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JB Pacific – Extreme Weather Engineering
Wave Modelling Summary with the Australian Water School

jbpacific.com.au

JB Pacific

Agenda

1) Coastal Training with AWS
2) Why model the coast
3) Waves!
4) Wave modelling

Coastal Training with AWS

Coming up: Wave modelling using SWAN

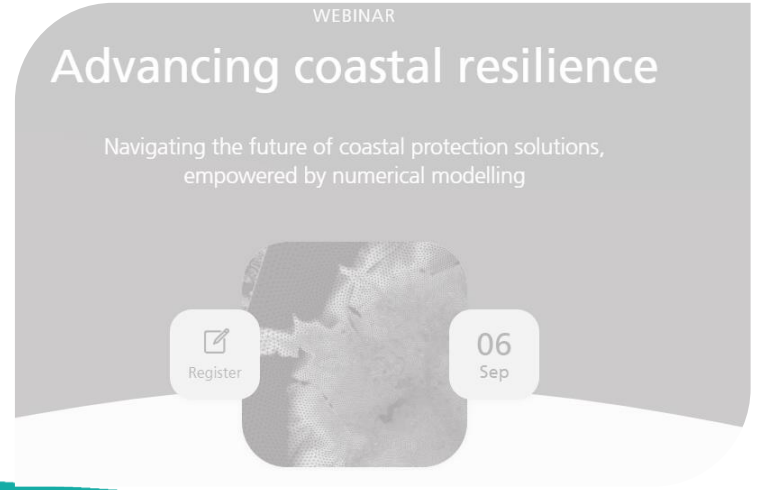
https://awschool.com.au/training/swan-wave-modelling/

- 3x hands-on interactive sessions including tutorials
- Step-by-step guidance to develop wave models for real-world applications.
- Case study in Fiji (Savusavu)

Past: Advancing coastal resilience (free webinar):

https://awschool.com.au/training/advancing-coastal-resilience/

- Coastal modelling (JB Pacific)
- Physical modelling (Ben Modra)
- Webinar Q&A: Advancing coastal resilience



Coastal Training with AWS

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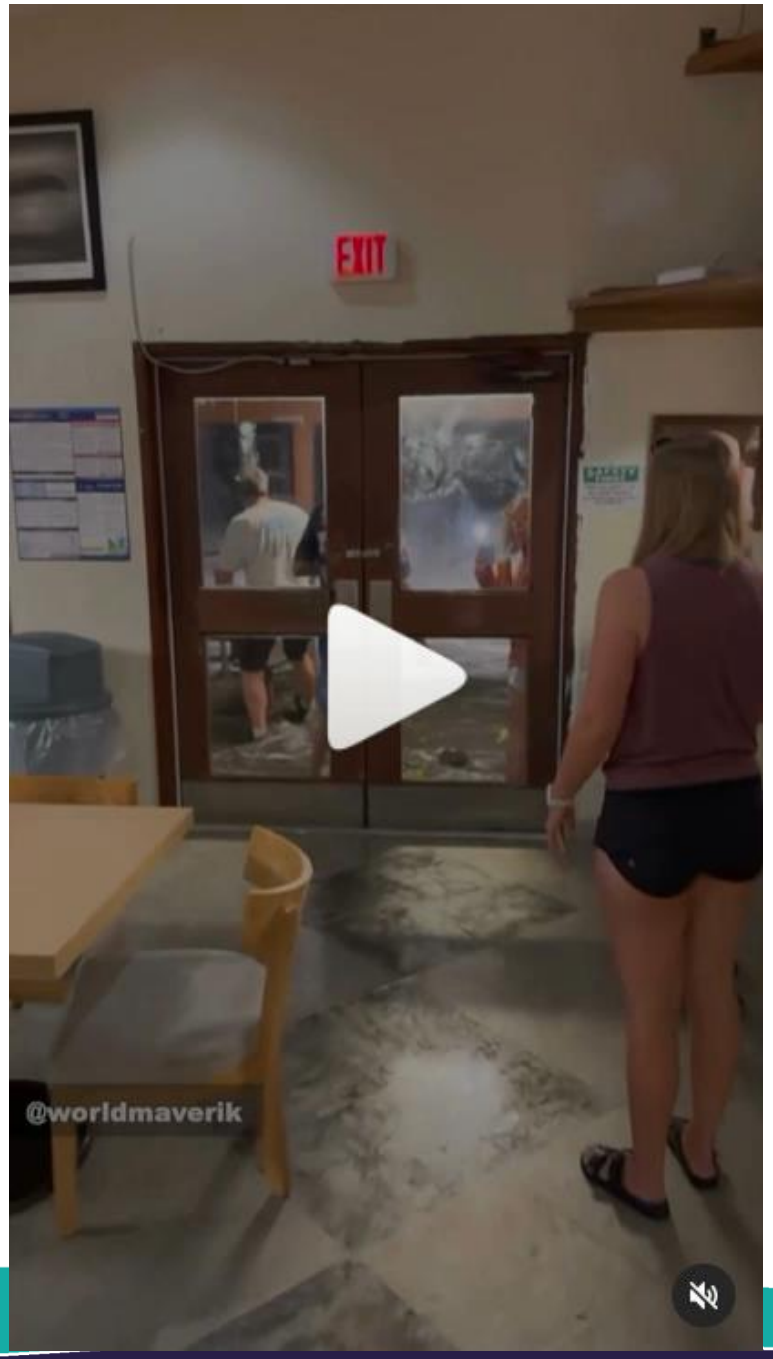
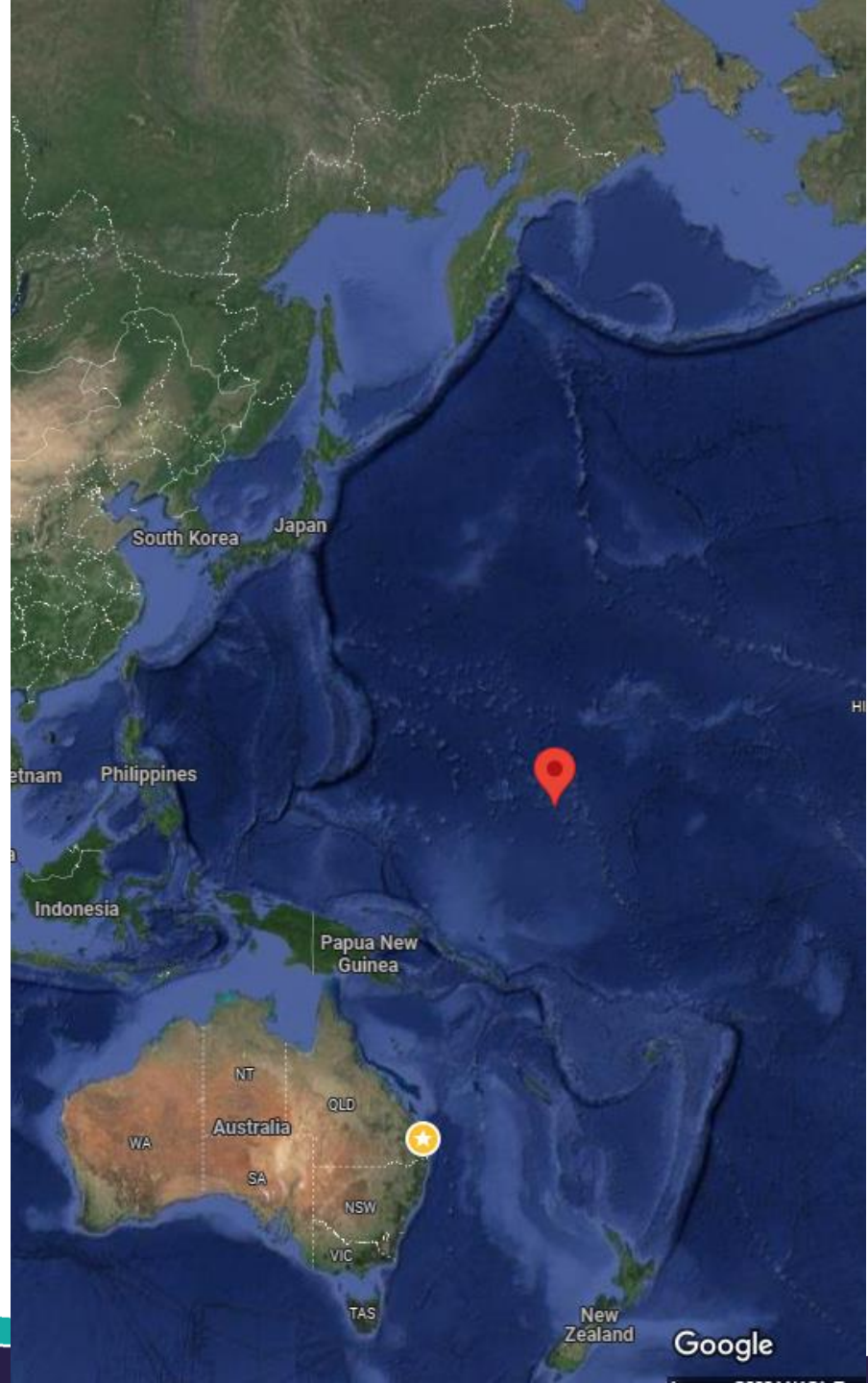
Why model the coast?



