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# *Interactive comment on* "Determinants of thermal regime influence of small dams" *by* André Chandesris et al.

**André Chandesris et al.**

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Dear Editor and Referees,

Thank you for the quality of your proofreading and comments; they have greatly improved the manuscript. We also appreciate your interest in the subject matter, which we think is of critical importance to managers across France and the world who are dealing with issues of small dam removal and ecological integrity. We believe we have substantially addressed all of the outstanding comments and issues, and we look forward to your second review of the work. All of the referees remarked on the issue of data representativeness, so we will briefly discuss this issue here. Data scarcity (i.e., lack of data across years within sites) is a primary challenge for understanding thermal



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effects of small dams, and it is one of the primary reasons that we used a compiled dataset with data from field operators, which we bolstered with our own sampling. We acknowledge that using these two data sources may make reading and understanding a little more difficult, but we believe it enriches the analysis by increasing the number of time series and across-year examples, (though we agree this dataset is probably still insufficient to draw broad conclusions). Hence, we are aware of the issues with the dataset, and we have added text throughout to underscore this issue. However, we feel that the analysis and general results are valid and useful, regardless of data scarcity issues, which every study must deal with. Throughout the manuscript, we have made major revisions based on the referees comments and suggestions. The major changes are: - use of new statistical analysis methods to strengthen the robustness of the results, - improved consistency between points raised in the comments and proposed figures, - grammatical quality review: a final revision of English was done by a native speaker.

General comments: "In general, the paper discusses a relevant research issue, as is discussed based on the literature in the discussion. It is apparently based on an interesting dataset (though with some limitations, mentioned below), but the presentation and discussion of the results is relatively poor and not very clear, and calls for major revisions." "the presentation and discussion of the results is relatively poor"

Response: We have significantly improved the version submitted, adding all the statistical analyses required to support the results. They reinforce, but do not change their meaning.

General comments:"It should be made more clear (in the introduction etc.), that the results are probably not easily transferrable to other areas, as the choses study sites are quite homogenous (focus on a certain region of France). "

Response: While we acknowledge the reviewer's comment that our study is based on a regional dataset, we believe that the results (i.e., that dam physical attributes influence





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downstream thermal regimes) is applicable to many other regions and systems. Additionally, we wanted to focus our results on the importance of these thermal regimes on ecophysiological processes, like effects to the brown trout. We have added new text throughout the paper to clarify this point. To remove any ambiguity, we also delete the reference to regional stream temperature model in the abstract (L 12) and the introduction (L 114) On the other hand, we propose in the discussion to complete the notion of the possibility of regionalization as follows

Previous text: L 323 One potential path for deepening research is regionalization as a function of thermal regimes and their governing factors (characteristics of aquifers/climate/bed material/conductivity).

Replaced by

One potential path forward is to create regionalized statistical models based on geographical data and dam databases, analogous to the way that ecological risk analyses are constructed (Allan et al. 2012; Van Looy et al., 2015). However, we realize that our dataset is provincial in temporal and regional extent, potentially limiting extrapolation of results to other areas with different groundwater and climatic influences.

General comments: "Furthermore, the study would greatly benefit from including more temperature data from the same site for several years – one would expect to also see quite some inter-annual differences. As this does not seem to be possible, the authors should at least discuss this shortcoming. Especially as the authors try to hint at a regionalization (e.g. at the end of section 4.1), this should be discussed better: What, for example, about the different groundwater regimes – are we talking about gaining or losing rivers? Etc."

Response: We have added a sentence to the discussion acknowledging these issues. Line 325 However, we realize that our dataset is provincial in temporal and regional extent, potentially limiting extrapolation of results to other areas with different groundwater and climatic influences.





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General comments: "The overall result – that the most important drivers of temperature regime changes in dams are residence time and surface area are not particularly surprising. Discuss this. (maybe one could even come up with some empirical linear relationship or empirical model, including those parameters, and water temperature, air temperature, solar radiation etc.?)"

Response: We agree that the results are not particularly surprising, but we note that these results are surprisingly absent from the literature. Hence, this work provides an important result that, to our knowledge, has not been previously presented. We have tried to quantify the heating due to the structures of small dams. The major determining parameters that emerge do not contradict physical knowledge. But it is important to point out that we were not seeking to highlight the physical determinants of the thermal regimes of rivers, but rather the factors responsible for heating due to a dam and its associated impoundment. We have thus provided knowledge on the orders of magnitude of heating for structures that have not yet been well documented. We have added statistical analysis (see later) to explain more efficiently these relationships, and have added text throughout to better address the issues raised in this comment. Sentence added L307 We confirm with the redundancy analysis that residence time and surface area of the water body are the principal explanatory variables of the upstream/downstream temperature differences. However, these relationships are not entirely clear, as the multiple regressions (Table 4) indicate that diff_Tmax is best explained by both residence time and surface area, whereas diff_Tmin is best explained only with residence time. "Specific comments:" "Section 1: Please include some more general explanation on why the whole issue of dams changing the thermal regime is relevant (make your motivation more clear)"

Response: We have clarified the motivation for this study explained in the introduction with an English speaker and hope it addresses this comment (paragraph 1.5, line 87 to 107). We review the literature and show that knowledge is scattered regarding the orders of magnitude of thermal effects that are significant for biological processes. Our





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goal is therefore to better document these orders of magnitude.

"Line 27: “These determinants are candidate to generalize results” – sentence a bit unclear, please reformulate"

Response: Sentence deleted.

