NOAA-OHDL Progress Report for Project:

'Scaling Snow Observations From the Point to the Grid Element: Supporting NOHRSC's National Snow Analysis System'

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Reporting Period: April 1, 2008 – September 30, 2008

Project Objective

By merging detailed field observations and advanced remote sensing snow products into a spatially distributed snowmelt model, this project is focused on characterizing the subgrid variability in SWE surrounding select SNOTEL sites in 4 regions of the Western US. These analyses aim to improve understanding of the relationship between measured SWE at SNOTEL sites and the SWE of the surrounding grid elements, providing the National Operational Hydrologic Remote Sensing Center (NOHRSC) with an improved ability to evaluate residuals in the National Snow Analysis system (NSA), ultimately improving snowpack information for end-users. Since the last reporting period we have made considerable progress in both the field-based and modeling activities of this research.

Field Data Collection

Since the last reporting period our field data collection has continued with an ambitious set of measurements made in mid-April and mid-May of 2008. The field measurements are focused on evaluating *'the distribution of SWE within grid elements encompassing SNOTEL sites and determining how representative SNOTEL sites are relative to the mean of the surrounding distribution'.* As reported in April, our March field campaigns involved intensive field surveys of the distribution of snowpack properties (snow depth, grain size, SWE, and snow temperature) have been conducted in the 1-km^2 area surrounding 12 SNOTEL sites in the Sierra Nevada, Colorado, and Idaho / Oregon regions. We have repeated this sampling in mid-April and have added an additional site in the Sierra Nevada region, located at Virginia Lakes Ridge in the Eastern Sierra Nevada. As with the previous surveys, we made snow depth observations at over 230 locations, with triplicate samples this equals over 690 snow depth measurements within each 1 km^2 area. Across all of our regions and associated 13 study sites this is equivalent to nearly 10,000 snow depth measurements; with the repeated sampling we now have over 15,000 sample points collected. Since the last reporting period we have analyzed and completed quality assurance of these data. The root mean square deviation between measured snow depth at the snow stations versus the mean of the surrounding areas was 17, 14, and 12% relative to the mean observed snow depth at the Idaho-Oregon, California, and Colorado sites, respectively. Snow depth values at the snow pillows were as much 30% greater than the corresponding mean grid-element SWE; indicating considerable overestimation of total snow accumulation. These relationships were not consistent from site to site or from region to region as some sites underestimated mean snow depth by 30% (Figure 1). A data base is currently under development which will be used to disseminate this information amongst project collaborators, NOHRSC, NOAA-OHDL, and the broader community. Analyses of binary regression-tree interpolation models are being used to interpolate these field data over the 16-km^2 areas surrounding each SNOTEL site (see below).

Modeling Activities

Since the last reporting period we have made considerable headway in the project modeling activities. First, we have developed a down-scaling algorithm to integrate 1/8 degree NDLDAS data into our 30-m modeling approach; testing has been completed at one of our sites and NLDAS forcings for all 13 sites have been archived in preparation for downscaling and modeling. Second, we have made headway in analyzing remotely sensed data needed for this project. In this regard we aim to evaluate the represenativeness of the SNOTEL network in terms of remotely sensed snow cover persistence as detected from the Moderate Resolution Imaging Spectrometer. Third, we have begun interpolating the field data across the modeling domains using binary regression tree models – as proposed in response to the RFP. This involves calculating a number independent variables related to topography and vegetation characteristics. To date, we have trained an undergraduate student to generate the regression trees, three sites in California have been modeled; preliminary results have been completed but final products are forthcoming. Now that the project is adequately staffed to perform these activities, it is anticipated that regression trees for the additional sites will be generated prior to the next reporting period in April of 2009. In addition to the activities mentioned above, our continuously sampling ground-based meteorological observations have operated as planned during the winter-spring 2008 and thus we have a complete data set for evaluating the downscaled forcings at 3 of our focus sites (one in each of the Northern Rockies, Sierra Nevada, and Central Rockies regions). Note: these ground-based meteorological measurements are supported by NSF funds but provide useful leveraged data for this project.

