Supplementary Material on "Constraining the Stream Power Law : a novel approach combining a Landscape Evolution Model and an inversion method"

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– **Figure 1** : Scatter plots of misfit behaviour in a region of small misfit (i.e misfit < 30, colors red to yellow in fig. 2 of the manuscript) for the parameters m and n in the synthetic case where m and n are free. The misfit reduction is clear for the value of m and n used to generate the observed topography and confirms the sharp peaks in the PDF.

– **Figure 2** : Scatter plots and PDF for the case where n and m are free with $n \neq 1$ for the target model. As for the case where $n = 1$, a reduction of the misfit value is observed around the n and m combination corresponding to the target model (i.e. $n = 2$ and $m = 1$) proving that the method is efficient even for a non linear version of the Stream Power Law.

– **Figure 3** : Plot showing the "target" river profile (in black) and theoretical ones (in red, blue and purple) generated for different combinations of n, m and K.
Synthetic case where n and m are free : When the observed river profile and the blue (misfit $= 20$) and purple (misfit $= 100$) profiles are compared, significantly differences in elevations appear. The two combinations of m and n yield a concavity of 0.27 and 0.1 respectively which explains why the observed river profile is not retrieved.
Synthetic case where n and m are free : The intrinsic minimum of the misfit function is clearly underlined here with the red profile matching the observed one. Even though m and n values are relatively low, their ratio is conserved and proves to be an important criterion to reduce the misfit value.

– **Figure 4** : Maps of the difference between "target" and theoretical topography (Diff (in m)) for the case where n, m and K are free. **a)** Map of the parameter combination for the observed topography which yields a reduced misfit value but not the lowest one. The difference in river elevation is not nil but is relatively low : diff $< 3m$. **b)** Here, m and n are equal to 0 which leads to a nil difference map. This illustrates once again the intrinsic minimum of the misfit function for low value of m and n. **c)** $n = 3$ and $m = 1$. The map shows that in rivers the difference in elevation could be as high as $600m$ for low order rivers which leads naturally to a high misfit value. **d)** $n = 2$ and $m = 0.5$. Differences in river are lower (diff$< 50m$) which leads to an intermediate misfit value.

– **Figure 5** : a) Digital Elevation Model of the Whataroa catchment implemented in FastScape. The DEM comes from the SRTM3 data and has a resolution of 90m. In white : pixels picked to make the inversion using a threshold drainage area of $10km^2$ b) River profiles of the 2 main rivers of the Whataroa catchment : the Whataroa River (in red) and the Perth River (in black)

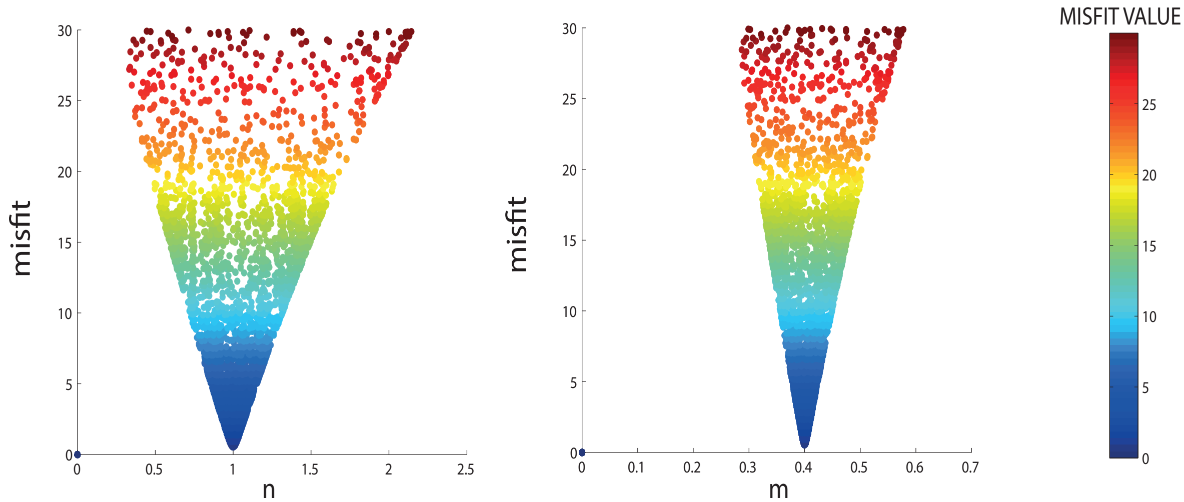

FIGURE 1 – Plots showing the value of n and m versus the misfit for misfit values under 30 for the synthetic case where n eand m are free.

