# NASA Airborne Snow Observatory

*Measuring the Spatial Distribution of Snow Water Equivalent and Snow Albedo*

NASA
JPL
Jet Propulsion Laboratory
Northwest Watershed Research Center
USDA
Agricultural Research Service
ASO
NSIDC
National Snow and Ice Data Center
Department of Water Resources
State of California

# Motivation for ASO

- The two most critical properties for understanding snowmelt runoff timing and magnitude are the spatial and temporal distributions of snow water equivalent (SWE) and snow albedo
- These remain largely unquantified in the US (and globally), leaving runoff models poorly constrained and limiting our physical understanding of mountain snowmelt driven systems

# Snow Water Equivalent

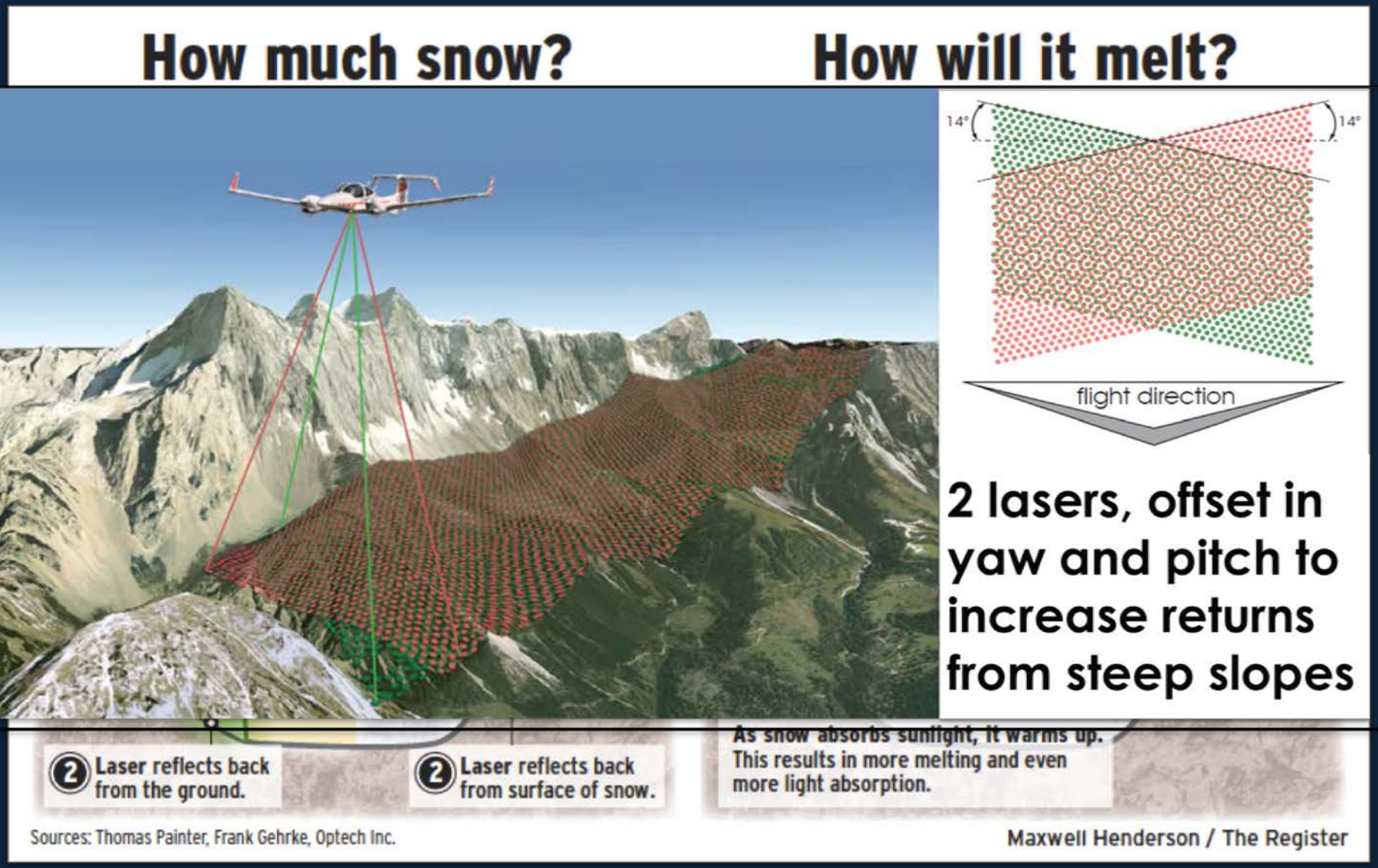
Riegl Q1560 dual laser scanning lidar
1064 nm, Full-waveform sensor
60° field of view

