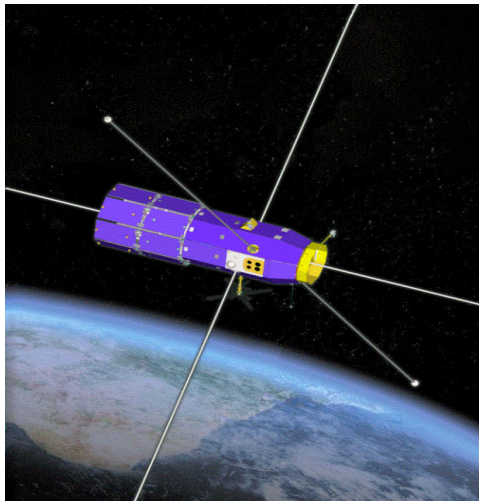
Initial Results from the Vector Electric Field Investigation on the C/NOFS Satellite -- Brief Overview



R. Pfaff, D. Rowland, M. Acuna, N. Maynard, G. Le, W. Farrell, R. Holzworth, G. Wilson, W. Burke, H. Freudenreich, K. Bromund, S. Martin, J. Kujawski, P. Uribe, R. Fourre, M. McCarthy

NASA/Goddard Space Flight Center
Air Force Research Laboratory
University of Washington, Seattle

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(Slides are excerpts from Dec. 2008 AGU presentation.)

Experiment Motivation and Objectives

- VEFI is a NASA/GSFC instrument funded by AFRL whose main objectives are to:

  1) Investigate the role of the ambient DC electric fields in initiating ionospheric density depletions and turbulence;
  2) Determine the quasi-DC electric fields and resultant **E** x **B** motions associated with density depletions, and
  3) Quantify the spectrum of the wave electric fields and plasma densities (irregularities) associated with density depletions typically referred to as equatorial spread-F.

- To accomplish these objectives, VEFI includes two main instruments:

  (1) a vector DC electric field instrument designed with an accuracy goal of 0.1 mV/m

  (2) a DC magnetometer to measure magnetic fields with an accuracy better than that of existing models, in order to subtract **V** x **B** contributions to the measured DC electric field.

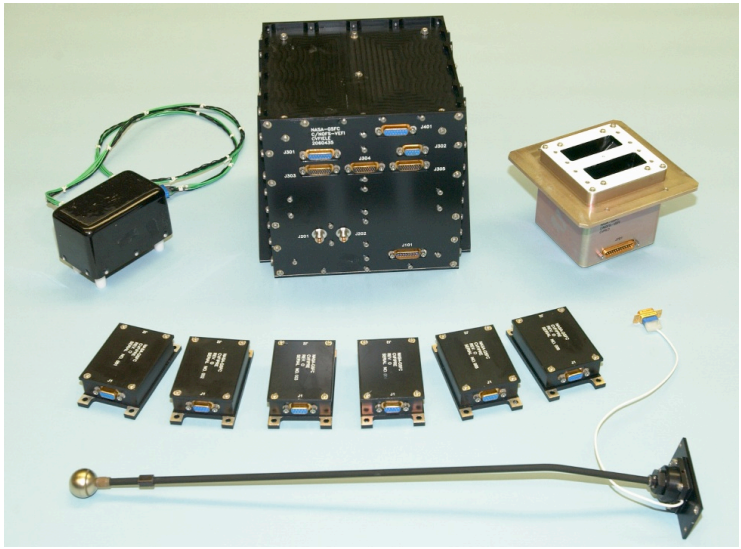
- Instrumentation that measures AC electric field and plasma density irregularities as well as optical lightning flashes are also included as part of VEFI, providing important data that address the C /NOFS objectives.

VEFI Instruments

- DC and AC Electric field detectors:
  - DC electric fields over a range of ± 500 mV/m with an accuracy (goal) of 0.1 mV/m;
  - Time domain quasi-DC electric field structures within plasma depletions
  - Plasma waves and irregularity time series collected in a triggered burst memory;
  - Electric field irregularity spectra including spectrograms up to 16 kHz;
  - Phase velocity and wavelengths of electrostatic structures and waves;
  - Average Spacecraft/Probe potentials.
- Magnetometer
  - -- DC magnetic fields at 1 s/sec in ± 45,000nT range
  - -- AC magnetic fields at 16 s/sec in ± 900nT range
- Fixed-bias Langmuir Probe (Trigger Probe)
  - -- Relative Plasma Density (from 10^2 to 10^7 cm^{-3}) and $\Delta N/N$ fluctuations
- Lightning Detector (w/Univ. of Washington)
  - -- Count rates of lightning flashes in 5 amplitudes levels in 2 directions.
- Burst memory
  - -- 1-8 selectable channels from all sensors sampled at up to 32kHz/channel.

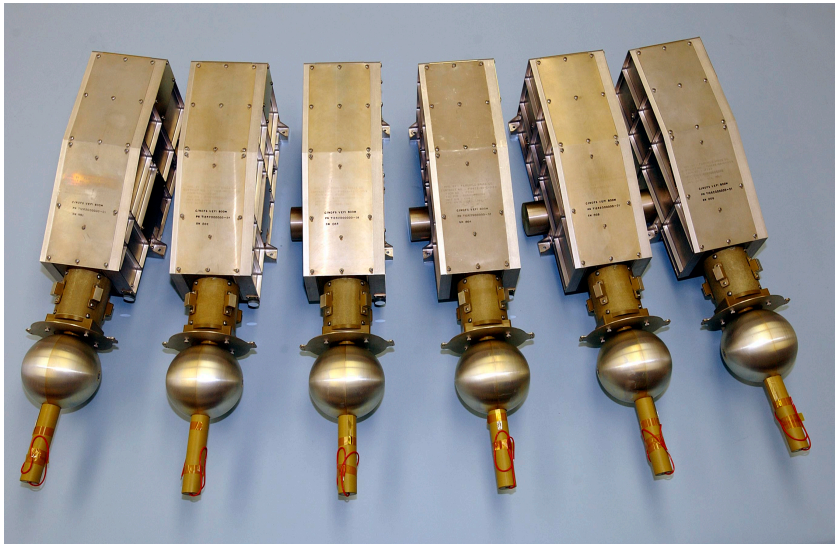
Vector Electric Field Investigation (VEFI) Hardware

Main VEFI Electronics Box, Pre-amps(6), Magnetometer Sensor, Lightning Detector, Trigger Probe:

