ISEST/MiniMax 2015
Workshop
26-30 October, Mexico City

Ionospheric disturbances associated with major geomagnetic storms

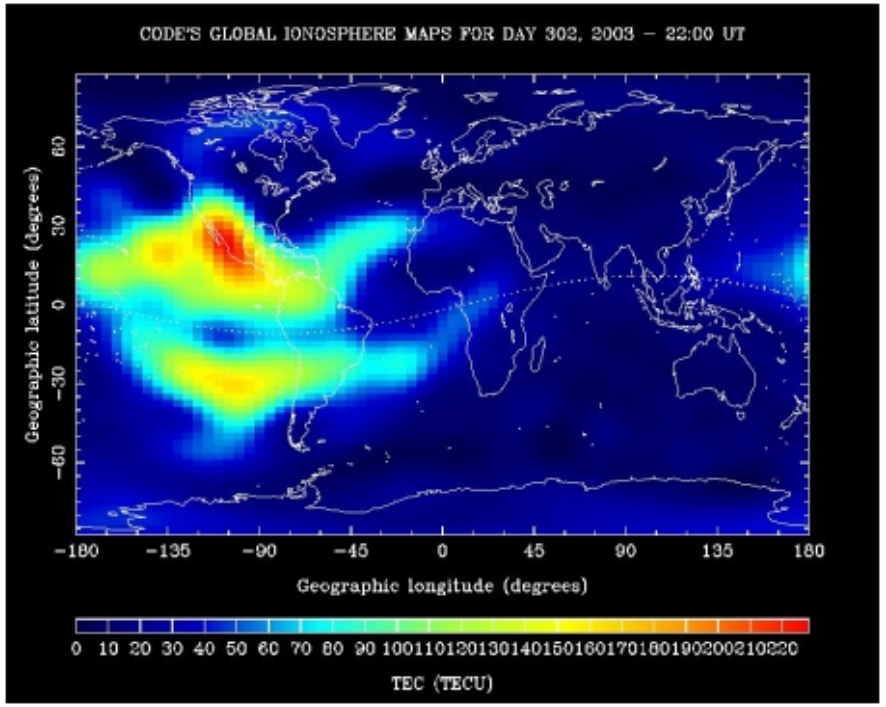
Rebeca López-Montes

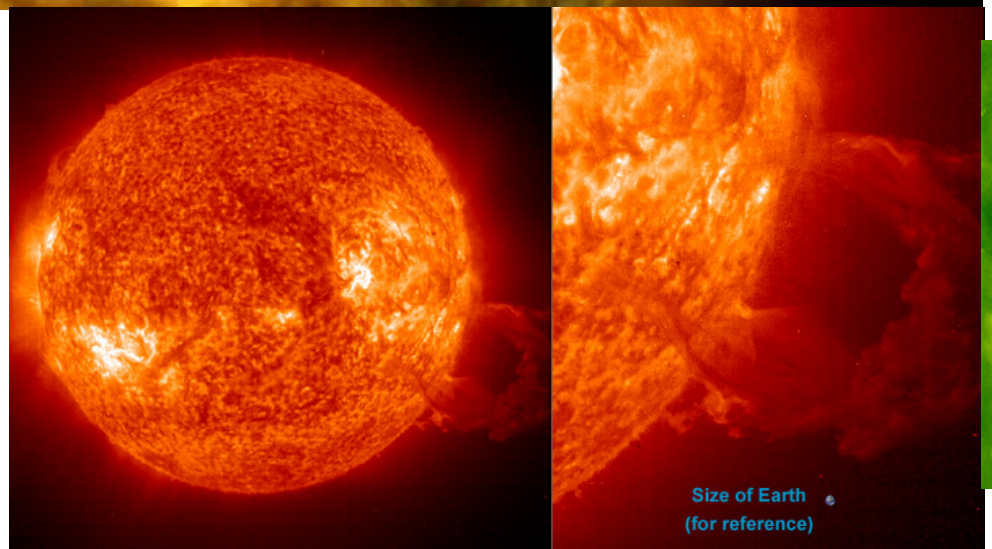
Instituto de Geofísica, UNAM

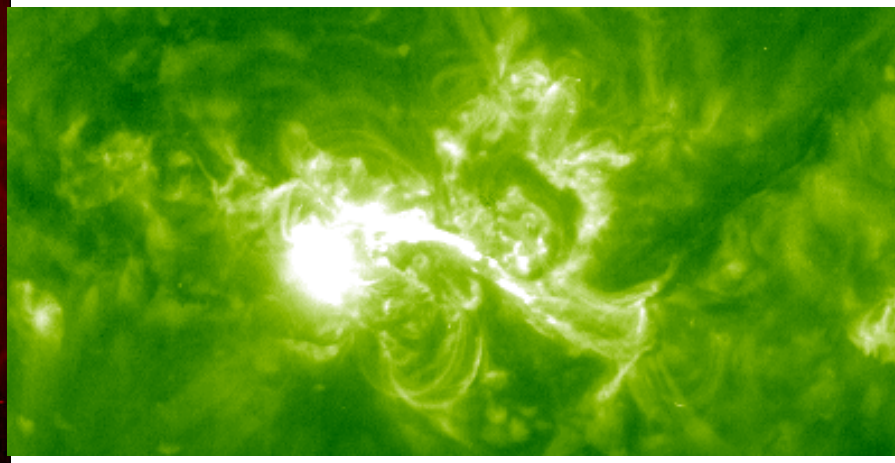
28 October 2015

The purpose of this study is to characterize the impact of some major geomagnetic storms (Dst < -200 nT) on the ionosphere at mid latitudes, especially the ones that occurred in March and June 2015. The analysis consists in the TEC determination using data from several Mexican GPS stations and the quantification of the diurnal variation changes observed in the TEC time series.

