A STATISTICAL STUDY OF LOW FREQUENCY ULF WAVES AS MEASURED BY SPACE-BORNE AND GROUND-BASED MAGNETOMETERS

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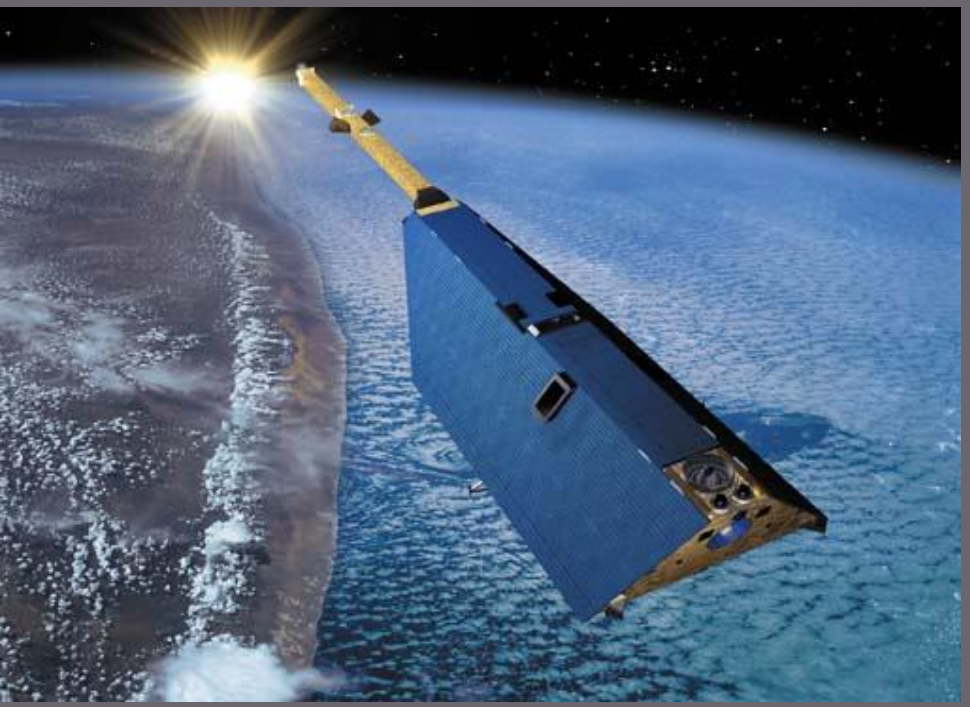
Geospace Revisited, 15-20 September 2014,
Rhodes, Greece

CHAMP (CHALLENGING MINISATELLITE PAYLOAD)



Launch: July 15, 2000

Design Lifetime: 5 years

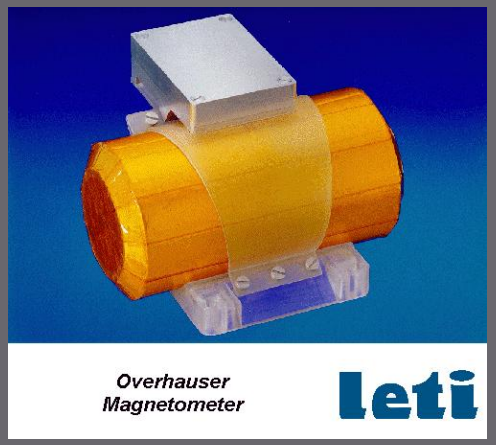
End of Mission: September 19 2010

(ten years, two month, four days)
(58277 orbits)

Orbit Characteristics:

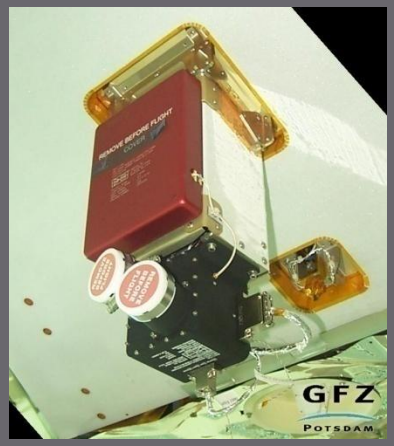
- Low Earth Orbit (initial altitude of 454 km)
- Almost circular
- Near polar (87° inclination)
- Approx. 90′ per Orbit

Overhauser Magnetometer



Range	18 000 - 65 000 nT
Resolution	10 pT
Noise level	< 50 pT (rms)
-3 dB bandwidth	0.28 Hz
Sample rate	1 Hz
Absolute accuracy	< 0.5 nT

Digital Ion Drift Meter



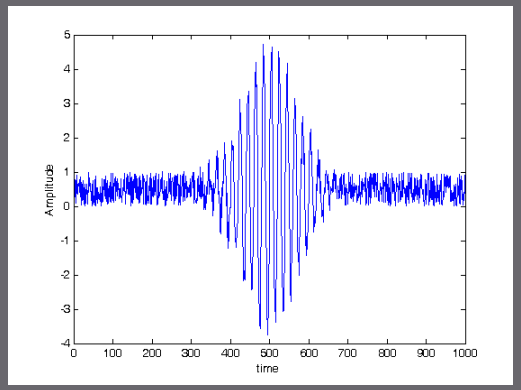
Range of ion density	10^8 - 10^{12} ions/m^3
Range of ion temperature	200 - 55 000 K
Range of drift velocity	0 - 6 km/s
Resolution of ion velocity	< 1° direction, < 130 m/s speed
Sample rates	
DM mode	0, 1, 2, 4, 8, 16 HZ
RPA mode	0, 8, 16 Hz
PLP mode	0, **1/15 Hz**

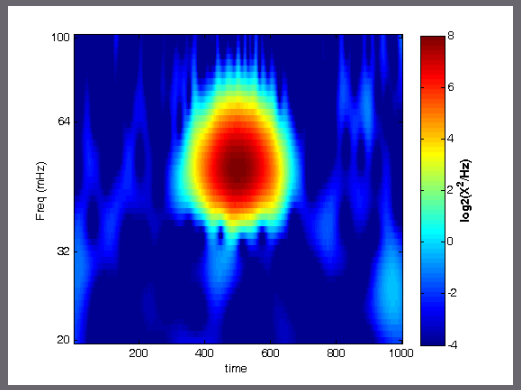
Methodology

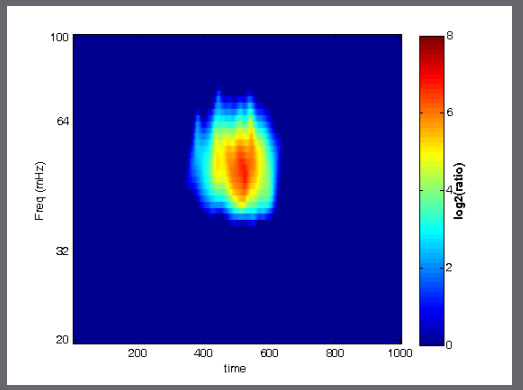
- Read Data (daily files) in a day-to-day basis
  (+/- a few minutes to avoid edge effects)
- Interpolate (small) gaps
- Filter (cutoff at 20 mHz)
- Wavelet Transform
  (logarithmically spaced frequencies
  from 20 to 100 mHz)
- Track Segmentation
  [-55, +55] degrees in Mag. Lat.
- Event Detection
  (statistical thresholding)
- Parameter Extraction
- Database Creation
- **Post Processing**

