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Spectral behavior of sand bed rivers at small wavelengths

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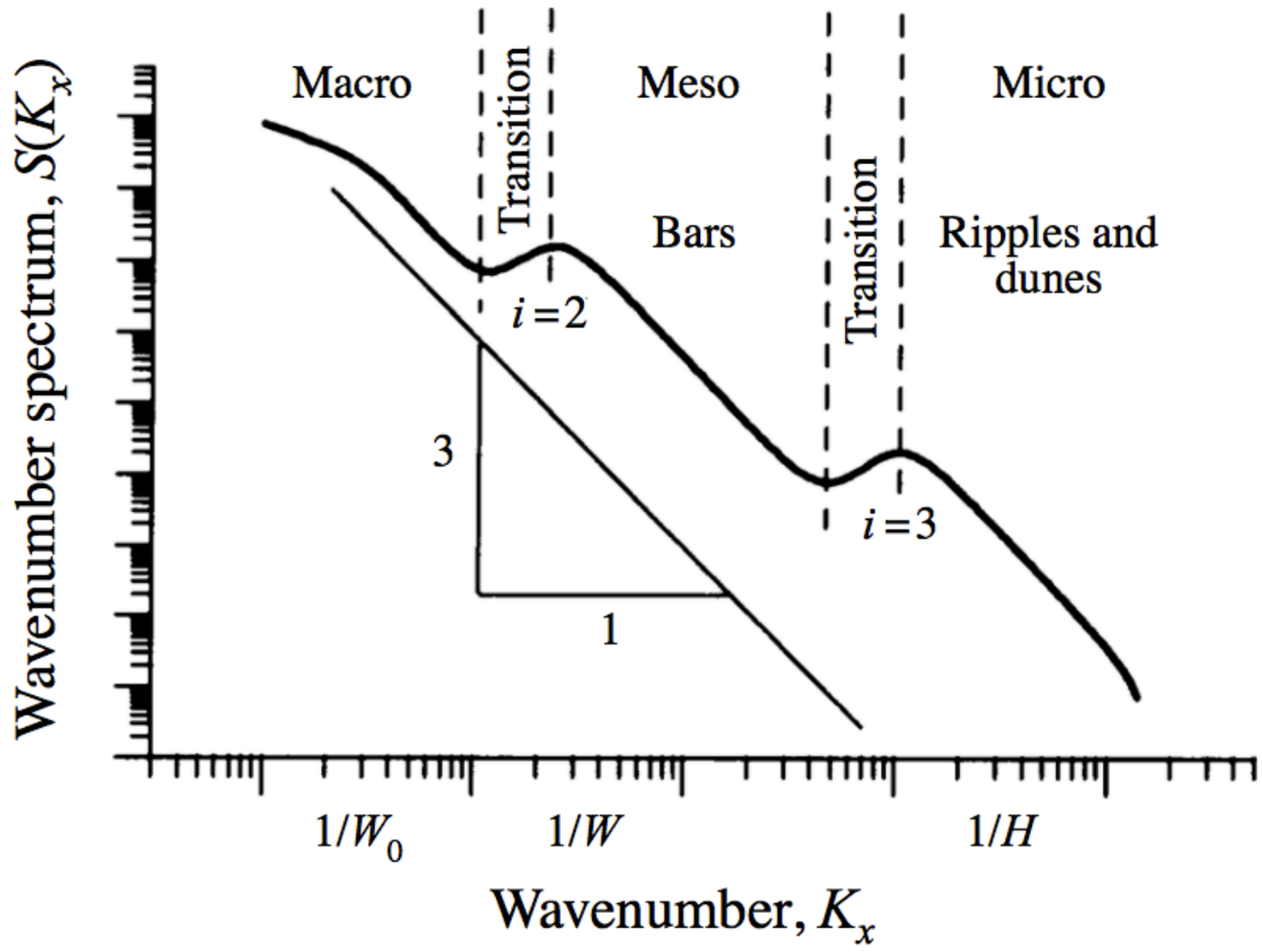
Outline

1. Introduction
2. Data
3. Results
4. Discussion
5. Conclusions

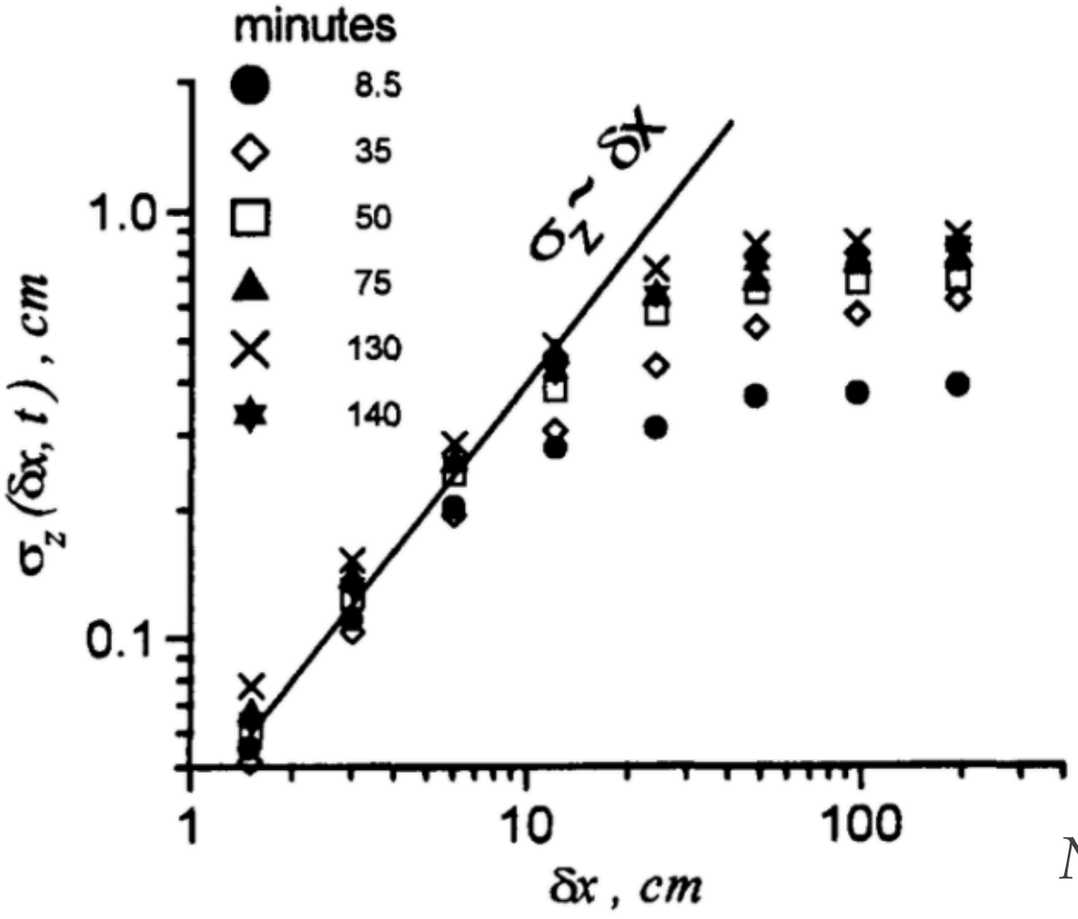
'-3' scaling law

Schematic spectrum of the longitudinal profile of bed elevations in sand rivers: macro, meso, and micro, characterized by three length scales; flow depth, river width, and valley width (*Hino, 1968; Nikora et al., 1997*).



