EGU22-11994
https://doi.org/10.5194/egusphere-egu22-11994
EGU General Assembly 2022

Applying PIV algorithms to understand the dynamic behaviour of tidal compound dunes

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Particle Image Velocimetry (PIV) is an optical method typically applied to measure two- and three-dimensional fluid flows. In combination with a synchronized laser or strobe light, a high-resolution camera is used to observe the movement of tracer particles within a water volume. Advancing the concept of cross-correlation, modern PIV algorithms analyze the obtained images for most probable displacements in pre-defined interrogation areas and, in doing so, are able to reveal detailed flow patterns and velocities. Although this methodology is widely applied to study turbulent flows and even track grain-scale sediment transport, hardly any investigation is known that makes use of one of the more sophisticated PIV tools to quantify the dynamics of major geomorphological features such as subaqueous dunes.

In order to test its applicability in morphodynamic analyses, we used a prominent PIV software for interpreting a long-term bathymetric time series recorded by multibeam echo-sounding (MBES). The data set shows a field of compound dunes in the Jade tidal inlet channel well-documented in 100 monthly fairway surveys. In contrast to conventional PIV settings, observed displacements in the assessed greyscale surface plots do not represent the movement of individual particles but migration of complete morphological features across the seafloor. Accordingly, this methodology results in a reduction of correlation clarity, which we compensated by two types of pre-processing. On the one hand, PIV analyses were conducted for the different derivatives of the digital terrain model comprising slope, curvature and variability. On the other hand, reports about the physical composition of primary and secondary dunes were used to separate the inherent length scales, which are expected to show different migration rates. Depending on these filtering techniques, preliminary results are in promising agreement with previous findings, thus, illustrating the versatility of the PIV concept and its potential for two-dimensional morphodynamic analyses. Based on a systematic comparison of the achieved correlation qualities, we now aim at deriving best practices for applying PIV algorithms to understand the dynamic behaviour of tidal compound dunes.