IRI-2016 evaluation of African low-latitude ionosphere during 2015 St. Patrick's Day storm main phase

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JACOB OLUSEGUN ADENIYI SYMPOSIUM ON EQUATORIAL IONOSPHERE
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OUTLINE

- **INTRODUCTION**
  - ✓ **International Reference Ionosphere (IRI) overview**
  - ✓ **Description of 2015 St. Patrick's Day storm**
  - ✓ **Some geospace response to the storm**
- **DATA AND METHOD**
- **RESULTS**
  - ✓ **African southern low-latitude TEC response to Main Phase event**
  - ✓ **IRI storm-time model validation**
- **CONCLUSION**

INTRODUCTION

- **IRI is a data-based/empirical model.**
- **Limitations of theory-based models such as evolving theoretical understanding.**
- **Based on most of the available and reliable observations.**

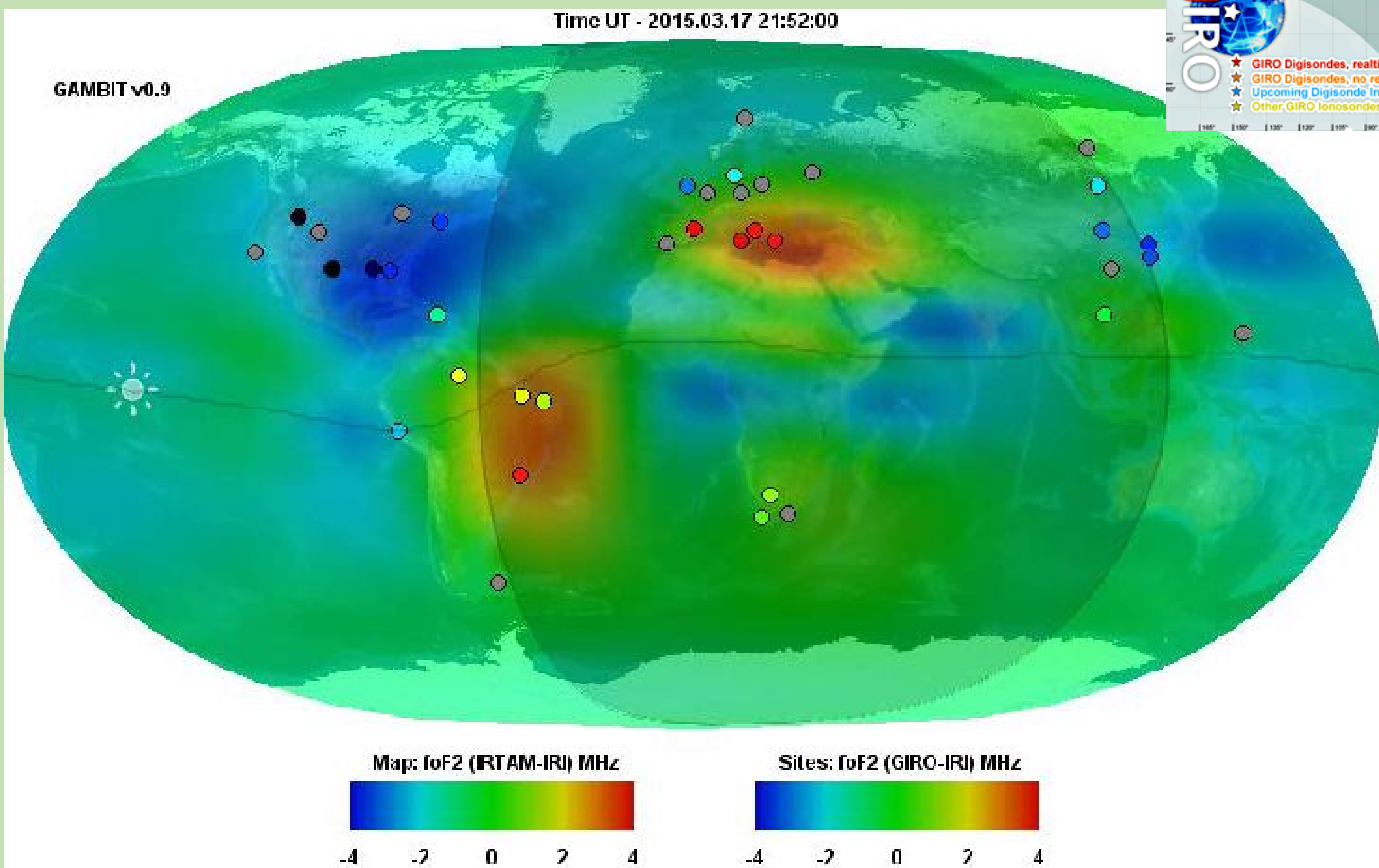
  IRI-95, IRI-2001, IRI-2007, IRI-2012, IRI-2016
- **About 50 international experts "Working Group" - IRI development & improvement.**
- **Extensive and excellent results.**
- **Standard Ionospheric Climatological model (ISO 16457:2014)**

