

# Innovating Fast Wave Emulator

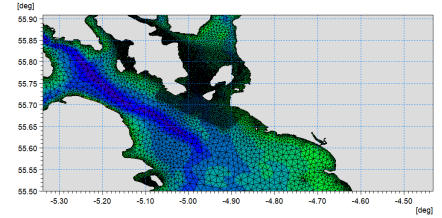
*MIKE Powered by DHI, UK & Ireland Symposium 2023*

*Date: 13 June, 2023*

*Jacob Tornfeldt Sørensen, Innovation and Product Portfolio Manager, DHI*



# Fast models – Why?



Tendering phase, coastal wave transformation, site assessment, feasibility studies, owners engineer QA, climate change downscaling, workability, ensemble-based uncertainty etc.

Ambition: 40 years of point based local wave hindcast data in 1-2 hours with modest reduction of accuracy

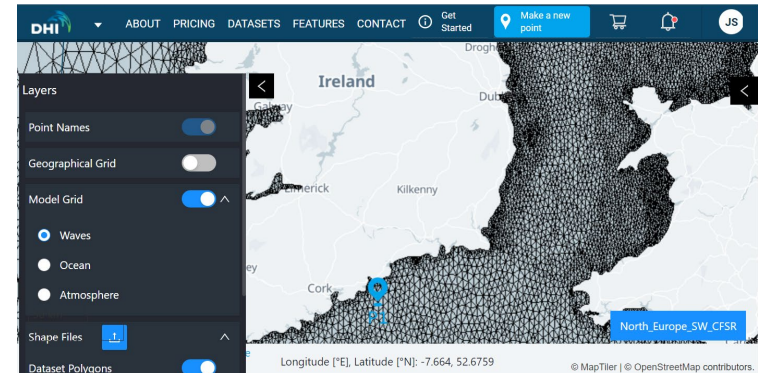
Meant for a **quick assessment of nearshore wave conditions**

For detailed spectral wave transformation modeling DHI recommends

**MIKE 21 SW**

# Fast Wave Emulator

- Speedy set up time
- Speedy simulation time
- Reduced computational cost
- User is not required to maintain hardware
- Link to DHI's Metocean Data Portal
- Which innovation path are we on?



# Foundation

Summer 2021:

- DHI expertise and MIKE Powered by DHI recognition
- MIKE engines and cloud infrastructure, developer and domain competence
- Ongoing significant R&D projects
- Close relations to commercial clients and two specific tenders out for delivering a fast wave transformation tool (both from major offshore contractors)

# Go decision

August - December 2021:

- We won one of the tenders to deliver bespoke solution -> user value confirmation
- DHI and contractor client agreed to co-create using DHI's Innovation Lab
- DHI accelerated investment and resource allocation for bespoke solution development





# Building the prototype – ingredients for succes!

January - December 2022

- Client value creation at the core
- Thorough UX design up-front
- Simple, robust and adaptable solution
- Successful collaboration between Clients and DHI's scientific and software experts



Transparency



Trust



Communication



Flexibility

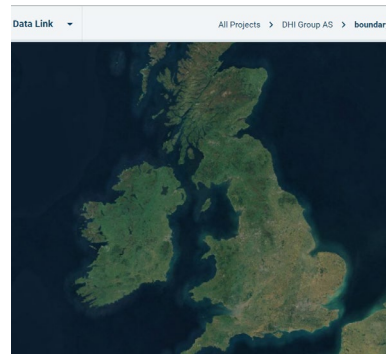
# Scale investment – Broadening to more applications

January – now 2023

- Debugging to enhance smooth user experience
- Optimizing performance
- Tighter integration with Metocean data portal, Data Link, Mesh Builder, MIKE Zero
- Dissemination, pilot testing and launch preparations



