

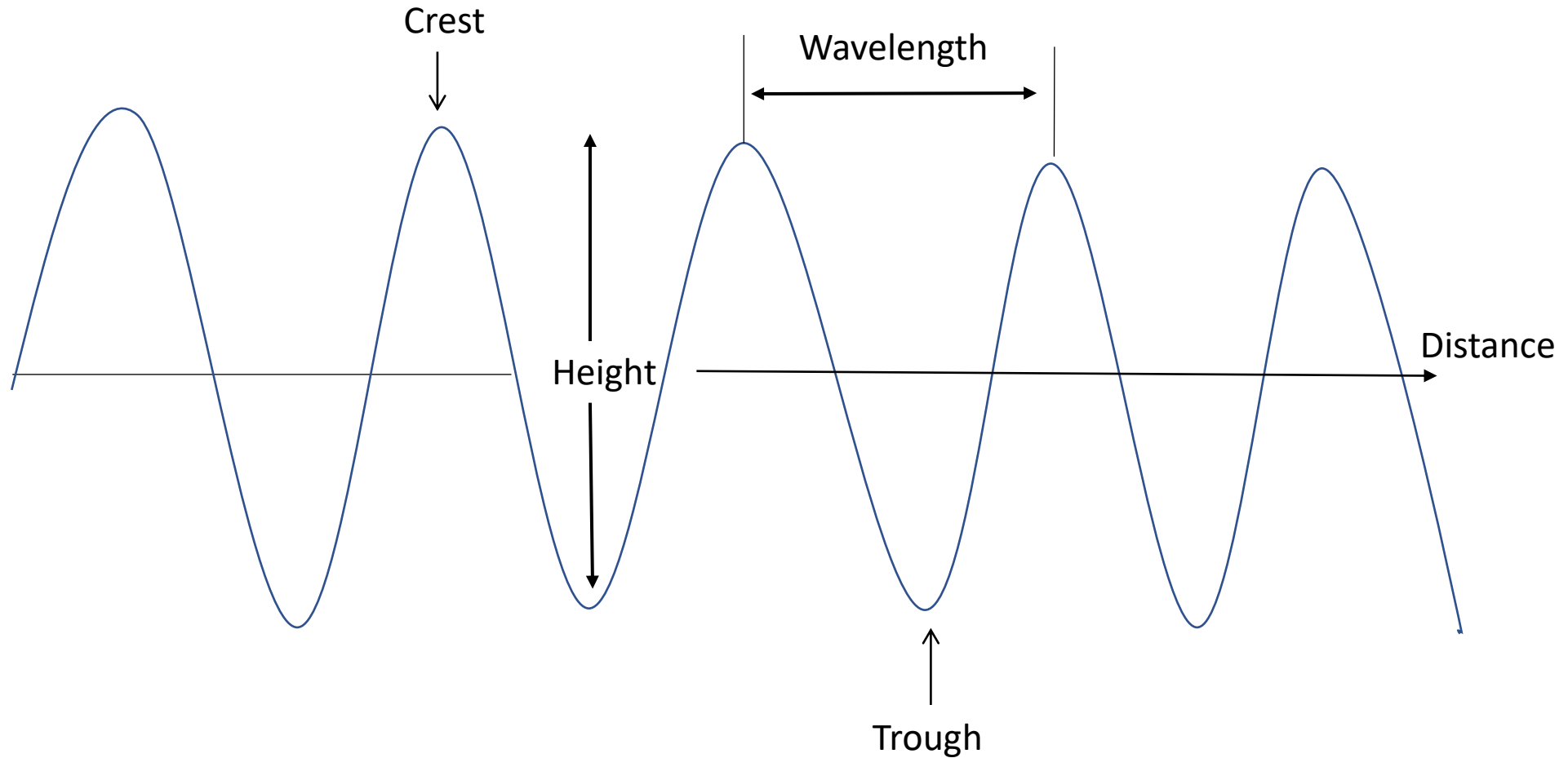
CTCN Project

Wave Modelling Training

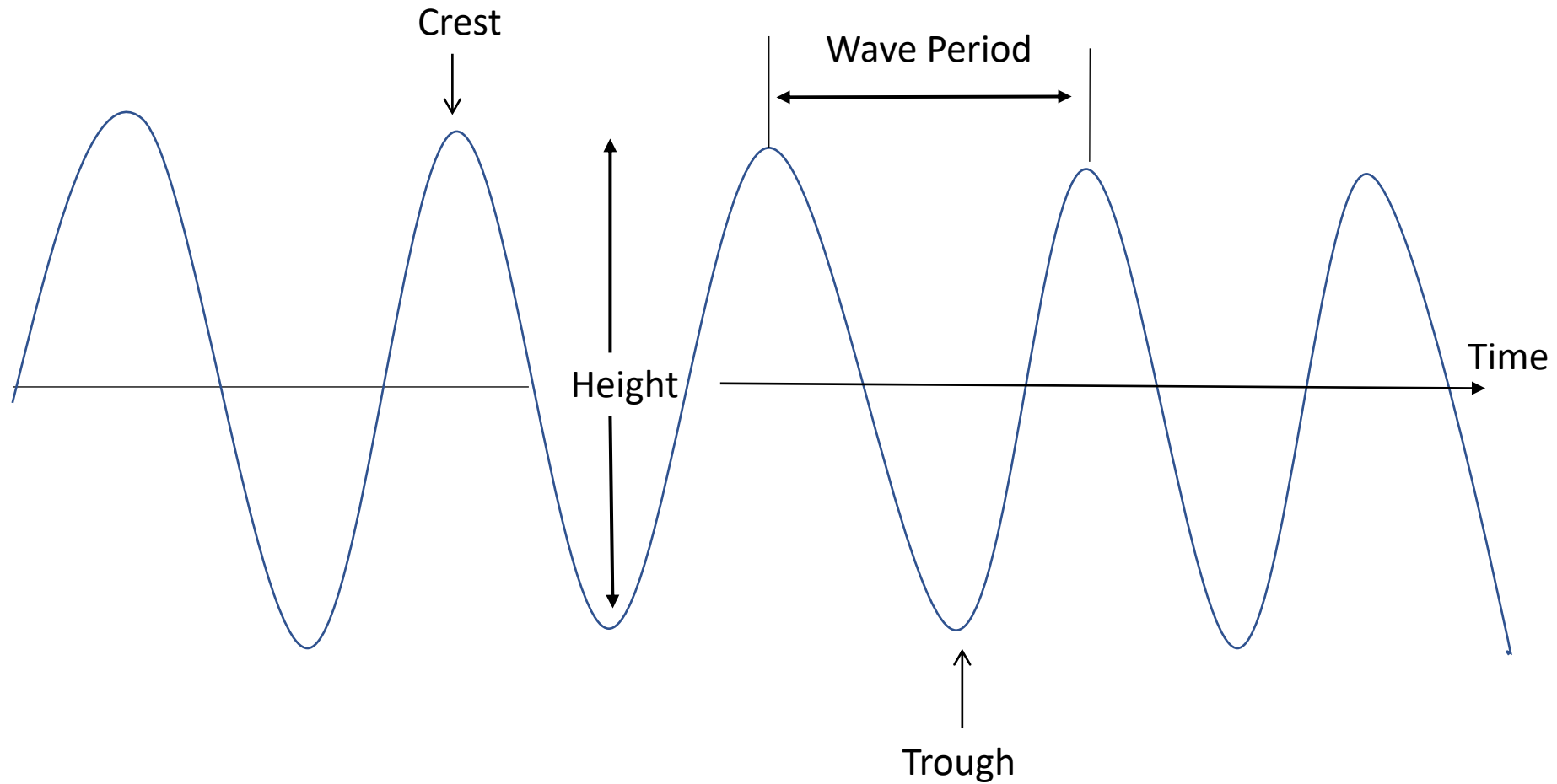
Topics

- Wave models developed
- User Interface Developed
- Discussion: How could this capacity be used in-country?

BASIC OF WAVE



Basic of Wave



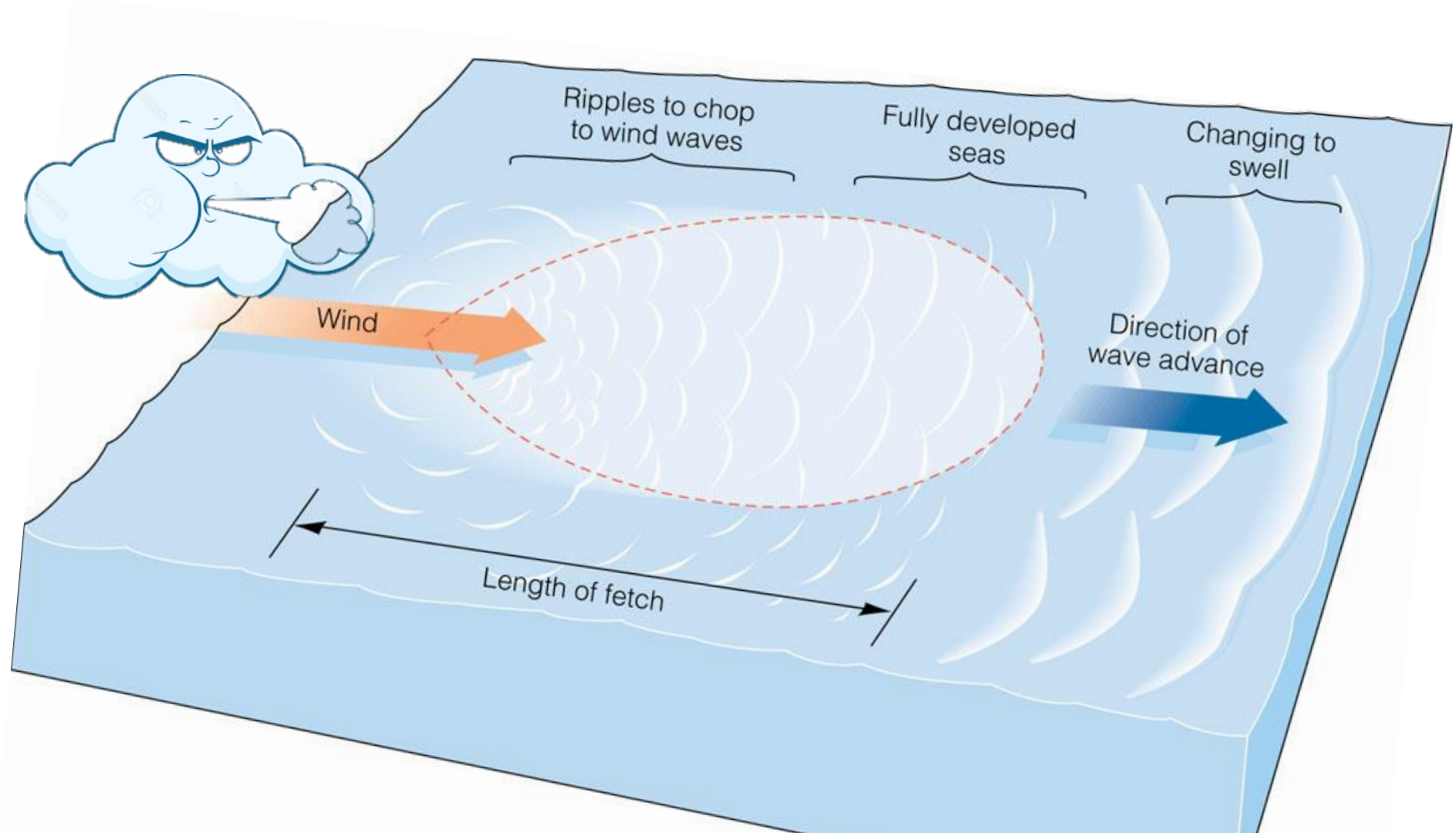
Wind Wave Generation

Influenced by:

Wind Strength

Wind Duration

Fetch



Fully Developed Sea



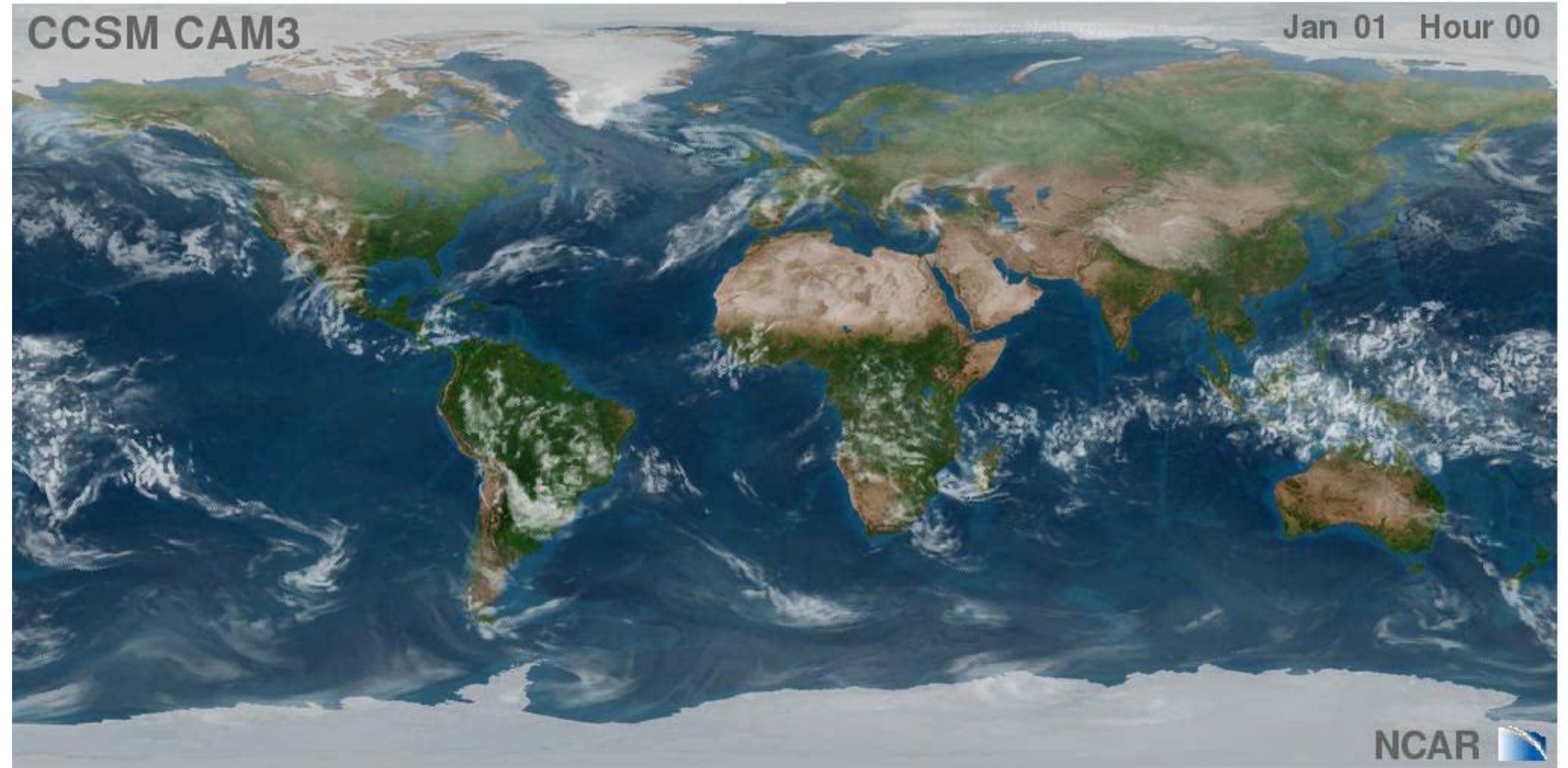
SWELL



Global Wave Climate

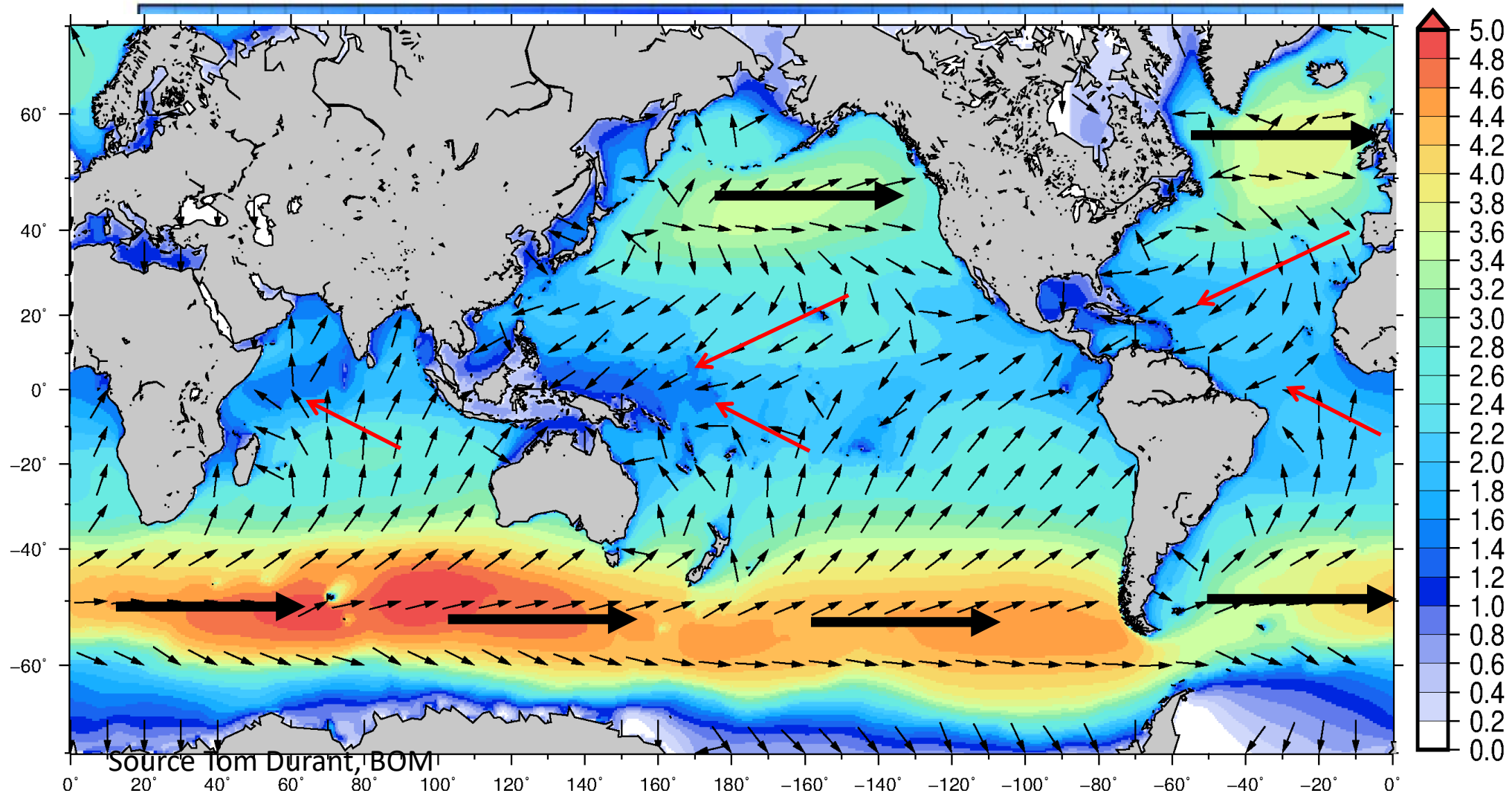
CCSM CAM3

Jan 01 Hour 00



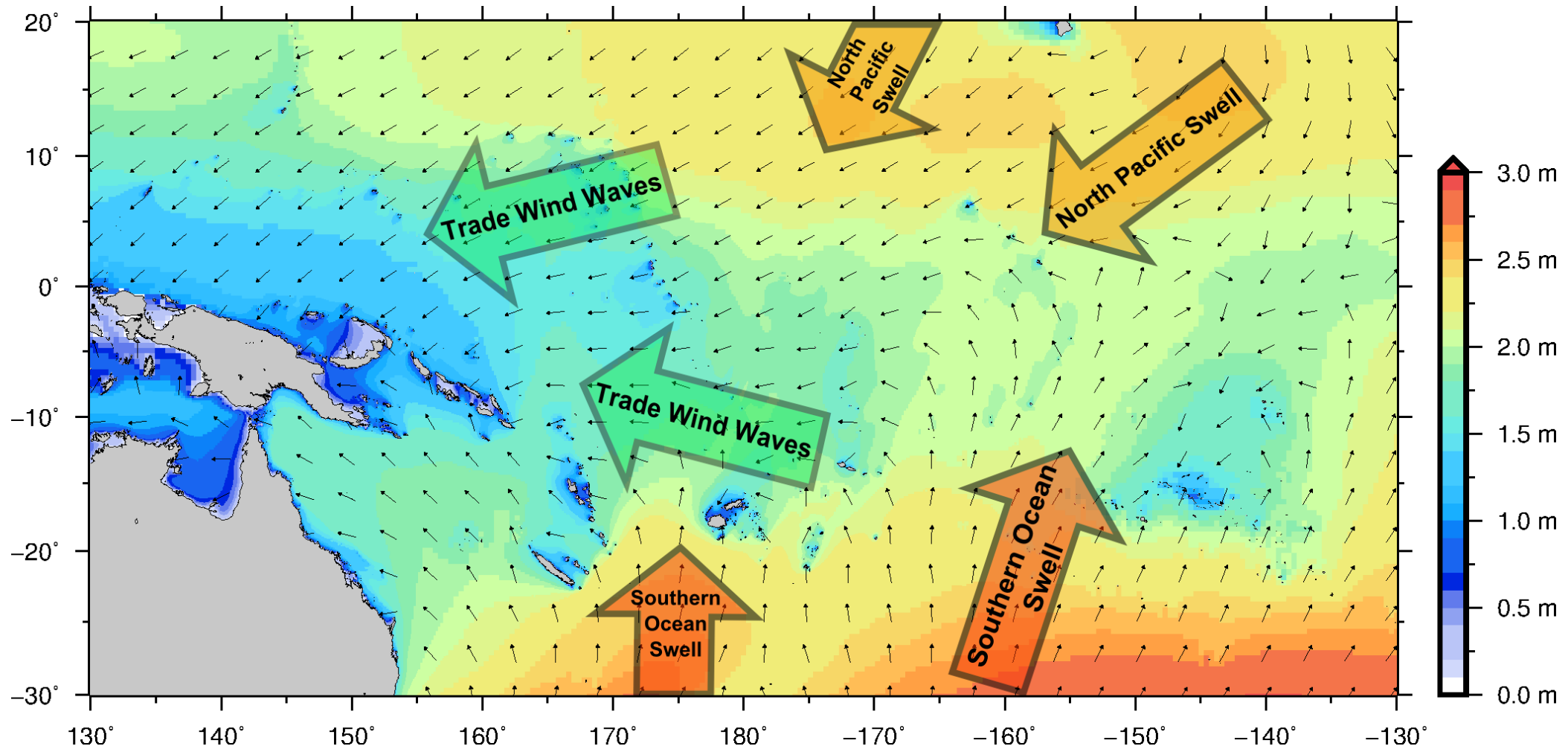
1-A) Wave Climate In The Pacific

Mean annual wave height and direction



REGIONAL WAVE CLIMATE

Mean annual wave height and direction



Nearshore Wave Transformation

1) WAVE

- Basic of waves
- Wave climate in the Pacific
- Wave transformation



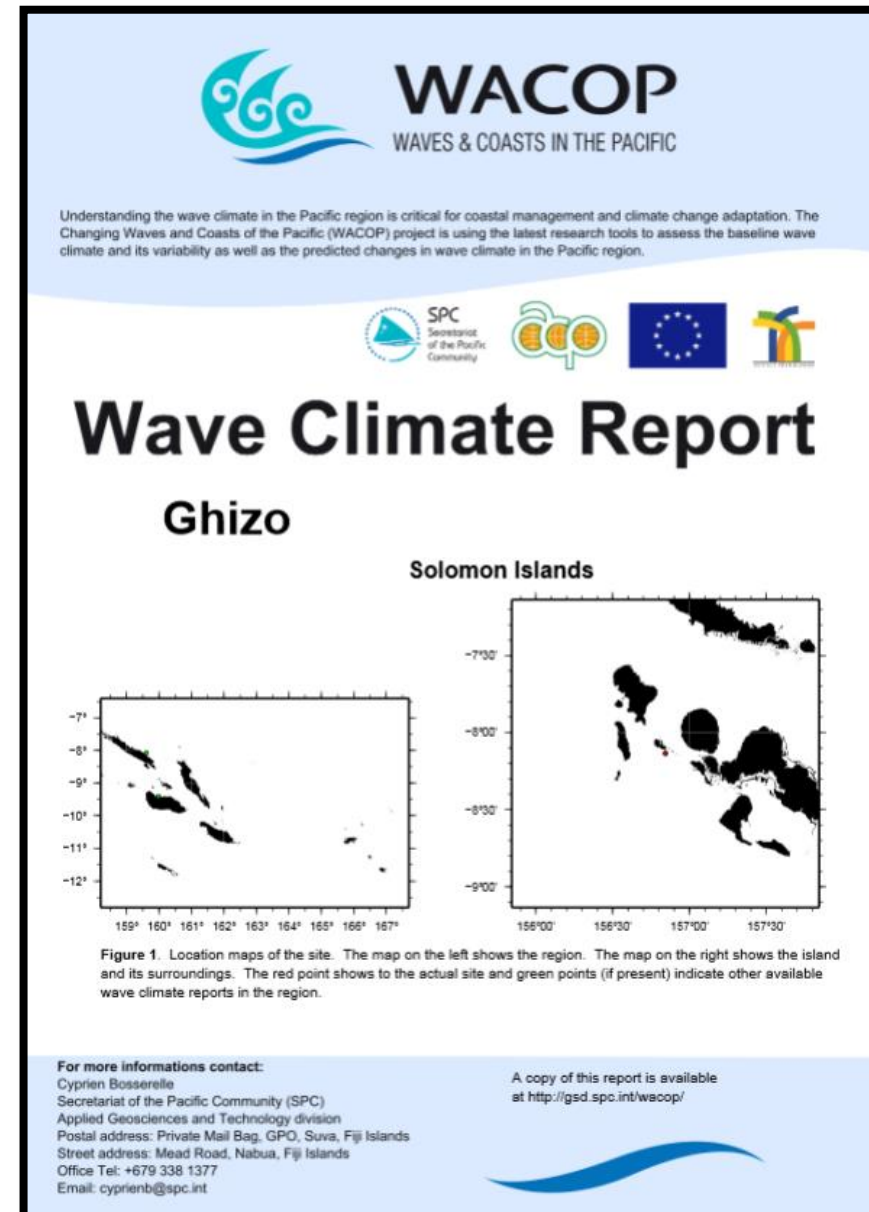
- Refraction, Diffraction
 - Shoaling
 - Breaking
- Infragravity wave generation

WAVE ATLAS REPORTS

<http://gsd.spc.int/wacop/>

Includes:

- General Wave climate
- Wave climate variability
- Large and Severe Wave
- Extreme Wave
- Wave Energy
- Wind Climate
- Projected Wave Climate





Incident wave

REFRACTION,

2/25/2009

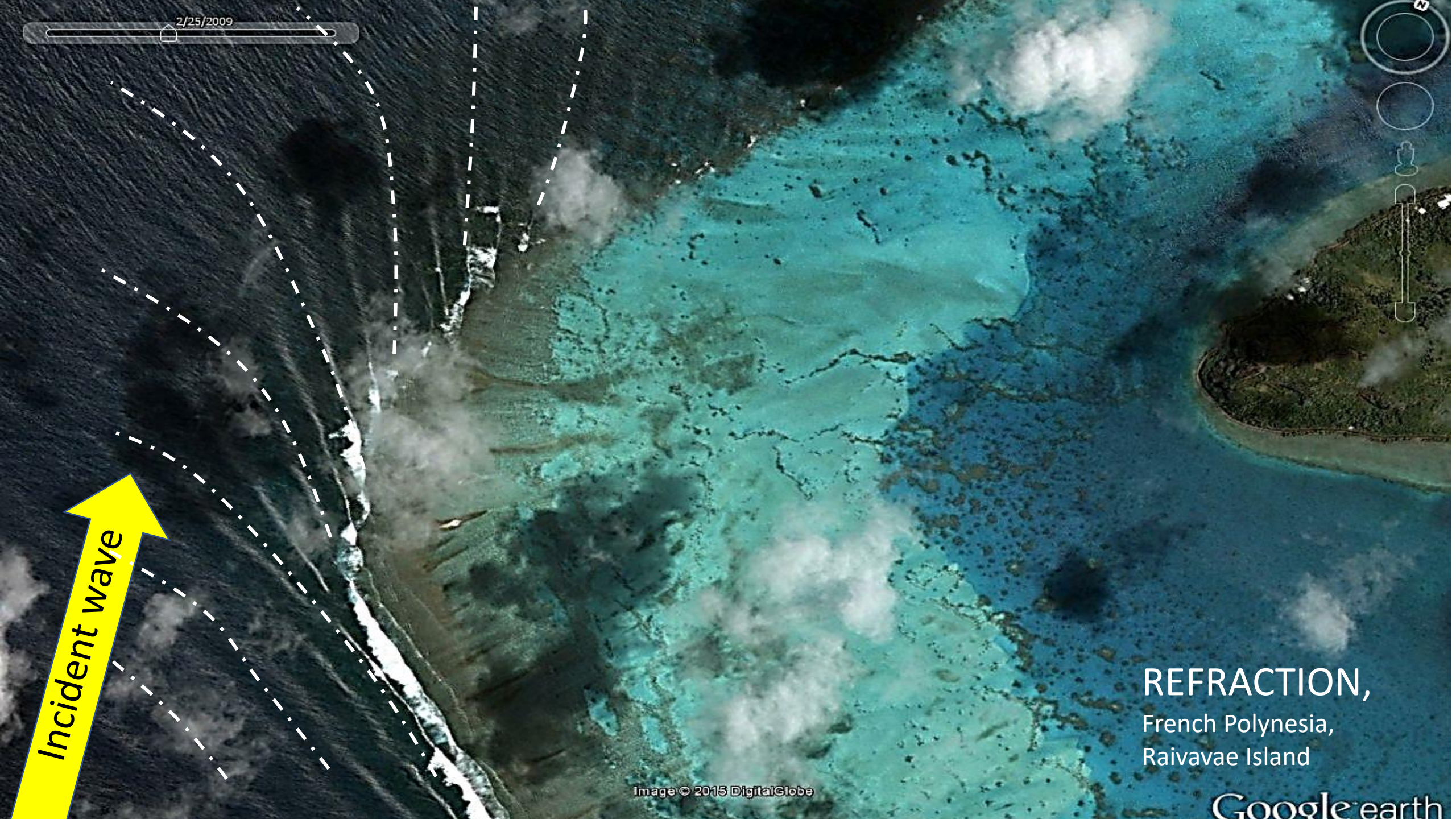


Incident wave

REFRACTION,
French Polynesia,
Raivavae Island

Image © 2015 DigitalGlobe

Google earth



Nearshore Processes: DIFFRACTION

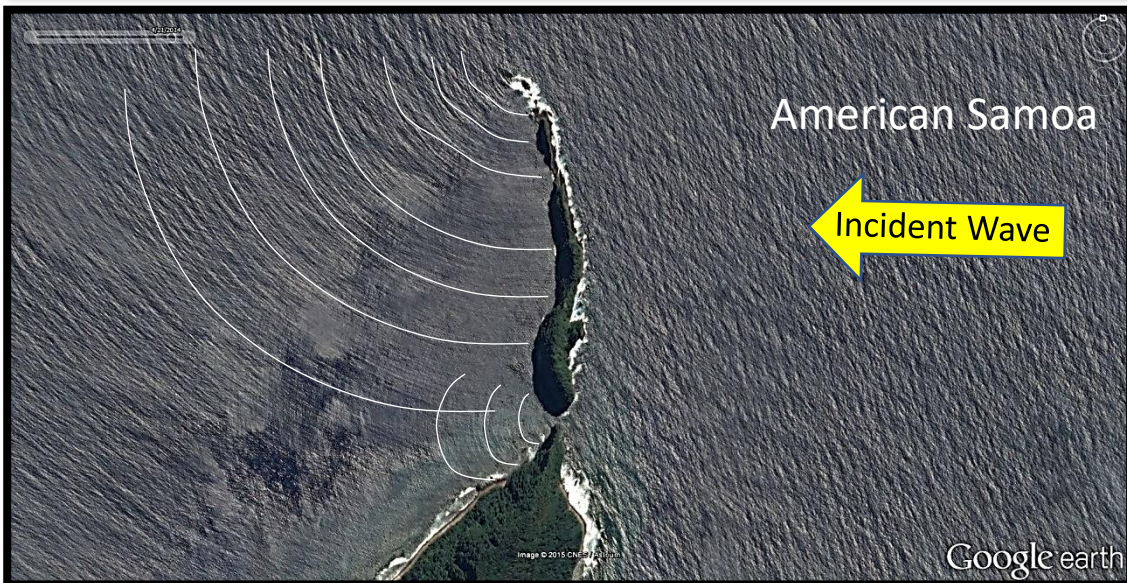
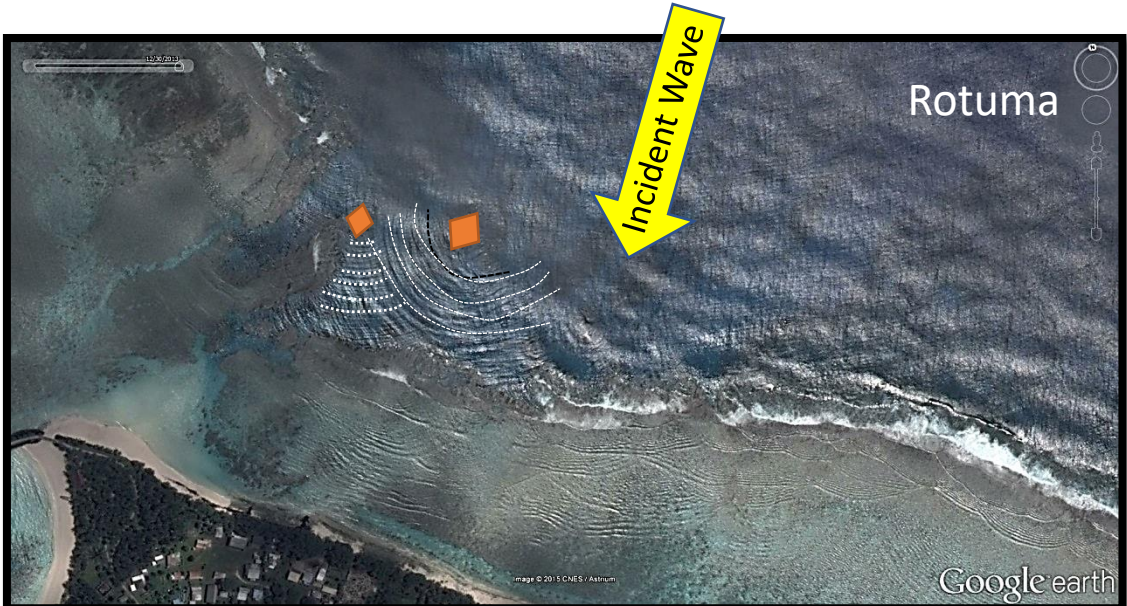
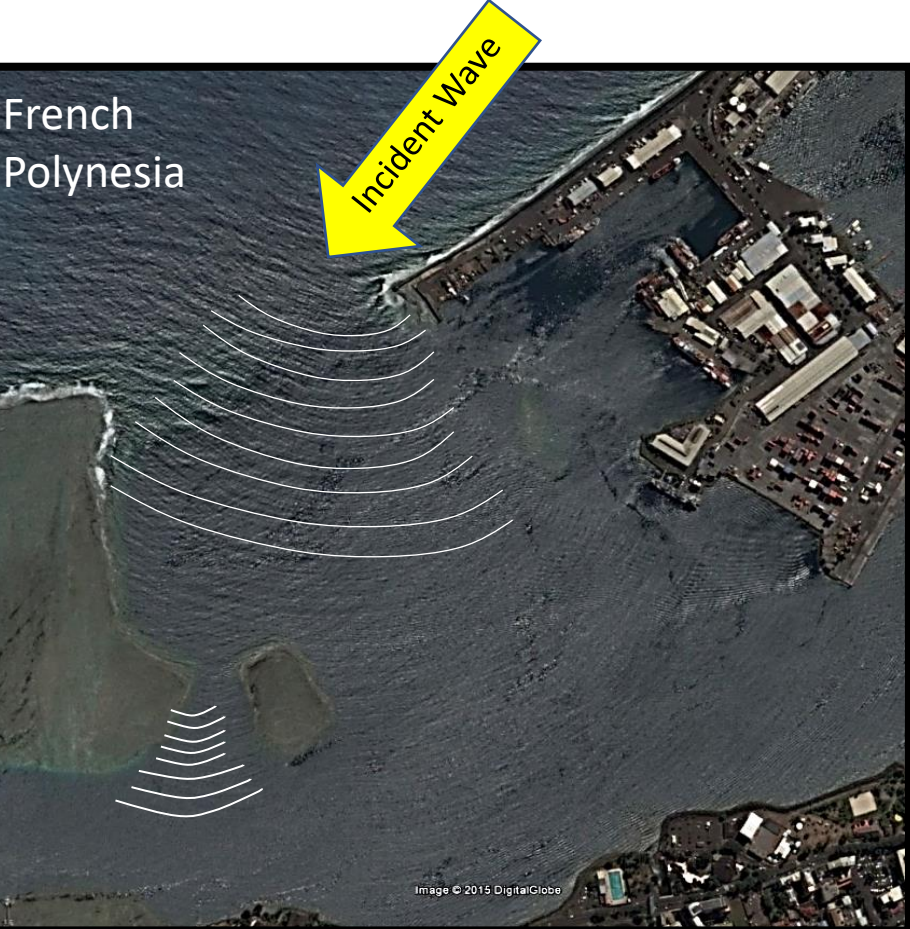
Diffraction:

- Wave hit an obstacle (e.g. emerged/shallow water reef) or travels through a small gap (e.g. in-between two islands)
- Wave energy is transferred laterally along the wave crest
- Important for ports, harbor designs