"Line 47: “During summer, the factors leading to warming are: (i) the input of heat from upstream” – maybe you should be a bit more specific here. Mention why you focus on summers. What do you mean by the input of heat from upstream? Tributaries that are warmer than the main stream?" Responses: Focus on summer: We have mainly targeted the biological risk related to global warming. Introduction §1.1 line 35 – 37 "As ectotherms, aquatic organisms are very sensitive to ambient water temperature and to its alteration, especially in the vicinity of their upper thermal temperature tolerance (Brett, 1979; Coutant, 1987; McCullough et al., 2009 for Coldwater fish review; Souchon and Tissot, 2012 for European non salmonid fish review).".

Heat from upstream We refer to the conceptual heat flow balance model of Kelleher et al., 2012: the heat flow from upstream depends on the inflow flow Qi and the temperature of the watercourse, which results from the addition of flows from the main river and its tributaries upstream of the studied section. Kelleher, C., Wagener, T., Gooseff, M., Mcglynn, B., Mcguire, K. and Marshall, L. (2012). Investigating controls on the thermal sensitivity of Pennsylvania streams. Hydrological Processes. 26(5): 771-785. To be precise we add “fluxes” in L 47

"Line 50: If you talk about different anthropogenic influences on stream temperature, you probably also should mention cooling water from power plants etc."

Response: The objective of the study is to quantify the effects small dams in stream; this does not concern cooling water from power plants affecting large rivers.

"Line 56: > 15 m of what?"

Fixed 15 m high





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"Line 61 ff: These two “predictions” you are mentioning from 1983 and 1990 should be verified by now? Can you say something about this?"

The term prediction is inappropriate

Fixed

Previous text: L 61 to 63 In addition, Ward and Stanford (1983) predicted that dams in headwaters might not alter the natural temperature range, with the assumption that canopy and springs or groundwater influx can buffer annual temperature variations.

Replaced by

In addition, Ward and Stanford (1983) have made the general assumption that dams in headwaters might not alter the natural temperature range, with the assumption that canopy and springs or groundwater influx can buffer annual temperature variations. Furthermore, SDC mentioned summer water temperature warming downstream of surface reservoir’s release (O’Keeffe et al., 1990).

"Line 84: With a height smaller than 5m?"

Fixed L 84 We studied dams with height smaller than 5 m, called hereafter simply small dams.

"Line 88ff: Be more precise here. There are few articles even considering temperature effects? Those are the 43 sites or articles?"

Fixed on 43 studies , 25 % have been considered having a temperature increase effect

"Line 106: “with closed riparian canopy or aquifers” – what do you want to say here?"

Previous text: L105 to 106 This variability is greater in headwaters due to the weak thermal inertia and great diversity of these waterbodies, and also to heterogeneous effects with closed riparian canopy or aquifers.

Replaced by





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This variability is greater in headwaters due to the weak thermal inertia and great diversity of these waterbodies, especially with regard to local shading effects from riparian canopy cover and relative importance of spring or tributary discharges.

"Line 106ff: “This is the reason why it seems preferable in a first study to focus on the single effects of the impoundment immediately downstream the dam.” – please reformulate/make your motivation more clear. How exactly is this resulting from the above?"

Fixed Previous text L 106 to 107 This is the reason why it seems preferable in a first study to focus on the single effects of the impoundment immediately downstream the dam

Replaced by

Given this potential complexity with several possible confounding factors, the study focused only on the warming effect of small dams and their impoundment. "Line 130: How is a “day of heat wave” defined?"

For scenario A1B (mean concentration of greenhouse gases), the estimation was more than ten additional days of heat waves by 2050.

Response: The definition is conform to International meteorological vocabulary WMO, 1996. WMO, No. 182. TP. 91. Geneva (Secretariat of the World Meteorological Organization) 1966. Pp. xvi, 276. Sw. fr. 40 "Marked warming of the air, or the invasion of very warm air, over a large area; it usually lasts from a few days to a few weeks"

Fixed

Previous text: L129 to 130 For scenario A1B (mean concentration of greenhouse gases), the estimation was more than ten additional days of heat waves by 2050.

Replaced by





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For scenario A1B (mean concentration of greenhouse gases), the estimation was more than ten additional days of heat waves (WMO, 1966) by 2050.

"Section 2.2: Mention right away in the text how many dams you study. And how did you chose those specific sites?"

Fixed

L 132 The 11 dams in the study area are overflow structures and . . .

The sites were chosen taking into account their distribution in the upstream downstream gradient and the size gradient of the reservoirs.

Line 145: Make it clear that the temperature sampling was performed for single summers (or two) per site, between 2009 and 2016

Fixed We add sentence: L 146 For two sites, we have series for 2 different summers (Champagne2009 and 2015, Fretas 2002014 and 2016) because the local water management organization was particularly interested in the thermal regimes of these rivers. (Table 1).

"Section 2.5: Please elaborate further on how you performed your PCA. Illustrative variables are explanatory variables? “In order to identify characterization of the impacts of the different dams” – reformulate, unclear!"

