

**TH13F: NASA SnowEx - Enhancing new sensing technologies to retrieve snow water equivalent in forested and other lands**

**Monday, December 12, 2016  
12:30 – 1:30 PM**

**Moscone West - 2002**

# Agenda

12:30-12:31	Welcome	Jared Entin
12:31-12:40	Overview of SnowEx current status	Ed Kim
12:40-12:50	Report on fall campaign in Grand Mesa and Senator Beck	Kelly Elder
12:50-1:05	iSWGR	Alex Langlois & Jessica Lundquist
1:05-1:15	2017 winter campaign information	Amy Misakonis
1:15-1:20	ASO - SnowEX	Tom Painter
1:20-1:25	SnowEx update	Jared Entin
1:25-1:30	Q/A	C. Gatebe



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# SnowEx: a NASA airborne campaign leading to a snow satellite mission

SnowEx update @ AGU townhall  
Dec 12, 2016

**SnowEx Team/contributors to this report:** Edward Kim, Charles Gatebe, Amy Misakonis, Dorothy Hall, HP Marshall, Ludovic Brucker, Kelly Elder, Chris Hiemstra, Matt Beckley, Alex Coccia, Amanda Leon, Jeff Deems, Tom Painter

**Sponsored by NASA Headquarters/Terrestrial Hydrology Program Manager:** Jared Entin

# What/When/Where/Why

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## What is SnowEx?

- Multi-year airborne snow campaign

## Why?

- Address key issues for a global snow satellite mission
- Collect multi-sensor obs + ground truth
- Year 1 will challenge sensing techniques with forested conditions

## Where?

- Western Colorado
- Primary: Grand Mesa
- Secondary: Senator Beck basin

## When?

- Year 1 = 2016-17
- Year 2: no campaign
- Years 3,4,5: campaigns

# Who

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- Lead: NASA Goddard Space Flight Center
- Partners
  - US Forest Service
  - Cold Regions Research Engineering Lab
  - Naval Research Lab
  - Jet Propulsion Lab
  - European Space Agency
  - Center for Snow & Avalanche Studies
  - National Snow & Ice Data Center
  - National Weather Service
  - NOAA
  - Universities, research centers

# Confirmed and potential sensors

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## CONFIRMED CORE SENSORS

- **SnowSAR: X & Ku-band radar (ESA)**
- **CAR (BRDF from GSFC)**
- **AESMIR (passive mw, from GSFC) 18 & 36 GHz**
- **Thermal IR/video suite**
  - **Imager (GSFC)**
  - **High-accuracy non-imaging (KT.15, from U.Washington)**
  - **Video camera (GSFC)**
- **ASO suite (JPL)**
  - **Lidar**
  - **Hyperspectral imager**

## CONFIRMED EXPERIMENTAL SENSORS

- **UAVSAR: L-band radar (JPL)**
- **GLISTIN-A: Ka-band radar (JPL)**

## POTENTIAL SENSORS

- **WISM: X, Ku, & Ku-band radar (GSFC)**
- **UAV w/lidar (CRREL)**
- **NRL ice suite**

# Confirmed and potential aircraft

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List as of Dec 12

## Confirmed

- NRL P-3 (VXS-1)
- King Air with ASO (same as fall)
- NASA G-III with GLISTIN-A (same as fall)
- NASA G-III with UAVSAR

## Potential

- Twin Otter with WISM
- Another Twin Otter with NRL ice suite
- UAS (drone) with lidar

Flight coordination for safety & science quality will be essential

# Overview of Current status – Dec 2016



- 13 yrs ago... the last big community campaign – CLPX-1
- 2yrs ago...SnowEx was announced at AGU
- 1.5 yrs ago...1<sup>st</sup> workshop (May 2015, Columbia MD)
- Only 1 yr ago...serious prep started
- Only 9 months ago (March 2016)...Seattle meeting
  - No site selected
  - Primary aircraft not known
- Only 7 months ago (May) ...sites selected
- Only 5 months ago (July) ...major aircraft decided; LSOS identified
- Only 2 months ago (Sep/Oct) ...first airborne & ground truth obs, met stations, GBRS begun
- Only 1 month ago (Nov) ...winter participant selection was still in process

## TODAY:

- 8 airborne instruments confirmed
- 4 aircraft confirmed
- 2 sites confirmed
- ~100 participants from dozens of institutions notified
- Nearly 100 transects marked
- 14 TLS sites identified
- 22 GBRS instruments planned
- 4 new met stations installed
- 2 existing met stations augmented
- Data center identified/prep started
- **SnowEx year 1 is on target**
- **AMAZING what the snow community can do when it pulls together!!!**

# SnowEx Ground Measurements

★ *Safety for all, high-quality measurements* ★

Kelly Elder (US Forest Service - RMRS)

*Physical measurements of the snowpack*

Christopher Hiemstra (US Army - CRREL)

*Snow-Vegetation interactions – Land cover classification*

Ludovic Brucker (NASA - Goddard)

*Ground based remote sensing (GBRS)*

*Local scale observation site (LSOS)*

Hans-Peter Marshall (Boise State University)

