BOMEX BULLETIN NO. 1

Prepared by
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An Interagency Scientific
Planning Group

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The BOMEX Project Office was established by the Interagency Committee for International Meteorological Pro
to serve as the focus for planning and coordinating the Barbados Oceanograhic and Meteorological Experimen

mid-Feb.

The purpose of this bulletin is to inform you of the current status and developments in the scientific and operational planning of BOMEX. It is intended primarily to begin a useful exchange between a scientific planning group and the community of scientists and students in the universities, in government and in private laboratories.

1. Introduction

The Barbados Oceanographic and Meteorological Experiment is a national scientific effort with well defined objectives which may be summarized in the phrase: "the joint behavior and interactions of the atmosphere-ocean system in sub-tropical and tropical waters." The field phase is scheduled for May-July 1969. The experimental area is approximately a 5° square east of the island of Barbados.

The experiment is part of the Global Atmospheric Research Program (GARP) but is a relatively modest effort compared to the larger scale national and international GARP programs planned for the next decade. It is an important experiment, for in addition to realizing the considerable scientific objectives of BOMEX, we must seek to establish the methodology of such large programs. To be successful, such programs must excite the interest and active participation of the scientific community so that the experiment can represent the thought, skill, and technological development of the nation as a whole.

The experimental design itself will remain in a more or less fluid state for the next year or so. In early '69, however, the plans must become concrete and formal. Meanwhile, there is ample time for scientists and mature students interested in participating in the experiment or in using the data for scientific investigation (including thesis work) to have their thoughts, their philosophy, and their efforts become part of the program. If required, financial support for well conceived programs may be available from the National Science Foundation or other sponsoring agencies. In any case, this Bulletin is part of our initial conversation with you. Please feel not only free but perhaps even obliged to communicate with us if so much as a momentary relevant thought comes to mind.

The initial issue of the BOMEX Bulletin is devoted to a statement of the broad objectives of the program, a list (so far incomplete) of the available resources, and a brief preliminary climatological description of the experimental area. Subsequent issues (at 4 to 6 week periods) will discuss individual objectives in greater detail and will examine the ability of existing observational systems to meet specific objectives in given configurations.

2. Scientific Objectives

The central theme of the experiment is air-sea interactions. The experiment is, first of all, an implementation of the classical "area" study called for in the 1962 National Academy of Science Report on Interaction between the Atmosphere and the Oceans. NAS-NRC Pub. 983.

Objectives contained in the oceanographic, meteorological and satellite programs are equally important and will be discussed in subsequent issues.

In brief, the sea-air interaction objectives are:

(a) Study of the vertical flux of momentum, sensible heat, latent heat, radioactivity and other properties at the interface and the horizontal transport of these properties through the lateral boundaries of the observational array.

