USA 1963

one of the most important predictors. Thus, if the hygrometer is reporting a true dew point of 0F at a temperature of 0F, the air is saturated and immediate condensation of some type can be expected. On the other hand, if the observer mistakenly assumes the hygrometer is reporting a frost point of 0F, he would believe the air to be at 84 per cent saturation with respect to water (Fig. 2), with a long way to go before condensation begins. Similarly, the forecasting of ice fog at the surface (Appleman, 1953a) and condensation trails aloft (Appleman, 1953b) requires an accurate knowledge of the actual water-vapor content in order to know whether the combustion of fuels will result in saturation of the air.

Further, a misinterpretation of the hygrometer mirror deposit negates the value of an accurate instrument. In the above case, for example, when the free-air and dew-point temperatures are both 0F, a misinterpretation of the mirror deposit as frost is equivalent to an instrument error of over 3.5F, as compared to the actual instrument error of approximately 1F (Beaubien and Francisco, 1962).[2]

5. Summary and conclusions

Consideration is being given to replacing the current devices for measuring surface humidity with a recording dew-point hygrometer, largely because of the greater accuracy of the hygrometer in measuring humidities at low temperatures. Unfortunately, for a considerable temperature range below 32F an uncertainty exists as to whether the instrument is measuring dew point or frost point. As shown above, this ambiguity can lead to significant errors in the reported relative humidity, thus limiting the value of forecasting techniques dependent on humidity as a predictor. Furthermore, this ambiguity negates the value of an accurately measuring hygrometer.

[2] Beaubien, D., and C. Francisco, 1962: *Design, construction, and evaluation of an electronic dew point indicator.* Air Force Cambridge Res. Lab. Report, AFCRL-62-218, 42 pp.

It is clear that the resulting error is sufficiently serious to require its elimination before the dew-point hygrometer can be accepted for operational use. One solution might be personal observation of the mirror surface by an observer trained to differentiate between a frost and dew deposit. However, in some hygrometer designs or instrument locations, direct observation would not be possible. Another approach might be the use of some technique to ensure the freezing of the deposit at all mirror temperatures below 32F. Kobayashi (1960) was successful in limiting supercooling to about 21F by coating the mirror with silicone varnish containing silver iodide particles. Further study would need to be made to determine the long-term effectiveness and feasibility of such a coating in an operational instrument.

Another approach might be initially to lower any below 32F mirror temperature sufficiently (e.g., to −40F) to ensure freezing, then raising it back to the frost-point temperature. After a mirror deposit has once frozen, it will remain as frost as long as 1) its temperature stays below 32F and 2) the deposit is not completely evaporated. Thus, if the hygrometer is designed to operate in accordance with these criteria, it should be possible to eliminate the ambiguity entirely.

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The Influence of a Ship on the Surrounding Air and Water Temperatures

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1. Introduction

In the early months of 1961, certain personnel of the Allan Hancock Foundation, University of Southern California, and the U. S. Weather Bureau were investigating the feasibility of using tetroons to track the planetary air flow over the waters off southern California. The tetrahedral-shaped balloons were ballasted so that they floated at altitudes of between 500 and 1000 ft. Each tetroon carried a radar reflector so that it could be followed on the Sperry Mark III radar on the R/V VELERO IV, a research vessel operated by the University of Southern California.

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Cruises along the southern California coast in September and December 1960, during which a number of tetroons were released and tracked, proved the reliability of the technique in studying the offshore air flow. Directional eccentricities of the winds, such as loops, deviations and gyrals, were easily noted and variations of velocity in respect to time and place could be precisely evaluated.[2] To capitalize on these details of air trajectories it seemed reasonable to study, from the VELERO IV, the distribution of air and water temperatures along the trajectories of the tetroons.

It was fully recognized that a ship, or any other structure, will modify the characteristics of the surrounding air and water. In order to obtain data which were reasonably typical of those prevailing over the open sea, it was, therefore, neccessary to know the influence produced by the VELERO IV. Once this was known, thermal elements could be placed so as to record temperatures which were the least affected.

On 14 March 1961, the VELERO IV (Fig. 1) was taken to sea and anchored, bow and stern, on the open shelf. While water and air temperatures were being measured from the vessel, a launch was used to make similar measurements around the ship. The two sets of psychrometers and thermometers had been calibrated and the deviations were known. The positions of the launch were determined by pelorus bearings from the ship.