Fixed Previous text: L 166 to 170 2.5 PCA analysis In order to identify the characterization of the impacts of the different dams, a principal component analysis (PCA) was carried out using the software XLStat (ADDINSOFT$^{TM}$) on the water temperature variables: downstream / upstream difference of the maximum, average and minimum daily temperature and daily temperature amplitude. The physical characteristics of the structures (Table 1) were used as illustrative variables to evaluate the correlations with the temperature variables

Replaced by





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2.5 Ordination analysis To characterize the impacts of the different dams, a principal component analysis (PCA) was carried out using the software XLStat (ADDINSOFT$^{TM}$) on the three water temperature variables: downstream/upstream difference of the maximum and minimum daily temperature and daily temperature range. We used the median values for variables on each time-series in order to build an input matrix (13 occurrences for three variables). Then a complementary redundancy analysis (RDA) with automatic stepwise variable selection procedure was used to identify the physical dam characteristics (Table 1) that significantly explain the PCA results (ter Braak 1986). After the RDA identified the relevant physical dam characteristics, we conducted multiple linear regression between these characteristics and temperature variables to determine specific effect sizes of these characteristics on thermal regime. Ter Braak, C. J. F.: Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis, Ecology, 67, 1167-1179, 1986.

Previous text : L 220 232 3.6 PCA results The first axis of the PCA analysis (78.3 %) is correlated to all temperature daily variables (calculated as differences between downstream versus upstream), in particular to the maximum daily temperature difference (Tmax_diff). The second axis discriminates the daily amplitude difference (Range_diff) with the minimum temperature (Tmin_diff) difference (Fig. 7). For the determinants, the water residence time is the most correlated variable to the first axis F1, the size of the reservoir (surface, volume, length) correlates to both the first and second axis. The other physical-geographical characteristics related to the size of the watercourse (watershed, distance to the source), are correlated with the daily maximum temperature and associated with the second axis F2 (20.7 %); dam height has a very weak correlation with the axis F1. The projection of the site series on these axes shows a strong spreading along the first axis. The dams measured two different years stay within the same range on this axis (Fretaz and Champagne) (Fig. 8). Groups B1 and B2 are distinguished by respectively the first and second axis association. This can be linked to the determinants of strong residence time influence for group B2, whereas group B1





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is mainly characterized by the size of the impoundment (large impoundments, yet with relatively smaller residence time and thus less exacerbated thermal regime effects).

Replaced by

3.6 Ordination results The first axis of the PCA analysis (74.1% of total inertia) is correlated to all temperature daily variables (calculated as differences between downstream versus upstream), in particular to the maximum daily temperature difference (Tmax_diff). The second axis (25.3%) discriminates the daily amplitude difference (Range_diff) with the minimum temperature difference (Tmin_diff) (Fig. 7). Results of the RDA show that the water residence time and the impoundment surface explain 95.2% of the PCA structure (time series plotted on the first and second axis).The projection of the site series on these axes shows a strong spreading along the first axis. The dams that had two different measurement years stay within the same range on this first axis (i.e., Fretaz and Champagne) (Fig. 8).

Multiple regression analyses between the temperature variables (median values of Tmin_diff and Tmax_diff) and the physical characteristics obtained by the RDA (residence time and impoundment surface) resulted in high explanatory power ($R2 \approx 0.7$). These regressions identified the significant contribution of residence time for Tmin_diff and Tmax_diff, whereas only surface area had a significant contribution for Tmax_diff (Table 4).

A new table is added

Table 4. Results of multiple linear regressions performed on the 2 indicators Tmin_diff, Tmax_diff using the physical characteristics: i) surface, ii) residence time. Significant pvalue are in bold.

Dependent variable; Independent variable physical characteristics; R2; standardized coefficient; pvalue

Tmax_diff ;surface; 0.72; 0,39;0.041;





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; residence time;;0.80;0.001

Tmin_diff; surface; 0.68; -0.13; 0.48

;residence time; ;0.80;0.001

"Section 3.2/Fig. 4: I understand that the scatter plot for Dompierre shows “type 2”, so like in Figure 3. However, Neuf in Fig. 4 does not show “type 1”, like in Figure 2, because there is almost no difference between minimum temperatures up- and downstream. And, why don’t you simply show the same data in your timeseries plots (Fig. 2 and 3) and the scatterplot (Fig. 4) to illustrate the two types. Also, better to combine the figures and make the two types more clear by that."

Response: We follow the recommendation and propose a new set of figures

Fig. 2 Fretaz 2014 and 2016 and Fig. 4 Dompierre (type 2) and Fretaz (type 1)

Previous text: L 191 to 194 The two dominant patterns can be illustrated by plotting the minimum and maximum temperature values at the site "Dompierre 2010” with a difference of order of + 1.5°C between the upstream and downstream of the site, comparing to "Neuf 2016", where these values are the same for minimum daily temperatures, or even slightly negative for the maximum temperatures (Fig. 4).

Replaced by

The two dominant patterns of temperature differences are further illustrated by plotting the minimum and maximum temperature values at the site. For example, at Dompierre in 2010, we observed a consistent shift of approximately +1.5°C (both maximum and minimum daily temperature) between the upstream and downstream of the dam (Fig. 4A). In contrast, at Fretaz in 2014, this shift is dampened, and temperature values between upstream and downstream follow a 1:1 relationship (Fig. 4B). New figure 4

"Section 3.3: 0.46% of what?"

L 197 This difference averages 0.46% for the 13 cases.





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Response: This precision is deleted, as it is secondary

"Section 3.5: Specify how you calculate your differences (downstream – upstream?). And don't groups B1 and B2 both exhibit net warming? Be more precise."

Response: We propose to modify the section 2.4 Data analysis (l 156 à 159)

Previous text: L156 to 159 To determine if the dams alter the temperature regime, the minimum, average and maximum temperatures and amplitudes were calculated for each full day recorded, and the median values were recorded for the period. The calculations of daily differences of maximum and minimum water temperatures were performed for each pair of upstream/downstream records, and the median of these differences over the recording period was calculated.

