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Prediction of bedload sediment transport for heterogeneous sediments in shape

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Bedload sediment transport in the coastal area is a dynamic process mainly influenced by the type of hydrodynamic forcings involved (current and/or waves), the flow properties (velocity, viscosity, depth) and sediment heterogeneity (particle size, density, shape). Although particle shape is recognized to be a significant factor in the hydrodynamic behavior of grains, this parameter is not currently implemented in bedload transport formulations: firstly because the mechanisms of initiation of motion according to particle shape are still not fully understood, and secondly due to the difficulties in defining common shape parameters.

In March 2011, a large panel of in-situ instruments was deployed on two sites in the Eastern English Channel, during the sea campaign MESFLUX11. Samples of the sediment cover available for transport are collected, during a slack period, per 2cm thick strata by divers and by using a Shipeck grab. Bedload discharges along a tidal cycle are also collected with a Delft Nile Sampler (DNS; Gaweesh and Van Rijn, 1992, 1994) on both sites. The first one is characterized by a sandy bed with a low size dispersion, while the other study area implies graded sediments from fine sands to granules. A detailed analysis of the data is performed to follow the evolution of in-situ bedload fluxes on the seabed for a single current.

In-situ measurements are compared to existing formulations according to a single fraction approach, using the median diameter of the mixture, and a fractionwise approach, involving a discretization of the grading curve. Results emphasize the interest to oscillate between these two methods according to the dispersion in size of the site considered. The need to apply a hiding/exposure coefficient (Egiazaroff, 1965) and a hindrance factor (Kleinhans and Van Rijn, 2002) for size heterogeneous sediments is also clearly highlighted. A really good agreement is found for the non-uniform site between measured fluxes and predictions given by the Wu et al. (2000) model. However, some discrepancies still remain, especially for granules.

Hundreds of pictures of grains composing the sediment cover and the bedload discharges are performed. Particle shapes are statistically characterized by three 2D coefficients (circularity, roundness and elongation) after an image processing with the ImageJ software. Present results show a preferential transport of the most circular sediment particles available for transport and reveal that the consideration of particle shape, through the integration of the circularity index in formulations, enhanced the estimations of bedload rates. A new adjustment of the Wu et al. (2000) formula is proposed, which improves significantly the model predictions, especially for granules.

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