Balasis et al. 2013; Earth, Planets and Space

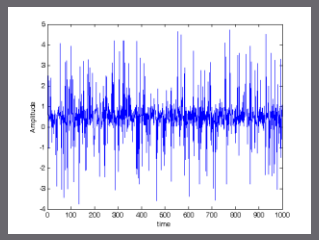
IAASARS

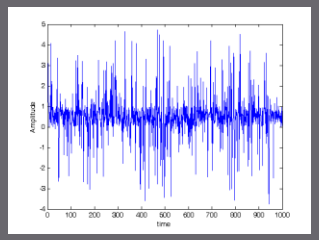


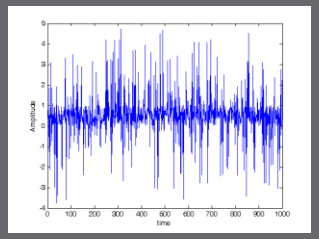


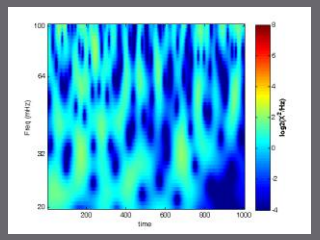


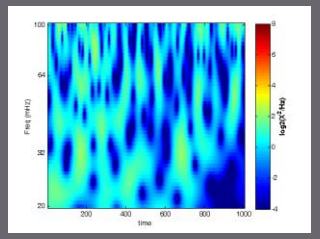
SHUFFLED SERIES

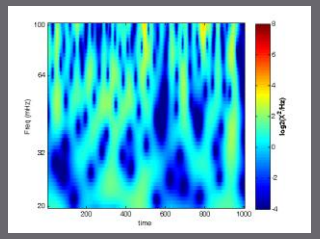


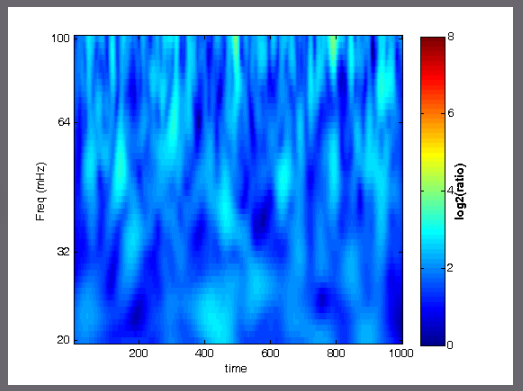






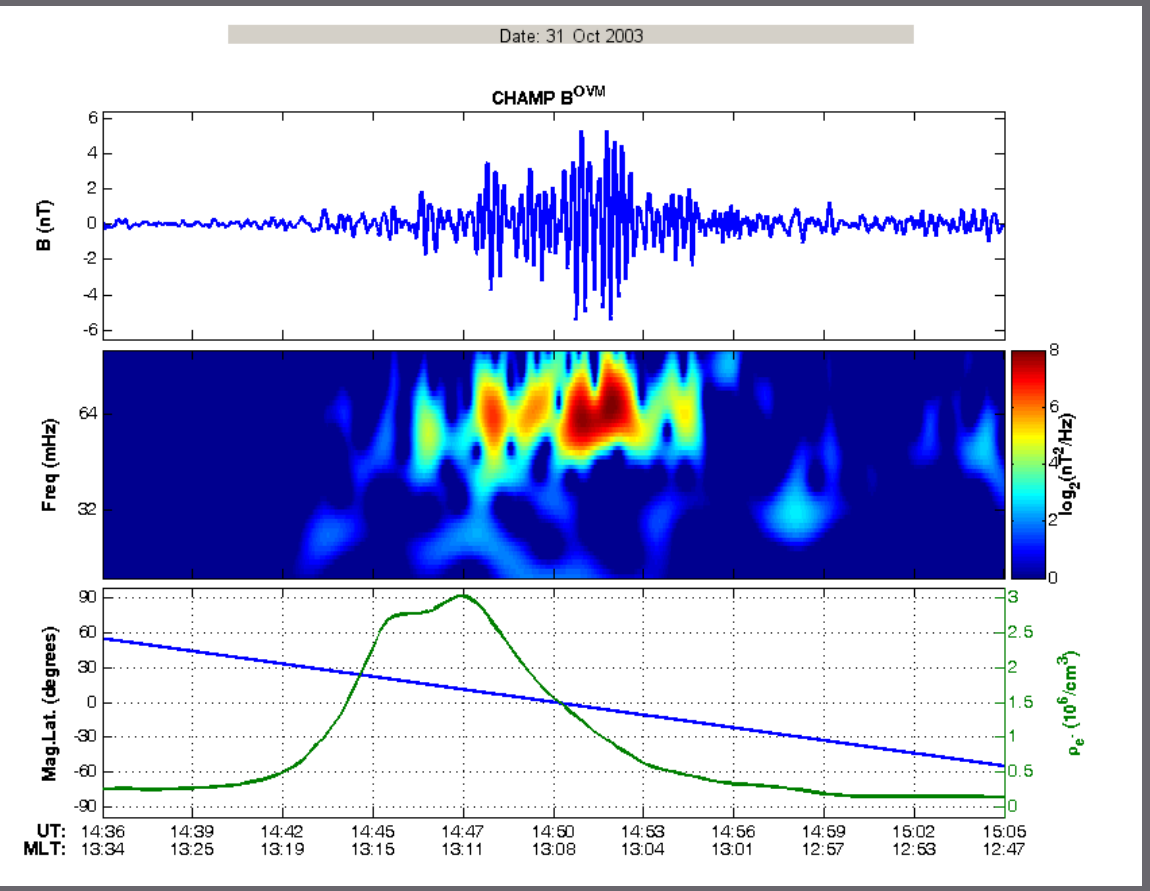






MEAN + 3 ST.DEV

Ignoring largest 10% points to minimize spike influence



t_{peak} = 14:42
f_{peak} = 79 mHz

$\Delta t \sim 23'$

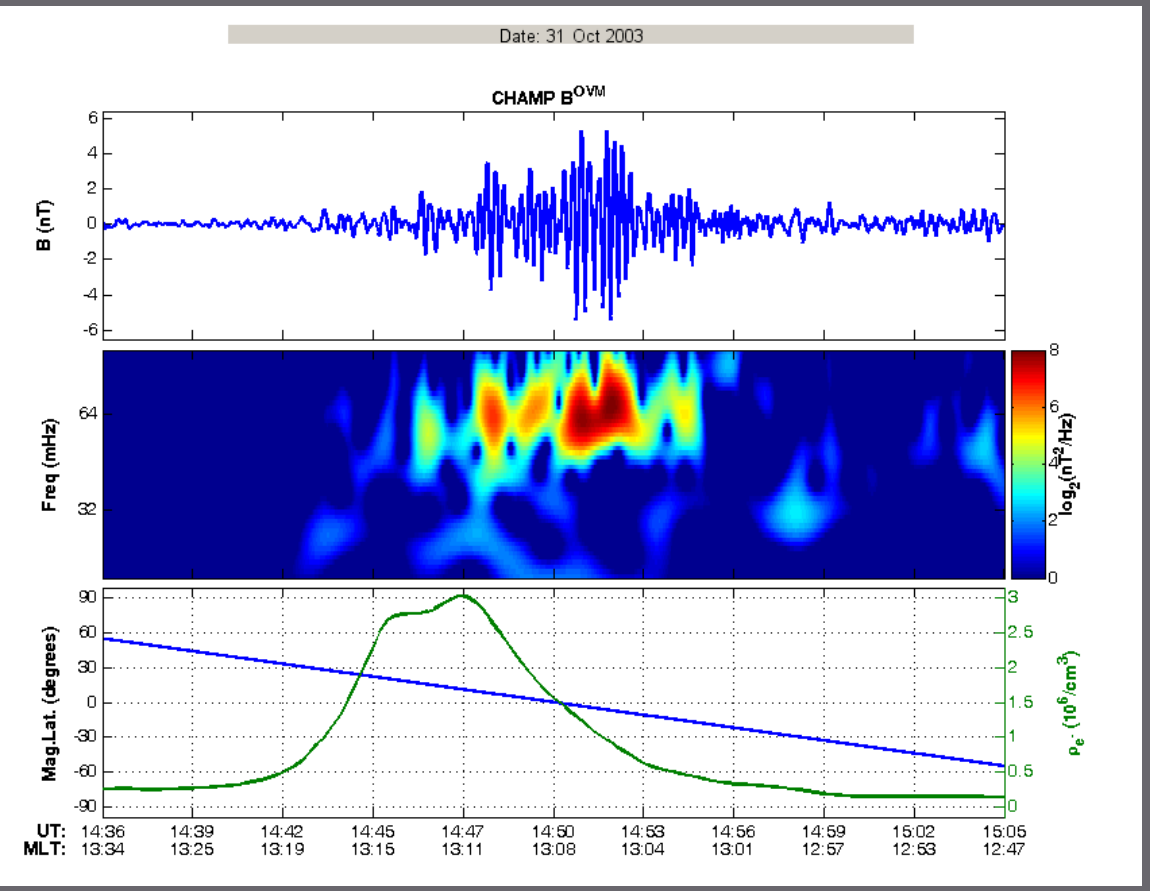
$Power_{peak} = 2^8\ nT^2/Hz$

Max(|B|) = 5.45 nT
Max(|ΔB|) = 2.73 nT/sec

r_{MAG} = (-7°, 40°, 401 km), MLT = 13:06, Lshell (ONERA IRBEM LIB)

roughness(n) ~ $5\ 10^3\ cm^{-3}$

Balasis et al. ULFwave activity during the 2003 Halloween superstorm: multipoint observations fromCHAMP, Cluster and Geotail missions,Ann. Geophys., 30, 1751-1768, doi:10.5194/angeo-30-1751-2012



