On the fetch dependency of air-water gas exchange

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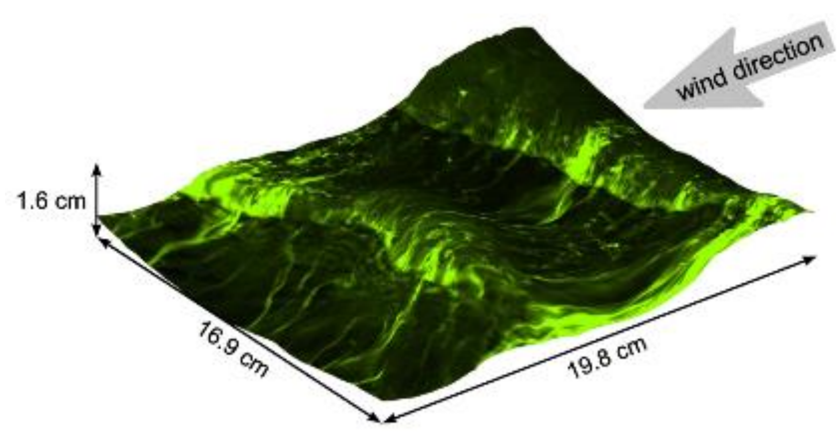
September 2016

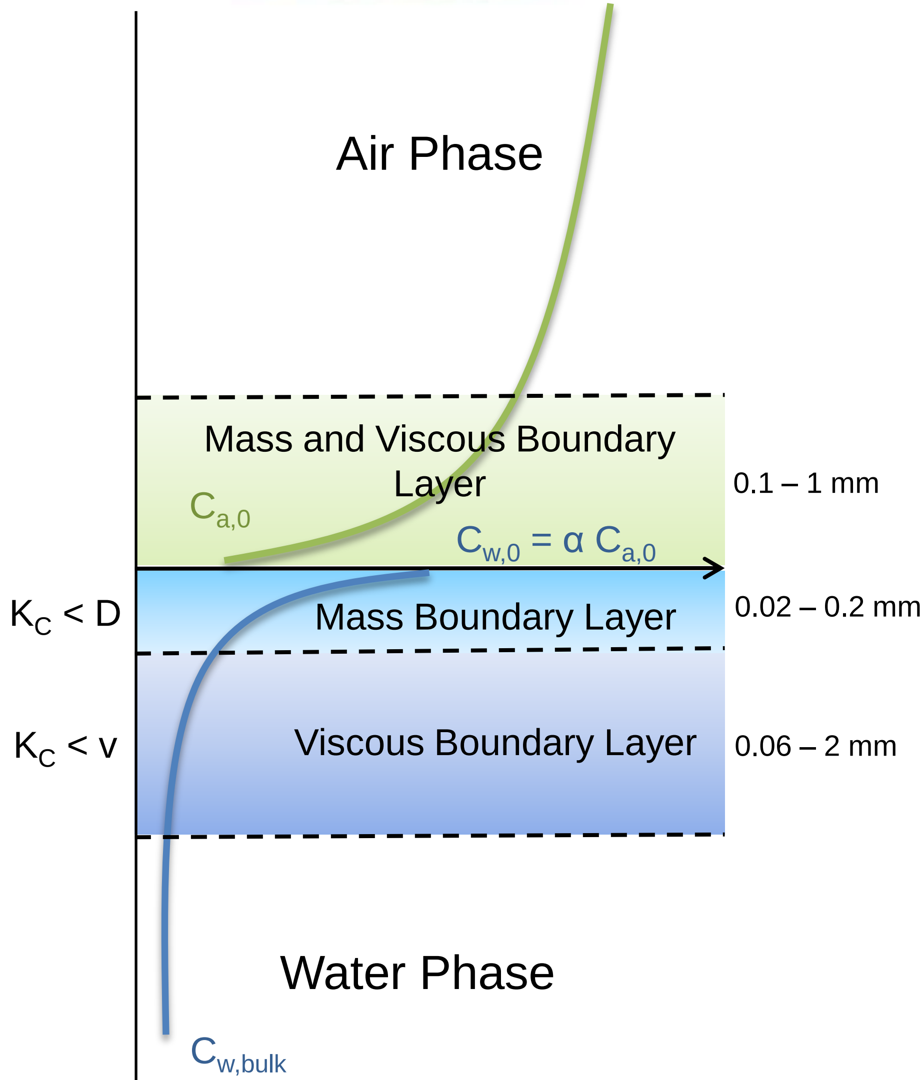
Investigation of the mass boundary layer

- fetch dependency of boundary layer:

  Understanding mechanisms driving small scale air-sea gas exchange at low windspeeds

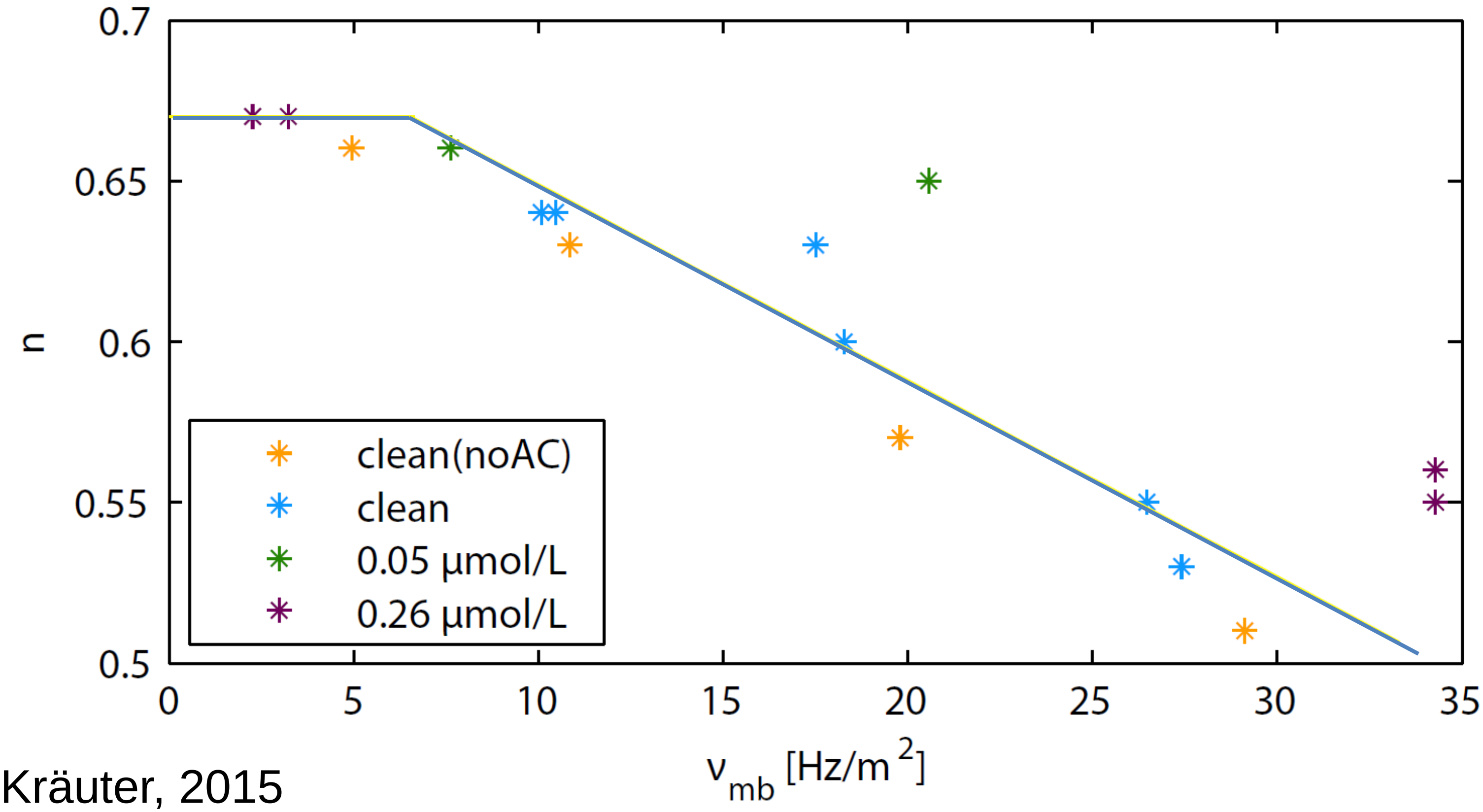
  - boundary layer streaks
  - microscale breaking





