Monitoring, Understanding, and Forecasting the Ionosphere: Thirteen Years of Progress Recorded in the Space Weather Journal

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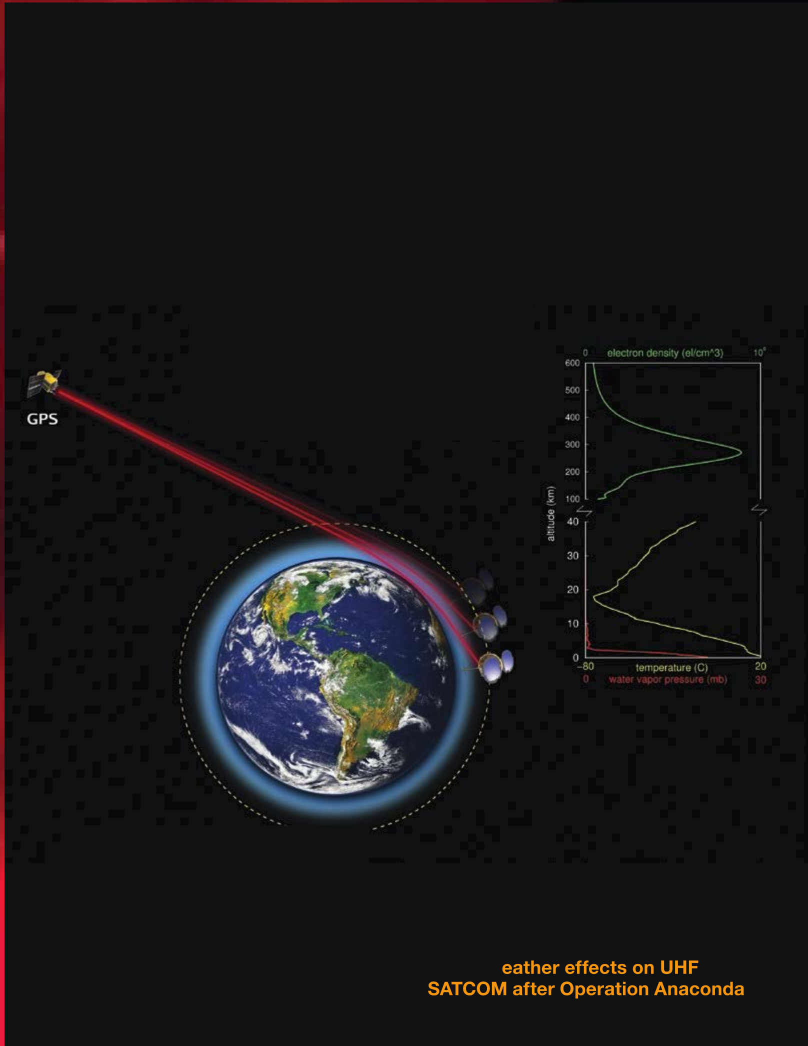
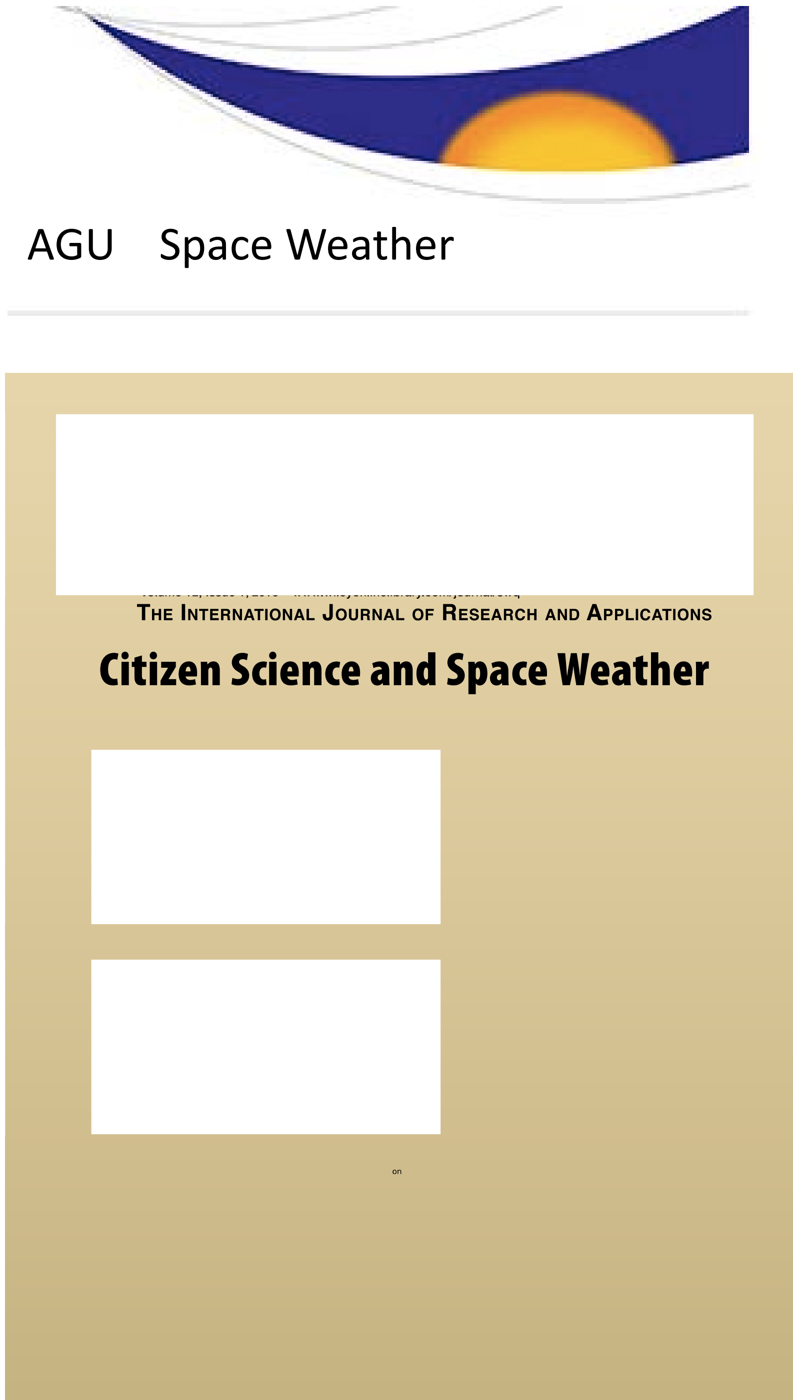


ICTP-IBSS June 2016

Overview

- Background/Facts about Space Weather (SWE)
- Trends in Publications
- Highlights and Progress
- Summary



Space Weather:
The International Journal of Research and Applications

- **An American Geophysical Union (AGU) Journal (2003-present) devoted to**
  - Understanding and forecasting space weather and
  - Other interactions affecting the space atmosphere interaction region
- **Describe impacts on**
  - Tele- and satellite-communications, electric power, satellite navigation and operation, precise location, imaging, orbit determination and other systems.
- **SWE Papers include**
  - Original research articles
  - Features
  - Commentary (policy, opinion and critique)
  - Meeting reports and news (availability of curated data sets, awards etc).
- **Audience**
  - Scientists, Space Operators, Engineers, Policy Makers, Government Officials, Students

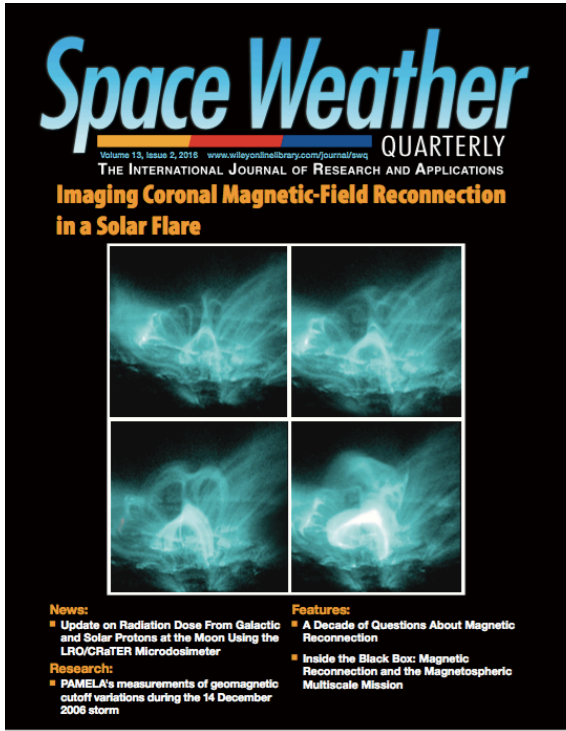
Aims and Scope

Monitoring and Understanding to the Point of Prediction

- Origins, propagation and interactions of solar-produced processes within geospace;
- **Interactions in Earth's space-atmosphere interface region produced by disturbances from above and below;**
- Influences of cosmic rays on humans, hardware and signals;
- Comparisons of the these types of interactions and influences with the atmospheres of neighboring planets and Earth's moon.
- Manuscripts should
  - Emphasize impacts on technical systems
  - Have a clear scientific result(s) stated in the three main points
  - Manuscripts that describe models, space environment climatology or data sets should clearly state how the results can be applied to understanding variability or background physics that contributes to space weather