MIKE Powered by DHI



MOOD



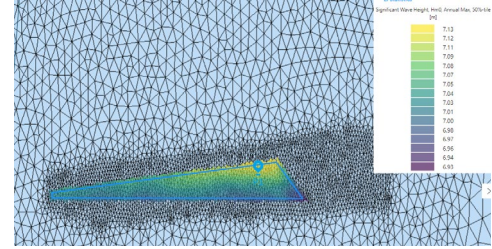
Communication



Flexibility

# Downscaling methodologies

Local Numerical Modeling

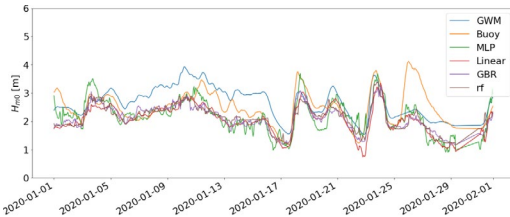


Complexity

high-resolution

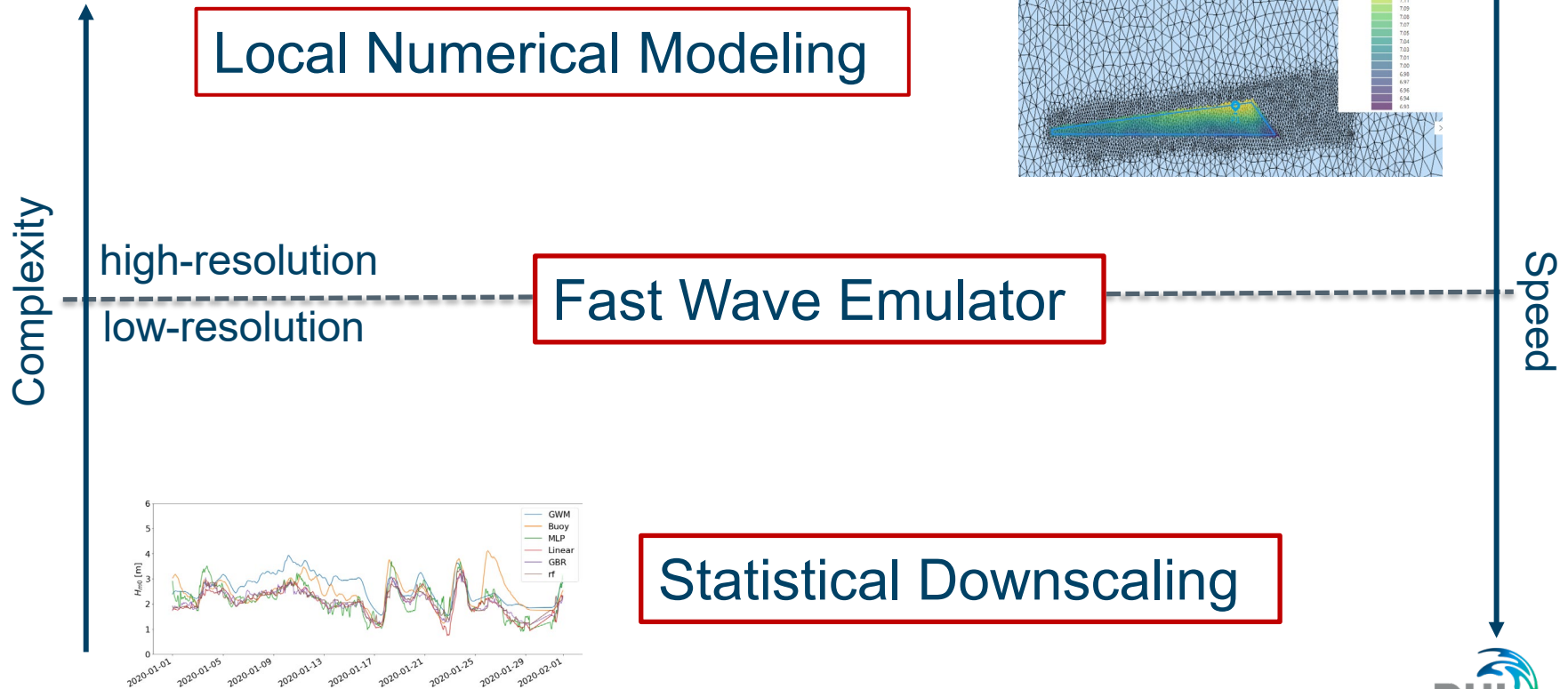
low-resolution

Speed