adapted from Jähne & Haußecker (1998)

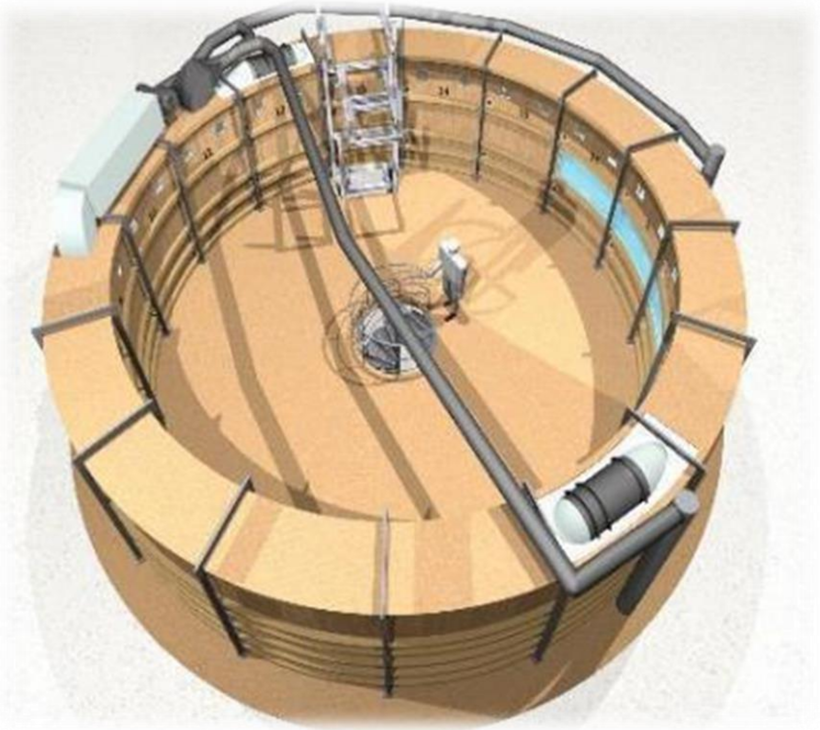
Microscale breaking and Schmidt number exponent



