Anonymous Referee #1

Received and published: 25 January 2019

Review of 'Acoustic wave propagation in rivers: an experimental study' by Geay et al

General comment.

The manuscript reports on underwater measurements of ambient acoustic noise levels collected in several shallow rivers in the French Alps. The rational for collecting the data is to improve the measurement of the bedload gravel transport, using passive underwater acoustic receivers, hydrophones. Unfortunately, there was an order of magnitude variation in the acoustical noise levels between the different rivers. This variability complicates the generic application of the data to the enhancement of passive acoustic detection of gravel transport. However, given the limited studies of ambient acoustical noise levels in rivers, the data does provide indicative background sound levels, which may be of some value for the passive acoustic detection of gravel transport.

The study may also be of interest to others concerned with acoustical riverine noise levels e.g. naval, marine noise pollution etc. The publication of the work could possibly be considered to be of broader interest than solely the gravel transport community.

Specific comments

Review	Reply
1 In the abstract the word 'rugosity' is used, this word is not in common usage; the selection of an alternative to describe this feature of the bed would be helpful.	"Rugosity" has been replaced by "Surface grain-size". "Bed rugosity" has been replaced by "bed roughness".
2 P2 line 5 'frequential characteristics' is a slightly odd phrase, 'spectral characteristics' would be more commonly used.	Done.
3 P3 line 11 'interfaces are totally transparent, acoustic waves propagate' it is unlikely that the interfaces would be 'totally transparent', however, they could be 'highly absorbing'.	Thank you for the suggestion. We replaced "totally transparent" by "highly absorbing (as in an anechoic chamber)"
4 P3 line 20 'c is the celerity of the acoustic waves in water (m/s)'; why not simply say 'c is the velocity of sound in water (m/s)'?	Has been changed as suggested.
5 On P4 and in figure 2 the transmit sensitivity of the underwater loudspeaker is presented, however, this is only valid if the hydrophones have uniform receive sensitivity over the bandwidth of the transmitter. What was the receiver response over the transmit bandwidth?	According to manufacturers, the frequency response of the loudspeaker is 0.5-21 kHz (+/- 10 dB) and the frequency response of HTI96 hydrophones is 2Hz-30 kHz. AS this is an important feature, we decided to add this two sentences: "The loudspeaker has a frequency response of +/- 10 dB between 0.5 kHz and 21 kHz, enabling the generation of sounds in this spectrum."

	and "HTI96 hydrophones have a flat frequency response between 2 Hz and 30 kHz (+/- 2dB), enabling absolute measurement of the acoustic power in this frequency range."
6 P4 line 29 It is not clear what is meant by 'shared' in 'The system is shared by a Carlson river board'. Was it 'mounted' on a Carlson river board?	The "system is shared" has been replaced by "The acoustic recorder and the hydrophone are shared by …"
7 P 4 line 30/31 'Lagrangian measurements were preferred to fix-position measurements to optimize the signal to noise ratio.' A few words explaining why this was 'optimize' would be useful.	This sentence has been added: "By measuring when drifting, noises generated by the resistance of the river board against the flow are drastically reduced."
8 P5 line 12 'describes how are processed the hydrophone signals' 'how the hydrophone signals were processed' would be better.	Done.
9 P7 line 5 and fig 5. Some explanation needs to be provided for choosing 1.0 kHz to assess the acoustic power with range, given that it is cited on P7 line 16 'that estimate a cut-off frequency around1.1 kHz' Why choose to use 1.0 kHz when it is below the cut-off frequency?	1.0 kHz is just an example of the data set for one frequency band. The paragraph has been rephrased to read: "As an example, the results obtained with the third-octave band centered on 1 kHz are shown in Figure 5." The cutoff frequency is a rough estimate. The uncertainty of this estimate has been highlighted by adding the following sentences: "The cutoff frequency is dependent on the water depth (mean water depth of 0.95 m), the sound speed in water (assumed to be equal to 1500 m/s) and the sound speed in the sediment layer. Typical values of sound speed in sea floor materials (from silt to gravel) were observed to vary between 1550 to 2000 m/s (Jensen et al., 2011), depending on many factors such as the type of materials, grain-sizes or porosity (Hamilton and Bachman, 1982). Using sound speed of 1550 and 2000 m/s in the sediment leads to cutoff frequencies of 1500 Hz and 600 Hz, respectively, which is consistent with our observation."
10 P7 line 9 'is repeated' should be 'was repeated'.	Thanks, done.