NEARSHORE PROCESSES: DIFFRACTION

Pacific Islands examples of Diffraction

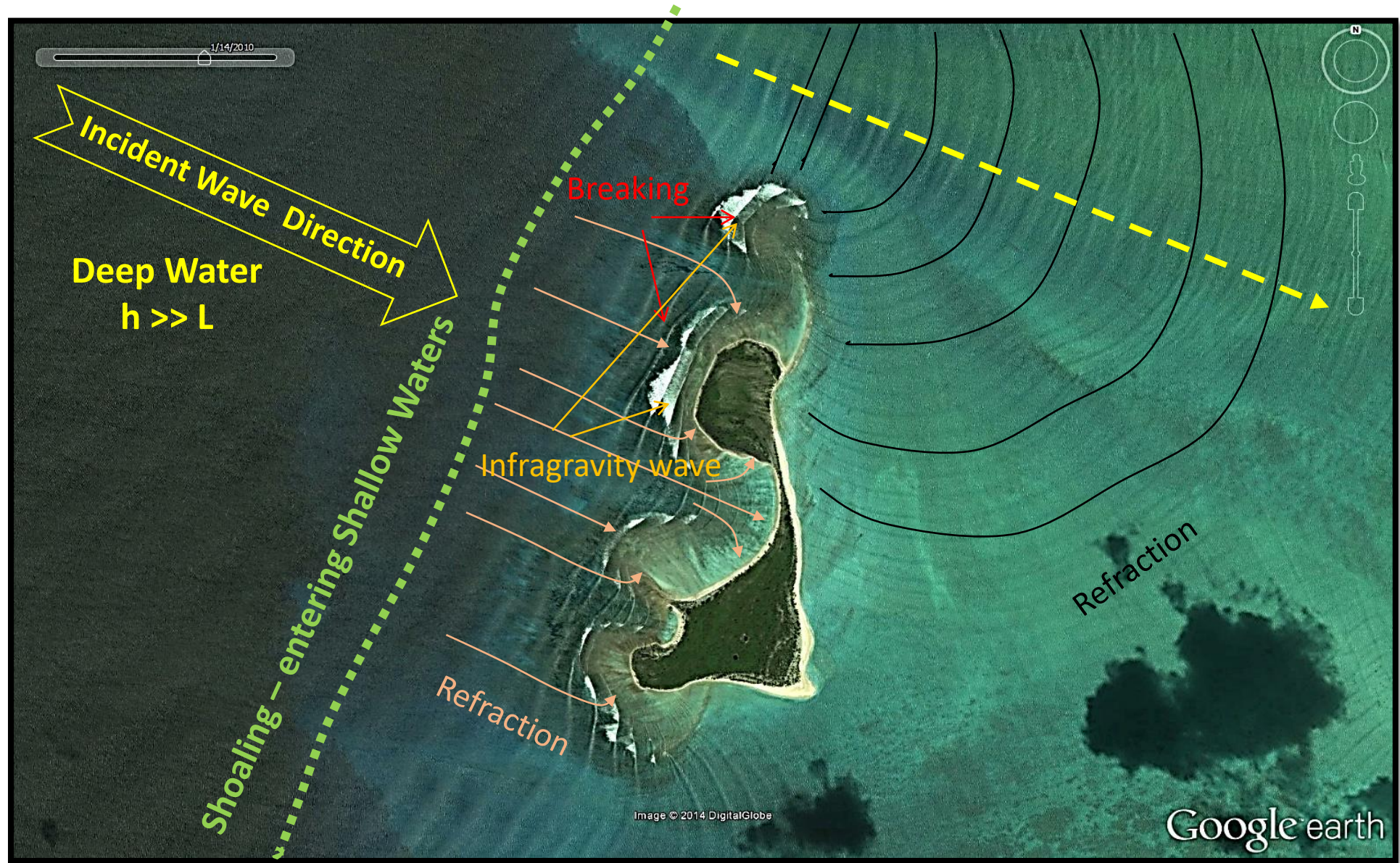


Nearshore Processes: SHOALING & BREAKING



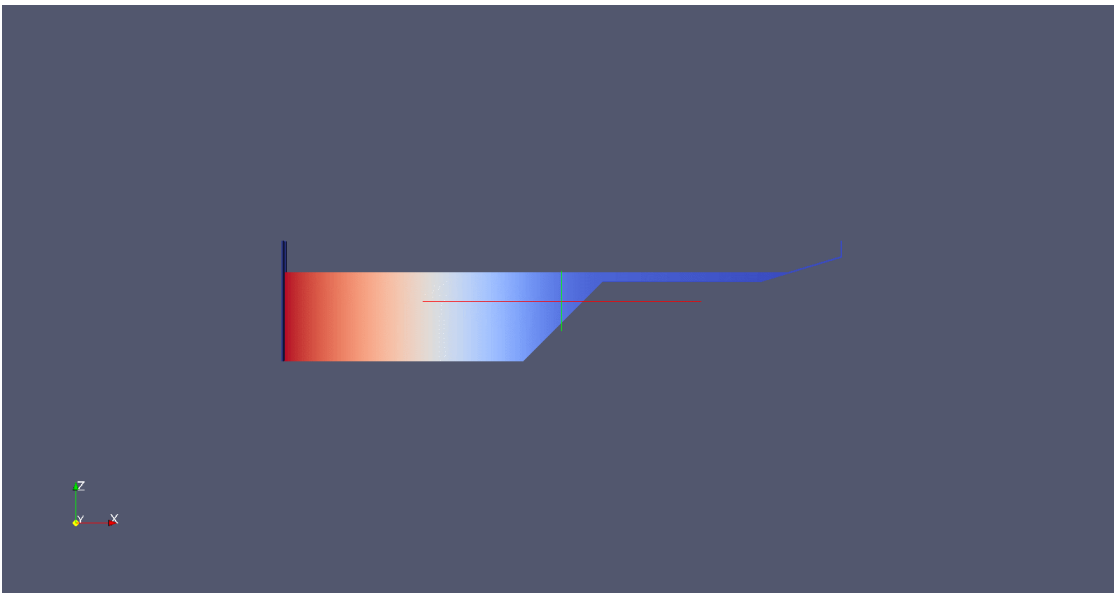
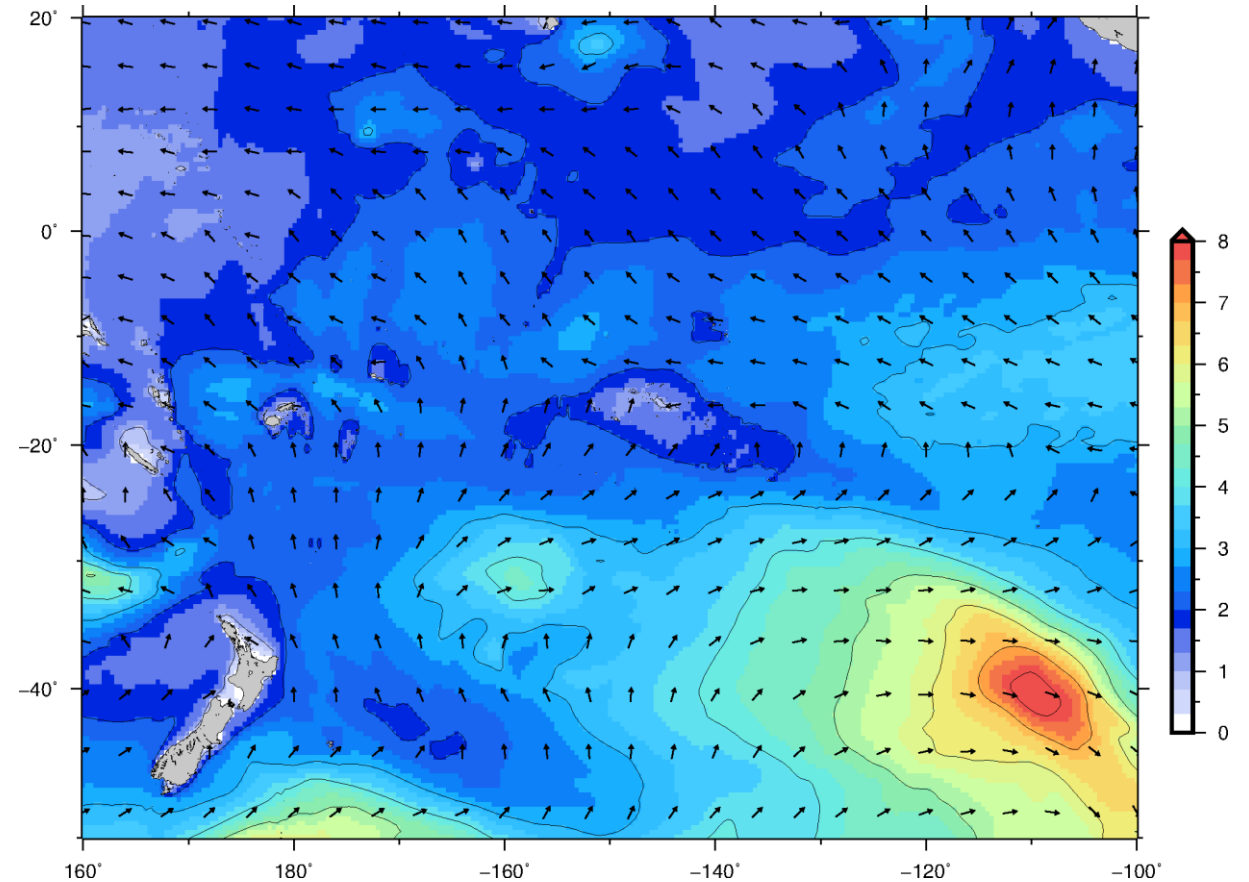
Shoaling and breaking in Tavarua, Fiji

Nearshore Processes: Wave Transformation



Modern wave models

- Phase resolving
 - Boussinesq, Non-hydrostatic, SPH... (form of hydrodynamics models)
 - Good for very local problems (e.g. Harbour design)
- Phase averaging
 - Based on the wave action balance
 - Wave Watch 3, SWAN
 - Good at a lot of scales
 - Computationally efficient
 - good for forecasts



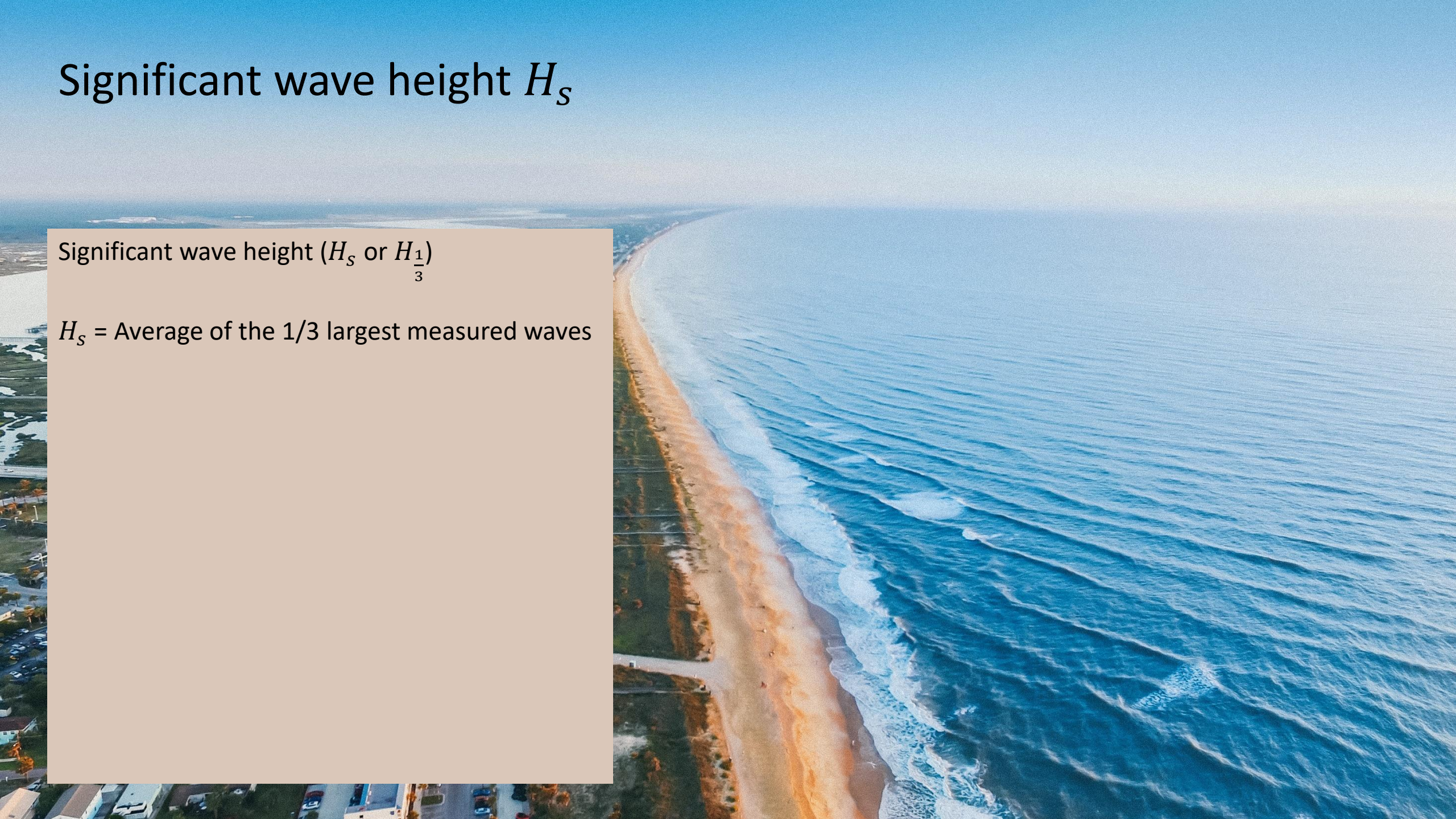
How do we define wave height?



Significant wave height H_s

Significant wave height (H_s or $H_{\frac{1}{3}}$)

H_s = Average of the 1/3 largest measured waves



Significant wave height H_s

Significant wave height (H_s or $H_{\frac{1}{3}}$)

H_s = Average of the 1/3 largest measured waves



Significant wave height H_s

1	1.5 m
2	1 m
3	2 m
4	2 m
5	1 m
6	2.5 m
7	1.5 m
8	1 m
9	1 m
10	0.7 m
11	0.5 m
12	2 m



Significant wave height H_s

1	2.5 m
2	2 m
3	2 m
4	2 m
5	1.5 m
6	1.5 m
7	1 m
8	1 m
9	1 m
10	1 m
11	0.7 m
12	0.5 m



Significant wave height H_s

1/3 of all measured waves

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2	2 m
3	2 m
4	2 m
5	1.5 m
6	1.5 m
7	1 m
8	1 m
9	1 m
10	1 m
11	0.7 m
12	0.5 m



Significant wave height H_s

$$H_s = \frac{2.5 \text{ m} + 2 \text{ m} + 2 \text{ m} + 2 \text{ m}}{4} = 2.125 \text{ m}$$

1/3 of all measured waves

1	2.5 m
2	2 m
3	2 m
4	2 m
5	1.5 m
6	1.5 m
7	1 m
8	1 m
9	1 m
10	1 m
11	0.7 m
12	0.5 m



Significant wave height H_s

Wave height



It is normal for waves to vary in height from one to the next. To give you an idea of the range of waves to expect at a given time, the Bureau provides the **significant wave height** in its marine forecasts.

Most frequent waves

The most frequent wave height will be about half the height of the significant wave

Significant waves

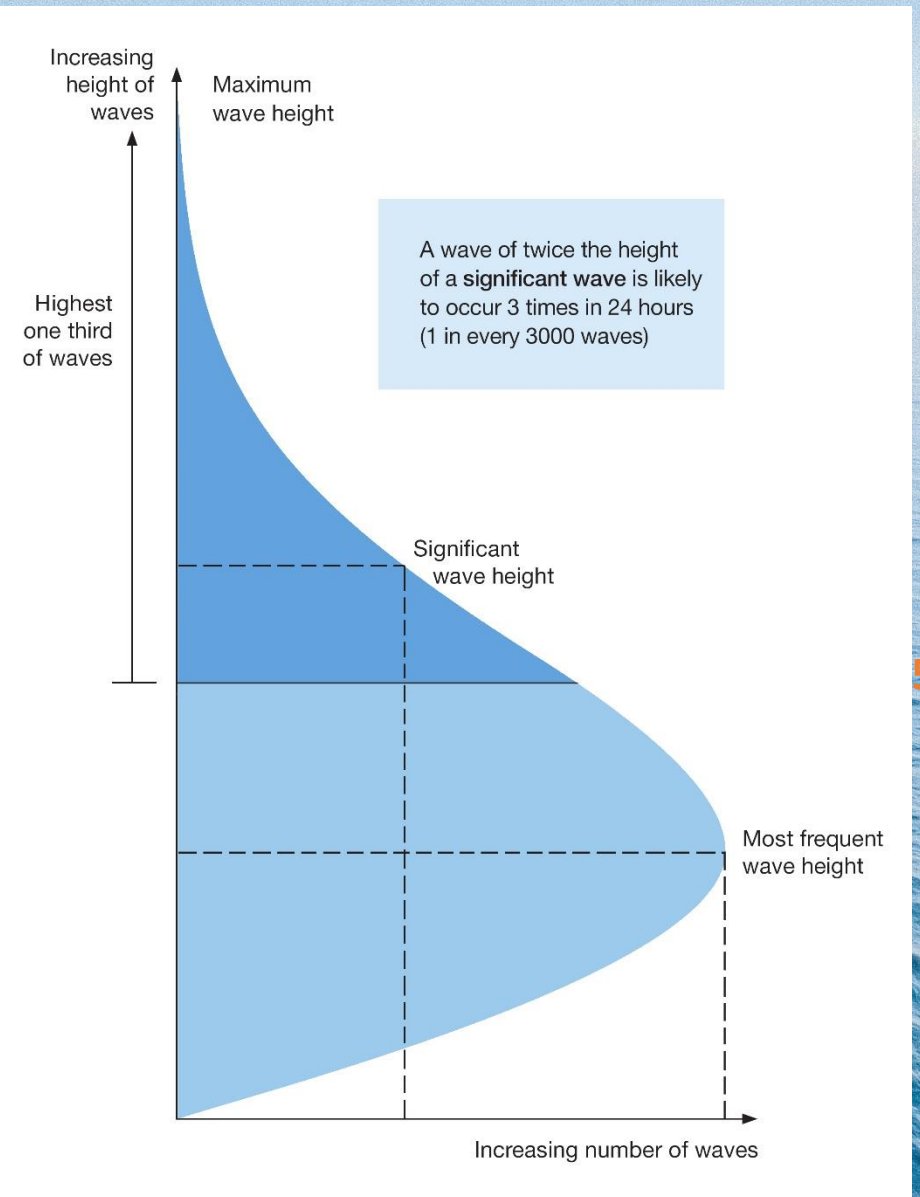
About 14% of waves will be higher than the **significant wave height** (about 1 in every 7 waves)

Maximum waves

It is normal to expect a wave of twice the height of the significant wave about 3 times in 24 hours.

This means you need to be prepared for a wave of this height before heading out on the water.

Matches a human's perception of the sea state

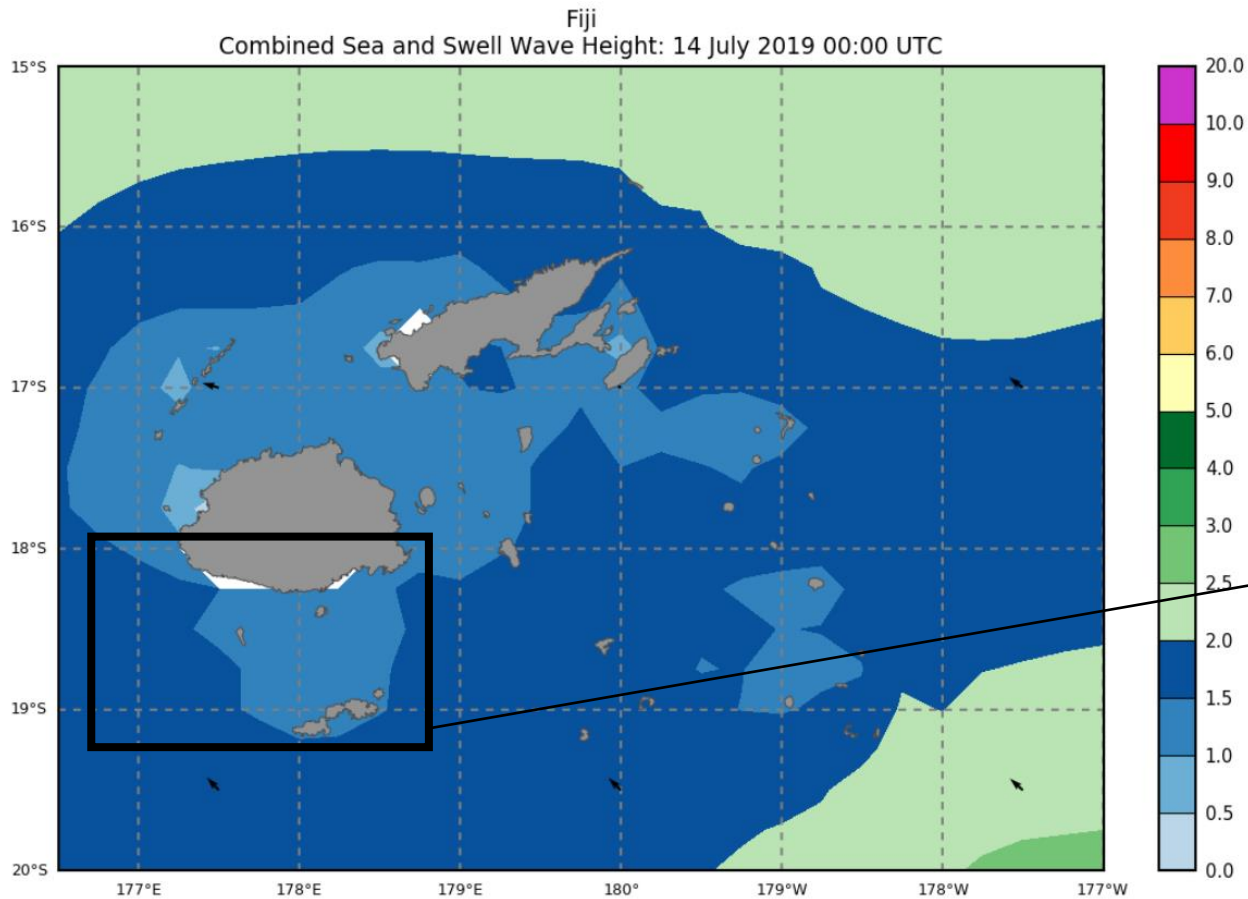


Wave Models for training purposes

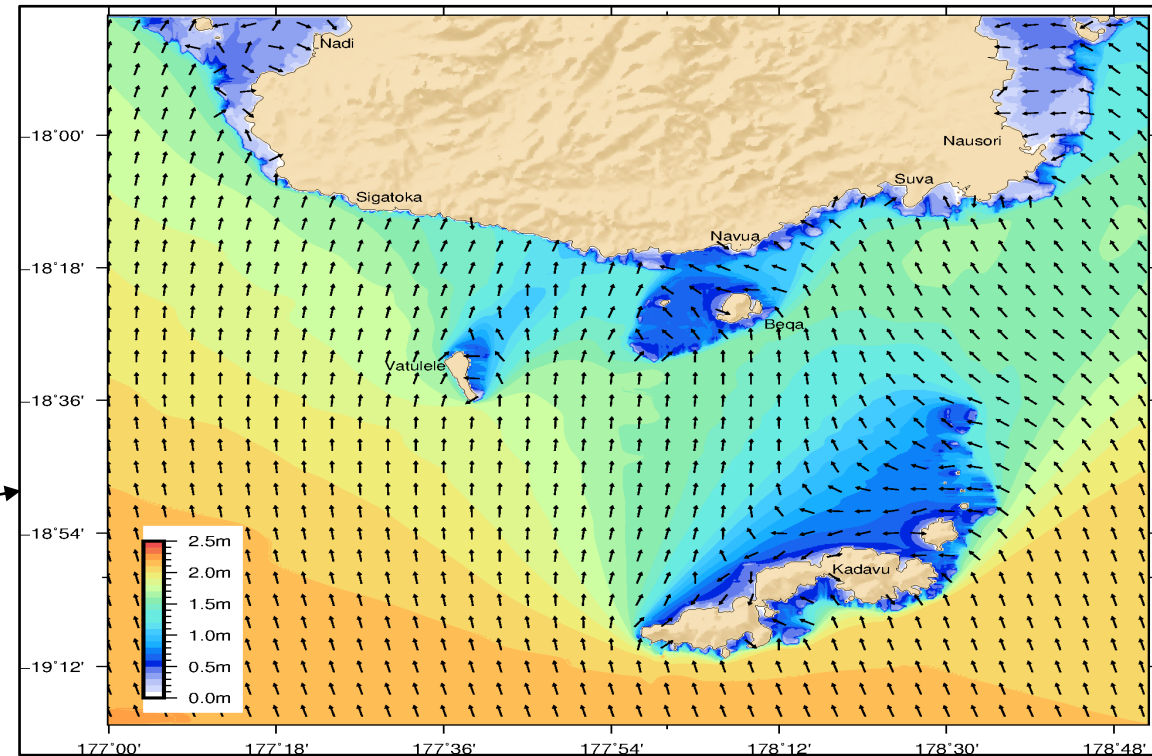
Country	Models Grid Size
RMI	
National	2km
Majuro	450m
Palau	
National	2km
Area A	500m
Area B	500m
Kiribati	
Sub Regional Tarawa	2km
Sub Regional Kirimati	2km
Tarawa	100m
Kirimati	500m
Solomon	
National	2km
Honiara	250m
Gizo	250m

Global to local information

Coarse resolution: 10s of kms



Fine resolution: 100s of metres



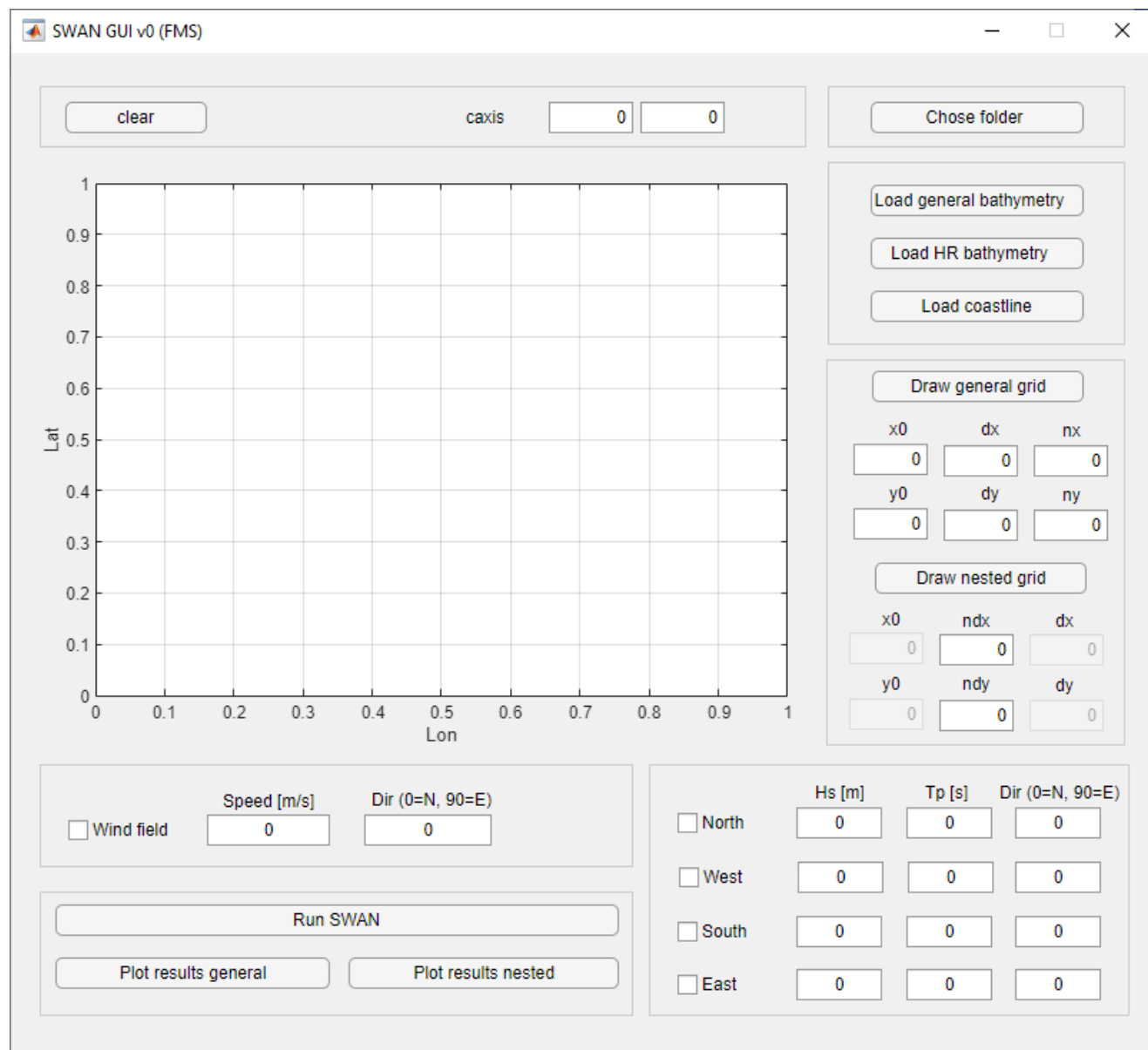
Swan Wave Model

Graphical user interface - manual

Wave model (SWAN) GUI

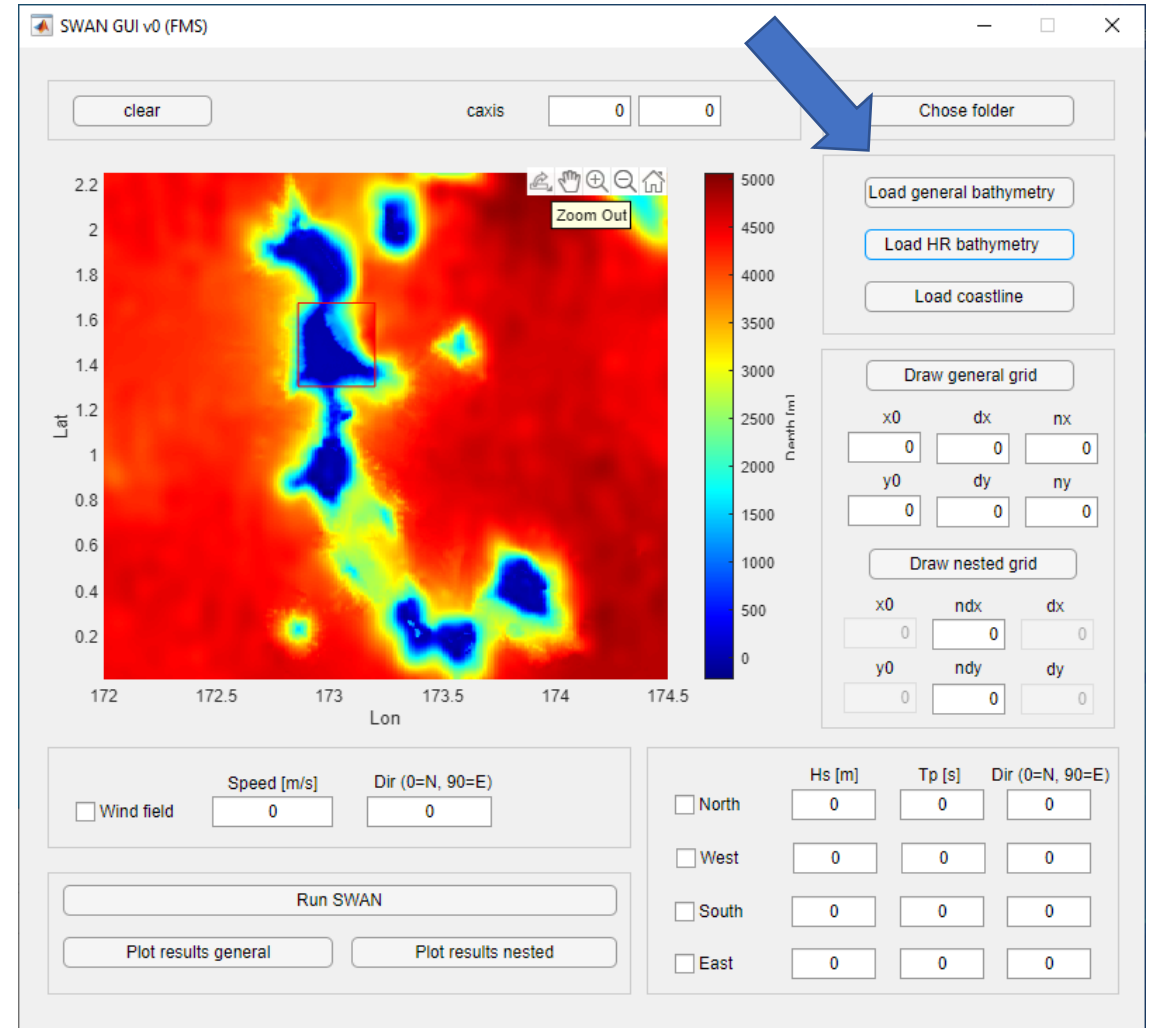
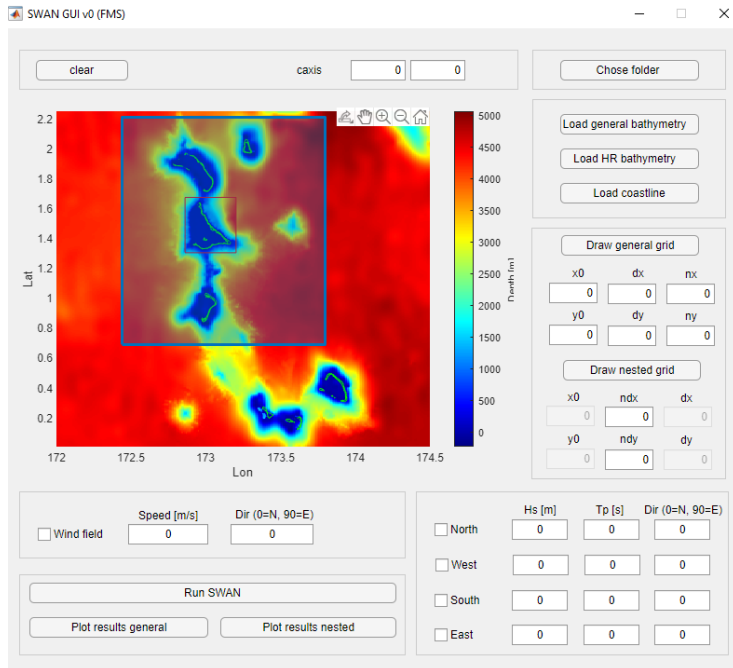
1. Easy to install: Executable (.exe)
2. Organised through a fixed folder structure

- 📁 bathymetries
- 📁 cases
- 📁 coastline
- 📁 GUI
- 📁 runs
- 📁 swan_files
- 📁 swan_manuals



Wave model (SWAN) GUI

- The GUI supports the importing of a maximum of two bathymetry datasets (with identical projection), a global and a high resolution datasets.
- **Load Coastlines**
- **Flexible computational domain, Automated nesting capability.**



