Aeolus over water

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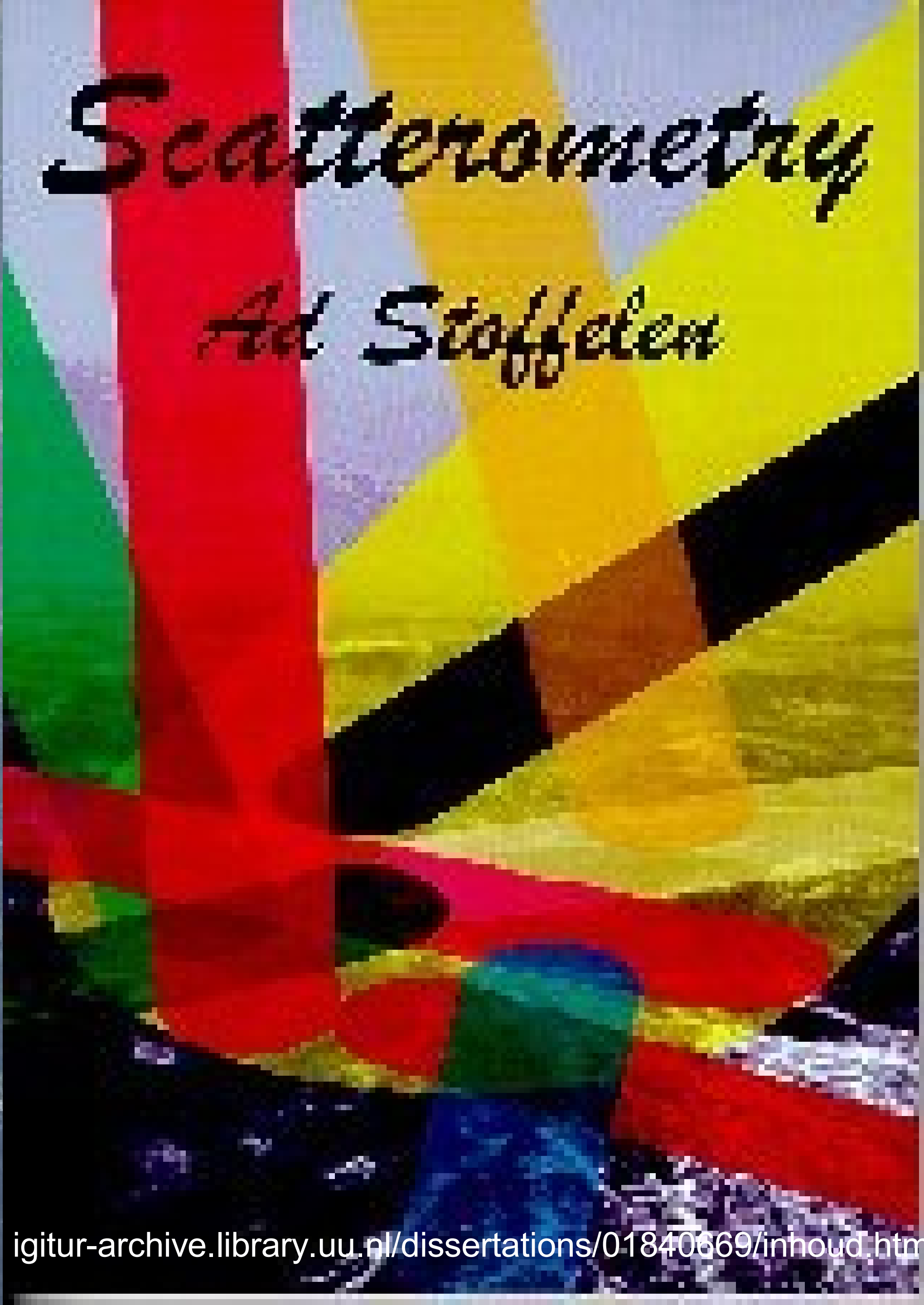
Overview

