Combined assessment of fluvial-marine sediment transport to determine the impact of coastal risks

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The study of morphological changes of a river channel, linked to erosion-deposition processes, taking place in the riverbed, is a topic of current interest in relation not only to the morphometric variations of the fluvial features (e.g., active channel width, area of sediment bars) and the sedimentary balance of the whole relative hydrographic basin but also in relation to the role of the sediment load transferred downstream up to the near shore area (Figure 1).

Figure 1. Fluvial sediments transferred to the coast. Alcantara river (Sicily).

These sediments constitute the solid transport that is pushed towards the coast and poured into the sea, representing a crucial sedimentary contribution to the beaches volumetric balance. The quantitative estimate of the volume of this fluvial load is currently achievable through robust approaches such as the morphological method grounded in the continuity principle applied to river sediments. To define the transport rates at selected locations (e.g., the river mouth) over a given time period, the method requires to measure the erosion and sedimentation volumes, which can be calculated using repeated Digital Elevation Models (DEM)and deriving a DEM of Difference (DoD) (Vericat et al., 2017; Capito et al., 2023). The coastal sedimentary balance is function of both the sediment load provided by rivers and the quantity of sediment transported by the longshore currents that move parallel to the coastline. For this reason, it is crucial to assess the impact of coastal erosion considering both the sediment input from the hydrographic basins and the longshore transport.

Up to now there are no techniques capable of providing continuous and spatially distributed measurement of this sediment transfer, a fact of considerable interest if we think of the anthropic structures present along the shores, and the coast erosional problems.

This study aims to evaluate, at the regional scale, the possibility of borrowing some techniques that are often used in fluvial contexts (e.g., geomorphological approach), to estimate the quantity of sediment that nourishes the coast. This information is essential as a preliminary step for further studies on the sediment transport process, considering, for instance, different climatic scenarios. A measured volume of sediments deposited over a specific time interval can be used to calibrate a physically-based sediment erosion and transport model, such as SMART-SED described by Gatti et al., 2023. Following calibration, the model can be employed to predict future scenarios by considering climate projections.

An important aspect will be to assess the transferability of such methodologies taking into consideration the technical limitations (e.g., greater difficulty in acquiring bathymetric data in the submerged environment) and the morphodynamic differences of the two contexts (e.g., partial lack of lateral confinement of flows in the marine environment).

Once it is established that meaningful estimates can be obtained, using the two solid transport estimates volumes (river and marine) it could be possible to obtain the budget of sediments that could benefit the near shore. This estimation certainly has a margin of error linked to all the uncertainties processes both in the river and coastal contexts, but it reveals an evaluation of sedimentary tendency of a coastal area: retreat, advancement or stationary.

Today the studies of coastal balances certainly not considered the presence of submarine morphologies that favor the sediments deposition (e.g., submerged bars and terraces) or the sediments removal (e.g., submarine canyons that arise very close to the coast) from near shore environment, significantly influencing the trend of longshore currents. In Italy there are many regions in which submarine canyons are very close to the coasts; these structures can act as collectors of sediments which are swallowed up towards greater depths (Lo Presti et al., 2022).

Therefore, the quantitative study of sediment volume available on a near shore environment, linked to the presence of submarine morphologies favorable or not to the removal or stasis of sediments and to the intrinsic characteristic of the beach (e.g., long exposed beach, gulf, pocket beach), it constitutes a means of defining the sediment load that moves along a near shore area and which could influence and define possible scenarios of anthropic damage, as ports and fluvial bridges siltation but above coastal erosion risks.

References

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