

NASA SnowEx 2020: *Post-campaign update*



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Time Series Leads, Aircraft Teams, Field Teams, Partnerships



NASA Terrestrial Hydrology Program (THP)
Updates to SnowEx Community, April 16, 2020



Agenda

- SnowEx2020 Brief Overview – HP Marshall
- SnowEx2020 Time Series – HP Marshall
- SnowEx2020 Grand Mesa IOP – Carrie Vuyovich
- Data submission to NSIDC and timeline – Megan Mason
- Future SnowEx activities and Roadmap – Carrie Vuyovich
- Discussion / Questions - All



SnowEx 2020



The SnowEx 2020 Campaign consisted of coordinated airborne and field-based experiments in the Western U.S. to test instruments under a variety of snow conditions. This effort includes two major components:

- 1. A time series experiment with L-band InSAR** *(50% completed; stopped due to pandemic. Remaining flight hours approved for 2020-21 season.)*
 - 13 sites, spanning 5 states
 - 6 total UAVSAR flight periods, Dec-Mar *(COMPLETED)*
 - Weekly in-situ field observations, Airborne LiDAR, TLS, ground-based radar for calibration/validation *(COMPLETED)*
- 2. A detailed experiment on Grand Mesa, Colorado**
 - 5-day snow-off campaign November 4-8, 2019 *(COMPLETED)*
 - 10-day snow-on campaign January 27 –February 14, 2020 *(COMPLETED)*
<campaign extended one week to adjust for aircraft delays>



Alignment with THP16 Science Plan

SnowEx 2020: Responds to 6 out of 7 Science Plan Gaps

- Snow climates (Forest, mountain, prairie, maritime)
- Wet snow, accumulation and melt (time series)
- Surface energetics (surface temperature)

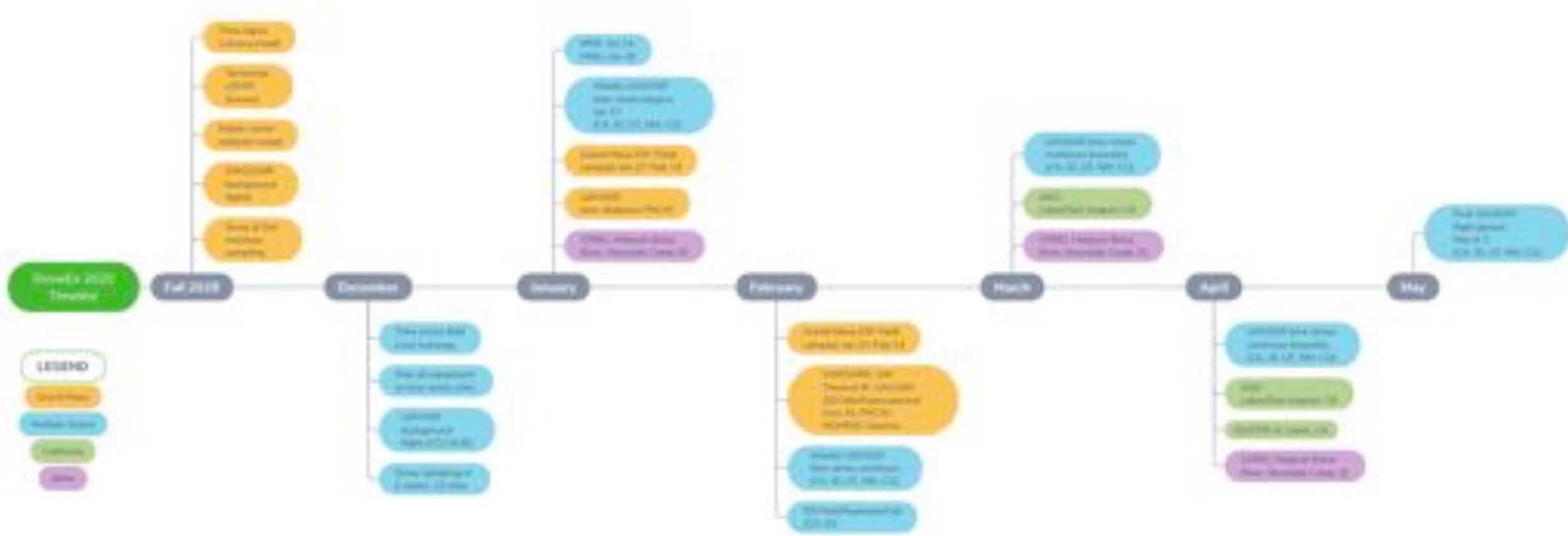


SnowEx 2020: Responds to all Science Plan *Mission Critical, Crucial, Important* priorities

