Climate, snow, and soil moisture data set for the Tuolumne and Merced River watersheds, California, USA

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Abstract. We present hourly climate data to force land surface process models and assessments over the Merced and
15 Tuolumne watersheds in the Sierra Nevada, California, for the water year 2010-2014 period. Climate data (38 stations) includes temperature and humidity (23), precipitation (13), solar radiation (8), and wind speed and direction (8) spanning an elevation range of 333 to 2987 m. Each data set contains raw data as obtained from the source (level 0), data that are serially continuous with noise and non-physical points removed (level 1), and, where possible, data that are gap-filled using linear interpolation or regression with a nearby station record (level 2). All stations chosen for this data set were known or
20 documented to be regularly maintained and components checked and calibrated during the period. Additional time-series data included are available snow water equivalent records from automated stations (8) and manual snow courses (22), as well as distributed snow-depth and co-located soil-moisture measurements (2-6) from four locations spanning the rain-to-snow transition zone in the centre of the domain. Spatial data layers pertinent to snowpack modelling in this data set are basin polygons and 100-m resolution rasters of elevation, vegetation type, forest basal area, tree height, and forest canopy
25 cover, transmissivity, and extinction coefficient. All data are available from online data repositories (https://doi.org/10.6071/M3FH3D).

1 Introduction

The snowpack of the Sierra Nevada mountains provides at least 40% of California's water supply (Roos, 1989) and has historically stored an amount of water equivalent to more than half of the available Sierra foothill reservoir storage (Bales et

30 al., 2011). Snowpack in the western U.S. is highly vulnerable to climate warming, both in the recent past (Mote et al., 2005) and as expected in the coming decades, particularly at lower elevations (Fyfe et al., 2017; Miller et al., 2003; Young et al.,

2009). Melting snow sustains soil moisture, streams, and other water sources well into the very dry and warm Mediterranean summer that typifies the area (e.g. Yarnell et al., 2010). Building our intuition about the sensitivity of the snowpack to current and future climates, as well as storm paths and timing, is critical to the future management of these areas. Snowpack water storage affects forest fire, forest health, invasive and threatened species, recreation, flooding, and local and

5 downstream water supplies (Brekke et al., 2009; Dettinger, 2011; Ligare et al., 2012; Miller et al., 2009; Sala et al., 2000).

Soil moisture is the other major component of water storage in mountain ecosystems. As snowpack storage diminishes, it will be essential to understand changes in soil moisture as it pertains to plant-available water, evapotranspiration, and, ultimately, forest health (e.g. Bales et al., 2018; Asner et al., 2016). The 2012-2016 California drought, including the 2015

10 "snow drought" (Harpold et al., 2017), and associated large-scale forest mortality highlight the importance of assessments that investigate the coupled changes in snowpack and soil moisture in mountain forests.

The purpose of this paper is to introduce climate, soil-moisture, snow, and spatial data that may be used for hydrologic or land-surface assessments and modelling in the Tuolumne and Merced watersheds in the Sierra Nevada mountains of central

15 California (Figure 1; Tables 1, 2, 3). Hourly climate data and snow and soil-moisture measurements were derived from stations within and immediately adjacent to the basins. Spatial data include basin polygon files and 100-m resolution raster files of elevation, and vegetation properties. We describe data sources, processing, limitations, and where to obtain the data.

2 Area description

The study basins are west-draining watersheds on the broad western slope of the Sierra Nevada and ultimately tributaries to

20 the San Joaquin River. The climate is generally characterized by cool, wet winters and long warm, dry summers. Winter storms derive from large synoptic systems from the northern Pacific and more-focused and moisture-laden atmospheric rivers from further south in the Pacific. Indeed, the latter may produce 20-50% of annual precipitation for the area, and just a few storms may determine the difference between above-average water years and drought (Dettinger, 2011). Within the seasonal snow zone above 1800 m elevation, much of the landscape consists of broad interfluves between deep river canyons

on the Merced and Tuolumne Rivers, the area of Yosemite National Park. Most snowmelt runoff is generated between 2100 and 3000 m elevation, with up to 40% of runoff originating from elevations greater than 3000 m above existing measurements (Rice et al., 2011). Nearly 60% of the snowpack zone lies between the elevations of 2000 and 3000 m (Rice et al., 2011) and small changes in temperature during storms can result in large changes in runoff due to shifts in precipitation

5   phase. This is illustrated in Figure 2, where wet-season winter temperatures in this zone hover close to 0ºC in representative wet and dry years in the data set.

