Extraction of coastal ocean wave characteristics using remote sensing and computer vision technologies

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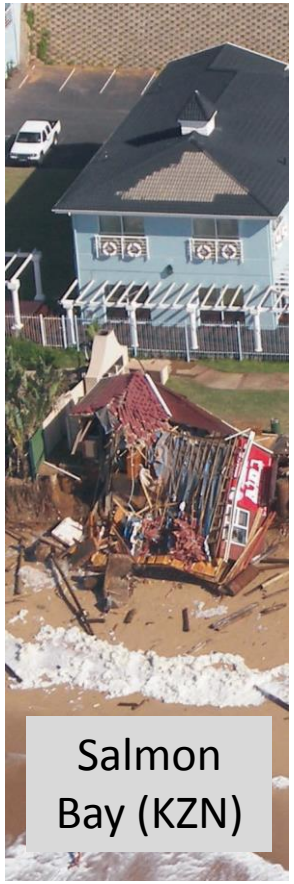
Why the coast is important

- Coastal zone is a extremely dynamic and complex environment
- There are continuous interactions occurring – many of these are driven by surface winds and ocean waves
- 40-60% of the population is concentrated along the coast – this number is constantly on the rise, resulting in an increase:
  - in population density ,
  - associated socio-economic activities and
  - economic opportunity within the coastal zone;

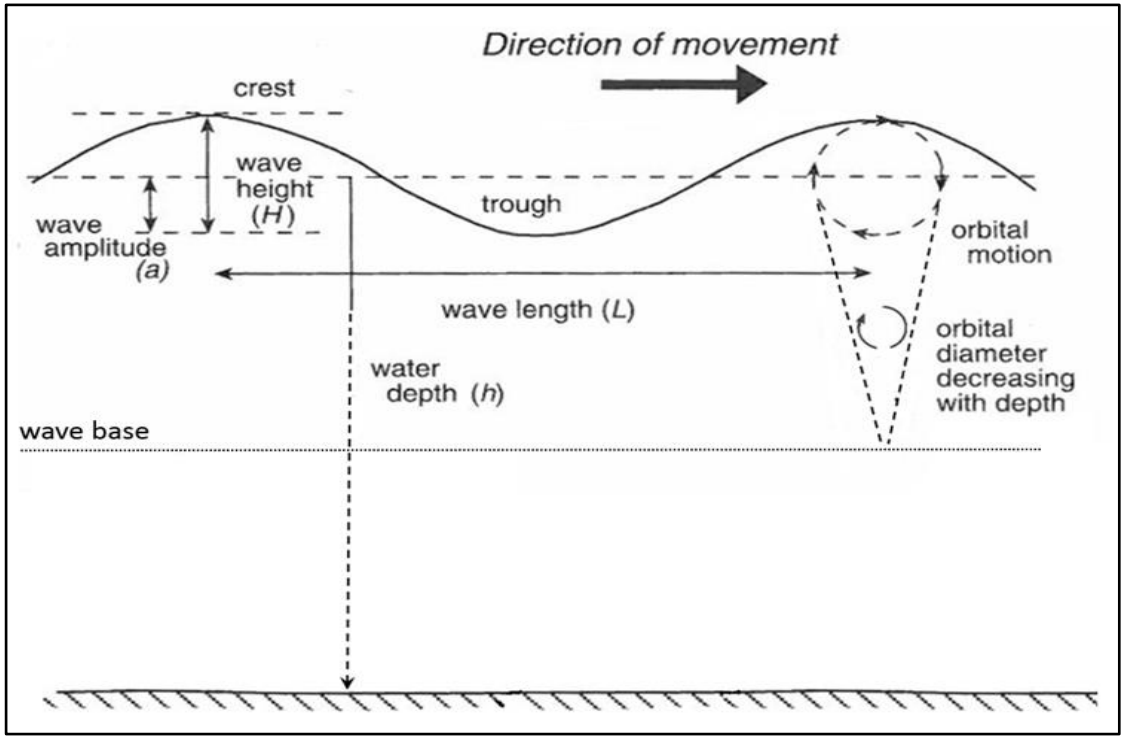
  Therefore, more and more people are being exposed to the ocean and the impacts of ocean waves

Ocean wave hazards



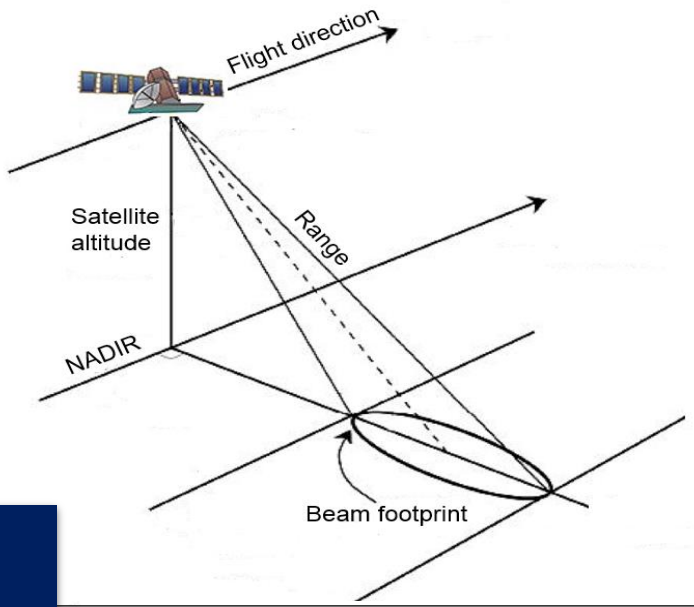
Ocean Wave Characteristics

- In order to protect and plan, good understanding of waves, their energy and characteristics is needed

