Water Availability and Risk Analysis of Sierra Nevada Basins

ESPM C172: Remote Sensing of the Environment, Fall 2021

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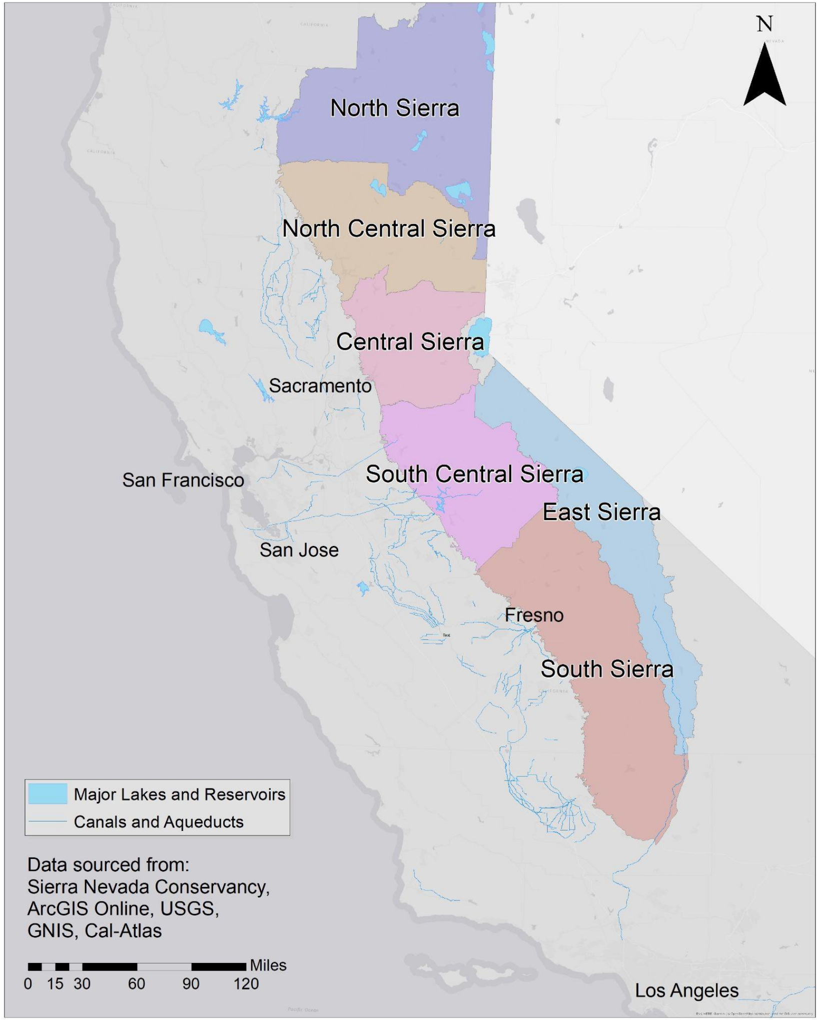
Sierra Nevada Watershed

- Provides 60% of California's water
  - Sierra Nevada water is vital to Central Valley crop irrigation, urban life in the San Francisco Bay Area, Southern California, and the Central Coast (USDA)

- Water accumulates during winter months due to topography of Sierras
  - Mountain ranges capture eastern-moving precipitation

- Water is stored in the form of snowpack until temperatures rise in the spring
- When snow melts in the spring this water flows down to fill surrounding rivers and recharge the groundwater

Sierra Nevada Watersheds

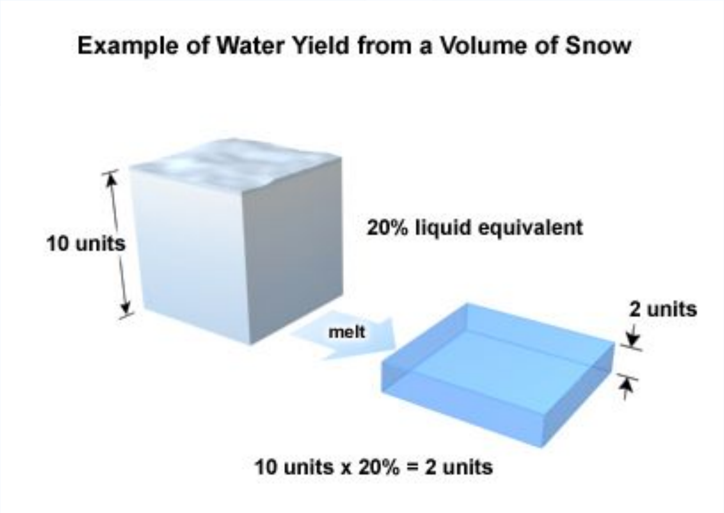


South Central Sierra is where Hetch Hetchy reservoir is located, inside Yosemite, providing water to the San Francisco Bay Area

Owens Valley, located in the East Sierra, is the main water source for Los Angeles

All basins feed tributaries to Sacramento and San Joaquin Rivers as well as aquifers which are essential for agriculture irrigation

