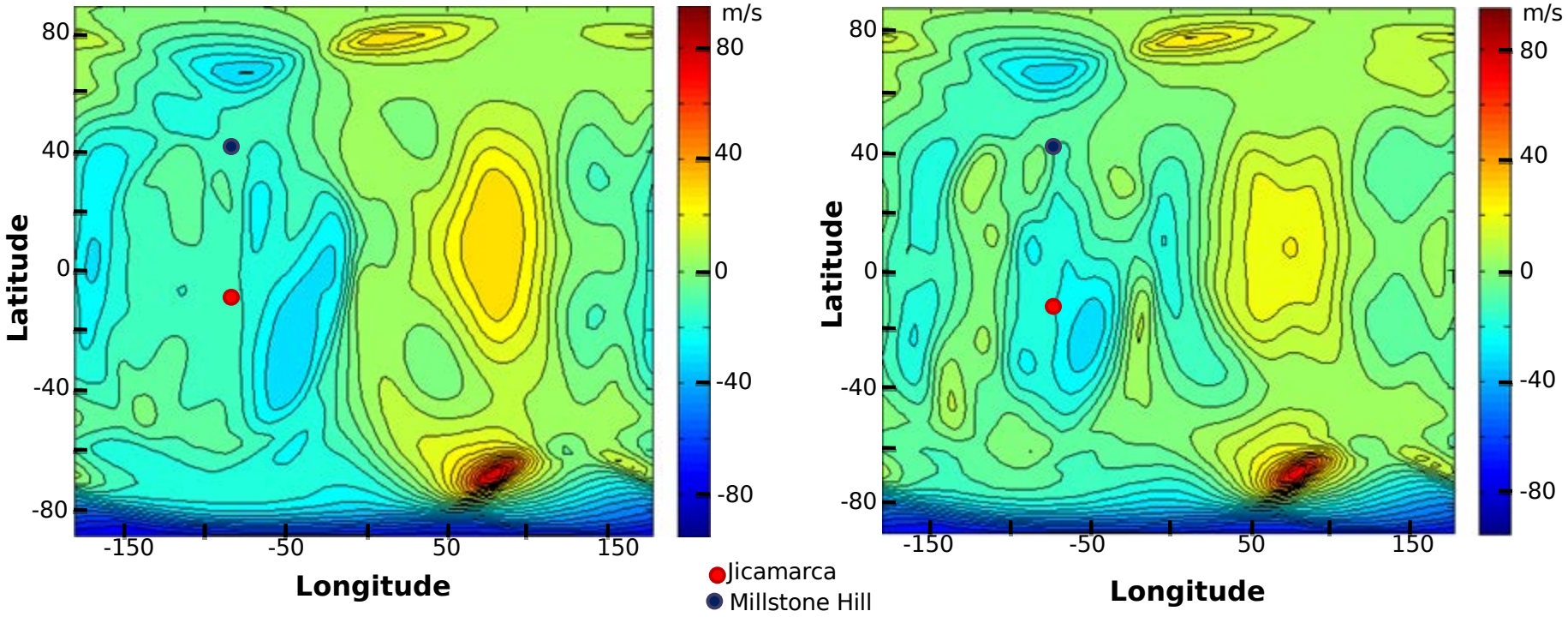


- There is a decrease in modeled electron density during the SSW event.
- Similar effects were seen in observational data.

