

Measurement of Storm-generated Surge and Waves in Support of Forecasting and Modeling

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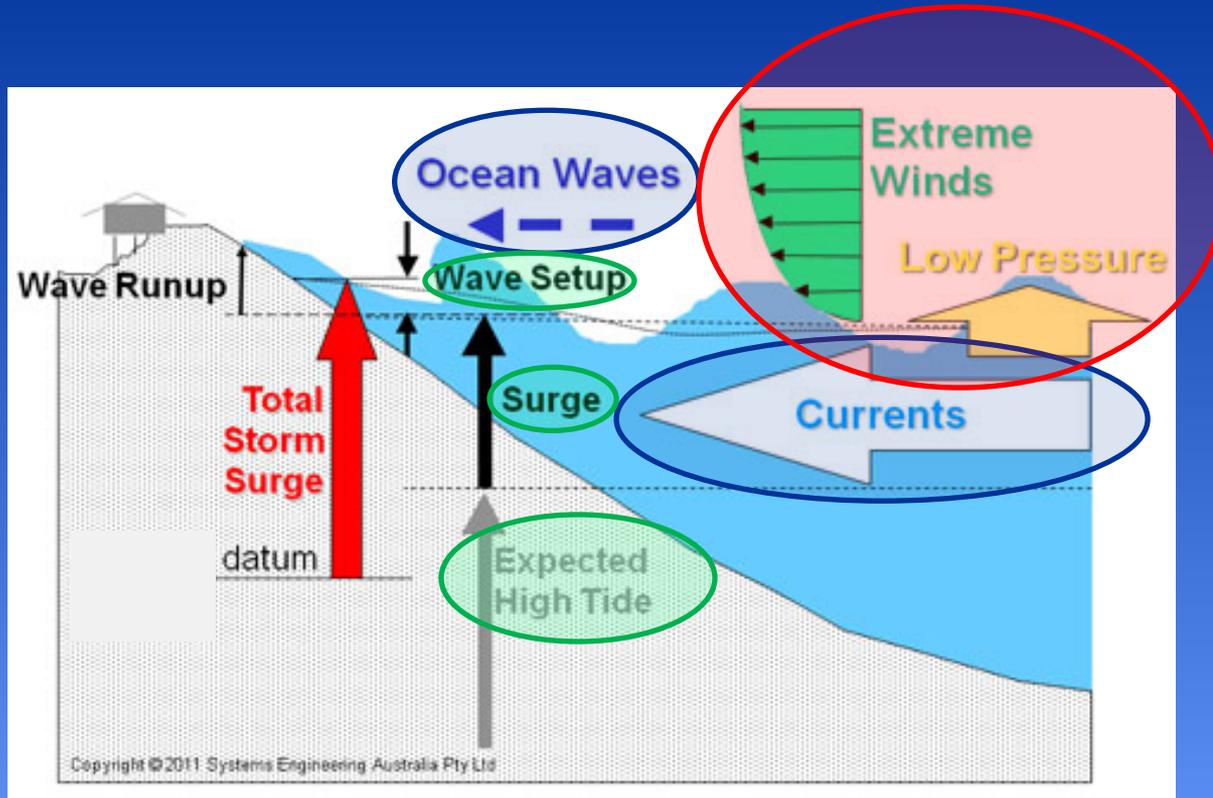
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What do we mean by “Storm Surge”?



Storm Surge is the “mean” rise in water level resulting from low atmospheric pressure and the accumulation of water driven shoreward by storm winds