- Knowledge from microwaves
- Optical properties
- Summary of findings



igitur-archive.library.uu.nl/dissertations/01840669/inhoud.htm

Microwave scattering

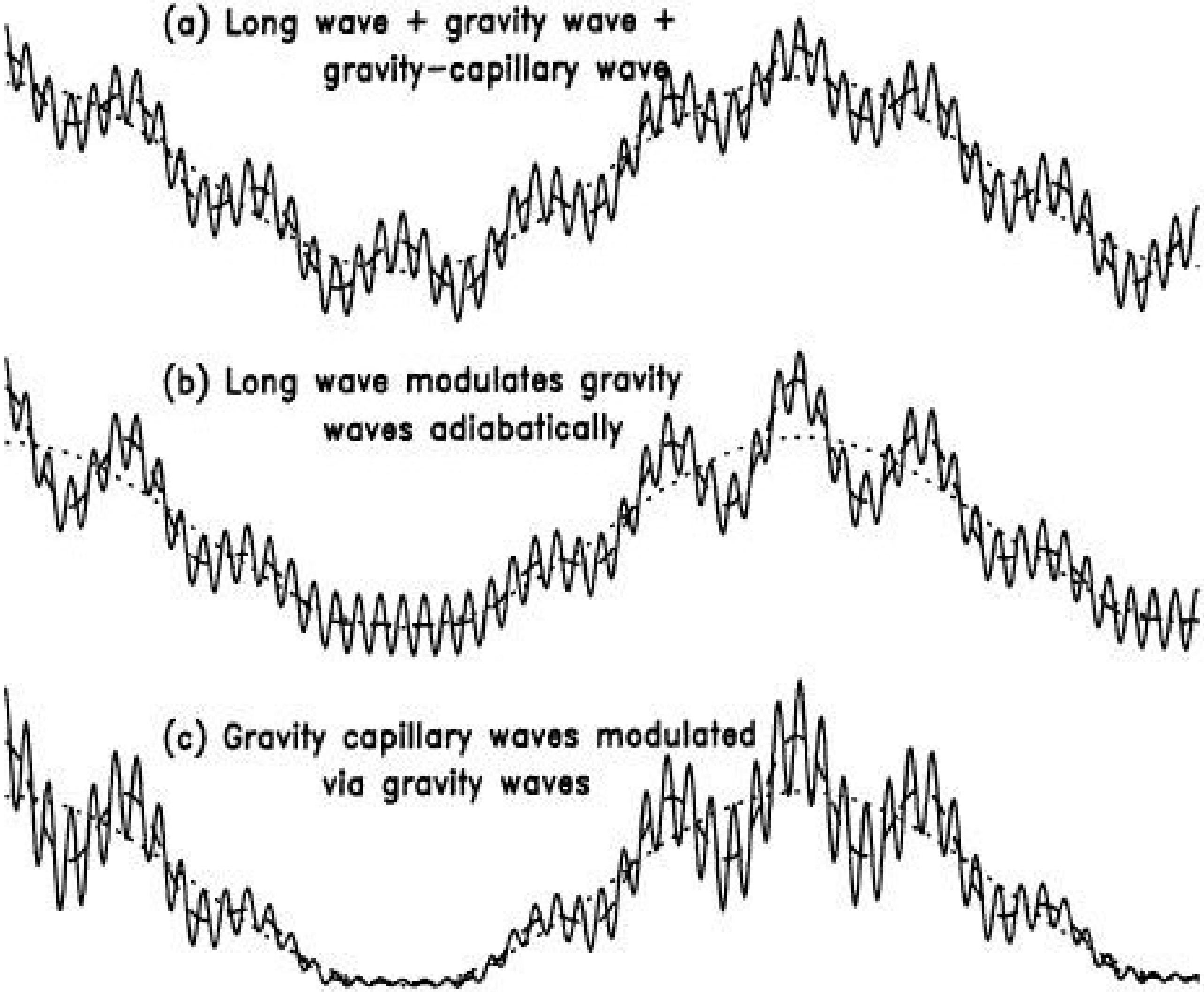
$$\sigma^0 = T(\theta)[E(2\boldsymbol{k}) + E(-2\boldsymbol{k})]$$

