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On the dynamics of compound bedforms in high-energy tidal channels: field observations in the German Bight and the Danish Wadden Sea

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Tidal inlets are a common feature along much of the world's coastlines. They interrupt the alongshore continuity of shoreline processes, and by being exposed to both wave and current forcing, tidal inlets belong to the morphologically most dynamic and complex coastal systems on Earth. The tidal channels in these inlets are characterized by high flow velocities and, accordingly, the channel beds are typically sandy and covered with bedforms. The bedform fields in nature are often complex systems with larger primary-bedforms superimposed by smaller secondary-bedforms (cf. Bartholdy et al., 2002).

There is a considerable amount of detailed field investigations on the dynamics of primary-bedforms at various temporal scales, ranging from short- to long-term tide-related cycles to flood hydrographs to seasonality. However, Julien et al. (2002) stated that a composite analysis of primary- and secondary-bedforms is recommended for future studies on resistance to flow. Such knowledge on the behaviour of compound bedforms is still deficient.

In this study, we combine the findings on the dynamics of primary- and secondary-bedform height from detailed field investigations carried out in two high-energy tidal channels during 2007 and 2008: the Knudedyb tidal inlet channel in the Danish Wadden Sea and the Innenjade tidal channel in the Jade Bay, German Bight (both survey areas being ebb-dominated). We provide process-based explanations of the bedform behaviour and present a conceptual model of compound bedform dynamics.

The conducted field investigations comprised repetitive, simultaneous measurements of high-resolution swath bathymetry (using a multibeam echosounder system) and flow velocity (using an acoustic Doppler current profiler) in combination with detailed spatial mapping of bed material characteristics (from grab sampling of bed material). For an objective and discrete analysis of primary- and secondary-bedforms a modified version of the bedform tracking tool originally developed by van der Mark and Blom (2007) was applied (cf. Ernstsen et al., 2010).

In both tidal channels primary-bedform height generally decreased during ebb tide and increased during flood tide. This was due to erosion and deposition of the crest, as the trough remained practically constant. The erosion of the crest occurred at high energy stages during ebb tide, while the overall deposition on the crest occurred during flood tide. The low erosion in the trough is due to a combination of low flow velocity and the development of an armour layer of shell lag-deposits. Regarding secondary-bedform height, both tidal channels displayed a general increase with increasing mean flow velocity and a general decrease with decreasing mean flow velocity (cf. Ernstsen et al., 2010).

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