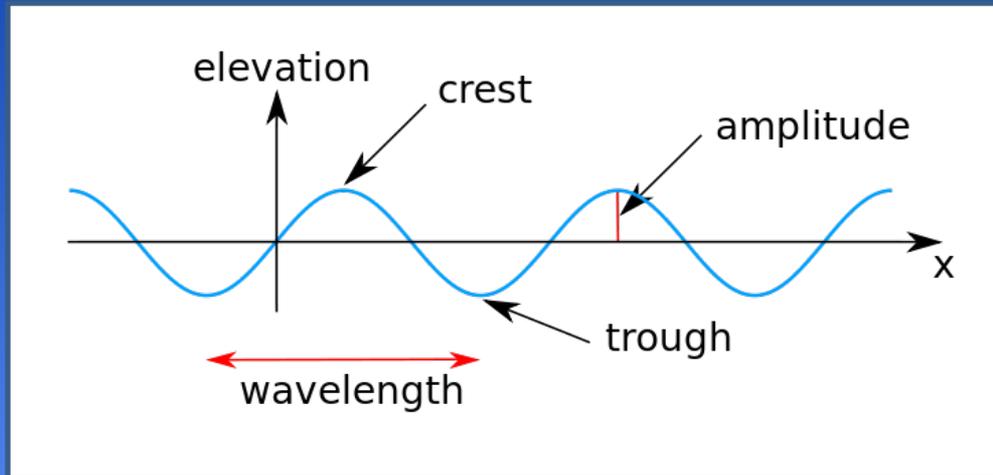
What's left after the surge is subtracted out?

Storm Waves

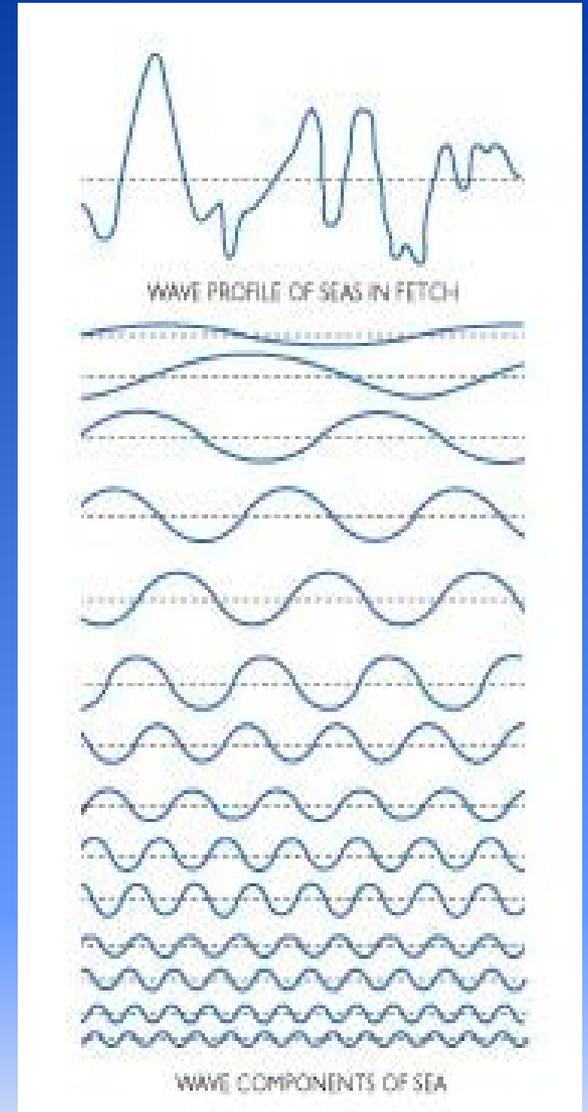
- Vary rapidly in time and space
- Carry a significant amount of energy



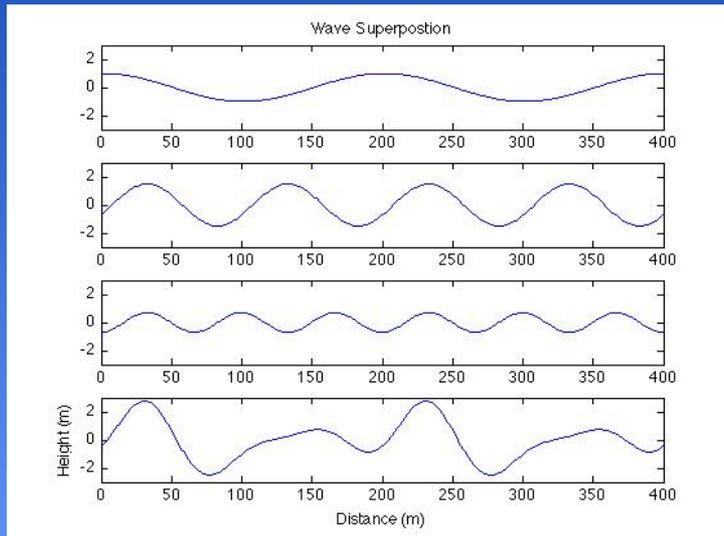
How do we characterize this “confused” sea state?