Space Weather:
The International Journal of Research and Applications

- **(Space Weather (SWE)**
  - Addresses the need for a journal in applied research in space weather
  - > 500 manuscripts published thus far
  - Quarterly hard copy digest (~32 pages of highlights for extra postage fee)
  - Indexed in IEEE Explore
  - All manuscripts freely available after 24 months
- **2015 Accomplishments**
  - First time to publish more that 100 manuscripts in a year
  - 82 technical/research articles last year
  - Impact Factor: 2.4
- **2016 Plans**
  - Several Special Collections
  - Reprise of 2001 AGU Monograph on Space Weather



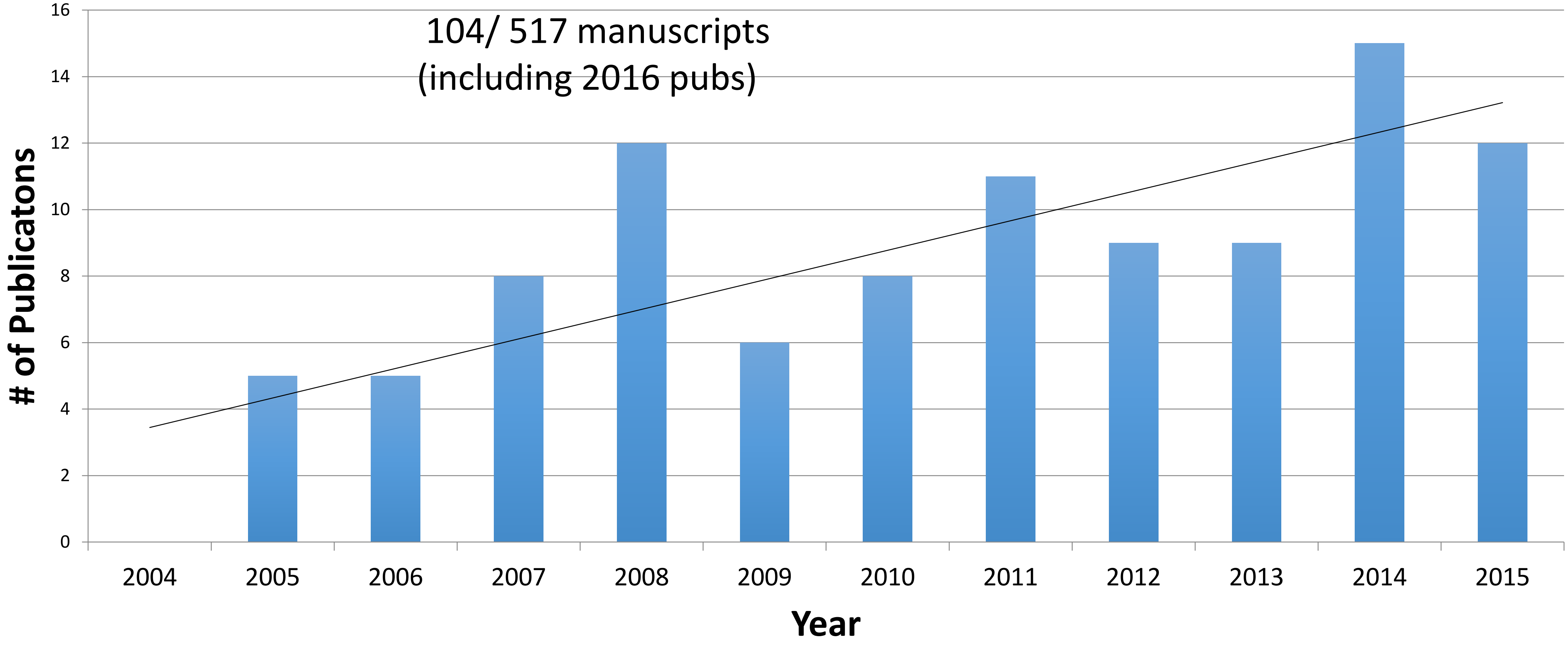
Space Weather

Author-selected Description Categories

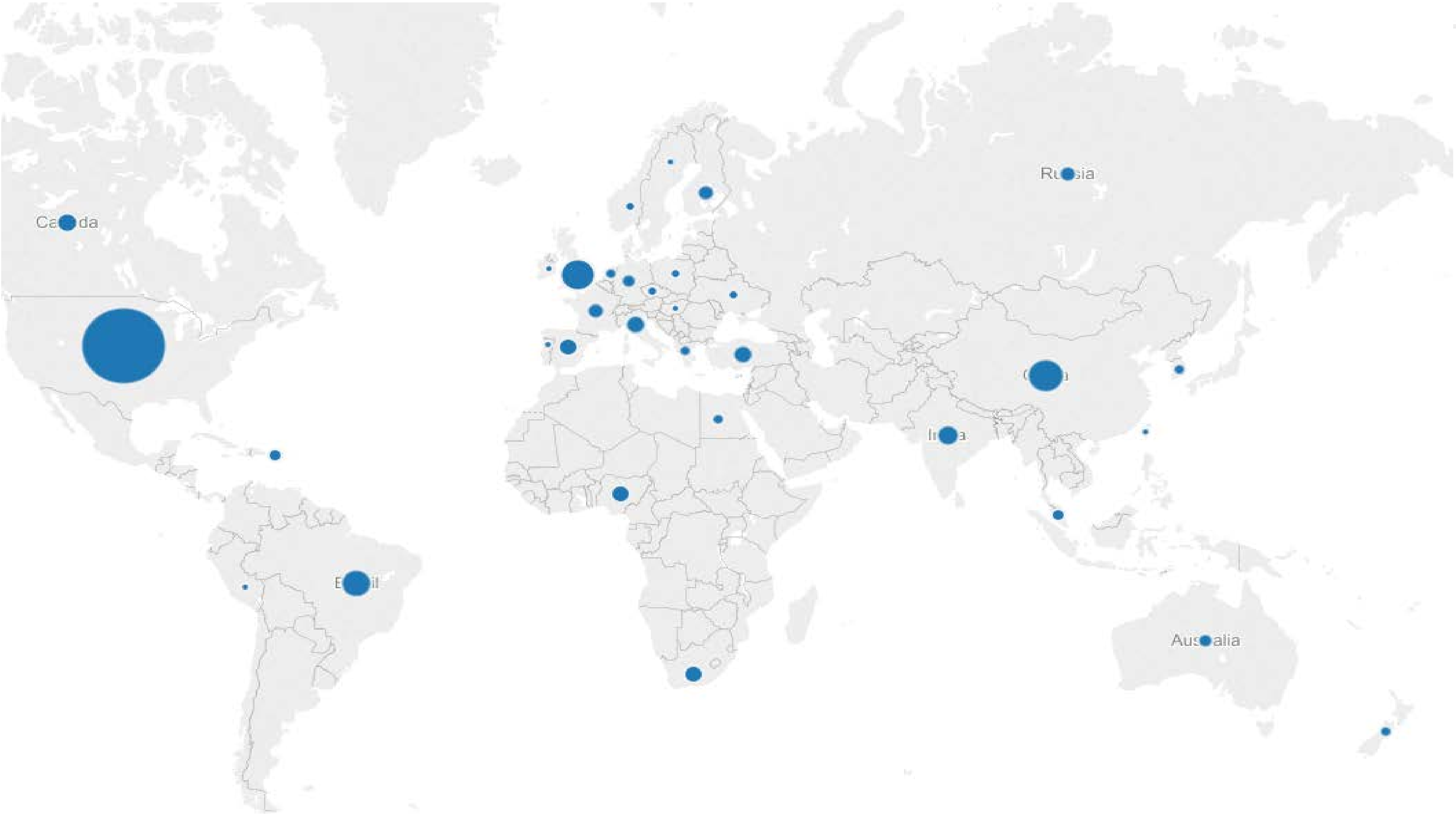
- (517) Space Weather
- (376) Magnetospheric Physics
- (308) Natural Hazards
- (206) Informatics
- (170) Interplanetary Physics
- (137) Solar Physics, Astrophysics, and Astronomy
- (135) Ionosphere
- (39) Radio Science
- (34) Space Plasma Physics
- (29) Policy Sciences

> 20% of 517 manuscripts relate to Ionosphere and/or technologies related to the Ionosphere