  (https://www.iso.org/standard/61556.html, Retrieved Sept. 25, 2017)
- **Improvement on transient and near-real-time values.**

- **March 17, 2015 storm**
  - Most intense in the 24th solar cycle, although underestimated by forecasters (Astafyeva et al. 2015, Jacobsen and Andalsvik 2016)
  - Severe scintillation in GNSS signal (Jacobsen and Andalsvik 2016)
  - Absence of PRE around the equator during main phase (Hairston et al. 2016, Kalita et al. 2016)

INTRODUCTION *cont'd*

Distribution of "GIRO" live and future stations as at Sept. 25, 2017.
(giro.uml.edu)



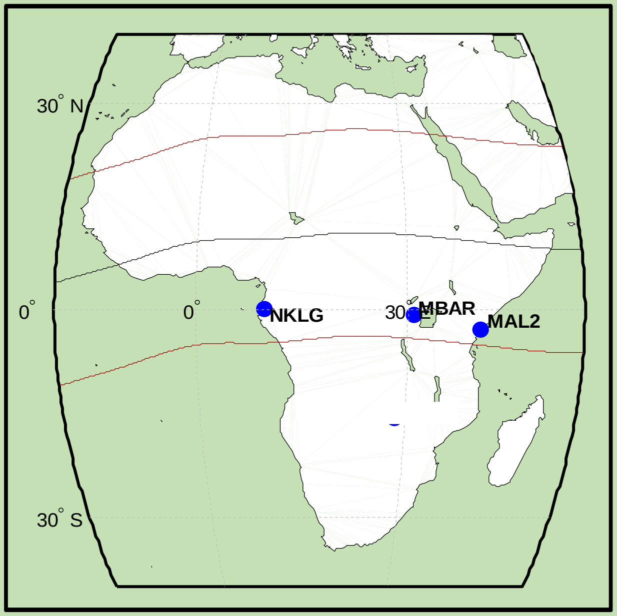
Global map of IRTAM-foF2 and GIRO-foF2 deviation from IRI at 21:52UT on St. Patrick Day storm – March 17, 2015 (Galkin et al. 2016)

METHOD

- **March 17, 2015**
  - ✓ $F10.7 = 113 \times 10^{-22} Wm^{-2}Hz^{-1}$
  - ✓ $minimum\ SYM - H = -234nT\ (around\ 2300\ UT)$
  - ✓ $Peak\ AE = 1570nT\ (at\ 1400\ UT)$
  - ✓ *Daily ap = 108nT*

