

SismoRiv : An innovative system for bedload monitoring based on the measurement of seismic noise through river banks

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Context

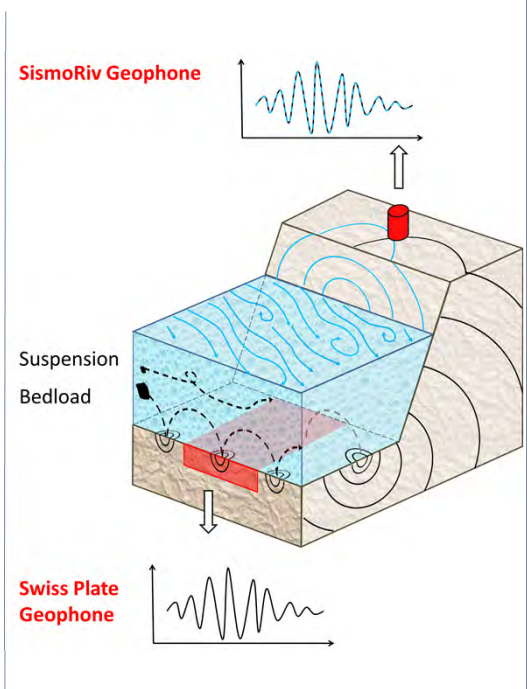
Sediment transport in watercourses results from bedload and/or suspension processes. Quantification of sediment transport is classically achieved through numerical equations that postulate a constant relation between sediment and water discharges. While this relation appears consistent over long period of time it doesn't in the short term, due to high variability, that making them poorly suited for analyzing sedimentary dynamics.

Within the current legal requirements of water protection in relation to revitalisation of watercourses, the monitoring of sediment transport, in space and time, represents a planning step for evaluating the disturbance of the bedload budget. Bedload real time monitoring could also help to prevent damages to hydraulic structure related to hydropower plants (intakes, tailwater reservoir).

Measurement Methods

In 2011, an experimental installation for measuring sediment transport based on the "Swiss Plate Geophone" technology developed by the WSL (Rickenman et al., 2012, 2014), was installed on the site of Zinal (VS). While transporting, sediment impact the river bed and generate vibrations. The latter are recorded by a set of geophones fixed underneath steel plates placed across the river channel. After a calibration process carried out in 2012, this station is now established as a reference measurement.

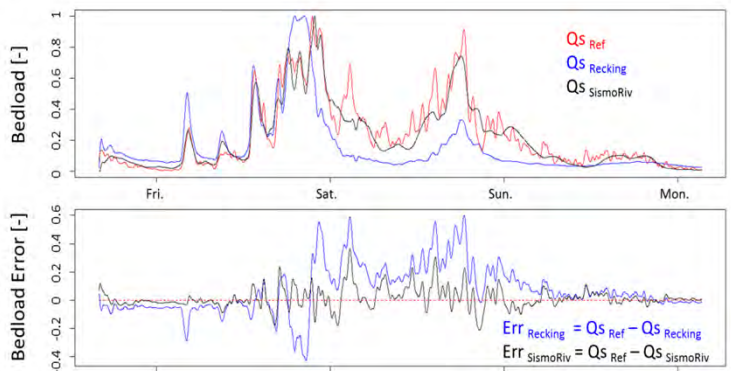
Based on work of Burtin et al. (2008, 2011), the CREALP proposes an innovative system for bedload monitoring based on the measurement of low-frequency seismic signal through river banks. With the support of the "Promotion des technologies environnementales" program founded by OFEV, a new measurement system was designed, implemented and tested during summer 2015 (SismoRiv project UTF 505.08.15)



Preliminary Results

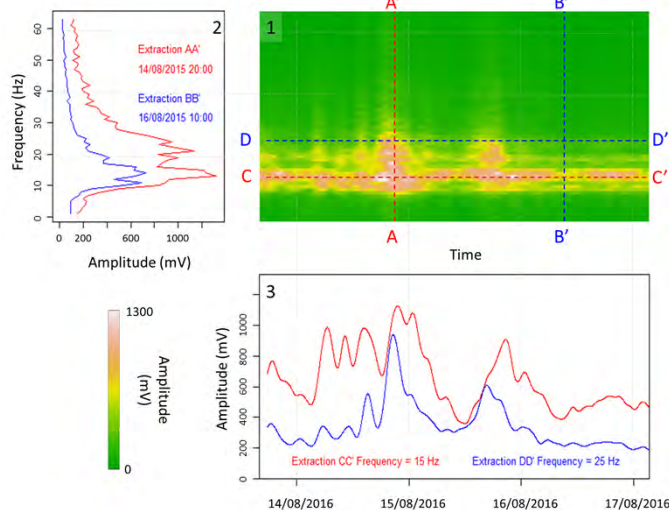
The spectrogram (1) decomposition shows :

- In the frequency domain (2) shows peak of high amplitude in frequency range of 10 to 30 Hz as reported by Gimbert et al. (2014)
- In the time domain (3) shows daily fluctuations that are coherent with the flow regime of the Navisence River (glacio-nival regime)



A preliminary analysis of results confirms the occurrence of frequency components representative for sediment and water discharges. Estimated bedload values inferred from seismic measurements ($Q_{S \text{ SismoRiv}}$) show strong analogy with values provided by the reference station ($Q_{S \text{ Ref}}$).

Furthermore the SismoRiv measurement system also allows to significantly minimize the error with respect to the estimations obtained from literature ($Q_{S \text{ Recking}}$). These first results are promising and highlight the potential of SismoRiv system to monitor sediment transport.



References

- Burtin, A., Bollinger, L., Vergne, J., Cattin, R. and Nábělek, J. L. (2008). *Spectral analysis of seismic noise induced by rivers: A new tool to monitor spatiotemporal changes in stream hydrodynamics*. J. Geophys. Res., 113(B5). ISSN 0148-0227. doi: 10.1029/2007JB005034.
- Burtin, A., Cattin, R., Bollinger, L., Vergne, J., Steer, P., Robert, A., Findling, N. and Tiberi, C. (2011). *Towards the hydrologic and bed load monitoring from high-frequency seismic noise in a braided river: The "torrent de St Pierre", French Alps*. J. Hydrol., 408(1-2). 43-53. ISSN 00221694. doi: 10.1016/j.jhydrol.2011.07.014.
- Gimbert, F., Tsai, V. C. and Lamb, M. P. (2014). *A physical model for seismic noise generation by turbulent flow in rivers*. J. Geophys. Res. Earth Surf., 119(10). 2209-2238. ISSN 2169-9011. doi: 10.1002/2014JF003201.
- Rickenmann, D., Turowski, J. M., Fritschi, B., Wyss, C., Laronne, J., Barzilai, R., Reid, I., Kreisler, A., Aigner, J., Seitz, H. and Habersack, H. (2014). *Bedload transport measurements with impact plate geophones: comparison of sensor calibration in different gravel-bed streams: IMPACT PLATE GEOPHONE CALIBRATION*. Earth Surf. Process. Landf., 39(7). 928-942. ISSN 01979337. doi: 10.1002/esp.3499.