Equilibrium & Non-equilibirm

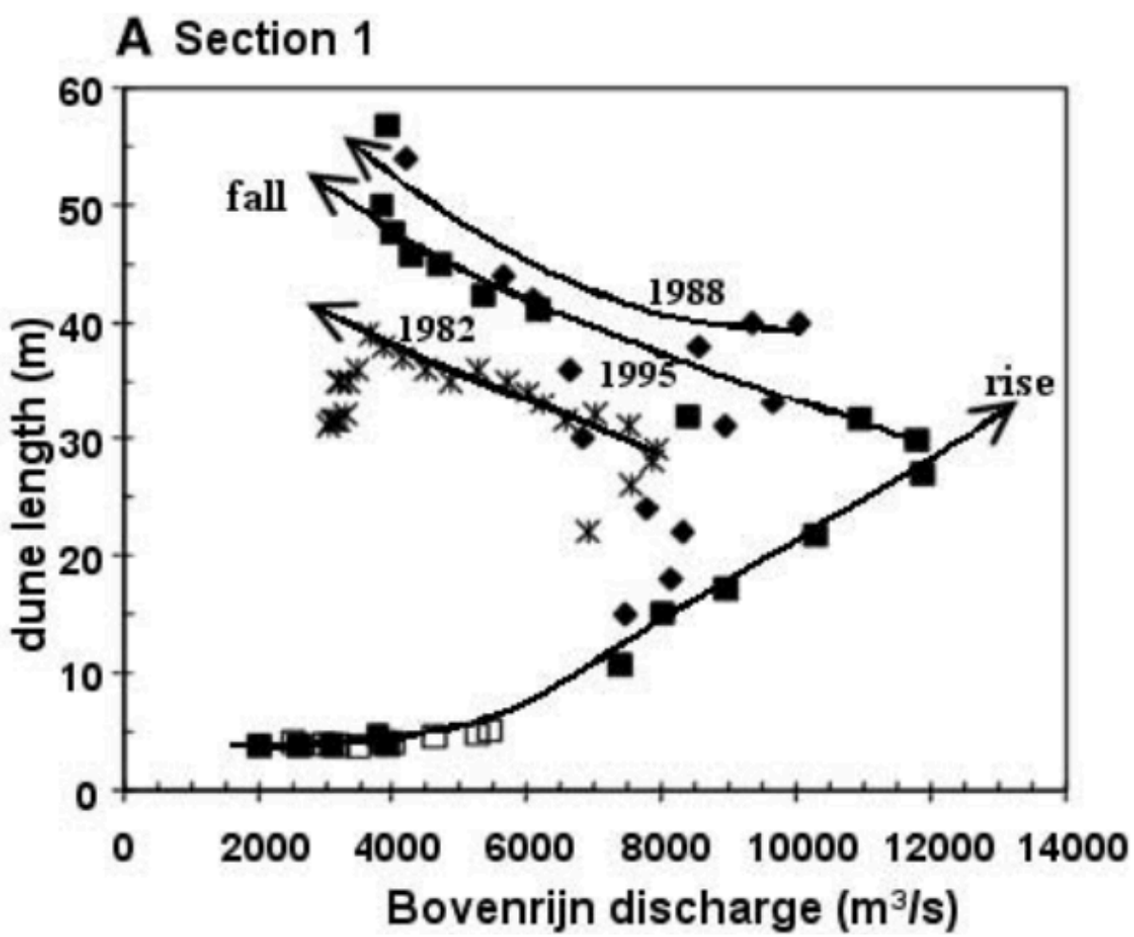
- The '-3' scaling law has been developed for sand waves at equilibrium conditions.
- Sand waves at equilibrium contains are characterized by Self-Similarity.

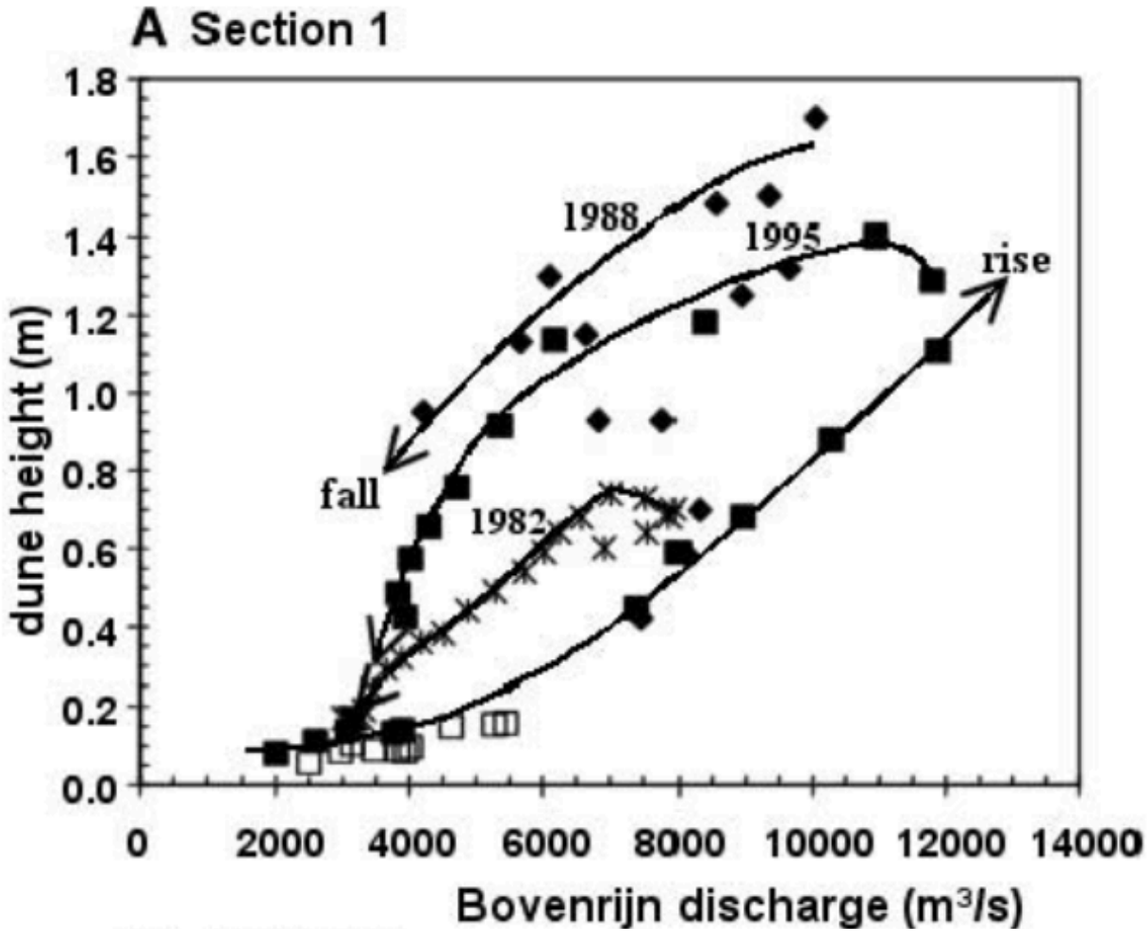


Nikora and Hicks (1997)

Equilibrium & Non-equilibirm

- The requirement of equilibrium conditions is, however, difficult to be satisfied in natural conditions.

