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Hydrology and Earth System Sciences Discussions

Interactive comment on "Estimation of permafrost thawing rates in a sub-arctic catchment using recession flow analysis" *by* S. W. Lyon et al.

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Comments on the influence of noise and uncertainty in observations

The reviewer comments that, while the method presented in this study for estimating long-term trends in permafrost thickness is certainly worthy of investigation, it should be considered that under the method outlined in Brutsaert and Nieber (1977) and Brutsaert and Lopez (1998) the spread in *-dQ/dt* at any particular value of *Q* may be due to stochastic variability and measurement noise (Rupp and Selker, 2006). This is particularly a concern over the short intervals between individual hourly measurements (Kirchner, 2009). While the reviewer acknowledges our attempt to avoid these issues by fitting to all data points of *-dQ/dt* and *Q*, and while this analysis yields similar results to estimating the lower envelop, the reviewer further comments and questions the ability of fitting trends to all data points. This is the basis for the primary comment from this reviewer. Specifically, the reviewer comments on the method of regression used to fit all the data points in Figure 2a.

Response: In the original manuscript, we have used a nonlinear least squares fitting (*nlinfit.m* in MATLAB r2007 (c)) to perform the fitting in this study. This is more robust against the uncertainty in *Q* and *-dQ/dt* values than a standard least squares regression. We have added text to clearly state the regression method used in the revised text to help eliminate any confusion and clarify methodology. While this addresses some of this reviewer's concern, the main point of this reviewer comment questions the method of fitting to all data points. The reviewer acknowledges that fitting to all data points attempts to avoid the practical drawbacks of the lower envelope approach and recommends that if a fitting of a line through all the points is the chosen method, then the arguments made by Kirchner (2009) against fitting a function to all the data points should be considered. This argumentation highlights how zero and negative values of *-dQ/dt* are omitted after the log transformation, therefore biasing the results.

To address these concerns over both the influence of noise and uncertainty in observations shown in the scatter of the plot of *-dQ/dt* versus *Q* and our methodology to fit all data points in the *-dQ/dt* versus *Q* plot (our Figure 2a), we have adopted the methodology of Kirchner (2009) in the revised manuscript, as a test of our original methodology. Appropriate text has been added to the methodology and results sections of the revised manuscript to outline the use of the method from Kirchner (2009) as a test of our nonlinear least squares method. The approach of Kirchner (2009) is to seek the best estimate of an average description of the behavior of the catchment, rather than to define a lower envelope. This requires estimation of the central tendency of *-dQ/dt* rather than of its lower bound, which may be affected by several sources of noise (see Kirchner, 2009).

As argued in Kirchner (2009), scatter in *-dQ/dt* during low flow points may represent random fluctuations around an average recession trend. To treat this, the scatter at low *Q* must be properly taken into account in order to estimate the functional relationship

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between *-dQ/dt* and *Q* (Kirchner, 2009) This can be accomplished by binning the *-dQ/dt* data in increments of *Q*, such that each bin spans at least 1% of the logarithmic range in *Q*, and to include enough points so that the standard error of *-dQ/dt* within the bin is less than half of its mean (Kirchner, 2009). Regression is then performed on the mean of the binned *Q* and the mean of the corresponding *-dQ/dt* values. According to the argumentation of Kirchner (2009), this approach keeps highly uncertain points from exerting too much influence on any regression and yields the maximum-likelihood estimator for the best fit curve, given that deviations from the mean representing the true relationship are approximately normal.

This method provides an alternative to fitting a function to all data points and should allow for better treatment of zero and negative values of *-dQ/dt*. Clearly (see revised Figure 2a), the slope and intercept of the linear relation between *-dQ/dt* and *Q* remains the same using the methodology of Kirchner (2009) (b = 1.16) to that determined by fitting all data points using our original nonlinear least squares fitting (b = 1.13). This result justifies the original assumptions used in adopting Eq. (2) and (3) in this analysis. Furthermore, since this study is primarily looking at the changes in the recession intercept values a, once we have justified both the slope of the linear relationship (via application of the method of Kirchner (2009)) and the robustness of our fitting methodology (nonlinear least squares fitting), the relative changes between years evaluated under the original study's methodology are further validated. This holds as (given the above) we have clearly demonstrated that the original analysis methodology fitting through all data points is appropriate and robust for the level of uncertainty and noise associated with the stream flow observations for the Abiskojokken catchment over the past 90 years. Thus, it is an adequate methodology for this study.

References

Brutsaert, W., and Lopez, J.P.: Basin-scale geohydrologic drought flow features of riparian aquifers in the southern Great Plains, Water Resour. Res., 34, 233-240, 1998.

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Brutsaert, W., and Nieber, J.L.: Regionalized drought flow hydrographs from a mature glaciated plateau, Water Resour. Res., 13, 637-643, 1977.

Rupp, D.E., and Selker, J.S.: Information, artifacts, and noise in dQ/dt-Q recession analysis, Adv. Water Resour., 29, 154-160, doi:10.1016/j.advwatres.2005.03.019, 2006b.

Kirchner, J.W.: Catchments as simple dynamical systems: Catchment characterization, rainfall-runoff modeling, and doing hydrology backward, Water Resour. Res., 45, W02429, doi:10.1029/2008WR006912, 2009.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 63, 2009.