



**The Abdus Salam
International Centre for Theoretical Physics**



SMR 2333-31

Workshop on Science Applications of GNSS in Developing Countries (11-27 April), followed by the: Seminar on Development and Use of the Ionospheric NeQuick Model (30 April-1 May)

11 April - 1 May, 2012

GNSS/Space Weather Research at the University of Ilorin

OLawePO Olayinka Adeniji and more authors
University of Ilorin, Faculty of Science
Department of Physics
P.M.B. 1515
Ilorin
Kwara State
NIGERIA

Space Weather Research at the University of Ilorin, Nigeria

J.O. Adeniyi¹, P. H. Doherty², A.O. Olawepo ¹, A. O. Adewale³, O. Bolaji⁴
and B. W. Reinisch⁵

¹Physics Department, University of Ilorin, P.M.B. 1515 Ilorin Nigeria

²Institute for Scientific Research, Boston College, USA

³Physics Department, University of Lagos, Nigeria

⁴Physics Department ,Bells University, Ota, Ogun State, Nigeria

⁵Lowell Digisonde International, LLC,175 Cabot Street, Suite 200 Lowell, MA
01854, USA

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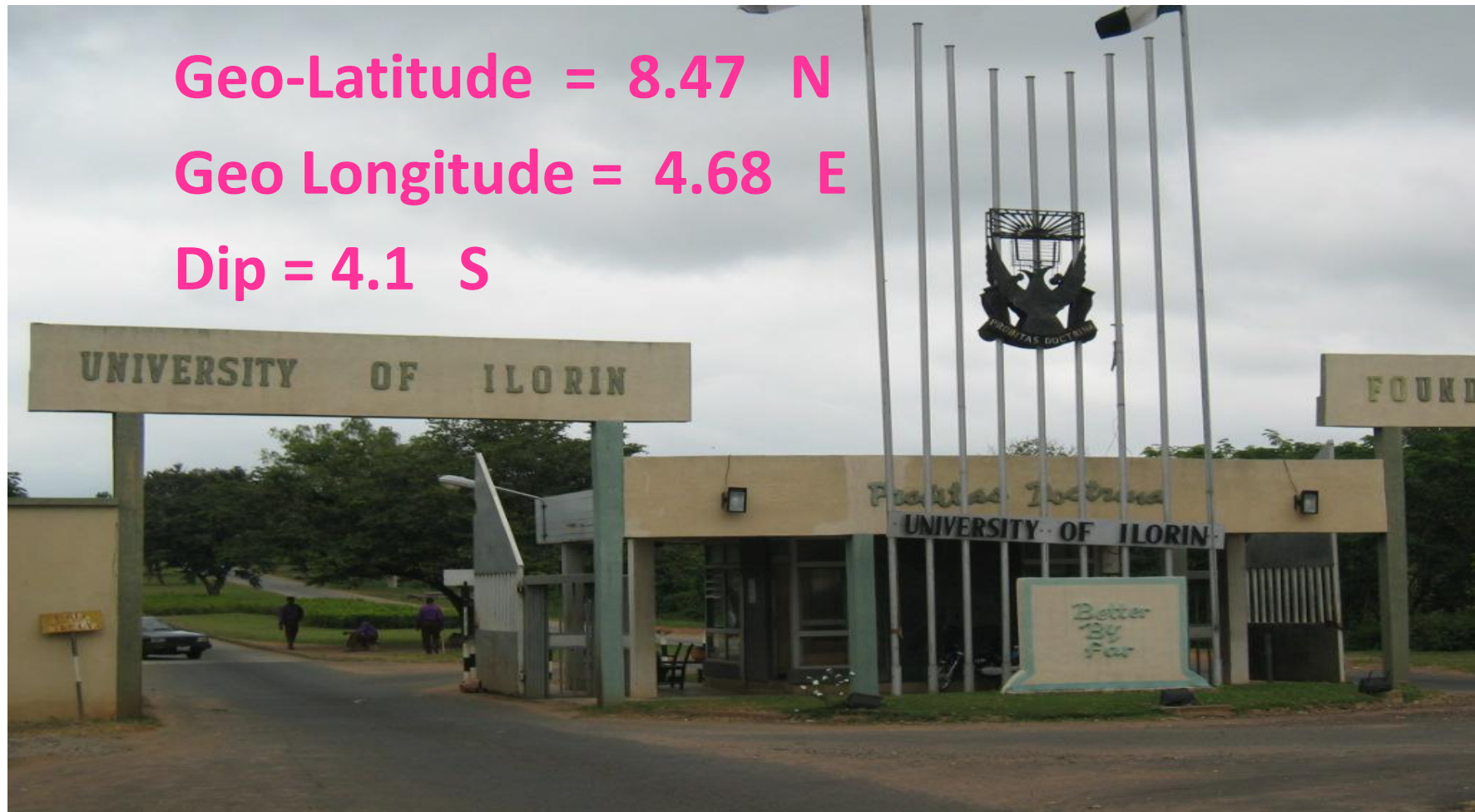


LOCATION

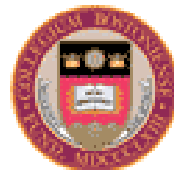
Geo-Latitude = 8.47 N

Geo Longitude = 4.68 E

Dip = 4.1 S



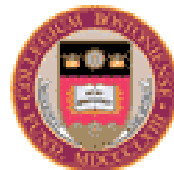
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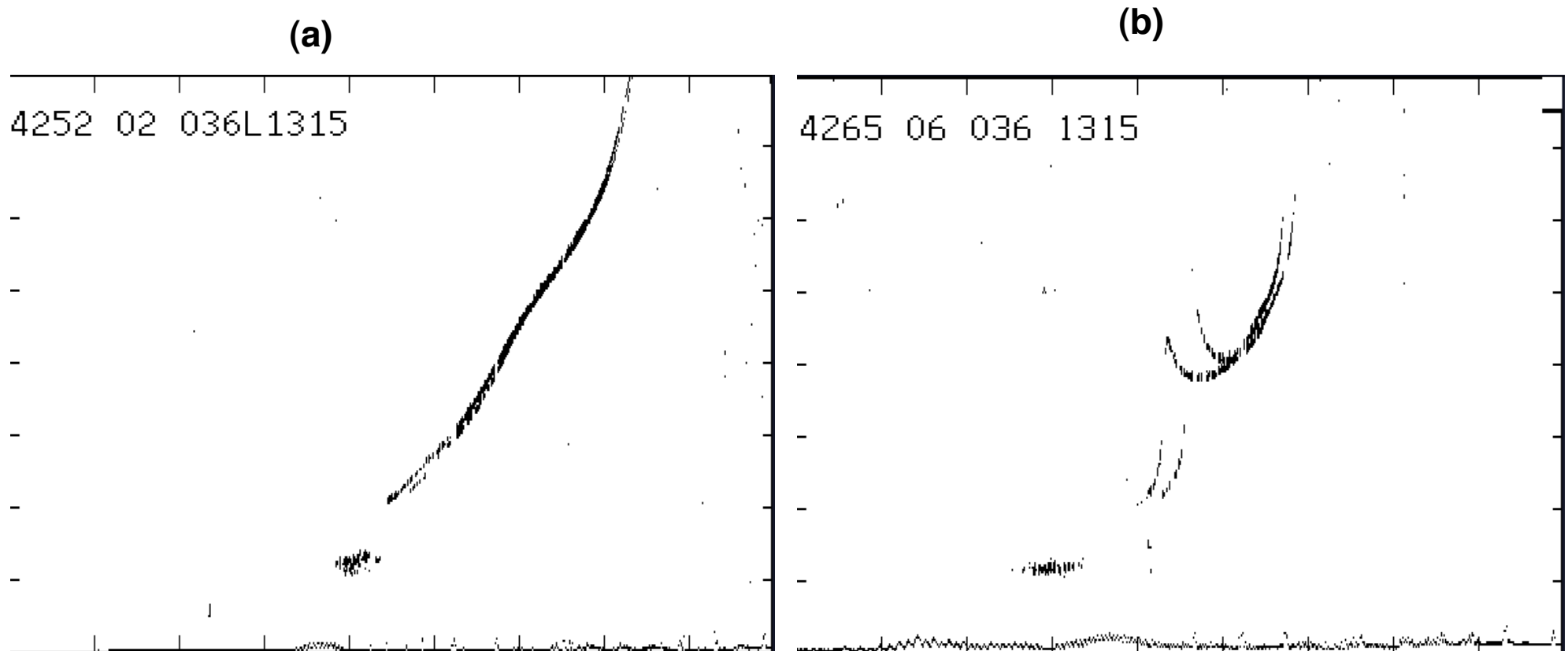
IONOSONDE/DIGISONDE



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Ilorin daytime (Ionosonde) ionogram at (a) high & (b) low solar activity



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Ilorin (Digisonde) Ionogram

(a) daytime and (b) nighttime



foF2 7.575
foF1 5.40
foF1p 4.50
foE 3.41
foEp 3.48
fxI 8.05
foEs 3.65
fmin 2.65

MUF(D) 19.92
M(D) 2.64
D N/A

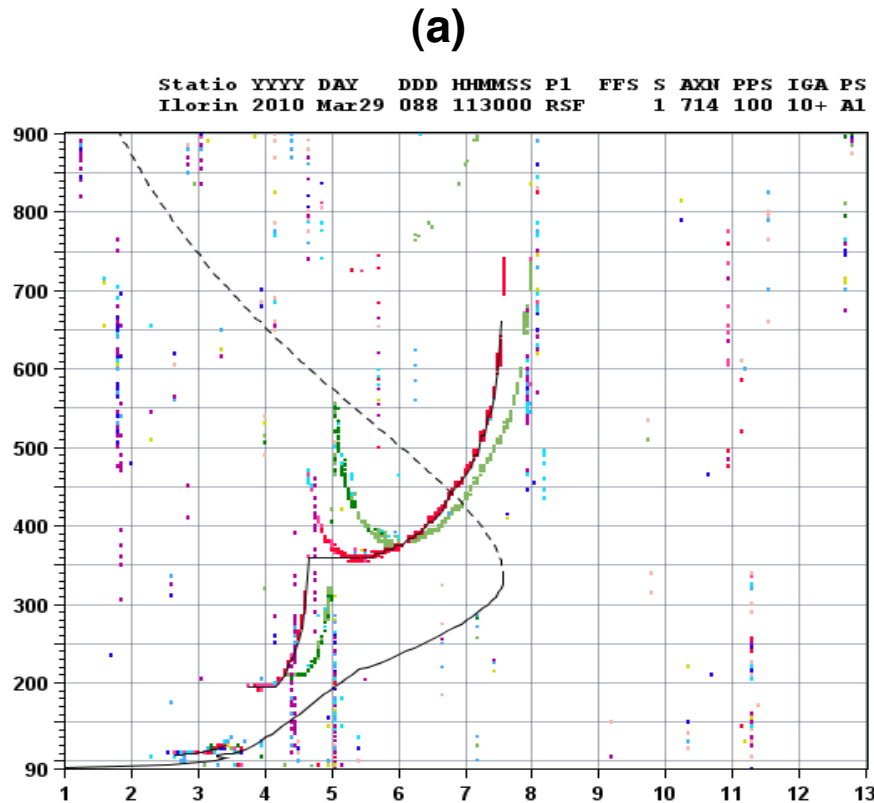
h'F 195.0
h'F2 360.0
h'E 107.5
h'Es 112.5

hmF2 332.1
hmF1 217.0
hmE 104.2
yF2 142.1
yF1 85.6
yE 13.8
B0 175.8
B1 1.78

C-level 11

Auto:
Artist5
500200

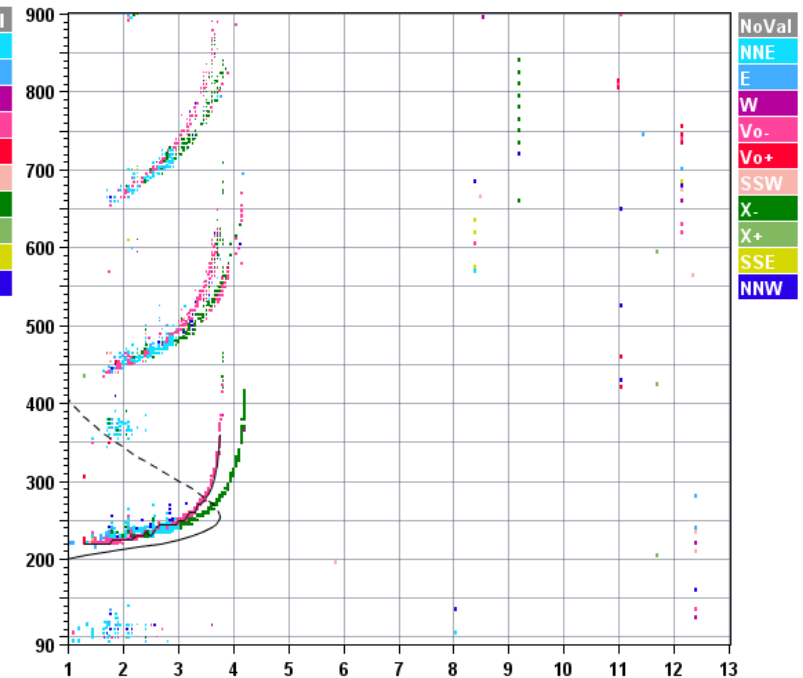
D 100 200 400 600 800 1000 1500 3000 [km]
MUF 8.0 8.1 8.3 8.8 9.4 10.4 13.1 19.9 [MHz]
IL008_010080113000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 8.5 N 4.5 E



NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW

(b)

Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Apr04 094 031500 RSF 1 714 100 10+ A1



NoVal
NNE
E
W
Vo-
Vo+
SSW
X-
X+
SSE
NNW

1 600 800 1000 1500 3000 [km]
1 4.8 5.2 6.0 8.0 13.3 [MHz]

Ion2Png v. 1.3.16 / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 8.5 N 4.5 E

Ion2Png v. 1.3.16

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Range and frequency Spread F



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Apr03 093 000000 RSF 1 714 100 10+ A1

foF2 5.600
foF1 N/A
foFlp N/A
foE N/A
foEp 0.38
fxI 7.25
foEs N/A
fmin 3.05

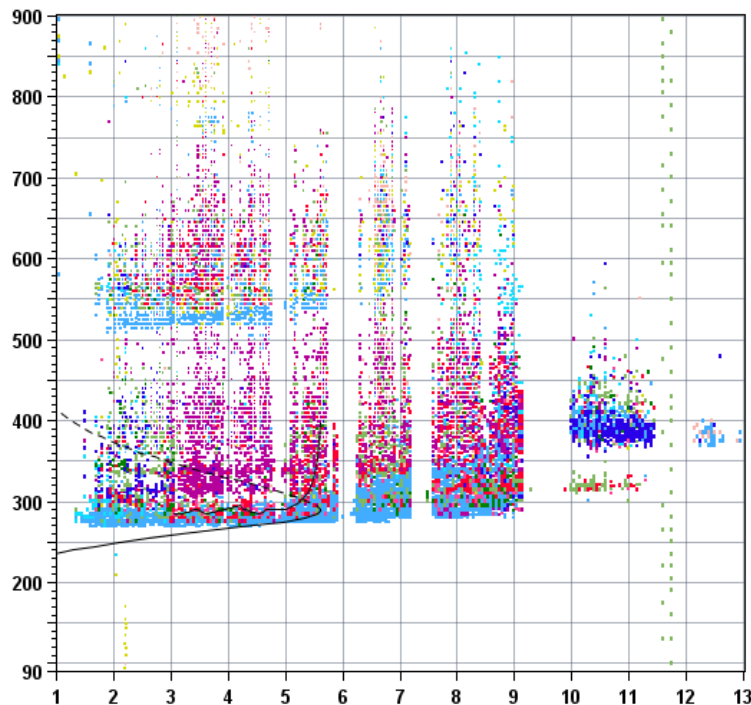
MUF(D) 19.16
M(D) 3.42
D N/A

h'F 285.0
h'F2 285.0
h'E N/A
h'Es N/A

hmF2 289.0
hmF1 N/A
hmE 110.0
yF2 33.1
yF1 N/A
yE 20.0
B0 33.5
B1 1.99

C-level 33

Auto:
Artist5
500200



D 100 200 400 600 800 1000 1500 3000 [km]
MUF 6.0 6.1 6.4 6.9 7.6 8.6 11.5 19.2 [MHz]
IL008_2010093000000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 100 / 0.5 N 4.5 E

Ion2Png v. 1.3.16



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Apr03 093 040000 RSF 1 714 100 10+ A1

foF2 3.650
foF1 N/A
foFlp N/A
foE N/A
foEp 0.38
fxI 4.25
foEs N/A
fmin 1.30

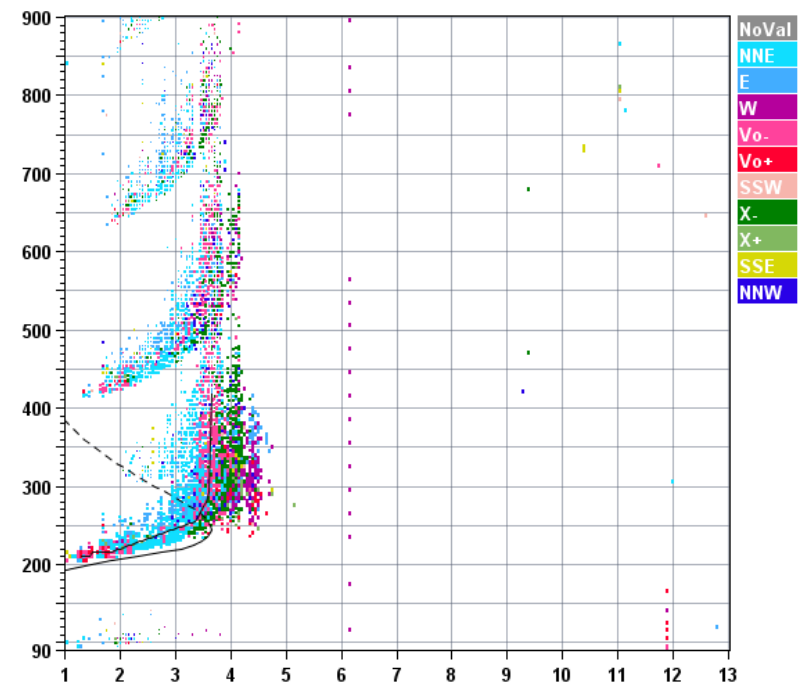
MUF(D) 13.47
M(D) 3.69
D N/A

h'F 210.0
h'F2 210.0
h'E N/A
h'Es N/A

hmF2 244.4
hmF1 N/A
hmE 110.0
yF2 45.2
yF1 N/A
yE 20.0
B0 39.9
B1 3.55

C-level 22

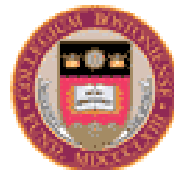
Auto:
Artist5
500200



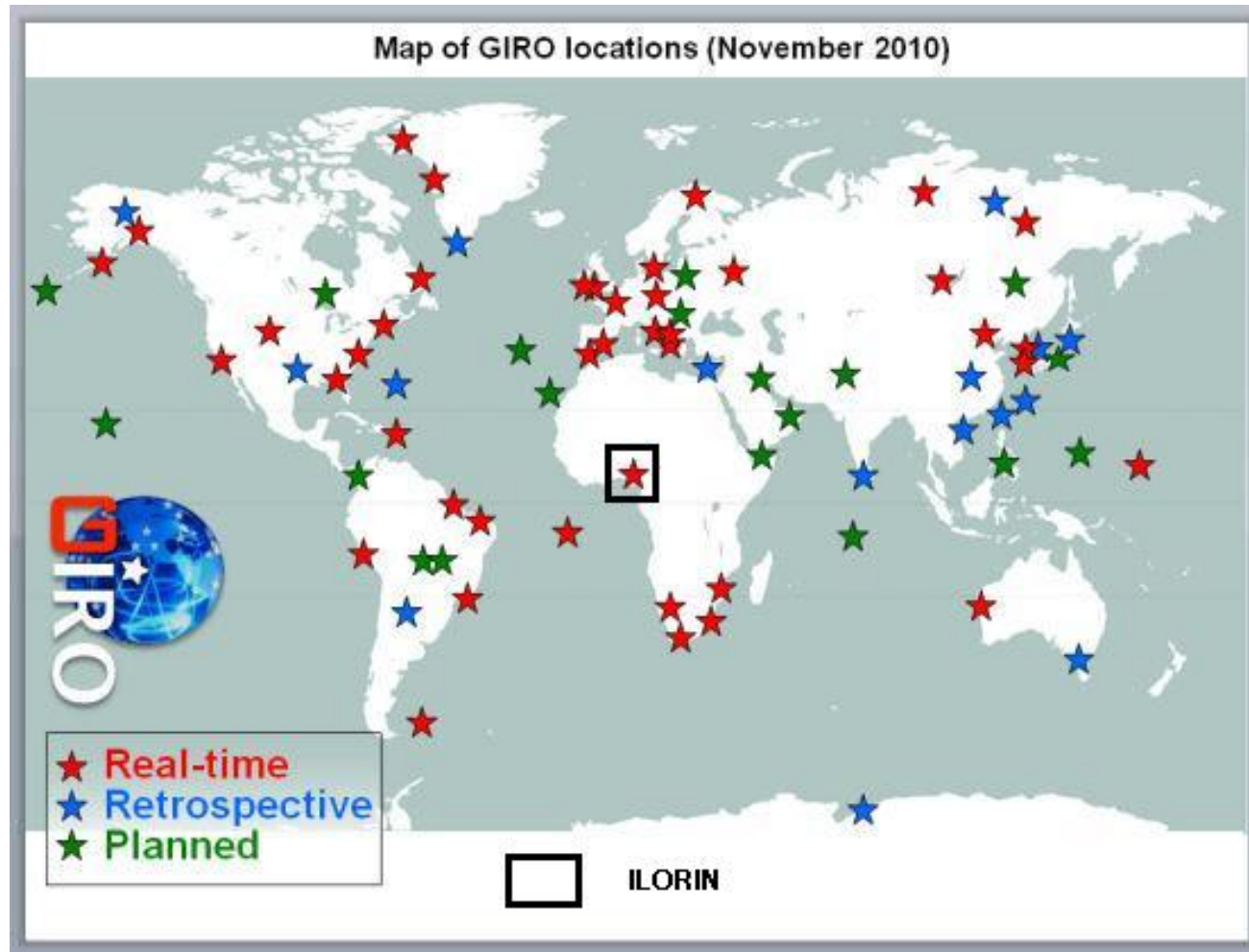
D 100 200 400 600 800 1000 1500 3000 [km]
MUF 4.1 4.1 4.3 4.7 5.2 5.9 8.0 13.5 [MHz]
IL008_2010093040000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 100 / 0.5 N 4.5 E

Ion2Png v. 1.3.16

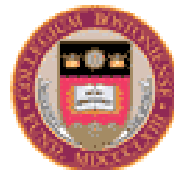
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Digisonde Locations