January 2024

Roi-Namur Island,
Marshall Islands

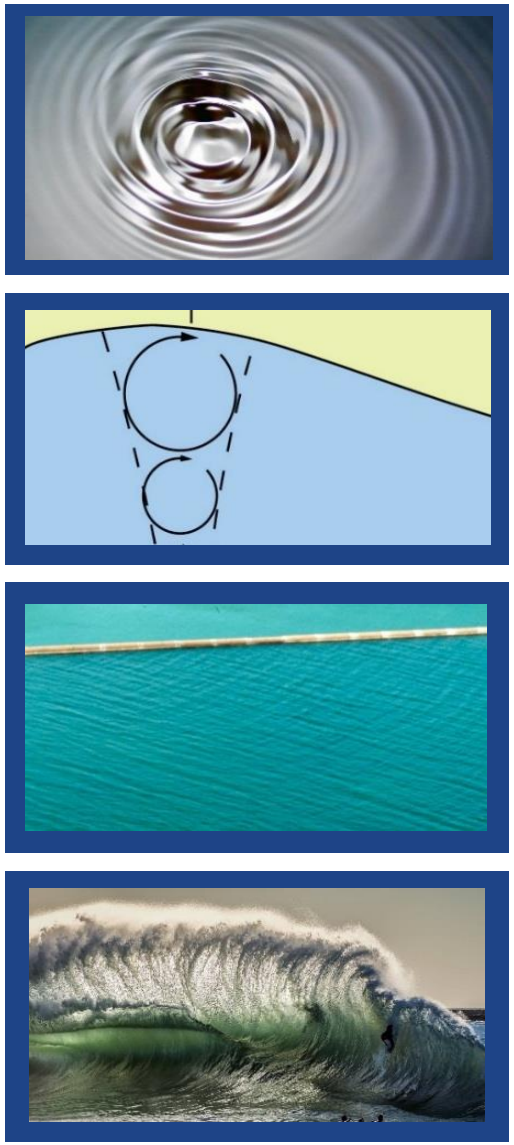


https://www.instagram.com/p/C2YybKOLsOn/

Waves!

What is a wave?

- A disturbance of the water surface that propagates in time and space
- They transmit energy but not mass*
- Their behaviour depends on size and depth
- They can:
  - Change direction (refraction, diffraction)
  - Reflect from solid objects
  - Interact with one another



Waves!

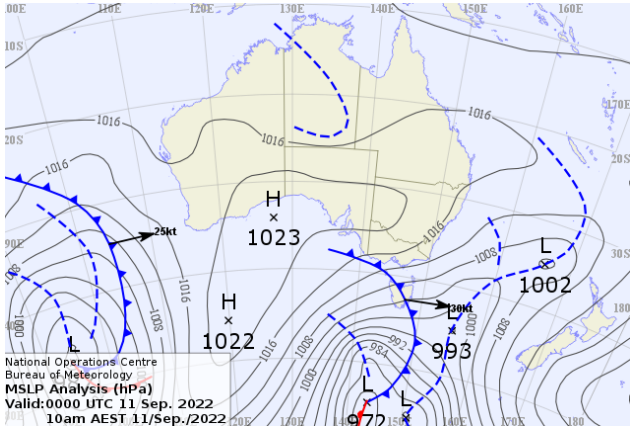
Waves come in a variety of shapes and sizes, not always harmful

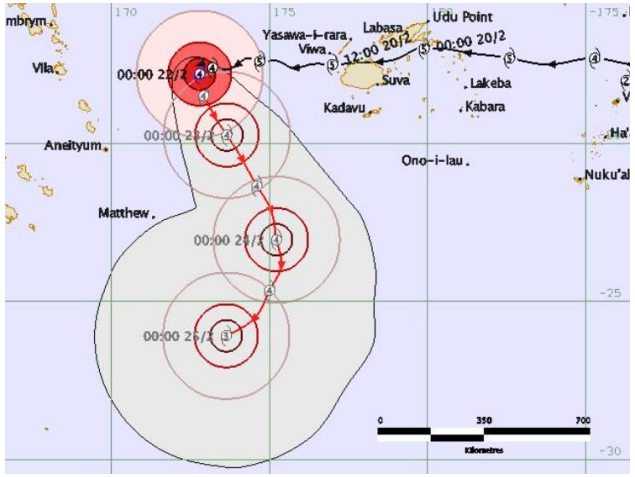
Type of wave	Typical period (s)	Driving force
Tide	12 hours	Moon and sun
Tsunami	3 hours	Earthquake
Seiches	20 minutes	Weather front
Surfbeat	2 minutes	Wave groups
Swell	8 – 30 seconds	Distant storms
Wind waves	2 -8 seconds	Wind
Capillary waves	0.1 seconds	Wind turbulence

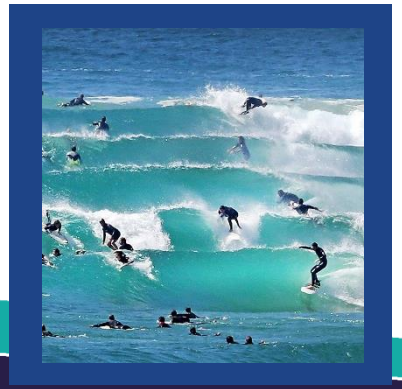
Waves!

Generation of wind waves

- Generated by the transfer of energy from wind
- Wind speed > 0.24m/s to overcome tension
- Initially creates ‘catspaws’ and ripples
- Eventually combine to create a regular wave crest pattern







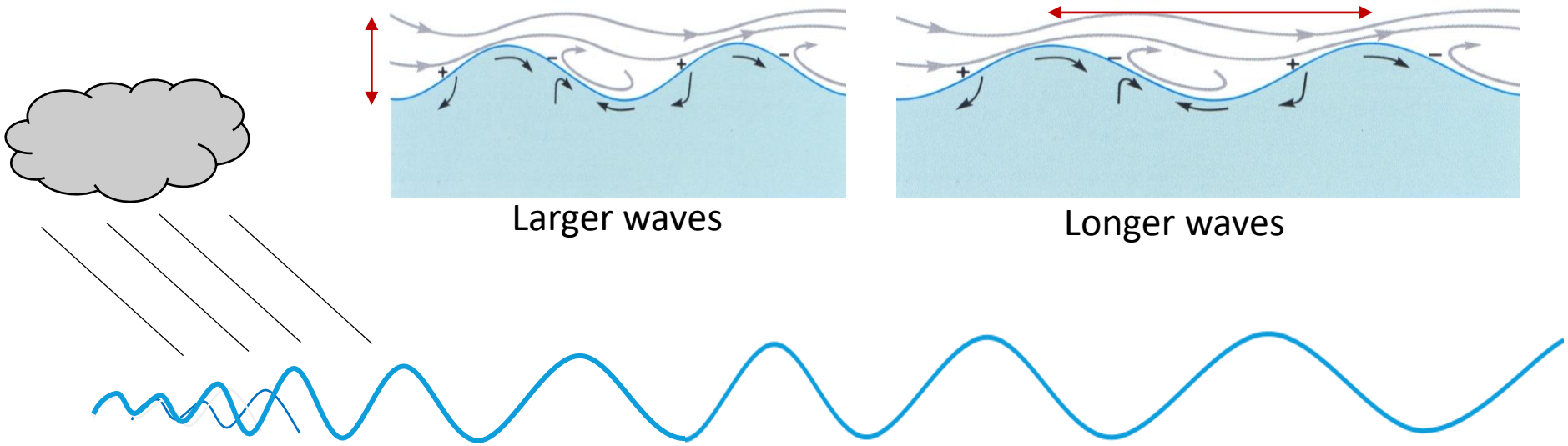
Waves!

Waves!

Wave conditions are initially controlled by the wind and fetch*

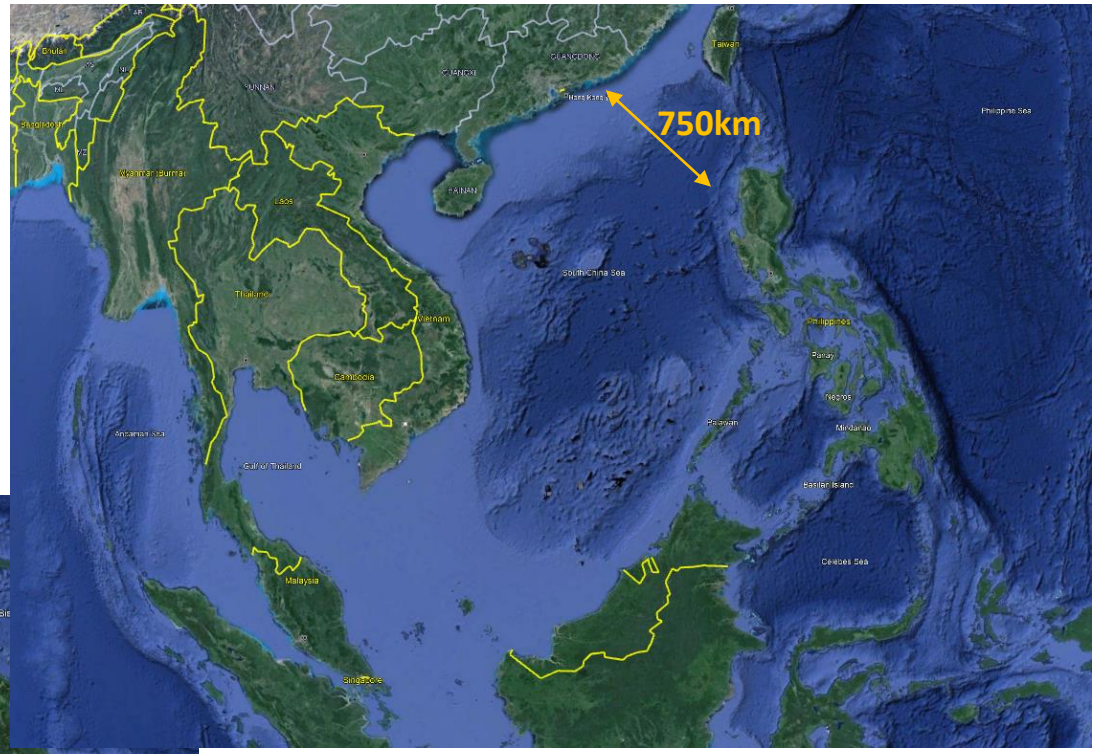
- Faster wind causes larger waves
- Prolonged wind causes longer waves*

