The Synoptic-Scale Subprogram

David E. Parker [1]

International Scientific and Management Group for GATE, Bracknell, U.K.

1. Introduction

The Synoptic-Scale Subprogram encompasses a broad range of scientific problems and serves in a supporting role for most of the special studies of GATE. It is unique among the five subprograms in its emphasis on data from a wide area of the tropics consisting of both land and ocean, and therefore is closely related to the coming First GARP Global Experiment (FGGE). However it can only fully be understood within the context of the GATE Central Program and the other four GATE subprograms. The Central Program and the relationships between it and the subprograms are described in the section "General Description and Central Program" above in the present paper; therefore this section on the Synoptic-Scale Subprogram must be read in the light of what is stated in that section.

Greater detail can be found in GATE Report No. 6, "The Synoptic-Scale Subprogram for GATE" (Houghton and Parker, 1974).

2. Scientific objectives

a. Scientific objectives within the Central Program

The scientific objectives of the Synoptic-Scale Subprogram falling within the scope of the Central Program are as follows.

Description of the synoptic-scale disturbances in the tropical troposphere and lower stratosphere from West Africa to the western Atlantic Ocean.

"Description" is a necessary prelude to the study of "interactions" involving the disturbances. The interactions can of course be with smaller-scale phenomena such as B-scale features including cloud clusters, or with larger-scale phenomena which comprise the basic state. For discussion of scale interactions in general see GATE Report No. 1, "Experiment Design Proposal for GATE" (Kuettner, Rider, Sitnikov, 1972) and see also the section "General Description and Central Program" above in the present paper. The lower stratosphere has been included because Murakami (1973) and Holton (1973) have in numerical modeling studies shown the induction of equatorial lower-stratospheric waves by tropospheric heat sources. Description for West Africa and the Atlantic Ocean is specified because such description will best facilitate the synoptic-subsynoptic interaction studies which can only be carried out in detail for the GATE B-scale area (5–15N, 20–27W) and environs.

Description of the averaged state of the GATE area troposphere particularly in terms of the jet streams, meridional circulations, and the Intertropical Convergence Zone, and clarification of the nature of the interactions between the basic-state flow and the synoptic-scale disturbances.

The behavior of the synoptic-scale disturbances and their interactions with subsynoptic features can be fully understood only when proper account is taken of the pervasive influence of the planetary-scale tropical background state. To provide sufficient information on this background state the troposphere over the whole GATE area needs to be monitored.

Description of the synoptic-scale environment of cloud clusters passing through the B-scale area in sufficient detail to allow investigation of the interactions between the clusters and the large-scale motions.

This scientific objective is a culmination of the two previous objectives: note that "synoptic-scale environment" includes not only disturbances as such but also the background atmospheric state.

Development of complete and internally consistent data sets for tropical numerical models.

Other than the fundamental aim of directly understanding the functioning of the atmosphere itself, the reason for placing such emphasis in GATE on synoptic-subsynoptic interactions is to facilitate the expression of sub-grid-scale features in large-scale numerical models implicitly in terms of grid-scale features, i.e., parameterization. New or improved parameterization schemes in the models will, it is hoped, provide an indirect avenue to increased understanding of the atmosphere, as well as to improving operational forecasting skills. This fourth scientific objective of the Synoptic-Scale Subprogram is therefore of great importance.

The contribution of the Synoptic-Scale Subprogram to the models will of course be in terms of synoptic-scale data, which should be spatially and temporally as complete and consistent as possible; other subprograms will supply additional data of the appropriate types. The synoptic-scale data should cover the whole GATE area so that the models can take into account planetary-scale as well as synoptic-scale features, and so that sufficient data will be available to cover all the coarse-resolution outer areas of nested-grid models whose fine-resolution inner areas will generally coincide with the GATE B-scale area. Data sets for the GATE A-scale area should be suitable for use as initial data for predictions, insertion data for four-dimensional or continual data assimilation models (see Miyakoda and Talagrand, 1971), and verification data for diagnostics. Some of the models served will be of limited area: such models can provide useful insights (Krishnamurti and Kanamitsu, 1973). Other models will of course be global.

Care needs to be taken concerning the internal consistency of the data sets for numerical modeling. For example, large-scale, long-period models could be adversely affected if there is a serious lack of equatorial upper-air wind data south of the B-scale area.

There is expected to be a large number of Synoptic-

[1] Seconded from the Meteorological Office, Bracknell, U.K.