# Albedo

CASI-1500 Imaging Spectrometer
72 bands between 0.35-1.05 µm
40° field of view

- High Spatial Resolution
- Weekly temporal resolution
- 24 hour processing latency

# How it Works

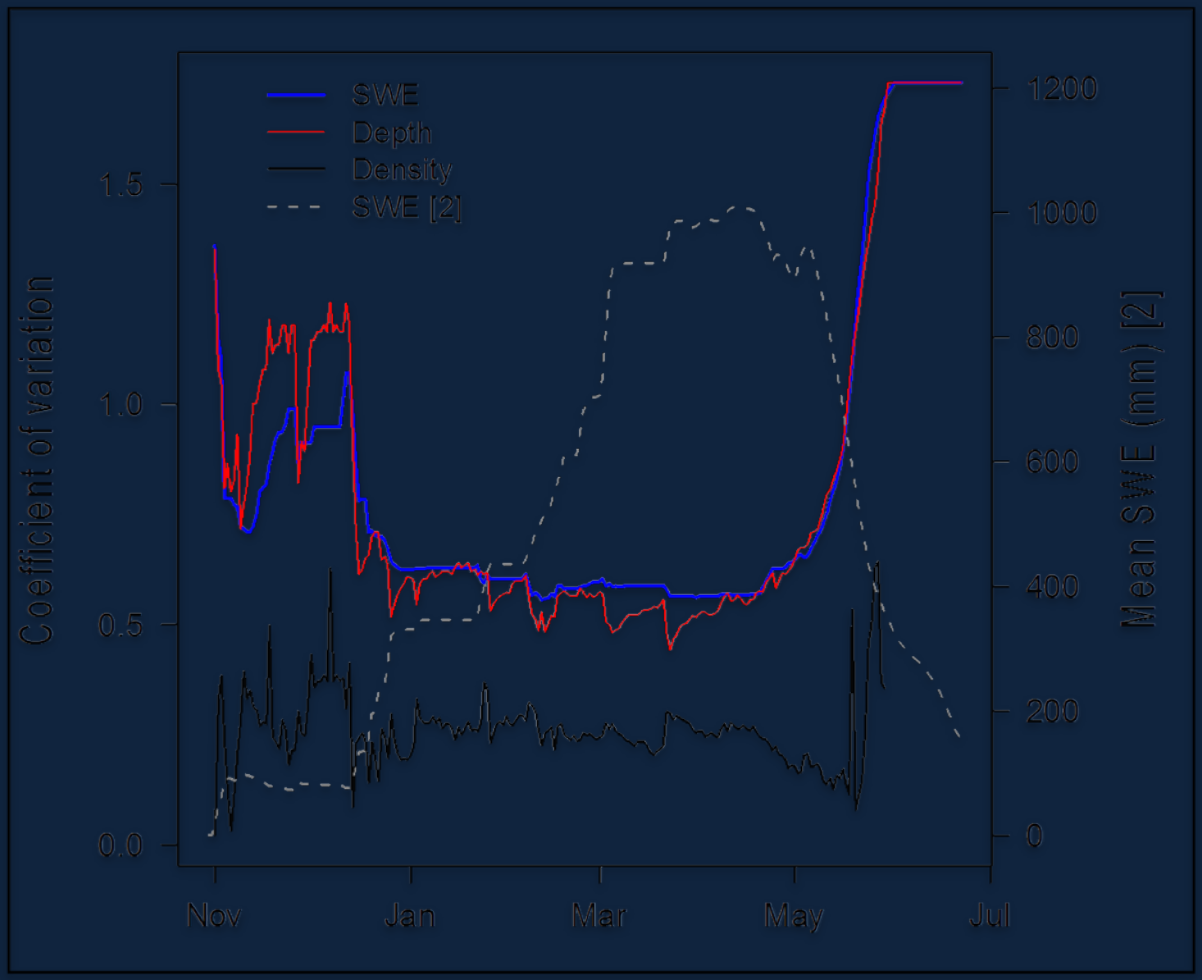

How much snow?
How will it melt?
14°
14°
flight direction
2 lasers, offset in yaw and pitch to increase returns from steep slopes
2 Laser reflects back from the ground.
2 Laser reflects back from surface of snow.
As snow absorbs sunlight, it warms up. This results in more melting and even more light absorption.
Sources: Thomas Painter, Frank Gehrke, Optech Inc.
Maxwell Henderson / The Register