*Senator Beck Basin*

# Physical Snowpack Measurements

## Snow depth – transects

*manual probes & MagnaProbes*

## Snow pits

*depth*

*density*

*water equivalent*

*stratigraphy*

*grain type*

*grain size*

*snow temperature*

*surface roughness*

*snow wetness*

*soil temperature*

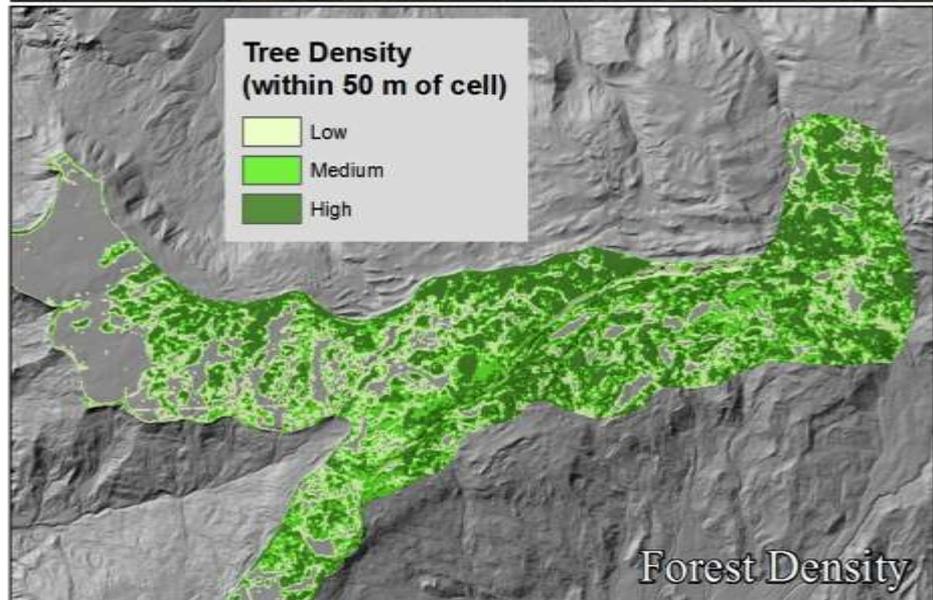
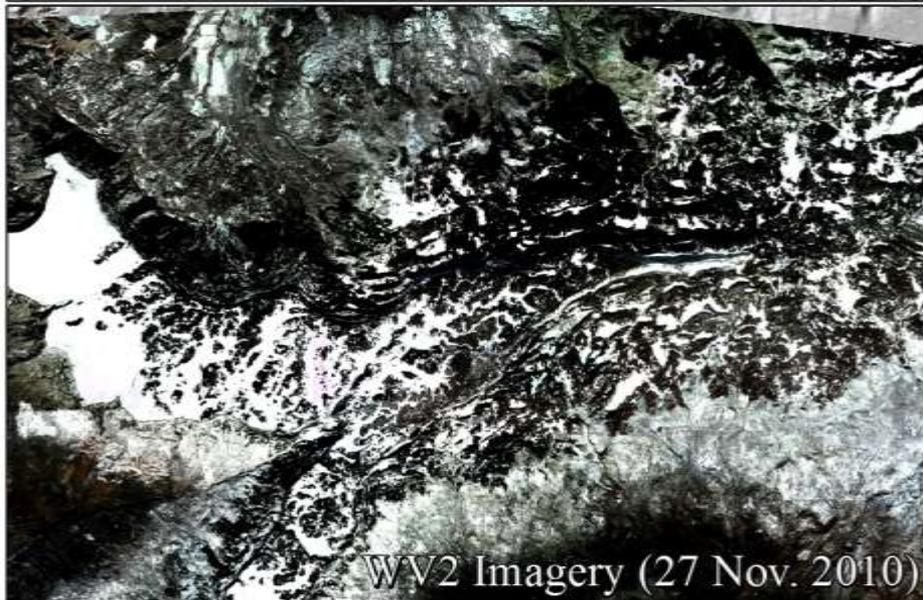
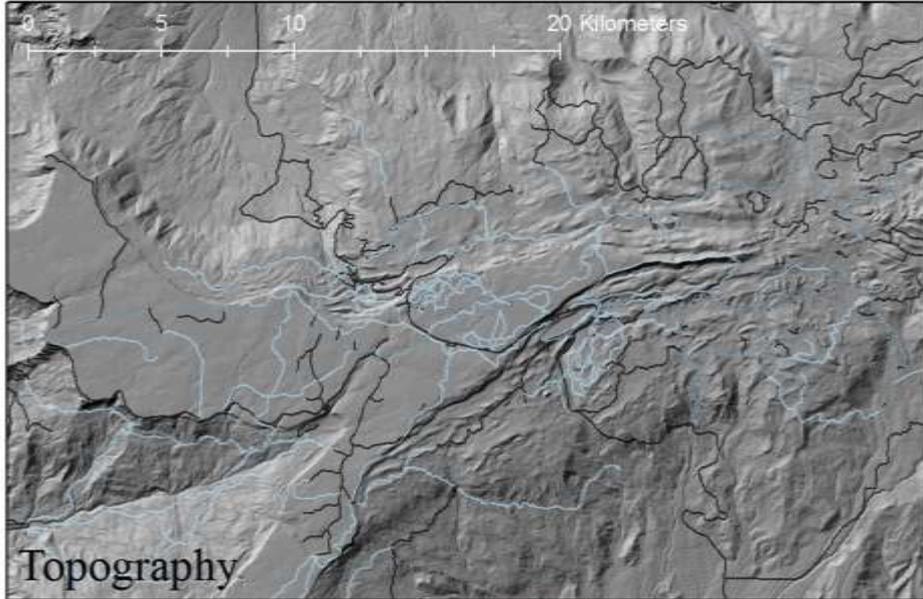
*soil moisture*

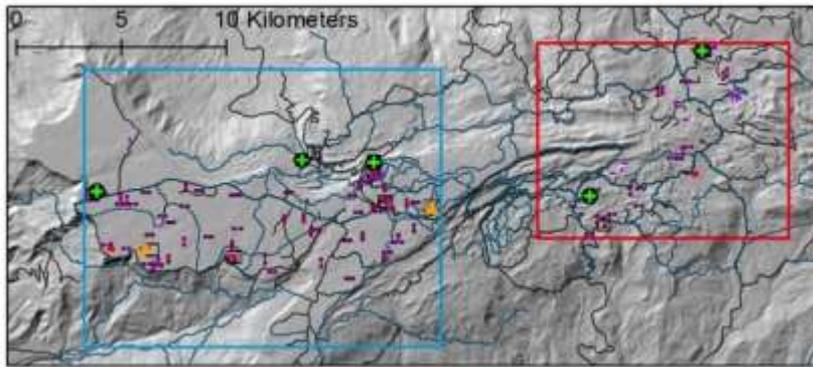
## Meteorology

*5 stations - Grand Mesa*

*2 stations – Senator Beck*







### Infrastructure

- Roads
- Trails
- ⊕ Meteorological Tower
- Transects
- Transect Markers
- ▭ TLS Area
- Time Lapse Camera
- ▲ Reflectors





NASA Distributed Active Archive Center (DAAC) at NSIDC

## NASA SnowEx

New Approaches for Mapping Snow Water Equivalent



Overview

Campaign Resources

### Overview

NSIDC DAAC will archive and distribute data products from the NASA SnowEx campaigns focusing on collecting snow data in forested regions with airborne multi-sensor and in situ validation observations.