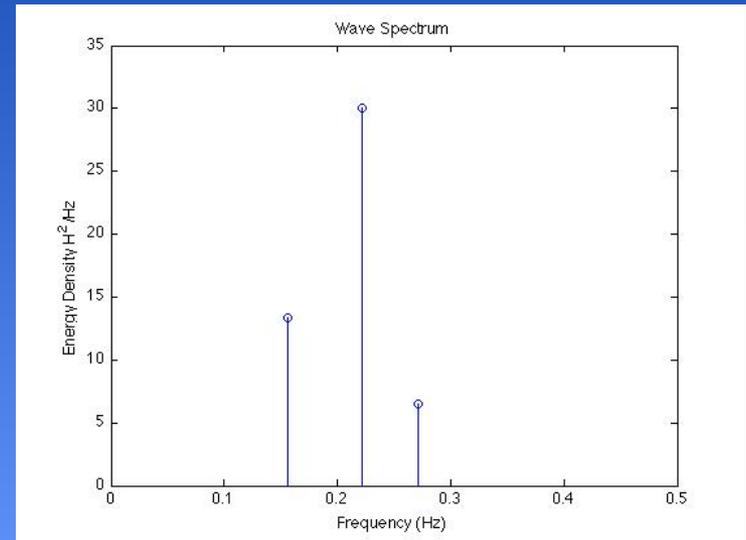
Wave Superposition



How do forecasters, and others concerned with storm waves, summarize the information about superposed waves in a way that is meaningful and useful to decision makers and emergency managers?



