University of New Orleans

ScholarWorks@UNO

Ocean Waves Workshop

Jan 15th, 3:15 PM - 4:00 PM

Session 4 Presentation - Establishing the Provenance of NDBC's Accuracy Statement for Directional Waves

Richard H. Bouchard
National Data Buoy Center (NDBC), Stennis Space Center, MS USA, Richard.Bouchard@noaa.gov

Rodney Riley
National Data Buoy Center (NDBC), Stennis Space Center, MS USA

Establishing the Provenance of NDBC's Accuracy Statement for Directional Waves

Richard H. Bouchard [1] and Rodney Riley[1]
[1] National Data Buoy Center (NDBC), Stennis Space Center, MS USA
*Corresponding author: richard.bouchard@noaa.gov

1. Introduction

The National Data Buoy Center (NDBC) has made measurements of wave directions from moored buoys for about 30 years. During that period, NDBC has fielded a variety of directional wave systems and has increased the number of stations with directional wave measurements as cost and size of the sensors and processing system have been reduced.

NDBC publishes an accuracy statement of 10° for wave directions

http://www.ndbc.noaa.gov/rsa.shtml.

However, the basis and traceability (or provenance) of that accuracy statement is not widely known or understood. Many of the analysis reports used to determine accuracy have not been published. NDBC is presently collecting and reviewing with the intent of publishing at least summaries of the methods used and the results.

This paper will review the basics of NDBC directional wave processing and terminology, and the common approaches NDBC has employed to make a determination of the accuracy of its wave direction measurements.

2. NDBC Directional Wave Parameters

NDBC uses the method of [1] for heave, pitch, and roll buoys to determine wave directions. The results of applying a Fast Fourier Transform are the first 5 Fourier Coefficients at each frequency. These Coefficients are then transformed into the four World Meteorological Organization [2] directional wave parameters at each frequency:

- Mean Wave Direction (α_1)
- Principal Wave Direction (α_2)
- First Normalized Polar Coordinate (r_1)
- Second Normalized Polar Coordinate (r_2)

The term *Mean Wave Direction* is also used as a short-hand for *Mean Wave Direction at the Peak Frequency* (MWD). *Peak Frequency* is the frequency of the most energy density in the spectrum. It is this latter use of the term *Mean Wave Direction* to which the accuracy statement generally refers. A complete description of NDBC's directional wave measurements can be found in [3].

3. Determination of Accuracy

The 10° accuracy claim can be traced to [4], although demonstrations of accuracy appear in the NDBC literature prior to this, and generally refer to the *Mean Wave Direction at the Peak Frequency.* The accuracy statement is one of the criteria used to certify or commission new wave systems for operational use. That determination is conducted by an intercomparison of a reference system, which is a previously certified or commissioned system, with a candidate system. The intercomparison is performed during a limited period field evaluation. The 10° metric is generally a *Root Mean Square Difference* (RMSD) and also generally confined to when the Peak Frequency is identical for both the reference and candidate systems.

4. Pre- and Post-deployment Directional Wave Calibrations

Recently NDBC undertook a program of bringing back buoys intact to conduct post-deployment calibrations of the buoy headings for comparison to their pre-deployment calibrations to determine the stability of the accuracy of the directional wave systems. This appears to be the first time such a comparison has been documented by NDBC. Pre-deployment calibrations require no more than a 4° error in buoy heading. Four systems, deployed for periods ranging from two to four years, were subjected to the same pre-deployment calibrations upon return to NDBC. Post-deployment errors of 6° to 8° indicate that there is no significant drift in wave directions for a normal deployment period.

5. References

[1] Longuet-Higgins, M.S, D.E. Cartwright, and N.D. Smith, Observations of the Directional Spectrum of Sea Waves Using the Motions of a Floating Buoy, *Ocean Wave Spectra*, Prentice Hall, Englewood Cliffs, NJ, pp. 111-136, 1963.

[2] World Meteorological Organization, FM 65-1 WAVEOB in *Manual on Codes, VI.1, Part A, WMO No. 306*, pp. A-129-132, 1995.

[3] National Data Buoy Center, *Nondirectional and Directional Wave Data Analysis Procedures, Technical Document 96-01*, 43 pp, 1996. Available online. URL: http://www.ndbc.noaa.gov/wavemeas.pdf.