t_{peak} = 14:42
f_{peak} = 79 mHz

NOT AT THE EDGES

$\Delta t \sim 23'$

$\Delta t > 2\ (1/f_{peak})$

$Power_{peak} = 2^8\ nT^2/Hz$

EXCLUDE WEAK EVENTS

Max(|B|) = 5.45 nT
Max(|ΔB|) = 2.73 nT/sec

REMOVE SPIKES

Max(|ΔB|) > 0.6*Max(|B|) + 0.7

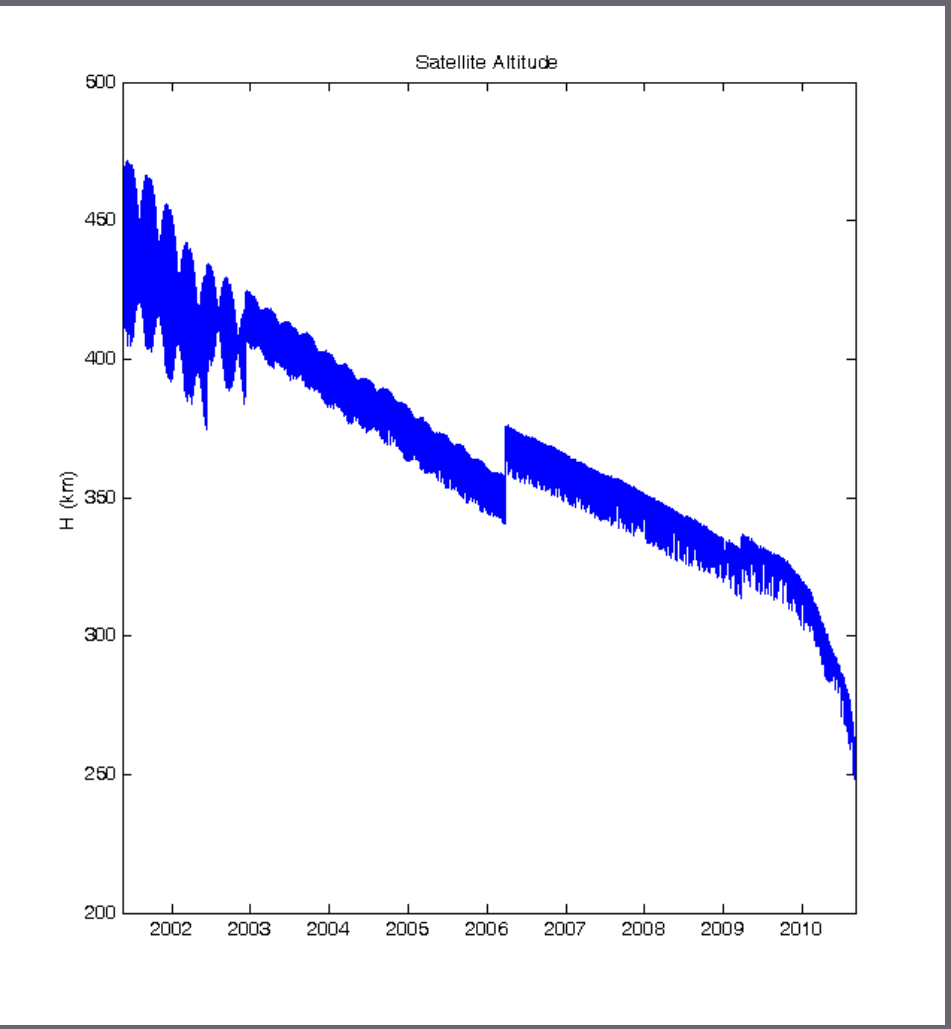
r_{MAG} = (-7°, 40°, 401 km)
MLT = 13:06

roughness(n) ~ 5 10^3 cm^{-3}

PLASMA INSTABILITIES

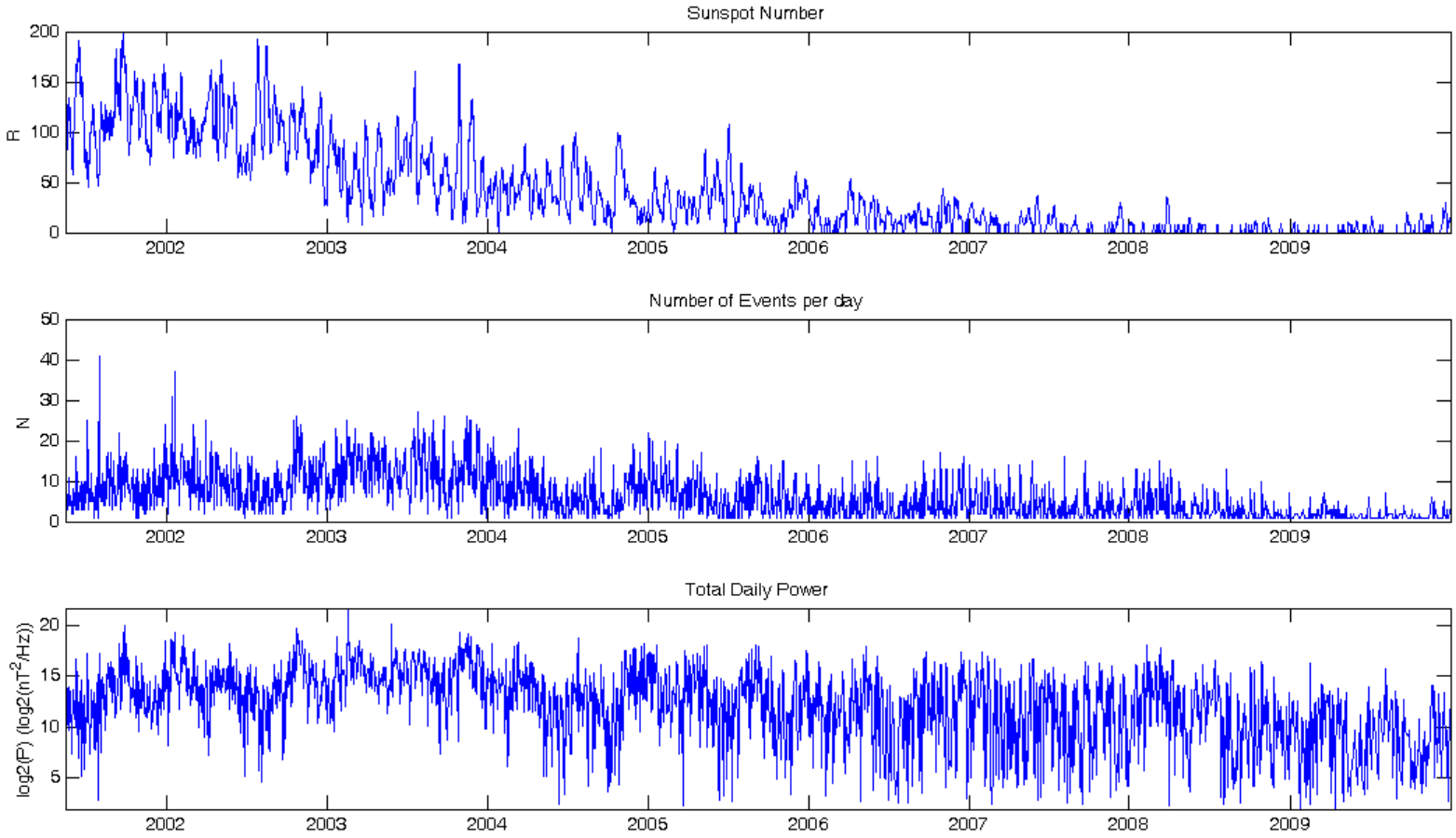
Balasis et al. ULFwave activity during the 2003 Halloween superstorm: multipoint observations fromCHAMP, Cluster and Geotail missions,Ann. Geophys., 30, 1751-1768, doi:10.5194/angeo-30-1751-2012

Dataset Description

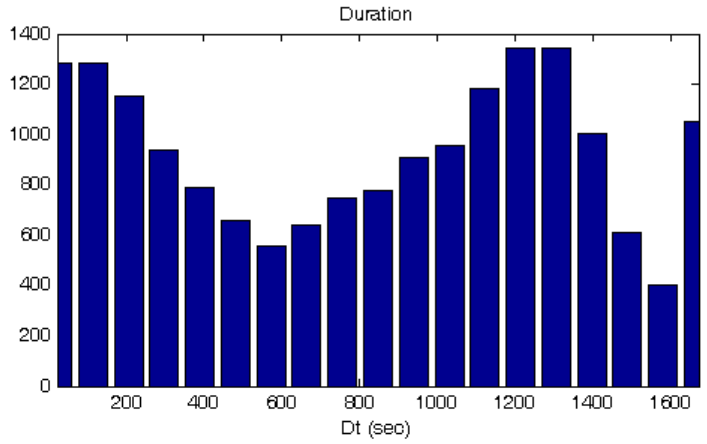


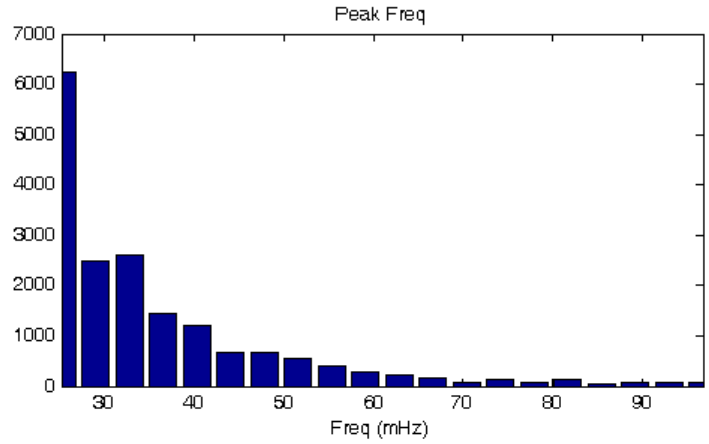
- 1 Hz magnetic field data (scalar)
- 15 sec ion density data
- Time span: May 2001 – Dec 2009
- > 90,000 Tracks
- Limited to [-55, +55] Mag. Lat.
- > 17,000 Wave Events Selected
- Additional Data: OmniWeb Service http://omniweb.gsfc.nasa.gov/

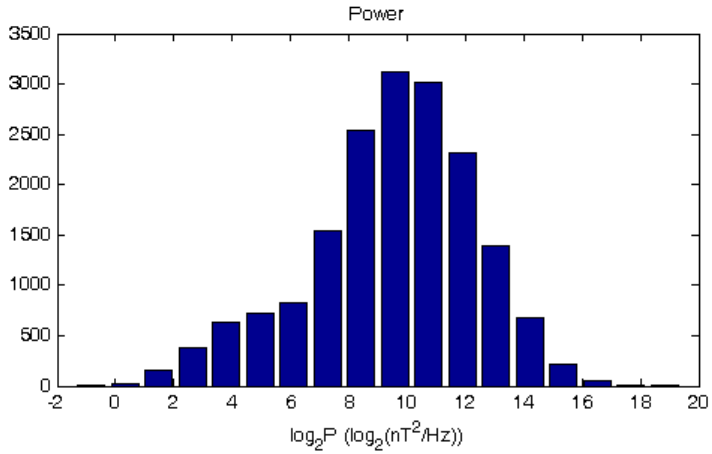
Overview (2001 – 2009)

