

Real Time Snow Water Equivalent (SWE) Simulation May 15, 2012 Sierra Nevada Mountains, California

Introduction

This report is a beta product and subject to revision. We are developing a real-time SWE estimation scheme based on historical SWE reconstructions between 2000-2009, a near real time MODIS 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.

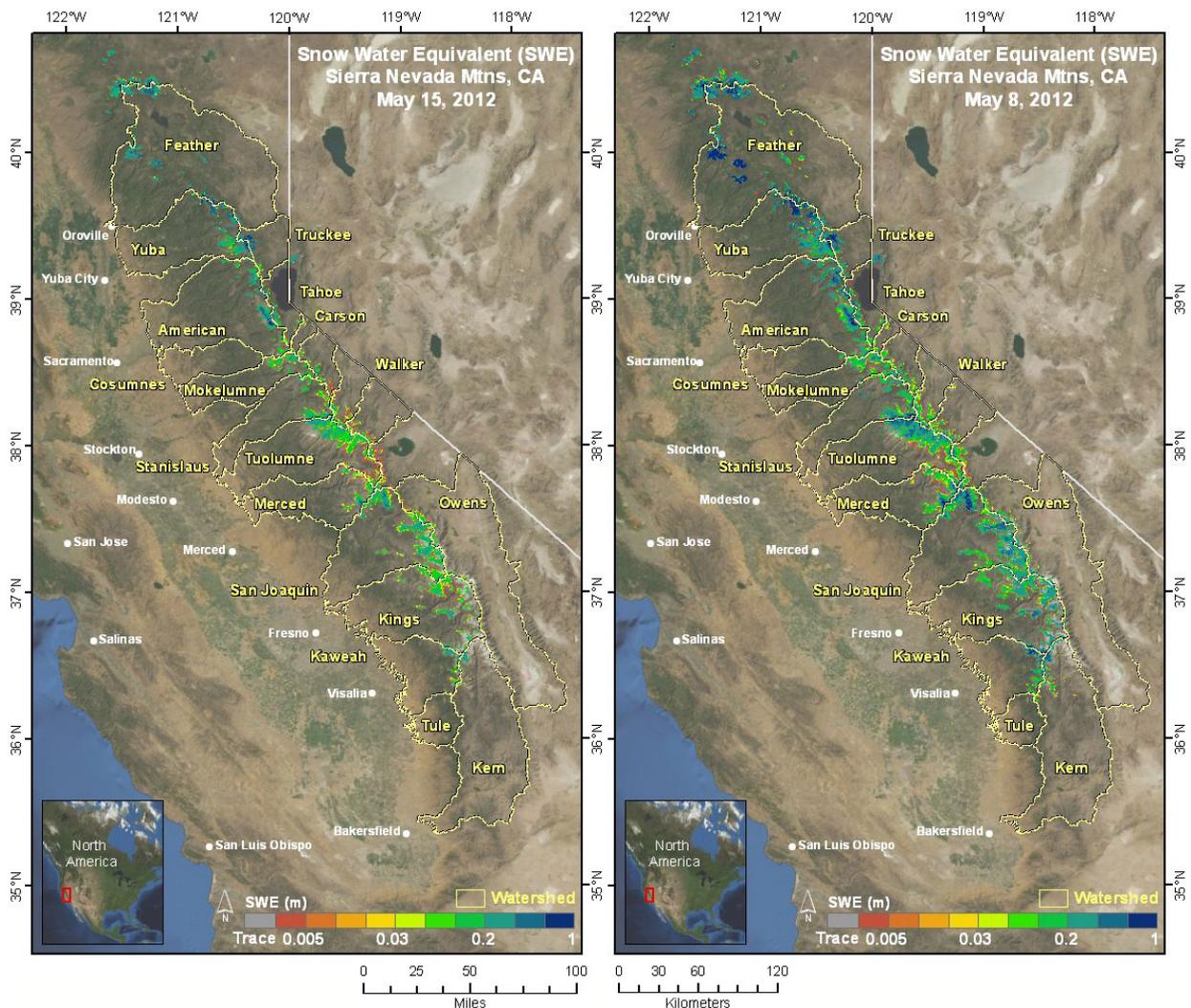


Figure 1. SWE amounts for May 15, 2012 are shown on the left and SWE amounts for May 8, 2012 are shown on the right.