11 P7 It is not clear in the text how figures 6a and 6b were obtained from the data and how they relate to figure 5. Given this process is central to the manuscript output, it needs to be explicitly and clearly explained. Are the measured spectra in the rivers being scaled to the lake spectra at 1.0 kHz? Are the lake spectral levels being used to obtain the attenuation? Are spectral measurements at different ranges used to calculate the riverine attenuation? Clarification is required if the manuscript is to be published.	An entire sub-section entitled “2.4. Fitting propagation laws” has been added in the method section.
12 P7 As with point 11 above it is not clear how the spectra in figure 7 and attenuations in figure 8 were actually obtained from the measurements. Again further clarification is required if the manuscript is to be published. It is not possible to ascertain the veracity of the results presented due to a lack of a clear explanation of the data analysis process.	An entire sub-section entitled “2.4. Fitting propagation laws” has been added in the method section.
13 P9 line 2 There needs to be some justification for the choice of 1600 m/s for the sound velocity in the bed sediments.	This paragraph has been rephrased: “The cutoff frequency is dependent on the water depth (mean water depth of 0.95 m), the sound speed in water (assumed to be equal to 1500 m/s) and the sound speed in the sediment layer. Typical values of sound speed in sea floor materials (from silt to gravel) were observed to vary between 1550 to 2000 m/s (Jensen et al., 2011), depending on many factors such as the type of materials, grain-sizes or porosity (Hamilton and Bachman, 1982). Using sound speed of 1550 and 2000 m/s in the sediment leads to cutoff frequencies of 1500 Hz and 600 Hz, respectively, which is consistent with our observation.”.
14 P9 line 9 ‘The variation of attenuation coefficients at higher frequencies is here discussed’ It would be useful to compare the measured attenuations with that calculated solely by the absorption due to the water itself. Was the water absorption a significant component of the measured attenuation in any of the rivers?	This sentence has been added: “The attenuation due to freshwater vary from 10^{-9} to 10^{-3} nepers/m from 1 to 100 kHz (Fisher and Simmons, 1977). The attenuation due to water only do not explain the coefficient of attenuation that were found in this study.”
15 P10 equation 10. It may be interesting to present equation 10. However, how would the attenuation coefficient be obtained for a new river in which SGN PSD measurements were being collected?	An experimental protocol has been presented in this paper, it could be used in this new river. This paragraph has been rephrased as: “The power generated by bedload sounds is proportional to the power of measured sounds

	multiplied by the attenuation coefficient. […] To achieve the estimation of sounds that are generated by bedload transport (PSD_s), both measurements of propagation properties (α) and ambient sounds (PSD_h) are needed. Note that equation 11 was obtained by assuming sound sources (i.e. bedload fluxes) that are homogeneously distributed. As this hypothesis will rarely be valid, more realistic inverse methods should be invented to estimate the real sounds (PSD_s) generated by bedload transport and its spatial distribution.”
16 P11 line 16 ‘αλ is higher for higher bed slopes of the river’. Any physical explanation for this?	The following sentence has been rephrased to read: “It has been found that $\boldsymbol{\alpha_\lambda}$ was well correlated to the slope of the river-bed reaches (and to the surface D_{84} of the emerged bars as well), where $\boldsymbol{\alpha_\lambda}$ is higher for higher bed slopes of the river. Assuming that river-bed slope and surface D_{84} of bars are good proxies for the river-bed texture, it can be concluded that attenuation properties is dominated by processes related to the river-bed roughness at high frequencies, including the entrainment of air bubbles in the water column and scattering effects on rough boundaries.”

The manuscript presents a series of observations, which require further explanation as to how the attenuation and source levels are obtained over the spectra presented. In addition, because no ancillary data were collected on the sediments beds and water surface roughness the results presented are of limited value. However, there are not many measurements of riverine soundscapes and therefore it could be considered a publishable manuscript if this is deemed sufficiently original.

Anonymous Referee #2

Received and published: 1 February 2019

General comments:

The manuscript describes and discusses an important aspect of a potential new technique for bedload transport measurements in rivers using passive acoustic monitoring with hydrophones. Controlled experiments were performed in seven rivers to assess the sound propagation in stream reaches with site-specific, different morphological characteristics. Using an acoustic source with known characteristics, the attenuation of the sound was determined for different hydrophone positions along the stream channel, essentially determining the cutoff frequency and attenuation coefficients as a function of acoustic frequency. These experiments and the associated findings represent an important step towards a better interpretation and quantification of hydrophone measurements to determine bedload transport in river environments.

Specific comments

Review	Response
P2L24: These two sentences about results belong rather to the abstract or conclusion section. At this point you should rather more clearly state what the objectives of this study are.	Ok, this has been replaced by: " The variation of propagation properties is observed from one river to another and related to river characteristics. "
P3L22 and P4L9: The two frequency ranges mentioned are largely similar, but the lower end is different by a factor of 5. You may clarify in section 5.1 why exactly the sound source had a frequency range of 0.2 kHz to 50 kHz.	This sentence has been added: "The loudspeaker has a frequency response of +/- 10 dB between 0.5 kHz and 21 kHz, enabling the generation of sounds in this spectrum." And this sentence has been precised: "… logarithmic chirp varying from 0.2 kHz to 50 kHz in 1 second, a bit larger than the theoretical frequency response of the loudspeaker."
P4L31 and P7L29: As the hydrophone was fixed at a constant depth from the water surface, it had different relative positions (between water surface and streambed). Although you state in section 3.2 that you did not notice any representative differences in the results for the discharges investigated, you may comment on why different relative positions of the hydrophone may possibly not have a large effect on the results.	Yes, varying water depth (i.e. varying discharge) should have an impact on the attenuation coefficients in the lower frequency range (because the cutoff frequency is dependent on the water depth). However, our study did not experience enough water discharges (levels) to give significant results. Concerning the effect of varying relative positions, our hydrophone was almost set at the same depth for almost same water levels, and we don't have the data to show that his effect may have a large or small effect on the determination of attenuation coefficients. In relation to this review: the following sentence "As we did not notice any representative differences in the results for the discharges

