Hydrology and Earth System Sciences Discussions

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Interactive comment on "Guidelines for depth data collection in rivers when applying interpolation techniques (kriging) for river restoration" *by* M. Rivas-Casado et al.

M. Rivas-Casado et al.

Received and published: 19 November 2007

1-Referee 2: The introduction, discussion and conclusions were considered incomplete..

1-Author: The introduction, discussion and conclusions will be modified in the revised paper and now include relevant references which are given at the end of this response.

2-Referee 2: This submission is presented as a "methods" paper, but really it is an analysis paper. The authors provide a through examination of different spatial sampling strategies for providing robust estimates of river depth.

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2-Author: The paper we presented is a summary of the methodology we have used to analyse the spatial, temporal and scale variability in rivers. The objective here is not to present the results of the analysis or describe details on the conclusions reached but just to describe the methods or analysis carried out to investigate the spatial, temporal and scale variability. The work was so extensive that the authors prefer to present an initial paper with a summary of the general methodology/analysis and then publish independent papers on each part of the analysis (ie: spatial analysis, temporal analysis and scale analysis). The title will be changed to "A proposed methodology to define guidelines for depth data collection in rivers when applying geostatistical interpolation techniques (kriging)".

3-Referee 2: The temporal analysis has been found to be confusing and undeveloped. Moreover, there were doubts about the validity of the analysis since it is only a comparison of two discharges in one river. More data was thought to be needed to obtain general guidelines on river restoration.

3-Author: The temporal analysis was an initial study to assess the sensitivity of the river habitat to small changes in discharge. Analysing the same stretch under different discharge profiles; essentially observing the difference in the units at different points in the flow duration curve. Its objectives were (i) to determine whether or not it was possible to assess changes in habitat/hydraulic units due to small changes in discharge over time and (ii) to determine which habitat/hydraulic units were more sensitive to these changes. The reason for assessing small changes in discharge is simple: if it is possible to find changes in habitat/hydraulic units for small changes then it is worth analysing these changes for higher changes in discharge and further research in this topic will be justified. For this objective two discharges collected at low flows at a river sites was considered appropriate.

4-Referee 2: I don't really follow the logic and structure of the last paragraph in section 4.4. Are Fig. 5 and Table 6 supposed to show the same information (as the text implies?). How are the means in Fig. 5 and Table 6 different?

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4-Author: Figure 5 and Table 6 do not show the same information. Table 6 shows the absolute mean depth change, absolute maximum depth change and the standard deviation of depth change observed for each of the mesohabitats (i.e habitat units) studied. So for example, the mean change of depth in shallow glides when changing the discharge from 0.52 m3s-1to 0.34m3s-1 is 0.048 m. To determine whether there is a significant difference between mesohabitats in terms of depth change when decreasing the discharge, it is necessary to carry out an Analysis of variance. Figure 5 is the LS Means plot resulting from the Analysis of variance (ANOVA). As mentioned in the text (p1080, lines 22-23) the LS means plot shows the least squares means which are the best linear unbiased estimates of the marginal means for the design. The Figure must be interpreted as follows: two mesohabitats will be different in terms of changes in depth when their means and 95% confidence intervals do not overlap. In Figure 5 Shallow glides and Deep Glides do not overlap and therefore can be considered as different in terms of depth change. Riffles and pools overlap and therefore their depth changes are not significantly different. Table 6 will be removed from the revised paper as it is confusing.

5- Referee 2: Referee 2 questions the validity of the “scale” analysis.

5- Author: The first step of river restoration projects is to assess the channel morphology of the reach to define which types of changes are required. When long reaches (e.g. $> 2km$) require restoration it is not possible to carry out the initial assessment along the full reach as this will be highly time and cost consuming. Generally, selected sub-reaches are sampled and conclusions are drawn from these results. Suggestions on the length of the sub-reaches to be sampled have been made in previous guidelines for habitat/morphological assessment but results vary amongst authors . There is a need for a methodology that helps to define the length of the sub-reach to be sampled so the morphological/habitat characterisation is representative of the section to be restored. We will include this clarification in the discussion.

6-Referee 2: what is the significance of the spatial repetition and how does this help

define the sampling strategy?

6-Author: if there is spatial repetition in the river then it would be adequate to characterise/sample a sub-reach which length includes one full cycle of repetition. In this way one makes sure that the results/conclusions obtained from this characterisation are representative of the river (e.g if the final assessment identifies a need for habitat improvement this will be due to the analysis of a representative reach and not to the characterisation of a section that presents reduced habitat conditions). The author would like to discuss this in a different publication where scale issues will be the main topic.but has included this in the discussion in the revised paper.

7-Referee 2: what is the significance of spatial repetition differences amongst rivers?

7-Author: rivers present different repetition patterns due to their catchment/reach characteristics. Variables such as the discharge regime, geomorphology amongst other will have an impact on the way the river develops and therefore, on its morphological - hydromorphological characteristics. This defines the length at which the hydromorphological characteristics are repeated and therefore has an impact on the results from the spectral analysis.- again see discussion in revised paper

8-Referee 2: some substantial conclusions are reached but it is necessary to clarify few points. p1081, lines 25-28: is replication of measurement locations important? (for example, how does this effect the time variability issue)

8-Author: We have not tried to combine the spatial and temporal aspects within this methodology. This paper is a small step towards understanding the complex relationships between space, scale and time – so we are unable to answer this question until further research has been carried out – lines 25-28 were intended to indicate issues for further research.

9-Referee 2: p1082, lines 1-12: where are these tables referred to?

9-Author: the tables are available in the PhD thesis and will be published in further

articles. The reference is Rivas Casado, M.: The use of geostatistics for hydromorphological assessment in rivers. Thesis (Ph.D thesis) Cranfield University at Silsoe. It is available online through the library catalogue.