Discussion

The most recent cloud-free MODIS/MODSCAG image available is for May 15, 2012. Figure 1 shows SWE amounts for May 15, 2012 on the left and SWE amounts for May 8, 2012 on the right. Depth of SWE has decreased between May 8, 2012 and May 15, 2012, with marked decrease in snow extent. Figure 2 shows the percent of average SWE for May 15, 2012 for the snow-covered area on left and on the right is the mean percent of average for May 15, 2012 shown by watershed for all model pixels above 3000' (shown as black elevation contour line). Figure 3 shows a banded elevation map. Table 1 shows mean SWE and % of Average SWE for 5/15/2012, mean SWE for 5/8/2012, change in SWE between 5/8/2012 and 5/15/2012 summarized for each watershed above 3000'. Table 2 shows the average SWE by elevation band inside each watershed for 5/15/2012, 5/8/2012, the percent of average for 5/15/2012 and the change in SWE between 5/8/2012 and 5/15/2012.

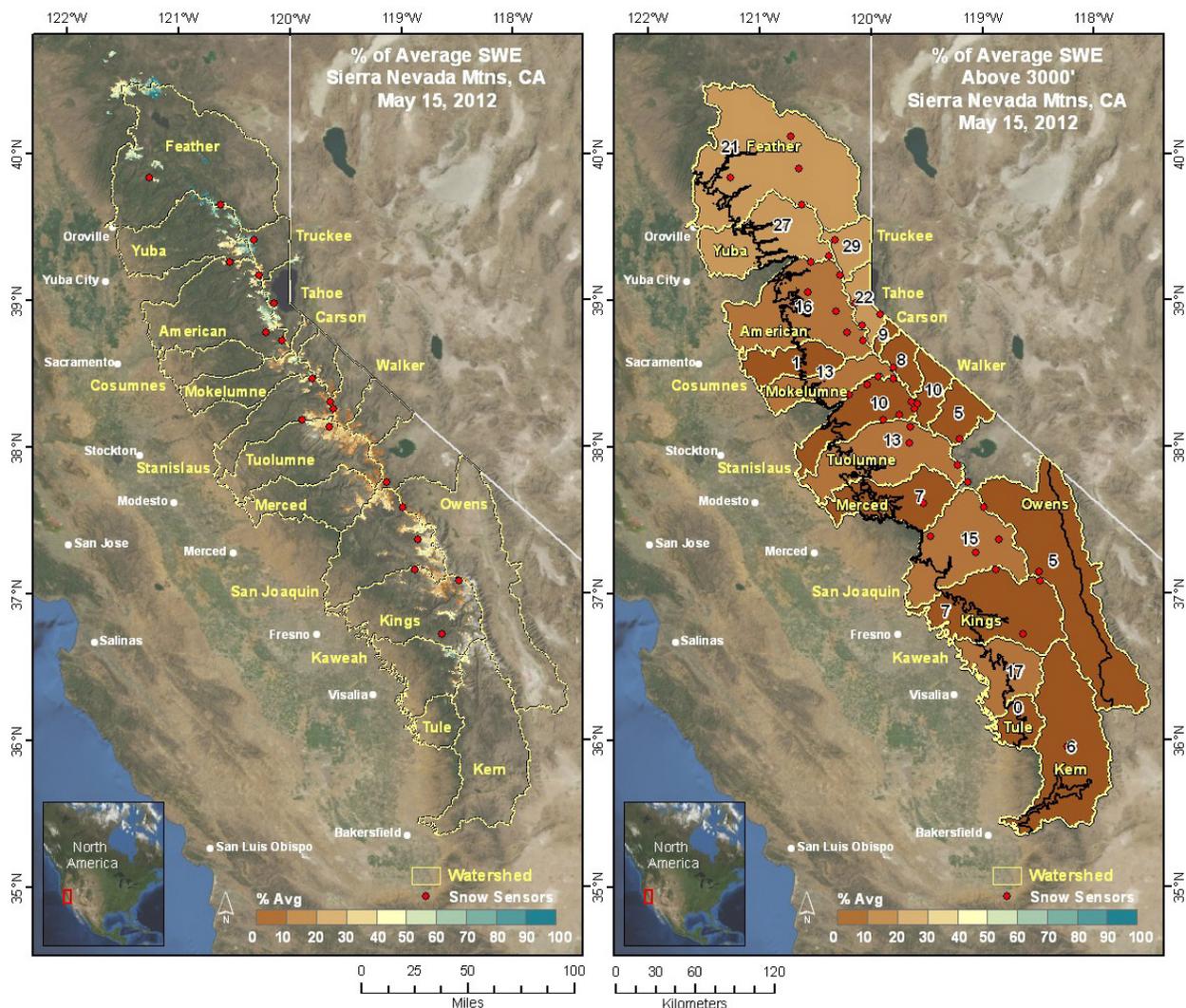


Figure 2. Percent of average SWE for May 15, 2012 for the entire Sierra (on left) and by watershed (on right). Watershed percentages are calculated for all model pixels above 3000'.

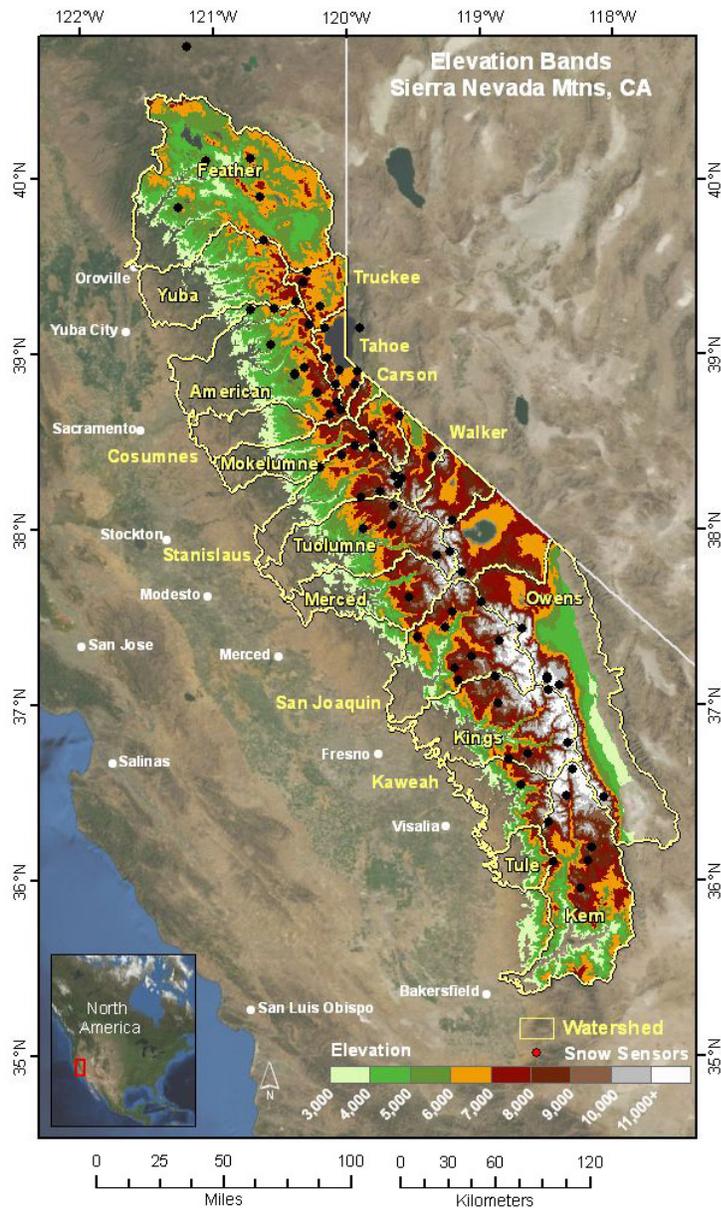


Figure 3. Map of elevation bands for the Sierra.