	investigated, we decided to gather data to propose a unique result for each river." has been replaced by "For the discharge investigated, hydrodynamic conditions were not enough variable to observe major differences in the results. We therefore decided to gather data to propose a unique result for each river. " Secondly, a small paragraph has been added in the discussion on both aspects (water depth and relative positions): "Note also that different hydrodynamic conditions were investigated for some rivers. Varying water depth results in different cutoff frequencies and relative positions of the hydrophone between water surface and streambed. These two parameters (water depth and relative positions) have been observed to modify the response of the hydrophone (Geay et al., 2017b) in the lower frequency range, around the cutoff frequency. The range of experimental conditions that was investigated in this study did not enable the characterization of such effects."
P7L14 and P9 top: In the context of eq. (7) you should also indicate the sound speed in water cw (which is only given in the caption of Fig. 8), and discuss the sensitivity of the cutoff frequency fcutoff to uncertainties in the sound speed in the sediment layer cs. For cw = 1450 m/s, h = 1 m, and cs varying from 1500 m/s to 1700 m/s, for example, fcutoff varies by about a factor of 2. What are reasonable bounds for the potential variation of cs?	This paragraph has been rephrased to read: "The cutoff frequency is dependent on the water depth (mean water depth of 0.95 m), the sound speed in water (assumed to be equal to 1500 m/s) and the sound speed in the sediment layer. Typical values of sound speed in sea floor materials (from silt to gravel) were observed to vary between 1550 to 2000 m/s (Jensen et al., 2011), depending on many factors such as the type of materials, grain-sizes or porosity (Hamilton and Bachman, 1982). Using sound speed of 1550 and 2000 m/s in the sediment leads to cutoff frequencies of 1500 Hz and 600 Hz, respectively, which is consistent with our observation."
Fig. 10, Table 1, and Table 2: The values of h/D84 in Fig. 10 are incorrect. I suggest to list these values also in Table 1 explicitly, and to indicate additionally the mean alpha-lambda values in Table 2.	The mean alpha-lambda values have been added in a new table 3. Fig. 10 has been corrected (D84 converted from mm to m). However, the ratio H/D84 is simple to calculate and as the values of H and D84 are listed in the table 1, we don't think valuable to indicate this ratio in the table.

Fig. 10: How was the Froude number determined? Using surface velocity? Using a mean flow depth? Please clarify.	Previous version was done using surface velocity, it has been changed using averaged flow velocity (Q/H*L). Has been clarified in the legend of fig. 10: "Froude number computed with averaged flow velocity and water depth"
In addition to the important comments no. 11 and no.12 of Referee #1, you should clarify how the mean values of the attenuation coefficients alpha (given in Table 2) and alpha-lambda (given in Fig. 10) were determined (e.g. over which frequency range?).	In the original manuscript, mean values were determined over the frequency range observed during the experiment (so variable according to the field site, see Fig. 8). In the revised manuscript, a fixed band-width (1-10kHz) has been used to compute the mean values. This has been precised in the legend of table 2 and slight changes can be observed in the values of table 2. Concerning the mean values of alfa lambda, they were estimated for different frequency bands. The lower frequency bound was determined by looking at the local minimum observed alfa (alfa function of frequency, figure 8b). The maximum frequency was determined by the limits of our observations (when impossible to measure high-pitched sounds at different distances from the loudspeaker with too strong attenuation). Finally, to clarify this aspect of varying frequency bands, an additional table was added, containing the limits of the frequency bands over which is averaged alfa lambda (table 3).

Technical corrections:

Review	**Reply**
P2L2: Theoretical and experimental studies have shown . . .	done
P4L16: The Power Spectral Density . . . has been computed	done
P8L6: the attenuation coefficient varies by more than	done
P8L27: At "low" frequencies: please give a numeric range of f values here.	"around 1 kHz" has been added
P9L5: lithology, grain sizes, porosity . . .	done

P9L6: but varies from . . .	done
P9L7: For these reasons, cutoff frequencies are rough estimates and do not . . .	
P9L19: Maybe reformulate to: The possible influence of typical nondimensional numbers has also been tested.	done
P9L27: Also, as observed in a flume experiment . . .	done
P10L1: difficult to access the riverbed, and . . .	done
P10L13: and r the horizontal distance from: Do you really mean horizontal or rather bed-parallel, stream-wise direction here?	Yes, this is the horizontal distance (assuming that the horizontal is parallel to the riverbed at the scale of the section).
P10L17: This has several implications for the use . . .	done
P10L23: measured spectra should be corrected for propagation effects . . .	done
Fig. 6d: Correct to "(d) Squared correlation coefficient of the fits"	done
Fig. 6 and Fig. 7: Indicate that measurements refer to the Leysse river (apart from Bourget lake).	Done for figs. 5 and 6.
Fig. 10c: The abscissa label should read surface D84.	Done