

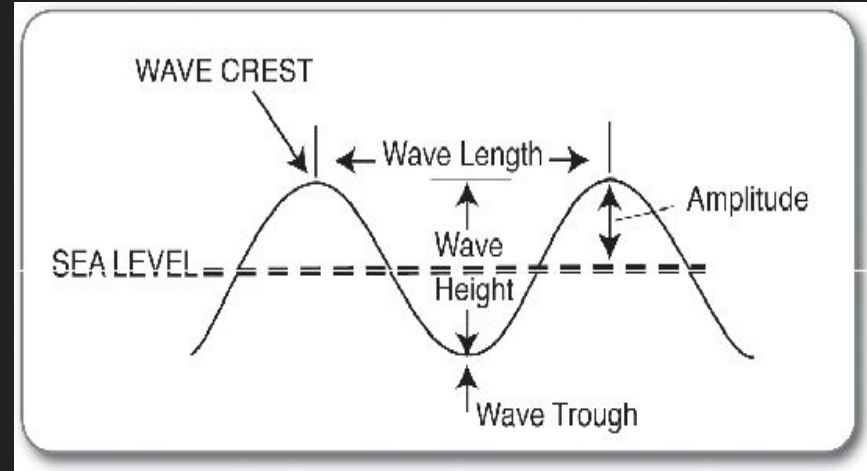
Waves and Tides

Methods of Measuring Ocean Dynamics on the Coasts of France and Spain

Bruce Allen, Greta Miller, Remi Shaul-Thompson, James Tralie, Lillian Wu, & Sophie Zhang

Waves

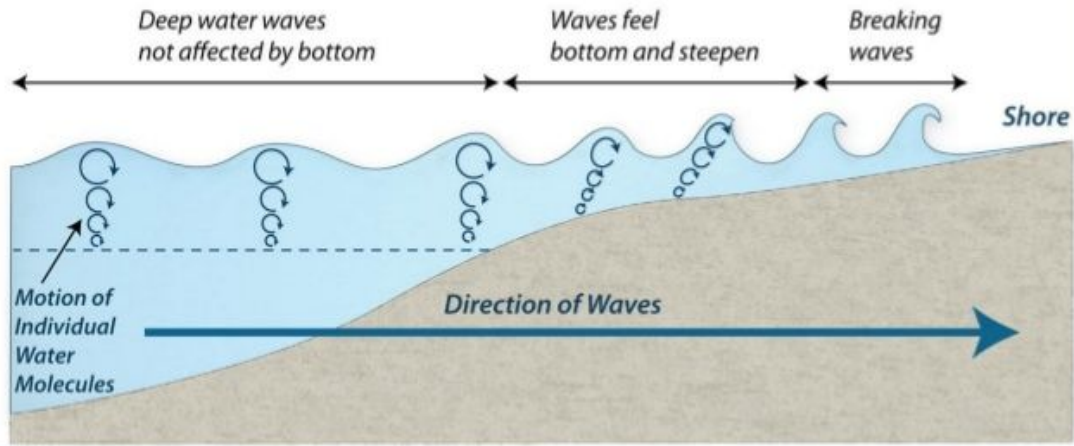
- Waves - movement of energy through water
- Caused by anything that causes water to move
- Energy transferred by wind depends on
 - Speed, duration, consistency
 - Fetch (space over which it blows)



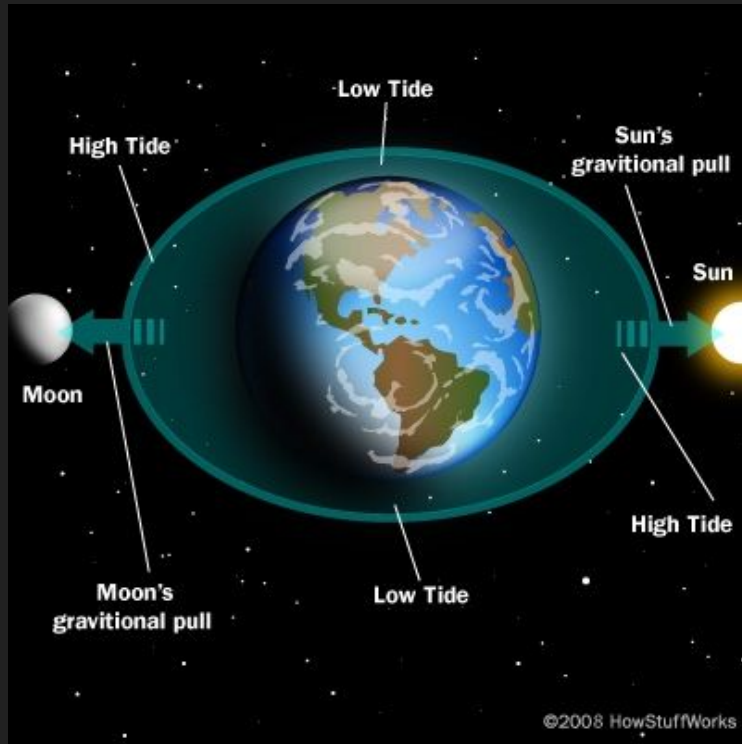
Wave Propagation

Deep Water vs. Shallow Water Waves

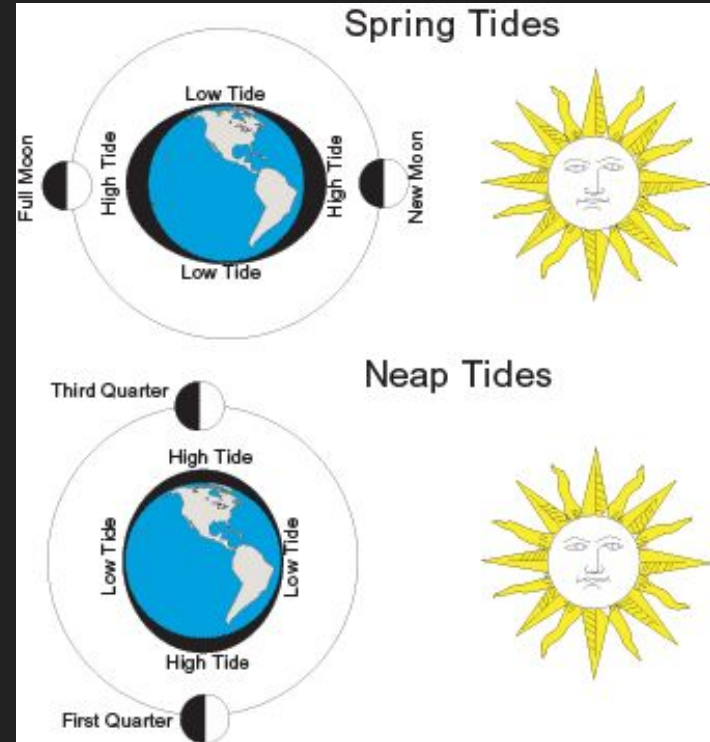
Breaking Waves



Tides

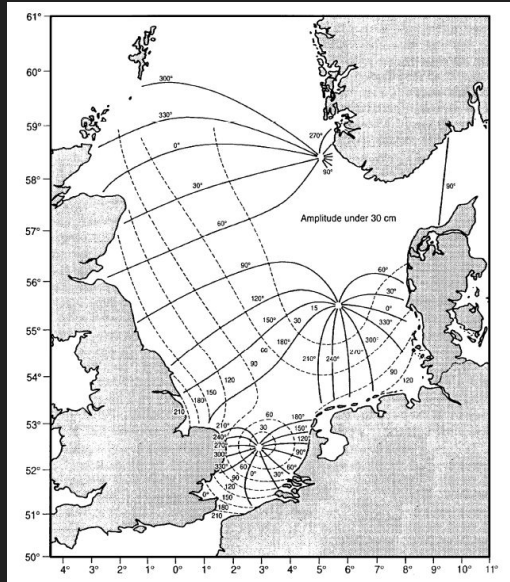


<http://science.howstuffworks.com/environmental/earth/oceanography/tide-table1.htm>



