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Hydrology and Earth System Sciences
Discussions

Interactive comment on "ESOLIP – estimate of solid and liquid precipitation at sub-daily time resolution by combining snow height and rain gauge measurements" *by* E. Mair et al.

Anonymous Referee #1

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Review of: "ESOLIP – estimate of solid and liquid precipitation at sub-daily time resolution by combining snow height and rain gauge measurements" by E. Mair, G. Bertoldi, G. Leitinger, S. Della Chiesa, G. Niedrist, and U. Tappeiner

General Comments:

The paper by Mair et al., proposes an approach to quantify solid and liquid precipitation from snow depth, rain gauge and other micro-meteorological observations on a sub-daily time scale. Sub-daily estimates of solid and liquid precipitation are very important for hydrological purposes and any advances in this area have potential in improving

hydrological prediction and process understanding. While the approach proposed is theoretically valid some assumptions and approaches taken either oversimplify (precipitation phase separation) or ignore relevant factors (wind redistribution of snow over snow pillows and under snow depth sensors). Each of the steps of the ESOLIP algorithm make assumptions that introduce uncertainty which need to be quantified. The largest deficiency of this paper is that it does not acknowledge the use of weighing gauges (eg. Geonor T-200B) which are standard sensors to measure total (solid and liquid) precipitation; the same parameter which this paper is trying to estimate in a much more complex manner. The uncertainty of ESOLIP makes it irrelevant at sites where weighing gauges are utilized and thus the case for using ESOLIP elsewhere must justify its added uncertainty relative to the higher costs of a weighing gauge. No attempt at this was made. As the method was compared to improper measurements of total precipitation (a combination of rain gauge and snow pillow measurements) the paper is presenting a model (hypothesis) without proper testing. The scientific method requires proper testing which is not done in this article. A second major deficiency is in the model itself in the filtering of snow height measurements. This filtering which is crucial to the performance of ESOLIP, proposes the use of a moving–average, which has significant temporal scaling issues that are not fully addressed. Either a discussion of the scaling issues is needed or a new filtering method is needed as hourly estimates of precipitation are invalid when using a 5 hr moving average. Implementation of ESOLIP elsewhere may be problematic as ESOLIP thresholds may change at other locations and the large amounts of data from other sensors or observers needed will limit possible sites where this can be used. From a writing and organization perspective the paper is more of a technical rather than scientific contribution to the field and is long relative to the significance of its technical contribution. Reorganization is needed to reduce overlap as well as length (need to clearly define intro/lit review and methodology sections).

In summary I do not think that this article is currently ready for publication, recommend rejection, as ESOLIP is not tested against a storage gauge, the filtering method is

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inappropriate for the stated objective and the assumption that snow depth (even on the hourly interval) is solely a function of precipitation is fundamentally flawed.

Specific Comments:

Pg 8685 line 11: What about weighing gauges (eg. Geonor T-200b)? These gauges are commonly utilized and are designed for measuring both solid and liquid precipitation in all conditions (oil covered anti-freeze solution) at sub-daily times scales. There was no attempt at using such observations in the article for developing or testing the algorithm. Was there no gauge available? Are there other sites where one would be? Validation of proposed method to such observations (current standard) would be of importance to potential users of this algorithm.

Pg 8685 line 16: Wind undercatch (and its correction) of solid precipitation needs to be addressed more completely (see Thériault et al., 2012 for an in-depth discussion). Explanation in article is overly simplified.

Pg 8685 line 19: Wind influence is also very critical at the surface. What about blowing snow redistribution on the ground (affects snow pillows but not rain gauge). Needs to be considered here and elsewhere in the article.

Pg. 8686 line 2: What about weighing gauges which are designed for this??

Pg. 8686 line 7: Why the reference to snow line and flood magnitudes. Describe this relationship in context of your method or remove.

Pg. 8686 line 11: Precipitation does not equal SWE on seasonal scale (sublimation, mid winter melts modify snow cover (SWE)). This needs to be incorporated.

Pg. 8686 line 14-19: Need to transition more clearly between paragraphs. A sentence to clarify that SWE from snow height is not appropriate (as snowpack has many processes acting on it over the course of the winter) for this method therefore need to use snow density instead.

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Pg 8687 line 3: Should move discussion of phase transition literature from 3.3 to here.

Pg 8687 line 8: If you are not distributing this method across a basin then why refer to snowline elevation?

Pg. 8687 line 20: what about the bias/ disadvantages this method may introduce. Temperature is only one factor for the observed fluctuations. What about the sensor bouncing around in wind?

Pg. 8687 line 26: So ESOLIP requires 5 parameters thus one needs: a rain gauge, a snow depth sensor, temperature and humidity (for wet bulb calculation) sensor and anemometer to estimate total precipitation. Each sensor has uncertainty associated with it that is introduced into the method. For this method to be adopted one needs to justify that the added uncertainty is worth it versus the added cost (and lower uncertainty) of installing a weighing gauge?

Pg. 8689 line 1: Can you get hourly estimates when you are averaging over multiple hours? Either modify your objective or your method.

pg 8689 line 15-16: using a threshold on wet bulb temperature -> using a wet bulb temperature threshold

Pg 8689 line 20: What are considered outliers or incorrect values (more details)?

