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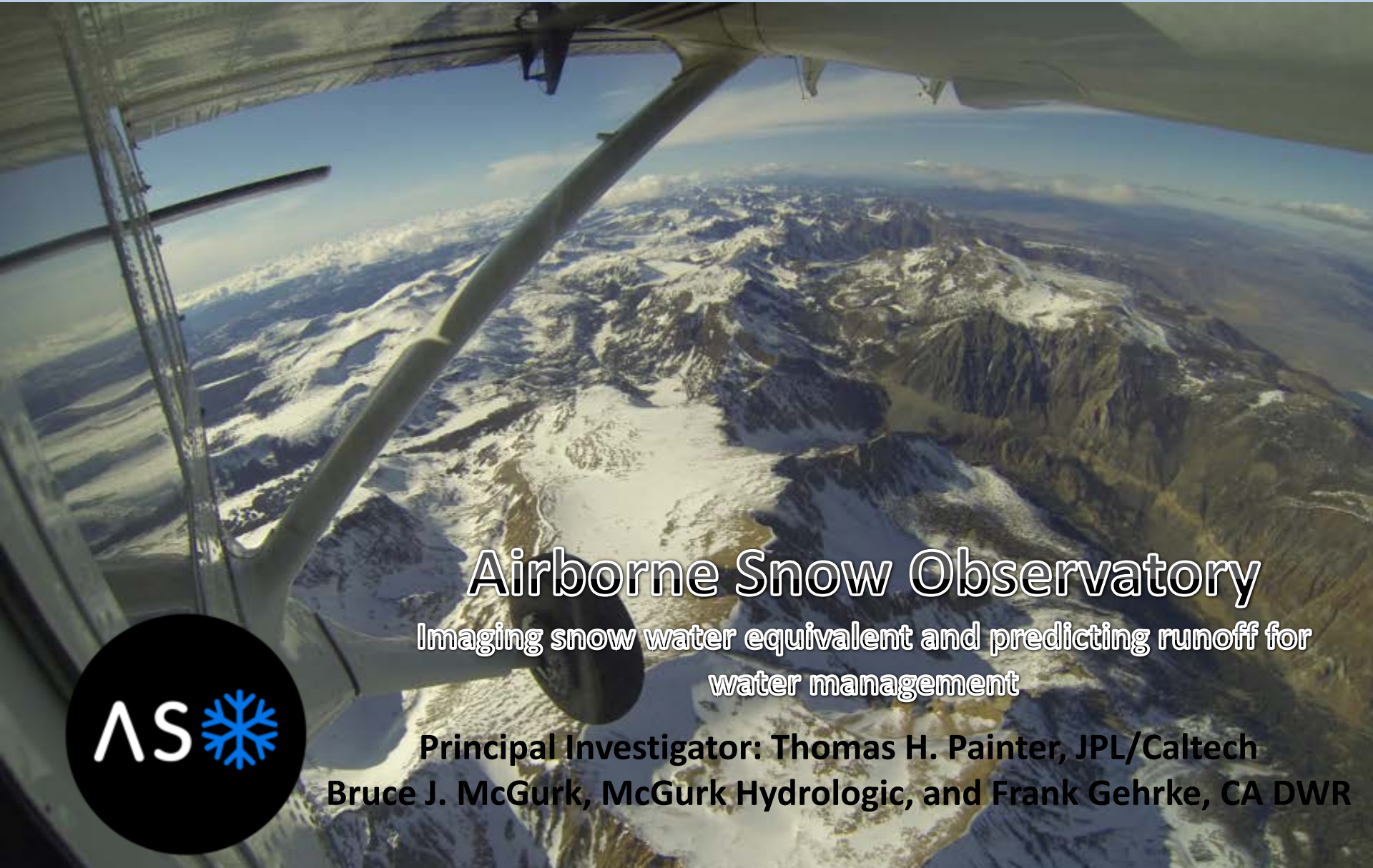

Airborne Snow Observatory

Imaging snow water equivalent and predicting runoff for water management

Principal Investigator: Thomas H. Painter, JPL/Caltech
Bruce J. McGurk, McGurk Hydrologic, and Frank Gehrke, CA DWR

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Need frequent, dense SWE data at all elevations

Manual measurement of SWE (snow water equivalent), started in the Sierra Nevada in 1910

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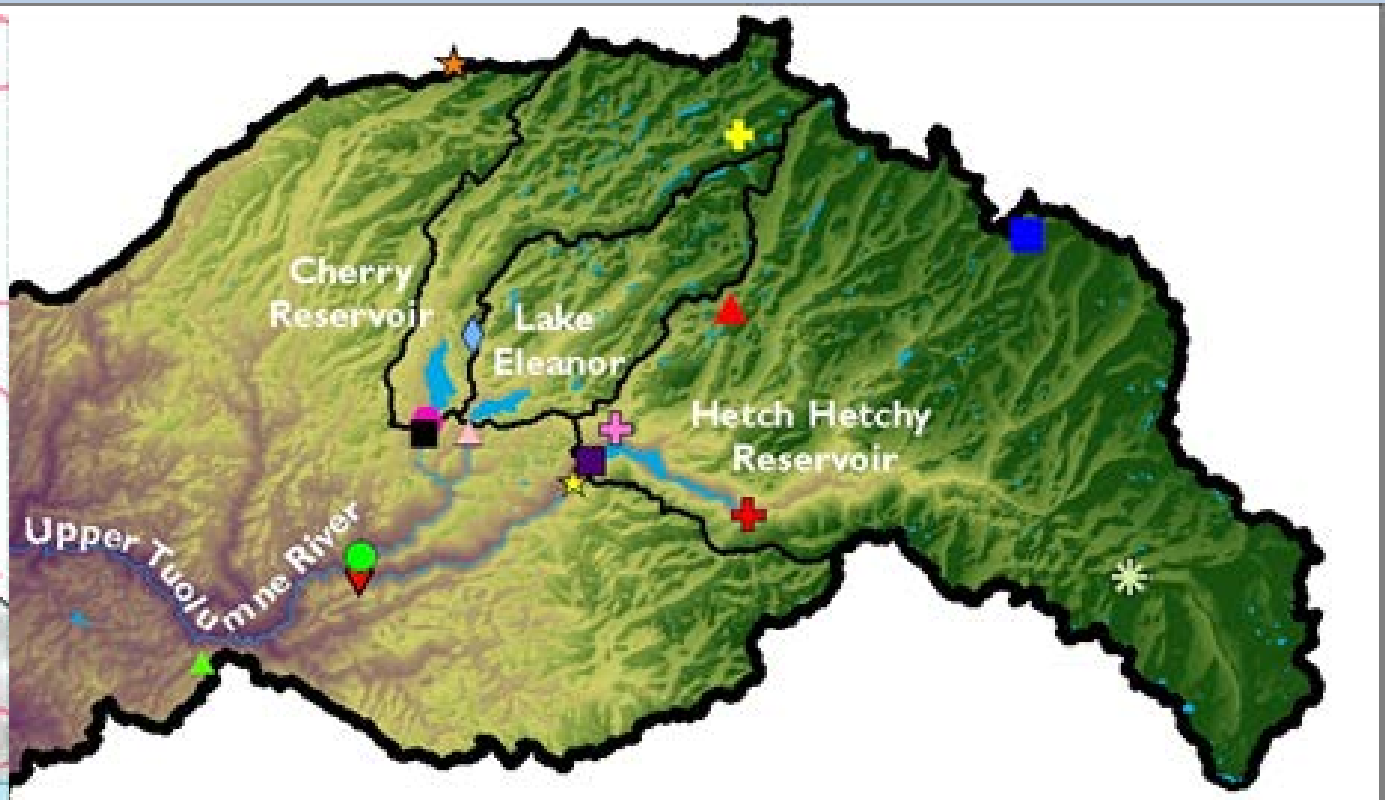
Snow Measurement - Tuolumne

- 17 snow courses, 5 below 7000 ft, 3 > 9000 ft
- Only 8 snow sensors, 5 co-located
- 80 sq ft/sensor, 20 sq ft/course = .06 millionth of a percent of the basin is measured



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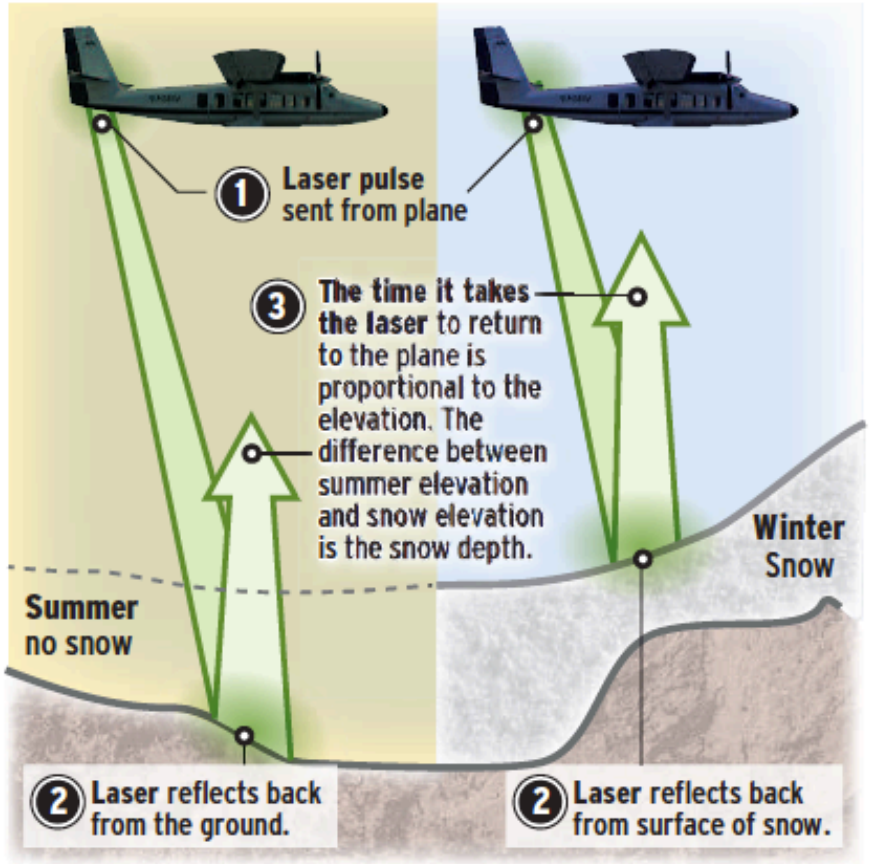
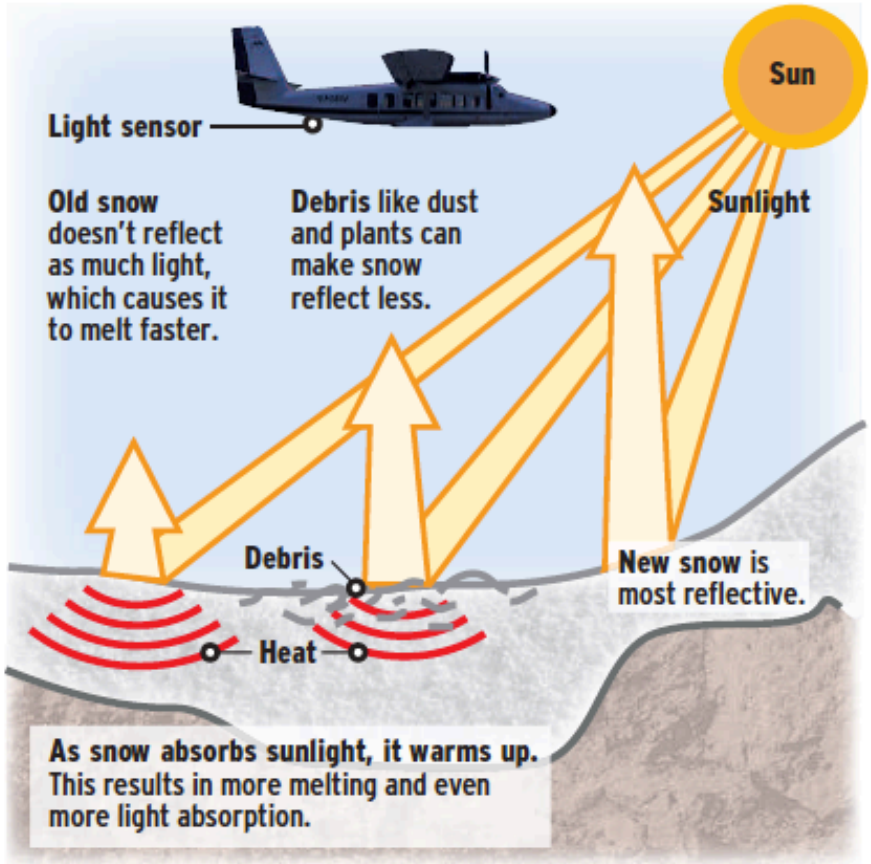
How much snow?

Using laser radar, known as Lidar, researchers measure the depth of snowpack in California.



How will it melt?

