Measurements of the relationship between turbulence and sediment in suspension over mobile sand dunes in a Laboratory flume

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Purpose

To understand sediment transport mechanisms over dunes by examining the relationship between fluid and sediment within the context of a mobile dune bed.
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I. Fixed Bedforms
   Vendetti & Bennett (2000): experiments linking turbulence and sediment suspension reveal fluctuating velocity components and suspended sediment concentration ~ independent of one another. (optical backscatter probe and acoustic Doppler velocimeter-ADV)
   Nelson et al. (1995): Sediment particle movement over a negative step shows Q4 events (sweeps) and Q1 events (outward interactions) were equally effective in terms of moving particles.

I. Mobile Bedforms
**Experimental Setup**

Recirculating flume with adjustable slope: 15 m x .36m x .46 m (L,W,H)

Acoustic sensor measured water surface slope

3 axis ball screw linear position system enabled x axis velocity to equal bed form migration rate

Acoustic backscatter system (BSS) recorded bed elevation and sediment concentration (derived from backscatter) at a frequency of 1.25 Hz.
Experimental Setup

The creation of the “Unit dune”

a. The irregular sample spacing (fig. 5) is a reflection of the data collection method.

Total of 8 runs; 207 two minute time series
Mean dune migration rate: 5.0 cm/min
Comparison of results to other studies
Results

a. Downstream velocity: U
b. Vertical velocity: V
c. Reynolds Stress: (-u’v’)
d. Root mean squared difference from the mean in the vertical direction: RMS v’
e. Root mean squared difference from the mean in the downstream direction: RMS u’
The effect of dune topography on local suspended sediment concentration

Note: Points represent LDV sampling volume during the 2 min. sampling periods.
Turbulence

$v' > 0$ is a better suspension mechanism than $v' < 0$
Figure 14. Quadrant contributions to sediment suspension.
Conclusion

- Reynolds stress, RMS $u'$ and $v'$ were not strongly affected by length or height changes of the dunes.
- 20% more Quadrant 4 events to Quadrant 2 events for $H = 0$.
- 35% more Quadrant 2 events to Quadrant 4 events for $H = 2$.
- Quadrant 2: suspended sediment over entire unit dune
- Quadrant 4: suspended sediment just downstream of the crest