### SWE and Snow Energy Balance

Distribution of snow-water equivalent and snow energy balance. Photo credit: Randi Hausken  
[Read more ...](#)

Overview

Campaign Resources

### Campaign Resources

#### Year 1: Colorado

[Shapefiles of the campaign study areas](#) including transects, Terrestrial Laser Scan (TLS) areas, met towers, and raster data imagery with some tree classification/density layers. Also including flight-line boxes.

[Photographs taken with SnowEx cameras](#) during the Fall 2016 campaign. Photos depict terrain and environment for the upcoming February 2017 campaign.

# Local Scale Observation Site & Ground Based Remote Sensing

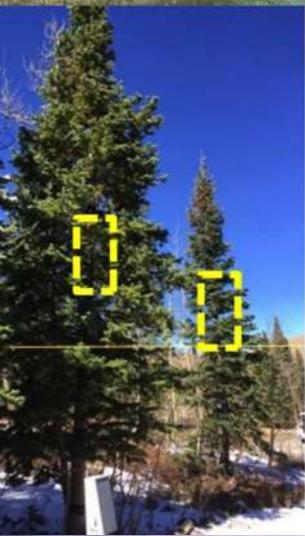
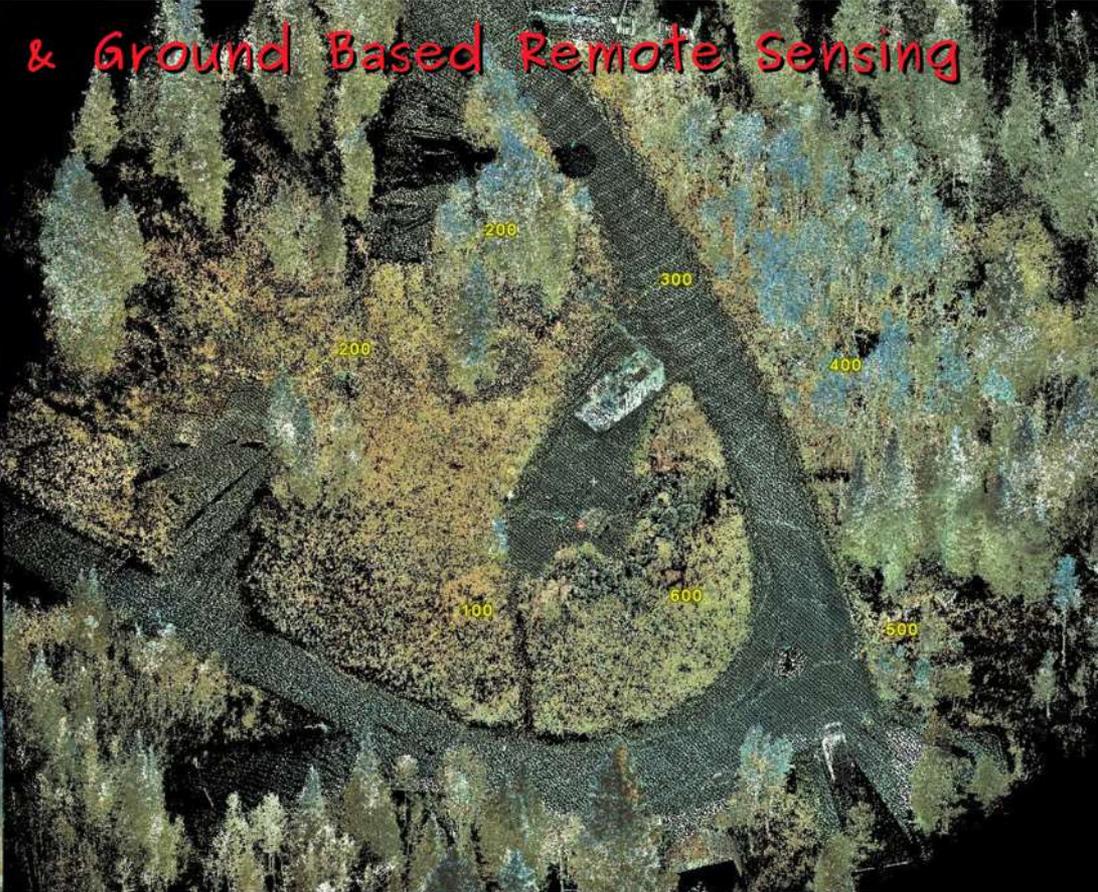


Continuous monitoring by

- 12 instruments
  - Microwave radiometers [Uni Michigan]
  - Radars [Boise State Uni]
  - Sun photometer [NASA GSFC]
  - GPS [Uni Colorado]
  - Tree accelerometers [Uni Colorado]
  - Precipitation instruments [NASA WFF]
  - Snow depth sensors [Uni Colorado]
  - Time lapse camera [Uni Washington]
- weather station



# Local Scale Observation site & Ground Based Remote Sensing



Truck-mounted microwave radiometers [Uni Michigan]

Terrestrial Lidar Systems [CREEL, Uni Colorado, Boise State Uni]

>12 sites with snow free data from Sept.

Tree sway [Uni Colorado]



# Local Scale Observation Site & Ground Based Remote Sensing

## Ground-Based

Lidars

Radars & Scatterometers

Microwave radiometers

Spectroradiometers

Goniometer

## Airborne

Airborne Snow Observatory

SNOWSAR, UAVSAR, GLISTIN-A

AESMIR

Imaging spectrometer

Cloud Absorption Radiometer

... VISION ...

