GARP TOPICS

No. 54 May 1979

An occasional series reporting on U.S. and international GARP scientific, technical, and planning activities, developments, and programs, presented as a public service to the meteorological community by the American Meteorological Society through arrangements with the U.S. Committee on the Global Atmospheric Research Program of the National Academy of Sciences–National Research Council. Opinions expressed in "GARP Topics" do not necessarily reflect the point of view of the U.S. Committee.

The Winter Monsoon Experiment—Report of December 1978 Field Phase

Richard S. Greenfield

National Science Foundation
Washington, D.C. 20550

T. N. Krishnamurti

Florida State University
Tallahassee, Fla. 32306

Abstract

These notes provide a short summary of the field phase of the GARP Winter Monsoon Experiment. The field phase commenced on 1 December 1978, with the field operations coordinated from Kuala Lumpur. The participants included scientists and technical personnel from Malaysia, Indonesia, Thailand, the Philippines, Hong Kong, Japan, Saudi Arabia, Singapore, Australia, People's Republic of China (PRC), the U.S.S.R., and the U.S.A. The observing systems, type of experiments, mission objectives, components of overall data sets, and a preliminary evaluation are presented in this short survey.

1. Introduction

The Winter Phase of the Monsoon Experiment (WMONEX) was inaugurated on 30 November 1978 at a ceremony at the Subang International Airport in Kuala Lumpur, Malaysia. The ceremony included addresses by the Minister of Transport for Malaysia; the Director of the GARP Activities Office, World Meteorological Organization; and the Director-General of the Malaysian Meteorological Service. The WMONEX Operational Center (WMOC) became fully operational at the airport on that date.

Approximately 80 scientists, technicians, and support staff had gathered at the Operational Center in Kuala Lumpur to take part in the massive data-gathering operation connected with WMONEX. Many others were involved with remote site observational programs, including ships in the South China Sea and island stations. The nations that were actively involved in WMONEX include Australia, PRC, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Saudi Arabia, Singapore. Thailand, the U.S.A., and the U.S.S.R. There were approximately 60 participants from the U.S.A.

The field phase of WMONEX extended from 1 December 1978 to 5 March 1979. During the month of December, a major intensive observing period was mounted. This report covers that particular phase of the experiment.

MONEX is part of the monsoon subprogram of the Global Atmospheric Research Program (GARP) and is divided into two phases. The winter phase concentrated on the northeast monsoon that occurs during the months of December, January, and February. The summer phase, called Summer MONEX (SMONEX), will concentrate on the southwest monsoon that occurs over the Indian Ocean and the Indian subcontinent during the months May–August. Both phases of MONEX are regional components of the Global Weather Experiment—

0003-0007/79/050439–06$05.50

First GARP Global Experiment (FGGE). WMONEX overlaps with the FGGE Special Observing Period-I (SOP-I), and SMONEX overlaps with SOP-II.

The overall objectives of the Winter Monsoon Experiment are to obtain a data set that will allow research on the following aspects of the monsoon:

I. *Planetary-Scale Aspects and Heat Sources*
  A. Planetary circulations
    1) The Hadley type circulation
    2) The east-west planetary circulation
    3) The equatorial trough
  B. Heat sources and the effects of orography on the radiation balance.

II. *Synoptic Scale Regional Aspects*
  A. The cold surges
  B. The near-equatorial disturbances
  C. The eastward moving upper tropospheric trough

III. *Interactions on the Planetary and Synoptic Scale*
  A. Interactions between the Northern and Southern Hemispheric planetary scale circulation systems.
  B. Interactions between planetary scale mid-latitude circulation systems and equatorial disturbances.
  C. Interactions between planetary scale equatorial circulation systems and equatorial disturbances.
  D. Interactions between equatorial disturbances and stratospheric circulations.