<https://www.atlantickaytours.com/pages/expertcenter/navigation/navigation-04.shtml>

Mont St Michel and Omaha Beach



Amphidromic System: North Sea



Omaha Beach



Le Mont St Michel



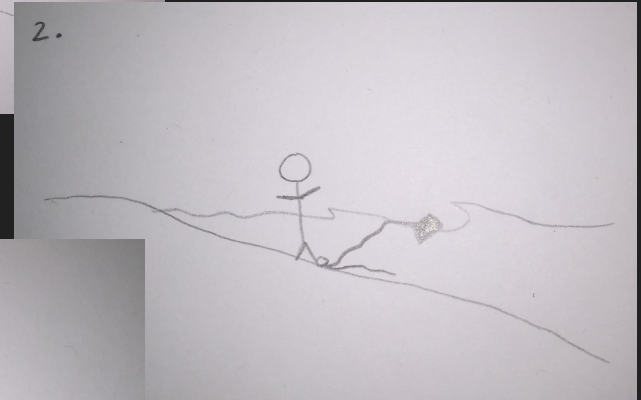
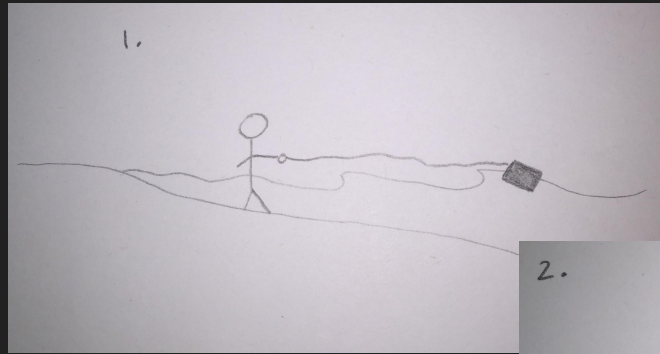
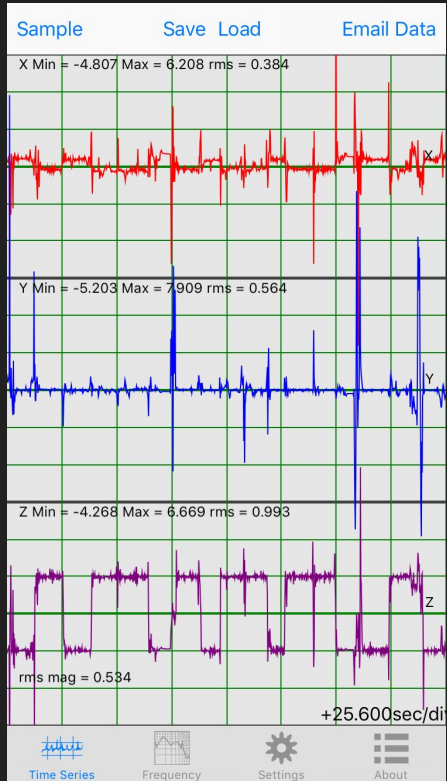
Measuring the Waves

Wave Measuring Buoy

Smart Phone



Methods

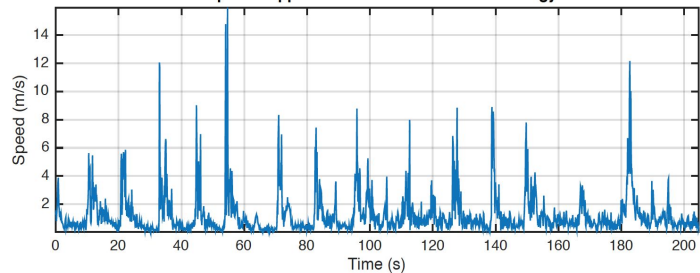


Problems with Vibrations Data Collection

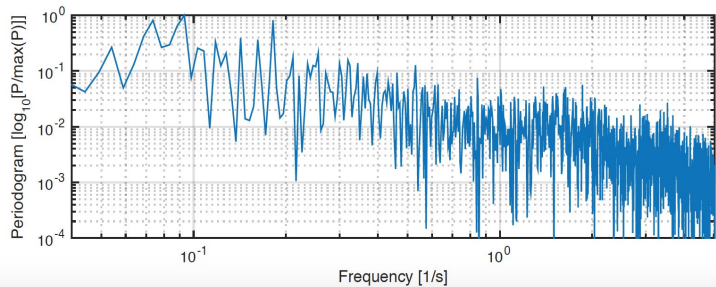
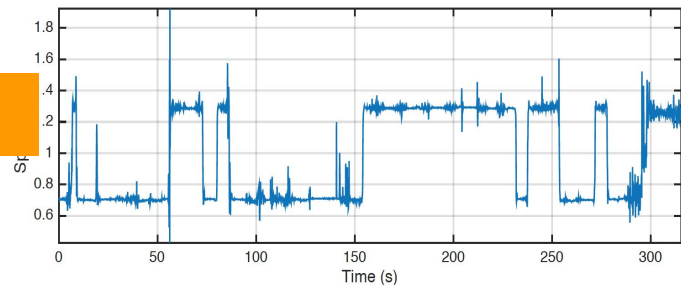


Making Sense of our Data

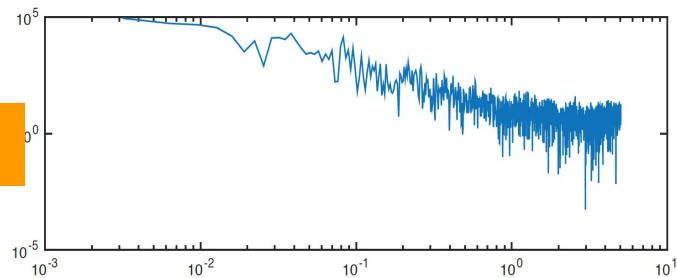
5 Smartphone app data brucema-20151104140940-gyr.csv