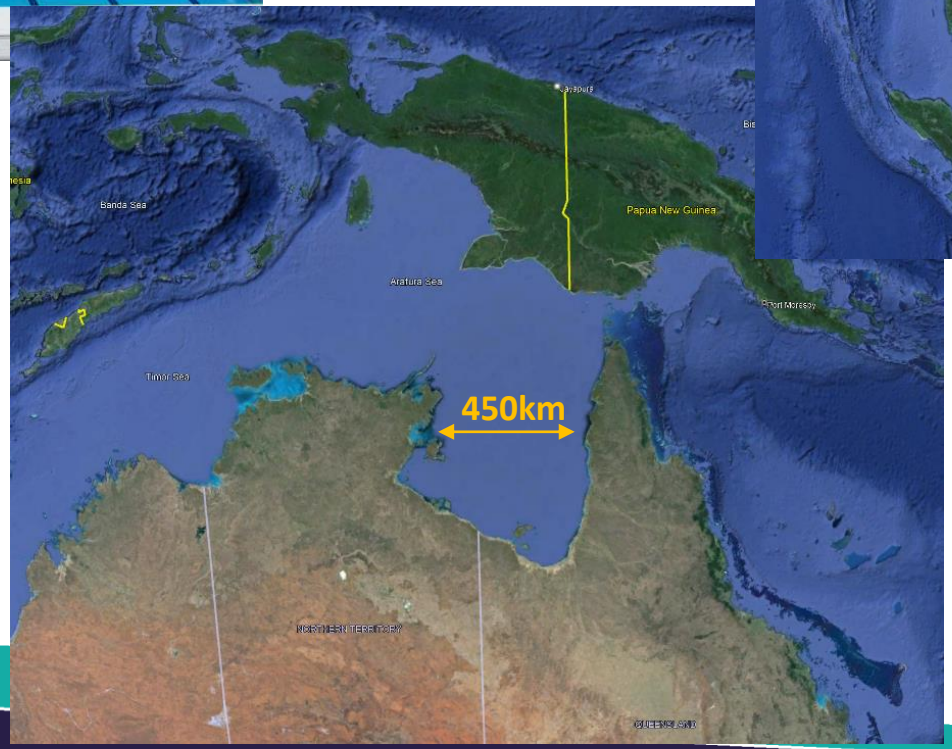
- *Fetch is the distance the wind blows over



Waves!


50m


750km
Philippine Sea
South China Sea
Thailand
Vietnam
Cambodia
Malaysia
Singapore
Celebes Sea


450km
Banda Sea
Papua New Guinea
Arafura Sea
Timor Sea

Waves!

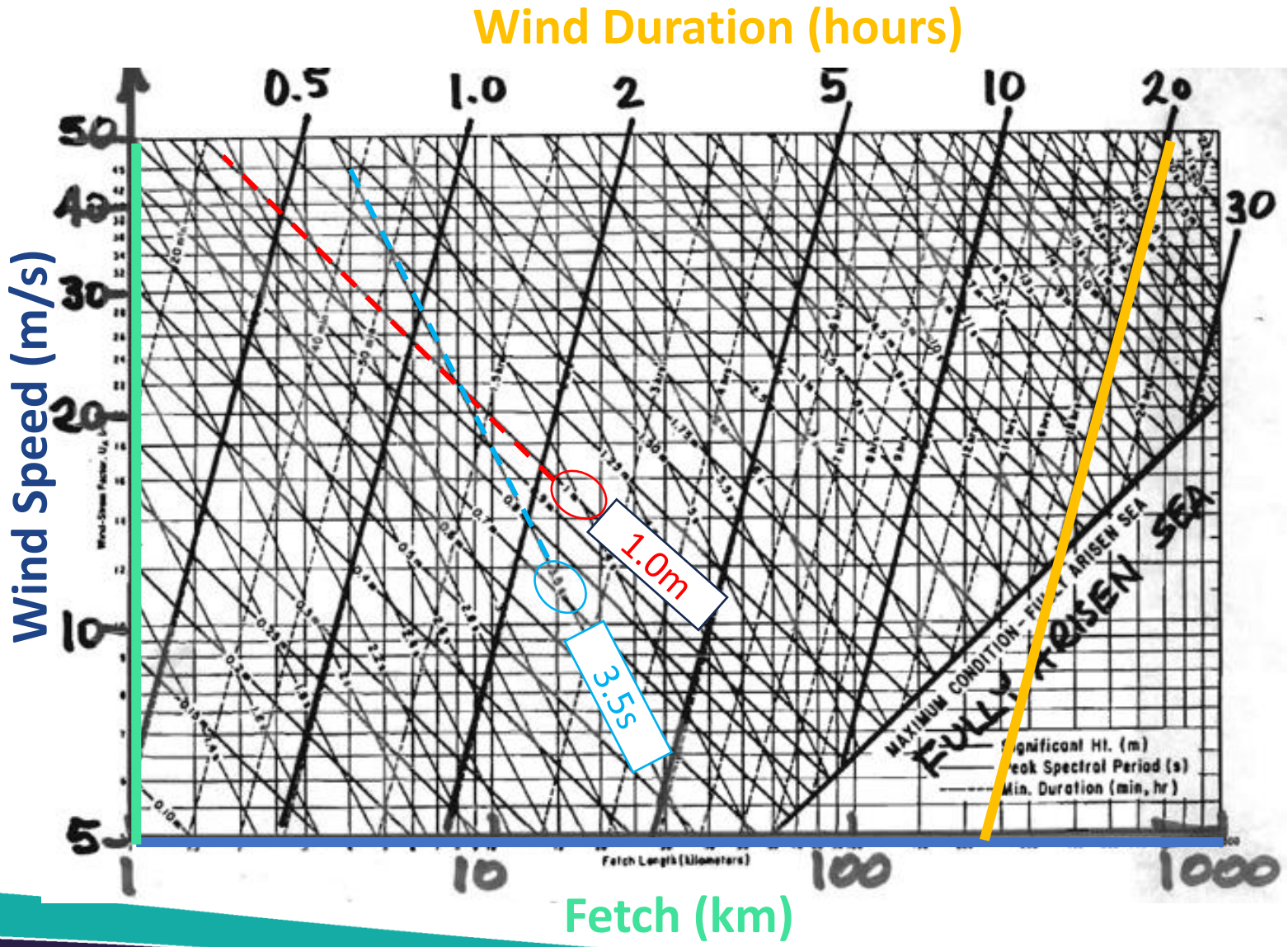

Taiwan
China
Hong Kong
Vietnam
South China Sea
Philippines

Waves!

Wave nomograph

- Visual calculator
- Steps:
  - Enter Wind Speed (m/s)
  - Enter Fetch (km)
  - Correct for Duration (h)

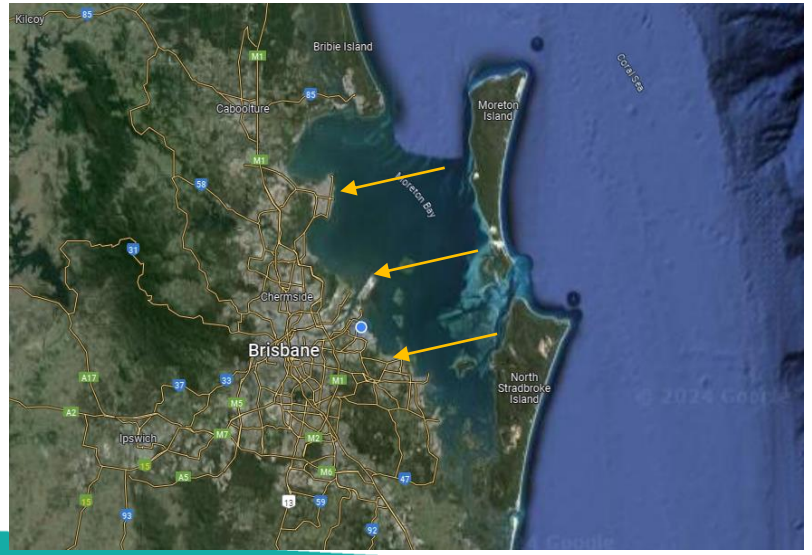
In this example, a 20 m/s wind, blowing over 10km fetch for 10.5h will generate a wave around 1m, 3.5s



Waves!

If wind blows for long enough, the wind waves turn into ‘swell’

- Wind Waves - locally generated waves (2 to ~ 8 seconds)
- Swell Waves – externally generated waves (~12 to 30 seconds)



Waves!

