NCAR/TN-363+PROC
NCAR TECHNICAL NOTE

August 1991

Workshop Review: Management of Data Collected in GRAMP (Gulf Region Atmospheric Measurement Program)

22-24 July 1991

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LIST OF ACRONYMS

ARAC	The Atmospheric Release Advisory Capability
ASAP	A System for Assessment of Pollution
BTAB	BUFR Tabular Form
BU	Bahrain University
BUFR	Binary Universal Form for Data Representation (WMO spec FM 92)
CBS	Commission for Basic Systems
CD	Compact Disk
DAT	Digital Audio Tape
DCP	Data Collection Platform
DDB	Distributed Databases Concept
DM	Data Management
DMSP	Defense Meteorological Satellite Program
DNA	Defense Nuclear Agency
ECMWF	European Climate Modeling Weather Forecast
FGGE	First GARP Global Experiment
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GKS	Graphics Kernel System
GMEP	German Ministry of Environmental Protection
GOS	Global Observing System
GRAMP	Gulf Region Atmospheric Measurement Program
GRIB	Grid in Binary (Gridded data format--WMO spec)
GTS	Global Telecommunications System
IFC	IGOSS Flexible Code
ISS	Integrated System Study
KFUPM	King Fahd University for Petroleum and Minerals
MDD	Meteorological Data Dissemination
MEPA	Saudi Arabian Meteorological and Environmental Protection Agency
METEOSAT	Meteorological Satellite
MTN	Main Telecommunication Network
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NIST	National Institute of Standards and Technology
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NOAA/ARL	NOAA/Atmospheric Research Laboratory

NOAA/AVHRR	NOAA/Advanced Very High Resolution Radiometer
NOAA/NESDIS	NOAA/Earth System Data Directory
RSMC	Regional Specialized Meteorological Centers
RTH	Regional Telecommunications Hubs
SPOT	Système Probatoire pour l'Observation de la Terre
USAEHA	US Army Environmental Health Agency
WGDM	Working Group on Data Management
WMO	World Meteorological Organization
WWW	World Weather Watch

PREFACE

The demolition and subsequent burning of the Kuwait oil fires was a senseless act of destruction that has threatened public health, damaged the environment, and may possibly cause short or longer term changes in regional and global climate. Many nations responded to this disaster by offering aid and by rushing teams into the affected area to make measurements that would assess the impact of the fires.

The following report summarizes a workshop that was held July 24-26, 1991 at the National Center for Atmospheric Research (NCAR) to discuss a plan to gather all the atmospheric measurements that are being made in the Gulf region and make them available for general dissemination. This workshop was initiated by the World Meteorological Organization and co-sponsored by the National Oceanic and Atmospheric Organization.

ACKNOWLEDGEMENTS

The idea for the workshop was originally discussed in early June but the actual planning effort did not get started in earnest until the end of that month. The fact that the workshop was conducted and well attended can be attributed to the hard work and fast action of a number of people. John Robinson of NOAA deserves special thanks, not only for obtaining financial backing to help underwrite the expenses of the workshop, but also for his relentless enthusiasm and support. Danny Foster of the WMO contacted all the potential participants. Larry Radke, manager of the NCAR Research Aviation Facility and the co-principal investigator of the NCAR effort in the Gulf, provided the necessary resources from the RAF to accomplish this workshop in what might be record time. We would particularly like to thank all the participants who managed to break away from thier already overloaded schedules to attend this workshop and provide their valuable input. Finally, we would like to offer special thanks to Barbara Knowles who made the majority of the meeting room arrangements, took notes, arranged for refreshments, typed the workshop report and managed to keep a big smile on her face the whole time.

PART I--INTRODUCTION

A large-scale, international effort has been initiated by the World Meteorological Organization to assess the atmospheric effects caused by the man-made pollution that is introduced by the burning of more than 500 oil wells in the Kuwait oil fields. The WMO called a meeting of experts to discuss how to assess the effects and to coordinate an international response for the atmospheric part of the environmental emergency in the gulf.[1] This meeting identified a large number of agencies that had been or would soon be participating in measurement programs in the Arabian Gulf region and focused on the critical environmental issues that needed to be addressed by these measurement programs. All of these programs are being coordinated by the WMO whose responsibility is to ensure that adequate measurements are made and that these measurements are integrated and disseminated to international research organizations in a systematic and timely fashion.

