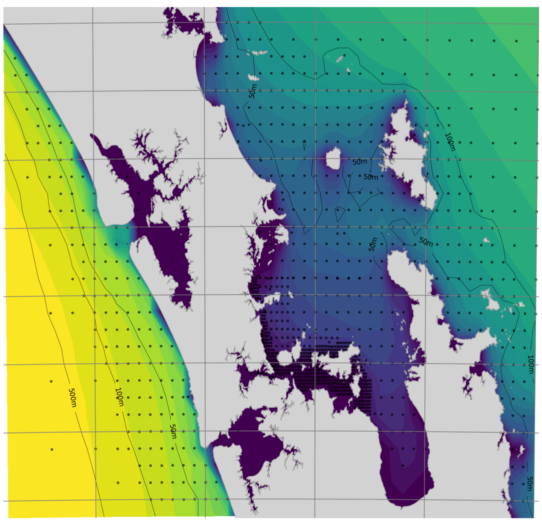
Technical Note on Specification and Validation of the Oceanum Auckland Wave Forecast

August 2024

Model	SWAN 41.31
Spatial resolution	0.002 to 0.01 degree
Forecast horizon	7 days
Temporal resolution	1 hourly
Region	173.6E - 176E
	37.25S - 35.75S
Forcings	GFS winds, Calypso tidal currents and Oceanum spectra



Dataset description

The wave forecast dataset for Auckland, New Zealand, provides detailed predictions of ocean wave spectral conditions. This dataset includes hourly projections of two-dimensional wave spectra and integrated spectral parameters over a seven-day forecast horizon, updated every six hours to incorporate the latest meteorological and oceanographic forcing data. Additionally, the first six-hours of each cycle are stored into an updating "nowcast" archive which provides an up-to-date representation of current wave conditions from the start of the forecast period in April 2024.

The model domains cover the East and West coasts of Auckland with a special focus on the Southern Hauraki Gulf (Figure 1). Wave spectra are computed using the SWAN (Simulating WAves Nearshore) third-generation spectral wave model. The model is driven by inputs from the Oceanum GFS Global Wave Model for spectral boundaries, the NOAA Global Forecast System for wind data, and tidal currents from a nearshore tidal model from Calypso Science. Bathymetry is derived from the high-resolution Auckland Council bathy grid 2021 combined with the GEBCO 2023 400 m grid. The dataset specification is detailed in Table 1.

SWAN is configured with the ST6 source term parameterisations. Spectra are discretised into 36 directional bins and up to 43 frequency bins, spanning the range of 0.037 to 2 Hz at 10% logarithmic increments. The model employs a 3-stage nest, featuring a 5 km resolution New Zealand parent nest, a 1 km nest of the wider Auckland area and a 200 m nest over the Eastern Auckland region (Figure 1). This nested approach enhances the resolution and accuracy of the wave forecast, particularly in the key Southern Hauraki gulf area, offering detailed insight into the expected sea state to support maritime operations, coastal management, and recreational activities. The model has been validated[1] against wave observations within the Hauraki gulf provided by the Auckland Council (Figure 2-11), ensuring a high level of accuracy and reliability in capturing real-world conditions.

The dataset provides hourly estimates for an extensive array of ocean wave parameters (Table 2) including spectral quantities integrated over the full spectrum and for spectral partitions (defined from a 8-second split and from the Watershed method). These data are stored over the entire grid at native resolution. Additionally, frequency-direction wave spectra are available at 1088 sites, with resolution increasing from deep ocean areas towards the coast (see Figure 1).

[1] Model validation utilising Datamesh is thoroughly documented and explained in this notebook.