# Why a lidar?

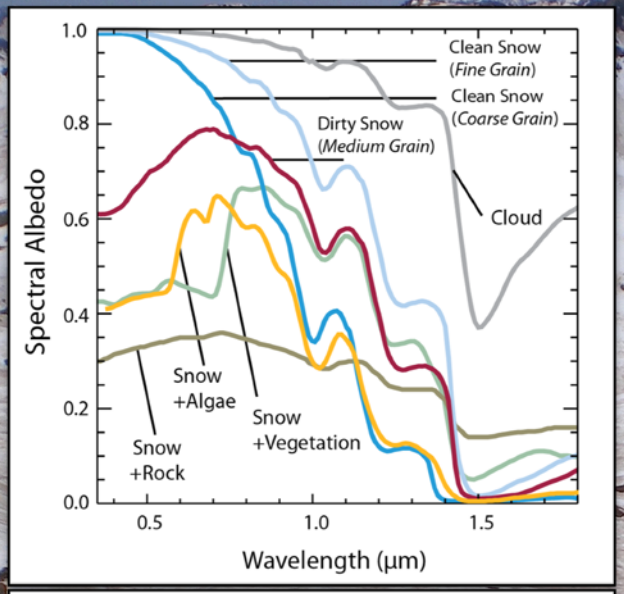
Majority of spatial variability in SWE is due to snow depth

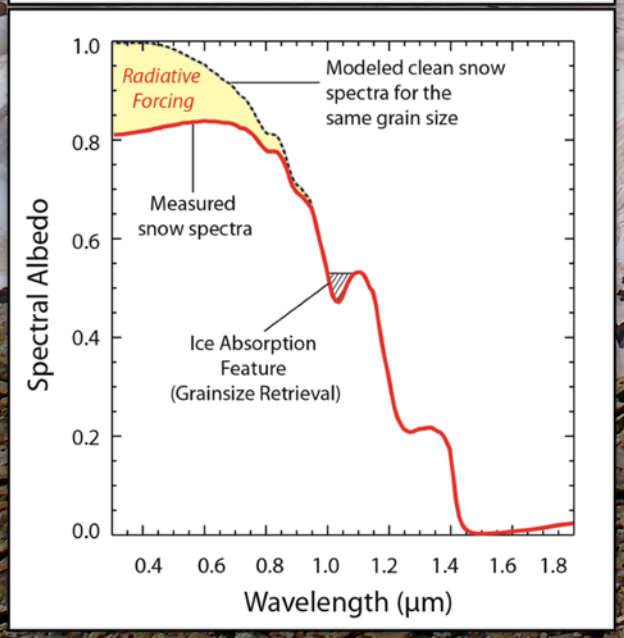
Depth can be measured by differential elevation mapping

- Collect snow-free & snow-covered data sets
- Classify & remove vegetation
- Subtract snow-free
- from snow-covered