IV. *Numerical Simulation and Prediction*
  A. Regional forecast problems
    1) Cold surges
    2) Equatorial disturbances
    3) Heavy rain periods
    4) Dry spells
  B. Global prediction
    Numerical forecasts of the general circulation and its modulation by the Winter Monsoon.

The details of the plans to achieve those objectives are in the 1977 report of the National Academy of Sciences, *Plan for U.S. Participation in the Monsoon Experiment (MONEX)*.

The WMONEX data set makes use of the background observations provided through the World Weather Watch Observational System for FGGE, enhanced by the Japanese Geostationary Meteorological Satellite (GMS) and the U.S. TIROS-N polar orbiting satellite. In addition, especially for WMONEX, three portable upper-air stations were deployed at various islands in the South China Sea and a more extensive network of portable surface stations covering seven islands in the South China and Java Seas. During the enhanced observing period of December 1978, this observational system was expanded by the presence of three Soviet ships in the South China Sea, two U.S. research aircraft, and a digitized Doppler radar system from MIT deployed at Bintulu in eastern Malaysia. Figure 1 illustrates the domain of the regional Winter Monsoon Experiment. The diagram shows the locations of the World Weather Watch (WWW) upper-air network. The triangle denotes the sites occupied by the three Soviet ships during the first 10 days of December. (The southern ship moved equatorward in the latter half of December). The dashed circle identifies the site of the U.S. radar at Bintulu. The dark squares identify the sites of the portable upper air units, some of which were implemented during the experiment. Normally every 6 hours the Soviet ships launched radiosondes that were tracked with radar wind-finding equipment. The research aircraft were a NOAA P-3 and the NCAR Electra, both equipped with Omega Dropwindsonde Systems and an extensive array of sensors for flight-level observations.

Since the primary flexibility in the observational program was afforded by the research aircraft, the major emphasis at the WMOC during December was the flight planning necessary to effectively deploy those aircraft. An international team of forecasters and analysts operated around the clock at the WMOC to provide the necessary forecasts of conditions for flight planning purposes. At 5:00 P.M. each day during the month of December, the Scientific Planning Team met at the WMOC to consider the possibilities for flight tracks for the following day. The Scientific Planning Team consisted of a representative from each participating nation, a mission scientist from each of the two aircraft, and the Chairman of the U.S. MONEX Panel. At this meeting, the forecast and analysis team presented a detailed weather briefing and then all of the scientists who were attending the meeting presented their views on the aircraft deployment strategies for the following day. Based on these discussions and proposals for aircraft missions, the Scientific Planning Team made decisions for the primary and alternative mission for the next day. If the situation was appropriate, an intensive observing period was declared that involved more extensive observations by the various observing platforms (the portable upper-air stations, the ships and the GMS).

2. Experiments during the field phase

A summary of the experiments is presented in Table 1. During the period of 1–8 December, the synoptic situation over the WMONEX region was not favorable for aircraft missions directed at the highest priority MONEX scientific objectives. A variety of logistics problems also precluded the full deployment of the WMONEX observational system during that week. During that time, a shakedown mission was flown by both aircraft to survey a small disturbance north of Borneo. Several other secondary missions were flown, including an air chemistry sampling effort over Borneo, an inspection of the active equatorial trough over the Java Sea and a very weak cold outbreak survey over the South China Sea. By 8 December, most of the observational systems were deployed. The portable surface stations, however, remained inoperative until near the end of December. All of the upper-air stations were not operational until almost the end of the month.