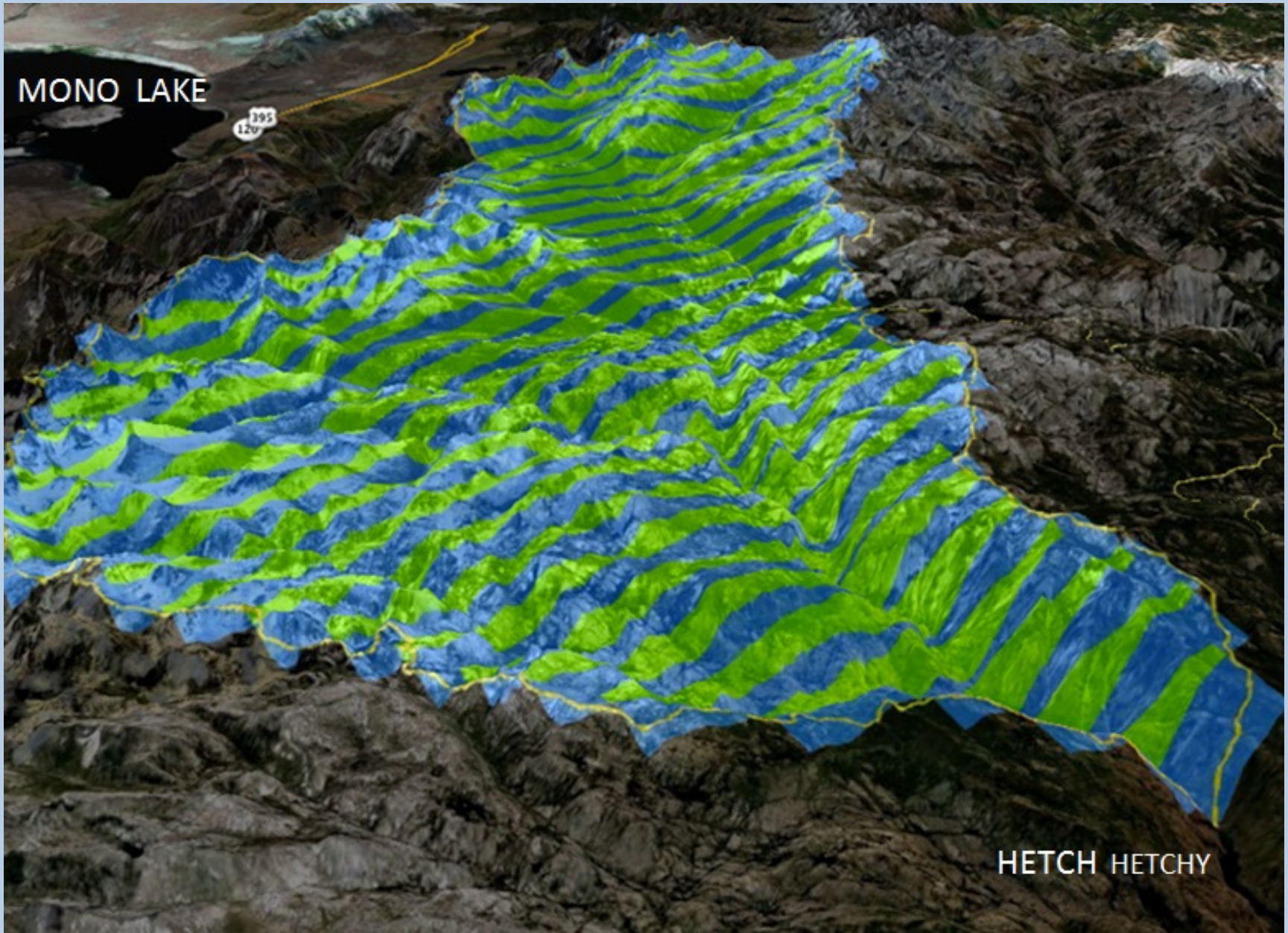
With an advanced light sensor, scientists measure snow's reflectivity – an indicator of how it will melt.



Sources: Thomas Painter, Frank Gehrke, Optech Inc.

Maxwell Henderson / The Register

Winter Data Collection - Weekly



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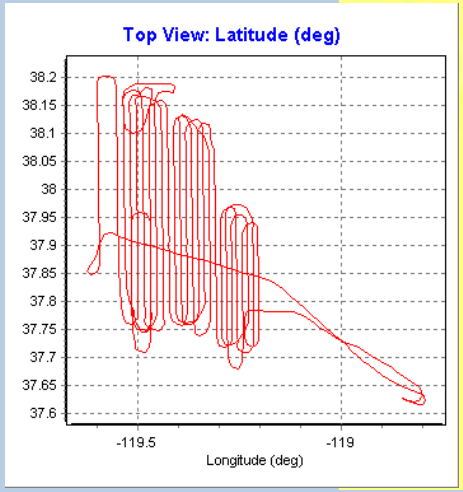
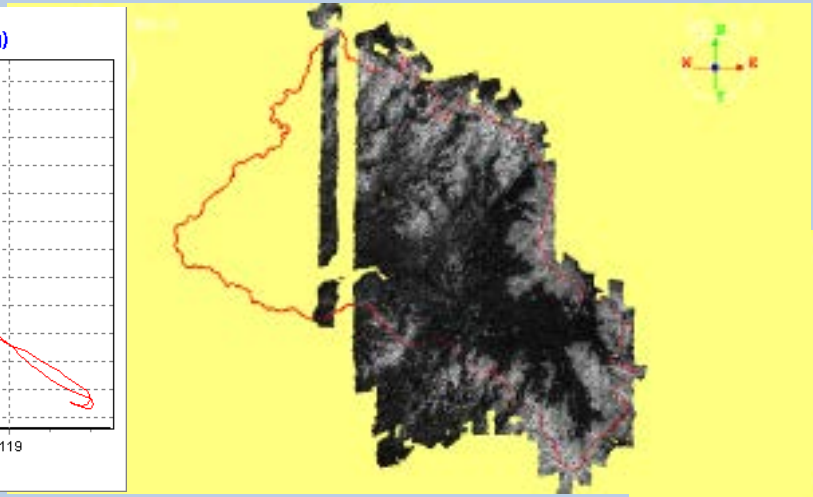
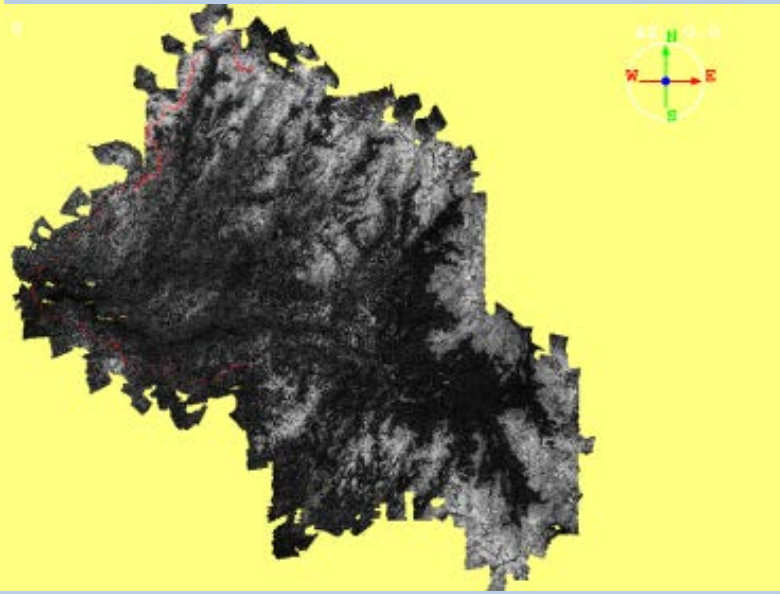
April 10, 2013