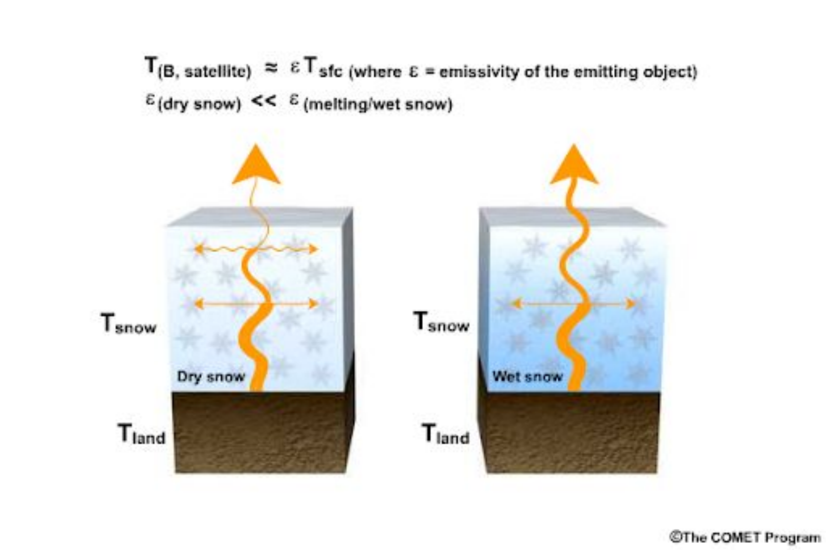
Importance of Measuring Snow Water Equivalent

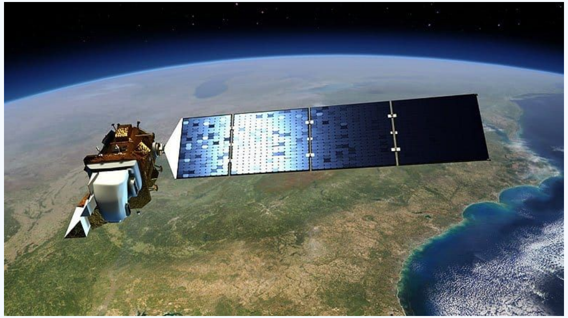


- Helps monitor and track water availability
- Beneficial for water resource planners/hydrologists to understand
- Important to measure during summer and spring in order to better understand how warmer temperatures are shifting the melting periods of snowpack

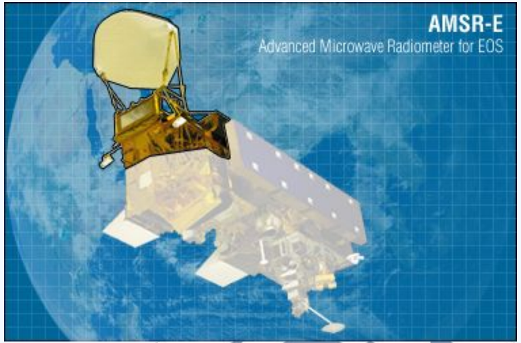
Passive Microwave Radiometer/Thermal IR

- Used by Landsat, AMSR-E
  - Measures brightness temperatures determined by emissivity due to water content





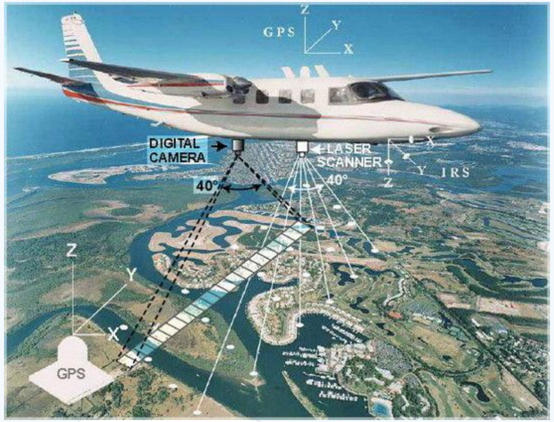
Landsat: Thermal IR, 30m, 16 days



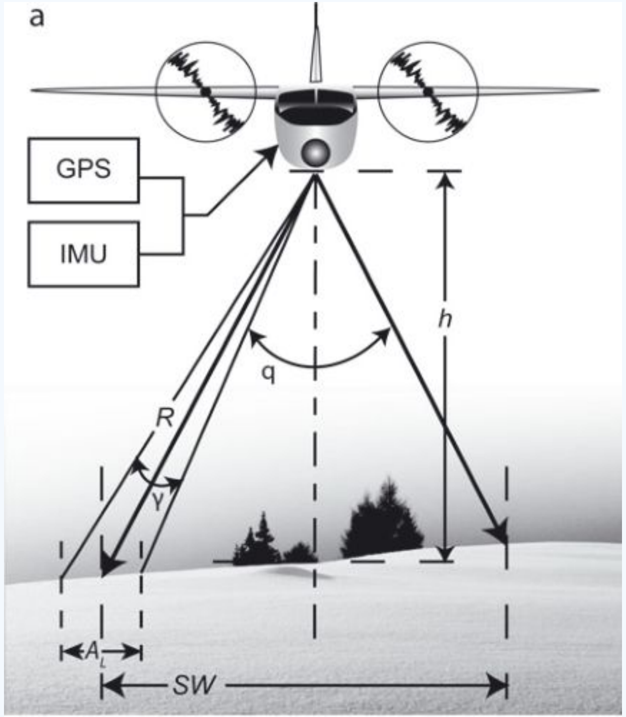
AMSR-E: Passive MW, 25km, daily to monthly

