Data Requirements in Support of the Marine Weather Service Program

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I. Introduction

The National Weather Service (NWS) furnishes weather and river forecasts and warnings to the public, and provides specialized services concerned with marine, aviation, agricultural and forestry operations and air pollution control.

Historically, marine weather support was a principal basis for the development of a government weather service, beginning with a Congressional Resolution in 1870. In 1891 the newly established Weather Bureau took over the weather services, and finally, just a year ago with the formation of NOAA we became the National Weather Service, with a constantly growing awareness of, and interest in, serving mariners, boatmen, and all others who work or relax in the marine environment.

Much of the work within the National Weather Service has to do with the description and prediction of weather patterns over most of the globe, and the closely related sea and swell patterns in ocean areas. The operating program is widespread. Its personnel are found at approximately 400 facilities within the 50 states, at 15 overseas stations, 7 ocean stations, and 20 moving ships. To meet our responsibilities for the provision of forecasts and warnings over wide areas of the globe, rapid receipt and processing of global data are required on a continuing and regular basis. Data must be gathered in real-time, within one to three hours or so, from international organized networks covering the land and ocean areas, and extending up through the atmosphere. The inter-relations of the fluid envelope are such that these data are required even for forecasting the state of the ocean.

In order to satisfactorily predict future conditions of the atmosphere and the ocean, it is necessary that we have a running account of these conditions delivered to the forecasters at regular intervals and as soon after the observations as is possible. Any data delayed in delivery may be useful for climatological purposes or for hind-casting, but it simply does not exist as far as the forecaster is concerned. As high-speed communications improve, so our operational weather data base improves. We reached the point about 15 years ago where high-speed computers became necessary to assimilate the vast amount of data. Computers at the National Meteorological Center, aided by human judgment and prompting, calculate the broad-scale weather analyses and predictions, and the results are immediately relayed by teletypewriters and facsimile machine to "the field."

Our field forecast offices use the broadscale predicted patterns and statements as guidance in preparing forecasts for their respective areas of responsibility, and these forecasts in turn are further refined for local use by Weather Service Offices (WSOs) scattered in communities throughout the country. These forecasts include, as applicable, information on wind, waves, weather, air temperature, and visibility. At coastal locations the Weather Service Offices make available the astronomical tide predictions and in some cases also the "surf" temperature. In addition to the general public services, we provide more specialized services to agriculture, aviation and other weather-sensitive endeavors, including, of course, marine interests on the high seas, in coastal waters, and on the Great Lakes. Because of the special threats presented by severe local storms and by hurricanes, expertise and communications necessary to deal with these phenomena are concentrated at a few key locations. The National Severe Storms Forecast Center at Kansas City rides herd on tornadoes, severe thunderstorms and the like, while the wild ocean storms are handled by the National Hurricane Center, Miami, and our forecast offices at San Francisco and Honolulu. Storm surge and high waves are forecast, along with atmospheric phenomena.

Very briefly, the marine service program is concerned with furnishing information on the present state of the marine environment, predictions of future developments, and warnings of expected hazardous conditions. Timely warnings of severe storms, hurricanes, and other marine environmental hazards contribute substantially to the safety and efficiency of marine operations. Ships on the high seas use regularly broadcast warnings and forecasts to navigate around severe storms, to select time-saving routes, and to schedule shipboard operations.

Our present program includes information about anomolous water levels, including sea and swell, surf and breakers, and storm surge. Advisories concerning sea ice on the Great Lakes and Cook Inlet in winter, and in the Bering, Chukchi, and Beaufort Seas in summer, are a part of our existing program. In the future we hope to do more. We think we can deal with ocean currents such as the Gulf Stream, with areas of upwelling, with the thermal structure at least down through the mixed layer, and with the day to day anomolies in the tide height and tidal currents. To gather data necessary for this ambitious program we will look to various methods, including in situ measurements and surface-based remote sensing as well as to satellites.

The NWS is working very closely with the National Data Buoy Project people and other NOAA components in marine instrumentation. Although the NWS is involved in some sensor development, our principal efforts lie in helping to devise methods for rapid data relay, in improving forecast techniques, and in finding ways to reach the people who need our service products.

