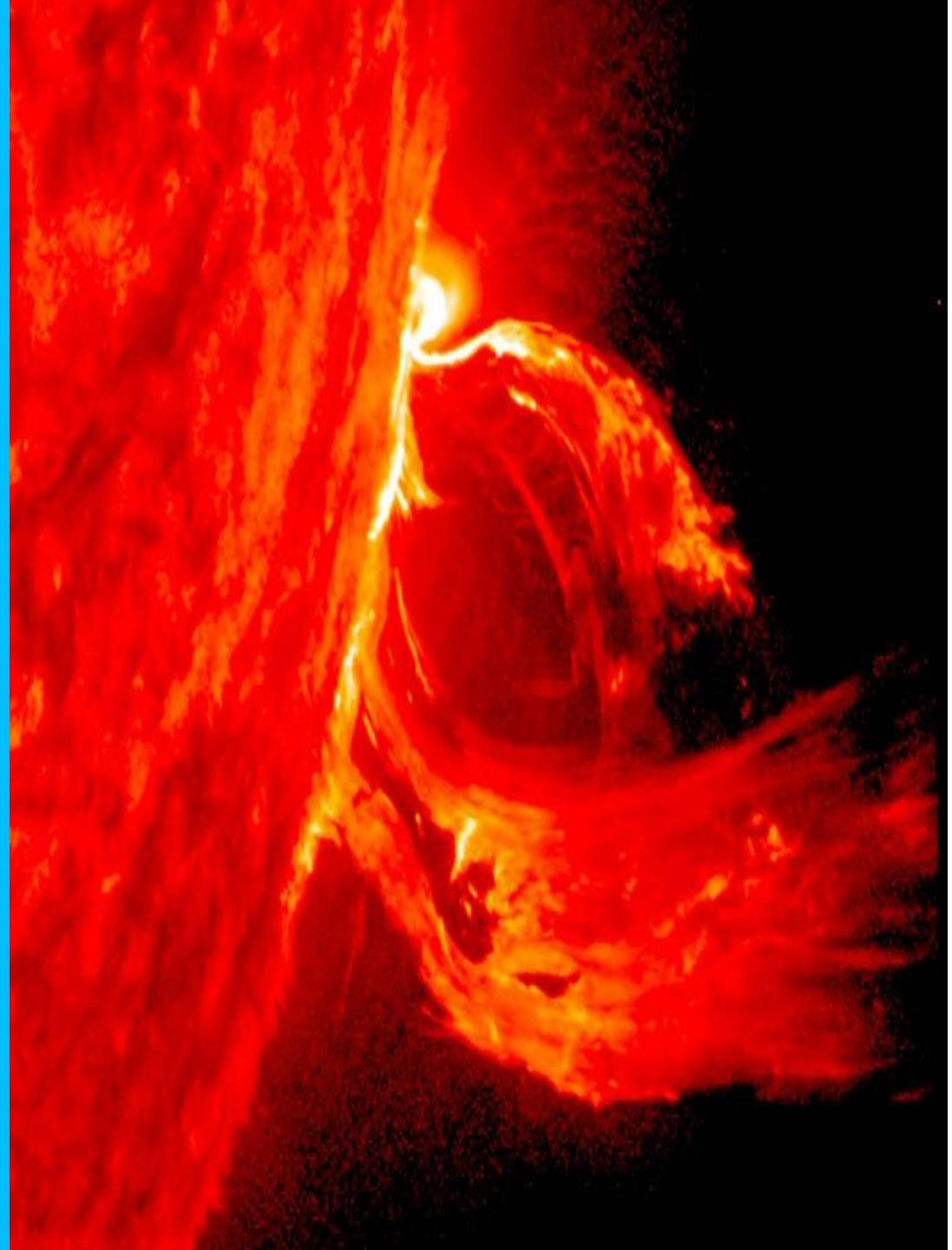
International Beacon Satellite Symposium BSS2019
Olsztyn, Poland



B2 thickness parameter response to Equinoctial geomagnetic storms

Y. Migoya-Orué[1], K. Alazo-Cuartas[1], S. Radicella[1], B. Nava[1],A. Kashcheyev[2], C. Amory-Mazaudier[1,3] and R. Ezquer [4,5,6]

1. The Abdus Salam International Centre for Theoretical Physics (ICTP) T/ICT4D, Trieste, Italy.
2. Physics department, University of New Brunswick, Fredericton, Canada
3. LPP, CNRS/Ecole Polytechnique/Sorbonne Université/Université Paris-Sud/Observatoire de Paris.
4. CONICET 5. Laboratorio de Ionosfera, Dto. de Fisica, FACET, UNT, 6. CIASUR, FRT, UTN, S. M. de Tucuman, Argentina

Introduction

Base Point and B2 definitions

Introduction

Thickness Parameters

Most of the ionospheric empirical models make use of thickness parameters to characterize the shape of an electron density profile.

These thickness parameters are generally defined by empirical relations related to ionogram characteristics.

Purpose

In this study we analyze the behavior of the B2 thickness parameter during three CME events that occurred during Equinox of years 2013 and 2015.

Base Point and B2
Concepts

Base Point (BP)

Inflection point of Ne below the F2 peak.
Where the height gradient is maximum.

(Mosert de Gonzalez and Radicella., 1990)

BP is not related to any given type of analytical profile and can be experimentally derived from any Electron Density Profile (EDP).

The NeQuick model

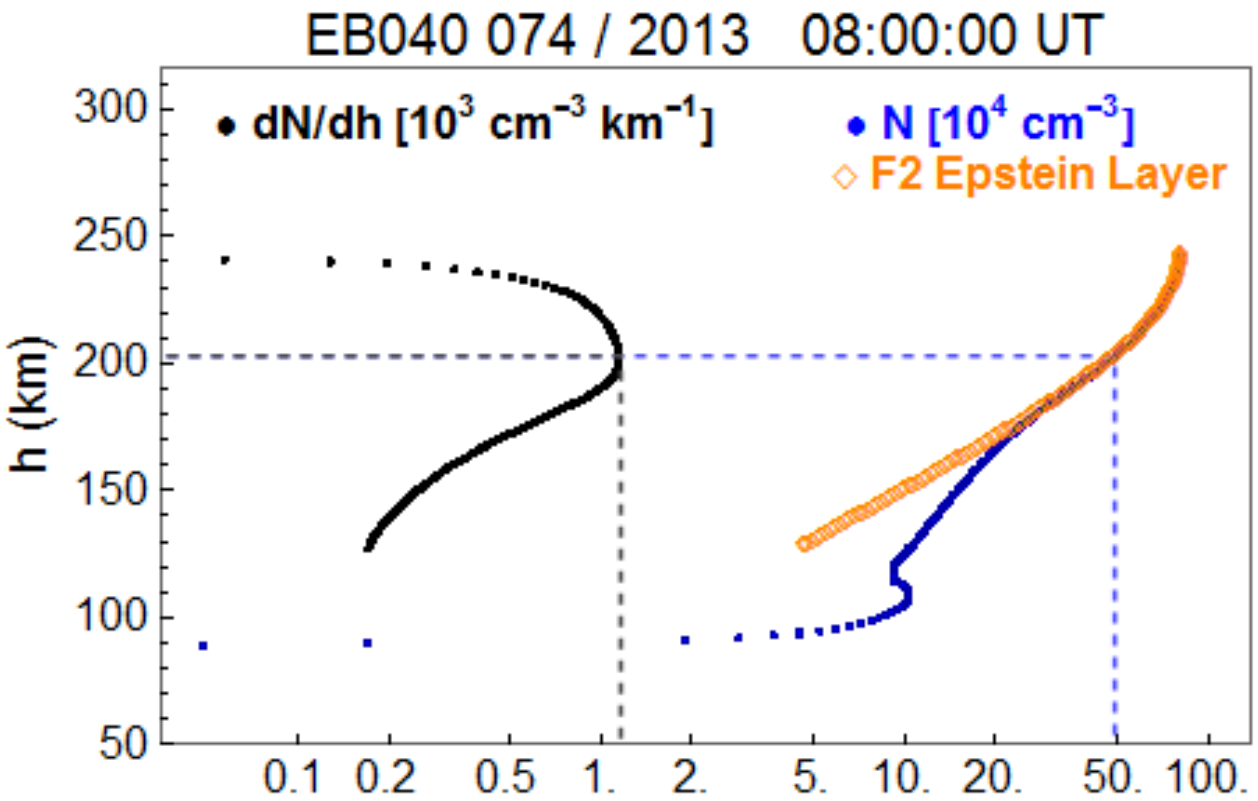
Uses this BP as an anchor point to define a thickness parameter of the F2 bottomside of the EDP, which is named **B2.**

The B2 thickness parameter

Describes the shape of an Epstein Layer EDP below the F2 region peak. It can be derived analytically as:

$$B2 = 0.385\ NmF2 / dN/dh_{max}$$

(Nava et al., 2008)