This latter task requires gathering the many measurements from multiple platforms, cataloguing the attributes of each of the data sets, archiving and then disseminating this information. The need for this operation is stated in section 6.5 of the draft report. However, the methodology and mechanisms for accomplishing this task are omitted. A number of factors are involved with establishing a data archive and this task should not be undertaken without careful consideration and utilization of input from the agencies that were involved in the measurement programs. The World Meteorological Organization (WMO), seeing the need to solicit this input, asked the National Center for Atmospheric Research (NCAR, Boulder, Colorado) to organize a workshop that would focus on the salient aspects involved with starting the data archiving process. This workshop was held at the NCAR facilities on July 22-24, 1991.

The urgency of the problem and need to initiate an archiving process as soon as possible made it difficult to obtain representatives from all agencies who had participated in the Gulf Regional Air Monitoring Program (GRAMP) since there was only about a three week period between notification and start of the workshop. Nevertheless, over 45 attendees from more than 20 agencies and five countries participated in the workshop (Appendix C lists all the participants).

The remainder of this document summarizes the workshop proceedings (the agenda may be found in Appendix A).

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[1] Draft Report of the WMO Meeting of Experts on the Atmospheric Part of the Joint U.N. Response to the Kuwait Oil Fields, Geneva, 27-30 April 1991.

PART II--OVERVIEW AND CONTEXT OF WORKSHOP

There were several objectives to be met by the workshop.

- To identify as many data sources as possible that could be assembled into an archived data set which will assist the scientific community in assessing the impact of the Kuwait oil well fires.

- To identify measurements that are still needed and things that should be done to present data sets for future analysis.

- To make recommendations with regard to how the data should be documented, archived, accessed, and disseminated to achieve maximum accessibility and portability.

Identification of Data Sources

During the course of the workshop, representatives from a number of agencies summarized the types of measurements that their groups have been making in the Gulf region. The measurements are generally grouped in four categories: ground-based, airborne, satellite, and computer models.

Ground-based Measurements

Representatives from the King Fahd University for Petroleum and Minerals (KFUPM, Dhahran, Saudi Arabia)[2], National Oceanic and Atmospheric Administration (NOAA), Defense Nuclear Agency (DNA)[3], Environmental Protection Agency (EPA), the National Institute of Standards and Technology (NIST) and the United States Army Environmental Health Agency (USAEHA) presented overviews of their measurement programs. These are summarized as follows:

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[2] KFUPM is one of several facilities that make up the Saudi Arabian Meteorological and Environmental Protection Agency (MEPA).

[3] The representative from this group also discussed measurements made by the University of Bahrain who collaborated with the DNA on radiation measurements.

- MEPA - Atmospheric measurements of PM-10[4], SO_2, O_3, CO, H_2S, Polycyclic Aromatic Hydrocarbon (PAH) analysis, inorganic acids, volatile organic hydrocarbons (VOC) and heavy metals. Soil samples were analyzed for nickel and vanadium. Solar radiation measurements are also being taken at KFUPM.

- NOAA - 16 meteorological towers in Kuwait are telemetering 15 minute averages of temperature, humidity, horizontal winds, and solar radiation into Kuwait City.

- EPA - Measurements of SO_2, Polycyclic Aromatic Hydrocarbon (PAH) analysis, inorganic acids, volatile organics and Heavy metals. Single measurements were made at 10 different locations from March 13 - March 20.

- DNA - In Collaboration with Bahrain University (BU), direct, diffuse, and spectral radiation data were taken in Bahrain with DNA and BU radiometers. The university of Bahrain has also been making spectral measurements since 1986 that can serve as useful pre-fire background data.

- NIST - Has made measurements of flame height on five oil wells, heat flux and release rate on one well, and analysis of particulate mass and PAHs from an oil pool fire.

- USAEHA - Soil sample analysis for metals.

In addition to the ground-based measurement programs presented at this workshop, several other agencies were identified either as having made measurements or planning to. Those that were mentioned were groups from Saudi Arabia (Royal Commission, ARAMCO, MODA/MSD), Kuwait, Bahrain (Environmental Protection Committee), France (Air Parif), Germany (Ministry for Environment), Norway (Institute for Air Research), and Japan. The specifics of these measurement programs were not available for further discussion but the archiving process will need to encompass these data sets if they become available.

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[4] PM-10 is the particle mass of all particles less than 10 μm diameter. This is a technique whereby particles are deposited on a filter after particles larger than 10 μm have been removed from the air.