Replaced by To characterize the influence of dams on stream thermal regimes we first calculated three variables: daily difference between upstream and downstream temperature 1) maximums, 2) minimums, and 3) ranges for each site and year. (..). With these data, we then conducted the following analyses: 1. Median summer differences in maximum, minimum, and range between upstream and downstream (median is used instead of mean to characterize a season in order to limit the effect of a specific weather event), 2. . ..

"Section 3.7: Confusing to speak of "short period of time" or "three consecutive days" – what you actually do is to look at shifts in intra-daily temperature variation."

Fixed

Previous text: L 234 Focus on temperature pattern in short period of time. Replaced by L 234 Focus on temperature pattern in intra-daily temperature variation. Previous text: L 235 239 Looking more specifically on a short period of time (three consecutive days), differences in the diurnal variation of the temperature of the river upstream and downstream of the dam shows that for the first group A, the maximum water temperatures upstream and downstream are close, while the minimum temperature down-





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stream does not return to that of upstream (Fig. 9A). In the second group B the water temperature difference between upstream and downstream are more important and remain persistent during all the day period (Fig. 9B). Replaced by To further illustrate the different thermal regime effects from our typology analysis, we compare intra-daily temperature variations for a three-day time series in group A (small thermal effect) with group B (large thermal effect; Fig. 9): - In the example of group A (Fig. 9A), the downstream temperature is generally warmer than the upstream temperature (observed difference of 1°C warmer) except for a few hours during the three day sample observation period. The biological benchmark of 22°C is exceeded both upstream and downstream during the day of August 20. The rest of the time, temperatures are below this threshold. From a biological point of view, the duration above the thermal threshold is short, preceded and followed by more favorable temperatures (i.e., the remission period). - In the example of group B (Fig. 9B), the downstream temperature is systematically higher than that of the upstream, with a temperature difference varying between +0.8–2.4°C. The 22°C threshold is exceeded downstream for a cumulative 42 h over the three-day period. August 15 and 16 have downstream temperatures that rarely go below 22°C, leaving no time for thermal remission (return to a temperature that is better tolerated physiologically by fish). At the same time, the upstream part of the stream is maintained at daily temperatures not exceeding this threshold. - Additionally; differences in the diurnal temperature variation upstream and downstream of the dam shows that for group A, the maximum water temperatures are close, whereas the minimum temperature downstream does not return to that of upstream (Fig. 9A). In group B the water temperature difference between upstream and downstream are persistent throughout the diurnal cycle (Fig. 9B). For all sites, by studying the average daily duration with a temperature exceeding 22°C continuously, we can see (Fig. 10): - downstream durations are always greater than or equal to that of the upstream durations, regardless of site typology, - the largest upstream/downstream differences occur in the group B2 group, - group A is generally not affected by an upstream/downstream increase, except for two sites which exhibit a two hour increase.





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A new sentence is added in 2.4 data analysis To assess the potential biological importance of dam thermal effects, we also calculated 1) the number of days that water temperatures were greater than 22°C, and 2) the mean of the maximum daily duration (in hours) where water temperature was greater than 22°C. We chose 22°C as an illustrative threshold known to be a thermal stress benchmark value for salmonids (Elliott and Elliot, 2010; Ojanguren et al., 2001).

L 162 (iv) the dam thermal effect considering an arbitrary threshold of 22 °C, with a calculation of the number of days above this threshold. Replaced by

4. calculation of the number of days above the biological 22°C threshold, and 5. calculation of the average maximum daily duration (in hours) above the biological 22°C threshold.

And in discussion L 344 to 349 We have chosen temperature > 22°C as an illustrative threshold known to be a thermal stress benchmark value for salmonids especially for brown trout, Salmo trutta (Elliott and Elliot, 2010: upper critical incipient lethal temperature for alevins considered as a very sensitive stage; Ojanguren et al., 2001: general activity of brown trout juvenile). We also know that thermal regime and threshold values are important for the life cycle of aquatic invertebrates (Ward, 1976; Brittain and Salveit, 1989), and it is possible that changes in natural temperature regimes may be as important as altered stream flows to the ecological impacts of dam operations (Olden and Naiman, 2010). Replaced by In this study, we used a temperature of 22°C as an illustrative threshold known to be a thermal stress benchmark value for salmonids, especially for brown trout, Salmo trutta (Elliott and Elliot, 2010: upper critical incipient lethal temperature for juveniles, which is considered a very sensitive stage; Ojanguren et al., 2001: general activity of brown trout juvenile). In addition; this threshold is known to be important for the life cycle of aquatic invertebrates (Ward, 1976; Brittain and Salveit, 1989).

We add a new figure (Fig.10) "Section 4, first paragraph: Some of this would be better





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in the introduction. Same applies to first two paragraphs of section 4.1."

Response: That's right. We think that the recall of the context in a few sentences make the discussion as an independently readable part.

"Line 317, 318: Again, specify the sign of your temperature differences."

Fixed L317 in the order of + 0.6 to + 2.4°C

"Line 344ff: Is Salmo trutta a common species in the rivers of your test sites?"

Response: Yes, Salmo trutta is endemic and emblematic and at the ecological limit of his distribution. This is why a warming effect added by dams to the natural thermal regime is likely to further limit its range.

"Line 378: "The thermal landscape is therefore potentially very fragmented due to this fact alone." What do you mean by this and the following sentences?"

Fixed Previous text: L378 The thermal landscape is therefore potentially very fragmented due to this fact alone.

Replaced by

because of the high density of dams in the landscape (0.64 per km), the thermal landscape of this region is potentially fragmented.