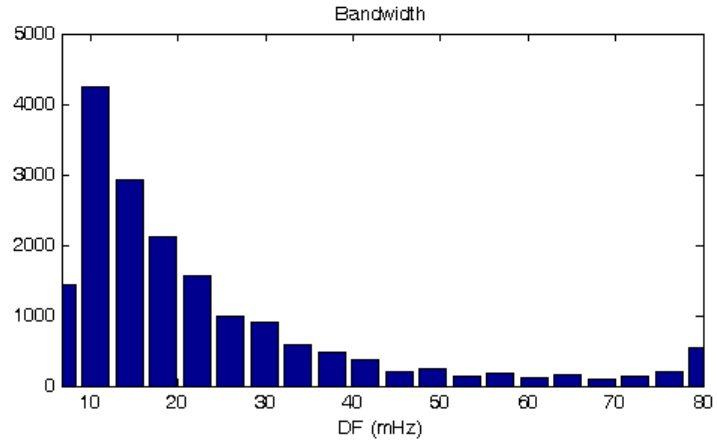


Statistical Distributions of Wave Parameters

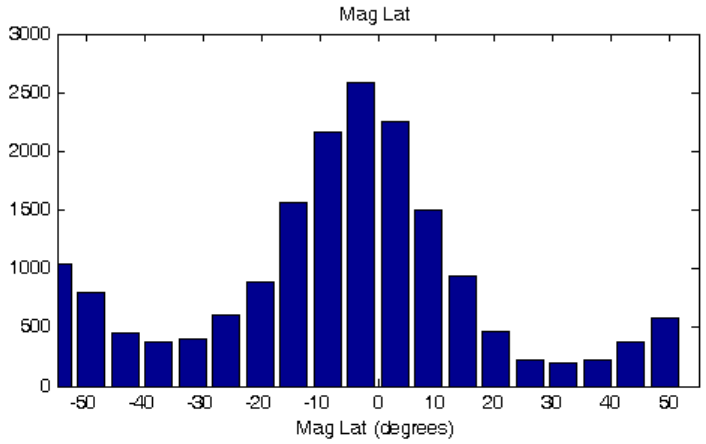


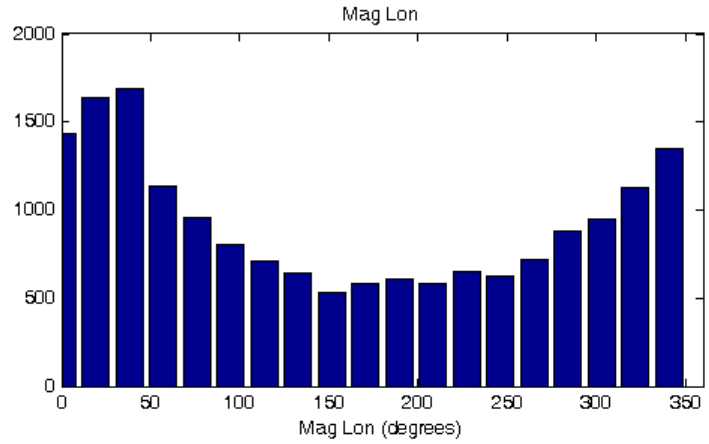


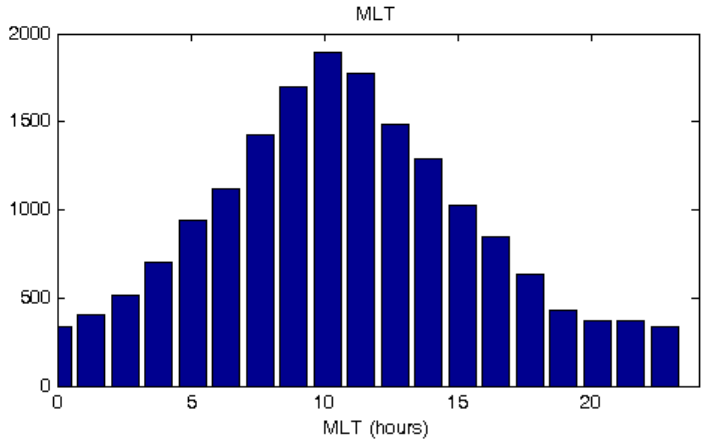


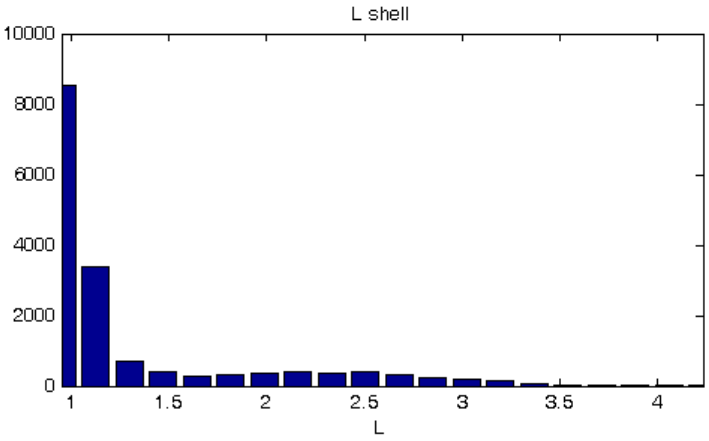


Statistical Distributions of Wave Parameters