Wave model (SWAN) GUI

- Define wave boundary conditions for each side of the general grid
 - Hs: significant wave height
 - Tp: Peak period
 - Dir: Mean direction
- Define constant wind
 - Speed
 - Direction
- **Run SWAN** button: Use to start the model run

```
C:\WINDOWS\SYSTEM32\cmd.exe - swanrun_general

SWAN is preparing computation

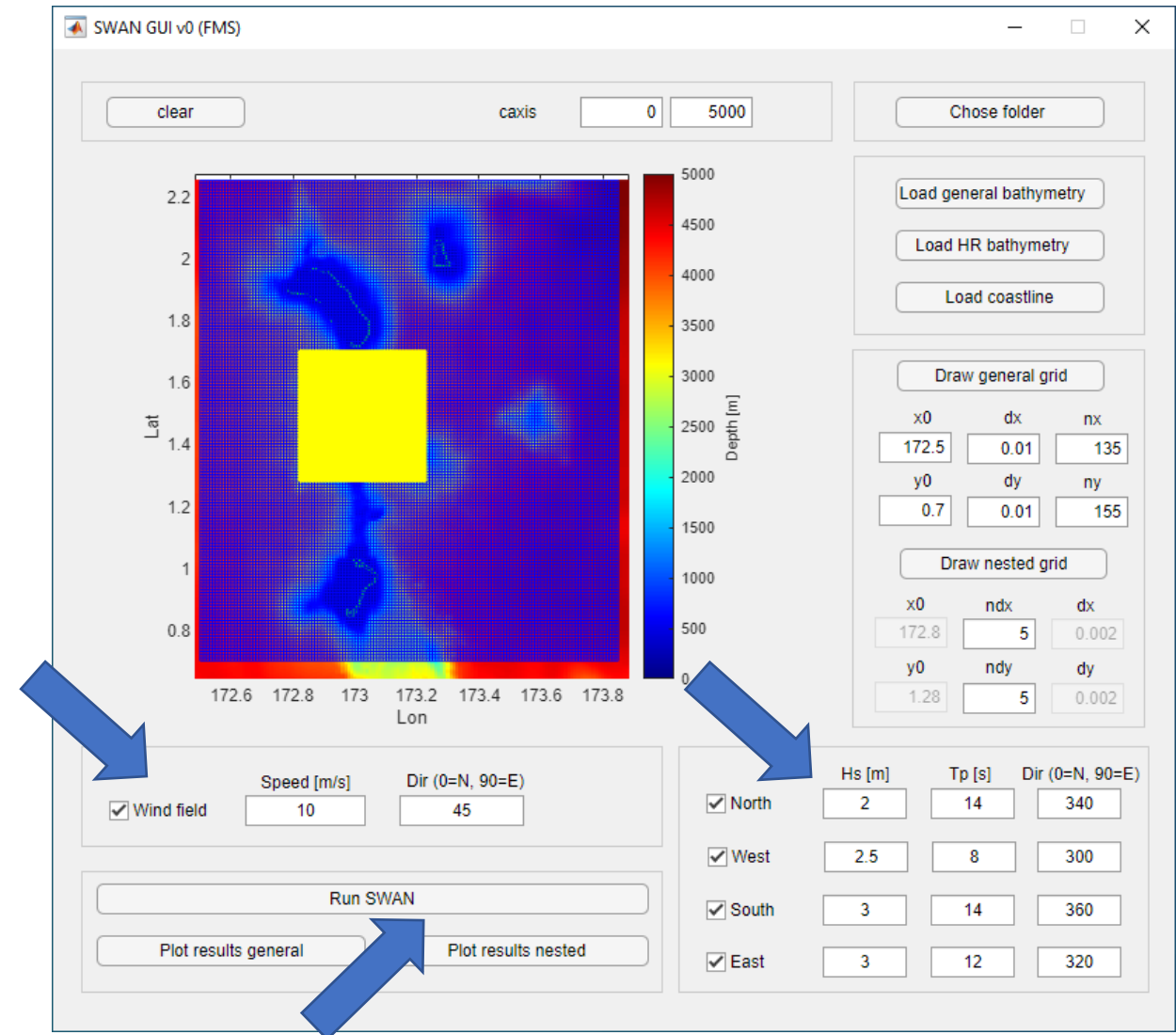
iteration 1; sweep 1
+iteration 1; sweep 2
+iteration 1; sweep 3
+iteration 1; sweep 4
not possible to compute, first iteration

iteration 2; sweep 1
+iteration 2; sweep 2
+iteration 2; sweep 3
+iteration 2; sweep 4
accuracy OK in 29.56 % of wet grid points ( 95.00 % required)

iteration 3; sweep 1
+iteration 3; sweep 2
+iteration 3; sweep 3
+iteration 3; sweep 4
accuracy OK in 0.01 % of wet grid points ( 95.00 % required)

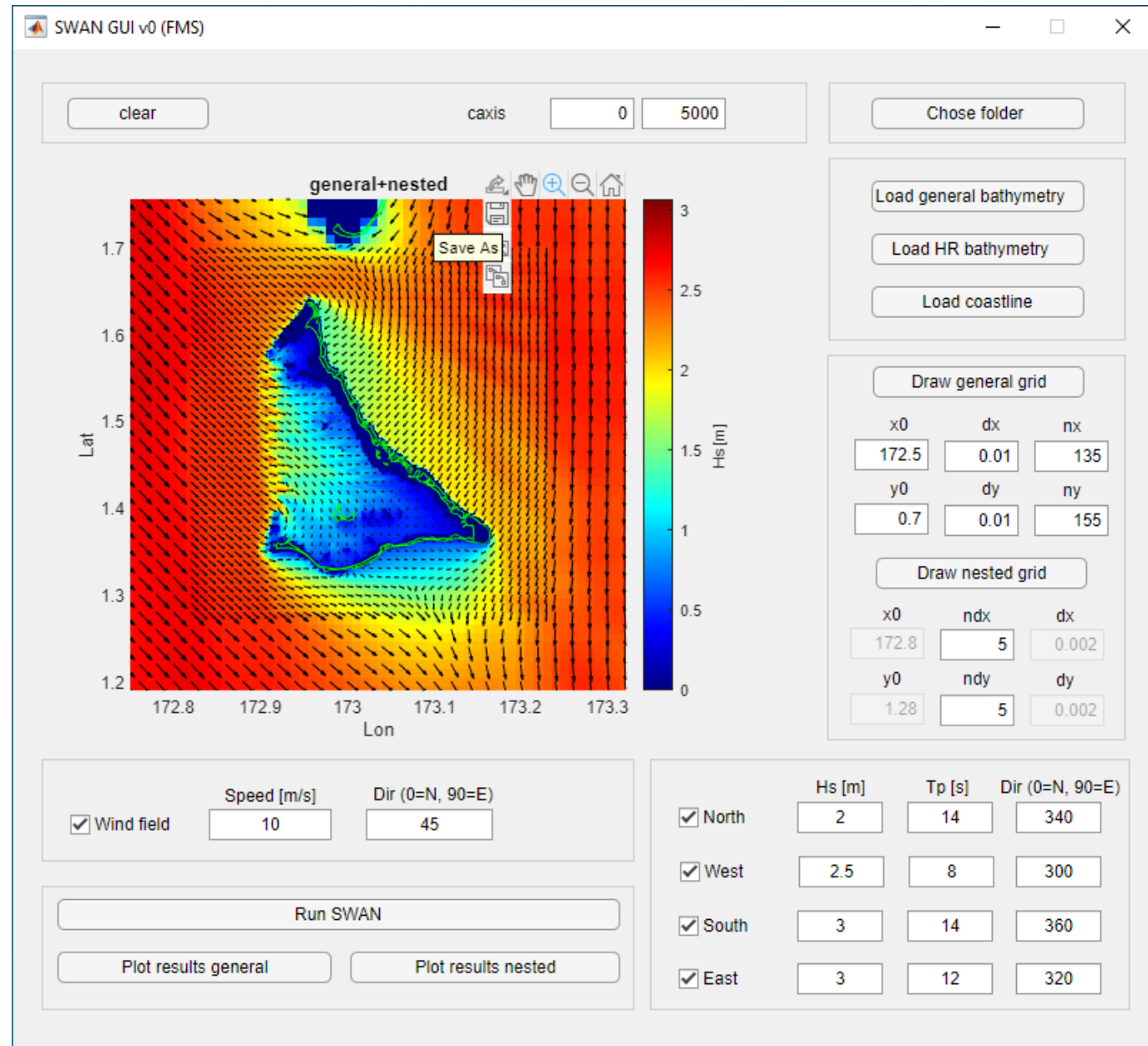
iteration 4; sweep 1
+iteration 4; sweep 2
+iteration 4; sweep 3
+iteration 4; sweep 4
accuracy OK in 13.26 % of wet grid points ( 95.00 % required)

iteration 5; sweep 1
```



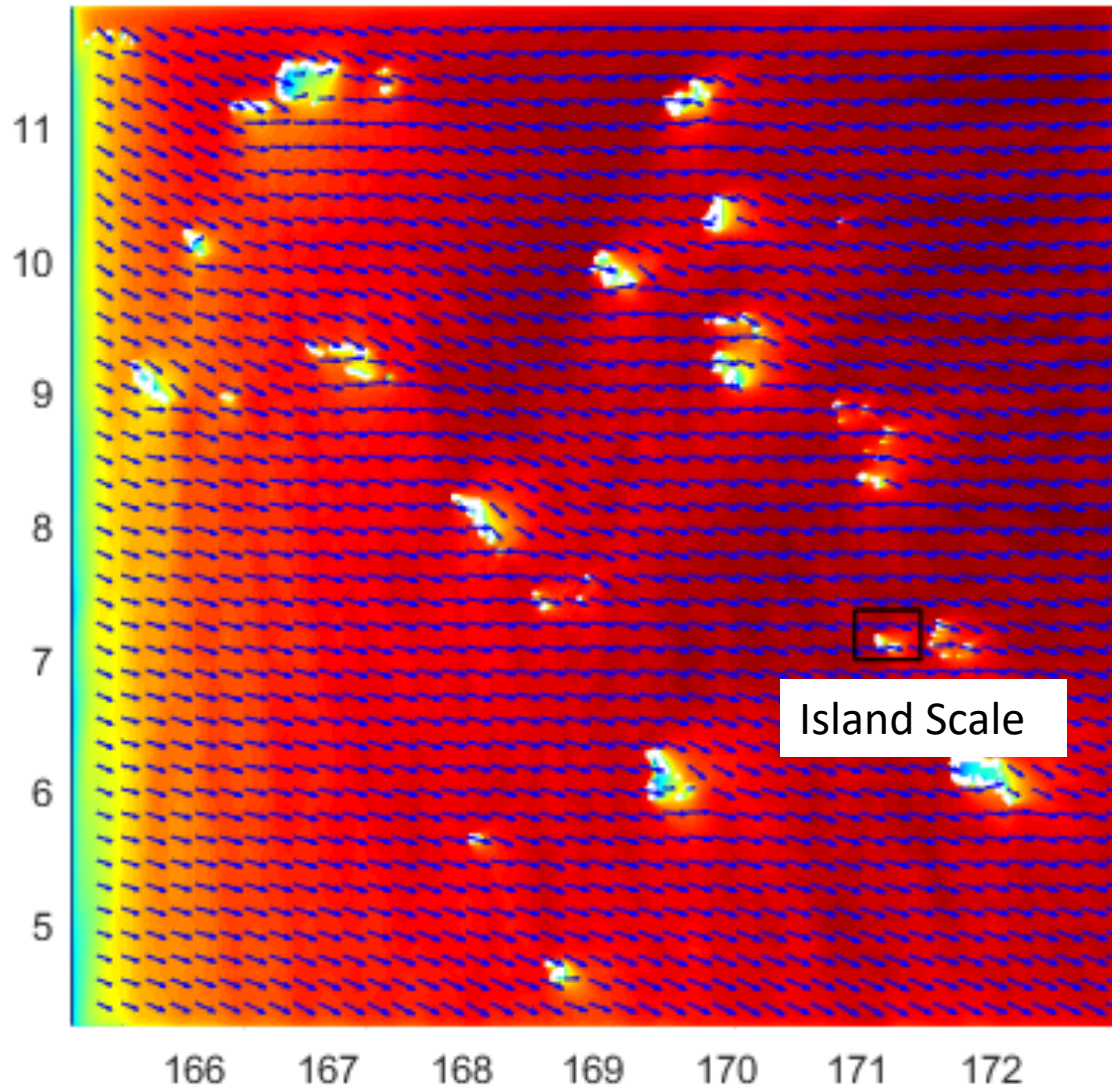
Wave model (SWAN) GUI

- **Plot result general** button: Use to plot the result from the general wave model as a 2D map of the wave height and direction.
- **Plot result nested** button: Use to plot the result from the HR wave model as a 2D map of the wave height and direction.
- The colorbar can be adjusted (Caxis) to better represent wave gradients in the area of interest.
- The result can be exported as ...

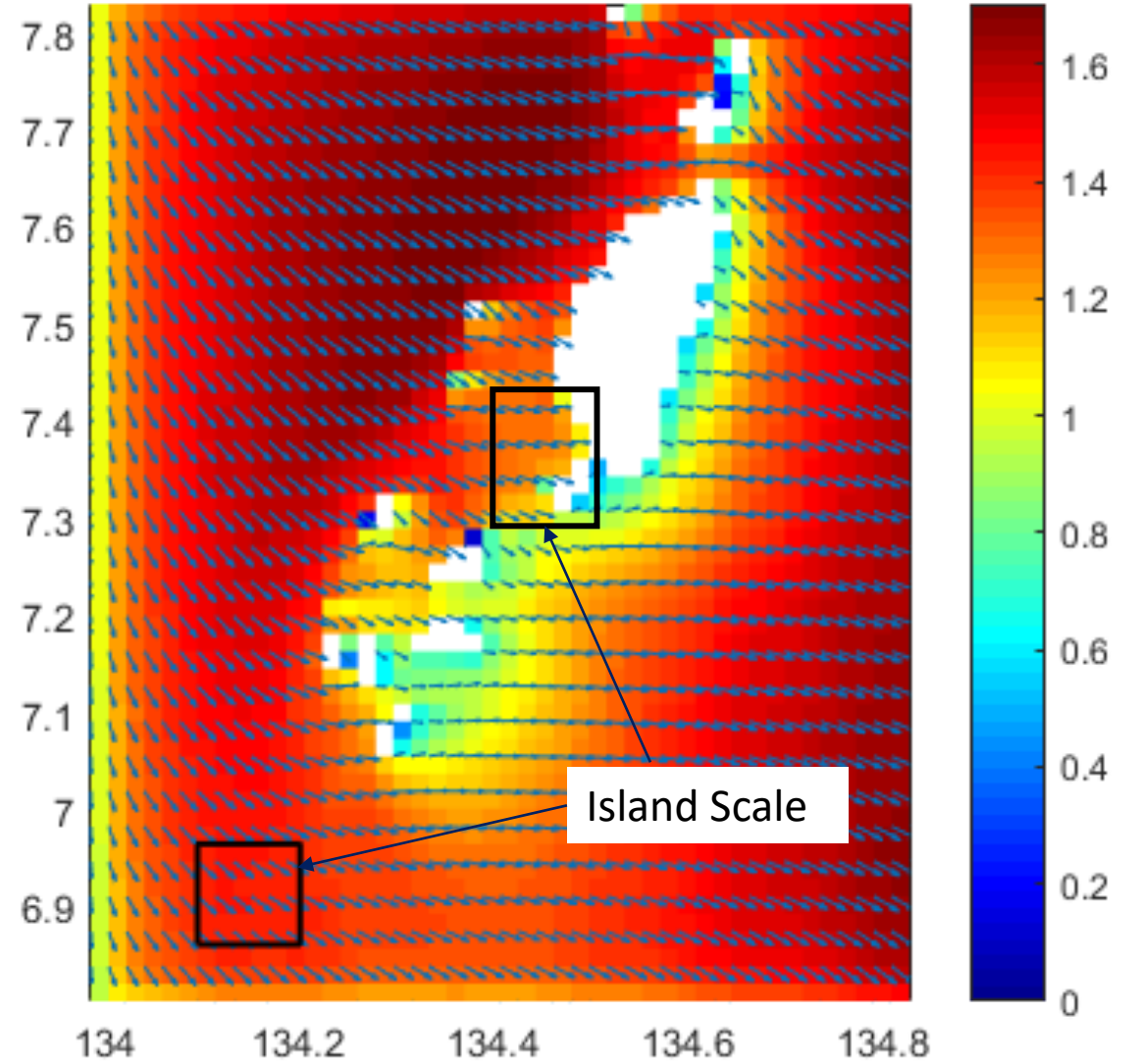


RMI

National Scale

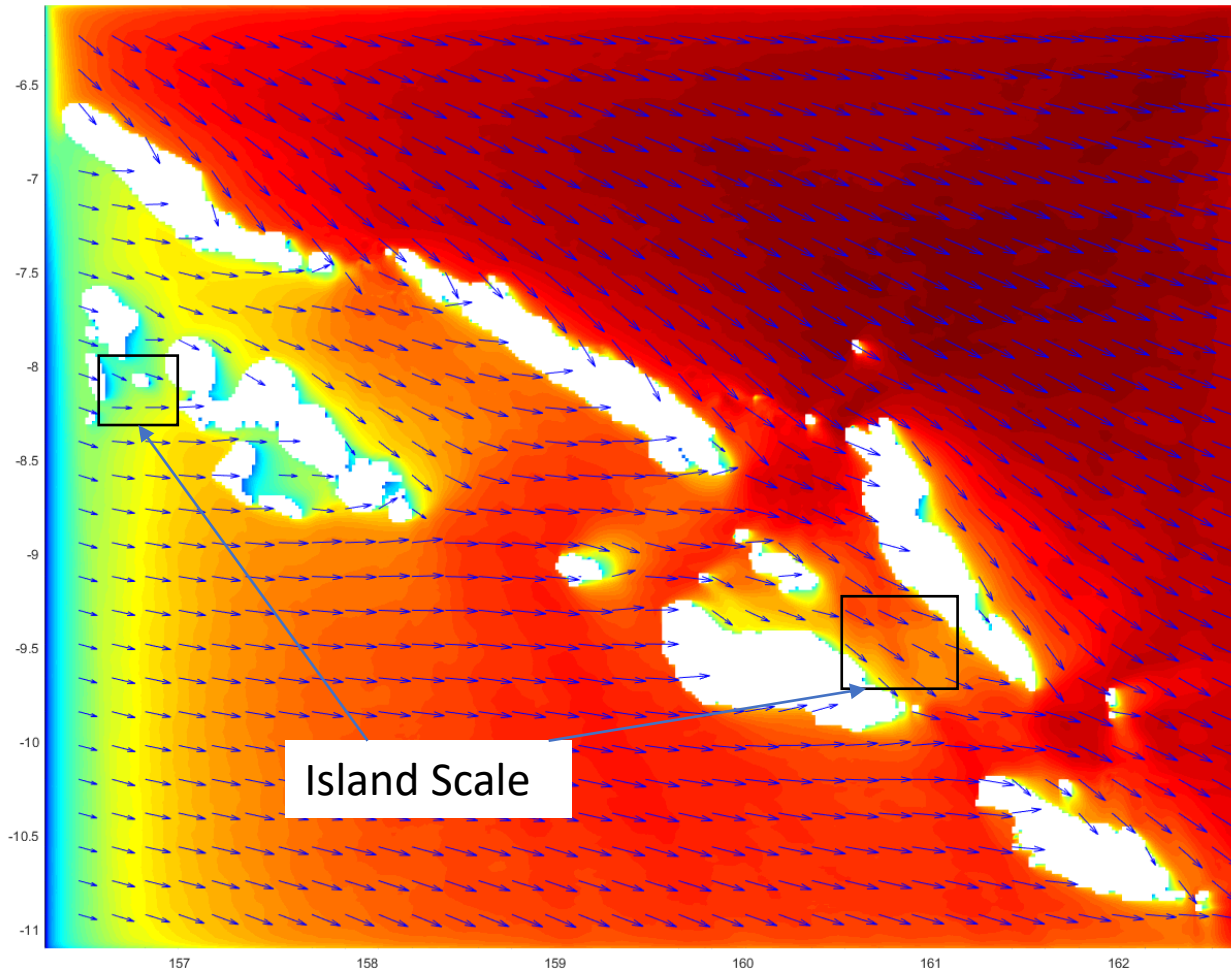


Palau



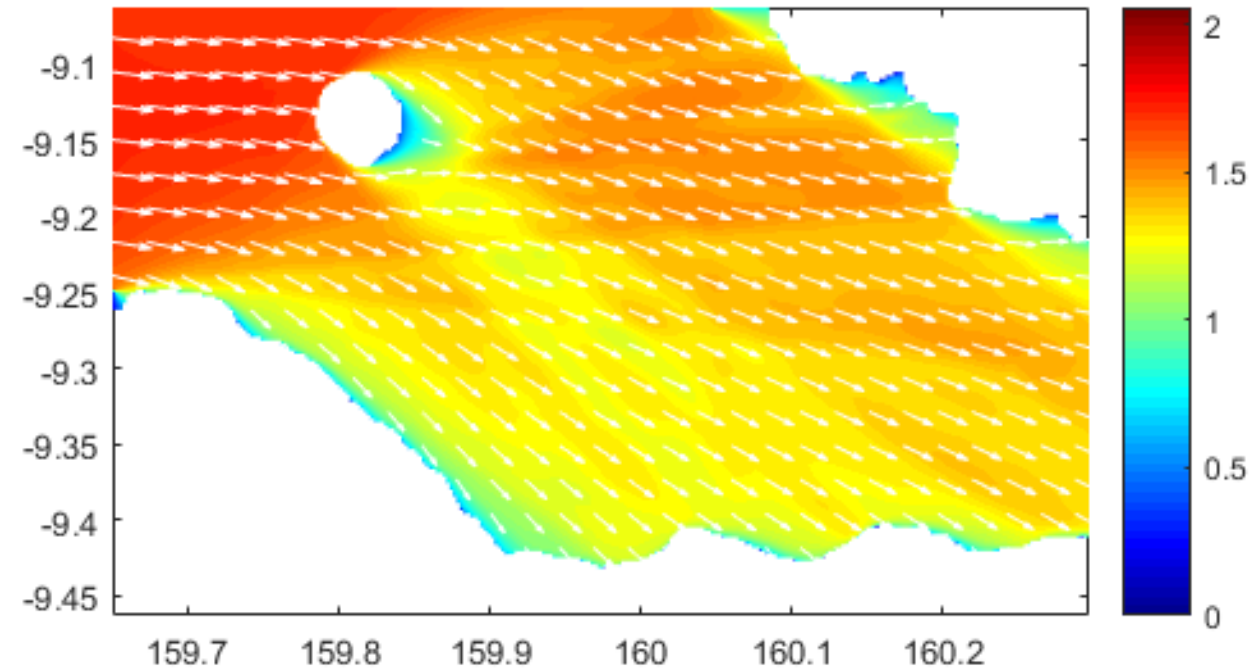
Solomon(Honiara)

National Scale



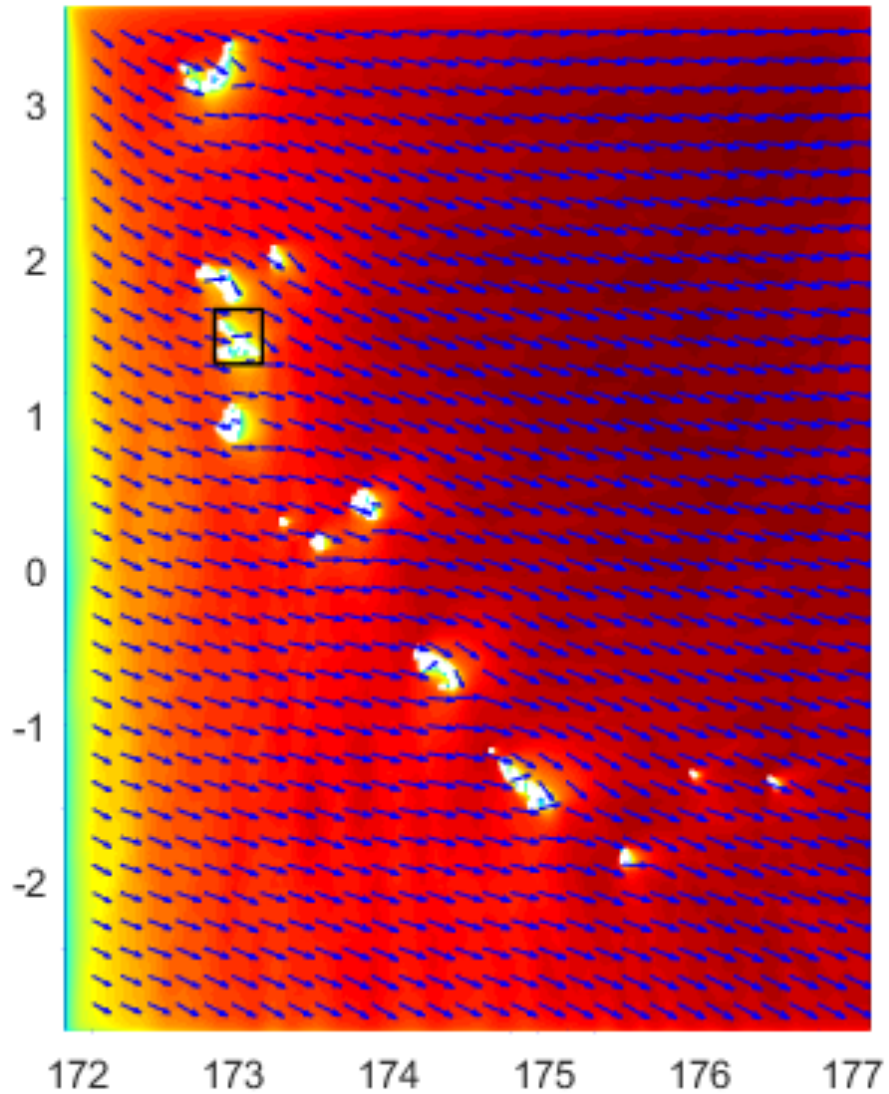
Guadalcanal/Honiara

Nested Grid

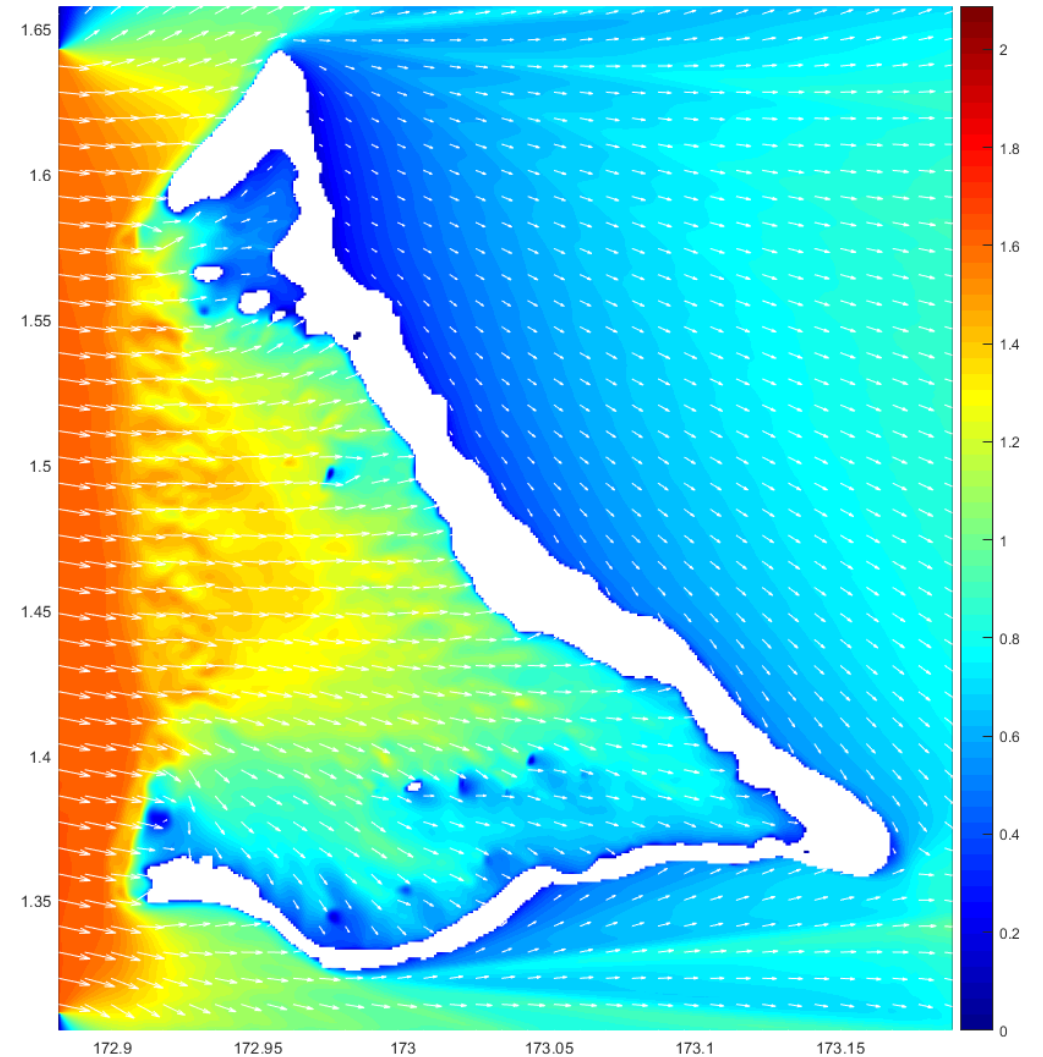


Kiribati (Tarawa)

National Scale (Gilbert Islands)



Island Scale



How could this tools and capacity be used:

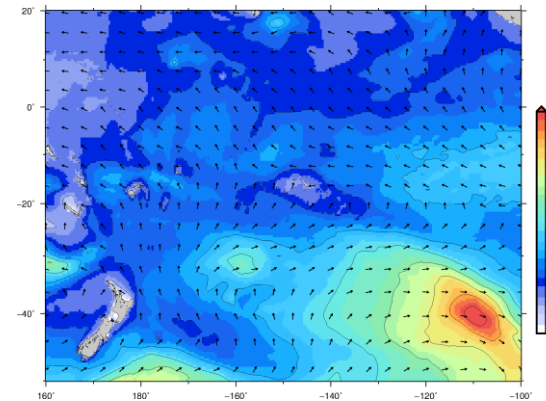
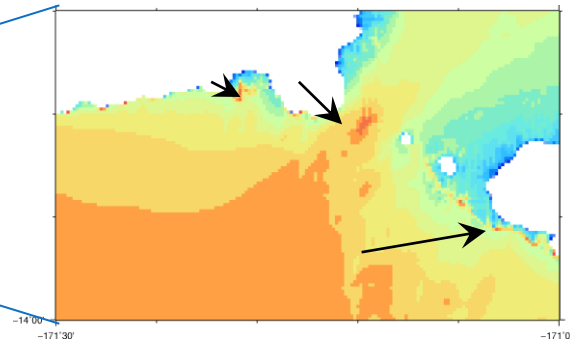
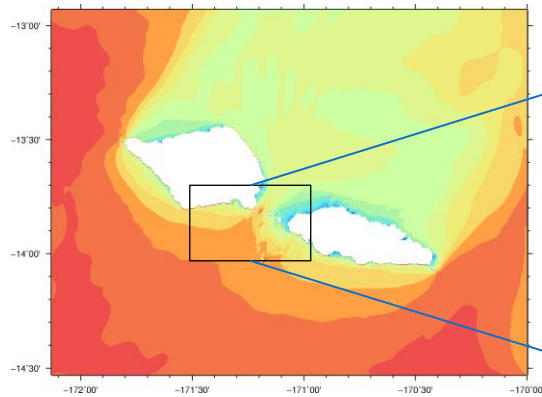
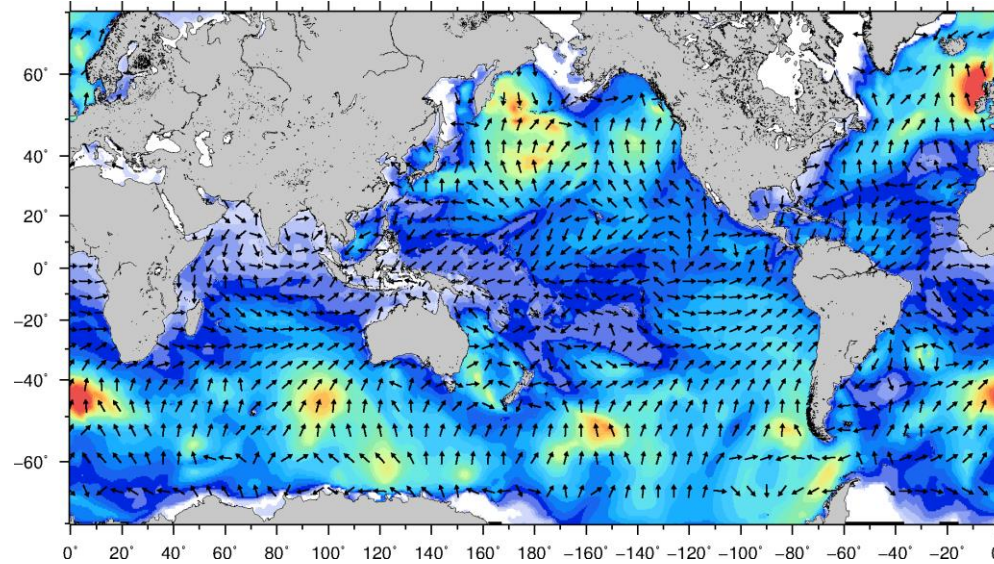
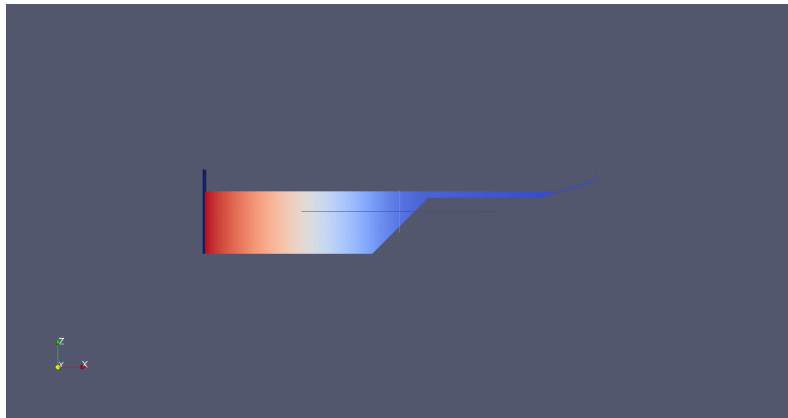
- In your country?
- In your line of work?
- In upcoming projects?

Recap

- Under the CTCN project, the project team produced a flexible user interface to easily develop wave models and see the results
- The GUI was used to create national and island scale wave models for the participating countries
- Wave models can be improved as better baseline data are made available

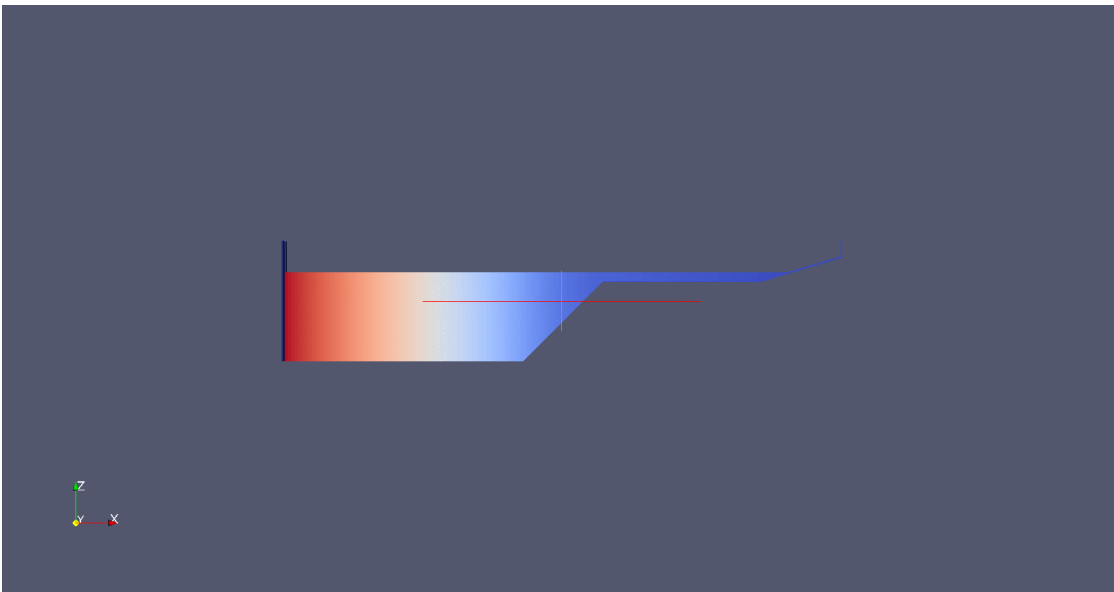
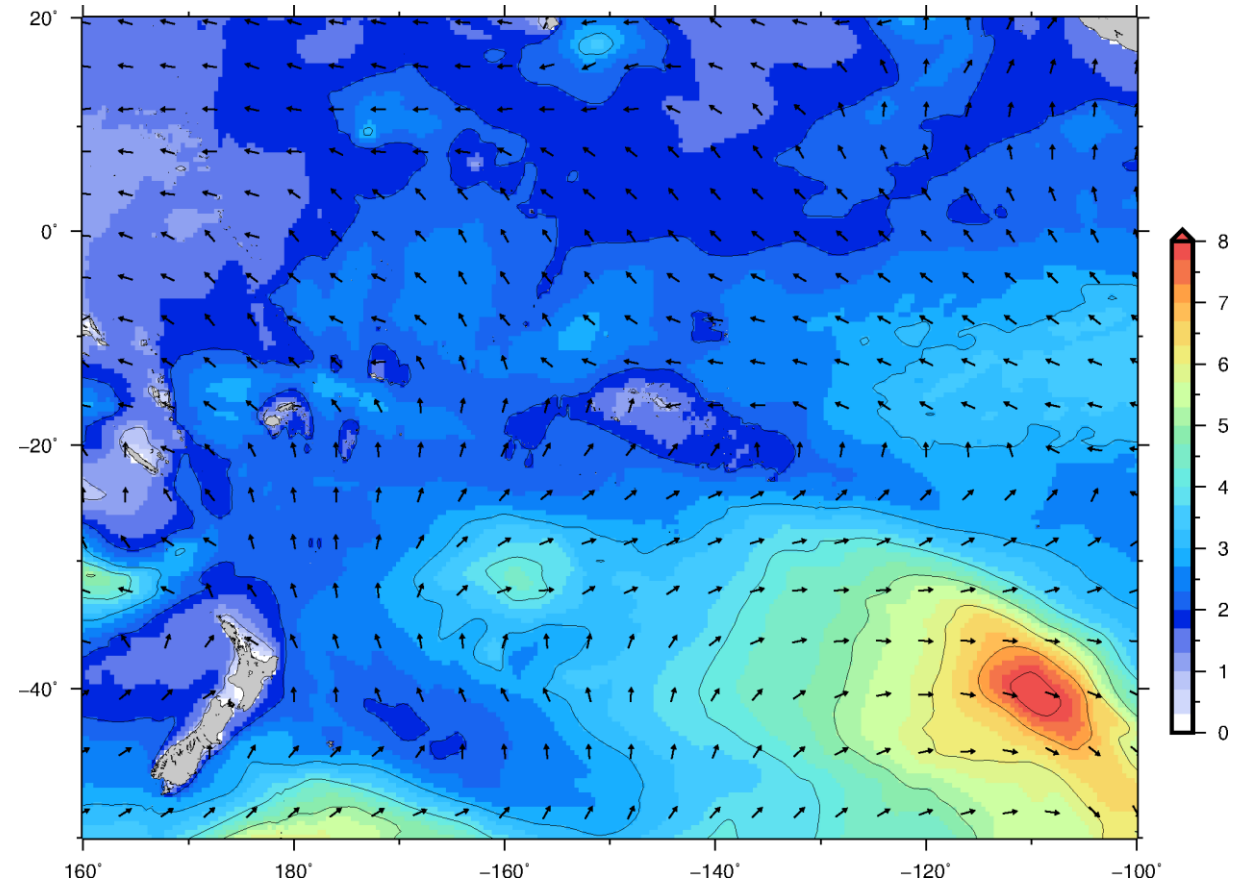
WAVE MODEL TUTORIAL

INTRODUCTION TO WAVE MODELLING



MODERN WAVE MODELS

- Phase resolving
 - Boussinesq, Non-hydrostatic, SPH... (form of hydrodynamics models)
 - Good for very local problems (e.g. Harbour design)
- Phase averaging
 - Based on the wave action balance
 - Wave Watch 3, SWAN
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 - good for forecasts



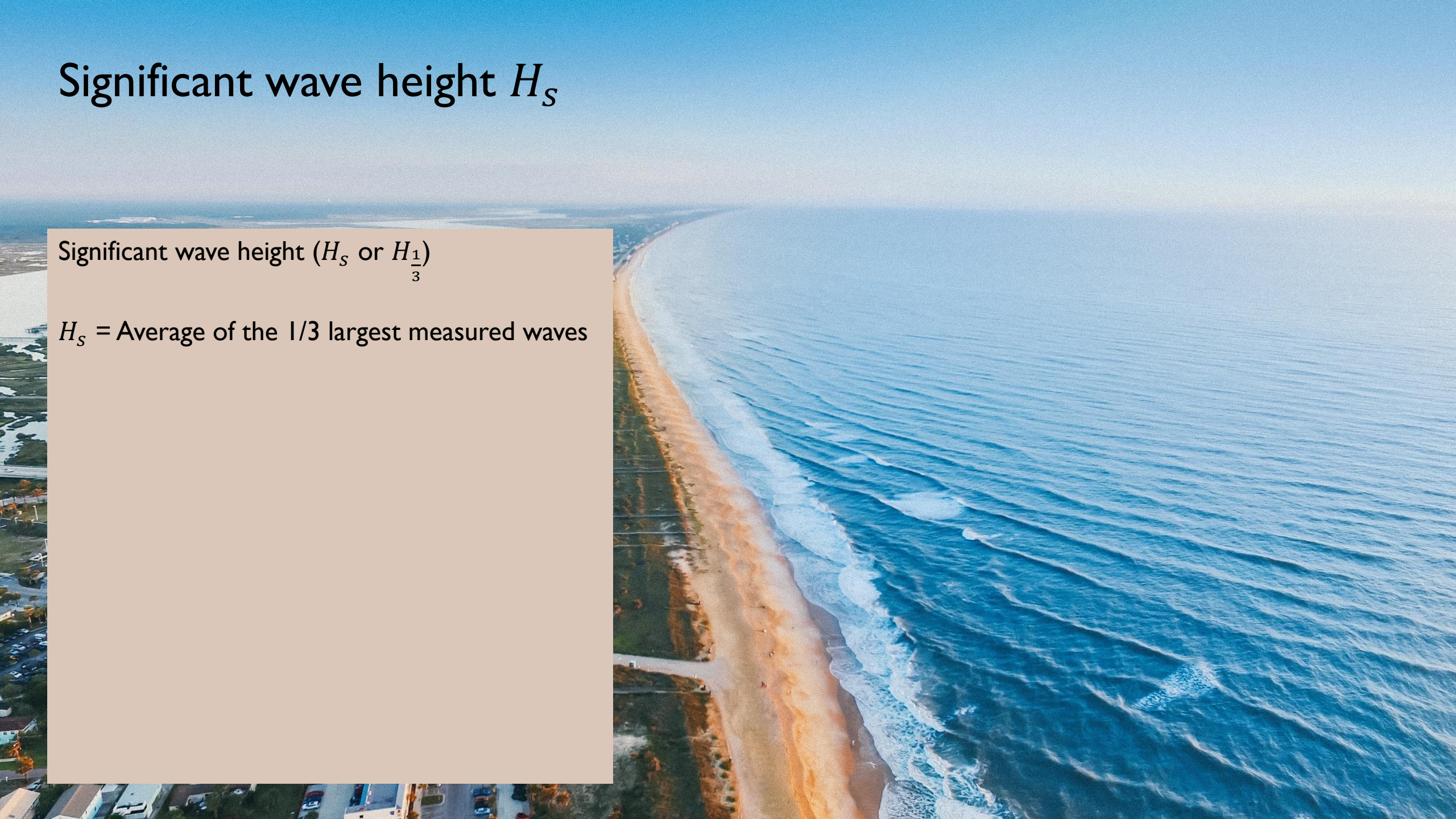
How do we define wave height?