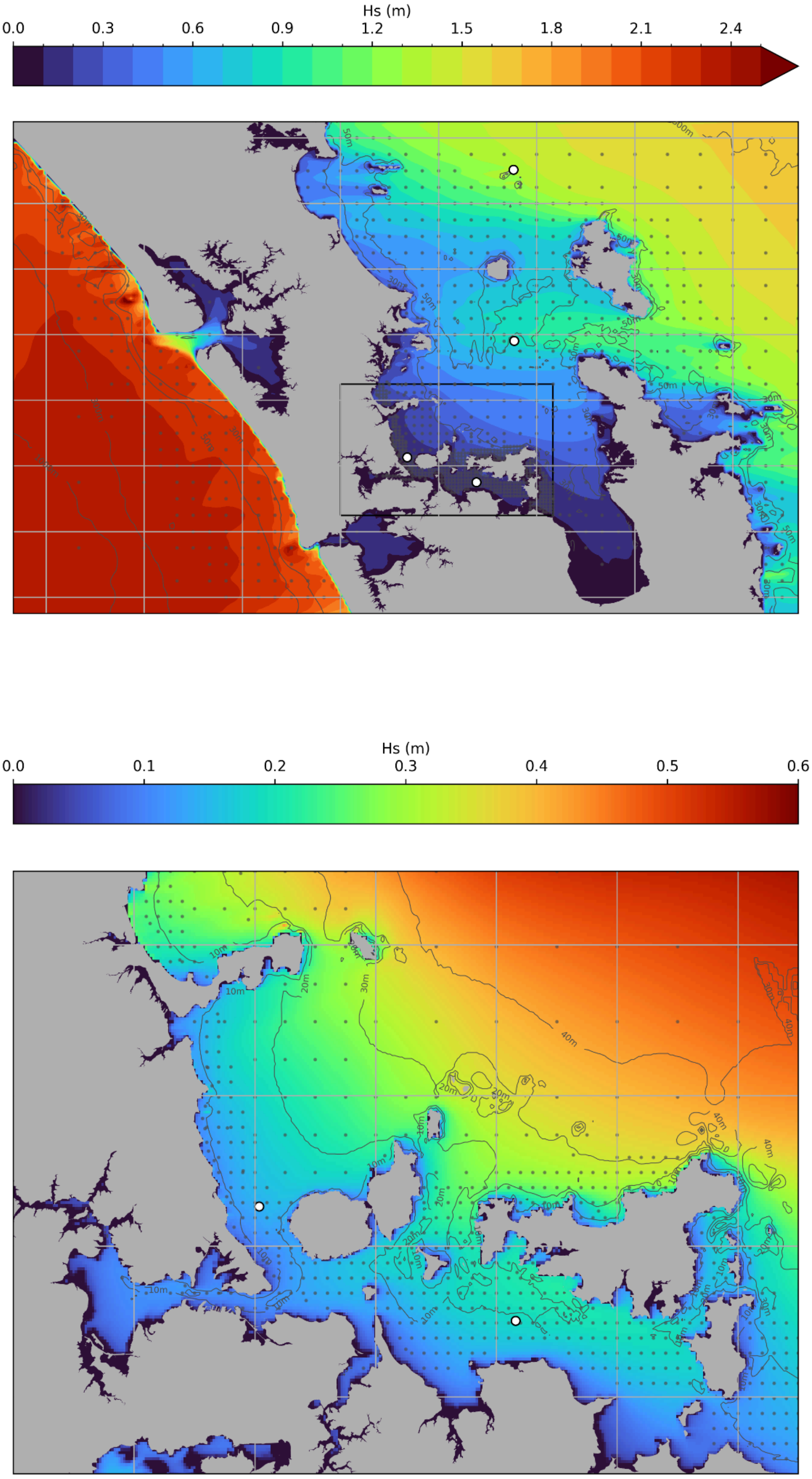


Figure 1. Significant wave height Hs from the (top) Auckland 1 km, and (bottom) Eastern Auckland 200 forecast domains averaged over a forecast cycle. Grey circles show the locations of spectra output. Rectangle indicates the location of the 200 m domain. White circles show the wave buoy locations used to validate the model.

Table 1. Data description.

Title	Oceanum Auckland wave forecast
Institution	Oceanum
Access	Oceanum Datamesh
Source	SWAN 41.31A
Source terms	ST6
Temporal resolution	Hourly
Forecast horizon	7 days
Forecast cycles	00 UTC, 06 UTC, 12 UTC, 18 UTC
Spatial coverage	Auckland 1km: [173.6, -37.25, 176.0, -35.75] at 0.01 degree Eastern Auckland 200m: [174.6, -36.951, 175.25, -36.551] at 0.002 degree
Spectra sites	1088
Frequency discretisation	Up to 43 frequencies between 0.037 - 2.027 Hz at 10% logarithmic increments
Direction resolution	10 deg
Bathymetry	Auckland Council bathy grid 2021 and GEBCO 2023 Grid
Winds	GFS
Currents	Nearshore tidal model from Calypso Science
Boundary	Oceanum New Zealand 5km GFS Wave Forecast Spectra
Linked Datamesh datasources	AKL 1 km forecast parameters: oceanum_wave_gfs_akl1km_grid AKL 1 km forecast spectra: oceanum_wave_gfs_akl1km_spec AKL 1 km nowcast parameters: oceanum_wave_gfs_akl1km_grid_nowcast AKL 1 km nowcast spectra: oceanum_wave_gfs_akl1km_spec_nowcast EAKL 200 m forecast parameters: oceanum_wave_gfs_eakl_grid EAKL 200 m forecast spectra: oceanum_wave_gfs_eakl_spec EAKL 200 m nowcast parameters: oceanum_wave_gfs_eakl_grid_nowcast EAKL 200 m nowcast spectra: oceanum_wave_gfs_eakl_spec_nowcast

Validation against historical buoy data

The wave model was validated against historical buoy records provided by the Auckland Council at two locations: Mokohinau (175.129E, 35.896S) and Old Anchorite Rock (175.1E, 36.42S). The data spreads the period between May 1998 and March 2004. Validation was performed against the [Oceanum New Zealand 1km ERA5 wave hindcast] which covers the period between 1979 and present. Although the wind forcing is different from the forecast implementation, the model physics and overall configuration is similar. The hindcast validation process utilising Datamesh is thoroughly documented and explained in [this notebook].

