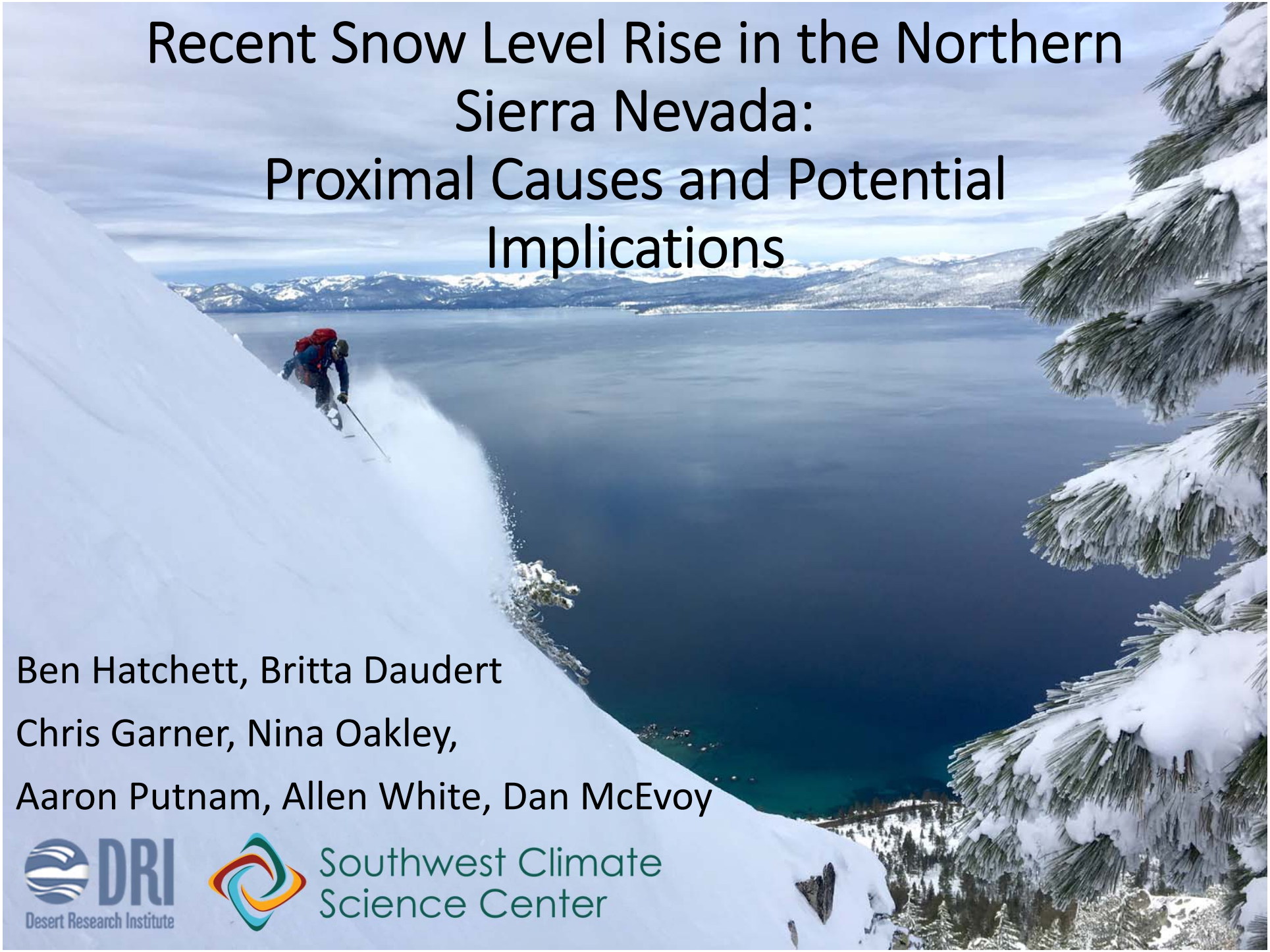
Recent Snow Level Rise in the Northern Sierra Nevada: Proximal Causes and Potential Implications