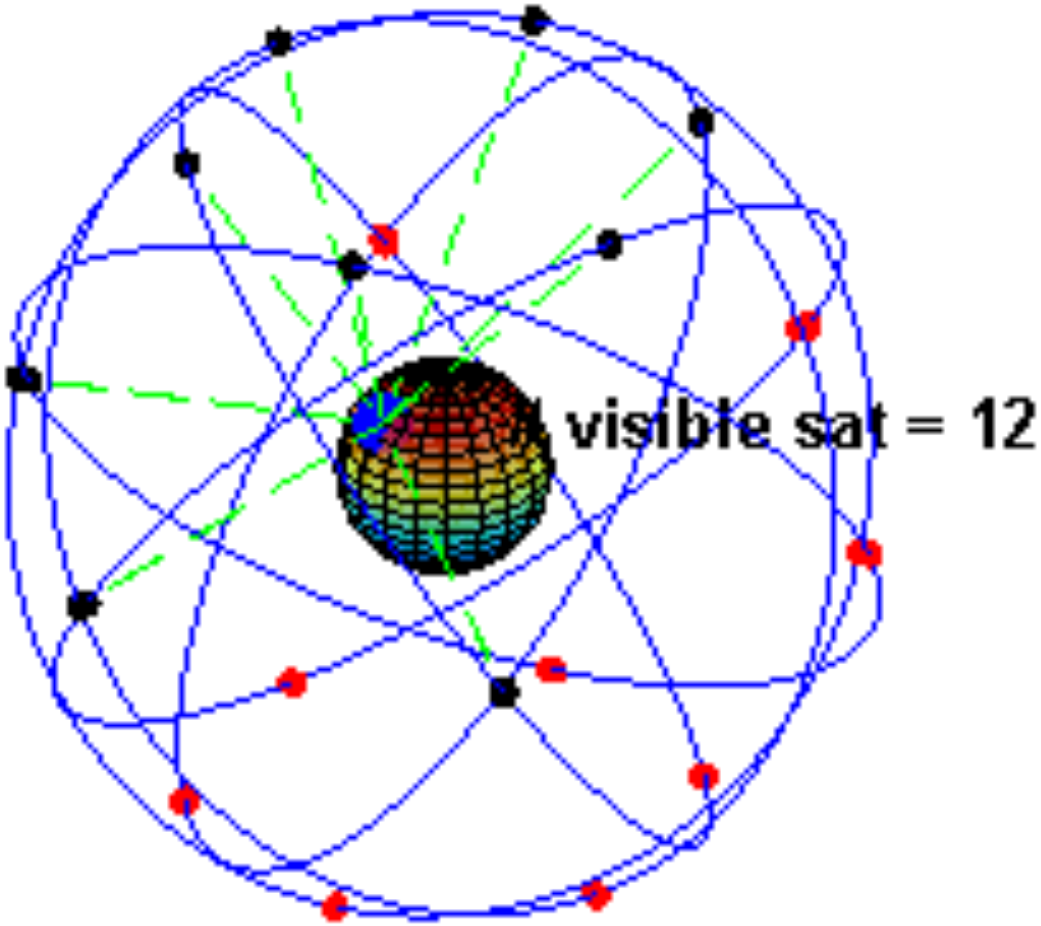
Ionospheric disturbances

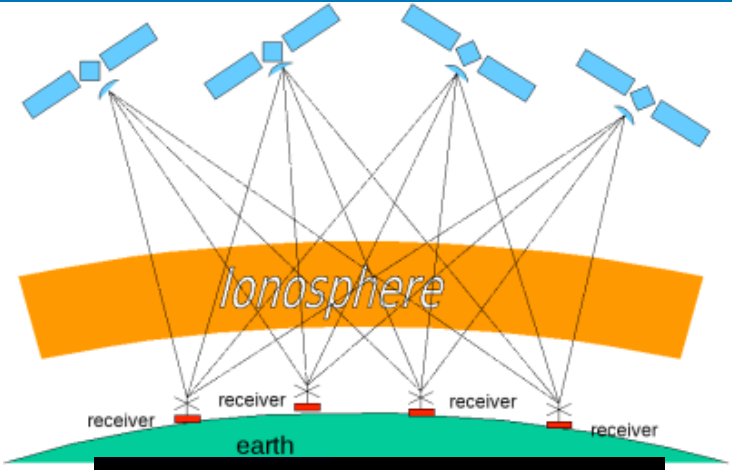


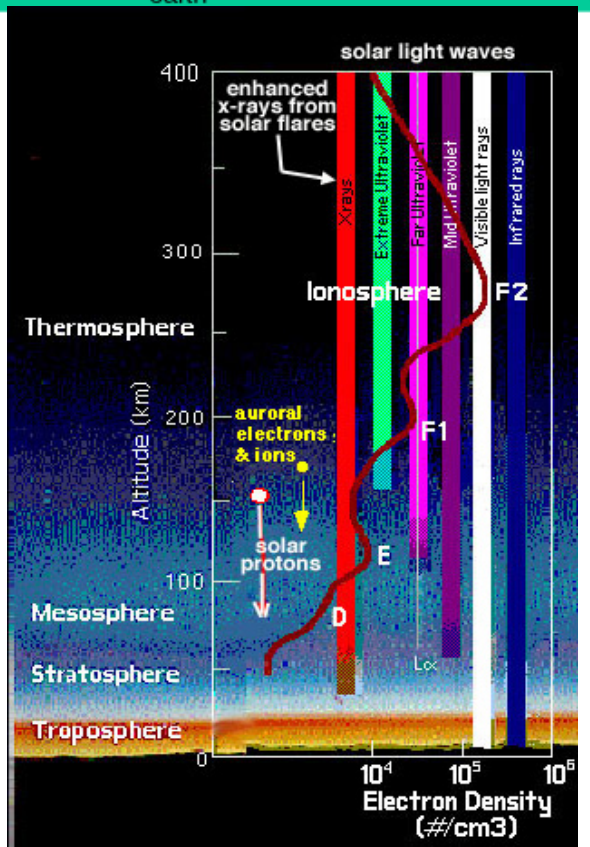




GPS


visible sat = 12


Ionosphere
receiver
receiver
receiver
receiver
earth


solar light waves
enhanced x-rays from solar flares
Xrays
Extreme Ultraviolet
Far Ultraviolet
Mid Ultraviolet
Visible light rays
Infrared rays
Ionosphere
F2
F1
E
D
Thermosphere
Mesosphere
Stratosphere
Troposphere
auroral electrons & ions
solar protons
Altitude (km)
400
300
200
100
0
10^4
10^5
10^6
Electron Density (#/cm3)

Calculation of TEC

L1 = 1575.42 MHz
L2 = 1227.60 MHz

Equation to determine the total electron content using the observed pseudoranges :

$$TEC_R = 9.52(R_2 - R_1)$$

Equation to determine the total electron content using the observed signal phase :

$$TEC_\Phi = 9.52(\lambda_1 \Phi_1 - \lambda_2 \Phi_2)$$

Where λ1 y λ2 are the wavelength of L1 and L2 respectively; and φ1 and φ2 are the signal phase of L1 and L2.

$$TEC_{comb_i} = TEC_{\Phi_i} - \left(\frac{\sum_{j=i-n(j\neq 1)}^{i+n} P_j (TEC_{\Phi_j} - TEC_{R_j})}{\sum_{j=i-n(j\neq 1)}^{i+n} P_j} \right)$$

Where 1 TEC units = 10^{16} m^{-2} electrons.

