Gulf Stream Recirculation Experiment – Part II

by

C.M. Wooding, W. B. Owens, M.E. Zemanovic and J. E. Valdes

September 1989

Technical Report

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Approved for Distribution:

Robert C. Beardsley, Chairman
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Gulf Stream Recirculation Experiment — Part II

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June 13, 1989
Abstract

This report presents trajectories and time series of velocity, pressure, and temperature for twelve neutrally-buoyant floats launched during the Gulf Stream Recirculation EXperiment (GUSREX) and two from earlier experiments, that continued to operate after May 1982. These float data were obtained from Autonomous Listening Stations (ALSs) deployed from May 1982 to August 1985.
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1 Background

Twelve neutrally-buoyant, SOund Fixing And Ranging (SOFAR) floats launched between April 1980 and August 1981 as part of the Gulf Stream Recirculation EXperiment (GUSREX) continued to work after the first two years of the experiment reported by Kennelly and McKee (1984). In addition, two floats, one launched in October 1976 over the Nares Abyssal Plain as part of POLYMODE and another launched in June 1979 as part of an earlier Gulf Stream experiment also were heard after May 1982. This report presents the trajectories and time series of temperature, pressure, and velocity for these fourteen floats. GUSREX part II coverage of the Northwest Atlantic Ocean lasted for 33 months and then was supplemented by an array of five ALSs deployed to track SOFAR floats launched in the close vicinity of 34°N, 70°W (Site L, Price et al., 1987) (Figure 1).

The GUSREX program, including the Site L coverage, lasted nearly five-and-a-half years. GUSREX was a joint program of Woods Hole Oceanographic Institution and the University of Rhode Island. It focused on the recirculation of the Gulf Stream, addressing such questions as the size and structure of the recirculation south of the Gulf Stream as proposed by Worthington (1976) and the interconnection of the Gulf Stream and the North Atlantic Current at the tail of the Grand Banks (Worthington, 1976; Clarke et al., 1980). As part of GUSREX, a total of forty-three floats was launched along 55°W from 24 to 44°N during two cruises in April–May 1980 and July–August 1981 (Kennelly and McKee, 1984). Except for one case, these floats were launched in pairs with one float ballasted to 700 m and the other to 2000 m (see Figures 2, 3, 4 and 5). Twelve of these floats, five shallow and seven deep, are presented in this report. Table I shows the duration and start and end locations for each float.
Figure 1: ALS tracking arrays for duration of GUSREX Site L Experiment.
Figure 2: Composite 700-meter trajectories for floats covered in this report. Arrowheads mark every thirtieth day.
Figure 3: Composite 2000-meter trajectories for floats covered in this report. Arrowheads mark every thirtieth day.
Figure 4: Composite 700-meter trajectories for floats covered in this report and earlier Gulf Stream floats. Arrowheads mark every thirtieth day.
Figure 5: Composite 2000-meter trajectories for floats covered in this report and earlier Gulf Stream floats. Arrowheads mark every thirtieth day.
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segment. The initial and average values for temperature and pressure are shown (dash indicates absence of data).

Another float still operating in May 1982 was PL12 which was launched on October 4, 1976, at 24.4°N, 69.0°W, as part of a pilot study for POLYMODE called Pre-LDE (Spain et al., 1980; McKee, 1986). This float was launched by Riser and Rossby (1983) in an isolated eddy of warm, saline Mediterranean water in the Nares Abyssal Plain. It was ballasted to approximately 900 m depth in order to track the “meddy”. PL12 is the longest operating SOFAR float (Owens et al., 1988). In figures where the floats are divided by depth, PL12 is included with the 700-meter floats.

The other non-GUSREX float covered in this report is GS72B, launched on June 6, 1979, at 38.4°N, 67.9°W, near but south of the axis of the Gulf Stream (Kennelly and McKee, 1984). This float had a nominal depth of 700 m.

Figure 6 is a histogram of total durations. Excluding PL12 because it had such a different history, the average duration for all the Gulf Stream floats is 1.45 years (1.65 if floats with reused batteries aren’t included). The average duration of the 13 floats reported here (without PL12) is 2.8 years, which could be lower than the actual value, since five floats (see plus signs on Figure 6) appeared to still be in operation when the last ALS array was retrieved. Of these, four were deep and one shallow, which agrees with earlier observations that the 700-meter floats were more prone to sudden failure (Kennelly and McKee, 1984). In addition, five other floats were fading at the end of their data records. For at least four of these, moving out of range appears to be a sufficient cause of the decreased signal power. GU120, on the other hand, looks like its lithium batteries, reused from an earlier experiment, were giving out. Alkaline-powered floats tend to die abruptly, as GU113 and GU116 did (Kennelly and McKee, 1984).
Figure 6: Total duration of floats covered in this report.
2 Instrumentation

SOFAR floats are freely drifting, neutrally-buoyant subsurface instruments. Every eight hours each instrument transmits a low-frequency acoustic signal which, under optimal conditions, can be heard by an ALS at distances on the order of 2500 km. Forty-eight-hour averages of pressure and temperature are transmitted on alternate days. The ALSs are vertical arrays of hydrophones deployed on a subsurface mooring. A microprocessor-controlled detection system records the times of arrival of the four strongest float signals during each ten-minute interval. During the GUSREX experiment, the ALSs were renewed annually.