Experiment Plan

[Defined by the community (GBRS =30+ people)]



Field Campaign

[Executed by the community (80+ people)]



Data Delivery to NSIDC

[Controlled by the community (>35+ instruments)]

Science

[Carried out with collaborations]

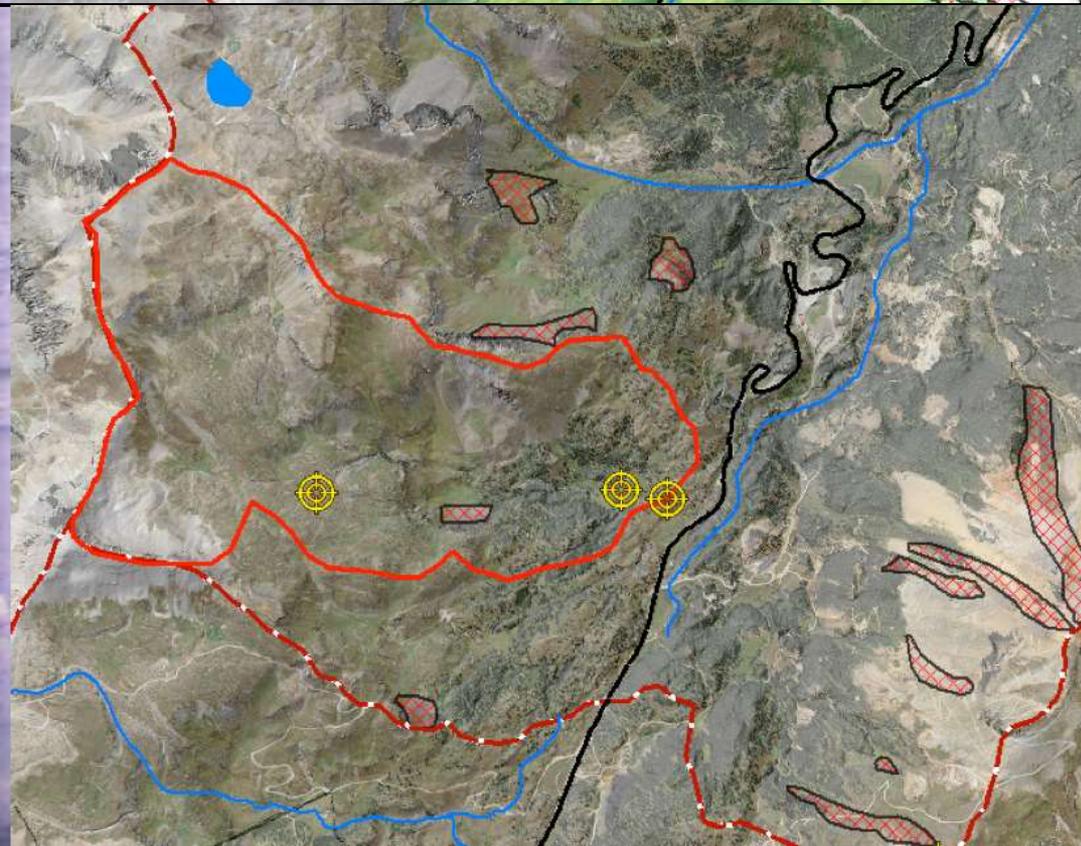
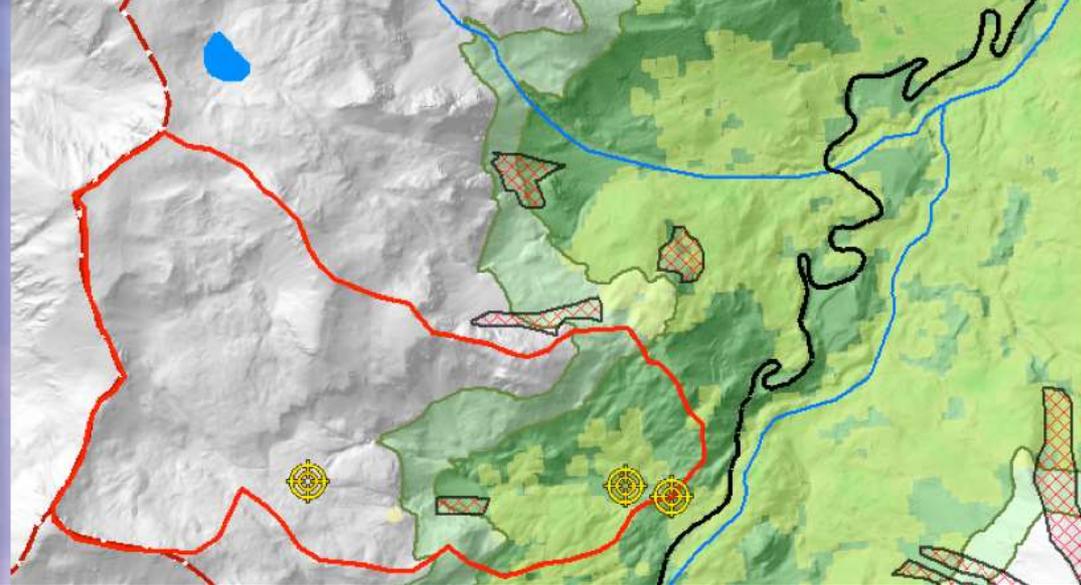
# Senator Beck Basin