Araujo-Pradere, 2005

Available online at www.sciencedirect.com

ScienceDirect

Advances in Space Research 55 (2015) 586–596

ADVANCES IN SPACE RESEARCH (a COSPAR publication)

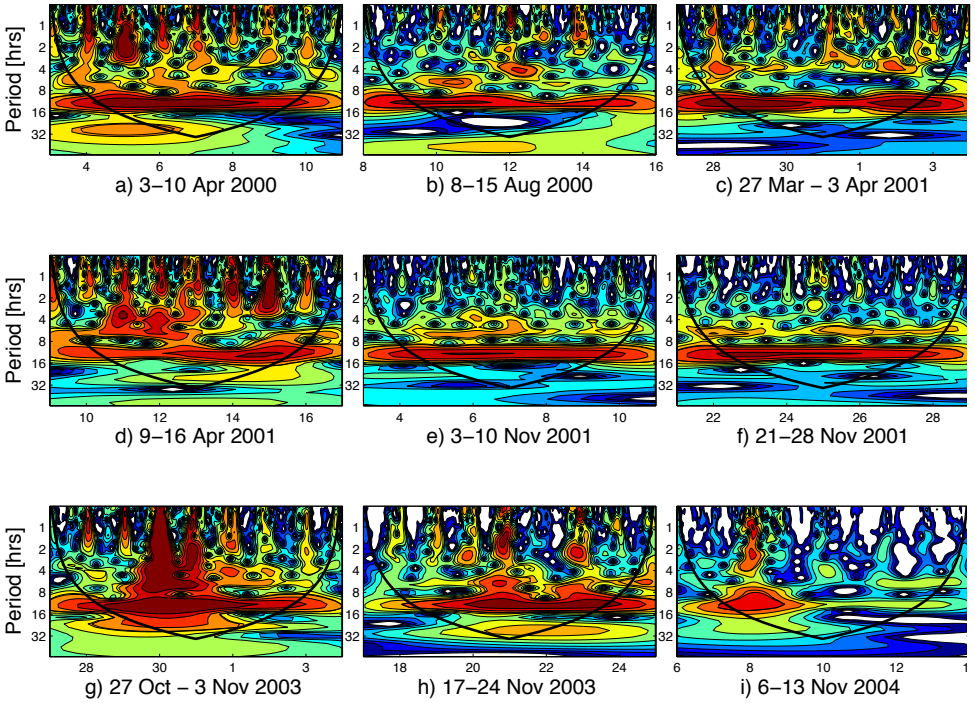
www.elsevier.com/locate/asr

Fractal and wavelet analysis evaluation of the mid latitude ionospheric disturbances associated with major geomagnetic storms

Rebeca López-Montes [a], Román Pérez-Enríquez [a,*], Eduardo A. Araujo-Pradere [b], Jose Antonio López Cruz-Abeyro [a]

[a] Centro de Geociencias, Universidad Nacional Autónoma de México, Mexico
[b] CIRES, University of Colorado, Boulder, CO, United States

Received 1 September 2014; received in revised form 24 October 2014; accepted 29 October 2014
Available online 4 November 2014



