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

SnowEx update: Oct 20, 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, Paul Houser, Amanda Leon, Jeff Deems

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

Outline

- Welcome – Ed/Gatebe (3 min)
- Fall campaign report
  - Grand Mesa Ground Truth – Kelly/C.Hiemstra (5 min)
  - LSOS/Senator Beck – HP/Ludo/Deems (5 min)
  - Met stations – Paul Houser (5 min)
  - Airborne – Jeff Deems (5 min)
- Winter campaign
  - Schedule & Logistics – Amy (5 min)
  - Participant Selection – Dorothy (5 mins)
- Data management – Amanda (10 min)
- Website –Gatebe (3 min)
- Upcoming Meetings- Dorothy (5 min)
- Q&A – (10 min)

For more information, see snow.nasa.gov → snowex
Slides will be posted there, too.

Fall campaign participants

Ryan Webb
Justin Pflug
Travis Roth
William Currier
Nicholas Wright
Karl Rittger
Mark Raleigh
Tarendra Lakhankar
Zoe Courville
Ty Brandt
Alex Studd-Sojka
Clint Boaz
Roger De Roo
Mohammad Mousavi
Jeff Deems
Peter Gadomski
Art Gelvin

Luke Spaete
Ann Marie Raymond
Amy Misakonis
Ed Kim
Charles Gatebe
Kelly Elder
HP Marshal
Ludovic Brucker
Chris Hiemstra
Paul Houser
Alicia Joseph
Aakash Ahamed
Joel Gongora
Peter Pantina
Dan Berisford
Kat Borman
ASO pilots
Tom Painter
Delwyn Moller & GLISTIN-A team

Fall Campaign Report

Grand Mesa Ground Truth fall campaign report

K.Elder/C.Hiemstra

Grand Mesa Ground Truth fall campaign report

Fall Field Campaign

Snow sampling transects:

- 102 potential sites selected through veg/terrain/climate analyses
  - Recon on 102 in the field
  - 88 installed and marked
  - 14 reserved for on-snow access due to remote access issues
  - 1 removed for terrain/safety considerations
- 101 likely candidates for winter campaign

Most transects are:

- 300 m long
- NS and EW orientation
- ~50/50 NS and EW
- Staked at end points and at some 50 m intervals
- Flagged in trees

LSOS & Senator Beck Ground Truth fall campaign report

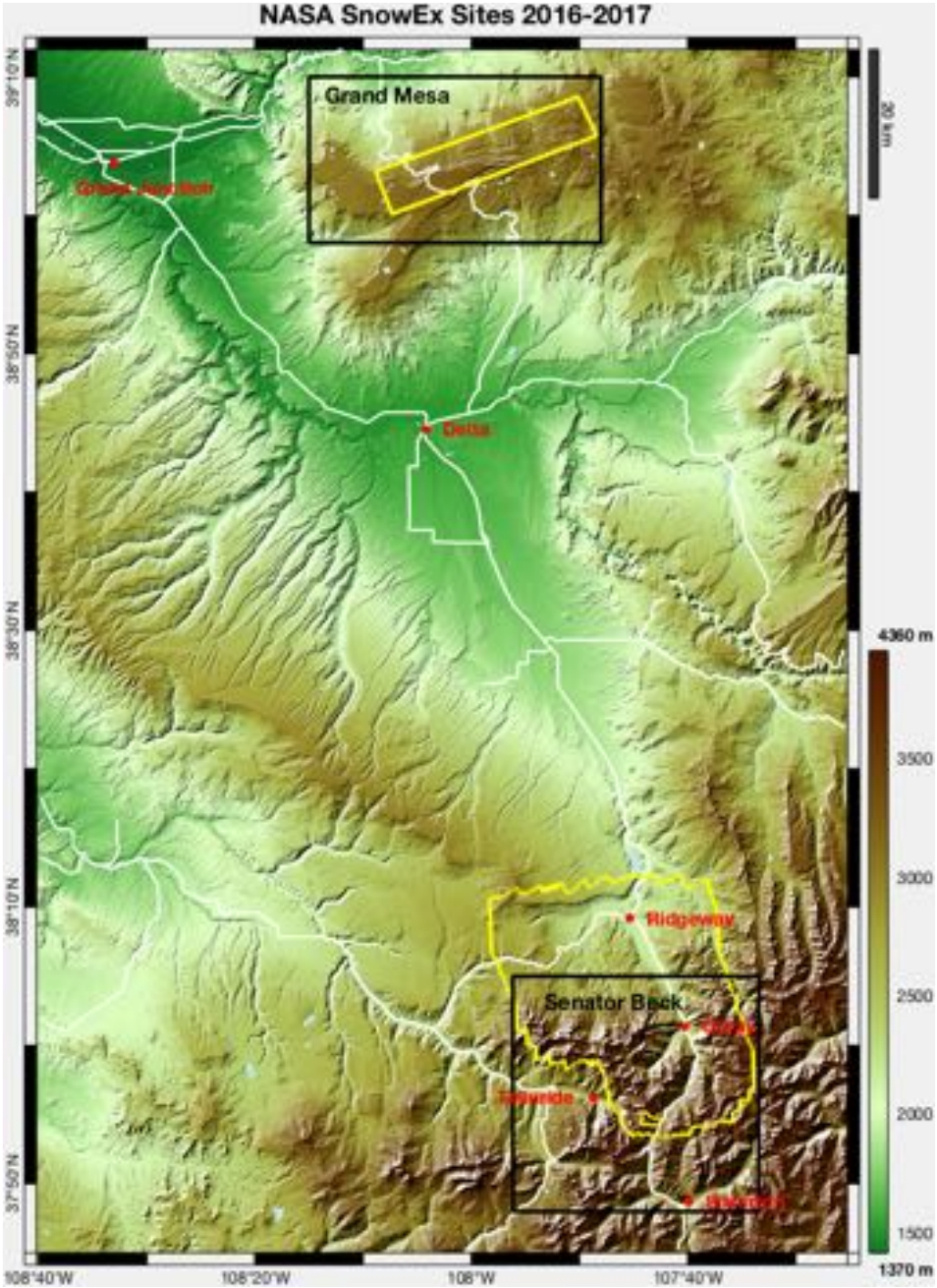
HP Marshall/Ludo Brucker

Local Scale Observation Site (LSOS)

(Mesa Lakes Ranger Station and Jumbo Campground)

Grand Mesa LSOS Instrumentation

- **Full Met station (1 of 4) *[Houser, George Mason Univ.]***
- **Truck mounted radiometers (1.4,19,37 GHz) *[DeRoo, Univ. Mich.]***
- **Pluvio, laser distrometer, PIP snow precipitation instruments *[GPM, Brucker, Goddard]***
- **Time lapse cameras, Tree accelerometers *[Raleigh, Univ. CO]***
- **1-6 GHz impulse, 24-26 GHz FMCW microwave radars *[Rodriguez, Marshall, Boise State Univ]***
- **NetR9 GPS *[Small, Univ. CO]***
- **Sun photometer *[Aeronet]***
- **Moose *[Grand Mesa]***

