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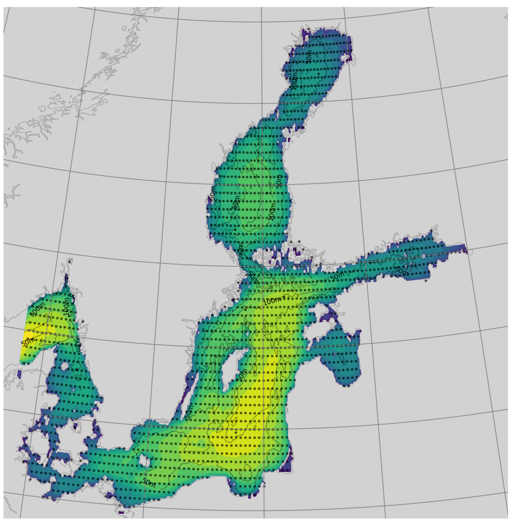
Technical Note on Specification and Validation of the Oceanum Baltic Sea Wave Hindcast

December 2024

Model	SWAN 41.31
Period	Feb 1979 - Updating
Spatial resolution	0.05 degree
Temporal resolution	1 hourly
Region	9E - 30.3E
	53.8N - 66N
Forcings	NORA3 winds, ERA5 sea Ice, Oceanum spectra



Dataset description

The Baltic Sea wave hindcast dataset provides a detailed account of ocean wave parameters across the Baltic Sea area (Figure 1). Wave spectra are computed over a 45-year period between 1979 and 2024 using the SWAN (Simulating WAves Nearshore) third-generation spectral wave model. The model is driven by inputs from the Oceanum Global Wave Model for spectral boundaries, the Norwegian Meteorological institute NORA3 for wind data and the ECMWF ERA5 reanalysis for ice concentration. Bathymetry is derived from the GEBCO 2024 400 m grid and nautical charts. The wave data have been calibrated against satellite altimeters (Figure 2) and selected buoy data (Figures 4-10), ensuring a high level of accuracy and reliability in capturing real-world conditions.

The modelling setup employs the ST6 source term parameterisations. Spectra are discretised into 36 directional bins and 43 frequency bins, covering a frequency range from 0.037 to 2.0263 Hz with 10% logarithmic increments. The model features a regular nest with a 5 km resolution, spanning the entire Baltic Sea and extending to the Danish coast, where it connects with the North Sea.

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 1610 sites, with a spacing of 0.2 degree (see Figure 1).