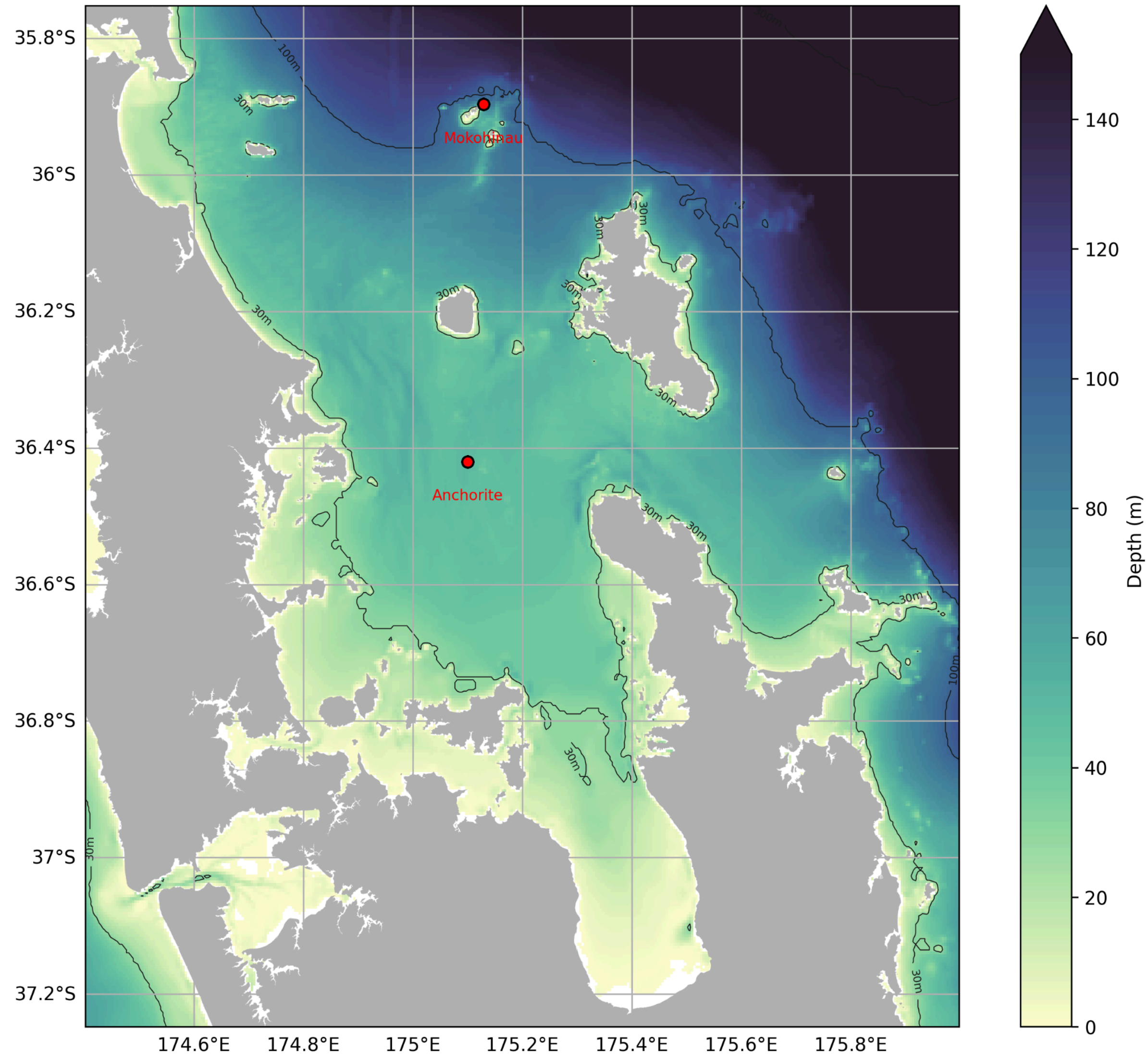


Figure 2. Bathymetry map of the Hauraki Gulf and adjacent coast showing the locations of the two historical wave buoy observation sites.

