ANALYSES OF ELEMENTS OF THE MARINE ENVIRONMENT FOR THE
ATLANTIC REMOTE SENSING LAND OCEAN EXPERIMENT (ARSLOE)

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ABSTRACT

The Atlantic Remote Sensing Land Ocean Experiment (ARSLOE) took place from October 6 through November 30, 1980. During the period October 22 through October 27, two events of meteorological significance to ARSLOE occurred. A weak cold front moved through the operating area, and an intense extratropical cyclone passed near it. The fronts associated with the cyclone traversed the area. Analyses of sea surface temperatures, streamlines and isotachs, and surface air temperatures were made for the period of interest. This report describes uncertainties in the data used in the analyses and discusses the impact of these uncertainties and of data sparsity on the analyses. The procedures used to produce the analyses, which were designed to minimize the effects of data uncertainty and sparsity and bias on the part of the analyst, are also presented.

1. INTRODUCTION

At the inception of the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE), the National Weather Service (NWS) was asked to provide a variety of forecasts and to aid in gathering and calibrating wind and temperature measurements. Later, the Techniques Development Laboratory (TDL) of the NWS agreed to analyze surface wind, surface air temperature (SAT), and sea surface temperature (SST) fields.

TDL agreed to analyze data for only the most significant events during the experiment. As it turned out, the most significant events occurred during the period October 22 through October 27, 1980.

A preliminary and a final set of analyses were prepared. Soon after the experiment was finished, the preliminary set of analyses was prepared with available data. In February 1981, this set was microfilmed and made available to ARSLOE investigators through the National Oceanographic Data Center (NODC). The final set used every usable piece of data obtained. Correction or reanalysis was done where necessary. This set of analyses was microfilmed and made available to ARSLOE investigators, through NODC, in July 1981.

This report describes the data used in the analyses, how the analyses were prepared, what

some of the uncertainties in the data were, and how the uncertainties in the data affected the analyses. In an effort to analyze the data in a timely way and to make the analyses available to other ARSLOE investigators as early as possible, objective techniques were not used. The data were checked for gross errors, corrected where possible, or deleted entirely where not correctable. The remaining data were subjectively analyzed. Therefore, the analyses are vulnerable to the preconceived notions and biases of the analyst. With this in mind, the procedures used to produce the analyses were designed to minimize the effects of the analyst's biases as well as data uncertainty and data sparsity.

2. DATA

Data were assimilated from a variety of sources of varying quality and availability. These sources were given a qualitative rating from 1 to 10 based on instrument error or resolution, positional errors of the moving platforms, instrument placement, observation availability, and observer priorities. Table 1 lists the various sources of data by rating. Where possible, station identifiers are given for each data source to help identify areas where analyses may be less reliable.

Uncertainty in the data measurements varied with the parameter being measured. For SSTs it ran from $+0.1^{\circ}$ to $+1.0^{\circ}\text{C}$. For SATs it ran from $+0.1^{\circ}$ to $+0.5^{\circ}\text{C}$. Uncertainty in wind direction varied from $+5^{\circ}$ to $+16^{\circ}$, while it varied from $+0.5$ to $+1.0$ m/s for wind speed. Resolution for the satellite still photos is 4 km, while for film loops it is 8 km. The positional error for the aircraft is $+1.0$ n mi, while for ships it is $+5.0$ n mi. Other factors which affect the data but cannot be readily quantified include: observing when not a primary duty of the observer, averaging differences (Bouy data are an 8.5-min average, while all other data are a 1.0-min average), and poor positioning of instruments. For a full evaluation of the data by source see Burroughs (1982).

Where necessary, wind speed was converted from knots to meters per second; temperature was converted from $^{\circ}\text{F}$ to $^{\circ}\text{C}$, and wind direction was converted from a 16-point compass to a 36-point digital compass (Table 2).

Table 1. List of data sources by qualitative rating (1-lowest to 10-highest). Station identifiers used on charts are also given.

Data Source	Qualitative rating	Stations
Airborne infrared radiometer temperature (ART)	8	
Sectorized satellite still photographs	8	
WSO (hourly)	8	ORF, HAT
FAA (hourly)	7	DOV, SBY, ECG
Hemispheric satellite film loops	7	
Field Research Facility	7	Pier
BUOY	7	X, 41001
Ship	6	
Marine reporting station (MARS)	5	45W, 79W, 62W, 64W, W30, 61N, N91, 55N, CAPE CHARLES, COVE POINT, CRISFIELD, W39

Table 2. Conversion from a 16-point (pt) compass to a 36-pt compass.

16 pt	36 pt	16 pt	36 pt
N	36	S	18
NNE	02	SSW	20
NE	04	SW	22
ENE	07	WSW	25
E	09	W	27
ESE	11	WNW	29
SE	14	NW	32
SSE	16	NNW	34

3. ANALYSES

The data were checked for gross errors, corrected where possible, or thrown out where not correctable. The remaining data were subjectively analyzed. The procedures described in the following sections were designed to minimize the effects of data uncertainty, data sparsity and the biases and preconceived notions of the analyst.

A. Base Map

The base map used was composited from two U.S. Geological Survey charts by the U.S. Army Corps of Engineers Research Center and reproduced under a NOAA contract. They are scaled 1:500,000 and cover an area from 34° to just over 39° north and from about 72° to 77° west.

B. SST Analyses

Two types of SST analyses were prepared: a 6-d composite of all data for the entire period and a daily composite for each individual day's data. Because of the mix of data, the charts are a composite in depth as well as time since the data were taken between the surface and 10-m depth. Figure 1 shows an example of a daily SST analysis.

