Met.O.893
METEOROLOGICAL OFFICE

the meteorological magazine

GATE 1974 – some U.K. contributions – Part I

AUGUST 1976 No 1249 Vol 105
Her Majesty's Stationery Office

METEOROLOGICAL OFFICE Met.O.893

THE METEOROLOGICAL MAGAZINE

Vol. 105, No. 1249, August 1976

551.506.24

THE GARP ATLANTIC TROPICAL EXPERIMENT—AN INTRODUCTION

By B. J. MASON
(Chairman, Tropical Experiment Board)

The GARP Atlantic Tropical Experiment (GATE), designed to explore the tropical atmosphere, was successfully completed in September 1974. In what was probably the largest and most complex international scientific experiment ever undertaken, ten nations—Brazil, Canada, France, Federal Republic of Germany, German Democratic Republic, Mexico, The Netherlands, USA, UK and USSR—working in close collaboration, contributed 39 specially equipped ships, 13 large research aircraft, several meteorological satellites and some 5000 personnel to an intensive three-month study of weather systems in the tropical eastern Atlantic Ocean; in addition, more than 50 countries in Africa and South America participated by making conventional surface and upper-air observations. Despite all the technical and logistic problems, the field phase of the experiment went remarkably smoothly and, although one cannot be certain until the vast mass of data is processed and analysed, there is good reason to believe that the main scientific objectives will be largely achieved and that our knowledge and understanding of tropical weather systems will be greatly enhanced thereby. This is a tribute to three years of detailed, prescient planning and, above all, to a remarkable degree of enthusiastic co-operation between the countries that not only contributed large resources but worked amicably to achieve common objectives according to a unified operational plan.

Although the traditions for international collaboration in meteorology and geophysics were laid in the Polar Years of 1882–83 and 1932–33, the International Geophysical Year of 1957–58 and the International Year of the Quiet Sun 1964–65, GATE was quite different in character. It was not just the sum of many simultaneous national programs but a single co-ordinated experiment of unprecedented complexity, scale and intensity.

The philosophy and scientific objectives of the experiment were based on the fact that meteorological disturbances in the tropics, which behave differently in many respects from those in middle latitudes, play an important role in the circulation and energetics of the atmosphere as a whole. A better understanding of their working is essential not only for the improvement of weather forecasting in the tropics but also because, unless their influence is properly taken into account, it may not be possible to predict the weather in temperate latitudes for more than a few days ahead.

Tropical weather is dominated by showers and thunderstorms which, as satellite photographs reveal, are often organized into large clusters, 100 to 1000 km across. They are associated with the development of even larger-scale disturbances in the trade winds and play an important role in pumping heat and moisture from the tropical oceans upwards and polewards to drive the atmospheric engine.

The main task of the GATE project was to study the structure, evolution and transport properties of the various tropical weather systems and to investigate how they may interact through the transfer of energy between the different scales of motion involved. In particular it is important to discover how the transports of heat, moisture and momentum by the convective clouds, which are too small to be described by conventional observing systems and cannot be represented individually in computer models of the global atmosphere, are related to the properties of the larger-scale motions that can be measured.

The United Kingdom contributed four of the 39 ships. The hydrographic survey vessel *Hecla* executed an intensive program of meteorological and oceanographic observations and carried the Meteorological Office tethered balloon equipped with instrumental packages to measure profiles and fluxes in the atmospheric boundary-layer. The R.R.S. *Discovery* of the Institute of Oceanographic Sciences, besides carrying out its normal observational program, towed a specially designed probe to make fine-scale measurements of temperature and salinity in the upper 50 metres of the ocean. The Meteorological Office chartered two small ships to make upper-air soundings of wind using the NAVAID system to determine the wind.

The Hercules flying laboratory of the Meteorological Research Flight, equipped with radar, an inertial platform, Doppler wind-finding equipment, radiometers, and particle-samplers, was probably the most effective aircraft in the whole exercise. It flew 40 missions totalling 386 hours and recorded some 10^9 digital words of data.

During the field phase of the experiment, the Meteorological Office carried out real-time forecasts every 12 hours using an 11-level numerical model developed very quickly for the purpose and the observations gathered in the GATE area that arrived at Bracknell over the Global Telecommunication System. Experience gained then and also with the greater quantities of data that arrived later indicates that, given adequate observations, the forecasting of synoptic-scale developments in the tropics is unlikely to be more difficult than in middle latitudes.

With the field phase of the experiment successfully accomplished, we now face the daunting and most important task of processing and analysing the vast quantity of data collected. Responsibility for reduction of the observations acquired on national platforms—ships, aircraft, satellites, etc.—lies primarily with the nations themselves but, because of the different systems and instruments employed, these will have to be compared and made consistent using the results of the intercomparison and calibration trials made during the experiment. These tasks of co-ordination and integration will be carried out at five centres, each being responsible for a particular subprogram. Thus all the basic surface and upper-air observations from the GATE ships and African and South American countries in the GATE area will be processed at Bracknell and produced in the form of data sets on magnetic tape. Similarly the USA, USSR, France and Germany will be responsible for other parts of the program.

Co-ordination between the five centres and monitoring of the whole program is being carried out by a small group of scientists located in the WMO Secretariat in Geneva. Their task will end in two years' time with the deposition of the final data sets in the World Data Centres in Washington and Moscow where they will be available on demand to scientists throughout the world.

The international meteorological community will then have an unprecedented opportunity to improve our knowledge of the structure and development of tropical weather systems and to understand the interaction between the various physical and dynamical processes and between the different scales of motion. It will then be in a much better position to assess the role of tropical disturbances in the energetics of the global circulation and to incorporate more realistic representations of them into computer models for the prediction of weather and climate.

It is also intended to document the unique experience gained in, and the lessons learned from, the planning and excecution of such a large and complex experiment for the benefit of the First GARP Global Experiment and other major projects in the future.

551.506.24

GATE—THE FIELD PROJECT IN 1974

By D. E. PARKER

SUMMARY

An account is given of the conduct of the 1974 GARP Atlantic Tropical Experiment (GATE). The planning procedures and scientific aims of the experiment are described. The observational network implemented for GATE, including ships, aircraft, satellites, and land stations is also described and indications are given of the performance of this network, of the particular difficulties encountered, and of the progress of the resulting work in the GATE data-processing centres.

1. INTRODUCTION

This paper gives a general description of the GARP Atlantic Tropical Experiment (GATE), as a background for the following articles on particular United Kingdom contributions. The description here will be brief; fuller details can be found in GATE Reports Nos. 15 to 19.

2. PLANNING AND INTERNATIONAL CO-OPERATION

It has long been realized that meteorological disturbances in the tropics are important in the general circulation of the atmosphere. Improved knowledge and understanding of tropical meteorology is vital for the success of forecasting not only locally but also, at least for forecasts for more than two or three days ahead, in middle and high latitudes. This was one of the major factors which led to international discussions on and proposals for a tropical meteorological experiment.

Note. Certain words and expressions which may not be familiar to some readers are explained in the 'short glossary' on pages 244–245.

Initially the Joint Organizing Committee (JOC) of the Global Atmospheric Research Program (GARP) proposed that the experiment be held in the tropical North Pacific; but logistic considerations led to a decision to carry out the experiment in the tropical North Atlantic. Subsequently, satellite cloud photographs showed that large cloud clusters, which are generally manifestations of tropical disturbances of similar or larger scale, were most abundant in the eastern tropical North Atlantic which was therefore chosen as the location of the experiment. It was decided, however, not to have the experiment too near the African mainland because one aim was to study the disturbances and clusters away from the influence of land and topography.

Once the basic aims had been formulated by the JOC (see Section 3 below), the major tasks of completing the details and designing a practicable experiment were allotted to an International Scientific and Management Group (ISMG) formed for the purpose. The ISMG was located in Bracknell where it had access to excellent facilities (e.g. the National Meteorological Library) but there was also very close liaison between the ISMG and the WMO which with ICSU (International Council of Scientific Unions) (mainly Universities and non-governmental scientific organizations) is joint patron of GARP.

The operation's base for GATE was chosen to be Dakar, Senegal, where excellent harbour, airport and general technical and accommodation facilities are available.

3. Aims

Meteorological observations in the tropics, especially in the upper air and over the oceans, have nearly always been sparse. Before GATE they had none the less demonstrated that tropical disturbances and cloud formations occur on many scales. These scales encompass the mean Hadley north–south circulation, monsoon flows, and various east–west circulations (global-scale); tropical waves and monsoon cloud-clusters (1000 to 5000 km: A-scale); cloud clusters and tropical storms and hurricanes (100 to 1000 km: B-scale); cumulonimbus groups and lines and other mesoscale effects (10 to 100 km: C-scale); and phenomena on the 1 to 10 km or D-scale such as individual large clouds and thunderstorms and downdraughts. What GATE set out to elucidate was how the motions on one scale influence those on another, and what were the mechanisms by which tropical motions affected higher latitudes. The relationship between A and B scales is particularly significant, and A–B interaction was therefore the central interest of the experiment.

A single numerical model cannot deal with motions on all scales from A to D explicitly. It is therefore necessary to 'parameterize' the smallest scales in terms of the larger, whose structure is defined by the variables of the model. It was a prime object of GATE to provide data that would enable the formulation and testing of parameterization of motions on scales below about 100 km.

A further aim of GATE was to obtain data over a large area from eastern Africa to western South America in sufficient quantity and of adequate quality to provide numerical models with a good basis for making and checking experimental forecasts involving the tropics.

To see the central aim in less abstract terms, consider for example 700-mb easterlies over West Africa and the Atlantic with easterly-wave troughs over Nigeria (5°E) and off the west coast (20°W). Suppose that an area of strong convection of dimension 200 km ('convective cloud cluster') exists near the western trough (i.e. near the concentrated part of the GATE ship network (Figure 1)). Then we would very much like to know:

To what degree will the convective cloud cluster weaken the trough or strengthen it?
Will the cluster aid the normal westward movement of such a trough?
To what extent will the horizontal flow and vertical motion and large-scale advection (if any) associated with the trough help to strengthen or weaken the cluster, or move it?
How will the large-scale temperature and moisture fields change?

Cloud clusters themselves are made up of large numbers of individual cumulonimbus cells, which are often observed to form coherent C-scale groups. The extent and intensity of the cluster is therefore probably not wholly dependent on the large-scale flow but is influenced by C-scale features. In other words, B–C interactions may be important and C-scale phenomena may thereby have an important influence on motions on the largest scales. It is hoped that the GATE data will clarify this.