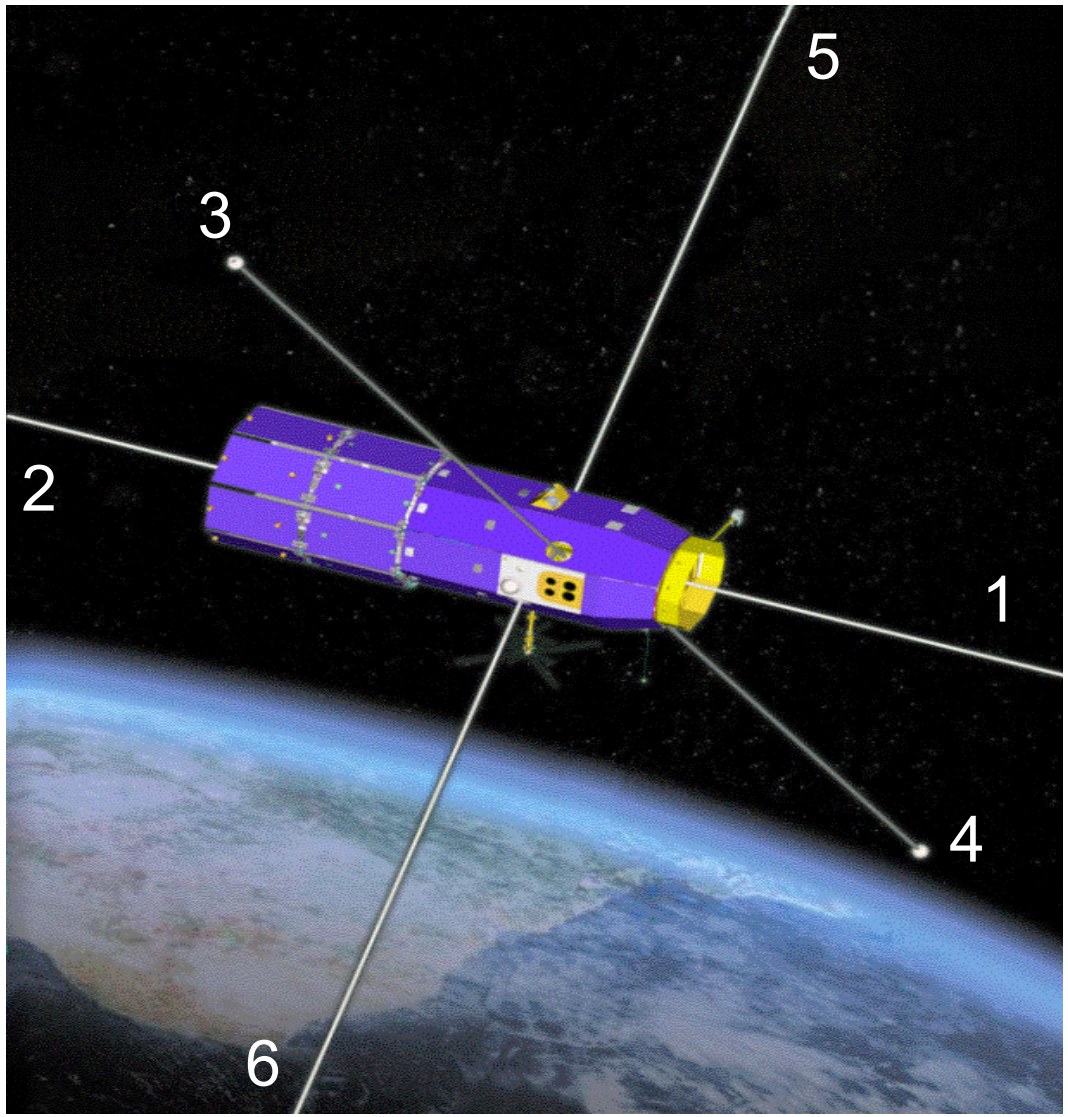


and

6 Electric Field Booms with Spherical Sensors:

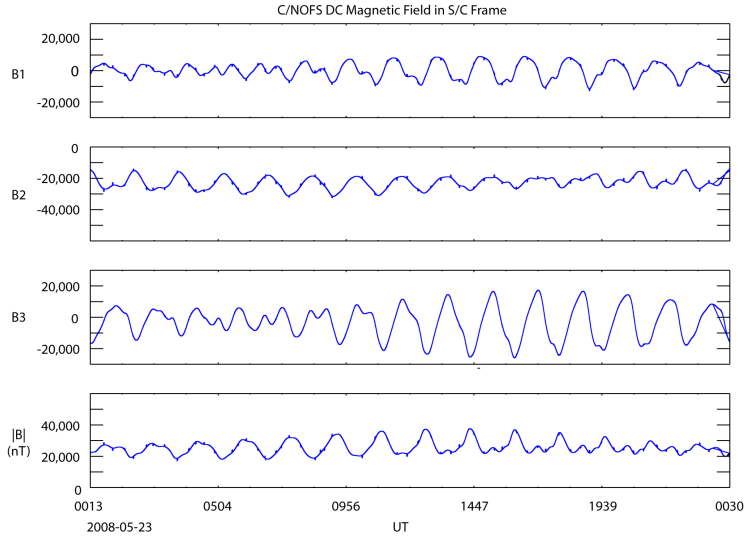


VEFI Boom Orientation

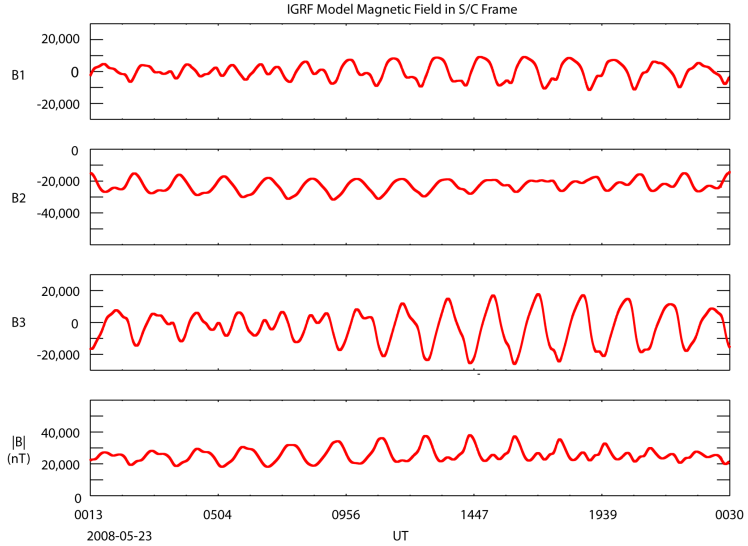


VEFI Magnetometer Data, Comparison with Model