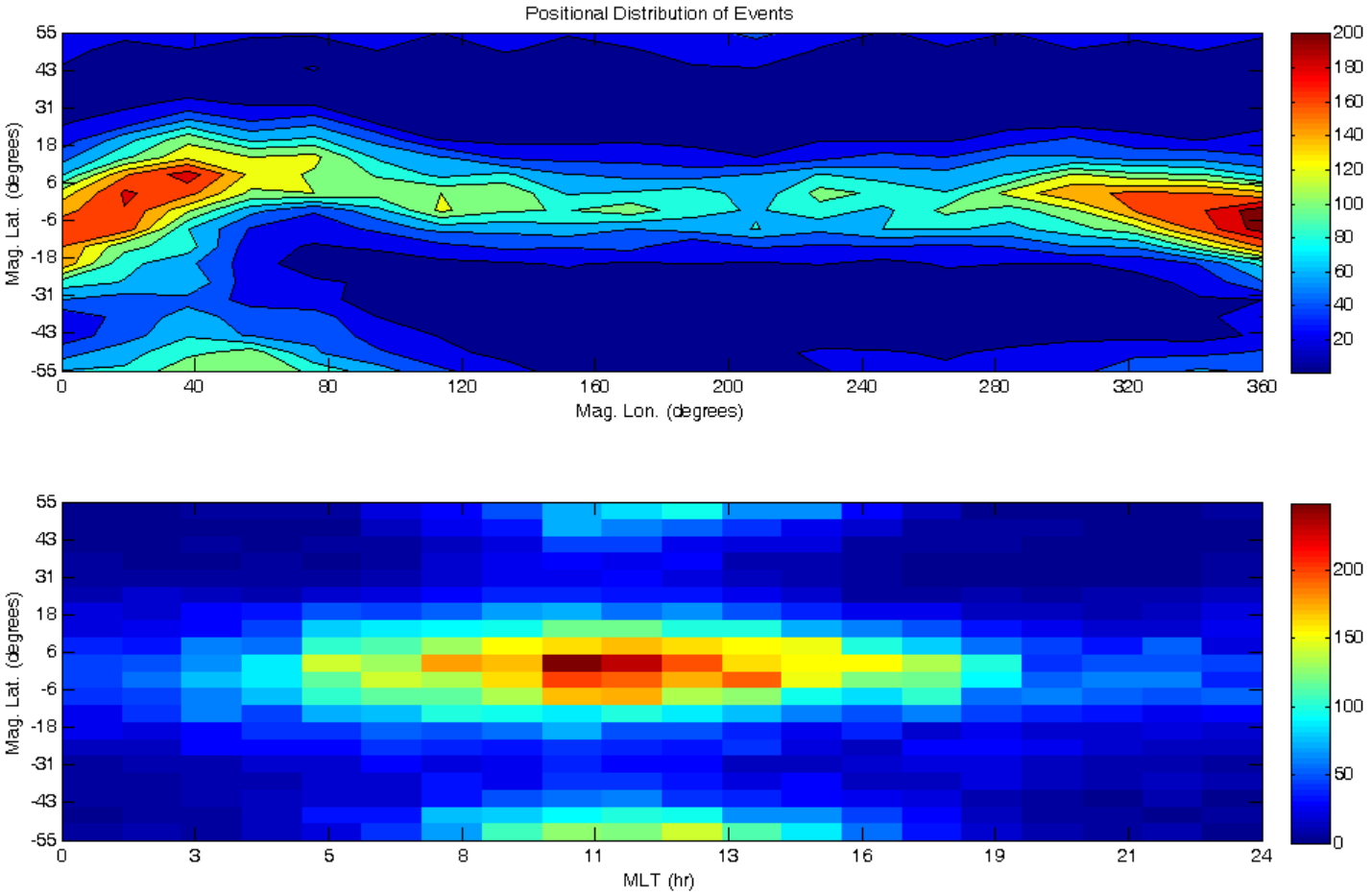




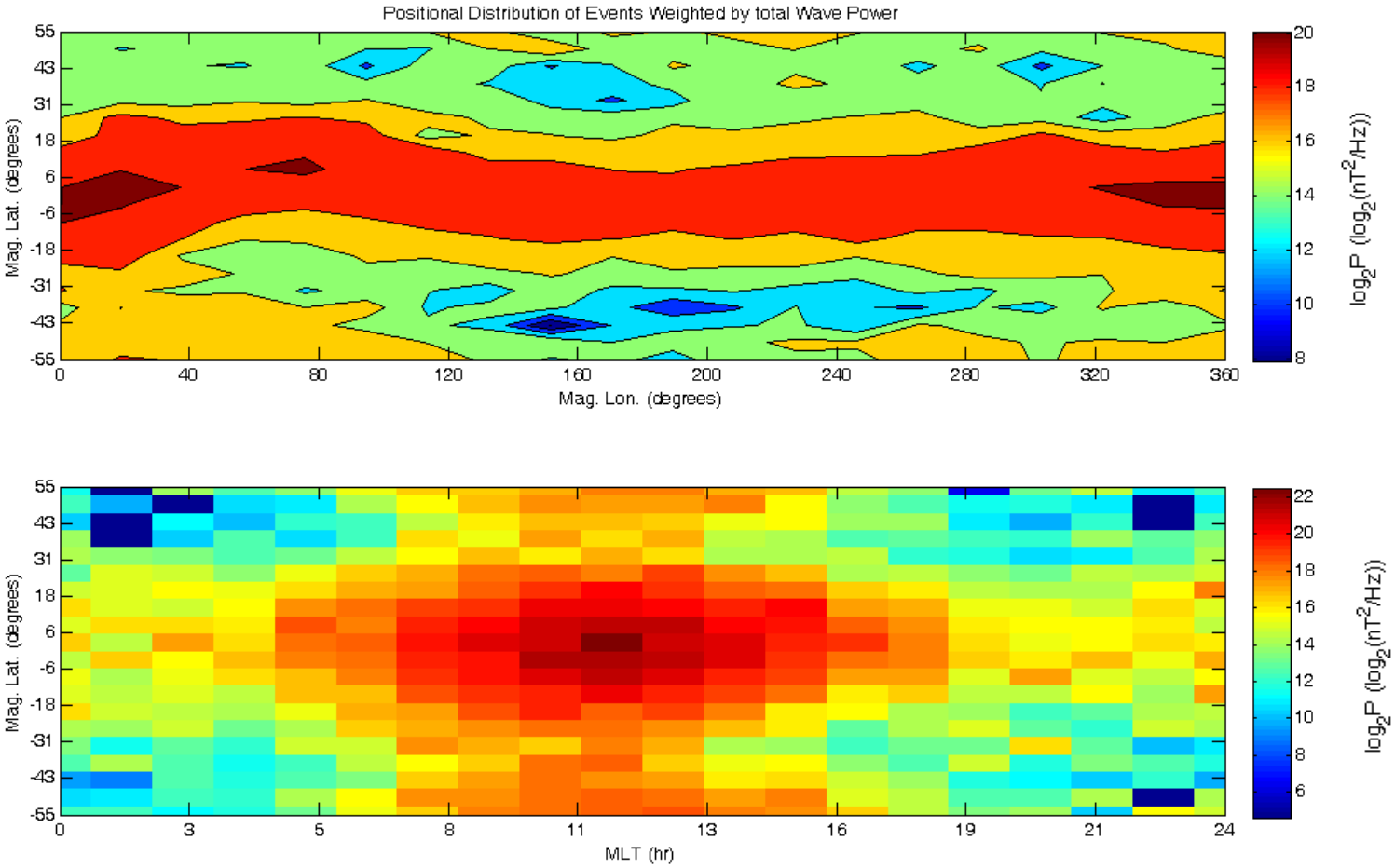




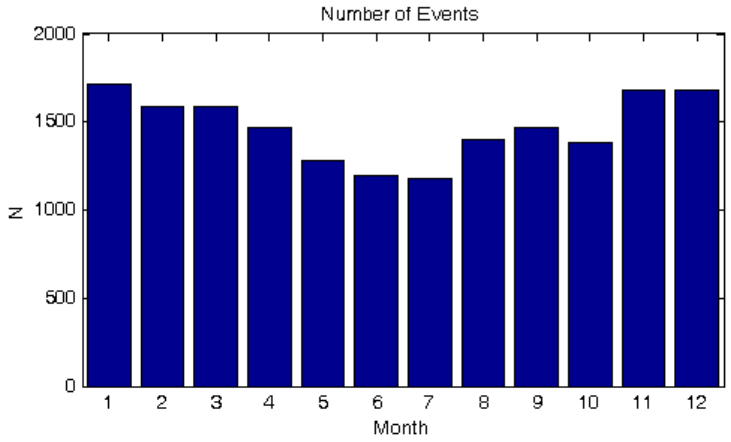
Positional Distribution

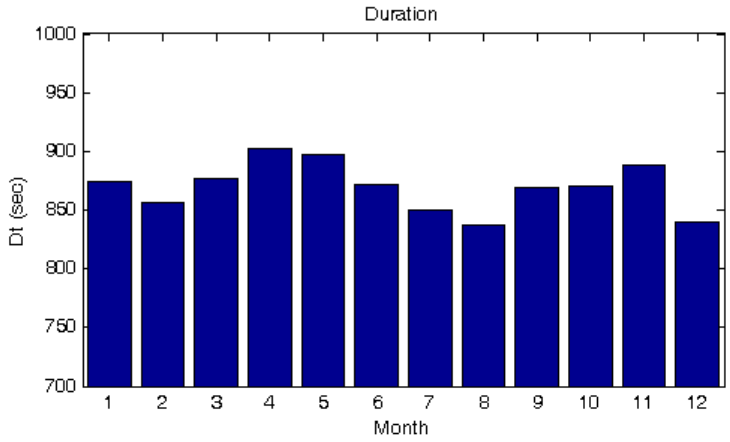


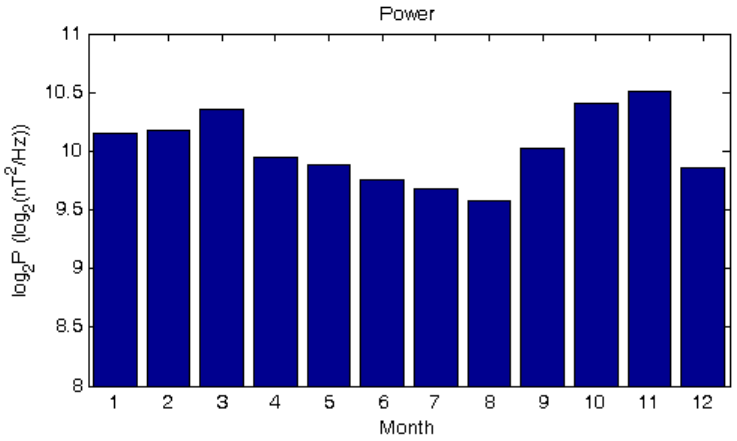
Weighted Distribution (log2)

