

RASHMI SHAH

Research Technologist

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EDUCATION

Purdue University

Ph.D., Aeronautics/Astronautics

West Lafayette, IN

May 2014

Dissertation: Remote Sensing of Ocean Surface Using Digital Communication Signals.

M.S., Aeronautics/Astronautics

December 2010

Thesis: Analysis of the Correlation Properties of Digital Satellite Signals and Their Applicability in Bistatic Remote Sensing.

Rochester Institute of Technology

B.S., Electrical Engineering, Highest Honors, GPA: 3.86/4.00

Rochester, NY

May 2007

PROFESSIONAL EXPERIENCE

Jet Propulsion Laboratory

Pasadena, CA

Associate Technologist for Earth Science and Technology Directorate

Nov. 2021 - Present

- **Strategic Development:** Participate and support Earth Science Strategy by contributing in technology strategy, roadmap, and portfolio development.
- **Strategic Initiative Lead:** Strategic Initiative lead for Planetary Boundary Layer and Surface Topography and Vegetation Instrument development in preparation for next Decadal Survey.
- **Principal Investigator/Study Lead:** Lead for a concept study for NASA to develop architecture for passively monitoring wildland fire, in collaboration with commercial space-based remote sensing providers.

Research Technologist

Apr. 2014 - Present

- **Project Lead:** JPL lead and project manager for NASA InVEST Mission SNOOPI in collaboration with Purdue University and Goddard Space Flight Center for measurement of soil moisture and snow.
- **Concept Formulation:** Instrument lead and science implementation lead for development of mission proposals in response for Earth Venture Mission and Earth System Explorer call.
- **Payload Specialist:** Payload specialist for airborne campaign to measure snow water equivalent using signals of opportunity reflectometry (SoOp-R) technique.
- **Concept Formulation:** Develop ideas and write proposals as PI (or Co/I) to design future missions for remote sensing using SoOp-R technique.
- **Concept Development:** Build instrument, conduct experiment to collect data, and develop new algorithms to measure land and ocean remote sensing parameters using reflected SoOp-R from VHF-K bands.
- **Algorithm Development:** Analyze data and develop algorithms for inundated wetland mapping and soil moisture retrieval using spaceborne and airborne reflected Global Navigation Satellite System (GNSS-R) data.

Science Systems Engineering

Oct. 2021 - Present

- **Observing Systems Architecture:** Co-manage project with PI in development of systems architecture for Earth Systems measurement in preparation for next Earth Science Decadal Survey.

Architecture-Team Core Team Member

Jan. 2018 - Sept. 2022

- **Concept Formulation:** Lead studies as study lead and/or participate as a subject matter expert (SME) in JPL's formulation team studies.

Starlab Barcelona S.L.

Barcelona, Spain

Visiting Researcher

Sept. 2013 - Nov. 2013

- **Concept Development:** Collaborated on experiments to develop commercial GNSS-R receiver for ocean remote sensing

NASA Goddard Space Flight Center

Greenbelt, MD

Visiting Researcher

Summer 2013

- **Requirements Development:** Conducted reflectometry experiment to develop calibration requirements for remote sensing measurements.

Summer Intern

Summers of 2009, 2010, and 2011

- **Software Receiver:** Coded, tested, and verified USRPv2 based TDRSS software receiver to demonstrate the unique capabilities of software defined radio to support NASA space communications.
- **Communication System:** Prototyped elements for TDRSS Waveform and Noise Generator in MATLAB/C to accurately simulate a communication system.
- **Multipath Analysis:** Analyzed multipath GPS flight data from Relative Navigation System experiment that flew on STS-125 Hubble Servicing Mission. Data collected during Hubble-Shuttle rendezvous phase was evaluated for its potential use for autonomous rendezvous and docking

Purdue University

Graduate Fellow/Assistant

West Lafayette, IN

July 2007 - Apr. 2014

- **Research Fellow:** Conducted successful offshore reflectometry experiment at Platform Harvest to develop models for ocean remote sensing using digital communication signal reflectometry to measure significant wave height and sea surface height.
- **Research Assistant:** Acquired and evaluated GPS/digital communication satellite signals for radio navigation application and analyzed signal properties to develop requirements for purpose of remote sensing.

