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Spatio-temporal variability of channel bank erosion in mega-tidal salt-marshes (Mont-Saint-Michel bay) quantified by terrestrial laser-scanner surveys

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Many mega-tidal estuaries in the north-western part of France are currently trapping sediment leading to a rapid extension of salt marshes. Due to ecological and economical issues, it is critical to moderate accumulation of sediment in these estuaries. In the Mont-Saint-Michel bay, salt marshes development is even threatening the marine character of this UNESCO world heritage site. Large remediation works are currently undertaken to drive salt marsh regression and to remove the accumulated sediment. Since mid-2009, a new dam over the main river (Couesnon) stores large amounts of water during the flood at high tide, and releases it at low tide to flush out sediment towards the sea. This controlled change in hydraulic forcing offers an opportunity to better understand bank erosion and the resulting tidal channel lateral mobility which is the dominant mechanism by which existing salt marshes are eroded and transformed back into inter-tidal flats. Given the very large range of hydraulic forcings in mega-tidal estuaries, it is particularly important to quantify the contribution of events of variable frequency and magnitude which requires measurements at almost daily frequency. To cover the pre and post dam phases, we have assembled a large dataset of terrestrial laser scans (TLS), GPS and aerial photographs covering a period from 1986 to 2011 with 40 frequent TLS surveys after 2009. Our study compares 5 salt marsh banks in the Mont-Saint-Michel bay with different channel curvature and exposure to incoming tide.

For active and steep bank, retreat is calculated along the bend every 2 meters. Amongst the 5 banks, maximum recorded bank retreat varies between 17 m and 110 m over a period of respectively 2 and 20 years. Retreat rates exhibits significant temporal variability, especially during a single tide when rates of bank retreat for the same point vary from no detectable change to 2.5 m during spring tide. For each bank, there is a factor 5 change in retreat rates between high and low curvature parts of the bank which highlights the control of channel curvature. To better understand the retreat mechanisms, we introduce the normalized bank retreat to factor in geometrical effect and emphasize the hydraulic controls. Couesnon's bank shows non-homothetic bank retreat along the largest bend suggesting a more complex mechanism than a simple combination of bank geometry and tidal forcing.

Precise measurements show that the impact of the dam is not as immediate as expected. Rates of bank retreat in the Couesnon sinuous zones increased drastically only during the 2010 spring tides compared to the pre-2009 rates. Preliminary results suggest that during the ebb, the dominant role of the dam release is to redistribute the meander inner bar sediment during neap tides rather than directly driving salt marsh bank erosion. This redistribution tends to enhance the transverse gradient in meander bends. During subsequent spring tide floods, outer bank retreat is then more effective than before dam operation. This highlights the primary role of inner bend sedimentation in driving outer bend bank erosion in sinuous sections, rather than the opposite.