## *Instrumentation, Spatial surveys*



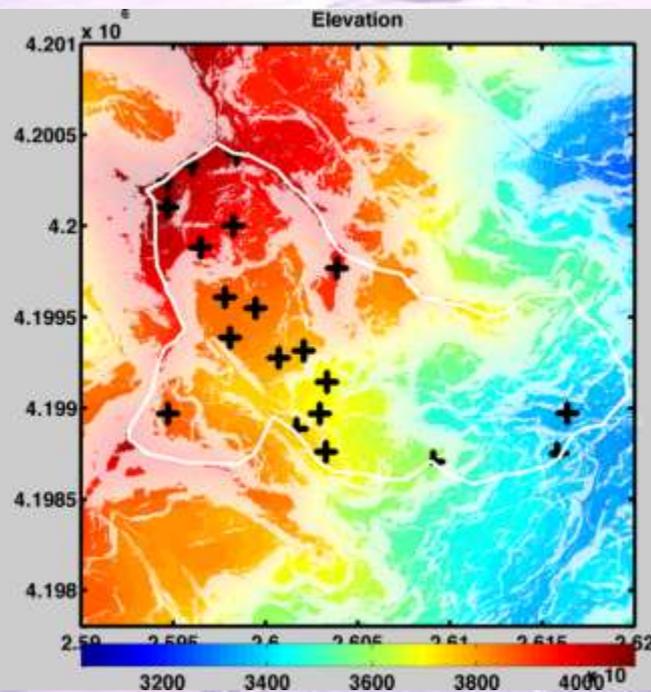
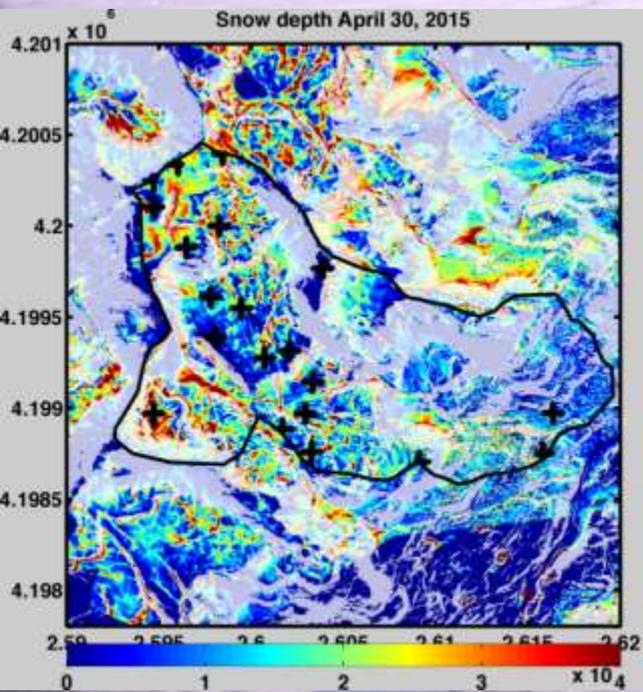
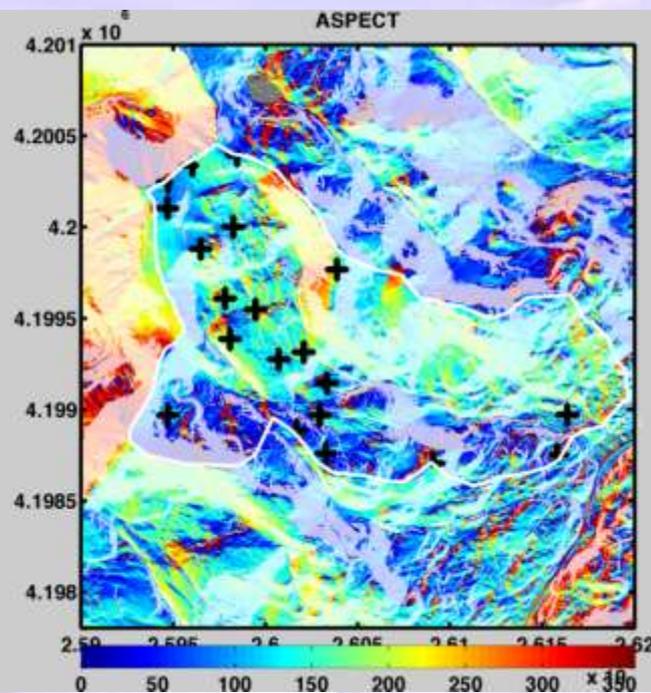
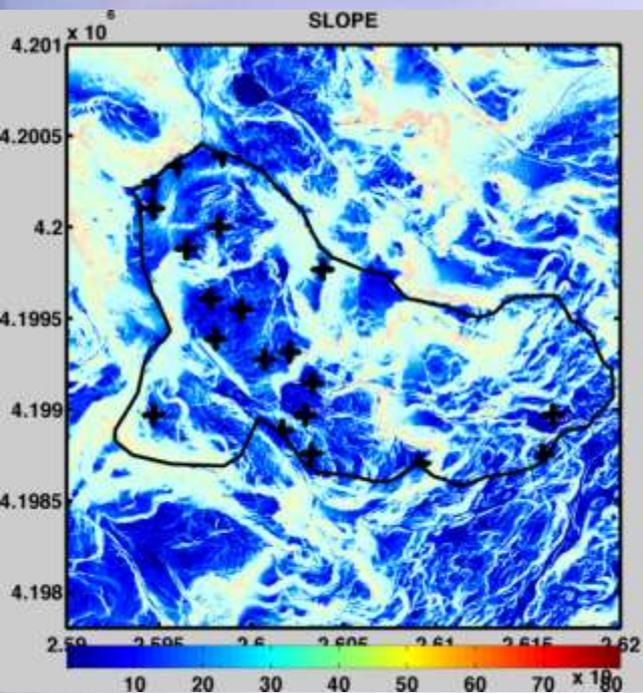
- **Two energy-balance met stations** [*Center for Snow and Avalanche Studies*]
- **Time lapse cameras and tree accelerometers** [*CU*]
- **NetR9/NetRS GPS** [*CU, NSIDC, UNAVCO*]
- **Sun photometer** [*Aeronet*]
- **1-6 GHz impulse, 24-26 GHz FMCW tower-based microwave radars** [*BSU*]
- **Stream gauge** [*Center for Snow and Avalanche Studies*]
- **TLS surveys** [*NSIDC, CRREL*]
- **GB radar surveys** [*BSU*]
- **Historical ASO overflights** [*NASA JPL*]