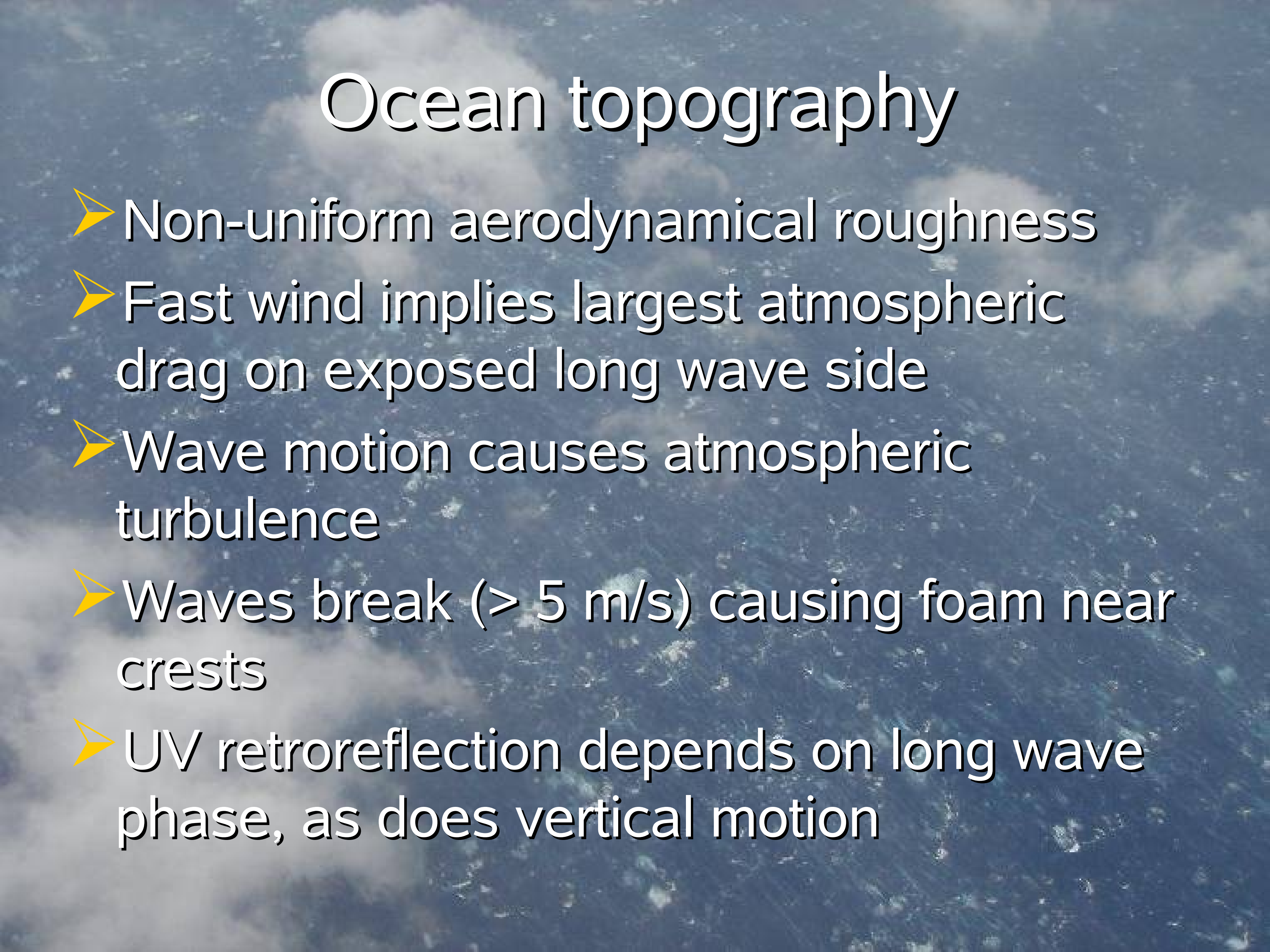
σ^0	normalized radar cross section
T	e.m. interaction transfer function
θ	incidence angle
E	spectral energy density
$\boldsymbol{k}$	wave number vector; $k = 2\pi/\lambda$ with λ wavelength (cm)

- Depends on gravity-capillary wave amplitude (E) and its tilt modulation (θ), known to be non-uniform over a wave (up-, cross-, downwind effect)
- UV Light will be specularly reflected (other T), but also greatly affected by (breaking) gravity-capillary waves