LIDAR/Imaging Spectrometer

- Used by Airborne Snow Observatory (ASO)
  - Measures snow depth (volume) with LIDAR, finds water density through albedo
  - GPS for spatial reference, IMU for aircraft angle



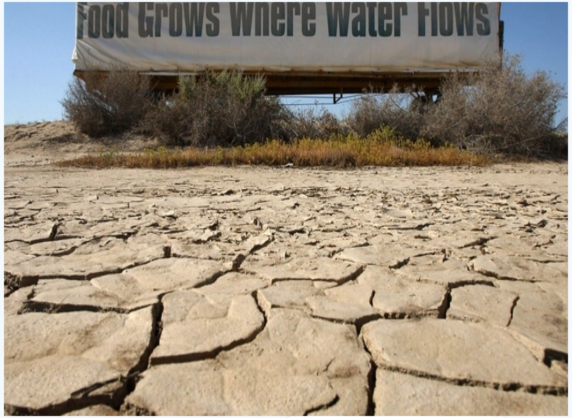
ASO: LIDAR/VIS, 50m, annual



Motivation of our Research

Objective:

- To analyze the differences in SWE across the Sierra Nevada watersheds over time and discuss the various issues surrounding these fluctuations
- To better understand the general trend of SWE in California over time



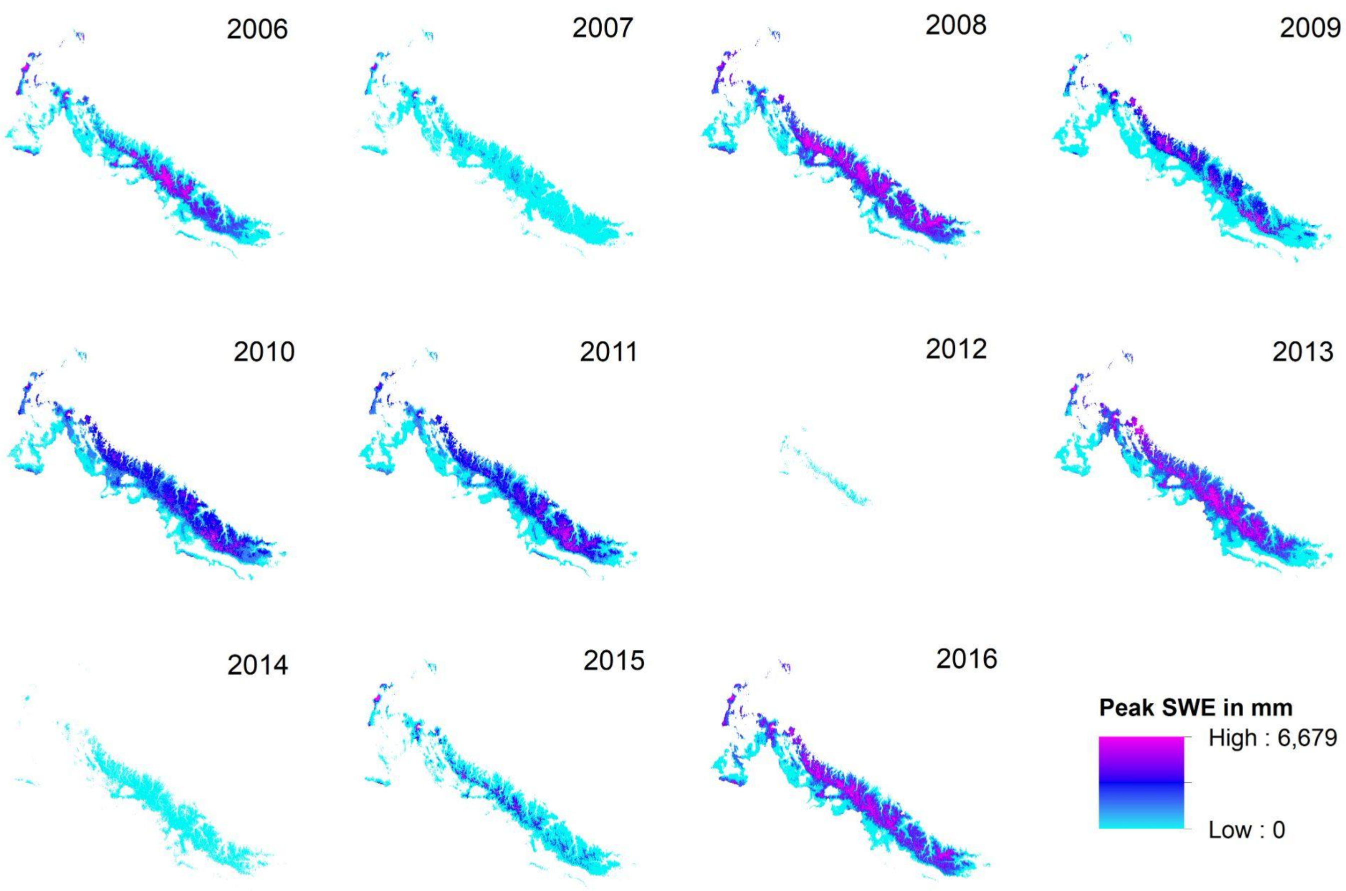
Margulis Group Research and our Analysis

