RELATIONS BETWEEN THE EQUATORIAL VERTICAL DRIFTS, ELECTROJET, GPS-TEC AND SCINTILLATION DURING THE 2008-09 SOLAR MINIMUM

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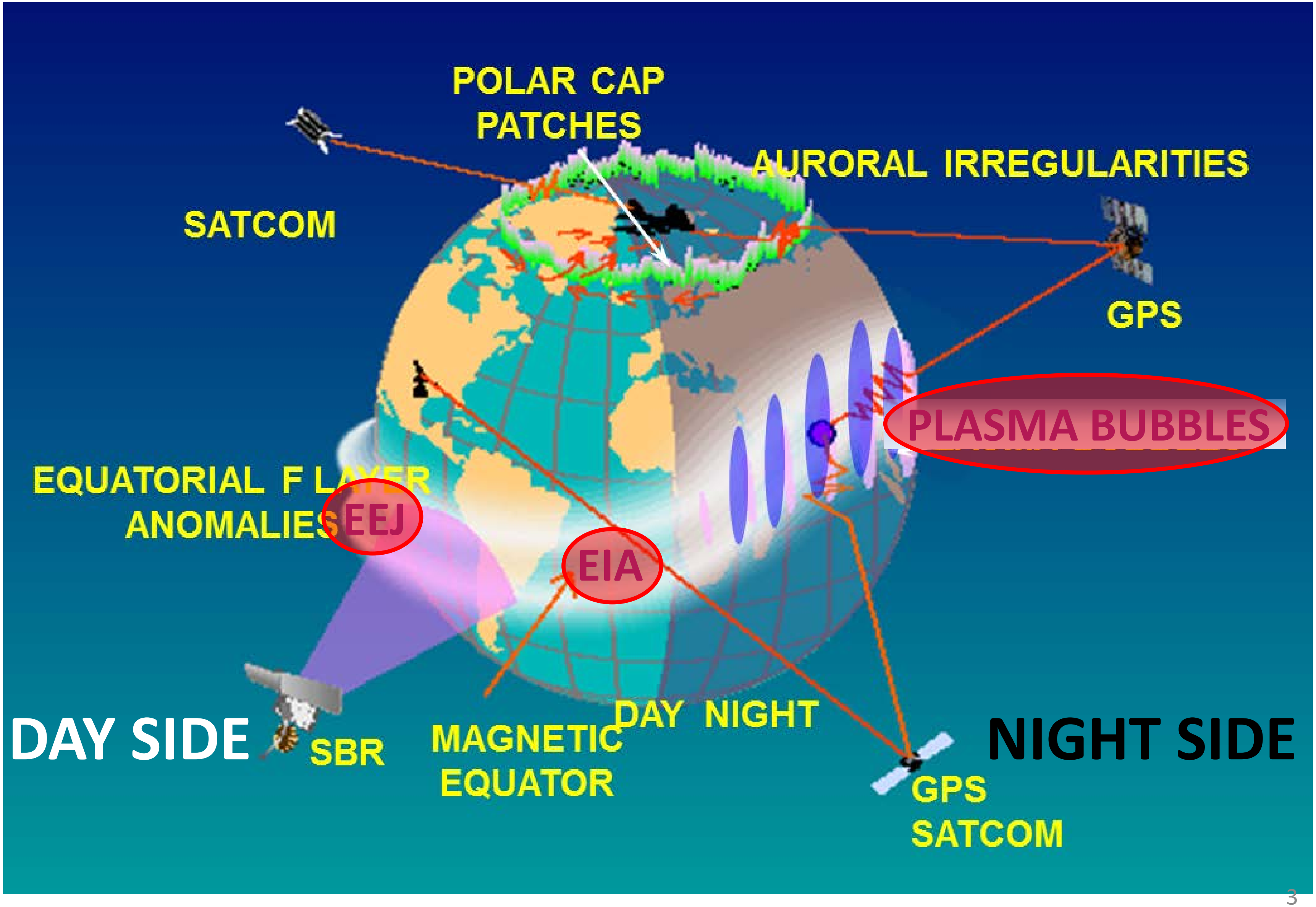
May 14, 2015

Alexandria, VA, USA

Outlines

- **Background**
  - Equatorial Ionosphere: EEJ, EIA & EPB
  - Ionospheric Parameters
- **Methodology**
  - Instruments/ Data Locations
  - Artificial Neural Network
- **Data Analysis**
  - Data Selection
  - Neural Network Inputs
  - Scintillation Threshold
- **Results**
- **Summary**

Background


POLAR CAP
PATCHES
AURORAL IRREGULARITIES
SATCOM
GPS
PLASMA BUBBLES
EQUATORIAL F LAYER
ANOMALIES
EEJ
EIA
DAY NIGHT
DAY SIDE
SBR
MAGNETIC
EQUATOR
NIGHT SIDE
GPS
SATCOM

Ionospheric Parameters: TEC & S_4 Index

Total Electron Content (TEC) Measurement

- Number of free electrons in a rectangular solid with a one-square-meter cross section extending from the receiver to the satellite.

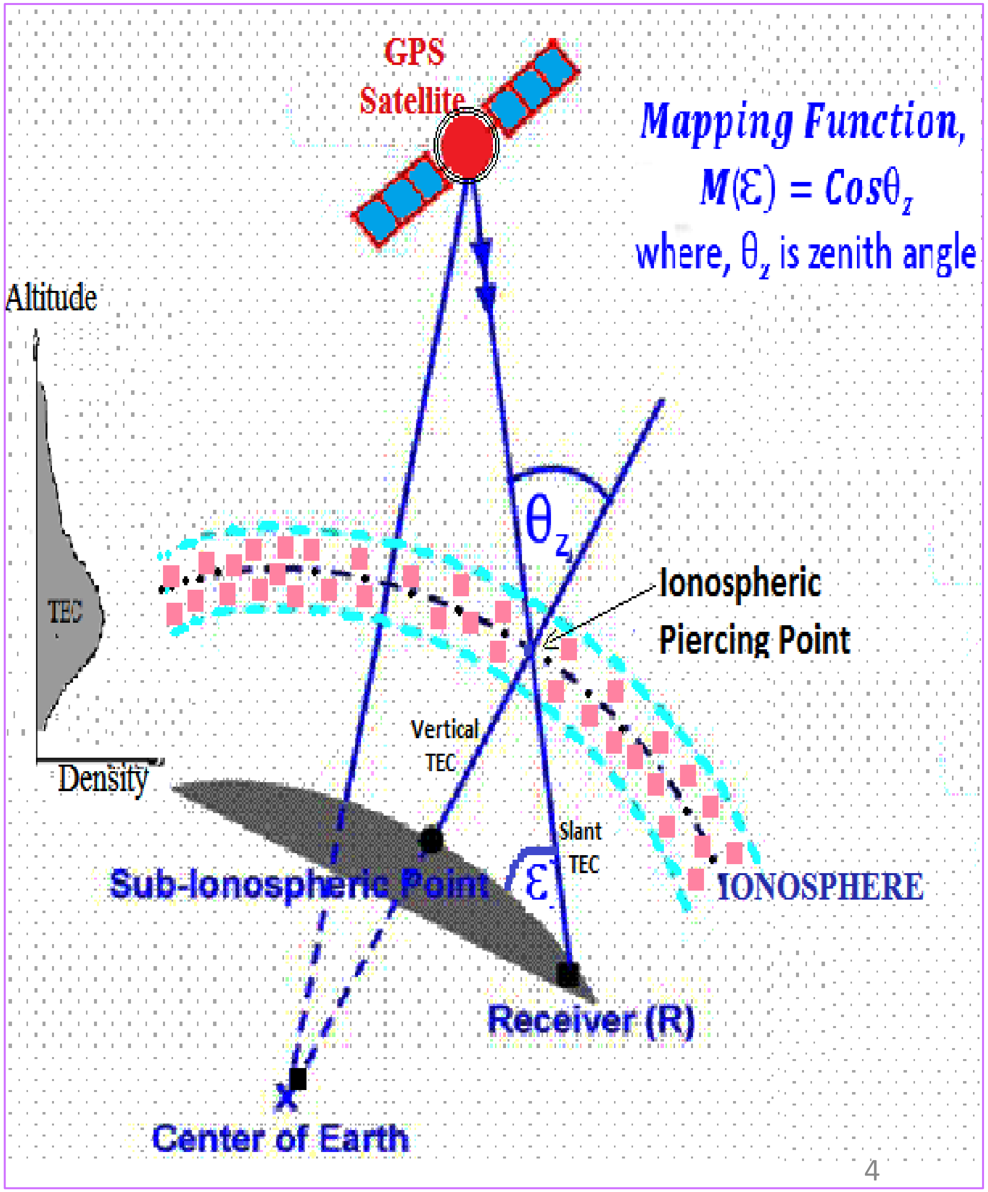
$$TEC = \int_{Receiver}^{Satellite} n(h)dh$$

$1\text{TECU} = 10^{16}$ electrons/m^2

Ionospheric Scintillations Measurement

- Rapid fluctuation of the phase and intensity of signal that passed through ionosphere.
- **S4 index**: Normalized standard deviation of signal intensity,

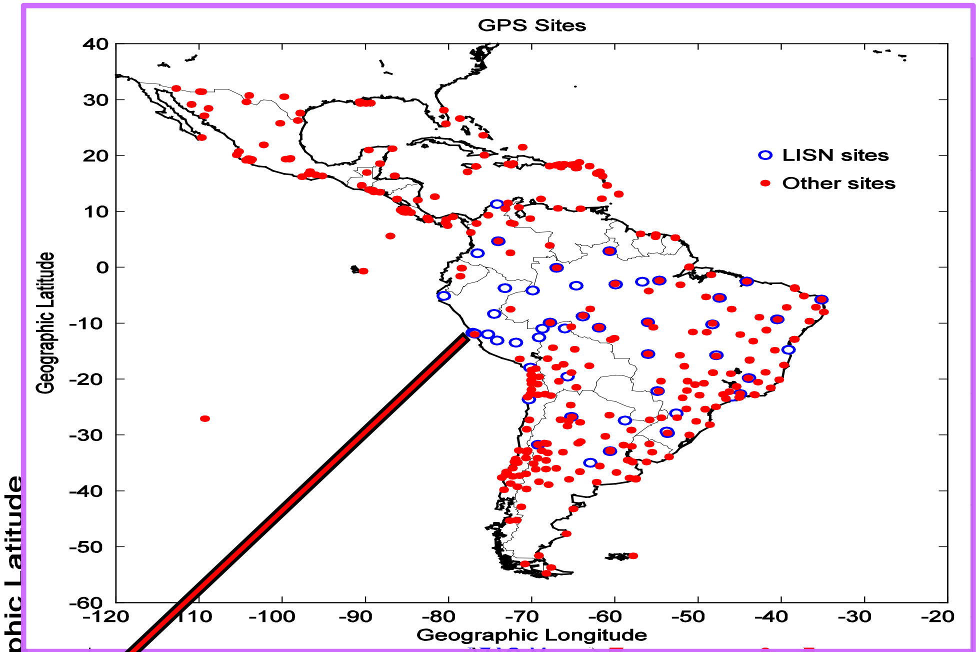
$$S_4 = \frac{\sqrt{(<I^2> - <I>^2)}}{<I>}$$



