National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Earth System Explorer - Snow Depth and Snow Water Equivalent (3 of 5)

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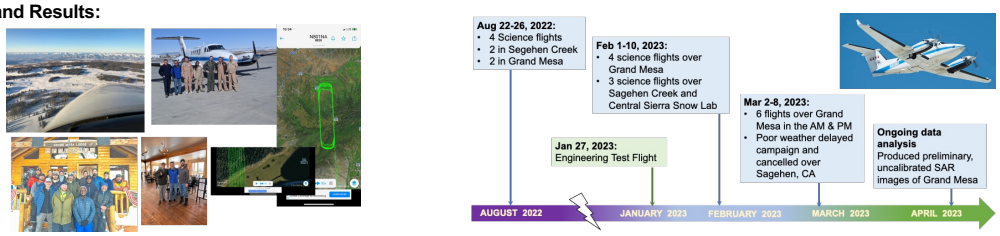
Strategic Focus Area: Earth System Explorer – Science Definition and Technology Maturation **| Strategic Initiative Leader:** Sabrina M Feldman

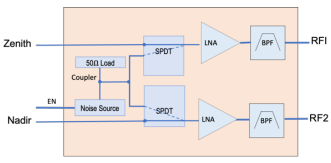
Objectives: Our overarching objective is to develop a scientifically compelling terrestrial snow mission concept that JPL can propose to NASA Earth System Explorer (ESE) calls over the next decade.

Background: Snow is both the fastest changing component of the water cycle and the least known and monitored. Terrestrial snow plays an important role in weather and climate forecasts through its influence on the heat exchange between land and atmosphere. Models that predict how snow evolves seasonally and into a warmer future are largely unconstrained by measurements or have poor parameterization of snow processes, leading to large uncertainties. The hydrology of snow-dominated watersheds is also changing as the climate warms. Spring snow accumulation has substantially declined over the last half-century in the Western U.S., and similar patterns are apparent globally. The most important snow water towers in the Alps, Andes, High-Mountain Asia, and Western North America are also the most vulnerable to these climate change drivers and other socioeconomic pressures. Yet despite snow's importance to basic human and ecosystem needs, we are not currently able to measure how much fresh water is stored in global mountains. In-situ snow observations are challenging and often impractical, so spaceborne investigations are essential for frequent and global monitoring of terrestrial snowpack. The 2017 Earth Decadal Survey (DS) established the Explorer mission line, which calls for PI-led concepts in seven investigation categories. This task focuses on concept and technology maturation for Snow Depth and Snow Water Equivalent (SD/SWE).

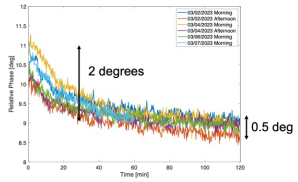
Approach and Results:



Airborne SoOp-SAR field campaign using the AFRC Super King Air with racetrack flights over Grand Mesa Colorado. In situ snow measurements were acquired by a ground team during the 2023 operation periods.



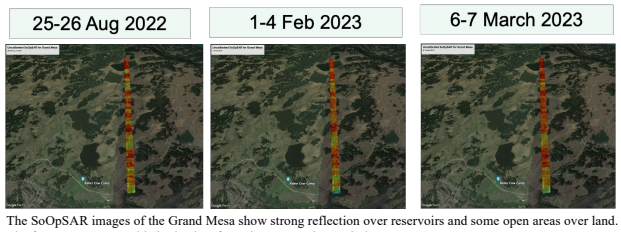
- SoOpSAR receiver has two parallel receiving channels for simultaneous recording of data from direct and reflected signals.
- A built-in calibration scheme with a noise diode and reference load is included for relative phase and gain calibration.



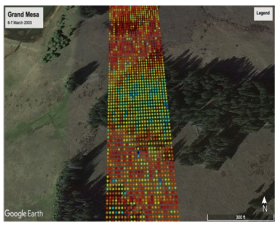
- The relative phase between the two receiver channels was computed using the common noise source data had a very small phase drift after receiver turn-on
- The data was repeatable from flight to flight to within 0.5 degrees.

Significance/Benefits to JPL and NASA:

- Our airborne P-band SoOp campaign data have confirmed the P-band SoOpSAR instrument receiver design by showing that the necessary phase calibration stability of SoOp receivers can be obtained with a well-defined internal calibration scheme.
- We have also shown that the multistatic SAR processing can be performed to achieve high spatial resolution by using data from multiple airborne or satellite tracks.
- The results have already been incorporated into the SnoWatch mission proposal recently submitted by the University of California at Los Angeles (UCLA) and JPL to the first NASA ESE program announcement of opportunity.



- The SoOpSAR images of the Grand Mesa show strong reflection over reservoirs and some open areas over land.
- The features are repeatable in the data from three campaign periods.



A zoom-in of the data show a weaker reflection over a forested region on the Grand Mesa than the surrounding open areas. This demonstrates the multistatic SAR processing with a high spatial resolution of 5 meters.

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Publications:

Simon Yueh, Rashmi Shah, Javier Bosch-Lluis, Mario J. Chaubell, Garth Franklin, and Xiaolan Airborne P-band Signals of Opportunity Observations Acquired over Mountainous Terrain, XXXVth URSI General Assembly and Scientific Symposium (URSI GASS 2023), Sapporo, Japan

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