Methods

Results for the date of May 15, 2012 are based on May 15, 2012 real-time data from 19 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 SWE image for March 1, 2006, and an anomaly map based on 10 years of modeled SWE (2000-2009). This year the near real time SWE product is an iterative process, we are refining the processing as we get better data and develop better methodology. Relative to snow stations and the NWS SNODAS product, the reconstructed SWE product correlates strongly with full natural flow, especially late in the snowmelt season (Guan, et. al.).

Table 1. All calculations are for elevations above 3000'. Mean SWE and % of Average SWE for 5/15/2012, mean SWE for 5/8/2012, change in SWE between 5/8/2012 and 5/15/2012 for each watershed.

Watershed	5/15/12 SWE (in)	5/15/12 % Avg to Date	5/8/12 SWE (in)	5/8 thru 5/15 Change in SWE (in)
AMERICAN	1.17	16.28	2.75	-1.58
FEATHER	0.86	21.05	2.02	-1.17
KAWEAH	0.82	16.87	2.20	-1.38
KERN	0.13	5.63	0.44	-0.30
KINGS	0.75	7.46	2.64	-1.89
TAHOE	2.09	21.78	4.15	-2.06
MERCED	0.57	7.29	1.67	-1.10
OWENS	0.15	5.42	0.46	-0.31
SAN JOAQUIN	1.66	14.85	4.02	-2.36
STANISLAUS	1.01	9.58	2.42	-1.41
TRUCKEE	1.84	28.80	3.28	-1.44
TUOLUMNE	1.46	13.36	3.29	-1.83
YUBA	2.30	27.39	4.80	-2.50
COSUMNES	0.01	0.50	0.17	-0.16
MOKELUMNE	1.11	12.73	2.29	-1.18
TULE	0.00	0.29	0.07	-0.07
WEST WALKER RIVER	0.75	9.73	1.65	-0.90
EAST WALKER RIVER	0.30	5.46	0.73	-0.43
WEST FORK CARSON RIVER	0.57	8.68	1.26	-0.69
EAST FORK CARSON RIVER	0.48	7.59	1.23	-0.75

Table 2. Mean SWE and % of Average SWE for 5/15/2012, mean SWE for 5/8/2012, change in SWE between 5/8/2012 and 5/15/2012 and area in square miles for each elevation band inside each watershed.