Ben Hatchett, Britta Daudert

Chris Garner, Nina Oakley,

Aaron Putnam, Allen White, Dan McEvoy

DRI Desert Research Institute

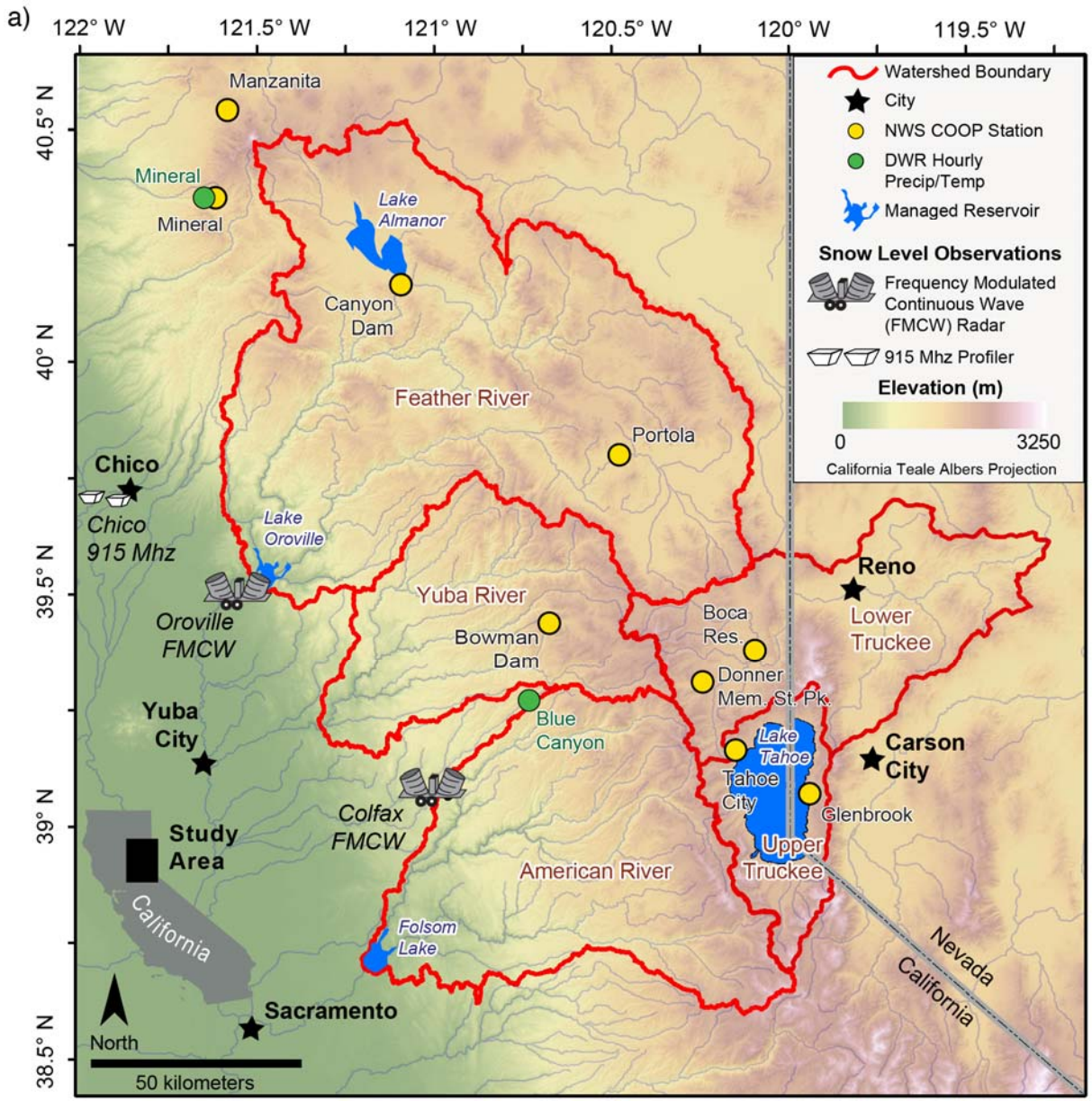
Southwest Climate Science Center

Motivation: Abruptly changing mountain environments

Mt. Tom: January 2017

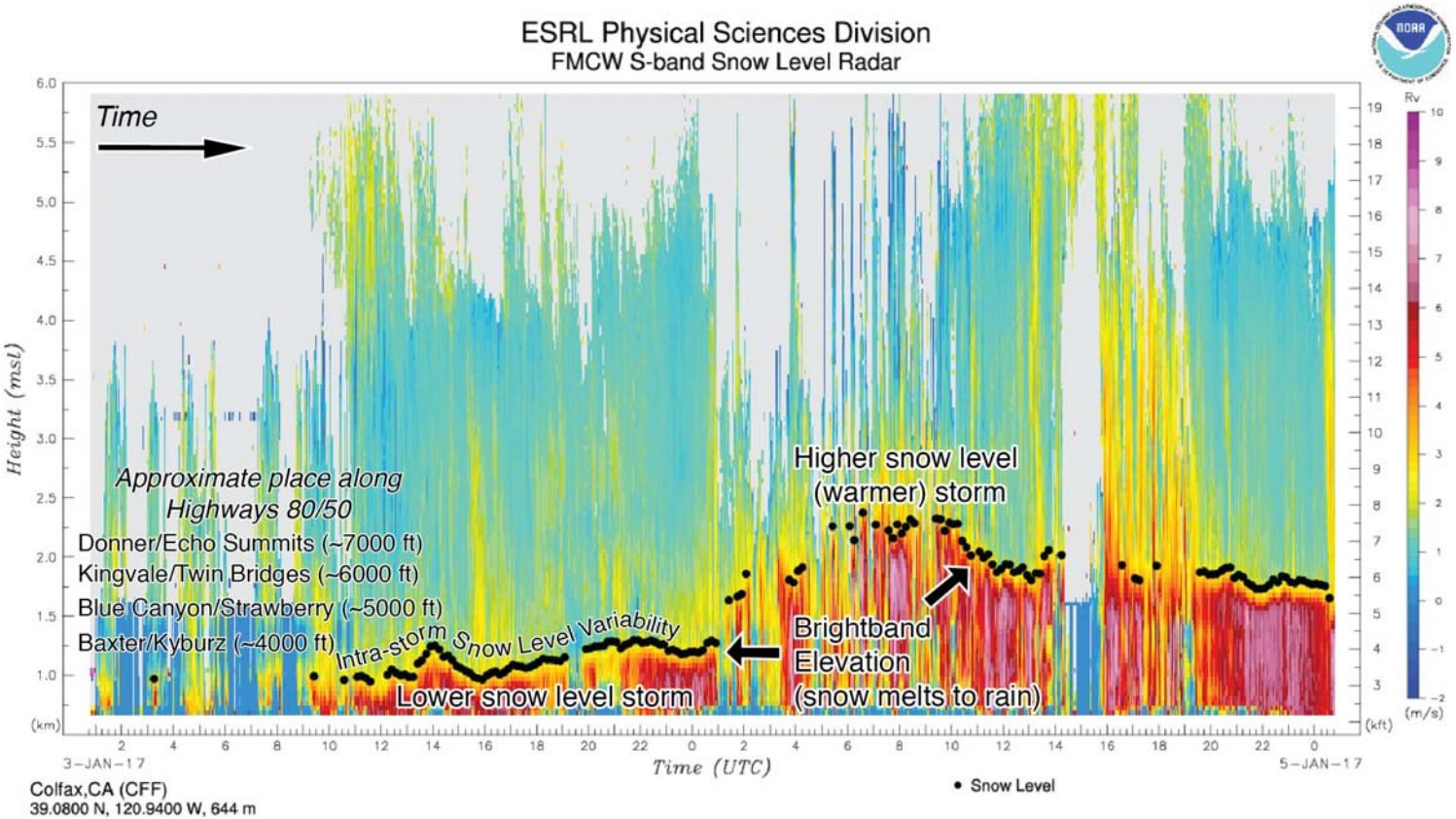
Mt. Tom: January 2018

Northern Sierra Nevada study area



Hatchett et al. (2017)

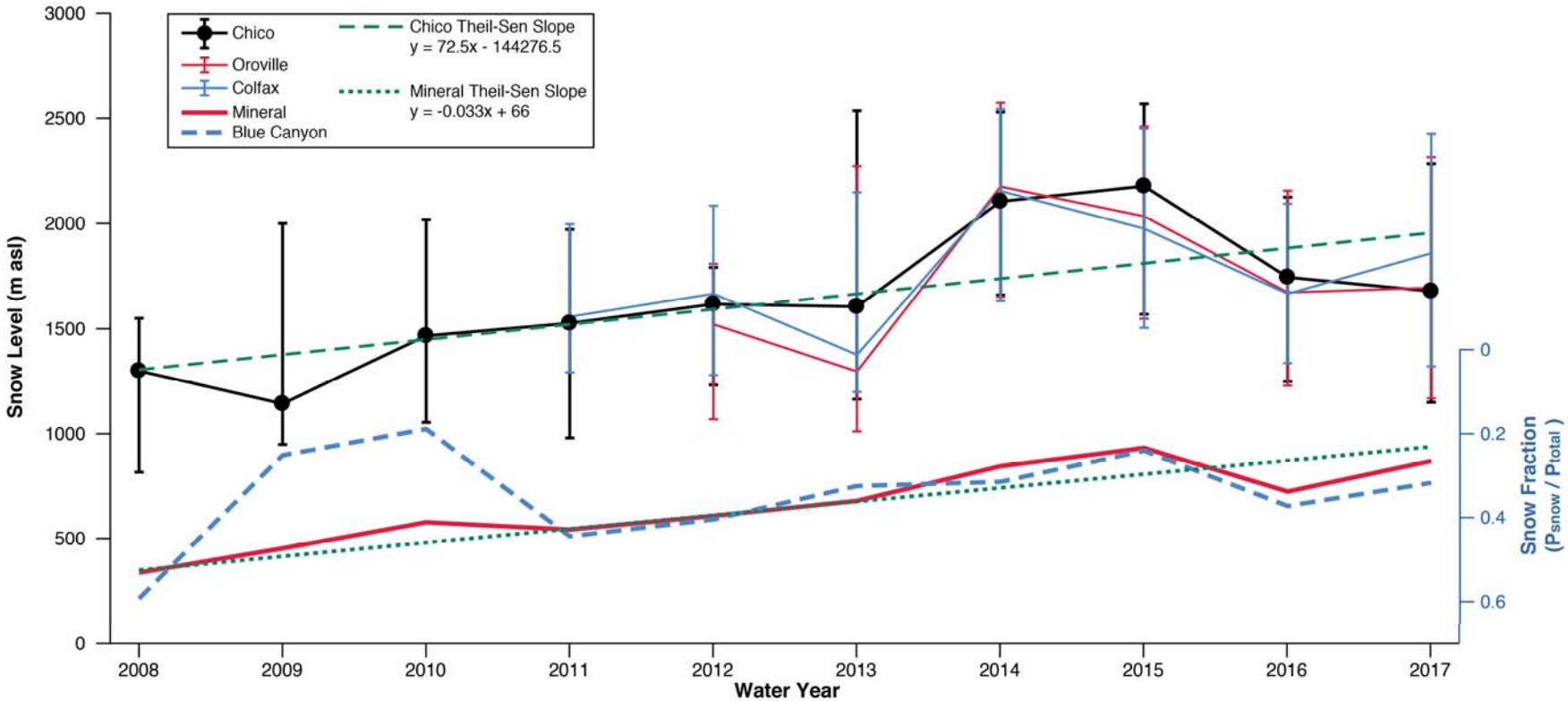
Snow level radar: A novel method to estimate height of snow-rain transition (brightband) elevation