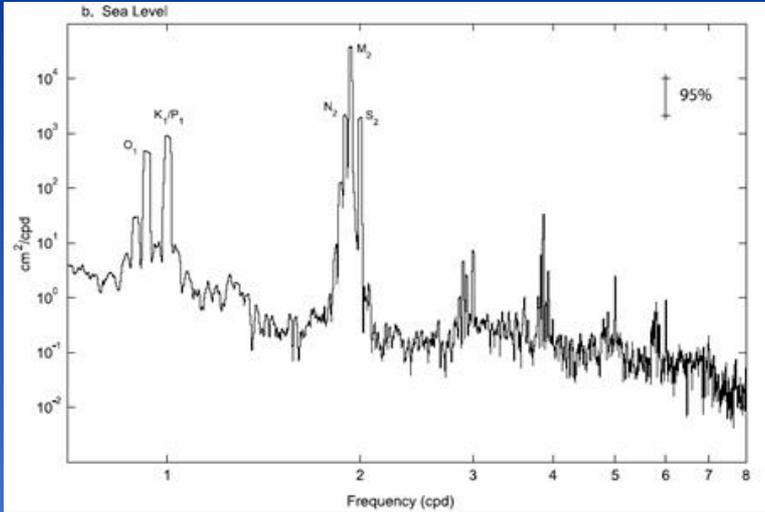
Fourier Transform



Timeseries

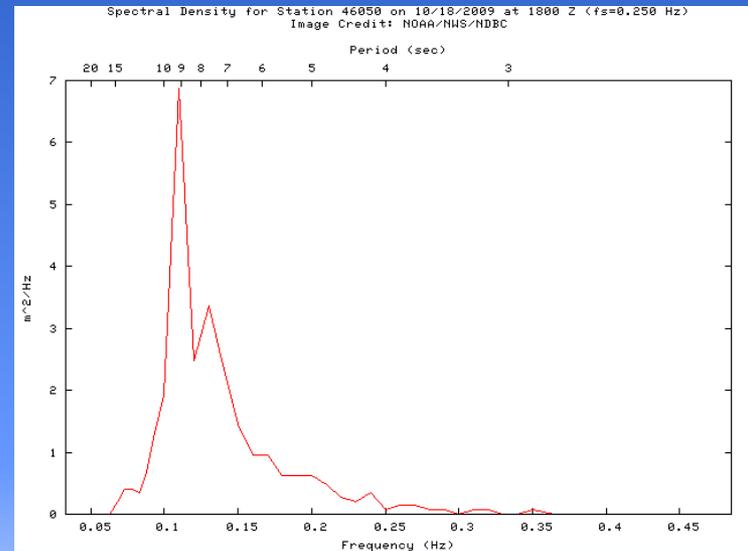
Wave Spectra

How do "real world" wave energy spectra look?



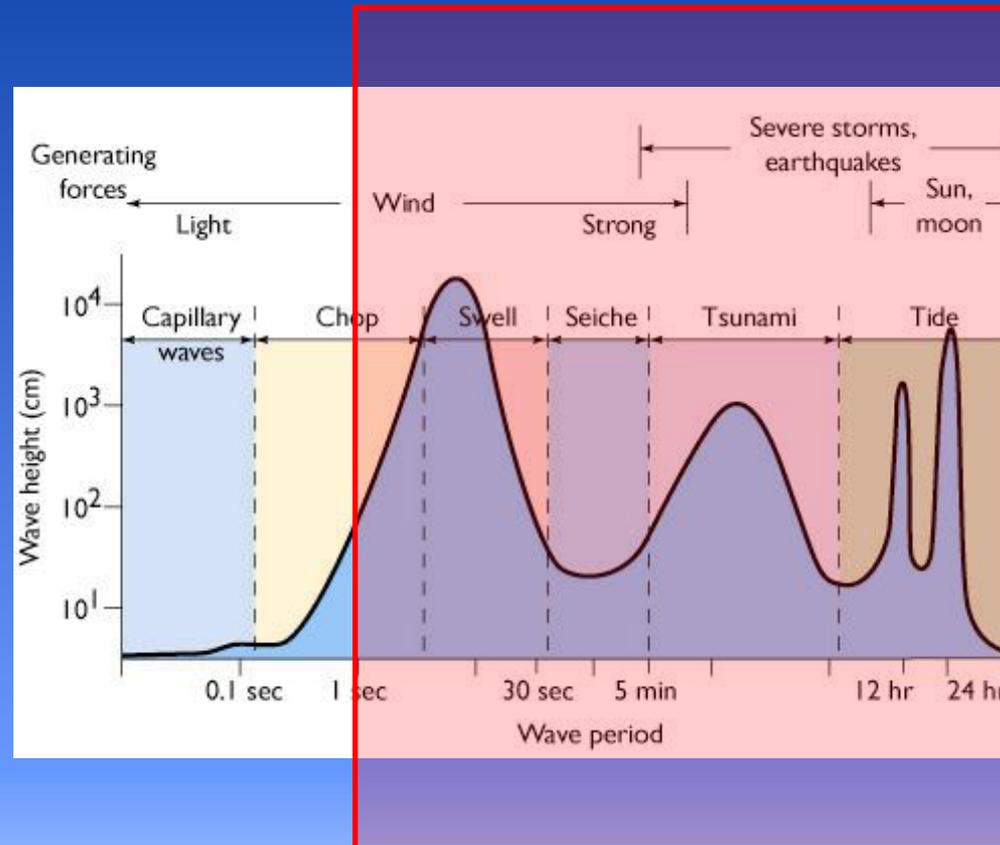
← Tides

Wind →



What do forecasters and other modelers need in order to characterize the sea surface accurately?

Rapid measurements over a long period of time



What are the sampling requirements?

- 4 Hz sampling rate
- 7-10 day sampling period
- Continuous (or near-continuous) sampling
- 1 cm vertical accuracy

DURING A HURRICANE!

What are the technical and logistical challenges?