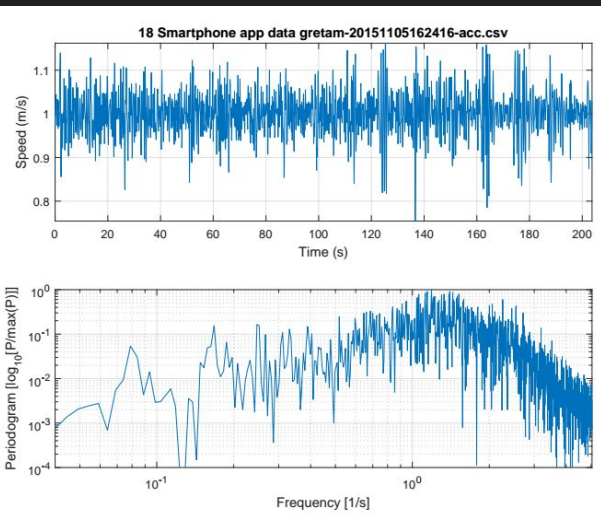
Raw Data



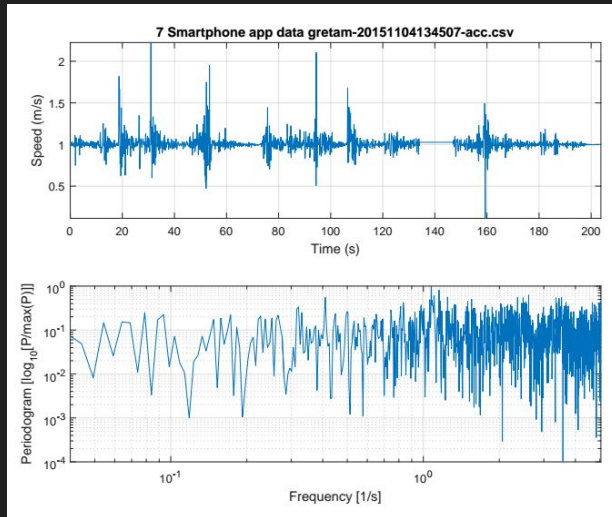
Periodogram



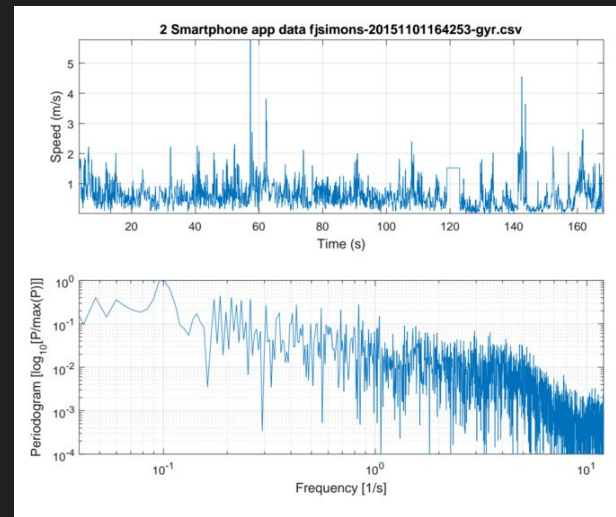
Successes: Types of Periodogram



“Hump”
27%

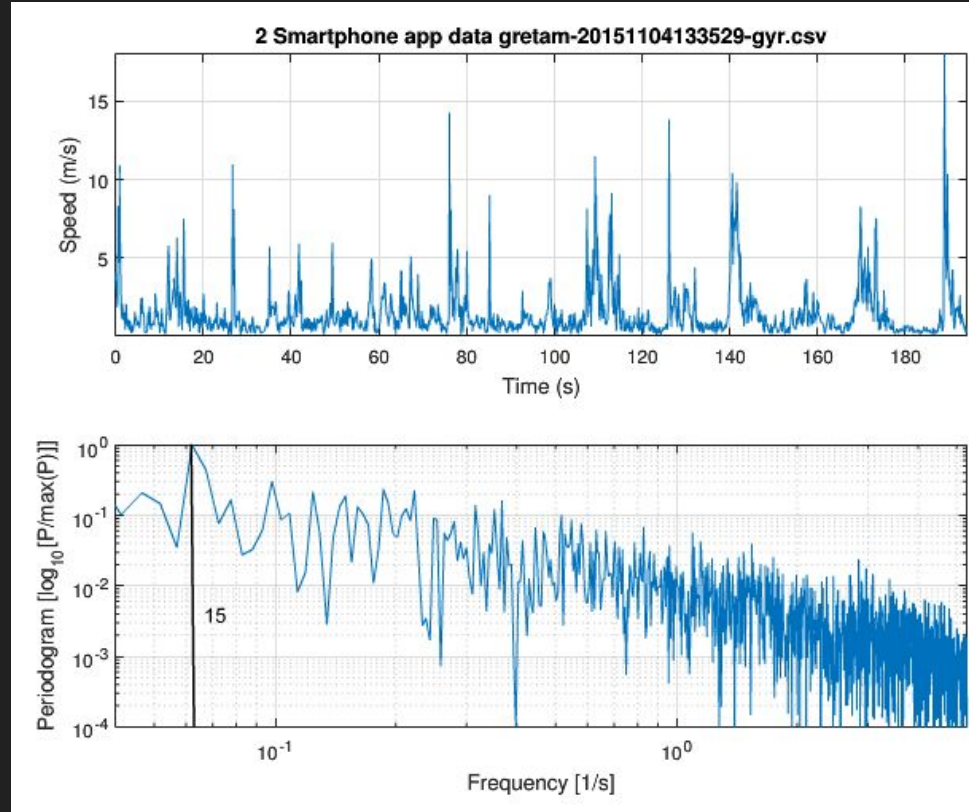


“Plateau”
30%



“Down”
43%

Successes: Wave Periodicity



Smartphone Conclusions

- Wave measurements are useful to coastal communities
 - Ensure safety of swimmers and surfers
 - Assess risk to boats and offshore infrastructure
- More advanced applications
 - Long-term forecasting
 - Tsunami risk
 - Waves as energy sources





Figure from Emory (1963)

Photogrammetry

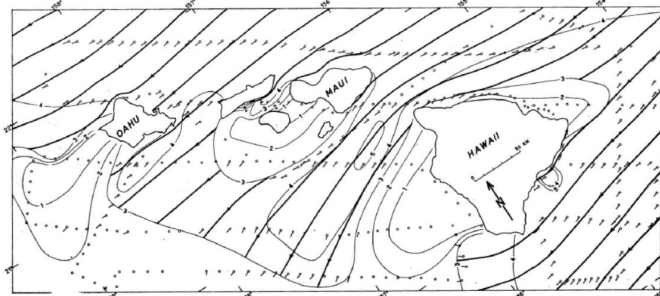
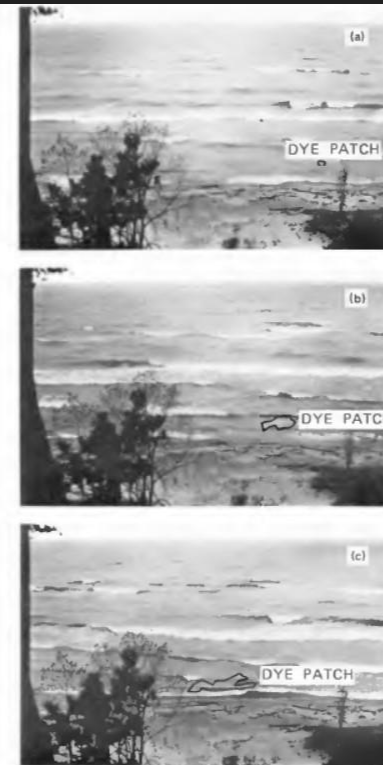


FIG. 2. Results of aerial observation of wind at sea surface on 31 August and 1 September 1961. Wind flow lines (wide lines) are based upon wind slicks observed at each position (note weather-vane line at each position). Wind speeds are based upon condition of sea surface expressed in Beaufort scale (indicated by narrow numbered lines).

Figure from Emory (1963)



SINGLE OBLIQUE IMAGE OF A FLUORESCIN DYE PATCH.
(a) At time of release, (b) 30 s after release, (c) 60 s after release.

Figure from Maresca (1976)