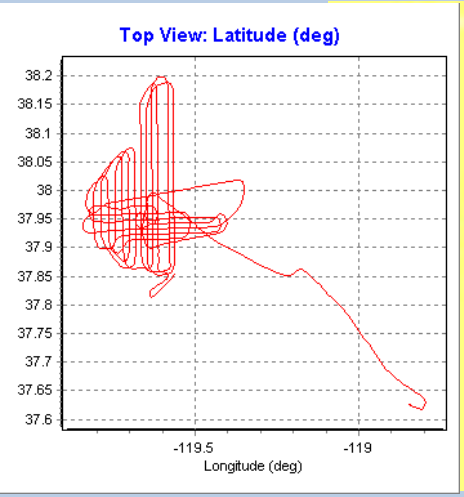
Morning flight

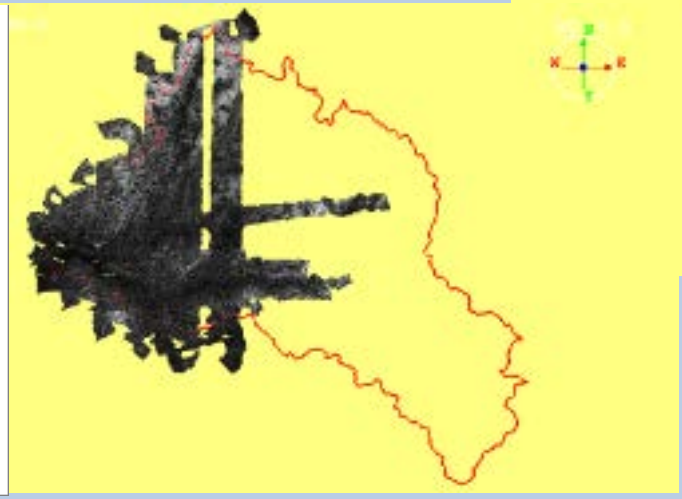




Composite lidar







Afternoon flight

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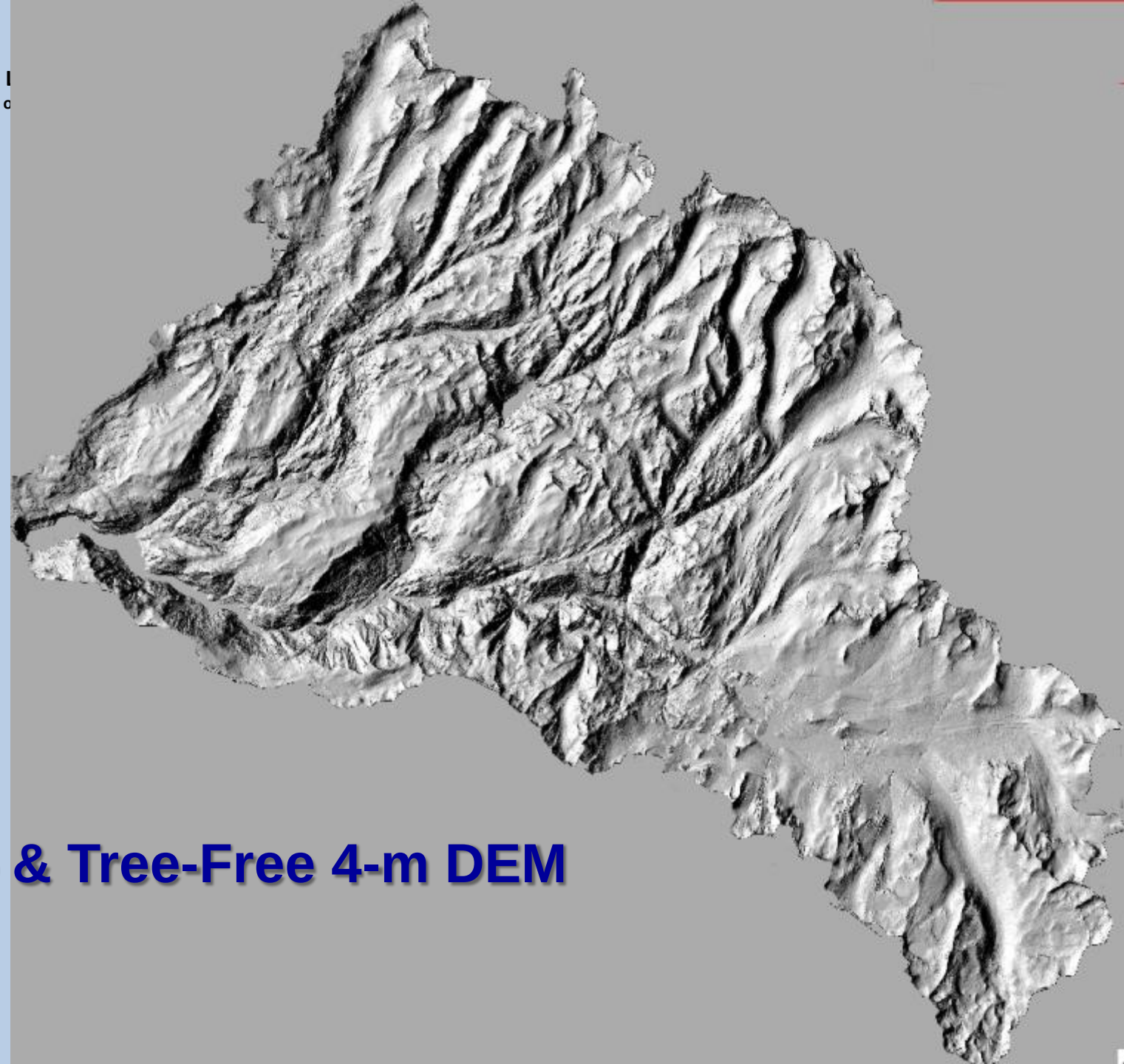
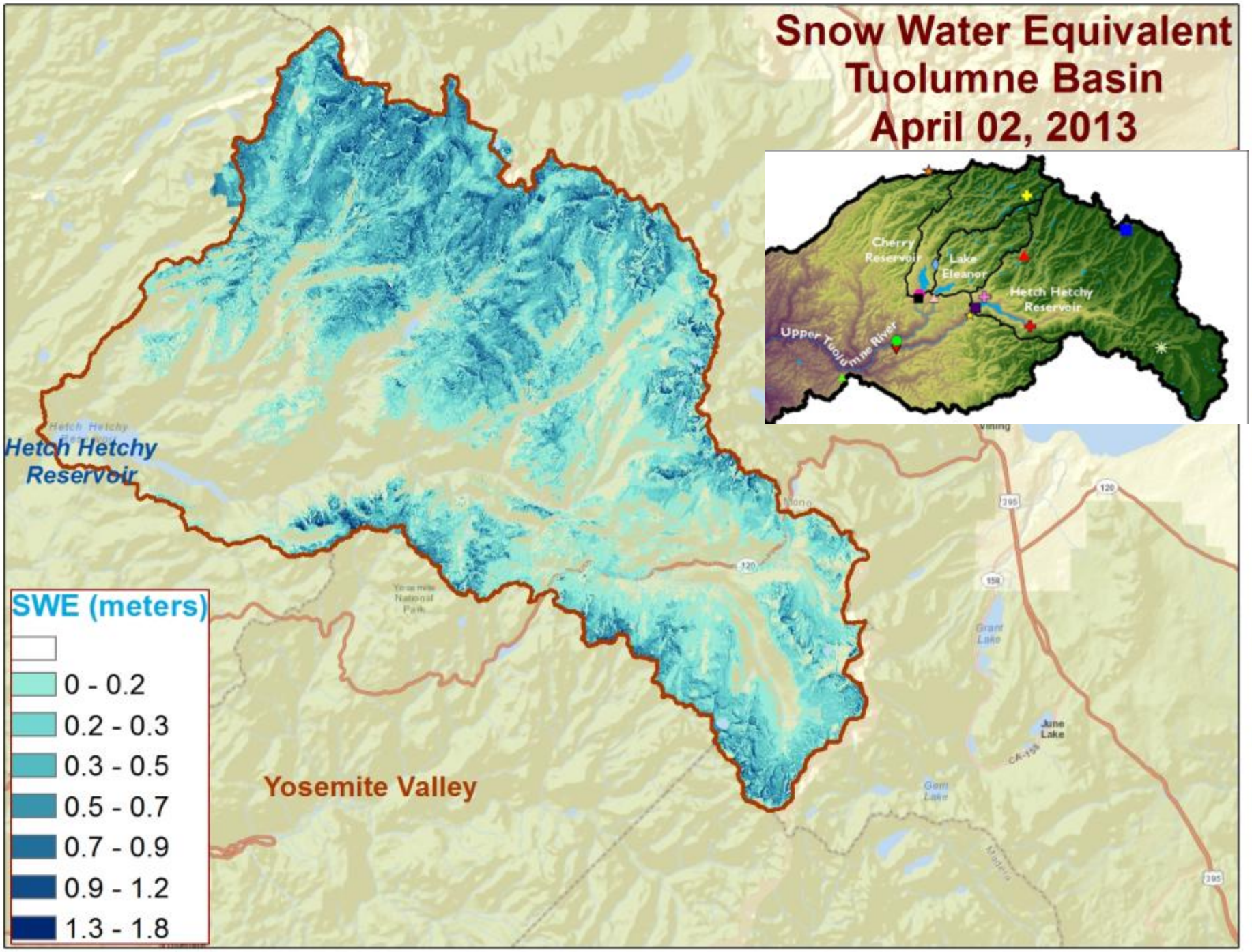
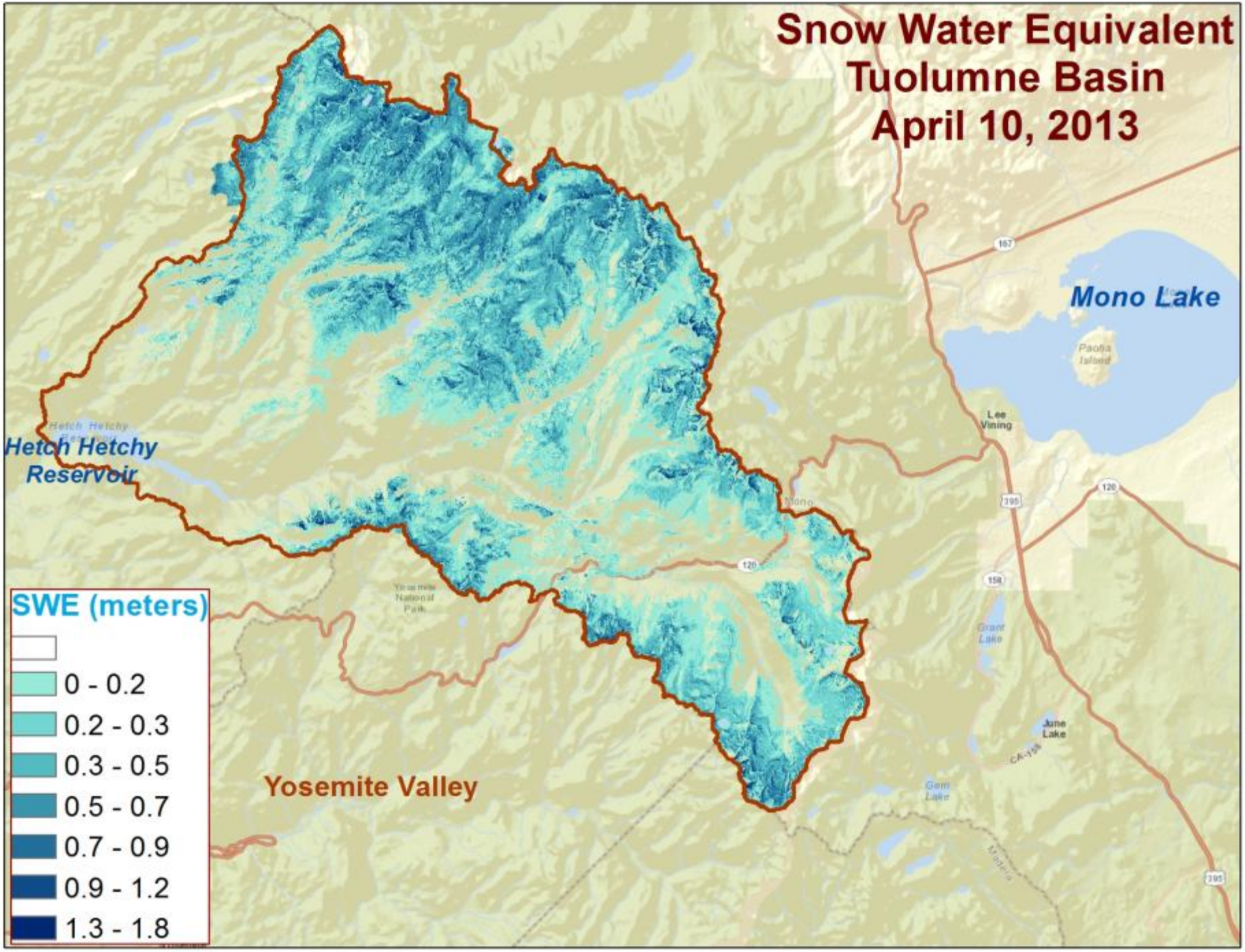
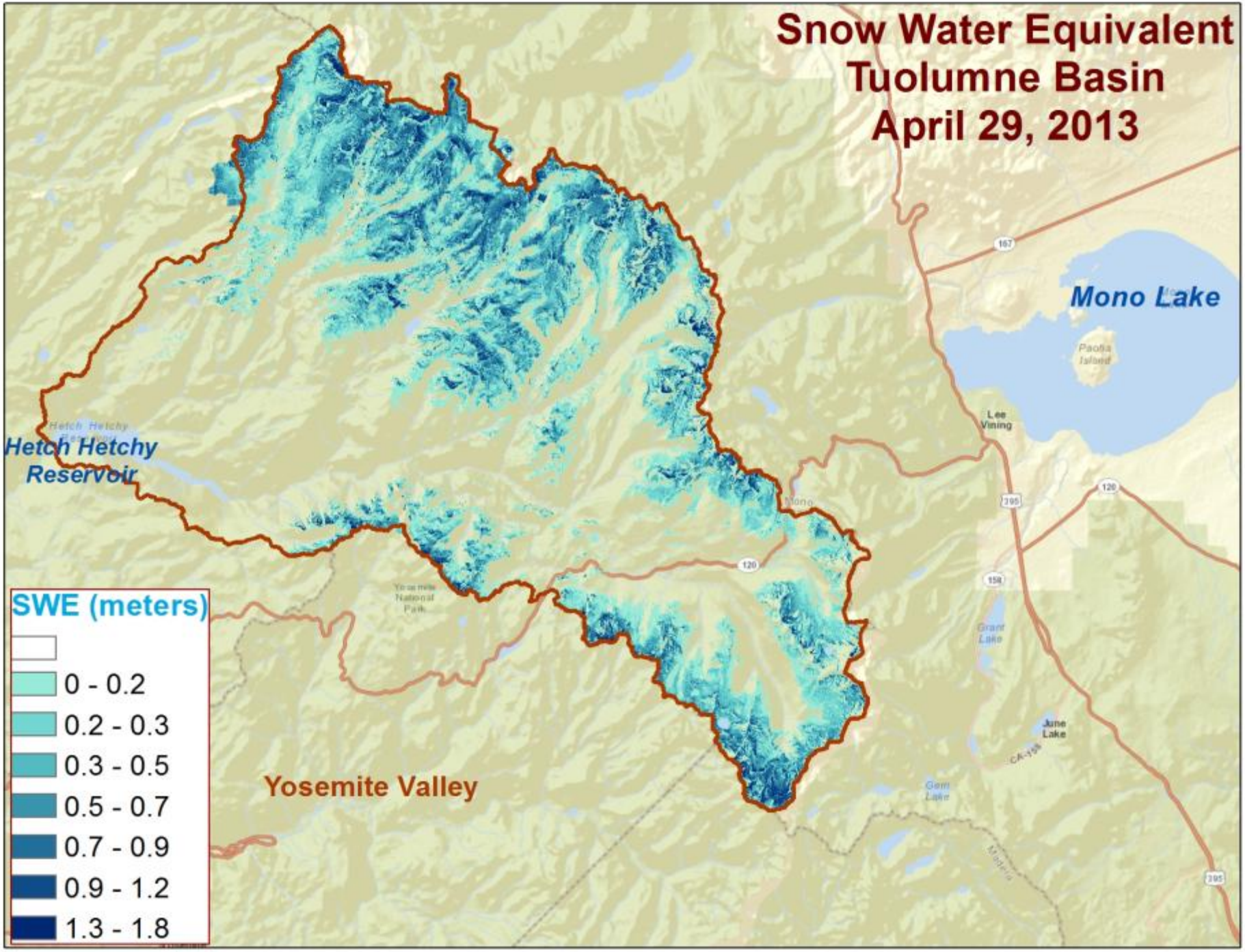
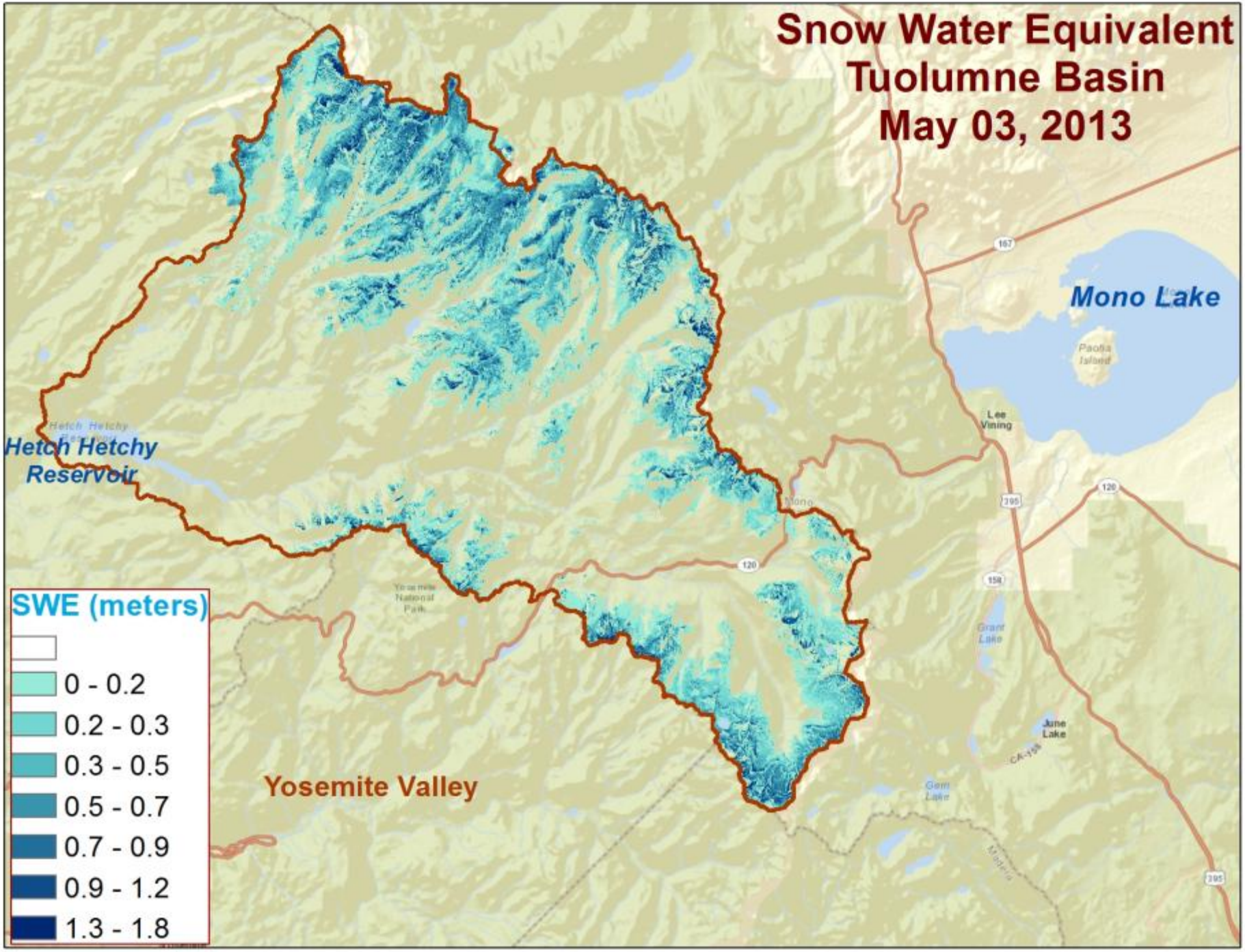