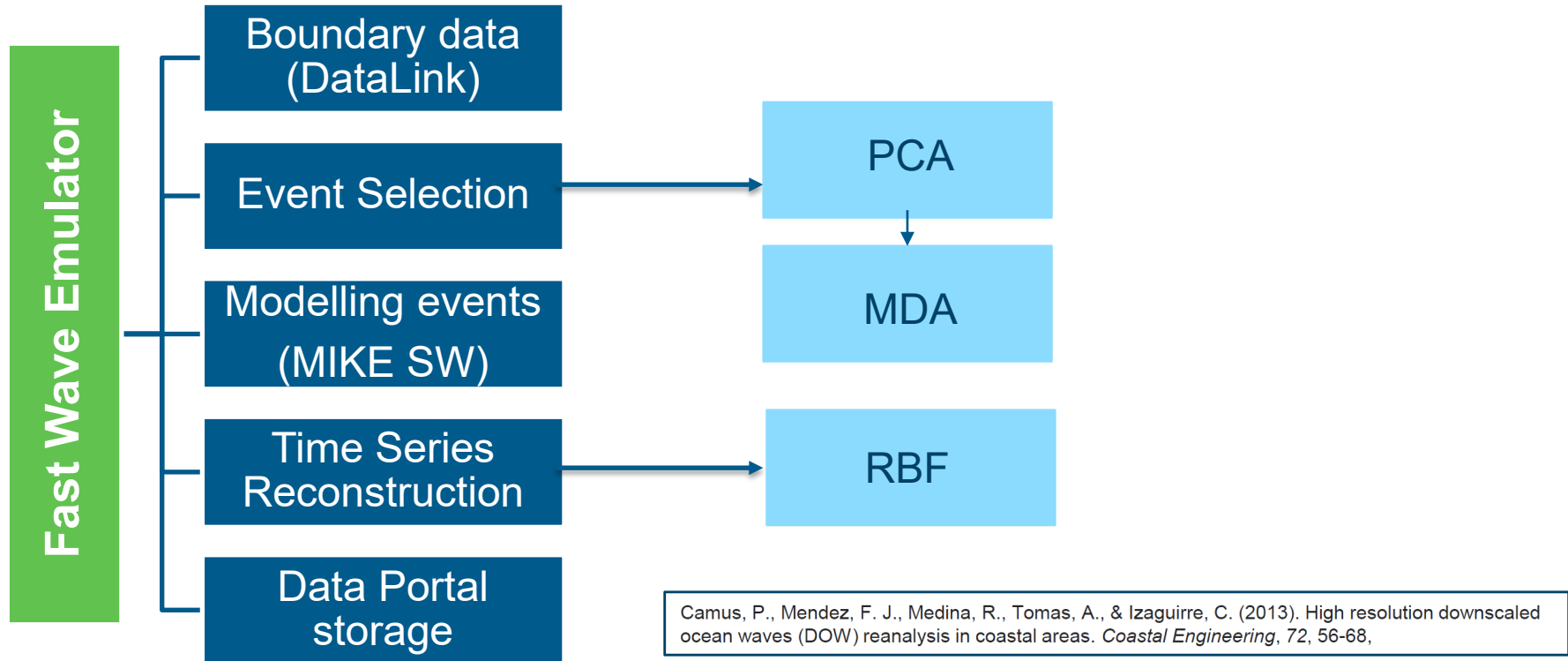
Statistical Downscaling

# Downscaling methodologies





# Fast Wave Emulator – How does it work?



Mike SW: Mike by DHI Spectral Waves Model  
MDA: Maximum Dissimilarity Analysis

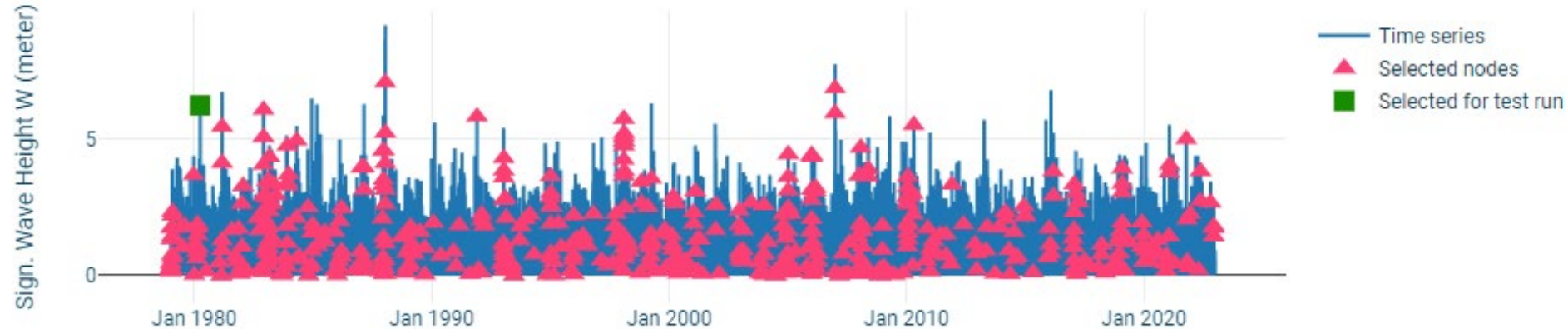
PCA: Principal Component Analysis  
RBF: Radial Based Function

