

## CURRICULUM VITAE

### **CHARLES S. CARRANO, Ph.D.**

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#### **Biography**

Dr. Carrano is a Senior Research Physicist and Principal Investigator at Boston College's Institute for Scientific Research (ISR). His principal contributions have been in the areas of ionospheric impacts on radar, satellite communications, and the Global Positioning System (GPS). Recently he served as Principal Investigator of a project related to high-fidelity simulation of ionospheric scintillation and its impact on dual-frequency GPS receivers. He introduced and taught GE 195, the first course on Space Weather for undergraduate students at Boston College. He is an Associate Editor of the American Geophysical Union (AGU) journal *Radio Science*, and has served on the Editorial Board of the quarterly journal *GPS Solutions*. He is a member of the AGU, the Union Radio-Scientifique Internationale (URSI), and the Institute of Navigation (ION).

Before joining the ISR research staff, Dr. Carrano managed the Ionospheric Environments and Impacts group of the Space Weather and Effects Division at Atmospheric and Environmental Research, Inc. (AER). He has been Principal Investigator for an SBIR related to real-time specification of the near-Earth space environment and as Co-Investigator for a BAA involving data fusion techniques for ionospheric monitoring. He has also served as AER project leader for the AFRL SCintillation Network Decision Aid (SCINDA), a real-time global network for ionospheric scintillation specification and forecasting. Dr. Carrano has developed systems for real-time monitoring of the ionosphere that are deployed in networks spanning the globe including the AFRL-SCINDA network, the Low-latitude Ionospheric Sensor Network (LISN), the Canadian High Arctic Ionospheric Network (CHAIN), and the Instituto Nacional de Pesquisas Espaciais (INPE). He has managed the development of operational space weather products at Air Force Weather Agency (AFWA), Space Environment Technologies Application Division (SMC/WXT), and the Defense Modeling and Simulation Office (DMSO).

Dr. Carrano earned his Ph.D. in aerospace engineering at The Pennsylvania State University and his B.S. in mechanical engineering at Cornell University. At PennState he taught advanced mathematics for engineers. He has published a number of journal articles, and presented papers and tutorials at numerous domestic and international scientific meetings. He has been granted five Scientific and Technical Achievement Team Awards by the Air Force Research Laboratory's Space Weather Center of Excellence, been granted awards by the Institute for Scientific Research for Outstanding Achievement and Scientific Excellence, and been named Employee of the Year by Atmospheric and Environmental Research, Inc.

#### **Education**

- 1993-1997 **The Pennsylvania State University**, State College, PA  
Ph.D. Aerospace Engineering; minor in Mathematics · GPA 4.00  
Dissertation: General Decompositions and Spectral Dynamics of Burgers' Model of Turbulence
- 1991-1993 **The Pennsylvania State University**, State College, PA  
M.S. Aerospace Engineering · GPA 4.00  
Dissertation: Fourier Analysis and Optimization of the Petrov-Galerkin Finite Element Method
- 1990-1991 **Joint Institute for Advancement of Flight Sciences** (NASA/GWU), Hampton, VA

First year graduate study in aerospace engineering · GPA 3.67

1986-1990 **Cornell University**, Ithaca, NY  
B.S. Mechanical Engineering · GPA 3.33

### **Employment**

2009- **Boston College, Institute for Scientific Research**, Chestnut Hill, MA.  
Senior Research Physicist

2005-2009 **Atmospheric and Environmental Research, Inc.**, Lexington, MA.  
Staff Scientist and Section Manager, Ionospheric Environments and Impacts group