Time (UTC)	0115	0215	0315	0415	0515	0615	0715	0815	0915	1015	1115	1215	1315	1415	1515	1615	1715	1815	1915	2015	2115	2215	2315	0015
Snow Level (m)	none	none	969	none	none	none	none	none	990	960	980	1019	1001	1179	1048	1000	1068	1120	1125	1239	1273	1285	1205	1197
Snow Level (ft)	none	none	3178	none	none	none	none	none	3247	3148	3216	3342	3284	3867	3439	3281	3503	3673	3690	4063	4175	4214	3952	3926
Sfc Temp (C)																								

Time (UTC)	0115	0215	0315	0415	0515	0615	0715	0815	0915	1015	1115	1215	1315	1415	1515	1615	1715	1815	1915	2015	2115	2215	2315	0015
Snow Level (m)	1290	1690	none	1845	2260	2261	2249	2266	2322	2250	2015	1891	1863	2038	none	1933	1812	1928	1872	1869	1827	1751	1802	1769
Snow Level (ft)	4231	5543	none	6051	7412	7416	7376	7432	7616	7380	6609	6202	6112	6684	none	6340	5945	6323	6140	6131	5994	5743	5912	5803
Sfc Temp (C)																								

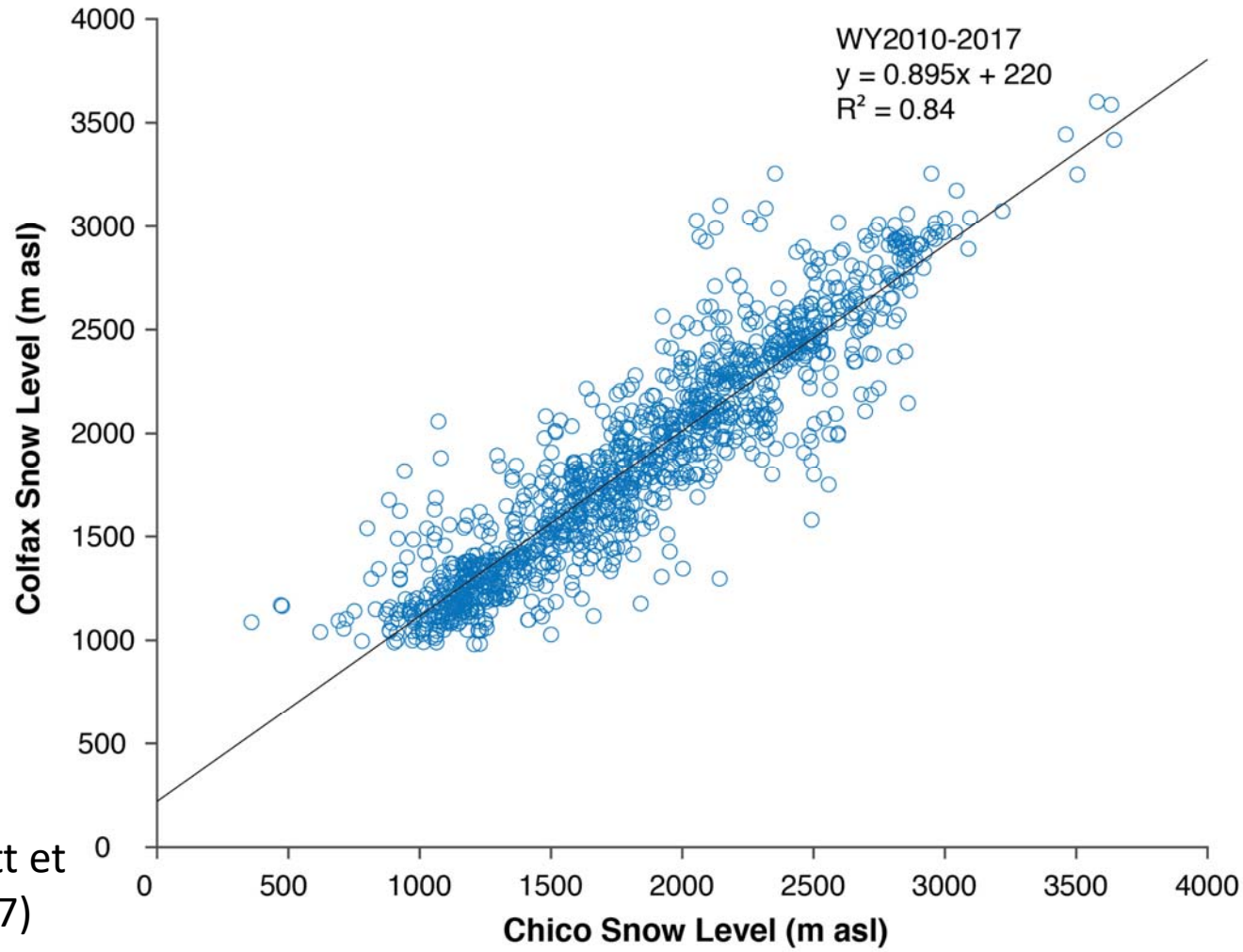
Hourly snow level radar indicates recent rise in snow levels during winter (DJF) during past 10 years



Decreases in snow fractions at Mineral and Blue Canyon: ~ 3% per year

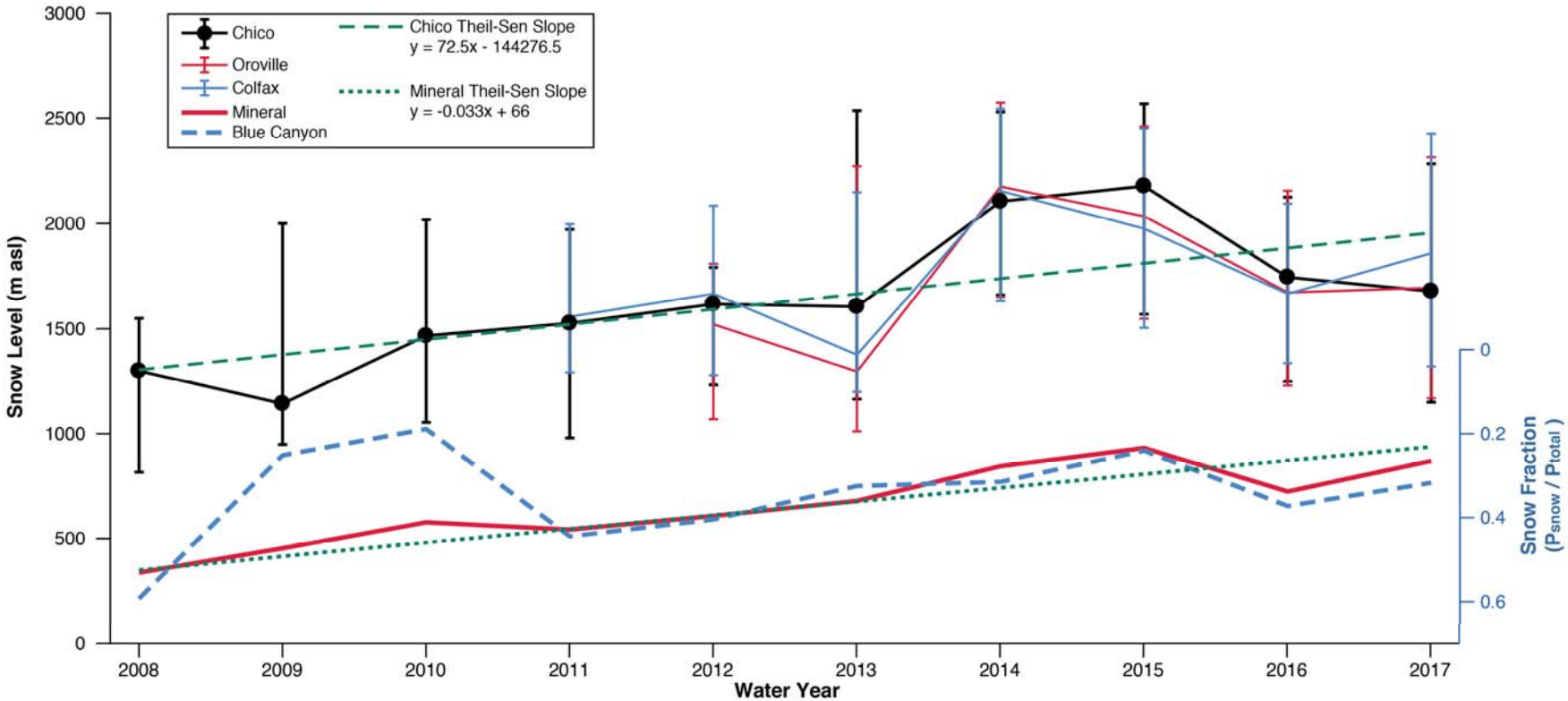
Hatchett et al. (2017)