# Why a spectrometer?



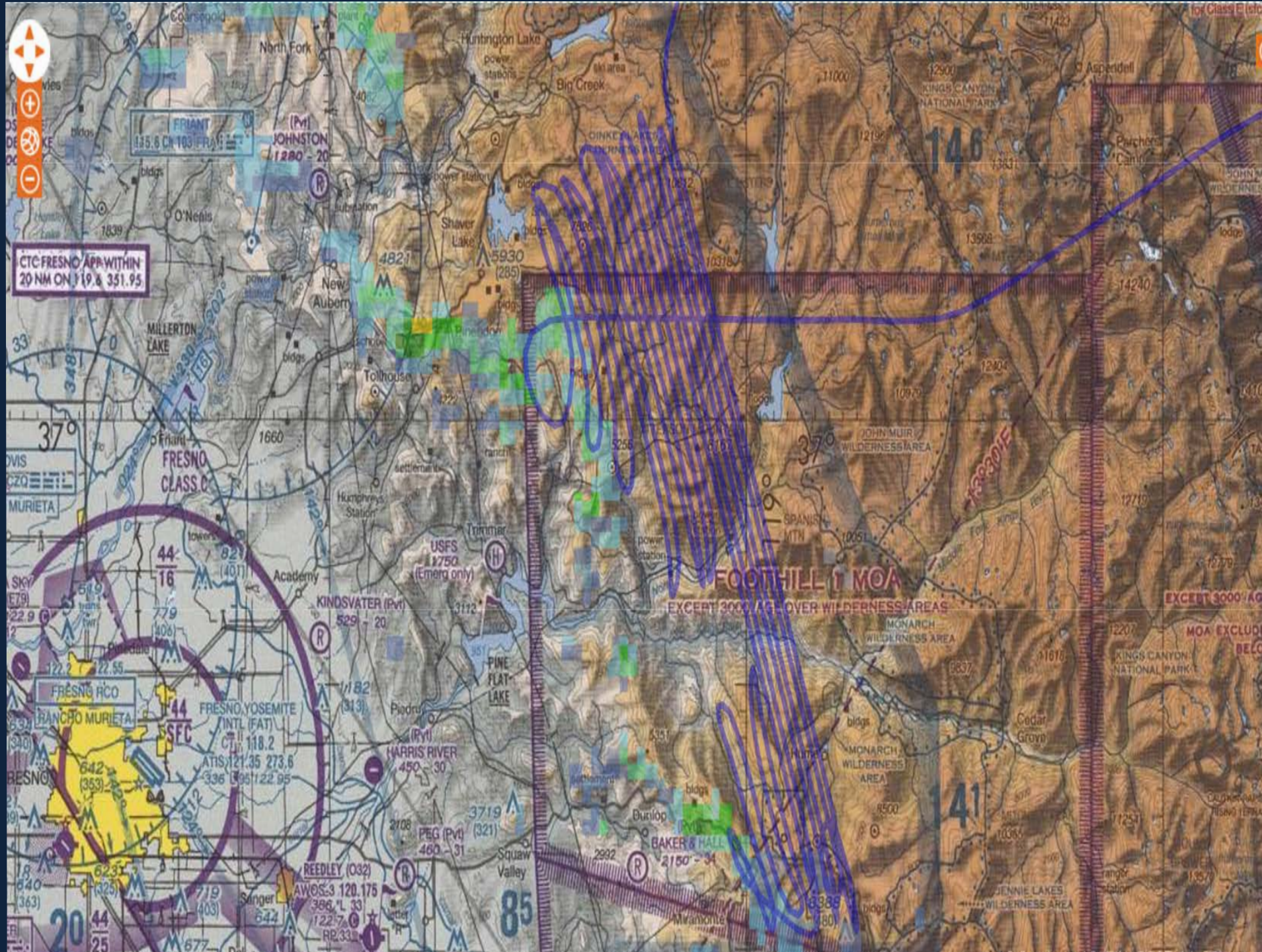

## Land surface classification

- Vegetation, water, snow and rock all have unique spectral signatures

## Snow Energy Balance

- Solar radiation dominates melt in almost all snow covered environments
- Absorbed solar radiation is controlled by impurity content and grain size, which impact different part of the snow spectrum

ASO utilizes a proven algorithm to retrieve these snow properties (*Painter et al*. 2013)