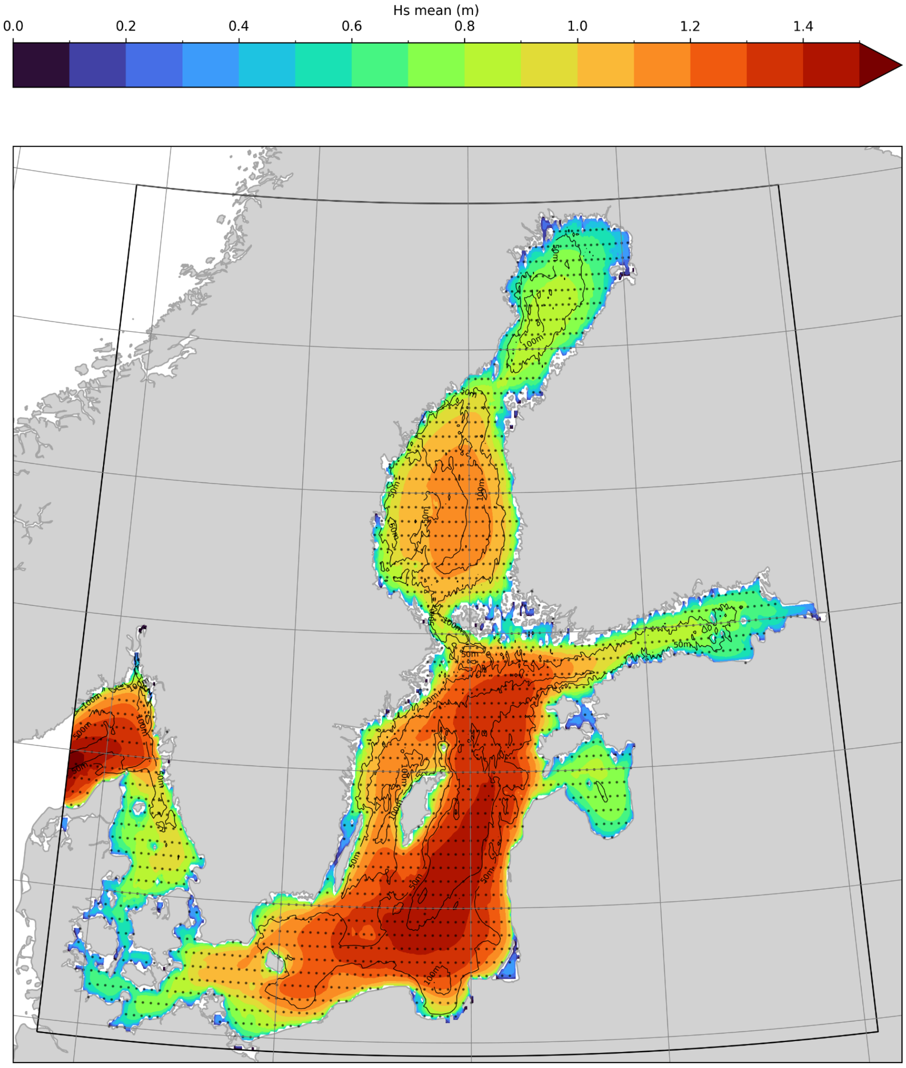


Figure 1. Mean significant wave height from the Baltic Sea hindcast. The locations of 2D spectra hourly output are shown by the black dots.

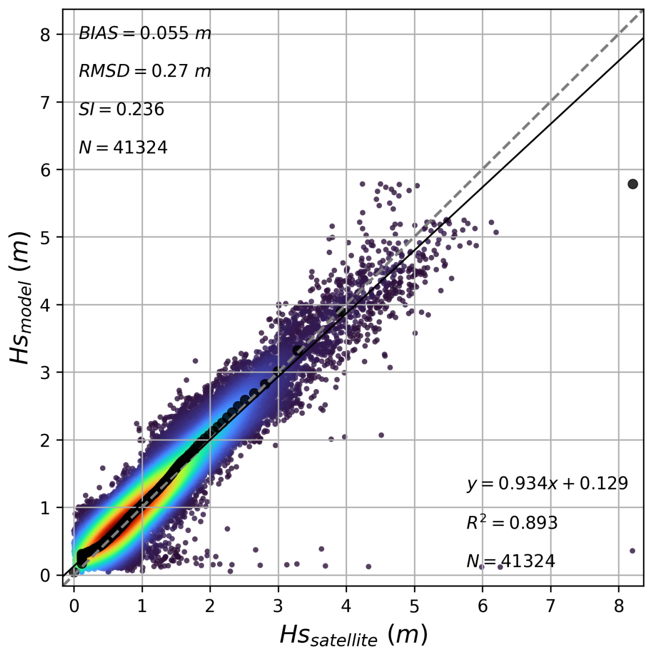


Figure 2. Comparison of hindcast significant wave height (Hs) with satellite altimeter observations for 2016. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