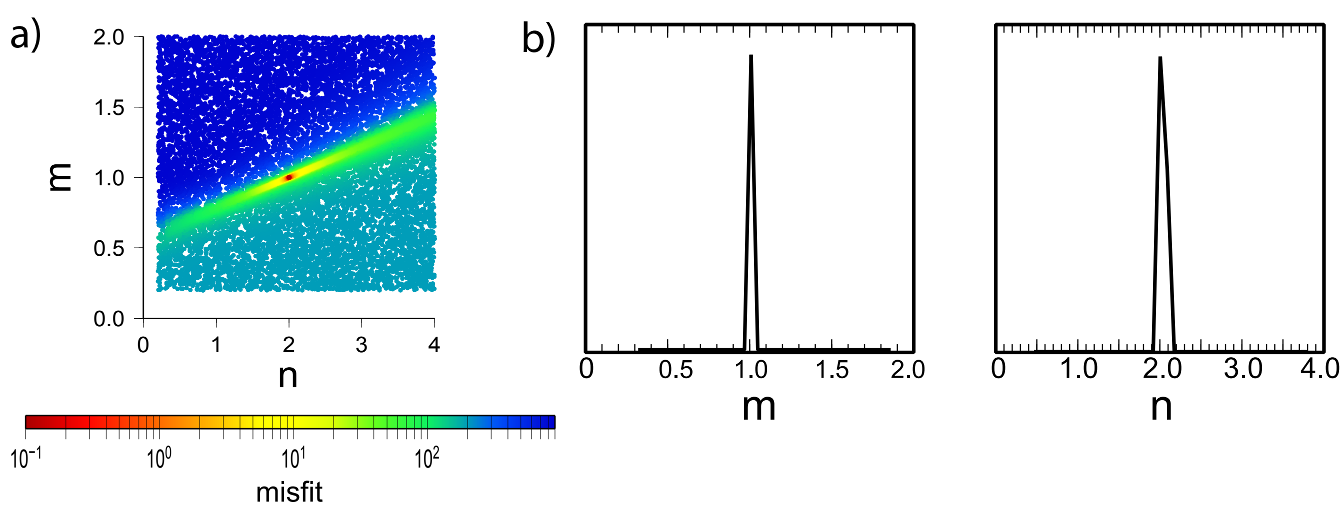

FIGURE 2 – Results from inversion for the free parameters m and n, for a reference landscape generate with $n \neq 1$. a) Scatter plot showing the results from NA sampling stage. b) PDF of the two parameters.

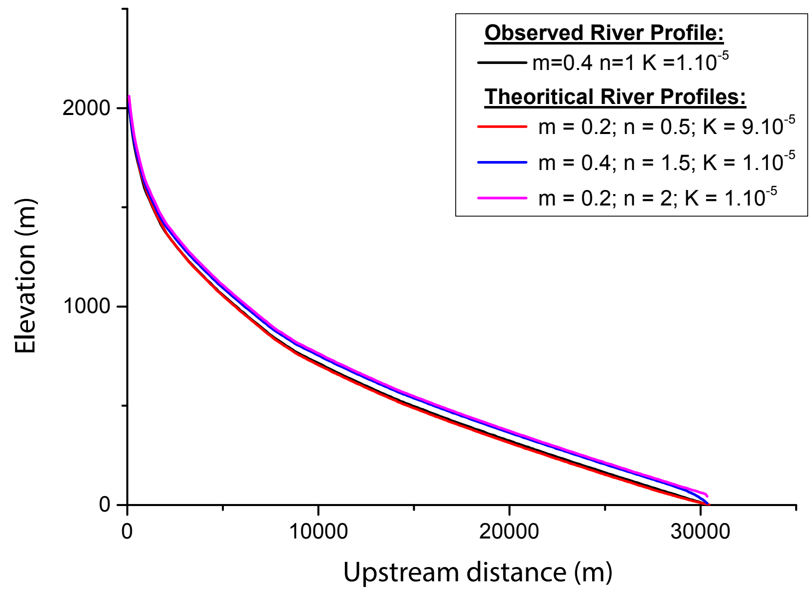

FIGURE 3 – River profiles for different combinations of n, m and K. These river profiles illustrates the inversion results for the first synthetic case where n and m are free when $K = 1 \times 10^{-5}$ (blue and purple profile) and also the second synthetic case where n, m and K are free (red, blue and purple profile).