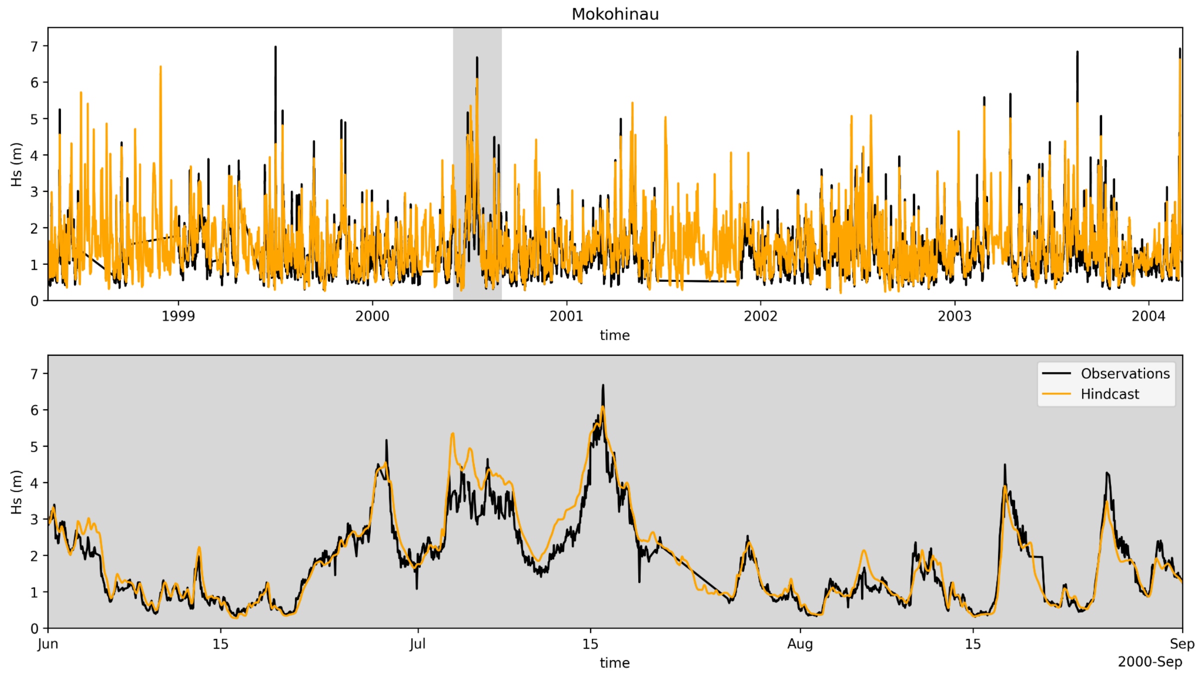


Figure 3. Time series of significant wave height Hs from the Mokohinau wave buoy and the wave hindcast, the shaded period is shown in detail at the bottom.

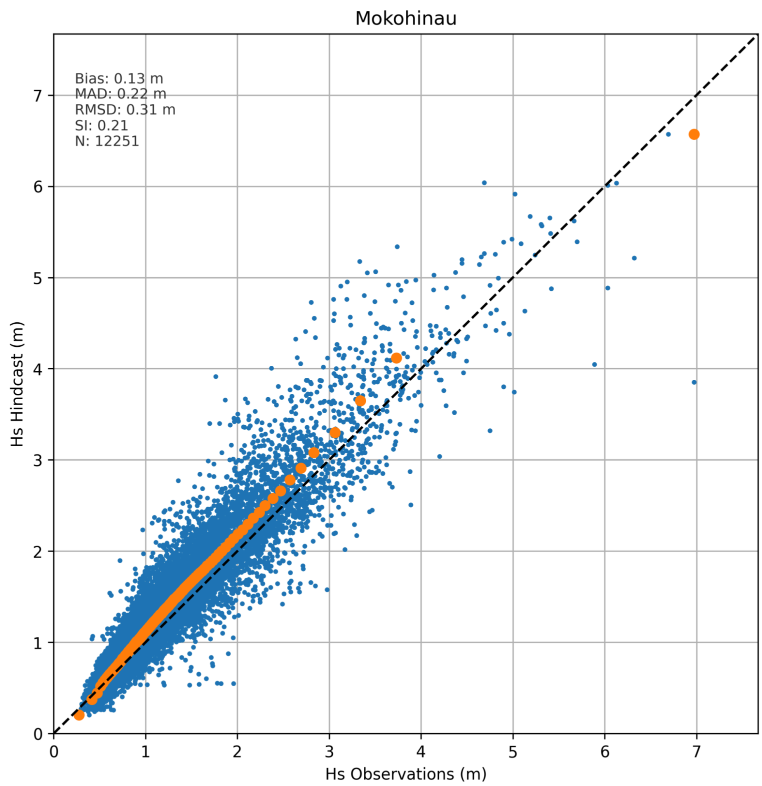


Figure 4. Scatter plot comparing hindcast and measured significant wave height Hs at Mokohinau. The orange markers represent the 0.01 quantiles, while the black dashed line denotes the equality line. Key statistics are shown in the upper left corner, including Bias, Mean Absolute Deviation (MAD), Root Mean Square Deviation (RMSD), Scatter Index (SI), and the number of data points (N).