Significant wave height H_s

Significant wave height (H_s or $H_{\frac{1}{3}}$)

H_s = Average of the 1/3 largest measured waves



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10	1 m
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Significant wave height H_s

1/3 of all measured waves

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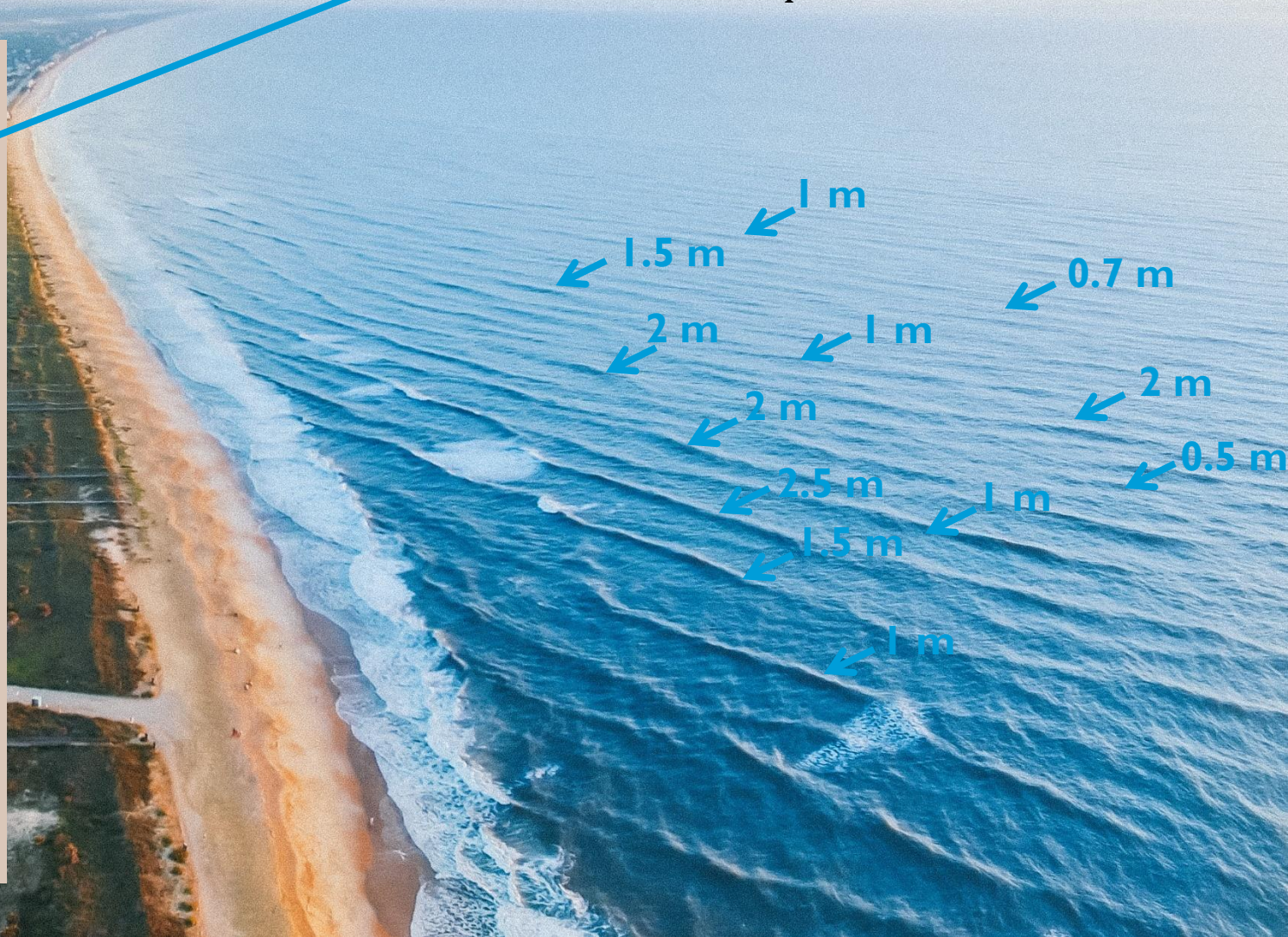


Significant wave height H_s

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Significant wave height H_s

Wave height



It is normal for waves to vary in height from one to the next. To give you an idea of the range of waves to expect at a given time, the Bureau provides the **significant wave height** in its marine forecasts.

Most frequent waves

The most frequent wave height will be about half the height of the significant wave

Significant waves

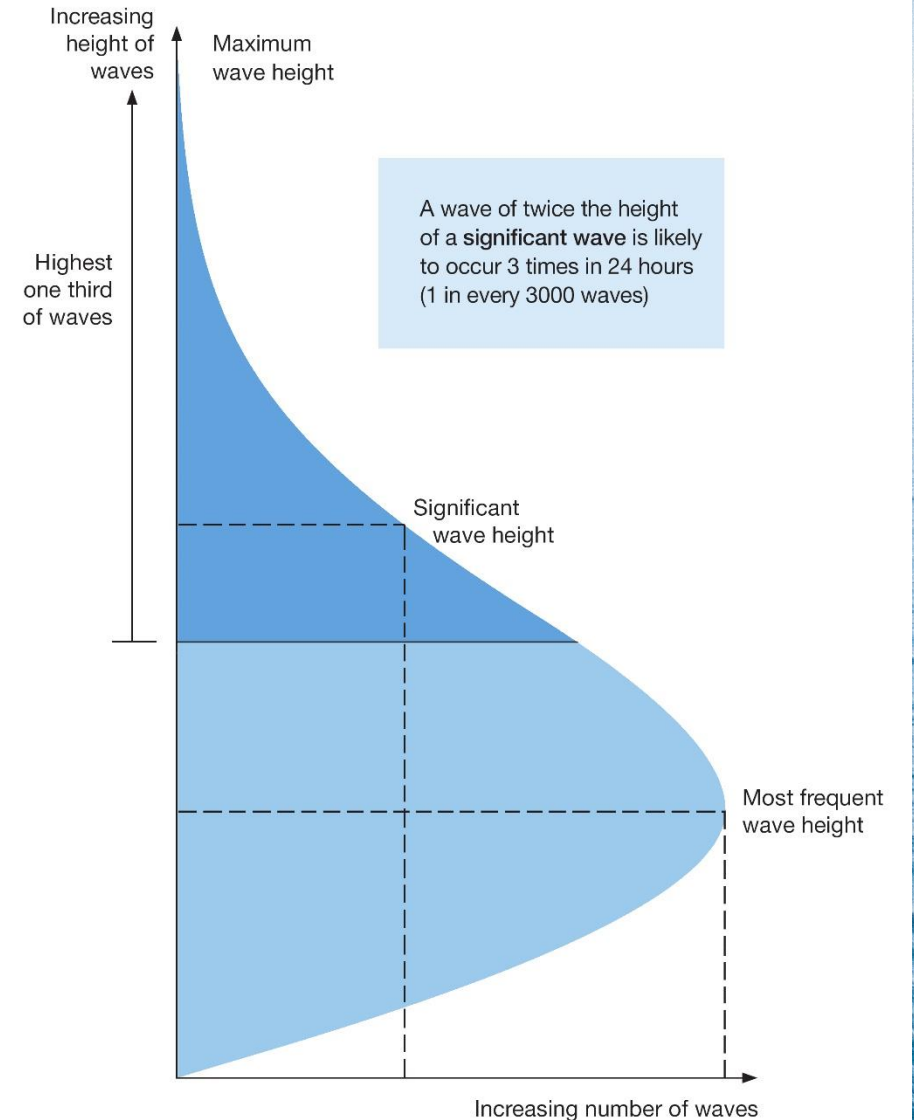
About 14% of waves will be higher than the **significant wave height** (about 1 in every 7 waves)

Maximum waves

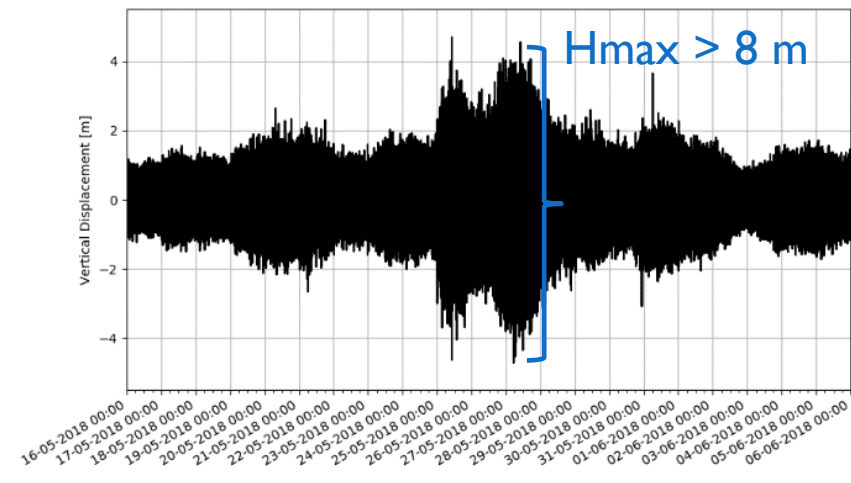
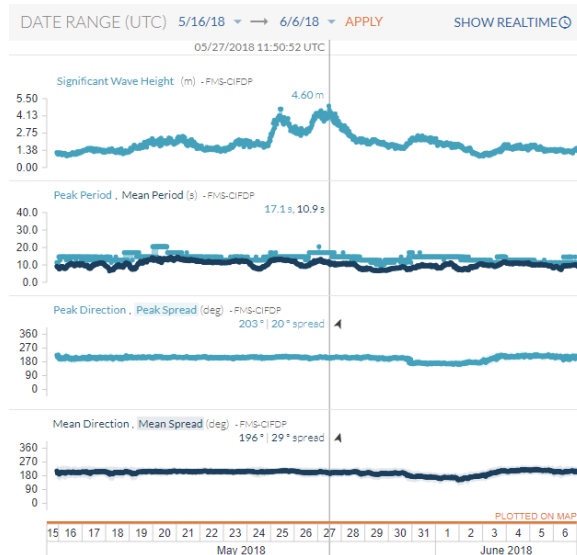
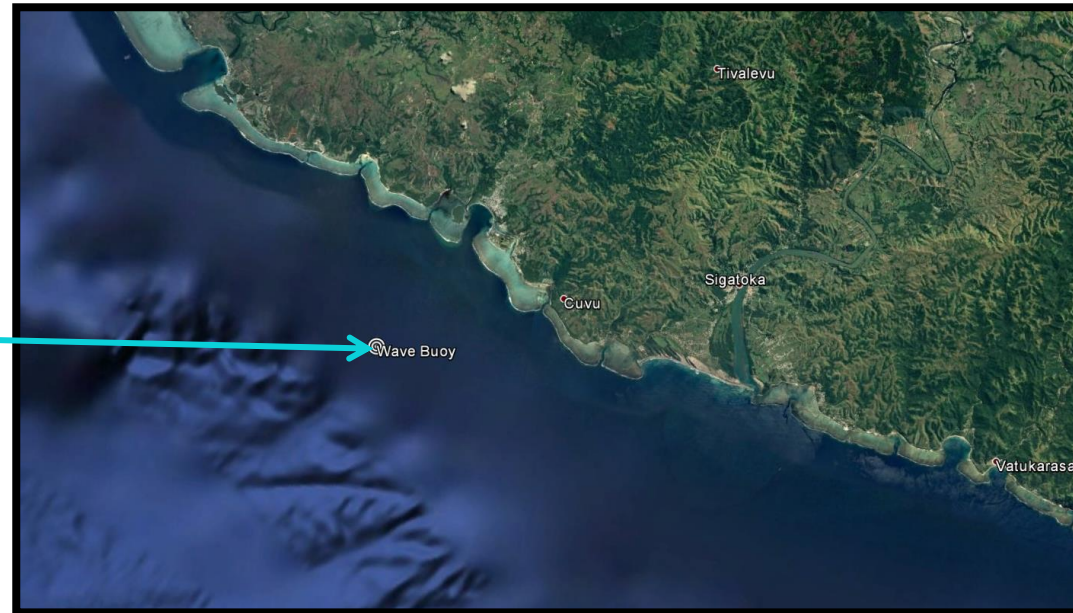
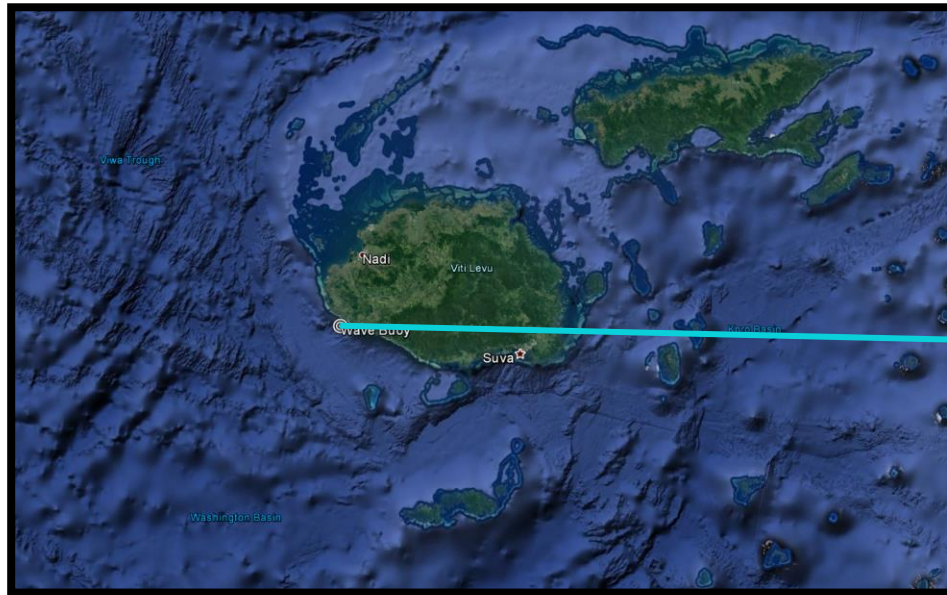
It is normal to expect a wave of twice the height of the significant wave about 3 times in 24 hours.

This means you need to be prepared for a wave of this height before heading out on the water.

Matches a human's perception of the sea state



Case Study: May 2018 Wave event



Beaufort scale (1838)

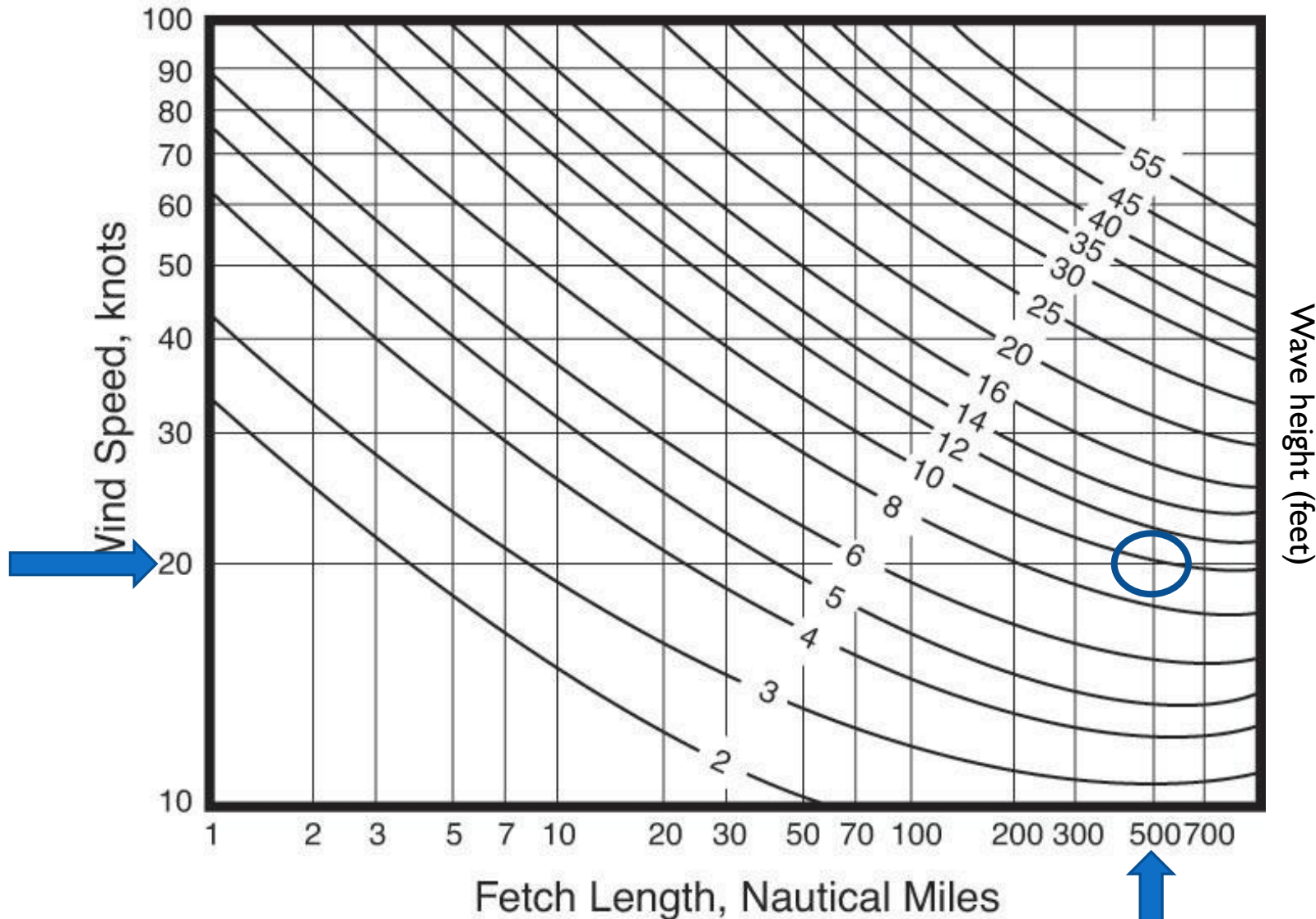
Estimating Wind Speed and Sea State with Visual Clues

Beaufort number	Wind Description	Wind Speed	Wave Height	Visual Clues
0	Calm	0 knots	0 feet	Sea is like a mirror. Smoke rises vertically.
1	Light Air	1-3 kts	< 1/2	Ripples with the appearance of scales are formed, but without foam crests. Smoke drifts from funnel.
2	Light breeze	4-6 kts	1/2 ft (max 1)	Small wavelets, still short but more pronounced, crests have glassy appearance and do not break. Wind felt on face. Smoke rises at about 80 degrees.
3	Gentle Breeze	7-10 kts	2 ft (max 3)	Large wavelets, crests begin to break. Foam of glassy appearance. Perhaps scattered white horses (white caps). Wind extends light flag and pennants. Smoke rises at about 70 deg.
4	Moderate Breeze	11-16 kts	3 ft (max 5)	Small waves, becoming longer. Fairly frequent white horses (white caps). Wind raises dust and loose paper on deck. Smoke rises at about 50 deg. No noticeable sound in the rigging. Slack halyards curve and sway. Heavy flag flaps limply.
5	Fresh Breeze	17-21kts	6 ft (max 8)	Moderate waves, taking more pronounced long form. Many white horses (white caps) are formed (chance of some spray). Wind felt strongly on face. Smoke rises at about 30 deg. Slack halyards whip while bending continuously to leeward. Taut halyards maintain slightly bent position. Low whistle in the rigging. Heavy flag doesn't extended but flaps over entire length.
6	Strong Breeze	22-27 kts	9 ft (max 12)	Large waves begin to form. White foam crests are more extensive everywhere (probably some spray). Wind stings face in temperatures below 35 deg F (2C). Slight effort in maintaining balance against wind. Smoke rises at about 15 deg. Both slack and taut halyards whip slightly in bent position. Low moaning, rather than whistle, in the rigging. Heavy flag extends and flaps more vigorously.
7	Near Gale	28-33 kts	13 ft (max 19)	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of wind. Necessary to lean slightly into the wind to maintain balance. Smoke rises at about 5 to 10 deg. Higher pitched moaning and whistling heard from rigging. Halyards still whip slightly. Heavy flag extends fully and flaps only at the end. Oilskins and loose clothing inflate and pull against the body.
8	Gale	34-40 kts	18 ft (max 25)	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the direction of the wind. Head pushed back by the force of the wind if allowed to relax. Oilskins and loose clothing inflate and pull strongly. Halyards rigidly bent. Loud whistle from rigging. Heavy flag straight out and whipping.
9	Strong Gale	41-47 kts	23 ft (max 32)	High waves. Dense streaks of foam along direction of wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	Storm	48-55 kts	29 ft (max 41)	Very high waves with long overhanging crests. The resulting foam, in great patches is blown in dense streaks along the direction of the wind. On the whole, the sea takes on a whitish appearance. Tumbling of the sea becomes heavy and shock-like. Visibility affected.
11	Violent Storm	56-63 kts	37 ft (max 52)	Exceptionally high waves (small and medium-sized ships might be for time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere, the edges of the wave crests are blown into froth. Visibility greatly affected.
12	Hurricane	64+ kts	45+ ft	The air is filled with foam and spray. The sea is completely white with driving spray. Visibility is seriously affected.

Example:

What is the wave height if the wind speed is 20 knots?

Sverdrup-Munk-Bretschneider Nomogram (1952)



Example:

What is the wave height if the wind speed is 20 knots and the wind fetch is 500 nmi?

Manual Wave Forecasting Diagram

(Gröen and Dorrestein, 1976)

Example:

What is the wave height and period if the wind speed is 20 knots and the wind fetch is 100 nmi?

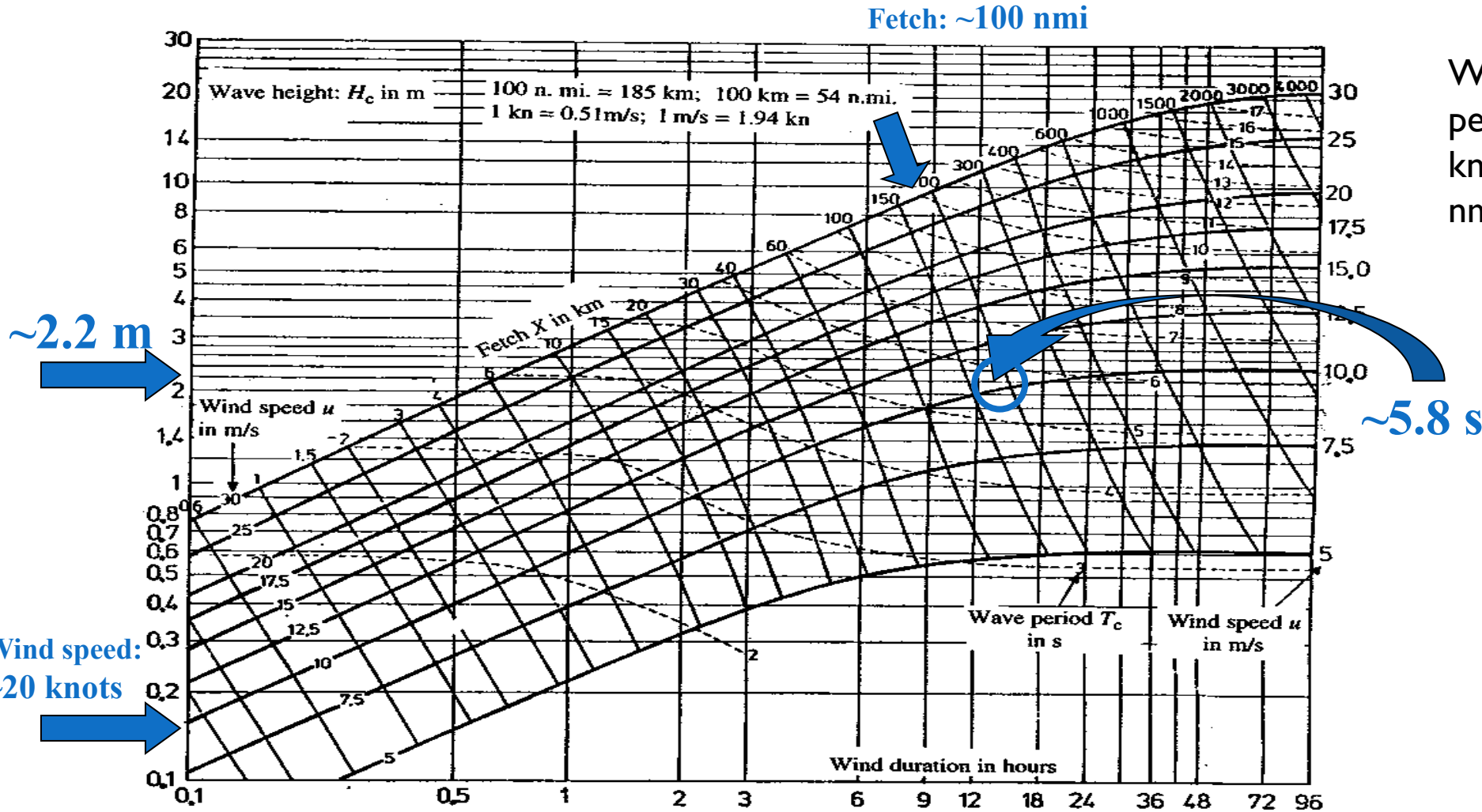


Figure 4.1 — Manual wave forecasting diagram (from Gröen and Dorrestein, 1976)

Excercise

Predict the wave heights (and if possible wave periods) in Fiji for tomorrow 12 pm, using Windy.com and the following tool:

- a) the Beaufort Scale
- b) the Sverdrup-Munk-Bretschneider Nomogram
- c) the manual wave forecasting diagram

Hint: You can use windy.com and the distance tool.

How do your predictions differ from the windy.com wave forecast?

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TAVARUA - CLOUDBREAK SURF REPORT AND FORECAST

FJI, SAMOA + TONGA / FJI / MAMANUCAS AND VITI LEVU

[FORECAST](#) [HISTORIC](#) [SEASONAL](#) [TIDE](#) [SPOT GUIDE](#) [REPORTS](#) [PHOTOS](#) [SPOTS](#) [BUOYS](#) [WINDS](#)

CURRENT SURF REPORT FOR TAVARUA - CLOUDBREAK

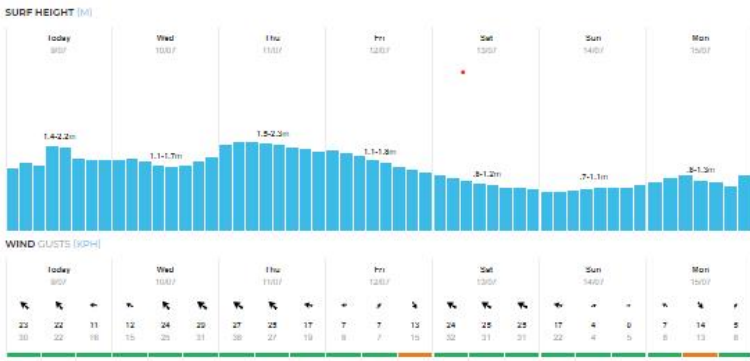


ABOUT TAVARUA - CLOUDBREAK

Once the exclusive domain of well-heeled surfers able to pay the hefty daily rate to stay at the Tavarua Island surf resort, the Fijian government recently changed the law which allowed the resort to control... more



TAVARUA - CLOUDBREAK SURF FORECAST



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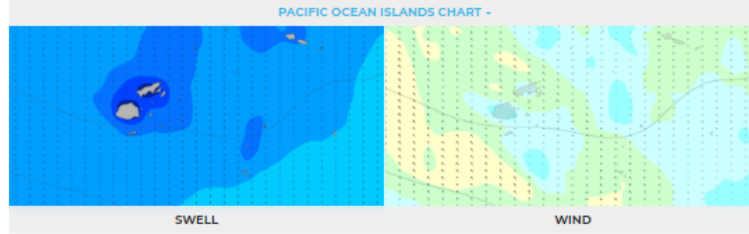
FOURTH SURFBOARDS DOOFER ESE CONSTRUCTION FCS II 5'5IN SURFBOARD

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PHOTO MENTAWAI MIND SURF

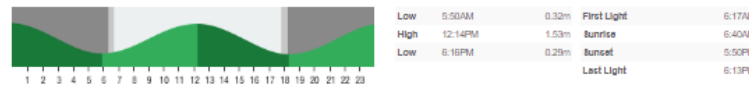
SWELL WIND



HOURLY MULTIPLE SWELLS WIND HIGHLIGHTING MODEL UNITS M, KPH

TUESDAY 09/07	SURF	SWELL RATING	PRIMARY SWELL	SECONDARY SWELL	WIND	WEATHER	PROB.
12am	1.1-1.7m	★★★★★	1.2m 10z	1.1m 14z	0.6m 4z	21 ²⁵ Kph	24°C 100%
3am	1.2-1.8m	★★★★★	1.3m 9z	1.2m 13z	0.8m 4z	22 ²⁹ Kph	24°C 100%
6am	1.1-1.7m	★★★★★	1.3m 13z	0.8m 10z	1.3m 8z	23 ²³ Kph	23°C 100%
9am	1.4-2.3m	★★★★★	1.9m 13z	0.8m 16z		24 ²¹ Kph	26°C 100%
Noon	1.4-2.2m	★★★★★	1.9m 12z	0.9m 15z		22 ²² Kph	27°C 100%
3pm	1.2-1.9m	★★★★★	1.8m 12z	0.9m 15z		29 ²³ Kph	27°C 100%
6pm	1.2-1.9m	★★★★★	1m 15z	1.7m 12z		11 ¹⁵ Kph	26°C 100%
9pm	1.2-1.9m	★★★★★	1m 14z	1.6m 11z		8 ¹¹ Kph	24°C 100%

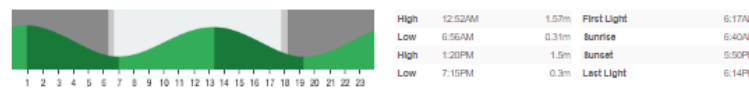
TIDE AND DAYLIGHT TIMES FOR NANDI WATERS, VITI LEVU, FJI ISLANDS



WEDNESDAY 10/07

12am	1.2-1.9m	★★★★★	1m 14z	1.4m 11z	0.7m 4z	8 ⁹ Kph	24°C 100%
3am	1.2-1.9m	★★★★★	1m 14z	1.4m 11z		9 ⁹ Kph	23°C 100%
6am	1.2-1.8m	★★★★★	1m 14z	1.4m 11z	0.6m 10z	12 ¹⁵ Kph	23°C 100%
9am	1.1-1.8m	★★★★★	0.9m 14z	1.4m 10z	0.6m 10z	16 ²² Kph	24°C 100%
Noon	1.1-1.7m	★★★★★	0.9m 13z	0.6m 18z	1.4m 7z	24 ²⁵ Kph	27°C 95%
3pm	1.1-1.7m	★★★★★	0.8m 17z	0.7m 13z	1.5m 7z	37 ³³ Kph	28°C 95%
6pm	1.2-1.8m	★★★★★	0.9m 17z	0.7m 13z	1.5m 7z	29 ²¹ Kph	26°C 100%
9pm	1.2-1.9m	★★★★★	1m 16z	0.7m 13z	1.6m 7z	30 ³³ Kph	24°C 100%

TIDE AND DAYLIGHT TIMES FOR NANDI WATERS, VITI LEVU, FJI ISLANDS



THURSDAY 11/07

12am	1.5-2.3m	★★★★★	1.2m 16z	0.6m 16z	1.7m 7z	27 ¹⁷ Kph	24°C 100%
3am	1.5-2.4m	★★★★★	1.3m 16z	0.6m 17z	1.7m 7z	30 ³³ Kph	24°C 100%

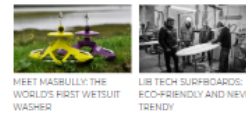


TWO DAYS OF CARNAGE AT CAPE SOLANDER



IS JONATHAN CURBINS THE MOST BARRELLED MAN ALIVE?
HOW DO LOW PRESSURES FORM AND WHY IT'S IMPORTANT FOR SURFING
SIX TRAVEL ESSENTIALS YOU DIDN'T KNOW YOU NEEDED
SURFING AN ENDLESS WAVE ON THE AMAZON RIVER

PROMOTED CONTENT



MEET MASBULLY: THE WORLD'S FIRST WETSUIT WASHER
LIB TECH SURFBOARDS: ECO-FRIENDLY AND NEVER TRENDY
OCEANIZ CALLS SURFERS OF THE WORLD TO LEAD THE CHANCE FOR THE OCEAN
WATCH: WILLIAM ALLOTT'S FIRST FLICK NEW RELIGION