List of Stations used for this work

Location	Station ID	Country	Geographic		Geomagnetic		LT
			Latitude	**Longitude**	**Latitude**	**Longitude**	
Libreville	NKLG	Gabon	0.35º N	9.67º E	8.05º S	81.05º E	UT+1hr
Mbarara	MBAR	Uganda	0.60º S	30.74º E	10.25º S	102.36º E	UT+2hr
Malindi	MAL2	Kenya	2.70º S	40.19º E	12.10º S	111.87º E	UT+3hr

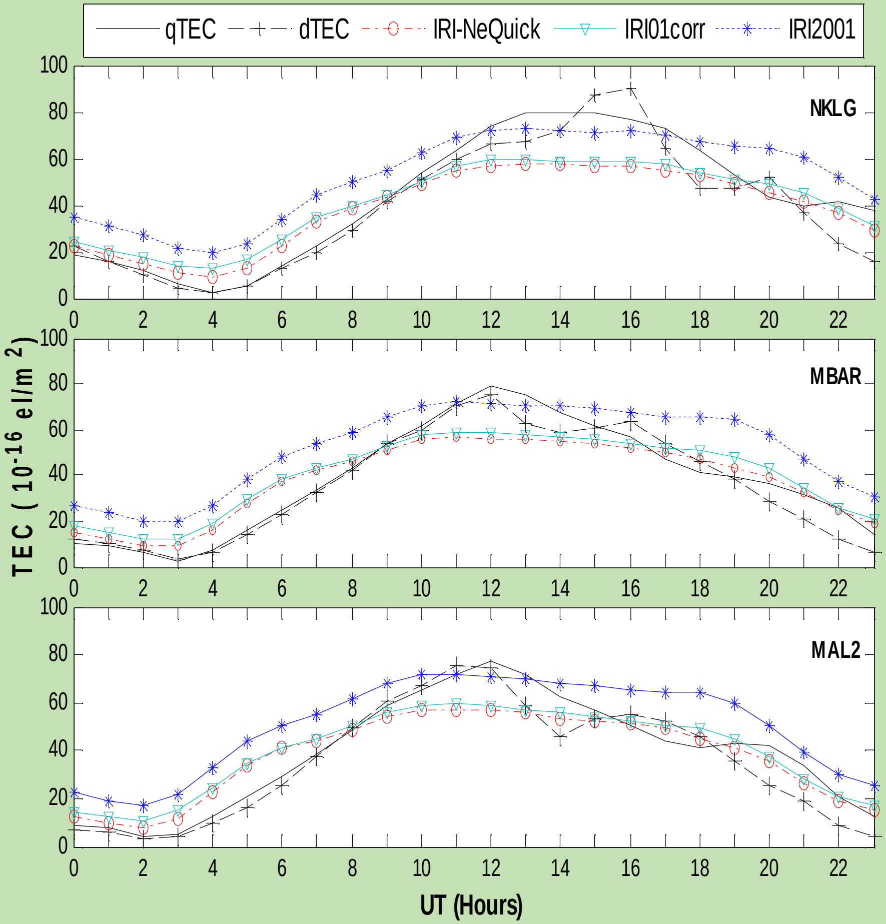


- **IRI-2016**

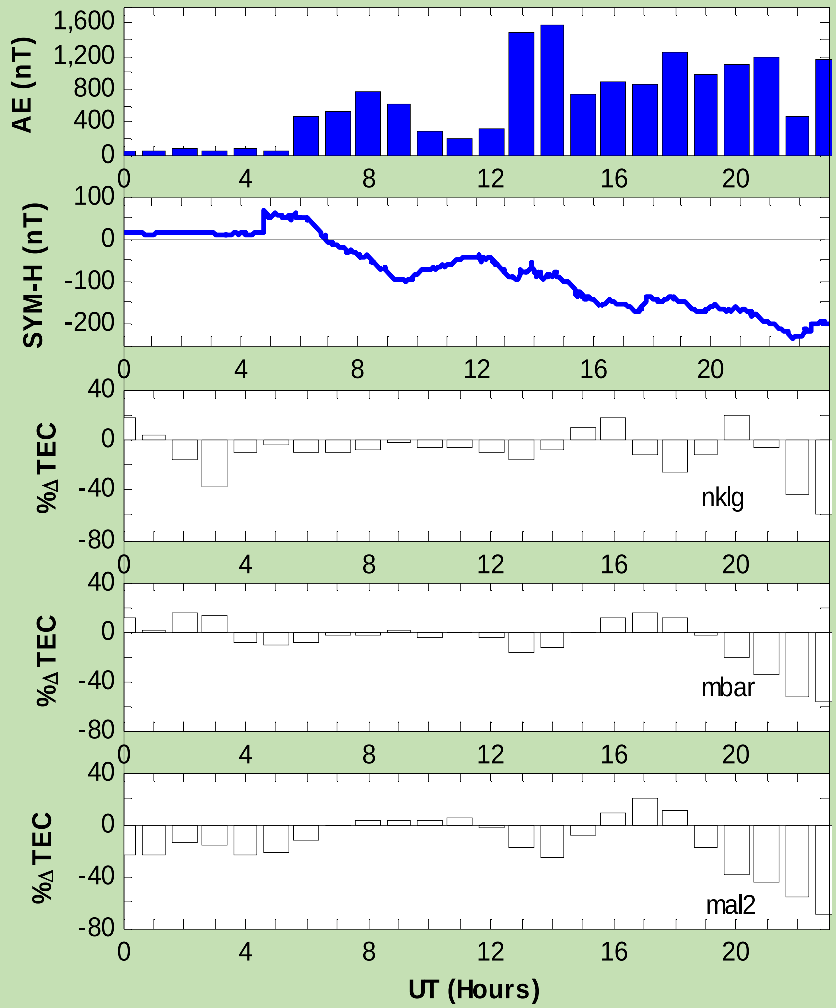
  Topside options - NeQuick
  - IRI01corr
  - IRI2001