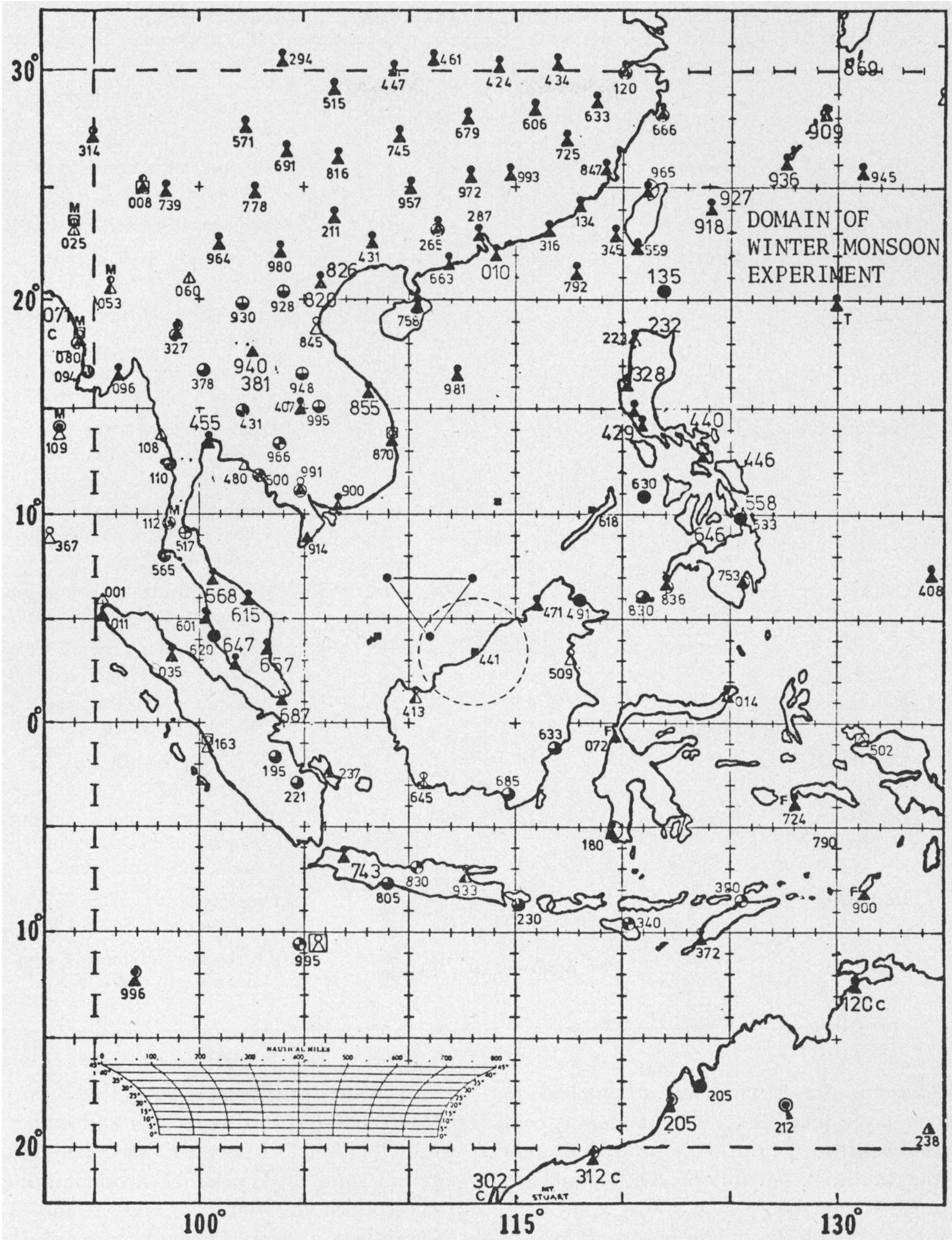

FIG. 1. The domain of the Winter Monsoon Experiment illustrating locations of the surface and upper air stations; the triangle formed by the Soviet ships; the dark squares illustrating portable radiosonde sites, and the circle identifies the converage by the MIT radar at Bintulu.