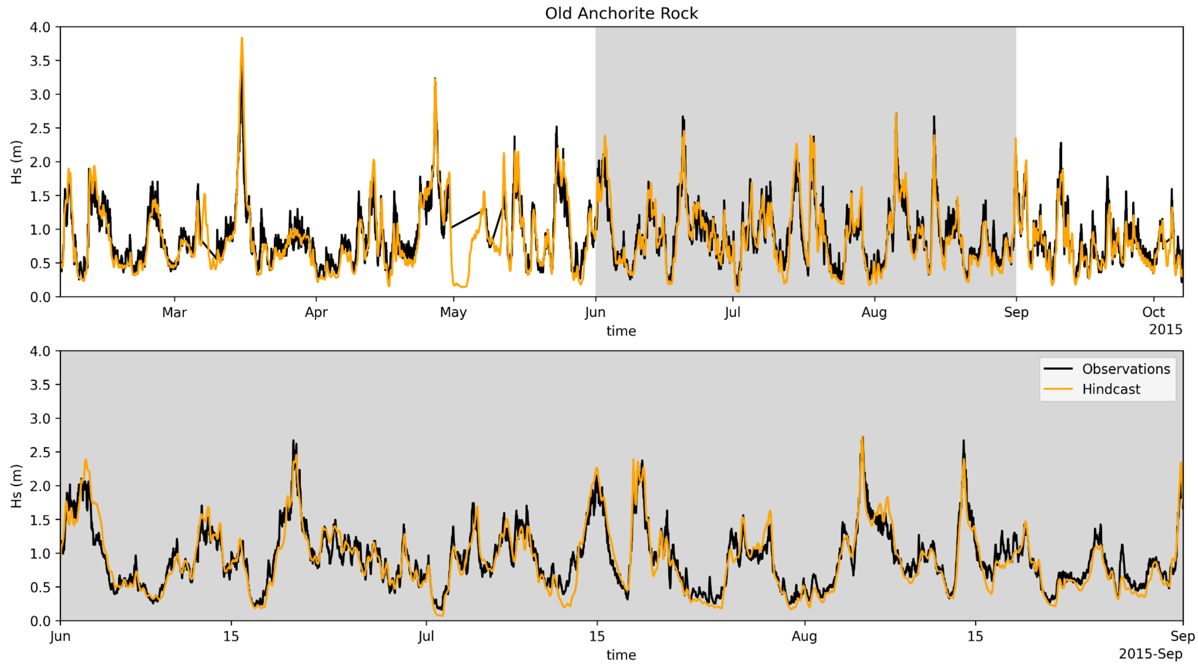


Figure 5. Time series of significant wave height Hs from the Old Anchorite Rock wave buoy and the wave hindcast, the shaded period is shown in detail at the bottom.

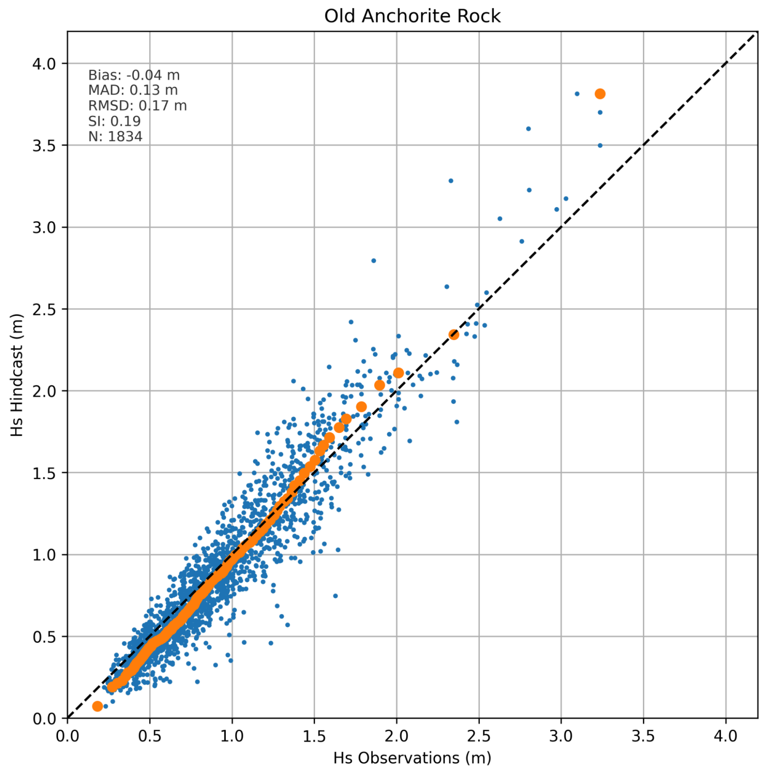


Figure 6. Scatter plot comparing hindcast and measured significant wave height Hs at Old Anchorite Rock. The orange markers represent the 0.01 quantiles, while the black dashed line denotes the equality line. Key statistics are shown in the upper left corner, including Bias, Mean Absolute Deviation (MAD), Root Mean Square Deviation (RMSD), Scatter Index (SI), and the number of data points (N).

Validation against recent buoy data

Recent wave buoy observations from February - March 2024 were used to assess the model skills in the more sheltered locations: Rangitoto (174.8035E, 36.419S) and Tamaki (175.016E, 36.8495S). The forecast model configuration was run over the same period of the buoys using nowcast winds and boundaries archived from GFS and Oceanum's New Zealand 5 km forecast wave model. The location of the buoys are shown in Figure 7.