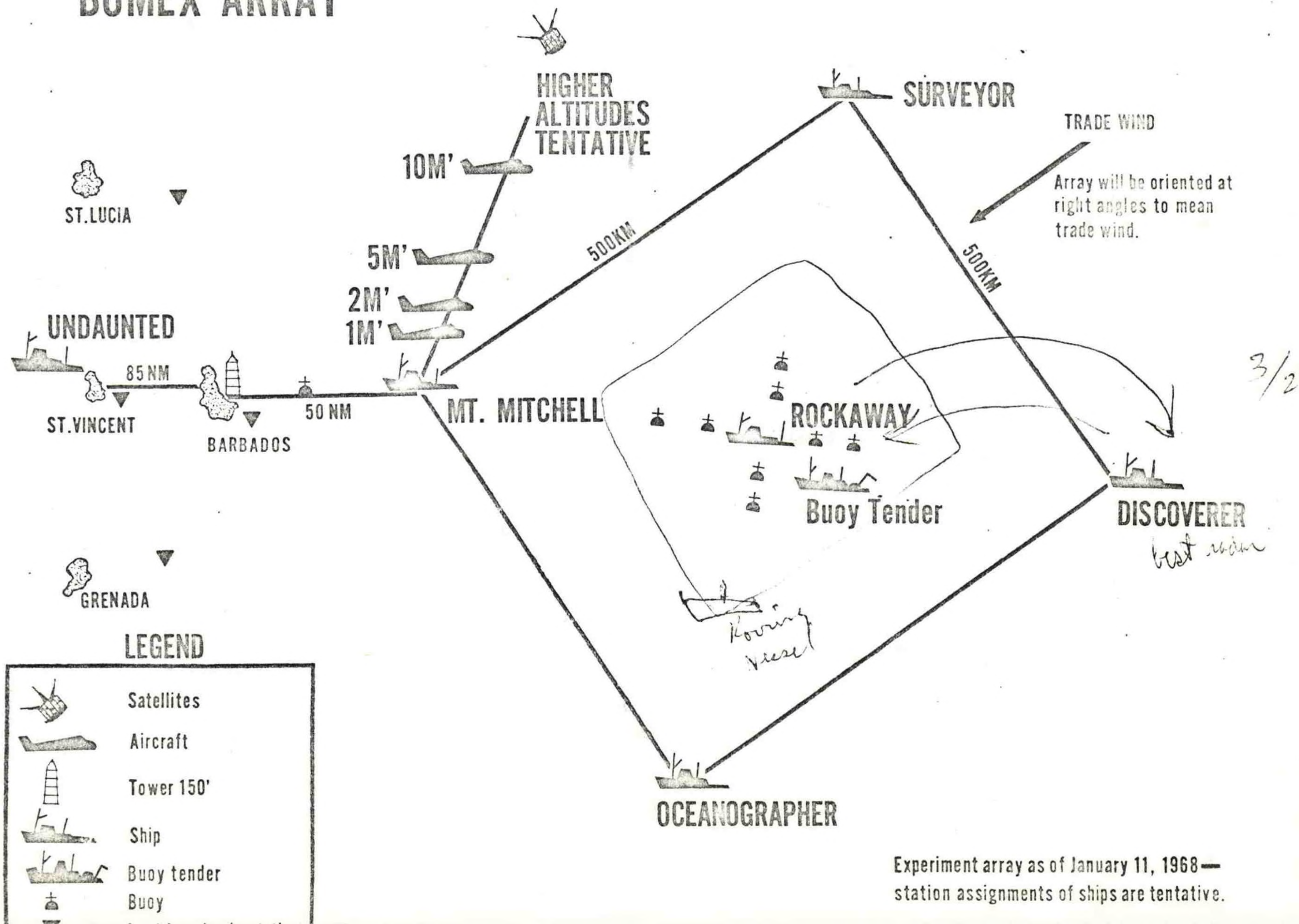
(b) Study of the vertical and horizontal divergence of these fluxes within the interior of each fluid.

(c) Study of the feasibility of parameterizing the area wide integral of at least the surface fluxes from conventional observation at the fixed corners of the array.

A possible configuration of the currently available resources is shown in figure 1, page 3. It is evident that such an array combined with island stations, and satellite observations can yield coherent information on meso and synoptic scale disturbances in the atmosphere, and certainly can yield a wealth of information of the time and space scale of variability in the ocean.

Figure 1

BOMEX ARRAY



Experiment array as of January 11, 1968—station assignments of ships are tentative.

Because of the extensive documentation of the total fluid environment, a host of possible sub-experiments come to mind ranging from convective transport studies in the atmosphere to studies of the Deep Scattering Layers in the sea.

It is relatively easy to state objectives in broad terms; it is infinitely more difficult to devise an experiment which has a finite probability of meeting these objectives. To accomplish this one must evaluate current technology and plan the use of resources in the most efficient manner possible. At the same time one must sharpen the scientific questions so that in the end the data collected will be relevant to the questions asked and the pertinent time scale inherent in each question. This is precisely the work the planning group must accomplish hopefully with your help, during the next year.