# Event Selection

Maximum Dissimilarity Algorithm (MDA)

Selection of the most dissimilar events for modelling such that the variation on the metocean parameters can be captured

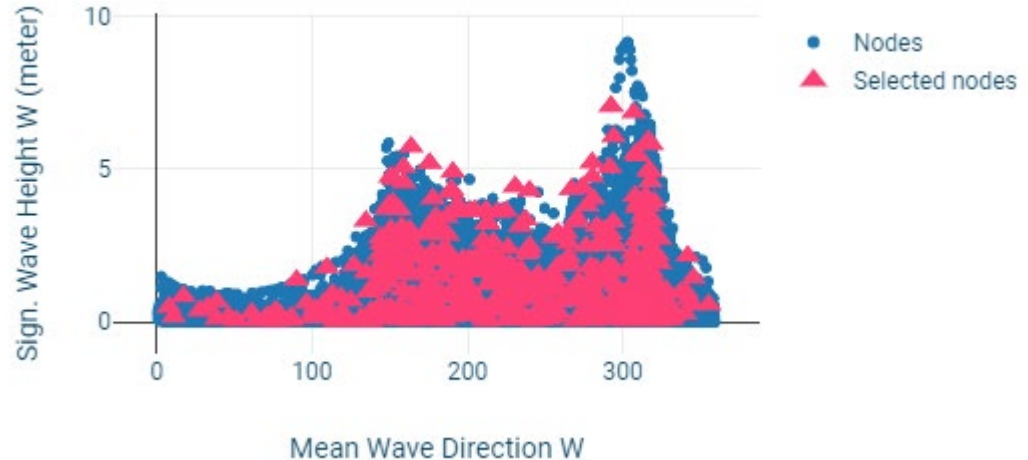
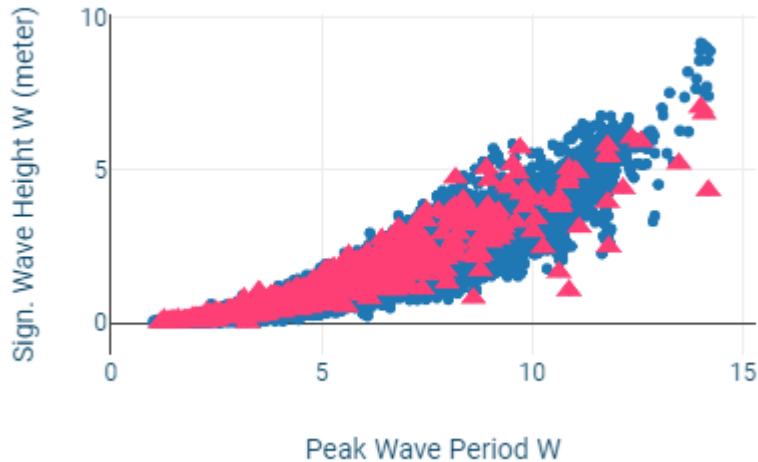
Data at central point of selected boundary or forcing



- Only the **red dot events** are modelled (500 events selected in this example)
- Not shown here is parameters for wave direction, wave spreading or sea/swell split

# User verifies selected points

User can do quality control of the selected nodes by making scatter plots of the data. User can also select more data points



- User can select more nodes by clicking on the chart
- Not shown here is parameters for wave direction, wave spreading or sea/swell split