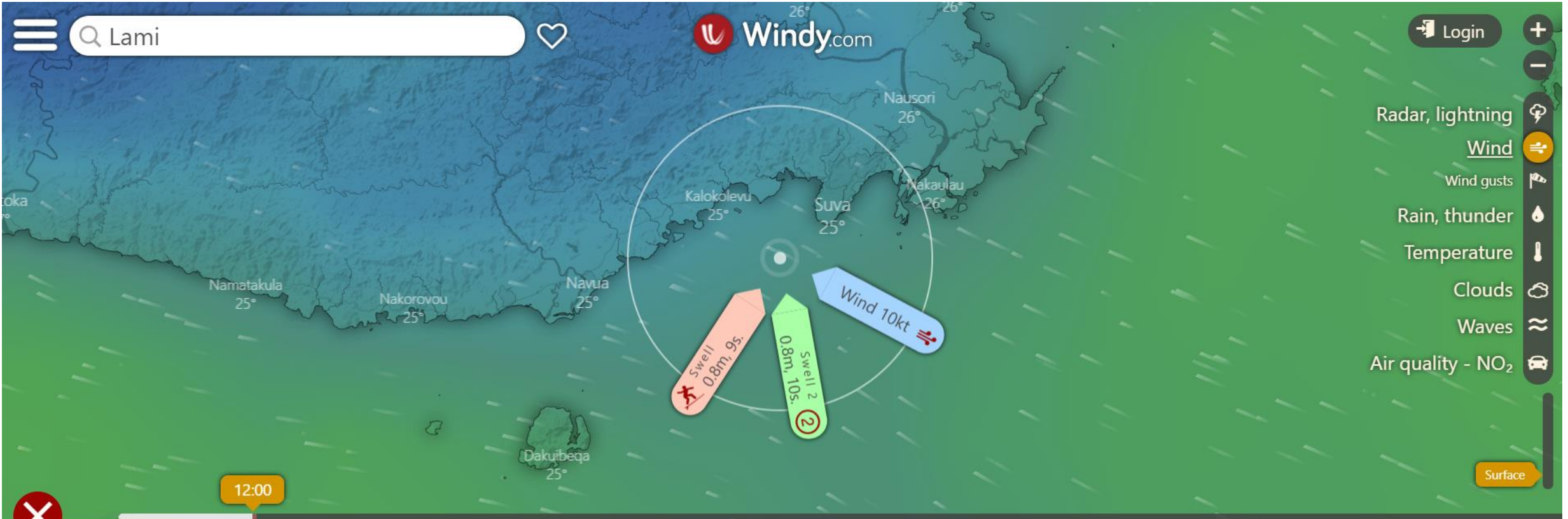
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Init:	Tu	Tu	Tu	Tu	Tu	We	We	We	We	We	We	We	Th	Th	Th	Th	Th	Th	Fr	Fr	Fr	Fr	Fr	Fr	Sa	Sa	Sa	Sa	Sa	Sa	Su	Su	Su	Su	Su	Su	Mo	Mo	Mo	Mo	Mo	Mo	Tu	Tu	Tu	Tu	Tu	We	We	We	We	We	We	Th	Th	Th	Th	Th	Th	Fr	Fr																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
08.07.2019 18 UTC	09.06h	09.09h	09.12h	09.15h	09.18h	09.03h	09.06h	09.09h	09.12h	09.15h	09.18h	09.21h	10.03h	10.06h	10.09h	10.12h	10.15h	10.18h	10.21h	11.03h	11.06h	11.09h	11.12h	11.15h	11.18h	11.21h	11.24h	11.27h	11.30h	11.33h	11.36h	11.39h	11.42h	11.45h	11.48h	11.51h	11.54h	11.57h	12.00h	12.03h	12.06h	12.09h	12.12h	12.15h	12.18h	12.21h	12.24h	12.27h	12.30h	12.33h	12.36h	12.39h	12.42h	12.45h	12.48h	12.51h	12.54h	12.57h	13.00h	13.03h	13.06h	13.09h	13.12h	13.15h	13.18h	13.21h	13.24h	13.27h	13.30h	13.33h	13.36h	13.39h	13.42h	13.45h	13.48h	13.51h	13.54h	13.57h	14.00h	14.03h	14.06h	14.09h	14.12h	14.15h	14.18h	14.21h	14.24h	14.27h	14.30h	14.33h	14.36h	14.39h	14.42h	14.45h	14.48h	14.51h	14.54h	14.57h	15.00h	15.03h	15.06h	15.09h	15.12h	15.15h	15.18h	15.21h	15.24h	15.27h	15.30h	15.33h	15.36h	15.39h	15.42h	15.45h	15.48h	15.51h	15.54h	15.57h	16.00h	16.03h	16.06h	16.09h	16.12h	16.15h	16.18h	16.21h	16.24h	16.27h	16.30h	16.33h	16.36h	16.39h	16.42h	16.45h	16.48h	16.51h	16.54h	16.57h	17.00h	17.03h	17.06h	17.09h	17.12h	17.15h	17.18h	17.21h	17.24h	17.27h	17.30h	17.33h	17.36h	17.39h	17.42h	17.45h	17.48h	17.51h	17.54h	17.57h	18.00h	18.03h	18.06h	18.09h	18.12h	18.15h	18.18h	18.21h	18.24h	18.27h	18.30h	18.33h	18.36h	18.39h	18.42h	18.45h	18.48h	18.51h	18.54h	18.57h	19.00h	19.03h	19.06h	19.09h	19.12h	19.15h	19.18h	19.21h	19.24h	19.27h	19.30h	19.33h	19.36h	19.39h	19.42h	19.45h	19.48h	19.51h	19.54h	19.57h	20.00h	20.03h	20.06h	20.09h	20.12h	20.15h	20.18h	20.21h	20.24h	20.27h	20.30h	20.33h	20.36h	20.39h	20.42h	20.45h	20.48h	20.51h	20.54h	20.57h	21.00h	21.03h	21.06h	21.09h	21.12h	21.15h	21.18h	21.21h	21.24h	21.27h	21.30h	21.33h	21.36h	21.39h	21.42h	21.45h	21.48h	21.51h	21.54h	21.57h	22.00h	22.03h	22.06h	22.09h	22.12h	22.15h	22.18h	22.21h	22.24h	22.27h	22.30h	22.33h	22.36h	22.39h	22.42h	22.45h	22.48h	22.51h	22.54h	22.57h	23.00h	23.03h	23.06h	23.09h	23.12h	23.15h	23.18h	23.21h	23.24h	23.27h	23.30h	23.33h	23.36h	23.39h	23.42h	23.45h	23.48h	23.51h	23.54h	23.57h	24.00h	24.03h	24.06h	24.09h	24.12h	24.15h	24.18h	24.21h	24.24h	24.27h	24.30h	24.33h	24.36h	24.39h	24.42h	24.45h	24.48h	24.51h	24.54h	24.57h	25.00h	25.03h	25.06h	25.09h	25.12h	25.15h	25.18h	25.21h	25.24h	25.27h	25.30h	25.33h	25.36h	25.39h	25.42h	25.45h	25.48h	25.51h	25.54h	25.57h	26.00h	26.03h	26.06h	26.09h	26.12h	26.15h	26.18h	26.21h	26.24h	26.27h	26.30h	26.33h	26.36h	26.39h	26.42h	26.45h	26.48h	26.51h	26.54h	26.57h	27.00h	27.03h	27.06h	27.09h	27.12h	27.15h	27.18h	27.21h	27.24h	27.27h	27.30h	27.33h	27.36h	27.39h	27.42h	27.45h	27.48h	27.51h	27.54h	27.57h	28.00h	28.03h	28.06h	28.09h	28.12h	28.15h	28.18h	28.21h	28.24h	28.27h	28.30h	28.33h	28.36h	28.39h	28.42h	28.45h	28.48h	28.51h	28.54h	28.57h	29.00h	29.03h	29.06h	29.09h	29.12h	29.15h	29.18h	29.21h	29.24h	29.27h	29.30h	29.33h	29.36h	29.39h	29.42h	29.45h	29.48h	29.51h	29.54h	29.57h	30.00h	30.03h	30.06h	30.09h	30.12h	30.15h	30.18h	30.21h	30.24h	30.27h	30.30h	30.33h	30.36h	30.39h	30.42h	30.45h	30.48h	30.51h	30.54h	30.57h	31.00h	31.03h	31.06h	31.09h	31.12h	31.15h	31.18h	31.21h	31.24h	31.27h	31.30h	31.33h	31.36h	31.39h	31.42h	31.45h	31.48h	31.51h	31.54h	31.57h	32.00h	32.03h	32.06h	32.09h	32.12h	32.15h	32.18h	32.21h	32.24h	32.27h	32.30h	32.33h	32.36h	32.39h	32.42h	32.45h	32.48h	32.51h	32.54h	32.57h	33.00h	33.03h	33.06h	33.09h	33.12h	33.15h	33.18h	33.21h	33.24h	33.27h	33.30h	33.33h	33.36h	33.39h	33.42h	33.45h	33.48h	33.51h	33.54h	33.57h	34.00h	34.03h	34.06h	34.09h	34.12h	34.15h	34.18h	34.21h	34.24h	34.27h	34.30h	34.33h	34.36h	34.39h	34.42h	34.45h	34.48h	34.51h	34.54h	34.57h	35.00h	35.03h	35.06h	35.09h	35.12h	35.15h	35.18h	35.21h	35.24h	35.27h	35.30h	35.33h	35.36h	35.39h	35.42h	35.45h	35.48h	35.51h	35.54h	35.57h	36.00h	36.03h	36.06h	36.09h	36.12h	36.15h	36.18h	36.21h	36.24h	36.27h	36.30h	36.33h	36.36h	36.39h	36.42h	36.45h	36.48h	36.51h	36.54h	36.57h	37.00h	37.03h	37.06h	37.09h	37.12h	37.15h	37.18h	37.21h	37.24h	37.27h	37.30h	37.33h	37.36h	37.39h	37.42h	37.45h	37.48h	37.51h	37.54h	37.57h	38.00h	38.03h	38.06h	38.09h	38.12h	38.15h	38.18h	38.21h	38.24h	38.27h	38.30h	38.33h	38.36h	38.39h	38.42h	38.45h	38.48h	38.51h	38.54h	38.57h	39.00h	39.03h	39.06h	39.09h	39.12h	39.15h	39.18h	39.21h	39.24h	39.27h	39.30h	39.33h	39.36h	39.39h	39.42h	39.45h	39.48h	39.51h	39.54h	39.57h	40.00h	40.03h	40.06h	40.09h	40.12h	40.15h	40.18h	40.21h	40.24h	40.27h	40.30h	40.33h	40.36h	40.39h	40.42h	40.45h	40.48h	40.51h	40.54h	40.57h	41.00h	41.03h	41.06h	41.09h	41.12h	41.15h	41.18h	41.21h	41.24h	41.27h	41.30h	41.33h	41.36h	41.39h	41.42h	41.45h	41.48h	41.51h	41.54h	41.57h	42.00h	42.03h	42.06h	42.09h	42.12h	42.15h	42.18h	42.21h	42.24h	42.27h	42.30h	42.33h	42.36h	42.39h	42.42h	42.45h	42.48h	42.51h	42.54h	42.57h	43.00h	43.03h	43.06h	43.09h	43.12h	43.15h	43.18h	43.21h	43.24h	43.27h	43.30h	43.33h	43.36h	43.39h	43.42h	43.45h	43.48h	43.51h	43.54h	43.57h	44.00h	44.03h	44.06h	44.09h	44.12h	44.15h	44.18h	44.21h	44.24h	44.27h	44.30h	44.33h	44.36h	44.39h	44.42h	44.45h	44.48h	44.51h	44.54h	44.57h	45.00h	45.03h	45.06h	45.09h	45.12h	45.15h	45.18h	45.21h	45.24h	45.27h	45.30h	45.33h	45.36h	45.39h	45.42h	45.45h	45.48h	45.51h	45.54h	45.57h	46.00h	46.03h	46.06h	46.09h	46.12h	46.15h	46.18h	46.21h	46.24h	46.27h	46.30h	46.33h	46.36h	46.39h	46.42h	46.45h	46.48h	46.51h	46.54h	46.57h	47.00h	47.03h	47.06h	47.09h	47.12h	47.15h	47.18h	47.21h	47.24h	47.27h	47.30h	47.33h	47.36h	47.39h	47.42h	47.45h	47.48h	47.51h	47.54h	47.57h	48.00h	48.03h	48.06h	48.09h	48.12h	48.15h	48.18h	48.21h	48.24h	48.27h	48.30h	48.33h	48.36h	48.39h	48.42h	48.45h	48.48h	48.51h	48.54h	48.57h	49.00h	49.03h	49.06h	49.09h	49.12h	49.15h	49.18h	49.21h	49.24h	49.27h	49.30h	49.33h	49.36h	49.39h	49.42h	49.45h	49.48h	49.51h	49.54h	49.57h	50.00h	50.03h	50.06h	50.09h	50.12h	50.15h	50.18h	50.21h	50.24h	50.27h	50.30h	50.33h	50.36h	50.39h	50.42h	50.45h	50.48h	50.51h	50.54h	50.57h	51.00h	51.03h	51.06h	51.09h	51.12h	51.15h	51.18h	51.21h	51.24h	51.27h	51.30h	51.33h	51.36h	51.39h	51.42h	51.45h	51.48h	51.51h	51.54h	51.57h	52.00h	52.03h	52.06h	52.09h	52.12h	52.15h	52.18h	52.21h	52.24h	52.27h	52.30h	52.33h	52.36h	52.39h	52.42h	52.45h	52.48h	52.51h	52.54h	52.57h	53.00h	53.03h	53.06h	53.09h	53.12h	53.15h	53.18h	53.21h	53.24h	53.27h	53.30h	53.33h	53.36h	53.39h	53.42h	53.45h	53.48h	53.51h	53.54h	53.57h	54.00h	54.03h	54.06h	54.09h	54.12h	54.15h	54.18h	54.21h	54.24h	54.27h	54.30h	54.33h	54.36h	54.39h	54.42h	54.45h	54.48h	54.51h	54.54h	54.57h	55.00h	55.03h	55.06h	55.09h	55.12h	55.15h	55.18h	55.21h	55.24h	55.27h	55.30h	55.33h	55.36h	55.39h	55.42h	55.45h	55.48h	55.51h	55.54h	55.57h	56.00h	56.03h	56.06h	56.09h	56.12h	56.15h	56.18h	56.21h	56.24h	56.27h	56.30h	56.33h	56.36h	56.39h	56.42h	56.45h	56.48h	56.51h	56.54h	56.57h	57.00h	57.03h	57.06h	57.09h	57.12h	57.15h	57.18h	57.21h	57.24h	57.27h	57.30h	57.33h	57.36h	57.39h	57.42h	57.45h	57.48h	57.51h	57.54h	57.57h	58.00h	58.03h	58.06h	58.09h	58.12h	58.15h	58.18h	58.21h	58.24h	58.27h	58.30h	58.33h	58.36h	58.39h	58.42h	58.45h	58.48h	58.51h	58.54h	58.57h	59.00h	59.03h	59.06h	59.09h	59.12h	59.15h	59.18h	59.21h	59.24h	59.27h	59.30h	59.33h	59.36h	59.39h	59.42h	59.45h	59.48h	59.51h	59.54h	59.57h	60.00h	60.03h	60.06h	60.09h	60.12h	60.15h	60.18h	60.21h	60.24h	60.27h	60.30h	60.33h	60.36h	60.39h	60.42h	60.45h	60.48h	60.51h	60.54h	60.57h	61.00h	61.03h	61.06h	61.09h	61.12h	61.15h	61.18h	61.21h	61.24h	61.27h	61.30h	61.33h	61.36h	61.39h	61.42h	61.45h	61.48h	61.51h	61.54h	61.57h	62.00h	62.03h	62.06h	62.09h	62.12h	62.15



12:00

	Tuesday 9							Wednesday 10							Thursday 11							Friday 12							Saturday 13										
Hours	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21
Wind kt	6	7	7	10	10	9	8	9	8	7	8	10	10	10	10	11	13	14	13	12	12	14	15	15	16	12	13	13	12	12	10	10	10	12	13	13	15	14	14
Wind gusts	10	11	12	14	17	15	12	13	14	12	13	14	14	15	14	15	18	19	20	18	17	20	21	21	23	21	18	19	18	18	16	15	15	16	18	19	20	21	19
Waves m	1.2	1.3	1.3	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.4	1.4	1.6	1.7	1.8	1.8	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3
Swell m	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.8	1.1	1.1	1.1	1.2	1.3	1.2	1.2	1.1	1	0.9	0.9	0.9	0.7	0.8	0.8	0.7	0.8	0.8
Swell period	11.3	10.1	9	8.9	9.6	8.7	8.7	8.8	6.6	9.3	9.5	8.7	8.6	9	8.4	13.1	15	14.9	11	9.9	10	10.3	7.6	10.4	10.3	10.3	10.3	9.9	7.1	7.1	6.5	9.6	9.6	9.3	9.2	9.4	9.4	9.3	9.3



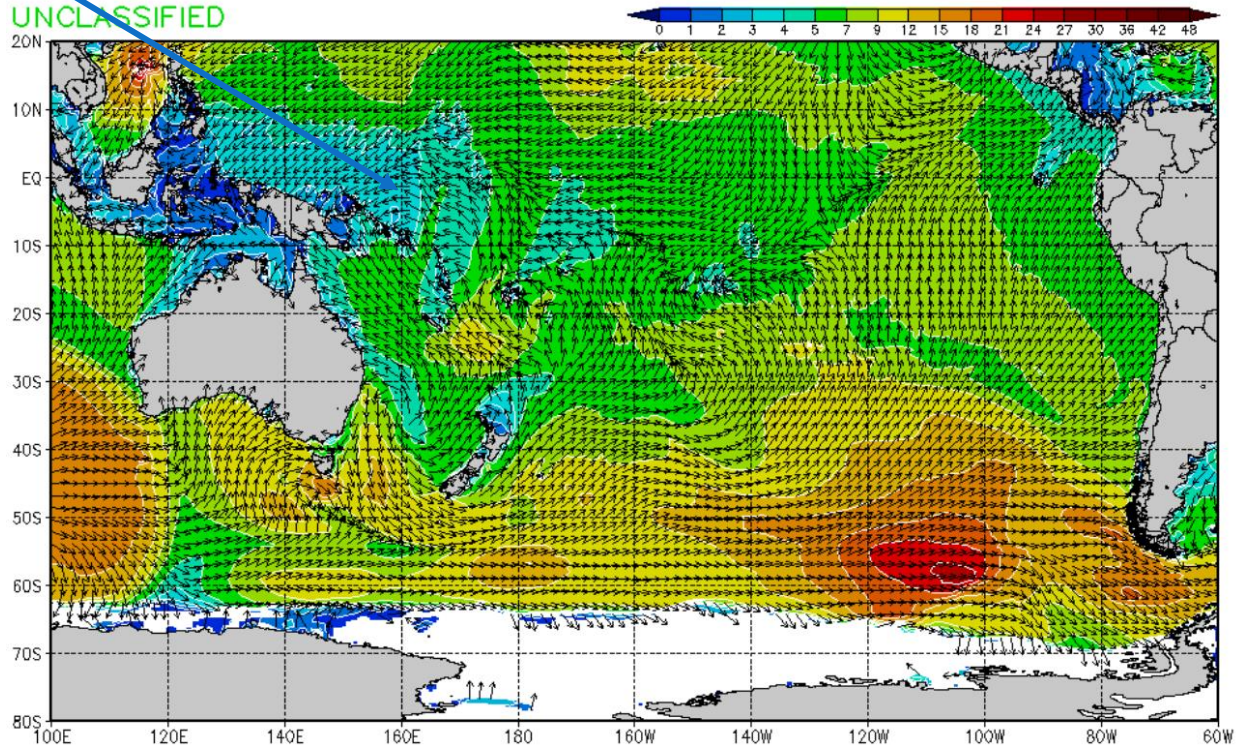
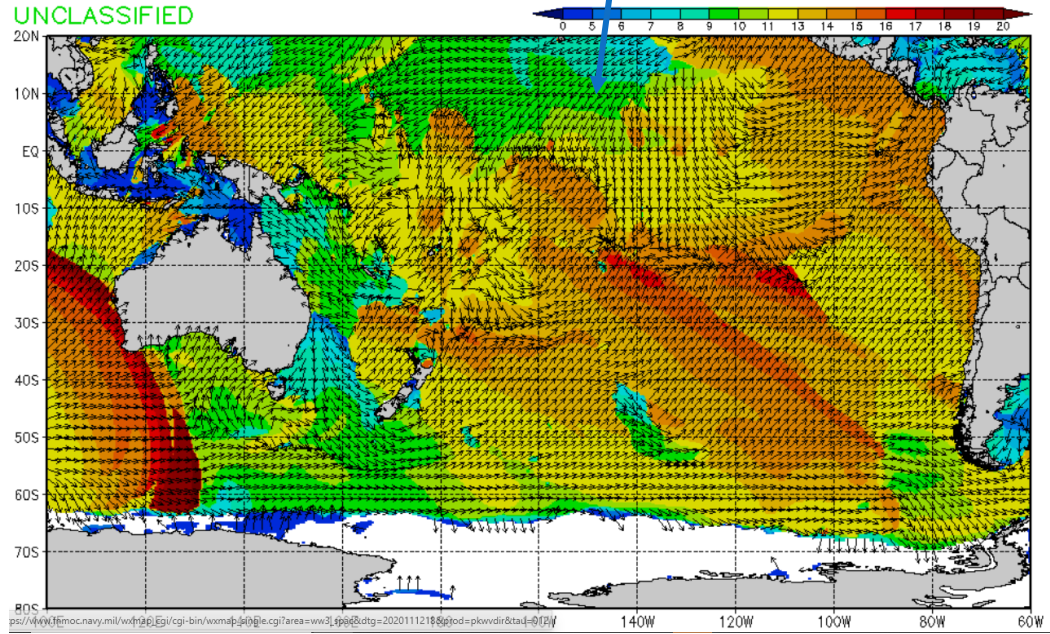
Naval Oceanography Portal




FNMOC

<https://www.usno.navy.mil/FNMOC>

- Significant Wave Height & Direction (based on Official TC Warning)
- Significant Wave Height & Direction
- Swell Wave Height & Direction
- Wind Wave Height & Direction
- Swell Wave Period & Direction
- Wind Wave Period & Direction
- Peak Wave Period & Direction
- White Cap Probability
- Sea Surface Temperature





FR IT ES PT DE UK US

Search for surf breaks navigate by:

> start typing a break name


country: Fiji

region: Mamanucas


break: Cloudbreak

Home
Surf Spots
Wave & Wind Maps
Surf & Wind Alerts
Gallery
Help
Contact
Sign in
Sign up

Cloudbreak Surf Forecast / Mamanucas (7 surf breaks) / Fiji (26 surf breaks)



Cloudbreak



Cloudbreak


Forecast
48 Hour Detail
7 Days


Maps
Wave height
Wave energy
Wind

Live
Live Weather
Surf Webcam

Weather State
Tides
Surf/Wind Alert
Water Temp.

Spot Info
Local Surf Guide
Reviews & Ratings (1)
Photos (6)


Recent Eyeball Surf Reports for Mamanucas




Wind Update Continuing clean conditions at Cloudbreak (light winds from the SE at Nadi 32 km from Cloudbreak). 1.3m 8 s period swell from SSW
3 hours 28 minutes ago **Cloudbreak**

32 km away,
3 h 28 min ago

7 km/h
SE

22.3
28.1

Air / Water (°C)



GET EMAIL ALERT

Cloudbreak Surf Forecast / Mamanucas / Fiji

48hr Weather and Surf, issued 5 am Tuesday 09 Jul 2019 FJT

Cloudbreak surf forecast is for near shore open water. Breaking waves will often be smaller at less exposed spots.
Today's Cloudbreak sea temperature is 28.1 °C (Statistics for 09 Jul 1951-2005 - mean: 25.5 max: 26.6 min: 23.8 °C)

Secret spot?

48 hr
7 days
Mamanucas Surf

m, °C	Tuesday 09			Wednesday 10			Thursday 11			Friday 12			Saturday 13			Sunday 14			Monday 15		Tue		
ft, °F	AM	PM	Night	AM	PM	Night	AM	PM	Night	AM	PM	Night	AM	PM	Night	AM	PM	Night	AM	PM	AM	PM	
Rating (10 max)	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	
Wave Height (m) & direction (?)	1 S	1.7 S	1.2 S	1.4 SSE	0.7 SSW	1.1 SSW	1.2 SSW	1.2 SSW	1.2 SSW	1.1 SSW	1 SSW	0.8 SSW	0.7 SSW	0.4 SW	0.4 SW	0.8 SE	0.4 SSW	0.5 SW	0.7 SW	0.6 SSW	0.6 SSW	1.4 SW	1.7 SW
Period(s) (?)	13	12	11	10	17	16	15	14	14	13	13	13	12	18	18	6	11	15	15	14	17	14	13
Wave Graph (10m) (?)																							
Energy (?)	314	841	362	426	267	651	661	602	504	336	312	181	129	109	80	47	46	116	217	136	206	661	396
Wind (km/h)	20 SE	15 SE	5 ENE	15 ESE	25 SE	25 SE	25 ESE	20 SE	10 E	5 E	5 SW	5 E	25 ESE	10 ESE	25 ESE	10 E	5 SW	5 NE	10 NE	10 WNW	5 ESE	5 E	5 WSW
Wind State (?)	cross-off	cross-off	glass	cross-off	cross-off	cross-off	cross-off	cross-off	cross-off	cross-off	on	off	cross-off	cross-off	cross-off	off	glass	off	off	cross-on	cross-off	glass	glass

Cloudbreak ratings

Quality on a good day: 5.0
★★★★★

Consistency of Surf: 4.0
★★★★☆

Difficulty Level: 4.0
★★★★☆

Crowds: 4.0
★★★★☆

Overall: 4.2
★★★★☆

See all 18 ratings
Based on 1 vote. Vote

Add our forecast to your site

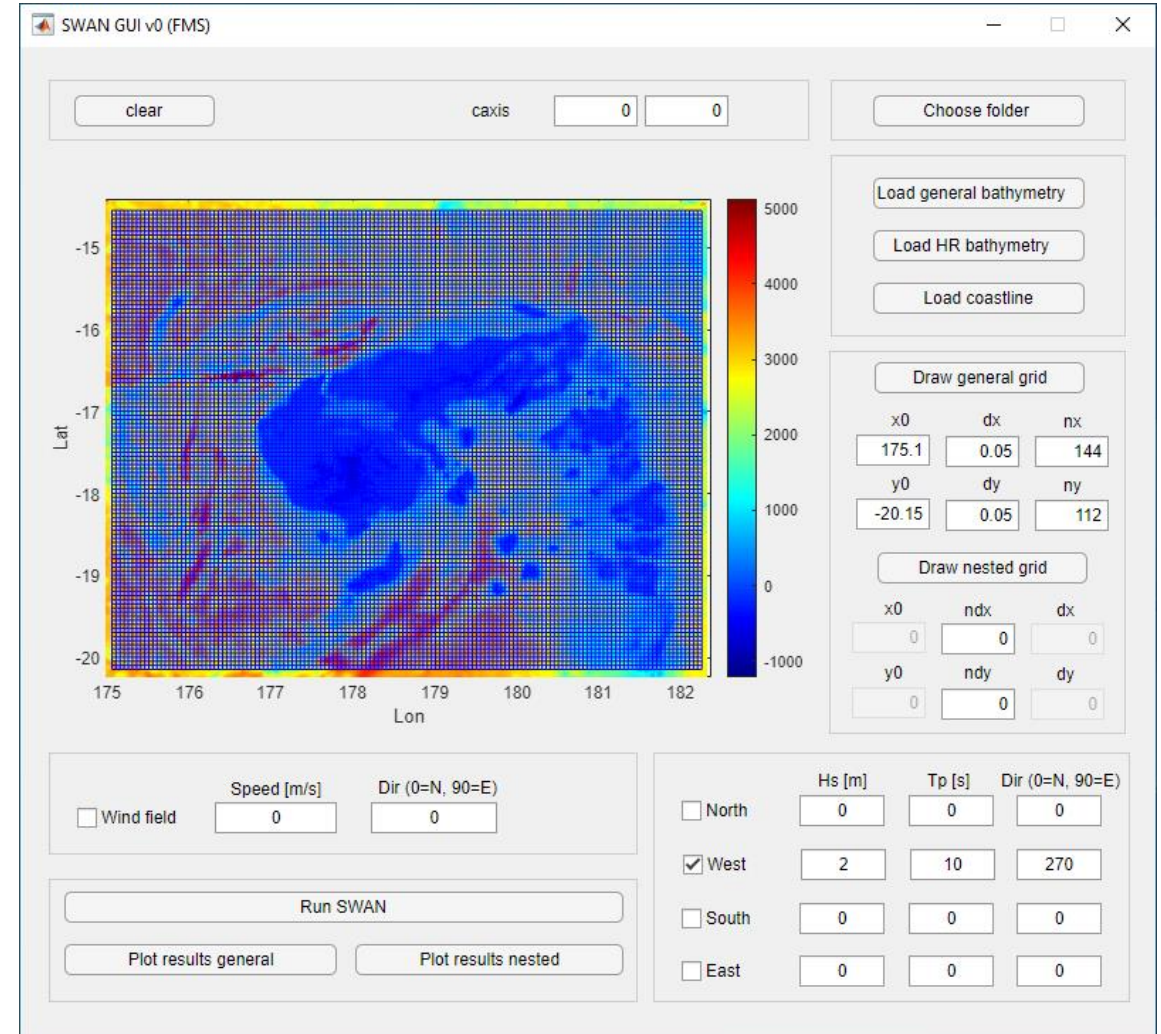


ADVANCED SWAN MODELLING

OVERVIEW

So far we have used a friendly easy to use GUI to set up basic SWAN model configuration

- We have run stationary scenarios.
 - Shouldn't be applied to big domains, when the dimension of the domain is so big that waves take more than 30 min to 1 hour to travel from the boundaries to our target area is (i.e. <<50-100 Km)
 - When waves and winds are changing quickly.
- Wave boundaries have been defined by means of bulk parameters
 - Not valid when we have more than 1 wave system *(i.e. south swell + wind waves)
 - Critical to model wave inundation
- Wind conditions are spatially constant
 - Not applicable to big domains where winds changes substantially
 - Tropical cyclones

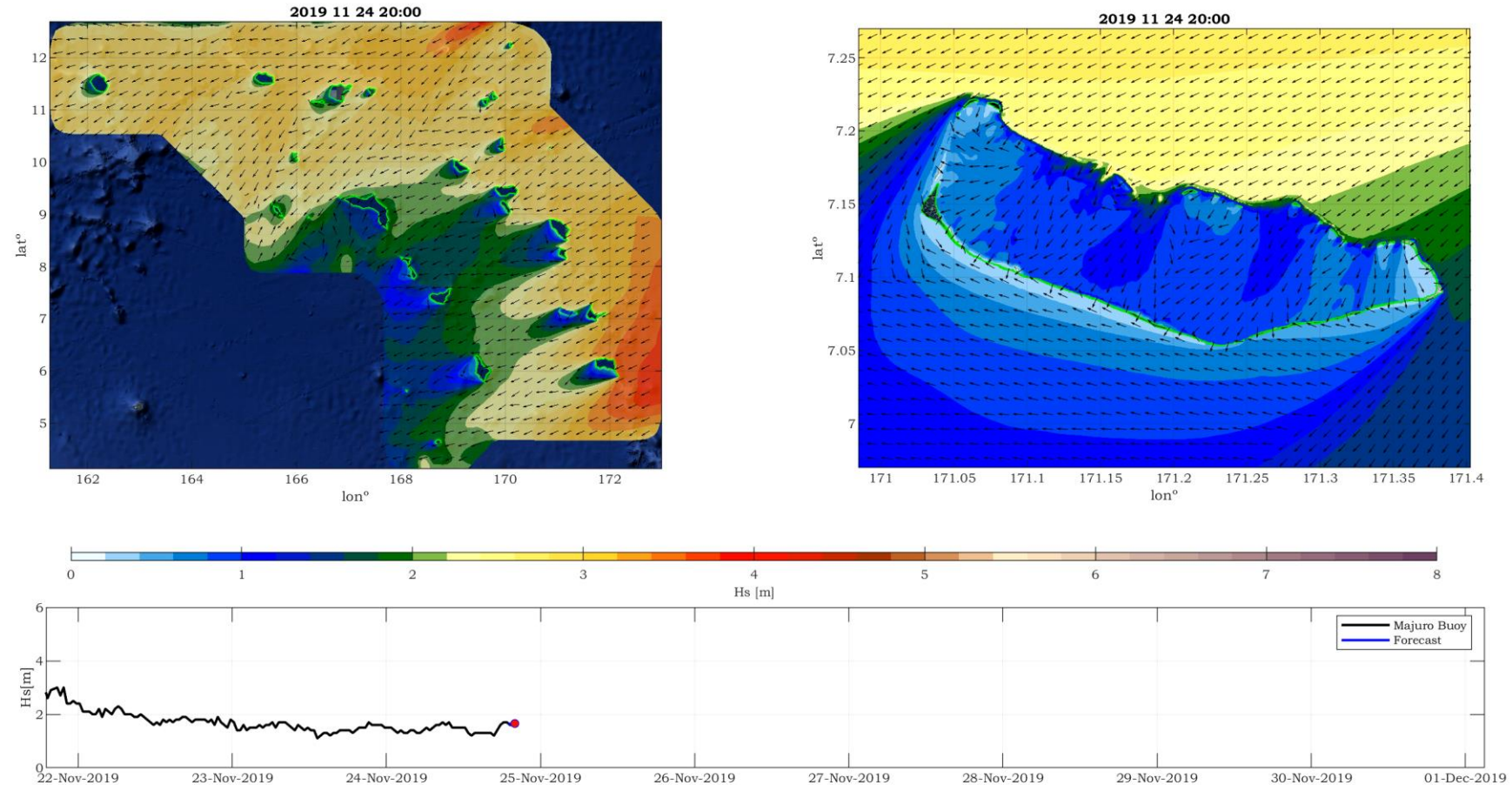


SWAN USER MANUAL

A general suggestion is: start simple. SWAN helps in this with default options. Furthermore, suggestions are given that should help the user to choose among the many options conditions and in which mode to run SWAN (first-, second- or third-generation mode, stationary or nonstationary and 1D or 2D).

STATIONARY vs. NONSTATIONARY

- Stationary runs are used to analyse how certain wave conditions will propagate under a given bathymetry (engineering applications)
- For wave forecast, non-stationary is more convenient as we are interested in resolving large domains with no steady boundary conditions



BULK PARAMETERS vs. WAVE SPECTRA

How you would define the waves approaching to the coast in this image?

Hs_1, Tp_1, Dir_1



Hs_2, Tp_2, Dir_2



Image NASA
Image © 2015 DigitalGlobe

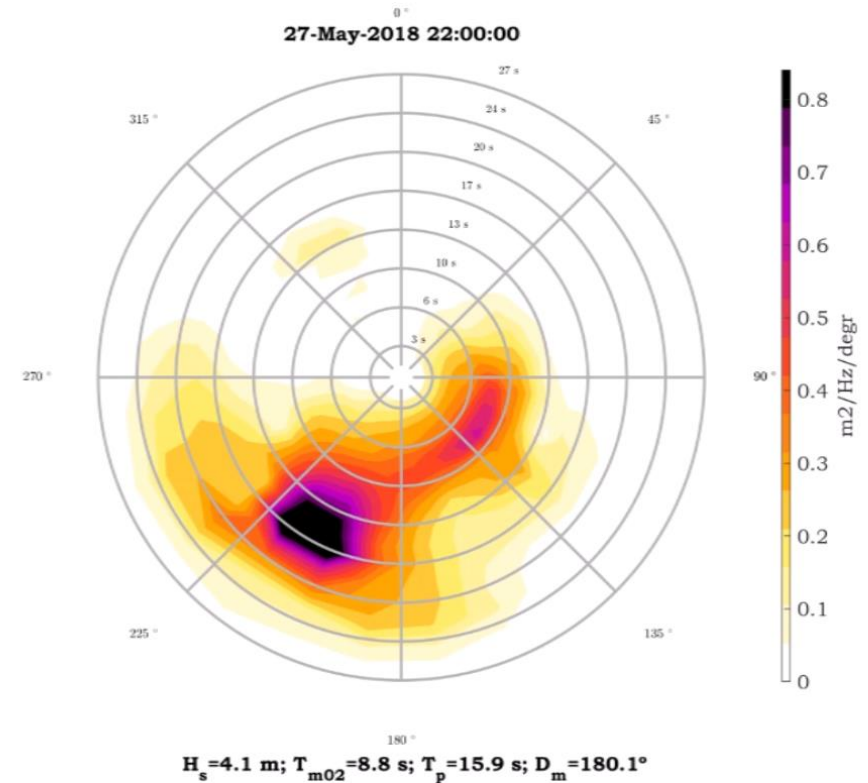
$$\eta(x, y, t) = \sum_j a_j \cos \left\{ \frac{\omega_j^2}{g} (x \cos \theta_j + y \sin \theta_j) - \omega_j t + \varepsilon_j(\omega_j, \theta_j) \right\}$$

BULK PARAMETERS vs. WAVE SPECTRA

- The sea surface at any time can be approximated to a summation of a number of waves trains coming from different wave periods and directions
- The wave spectra tell us how the wave energy is distributed on the frequency (wave periods) and direction domain.

