COMPARISONS OF SPATIALLY DISTRIBUTED HYDROLOGIC MODEL OUTPUTS FOR THE DUNGENESS WATERSHED TO FIELD-BASED MEASURES OF SNOW WATER EQUIVALENT

G. Brandon Massey[1,2], Dwight Barry[1,2], Shea McDonald[1] and Chris DeSisto[1]

ABSTRACT

Many spatially distributed estimates of snow water equivalent (SWE) rely on modeling based in part on remotely sensed data. The Hybrid model is a spatially distributed streamflow forecasting model developed recently for the Dungeness Watershed of western Washington State that incorporates estimates of snow cover using NASA's MODIS. Prior to generating streamflow estimates, the Hybrid model estimates SWE across the watershed in 500m grid cells. Another NASA product, SNODAS, also estimates SWE through a combination of remote sensing and modeling. Over three winters, we monitored SWE on the ground at 12 field sites, and compared field results with those estimated by both the Hybrid and SNODAS models at two different scales (25 ha and 225 ha). Taking into account the size of the confidence intervals, only one snow course had a reasonable correlation of ground SWE with the model outputs at either scale. Both models consistently and slightly overestimated actual SWE for sites below 1400 m. However, both models showed considerable variability for differences between modeled and ground SWE for snow courses above 1400 m. Above that elevation, SNODAS consistently overestimated ground SWE, and the Hybrid model usually underestimated ground SWE, though to a lesser extent. Although the current Hybrid model performs reasonably well, more accurate point (cell) estimates of SWE within the Dungeness Watershed could provide more precise estimates of watershed-scale SWE, and, as a result, subsequent estimates of streamflow in the Dungeness River. (KEYWORDS: snow water equivalent, SNODAS, HYBRID model, elevation effect, Dungeness Watershed)

INTRODUCTION

The Hybrid hydrologic forecasting model was recently developed for the Dungeness Watershed of western Washington (see pcnasa.ctc.edu for details). To improve understanding of snow water equivalent (SWE) variability in the mid-elevations (~400-1400 m) and to ground-truth model outputs for the Hybrid model and NASA's Snow Data Assimilation (SNODAS) model, we monitored SWE at 12 sites in the Dungeness Watershed between December 2007 and May 2010. We specifically wanted to know whether the Hybrid and SNODAS models (Figure 1) provide a reasonable estimation of ground SWE in the mid-elevation, an area often subject to winter rain-on-snow events.

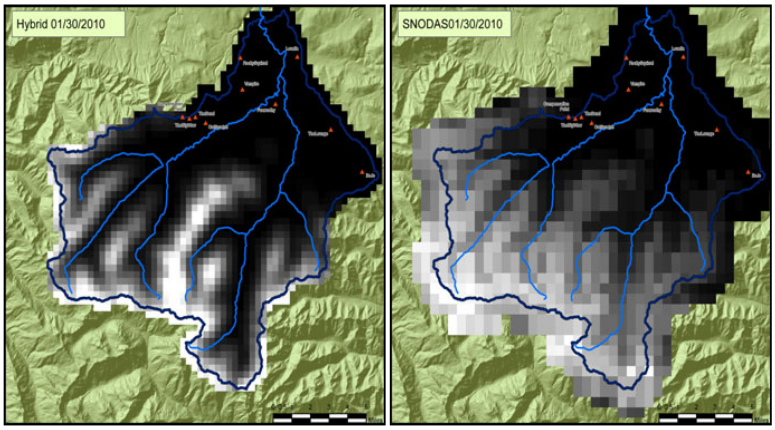

Figure 1. Example of Hybrid and SNODAS model outputs in the Dungeness Watershed for 30 Jan 2010.

METHODS

Field work followed standard NRCS snow survey protocols. We compared modeled and ground SWE values within each model's corresponding grid cells, (25 ha area) as well as for neighborhoods of 9 cells (225 ha). SNODAS outputs were resampled and downscaled for direct comparisons with Hybrid model. Because the

Poster paper presented Western Snow Conference 2011
[1] Peninsula College, 1502 E. Lauridsen Blvd., Port Angeles, WA, 98362, dbarry@pencol.edu
[2] Western Washington University-Huxley College on the Peninsulas, Port Angeles, WA, 98362

Hybrid's modeling grid does not line up precisely along the watershed boundary, two snow courses located near the watershed boundary were excluded from the single-cell analysis. Average SWE values were calculated for the nine cell neighborhoods using ArcGIS 10. Pearson's correlation coefficients with 95% confidence intervals were obtained between ground SWE readings gathered at the Dungeness snow courses and the Dungeness SNOTEL with modeled SWE outputs from both the SNODAS and Hybrid models, at both 1-cell and 9-cell scales using R. Differences between modeled and ground SWE were obtained for both models and both neighborhood sizes.