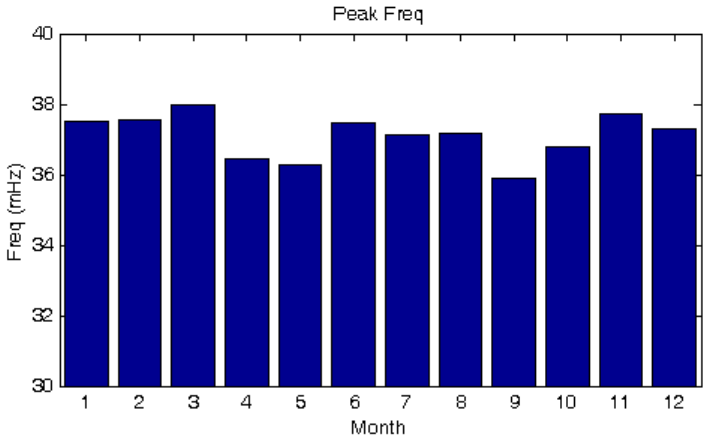


Seasonal Variations









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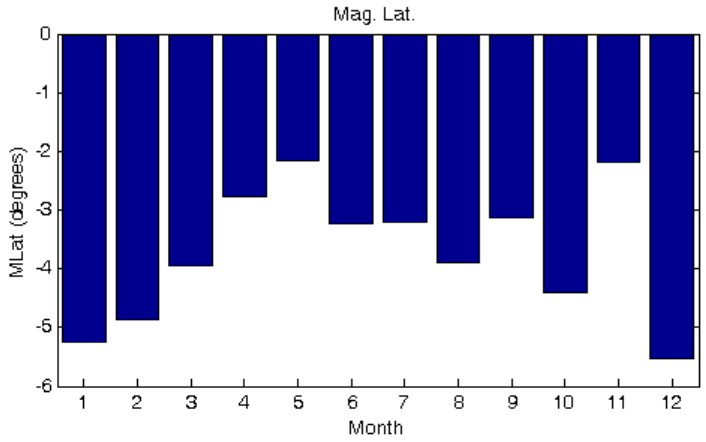
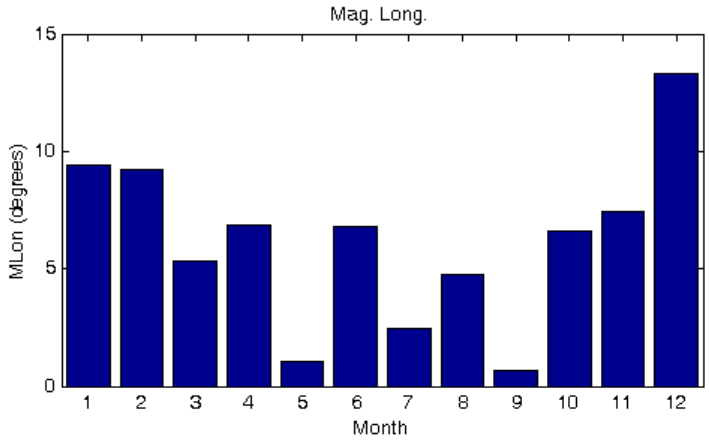
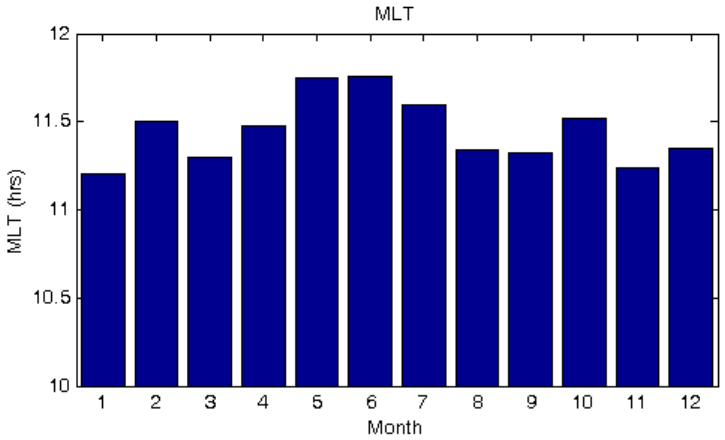
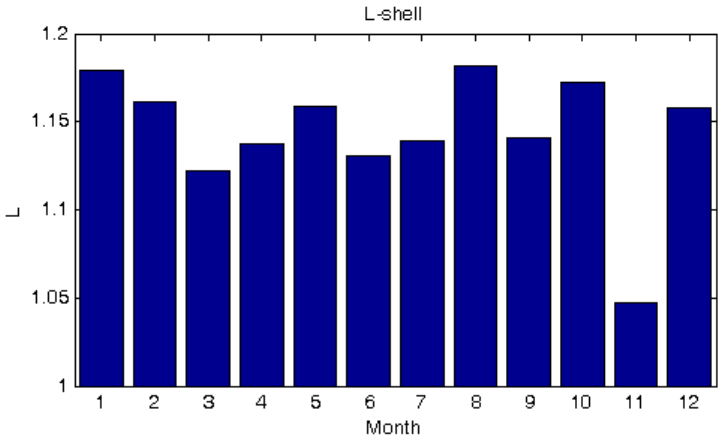
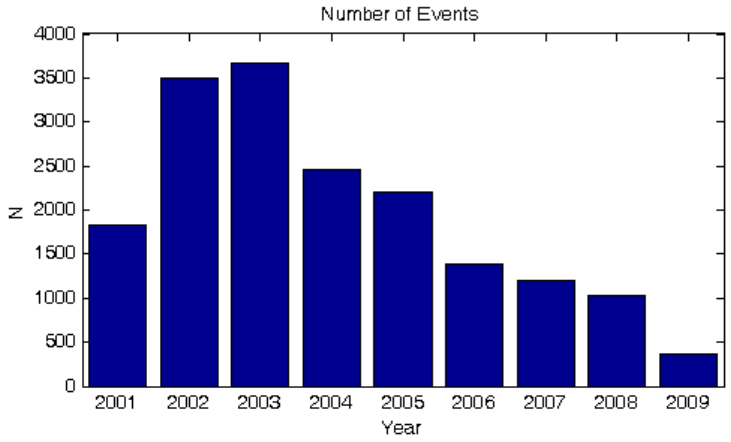