# Senator Beck Basin



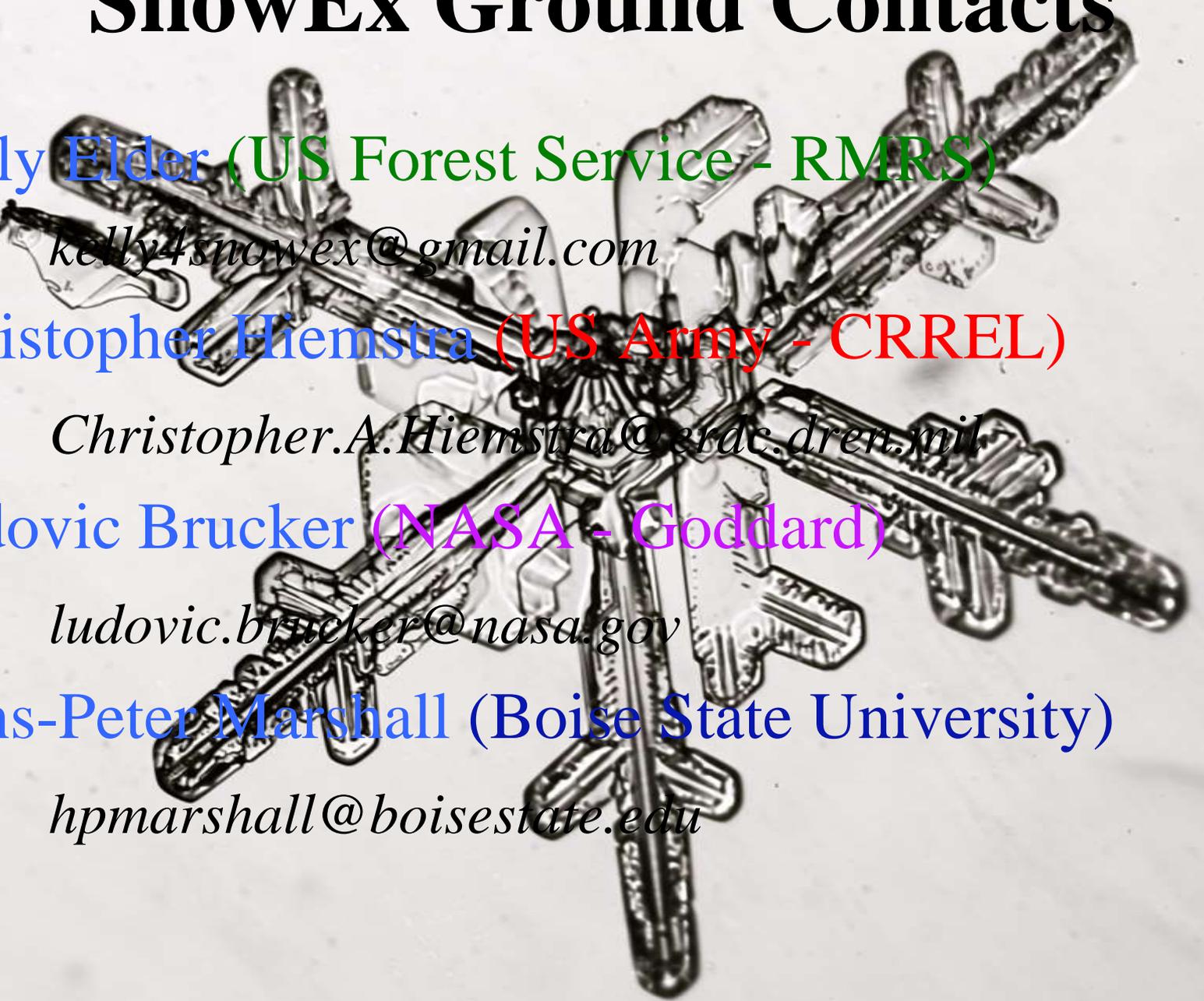
- Alpine
- Treeline
- Subalpine





- *DRAFT sampling plan*
- Sampling in safe areas 1<sup>st</sup> priority
- Focus on high snow variability, complex terrain
- 100 m N/S, E/W depth transects, central snowpits
- TLS surveys
- Radar surveys
- Spectrometer
- NIR photography
- SnowMicroPen
- Snow casting

# SnowEx Ground Contacts



Kelly Elder (US Forest Service - RMRS)

*kelly4snowex@gmail.com*

Christopher Hiemstra (US Army - CRREL)

*Christopher.A.Hiemstra@erdc.dren.mil*

Ludovic Brucker (NASA - Goddard)

*ludovic.brucker@nasa.gov*

Hans-Peter Marshall (Boise State University)

*hpmarshall@boisestate.edu*



# iSWGR 2013-2016 Snow schools

Fraser, Colorado 2014: Snow measurements  
27 students





# iSWGR 2013-2016 Snow schools

**Boulder, Colorado: Snow modelling**  
**32 students**





# iSWGR 2013-2016 Snow schools

Sherbrooke, Québec 2015: Snow remote sensing  
30 students





# iSWGR 2013-2016 Snow schools

Fraser, Colorado 2016: Snow measurements  
35 students





# iSWGR 2013-2016 Snow schools

- Clear growing interest;
- Unfortunately no school in 2017, but received >130 applications;
- Working on plans and location for the next snow school 2018.



# iSWGR 2013-2016 Workshops

Next meeting, past workshops (reports available at [iswgr.org](http://iswgr.org)).

Workshop #1: 14-16 August 2013 (Boulder, Colorado)

Workshop #2: 13-16 January 2014 (Granby, Colorado)

Workshop #3: 26-27 June 2014 (Boulder, Colorado)

Workshop #4: 29-31 March 2016 (Seattle, Washington)

Next meeting:

- Joint SnowEx-iSWGR meeting
- Boulder, Colorado, Week of August 7<sup>th</sup> 2017



# iSWGR Charter

**Opportunity to be the first to sign the Charter here.  
Elections for new steering committee will take place at  
the next meeting:**

- Joint SnowEx-iSWGR meeting**
- Boulder, Colorado, Week of August 7<sup>th</sup> 2017**

# NASA's Airborne Snow Observatory - SnowEx

- Wall to wall mapping of SWE and albedo
- Weekly flights in winter and spring
- < 24 hour turnaround of distributed products and modeling/management distillations

## Snow depth

- Riegl Q1560 dual laser scanning lidar
- 1064 nm
- Full-waveform
- 60° field of view

## Snow albedo

- CASI-1500 Imaging Spectrometer
- 72 bands between 0.35 and 1.05  $\mu\text{m}$
- 40° field of view