1998-2005 **Radex, Inc.**, Bedford, MA  
Associate Engineer

1989 **The Analytic Sciences Corporation**, Reading, MA  
Staff Engineer

### **Awarded Proposals**

1. Next Equatorial Scintillation Forecasting Model, with Creare Inc., Air Force Research Laboratory SBIR AF183-030, 2019.
2. Specification and Forecast of the Space Environment and System Survivability, Air Force Research Laboratory Broad Agency Announcement BAA RVKV-2014-0005, Call 003, 2019.
3. Living with a Star Institute Proposal on TEC and Ionospheric Scintillation for GPS Applications, UCAR/CPAESS, 2019.
4. High Frequency Geolocation and Characterization (HFGeo), with STR Inc., Intelligence Advanced Research Projects Activity (IARPA), IARPA-BAA-14-05, 2015.
5. Modeling Impacts of Coherent and Random TID Structures on OTHR Performance, with ASTRA Inc., Air Force Research Laboratory SBIR AF151-154, 2015.
6. GPS Awareness Enabling Algorithms for Theater and Space Environment, with ASTRA Inc., Air Force Research Laboratory SBIR FA9453-13-M-0180, 2013.
7. A Data-Based Approach for Modeling and Simulating Ionospheric Scintillation and its Effects on GPS Performance, BAA-RV-10-01, 2012.
8. Next Generation Sensor Resource Management for Persistent and Responsive Situational Awareness, SBIR Topic AF083-185, 2008.
9. Unresolved Resident Space Object Characterization Using Time-Frequency Analysis, Air Force Research Laboratory SBIR AF071-283 Phase I, 2007.
10. Real-Time Specification of Battlespace Environment, Air Force Research Laboratory SBIR AF06-248 Phase II, 2007.

11. Real-Time Specification of Battlespace Environment, Air Force Research Laboratory SBIR AF06-248 Phase I, 2006.
12. Fusion of multiple measurements of ionospheric disturbances for robust now-casting and predictive modeling, Air Force Research Laboratory BAA VS-05-01, 2006.

### Professional Awards

- Best Young Scientist Paper Award (Shradha Mohanty), 15th International Symposium on Equatorial Aeronomy, 2018.
- Outstanding student paper award (Shradha Mohanty), Fall Meeting of the AGU, 2017.
- Best paper in session, 2016 Beacon Satellite Symposium, Trieste, Italy, June 27 – July 1, 2016.
- Best presentation in session, ION GNSS 2012 Meeting, Nashville, TN, September 2012.
- Best paper award, 13<sup>th</sup> Ionospheric Effects Symposium, Alexandria, VA, 17-19 May 2011.
- Institute for Scientific Research, Scientific Excellence, 2011.
- Institute for Scientific Research, Outstanding Achievement, 2010.
- Air Force Research Laboratory, Finalist for Scientific/Technical Achievement Team Award 2005.
- Atmospheric and Environmental Research, Inc., Employee of the Year, 2005.
- Space Vehicles Directorate, Scientific and Technical Achievement Award, 4th quarter 2005.
- Space Vehicles Directorate, Scientific/Technical Achievement Team Award, year 2004.
- Space Vehicles Directorate, Scientific /Technical Achievement Team Award, 4th quarter 2001.

### Teaching Experience

2012-2014 GE 195 – Introduction to Space Weather, Boston College  
 1996 Graduate Lecturer, advanced engineering mathematics, The Pennsylvania State University

### Professional Service

- 2017-2018 Fulbright Scholar Mentor for Shradha Mohanty
- 2011- Associate Editor, Radio Science
- 2011-2015 Editorial Board, GPS Solutions

### Publications and Conference Proceedings

1. **Carrano C.**, K. Groves, and C. Rino (2019), On the relationship between the rate of change of total electron content index (ROTI), irregularity strength (CkL) and the scintillation index (S4), Journal of Geophysical Research: Space Physics, doi:10.1029/2018JA026353.
2. **Carrano, C.** and C. Rino (2019), Irregularity parameter estimation for interpretation of scintillation Doppler and intensity spectra, Proc. URSI NRSM, Boulder, CO, Jan 2019.
3. Rino, C., B. Breitsch, Y. Morton, Y. Jiao, D. Xu, and **C. Carrano** (2018), A compact multi-frequency GNSS scintillation model, J. Inst. of Navigation, <https://doi.org/10.1002/navi.263>.
4. Mohanty, S., **C. Carrano**, and G. Singh (2018), Effect of anisotropy on ionospheric scintillations observed in Synthetic Aperture Radar (SAR), IEEE International Geoscience and Remote Sensing Symposium (IGARSS), July 22-27, Valencia, Spain, doi: 10.1109/IGARSS.2018.8518515.

