

Wave Forecasting at the Site

A Practical Solution for Terminal
Operation and Planning

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moffatt & nichol

Creative People, Practical Solutions.®

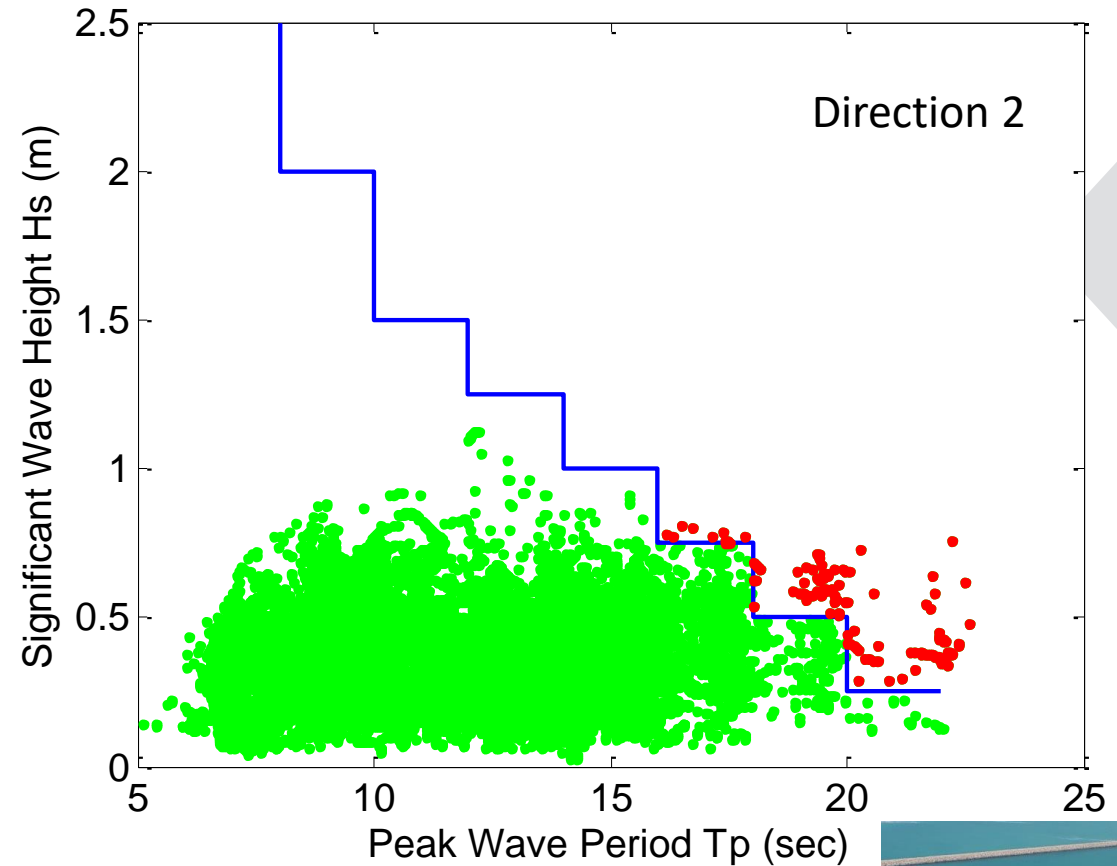
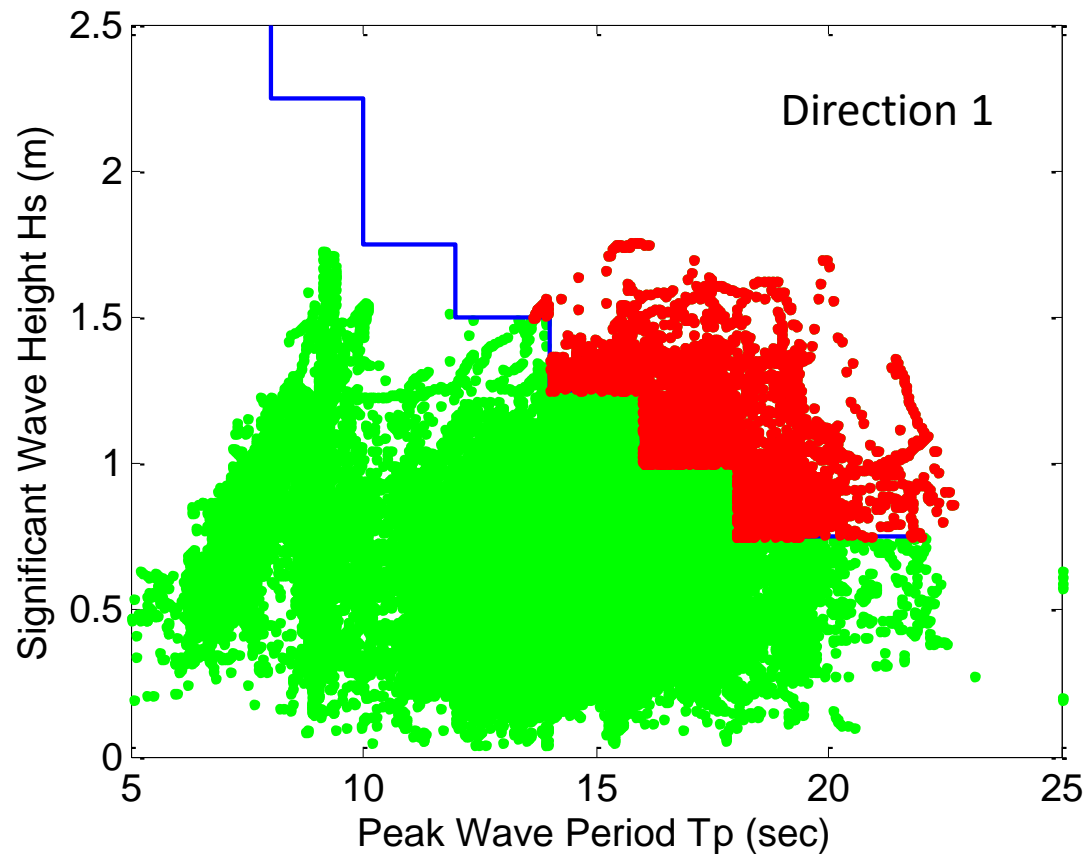
Oil/LNG Terminals Move More Offshore

- Benign sites are already taken
- Gas fields developed in more exposed locations
- Permission and Environmental Restrictions
- Construction schedule and cost
- ...

WAVES – Downtime!

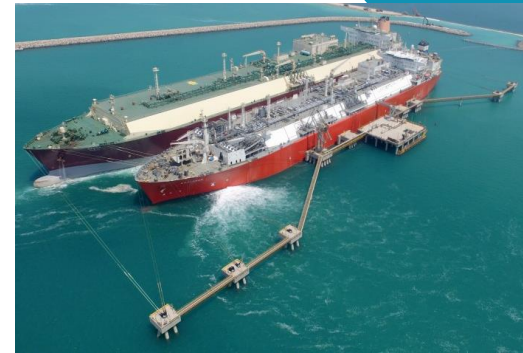


Why Accurate Wave Forecast at Site is Needed?

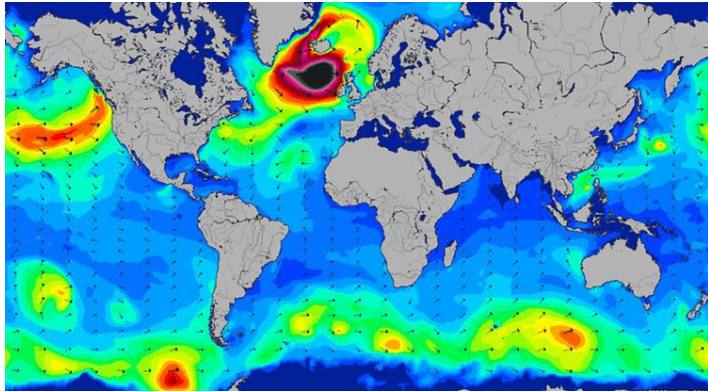


Wave Period, Height, Direction – All Matter

Need Confidence



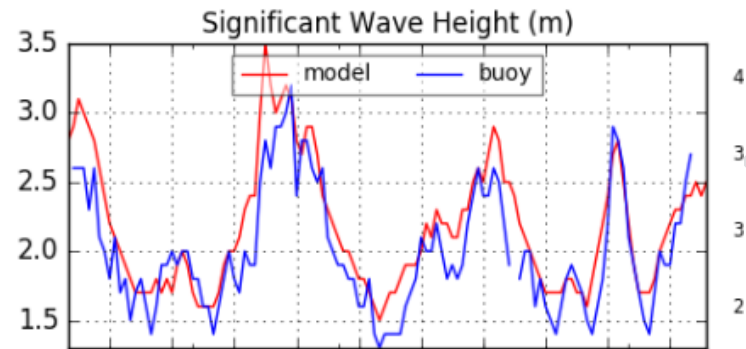
Wave Forecasting at the Site – 3 Elements



Offshore Wave Forecast

Build Look-up Matrix

- Numerical modeling
- Neural network tools
- Direct correlation



Wave Forecast at Site

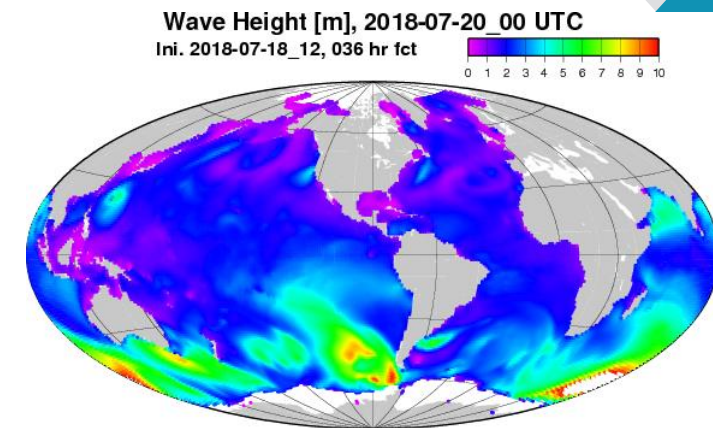
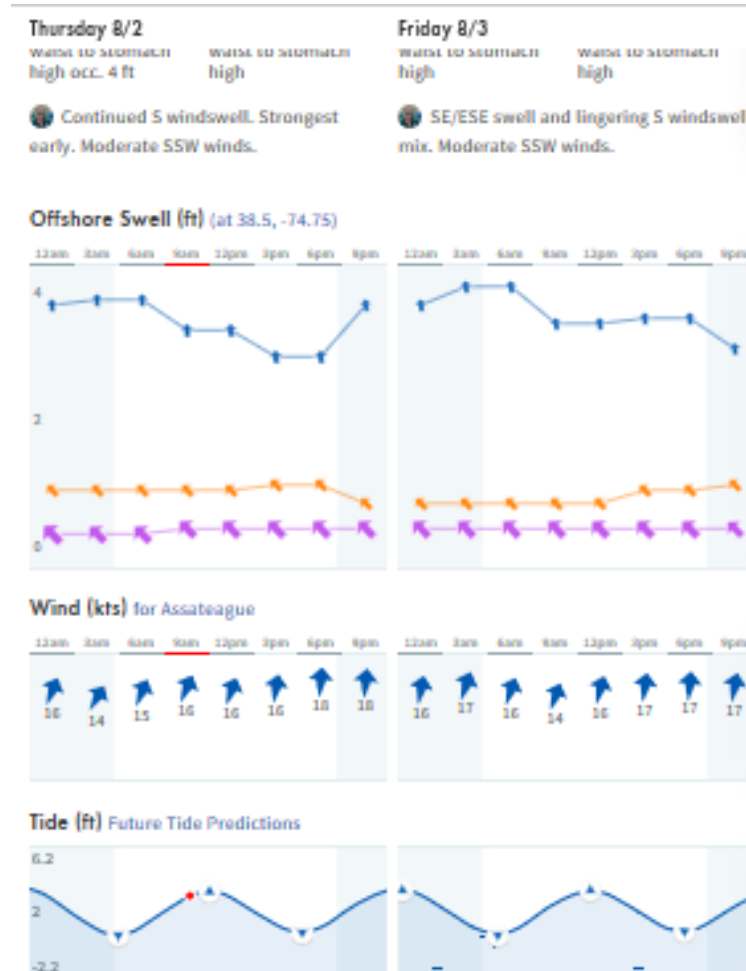