# Time Series Reconstruction - Radial Basis Function (RBF)

Reconstruction of the full timeseries using interpolation between the modelled events

## RBF - Radial Basis Function

•  $\varphi = \varphi(r)$

- $r = \|x - x_i\|$  - Euclidian distance
- $x_i$  - centers
- Gaussian RBF -  $\varphi = e^{-\varepsilon^2 r^2}$
- $\varepsilon_i$  - shape parameters

• RBF Interpolant, given by a linear combination :

$$\phi(x) = \sum_{i=1}^N \lambda_i \varphi(\|x - x_i\|, \varepsilon_i)$$

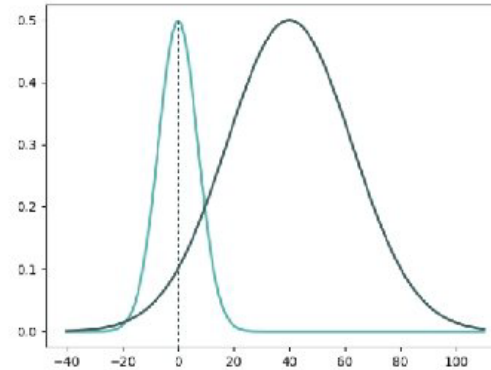
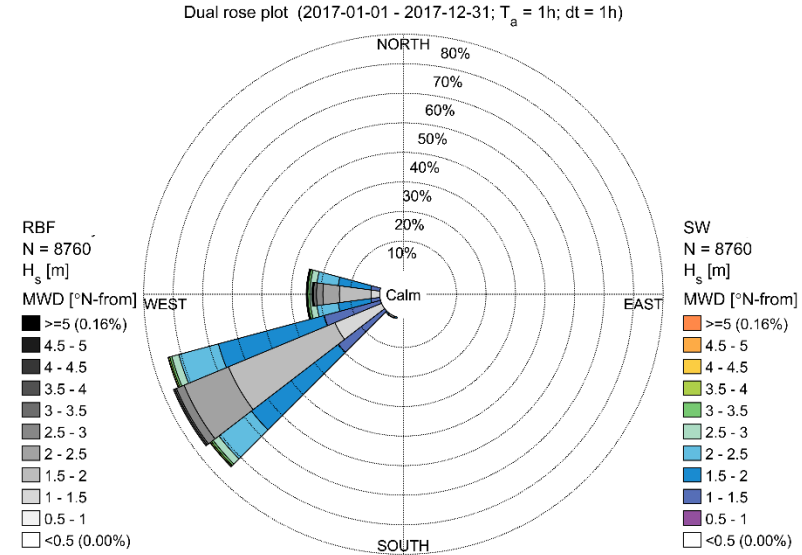
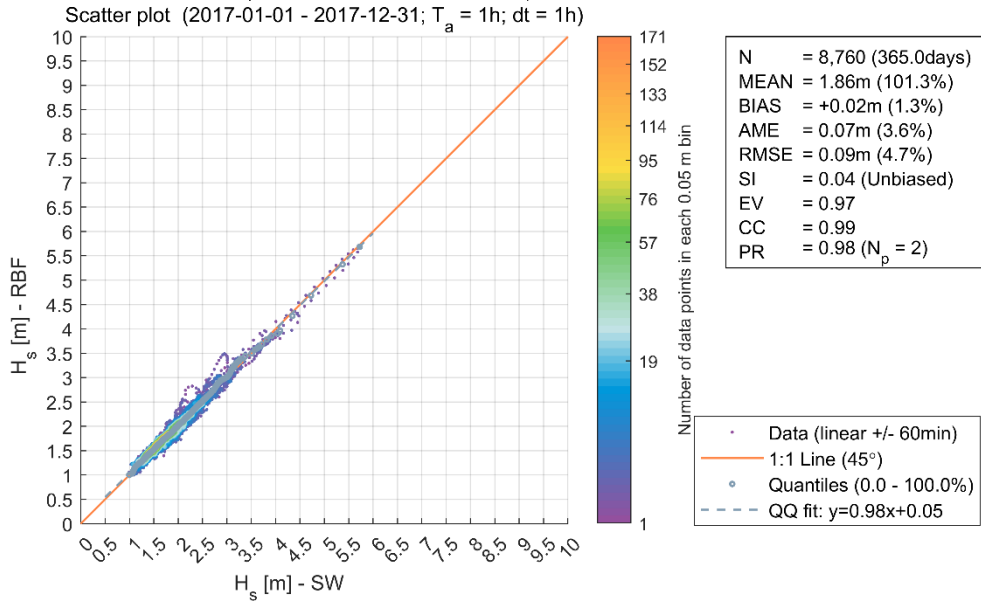