- L-band InSAR (UAVSAR)
- X-, K-, Ka-band Passive microwave (SWESARR)
- X-band, dual Ku-band SAR (SWESARR)
- Ka-band InSAR (GLISTIN-A) <scheduled for April, cancelled due to pandemic>
- LiDAR (ASO, Quantum Spatial, CRREL HeliPod)
- Thermal IR (UW)
- Hyperspectral imaging (ASO, Quantum Spatial, SaraniaSat) <SaraniaSat postponed>
- Modeling / Data Assimilation (SEUP, NOHRSC)
- Photogrammetry / Structure from Motion (drone/airborne/satellite)
- FMCW radar (similar to IceBridge SnowRadar; University of Alabama)



SnowEx 2020 Timeline



SnowEx2020 Time Series – Airborne / Spaceborne

- UAVSAR – testing algorithms for estimating change in depth and SWE between overflights
- LiDAR – used to define snow depth distribution, for calibration and validation of retrievals
- Sentinel C-band radar was tasked for ~6-day repeats over many SnowEx2020 time series sites
- World View tasking, coordinated drone campaigns for surface reconstruction

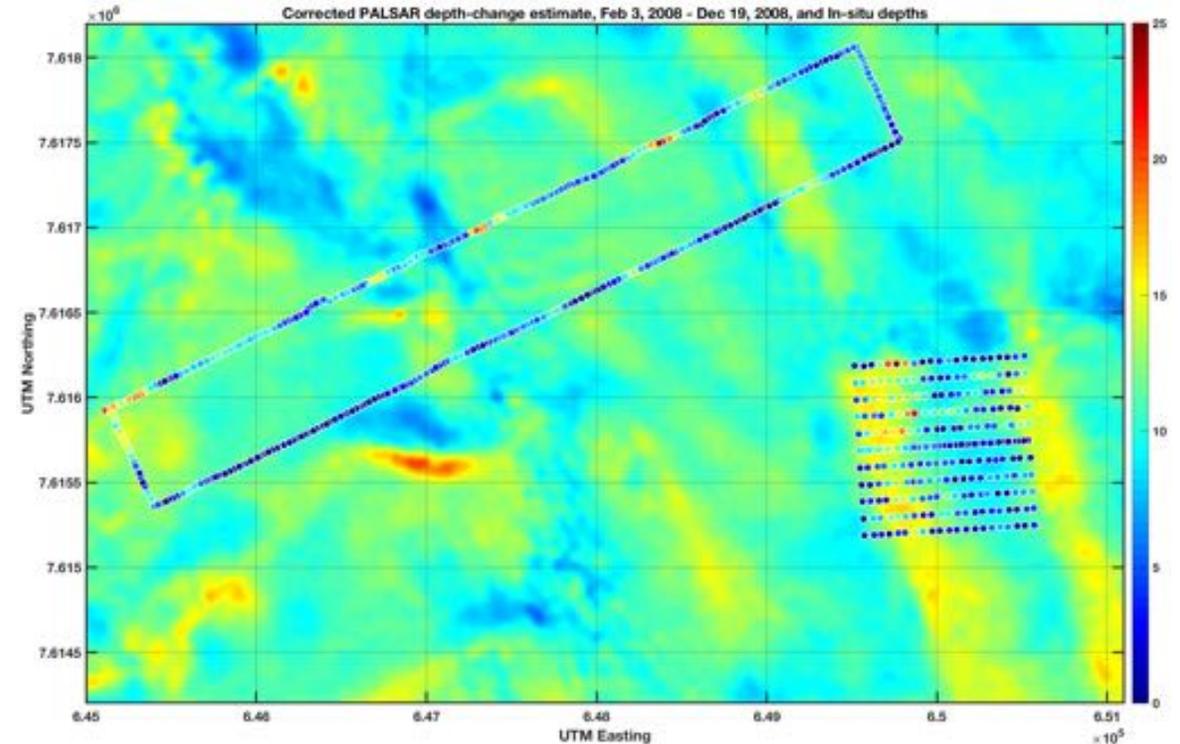


SnowEx 2020 – UAVSAR

- L-band Interferometric Synthetic Aperture Radar
 - L-Band (1 GHz; 23 cm)
 - Weekly to biweekly flights, Dec-March
 - Relationship between change in SWE/depth vs. change in InSAR phase
- Validation for a range of snow climates, vegetation, and during accumulation & melt
- Opportunity for further validation in preparation for NASA-ISRO SAR (**NISAR**) satellite mission, <https://nisar.jpl.nasa.gov>
 - L- and S-band (12 cm)
 - 12-day (or shorter) exact repeat orbit
 - Launch date: Dec. 2021
 - 3-10 m resolution