II. Present Data and Problems

At the present time we have, in addition to observations from coastline points and islands, regularly scheduled observations from seven "stationary" ships in the Atlantic and Eastern Pacific, from 20 moving ships that carry NWS personnel, and from a great many moving ships that have NWS instrumentation. The reports are collected each six hours, averaging about 560 reports each collection period. Unfortunately, only about three-fourths of these arrive at the National Meteorological Center (NMC) in time to be included in the working analyses. In addition to observed weather phenomena and the barometric pressure, the reports include wind speed and direction, wave and swell height, period, and direction, air temperature and dew point, ice information, and sea surface temperature. Unfortunately, these ship reports come almost entirely from ships on well-traveled regular trade routes, leaving very large areas of the oceans unreported.

In addition there are reports from shore stations and a limited number of reports from airlines over the ocean, and while these aircraft reports do not speak directly to surface conditions, we can make large scale inferences from their altimetry and wind calculations. From satellites we already have a limited subjective ocean roughness parameter, in that the sun glint from the ocean surface has different characteristics and brightness with different surface conditions.

We hope to enroll additional ships into the internationally sponsored cooperative ship program, to at least make our data base more dense over the trade routes. Furthermore, these ships and those already in the program provide potential platforms for obtaining bathythermograph data as well as additional ocean surface data. We have some hope for this new data now because of our cooperation, along with other NOAA elements and other government agencies, in the Integrated Global Ocean Stations Systems (IGOSS), a joint effort of the Intergovernmental Oceanographic Commission and the World Meteorological Organization. The first phase of the IGOSS will be to obtain and distribute bathythermograph data in real time. The target date for commencing this new data distribution is January 1972. Satellite observations of sea surface temperature, already available, will be incorporated with those from ships, for a complete analysis of this parameter.

III. Needs For Sea Surface Data

The National Weather Service has agreed in principle to common DOC-DOD requirements for sea state data in the Federal Plan for Meteorological Data from Satellites. As stated in that document they are:

Waves (sea and swell) (global and local)

Frequency of observation	4 obs per day
Timeliness (receipt after obs)	3 hours
Grid spacing	100 n.m. (over open ocean: closer near shores)
Vertical resolution	2 ft. intervals 0-10 ft. 5 ft. intervals 10-30 ft. 10 ft. intervals above 30 ft.

The Federal Plan also states a common requirement for location accuracy of one nautical mile. However, it seems that a location accuracy of 4 or 5 n.m. will meet National Weather Service needs for a few years.

The above requirements are for data over the high seas in the Northern Hemisphere, and will be used to furnish a base line for our numerical wave prediction model. They should be looked on as goals for satellite observation capabilities in the next 5 years or more.

The principal requirement of NWS is for information concerning wave height. In addition, some measure of wave direction and of length or period would be useful. If these requirements cannot be met, it would still be useful to have an indication of roughness or some other parameter that can be related to wave energy, which in turn can be related to wave heights.

Other anomalous water levels are also of interest, such as storm surge, and lesser deviations from astronomical tide calculations, changes in Great Lake levels due to wind set-up or seiche, and surf and breakers along the coast. The above requirements represent the more urgent operational concerns of the Marine Weather Service Program of NWS.

As the satellite's capability to provide more quantitative data grows, we expect to use such data as direct input to the numerical wave prediction model. The availability of such data should result in increased accuracy of sea state predictions. In terms of safety of life and property on the high seas, sea state is one of the most important parameters.

Tide gage observations of wave height are desired to an accuracy of one foot or 10%. However, from the point of view of remote sensors, let us assume that this represents a future research need which might become an operational need several years from now.

Numerical weather analysis programs at the National Meteorological Center are capable of handling input weather data in many forms. Objective

analysis schemes used on the computer to prepare input for numerical weather forecast models can be designed to weight various forms of input data according to accuracy and timeliness. Thus, the derived surface wind speeds in the range from about 5 to 30 knots said to be possible from radar scatterometry data could be integrated into the forecast system. The speed information merged with wind speed and direction observations from ships and islands would be helpful over the broad ocean areas for wind, weather and sea state forecasts.

IV. Summary

One of the greatest responsibilities of the NWS is to provide forecasts of atmospheric and ocean surface conditions over vast areas where data is usually scarce and sometimes unreliable. An improvement in our services would represent a considerable improvement in the safety and efficiency of shipping and fishing industries, and in the safety of the growing population of those who find recreation on the oceans and Great Lakes. Our efforts toward improved services are considerably hampered by lack of information concerning those parameters we hope to forecast. We have traditionally depended largely on our prime users, the ships at sea, for our data. It is a little ironic that the better we get in forecasting, the less data we have from storm areas, rough sea areas, and ice areas. Furthermore, there are large parts of the oceans not usually populated with ships in normal commerce. Therefore our requirements for additional data are immediate and will be of long standing, and hopefully can be met in part by observations from satellites.