RESULTS

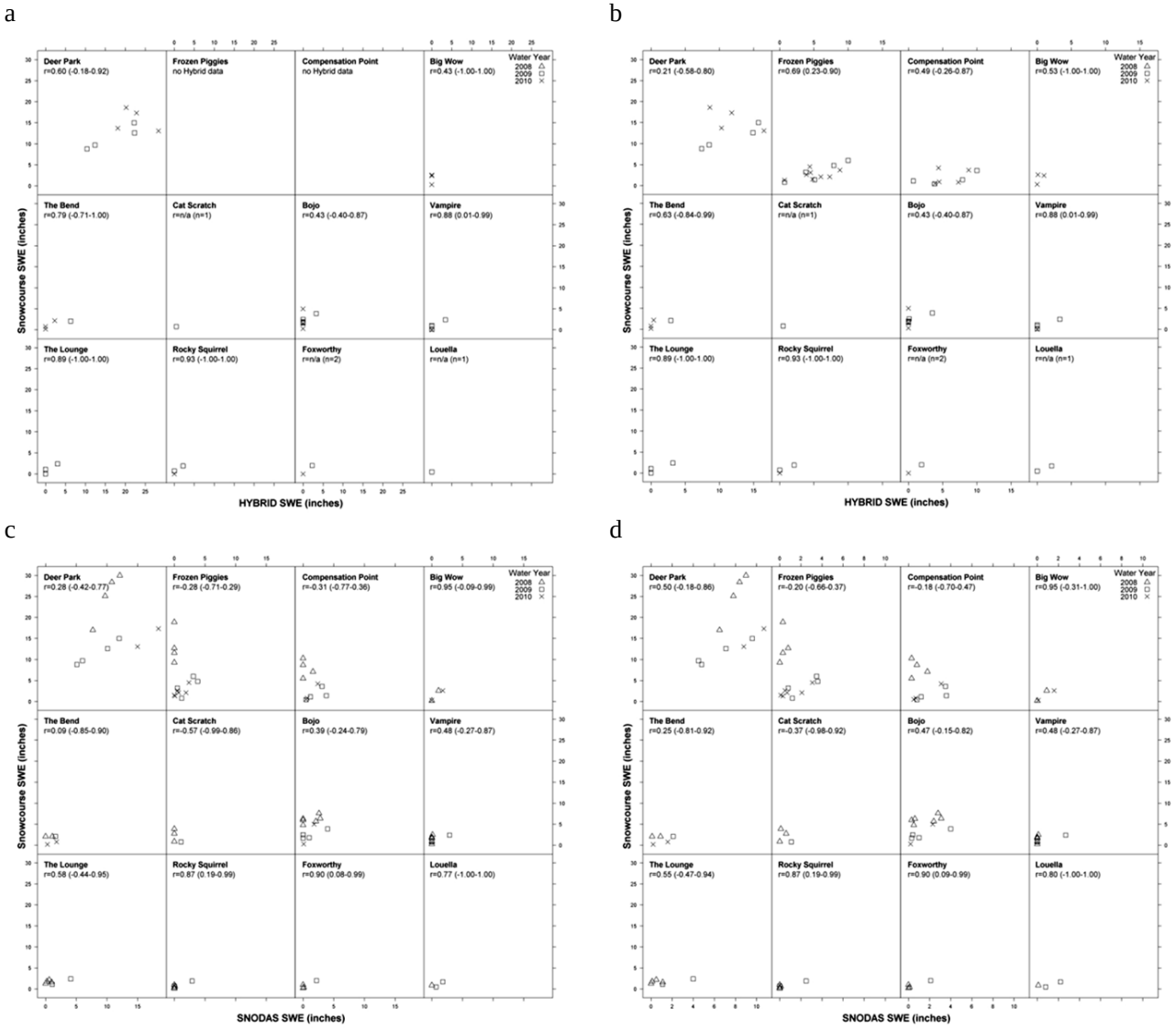

Figure 2. Correlations between ground and a) Hybrid 1 cell (25 ha); b) Hybrid 9 cell (225 ha); c) SNODAS 1 cell; and d) SNODAS 9 cell snow water equivalent.