RESEARCH GRANTS

- **JPL Strategic University Partnership Program**
PI, A new phase in GNSS-R: using coherent phase measurements to estimate surface parameters *2019-2020*
- **NASA ROSES In-Space Validation of Earth Science Technologies**
Co-I, SNOOPI: SigNals-Of-Opportunity P-band Investigation *2018-2024*
- **NASA ROSES New Investigator Program**
PI, Coherence Properties Characterization of Signals of Opportunity Over Land Surface for Snow Retrieval *2018-2021*
- **NASA ROSES CYGNSS Competed Science Team**
Co-I, CYGNSS Soil Moisture Algorithm and Validation *2018-2021*
- **JPL Blue Sky Program**
PI, Signals of Opportunity (SoOp) and their potential to revolutionize *2017*
- **PI, NASA ROSES Physical Oceanography**
PI, Wideband Altimetry Using Signals of Opportunity *2015-2020*
- **JPL Topical Research & Technology Development**
PI, Bistatic Reflectometry Using UHF Signals of Opportunity (SoOps) for SWE and RZSM Measurement *2015-2018*

AWARDS AND FELLOWSHIPS

- JPL Lew Allen Award *2023*
- JPL Voyager Award *2023*
- IEEE Geoscience and Remote Sensing Society Early Career Award *2020*
- JPL Voyager Award *2019*
- NASA Early Career Public Achievement Medal *2019*
- National Academies Early Career Program Awardee *Mar. 2019*
- JPL Discovery Award *2014*
- NASA Earth and Space Science Fellowship *2011-2014*
- Zonta International Amelia Earhart Fellowship *2011-2012*

PROFESSIONAL ASSOCIATIONS

- **Institute of Electrical and Electronics Engineers (IEEE):**
 - Member (2007-2017), Senior Member (2017-Present)
- **IEEE Geoscience and Remote Sensing Society (GRSS):**
 - *IEEE GRSS Instrumentation and Future Technologies Technical Committee:* Technical Committee Chair (2023-Present)
 - *IEEE Geoscience and Remote Sensing Symposium (IGARSS), 2023:* Technical Program Co-Chair and Website Coordinator Chair
 - *Metropolitan Los Angeles Chapter:* Secretary (2017-2018), Vice-Chair (2019-Present), Chair (2020- Present)
 - *IFT Technical Committee GNSS and Signals of Opportunity Working Group:* Co-Chair, (2017-2023)

- *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS)* Associate Editor, (2019-Present)
- Member (2011-2016), Senior Member (2017-Present)
- **IEEE Young Professionals (YP):**
 - *Metropolitan Los Angeles Affinity Group*: Treasurer and Founding Member (Jan. 2016- Dec. 2016)
 - Member (2013-2017), Senior Member (2017-Present)

ORGANIZATIONAL LEADERSHIP

- **JPL New Researcher's Support Group:**
 - Proposal and Paper Chair (2017), Vice President (2018), President (2019)
- **JPL Pitch Day:**
 - Founding member and organizer (2015-2020)
- **JPL's Advisory Council for Women:**
 - Events Coordinator (2015-2017)

ADDITIONAL SKILLS

- **Languages:** English (fluent), Hindi (fluent), Nepali (intermediate)
- **Software/Programming:** MATLAB, Simulink, C/C++, Python, Unix shell scripts, Satellite Tool Kit, ArcGIS, LaTeX
- **Flying:** Private Pilot License
- **Amateur Radio:** General Class

PUBLICATIONS

Peer Reviewed Journal Publications

1. S. H. Yueh, **R. Shah**, X. Xu, B. Stiles and X. Bosch-Lluis, "A Satellite Synthetic Aperture Radar Concept Using P-Band Signals of Opportunity," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 14, pp. 2796-2816, 2021, <https://doi.org/10.1109/JSTARS.2021.3059242>
2. I. Collett, Y. Wang, **R. Shah** and Y. J. Morton, "Phase Coherence of GPS Signal Land Reflections and its Dependence on Surface Characteristics," *IEEE Geoscience and Remote Sensing Letters*, vol. 19, pp. 1-5, 2022, Art no. 3003705, <https://doi.org/10.1109/LGRS.2021.3094407>
3. T.M. Roberts, I. Colwell, C. Chew, S. Lowe, **R. Shah**, "A Deep-Learning Approach to Soil Moisture Estimation with GNSS-R," *Remote Sens.*, 2022, 14, 3299. <https://doi.org/10.3390/rs14143299>
4. H. Carreno-Luengo, A. Camps, C. Ruf, ..., **R. Shah**, et al., "The IEEE-SA Working Group on Spaceborne GNSS-R: Scene Study," *IEEE Access*, vol. 9, pp. 89906-89933, 2021, <https://doi.org/10.1109/ACCESS.2021.3089762>
5. S. Abdalla, A.K. Abdolnabi, M. Ablain, S. Adusumilli, S. A. Bhowmick, ..., **R. Shah**, et al., "Altimetry for the future: Building on 25 years of progress." *Advances in Space Research* 68, no. 2 (2021): 319-363. <https://doi.org/10.1016/j.asr.2021.01.022>
6. M. M. Al-Khaldi, ..., **R. Shah**, et al., "Inland Water Body Mapping Using CYGNSS Coherence Detection," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 59, no. 9, pp. 7385-7394, Sept. 2021, <https://doi.org/10.1109/TGRS.2020.3047075>
7. M. M. Al-Khaldi, **R. Shah**, C. C. Chew, J. T. Johnson and S. Gleason, "Mapping the Dynamics of the South Asian Monsoon Using CYGNSS's Level-1 Signal Coherency," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 14, pp. 1111-1119, 2021, <https://doi.org/10.1109/JSTARS.2020.3042170>