5. Mohanty, S., **C. Carrano**, and G. Singh (2018), Monitoring of Ionospheric scintillation phenomena using Synthetic Aperture Radar (SAR), *ISPRS Ann. Photogramm. Remote Sens, Spatial Inf. Sci.*, IV-5, 331-337, <https://doi.org/10.5194/isprs-annals-IV-5-331-2018>.
6. Rino, C., and **C. Carrano** (2018), On the Characterization of Intermediate Scale Ionospheric Structure, *Radio Sci.*, doi:10.1029/2018RS006709.
7. Rino, C., **C. Carrano**, T. Yokoyama, K. Groves (2018), A Configuration-Space Model for Intermediate-Scale Ionospheric Structure, *Radio Sci.*, 10.1029/2018RS006678.
8. Lay, E. H., P. A. Parker, M. Light, **C. S. Carrano**, S. Debchoudhury, and R. A. Haaser (2018). Midlatitude ionospheric irregularity spectral density as determined by ground-based GPS receiver networks. *Journal of Geophysical Research: Space Physics*, doi: 10.1029/2018JA025364.
9. Jiao, Y., D. Xu, C. Rino, Y. Morton, **C. Carrano** (2018), A Multi-Frequency GPS Signal Strong Equatorial Ionospheric Scintillation Simulator: Algorithm, Performance, and Characterization, *IEEE Transactions on Aerospace and Electronic Systems*, 54, 4, 1947 - 1965, doi: 10.1109/TAES.2018.2805232.
10. Rino, C., T. Yokoyama, and **C. Carrano** (2018), Spectral Characteristics of High-Resolution Simulated Equatorial Plasma Bubbles, *Progress in Earth and Planetary Science*, 5, 83, 1-13, <https://doi.org/10.1186/s40645-018-0243-02018>.
11. Mohanty, S., G. Singh, and **C. Carrano** (2018), Ionospheric Scintillation Observation using space-borne Synthetic Aperture Radar (SAR) data, *Radio Sci.*, doi:10.1029/2017RS006424.
12. Rino, C., B. Breitsch, Y. Jaio, Y. Morton, **C. S. Carrano**, A New GNSS Scintillation Model, *ION GNSS+ 2017*, Portland OR, Sept. 25-29, 2017.
13. **Carrano, C. S.**, C. L. Rino, and K. M. Groves, Maximum Likelihood Estimation of Phase Screen Parameters from Ionospheric Scintillation Spectra, 15th International Ionospheric Effects Symposium, Alexandria, VA, May 9-11, 2017.
14. Rino, C., **C. Carrano**, B. Breitsch, J. Morton, Simulation Study of GPS Phase Scintillation, 15th International Ionospheric Effects Symposium, Alexandria, VA, May 9-11, 2017.
15. Rino, C., **C. Carrano**, K. Groves, Localization of Structure on Extended RO Propagation Geometries, 15th International Ionospheric Effects Symposium, Alexandria, VA, May 9-11, 2017.
16. Joshi, D., K. Groves, W. McNeil, **C. Carrano**, R. Caton, R. T. Parris, T. Pedersen, P. Cannon, M. Angling, and N. Jackson-Booth (2017), HF Propagation Results from the Metal Oxide Space Cloud (MOSC) Experiment, *Radio Sci.*, 52, doi:10.1002/2016RS006164.
17. Rino, C. L., **C. S. Carrano**, and K. M. Groves, A Configuration Space Model for Stochastic Ionospheric Structure: Part 1 Structure Realization, Submitted to *Radio Sci*, Feb 2017.
18. **Carrano, C. S.**, Keith M. Groves, Charles L. Rino, and William J. McNeil (2017), A Propagation Model for Geolocating Ionospheric Irregularities along Radio Occultation Ray-Paths, *Proceedings of the 2017 USNC-URSI National Radio Science Meeting*, Boulder, CO, 4-7 January 2017.
19. **Carrano, C. S.**, and C. L. Rino (2016), A theory of scintillation for two-component power law irregularity spectra: Overview and numerical results, *Radio Sci.*, 51, doi:10.1002/2015RS005903.