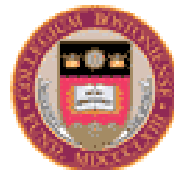


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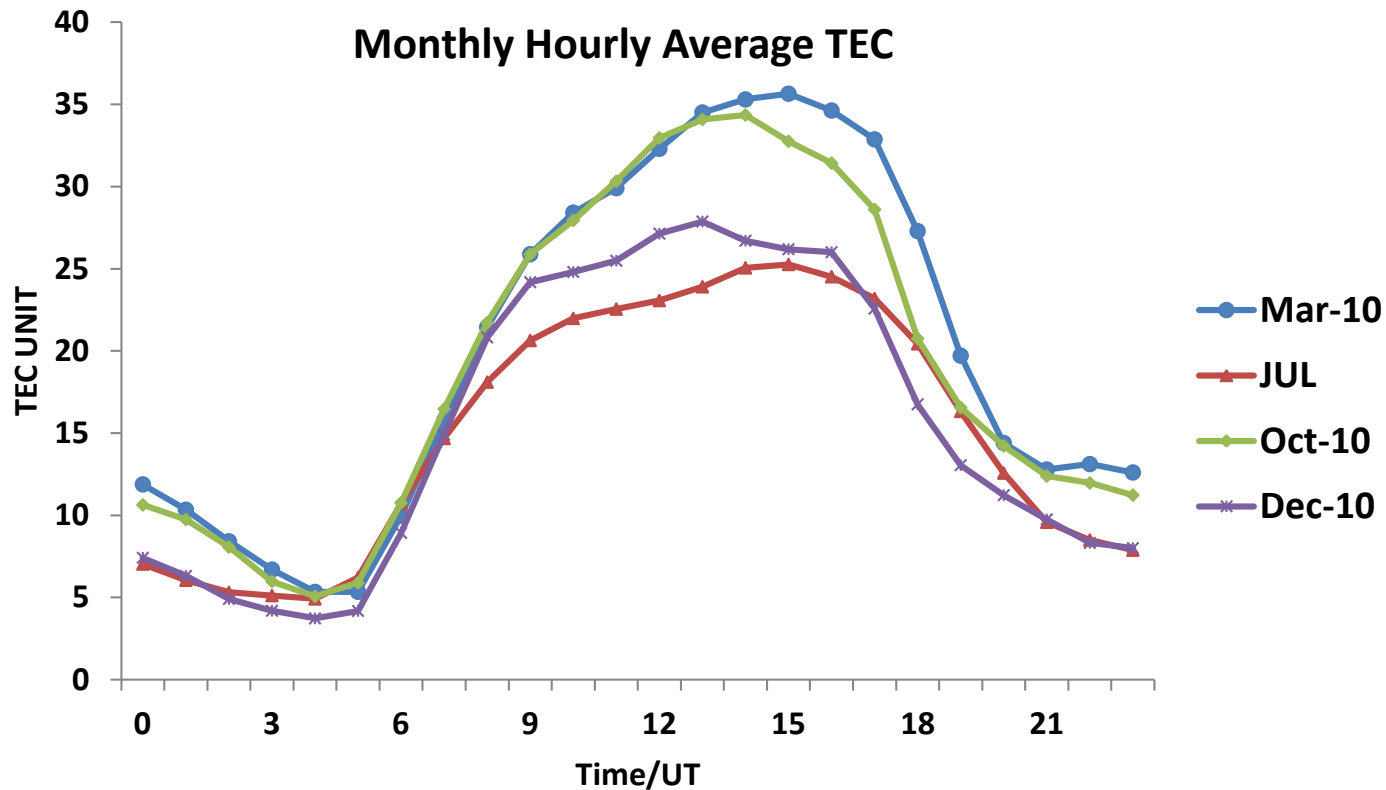


GPS RECEIVER

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Seasonal Effect on TEC

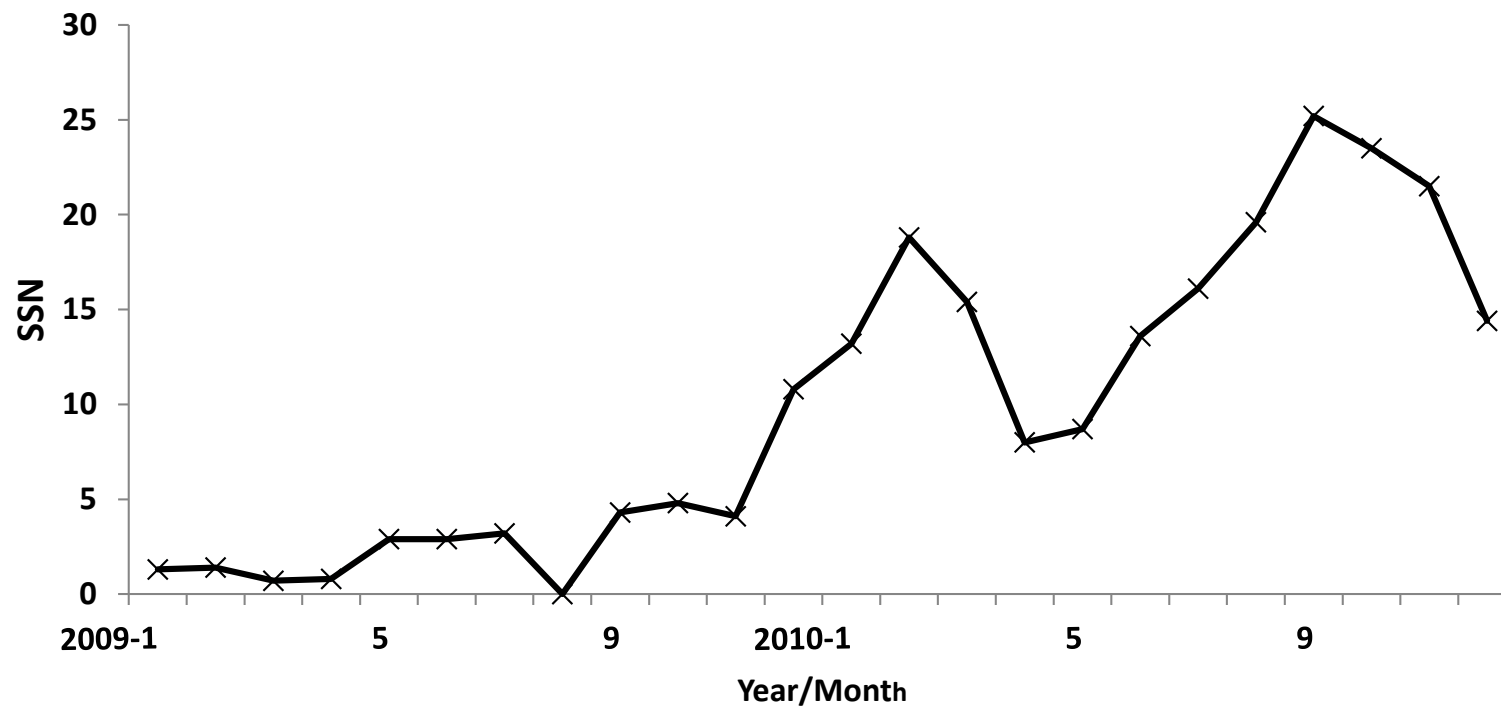


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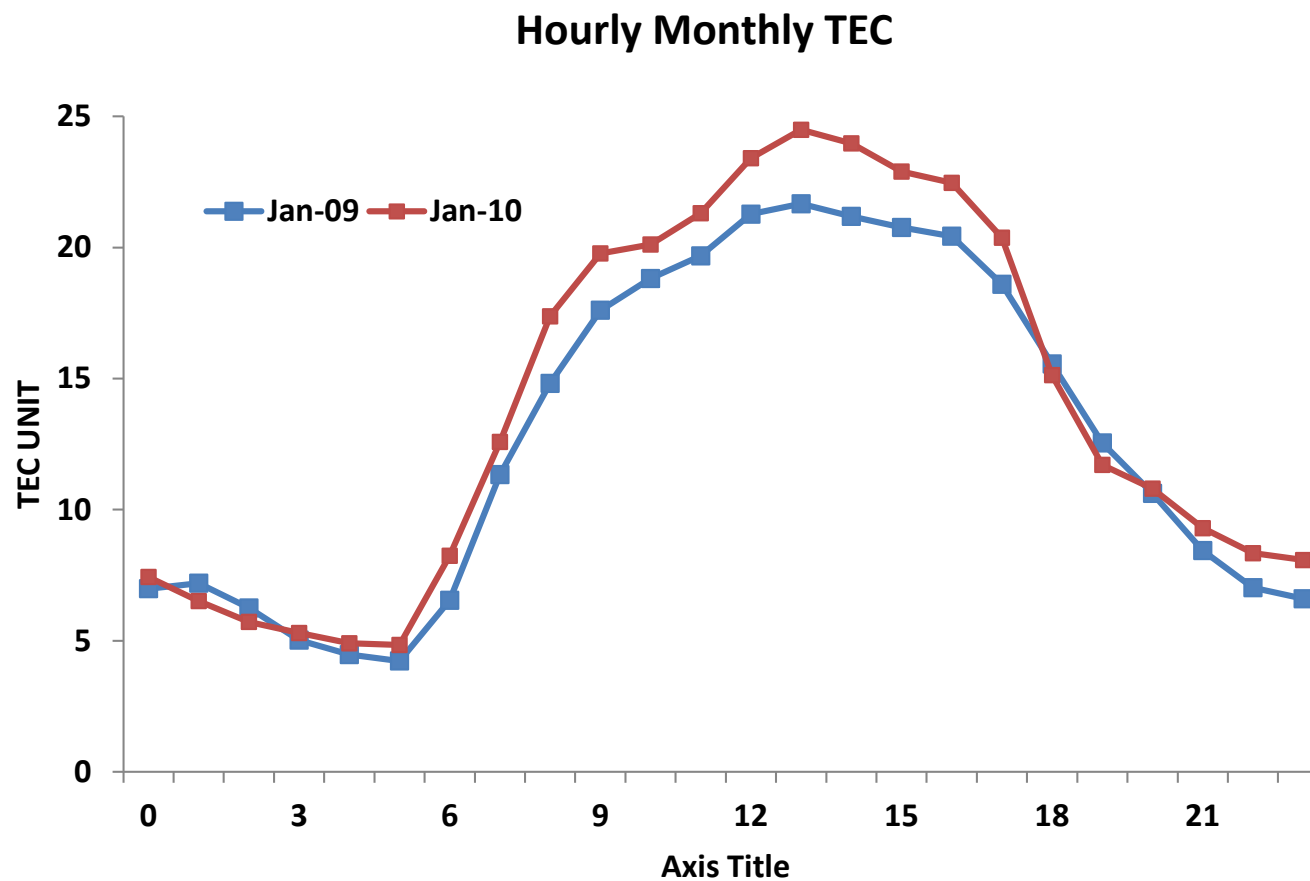
Average Monthly Sun Spot Number 2009-2010

Average Monthly SSN 2009-2010



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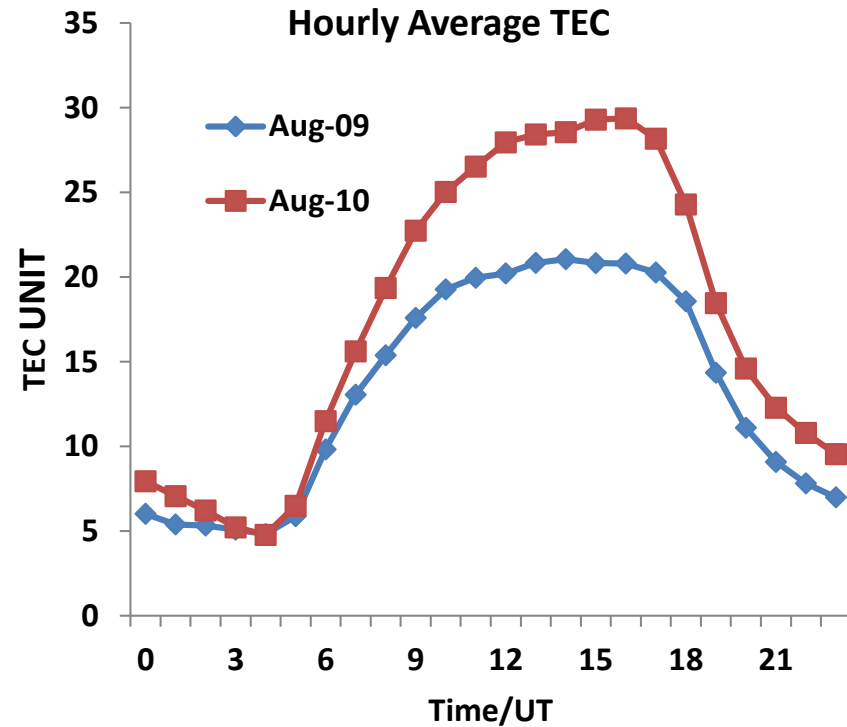
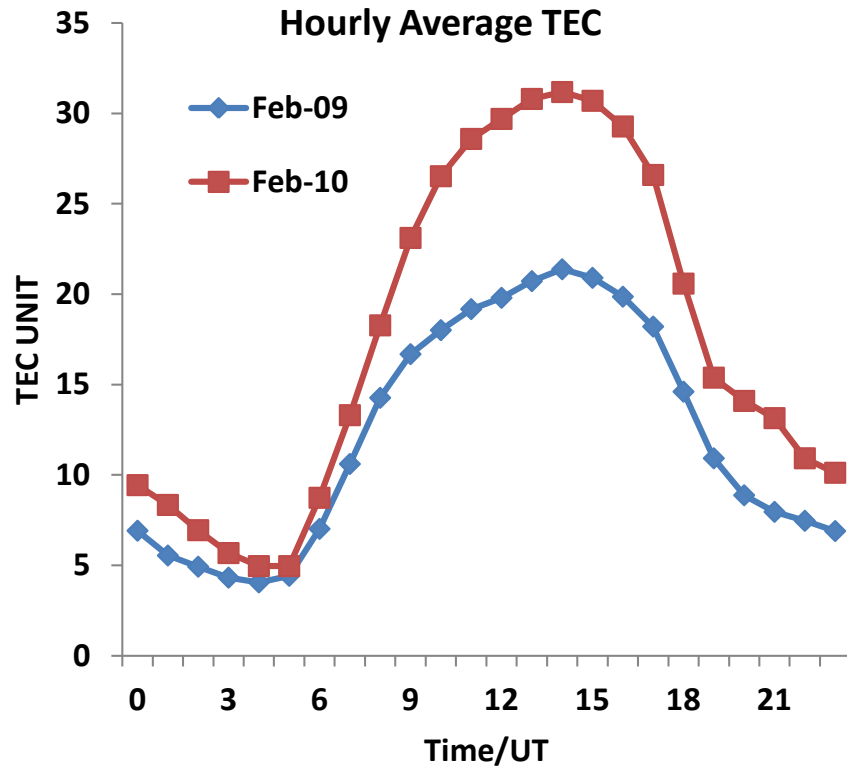