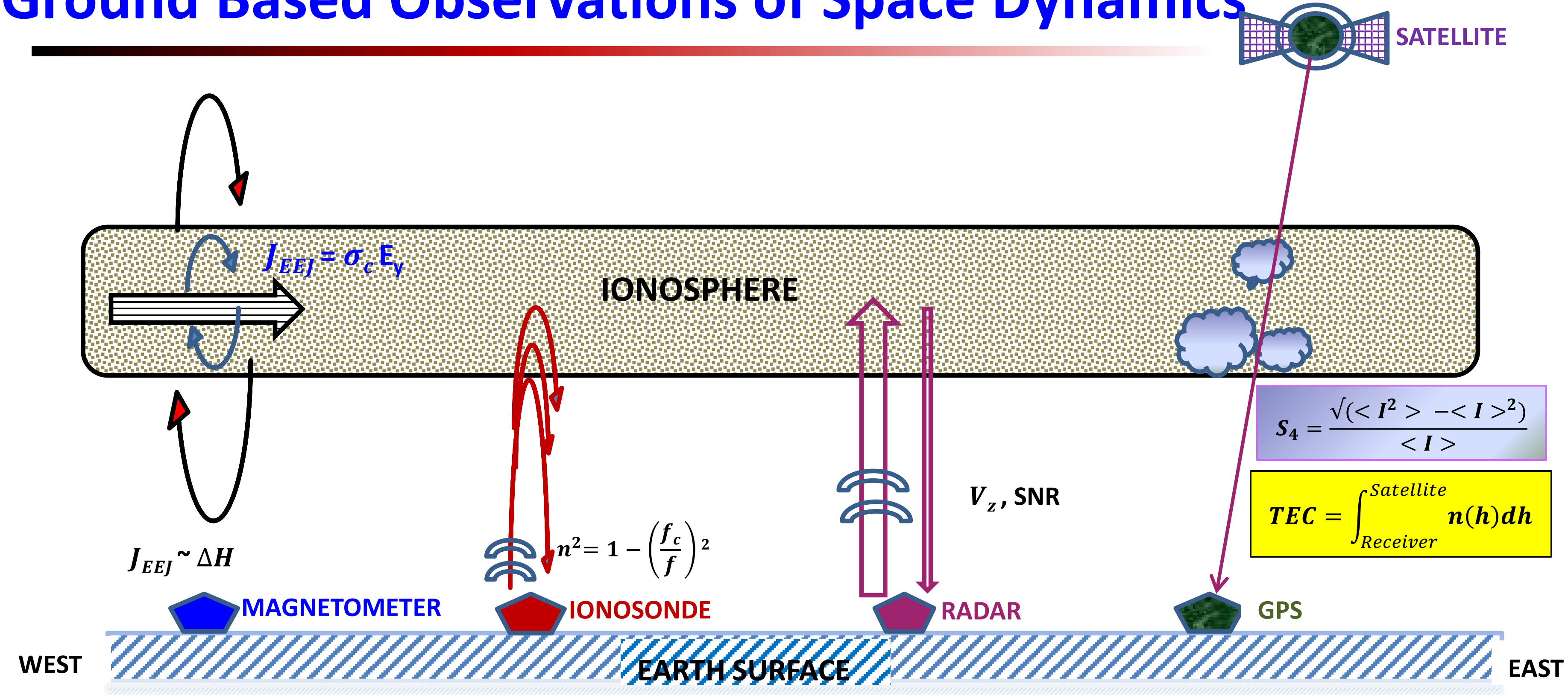
Methodology

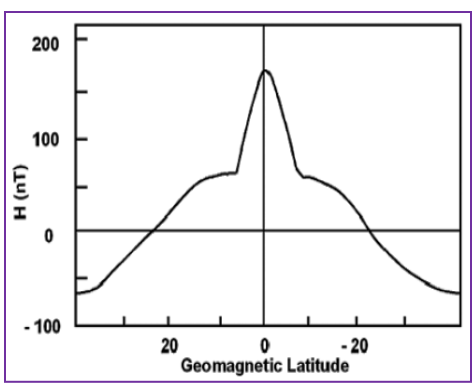
- **Sensor Techniques**
  - -Magnetometer

- **Radio Techniques**
  - -Radars (CS, IS & UHF)
  - -GPS
  - -Ionosondes

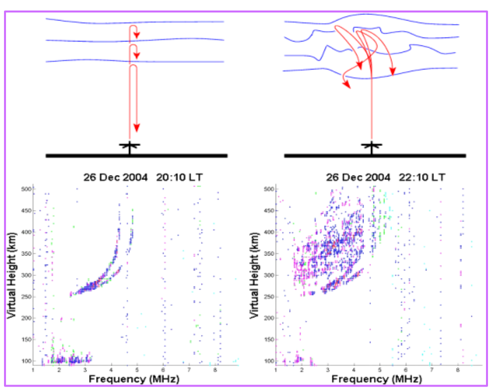


Ground Based Observations of Space Dynamics

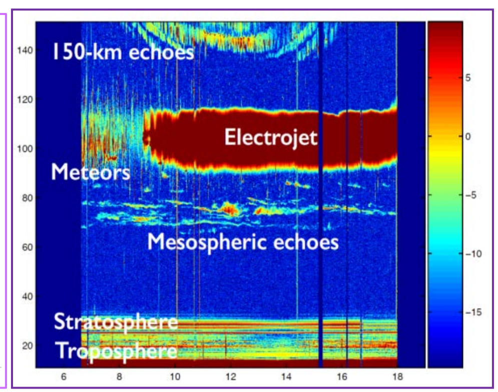




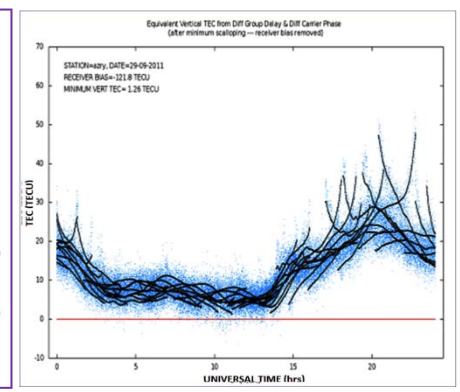
H ENHANCEMENT AT NOON



IONOGRAM



RADAR



TOTAL ELECTRON CONTENT

Artificial Neural Network Approach

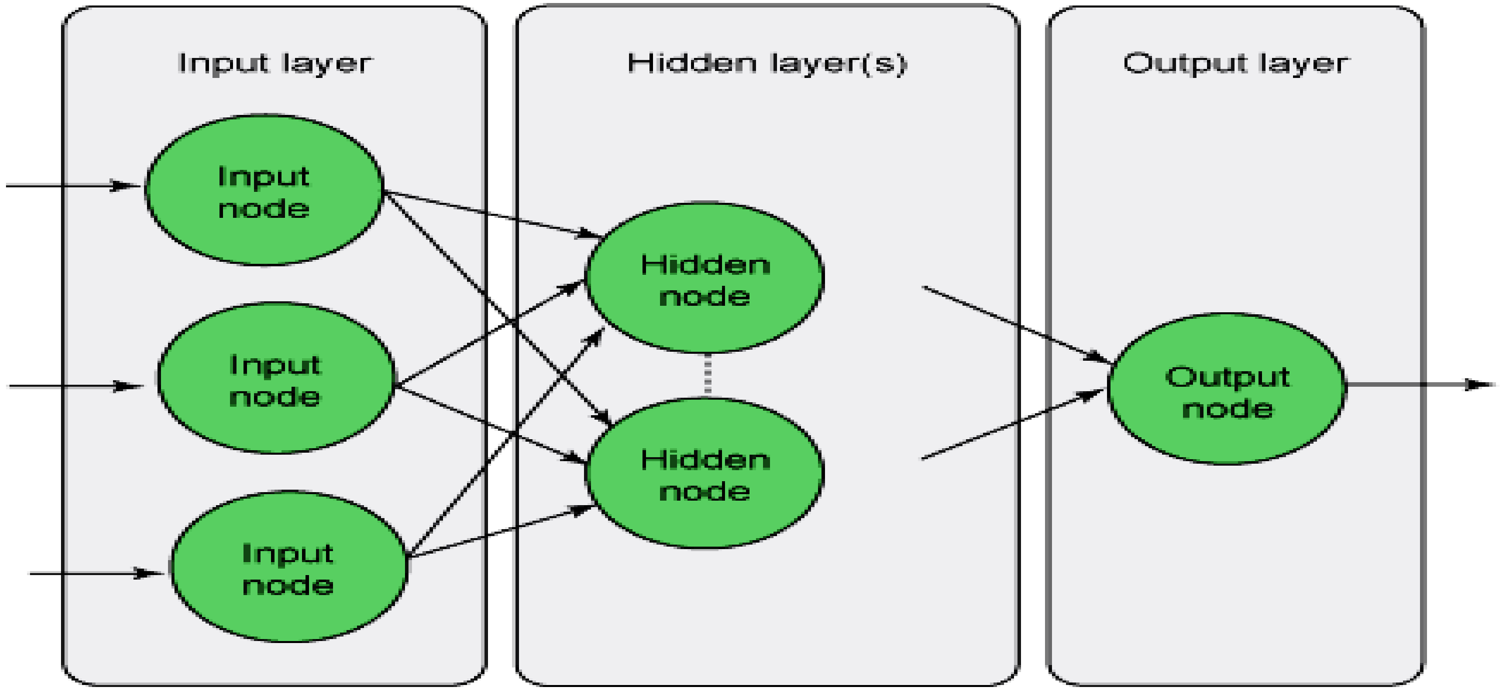
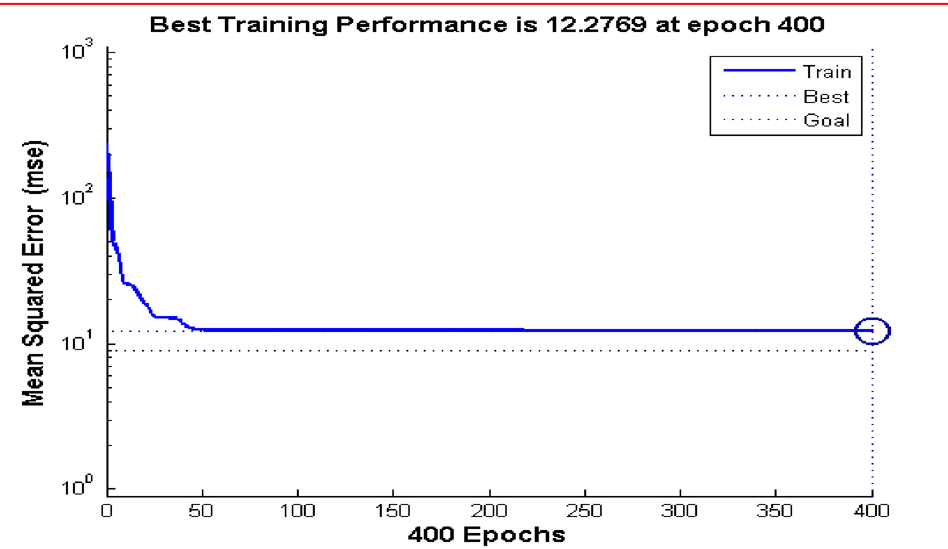


