Workshop on the Applications of Global Navigation Satellite Systems, 24-28 June , USP, Suva, Fiji

THE UNIVERSITY OF THE SOUTH PACIFIC

Ionospheric response to Space Weather Events in March 2013 and 2015 and Comparison with Similar Strength Storms of July 2012 and June 2015

Professor Sushil Kumar

School of Engineering and Physics, The University of the South Pacific, Suva, Fiji.

Fax: +679-3231511: kumar_su@usp.ac.fj

THE UNIVERSITY OF THE SOUTH PACIFIC

Space Weather: Geomagnetic Storms

Geomagnetic storms are an important space weather phenomenon which apart from affecting ground and satellite based technological systems can severely affect the dynamics and structure of the Earth's entire thermosphere and ionosphere.

The ionospheric response to a geomagnetic storm is called an **ionospheric storm** and are classified as **positive/negative** ionospheric storm depending upon **increase/decrease** in total electron content (TEC) or critical frequency of the F2-layer (*foF2*).

THE UNIVERSITY OF THE SOUTH PACIFIC

St. Patrick's Day Storms

Three geomagnetic storms with moderate, intense and very intense (severe) intensity occurred near St. Patrick's Day in the month March of years 2012, **2013, and 2015**, respectively.

These storms were driven by intense interplanetary **coronal mass ejections.**

The St. Patrick day geomagnetic storm of 17-19 March 2015 was most intense storm of current solar cycle 24 with minimum of Dst index reaching -222 nT.

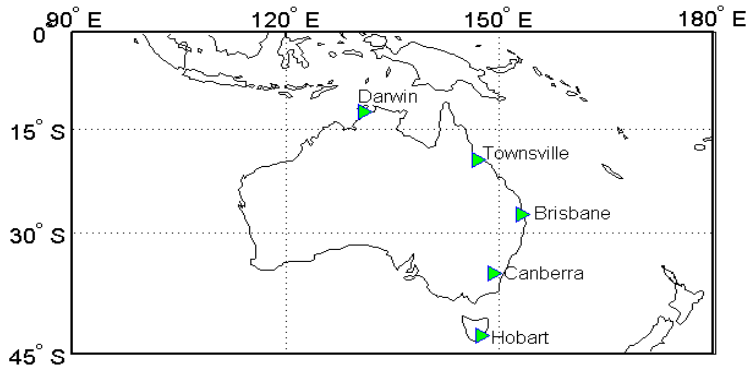
The storm events on 2013 and 2015 were unique in the sense that that they occurred on the same day (17 March) of the year and nearly at the same time (20-22 UT) and attained maximum strength by two step development in the ring current to the different levels.

THE UNIVERSITY OF THE SOUTH PACIFIC

Stations, Data and Analysis

The hourly values of *foF2* measured with ionosonde at two low (DW, TV) and three middle latitude stations (BR, CB, HO) were obtained from World Data Centre, Bureau of Meteorology, Australia (online at http://www.sws.bom.gov.au/World_Data_Centre).