Figure 1.   
■  $\varepsilon^2=0.01$    
■  $\varepsilon^2=0.001$

# Comparison - Significant Wave Height

1 year fully modelled data vs reconstructed data using 100 time steps

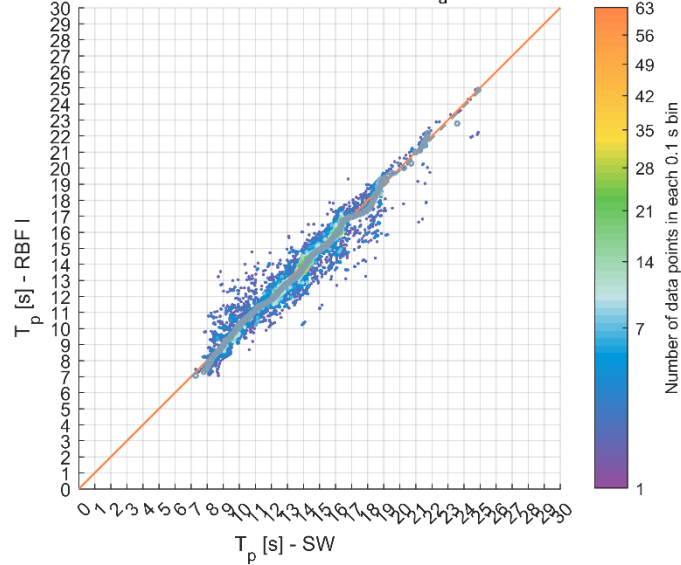




# Comparison- Peak Wave Period

1 year fully modelled data vs reconstructed data using 100 time steps

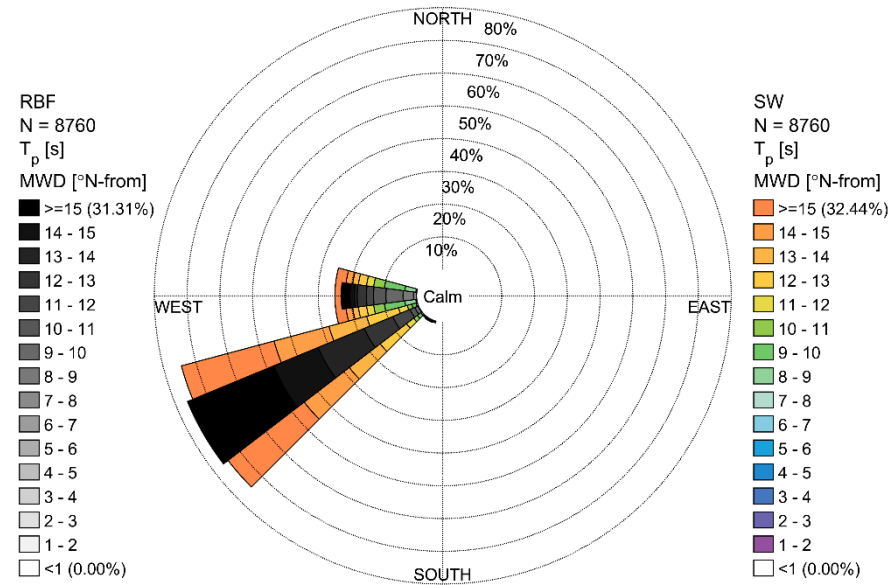
Scatter plot (2017-01-01 - 2017-12-31;  $T_a = 1h$ ;  $dt = 1h$ )



N = 8,760 (365.0days)  
 MEAN = 13.77s (99.3%)  
 BIAS = -0.09s (-0.7%)  
 AME = 0.43s (3.1%)  
 RMSE = 0.66s (4.8%)  
 SI = 0.05 (Unbiased)  
 EV = 0.94  
 CC = 0.97  
 PR = 1.00 ( $N_p = 2$ )