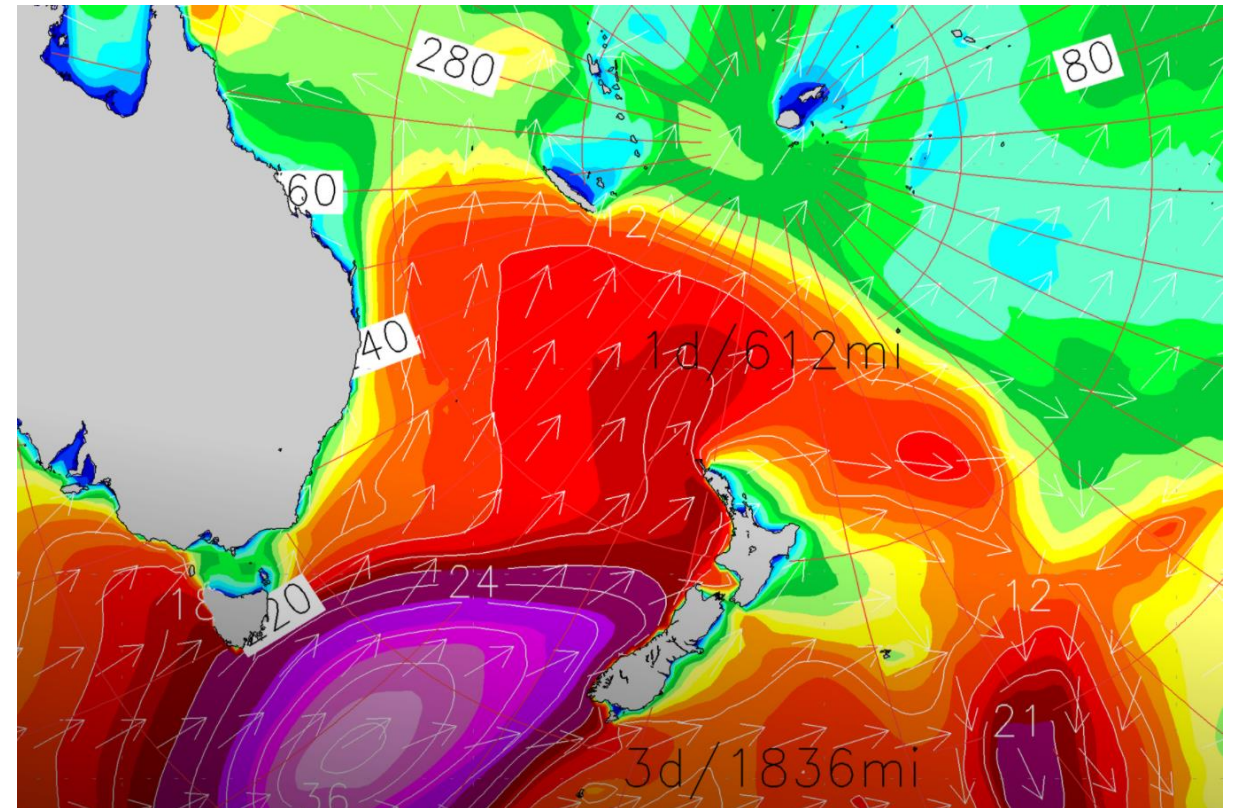
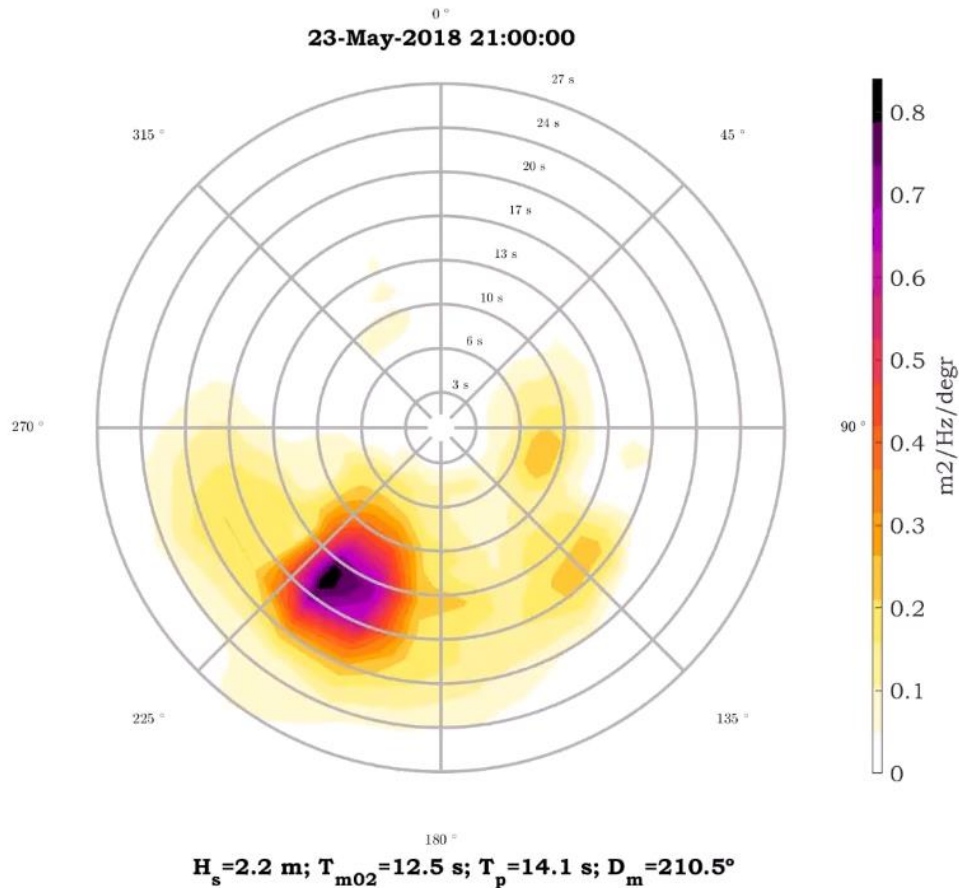


$$\eta(x, y, t) = \sum_j a_j \cos \left\{ \frac{\omega_j^2}{g} (x \cos \theta_j + y \sin \theta_j) - \omega_j t + \varepsilon_j(\omega_j, \theta_j) \right\}$$



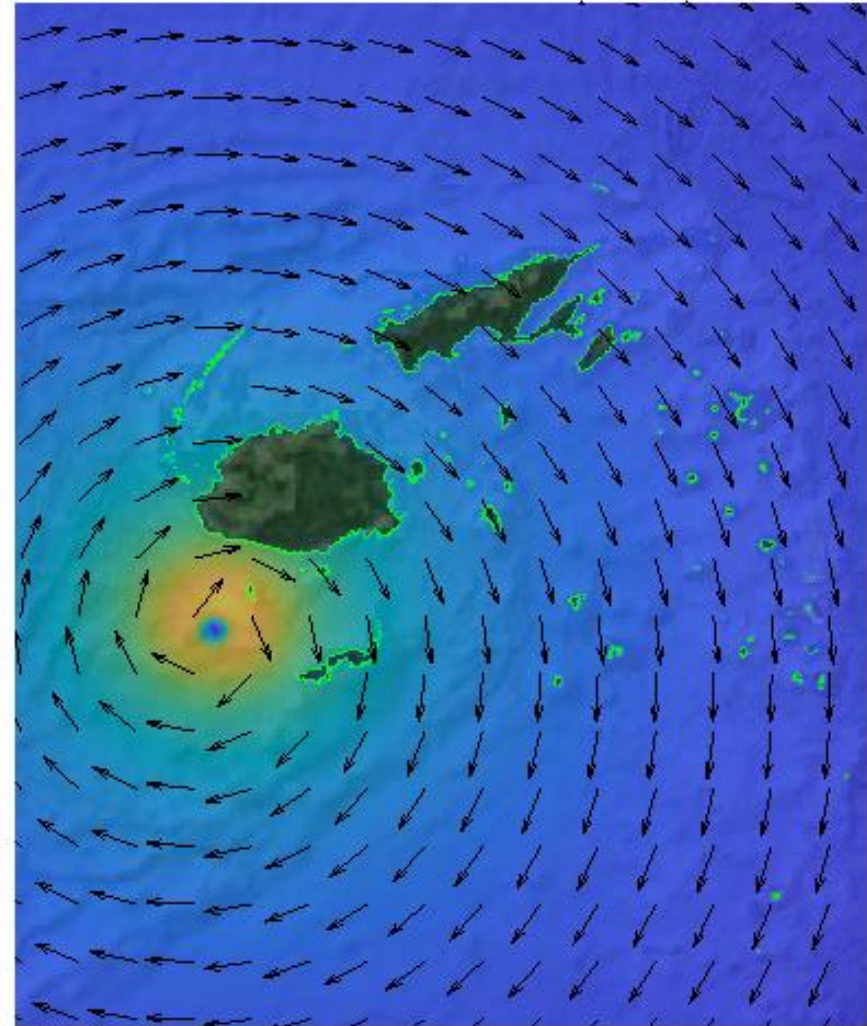
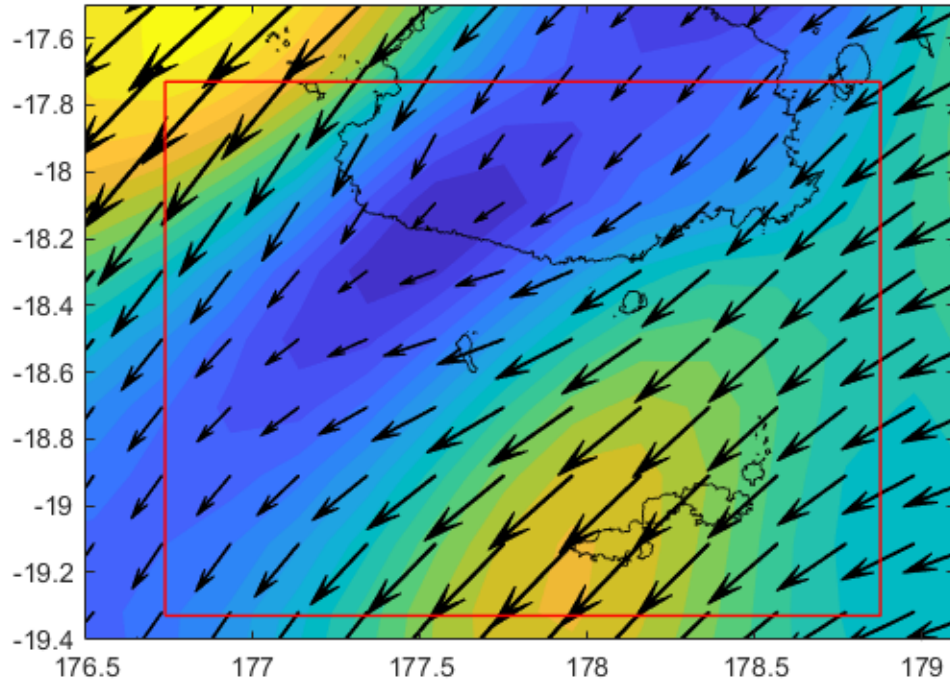
BULK PARAMETERS vs. WAVE SPECTRA

- The wave spectrum can tell us a lot of what is happening around (in term of atmospheric conditions)



VARIABLE WIND CONDITIONS

- Examples of highly variable winds

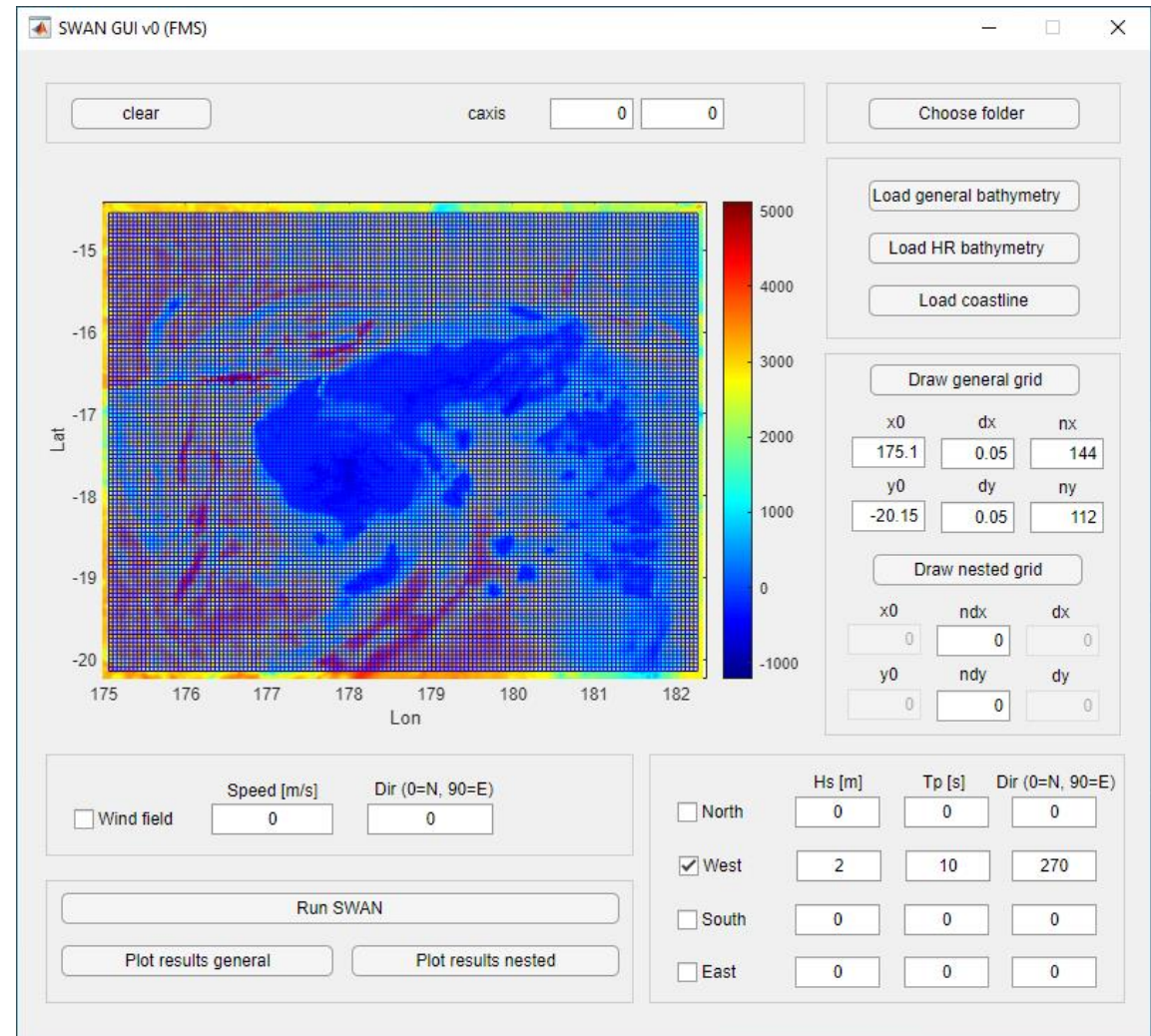


HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI



HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI

1. Generate a folder inside runs named Harold
2. Load Gebco_2020_Fiji_500m.xyz in the SWAN_GUI
3. Draw a grid covering as much as possible
4. Define a resolution of 0.005 degrees ~ 5 Km
5. Define wave/wind boundary conditions and run SWAN



HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI

I. Go into Harold/Winston folder and open general.swn with a text editor and edit the following lines

```
$$$ startup command  
PROJ 'Gen' '01'  
$  
$$$ General parameters  
SET level=0 NAUTICAL  
COORDINATES SPHERICAL CCM  
$  
$$$ Computational grid  
CGRID 175.0602 -20.1460 0 7.2000 5.6000 144 112 CIRCLE 36 0.0345 1.00 24  
$  
$$$ Bathymetry  
INPGRID BOTTOM REGULAR 175.0602 -20.1460 0 144 112 0.0497 0.0496 EXC -999  
READINP BOTTOM 1 'bot_general.dat' 1 0 FREE  
$  
$$$ Constant wind definition  
WIND 10.00 45.00  
$  
$$$ Definition of wave boundary conditions  
BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES  
BOUN SIDE W CON PAR 2.00 10.00 270.00 20  
$  
$$$ Physics  
QUAD  
WCAP  
BREA  
FRICTION JONSWAP  
NUM STOPC 0.005 0.01 0.005 95  
$  
$$$ Grid nesting  
$$$ Outputs  
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR  
$  
$$$ Lockup commands  
TEST 1,0  
COMPUTE  
STOP  
$
```

MODE NONSTAT

SET level=0 NAUTICAL

COORDINATES SPHERICAL CCM

MODE NONSTAT tells the model to run in nonstationary

HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI

```
$$$ startup command
PROJ 'Gen' '01'
$
$$$ General parameters
SET level=0 NAUTICAL
COORDINATES SPHERICAL CCM
$
$$$ Computational grid
CGRID 175.0602 -20.1460 0 7.2000 5.6000 144 112 CIRCLE 36 0.0345 1.00 24
$
$$$ Bathymetry
INPGRID BOTTOM REGULAR 175.0602 -20.1460 0 144 112 0.0497 0.0496 EXC -999
READINP BOTTOM 1 'bot_general.dat' 1 0 FREE
$
$$$ Constant wind definition
WIND 10.00 45.00
$
$$$ Definition of wave boundary conditions
BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES
BOUN SIDE W CON PAR 2.00 10.00 270.00 20
$
$$$ Physics
QUAD
WCAP
BREA
FRICTION JONSWAP
NUM STOPC 0.005 0.01 0.005 95
$
$$$ Grid nesting
$$$ Outputs
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR
$
$$$ Lockup commands
TEST 1,0
COMPUTE
STOP
$
```

INPgrid command defines the domain of the wind field, the resolution and the duration of the time and the time interval the windfields are given (300 sec)

READIN WIND tells SWAN the name of the file where the winds are contained and how to read that file

```
INPgrid WIND REG 175.0 -21.0 0 159 139 0.05 0.05 NONSTAT 20200406.190000 300 SEC
20200410.000000
READINP WIND 1 'Harold_winds.dat' 3 FREE
```

HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI

```
$$$ startup command
PROJ 'Gen' '01'
$
$$$ General parameters
SET level=0 NAUTICAL
COORDINATES SPHERICAL CCM
$
$$$ Computational grid
CGRID 175.0602 -20.1460 0 7.2000 5.6000 144 112 CIRCLE 36 0.0345 1.00 24
$
$$$ Bathymetry
INPGRID BOTTOM REGULAR 175.0602 -20.1460 0 144 112 0.0497 0.0496 EXC -999
READINP BOTTOM 1 'bot_general.dat' 1 0 FREE
$
$$$ Constant wind definition
WIND 10.00 45.00
$
$$$ Definition of wave boundary conditions
BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES
BOUN SIDE W CON PAR 2.00 10.00 270.00 20
$
$$$ Physics
QUAD
WCAP
BREA
FRICTION JONSWAP
NUM STOPC 0.005 0.01 0.005 95
$
$$$ Grid nesting
$$$ Outputs
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR
$
$$$ Lockup commands
TEST 1,0
COMPUTE
STOP
$
```

Delete all these lines as no wave boundary conditions will be used to simulate the cyclones

HANDS ON, MODELLING CYCLONE HAROLD WAVES IN FIJI

```
$$$ startup command
PROJ 'Gen' '01'
$
$$$ General parameters
SET level=0 NAUTICAL
COORDINATES SPHERICAL CCM
$
$$$ Computational grid
CGRID 175.0602 -20.1460 0 7.2000 5.6000 144 112 CIRCLE 36 0.0345 1.00 24
$
$$$ Bathymetry
INPGRID BOTTOM REGULAR 175.0602 -20.1460 0 144 112 0.0497 0.0496 EXC -999
READINP BOTTOM 1 'bot_general.dat' 1 0 FREE
$
$$$ Constant wind definition
WIND 10.00 45.00
$
$$$ Definition of wave boundary conditions
BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES
BOUN SIDE W CON PAR 2.00 10.00 270.00 20
$
$$$ Physics
QUAD
WCAP
BREA
FRICTION JONSWAP
NUM STOPC 0.005 0.01 0.005 95
$
$$$ Grid nesting
$$$ Outputs
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR
$
$$$ Lockup commands
TEST 1,0
COMPUTE
STOP
$
```

BLOCK 'COMGRID' tells SWAN to save the results in the whole computational grid, the name of the file containing the results, the variables to save, the starting time and the time interval

```
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR
OUTPUT 20200406.200000 1.0 HR
```

HANDS ON, MODELLING CYCLONE WINSTON AND HAROLD WAVES IN FIJI



```
$$$ startup command
PROJ 'Gen' '01'
$
$$$ General parameters
SET level=0 NAUTICAL
COORDINATES SPHERICAL CCM
$
$$$ Computational grid
CGRID 175.0602 -20.1460 0 7.2000 5.6000 144 112 CIRCLE 36 0.0345 1.00 24
$
$$$ Bathymetry
INPGRID BOTTOM REGULAR 175.0602 -20.1460 0 144 112 0.0497 0.0496 EXC -999
READINP BOTTOM 1 'bot_general.dat' 1 0 FREE
$
$$$ Constant wind definition
WIND 10.00 45.00
$
$$$ Definition of wave boundary conditions
BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES
BOUN SIDE W CON PAR 2.00 10.00 270.00 20
$
$$$ Physics
QUAD
WCAP
BREA
FRICTION JONSWAP
NUM STOPC 0.005 0.01 0.005 95
$
$$$ Grid nesting
$$$ Outputs
BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR
$
$$$ Lockup commands
TEST 1,0
COMPUTE
STOP
$
```

COMPUTE NONSTAT, tells SWAN to run in nonstationary mode from the starting date, each 1800 sec to the final date

Times here are for Harold, for Winston use:

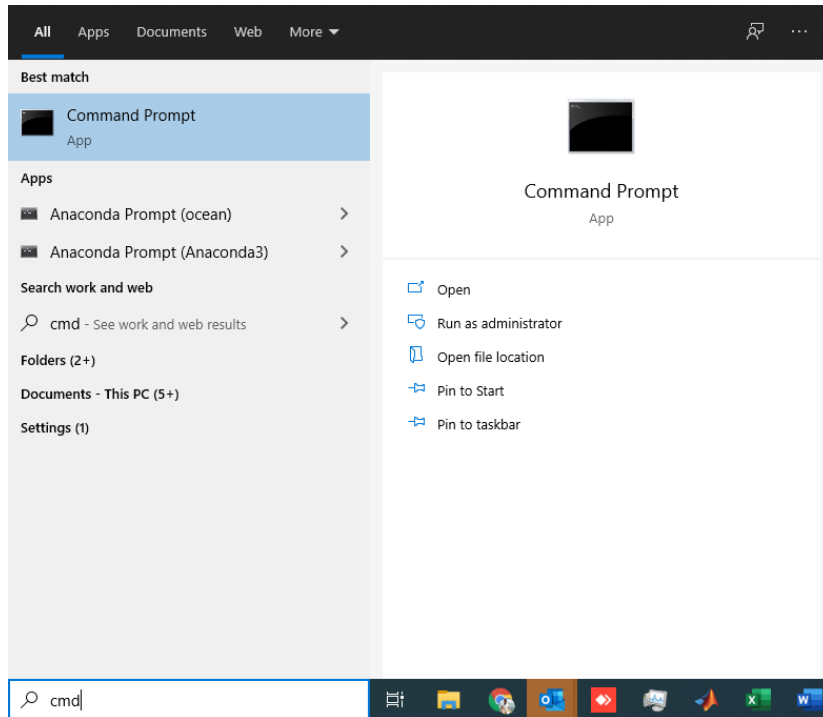
XXX

COMPUTE NONSTAT 20200406.200000 1800 SEC 20200410.000000

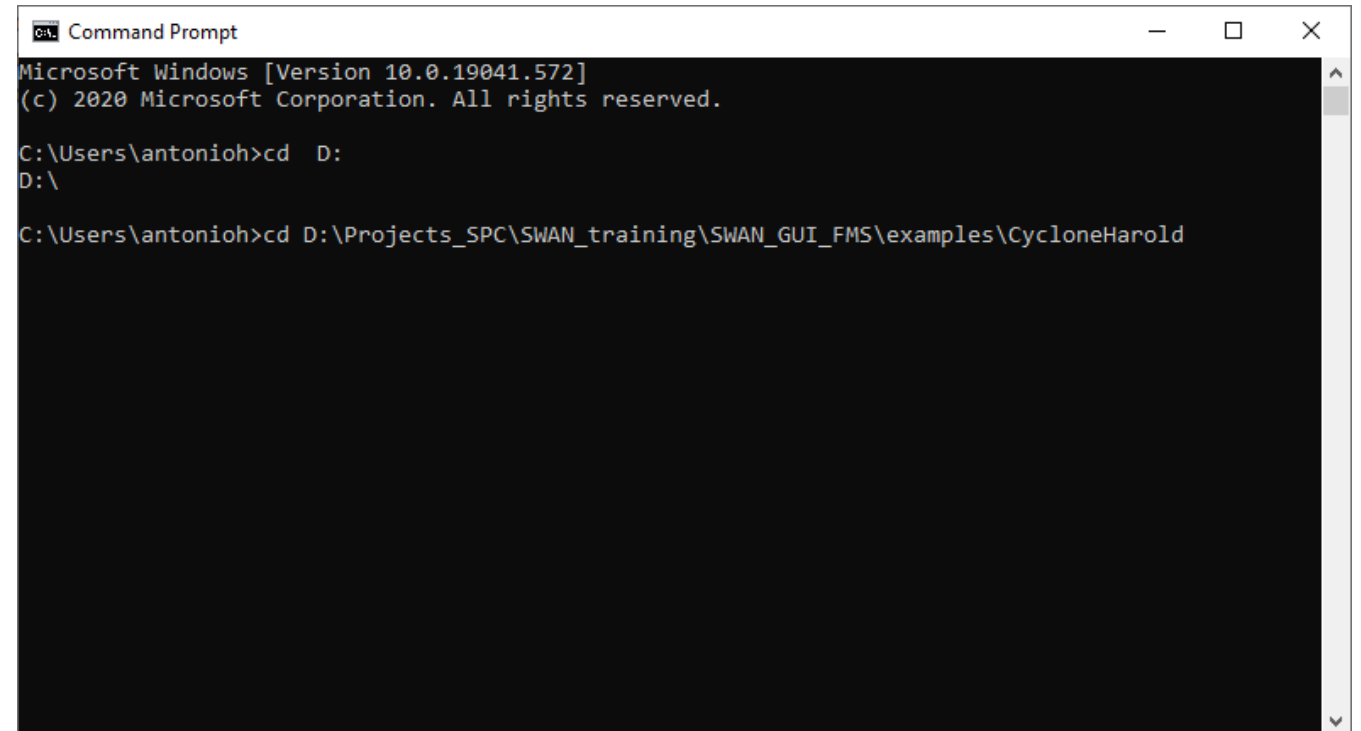
HANDS ON, MODELLING CYCLONE WINSTON AND HAROLD WAVES IN FIJI

Run SWAN from the cmd

1. Open Command Prompt



2. Go to your directory



HANDS ON, MODELLING CYCLONE WINSTON AND HAROLD WAVES IN FIJI

Run SWAN from the cmd

swanrun general

```
C:\WINDOWS\SYSTEM32\cmd.exe - swanrun general

D:\Projects_SPC\SWAN_training\SWAN_GUI_FMS\examples\CycloneHarold>swanrun general

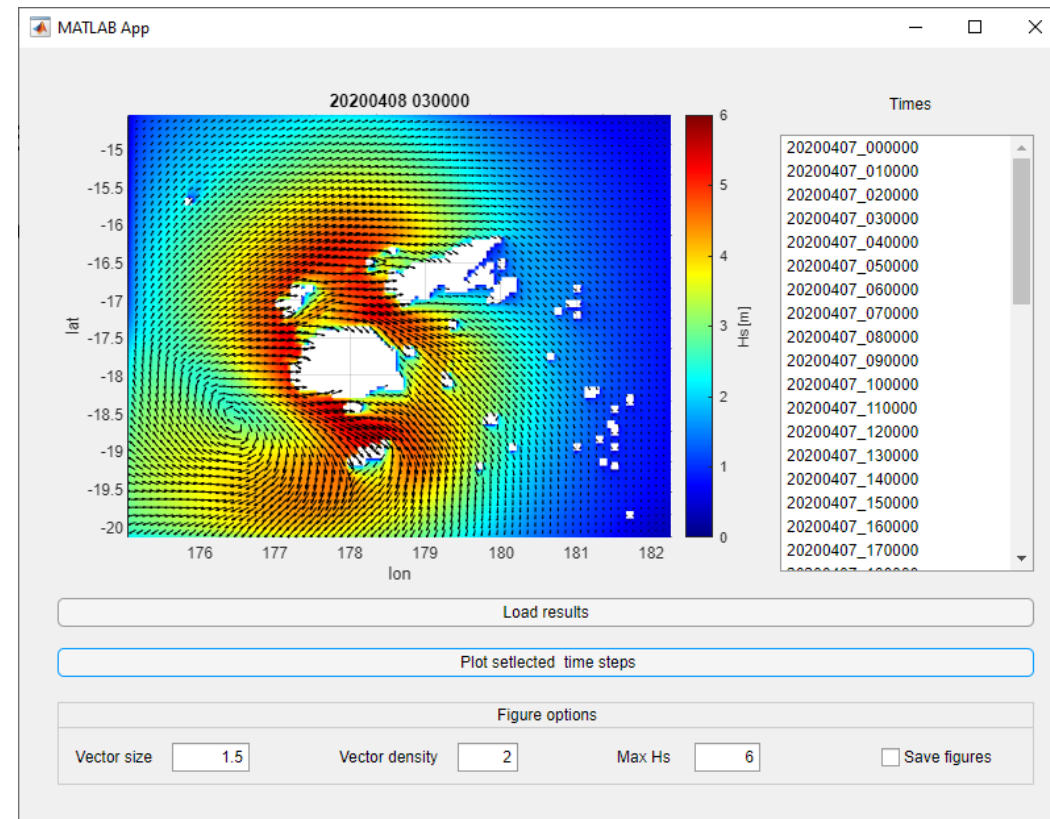
SWAN is preparing computation

+SWAN is processing output request 1
+time 20200407.003000 , step 1; iteration 1; sweep 1
+time 20200407.003000 , step 1; iteration 1; sweep 2
+time 20200407.003000 , step 1; iteration 1; sweep 3
+time 20200407.003000 , step 1; iteration 1; sweep 4
+time 20200407.010000 , step 2; iteration 1; sweep 1
+time 20200407.010000 , step 2; iteration 1; sweep 2
+time 20200407.010000 , step 2; iteration 1; sweep 3
+time 20200407.010000 , step 2; iteration 1; sweep 4
+SWAN is processing output request 1
+time 20200407.013000 , step 3; iteration 1; sweep 1
+time 20200407.013000 , step 3; iteration 1; sweep 2
+time 20200407.013000 , step 3; iteration 1; sweep 3
+time 20200407.013000 , step 3; iteration 1; sweep 4
+time 20200407.020000 , step 4; iteration 1; sweep 1
+time 20200407.020000 , step 4; iteration 1; sweep 2
+time 20200407.020000 , step 4; iteration 1; sweep 3
+time 20200407.020000 , step 4; iteration 1; sweep 4
+SWAN is processing output request 1
+time 20200407.023000 , step 5; iteration 1; sweep 1
```

HANDS ON, MODELLING CYCLONE WINSTON AND HAROLD WAVES IN FIJI

Run SWAN_GUI_FMS_Installer_web.exe inside the GUI folder and plot the results

- Arrows size and density can be modified
- Set up maximum Hs
- Figures can be exported





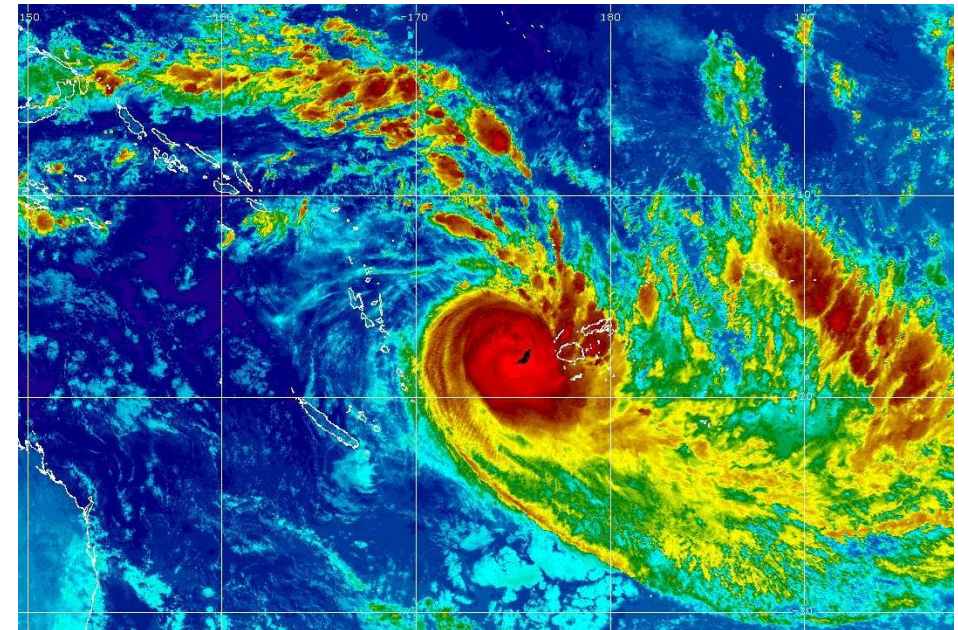
SPC'S TC HAROLD WAVE AND STORM SURGE MODEL

TC HAROLD

- On April 2020, TC Harold caused widespread destruction In Solomon, Vanuatu, Fiji and Tonga
- Max sustained winds of 220 Km/h and gust of 270 Km/h

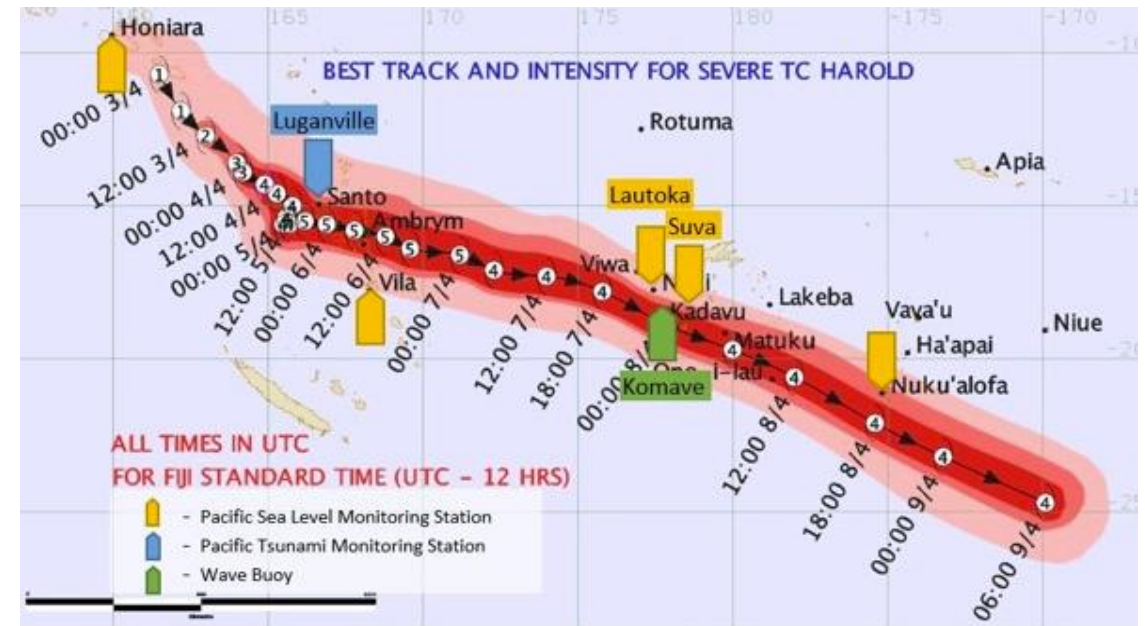
OBJECTIVES

- Provide reliable information to the post disaster field survey team about the areas most affected in terms of winds, waves and storm surge
- Demonstrate that the state of the art technologies to build up impact based forecast system for TC are available in the region



What input do we need to build an accurate storm surge and wave model?

- Best possible bathymetry and topography
- Astronomical tide forecast
- Mean sea level forecast
- **A reliable track forecast:**
 - **Position**
 - **Intensity (wind and pressure)**
 - **Size (radius of maximum winds)**

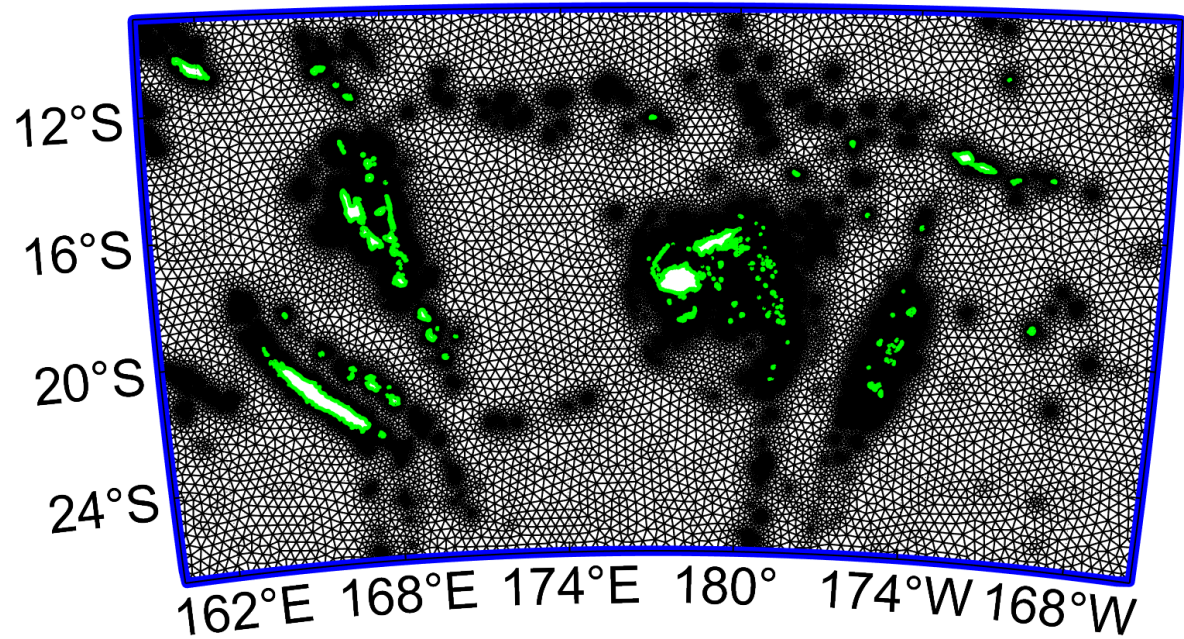


SPC's storm surge and wave model, what is different from other models?