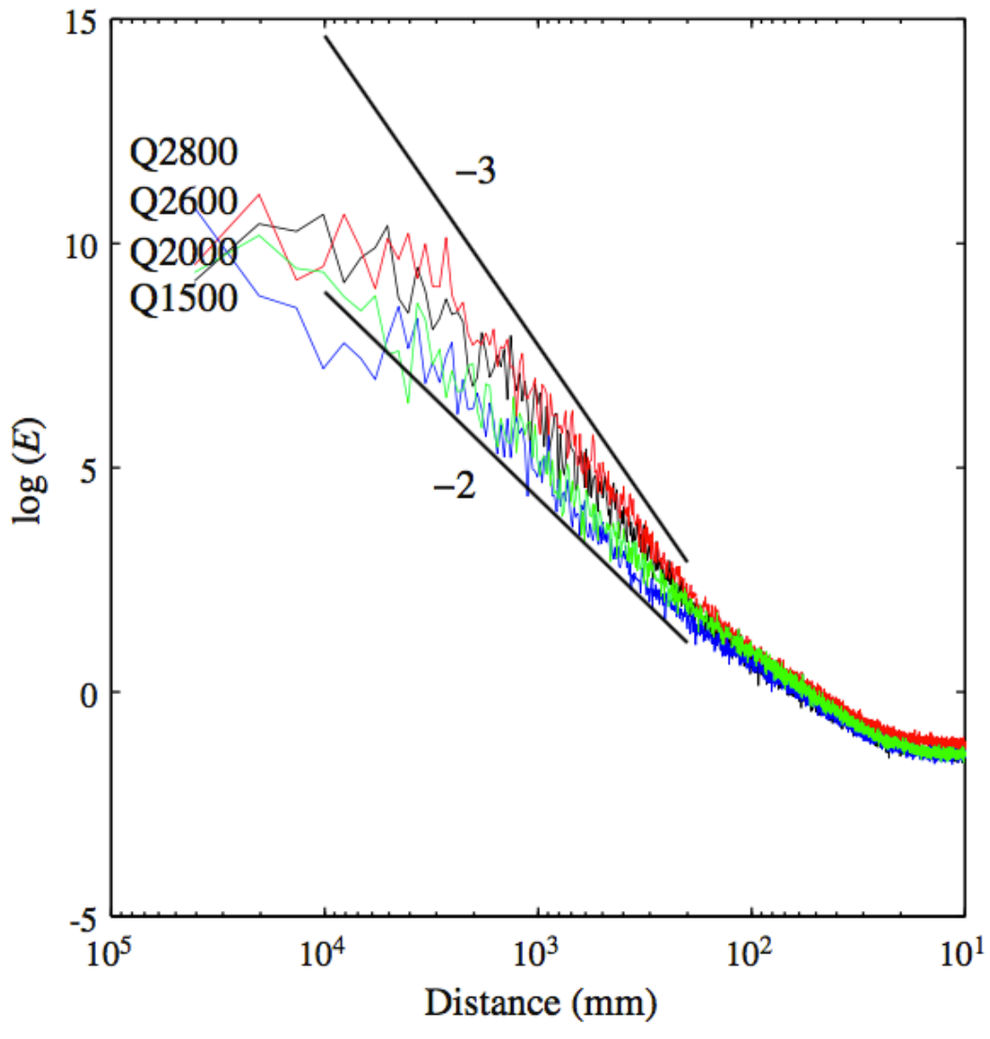




Wilbers and ten Brinke (2003)

Uniform & Non-uniform sediment

- The bed material has also an important effect on dune characteristics.



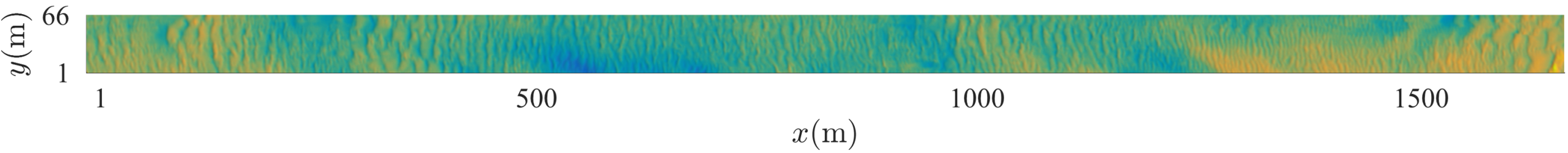
Qin et al (2015)

The research problems

- (1) whether the spectra of the river bed surfaces show a deviation from the '-3' scaling law;
- (2) the possible reasons causing such a deviation.

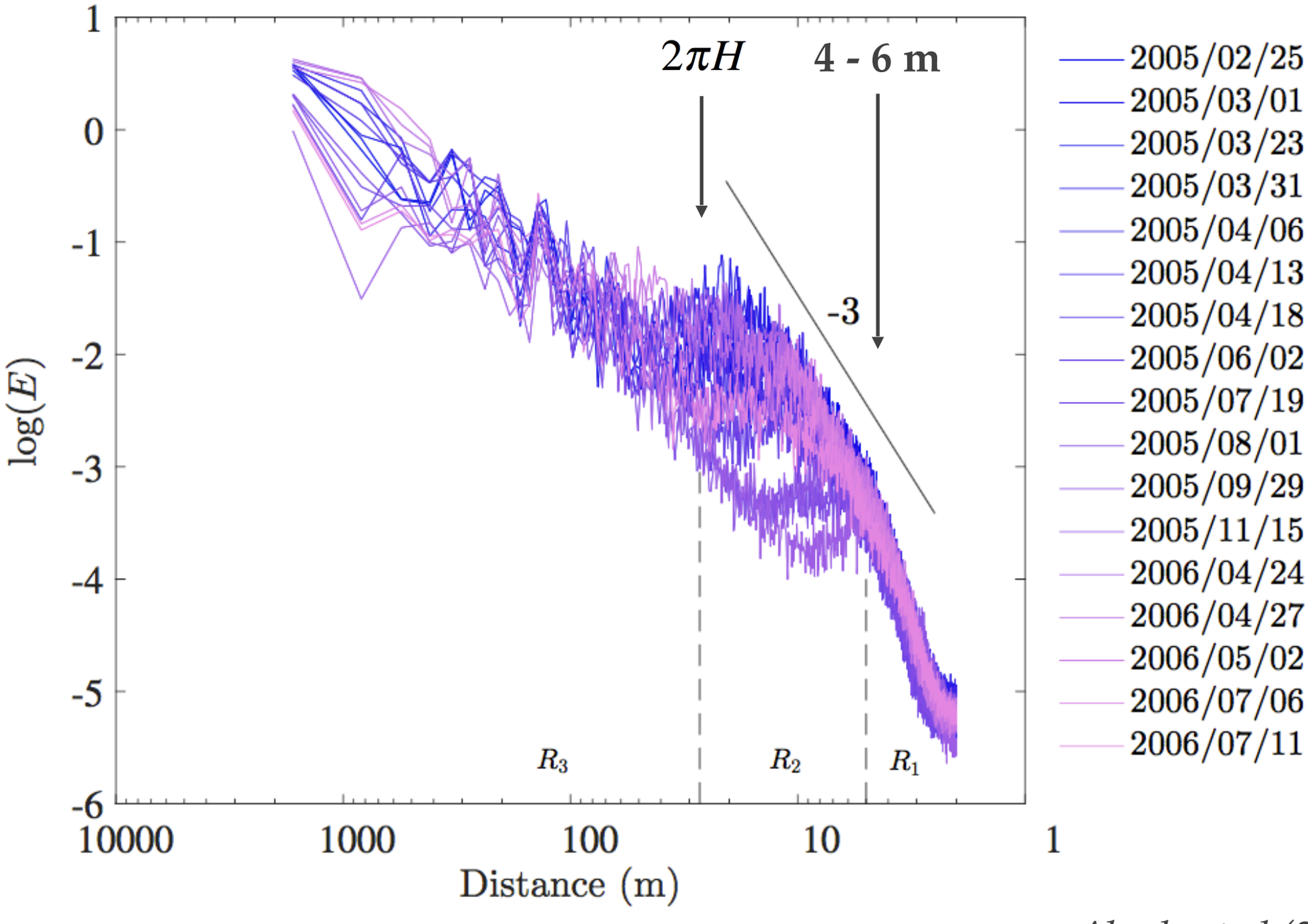
Elbe River

- A 2 km long straight reach of the Elbe Rive. The mean diameter of bed load particles is dm = 2.0 mm, and the underlying bed material is slightly coarser (dm = 3.3 mm).
- Each DEM has a grid size of 1 m × 1 m and an area of 1664 m × 66 m



Aberle et al (2010)