- Use Landsat 5 Thematic Mapper
- Measured over 27 year period
- Temporal Resolution: daily
- Spatial Resolution: 90 meters
- Indicates SWE in mm
- Water years 1985–2016 over the full Sierra Nevada

Our Analysis:

- Analyzed SWE from 2006 – 2016 to see most recent measurements
- Looked at peak snowpack date for each year (April 1st)

Yearly Peak SWE 2006 - 2016 for Sierra Nevada Watershed



Each map represents peak SWE for the year; April 1

Data sourced from Margulis Research Group

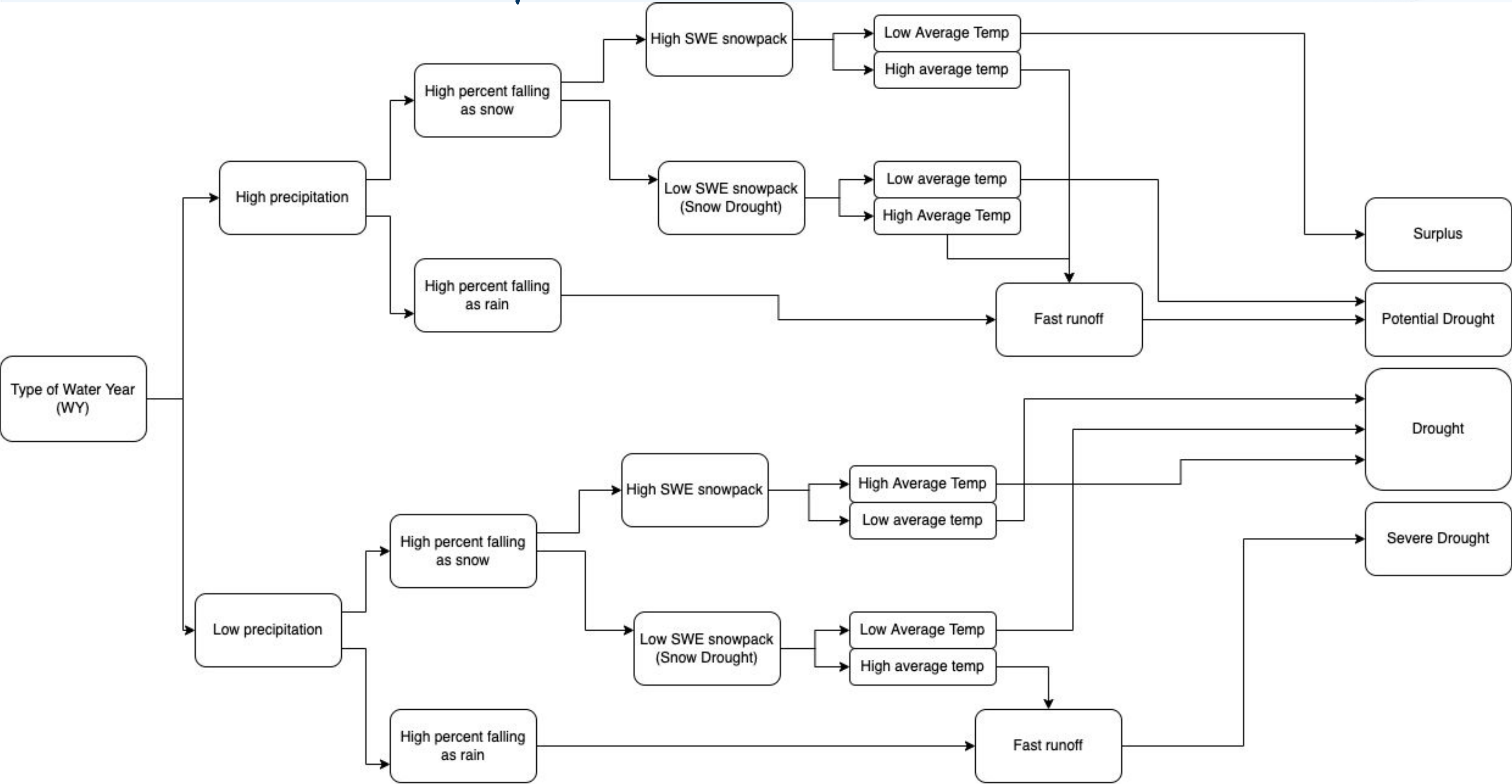
If data was available 2016 – present, this would enable us to map more recent SWE trends

Implications of Low SWE and Risk Analysis

- Less runoff in late summer/autumn
- Drier soil → drier vegetation → increased fires
- Economic impact on agriculture
- Ecosystem