3. Participating Agencies and Contacts

Department of Interior	Dr. Merton C. Ingham Mr. Paul Sund (Alternate)
Atomic Energy Commission	Dr. Rudolf Engelmann
Department of Transportation U.S. Coast Guard	Commander R. E. Lenczyk
National Science Foundation	Mr. Eugene Bierly
Department of Defense	Captain T. H. O'Neil, USN
U.S. Army	Lt. Col. Martin Schroeder
U.S. Air Force	Colonel L. A. Gazzaniga
U.S. Navy	Dr. J. B. Hersey Mr. J. J. Schule, Jr.
Department of Commerce ESSA	Mr. Feodor Ostapoff
National Oceanographic Data Center	
National Center for Atmospheric Research	Dr. William Kellogg Dr. Daniel F. Rex

4. Resources

All agencies have responded affirmatively to the BOMEX requirement for major resources. Several have made firm commitments while others have the matter under active study to determine what they will allocate. In order to give some idea of the scope of the experiment as of this date the reasonably secure (firm and programmed) major commitments are shown below:

SHIPS

Agency:	Firm:	Programmed:
Interior (BCF)	R/V UNDAUNTED (Caribbean Operation)	
Transportation (USCG)	ROCKAWAY	1-Buoy Tender
Commerce (ESSA) (C&GS)	DISCOVERER SURVEYOR MT. MITCHELL OCEANOGRAPHER	

Each of these ships has oceanographic capability (salinity, temperature, density, etc.). The ROCKAWAY is presently equipped with wind-finding radar. The DISCOVERER will have wind-finding and precipitation radar by early 1969. The OCEANOGRAPHER, SURVEYOR and MT. MITCHELL will be equipped with a stabilized antenna wind-sounding system (SCANWELL) now under procurement.

AIRCRAFT

Agency:	Firm:	Programmed:	Tentative:
AEC			1
DOD			
USAF			6
Commerce			
ESSA (RFF)	3		

Two DC-6's of Research Flight Facility (RFF) of ESSA are instrumented with a Doppler wind system, infra-red hygrometer, temperature, precipitation radar, liquid water, and an associated data acquisition system.

They are committed to BOMEX on a first priority basis. It is anticipated that at the time of the experiment a dewpoint hygrometer system will be available. The RFF will also furnish one instrumented DC-4. The AEC aircraft will be equipped with a sonic anemometer for measuring turbulence. DoD aircraft listed as tentative are presumed to be weather reconnaissance aircraft of the AWS of USAF. AWS aircraft have the capability for particulate and gaseous sampling in addition to their standard instrumentation as do those of the RFF.

BUOYS

Agency:	Firm:	Programmed:
Commerce		
ESSA		
C&GS	5	
SAIL	3	

Five C&GS ODESSA buoys have the following oceanographic capability: Temperature, salinity, current at six levels with associated recording. Plans are now underway to support a tower and a set of meteorological (wind, temperature and humidity) sensors. The ODESSA BUOY was first developed as a shallow-water buoy. Deep sea anchoring trials for the new hulls will be scheduled for later in the year.

Three micro-meteorological Spar Buoys, developed at Florida State University by Dr. M. Garstang, will have multi-level meteorological sensing and water temperature measurement capabilities. In addition, one of the buoys will be equipped to measure wave heights.

In addition, Boundary Layer Wind Systems designed for shipboard use are currently in the development and testing phase by the Sea-Air Interaction Laboratory (SAIL). It is anticipated that three to five of these systems will be available for the experiment. They are tethered balloon systems with temperature, humidity, wind speed, and height (pressure) sensors with design altitude capability of 1500 meters.

Further information covering the BOMEX instrumentation, including type, platform, frequency of observation and accuracies will be contained in subsequent issues of this bulletin.

5. Climatic and Oceanographic Data

The experimental area is in the trade wind region downwind of a long, over-water trajectory. In July, the area is subject to tropical storms. The frequency of storm tracks in the area 10-20°N, 50-60°W, in July, is:

Type	No.	Period of Record
Depression (max wind < 34 knots)	3	1951-1967
Tropical Storm (wind > 34 knots)	14	1901-1967

Source: Tropical Cyclones of the North Atlantic Oceans (Technical Paper No. 55, 1965, U.S. Department of Commerce, Weather Bureau) and Monthly Weather Review

In addition to these closed surface circulations, weak disturbances probably mostly of mid-tropospheric origin are fairly frequent in the area of interest. For example, out of a total period of 40 days, mostly in August, 1957 and 1963, Garstang, La Seur and Aspliden (1967) were able to isolate eight synoptic scale disturbances on a 500-1000 km space scale and a 1-3 day time scale.