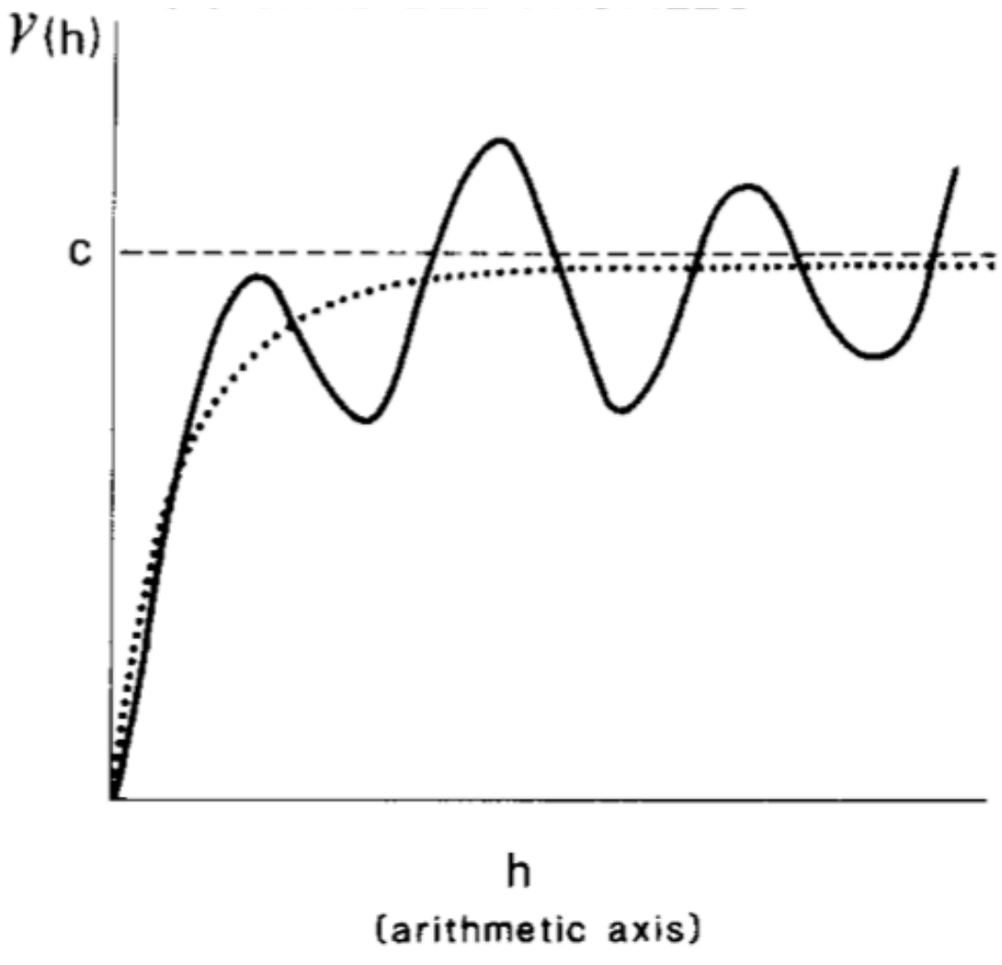
Power spectra



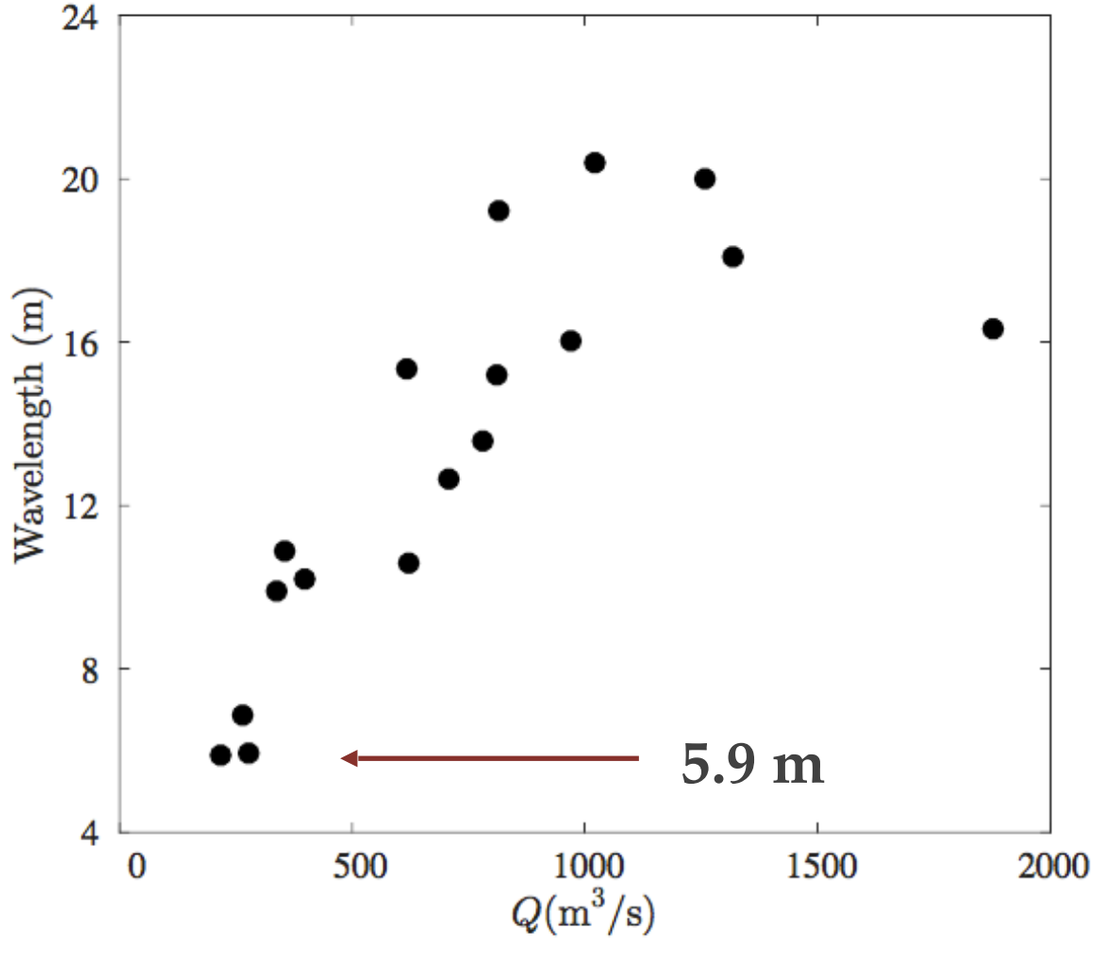
Aberle et al (2010)

The dominant wavelengths

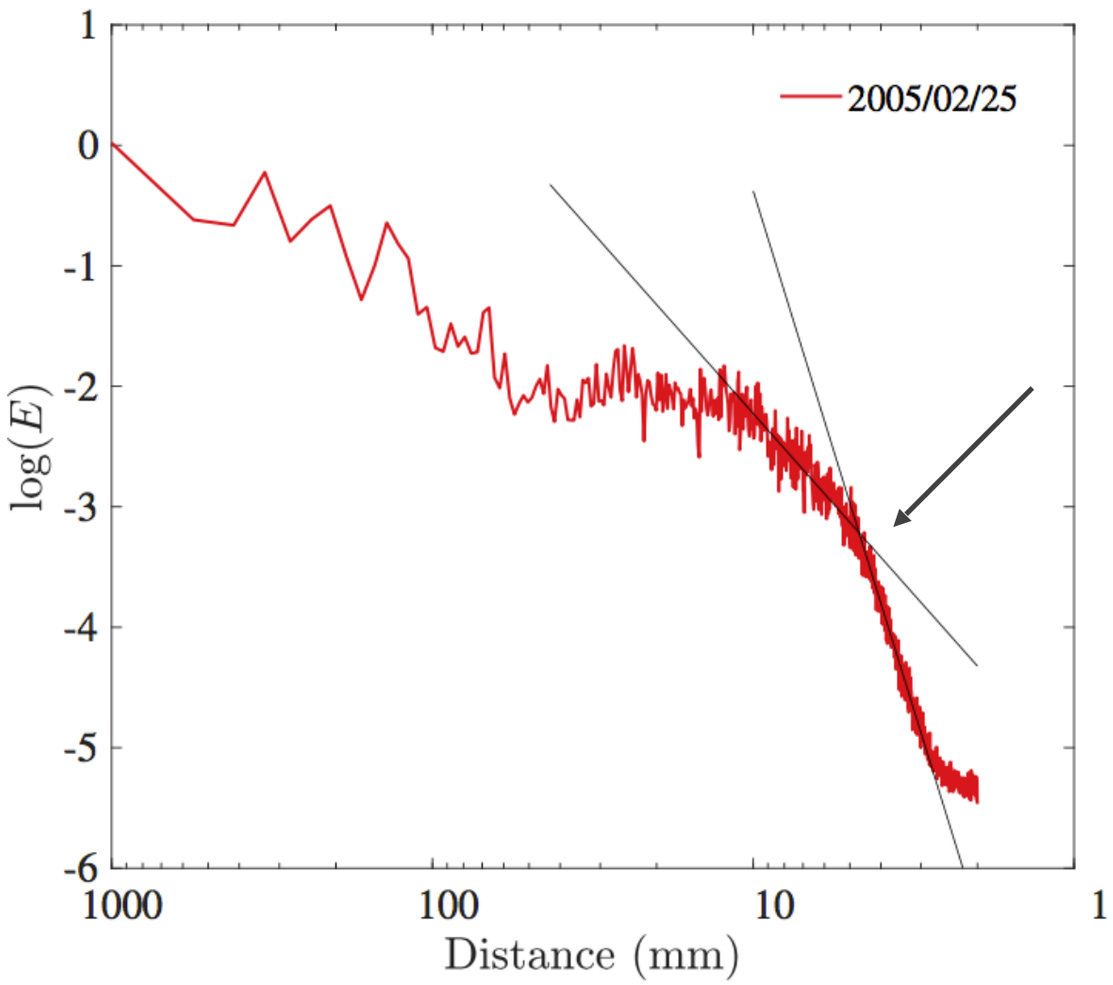
- By fitting the structure function with a combination of exponential and periodic components. This analysis detects the wavelength of the dominant periodic bedform.