20. **Carrano, C. S.**, K. M. Groves, C. L. Rino, and P. H. Doherty (2016), A Technique for Inferring Zonal Irregularity Drift from Single-Station GNSS Measurements of Intensity (S4) and Phase ( $\sigma\phi$ ) Scintillations, *Radio Sci.*, doi:10.1002/2015RS005864.
21. Rino, C. L., **C. S. Carrano**, K. M. Groves, and P. A. Roddy (2016), A characterization of intermediate-scale spread F structure from four years of high-resolution C/NOFS satellite data, *Radio Sci.*, 51, doi:10.1002/2015RS005841.
22. **Carrano, C. S.**, C. Rino, Constrained And Unconstrained Power Law Irregularity Models for Interpreting Strong Scintillation Data, *International Beacon Satellite Symposium BSS-2016*, Trieste, Italy.
23. Groves, K. M., **C. S. Carrano**, *Space Weather Effects on Communication and Navigation*, chapter in *Space Weather Fundamentals*, edited by G. Khazanov, CRC Press/Taylor & Francis Group, November 2015.
24. **Carrano, C. S.**, C. Rino, A Strong-Scatter Theory of Ionospheric Scintillations for Two-Component Power Law Irregularity Spectra, *14th International Ionospheric Effects Symposium*, Alexandria, VA, May 12-14, 2015.
25. Rino C. L., **C. S. Carrano**, K. M. Groves, P. Roddy, Reconciling two-component power spectra, *14th Ionospheric Effects Symposium*, Alexandria, VA, May 12-14, 2015.
26. **Carrano, C. S.**, C. Rino, K. Groves, P. Doherty, Inferring Zonal Irregularity Drift from Single-Station Measurements of Amplitude (S4) and Phase (Sigma-phi) Scintillations, *14th International Ionospheric Effects Symposium*, Alexandria, VA, May 12-14, 2015.
27. Groves, K. M., **C. S. Carrano**, C. Rino, J. Retterer, P. Straus, Scintillation Nowcasting with GNSS Radio Occultation Data, *14th International Ionospheric Effects Symposium*, Alexandria, VA, May 12-14, 2015.
28. McNeil, W., K. Groves, **C. S. Carrano**, A Look at GPS Positioning Errors in Solar Cycle 24, *14th International Ionospheric Effects Symposium*, Alexandria, VA, May 12-14, 2015.
29. Akala, A., H. Ejalonibu, P. Dorherty, S. Radicella, K. Groves, **C. Carrano**, C. Bridgwood, R. Stoneback, Characterization of GNSS Amplitude Scintillations over Addis Ababa, Ethiopia: 2009-2013, submitted to *J. Geophys Res. Space Phys* 2015.
30. Lay, E. H., X.-M. Shao, A. K. Kendrick, and **C. S. Carrano** (2015), Ionospheric acoustic and gravity waves associated with midlatitude thunderstorms, *J. Geophys. Res. Space Physics*, 120, 6010–6020, doi:10.1002/2015JA021334.
31. **Carrano, C. S.**, K. M. Groves, S. H. Delay, and P. H. Doherty (2015), On the Mutual Coherence Function for Transionospheric Waves and its Utility for Characterizing Ionospheric Irregularities with a GNSS Scintillation Monitor, *Proceedings of the 2015 ION Pacific PNT Conference*, Honolulu, Hawaii, April 20-23, 2015.
32. Delay, S. H., **C. S. Carrano**, K. M. Groves, and P. H. Doherty (2015), A Statistical Analysis of GPS L1, L2, and L5 Tracking Performance During Ionospheric Scintillation, *Proceedings of the 2015 ION Pacific PNT Conference*, Honolulu, Hawaii, April 20-23, 2015.