B2 parameter study

Analysis of B2 variation during geomagnetic storms

Dataset and Methodology

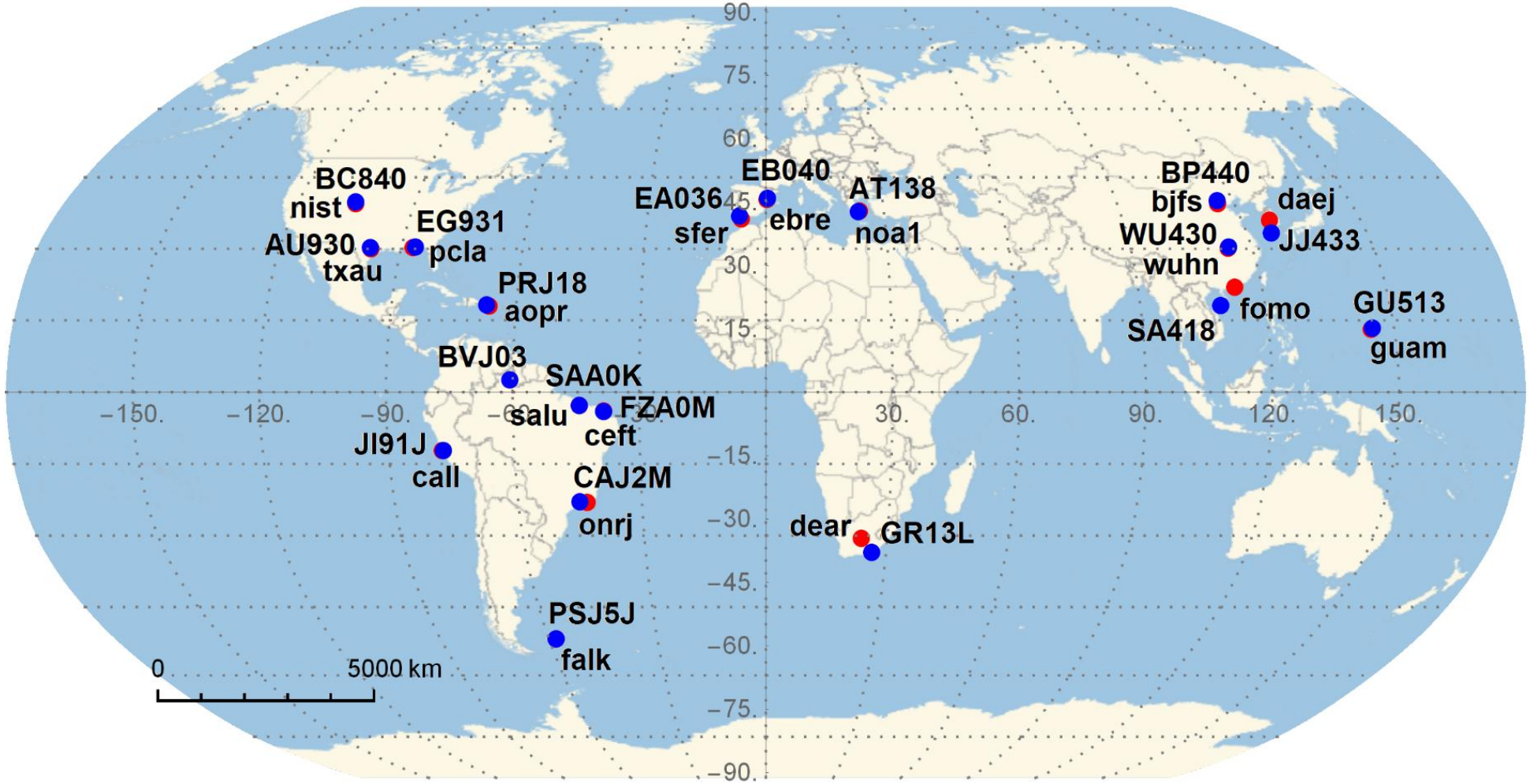
- Three ionospheric storms caused by CME occurring during the same season (Equinox) selected. All of them developed after a magnetic quiet period and with an onset time between 02 and 06 UT.
  The events are those of **March 17th, 2013; October 2nd, 2013** and **March 17th, 2015.**

- The experimental maximum dN/dh gradient values, **(dN/dh)max**, were obtained from hourly ionograms from about 20 digisondes at middle and low latitudes from GIRO network (*Reinisch and Galkin, 2011*)**.**

- B2 behavior was analyzed before, during and after the aforementioned events, together with vertical TEC (VTEC) and NmF2 variations for different longitude sectors.

- The response time of the different measurements according to location were subsequently analyzed by means of cross correlation.

Geographical Locations of digisonde stations used



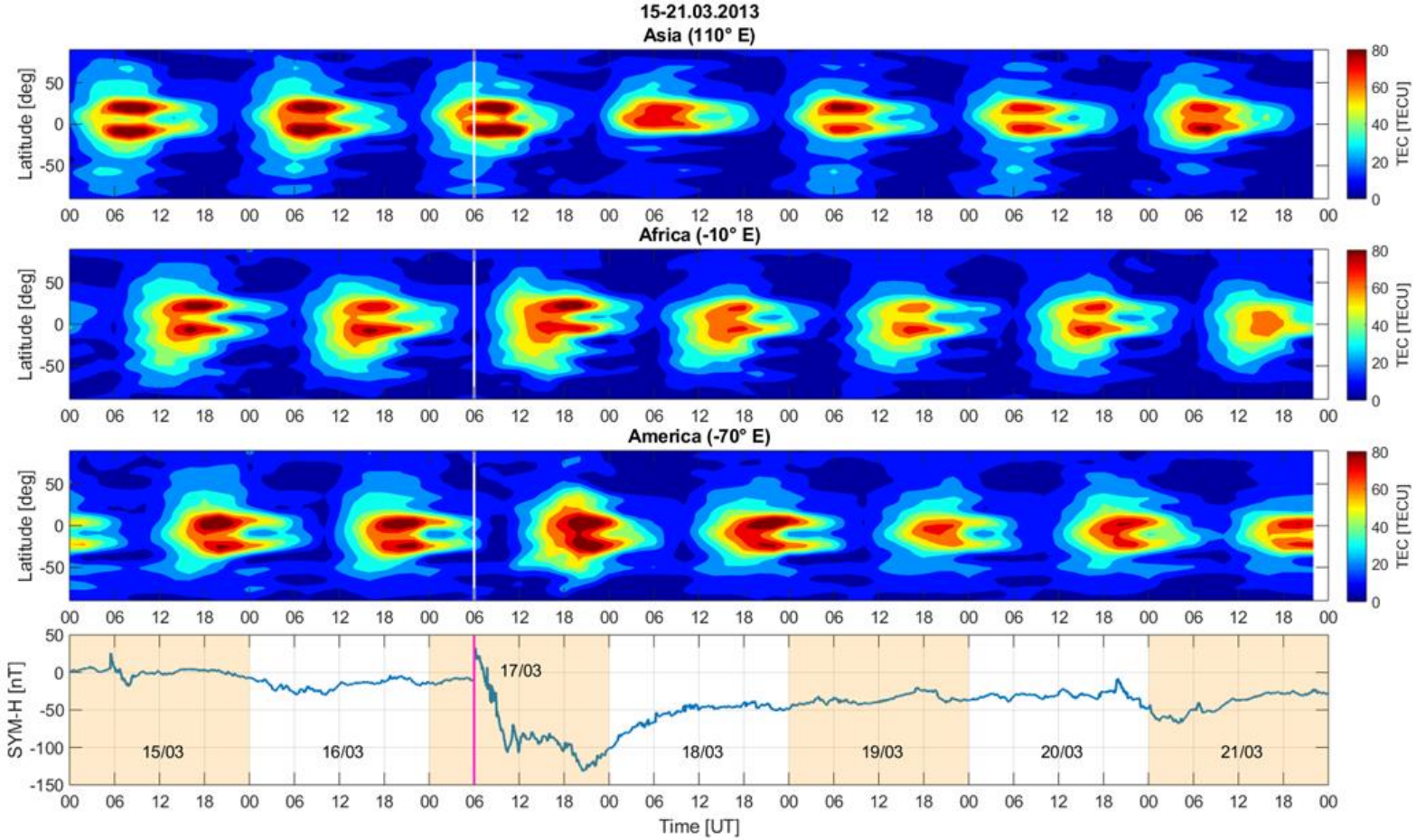
GIRO network (*Reinisch and Galkin, 2011*)

GNSS station

Storms parameters

Storm/ Onset Date & Time	Mar 2013 06 UT	Oct 2013 02 UT	Mar 2015 04.45 UT
Min Bz southward	-20 nT	-30 nT	-23 nT
Vz max after SSC	300km/s => 700km/s	250km/s => 600km/s	120km/s => 520km/s
SYMH min	-130 nT	-90 nT	-234 nT
AE max	2000 nT	2000 nT	2300 nT