Ocean topography

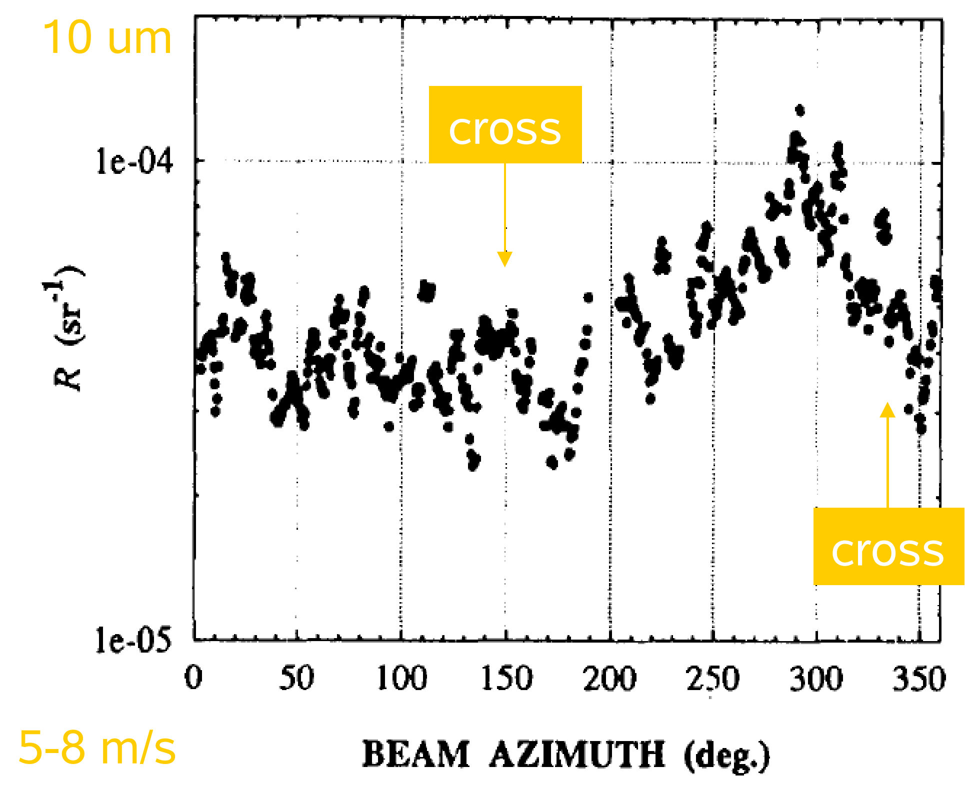
- Wavelengths over 5 orders of magnitude
- Long waves are fast, small waves slow
- Wind is fastest
- Wind input at small waves and breaking coupled to phase of large wave





Ocean topography

- Non-uniform aerodynamical roughness
- Fast wind implies largest atmospheric drag on exposed long wave side
- Wave motion causes atmospheric turbulence
- Waves break (> 5 m/s) causing foam near crests
- UV retroreflection depends on long wave phase, as does vertical motion