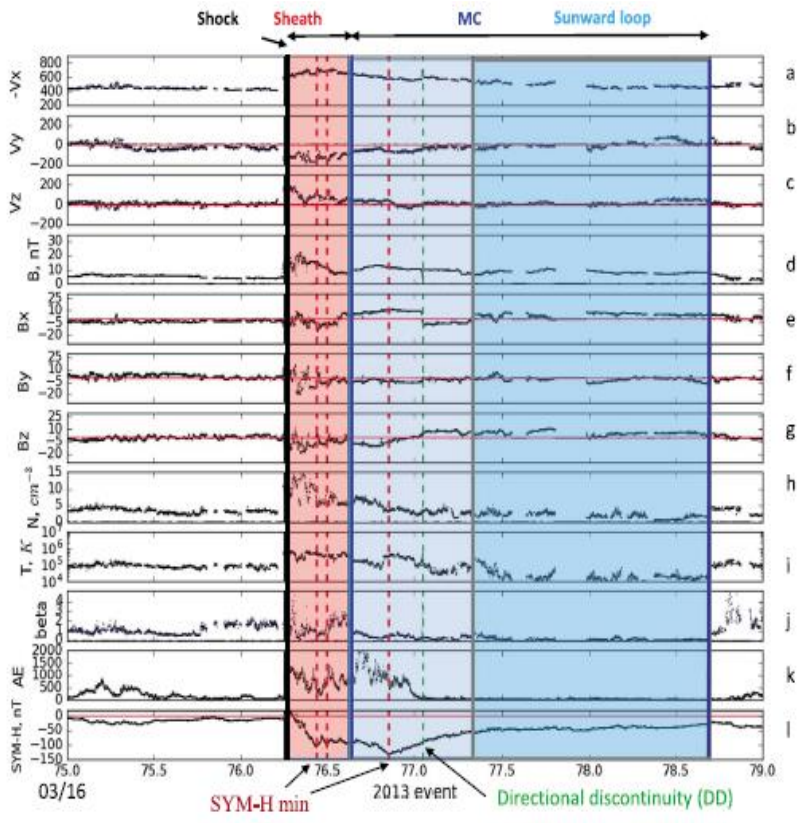
Station	Geographic. Coordinates Lat (°N), Long (°E)	Geomagnetic Coordinates GLat (°N), GLong (°E)
Darwin	-12.45, 130.95	-21.96, 202.84
Townsville	-19.63, 146.85	-28.95, 220.72
Brisbane	-27.53, 152.92	-36.73, 228.93
Canberra	-35.32, 149.00	-45.65, 226.30
Hobart	-42.92, 147.32	-54.17, 226.52



The percentage changes in *foF2* ($\Delta foF2$ %) from median values during the storms were calculated using:

$$\Delta foF2\ \% = \frac{foF2_{storm} - foF2_{mean}}{foF2_{mean}} \times 100$$

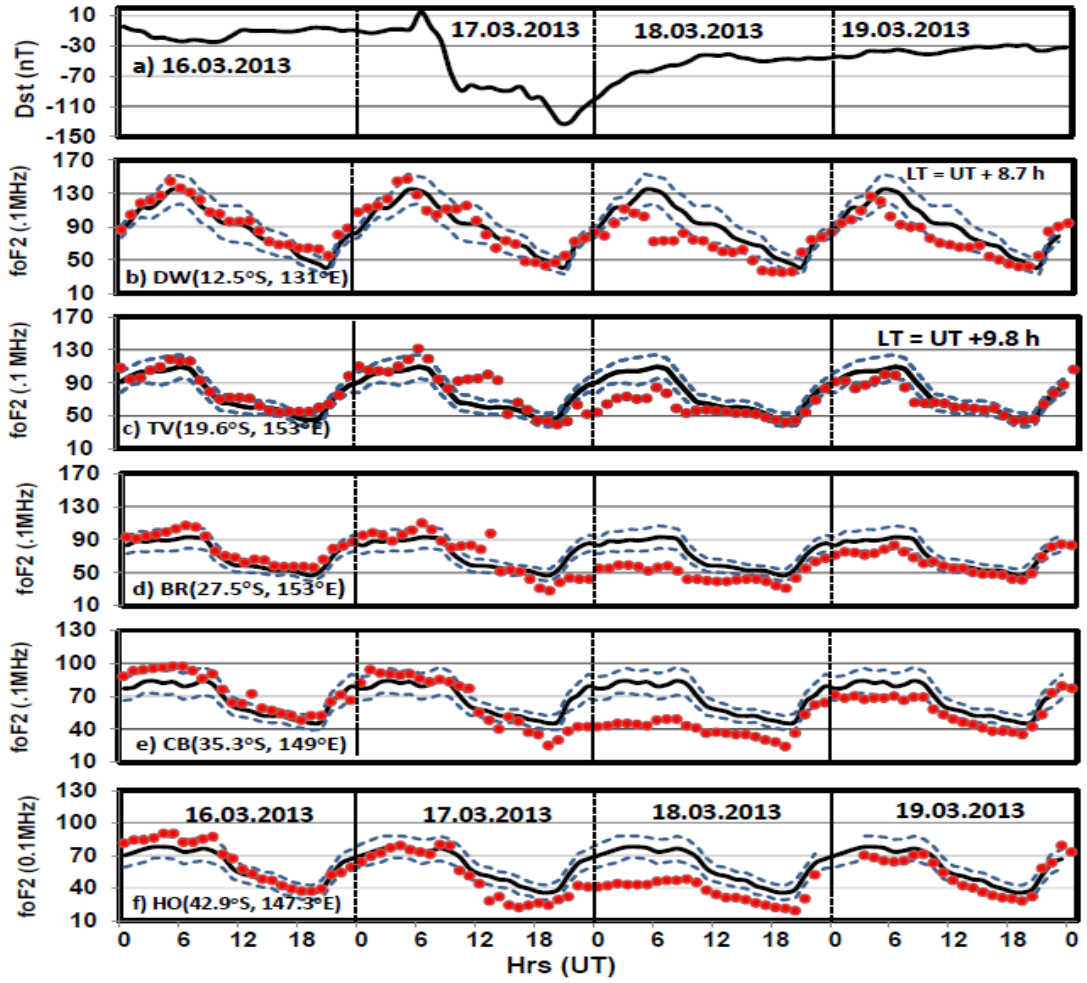
St. Patrick's Day Storm of March 2013



Verkhoglyadova, et al., J. Geophys. Res. Space Physics, 121, doi:10.1002/ 2016JA022883.

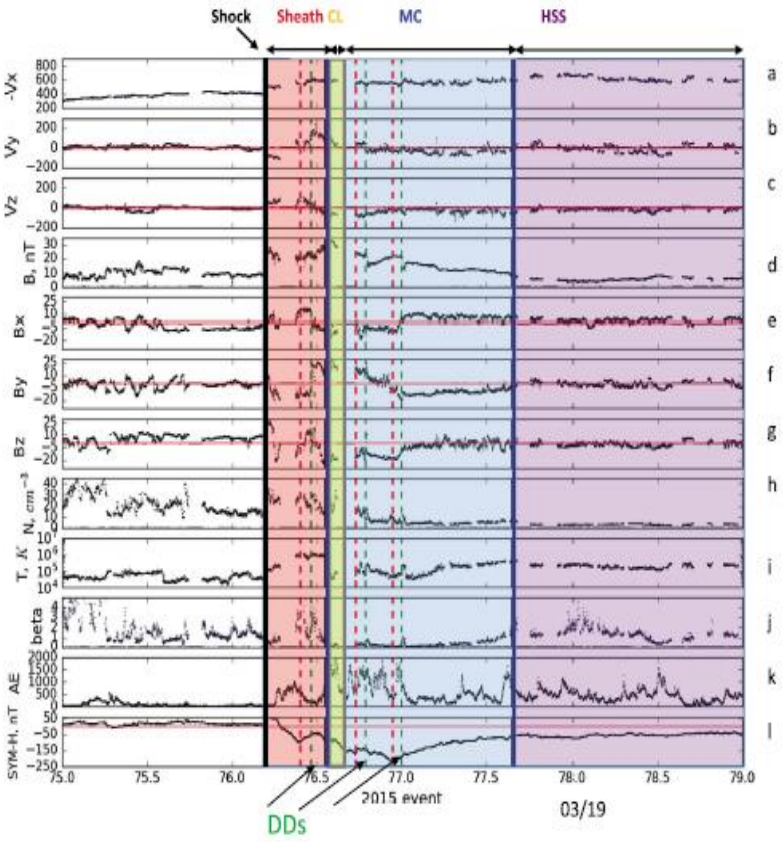
It was associated with coronal mass ejections and developed through two step growth in the ring current. First-step of decrease in *Dst* occurred coincident with initial southward turning of IMF B_Z in the sheath region and *Dst* reached to a minimum value of -89 nT at 10 UT on 17 March. During the slow recovery of the first step of the storm (*Dst*), a long duration MC occurred ~15:22 UT on 17 March to ~16:48 UT on 19 March and during this MC the IMF *Bz* turned southward and second step storm development started in which *Dst* went to a minimum of -132 nT at 20 UT

St. Patrick's Day Storm of March 2013



The important feature to note is the strong decrease in the *foF2* (negative ionospheric effect) during local daytime (~20-08 UT) as compared to local night time (08-20 UT).

