# MOTUS Wave Buoys

*Powered By the Aanderaa MOTUS Directional Wave Sensor*

# Two Buoys, One Brain

The Aanderaa MOTUS directional wave sensor factory calibrated and currently available on two proven buoy platforms:


Tideland SB138-P MOTUS

- Globally proven navigation buoy
- Deployable in waters with up to 500 meter depths

YSI EMM 2.0 MOTUS

- Extremely robust
- Additional payload security
- Utilizing Gilman floats

*Ask Aanderaa about additional buoy platforms*

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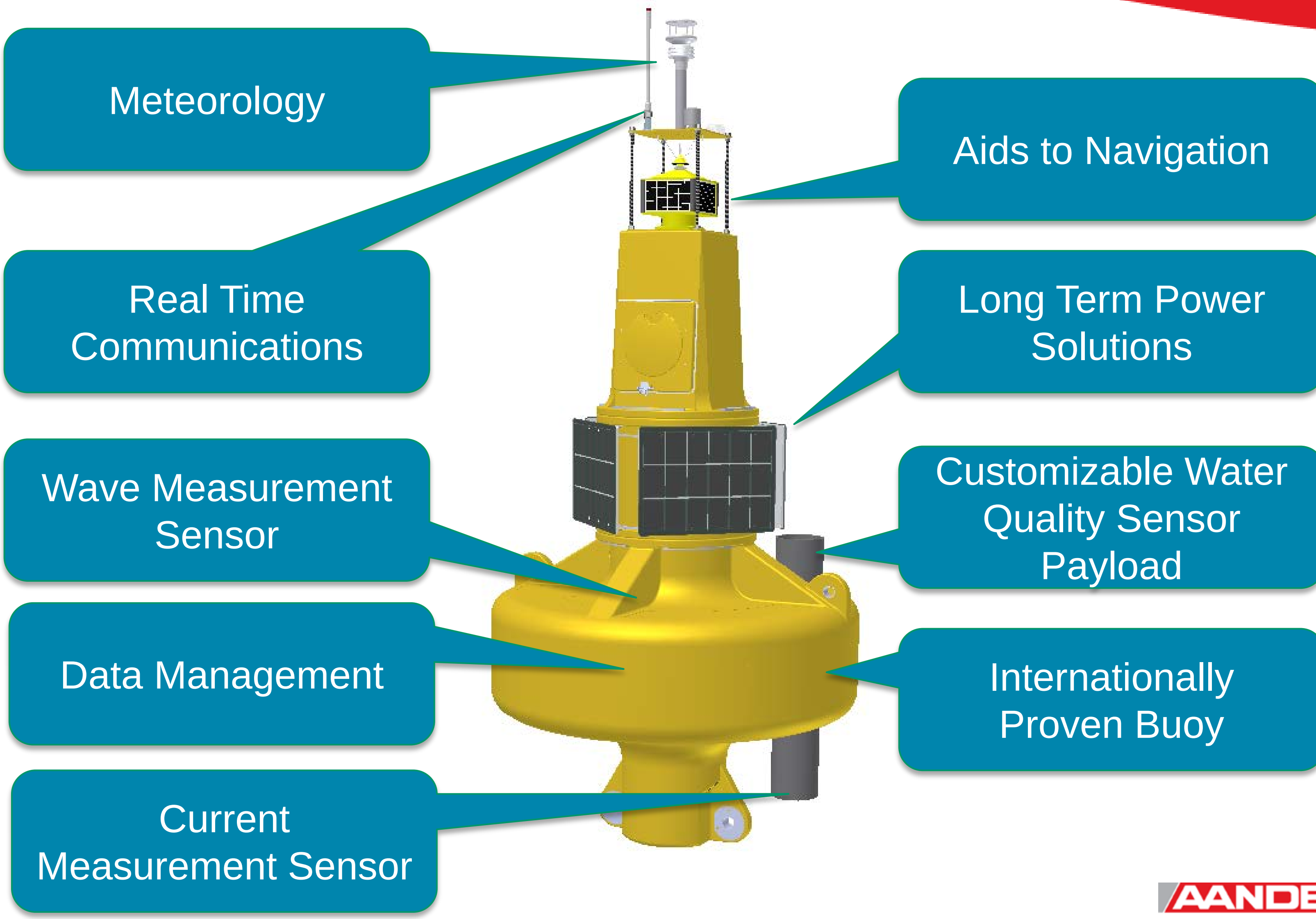
# Measure accurate wave parameters

with the flexibility of a Met Ocean (ODAS) buoy

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# Data Buoy Instrumentation Packages

**Wave**

- Height
- Period
- Direction
- More…

**Currents**

- Single point
- Current Profile

**Water Quality**

- Dissolved Oxygen
- Conductivity
- Temperature
- pH
- Oil in Water
- More…

**Meteorology**

- Wind
- Atmospheric Pressure
- Air Temperature
- Visibility
- Third party sensors