Modeled Vertical Ion Drift

Before SSW Event – 2008-01-19 at 6 UTC

During SSW Event – 2008-01-26 at 6 UTC

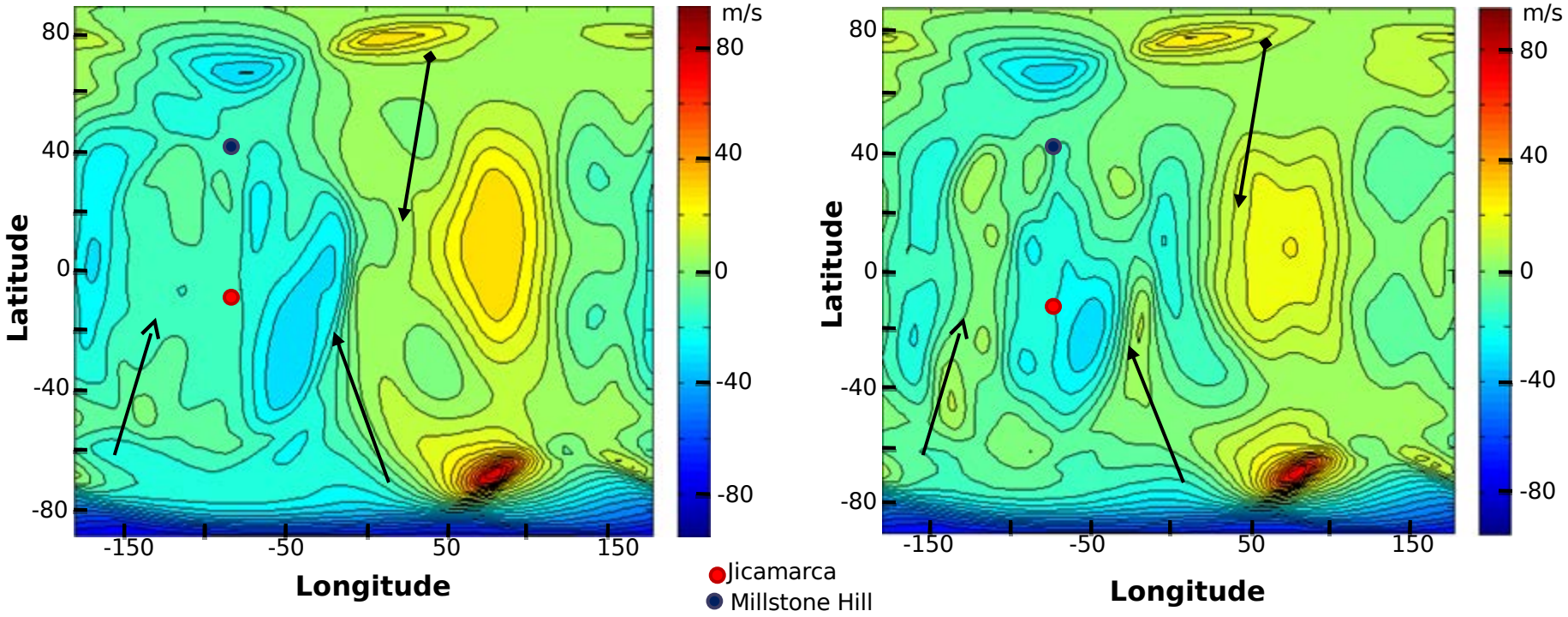


•During SSW, the model shows increased structure between -40 and 40 degrees latitude.