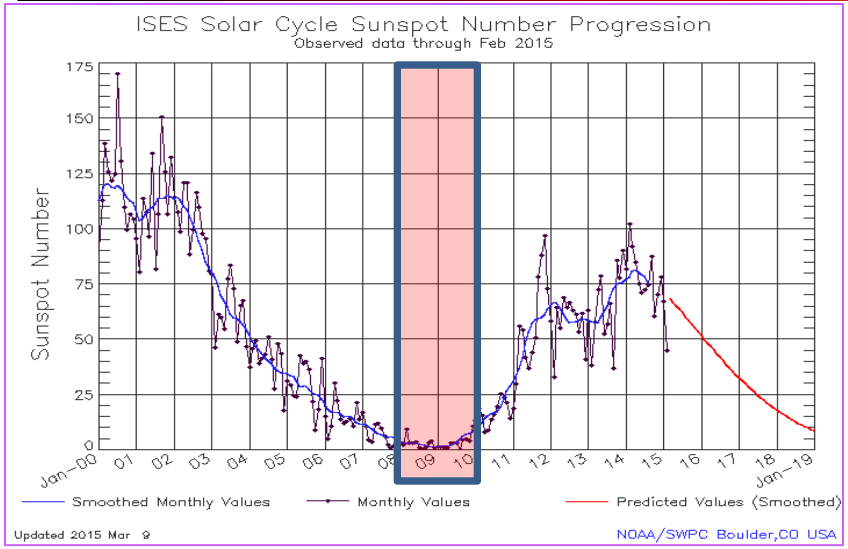
Fig.: Neural network schematic

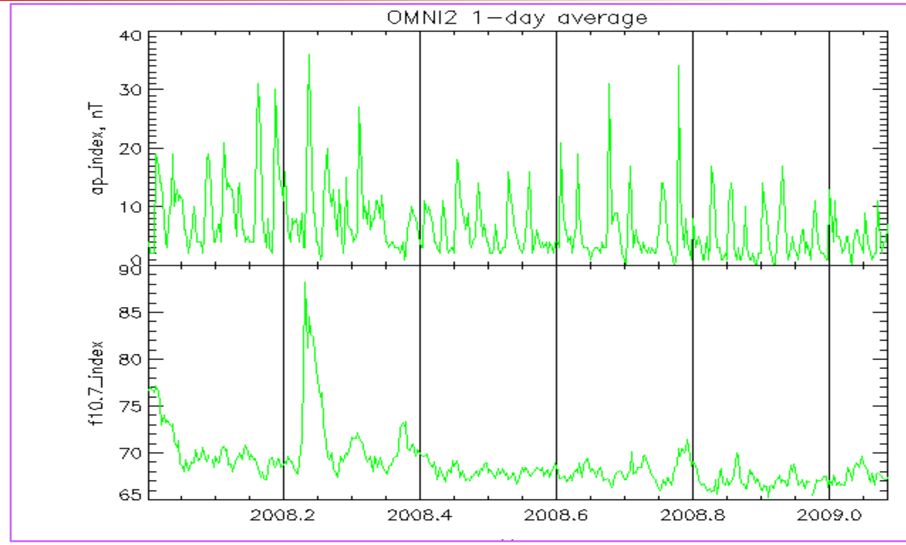
Least Squares Method (LSM) and Neural Network (NN) Approach	RMS Error, m/s
E × B (LSM) = $a_0 + a_1\Delta H$	3.82
E × B (NN) = 1 input (ΔH)	3.76
E × B (LSM) = $a_0 + a_1\Delta H + a_2\Delta H^2 + a_3\Delta H^3$	3.79
E × B (NN) = 1 input (ΔH)	3.76
E × B (LSM) = $a_0 + a_1\Delta H + a_2\Delta H^2 + a_3\Delta H^3 + a_4$LT	3.75
E × B (NN) = 2 inputs (ΔH, LT)	3.75
E × B (LSM) = $a_0 + a_1\Delta H + a_2\Delta H^2 + a_3\Delta H^3 + a_4Kp + a_5Ap + a_6$LT	3.68
E × B (NN) = 4 inputs (ΔH, LT, Ap, Kp)	3.67
E × B (LSM) = $a_0 + a_1\Delta H + a_2\Delta H^2 + a_3\Delta H^3 + a_4$DOY + $a_5$year + a_6LT	3.39
E × B (NN) = 4 inputs (ΔH, LT, year, DOY)	3.24
E × B (LSM) = $a_0 + a_1\Delta H + a_2\Delta H^2 + a_3\Delta H^3 + a_4$F10.7 + a_5F10.7a + a_6LT	3.25
E × B (NN) = 4 inputs (ΔH, LT, F10.7, F10.7A)	3.02