Pg 8690 line 9: Have serious problems with the use of a moving average to calculate hourly values. 5 hr moving average will not give you hourly observations (calculates a number for every hour but that number represents conditions of the 5 hour span not that hour). If one wants to calculate total precipitation on the hourly scale one needs a different method to filter data or if using moving averages to rescale the data to 6 hr (or other length) periods. Extracting interval precipitation from smoothed observations of snow depth can lead to introduction of compounding errors (just look at the change in precip amounts from original to 7hr moving average in table 2 and 3). 7h moving average precip can be as low as half of observed hourly precip. This method has

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significant scaling issues that need to be addressed or changed.

Pg 8690 lines 23-26: Sentences not clear. Is the goal 2.5 or 1%? What is the significance/why did you pick these thresholds?

Pg 8691 lines 8 – 15: Very large range in values from average to max and thresholds. How effective/ sensitive is this parameter to variations then? Needs more justification.

Pg 8691 line 21: How much precip was assumed to be melting snow in the rain gauge? Such a value will give an indication of how effective these filters are. Not all of this will be melting snow as filters don't take into account all possible conditions.

Pg 8692: line 5: Why would this work better, explain.

Pg 8692 line 6: Marks et al. 2013 found otherwise.

Pg 8692 line 7: fixed threshold even when taking to account humidity (with Tw) separate phase poorly. Not a fixed point (transition range function of temporal scale) see Harder and Pomeroy 2013.

Pg 8692 line 9-10: with the noted issues and fluctuations in snow height sensor is 1mm (very small) an appropriate threshold. Need to justify the use of this threshold in light of the sensor uncertainty.

Pg 8692 line 13-14: Units

Pg 8692 line 17-18: I agree that there is no easy way to consider mixed phase but mixed phase events must be incorporated (can constitute a large amount of precipitation). One option would be to use an appropriate probability of phase parameterisation to calculate a mixed precipitation phase and apply that to observed precipitation.

Pg 8692 line 21-23: Needs more explanation. Is this saying that changing the value of the Tw threshold did not change the method performance? What range in Tw values was used to assess sensitivity? Changing the amount of rain and snow should change the performance of the method dramatically. How was performance assessed? Cu-

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mulative precipitation may not change as much but will change precipitation on the individual event timescale. Both are important if using this precipitation data for hydrological modelling.

Pg 8693: Much of the first section of results and discussion should be place in the methodology section

Pg 8694 line 18-20: ESOLIP as it is using snow height measurements needs to take this into account in the filtering of snow height. Justify if not important otherwise.

pg 8695 lines 1-3: sentence not clear.

Pg 8695 lines 1-19: Section needs to clarified (difficult to follow). What is being taken as true precipitation (observer or hourly readout). I am assuming that observed precipitation is correct (more correct than sensor) therefore filtering methods overestimates snowfall with respect observer. Need better justification for 5 hour averaging interval rather than balancing the errors between the hourly readout and observer. Both datasets cannot be right, need to pick one (observer) and develop a method that can replicate it well.

Pg 8696 line 23: If methods don't meet the requirements and you don't use them why include them in your discussion?

Pg 8697 line 9-12: sentence not clear.

Pg 8697 line 14: snowfall or precipitation

Pg 8697 line 17: how does a different method perform better than the snow pillow (the reference you are evaluating your method with). Need to clarify this.

Pg 8697 line 24: remove "with little snow". Irrelevant.

Pg 8697 line 25: for -> of

Pg 8698 line 14: what does this smoothing mean? Is there precipitation calculated

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when it shouldn't be or not?

Pg 8698 line 19-21: Confusing. ESOLIP uses rain gauge data so why would it matter if the snow pillow does not observe the rain?

Page 8698 line 24: why calculating SWE and total precipitation. Is this SWE of precipitation? SWE typically is used to quantify the snowpack (it accumulation and subsequent melt along with all of the processes, compaction blowing snow etc.. which modify it) rather than quantify snowfall. Objective of paper is to quantify total precipitation so why included SWE?

Pg 8699 line 10-11: why can one only compare when snow pillow has no snow? Rainfall is measured with rain gauge (can remove rainfall signal (from rain gauge) from snow pillow signal) and rainfall on snow will not increase snow height (so no snow identified)

Pg. 8700 line 4: "giving better information on snow line". Results do not substantiate this statement- not focus of paper.

Pg. 8700 line 7: so with "loss of time resolution" what is the timescale of this method?

Fig 6: Include unheated rain gauge data

Fig 7. a) plot labels y axis as snow precipitation (mm) but caption refers to SWE. Clarify as snow precipitation could be confused as snow depth.

References: Harder P, Pomeroy JW. 2013. Estimating precipitation phase using a psychrometric energy balance method. Hydological Processes DOI: 10.1002/hyp.9799

Marks D, Winstral A, Reba M, Pomeroy J, Kumar M. 2013. An Evaluation of Methods for Determining During-Storm Precipitation Phase and the Rain/Snow Transition Elevation at the Surface in a Mountain Basin. Advances in Water Resources http://dx.doi.org/10.1016/j. advwatres.2012.11.012.

Thériault JM, Rasmussen R, Ikeda K, Landolt S. 2012. Dependence of Snow Gauge Collection Efficiency on Snowflake Characteristics. Journal of Applied Meteorology

and Climatology 51:745-762.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 8683, 2013.