Atmospheric River Storms in the Tuolumne Basin and other California Watersheds

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Yosemite Hydroclimate Workshop
What is an Atmospheric River?

“A long, narrow, and transient corridor of strong horizontal water vapor transport that is typically associated with a low level jet stream ahead of the cold front of an extratropical cyclone”

-AMS Glossary
California’s Variable Precipitation

- Southwestern (SW) U.S. has the largest year to year precipitation variability in the US.
- The year to year variability in CA is largely caused by the wettest days (ARs).
- ARs contribute ~30-40% to seasonal SWE accumulations in the Sierra Nevada (6-7 events/year on average)

Coefficient of variation for annual precipitation 1950-2008

Dettinger et al. (2011), Guan et al. 2010
ARs in Western California

**Water Supply** vs. **Flooding**

All 7 floods in the Russian River over 8 years (Oct 1997-Feb 2006) are associated with atmospheric rivers

Contribution (%) of ARs to total annual precipitation (1950-2013)

Gershunov et al. 2017

Ralph et al. 2006
Forecast Informed Reservoir Operations (FIRO)

- FIRO is a proposed management strategy: *Can reservoir operators use state of the art weather forecasting and watershed monitoring to make adaptive management decisions?*

- Lake Mendocino is a proof-of-concept testbed that could have application to other reservoirs.
Unique Observational Network in CA

California Extreme Precipitation Network

- FM-CW snow-level radar
- 449-MHz wind profiler
- GPS receiver for integrated water vapor
- Soil Moisture and Temperature Probes

CA Dept. of Water Resources (DWR), NOAA and Scripps Inst. Of Oceanography
- Installed 2008-2014
- >100 field sites

White et al. 2013
Scripps Hydroclimate Network
Elevational Transect across Sierra

Priest Reservoir
Scripps Hydroclimate Network

- 12 sites along Hwy 120 from Priest Reservoir to Lee Vining
- 1 site at Devils Postpile National Monument
- 7 sites in White Mountains adjacent to Piute Creek Drainage
- 4 time lapse camera systems
A Tale of Two (Warm and Wet) Storms

March 22-23

April 6-8

Photo: The Union via AP

Photo: National Park Service
Streamflow

Merced River at Pohono Bridge Near Yosemite

Max = 12,100 cfs
April 7, 5:00 pm PDT

Flood Stage: 7,000 cfs

Big Creek above Whites Gulch

Max = 2,690 cfs
March 22, 2:00 pm PDT
Storm 1: March 21-22

0600Z 03/22/2018

72-hr QPE ending 5 AM PDT 23 March
Melting Level: ~ 2700 m (8900 ft)

~80% of Upper Tuolumne & Merced watersheds below melting level
Snow at Dana Meadows
Sierra Snow Extent

March 19, 2018

March 26, 2018

Data Source: MODIS
Hydroclimate Network
Hydroclimate Network

Forty Mile 1720m

%VWC

Feb Mar Apr May

10cm 30 cm 60 cm 90 cm

Soil Temperature °C

Feb Mar Apr May
Storm 2: April 6-7
Rain at Dana Meadows

APRIL 6 - APRIL 7
RAIN ON SNOW
Melting Level: ~ 3950 m (12900 ft)

100% of Upper Tuolumne & Merced watersheds below melting level

Snow Level Radar: https://www.esrl.noaa.gov/psd/data/obs/datadisplay/
Sierra Snow Extent

Data Source: MODIS
Hydroclimate Network
Hydroclimate Network
CW3E Snow-Level Tool

http://cw3e.ucsd.edu/DSMaps/DS_freezing.html

Developed by Brian Henn & Jay Cordeira, CW3E
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http://cw3e.ucsd.edu/DSMaps/DS_freezing.html
Are Winter Storms Getting Warmer?

Snow level observed by profiling radars at Chico, Oroville, and Colfax

Hatchett et al. 2017
Summary & Conclusions

• March 21-22:
  • Primarily low-elevation snow melt, with snow accumulation above ~9000 feet
  • Flooding at lower-elevation gauges

• April 4-6:
  • Rain up to ~12000 feet
  • Flooding at upper-elevation gauges

• As climate warming continues, will ARs remain known as important snow producers for California?
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