Watershed	Elevation	5/15/12 SWE (in)	5/15/12 % Avg to Date	5/8/12 SWE (in)	5/8 thru 5/15 Change SWE (in)	Area Sq Mi
AMERICAN	3000-4000'	0.00	0.00	0.00	0.00	191.9
	4000-5000'	0.00	0.00	0.01	-0.01	249.3
	5000-6000'	0.00	0.19	0.09	-0.09	294.8
	6000-7000'	0.49	5.26	2.45	-1.96	296.4
	7000-8000'	3.58	18.63	8.97	-5.39	175.7
	8000-9000'	8.65	31.35	14.84	-6.19	74.2
	9000-10,000'	13.15	37.87	19.80	-6.65	8.9
COSUMNES	3000-4000'	0.00	0.00	0.00	0.00	77.8
	4000-5000'	0.00	0.00	0.00	0.00	84.7
	5000-6000'	0.00	0.00	0.00	0.00	63.6
	6000-7000'	0.00	0.00	0.20	-0.20	28.1
	7000-8000'	0.32	1.93	4.71	-4.39	8.6
E CARSON	5000-6000'	0.00	0.00	0.00	0.00	32.7
	6000-7000'	0.00	0.01	0.00	0.00	77.7
	7000-8000'	0.02	0.67	0.16	-0.14	102.6
	8000-9000'	1.01	9.58	2.54	-1.53	96.5
	9000-10,000'	1.87	10.66	4.17	-2.30	29.7
	10,000-11,000'	1.02	5.12	3.56	-2.53	13.5
	> 11,000'	1.60	5.86	9.16	-7.56	0.3
E WALKER	6000-7000'	0.00	0.00	0.00	0.00	73.6
	7000-8000'	0.00	0.00	0.00	0.00	157.4
	8000-9000'	0.00	0.10	0.05	-0.04	154.9
	9000-10,000'	0.55	4.78	1.55	-0.99	63.1
	10,000-11,000'	2.11	10.75	4.71	-2.59	48.8
	> 11,000'	1.74	8.54	4.63	-2.88	7.8
FEATHER	3000-4000'	0.00	0.00	0.02	-0.02	286.2
	4000-5000'	0.00	0.08	0.03	-0.03	735.8
	5000-6000'	0.12	3.93	0.82	-0.70	1305.1
	6000-7000'	2.19	33.32	5.09	-2.90	871.3
	7000-8000'	5.84	43.15	9.20	-3.36	124.6
	8000-9000'	8.53	40.48	11.73	-3.21	5.2
KAWEAH	3000-4000'	0.00	0.00	0.00	0.00	74.4
	4000-5000'	0.00	0.00	0.00	0.00	64.8
	5000-6000'	0.00	0.00	0.00	0.00	60.9
	6000-7000'	0.00	0.00	0.00	0.00	63.1
	7000-8000'	0.00	0.11	0.09	-0.08	63.5
	8000-9000'	0.30	3.94	1.85	-1.56	56.3
	9000-10,000'	1.19	10.79	5.81	-4.62	38.8
	10,000-11,000'	7.28	38.53	15.21	-7.93	36.6
> 11,000'	7.08	29.57	18.14	-11.06	8.9	
KERN	3000-4000'	0.00	0.00	0.00	0.00	175.2
	4000-5000'	0.00	0.00	0.00	0.00	221.9
	5000-6000'	0.00	0.00	0.00	0.00	273.6
	6000-7000'	0.00	0.00	0.00	0.00	391.9
	7000-8000'	0.00	0.00	0.01	-0.01	334.9
	8000-9000'	0.00	0.11	0.04	-0.04	308.7
	9000-10,000'	0.01	0.33	0.18	-0.17	166.3
	10,000-11,000'	0.60	8.26	2.13	-1.53	149.7
	> 11,000'	1.37	9.41	4.14	-2.76	142.5