# Additional Buoy Packages

**Aids to Navigation**

- Lights
- AIS
- RACON

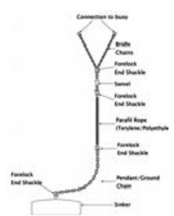
**Communication & Data Management**

- Data loggers
- GOES
- Satellite
- Acoustic Modem
- AIS

**Power Solutions**

- Solar
- Battery
- Power manager

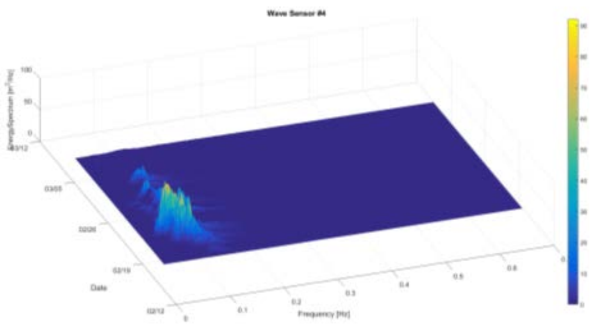
**Mooring**



- Wide Variety to match needs

# Aandeara MOTUS Processed Wave Parameters

| Output parameters | Symbol | Type |
|---|---|---|
| Significant Wave Height/Swell/Wind | $H_{m0}$ | Operational |
| Peak Wave Direction Height/Swell/Wind | $\theta$ | Operational |
| First Order Spread | $\sigma$ | Operational |
| Mean Spreading Angle | $\theta_k$ | Operational |
| Peak Wave Period | $T_p$ | Operational |
| Mean Wave Period | $T_{m02}$ | Operational |
| Long Crestedness Parameter | $\tau$ | Operational |
| Mean Wave Direction | $\theta_{avg}$ | Operational |
| Wave Energy Spectrum | E(f) | Research |
| Directional Wave Spectrum | $DWS_m(f)$ | Research |
| Principal Wave Directional Spectrum | $DWS_p(f)$ | Research |
| Orbital Ratio Spectrum | K(f) | Research |
| Fourier Coefficients Spectra | A1,B1,A2,B2 | Research |

- Possibility to independently select which parameters to store and transmit to shore
- User selectable separation frequency for swell/wind driven wave parameters.

# Improved Measurement Accuracy by a Fast Sampling Rate and Mechanical Dampening

- In the Aanderaa MOTUS Directional Wave Sensor, accuracy is improved and noise reduced by sampling the movement **100 times a second**, advanced **filtering** techniques, and mechanical **dampening** to remove unwanted vibrations

- The **inertial measurement unit** (**IMU**) is the core of the Aanderaa MOTUS Directional Wave Sensor
  - Sample rate, external noise, and sensor accuracy largely define reading accuracy
  - The fast sampling rate and external compass option ensure the performance of the MOTUS sensor
  - The accurate 9-axis IMU selected measures a body's orientation and linear acceleration as well as the magnetic field surrounding the body,
  - It uses a combination of accelerometers, gyroscopes, and magnetometers.



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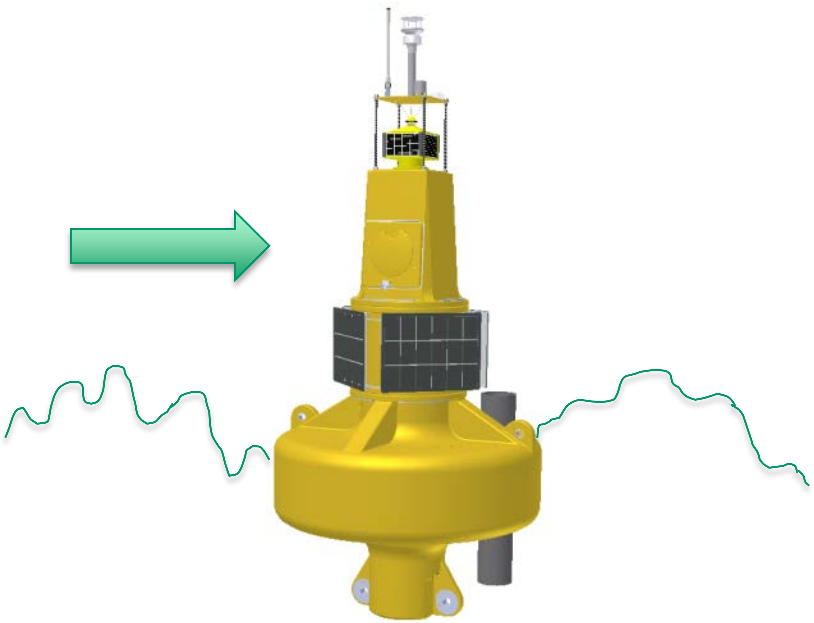
# Compensate for Load on Buoy