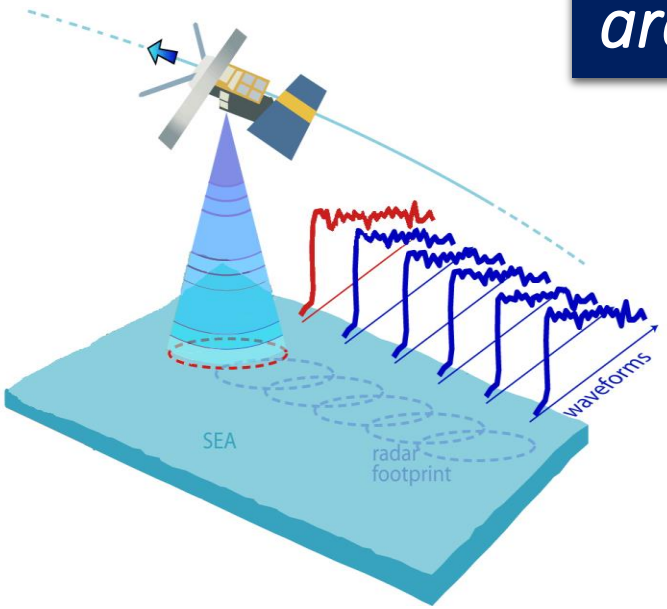


In-situ instruments

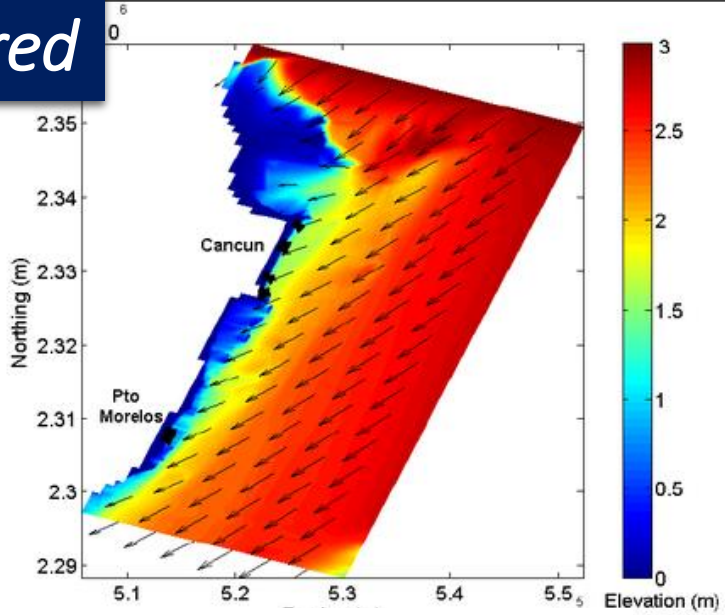
Synthetic Aperture Radar



How waves are measured



Satellite Radar Altimetry



Wave Models

Aim of this research

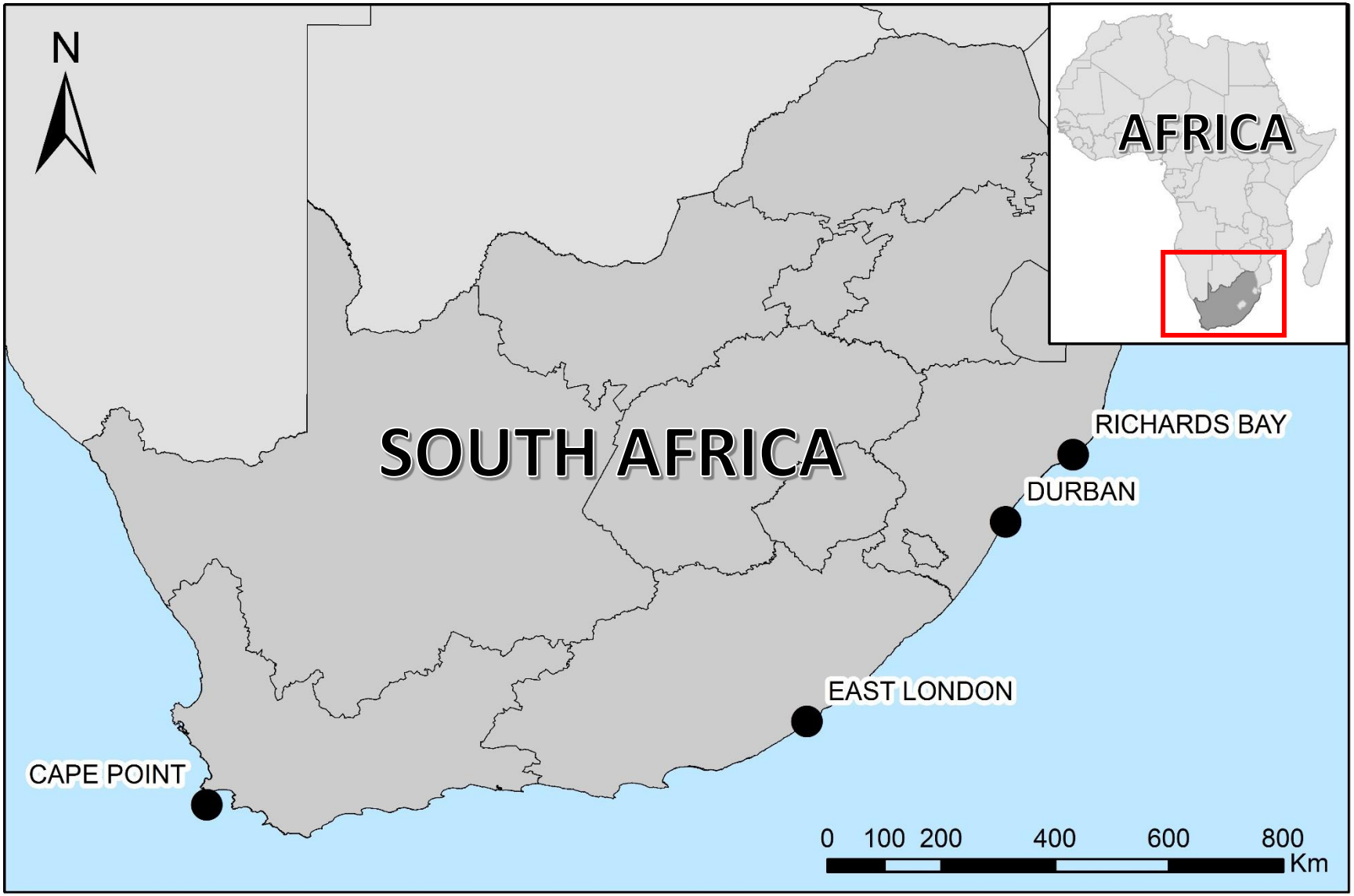
Extract wave characteristics such as:

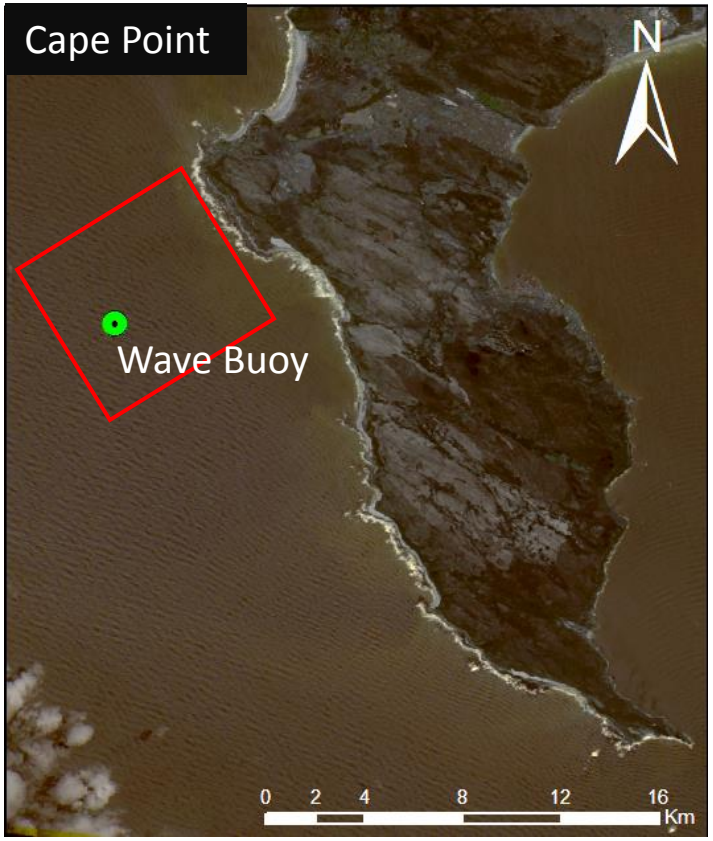
- Wave direction
- Wavelength
- Wave period
- Wave phase velocity

