



# Ocean Calibration: subsurface scattering

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## Previous results

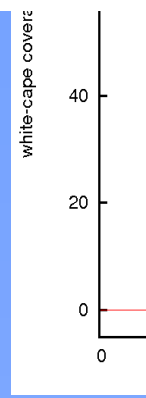
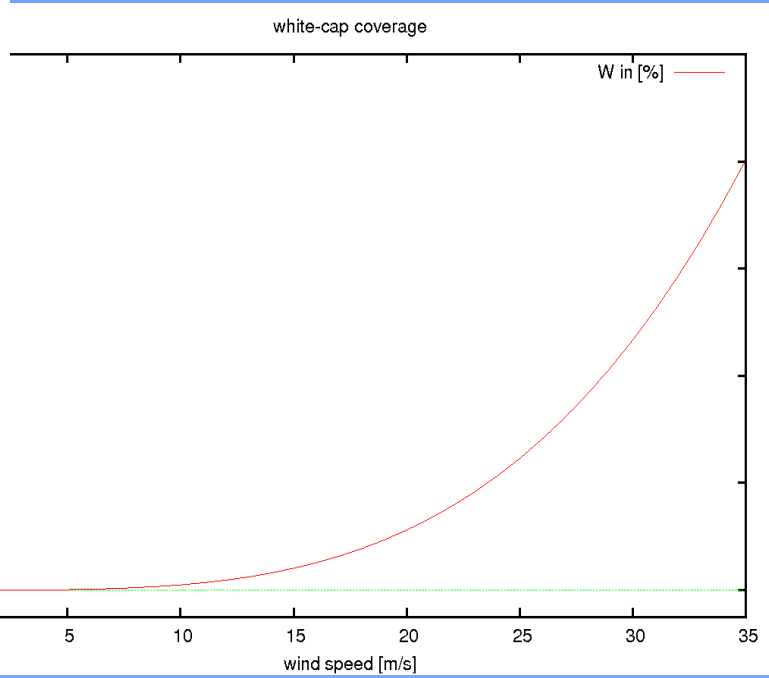
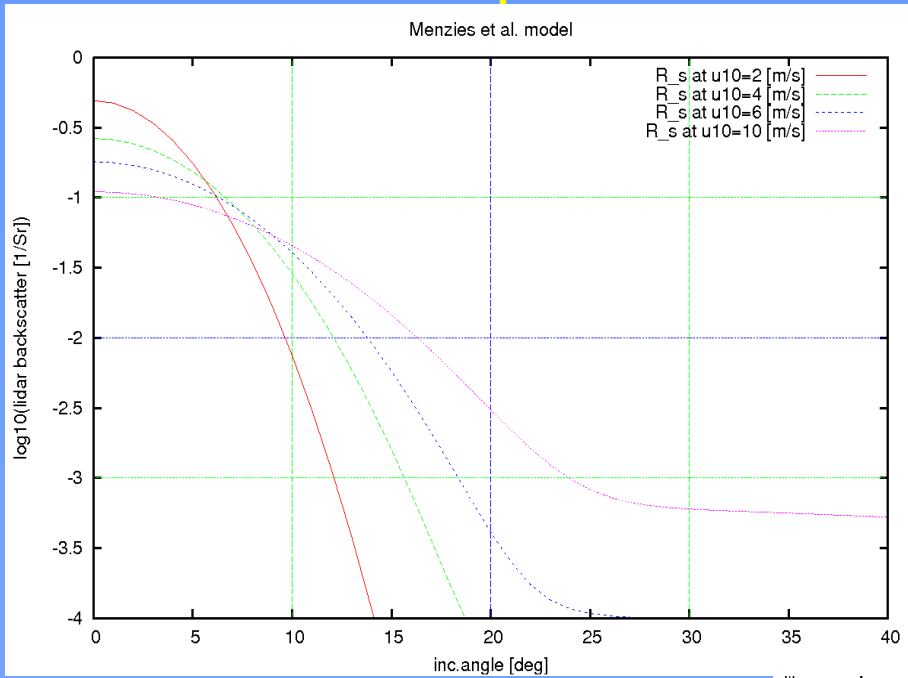
- ocean surface scattering may show Doppler effect due to net water movement along LOS
- method:
  - take a simple wave-shape model (depends on windspeed)
  - combine with reflectivity estimates (also depends on windspeed)
  - see what happens for different wind speeds