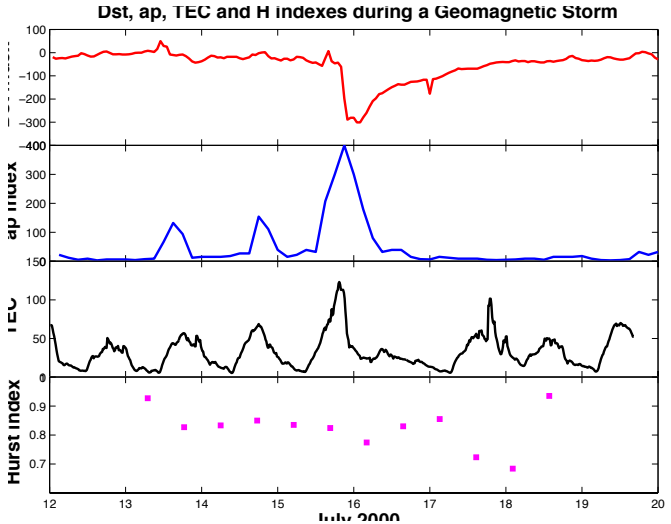
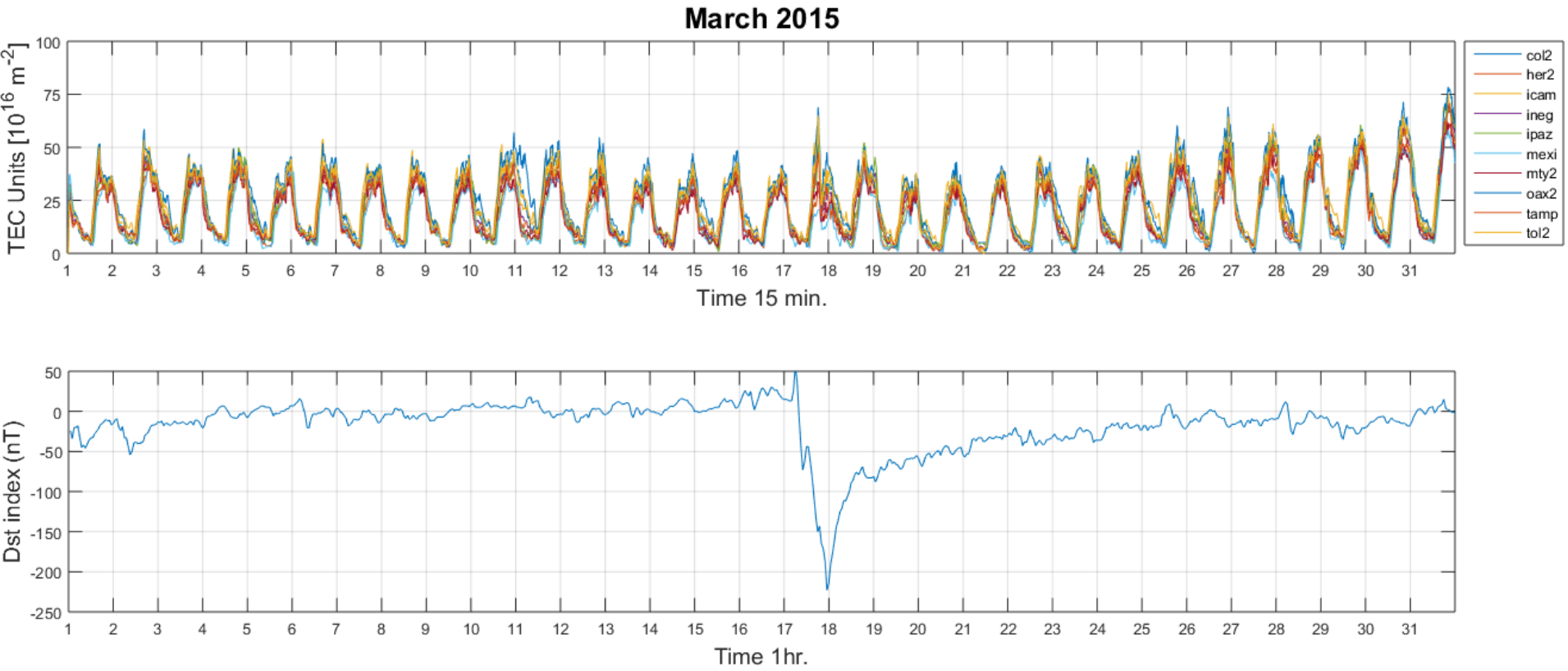