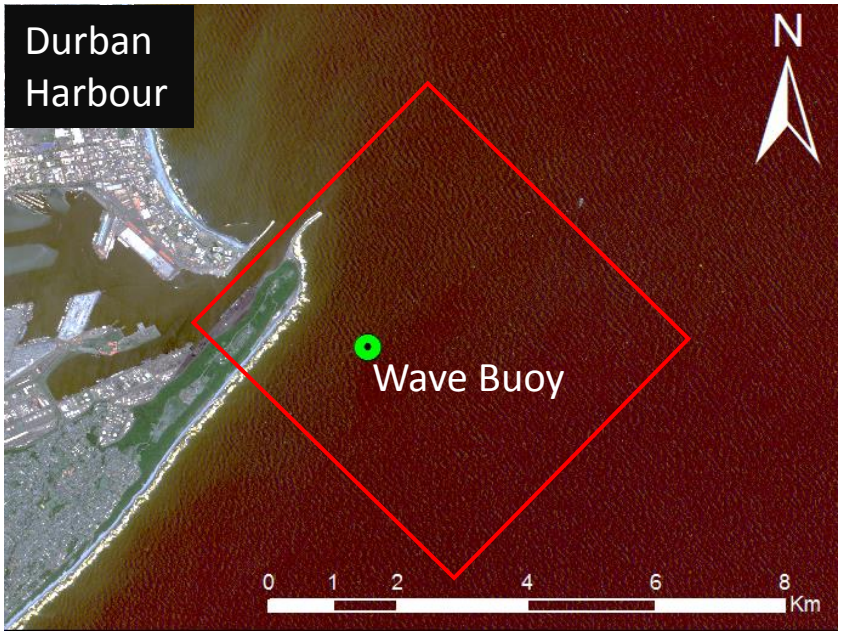
Approach 1: Extract 2D wave spectra using FFT for single band image

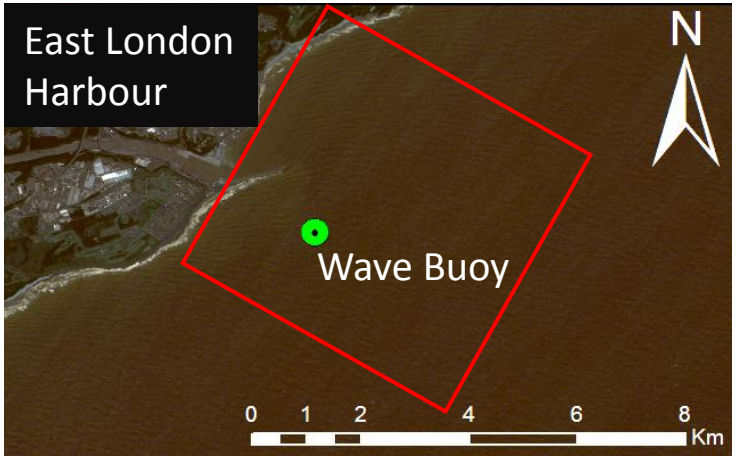
Approach 2: Extract phase velocity field from two single band images