On 9 December, an interesting situation developed west of Sumatra that indicated the formation of a pair of vortices to the westward side of the northern and southern tips of this "barrier" to a deep easterly flow regime. A P-3 mission was approved to carry out a dropwindsonde survey of that phenomenon. Simultaneously, the Electra was deployed to study a weak vortex in the South China Sea north of Borneo. A lightning strike disabled the navigational system, resulting in an aborted mission. By the evening of 9 December, the Siberian high was developing southward rather vigorously. Both the Hong Kong and the WMONEX Operational Center forecasts indicated an anticipated cold surge with passage through Hong Kong expected during the night of 10 December. The Scientific Planning Team (SPT) responded by scheduling a full scale 3-day cold surge survey, and an intensive observing period for 10 and 11 December was implemented. The strategy was to cover the South China Sea with an array of dropwindsondes on a 2–3° resolution grid for the 3-day period, before, during, and after the cold surge swept across the region. A moderate surge did develop and the missions were successfully flown on 10 and 11 December. On the 12th, because of a failure of its

TABLE 1. Summary of experiments, WMONEX, 2–31 December 1978.

Expt. No.	Date	Aircrafts	Flight Levels ≈ (km)	Dropsondes Deployed	Mission Scientific Objective
1	Dec 2	Electra NOAA P-3	5.5 6.7	— 5	Checkout of aircraft for dropsonde systems
2	Dec 4	Electra	1	—	Air chemistry over the Borneo Jungle
3	Dec 6	Electra P-3	1–5 1–5	— —	Equatorial trough over Java Sea
4	Dec 7	Electra P-3	5.5 6.5	11 18	Moderate surge over the South Sea
5	Dec 9	P-3	6.5	22	Double vortices on either side of the equator west of Sumatra
6	Dec 9	Electra	2–5	2	Weak vortex over the South China Sea. Mission aborted due to lightning on Electra
7	Dec 10 11 12	P-3 Electra	7 5.5	60 24	Three-day "Moderate Surge" Mission Last day Electra mission limited to boundary layer
8	Dec 15	P-3	7	7	Meridional flight missions into equatorial trough west of Sumatra
9	Dec 15	Electra	1	—	Planetary boundary layer of weak surge
10	Dec 16 17	P-3 Electra	6.5	22 17	Two-day "Vortex Mission" over South China Sea
11	Dec 18	P-3	1	—	Cloud physics mission over N. Malaysia
12	Dec 21	Electra	2–5	2	Radiative flux measurements over South China Sea during steady weak surge conditions
13	Dec 24	Electra	6	10	One-day weak vortex data gathering mission over South China Sea
14	Dec 29 30 31	Electra	6	46	Three-day "Moderate Surge" Mission over South China Sea

dropwindsonde system, the Electra was dispatched to measure boundary layer fluxes during a moderate cold surge while the P-3 continued to provide dropwindsonde coverage over the southern portion of the region surveyed on the previous 2 days.

On 15 December, the Electra made a second survey of the South China Sea boundary layer fluxes in a nonsurge, steady northeasterly flow regime. This would permit a comparison of the fluxes in these two characteristic winter monsoon synoptic situations. Simultaneously, the P-3 accomplished a mission across the equatorial trough south of the equator to provide data sets for cross-equatorial interactions during the monsoon season.

Examination of the GMS satellite pictures for the period prior to the evening of 15 December revealed the apparent development of a westward propagating and developing disturbance that was moving to the north of Borneo within range of the aircraft by the morning of the 16th. The SPT scheduled a 2-day survey of the disturbance as it continued westward. Real-time analysis of the flight level and dropwindsonde data on 16 and 17 December missions revealed that a vortex circulation existed in the disturbance as it continued to move westward. Figure 2 illustrates an example of streamline analysis from the quick-look dropwindsonde data for 17 December at the 700, 850, and 950 mb. The dropsonde data entries at a site, denote (going clockwise from the top left) the temperature, wind direction, wind speed, and the relative humidity measurements. The analysis illustrates a weak lower tropospheric vortex in the South China Sea. Scientists desirous of examining such disturbances should make efforts to examine the total data sets from the diverse FGGE/MONEX platforms. These are identified in the next section.