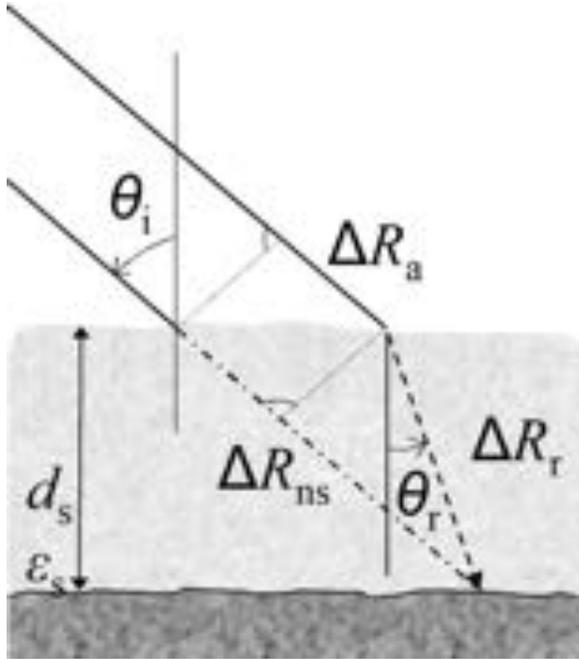
North Slope Brooks
Range, AK
[from E. Deeb]



Previous studies have found agreement in accumulation patterns, compared to LiDAR and magnaprobe depth observations

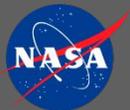
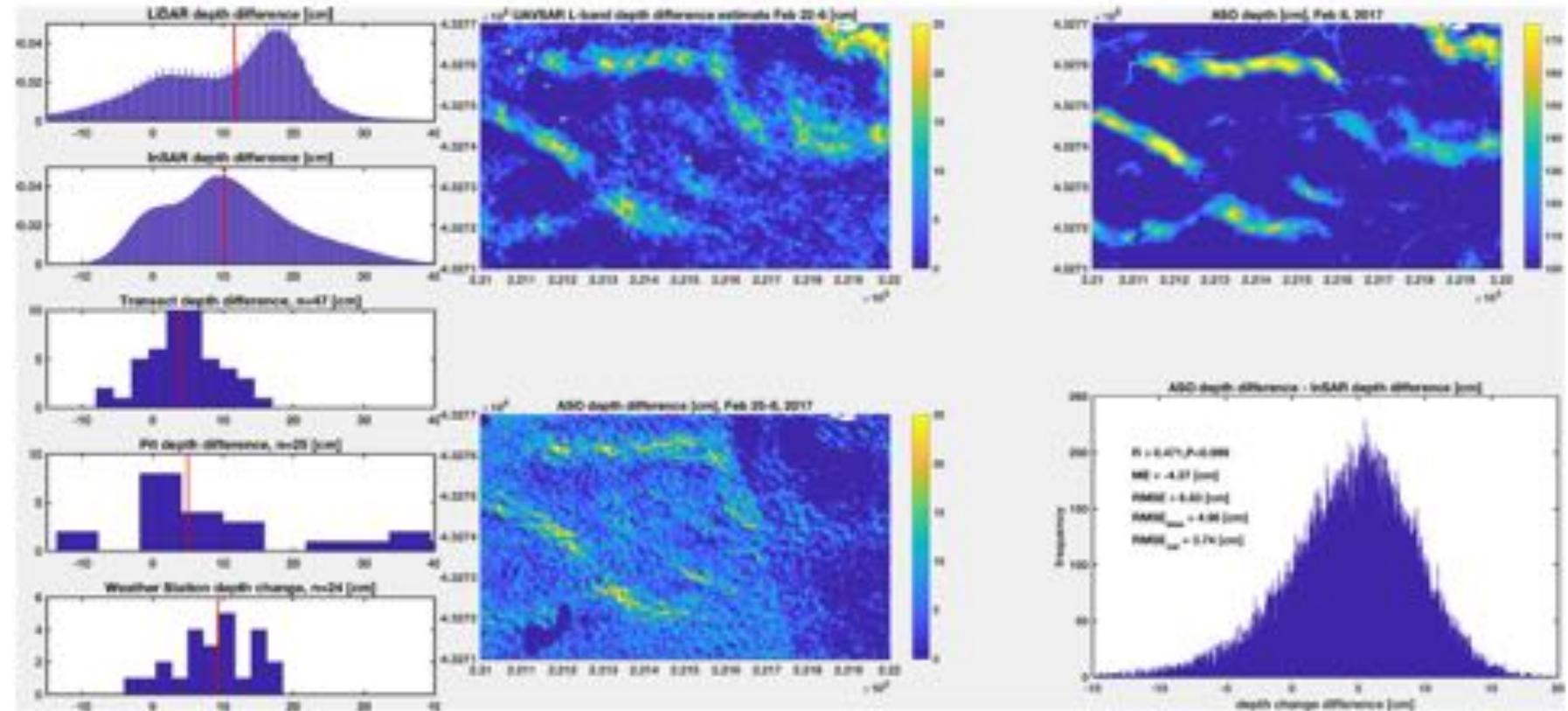