Dominant vegetation ranges from moisture-limited grasslands and oak woodlands below 1000 m elevation through ponderosa, mixed-conifer (sugar pine, incense cedar, Jeffrey pine, and white fir), and red-fir forests, to energy-limited

10   western white and lodgepole pine forests at and above 2500 m (Fites-Kaufman et al., 2007; Keeler-Wolf et al., 2012). Some of the largest and most productive forests in the world are located in the 1500-2000 m elevation range where there is neither moisture nor energy limitation (Kelly & Goulden, 2016; Matchett et al., 2015). Here, the mean winter temperature is a few degrees above freezing and precipitation averages 1100-1200 mm yr^{-1} (PRISM Climate Group, 2012).

15   Like all major river basins in California, the Tuolumne and Merced are vitally important water sources to the economy of the region. The watersheds provide water for a large agricultural region of the Central Valley between Merced in the south to Modesto in the north, fed primarily by Lake McClure on the Merced and Lake Don Pedro on the Tuolumne River. Further upstream on the Tuolumne River, the Hetch Hetchy water system supplies water to 2.6 million San Francisco and other Bay Area residents.

20   **3 Climate data**

The original intent of assembling this dataset was to force the snow energy- and mass-balance model iSnobal (Marks et al., 1999) at an hourly time step. The data represent the required parameters to drive the model: incoming solar radiation, temperature, relative humidity, wind speed and direction, and precipitation. That modelling effort (Roche et al., 2018) employed a subset of this data archive, which is described in succeeding sections (bold attributes in Table 2). Data were

obtained from the California Data Exchange Center (CDEC) for California Department of Water Resources stations, Western Regional Climate Center for Fire Remote Access Weather Station (RAWS) network stations, and the Scripps Institution of Oceanography (SIO), which operates a transect of stations across the Sierra through the middle of the study domain. All raw data (Level 0) were processed to be serially continuous and to remove noise and non-physical data (Level 1)

5   and gap-filled where possible using linear interpolation and regression with nearby stations (Level 2). Very few stations adequately measured all parameters and several stations have extensive periods with no data that precluded gap filling. As is typical in large mountain basins, instrumentation distribution is not uniform, often located where it is convenient to service, and heavily weighted to the lower elevations. More than two-thirds of the stations are below 2000 m elevation and no stations are located above 3000 m (Figures 1, 2). Above 1800 m, where seasonal snowpack occurs, there are three

10 precipitation measurement stations, two of which are rain-shadow affected (Figure 1). For this paper we have added the additional meteorological station and soil moisture data available in the same area, which provides a more complete hydrologic data set.

3.1 Temperature and humidity

Paired temperature (°C) and relative humidity (KPa KPa^{-1}) used for snow modelling were measured at 23 stations in this

15 dataset. Stations were chosen for modelling given known maintenance records at each site that assured minimal drift and accurate subsequent calculation of dew point and vapour pressure. Figure 3 illustrates dew-point and air temperature variability as recorded at Crane Flat Lookout over a two-week period in late 2012 and early 2013. Also shown is the dew-point lapse rate (using the methods of Marks et al. (1999)), which averaged -0.0055 and -0.0065°C m^{-1} during and between precipitation events. Temperature gradient varied from -0.0075 to -0.0044°C m^{-1} during wet periods and -0.0079 to -

20 0.0016°C m^{-1} during dry periods.