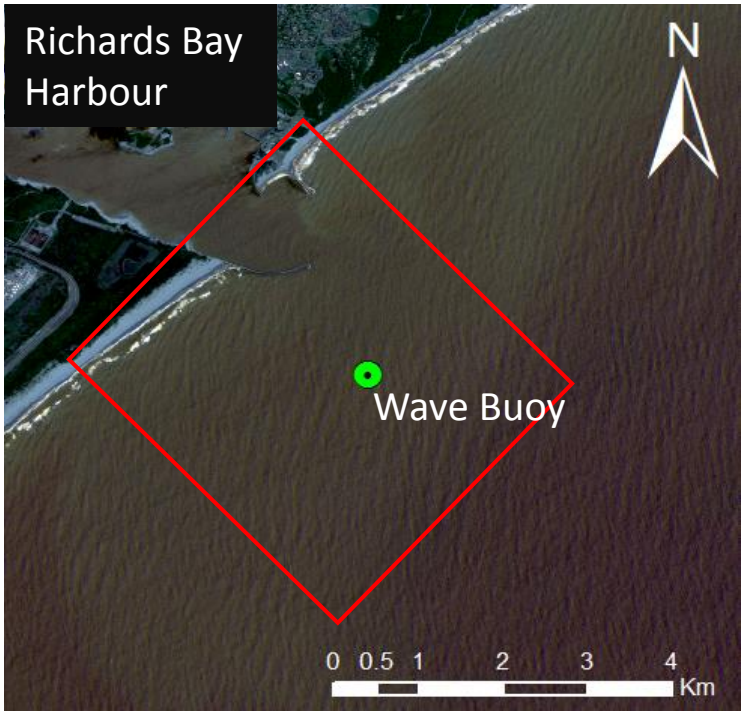
Study areas


N
AFRICA
SOUTH AFRICA
RICHARDS BAY
DURBAN
EAST LONDON
CAPE POINT
0 100 200 400 600 800
Km


Cape Point
N
Wave Buoy
0 2 4 8 12 16
Km

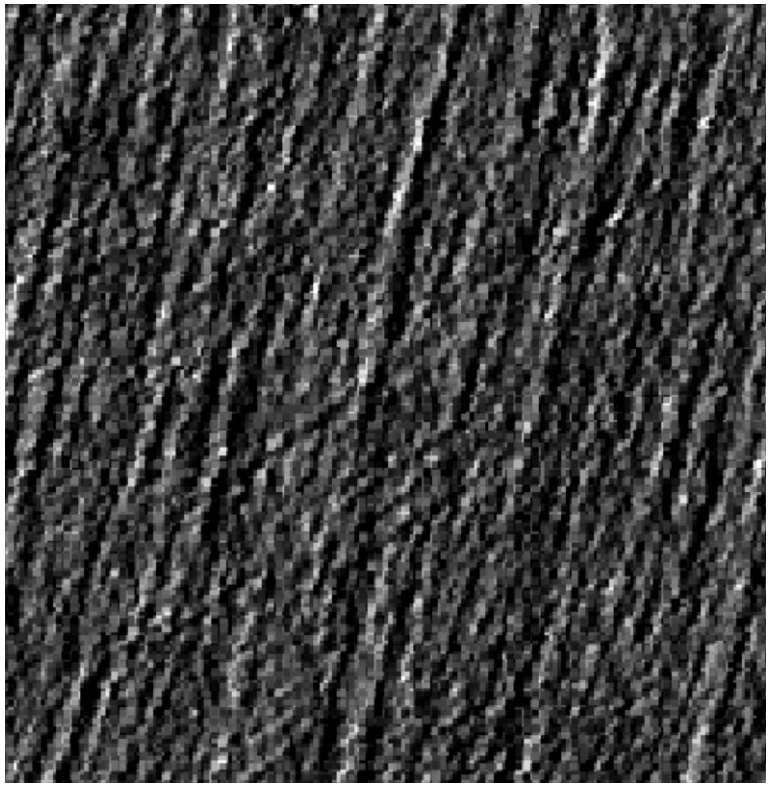

Durban Harbour
N
Wave Buoy
0 1 2 4 6 8
Km


East London Harbour
N
Wave Buoy
0 1 2 4 6 8
Km

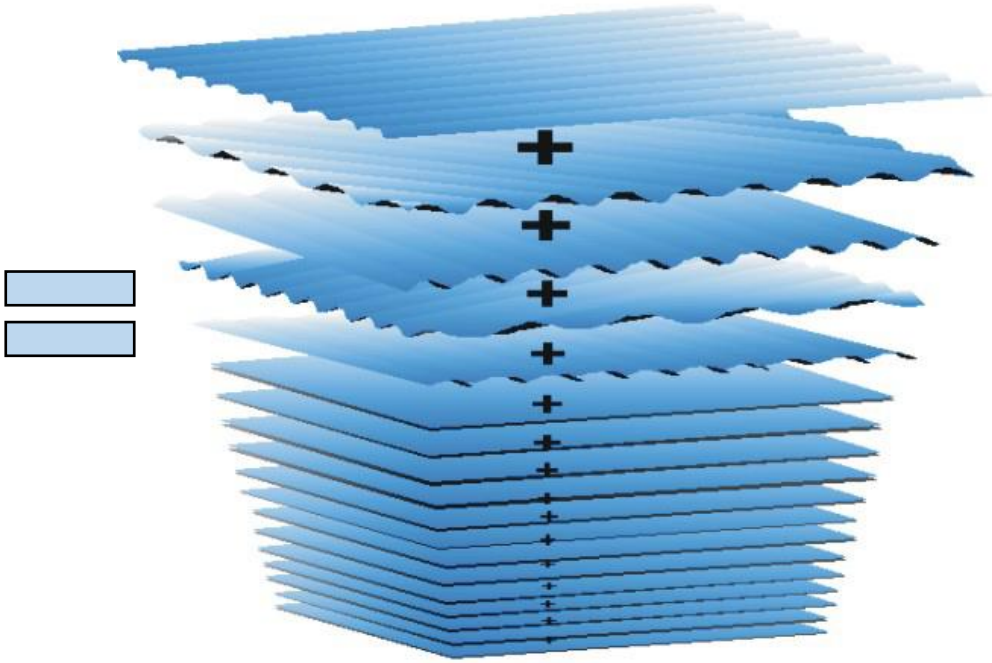

Richards Bay Harbour
N
Wave Buoy
0 0.5 1 2 3 4
Km

Approach 1: Extracting the wave spectra