Modeled Vertical Ion Drift

Before SSW Event – 2008-01-19 at 6 UTC

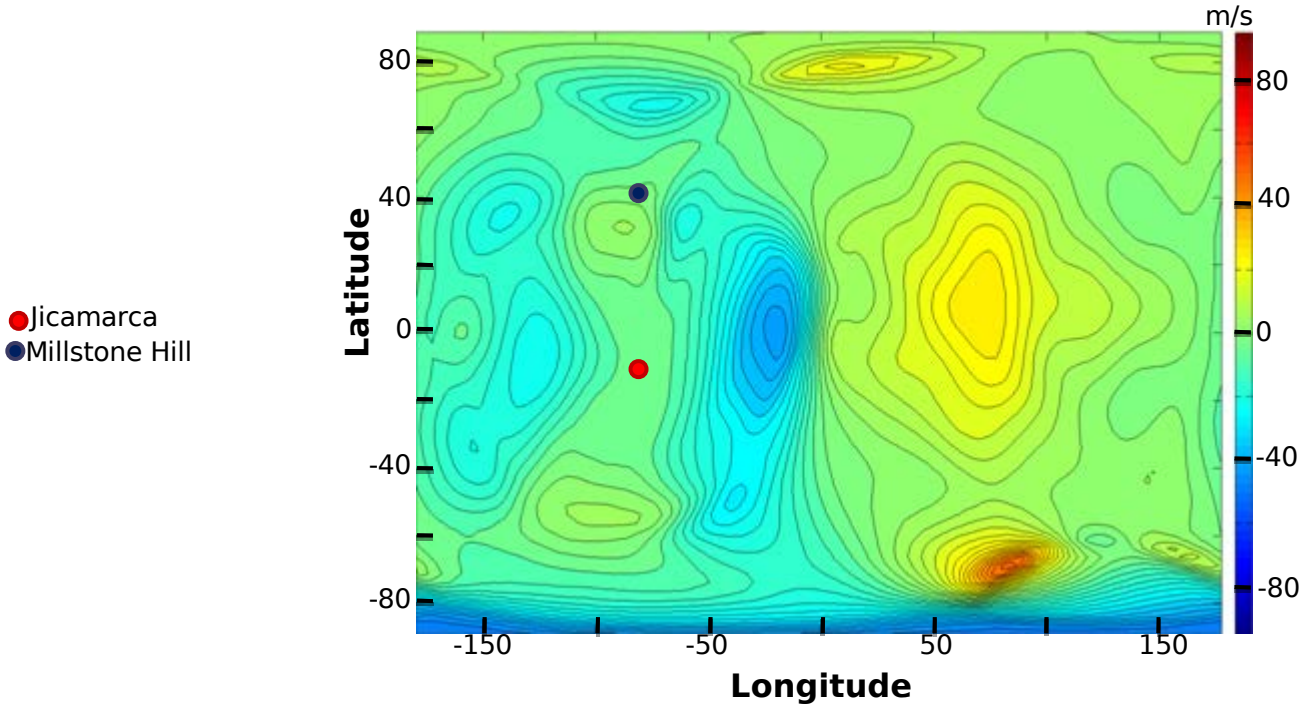
During SSW Event – 2008-01-26 at 6 UTC



•During SSW, the model shows increased structure between -40 and 40 degrees latitude.

Change in Modeled Vertical Ion Drift

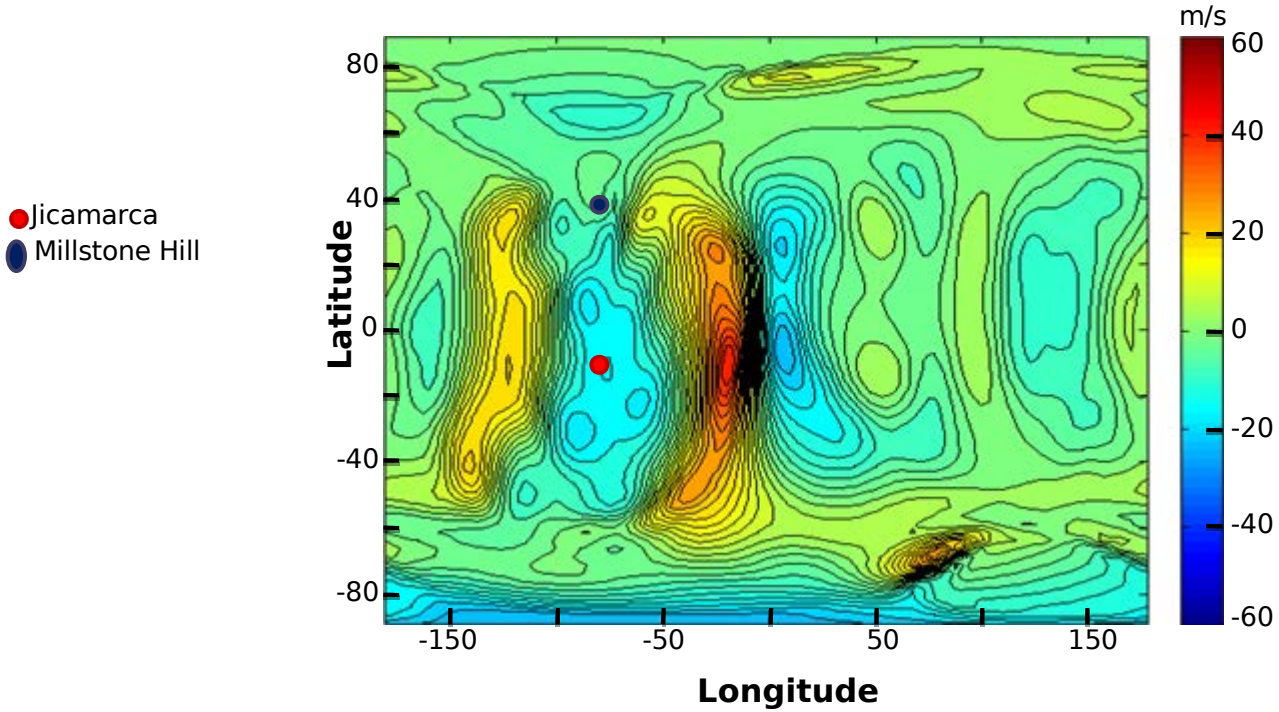
Baseline Vertical Ion Drift at 6UTC



•Calculated by averaging vertical ion drifts from the period of 2007-12-25 to 2007-12-29.