  Bottomside options - URSI

RESULTS

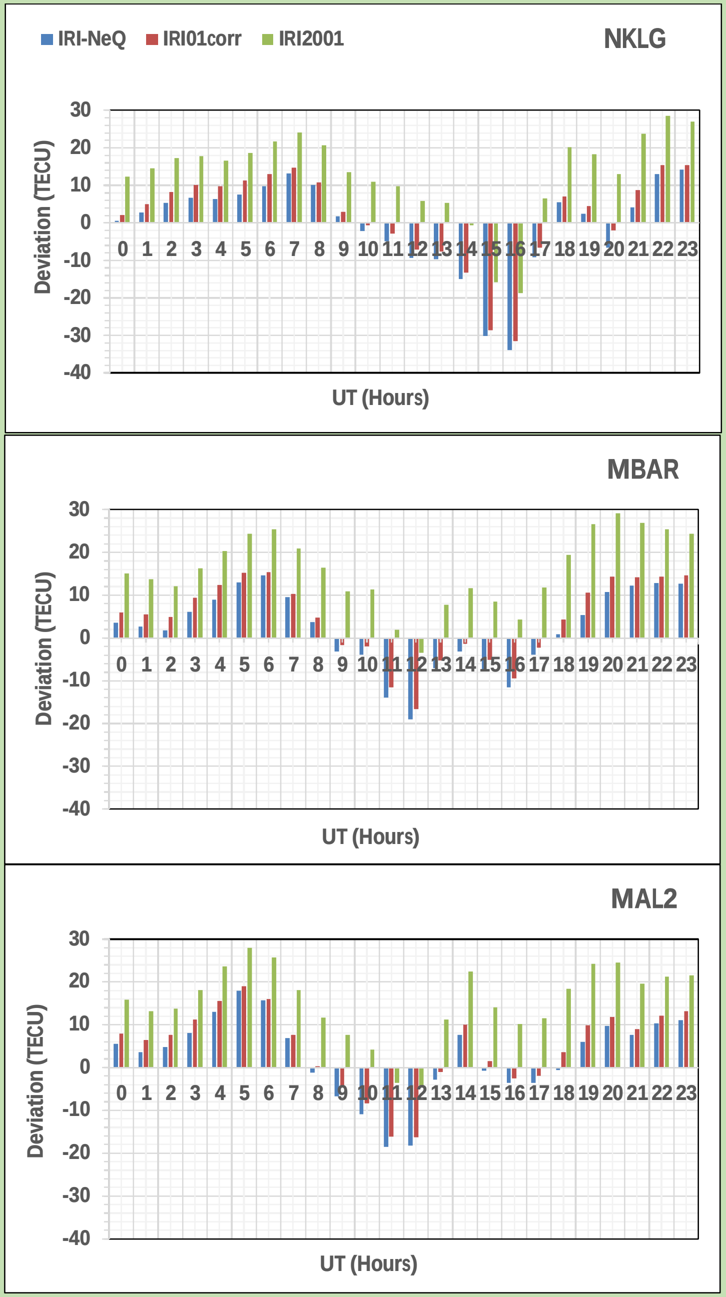


Morphology of observed and modelled TEC data at the three African low latitude stations.

