Real Time Snow Water Equivalent (SWE) Simulation
February 5, 2014
Sierra Nevada Mountains, California

Introduction

We have developed a real-time SWE estimation scheme based on historical SWE reconstructions between 2000-2012, a near real time MODIS/MODSCAG image, and daily in situ SWE measurements for the Sierra Nevada in California (Molotch, 2009; Molotch and Margulies, 2008; Molotch and Bales, 2006; Molotch and Bales, 2005, Molotch, et. al., 2004 and Guan). Real-time SWE will be released on a weekly basis during the maximum snow accumulation/ablation period.

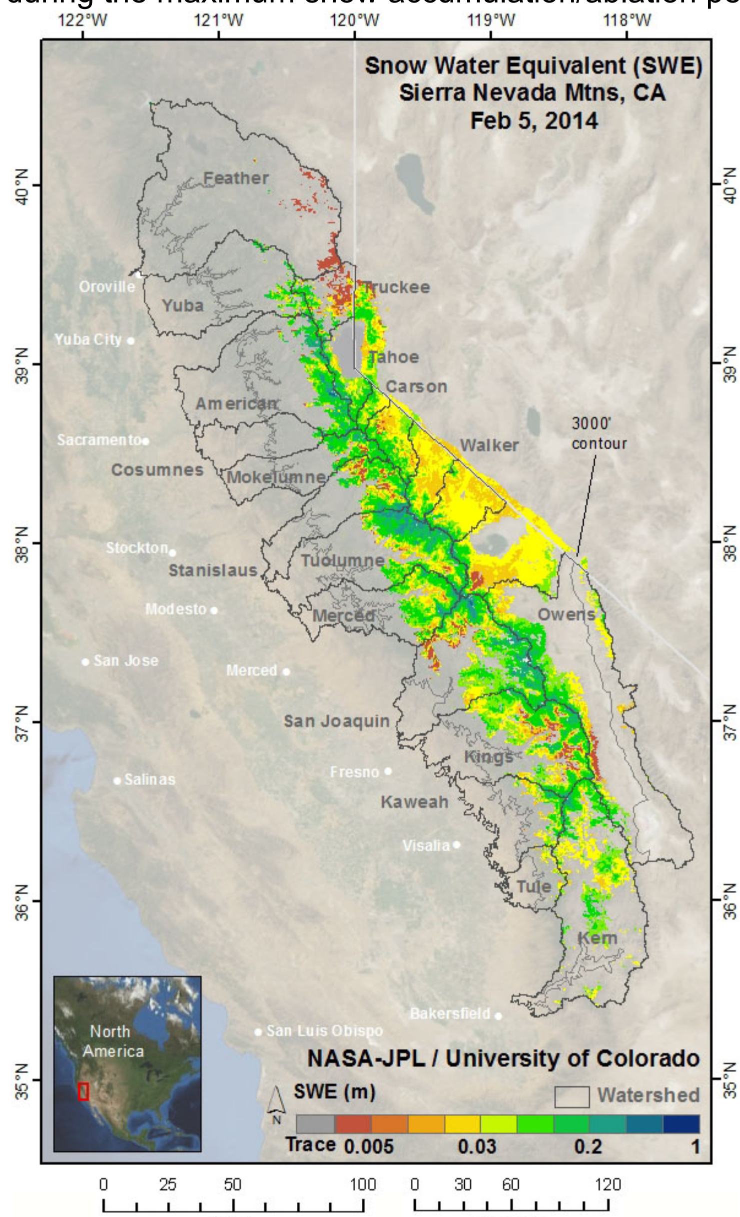

Figure 1. SWE amounts for February 5, 2014 are shown in the map above.

