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

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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

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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

There is a decrease in modeled electron density during the SSW event.
• Similar effects were seen in observational data.
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.
• See large increases around -50 degrees longitude of up to 50 m/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

AP 3 Values at 0 UTC

Solar Flux Values at 0 UTC
Change in Modeled Total Electron Content

AP 3 Values at 0 UTC

Solar Flux Values at 0 UTC
Change In Modeled Total Electron Content

AP 3 Values at 0 UTC

Solar Flux Values at 0 UTC
Dependence of TEC on Solar Flux and Geomagnetic Activity

- There is 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
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