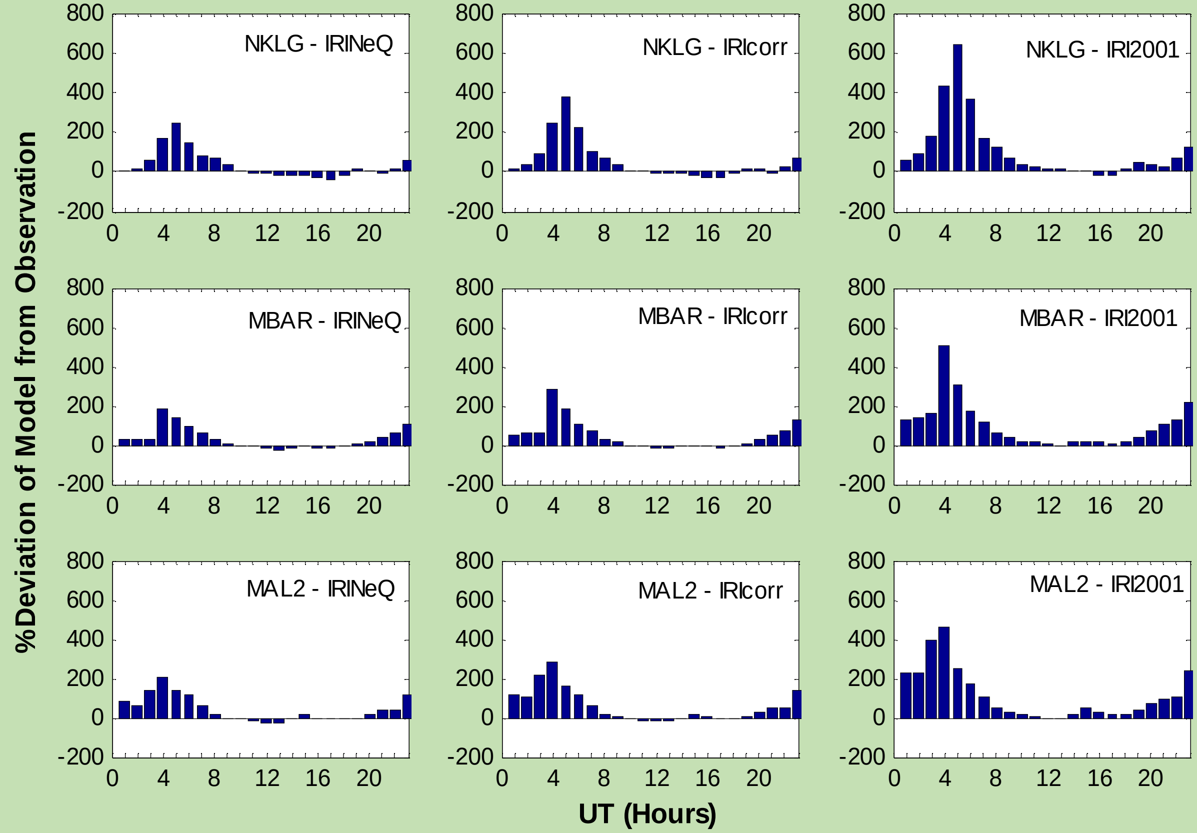


%Deviation of TEC from quiet time value during the Storm Main Phase at the three African low latitude stations

RESULTS *cont'd*



Deviation of modelled TEC values from Observed TEC values on 17 March 2015



% Deviation of modelled TEC values from Observed TEC values on 17 March 2015

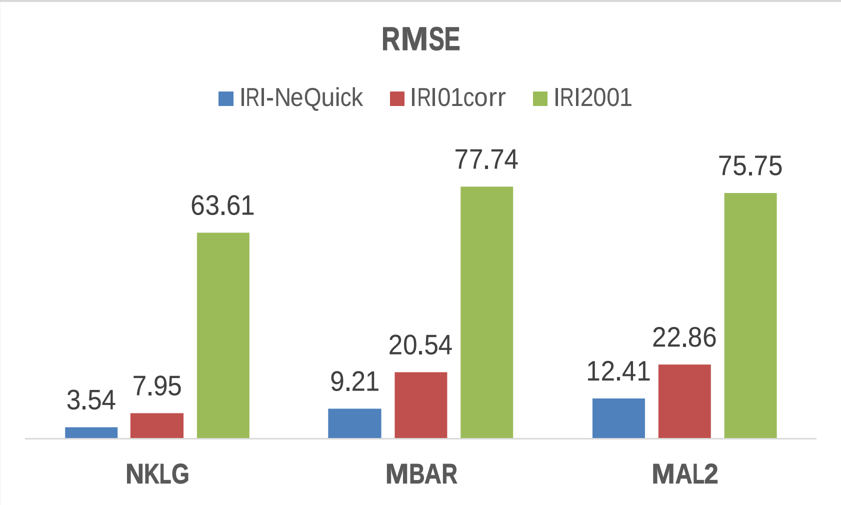
RESULTS *cont'd*