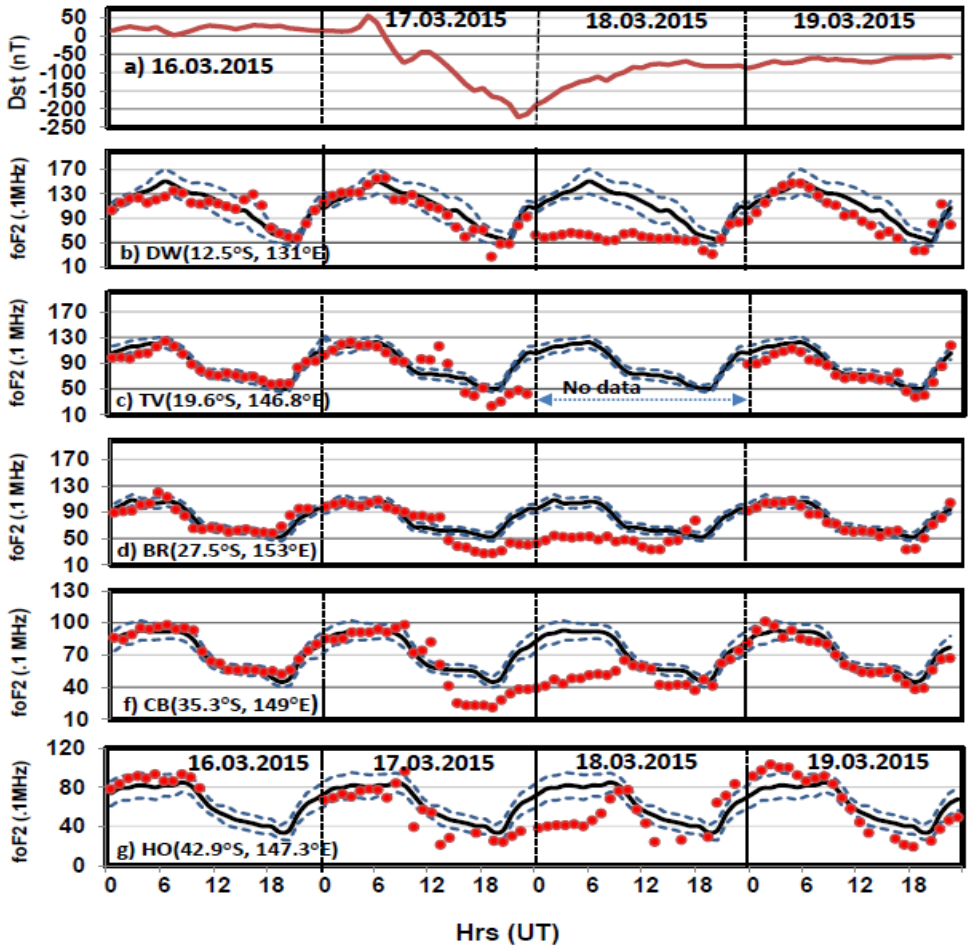
St. Patrick's Day Storm of March 2015



The first step was caused by a southward IMF B_Z in the sheath region and second step by passage of the MC thus showing sheath-sheath-ejecta scenario for the multi-step development of this super storm. The second step of the storm development was of longer duration which was consistent with intense (-10 to -20 nT) and long duration of southward IMF B_Z in the MC which intensified the storm.

Verkhoglyadova, et al. (2017), J. Geophys. Res. Space Physics, 121, doi:10.1002/ 2016JA022883.

St. Patrick's Day Storm of March 2015



The percentage decrease in *foF2* ($\Delta foF2$ %) varied between 35-60% at DW, 40-58% at BR, 43-54% at CB and 35-50% at HO with average percentage decrease in *foF2* ($\Delta foF2$ %) above 40% (table 1) at all the stations.