Different snow level radars in good agreement for 2010-2017



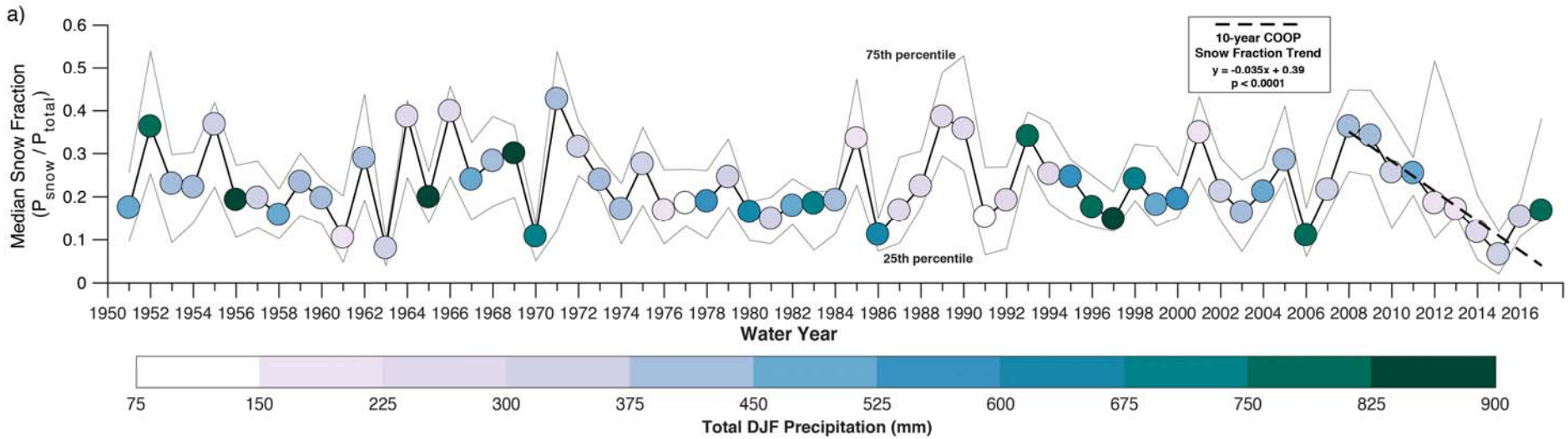
Hatchett et al. (2017)

Question: *Is the observed 10 year rise (green line) out of the ordinary?*



Hatchett et al. (2017)

Incorporate more data to check: COOP Network (1951-2017; daily)

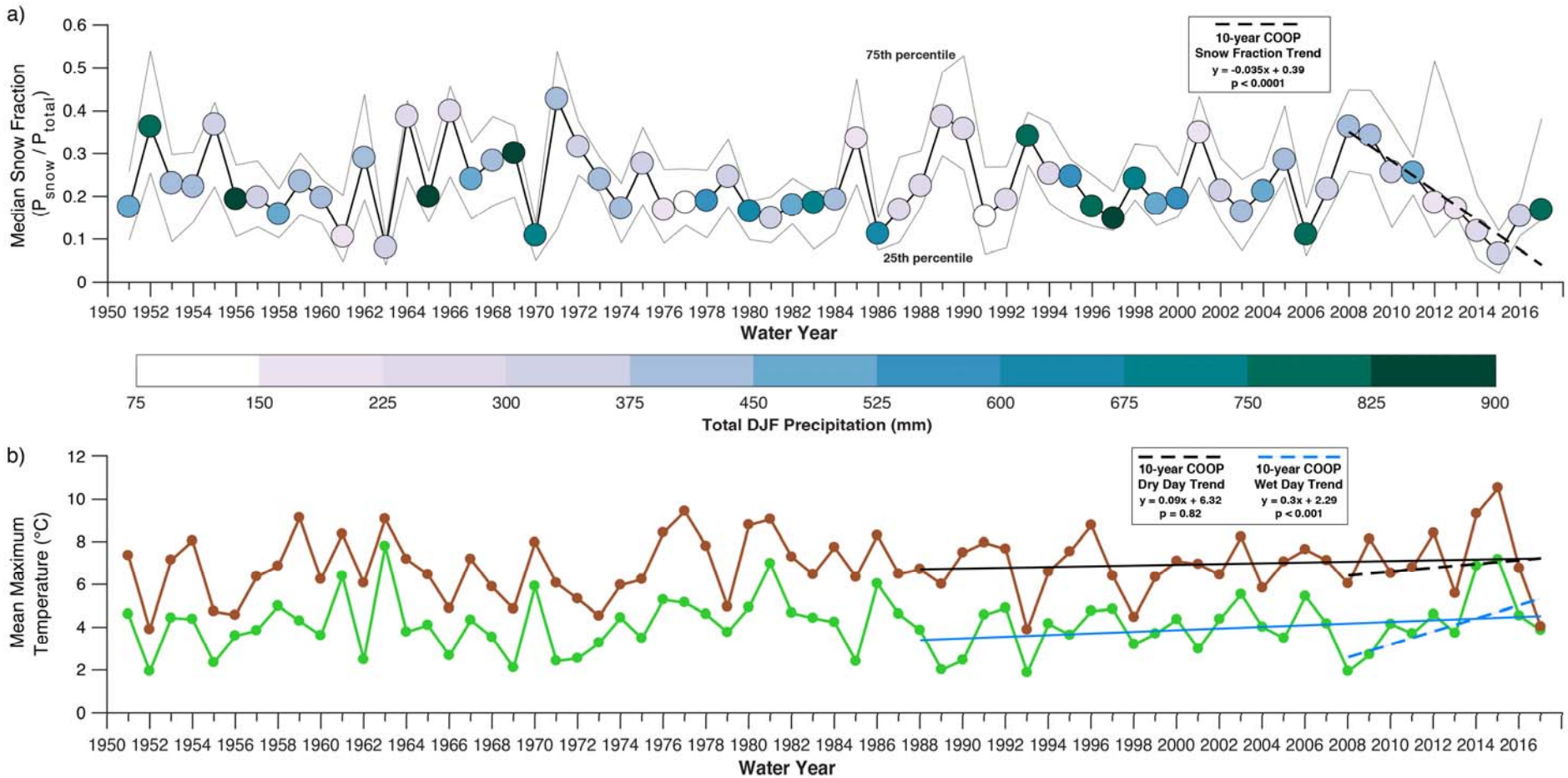


Hatchett et al. (2017)

- Strong correlation between 2003-2017 Chico snow levels and COOP snow fractions (R^2 = 0.75, $p<0.01$) → stations can provide good information about precipitation

- Last 10 years (dashed black line) have steepest decline in snow fraction of any 10 year period since 1951!