Storms Overview

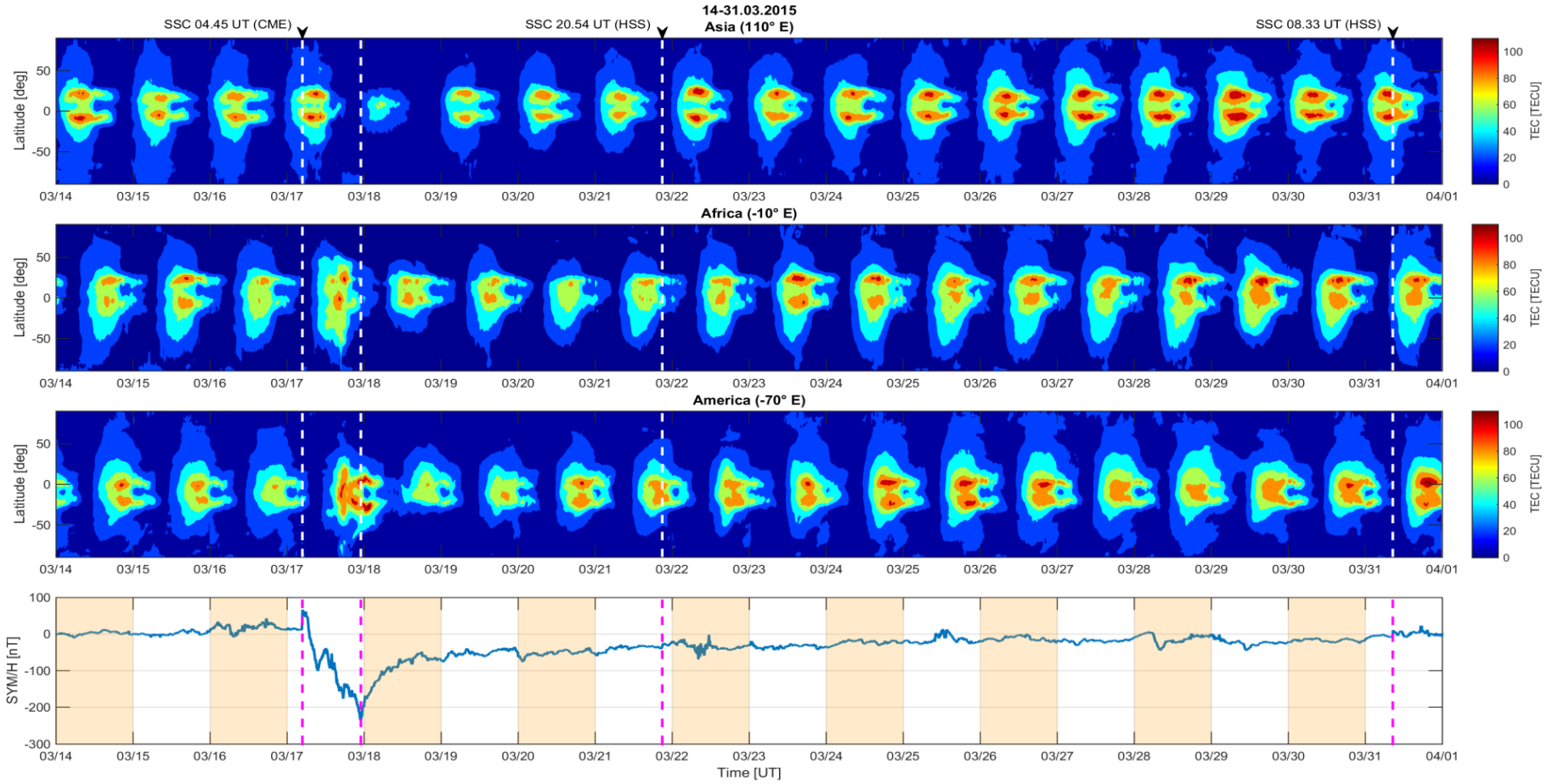


The three storms occurring on Equinox and beginning between 02.00 UT and 6.00UT highlights a similar pattern:

1) VTEC decreases in the Asia and increases in Europe and Africa during the day of the storm.

2) VTEC decreases, in all the longitude sectors, the day after the storm.

Storms Overview

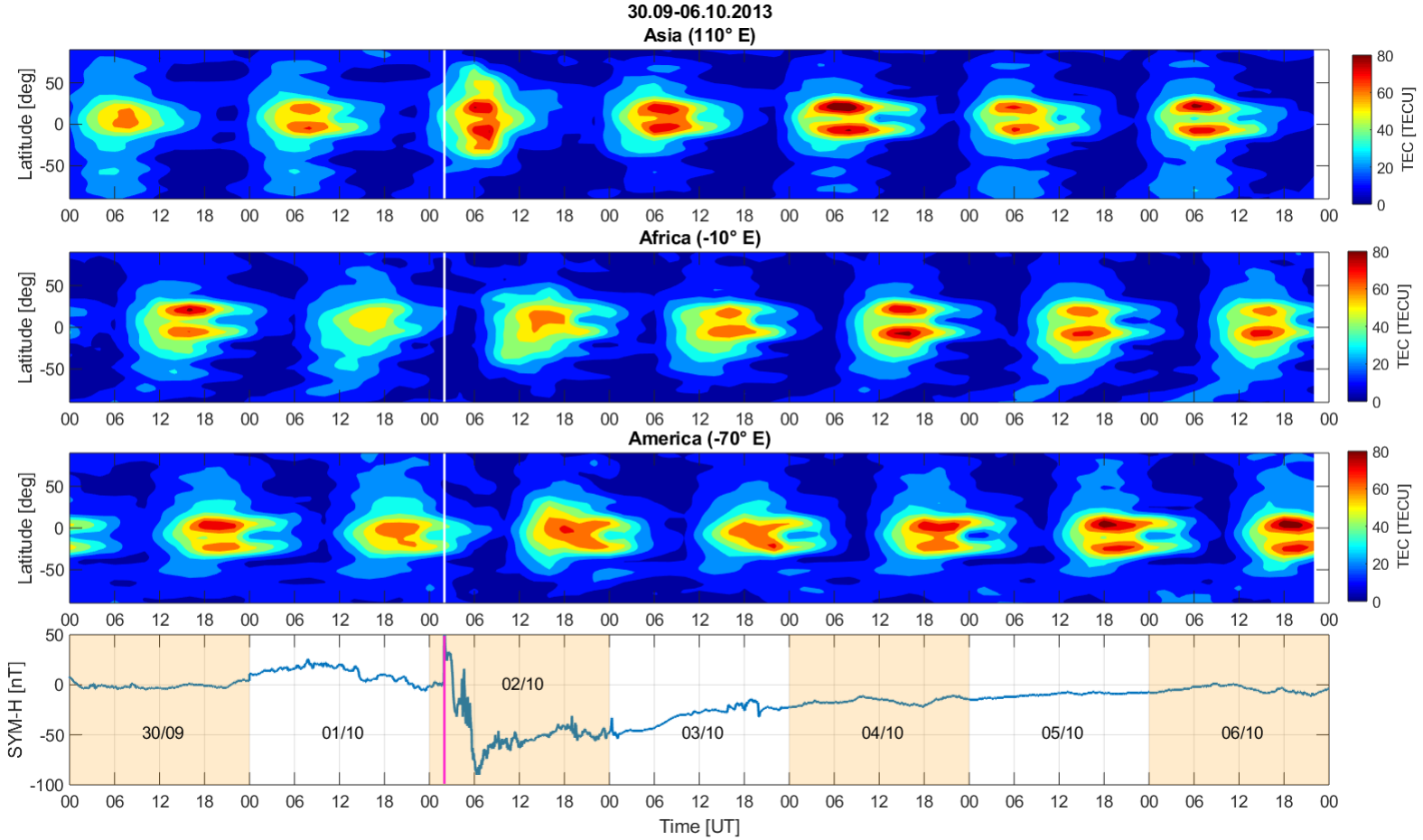


The three storms occurring on Equinox and beginning between 02.00 UT and 6.00UT highlights a similar pattern:

1) VTEC decreases in the Asia and increases in Europe and Africa during the day of the storm.

2) VTEC decreases, in all the longitude sectors, the day after the storm.

Storms Overview

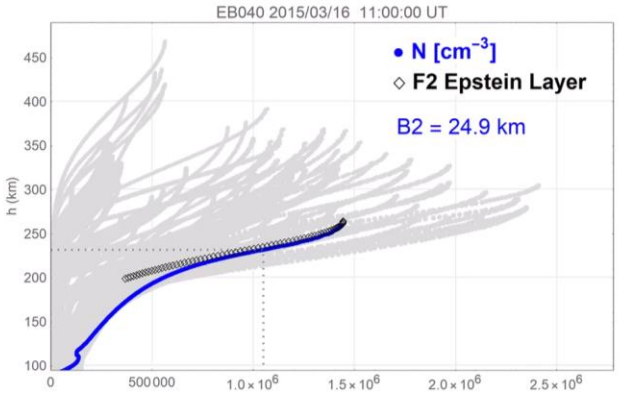


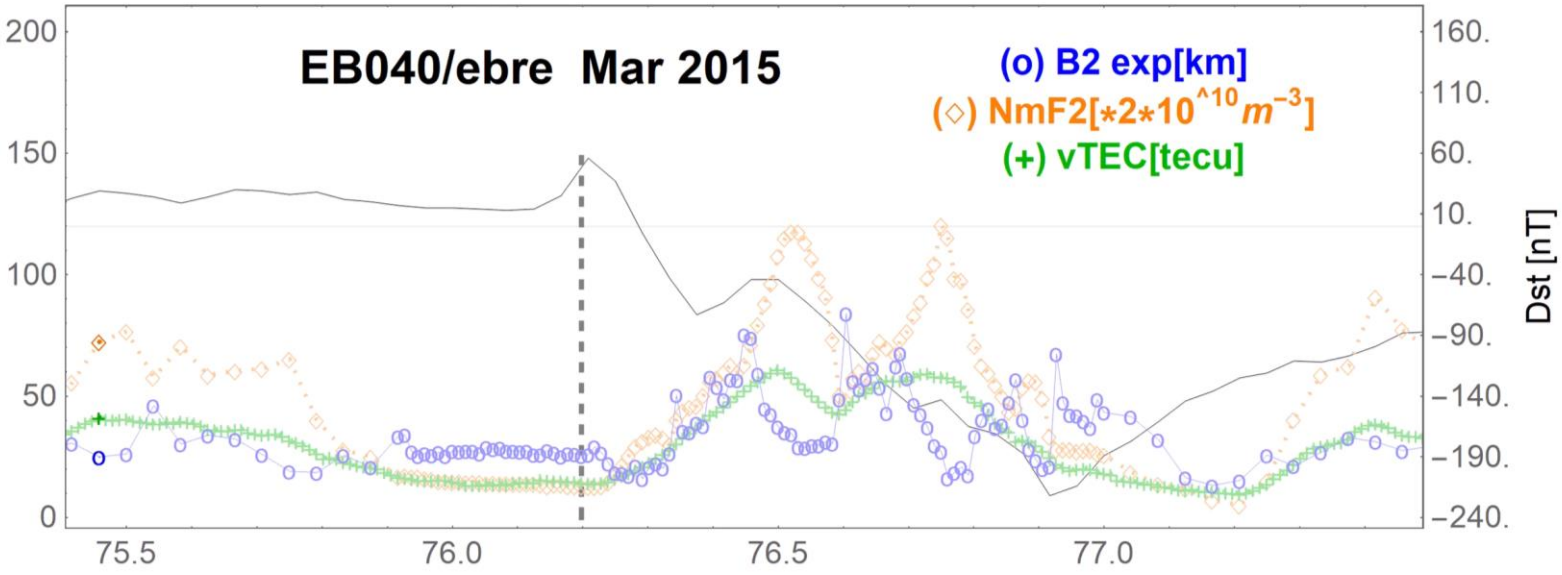
The three storms occurring on Equinox and beginning between 02.00 UT and 6.00UT highlights a similar pattern:

1) VTEC decreases in the Asia and increases in Europe and Africa during the day of the storm.

2) VTEC decreases, in all the longitude sectors, the day after the storm.