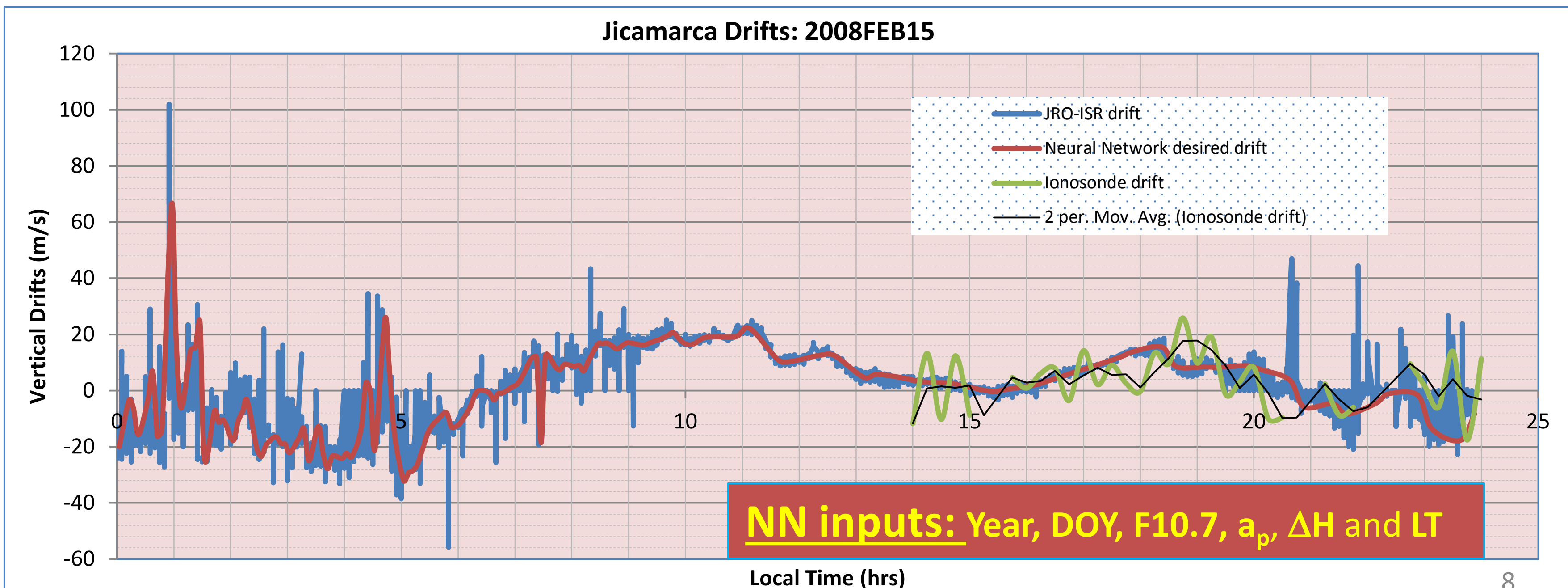
Anderson et al., 2004



Neural Network Inputs







Instruments & Data Locations

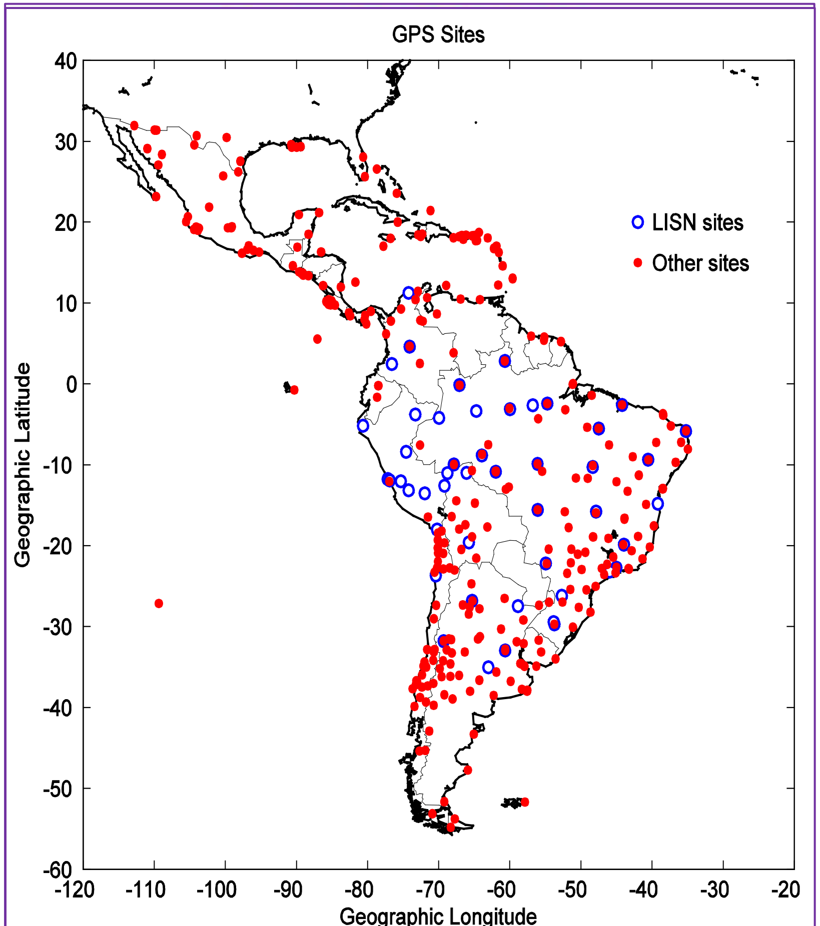
Locations

Jicamarca:- Geographic: 11.92°S; 283.13°E

Geomagnetic: 0.8°N

Piura:- Geographic: 5.18°S; 279.36°E

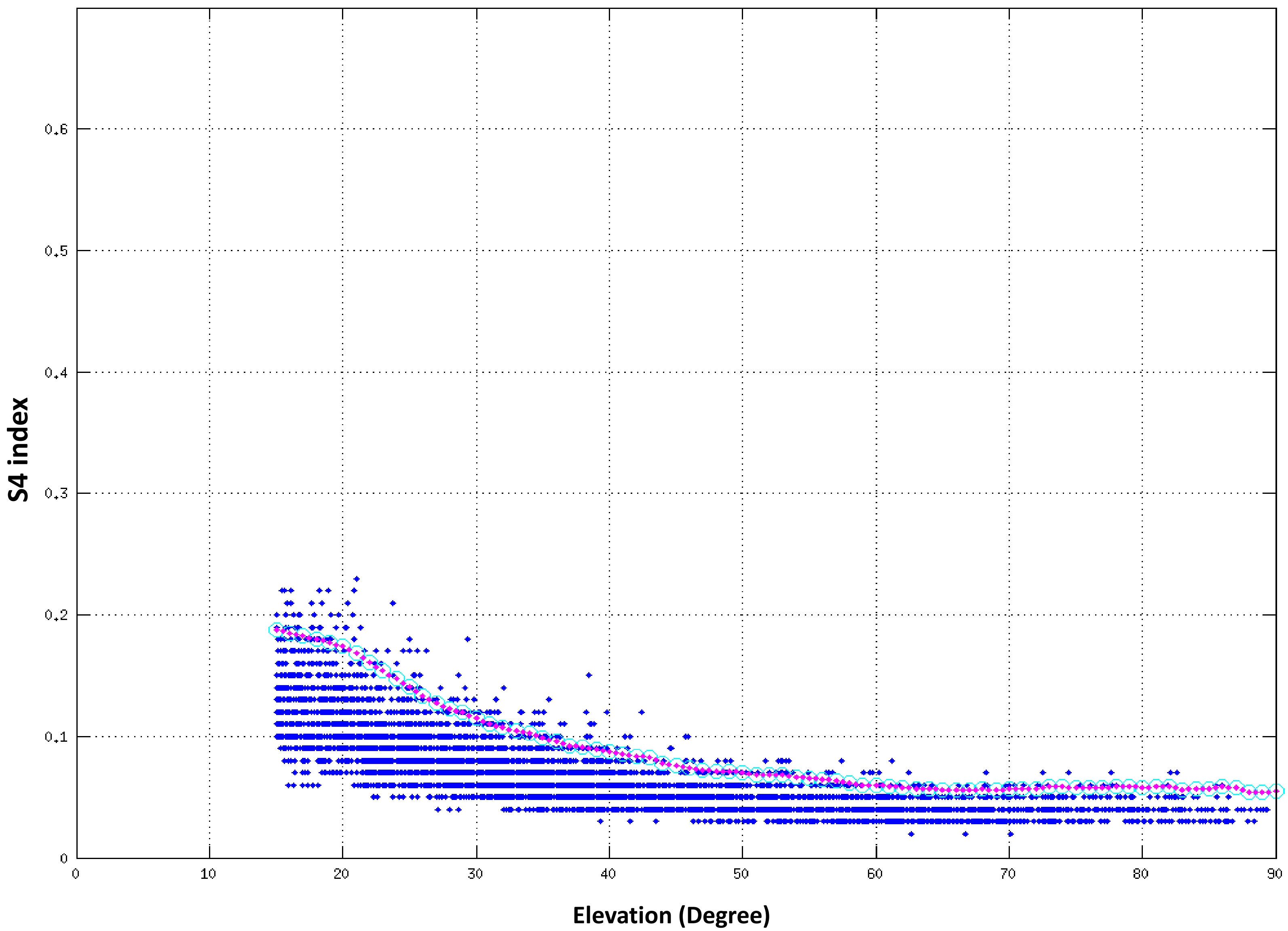
Geomagnetic: 6.8°N



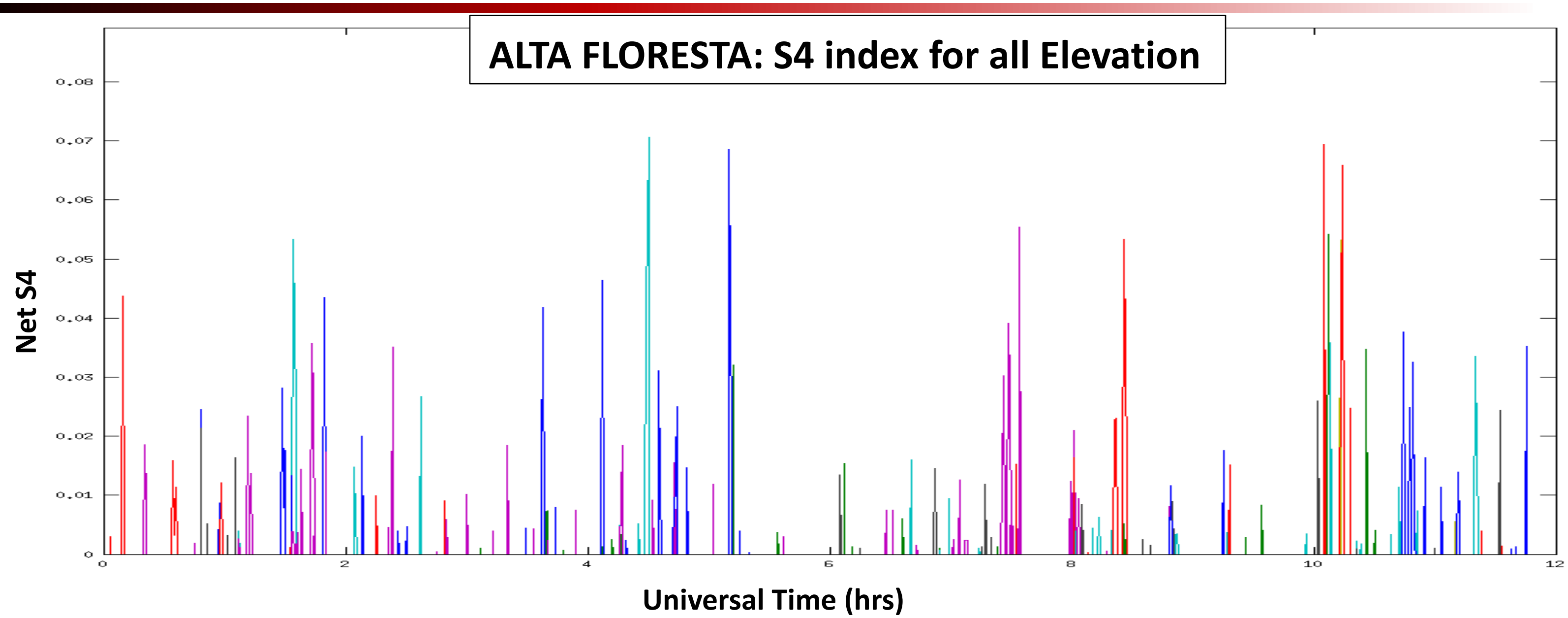
GPS(Global Positioning System) Locations

