

Interactive comment on “Diel fluctuations of viscosity-driven riparian inflow affect streamflow DOC concentration” by Michael P. Schwab et al.

Anonymous Referee #2

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The study deals with an original time scale of dissolved organic matter variations as diel cycles have been less studied than event responses or seasonal patterns and long-term trends. DOM is described via 2 parameters: DOC concentration and its properties through SUVA index as a proxy of the aromaticity. The studied hypothesis is also original and mainly supported by a previous work by Schwab et al in 2016 that compared the respective role of evapotranspiration and riparian inflow changes (due to temperature-driven viscosity changes) on diel fluctuations of stream flow. For riparian GW temperature, DOC stream concentration and corresponding SUVA-254, diel cycles are in phase over the whole time series with daily max occurring in the afternoon (between 2pm and 6 pm). Amplitude of the cycles is minimal in winter. Amplitude of riparian shallow groundwater and DOC concentration cycles is relatively constant dur-

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ing the rest of the period. Amplitude of SUVA-254 cycles is high in spring (at the end of the dormant period) and small in summer (middle of the growing period). For discharge, diel cycles change in phase between the dormant season (morning max) and the growing season (afternoon max) and disappear during winter (start of the dormant period). Amplitude of the discharge diel cycles seems higher in spring (end of dormant period) than in the growing period. From these observations the authors suggest that the variations of riparian flow (due to water viscosity variations with the temperature) are the major control of DOM diel cycles. I found the manuscript well written with clear messages. The analyses and supporting data set are valuable. However I found the conclusion on the respective hypothesized controlling processes (in-stream biology versus riparian flow conductivity) quite hasty and maybe too categorical regarding what is effectively observed and demonstrated. The results support the hypothesis but some questions remain and interpretation should remain more careful in my point of view (please see specific comments).

Detailed comments and questions

Introduction

p.2 line 3: Do you have an idea of the relative concentration levels of DOC and DIC in the study stream?

p.5 line 5 indeed photodegradation has been shown significant on highly brown DOM coming from peatlands (references cited by the authors). I am not sure that it has been reported as important on forested-derived DOM

Methods

p.4 lines 5-6 This point may be an output from previous research conducted on this well-studied catchment but how the significance of riparian zone contribution has been demonstrated? And quantifications if available would be useful

p. 4 lines 11-13 provide information about average annual pattern of flow. Similar

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information about the annual behaviour of DOC concentration and SUVA-254 would be useful to understand the catchment: from Fig. 2 it seems that mean DOC and mean SUVA-254 are maximal in summer low-flow period (increase from Feb to Aug 2014 and from Feb to June 2015). If riparian subsurface flow is the main source of aromatic DOC, I expected this contribution being higher in high flow periods and lower in low flow periods when catchment saturation decreases and therefore minimal DOC and SUVA values in this low flow period. . .

p. 4 lines 16-17 I think there is an error: unless I am mistaken a variation of 5°C leads to a viscosity change of 2% only. Using Eq. 3 from Schwab et al. (2016):

$$\eta(T^\circ) = e^{(3.7188 + 578.919 / (137.546 + T^\circ))}$$

If T° is the temperature in Kelvin degree (as said "T in K"). I think that the 12 to 15% of change of viscosity have been deduced by applying the formula with Temp in Celsius degree, right?

As brief example, for $T=15$ Celsius deg (288 Kelvin deg) I found $\text{Nu}=164$ Pa.s

for $T=20$ Celsius deg (293 Kelvin deg) the formula gives $\text{Nu}=161 = 164 -2\%$

p. 4 lines 26-31: Did you compare also the absorbance values at 254 nm from spectro::lyser and from the lab? (Since Absorbance values are available for the end-members - p4 lines 33-34- I suppose that some exist for the stream as well. . .?)

p. 5 lines 1-5 sampling points for the end-members, as well as the stream station and the temperature monitoring point should be located on a map of the site.

p. 5 line 3 Regarding the method to sample riparian water, I wonder if the riparian area was effectively fully saturated? On another hand, viscosity of riparian water is calculated from a temperature sensor located in the riparian groundwater at 10 cm depth so I imagine that riparian groundwater remains shallower than those 10 cm depth? . . . Is the water table level in this specific zone monitored (that could help giving the local hydraulic gradient with the stream)? Is riparian water sampled at 6 different depths too

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or only at 10 cm? Do you observe any vertical variability of DOC and SUVA in this riparian zone as shown for soil water in Fig 5 b,d? Regarding Fig 5a, the DOC richness is finally much closer between riparian water and groundwater and low.

p.5 line 13 It is not clear in the following which analyses do use this smoothed SUVA time series (obtained from 3 hours moving window) or the raw time series: p. 5 line 25 “the original time series with the 15 min time intervals” is used to compute the distance to daily average

Results

p.7 The difference in amplitude of diel discharge cycle between dormant and growing period is not characterized but amplitude of the discharge diel cycles seems higher in spring (end of dormant period) than in the growing period? Maybe a scale effect to due difference in base flow?