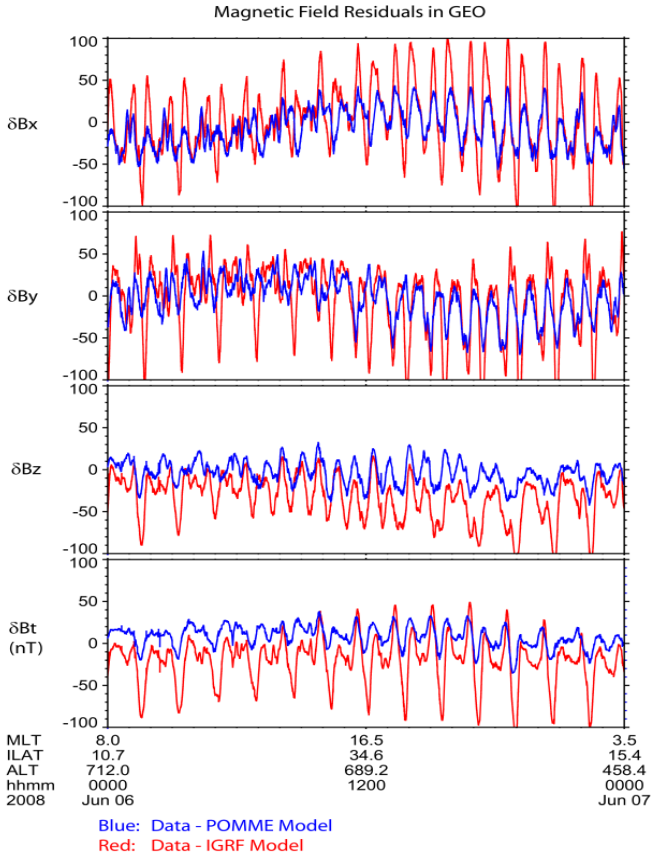
Measured magnetic field, 3 components, 1 day (15 orbits)



Model magnetic field, same day

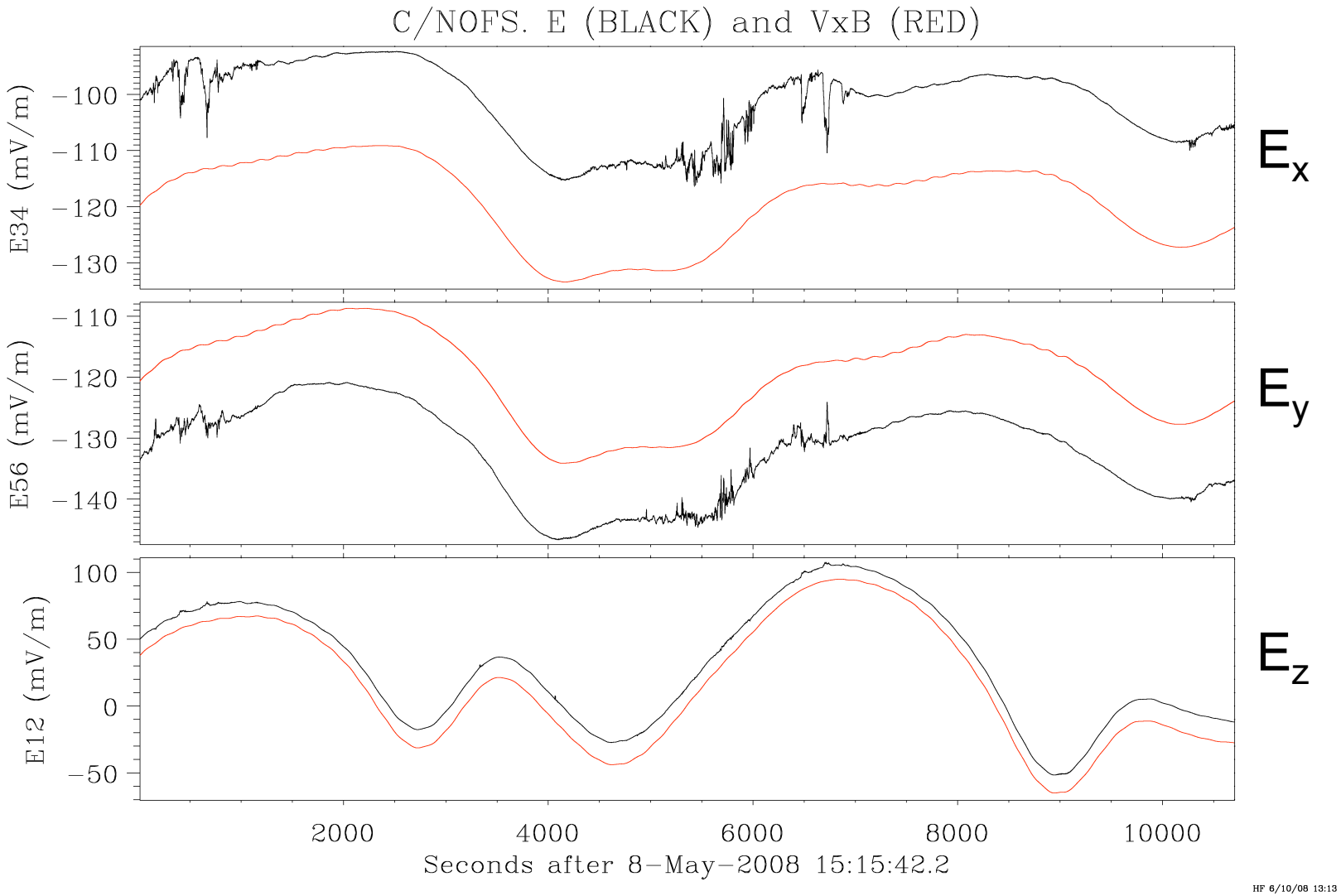


Residuals (Measurements - Model)