Wave Measurement at Site

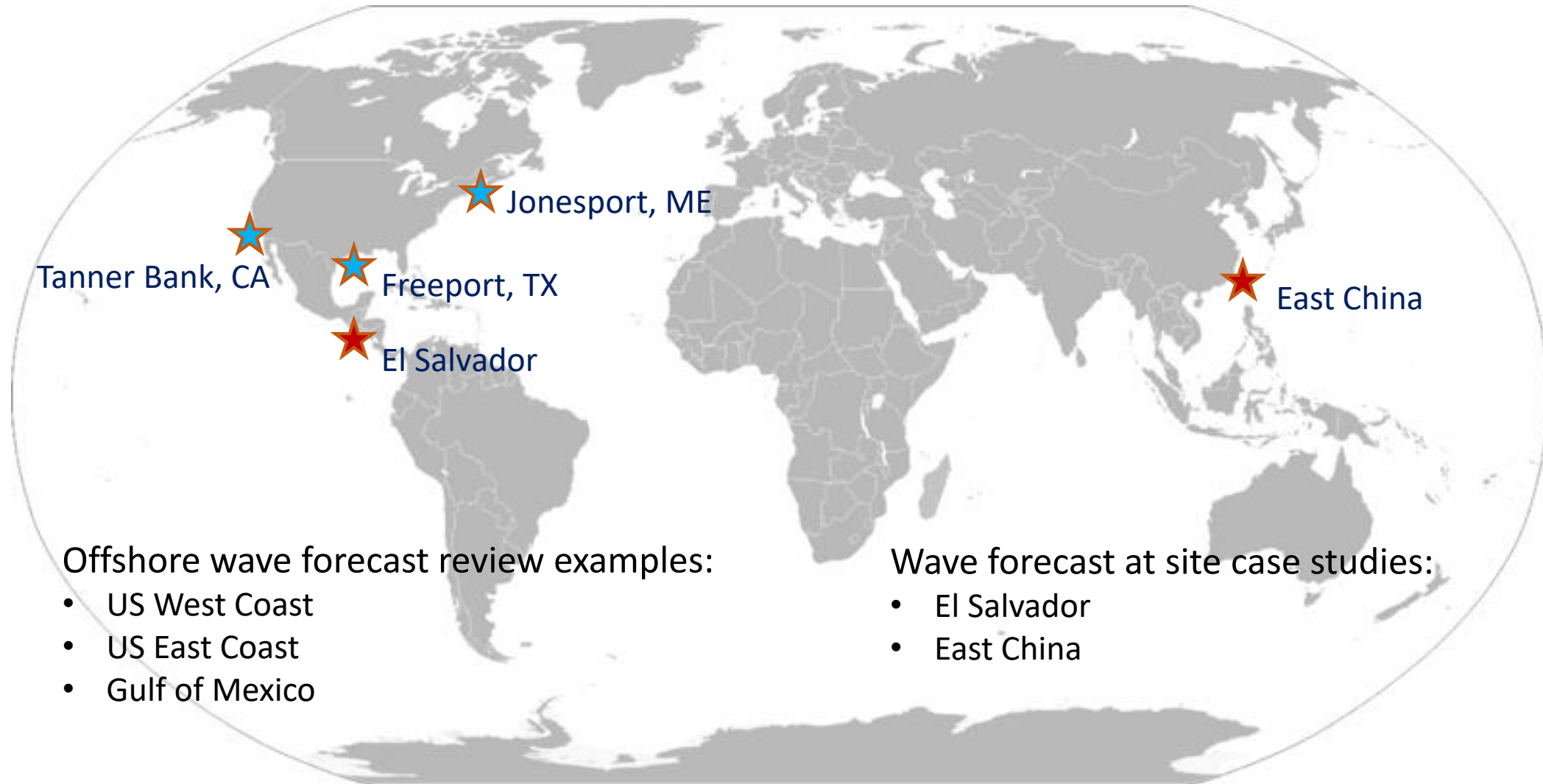
Calibration and Validation

Offshore Wave Forecast Models

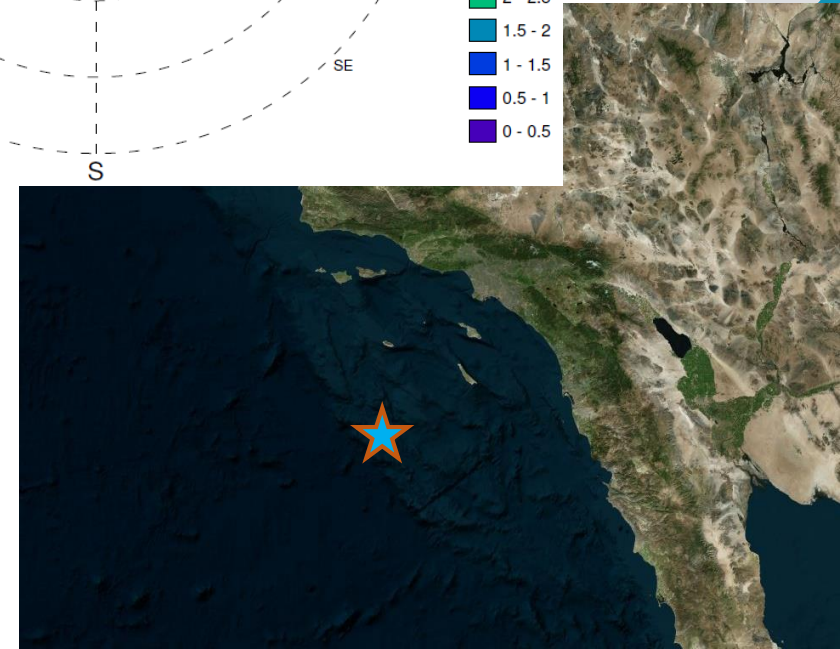
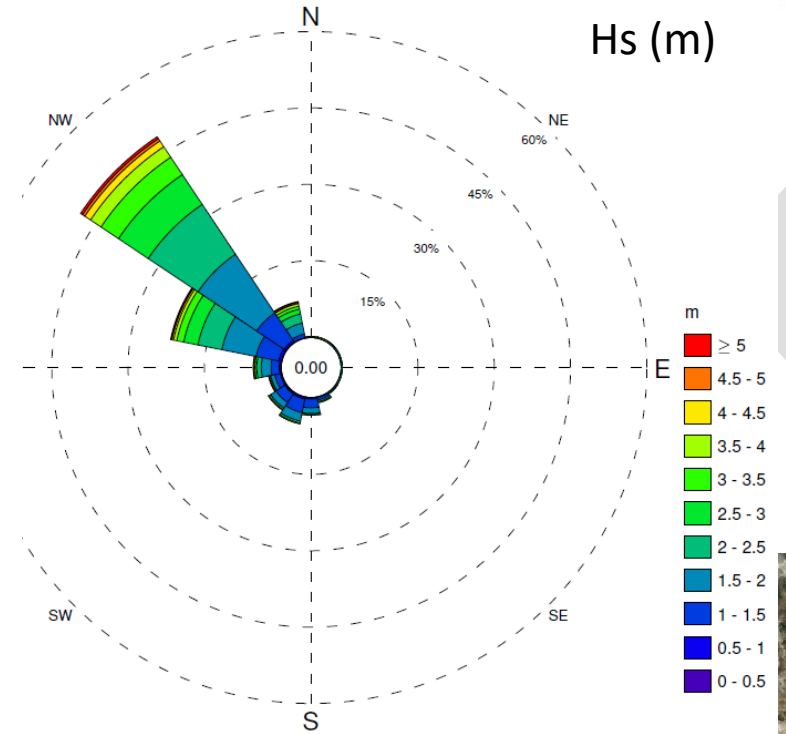
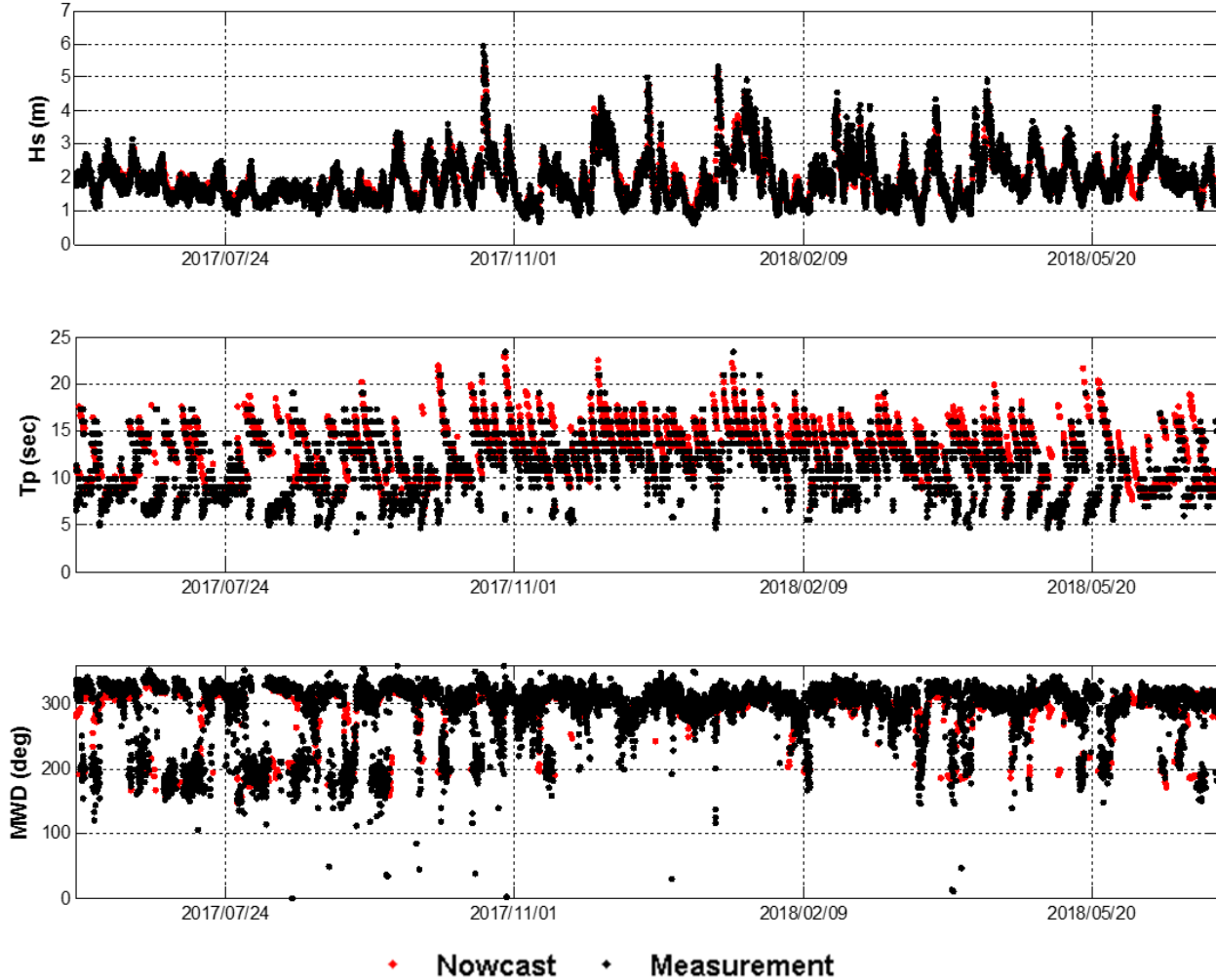
- NOAA
- Environment Canada
- Met office (UK)
- BOM (Australia)
- Ocean Weather Inc.
- Surf-line
- ...