Airborne Measurements

The airborne measurements were discussed by the representatives of the German Ministry of Environmental Protection (GMEP) and the National Center for Atmospheric Research (NCAR). The measurements made by these organizations are as follows:

- NCAR - Temperature, pressure, humidity, horizontal and vertical winds, turbulence
  Particle size distributions (0.05 - 600 μm diameter)
  Cloud condensation nuclei, condensation nuclei
  Cloud droplet composition
  Soot mass
  O_3, CO, NO_x, SO_2, H_2S, OCS, CS2, Methane, Total Sulfur, Speciated and Continuous Peroxides, Formaldehyde, Total Hydrocarbons
  Short Wave, IR, and UV radiation, Surface temperature
  Single particle albedo
  Lidar - 0.5 μm, 1.06μm, 10.6μm
  Dropsondes - vertical profiles of winds, temperature, and humidity
  A total of 15 flights and 100 flight hours were flown covering the time period from May 19 - June 4, 1991.

- GMEP - Temperature, pressure, humidity, horizontal winds
  Particle size distributions (0.1 - 50 μm diameter)
  Soot mass
  O_3, NO_x, SO_2, VOC, PAH, Anions, Cations, metals
  UV radiation
  A total of 29 flights were flown from the period May 20 - June 6, 1991.

In addition to these airborne measurement programs, other airborne measurement projects were identified. The British Meteorological Service operated an aircraft and flew 55 hours during seven flights from March 22 to April 2, 1991. The University of Washington aircraft flew during the same period as the NCAR aircraft in a cooperative experiment and its instrumentation was fundamentally the same as NCAR's. The Department of Energy has made airborne measurements during the months of July and August and NASA had plans to fly a helicopter near the plumes to make better estimates of emission factors. There has also been discussions of sending the NOAA P-3 to the Gulf in the October-November time period of 1991.

Satellite Measurements

A number of satellites cover the Gulf region and this data can be obtained from several different sources.

- Meteosat 4 and 5 (Geo-Stationary)
- NOAA 9, 10 and 11 (two passes/day, each satellite)
- Defense Meteorological Satellite Program (DMSP) F8, F9, F10 (two passes /day, each satellite)
- Landsat
- SPOT

Surface and Upper Air Stations

The WMO World Weather Watch has 180 surface observing stations and about 40 upper air stations in the countries concerned. The data from those stations that report are archived daily at NCAR.

Modeling Efforts

Numerous modeling efforts are presently going on around the world, many of which were identified at the WMO meeting of experts. Three of these models were discussed at the workshop.

- Lawrence Livermore National Laboratory - The Atmospheric Release Advisory Capability (ARAC) is used to model optical density and provides near-real-time assessments of concentration, dose, and deposition of particulate as a function of time and location.

- NOAA/ARL - The ARL (Atmospheric Research Laboratory) runs three models for emergency response smoke plume dispersion forecasts. These models are used for concentration and trajectory forecasts.

- Royal Netherlands Meteorological Institute - "Puff model" provides isopleths of vertically integrated soot concentration and dispersion forecast in 24, 48, and 72 hour time intervals.

Data Analysis Requirements

One of the primary reasons for archiving large data sets is to provide an easily accessible, centralized database to facilitate extensive analysis. The database will be used to address four major issues:

- What is the composition and amount of gaseous and particulate by-products being produced by the burning oil wells?
- What is the magnitude of the exposure to toxic substances in the Gulf region in relation to human health risks?
- What are the expected effects in areas more remote from the source with regard to additional air pollution and deposition?
- Are there any global effects to be expected and what would be the magnitude and duration?

The analysis of the measurements fall into categories of diagnostic and prognostic. In the first case diagnostic analysis is used:

- To assess the immediate regional impact on public health and the environment.
- To characterize the regional emission rates of smoke particles and trace gases.
- To measure radiative properties of the smoke particles and the radiative effects of the plumes with attention to how radiation affects the altitudes of the plumes and the stability of the atmosphere.
- To measure characteristics of the smoke particles, i.e., size, shape, composition, and optical properties.
- To evaluate the degree to which smoke particles are scavenged in clouds, their subsequent effects on composition and radiative properties of clouds.
- To measure how the properties of the plume change with time.

The prognostic use of the data will be:

- To help in developing emergency response systems to warn the populace of health risks.

- To provide measurements that will aid in better parameterization of turbulent diffusion fields, particulate size distributions, and chemical reaction rates.

- To provide data on smaller scale than available from Radiosonde Observations to initialize dispersion models.

- To validate and help adjust medium, long-range, and global climate models.

Data Archival Objectives

The primary objectives to be met when archiving data from the atmospheric measurements made in the vicinity of the Kuwait oil fires are as follows:

- To catalogue and document as many atmosphere related measurements as possible that are of relevance to assessing the impact of the fire;

- To assemble as many of these data sets as possible;

- To store these data sets on high density medium that can be easily accessed;

- To maintain these data sets and update them as necessary;

- To provide utility software to allow easy access and perusal, and retrieval of these data sets.

