Incidence Angle Dependence of EM Bias

Karl F. Warnick, Floyd W. Millet and David V. Arnold
Department of Electrical and Computer Engineering
Brigham Young University

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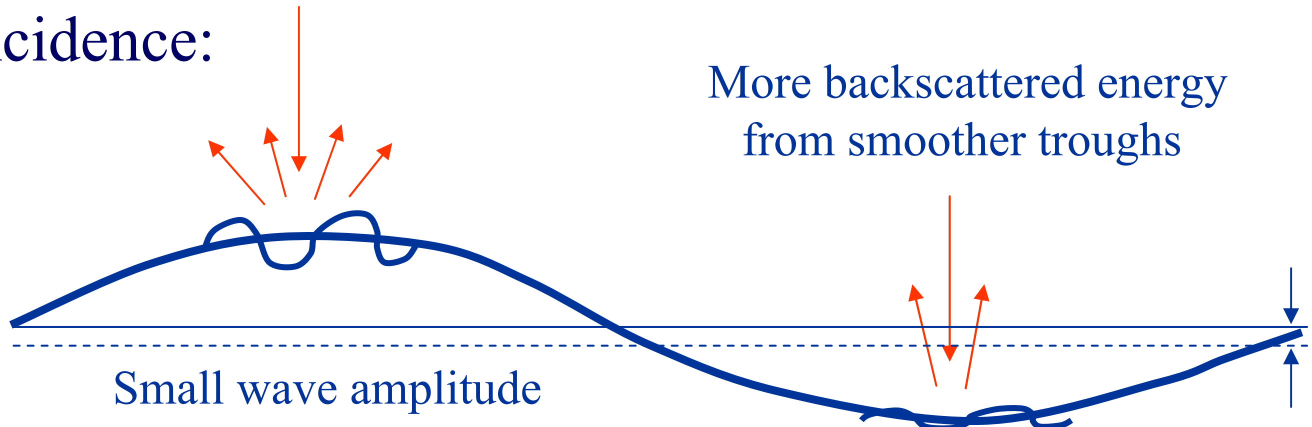
Hydrodynamic modulation

Nadir incidence:

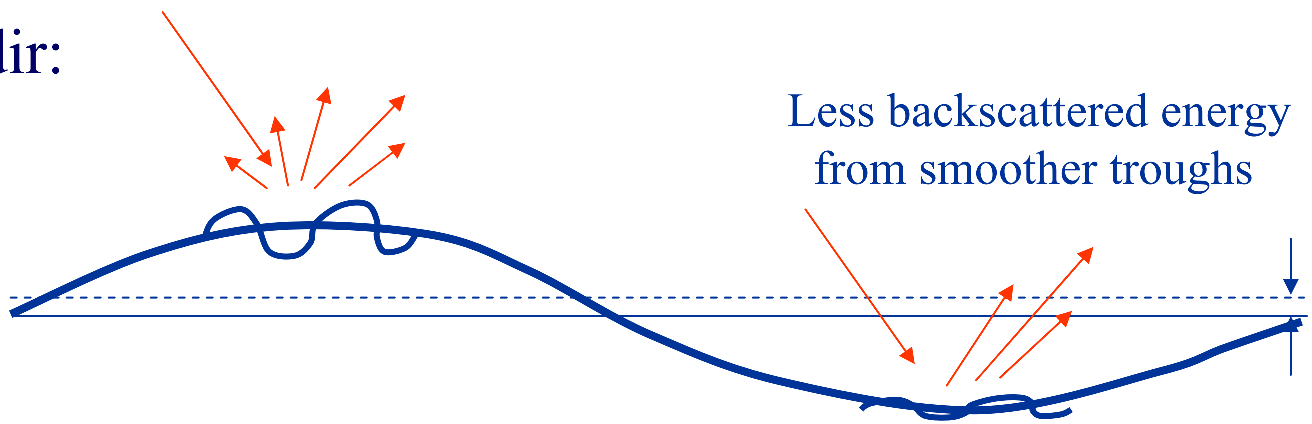


More backscattered energy
from smoother troughs

Small wave amplitude
larger on crests than troughs

Negative EM bias

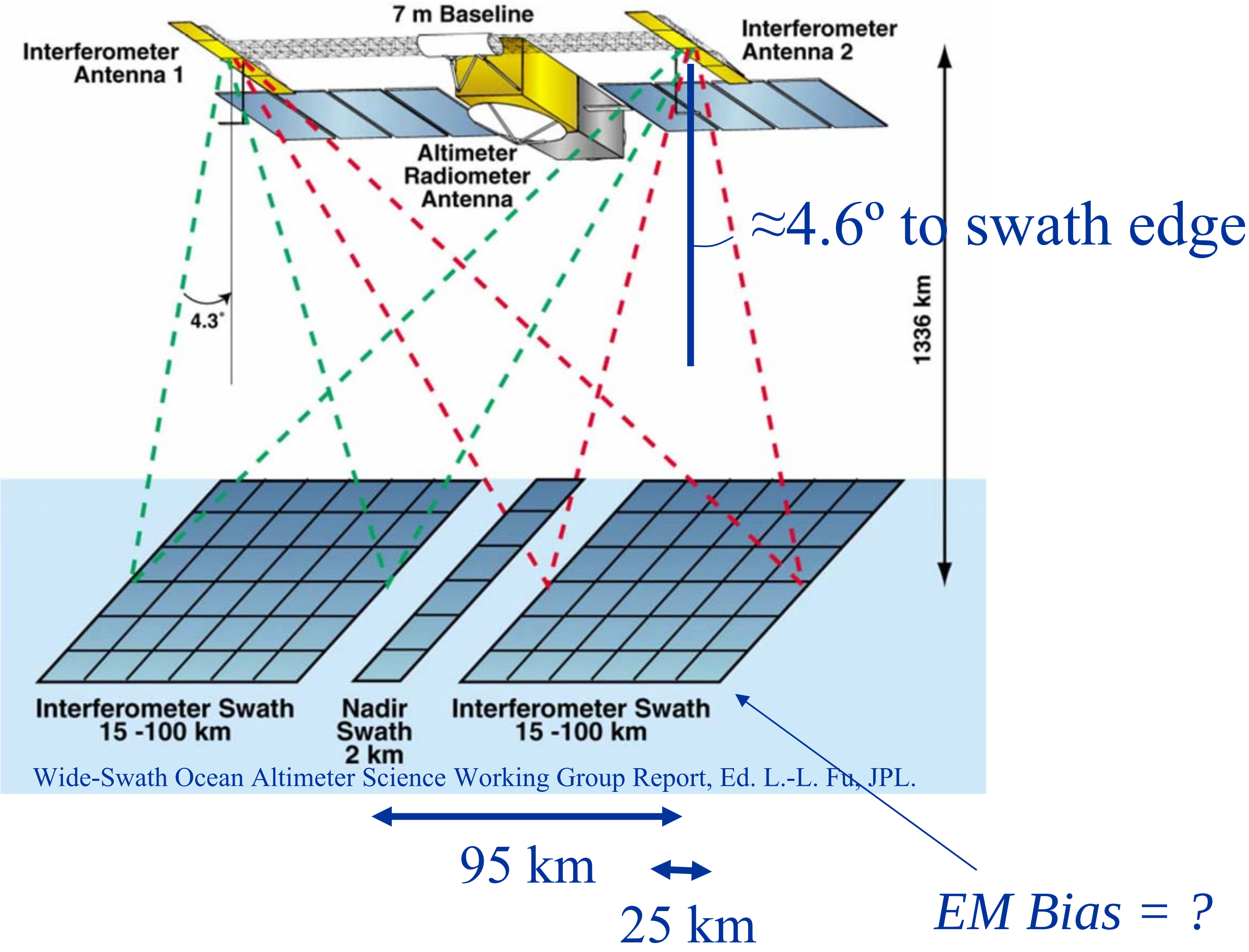
Off-nadir:



Less backscattered energy
from smoother troughs

Smaller or even
positive EM bias

Wide-swath altimeter



Wide-Swath Ocean Altimeter Science Working Group Report, Ed. L.-L. Fu, JPL.