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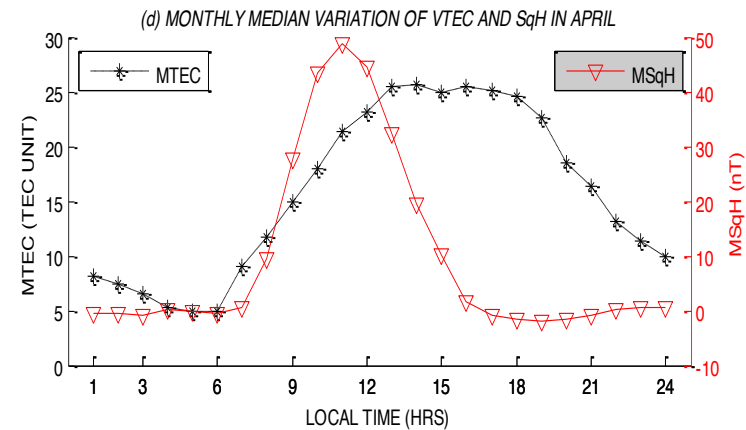
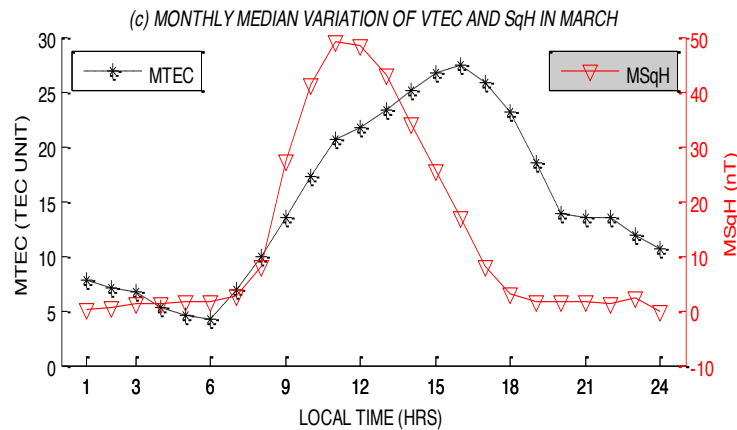
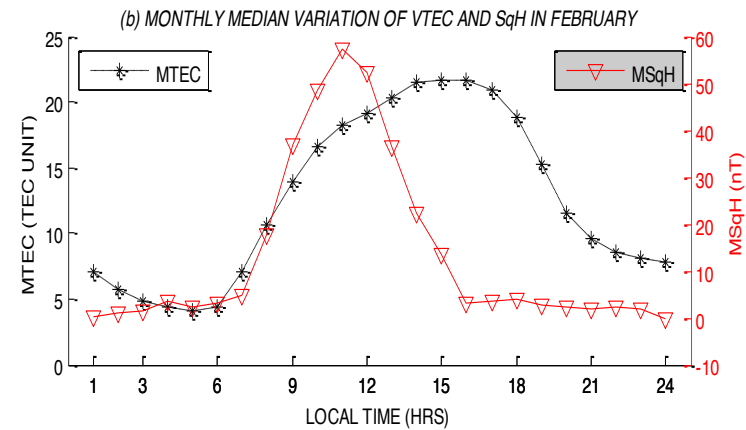
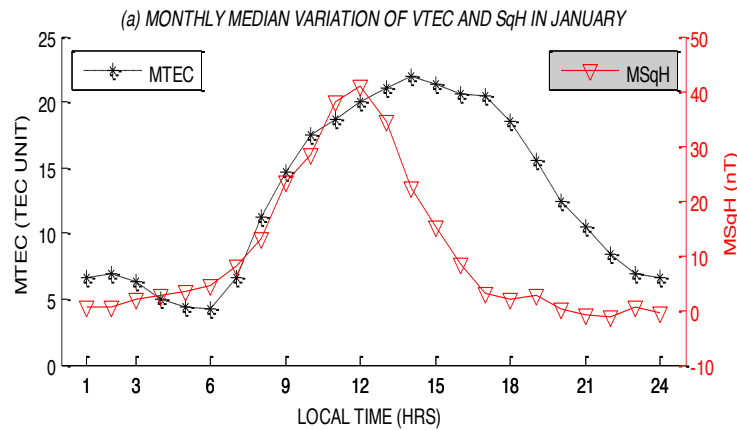
Solar Cycle Effect



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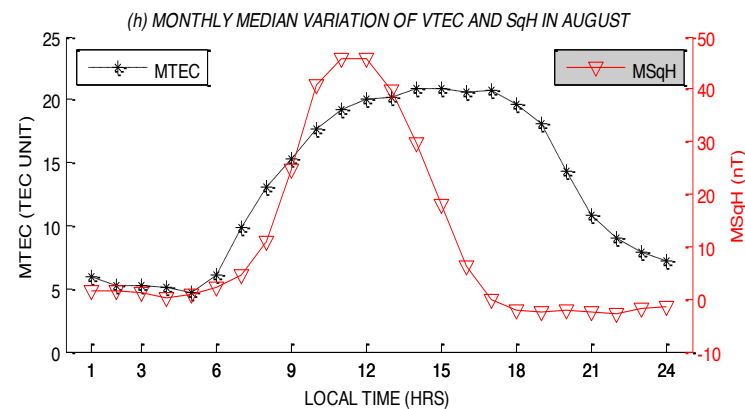
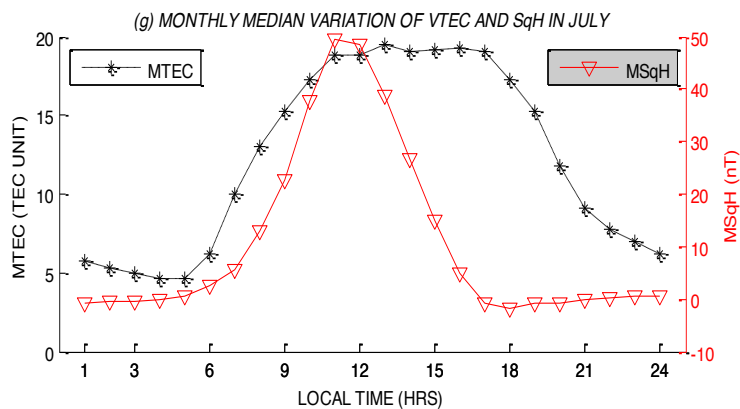
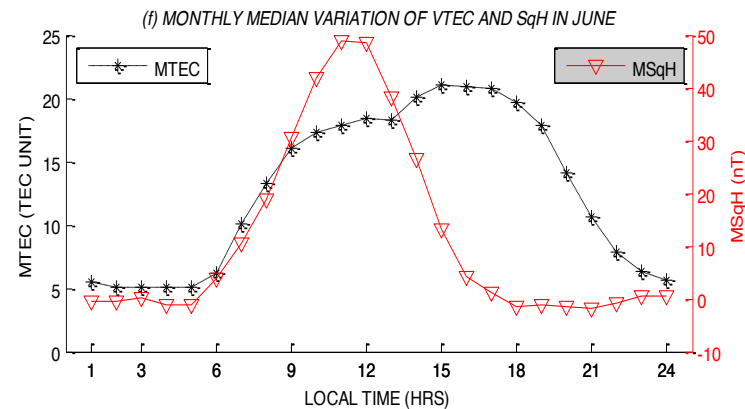
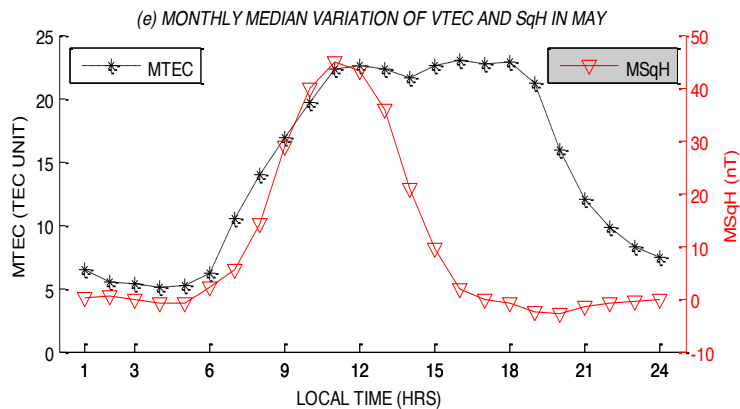
Monthly median variation TEC and H (Jan-April)



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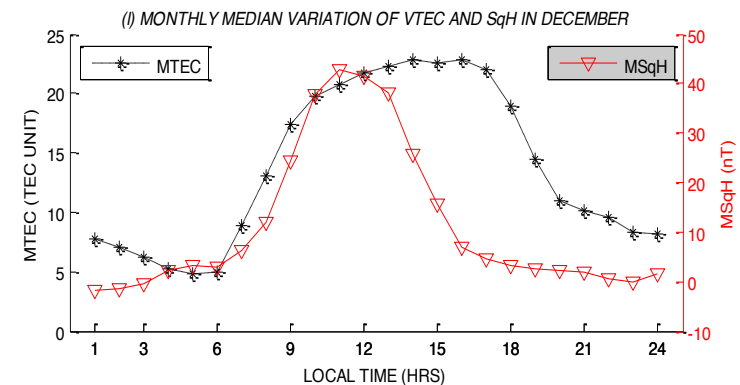
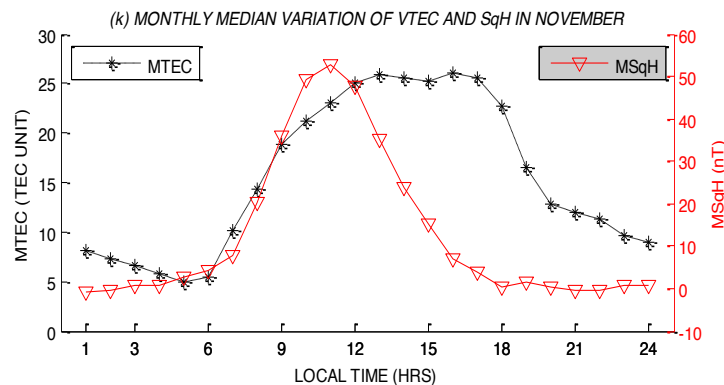
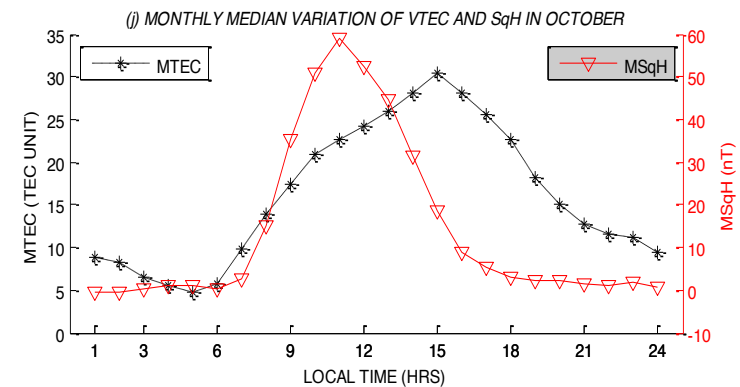
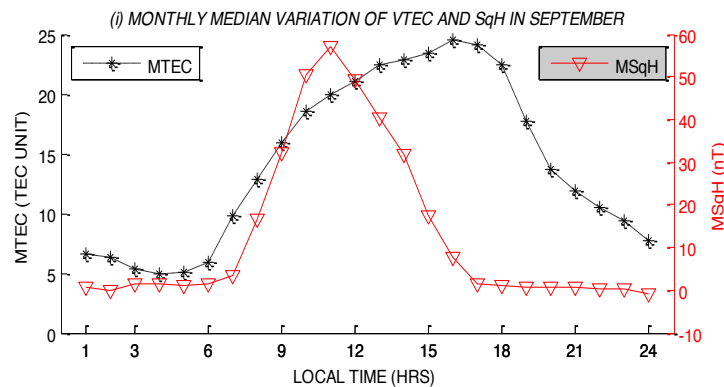
Monthly median variation TEC and H (May-August)