THE UNIVERSITY OF THE SOUTH PACIFIC

Summary of Storm Effects

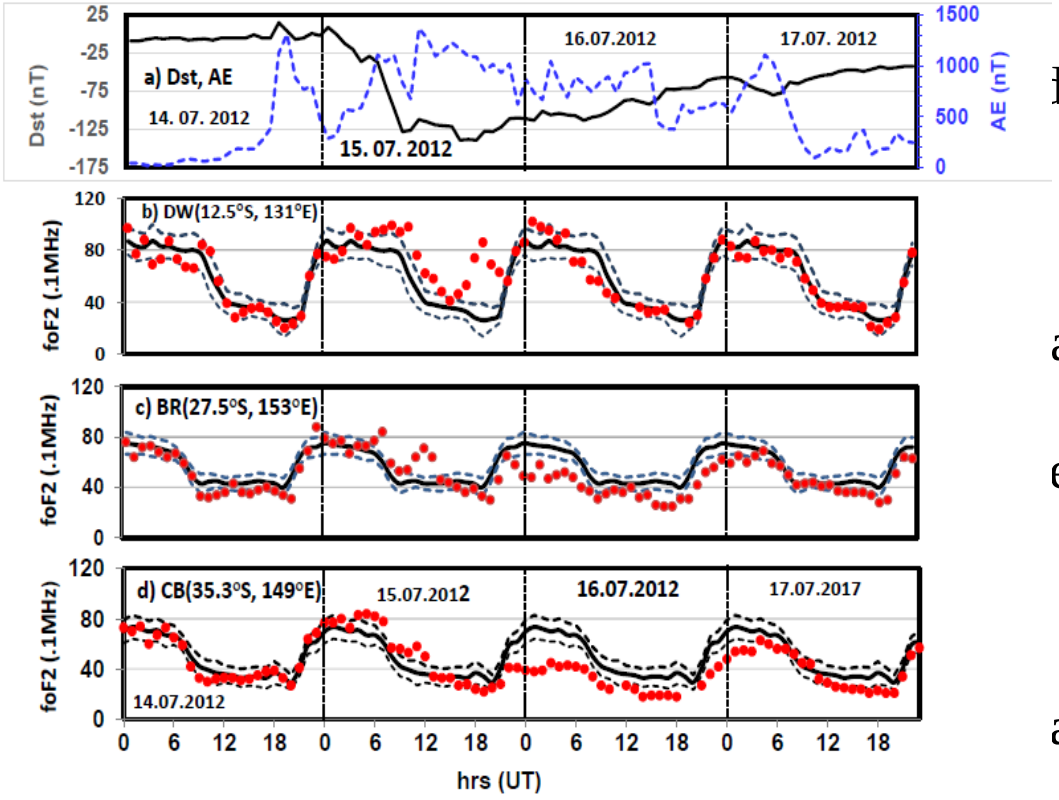
Table 1.0.The geographic and geomagnetic coordinates of IPS stations and average percentage of change in foF2 (Δ*foF2*) from the median values and duration of storm effect (Δ*foF2*) during three storms near St. Patrick's Day in 2013, and 2015.

•NC indicates no change. The minus sign in %Δ*foF2* indicates the decrease in *foF2* from median level.

Station	Geographic. Coordinates Lat (°N), Long (°E)	Geomagnetic Coordinates GLat (°N), GLong (°E)	March 2013 -132 nT		March 2015 -234 nT	
			%ΔfoF2	ΔfoF2(h)	%ΔfoF2	ΔfoF2(h)
Darwin	-12.45, 130.95	-21.96, 202.84	-26.0	18	-42.3	24
Townsville	-19.63, 146.85	-28.95, 220.72	-29.9	15	ND	ND
Brisbane	-27.53, 152.92	-36.73, 228.93	-29.1	40	-44.8	26
Canberra	-35.32, 149.00	-45.65, 226.30	-30.0	50	-46.5	20
Hobart	-42.92, 147.32	-54.17, 226.52	-36.6	36	-34.7	23

