Controls on the spatio-temporal variability of meandering bedrock river dynamics measured from 14 years of repeat Terrestrial LiDAR scanning

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Résumé

Meandering bedrock rivers exhibits a range of morphology whose origin is still unclear. They feature elements of bedrock incision rivers processes (e.g., abrasion, cover effects, potholing...) as well as alluvial meandering rivers (e.g., point bar accretion, vegetation development...), and generally create a large number of strath terraces whose cause is debated (internal dynamics vs external forcing). Key questions remain on the role of discharge and sediment supply on meander dynamics, the processes and rates of inner bar terrace formation, and the coupling between lateral migration and outer bank hillslope instability. Modelling such systems remain a challenge both numerically and experimentally. For this reason, we started in 2009 a long-term project to fully digitize at mm precision and cm resolution 5 meanders of the Rangitikei river in the North-Island of New-Zealand. The Rangitikei river has incised nearly 100 m of weakly consolidated mudstone since the LGM, leaving many strath terraces that are well dated (Bonnet et al., 2020). We report on the spatio-temporal variations in migrating rates measured over time intervals ranging from one 10-year return flood to 14 years. Our last survey in 2023 includes the impact of Cyclone Gabrielle. We describe the technical challenges of reaching sub-cm registration error over a 14 year period with 3 different type of LiDAR instrument. We present the full processing workflow of the 4D point clouds (3D + time), including new classification approaches (3DMASC, Letard et al., subm), high accuracy cloud matching registration methods, and classical change detection tools (M3C2, Lague et al., 2012). The whole dataset contains a wealth of information, and fully document infrequent events such as large cliff collapse driven by meander migration and their subsequent removal, alluvial cover intermittency and the rates of accretion and vegetation development conducive of inner bar terrace generation. Critically, we show that

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bank erosion during floods can be highly localized in these meanders, and that trying to model the evolution of such rivers with a constant discharge misses the discrete nature of bank erosion both in space and time tightly coupled to the inner bar alluvial cover geometry.

Mots-Clés: LiDAR, Meandering Bedrock River, Point Clouds, Extreme Events