NASA Science

AGU Fall 2003 Meeting

The Ionospheric Response to the Interplanetary Events of October 28th and 30th, 2003

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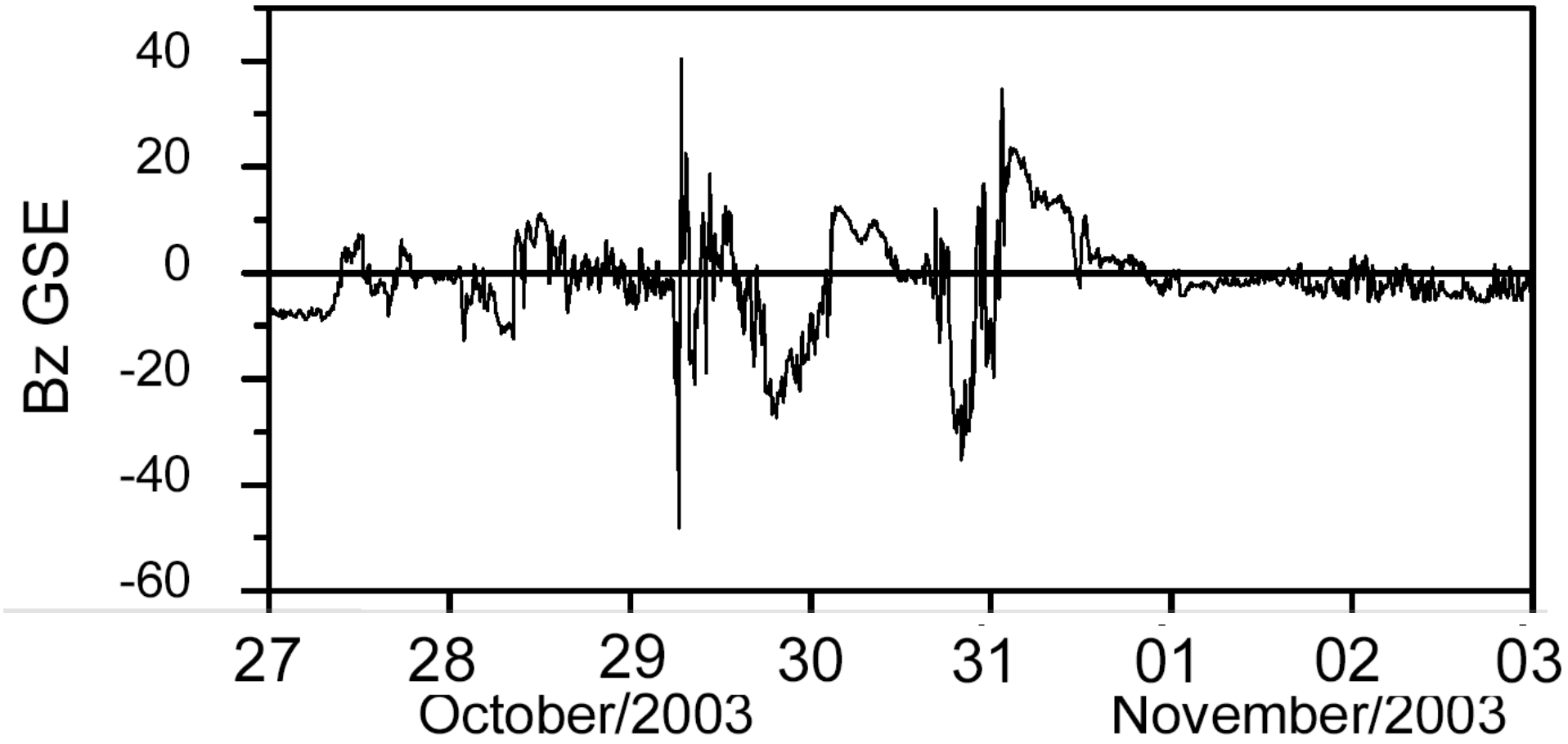
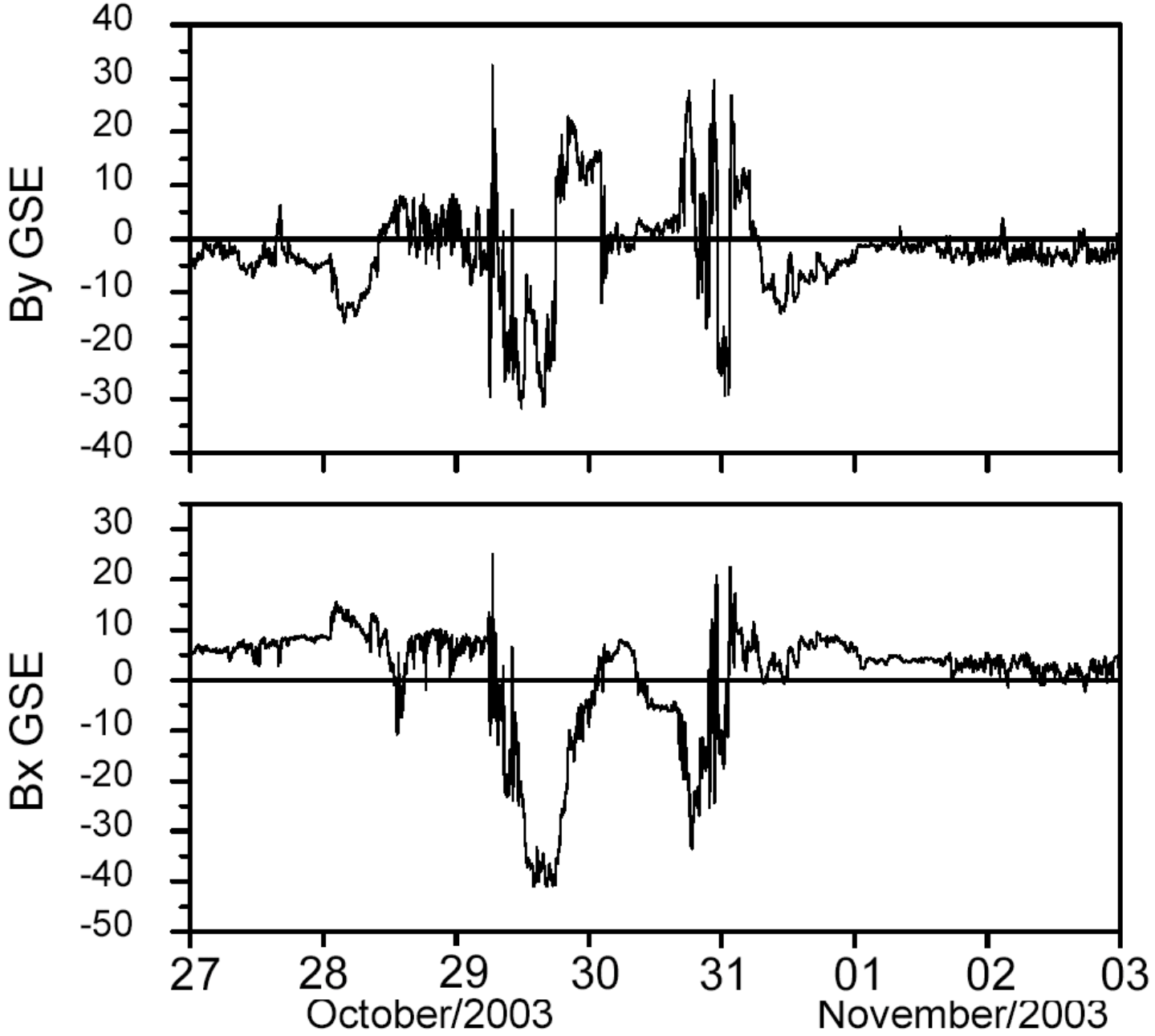
1. Introduction

The twin interplanetary shock events occurring on October 29th and October 30th, 2003, had major impact on the terrestrial ionosphere. Both events created high values of total electron content (TEC) and significant global-scale dayside redistributions of ionospheric plasma, as measured by a global network of GPS receivers and the JASON ocean altimetry satellite, continuously obtaining TEC data throughout the events.