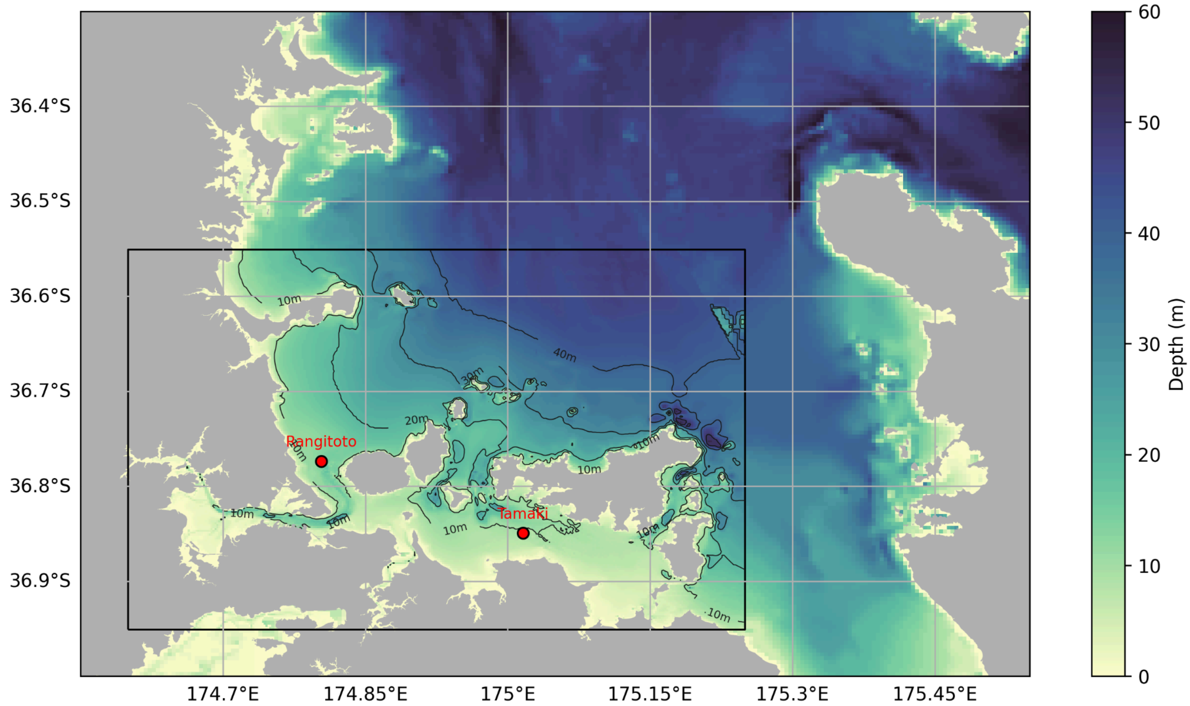


Figure 7. Bathymetry map of the Hauraki Gulf showing the locations of the two recent wave buoy observation sites. Black rectangle shows the extent of the 200 m grid.

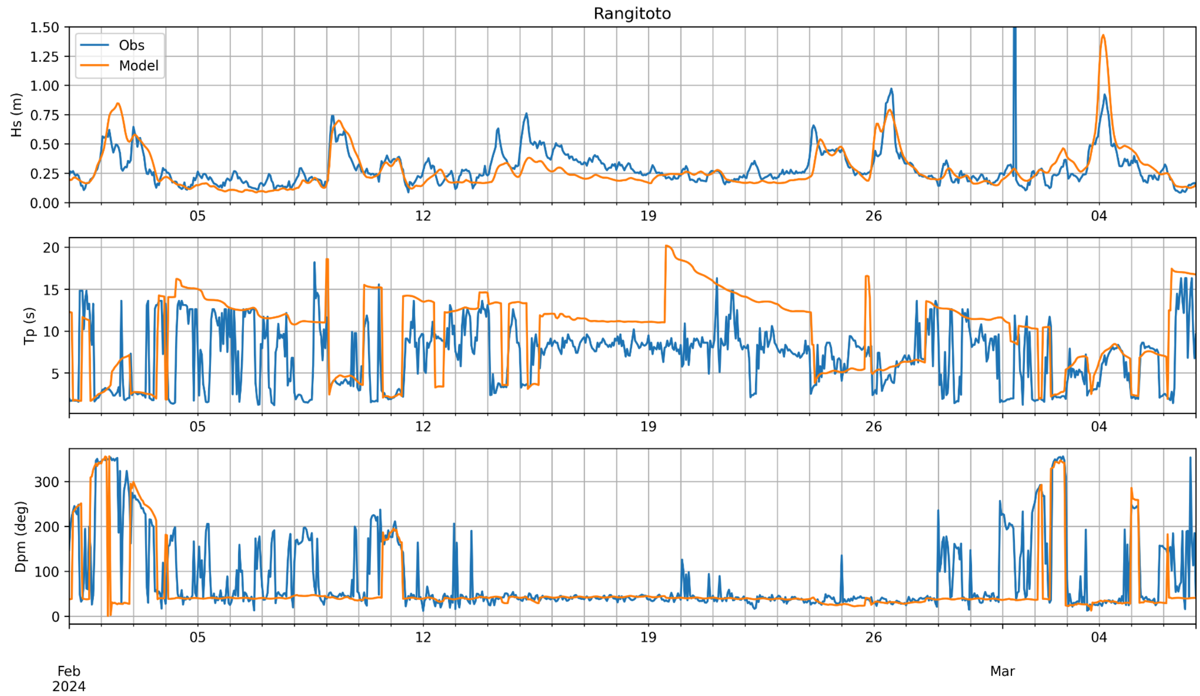


Figure 8. Time series comparison of observed (blue) and modelled (orange) wave parameters at Rangitoto from February to March 2024. The plots show (top) significant wave height Hs, (middle) peak wave period Tp, and (bottom) mean wave direction Dpm.