Table 3: Variation of the TEC during Geomagnetic Storms

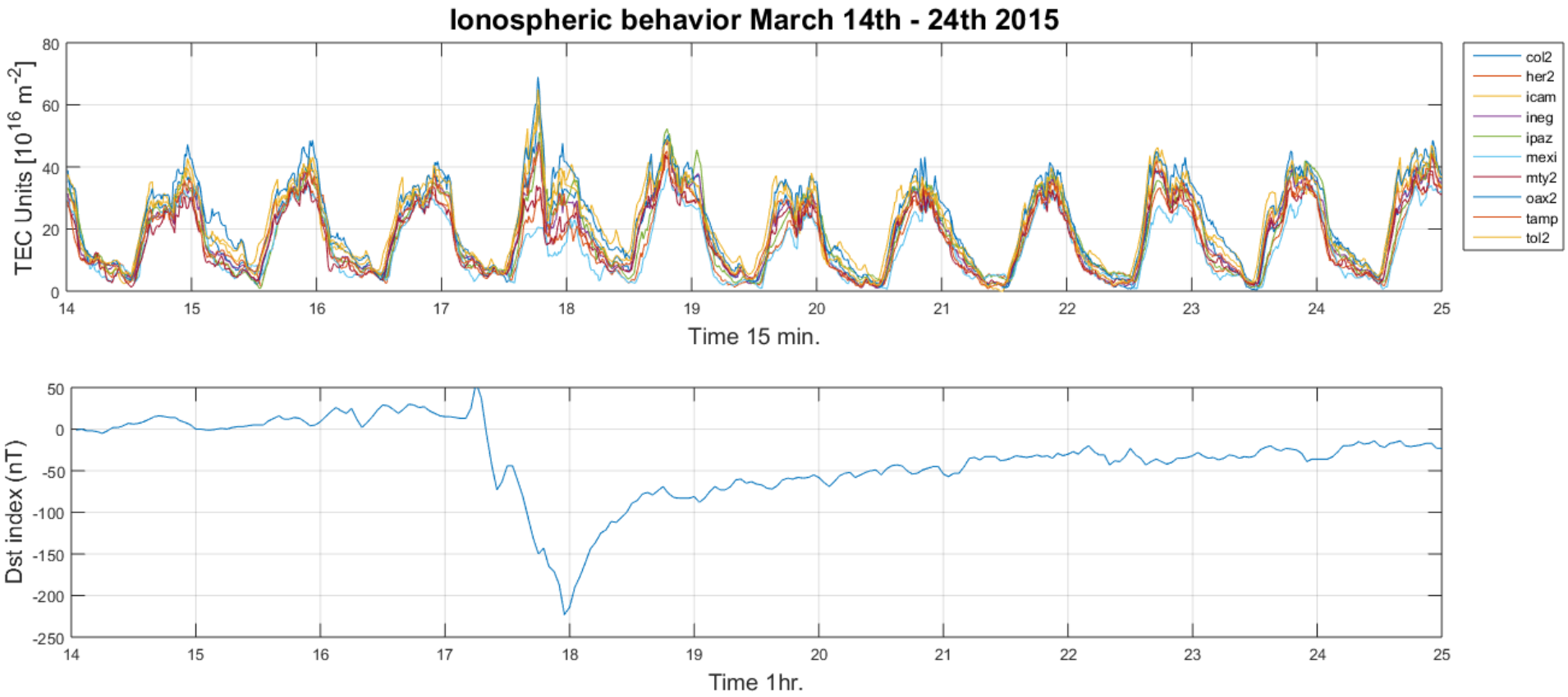
Date	Maximum TEC	Mean	Std. dev.	Variation	H_{max}	H_{min}
07/04/2000	215.99	69.82	33.83	4.32	0.952	0.654
16/07/2000	123.07	32.50	21.43	4.23	0.927	0.684
12/08/2000	69.19	31.57	16.87	2.23	0.903	0.657
31/03/2001	113.05	44.12	24.82	2.78	0.991	0.859
11/04/2001	161.63	60.08	30.89	3.29	0.861	0.628
06/11/2001	111.7	38.28	28.77	2.55	0.988	0.709
24/11/2001	84.5	29.93	23.24	2.35	0.954	0.679
30/10/2003	393.57	41.89	39.86	8.82	0.992	0.204
20/11/2003	140.69	27.54	24.72	4.58	0.888	0.757
08/11/2004	72.91	11.21	10.51	5.87	0.964	0.870
15/05/2005	57.72	18.88	10.92	3.56	0.937	0.550