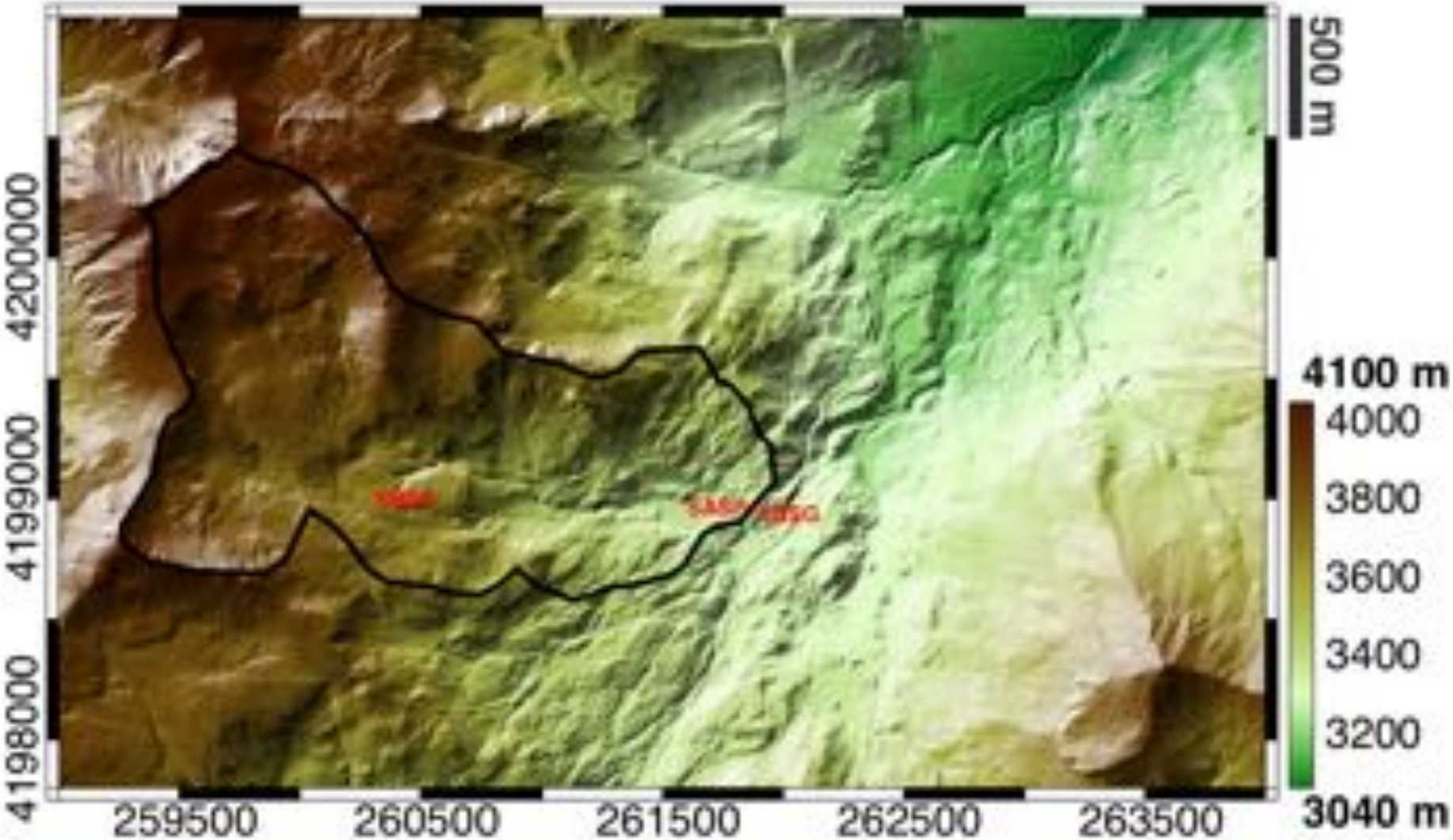


Senator Beck Basin

[Center for Snow and Avalanche Studies]

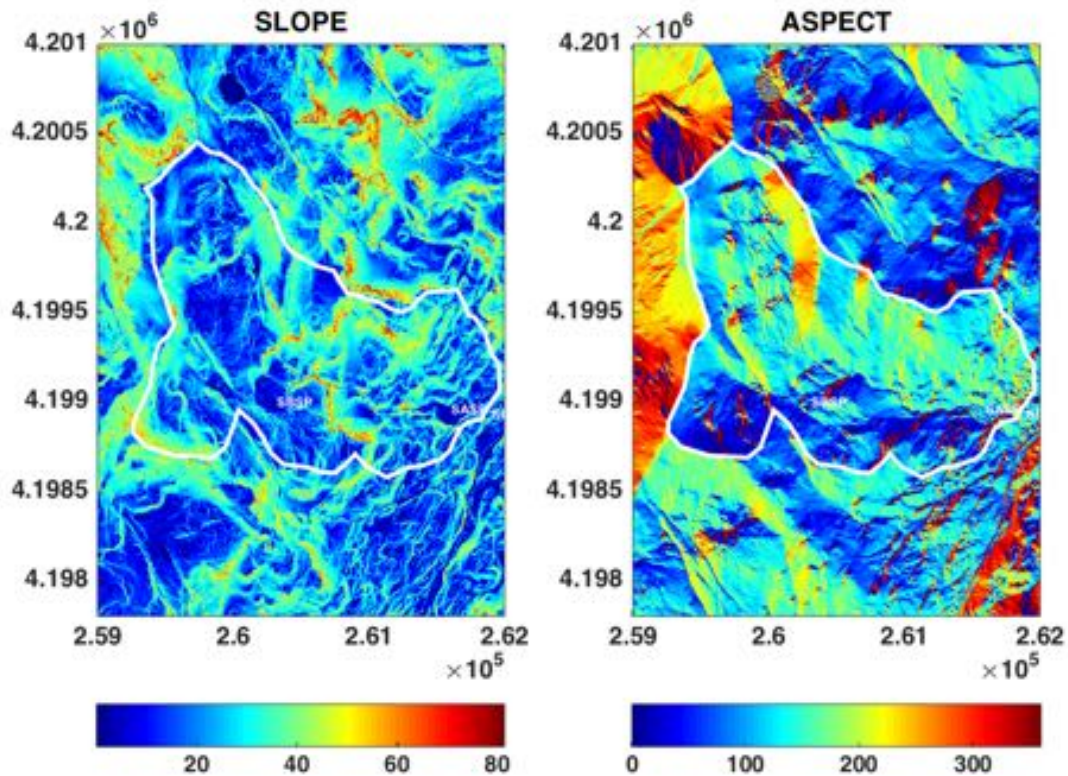
- Complex Terrain
- Gauged basin
- Long-term datasets
- High alpine terrain
- Large SWE variability (0-6+ meters)

Senator Beck Basin



- Forest
- Grass
- Talus
- Wind + topography
- Large SWE variability

- Efficient sampling of 4+ meter drifts requires different tools (radar, LiDAR)
- Low angle terrain for safe sampling
- Small experienced team, during 1st and 3rd weeks of Feb SnowEx



Senator Beck Basin
SnowEx September 2016

TLS

- Wed Sept 28 upper basin; 5 scan positions
- Thurs Sept 29 lower basin; 6 scan positions

Tree accelerometers

- M. Raleigh: 2 installed @SASP

Time lapse cameras

- M. Raleigh one camera installed @SASP
- EIS cameras @PTSP & SBSP

GNSS

- E. Small: new antenna & NetR9 installed @SASP
- 1Hz data retrieved from UNAVCO RG20 (@PTSP) for airborne support