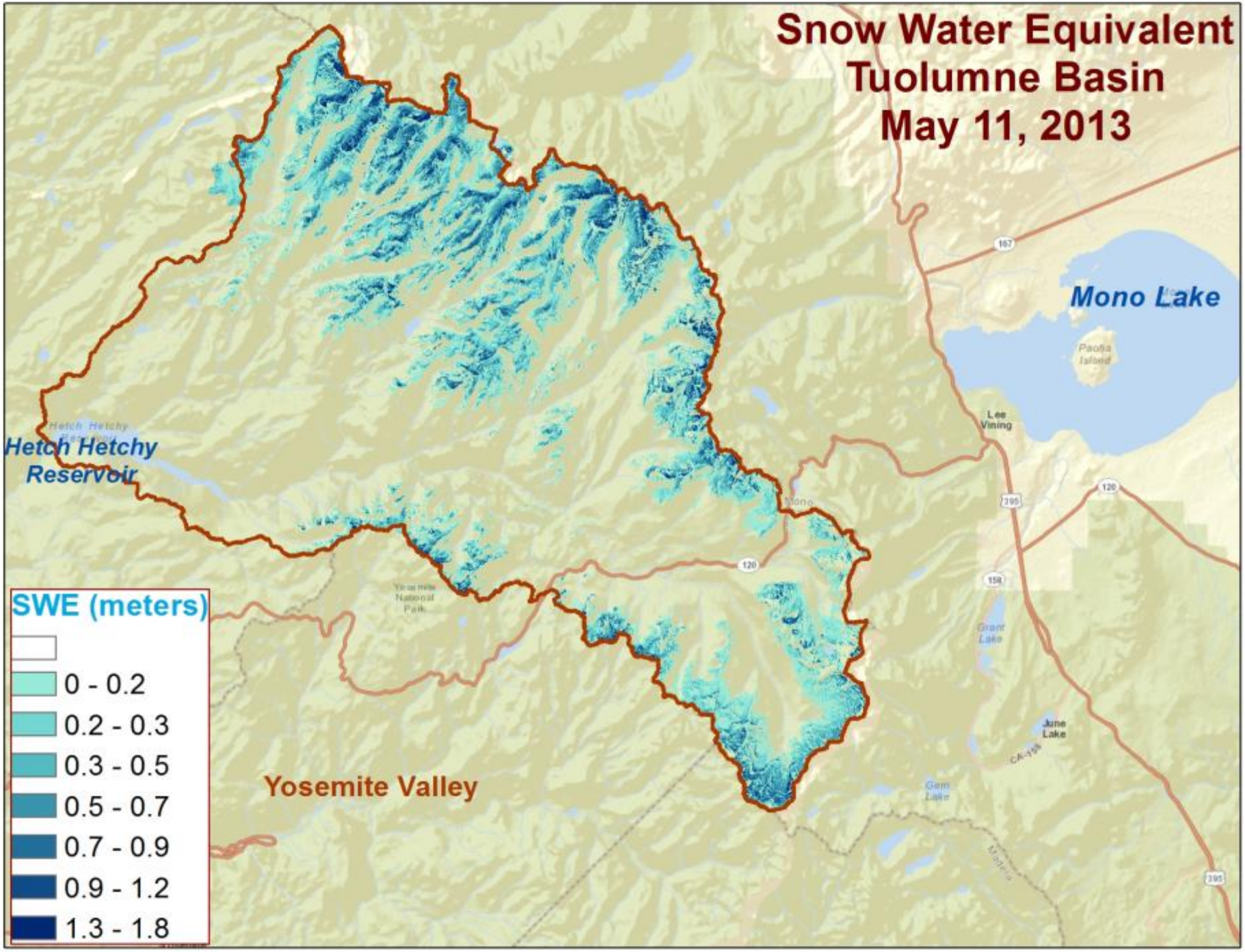
Snow- & Tree-Free 4-m DEM

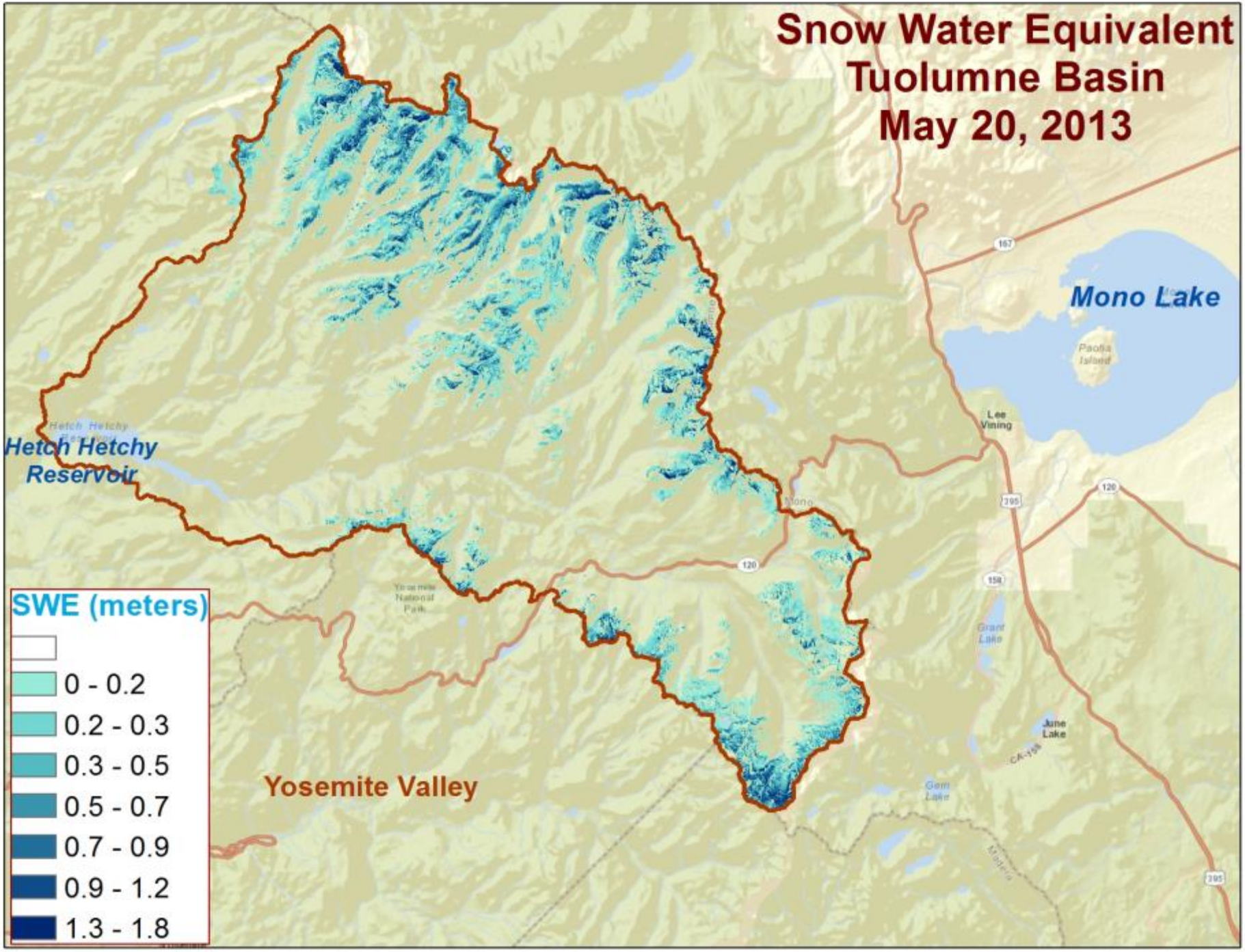

Snow Water Equivalent
Tuolumne Basin
April 02, 2013
Cherry Reservoir
Lake Eleanor
Hetch Hetchy Reservoir
Upper Tuolumne River
Hetch Hetchy Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8
June Lake
Grant Lake
Gem Lake
Mono
120
395
158

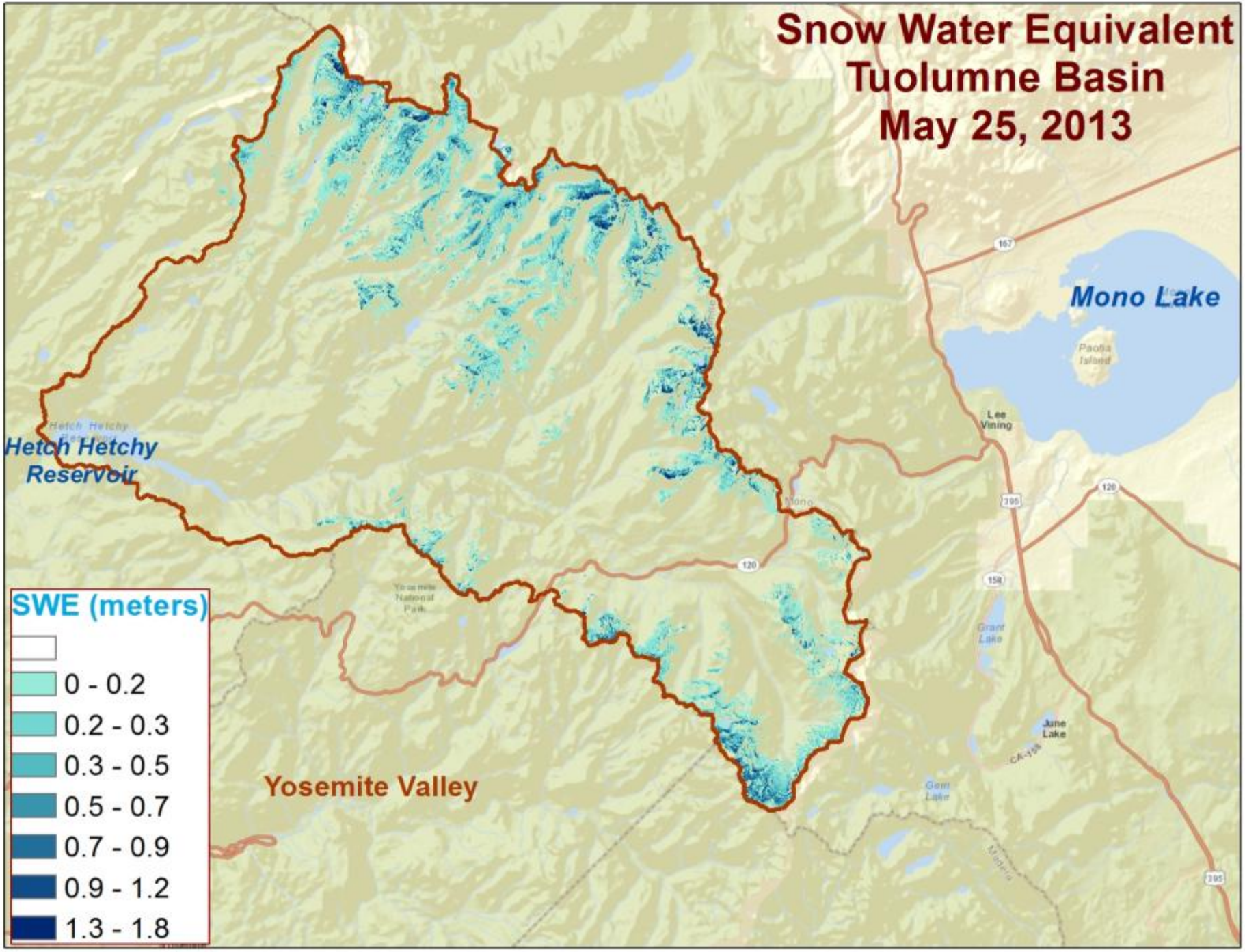

Snow Water Equivalent
Tuolumne Basin
April 10, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
Lee
Vining
June
Lake
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8

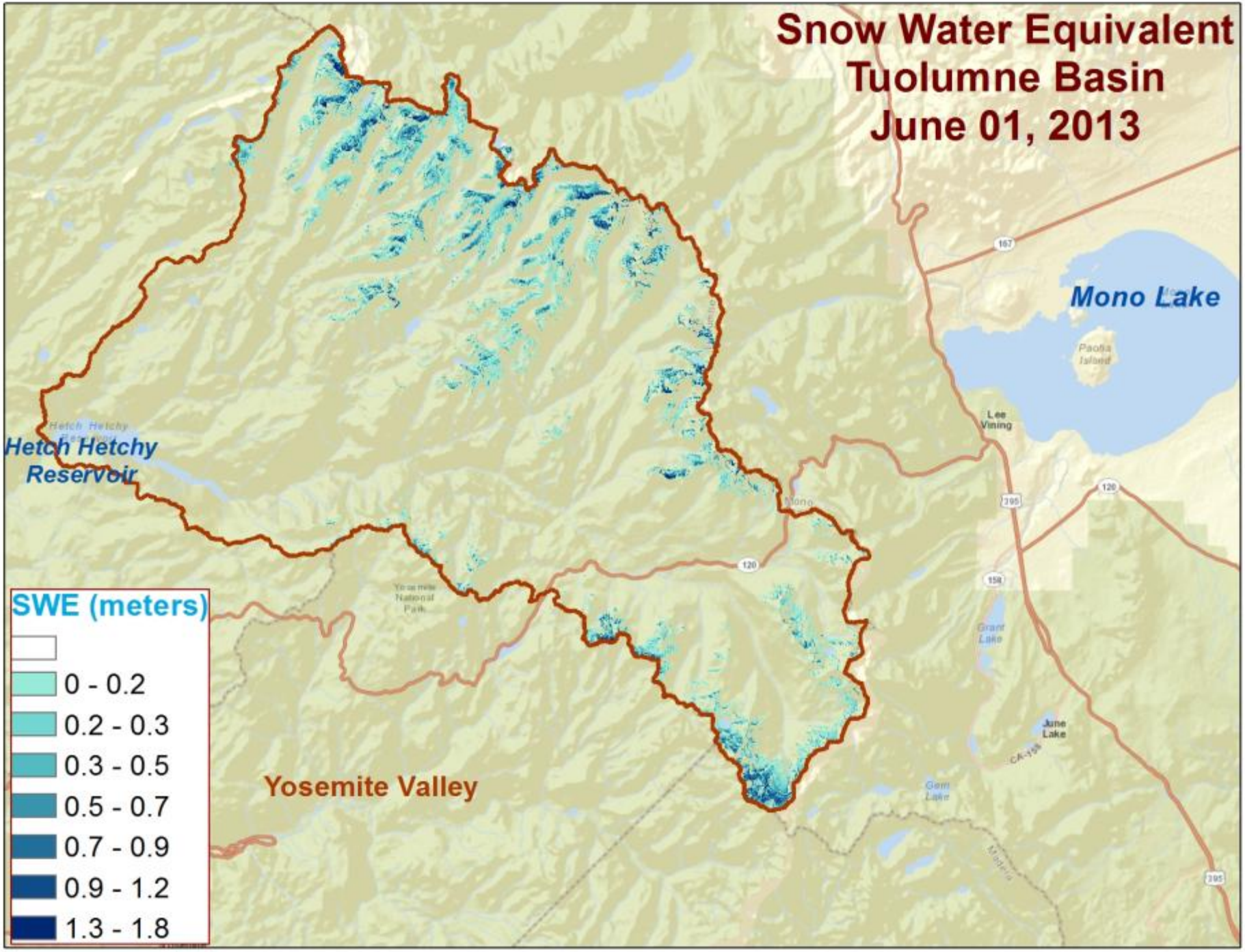

Snow Water Equivalent
Tuolumne Basin
April 29, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8