NOAA WAVEWATCH III Wave Forecast

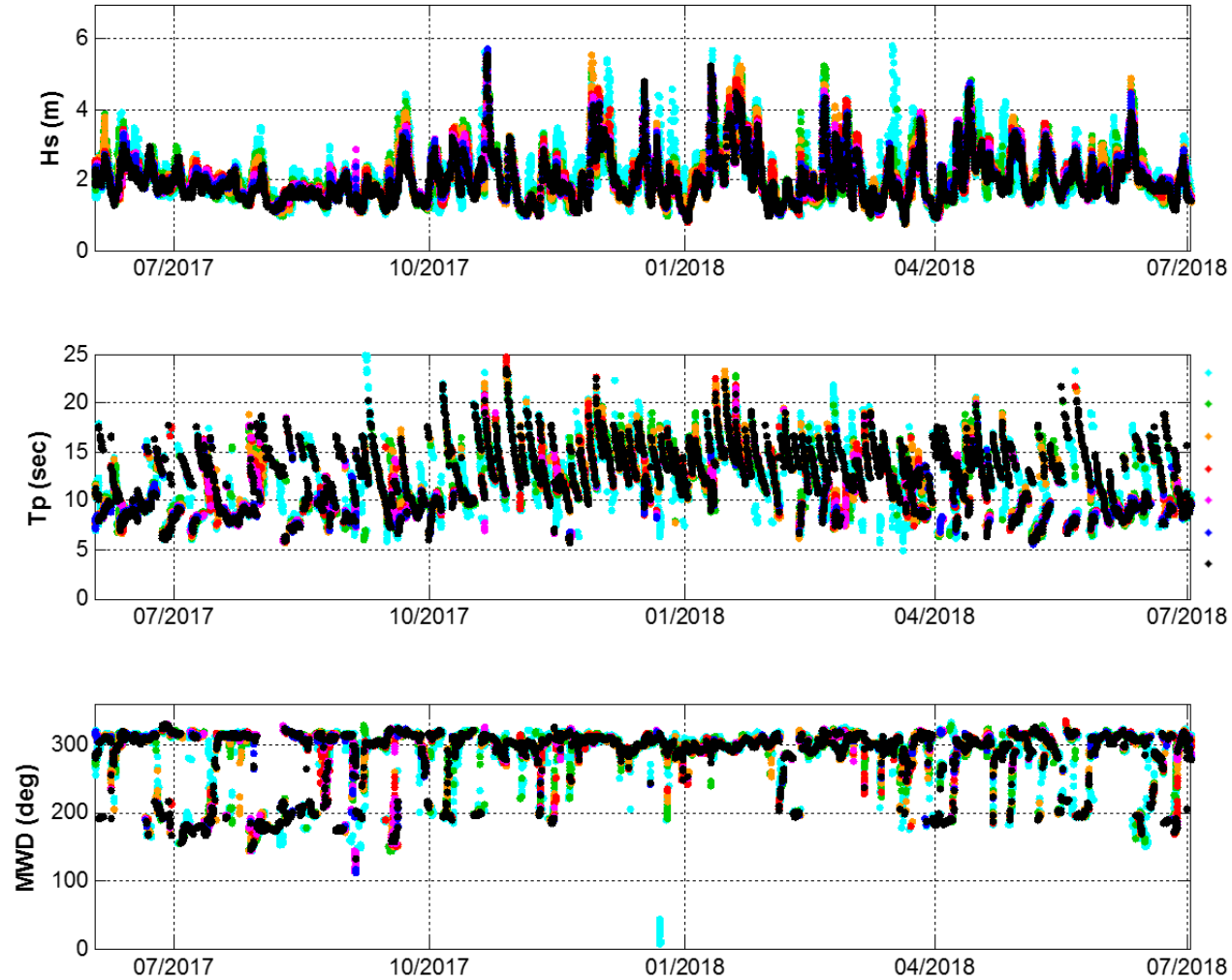


WWIII Wave Forecast – West Coast Offshore

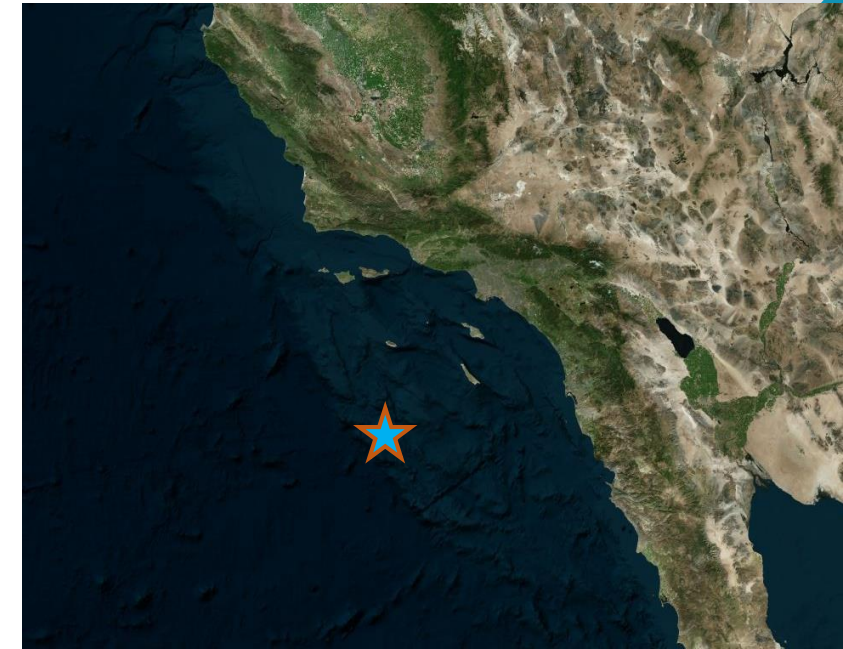


Wave Forecast vs Measurement

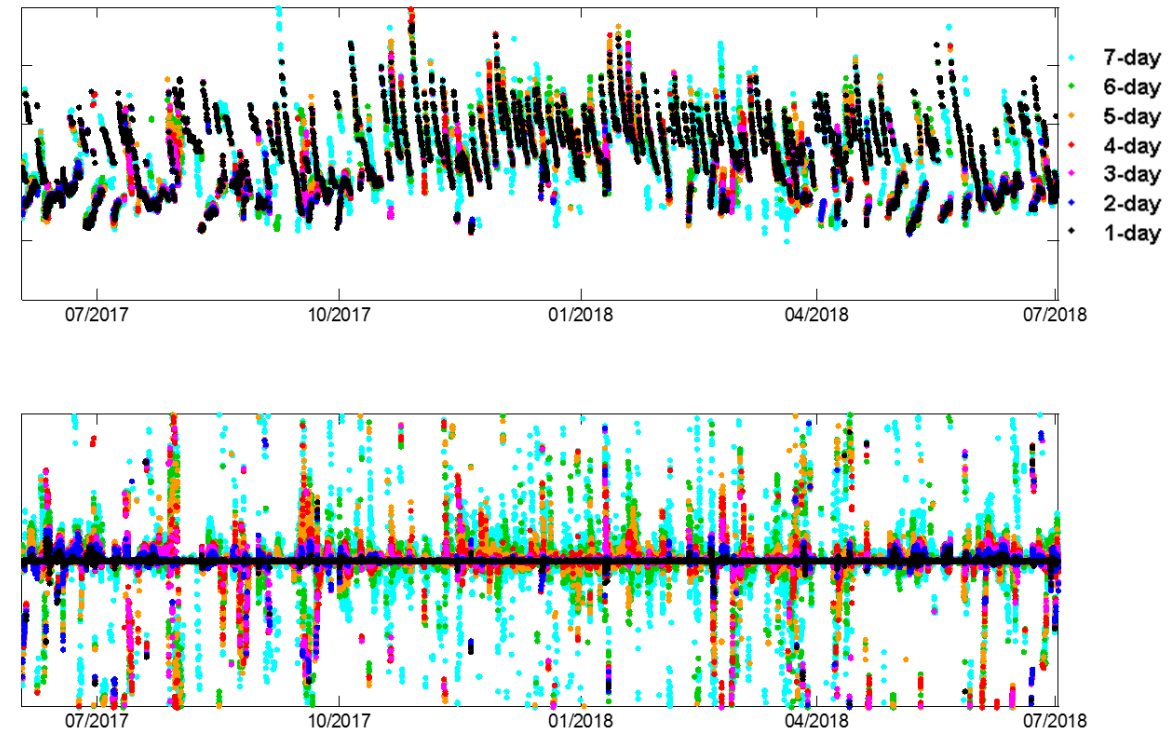
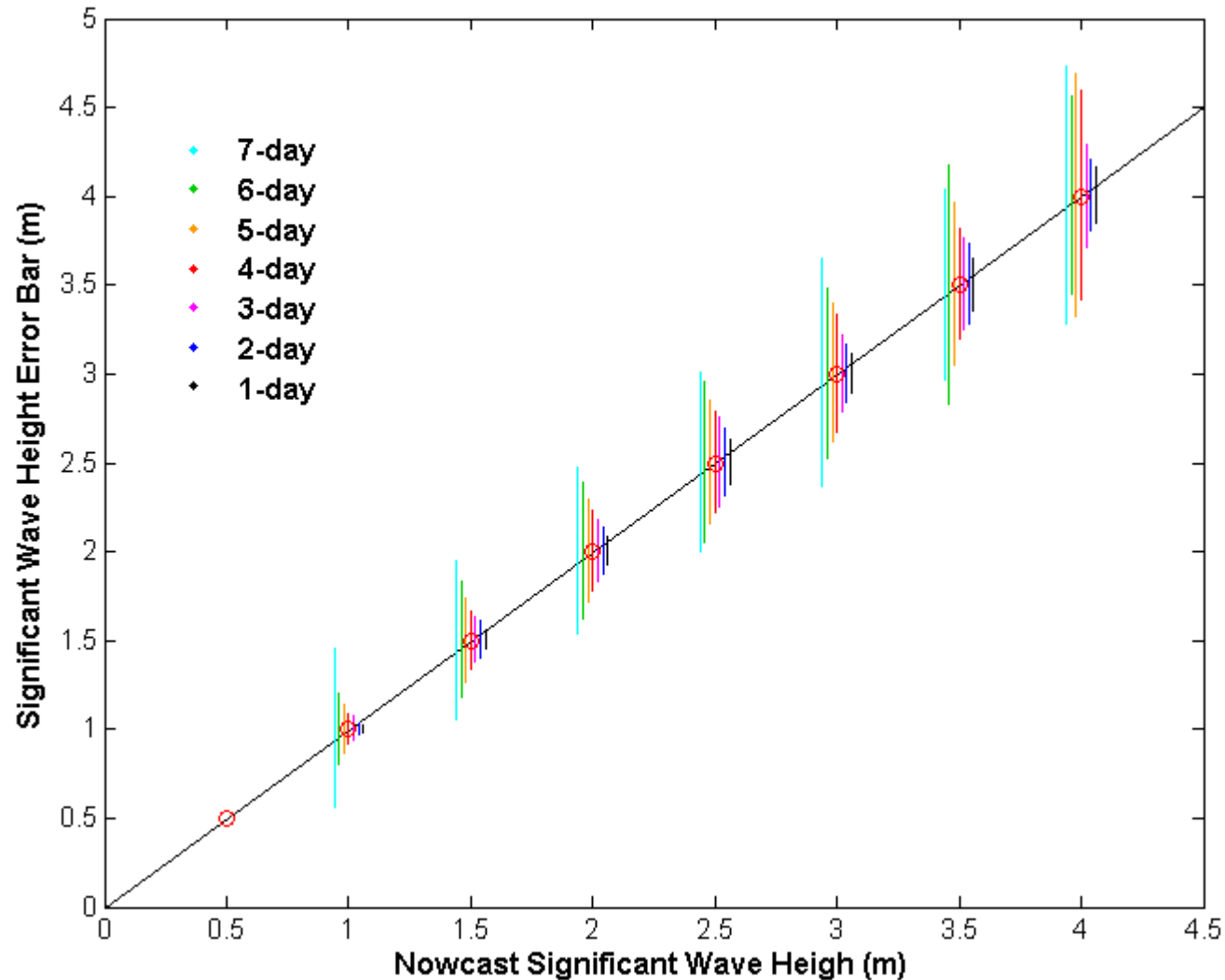
WWIII Wave Forecast – West Coast offshore