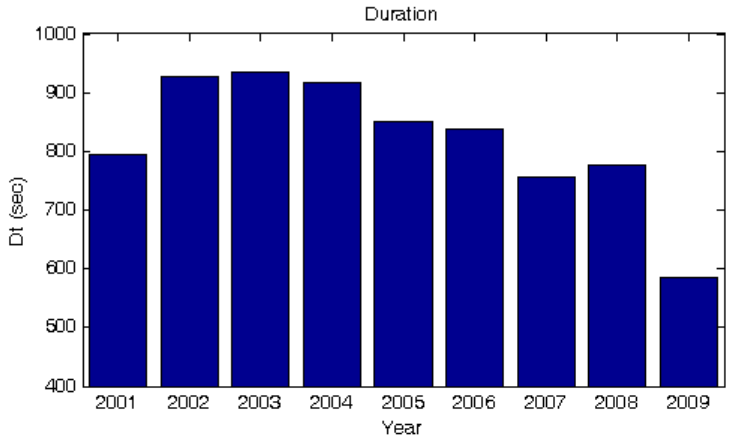


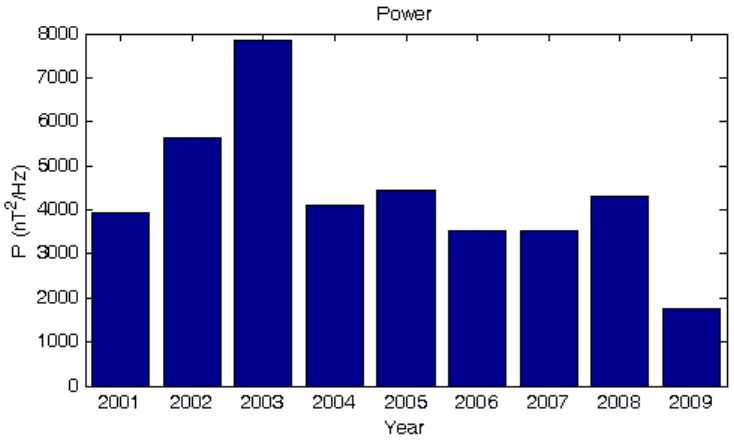


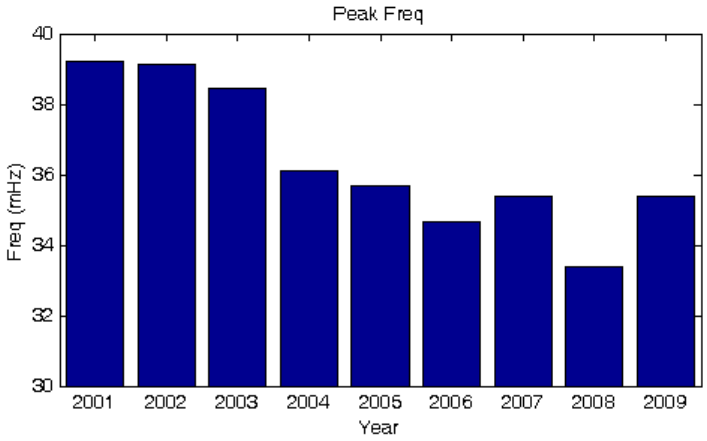


Yearly Variations

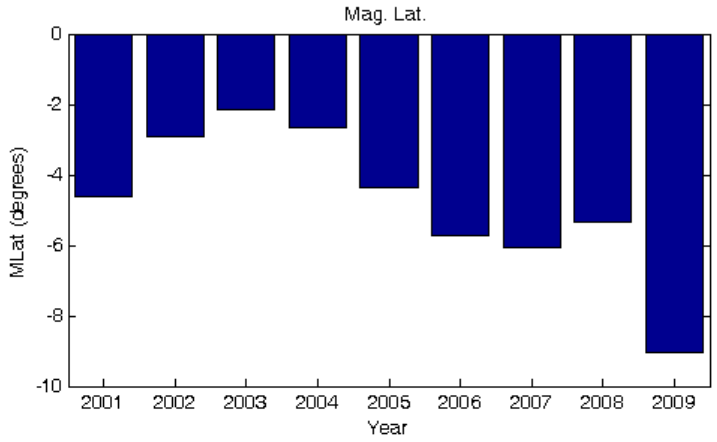


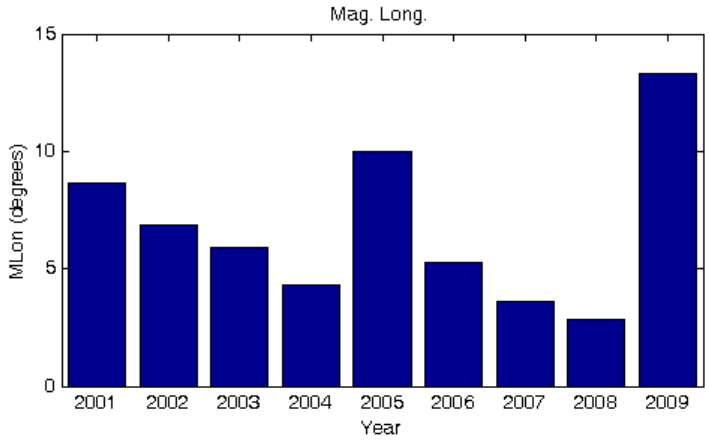


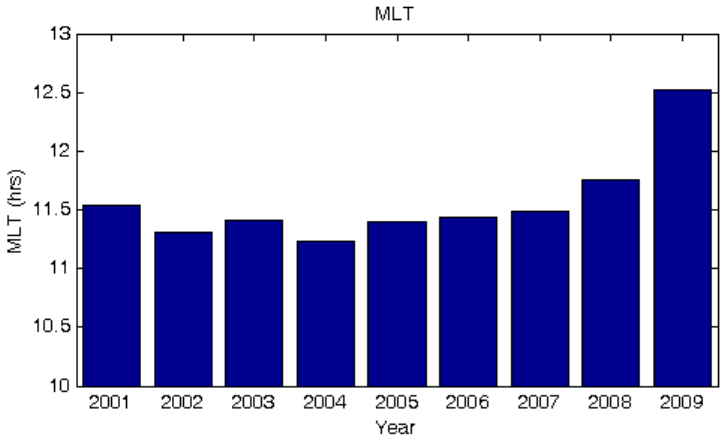


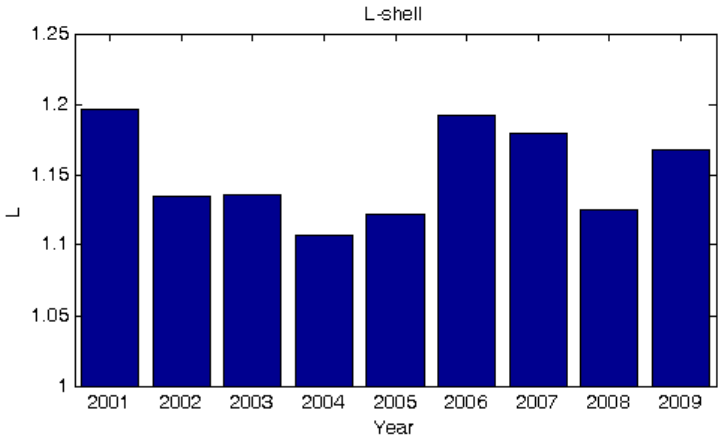


Yearly Variations

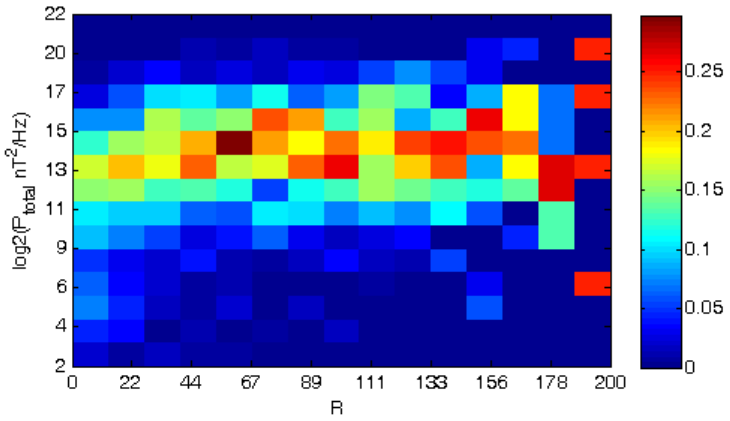


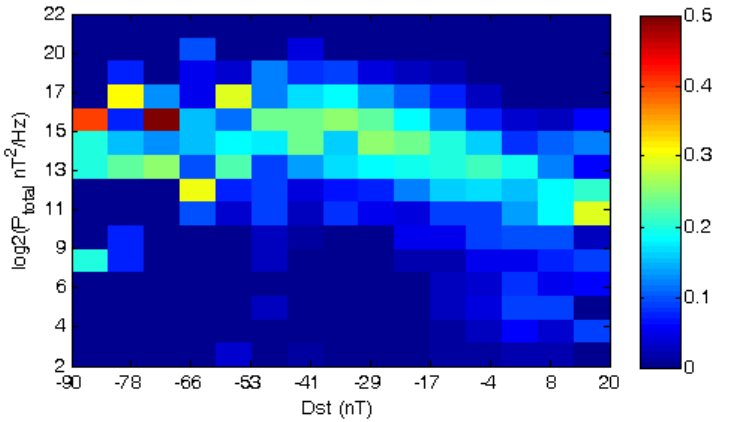


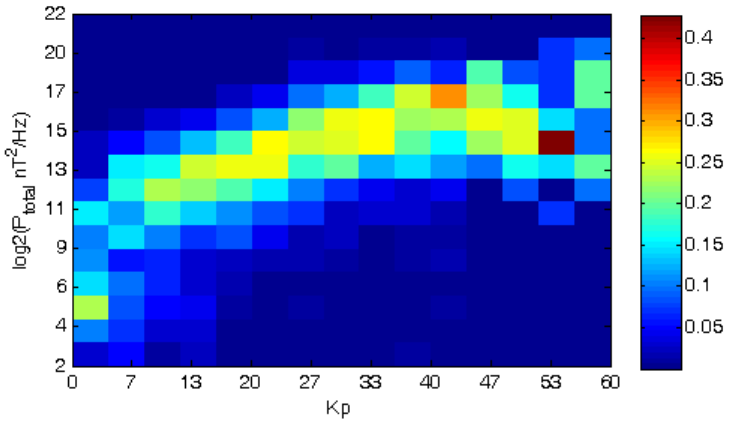


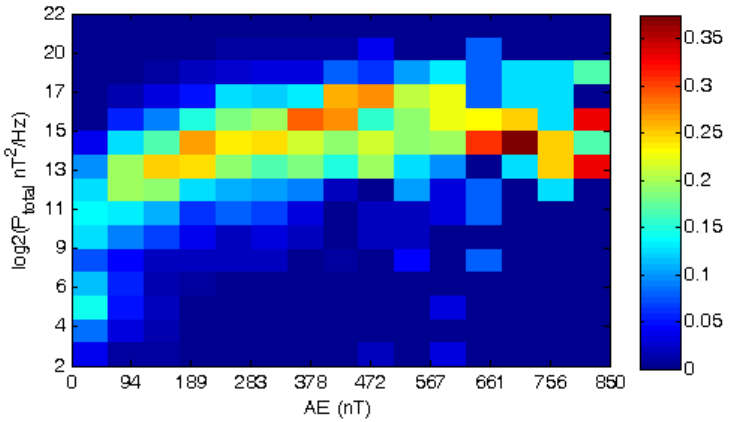


Correlations with Indices

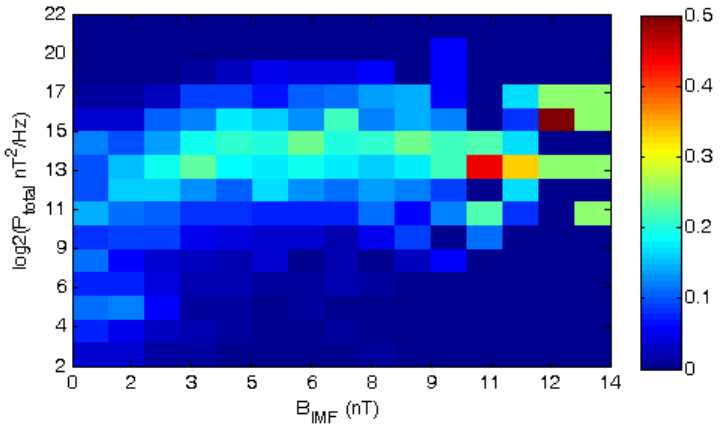


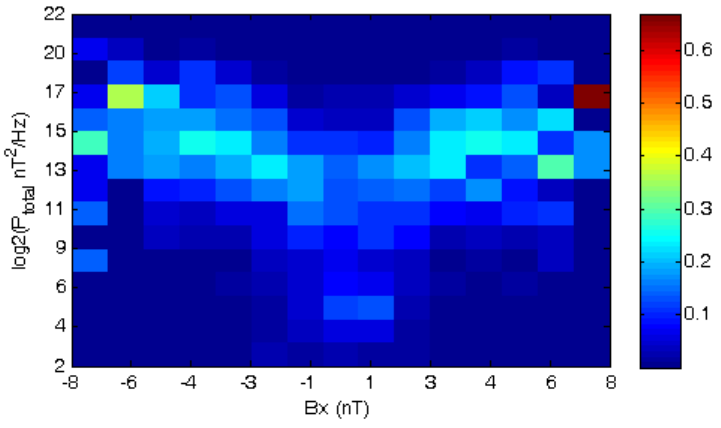


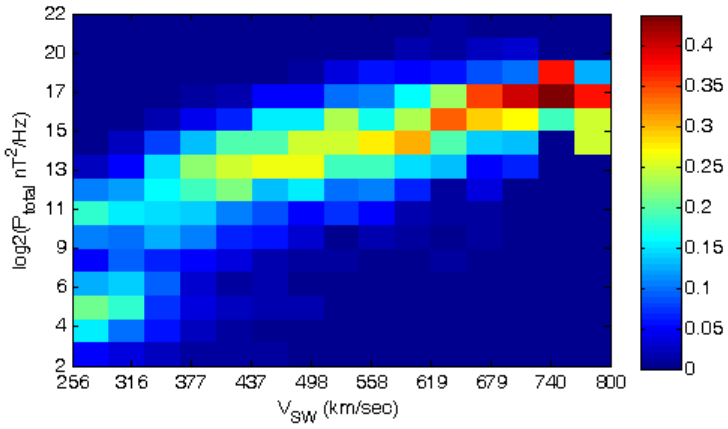


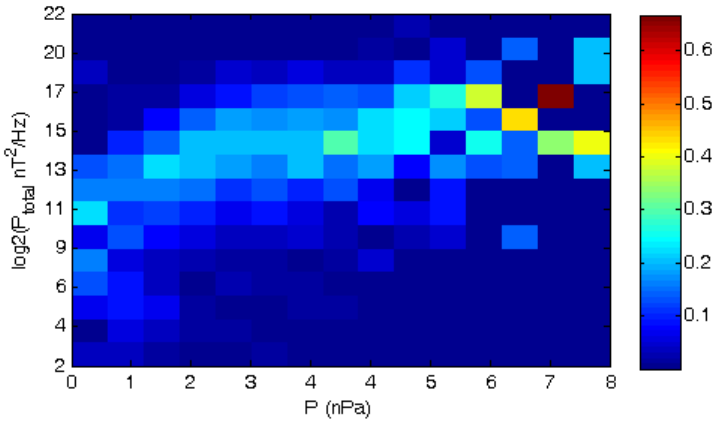


