Hydrol. Earth Syst. Sci. Discuss., 10, C709–C715, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C709/2013/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Spatial distribution of stable water isotopes in alpine snow cover" *by* N. Dietermann and M. Weiler

N. Ohlanders (Referee)

nvidar@ing.uchile.cl

Received and published: 8 April 2013

First of all, I would also like to send my condolences to the family and working group of Nikolai Dietermann. Dr. Weiler, you have my greatest respect for being able to carry on working with his data.

General comments:

This paper presents a large data set of isotopic composition of snow. Results are well presented in a few informative diagrams. The study makes a good contribution to an important research field: the use of natural tracers to describe physical processes occurring during the accumulation and re-distribution (and potentially melting) of snow-packs. Although the findings are very relevant and well presented, I find that their

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

importance in a broader context is not discussed with much depth. The discussion should be extended to not only compare the significance of the different variables affecting isotope composition of the snowpack but also to include how these variables might be distributed over the landscape and which variables are likely to be dominant from a (large) catchment perspective. I recommend that the paper should be accepted for publication in HESS, provided that the discussion is improved so that it includes the impact that different variables and processes affecting snowpack isotopic composition might have on a catchment snowpack scale and maybe also in meltwater (see specific comments for the discussion section below).

Specific comments (by section):

Introduction:

The link between snow isotope composition and downstream population and industrial activity is mentioned. However, the importance of the results from this kind of study for present and future water availability is not made clear. For example it could be mentioned that once we understand the isotope composition of snow, this could help us explain the snowmelt contribution to streamflow and/or the lag between snowmelt and streamflow?

Site Description:

Approximately how far apart are the samples in each gradient? It's hard to grasp the scale of this study if the length and sampling frequency of each slope is not presented.

Results:

Both δ18O results δ 2H results for all snow samples should be demonstrated/compared somewhere, preferably along with a local meteoric water line.

Discussion:

It is an interesting finding that an altitude gradient was only found in a few slopes

HESSD

10, C709–C715, 2013

but does this necessarily imply that there is no such gradient seen to a whole snowpack/catchment scale? To me, the varied results demonstrated in Figure 3, merely suggest that we are not yet able to tell if the frequently observed pattern of depleted signals at higher altitudes is significant in the Swiss Alps, or if other variables, which are harder to define, are important enough to downplay this pattern. Given the smaller sampling number and higher pre-sampling disturbance on the southern slopes, and the disturbance of ski-slopes in the Engstlingen catchment, I would not preclude from the "depletion-with-altitude" effect being the most important factor determining the isotope composition of (at least pre-melt) snowpack. In the first review, Paul Brooks gives a possible explanation which likely explains enrichment with altitude on the Southern slopes – water vapour losses. Further, you suggest that east slopes may have a reverse altitude gradient because precipitation becomes progressively enriched as the weather front move eastwards on the lee-side of the crest. How do you suggest that the trade-off between the positive and negative relationships between δ2H and altitude, combined with the evaporation effect on the Southern slopes affect the snow pack on a macro- (catchment-) scale?

I suggest making it clear that the spatial (e.g. altitude gradient) and temporal (e.g. preferential release of lighter isotopes) isotopic variation cannot necessarily be directly compared using the study design and significance test presented in the paper. Rather, they are variables working on different scales. Like the first reviewer, I would therefore prefer analysing the different ascents (sampling dates) independently. Preferential release of lighter isotopes is a process that will occur at different altitudes at different times. This must be considered when estimating the total effect on meltwater or streamflow. For example it is possible that, on a catchment scale, the different melt stages at high and low altitudes cancel each other out – at a certain point in time, high altitude snowmelt will be in an early melt-stage, releasing isotopically depleted snow (relative to the average snowpack at that altitude) while low altitude melt will be in late melt-stage and therefore release relatively enriched snow. In total meltwater/streamflow, this would diminish the total effect of preferential release of lighter isotopes.