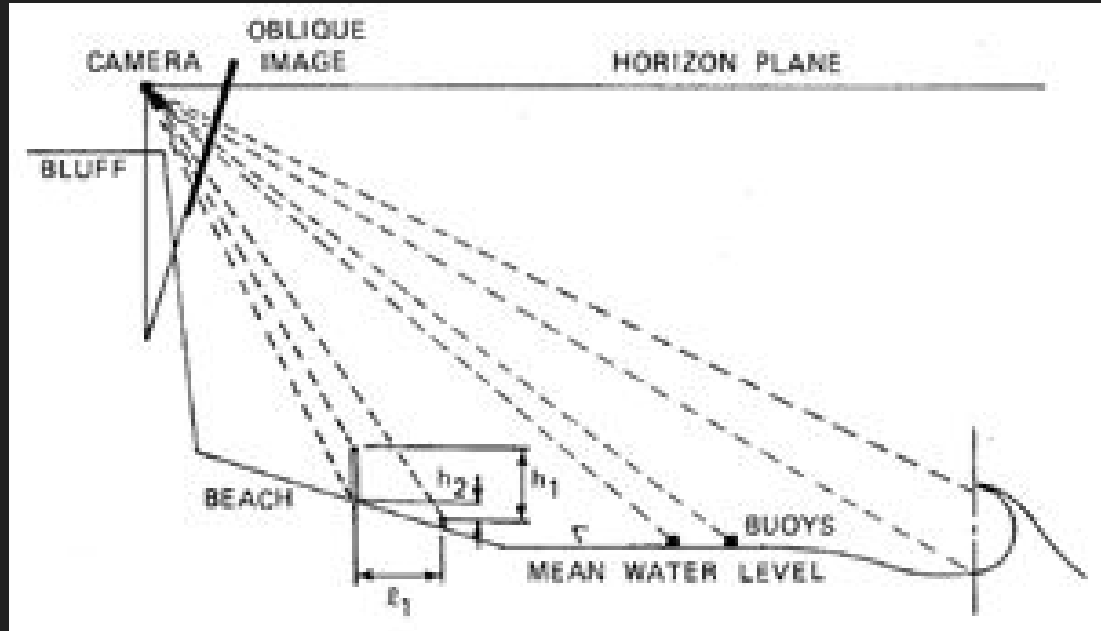
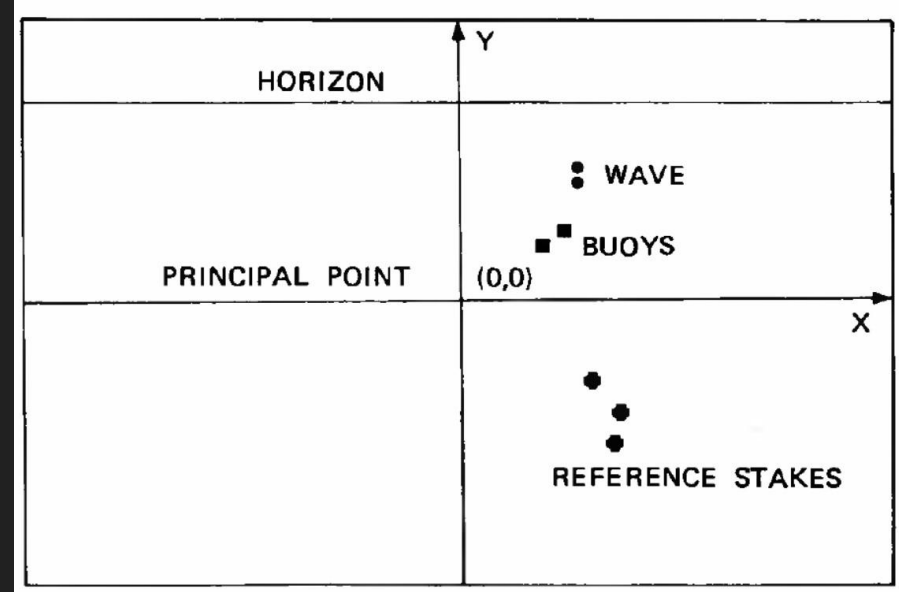


Figure from Maresca(1976)



Figures from Maresca (1976)

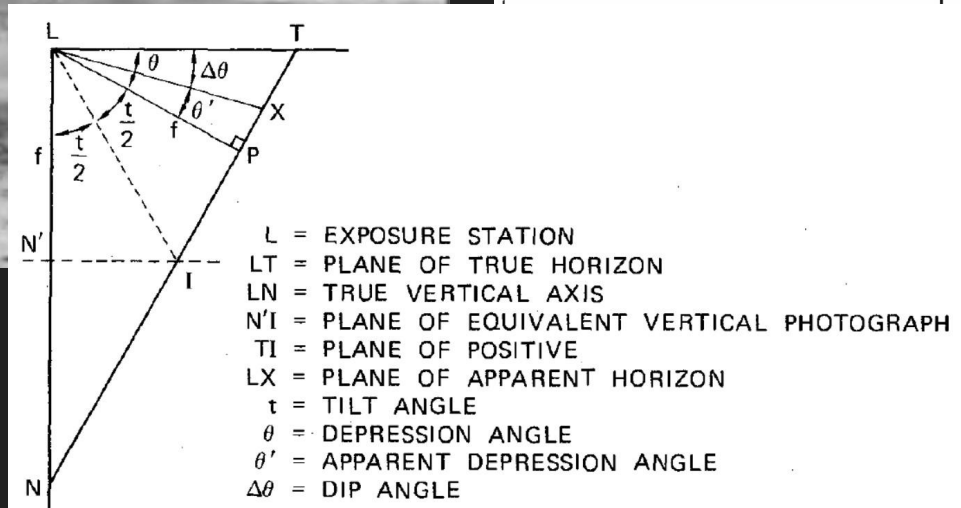
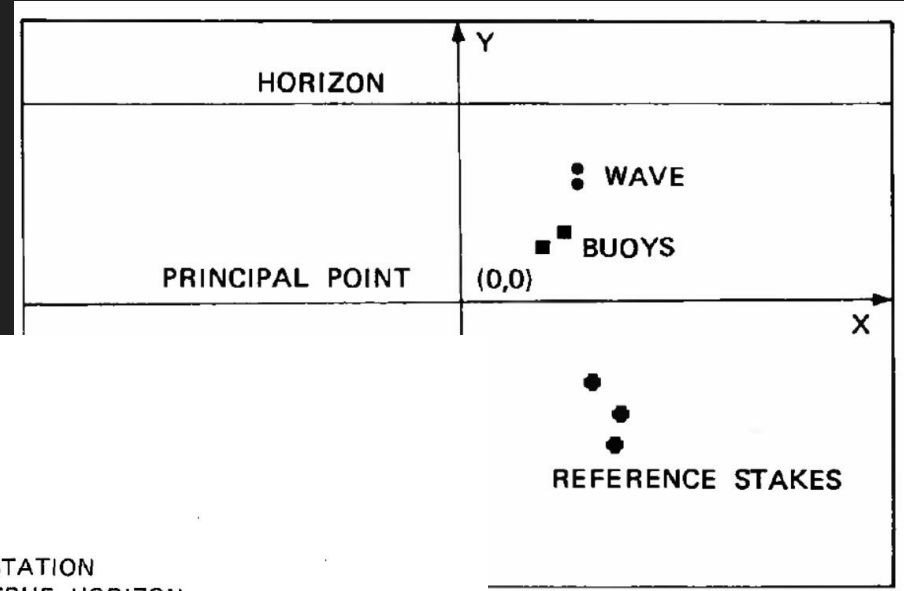
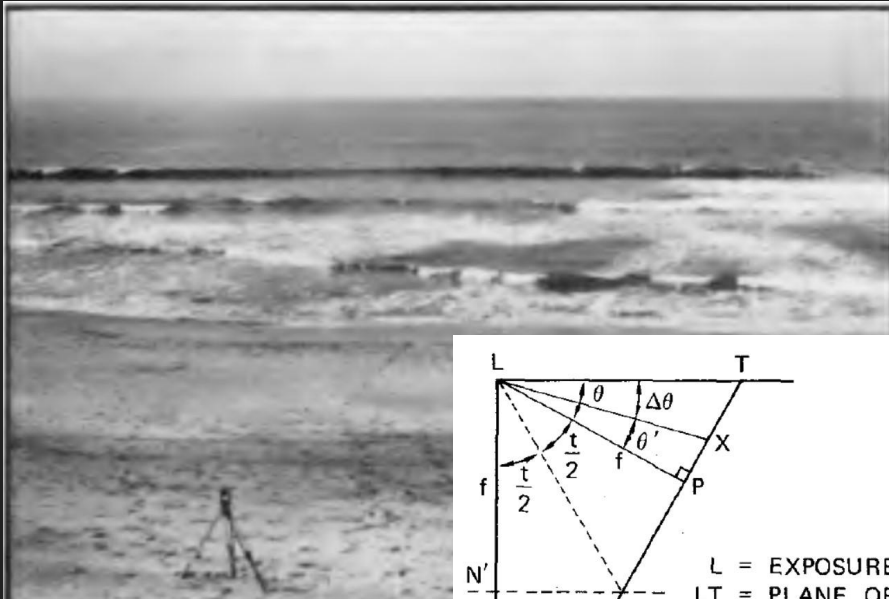