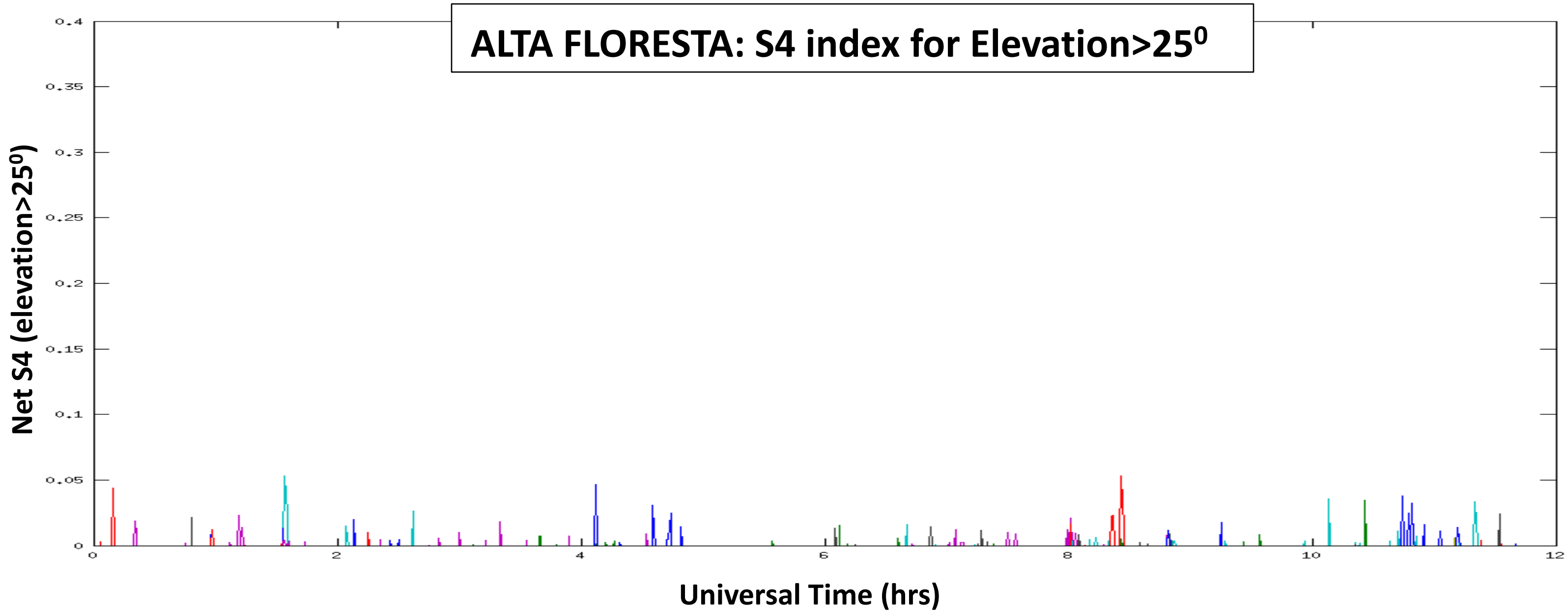
Data Analysis

Scintillation Threshold Model



Net Scintillation

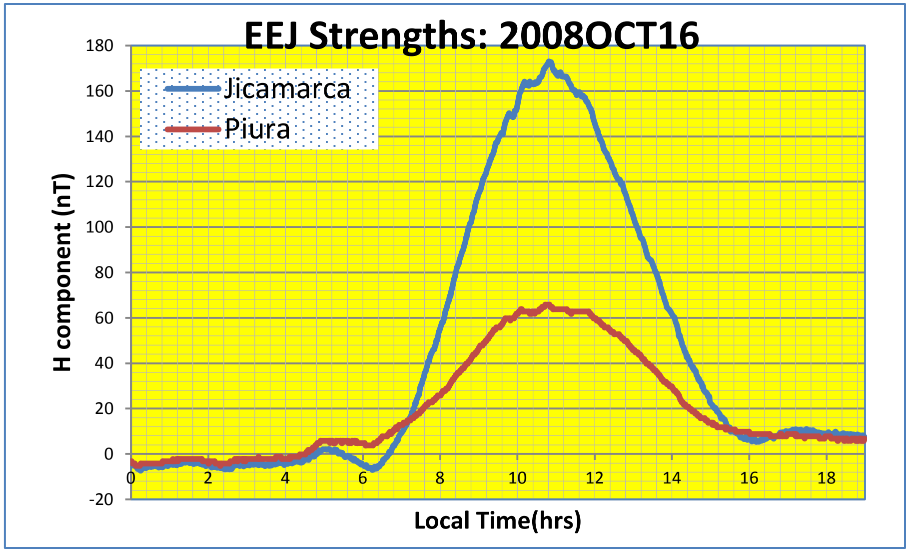


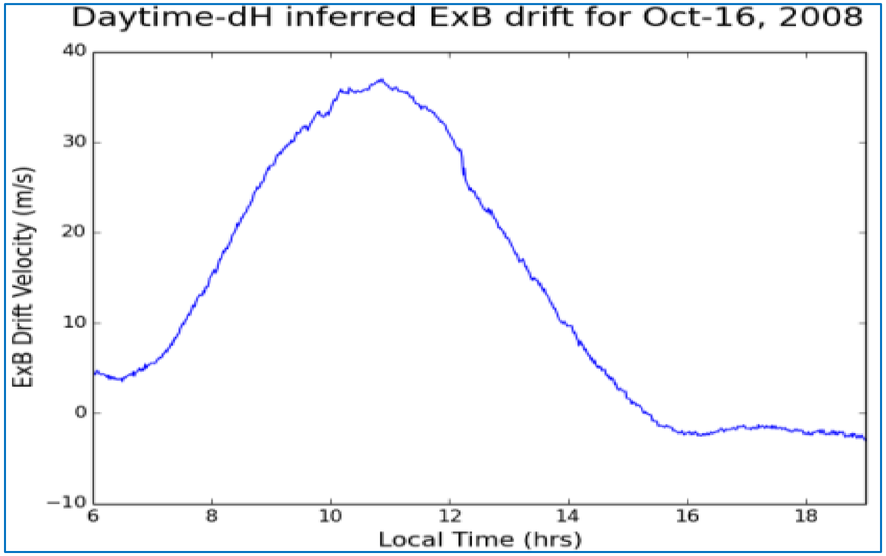


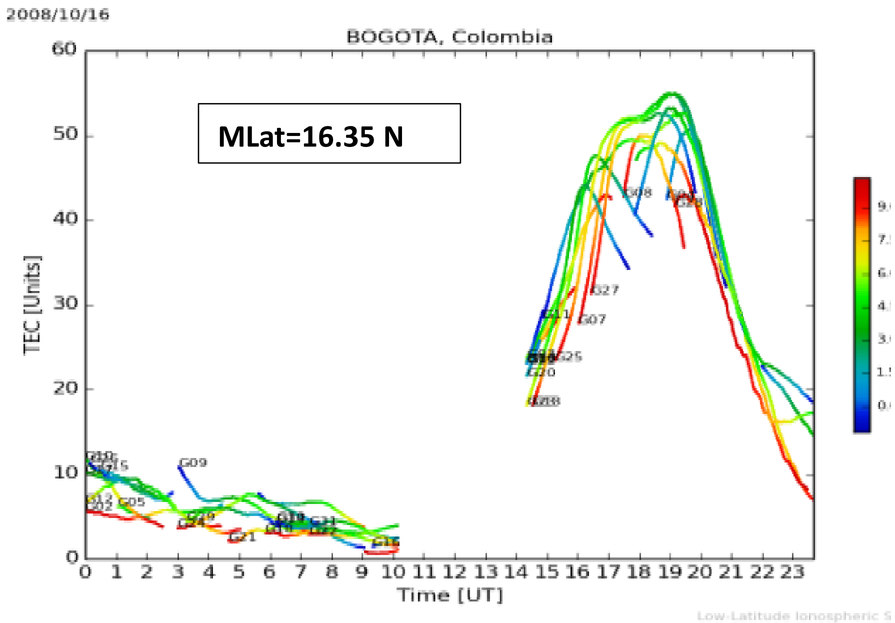
Results

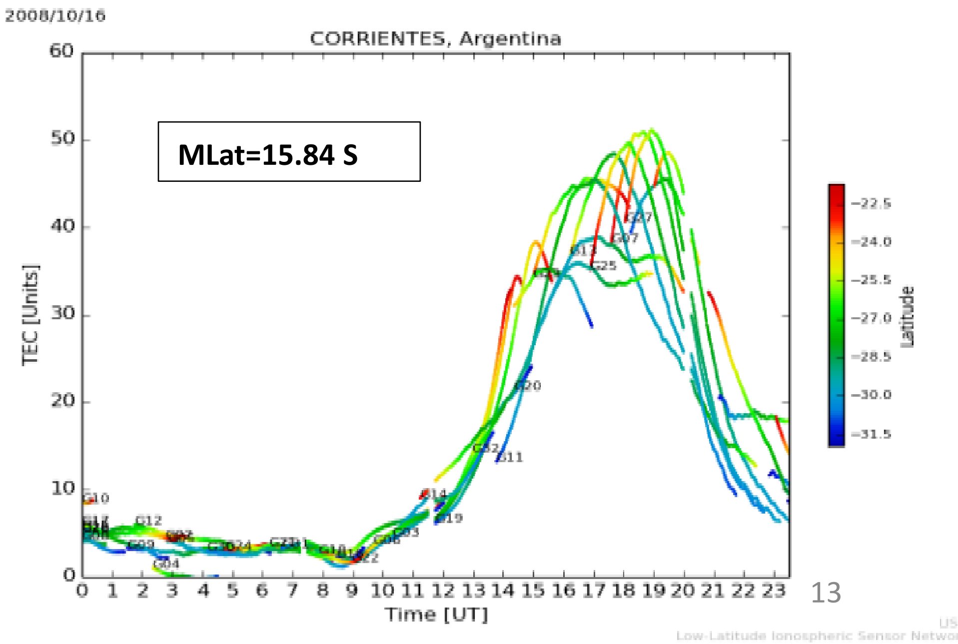
Kp	Date	EEJ Strength (nT) (Jicamarca-Piura)	Vz, m/s	TEC, TECU	GPS S4 index	Ancon UHF, S4	EIA Location: G.Latitude
<3	OCT16'08	@10.81LT 173.02-65.79=**107.23**	~37	BOGT~ 55 CORR~ 51	CUZC: **0.13**; HUAN: **0.03** JICA: **0.10**; PIUR: **0.11** PUER: **0.16**; TACN: **0.13**	0.2	34
<3	SEP29'08	@11.15LT 138.2-43.47= **94.73**	~34	BOGT~ 34 CORR~ 25	CUZC: ; HUAN: **0.07** JICA: ; PIUR: **0.14** PUER: **0.09**; TACN: **0.09**	1	28
<3	NOV07'09	@11.76LT 89-59.92= **29.08**	~17	BOGT~ 35 CORR~ 33	CUZC: ; HUAN: JICA: ; PIUR: PUER: ; TACN:		24
=4	NOV08'08	@9.53LT 57.92-49.17= **8.75**	~5	ANTF~ 28 CORR~ 25	CUZC: **0.12**; HUAN: **0.4** JICA: **0.2**; PIUR: **0.4** PUER: **0.19**; TACN:	0.88	10
=4	JUL23'08	@11.61LT 85.74-33.73= **52.01**	~18	BOGT~ 23 CORR~ 14	CUZC: **0.08**; HUAN: **0.07** JICA: PIUR: PUER: **0.08**; TACN: **0.05**	0.03	15
=4	JAN03'09	@11.6LT 164.23-61.62= **102.61**	~34	BOGT~ 32 CORR~ 31	CUZC: **0.16** ; HUAN: JICA: **0.07** ; PIUR: PUER: ; TACN:		28
>5	MAR01'08	@10.21LT 99.07-44.59= **54.48**	~24	BOGT~ 44 CORR~ 35	CUZC: ; HUAN: **0.14** JICA: ; PIUR: **0.4** PUER: **0.12**; PUCA: **0.07**	1.1	29
>5	APR06'08	@11.21LT 159.32-43.66=**115.66**	~39	IQTS~ 40 CORR~52	CUZC: **0.1**; ANCN: **0.37** JICA: **0.1**; PIUR: **0.39** PUER: **0.07**; TACN: **0.03**	0.79	30
>5	AUG18'08	@12.6LT 138.7-58.556= **80.14**	~31	BOGT~ 37 CORR~ 22	CUZC: **0.14** ; HUAN: **0.06** JICA: ; PIUR: **0.07** PUER: **0.07** ; TACN:		27