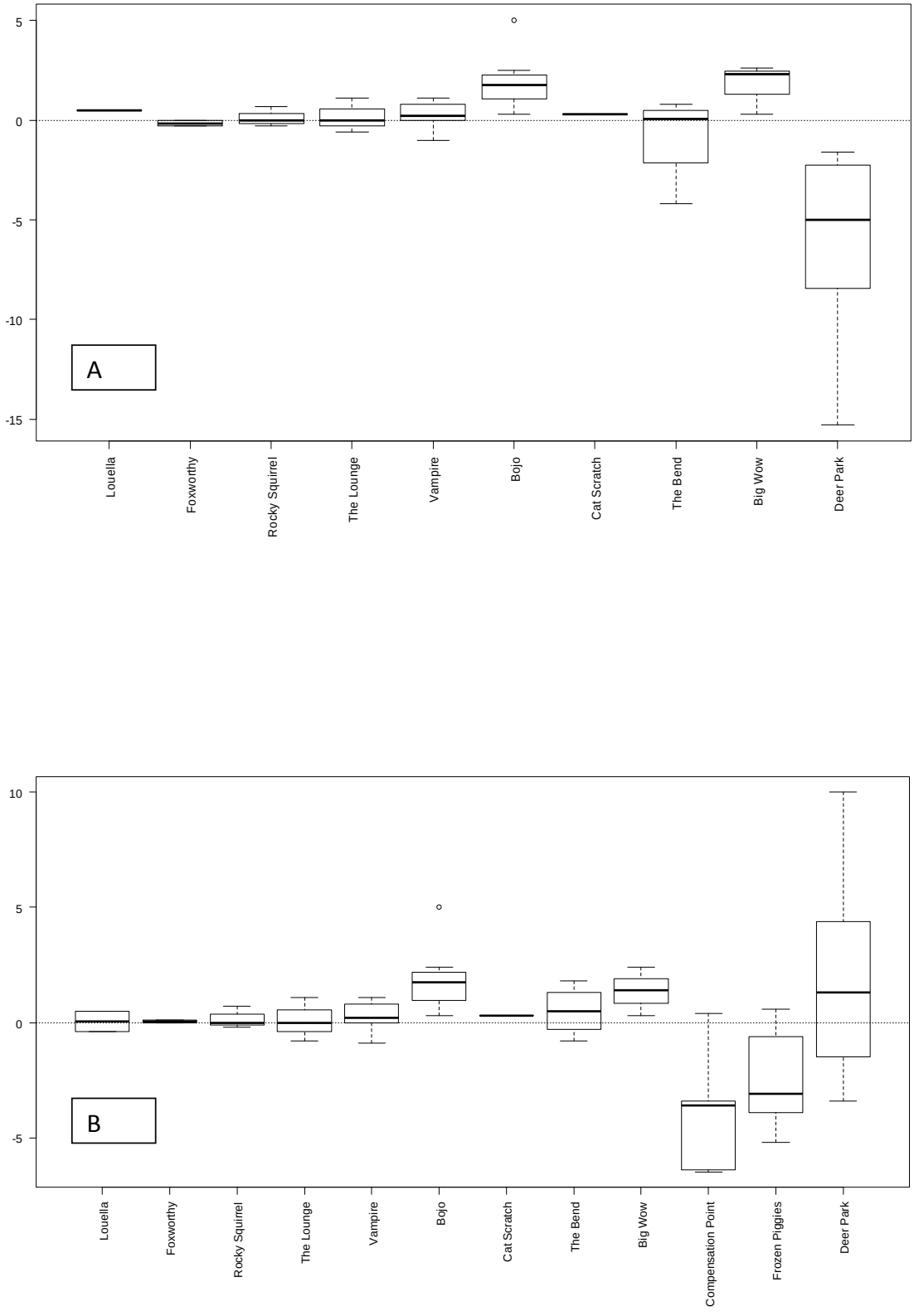

Figure 3 A & B. Boxplots of the difference between ground and a) Hybrid 1 cell (25 ha); b) Hybrid 9 cell (225 ha); c) SNODAS 1 cell; and d) SNODAS 9 cell snow water equivalent.