Theoretical model

Simple hydrodynamic model [Melville and Felizardo, 1999]:

$$h_s(\eta) = h_s(0)\left[1 + S\eta / h_l\right]$$

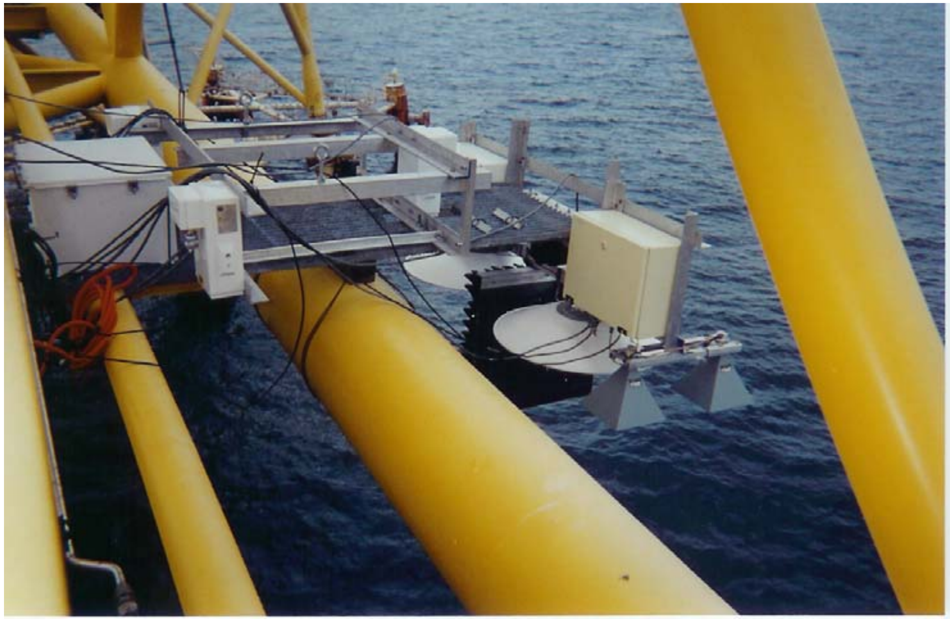
where S is RMS long wave slope, h_s is small wave surface height standard deviation, and η is displacement from mean sea level.

Physical optics scattering from tilted/modulated surface facets

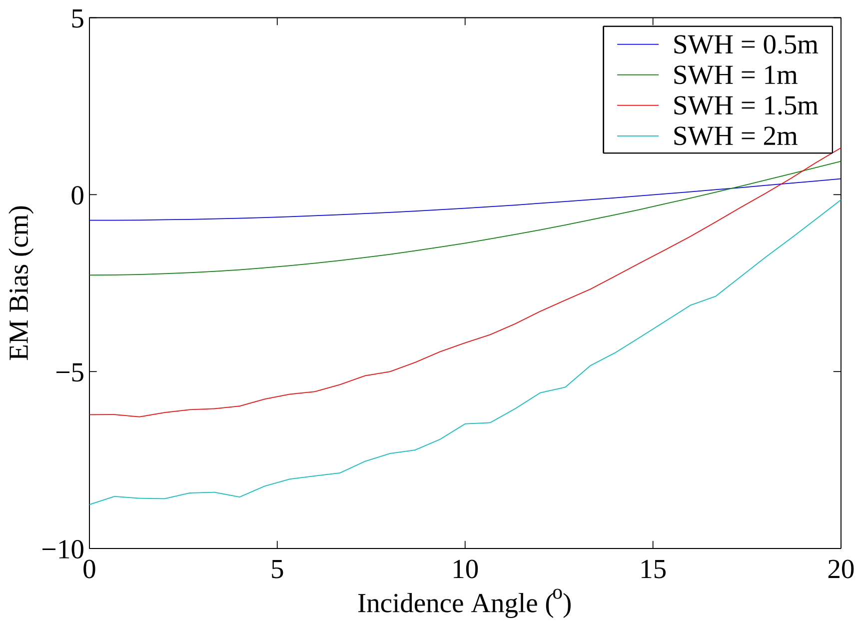
$$\mathrm{Bias}(\theta) = \frac{E[\eta\sigma_0(\theta)]}{E[\sigma_0(\theta)]}$$