"Line 385: Please specify which "spatial generalization elements" you mean."

Fixed Previous text : L384 to 385 Our work provides spatial generalization elements to better document the present and future thermal landscape

Replaced by

Our work highlights physical dam characteristics that could be useful in a large-scale heat risk analysis, or in modeling scenarios aiming to account for changes in thermal regimes.





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Technical comments: "Be consistent with thousand separators (for example, you have 2 710000, 96 222, 59071)"

Fixed

"Be consistent on how to write “run-of-the-river dam”."

Fixed

"Line 38: Why do you cite Rader et al., 2007 as part of the review by Ellis and Jones?"

Fixed L38 (Rader et al., 2007 in Ellis and Jones, 2013)

Replaced by

(Rader et al., 2007)

"Line 42: “precipitation”, not “precipitations”, this comes up several times"

Fixed Lines 42,153, 154

"Line 68: reformulate to “they are expected to increase downstream water temperature” or similar" Fixed Previous text: L68 they are expected to deliver downstream warmer water

Replaced by they are expected to increase downstream water temperature

"Line 78: “(ROE, sept 2017)” why is this cited this way?"

Fixed Suppressed

"Line 59: “water temperature patterns for tens of km”?"

Fixed Previous text: L59 alter longitudinal downstream water temperature pattern tens of km

Replaced by

alter longitudinal downstream water temperature pattern for tens of km





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"Line 72ff: “very imprecise depending on national databases. For example, the International Commission on Large Dams”"

Fixed Previous text: L 72 nation databases.

Replaced by

national databases.

"Line 90ff: “Dripps et al. (2013): : :.” – please reformulate, sentence unclear"

Fixed

Previous text : L90 to 92 Dripps et al. (2013) studying 3 residential artificial headwater lakes (17 to 45 ha) on stream (low flow discharge 0.0024 to 0.0109 m3/s) showed that they could increase summer downstream temperature by as much 8.4°C and decrease diurnal variability by as much 3.9°C.

Replaced by

.Dripps et al. (2013) studied the influence of three residential artificial headwater lakes (17–45 ha) on stream (low flow discharge 0.0024 to 0.0109 m3/s) thermal regimes. They measured a summer downstream temperature increase by as much 8.4°C and a decrease of diurnal variability by as much 3.9°C. "Line 95 ff: “Hayes et al. (2008) in the region of the Great Laurentian Lakes” – all this paragraph contains typos and grammar mistakes, please revise"

Fixed

Previous text: L95 to 97 Hayes et al. (2008) in the region of Great Laurentian Lakes measured a weak to null thermal effect of low-head barriers (<0.5 m in height) built to prevent the upstream migration of sea lamprey Petromyzon marinus, but a temperature elevation comprised between 0.0 to 5.6°C below small hydroelectric dams.

Replaced by





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In the region of Great Laurentian Lakes, Hayes et al. (2008) studied two types of dams with different uses. They measured a weak to null thermal effect of low-head barriers (height <0.5 m) built to prevent upstream migration of sea lamprey (Petromyzon marinus, L.). On the other hand, they measured a greater effect for small hydroelectric dams (downstream temperature increases up to 5.6°C).

"Line 101: Maybe “explaining variables” is a better term" Fixed Previous text: L 101 to 102 and the difficulty to identify the master variables governing the thermal regime

Replace by

and the difficulty to identify the explaining variables governing the thermal regime

"Sector 2.1: Please revise language. Remove repetitive “on a basis of 230 000 km streams with permanent flow”"

Fixed

Previous text: L 121 to 123 with a dam and weir density of 0.64 features per km greater than the French average of 0.42 features per km (Référentiel national des Obstacles à l’Ecoulement, ROE, September 2017) on a basis of 230 000 km for streams with permanent flow.

Replaced by

Dam and weir density are 0.64 features per km, which is 50% greater than the French average of 0.42 features per km for streams with permanent flow.

We hope we have satisfactorily replied to your comments and issues, which we believe substantially increased the readability and understanding of this manuscript.

Best regards,

The Authors.âĂČ





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Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-136/hess-2019-136-AC2-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-136, 2019.



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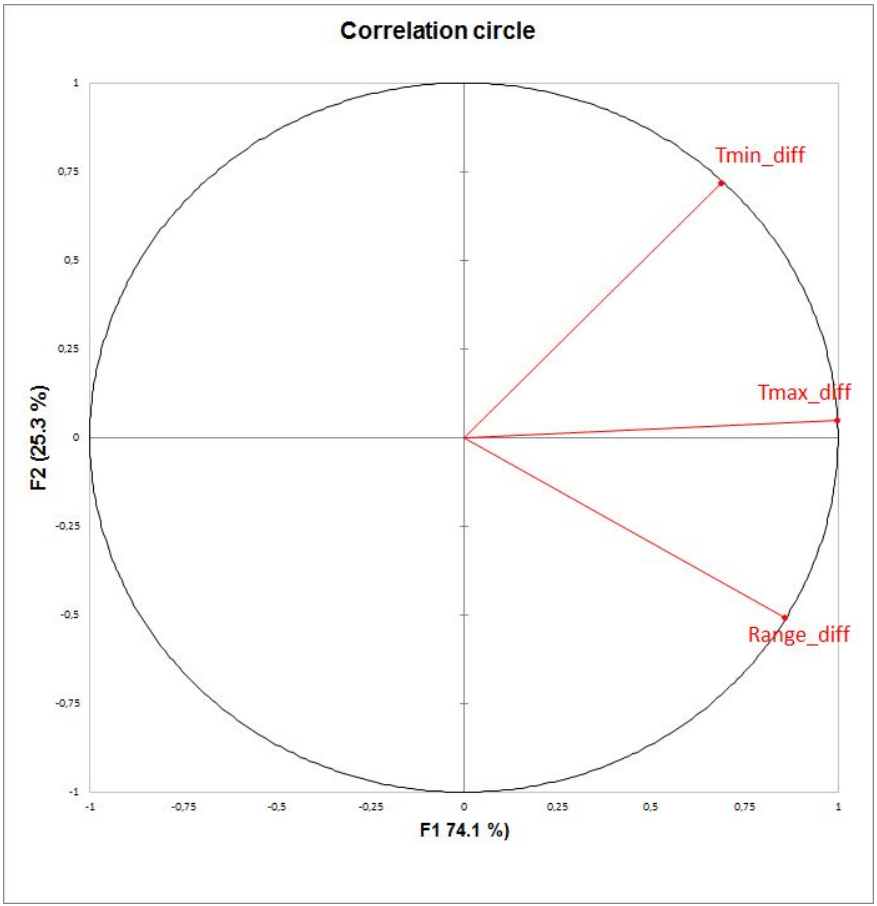