C. Kräuter, 2015

$$\boxed{k \propto u_* * Sc^{-n}}$$

Aeolotron with beach



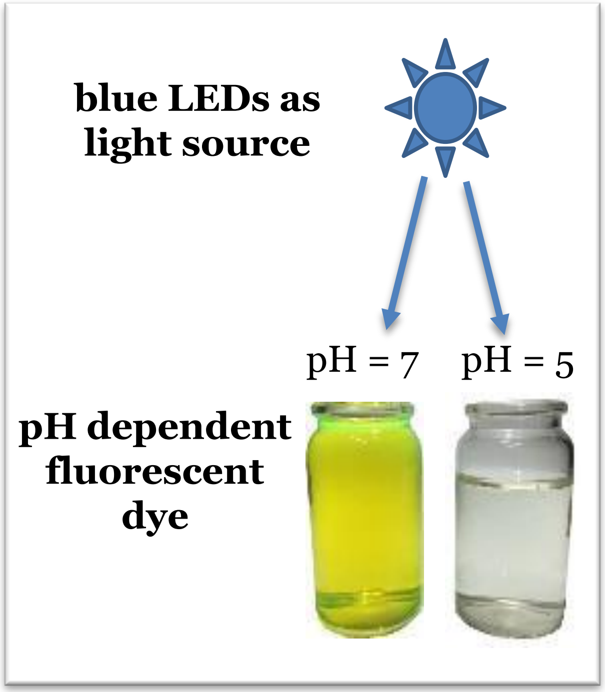
Krall, 2014

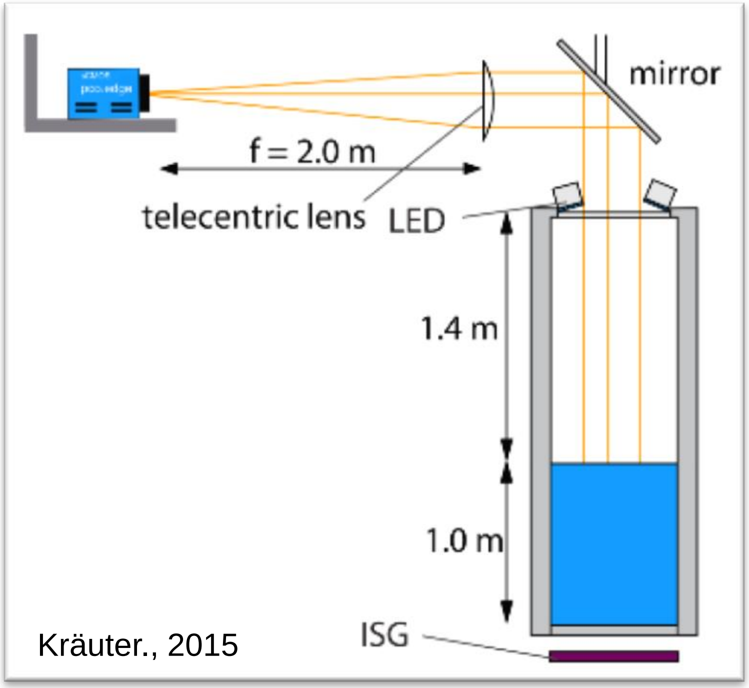
Kropp, 2015

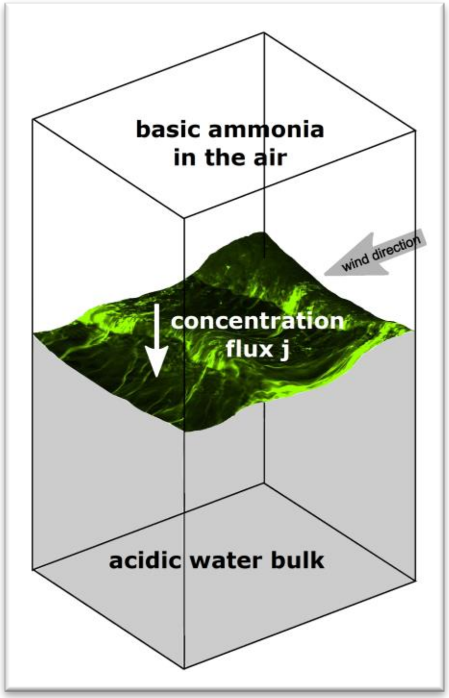
- annular wind-wave facility
- diameter: 10 m
- water volume: 18000 l

- water height: 2m
- flume width: 61 cm
- Operation with unlimited fetch and fetch between 0 and 27 m by using a wave absorbing beach

Boundary Layer Imaging







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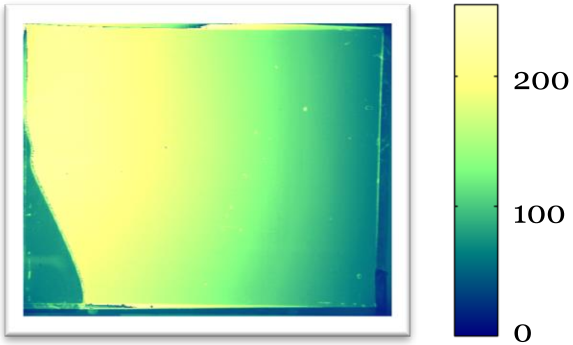
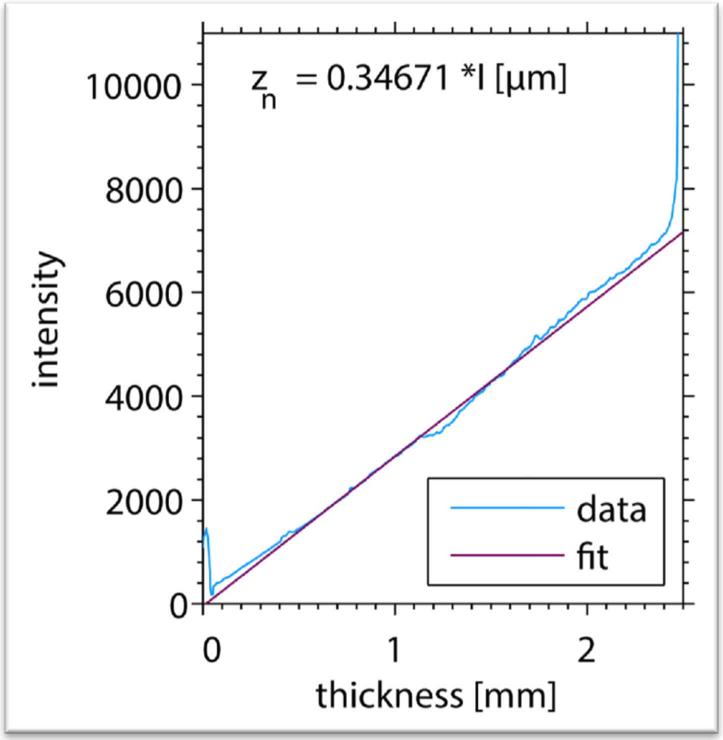


Kräuter., 2015

Fluorescence Intensity I ∝ Thickness of Boundary Layer

transfer velocity $\boxed{k = \frac{D}{z}}$

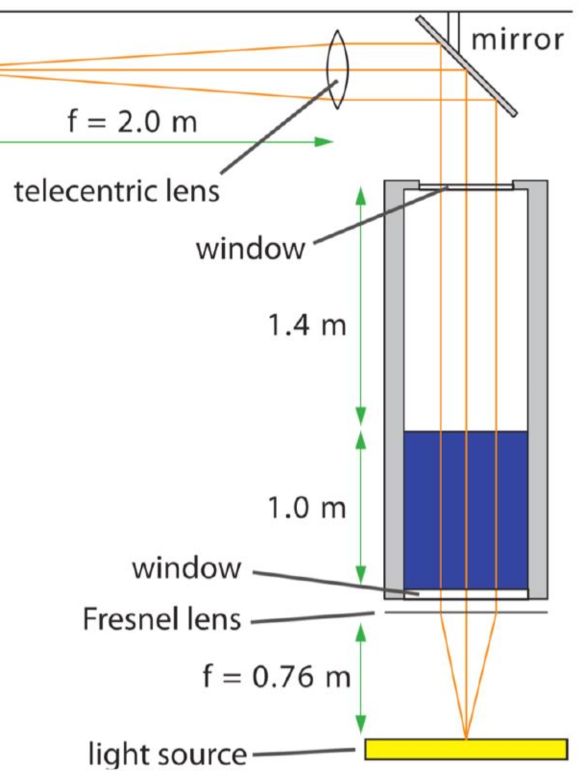


Kräuter., 2015

fraction of mass boundary layer thickness captured by the technique can be adjusted by varying ammonia concentration in the air compartment