Strong EEJ & Vertical ExB Drift: Quiet Day (Oct-16, 2008) Kp<3



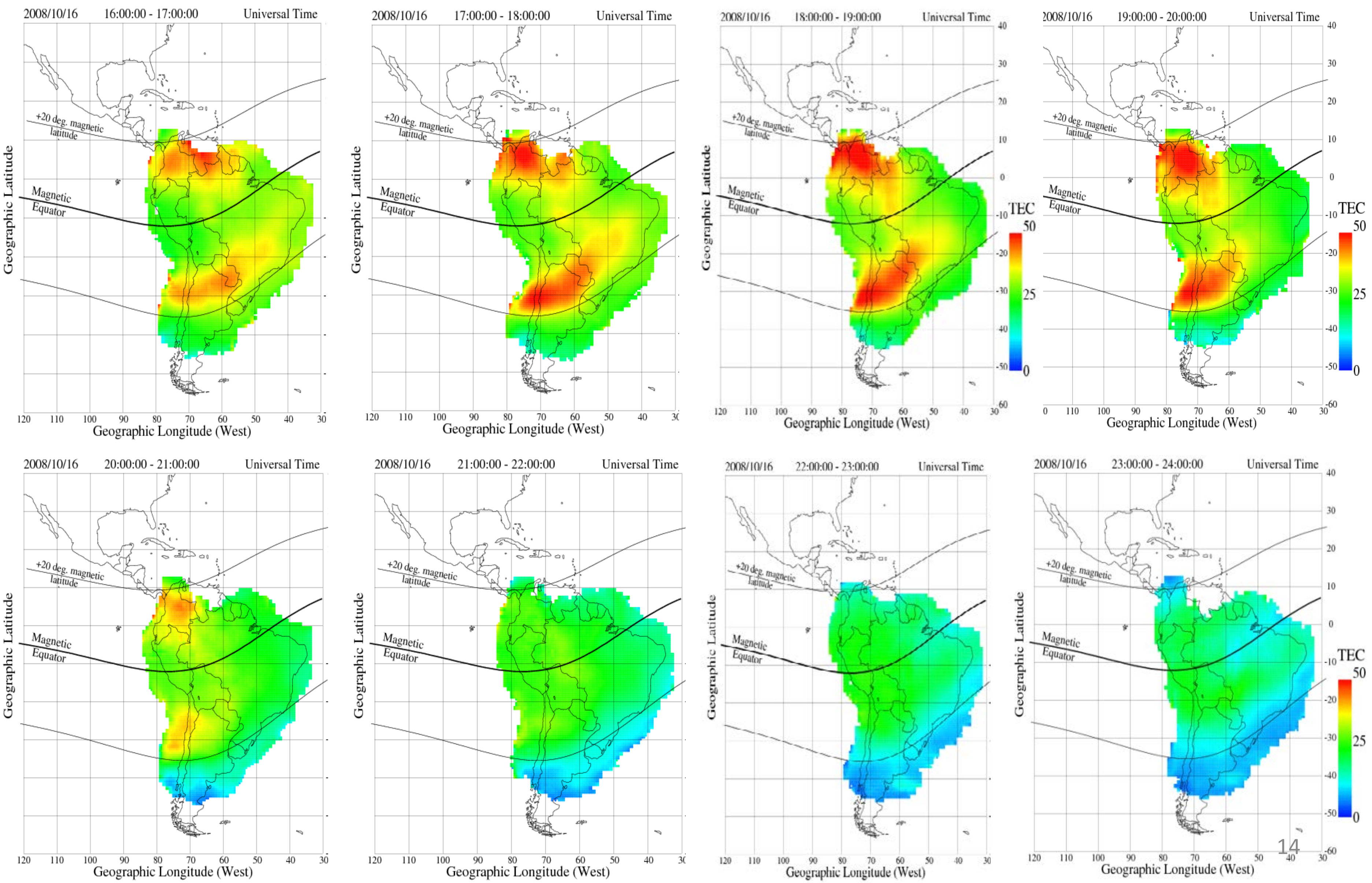






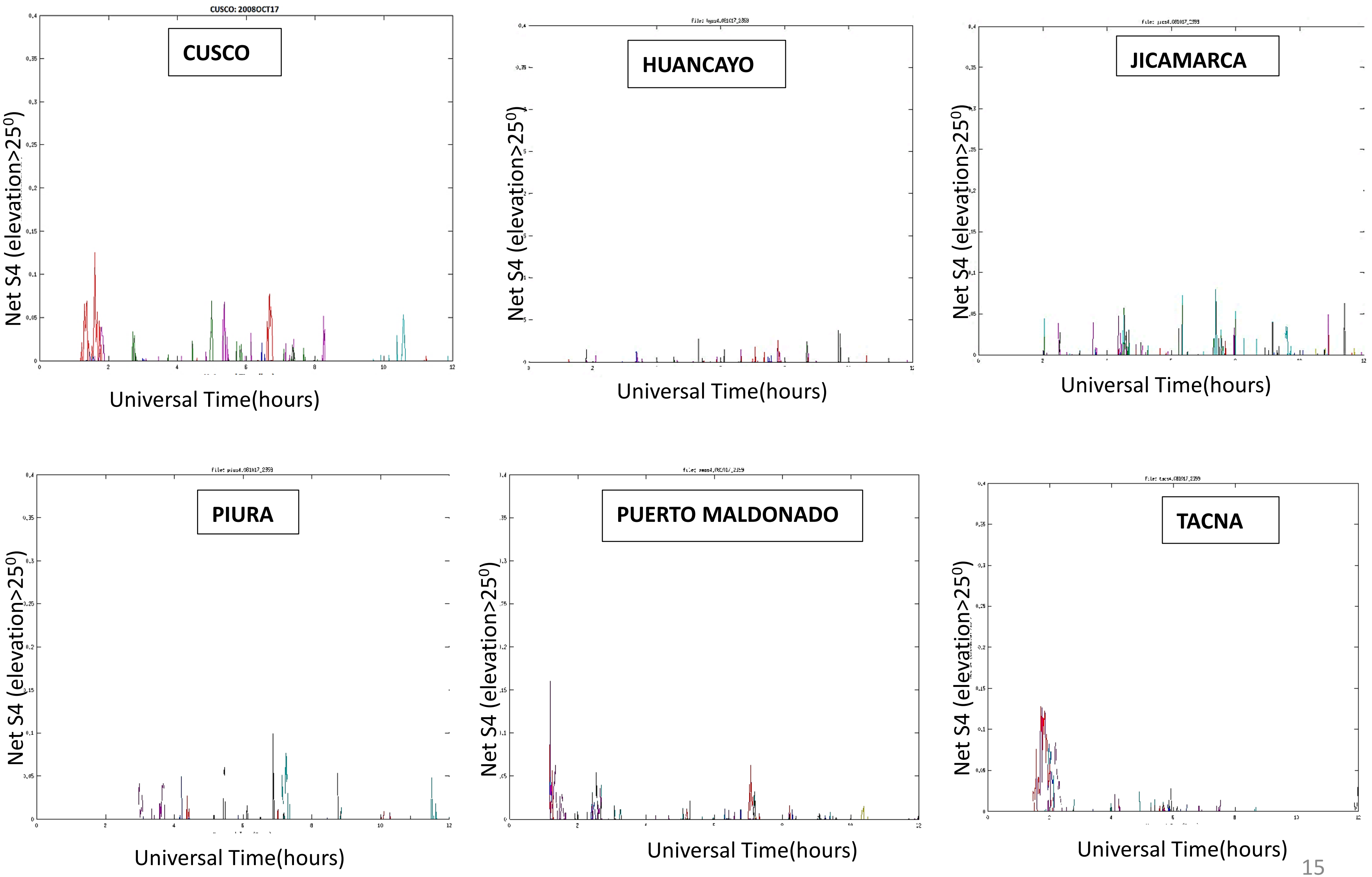
TEC Fitted Map: Oct-16, 2008

(Strong EEJ & Vertical ExB Drift/ Quiet Day: Kp<3)

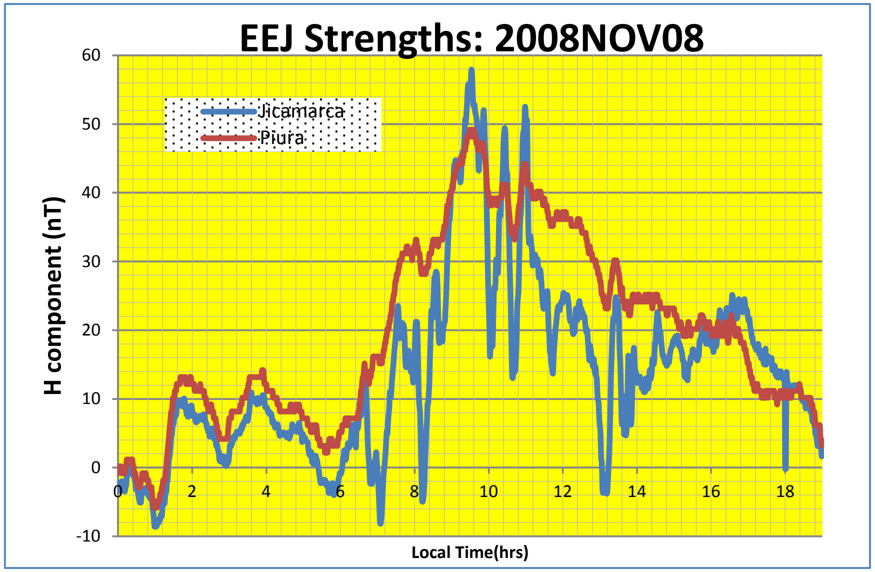


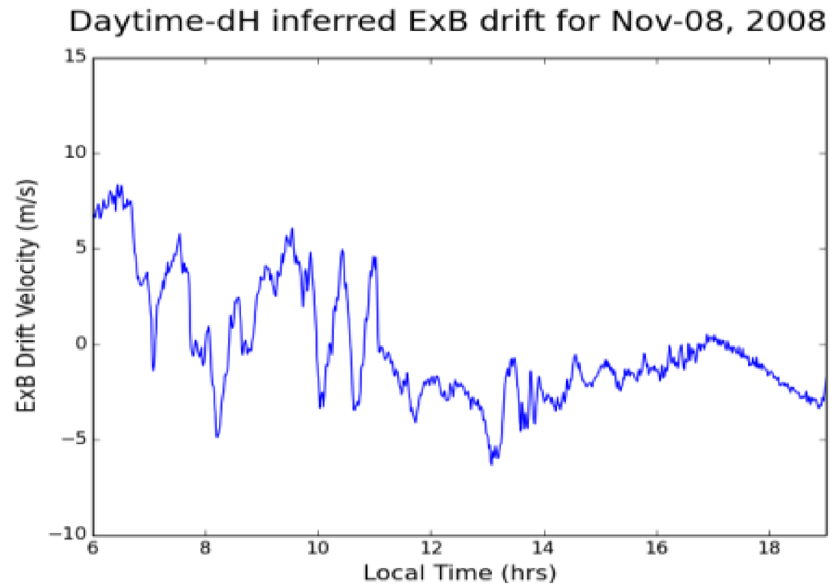
Net Scintillation(Elevation>25^0): Oct-17, 2008

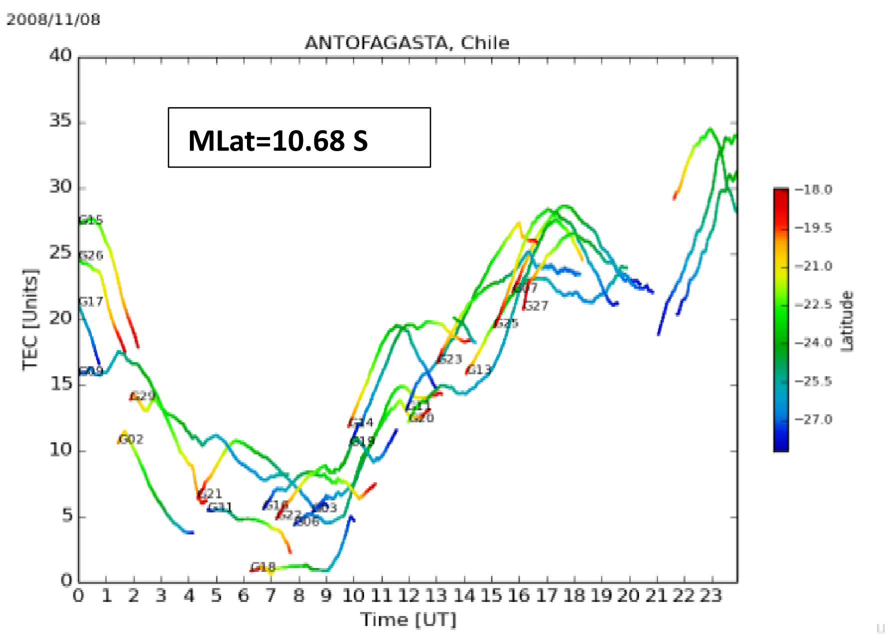
(Strong EEJ & Vertical ExB Drift/ Quiet Day: Kp<3)