**Fig. 1.** Figure 7. PCA analysis. Correlation circle with temperature as active variables



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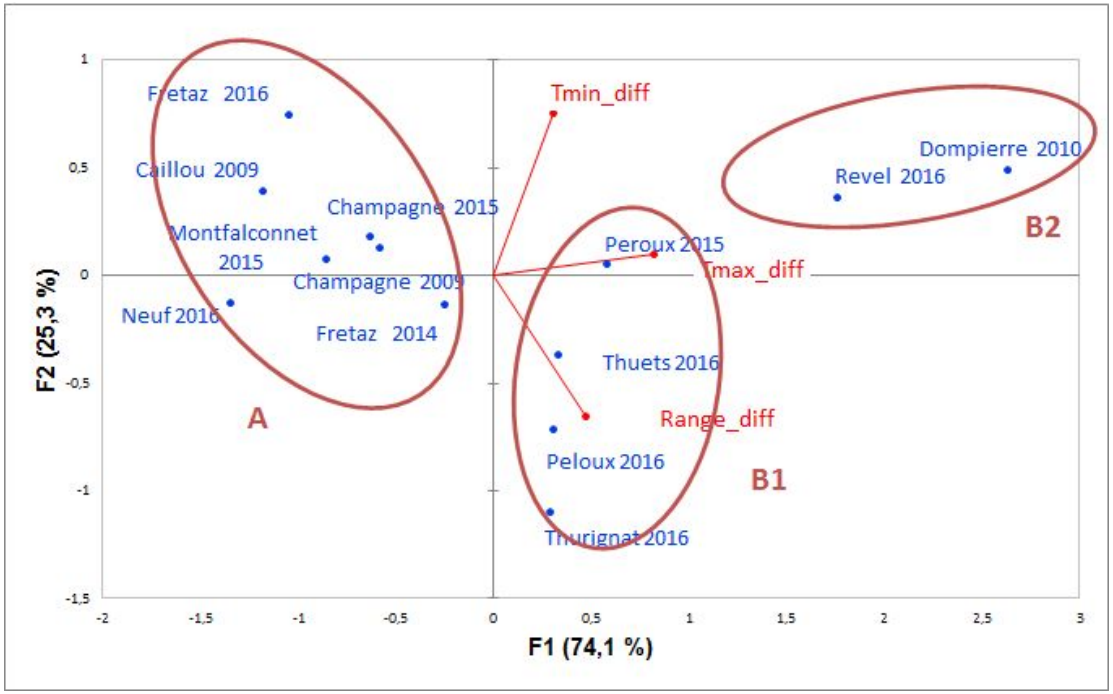


**Fig. 2.** Figure 7. PCA analysis. Correlation circle with temperature as active variables



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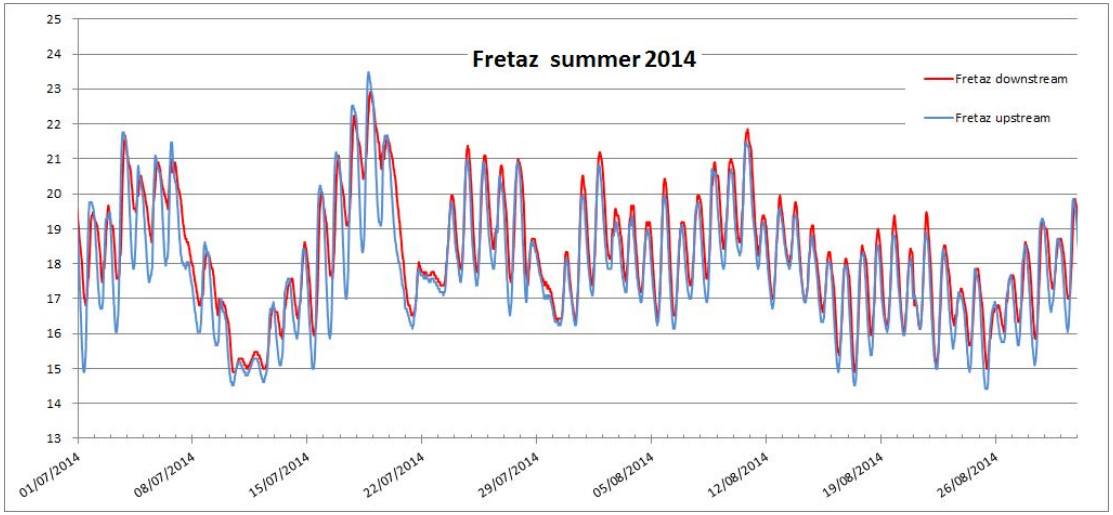


**Fig. 3.** Figure 2. Time-series of water temperature (°C) upstream (blue) and downstream (red) of the dam Fretaz, Veyle stream, respectively in years 2014 and 2016.