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Monthly median variation TEC and H (Sept-Dec)

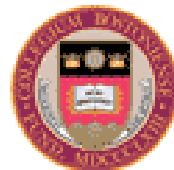


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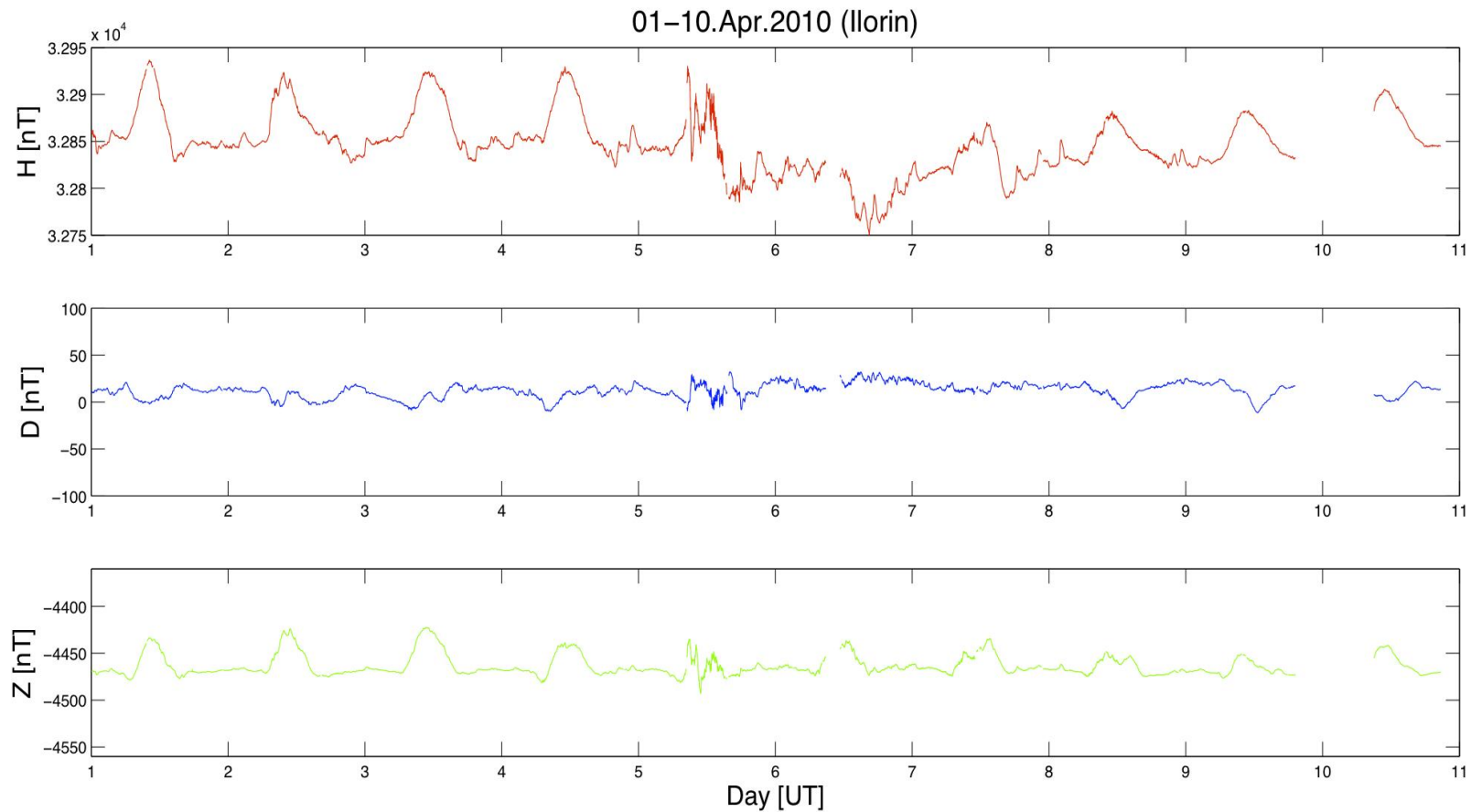


MAGNETOMETER/MAGNETIC STORM

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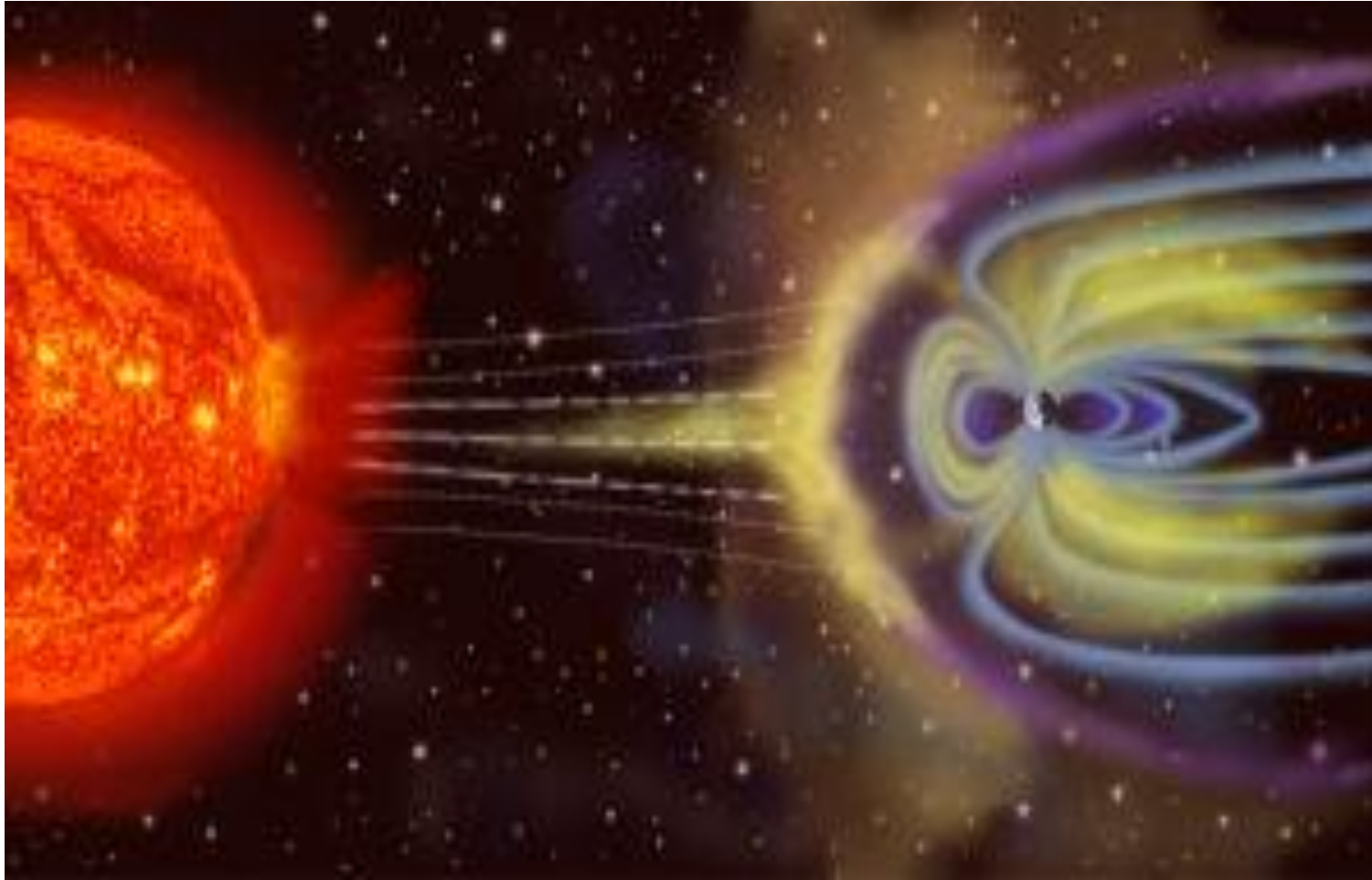
Z, D, & H MAGNETIC COMPONENT



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The earth's magnetic field



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Identification of Magnetic Storm Days

Days with $K_p \geq 5$ and
 $AP \geq 26$

e.g.