33. Meyer, F.J.; Chotoo, K.; Chotoo, S.D.; Huxtable, B.D.; **Carrano, C. S.**, The Influence of Equatorial Scintillation on L-Band SAR Image Quality and Phase, *IEEE Trans. Geosci. and Remote Sensing* , vol. PP, no.99, 1-12, doi: 10.1109/TGRS.2015.2468573.
34. Rino, C. L., K. M. Groves, **C. S. Carrano**, J. H. Gunter, and R. T. Parris (2015), Digital signal processing for ionospheric propagation diagnostics, *Radio Sci.*, doi:10.1002/2014RS005625.
35. **Carrano, C. S.**, K. M. Groves, S. H. Delay, and P. H. Doherty (2015), A Novel Approach for Monitoring Zonal Irregularity Drift using a Stand-Alone GNSS Scintillation Monitor, *Proceedings of the 2015 International Technical Meeting of The Institute of Navigation*, Dana Point, California, January 26-28, 2015.
36. **Carrano, C. S.**, K. M. Groves, C. E. Valladares and S. H. Delay (2014), On the Longitudinal Morphology of Zonal Irregularity Drift Measured using Networks of GPS Scintillation Monitors, poster presented at the 2014 Fall Meeting of the AGU, San Francisco, December 15-19, 2014.
37. **Carrano, C. S.**, K. M. Groves, S. H. Delay (2014), A data-based approach for modeling and simulating ionospheric scintillation and its effects on GPS performance, submitted as an AFRL Technical Report, July, 2014.
38. Rino, C. L., **C. S. Carrano**, and P. Roddy (2014), Wavelet-based analysis and power law classification of C/NOFS high-resolution electron density data *Radio Science*, 49, 680–688, doi:10.1002/2013RS005272.
39. Meyer, F.J., K. Chotoo, S. Chotoo, B. Huxtable, **C. Carrano**, Studying the influence of equatorial TEC scintillation on low-frequency SAR data, *Proceedings of the 2014 IEEE Geoscience and Remote Sensing Society (IGARSS) meeting*, Quebec, July 13-18, 2014.
40. **Carrano, C. S.**, K. M. Groves, S. H. Delay, and P. H. Doherty (2014), An Inverse Diffraction Technique for Scaling Measurements of Ionospheric Scintillations on the GPS L1, L2, and L5 Carriers to Other Frequencies, *Proceedings of the 2014 Institute of Navigation ION ITM meeting*, San Diego, California, January 27-29, 2014.
41. Deshpande, K. B., G. S. Bust, C. R. Clauer, C. L. Rino, and **C. S. Carrano** (2014), Satellite-beacon Ionospheric-scintillation Global Model of the upper Atmosphere (SIGMA) I: High-latitude sensitivity study of the model parameters, *J. Geophys. Res. Space Physics*, 119, 4026–4043, doi:10.1002/2013JA019699.
42. Akala, A.O., L.L.N. Amaeshi, P.H. Doherty, K.M. Groves, **C.S. Carrano**, C.T. Bridgwood, G.K. Seemala, E.O. Somoye (2014), Characterization of GNSS scintillations over Lagos, Nigeria during the minimum and ascending phases (2009–2011) of solar cycle 24, *Advances in Space Research*, Volume 53, Issue 1, 1 January 2014, Pages 37-47.
43. Akala, A. O., G. K. Seemala, P. H. Doherty, C. E. Valladares, **C. S. Carrano**, J. Espinoza, and S. Oluyo (2013), Comparison of equatorial GPS-TEC observations over an African station and an American station during the minimum and ascending phases of solar cycle 24, *Ann. Geophys.*, 31, 2085-2096.
44. Herne, D., J. Kennewell, M. Lynch, **C. Carrano** (2014), Ionospheric Phenomena and Low-Frequency Radio Astronomy, 13th Australian Space Science Conference Sydney, National Space Society of Australia Ltd., Sydney Australia, September 30 - October 2, 2013.
45. Rino, C. and **C. S. Carrano**, A compact strong-scatter scintillation model, *Proceedings of the International Beacon Satellite Symposium*, July 8-12, 2013, Bath, UK.

