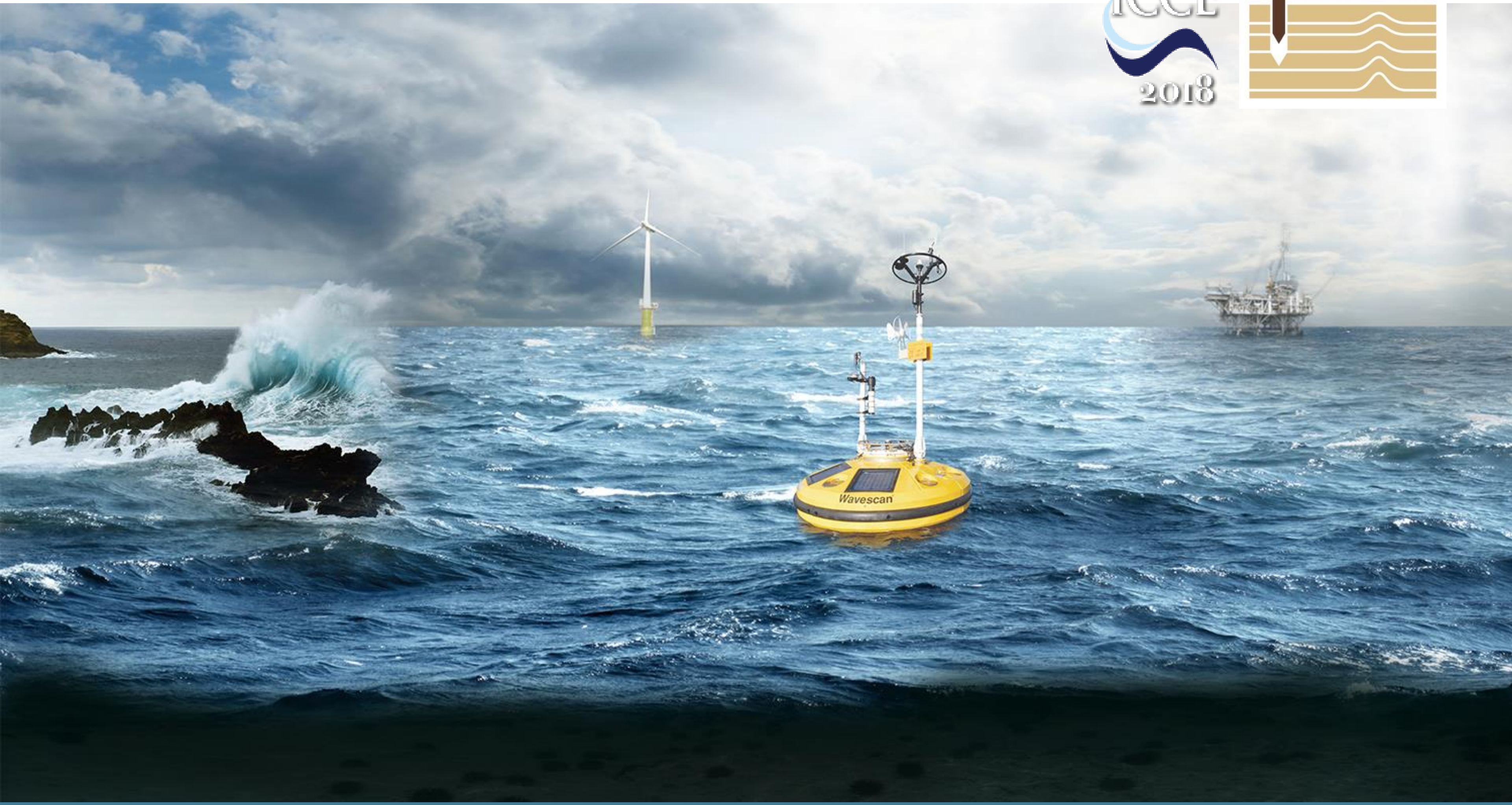

On Spectrum Calibration for Nearshore Wave Transformation

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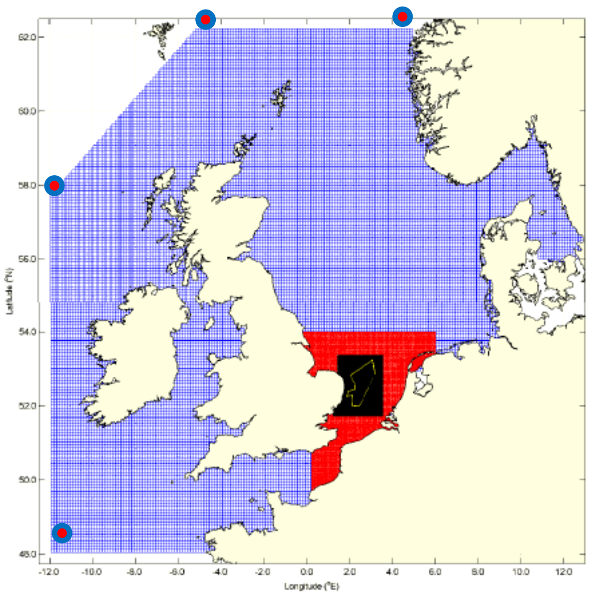
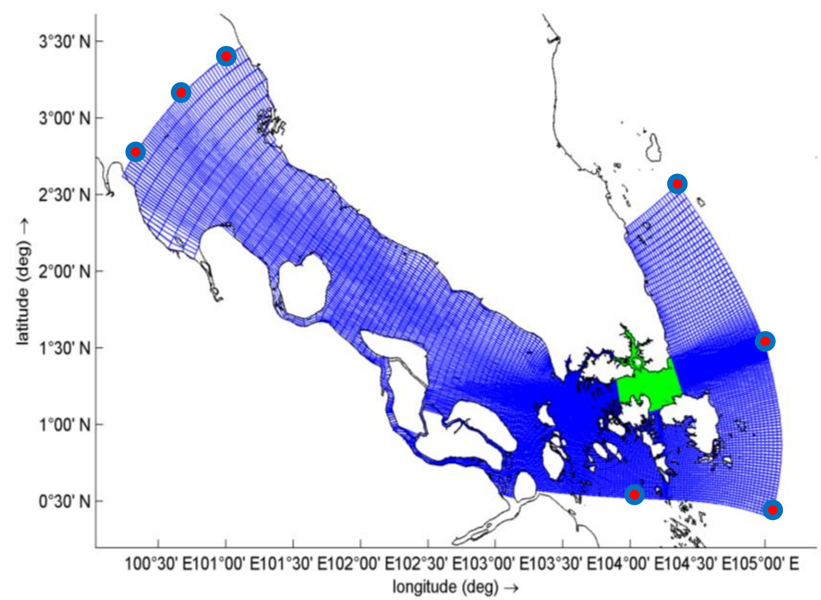
Fugro GB Marine Ltd.

10 November 2018

- Nearshore Wave Transformation are necessary for coastal engineering due to shallow water physics, local bathymetry and local topography;
- Existing hindcast databases are generally not calibrated for specific sites but global areas
- Offshore boundary conditions directly impact accuracy of nested models

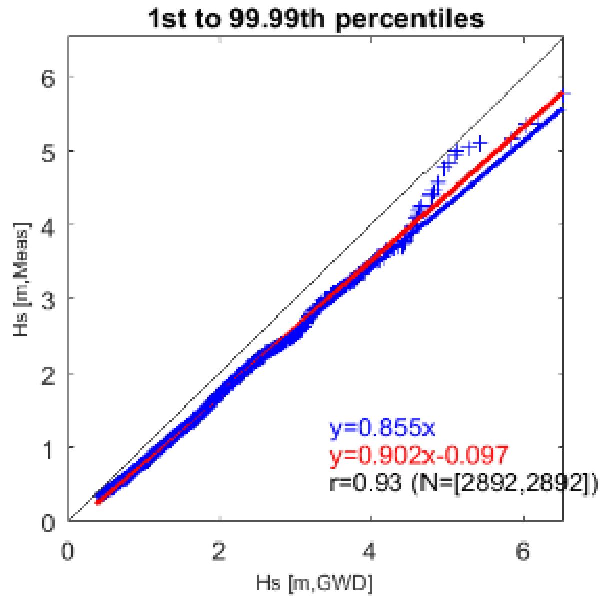


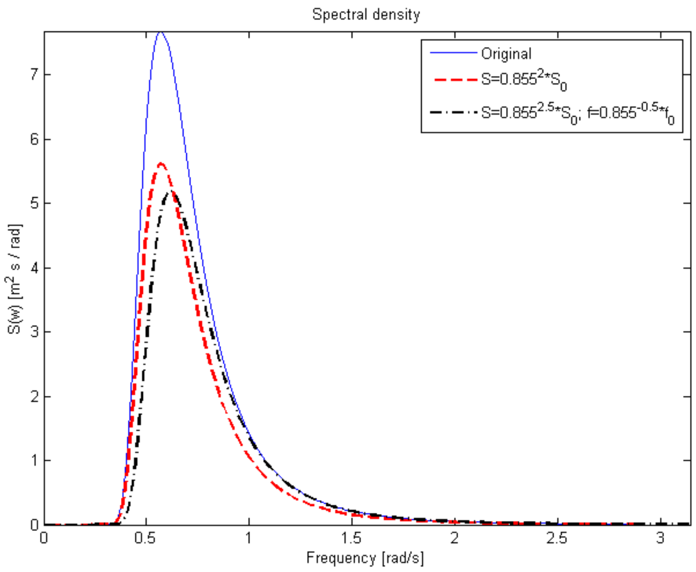


Previous Solutions

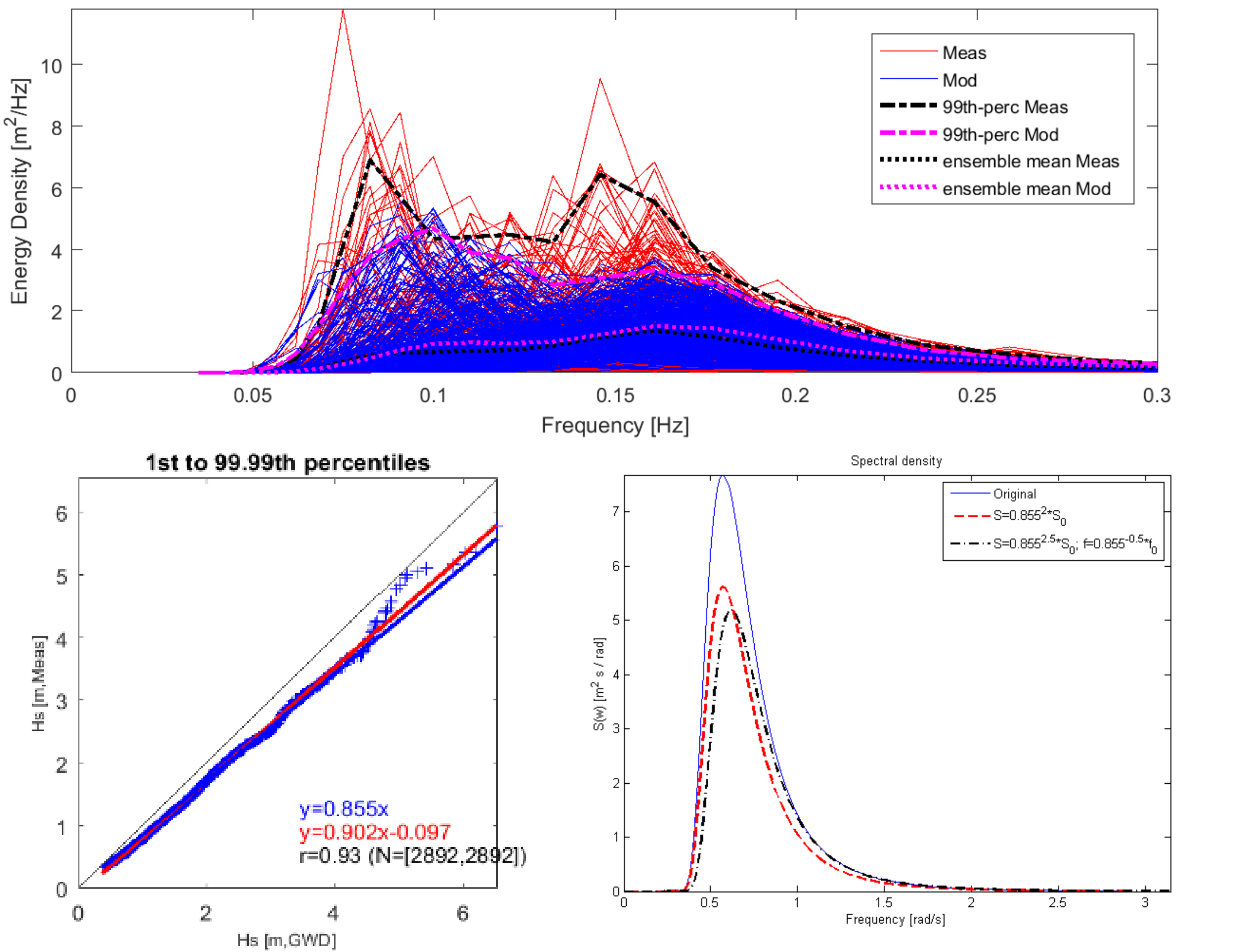
Scaling the spectrum without changing its general shape. That is, stretching each of the axes by a **constant factor** for all times.