Discussion

The most recent cloud-free MODIS/MODSCAG image available is for February 5, 2014. Figure 1 shows SWE amounts for February 5, 2014. On February 5, 2014, 78 snow sensors in the Sierra network were recording snow out of a total of 99 sensors. For comparison in 2012, a very dry year, 85 out of 99 recorded snow on February 5th, and in 2009, a normal year, 89 out of 99 sensors recorded snow on February 5th. Note the locations of sensors that aren't recording snow (shown in yellow in Figure 3, left map) are lower elevation sensors in the north and a number that are offline in other strategic locations, so calculations from sensors alone do not accurately calculate SWE for each watershed. Figure 2 shows the percent of average SWE for February 5, 2014 for the snow-covered area on left and on the right is the mean percent of average for February 5, 2014 shown by watershed for all model pixels above 3000' (shown as gray elevation contour line on left map). Note that watershed averages are much lower than those calculated using snow sensors alone. Snow sensors produce a point value whereas the spatial SWE allows for areal calculations. Every square foot above 3000' in the watershed can be used to calculate the mean, therefore the mean value will be different than those calculated by snow sensor point data. Figure 3 shows the 13 year modeled average SWE for March 1st (reanalysis SWE modeling begins on March 1st each year) on the left with snow sensors shown in yellow that recorded no snow on February 5, 2014 and in red for sensors that recorded snow on February 5, 2014; and a banded elevation map on the right. Table 1 shows mean SWE and mean % of Average SWE for February 5, 2014, summarized for each watershed above 3000'. Table 2 shows mean SWE by elevation band inside each watershed for February 5, 2014 and the mean percent of average by watershed for February 5, 2014.

Important Note: Some mean percent of average values in Table 2 are high because of snow cover east of the Sierras in low elevation areas. Typically there is no or very low snow there when SWE models are run starting March 1st, and there are no sensors there for valid real time SWE values. Please take this into consideration when viewing average values for eastern Sierra watersheds.