p. 7 Figure 2: It would help to represent dormant and growing periods on the graph by color or shadings or vertical lines for instance

Figure 5: If possible with the scales, the corresponding values in stream water could be added in (a) and (c) to have in mind the relative position of stream between the end members

Discussion

p. 10 lines 5-9: Correlation between DOC and SUVA₂₅₄ fluctuations sounds consistent and I certainly agree with the authors on the value of SUVA₂₅₄ or such indices as proxy of DOM composition and properties. However, there is a point absolutely not discussed here: the fact that DOC concentration value is computed by the spectro:lyser algorithm using the absorbance value at 254 (or absorbance at 252 & 255nm). Other absorbance values are obviously included in this concentration estimate but the DOC and SUVA variables used here are somehow both functions of measured absorbance at 254 nm, so that their correlation is not fully surprising. . .At least I feel that it deserves

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a word in the discussion. See also my comment on (p. 4 lines 26-31)

p. 10 lines 14-15 I feel the rejection of the first hypothesis arrives a little bit fast. The absence of in-stream processes is not fully demonstrated to my opinion. Microbial processes are numerous, here you assume DOC concentration increase due to in-stream production should exhibit a low aromaticity and therefore a low SUVA but i) biological processes that recycle the DOC are numerous enough to lead to complex antagonistic results; ii) keep in mind that SUVA is only a proxy of the complex composition of DOC; iii) and again that in this case SUVA is computed using absorbance properties only .

On the other hand, all the conclusions are based on relationships between DOC, SUVA and viscosity which is actually an interpretation of measured temperature variations. Therefore, what is established strictly speaking is that DOC and SUVA variations are correlated with temperature in riparian water isn't it? I wonder if the correlations would have been poorer using for instance stream temperature? And temperature is a factor control of viscosity but also many processes, biological processes, evapotranspiration. . .

If I didn't make a mistake on comment regarding (p. 4 lines 16-17) above, variations of 5°C would induce a change (in viscosity and thus also) in hydraulic conductivity of 2%, which is a very small change, and even if the 10-15% of variations are right, I wonder how significant it is on the flow from this area. If you had an estimate of the range of hydraulic conductivity and of the hydraulic gradient to stream (via measurement of groundwater level) this would help to understand the relative weight of such an increase of the viscosity?

Finally there are still missing pieces of discussion:

(p. 8 & p. 9 lines 1-2) Correlation between DOC and SUVA daily variations are stronger during dormant period: why if their diel fluctuations have the same origin (riparian flow)? Would this be related to a change of riparian DOM composition? If so, such change would be visible on the end-members samples? Looking back at Fig 6, it

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appears to me that this difference is explained actually by stronger in-stream processes that would have during growing season comparable effects to viscosity fluctuations. So that seasonal processes would be also a dominant control, isn't it?

p. 9 lines 10-11 If riparian water is responsible for diel increase of DOC stream concentration, I found it surprising that the DOC concentration in the riparian water is finally rather low compared to soil water in the hillslope. . .

p. 11 lines 1-4 see my suggestion for Figure 5

p. 11 lines 14-20 Schwab et al. (2016) concluded that Q fluctuations during dormant season was indeed resulting from viscosity changes resulting in variable riparian flow to stream, but in the growing season, the role of evapotranspiration fluctuations was dominant (leading to diel cycle inversion). The authors explain the fact that Q and DOC are not affected by the same processes because of the relative influence of those processes on the respective "sources" of water and DOC. ET controls Q cycle affecting the whole catchment storage while viscosity controls the DOC from riparian upper layers. So at the end, those stream signatures are integrating various catchment processes and disentangling those processes faces the same issue as distinguishing the processes that can control seasonal cycles on water quality. Maybe in further studies, it would be worth to try looking at some other parameters that could play the role of riparian flow tracers to support further the hypothesis.

p. 13 lines 5-14: this answers partially my comment on (p. 4 lines 11-13). However I found this seasonal pattern quite surprising. In many study, Hillslope subsurface flows merely active during wet conditions intercept the riparian area flushing somehow their upper soil layers rich in DOC leading to high DOC concentration (and more aromatic as well). During low flow, saturated area extension is decreased, and connection between those DOC sources and the stream can be interrupted. Flow is sustained mainly by groundwater which is poor in DOC so should lead to minimal DOC concentrations excepted if autochthonous production increases this DOC concentration. The proposed

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interpretation for Weierbach catchment should be discussed regarding general understanding that have been proposed elsewhere.

It would be interesting to have an idea of the importance of the variations we are looking at (as percentage of flow/concentration/SUVA mean value). I do not discuss the interest of the topic that has been scarcely studied so far but I think that keeping in mind the relative orders of magnitude of the studied phenomena sounds relevant

Conclusion

p. 13 lines 26-29: I wonder if other tracers unrelated to carbon dynamics could be interesting for tracking independently the riparian flow for instance. I would also suggest the use of O₂ probes to try catching indirect information on metabolic activity of the stream?

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