Scale Subprogram participants involved in modeling. Over a dozen models will be used. See Section 7 of GATE Report No. 6 (Houghton and Parker, 1974).

b. Other scientific objectives

The scientific objectives listed below are outside the scope of the GATE central program, but their achievement will nevertheless provide a useful supporting role for GATE and will help in further understanding the atmosphere as a whole.

Investigation of planetary-scale waves in the lower stratosphere throughout the equatorial zone.

Investigation of lower stratospheric features in the central parts of the GATE area has a place in the Central Program objectives (see above). It is clear from the argument given above that an increase of understanding of the atmosphere could result from a study of equatorial stratospheric waves in general. The more notable of these waves are of a planetary scale (Yanai *et al.*, 1968; Wallace and Kousky, 1968).

Investigation of the causes and origins of the West African easterly waves.

Fulfillment of this objective will aid fulfillment of the first three Central Program objectives of the subprogram mentioned above.

Clarification of the role of the tropics in the general circulation of the atmosphere.

The tropics should not be considered in isolation from higher latitudes. Direct tropical-extratropical interactions are important (Mak, 1969; Nitta, 1970; and Morell, 1973).

Provision of data for intercomparison between satellite and conventional observations.

Many areas of the tropics are endowed with only very sparse networks of surface-based data. Oceanic areas are particularly severe examples of this. However, satellite data can cover the whole globe, and therefore an ability to infer atmospheric flow and thermodynamic conditions in a precise manner from satellite data alone would be of immense value.

Contribution to other experimental programs of GARP concerned with global observation and data collection, particularly those relating to FGGE.

The FGGE data systems test (DST) was particularly in mind when this objective was formulated.

3. Observations

The data proposed in support of the Synoptic-Scale Subprogram will come principally from GATE ships, WWW land stations, and satellites. There will also be valuable data from commercial ships, commercial aircraft, and GATE aircraft.

Figure 8 shows the proposed network of 00 and 12 GMT land and (observing phase II) GATE ship radiowind[2] and radiosonde observations. The GATE observ-

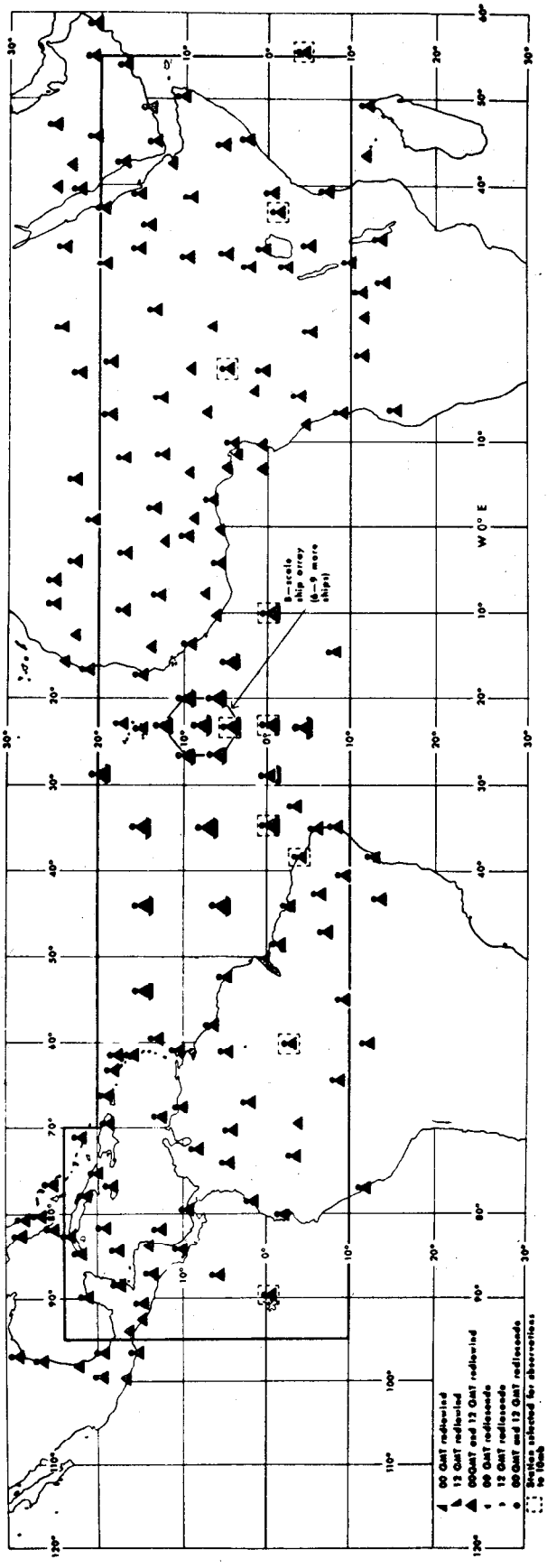

FIG. 8. Land radiowind and radiosonde network during GATE in the GATE area and up to 5° outside it, and (observing phase 2) synoptic-scale ship distribution.