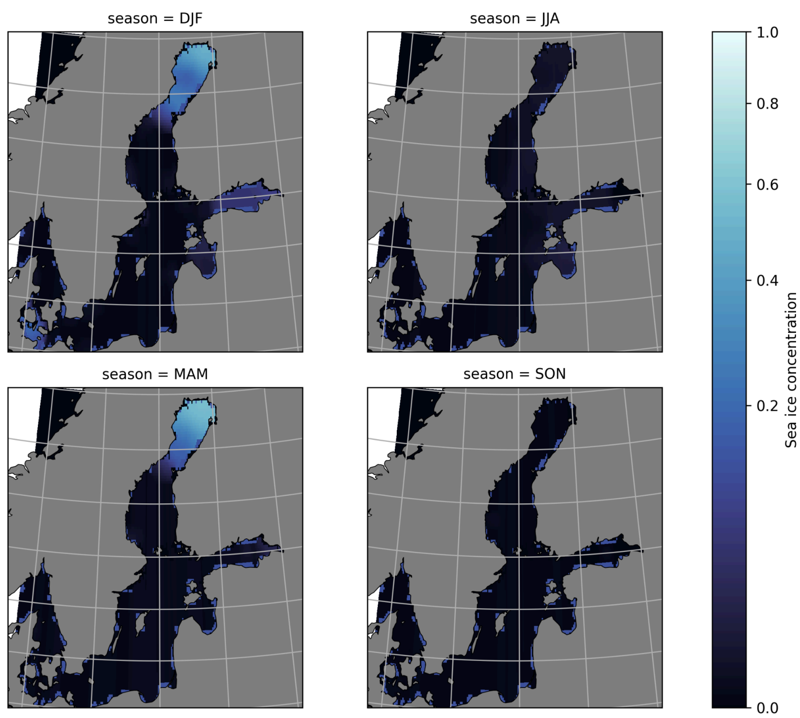


Figure 3. Seasonal average sea ice concentrations in the Baltic Sea for the year 2016, based on ERA5 data. The panels represent the four seasons: DJF (December–February), MAM (March–May), JJA (June–August), and SON (September–November). The color scale indicates sea ice concentration, ranging from 0 (no ice) to 1 (full ice cover).

Table 1. Data description.

Title	Oceanum Baltic Sea wave hindcast
Institution	Oceanum
Access	Oceanum Datamesh
Source	SWAN 41.31A
Source terms	ST6
Temporal coverage	1979-02-01 to present (updating)
Temporal resolution	Hourly
Spatial coverage	[9.0E, 53.8N, 30.3E, 66.0N] at 0.05 degree
Spectra output sites	1610
Frequency discretisation	43 frequencies between 0.037 - 2.0263 Hz at 10% logarithmic increments
Direction resolution	10 deg
Bathymetry	GEBCO 2024 Grid
Winds	NORA3 Reanalysis
Ice concentration	ERA5 Reanalysis
Boundary	Oceanum Global WW3 ERA5 hourly wave spectra
Linked Datamesh datasources	Oceanum Baltic Sea 5 km hourly wave parameters Oceanum Baltic Sea 5 km hourly wave spectra Oceanum Baltic Sea 5 km gridded wave statistics

Validation against buoys

The wave hindcast was validated using historical wave spectra from buoy observations recorded in 2016 (Figure 4). The validation results are presented in Figures 5–10, which also include a comparison between the Norwegian's NORA3 wave hindcast and the same buoy data.