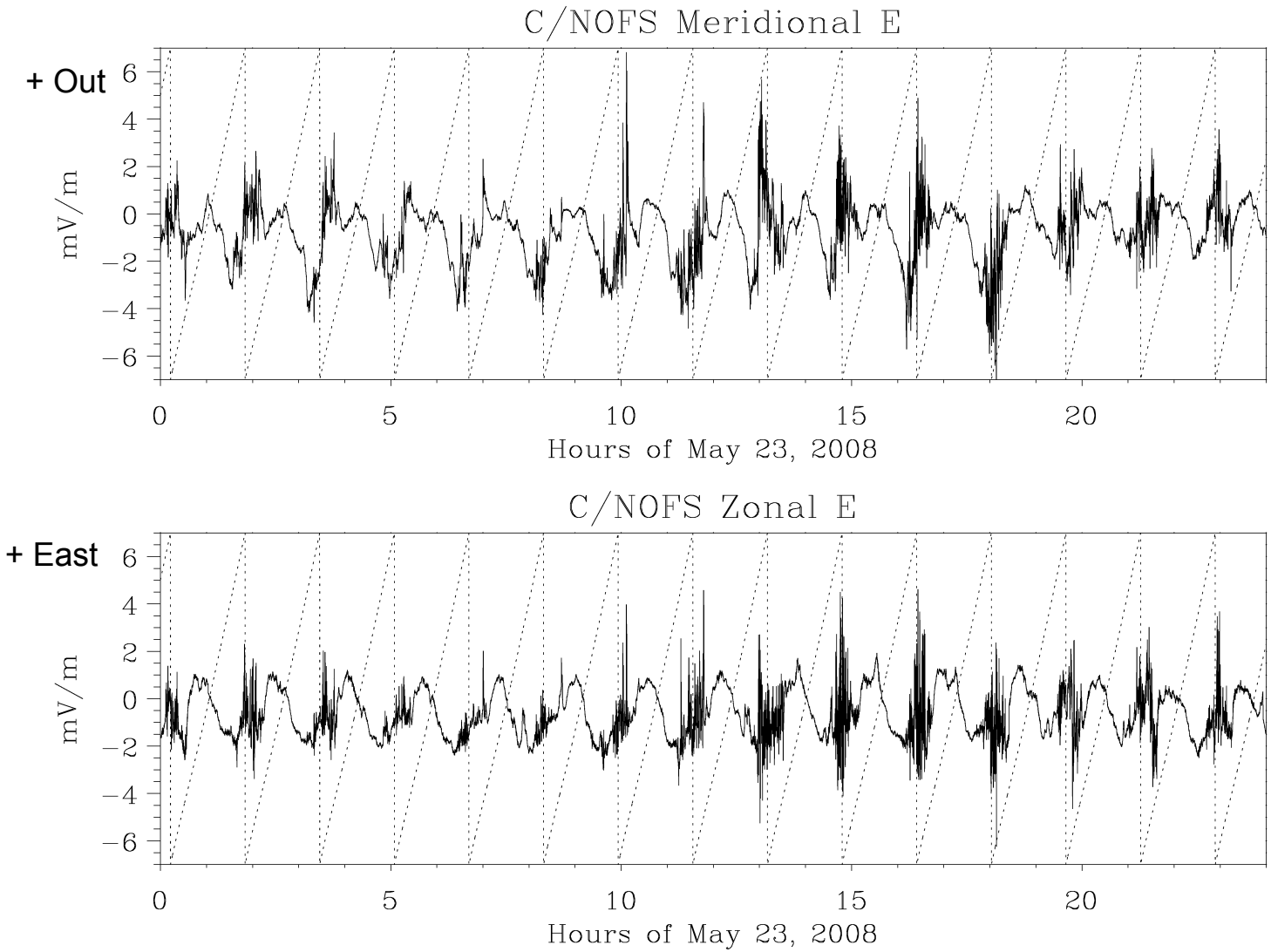


- Data and POMME model agree to within ~ 25 nT except in regions of South Atlantic Anomaly
- VEFI uses *measured* magnetometer data in all **V** x **B** calculations.

Measured Electric Fields and **V** x **B** -- 8 May 2008



C/NOFS DC Electric Fields -- May 23, 2008



Preliminary

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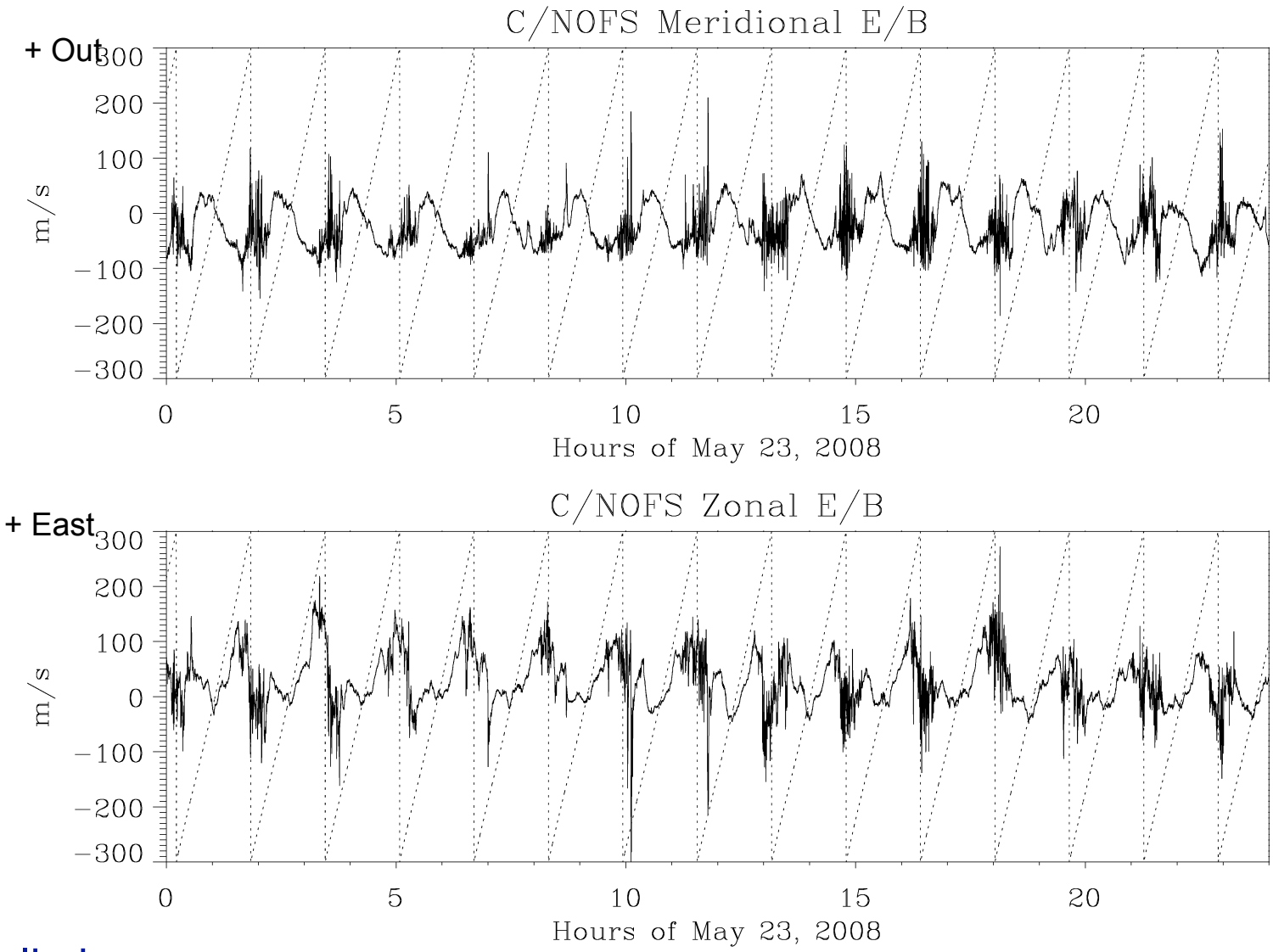
E x B Velocities from DC Electric Fields -- May 23, 2008