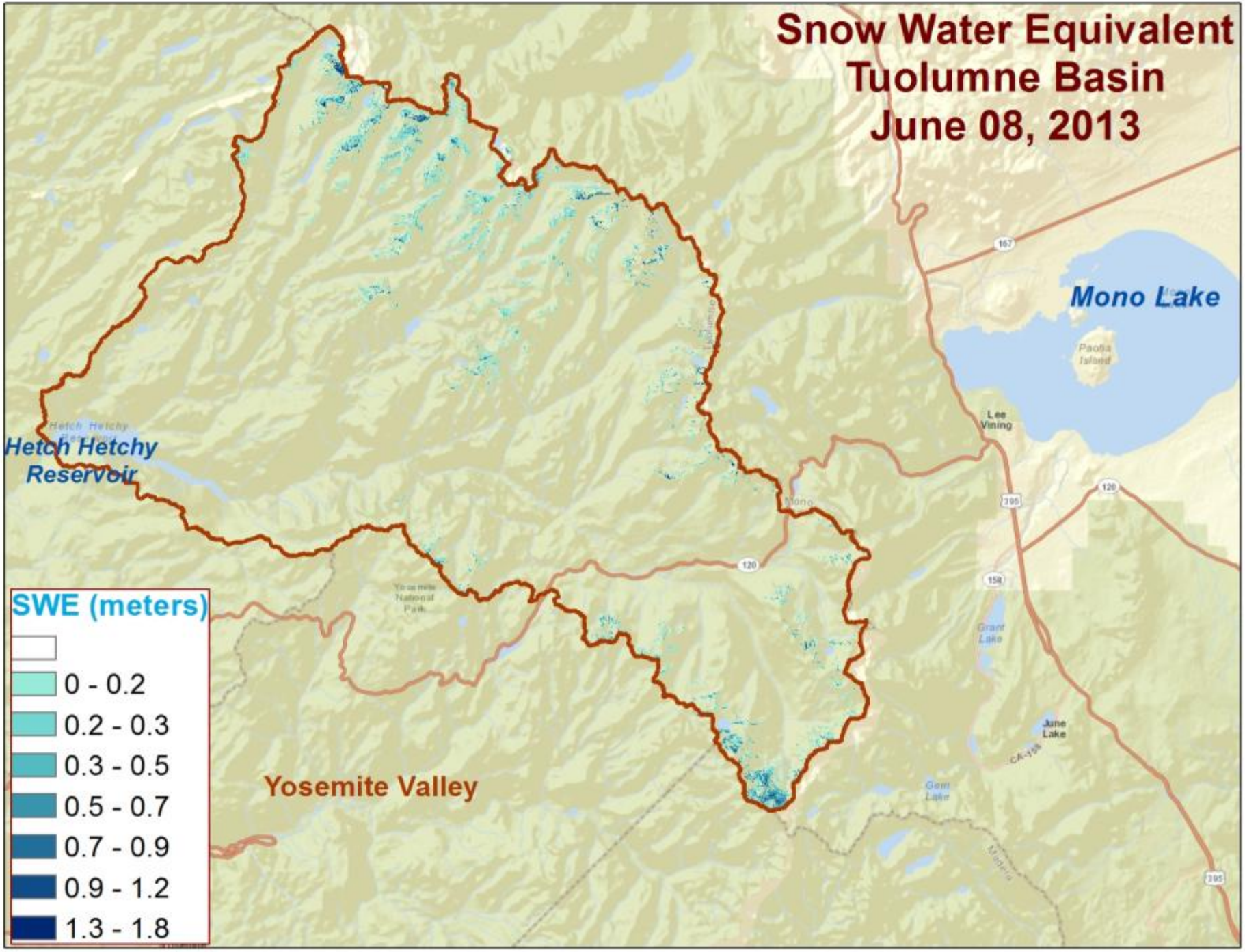

Snow Water Equivalent
Tuolumne Basin
May 03, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8
Lee
Vining
June
Lake
Grant
Lake
Gem
Lake
Paoha
Island
Yosemite
National
Park
Mono
167
120
295
158
CA-158


Snow Water Equivalent
Tuolumne Basin
May 11, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8
Lee
Vining
June
Lake

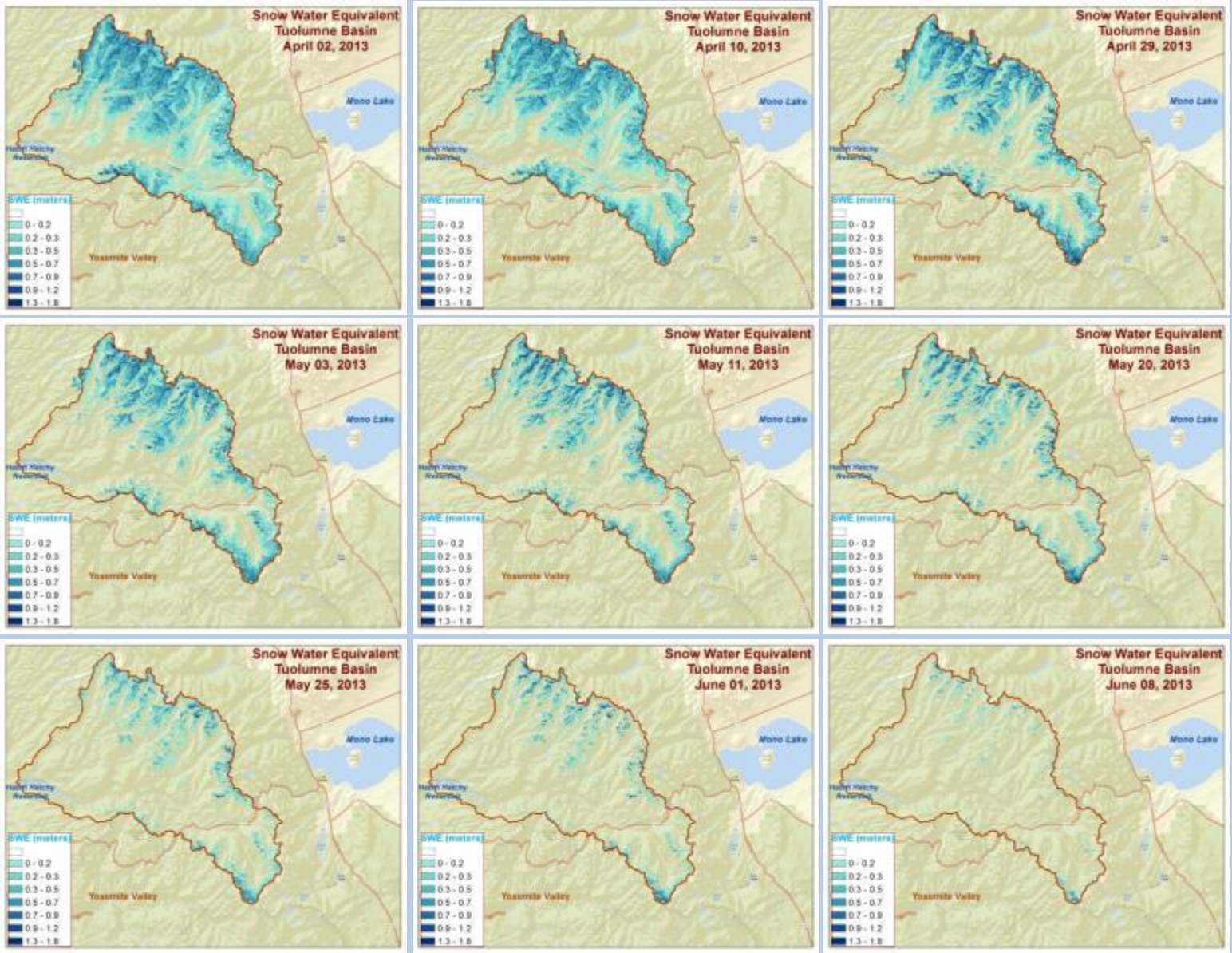

Snow Water Equivalent
Tuolumne Basin
May 20, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
Lee
Vining
June
Lake
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8


Snow Water Equivalent
Tuolumne Basin
May 25, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
Lee
Vining
June
Lake
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8


Snow Water Equivalent
Tuolumne Basin
June 01, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8
Lee
Vining
June
Lake
Grant
Lake
Gem
Lake
Paoha
Island
Yosemite
National
Park
Mono
167
120
395
158
CA-158


Snow Water Equivalent
Tuolumne Basin
June 08, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
Lee
Vining
June
Lake
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8

ASO time series of snow water equivalent Tuolumne Basin 2013



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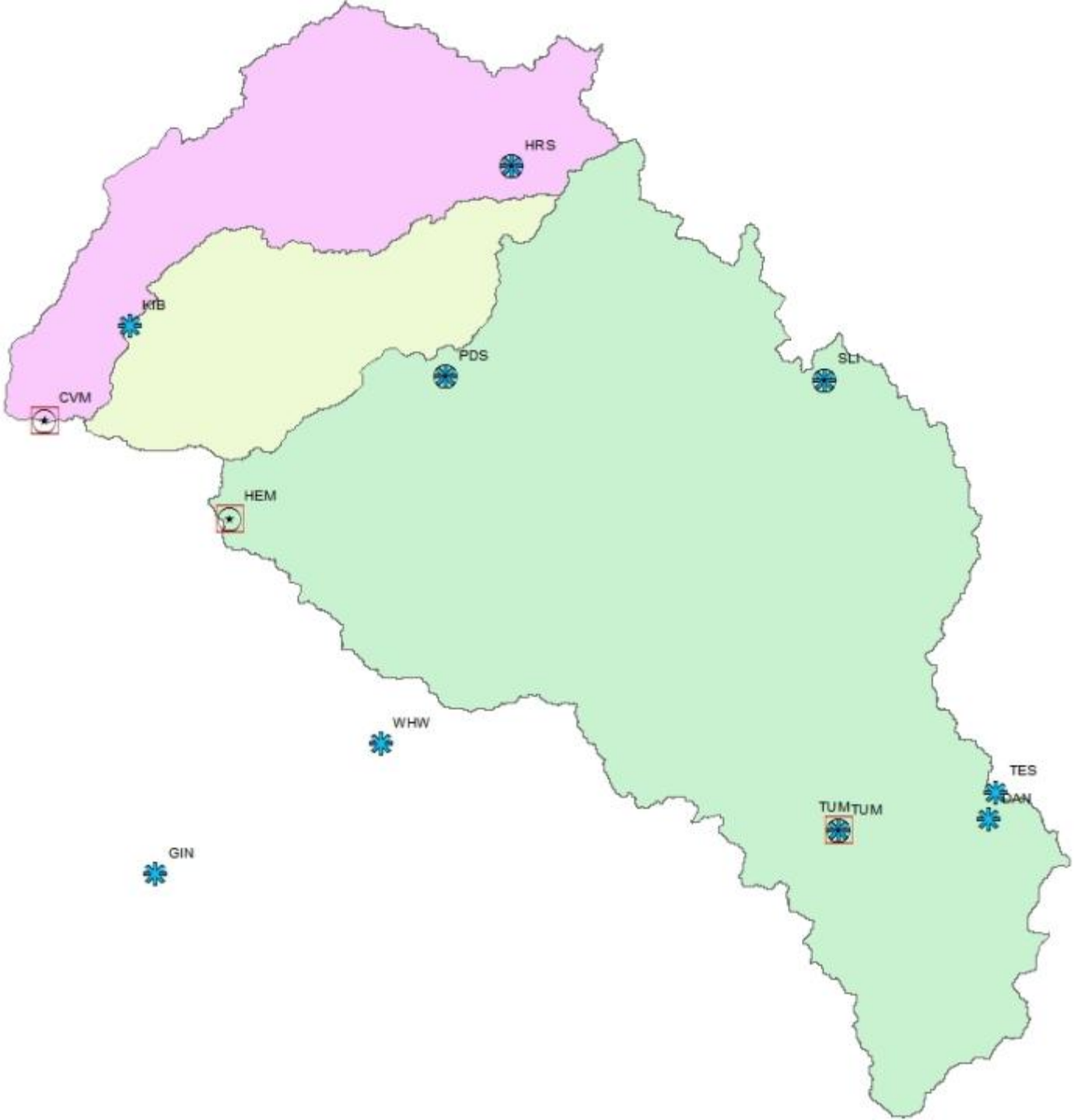
Tuolumne Basin – Sensor and Met Stations



