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Stormtime effects in the thermospheric neutral winds and temperatures over Brazil

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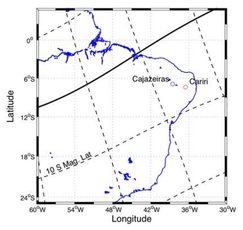
ABSTRACT

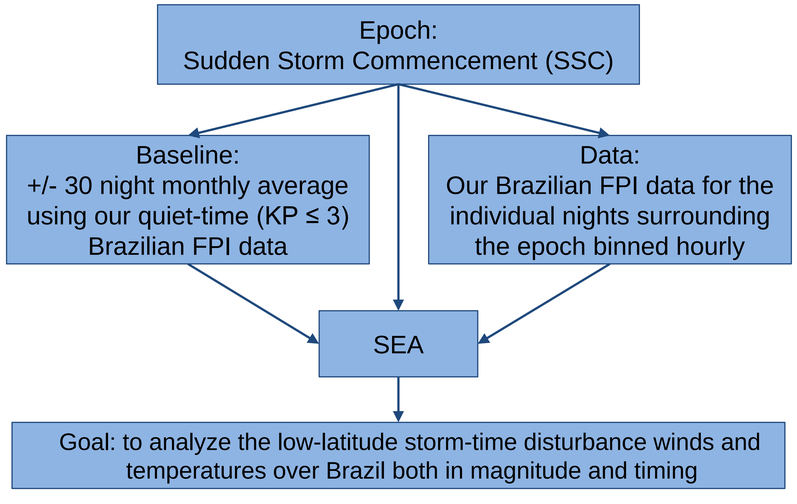
We present a collection of storm-time results from Fabry-Perot interferometer measurements taken over northeast Brazil. Two FPIs have been operating nearly continuously since September 2009, observing the storm-driven effects on the thermospheric neutrals via the redline emission. Analyzing these dynamics are useful in studying the low-latitude forcing from energy input in the auroral region that propagates through the disturbance dynamo mechanism. We use both individual case studies and an epoch analysis approach to track the neutral wind, temperature, and brightness changes associated with storms of varying intensity and local-time onset. This study aims to validate the disturbance dynamo effects seen in satellite-based observations.

THERMOSPHERIC STORM STUDY

- Two ground-based Fabry-Perot Interferometers (FPI) in Brazil (low-latitude fixed-location)
- Observations of the nighttime 630.0-nm redline emission spectra (around 250 km)
- Nearly continuous nightly neutral temperatures and winds were recorded from mid 2009 to the end of 2015



SUPERPOSED EPOCH ANALYSIS



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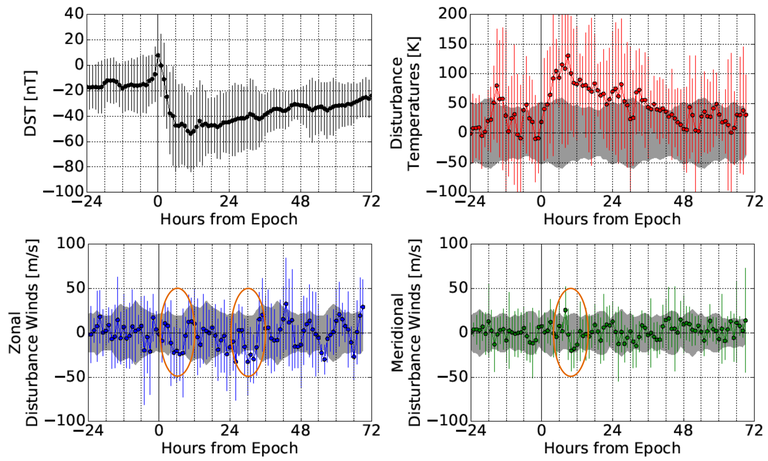
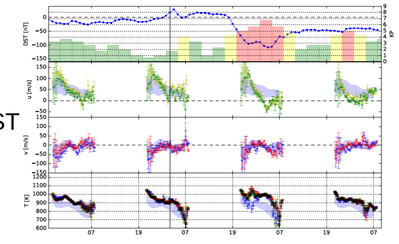
EPOCH ANALYSIS USING FPI DATA



- Of the 60 SSC events that occurred from 2009 to 2015, only 20 nights had reasonable, cloud-free data
- The combined (by SSC epoch) disturbance storm-time (DST) index shows an ideal signature for geomagnetic storms
- Neutral temperatures dramatically increase hours after SSC
- Zonal winds show a small westward turning at ~6 hours and ~30 hours after SSC
- Meridional winds may show a small northward ~6 hours and then southward surge ~10 hours after SSC, however this is on the border of statistical significance
- Note during storms, SNR decreases, increasing our measurement uncertainties

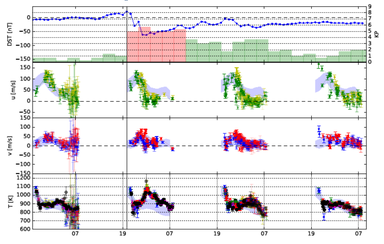
CASE STUDY I: APRIL 23, 2012

- Strong storm: -108 nT
- Very long initial phase
- Strong westward turning seen in the neutral winds after drop in DST
- Temperature increase
- No meridional disturbance



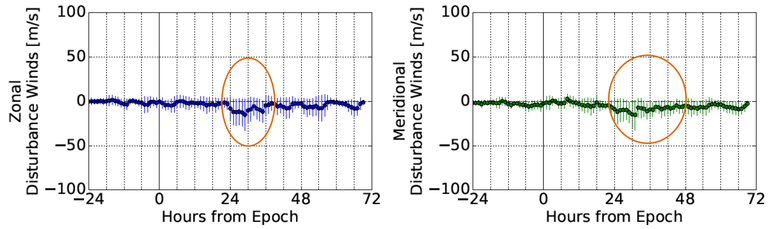
CASE STUDY II: OCTOBER 8, 2013

- Weaker storm: -64 nT
- Short initial phase
- Strong westward turning seen in the neutral winds coincident with drop in DST
- Temperature increase
- No meridional disturbance



EPOCH ANALYSIS USING HWM14

- The disturbance wind model (DWM) of HWM14 is used for validation
- Zonal disturbance winds are westward around 15 m/s
- Zonal disturbance winds are seen from 24 to 36 hours after SSC
- Meridional disturbance winds are southward around 15 m/s
- Meridional disturbance winds begin about 24 hours after SSC and gradually recovers over the next 24 hours



DISCUSSION

- Seasonality, local time, and solar cycle may all factor into disturbance dynamo, however, the limited storm data prevents a statistically significant analysis across these variables
- Disturbance dynamo theory suggests that zonal winds should be westward; this is supported by the data and HWM
- Meridional wind data show no significant effect; this could be due to the relatively small magnitude of the disturbance or due to averaging effects of the disturbances launched from each hemisphere
- The timing of disturbance propagation should be 3-6 hours; both data and model results indicate a later propagation time
- Further analysis will separate storms based on magnitudes and will investigate different determinations of the zero epoch

CONCLUSIONS

- FPI data show significant storm driven heating at low-latitudes immediately after SSC
- Both Brazilian data and DWM show minimal disturbance dynamo effects; this is reasonable for the low-latitude thermosphere
- A westward turning of the measured zonal winds occurs around 6 and 30 hours; DWM only shows a disturbance centered around 30 hours
- No clear meridional disturbance wind is seen in the analysis
- More storm-time data is required to analyze the seasonal and local time variations from this fixed location instrument

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