- The Aanderaa MOTUS compensates for different buoy loads
  - Variety of sensor packages
  - Variety of moorings

- A heavy chain in deeper waters may result in a different wave response from the buoy than utilizing a lighter mooring with floats

- Up to 171 possible correction factors for buoy frequency response

- MOTUS provides maximum system flexibility without sacrificing wave measurement accuracy



*Compensate for dampening of higher frequency waves*



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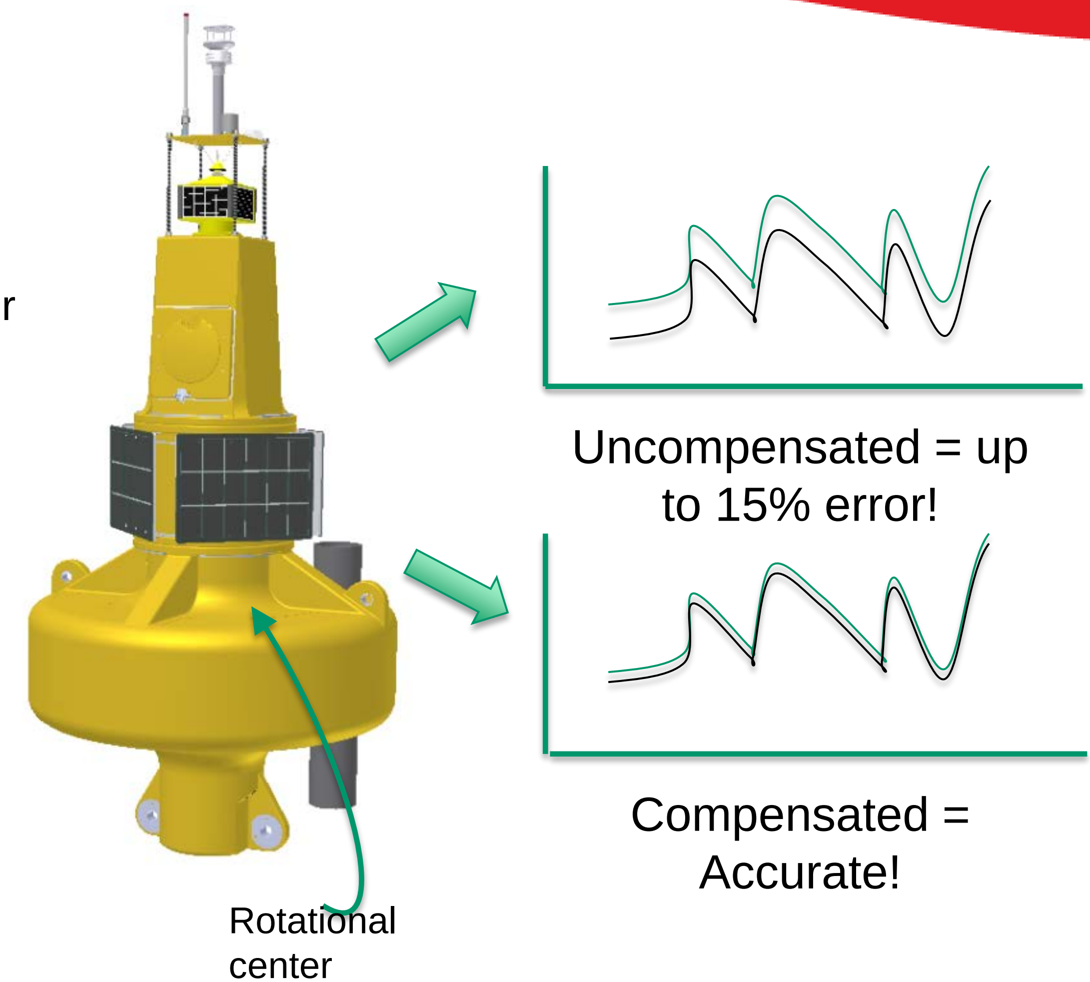
# Compensate for Sensor Position

- The Aanderaa MOTUS compensates for different sensor positions
- Provides flexible solutions for mounting the sensor where possible on a MetOcean buoy



# Eliminate Errors from System Interference

Buoy steel structures and some magnetic sensor components can affect direction measurements.

