URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Enabling Low-Cost Versatile Remote Sensing of Water Cycle Variables with Ultrawideband UAV-mounted Software-Defined Radar

Mahta Moghaddam*[(1)], Ruzbeh Akbar [(2)], Kazem Bakian-Dogaheh[(1)], Sepehr Eskandari[(1)], Asem Melebari[(1)], Piril Nergis[(1)], Sam Prager [(2)], Agnelo Silva [(3)]
(1) University of Southern California; e-mail: mahta@usc.edu
(2) Jet Propulsion Laboratory, California Institute of Technology
(3) Independent Consultant

Quantifying the constituents of the Earth water cycle is one the grand challenges of climate research. Active microwave remote sensing instruments are among the key tools in this effort, due to the well-known sensitivity of electromagnetic waves to water content of natural targets within the megahertz to terahertz range of frequencies. The components of interest when studying the global water cycle include snow water equivalent (SWE), surface water such as water present in rivers and lake, surface and root-zone soil moisture, ground water, sea ice, and land ice. Quantifying the stores and dynamics of each of these quantities requires different observational scenarios and instrument characteristics. For example, to quantify the stores of groundwater or ice thickness, frequencies are needed that are one or two orders of magnitude lower than those needed to characterize SWE and surface soil moisture. Temporal observation frequency requirements could also be quite different for these variables depending on their natural dynamics. Because of the diversity of observational requirements, traditionally many distinct spaceborne and airborne observatories have been proposed and developed, each to suit a specific need (e.g., the NASA SMAP mission for surface soil moisture and the NASA SWOT mission for surface water). Some observational needs, such as groundwater, are currently unaddressed via remote sensing. To enable the multitude of observational needs, such as spatial and temporal resolutions, as well as sensing depth and data record continuity, and at the same time to reduce the cost and risk of providing such measurements, we have recently developed ultrawideband radars based on commercial-off-the-shelf software-defined radio architectures for integration on un-crewed aerial vehicles (UAVs). The resulting software-defined radar (SDRadar) systems are capable of wideband (> 1 GHz bandwidth) and multi-mode (nadir- and side-looking, single- and dual-polarized) operations and can be launched on-demand either manually or based on autonomous command from ground sensor network observational decisions. They can be implemented on universal software radio peripheral (USRP) or radio frequency system-on-chip (RFSCoC) platforms. In this talk, we will present the recent SDRadar developments in our group and show results of laboratory- and field-testing of these systems at different frequency ranges, in different natural environments, and for different water cycle variables including snow, soil moisture, and groundwater. Future directions in hardware development and information retrieval challenges will be discussed.