- Robust
- Portable
- Rapidly-deployed
- Stable and recoverable
 - Built environment
 - Beach environment
 - Wetland environment
- Inexpensive

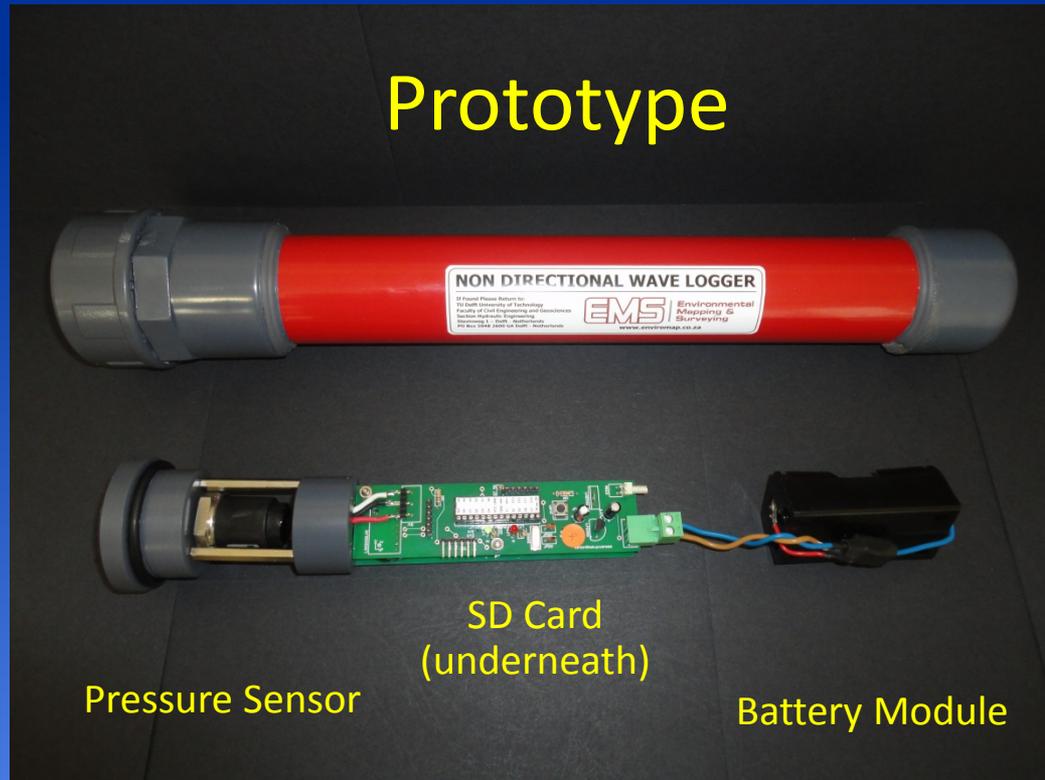
Our current effort is focused on making progress in addressing as many of the technical challenges as we can.

A Pressure Sensor



Additional Data
Processing Challenges!

Prototype



- Two prototype instruments purchased (2-cm accuracy). \$650/instrument
- Performance-based work statement being written to meet all sampling requirements and provide patent-free design
- Instrument tested by Delft University of Technology
- Further testing to occur at USGS Hydrologic Instrumentation Facility

Prototype Testing by TU Delft during the BARDEX II Experiment



Deltares Flume

- 240m long, 5m wide, 7m deep
- 1s – 12s random wave generation
- 2.5m maximum wave height