Optical

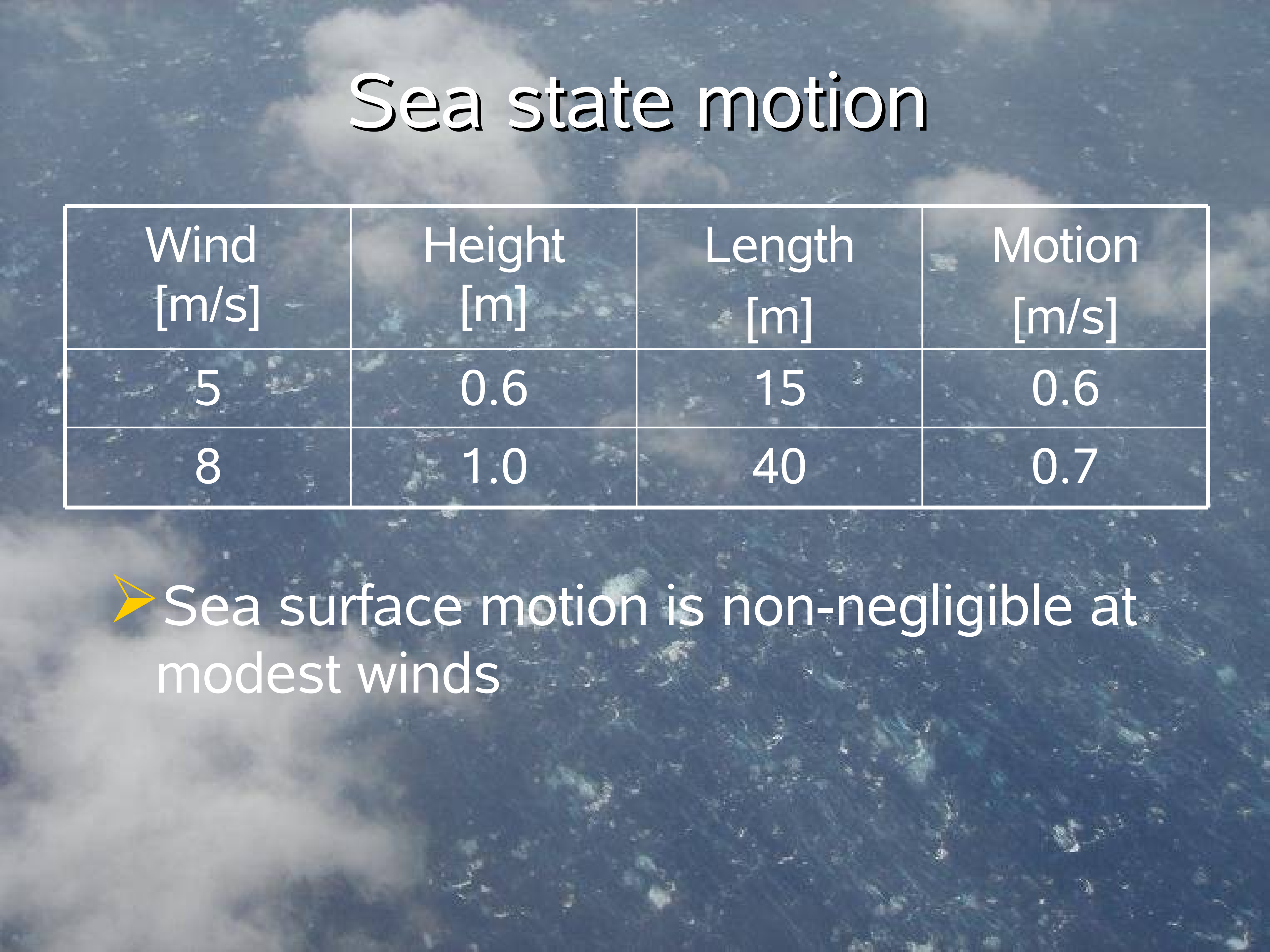
- Slope distributions differ for up-, cross-, and downwind
- Bubbles, foam (> 5 m/s)

C. Cox, ‘ Measurements of the Slopes of High Frequency Wind Waves’, J. Marine Res. 16, 199-225 (1 958).

David M. Tratt and Robert T. Menzies, Dean R. Cutten, Wind-Driven Angular Dependence of Sea-Surface Reflectance Measured with an Airborne Doppler Lidar

R. T. Menzies, D. M. Tratt, and W. H. Hunt: Lidar In-space Technology Experiment measurements of sea surface directional reflectance and the link to surface wind speed. *Appl. Opt.*, **37**(24), 1998, 5550-5559

D. M. Tratt, R. T. Menzies, M. P. Chiao, D. R. Cutten, J. Rothermel, R. M. Hardesty, J. N. Howell, and S. L. Durden: Airborne Doppler lidar investigation of the wind-modulated sea-surface angular retroreflectance signature. *Appl. Opt.*, **41**(33), 2002, 6941-6949