2(a) ACE Data


Bz GSE
40
20
0
-20
-40
-60
27
28
29
30
31
01
02
03
October/2003
November/2003

2(b) ACE Data


By GSE
40
30
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-40
Bx GSE
30
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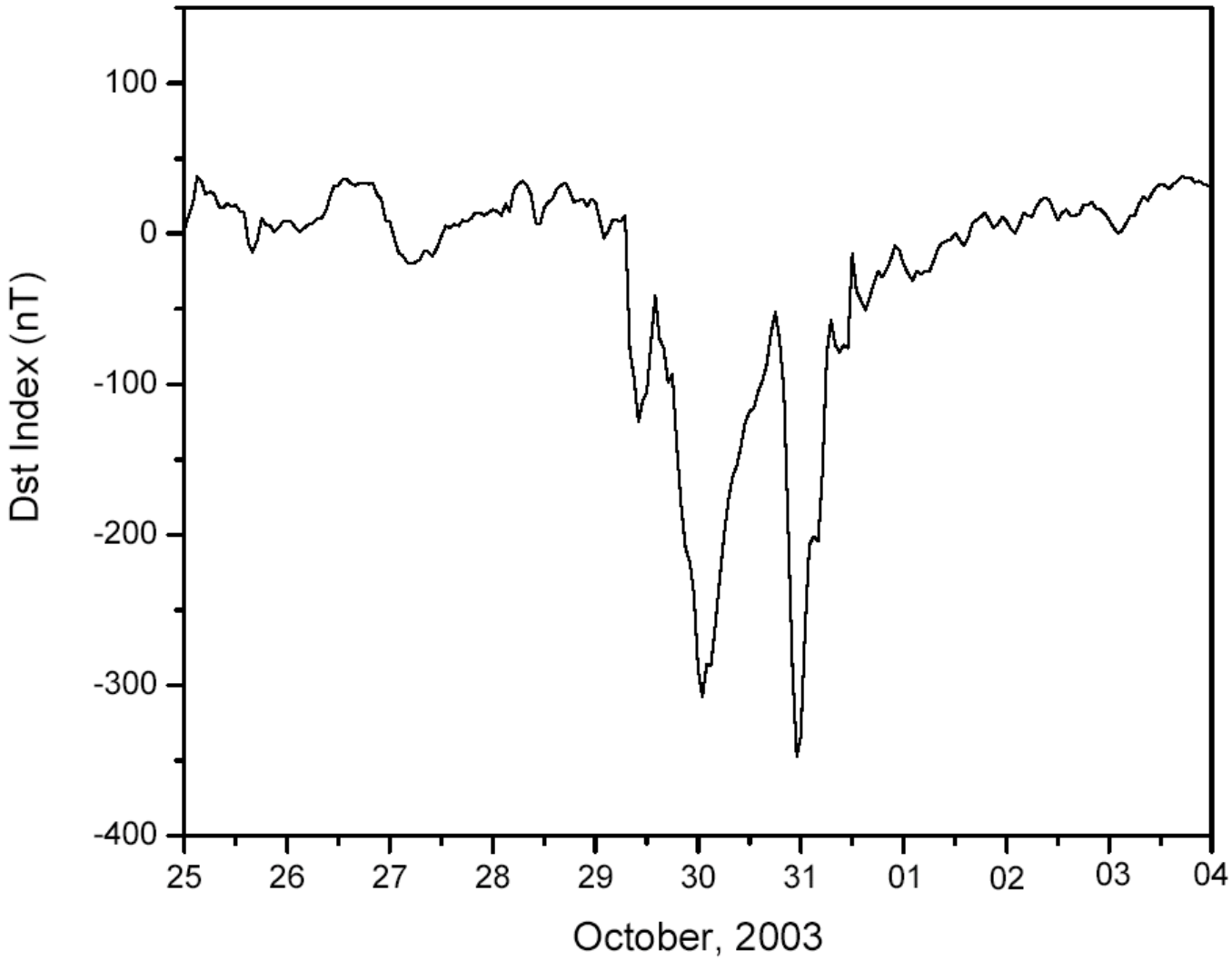
0
-10
-20
-30
-40
-50
27
28
29
30
31
01
02
03
October/2003
November/2003