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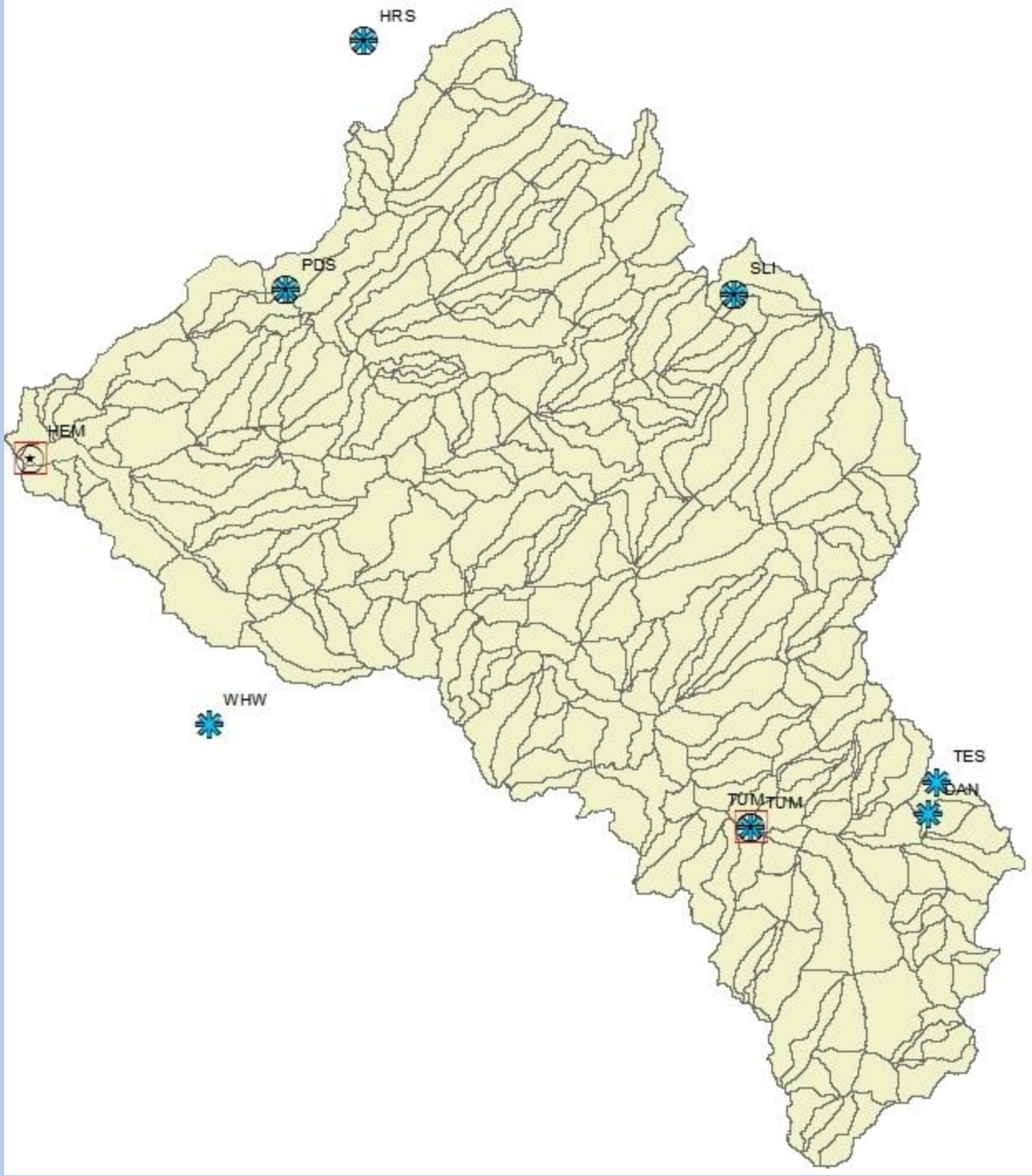
Hetch Hetchy Basin – Sensor and Met Stations & PRMS HRUs



Snow Sensors in Tuolumne, 2013

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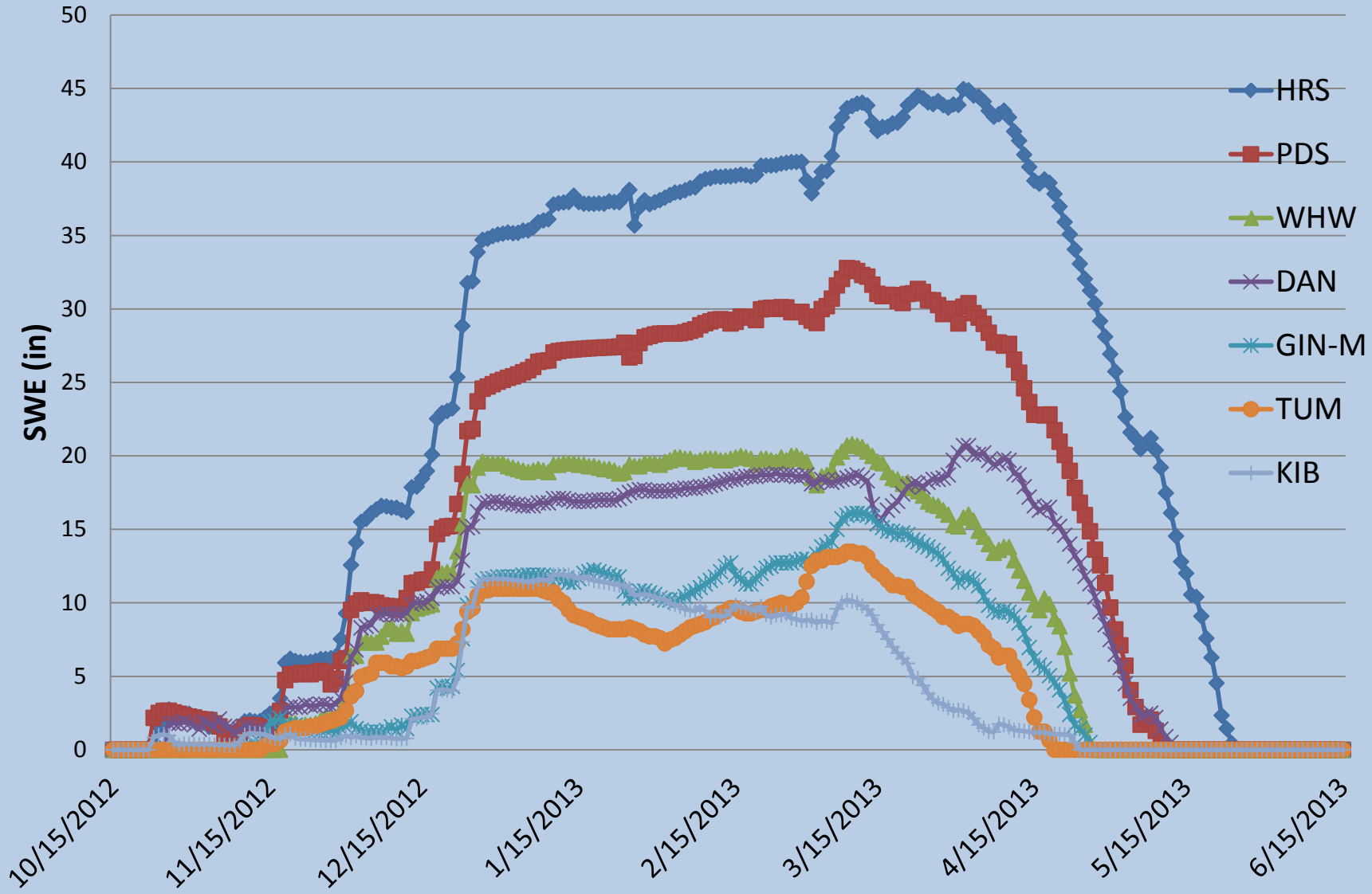

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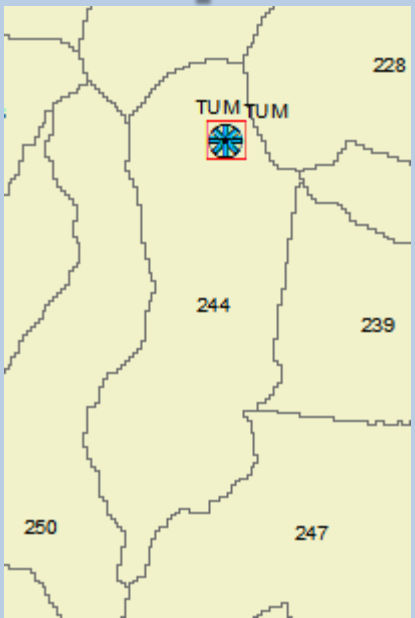
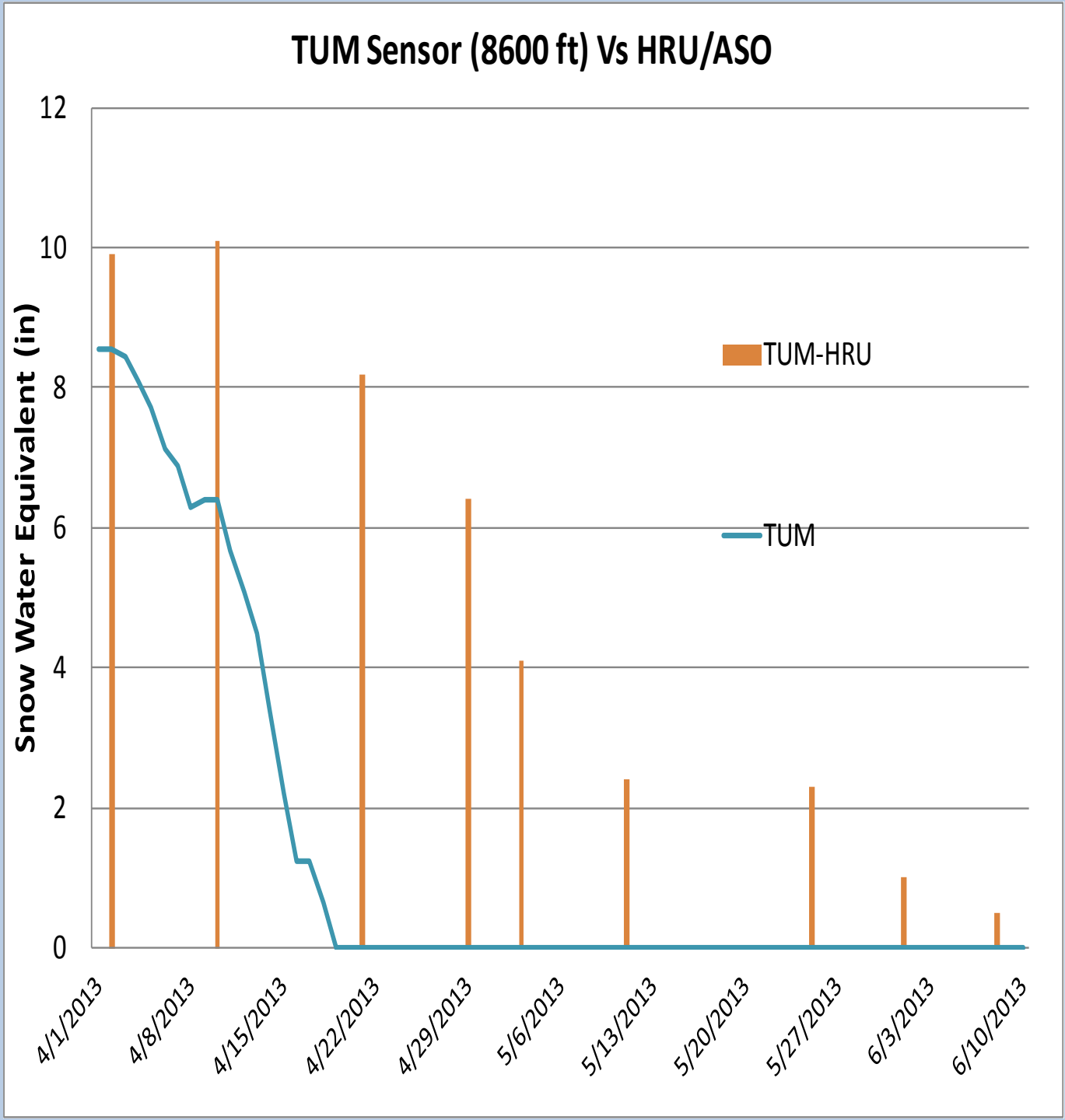
TUM Sensor & HRU Mean Depth