10-Referee 2: Is one high density survey always required to assess the "hydromorphological uniformity and continuity"? What should be the data density of this initial survey?

10-Author: The aim of this paper was to investigate whether the methodology described could be used represent the variability in depth in a range of rivers, so that a set of guidelines could be established for rivers with similar characteristics. This means that the high density survey used to establish the spatial variability of a river would not be required when designing a monitoring scheme for a new project and was used in this paper to investigate the loss of information due to a reduction in sampling density or change in sampling strategy. We will include this in the revised paper

11- Referee 2: Does the title clearly reflect the contents of the paper? No. The paper is about a comparison of sampling strategies and application of geostatistical techniques to uncover patterns.

11-Author: We suggest to change the title to "A proposed methodology to define guidelines for depth data collection in rivers when applying geostatistical interpolation techniques (kriging)."

12-Referee 2: I am not sure that "scale" can be differentiated from "time" and "space" as an independent variable.

12-Author: we are dealing with scale in space in this section. Scale refers to the length to be sampled. "Space" refers to sampling strategy and density to be applied within that length.

13-Referee 2: P 1072, line 9: is the channel simulated or is it artificial?

13-Author: the channel is artificial.- added to revised paper

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14- Referee 2: in Equation (4) units are not indicated. Do they cancel out correctly to yield L in m?

14-Author: yes, they cancel. L=20(1/F)

Wavelength (in sampling intervals) = 1/Frequency

Example: The Frequency can be indentified by looking at Figure 4. The first peak appears at a low frequency 0.057 cycles, which corresponds to a wavelength of 1/0.057=17.50 sampling intervals. Each sampling interval is 20 m, and therefore this corresponds to a length of 350 m.

15-Referee 2: information in Table 2 can be included in Figure 2.

15-Author: yes. We separated the information as it is easier to read the numbers from the table rather than from the figure. We will combine them in the revised version

16-Referee 2: what is “objective”? This is never discussed in the text.

16-Author: the variogram model is fitted via weigthed least squares: for the fitting of the model the program proceeds to minimize the sum of the square residuals accordingly. The objective function is the sum of the squares residuals. The model for which the objective function is minimized is selected. The objective function is generally used to compare the good of fitness of the model. In Table 2 it is possible to define which model was better fitted by just observing the objective function column. The smallest objective function corresponds to the original data set, followed by the regular transects and the random grid sampling strategies. The objective does not provide any extra information on which sampling strategy is best for the prediction of depth in rivers, therefore it can be deleted from Table 2.-

17-Referee 2: What is the significance of the range, sill and nugget? This is never discussed in the text.

17-Author: The nugget is the intrinsic variance of the variable under study and we will

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assume in this study that is represented by the measurement error. The nugget identifies the variance of 2 points that are measured at the same coordinates: one expects these measurements to have the same value but due to field conditions/equipment these measurements may differ in value. The range is the distance at which the spatial correlation between points is null. Prediction of the variable under study cannot be obtained if the sample density is such that points are located further apart than the range. Therefore, the sample density should be selected in such a way that the distance between consequtive pair of points is smaller than the range of the variable uder study (i.e. depth). The sill is the expected variance (semivariance) of points located at a distance equal to the range. Nugget, sill and range will vary depending on the level of detail at which the reach is to be represented. The author would like to present and discuss this information in a second and third publication where the issue of sampling density and strategy will be discussed in more detail-however some explanation has been added to the revised paper

18- Referee 2: Should "cycle" be "frequency" in Table 3? It can be combined with Figure 4.

18-Author: no, "cycle" means that one cycle of periodicity is complete at the value given in the table. This value is the frequency at which the cycle is completed. Table 3 and Figure 4 can be combined.

19-Referee 2: what is the vertical line on Figure 4 indicating?

19-Author: the vertical line in Figure 4 is the Bandwith as defined in Bloomfield, P. (1976) Fourier analysis of time series: an introduction. Wiley. I copy the definition below and has been added to the figure

"Bandwith is the ability of a spectrum estimate to represent fine structure in the frequency properties of the data, such as narrow peaks in the spectrum. Because of the averaging involved in computing a spectrum estimate, a spike or narrow peak in the periodogram is spread out into a broader peak. This peak is roughly an image of the

spectral window of the estimate, and its “width”, suitable defined, is the bandwith of the estimate”… “If the spectrum of a series contains two narrow peaks closer together than the bandwith of the estimate used, the resulting broad peaks in the estimated spectrum overlap and form a single peak.”

20-Referee 2: What is the point of showing the parameters listed in Table 5 (never discussed in the text)?

20-Author: parameters in Table 5 have not been discussed in the text one by one, they are informative, easy to interpret and give information on the distribution of depth changes.

21-Referee 2: In Figure 3, the eye is drawn immediately to the excursion in the Leigh Q90 line in the upper panel. What is the cause?

21-Author: a poor variogram model fit and therefore an imprecise prediction of depth.

22-Referee 2: Figure 4 shows 4 peaks but the text indicates 3 peaks (p 1080 line 10).

22-Author: Figure 4 is just an example for one of the longitudinal profiles analysed for the Sulphur river site. More longitudinal profiles were analysed for this river and all of them shown peaks at 350 m, 87 m and 60 m but not at 87.5 m. This is why only 3 peaks are mentioned in the text. This can be due to the fact that 87.5 m and 60 m are very close together and have been merged in one single peak in the other profiles analysed.

23-Referee 2: Are the number and quality of references appropriate?

23-Author: the introduction, discussion and conclusions have changed. A list with the references cited in the introduction and discussion is provided below.

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