The mean August 1963 position of the confluence line separating the southern and northern hemisphere trades was at about 12°N in the longitudes of interest. (Aspliden, Dean and Landers, 1965)

The National Environmental Satellite Center made a survey of the cloud cover in the region 10-20°N, 50-60°W for May, June and July 1967 from weather satellite photographs. A brief summary follows:

May 1967 - This month had the least cloud cover of the three surveyed. Convective and cirrus cloudiness covered 1 to 3 tenths of the area on most days. A dense band of cirrus and cumulus was near the northwest corner of the area on three days of the month.

June 1967 - The cloud cover varied from 1 to 4 tenths. On 5 days a large cloud mass 5 to 8 degrees in diameter was situated west of the BOMEX region by 5-10 degrees. A tropical storm was north of the area on one day. A band of cirrus 2 degrees wide ran north-south through the area on one day.

July 1967 - The cloud cover on any day varied from 1 to 4 tenths. On three days large cloud masses were found west of the region. Considerable cirrus cloudiness was along the southern edge of the region on 5 days of the month.

Preliminary climatological data of interest in defining the environment in which we will work follows:

TABLE I. SURFACE ENVIRONMENTAL CONDITIONS

Temperatures

	Air Temp °F	Dew Point °F	Sea Surface Temp.	Max. Observed Sea-Sfc. Temp.
May	70°-80°	69°-74°	79 -80°	84
June	80°-82°	74°-76°	80 -81°	84
July	80°-81°	74°-76°	80 -82°	> 84

Surface Salinity Range

April-June	35-36 ‰
July-September	32-36.25 ‰

Sea State for 17½°N, 54½°W

Percent Frequency	May	June	July
< 3 feet	50%	43%	30%
3- 5 feet	33%	36%	41%
5- 8 feet	15%	17%	21%
8-12 feet	2%	4%	7%
≥ 12 feet	-	-	1%
Percent frequency of sea > 5 feet	17%	21%	29%
Direction			
45°	26%	35%	41%
90°	68%	59%	54%
135°	8%	6%	5%

Swell for 17½°N, 54½°W

Percent Frequency	May	June	July
No Swell	4%	3%	4%
1- 6 feet	53%	46%	39%
6-12 feet	40%	48%	52%
> 12 feet	3%	3%	5%

	May	June	July
Surface pressure gradients and geostrophic winds for 13°-18°N and 54°-59°W			
	$\frac{2.6\text{ mb}}{500\text{ km}}$	$\frac{3.0\text{ mb}}{500\text{ km}}$	$\frac{3.0\text{ mb}}{500\text{ km}}$
Direction	23°	20°	15°
Sfc. Geostrohpic wind speed	8 m/s	10 m/s	10 m/s
Sfc. Geostrophic wind direction	113°	110°	105°

Sfc. Wind Distribution (June - 17°N 57°W)

Direction	Frequency (%)
NE	44
E	51
SE	3

Speed (knots)	Frequency (%)
4-6	5
7-10	21
11-16	41
17-21	26
22-27	5
> 27	+

Sources: Oceanographic Atlas of the North Atlantic Ocean Section II, Section IV, U.S. Naval Oceanographic Office

U.S. Navy Marine Climatic Atlas of the World Volume I

Climatological and Oceanographic Atlas for Mariners Vol. I, North Atlantic Ocean, Department of Commerce

TABLE II. DISTRIBUTION OF WIND SPEED AND DIRECTION OCCURRENCES AT 500 M., SEAWELL AIRPORT, BARBADOS. $13^{o}04'N$, $50^{o}30'W$, May 15 - July 31, 1966 1200 GMT
Source: WBAN 20 (All Data Shown as percentages)