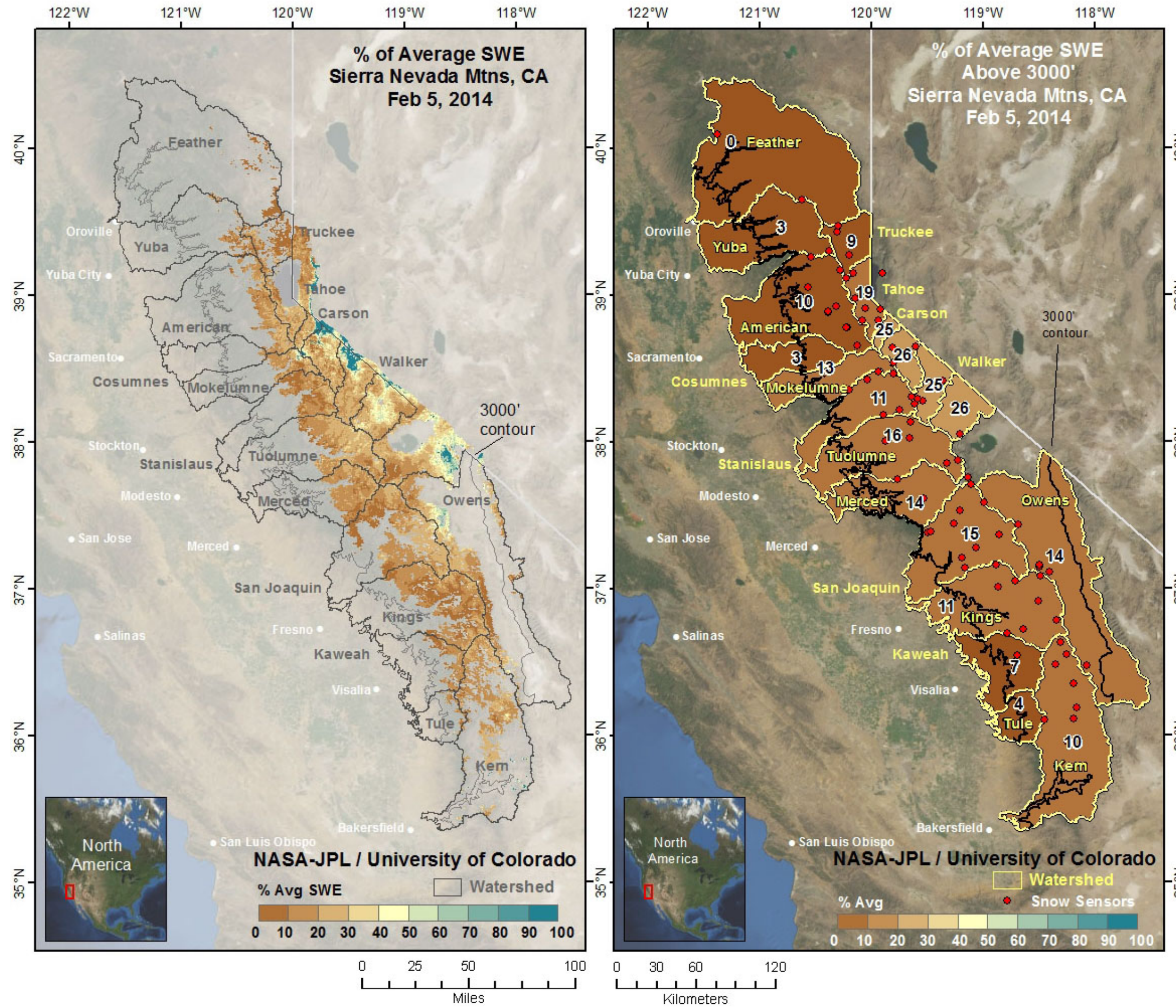

Figure 2. Percent of average SWE for February 5, 2014 for the entire Sierra (on left) and by watershed (on right). Watershed percentages are calculated for all model pixels above 3000' (shown as gray line on left map). SWE snow sensors that had snow on February 5, 2014 have been added to the map on the right