SWE Ionosphere/Radio Science and Related Plasma Physics Publications



International author base

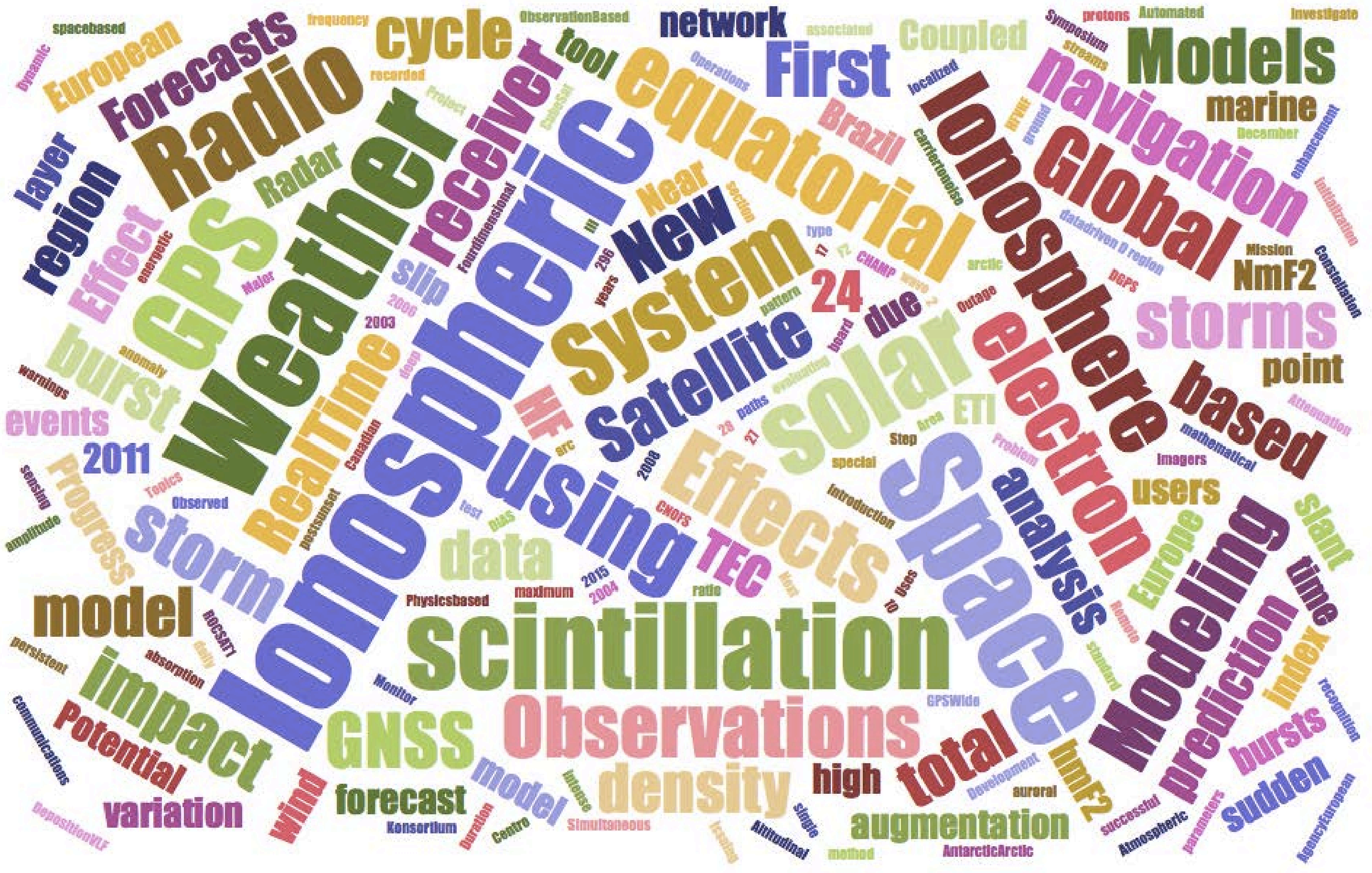


Highlights

- Pictorial Review of Science
  - Teaching and Learning
- Listing of all related manuscripts appended

What are SWE authors communicating?

- ionosphere(ic) 51
- GPS/GNSS   26
- space weather 22
- model/modeling/simulation 16
- solar 14
- TEC /total electron content 11
- Scintillation 11
- radio 11
- storm(s) 10
- forecast(ing) 10
- users (ing) (10)
- navigation 9
- observe (ing)   8
- measure (ng) 6
- monitor(ing) 5

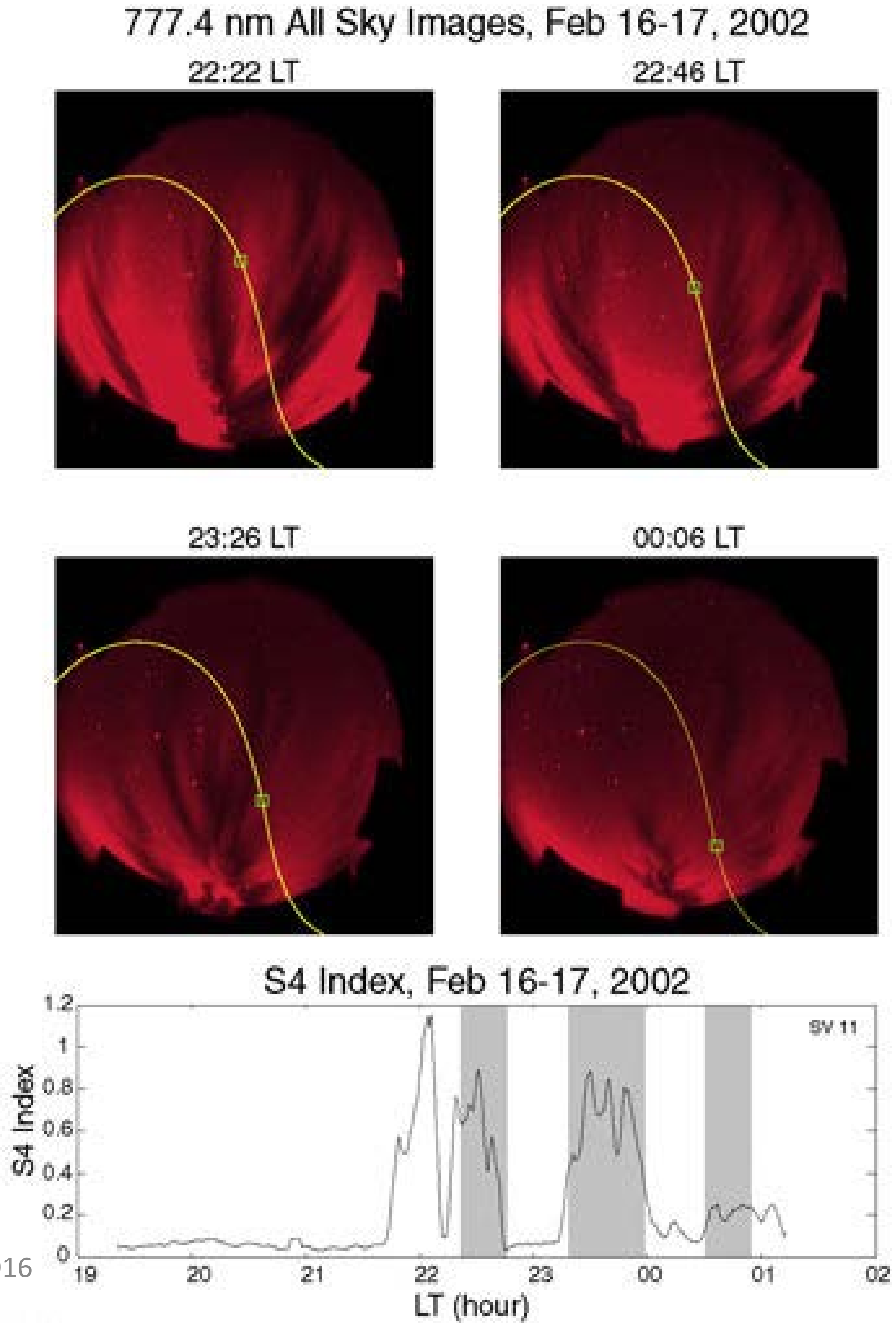


2004-2009: Ionospheric, Space, Weather Scintillation, Effects, Solar, GPS, System Observations, Storms

2010-2015: Ionospheric, Space, Weather Scintillation, Models, Equatorial, GNSS, Using, Electrons, GPS

Convective Ionospheric Storms: A Major Space Weather Problem

Disruption of GPS signals as they traverse a Convective Ionospheric Storm event documented by an all-sky camera on Maui. As the line of sight to the satellite, indicated by the small box along the satellite trajectory in the top panels, intercepts an airglow depletion, the scintillation index (S4) rises dramatically and the signal is too noisy to measure the TEC