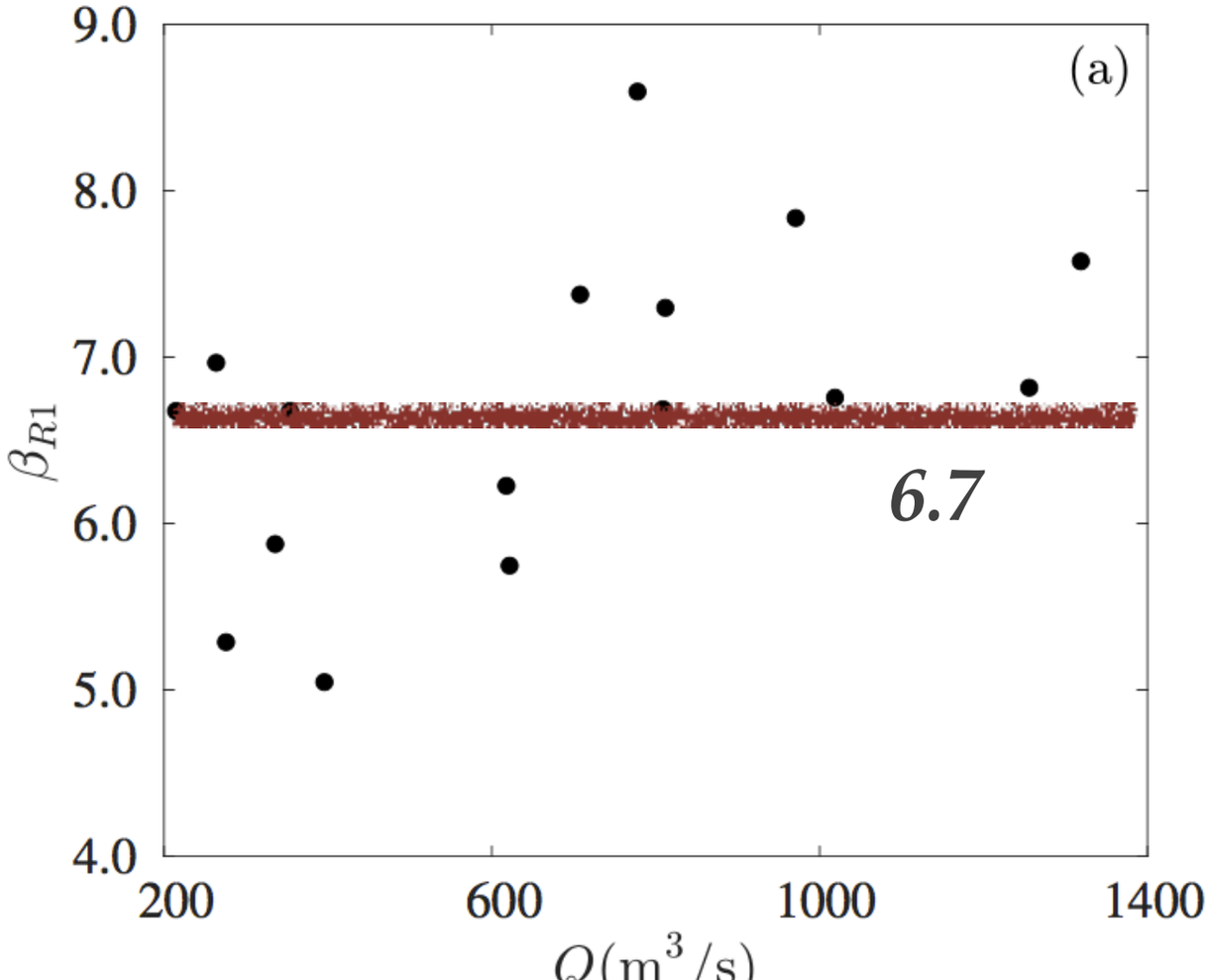


Robert and Richards (1988)