We should also like to know how the boundary-layer influences the cluster. It may be for example by a positive feedback involving boundary-layer convergence, vorticity and moisture content on one hand and cluster development on the other (Conditional Instability of the Second Kind or 'CISK').

The influence of the ocean on the cluster is likely to be important: clusters appear to undergo changes when they cross coastlines, and areas of warmer water favour their development.

The Intertropical Convergence Zone (ITCZ) is a region where cloud clusters are numerous. The intensity of the convergence will affect any cluster in the zone.

The cluster transports heat upwards and the flow in the upper troposphere transports this heat polewards. It would be valuable to know what are the exact mechanisms involved and whether the interaction between the cluster and the upper tropospheric flow enhances or inhibits the process.

For practical reasons the planning of GATE was divided into five parts: synoptic-scale, convection, boundary-layer, radiation and oceanography. Each of these formed a 'subprogram' of GATE. The subdivision was made to facilitate planning (suitable persons could more easily be found if only a small scientific area were to be covered by their work) and to facilitate data management. The subprograms each elaborated the basic aims of GATE in their own terms and added subsidiary subprogram objectives.

4. Experimental design and implementation

For GATE a network of 'B' (and 'C') ships at not more than 150-km spacing (for B- and C-scale data) in the eastern Atlantic 'B-scale area' needed to be surrounded in the immediate vicinity by 'A/B' ships less than 500 km apart (for B-scale and synoptic-scale data) and in remoter areas by 'A' ships 500 to 1000 km apart (for synoptic-scale data). Special aircraft were needed to supply additional detail to the measurements within the concentrated network of ships. Satellites were vital if a complete picture was to be obtained, and so were the shipboard boundary-layer and oceanographic measuring systems, especially in the B-scale area. Finally, the existing World Weather Watch land station network needed to be enhanced to provide adequate synoptic-scale information.

For practical reasons the observation periods for ships and special aircraft were limited to three 21-day 'phases': 26 June to 16 July, 28 July to 17 August, and 30 August to 19 September. Land stations and satellites, however, functioned continuously for the whole 100 days of GATE (15 June to 22 September 1974). The limitation on the lengths of time of ship observations would of course be unacceptable for climatological studies, but the synoptic-scale atmospheric waves and disturbances have a typical time-scale of 4 or 5 days while the smaller-scale features are much more short-lived (lifetimes 1 day or less) so that the limitation was not serious.

Figures 1 and 2 show the ship network during Phase III. Because of problems with upper-wind measurement on some 'A' ships, modifications to plans for ship locations had been made and are indicated on the diagram. The distributions of 'A', 'A/B' and 'B' ships in Phases I and II were similar, but there were no 'C' ships. Locations of 'A/B', 'B' and 'C' ships are shown on an expanded scale in Figure 2, which also indicates which of these ships had weather radars. 'A' ships made 6-hourly upper-air soundings but 'A/B', 'B' and 'C' ships usually made 3-hourly soundings.

Figure 3 illustrates the shipboard equipment for boundary-layer measurements. Many ships also made extensive oceanographic measurements, and radiation measurements including radiometer-sonde soundings.

Thirteen aircraft out of a hoped-for fourteen took part in GATE. The USA provided nine, the USSR two, and the UK and France one each. Aircraft missions were divided into Basic GATE (B-scale area convection), Boundary Layer, Radiation and Oceanographic, with short-range missions into convective vortices near Dakar, cloud-physics missions and windfinding-dropsonde missions as additions.

The mission type was selected each day by an international 'Mission Selection Team' in Dakar, Senegal, where the aircraft were based. Their selection was based on forecast weather conditions, aircraft availability, and an approximate knowledge of the achievements of previous GATE missions so that for example hitherto deficient aspects could be remedied. The weather forecasts, which were greatly aided by frequent satellite images, achieved a high degree of success from an early stage in the experiment. They were produced by an international team in Dakar. The total number of sorties was about 290—the maximum hoped for, and there were no serious accidents.

The Basic GATE aircraft missions concentrated on B- and C-scale convective features in the B-array and sampled many C-scale features which turned out to be more numerous than B-scale ones, the incidence of which had probably been overestimated from satellite photographs because of the occurrence of large thick cirrus shields. There was a change in emphasis too in the Basic GATE missions because convective features in the B-array were found to be very transient, so that it was impossible to fly successive missions into the same feature at e.g. 12-hour intervals. Also the convection did not 'move' westwards so as to allow studies of the recovery of the atmosphere in the wake of clusters. These factors all increased the amount of mission time spent sampling C-scale convective phenomena which grew and decayed *in situ*. After their decay further convection would develop and decay *in situ* at some point further west according to the progress of the associated synoptic-scale disturbances. Because of the short lifetime of systems, detailed mission planning

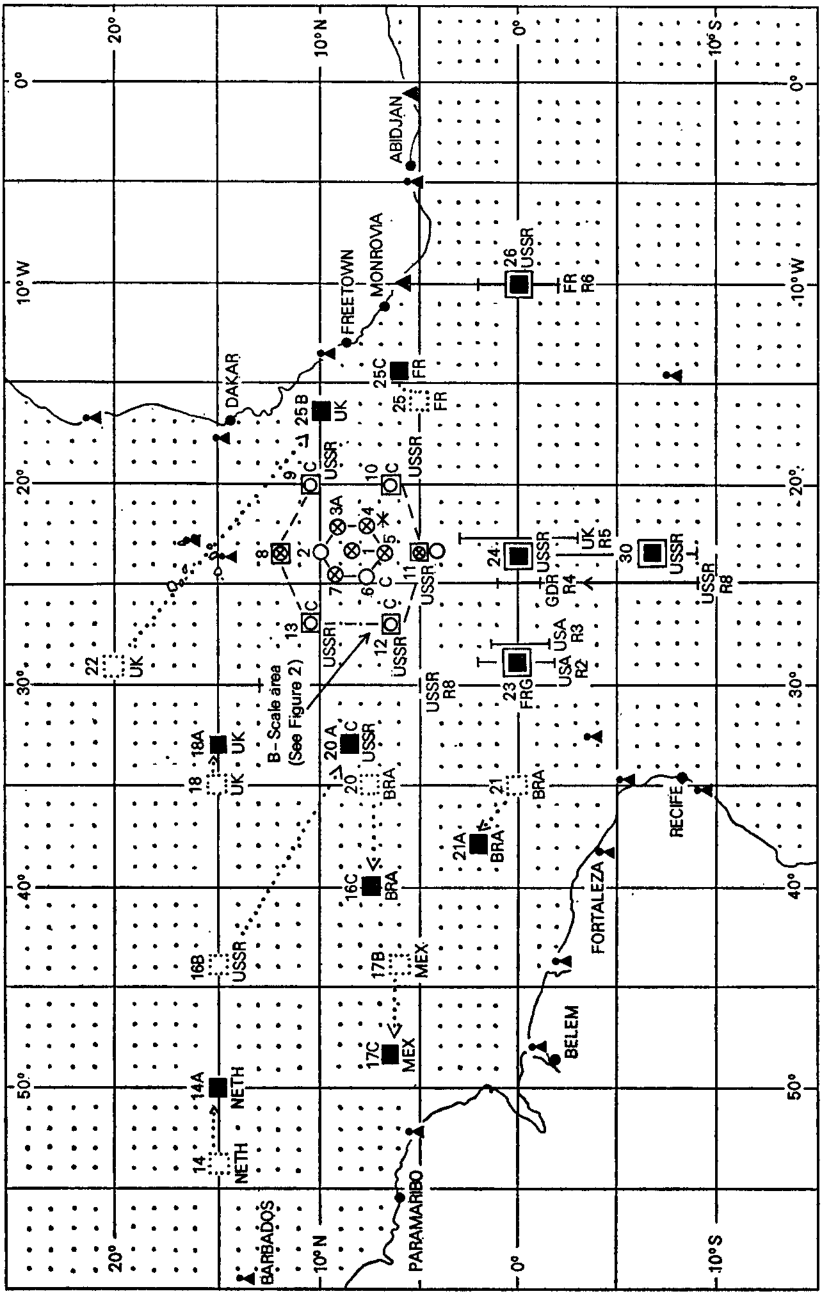

FIGURE 1—SHIP DISTRIBUTIONS, PHASE II (28 JULY–16 AUGUST 1974)
See Figure 2 for definition of symbols used to designate types of ship's positions.

