Using MODIS estimates of fractional snow-covered area to improve streamflow forecasts in Interior Alaska by Bennett et al. examines improvements in model skill when remotely-sensed snow-covered area estimates are used to model streamflow, compared to model runs where model-generated areal depletion curves are used. For this study, two MODIS-derived snow covered area products were used, MOD10A1 and MODSCAG. This study is a nice assessment of the use of remotely-sensed snow cover products with the new CHPS modeling framework for several watersheds in the interior of Alaska. This study demonstrates the improvements as well as pitfalls of using areal depletion curves vs. remotely sensed snow-covered area. The authors find that using remotely sensed snow-covered area yields modest improvements in some basins, especially the sparsely measured ones, but not in others.

These findings agree with previous studies, which the authors cite. Overall, the techniques are well researched and the findings are sound, but I have a few major concerns that I would like to see addressed prior to publication:

Thank you for your review and your positive words about our study.

1) In most of the cited publications, e.g. Painter et al. (2009); Rittger et al. (2013), what is referred to in this manuscript as snow covered extent is called fractional snow-covered area, or fSCA. Since MODSCAG and MOD10A1 are both fractional products, fractional snow-covered area is a more accurate term than snow-covered extent. Thus, I suggest changing snow-covered extent to fractional snow-covered area to align with most other publications.

We agree with this point, and we have changed the referral of fractional snow cover extent (SCE) to fractional snow covered area (fSCA) when we are discussing the remotely sensed products in the paper.

2) What is really needed for model input is the total volume of snow water equivalent (SWE). The fSCA contains no information on depth. Among other problems, as the authors point out, when fSCA reaches 100%, it gives little information about the snow volume. I realize that there is no good direct SWE estimate for model input, however there have been many attempts to create basin-wide SWE estimates, for example by fusing snow telemetry estimates with fSCA (Fassnacht et al., 2003; Dozier et al., 2016; Schneider and Molotch, 2016). It would be worthwhile to at least discuss why fSCA only was chosen to improve the streamflow forecasts.

We agree with your point, and if were we working in the lower 48, our study would have been set up differently. SWE is the more important variable, and the ‘grail’ for water resources managers and snow scientists. However, in Alaska, there are limitations with regards to the ground-based observations to carry out validation and testing of basin-wide SWE simulations and the remote sensing of snow and topography that can be used for simulations in this environment. Regarding a), ground-based observations such as SNOTEL, as used by Fassnacht et al. (2003) and Schneider and Molotch (2016), are available in Alaska. However, as noted by Fassnacht et al. (2003), to interpolate between the stations there should be a minimum distance between them. In the Upper Colorado River basin (277,000 km^2) there are noted to be 240 SNOTEL sites, operating since 1991. In Alaska, there are 40 SNOTEL sites (1.718 million km^2), and in the basins where we undertook this study (10,160 km^2) there are 7 SNOTEL stations, all of which are located in the Chena River basin. Another issue is the quality of SNOTEL data, including station siting, have been noted by various authors, although the

Alaska SNOTEL station network is not included in these reviews (Dozier et al. 2016, Oyler et al. 2015, Ragwala et al. 2015).
Issues with remote sensing in Alaska are related to availability and quality of polar orbiting remote sensing products, availability of data on snow pack depth and snow density (Muskett 2012), issues related to deep and shallow snow packs, issues related to the mapping forests cover fractions and the density of boreal forest canopies. Unfortunately, many of the remote sensing of snow products that are available are not tested well in the high latitudes and under dense boreal forest cover, which highlights the importance of our work in these regions and necessitates a simpler initial approach to research in the region.
Additionally, the availability of digital elevation models (DEM) information in Alaska hinders the kind of analysis performed in the aforementioned studies; Alaska's 5-m IFSAR product is nearing completion in 2018 but was not available when this project was carried out. The 30 m National Elevation Model (NED) DEM used in the study likely contains issues (that will be corrected by the updates to the IFSAR Alaskan product), including data voids, data currency, geodetic datum issues. For example, all datums for Alaska DEMs were previously in NAD27, which caused offsets in the data (Maune, 2008). For these reasons, it has previously been difficult to successfully apply regression or interpolation of fSCA to extract SWE. We are hopeful with the IFSAR DEM for Alaska, these methods may be applied for future work.