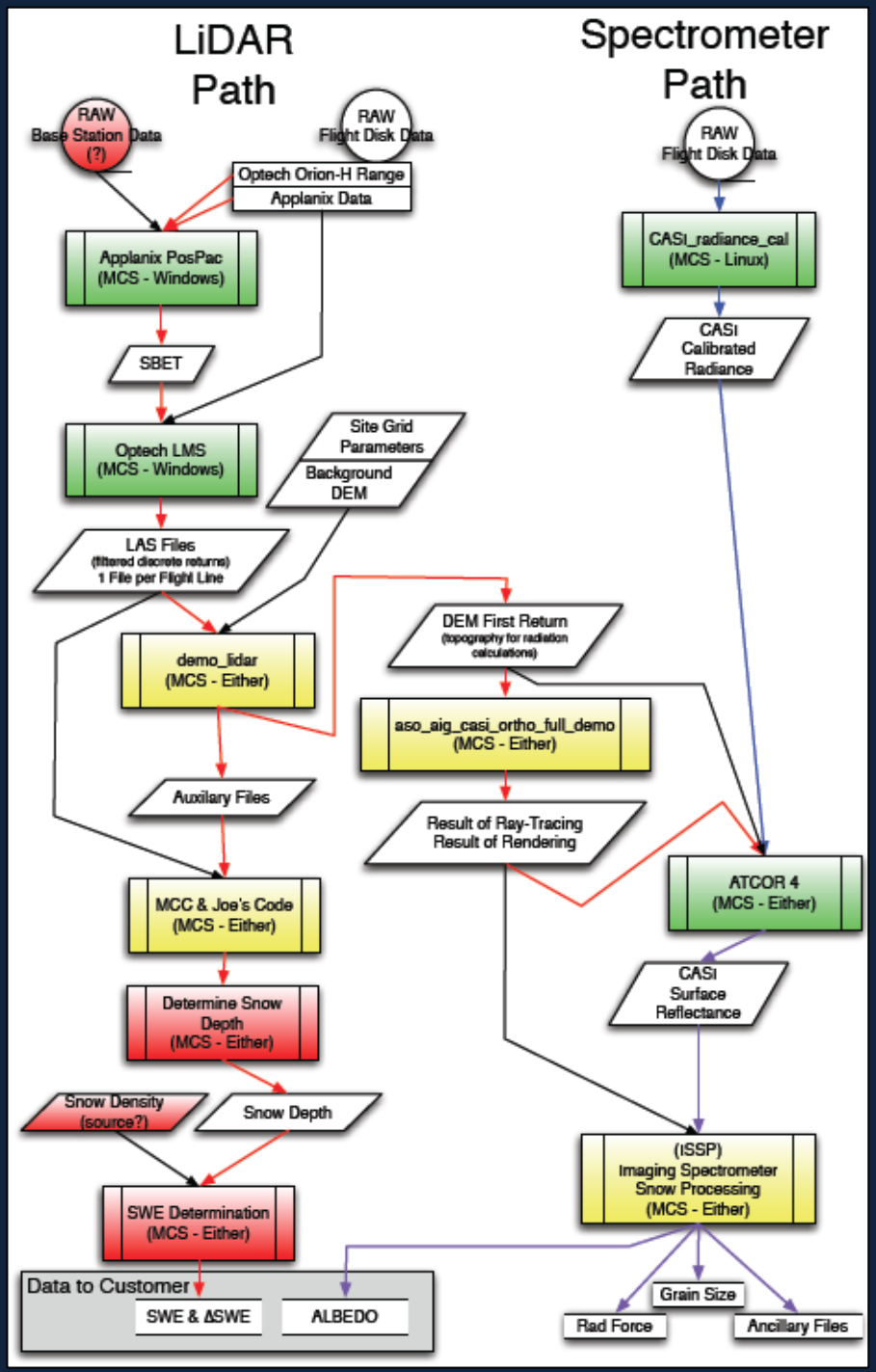


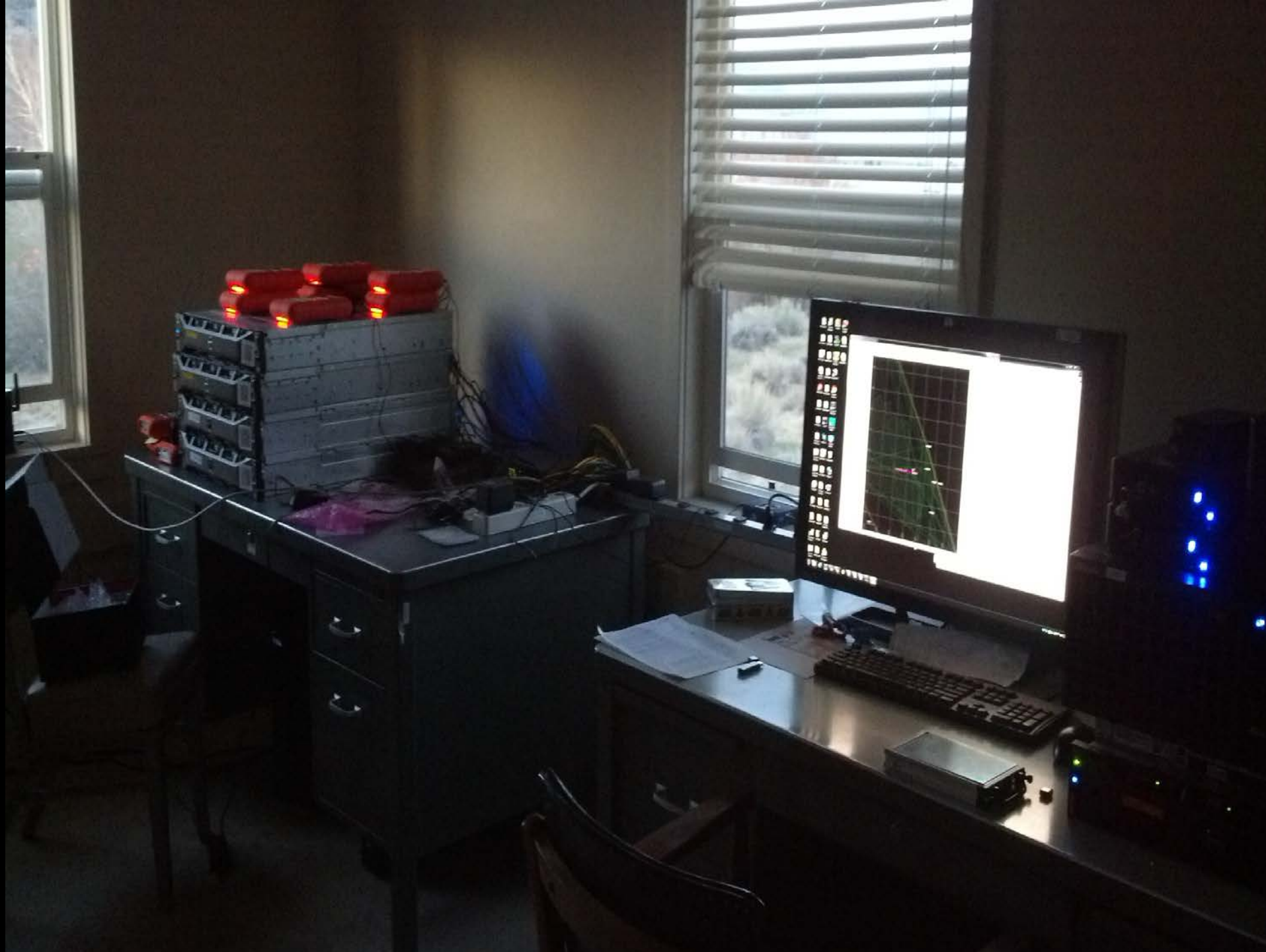
CTC FRESNO APP WITHIN 20 NM ON 119.6 351.95
FRIANT
JOHNSTON
O'Neals
MILLERTON LAKE
New Auberry
Tollhouse
Shaver Lake
Huntington Lake
Big Creek
North Fork
Coarsegold
Aspendell
KINGS CANYON NATIONAL PARK
JOHN MUIR WILDERNESS AREA
FOOTHILL 1 MOA
EXCEPT 3000' AGE OVER WILDERNESS AREAS
MONARCH WILDERNESS AREA
FRESNO CLASS C
MURIETA
Academy
KINDSVATER (Pvt)
USFS
Trimmer
PINE FLAT LAKE
FRESNO RCO
RANCHO MURIETA
FRESNO YOSEMITE INTL (FAT)
HARRIS RIVER
PEG (Pvt)
Squaw Valley
REEDLEY (O32)
Sanger
Dunlop
BAKER & HALL
Cedar Grove
JENNIE LAKES WILDERNESS AREA
146
141
85
20