L-band InSAR: Inverting for depth change



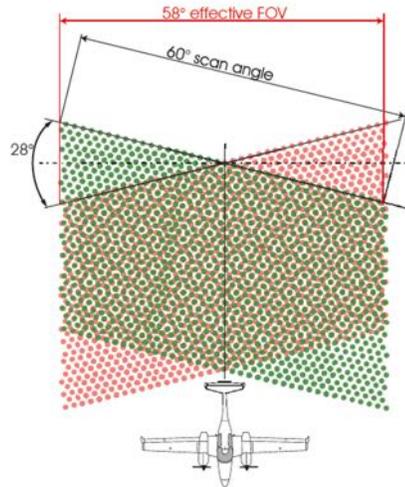
[e.g., Gunnerison et al., 2001]

$$\Delta d = -\frac{\Delta\phi\lambda}{4\pi} \frac{1}{\cos\alpha - \sqrt{\epsilon_s - \sin^2\alpha}}$$



Riegl VQ1560i Airborne LiDAR Scanner

- Dual channel LiDAR sensor
 - 1 mHz/Laser channel
 - 1064nm Class 3B Laser
 - 58° effective Field of View



Itres CASI 1500H Hyperspectral Sensor

- VNIR Imager
 - 380-1050nm Spectral Range
 - 40° Field of View
 - Pushbroom
 - Up to 288 Spectral Channels

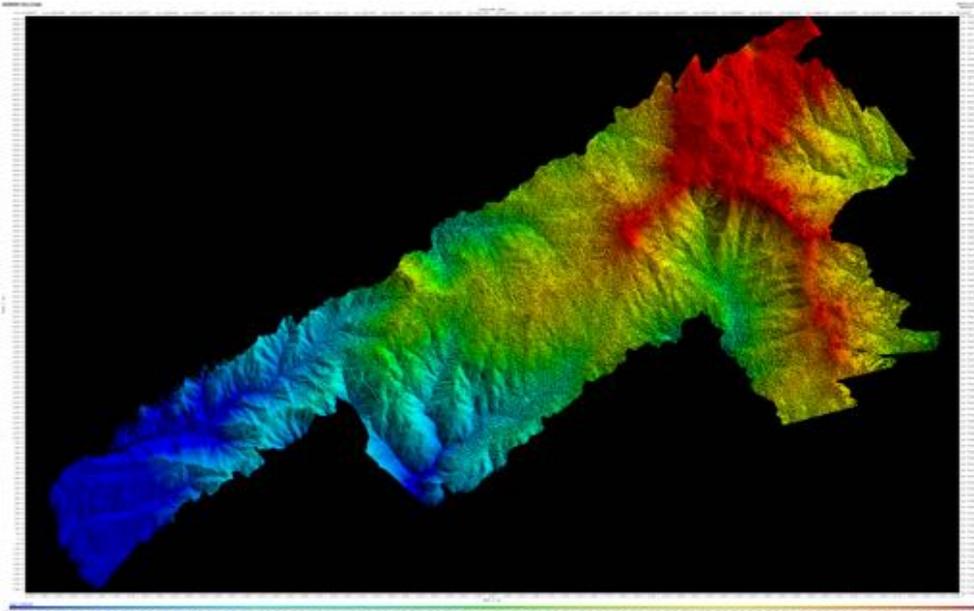




CRREL Helipod LiDAR



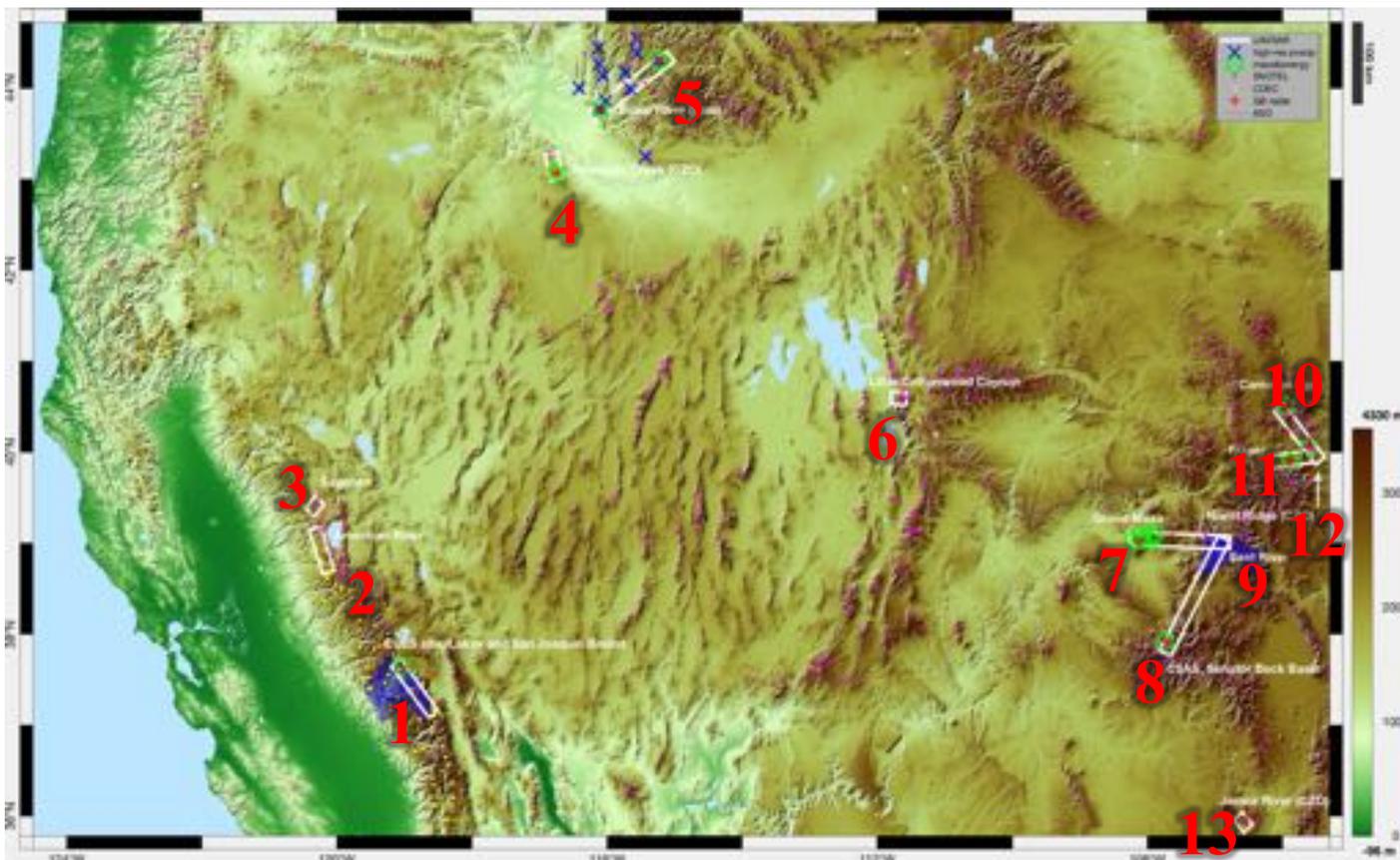
- Robinson R66 Helicopter
- Riegl LMS VQ-580 laser scanner
- iXBlue ATLANS-C IMU
- Silverhawk Aviation, Idaho