- Scaling the spectral density (through Y) affects the wave height, but not the periods.
- Scaling the spectral density and frequency (through X and Y) affects both the wave height and the periods.

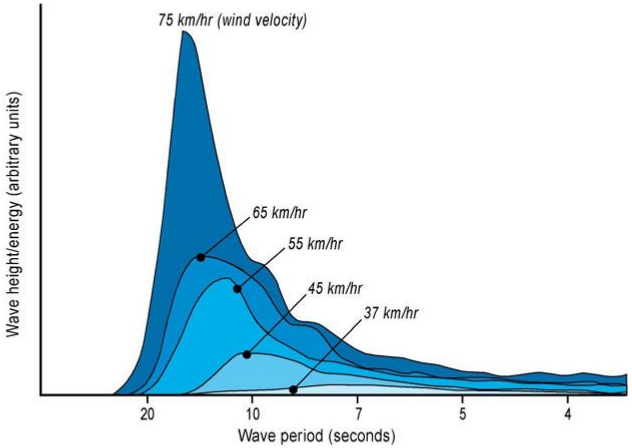




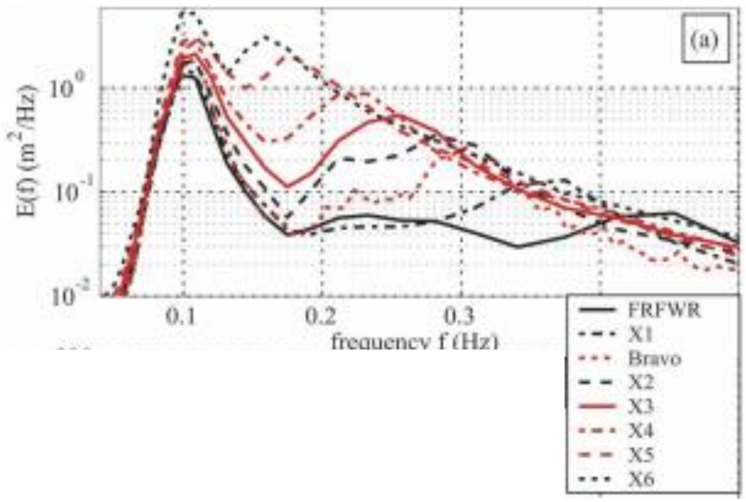
Previous Solutions



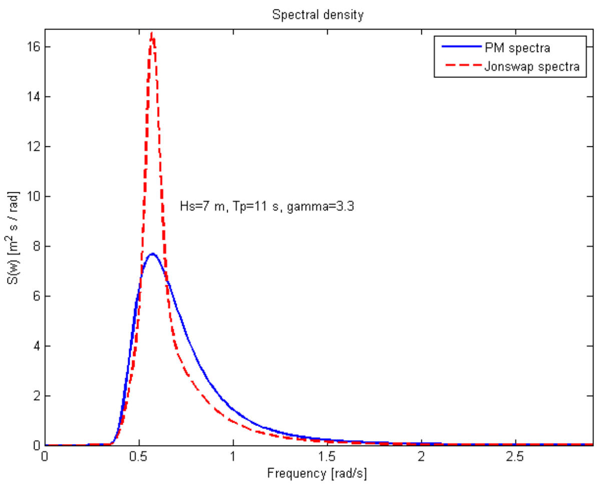
New Solution



Short, A. D. (2012) Coastal Processes and Beaches. Nature Education Knowledge 3(10):15



Evolution of Wave Spectrum. X1 to X6 are locations from coast to offshore. Sourced from Fig.3 in Ardhuin et al. (2007)



Pierson-Moskowitz (P-M) spectra vs Jonswap spectra

Spectrum evolves continuously

- Wind forcing builds up the spectrum energy
- Deep water: Quadruplet wave-wave interaction (energy from spectral peak to low frequencies or high frequencies)
- Shallow water: Triad wave-wave interaction (energy from low frequencies to high harmonics)

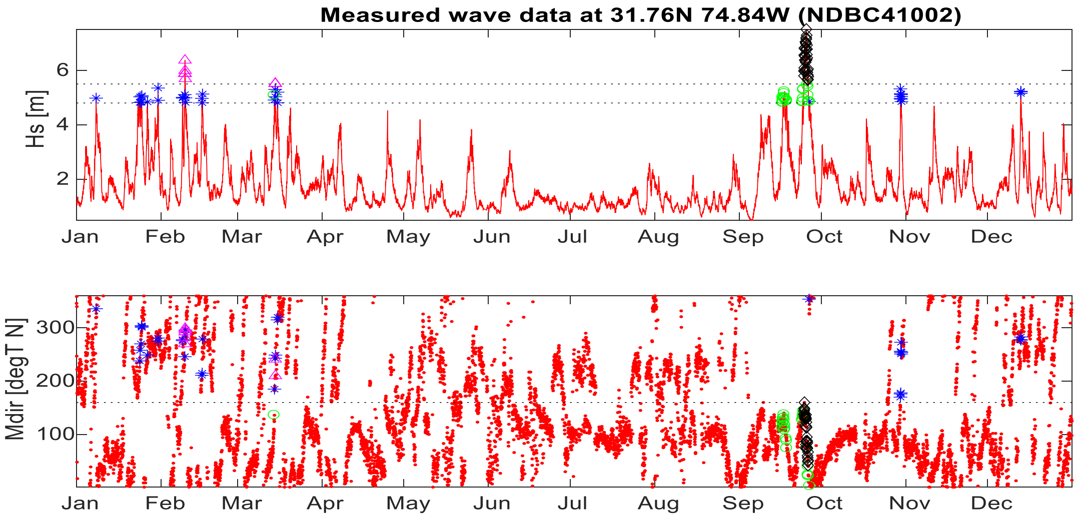
New Solution

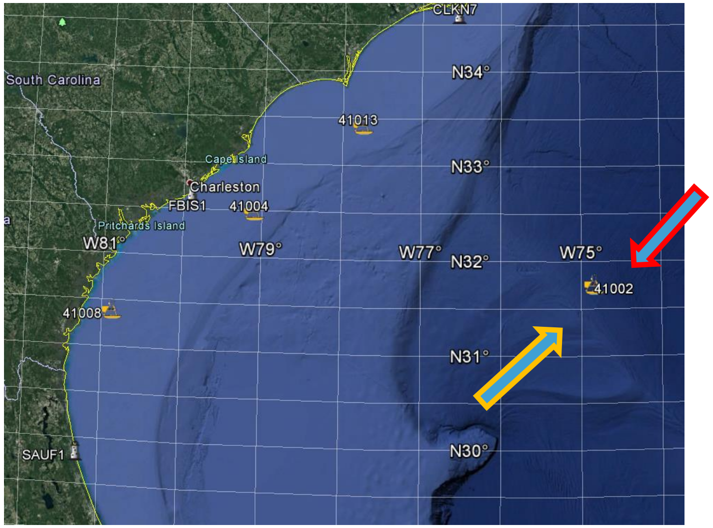
Shape-focus method: to calibrate the wave energy magnitude and take into account of spectrum evolution and shape changes.

1. Group significant wave height and mean wave direction into classes;
2. Ensemble spectrum for each class.
3. Derive calibration factors for each frequency bin through Least Square Error method (Meas-Mod).
4. Calibrate hindcast spectrum by applying calibration factors to each frequency bin and each class.

New Solution: Step 1

Group significant wave height and mean wave direction into classes.

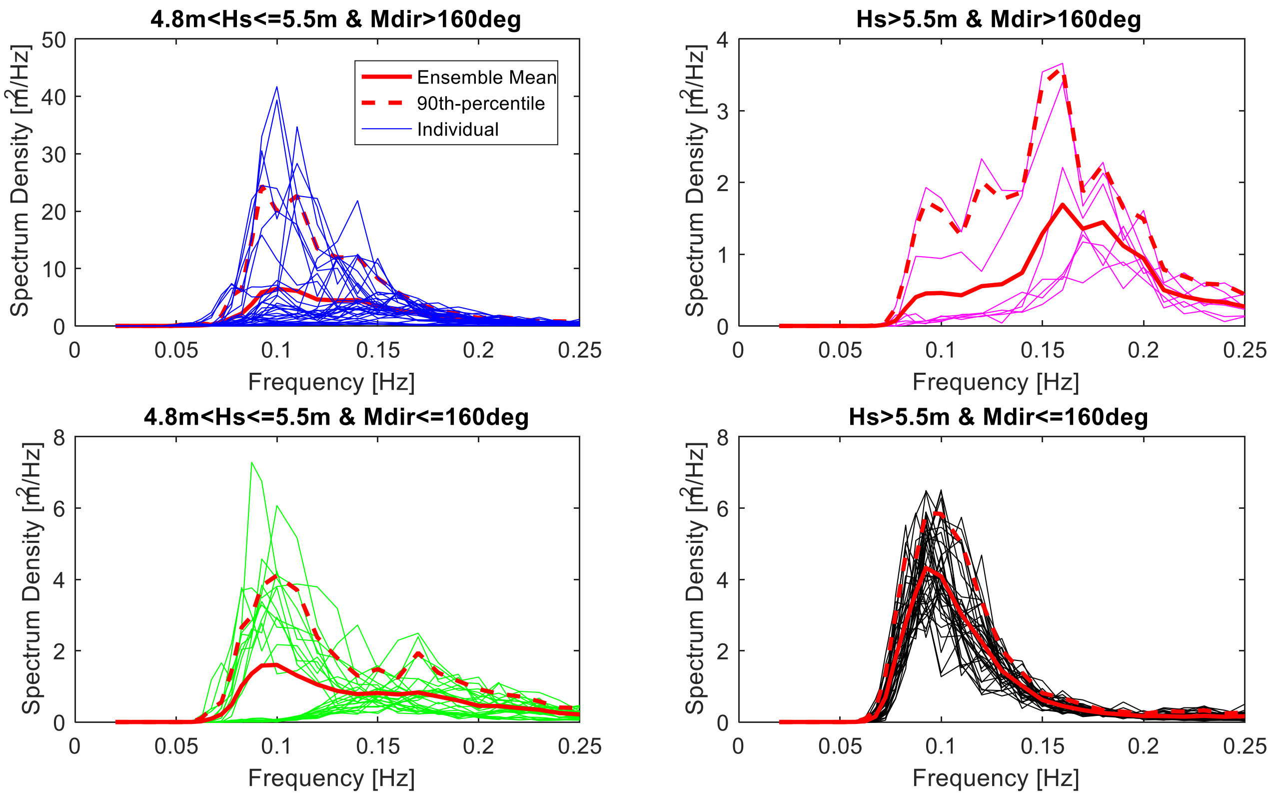




- Ensure similar physics exist in the same class.
- Help extend spectrum calibration to the whole hindcast model data, from limited measurement period.