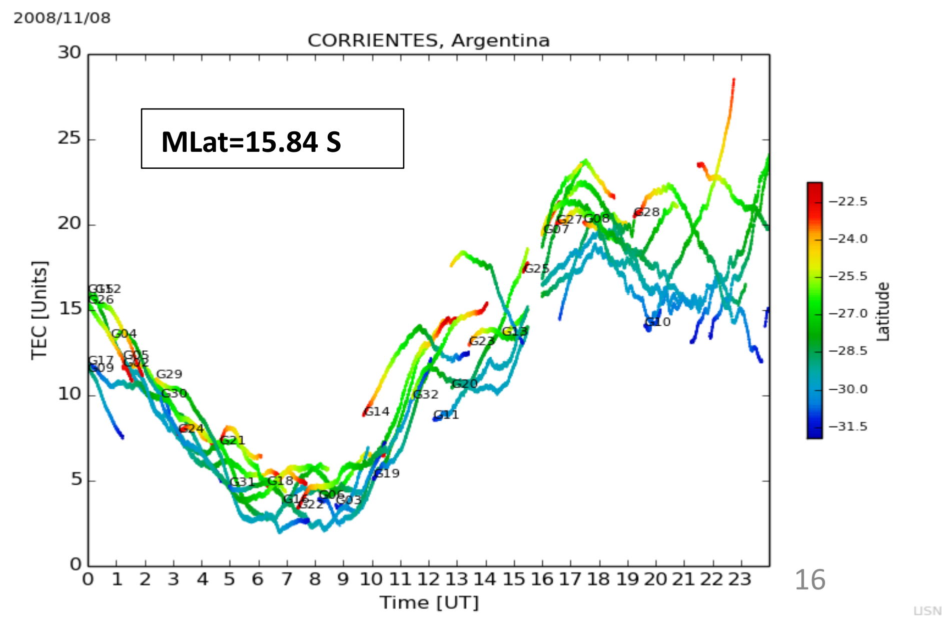


Weak EEJ & Vertical ExB Drift: Non-Quiet Day (Nov-08, 2008) Kp=4



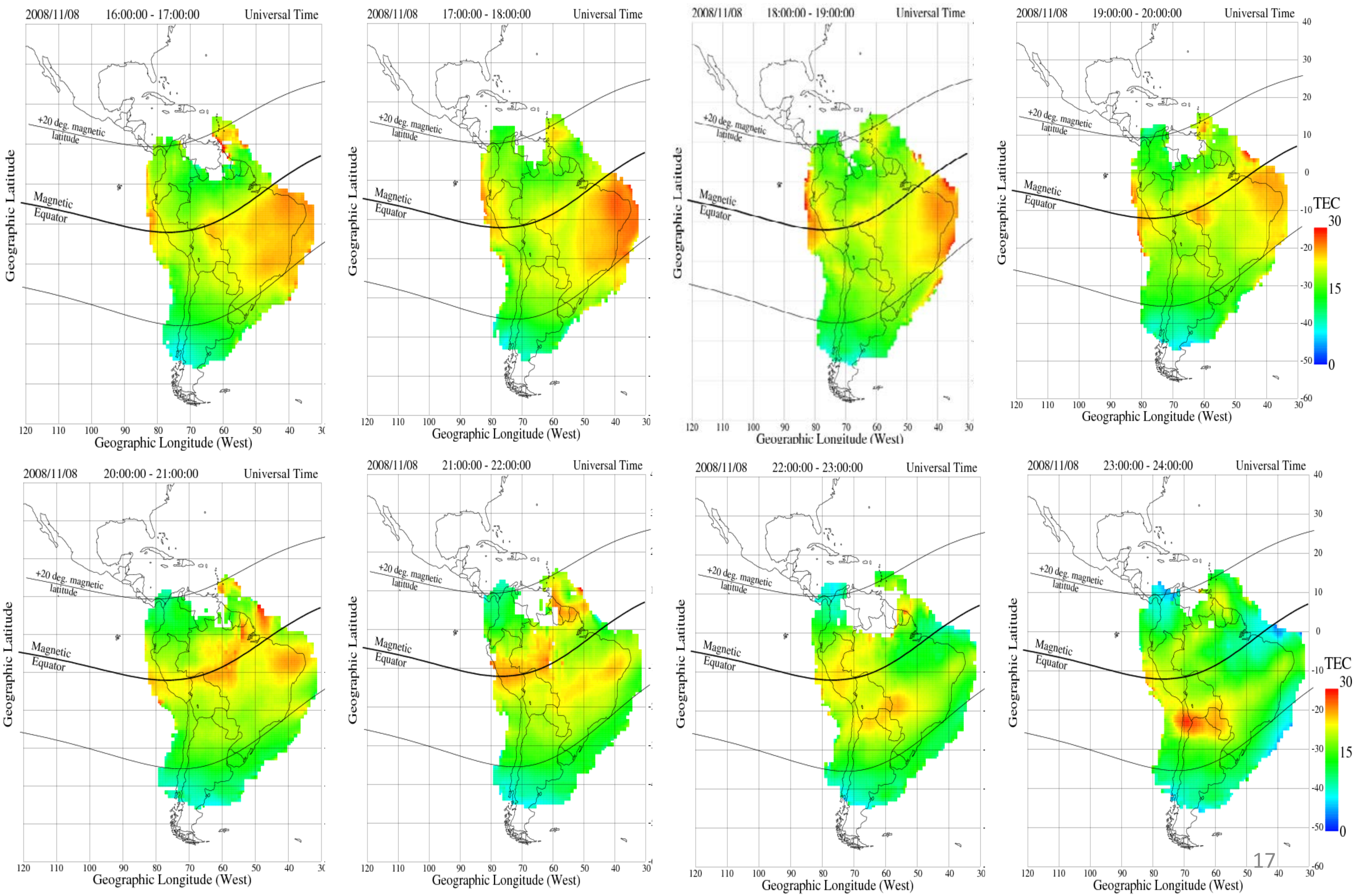






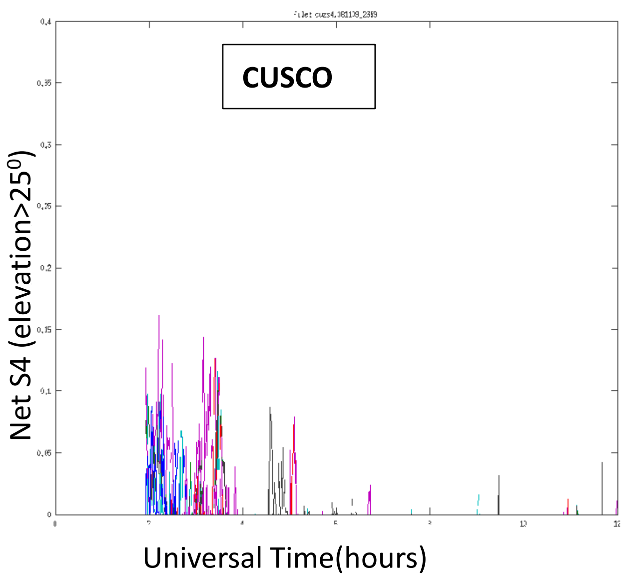
TEC Fitted Map: Nov-08, 2008

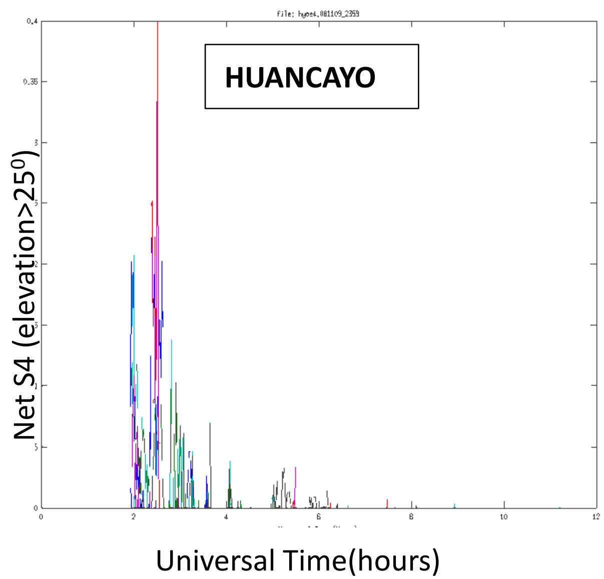
(Weak EEJ & Vertical ExB Drift/ Non-Quiet Day: Kp=4)

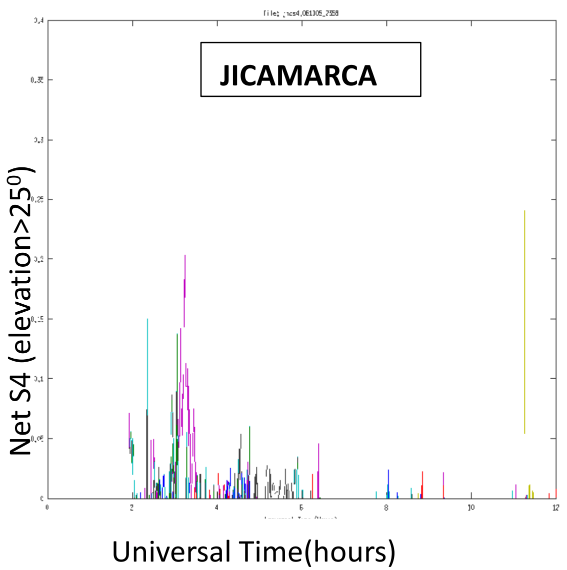


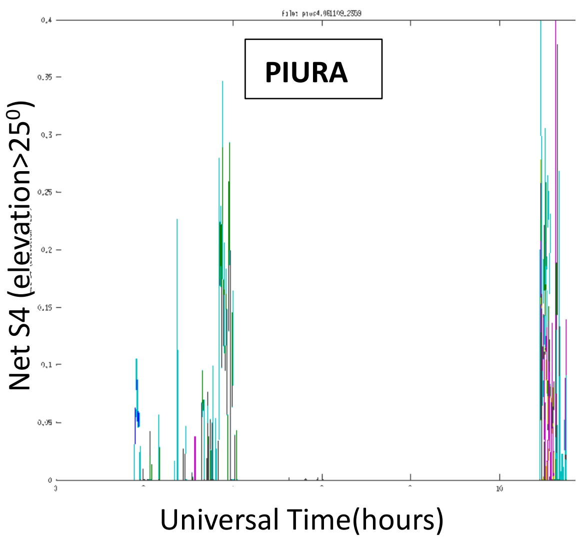
Net Scintillation(Elevation>25^0): Nov-09, 2008

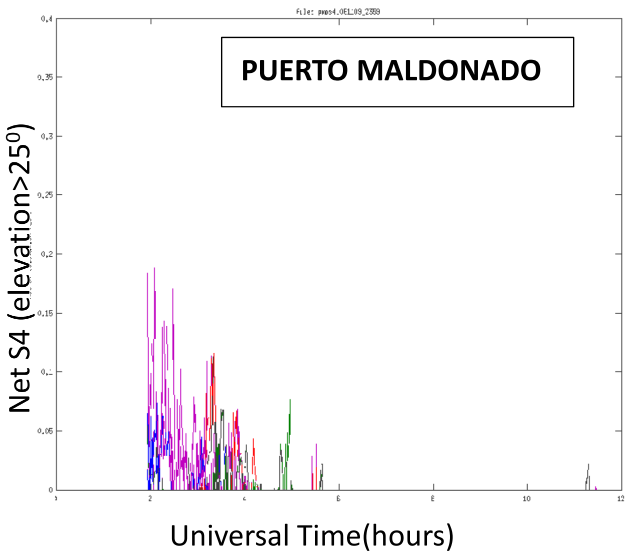
(Weak EEJ & Vertical ExB Drift/ Non-Quiet Day: Kp=4)