Results B2, NmF2 and VTEC variations



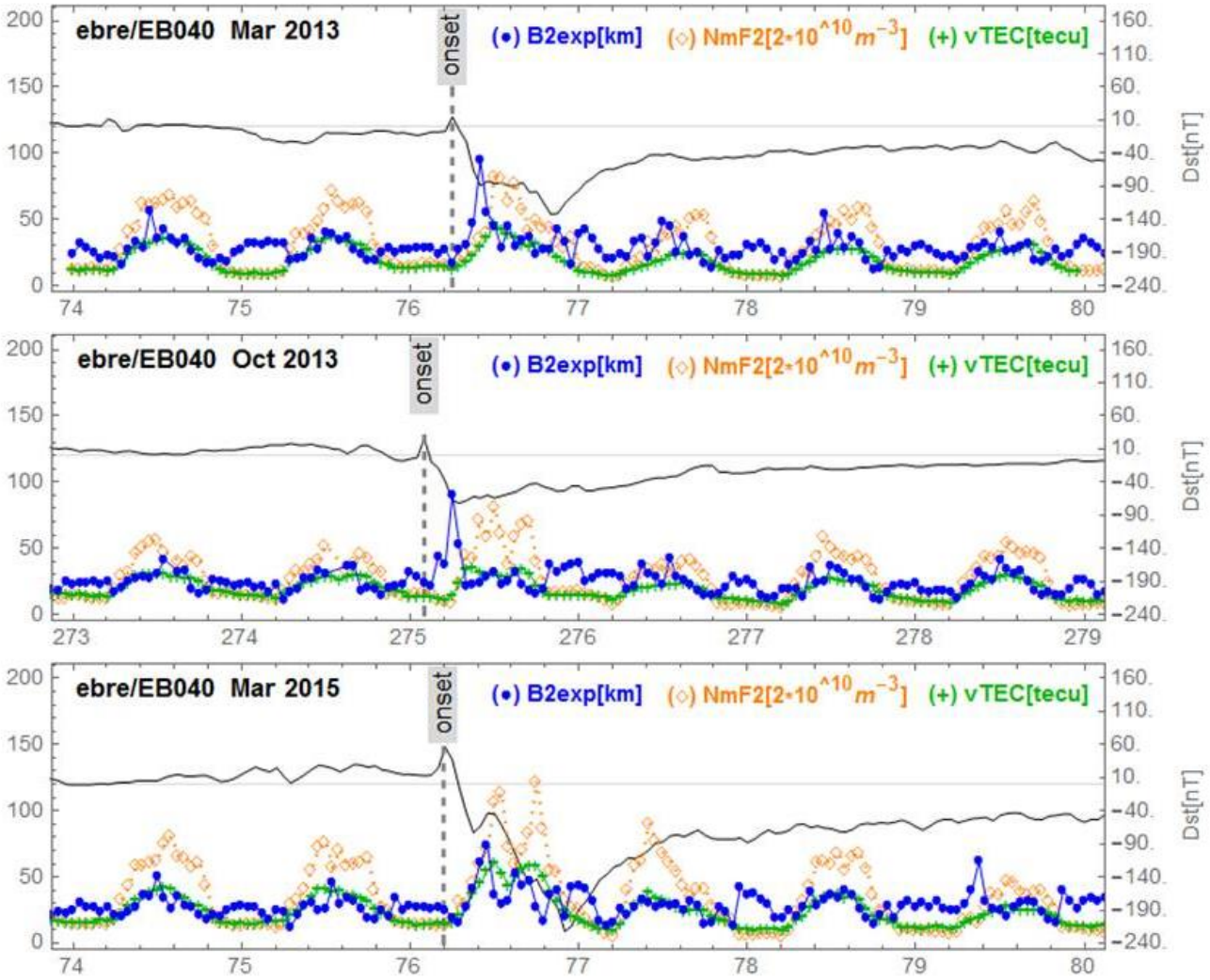


Profiles and Variations of B2, NmF2 and VTEC at Ebro station before and during the storm March 17, 2015.

Europe – middle latitudes

Results B2, NmF2 and VTEC variations

LT ~ UT

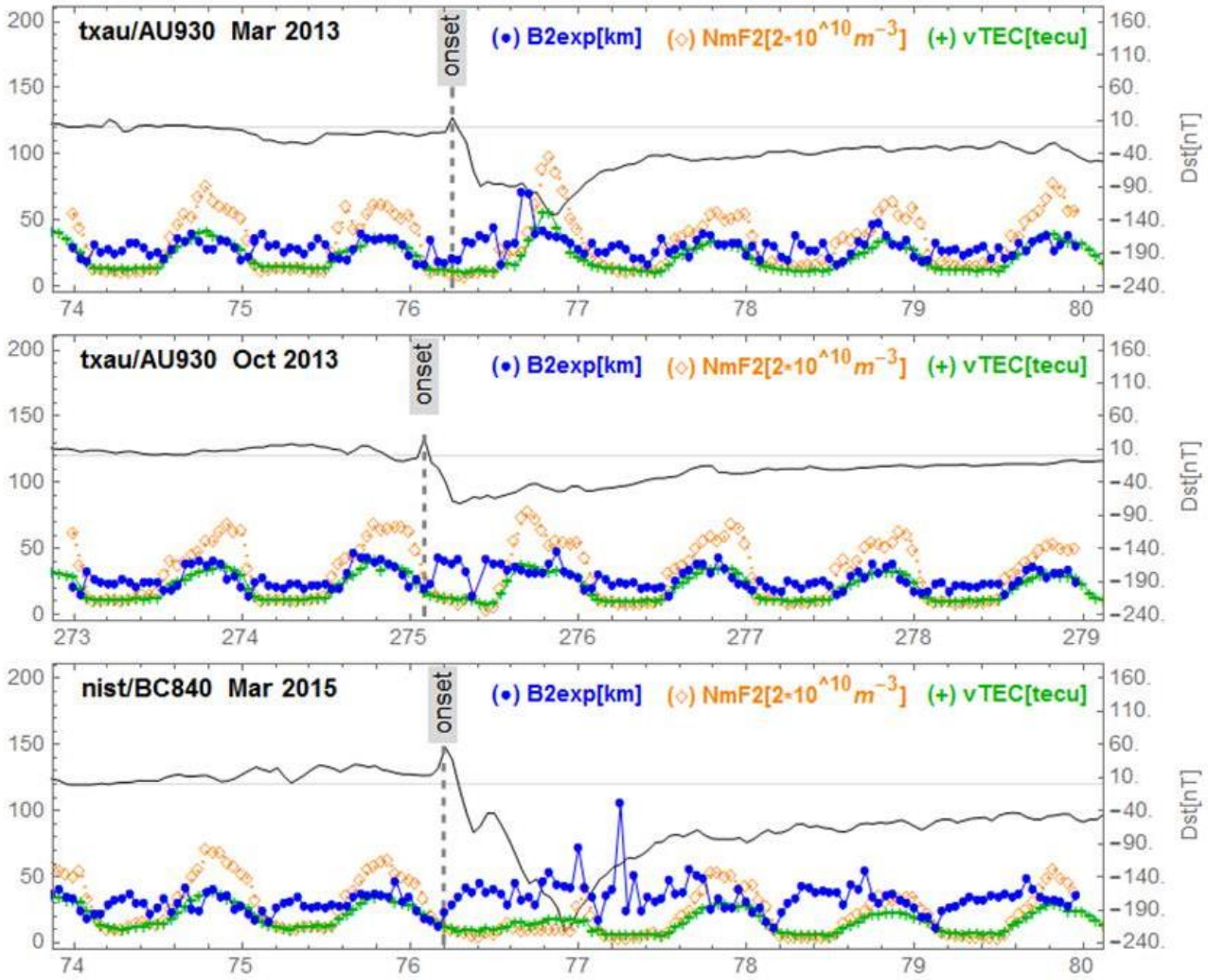


Variations of B2, NmF2 and VTEC at Ebro station during the three equinoctial storms March 17, 2013, October 2, 2013 and March 17, 2015.