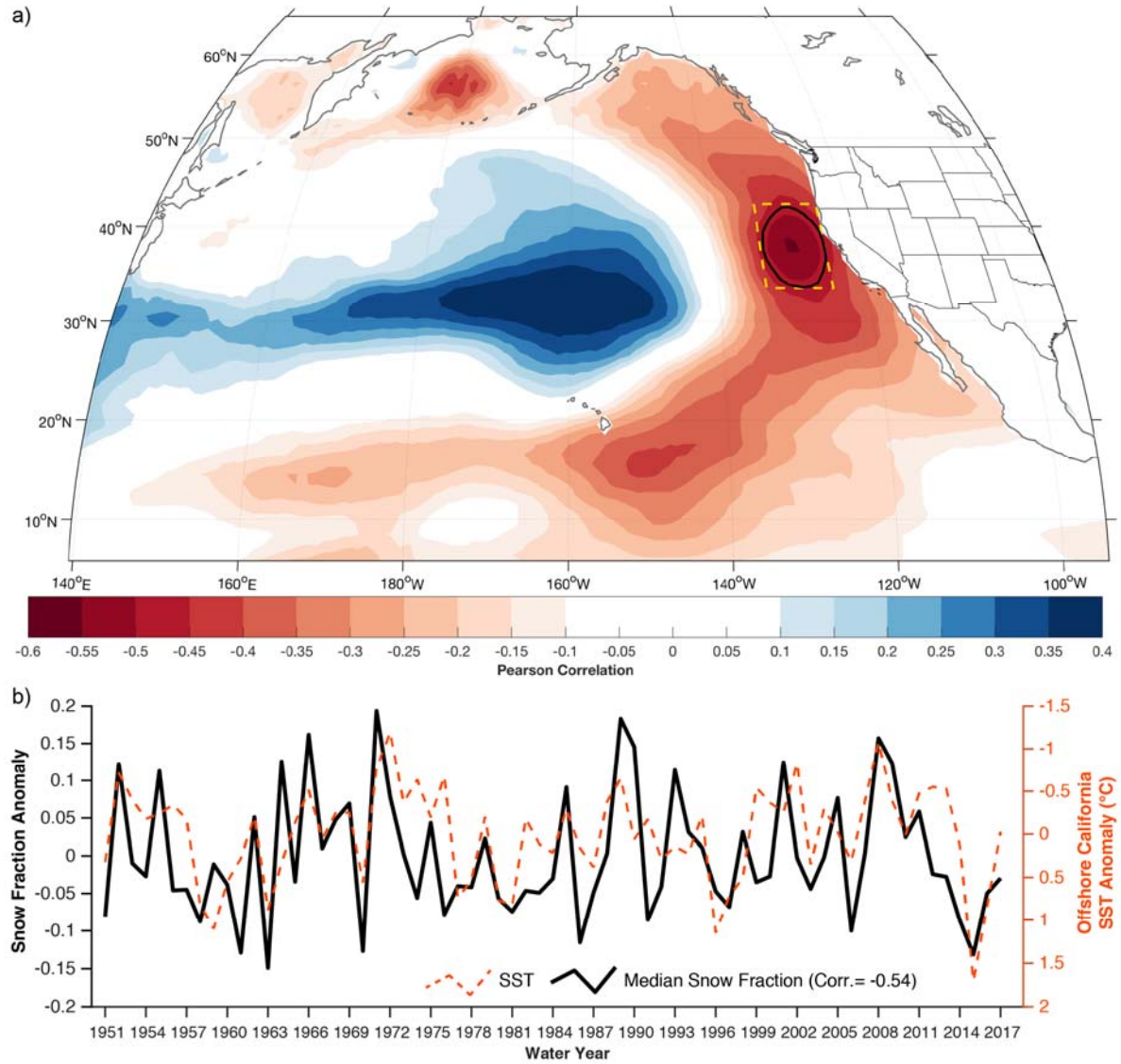
Is it **all** days or just wet days?



- Wet day rate of warming greater than last 30 years and dry days (10 + 30 yr periods).

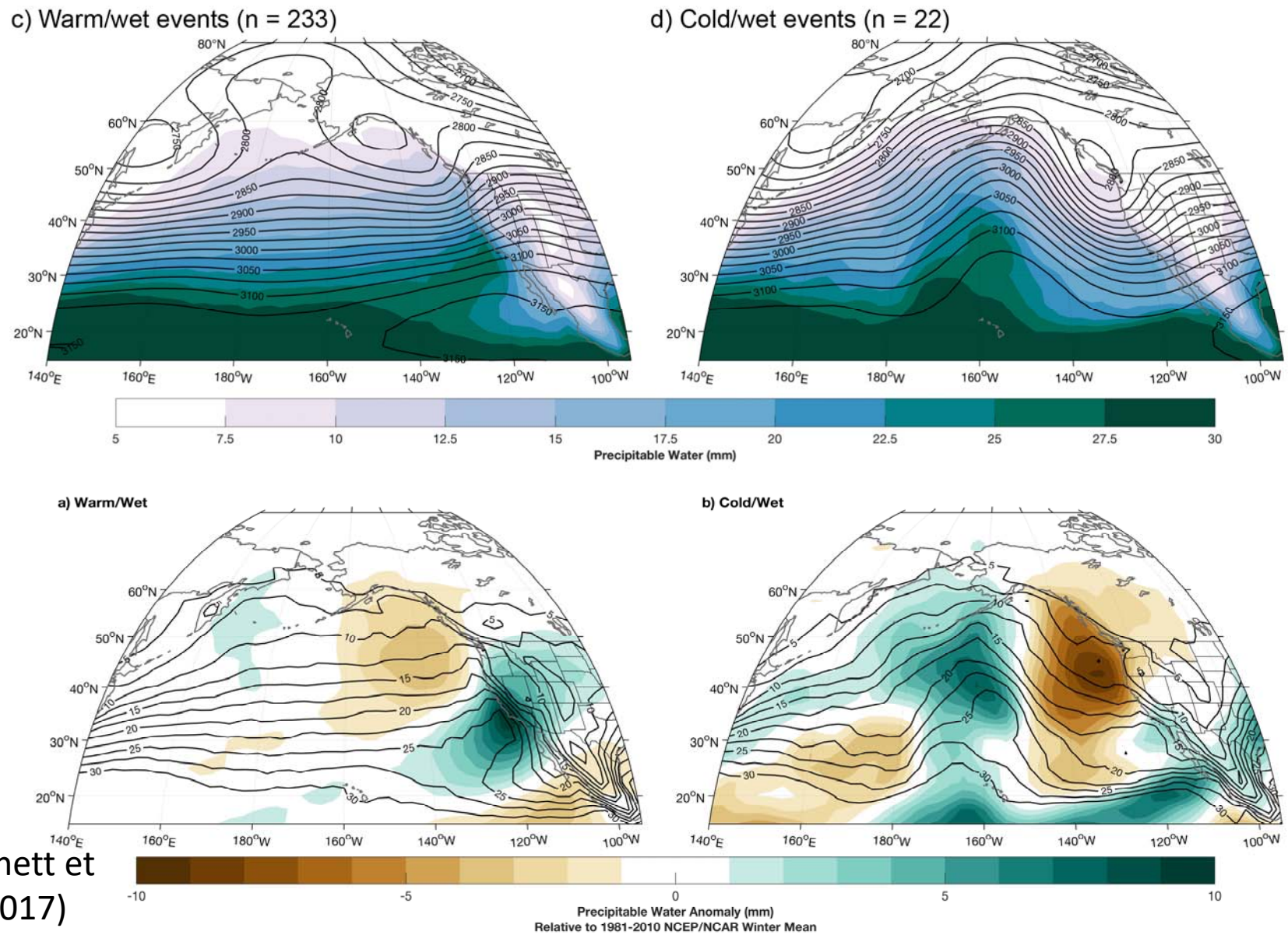
Could it be related to SSTs?