• Data (linear +/- 60min)  
 — 1:1 Line (45°)  
 ○ Quantiles (0.0 - 100.0%)  
 - - - QQ fit:  $y=0.99x-0.00$

Dual rose plot (2017-01-01 - 2017-12-31;  $T_a = 1h$ ;  $dt = 1h$ )



RBF  
 N = 8760  
 $T_p$  [s]

MWD [°N-from]  
 ■ >=15 (31.31%)  
 ■ 14 - 15  
 ■ 13 - 14  
 ■ 12 - 13  
 ■ 11 - 12  
 ■ 10 - 11  
 ■ 9 - 10  
 ■ 8 - 9  
 ■ 7 - 8  
 ■ 6 - 7  
 ■ 5 - 6  
 ■ 4 - 5  
 ■ 3 - 4  
 ■ 2 - 3  
 ■ 1 - 2  
 ■ <1 (0.00%)

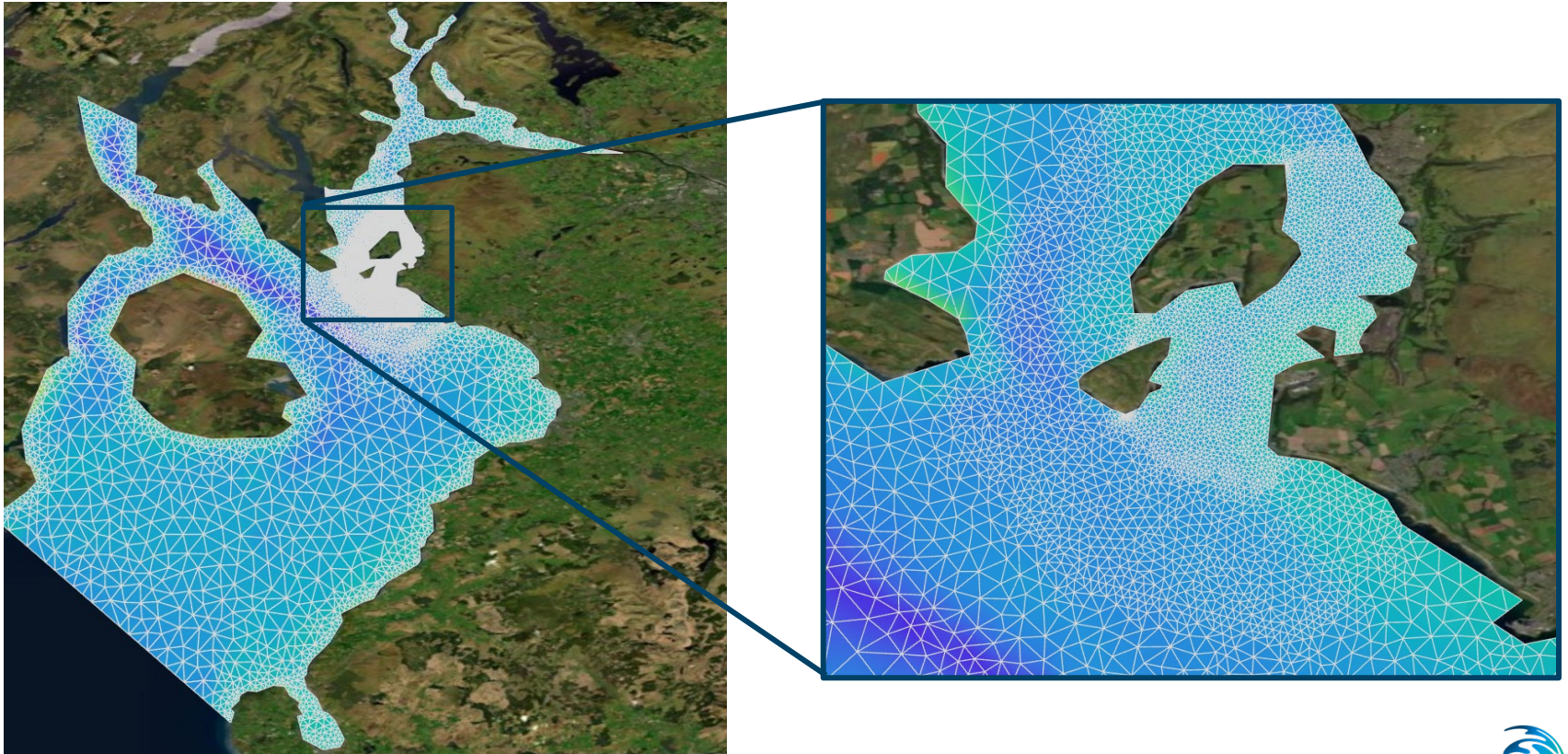
SW  
 N = 8760  
 $T_p$  [s]

