UNIVERSIDAD DEL BÍO-BÍO

Interactive Discussion: Author Response to Reviewer 02

Variability and persistence of scour at bridges using stochastic simulations

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RC: ***Reviewer Comment***, AR: Author Response, □ Manuscript text

Dear Reviewer 02 (Anonymous Referee),

Thank you for taking the time and effort to review this manuscript. Surely, incorporating your suggestions will improve the manuscript's readability and overall quality. Please find our responses to your comments below. These should be considered as preliminary (part of the interactive discussion) since the actual implementation of changes depends on the editorial decision. Below, we list reviewer's comments verbatim in bold, followed by responses to these comments in blue.

Thank you again for your helpful feedback!

Yours faithfully,

Alonso Pizarro, Oscar Link, and Demetris Koutsoyiannis

RC 1: ***I have contacted the editor and NHESS twice because I feel unable to review a large part of this manuscript. However, I have received no reply. The hydrodynamic concepts and the stochastic tools that the authors refer to, are out of my domain. I am not able to judge the scientific correctness of their approach and would therefore advise to find another reviewer. In lack of any response, I will now submit a partial review and will point out for which points an additional reviewer should be consulted. I regret the delay that this situation has caused the authors and apologize for any inconvenience my lack of knowledge in the field is causing the authors. The authors present a framework for the investigation of scour dynamics. The data basis is increased by creating a large set of synthetic stream flow time series which are used to force a scour and fill model. The manuscript has a good structure and is well written. However, the manuscript is highly technical. Advanced statistical methods and hydrodynamic scour modelling are constantly referred to and fill many consecutive pages in the methods section. Any reader who is just slightly in a different research field, will have a very hard time to understand the methods or find the manuscript simply unreadable. This aspect also reflects in the***

fact that the authors, apart from the introduction, mainly cite their previous work, which complicatest the independent validation of the underlying methods, as any unnoticed flaws in earlier work may be amplified through continued reliance on the same line of research. The study is very specialized. This should be in itself no problem but it is unfortunate for the authors. It would help the manuscript, if the authors were able to add short explanations why certain methods are used. E.g. climacographs, climacospectrums, generalised Cauchy-Dagum-type climacogram, Hurst and Mandelbrot parameters, FHK-CD model should be explained, as I doubt that every reader is aware of these concepts and is willing to dig in the references. I am certainly not. To this end, I wonder if this manuscript fits into the rather broad scope of NHESS.

AR 1: We thank the reviewer for the careful partial assessment and for explicitly indicating the limits of their expertise regarding some of the components of the manuscript. Given that the reviewer explicitly stated they could not assess the scientific correctness of parts of the manuscript, we have focused our revision on the aspects the reviewer could assess: readability, accessibility, contextualization, and scope.

RC 2: ***Section 2.1: Please add some information on the annual rainfall.***

AR 2: Information related to the mean annual precipitation is stated in the preprint's line 70: *"…The catchment area is 1380 km^2, the mean annual precipitation is 2853 mm, and the aridity index is 0.3…"*.

RC 3: ***l.69: What do you mean with "near-natural" flow conditions?***

AR 3: Thank you for pointing out this concept. Near-natural flow conditions are related to a near-natural hydrological regime (i.e., hydrology as it is). Eight different criteria were considered. Information from b) to h) was retrieved using the CAMELS-CL database (Alvarez-Garreton et al., 2018):

a) Less than 25 % of missing values in the discharge time series for the selected period;
b) Absence of large dams (big_dam = 0);
c) Less than 10 % of discharge allocated to consumptive uses (interv_degree < 0.1);
d) Not dominated by glaciers (lc_glacier < 5 %);
e) Less than 5 % of the area defined as urban (imp_frac < 5 %);
f) Less than 20 % of irrigation abstractions (crop_frac < 20 %);
g) Less than 20 % of the area is covered by forest plantations (fp_frac < 20 %);
h) No signs of artificial regulation in the hydrograph.

References:

Alvarez-Garreton, C., Mendoza, P.A., Boisier, J.P., Addor, N., Galleguillos, M., Zambrano-Bigiarini, M., Lara, A., Puelma, C., Cortes, G., Garreaud, R., 2018. The CAMELS-CL dataset: catchment attributes and meteorology for large sample studies-Chile dataset. Hydrol. Earth Syst. Sci. 22 (11), 5817–5846.

RC 4: Stationarity: river flow from 2001-2024, can you assume stationarity here? Did you test it?