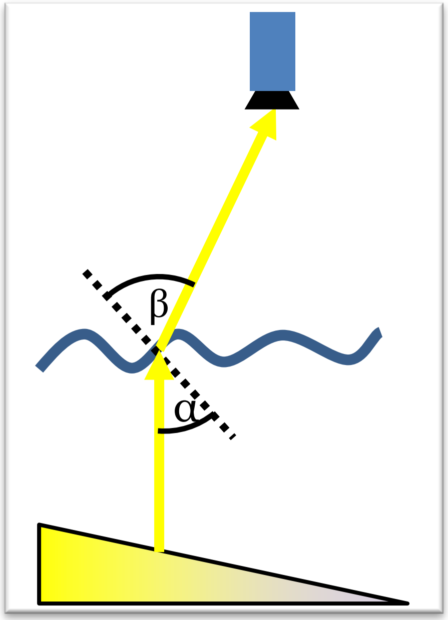
D: diffusion constant

Wave Slope Imaging by Refraction



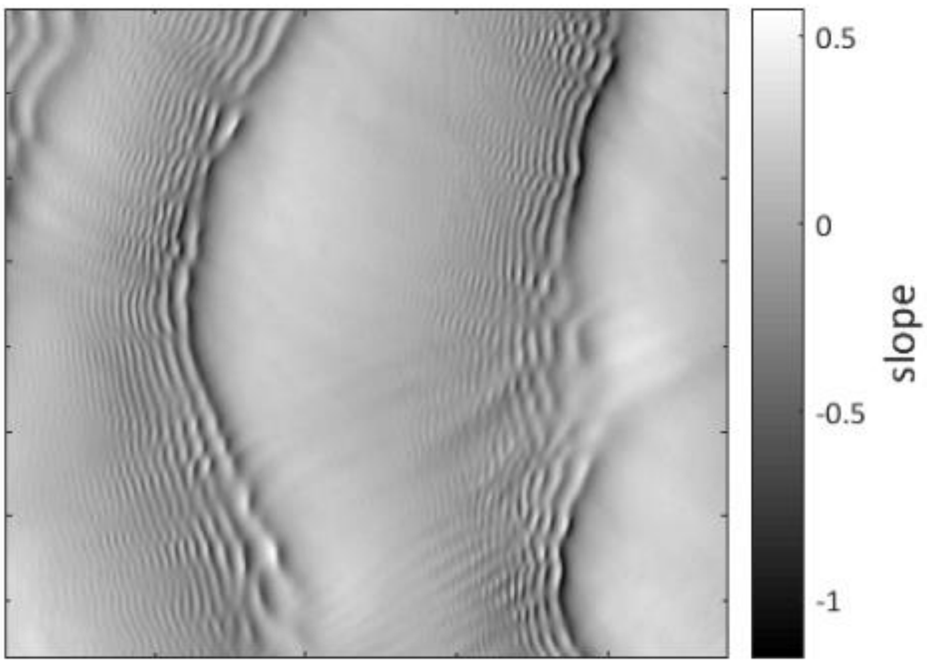
Kiefhaber et al., 2014

- Measures two-dimensional distribution of surface slope
- More than 1500 frames per second
- 0.22 mm resolution
- Observes 16.9 cm × 19.8 cm water patch

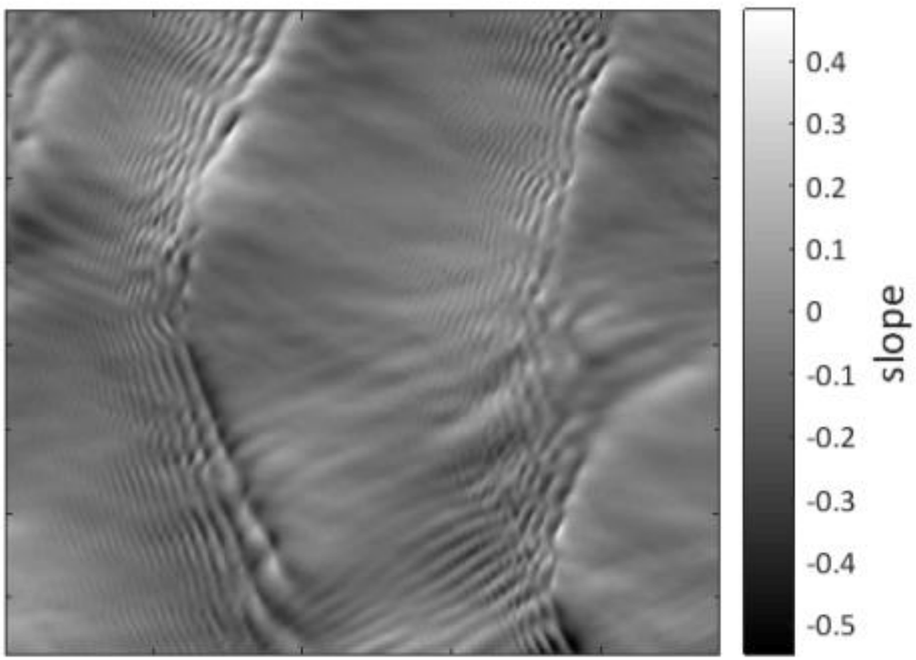


Imaging Slope Gauge (ISG)

