

Analysis of 3D-bed form migration rates

M. Henning & J. Aberle

Leichtweiß-Institut für Wasserbau, Technische Universität Braunschweig, Braunschweig, Germany

S. E. Coleman

The University of Auckland, Auckland, New Zealand

ABSTRACT: Migration rates of 3D-bed forms were analyzed applying cross-correlation techniques to subsequently recorded digital elevation models (DEMs) of polystyrene dune fields. The data were obtained from a scale model of an 8 km long section of the River Oder at the Federal Waterways Engineering and Research Institute (BAW), Germany. The lightweight sediment model was designed to simulate bed-load transport and to investigate different river maintenance strategies. In the experiments, time series of bed form movement were measured with high spatial and temporal resolution using a 3D photogrammetric measurement system. Cross-correlation techniques were used to estimate bulk dune field migration velocities as well as depth resolved migration rates. The latter were obtained using the high spatial and temporal resolution of the data by dividing the measured DEM in sub-sections. This analysis allowed for the detailed investigation of longitudinal and transverse migration rates. The preliminary results presented in the paper suggest that it is possible to relate small scale bed form migration rates to bed form deformation processes.

Keywords: Sediment Transport, Dunes, Morphodynamics, Light-weight sediment, Random field approach

1 INTRODUCTION

Bed forms in river flows determine hydraulic resistance, sediment transport, channel morphodynamics, and hydraulic habitat for biota. They also often present a major problem for engineering structures (e.g., water intakes or discharges, pipelines, groynes, etc.) and may introduce severe restrictions to navigation. In fact, dunes are considered as the most important bed form in practical river engineering (Engelund & Fredsoe, 1982; Southard, 1991) and the prediction of the associated flow and sediment transport still presents a major obstacle in the solution of sedimentation problems in alluvial channels (ASCE, 2002).

When sediment transport takes place over bed forms, their migration rate represents an important kinematic characteristic determining bed load transport (Best, 2005). The corresponding transport rate may be estimated using the so called dune tracking method in which bed load transport rate is related to bed form height and speed (e.g., Engel & Lau, 1980; Jerolmack & Mohrig, 2005).

Until today this method has mostly been applied to 2D longitudinal sections of laboratory and field data and studies focusing on 3D bed forms are rare. However, recent advances in measure-

ment technology (e.g., Henning et al., 2009) make it possible to measure 3D bed form topographies with high spatial and temporal resolution during water flow. Such data enable detailed spatial analyses of bed form roughness and bed form migration.

In spite of these developments, approaches for the determination of bed form geometry as well as migration rates are mostly based on the analysis of 2D-longitudinal profiles. In fact, studies of dunes to date have principally measured and characterised 2D sections of 3D-dune fields, with consequent limited interpretations of the dynamics of natural 3D-dune fields. This shows the need for the development of adequate methods to investigate the 3D-nature and dynamics of bed forms.

Using the random field approach, it becomes possible to describe bed form geometry and dynamics using various statistical measures such as the probability distribution of bed elevations and its moments, space-time correlation and structure functions, and frequency and wave number spectra (e.g., Nikora et al., 1997). Altogether, these measures provide a full, in practical sense, description of geometry and roughness properties due to bed forms. Hence, using the random field approach it becomes possible to investigate the

