



Interactive comment on “Dye tracing for investigating flow and transport properties of hydrocarbon-polluted Rabots glaciär, Kebnekaise, Sweden” by C. C. Clason et al.

Anonymous Referee #2

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This study presents results and interpretation of a glacier dye experiment conducted on Rabots glaciär in northern Sweden. Fundamental characterizations and subsequent variability in glacial hydrology are then inferred from the various injections. Attempts (for better or worse) are made to relate these to pollutant transport. The writing is good for the most part, but suffers from clarity throughout. While I do believe the study could make a contribution to the glacier hydrology scientific literature, major revisions are recommended to help improve the quality of the manuscript and bring forward the novelty of the contribution.

General Comments

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Discussion Paper



A general issue I have with this study is the general link drawn between the dye tracing, transport properties and pollutants. It goes a bit circular for me since assumptions about transport are made when analyzing dye tracing which is then invoked to infer something about transport for pollutants. Are the “transport properties” derived here any different what would be estimated for any glacier where a dye tracer study was performed? If the answer is “yes” then a much better job bring that front and center (along with motivating why such different estimates are needed). If the answer is “no”, the study should be conceptualized to focus in on what is learned from the dye tracing for glacier hydrology. Consider the first sentence of the conclusion: “The results of dye tracing experiments provide a new and unique insight to the internal hydrological system of Rabots glaciär, and offer an understanding of the pathways and transit times of pollutants through the glacier.” I would tend to agree with the first part of this statement but not necessarily the second part. If you remove the words “of pollutants” from the second part, it is simply a restatement of the first part. What have you learned explicitly about movement of pollutants in this system? My point is that I am guessing (and hoping) there is enough novelty here to motivate the study without what can currently be considered a tenuous connection to pollutants and/or transport.

Along similar lines, the introduction lacks clear structure and tends to mix site descriptions and even some apparent results and discussion of the study (see P13714L17). A better job of putting the study in context must be done. It would also be nice to have a fundamental research question or hypothesis in there that the study seeks to test. I think that would really help pull things together and clarify the scope of the study. Where I primarily get confused is the introduction’s tendency to focus on the storyline of the fuel spill while the study itself is focused on dye tracing experiments over the glacier. I fail to see the connection between about P13713L19 through P13714L16 and the main objectives outlined at the end of the introduction. Is the only connection that the dye tracing was carried out as part of the post-spill monitoring? That is rather weak.

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11, C6309–C6315, 2015

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[Discussion Paper](#)

This mixing of information and tendency towards a lack of clarity comes up throughout. The results and discussion section is a good example (there are even some methods mixed up in there – see P13724L4). To help streamline the presentation and clarify the central findings, these sections really should be separated (and thinned to some extent). I will admit that I get lost in the wealth of information and results and interpretation being put forward in the current section. The text essentially jumps in and out of detail making it difficult to follow. My read is that many hypotheses are developed rather than tested through these results. In addition, even in this current results and discussion section, there is referencing back to pollution spreading that apparently comes out of nowhere. By separating into a traditional results section and discussion section, you can include some sub-sectioning and present, for example, a discussion on “Implications for transport in glacier environments” where you discuss clearly the fate of the hydrocarbons in this landscape based on your experimental results. In addition, there could be a sub-section where you present and develop your meltwater regimes and how the glacier hydrology changes over time (P13725L25). This would really lend clarity to what was learned from the experiments. I would also recommend a simple schematic outlining the shifts and changes under the different time periods to allow syntheses across the many strands of evidence (it would help the reader). As currently presented, it is hard to distill out what is learned in this experiment and the extent to which it advances our understanding of glacier hydrology.

With regards to the estimates and modeling made, it would be relevant to include some uncertainty and error estimates. There are many assumptions made and many inherent calibrations. Given the error potential in your experimental design (both in the sampling equipment and frequency), what are the implications for your final estimates? Given that you have several dye injections and have mixed different resolutions and types of sampling, you have a rather natural setup to explore the inherent role of error and uncertainty. Further, it could be interesting when considering the potential for distributions of travel times and (for example) small but really fast preferential flow pathways relative to the slower average bulk. Such an analysis can only serve to make your results and

conclusion more robust!

Last, the conclusion section needs trimmed. Much is just repetition of previous statements. Further, it gets rather far off topic when speculating about further experiments and pollution transport (especially given the current study). Also, the last paragraph is not connected to the rest of the study. Specifically, I do not see how this research offers unique insights about pathways. The insights gained here would be fundamentally the same as insights gained about pathways for transport from any glacial dye experiments.