Contact:

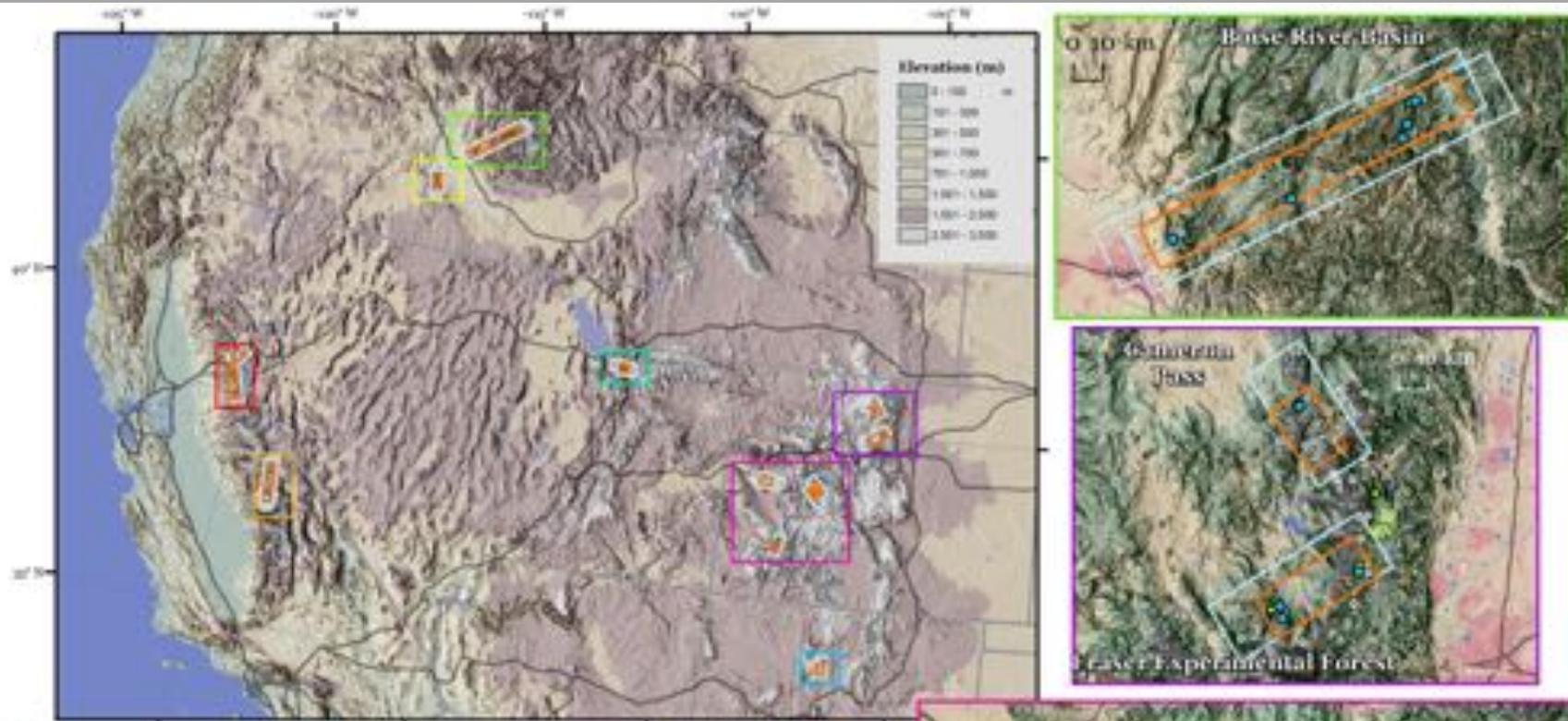


SnowEx 2020 – Time Series



Site	Site Name	Site Lead
1	Lakes Basin, CA	Ned Bair
2	American River Basin, CA	Roger Bales
3	Sagehen Creek, CA	Anne Nolin
4	Reynolds Creek, ID	Ernesto Trujillo
5	Boise River Basin, ID	Maggie Kraft, Chago Rodriguez
6	Little Cottonwood Canyon, UT	McKenzie Skiles
7	Grand Mesa, CO	Hiemstra, Brucker
8	Senator Beck Basin, CO	Andy Gleason
9	East River, CO	Jeff Deems
10	Cameron Pass, CO	Dan McGrath
11	Fraser Experimental Forest, CO	Kelly Elder
12	Niwot Ridge, CO	Kate Hale
13	Jemez River, NM	Ryan Webb