wind direction

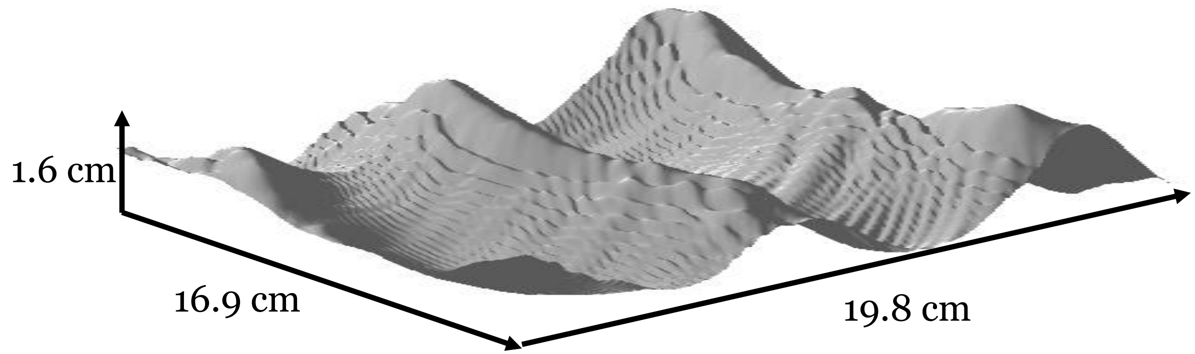


Along-wind slope

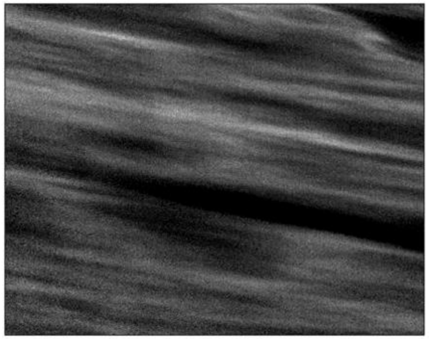


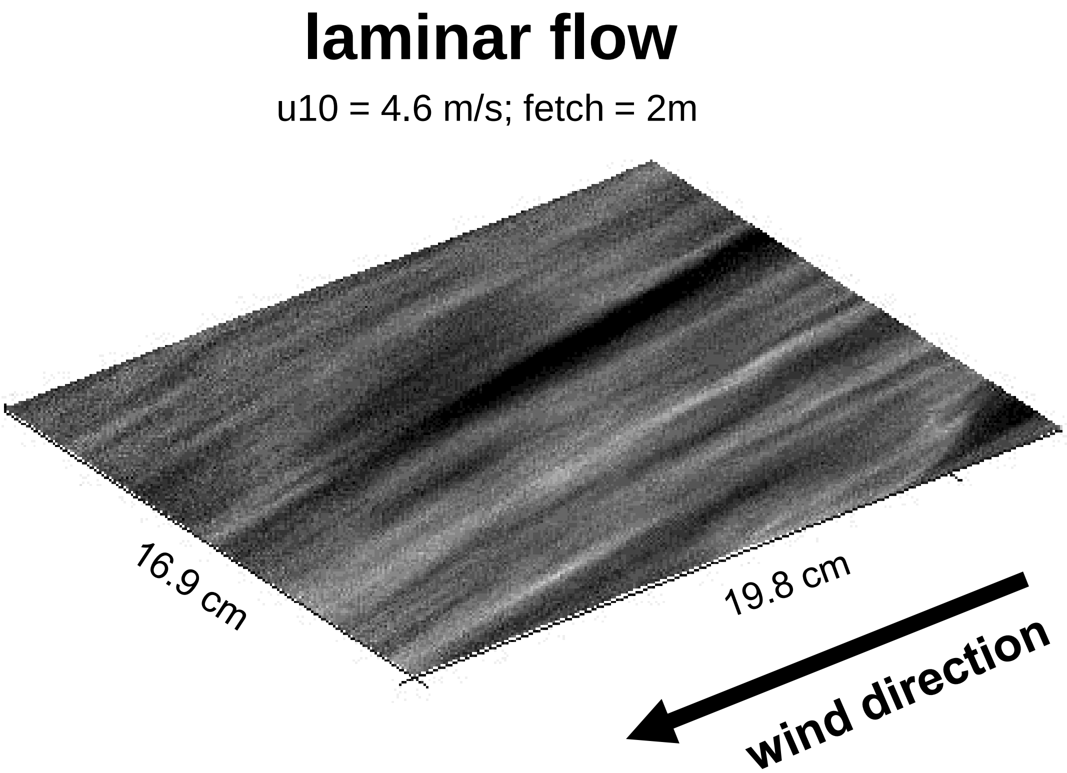
Cross-wind slope

Applying a Height Reconstruction Algorithm:



Development of the mass boundary layer with fetch at the Aeolotron





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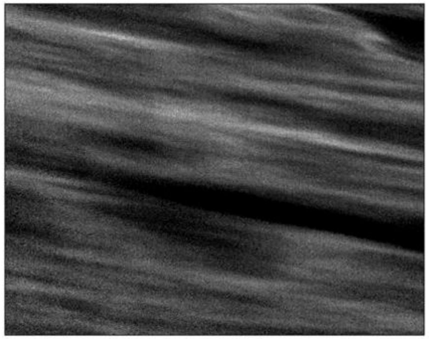