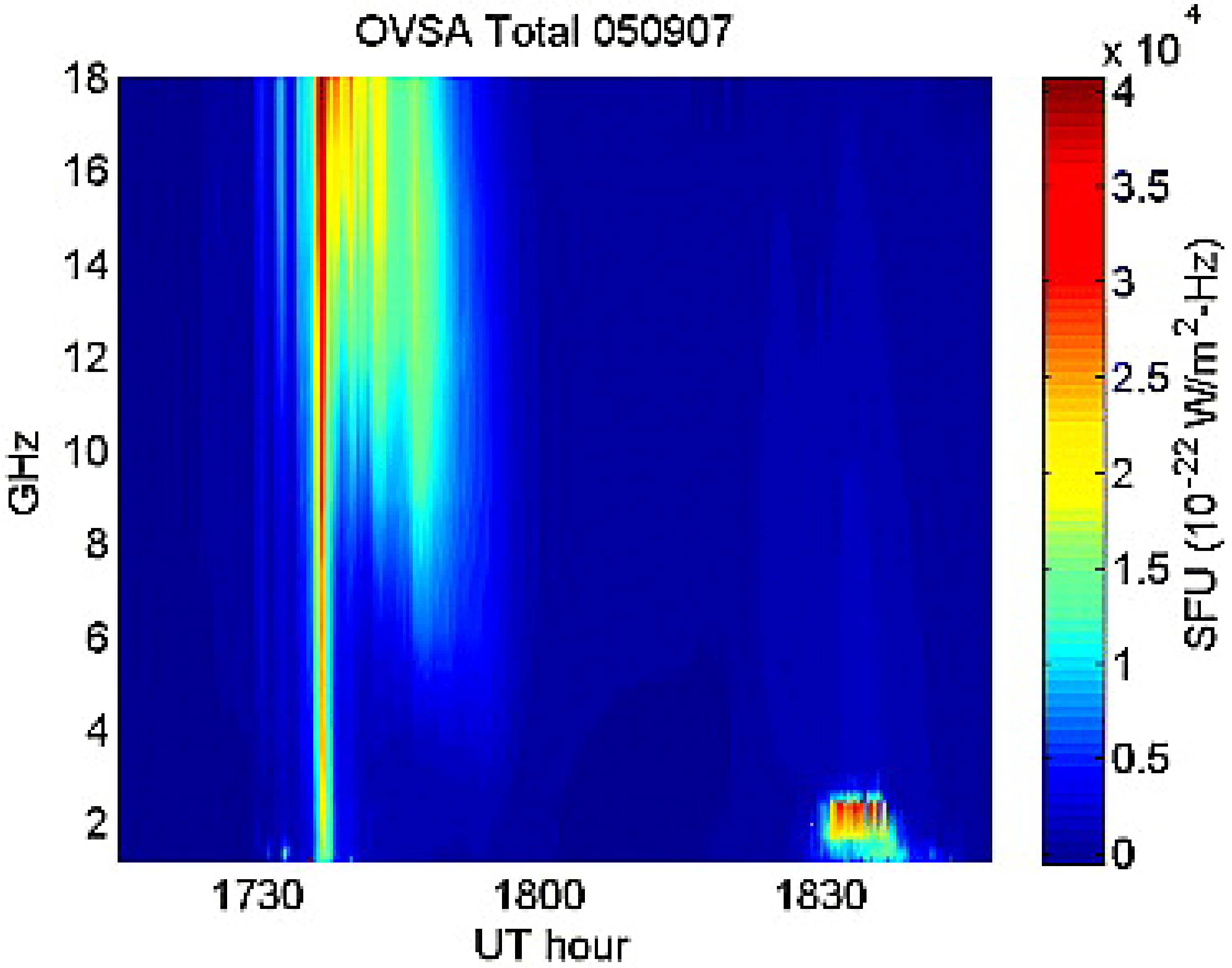


Makela, J. J., Kelley, M. C. and de la Beaujardiére, O. (2006), Convective Ionospheric Storms: A Major Space Weather Problem. Space Weather, 4: n/a. doi:10.1029/2005SW000144

Space Weather
Volume 4, Issue 2, S02C04, 7 FEB 2006 DOI: 10.1029/2005SW000144
http://onlinelibrary.wiley.com/doi/10.1029/2005SW000144/full#swe98-fig-0002

Observed solar radio burst effects on GPS/Wide Area Augmentation System carrier-to-noise ratio

Total solar radio burst power spectral density from 1.2 to 18 GHz on 7 September 2005 as measured by the OVSA. There are two periods of activity at 1736 UT and at 1830 UT on Sept 7 2005

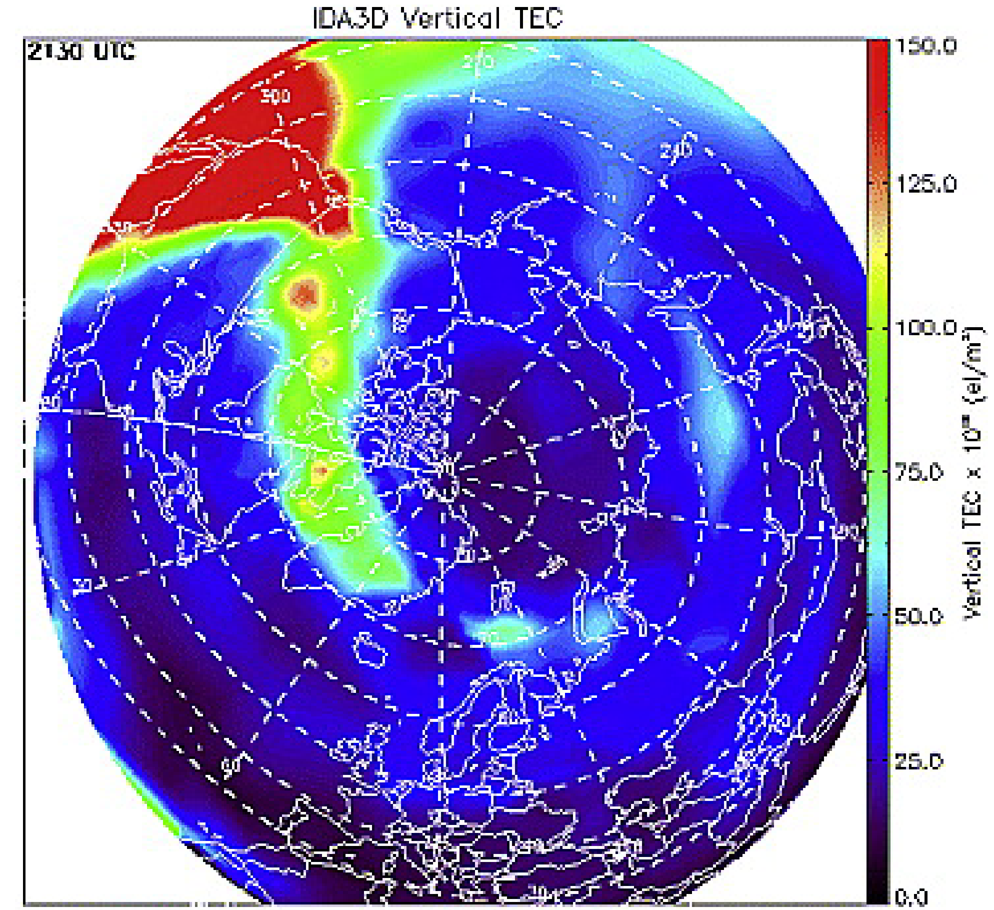


Cerruti, A. P., et al., (2006), Observed solar radio burst effects on GPS/Wide Area Augmentation System carrier-to-noise ratio, Space Weather, 4, S10006, doi:10.1029/2006SW000254.

Space Weather
Volume 4, Issue 10, S10006, 31 OCT 2006 DOI: 10.1029/2006SW000254
http://onlinelibrary.wiley.com/doi/10.1029/2006SW000254/full#swe172-fig-0001

Four-dimensional GPS imaging of space weather storms

Polar plot of vertical TEC from IDA3D at 2130 UT on 30 October 2003. The figure shows the SED forming into a tongue of ionization over western Canada and extending across the pole, to the nightside over EISCAT.