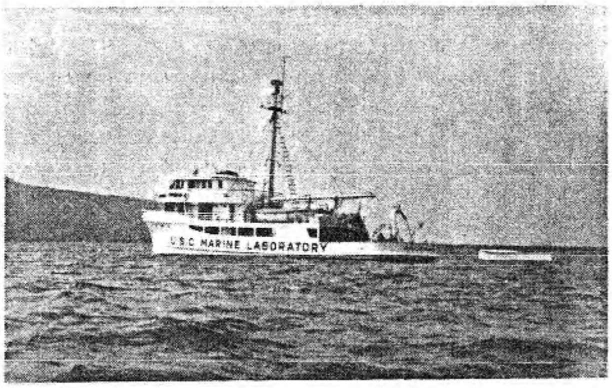

FIG. 1. The R/V VELERO IV, 110-ft research vessel operated by the University of Southern California.

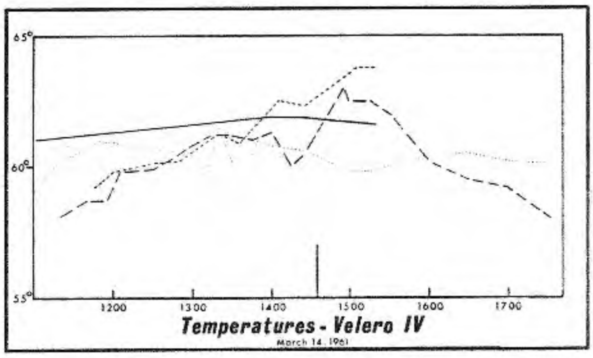

FIG. 2. Air and water temperatures taken on, and around, the VELERO IV on 14 March 1961. —— = temperature of entering air; - - - - = air temperature taken in the shade on the stern; — — — = air temperature taken in the sun on the stern; and ...... = the water temperature from bucket samples taken off the stern.

2. The temperatures

Anchored ship. The temperatures taken aboard the ship during the period of this investigation (Fig. 2) differed from those over the open water, and from each other. Neither location on the ship where air temperatures were measured produced values consistent with those over the water. Those agreeing more closely to the open-water air temperatures were obtained from a shaded position on the stern. Of special interest were the fluctuations in the bucket water temperatures between 1300 and 1430 PST hours. The ship was broadside to the wind at the time and wind velocities had increased to about 12 knots.

The distribution of air and water temperatures around the ship when breezes blew from the starboard side is depicted in Fig. 3. During these hours, the temperature of the "entering" air was 61F. The influence of the ship extended just over 150 ft downwind, and the heating of the air on the vessel was 2F. Water temperatures were also modified around the ship with a decrease of just over 0.5F. This came as a result, apparently, of water rising from the keel depth (14 ft) on the leeward side of the ship.

At higher wind velocities (10–12 knots), the area of low water temperatures around the vessel was greater than at slower wind speeds (Fig. 4). Adjacent to the stern, water temperatures were 59.2F, and 59.3F on the leeward side. The air continued to be heated by the ship, with temperatures of 62.8F being measured along the downwind side. However, the warming influence did not extend as far from the vessel as during winds of lower velocities.

When the VELERO IV was headed into the wind (Fig. 5), the air temperatures were modified to a much lesser extent than when winds blew from the side. The water continued to be influenced throughout a large area off the stern.

From these measurements, it was perfectly obvious that there was no location on the ship where air temperatures were typical of those existing over the open sea. Also, water temperatures, measured from bucket samples taken at the stern of the vessel, were not indicative of unaffected surface water conditions.

Consequently, a probe was placed on the bow of the vessel so that thermal elements (thermistors), to meas-

[2] Holzworth, G. C., and R. E. Stevenson, 1962: Some observed low-level air trajectories over the ocean adjacent to Southern California. Duplicated report submitted to Headquarters, U. S. Weather Bureau.