3.2 Precipitation

Hourly precipitation (mm) was the most difficult parameter to obtain and process. The best quality records were those obtained from stations equipped with tipping-bucket gauges that were below 1000 m elevation where snow and ice are minimal. Weighing gauges in Yosemite Valley (1208 m), Yosemite South Entrance (1511 m), and Stanislaus Powerhouse

(333 m), and Geonor™ gauges at Hetch Hetchy (1195 m) and the Crane Flat NOAA Climate Reference Network site (2017 m) were regularly maintained and appear to produce acceptable data. The only two high-elevation gauges were at Tuolumne Meadows (TUM) and Virginia Lakes Ridge (VLR) and both were accumulation-type gauges equipped with pressure transducers. The records from these gauges exhibit substantial diurnal expansion and contraction effects adding uncertainty

5   to the hourly records. To process these records, we first established a daily record by extracting the midnight value to minimize heating and cooling effects, differencing from the previous day and removing any negative values. For days with zero midnight values, all hourly values were set to zero. For days with non-zero accumulation, we first set all negative incremental values to zero and we examined data from the adjacent snow pillows, other stations with snow pillows in the vicinity, and compared the records of both TUM and VLR in order to weight the positive increments such that the sum

10   equalled the daily total. Given that these gauges recorded 50-60% of PRISM estimates in their respective elevation bands in water years 2011 and 2013 (Figure 2), the use of these records may be primarily to weight snow-pillow records as approximate measures of precipitation elsewhere in the basin (e.g. Lundquist et al., 2016), or as simple measures of precipitation timing rather than quantity.

3.3 Wind speed and direction

15   For snow modelling, we selected wind data from eight sites that were primarily located on open ridge lines in order to avoid the terrain- or forest-influenced winds. Terrain and vegetation effects could then be modelled using methods such as those of Winstral et al. (2009). Additional stations such as Tioga Pass Entrance Station (TES) and Gin Flat (GIN) provided a reference for forest wind speeds.

3.4 Solar radiation

20   All stations measured solar radiation using pyranometers that introduce substantial aspherical effects at dawn and dusk. Moreover, their calibration history was not known. Hence, the sites chosen for snow modelling were those with a largely complete record that spanned the domain and that exhibited minimal vegetation and terrain shading. As such, this record is best used as an estimate of cloudiness when combined with an independent estimate of incoming clear-sky solar radiation at each site. Other stations in the dataset exhibit substantially more terrain and vegetation shading influences.

4 Snow and soil moisture data

4.1 Snow water equivalent

We extracted all available monthly snow course and daily snow pillow data from CDEC for purposes of evaluating snow modelling performance. Missing snow-course data were not gap-filled, given substantial inter-site variability. Snow-pillow

5 data were checked for serial completeness and outliers and gap filled using linear interpolation only.

4.2 Snow depth and soil moisture

Snow-depth data were collected at four locations spanning the rain-to-snow transition zone along the Tioga Road at the Merced Grove (1810 m), Gin Flat (2149 m), Smoky Jack (2182 m), and Olmsted Quarry (2604 m). Each site contained 2-6 operational snow depth sensors arranged to sample various aspects and tree canopy cover. Snow data were filtered to remove

10 unrealistic depths and checked for serial continuity (Level 1) and then gap-filled using linear interpolation for periods of a few hours and regression with adjacent stations for larger gaps (Level 2). Soil-moisture data, included volumetric soil-moisture content and soil temperature, was collected at depths of 10, 30, 60, and, where possible, 90 cm below the ground surface at three of the snow depth measurement points within each of the four sites. Soil moisture data were processed in a manner similar to other measurements.

15 5 Spatial data

Spatial data included in this data set are basin polygons and raster files. All spatial data are in Universal Transverse Mercator (UTM) Zone 11 projection with the 1983 North American Datum. Basin polygons are in Earth Systems Research Institute (ESRI) ArcGIS shapefile format while raster files are in ESRI ArcGIS ASCII grid format. Raster files include 100-m resolution elevation (m), canopy cover (percent), generalized vegetation type, derived tree height (m), derived canopy

20 transmissivity (dimensionless), and canopy extinction coefficient (m^{-1}) (Table 4). The digital elevation model (DEM) was derived by resampling the 10-meter U.S. Geological Survey National Elevation Dataset (NED) using bilinear interpolation. All other raster data sets were aligned with this DEM. The resulting raster contained 1296 columns and 1107 rows. Vegetation type, canopy cover, and tree basal area were derived from the U.S. Forest Service 30-meter resolution California Region 5 Vegetation Maps (U.S. Forest Service, 2014) by determining the dominant over-story vegetation in each raster cell

(Wildlife Habitat Relation (WHR) Lifeform), or spatially averaging canopy cover or basal area within each raster cell. We calculated tree height using basal area and the allometric relation of Zhao et al. (2012). The WHR Lifeform designation was used to assign canopy transmissivity and extinction coefficients to each pixel as shown in Table 2 based on the values from Link and Marks (1999). Basin polygons for the Merced and Tuolumne watersheds are in ESRI ArcGIS shapefile format.