HESSD

10, C709–C715, 2013

Interactive Comment

I mention, as an example of how spatial and temporal isotopic variation in snowpack can be compared to that of streamflow, a study from Chile (http://www.hydrol-earth-syst-sci.net/17/1035/2013/hess-17-1035-2013.html). Here, the depletion-with-altitude was evident in pre-melt snowpack (only one altitude gradient sampled). The altitude-depletion-gradient had a profound effect on stable water isotope composition of streamflow (as snowmelt arrived from higher altitudes, streamflow became more isotopically depleted). I suspect that the strong effect of the "depletion-with-altitude" gradient was partly due to more homogenous precipitation conditions in Central Chile and that the more varied direction of precipitation fronts in the European Alps would cause a larger variation in snowpack composition, as you suggest. The "altitude factor" might therefore not have the same effect on the evolution of streamwater isotopic composition in the Alps. In your discussion you could maybe discuss how isotopes in snow could affect the streamflow signal and you could mention that in future work, isotopic measurements of streamflow could be measured alongside snow samples.

Technical comments:

2644, row 20: "expert" should be "exert"?

2646, row 14: Please mention the total number of samples taken in each catchment and slope (and the approximate distance between samples in the gradients as suggested above).

2647, row 5: I assume that this standard error is calculated using lab standards? Were any of the snow samples repeatedly analysed for isotopes and/or repeatedly sampled in the field (e.g. making a second snow core next to the first one)?

2647, row 6: The word "than" should be changed to "that" ?

Section 2.2: Was the regression analysis ever performed using only the first (pre-melt) ascent? If we want to know whether there is an effect of altitude, snow depth etc., we need to use samples representative of pre-melt conditions? Especially for snow depth,

HESSD

10, C709–C715, 2013

it seems to make very little sense to include the early and late sample dates in the same regression analysis.

2647, row 12: This sentence is hard to follow; I would suggest changing the text to: "...were selected. Since the behaviour of both isotopes in the hydrological cycle is similar, as long as evaporation is not a dominating process, and because of the smaller relative standard error of δ2H..."

2647: row 16: "whose value" should be "the value of which"

2647: row 22: add a comma after "variables"

2647, row 26: "at a point" should be "for each given point in time"?

2648, row 3: "is used" should be "was used"? Check that all description of what was done uses the same tense.

2648, row 26: As significance is determined by p-values, please indicate in this sentence which p-value is represented by r2>0.5.

2649, row 1: "These were first samplings in north-facing slopes of..:" This is not correct English, I would change the beginning of the sentence to "These were the first two ascents in the north-facing slopes of..." or "These were the first two sampling days in the north-facing slopes of..."

2649, row 10: this sentence should be written "The last two gradients are derived from five and three samples, respectively."

2649, row 14: I would simply state here that a few north-slope, first ascent gradients had a significant depletion gradient with altitude, whereas others had an enrichment gradient. Then in the discussion, I would go on to discuss the implications for the whole snowpack.

2649, row 16: "Significantly" is misspelled here.

HESSD

10, C709–C715, 2013

Interactive Comment

2650, row 23: I suggest putting the text “aspect and slope” inside brackets or commas.

2650, row 24: Insert comma after “dates”.

2650, row 26: Change this sentence to “Δsnow and DOY were the most significant variables.”

2651, row 7: Insert comma after “melting season”

2651, row 9: Change wording of “...in entire snowpack”. Maybe to “...on a total-snowpack scale”?

2651, row 12: Change wording in this sentence, I suggest “On the second date of sampling, the gradients were less pronounced...”.

2651, row 17: Insert comma after “gradients”.

2651, row 26: “in average” should be “on average”

2651, row 28: “more north” should be “further north” and should be followed by a comma

2652, row 2: change “all altitudinal gradients were not significant” to “no altitudinal gradient was significant”

2652, Consider changing “To sum up...” to “To conclude,...”

2652, row 24-25: Specify the isotope here: 3 to 35 ‰ of δ2H...

2652, Change “relative stable” to "relatively stable”.

2653, row 1: “show” should be “shows”

2653, row 10: Consider changing “taken” to “collected”.

2653, row 13-14: Consider wording: “like at catchment-scale”

2653, row 15: Add comma after “In summary”.

HESSD

10, C709–C715, 2013

2653, row 21: I would suggest making a new paragraph out of the last few sentences of the discussion section, which describe suggestions for further research. Please clarify somewhat the suggested experiment set-up and how it is useful in catchment hydrology. Would the (relative? absolute?) snow depth and isotope composition of two sampling points be representative for melt within a catchment?

2654, row 6: “proof” should be replaced by “prove”

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 2641, 2013.