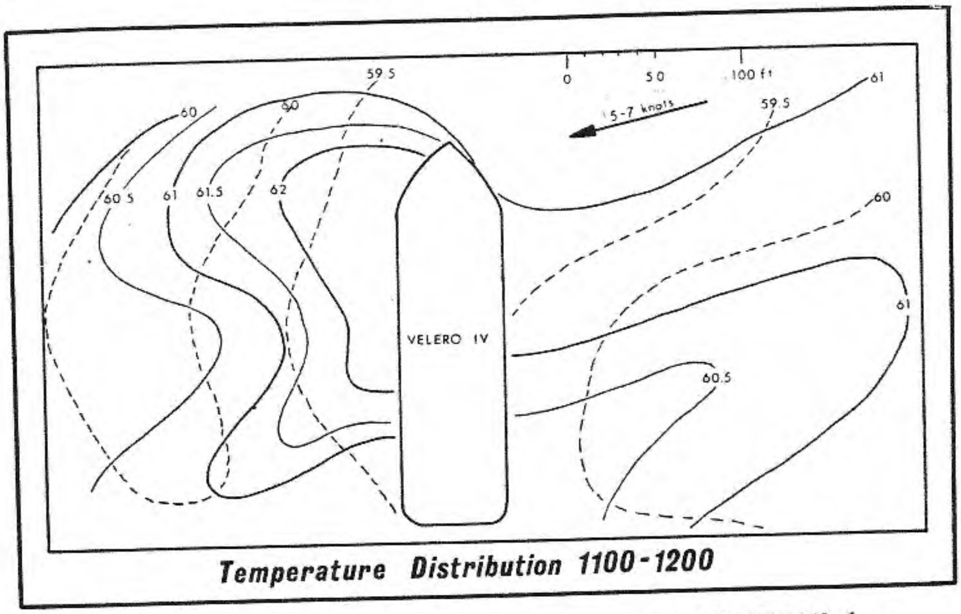

FIG. 3. The distribution of air and water temperatures around the VELERO IV when a light breeze blew from the starboard.

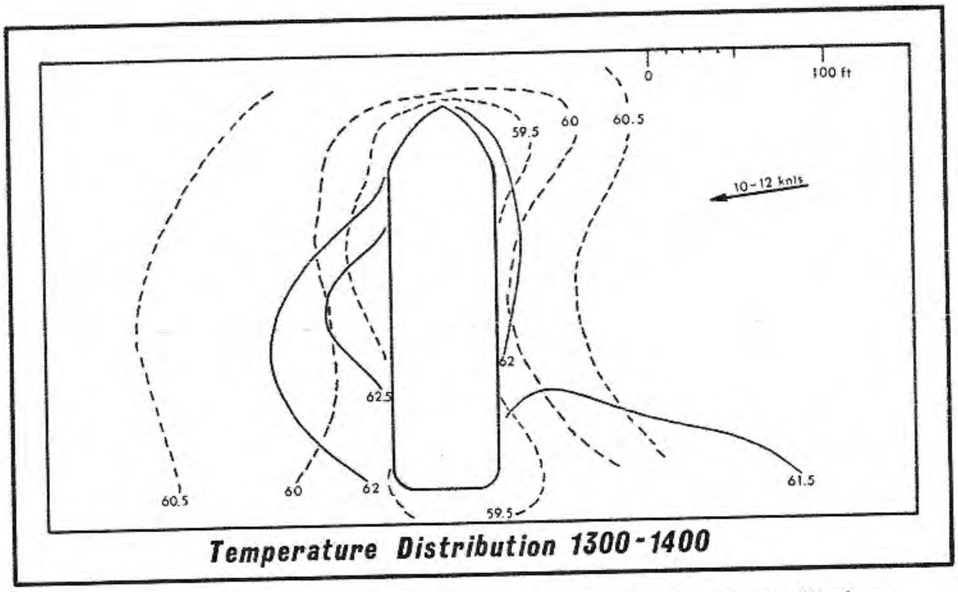

FIG. 4. The distribution of air and water temperatures around the VELERO IV when a brisk breeze blew from the starboard.

are water and air temperatures, extended 20 ft ahead of the bow. The element in the water remained in the upper six inches. That in the air was set at a height of five feet from the water, but obviously this distance varied in response to the waves, and the rock and roll of the ship.

Cruising ship. The following day, with the thermal probe in place, the ship cruised on various headings. Water temperatures were recorded from the bow probe, from bucket samples taken from the stern and from bathythermograph casts made from the port side. Air temperatures were also recorded from the bow probe, on the bridge deck and on the main deck at the stern (Fig. 6).