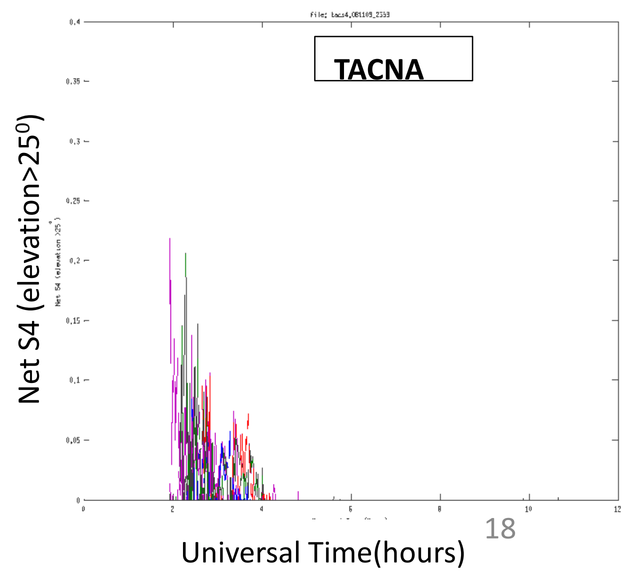




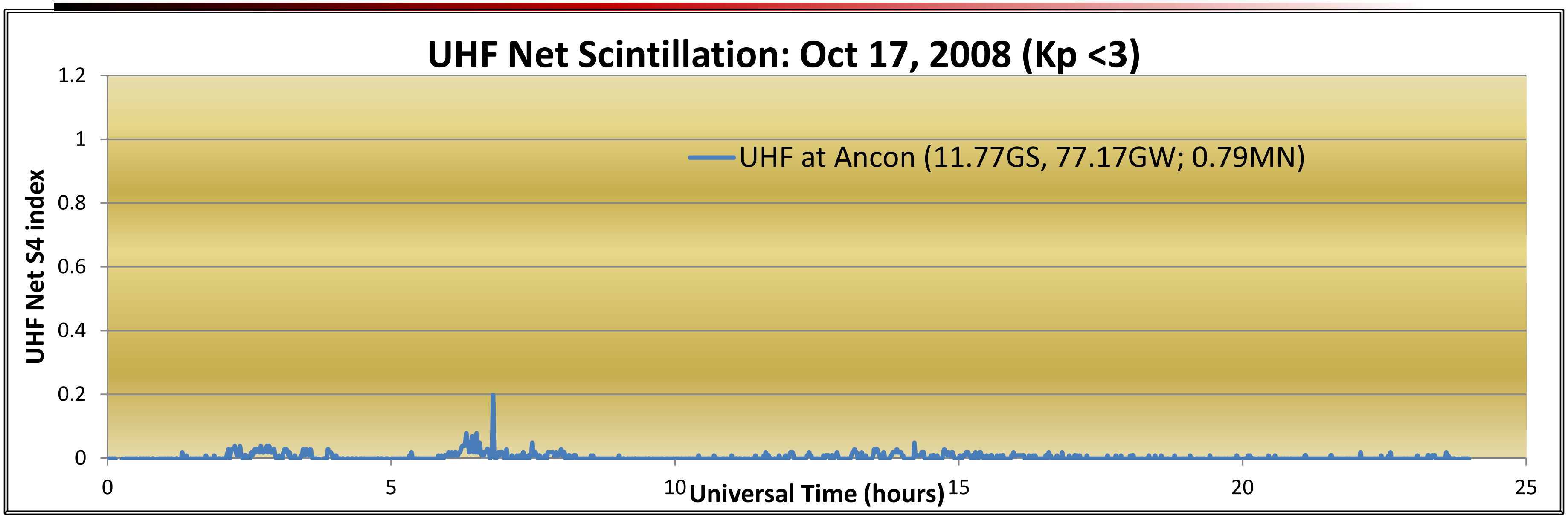


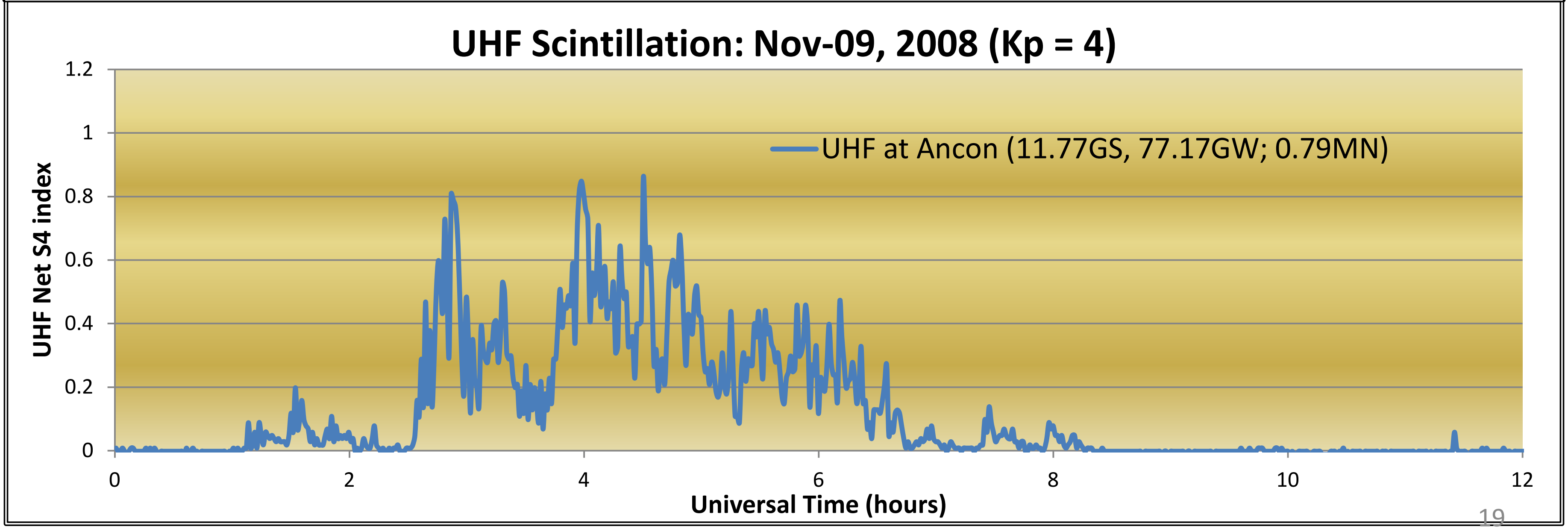




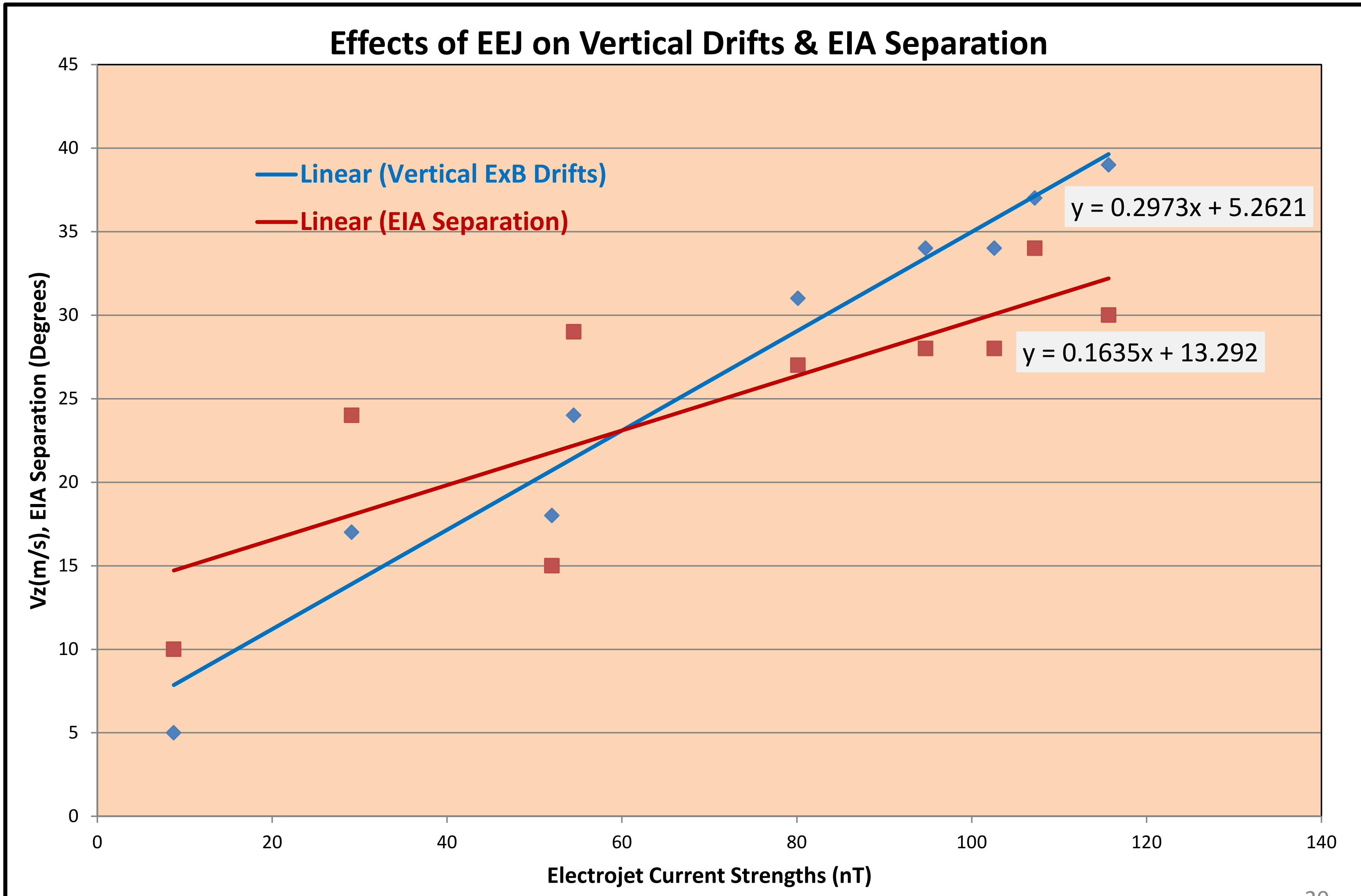


Ancon UHF Scintillation



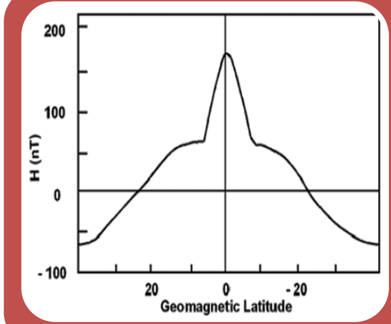


Results

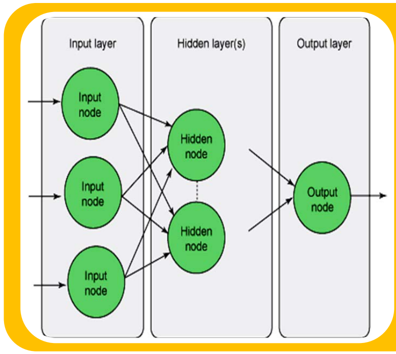


Effects of EEJ on Vertical Drifts & EIA Separation
Linear (Vertical ExB Drifts)
Linear (EIA Separation)
y = 0.2973x + 5.2621
y = 0.1635x + 13.292
Vz(m/s), EIA Separation (Degrees)
Electrojet Current Strengths (nT)
0
5
10
15
20
25
30
35
40
45
0
20
40
60
80
100
120
140

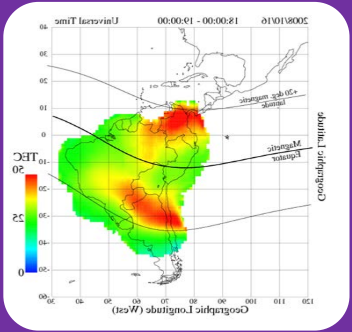
Summary



There is a quantifiable relation between daytime vertical ExB drift and EEJ current. Hence, magnetometer observation can be used to infer vertical ExB drift.



Neural network technique with suitable inputs for the estimation of daytime vertical drift potentially gives better result than other approaches, based on the RMS errors comparison.



EEJ strengths and daytime vertical ExB drifts have noticeable connection to GPS-TEC. The EEJ strength controls the shape and location of EIA crests. But, their relation with the increase of the S4 index after sunset is not as obvious.

Thank you!