[4] Gilhousen, D.B., NDBC Directional Wave Measurements, *Proceedings of Marine Instrumentation '90, San Diego, CA*

Session IV Presentation

The Session IV Presentation can be accessed online at URL:

http://scholarworks.uno.edu/oceanwaves/2015/Session4/

Session IV Notes

Accessibility off Wave Information or Scientists, Engineers, and Managers

These notes are intended as a supplement to the presentation, "Establishing the Provenance of NDBC's Accuracy Statement for Directional Waves." The following discussion points were captured by workshop rapporteurs:

- Some earlier archived National Data Buoy Center (NDBC) wave data do not accurately compare with more recent data.

- Wave measurement networks require reliable and effective instrumentation. Large 10-12m discus hull buoys are affected by currents that will confound wave measurements. NDBC limits distribution of directional data in real-time for frequencies below 0.20 Hz.

- Magnetometer-only wave sensors have been shown to have instances of inaccurate wave directions. These systems were primarily used in the Great Lakes and Gulf of Mexico, but are no longer in use by NDBC.

- Whenever possible, wind measurements should be made from the same platforms as the wave measurements.

- Geographical coverage of *in situ* data is limited owing to the expense of deployment and maintenance of wave buoys, but efforts are underway to reduce the size and cost and increase the reliability of buoy measurements. Geographic coverage can be limited by spatial correlations in which a limited number of *in situ* sensors can accurately characterize much larger areas.

- NOAA is involved in the assessment of quality from NDBC observations that cover past and present. The addition of new wave buoys is based on operational requirements.

- Operational organizations such as NDBC are testing and evaluating sensors on a pre-operational, operational, and post-operational basis.

- Data, analyses, and reports have not been standardized to account for the traditionally provided Mean Wave Direction Root Mean Square Deviation (RMSD), biases of the Mean Wave Direction, and statistics of the spreading factor 'r_1' (The First Normalized Component from the Fourier Coefficients).

- Define terms that facilitate the comparison of standard variables at a particular wave frequency (or period). For example, NDBC uses the terminology of the World Meteorological Organization (WMO) and the conventions of the International Association for Hydro-Environment Research and Engineering (IAHR). Similarly, at NDBC "Mean wave direction" really means mean wave direction at spectral peak.

- Differences exist in measured waves from different types of platforms, sensors, processing and moorings.

- Metadata is important to making data discoverable and useful to others. It is essential to properly account for observations from varying platforms, payloads and processing systems. Pre-2011 archives at the National Ocean Data Center (NODC) have limited metadata, but more than can be found presently on the NDBC website. Since 2011, increasing amounts of metadata are now included in the netCDF files.

- Wave measuring programs need to include available programmatic and technical publications, especially data reports. Publications should be developed that improve the confidence that users have for wave measurements coming from the various types of moored buoy systems, models, and fully-integrated solutions.

- Resources such as the Coastal and Ocean Modeling Testbed (COMT) facilitate evaluation of models and provides information on selected storms and input and output values for a variety of modeling systems.

Conclusions

This workshop has been designed to support those involved in producing maritime products that increase the efficiency and safety of marine operations. At a given seaport, a variety of professionals and skilled tradesmen benefit the global economy through interactions with ships that carry cargo into and out of seaports. Meteorological and oceanographic information, especially information on waves, supports those people who bring their products to market by sea and the people at the terminals who load and unload cargo. The findings from this workshop address improvements that are possible to cope with natural hazards such as changes in sea level, extreme waves, seiching, inundation, and methods. Of particular interest are hydrological risks and capabilities that facilitate the resumption of normal marine operations following severe weather such as hurricanes or tsunami.

Areas for improvement involve better characterization of the intensely non-linear transformations that take place in the shallow waters of the inner shelf and surf zone which play critical roles in driving the processes of coastal erosion, sediment redistribution and inundation height. Included among these processes are infragravity oscillations, wave set up and surf zone circulation (along-shore currents, rips etc.). Significant advances in recent years involving nearshore field experimentation and model development could benefit from activities that are facilitated by inter-comparisons and refinements. One example described during the workshop where this is being accomplished involves the Coastal and Ocean Modeling Testbed (COMT) which encourages participation among various members of the marine technology community such as universities, government, and industry.

The Ocean Waves Workshop was initiated by applied oceanographers from Marine Information Resources Corporation and AXYS Technologies and basic researchers from the University of New Orleans to facilitate the transition of advanced buoy technologies, models, tools, toolkits and other capabilities to operational facilities and to improve the understanding and prediction of wave consequences for those involved in marine operations, naval architecture, ocean engineering, coastal construction, and product development. The Ocean Wave Workshop is held on odd years as a complement to the ONR/MTS Buoy Workshop which is held on even years.