- Interface for external compass
  - Direct to sensor
  - Through Data logger

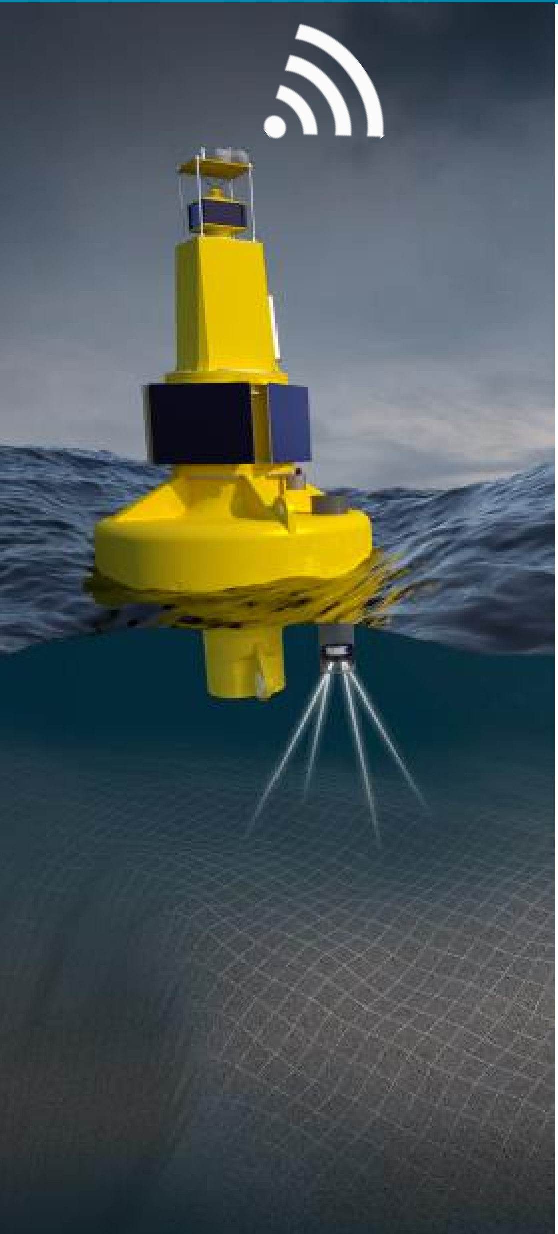
- External Compass Options:
  - Aanderaa compass unit
  - General NMEA compass
  - Specific NMEA compass

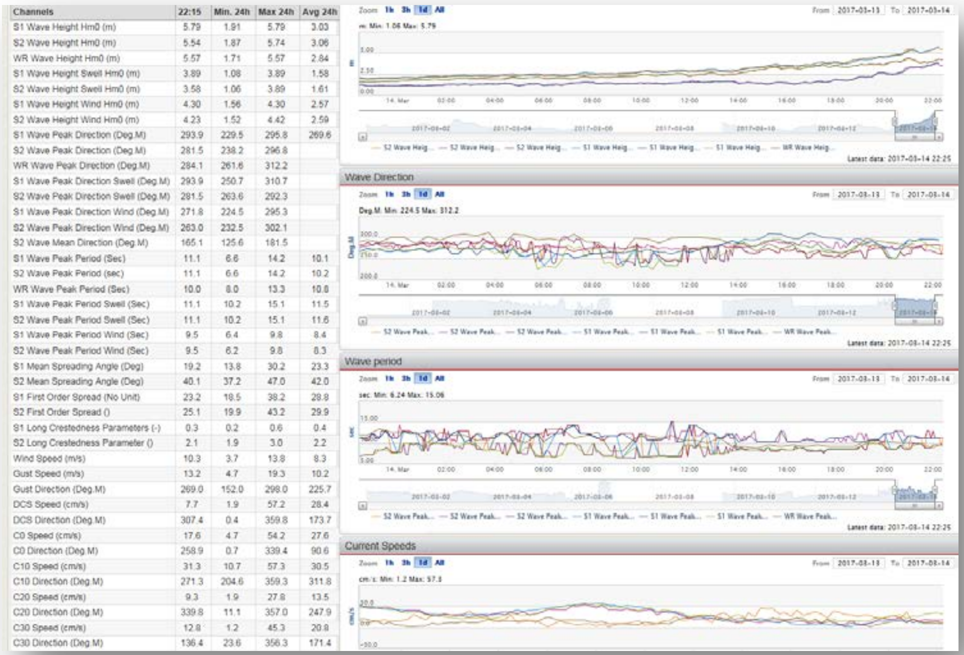

# Low Power

- MOTUS utilizes active low power techniques
- Requires 110mW
- Reduced need for big, bulky battery compartments and solar panels

*Low power – less batteries and solar cells – easier deployment – simpler mooring – lower initial cost  - lower total cost of ownership*