46. Lay, E. H., X.-M. Shao, and **C. S. Carrano** (2013), Variation in total electron content above large thunderstorms, *Geophys. Res. Lett.*, 40, 1945–1949, doi:10.1002/grl.50499.
47. **Carrano, C. S.**, Groves, K. M., McNeil, W. J., Doherty, P. H. (2013), Direct Measurement of the Residual in the Ionosphere-Free Linear Combination during Scintillation, *Proceedings of the 2013 International Technical Meeting of The Institute of Navigation*, San Diego, California, January 2013, pp. 585-596.
48. **Carrano, C. S.**, Groves, K. M., McNeil, W. J., Doherty, P. H. (2012), Scintillation Characteristics Across the GPS Frequency Band, *Proceedings of the 25th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS 2012)*, Nashville, TN, September 2012, pp. 1972-1989.
49. Akala, A. O., P. H. Doherty, **C. S. Carrano**, C. E. Valladares, and K. M. Groves (2012), Impacts of ionospheric scintillations on GPS receivers intended for equatorial aviation applications, *Radio Sci.*, 47, RS4007, doi:10.1029/2012RS004995.
50. **Carrano, C. S.**, K. M. Groves, and R. G. Caton (2012), The effect of phase scintillations on the accuracy of phase screen simulation using deterministic screens derived from GPS and ALTAIR measurements, *Radio Sci.*, 47, RS0L25, doi:10.1029/2011RS004958.
51. **Carrano, C. S.**, K. M. Groves, and R. G. Caton (2012), Simulating the impacts of ionospheric scintillation on L band SAR image formation, *Radio Sci.*, 47, RS0L20, doi:10.1029/2011RS004956.
52. **Carrano, C. S.**, C. E. Valladares, and K. M. Groves (2012), Latitudinal and local time variation of ionospheric turbulence parameters during the Conjugate Point Equatorial Experiment in Brazil, *International Journal of Geophysics*, vol. 2012, Article ID 103963, 16 pages, doi:10.1155/2012/103963 (invited paper).
53. Paznukhov, V., **C. Carrano**, P. Doherty, K. Groves, R. Caton, C. Valladares, G. Seemala, C. Bridgwood, J. Adeniyi, L. Amaeshi, B. Damtie, F. D'Ujanga Mutony, J. Ndeda, P. Baki, O. Obrou, B. Okere, and G. Tsidu (2012), Equatorial plasma bubbles and L-band scintillations in Africa during solar minimum, *Ann. Geophys.*, 30, 675-682, doi:10.5194/angeo-30-675-2012.
54. Akala, A. O., P. H. Doherty, C. E. Valladares, **C. S. Carrano**, and R. Sheehan (2011), Statistics of GPS scintillations over South America at three levels of solar activity, *Radio Sci.*, 46, RS5018, doi:10.1029/2011RS004678.
55. **Carrano, C. S.** and C. L. Rino (2011), Split-step solution of the 4th moment equation for propagation through intense ionospheric disturbances, *Proceedings of the International Conference on Electromagnetics in Advanced Applications (ICEAA 2011)*, Turin, Italy, 2011.
56. **Carrano, C. S.**, K. M. Groves, and R. G. Caton (2011), Accuracy of phase screen models using deterministic screens derived from GPS and ALTAIR measurements, *Proceedings of the Ionospheric Effects Symposium*, Alexandria, VA, May 17-19, 2011.
57. Rino, C. S., **Carrano, C. S.**, K. M. Groves (2011), Geometric translation and signal processing for beacon satellite data assimilation, *Proceedings of the Ionospheric Effects Symposium*, Alexandria, VA, May 17-19, 2011.

58. **Carrano, C. S.**, Keith M. Groves, and Ronald G. Caton (2011), Modeling scintillation impacts on L band SAR image formation using the SAR Scintillation Simulator (SAR-SS), *Proceedings of the Ionospheric Effects Symposium*, Alexandria, VA, May 17-19, 2011.
59. Paznukhov, V.V., **C. S. Carrano**, C. E. Valladares, G. K. Semala, C. T. Bridgwood, J. Adeniyi, L. L. N. Amaeshi, B. Dantie, F. D. Mutonyi, J. D. H. Ndeda, P. Baki, O. K. Obrou, B. Okere, G. M. Tsidu (2011), GPS observations of plasma bubbles and scintillations over equatorial Africa, *Proceedings of the Ionospheric Effects Symposium*, Alexandria, VA, May 17-19, 2011.
60. Akala, A., P. Doherty, **C. S. Carrano**, C. E. Valladares, K. M. Groves, Impacts of ionospheric scintillations on GPS receivers intended for equatorial aviation applications, *Submitted to Radio Sci.*, 2011.
61. Akala, A., P. Doherty, C. Valladares, **C. S. Carrano**, R. Sheehan (2011), Statistics of GPS scintillations over South America at three levels of solar activity, accepted for publication in *Radio Sci.*, 2011.
62. **Carrano, C. S.**, K. M. Groves, R. G. Caton, C. L. Rino, and P. R. Straus (2011), Multiple phase screen modeling of ionospheric scintillation along radio occultation raypaths, *Radio Sci.*, 46, RS0D07, doi:10.1029/2010RS004591.
63. Rino, C. L., and **Carrano, C. S.** (2011), The application of numerical simulations in Beacon scintillation analysis and modeling, *Radio Sci.*, 46, RS0D02, doi:10.1029/2010RS004563.
64. **Carrano, C. S.**, K. M. Groves (2010), Temporal decorrelation of GPS satellite signals due to multiple scattering from ionospheric irregularities, *Proceedings of the 2010 Institute of Navigation ION GNSS meeting*, Portland, OR, September 21-24.
65. **Carrano, C. S.**, K. M. Groves, and R. G. Caton (2010), A phase screen simulator for predicting the impact of small-scale ionospheric structure on SAR image formation and interferometry, *Proceedings of the 2010 IEEE Geoscience and Remote Sensing Society meeting*, Honolulu, July 25 - 30, 2010.
66. Basu, S., Su. Basu, E. MacKenzie, C. Bridgwood, C. E. Valladares, K. M. Groves, and **C. Carrano** (2010), Specification of the occurrence of equatorial ionospheric scintillations during the main phase of large magnetic storms within solar cycle 23, *Radio Sci.*, 45, RS5009, doi:10.1029/2009RS004343.
67. **Carrano, C. S.**, A. Anghel, R. A. Quinn, and K. M. Groves, Kalman filter estimation of plasmaspheric total electron content using GPS, *Radio Sci.*, 44, RS0A10, doi:10.1029/2008RS004070, 2009.
68. **Carrano, C. S.**, C. T. Bridgwood, and K. M. Groves (2009), Impacts of the December 2006 solar radio bursts on the performance of GPS, *Radio Sci.*, 44, RS0A25, doi:10.1029/2008RS004071, 2009.
69. Jayachandran, P. T., R. B. Langley, J. W. MacDougall, S. C. Mushini, D. Pokhotelov, A. M. Hamza, I. R. Mann, D. K. Milling, Z. C. Kale, R. Chadwick, T. Kelly, D. W. Danskin, and **C. S. Carrano**, Canadian High Arctic Ionospheric Network (CHAIN), *Radio Sci.*, 44, RS0A03, doi:10.1029/2008RS004046, 2009.
70. Anghel, A., **C. S. Carrano**, A. Komjathy, A. Astilean, and T. Letia, Monitoring the Ionosphere and Plasmasphere with GPS in Near-real Time, *JASTP*, vol 71, no 1, 158-174, 2009.
71. Caton R. G., **C. S. Carrano**, C. M. Alcalá, K. M. Groves, T. Beach, D. Sponseller, Simulating the effects of scintillation on transionospheric signals with a two-way phase screen constructed from ALTAIR phase-derived TEC, *Radio Sci.*, 44, RS0A12, doi:10.1029/2008RS004047, 2009.