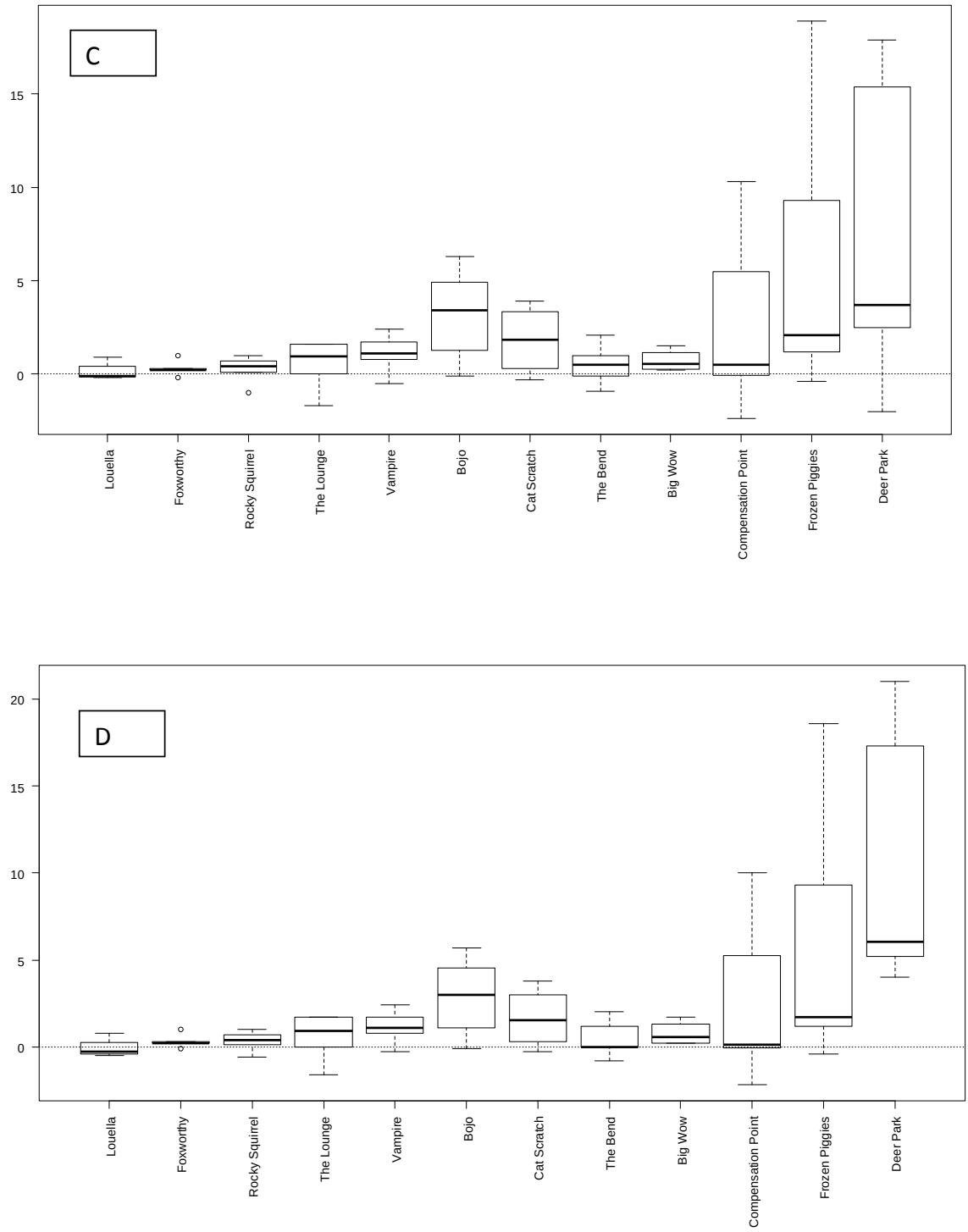

Figure 3 C & D. Boxplots of the difference between ground and a) Hybrid 1 cell (25 ha); b) Hybrid 9 cell (225 ha); c) SNODAS 1 cell; and d) SNODAS 9 cell snow water equivalent.

CONCLUSIONS

Taking into account the size of the confidence intervals, only one snow course had a reasonable correlation of ground SWE with the model outputs at either scale (Figure 2). A few other comparisons that could be considered statistically significant (CIs did not overlap zero) had confidence limits too wide for realistic interpretation. However, visual inspection of the distribution of points by year suggests the possible impact of ENSO (2008 was a La Niña year) on the results; considerably more data would be required to explore this possibility.

While the correlations were mostly meaningless (largely as a result of small sample size), both the Hybrid and SNODAS model SWE estimates were fairly close to ground SWE measures for most of the snow course sites (Figure 3). Both models consistently but very slightly overestimated actual SWE for sites below 1400 m. However, both models showed considerable variability for differences between modeled and ground SWE for snow courses above 1400 m, diverging in sign for these three snow courses. Above this level, SNODAS consistently overestimated ground SWE, and the Hybrid model usually underestimated ground SWE, though to a lesser extent.

Although the current Hybrid model performs reasonably well, more accurate point (cell) estimates of SWE within the Dungeness Watershed could provide more precise estimates of watershed-scale SWE, and, as a result, subsequent estimates of streamflow in the Dungeness River.

ACKNOWLEDGEMENTS

Special thanks to the many field assistants from Peninsula College and Western Washington University who helped us gather the Dungeness Watershed snow data, often under adverse winter conditions. This material is based upon work supported in part by NASA's Science Mission Directorate under Cooperative Agreement #NNA06CN06A, as well as through the National Science Foundation under REU Grant #0452328. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NASA or the National Science Foundation.