## Different scattering processes

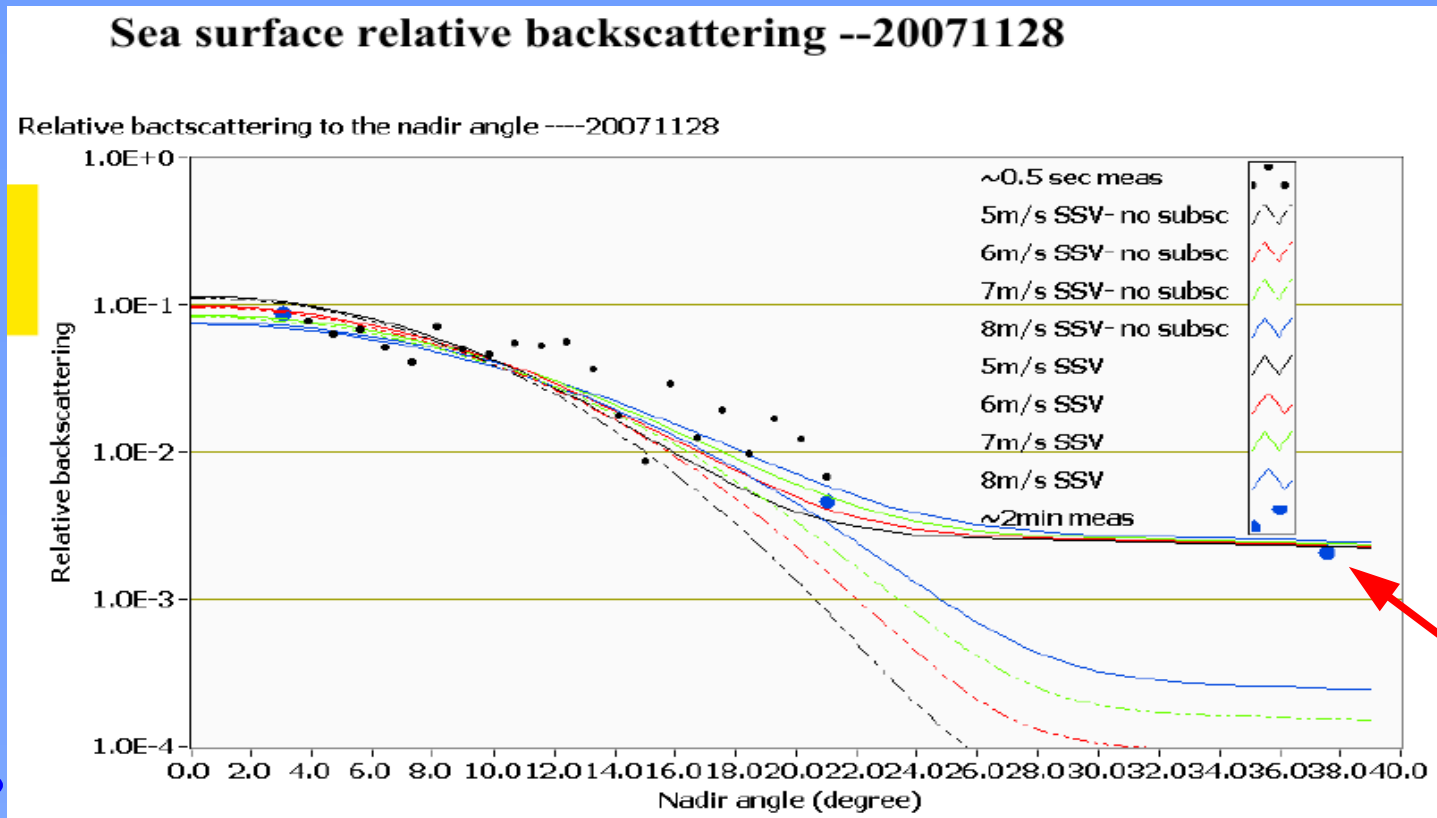
- specular reflection on smooth surface facets
  - for off-nadir this typically gives LOS velocities of **2.5 m/s**
  - for nadir reflection LOS velocity is very close to **zero**
- Lambertian reflection on white-caps
  - for nadir reflection LOS velocity again is very close to **zero**
  - for off-nadir reflection:
    - uniform white-cap distribution gives small LOS velocities, typically below **1 cm/s**
    - non-uniform white-cap distribution gives noticeable LOS velocities of upto **0.25 m/s** for winds of 25 m/s
- sub-surface reflection was ignored