Direction	Speed (mps) 0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	Percent
050-059			1			1				3%
060-069		1	3	1	1		1	1	1	12%
070-079				4	4	4	9			22%
080-089				4	7	9	6		3	29%
090-099			3	4	3	6	1	1		19%
100-109				4		1		1		7%
110-119				1		1				3%
120-129		1	1							3%
130-139					1					1%
160-169			1							1%
(Percent)		3%	10%	20%	18%	23%	18%	4%	4%	100 %

TABLE II. (Con't) DISTRIBUTION OF WIND SPEED AND DIRECTION OCCURRENCES AT 500 M., RAIZET, GUADELOUPE 16° 16'N, 61° 31'W; May-July 1966, 0000 and 1200 GMT (Source WBAN 20) (All Data shown as percentages)

	Speed (mps)									(Percent)
Direction	0-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	
050-059			0.5		1					2%
060-069			1	2						3%
070-079			4	9	3	0.5	1			17%
080-089		0.5	4	12	4	1				22%
090-099			5	10	5	0.5				21%
100-109			5	9	4	0.5	0.5			19%
110-119	0.5		4	4	3	1				12%
120-129			1	0.5	0.5	0.5				3%
129-165						0.5				1%
(Percent)	0.5%	0.5%	24%	47%	21%	5%	2%			100%

Latent Heat Exchange

Table III was obtained from Budyko's Atlas, Jacobs (1951) and a paper by Garstang (1965) tabulating latent heat fluxes or evaporation.

TABLE III. CLIMATOLOGICAL ESTIMATES OF LATENT HEAT FLUX ($Cal/cm^2/day$)

				Budyko		Jacobs	Garstang
		May	June	July	Average	June-Aug.	August
20°N	60°W	260	280	340	293	300	365
20°N	55°W	260	280	340	293	300	370
20°N	50°W	260	260	330	283	300	380
15°N	60°W	260	300	340	300	300	390
15°N	55°W	260	300	340	300	300	430
15°N	50°W	260	270	330	287	300	480
10°N	60°W	260	330	320	303	300	380
10°N	55°W	260	330	320	303	300	380
10°N	50°W	260	330	320	303	300	380

TABLE IV. PERCENT OF OBSERVATIONS WITH PRECIPITATION
(After W. C. Jacobs, 1951)

	March-April-May		June-July-August	
	Long	Long	Long	Long
Latitude	50°-55°W	55°-60°W	50°-55°W	55°-60°W
10°-15°N	20%	20%	30%	30%
15°-20°N	7%	10%	15%	15%

TABLE V. CASES OF CONSECUTIVE RAIN-FREE DAYS AT ALL FIVE SELECTED STATIONS ON BARBADOS.

Table V as prepared from five years rainfall data, kindly provided by Dr. Garstang, FSU, from the Island of Barbados. Of the some 90 rain gage stations, five were selected on the upwind side of the island, two at the northern tip, one at the middle along the east coast, and two at the south-eastern end of the island. Island data may not be truely representative of the open ocean. Great variability as to amounts and occurrences show up in the data between one station and another.
In order to obtain some feeling about the large-scale precipitation features, the number of days at which no rain or less than .01 inch occurred simultaneously at all five stations are tabulated in Table IV. Clearly, convective activities increase toward the end of the summer and are reflected in a minimum of rain-free days in July.

Month	May						June						July					
No. of consecutive rain-free days.	6	5	4	3	2	1	6	5	4	3	2	1	6	5	4	3	2	1
1958				1	1	2					1	3						2
1959	1					1	1			1	1	2					1	3
1960		1		2	1	2				1	1	2						2
1961			1		2	4					3	3					1	2
1962		1		2	1	4					2	4				2		2
TOTAL	1	2	1	5	5	13	1	0	0	2	8	14	0	0	0	2	2	11

Surface Currents

The reproduced current chart for July is obtained from G. Wust's (1964) Stratification and Circulation in the Antillean-Caribbean Basins. Comparison with the April conditions reveals an increase of current velocity and observed currents in July. Also, the current direction in July is more easterly than in April.