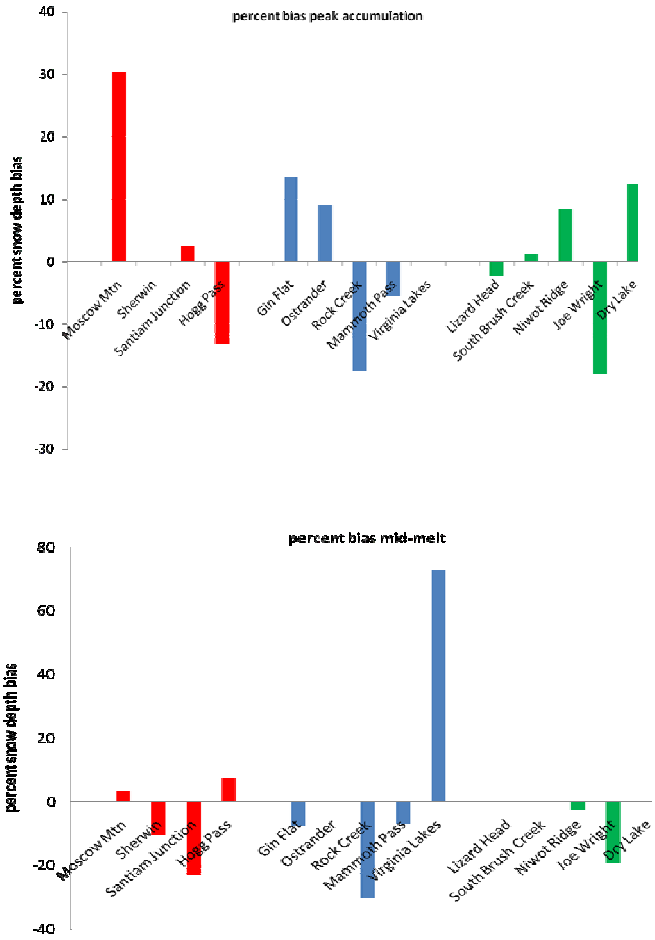

Figure 1. Difference between snow depth at operational stations and the surrounding 1-km grid elements at peak accumulation in April (top panel) and in mid-melt season in May (bottom panel). Values are expressed as a percentage of the mean observed depth. Positive (negative) values represent station overestimates (underestimates) relative to the surrounding area. Red = Idaho-Oregon; Blue = California; Green = Colorado.

Dissemination of Results and Inter-Agency Collaboration

During the reporting period the PI's have actively engaged the water resources communities regarding the project objectives and forthcoming deliverables. As noted in the last report we have designed this project to dovetail with NOHRSC daily modeling activities. Some additional developments have occurred since the last reporting period regarding the California Department of Water Resources plans for additional snow measurement infrastructure. This has involved a consortium of University of California researchers, the California Department of Water Resources, various Federal, State, and local agencies brought together by California's Lt. Governor John Garamendi to develop H_2O 2.0 – an initiative for California's water infrastructure future. Results and planning associated with NOAA's support of this research has guided much of these discussions and provides proof of concept for observation network design in the context of scaling to the model grid element scale.

We have continued engagement of the scientific community regarding our project activities. Since the last reporting period, the PI's have presented 4 papers at scientific meetings (see below) related to previous analyses of data that will be used in this project. In this regard, this project has supported further development of these previous analyses leading to new understanding of the relationships between vegetation, topography, and snow distribution which have been submitted to a leading scientific journal (*Molotch et al., in review; Fassnacht et al., in revew*). Such understanding is critical for scaling operational snow observations to the NSA grid element scale and will guide the modeling analyses throughout the duration of this project.

Presentations at Scientific Meetings Since Last Report:

Michael Durand, Noah Molotch, and Steven A. Margulis, Validation of an Ensemble-based Bayesian Snow Water Equivalent Reconstruction, 2008 Eastern Snow Conference.

Molly E. Tedesche, Steven R. Fassnacht, P. Meiman, and M.E. Fernandes-Gimenez, Snowcover Variability Due to Wind and Rangeland Shrub Interactions in North Park, Colorado, 2008 Eastern Snow Conference.

Steven R. Fassnacht, Magdalena E. Skordahl, and Jeffrey E. Derry, Variability in Operational Snow Measurement Sites: Snow Course and Snow Telemetry Stations Across Colorado, 2008 Eastern Snow Conference.

Noah P. Molotch, Joseph R. McConnell, Marcy Litvak, Sean P. Burns, Russell K. Monson, K. Musselman, and Paul D. Brooks, Ecohydrological Controls on Snowmelt Partitioning in Mixed-conifer Sub-alpine Forests, *2008 Eastern Snow Conference.*