# Relative importance



# Sub-surface reflections?

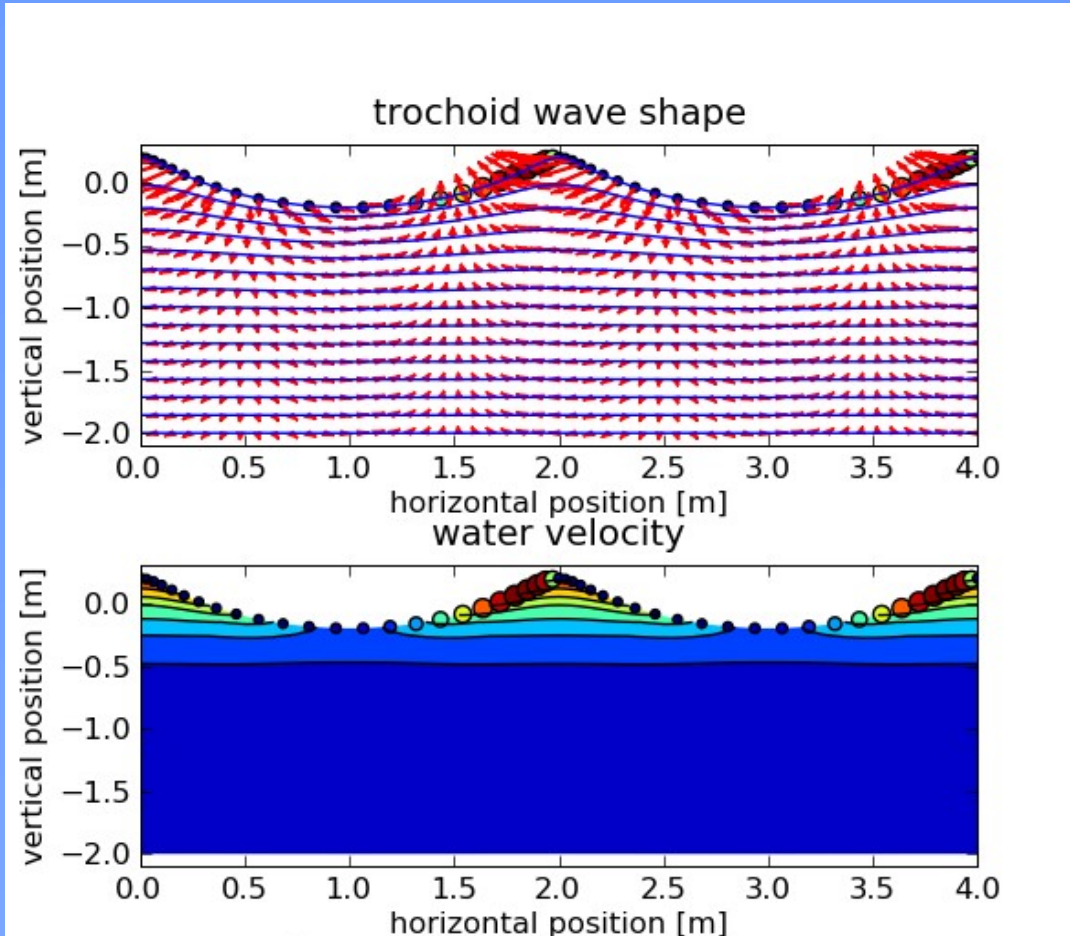
- A2D results from Zhigang Li (PM<sub>10</sub>):