- Single-point correlations between COOP snow fraction and DJF SSTs (Chang et al. (2015)
- Black lines indicate significant (p<0.05) negative correlations
- Pattern similar to PDO/ARC (DiLorenzo and Mantua 2016) which favors southerly moisture transport (Gershunov et al. 2017)



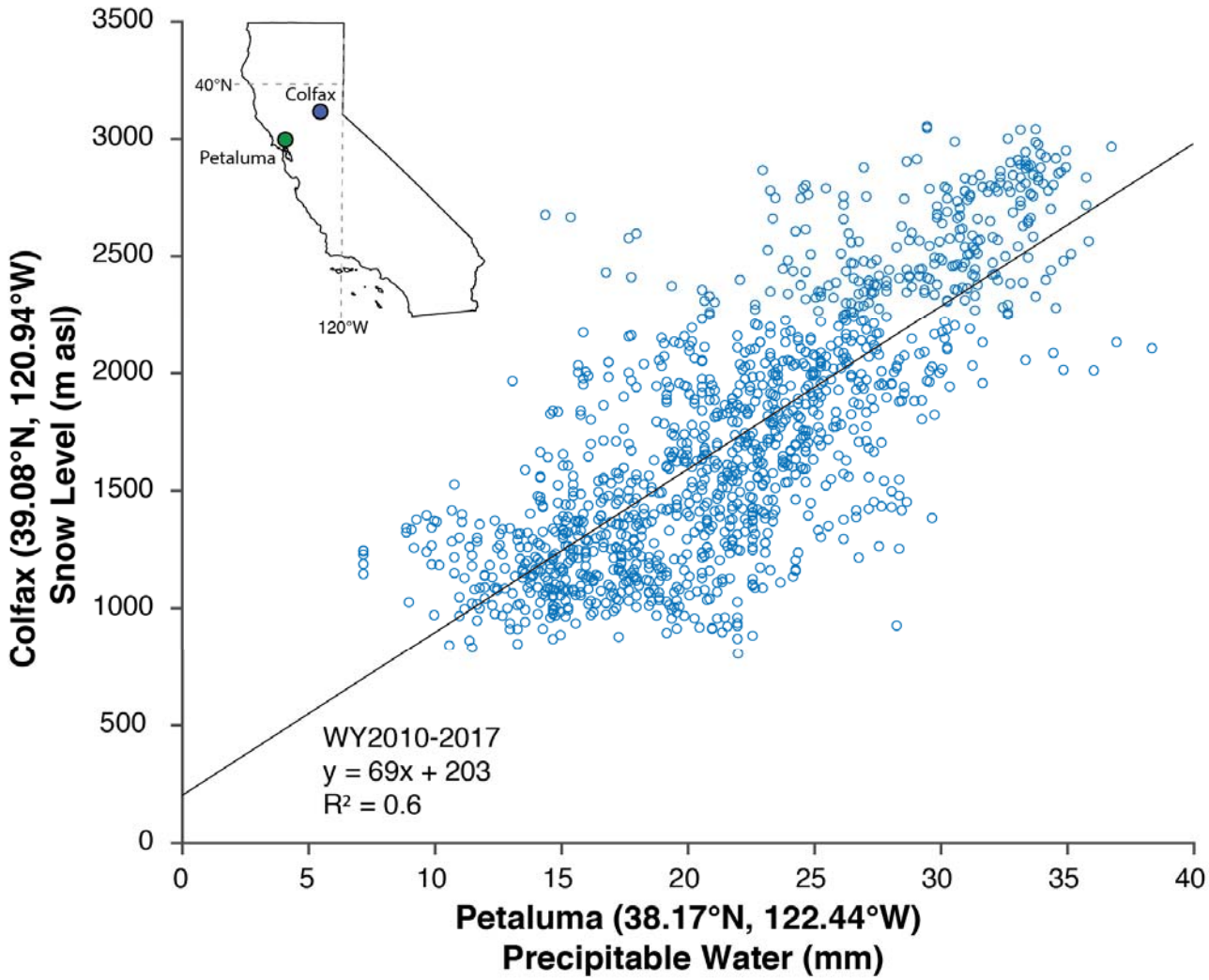
Hatchett et al. (2017)

Plausible mechanism: Roles of atmospheric rivers (ARs) and SST-favored warm/wet storms



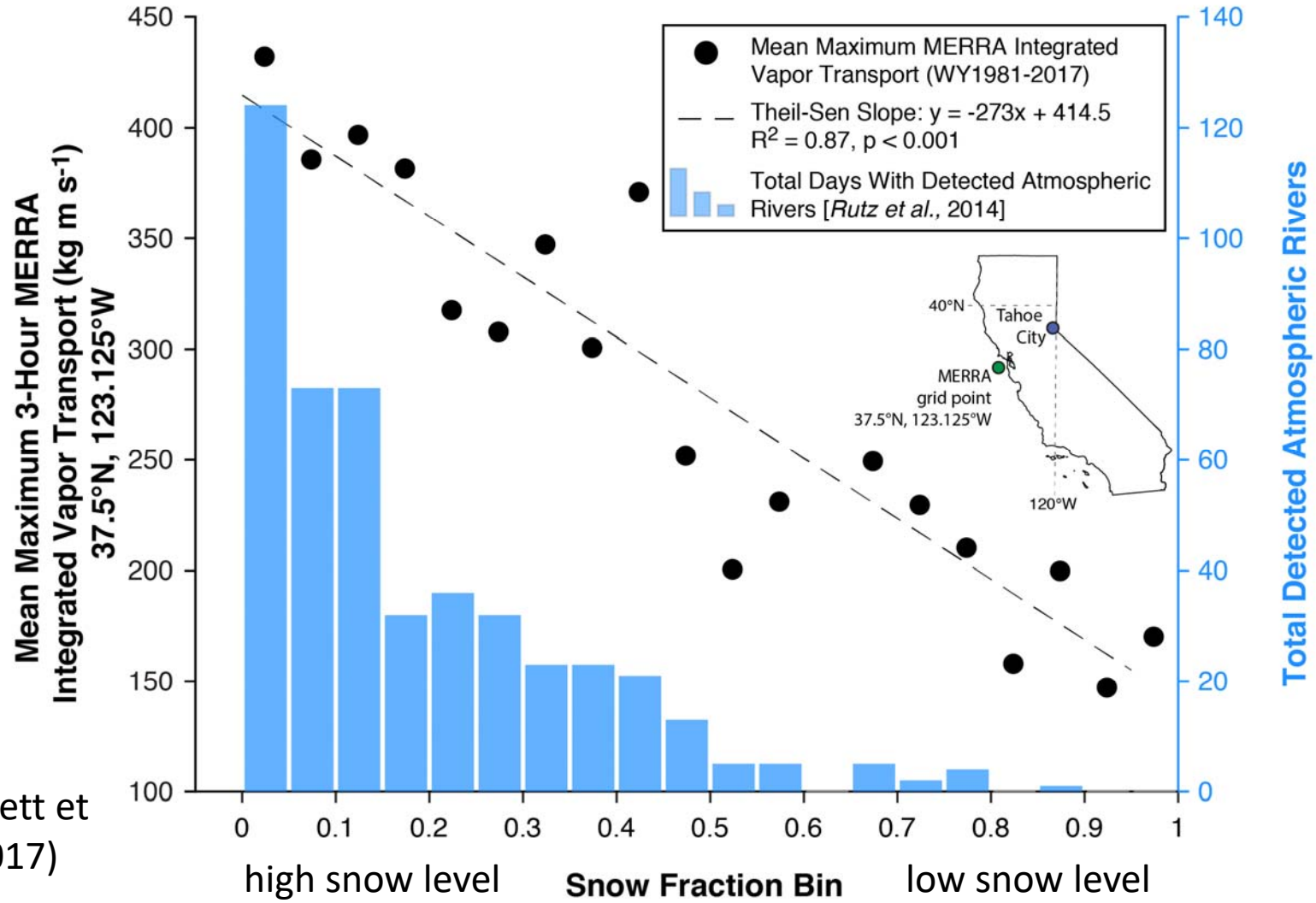
Hatchett et al. (2017)

Atmospheric River Observatory at Petaluma indicates that as precipitable water increases, so does snow level



Hatchett et al. (2017)

Satellite-based reanalysis (MERRA) and atmospheric river catalog indicates role of ARs in high snow level (low snow fraction) storms



Hatchett et al. (2017)

Remarks

- Snow level radars agree well station observations of snow fractions (inverse relationship)
- Abrupt rise in snow levels during past decade is greatest 10-year rise since 1951
- Rise likely driven by wet days, not background warming
- Coastal/AR-region SST warming favors high snow levels via zonal circulations transporting subtropical airmasses (high precipitable water) into CA
- Important role of ARs and moisture flux in high snow level storms