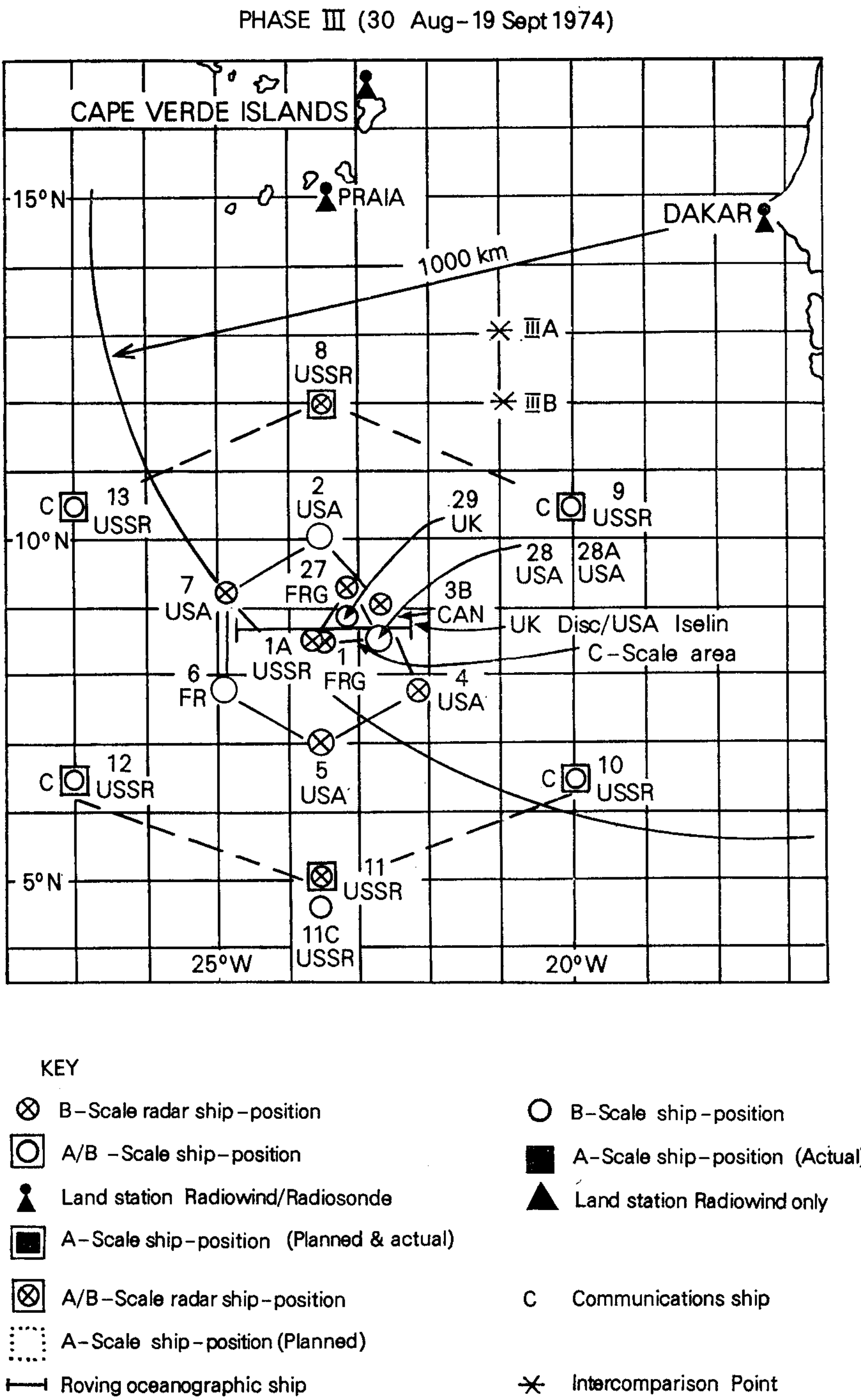

FIGURE 2—SHIP DISTRIBUTIONS FOR THE B-SCALE AREA

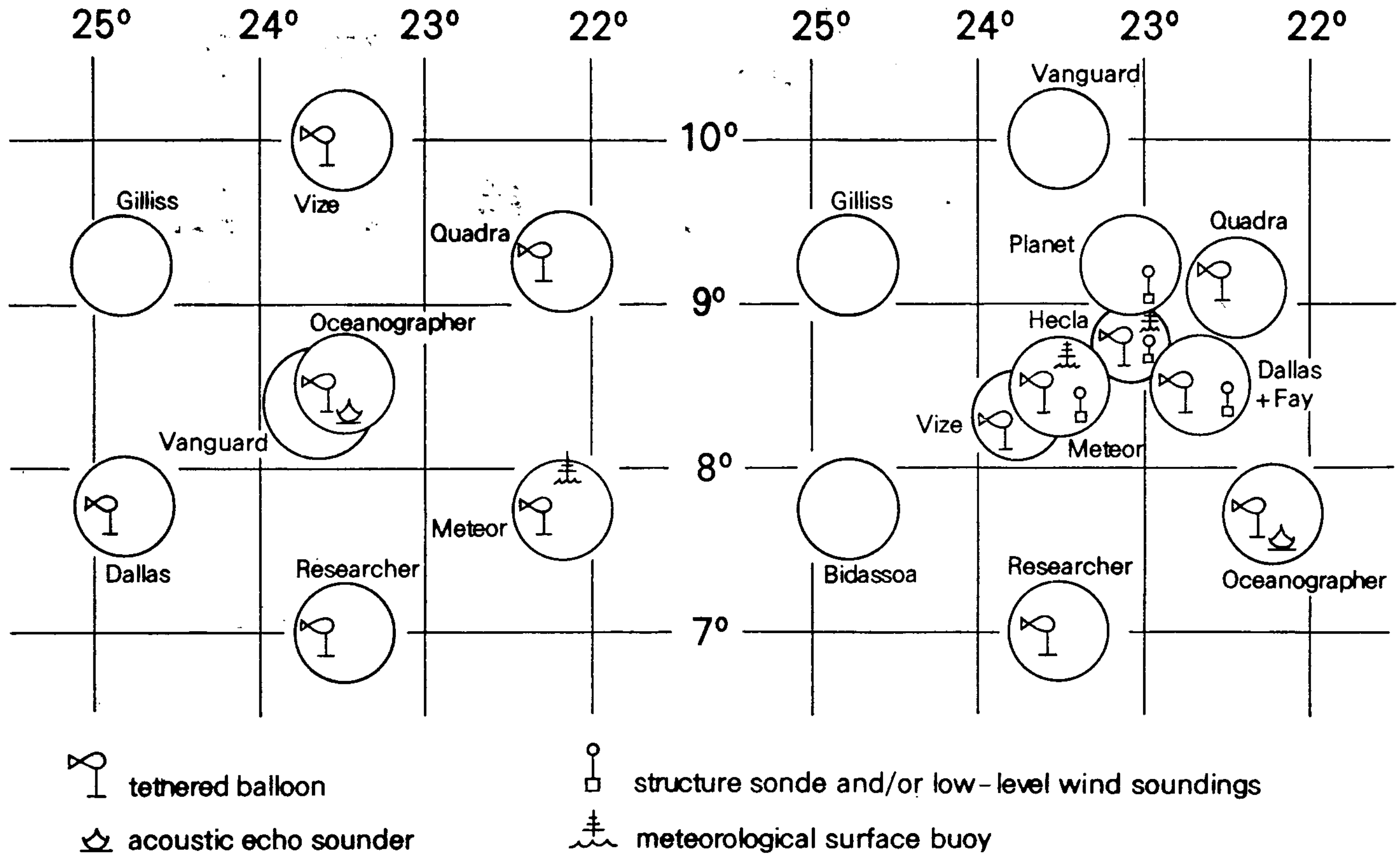

FIGURE 3—SHIP POSITIONS OF THE INNER B-SCALE HEXAGON AND SPECIAL BOUNDARY-LAYER EQUIPMENT
Left: Phase I and Phase II. Right: Phase III (*Vanguard* and *Vize* exchanged positions before Phase II).

had to be carried out by the Airborne Mission Scientist on arrival in the B-area. However, the basic type of mission could be planned beforehand because it was possible in general to give a successful 24-hour forecast of B-area weather type.

For the Boundary Layer missions, the Mission Selection Team introduced a new type of mission involving repeated short north–south transits of the ITCZ, in addition to the original type of ITCZ mission which involved a single long north–south transit reaching near to the equator. Most Boundary Layer missions, however, concentrated not on the ITCZ as such but on B- and C-scale convective features or on fair weather areas in the B-area.

A few missions into convective vortices and squall lines near Dakar were flown by the short-range aircraft. For safety reasons the most active parts of squall lines had to be avoided, but interesting data are expected.

The windfinding-dropsonde aircraft played a vital part in filling in gaps in the A-scale ship network east, north, and north-west of the B-array, and in monitoring synoptic-scale disturbances and their associated convection as these progressed westwards from the B-array or from the Cape Verde Islands area.

After considerable apprehension due to delays in launching, the USA geostationary satellite SMS-1 began successful transmission in the visible (½-n.-mile resolution) and infra-red (4-n.-mile resolution) in time for the first day of Phase I, and continued to function excellently throughout GATE (see Plate IV). The subsatellite point at 0°N, 45°W was 15° further west than planned, but this did not affect operations over the Atlantic. Images were normally available at ½-hourly intervals, though on a few special days in Phase III 15-minute imaging was carried out. Visible images with resolutions of ½ and 2 n. mile were generally produced, the former covering the B-area and environs and the latter covering the GATE area from about 0° to 50°W. These images were available in Dakar and also archived in the USA. In addition ½-n.-mile resolution visible images covering the whole earth-view disc, which included all the GATE area west of 15°E, have been archived in the USA. Infra-red images at 4-n.-mile resolution covering the whole disc were also available in Dakar and archived in the USA.

The SMS-1 images not only aided forecasting and detailed mission planning, but are an enormous reservoir of data for studies of convection, radiation, and synoptic-scale meteorology. Sequences of SMS-1 images were made into movie loops in Dakar, so that wind patterns could be estimated, thus aiding operational planning, and winds were also derived and archived in the USA. These latter winds were mainly for low and high levels and were on the synoptic scale, and were transmitted globally for use in forecasts and real-time numerical models, but there have since GATE been derived some subsynoptic-scale winds for low, medium and high levels over the B-area.

The GATE data coverage would have been far from complete without the surface, pilot-balloon and particularly radiowind and radiosonde data from World Weather Watch land stations. The functioning radiowind and radiosonde land stations are shown in Figure 4 which also depicts the GATE area boundary. In addition several equatorial land stations round the globe outside the GATE area provided radiowind and radiosonde data for studies of global-scale equatorial waves.