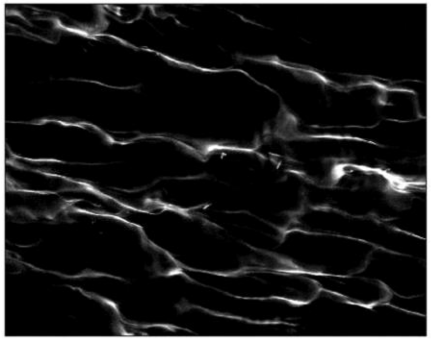

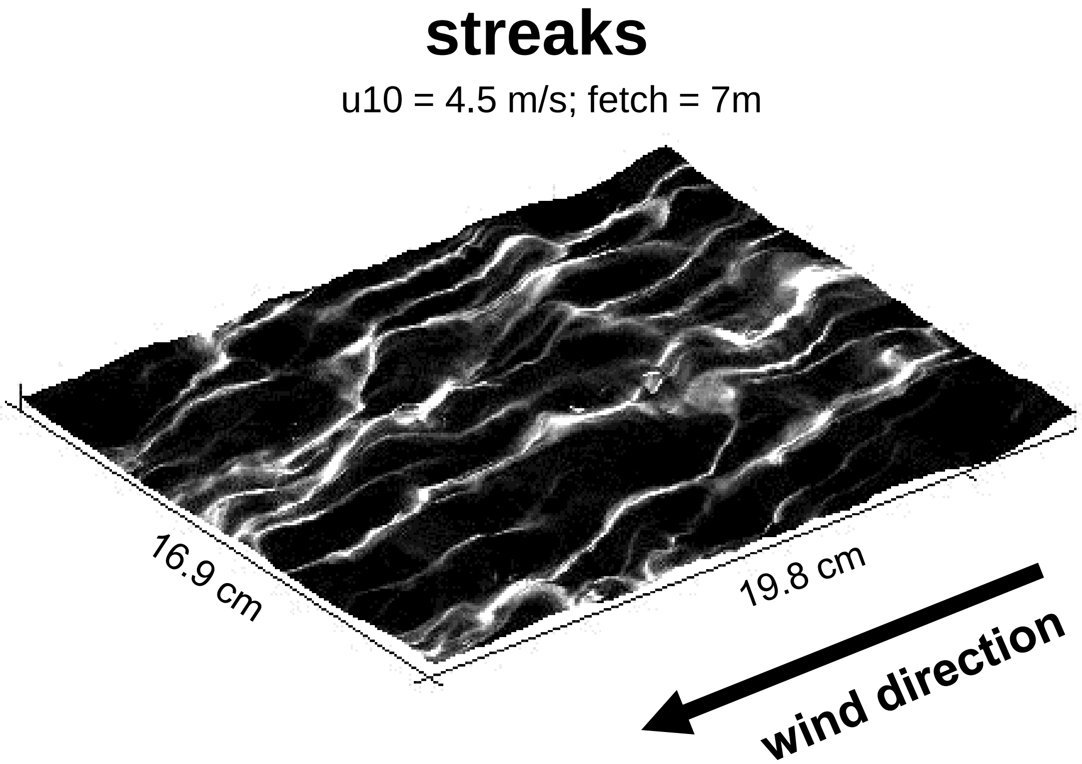

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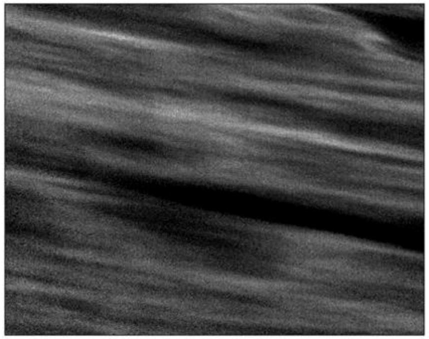
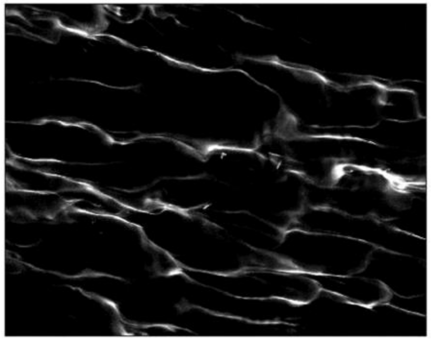
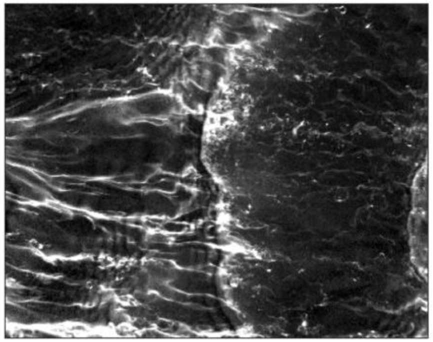
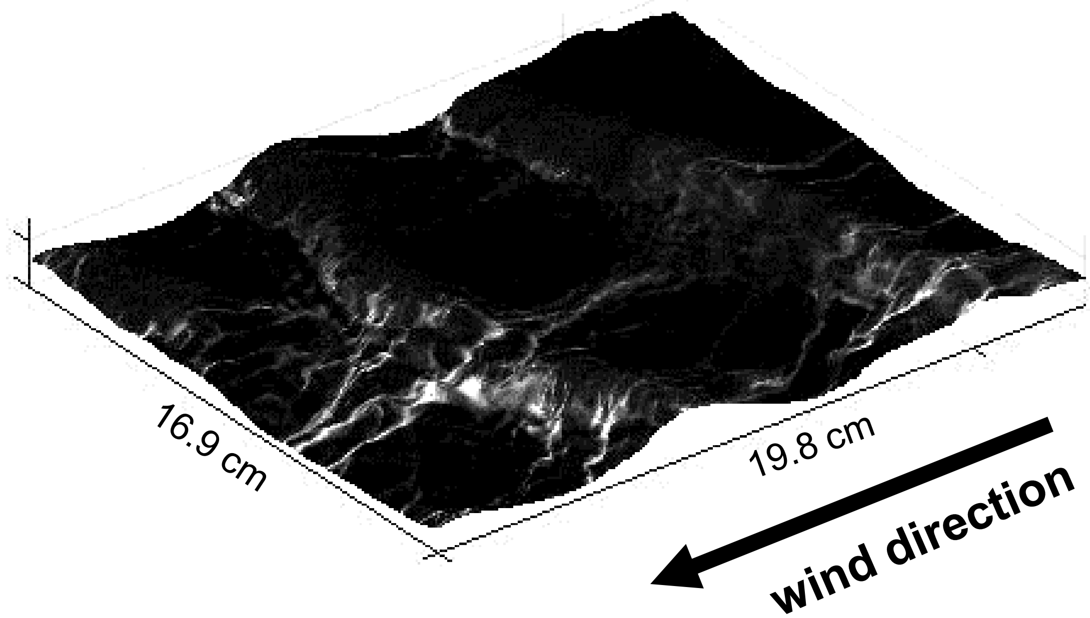






microscale breaking

u10 = 6.2 m/s; fetch = 12m



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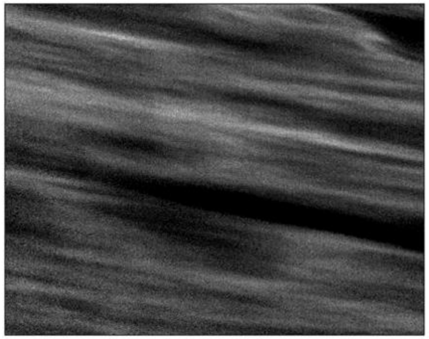
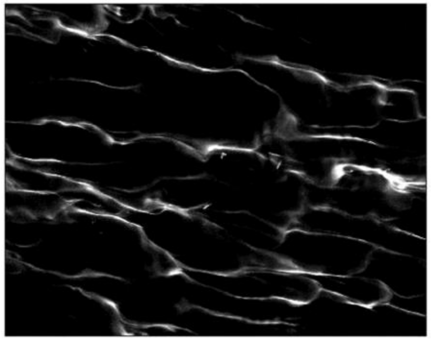
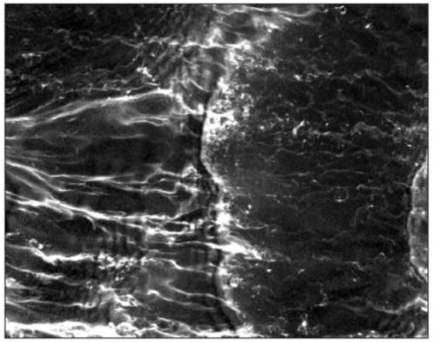


laminar flow



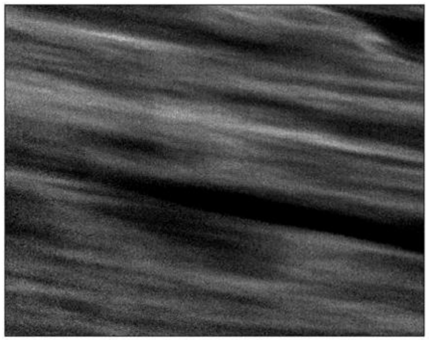
streaks



few microscale breaking

many microscale breaking

Development of the mass boundary layer with fetch at the Aeolotron



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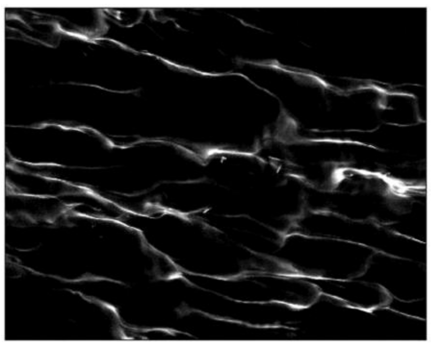