Preliminary

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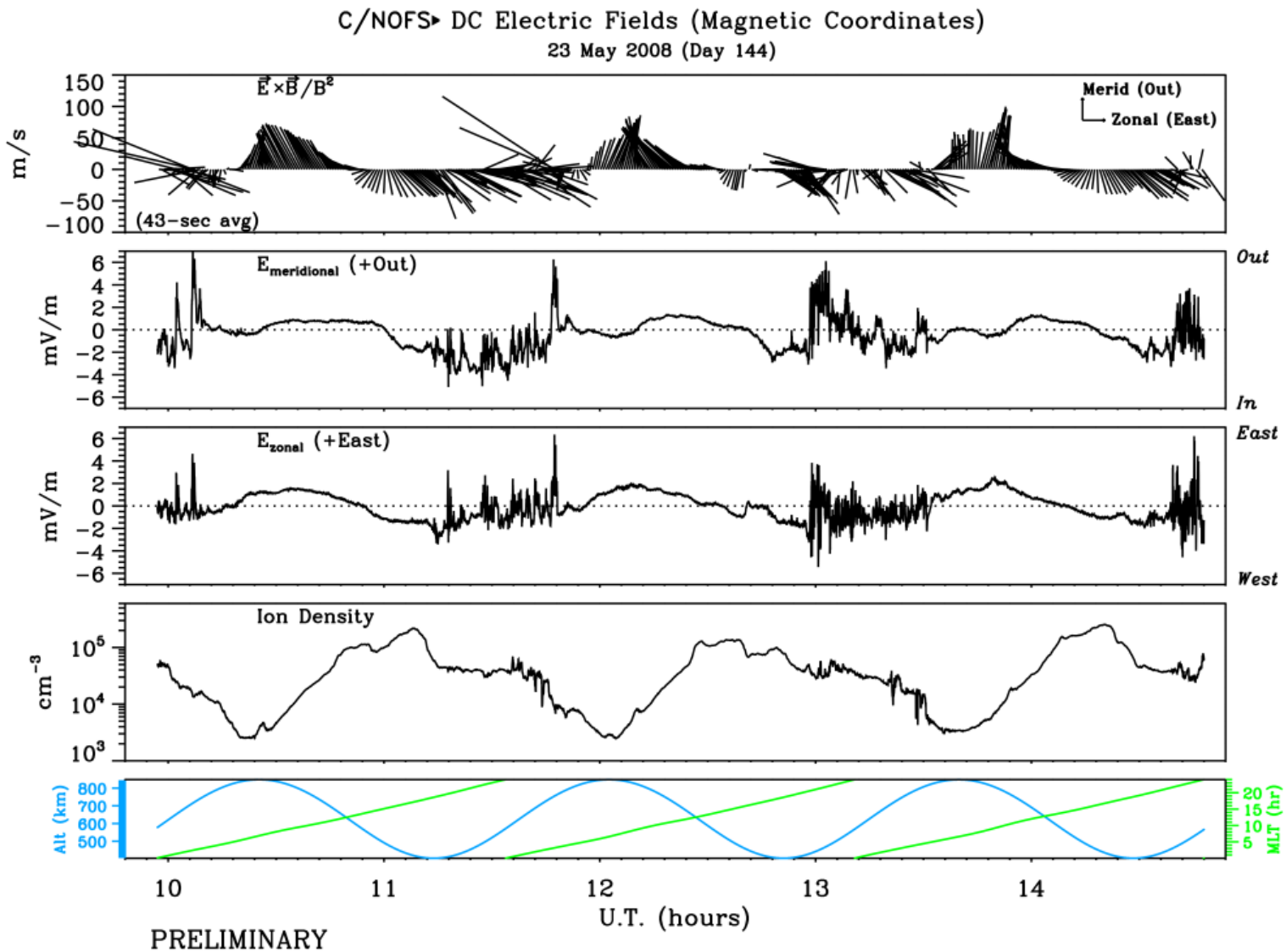
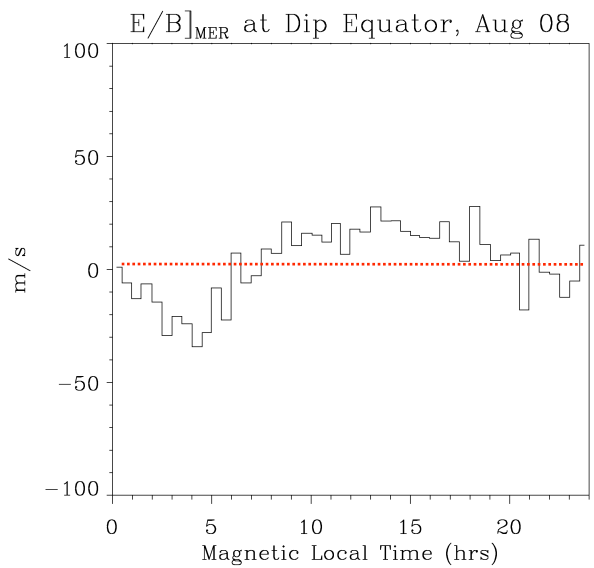
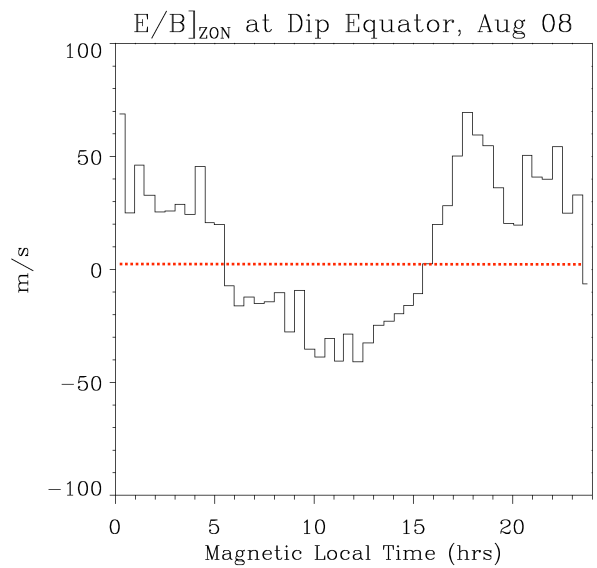

C/NOFS▸ DC Electric Fields (Magnetic Coordinates)
23 May 2008 (Day 144)
E×B/B²
Merid (Out)
Zonal (East)
(43-sec avg)
m/s
150
100
50
0
−50
−100
E_meridional (+Out)
Out
In
mV/m
6
4
2
0
−2
−4
−6
E_zonal (+East)
East
West
Ion Density
cm⁻³
10⁵
10⁴
10³
Alt (km)
800
700
600
500
MLT (hr)
20
15
10
5
10
11
12
13
14
U.T. (hours)
PRELIMINARY