RMSE for the three IRI topside options during the period of high deviation from observation

	NKLG		MBAR		MAL2	
	0100 – 0800 UT	1800 – 2300 UT	0100 – 0800 UT	1800 – 2300 UT	0100 – 0800 UT	1800 – 2300 UT
IRI-NeQuick	21.9	13.3	21.3	22.3	24.3	18.0
IRI-01corr	29.3	20.0	27.5	29.5	29.6	24.3
IRI-2001	53.5	53.5	52.9	61.9	53.8	52.9

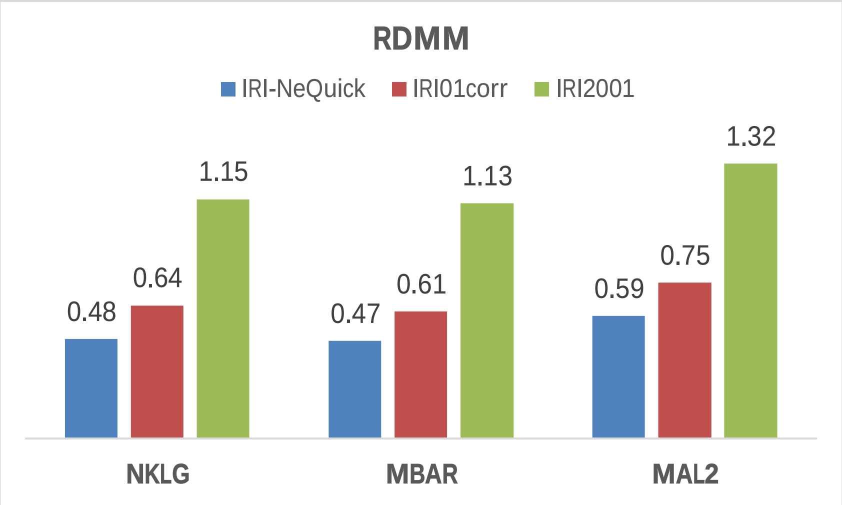
RMSE for the three IRI topside options during the storm main phase