Sea state motion

Wind [m/s]	Height [m]	Length [m]	Motion [m/s]
5	0.6	15	0.6
8	1.0	40	0.7

- Sea surface motion is non-negligible at modest winds

Simple wave example

Height: $h = H \cos \omega t$; $\langle h \rangle = 0$

Motion: $w = - W \sin \omega t$; $\langle w \rangle = 0$

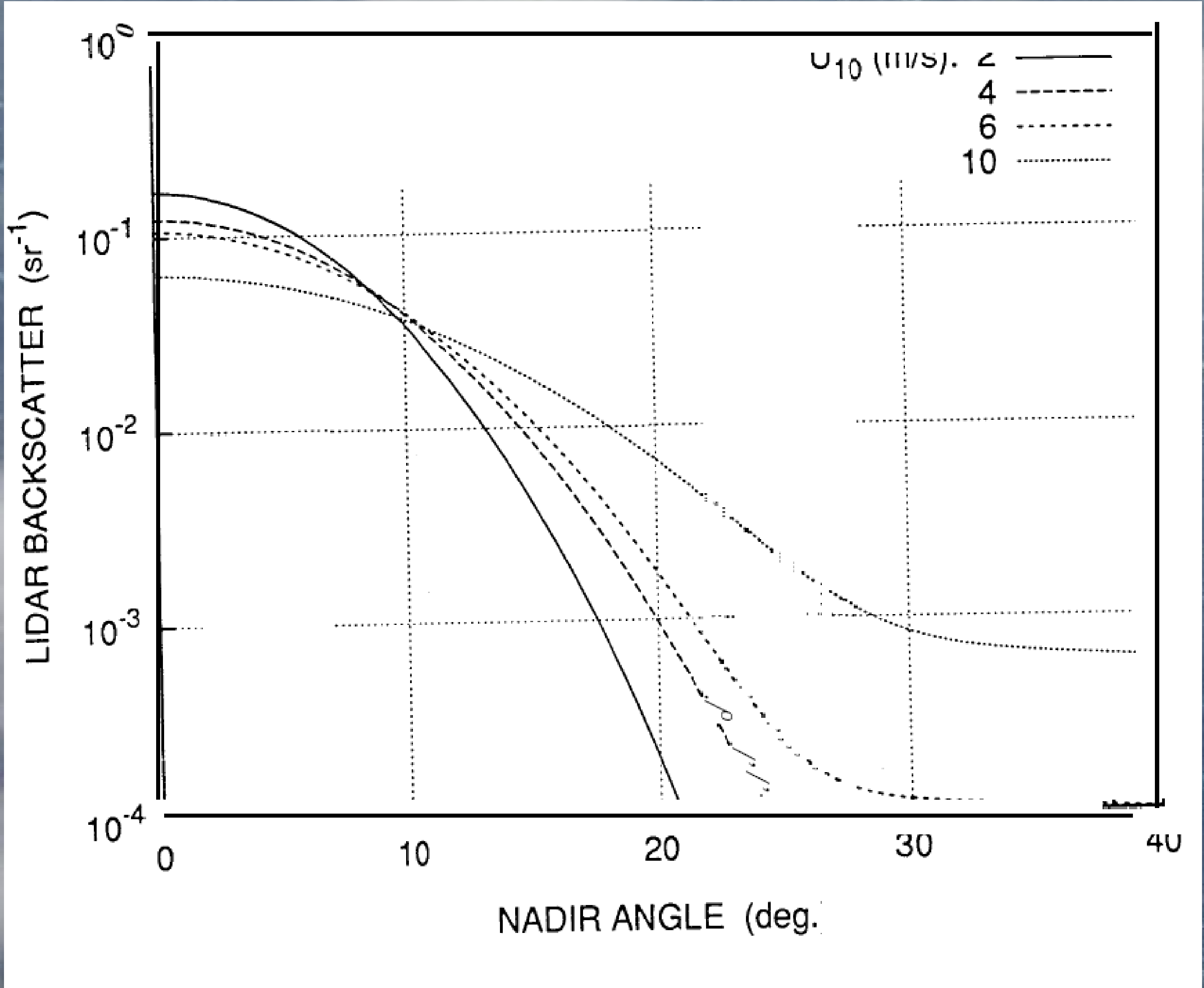
Signal: $\beta = B - \delta \cos (\omega t + \alpha)$; $\langle \beta \rangle = B$

δ : signal modulation

α : phase shift signal and motion

Effective motion $w * \beta$: $- W \delta \sin \alpha / 2B$

LITE speed dependence



- Weak at nadir
- low β at 37deg. for low speeds

R. T. Menzies, D. M. Tratt, and W. H. Hunt, *Appl. Opt.* **37** (24), 1998, 5550-5559

Summary

- The sea surface moves a lot and interacts with air
- Water backscatter depends on slope distributions that depend on long wave phase due to varying capillary-gravity wave amplitudes
- Above 5 m/s breaking occurs (bubbles, foam)
- Waves and wind often move in different directions, further complicating air-sea interaction (3D)
- At 37 degrees the surface motion spectrum is yet more complicated than at nadir due to larger foam contributions, crest-valley flow and β variability and wave currents
- Aeolus water calibration opportunities appear rare