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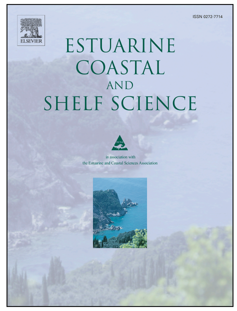

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Modeling wave and wind climate effects on tidal sand wave dynamics: A North Sea case study

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Abstract

To obtain site-specific wave and wind climate averaged sand wave dynamics, we combine an idealized linear stability model with 20 years of wave and wind data taken from the Euro Platform in the North Sea. The model output results in a wave and wind climate-averaged growth and migration rate. The results show that waves and wind affect particularly migration and to a much smaller extent the growth rate. Seasonal variations in wave and wind conditions during winter and summer periods result in seasonal variations in sand wave dynamics, in particular during winter the migration rate is larger, the growth rates are lower and the preferred wavelength is larger compared to summer. Medium wave and wind conditions are responsible for two thirds of the migration rate, while these conditions occur roughly only one third of the time. Extreme wave and wind conditions result in only a moderate contribution to the migration rate. Furthermore, we see a seasonal variation in migration as well as reasonable correlation with observed migration rates for the intervals between surveys in the period 1996-2010. Our work shows that storms are able to affect sand wave migration, and cause variability in migration rate.

Keywords: tidal sand waves, storm effects, linear stability analysis, wave and wind climate, idealized modeling, morphodynamics

1. Introduction

Tidal sand waves are rhythmic bed forms observed in tidally dominated shallow seas all around the world. They have typical wavelengths of hundreds of meters and heights of several meters (Terwindt, 1971; Van Dijk and Kleinhans, 2005, also see Fig.1a). These large bed forms are dynamic, e.g. showing migration and growth. Because of their dynamical behavior in combination with their large dimensions, they interfere with various human activities in shallow seas. For example, sand waves may pose a hazard to navigation, pipelines, cables as well as the foundation of wind farms and gas/oil platforms (Németh et al., 2003). Therefore, an accurate understanding of sand wave dynamics is required.

Sand waves have been studied both using observations and from a modeling perspective. Hulscher (1996) explained sand waves as a free instability of the sandy seabed subject to tidal flow. Tidally averaged circulation cells tend to move sediment towards the crests, while gravity favors sediment transport towards the troughs. Observational studies show that storms, which occur on a much more irregular basis compared to the tidal flow, also affect sand wave dynamics. In particular, sand wave heights are reduced during stormy periods (Terwindt, 1971; Houthuys et al., 1994; Van Dijk and Kleinhans, 2005) and migration speed or even direction may change (Harris, 1989; Fenster et al., 1990; Le Bot et al., 2000).

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