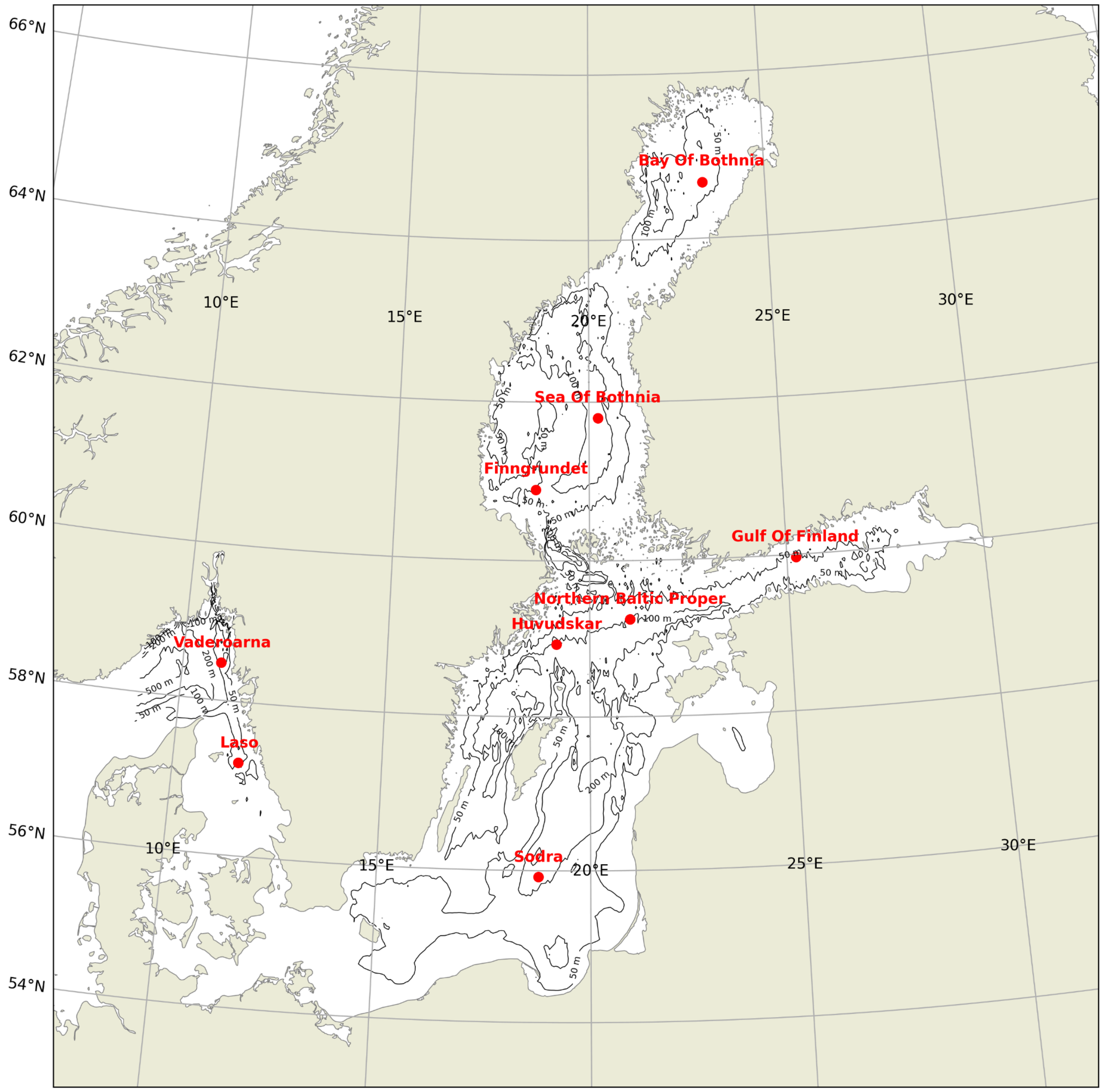


Figure 3. Locations of the selected wave buoy observations used to validate the wave hindcast..