On 19 December, the NOAA P-3 departed Kuala Lumpur, as scheduled, to prepare for its participation in FGGE. The aircraft program for the remaining days of December continued with a single aircraft: the NCAR Electra. On 21 December, the Electra was flown over the South China Sea gathering radiation and cloud physics observations during steady NE monsoon conditions. On 24 December, another mission was flown over the South China Sea to examine a vortex disturbance.

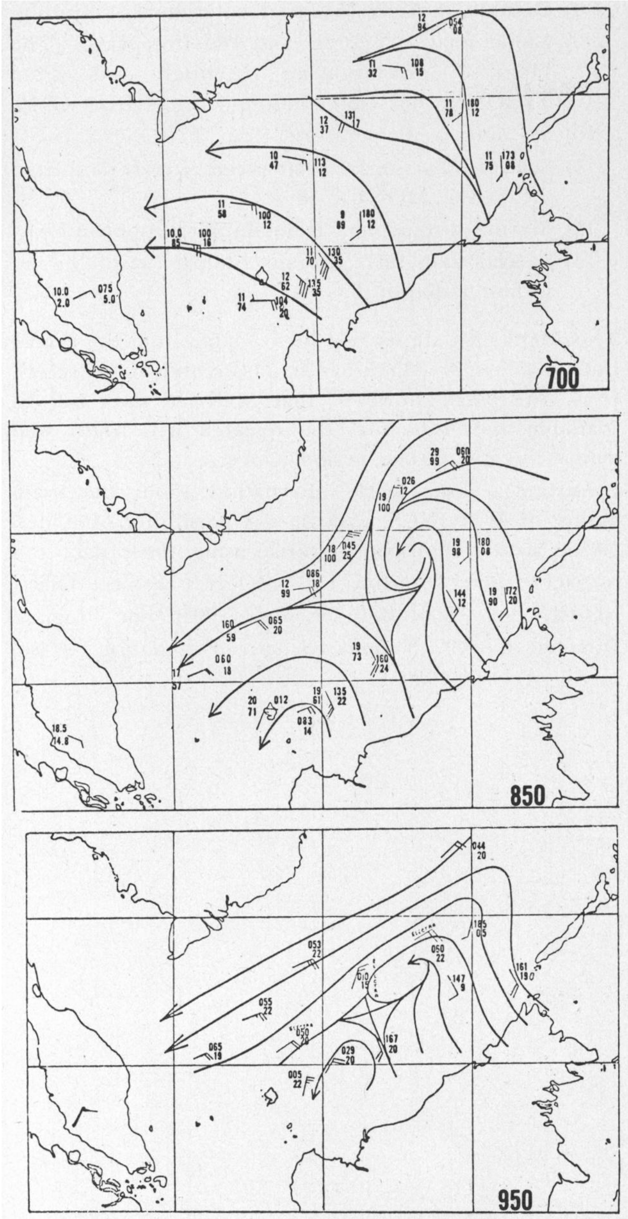

FIG. 2. Illustrates a weak vortex over South China Sea. Seven-hundred, 850, and 950 mb streamlines are constructed from the dropwindsonde data. The plotted numbers at dropwindsonde sites from top left (going clockwise) denote air temperature, wind direction, wind speed (kt) and relative humidity (%).

Finally, a 3-day cold surge mission was again mounted for the period 29–31 December. The Electra landed at Kota Kinabulu in East Malaysia (Borneo) on 29 December and staged out of that airport for the 30 December mission.

On 31 December, the Soviet ships came together for an instrument comparison and departed their stations in the South China Sea for arrival in Singapore on 2 January. The Electra ceased operational activities as of 1 January. Joachim Kuettner, Director, U.S. MONEX Project Office and Scientific Director of the WMONEX Operational Center provided the following as his overall assessment of the December period of enhanced observations for WMONEX: "Winter monsoon was weaker and precipitation lower then normal; however, northeast monsoon flow was steady throughout. No deep surge vortex formed, but frequent eddies over the South China Sea were observed." With the exception of these abnormally weak synoptic situations and a somewhat marginal performance of the portable upper-air stations, the observational phase of the project is considered successful.