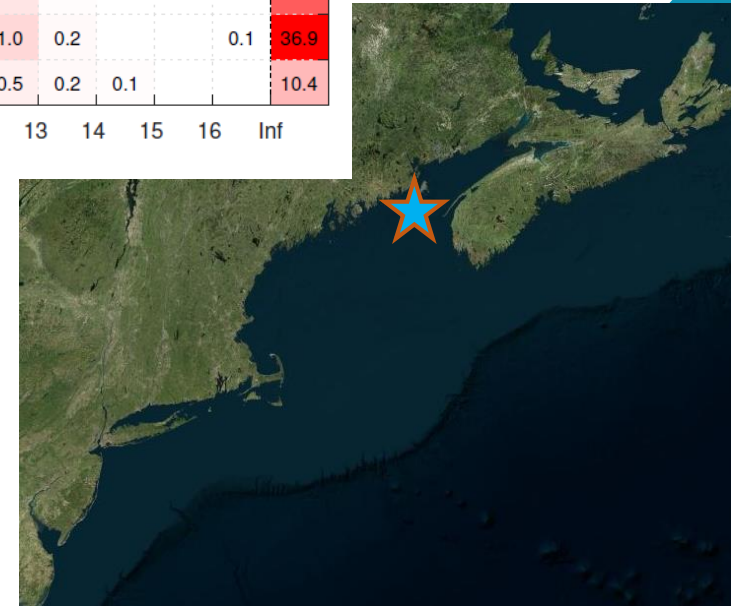
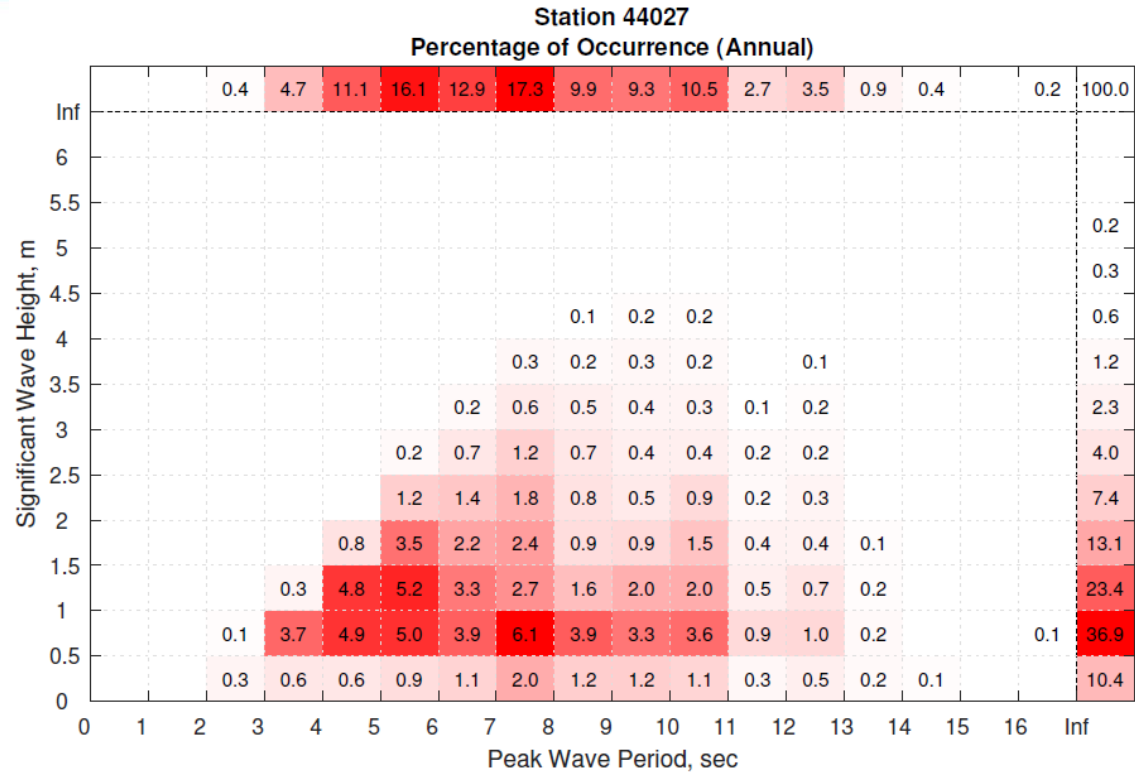
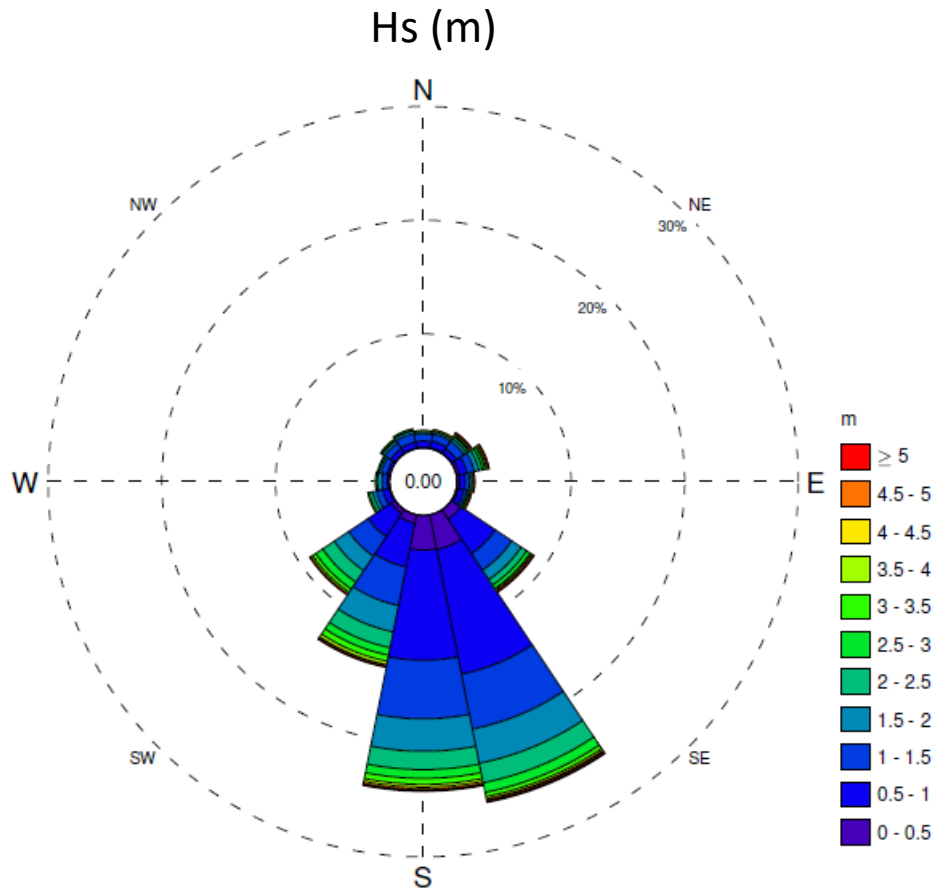
- 7.5 days of forecast
- Update every 6-hour
- 30 predictions for one time



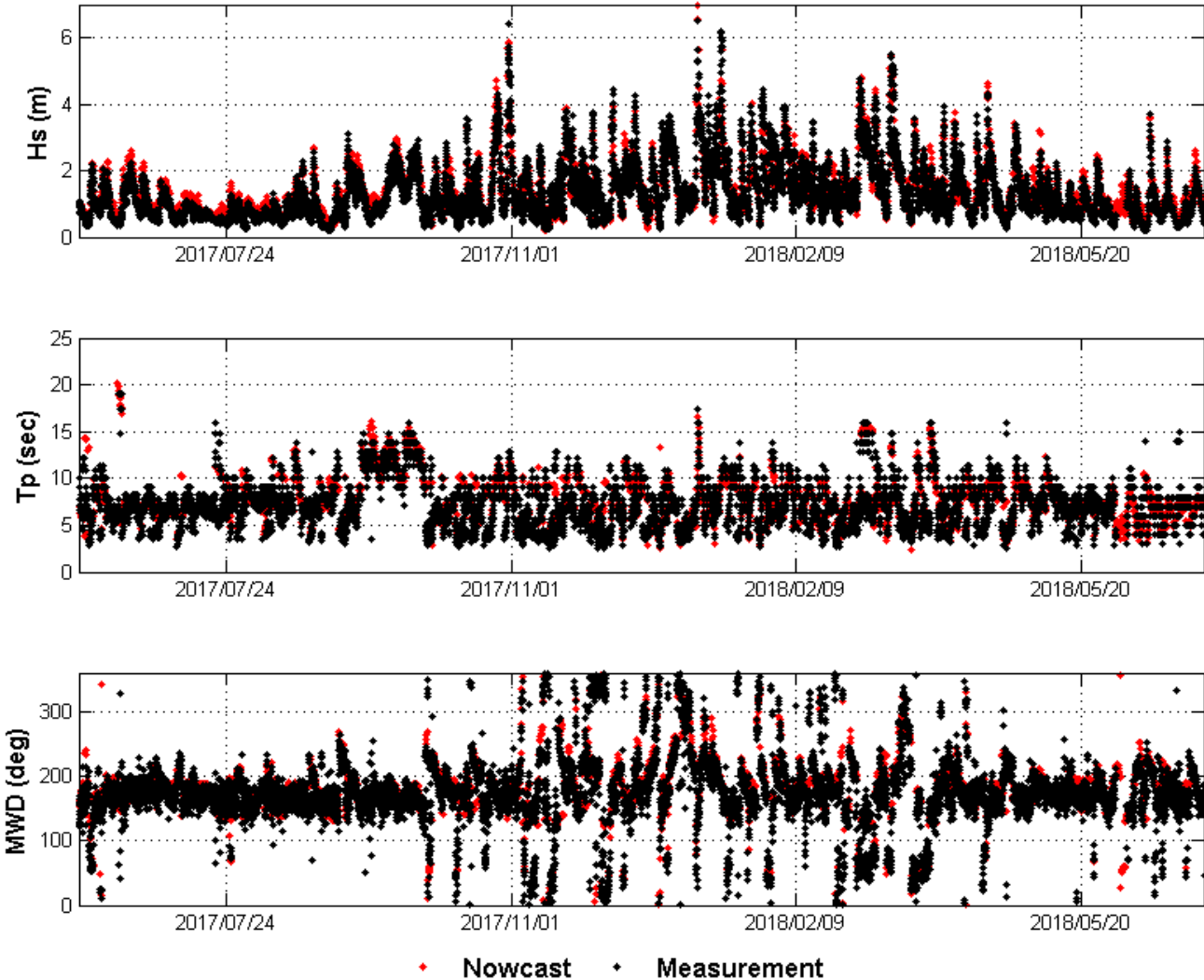
WWIII Wave Forecast – West Coast Offshore



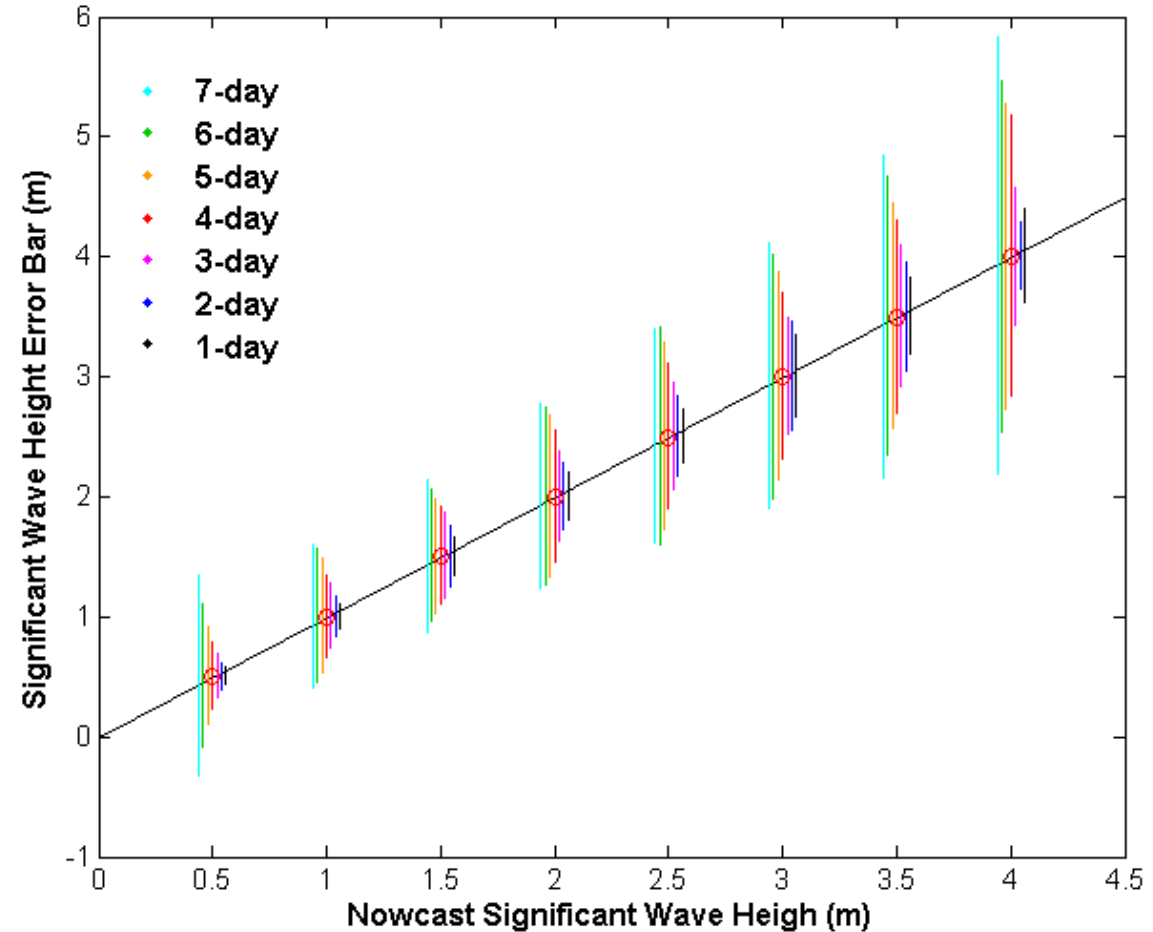
WWIII Wave Forecast – East Coast Offshore