These five objectives formed the focus of the remainder of presentations and discussions the final two days of the workshop.

Cataloguing and Documenting Measurements

The large quantity and variety of measurements that have been and are being made in the region of the oil fires makes it imperative that a major effort is made to compile comprehensive documentation on these data sets. At the minimum the following information must be included:

- What atmospheric constituents were being measured?

- What sensors were being used to make the measurements?

- What are the ranges, resolutions, sample rates and accuracies of the instruments?

- Where and when were the measurements made?

- Who is the primary contact to whom questions about the dataset should be directed?

Some data cataloging efforts are already underway, one instigated by UNEP and one by the U.S. Public Health Service. The UNEP effort is being developed by the Delft Corporation (The Netherlands) to be delivered to ROPME (Saudi Arabia). This system is called "A System for Assessment of Pollution" (ASAP) and is a PC-based database system that will contain as much information as possible about the measurements efforts taking place in the Gulf region. Information about this system can be obtained by contacting Dr. H.J. Van Zuylen (see Appendix B).

The Public Health Service has developed a database of published literature that pertains to the health effects of the Kuwait oil well fires. This database is presently on-line and can be accessed by computer dial-up. More information on this service may be obtained from Dr. John Andrews (see Appendix B).

Gerald Barton (NOAA/NESDIS) described the NOAA Earth System Data Directory that is a referral service for national environmental data. He suggested that this directory might be a possible place to put the Kuwait data catalogue information once it is assembled.

Assembling and Accessing Data Sets

Assembling the data sets requires full cooperation of each of the participating agencies. All of the organizations that attended the WMO meeting of experts agreed to participate in the sharing of data. To expedite the archiving process, these data sets will need to be available on commonly available magnetic media (e.g., magnetic tape, CDs, floppy discs) and in a easily readable format (i.e., ASCII, packed integer, etc.). It is critical that each data point is labeled in some manner with the sensor type (e.g., SO_2), time (local or UTC) and location (preferably latitude, longitude and, where applicable, altitude). This labeling method will allow rapid retrieval for subsequent analysis.

Storing Data Sets

The amount of information to be stored in a central archive is enormous. The actual magnitude is difficult to assess at this time; however, it is clear that sufficient space must be planned carefully at the archival center. In addition, since the data must be disseminated on an easily accessible medium, a high density media must also be identified.

A number of agencies routinely archive large data sets that are accessed frequently by large numbers of users. Technology is presently available for storing data in terrabyte quantities. Likewise, recent technology has been developed to store large quantities of data on relatively small devices such as compact optical discs or 8 mm video cartridges. These are but a few of the possibilities that must explored before embarking on a project of this magnitude. Discussions during the workshop concerning long-term storage of magnetic media, especially newer technology such as DATs and Exabytes, emphasized the need to use multiple storage techniques.

Disseminating, Maintaining and Updating Data Sets

The data taken during the Kuwait oil fires is unique in its breadth and scope. The number of agencies and individuals who will seek access to this data set cannot be fully determined at this time, but is quite likely to be large. This data set is also likely to be accessed over a longer period of time and will continue to evolve as the fires are extinguished or as some of the measurements are modified to account for sensor recalibration or other corrections, and as more baseline measurements become available.

A suggestion was made at the meeting of experts that the center for data archival should be located in either Kuwait or Saudi Arabia. Local impacts of the oil fires will most affect these two countries and it is reasonable that a data dissemination center be located in one of these two nations. Experience has shown, however, that a strategy should be explored in which multiple centers are established to be used as dissemination centers. International communications and computing equipment continues to improve in both speed and reliability. However, there will always be a finite chance that a power or equipment failure will temporarily disable an archive center's ability to function, oftentimes at inopportune moments when data is most needed. Locating centers in the Middle East, Europe, and the US would ensure that the flow of data remain uninterrupted and that a catastrophic failure will not jeopardize an irreplaceable data set.

Establishing three data centers does not mean three archiving centers if, by definition, an archiving center is the one that generates the initial cataloguing and formatting of data sets. The strategy is to maintain a constant line of communication between centers so that any updates or modifications be implemented in the auxiliary centers once they have been certified by the central archiving facility.