# Compute System

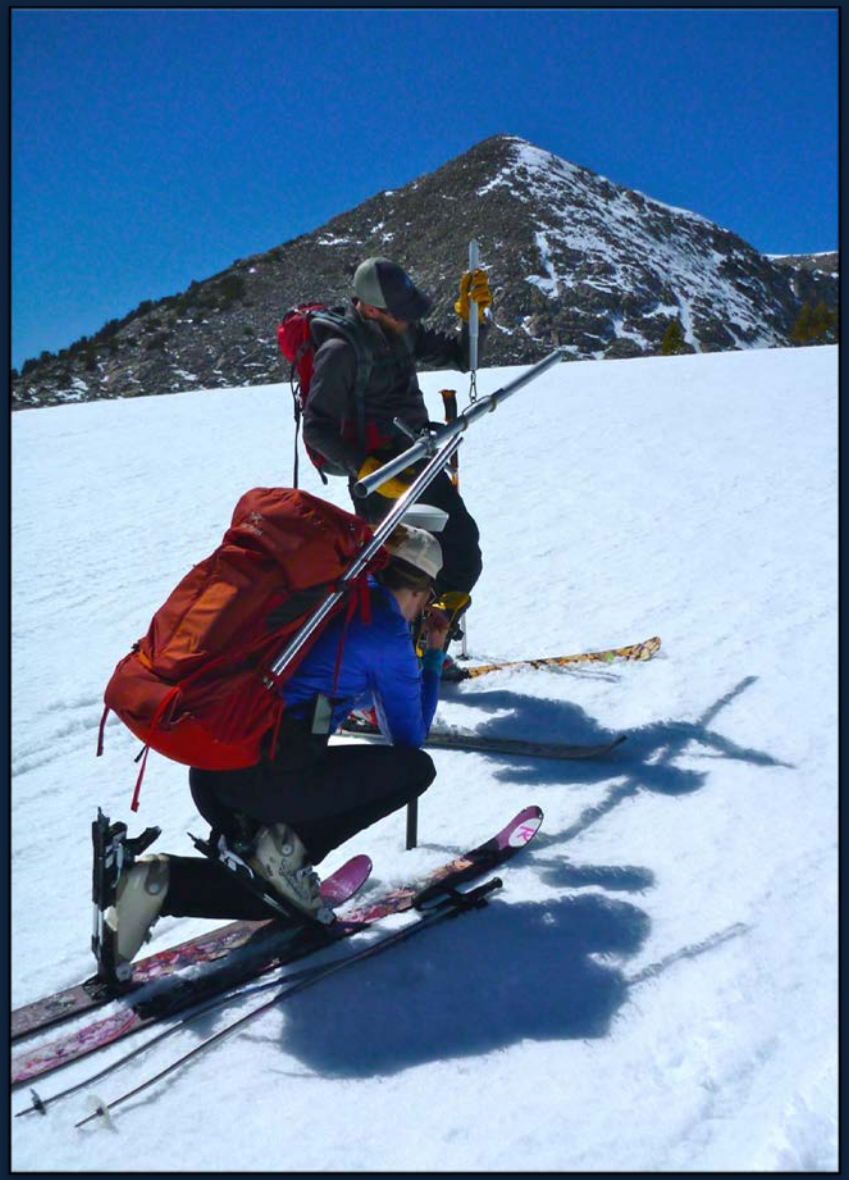
## Operational Products

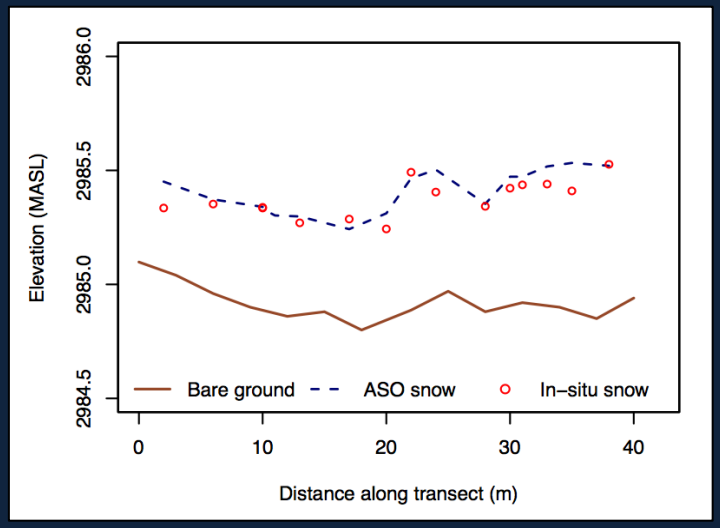
- 24-hour data product latency
- Products:
  - Snow Depth
  - SWE (using ground measurements + iSNOBAL modeled densities)
  - Broadband Snow Albedo
- LiDAR/spectrometer