The thermistor measuring the air temperature was not protected during this cruise and it was, thus, subjected to moisture from spray and to the direct rays of the sun. The low temperatures at the beginning of the test period (54.7F) and those near noon were actually wet-bulb temperatures. Even so, the recorded air temperatures were not dramatically different from what would have been expected over the water. Temperatures

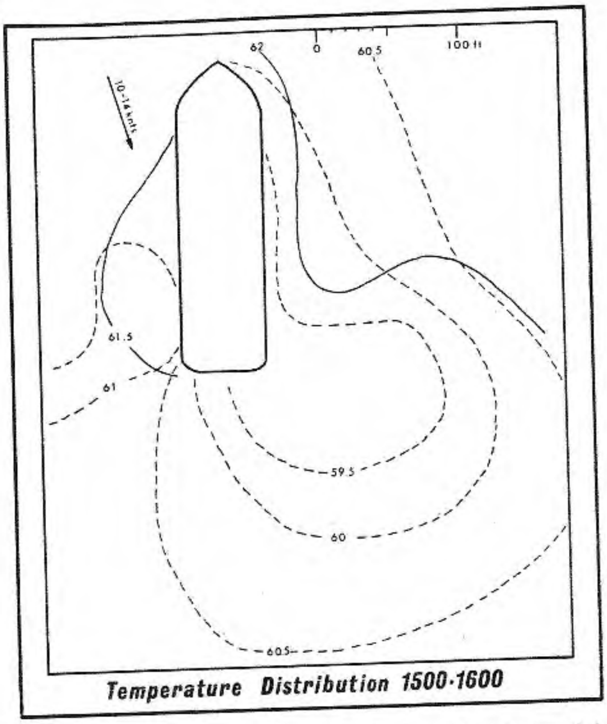

FIG. 5. The distribution of air and water temperatures around the VELERO IV when a brisk breeze blew from the bow.

taken on the bridge and work decks were decidedly different.

The bucket water temperatures were consistently lower than those measured by the probe. From the bathythermograms, it was noted that waters with such temperatures were at depths of 15–20 ft.

3. Conclusions

This investigation indicated that temperatures taken from any location on the ship were considerably different from those prevailing over the water. Only data obtained from the bow probe when the ship was headed into the wind, or cruising downwind at a speed greater than the wind velocity, were representative.

It seems reasonable to assume that the influence of any vessel will vary according to its size. Thus, data taken aboard a large ship, even with an extended thermal probe, would be much different from the actual conditions existing over the ocean.

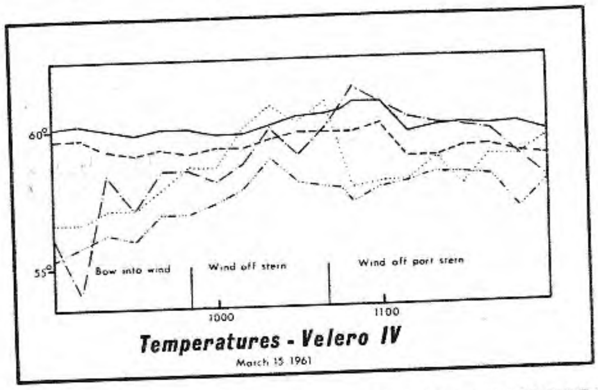

FIG. 6. Air and water temperatures measured from the VELERO IV while the ship was cruising. —— = water temperature from thermal unit; – – – – = water temperature from bucket samples; —···— = air temperature from thermal unit; —·—·— = air temperature from psychrometer on ship's bridge; and ·:····· = air temperature from psychrometer in shade on ship's stern.

The differences in water temperatures resulting from the presence of a ship will depend, to a considerable extent, on the temperature distribution in the upper layers. The occurrence of a thoroughly mixed layer extending well below the keel depth would preclude any significant changes in temperature caused by the ship. However, should there be a shallow thermocline disturbed by the vessel's progress, modifications of water temperatures could be extreme, or even spectacular.

One may then question the value of temperatures taken aboard a ship, or from any large structure at sea.[3] Because the measurements vary with the wind velocity and the orientation of the ship with respect to the wind direction, no factor can be applied to correct the data. It is likely that the temperatures are, therefore, useless for any but gross analyses of climatic factors, excepting, perhaps, those taken with a carefully oriented probe.

Acknowledgments. I wish to express my thanks to Captain G. Allan Hancock for making the VELERO IV available for the meteorological studies; to the officers of the ship, F. C. Ziesenhenne and W. C. Phalen; and to Detlef Warnke who made the measurements from the launch.

[3] Thornthwaite, C. W., W. J. Superior and R. T. Field, 1962: Evaluation of an ocean tower for the study of climatic fluxes. Thornthwaite Associates, Tech. Rept. No. 2, Office of Naval Research, 32 pp.