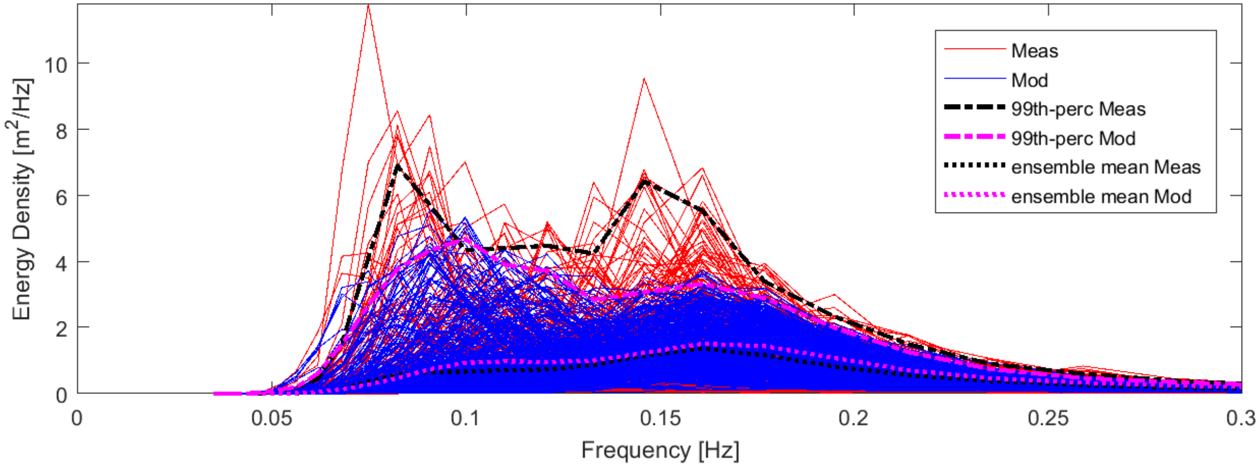
New Solution: Step 2

Ensemble spectrum for each class.

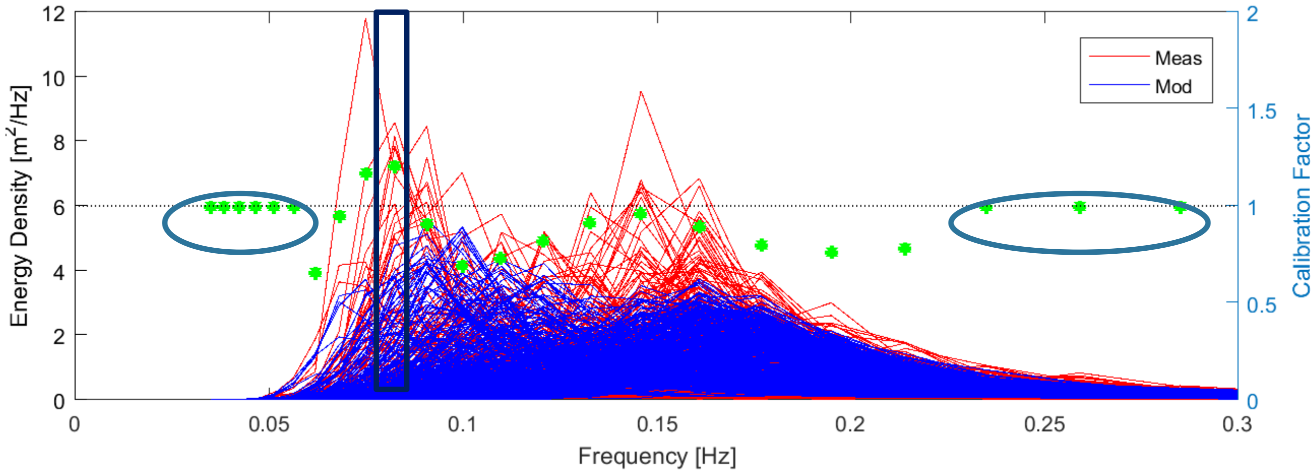


Identify the representative spectral shape, check the classes.

New Solution: Step 3



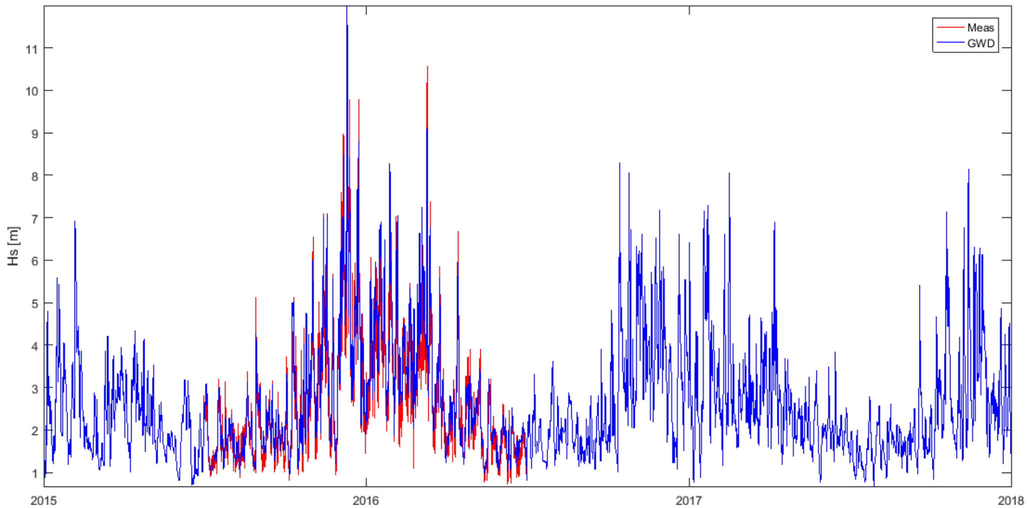
Derive calibration factors in each frequency bin through Least Square Error method (Meas vs Mod).

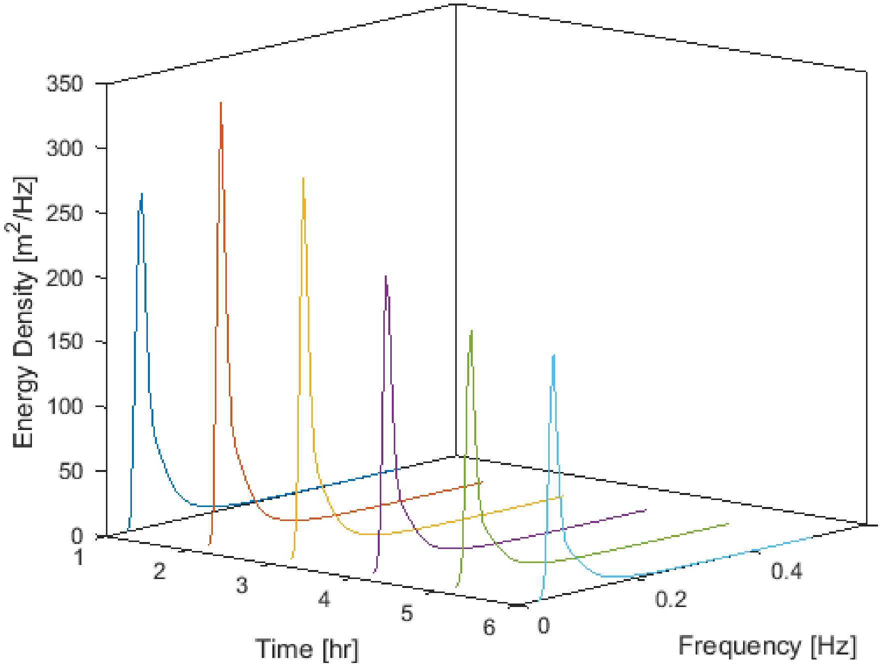


Calibrating spectrum in each frequency bin ensures both magnitudes and shape are correct from a statistical point of view.

New Solution: Step 4

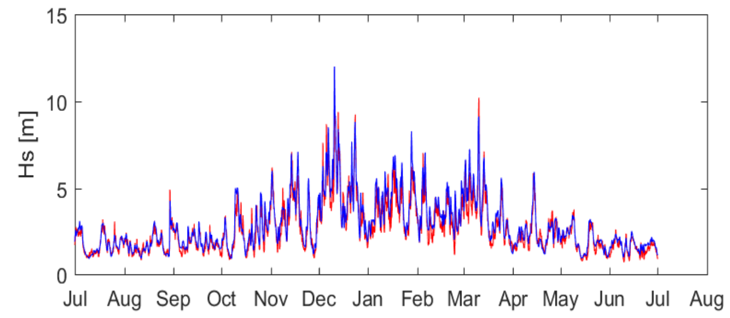
Calibrate hindcast spectrum using calibration factors for each frequency bin and for each class.