WWIII Wave Forecast – East Coast Offshore

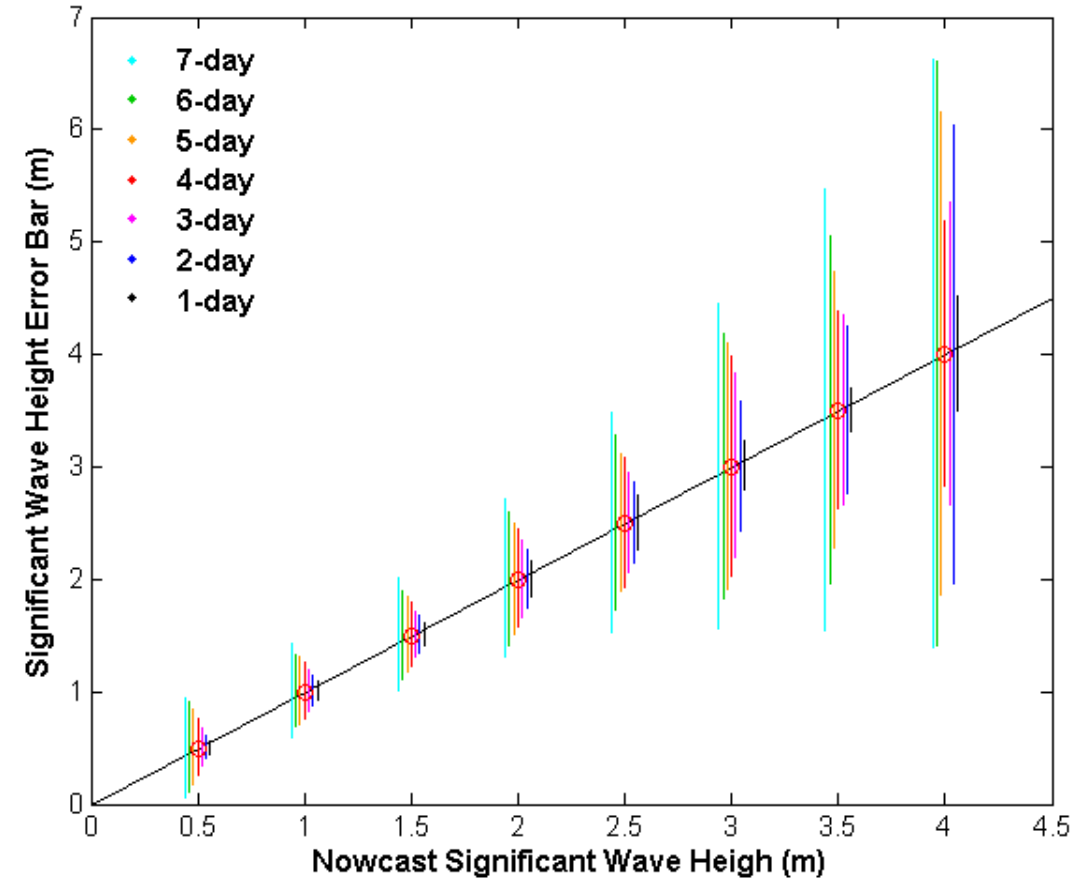
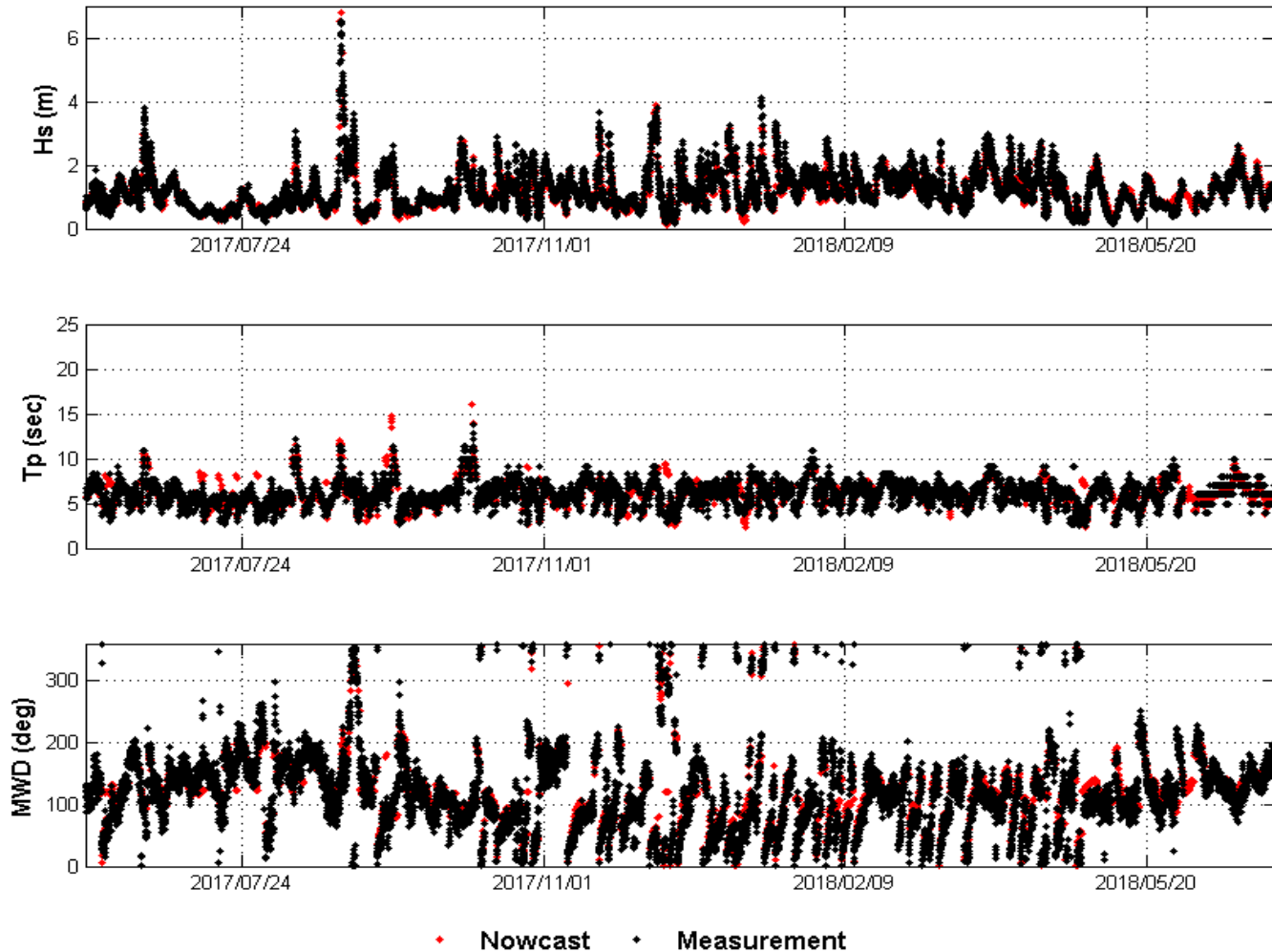


Wave forecast vs Measurement



Wave forecast in 7 days

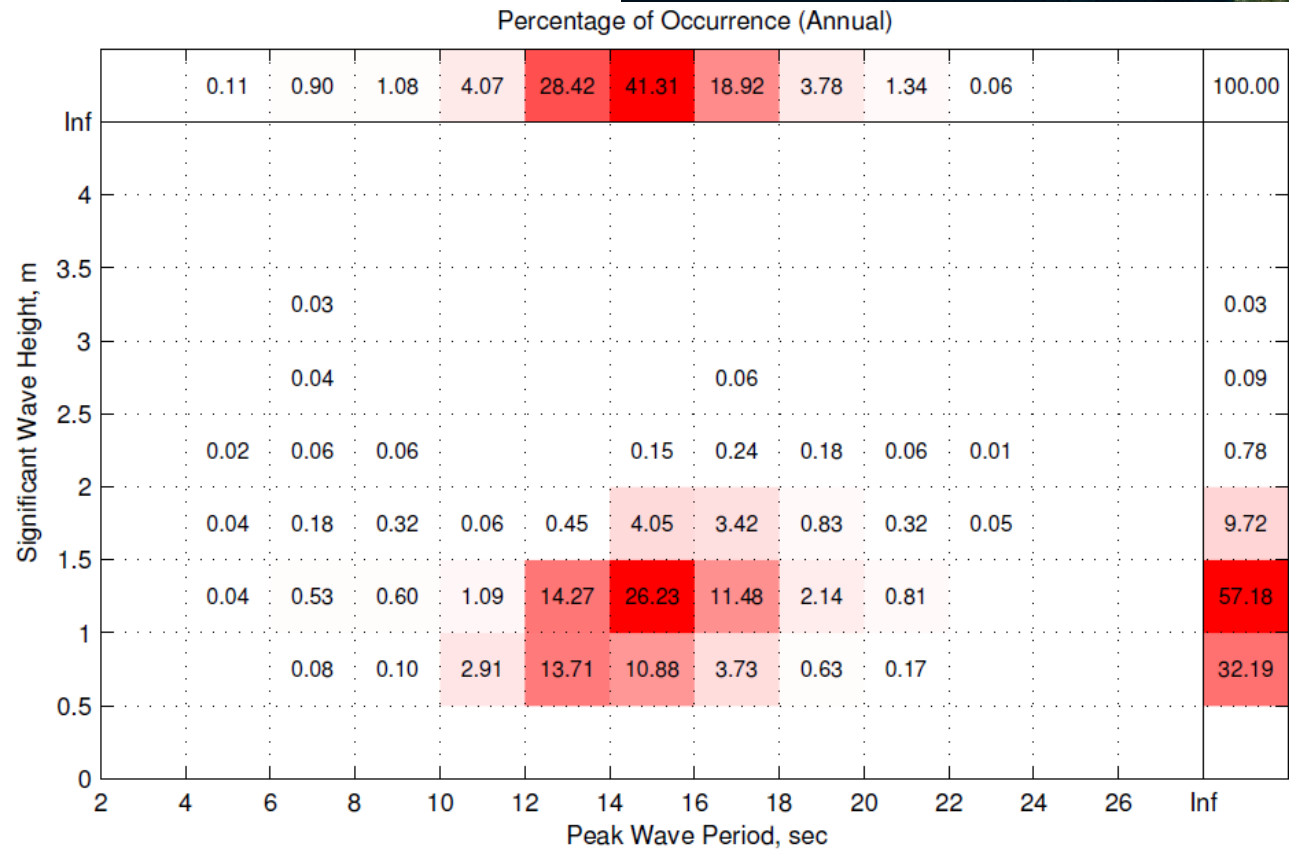
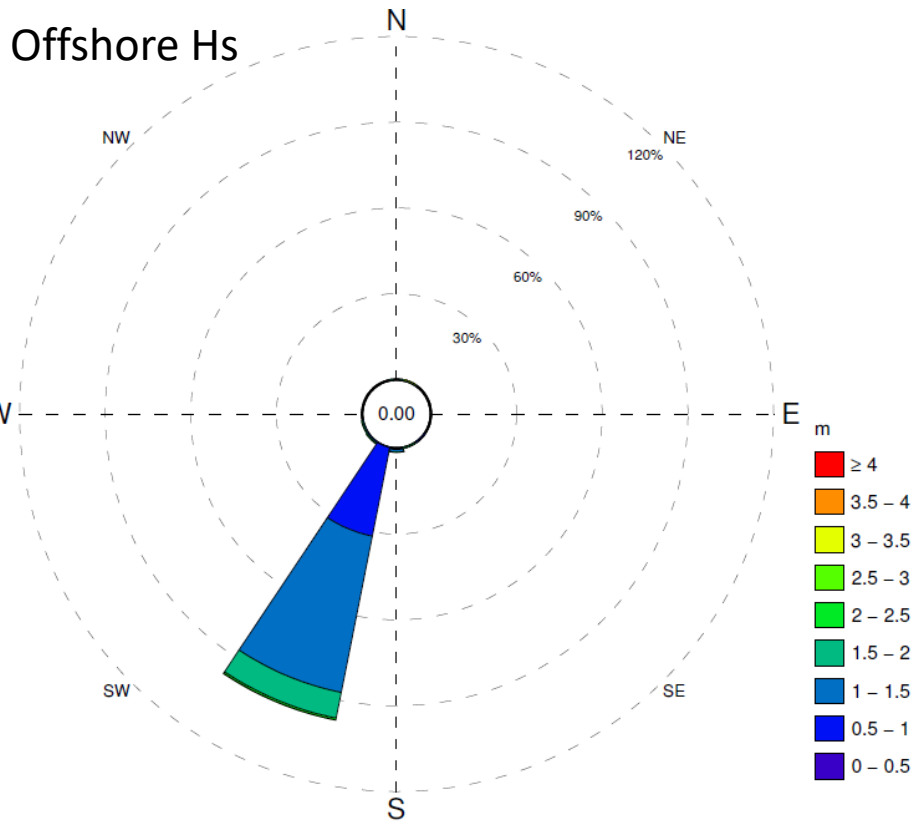
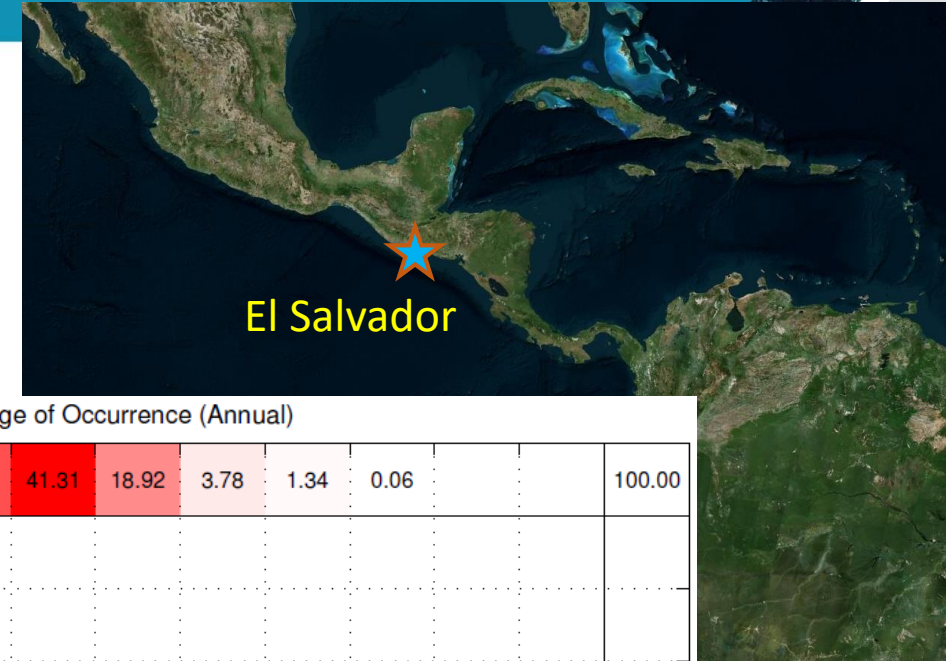
WWIII Wave Forecast – Gulf of Mexico