2(c) *Dst* Data



This is the figure plotted with the Dst data downloaded from Kyoto website. The Dst data resolution is one hour.

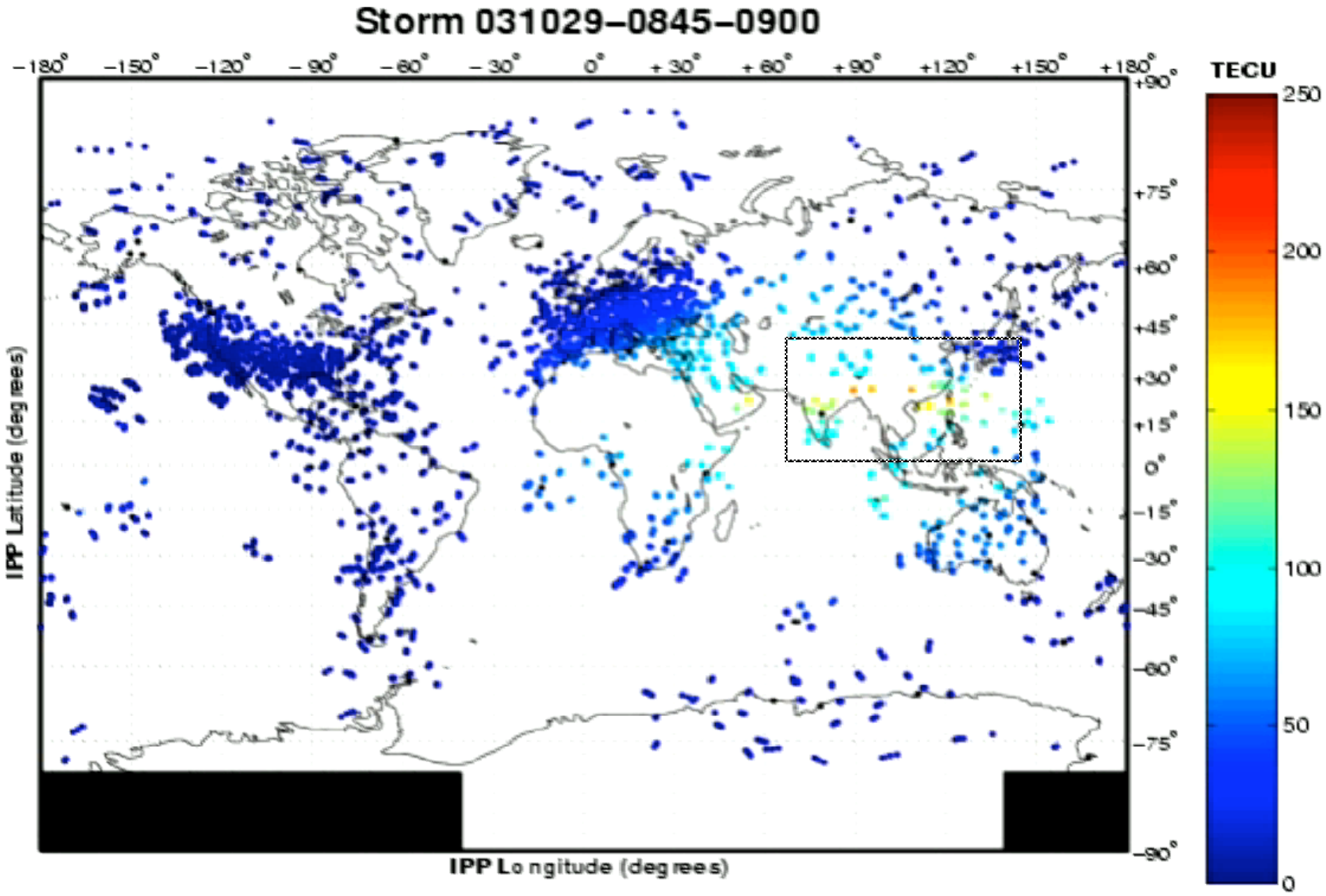
2(d) ACE Velocity Data

3(a) Initial Bz Southward

The October 29 event was characterized by a very brief (less than 1 hour) southward Bz "spike" of ~ 45 nT at about 6.5 hours UT that quickly turned northward. As viewed using global point-wise maps of ionospheric TEC, there appears to be evidence of a significant low-latitude TEC response in the East Asia/India longitude sector approximately 1-2 hours later, corresponding to a ~ 70% increase in vertical TEC from about 120 TECU maximum on the previous day to about 200 TECU on October 29 between 8-9 UT, corresponding to afternoon local times (14-15 LT). The response appears to subside within 1-2 hours, although this subsidence may simply be due to a lack of measurements (e.g over Africa and the Indian ocean).