## Estimate what would be the effect

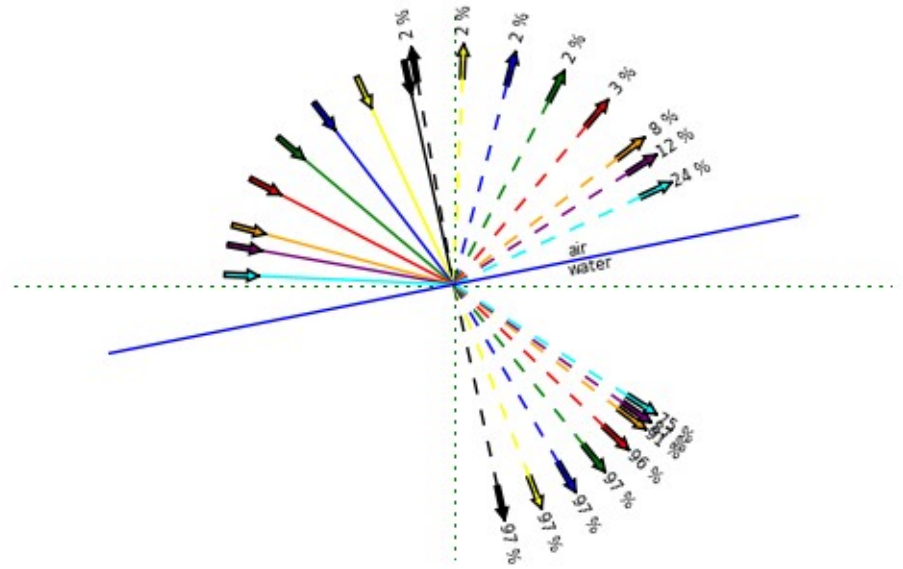
- again calculate a wave shape, but now also calculate water movement below the surface
- or alternatively use a collection of water surface facets defined by the distribution originally proposed by Cox and Munk
- calculate for each facet the transmission (2-way)
- ignore multiple scattering for now
- first simple case: take water velocity identical at all depths (equivalent to assuming that scattering takes place just below the surface)

# Wave shape and water movement

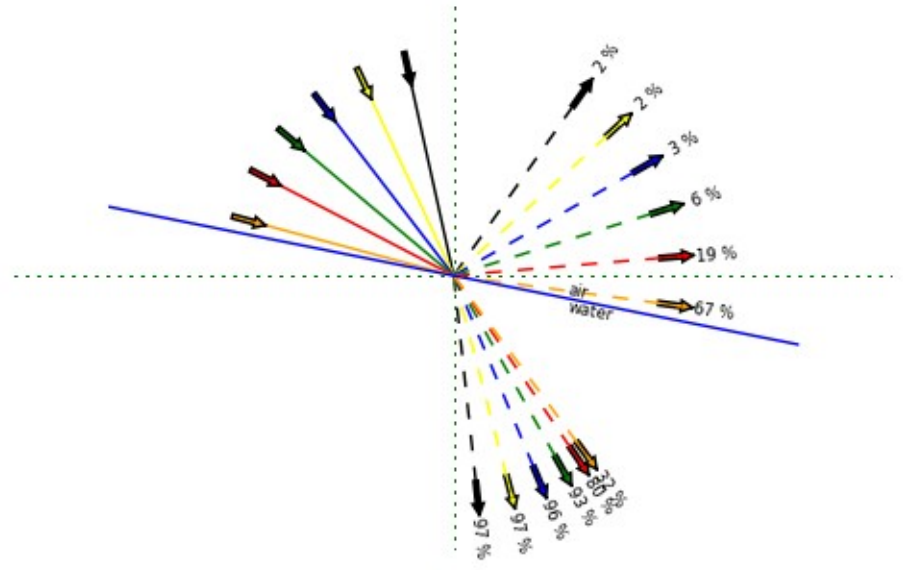


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Reflection  
and  
refraction  
reflection  
increases and  
transmission  
decreases for  
shallow  
incidence  
angles  
••••