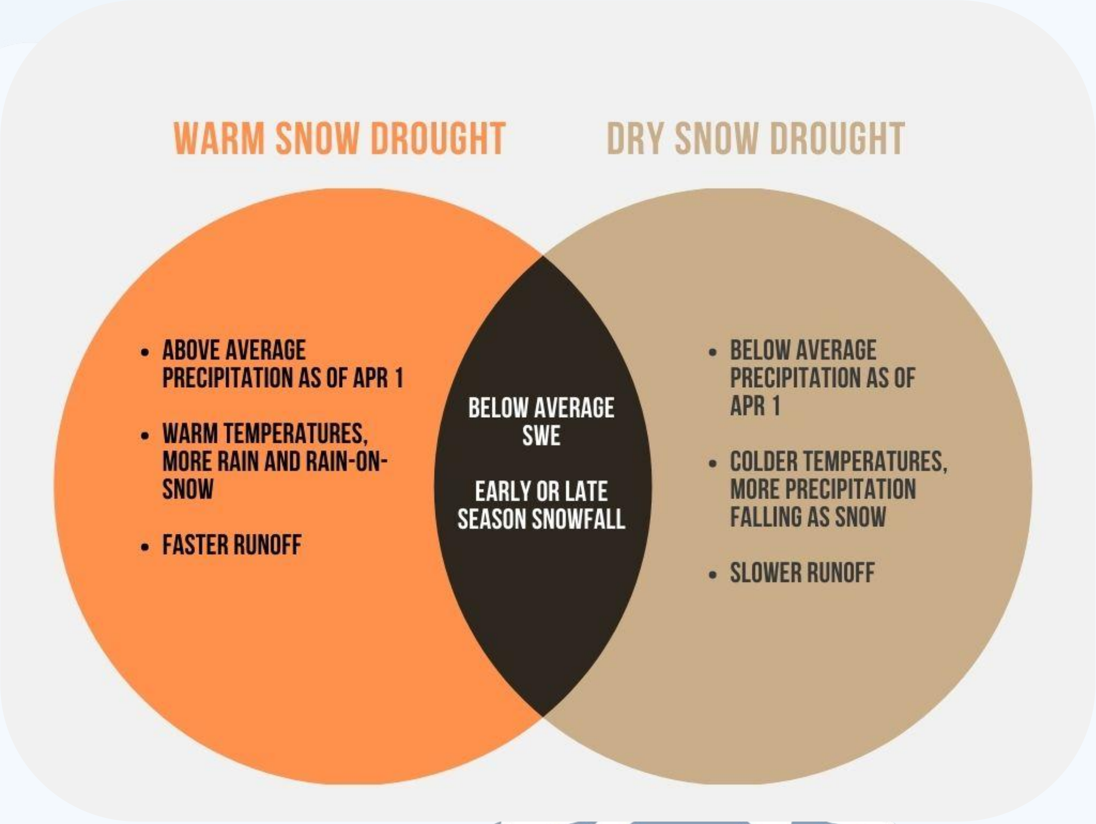
In addition to SWE level, interannual variability of SWE trends is important for risk analysis i.e. water allocations for farms, reliability of hydroelectric power, fire preparedness, etc.


Implications of Low SWE



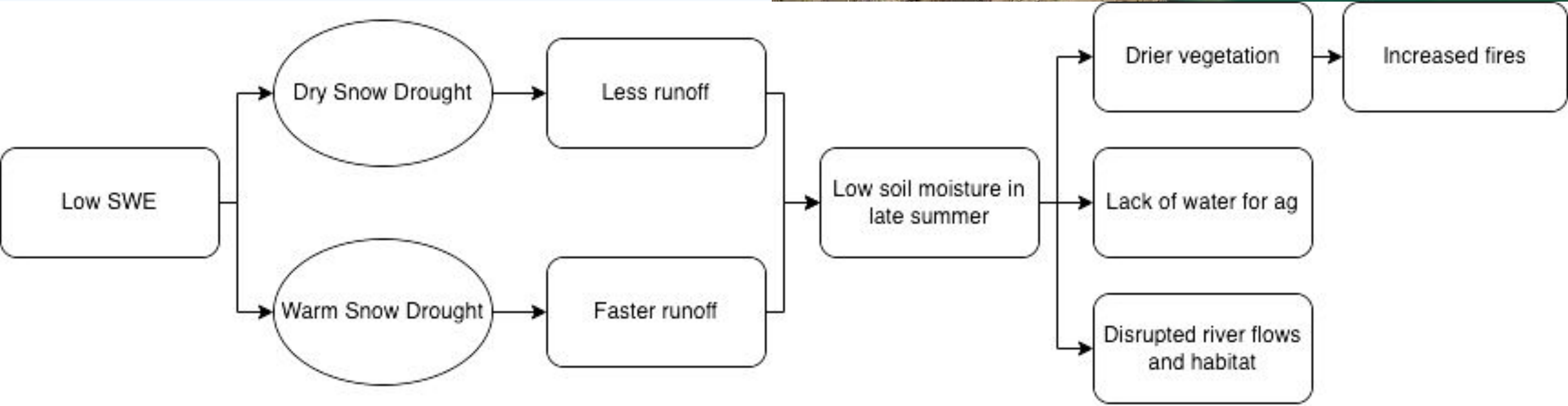
Snow Drought

- Primary reason for low SWE, even during years of above average precipitation
- Largely affected by temperature



