Application of an Airborne System for Observing Ocean Surface Waves over a Wide Range of Scales

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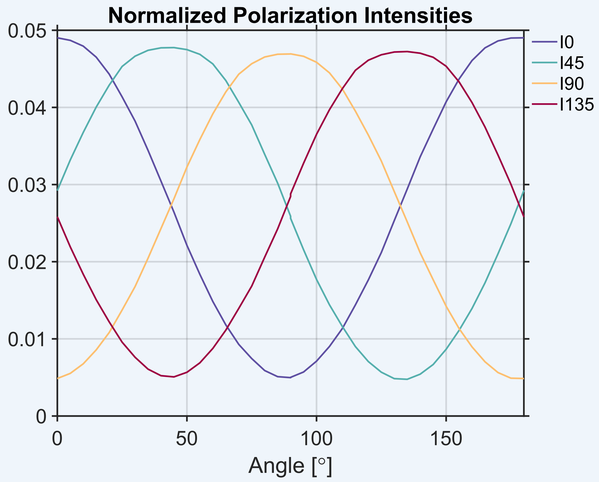
Background

High-resolution spatial and temporal characteristics of ocean surface waves are important for describing the dynamics of air-sea fluxes. Widely used wave measurement techniques (including wave staffs, LiDAR, and radar) do not fully resolve small-scale waves which are affecting the large-scale motions. We aim to:

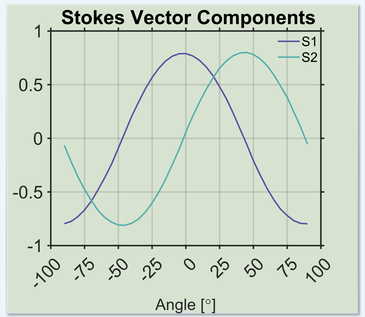
- Establish new observational techniques for resolving waves ranging from surface gravity to gravity capillary waves.
- Better describe the ocean surface response to varying wind forces.
- Parametrize air-sea momentum exchange, considering the role of ocean surface wave.

Methods and Calibration

The sea surface slope fields are obtained by polarimetric slope sensing (PSS) technique. Surface looking camera sensor has 4 subdivisions each of which is receptive to intensities of polarized light at different angles (0° 45° 90° 135°).

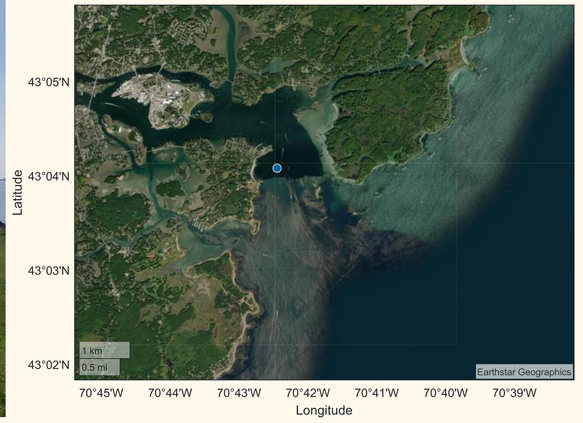


- With a uniform light scattering source, the sensor is verified to transmit only at orthogonal polarizations.
- Linear Stokes vector components (S1, S2) are calculated. A gain factor is estimated to account for the amplitude variations at specified angles.



Observational Setup

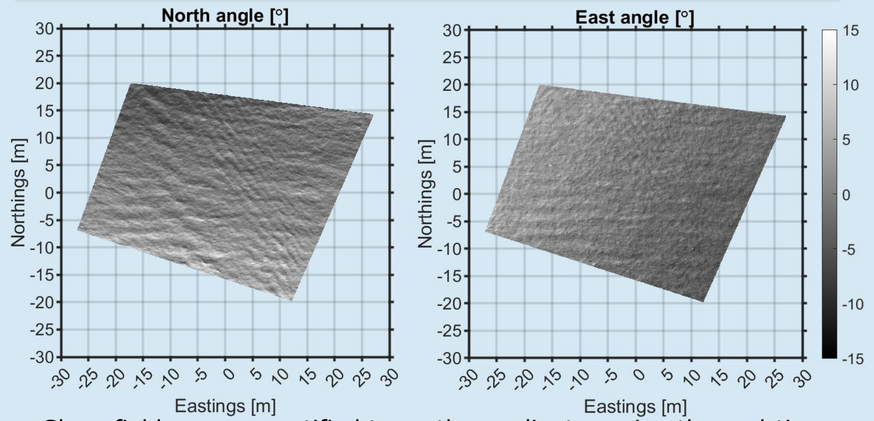
The field observations took place on the New Castle Coast Guard region in the **Gulf of Maine on June 30th 2023.**



Surface looking polarimetric camera is mounted on the UAV system. Camera motions are controlled and smoothed out using a gimbal.

Sea surface slope imagery is retrieved at various heights with a total flight time of 20 minutes.

Image Processing



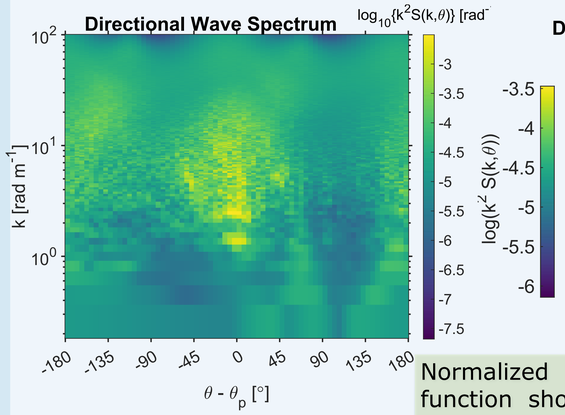
- Slope fields are georectified to earth coordinates using the real-time kinematic (RTK) positioning system in the UAV which yields centimeter-scale accuracy.

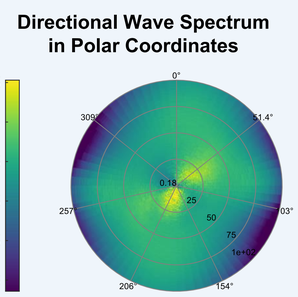
Please scan this QR code to see the ocean motion in action!

Results

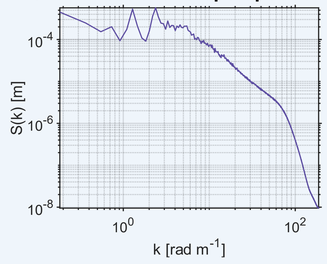
The directional wave spectrum is obtained from FFT of the 10 second recording. The results show:

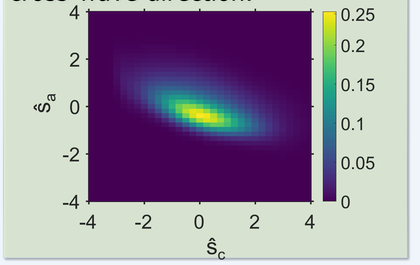
- Directional spreading of short gravity waves through the mean wave direction
- Recovery of 6 m to 20 cm wavelengths fills in the gap between airborne LiDAR measurements (Lenain et al. 2017) and polarimetric measurements from a floating platform (Laxague et al. 2018) by resolving short gravity waves.





Normalized probability density function shows that the highest wave slopes are mostly in the cross-wave direction.





Omnidirectional Spectra for Ascending UAV Recordings

Saturation spectra of a surface wave field recorded at different altitudes from the ascending UAV.
Spectra comparison with the model spectrum (red line) by Elfouhaily et al. 1997 at the same wind speed.