An Accuracy Statement for the Buoy Heading Component of NDBC Directional Wave Measurements

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ABSTRACT
The National Data Buoy Center (NDBC) conducted post-deployment calibrations of directional wave buoys to determine the stability of the accuracy of the heading component of the directional wave system. The systems are required to meet a heading accuracy of 4 degrees before leaving NDBC for deployment. Four buoys were returned to NDBC to determine the stability of their heading accuracy. The post-deployment calibrations indicated maximum heading errors from 6 to 8 degrees for the two to four-year deployments. NDBC publishes an overall accuracy statement of 10 degrees for its directional wave measurements. This paper will discuss the pre-deployment calibration techniques, the post-deployment results of the four test buoys, the environmental conditions during the calibrations and the deployments, and the provenance of NDBC’s directional wave accuracy statement.

KEY WORDS: Moored buoy; ocean wave measurements.

INTRODUCTION
NDBC has conducted directional wave measurements from moored buoys for more than 30 years. NDBC deploys these directional wave systems after applying rigorous pre-deployment calibration and checks, as well as quality control procedures during the deployment. NDBC has documented, through limited field tests, an accuracy of 10 degrees for its directional wave measurements, but has not documented any post-deployment calibrations. Upon recovery, the buoys are broken down for shipment back to NDBC. “Broken down” is a term used by NDBC technicians to describe a process where the upper mast section is removed. Cables are cut that connect between the upper mast and internal equipment compartment. This facilitates packing, shipping and is less-costly. The cut cables are replaced during the buoy refurbishment process. Anemometers and other sensors are also removed from the upper mast. The internal section of the buoy hull is not modified. This is where all wave measurement equipment and batteries are located (see Fig. 1). Thus the shipping process prevents effective post-deployment calibrations to document the stability of the accuracy of its directional wave measurements during their usual two to three-year deployments.

A critical component of NDBC directional wave measurements is determining the heading of the buoy so that directional wave measurements can be rotated from the buoy frame of reference into magnetic compass frame of reference and then into directions relative to True North. Heading is determined by measuring the earth’s magnetic flux using three orthogonal magnetometers. The flux measurements are corrected for magnetic influences on the buoy. These influences, such as battery currents, can change over the deployment time.

The description of NDBC directional wave measurements follows the complete details given in NDBC (1996).

DETERMINING THE DIRECTION OF OCEAN WAVES

Pitch and Roll
NDBC’s wave measurements employ the method of Longuet-Higgins, Cartwright and Smith (1963) for a moored, discus buoy measuring heave, pitch, and roll of the buoy’s hull. Heave is determined by the double integration of the vertical acceleration to produce a displacement spectrum. An arbitrary point on a discus hull is designated as the bow and diametrically opposite is the stern. Athwart (or perpendicular in the horizontal plane) this bow-stern axis is the port-starboard axis. Rotation about the port-starboard axis is termed pitch, and rotation about the bow-stern axis is termed roll. The initial measurements are made within this buoy frame of reference.