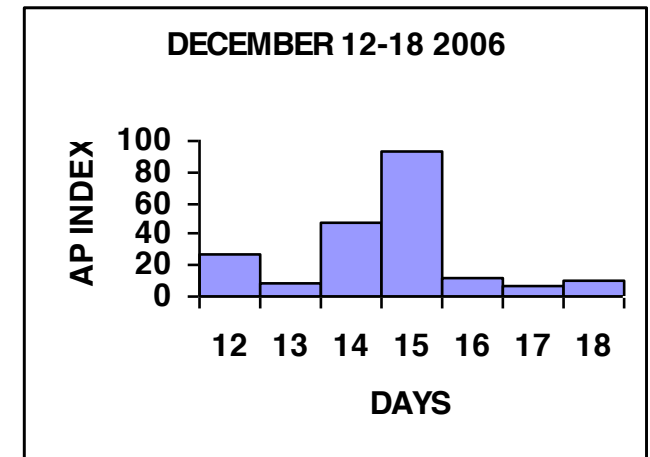
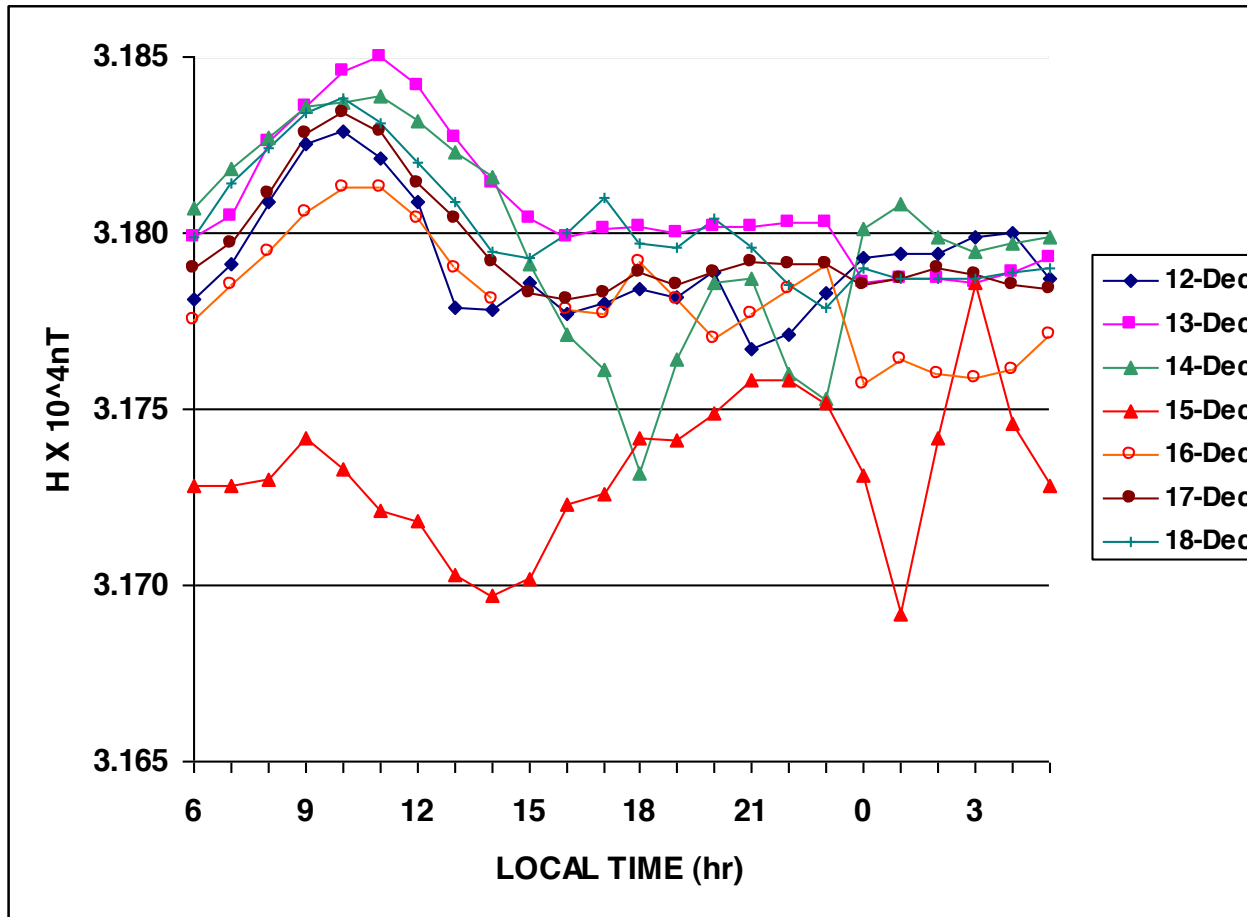
December 15 2006 storm had maximum $k_p = 8$
maximum $AP = 94$

AUGUST 4, 2010 storm had maximum $k_p = 6$
Maximum $AP = 49$

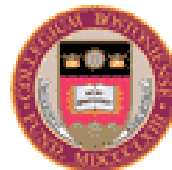
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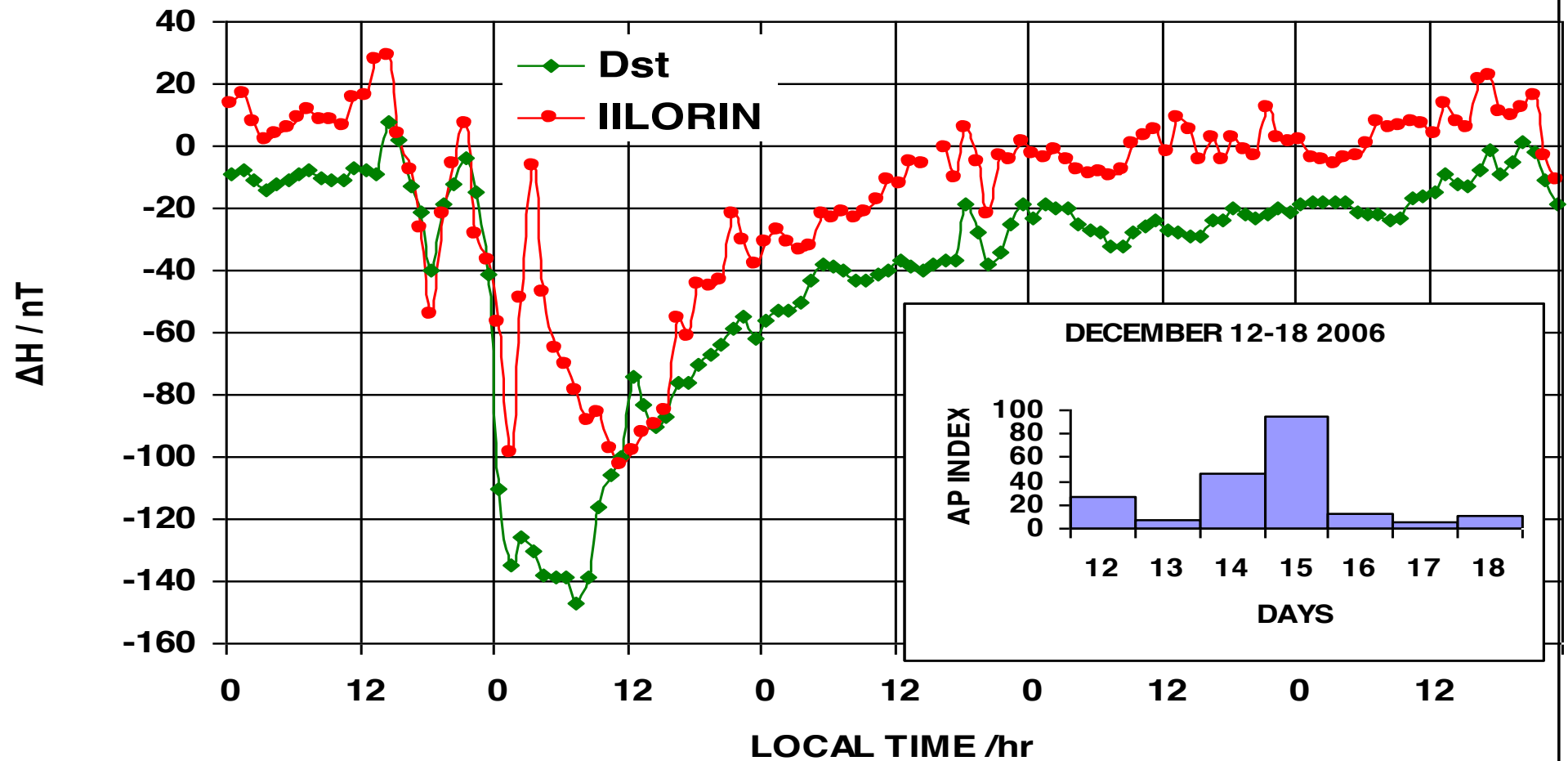
MAGNETIC H PARAMETER AT ILORIN 12-18 DEC. 2006



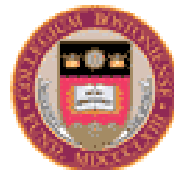
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14-18 DECEMBER 2006 GEOMAGNETIC STORM

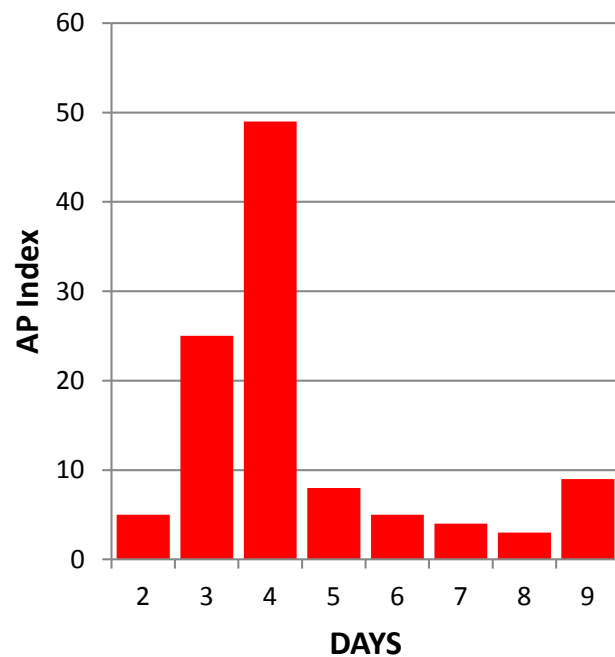


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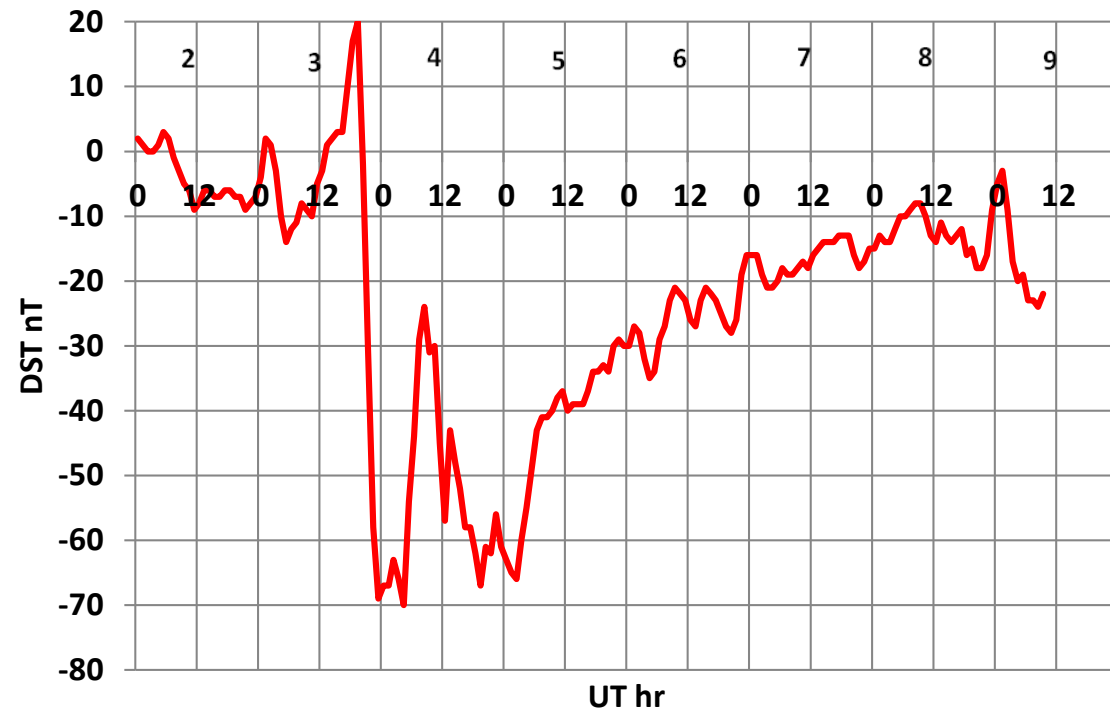


DST VS TIME (1-9 AUGUST 2010)

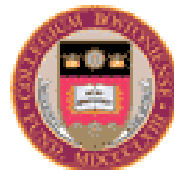
(a) AP Indices August 2-9



(b) DST for August 2-9



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Effect of initial phase



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Aug02 214 073000 RSF 1 714 100 10+ A1

foF2 6.913
foF1 4.27
foF1p N/A
foE 2.81
foEp 2.72
fxI 7.55
foEs 5.25
fmin 1.50

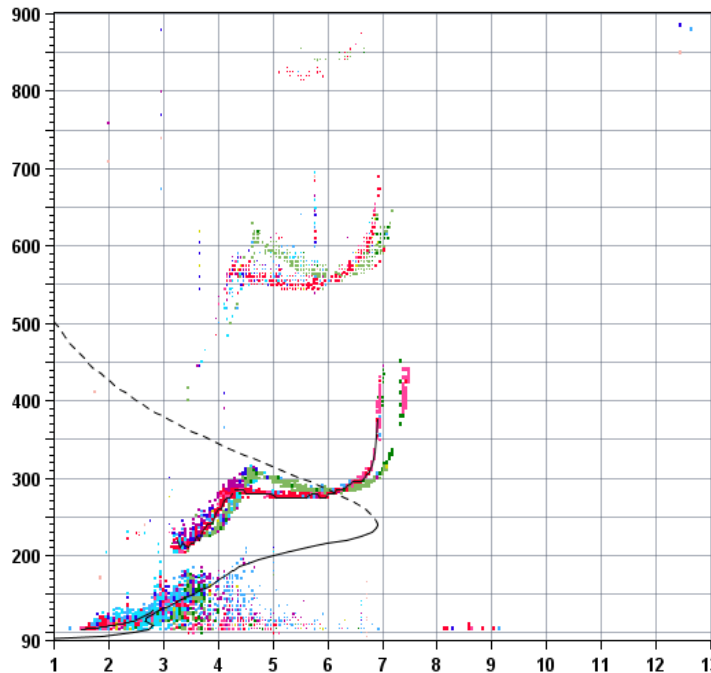
MUF(D) 24.31
M(D) 3.52
D N/A

h'F 210.0
h'F2 275.0
h'E 104.4
h'Es 109.1

hmF2 238.4
hmF1 181.3
hmE 109.3
yF2 47.5
yF1 47.5
yE 18.9
B0 67.1
B1 1.49

C-level 11

Auto:
Artist5
500200



D 100 200 400 600 800 1000 1500 3000 [km]
MUF 7.3 7.4 7.8 8.5 9.3 10.7 14.4 24.3 [MHz]
IL008_2010214073000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 0.5 N 4.5 E