The actual dissemination of the data can be accomplished in two ways. One way is to put the complete data set on a portable media such as magnetic tape or optical disc and mail it to the user who reads the data on his own system. An alternative way, to be used with much smaller, selected data sets, is for the user to communicate over the electronic network with one of the data centers and to request the specific information from the centralized mass

storage center. This is a technique routinely used at a number of agencies at this time. A representative from NCAR discussed the present electronic network that spans the world. This network continues to expand in size and speed. Branches already stretch into the Middle East, although the coverage is not yet as extensive as found in the United States and Europe.

Some of the measurement systems provide a relatively simple set of data that is easily manipulated and analyzed. However, other measurement platforms such as aircraft can produce a complex set of measurements that is much more difficult to manipulate and interpret. As an example, there are more than 500 possible raw and derived variables available from measurements made by the NCAR Electra alone. Rapid display and manipulation of these data, coordinated with other data such as upper air and satellite measurements will require sophisticated analysis tools if useful information is to be extracted in a minimum amount of time. Some such analysis tools were demonstrated at the workshop that allow easy display of complex data sets from aircraft and for integrating measurements from multiple platforms such as satellite and ground-based measurements.

PART III--RECOMMENDATIONS

The workshop concluded with a summary session in which a number of recommendations were made concerning the handling of data from the Kuwait oil fires. The workshop has recommended (without assigning specific priorities) that:

- NCAR should be the international archive center for regional datasets which are related to the Kuwaiti oil fires. In fulfilling this function, NCAR should:

    - Identify, collect and store the relevant datasets.
    - Manage the archive.
    - Facilitate access to the datasets.
    - Compile, maintain, and publish an inventory of the data sets.
    - Maintain a set of appropriate software tools for accessing and viewing the datasets.
    - Further develop archival perusal and display tools.
    - Make these software tools available upon request.

- The datasets should be generally available without restrictions except for necessary nominal charges covering handling and shipping of data storage media.

- NCAR should provide special assistance to Gulf Region countries to meet their requirements for accessing the data.

- NCAR should consider appropriate data formats for long-term archiving with a view to supporting efficient access to the data, taking into account the needs of the major disciplines of evaluating groups such as public health agencies, modelers, emergency response teams, etc.

- Relevant archived data should be made available to health agencies as soon as possible.

- An assessment should be made as soon as possible of current measurements to determine what additional measurements should be made and what on-going measurements should be continued.

- An electronic Bulletin board needs to be established for providing archive information to interested users.
- An advisory group should be formed to review the archival process.
- An Internet link to Gulf region should be established.
- WMO should take active role in publicizing Kuwait measurement activities.
- A WMO Gulf coordinator should publish quarterly situation reports.
- Encourage the Public Health Service to continue archiving health-related literature.
- Need of data focal points in the Gulf Region countries with active collaboration by scientists in the archival process.
- There should be a follow-up meeting later this year.

A number of additional measurement and analysis efforts were recommended:

- A climatological summary of the Gulf region should be made available as soon as possible. A Gulf region meteorologist should take a lead role in this effort.
- The Air Force Defense Meteorological Satellite Program (DMSP) local ground-receiving station should remain in operation in Gulf area throughout the duration of the project (5th Weather Wing from Langley AFB, VA).
- Better source term characterization is critically needed.
- Modeling must be continued but with more realistic physics, and measurements must be used to validate these models.
- Data from any classified satellite, airborne, or ground-based measurements pertinent to the problem should be made available as soon as possible.
- Continued archival of Meteosat and NOAA AVHRR data is needed until at least the end of the fires.

- Continued acquisition of higher resolution satellite data by landsat and SPOT is encouraged.

- Encourage NASA to continue hand-held camera photography of Kuwait oil fire plumes during space shuttle missions until oil well fires are extinguished.

PART IV--APPENDICES

APPENDIX A--Agenda

Agenda
A Workshop on the Management and Analysis
of Data Relating to the Kuwait Oil Fires
July 22 - 24, 1991
Boulder, Colorado

Workshop Registration

Opening Comments--WMO Representative

Workshop Objectives--*WMO/NCAR*

Review of Available Data Sets--*WMO*

Ground-Based	Airborne	Other
MEPA, Saudi Arabia	United Kingdom	Climatological
KFUPM, Saudi Arabia	NCAR	Satellite
EPC, Bahrain	U. Washington	
NOAA	Germany	
EPA		

WMO Procedures & Formats for Data Exchange--*WMO*

WWW Structures & Capabilities for Data Management--*WMO*

Data Analysis Issues - Who will use the data archive?--*WMO*

Integrating and Analyzing Multiple Data Sets--*Darrel Baumgardner, NCAR/RAF*

Introduction to McIDAS--*Tom Yoksas, UNIDATA, NCAR*

Aircraft Data Analysis, Introduction to WINDS--*Gary Horton/Darrel Baumgardner, NCAR/RAF*

