

Initial results from long-term measurements of atmospheric humidity and related parameters in the marine boundary layer at two locations in the Gulf of Mexico

Laurence C. Breaker^{a,*}, David B. Gilhousen^b, Hendrik L. Tolman^a,
Lawrence D. Burroughs^a

^a NOAA / National Weather Service, NCEP, Washington, DC 20233-9910, USA

^b NOAA / National Weather Service, National Data Buoy Center, Stennis Space Center, Stennis, MS 39529, USA

Received 16 August 1996; accepted 8 August 1997

Abstract

Measurements of boundary layer moisture have been acquired from Rotronic MP-100 sensors deployed on two NDBC buoys in the northern Gulf of Mexico from June through November 1993. For one sensor, which was retrieved approximately 8 months after deployment, the post- and precalibrations agreed closely and fell well within WMO specifications for accuracy. The second sensor operated continuously from June 1993 to February 1997 (~ 3.5 years). Buoy observations of relative humidity and supporting data were used to calculate specific humidity and the surface fluxes of latent and sensible heat. Specific humidities from the buoys were compared with observations of moisture obtained from nearby ship reports, and the correlations were generally high (0.7–0.9). Surface gravity wave spectra were also acquired. The time series of specific humidity and the other buoy parameters revealed three primary scales of variability, small (~ h), synoptic (~ days), and seasonal (~ months). The synoptic variability was clearly dominant and occurred primarily during September, October, and November. Most of the synoptic variability was due to frontal systems that dropped down into the Gulf of Mexico from the continental US followed by air masses which were cold and dry. Cross-correlation analyses of the buoy data indicated that: (1) the moisture field was highly coherent over distances of 800 km or more in the northern Gulf of Mexico; and (2) both specific humidity and air temperature served as tracers of the motion associated with propagating atmospheric disturbances. These correlation analyses also revealed that the prevailing weather systems generally entered the buoy domain from the South prior to September, but primarily from the North thereafter. Spectra of the various buoy parameters indicated strong diurnal and semidiurnal variability for barometric pressure and sea surface temperature (SST) and lesser variability for air temperature, wind speed and significant wave height. The surface fluxes of latent and sensible heat were dominated by the synoptic events which took place from September through November with the transfer of latent heat being primarily from the ocean to the atmosphere. Finally, an analysis of the surface wave observations from each buoy, which included calculations of wave age and estimates of surface roughness, indicate that major heat and moisture flux events coincide with periods of active wave growth, although the data were insufficient to identify any causal relationships.

Keywords: Rotronic MP-100 humidity sensors; humidity; marine boundary layer; Gulf of Mexico; latent heat flux; surface waves

* Corresponding author.

1. Introduction

Due to the proximity of the ocean surface to the sensor location, and the constant state of motion of the surface itself, the acquisition of meteorological observations within the marine boundary layer has always posed unique problems. Atmospheric humidity has been a particularly difficult parameter to measure near the ocean surface. First, it is difficult to protect humidity sensors from salt spray which accumulates over time and consequently degrades calibration accuracy; second, humidity sensors must be adequately protected from excess heating due to incoming solar radiation; and third, humidity sensors must recover rapidly from periods of saturation without change to their calibration (Coantic and Friehe, 1980).

Since atmospheric moisture is a difficult parameter to measure accurately over the ocean, it is not surprising that it has been even more difficult to acquire observations from unattended instruments for extended periods. Recently, a number of humidity sensors have been evaluated for possible use in measuring atmospheric moisture in the marine environment (e.g. Semmer, 1987; Muller and Beekman, 1987; Crescenti et al., 1990; Katsaros et al., 1994).

Based on promising test results from Muller and Beekman (1987) and Semmer (1987), and because of the continuing need for long-term measurements of moisture within the marine boundary layer, the National Data Buoy Center (NDBC) evaluated the Rotronic MP-100 humidity sensor for possible deployment on their moored ocean data buoys. Initial field tests were conducted along the US West Coast in 1989. A Rotronic humidity sensor was installed on a Coastal-Marine Automated Network (C-MAN) station at Point Arguello, California and showed high correlations between saturation events and restricted visibilities in fog. Calculated dew point temperatures following fog events were in general agreement with those reported at nearby Vandenberg Air Force Base. After a 4-month evaluation, Rotronic humidity sensors were introduced on several NDBC buoys and C-MAN stations along the California coast. Initially, several instrument failures occurred within weeks after installation. These failures led to several improvements to the sensor and its installation. First, the cabling from the sensor to the onboard electronic

payload was replaced. The original cables had inadequate insulation, and cable flexing often produced large calibration shifts. Second, the method of calibration was changed by exposing the sensor to a series of different saturated salt solutions in closed flasks and then comparing the observed relative humidities to the known equilibrium vapor pressure of water at the observed temperatures for these solutions. Test flasks with relative humidities ranging from 11 to 96% were used. These modifications led to significantly greater measurement accuracy and sensor reliability. The enhanced instruments have been installed on a number of NDBC buoys, and their performance has steadily improved.

As a basis for this study, we acquired hourly measurements of relative humidity and other supporting environmental data from two NDBC buoys in the Gulf of Mexico (Fig. 1). These buoys were equipped with the improved Rotronic MP-100 humidity sensors for the period 5 June to 30 November 1993. First, details of the sensor calibration, deployment and reliability are addressed. Then the relative humidity and supporting data are used to calculate specific humidity at each buoy location. To provide a measure of validation for these observations, the

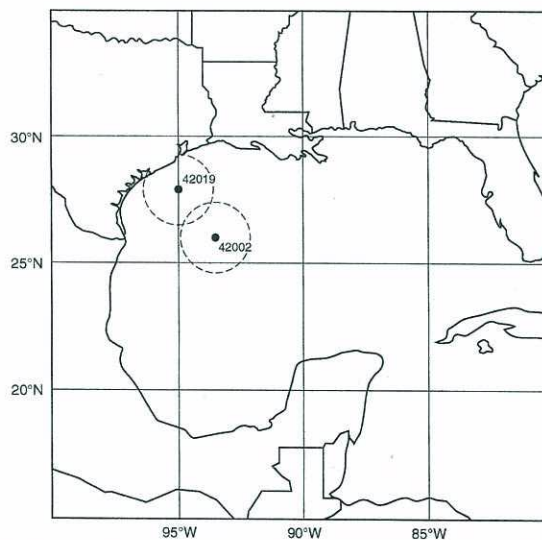


Fig. 1. The locations of NDBC buoys at stations 42019 (27.9°N, 95.0°W) and 42002 (25.9°N, 93.6°W) are shown together with co-located circles within which ship reports for search radii of 150 km were acquired (see text for details). The distance separating the buoys is 263 km.