Airborne

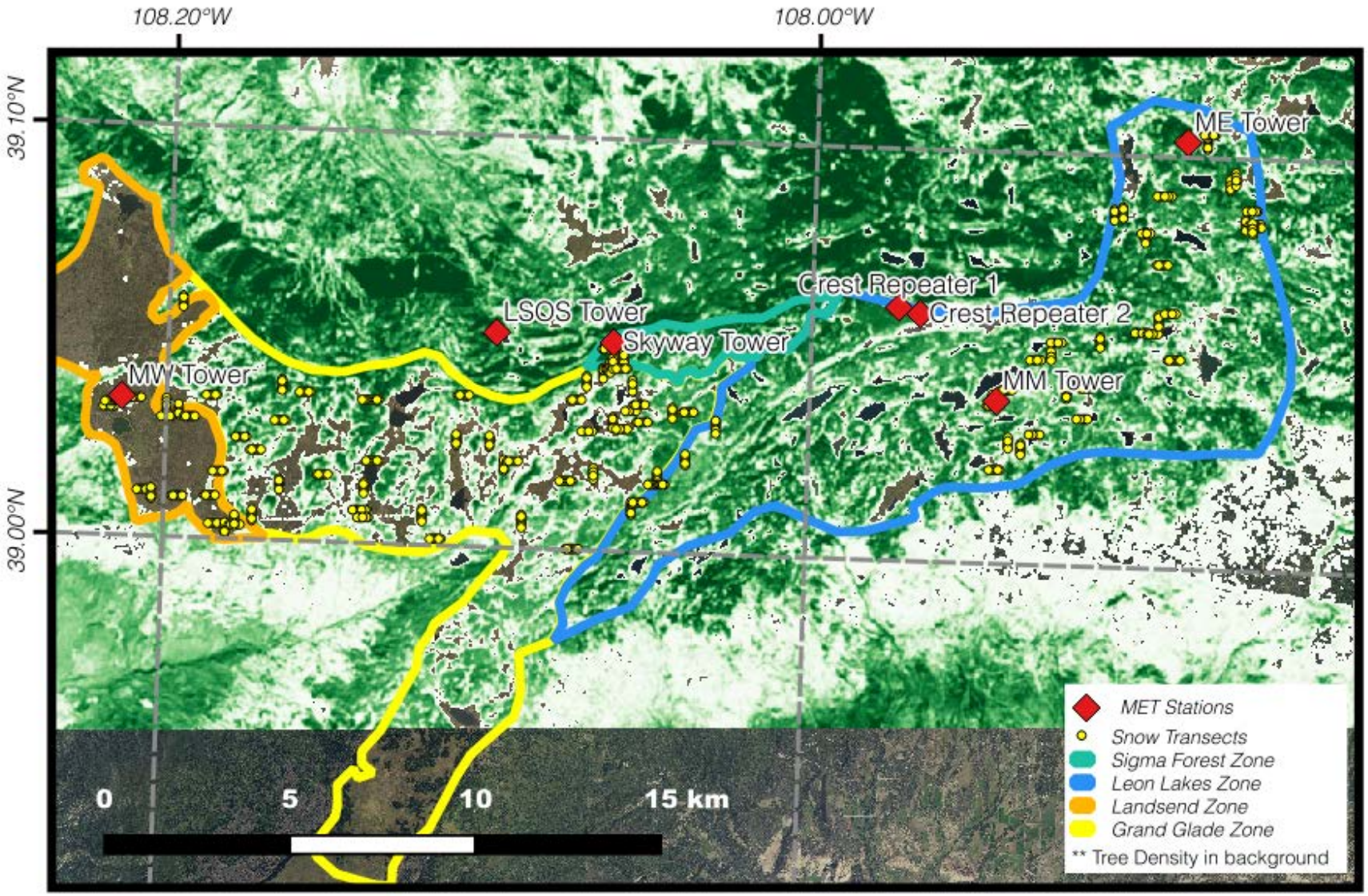
- ASO: Mon Sept 26, SBB at 10-20 pts/m^2
- GLISTN-A: Tues Sept 27

SBB SnowEx Installations
September 30, 2018
Time Lapse camera (M. Raleigh)
WINGSCAPES
Upgraded GPS (E. Small)
- Antenna (Trimble Zephyr 2)
- Receiver(Trimble NetR9)
Swamp Angel
Study Plot
Tree accelerometers (M. Raleigh)
- Two trees, GCDC X16-1D
- Solar panel and battery array
Google earth
© 2016 Google
N
80 m

- **Full Met station (1 of 2) *[Center for Snow and Avalanche Studies]***
- **Time lapse cameras, Tree accelerometers *[Raleigh, Univ. CO]***
- **NetR9/NetRS GPS *[Deems, Small, Univ. CO]***
- **Sun photometer *[Aeronet]***
- **1-6 GHz impulse, 24-26 GHz FMCW microwave radars *[Rodriguez, Marshall, Boise State Univ]***
- ***Stream gauge [Center for Snow and Avalanche Studies]***

Grand Mesa Met Stations fall campaign report

Paul Houser


108.20°W
108.00°W
39.10°N
39.00°N
ME Tower
Crest Repeater 1
Crest Repeater 2
LSOS Tower
Skyway Tower
MW Tower
MM Tower
0
5
10
15 km
MET Stations
Snow Transects
Sigma Forest Zone
Leon Lakes Zone
Landsend Zone
Grand Glade Zone
** Tree Density in background

Skyway Tower (30ft)

- Lat: 39.05074
- Lon: -108.06143
- Elev: 3239m
- 1X Campbell CR6, 10s sampling, 10min and hourly sample, average, max, min, standard deviation)
- 3X Stevens HydraProbe II soil moisture sensors (-5cm, -20cm, -50cm)
- 3X Apogee IR Radiometers (Nadir, 30deg N, 30deg S)
- 25 node Soil/Snow Thermocouple String (300,275,225,175,150,125,100,75,50,40,30,20,10,5,2.5,0,-2.5,-5,-10,-20,-30,-40,-50cm)
- 1X Verizon Raven Cellular Modem
- 2X RF451 Radio Modems
- 1X Time-lapse Camera, 3hr