5 **6 Data availability**

All data presented in this paper are available on the California Digital Library (https://doi.org/10.6071/M3FH3D). Detailed metadata are associated with each file including contact information.

7 Summary

The dataset assembled here represents the nature of data available in sparsely instrumented mountain basins coupled with the

10 higher-quality SIO Sierra transect and complimentary snow-depth and soil-moisture dataset that has undergone quality control and gap filling. While it was used for one snow-modelling effort (Roche et al, 2018), there are many opportunities to use the data for other applications, combining available raster datasets (PRISM, Basin Characterization Model, etc.), and testing the sensitivity of using more or fewer stations for estimating the attribute of interest. One outstanding use of the dataset is an assessment of the temporal evolution of soil moisture with respect to snow accumulation and ablation across the

15 rain-to-snow transition zone. Given the stark lack of measured short- and long-wave radiation in the watershed, other estimates of these attributes may be used to explore the sensitivity of model results. It is important for these kinds of data to be available for longer periods of time and in other watersheds in order to apply data-driven land surface modelling efforts that seek to minimize calibration in order to more robustly assess stressors on ecosystems.

Author contributions

20 RB, RR, MD, DC, DA, and MC designed the University of California Merced (UCM) and Scripps Institution of Oceanography (SIO) instrument networks. RR, DC, MD, DA, and JR installed and maintained these same networks. DA,

RR, XM, JR, SP, and MM processed UCM, SIO, and external network station data. JR prepared the manuscript with

contributions from all authors.

Competing interests

The authors declare that they have no conflicts of interest.

5   **Special issue statement**

This article is part of the special issue "Hydrometeorological data from mountain and alpine research catchments". It is not

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Table 1. Measurements, operator, and instrumentation at each site.

Measurement	Operator / Instruments[1]	Instrument height (m)
Air temperature	RAWS (various[2])	5
	SIO, UCM (in-house-calibrated thermistors)	
	CA-DWR (Vaisala HMP45A/H DUS, Dana Meadow; FTS THS-3, Mariposa Grove)	
Relative humidity	RAWS (various[2])	5
	SIO, UCM (Sensirion, SHT15DV)	
	CA-DWR (Vaisala HMP45A/H DUS, Dana Meadow; FTS THS-3, Mariposa Grove)	
Precipitation	RAWS (Tipping bucket (typical); various[2])	3
	MID (Weighing-type, ETI Instrument Systems; tipping bucket, Briceburg)	3
	CRN (Geonor™)	
	NRCS (storage with pressure transducer)	3
	DWR (storage with pressure transducer)	5
	PGE (Weighing-type, ETI Instrument Systems)	5
	HHWP (Geonor™)	3
		3
Solar radiation	RAWS (Pyranometer, LICor 441A (typical)[2])	5
	CA-DWR (LICor 441A)	
Wind speed / direction	RAWS (various[2])	5
	CA-DWR (Vaisala 425A Ultrasonic)	
	UCM (3D sonic anemometer)	
Snow depth	Judd ultrasonic depth sensor	n/a
Soil moisture	Decagon Devices, 5TE	n/a

[1] Operator abbreviations are: RAWS – Interagency Fire Remote Access Weather Station network managed by the Bureau of Land Management; SIO –

Scripps Institution of Oceanography; UCM – University of California Merced; CA-DWR – California Department of Water Resources; MID – Merced

Irrigation District; HHWP – Hetch Hetchy Water and Power; NRCS – Natural Resource Conservation Service; PGE – Pacific Gas and Electric; NOAA –

5   National Oceanic and Atmospheric Administration Climate Reference Network.

[2] See RAWS (various; see https://famit.nwcg.gov/applications/RAWS) for a description of instrument types.