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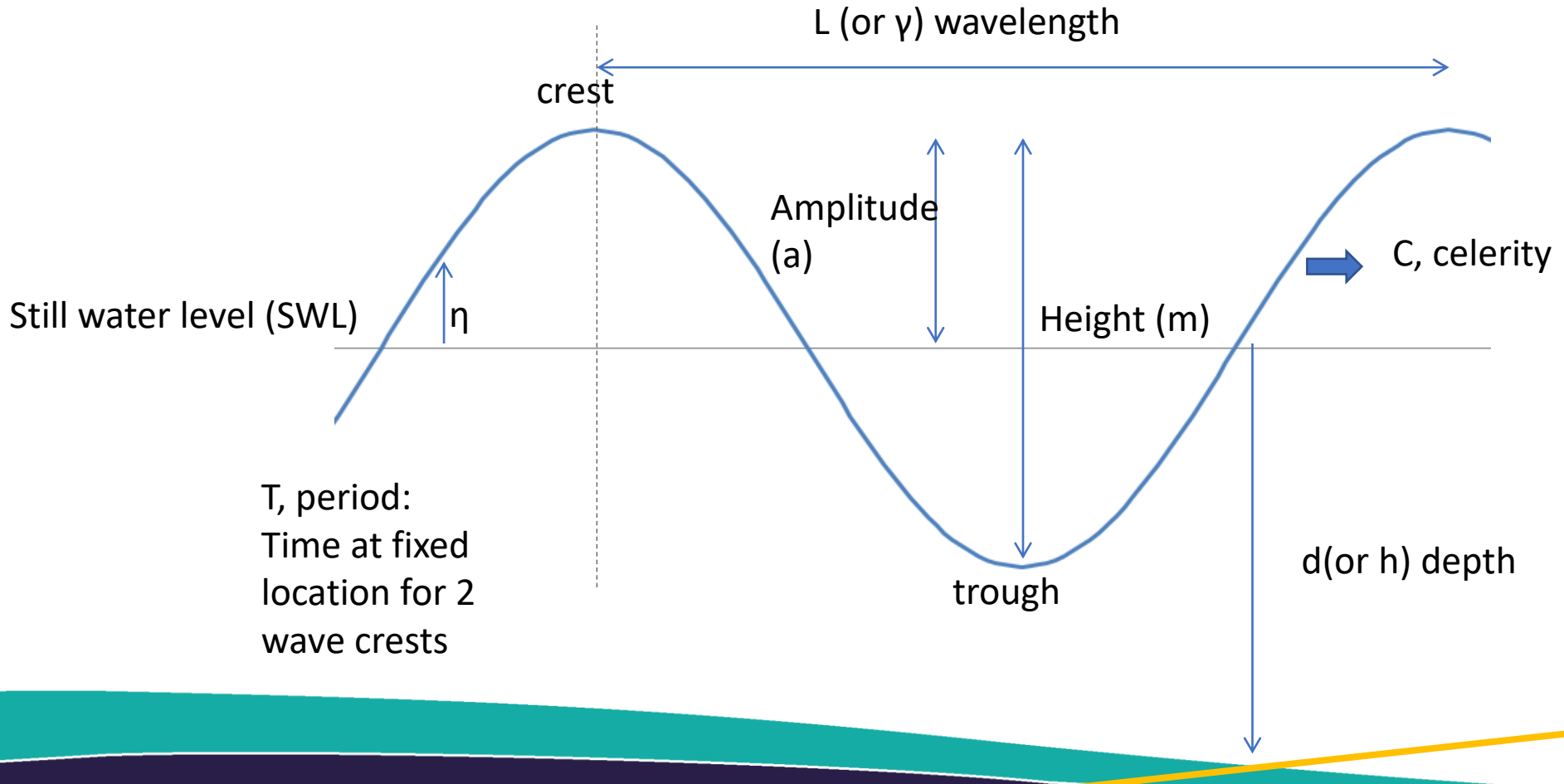
- Wind Waves - locally generated waves (2 to ~ 8 seconds)
- Swell Waves – externally generated waves (~12 to 30 seconds)

Long waves in California, Dec. 28, 2023.
https://www.youtube.com/watch?v=phUW3PK_ZRk

Waves!

Wave Height:
Vertical distance between a crest and the preceding trough



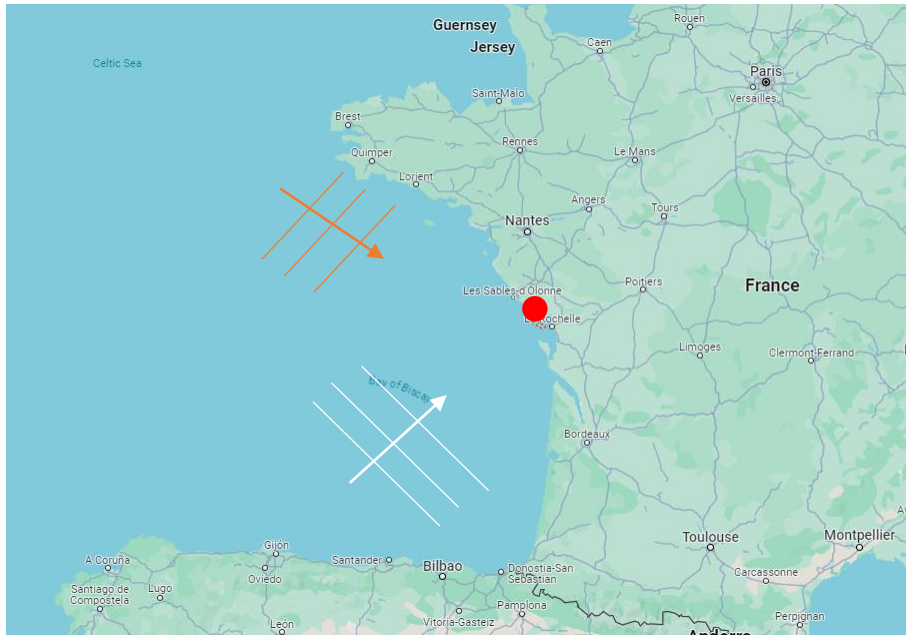
Waves!

What else can they can do?

- They can pass through each other
- They can interact
- They can get very big
- They can overtop

Waves!

- They can pass through each other
  - Île de Ré, France



Waves!