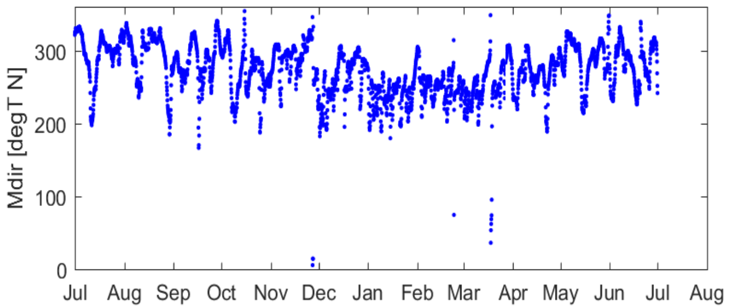


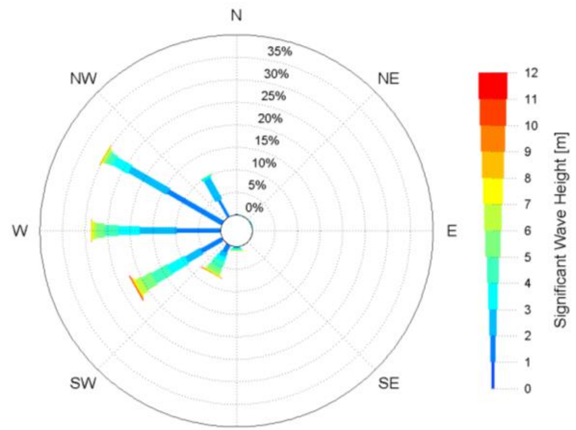


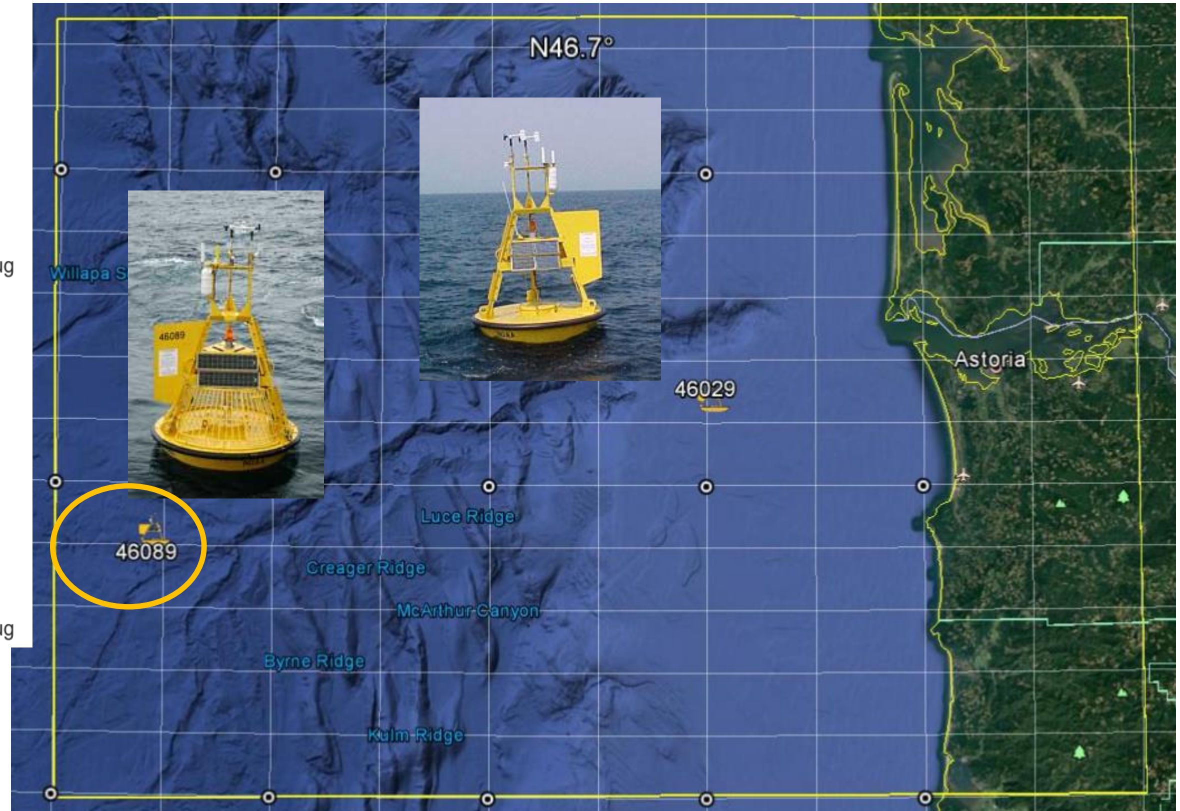
Provide the hindcast spectrum data after calibration