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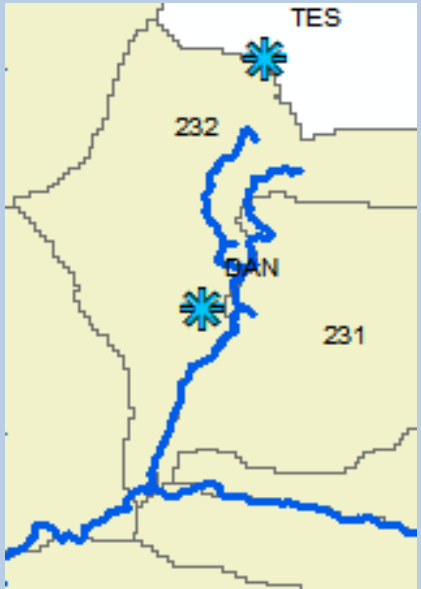
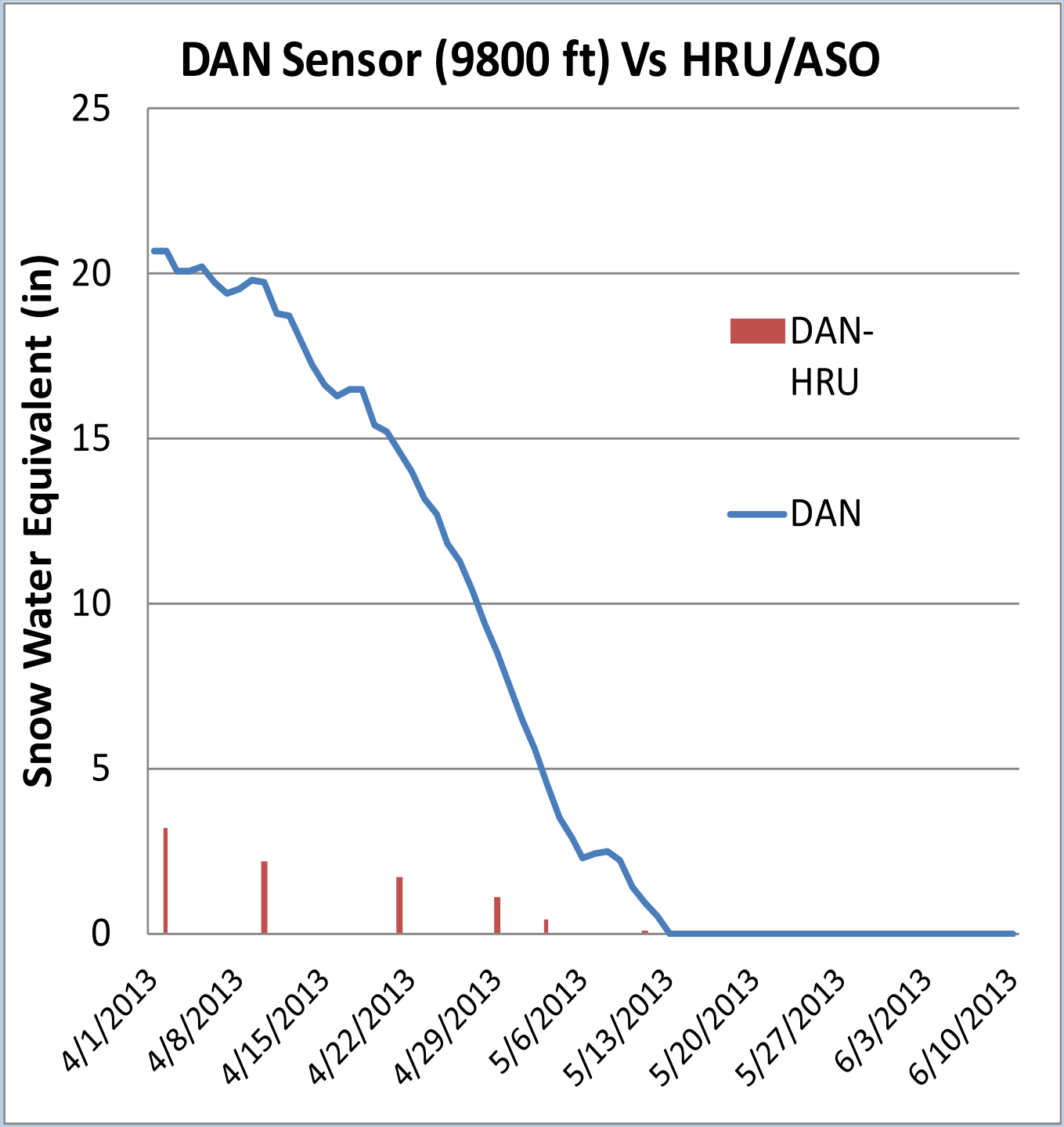
DAN Sensor & HRU Mean Depth





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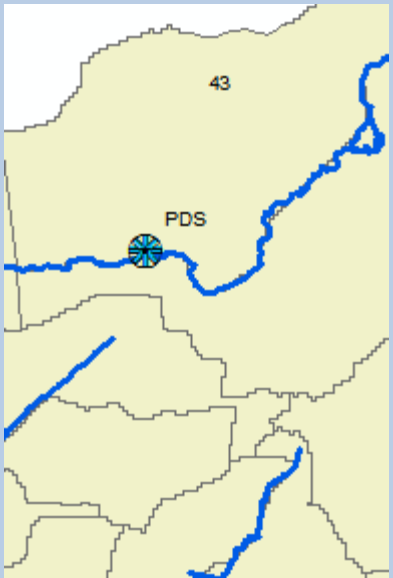
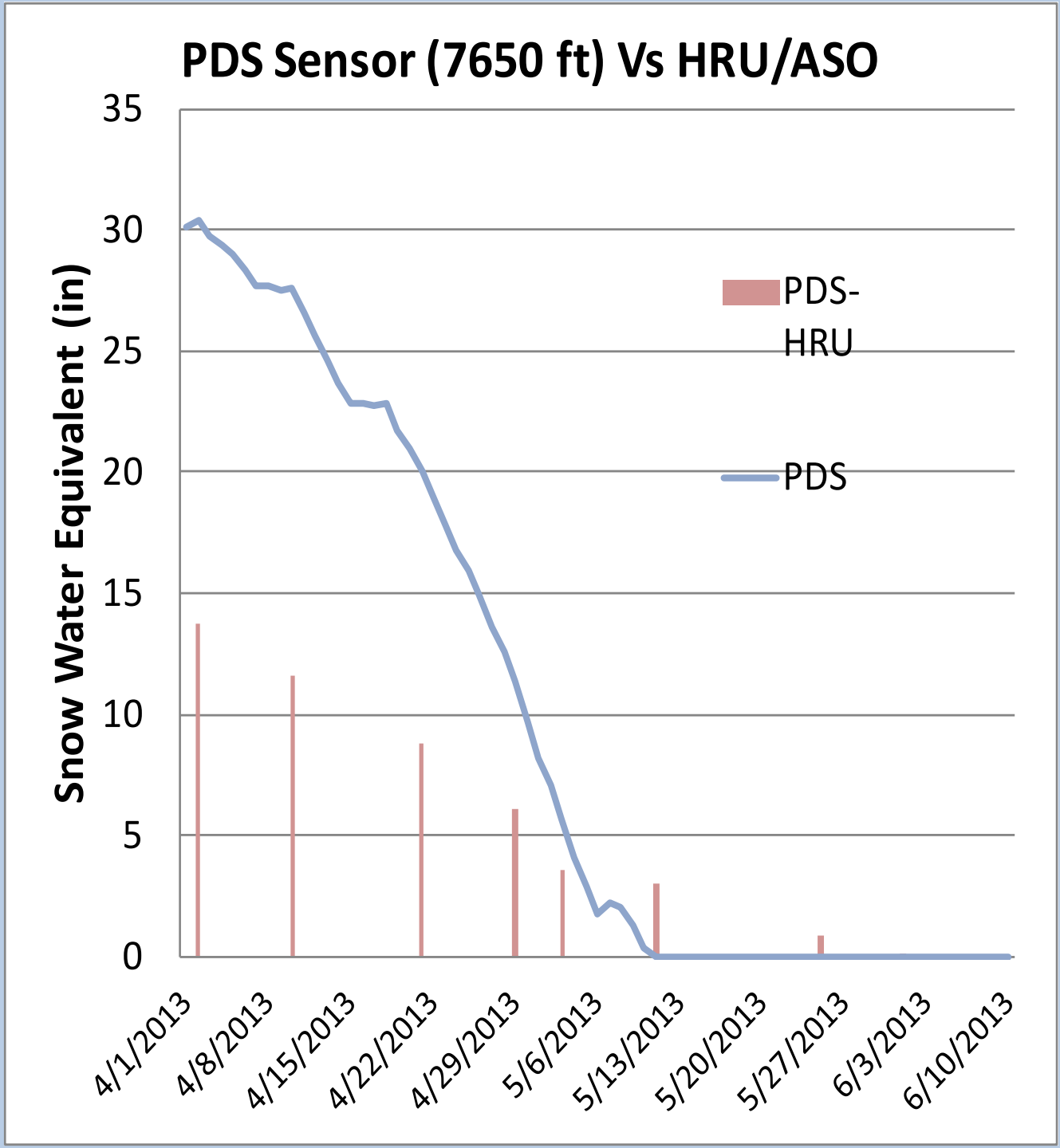
PDS Sensor & HRU Mean Depth





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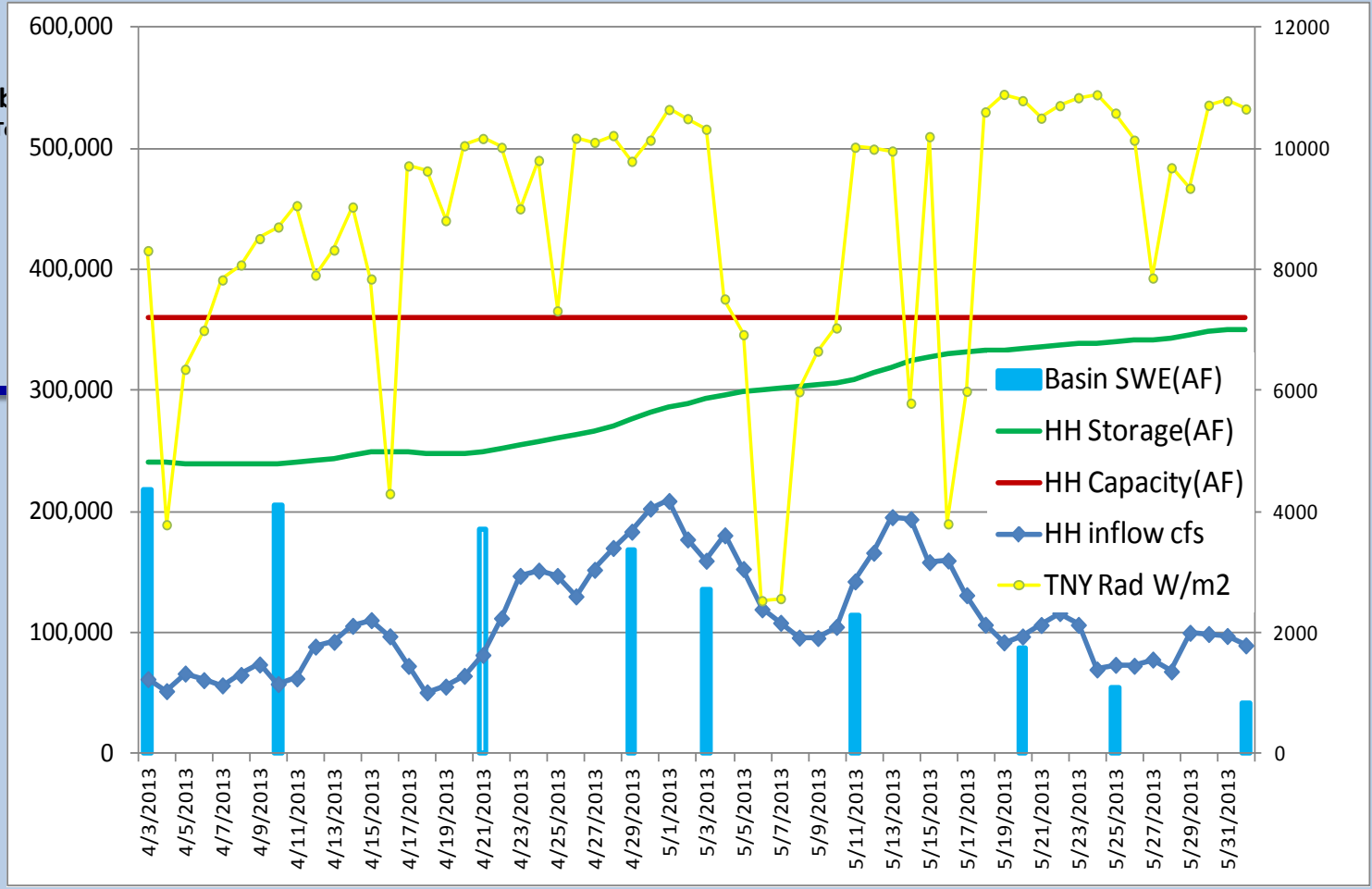
ASO Results – Basin SWE



- Basin SWE declined from 218 to 42 TAF in 59 days
- Inflow was 289 TAF
- Precipitation and transient storage accounted for the difference
- Melt rates varied based on solar input (yellow line)