Sea state



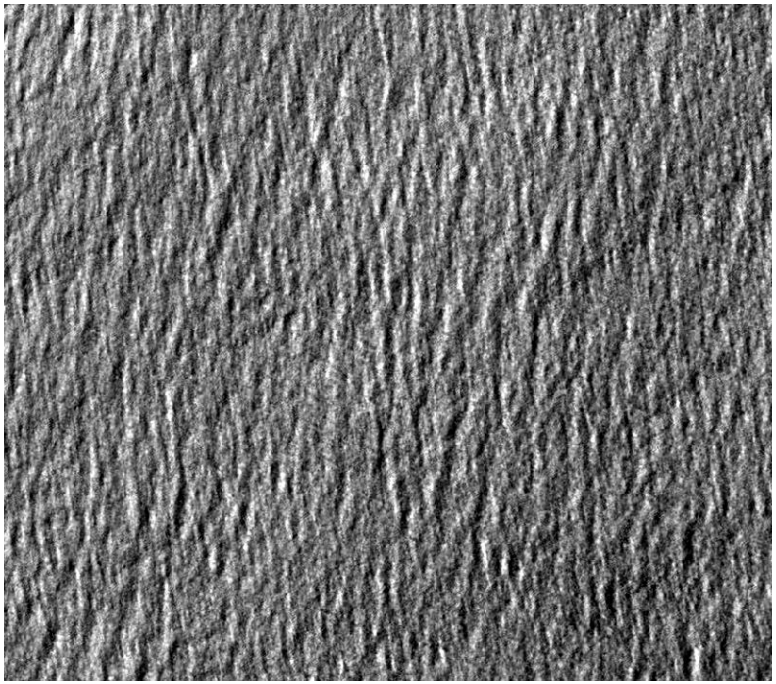
Number of harmonic wave components



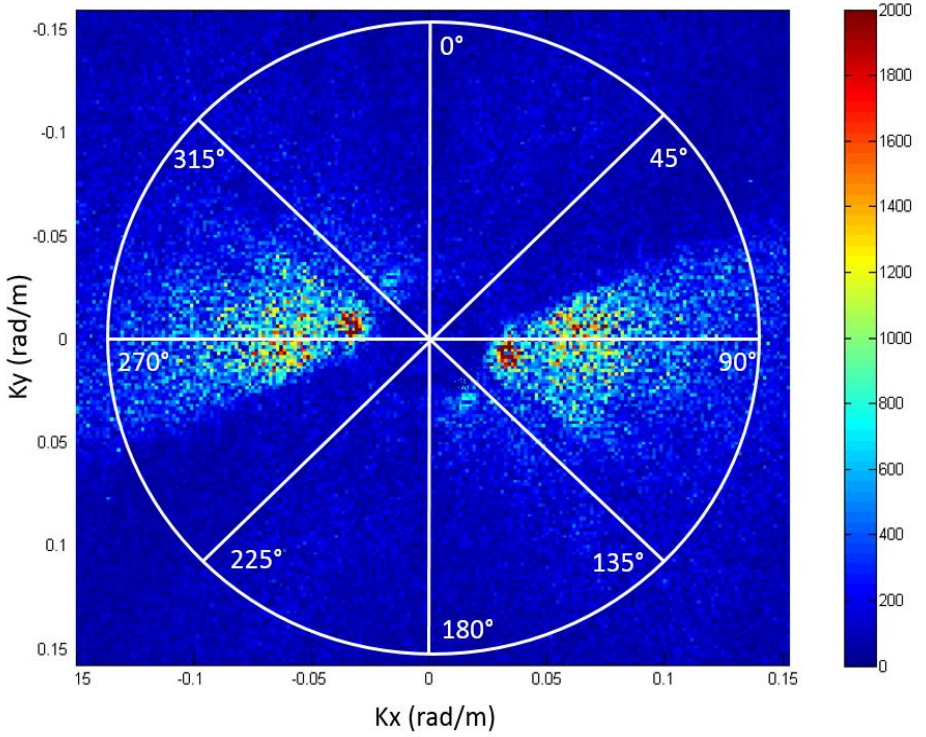
Approach 1: Extracting the wave spectra

Fast Fourier Transform the NIR image

NIR band

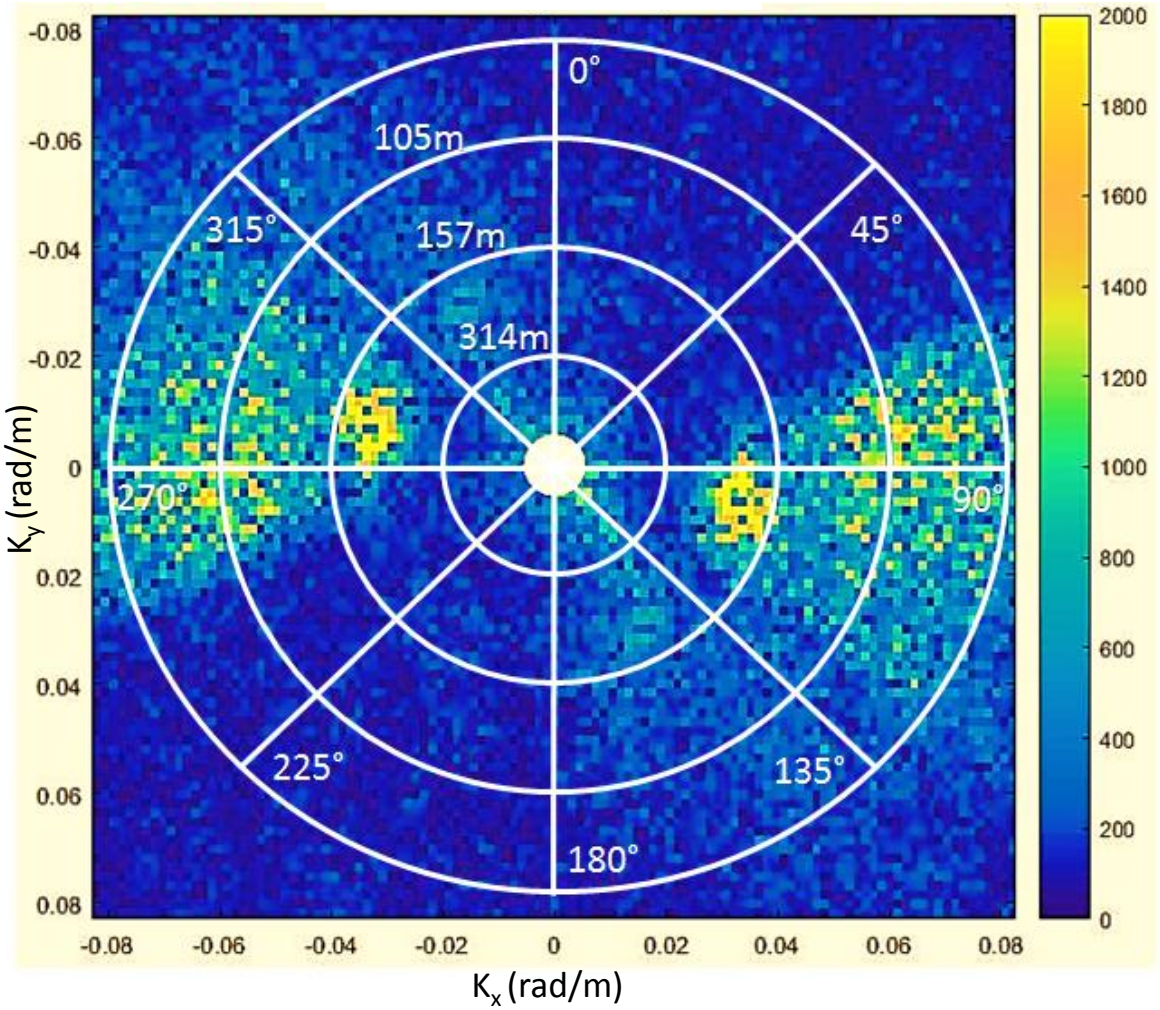


2-D image spectrum



Approach 1: Extracting the wave spectra

2-D image spectrum



Wavelength

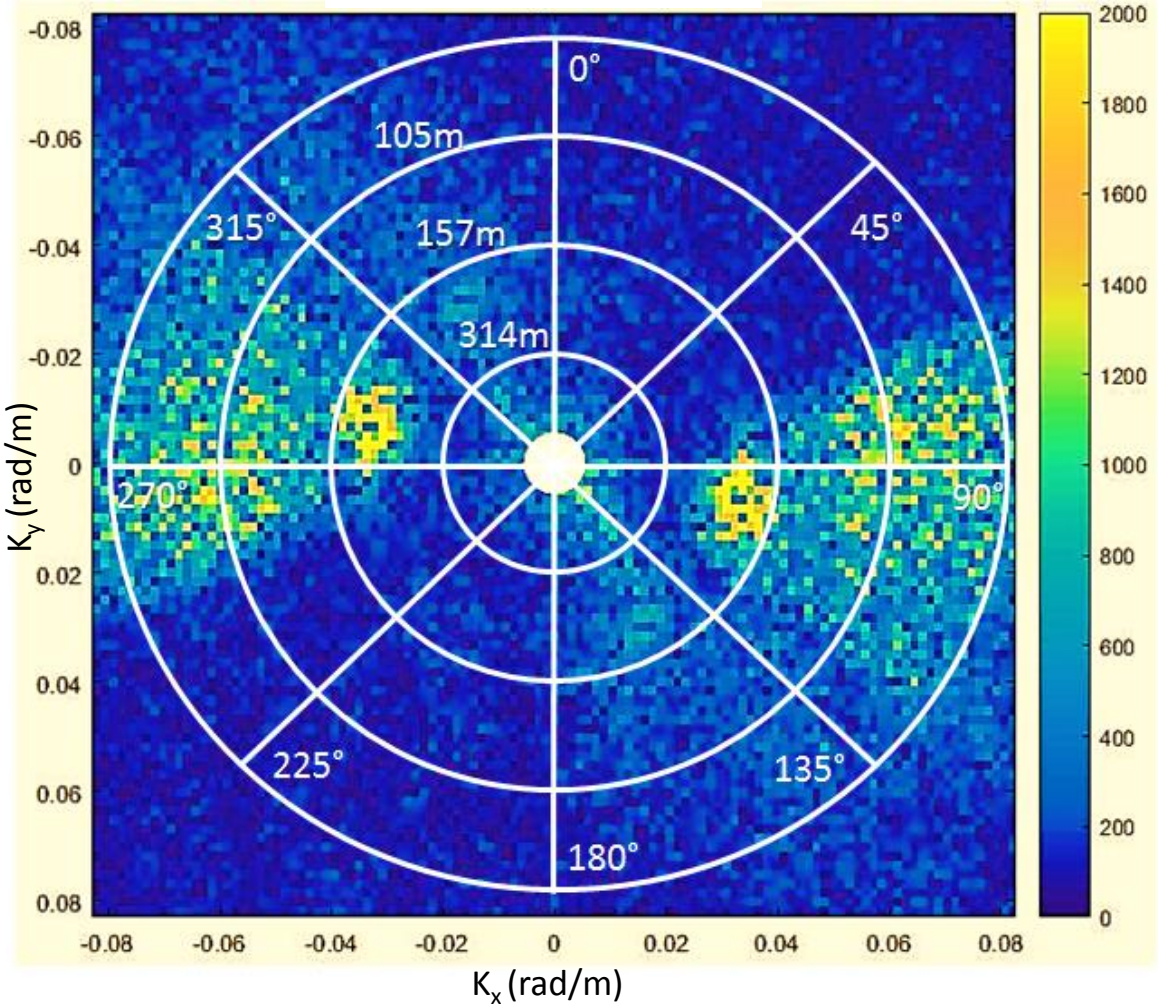
$$\frac{2\pi}{\sqrt{{K_x}^2 + {K_y}^2}}$$

