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# Combining remote sensing with an inverse Bruun Rule for the analysis and management of almost equilibrium beaches

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The management of beaches that suffer from sediment deficit and construction of nearshore infrastructure in locations with intense sediment transit require adequate predictions of the future of the relevant sedimentary systems. To a large extent, this task can be accomplished by using jointly the information about sediment texture and long-term changes in the dry beach volume and the location of the waterline.

It is straightforward to evaluate relative changes in the dry beach volume from a succession of airborne laser scanning (ALS) surveys. We use in addition terrestrial laser scanning (TLS) technique to reduce ALS surveys performed with different devices and from different height to the same absolute height. This is accomplished using a TLS survey of a large horizontal surface of constant elevation within ALS snapshots.

The most complicated, time-consuming and expensive task in beach management and planning of nearshore infrastructure is to get an adequate picture of the intensity and direction of underwater sediment transport processes. We demonstrate how a simple application of so-called inverse Bruun Rule makes it possible to evaluate the underwater volumetric changes for almost equilibrium beaches. The approach requires three data sets: wave statistics, sediment texture and changes in the average position of the waterline. The main properties of the wave climate, closure depths, magnitude and direction of wave-driven alongshore transport near the test areas are established using a triple nested high-resolution version of the wave model WAM that is forced for 34 years by high-quality marine winds. The relocation of the waterline is extracted from the ALS scanning of elevation isolines of 0.4–0.7 m on the subaerial beach.

The technique has been applied to two basically different sections of Tallinn Bay, the Baltic Sea. Pirita Beach is gradually losing sand and requires beach refill while a moderate reclamation action is planned in the vicinity of gradually widening beach in the bayhead of this bay (Russalka beach). Sand volume in the latter area exhibits extensive interannual variations. The changes in the subaerial and underwater part are synchronised whereas the magnitude of changes in the underwater part is by a factor of 2–2.5 larger than similar changes in the subaerial part (that gains about 2000 m3/yr sand in 2008–2014).

The discussed technique combined with classic estimates of the wave-driven sediment transport direction demonstrates that the Russalka beach is a convergence area of littoral flow. The existing pattern of sediment motions is such that even a minor shift in the coastline may lead to considerable increase in the transport of sand to neighbouring coastal sections. This conjecture is consistent with the general perception in coastal science that even seemingly small activities may have unexpectedly large potential for remote impacts. Such impacts are well known on high-energy open sea coasts but often considered as minor in relatively sheltered locations.