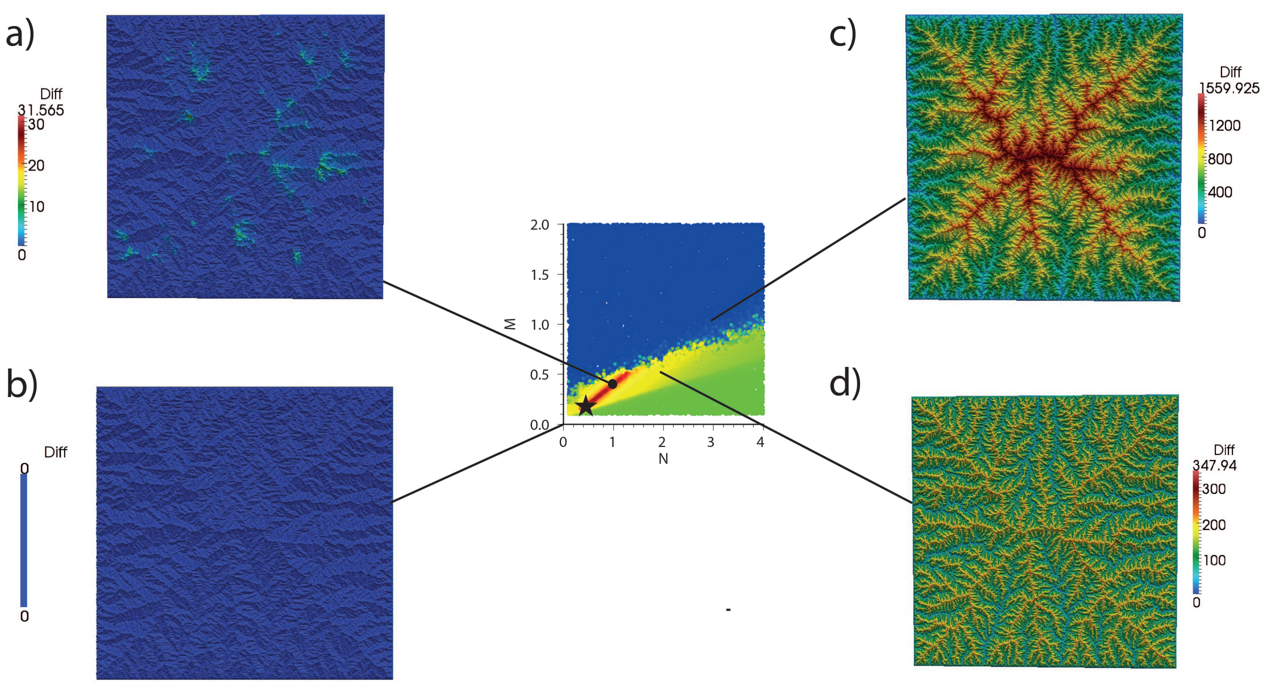

FIGURE 4 – Maps of the difference between observed and theoretical topography (Diff (in m)) for the case where n, m and K are free. a) Theoretical topography generated with n = 1 and m = 0.4. b) Theoretical topography generated with n = 0 and m = 0. c) Theoretical topography generated with n = 3 and m = 1. d) Theoretical topography generated with n = 2 and m = 0.5.

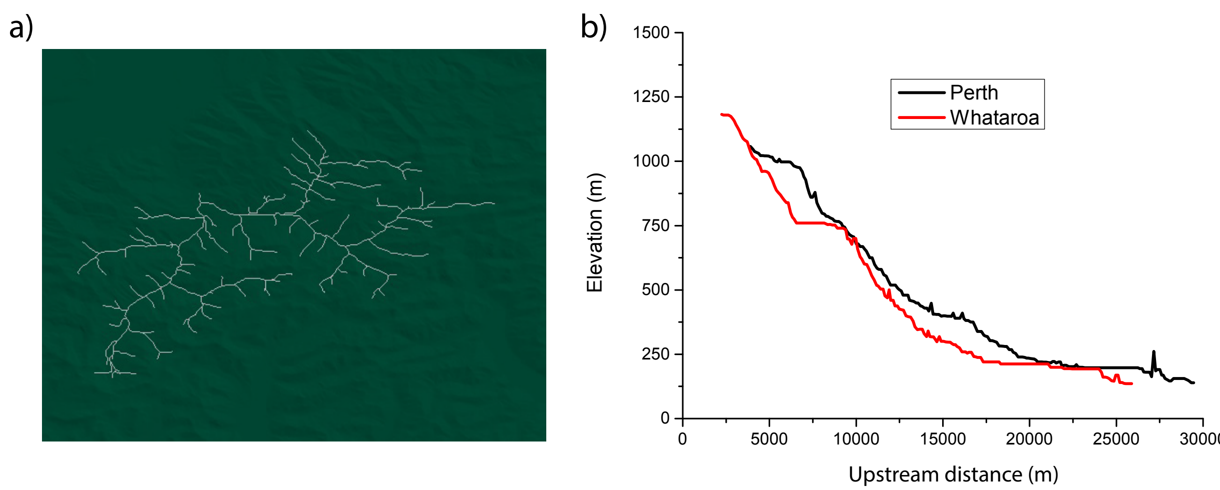

Figure 5 – a) Digital Elevation Model of the Whataroa catchment implemented in FastScape. In white : pixels used to make the inversion. b) River profiles of the 2 main rivers : the Whataroa (in red) and the Perth (in black)