Table 2. Meteorological stations and data used to force model.

Station name[1]	Elev., m	UTM easting[2], m	UTM northing[2], m	Measurements used[3]	Operator[4]
Green Springs (GRN)	311	4193067	191966	**t, rh, p,** sr, w	RAWS
Stanislaus Powerhouse (SPW)	333	4225930	204880	**p**	PGE
Cathey's Valley (CVR)	366	4151342	224905	**t, rh, p**	RAWS
Briceburg (MBB)[5]	670	4153062	238501	**p**	MID
Mariposa (MRP)	680	4154996	235967	**t, rh, p**	RAWS
Priest Reservoir (PRR-SIO)	709	4189078	212647	**t, rh**	SIO
Metcalf Gap (MCF)	938	4143892	255011	**t, rh,** sr, w	RAWS
Batterson (BTT)	943	4140575	268301	**p**	RAWS
Dudley Ranch (DUC)	1114	4151264	224864	**p**	MID
Smith Peak (SEW)	1168	4188222	226980	**sr, w,** p, t, rh	RAWS
Smith Peak (SEW-SIO)	1168	4188222	226980	**t, rh**	SIO
Jerseydale (JSD)	1189	4158967	249214	**t, rh,** sr, w	RAWS
Hetch Hetchy (HEM)	1195	4203412	255489	**p**	HHWP
Wawona (WWN)	1235	4158119	265654	**t, rh, sr**	RAWS
Yosemite Valley (YYV)	1208	4181238	271843	**p**	MID
Miami Mountain (MIA)	1321	4144912	257059	**t, rh, sr, w**	RAWS
Sunset Inn (SUN-SIO)	1371	4188288	245001	**t, rh**	SIO
Hodgdon (HDG-SIO)	1397	4187075	248304	**t, rh**	SIO
Mount Elizabeth (MTE)	1504	4217791	215134	**t, rh, sr, w**	RAWS
Yosemite South Entrance (YOW)	1511	4154480	267291	**p**	MID
Forty Mile (FTY-SIO)	1723	4184565	247936	**t, rh**	SIO
Pinecrest (PNW)	1738	4230750	236322	**t, rh, sr, w**	RAWS
Merced Grove (MEG-SIO)	1810	4183446	249675	**t, rh**	SIO
Mariposa Grove (MPG)	1951	4154932	269754	**t, rh,** w, sr, p	RAWS
Crane Flat (CFL-CRN)	2017	4182829	251510	**p**	NOAA
Crane Flat Lookout (CFL)	2026	4182878	251530	**t, rh, sr, w,** p	RAWS
Gin Flat (GIN-SIO)	2149	4183578	255577	**t, rh**	SIO
Gin Flat (GIN)	2149	4183578	255577	t, rh, w, p, sr	CA-DWR
Fresno Dome (FRS)	2177	4149346	275698	**t, rh, w**	UCM
Smoky Jack (SMK-SIO)	2182	4188935	261192	**t, rh**	SIO
White Wolf (WHW)	2408	4193540	266732	**t, rh, sr, w**	RAWS
Ostrander Lake (STR)	2499	4168599	274999	t, rh, w	CA-DWR
Horse Meadow (HRS)	2560	4226695	266766	t	CA-DWR
Olmsted Quarry (OLM-SIO)	2604	4187768	279089	**t, rh**	SIO

Station name[1]	Elev., m	UTM easting[2], m	UTM northing[2], m	Measurements used[3]	Operator[4]
Tuolumne Meadows (TUM)	2622	4194700	293480	**p,** t, sr	CA-DWR
Virginia Lakes Ridge (VRG)	2879	4215567	304085	**p**	NRCS
Dana Meadow (DAN)	2988	4196683	301507	**t, rh, sr, w**	CA-DWR
Tioga Pass Entry Station (TES)	3041	4198329	301461	t, rh, w	CA-DWR

[1]Station name abbreviations: Three letter abbreviations are derived from conventions in the California Data Exchange Commission database (http://cdec.water.ca.gov/). Abbreviations ending with "-SIO" indicate stations operated by Scripps Institution of Oceanography that are not currently available through CDEC. CFL-CRN indicates the NOAA Climate Reference Network Station located near the Crane Flat Lookout.