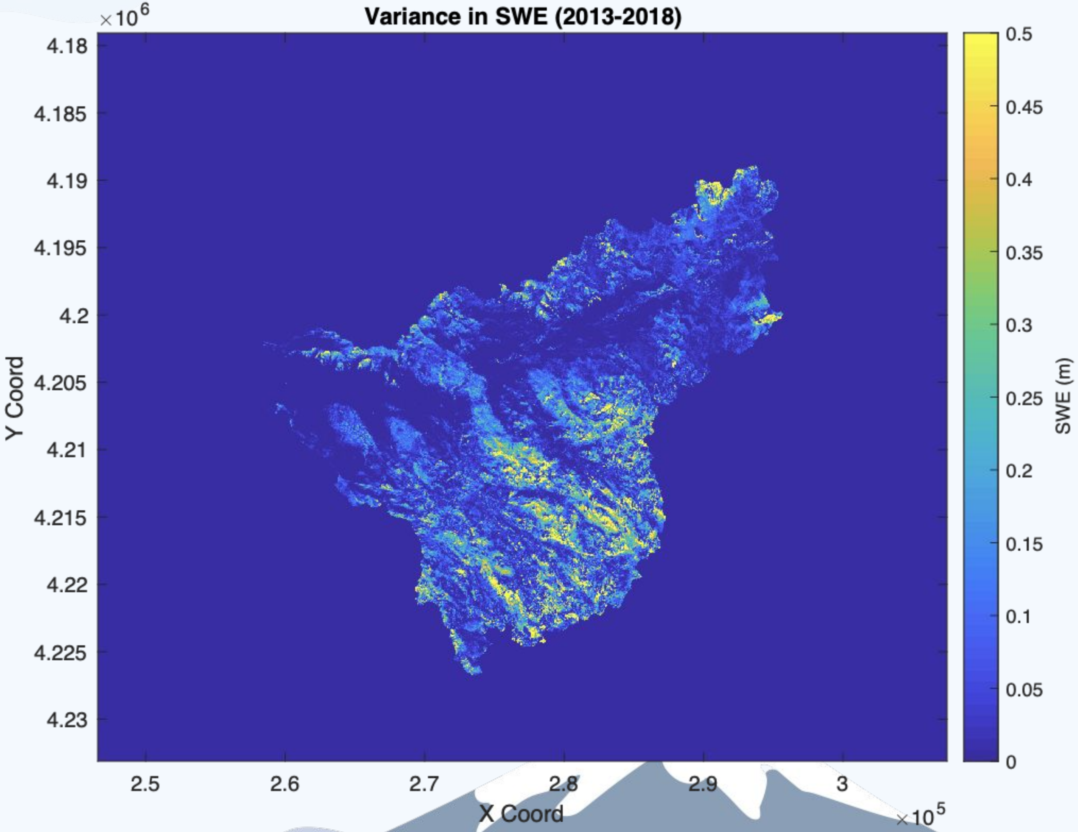
Snow Drought


Lake Oroville in California, at 42% capacity



SWE Interannual Variability

Variance was calculated from 2013 – 2018 using ASO data due to its higher spatial resolution. Applied to the whole Sierras, this can help regions assess drought risk.