8. S. H. Yueh, **R. Shah**, M. J. Chaubell, A. Hayashi, X. Xu and A. Colliander, "A Semiempirical Modeling of Soil Moisture, Vegetation, and Surface Roughness Impact on CYGNSS Reflectometry Data," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-17, 2022, Art no. 5800117, <https://doi.org/10.1109/TGRS.2020.3035989>
9. M. Morris, C. Chew, J. T. Reager, **R. Shah**, and C. Zuffada, "A novel approach to monitoring wetland dynamics using CYGNSS: Everglades case study," *Remote Sensing of Environment*, vol. 233, pp. 111417, 2019. <https://doi.org/10.1016/j.rse.2019.111417>
10. P. N. Mohammed, A. J. Schoenwald, R. Pannu, J. R. Piepmeier, D. Bradley, S. C. Ho, **R. Shah** and J. L. Garrison, "Detection of Radio Frequency Interference in Microwave Radiometers Operating in Shared Spectrum," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 57, no. 9, pp. 7067-7074, Sept. 2019. <https://doi.org/10.1109/TGRS.2019.2911290>
11. J. Benveniste, A. Cazenave, S. Vignudelli, L. Fenoglio-Marc, **R. Shah**, R. Almar, O. B. Andersen, et al., "Requirements for a Coastal Zone Observing System," *Frontiers in Marine Science, section Coastal Ocean Processes*, vol. 6, pp. 348, Jul. 2019. <https://doi.org/10.3389/fmars.2019.00348>
12. S. Yueh, **R. Shah**, X. Xu, K. Elder, and B. Starr, "Experimental Demonstration of Soil Moisture Remote Sensing Using P-Band Satellite Signals of Opportunity," *IEEE Geoscience and Remote Sensing Letters*, Jul. 2019. <https://doi.org/10.1109/LGRS.2019.2918764>
13. S. C. Ho, **R. Shah**, P. Mohammed, A. Scheonwald, J. Piepmeier, and R. K. Pannu, "Wideband Ocean Altimetry using Ku and K-band Satellite Signals of Opportunity (SoOp): Proof of Concept," *IEEE Geoscience and Remote Sensing Letters*, vol. 16, no. 7, pp. 1012-1016, Jul. 2019. <https://doi.org/10.1109/LGRS.2019.2891976>
14. S. H. Yueh, X. Xu, **R. Shah**, Y. Kim, J. L. Garrison, A. Komanduru, and K. Elder, "Remote Sensing of Snow Water Equivalent Using Coherent Reflection From Satellite Signals of Opportunity: Theoretical Modeling," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 10, no. 12, pp. 5529-5540, Dec. 2017. <https://doi.org/10.1109/JSTARS.2017.2743172>
15. **R. Shah** and J. L. Garrison, "Precision of Ku-Band Reflected Signals of Opportunity Altimetry," *IEEE Geoscience and Remote Sensing Letters*, vol. 14, no. 10, pp. 1840-1844, Oct. 2017. <https://doi.org/10.1109/LGRS.2017.2737949>
16. **R. Shah**, X. Xu, S. Yueh, C. Chae, K. Elder, B. Starr, and Y. Kim, "Remote Sensing of Snow Water Equivalent Using P-Band Coherent Reflection," *IEEE Geoscience and Remote Sensing Letters*, vol. 14, no. 3, pp. 309-313, March 2017. <https://doi.org/10.1109/LGRS.2016.2636664>
17. S.V. Nghiem, C. Zuffada, **R. Shah**, C. Chew, S. T. Lowe, A. J. Mannucci, E. Cardellach, G. R. Brakenridge, G. Geller, and A. Rosenqvist, "Wetland Monitoring with Global Navigation Satellite System Reflectometry," *Earth and Space Science*, vol. 4, pp. 16-39, 2017. <https://doi.org/10.1002/2016EA000194>
18. C. Chew, **R. Shah**, C. Zuffada, G. Hajj, D. Masters, and A.J. Mannucci, "Demonstrating soil moisture remote sensing with observations from the UK TechDemoSat-1 satellite mission," *Geophysical Research Letters*, vol. 43, no. 7, pp. 3317-3324, Apr. 2016. <https://doi.org/10.1002/2016GL068189>
19. **R. Shah**, J.L. Garrison, A. Egido, and G. Ruffini, "Bistatic Radar Measurements of Significant Wave Height Using Signals of Opportunity in L-, S-, and Ku-Bands," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 54, no. 2, pp 826-841, Feb. 2016. <https://doi.org/10.1109/TGRS.2015.2466682>
20. **R. Shah** and J.L. Garrison, "Application of Digital Communication Signals to Measure Ocean Parameters using ICF Coherence Time Method," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 7, no. 5, pp. 1584-1591, May 2014. <https://doi.org/10.1109/JSTARS.2014.2314531>
21. **R. Shah**, J.L. Garrison, and M.S. Grant, "Demonstration of Bistatic Radar for Ocean Remote Sensing Using Communication Satellite Signals," *IEEE Geoscience and Remote Sensing Letters*, vol. 9, no. 4, pp. 619-623, July, 2012. <https://doi.org/10.1109/LGRS.2011.2177061>