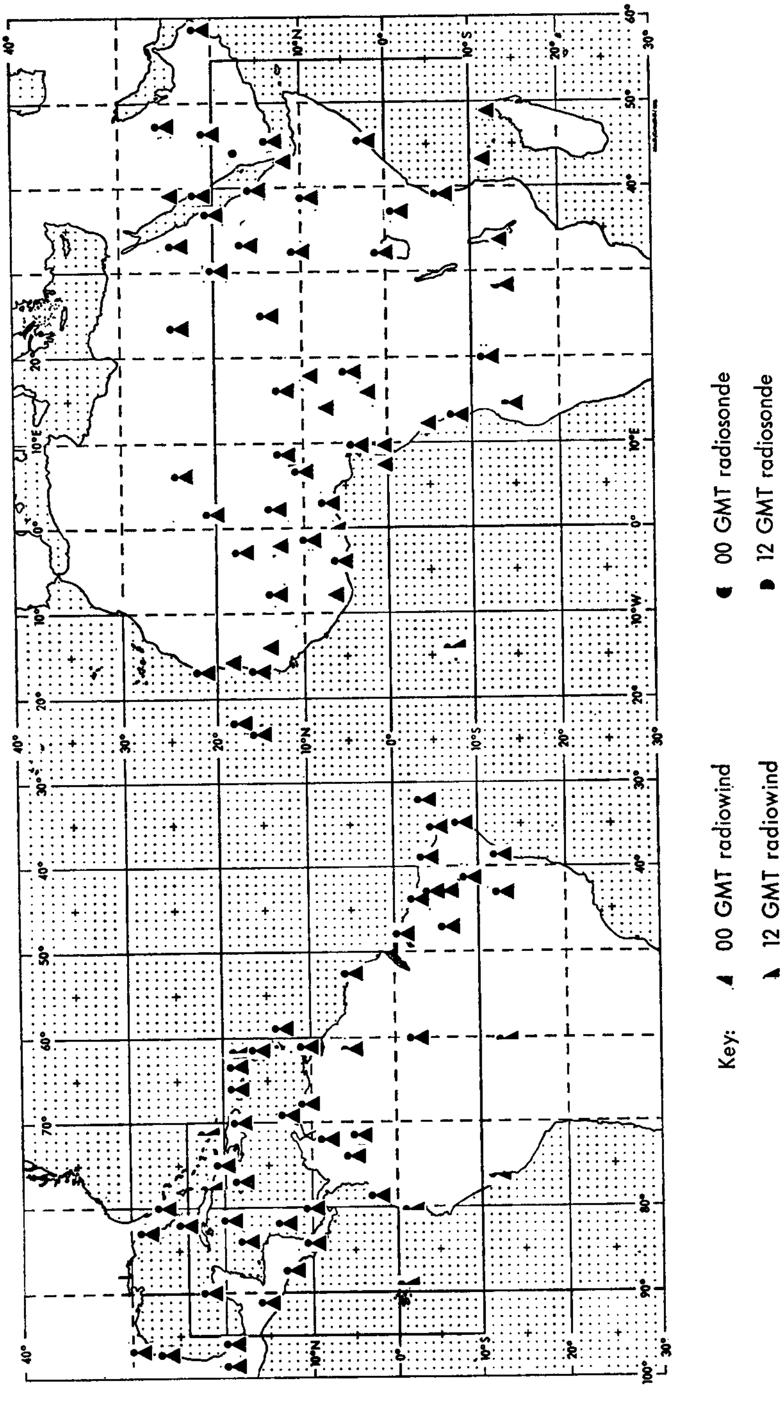

FIGURE 4—LAND RADIOWIND AND RADIOSONDE STATIONS WHICH ARE KNOWN TO HAVE FUNCTIONED DURING GATE

5. Major problems encountered

During the field operations two major problems were encountered: firstly, there were serious difficulties in operating shipboard upper-air windfinding systems based on navigational-aid 'Omega' or 'very-low frequency (VLF)' signals, and secondly, little or no upper-air data arrived from a substantial number of important land stations scheduled to measure upper winds. There were other problems too, such as difficulties in co-ordinating low-flying aircraft with tethered balloons, but these problems were generally solved satisfactorily, and although we cannot yet be completely certain that data from apparently perfectly operating systems will turn out to be satisfactory, we can state that apart from the above two major problems GATE proceeded very smoothly and is expected to have produced plentiful high-quality data.

(a) *Omega and VLF upper-air windfinding*

Omega and VLF windfinding are both based on the following principle. Signals of very long wavelength from three widely separated source stations are received by the sonde. From the relative phases of the signals, the sonde location is determined. Repeated locations are used to derive sonde velocity.

It was found that the signals were often rather weak and noisy, especially (as expected) in the south of the ship area. Also some ships had software and hardware problems with their signal processors. However, where even weak signals were obtained, the possibility exists of recovering the wind data by means of a complex computer program if the signals were recorded magnetically, or manually from strip-charts.

Because of the Omega and VLF windfinding problems the planned 'A'-ship positions in Phases II and III were modified so as to have ships providing reliable upper-wind data on the synoptic scale immediately outside the 'A/B' ship network (in which only radar windfinding was used).

(b) *Upper-air data from land stations*

One of the changes in an 'A'-ship position, that to position 25B at 10°N, 16½°W (Figure 1) was mainly the result not of ship upper-air windfinding difficulties but of the absence of two vital coastal land stations which should have provided upper-wind data. The absence of these two stations did not constitute the whole problem, however, and during the field phase it was found that only 36 per cent of planned radiowind and radiosonde messages were received at Bracknell within nine hours of observing time. It had been suspected that poor communications would cause many data to be lost and therefore a mail collection of teleprinter paper tapes had been arranged (Jarvis (1976) and Spackman (1976) in this issue of the *Meteorological Magazine*). This collection was very successful.

6. Data handling

Data from ships, buoys, aircraft, and satellites specifically devoted to GATE were collected by the National Processing Centres (NPCs) of the nations operating the platforms. At the NPCs preliminary quality controls ('national validation') are being carried out, with the aid of data from the special intercomparison measurements made on board their own ships and aircraft during the experiment. Where necessary Omega and VLF upper-air data are being reprocessed. Also at the NPCs the data are being sorted and put into agreed formats on agreed computer-compatible media.

The Subprogram Data Centres (SDCs) will further control the quality of the data ('international validation') using if necessary the special intercomparison data from as many platforms as needed. After final formatting the data will be sent to the World Data Centres (WDCs) A and B, at some time between late 1976 and the end of March 1977.

In addition the Synoptic-Scale Subprogram Data Centre (SSDC) at Bracknell will format and control the quality of the GATE land station data received there and send them to WDCs A and B as internationally validated data by late 1976 or early 1977.

7. Conclusion

It appears that despite the problems described in Section 5, GATE has met with substantial success. It now remains for us to complete the data management and to use the data to improve our understanding of the tropical atmosphere. Interested readers can find preliminary scientific results presented already in GATE Report No. 14. But for those who wish to know first the details of the specific UK contributions to GATE, the following papers in this present issue will supply them with at least some of the information they need.

551.506.24

GATE—THE SYNOPTIC-SCALE SUBPROGRAM DATA CENTRE

By E. A. SPACKMAN

Summary

The paper describes the work of the Synoptic-scale Subprogram Data Centre, which is dedicated to preparing data sets of synoptic-scale observations made during GATE. The data sets, most of which will be processable by simple computer programs, will be supplied to GATE Archives for the use of scientists carrying out research on the tropical atmosphere. The purpose of the Data Centre, its data sources, products and progress up to March 1976 are briefly indicated.

Introduction

The Synoptic-scale Subprogram of GATE is one of five subprograms which make up the scientific content of GATE. It is principally concerned with the large-scale features of the atmosphere in the GATE A-scale region covering the tropics from west of Panama to the Seychelles. Basic information and guidance is given in GATE Report No. 6 (The Synoptic-scale Subprogramme for the GARP Atlantic Tropical Experiment) which is also an historical record of the planning phase. The main aims of the subprogram may be summarized as follows:

1. To describe the synoptic-scale disturbances in the tropical atmosphere from eastern South America to West Africa.
2. To describe the average state of the troposphere over the GATE area.
3. To describe the synoptic-scale environment of cloud clusters passing through the B-scale area (centred on 8½°N, 23½°W) in sufficient detail to allow investigations to be made of the interactions between the clusters and larger-scale motions.
4. To create complete and internally consistent data sets for tropical numerical prediction models.

In order to achieve these aims, observations are being collected by the Synoptic-scale Subprogram Data Centre (SSDC) from many sources and assembled into data sets. The work is being carried out by a small group within the Dynamical Climatology Branch. Supporting work which involves processing a large amount of paper tape in telecommunication format is being undertaken by the Data Processing Branch.

The Data Centre Plan is given in GATE Report No. 13, Part III, Section 5, and more recent additional information on the contents of the data sets can be found in GATE Report No. 16, Section 5.6.

The SSDC has already sent two data sets (a Quick Look Data Set and an Unvalidated Teleprinter Tape Data Set) to GATE Archives (World Data Centre-A in Asheville, USA and World Data Centre-B in Moscow, USSR). Three other Data Sets are being produced—an Intercomparison Data Set, a Final Validated Data Set and a SPECI Data Set. They are expected to be ready by the end of 1976. Each data set will conform to the format prescribed for the international exchange of GATE data in GATE Report No. 13, and will have comprehensive written documentation. Layouts for each type of observation (upper-air sounding, surface, upper-air single-level etc.) that allow all reported values and quality-control information to be stored in a reasonably compact fashion have been developed by the SSDC. It is believed that there are no other suitable character formats in international use at the present time.

OBSERVATIONS

Most type of observation used in synoptic studies of the atmosphere are being collected. During GATE the usual surface (SYNOP, SHIP and SHRED), upper-air (TEMP, TEMP SHIP, PILOT and PILOT SHIP), aircraft (AIREP) and satellite (SIRS and GOES) observations were made and transmitted over the Global Telecommunication System (GTS). Many radiosonde stations (particularly in West Africa) augmented their schedules and made two ascents a day whilst three stations (Praia in the Cape Verde Islands, Dakar and Bamako) usually made four ascents a day. In addition to the above, automated in-flight recordings were made by some specially equipped commercial aircraft, and 'dropsonde' soundings were made by some GATE aircraft.

SOURCES OF DATA

Observations are being collected from three principal sources:

(a) Bracknell Regional Telecommunication Hub (RTH), which received data in near real time.
(b) Selected Meteorological Centres, which sent paper tapes in telecommunication format by mail to Bracknell.
(c) GATE National Processing Centres (NPCs) which are processing the observations made from the GATE platforms (ships and aircraft).

Paper tapes in telecommunication format from the Bracknell RTH and selected Meteorological Centres are being processed through the Synoptic Data Bank stored in the United Kingdom Meteorological Office COSMOS Computing System by the use of methods developed for operational forecasting purposes. The reports are retrieved from the Bank by means of standard Meteorological Office routines and are rearranged before storage in the Data Centre data sets. For upper-air soundings, the various parts of a report (in near real time they

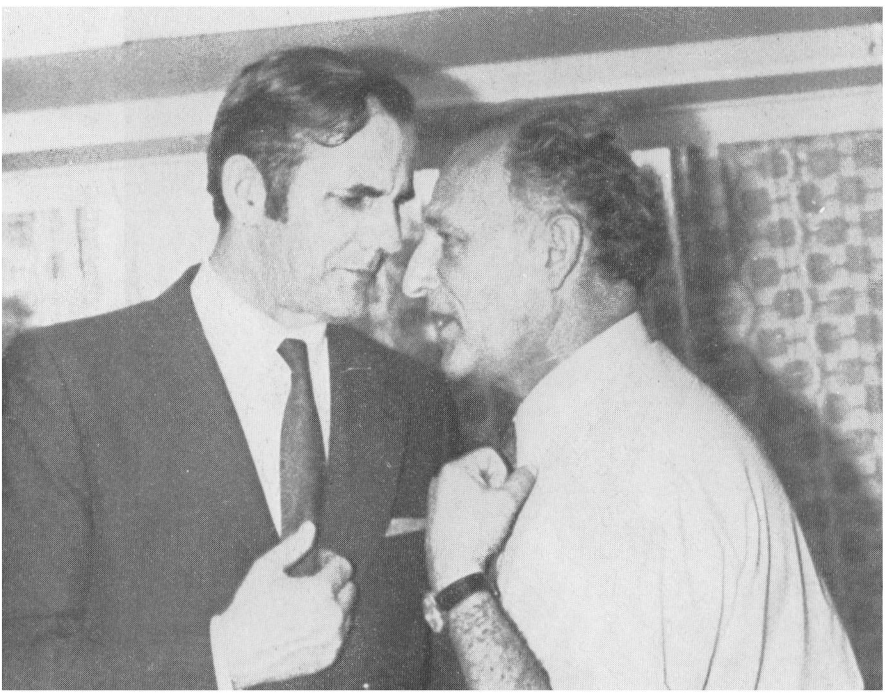

PLATE I—DR B. J. MASON, CHAIRMAN, TROPICAL EXPERIMENT BOARD, AND PROFESSOR M. A. PETROSYANTS, CHIEF SCIENTIST OF THE SOVIET GATE EXPEDITION AT A PARTY ON BOARD THE USSR RESEARCH SHIP *Professor Zubov* IN DAKAR, 25 JULY 1974