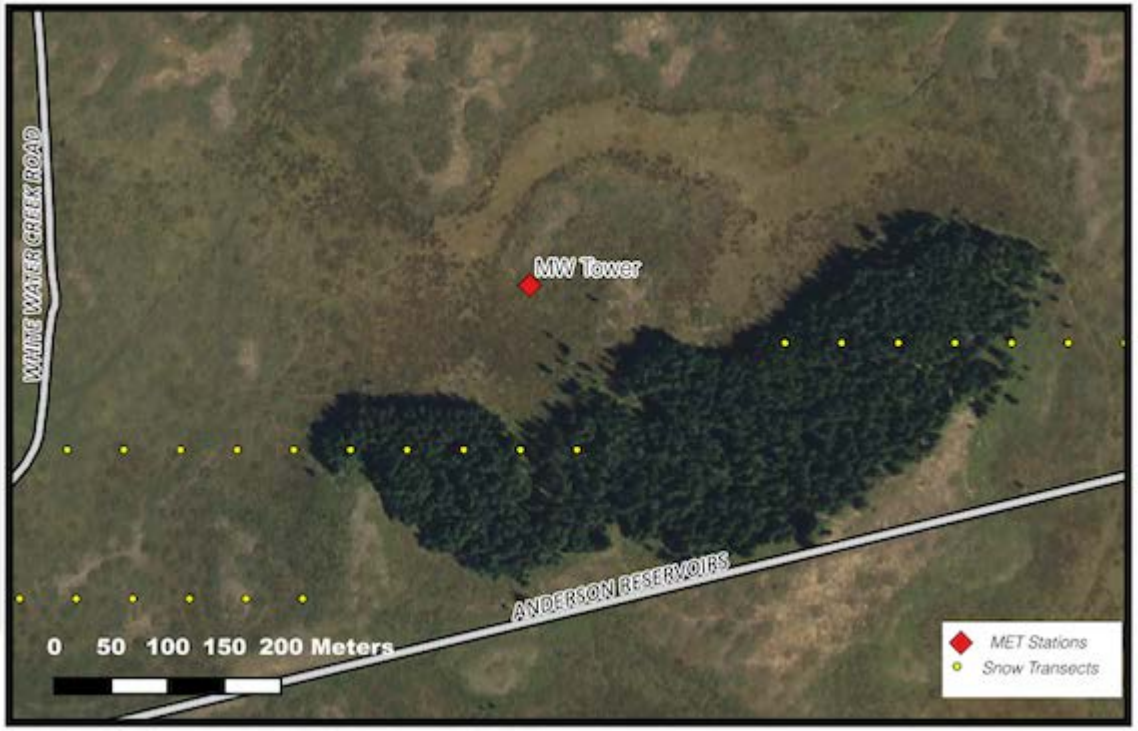
LSOS Tower (20ft)

- Lat:39.05225L
- Lon:-108.09792
- Elev:2974m
- 1X Campbell CR6, 10s sampling, 10min and hourly sample, average, max, min, standard deviation
- 3X Stevens HydraProbe II soil moisture sensors (-5cm, -20cm, -50cm)
- 4X Apogee IR radiometers (2X Nadir, 30deg N, 30deg S)
- 2X RM Young 05103 wind sensor (10ft, 20ft)
- 2X HC2S3 temperature/humidity sensor (10ft, 20ft)
- 1X SR50A sonic snow depth sensor
- 1X CNR4 4 component net radiometer
- 1X CS106 barometric pressure
- 25 node soil/snow thermocouple string (300,275,225,175,150,125,100,75,50,40,30,20,10,5,2.5,0,-2.5,-5,-10,-20,-30,-40,-50cm)
- 1X RF451 radio modem
- 1X time-lapse camera, 3hr

(note that several other sensors are installed nearby)

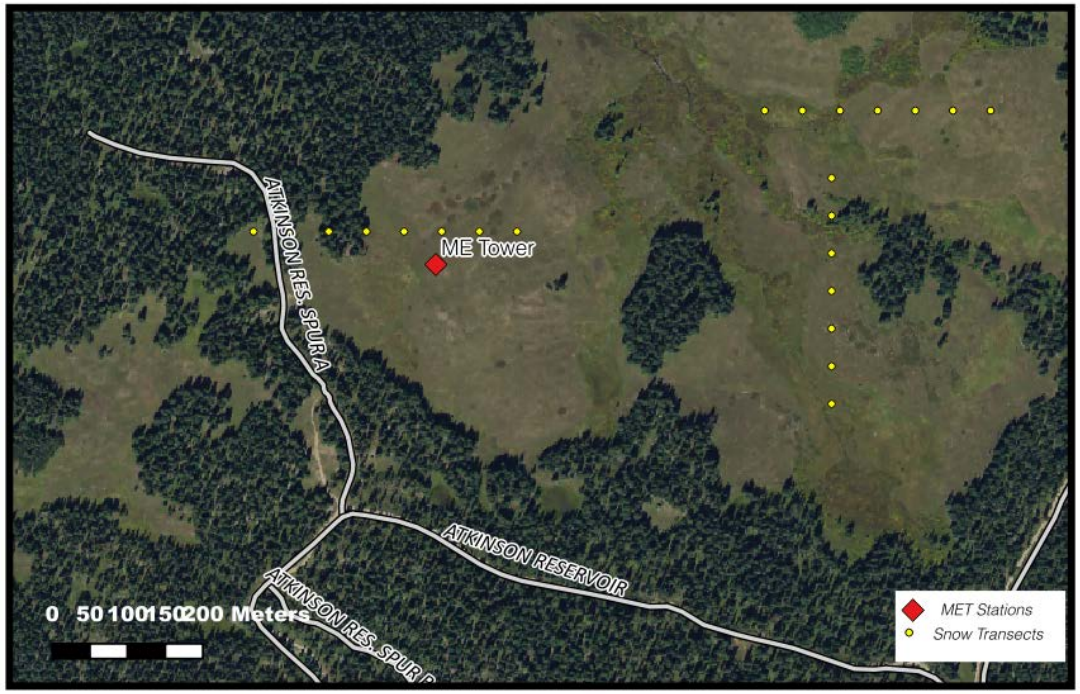
MW Tower (20ft)

- Lat:39.03388
- Lon:-108.21399
- Elev:3033m
- 1X Campbell CR6, 10s sampling, 10min and hourly sample, average, max, min, standard deviation
- 3X Stevens HydraProbe II soil moisture sensors (-5cm, -20cm, -50cm)
- 4X Apogee IR radiometers (2X Nadir, 30deg N, 30deg S)
- 2X RM Young 05103 wind sensor (10ft, 20ft)
- 2X HC2S3 temperature/humidity sensor (10ft, 20ft)
- 1X SR50A sonic snow depth sensor
- 1X CNR4 4 component net radiometer
- 25 node soil/snow thermocouple string (300,275,225,175,150,125,100,75,50,40,30,20,10,5,2.5,0,-2.5,-5,-10,-20,-30,-40,-50cm)
- 1X RF451 radio modem
- 1X time-lapse camera, 3hr



ME Tower (20ft)

- Lat: 39.10374
- Lon: -107.88448
- Elev: 3078m
- 1X Campbell CR6, 10s sampling, 10min and hourly sample, average, max, min, standard deviation
- 3X Stevens HydraProbe II soil moisture sensors (-5cm, -20cm, -50cm)
- 4X Apogee IR radiometers (2X Nadir, 30deg N, 30deg S)
- 2X RM Young 05103 wind sensor (12ft, 20ft)
- 2X HC2S3 temperature/humidity sensor (12ft, 20ft)
- 1X SR50A sonic snow depth sensor
- 1X CNR4 4 component net radiometer
- 1X CS106 barometric pressure
- 25 node soil/snow thermocouple string (300,275,225,175,150,125,100,75,50,40,30,20,10,5,2.5,0,-2.5,-5,-10,-20,-30,-40,-50cm)
- 1X RF451 radio modem
- 1X time-lapse camera, 3hr



MM Tower (20ft)

- Lat: 39.03954
- Lon: -107.94174
- Elev:3176m
- 1X Campbell CR6, 10s sampling, 10min and hourly sample, average, max, min, standard deviation
- 3X Stevens HydraProbe II soil moisture sensors (-5cm, -20cm, -50cm)
- 4X Apogee IR radiometers (2X Nadir, 30deg N, 30deg S)
- 2X RM Young 05103 wind sensor (12ft, 20ft)
- 2X HC2S3 temperature/humidity sensor (12ft, 20ft)
- 1X SR50A sonic snow depth sensor
- 1X CNR4 4 component net radiometer
- 25 node soil/snow thermocouple string (300,275,225,175,150,125,100,75,50,40,30,20,10,5,2.5,0,-2.5,-5,-10,-20,-30,-40,-50cm)
- 1X RF451 radio modem
- 1X time-lapse camera, 3hr