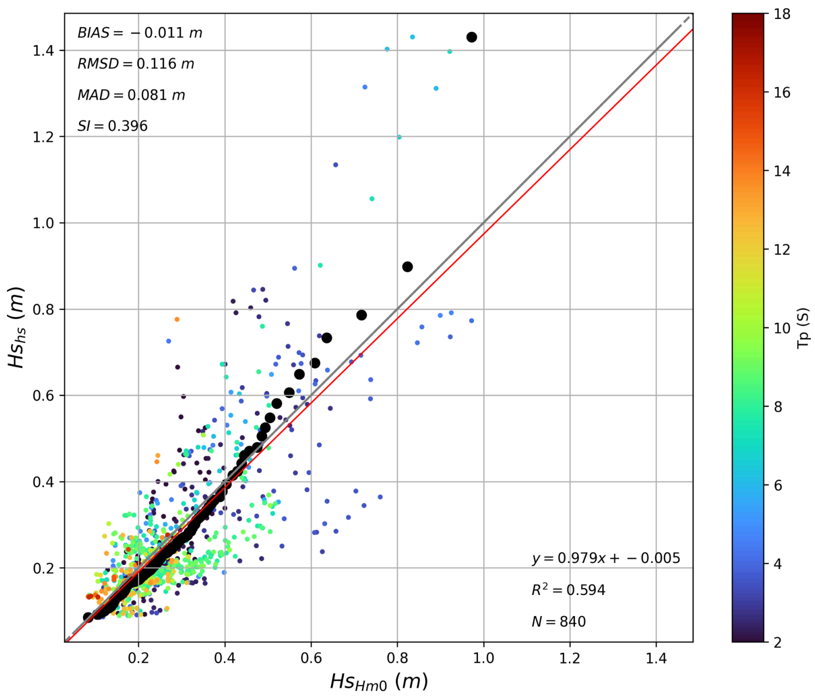


Figure 9. Scatter plot comparing hindcast and measured significant wave height Hs at Rangitoto. Data points are coloured by peak wave period (Tp), with larger black circles representing the 0.01 quantiles, the red line the linear regression and the black line the equality. Key statistical metrics are displayed in the upper left corner, including Bias, Root Mean Square Deviation (RMSD), Mean Absolute Deviation (MAD), and Scatter Index (SI).

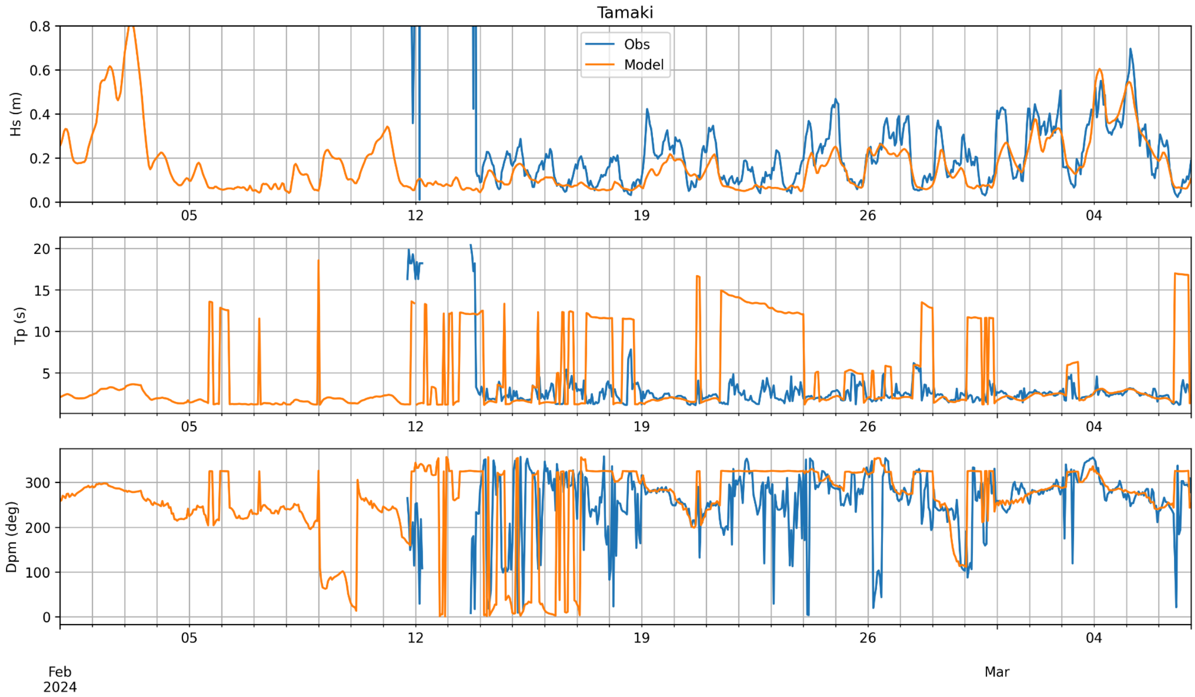


Figure 10. Time series comparison of observed (blue) and modelled (orange) wave parameters at Tamaki from February to March 2024. The plots show (top) significant wave height Hs, (middle) peak wave period Tp, and (bottom) mean wave direction Dpm.