KINGS	3000-4000'	0.00	0.00	0.00	0.00	83.1
	4000-5000'	0.00	0.00	0.00	0.00	92.8
	5000-6000'	0.00	0.00	0.00	0.00	95.0
	6000-7000'	0.00	0.00	0.00	0.00	136.0
	7000-8000'	0.00	0.00	0.03	-0.03	170.0
	8000-9000'	0.03	0.37	0.70	-0.66	209.9
	9000-10,000'	0.41	3.40	2.59	-2.18	187.6
	10,000-11,000'	2.53	15.03	6.25	-3.72	221.4
> 11,000'	2.09	9.68	8.51	-6.42	199.5	
MERCED	3000-4000'	0.00	0.00	0.00	0.00	138.3
	4000-5000'	0.00	0.00	0.00	0.00	88.7
	5000-6000'	0.00	0.00	0.00	0.00	72.9
	6000-7000'	0.00	0.00	0.00	0.00	78.3
	7000-8000'	0.01	0.09	0.05	-0.04	132.8
	8000-9000'	0.05	0.43	1.09	-1.04	124.1
	9000-10,000'	1.05	6.38	4.63	-3.58	76.2
	10,000-11,000'	4.90	18.53	11.63	-6.73	50.6
> 11,000'	8.94	22.68	18.09	-9.15	13.5	
MOKELUMNE	3000-4000'	0.00	0.00	0.00	0.00	83.3
	4000-5000'	0.00	0.00	0.00	0.00	87.2
	5000-6000'	0.00	0.00	0.00	0.00	84.0
	6000-7000'	0.02	0.20	0.27	-0.25	72.7
	7000-8000'	1.10	6.04	3.94	-2.84	85.9
	8000-9000'	5.10	22.68	8.69	-3.59	81.2
	9000-10,000'	6.59	24.80	11.96	-5.38	7.8
	10,000-11,000'	8.98	32.94	14.04	-5.05	0.1
OWENS	3000-4000'	0.00	0.00	0.00	0.00	184.1
	4000-5000'	0.00	0.00	0.00	0.00	428.5
	5000-6000'	0.00	0.00	0.00	0.00	254.6
	6000-7000'	0.00	0.00	0.00	0.00	255.2
	7000-8000'	0.00	0.00	0.00	0.00	302.6
	8000-9000'	0.04	0.88	0.33	-0.29	165.3
	9000-10,000'	0.09	1.43	0.67	-0.59	112.4
	10,000-11,000'	0.49	6.15	1.19	-0.70	188.0
> 11,000'	1.22	8.48	3.53	-2.31	167.2	
SAN JOAQUIN	3000-4000'	0.00	0.00	0.00	0.00	76.2
	4000-5000'	0.00	0.00	0.00	0.00	93.8
	5000-6000'	0.00	0.00	0.00	0.00	130.9
	6000-7000'	0.00	0.00	0.01	-0.01	183.9
	7000-8000'	0.01	0.23	0.14	-0.13	214.5
	8000-9000'	0.29	2.37	2.30	-2.01	194.1
	9000-10,000'	1.83	10.58	6.02	-4.19	173.8
	10,000-11,000'	5.58	23.42	11.45	-5.87	188.0
> 11,000'	6.17	23.85	13.49	-7.31	146.3	
STANISLAUS	3000-4000'	0.00	0.00	0.00	0.00	61.6
	4000-5000'	0.00	0.00	0.00	0.00	100.0
	5000-6000'	0.00	0.00	0.00	0.00	105.7
	6000-7000'	0.00	0.00	0.17	-0.17	142.3
	7000-8000'	0.14	1.08	1.49	-1.35	145.4
	8000-9000'	2.68	12.09	6.22	-3.54	121.9
	9000-10,000'	5.62	18.69	11.42	-5.80	47.1
	10,000-11,000'	7.87	21.01	14.87	-7.00	18.0
> 11,000'	4.11	12.62	11.28	-7.17	0.7	

