THREE-DIMENSIONAL MEASUREMENT OF LABORATORY SUBMERGED BED FORMS USING MOVING PROBES

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A new technique for measurement and analysis of the development of three-dimensional bed forms is reported. Conventionally, laboratory bed forms are often assumed to be two-dimensional and described using longitudinal bed profiles measured along the centre-line of the flume. Seatek's multiple transducer arrays (MTAs) allow bed forms measurement along many profiles in spatial or temporal domain or in both, which may be transformed into a three-dimensional field of bed elevations. Measuring bed forms at a fixed position in the flume provides a comparison of the downstream migration of neighbouring bed forms, a technique termed stationary measurement herein. The ability to move the transducers along different sections of the flume results in a continuous area of bed observation, herein termed moving measurement of bed forms.

A 5-MHz ultrasonic ranging system, comprising 31 transducers, was employed for the measurements. The sensors were interrogated sequentially and the same sequence was repeated every 0.2-s.

For stationary probe measurements the probe arrangement employed was the same as the resulting recording grid, because no movement of the carriage occurs. The resolution of the grid was 40-mm in the longitudinal and transverse directions. An array of 8 probes along the flume and 4 probes across the flume gives a rectangular grid of dimensions 28-cm x 12-cm over which the migrating bed forms are recorded.

For moving probes measurements the sensors were mounted on a skewed grid to allow for the movement of the carriage and the time interval between readings of the components of the sensor array. The accuracy of the recorded longitudinal distance was validated by an independent position measurement.

Eight experiments were carried out in a 12m-long, 0.38m-deep and 0.44m-wide, glass-sided, open-channel flume. In operation of the flume, both water and sediment are continuously re-circulated. Experimental parameters are given in Table 1. Four runs were undertaken with each of two uniform sands. The sands used were a fine sand with median size d_{50} = 0.24-mm and a coarse sand with d_{50} = 0.8-mm. Froude number F for the 8 experiments ranged from 0.29 to 0.72. Flow depth y was kept constant at 150-mm.

Table 1. Experimental parameters.

Run Name	Pump Setting	d_{50}	S_e	Run Duration	Equilibrium	U_{avg}	Fr	Re
		(mm)		(h:m:s)		(m/s)	(-)	(x10³)
nsf10	10	0.24	0.001	08:00:00	yes	0.35	0.29	125
nsf15	15	0.24	0.001	05:16:00	yes	0.45	0.37	161
nsf18	18	0.24	0.001	05:26:00	yes	0.55	0.45	196
nsf20	20	0.24	0.001	05:03:00	yes	0.6	0.49	214
nsc17	17.5	0.8	0.002	06:17:00	yes	0.5	0.41	178
nsc20	20	0.8	0.003	05:45:00	yes	0.6	0.49	214
nsc24	24	0.8	0.003	04:45:00	yes	0.7	0.62	250
nsc28	28	0.8	0.004	03:08:00	yes	0.87	0.72	310

Note: Kinematic viscosity ν=0.000001 m²/s; Critical shear velocity $u^*_c(d_{50}$=0.24mm)=0.0132m/s; $u^*_c(d_{50}$=0.8mm)=0.02065m/s; Temperature T=18°C; Specific gravity s=2.65; Flow depth y=0.15m; Hydraulic radius m=0.089m
d_{50} Median grain size, S_e Flume Slope, U_{avg} Average Flow Velocity, Fr Froude Number, Re Reynolds Number

Examples of contour plots obtained using the moving probes are given in Figure 1, for dune (see Figure 1a) and ripple development (see Figure 1b), respectively. The two different bed form types were a function of the sediment size; only dunes developed in the coarse sand, while ripples were observed in the fine sand.

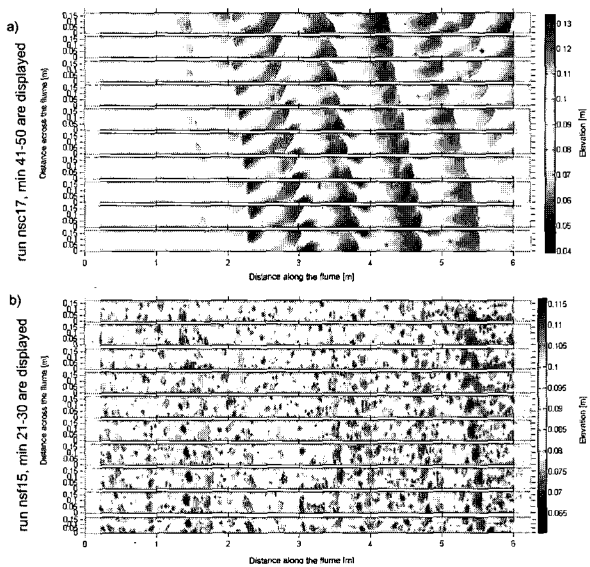

Fig. 1 Contour plots of moving probe measurements for dune development a) and ripple development b).