THE UNIVERSITY OF THE SOUTH PACIFIC

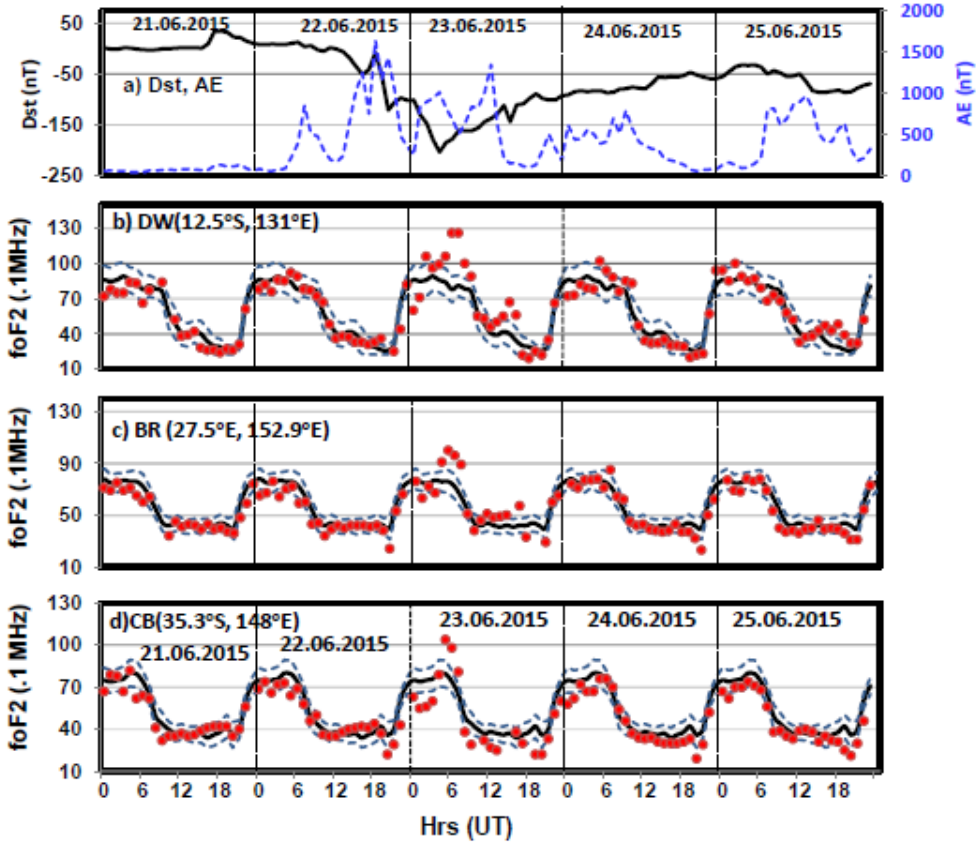
Intense Storm of July 2012



There was an increase in f_oF_2 during both the step levelopments of July 2012 storm which was most (up to 210%) pronounced at the low latitude station, DW less (~48%) at BR and least (24%) at CB and lasted for about 06, 03 and 03 hrs, espectively. During the recovery phase of the July 2012 storm, there occurred a long duration decrease in the foF2 at mid-atitude stations, BR and CB only

THE UNIVERSITY OF THE SOUTH PACIFIC

Intense Storm of June 2015:



Associated with the second step storm development, the f_oF_2 increased sharply with a maximum increase at the low latitude station, DW. This increase in f_oF_2 lasted for about 3-5 hrs with a few hours in the recovery phase. The percentage increase in f_oF_2 (Δf_oF_2 %) varied from about 25 to 61 % at DW, 19.7 to 39% at BR and 28.9 to 38.9 % at CB.

Comparison: March 2013 and July 2012 storms

A comparison of average $\Delta foF2$ (%) and $\Delta foF2$ (h) using ionosonde foF_2 between March 2013 and July 2012 storms at three stations during recovery phases of these storms.