America – mid-latitudes

Results B2, NmF2 and VTEC variations

LT = UT – 5

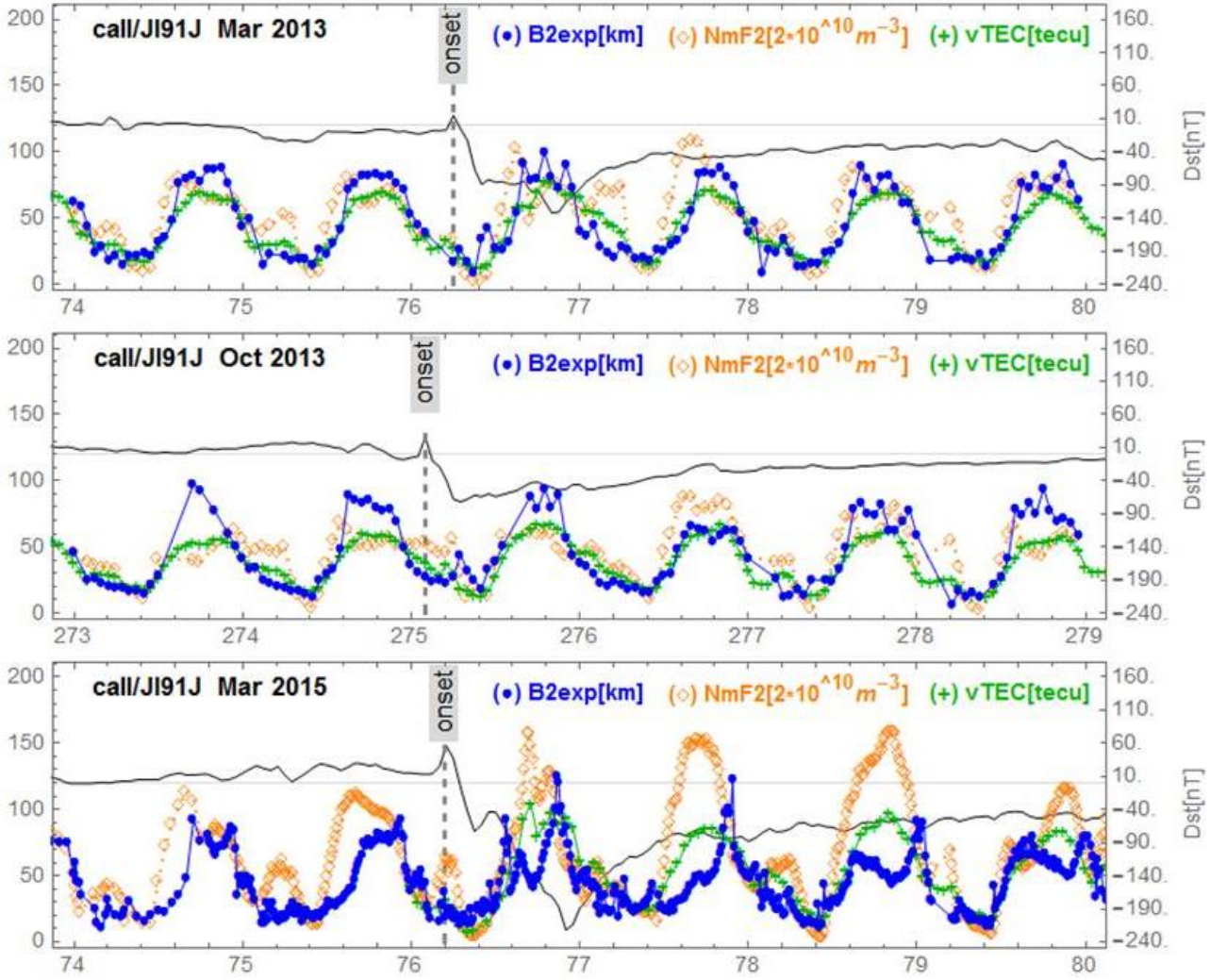


Variations of B2, NmF2 and VTEC at Austin and Boulder stations during the three equinoctial storms March 17, 2013, October 2, 2013 and March 17, 2015.

America – low latitudes

Results B2, NmF2 and VTEC variations

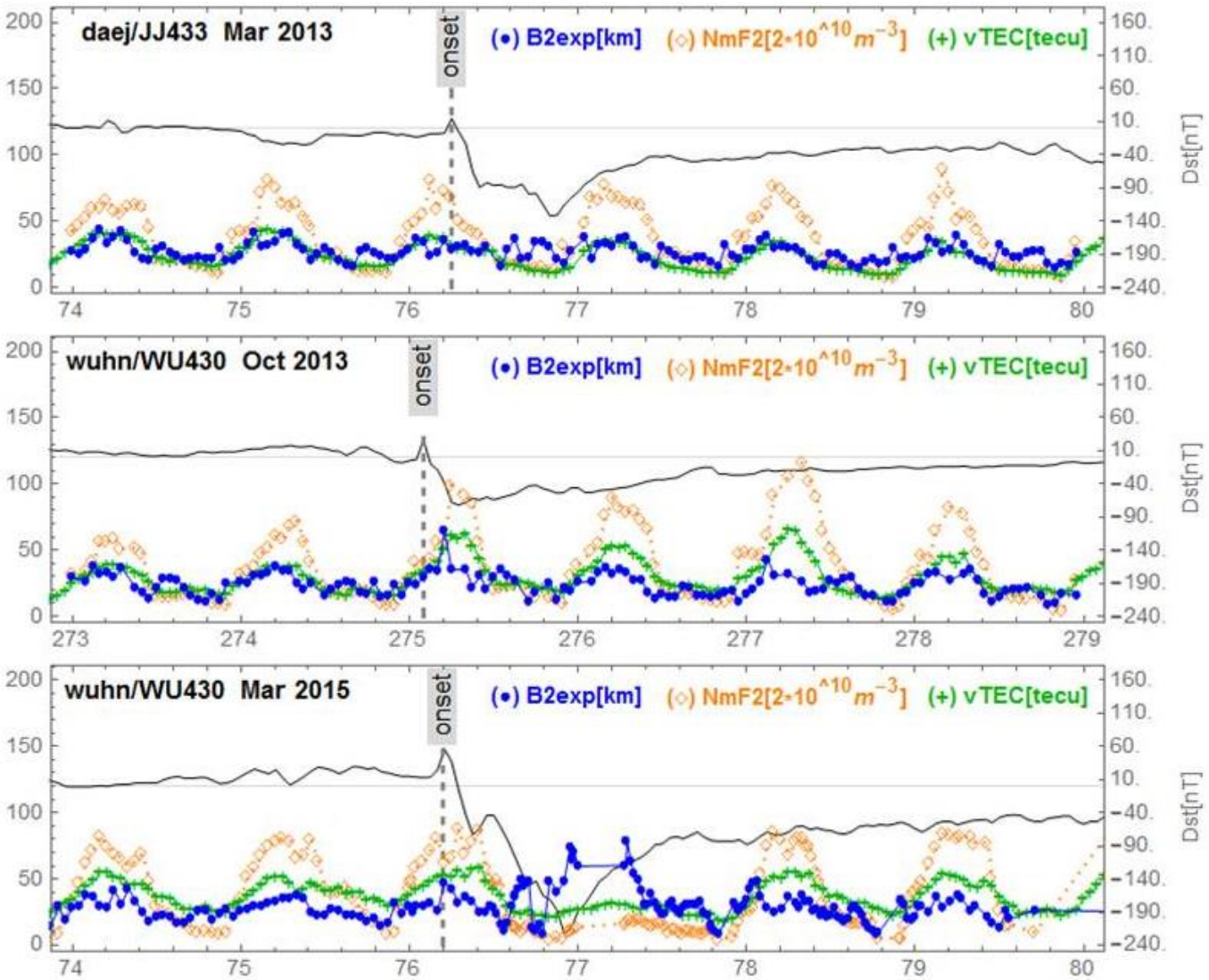
LT = UT – 5



Variations of B2, NmF2 and VTEC at Jicamarca station during the three equinoctial storms March 17, 2013, October 2, 2013 and March 17, 2015.

Asia – mid-latitudes

Results B2, NmF2 and VTEC variations



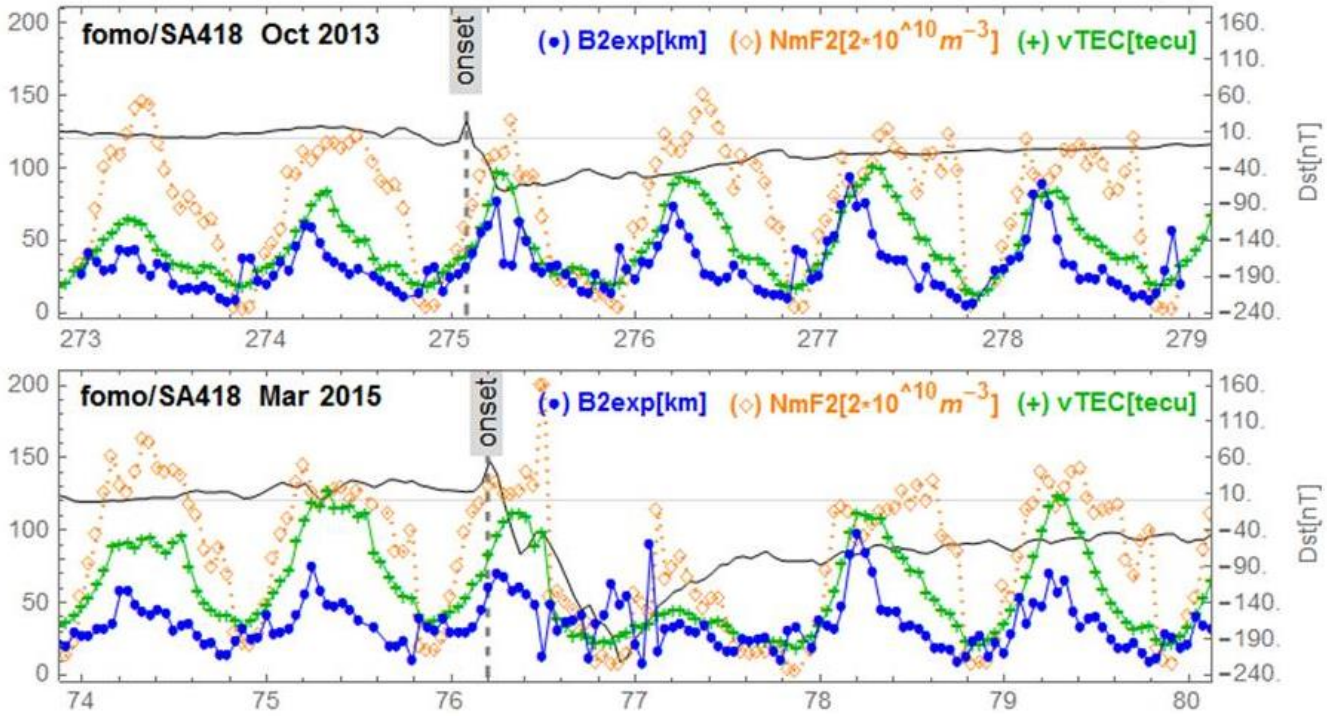
LT = UT + 7

Variations of B2, NmF2 and VTEC at Jeju and Wuhan stations during the three equinoctial storms March 17, 2013, October 2, 2013 and March 17, 2015.