# Real Time and Historical Information with GeoView





| Channels | 22:15 | Min. 24h | Max 24h | Avg 24h |
|---|---|---|---|---|
| S1 Wave Height Hm0 (m) | 5.79 | 1.91 | 5.79 | 3.03 |
| S2 Wave Height Hm0 (m) | 5.54 | 1.87 | 5.74 | 3.06 |
| WR Wave Height Hm0 (m) | 5.57 | 1.71 | 5.57 | 2.84 |
| S1 Wave Height Swell Hm0 (m) | 3.89 | 1.08 | 3.89 | 1.58 |
| S2 Wave Height Swell Hm0 (m) | 3.58 | 1.06 | 3.89 | 1.61 |
| S1 Wave Height Wind Hm0 (m) | 4.30 | 1.56 | 4.30 | 2.57 |
| S2 Wave Height Wind Hm0 (m) | 4.23 | 1.52 | 4.42 | 2.59 |
| S1 Wave Peak Direction (Deg.M) | 293.9 | 229.5 | 295.8 | 269.6 |
| S2 Wave Peak Direction (Deg.M) | 281.5 | 238.2 | 296.8 | |
| WR Wave Peak Direction (Deg.M) | 284.1 | 261.6 | 312.2 | |
| S1 Wave Peak Direction Swell (Deg.M) | 293.9 | 250.7 | 310.7 | |
| S2 Wave Peak Direction Swell (Deg.M) | 281.5 | 263.6 | 292.3 | |
| S1 Wave Peak Direction Wind (Deg.M) | 271.8 | 224.5 | 295.3 | |
| S2 Wave Peak Direction Wind (Deg.M) | 263.0 | 232.5 | 302.1 | |
| S2 Wave Mean Direction (Deg.M) | 165.1 | 125.6 | 181.5 | |
| S1 Wave Peak Period (Sec) | 11.1 | 6.6 | 14.2 | 10.1 |
| S2 Wave Peak Period (sec) | 11.1 | 6.6 | 14.2 | 10.2 |
| WR Wave Peak Period (Sec) | 10.0 | 8.0 | 13.3 | 10.8 |
| S1 Wave Peak Period Swell (Sec) | 11.1 | 10.2 | 15.1 | 11.5 |
| S2 Wave Peak Period Swell (Sec) | 11.1 | 10.2 | 15.1 | 11.6 |
| S1 Wave Peak Period Wind (Sec) | 9.5 | 6.4 | 9.8 | 8.4 |
| S2 Wave Peak Period Wind (Sec) | 9.5 | 6.2 | 9.8 | 8.3 |
| S1 Mean Spreading Angle (Deg) | 19.2 | 13.8 | 30.2 | 23.3 |
| S2 Mean Spreading Angle (Deg) | 40.1 | 37.2 | 47.0 | 42.0 |
| S1 First Order Spread (No Unit) | 23.2 | 18.5 | 38.2 | 28.8 |
| S2 First Order Spread () | 25.1 | 19.9 | 43.2 | 29.9 |
| S1 Long Crestedness Parameters (-) | 0.3 | 0.2 | 0.6 | 0.4 |
| S2 Long Crestedness Parameter () | 2.1 | 1.9 | 3.0 | 2.2 |
| Wind Speed (m/s) | 10.3 | 3.7 | 13.8 | 8.3 |
| Gust Speed (m/s) | 13.2 | 4.7 | 19.3 | 10.2 |
| Gust Direction (Deg.M) | 269.0 | 152.0 | 298.0 | 225.7 |
| DCS Speed (cm/s) | 7.7 | 1.9 | 57.2 | 28.4 |
| DCS Direction (Deg.M) | 307.4 | 0.4 | 359.8 | 173.7 |
| C0 Speed (cm/s) | 17.6 | 4.7 | 54.2 | 27.6 |
| C0 Direction (Deg.M) | 258.9 | 0.7 | 339.4 | 90.6 |
| C10 Speed (cm/s) | 31.3 | 10.7 | 57.3 | 30.5 |
| C10 Direction (Deg.M) | 271.3 | 204.6 | 359.3 | 311.8 |
| C20 Speed (cm/s) | 9.3 | 1.9 | 27.8 | 13.5 |
| C20 Direction (Deg.M) | 339.8 | 11.1 | 357.0 | 247.9 |
| C30 Speed (cm/s) | 12.8 | 1.2 | 45.3 | 20.8 |
| C30 Direction (Deg.M) | 136.4 | 23.6 | 356.3 | 171.4 |



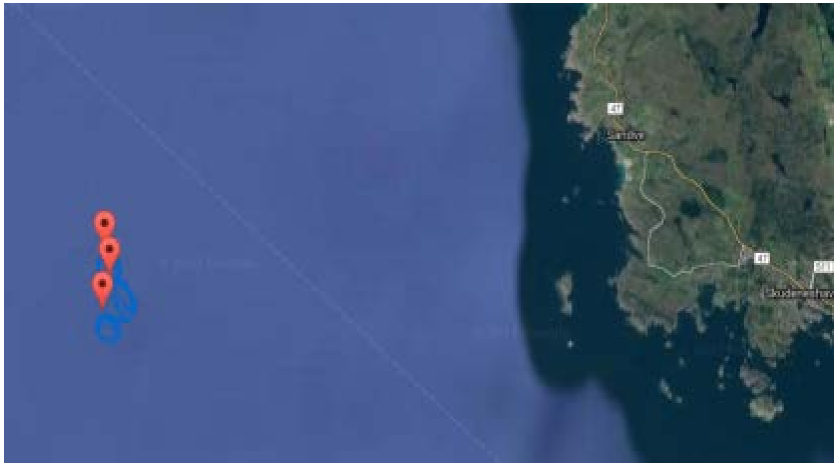
GeoView provides vast opportunities for interfacing meteorological, oceanographic or other environmental research equipment in a networked solution giving access to data real-time.