Peer Reviewed Conference Articles

1. Garrison, J. L., J. Piepmeier, **R. Shah**, M. A. Vega, D. A. Spencer, R. Banting, C. M. Firman, B. Nold, K. Larsen, and R. Bindlish. "SNOOPI: A Technology Validation Mission for P-band Reflectometry using Signals of Opportunity." *2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2019)*, Yokohama, Japan, 2019, pp. 5082-5085.. <https://doi.org/10.1109/IGARSS.2019.8900351>
2. Loria, E., A. O'Brien, V. Zavorotny, M. Lavalley, C. Chew, **R. Shah**, and C. Zuffada. "Analysis of Wetland Extent Retrieval Accuracy Using Cygnss." *2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2019)*, Yokohama, 2019, pp. 8684-8687. <https://doi.org/10.1109/IGARSS.2019.8898132>
3. Meyer, V., A. A. Bloom, M. S. Burgin, J. T. Reager, **R. Shah**, and A. Konings. "Reduced Uncertainties from Multifrequency Constraints on Terrestrial Carbon and Water Processes." *2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2019)*, Yokohama, 2019, pp. 5504-5507. <https://doi.org/10.1109/IGARSS.2019.8898132>
4. Nghiem, S. V., D. K. Perovich, C. Polashenski, S. T. Lowe, **R. Shah**, A. J. Mannucci, A. Camps, E. Cardellach, et al. "Polar Sea Ice Thickness and Melt Pond Fraction Measurements with Multi-Frequency Bistatic Radar Polarimetric and Interferometric Reflectometry." *2019 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2019)*, Yokohama, 2019, pp. 4012-4015. <https://doi.org/10.1109/IGARSS.2019.8900079>
5. S. Yueh, **R. Shah**, X. Xu, K. Elder, S. Margulis, G. Liston, M. Durand, C. Derksen, and J. Elston. "UAS-based P-band signals of opportunity for remote sensing of snow and root zone soil moisture." *Sensors, Systems, and Next-Generation Satellites XXII*, Berlin, Germany, 2018, vol. 10785, p. 107850B. <https://doi.org/10.1117/12.2325819>
6. **R. Shah**, T. Freeman, and J. L. Garrison. "Constellations of CubeSats to exploit signals-of-opportunity for Earth system science." *CubeSats and NanoSats for Remote Sensing II*, San Diego, CA, 2018, vol. 10769, p. 107690D. <https://doi.org/10.1117/12.2319863>
7. J. L. Garrison, J. R. Piepmeier, and **R. Shah**. "Signals of Opportunity: Enabling New Science Outside of Protected Bands." *2018 International Conference on Electromagnetics in Advanced Applications (ICEAA 2018)*, Cartagena des Indias, 2018, pp. 501-504. <https://doi.org/10.1109/ICEAA.2018.8520391>
8. X. Xu, K. Elder, **R. Shah**, H. Huang, S. Yueh, and L. Tsang. "Retrieving Snow Water Equivalence using Signals of Opportunity Bistatic Radar." *2018 International Conference on Electromagnetics in Advanced Applications (ICEAA 2018)*, Cartagena des Indias, 2018, pp. 518-520. <https://doi.org/10.1109/ICEAA.2018.8520425>
9. **R. Shah**, J. Garrison, Z. Li, and S. C. Ho. "Coastal Application of Sea Surface Height Measurement Using Direct Broadcast Satellite Signals." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 7676-7679. <https://doi.org/10.1109/IGARSS.2018.8518108>
10. S. Yueh, X. Xu, **R. Shah**, S. Margulis, and K. Elder. "P-Band Signals of Opportunity for Remote Sensing of Root Zone Soil Moisture." *2018 IEEE International Geoscience and Remote Sensing Symposium*, Valencia, Spain, 2018, pp. 1403-1406. <https://doi.org/10.1109/IGARSS.2018.8518079>
11. J. Mashburn, A. O'Brien, P. Axelrad, C. Zuffada, S. Lowe, **R. Shah**, A. Voronovich, and V. Zavorotny. "A Comparison of Waveform Model Re-Tracking Methods Using Data from CYGNSS." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 4289-4292. <https://doi.org/10.1109/IGARSS.2018.8518280>
12. **R. Shah**, S. Yueh, X. Xu, K. Elder, H. Huang, and L. Tsang. "Experimental Results of Snow Measurement Using P-Band Signals of Opportunity." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 6280-6283. <https://doi.org/10.1109/IGARSS.2018.8517749>
13. M. Lavalley, M. Morris, **R. Shah**, C. Zuffada, S. V. Nghiem, C. Chew, and V. U. Zavorotny. "Bistatic Scattering Modeling for Dynamic Mapping of Tropical Wetlands with Cygnss." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 239-242. <https://doi.org/10.1109/IGARSS.2018.8519285>

