

## ***Interactive comment on “Technical Note: Using wavelet analyses on water depth time series to detect glacial influence in high-mountain hydrosystems” by S. Cauvy-Fraunié et al.***

**S. Cauvy-Fraunié et al.**

sophie.cauvy@gmail.com

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Dear reviewer, Thank you for your very useful and constructive critiques. They were helpful and allowed us to improve our manuscript in many ways. We feel we have addressed all your concerns. Below, you will find the numbered point-by-point responses [R] to your comments [C] and the changes that we would make in the manuscript. Note that we numbered the revised figures with letters (Figure A, B etc. . .) to avoid confusion with figure in the initial version of the manuscript.

[C-1] I would suggest some clarification right in the abstract and in the Introduction

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section of the paper. Readers that are not familiar with spectrum analysis will learn only in the Materials and Methods section that the wavelet approach is based on the diurnal variations of meltwater from the glacier. Thus it can be applied only during the ablation period which is restricted to the summer period at higher latitudes.

[R-1] Our new wavelet analyses now include a description of the power spectrum over time and thus not only during the ablation period. We have added more details on the wavelet methods in the Introduction (see our response R-2b to Reviewer 1) and will also add a few words in the Abstract.

[To add in the abstract] We determined the scale-average wavelet power spectrum over time for each time series and defined three metrics, namely the power, frequency and temporal clustering of the diurnal variation, to properly characterize diurnal flow variations.

[C-2] In addition, diurnal variations of stream runoff might be generated by plant water uptake in the riparian zone, especially during low flow periods which has often been described in the literature. This should be checked, e.g., at sites 13 and 14 in this study. For example, using the Fourier transform instead of wavelets, phase lags can be checked for consistency with travel time in the streams from the glacier to the monitoring sites. Alternatively, plant water uptake will more strongly correlate with radiation and air humidity, whereas melting should be related to air temperature. Radiation and air temperature can be decoupled, e.g., during overcast or rainy days.

[R-2] We agree that this issue may be important, in particular in glacial valleys where the riparian vegetation is abundant. In our study area however, streams do not run through large vegetated floodplains, but rather into small canals with bare sediments. The surrounding vegetation of the paramo is characterized by small grasses and an absence of trees, suggesting a limited water uptake by plants. Moreover, all studied streams were located between 4050 and 4200 m a.s.l. with no significant differences in vegetation cover, so that this factor is unlikely to be an explanatory variable for ob-

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served differences among streams. Note that, as explained with rainfall data (see our response R-5 to reviewer 1), time series of other climatic parameters (e.g. radiation, air temperature, air humidity) can be used in a cross-wavelet analysis to quantify their impact on flow diurnal variations. Such analysis can also quantify time lags between two time series of parameters.

[C-3] I do not agree that the 24 h peaks in the global wavelets should be tested against white noise. The catchment usually acts as a low-pass filter, which transforms the (approximately) white noise of the precipitation input (daily values) into the red noise of the hydrograph at the catchment outlet.

[R-3] Yes, wavelets have now been tested against red-noise (see our responses R-3 to reviewer 1).

[C-4] Fig. 2, Fig. 3: The minor peaks at 12 h period length obviously are harmonics to the diurnal cycle. This would suggest that the diurnal variations are not symmetric. Thus, this peak should be included when calculating the wavelet glacier signal.

[R-4] Good point. At this stage of our investigation, the presence of these minor peaks is still quite "mysterious" for us. We also thought that they may be harmonics to the diurnal cycle but these minor peaks do not occur in all glacial streams and vary independently of diurnal flow variations. Overall, when taking into account red-noise corrections, these peaks were significant at only 5 sites. For these reasons, we decided not to include them when calculating the diurnal variation power of our time series in the present MS but we plan to further investigate this issue.

[C-5] Fig. 5: When all of the regression lines pass through the origin, the only information the figure provides is that about the different slopes. However, in the current form it is very cumbersome to compare slopes for different months. Instead, I would suggest to present the information about the slopes in a bar plot (which would nicely depict the seasonal pattern), and to give the confidence intervals for the determination of the slopes of the regression lines as error bars in addition.

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[R-5] As we performed additional wavelet analyses that include a temporal dimension we believe that this figure is no more useful and we think that it could be removed from a new version of the manuscript.

[C-6] Details: 1) P. 4372, l. 12: I suggest to replace “water security” by “flood risk”. 2) P. 4373, l. 13: Use plural “catchments”. 3) P. 4374, l. 22 and later on: Delete “superficial” in “superficial tributaries”. 4) P. 4375, l. 14: Replace “into” by “in”. 5) P. 4375, l. 25 and later on: Replace “water depth” by “water level”. 6) P. 4376, l. 9: “expresses” 7) P. 4377, l. 6 (eq. 2): Replace “6” in the exponent of the second factor by, e.g., “!”. 8) P. 4380, l. 6: Use plural “contour lines”. 9) P. 4380, l. 28: Replace “which increases costs” by “with high costs”. 10) P. 4381, l. 12: Replace “daily glacial flood” by “diurnal variations”. 11) P. 4381, l. 23: Replace “glacier” either by “glacier” or “glacial”. 12) P. 4382, l. 1: Use the adverb “seldomly” (or “rarely”). 13) P. 4382, l. 4: Don’t you mean “experienced” rather than “experimented”? 14) P. 4382, l. 16: Better insert “the”: “when compared to the upstream site”. 15) P. 4382, l. 22: Don’t you mean “lay” rather than “laid”? 16) P. 4382, l. 26: Does “this phenomenon” mean precisely at these two sites? 17) P. 4384, l. 2: Replace “were” by “have been” (they are still in use!). 18) P. 4384, l. 16: No plural “s” for “descriptor”. 19) P. 4384, l. 17: Replace “they” by “it”. 20) P. 4384, l. 19: Better “meltwater infiltration occurs” 21) P. 4384, l. 27: Omit “a” in “to much wider temporal scales”. 22) P. 4384, l. 28: “Glaciated” rather than “glacierized” 23) P. 4386, l. 9: Use plural for “scales”. 24) Fig.1: I would strongly recommend omitting the arrows in this graph. They suggest well known and clearly defined single flowpaths. However, this study gave only some first evidence that such flowpaths might exist, but did not allow any inferences about their location. 25) Fig. 3: The lines of the cone of influence and the lines of significance are hardly discernible. Moreover, please give a legend for the different colours. 26) The PhD thesis of Villacis (2008) is in French and thus might not be very helpful for most of the readers

[R-6] Ok all these points have been considered in the revised version. For the Villacis PhD thesis, we think that many figures and Tables included in this document can be

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easily understood by non-French readers.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 4369, 2013.

**HESD**

10, C1936–C1940, 2013

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