The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2017-56-AC1, 2017

The Cryosphere
Discussions

Interactive comment on "Improving gridded snow water equivalent products in British Columbia, Canada: multi-source data fusion by neural network models" *by* Andrew Snauffer et al.

Andrew Snauffer et al.

asnauffer@eoas.ubc.ca

Received and published: 2 September 2017

The authors greatly appreciate the comments in RC1: 'Review Snauffer et al.', by Jean Bergeron, 11 Aug 2017 (https://doi.org/10.5194/tc-2017-56-RC1). The following are responses to those comments.

Reviewer Comment: The study assesses the use of an artificial neural network (ANN) to extract more accurate snow water equivalent (SWE) information from multiple sources of gridded SWE data in the province of British-Columbia, Canada. When comparing with manual surveys, results show a much improved performance compared with other approaches, such as using a multiple linear regression or the mean of

gridded products, or simply the products themselves. The results are interesting and fit the scope of The Cryosphere.

My main comment relates to the lack discussion on the assumptions and limitations of the study. These would include the dependency on ANN-specific parameters, such as the number of layers, and the number and quality of predictor variables. I think some discussion on potential scaling issues is indispensable. The study uses elevation difference between manual surveys and cells of gridded products as a predictor variable and I am assuming this is to get around part of this issue (I would suggest adding clarifications to justify the use of predictor variables). While this is possibly the most important variable, other relevant factors are affected by gridcell size, such as slope and orientation, vegetation and surface water/ice. How does the spatial resolution of each gridded product affect the results?

Author Response: The authors agree that study assumptions and limitations as well as scaling issues can be augmented. ANN topology consisted of an input layer, a single hidden layer and an output later with a single node for SWE. One hidden layer is enough to model any nonlinear continuous function (Hsieh, 2009), which describes the problem at hand. The scale of the gridded products varies from 0.25 degrees to 0.7 degrees. Slope, aspect, vegetation and surface water/ice at these scales do not serve as reliable analogues to local conditions, and hence a predictor to represent scale differences for these factors (such as elevation difference provides for elevation) would be difficult to create.

A scatter plot of the key results on gridded product spatial resolution is shown here in Fig. 1. There is no clear dependency of either province-wide MAE or April correlation on grid cell size. The better results of some products seems to be tied to superior product performance in this region rather than simply higher or lower resolution.

The authors agree with most comments put forth in supplement https://www.the-cryosphere-discuss.net/tc-2017-56/tc-2017-56-RC1-supplement.pdf. Two important questions posed are addressed below.

Supplement Responses:

Page 5: Why were automated snow pillow measurements omitted? They provide daily data going back a few decades and are made available by the BC River Forecast Centre.

Response: Automated snow pillow data were also examined as a part of this work. These data were found to be considerably more prone to obvious errors than the manual snow surveys. Such errors included negative values, snow accumulation and melt curves that contained sudden jumps, drops and unrecognizable noise, missing values that were sometimes interpolated and other problems. In addition to passing such errors into the model, the likelihood exists to introduce significant autocorrelation, as many of the snow pillows are co-located with manual snow survey sites, potentially leading to overfitting and degradation of model performance. As such, we decided to use only the manual snow surveys as target data.

Page 8: I feel that, though MAE (and correlation for that matter) is a useful metric, it provides no information on bias. Why was bias not considered? It was included in a previous manuscript by mostly the same authors (doi: 10.1016/j.jhydrol.2016.07.027). Do the ANN approaches reduce this bias?

Response: Mean station biases as shown here in Fig. 2 broadly reflect mean station MAEs in Fig. 4 in the submitted manuscript. Most gridded products underestimate the large SWE accumulations in most of BC, so MAE is largely attributable to this negative bias. Significant reductions in bias reflecting lower MAEs are seen in the ANN models. MLR models also significantly reduce bias, in some cases even more than the ANNs. While this suggests both MLR and ANN models effectively reduce systematic errors, the lower MAEs and higher April correlations of the ANNs point to better reductions in unsystematic errors.

References:

Hsieh, W. W.: Machine Learning Methods in the Environmental Sciences: Neural Networks and Kernels. Cambridge University Press, 2009.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2017-56, 2017.

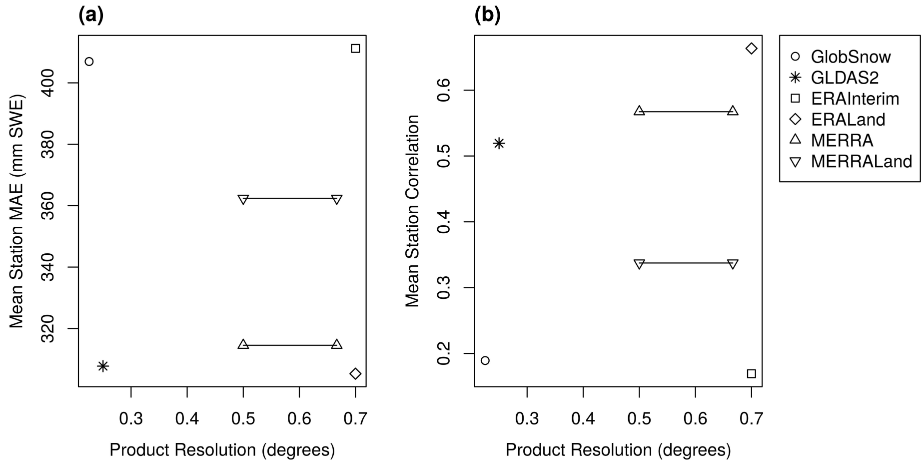

Fig. 1. Province-wide mean station (a) MAE and (b) April correlation vs. resolution of gridded products. MERRA and MERRALand have an irregular grid size of 1/2° × 2/3°, indicated by a horizontal line.

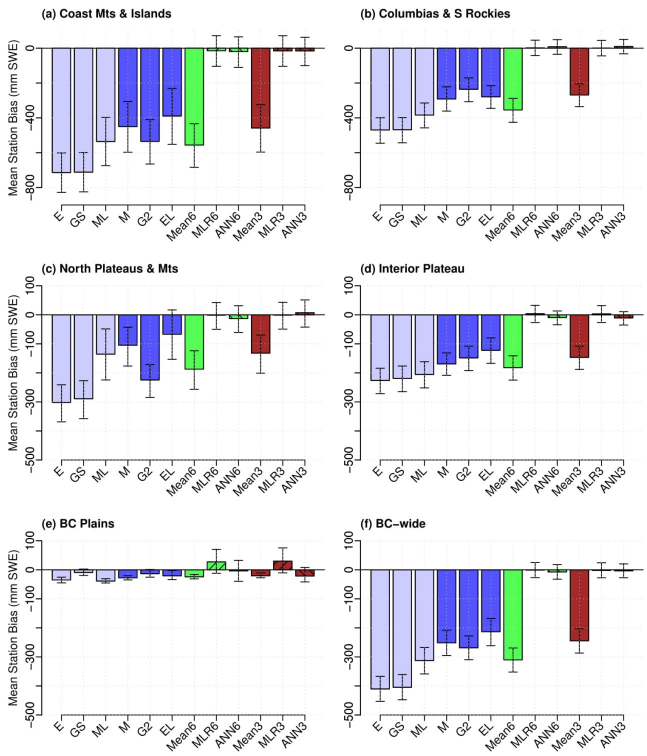

Fig. 2. Mean station bias for several SWE products/combinations for regions of BC in order of descending accumulations. Regions, products and combinations are as in Figs. 4 and 5 in the submitted manuscript.