3) The interpolation, filtering, and smoothing of both MOD10A1 and MODSCAG is barely mentioned in the text and the supplement. Snow-cloud discrimination and how MODIS data are smoothed is a critical step that the authors have, at the least, not fully addressed. Likewise, viewing geometry also greatly affects the accuracy of MODIS surface reflectance (Tan et al., 2006), which both MOD10A1 and MODSCAG are based on. I recommend the following two studies as examples of different smoothing approaches for snow cover from MODIS, Dozier et al. (2008); Morriss et al. (2016). I would like to know how the authors' approach compares to these two smoothing techniques.

Our interpolation, filtering and smoothing of MODIS data is dealt with through pre-processing and in the CHPS software. We have added more detail through the paper, and the supplement, to reflect this question. In addition, we have added these references to the paper.

Interpolation: We used the MODIS Re-projection Tool (Dwyer and Schmidt, 2006) to pre-process imagery into an Alaska Equal Area Conic projected GeoTIFF of fractional SCA (USGS, 2011). This preprocessing step assisted us to correct, in part, the viewing geometry and other issues related to projections of the original MODIS data and the influence these projections have on the MODIS data for Alaska. We interpolated the data using Nearest Neighbor interpolation methods available in this tool. We interpreted only cloud-free pixels.

Filtering: We input the MODIS data products, with corrections for viewable area. While we did experiment with a cloud correction, and also with different sized aggregates of MODIS grid cells to determine the influence of spatial aggregation approaches, we only applied the tree correction as detailed in the paper. The reasoning for this is that these methods did not make a difference within the CHPS software, while only considering streamflow responses. We discuss in the paper why we might want to look at different metrics to really evaluate these types of pre-processing methods.

Smoothing: We ingested the MODIS data into CHPS. CHPS provided several different means to filter and smooth the data. First of all, there is the optional element in CHPS, maxGapLength, can be configured to define the maximum length of gaps that should be filled. Gaps equal to or smaller than maxGapLength will be filled with interpolated values, while gaps larger than maxGapLength will not be filled. This ensures that periods with extensive cloud cover obscuring the MODIS fSCA data are interpolated but long periods with no data, such as the summer period, are not interpolated. A maxGapLength of 11 days was selected after testing revealed that longer and shorter interpolation time steps resulted in lower streamflow simulation skill. We describe the use of maxGapLength in the supplemental.

I have included minor comments as an annotated PDF. Several citations in the text were not in the bibliography. Thus, I suggest the authors carefully check that the citations in the text correspond to those in the bibliography. If the authors have any questions about my review, I encourage them to contact me at nbair@eri.ucsb.edu.

Thank you very much. We have gone through and addressed each point you have included as minor comments. They are listed below in incremental order. We have also gone through the paper and addressed all of the comments in the annotated PDF document provided. Please see the attached track-changes version of the manuscript as well.

1. We added to the sentence Two versions of MODIS fSCA are tested “against a base case aerial depletion curve-derived extent of snow cover”.
2. We changed this to “a myriad of impacts”.
3. We added the SWIPA report to the bibliography and also added several more references on snow melt disappearance timing. Although there are challenges, as the reviewer notes, snow covered area estimates and snow melt timing and disappearance timing are considered more robust. On the other hand, SWE estimates, snow depths, and snow density are elusive measurements that have high spatial variability and are not easy to obtain in Alaska, and globally.
4. We deleted the sentence and added Huntington into the bibliography. We added the Cohen reference to the previous sentence.
5. We deleted the second occurrence of “model output” on page 3 of the manuscript. Thank you for catching this.
6. In the equation, we changed *e* to *elev*.
7. Address the SB constant, look at UADJ. This was a confusing sentence, and we re-wrote it to make it clearer what the assumptions of SNOW17 are. Hopefully this clears up the two issues that you had raised.
8. We deleted gradient from the sentence.
9. We added units to Figure 1.
10. Regarding the low bias in the SWE estimates, we are comparing station locations to the modeled results for the entire Upper Chena River basin (lumped, north and south units are shown separately) unit. Thus, we would expect the average across the lumped basin unit to be lower than the SNOTEL sites. This is accentuated in some sites more than others, for example there is a lot more snow at the Upper Chena SNOTEL gage in water year 2001, as opposed to the Teuchet site where less snow fell. We added some additional clarification where we discuss the results of this figure in section 3.3 of the revised paper.

Sincerely,

Ned Bair

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