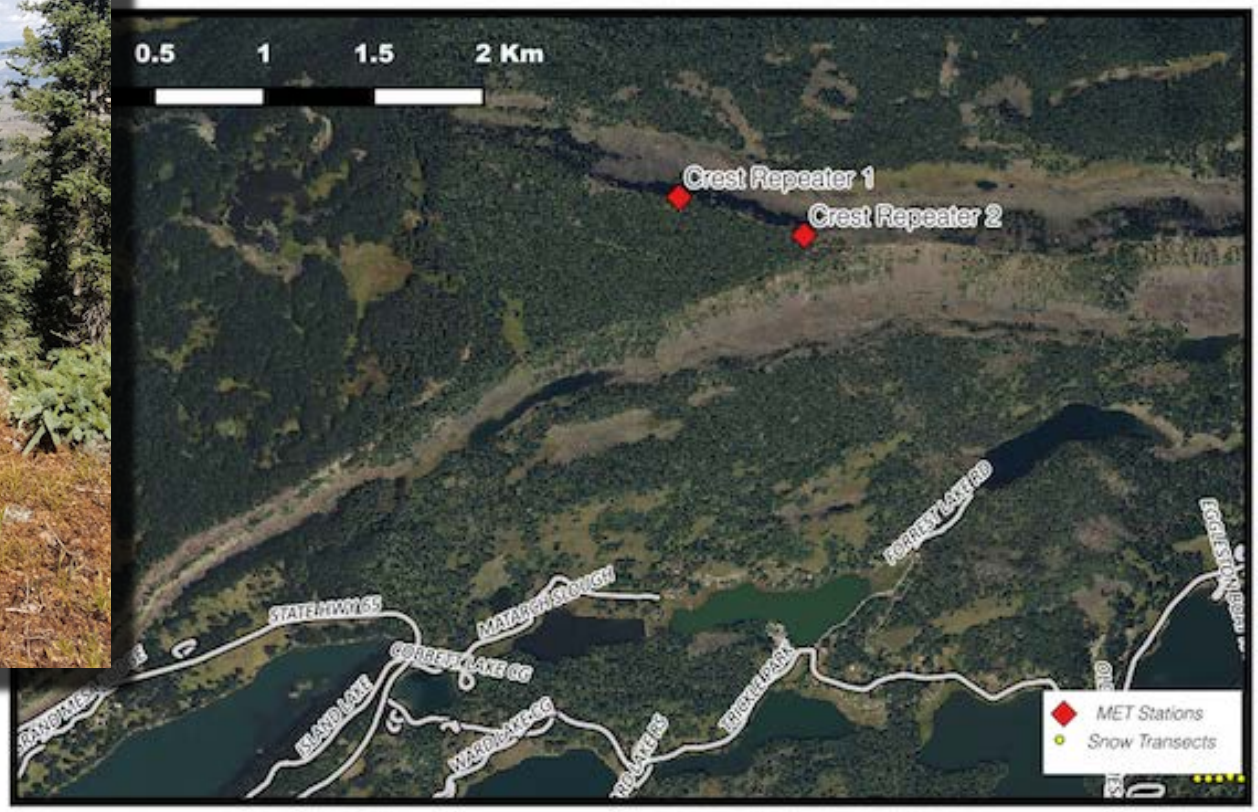
(note that a precipitation sensor is installed nearby)

