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Historical Wave and Wind Observations at Ocean Station P

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Abstract

An historical data set with 30 years of wave and wind observations from Ocean Weather Station P (50°N, 145°W) is described and validated against modern measurements. Observation biases are discussed and corrections are made where appropriate. Climate trends are explored, including a negative correlation between waves and the Pacific Decadal Oscillation. The validated historical data are deposited in a public archive with online access.

Introduction

Modern climate models require coupling between the ocean and atmosphere, and thus ocean waves are of growing interest in climate studies (*Bromirski et al*., 2013; *Cavaleri et al*., 2013). Interactions between the ocean and atmosphere form a complex feedback system of heat, energy, mass, and momentum, which is primarily facilitated by ocean surface waves (see, for example, *Large and Pond*, 1981; *Smith*, 1988; *Donelan*, 1993). Wave measurements are necessary to better understand and quantify these feedbacks and further refine the associated empirical models. With this motivation, scientists at the National Oceanic and Atmospheric Administration (NOAA) and University of Washington have been making continuous wind and wave measurements from buoys moored in the North Pacific since 2010. The mooring location, known as Ocean Station Papa (OSP; 50°N, 145°W), was originally occupied in the early 1940s as part of a U.S. military initiative to develop better weather prediction models for the Pacific Ocean. Adopted by the Canadian Coast Guard in 1951, the station remained occupied almost continuously by weather ships collecting meteorological and oceanographic measurements until the program was terminated in 1981 (*Freeland*, 2007).

Weather ship activity at OSP led to it becoming a popular location for field experiments in the North Pacific (e.g., *Martin and Fitzwater*, 1988; *Paduan and Niiler*, 1993). However, the historical data collected during the initial weather ship program have been largely forgotten. While attempting to recover these data, current OSP researchers identified numerous sources, but were unsure of the data's origin and quality. Long-term data sets that may be used to quantify climate trends are exceptionally valuable and, unfortunately, very rare. This makes the historical OSP data set especially important, as it contains wind and wave measurements spanning over 30 years. It also provides historical context for the ongoing work at OSP and an opportunity to explore the relationship of climate signals to wind and waves.

A growing body of research demonstrates the influence of climate cycles on wind and wave variability in the North Pacific (see, for example, *Gemmrich et al*., 2011; *Bromirski et al*., 2013). Some researchers have identified systematic problems with the use of buoys to determine long-period trends in wave data (*Gemmrich et al*., 2011). They also report that localized in situ measurements may be problematic when used to determine basin-wide characteristics. As a result, there has been a preference for using calibrated models and hindcasts to estimate long-term trends (*Bromirski et al*., 2013). While this assessment is generally true for wind measurements, it is less true for wave measurements. Though a wave height may be measured at a particular location, that measurement contains wave

components that were generated on a much larger scale. Indeed, some waves are generated over spatial and temporal scales as large as the Pacific Ocean itself (*Snodgrass et al*., 1966). While less ideal than a basin-wide wave field, point wave measurements, such as those collected during the weather ship program, represent basin-scale forcing to some degree and are therefore valuable as scientific tools for assessing larger trends.

Our analysis of the historical data from the Canadian weather ship program had several components. First, numerous sources of historical data were analyzed and their relevance assessed. Second, the distribution of historical values was compared to the modern measurements. For this analysis, we compared wind speed, wave height, and wave period. These three parameters provide a general classification of the wave climate and the local wind forcing that contributes to wave generation. Third, a time series analysis was conducted to determine what, if any, trends exist in the historical data set. Fourth, after removing the mean seasonal fluctuation, the influence of long-period trends on wind and wave variability in the North Pacific could be studied. Finally, the validated time series of wind speed, wave height, and wave period were placed in a public database, available online via the University of Washington Libraries ResearchWorks Archive (http://hdl.handle.net/1773/25570).

Data Discovery and Synthesis

In the search for historical weather ship data, several different sources were discovered that have a direct connection to the original observation program. It was unclear which resource contained the original measurements. Some of these data were provided by employees at the Institute of Ocean Sciences (IOS), the current version of the government body originally charged with the weather ship program, while another set was found archived at the University Corporation for Atmospheric Research (UCAR). After an exhaustive comparison of numerous data transects from each source, it became clear that the UCAR archive represented the most original, error-free version of the data. It appears that the data obtained from IOS staff were derived from the UCAR archive source. Additionally, a cursory analysis of wave heights showed that the IOS data had been manipulated erroneously at some point without documentation, resulting in spurious jumps in the time series and distribution of values. Having determined a suitable primary source (UCAR), we proceeded to more direct analysis of wind speed, wave height, and wave period (Figure 1).

Comparison of historical and modern measurements required accounting for methodological differences. Historical wind speeds were collected using

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Ocean Station Papa, weather ships, oceanographic observations, meteorological observations, time series, Northeast Pacific Ocean, Pacific Decadal Oscillation

Jim Thomson

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