Composite Analysis

Because of data sparsity, a composite SST analysis was required to provide a stable pattern from which the daily charts could be analyzed. The composite was made by using all the SST data available for the period. The data were coded by date and color coded by temperature. This allowed the stable features to be identified in much the same way as done by Gibson (1962). Comparisons were made with the National Meteorological Center's (NMC's) weekly SST analyses covering the same period and their bi-daily Gulf Stream Current Analyses.

Daily Analyses

Each daily analysis is a composite of all the data for a 24-h period centered on 0000 GMT. Where there were more than one observation at permanently located stations, such as at the FRF pier or the meteorological buoys, the data were averaged. The 6-d composite chart was used to underlay the daily chart during analysis to provide pattern stability and continuity.

Uncertainties

An envelope of uncertainty exists about each piece of data. This means that each analysis has uncertainty associated with it. In the area from 35° to 37° north and from the coast to 74° west, the isotherm patterns, gradients, and values are better than elsewhere in the analyses. This is so because the data found in this area (ART data) are densely packed and of higher quality than those found in other areas of the analyses. Even though these data were available on only 1 day, there were sufficient data from other sources on other days to corroborate the patterns and their persistence throughout the period. Elsewhere the analyses are less certain, but there is evidence, over the period, to corroborate the general pattern of warm and cool areas.

Figure 1. Sample sea surface temperature chart. Isotherms are depicted by solid lines at 2°C intervals. Intermediate isotherms are shown as dashed lines.

C. Wind Field and SAT Analyses

These analyses were prepared at 3-h intervals from 0000 GMT daily. Principles found in Saucier (1965) were used to analyse them. The NMC North American surface pressure analyses, reanalyzed for streamline and surface air temperature patterns, were used as a first-guess field. These charts are on a scale of 1:20,000,000 compared to 1:500,000 for the ARSLOE charts. The reanalyzed North American charts gave the synoptic patterns, aided with continuity, and provided a framework within which to place the local ARSLOE analyses. The effects from topography, mesoscale and micro-scale circulations, and any problems of data sparsity or uncertainty are apparent in the ARSLOE analyses.

Wind Field Analyses

The wind field has been depicted by streamline and isotach analyses. An example is given in Fig. 2.

Local effects from topography and landbreeze/seabreeze circulations are detectable on the analyses but are dominated by synoptic forcing such as frontal passages. Frontal locations were taken from the North American surface analyses and transferred to the ARSLOE analyses. Adjustments were made for local winds. Where difficulties arose in determining frontal positions or other synoptic features, satellite photographs were used to arbitrate the situation.

Figure 2. Sample streamline and isotach analyses. Streamlines are shown by solid lines with arrowheads spaced periodically along them in the direction of air flow. Isotachs are depicted by dashed lines at 5 m/s (mps on chart) intervals.

The synoptic pattern from the North American charts served as a basis for the ARSLOE charts. The pattern was appropriately modified according to the data available and then compared in a forward and backward looking manner for continuity and consistency. In the absence of data, isotach minima were analyzed along ridge or trough lines, at cyclonic (C) and anticyclonic (A) centers, and along lines of convergence.

SAT Analyses

Figure 3 shows an example of an SAT analysis. In the absence of data, temperatures over land were assumed to be warmer than those over nearby water bodies during the day. At night the reverse was taken to be true. During strong synoptic events, these local effects were largely overwhelmed by temperature advection into the area.

To ensure consistency, pattern changes were studied in a forward and backward looking manner. In addition, to be consistent from one day to the next and to filter out diurnal effects, each set of 3-hourly charts, i.e., all 0000 GMT, 0300 GMT, etc., were checked for day-to-day continuity. Finally, the charts were underlain by the streamline and isotach analysis of the same date and time to ensure consistency with those patterns as well. In this way, pattern changes were made as consistent and continuous as possible in spite of the problems of data sparsity and uncertainty.

Analytical Uncertainties

The streamline analyses appear to be less affected by data uncertainties and sparsity than do the isotach or SAT analyses. However, areas of divergence or convergence in the streamline

Figure 3. Sample surface air temperature chart. Isotherms are shown as solid lines at 2°C intervals.

analyses, which depend on the placement of isotach maxima or minima, are not well defined. The isotach and SAT analyses are very sensitive to data uncertainties and sparsity, particularly the latter. The analysis procedures employed were designed to minimize these effects. The resulting patterns for each field are reasonable, though general in nature.

4. SUMMARY

In the foregoing sections, we have discussed the quality and uncertainties of the analyses. The procedures used to produce them employ the best subjective techniques available. The resulting analyses are reasonable and give representative large-scale patterns and gradients for each marine environmental element analyzed. They do not give, nor can they give, a reasonable representation of the small-scale pattern for each element. Data sparsity and uncertainty preclude that.

5. AVAILABILITY OF ANALYSES

These analyses are available on microfilm at NODC. To obtain microfilm prints of the data or copies of the microfilm itself, call the Data Services Division of NODC at 202-634-7500, or write National Oceanic and Atmospheric Administration, Environmental Data Information Service, National Oceanographic Data Center, Data Services Division, 2001 Wisconsin Avenue, Washington, D.C. 20235.

REFERENCES

- Burroughs, L. D., 1982: Analyses of elements of the marine environment for the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE)--an atlas for October 22 through October 27, 1980. NOAA Technical Report NWS-29, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 112 pp.

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