1 TECU = 10^{16} el/m^2

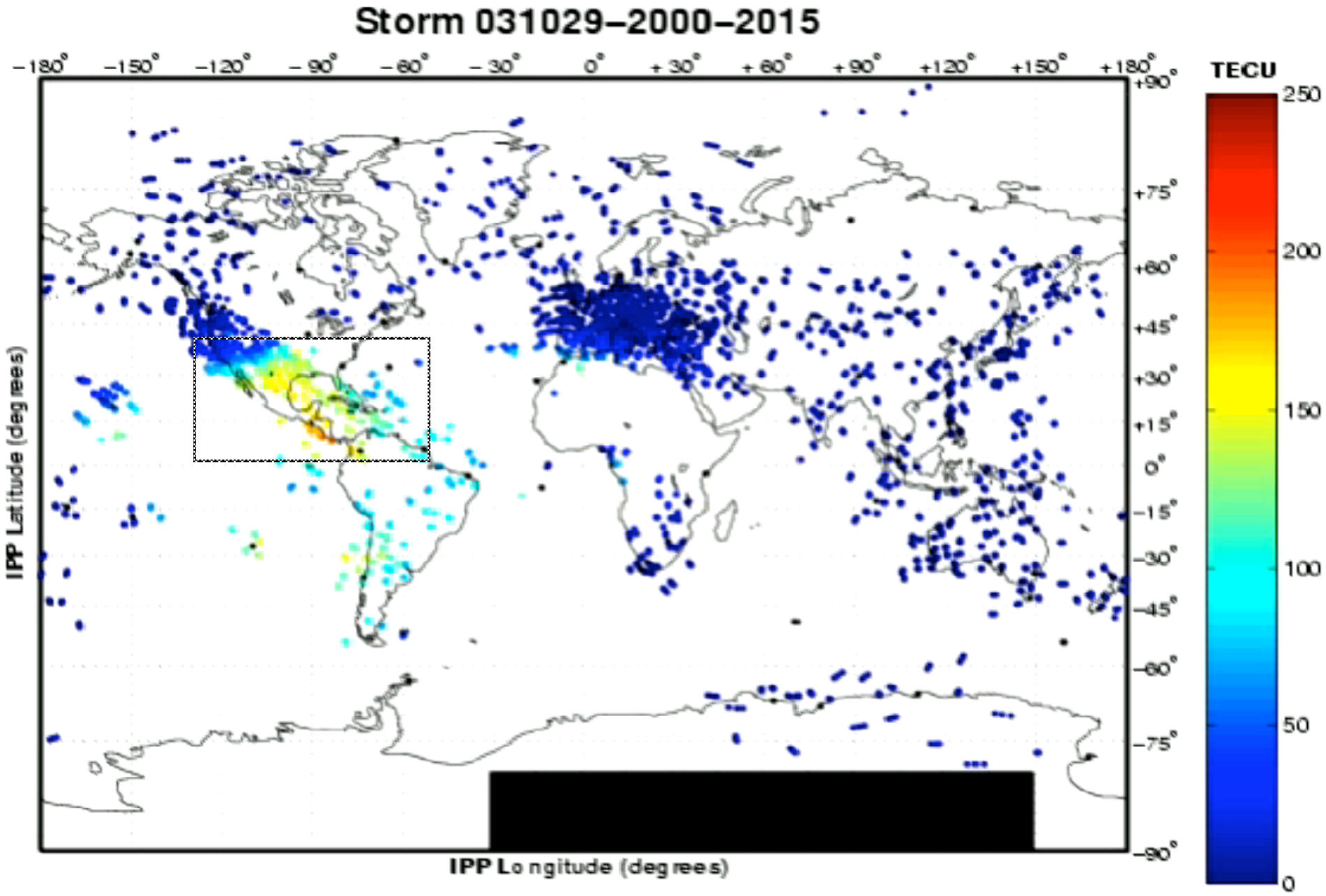
3(b) Point TEC Map



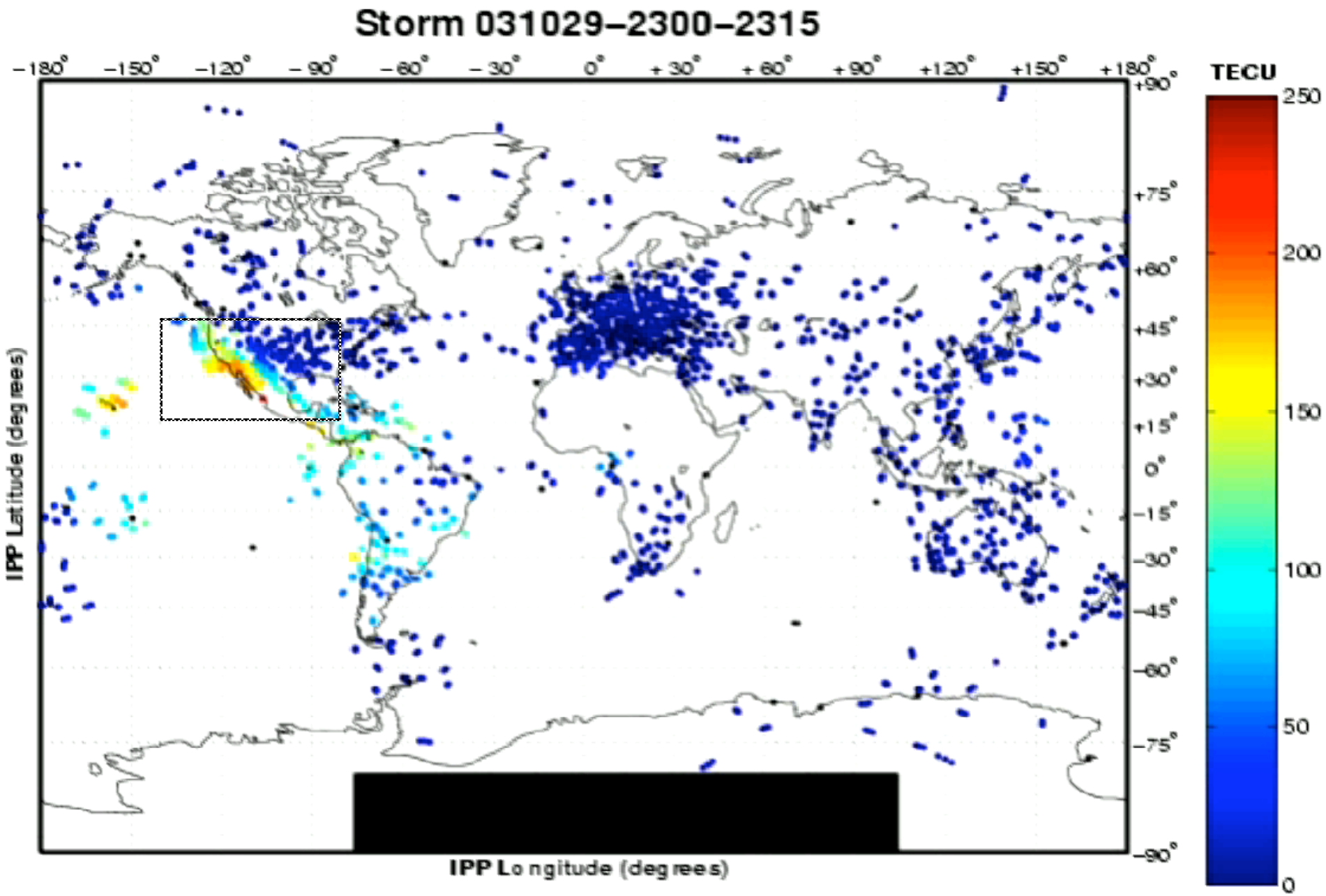
4(a) Gradual Southward Bz Oct 29

Later on October 29, the IMF turned more gradually southward starting at ~15 UT reaching ~ 25 nT southward at 19.5 UT. Somewhat larger (~225 TECU) vertical TEC values are observed in the equatorial American longitude sector starting at about 20 UT, corresponding to about 14 hours local time. A sunward-moving plume-like structure appears to redistribute plasma from low latitudes to northern mid-latitudes starting at about 22 UT (16 LT) and continuing for at least 2-3 hours. The apparent motion and magnitude of the plasma enhancement is reminiscent of a sub-auroral polarization stream (SAPS) electric field driver, although this needs to be confirmed using other measurements of auroral/sub-auroral electrodynamic patterns.