Reflection and refraction on an air-water surface

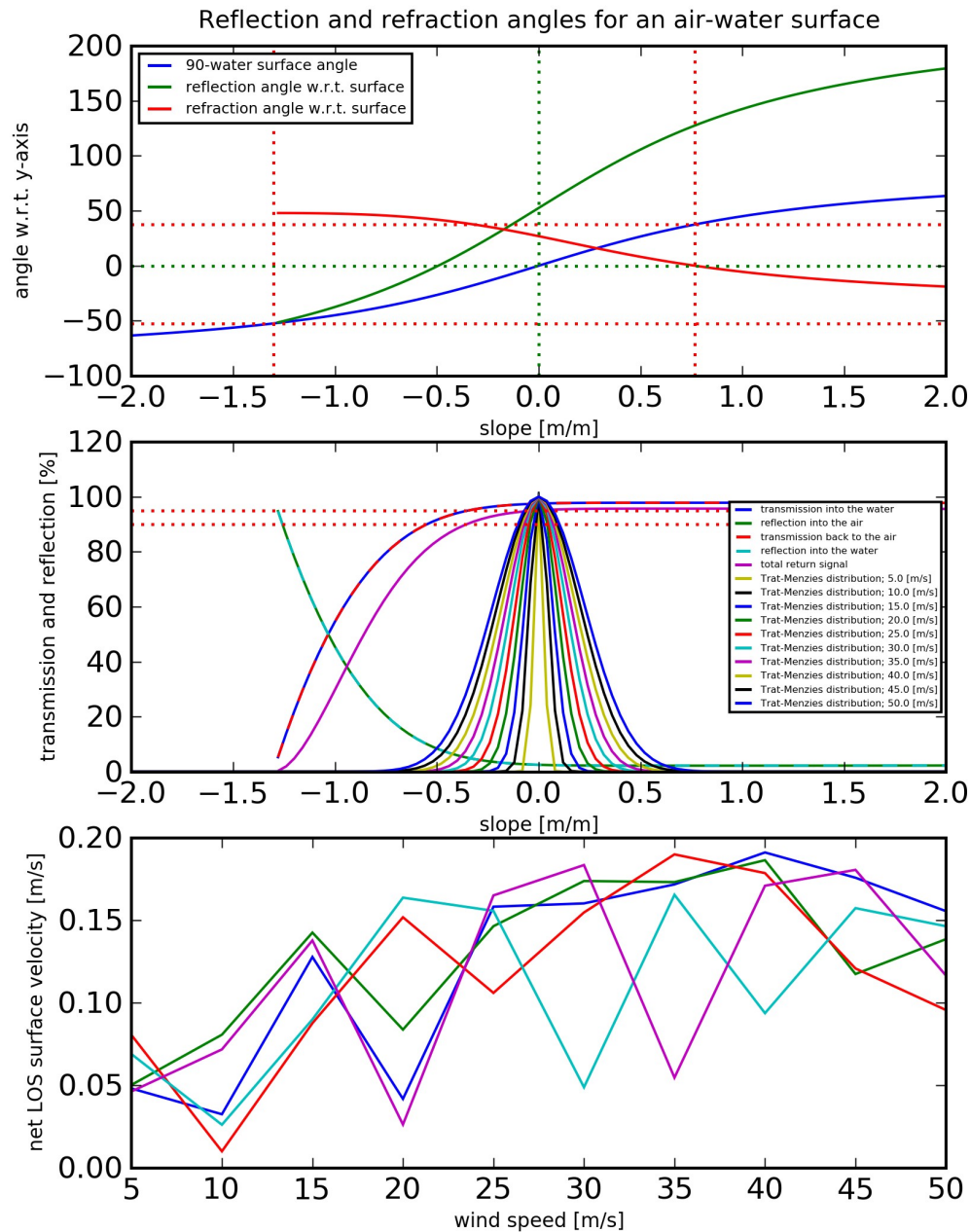


Reflection and refraction on an air-water surface



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**Com-  
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 effect**

Combining  
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 and trans-  
 mission  
 gives:  
 0.1 to  
 0.2 m/s



## Conclusion

- very simple estimate of sub-surface reflection gives LOS effect of 0.1 to 0.2 m/s
- this is probably overestimated because wave motion decays when going to deeper water
- typical absorption for pure water is 1 to 4 % per m (extrapolated estimates), so UV light will penetrate several 10's of meters, however exact numbers for 355 nm are hard to find.

## Conclusion

- Main question that remains: How important is subsurface scattering compared to whitecaps and specular reflection for different local windspeeds?
- if it is dominant over whitecaps at lower windspeeds, than ocean surface calibration still may be a valid option
- selection of data to only take low windspeeds into account may be possible
- when looking at subsurface scattering: what will be the importance of ocean currents?
- more actual data is needed to study this



# The end

- questions ?





# Spare

pure  
water  
proper-  
ties



### Properties for pure water