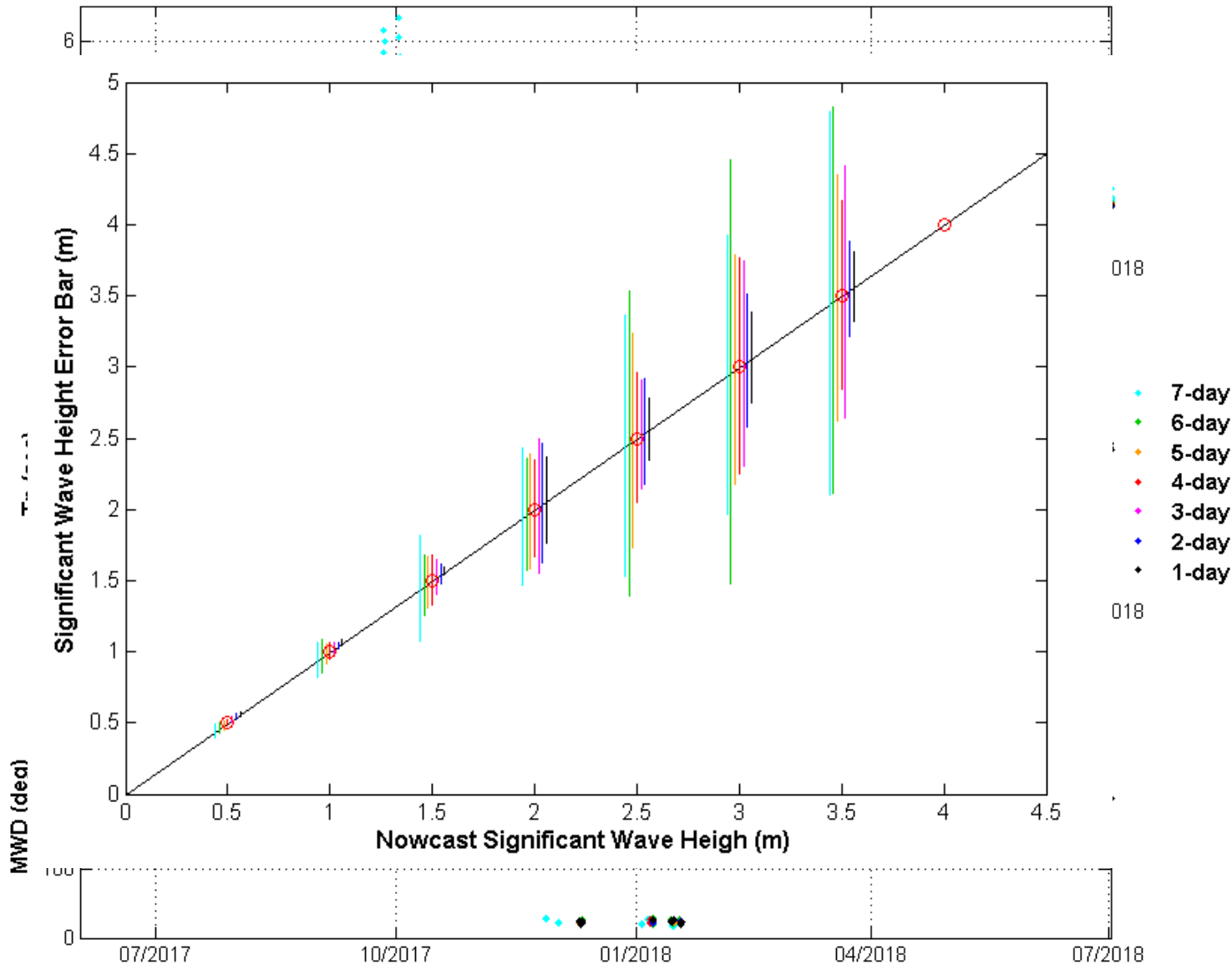
Wave Forecast vs Measurement

WWIII Wave Forecast – El Salvador Offshore

Unidirectional Swells



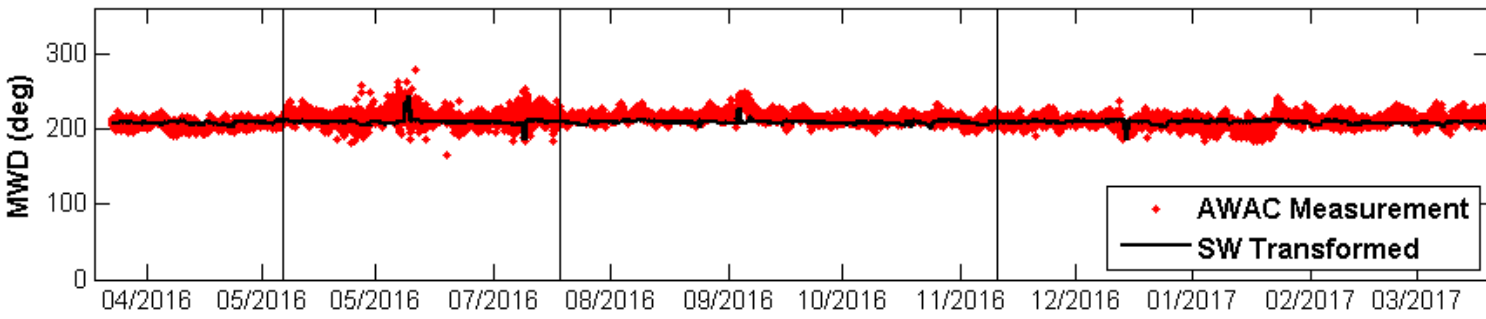
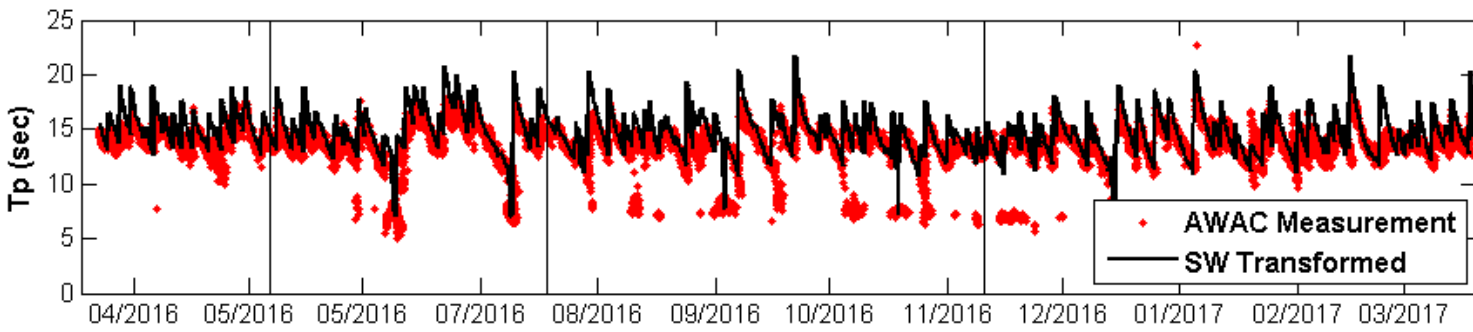
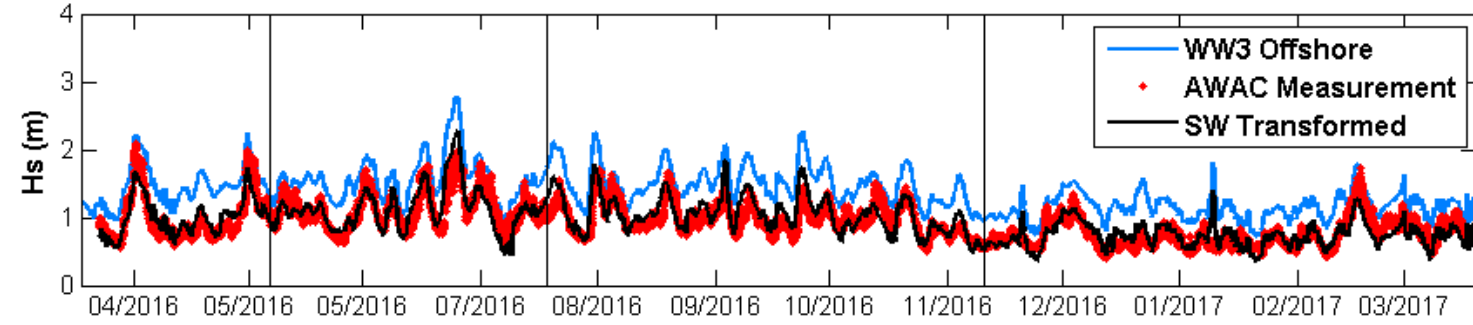
WWIII Wave Forecast – El Salvador Offshore