Ion2Png v. 1.3.16



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Aug03 215 073000 RSF 1 714 100 10+ A1

foF2 5.850
foF1 N/A
foF1p N/A
foE 2.81
foEp 2.72
fxI 6.35
foEs 3.35
fmin 1.35

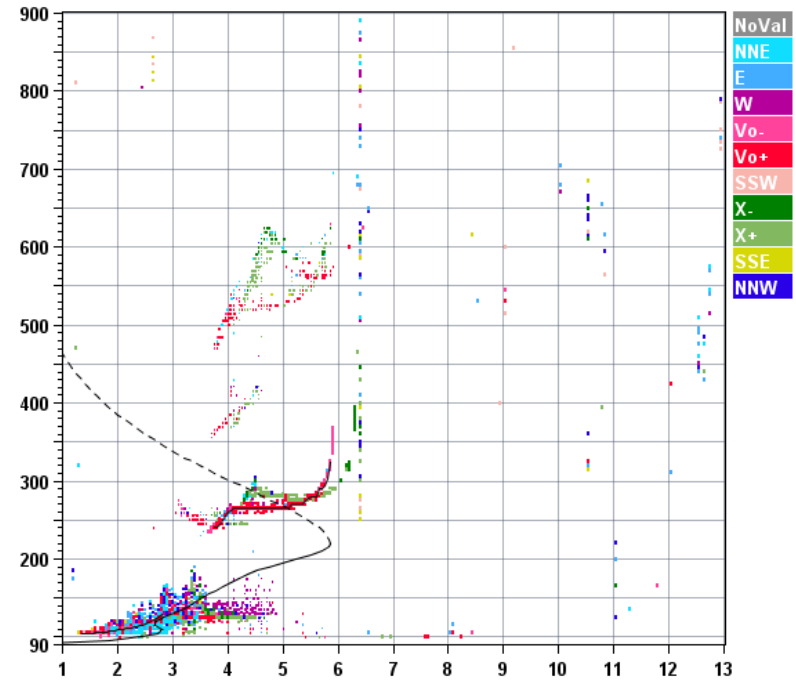
MUF(D) 21.25
M(D) 3.63
D N/A

h'F 240.0
h'F2 240.0
h'E 103.5
h'Es 118.1

hmF2 218.5
hmF1 N/A
hmE 109.5
yF2 48.6
yF1 N/A
yE 19.1
B0 87.2
B1 1.01

C-level 11

Auto:
Artist5
500200



D 100 200 400 600 800 1000 1500 3000 [km]
MUF 6.3 6.4 6.7 7.3 8.0 9.2 12.5 21.2 [MHz]
IL008_2010215073000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 0.5 N 4.5 E

Ion2Png v. 1.3.16

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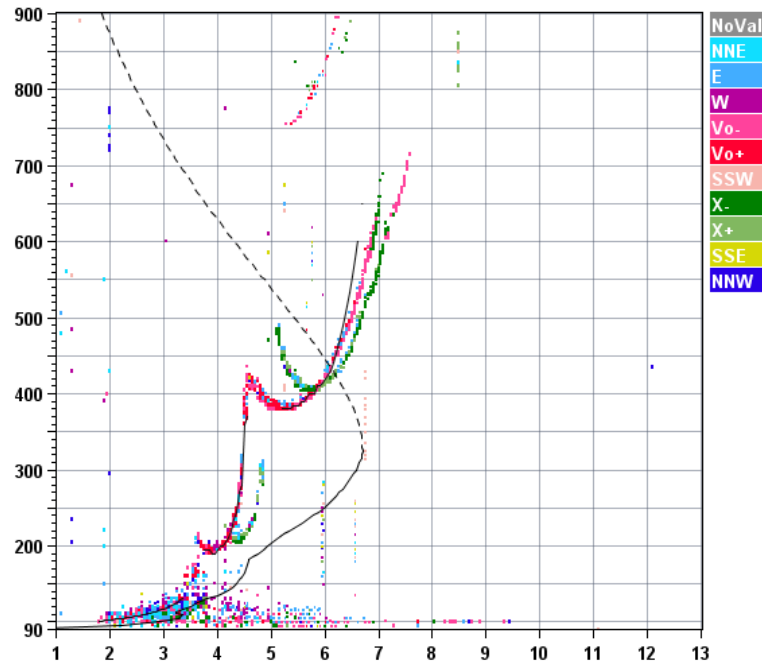


Effect of main phase



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Aug02 214 093000 RSF 1 714 100 10+ A1

foF2	6.700
foF1	4.57
foFlp	4.48
foE	3.36
foEp	3.31
fxI	7.30
foEs	6.25
fmin	1.80
MUF(D)	18.75
M(D)	2.80
D	N/A
h'F	190.0
h'F2	380.0
h'E	100.8
h'Es	102.5
hmF2	324.8
hmF1	181.7
hmE	109.2
yF2	163.0
yF1	96.5
yE	18.7
B0	203.6
B1	1.76
C-level	33



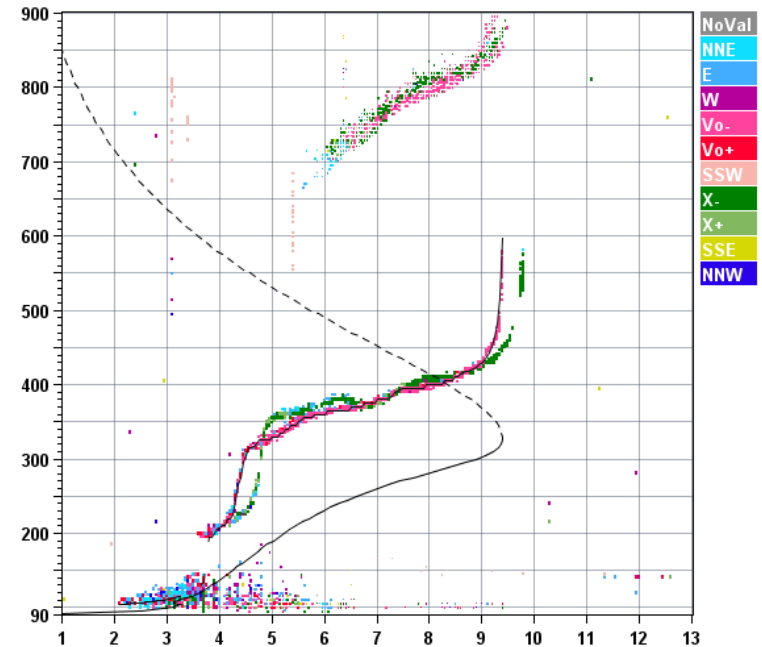
D 100 200 400 600 800 1000 1500 3000 [km]
MUF 7.1 7.2 7.4 7.9 8.5 9.4 12.1 18.8 [MHz]
IL008_2010C14093000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 8.5 N 4.5 E

Ion2Png v. 1.2.16



Statio YYYY DAY DDD HHMMSS P1 FFS S AXN PPS IGA PS
Ilorin 2010 Aug04 216 093000 RSF 1 714 100 10+ A1

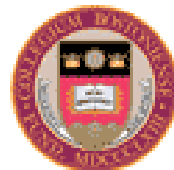
foF2	9.400
foF1	N/A
foFlp	4.48
foE	3.26
foEp	3.31
fxI	9.85
foEs	5.40
fmin	2.10
MUF(D)	26.69
M(D)	2.84
D	N/A
h'F	130.0
h'F2	130.0
h'E	104.2
h'Es	105.0
hmF2	325.5
hmF1	N/A
hmE	103.6
yF2	95.5
yF1	N/A
yE	13.3
B0	151.1
B1	1.00
C-level	11



D 100 200 400 600 800 1000 1500 3000 [km]
MUF 9.8 9.9 10.3 10.9 11.8 13.2 17.0 26.7 [MHz]
IL008_2010C16093000.RSF / 240fx256h 50 kHz 5.0 km / DPS-4 IL008 108 / 8.5 N 4.5 E