Craigs Crest Radio Repeater 1 & TimeCam

- Lat: 39.06154
- Lon: -107.97297
- Elev: 3407m

Craigs Crest Radio Repeater 2 |

- Lat: 39.06014
- Lon: -107.96630
- Elev: 3394m



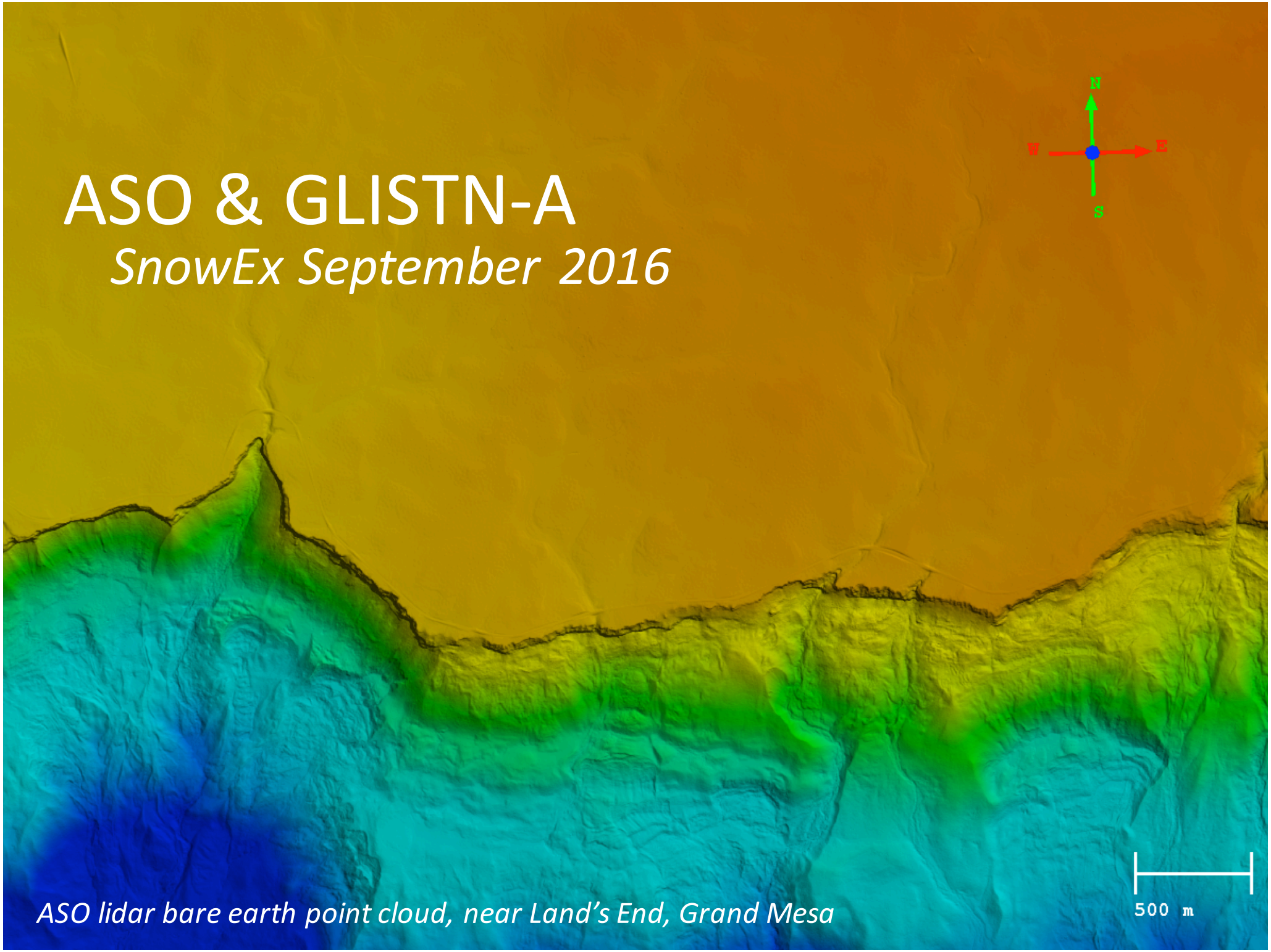
Fall Airborne Obs Report

Jeff Deems reporting for

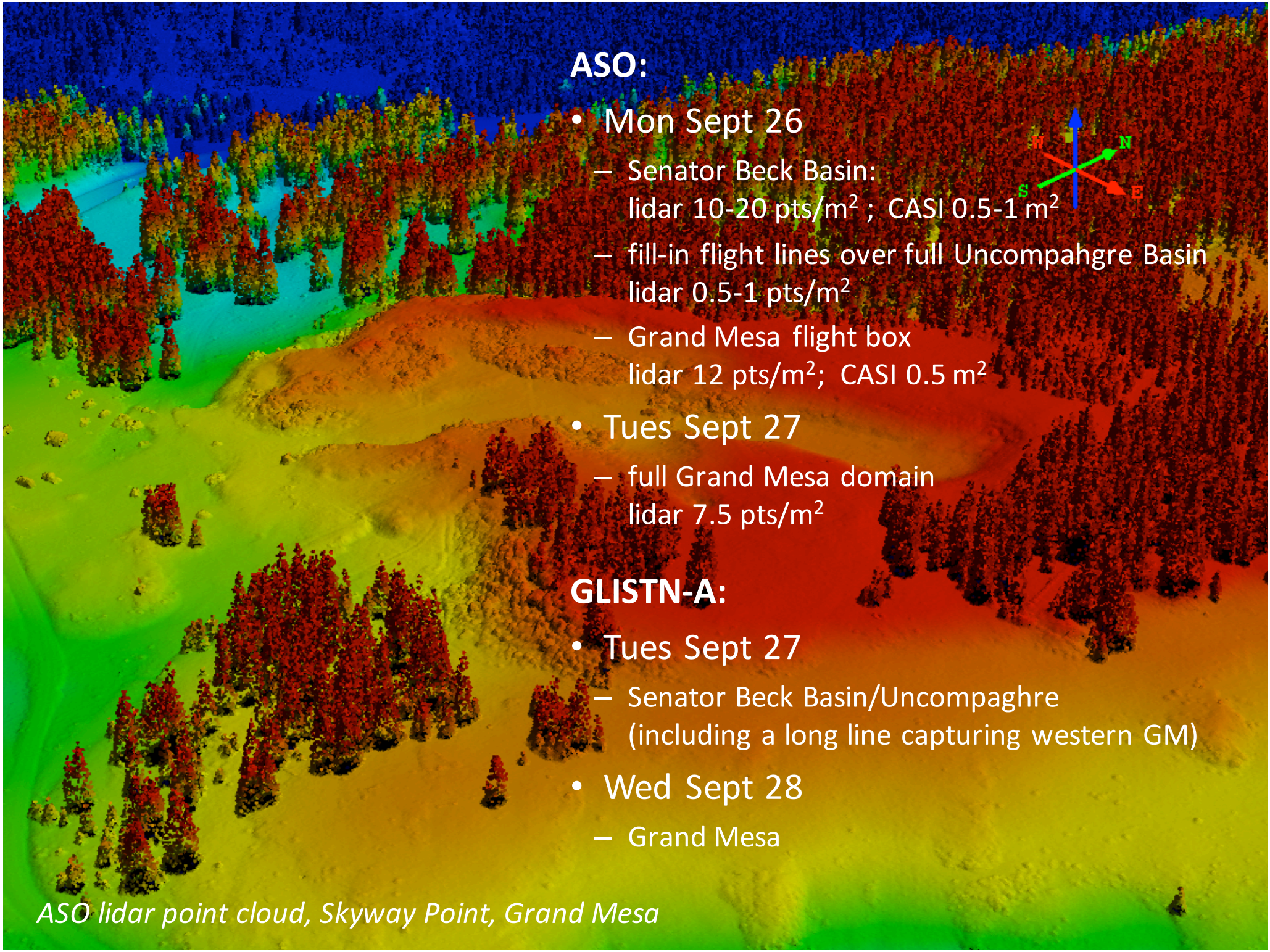
ASO & GLISTIN-A teams

ASO & GLISTN-A

SnowEx September 2016



ASO lidar bare earth point cloud, near Land's End, Grand Mesa



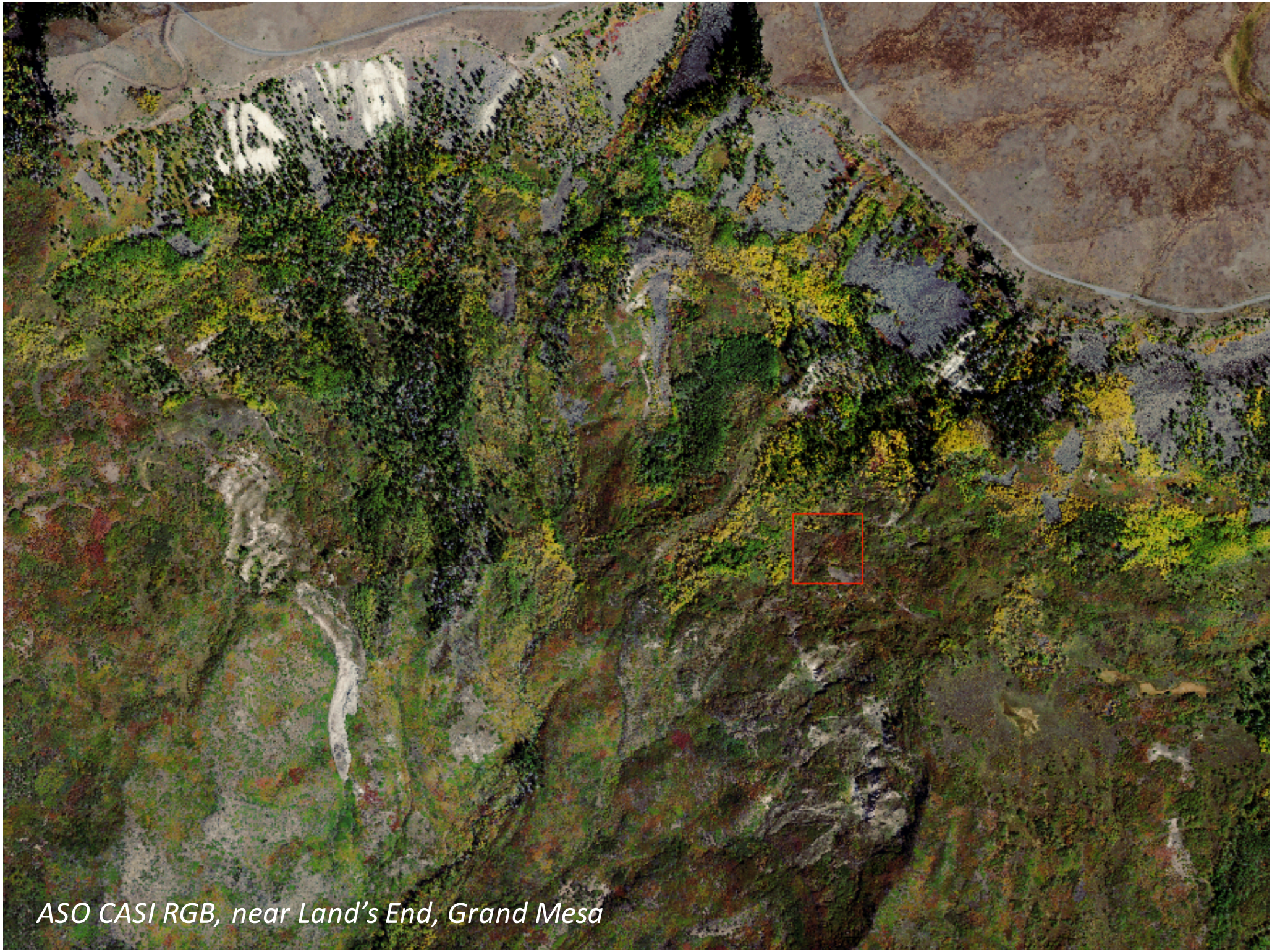
ASO:

- Mon Sept 26
  - Senator Beck Basin:
    lidar 10-20 pts/m^2 ; CASI 0.5-1 m^2
  - fill-in flight lines over full Uncompahgre Basin
    lidar 0.5-1 pts/m^2
  - Grand Mesa flight box
    lidar 12 pts/m^2; CASI 0.5 m^2
- Tues Sept 27
  - full Grand Mesa domain
    lidar 7.5 pts/m^2

GLISTN-A:

- Tues Sept 27
  - Senator Beck Basin/Uncompaghre
    (including a long line capturing western GM)
- Wed Sept 28
  - Grand Mesa

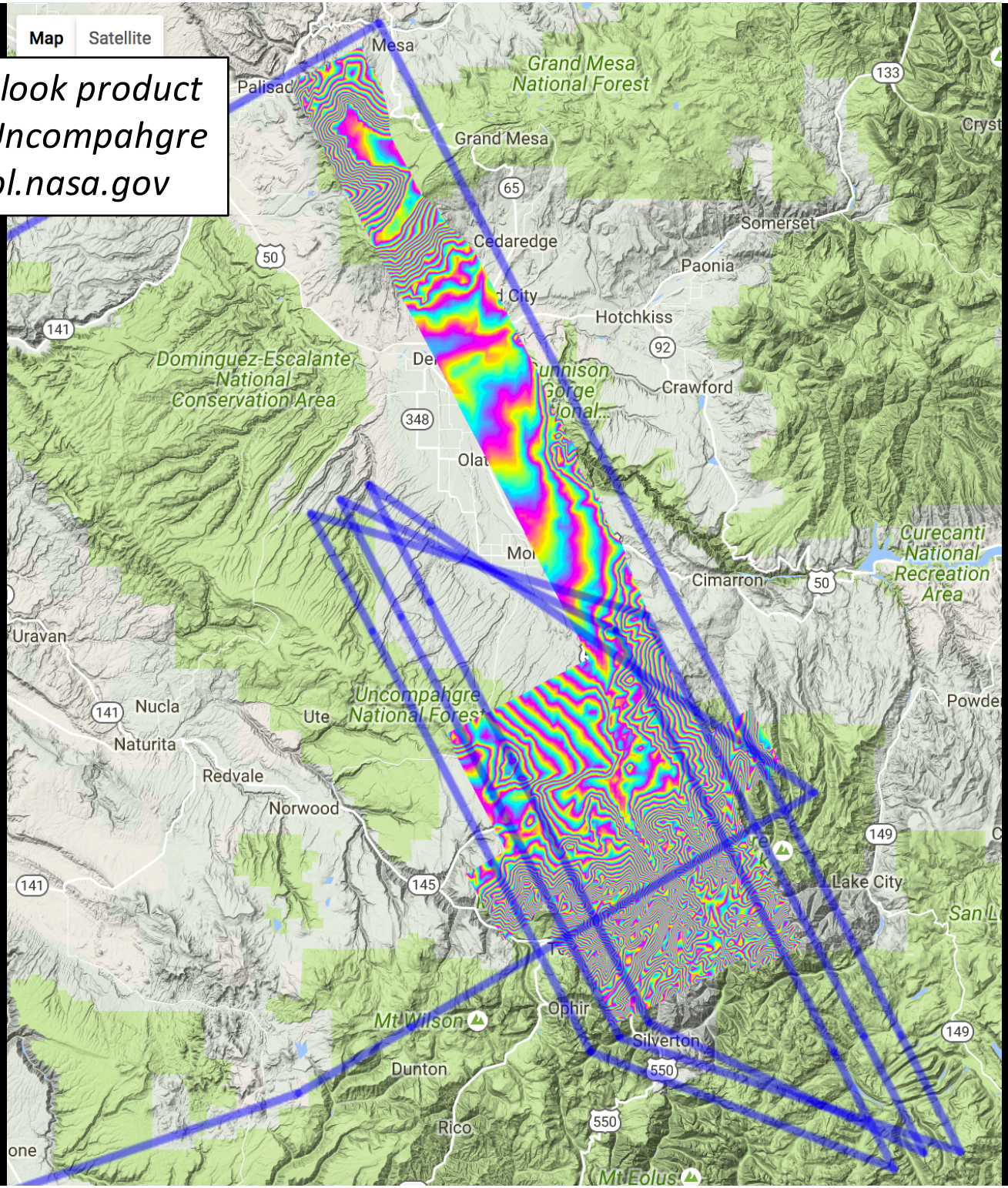
ASO lidar point cloud, Skyway Point, Grand Mesa