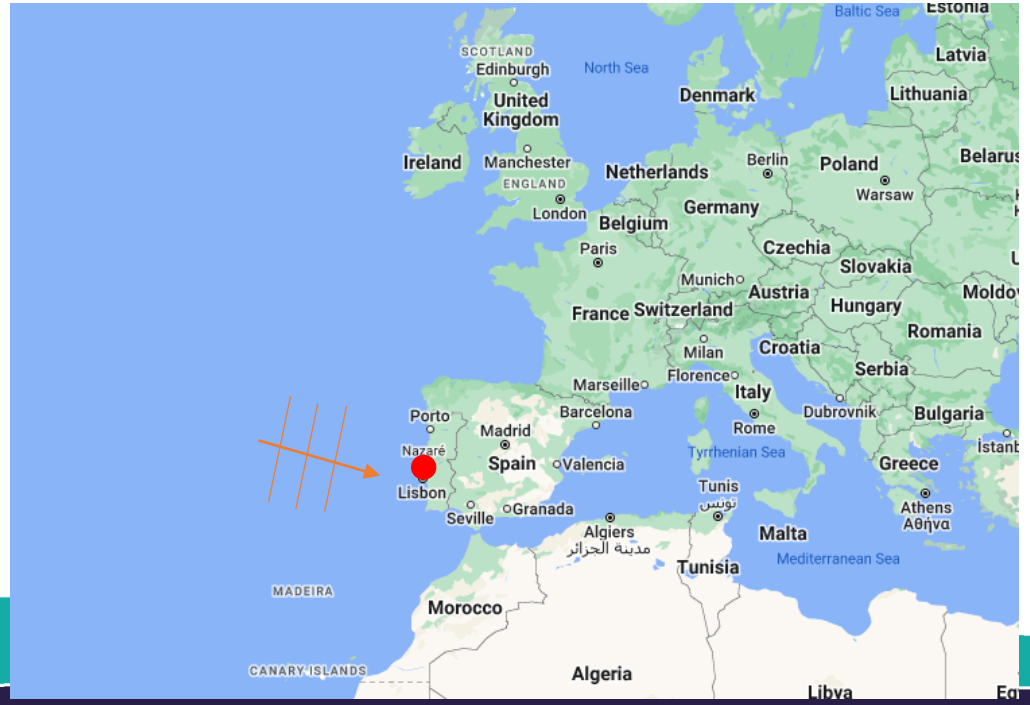
- They can interact

Adam Duffy photography
https://www.facebook.com/AdamDuffyPhotography/

https://www.youtube.com/watch?v=qOr3gwr7RJk

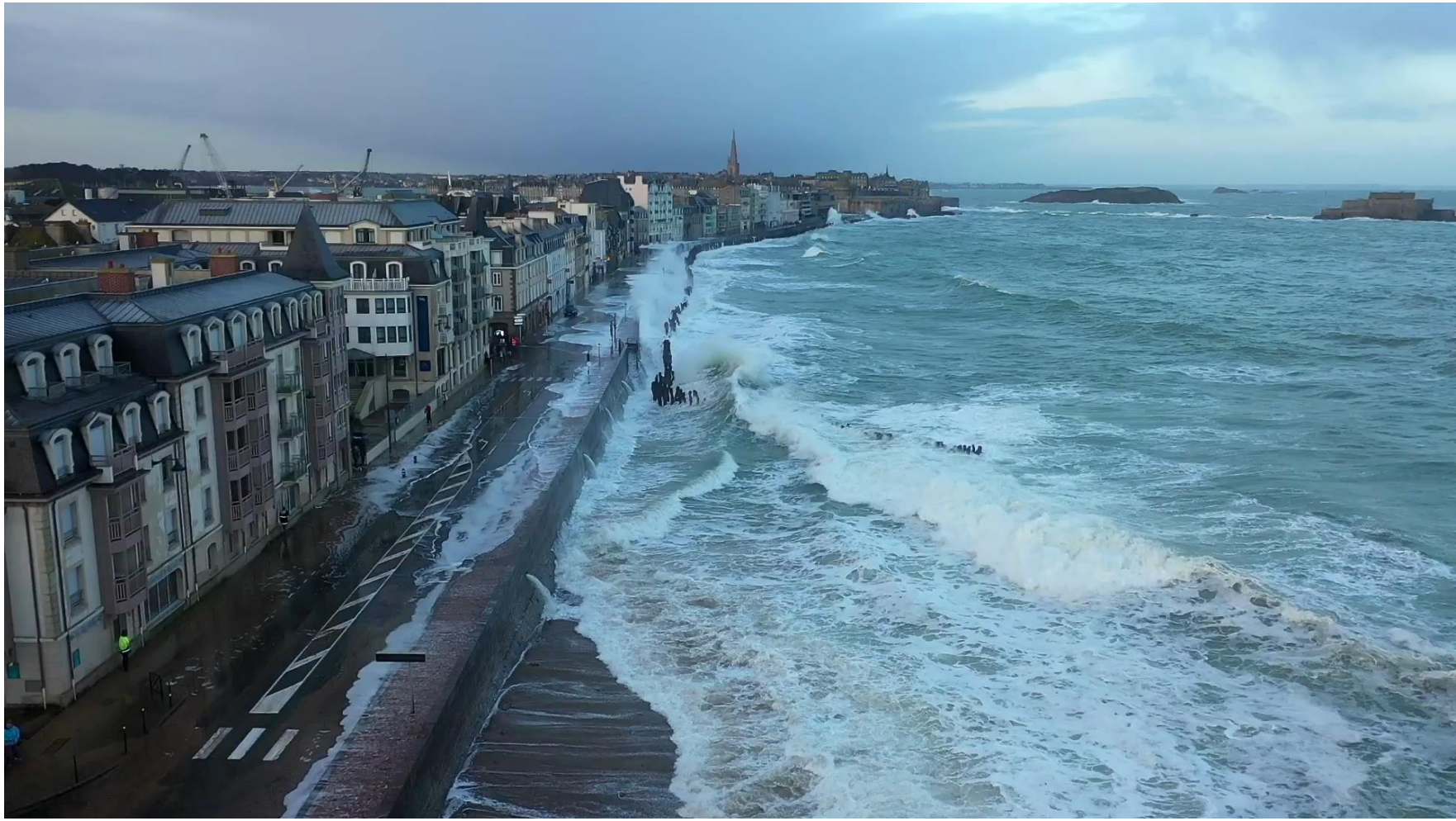
Waves!

- They can get very big
  - Sebastian Steudtner
  - Nazaré 2018
  - Biggest wave ever ridden?



Waves!

- They can overtop
  - Saint Melo, France 2020

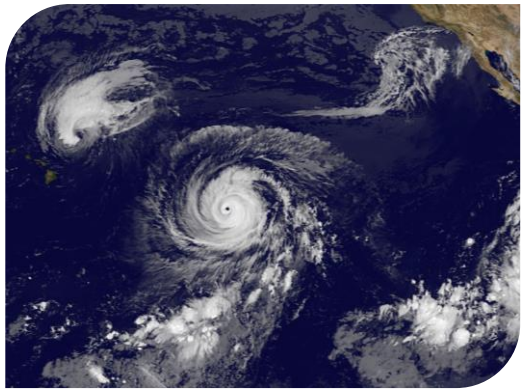


Why use coastal models?

1) Coastal extremes studies - waves, storm surges, cyclones

Our new course

2) Coastal processes – tides, currents, water levels
3) Sediment processes – sand estuarine dynamics, muddy coastlines,
4) Coastal designs and engineering
5) Nature based optioneering




Types of wave models

Wave models

- Phase (wave) averaging – spectral wave models like **SWAN**, MIKE SW
- Wave group resolving - XBeach
- Phase (wave) resolving – Xbeach, Mike Boussinesq wave, CFD

Key
Commercial
Free(ish)
Free, with New Training

Types of wave models

Wave models

- Phase (wave) averaging – spectral wave models like SWAN, MIKE SW

Typically used for medium to large scale assessments

They calculate the overall wave energy

Computations based on energy balance equations

Requires little understanding! Models are text-based, and can be as little as 20 lines.

Defines the project details

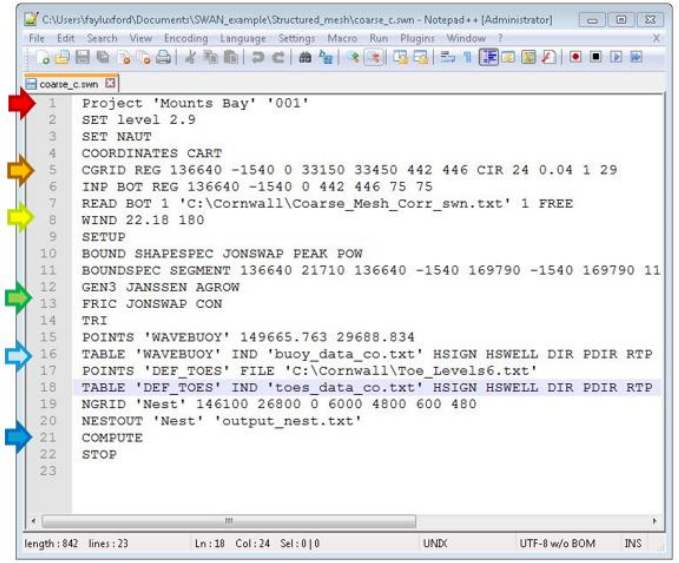
Defines the grid/bathy

Defines boundary conditions

Defines SWAN paramatres

Defines output points

Orders SWAN to run



Types of wave models

Wave models

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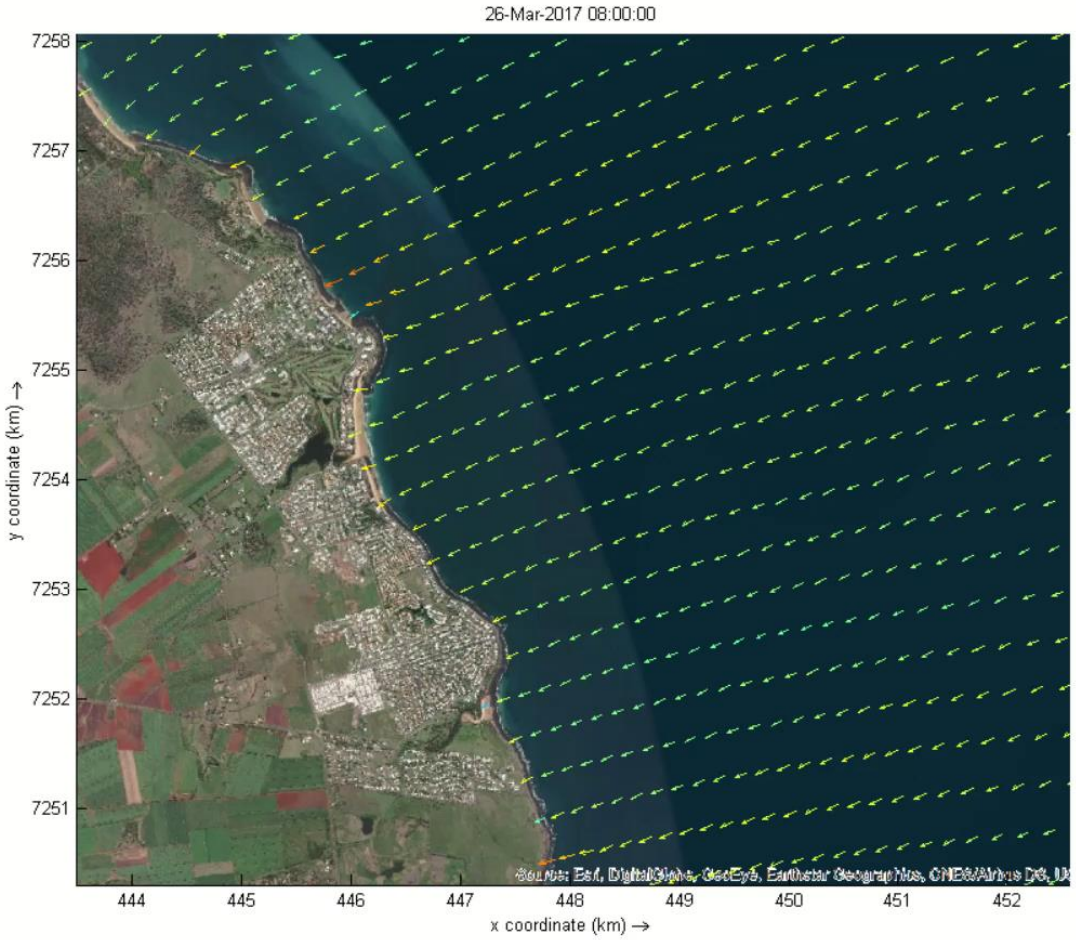