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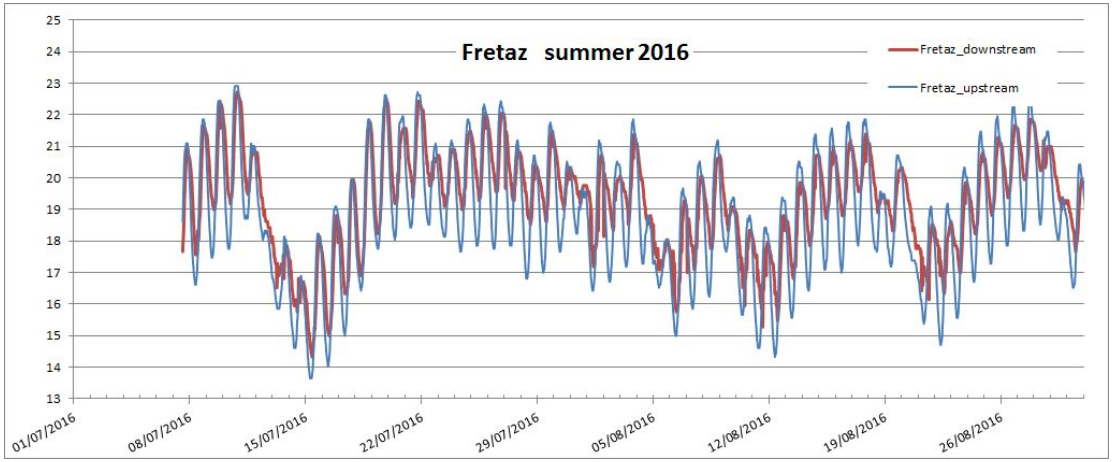


**Fig. 4.** Figure 2. Time-series of water temperature (°C) upstream (blue) and downstream (red) of the dam Fretaz, Veyle stream, respectively in years 2014 and 2016.



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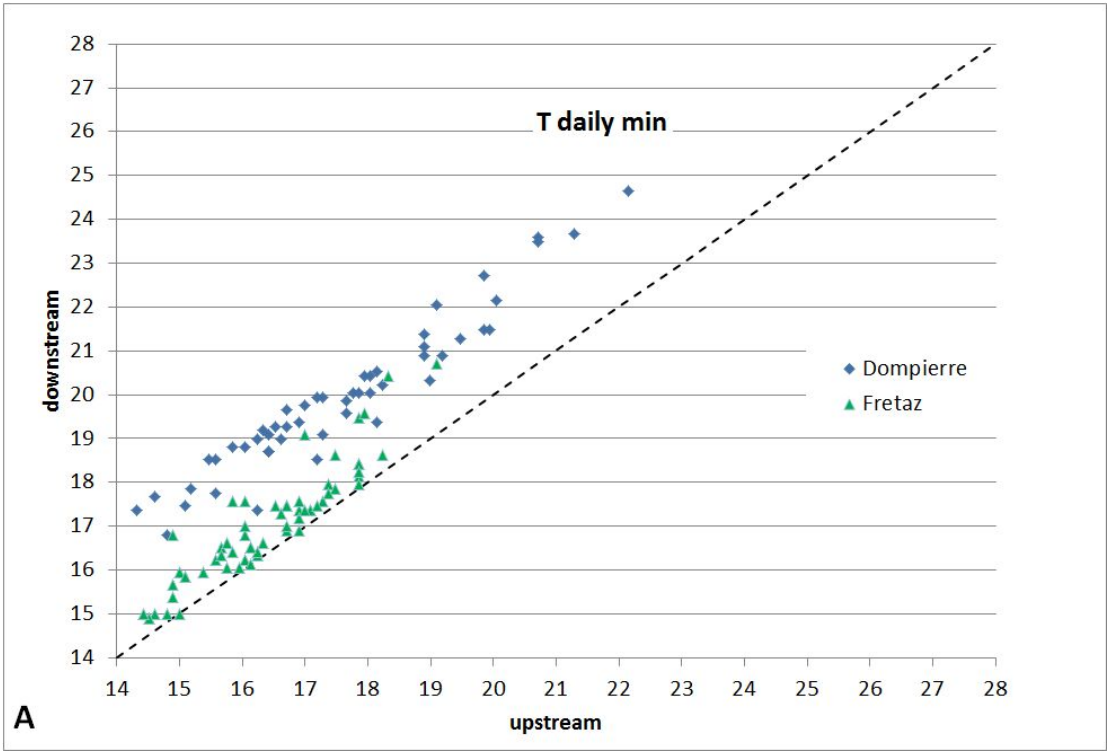


**Fig. 5.** Figure 4. Minimum (A) and maximum (B) daily temperatures upstream and downstream of the dams-of-the river (Dompierre site, Veyle stream in 2010; Fretaz site, Veyle stream in 2014). Dashed line is 1:1