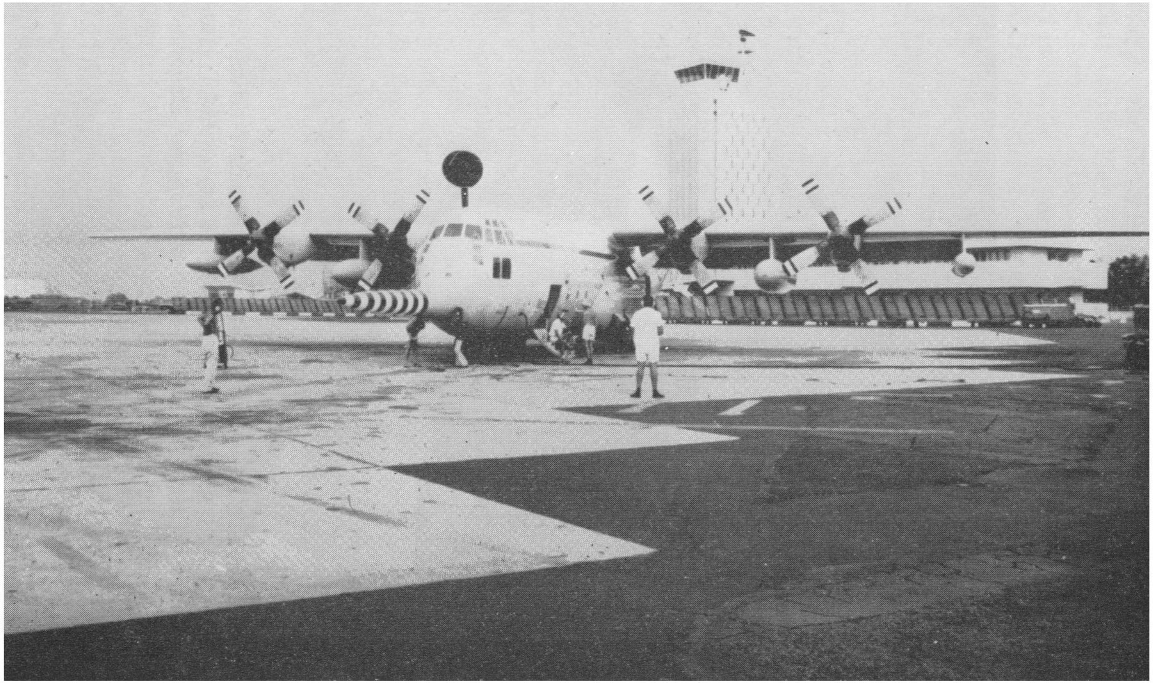

PLATE II—FINAL PREPARATIONS, AT DAKAR AIRPORT, BEFORE DEPARTING ON A 9-HOUR GATE MISSION

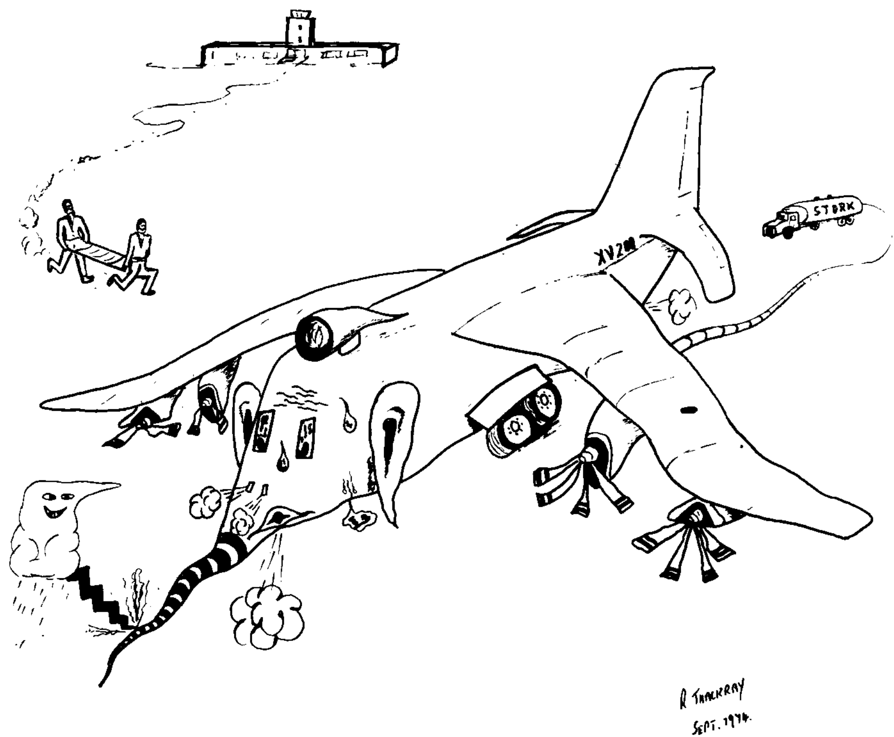

PLATE III—'AFTER 3 MONTHS IN THE TROPICS WE WERE ALL A LITTLE TIRED'

To face page 235

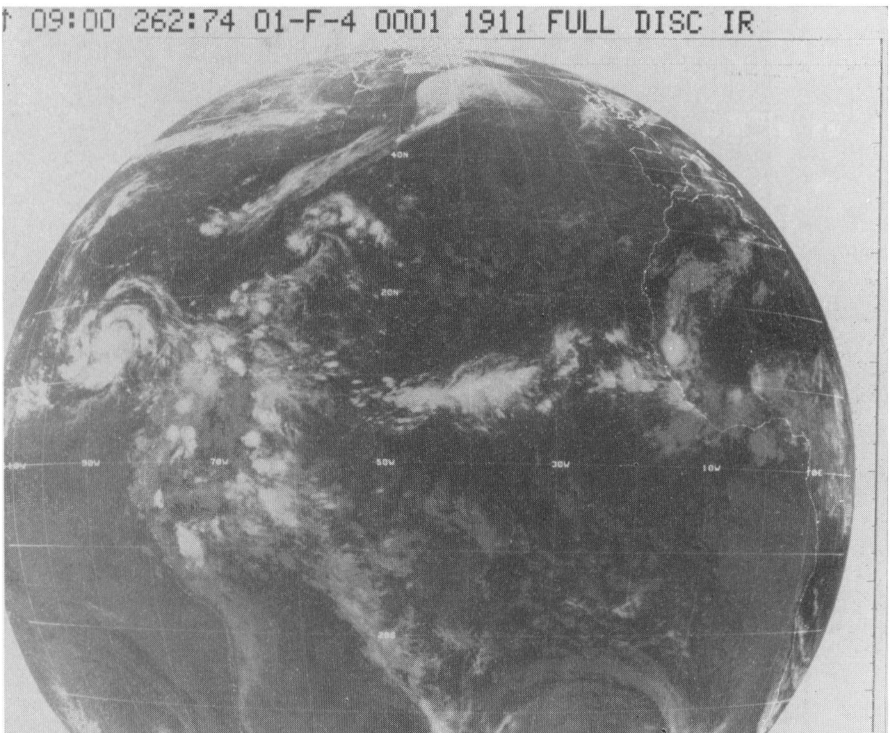

PLATE IV—INFRA-RED IMAGE OBTAINED FROM GEOSTATIONARY SATELLITE SMS-1 AT 0900 GMT ON 19 SEPTEMBER 1974

Cloud from a well-developed ITCZ is visible at about 10°N over the Atlantic. Hurricane Fifi can be seen at about 15°N, 85°W. See page 230.

are received in up to eight separate sections) are combined together into one report with levels in order of decreasing pressure. NPC data for the GATE platforms are being received on magnetic tape in GATE format and will have been nationally validated.

Additional observations are being collected in other ways. Some have been received in manuscript (e.g. from Angola and Cuba), some are being obtained from regular or special publications (e.g. from Cameroun) and some are already available within the Meteorological Office on punched cards (e.g. from some stations in the Sudan and East Africa). Surface observations from merchant ships, which were collected in the Federal Republic of Germany, have been received on magnetic tape in GATE format in the International Marine Meteorological Punched Card format. Commercial aircraft reports, collected by three groups in the USA have been received on magnetic tape; they consist of standard in-flight reports (AIREPs), special reports handed in at airfields and automated in-flight reports. Commercial aircraft reports have also been received from a Brazilian collection. Satellite winds have been received from the USA which make a more complete set of data than was available over the GTS.

VALIDATION

As well as creating the data sets the Data Centre has a responsibility to validate the observations. There are two aspects of this work—'format validation' and 'quality control'.

Format validation involves checking the layout of the input data, recognizing errors and, where possible, correcting them. This is done automatically as reports are recognized and stored in the Synoptic Data Bank and subsequently as they are retrieved from the Bank and decoded. NPC data, which will have been nationally validated by the country supplying them, should not contain format inconsistencies. However, if minor inconsistencies are found they will be corrected as the reports are converted into SSDC formats. More serious errors will be referred back to the appropriate NPC for corrections. Format validation also involves checking that the output of the Data Centre itself is consistently correct. This will be achieved by using the product for scientific investigations at the Centre and within the Meteorological Office (e.g. by the Tropical Group of the Dynamical Climatology Branch).

Quality control involves checking the meteorological content of each parameter. Observations in the Quick Look Data Set were only subjected to the normal checks of the Synoptic Data Bank routines, but more elaborate tests have been devised and programmed for the Final Data Set. Each parameter will be tested, where possible, and if appropriate, against climatological limits, for internal consistency within each report, for acceptable rate of change with time, for permissible value of a coded parameter and so on. Many of the tests are based on those already performed by the Synoptic Data Bank (but made appropriate to the tropics) and those in use by other meteorological services. Most reported parameters have a quality-control indicator to indicate the quality of the observation and the type of test failed (if any). Data will not be destroyed unless they are meaningless and a method based on the probable cause of the error exists for creating a better value.