Asia – low latitudes

Results B2, NmF2 and VTEC variations

LT = UT + 7

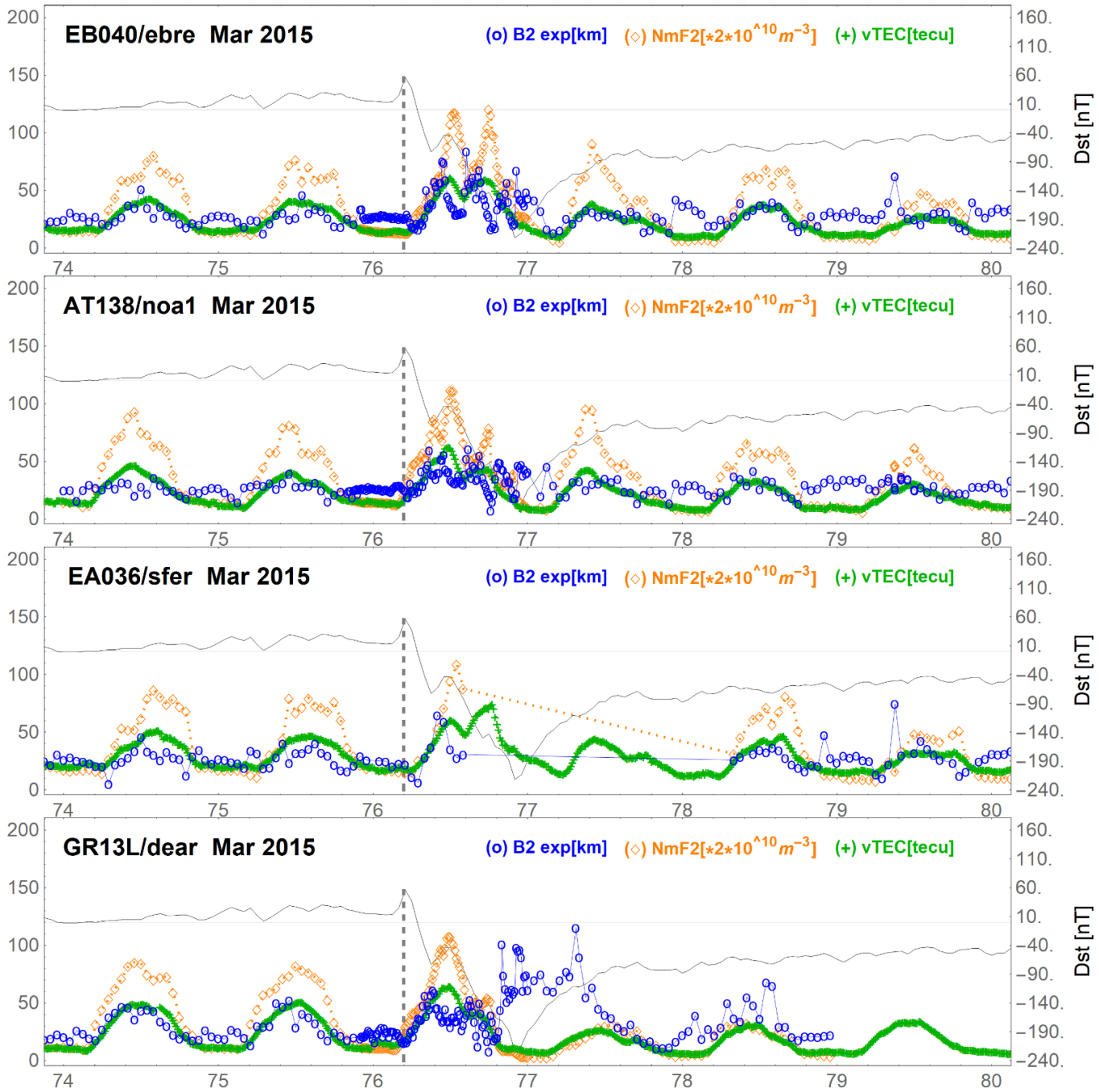


Variations of B2, NmF2 and VTEC at Sanya station during the equinoctial storms October 2, 2013 and March 17, 2015. *No available data for March 15, 2013.*

Storm Location	March 17, 2013 Intense storm Max SYMH => -130 nT	October 2, 2013 Moderate storm Max SYMH => -90 nT	March 17, 2015 Great storm Max SYMH => -234nT
Europe Mid-latitudes	Positive storm +NmF2 +B2 spike	Positive storm +NmF2 +B2 spike	Positive storm +NmF2 +B2 spike
America Mid-latitudes	Positive storm+NmF2 +B2 spike	Positive storm + NmF2 Decrease of B2 Particular case	Negative storm Complex case
America Low latitudes	Positive storm +NmF2 +B2 spike	Positive storm +NmF2 +B2 spike	Positive storm +NmF2 +B2 spike
Asia Mid-latitudes	No effects	Positive storm +NmF2 +B2 spike	Negative storm Complex case
Asia Low latitudes	No data	Positive storm +NmF2 Decrease of B2 Particular case	Negative storm Complex case