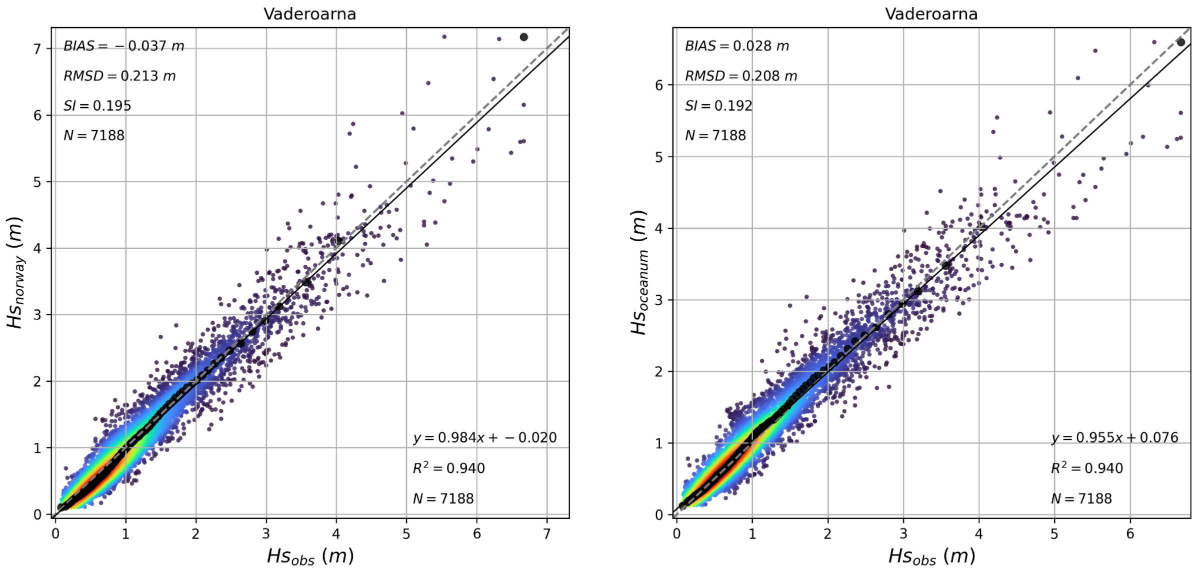


Figure 4. Density scatter plots comparing modelled and observed significant wave height for the Vaderoama buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

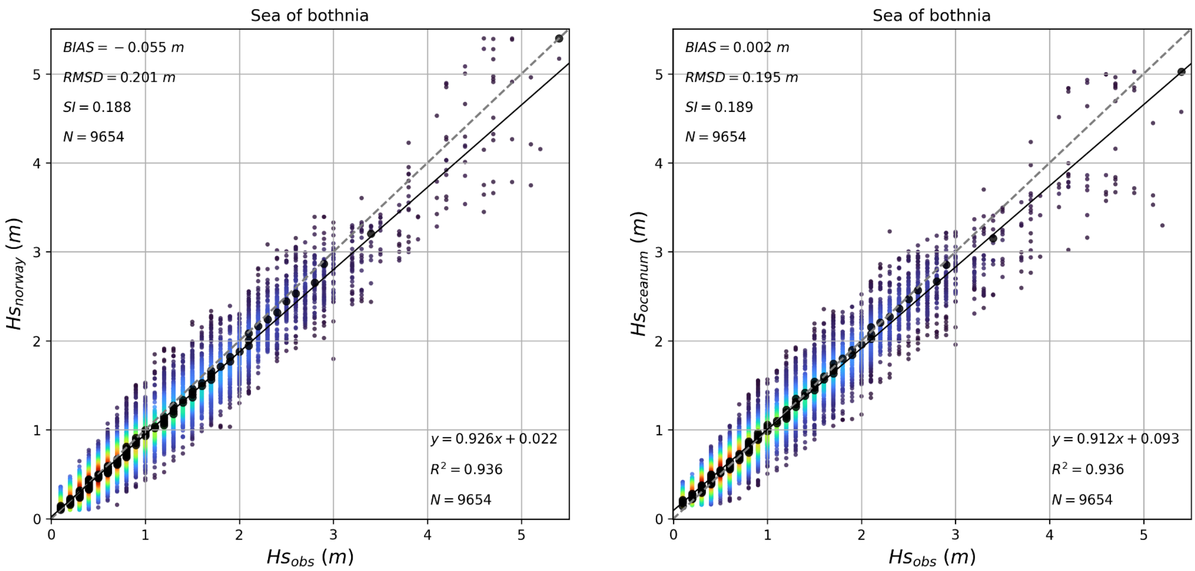


Figure 5. Density scatter plots comparing modelled and observed significant wave height for the Sea of Bothnia buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