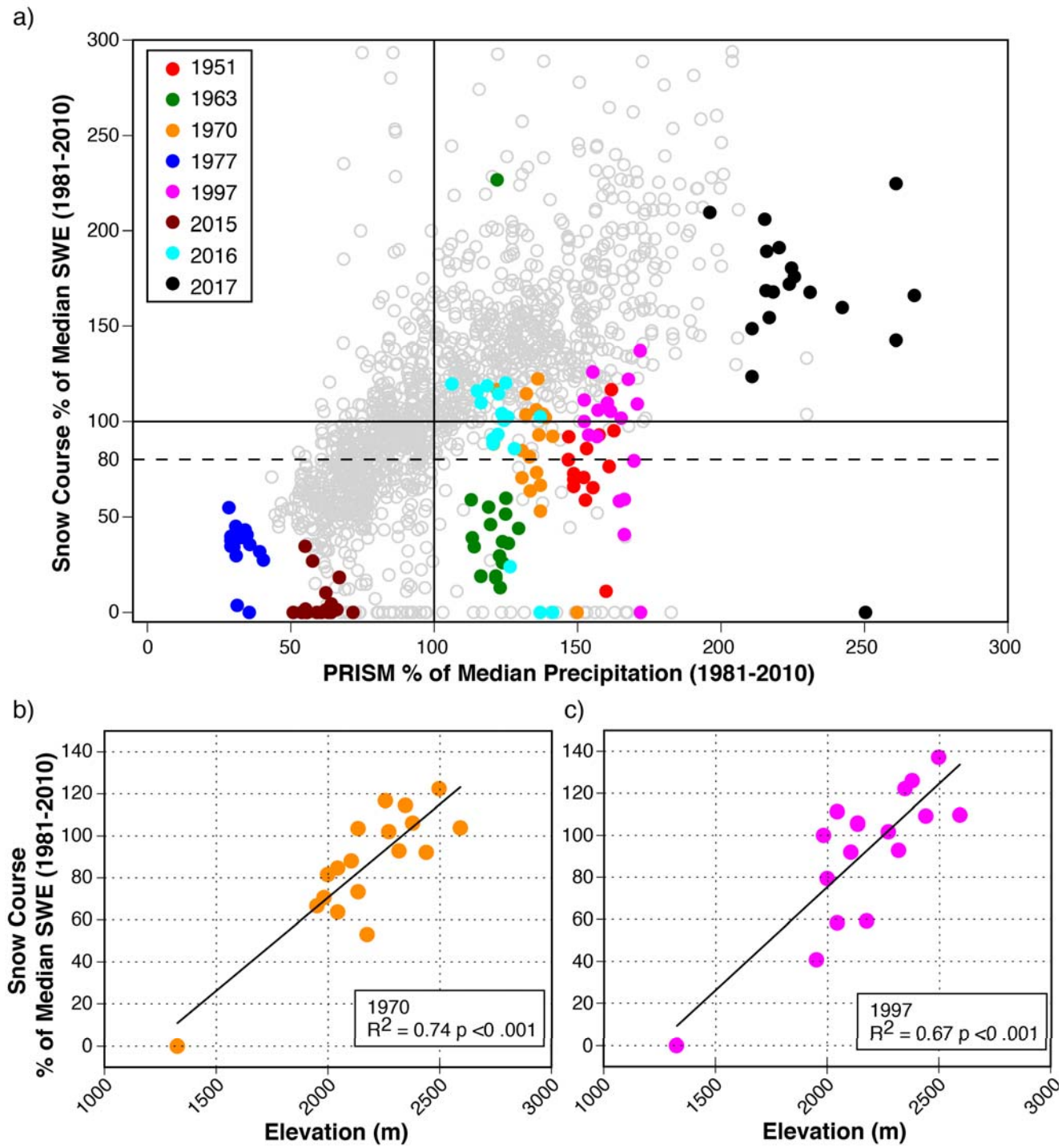
Implications?

Photo: Kevin Quinn/Points North Heli

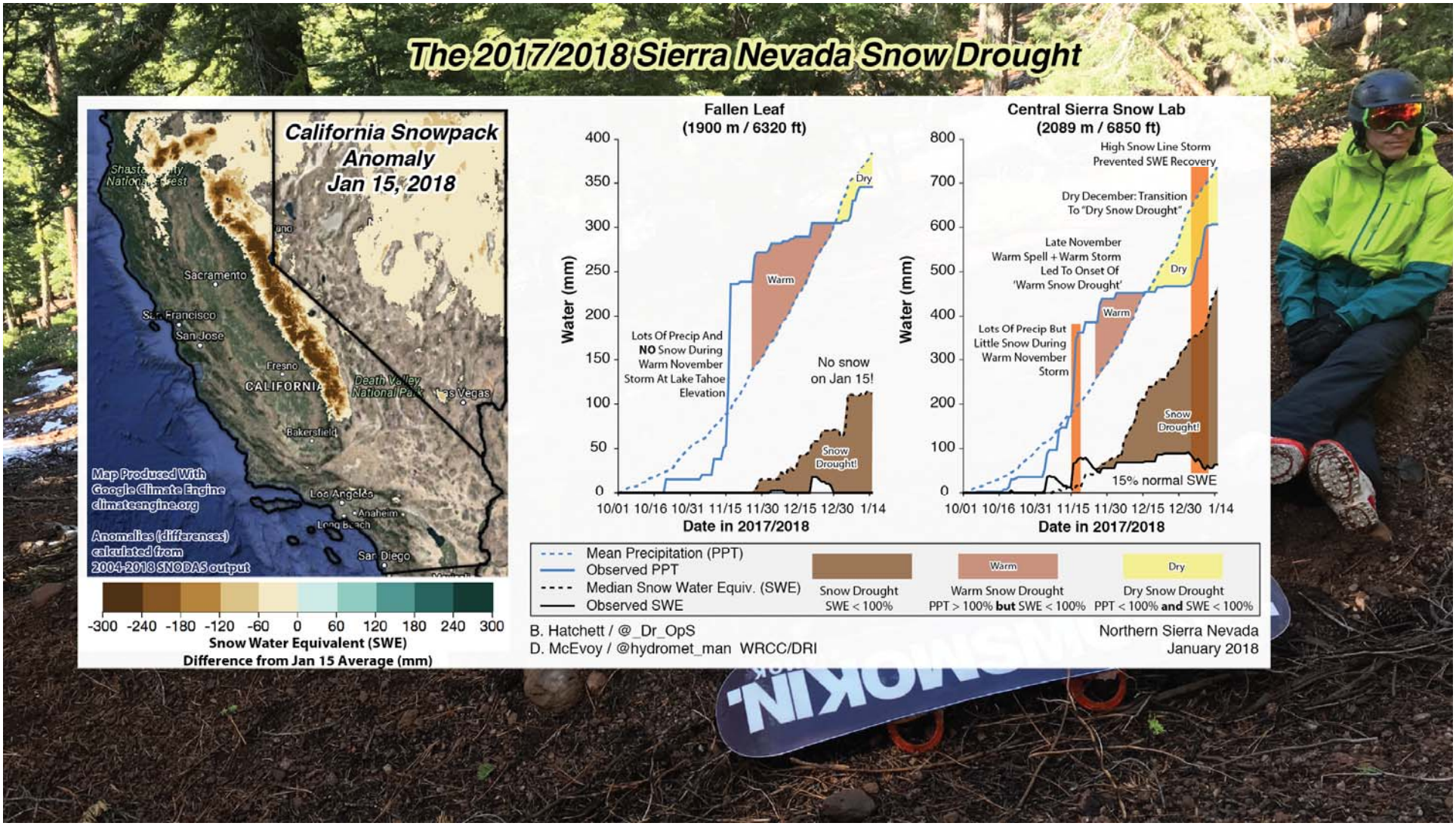
Higher Snow Levels ➔ More Frequent "Warm" Snow Droughts