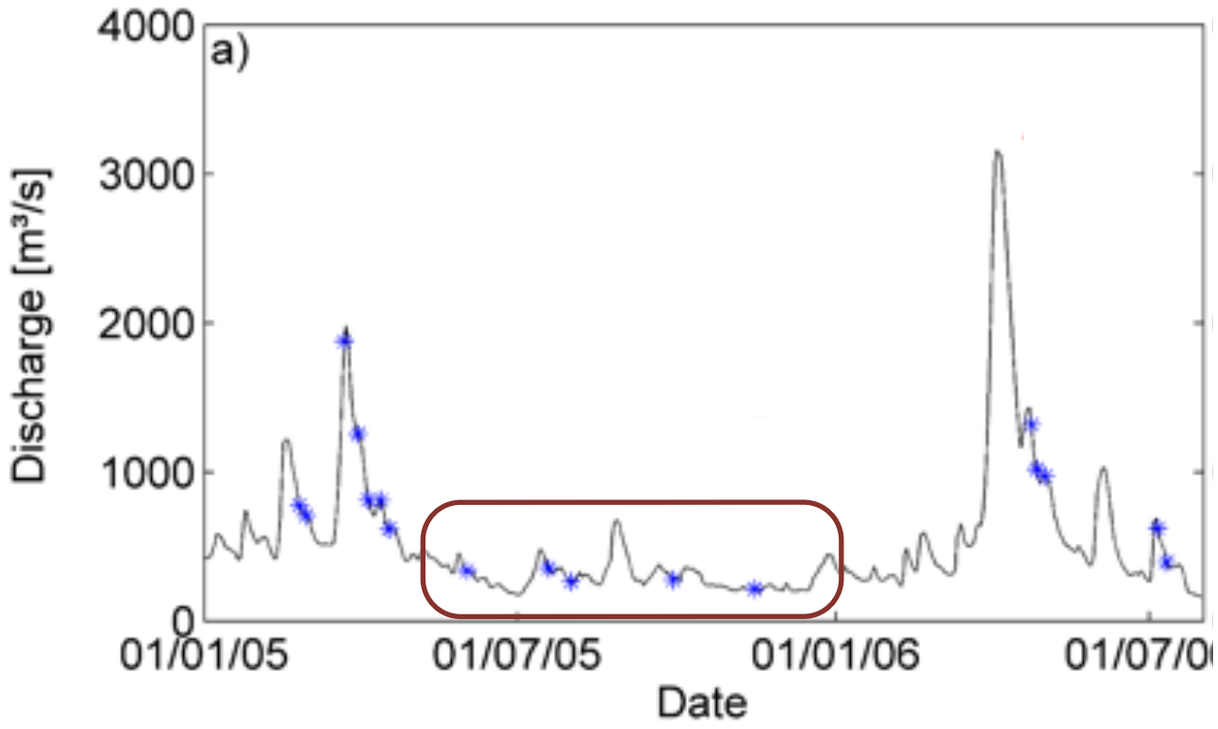


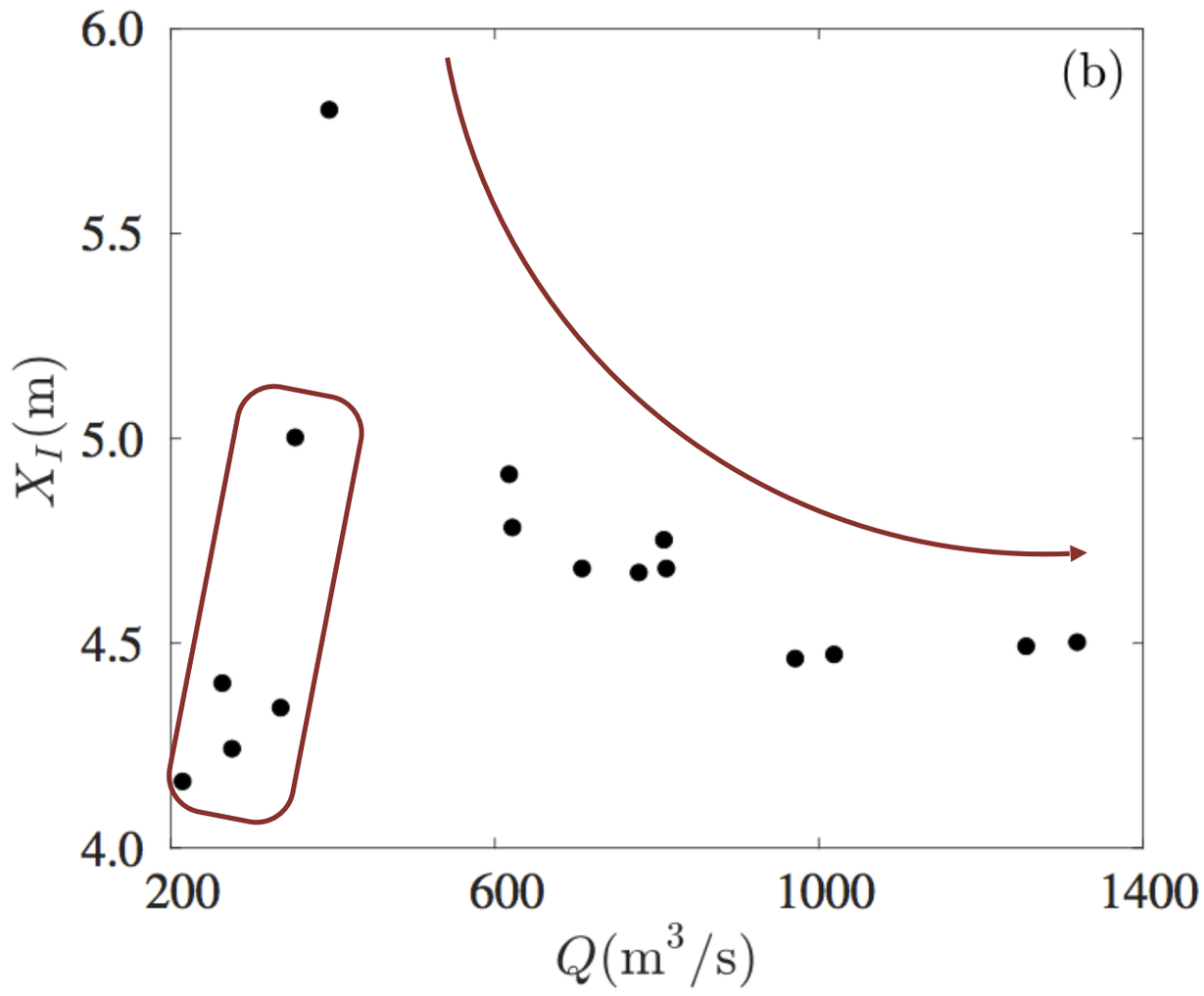
Spectral parameters





Spectral parameters

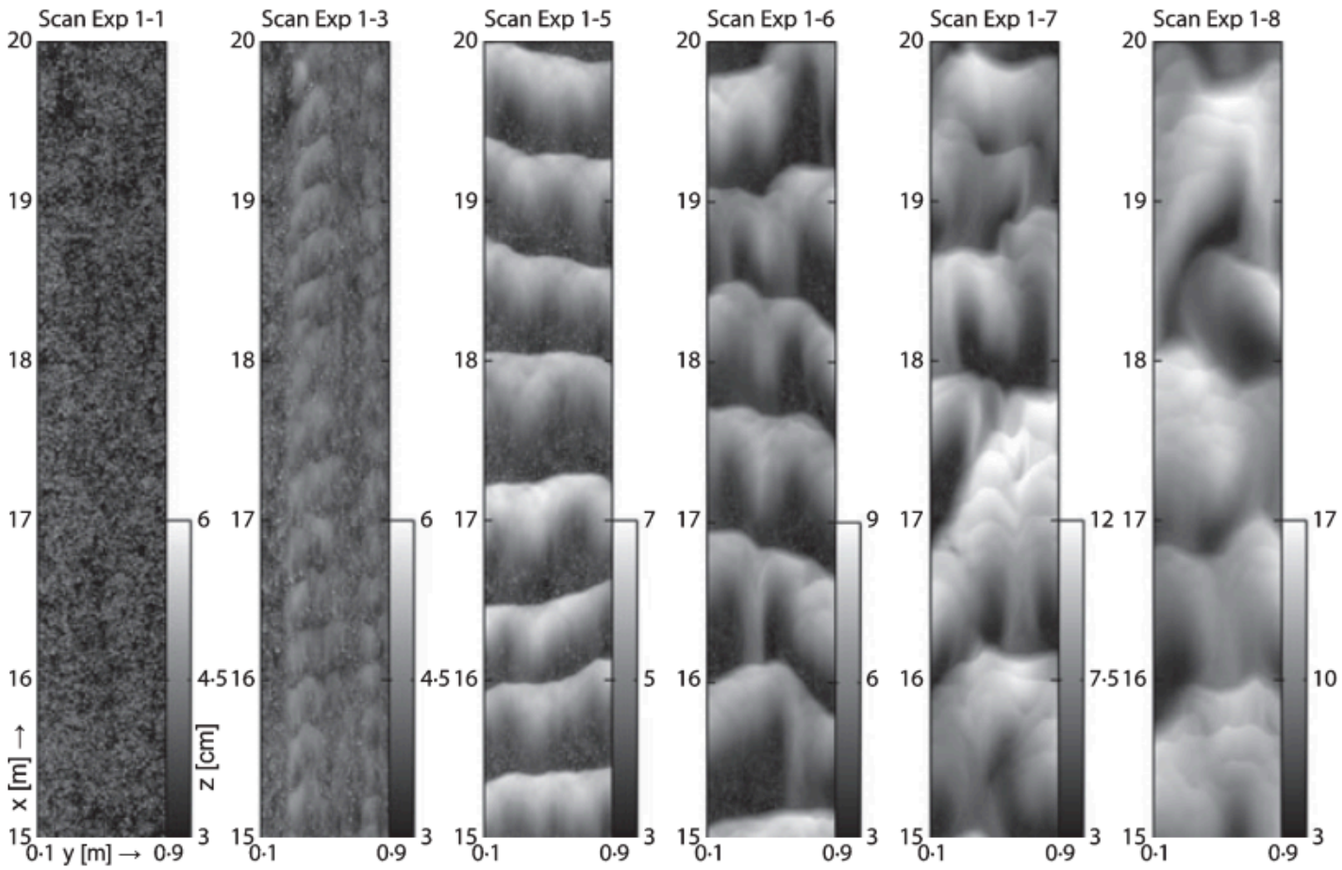




Secondary dunes

- Shen and Cheong (1977) proposed that the presence of superposed ripples on larger bedforms will decrease the exponent from -4 for a ripple bed to -3, which is further supported by the experiments conducted by Tuijnder et al. (2009) and Henning (2013).