4(b) Point TEC Map



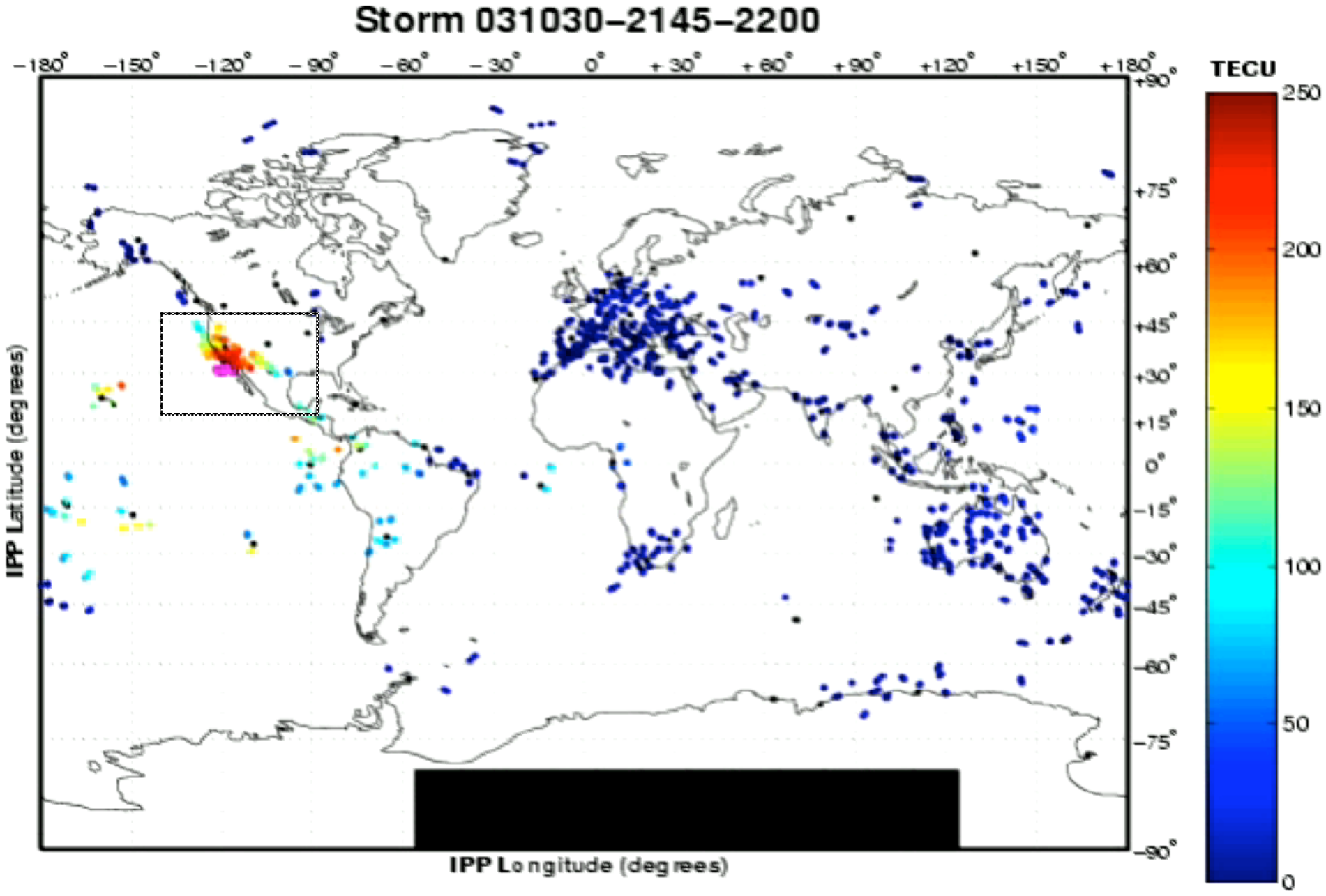
4(c) Point TEC Map



5(a) October 30, American Sector

On October 30, a rapid southward Bz turning occurs between 18.5 and 19.5 UT, reaching nearly ~ 35 nT southward. Very large, low to mid-latitude TEC values (250 TECU+) are observed in northern western American longitudes as early as 21 UT. This develops into a plume-like feature over the western United States similar to that observed on October 29.

5(b) Point TEC Map



6(a) Southern Pacific Features

At southern latitudes in the mid-Pacific sector, remarkable dayside plasma redistribution was captured by JASON TEC data: at about 22 UT, we observe a significantly enhanced equatorial peak TEC of ~250 TECU at noon local time and 30 degrees southern latitude (geographic). On October 28th the maximum TEC recorded by JASON was about 120 TECU at a southern mid-Pacific latitude of 20 degrees. Therefore, the interplanetary event may be causing a doubling in TEC magnitude and possibly a poleward shift in the southern anomaly peak.

6(b) Southern Pacific Features

The corresponding northern anomaly peak (captured at 10 LT by the JASON orbit in the western Pacific) is only 100 TECU in magnitude at 20 degrees northern geographic latitude, and is far more similar to values recorded on the geomagnetically "quiet" October 28. Therefore, either the anomaly has become very asymmetric (N-S direction) or a strong local time gradient has been introduced (neither feature seems to be present on October 28).

6(c) JASON Data Oct 30, 2003

6(d) Quiet Compare Oct 28, 2003

7. Concluding Remarks

Low-latitude plasma density increases associated with geomagnetic storms can be brought about by east-west electric fields uplifting the plasma. The electric fields can originate from under-shielded magnetospheric convection fields or the thermospheric dynamo, the latter typically requiring a few hours to reach the equator. Mid-latitude TEC enhancements are caused by aurorally generated equatorward neutral winds that uplift plasma vertically along field lines, as well as the SAPS electric field. The rapid global dayside TEC response to these significant interplanetary events is noteworthy, and unraveling the cause and effect relationships will require the coordination of multiple types of observations. We acknowledge the preliminary nature of both the observations and their possible interpretation, and more careful study is necessary to elucidate the detailed structure, and ultimately the causes, of the apparent responses noted here.