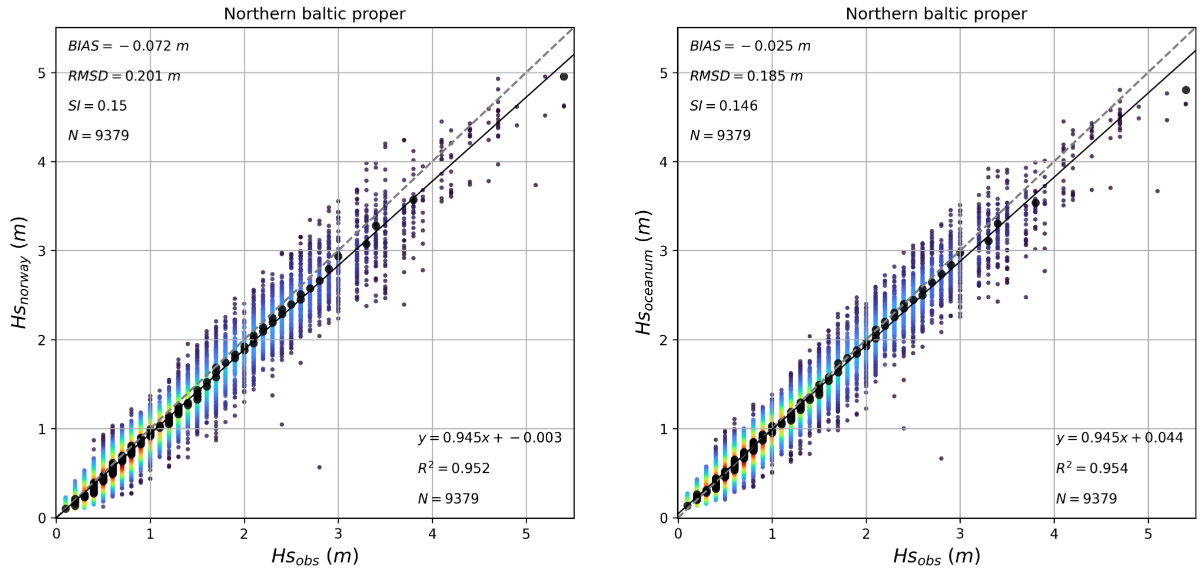


Figure 6. Density scatter plots comparing modelled and observed significant wave height for the Northern Baltic Proper buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

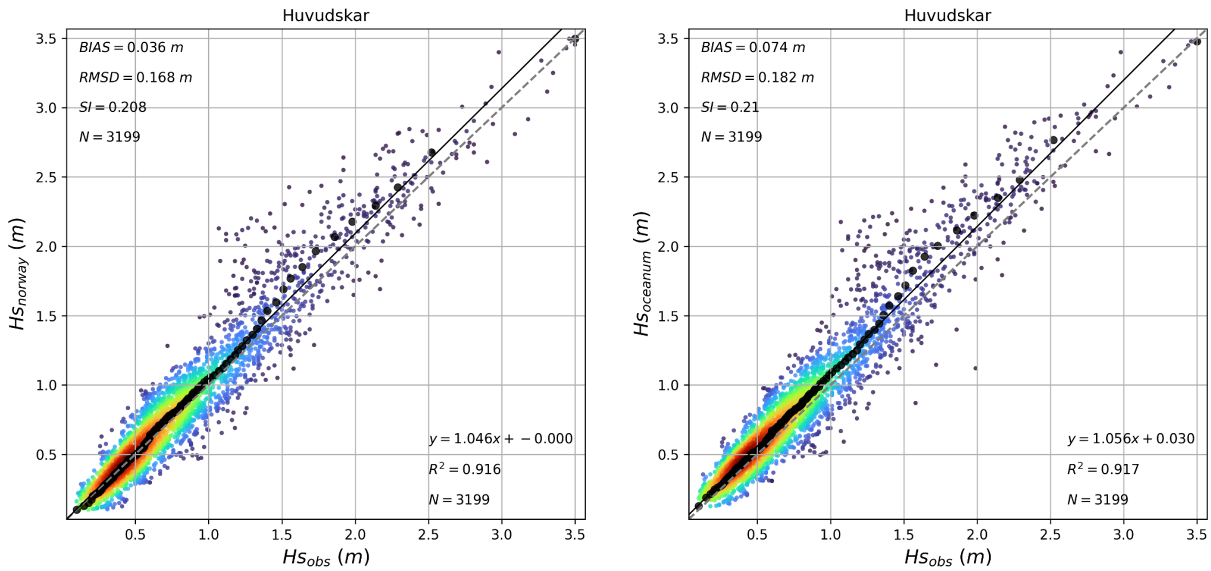


Figure 7. Density scatter plots comparing modelled and observed significant wave height for the Huvudskar buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