Tower experiment

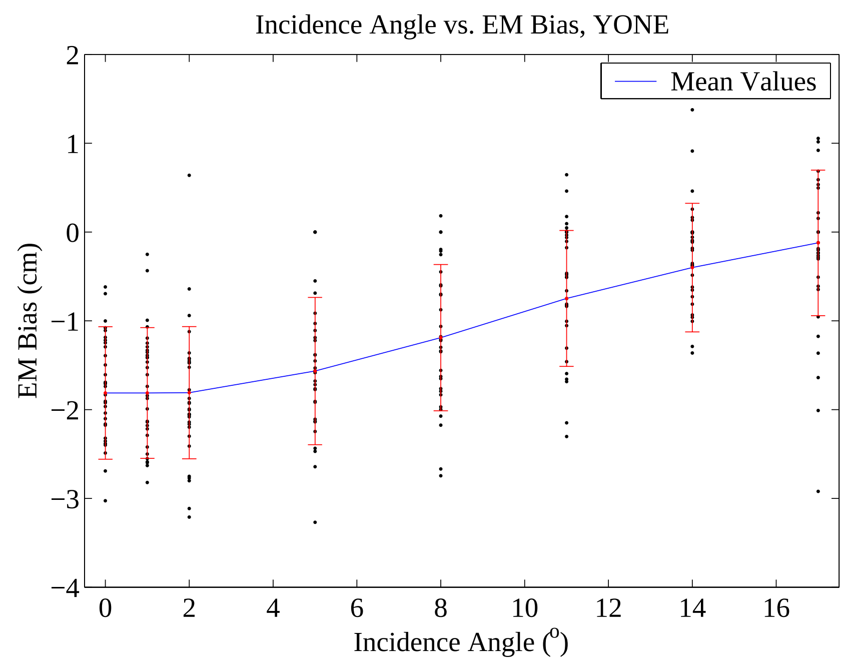
BYU Off-Nadir Experiment (Y-ONE)
March-April 2003
Gulf of Mexico, Shell Offshore platform
C, Ku band Doppler radars, laser rangefinder
Environmental data including wind, temp
Incidence angles: -3º to 17º, 5 minutes/angle