The SSDC is studying the climatology of the GATE area for 1974 in terms of the means for each Phase of GATE. This is to aid the Centre in its validation exercises and it is expected that charts of temperature, height and wind will be produced for selected levels in the atmosphere for the whole of the GATE A-scale region. From these charts the Centre will establish 'climatological' limits for GATE observations, attempt to reconcile differences between instruments (particularly those measuring upper-air temperature) and verify results obtained from studies of the special intercomparison observations.

THE DATA SETS

1. *The Quick Look Data Set*

The Quick Look Data Set (QLDS) contains all the synoptic reports received in near real time in a recognizable form through the Bracknell RTH, and for Phase I only, observations recovered from the paper-tape data collected by mail. The data set contains data for the period from 1 June 1974 to 30 September 1974 inclusive although particular attention is being given to those observations made during the three main phases of GATE. The area covered by the data set is 95°W to 55°E and 10°S to 25°N. A few upper-air stations, Atuona, Gan, Ponape and Singapore, which are very near to the equator but outside the area, are also included so that the equatorial stratospheric circulation can be studied.

2. *The Unvalidated Teleprinter Tape Data Set*

This data set (which has also been called the Quick Look Data Set—Supplementary) contains the paper-tape information in telecommunication form collected by mail during 1974. It is a direct copy on magnetic tape of the paper tapes and is intended to provide scientists with data much earlier than they would otherwise be available. Reports, which have not been validated or properly ordered, are reproduced as received in WMO codes and other miscellaneous codes and plain language and contain distortions and errors which characteristically occur with near-real-time data. Although it is relatively easy to print out the data set and use the information manually (e.g. for plotting synoptic charts) it will be extremely difficult to process automatically by computer unless the user has software with which to decode messages in WMO code. The data set is contained on five magnetic tapes and was sent to GATE Archives early in 1975.

3. *The Final Data Set*

This will contain reports for the same period as the QLDS but the area is extended from 10°S to 15°S, so that a few more upper-air reports will be available in South America and Africa (where data are otherwise sparse), and from 55°E to 60°E. It is planned that all observations will be comprehensively validated and doubtful values flagged. The purpose of this data set—the main product of the Data Centre—is to attempt to provide a complete and internally consistent set of observations which can be used in the development of tropical numerical prediction models and for synoptic studies of the tropical atmosphere. However, since most of the land data will have been collected in telecommunication codes—either on paper tapes mailed to Bracknell or over the Global Telecommunication System—it is inevitable that some observations will have been lost while others will have been corrupted to the point at which they cannot be recognized or used. It has not been possible to get back-up information on paper tape from all countries, particularly some with internal political or economic difficulties, and this causes a further loss of data. At present (March 1976) the indications are that recovery of observations for land stations will be good and that serious deficiencies will only occur in those areas where there were no observing stations—for the upper air this includes parts of central South America, Liberia, Sierra Leone, Guinea, northern areas of Mauretania and Mali and parts of central Africa. Coverage of the Atlantic Ocean, which will depend on the numbers of observations supplied by the NPCs, is expected to be good except to the west of the B-scale region where there will be less data than envisaged in GATE plans, near the northern boundary and south of the Gulf of Guinea. Also there are no upper-air observations in the GATE area of the Indian Ocean. It is expected that there will be about 25 per cent more data overall than there were in the QLDS, but the improvement will vary considerably from station to station and from observation hour to observation hour. Surface-data coverage will be considerably improved in South America (few observations were received in near real time), in Africa (there will be more reports at 03, 09, 15 and 21 GMT) and for GATE ships (hourly observations should be available). The biggest improvement in upper-air reports will be in western South America (a good supply of observations will be available for several stations which were rarely or never received over the Global Telecommunication System at Bracknell) and eastern Africa. There should also be reports at three-hourly intervals from some ships in the B-scale and A/B-scale regions—particularly in Phase III.

4. *The Intercomparison Data Set*

This will contain synoptic-type observations made by the GATE ships (and possibly GATE aircraft) during the formal intercomparison periods. The purpose is to provide the data in such a form that instrumental differences can be evaluated. The information may also be used to create or justify adjustments to the main body of observed data before its use. Most A-scale intercomparisons took place just before Phase I or just after Phase III. With upper-air intercomparisons the 'in-train' method of flying two radiosondes on one balloon was usually employed while the windfinding equipment tracked the same balloon. Surface intercomparison observations were made aboard adjacent ships or on board a ship while alongside a buoy which was automatically recording the same parameters.

5. *The SPECI Data Set*

A data set is to be created from the SPECI reports received on the paper tapes from Meteorological Centres. They contain information on the time of occurrence of certain phenomena, for example, the onset of rain, thunderstorms, strong winds etc. These can be useful in some synoptic studies or investigations such as the study of squall lines.

551.506.24:681.3

COMPUTER PROCESSING OF GATE TELECOMMUNICATION DATA

By C. H. JARVIS
(Meteorological Office, London/Heathrow Airport)

SUMMARY

The method of processing telecommunication data for GATE is described. The advantages of sending telecommunication paper tapes by post are assessed. The uses to which the processed data have been put are briefly mentioned.

INTRODUCTION

The responsibility for processing meteorological telecommunication data for GATE was undertaken by the Meteorological Office. The Data Processing Branch (DPB) already had considerable experience in the presentation of telecommunication data both for use in objective-analysis schemes and for archival storage. It was decided that the DPB Operational Synoptic Data Bank (SDB) could accommodate the additional data with trivial modification. Furthermore, only minimal computer-programming effort would be necessary to recognize and store the additional code types and message formats proposed for GATE. Paper tapes received through the normal postal system would be acceptable for computer processing even some weeks after the date-time of their report. The techniques used to test improvements in the SDB suite of programs were also capable of handling such late-arriving data.

Once the data were stored, the comprehensive library of retrieval routines already available to SDB users could supply the variety of GATE demands—primarily for telecommunication monitoring, computer modelling, and the GATE archival data set.

REAL-TIME DATA SOURCES

The routine telecommunication tapes provided for the SDB by the Telecommunications Branch already contained a substantial proportion of data for the GATE area. The Global Telecommunication System (GTS) was augmented by special bulletins from within the GATE area for stations and hours not normally transmitted, and for surface and upper-air reports from the participating GATE ships; use was also made of radio-teleprinter broadcasts from Nairobi, Nicosia, Offenbach, and Moscow, the last having a special direct link from a Russian ship in the area. The additional African observations were received regularly, but the South American contribution in real time was limited.

The Telecommunications Branch, on their own initiative, found that the interception of the Paris–Dakar point-to-point radio-teleprinter broadcast was possible at Bracknell. Within six hours of making this discovery in early August the SDB was processing the first Dakar observations. The Dakar broadcast continued to provide a valuable back-up to the GTS throughout the rest of GATE. A close informal liaison with the Telecommunications and Dynamic Climatology branches continued throughout the experiment. Thus improvements to the joint plans were quickly implemented.

POSTAL DATA SOURCES

Before the experiment began it was recognized that a significant number of observations would not be available from the GTS. Many of these observations were for the areas where data were sparse, which made it important wherever possible to collect them subsequently. Furthermore, the teleprinter data received at Bracknell are not sufficiently error-free for them to be the only source for GATE use. Radio-teleprinter reception is particularly variable in quality. A back-up was required. A 5-hole paper tape is usually produced by transmitting centres, coincident with their sending of reports. It was suggested that these tapes should be sent to Bracknell by mail. Most national and regional centres already cut these tapes, so very little extra work would be required. Furthermore since the messages are in international codes (and any 'national practices' are listed in WMO publications), the differing archiving conventions adopted by participating countries were not relevant. Some centres produced 5-hole paper tapes specially for this purpose, and three centres produced manuscript data (unfortunately in three different formats). Tedious clerical effort was required in each case to convert the data received to a suitable computer-input standard. This indicates how difficult the whole problem could have proved.

Participation was encouraged by providing each collecting centre with cartons for each day's tapes and addressed postal boxes for weekly despatch to the DPB. Some 8000 such cartons were labelled and sent out by the DPB staff during April 1974.

Problems were few, although one parcel of empty boxes languished in an overseas customs shed for the whole GATE period. The boxes were returned by a variety of methods despite instructions to senders to use only air and sea postal services. Airline captains personally handed some boxes to the Meteorological Office at Heathrow, others came by air freight. The last box was received in August 1975, having spent 10 months in transit.

Although in general the tapes were produced according to instructions there were some awkward variations. Some tapes were only partially perforated, and some were very short. Neither partial perforation nor length causes difficulty on slow 10-characters-per-second tape-readers of the type used in many telecommunication centres, but there are problems with the fast photoelectric readers which are commonly used as computer-input devices. Staff of the DPB performed the painstaking tasks of splicing and reperforating tapes in longer lengths suitable for computer processing.

A few centres had no capability for perforation, and, as planned, their manuscript data were accepted for hand punching at Bracknell.

REAL-TIME DATA PROCESSING AND USAGE

The GATE data obtained through telecommunication channels, together with normal current data, were processed by the SDB suite of programs used for the objective-forecast, chart-plotting and other routine tasks.

The Operations Control Centre for GATE (GOCC) at Dakar needed daily information on how the GATE telecommunication program was functioning. A monitoring program, originally written for the preparation of the United Kingdom statistics for the annual WMO telecommunication survey, was modified to list missing SYNOPs and both missing and incomplete TEMP/PILOTs. A further list of upper-air ascents that failed to reach 400 mb was also prepared. The lists of missing and incomplete reports were issued directly as paper tapes by the IBM 360/195 each day, soon after 11 GMT for midnight and 23 GMT for midday data. They were passed to the Telecommunications Branch and telexed to Dakar within the hour. This enabled GOCC to take action within about 12 hours to remedy teleprinter faults and to offer immediate technical assistance to non-reporting upper-air stations.

During the operational phase of GATE the Dynamical Climatology Branch prepared analyses and forecasts for tropical areas by using a newly programmed model. The source data for the model were obtained from the GATE-augmented SDB by using techniques developed for the routine 10-level octagon forecast.

QUICK LOOK DATA SET

An important aim within GATE was to make data available as soon as possible. To this end it was decided to produce a Quick Look Data Set (QLDS) of meteorological reports. The data set was discussed and agreed at Washington in February 1974. The present writer proposed and presented a format derived from a Basic Data Set Project used previously by the Global Atmospheric Research Program (GARP) of WMO and this was accepted. The programming work was undertaken by the Dynamical Climatology Branch. The QLDS relied on the real-time SDB for its data. However, during the first three weeks of GATE, important TEMP/PILOT reports from ships were not processed because the message format used by some participating countries was not that expected. These reports were included when they were received by post (about a month later) by which time programs had been suitably amended. The conversion to the QLDS format took longer than expected, but was completed by April 1975.