[2]Geographic coordinates are in Universal Transverse Mercator (UTM) projection, North American 1983 Datum, Zone 11.

5 [3]Variable abbreviations: p, precipitation; rh, relative humidity; sr, solar radiation; t, air temperature; w, wind speed and direction.

[4]Operator abbreviations are: RAWS – Interagency Fire Remote Access Weather Station network managed by the Bureau of Land Management; SIO – Scripps Institution of Oceanography; UCM – University of California Merced; CA-DWR – California Department of Water Resources; MID – Merced Irrigation District; HHWP – Hetch Hetchy Water and Power; NRCS – Natural Resource Conservation Service; PGE – Pacific Gas and Electric; NOAA – National Oceanic and Atmospheric Administration Climate Reference Network.

10 [5]Actually located in the town of Mariposa, CA.

Table 3. Snow and soil moisture data sources.

Station name[1]	Elev., m	UTM northing[2], m	UTM easting[2] m	Data type[3]
Merced Grove (MEG-SIO)	1810	4183446	249675	distributed snow depth, soil moisture
Bell Meadow (BEM)	1981	4228435	242260	monthly swe
Beehive Meadow (BHV)	1981	4208908	255883	monthly swe
Lower Kibbie (LKB)	2042	4213387	247407	monthly swe
Lake Vernon (VNN)	2042	4211186	261488	monthly swe
Upper Kibbie Ridge (UKR)	2042	4214521	246651	monthly swe
Kerrick Ranch (KRC)	2134	4229596	240718	monthly swe
Gin Flat (GFL)	2134	4183363	255739	monthly swe
	2134	4183578	255576	daily swe
Gin Flat (GIN-SIO)	2134	4183350	255550	distributed snow depth, soil moisture
Peregoy Meadow (PGM)	2134	4172111	268473	monthly swe
Smoky Jack (SMK-SIO)	2182	4188935	261192	distributed snow depth, soil moisture
Paradise Meadow (PDS)	2332	4214396	265710	monthly swe
	2332	4214326	265612	daily swe
Huckleberry Lake (HCL)	2377	4220692	259308	monthly swe
Spotted Fawn Lake (SPF)	2377	4219616	258135	monthly swe
Sachse Spring (SAS)	2408	4219048	251182	monthly swe
White Wolf (WHW)	2408	4193540	266732	daily swe
Wilma Lake (WLW)	2438	4218298	269071	monthly swe
Tenaya Lake (TNY)	2484	4190665	284584	monthly swe
	2484	4190534	284349	daily swe
Ostrander Lake (STR)	2499	4168599	274999	monthly swe
	2499	4168565	274701	daily swe
Horse Meadow (HRS)	2560	4226695	266766	monthly swe
	2560	4227164	266940	daily swe
Olmsted Quarry (OLM-SIO)	2604	4187768	279089	distributed snow depth, soil moisture
Tuolumne Meadow (TUM)	2621	4194327	293307	monthly swe
Snow Flat (SNF)	2652	4189558	280239	monthly swe
New Grace Meadow (NGM)	2713	4225694	270684	monthly swe
Slide Canyon (SLI)	2797	4218724	286737	daily swe

Station name[1]	Elev., m	UTM northing[2], m	UTM easting[2] m	Data type[3]
Bond Pass (BNP)	2835	4228817	270246	monthly swe
Rafferty Meadow (RFM)	2865	4190277	295406	monthly swe
Dana Meadow (DAN)	2987	4196789	301552	monthly swe
	2987	4196756	301486	daily swe

[1]See footnote 1 in Table 1.

[2]See footnote 2 in Table 1.

[3]Data type explanations: monthly swe denotes manually measured snow courses, hourly swe indicates a snow-pillow site, and distributed snow depth indicates sites with 4-6 snow depth sensors distributed across an area of approximately 100 meters square.