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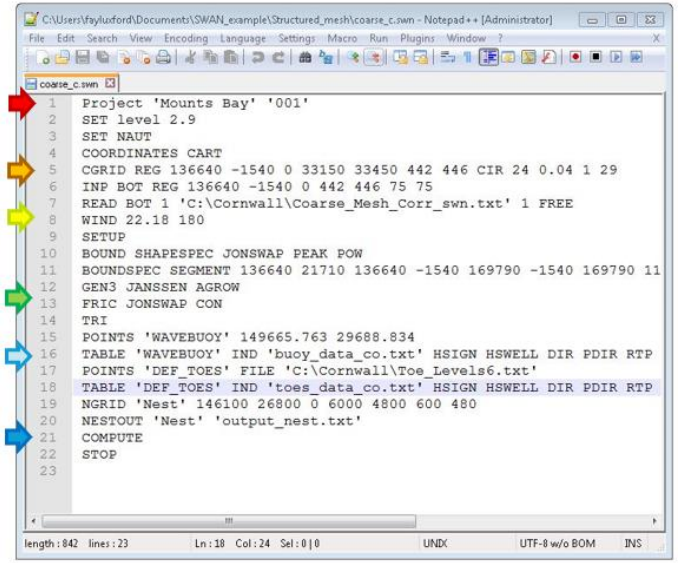


Project: Bargara SEMP

Types of wave models

Wave models

- Wave group resolving – Xbeach
- Phase (wave) resolving – Xbeach, Mike Boussinesq wave, CFD

Typically used for small to medium scale assessments

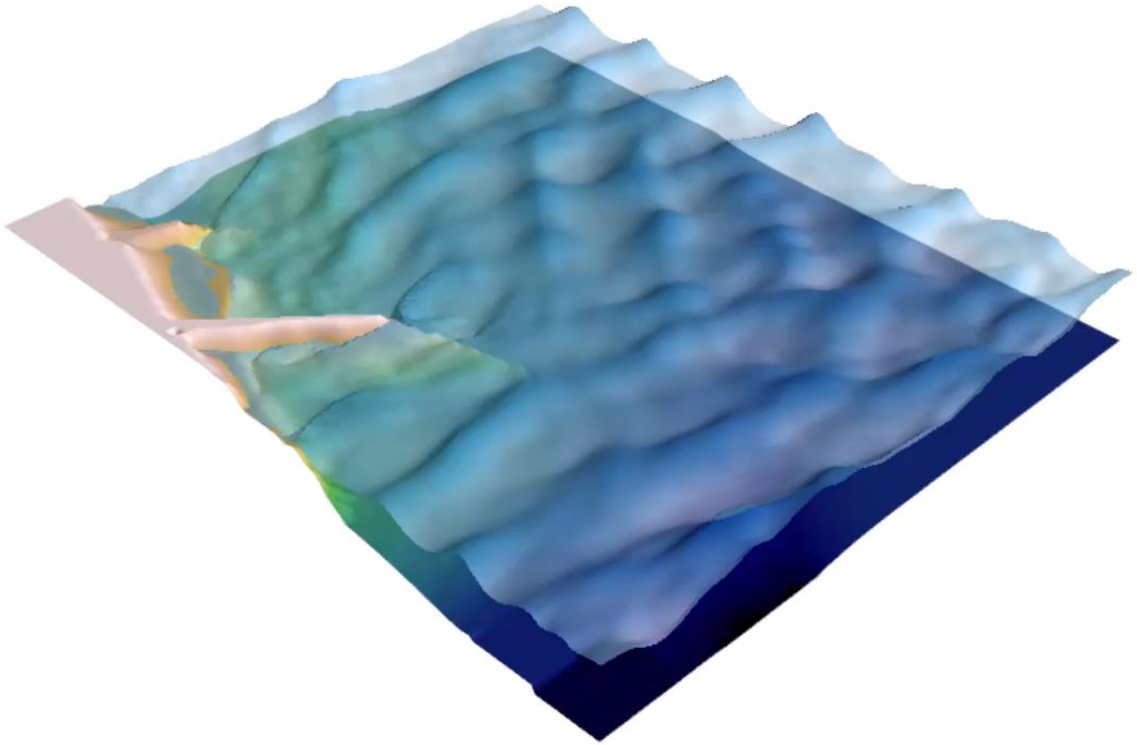
They calculate wave groups (sets of waves) propagating or individual waves.

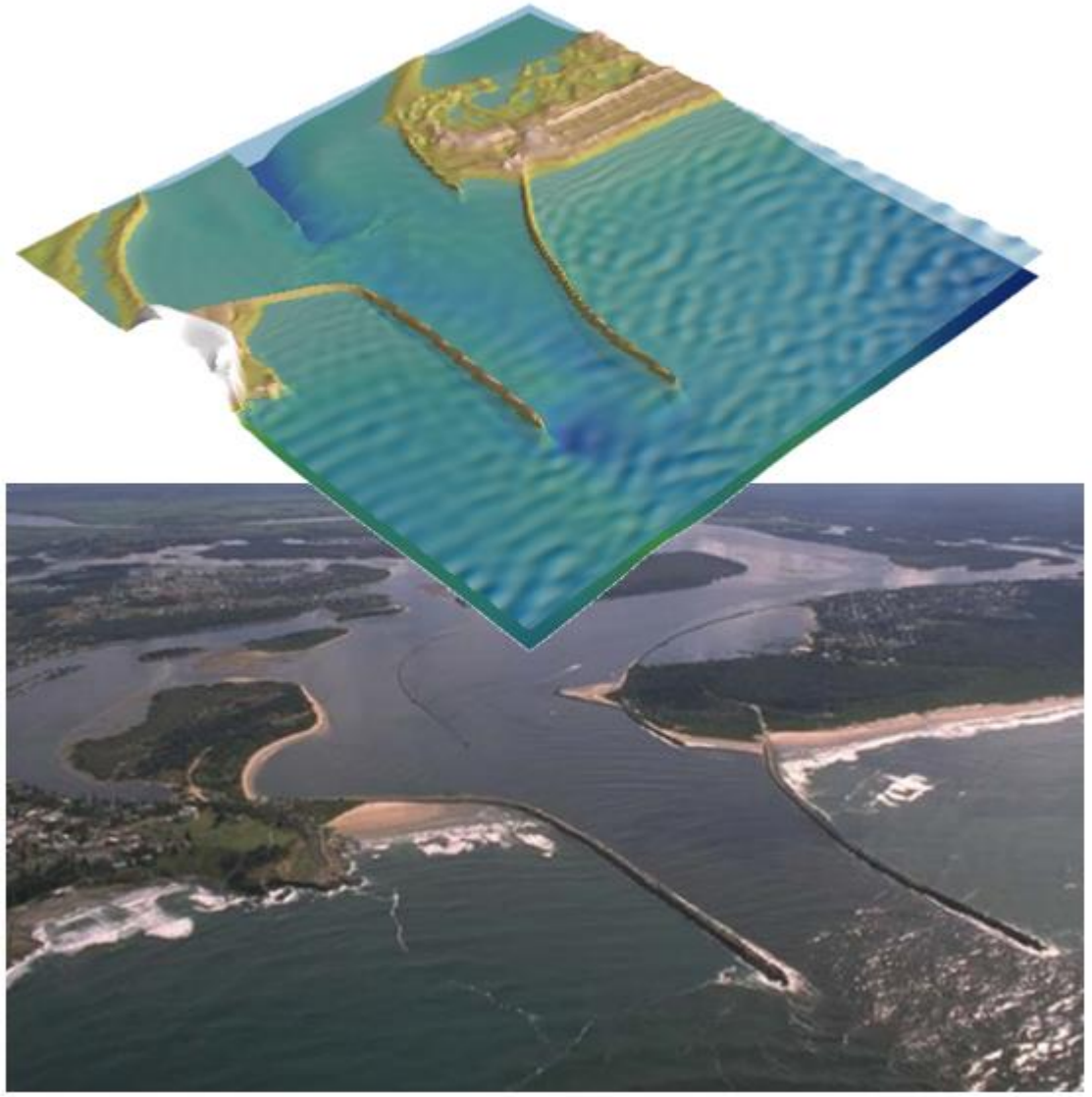
Requires fairly detailed understanding.