Specific/Editorial Comments

Title: Should have a 'the' in front of 'hydrocarbon-polluted'? Also, polluted is a relative term here since you are comparing (I assume) to a pristine background with no hydrocarbons. Also, see my general comments regarding transport. Would it make more sense to have a title like "Dye tracing to determine flow properties of Rabots glaciär, Kebnekaise, Sweden"?

P13712L7: Probably should be 'potential flow pathways'

Abstract: Many uses of the word 'efficient' suggesting it almost as a quantifiable aspect (here and throughout the entire manuscript). Some of these vague qualifiers must either be defined as measureable quantities and/or backed up with numbers.

P13713L17: Should be 'provides'

P13713L26: Change 'it' to 'the kerosene jet fuel'

P13714L25: Sure sounds like you know a lot about the glacier and flow pathways after I read the site description! I can imagine there are glaciers out there that we know nothing about.

P13716L19: Personally, I would change 'ca.' to 'about' or 'around' (here and everywhere)

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11, C6309–C6315, 2015

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Interactive Discussion

Discussion Paper



P13716L20: Remove 'for'

P13716L23: Why switch over to what I am assuming are days of the year? Up until now you were using dates.

P13717L17: This would be the initial estimated residence time since you would not know the residence time until you ran the experiments, correct?

P13718L11: Would be good to see how the essentially calibrated variable Q compared with the observed.

P13719L13: How does one account for error sources in such a calculation? It looks like any model-observed disagreement is chalked up as a retardation factor. Could disagreement be due to errors either in the sampling/analysis? This estimate sounds like a fudge factor to get around the physics mismatch of the advection-dispersion assumption.

P13720L7: Keep an eye on significant digits in your discharge (and all) estimates. In this paragraph you are bouncing around with the number of decimals shown.

P13720L14: Clarify if you intend stream water temperature or air temperature.

P13721L1: Why is this definition coming here? It is odd and even an over simplified definition for hysteresis neglecting system memory.

P13721L6: The hysteresis 'implies' and you 'infer'

P13721L9: Again, you are just giving a graphical definition of hysteresis here.

P13722L10: Are there any records of rainfall or precipitation activity in the region in this period to support your hypothesis?

P13722L13: "Easy mobilisation of sediments at Rabots glaciär may be a source of pollution spreading and transport, where pollutants sorb to sediment particles" This is a general statement that could be made about almost any system. What pieces of your

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Discussion Paper



results specifically support this?

P13723L5: What does it mean to be in agreement in terms of “form” of breakthrough? Should this be quantified?

P13723L12: What does efficient mean here? Fast?

P13723L15: Were these really measured? I would have thought they were calculated or inferred.

P13723L23: Now you are using ‘~’ instead of ‘ca.’ or ‘about’. Pick one and be consistent.

P13723L26: From your naming convention, this should be “Rabots glaciär’s”? It gets confusing with the mixed language naming.

P13723L27: Change to “observed” and keep in past tense for results. This will be easier and clearer if you split the section (see general comments).

P13724L24: You have switched to ‘en/subglacial’ from ‘en- and subglacial’. Be consistent here and everywhere.

P13725L5: This does not fit here and is just a generic definition.

P13725L20: Here is a definition of what you intend with efficiency. Be more specific throughout.

P13726L11: Change to ‘m s⁻¹’. Check throughout.

P13726L24: By efficient you mean low dispersion?

P13727L3: What are return curves?

P13727L5: “showed” (see line 8 on the same page). The tense shifting is awkward.

P13727L23: Does efficient now mean single peaked or rather narrow crested?

P13728L12: Yes, they may but did they?

C6314

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11, C6309–C6315, 2015

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P13728L20: I think you are highlighting my previous comment that it is difficult to isolate the role of processes and errors through this storage retardation estimate approach.

P13728L24: “The results of dye tracing experiments provide a new and unique insight to the internal hydrological system of Rabots glaciär, and offer an understanding of the pathways and transit times of pollutants through the glacier.”

Well, I would agree with the first part of this statement but not necessarily the second. If you remove the word “pollutants” from the second part, it is simply a restatement of the first part. What have you learned explicitly about movement of pollutants in this system? See general comments.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 13711, 2014.

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