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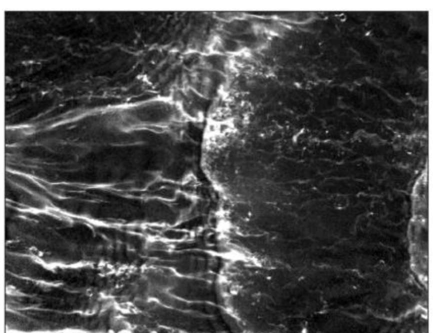
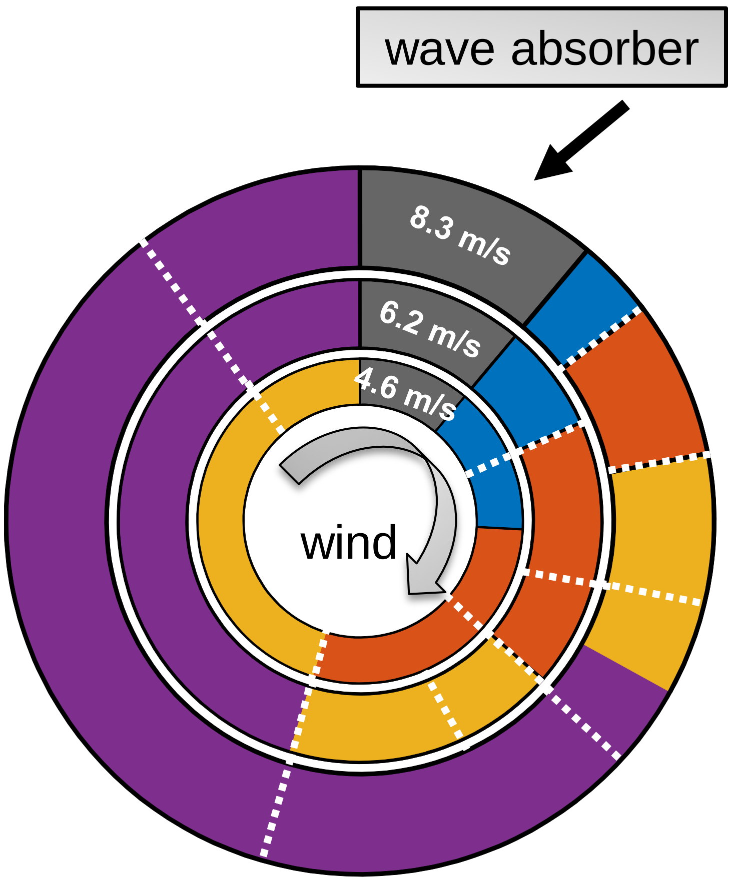


few microscale breaking

many microscale breaking

water surface of Aeolotron partly covered with a wave absorber



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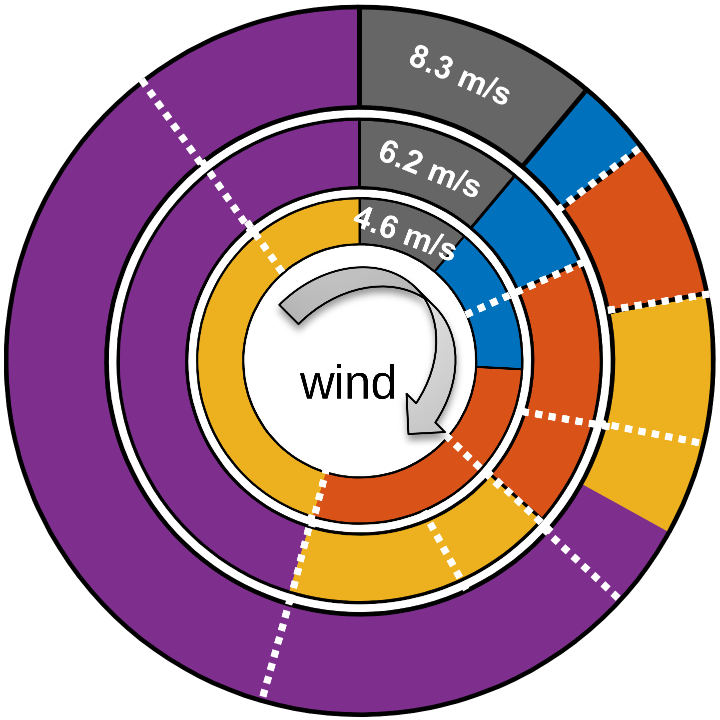
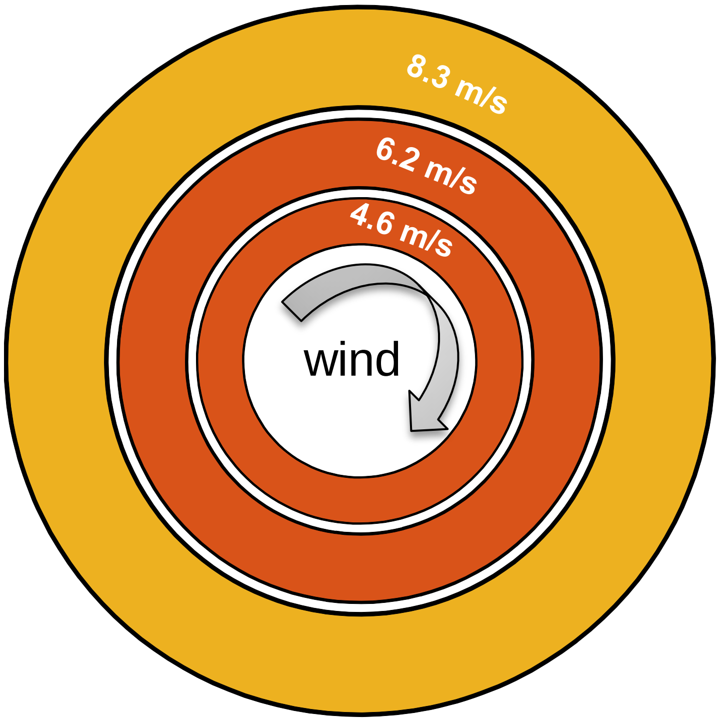