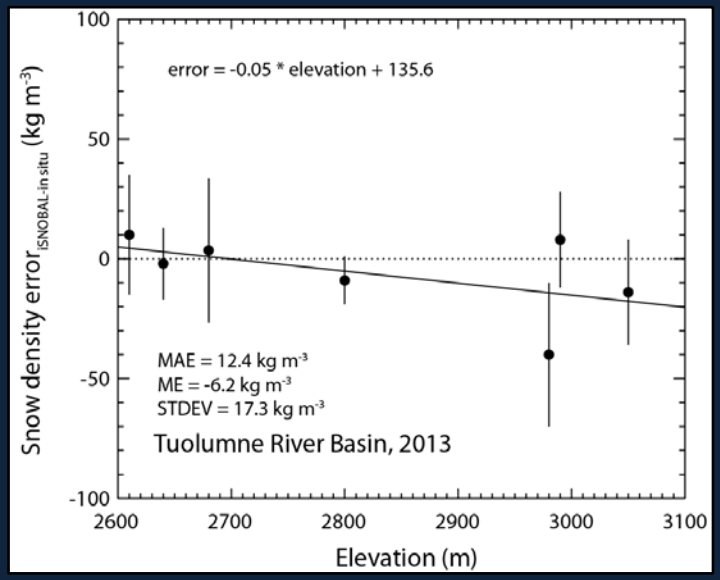




# Ground Validation





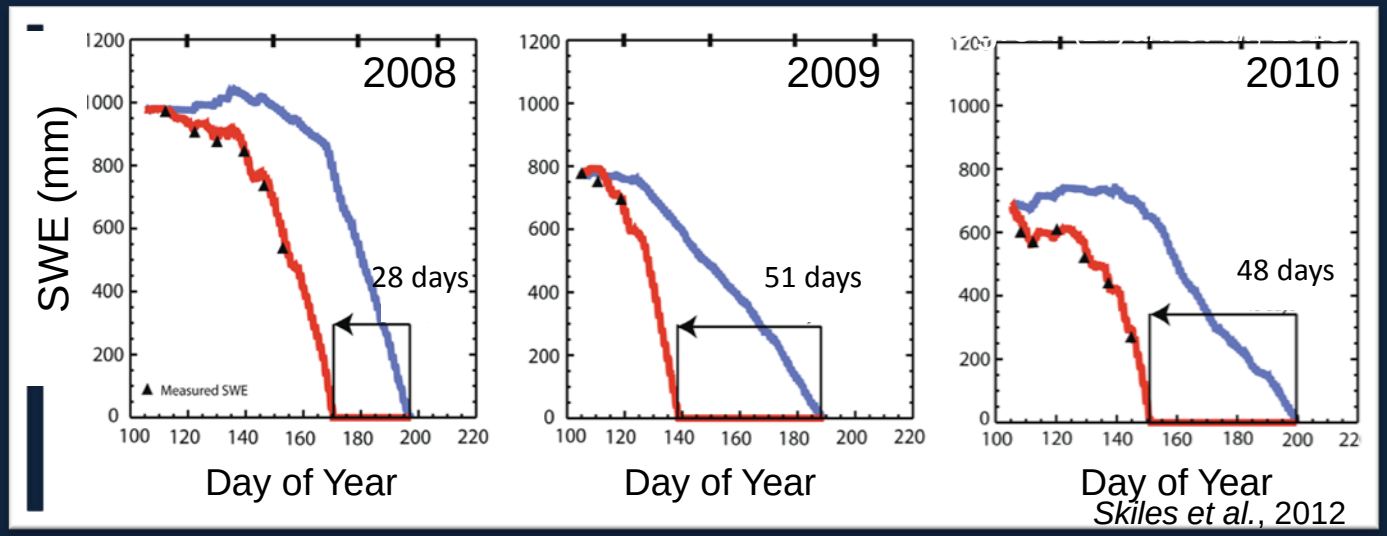



# Why a spectrometer?

Dust on snow is consistently observed in the Upper Colorado River Basin

Radiative forcing by dust

- Shifts runoff timing and intensity (*Skiles et al.*, 2012)
- Lowers total water yield (*Painter et al.*, 2010)
- High interannual and spatial variability (*Skiles et al.*, 2015)
- Correlates to runoff forecast errors in this




*Skiles et al.*, 2012

ASO has the spatial and spectral resolution to help us better understand these impacts

ALL BURIALS MUST BE
APPROVED AND LOCATED
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PRIOR TO INTERMENT.
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