Map shows all sites for UAVSAR, 6 flight periods, Dec-March

Sites chosen with existing infrastructure and ongoing research, CZO, LTER, long term well-instrumented watersheds, ground-based remote sensing sites; range of climatology, vegetation, topography

Airborne lidar/TLS: 7 sites
Ground-based radar: 5 sites

~9 weekly in-situ sampling days at each site, Dec 20-Mar 12



SnowEx 2020 – Time Series

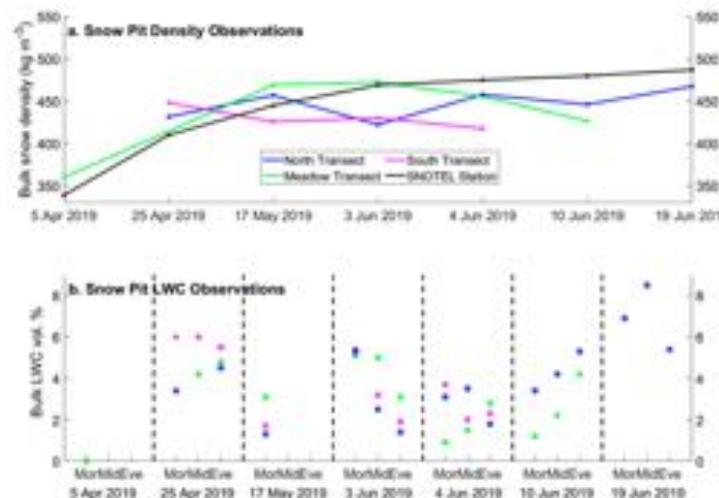
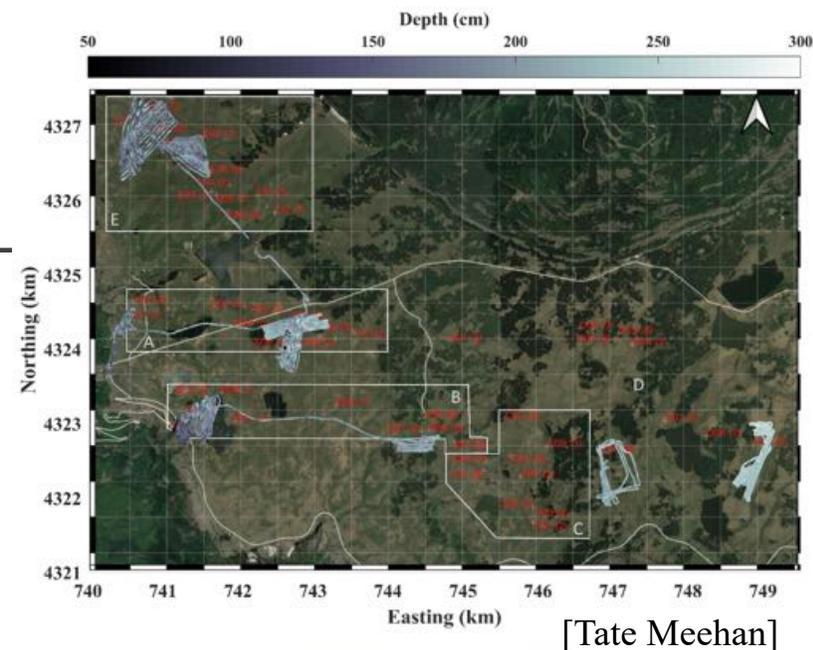
Focus on variability of snow and landscape conditions throughout the accumulation and melt season.