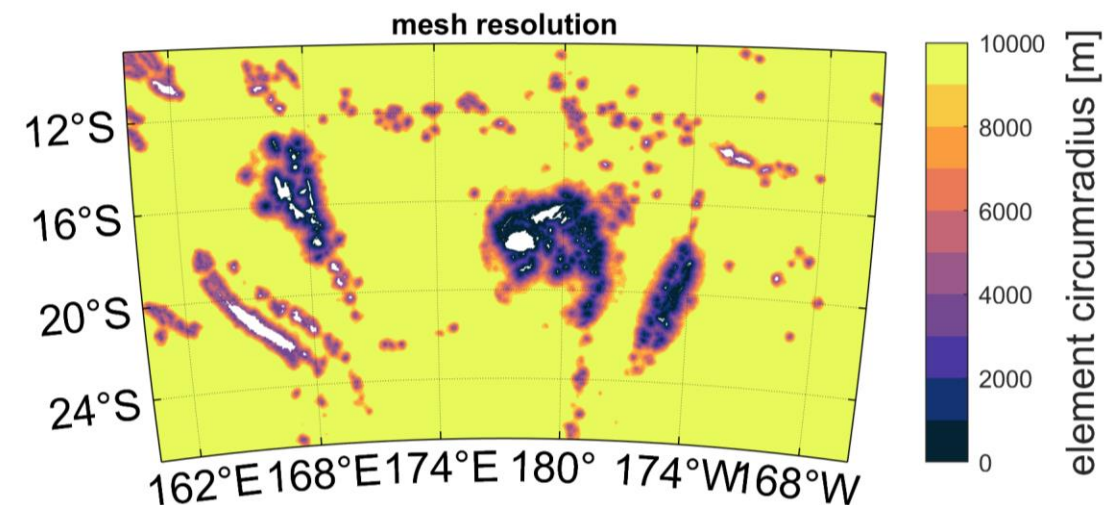
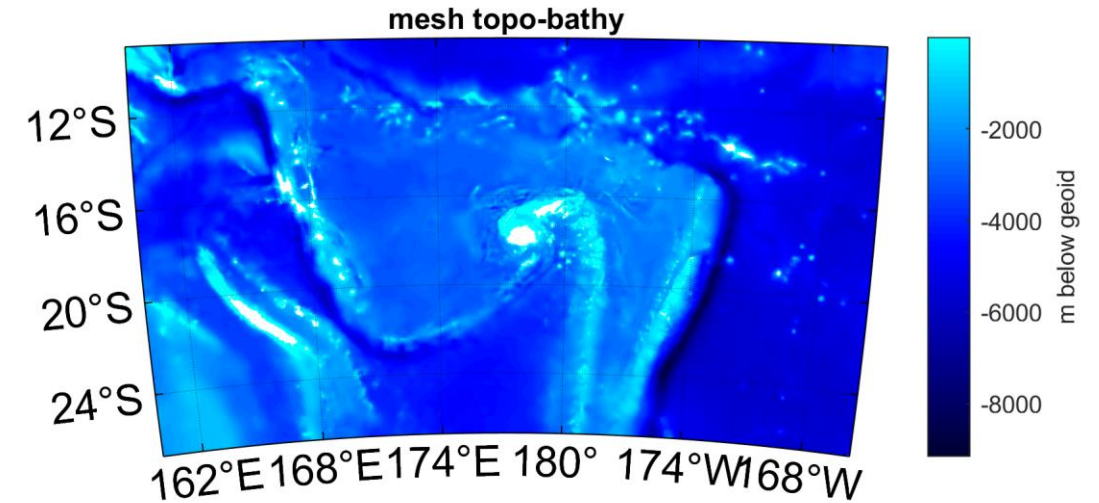
- Coupled ADCIRC+SWAN model : all dynamics are run together, hydrodynamics + waves
- ADCIRC+SWAN is the models used in the US territories (including the Caribbean) to forecast coastal inundation
- It works in non-structured mesh so resolution is variable doing the model highly efficient:
 - coarse resolution in open ocean
 - Super high resolution on the coast: better to resolve complex coast forms and small islands
- It is parallelizable: good computational times
- It resolves inundation overland if good topography is provided
- It resolves the wave set up but not the infragravity waves!!!! Empirical formulation can be used to estimate this part of the inundation process in reef fronted coasts

SPC's storm surge and wave model

- Contains 180.340 nodes
- Covers 3.400 Km in longitude by 1.970 in latitude
- Resolution ranges from 15 Km in the deep ocean to 300-500 m along the coasts of Vanuatu, Fiji and Tonga



SRTM_15_PLUS

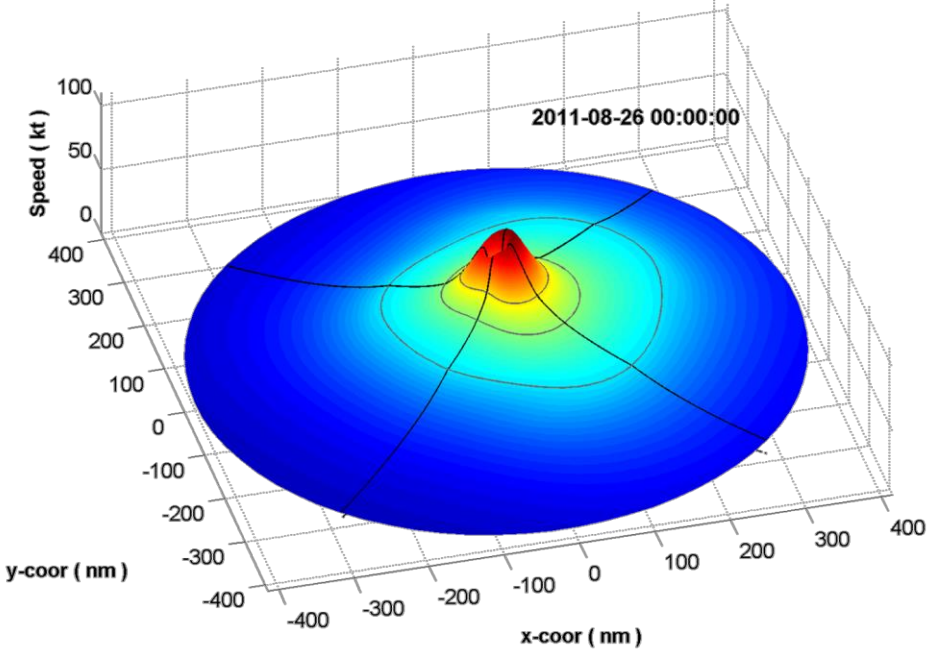
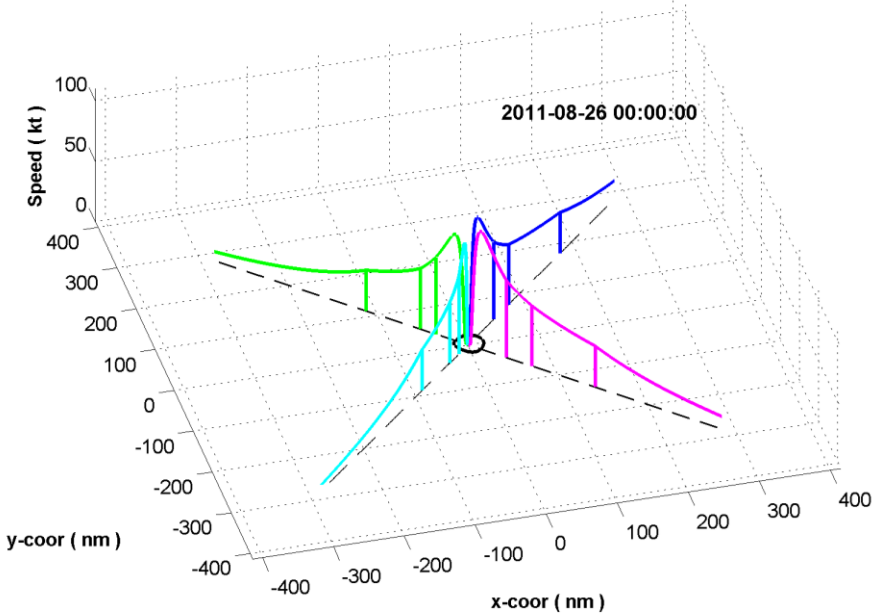
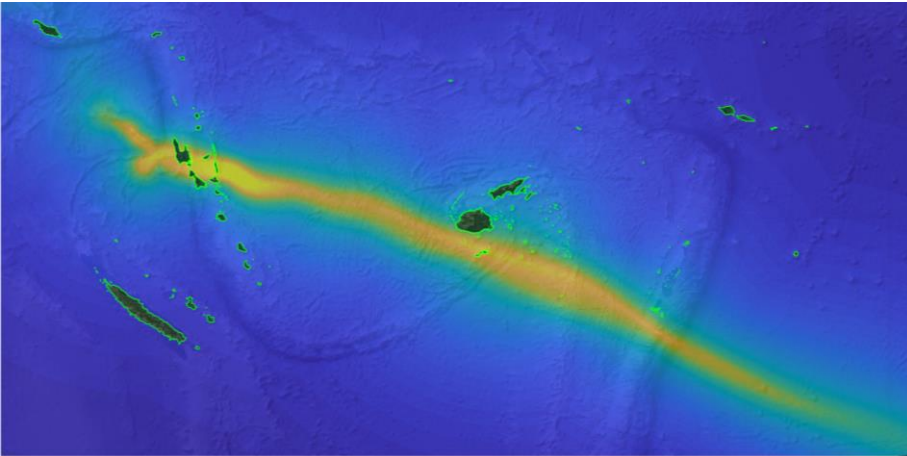


SPC's storm surge and wave model

Parametric WIND model

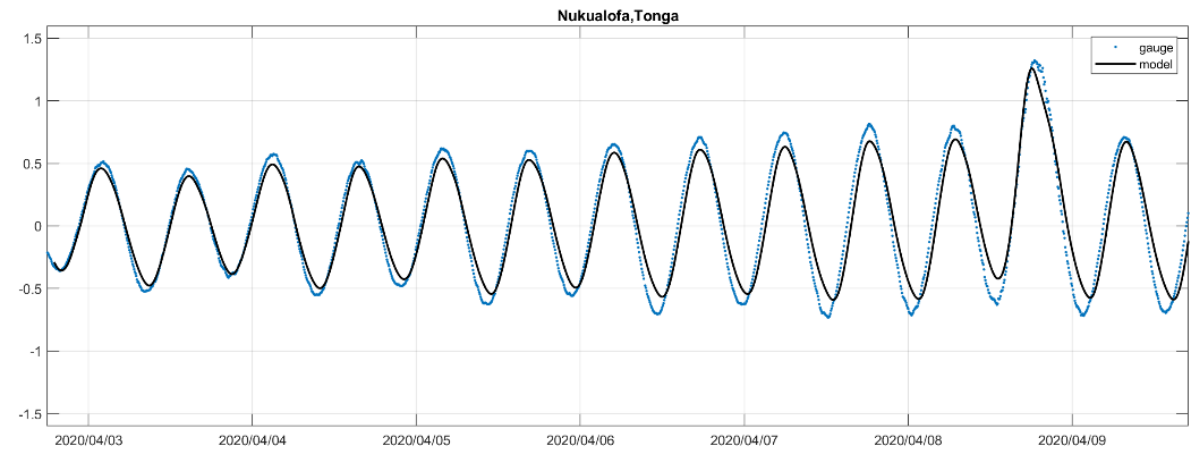
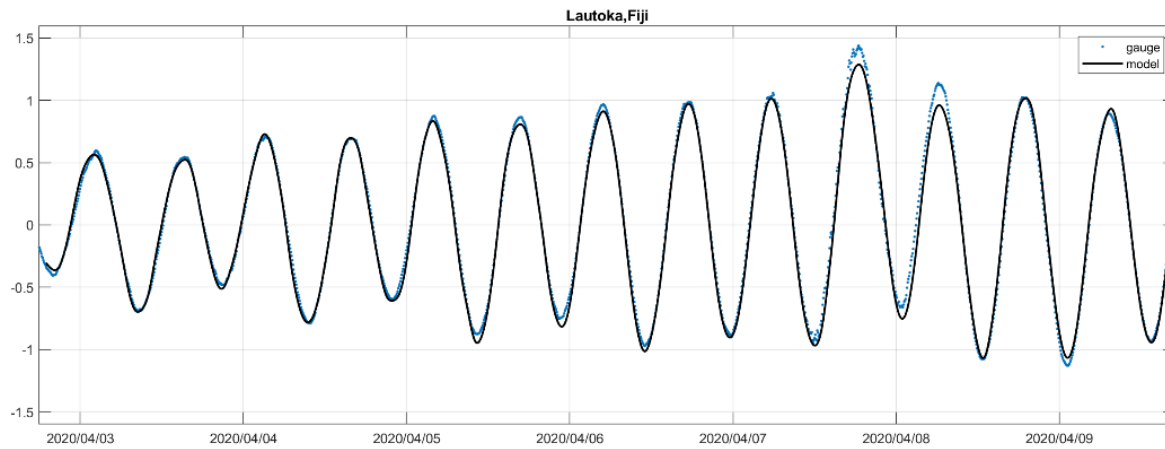
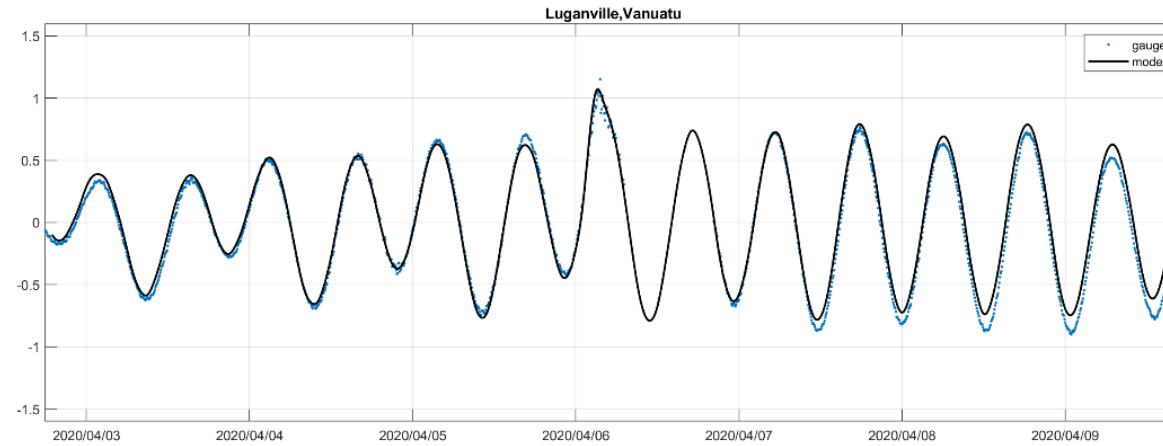
TC wind fields can be reproduced with relatively easy parametric models:

- Track: longitude, latitude
- Maximum wind
- Minimum pressure
- Size: radius of maximum winds, Rmax
- Rmax for each quadrant



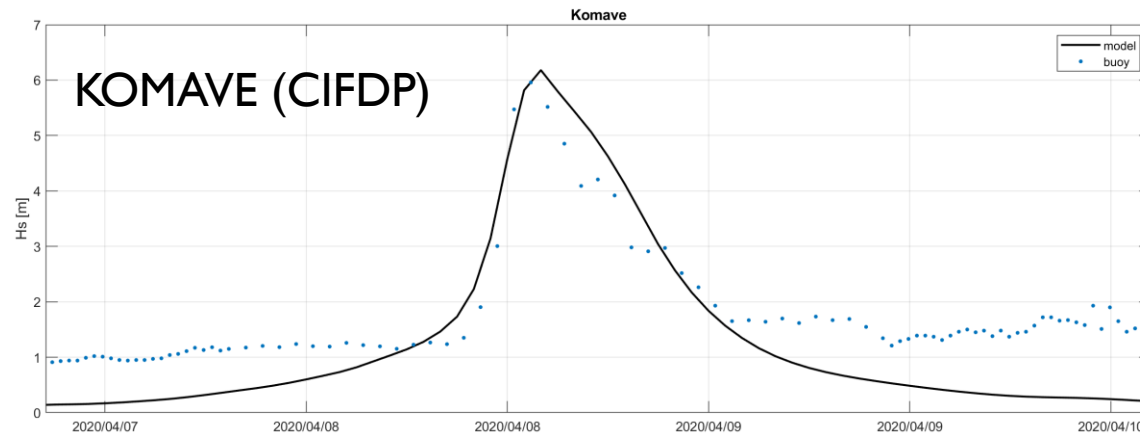
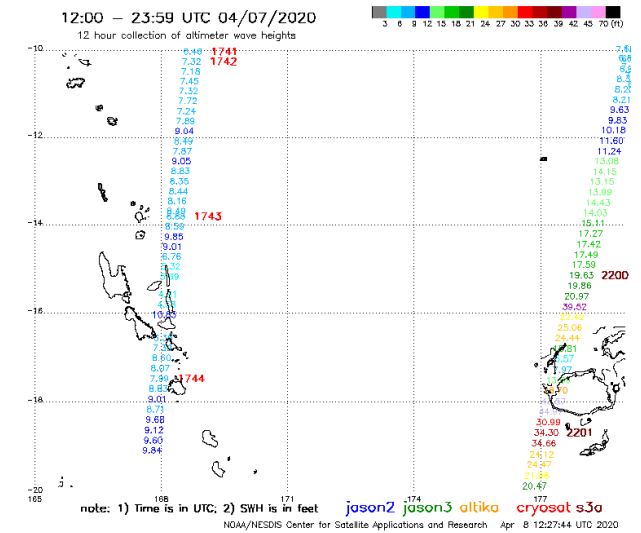
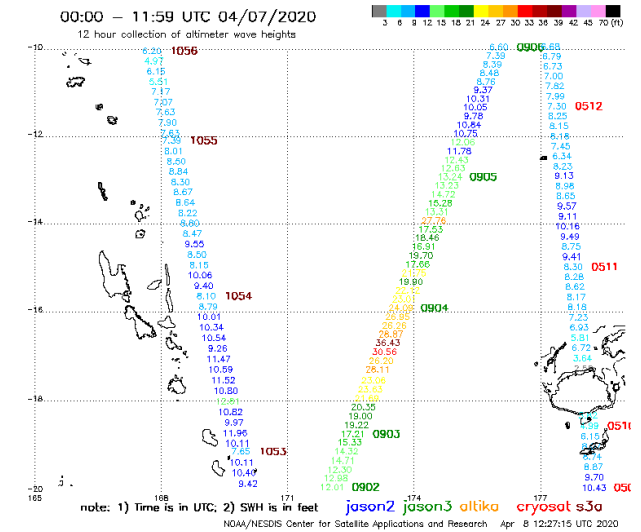
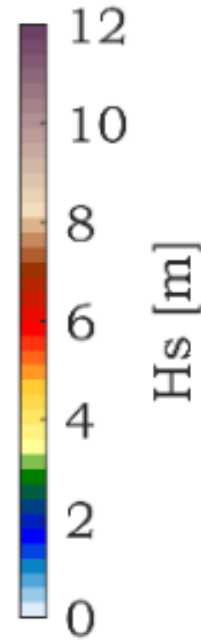
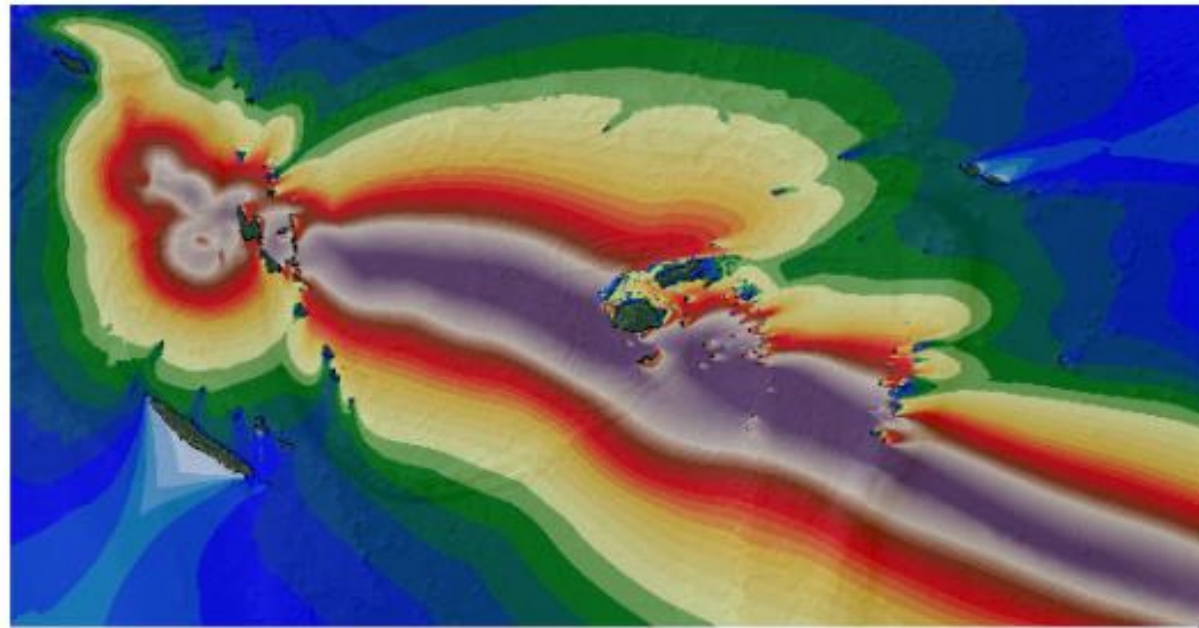
SPC's storm surge and wave model

Validation of water levels with tide gauges



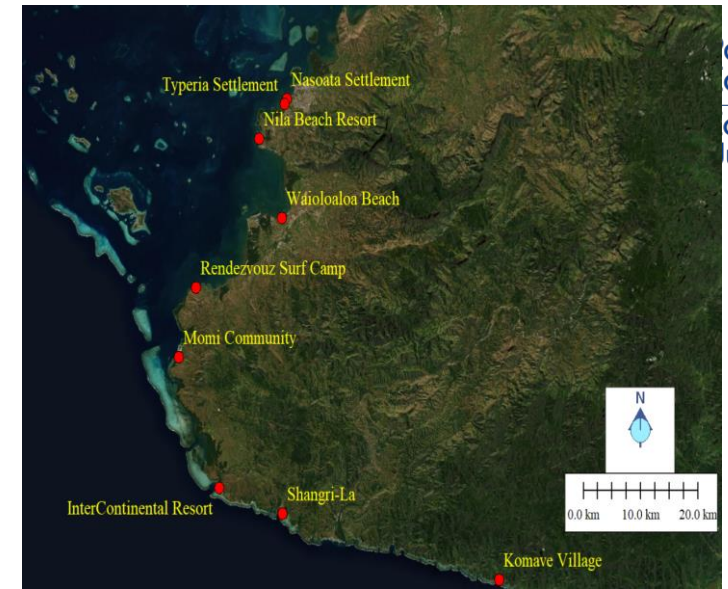
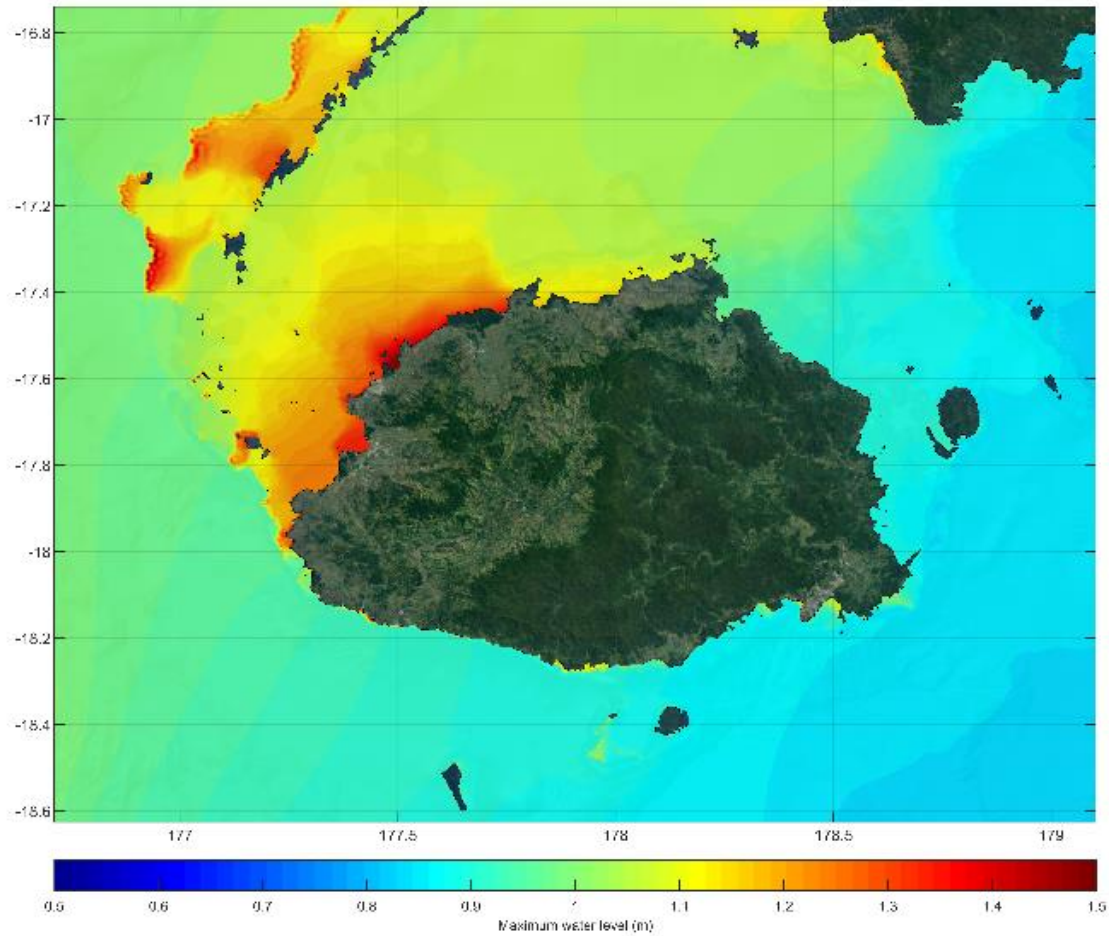
SPC's storm surge and wave model

Validation of waves with satellite and wave buoy



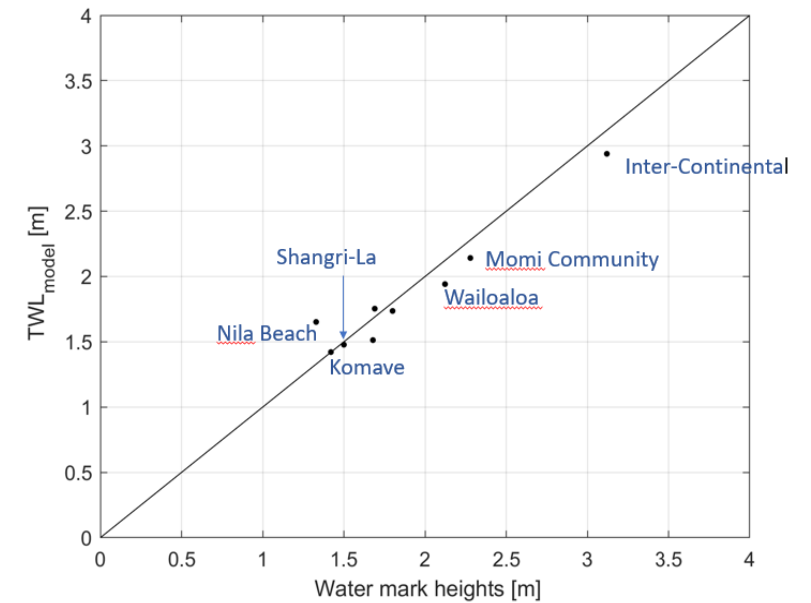
SPC's storm surge and wave model

Validation of inundation with high water marks

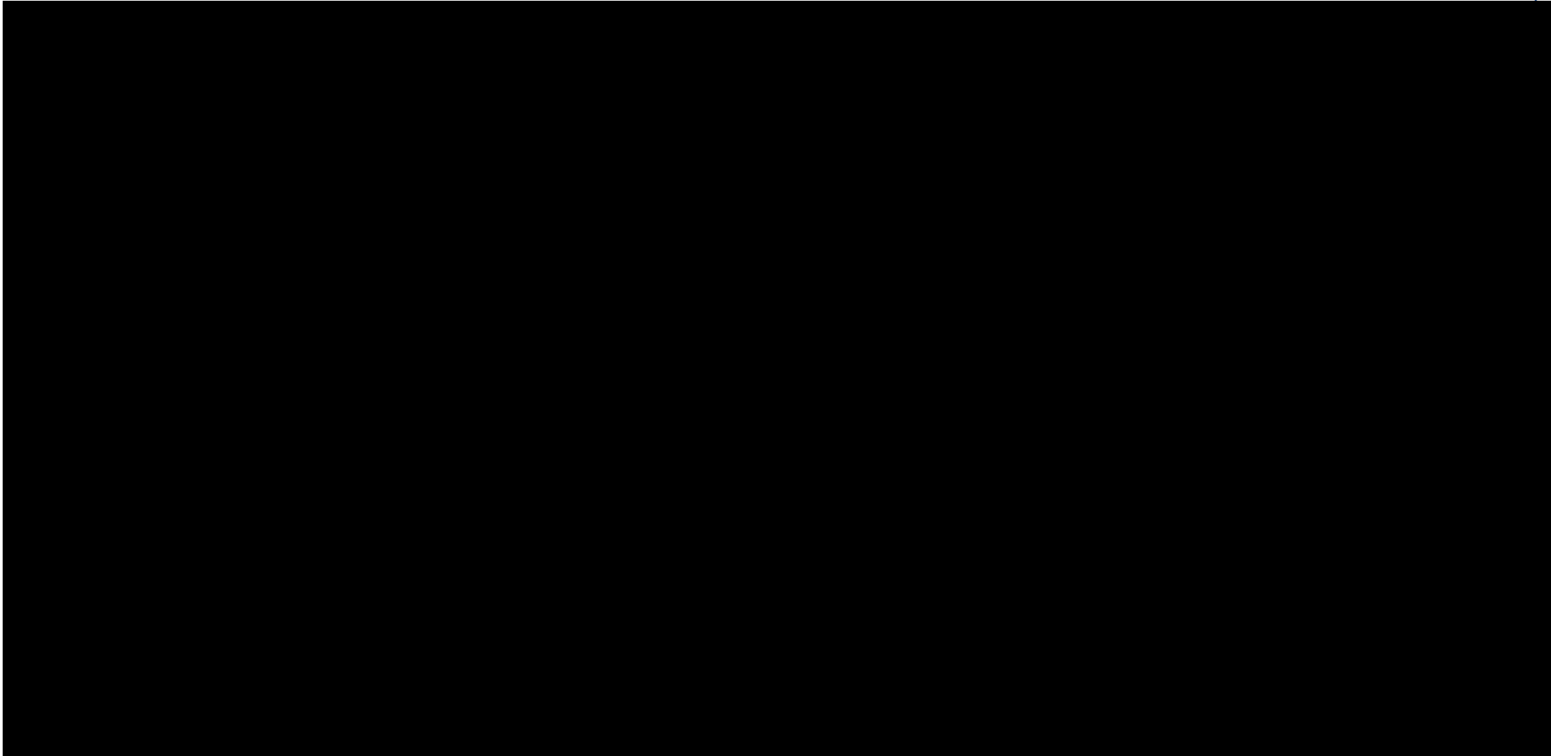


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$$R_2 = 0.73\beta_f(H_0L_0)^{1/2}$$

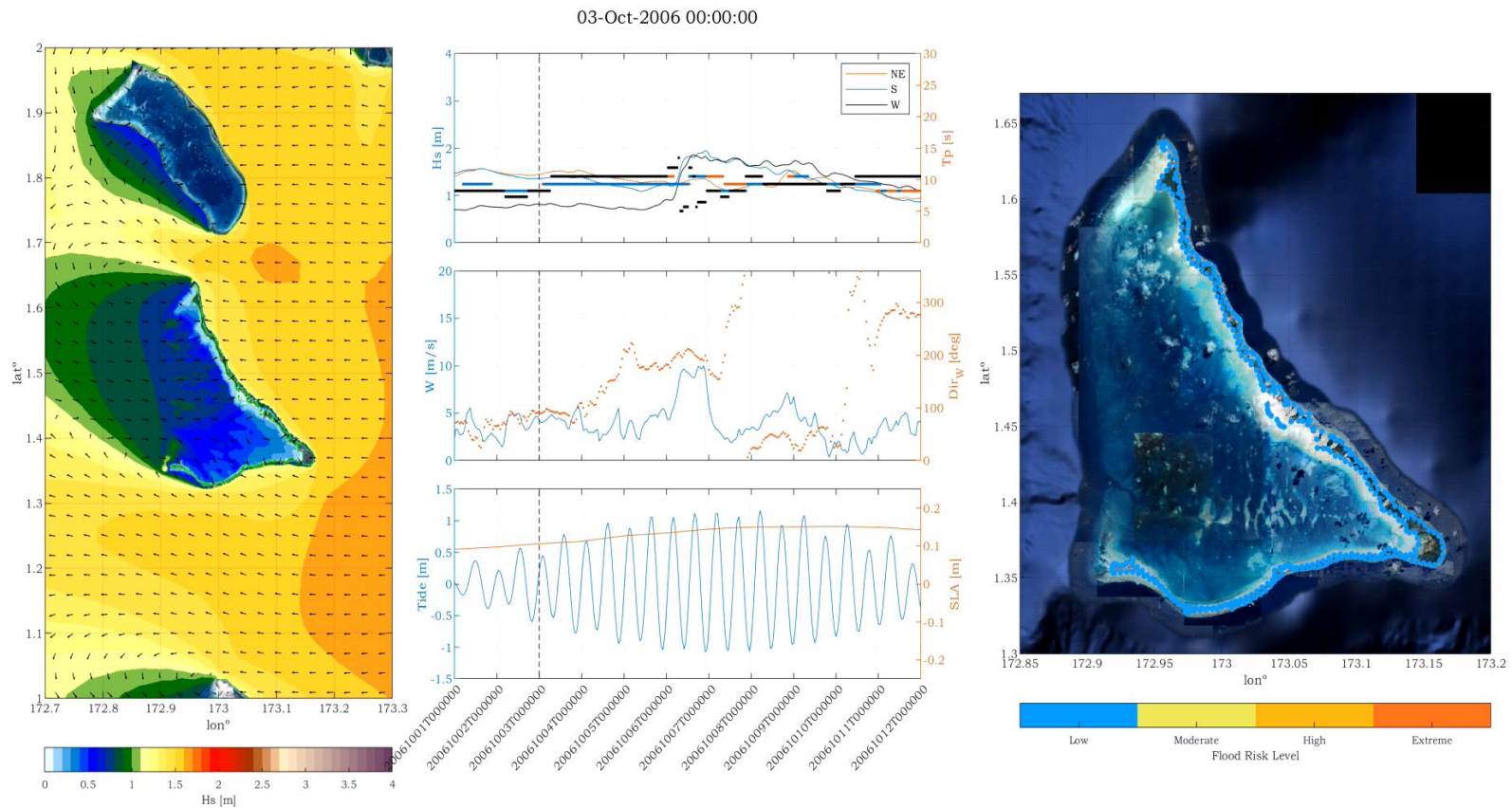


SPC's storm surge and wave model



Other examples, Tarawa inundation forecast (CREWS):

- SPC developed an innovative inundation warning system for Tarawa
- Tailored to areas with poor baseline data
- Could be applicable to national scale inundation early warning systems



Next steps to build up an operational storm surge and wave model:

- SPC is eager to support FMS TC warning activities for the upcoming season
- Need to discuss about the data needed to run the model and what FMS needs as a product
- Medium term activities:
 - Improve baseline data: beach profiles, reef geomorphology
 - Possibility if coupling of CIFDP inundation forecast system
 - Possibility of improving with machine learning algorithms
 - Possibility to increase resolution in flood prone areas (Nadi bay)
 - Extend the model to all countries under FMS area of responsibility

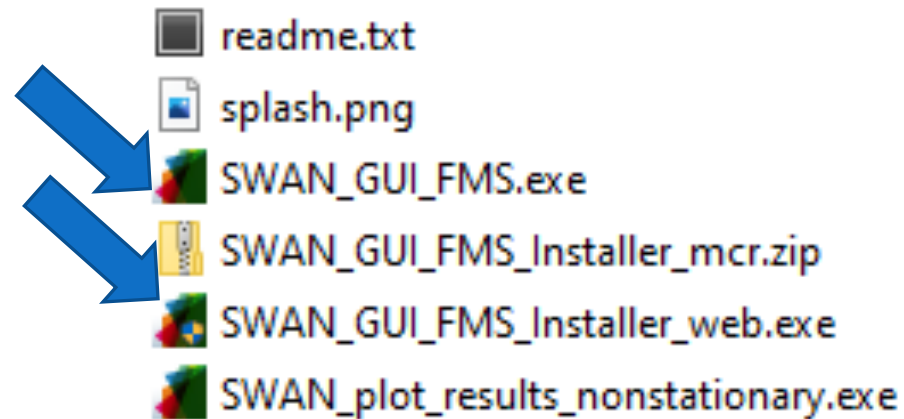
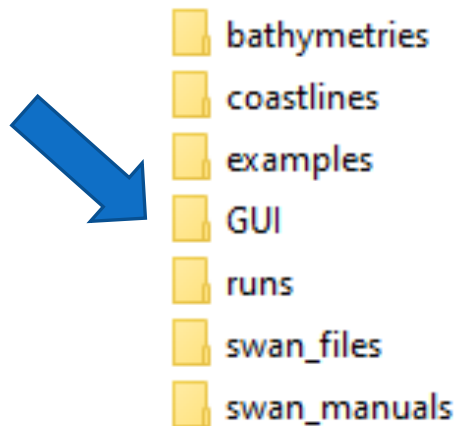


SWAN WAVE MODEL

GRAPHICAL USER INTERFACE - MANUAL

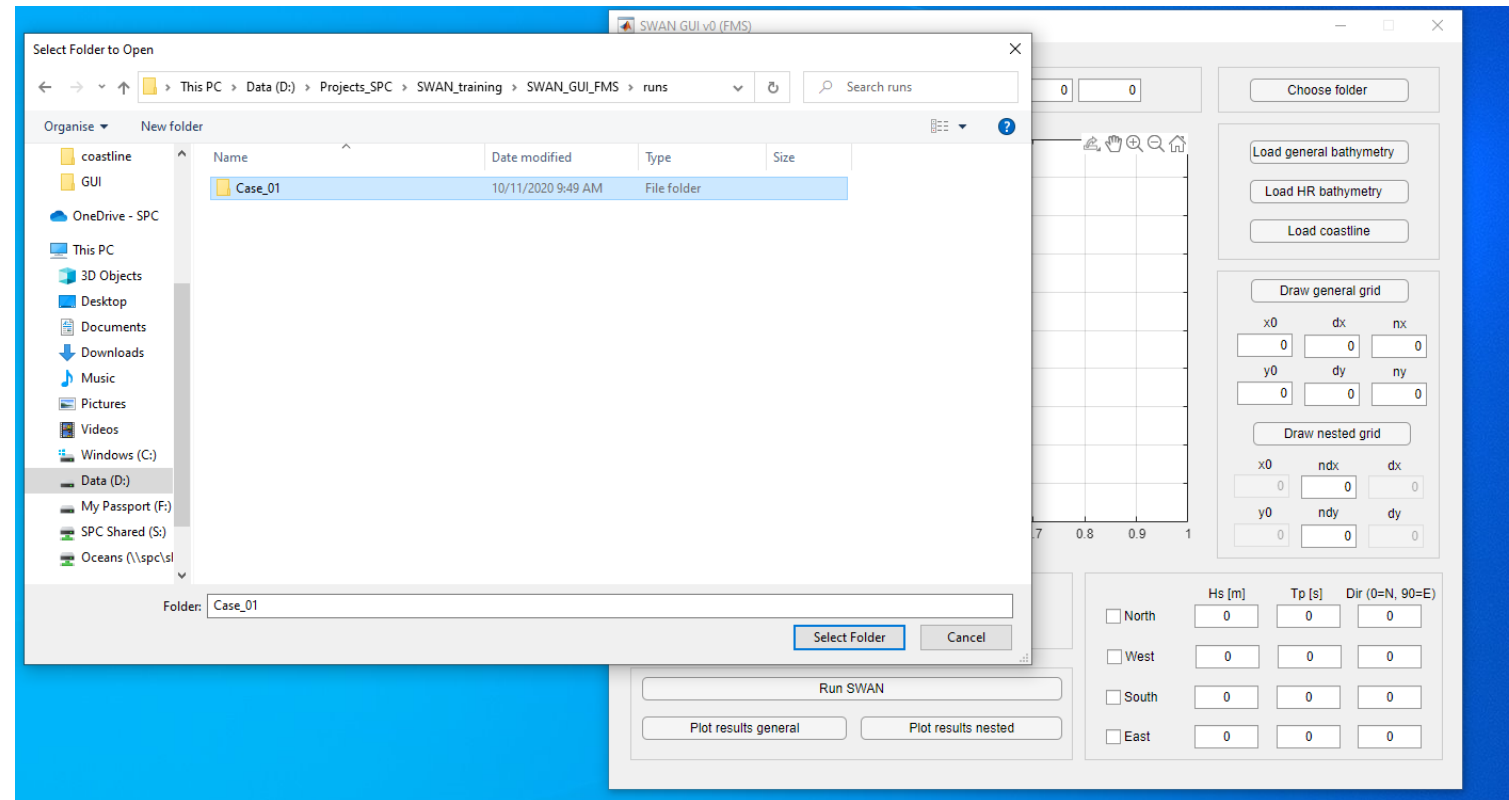
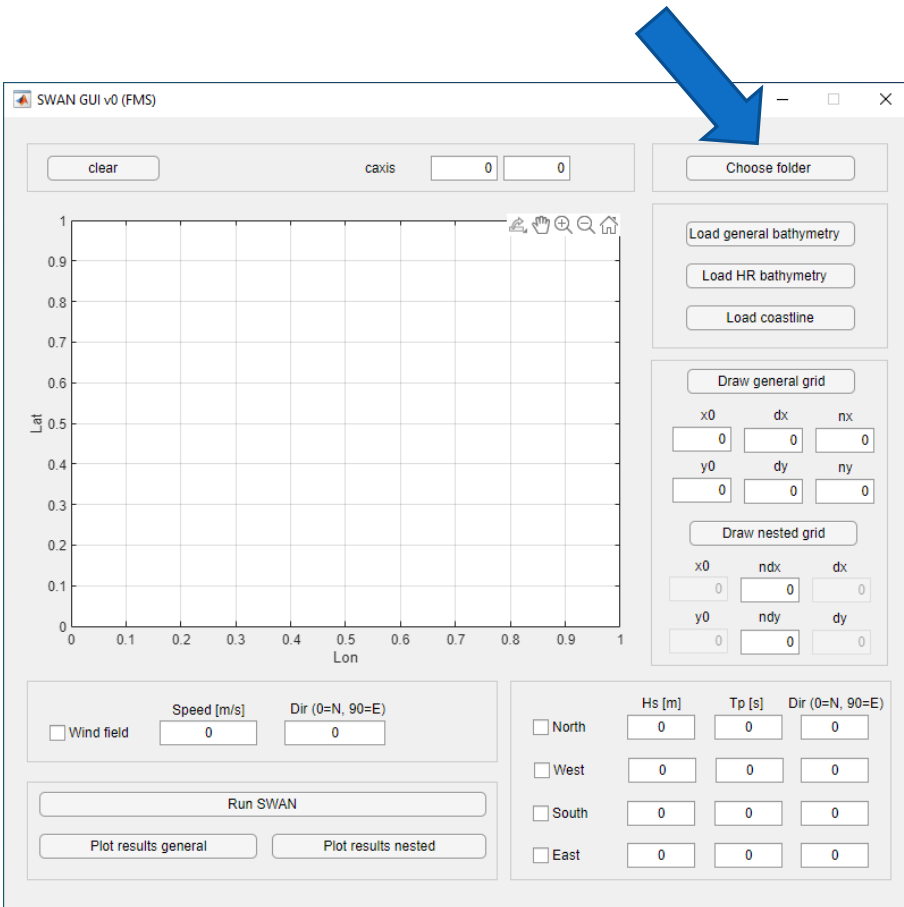
INSTALLATION STEPS

