USC Viterbi
School of Engineering
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Seminar

Advancing the science and technology of Signals of Opportunity (SoOp) remote sensing

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Abstract: Signals of Opportunity (SoOp) is an emerging field in microwave remote sensing in which existing anthropogenic signals (typically from communications or navigation satellites) are re-utilized in a non-cooperative manner as sources of illumination for bistatic radar. SoOp observations exhibit some properties common to either active radar or passive radiometry, but also have unique features distinct from these two classical approaches. Realizing the full potential of SoOp has required the development of new instruments, signal processing algorithms, geophysical model functions, and data assimilation methods. This presentation will review the fundamental theoretical and experimental research conducted by Prof. Garrison's group in these areas. SoOp signal models must integrate communication theory with the interaction between electromagnetic waves and natural media. Although many important geophysical variables measured by SoOp (e.g. ocean winds, soil moisture, and snow water equivalent) are the same as those observed by any other remote sensing technique, the basic electromagnetic quantities ("Level 1" data products) and their relationship to these geophysical variables are quite different. Direct assimilation of Level 1 data into Earth systems models, without explicitly inverting this relationship, could potentially reduce biases and improve their use in forecasting. Terrestrial and airborne campaigns are vital to this research both in the development of empirical model functions using in situ reference data and in the early-stage testing and demonstration of new instrument technologies.

This talk will also highlight some potential pathways from fundamental research to application of SoOp remote sensing in Earth science missions, using three examples covering different stages of technical maturity. First, Global Navigation Satellite System Reflectometry (GNSS-R) is the most advanced SoOp technique. CYGNSS, launched in 2016, now has a large science community making use of various ocean, land and cryosphere variables extracted from its GNSS-R observations. Second, P-band (<400 MHz) communication signals exist in frequencies low enough to penetrate dense vegetation and soil, offering a capability for directly sensing Root-Zone Soil Moisture (RZSM). Prof. Garrison is the principal investigator on SNOOPI (SigNals Of Opportunity: P-band Investigation), a cubesat mission to be launched in Spring 2024 to demonstrate this technique. Finally, wide-band (~1GHz) communications signals in Ku-band (12-18 GHz) and higher can theoretically provide altimetry (sea surface height) at cm-level precision. A constellation of passive SoOp receivers could be launched for a fraction of the cost of a single active radar altimeter. Such a constellation could provide high temporal sampling of inland lakes and rivers for streamflow and discharge monitoring, and better coverage of coastal regions to observe rapidly evolving oceanographic features such as eddies.

Prof. Garrison will conclude the talk with some speculative concepts and ideas for future research directions.

Biography: James L Garrison received the B.S. degree from the Rensselaer Polytechnic Institute, Troy, NY, USA, the M.S. degree from Stanford University, Stanford, CA, USA, and the Ph.D. degree from the University of Colorado Boulder, Boulder, CO, USA, in 1988, 1990, and 1997, respectively. He is a Professor with the School of Aeronautics and Astronautics, Purdue University, West Lafayette, IN, USA, with a courtesy appointment at the School of Electrical and Computer Engineering. In 2022, he was elected a University Faculty Scholar. He made the first airborne measurements of ocean surface winds using reflected Global Navigation Satellite Systems (GNSS) signals in 1996 and continues to lead research in Earth remote sensing using signals of opportunity. He is the Principal Investigator for SNOOPI, a NASA mission to demonstrate remote sensing with P-band signals of opportunity. Prior to his academic position, he was with the National Aeronautics and Space Administration (NASA). Dr. Garrison is a fellow of both the Institute of Navigation (ION) and the IEEE. He served as Editor-in- Chief for the IEEE Geoscience and Remote Sensing Magazine from 2018 to 2022.