

Interactive comment on “Has spring snowpack declined in the Washington Cascades?” by P. Mote et al.

Anonymous Referee #2

Received and published: 28 August 2007

Review of manuscript entitled, “Has spring snowpack declined in the Washington Cascades” by P. Mote, A. Hamlet, and E. Salathe

Overall Recommendation: Accept with minor revisions

General Comments:

The authors present analyses of observational (snow course) and modeling (VIC hydrologic model) results of snow water equivalent (SWE) that have been compiled for the greater Cascade Mountains region over the state Washington (USA). The aim of the analyses is to decipher what explanations can be offered as to the causes of the SWE trends. From the results presented, the authors show that the regional temperature warming plays a dominant role in explaining both the observed and modeled trends

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(i.e. decreases in SWE). However, limitations in various aspects of the data preclude any conclusive statements to be made as to whether the trends in question are a result of increased greenhouse gas concentrations.

The paper is well written and the authors make a good-faith effort to cover many facets of the data used in their analyses and consider the range of interpretations one can make with the results obtained. Overall, the tone of the presentation seems very balanced and objective. The only notable concern regarding the presented results is the somewhat limited discussion regarding the measurement error and model uncertainty, and how it would weigh into the analyses. Please see the comments provided below. In addition, some other specific (minor) comments and technical issues are provided below that this reviewer hopes the authors would consider prior to publication.

Specific Comments:

In the introduction, the third purpose for examining the data “to determine whether a human influence on snowpack can be detected” reads a bit more than what the manuscript really delivers. Perhaps more appropriate to the content of manuscript is “to discern any possible human influence on snowpack trends.”

Can the authors provide any estimate or insight as to the level of measurement error in the SWE snow course observations? It would seem that for the aerial marker (AM) sites, the uncertainty of the SWE measurement (inferred from aerial snow depth estimates) could be quite high, especially since a snow density must be assumed, and for the period surrounding April 1, the snow density could be quite variable. Similarly for the snow courses, what technique is used for the SWE measurement, and is there a standard measurement error associated with this technique? These errors/uncertainties would certainly factor into the trend, and its detection, as well as the regression analyses performed. Could the authors add some discussion and insights for the reader along these lines?

Using the VIC model at a daily timestep, and driven by daily min/max temperature and

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precipitation, it could be argued that it's not surprising that the model responds strongly to temperature (trends) and precipitation (variability). Further, it is stated that the snow model (embedded within VIC?) is run at an hourly timestep. How do you resolve the diurnal cycle of the necessary atmospheric forcing variables (i.e. temperature, radiation, winds, humidity), such that they are consistent with the daily min/max temperatures and precipitation? How is daily precipitation disaggregated into hourly timesteps (i.e. when does the precipitation event occur for that day and how long does it last)? What choices are made as to the timing of the min/max temperatures for any given day? Further, are these disaggregations assumed static in time (i.e. do not change with climate warming)? There are various assumptions one can reasonably make to produce the hourly data, which introduce uncertainties (and systematic behaviors) in the model derived SWE. Can the authors provide some additional details concerning their methods, and how they might impact the results and their interpretations?

(Some) Technical Corrections:

Bottom of Page 2075, "the facts that" should be "the fact that"

Last paragraph of Page 2081, in discussion surrounding Fig. 5, it is stated, "trends become more positive with increasing elevation," when in fact the dominant feature is that there are fewer (strong) negative trends. Please rephrase accordingly.

Page 2082, 1st paragraph Section 5: What percentage of the snow course timeseries data was missing? Also, using the "best correlated" other snow course data doesn't necessarily imply the snow course data that's closest in proximity, correct? Please clarify.

Page 2083, lines 6-8, 2nd half of sentence starting with "perhaps" seems to be a fragment.

Page 2087, discussion surrounding Table 3: The trends are given as having units of "%" but it should be a rate (i.e. % per unit increment of time), such that the trends

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for different starting times can be compared in consistent fashion. So, are the trends calculated as %/century... or something else?

Page 2088, lines 13-14 read a bit awkward. Please rephrase.

Page 2090, reference to Mote et al. (2005b), but only one 2005 paper provided in reference section.

For Figs. 3, 6, 9, and 14, please make the vertical axis the same in both the top and bottom frames. It makes the comparison of the time series visually easier to follow.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 2073, 2007.

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