Types of wave models

Wave models

- Phase (wave) resolving – Xbeach, Mike Boussinesq



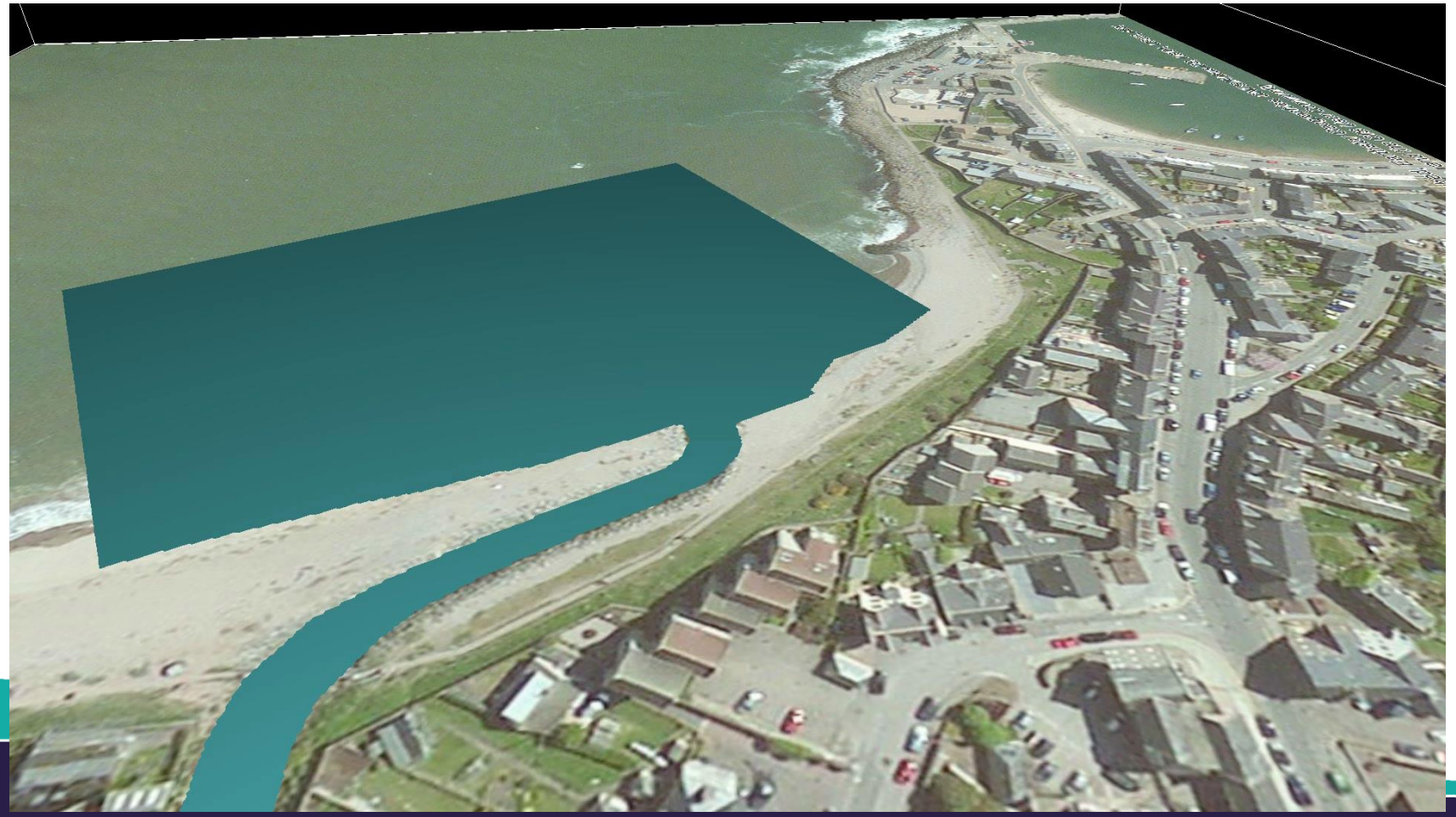


Types of wave models

Wave models

- Phase (wave) resolving – Xbeach, Mike Boussinesq wave, CFD

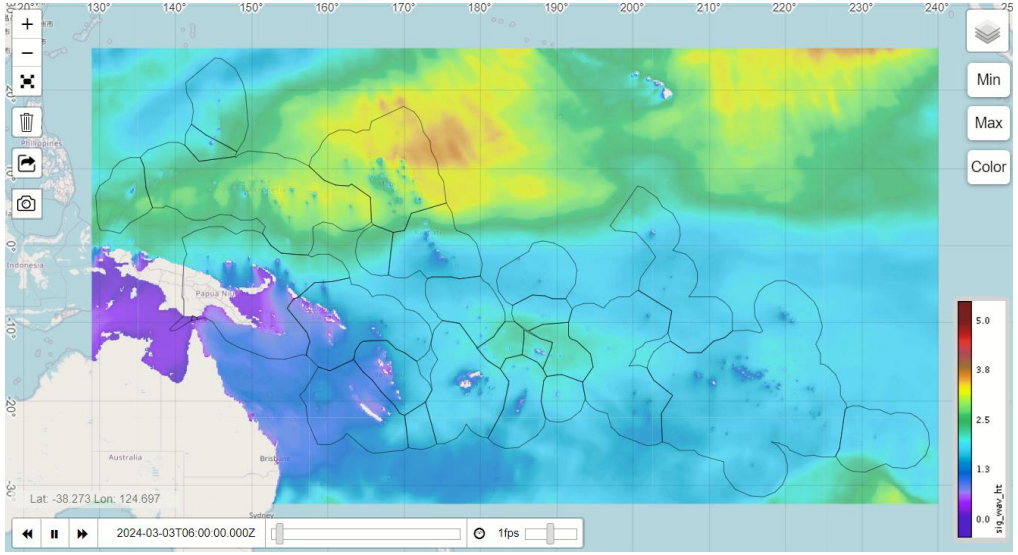
Project: River Carron Wave Propagation Study



Types of wave models

- Benefits of a phase (wave) averaging – spectral wave models like **SWAN**

1) Simple to setup a basic model (hours)
2) Very quick to run (minutes only)
3) Only needs 1 input to estimate waves: Wind
4) If you already know your offshore waves, can also be used for transformation



BoM AUSWAVE forecast for Pacific
4 March 2024
WW3 spectral wave model
(Not SWAN but similar)

https://shorturl.at/wELXZ

General wave modelling procedure

1) Choose Model → 2) Develop grid/mesh → 3) Process Bathymetry → 4) Boundary extent & conditions

1) Phase averaging models (e.g. SWAN)

- Large regional scale assessments
- Calculating nearshore conditions from offshore

2) Phase resolving models

- Small scale assessments
- Can model wave diffraction and reflection
- Typically used for structures

General wave modelling procedure

1) Choose Model

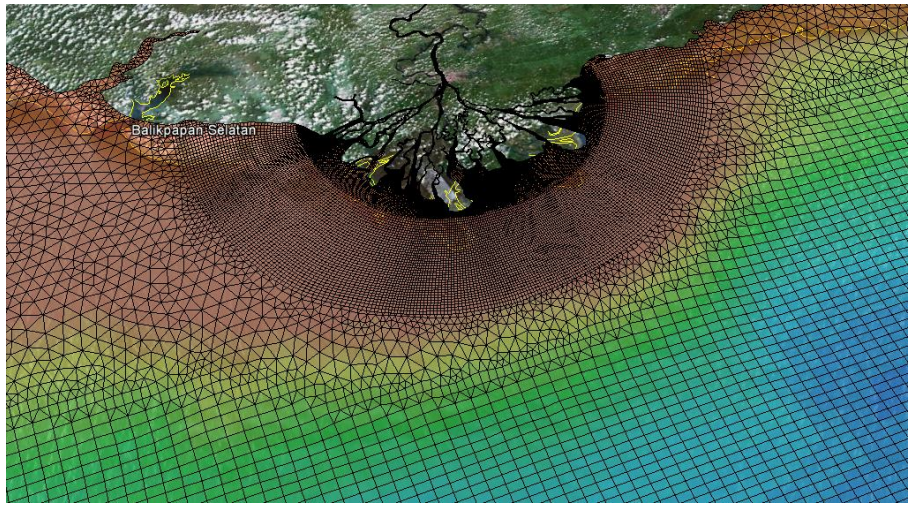
2) Develop grid/mesh

3) Process Bathymetry

4) Boundary extent & conditions

1D or 2D?

Structured grid or unstructured mesh?



General wave modelling procedure

1) Choose Model

2) Develop grid/mesh

3) Process Bathymetry

4) Boundary extent & conditions

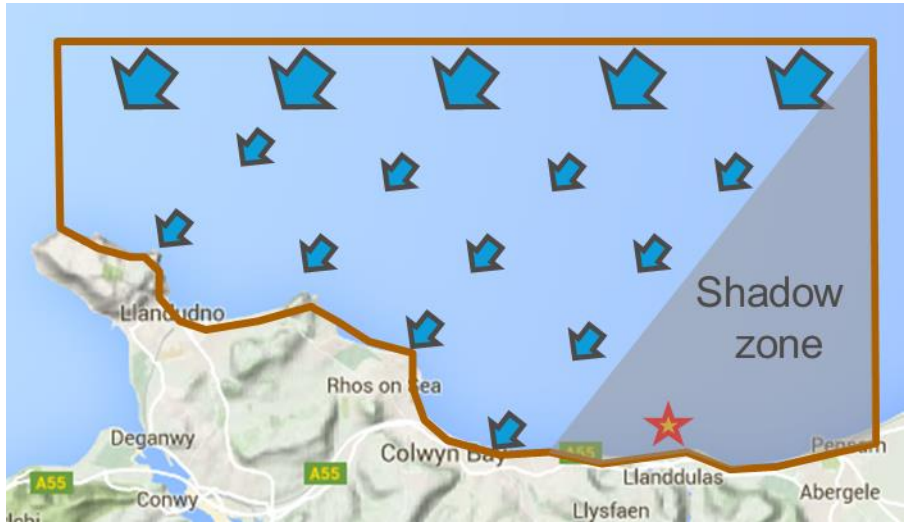
Consider sources of data

Consider datum!

Consider merging of datasets

General wave modelling procedure

1) Choose Model → 2) Develop grid/mesh → 3) Process Bathymetry → 4) Boundary extent & conditions



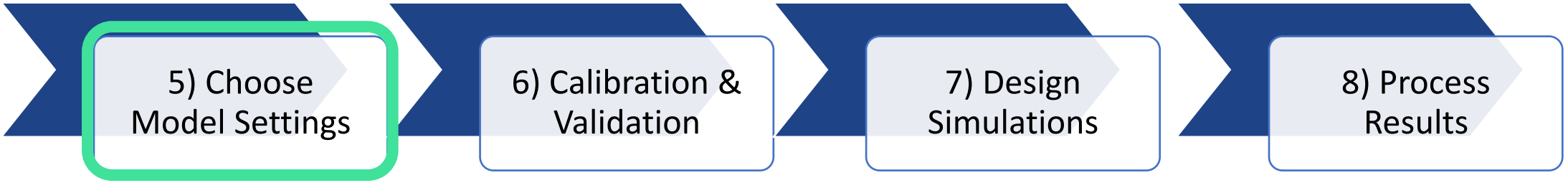
What input data do you have available? E.g.