Change in Modeled Vertical Ion Drift

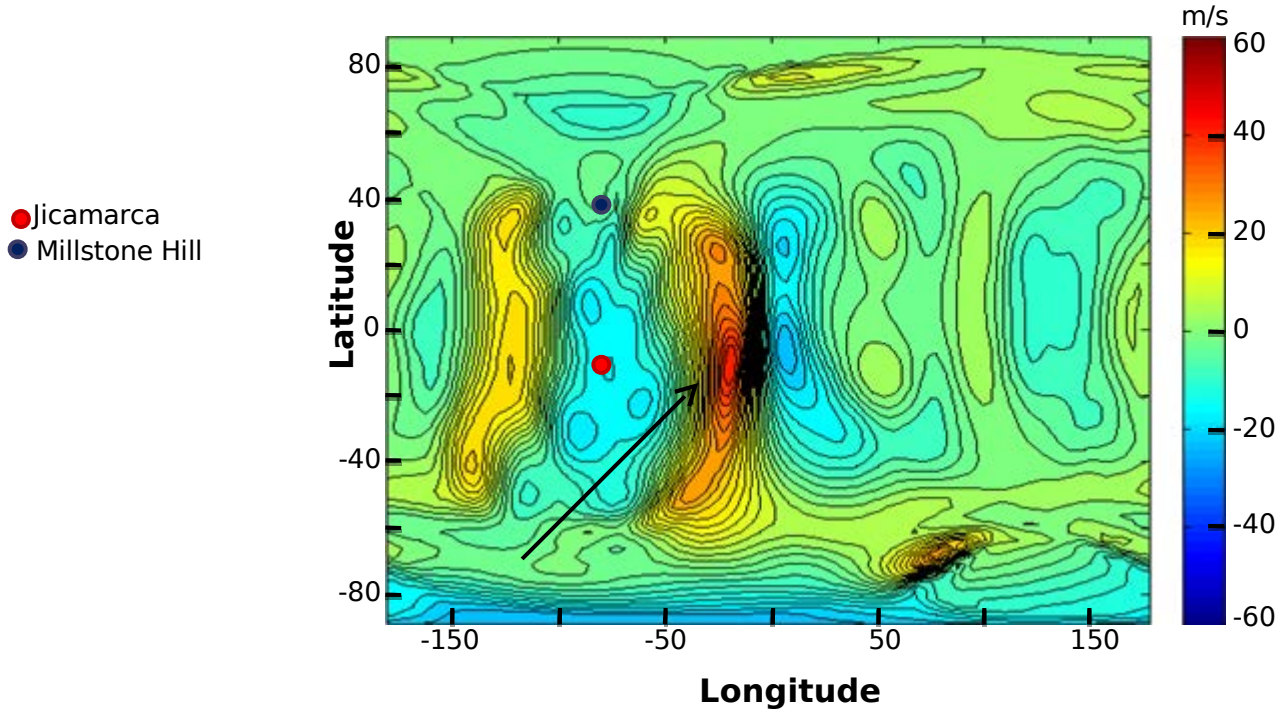
During SSW Event
2008-01-26 at 6UTC



•See large increases around -50 degrees longitude of up to 50m/s and has a complex longitudinal structure concentrated between -40 and 40 degrees latitude.