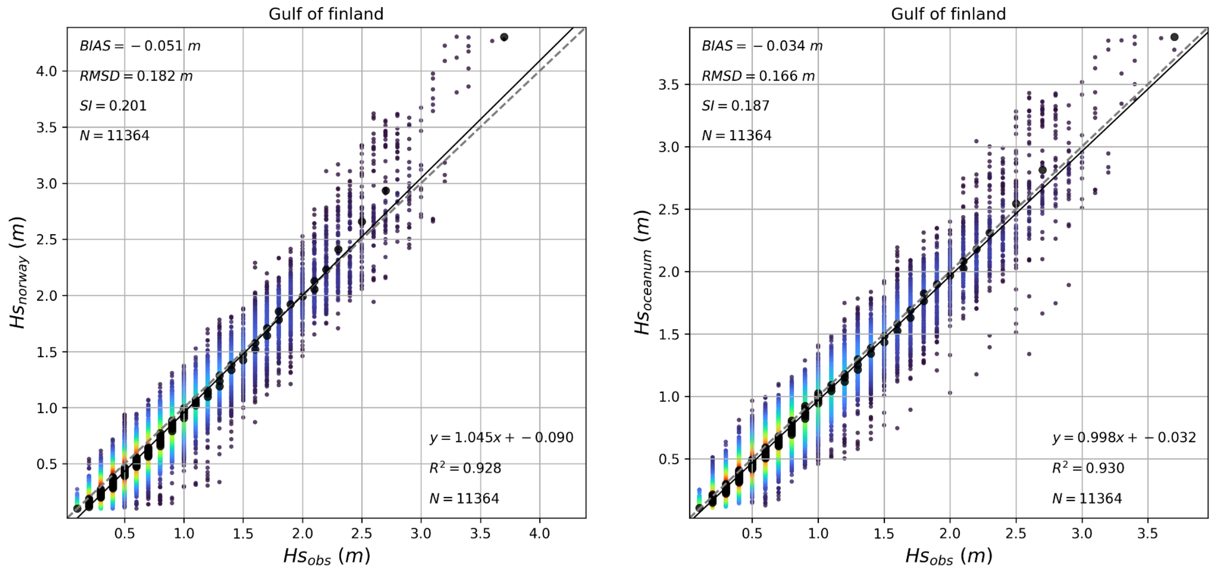


Figure 8. Density scatter plots comparing modelled and observed significant wave height for the Gulf of Finland buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