Results



Predicted bias



Experimental measurements

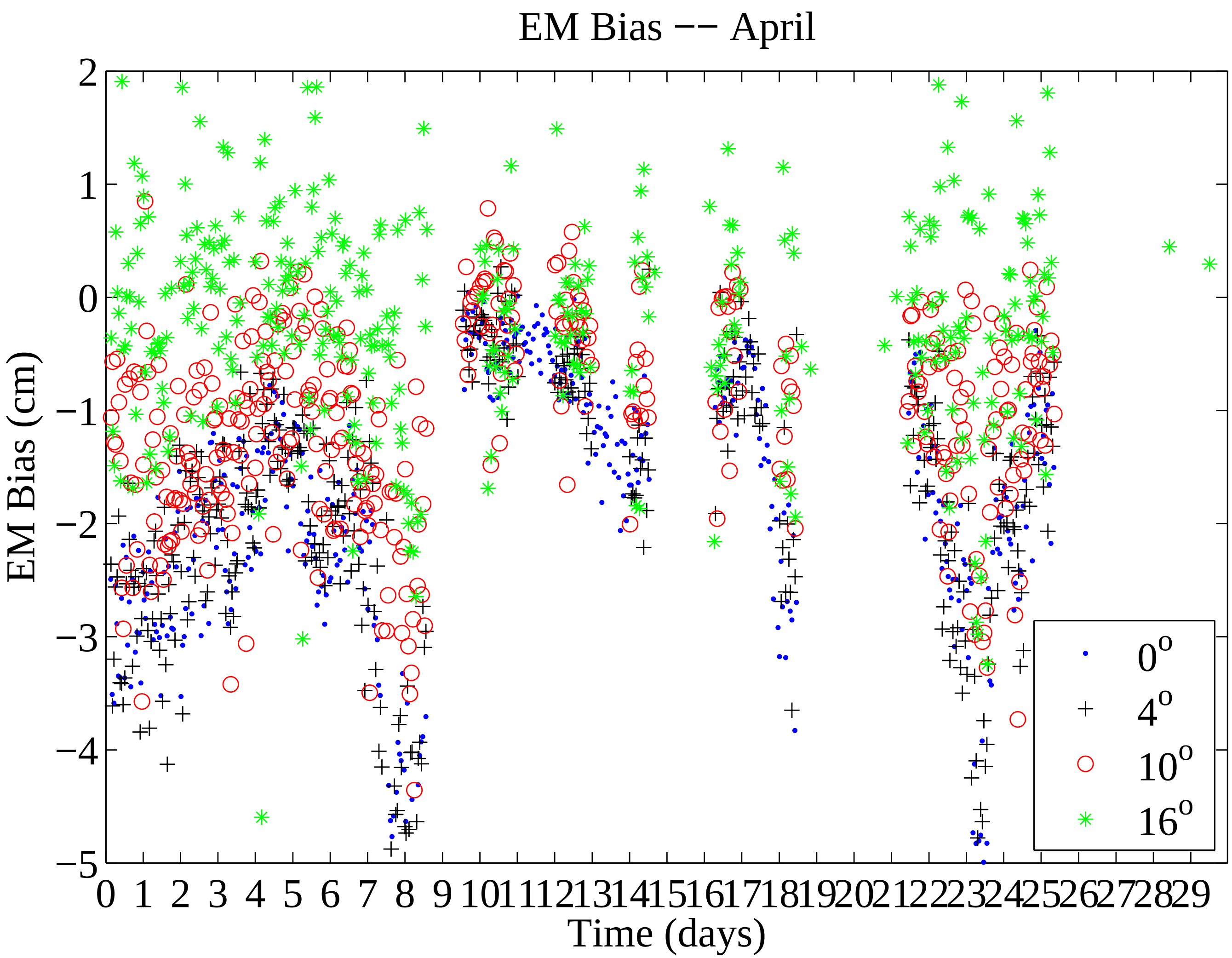
Error bars are ± one sigma

Mean significant wave height:

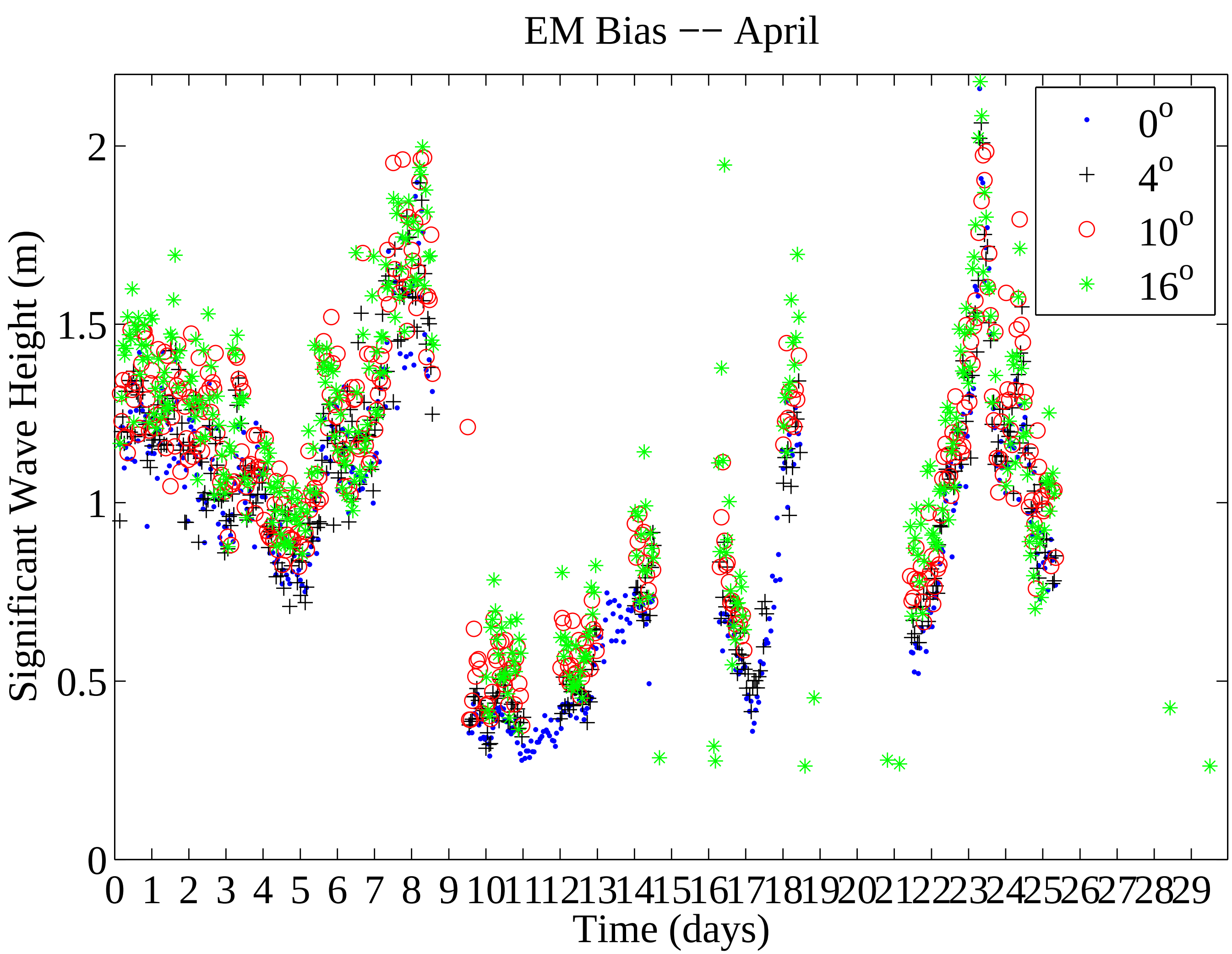
SWH = 0.9m

(results are preliminary)