PROCESSING OF POSTAL DATA

As soon as the first paper tapes arrived, they were converted to magnetic tape. By using a library program developed by the Systems Development Branch the PDP11/45 minicomputer produced a magnetic tape for each day of GATE—some 100 tapes in all. These tapes were updated at about monthly intervals as more postal data arrived until August 1975, when all available data had been processed.

The magnetic tapes are at present being processed to augment the SDB Archives. Each daily tape of postal observations is used to augment the SDB created for operational purposes at the time of observation. Any data not recognized by the programs are stored as 'Dregs'. This store contains valuable reports as well as non-meteorological information. Bulletins with incomplete headings and corrupt reports are the most important. Recently Visual Display Units (VDUs) have been added to the Meteorological Office COSMOS computer, and programs have been written within the DPB to display and edit the 'Dregs'. Staff are currently working through the 100 tapes to extract as much information as possible. On completion of this task the data will be processed once more to augment the SDB. This will be the only source of much of the land data for the GATE SSDC Final Data Set and will complement the ships' data received directly from the participating countries.

RESULTS

Comparisons of data available from some trial processing for the Final Data Set show increases of 20 per cent for SYNOP and 35 per cent for TEMP/PILOT reports over the amount available from normal telecommunication channels. There have been regional variations; in particular South American reports were rarely available immediately. Thus the postal contributions have been vital to the project and it would seem that they will be equally vital to any future similar experiment.

551.506.24:551.507.352

MRF IMPRESSIONS OF GATE

By D. B. HATTON*

SUMMARY

An informal account is given of the work of the Meteorological Research Flight aircraft, its crew and supporting staff during the field phase of GATE, with a brief description of the type of data collected and the plans for their analysis.

The realization that MRF were going to meet their target of full participation in GATE came early on the morning of 24 June 1974. Following several months of frantic preparations at Farnborough, caused mainly by the delay of the modified Hercules, the aircraft was finally on its way to Dakar, Senegal. On board were the MRF staff, RAE ground servicing crew and RAF aircrew totalling 28, for the first phase of the experiment; twenty-two days in a country about which very little seemed to be known in England—except that it was hot, and that French was spoken there.

Eight hours later the secrets of the country were beginning to unfold, as the airport immigration and customs officials were encountered. The most important word of French needed was 'le GATE'—this probably solved more problems and tricky situations than any fluent French during the period of our stay. This of course was due to the fact that French was the 'imported' language, and Woolof was spoken by 90 per cent of the population.

The headquarters for our stay were four rooms in the GATE Operational Control Centre building, GOCC, which was just being completed as we, and all the other nations' representatives, arrived. The main briefing room had an echo that resounded for several days to come to the builders' and decorators' work, whilst introductions and initial plans were made. Perhaps this, and the pauses of the interpreters, enabled us all to re-adjust more easily to the new pace of life in this country.

The first tasks for the MRF Hercules were intercomparisons with other aircraft, calibrations against an instrumented tower, and a practice of one of the flight plans before Phase I started in earnest. The aircraft were scheduled to fly two days in three, and initially we had only one crew of observers, so that any free time was obviously going to be at a premium. The flights were for about 8–9 hours, and usually five of these were at low level, on task, so that any flying day was pretty exhausting. Many of our days on the ground were required to get all the flight logs into a form suitable for the data co-ordination section, and many hours were spent initially in reaching the best compromise between the data co-ordination group's requests and our flight procedures.

The temperature in the data-recording compartment where the aircraft experimental instruments are monitored was frequently 35°C, and it was customary to operate with a gallon of water, or fruit cordial, on one side, and drink it all. Sometimes the aeroplane would return covered in salt and red Sahara dust,

* Mr D. B. Hatton is a Higher Scientific Officer at the Meteorological Research Flight, Farnborough. He departed for Dakar in late June 1974 aboard the MRF Hercules and remained there until the end of Phase III, returning towards the end of September. His main responsibilities were concerned with the maintenance and calibration of the meteorological instrumentation aboard the aircraft. As well as this he was a resident member of the MRF flight observer team, clocking up more than 250 flying hours.

or, if we found an active cloud cluster in the operating area, paint would be missing after five hours of rain erosion, and water would run from the instrument covers after flight.

Either way, post-flight instrument care would include washing and drying, while post-flight observer care also included washing and drying, and of course lubrication (thanks to Stork beer). The ground support team then took over, checking flight data tapes for obvious instrument or recorder faults so that, if necessary, repairs could be made before the next flight.

Dakar is a French holiday resort, so restaurants with French-style cooking abound. The Senegalese have been taught this art which has influenced their preparation of local foods as well as the imported ones.

Fish are plentiful in the sea, and fishing communities thrive on them, producing catches of all shapes and sizes, piled on the sand each evening. Some are sold fresh, some are dried in the sun. The communities have an aroma of their own—mixed in with fish odours were the smells of roasting peanuts and maize, fruits, vegetables and grain, and of course open sewers.

Dakar is full of variety. Perhaps the best way to appreciate it is to understand the people, and for that the key lies in the language. Their whole philosophy is different from the European; their reply to a simple greeting 'Hello, how are you?' is 'I'm alive'. Many words just do not exist, and a French and Woolof mixed sentence produces some consternation on ears accustomed to Parisian French. A measure of distance is given in units of 'over there', this phrase being repeated several times as the distance increases! The abounding labourers at GOCC were always enthusiastic about teaching us their language over a cup of tea or coffee, and the effect in the markets was amazing. A reply in the local tongue brought immediate friendship and reduced prices—even the beggars change from 'dix francs' to 'niar (2) francs' in Woolof!

Phase I drew to the finish, everyone being glad that the hardest period, of finding out if such an international exercise would work, was over. With sometimes 10 aircraft and up to 30 ships involved it was an achievement just to obtain the co-operation between the nations, and the amounts of scientific data being collected were enormous. It was with relief that we realized that some of the instrumentation on the other aircraft was as untried as ours, and it was with a certain amount of pride that the aircraft returned to the United Kingdom for servicing, after the first operational phase, knowing that the last-minute preparations had proved successful and reliable.

At this time, many of the ships were heading for Dakar from their various stations out in the Atlantic. Some had just been names on a map to us, some a faint voice over the aircraft intercom, while others were more familiar, being rendezvous or positioning points for the aircraft during the missions away from base. The port now became the scene of considerable activity; what did the gaze of those tethered balloons looking down all day on the people of Dakar mean to them? The rainy season had arrived on time this year—the witch doctors might be upset by the rumours of the 'GATE' rainmakers! Meanwhile, GOCC was having its 'spring clean' with grass and flowers appearing overnight, to herald the official opening of the building by the President of Senegal on 23 July.

With this formality over, the ships set sail for their stations, and the aircraft were soon returning, bringing with them some new faces and some familiar. Many of the initial teething troubles were overcome as Phase II began.

The air was much clearer now and the ground had a green sheen of new growth, as Dakar came under the influence of the Intertropical Convergence Zone. Sometimes we would fly south to the equator, leaving the towering cumulonimbus clouds behind, and passing over seas that reflected like a mirror the small cumulus clouds, a rare sight at England's wind-swept latitudes. Often at 500 ft or lower, we were measuring boundary-layer fluxes, with flying fish and whales for company. Other days we might visit the ship arrays to intercompare with the instruments on the tethered balloons. Phase II finished with an intercomparison between many of the ships—how strange to see such a vast fleet of ships lined up, and for peaceful purposes!

Dakar was probably at its wettest now, with rain in the form of showers in squall lines every few days. Further south the countryside grew rapidly greener; here was the 'Garden of Senegal', the region of Casamance, where tropical rain forests thrived in semi-continuous rain at this time of year, and much of the land was cultivated to grow rice, fruits and groundnuts. It was not hard to understand why some French people remained when the country became independent. Disease is probably the biggest drawback to living here, an observation borne out by the large numbers of small children, and the lack of adults over about forty.

At the end of August Phase III was about to start, with the addition of a few ships and aircraft. An emphasis on sea surface measurements due to the oceanographic bias of this phase necessitated the addition of one more instrument, an upward-facing infra-red radiometer, to the MRF Hercules during its interphase servicing absence. The airport authorities were now as familiar with the aircraft procedures as they ever would be. Several aeroplanes leaving within a few minutes of each other, or arriving back together after a mission, sometimes brought a little confusion, but the air traffic controllers always had the priorities right. A good example occurred one morning when several GATE aircraft had their engines running and were ready to taxi. The order came to stop engines while the President's aircraft departed. It is not etiquette to have the propellers turning while he passes.

So with only a few delays the flights went as planned, finishing with aircraft intercomparisons and another dreaded tower calibration. This tower was an open lattice construction, 120 ft high, with instruments to compare against aircraft height, temperature and dew-point measurements, erected on a disused airfield. The aircraft had to be flown to a height accuracy of about 20 feet, within a few wingspans of the tower, at various airspeeds within its operating range. It was a brave man who sat on top of the tower and judged whether the aircraft height was within the prescribed limits for each pass. From experience, there are many better places to be in than the cargo hold of a Hercules during such operations, considering the turbulence and acceleration forces resulting from tight turns and positioning corrections required to keep on track over the hot desert countryside. The relaxation at a farewell party was earned that evening. Three months was long enough for an experiment on such a large scale; everyone would still part as friends. Suddenly, hotel service became more efficient, waiters were always hovering expectantly and rooms were cleaned several times a day. Even the porters at GOCC were awake most of the time! The news had spread, GATE—a word that meant work for many in our host country —was over.

For MRF, however, the work was by no means over; 43 flights collecting data at 640 samples a second means that something in the order of 750 million words of data have been recorded. This has to be transcribed by the PDP8/I computer at MRF on to working magnetic tapes and then checked through to ensure that it is all valid before any processing can take place. The outputs from each instrument must be examined for errors and the appropriate calibrations applied. Derived parameters, e.g. wind and humidity are then evaluated from the basic measurements. All these data have then to be assembled in an internationally agreed format, for storage in the GATE world data centres in USA and USSR, and for use by the five subprogram data centres located in various participating countries. This is no small task as MRF had not established a comprehensive data-handling system for the Hercules prior to GATE, this being the aircraft's first experimental mission.