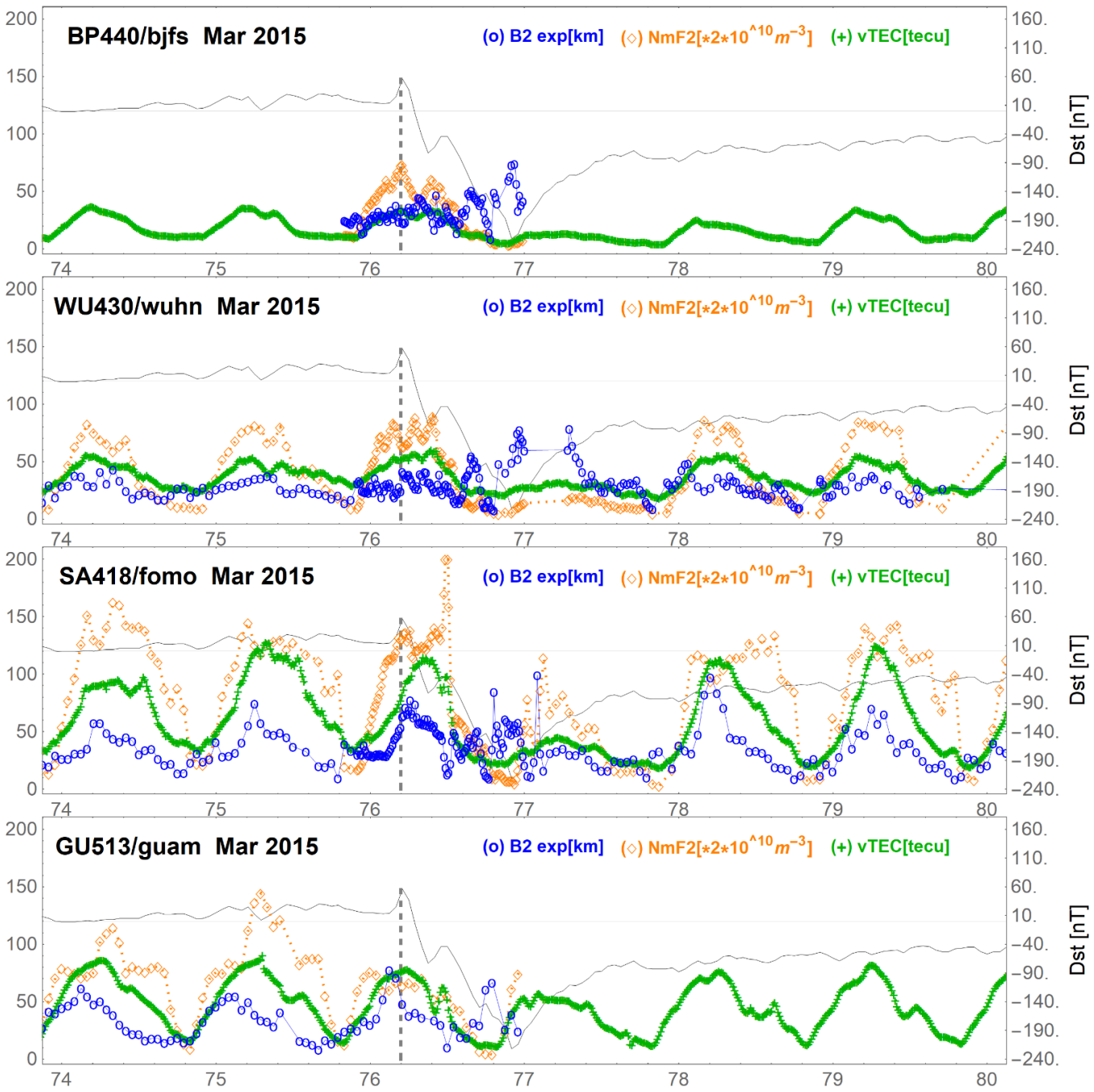
St Patrick 2015 – Europe-Africa

Results



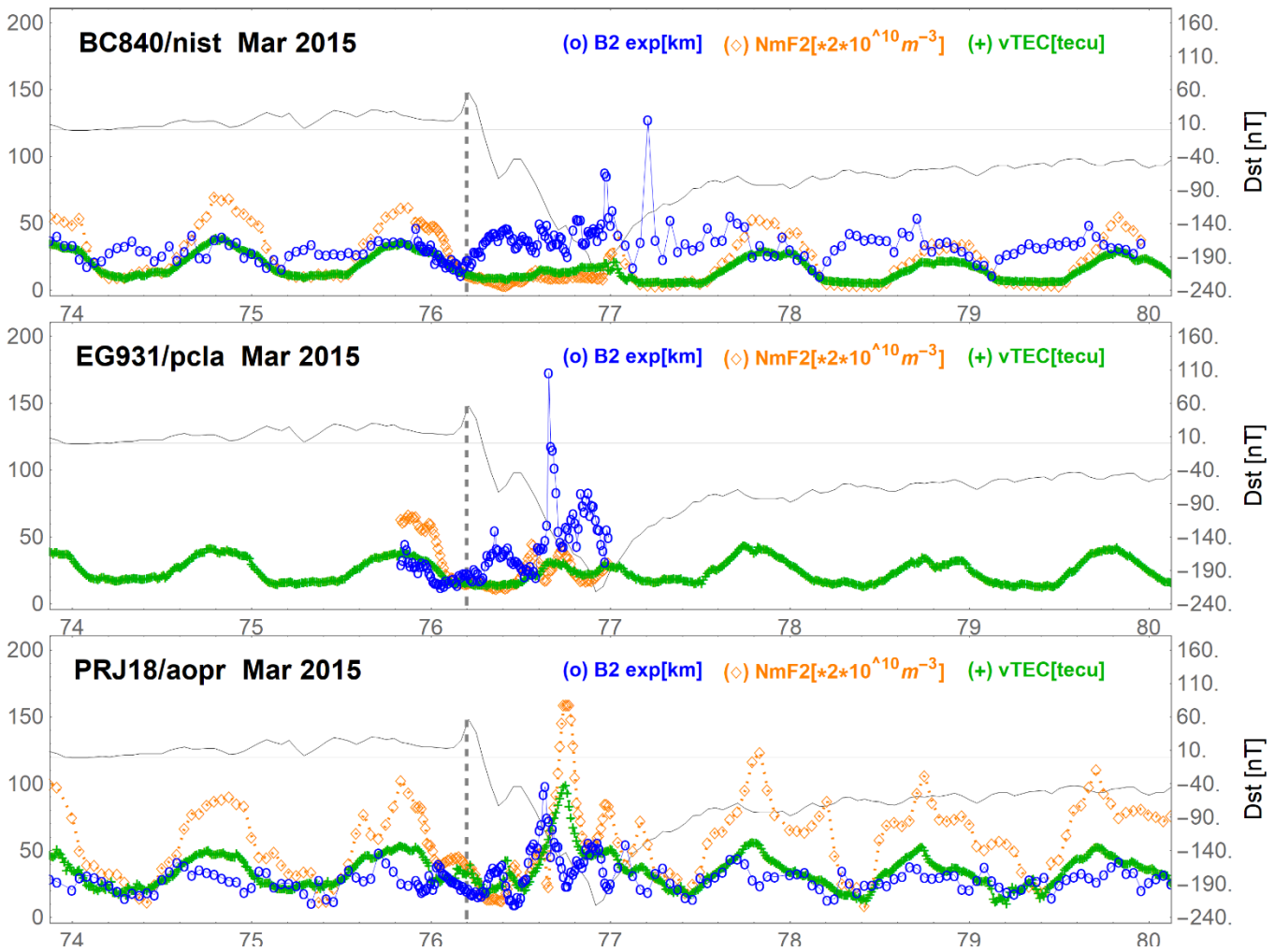
St Patrick 2015 – Asia

Results



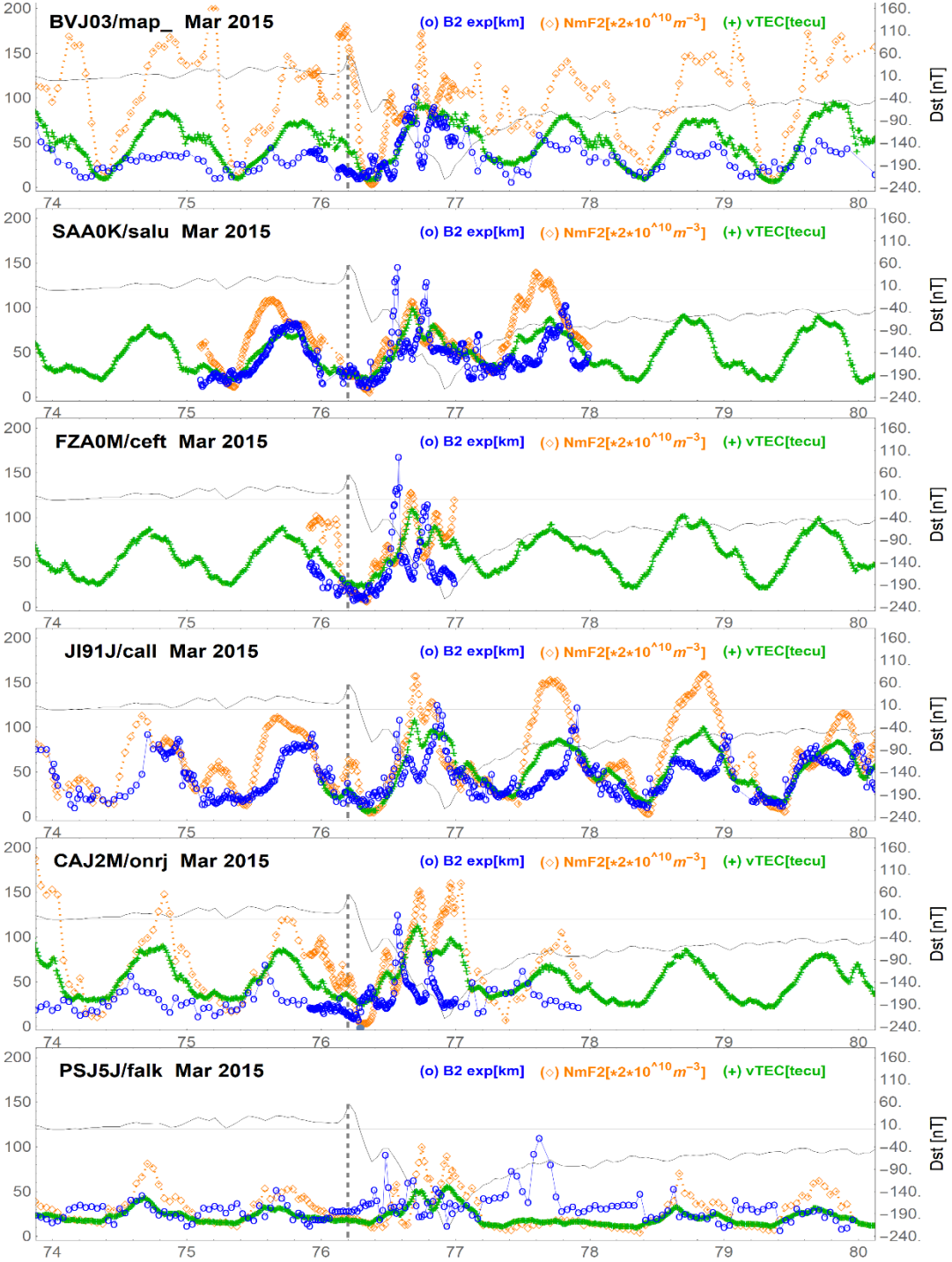
St Patrick 2015 – America (North Hemisphere)

Results



St Patrick 2015 – America (South Hemisphere)

Results



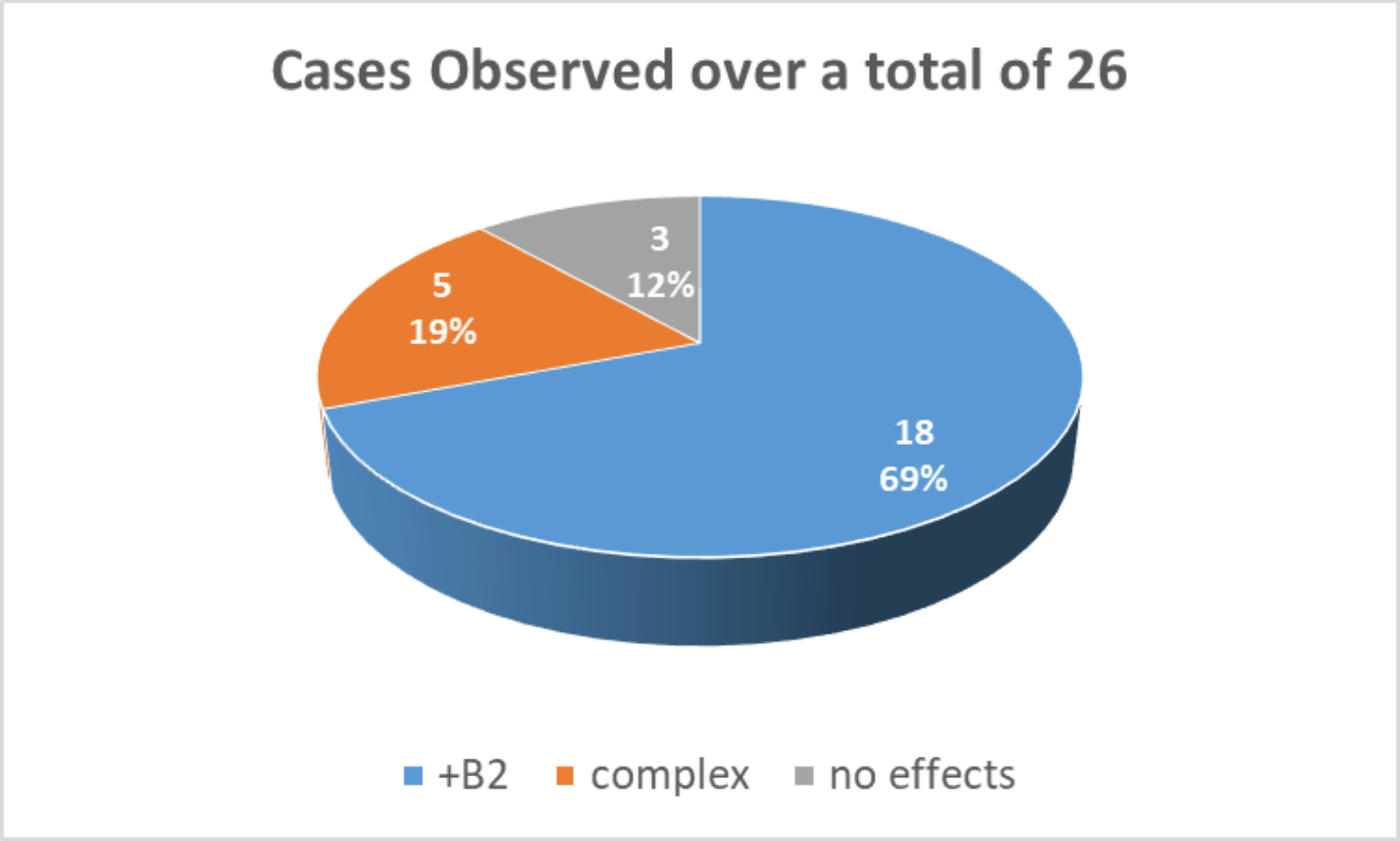
St Patrick 2015, Mid-latitudes

Location/ Station Code	March 17, 2015 Min SYMH => -234nT
America Mid-latitudes Eglin EG931	Positive storm +NmF2 +B2 spike
America Mid- latitudes Ramey PRJ18	Positive storm +NmF2 +B2 spike
America Mid-latitudes Port Stanley PSJ5J	Positive storm +NmF2 +B2 spike
Europe Mid-latitudes San Fernando EA036	Positive storm +NmF2 +B2 spike
Europe Mid-latitudes Athenas AT138	Positive storm +NmF2 +B2 spike
Europe Mid-latitudes Grahamstown GR13L	Both Positive storm +NmF2 +B2 spike Followed by Negative storm Complex case
Asia Mid-latitudes Beijing BP440	Negative storm Complex case