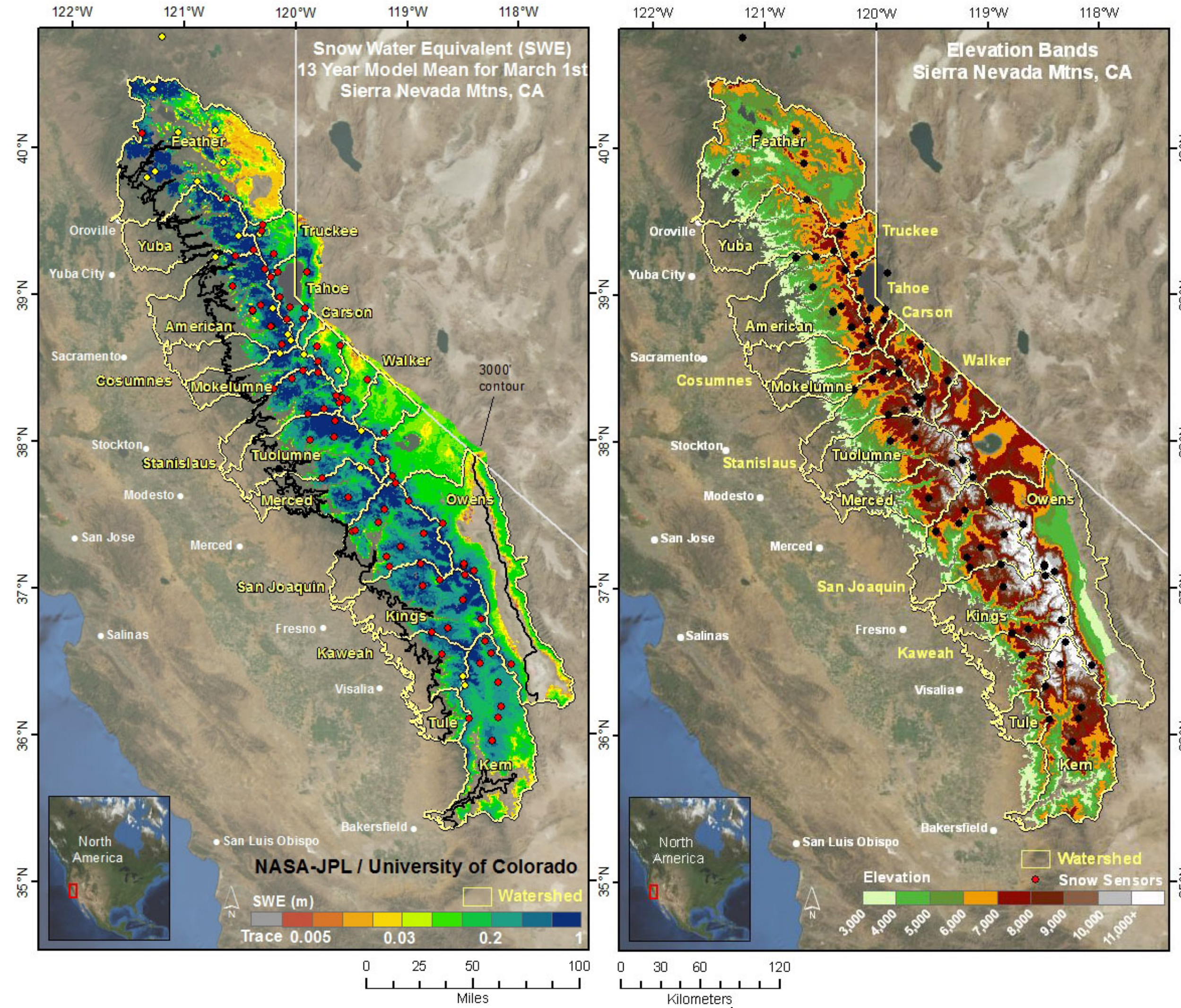

Figure 3. 13 year modeled average SWE for March 1st (SWE modeling begins on March 1st each year) on the left with snow sensors shown in yellow that recorded no snow (see discussion above for an explanation) and in red for sensors that recorded snow on February 5, 2014; and a banded elevation map on the right.

Methods

Results for the date of February 5, 2014 are based on February 5, 2014 real-time data from 78 in situ SWE measurements distributed across the Sierra Nevada, one Moderate Resolution Imaging Spectroradiometer (MODIS)/Terra Snow cover daily cloud-free image which has been processed using the MODSCAG fractional snow cover program (Painter, et. al. 2009), a normalized reconstructed spatial SWE image for March 1, 2009, and an anomaly map based on 13 years of modeled SWE (2000-2012). Relative to snow stations and the NWS SNODAS product, the spatial reconstructed SWE product correlates strongly with full natural flow, especially late in the snowmelt season (Guan, et. al. 2013).

Table 1. All calculations are for elevations above 3000’, which currently contain many 0 value pixels thereby making the mean much lower than those calculated by snow sensors. Shown are mean SWE and mean % of Average SWE for February 5, 2014. See note in discussion above for high averages in Eastern Sierra watersheds.

Watershed	2/5/14 SWE (in)	2/5/14 % Avg to Date
AMERICAN	1.18	9.90
FEATHER	0.03	0.22
KAWEAH	0.64	7.42
KERN	1.01	10.17
KINGS	1.75	10.99
TAHOE	4.39	19.18
MERCED	1.58	13.80
OWENS	0.85	13.75
SAN JOAQUIN	2.55	15.18
STANISLAUS	1.57	10.63
TRUCKEE	1.34	8.63
TUOLUMNE	2.46	16.45
YUBA	0.29	2.53
COSUMNES	0.09	2.77
MOKELUMNE	1.36	12.70
TULE	0.21	3.71
WEST WALKER RIVER	2.43	25.10
EAST WALKER RIVER	2.06	26.16
WEST FORK CARSON RIVER	3.73	25.26
EAST FORK CARSON RIVER	2.89	26.22

Table 2. Mean SWE, mean % of Average SWE for February 5, 2014, and area in square miles for each elevation band inside each watershed. See note in discussion above for high averages in Eastern Sierra watersheds.