Tuijnder's experiments



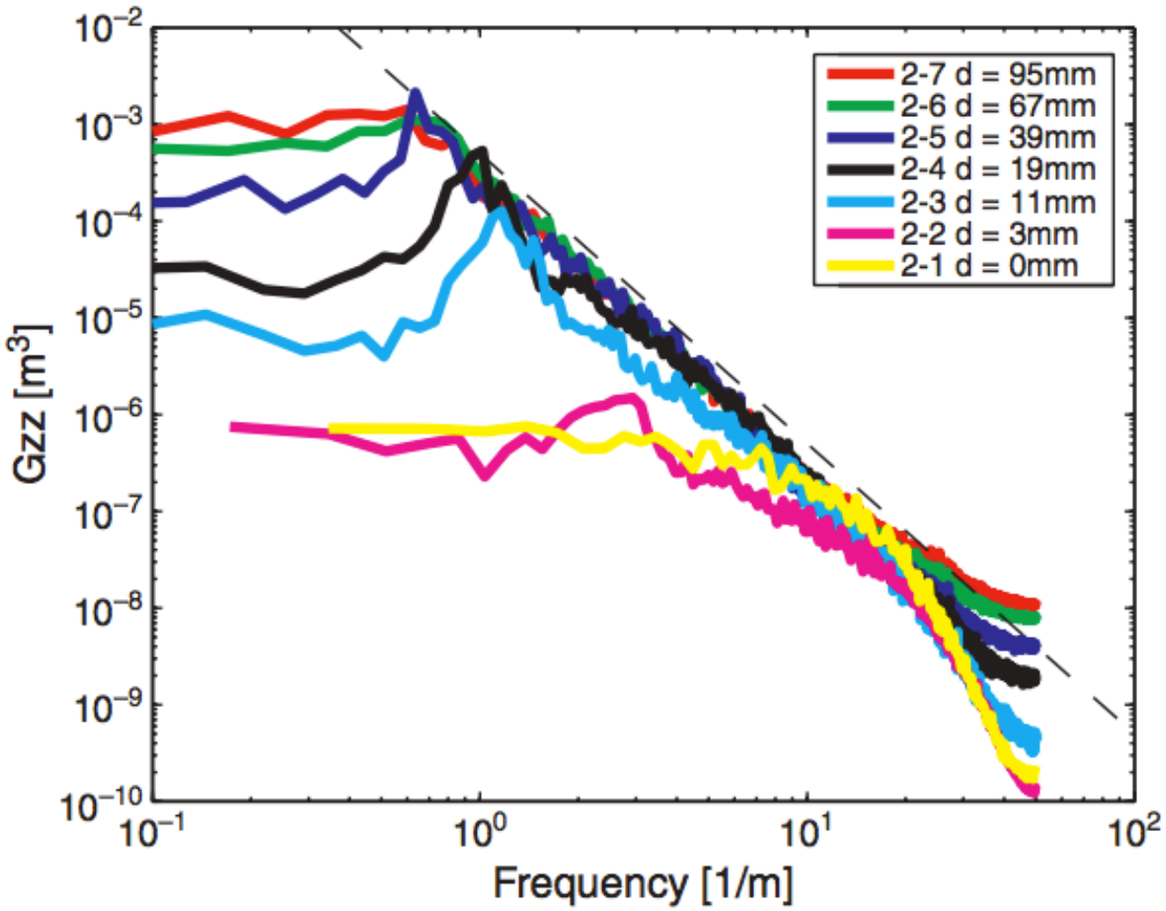
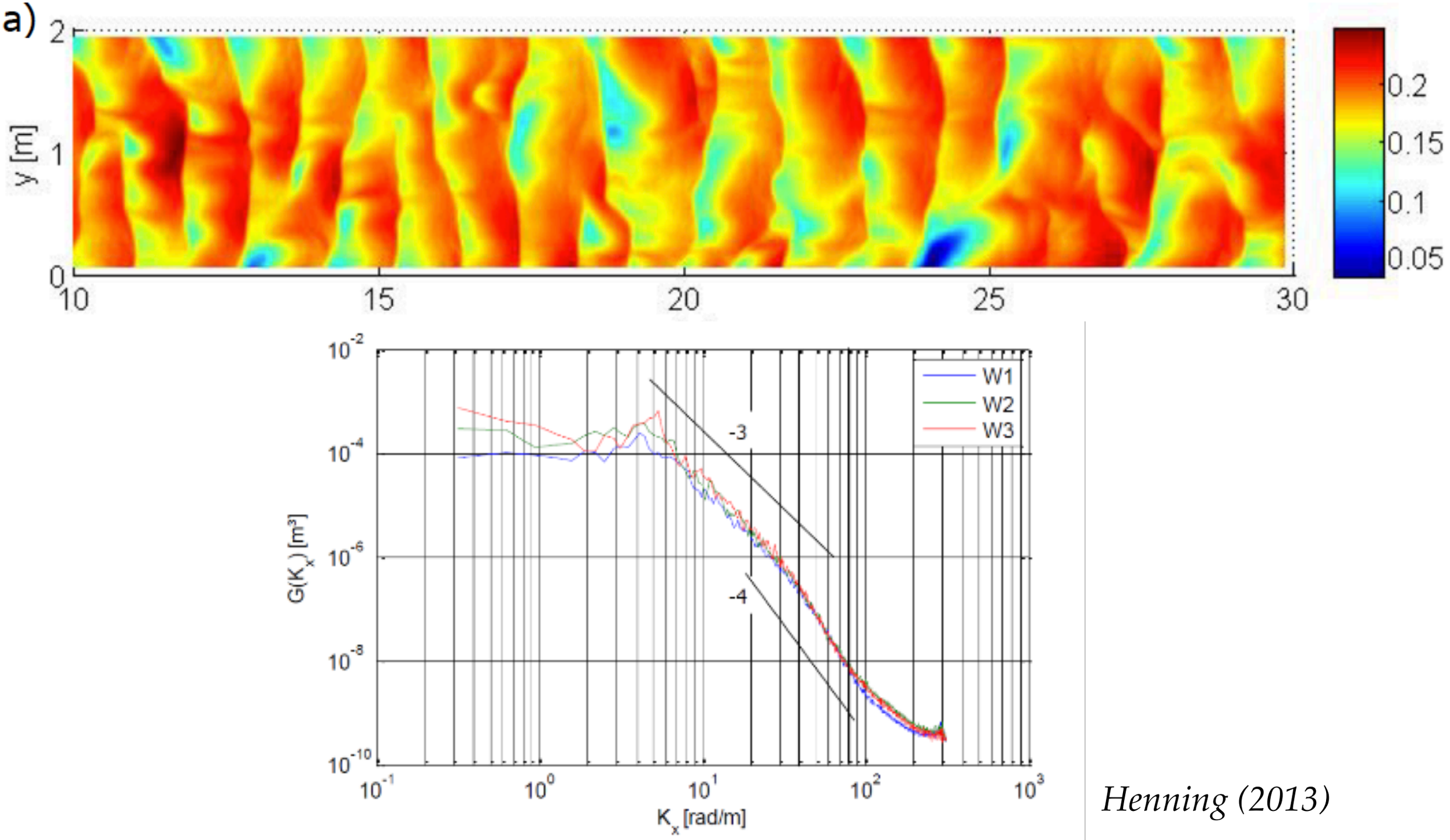


Fig. 9. The spectra for the experiments of Series 2.

Tuijnder et al. (2009).