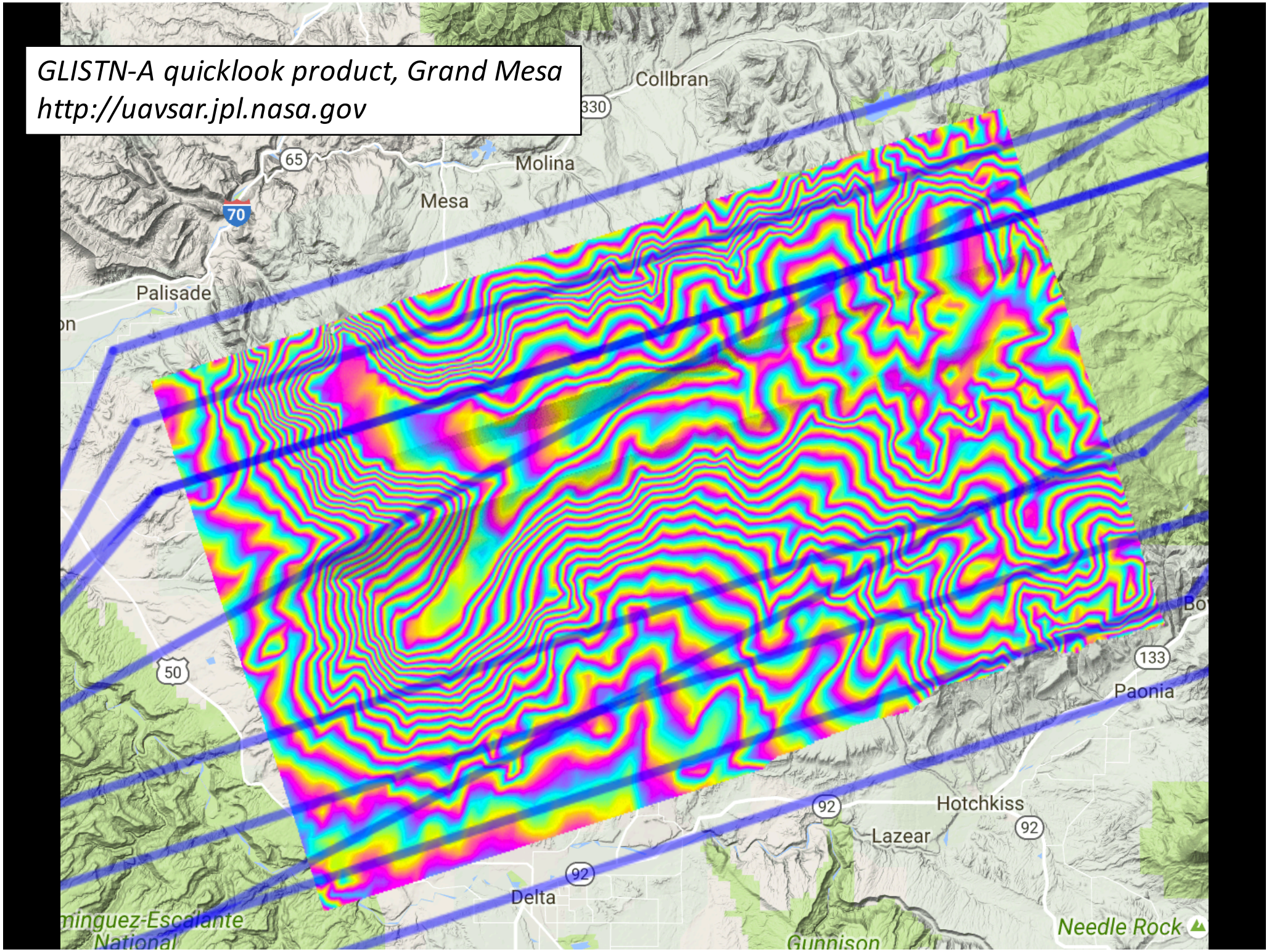


ASO CASI RGB, near Land's End, Grand Mesa

ASO CASI RGB, Skyway Point, Grand Mesa

GLISTN-A quicklook product
Senator Beck/Uncompahgre
http://uavsar.jpl.nasa.gov




GLISTN-A quicklook product, Grand Mesa
http://uavsar.jpl.nasa.gov
Collbran
330
65
Molina
Mesa
70
Palisade
50
133
Paonia
92
Hotchkiss
Lazear
92
92
Delta
Needle Rock
Gunnison

Winter Campaign Preparations

SCHEDULE STATUS AND RISKS

Amy Misakonis

Winter Schedule

- Airborne
  - NRL CDR: ~10/26
  - Instrument Readiness Review: 12/1
  - Instruments on deck at PAX: 12/19
  - Instrument integration: 1/3 – 1/11
  - Test Flights: 1/12, 1/13
  - Aircraft arrival in CO: 2/1
  - Campaign Flights: 2/6 – 2/24
- Ground
  - Fall Field Summary Released: 10/20
  - Experiment Plan completed: 11/18
  - All personnel notified and begin onboarding: 11/15
  - All procurements requested: by 12/22
  - All travel booked: by 1/1
  - Team leadership arrival in CO: 2/1
  - All Week 1 arrivals in CO: 2/5
  - Campaign begins: 2/6

Fall Summary

- Nearly 100 transects laid
- ~30 time lapse cameras installed
- 3 teams performed TLS measurements
- LSOS set up
- Mets stations built – return trip occurring in early November to complete
- ASO and Glisten-A completed “snow-off” flights

Lessons Learned

- Personnel
  - Clearly define roles and responsibilities
  - Understanding of what tasks/objectives you are assigned to
  - Back ups
- Communication
  - Need more reliable comm on the Mesa
- Safety
  - Check in and check out process
  - Contingency planning for any issues
  - Assessment of all hazardous ops
  - Minimize driving on Mesa during poor conditions
- Equipment
  - Buy a few extra quantities in case anything not delivered or not functional
- Training/Logistics
  - Add additional training for safety, unique activities, measurements, vehicle operations (snow mobiles)
- Lodging
  - Ensure that lodge owners are available for late arrivals
  - All personnel know when/where to arrive
  - Provide group transporation

Data Management

Amanda Leon/NSIDC

Upcoming meetings

Dorothy

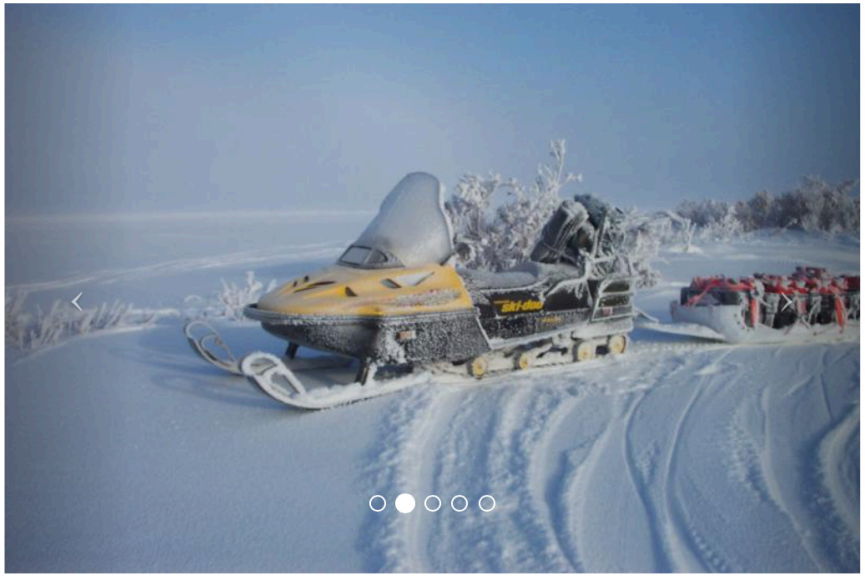
Website update

Gatebe

http://snow.nasa.gov/

SNOW

Home | News | SnowEx | iSWGR | Data | Meetings | ASO



Snow as a Vital Link in the Hydrologic Cycle

Snow is life. It is the water we drink and is needed to grow food that we eat. Mountains collect and store snow in winter, and spring snowmelt feeds streams and reservoirs that supply water to people and crops, and it also generates electricity. The white blanket of snow cover drives climate processes and cools the planet.

But changes in snow quantity and snowmelt timing are underway and have serious consequences. However, the quantity of snow stored

Upcoming Meetings

SnowEx Fall AGU Town Hall (San Francisco, CA, Dec. 12, 2016; 12:30pm)

SnowEx IGARSS (Fort Worth Texas, USA, July 23-28, 2017)

SnowEx Workshop (Boulder, CO, August 2017)

4th Winter Field Course for Snow Measurements Kananaskis, Canadian Rockies, Jan 5-9, 2017). (Application deadline: Nov 18. Decision: Dec 1. http://iswgr.org/fieldwork2017)

Q & A