Integrating and Analyzing Multiple Data Sets--*Paul Herzegh, NCAR/RDP*

Archiving and Storing Massive Data Sets--*Dennis Joseph, Scientific Computing Division, NCAR*

Electronic Communications and teleneting--*Joe Choy, Scientific Computing Division, NCAR*

Common Data Formats--*Russ Rew, UNIDATA, NCAR*

Requirements for Data Base Services--*WMO*

Tour of NCAR Computing and Archival facilities

Requirements for Data Base Services-Continued--*WMO*

Review and Summary--*WMO/NCAR*

End of Workshop

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APPENDIX C--WWW Involvement in Emergency Response to Kuwaiti Oil Fires

The introduction presented by Dieter Schiessl of the WMO at the onset of the workshop.

Reestablishing and Strengthening of the WWW Structures

The WWW operational component consists of the observing network, the telecommunication system, and the data processing facilities, and as an integrating and kind of overhead component, data management. It happens that I am the officer responsible for the WWW data management component. In this capacity, I have been asked to participate on behalf of WMO.

These major components of the WWW are represented in all the member countries in different degrees of sophistication and different degrees of completeness. The facilities in Kuwait have been nearly completely destroyed during the Gulf conflict. It is our major task and our major effort at the moment to assist Kuwait and other countries in the Middle East Region to reconstruct their weather services and improve their facilities to the extent necessary to ensure that the data and products required can be generated, exchanged, or transported to the centers in areas in need. We have noted that the meteorological staff is back to about 70 percent and is well-qualified. The upper-air station in the Kuwait airport will soon receive new Vaisala radiosonde equipment. I am here to report to you that the purchasing and contracting framework have been completed, and we are now only waiting delivery of the system. The existing wind finding radar has been repaired. This allows regular wind soundings at 06 and 18 UTC. Full radiosonde ascents (Pressure, Temperature, Humidity, Wind) will be made daily at 00 and 12 UTC.

Somewhere later in the workshop, I will present to you the latest numbers on monitoring contained we executed last week so you can where we stand in terms of surface observations and upper air observations covering all the countries of interest in the Middle East Region.

Surface observations at regular synoptic hours and, if required, more frequently are needed as input for the local assessment of the pollution situation and as input to forecast models. WMO's plan is to reestablish the five Synop stations of the Regional Basic Synoptic Network. This is considered to be the permanent routine observing system which is supplemented by 15 automatic meteorological stations established already by NOAA.

As a matter of highest priority, the Global Telecommunications System (GTS) link between the Kuwait National Meteorological Center and the Regional Telecommunication Hub (RTH) Jeddah is being established. We have been informed as of the middle of July that a low speed circuit (100 baud) connection between Jeddah to the PTT center in Kuwait has recently been established, and the next step will be to connect the NMC at the Kuwait Airport to the PTT center. An upgrade of the link between kuwait and RTH Jeddah to medium speed, telephone type is necessary to enable the timely transmission of data and products required in Kuwait through the GTS. As an additional measure, WMO installed at the end of July a Data Collection Platform (DCP) at Kuwait Airport which allows the relay of radiosonde data (TEMP and PILOT) as well as surface observations directly through METEOSAT for injection into the GTS.

Now, what I'm saying has been drafted and written around Monday last week, so it's about a week old. As far as I know, these devices I am referring to have been shipped, but they are not through custom clearance.

The reception of satellite data, in particular imagery is of considerable importance. The WMO plan therefore includes the establishment of APT/WEFAX receiving station. In addition, it is planned to establish a ground receiving station for the Meteorological Data Dissemination (MDD) system operated by METEOSAT which will allow direct reception of a broad selection of meteorological products urgently needed in Kuwait, including among others those from the ECMWF, from the World Area Forecast Centre in London (to serve aviation), and from other Global Data Processing System (GDPS) centers in Europe. Those centers took responsibility within the WWW scheme to provide products of a regional or super regional basis, or in some cases, on a global basis.

Apart from the situation in Kuwait, similar attention is being given to improve the operational WWW components in neighboring countries in the down wind area. The improvements of the observing network in Iran, Iraq, and Afghanistan appears to be most urgent. However, our monitoring results indicate that for various reasons, only a small percentage of reports from these stations are routinely available from some countries on the GTS. In particular the implementation of a radiosonde station in the Northwest Iran is a matter of priority. WMO is also making all efforts to improve the timely exchange of all available observational data.