FIGURE 5 PRINCIPAL-PLANE DIAGRAM

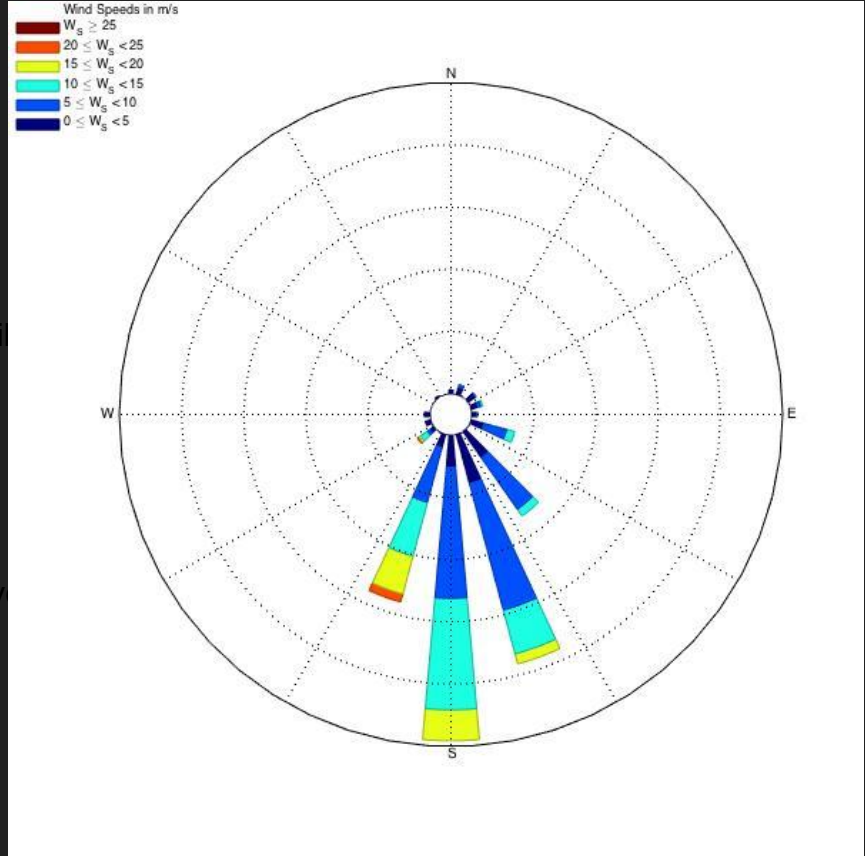


photo

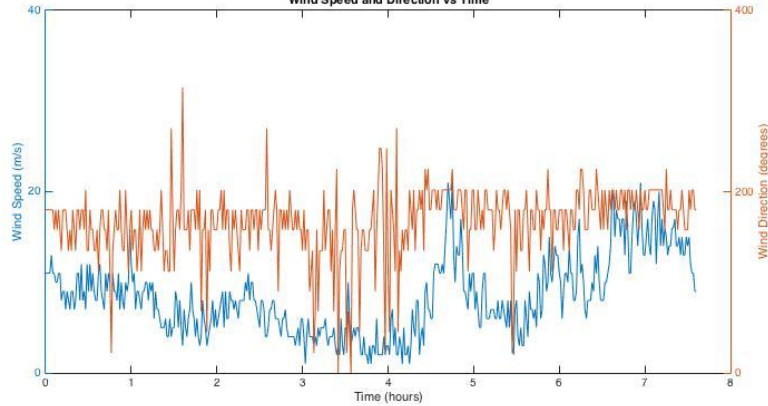
locate

recorded temp, pressure, wind speed, wind direction,

eral prevail



Wind Speed and Direction vs Time



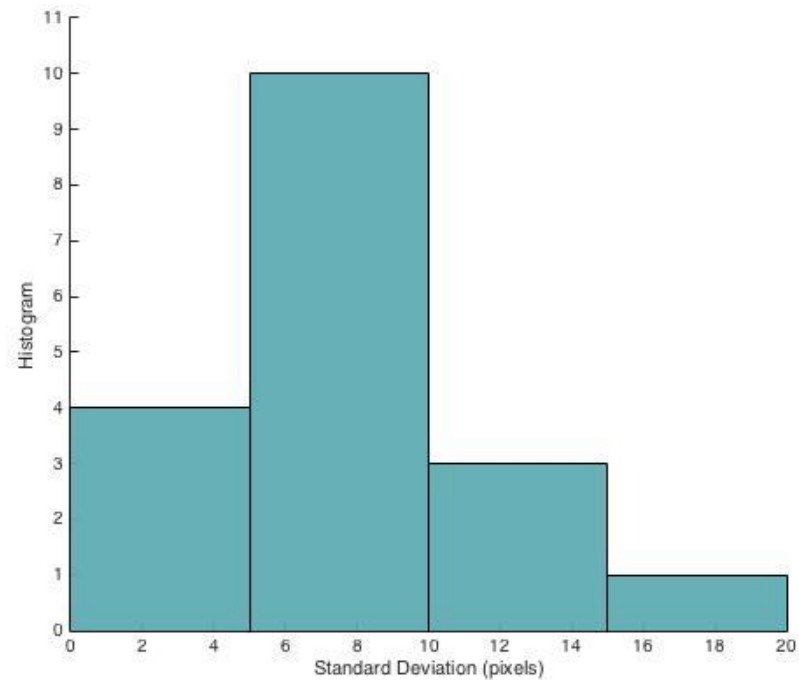
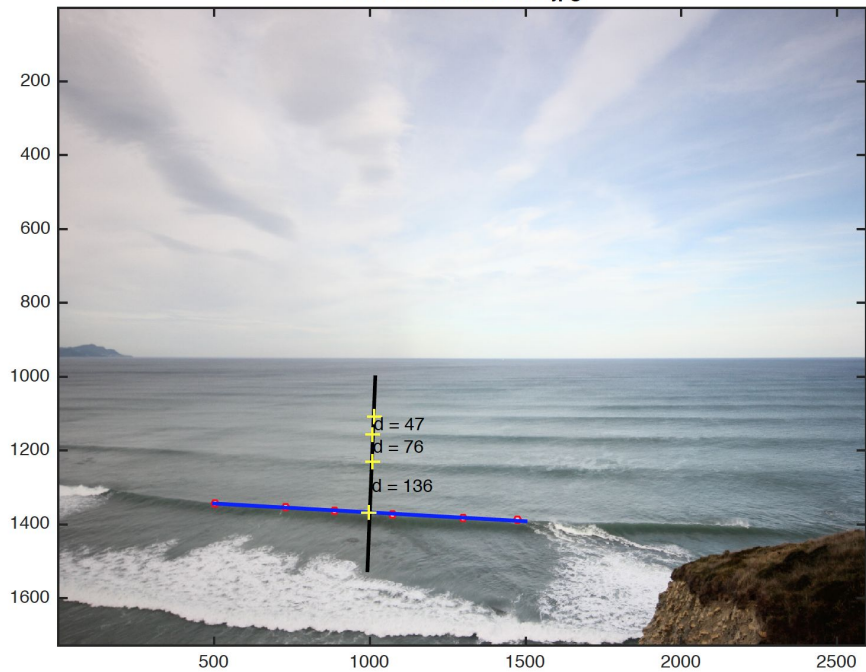