- Wind
- Waves

What are the key processes occurring at site?

Where is you location of interest?

General wave modelling procedure



Set up model run files

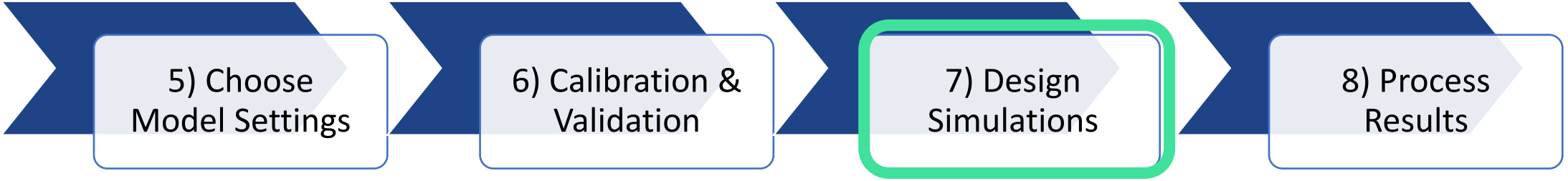
Choose model settings

General wave modelling procedure

How will you make sure the model is working correctly?

- Buoy data
- Anecdotal
- Sensitivity testing

General wave modelling procedure

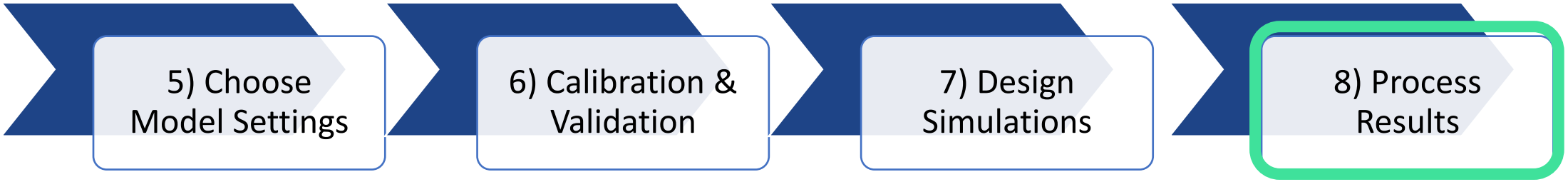


How many simulations are needed?

Probabilistic, deterministic?

Simulation library?

General wave modelling procedure



What is the purpose of calculating wave conditions?

- Overtopping
- Design
- Coupling to another model

Different water depths mean different wave results!

Introduction to SWAN Training Course

- Scheduled on 4, 11, 18 April
- Run over 3x 2hr sessions
- Will include how to:
  - Access software
  - Setup and run SWAN
  - Will include a case study in Fiji

JB PACIFIC

Specialists in extreme weather engineering.

Waves and wave modelling with SWAN

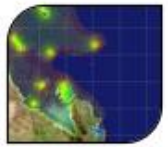
Course outline 2024

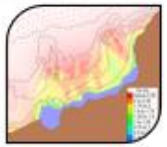
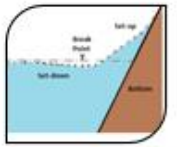
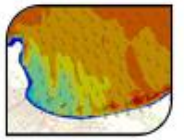
This course focusses on wave modelling; including theory, analytical calculations, numerical modelling and physical modelling. It will introduce the standards, best-practise guidelines and how to perform simple checks. It includes several hands-on tutorials, including step-by-step guidance to develop a wave model for Savusavu; a coastal town located in Fiji.

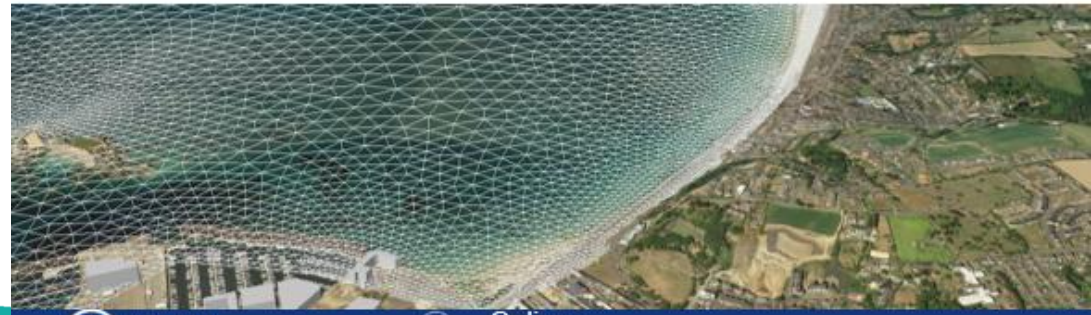
This course is targeted at early-stage practitioners, designers, assessors and Councils to better understand the numerical wave model SWAN and how it can be used for coastal assessments.

Our course includes:

- The theory of waves
- Sources of uncertainty
- Tutorial on setting up SWAN control files
- Grid generation and assigning bathymetry
- Selection of boundary conditions and simulation parameters
- Model calibration and validation
- Viewing and interpreting results





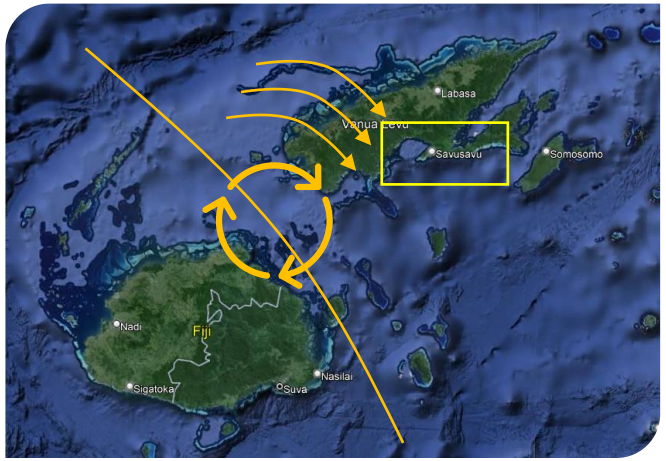
3 x 2 hr sessions

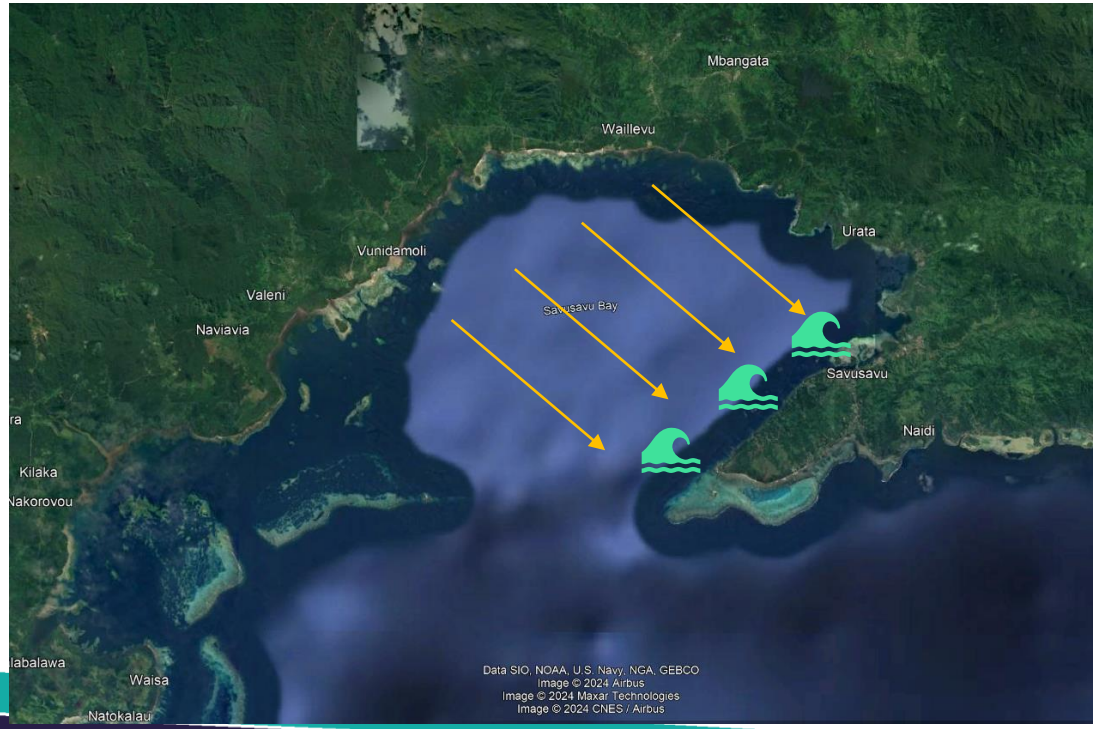
Online:
https://awschool.com.au/

Introduction to SWAN Training Course

- Case Study

1) Bay of Savusavu, Vanua Levu, Fiji
2) Scenario: Cyclone passing to the west
3) Aim: Estimate nearshore wave conditions at Savusavu





Sign up here:

https://awschool.com.au/training/swan-wave-modelling/

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Alexandra.Maskell@jbpacific.com.au

Thank you!

www.jbpacific.com.au