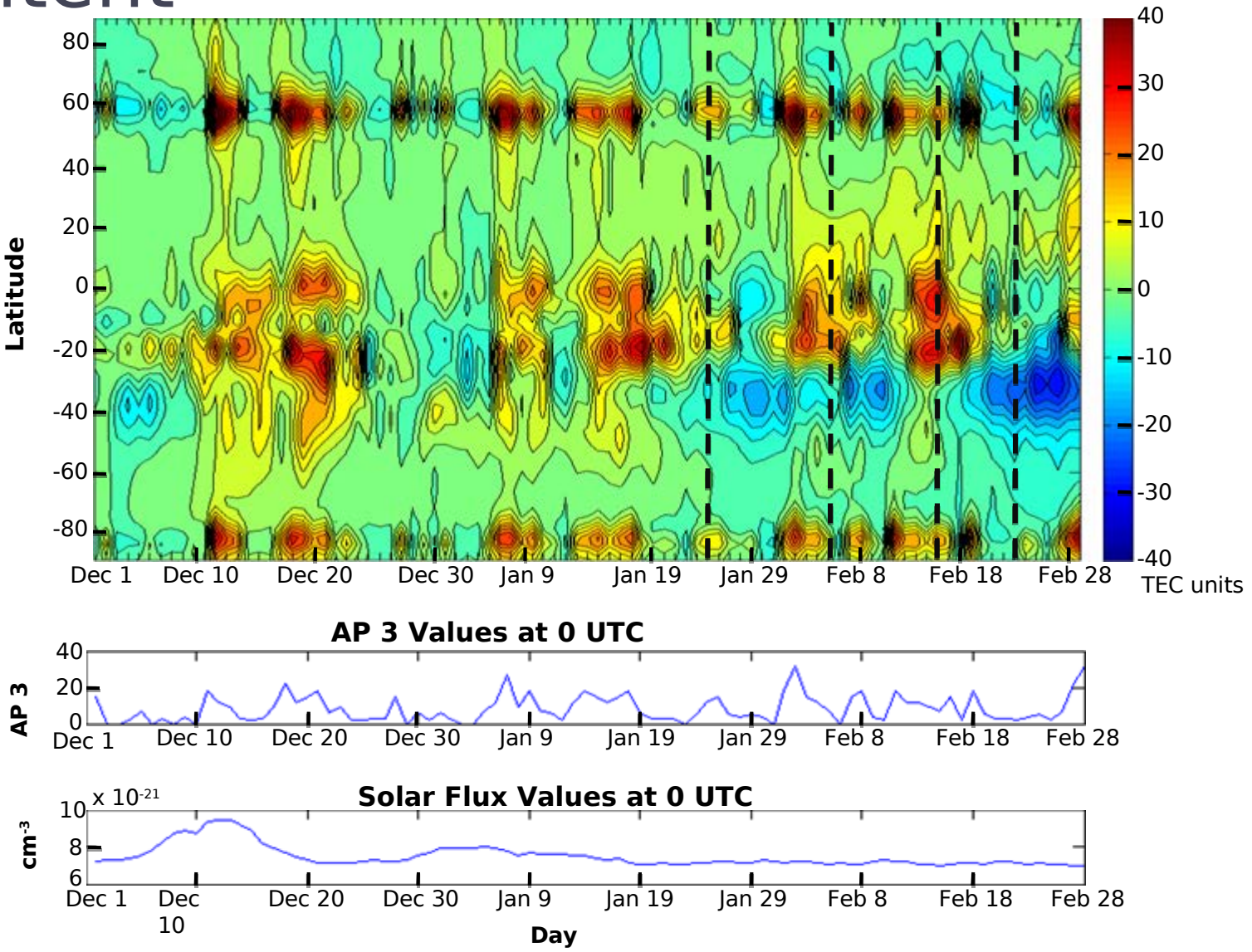
Change in Modeled Vertical Ion Drift

During SSW Event
2008-01-26 at 6UTC

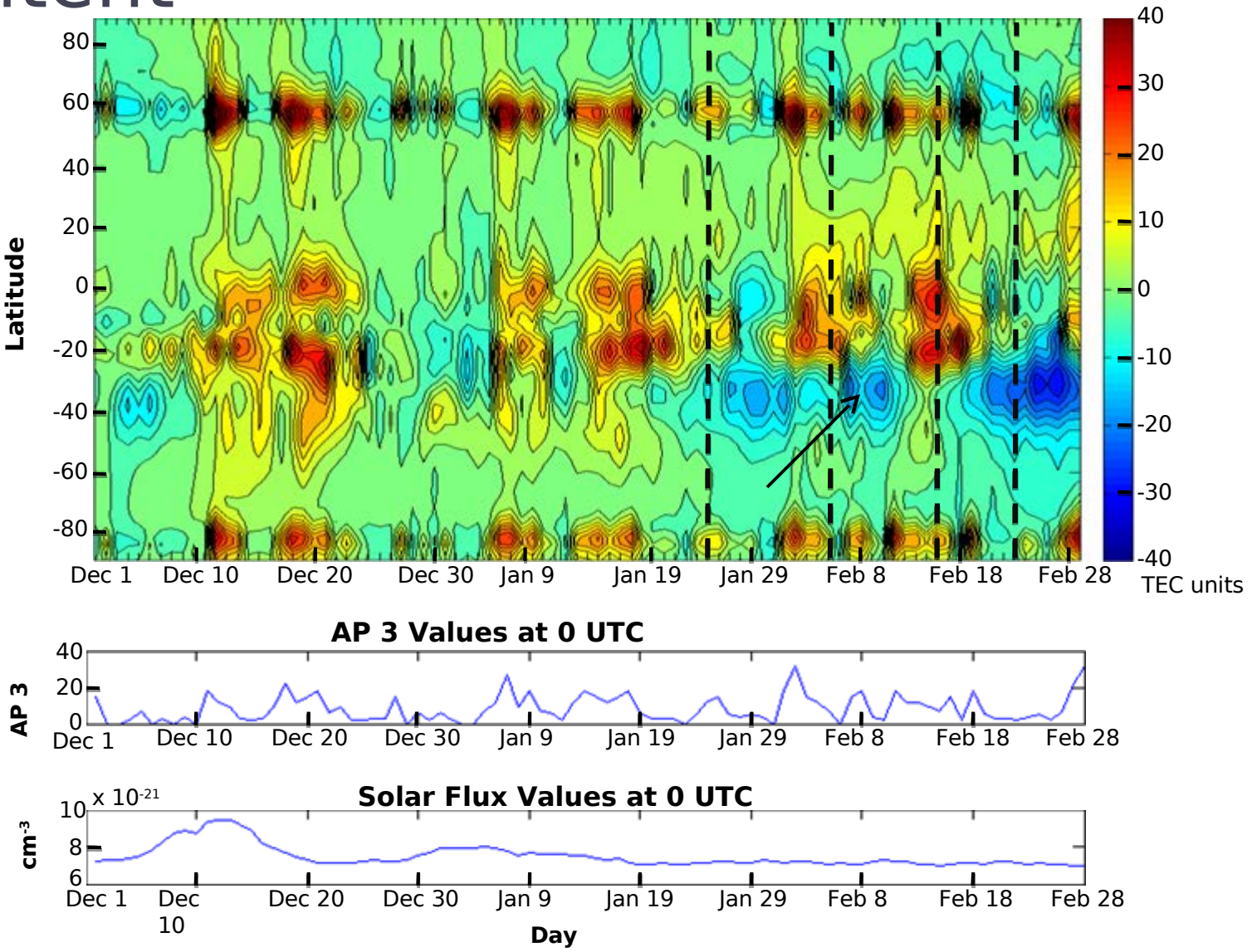


•See large increases around -50 degrees