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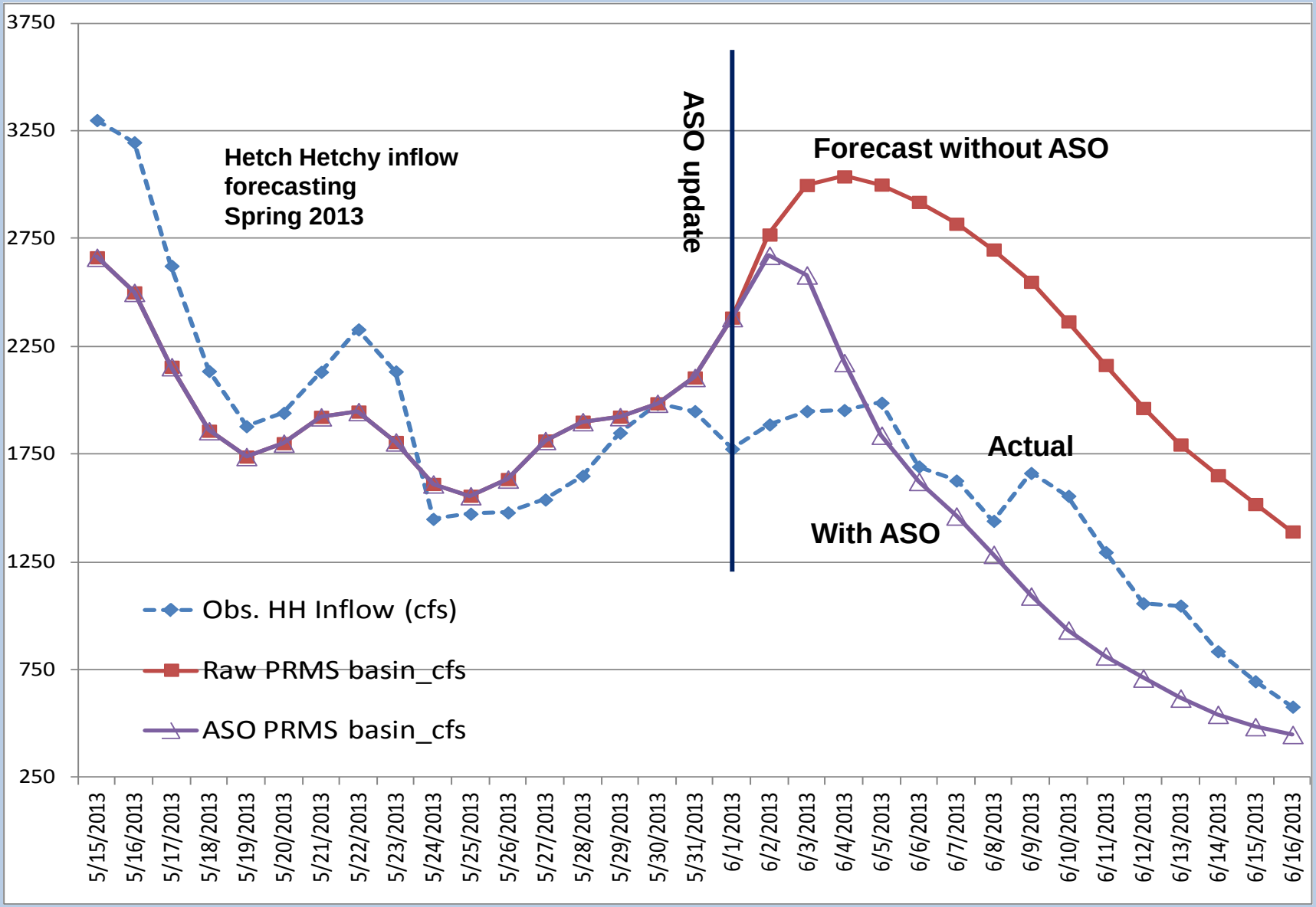
Improved Estimates for Water Management in California



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Getting to the entire Sierra Nevada

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Summary

- ASO provides a more complete picture of basin snow water storage for water management
- End to end ASO operations (hardware, software, data products) have been demonstrated
- ASO data will likewise improve snow science in the US and globe
- Substantial value to CA in having an operational system

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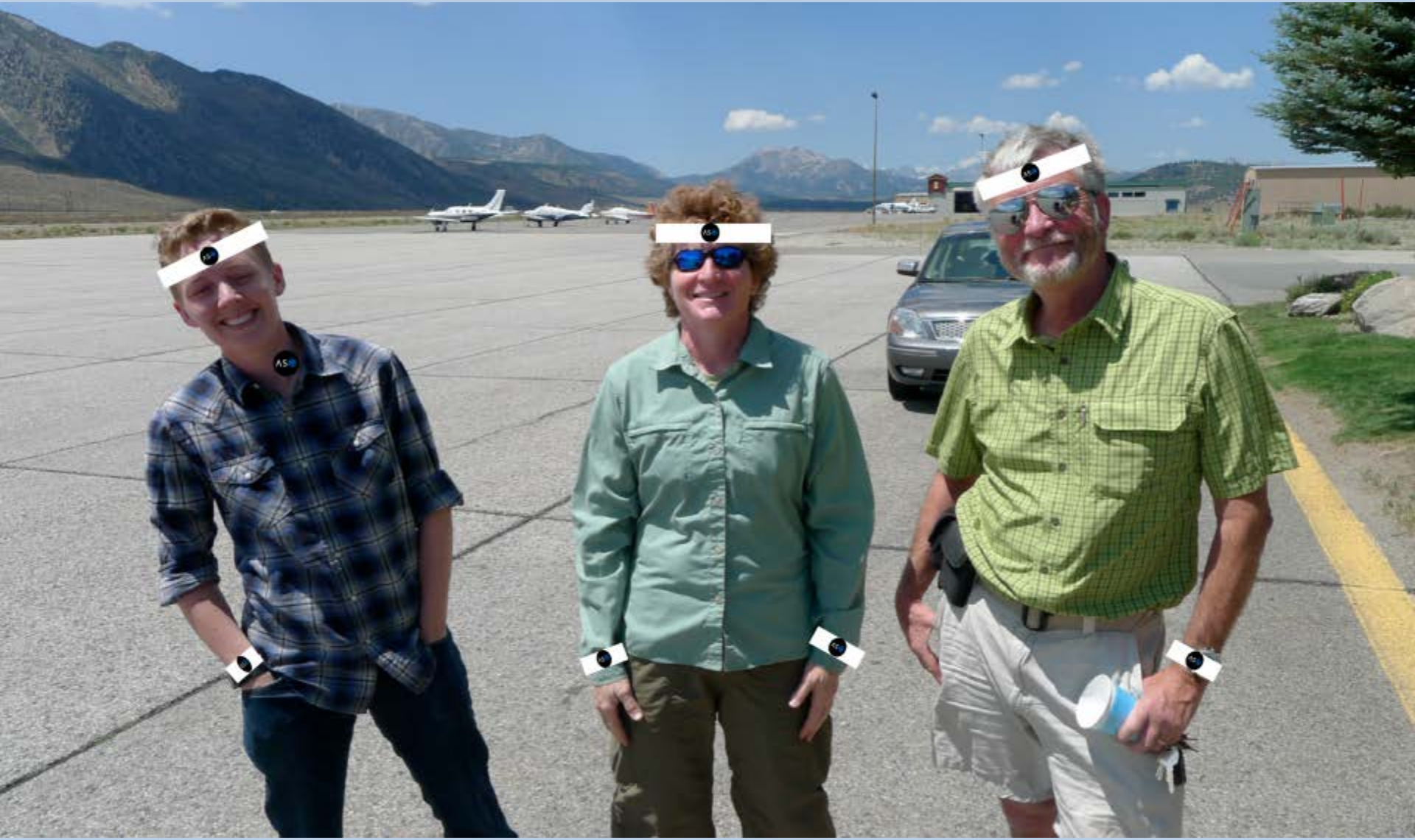
ASO Fanwear



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People & Gear Moving

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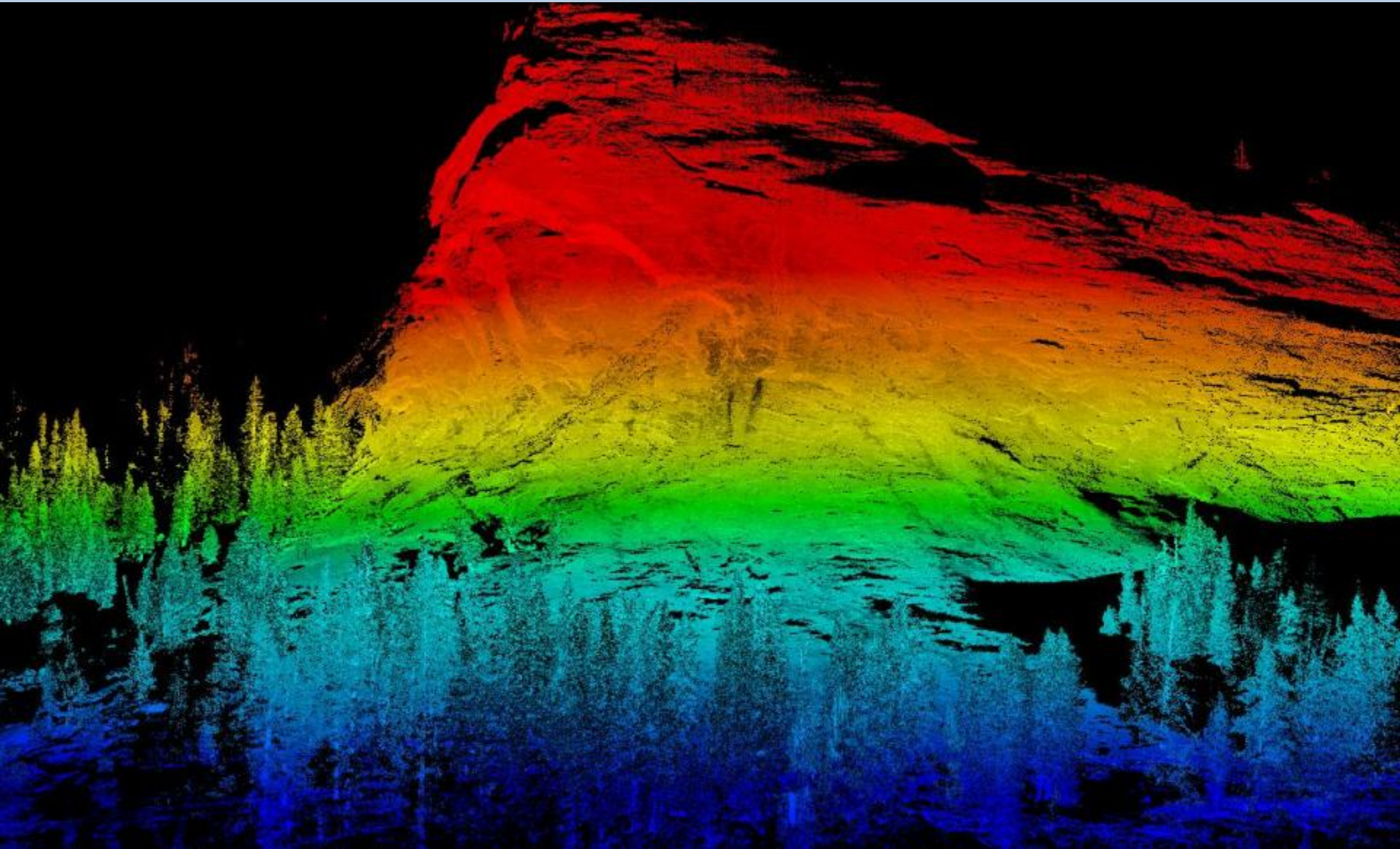
Lembert Dome



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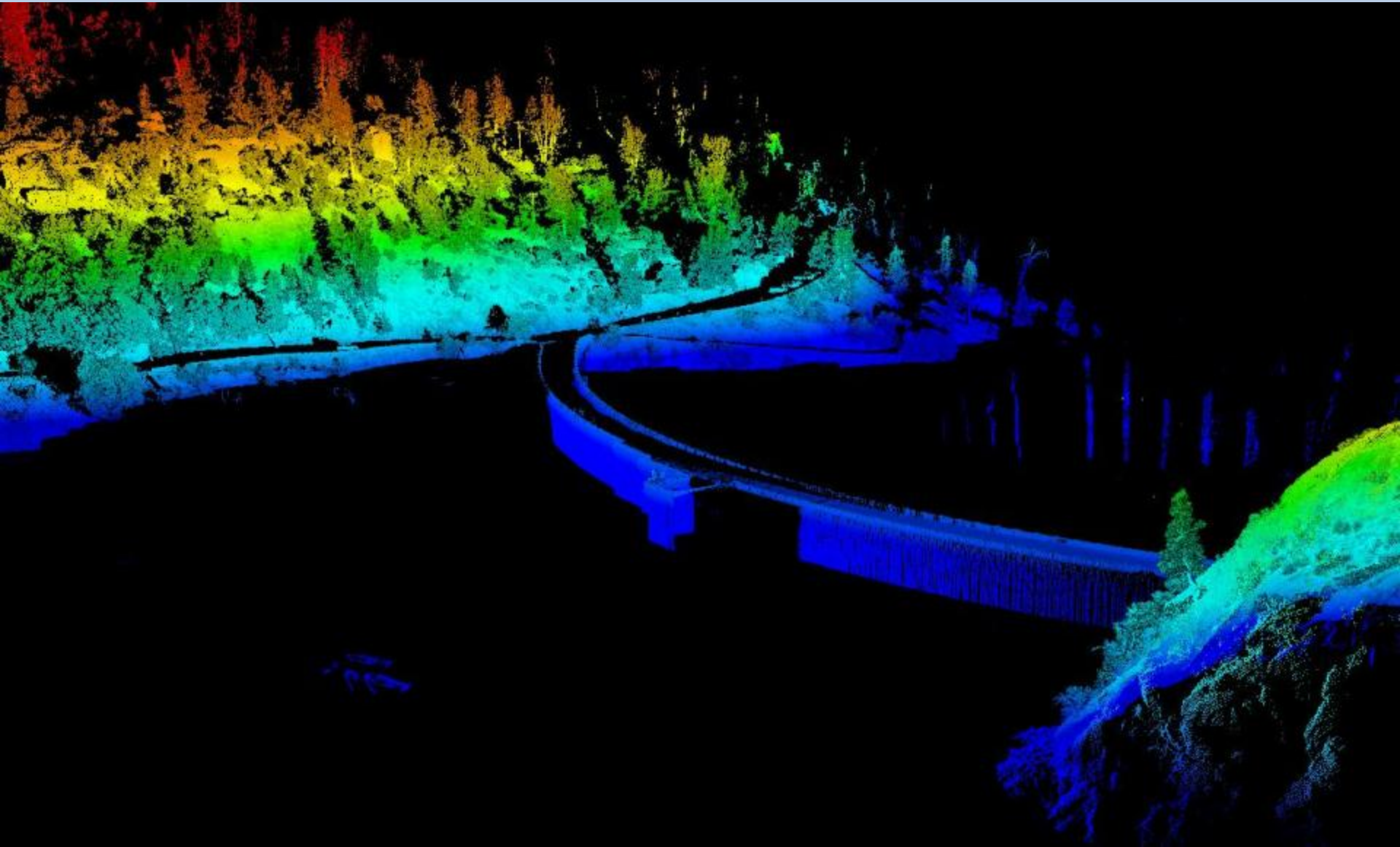
Hetch Hetchy LiDAR