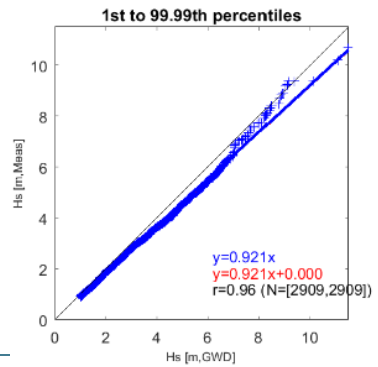
Case 1: Offshore Oregon

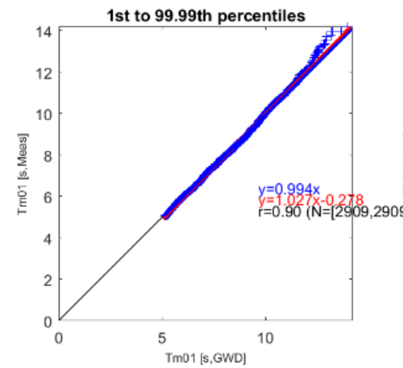


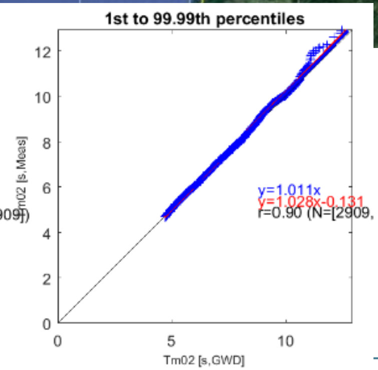




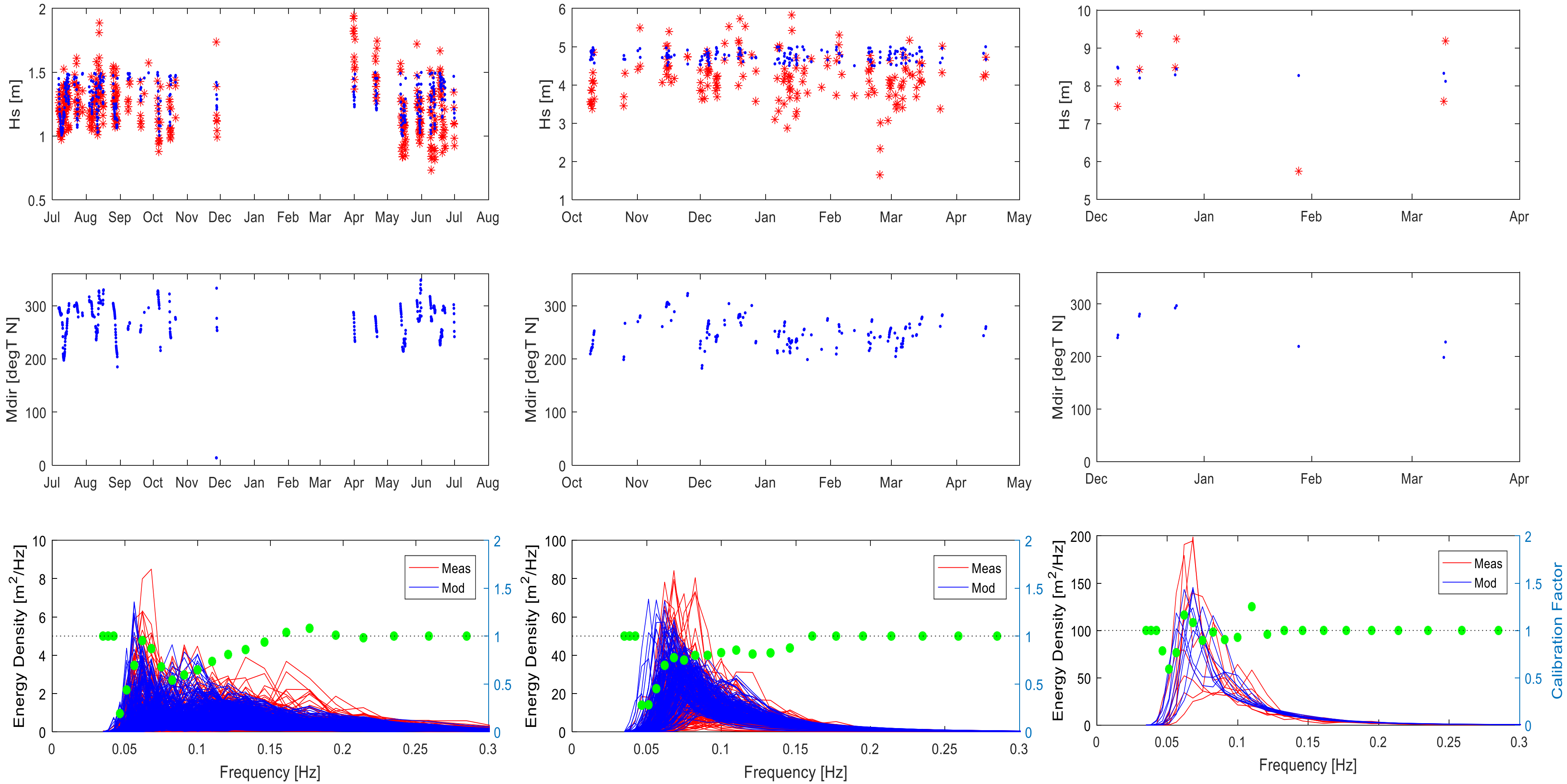






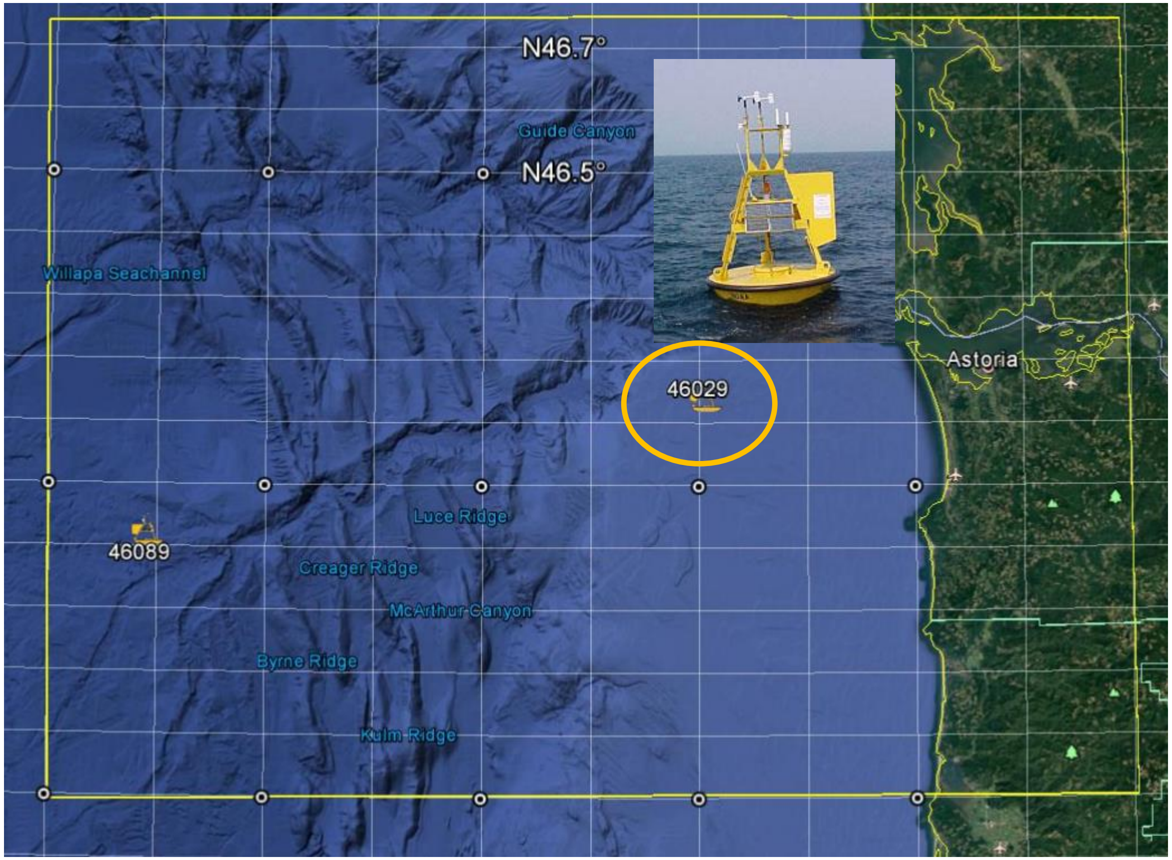


Case 1: Offshore Oregon



1.0m<Hs<1.5m   4.5m<Hs<5.0m   8.0m<Hs<8.5m

Case 1: Offshore Oregon

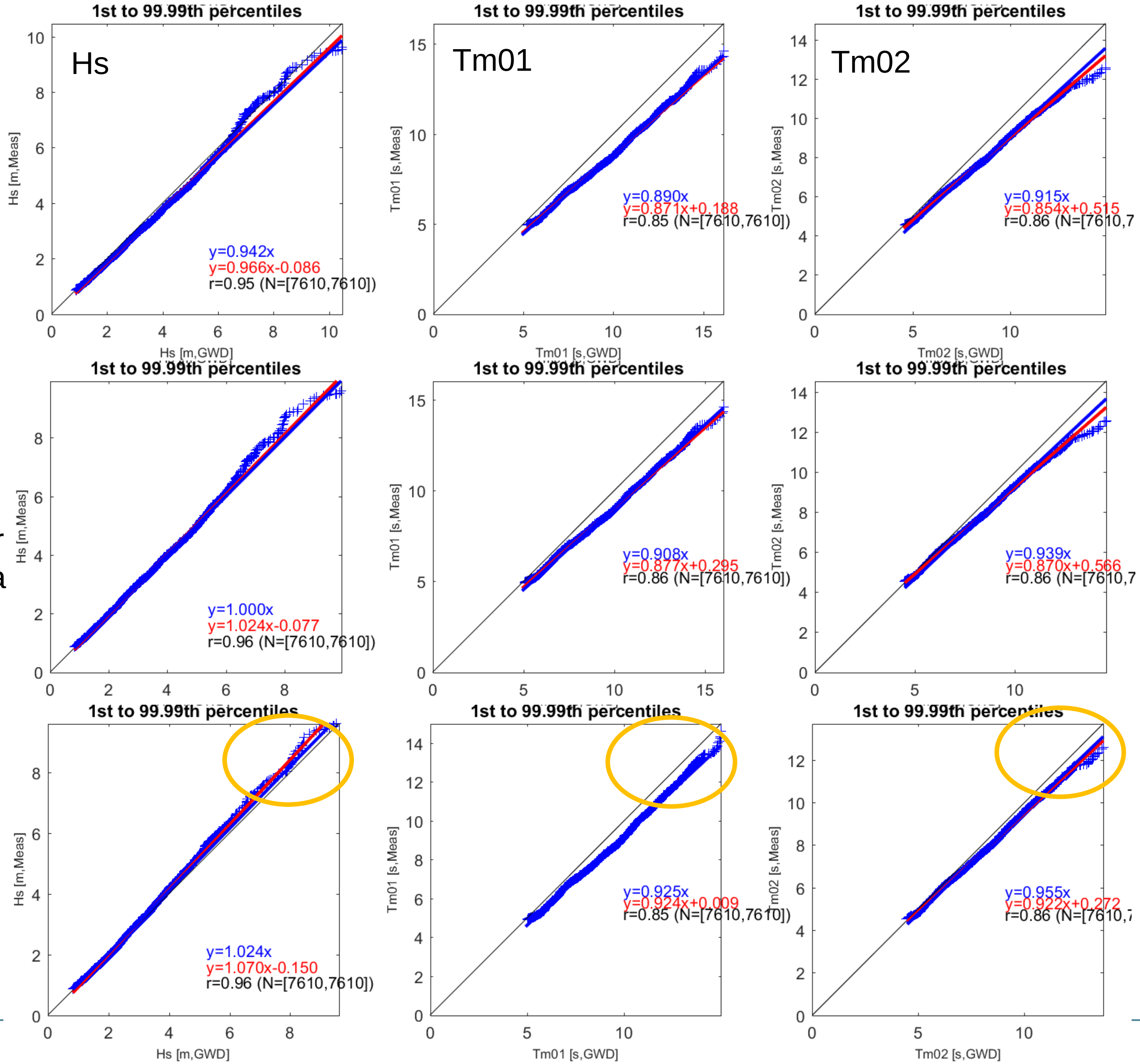


Case 1: Offshore Oregon

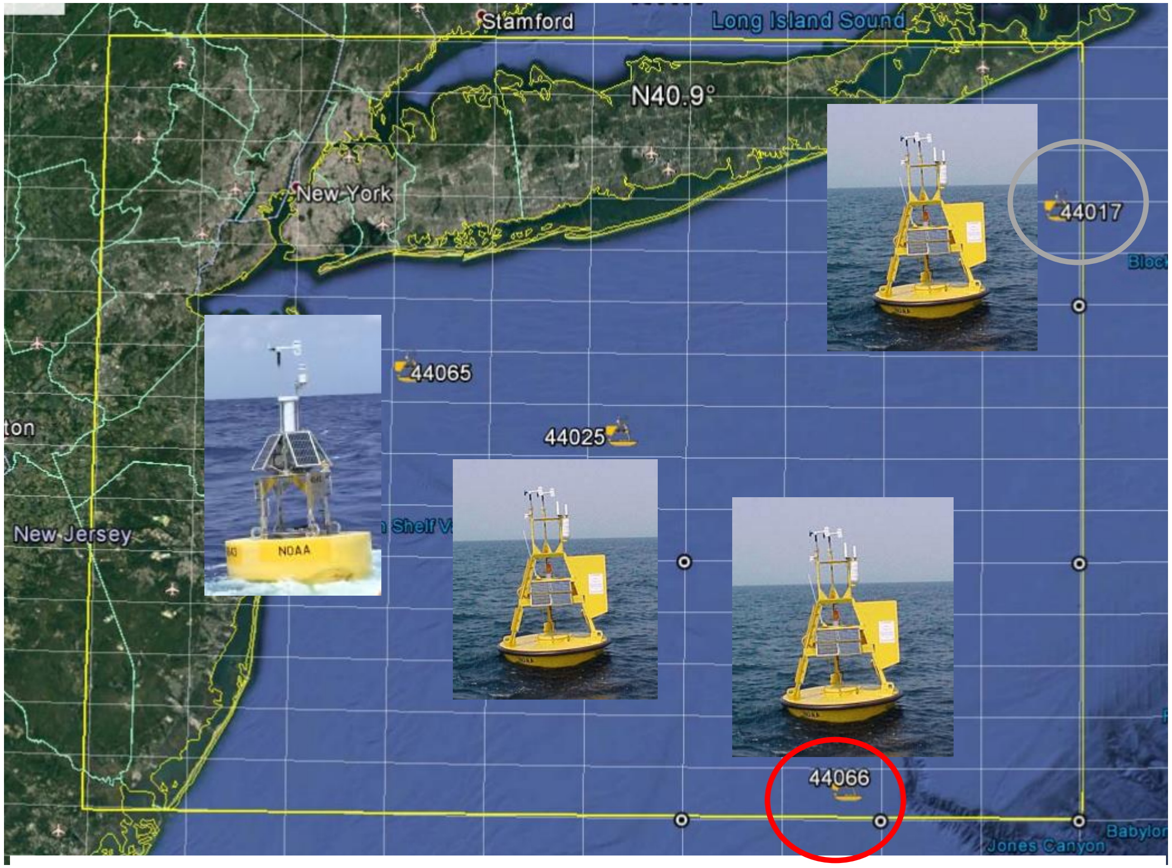
Original

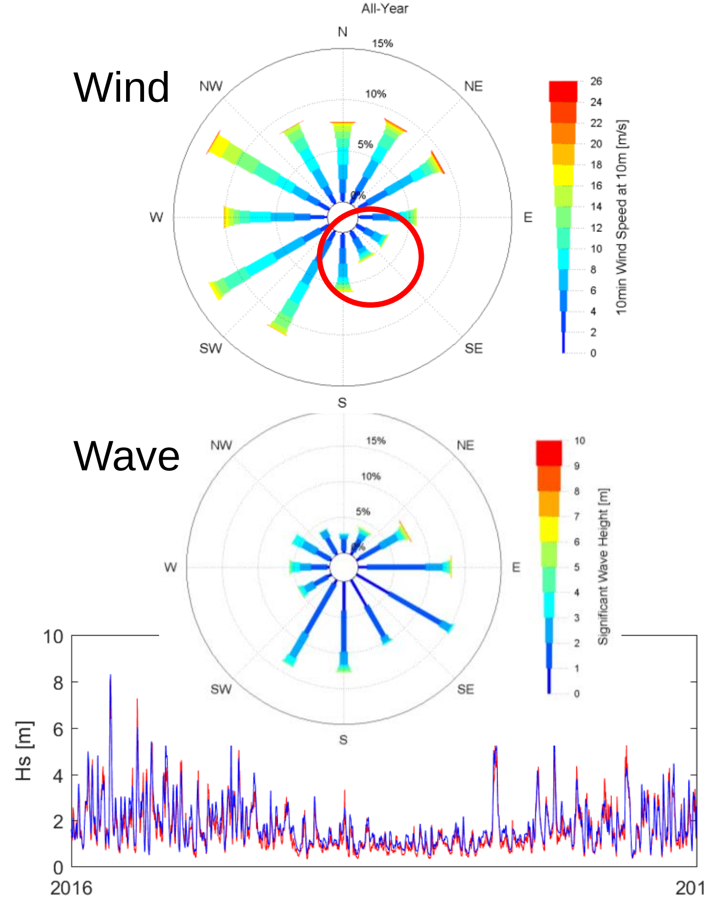
Constant factor Scaling spectra density