Table 4. Canopy parameters (adapted from Link and Marks (1999)).

Vegetation class	tau (τ)	mu (μ)
Herbaceous, sparse shrub, non-vegetated	1	0
Conifer forest/woodland	0.2	0.040
Mixed conifer and hardwood	0.3	0.033
Hardwood forest/woodland	0.4	0.025
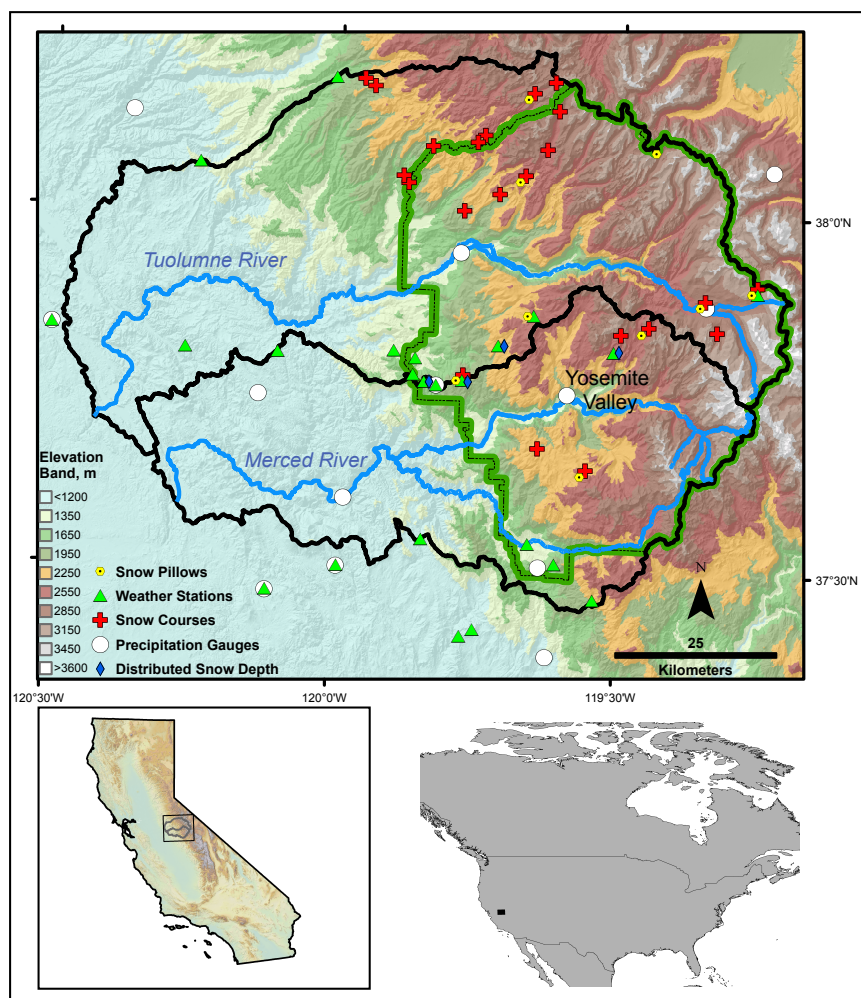
Figure 1: Hydrometeorological stations in and adjacent to the Merced and Tuolumne watersheds used in this data set. Co-located
5 **station types are offset for clarity. Yosemite National Park is demarked by the green boundary.**
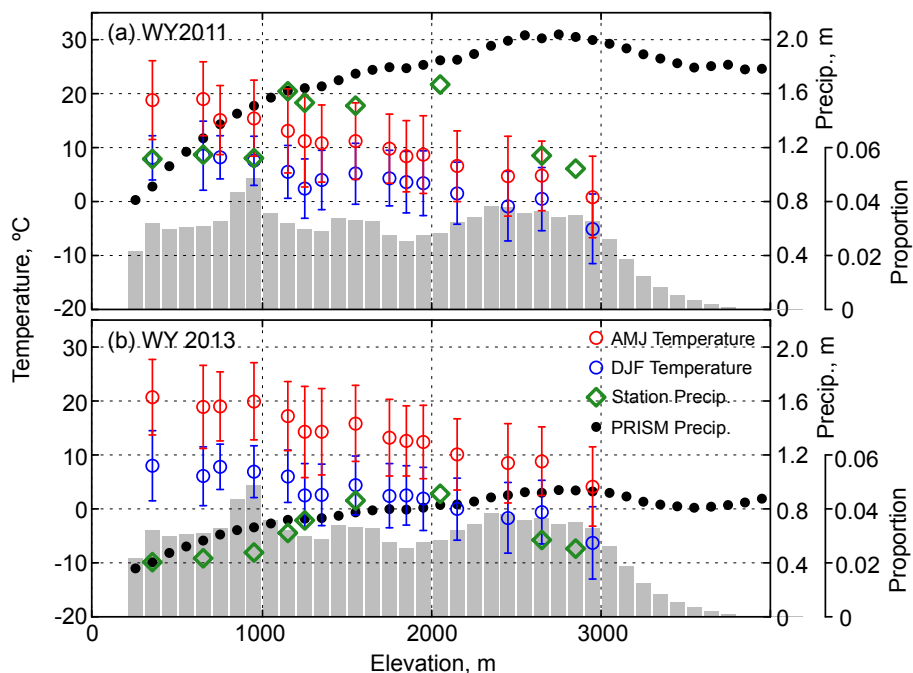
Figure 2: Elevation transects of temperature and precipitation in (a) wet and cold water year 2011, and (b) dry and warm 