Wave forecast in 7 days



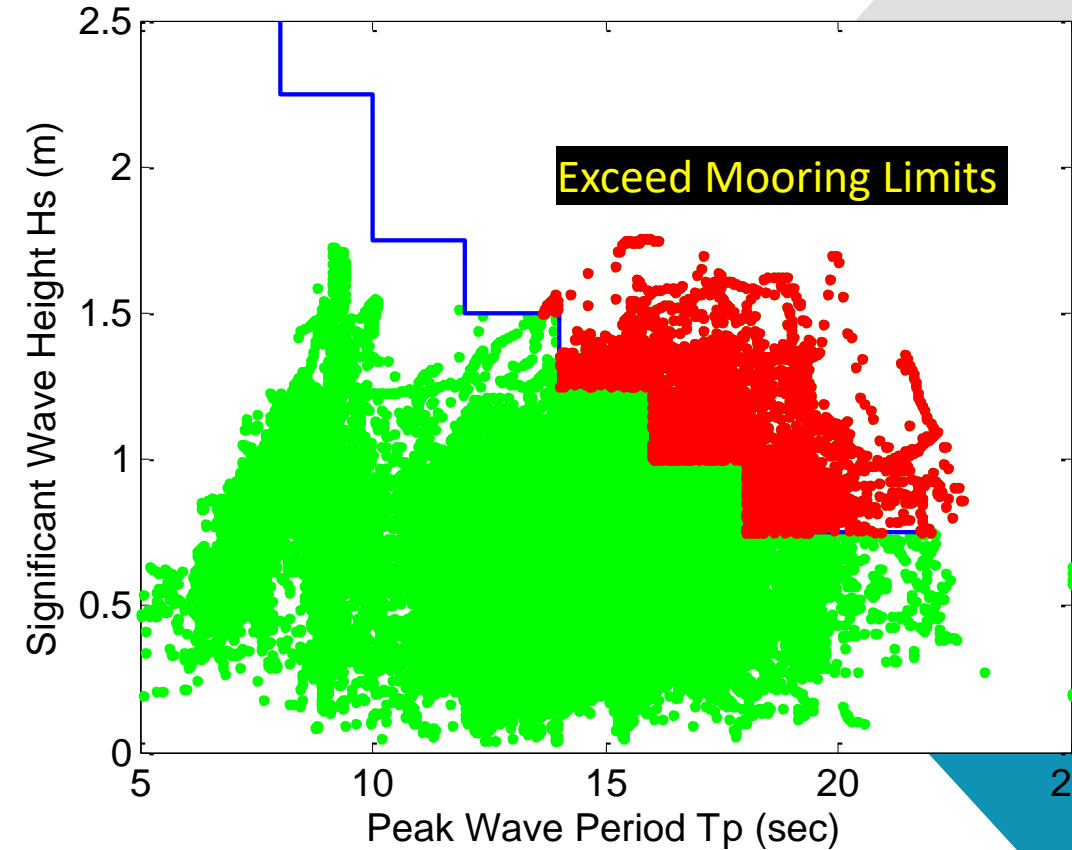
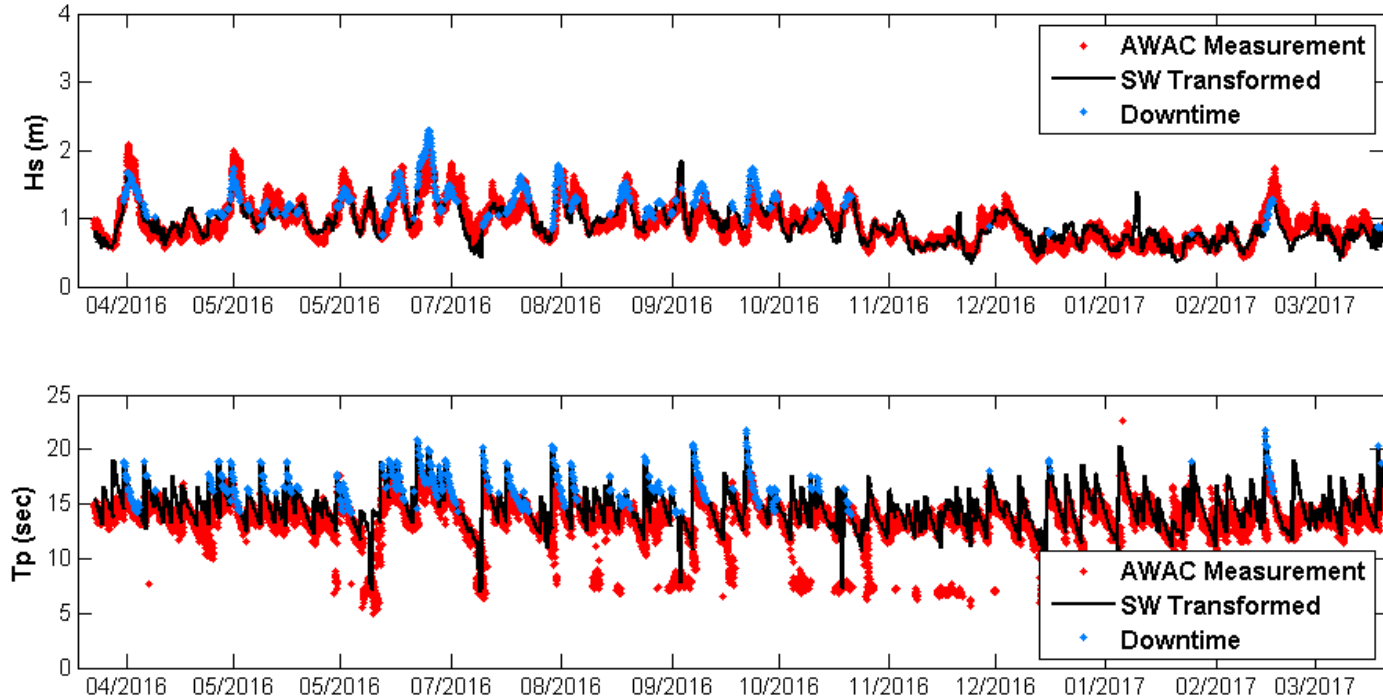
Wave Forecast at A Terminal in El Salvador



Wave forecast at the Site
Spectral Wave Modeling



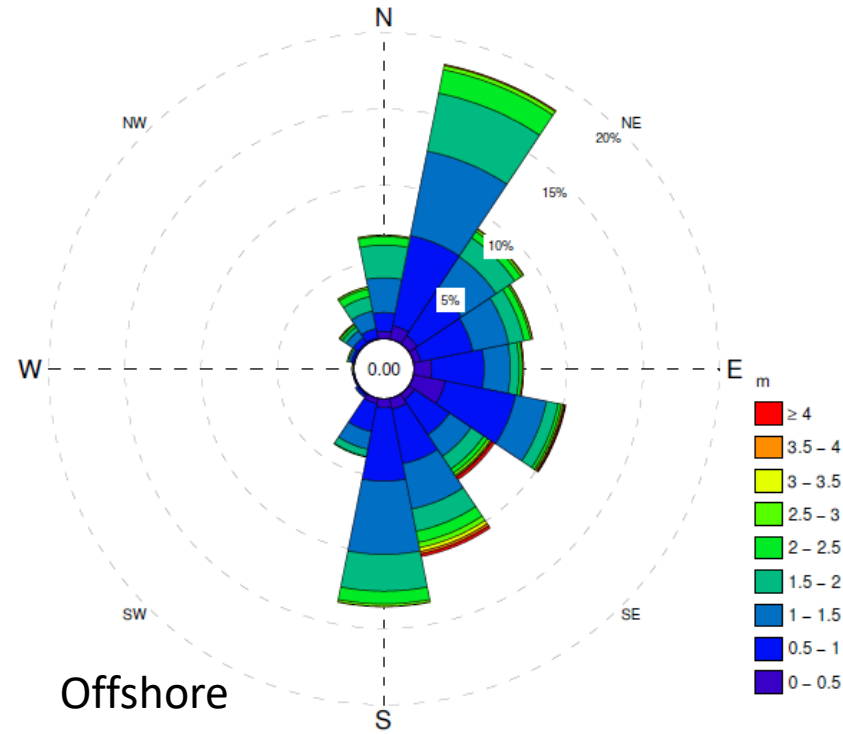
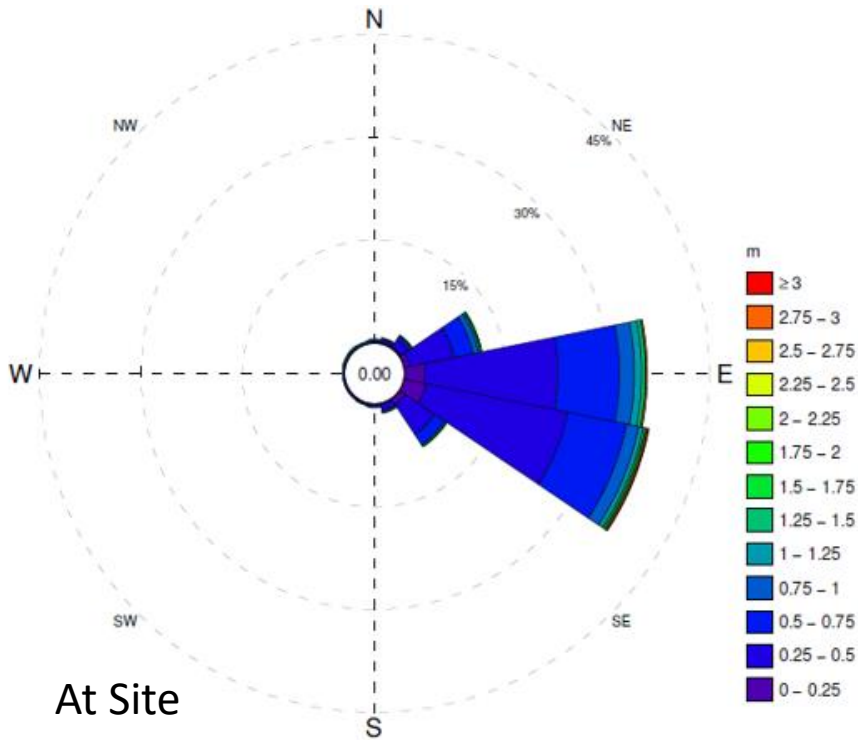
Wave Forecast at A Terminal in El Salvador



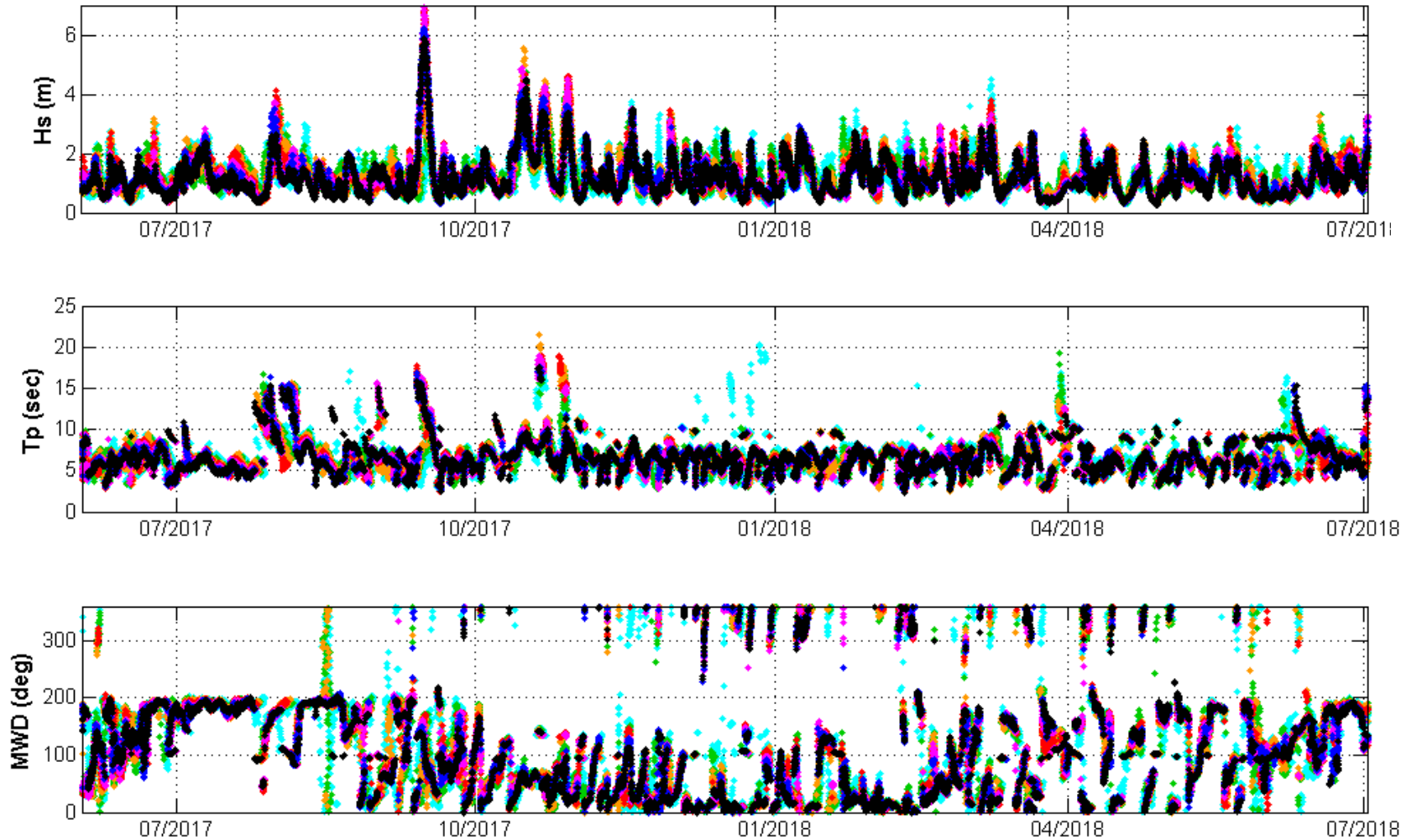
Confidence in Hs Estimated Error (m)	Downtime Estimate
0.0	20.7%
0.1	27.3%
0.2	37.4%
0.5	...