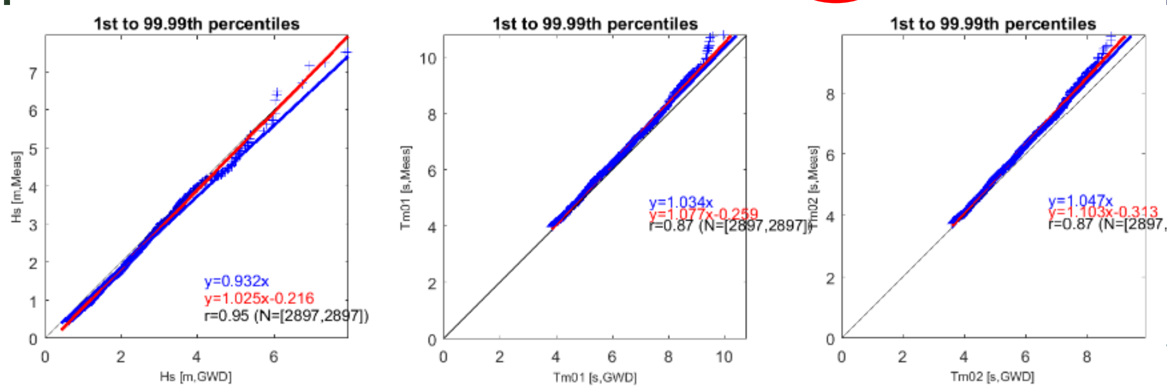
Shape-focus

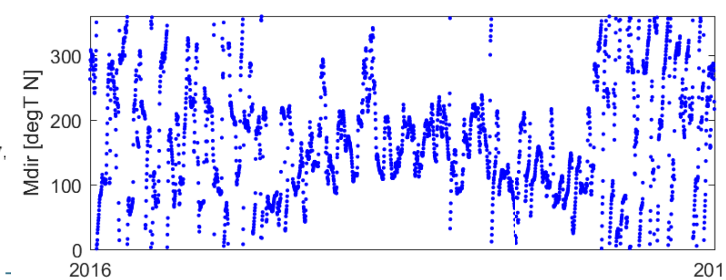


Case 2: Offshore New York

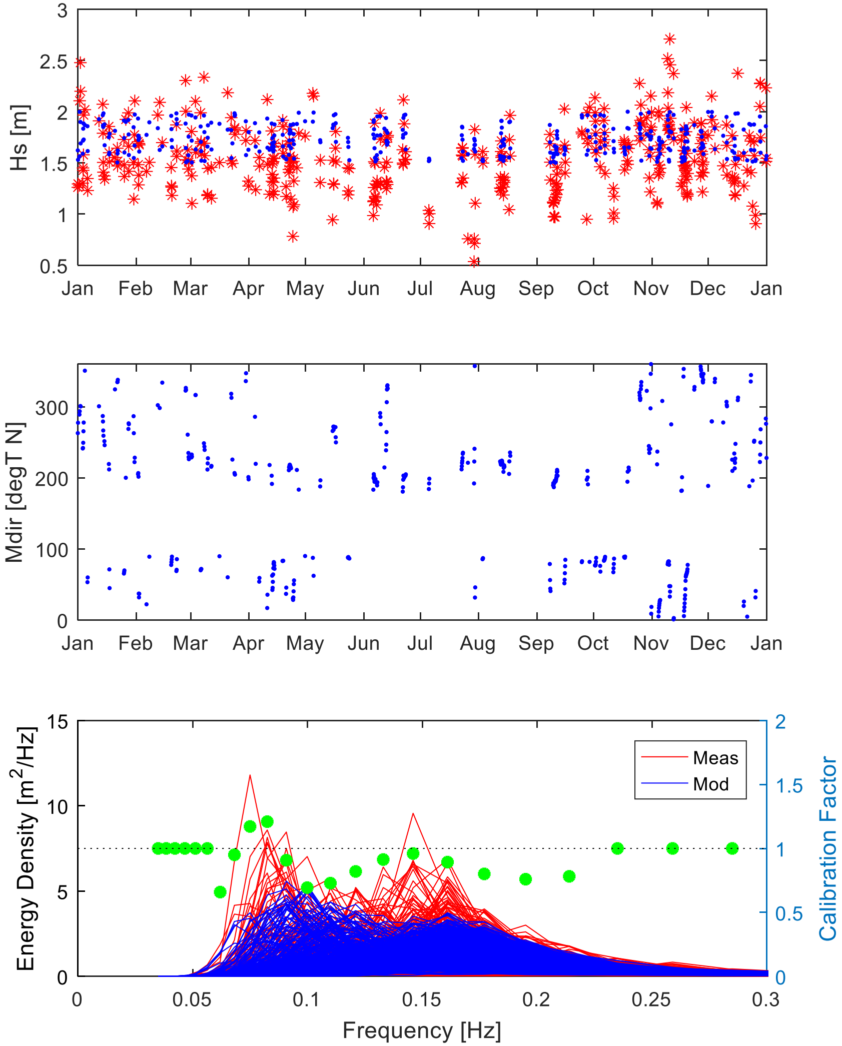




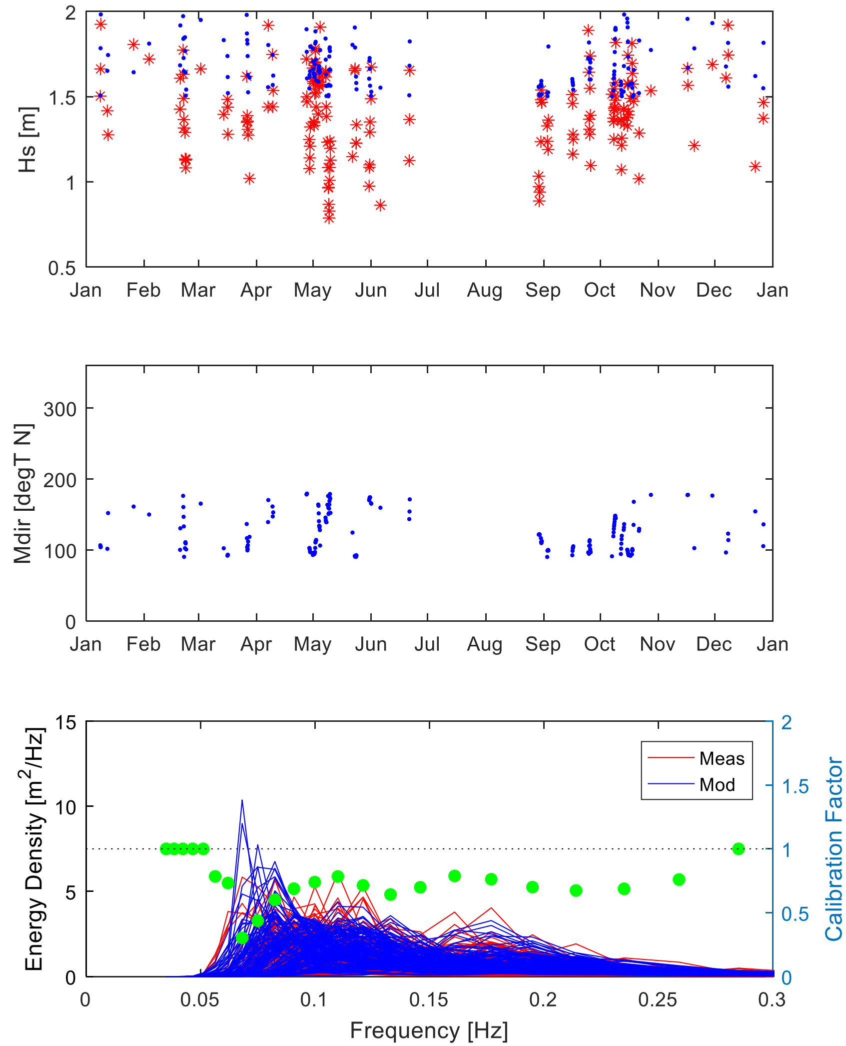




Case 2: Offshore New York

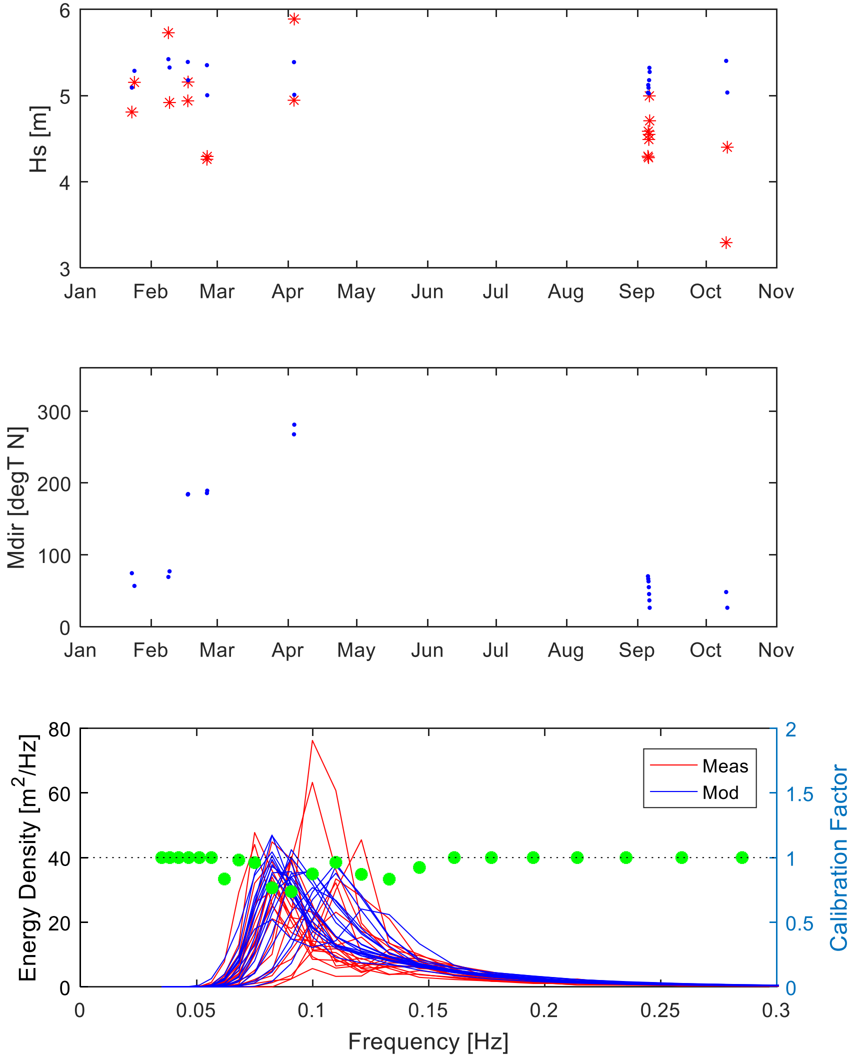


1.5m<Hs<2.0m
Mdir<90 deg or Mdir>180 deg

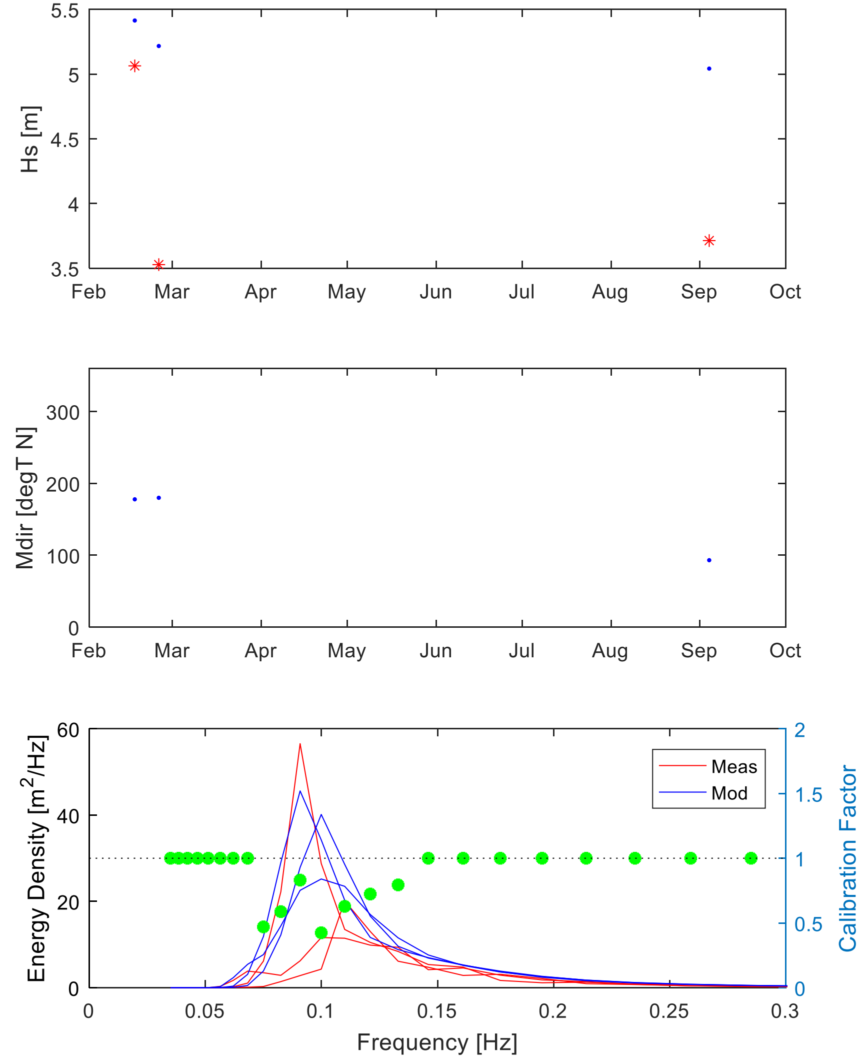


1.5m<Hs<2.0m
90 deg<=Mdir<180 deg

Case 2: Offshore New York

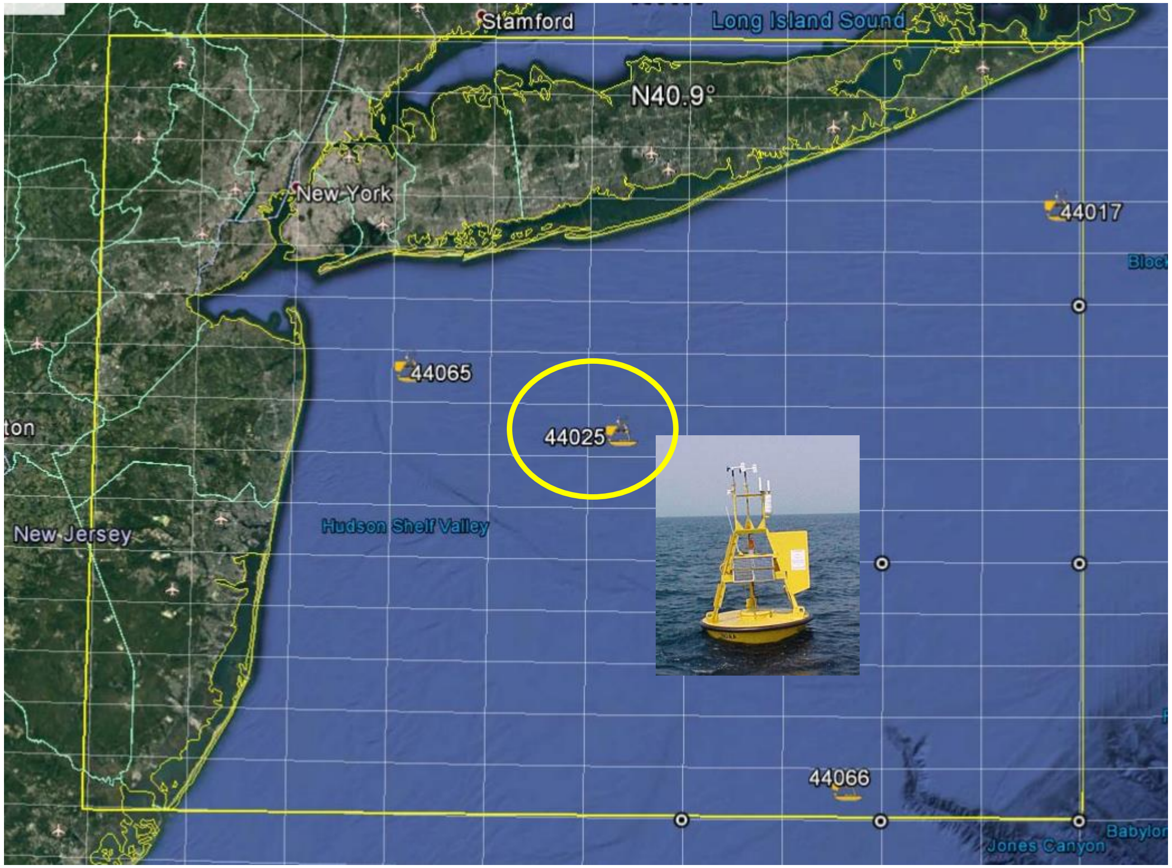


5.0m<Hs<5.5m
Mdir<90 deg or Mdir>180 deg