marker 1



marker 2

79 is 20151104050025.jpg

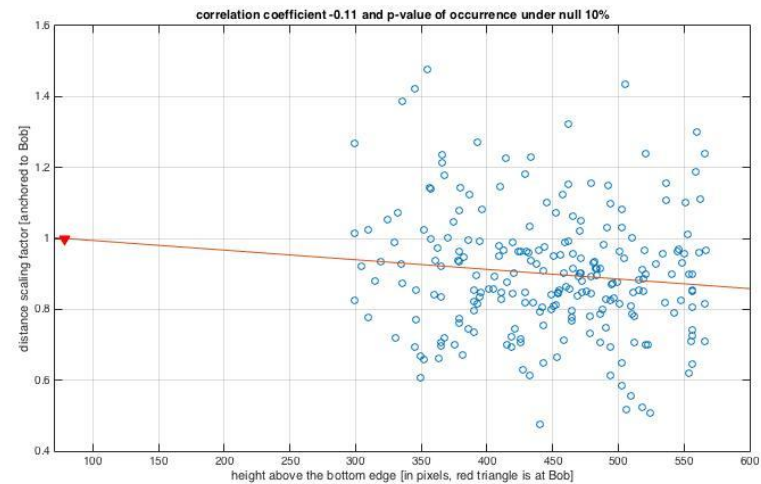


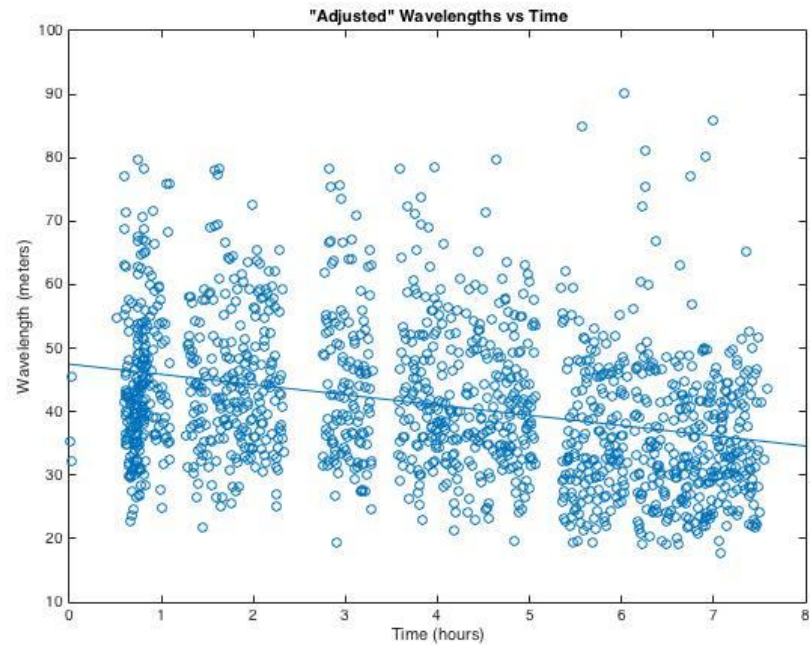
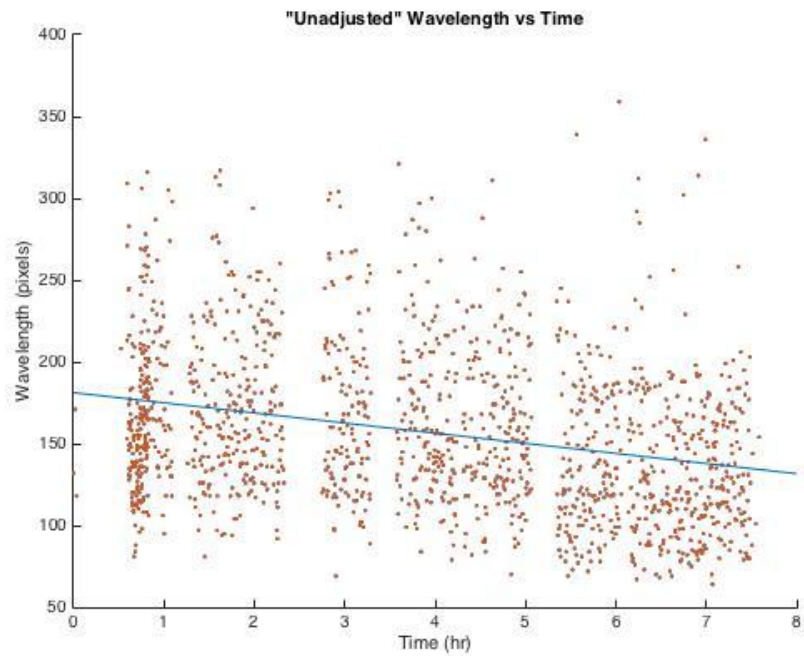
CAMERA

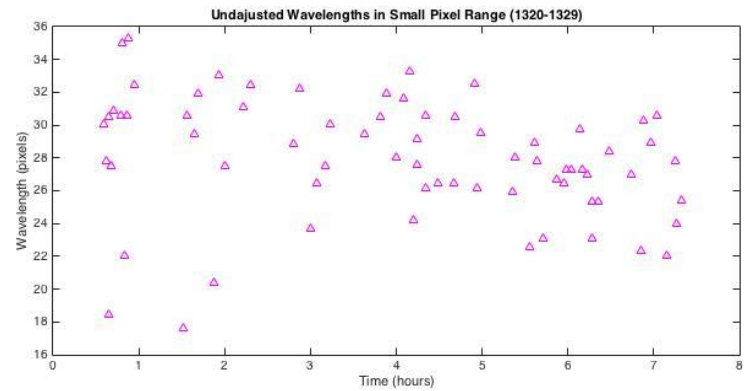
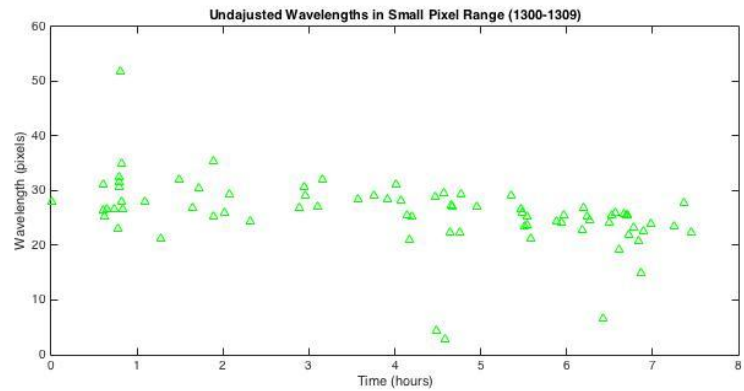
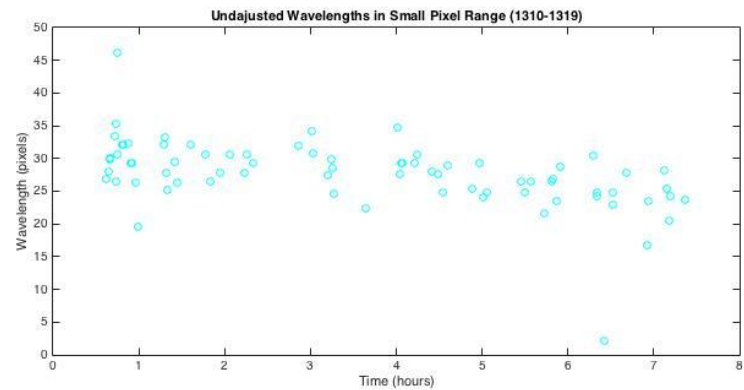
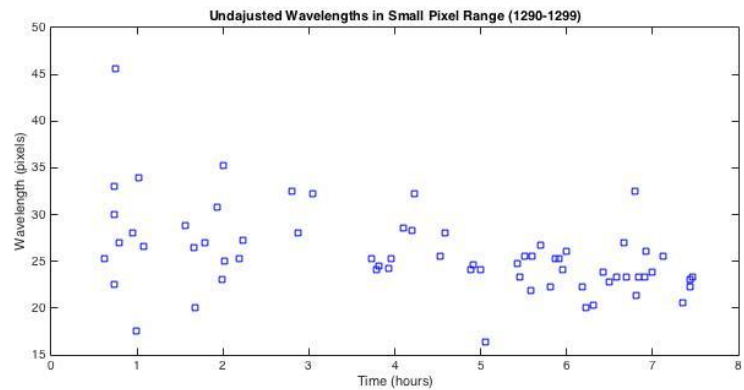
DISTANCE TO THE VISIBLE HORIZON (~25 km)