GNSS/IMU – Applanix AP60  
RTX GNSS correction

# ASO for SnowEx

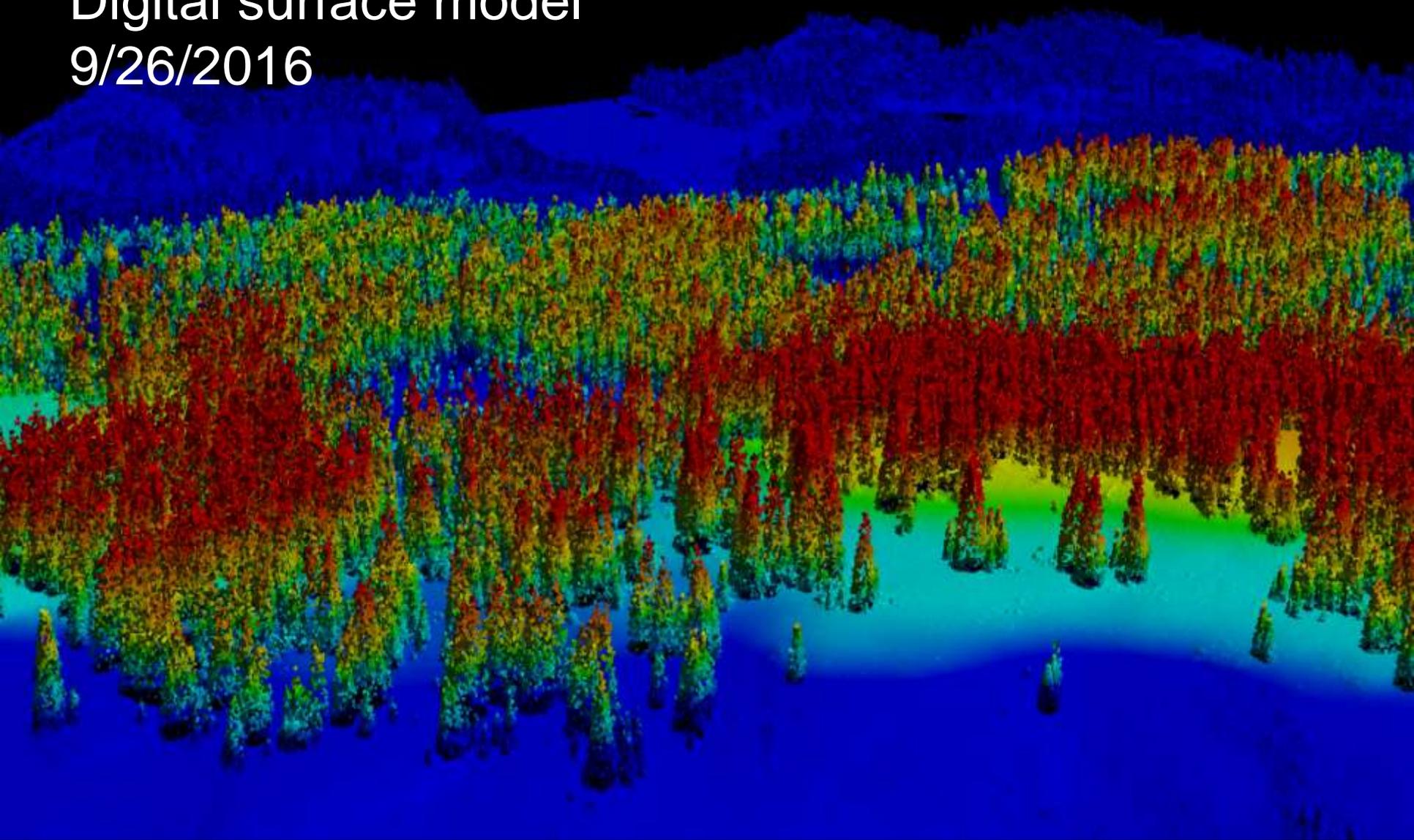
- Snow depth measurements
- SWE retrievals
- Snow albedo measurements
- Vegetation structure measurements for baseline for all other RS

## Products

- DSM+DTM+topographic metrics
- Snow depth + SWE
- Vegetation height + density + cover
- Snow grain size + albedo