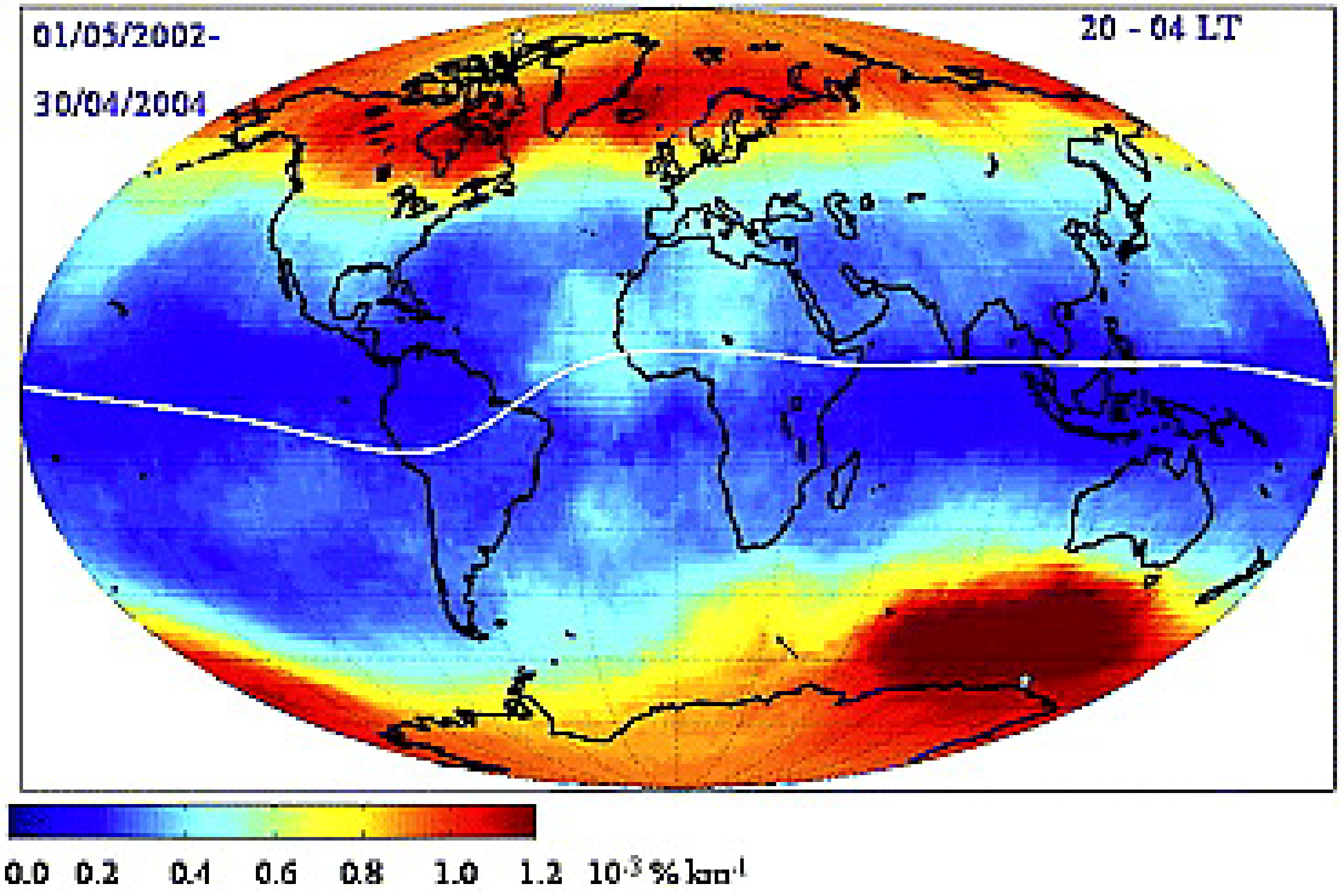
Bust, G. S., G. Crowley, T. W. Garner, T. L. Gaussiran II, R. W. Meggs, C. N. Mitchell, P. S. J. Spencer, P. Yin, and B. Zapfe (2007), Four-dimensional GPS imaging of space weather storms, Space Weather, 5, S02003, doi:10.1029/2006SW000237.

Space Weather
Volume 5, Issue 2, S02003, 22 FEB 2007 DOI: 10.1029/2006SW000237
http://onlinelibrary.wiley.com/doi/10.1029/2006SW000237/full#swe163-fig-0009

Space weather monitoring by GPS measurements on board CHAMP

Percentage variability of IRO derived nighttime total electron content (TEC) data (2000–0400 LT) obtained from CHAMP within 2 years from May 2002 to April 2004.

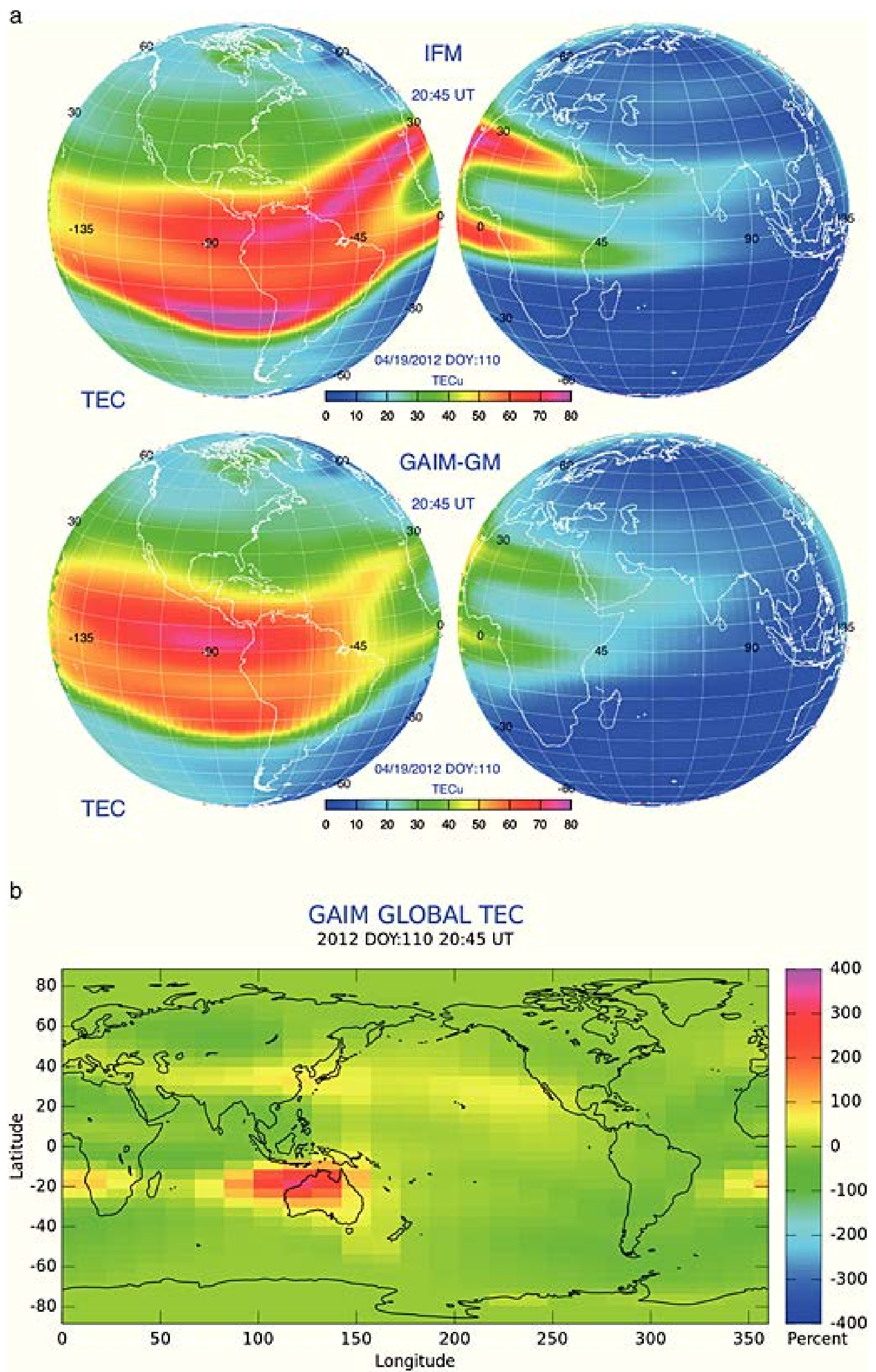
Jakowski, N., V. Wilken, and C. Mayer (2007), Space weather monitoring by GPS measurements on board CHAMP, Space Weather, 5, S08006, doi:10.1029/2006SW000271.



Space Weather
Volume 5, Issue 8, S08006, 31 AUG 2007 DOI: 10.1029/2006SW000271 http://onlinelibrary.wiley.com/doi/10.1029/2006SW000271/full#swe188-fig-0013

Global Assimilation of Ionospheric Measurements-Gauss Markov model: Improved specifications with multiple data types

(a) The IFM background physics-based ionosphere model (top) and GAIM-GM (bottom) TEC output at 20:45 UT. (b) Percent change to the IFM solution for TEC in order to get the GAIM-GM solution.