14. C. Zuffada, B. Haines, G. Hajj, Z. Li, S. Lowe, **R. Shah**, J. Mashburn et al., "Assessing the Altimetric Measurement from CYGNSS Data." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 8292-8295.
<https://doi.org/10.1109/IGARSS.2018.8518239>
15. H. Huang, L. Tsang, A. Colliander, **R. Shah**, and S. Yueh. "NMM3D Full Wave Simulations of Vegetation and Forest Effects in Microwave Remote Sensing." *2018 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2018)*, Valencia, Spain, 2018, pp. 260-263.
<https://doi.org/10.1109/IGARSS.2018.8517901>
16. H. Huang, L. Tsang, A. Colliander, **R. Shah**, Xiaolan Xu, Eni G. Njoku, and Simon Yueh. "Numerical 3D Solutions of Maxwell Equations Based on Hybrid Method Combining Generalized T Matrix and Foldy-Lax Multiple Scattering Theory for Vegetation/Trees Scattering." *2018 IEEE International Conference on Computational Electromagnetics (ICCEM 2018)*, Chengdu, 2018, pp. 1-3.
<https://doi.org/10.1109/COMPEM.2018.8496605>
17. S. Yueh, **R. Shah**, X. Xu, K. Elder, C. S. Chae, S. Margulis, G. Liston, M. Durand, and C. Derksen. "HydroCube mission concept: P-Band signals of opportunity for remote sensing of snow and root zone soil moisture." *Proceedings of the Sensors, Systems, and Next-Generation Satellites XXI*, Warsaw, Poland, 2017, vol. 10423, pp. 104230L. <https://doi.org/10.1117/12.2278511>
18. **R. Shah**, C. Zuffada, C. Chew, M. Lavalley, X. Xu, and A. Azemati. "Modeling bistatic scattering signatures from sources of opportunity in P-Ka bands." *2017 International Conference on Electromagnetics in Advanced Applications (ICEAA 2017)*, Verona, 2017, pp. 1684-1687.
<https://doi.org/10.1109/ICEAA.2017.8065616>
19. **R. Shah**, J. Garrison, S. C. Ho, P. Mohammed, J. R. Piepmeier, A. Schoenwald, R. Pannu, A. Korde-Patel, and D. Bradley, "Ocean Altimetry Using Wideband Signals of Opportunity," *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2017)*, Fort Worth, TX, 2017, pp. 2690-2693. <https://doi.org/10.1109/IGARSS.2017.8127550>
20. **R. Shah**, S. Yueh, X. Xu, K. Elder, and C. Baldi, "Remote Sensing of Terrestrial Snow Using Signals of Opportunity," in *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2017)*, Fort Worth, TX, 2017, pp. 1366-1369. <https://doi.org/10.1109/IGARSS.2017.8127216>
21. Xu, X., **R. Shah**, S. Yueh, and K. Elder, "Reflectivity Modeling of Signals of Opportunity for Remote Sensing of Snow and Soil Moisture," in *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2017)*, Fort Worth, TX, 2017, pp. 1438-1440.
<https://doi.org/10.1109/IGARSS.2017.8127236>
22. Cardellach, E., F. Fabra, W. Li, S. Ribó, A. Rius, **R. Shah**, C. C. Chew, S. V. Nghiem, M. Semmling, "Wetlands GNSS-R Measurements from Aircraft," in *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2017)*, Fort Worth, TX, 2017, pp. 1122-1125.
<https://doi.org/10.1109/IGARSS.2017.8127154>
23. Mannucci, A., S. Lowe, J. Dickson, L. Young, G. Franklin, T. Meehan, S. Esterhuizen, C. Ao, P. Vergados, C. Chew, S. Kim, S. Nghiem, J. Turk, C. Zuffada, **R. Shah**, A. Komjathy, "High-Value Remote Sensing for the Geosciences: Opportunistic Use of Navigation Satellite Signals," in *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2017)*, Fort Worth, TX, 2017, pp. 2686-2689. <https://doi.org/10.1109/IGARSS.2017.8127549>
24. **R. Shah**, S. Yueh, X. Xu, C. Chae, M. Simard, and K. Elder, "Snow Water Equivalent retrieval using P-band signals of Opportunity," *2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2016)*, Beijing, 2016, pp. 7064-7066. <https://doi.org/10.1109/IGARSS.2016.7730842>
25. Chew, C. C., **R. Shah**, C. Zuffada, and A. J. Mannucci, "Wetland mapping and measurement of flood inundated area using ground-reflected GNSS signals in a bistatic radar system," *2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2016)*, Beijing, 2016, pp. 7184-7187. 2016. <https://doi.org/10.1109/IGARSS.2016.7730874>
26. Zuffada, C., Z. Li, S. V. Nghiem, S. Lowe, **R. Shah**, M. P. Clarizia, and E. Cardellach, "The rise of GNSS reflectometry for Earth remote sensing," *2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2015)*, Milan, 2015, pp. 5111-5114. <https://doi.org/10.1109/IGARSS.2015.7326983>