5.0m<Hs<5.5m
90 deg<=Mdir<180 deg

Case 2: Offshore New York

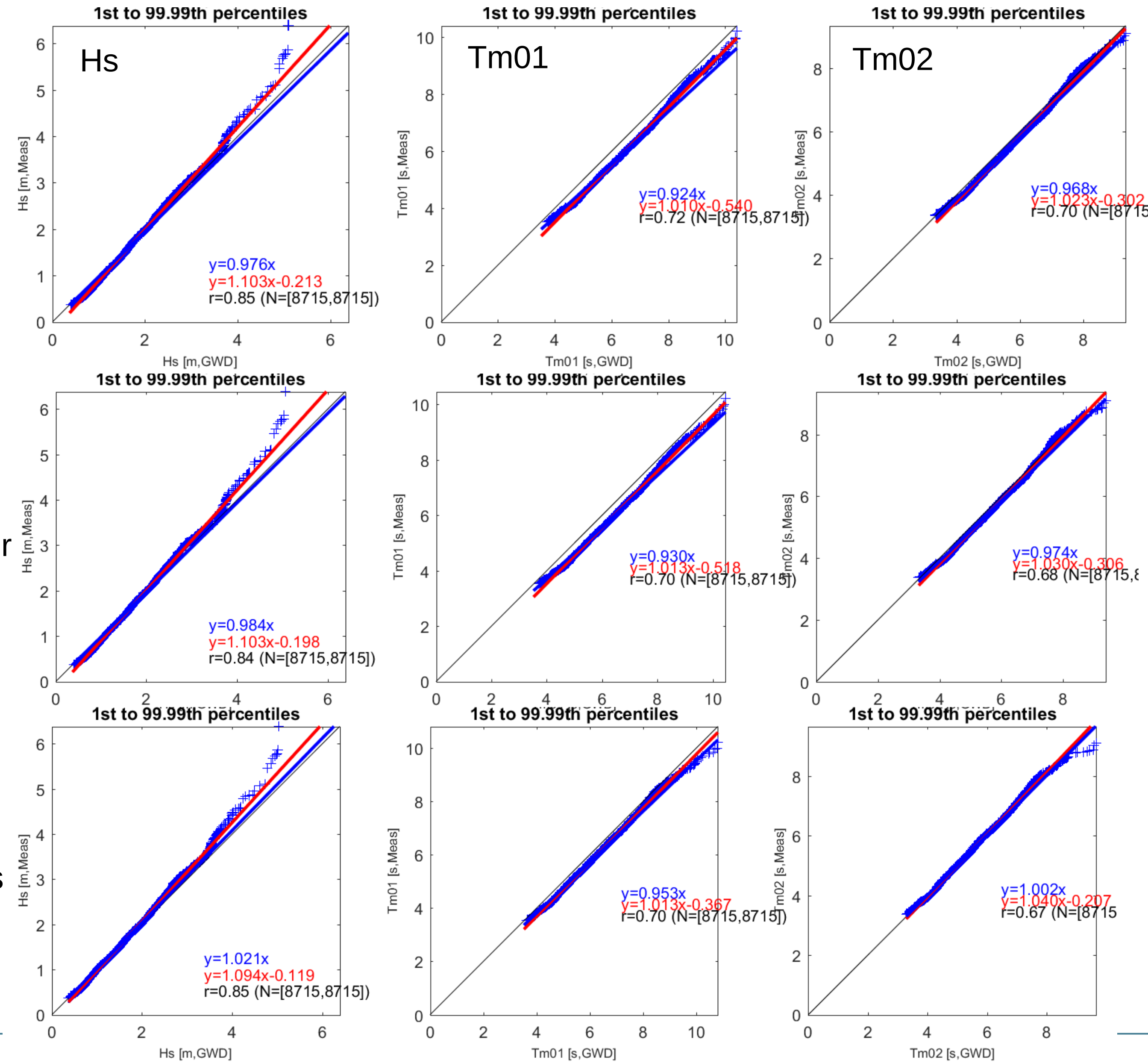


Case 2: Offshore New York

Original

Constant factor

Shape-focus



Summary

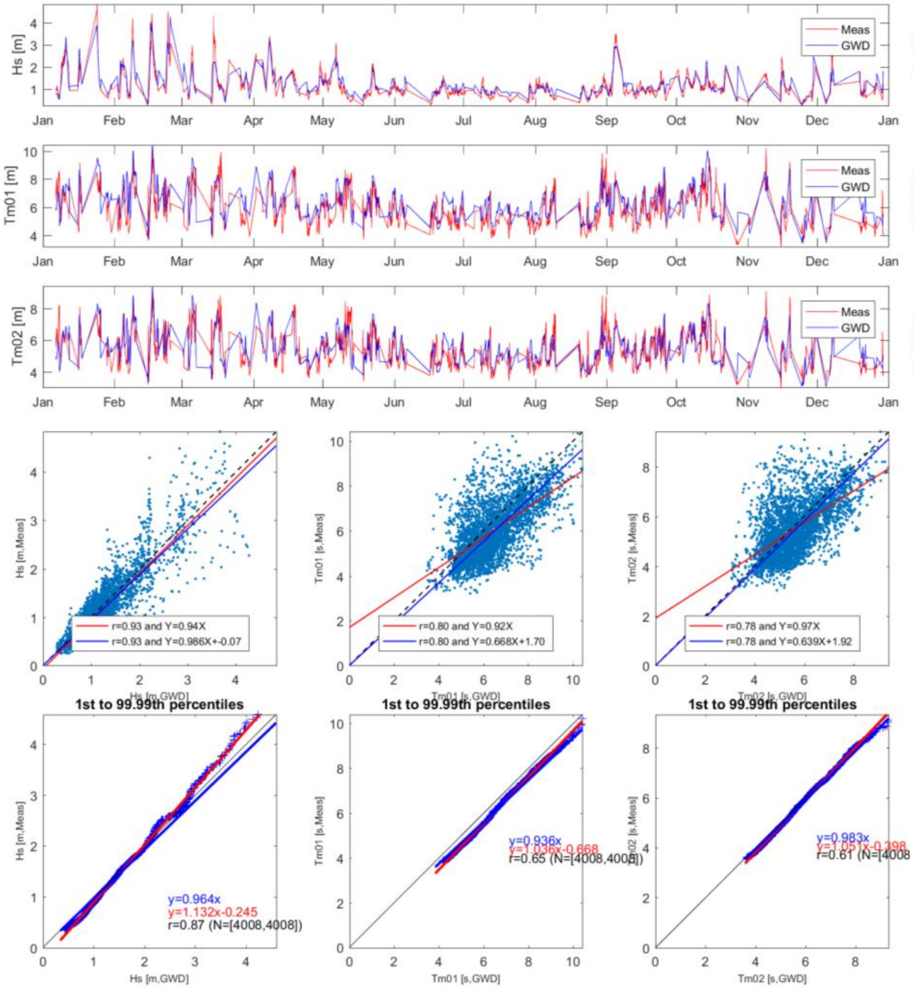
- Shape-focus method calibrates the wave energy spectrum in each frequency bin and in each class.
- SWAN site-specific modelling was used to verify the effectiveness of the Shape-focus method.
- Shape-focus method improved both mean wave periods and significant wave heights compared against buoy measurements.