Gardner, L. C., R. W. Schunk, L. Scherliess, J. J. Sojka, and L. Zhu (2014), Global Assimilation of Ionospheric Measurements-Gauss Markov model: Improved specifications with multiple data types, Space Weather, 12, 675–688, doi:10.1002/2014SW001104.

Space Weather
Volume 12, Issue 12, pages 675-688, 17 DEC 2014 DOI: 10.1002/2014SW001104
http://onlinelibrary.wiley.com/doi/10.1002/2014SW001104/full#swe20192-fig-0007

A Forecasting Ionospheric Real-time Scintillation Tool (FIRST)

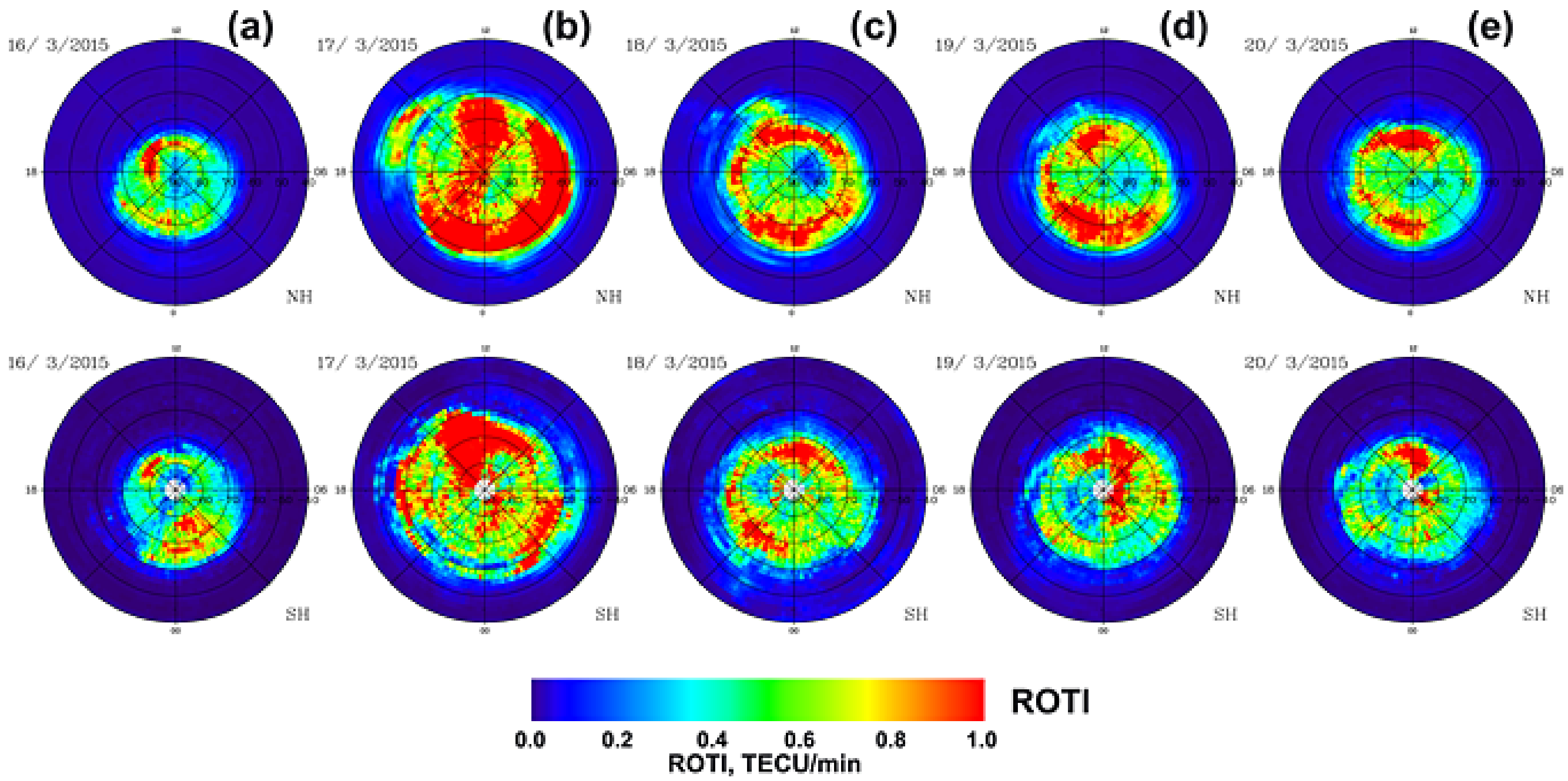
PDA accessible Jicamarca scintillation forecast for 23 April through 29 April 2010 LT.. Green, scintillation unlikely; yellow, scintillation possible; red, scintillation likely. Quality: white background, good; gray, suspicious. An asterisk indicates interpolation; inscribed numbers are h'F; THMS4 values have been retrospectively added 5 days in arrears.

Redmon, R. J., D. Anderson, R. Caton, and T. Bullett (2010), A Forecasting Ionospheric Real-time Scintillation Tool (FIRST), Space Weather, 8, S12003, doi:10.1029/2010SW000582.

Space Weather
Volume 8, Issue 12, S12003, 9 DEC 2010 DOI: 10.1029/2010SW000582
http://onlinelibrary.wiley.com/doi/10.1029/2010SW000582/full#swe395-fig-0009

Dynamics of the high-latitude ionospheric irregularities during the 17 March 2015 St. Patrick's Day storm: Ground-based GPS measurements

Diurnal ROTI maps in corrected geomagnetic coordinates for NH and SH, respectively for 16–20 March 2015. Polar view map covers 00–24 MLT and 40°–90° MLAT. In each map, magnetic noon/midnight is at the top/bottom.

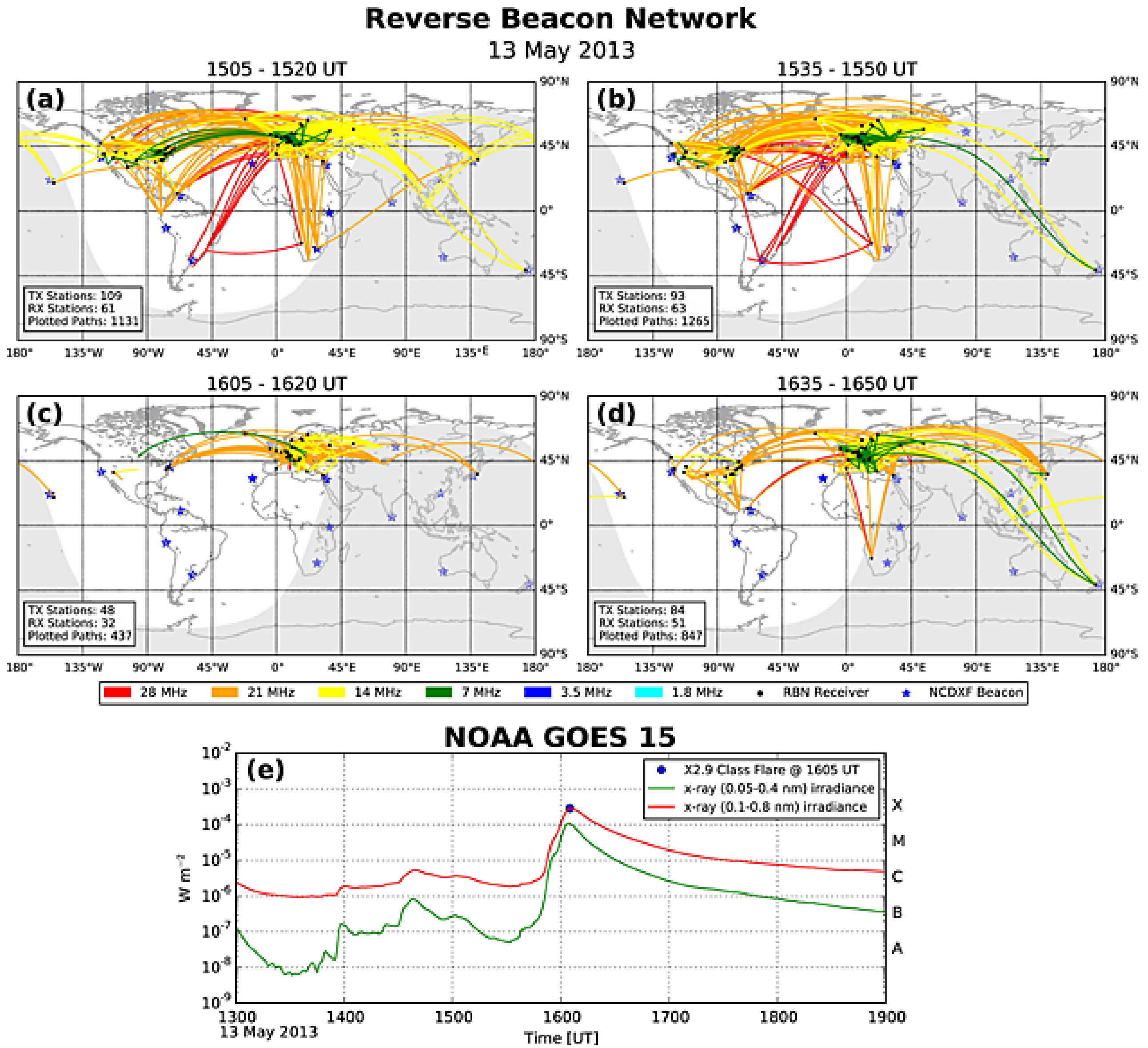


Cherniak, I., I. Zakharenkova, and R. J. Redmon (2015), Dynamics of the high-latitude ionospheric irregularities during the 17 March 2015 St. Patrick's Day storm: Ground-based GPS measurements, Space Weather, 13, 585–597, doi:10.1002/2015SW001237.