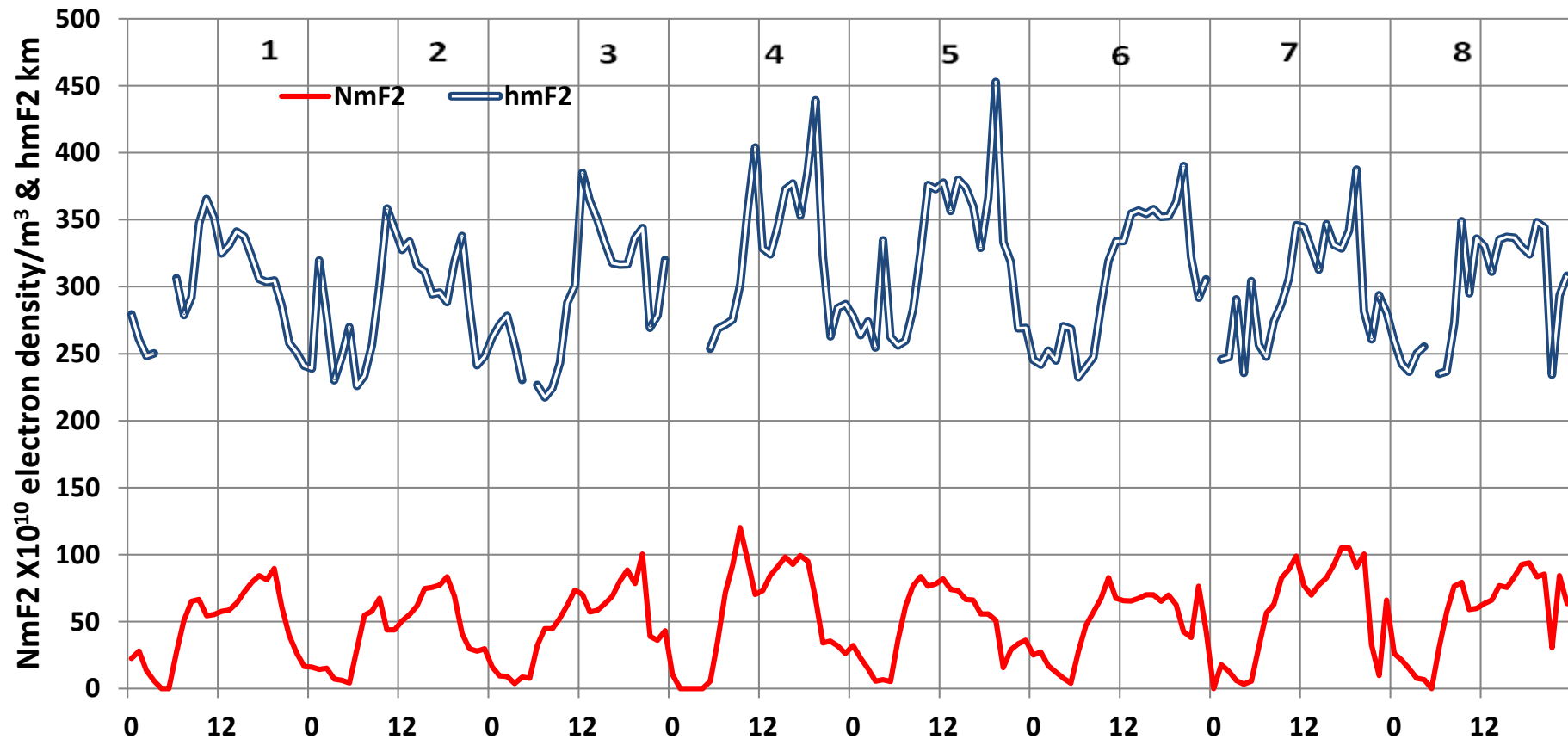
Ion2Png v. 1.2.16

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NmF2 and hmF2

August 1-8 2010 NmF2 & hmF2

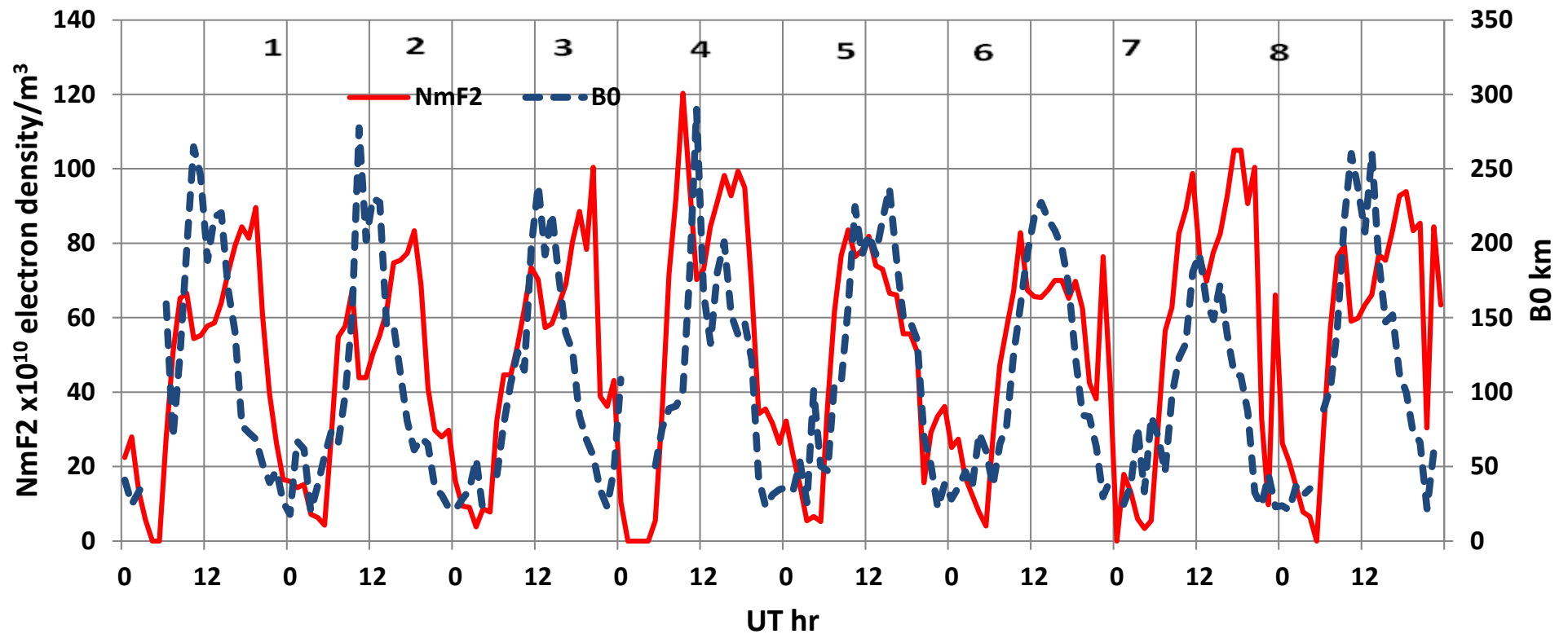


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NmF2 and B0

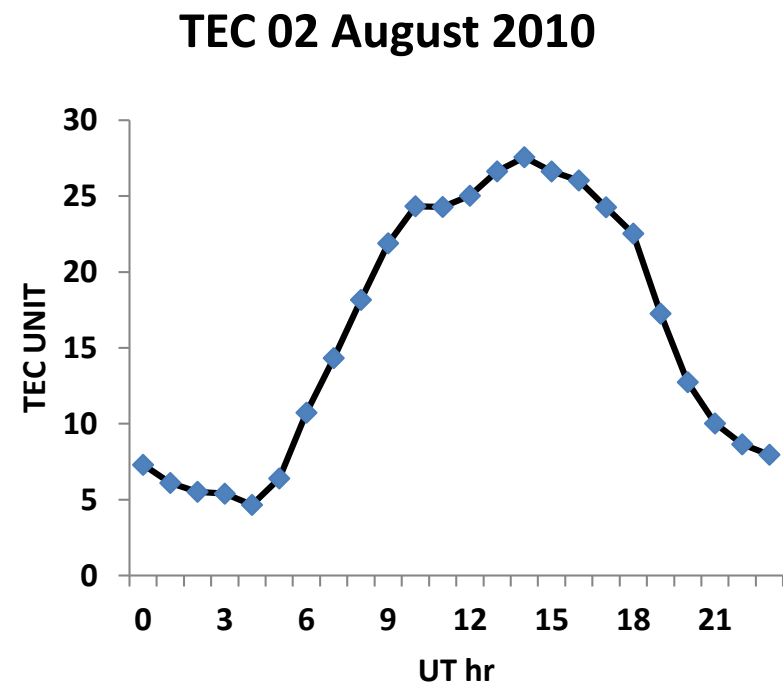
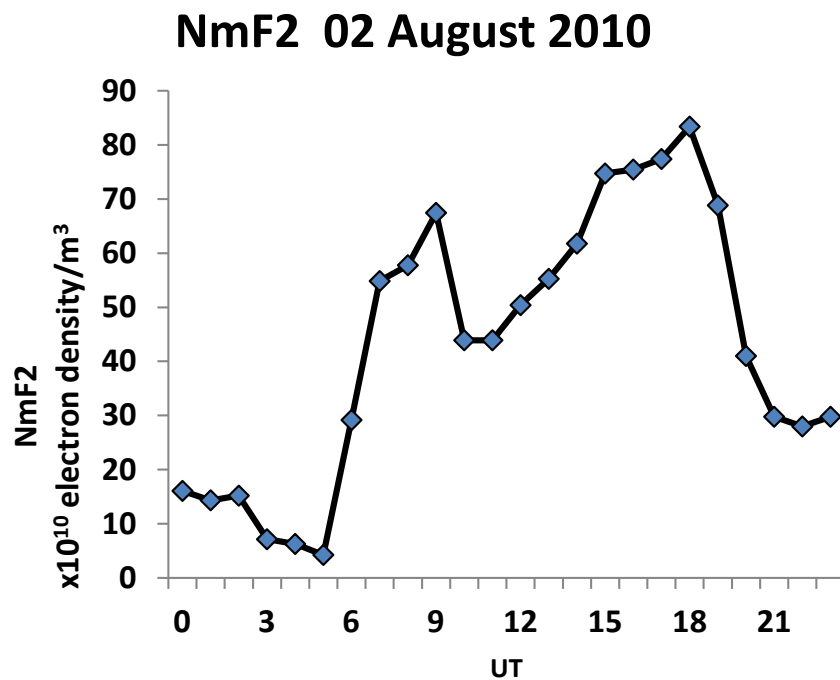
(b) August 1-8 NmF2 & B0



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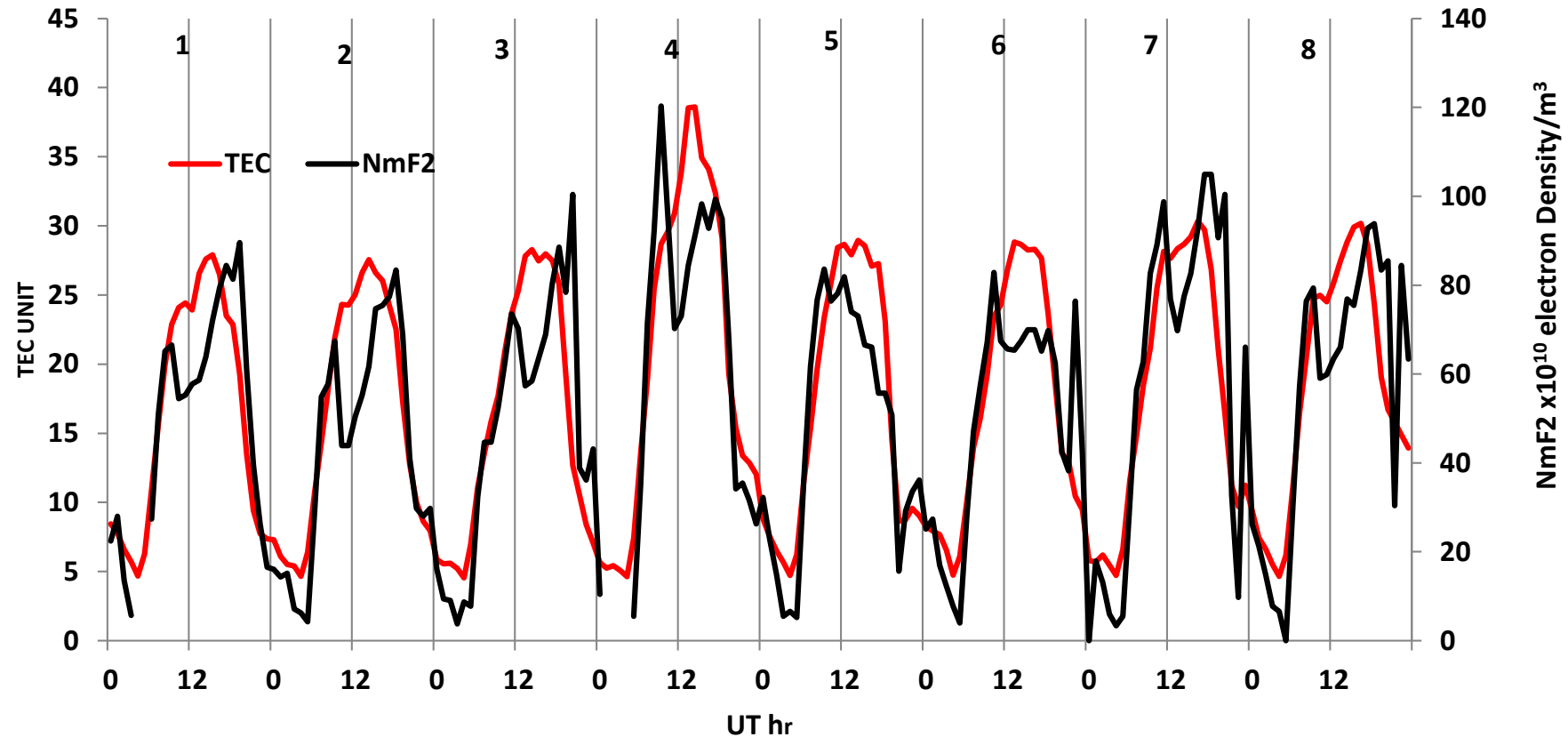
NmF2 & TEC



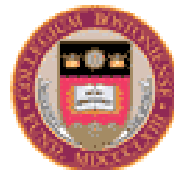
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Simultaneous Effect of Magnetic Storm on TEC and NmF2



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Summary/Conclusions

PARAMETERS USED

1. NmF2: Peak electron density of the F2 layer.
2. hmF2: The height of the peak electron density.
3. B0: The thickness parameter of the layer
4. TEC and
5. Magnetic H component.

MAGNETIC STORM EFFECTS

1. The morphology of NmF2, hmF2, B0 and TEC are altered. Changes are not limited to the peak parameters alone.
2. There is an increase in NmF2 and TEC during the storm's main phase.
3. B0 and NmF2 are negatively correlated on both quiet and disturbed days.
4. A positive correlation exist between B0 and hmf2

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Thank you for your attention

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