Data Management Concept

The WWW structures (Global Observing System [GOS], GDPS, and GTS) have been offered to support the management of atmospheric data generated by various groups in the Gulf region. The Regional Specialized Meteorological Center (RSMC) Jeddah has indicated that it is ready to act as a data center. This workshop in Boulder, Colorado, is expected to develop a concept for the management of air monitoring data from the Gulf collected under

the Gulf Air Monitoring Program (GRAMP). WMO will involve all concerned countries and scientific groups to reach agreement on data formats, exchange policy, management and archiving procedures, availability of data sets, etc.

The WMO Members and scientific groups concerned have requested that use should be made of proven methodology (such as NCAR data management systems) and existing WMO formats, procedures and structures, where possible to meet the requirements for data and products within and outside the Gulf Region. This may include the use of GDPS centers to provide specialized analysis and forecast products as well as data base services. It will also involve the use of the GTS for the real-time and nonreal-time exchange of data where required and appropriate.

Emergency Response

Several institutes are ready to provide analysis and forecast products to Kuwait, if required on a routine bases to support an appropriate emergency response system. WMO is taking steps to coordinate and organize such support. Although relatively high resolution meteorological (mesoscale) products are available from major GDPS centers, it is not guaranteed that these are always meaningful due to the general lack of data from the region. The products from major centers will therefore have to be interpreted by experienced forecasters before applied on a national scale and used as an input for air quality assessments and forecasts. WMO proposes that this capability be established as a warning center in Kuwait combining the expertise of a meteorologist, an air quality, and a health expert to cooperate routinely in providing analyses and regular advice to decision makers in the countries.

This briefly summarizes the position of WMO in the view of two major tasks we are trying to pursue and which I would like to convey to the workshop as objectives from the point of view of WMO, which is to provide recommendations for the establishment of an Emergency Response Scheme to give the countries in the region a mechanism at hand to warn their population and their economists in appropriate fashions. The second objective is to arrange for a consolidated, consistent, and common data storage and archiving for those centers for either producing or collecting data or who take responsibility in producing dedicated products for the region.

APPENDIX D--The WWW Data Management Concept of WMO

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Background

The World Weather Watch (WWW)--the basic program of WMO--is twenty-five years old. From the start, this program consisted of three components, namely the Global Observing System (GOS), the Global Data Processing System (GDPS) and the Global Telecommunication System (GTS). After the first GARP Global Experiment (FGGE) had revealed a number of serious deficiencies, the WMO Congress initiated in 1979 the WWW Integrated System Study (ISS). As a result of this study, the perception of the three component structure was replaced by a concept of an integrated WWW system, whereby appropriate data-management functions should effectuate the integration. The WWW Data Management Concept was introduced through the WMO Second Long-term Plan (1988-1997) and the WMO Congress (Cg-X 1987) noted its importance as the integrating element in the WWW system and urged its rapid implementation.

Problems and Opportunities

The volume of data produced and exchanged globally within the WWW system nearly doubles every five years. This in mainly caused by:

1. Progressing introduction of surface-based, automated, remote-sensing systems (Radar, Sodar, Lidar, etc.);

2. Increasing use of automated *in-situ* observing systems (AMDAR, ASDAR, drifting buoys, etc.);

3. Growing volume of satellite data;

4. Expanding data volumes generated by numerical meteorological productions.

The total amount of data is expected to exceed, in many cases, the requirements of individual Members. The widely uncontrolled injection of information sets into the GTS will lead to overloading of many telecommunication links and of national data bases and will hinder the Members' efficient access to those sets of information needed for their daily operations.

The present data exchange system (GTS) shows deficiencies, since it still carries, in many parts, the basic features of a conventional Teletype system (i.e., store and forward of character-based data via many nodes) and is, therefore, no longer capable to render the services needed to cope with growing requirements within a reasonable financial and technical framework. It is necessary to look for appropriate means in terms of Data Management to carry the present data exchange system forward through a transitional phase to a system fully developed for the requirements of the next decade.

But side-by-side with these problems, new opportunities have emerged. Cost-efficient technologies for data processing and telecommunications favor the coordinated design and implementation of automated systems and also facilitate the cooperation of Members within the WWW system at different levels of sophistication. An array of Regional Specialized Meteorological Centers (RSMC) with geographical and activity specialization in concert with the three WMCs and a number of advanced Regional Telecommunications Hubs (RTH) provide an ideal starting point for better coordinated and improved data exchange among each other and with presently 160 National Meteorological Centers worldwide.