3 Processing

In general, the floats discussed in this report were tracked using the methods which are standard at W.H.O.I. (Owens and McKee, 1989). Because of the long duration of some of these floats, special care had to be taken in calculating clock drifts. The data after May 1982 were the first floats tracked at W.H.O.I. The earlier data had initially been tracked at the University of Rhode Island (see Spain et al., 1980, for technique), but were later retracted at W.H.O.I. for consistency.

Analysis on Site L floats (Price et al., 1987, p.13) suggests that the precision of float positions is approximately 2 km.

Temperatures or pressures that drifted outside the range of the sensors have been deleted, as have values that were not associated with a position.

Trajectories having gaps greater than ten days were broken into subfiles and labelled A, B, C, etc. This was necessary for all floats being tracked in May 1983, since the first setting ALSs ran out of tape before the next ALSs could be deployed. Gaps of less than ten days in position, temperature, or pressure were
linearly interpolated to the eight-hour interval. See Figures 7 and 8 for times covered by each float. See Figures 9 and 10 for distance traveled by each float, by segment.

These interpolated series were then filtered using a seven point, one-day-half-width Gaussian filter. Finally, a cubic spline was fitted to the filtered positions to produce one location per day, and east and north components of velocity were calculated.

4 General Information for Individual Float Plots

A trajectory plot and a group of time series plots are presented for each float in Appendix A. The order of the time series plots is: “stick diagram” (u–v vectors), u and v velocity component overplot, and temperature and pressure overplot (where data are available). These plots were created with the objective of presenting the data for a particular float; thus the scales vary between floats. The time axis is consistent throughout, with 200 days per page. The time axis is annotated with the last four digits of the Julian day and with the calendar date. Data points are plotted at daily intervals.

The stick plots show a velocity vector for each day, with the stick length proportional to the speed in centimeters per second. North is toward the top of the page. The separate components on the u and v time series are plotted at the same scale.

Temperature and pressure are overplotted, temperature on a centigrade scale marked on the lefthand axis, pressure in decibars on the righthand axis. Pressure is plotted with deeper values at the bottom of the scale.

A trajectory for each float is plotted on a Mercator projection. Open circles denote the first float position, small dots mark the daily positions, large dots every
Figure 7: Float duration for all 700-meter GUSREX floats as a time line. + means reused from previous experiment.
Figure 8: Float duration for all 2000-meter GUSREX floats as a time line. + means reused from previous experiment.
Figure 9: Total displacement of 700-meter floats covered in this report, by segment. Arrows mark final locations.
Figure 10: Total displacement of 2000-meter floats covered in this report, by segment. Arrows mark final locations.
tenth day, and every twentieth day is annotated with the last four digits of the Julian day. Refer to Appendix C to convert Julian day to calendar date.

Acknowledgements

This research was made possible with funds provided by the National Science Foundation (OCE81-09145 and OCE81-17467). Principal investigators were W. B. Owens, J. F. Price, and P. L. Richardson. Technical support was provided by the float operations group. R. A. Goldsmith developed many of the programs for analyzing float data. B. Gaffron and T. K. McKee made helpful editorial remarks and M. A. Lucas typed the manuscript.
References


APPENDIX A: Individual Float Plots
GUSREX 115C

TEMPERATURE [°C]

PRESSURE [mbar]

JULIAN DAY

NOVEMBER 1982  DECEMBER  JANUARY 1983  FEBRUARY  MARCH  APRIL
GUSREX 118A

N. E. C.

LATITUDE

LONGITUDE ° W

34 33 32 31 30 29

-58 -57 -56 -55 -54 -53
GUSREX 118B

TEMPERATURE [°C]

PRESSURE [db]

JULIAN DAY

APRIL 1983

MAY

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER
GUSREX 118C

TEMPERATURE [°C] vs JULIAN DAY

AUGUST 1984 to JANUARY 1985

PRESSURE [Å] vs JULIAN DAY

5890 5910 5930 5950 5970 5990 6010 6030 6050 6070 6090
PRESSURE [kPa]

GUSREX 120A

TEMPERATURE [°C]
GUSREX 163B

EAST [cm/s] vs JULIAN DAY

NORTH [cm/s] vs JULIAN DAY

SEPTEMBER 1985  OCTOBER  NOVEMBER  DECEMBER  JANUARY  FEBRUARY 1986
GUSREX 165B

U & V cm/s

JULIAN DAY

NOVEMBER 1981  DECEMBER 1981  JANUARY 1982  FEBRUARY  MARCH  APRIL
GUSREX 165C

TEMPERATURE (°C)
GUSREX  165°C

TEMPERATURE [°C]

JULIAN DAY

AUGUST 1982  SEPTEMBER  OCTOBER  NOVEMBER  DECEMBER  JANUARY  FEBRUARY 1983
NORTH [cm/s]

EAST [cm/s]

JULIAN DAY

GUSREX 165D

1985

1986

181
GUSREX 169C

NORTH

s/m [0] cm's

JULIAN DAY

EAST s/m [x] cm's

JANUARY 1985

MARCH

APRIL

MAY

JUNE

6040 6060 6080 6100 6120 6140 6160 6180 6200 6220 6240

240
NORTH

GUSREX 170A

251
GUSREX

NORTH

EAST
APPENDIX B: Publications Using GUSREX Float Data


APPENDIX C: Calendar Conversion Tables —
1981 to 1986

These tables give the year-day and truncated Julian day for each calendar
date for the years 1981 through 1986. The truncated Julian days range from 4606
to 6796. To convert to true Julian day, add 2440000.5 to these numbers.
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