TAHOE	6000-7000'	0.17	5.49	0.47	-0.30	103.2
	7000-8000'	2.74	23.04	6.09	-3.34	74.7
	8000-9000'	4.50	25.97	8.21	-3.71	51.3
	9000-10,000'	4.26	23.64	6.60	-2.34	12.1
	10,000-11,000'	3.11	19.15	3.00	0.12	0.9
TRUCKEE	5000-6000'	0.00	0.03	0.00	0.00	51.2
	6000-7000'	0.13	5.12	0.63	-0.49	254.6
	7000-8000'	4.75	32.65	8.52	-3.77	111.9
	8000-9000'	16.17	52.02	21.46	-5.28	14.1
TULE	3000-4000'	0.00	0.00	0.00	0.00	34.9
	4000-5000'	0.00	0.00	0.00	0.00	48.0
	5000-6000'	0.00	0.00	0.00	0.00	51.8
	6000-7000'	0.00	0.00	0.00	0.00	45.2
	7000-8000'	0.00	0.00	0.00	0.00	27.0
	8000-9000'	0.00	0.00	0.32	-0.32	15.7
	9000-10,000'	0.20	2.90	2.08	-1.88	5.8
TUOLUMNE	3000-4000'	0.00	0.00	0.00	0.00	122.4
	4000-5000'	0.00	0.00	0.00	0.00	149.9
	5000-6000'	0.00	0.00	0.00	0.00	172.8
	6000-7000'	0.00	0.00	0.00	0.00	149.0
	7000-8000'	0.04	0.34	0.80	-0.76	151.1
	8000-9000'	2.45	13.39	5.60	-3.15	170.9
	9000-10,000'	4.46	18.67	9.18	-4.72	152.7
	10,000-11,000'	5.10	18.63	11.06	-5.96	116.7
	> 11,000'	3.34	12.15	9.59	-6.26	28.8
W CARSON	4000-5000'	0.00	0.00	0.00	0.00	1.6
	5000-6000'	0.00	0.00	0.00	0.00	16.8
	6000-7000'	0.00	0.00	0.00	0.00	8.3
	7000-8000'	0.06	1.11	0.35	-0.29	35.6
	8000-9000'	1.17	11.41	2.41	-1.24	32.7
	9000-10,000'	1.43	10.94	3.43	-1.99	9.5
	10,000-11,000'	3.18	20.01	5.26	-2.08	2.3
W WALKER	5000-6000'	0.00	0.00	0.00	0.00	46.8
	6000-7000'	0.00	0.00	0.00	0.00	60.0
	7000-8000'	0.00	0.00	0.00	0.00	91.4
	8000-9000'	0.03	0.43	0.21	-0.18	93.8
	9000-10,000'	2.07	11.56	4.65	-2.58	73.3
	10,000-11,000'	3.67	14.58	7.40	-3.73	42.4
	> 11,000'	0.45	2.79	2.18	-1.73	2.6
YUBA	3000-4000'	0.00	0.00	0.00	0.00	168.8
	4000-5000'	0.00	0.14	0.01	-0.01	202.8
	5000-6000'	0.18	4.18	0.94	-0.76	188.0
	6000-7000'	3.34	23.41	9.40	-6.07	238.7
	7000-8000'	9.77	40.97	15.96	-6.19	123.0
	8000-9000'	22.69	60.94	24.47	-1.78	6.3

Location of Past Reports and Excel Format Tables

ftp://snowserver.colorado.edu/pub/fromLeanne/forCADWR/

References

Guan, B., N. P. Molotch, D. E. Waliser, S. M. Jepsen, T. H. Painter, and J. Dozier. Snow water equivalent in the Sierra Nevada: Blending snow sensor observations with snowmelt model simulations. Submitted to *Water Resour. Res.*

Molotch, N.P., Reconstructing snow water equivalent in the Rio Grande headwaters using remotely sensed snow cover data and a spatially distributed snowmelt model, *Hydrological Processes*, Vol. 23, doi: 10.1002/hyp.7206, 2009.

Molotch, N.P., and S.A. Margulis, Estimating the distribution of snow water equivalent using remotely sensed snow cover data and a spatially distributed snowmelt model: a multi-resolution, multi-sensor comparison, *Advances in Water Resources*, 31, 2008.

Molotch, N.P., and R.C. Bales, Comparison of ground-based and airborne snow-surface albedo parameterizations in an alpine watershed: impact on snowpack mass balance, *Water Resources Research*, VOL. 42, doi:10.1029/2005WR004522, 2006.

Molotch, N.P., and R.C. Bales, Scaling snow observations from the point to the grid-element: implications for observation network design, *Water Resources Research*, VOL. 41, doi: 10.1029/2005WR004229, 2005.

Molotch, N.P., T.H. Painter, R.C. Bales, and J. Dozier, Incorporating remotely sensed snow albedo into a spatially distributed snowmelt model, *Geophysical Research Letters*, VOL. 31, doi:10.1029/2003GL019063, 2004.

Painter, T.H., K. Rittger, C. McKenzie, P. Slaughter, R. E. Davis and J. Dozier, Retrieval of subpixel snow covered area, grain size, and albedo from MODIS. *Remote Sensing of the Environment*, 113: 868-879, 2009.