Station	March 2013 -132 nT		July 2012 -139 nT	
	$\Delta f_o F_2$(%)	$\Delta f_o F_2$(h)	$\Delta f_o F_2$(%)	$\Delta f_o F_2$(h)
Darwin (low latitude)	-26.0	18	NC	NC
Brisbane (mid latitude)	-29.1	21	-24.8	24
Canberra (mid-latitude)	-30.0	26	-28.6	29

NC indicates no change. The minus sign in $\%\Delta foF_2$ indicates the decrease in *foF2* from median level

THE UNIVERSITY OF THE SOUTH PACIFIC

Comparison: March2013 and June 2015

A comparison of average $\Delta foF2$ (%) and $\Delta foF2$ (h) using ionosonde foF_2 between March 2015 and June 2015 storms at three stations during their recovery phases of these storms.

Station	March 2015 -234 nT		June 2015 −195 nT	
	$\Delta f_o F_2$(%)	$\Delta f_o F_2$(h)	$\Delta f_o F_2$(%)	$\Delta f_o F_2$(h)
Darwin (low latitude)	-42.3	24	+30.1	06
Brisbane (mid latitude)	-44.8	26	+30.9	05
Canberra (mid latitude)	-46.5	20	+30.0	04

•The minus sign in %$\Delta foF2$ indicates the decrease in foF_2 from median level.

THE UNIVERSITY OF THE SOUTH PACIFIC

Summary and Conclusions

- **During the recovery phase of the ST Patrick geomagnetic storms (March 2013, 15) ionosphere at southern mid-latitudes showed long duration negative ionospheric storm in foF2 which correlated well with strength of the storms as negative ionospheric storm was most intense for March 2015 storm (Dst = -222 nT) and less for March 2013 storm.**

- **The long duration negative ionospheric effect could be partly due to combined effect of change in electrodynamics due to PPEF and DDEF and mainly due to transport of high latitude gas with depleted O/N2 ratio and the TADs/TIDs to low latitudes associated with high latitude joule heating.**

Session Announcement

THE UNIVERSITY OF THE SOUTH PACIFIC

Session Title:

NH022. Global Ionospheric and Thermospheric Response to Extreme Terrestrial and Space Weather Hazards

Session Description:

The ionosphere and thermosphere system (IT) is strongly driven by energy, momentum and particle inputs from the solar EUV radiation, solar wind, magnetosphere from top and below by tropospheric events. Here we focus on consequences of terrestrial hazards such as tropical cyclones, earthquakes and volcanic eruptions and space weather hazards such as intense geomagnetic storms and strong solar flares that can seriously affect the IT System. We welcome papers on experimental observations, empirical and theoretical modelling studies, and forecasting efforts, concerning terrestrial and space hazards impact on the lower ionosphere (D-region) and upper ionosphere (F-region) and thermosphere using both satellite and ground based measurement techniques such as Ionosonde, GNSS/GPS, VLF radio waves, airglow, probes and detectors. Papers dealing with monitoring and characterization of ionospheric scintillation and irregularities and their influences on GNSS signals, GPS meteorology missions such as COSMIC, generation and propagation of AGWs/TIDs, and relevant topics, are also welcome.

Primary Convener **Sushil Kumar**

Primary Email: kumar_su@usp.ac.fj
Affiliation(s):
The University of the South Pacific
School of Engineering and Physics
Suva (Fiji)

Convener Steven A Cummer
Primary Email: cummer@ee.duke.edu
Affiliation(s):
Duke University
Electrical and Computer Engineering Department
Durham NC (United States)

Convener P. T. Jayachandran
Primary Email: jaya@unb.ca
Affiliation(s):
University of New Brunswick
Department of Physics
Fredericton (Canada)

FijiTV 1 News

6/25/2019 Workshop to raise global awareness on benefits of global navigation satellite systems – FIJI TV

The University of the South Pacific hosted participants from over 28 countries at the opening of a 4 day Workshop on the Applications of Global Navigation Satellite Systems(GNSS) in Suva today.

The workshop which was officiated by the Minister for Infrastructure & Transport and Disaster management for Infrastructure & Meteorological Services, Hon.Jone Usamate saw participants from America,China,Russia, Africa, Asia and Pacific Island countries.

USP
THE UNIVERSITY OF THE SOUTH PACIFIC

THANK YOU