Average Measured E x B drifts at Magnetic Equator -- August 2008

$E/B_{vertical}$



$E/B_{horizontal}$



Preliminary

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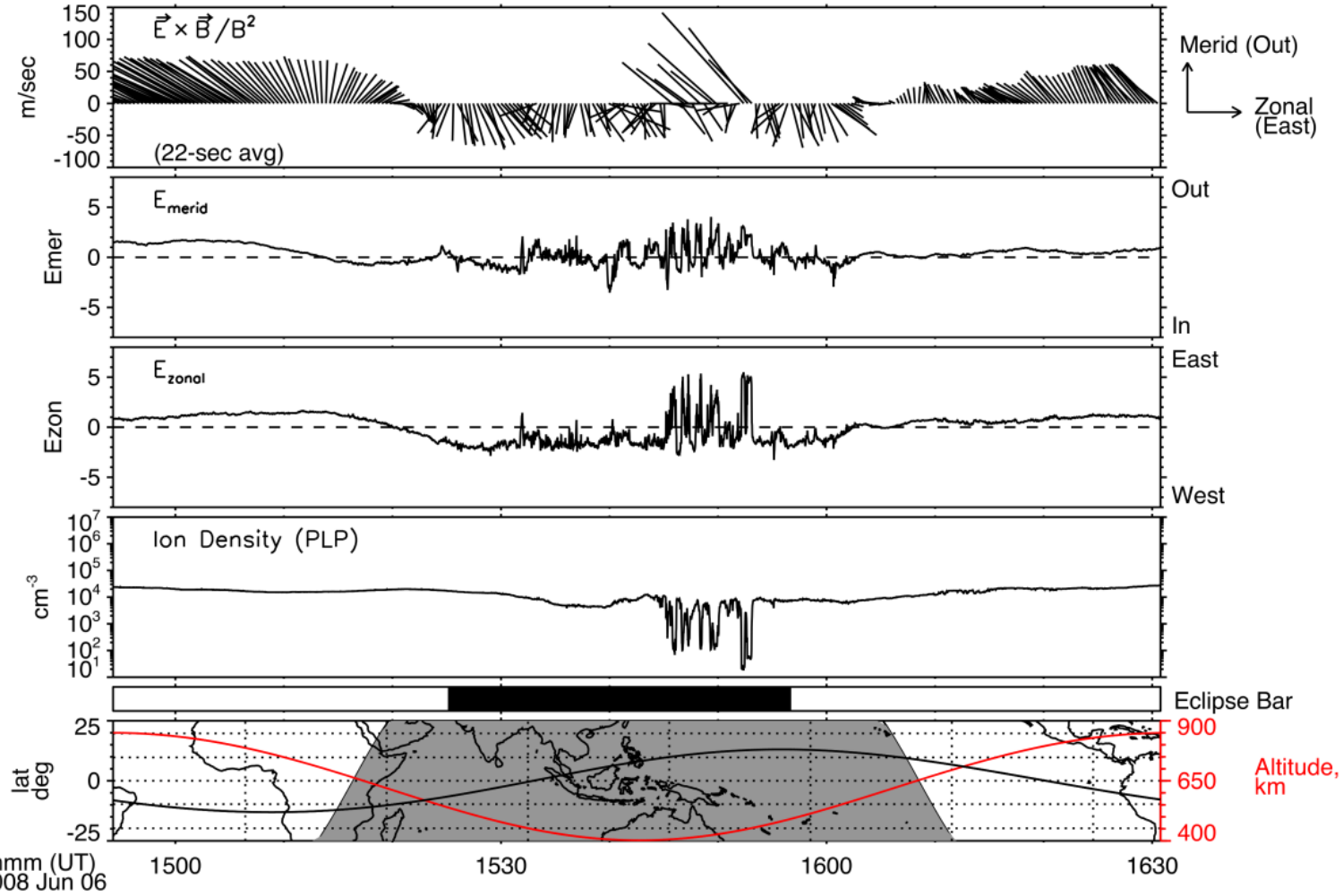
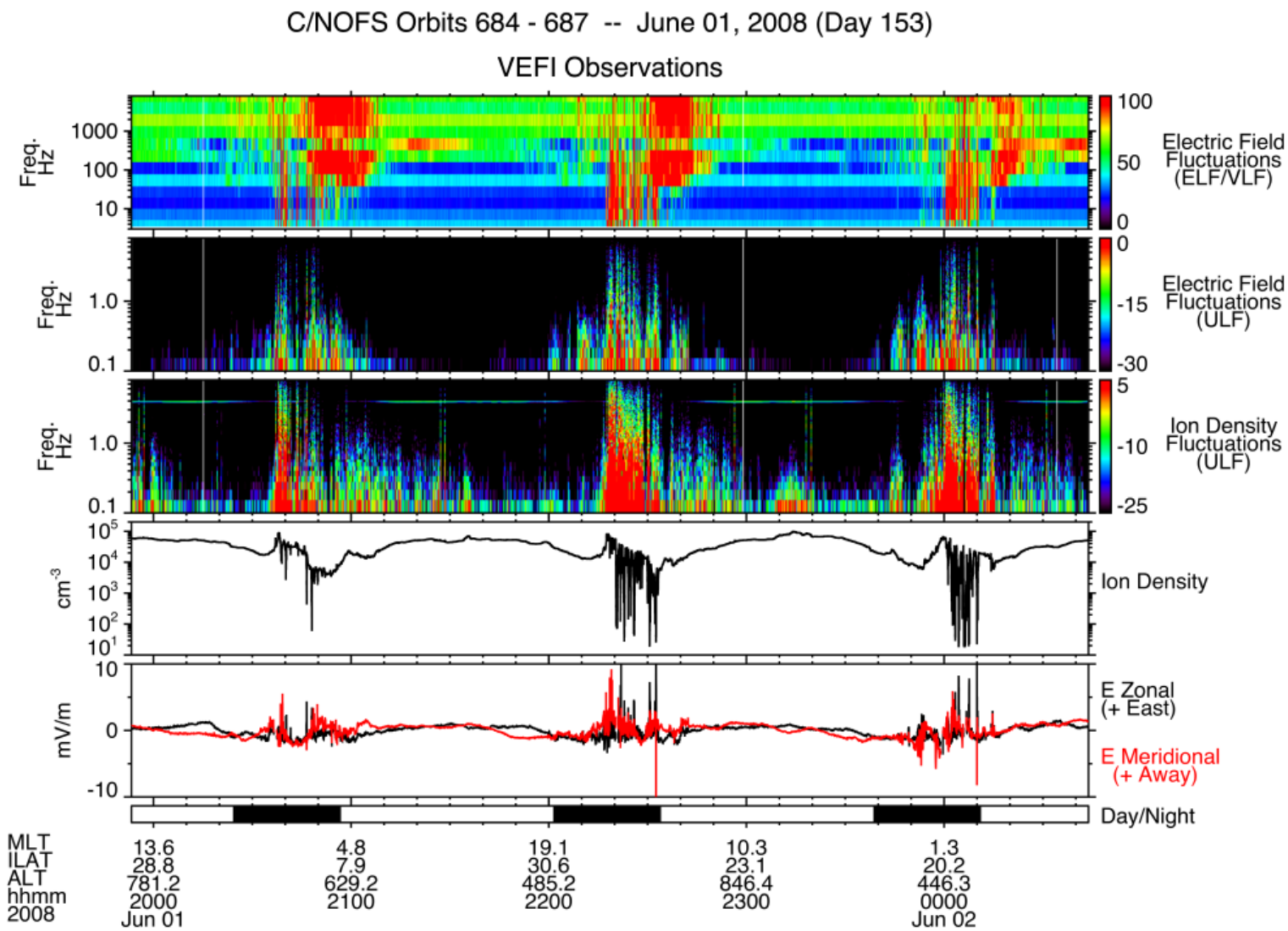
C/NOFS Orbit 756 -- June 06, 2008 (Day 158)