# Buoy Configuration Opportunities

- The MOTUS Wave Direction Buoys feature solutions with a proven track record
  - SB-138P and EMM2.0 in coastal environments
  - Library of buoy configuration customizable to your need
  - Vast number of buoy installations across the globe
- Solar Power provides years of service
- Industry leading sensors from Aanderaa and YSI with fouling resistance
- Real-time data solutions over Iridium, local mobile networks, radio, AIS

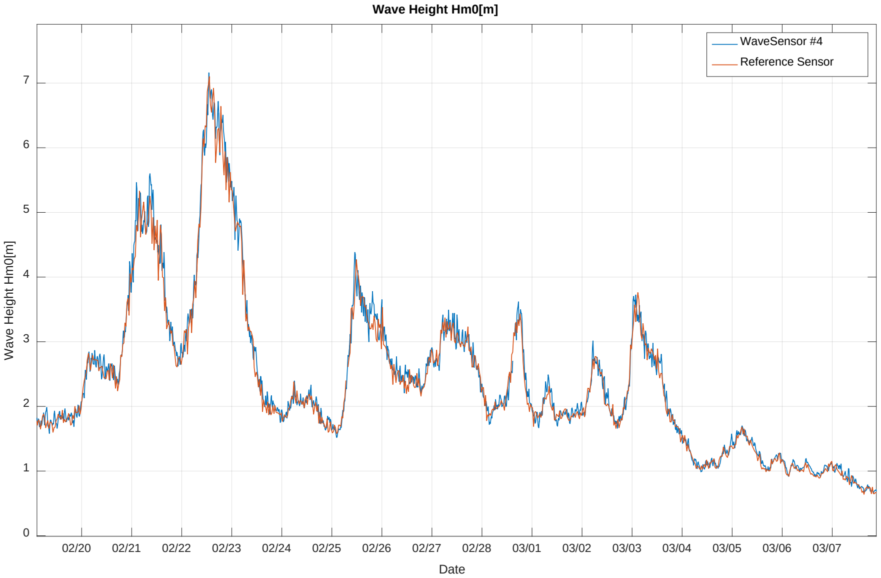
| | |
|---|---|
| Dedicated wave buoy | Hyd/Met buoy |
| Current/ wave buoy | Navigation/ wave buoy |
| Wave/ water quality buoy | |

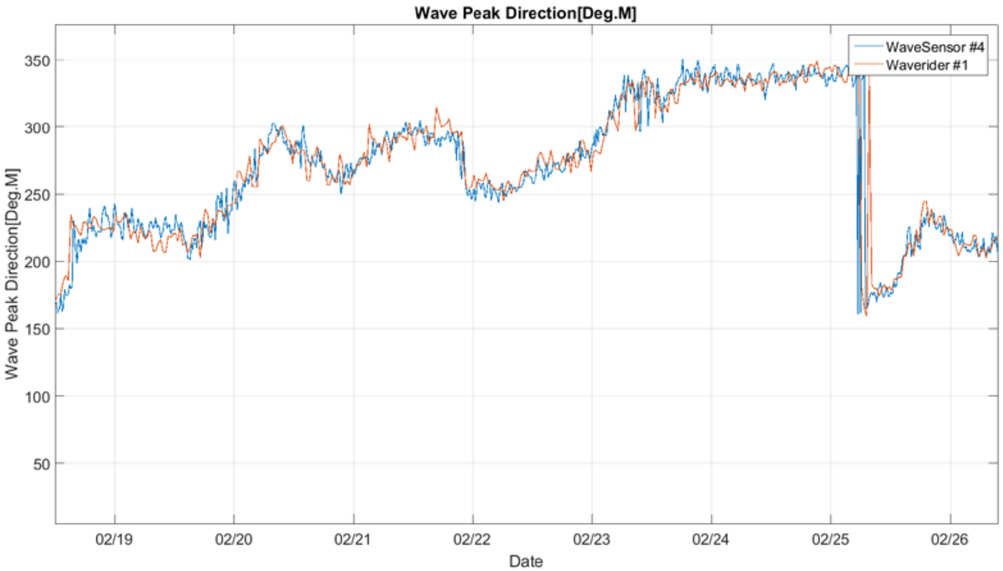
# Test site Area: Statoil Hywind Test Field West of Karmøy



- Two buoys and one Datawell Waverider were deployed in the North sea approximately 4 nm off the coast of Karmøy.
- One Tideland SB138P, buoy was fitted with Motus wave sensor #4, Buoy orientation sensor, In line DCS single point current sensor, Gill wind sensor and GPS.
- One EMM2.0 buoy was fitted with two Motus wave sensors, Buoy orientation sensor, In line DCS single point current sensor, DCPS Current profiler, Gill wind sensor and GPS.
- One of the EMM 2.0 wave sensors (#2) were located close to the buoy COG, and the other wave sensor were located close to the outer top edge of the floating cylinder in order to evaluate the effect of the installation position and the build in offset compensation algorithm.