longitude of up to 50m/s and has a complex longitudinal structure concentrated between -40 and 40 degrees latitude.

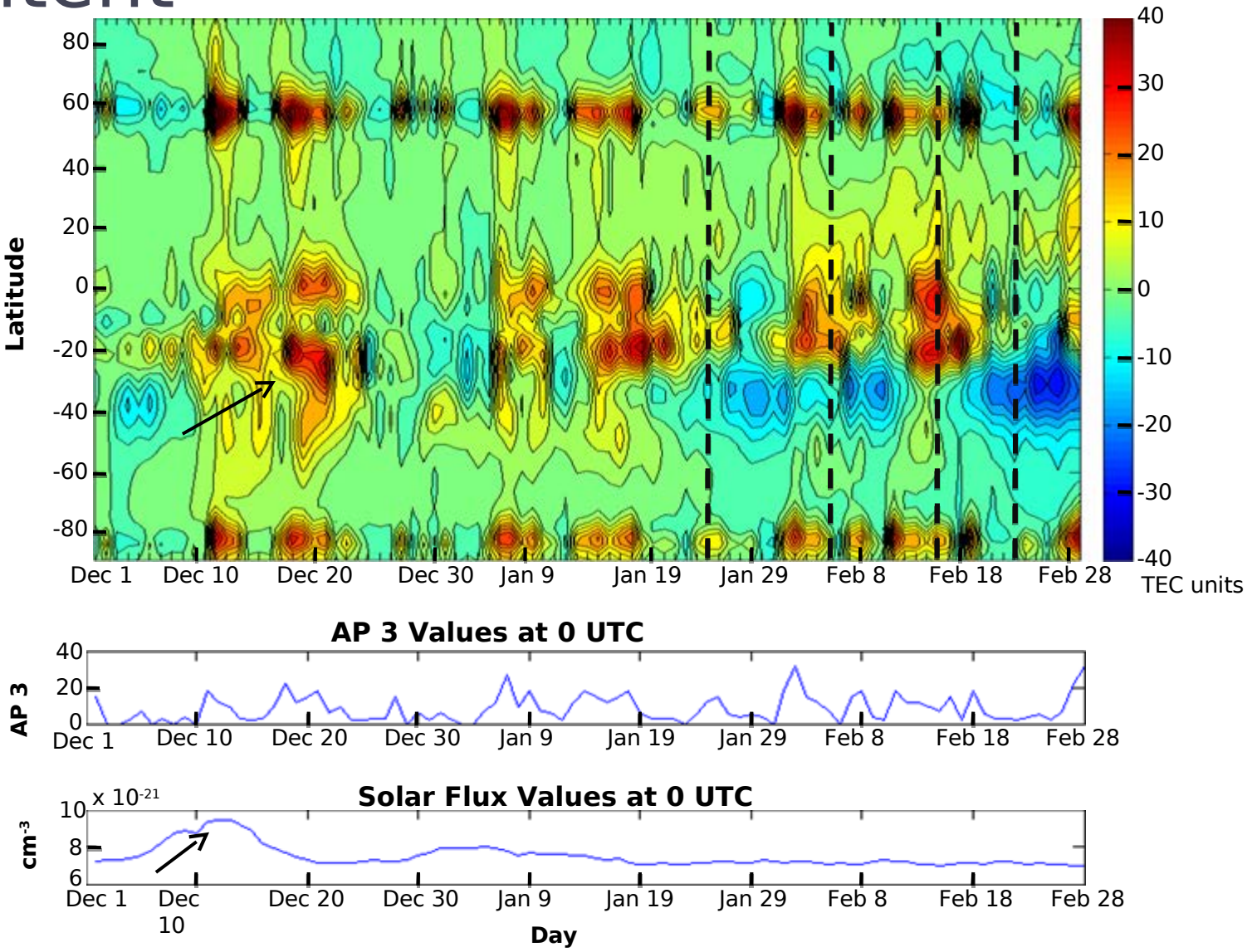
Change In Modeled Total Electron Content