Wave Direction

$$\arctan\left(\frac{K_y}{K_x}\right)$$

Approach 1: Extracting the wave spectra

2-D image spectrum



Wavelength

$$\frac{2\pi}{\sqrt{{K_x}^2 + {K_y}^2}}$$

Wave Direction

$$\arctan\left(\frac{K_y}{K_x}\right)$$

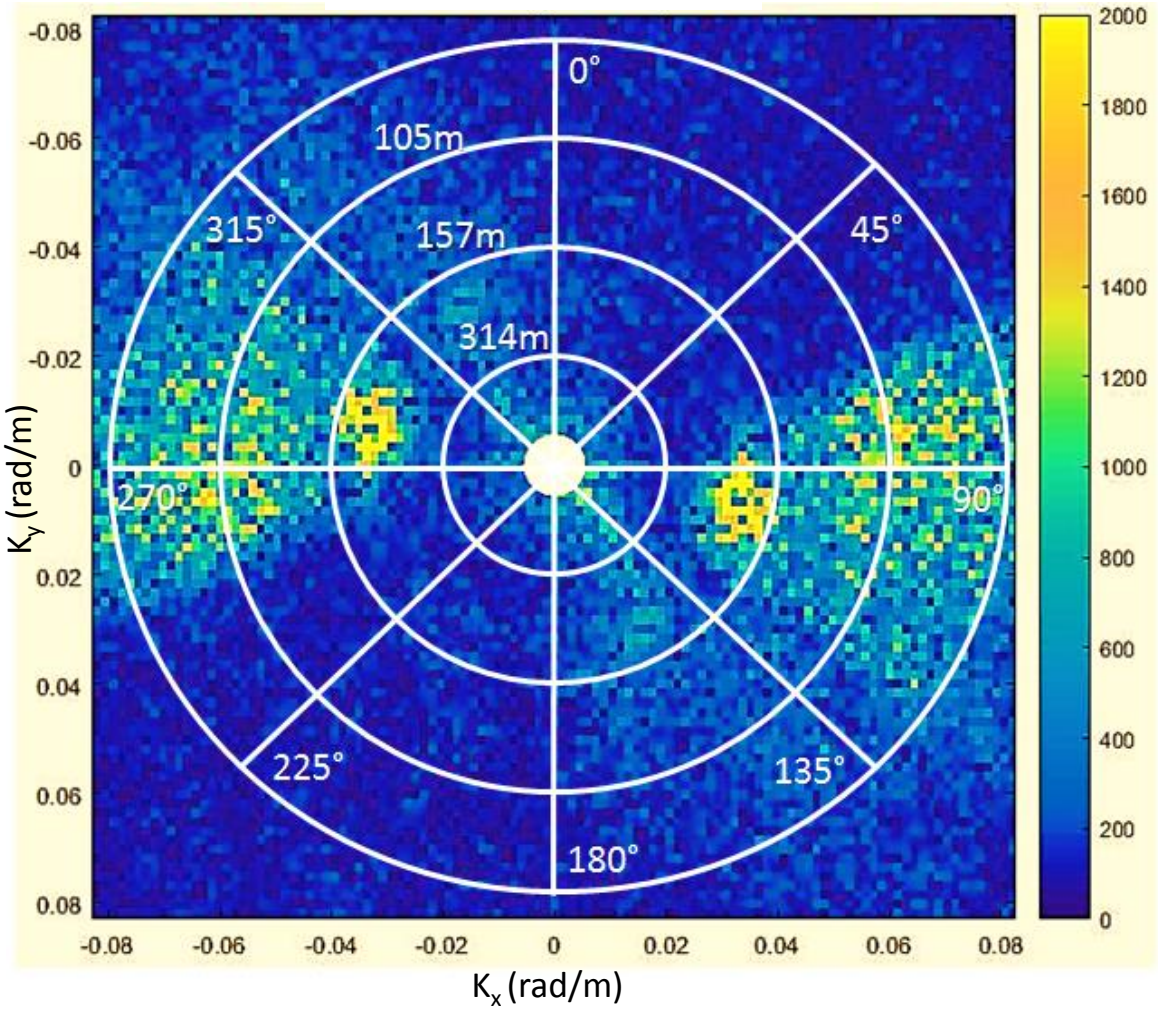
Parameters derived from Buoy

Wavelength = 202m

Wave direction = 106°

Approach 1: Extracting the wave spectra

2-D image spectrum



Wavelength

$$\frac{2\pi}{\sqrt{{K_x}^2 + {K_y}^2}}$$

Wave Direction

$$\arctan\left(\frac{K_y}{K_x}\right)$$

Parameters derived from spectrum