1. Unzip and copy the SWAN_GUI to your PC, path needs to be without spaces.
2. Install Matlab Runtime inside GUI folder: SWAN_GUI_Installer_web.exe (needs internet connection, it may take some time) or SWAN_GUI_Installer_mcr.zip
3. Open SWAN GUI: SWAN_GUI.exe



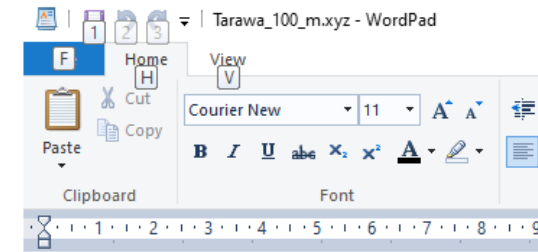
STEP 1: Create your working environment

I. Create/choose a folder where a SWAN simulation will be run. It is desirable to run each case in a different folder within the run folder



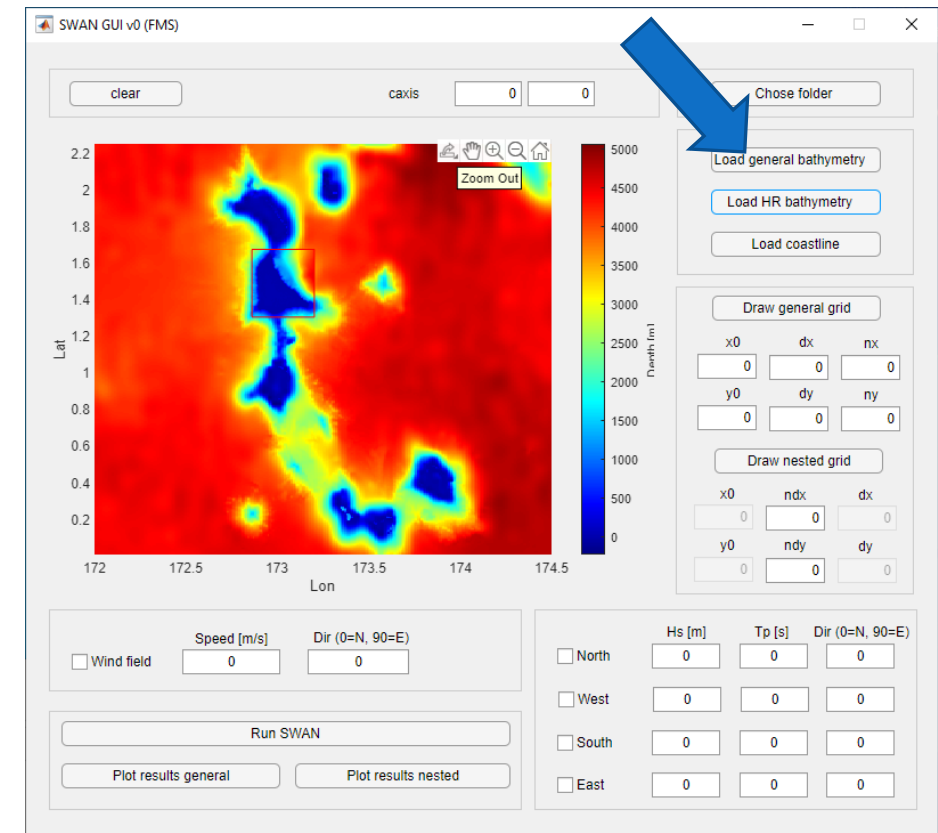
STEP2: Load your bathymetry data

- The GUI supports the importing of a maximum of two bathymetry datasets (with identical projection), a global and a high resolution datasets. **At least one bathymetry file must be imported to run the wave model.**
 - Bathymetry file (file extension *.xyz) is a three column file formatted as follow:
x/Lon/Easting, y/Lat/Northing, depth (positive)
Note that file is comma delimited with no header
 - The bathymetry files should be located in the folder named bathymetries (it will be easy to find them).
- Load general bathymetry** button: Use to load the coarse bathymetry. It is also used to load HR bathymetry file if only one bathymetry file is loaded.
- Load general Bathymetry** button: Use to load the HR bathymetry if a general bathymetry file (coarser) was already provided. If loaded, the HR bathymetry is highlighted by a red bounding box in the GUI.
- Load coastline** button: Use to import coastline into the GUI. The software can read 2 common coastline file format: shapefile polygon or polyline as exported from QGIS.



```
172.8608548,1.673313151,2763.69
172.8617541,1.673313151,2762.55
172.8626534,1.673313151,2762.55
172.8635527,1.673313151,2754.03
172.864452,1.673313151,2745.07
172.8653513,1.673313151,2726.91
172.8662506,1.673313151,2719.89
172.8671499,1.673313151,2713.94
172.8680492,1.673313151,2676.66
```

Example of the bathymetry file

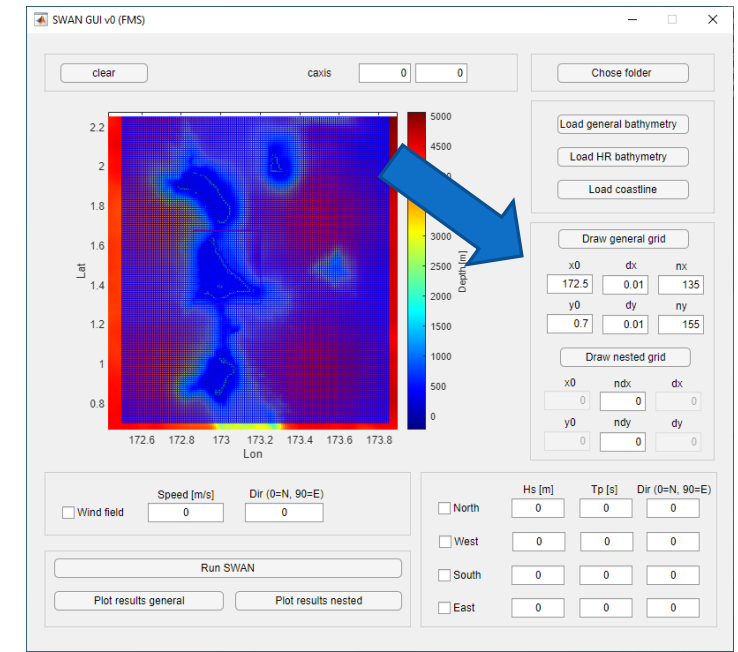
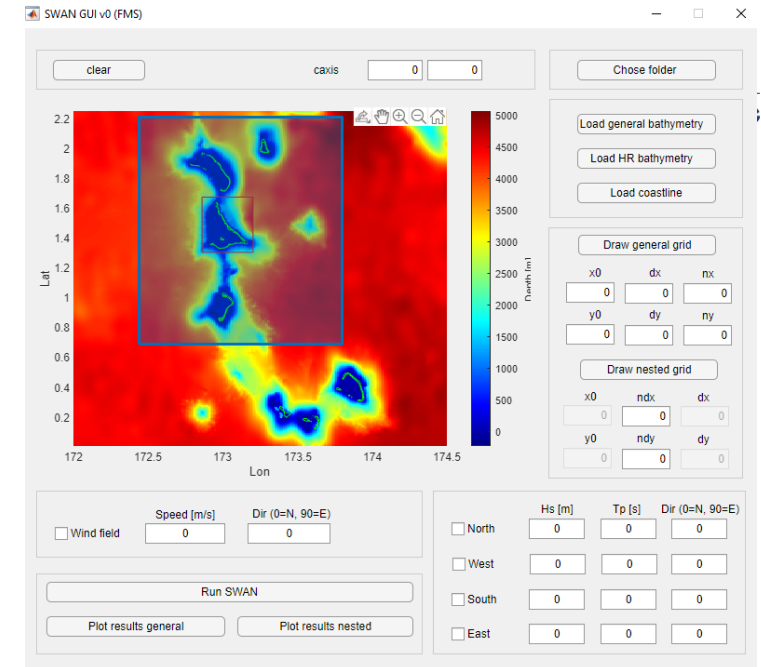


STEP3: Define your computational domain

Nesting: In order to gain efficiency, it is convenient to first propagate the waves towards the study site using a coarse grid. The waves from the coarse grid are then fed into the higher resolution grid (or nested grid) covering the area of interest where accuracy is most needed.

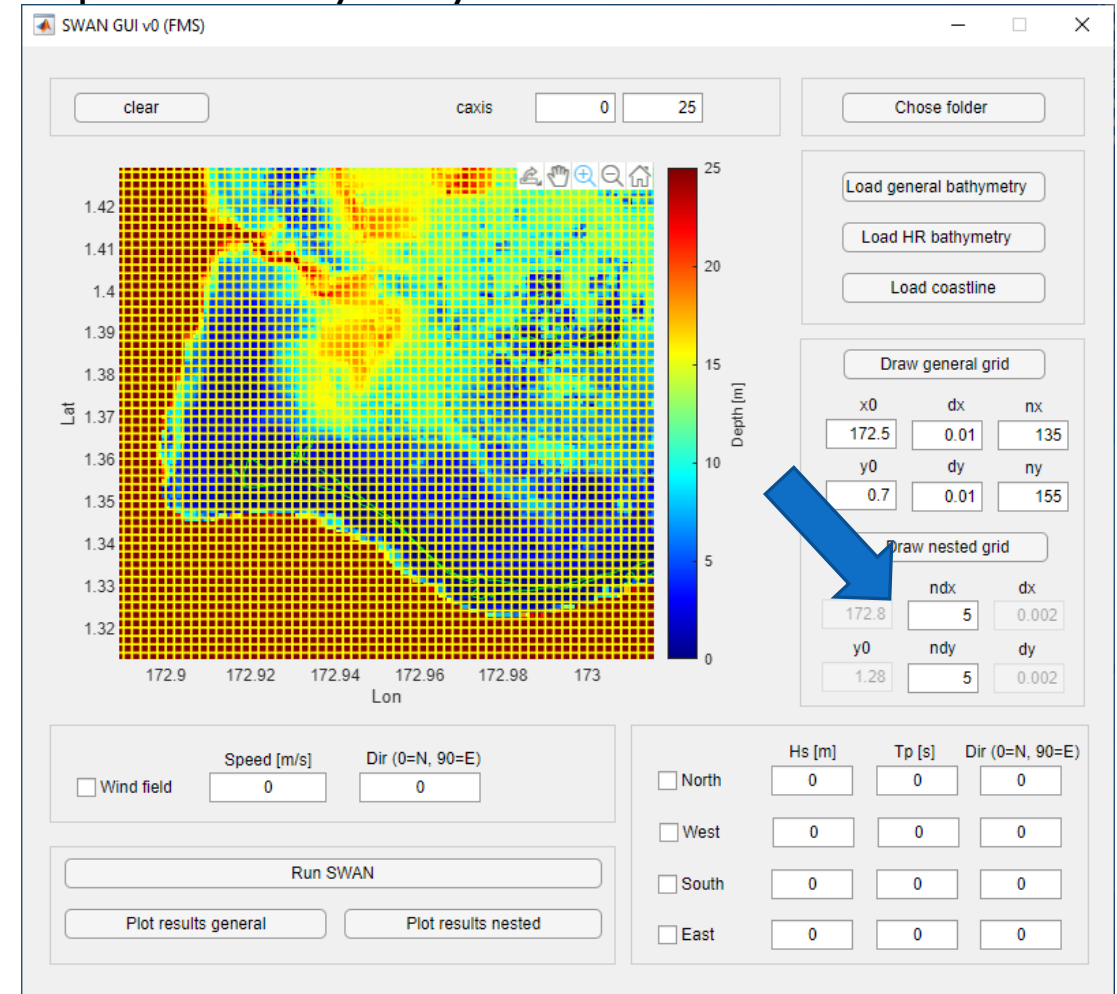
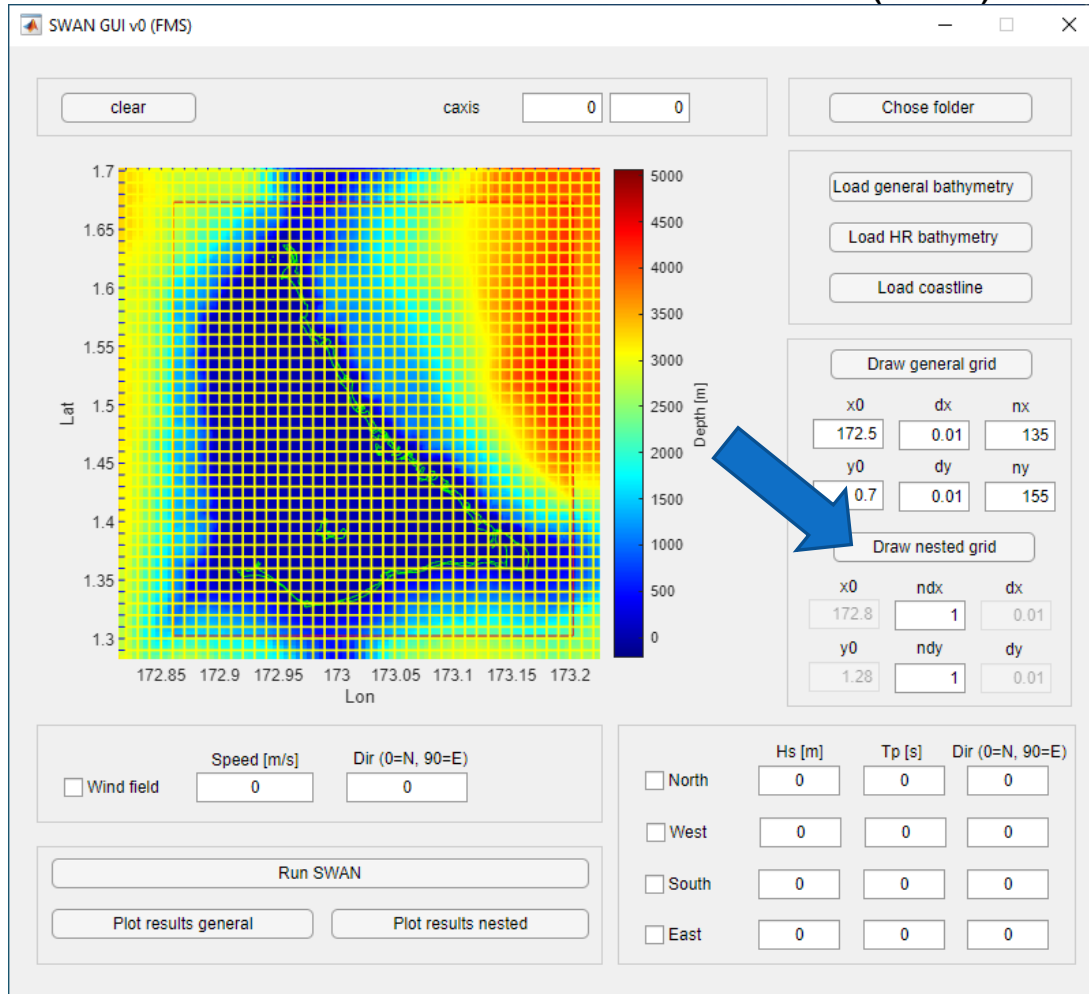
Draw the general grid button: Use to define the extent of the general grid/computational domain.

- Press the **Draw general grid** button and drag over the desired area.
- The grid can be refined using the following parameters:
 - Origin (X0,Y0)
 - Grid Spacing / resolution (dx,dy)
 - Number of Cells in x and Y directions (nx, ny)
- Note that the general grid can be generated without the need of using the free hand tool but by simply defining it numerically. In this example dx and dy have been set to 0,01 degrees (about 1 Km over the 3 Gilbert Islands) obtaining 135 cells in X and 155 in Y directions.



STEP3: Define the nested computational domain

- **Draw nested grid** button: Use to define the extent of the HR grid/HR computational domain. Define the HR grid resolution as a subdivision of the general grid (ndx and ndy). In this case it is set to 5 so that HR grid for Tarawa is 250m resolution (1km/5)
- Note that the colour scale can be modified (caxis) to better inspect the bathymetry dataset.



STEP4: Define the wave and/or wind forcing

- Define wave boundary conditions for each side of the general grid
 - Hs: significant wave height
 - Tp: Peak period
 - Dir: Mean direction
- Define constant wind
 - Speed
 - Direction
- **Run SWAN** button: Use to start the model run

```
C:\WINDOWS\SYSTEM32\cmd.exe - swanrun_general

SWAN is preparing computation

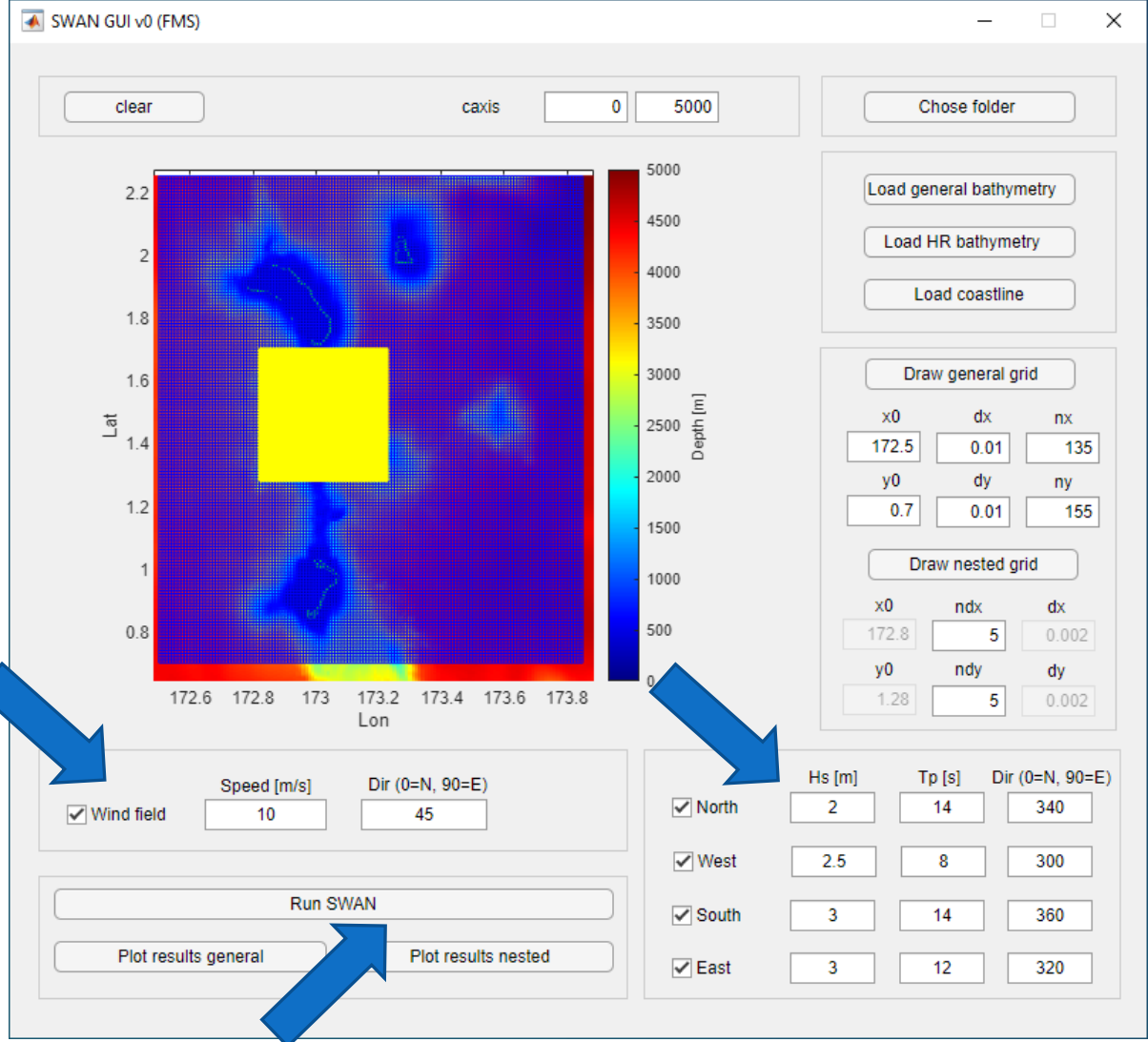
iteration 1; sweep 1
+iteration 1; sweep 2
+iteration 1; sweep 3
+iteration 1; sweep 4
not possible to compute, first iteration

iteration 2; sweep 1
+iteration 2; sweep 2
+iteration 2; sweep 3
+iteration 2; sweep 4
accuracy OK in 29.56 % of wet grid points ( 95.00 % required)

iteration 3; sweep 1
+iteration 3; sweep 2
+iteration 3; sweep 3
+iteration 3; sweep 4
accuracy OK in 0.01 % of wet grid points ( 95.00 % required)

iteration 4; sweep 1
+iteration 4; sweep 2
+iteration 4; sweep 3
+iteration 4; sweep 4
accuracy OK in 13.26 % of wet grid points ( 95.00 % required)

iteration 5; sweep 1
```



The SWAN GUI v0 (FMS) interface displays a bathymetry map of a region with a yellow square indicating the general grid area. The map axes are Latitude (Lat) from 0.8 to 2.2 and Longitude (Lon) from 172.6 to 173.8. A color scale on the right indicates Depth [m] from 0 to 5000. The interface includes several control panels:

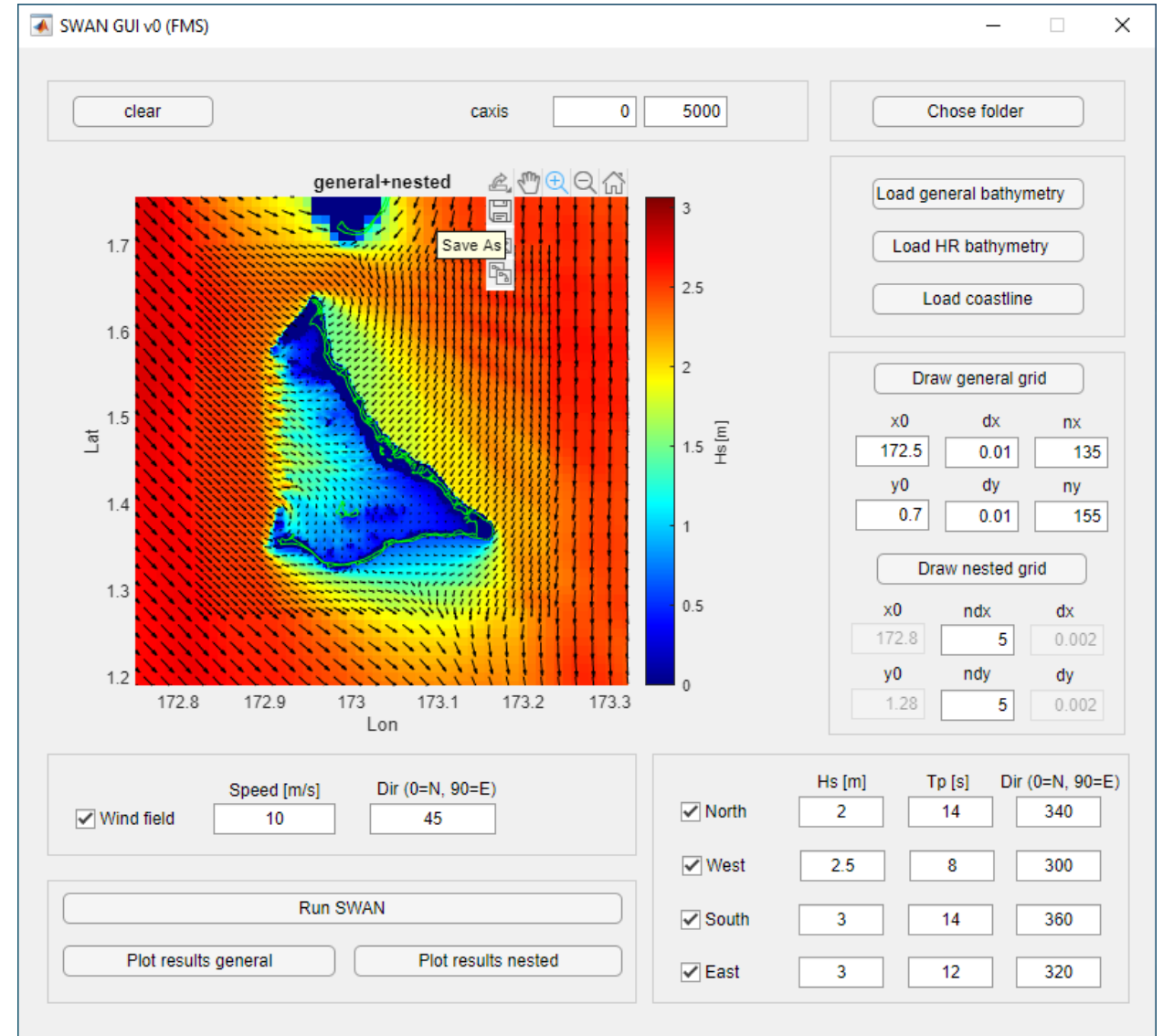
- Top Panel:** A 'clear' button, a 'caxis' field with values 0 and 5000, and a 'Chose folder' button.
- Right Panel:** Buttons for 'Load general bathymetry', 'Load HR bathymetry', and 'Load coastline'. Below these are 'Draw general grid' and 'Draw nested grid' sections with input fields for x0, dx, nx, y0, dy, ny, ndx, and ndy.
- Bottom Left Panel:** A 'Wind field' checkbox (checked), a 'Speed [m/s]' field with value 10, and a 'Dir (0=N, 90=E)' field with value 45.
- Bottom Right Panel:** A table for wave boundary conditions with checkboxes for North, West, South, and East (all checked).

	Hs [m]	Tp [s]	Dir (0=N, 90=E)
North	2	14	340
West	2.5	8	300
South	3	14	360
East	3	12	320
- Bottom Center Panel:** A 'Run SWAN' button, and two 'Plot results' buttons: 'Plot results general' and 'Plot results nested'.

Blue arrows point from the 'Run SWAN' button to the terminal window and from the 'Plot results' buttons to the terminal window.

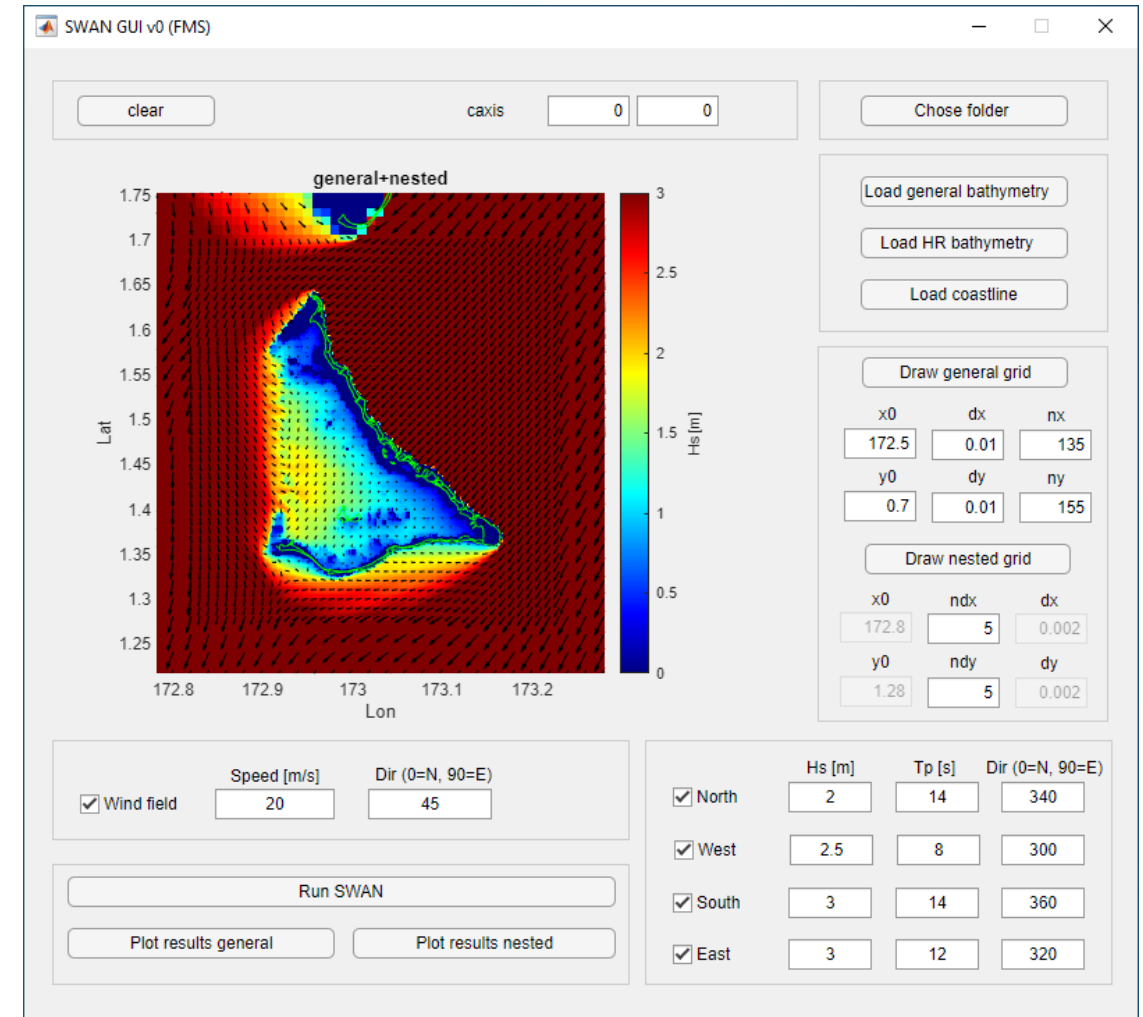
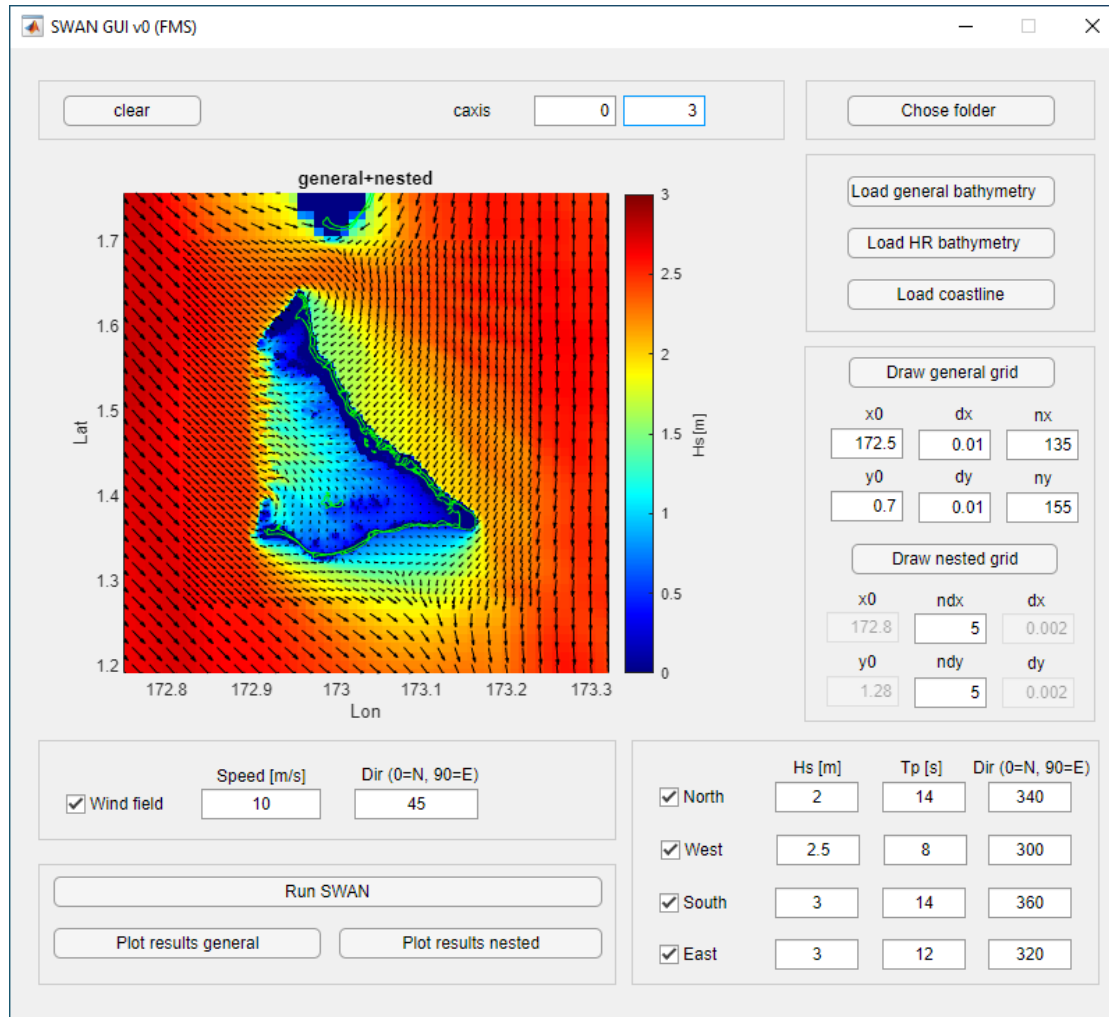
STEP5: Investigate the model output

- **Plot result general** button: Use to plot the result from the general wave model as a 2D map of the wave height and direction.
- **Plot result nested** button: Use to plot the result from the HR wave model as a 2D map of the wave height and direction.
- The colour scale can be adjusted (caxis) to better represent wave gradients in the area of interest.
- The result can be exported as ...















Tips: Run a new scenario

- For each new case, it is recommended to create a new folder using the **Choose folder** button. In the below example, 2 scenarios are run using different folder.



Exploring SWAN files for advanced user

- In each folder a set of files are generated, this files can be used to further improve the simulation with more sophisticated settings (i.e. variable boundary conditions, non-stationary runs, etc.)

SWAN executable	 swan.exe
Bathymetry files	 bot_general.dat
Nested grid boundary conditions	 bot_nested.dat
Normal SWAN termination	 nested_bnd
SWAN initialization	 norm_end
Results	 swaninit
Figure Hs map	 general_grid.mat
SWAN configuration files	 nested_grid.mat
SWAN bat file	 Hs_map.png
	 general.swn
	 nested.swn
	 swanrun.bat

Exploring SWAN files for advanced user

- The SWAN configuration files (*.swn) can be modified to change the model forcing, physics or outputs. For this task is recommended checking the SWAN User Manual inside the swan_manual folder

Project name and run	<pre> \$\$\$ startup command PROJ 'Gen' '01' \$ </pre>
General settings	<pre> \$\$\$ General parameters SET level=0 NAUTICAL COORDINATES SPHERICAL CCM \$ </pre>
Computational domain	<pre> \$\$\$ Computational grid CGRID 175.2000 -20.0000 0 6.9500 5.4000 139 108 CIRCLE 36 0.0345 1.00 24 \$ </pre>
Bathymetry	<pre> \$\$\$ Bathymetry INPGRID BOTTOM REGULAR 175.2000 -20.0000 0 139 108 0.0496 0.0495 EXC -999 READINP BOTTOM 1 'bot_general.dat' 1 0 FREE \$ </pre>
Wind forcing	<pre> \$\$\$ Constant wind definition WIND 8.00 70.00 \$ </pre>
Wave forcing	<pre> \$\$\$ Definition of wave boundary conditions BOUN SHAPE JONSWAP 3.3 PEAK DSPR DEGREES BOUN SIDE W CON PAR 2.00 15.00 200.00 20 BOUN SIDE S CON PAR 2.00 15.00 200.00 20 \$ </pre>
Physics	<pre> \$\$\$ Physics QUAD WCAP BREA FRICTION JONSWAP NUM STOPC 0.005 0.01 0.005 95 \$ </pre>
Nesting	<pre> \$\$\$ Grid nesting \$\$\$ Outputs BLOCK 'COMPGRID' NOHEAD 'general_grid.mat' LAY 3 XP YP DEP HSIGN TM02 RTP DIR \$ </pre>
Lockup commands	<pre> \$\$\$ Lockup commands TEST 1,0 COMPUTE STOP \$ </pre>