Texts: *The Avalanche Handbook* (2006), 3rd ed., by David McClung & Peter Schaerer, + assigned papers

Monday, March 26, 2018		**Lecture**	**Reading**
8:15	**Morning lectures – albedo, energy balance**		
	Welcome to SNARL	Carol Blanchette	Valentine/SNARL web page
	What's albedo and why should you care? Optical properties of ice and water; reflectance of snow in the solar spectrum	Jeff Dozier	Dozier, Mountain hydrology, snow color, and the fourth paradigm
	Instrumentation on Mammoth Mountain : Description of *CUES* (CRREL/UCSB Energy Site)	Ned Bair	Bair et al., CUES CRREL/UCSB snow energy balance
	Energy balance of the mountain snow pack: solar and longwave radiation, sensible and latent heat exchange, cold content.	Jeff Dozier	Fierz et al., Energy balance models.
	Properties of ice and snow crystals in the atmosphere and the ground: crystal structure; triple point; saturation vapor pressure; shapes.	Jeff Dozier	Avalanche Handbook, chapter 2 Shultz, Crystal growth in ice and snow
13:00	**Lunch break**		
14:00	**Afternoon lectures – practical matters**		
	Introduction to avalanches: Tutorial material to help understand Tuesday's gun and bomb tours	Ned Bair	Snowpack tests video (24 min)
	Why the US Army cares about snow: Operations, research gaps, technology maturation, and examples	Bert Davis	Army Geospatial Research Cold-weather warfare
	The rain-snow transition. Identifying it, trends	Danny Marks	Marks et al., Determining precipitation phase CW3E Ensemble-derived Freezing Level
	Q&A on day, break		
18:30	**Dinner**		
Evening	Study and read (most instructors gone for Jeff's retirement party)		
Tuesday, March 27, 2018			
8:00	**Morning lectures – remote sensing of snow and ice**		
	Tutorial on emote sensing of mountain snow: What we can tell in the visible through microwave spectrum	Jeff Dozier	Nolin, Remote sensing of seasonal snow Lettenmaier et al., Hydrologic remote sensing (just the material on snow)
	Airborne Snow Observatory: measurements of snow albedo (from spectrometer) and depth (from lidar)	Tom Painter	NASA Airborne Snow Observatory Painter et al., Airborne Snow Observatory
	Microwave remote sensing: Operational measurements of snow depth and water equivalent	Bert Davis	Dozier et al., Spatial distribution of SWE
12:00	**Lunch**		

13:00	**Afternoon – Mammoth Mountain**		
	USDA field experiment: Observations of drone, ground-penetrating radar, terrestrial lidar	Danny Marks McKenzie Skiles	
	Mammoth Mountain avalanche control: Tour of the gun and avalanche control demo	Mammoth Mtn	Mammoth Mountain Ski Patrol
18:00	**Dinner**		
19:00	**Evening**		
	Perspective on this year's snowpack and avalanche hazard	Josh Feinberg	Eastern Sierra Avalanche Center
	Avalanche airbag demo	West Vane	
Wednesday, March 28, 2018	**All day – Mammoth Mountain & Sidecountry**		
8:30	*Field measurements of snow properties:* Extended column tests; snowpit analysis for stratigraphy and SWE, metamorphism; observations of liquid water in snow (if it's wet); spatial variability to support the field experiment		Greene et al., Snow, Weather, Avalanches
16:30	*Field measurements:* Assembling and plotting the data		
18:00	**Dinner**		
19:00	**Evening**		
	Snow surveys and identifying the snow line, and Thursday's slide off McGee	Sue Burak	
Thursday, March 29, 2018			
8:00	**Morning lectures – snow hydrology**		
	Snow hydrology in the Sierra Nevada: W ater supply; runoff forecasting; droughts, trends; errors	Jeff Dozier	Bales et al., Mountain hydrology of western U.S. Calif Data Exchange Center
	Storms in the Sierra Nevada: How atmospheric circulation affects precipitation	Jeff Dozier	Rosen, Atmospheric rivers Center for Western Weather & Extremes
	Dirty snow: Acceleration of the hydrologic cycle by dust and black carbon	Tom Painter McKenzie Skiles	Painter et al., Dust radiative forcing 1 Skiles et al., Dust radiative forcing 2
	SWE Reconstruction: How it works, in mountains with and without surface measurements	Ned Bair	Bair et al., Validation reconstruction of SWE . . .
12:30	**Lunch**		
13:30	**Afternoon lectures – snow science**		
	Snow ecohydrology in mountain basins: How snow affects aquatic ecology in the Sierra Nevada.	John Melack	Sickman et al. Mechanisms for N export

	Economic value of snow forecasts	Timbo Stillinger	
	Variability in snow density. How to measure, how to model?	Danny Marks	
	Advanced topics in snow metamorphism: Effect of energy balance on avalanche hazard; theoretical basis of change in albedo; sintering; modeling of snow metamorphism at the grain scale.	Ned Bair	Avalanche Handbook, chapter 3. Fierz et al., International classification of snow.
	Q&A on day, break		
18:00	**Dinner**		
19:00	**Evening**		
	Field measurements: Assembling and plotting the data to compare with the field experiment	Ned Bair Mike Colee Danny Marks	
Friday, March 30, 2018			
8:30	**Morning – Mammoth Mountain**		
	Mammoth Mountain Snow: Tour of CUES instrument site, avalanche control routes	**Mammoth Mtn**	CRREL/UCSB snow energy balance Mammoth Mountain Ski Patrol
13:00	**Lunch**		
14:00	**Afternoon – lecture and discussion**		
	Structure from motion: Using a drone to measure elevation (and thereby snow depth)	McKenzie Skiles	Bühler et al., Snow depth mapping
	Review and discussion, whole course		
Saturday, March 31, 2018			
9:00	Final Exam, 3 hours, open notes, open Internet		
12:30	Lunch, clean up, move out		