Wavelength = 197.1m

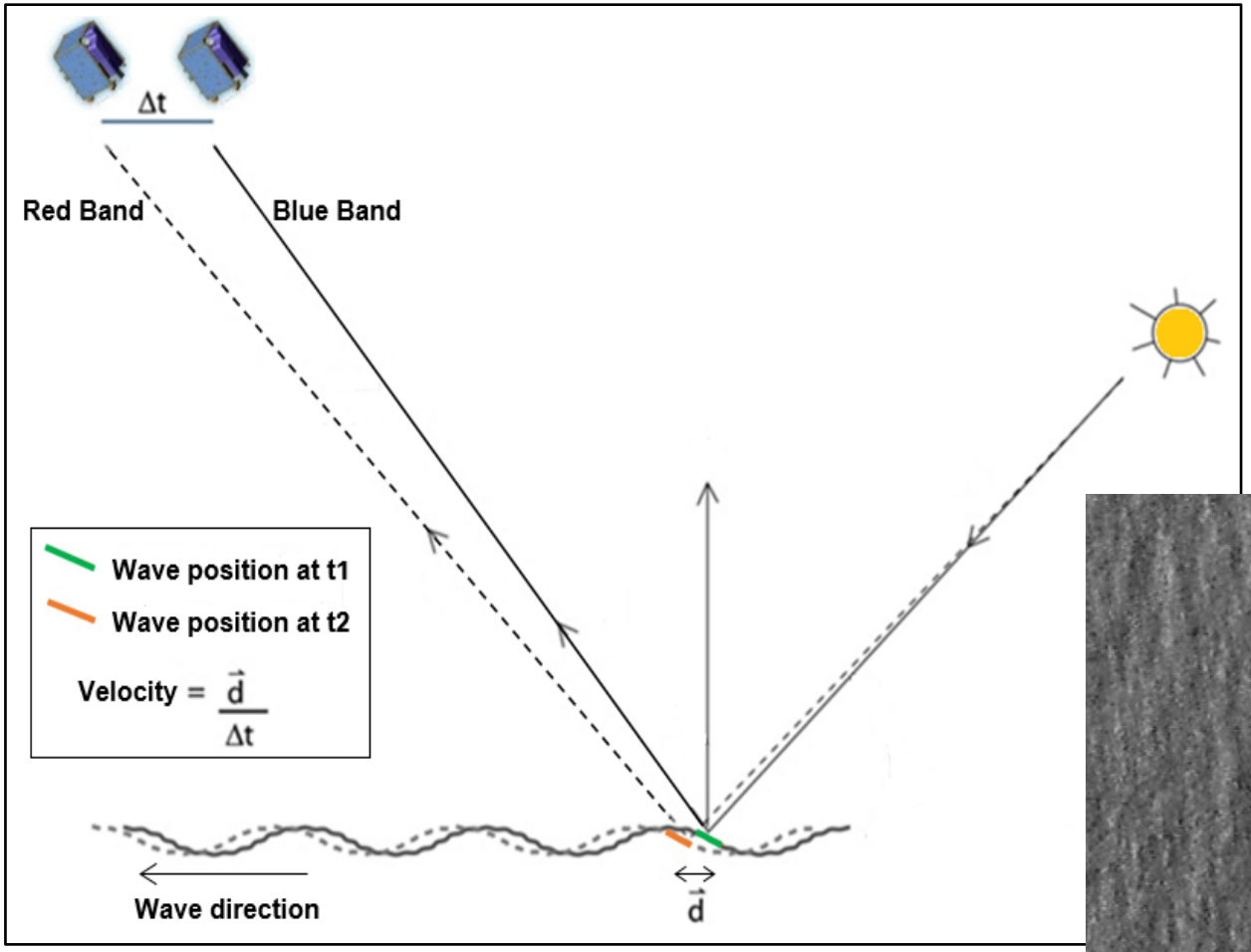
Wave direction = 105.2°

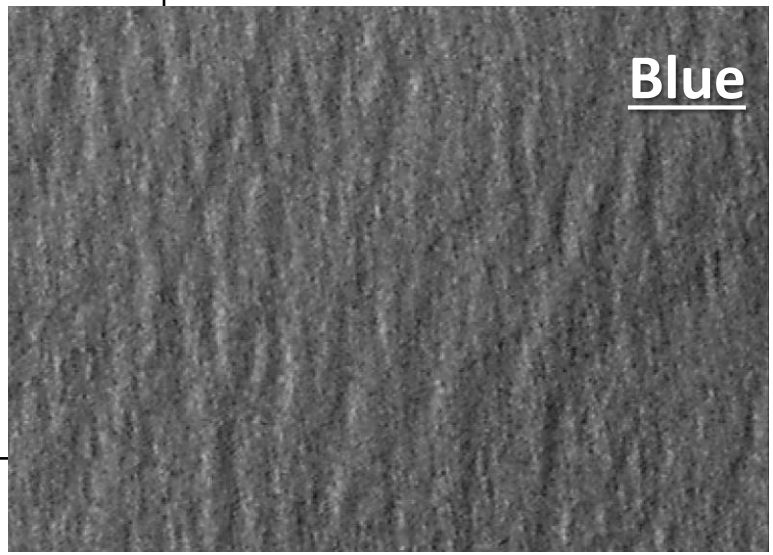
Parameters derived from Buoy

Wavelength = 202m

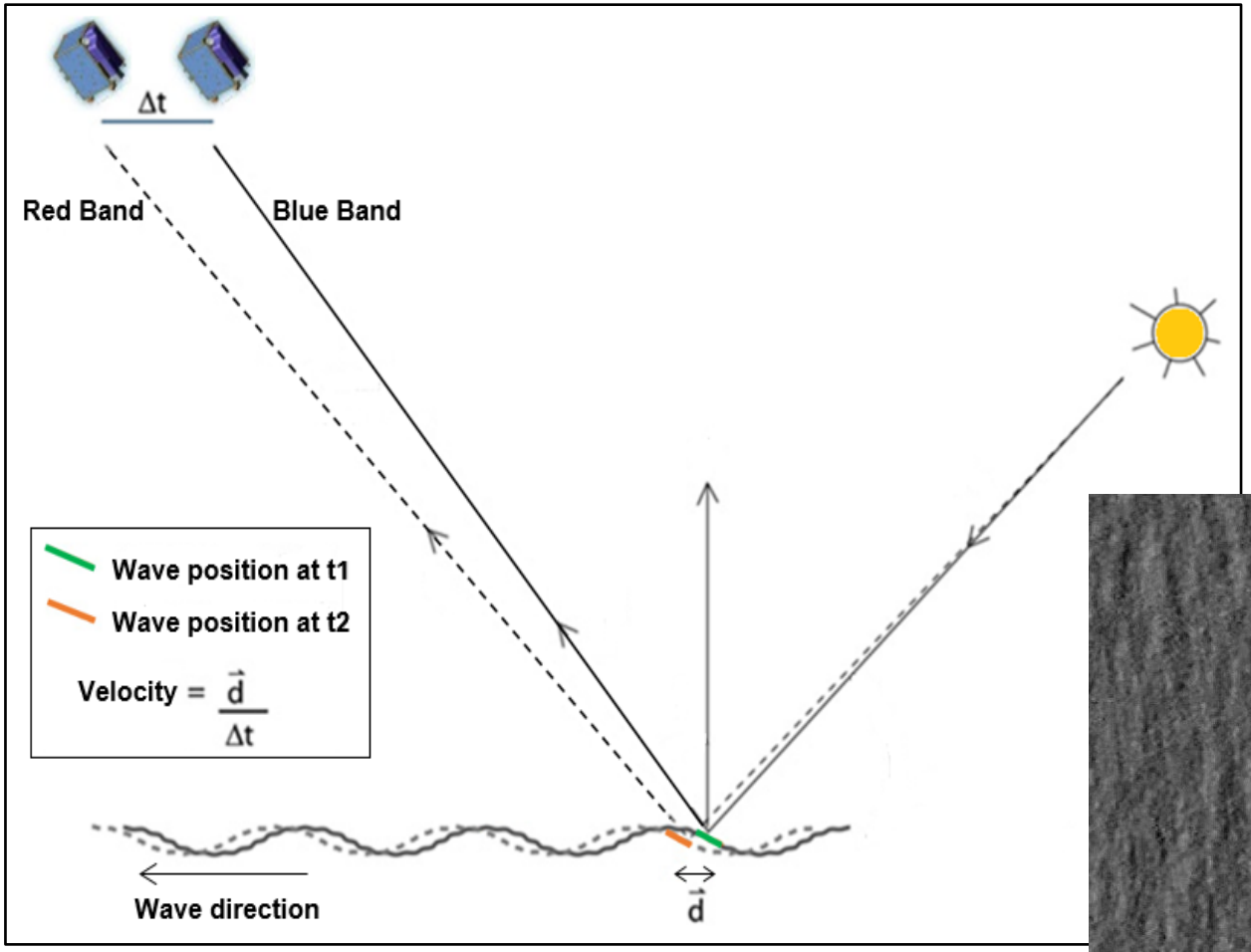
Wave direction = 106°

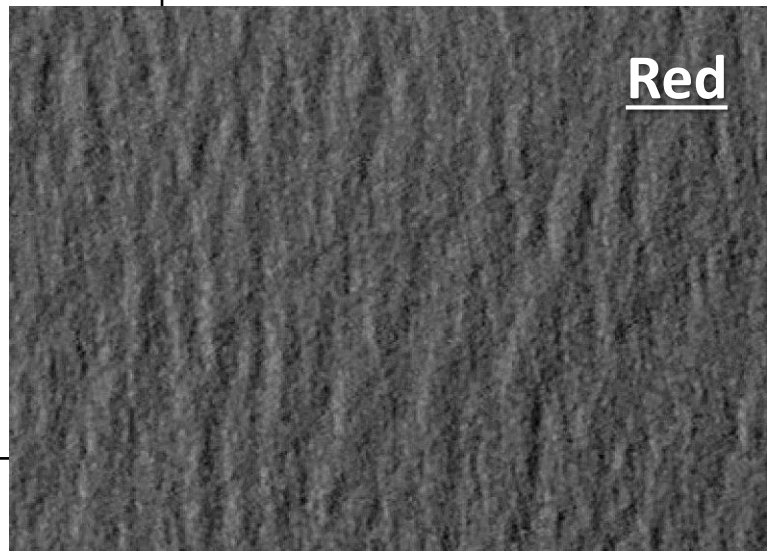
Approach 2: Extracting phase velocity field from RapidEye





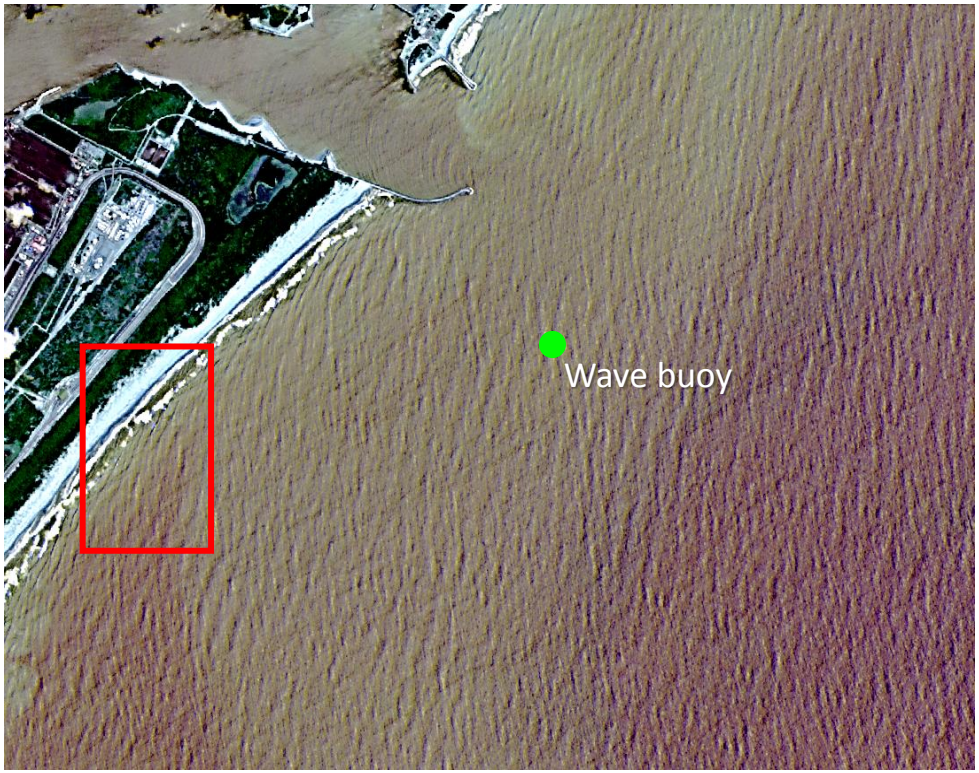
Approach 2: Extracting phase velocity field from RapidEye

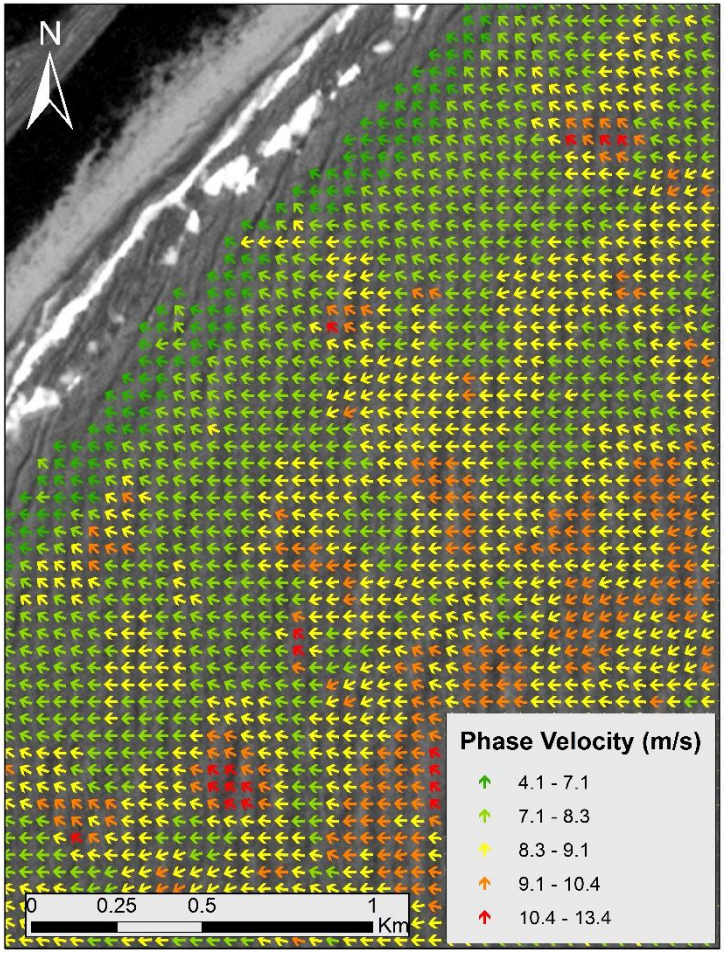




Approach 2: Extracting phase velocity field from RapidEye

Normalised cross correlation using CIAS software





Direction at buoy location	
Waverider Buoy	106°
Phase Velocity Field	104°

Conclusions

- Coastal wave direction, wavelength and phase velocity can be extracted from RE imagery (full validation pending)

- This could provide valuable input for understanding large scale near-shore wave characteristics
  - Used coastal modelling, protection & planning

- Way forward
  - Apply to other three study sites
  - Perform full accuracy assessment

Thank You

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