Correlations with SW parameters



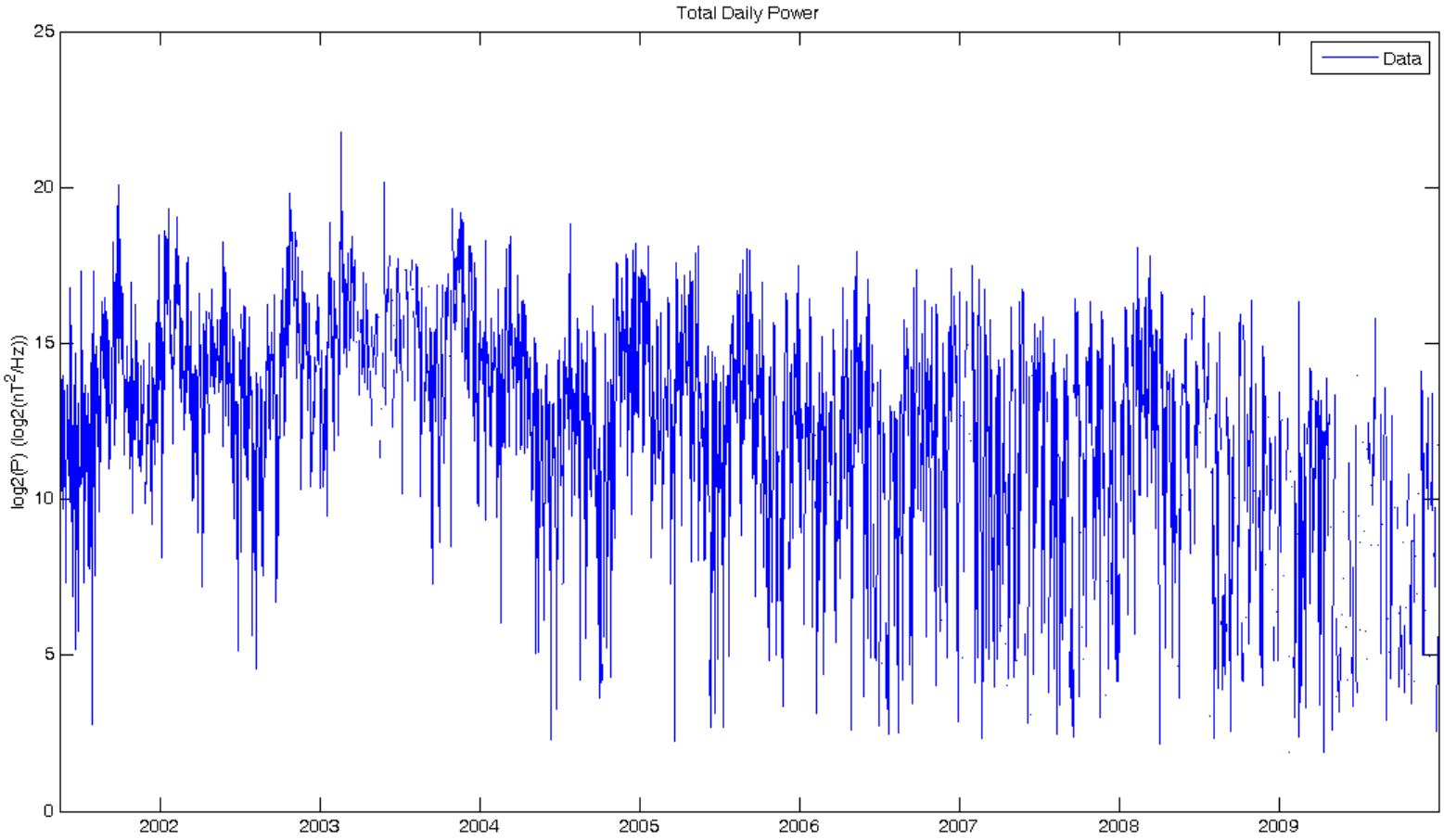




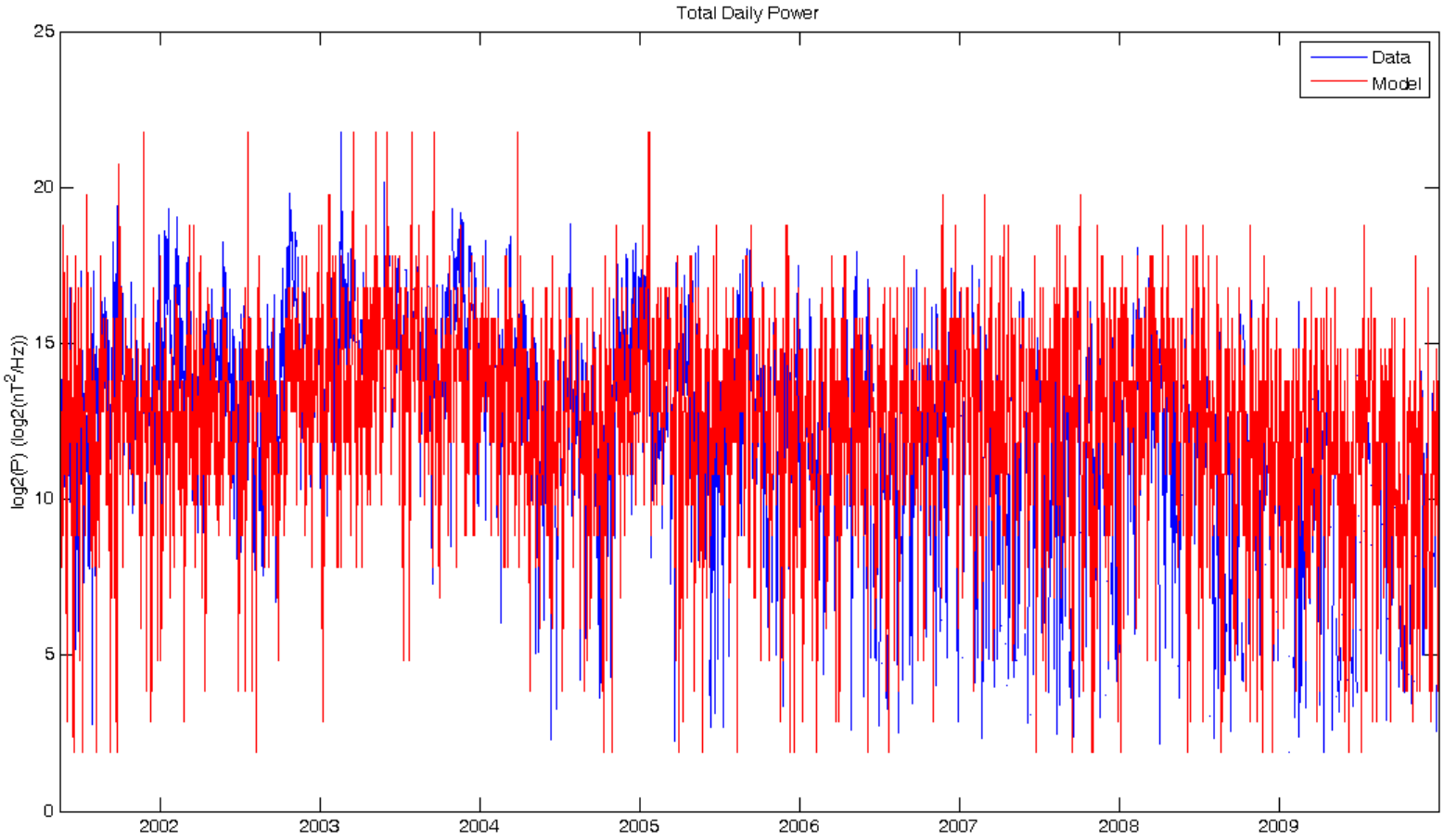


IAASARS

V_{SW}-driven Probabilistic Modelling



V_{SW}-driven Probabilistic Modelling



Summary

- ✓ Automated Detection Methodology
- ✓ Statistics of Wave Parameters
- ✓ Variations of Wave Parameters vs Time
- ✓ Correlations with Indices of Magnetospheric activity
- ✓ Correlations with SW parameters
- ✓ Modelling (?)

- ❑ Smaller time scales (~ hr)
- ❑ Vector Data of the Magnetic Field
- ❑ Propagation/Polarization parameters
- ❑ New datasets (SWARM Mission)

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Geospace Revisited, 15-20 September 2014,
Rhodes, Greece