[2] Some GATE ships will use very low frequency navigation signal windfinding and others radar windfinding. Some land stations will use radar and others radiotheodolites for windfinding.

ing period will be 15 June through 23 September 1974. Almost all regular GATE ship data will be limited to the three 21-day observing phases, although some upper-air observations are planned by some GATE ships en route to and from ports, and there will be surface observations from all moving GATE ships. The GATE ships, three land stations in West Africa west of 10W, and one land station in the Cape Verde Islands are expected to have 06 and 18 GMT radiowind and radiosonde observations during the three 21-day observing phases. Selected equatorial land stations around the globe will have radiowind and radiosonde ascents to 10 mb daily throughout GATE in order to investigate planetary scale waves in the lower stratosphere throughout the equatorial zone (see section 2b above). Ascents from GATE equatorial ships are planned to reach 10 mb for the same reason.

Land station pilot balloon data will be vital as backup data and as compensation for the marginal adequacy of the spatial resolution of the planned radiowind and radiosonde data. See Fig. 9.

Land station standard surface reports, rainfall total reports, graphical rainfall records, and special phenomena reports will all serve the needs of the Synoptic-Scale Subprogram. The graphical rainfall records will be useful in studies of estimation of rainfall from satellite images, and the special phenomena reports will aid in tracking squall lines and similar perturbations. The GATE ships and commercial ships will provide 6-hourly (hourly in the case of stationary GATE ships) standard surface data including sea-surface temperature. The GATE ships will also provide 6-hourly rainfall totals and some GATE ships will provide graphical rainfall records.

Five types of satellite are expected to provide the bulk of the needed satellite data. The synchronous meteorological satellite (SMS) should provide 1-km nadir resolution visible images (daytime only) and 10-km nadir resolution infrared images (day and night) at least every hour. The SMS data will cover the area from 20E to 110W. See Fig. 10 (in the Convection Subprogram section, p. 725) for details. From sequences of these images winds can be derived, although only for one or two levels. However, these winds can often have much better than the 500-km horizontal resolution which is the basic synoptic requirement. Image data from the remaining satellites, NOAA, DMSP, NIMBUS, and METEOR, which are all polar-orbiting, will provide coverage of the GATE area with approximately 6-hr time resolution when the data from all four are combined. Spatial nadir resolution will be 2/3 to 4 km in the visible and 2/3 to 15 km in the infrared. NOAA, DMSP, and NIMBUS will also provide valuable sounding data giving often better than 300-km horizontal resolution. These NOAA, DMSP, and NIMBUS soundings will separately give 12-hr time resolution, and the orbit times at a given location will be up to 4 hours different. METEOR will provide special radiation budget data. Infrared image data and sounding data from satellites in general can be used to derive sea-surface temperatures when the cloud conditions permit. For greater details see the GATE Satellite Operations Plan (Parker and Kaneshige, 1974).

A special effort will be made to collect standard meteorological reports from commercial aircraft. Plans are also under way to obtain automatically recorded data from some of these platforms. Commercial aircraft data coverage will be mainly at the 200-mb to 300-mb levels. Data for most parts of the GATE area will be available.

There should be thermodynamic and wind data from dropsondes launched from GATE aircraft over the Atlantic and some flight-level data from GATE aircraft particularly over the Atlantic.

Special measurements are planned to be made by GATE ships to compare their surface and upper-air observing systems: these special measurements will be treated in the follow-up article on the GATE international operations plans. Statistical techniques on the regular GATE ship observations can also, of course, be used for intercomparison. The unproven nature of the Omega windfinding system in the southeastern tropical Atlantic is a major unknown factor and increases the need for intercomparison. Quality control of land station data will have to be carried out by statistical techniques. Comparison of satellite winds and temperature/