Critiques of this Data

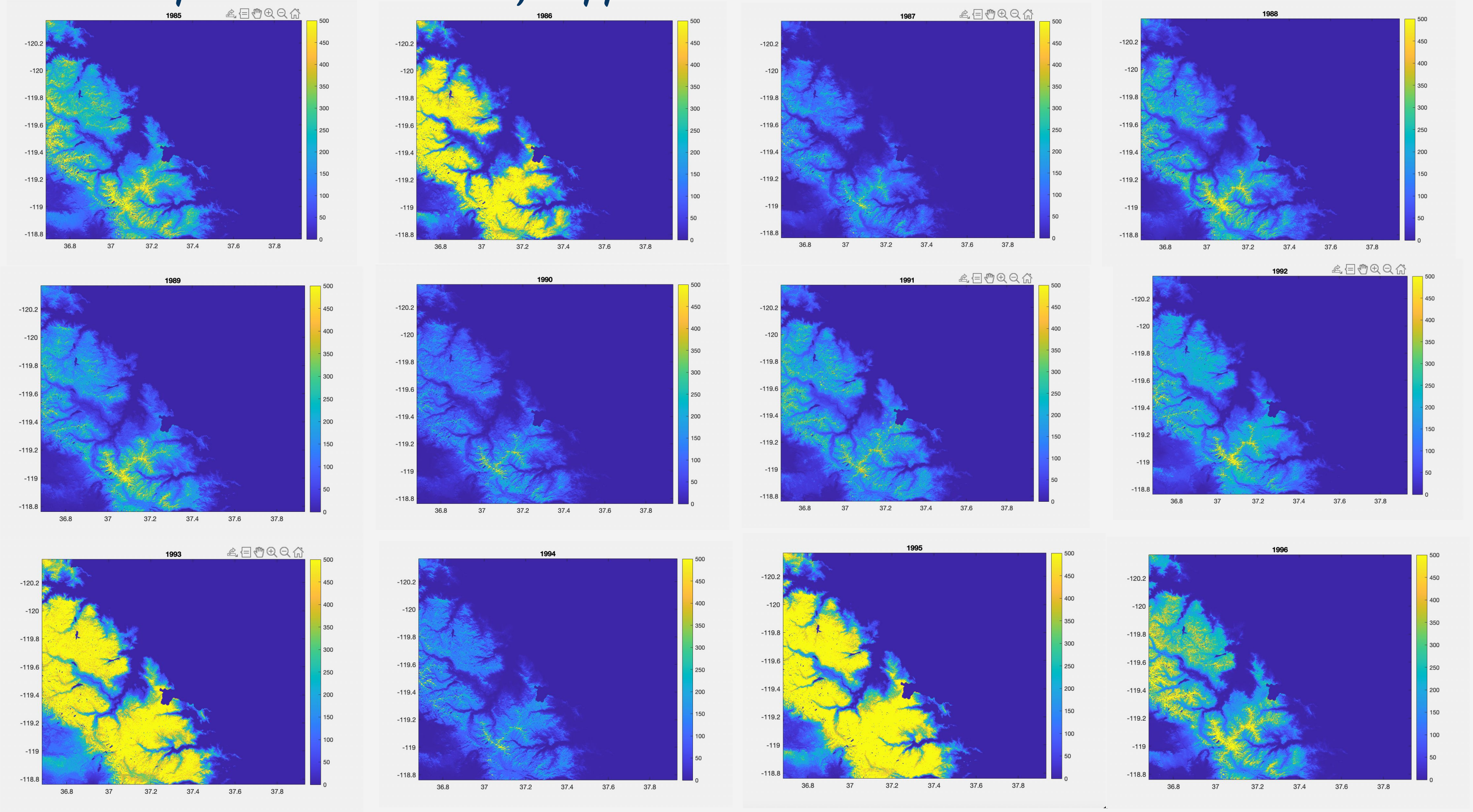
Margulis Research Group Data:

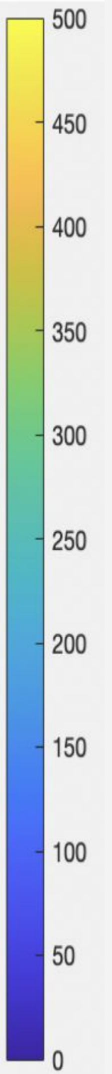
- Margulis data does not cover to present day and provides a mixture of low and high spatial resolutions for differing years and areas.
- There is great, high spatial resolution data for a clipped portion of the Southern Sierra Nevada for the years 1985-1996, post 1996, the spatial resolution of this data greatly decreases, and is missing the years of 2011-2015
- Daily SWE data for the entire Sierra Nevada only available until 2016; there is no comprehensive dataset for the entire Sierra Nevada from 1985-Present

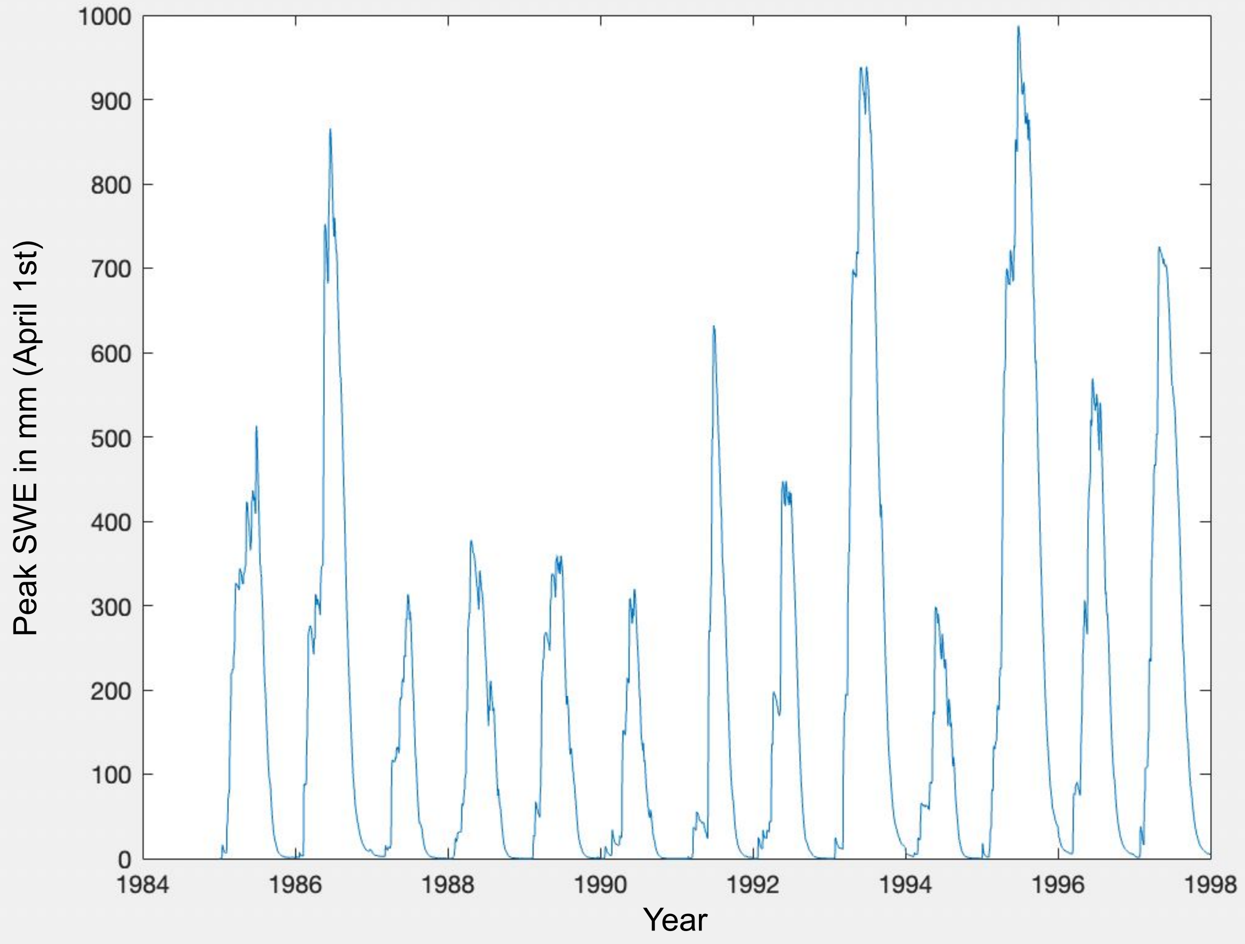
ASO Data:

- Though high in spatial resolution, ASO data is sporadic in its collection and occurs at inconsistent dates from year to year, resulting in non-standardized findings
- Missing years: no data from 2013-2016

SWE comparison: 1985 - 1996, Clipped Portion of the Southern Sierra Nevada Basin







Graphing SWE Change Over Time

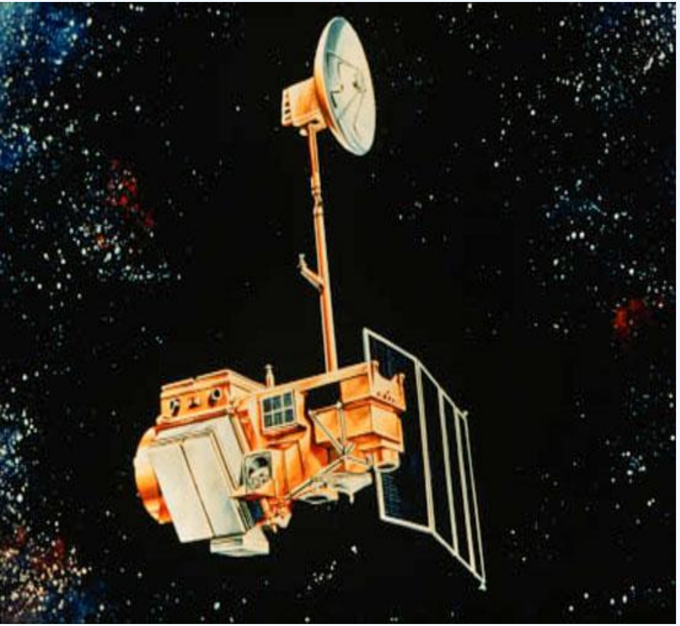
- If the data post 1997 was not of a lower resolution and quality, we would be able to use it to continue visualizing the trend in SWE fluctuation
- If this data was accessible for the entire Sierra Nevada, it would work far better for our ideal project
- Currently, the 1985-1997 figures and graph serves as a blueprint for our ideal SWE project

Ideal Future Project

Goal: To have continuously available data to inform California residents if they are at risk of water shortage for a given time period

- There is no SWE data for the Sierras with a high enough spatial resolution up to present day
- Would determine which basins provide water for which areas of CA
- Provide risk analysis app available for public use
- What sensor would measure this?

Ideal Future Project



New Sensor:

- Active Microwave remote sensor
  - Can detect snow depth since longer wavelengths can more easily penetrate snow
  - Has less coarse spatial resolution than passive microwave
- Spatial resolution: < 5km
- Temporal resolution: 3 months

Risk Analysis

- Standardize data collection dates to determine differences in SWE for Apr 1

Summary

- Measuring the SWE in the Sierra Nevada is important for water conservation, predicting drought conditions, water availability for crop irrigation purposes, analyzing change in snowpack, vegetation dryness and an increased fire hazard as a result
- Current SWE data is not readily available, comprehensive, or current, as it has gaps in years and does not exist after 2016
- Arguably, measuring the SWE 2016 – present is most important as anthropogenic changes are occurring more rapidly than before: our future ideal project outlines what type of remote sensor is necessary to accomplish this
- We would ideally design a new sensor to analyze more modern SWE levels with a higher spatial resolution than that of the sensors currently collecting this data

Conclusion

As climate change continues, it is increasingly important to monitor trends and fluctuations more accurately in order to plan ahead for water use.

Thank you!

Citations

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