27. **R. Shah** and J.L. Garrison, "Estimating Significant Wave Height Using Reflected Digital Communication Signals," *2013 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2013)*, Melbourne, VIC, 2013, pp. 3899-3902. <https://doi.org/10.1109/IGARSS.2013.6723684>
28. **R. Shah** and J.L. Garrison, "Correlation Properties for Direct Broadcast Signals for Bistatic Remote Sensing," *2012 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2012)*, Munich, 2012, pp. 7508-7511. <https://doi.org/10.1109/IGARSS.2012.6351895>
29. **R. Shah**, J.L. Garrison, and M.S. Grant, "Anisotropy in ocean scattering of bistatic radar using signals of opportunity," *2011 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2011)*, Vancouver, BC, 2011, pp. 4229-4232. <https://doi.org/10.1109/IGARSS.2011.6050164>
30. **R. Shah**, M.A. Walker, J. Voo, J.L. Garrison, P. Stout, K. Pekkarinen and D. LeJeune, "Study of GPS Reflections and Multipath During Hubble Servicing Mission 4 (STS-125)," *Proceedings of the 23rd International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS 2010)*, pp. 2743-2749, Portland, OR, 21-24 September, 2010. <https://www.ion.org/publications/abstract.cfm?articleID=9381>
31. **R. Shah**, J.L. Garrison, M.S. Grant, S.J. Katzberg and G. Tian, "Analysis of the correlation properties of digital satellite signals and their applicability in bistatic remote sensing," *2010 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2010)*, Honolulu, HI, 2010, pp. 4114-4117. <https://doi.org/10.1109/IGARSS.2010.5651392>