MWD [°N-from]  
 ■ >=15 (32.44%)  
 ■ 14 - 15  
 ■ 13 - 14  
 ■ 12 - 13  
 ■ 11 - 12  
 ■ 10 - 11  
 ■ 9 - 10  
 ■ 8 - 9  
 ■ 7 - 8  
 ■ 6 - 7  
 ■ 5 - 6  
 ■ 4 - 5  
 ■ 3 - 4  
 ■ 2 - 3  
 ■ 1 - 2  
 ■ <1 (0.00%)

**Under development for next release of FWE**



# Assisted meshing



# Option for user provided boundary conditions

Mesh & Output Points ——— **1** **Boundary Conditions** ——— **1** Quality Control ——— **1** Setup & Run

**Environmental data to use**  
 Confirm or select environmental data to extract
 Simulation period:  to

Extra data from one of our providers

Wind  ?     
 Waves: swell & Wind-sea  ?     
 Water levels  ?     

Or use your own environmental data

Uploaded Template      
      

To use your own data as forcings, download the template excel file "Download Template", fill it in and upload it.  
 Click [Instructions for using FWE data template](#) for more detailed instructions:

Existing feature:  
Provided by DHI

New feature:  
Provided by User

Datetime (dd/mm/YYYY HH)	Wind Spee	Wind Dire	Sign Wave	Peak Wave	Mean Wa	Directiona	Sign Wave	Peak Wave	Mean Wa	Directiona	Water level [m]
01/01/1900 00:00	10.0	0.0	1.0	5.0	0.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 01:00	10.0	45.0	1.0	5.0	45.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 02:00	10.0	90.0	1.0	5.0	90.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 03:00	10.0	135.0	1.0	5.0	135.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 04:00	10.0	180.0	1.0	5.0	180.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 05:00	10.0	225.0	1.0	5.0	225.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 06:00	10.0	270.0	1.0	5.0	270.0	40.0	2.0	12.0	270.0	30.0	1.0
01/01/1900 07:00	10.0	315.0	1.0	5.0	315.0	40.0	2.0	12.0	270.0	30.0	1.0



# Integration with MetOcean On Demand (MOOD)

The screenshot displays the DHI Metocean Data Portal interface. The main map shows bathymetry data for the North Atlantic region, with a color scale ranging from 375.03 mMSL (yellow) to 5850.42 mMSL (dark purple). A local model area is highlighted with an orange triangle, containing five points labeled P1 through P5. The interface includes a navigation menu at the top, a layers panel on the left, a bathymetry legend on the right, and a points table on the right side. The points table lists five points with their respective coordinates and a 'Global\_SW\_ERAS' label at the bottom right of the map area.

Points	Long	Lat
P1	25.45654	28.21536
P2	25.77777	28.11111
P3	25.88888	28.22222
P4	25.9999	28.33333
P5	25.9999	28.33333

Water depth relative to MSL [mMSL]	Value
375.03	375.03
740.05	740.05
1105.08	1105.08
1470.11	1470.11
1835.13	1835.13
2200.16	2200.16
2565.19	2565.19
2930.21	2930.21
3295.24	3295.24
3660.26	3660.26
4025.29	4025.29
4390.32	4390.32
4755.34	4755.34
5120.37	5120.37
5485.40	5485.40
5850.42	5850.42

Model data	Metadata	Start Date	End Date
Local and global		1979-01-01	2021-12-31
Water depth (mMSL)	Grid cell size (m)	Price (EUR)	
89.3	23218.4	4300.-	



Demo



# Firth Of Clyde Demo

2023-06-12 15:55 UTC

Recorded by

Pierre Brink Swiegers

Organized by

Pierre Brink Swiegers