	NKLG	MBAR	MAL2
IRI-NeQuick	3.5	9.2	12.4
IRI-01corr	7.9	20.5	22.9
IRI-2001	63.6	77.7	75.8



RDMM for the three IRI topside options during the storm main phase

	NKLG	MBAR	MAL2
IRI-NeQuick	0.48	0.47	0.59
IRI-01corr	0.64	0.61	0.75
IRI-2001	1.15	1.13	1.32



CONCLUSIONS

- TEC response to the storm main phase is inconsiderable except towards the period of minimum SYM-H, which falls towards 2200UT.

- The three IRI options presented the general morphology, but could not reproduce the signature of the storm event as reflected on the observed TEC.

- The three model options overestimated for the larger part of the day except between 0900 and 1700 UT, where there is underestimation.

- Deviation of modelled from observed TEC values is higher around the SSC and the minimum SYM-H, which falls around post-midnight and post sunset periods respectively.

- The NeQuick option performed better than others across the three low-latitude stations with a Root-Mean-Square Error (RMSE) value of 3.5TECU and Relative Deviation Module Mean (RDMM) of 0.48 at NKLG.

- With the lowest RDMM of 0.48, which is >0.06, even the best of the IRI options has poor agreement with observations.

Professor J.O. Adeniyi

-Father
-Mentor
-Role model
-Giant
-Angel

References

- Galkin I.A., Huang X., Reinisch B.W., Vesnin A.M., and Bilitza D. (2016), Assimilation of Sparse Continuous Ionosonde data into Real-Time IRI, *Internal Beacon Satellite Symposium (BSS-2016) Abstract.*
- Bilitza D. (2006), The International Reference Ionosphere – Climatological Standard for the Ionosphere. *In Characterising the Ionosphere* (pp. 32-1 – 32-12). Meeting Proceedimgs RTO-MP-IST-056, Paper 32, Neuilly-sur=Seine, France: RTO. Available from http://www.rto.nate.int/abstracts.asp
- Astafyeva, E., Zakharenkova, I., and Förster, M. (2015), Ionospheric response to the 2015 St. Patrick's Day storm: A global multi-instrument overview, *J. Geophy. Res. Space Physics, 120(10),* 9023 – 9037, doi:10.1002/2015JA021629
- Hairston M., Coley W.R., and Stoneback R. (2016), Responses in the polar and equatorial ionosphere to the March 2015 St. Patrick Day storm, *J. Geophys. Res. Space Physics, 121,* 11213 – 11234, doi:10.1002/2016JA02316
- Jacobsen, K.S. and Andalsvik, Y.L. (2016), Overview of the 2015 St. Patrick's day storm and its consequences for RTK and PPP positioning in Norway, *J. Space Weather Space Clim., 6,* A9, doi:10.1051/swsc/2016004
- Kalita B.R., Hazarika R., Kakoti G., Bhuyan P.K., Chakrabarty D., Seemala G.K., Wang K., Sharma S., Yokoyama T., Supnithi P., Komolmis T., Yatini C.Y., Huy M.L., and Roy P. (2016), Conjugate hemisphere ionospheric response to the St. Patrick's Day storms of 2013 and 2015 in the 100^{o}E longitude sector, *J. Geophys. Res. Space Physics,* doi:10.1002/2016JA023119