Ground observations of:

- Change in snow depth and SWE
- Snow stratigraphy, density, and liquid water content
- Ground-based radar (CSU, UNM, BSU)
- Terrestrial LiDAR (CRREL, BSU)
- Field spectrometer (Univ UT, UNR)

Airborne observations of:

- L-band InSAR (UAVSAR)
- LiDAR (ASO, CRREL Helipod, TLS)
- ~~Ka band InSAR (GLISTIN-A (CA))~~

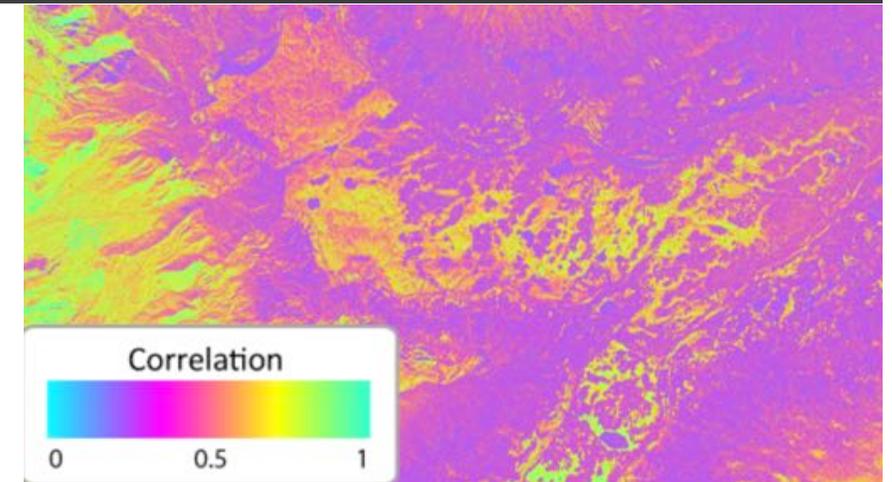
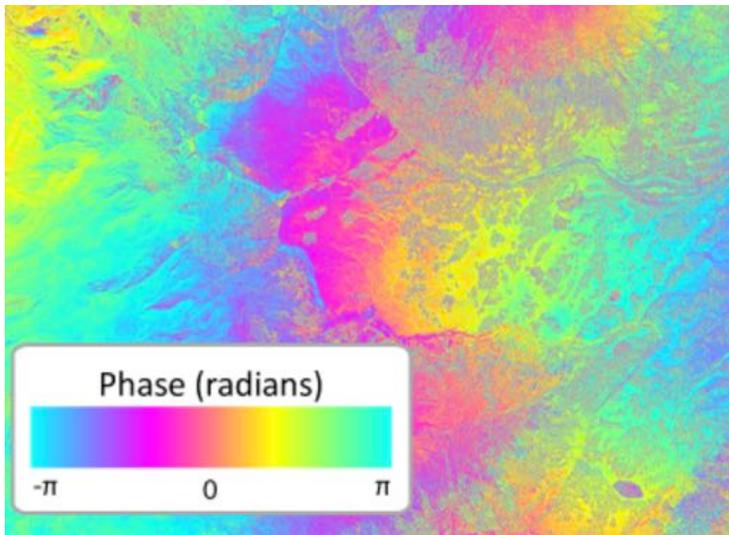


[Dan McGrath, Randall Bonnell]



L-band InSAR Preliminary Results

- Coherence is promising in many locations, but not in dense forest
- Complex topography will require significant reprocessing with higher-res DEMs



Ongoing Analysis

- Statistical analysis of coherence
- InSAR reprocessing, corrections for atmospheric, topographic and vegetation effects
- Phase unwrapping algorithms, constrained by met data
- Inversion of phase for depth and SWE change
- Comparison to in-situ field data

L-band InSAR Analysis Efforts

- UAVSAR Team [Yunling, Naiara, etc]
- Deeb, Morriss (CRREL, THP16)
- Marshall (BSU, THP16)
- Forster,Lund (U.Utah, THP16, NISAR SDT)
- Jones (JPL, THP16)
- McGrath (CSU, THP17)
- Webb (UNM, THP17)
- SnowEx2020 site leads
- CUAHSI Virtual University – Microwave Radar (Fall 2020)
- SnowEx Hackweek, Sept 2020 (Lundquist, Arendt)