Watershed	Elevation	2/5/14 SWE (in)	2/5/14 % Avg to Date	Area Sq Mi
AMERICAN	3000-4000'	0.00	0.00	191.9
	4000-5000'	0.00	0.09	249.3
	5000-6000'	0.06	0.41	294.8
	6000-7000'	1.81	6.13	296.4
	7000-8000'	6.59	17.75	175.7
	8000-9000'	8.38	20.88	74.2
	9000-10,000'	11.41	23.24	8.9
COSUMNES	3000-4000'	0.00	0.00	77.8
	4000-5000'	0.00	0.00	84.7
	5000-6000'	0.00	0.00	63.6
	6000-7000'	0.57	2.41	28.1
	7000-8000'	5.02	14.48	8.6
E CARSON	5000-6000'	1.32	68.15	32.7
	6000-7000'	1.68	26.83	77.7
	7000-8000'	2.61	24.94	102.6
	8000-9000'	4.01	25.57	96.5
	9000-10,000'	4.42	25.02	29.7
	10,000-11,000'	4.29	25.27	13.5
	> 11,000'	8.15	26.37	0.3
E WALKER	6000-7000'	1.66	44.50	73.6
	7000-8000'	1.43	32.03	157.4
	8000-9000'	1.39	21.80	154.9
	9000-10,000'	2.76	22.53	63.1
	10,000-11,000'	5.33	24.55	48.8
	> 11,000'	6.18	24.31	7.8
FEATHER	3000-4000'	0.00	0.00	286.2
	4000-5000'	0.00	0.00	735.8
	5000-6000'	0.00	0.01	1305.1
	6000-7000'	0.05	0.32	871.3
	7000-8000'	0.27	1.24	124.6
	8000-9000'	1.88	7.42	5.2
KAWEAH	3000-4000'	0.01	0.35	74.4
	4000-5000'	0.02	0.50	64.8
	5000-6000'	0.01	0.15	60.9
	6000-7000'	0.19	1.40	63.1
	7000-8000'	1.07	5.72	63.5
	8000-9000'	2.16	9.96	56.3
	9000-10,000'	2.59	11.00	38.8
	10,000-11,000'	5.78	15.22	36.6
	> 11,000'	8.03	18.64	8.9
KERN	3000-4000'	0.04	3.10	175.2
	4000-5000'	0.05	2.37	221.9
	5000-6000'	0.07	1.40	273.6
	6000-7000'	0.26	2.94	391.9
	7000-8000'	1.15	9.55	334.9
	8000-9000'	1.92	13.86	308.7
	9000-10,000'	1.33	9.34	166.3
	10,000-11,000'	1.95	10.00	149.7
	> 11,000'	5.07	18.71	142.5