March and June 2015

Ionospheric behavior March 2015



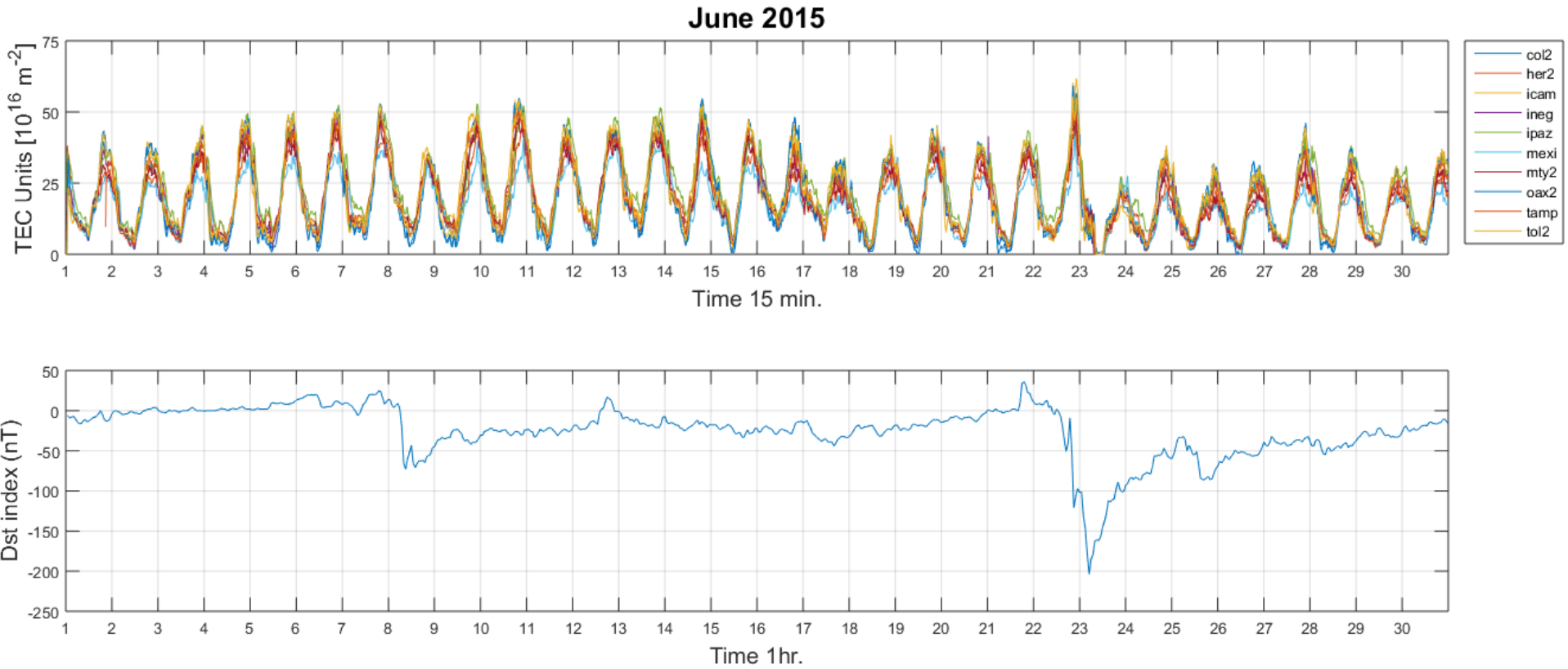
Geomagnetic storm 17 March 2015



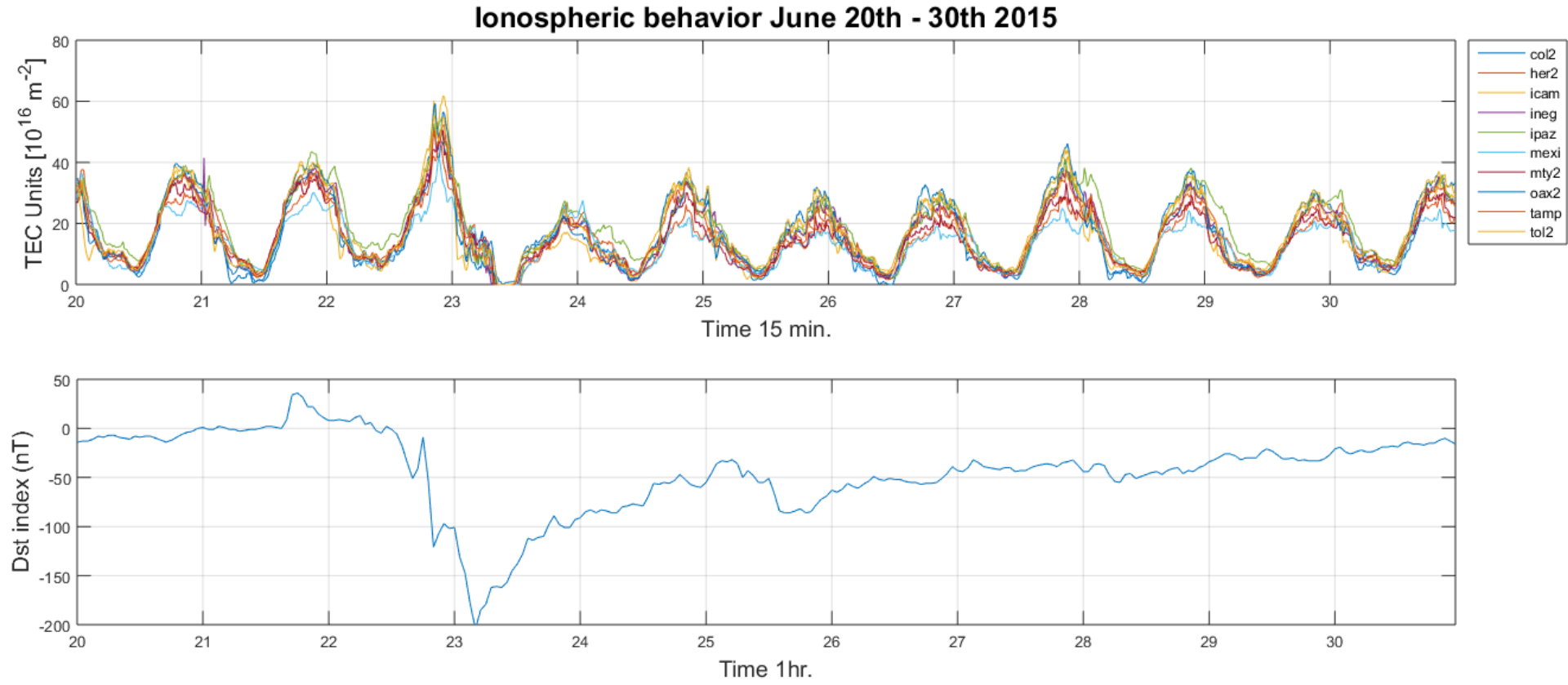
Variation of the TEC during geomagnetic storm			
Station	Maximum TEC	Mean	Variation
col2	59.96	19.5	3.21
her2	43.25	15.72	2.59
icam	61.34	21.77	3.25
ineg	48.49	18.27	2.55
ipaz	52.33	18.26	2.78
mexi	39.57	14.32	2.51
mty2	43.85	16.28	2.63
oax2	68.98	22.76	3.44
tamp	47.28	18.17	2.52
tol2	65.01	20.89	3.48

Percent deviation of TEC during the geomagnetic storm with respect to quiet day reached values of 200%.

Ionospheric behavior June 2015



Geomagnetic storm 22 June 2015



Variation of the TEC during geomagnetic storm			
Station	Maximum TEC	Mean	Variation
col2	52.34	15.97	3.36
her2	48.49	15.14	3.73
icam	61.83	16.48	4.08
ineg	50.37	16.49	3.19
ipaz	54.58	18.92	3.31
mexi	41.55	13.63	3.61
mty2	50.55	15.09	3.9
oax2	59.26	17.34	3.51
tamp	52.19	16.28	3.52
tol2	55.37	17.94	3.34

Percent deviation of TEC during the geomagnetic storm with respect to quiet day reached values of 98% for June 22 and -100% for June 23.

what next?

- Analyze the following 78 geomagnetic storms.
- Classify events as positive or negative ionospheric storms.
- Study the relation between of the variability of the ionosphere with the latitude, local time, season, geomagnetic activity, etc.

Thank you