Flight Line	12/20 Flight (AFRC) Collected?	1/31 Flight Collected?	2/12-13 Flights Collected?	2/19-20 Flights Collected?	2/26-27 Flights Collected?	3/11 -12 Flights Collected?
sierra_35402	yes	yes	yes	yes	yes	yes
sierra_17305	no	yes	yes	yes	yes	yes
dorado_34017	no	yes	yes	yes	yes	yes
donner_03904	yes	yes	yes	yes	yes	yes
silver_16718	no	yes	yes	yes	no	yes
silver_34715	no	yes	yes	yes	no	yes
lowman_05208	yes	yes	yes	yes	no	yes
lowman_23205	yes	yes	yes	yes	no	yes
stlake_27129	no	yes	yes	yes	no	yes
stlake_09127	no	yes	yes	yes	no	yes
rockmt_14107	no	yes	yes	yes	yes	yes
rockmt_32109	no	yes	yes	yes	no	yes
fraser_23307	no	yes	yes	yes	yes	yes
fraser_05209	no	no	yes	yes	yes	yes
grmesa_27416	no	yes	yes	yes	yes	yes
grmesa_09305	no	yes	yes	yes	yes	yes
peeler_31619	yes	no	yes	yes	yes	yes
peeler_13711	yes	no	yes	yes	yes	yes
irnton_01406	no	no	yes	yes	yes	yes
alamos_35915	no	no	yes	yes	yes	yes

no, at PI's request

Coordinated analysis effort planned. Contact us if interested.



Time Series Summary:

1. Time Series

- L-band InSAR (6 flight periods, 13 sites)
- LiDAR, Hyperspectral (subsets of 7 sites)
- Ground-based radar (4 sites)
- Online data entry system (NSIDC)
- ~Weekly field observations at all 13 sites, Dec 20 – March 12
- LWC observations
- Some aircraft maintenance and instrument issues, conflicts with other NASA campaigns (ISRO-ASAR, DeltaX)
- ~~GLISTIN-A planned flights coincident with ASO in CA in April~~
- ~~Univ Alabama FMCW flights planned late March / early April~~
- WWA SnowSchool K-12 students submitting data; Time Series leads submitted material for NASA blog
- NSIDC SnowToday Reports (Karl Rittger, Mark Raleigh)



Time Series Data Availability Timeline

- UAVSAR L-band InSAR data: Raw data available, preliminary InSAR products for some sites available, others within the coming weeks. Reprocessed data target: December 2020.
- QSI LiDAR: snow-on data available in ~ 1 month; snow-free flights planned for June/July; depth products fall 2020.
- CRREL Helipod: snow-on data available, snow-free planned for summer 2020
- Field data: Targeting July 1 deadline for instrument PIs; core data (pits, depths) to be released first, target date: end of May

- ***If you have SnowEx2017 or SnowEx2020 data to contribute, please publish with NSIDC: <https://nsidc.org/data/daac-project/submit>***



SnowEx 2020 – Collaborations/Coordination

In situ

Bi-weekly in situ sampling (Colorado, Idaho)

Natural Resources Conservation Service (NRCS)

A i r b o r n e

LiDAR flights (East River, Colorado and San Joaquin/Lakes, California)

ASO

Helipod LiDAR/thermal infrared (Boise River Basin, Idaho)

U.S. Army Corps of Engineers, CRREL

UltraWideBand radar (2-18 GHz) (Grand Mesa, Colorado)

Uni. of Alabama

Signal of Opportunity (SoOp) tower experiment (Fraser, Colorado)

JPL / U.S. Forest Service

Gamma flights (Colorado, possibly other states)

NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC)

Stereo satellite imagery (e.g., World View, TerraSAR-X)

Satellite

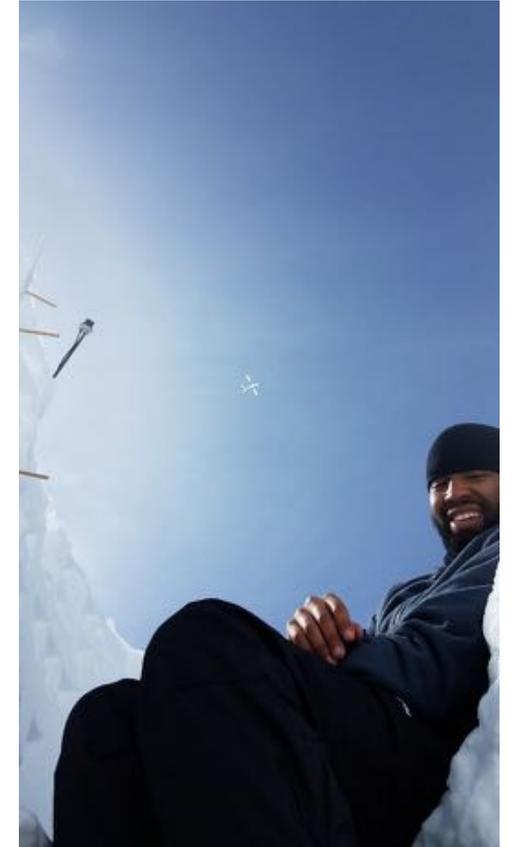
U. of Washington, U.S. Army CRREL

Sentinal-1/2 C-band SAR

FMI, KU Leuven (will also provide 1km snow depth products)

Modeling

Several modeling efforts focused on most sites (e.g., NOHRSC; Snow Ensemble Uncertainty Project – SEUP)



SnowEx 2020

NASA SnowEx 2020
Experiment Plan

Draft (July 2019)



Experiment Plan:

<https://tinyurl.com/y4r6oz9d>



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