2013. Temperatures are three-month means and standard deviations during the main snowpack accumulation period (December-February) and the main snowmelt season (April-June). Precipitation and temperature station data were averaged by 100-m elevation band. Shaded area is the proportional basin area in each 100-m elevation band.
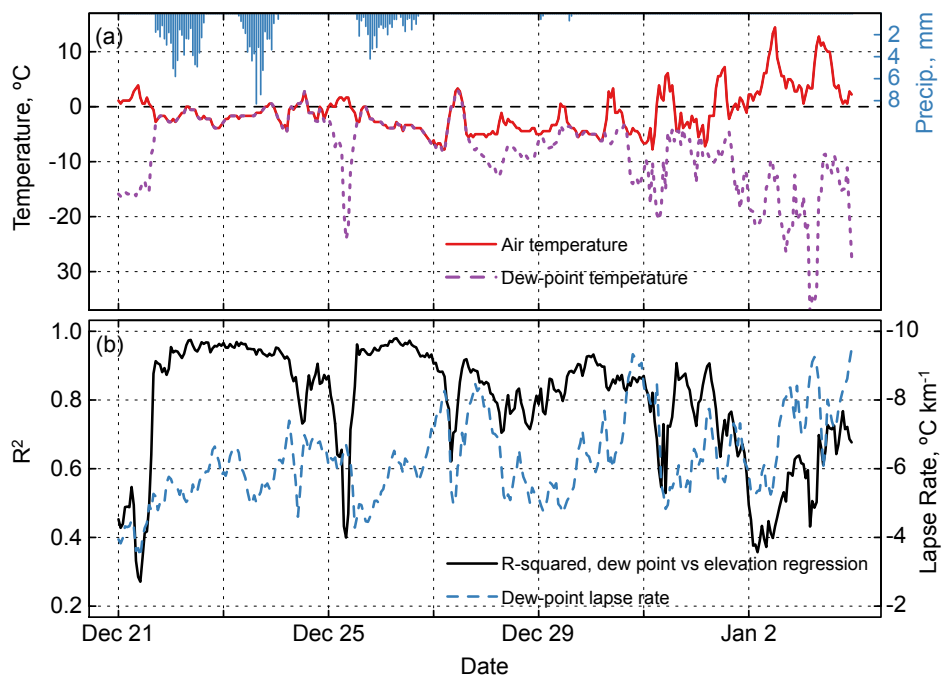
Figure 3: (a) Hourly time-series of air temperature, dew-point temperature, and precipitation as recorded at Crane Flat Lookout RAWS and Crane Flat CRN stations for a two-week period from December 21, 2012 through January 3, 2013. (b) Dew point lapse rate and corresponding coefficient of determination for the same period.