St Patrick 2015, Low latitudes

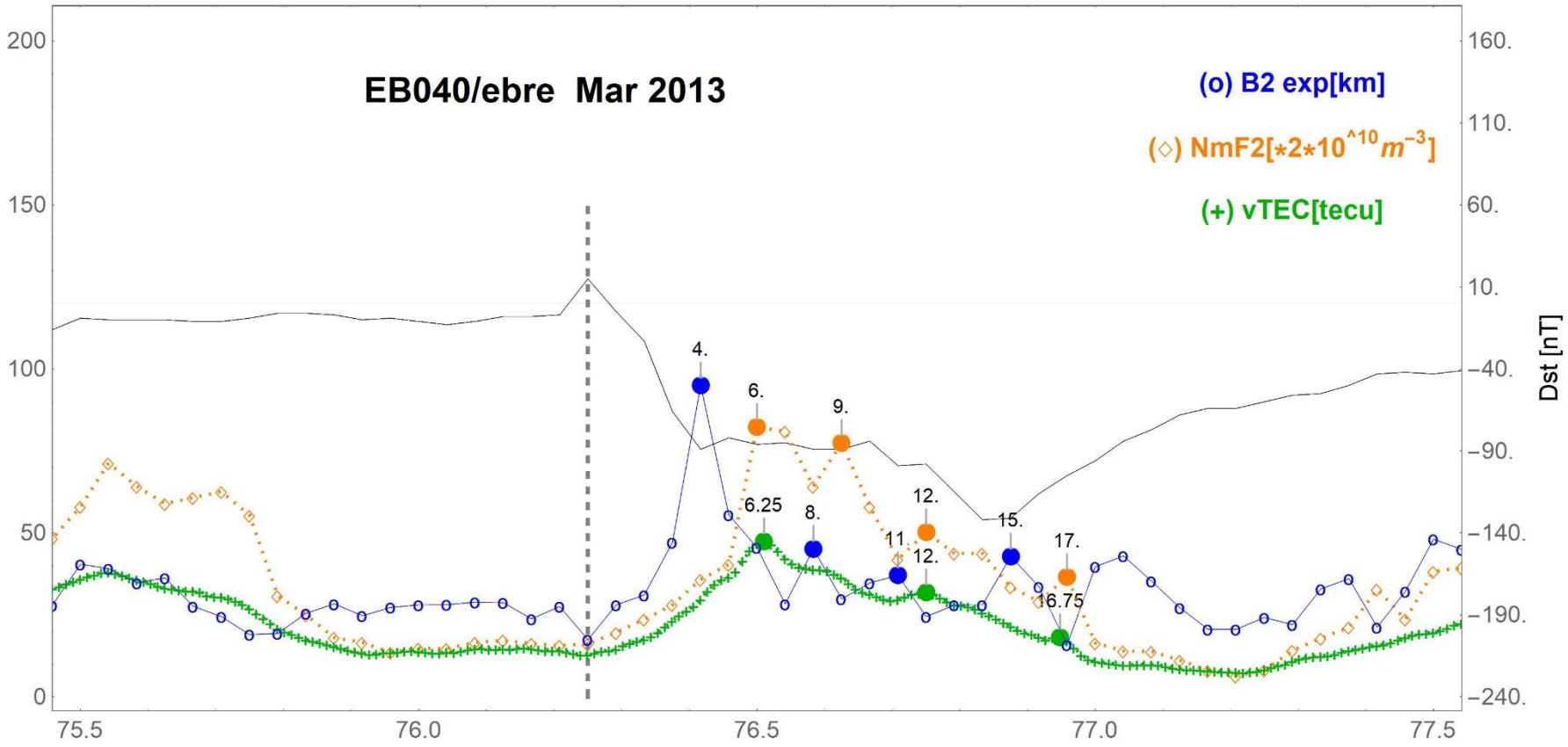
Storm Location Station Code	March 17, 2015 Great storm Min SYMH => -234nT
America Low latitudes Ramey PRJ18	Positive storm +NmF2 +B2 spike
America Low latitudes Boa Vista BVJ03	Positive storm +NmF2 +B2 spike
America Mid-latitudes Sao Luis SAA0K	Positive storm +NmF2 +B2 spike
America Low-latitudes Fortaleza FZA0M	Positive storm +NmF2 +B2 spike
Asia Mid latitudes Wuhan WU430	Negative storm Complex case +B2
Asia Low latitudes Sanya SA418	Negative storm Complex case +B2

Results – Cases Observed



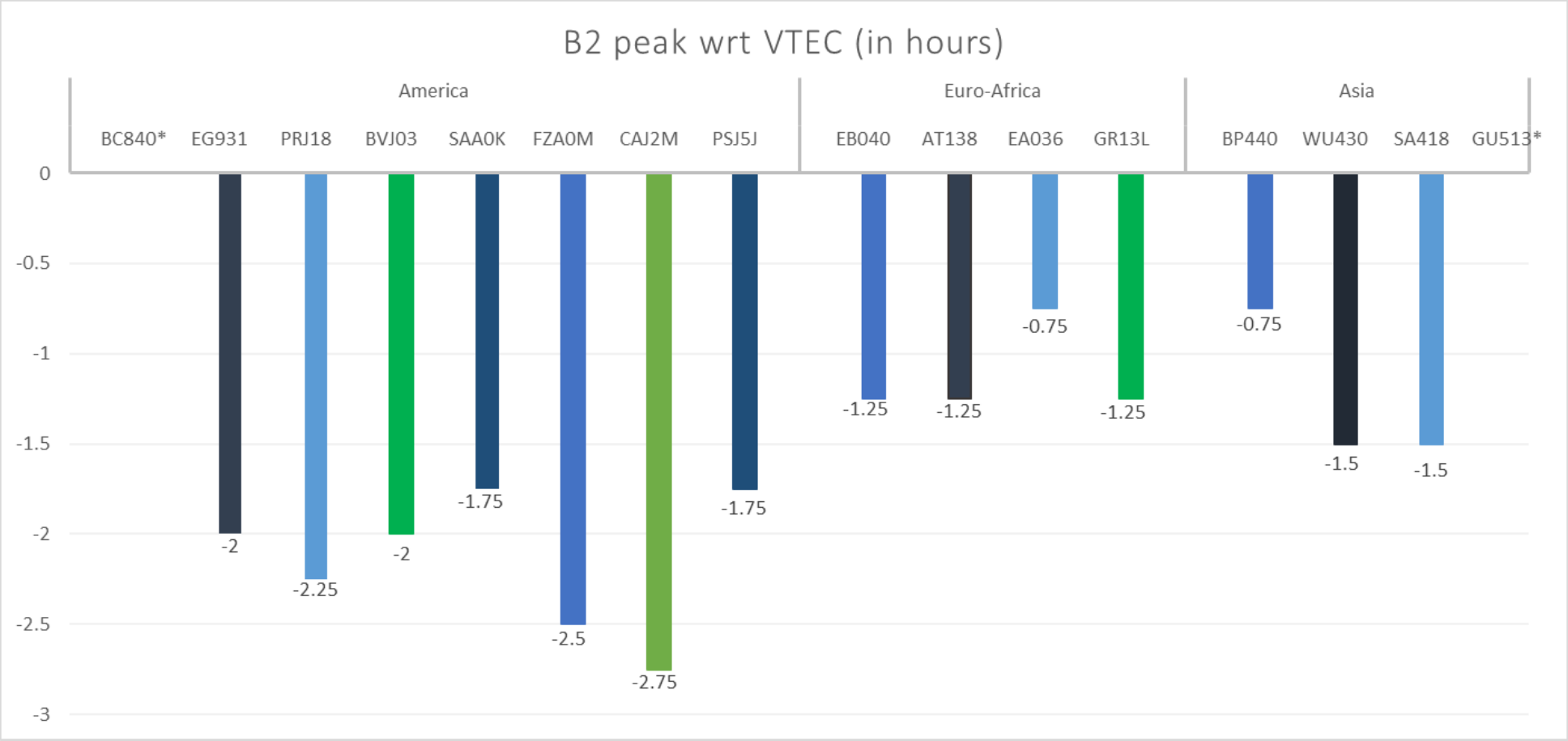
B2 time response Analysis

- To investigate the time of response of the different measurements according to location, data series were subsequently analyzed and correlated.



St Patrick 2015 – Correlation Analysis

Results – B2 response time Analysis



Evaluation of cross correlations between experimental B2bot and GPS VTEC during the 24 hours (UT) of the main phase of the storm of St Patrick 2015 by Regions.

Discussion & Conclusions

Analysis of B2 variation during geomagnetic storms

B2 Analysis
Summary

- The results show 2 main types of behavior of B2, NmF2 and VTEC: +B2 spike and complex cases.

- **Simple Cases**
  The cases of +B2 spike [~70% of observations] with a peak of B2 prior to the increases of NmF2 and VTEC corresponds to ionospheric positive storms.

- **Complex Cases**
  The complex case [~20% of observations] with a fluctuated B2 associated with a decay of NmF2 and VTEC has been observed during negative ionospheric storms.

- The 2 kind of behaviors found correspond to the action of different dominant factors

  Negative storm -> modification due to changes in composition

  Positive storm -> modifications due to transport of ionization

B2 Analysis
Summary (cont.)

- ☑ The analysis on the response time of the different measurements according to location for all the storms studied shows, in general, that B2 reacts before NmF2 and VTEC after the SSC.

- ☑ A detailed evaluation of the response time of B2 with respect to VTEC after SSC done with the St Patrick 2015 storm shows that times go from 45 min to ~3 hours depending on the sector and latitude.

- ☑ Due to the sensitiveness shown during storms, experimentally derived thickness parameters, like B2, can be entered to empirical models in order to adapt them to storm situations.

Thank You