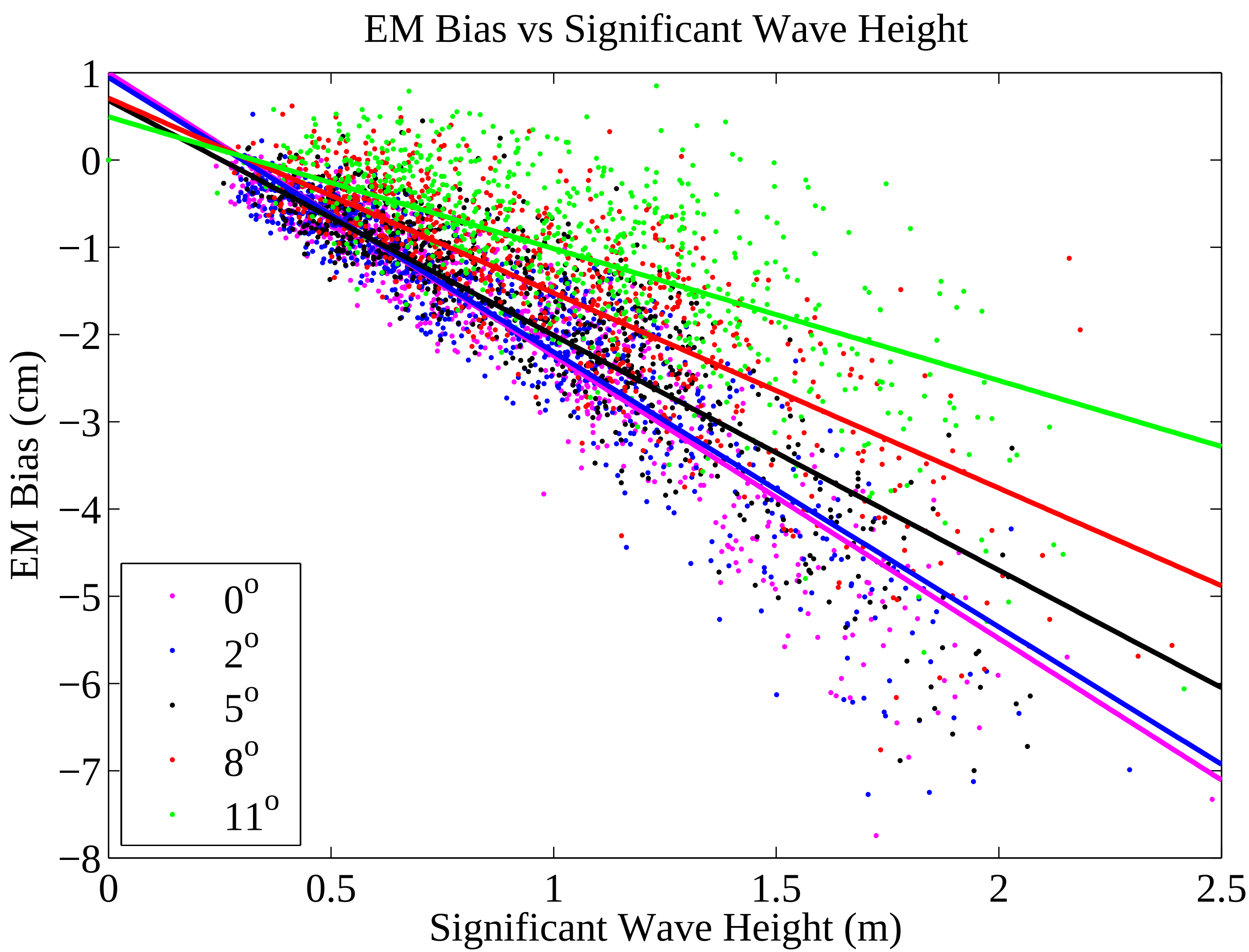
Time series – EM bias



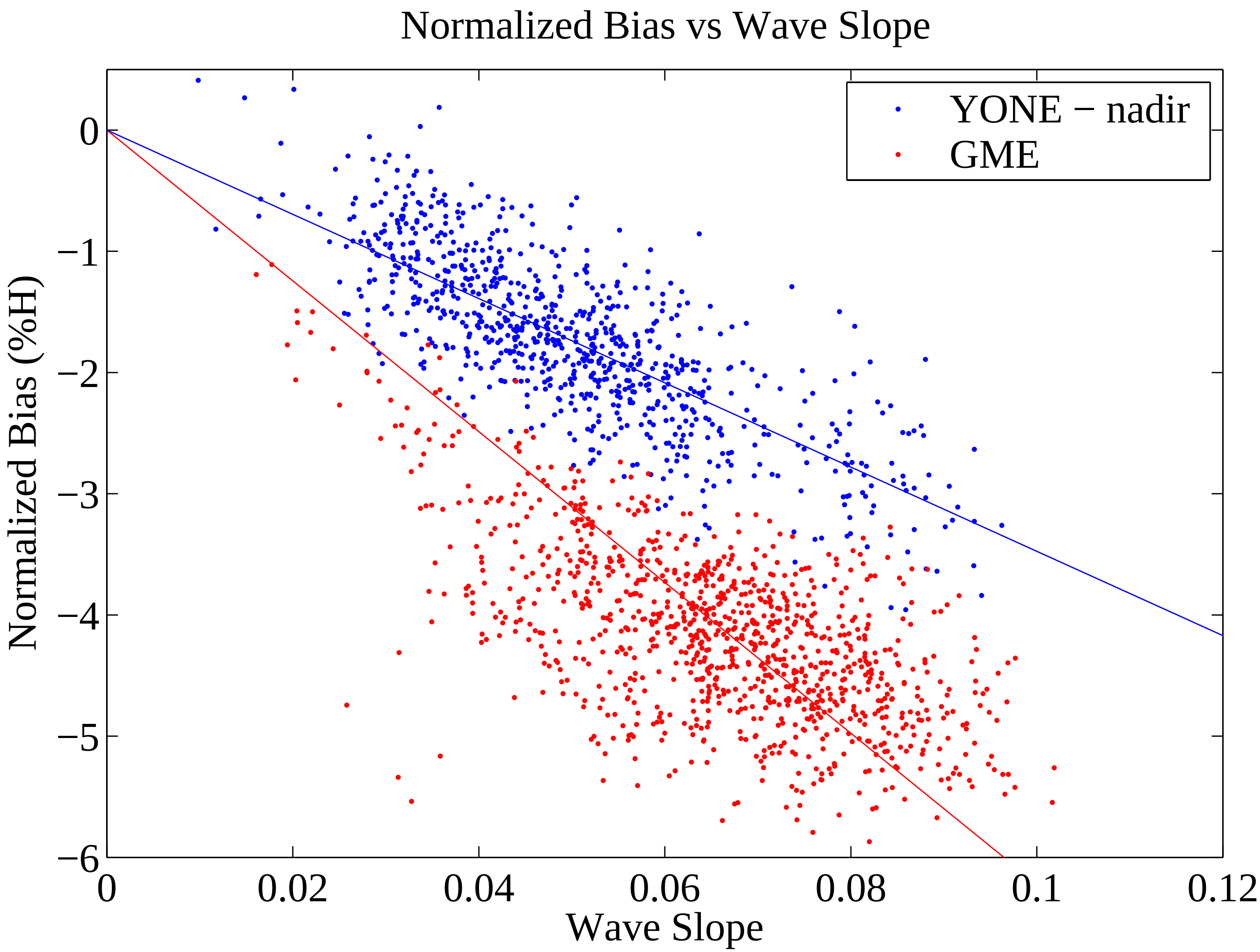
Time series - SWH



Bias vs. significant wave height



Relative bias vs. RMS slope



Summary/Conclusions

- Experimental measurements and theoretical analysis predict decrease in EM bias as incidence angle increases
- Mean EM bias may change sign at mid-range incidence angles
- Wide-swath instruments may require incidence-angle dependent correction
- Multiple looks at a given surface footprint at different incidence angles may be used to improve bias correction