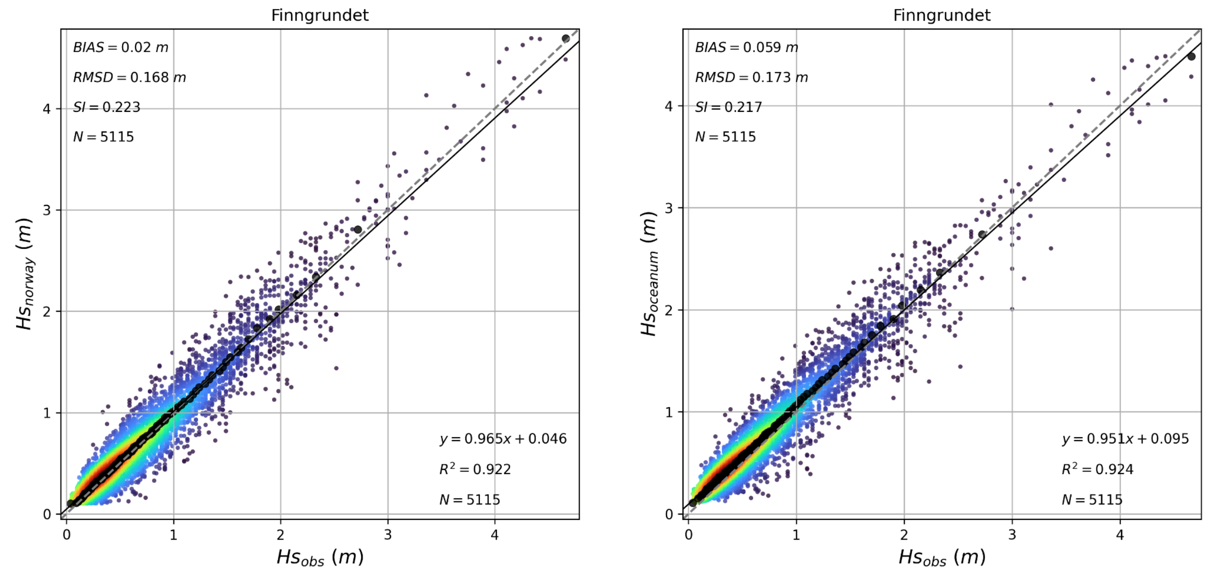


Figure 9. Density scatter plots comparing modelled and observed significant wave height for the Finngrundet buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

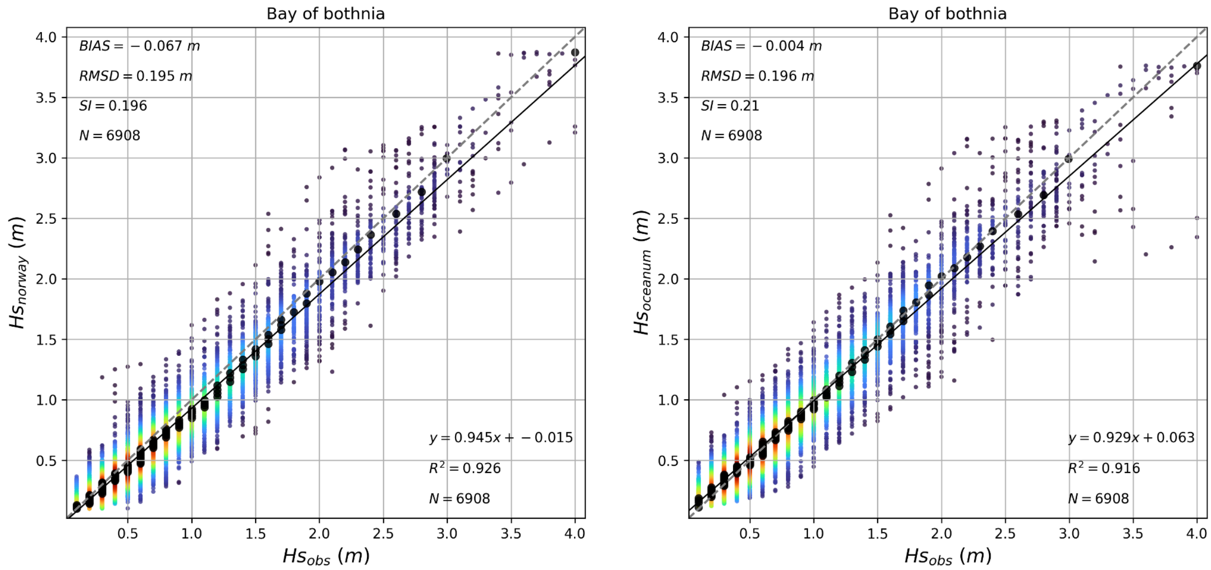


Figure 10. Density scatter plots comparing modelled and observed significant wave height for the Bay of Bothnia buoy: (left) NORA3 wave hindcast, and (right) Oceanum wave hindcast. The color scale represents data density, with red indicating high density and blue indicating low density. Black circles denote quantiles at 0.01 increments, while the solid black line represents the linear regression fit.

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
icec	Sea ice cover	-