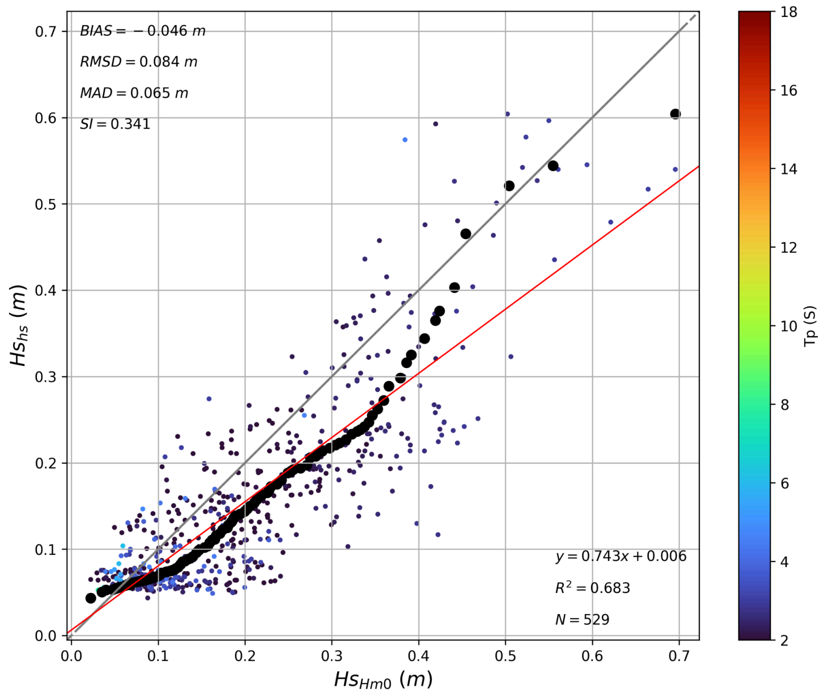


Figure 11. Scatter plot comparing hindcast and measured significant wave height Hs at Tamaki. Data points are coloured by peak wave period (Tp), with larger black circles representing the 0.01 quantiles, the red line the linear regression and the black line the equality. Key statistical metrics are displayed in the upper left corner, including Bias, Root Mean Square Deviation (RMSD), Mean Absolute Deviation (MAD), and Scatter Index (SI).

Integrated parameters gridded output

Integrated wave parameters are stored hourly over all domains at the native model resolution. Table 2 describes long names and units of all gridded output parameters.

Table 2. Gridded output parameters.

Variable	Long Name	Units
depth	depth below sea surface	m
dpm	mean direction at the spectral peak of wind and swell waves'	degree
dpmsea	mean direction at the spectral peak of wind waves below 8 seconds period	degree
dpmswe	mean direction at the spectral peak of swell waves above 8 seconds period	degree
dspr	directional spreading of wind and swell waves	degree
fspr	normalised width of the frequency spectrum of wind and swell waves	-
hs	significant height of wind and swell waves	m
hsea	significant height of wind waves under 8 seconds period	m
hswe	significant height of swell waves above 8 seconds period	m
pdir0	directional spreading of wind waves	degree
pdir1	directional spreading of primary swell waves	degree
pdir2	directional spreading of secondary swell waves	degree
pdir3	directional spreading of tertiary swell waves	degree
pdspr0	directional spreading of wind waves	degree
pdspr1	directional spreading of primary swell waves	degree
pdspr2	directional spreading of secondary swell waves	degree
pdspr3	directional spreading of tertiary swell waves	degree
phs0	sea surface wind wave significant height	m
phs1	sea surface primary swell wave significant height	m
phs2	sea surface secondary swell wave significant height	m
phs3	sea surface tertiary swell wave significant height	m
ptp0	sea surface wind wave period at variance spectral density maximum	s
ptp1	sea surface primary swell wave period at variance spectral density maximum	s
ptp2	sea surface secondary swell wave period at variance spectral density maximum	s
ptp3	sea surface tertiary swell wave period at variance spectral density maximum	s
pwlen0	mean wavelength of wind waves	m
pwlen1	mean wavelength of primary swell waves	m
pwlen2	mean wavelength of secondary swell waves	m

pwlen3	mean wavelength of tertiary swell waves	m
tm01	mean absolute wave period of wind and swell waves from the first frequency moment	s
tm02	mean absolute wave period of wind and swell waves from the second frequency moment	s
tps	smooth relative peak wave period of wind and swell waves	s
tpssea	smooth relative peak wave period of wind waves below 8 seconds period	s
tpsswe	smooth relative peak wave period of swell waves above 8 seconds period	s
xwnd	eastward component of wind velocity	m/s
ywnd	northward component of wind velocity	m/s
xcur	eastward component of current velocity	m/s
ycur	eastward component of current velocity	m/s