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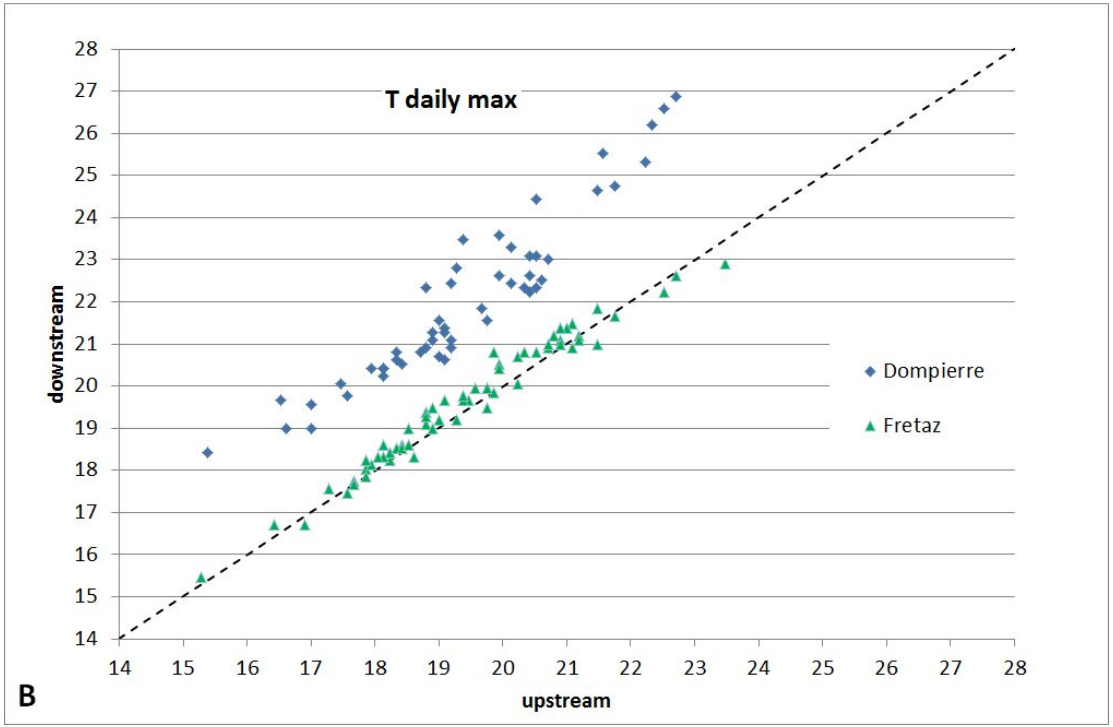


**Fig. 6.** Figure 4. Minimum (A) and maximum (B) daily temperatures upstream and downstream of the dams-of-the river (Dompierre site, Veyle stream in 2010; Fretaz site, Veyle stream in 2014). Dashed line is 1:1



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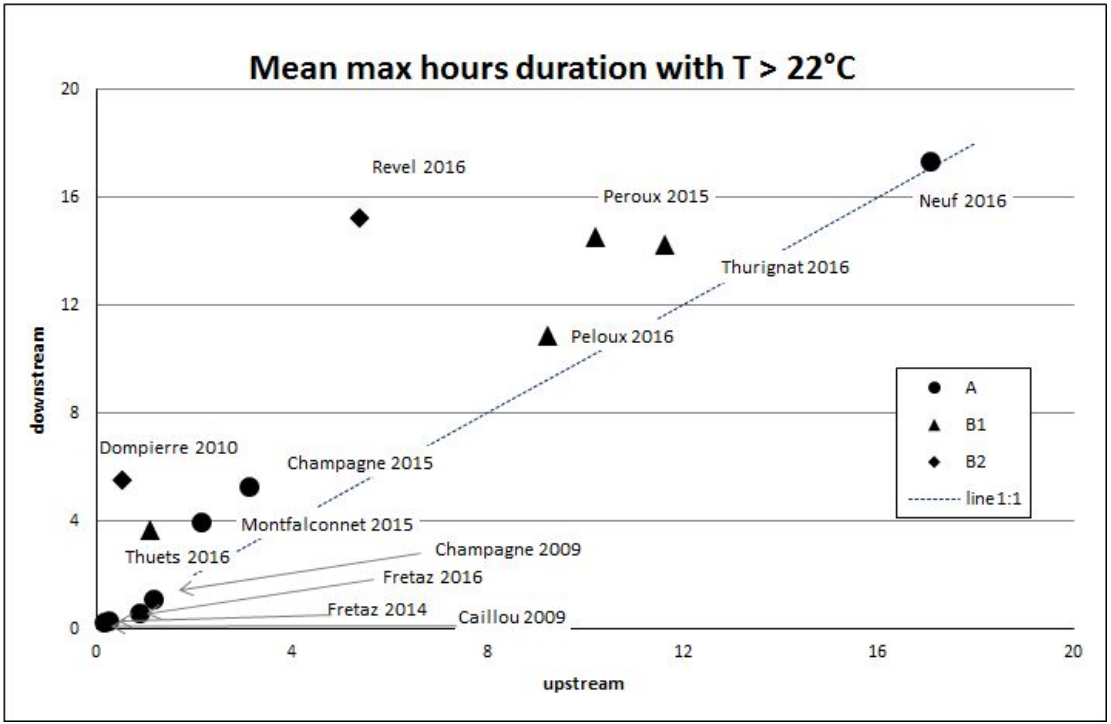


**Fig. 7.** Figure 10. Mean of the daily maximum duration with T above 22 °C , upstream and downstream each site monitored in the study. A (circles), B1 (triangles), B2 (rhombus) are the groups of sites resulting



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