CAMERA LINE OF SIGHT

WAVELENGTH







Measuring Tide Level in Zumaia, Spain - A Novel Approach



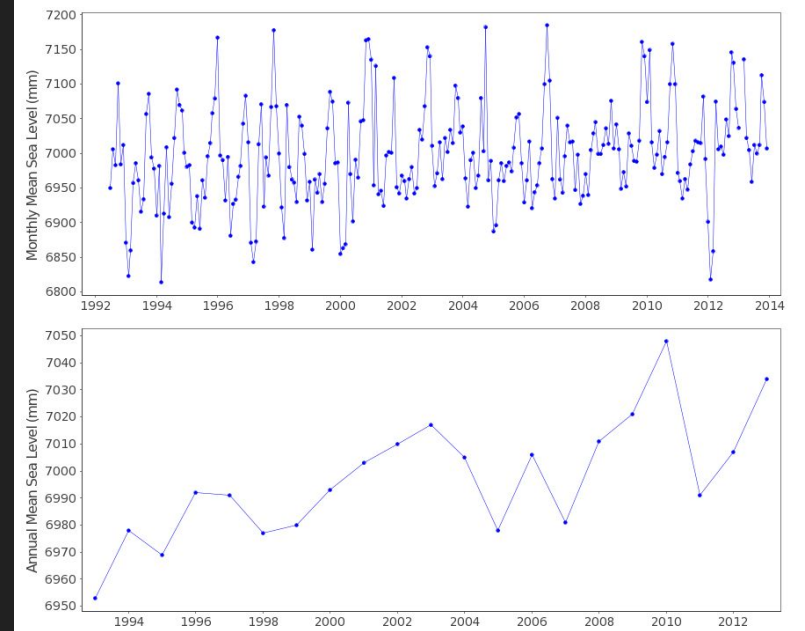
Day 2, Zumaia, Spain (November 5, 2015)

Tide Gauges

The approximately 2000 PSMSL stations



PSMSL Station #1806 (Bilbao, Spain)



Motivation

Historical

- D-Day Invasion
- Tide Gauge machine



Omaha Beach, Normandy, France
June 6, 1944

Scientific

- Localized tidal amplification
 - Due to local topography



The Cove at Zumaia, Spain
November 3, 2015

Our Methodology

Photo every five minutes (two days November 4 and 5, 2015)

Camera Setup

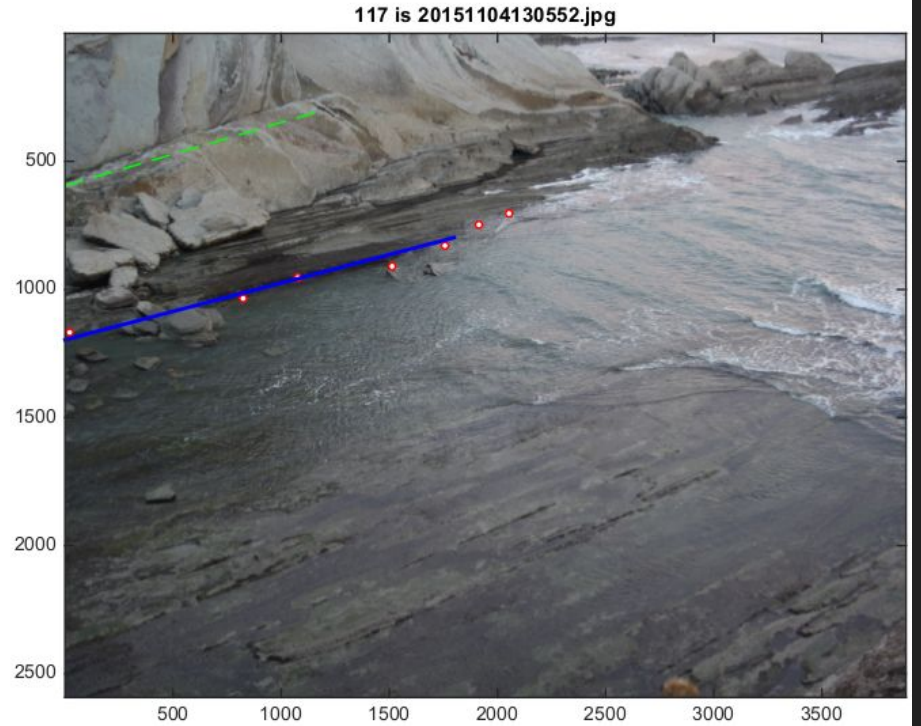


Camera Field of View



Day 2 - November 5, 2015

Photographic Analysis

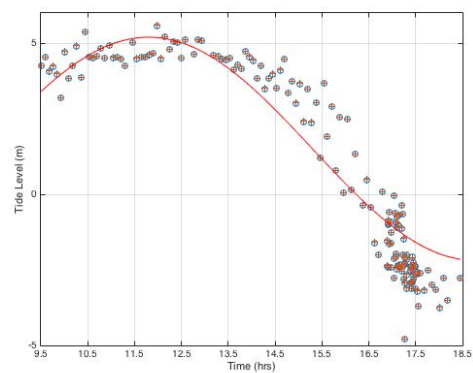
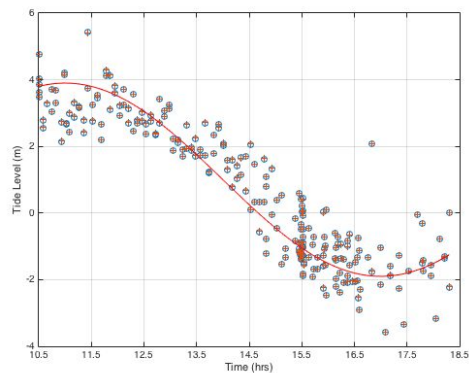
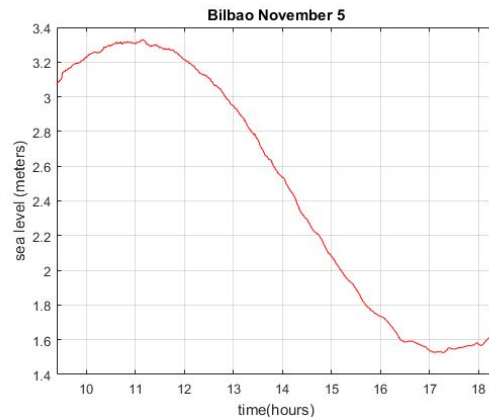
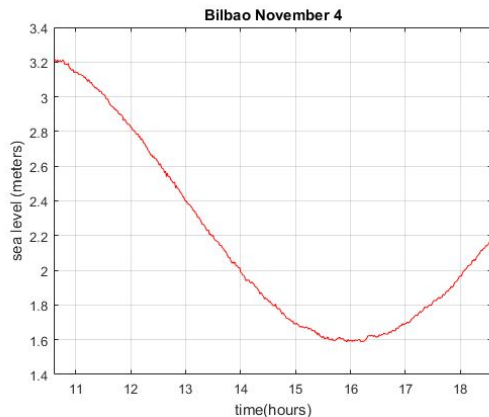