AR 4: Thank you for raising this observation. It is worth noting that stationarity is a property of the model, not of the observations. In this context, assuming stationarity (which also assumes ergodicity, crucial for statistical inference) implies model selection. Despite the latter, we explicitly tested stationarity using usual statistical tests. We therefore evaluated the annual streamflow series corresponding specifically to the period used in the stochastic analysis. Annual values were calculated for 21 complete hydrological years, defined from 1 April to 31 March. The results consistently support the stationarity assumption over the analysed period. The Mann–Kendall test did not identify a statistically significant monotonic trend ($S = -44$, Mann-Kendall's $\tau = -0.210$, $z = -1.299$, $p = 0.194$). Consistently, the confidence interval of Sen's slope included zero, indicating that the apparent negative slope cannot be distinguished statistically from the interannual variability of the record. The Pettitt test did not identify a significant change point in the annual series ($U^* = 56$, $p = 0.288$), providing no evidence of an abrupt shift in its central tendency. More importantly, the KPSS test did not reject stationarity around a constant level (KPSS statistic = 0.291, $p > 0.10$). Stationarity around a deterministic trend was likewise not rejected (KPSS statistic = 0.096, $p > 0.10$). Taken together, these tests provide no statistical evidence of a trend, abrupt regime shift, or departure from level stationarity during the period used in the study. We therefore consider the stationarity assumption appropriate for the temporal window over which the stochastic model was calibrated and evaluated.

RC 5: Can you elaborate to which extent your method of synthetically creating stream flow time series is able to generate previously unseen extreme events? How many extreme cases beyond the real observations were generated with your method?

AR 5: The AMA generator used in this work is not a bootstrap or a resampling procedure of the observed hydrographs. Therefore, it is not restricted to reproducing only observed events or observed sequences. Instead, the synthetic streamflow series are new stochastic realisations generated from a model that preserves the fitted second-order dependence structure, including Hurst–Kolmogorov dynamics, time asymmetry, and the first four moments of the marginal distribution. Consequently, the method can generate streamflow peaks larger than those observed in the historical record, provided that such values are compatible with the fitted stochastic structure and marginal distribution. In this sense, the method explores a wider range of hydrologically plausible sequences than the observed record, but it does not introduce new hydrological regimes or deterministic trends outside the fitted process. In the revised manuscript, we will compute the number of hourly synthetic values that exceed the observed maximum streamflow (per synthetic simulation) and make statistics about it. This analysis will be added to section *"3.1, Synthetic-generated streamflow coupled with scour and fill model"*.

RC 6: l. 346: "Scour–streamflow synchronisation is weak" This seems a bit strange. Can you elaborate on this?

AR 6: The Critical Success Index (CSI, see section 2.4) was computed in Eq. 30. CSI depends on the number of hits (H), misses (M) and false alarm (F) events. A value of 0.20 means that only 20% of all identified events occurred simultaneously for both river streamflow and scour. Our findings indicate that CSI values for streamflow and scour extreme events ranged from 0.15 to 0.60 (median CSI around 0.32), suggesting that not all hydrological extremes translate directly into scour extremes.

RC 7: The Methods and Result section should be reviewed by another reviewer. I am not able to review these sections.

AR 7: We trust the editor's informed judgement and decision.

RC 8: Fig 1: a) Shape outlines make the bottom part of Chile appear black. b) There are some weird stream segments which are unconnected or even seem to cross the catchment border. Legend missing.

AR 8: The figure in question will be improved in the new manuscript version.

RC 9: Table 1: Here, you provide streamflow in mm/d. Change to m³/s so it is comparable to Fig. 1.

AR 9: Done. The updated table reads now:

Table 1: Hydrological signatures characterising the magnitude, frequency, duration, timing, and rate of change of streamflow.

	Hydrological Signature	**Description**	**Value**	**Dimensional units**
Magnitude	Q_{mean}	Mean streamflow value	107.238	m^3/s
	Q_5	5-th streamflow percentile	28.510	m^3/s
	Q_{95}	95-th streamflow percentile	272.135	m^3/s
	BFI	Baseflow index	0.732	-
Frequency	HighQFreq	High Q frequency	0.002	-
	LowQFreq	Low Q frequency	0.017	-
Duration	HighQDur	High Q duration	1.583	d
	LowQDur	Low Q duration	12.143	d

Timing	HFD	Half flow date	147	date
	HFI	Half flow interval	122	d
Rate of change	AC1	Lag-1 autocorrelation	0.934	-
	Slope FDC	Slope of the flow duration curve	-2.338	-

RC 10: You are using a different color theme for almost every plot. I suggest that you stick to a more homogenous set of colors in your plots.

AR 10: We tried to use the same colours for the same variables (where possible), prioritising legibility. For instance, Figures 7, 8, and 9 show stochastic results. The red colour was always related to $\xi = 1.0$, while the blue and black colours were related to $\xi = 1.5$ and $\xi = 2.0$, respectively. In other figures, when the similar colours are used, it is explicitly stated its meaning in the figure caption or figure legend.