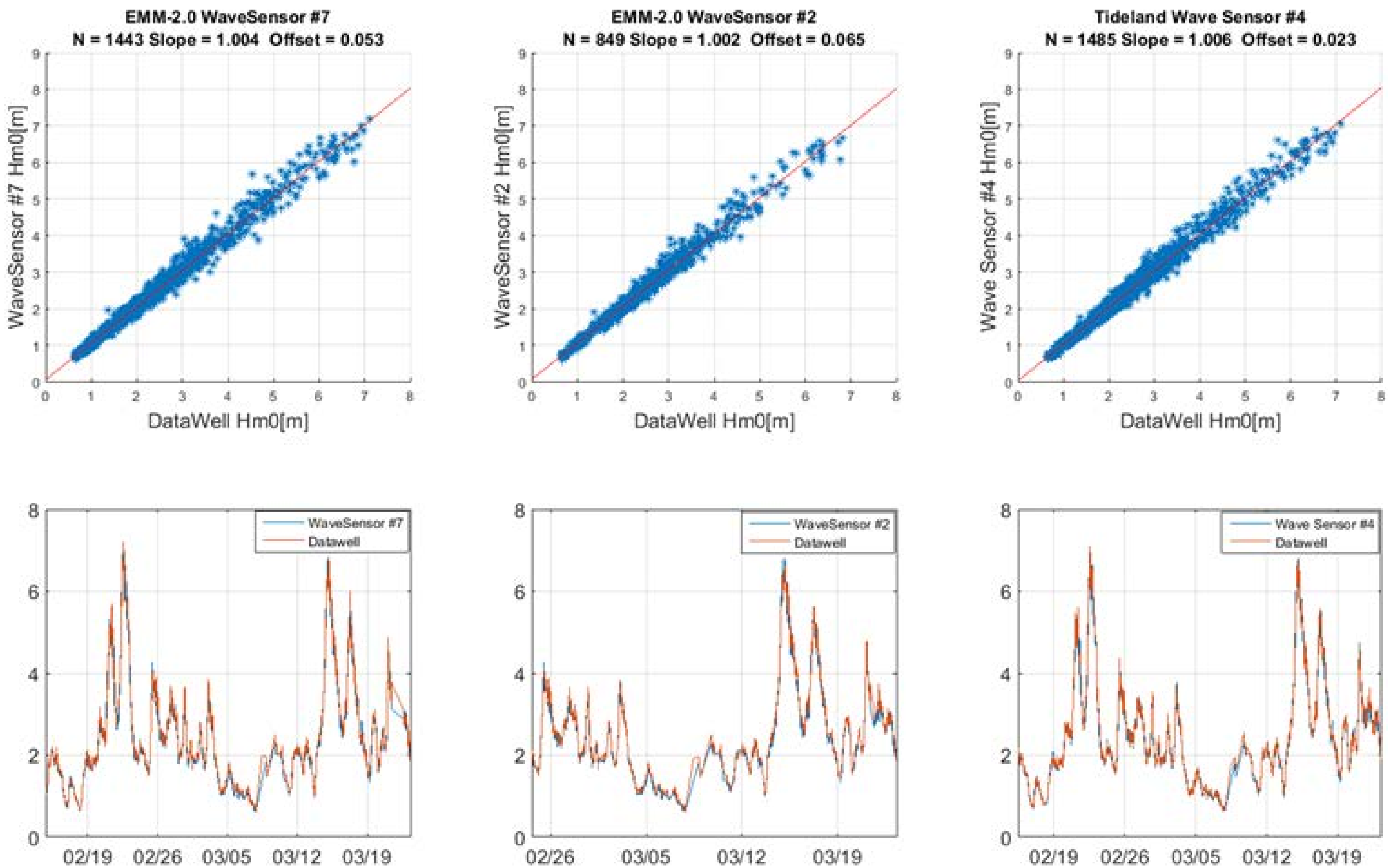
# Sea Comparison Results



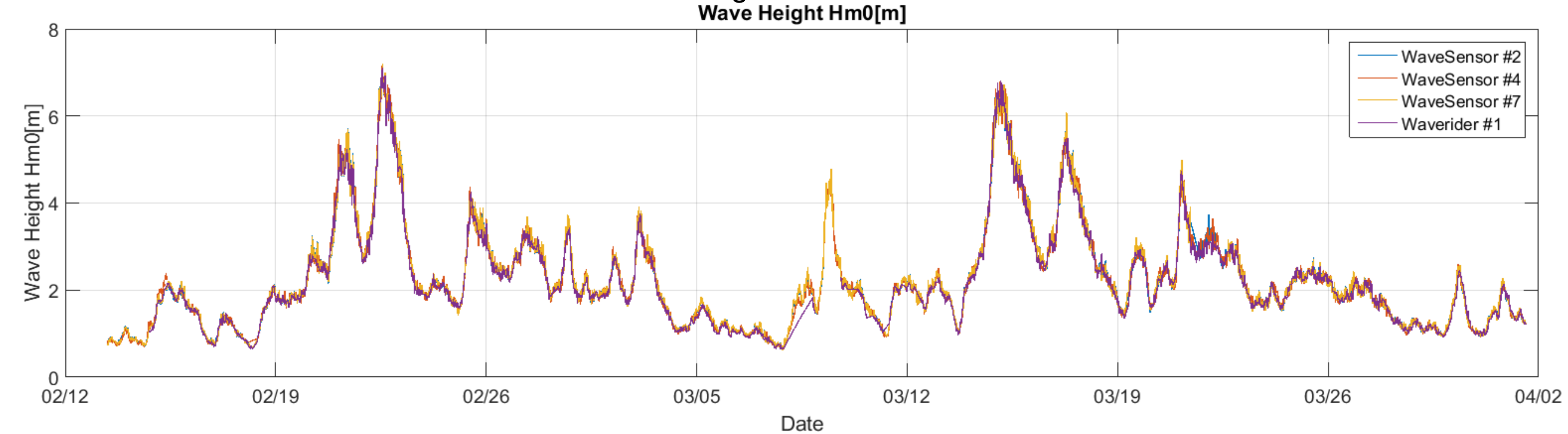

- Comparison of Significant wave height for Datawell and Tideland/EMM2.0 shows excellent agreement.
- Comparison of Wave Peak Direction for Datawell and Tideland/EMM2.0 shows excellent agreement.

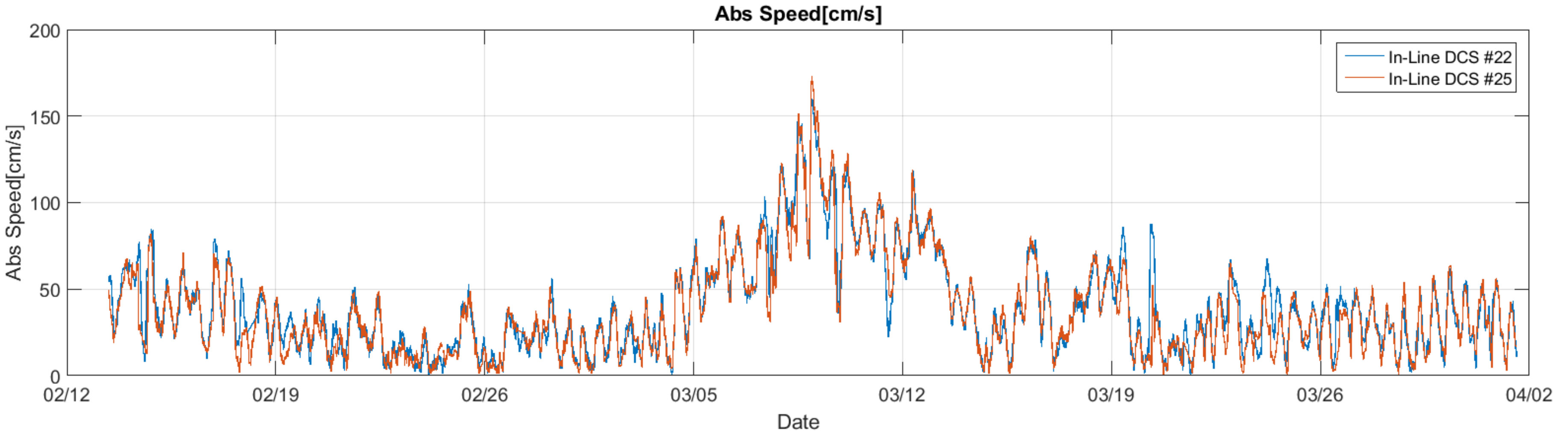
# Comparison MOTUS vs. Waverider



# Current measurements in high sea state

- Current measurements correlate well between buoys even in high waves
- Wave measurements correlate well even in high current condictions



# In Summary

- MOTUS Wave buoys offer accurate wave measurements from a full scale metocean buoy
- Utilizing different configuration settings, the buoys wave response can be optimized
- MOTUS buoys also measure accurate currents, water quality, meteorology and provides a platform to navigational aids