Future work:

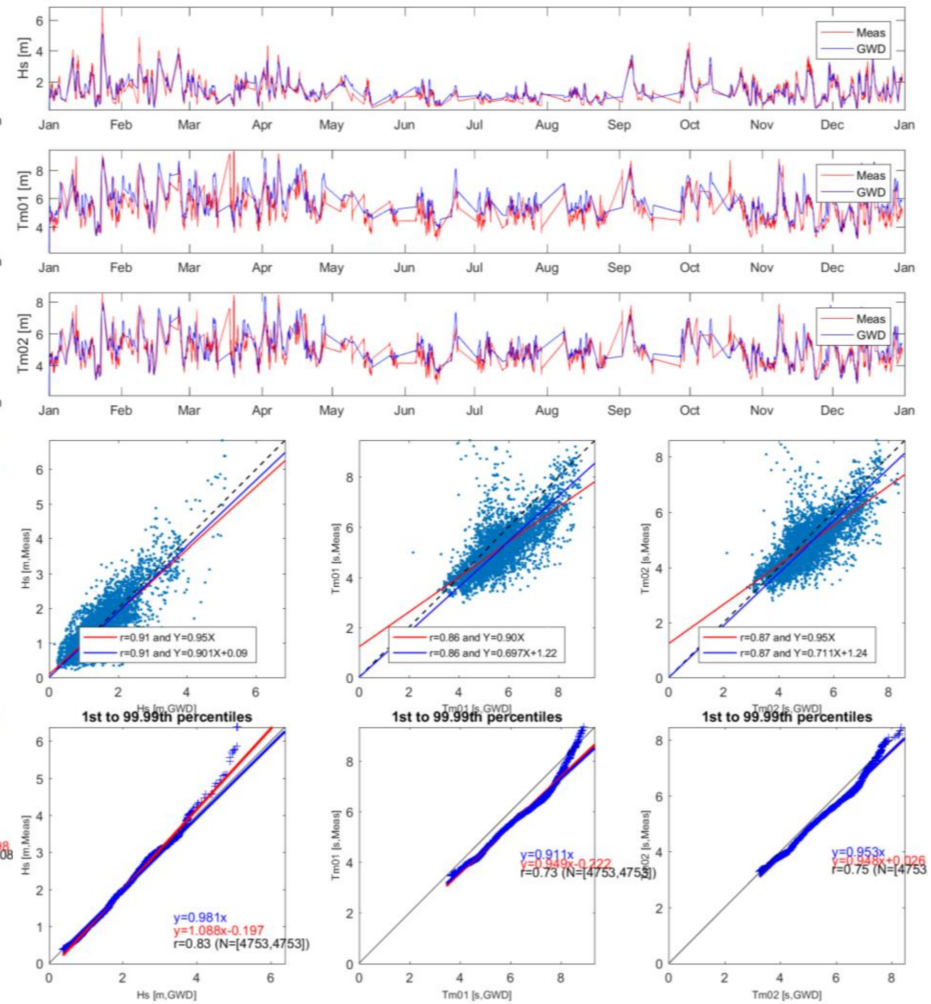
- Extend shape-focus method to directional wave spectrum.
- Calibrate the partitioned wind-sea and swell spectrum.

Thank you for your attention!

South-east Sector

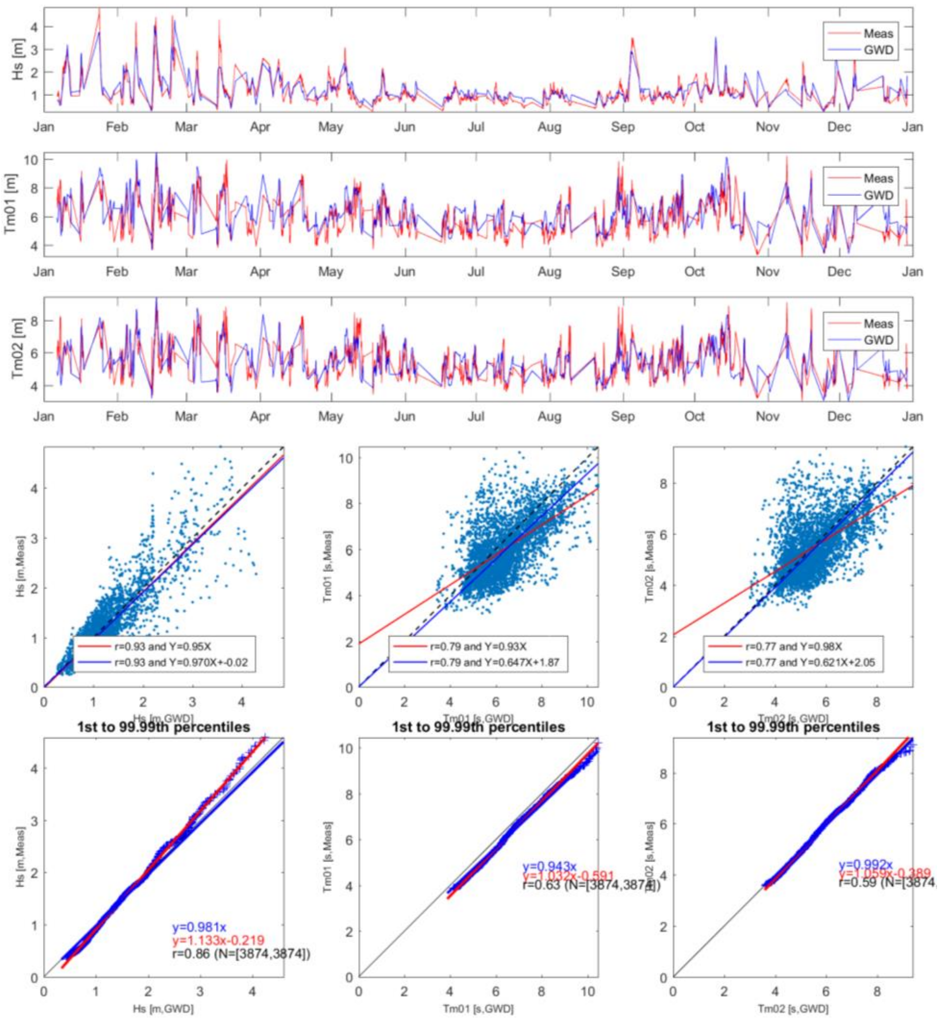


Other Sectors

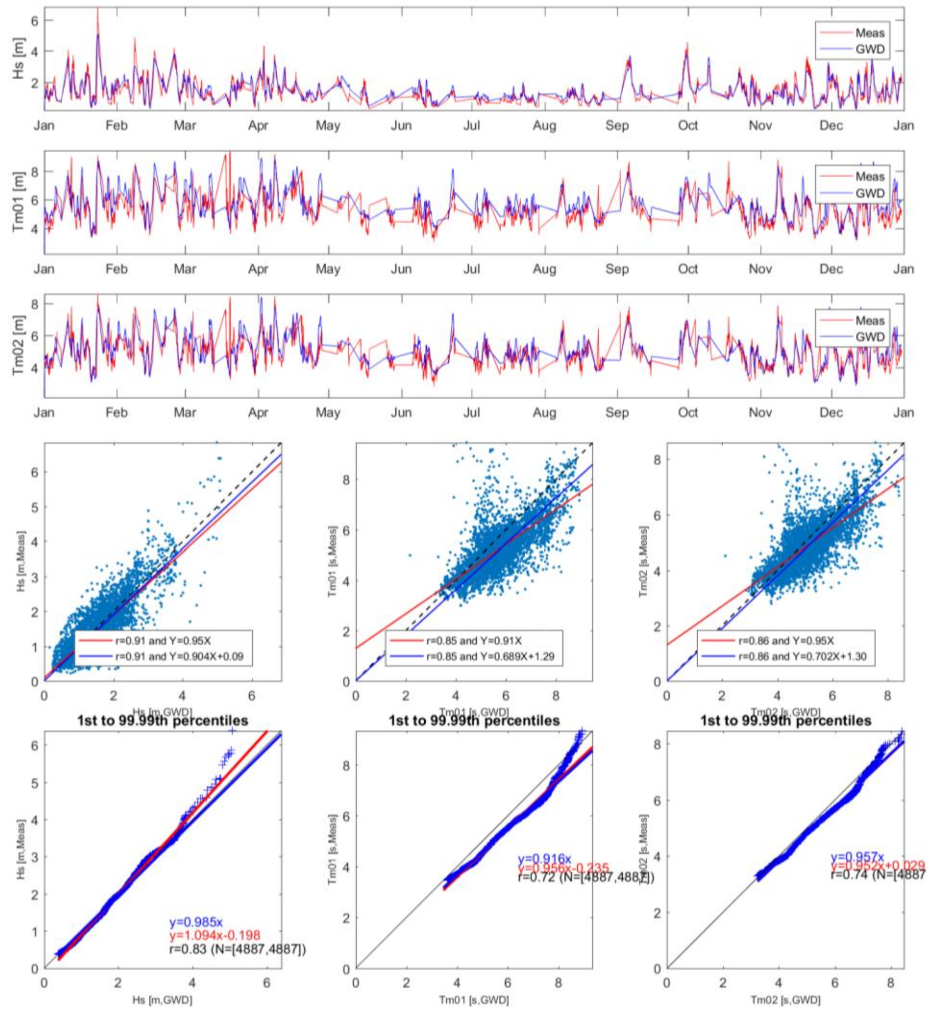


Case 2: After Calibration with Constant Factor

South-east Sector

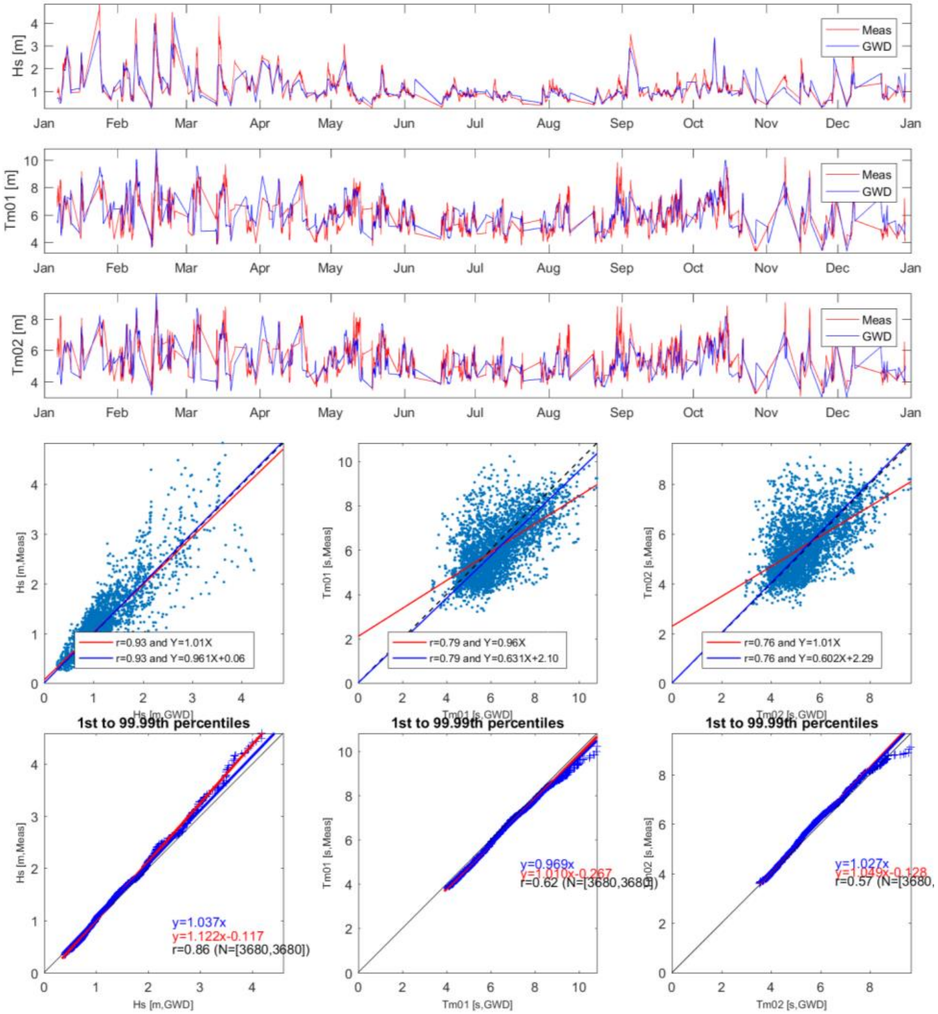


Other Sectors



Case 2: After Calibration with Shape-focus Method

South-east Sector



Other Sectors