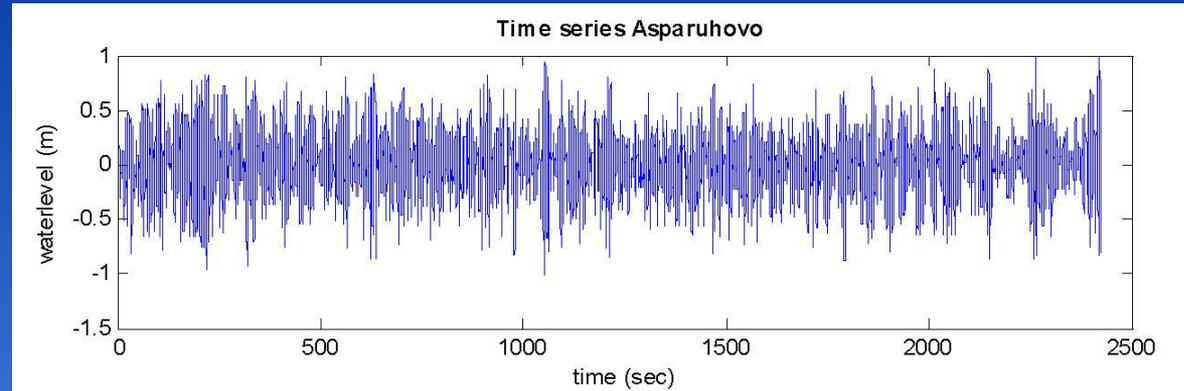
	H_{rms}	H_s	$H_{2\%}$ (measured)	$H_{2\%}$ (Rayleigh)	H_{m0}	H_{rms}	T_{01}	T_{10}
Deltares	0.6440	0.9110	1.3210	1.3210	0.9210	0.6440	5.6690	6.8560
Pressure meter	0.6297	0.9047	1.2274	1.2665	0.9098	0.6433	5.3945	6.5868
Deviation (%)	2.27	0.70	7.63	4.30	1.23	0.11	5.09	4.09

MATLAB Scripts for Data Processing

(Courtesy of Henk Jan Verhagen, TU Delft)

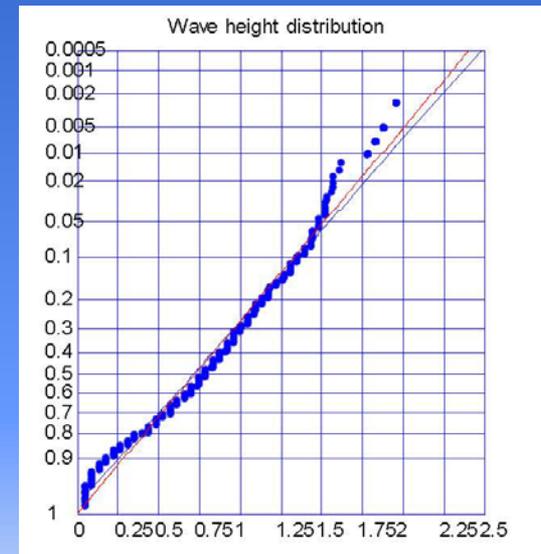
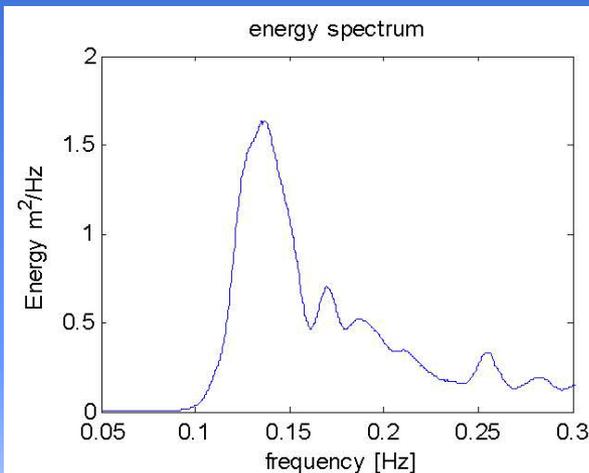
H_{rms} (m) 1.2
 H_{m0} (m) 1.7
 T_m (s) 3.5
 $T_{m0,1}$ (s) 3.8
 $T_{m-1,0}$ (s) 4.8
 T_{peak} (s) 2.5

Average depth (m) 8.5
 water density (kgm^3) 1018



H_{mean} (m) 0.77
 H_{rms} (m) 0.87
 H_s (m) 1.2
 T_{mean} (s) 6.1
 H_{tr} (m)(acc BG) 3
 Bed slope 1:1000

	obs	Rayleigh	BG
$H_{2\%}$ (m)	1.56	1.72	1.73
$H_{1\%}$ (m)	1.61	1.84	1.88
$H_{0.1\%}$ (m)	NaN	2.27	2.3



Next Steps?

- Inexpensive Armoring



(Courtesy of Andrew Kennedy, University of Notre Dame)

- Deployment/Retrieval Strategies
- Field Testing
- Workshop @ USGS February 2014