Space Weather Volume 13, Issue 9, pages 585-597, 25 SEP 2015 DOI: 10.1002/2015SW001237
http://onlinelibrary.wiley.com/doi/10.1002/2015SW001237/full#swe20258-fig-0003

Ionospheric Sounding Using Real-Time Amateur Radio Reporting Networks

(a–d) Reverse Beacon Network (RBN) high-frequency propagation path observations from 13 May 2013 beginning at 1505 UT with 15 min integration periods and a 30 min cadence. Paths are color coded by frequency band. Black dots indicate RBN receiving stations, while blue stars indicate Northern California DX Foundation (NCDXF) beacons. The number of unique transmitting (TX) and receiving (RX) stations within each 15 min period is given in the lower left corner of each map. Shading indicates the solar terminator. (e) GOES 15 X-ray sensor measurements for the 0.05–0.4 nm (green trace) and the 0.1–0.8 nm (red trace) soft X-ray bands for 13 May 2013 1300–1900 UT. A blue dot at 1605 UT on the red trace indicates the peak of an X2.9 class solar flare and corresponds to a dramatic decrease in RBN activity.

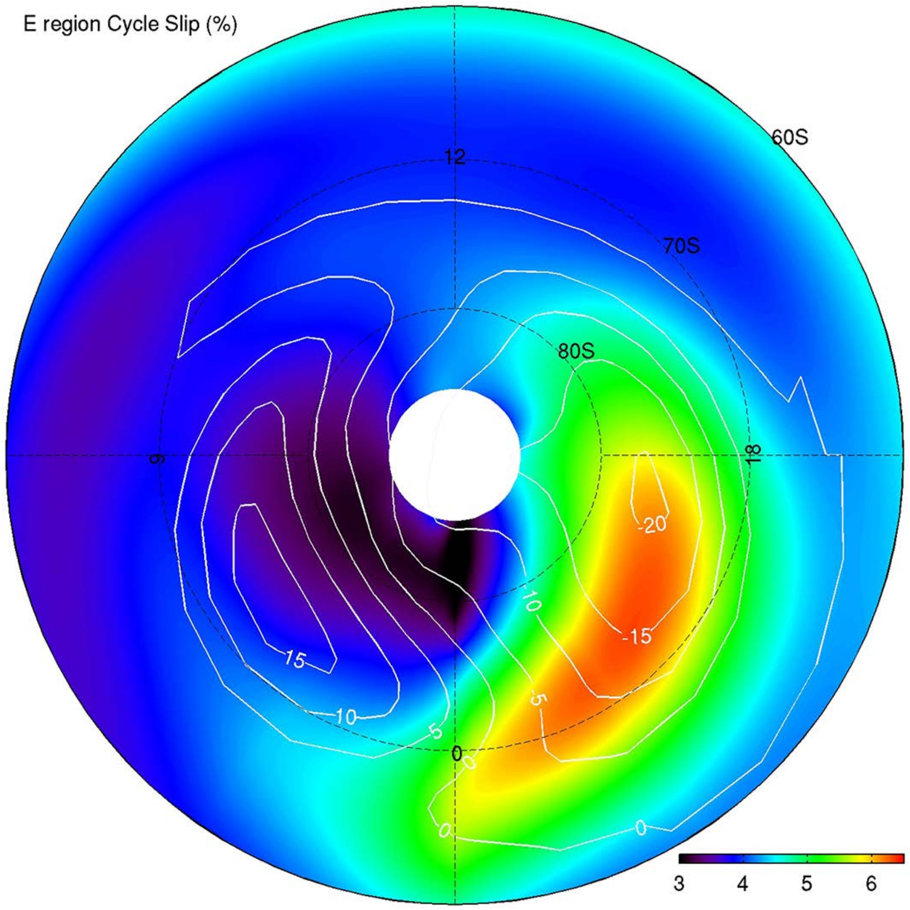


Frissell et al., (2015) Ionospheric Sounding Using Real-Time Amateur Radio Reporting Networks

Space Weather
Volume 12, Issue 12, pages 651-656, 5 DEC 2014 DOI: 10.1002/2014SW001132
http://onlinelibrary.wiley.com/doi/10.1002/2014SW001132/full#swe20187-fig-0003

Characterizing GPS radio occultation loss of lock due to ionospheric weather

(MLT)- (MLat) variation of cycle slip occurrence (% per occurrence) of southern high latitude and polar region in ionospheric *E* region observed by COSMIC satellites during 2007–2011.

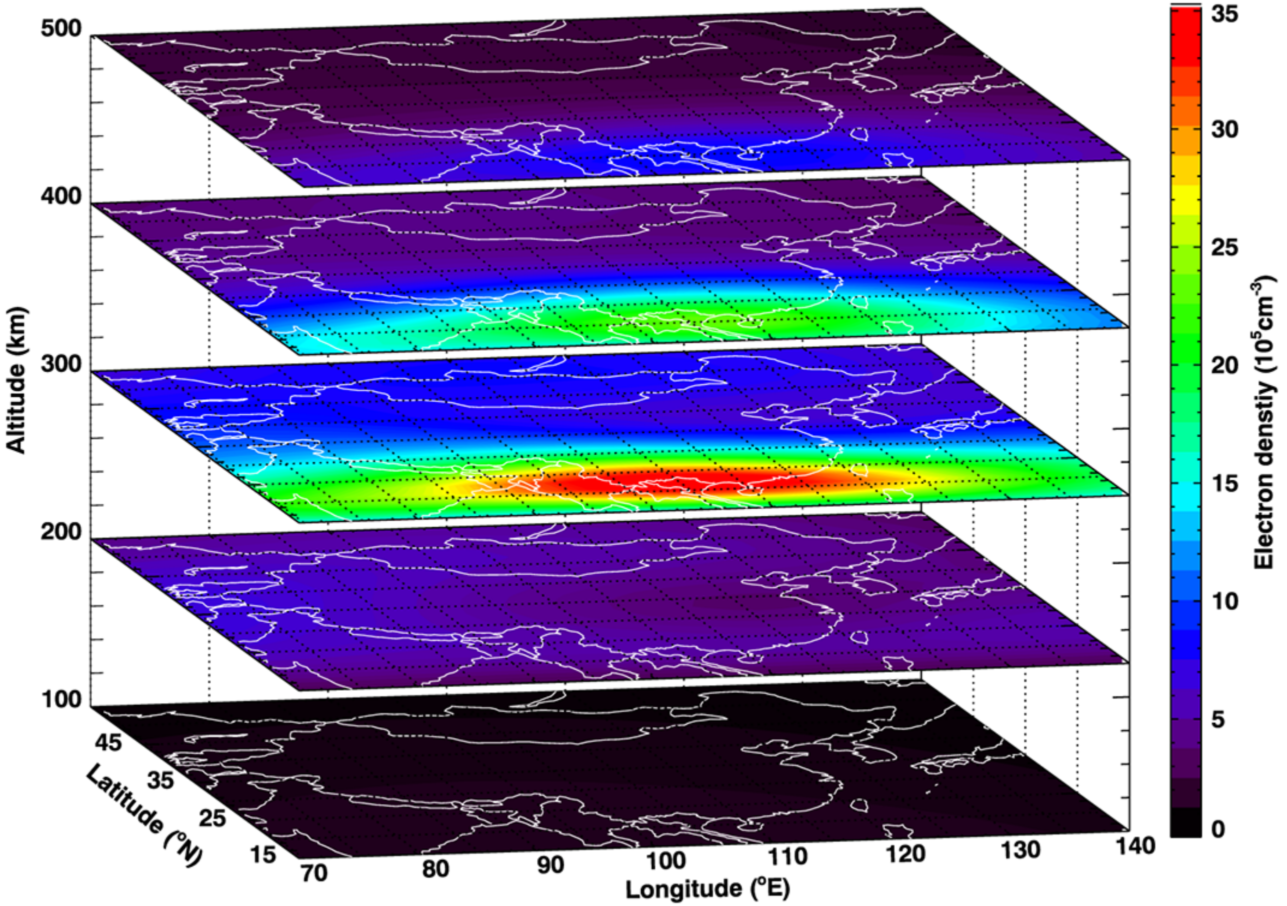


Yue, X., W. S. Schreiner, N. M. Pedatella, and Y-H. Kuo (2016), Characterizing GPS radio occultation loss of lock due to ionospheric weather, Space Weather, 14, 285–299, doi:10.1002/2015SW001340.