Computer programs have now been written to cope with the large number of different processes carried out on the data. A typical flight requires two passes through the master tapes to extract and process all the data. The reason for this is that there are two distinct requirements, firstly averages over 1 minute and 1 second for the whole of the flight and secondly 20-Hz data for the 'operational' part of the flight. The bulk of the processing is being carried out initially on the ICL 1904A at the RAE, and at present each flight requires about 40 hours of computer time. This assumes that there are no interruptions due to program or computer faults, or any other gremlins that manage to lurk so easily among 9000 million data bits! Considerable patience and ingenuity have been required to cope with the problems encountered during the development of these programs. A year after recording them, reliable methods of processing the data are still being finalized and at such times MRF impressions of GATE are rather different from those gained in West Africa. It isn't easy to decide whether the collection or extraction of GATE data will leave the most lasting impressions, and it will be many months yet before we know.

Illustrations of an MRF aircraft before and after the exercise are to be found in Plates II and III.

Short glossary of words and expressions occurring frequently in special GATE issues

platform—A structure to which measuring instruments are attached; it may be stationary (e.g. an ordinary ground station) or moving (e.g. a ship, aeroplane, balloon, or satellite).

data set—A set of data stored in a rigorously specified and consistent manner in a storage medium, such as magnetic tape, that can be read and processed by a computer.

format—The arrangement of numerical and other data in groups with exact correspondence between the position of a number or character in a group and its meaning.

validate—To check that data are arranged in the correct format and that all implied values of variables are reasonable and mutually consistent.

flag—An indicator placed in close association with a particular value of a variable occurring in a data set to show that this value is suspect or otherwise merits special attention.

real time—An expression used to refer to any system in which the processing of data that are input to the system to obtain a result occurs almost simultaneously with the event generating the data.

DR G. M. B. DOBSON, C.B.E., F.R.S.

Dr G. M. B. Dobson, formerly Reader in Meteorology in the University of Oxford, died on 10 March 1976 at the age of 87.

Gordon Miller Bourne Dobson was born in 1889, son of Thomas Dobson, M.D. of Windermere, and was educated at Sedbergh School, and at Caius College, Cambridge. Dobson's first job was as student-assistant at Kew Observatory in 1911, and was arranged between Sir Napier Shaw and Gonville and Caius College, Cambridge, the college providing a £50 per annum studentship and the Meteorological Office an assistantship. His terms of appointment as detailed in a letter from Shaw were as follows: 'The ordinary hours of attendance at the Observatory are, I believe, 9.30 to 5, with a half holiday on Saturday and a month's holiday in the year, but in my experience the exigencies of research pay little attention to office hours and if one wants to find out anything one has to take the opportunities that offer, so that the rules as to hours in this case would have to be sufficiently elastic to be comprehensive as well as reasonable'. Dobson stayed at Kew until 1913, during which time he carried out some investigations of atmospheric electricity and also spent some time with L. H. G. Dines at Eskdalemuir.

In 1913, after a short time at Kew Observatory, Dobson joined the Central Flying School at Upavon as Lecturer in Meteorology, and it was here that he carried out a classic set of balloon experiments on the upper winds, in the results of which G. I. Taylor (later Sir Geoffrey) at Cambridge was very interested. During the First World War he was head of the Physics Section at the newly formed Royal Aircraft Establishment at Farnborough where he met F. A. Lindemann (later Lord Cherwell). In 1920 he joined Lindemann at the Clarendon Laboratory, Oxford. Together they studied meteor trails, and this investigation led to the discovery of a region of high temperature at an altitude of about 30 miles. Since ultra-violet sunlight absorbed by the stratospheric ozone layer was thought to be responsible for this, Dobson set about the measurement of atmospheric ozone, work on which he was to continue for the rest of his life and for which he became internationally famous.

In order to make accurate measurements of stratospheric ozone he developed new techniques for ultra-violet spectroscopy and built the first photo-electric microphotometer for measuring photographic plates. With D. N. Harrison and I. O. Griffiths he wrote a textbook on photographic photometry in 1926. In the 1930s Dobson set up a world-wide network of ozone measuring stations, much of which is still in existence, employing the Dobson instruments.

In the early part of the Second World War a method was required of forecasting the conditions under which condensation trails would be formed by aircraft. In co-operation with A. W. Brewer, Dobson designed an instrument for measuring water vapour from aircraft. With the instrument they developed, known as the Dobson–Brewer Frost-point Hygrometer, which is still in use today, the first measurements of the very low water-vapour content of the stratosphere were made in 1943. Some of the early work on the freezing of cloud droplets was also carried out by Dobson and his students at Oxford.

In 1927 Dobson was elected a Fellow of the Royal Society, whose Rumford Medal he was awarded in 1942. Merton College elected him to a Research Fellowship and the title of Professor was conferred on him by the University. He was President of the Royal Meteorological Society from 1947 to 1949.

In the late 1930s Dobson was chairman of a committee of the Department of Scientific and Industrial Research set up to investigate atmospheric pollution. In 1941 he was one of the founder members of the Meteorological Research Committee, a body set up to bring together the expertise of academic meteorologists in universities and the research scientists in the Meteorological Office. Dobson was chairman of the committee from 1947 to 1952.

Much of Dobson's work was carried out in his laboratory at his homes in Oxford, first on Boar's Hill and later on Shotover. His main recreation was cultivating his large garden. After retirement in 1956 he carried on his observations on ozone, his last scientific paper being written in 1973. He was an active member of St Aldate's Church in Oxford, being a churchwarden there for many years.

All Dobson's students and colleagues will remember his unique skill as an experimental physicist; we have all benefited from being exposed to his very practical approach both to his science and to his life as a whole. We extend our sympathy in their loss to his wife, his two sons, and his daughter.

J. T. HOUGHTON

NOTES AND NEWS

Retirement of Mr L. P. Smith

Mr Lionel P. Smith, Special Merit Senior Principal Scientific Officer, retired from the Office on 6 May 1976 after some 38 years' service. Mr Smith gained B.A. degrees at Oxford University (Queen's College) in mathematics and physics and his official career commenced with postings to Kew Observatory and Croydon where, like most of his contemporaries, he received a rather informal professional training before serving as a forecaster at Croydon itself and then at a number of RAF stations in the United Kingdom throughout the Second World War. It might not be generally known that he qualified for membership of the Caterpillar Club as a consequence of his parachute escape from a Stirling bomber over Northern Ireland in 1944.

In 1946 Mr Smith commenced a three-year tour of duty overseas, serving firstly in the Levant and finally as Deputy Chief Meteorological Officer at Ismailia. He returned to the United Kingdom in 1949 to become Head of the then newly formed Agricultural Meteorology Branch and entered an area of activity which was to dominate the remainder of his career in the Office. It was not long before he became well known in agricultural as well as meteorological circles, partly because of his contributions to the solution of practical farming problems where the application of weather-based intelligence was appropriate and partly as the result of his publications in agricultural as well as the more familiar meteorological journals. In 1954 Mr Smith was awarded a Nuffield Travelling Fellowship which enabled him to visit Canada, New Zealand, Australia, the Republic of South Africa and most countries of western Europe to study their methods and progress in agricultural meteorology and allied fields. His reputation grew steadily throughout the fifties and in 1960 he was given Special Merit promotion and became completely free to devote his time to his main interest. His tenure of office as Head of the Agriculture Branch saw the establishment of outstations in some of the regional offices of what is now the Agricultural Development and Advisory Service of the Ministry of Agriculture, Fisheries and Food solely devoted to providing meteorologically based advice in the broadest sense for agricultural practitioners.

Over the 15 or so years following his Special Merit promotion, Lionel Smith continued to apply himself wholeheartedly to his subject and became a much-respected and sought-after contributor and participant in the international as well as the national sphere. He served two terms (1962–71) as President of the WMO Commission for Agricultural Meteorology and wrote many WMO reports and technical notes as well as acting as an organizer and lecturer at WMO-sponsored training seminars and the like. Throughout this period he published many scientific papers and a number of reports and received several awards including the L. G. Groves Memorial Prize for Meteorology in 1965 and the Clive Behrens Lectureship at Leeds University in 1965–67. His activities continued unabated until his retirement, by which time he had some 200 papers, reports, books etc. to his credit. His latest book 'Methods in agricultural meteorology' contains a distillation of his wide experience extending over a quarter of a century, and reflects his breadth of knowledge, humour, strongly held views and forceful but none the less fundamentally sympathetic attitudes. Above all, L. P. Smith is one of the outstanding characters of his generation of meteorologists. Although he has now officially retired it is certain that we have not heard or seen the last of him. His colleagues at home and overseas will miss the inspiration and stimulation which flowed in full measure from an extremely dedicated worker. We wish him a happy, and above all, an active retirement.

N. E. RIDER

COST 72 Technical Conference on Automatic Weather Stations

A Conference and Exhibition dealing with Automatic Weather Stations (AWS) will take place at the University of Reading, Berkshire from 22 to 24 September 1976. The event is the culmination of a study on the use of AWS in a group of European countries whose governments are participating in European Co-operation in the field of Scientific and Technical Research (COST).

Papers describing experiences of existing AWS systems and the problems and requirements of future systems have been promised from several countries including the German Federal Republic, The Netherlands, Finland, Yugoslavia and the United Kingdom. The Exhibition will have equipment from manufacturers of AWS systems and sensors, and exhibits from user organizations.

Further information may be obtained from

The Chairman of the Programme Committee,
COST 72 Technical Conference on Automatic Weather Stations,
Meteorological Office (Met.O.17),
London Road,
Bracknell,
Berks. RG12 2SZ.

MET.O.7 PRESS RELEASE

THE METEOROLOGICAL MAGAZINE

VOL. 105 NO. 1249 AUGUST 1976

CONTENTS

NOTICES

It is requested that all books for review and communications for the Editor be addressed to the Director-General, Meteorological Office, London Road, Bracknell, Berkshire, RG12 2SZ, and marked 'For Meteorological Magazine'.

The responsibility for facts and opinions expressed in the signed articles and letters published in this magazine rests with their respective authors.

Complete volumes of 'Meteorological Magazine' beginning with Volume 54 are now available in microfilm form from University Microfilms Ltd, St Johns Road, Tylers Green, High Wycombe, Buckinghamshire, England.

Full size reprints of out-of-print issues are obtainable from Johnson Reprint Co. Ltd, 24–28 Oval Road, NW1 7DX, London, England.

Issues in Microfiche starting with Volume 58 may be obtained from Johnson Associates Inc., P.O. Box 1017, Greenwich, Conn. 06830, U.S.A.

Printed in England by Heffers Printers Ltd, Cambridge
and published by
HER MAJESTY'S STATIONERY OFFICE

60p monthly **Annual subscription £8.28 including postage**

Dd. 290748 K17 8/76 ISBN 0 11 724374 4