Pixel to Meter Scaling

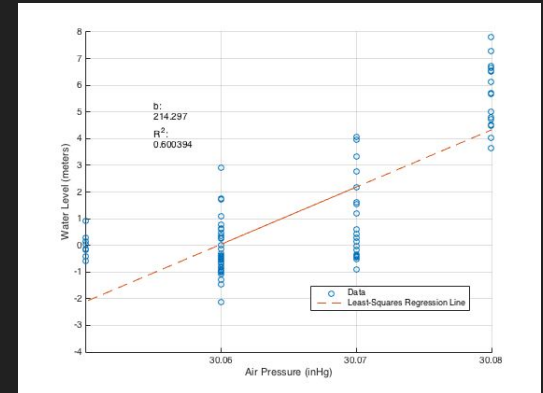
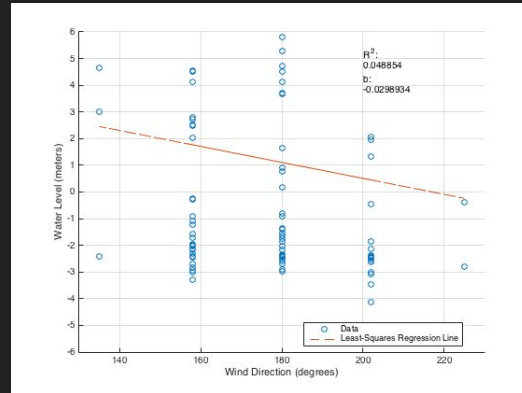
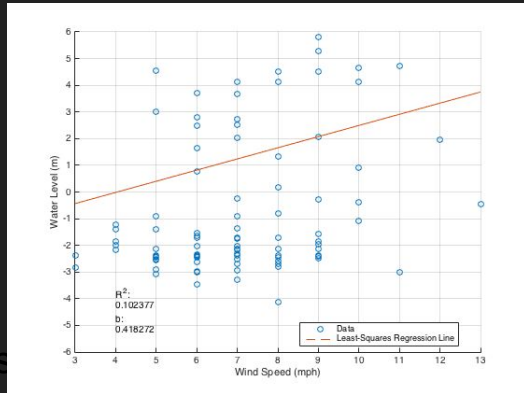
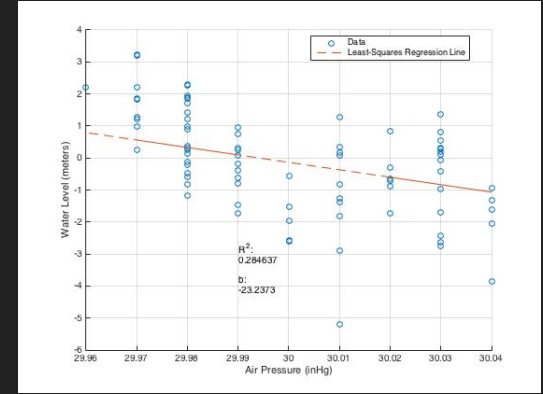
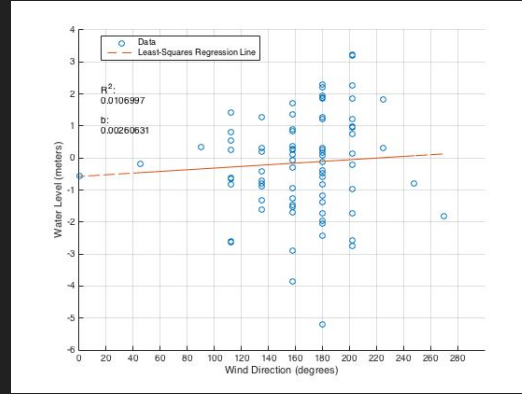
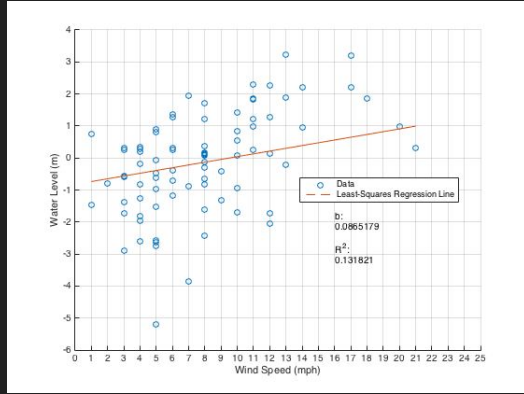


Local Tide Data (Bilbao, Spain)

PSMSL Station #1806



Correlation with Weather - Day 1 vs Day 2



Tide Amplification

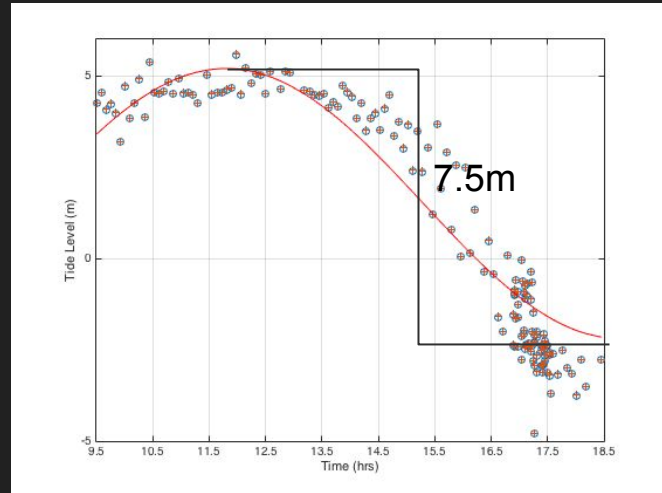
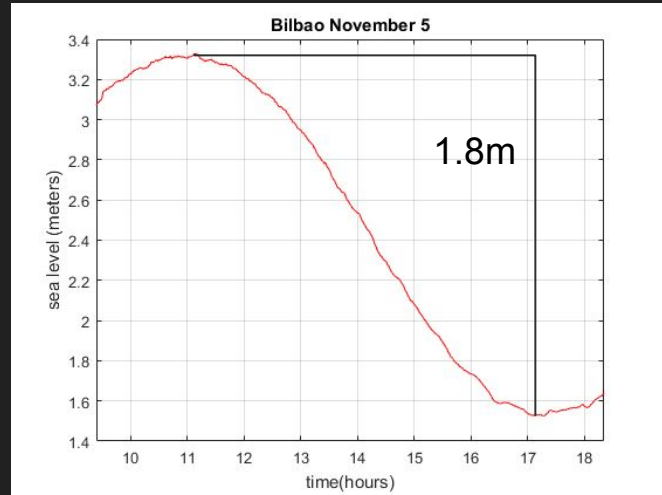
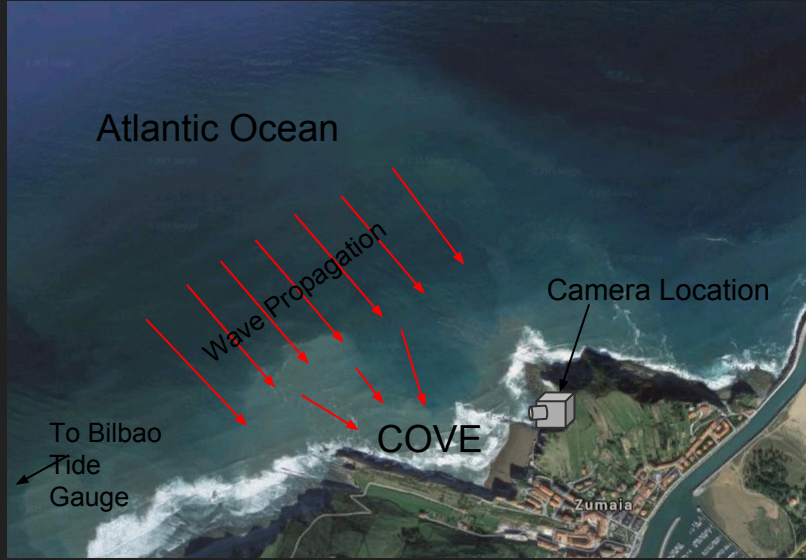
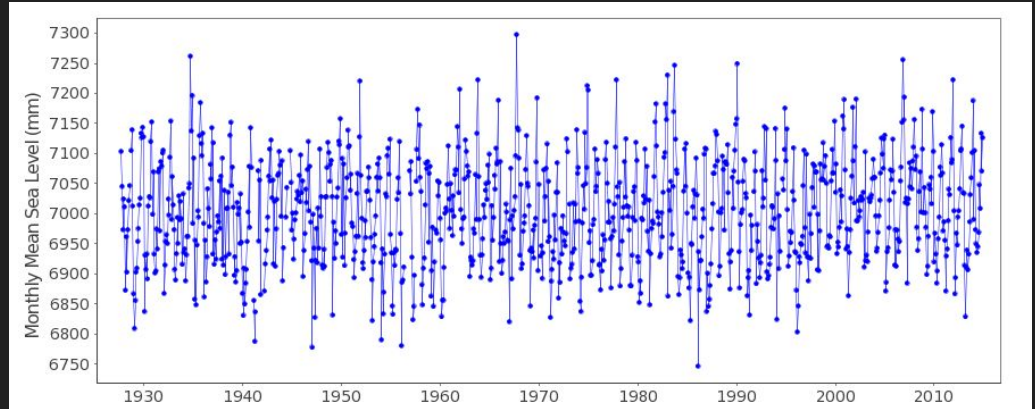


Photo Analysis vs Tide Gauges



Long-Exposure Needed



Conclusions

- High and low tide measurements were off
- Tide amplification caused larger range
- Our wind speed and tide level reveals positive correlation
- However, air pressure data and tide level data is flawed
- Tide gauges are more accurate

Acknowledgements

Thank you to

Professor Frederik Simons and Professor Adam Maloof

Akshay Mehra and Chris Harig