Space Weather
Volume 14, Issue 4, pages 285-299, 6 APR 2016 DOI: 10.1002/2015SW001340
http://onlinelibrary.wiley.com/doi/10.1002/2015SW001340/full#swe20320-fig-0003

Regional 3-D ionospheric electron density specification on the basis of data assimilation of ground-based GNSS and radio occultation data

Example of the data assimilation output at 0600 UT on 16 January 2014: horizontal sliced maps of regional electron densities at five selected altitudes from 100 km up to 500 km.



Aa, E., S. Liu, W. Huang, L. Shi, J. Gong, Y. Chen, H. Shen, and J. Li (2016), Regional 3-D ionospheric electron density specification on the basis of data assimilation of ground-based GNSS and radio occultation data, Space Weather, 14, doi:[10.1002/2016SW001363.](10.1002/2016SW001363)

Space Weather

2016SW001363, 29 JUN 2016 DOI: 10.1002/2016SW001363

http://onlinelibrary.wiley.com/doi/10.1002/2016SW001363/full#swe20331-fig-0003

Summary

- Provided aims and scope of Space Weather Journal (SWE)
- Showed positive trends for ionospheric related manuscripts in SWE
- Highlighted selected aspects of progress in related disciplines
- Encourage submission of space weather relevant articles to SWE

  - Technical/Research Manuscripts/ Feature Articles
  - Commentary/News/Meeting Reports

  - Special Collections
- 100 + related Manuscript Titles from SWE
- (next slide)

100 + Manuscripts from SWE

- Space weather effects on midlatitude HF propagation paths: Observations and a data-driven *D* region model, Space Weather, 3, S01002, doi:10.1029/2004SW000094.
- Kintner, P. M., B. M. Ledvina, and E. R. de Paula (2005), An amplitude scintillation test pattern standard for evaluating GPS receiver performance, Space Weather, 3, S03002, doi:10.1029/2003SW000025.
- Kelley, M. C., O. de La Beaujardiere, J. Retterer, and J. J. Makela (2005), Introduction to special section on Communications/Navigation Forecasting System: A Next Step in Space Weather, Space Weather, 3, S12C01, doi:10.1029/2005SW000189.
- Retterer, J. M. (2005), Physics-based forecasts of equatorial radio scintillation for the Communication and Navigation Outage Forecasting System (C/NOFS), Space Weather, 3, S12C03, doi:10.1029/2005SW000146.
- Makela, J. J., M. C. Kelley, and S.-Y. Su (2005), Simultaneous observations of convective ionospheric storms: ROCSAT-1 and ground-based imagers, Space Weather, 3, S12C02, doi:10.1029/2005SW000164.
- Makela, J. J., Kelley, M. C. and de la Beaujardiére, O. (2006), Convective Ionospheric Storms: A Major Space Weather Problem. Space Weather, 4: n/a. doi:10.1029/2005SW000144
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- Cerruti, A. P., P. M. Kintner, D. E. Gary, L. J. Lanzerotti, E. R. de Paula, and H. B. Vo (2006), Observed solar radio burst effects on GPS/Wide Area Augmentation System carrier-to-noise ratio, Space Weather, 4, S10006, doi:10.1029/2006SW000254.
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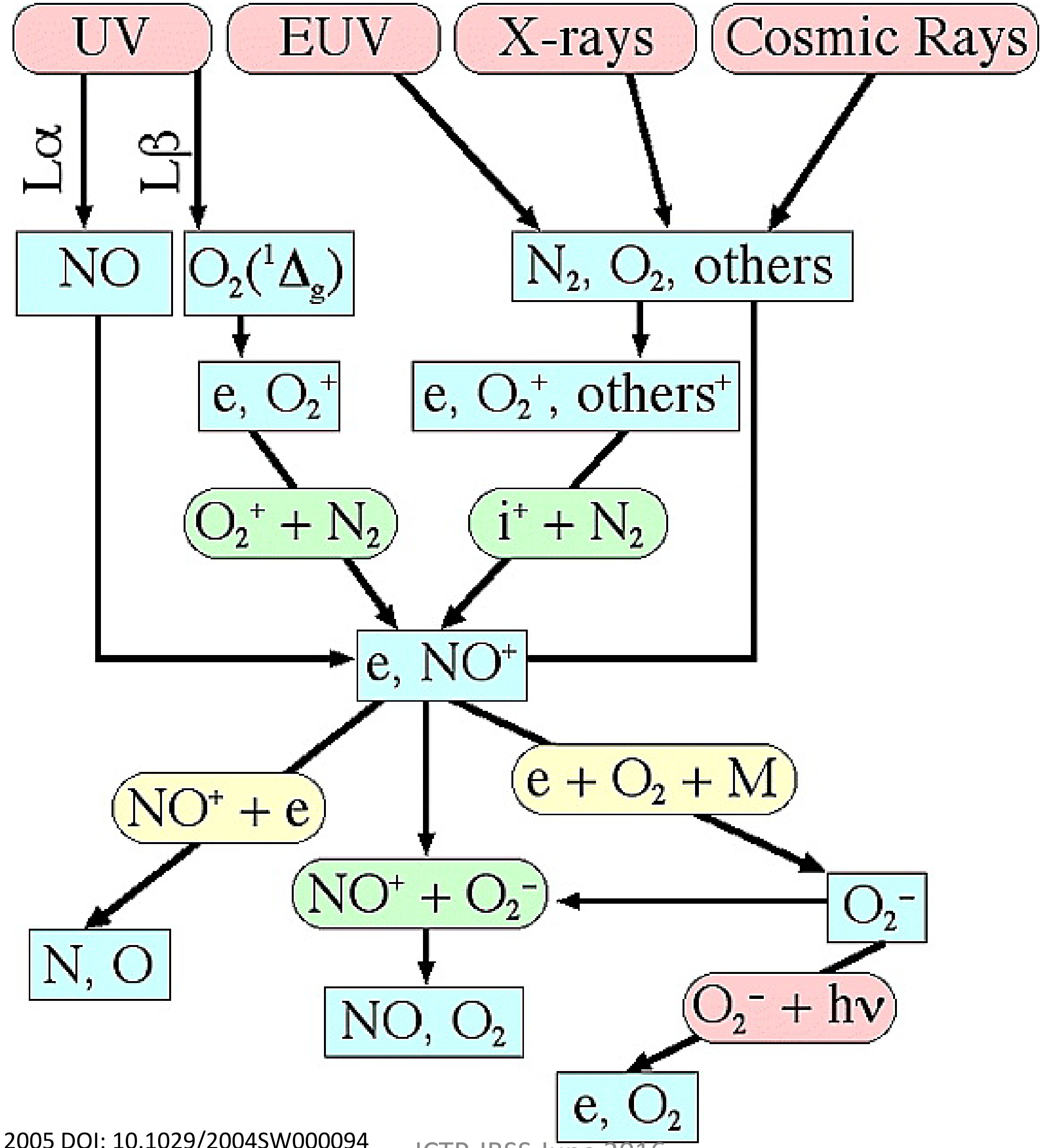
- Whalen, J. A. (2007), Weather of the postsunset equatorial anomaly recorded daily during 2 years near solar maximum, Space Weather, 5, S01002, doi:10.1029/2006SW000235.
- Jee, G., A. G. Burns, W. Wang, S. C. Solomon, R. W. Schunk, L. Scherliess, D. C. Thompson, J. J. Sojka, and L. Zhu (2007), Duration of an ionospheric data assimilation initialization of a coupled thermosphere-ionosphere model, Space Weather, 5, S01004, doi:10.1029/2006SW000250.
- Skone, S., and R. Yousuf (2007), Performance of satellite-based navigation for marine users during ionospheric disturbances, Space Weather, 5, S01006, doi:10.1029/2006SW000246.

Space weather effects on mid-latitude HF propagation paths: Observations and a data-driven *D* region model

Ionization and subsequent ion chemistry in a mixed neutral atmosphere.



Eccles, J. V., R. D. Hunsucker, D. Rice, and J. J. Sojka (2005), Space weather effects on midlatitude HF propagation paths: Observations and a data-driven *D* region model, Space Weather, 3, S01002, doi:10.1029/2004SW000094.

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Volume 3, Issue 1, S01002, 6 JAN 2005 DOI: 10.1029/2004SW000094
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