For the WMONEX program, a portable satellite readout station was provided by the U.S.A. in Kuala Lumpur. As a result, real-time imagery from the GMS was available for flight planning, analysis, and forecasting purposes.

Several of the scientists used the satellite photographs to examine time sequences of cloud patterns over the western Pacific, South China Sea, and Bay of Bengal regions. The preliminary indications from this examination are that there may be westward-propagating waves in the midtropospheric easterlies generating organized cloud patterns that move through the region being observed. Of course, the evidence is principally the satellite-observed cloud patterns, with scant dynamic observations available now. The apparent propagation of the cloud patterns is readily discernible from the satellite pictures. Superimposed on the translational features of the patterns are transients that are apparently related to both diurnal variations in the convective activity and responses to orography and land-sea contrasts. For example, the translating cloud patterns invariably diminished in intensity as they passed through the region of Mindanao in the Philippines. Throughout the WMONEX region, the satellite imagery gave ample evidence of a pronounced diurnal component in convective activity. The scientists were excited about the prospects of research on the existence of the pronounced diurnal modes as well as propagating wave disturbances and their interaction with the monsoonal circulations.

Given two successful 3-day cold surge missions, a 2-day vortex disturbance mission, and several other disturbance missions in the vicinity of Borneo, Sumatra, and the Java Sea, the authors feel that several valuable data sets have been produced during the first month of the WMONEX field phase. The scientists who participated in the field phase felt that high quality winter monsoon research could be accomplished using these data sets. It is hoped that the data from the remaining 2 months of WMONEX, when coupled with the FGGE data set, will also provide good opportunities for monsoon research.

3. Data sets

The international data management plan for WMONEX specifies that a Quick Look Data Set will be available for international dissemination within 6 months after the field phase of WMONEX, i.e., by September 1979. That data set will include microfilms of specific pressure levels of operationally analyzed data; microfilms of operationally plotted data, updated with delayed observations; an atlas of operationally received satellite pictures and radar imagery; and digital archives of the Global Telecommunications System (GTS) data. The Quick Look Data Set will also include some special data such as rainfall, radiation, radar, and agrometeorological observations. The international data management plan also specifies that a data set that merges dedicated MONEX data and FGGE background data will be available within 2 years after the experiment.

The final MONEX data sets for research include the following categories:

1) World Weather Watch surface and upper-air data.
2) FGGE/MONEX research ship surface and upper-air data.
3) Surface and upper-air data from special MONEX platforms.
4) Flight-level data from research aircrafts.
5) Dropsonde data from research aircrafts.
6) Digital radar data from NOAA P-3 research aircraft.
7) Cloud physics radiation and boundary layer data from research aircrafts.
8) Digital data from MIT radar stationed at Bintulu.
9) Cloud imagery (visible and IR) from GMS (The Japanese geostationary satellite) and from TIROS-N, and cloud motion vectors from GMS.
10) Sea surface temperatures from TIROS-N.
11) Special collection of commercial aircraft data from the FGGE/MONEX efforts.
12) Marine surface data from ships of opportunity.
13) Special data sets: agrometeorology, rainfall, and surface radiation.

This MONEX data set will be available from the World Data Centers A (Washington, D.C.) and B (Moscow). It is anticipated, however, that MONEX data will be available and, therefore, the research will begin well before the 2-year time period is over.

Anyone seeking more information about the availability of WMONEX data or the possibility of undertaking winter monsoon research using those data can contact either: Director, U.S. MONEX Project Office, NCAR, Box 3000, Boulder, Colo. 80307 or Program Director, GARP, National Science Foundation, Washington, D.C. 20550. •