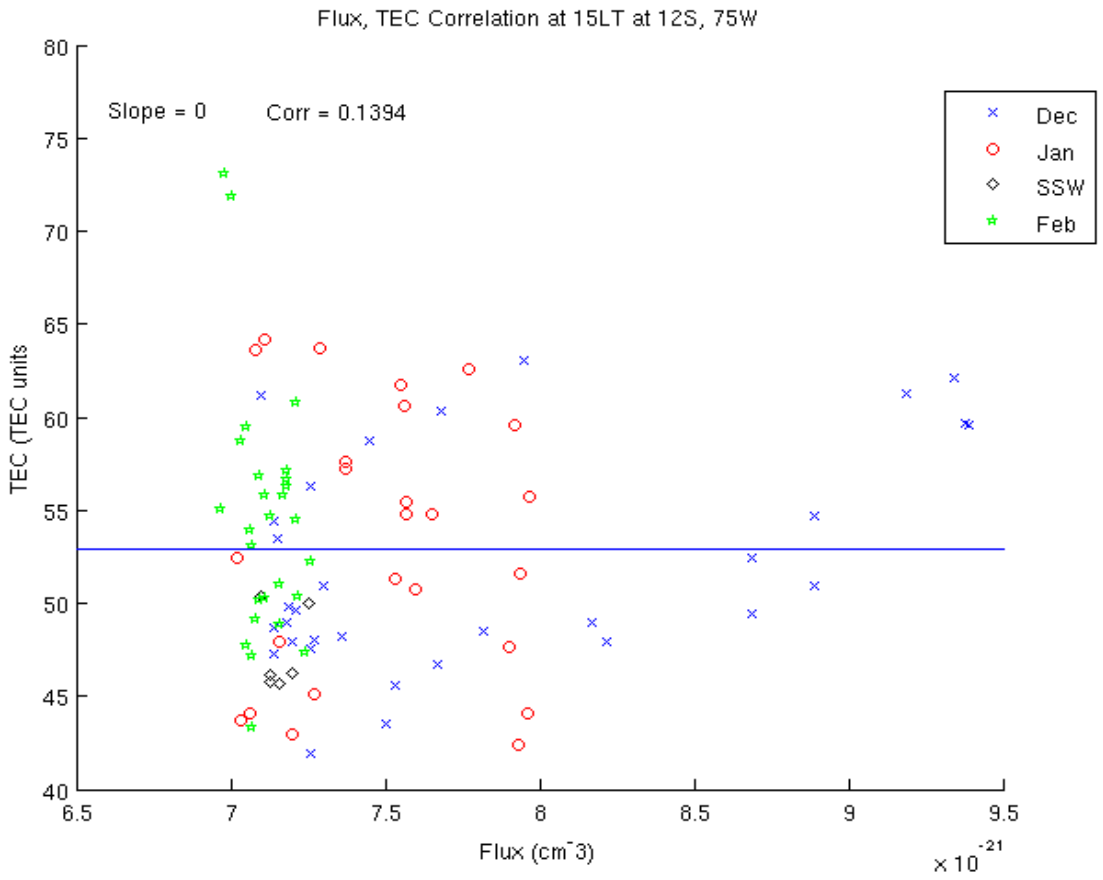
Change In Modeled Total Electron Content