Henning's experiments



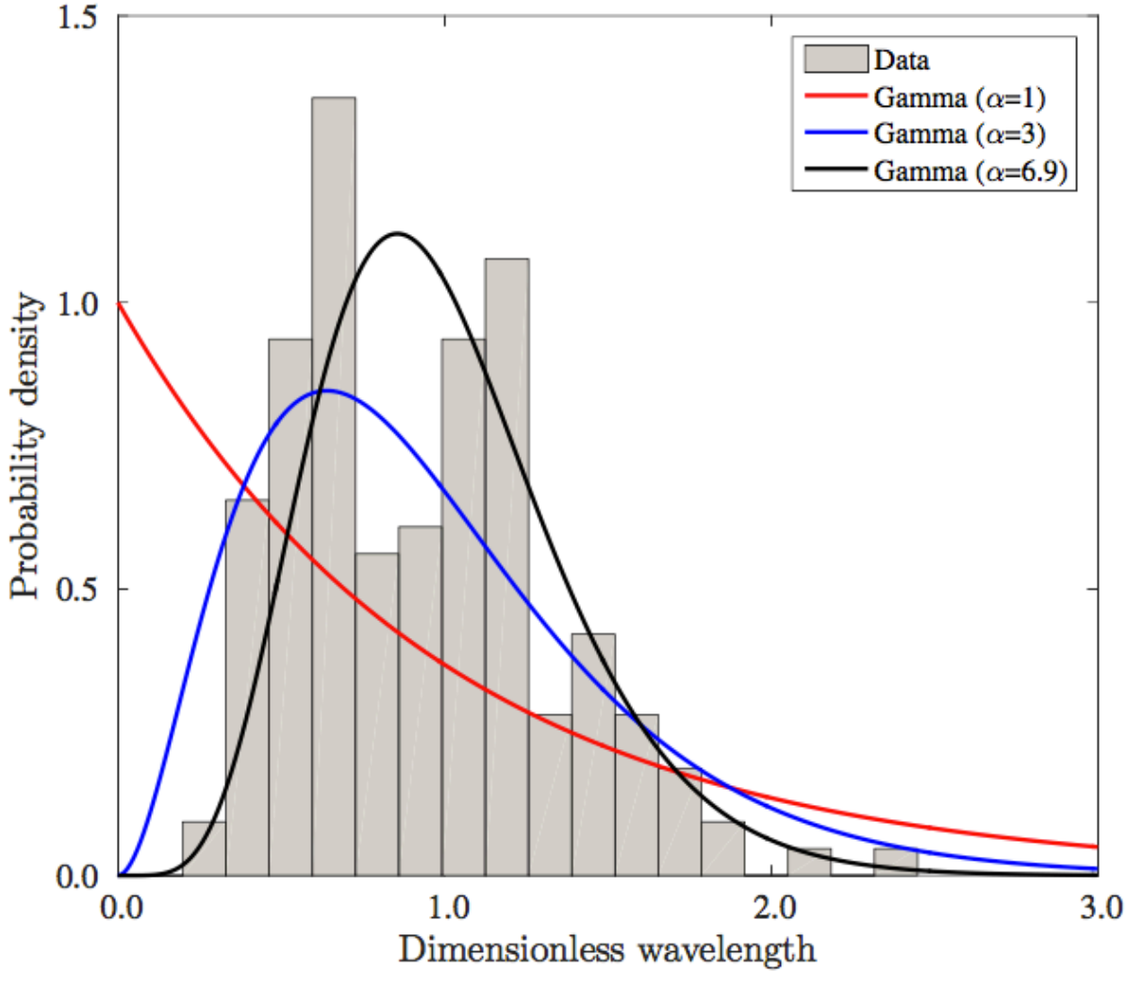
Henning (2013)

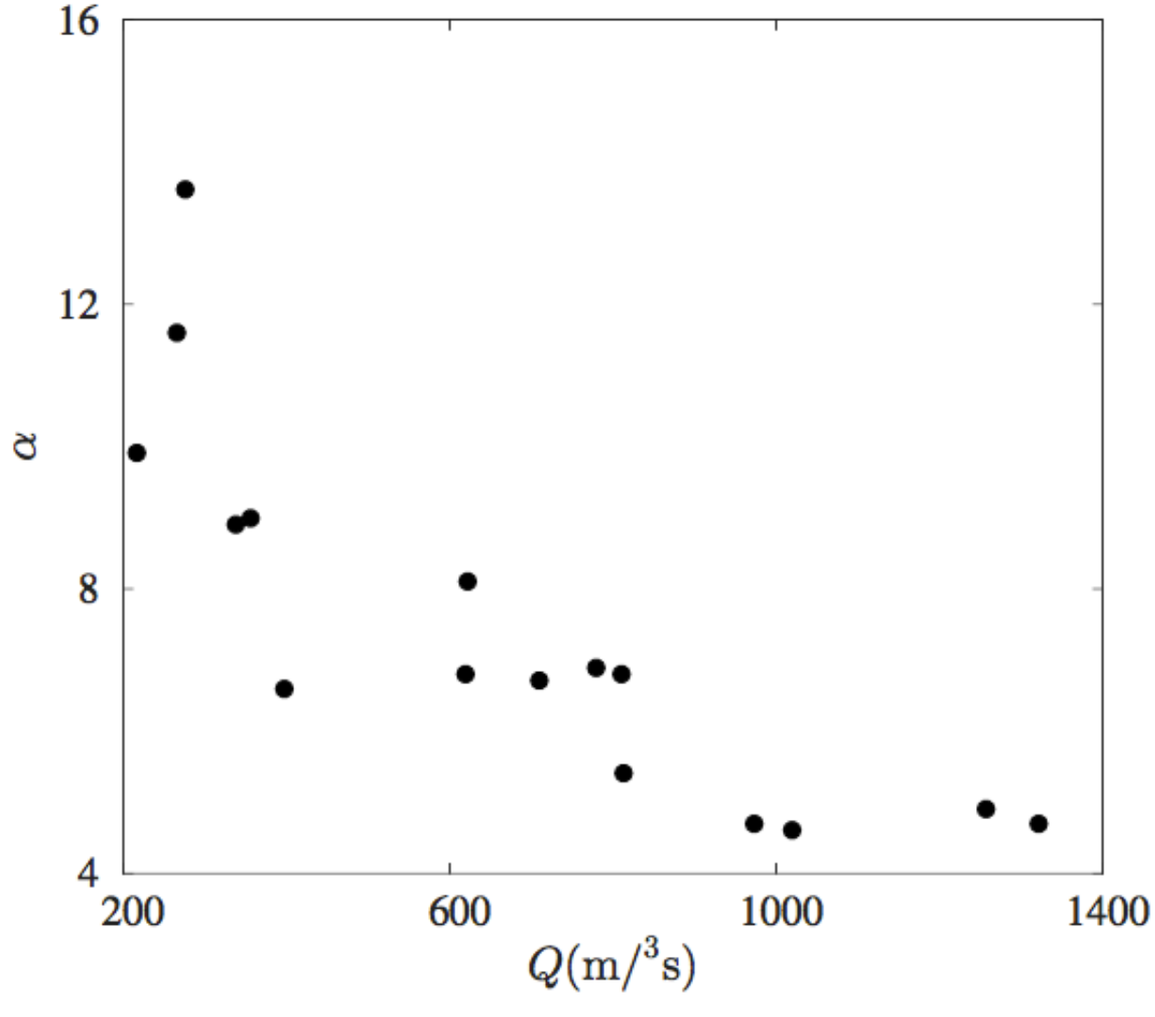
Sand sheets & Secondary dunes

Reesink and Bridge (2007)

Shen and Cheong's explanation

- Shen and Cheong (1977) assumed that the dune length follows a gamma distribution with a shape parameter (α) ranging from 1 to 3. β increases from -4 for $\alpha = 3$ to approximate -3 for $\alpha = 1$.





Conclusions

- The spectral behavior in this study at small wavelengths deviates from the '-3' scaling law and shows steeper slopes.
- β have no significant relationship with flow discharge, while the X_I varies with flow discharge.
- This study supports the hypothesis that the insufficient development of secondary dunes makes the spectra at small wavelengths deviate from the '-3' law.

Thank you

Questions?

Comments and opinions would be appreciated.