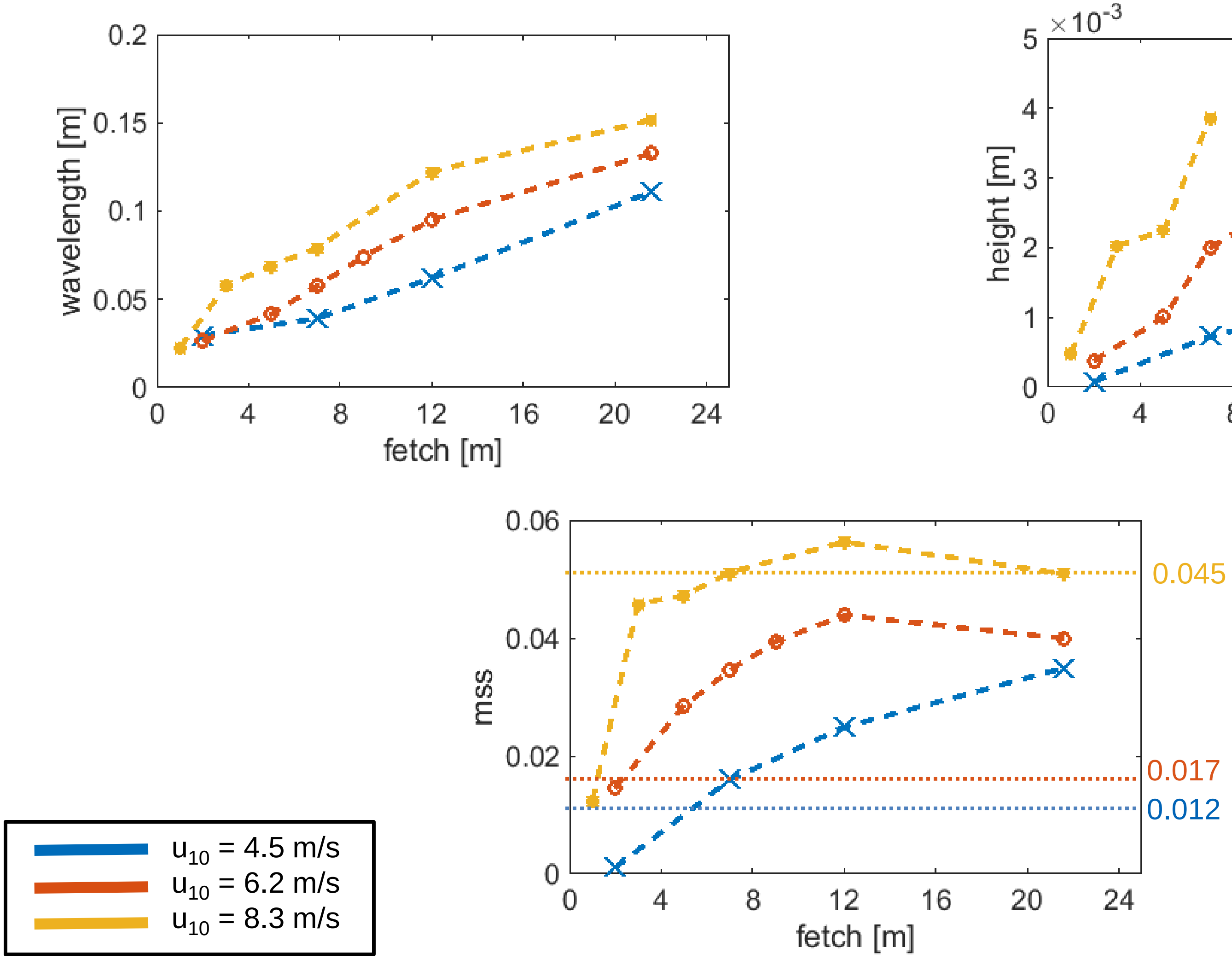
laminar flow

few microscale breaking

streaks

many microscale breaking

Boundary layer development with fetch – wavelengths and mean square slopes



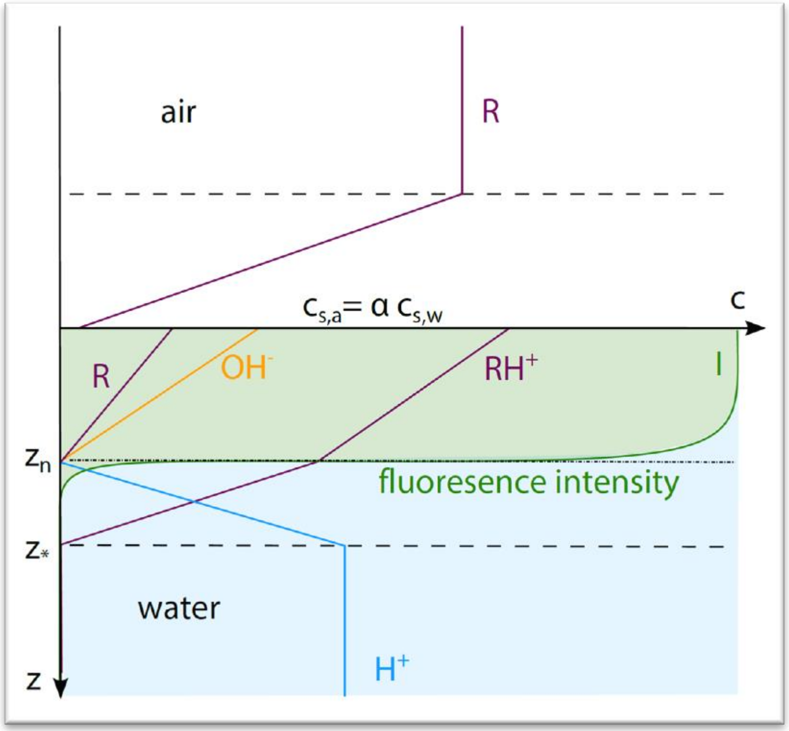
Conclusion

- Annular Aeolotron gives interesting insight into the fetch dependency of air-sea gas transfer, because with the basic same geometry, measurements at **short fetches (0 - 27 m) and infinite fetch** can be made.

- predominant wavelength with finite fetch leads to early onset of microscale breaking

- next steps:
  - ❖ direct determination of local gas transfer velocity from BLI
  - ❖ comparison with active thermography

Boundary Layer Imaging



Kräuter, 2015

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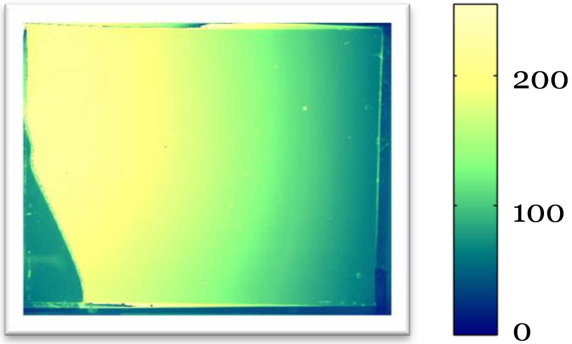

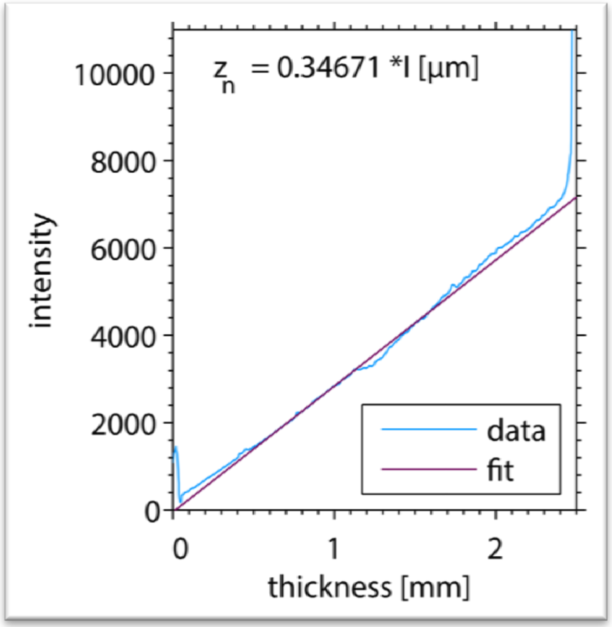

Kräuter., 2015

Fluorescence Intensity $\propto$ Thickness of Boundary Layer