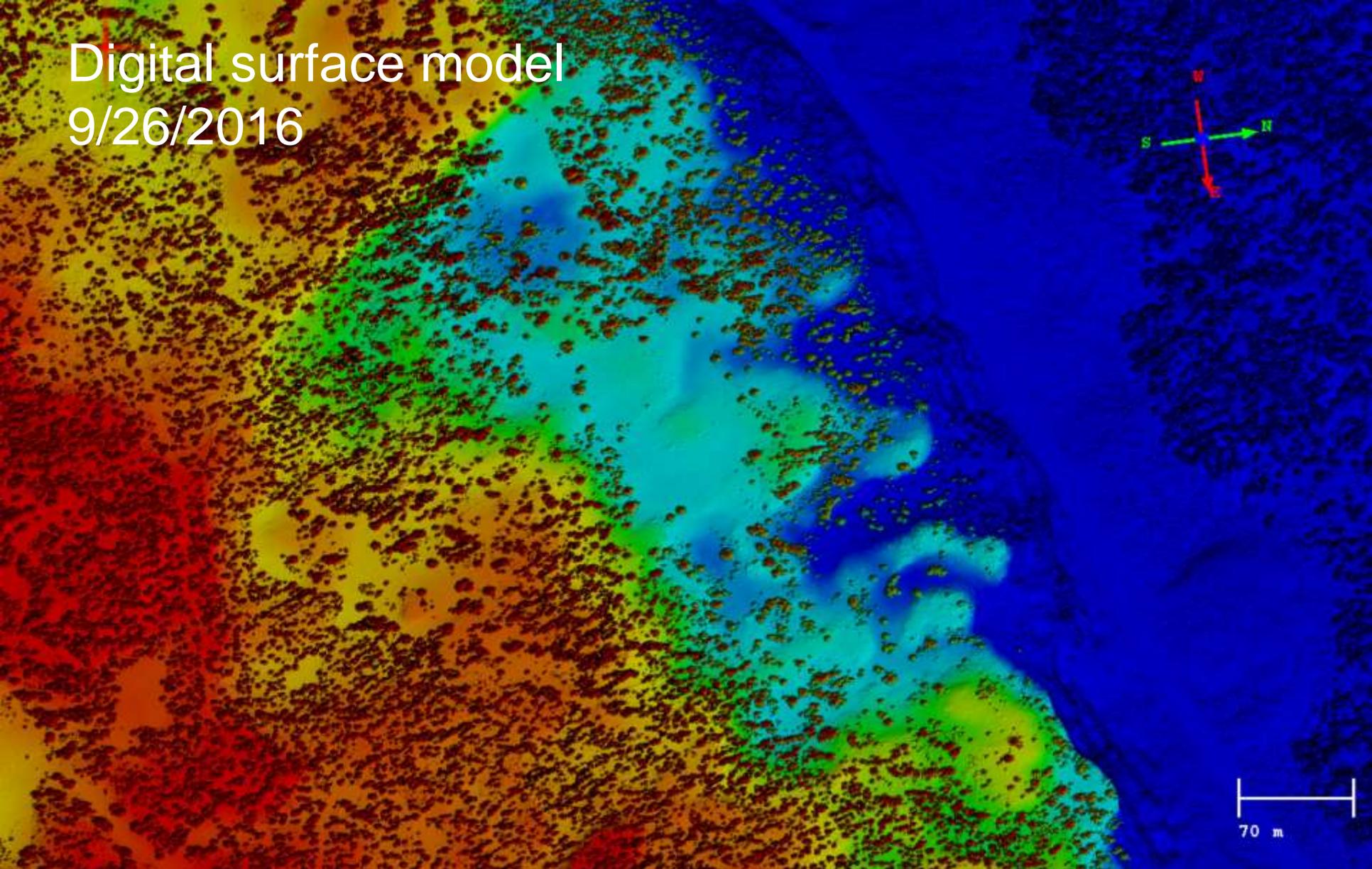
**Grand Mesa, Colorado**

Digital surface model  
9/26/2016



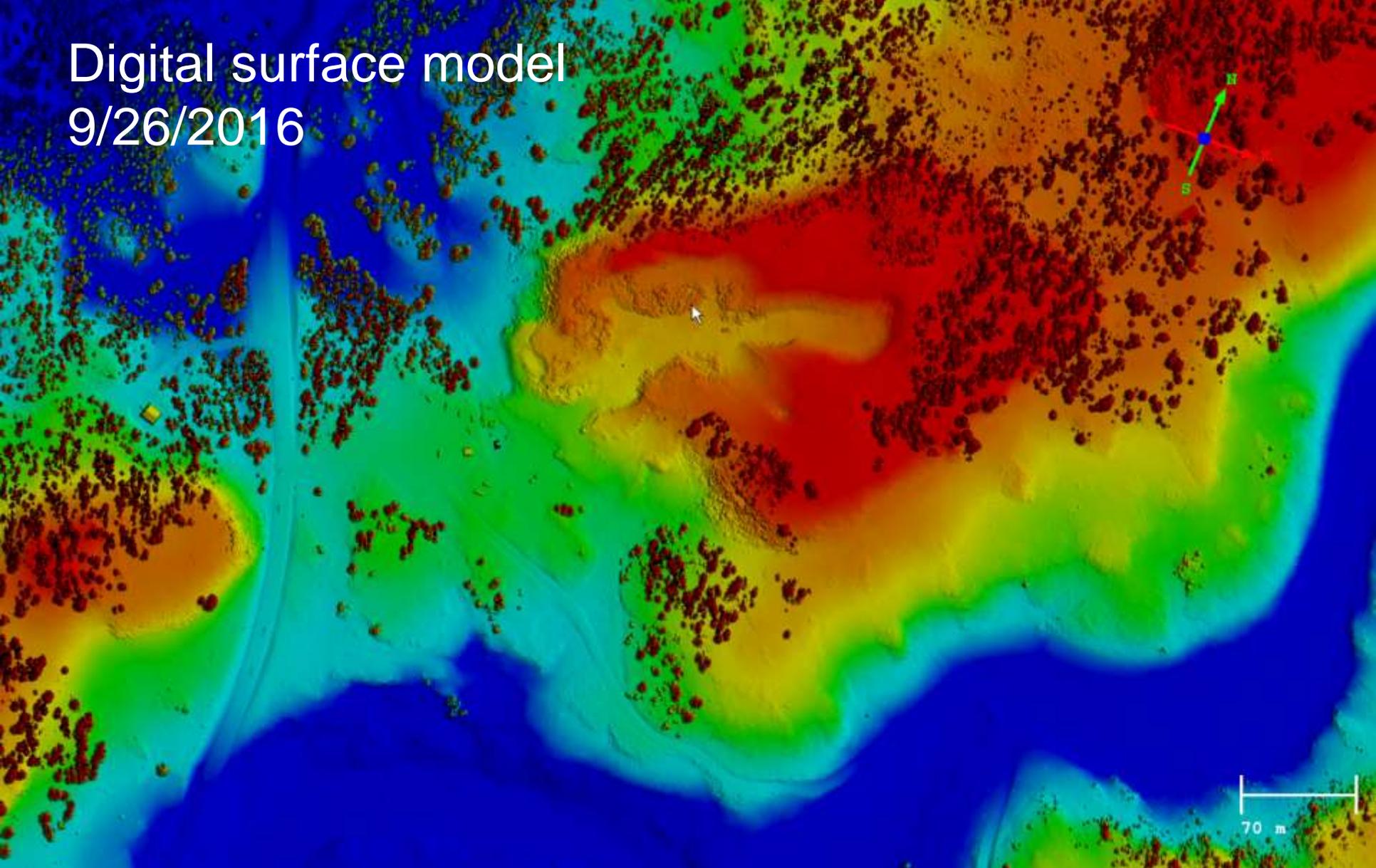
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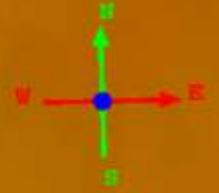
**Grand Mesa, Colorado**

Digital surface model  
9/26/2016



**Grand Mesa, Colorado**

Digital terrain model  
9/26/2016



**Grand Mesa, Colorado**