VEFI and PLP Observations

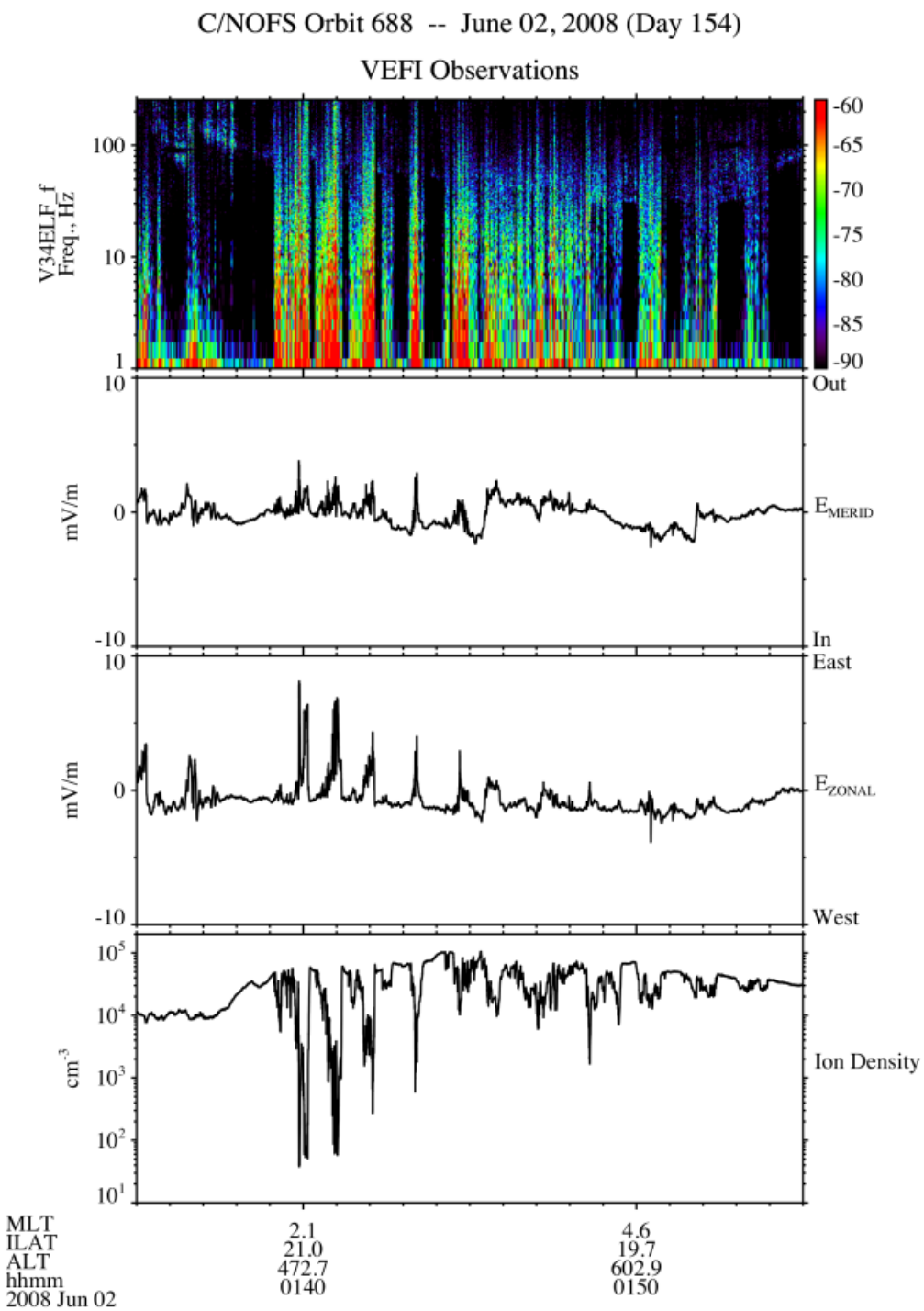


PRELIMINARY

VEFI Irregularities -- Most intense post midnight

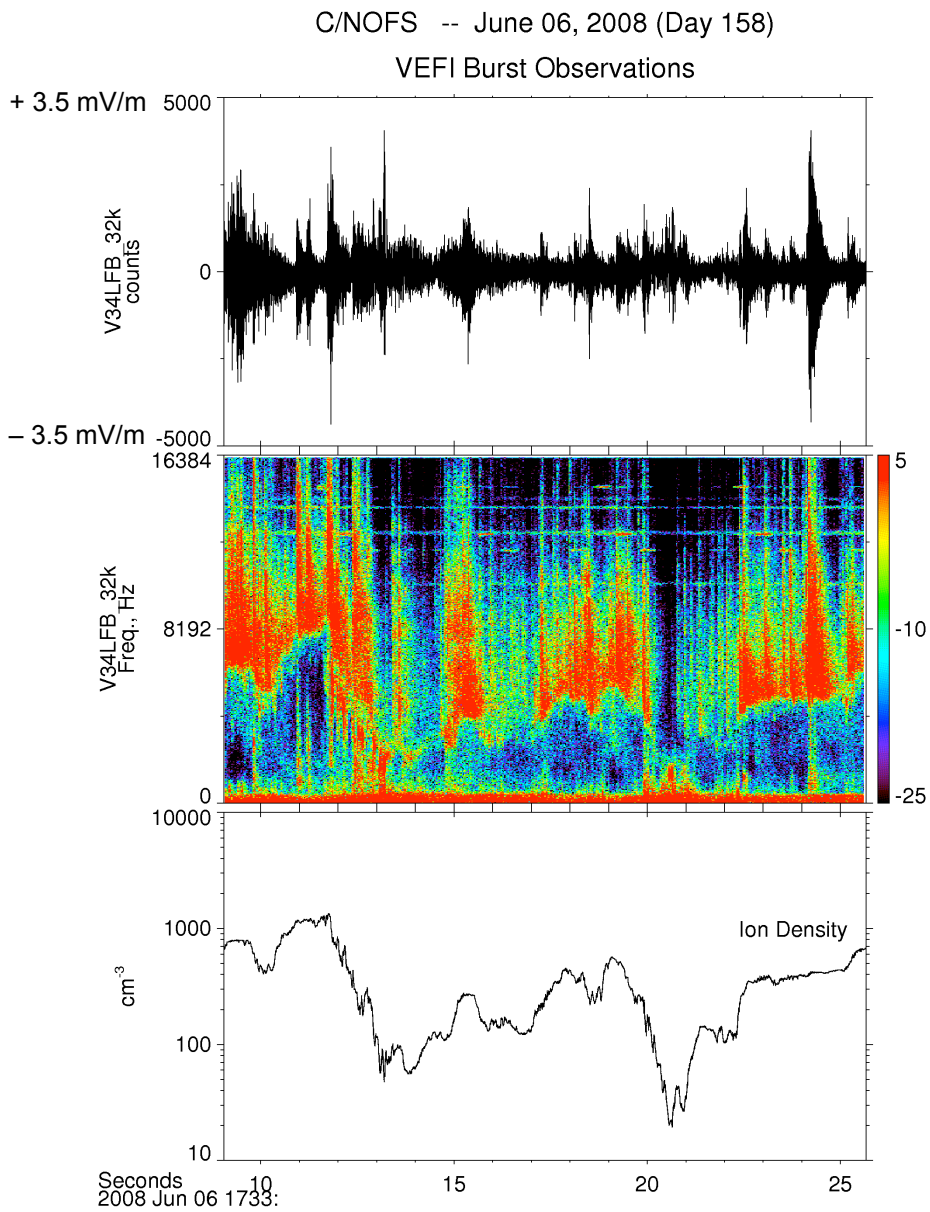


PRELIMINARY



DC Electric Fields within Depletions

Large eastward electric fields with a small outwards component in depletions correspond to upwards motion of depletions with a small westward tilt, as shown by radars.

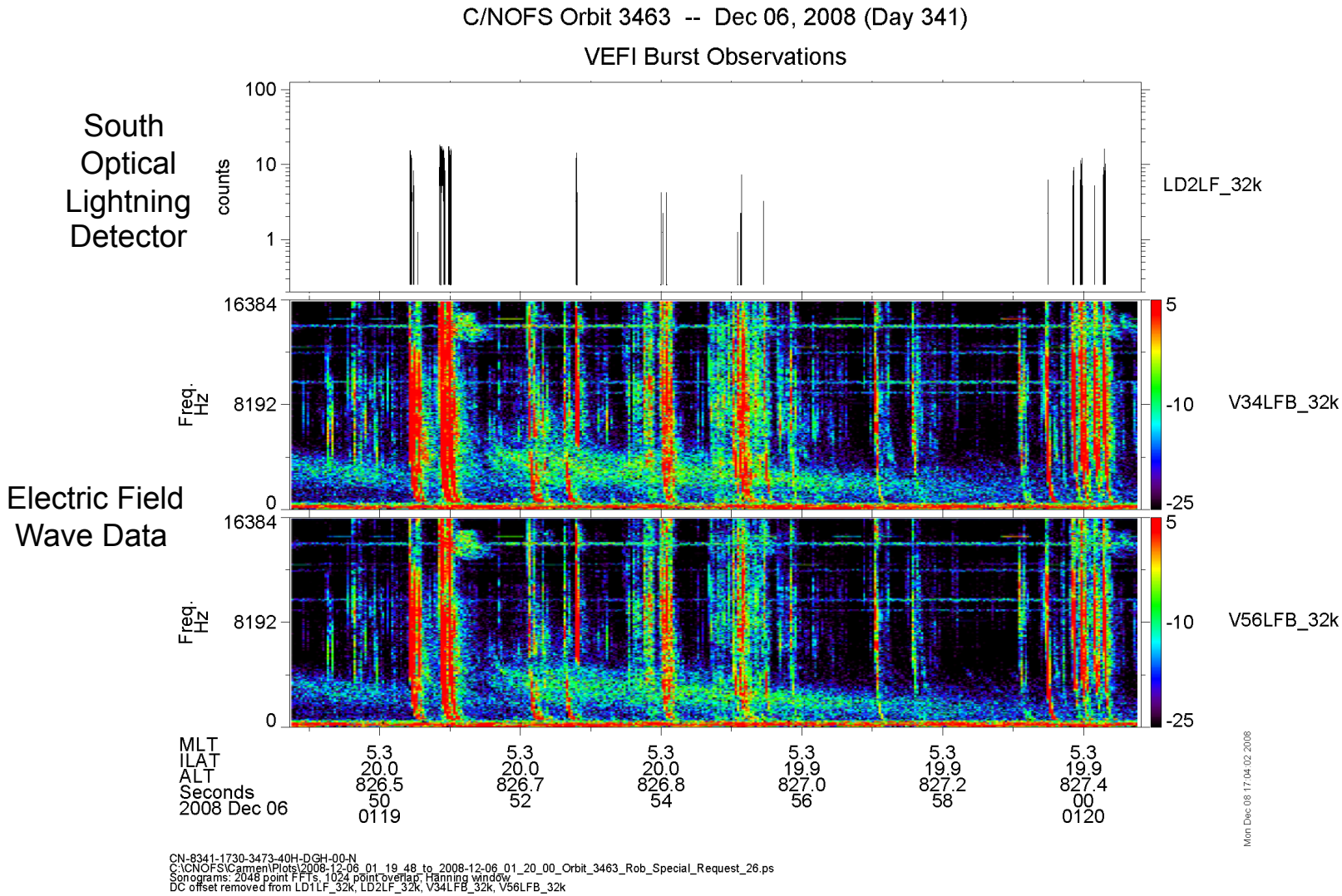


CN-8158-2052-0759-30G-DGH-00-N
C:\CNOFS\Carmen\Plots_2008-06-06_17_33_09_to_2008-06-06_17_33_25_Rob_Special_Request_21.ps
Sonograms: 2048 point FFTs, 1024 point overlap, Hanning window
DC offset removed from V34LFB_32k

AC Electric Fields Captured in VEFI Burst Memory

AC electric fields show lower hybrid emissions associated with lightning sferics enhanced within density depletions.

VEFI Lightning Detector Optical Counter with VLF Burst Data



Summary

- VEFI data gathers continuous DC electric field, DC magnetic field, and electric and density irregularity data on C/NOFS satellite.

- Magnetic field data are used for **V** x **B** computations. Data agree well with POMME model, expect in regions of South Atlantic anomaly.

- DC electric fields show ~0.5 – 2 mV/m fields corresponding to 20 – 100 m/s drifts that, in general, display diurnal pattern between upwards and westward flow during the day and the opposite at night.

- Nightside ionosphere highly structured, particularly post midnight.

- VEFI data set includes a wide range of electric field and plasma density irregularities, including measurements at high rates in burst memory.

- VEFI optical lightning detector provide flashes correlated with wave electric fields and statistics of lightning in north, south hemispheres.