72. Akala, A. O., P. H. Doherty, **C. S. Carrano**, and L. L. N Ameshi, The role of Global Positioning System (GPS) in Future Aviation Safety in Nigeria, *Proceedings of the Institute of Navigation*, International Technical Meeting, Anaheim, CA, January, 2009.
73. Burrell, A., N.A Bonito, and **C. S. Carrano**, Total Electron Content (TEC) Processing from GPS observations to facilitate ionospheric Modeling, *GPS Solutions*, doi 10.1007/s10291-008-0102-3, 2008.
74. Bernhardt, P., T. Ainsworth, K. Groves, T. Beach, R. G. Caton, **C. S. Carrano**, C. M. Alcala, D. D. Sponseller, Detection of ionospheric structures with L-band synthetic aperture radars, *Proceedings of the 2008 IEEE Geoscience and Remote Sensing Symposium*, Boston, MA, July 6-11, 2008.
75. Caton, R. G., **C. S. Carrano**, C. M. Alcala, K. M. Groves, T. Beach, D. Sponseller, Evaluation of a phase screen model: comparisons with the VHF/UHF ALTAIR radar, *Proceedings of the 12<sup>th</sup> International Ionospheric Effects Symposium*, Alexandria, VA, May 13-15, 2008.
76. **Carrano, C. S.**, R. A. Quinn, K. M. Groves, A. Anghel, and M. V. Codrescu, Kalman Filter Estimation of Plasmaspheric TEC using GPS, *Proceedings of the 12<sup>th</sup> International Ionospheric Effects Symposium*, Alexandria, VA, May 13-15, 2008.
77. **Carrano, C.**, Christopher T. Bridgwood, and Keith M. Groves, Impacts of the December 2006 Solar Radio Bursts on the Performance of GPS, *Proceedings of the 12<sup>th</sup> International Ionospheric Effects Symposium*, Alexandria, VA, May 13-15, 2008.
78. **Carrano C.**, K. Groves, and C. Bridgwood, Impacts of the December 2006 Solar Radio Bursts on GPS Operations, *Proceedings of the American Meteorological Society 88<sup>th</sup> Annual Meeting*, New Orleans, LA, Jan 20-24, 2008.
79. **Carrano C.**, K. Groves, and C. Bridgwood, Effects of the December 2006 Solar Radio Bursts on the GPS Receivers of the AFRL-SCINDA Network, *Proceedings of the International Beacon Satellite Symposium*, Boston, MA, June 11-15, 2007.
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