KINGS	3000-4000'	0.01	0.40	83.1
	4000-5000'	0.02	0.44	92.8
	5000-6000'	0.04	0.39	95.0
	6000-7000'	0.43	2.47	136.0
	7000-8000'	1.48	6.98	170.0
	8000-9000'	1.81	8.98	209.9
	9000-10,000'	1.97	9.77	187.6
	10.000-11.000'	3.73	14.07	221.4
	> 11,000'	6.52	19.46	199.5
MERCED	3000-4000'	0.00	0.00	138.3
	4000-5000'	0.07	1.37	88.7
	5000-6000'	0.03	0.39	72.9
	6000-7000'	1.28	7.12	78.3
	7000-8000'	2.95	14.17	132.8
	8000-9000'	2.99	15.18	124.1
	9000-10,000'	4.22	17.68	76.2
	10.000-11.000'	7.71	20.05	50.6
	> 11,000'	11.48	21.48	13.5
MOKELUMNE	3000-4000'	0.00	0.00	83.3
	4000-5000'	0.01	0.19	87.2
	5000-6000'	0.08	0.59	84.0
	6000-7000'	0.94	4.24	72.7
	7000-8000'	4.93	16.17	85.9
	8000-9000'	6.54	23.54	81.2
	9000-10,000'	7.76	23.58	7.8
	10.000-11.000'	9.85	22.27	0.1
OWENS	3000-4000'	0.00	0.00	184.1
	4000-5000'	0.00	0.00	428.5
	5000-6000'	0.00	0.21	254.6
	6000-7000'	0.12	2.18	255.2
	7000-8000'	0.62	8.88	302.6
	8000-9000'	1.64	15.92	165.3
	9000-10,000'	2.15	16.92	112.4
	10.000-11.000'	3.40	19.46	188.0
	> 11,000'	6.03	22.62	167.2
SAN JOAQUIN	3000-4000'	0.00	0.01	76.2
	4000-5000'	0.00	0.02	93.8
	5000-6000'	0.04	0.51	130.9
	6000-7000'	0.35	2.65	183.9
	7000-8000'	1.60	9.12	214.5
	8000-9000'	2.98	13.75	194.1
	9000-10,000'	4.06	16.45	173.8
	10.000-11.000'	6.74	20.15	188.0
	> 11,000'	9.10	23.06	146.3
STANISLAUS	3000-4000'	0.00	0.00	61.6
	4000-5000'	0.00	0.00	100.0
	5000-6000'	0.02	0.12	105.7
	6000-7000'	0.77	3.36	142.3
	7000-8000'	2.83	10.88	145.4
	8000-9000'	4.40	16.10	121.9
	9000-10,000'	6.67	20.40	47.1
	10.000-11.000'	9.89	23.47	18.0
	> 11,000'	7.93	25.13	0.7

TAHOE	6000-7000'	2.35	15.90	103.2
	7000-8000'	5.01	18.11	74.7
	8000-9000'	6.76	22.35	51.3
	9000-10,000'	7.20	24.75	12.1
	10.000-11.000'	6.33	23.66	0.9
TRUCKEE	5000-6000'	0.36	5.22	51.2
	6000-7000'	0.62	4.87	254.6
	7000-8000'	2.95	12.23	111.9
	8000-9000'	5.03	17.37	14.1
TULE	3000-4000'	0.04	0.99	34.9
	4000-5000'	0.06	1.28	48.0
	5000-6000'	0.07	1.18	51.8
	6000-7000'	0.27	2.55	45.2
	7000-8000'	1.21	7.90	27.0
	8000-9000'	1.62	9.68	15.7
	9000-10,000'	1.09	5.81	5.8
TUOLUMNE	3000-4000'	0.00	0.00	122.4
	4000-5000'	0.00	0.00	149.9
	5000-6000'	0.11	1.08	172.8
	6000-7000'	0.91	5.19	149.0
	7000-8000'	3.28	12.93	151.1
	8000-9000'	5.41	18.86	170.9
	9000-10,000'	7.45	22.70	152.7
	10.000-11.000'	8.59	24.25	116.7
	> 11,000'	8.63	23.33	28.8
W CARSON	4000-5000'	2.22	166.66	1.6
	5000-6000'	1.92	60.94	16.8
	6000-7000'	2.83	23.32	8.3
	7000-8000'	3.46	22.67	35.6
	8000-9000'	4.49	24.78	32.7
	9000-10,000'	5.49	23.85	9.5
	10.000-11.000'	7.38	23.82	2.3
W WALKER	5000-6000'	1.57	120.16	46.8
	6000-7000'	1.59	39.67	60.0
	7000-8000'	1.23	24.52	91.4
	8000-9000'	1.59	21.08	93.8
	9000-10,000'	4.14	22.11	73.3
	10.000-11.000'	5.96	23.20	42.4
	> 11,000'	4.64	23.25	2.6
YUBA	3000-4000'	0.00	0.00	168.8
	4000-5000'	0.00	0.00	202.8
	5000-6000'	0.00	0.00	188.0
	6000-7000'	0.59	1.79	238.7
	7000-8000'	2.16	6.35	123.0
	8000-9000'	5.96	16.00	6.3

Location of Reports and Excel Format Tables
ftp://snowserver.colorado.edu/pub/fromLeanne/forCADWR/Near_Real_Time_Reports/

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