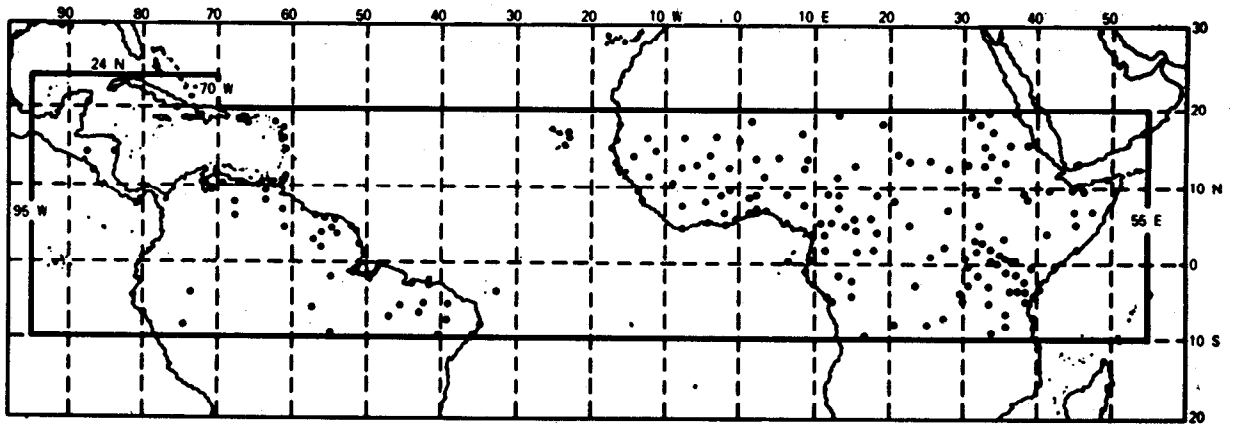

FIG. 9. Pilot balloon stations operating in October 1973.

humidity profiles with corresponding conventional data will involve a considerable amount of complex statistical work.

If all these types of data are successfully provided in the planned quantities and with the planned accuracies, and if the data requirements of the other subprograms are also satisfied, it will be possible to fulfill the scientific objectives, not only of this Subprogram, but of GATE as a whole; moreover, the way should then lie open for considerable advance in synoptic-scale tropical meteorology.

4. Data management

The most important Synoptic-Scale Subprogram task during the field phase of GATE will be the near-real-time collection of GATE area data at the Synoptic-Scale Subprogram Data Center (SSDC) at Bracknell, U.K., where a global, synoptic, near-real-time data bank is now operational. Thereafter the prime function of the SSDC will be to prepare in forms suitable for use by synoptic-scale scientists synoptic observations for the whole GATE area from WWW observing stations, GATE platforms, and satellites. The SSDC will use the existing routines of the operational, global, synoptic, near-real-time, data bank at Bracknell as a basis for the data organization method. For further details refer to the follow-up paper on the international operational plans for GATE.

5. Research participation

Information on research participation has been received from a considerable number of sources. See Table 6 and section 7 of GATE Report No. 6. It appears that most of the scientific objectives are covered by the proposed research programs.

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TABLE 6. Organizations and institutes participating in research within the Synoptic-Scale Subprogram

Country	Organization or institute
Brazil	Departamento Nacional de Meteorologia.
	Directoria de Hidrografia e Navegaçâo.
	Instituto de Pesquisas Espaçiais.
Canada	Atmospheric Environment Service.
East African Community	East African Meteorological Department.
France	La Météorologie Nationale.
Federal Republic of Germany	Deutscher Wetterdienst Seewetteramt.
	University of Berlin.
	University of Kiel.
Ghana	Meteorological Services Department.
Mexico	Dirección General de Geografia y Meteorologia. Ciudad Universitaria, Mexico.
Netherlands	Koninklijk Nederlands Meteorologisch Inst.
Nigeria	Meteorological Dept.
Senegal	Bureau d'Etudes, ASECNA
United Kingdom	Meteorological Office.
	University of Reading.
U.S.A.	Colorado State University.
	Drexel University.
	Fleet Numerical Weather Facility.
	Florida State University.
	Geophysical Fluid Dynamics Laboratory.
	Goddard Institute for Space Studies.
	University of Maryland.
	University of Missouri.
	Massachusetts Institute of Technology.
	National Aeronautics and Space Admin.
	National Center for Atmospheric Research.
	National Environmental Satellite Service.
	National Hurricane Center.
	National Hurricane Research Laboratory.
	National Oceanic and Atmospheric Admin.
	Naval Postgraduate School.
	Purdue University.
	University of California.
	University of Chicago.
	University of Hawaii.
	University of Illinois.
	University of Miami.
	University of Washington, Seattle.
	University of Wisconsin.
U.S.S.R.	Hydrometeorological Research Center.
	Institute of Experimental Meteorology.
	Institute of Geography of the Academy of Science of the U.S.S.R.
	Institute of Oceanography of the Academy of Science of the U.S.S.R.
	Research Institute of Hydrometeorological Information.
	State University Geophysical School, Moscow.

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