Warm snow drought:
Above average precip, below average SWE

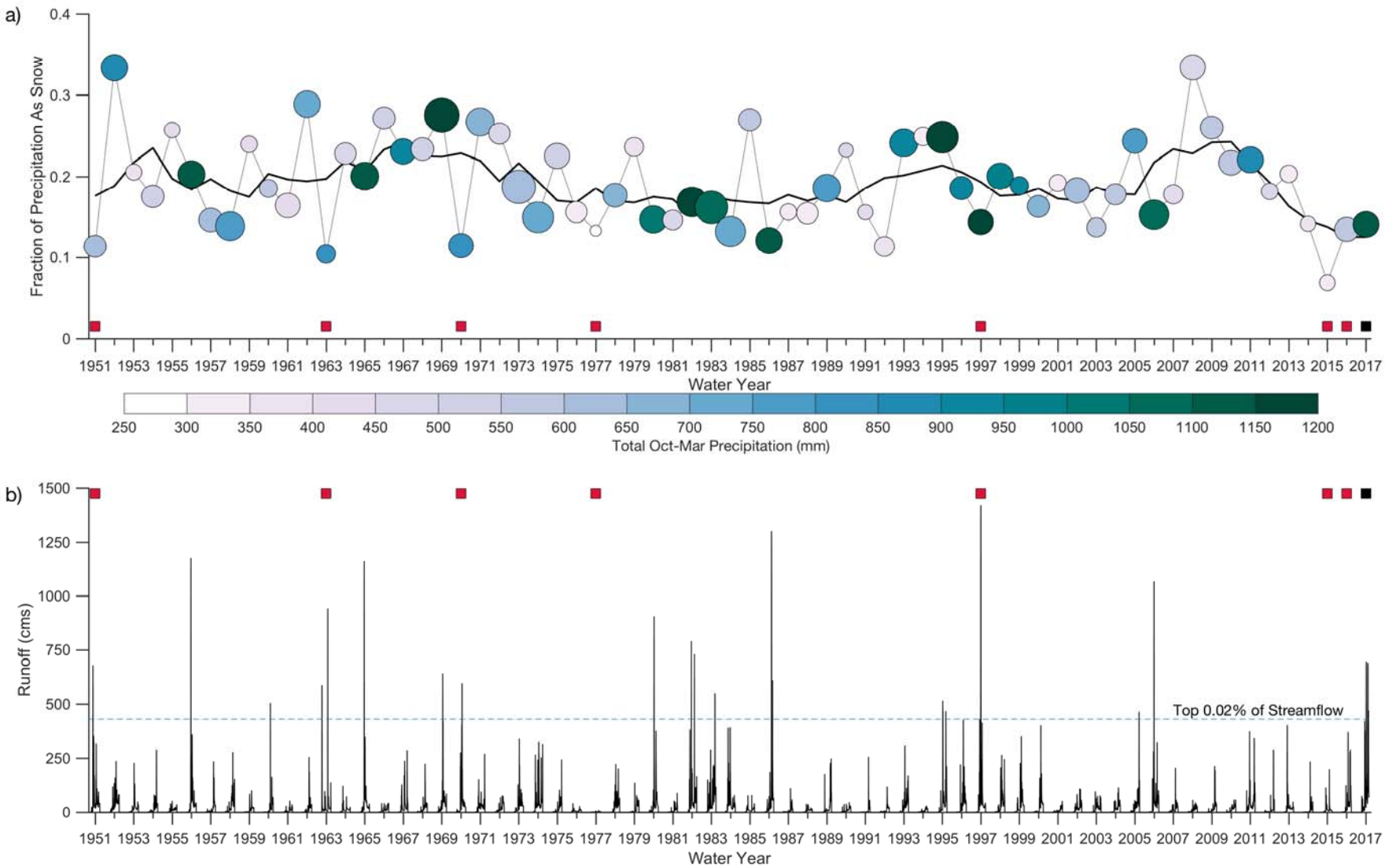
Harpold et al. (2017)
Hatchett and McEvoy (2018)



WY2018 Example



Mid-winter Runoff Peaks And Warm Snow Droughts (N. Fork American River)



Hatchett and McEvoy (2018)

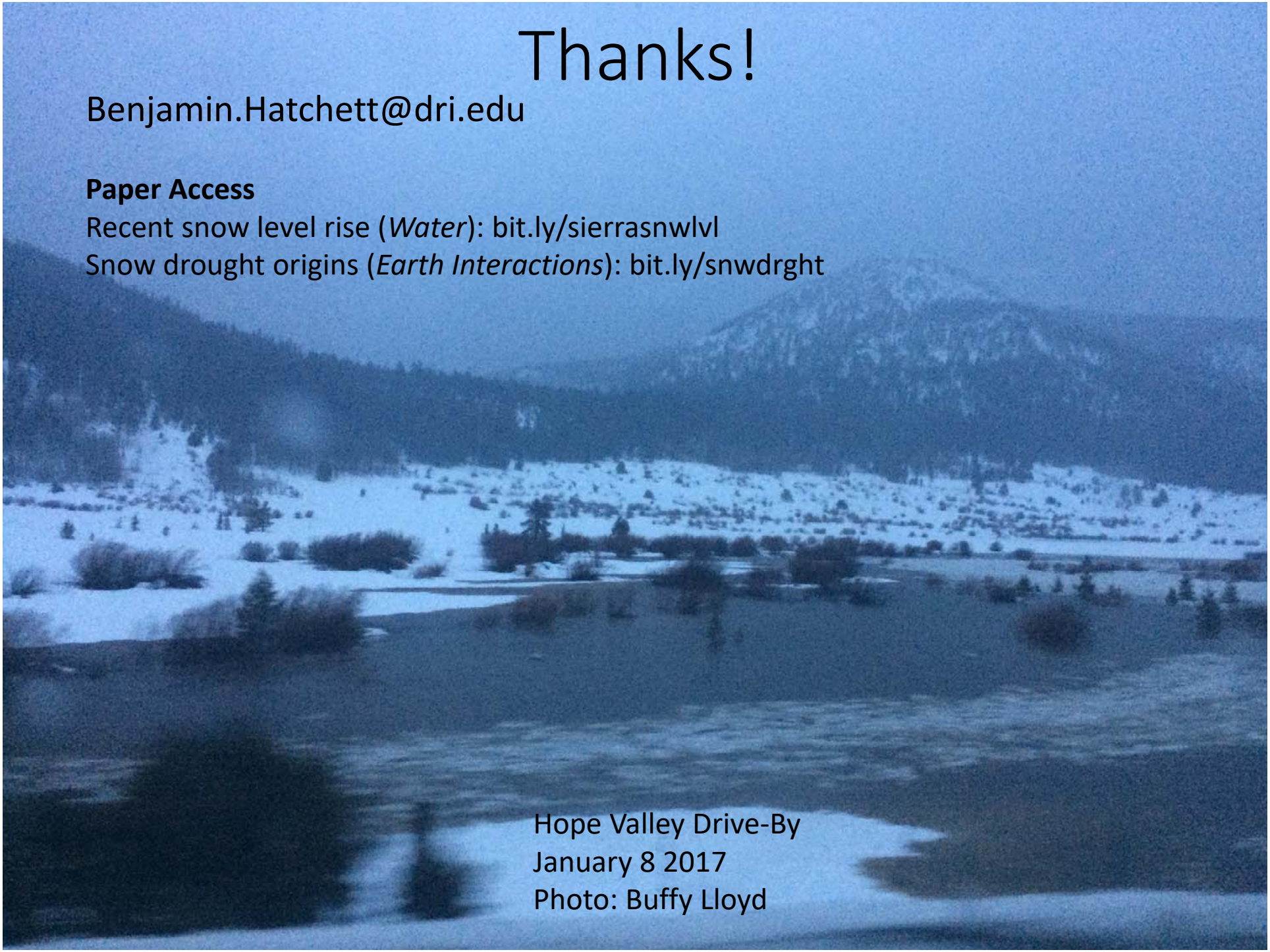
Thanks!

Benjamin.Hatchett@dri.edu

Paper Access

Recent snow level rise (*Water*): bit.ly/sierrasnwlvl

Snow drought origins (*Earth Interactions*): bit.ly/snwdrght



Hope Valley Drive-By
January 8 2017
Photo: Buffy Lloyd