Change In Modeled Total Electron Content

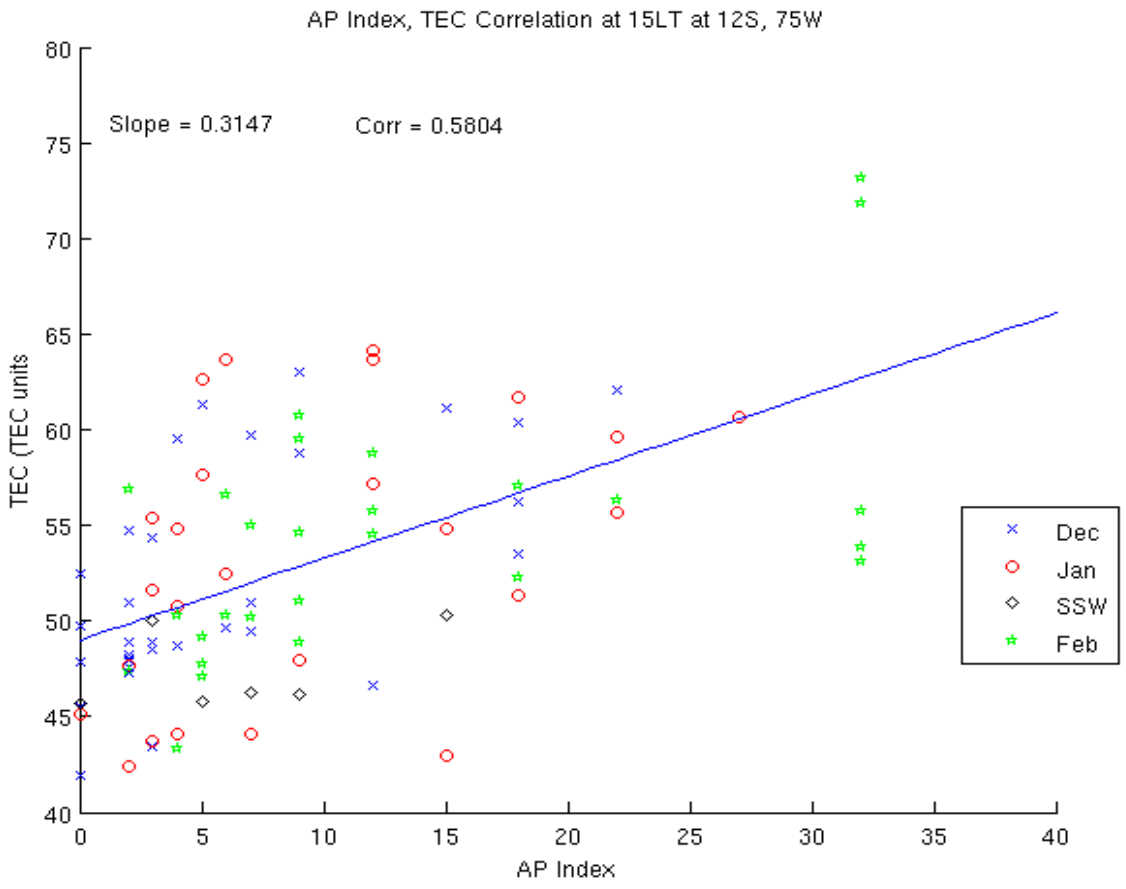


Dependence of TEC on Solar Flux and Geomagnetic Activity



- There is a no dependence on solar flux.

Dependence of TEC on Solar Flux and Geomagnetic Activity



•There is a weak linear dependence on geomagnetic activity.

Conclusions

- The model shows significant variation in ionospheric parameters in the winter of 2007 to 2008.
- Possible drivers may include: F10.7, AP 3 index, seasonal change, stratospheric events
- There is a weak linear dependence of total electron content on geomagnetic activity and no dependence on solar flux, showing that these major drivers cannot be responsible for all ionospheric variations

Future plans

- Expand investigation of TEC dependence to include more latitudes and times.
- Spectral analysis of variations
- Relationship and time delays between changes in stratospheric and ionospheric parameters

Acknowledgments

- Thanks to Larisa for her help this summer.
- Thanks to NCAR for the model data.
- Thanks to NSF for funding my project.