Wave limit from mooring study

WWIII Wave Forecast – China East



WWIII Wave Forecast - East China Offshore

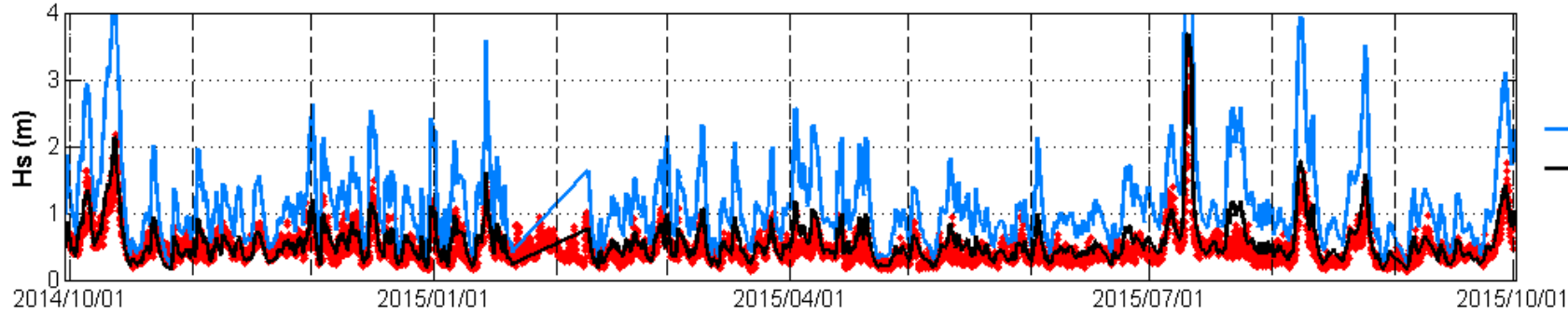


Wave forecast in 7 days

- 7-day
- 6-day
- 5-day
- 4-day
- 3-day
- 2-day
- 1-day

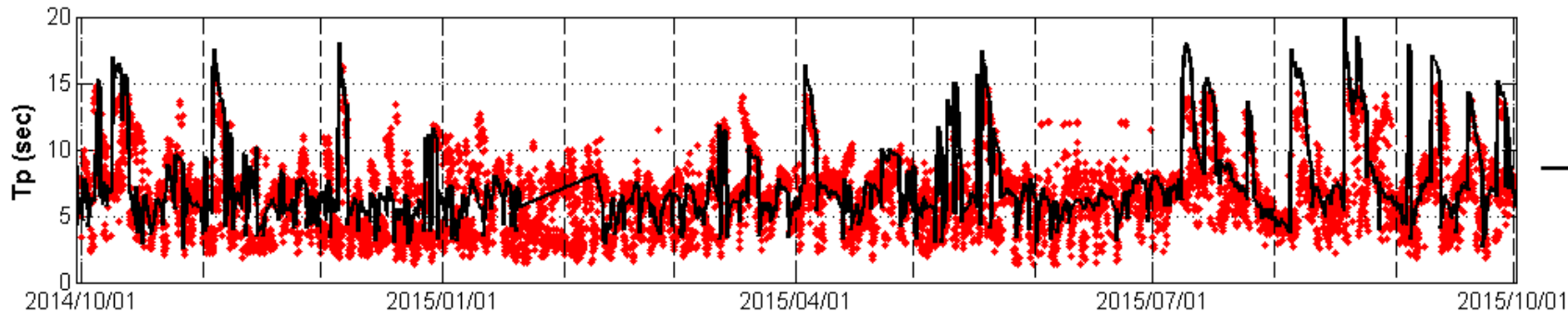


Wave Forecast at A Terminal in East China

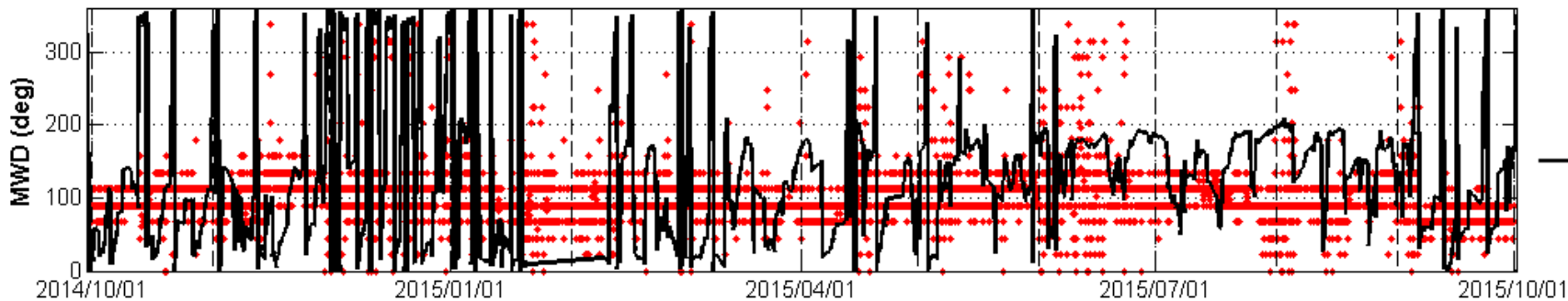


◆ Measurement
— WW3 Offshore
— Transformed

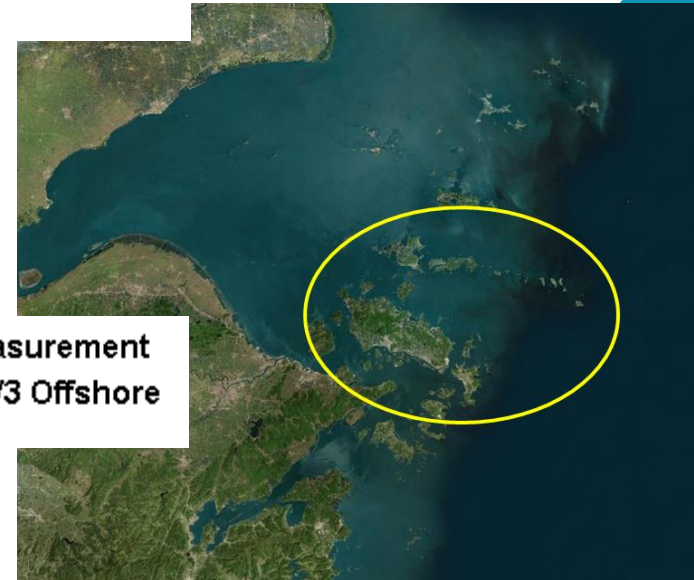
Wave forecast at the Site
Linear Regression



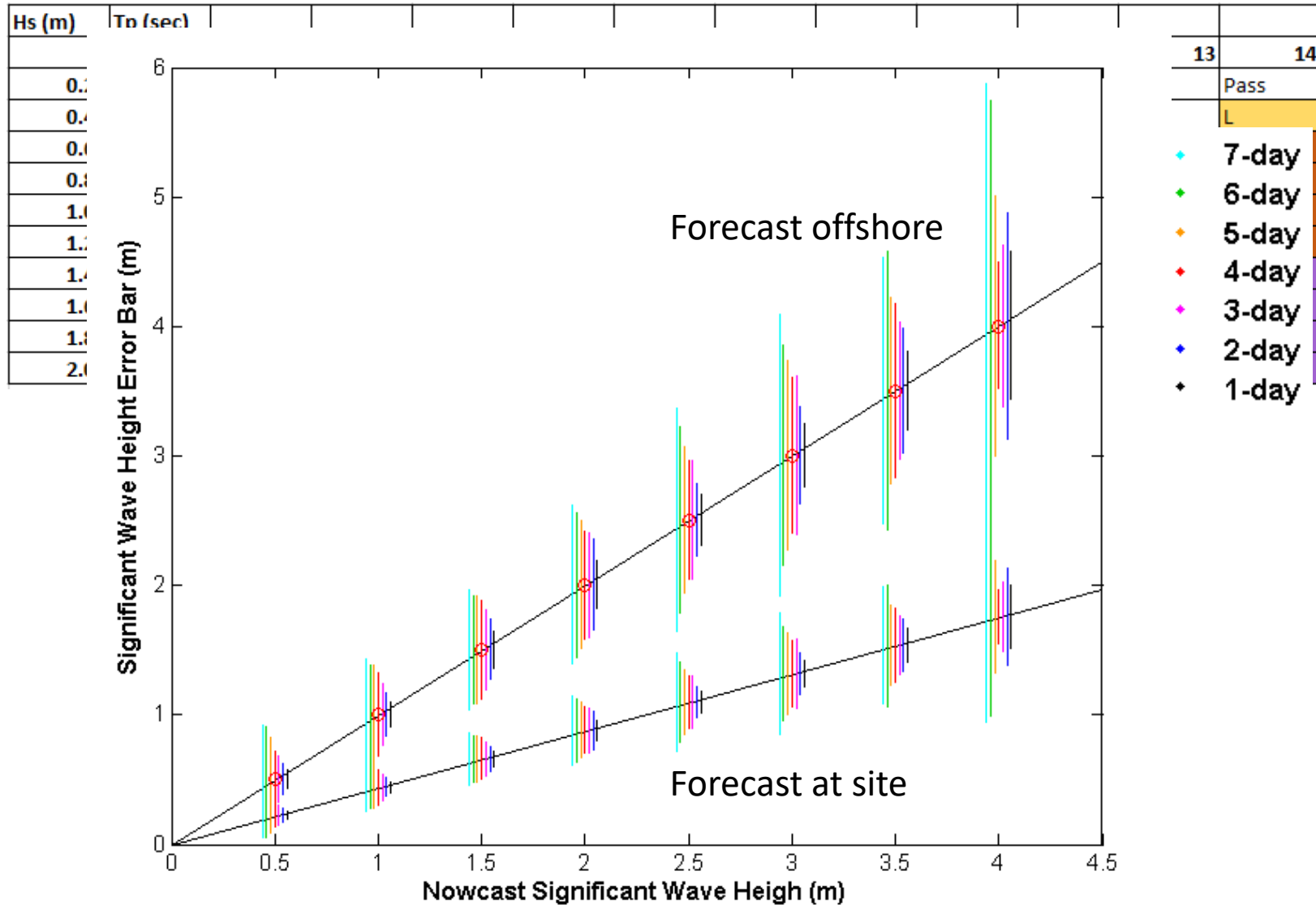
◆ Measurement
— WW3 Offshore



◆ Measurement
— WW3 Offshore



Wave Forecast at A Terminal in East China



Wave forecast in 7 days



Summary

- A reliable wave forecast system at the project site is possible:
 - ✓ An accurate offshore wave forecast (free, high quality)
 - ✓ A correlating look-up matrix (one-time relatively small effort)
 - ✓ Wave measurement done (on-going) at the site
- The onsite wave forecast system will help the terminal operators:
 - ✓ Increase confidence in terminal operations
 - ✓ Improve the vessel call & storage planning – could reduce capital \$\$
 - ✓ Reduce potential downtime – increasing throughput
 - ✓ Reduces likelihood of emergency evacuations & potential damage to the facility