The rapidly growing appreciation of and adherence to international standards for telecommunications and data processing technology in the meteorological community, mainly for computer graphics, software management and telecommunication are major assets which open new and promising prospects for the WWW system.

WMO fully recognized these new opportunities for its vast data handling requirements and responded by introducing the Data Management (DM) Concept as an element of WWW.

Data Management Concept

Purpose and Scope

Data Management is the component within the WWW system which provides those support functions needed for the orderly overall management of meteorological data and products of the WWW system, the most economical use of the resources of the WWW system components, the monitoring data and product availability and quality, the identification of operational deficiencies and the initiation of remedial activities. It will be realized by implementing DM functions and services in the networks and facilities of GOS, GTS, and

GDPS and in the interfaces between them. In order to enable each member to participate at a level commensurate with its abilities and requirements, it is necessary to allow for suitable interfaces, flexible developed and developing countries. Particularly in the area of data processing and telecommunications, DM will define and design proper procedures and interfaces which will allow Members to obtain the coherent and appropriate sets of data and products required. Hence, the main long-term objectives of DM concept are defined as follows.

1. To fully integrate WWW operations and monitoring activities including methods to correct deficiencies in the WWW System;

2. To establish common procedures for management and handling of data and products within the WWW System in order to meet effectively and efficiently Members' individual requirements;

3. To coordinate and support DM issues for the participation of Members in the technologically advancing WWW System.

Organization

The Commission for Basic Systems (CBS-IX 1988) established the Working Group on Data Management (WGDM) to deal with concept and implementation of DM. This group should coordinate with the Working Groups on the GTS, GOS, and GDPS in DM matters as appropriate. The Working Group on Data Management is assisted by the Sub-groups on Data representation and on Codes. As to the technical expertise, the working group relies on expert meetings, workshops, and consultants. This organizational framework is supplemented on the global level by Implementation Coordination Meetings on the DM on the Main Telecommunications Network (MTN), and on the regional level by the Regional Implementation Coordination Meetings on DM and Regional WWW Implementation Coordination Working Groups.

Current Activities

Although the DM concept is just beginning to evolve in the long history of WWW, CBS has already embarked on a number of prominent issues:

Distributed Databases Concept (DDBs)

The DDB concept envisages a number of databases, each owned and operated by a center, containing a number of data sets of observational data and products of the WWW system primarily for use in real time or near real time. In entirety, each data set provides all currently available data of a particular type or of a defined scope, e.g., all TEMP data, all satellite soundings at a defined resolution. Each database is intended to relate to a specific sub-set of WWW data, by data type, period of retention, and geographic area. Database centers are distributed in relation to geographic or other requirements recognizing the constraints imposed by telecommunication facilities.

Data from the DDB will be in principle available by routine arrangements. This mechanism will be supplemented by ad hoc request/reply and special arrangements, whereby the assignment of specific responsibilities above national level to individual data centers will be by international agreement through CBS and its working groups.

1. Routine arrangements handle data for exchange on a regular basis on the GTS;

2. Ad hoc requests will occur on an occasional basis and are temporary by nature;

3. Special arrangements handle data which are normally not made available over the GTS, but are exchanged by-lateral agreements such as experimental data or data-related to research projects.

Planning of the data center network should ensure that each set or subset of data provided at a data center to meet the needs of a particular service domain should be available at another center and that in event of failure arrangements are made for supply of required data to/from that domain from/to alternate centers and for the rapid re-establishment of database contents on recovery of the center which has suffered failure.

The logical organization for the DDBs is illustrated Figure 1. Designation of centers with primary and alternate responsibilities must be governed by availability of appropriate telecommunication services. Principally, these will be provided by the improved GTS as illustrated by the scheme in Figure 2. The use of other facilities, e.g., public data networks, for back-up and special purpose access must also be expected. Adequate measures to protect from unauthorized access must be provided.

Complementary to subsets of data of different types, e.g., those provided by different types of observing systems, the DDBs should include added information to original observational data, e.g., quality control information provided by GOS and GDPS services. Such

information should be made available as required. Data should also be provided selectively to meet routine or specific requirements, the smallest addressable data entity within the DDB being governed by the ability to represent such data within a single element of a WMO code form, e.g., one BUFR item, one GRIB representation.

The DDB concept is envisaged to extend to data-related to status information on availability and quality of data, including products, to climatological and oceanographic data, and to data in archives.

Procedures for Monitoring of the Status of WWW System

The objectives of the monitoring activities are to improve the performance of the WWW on a national, regional and global level through identifying deficiencies and initiating corrective actions as quickly as possible. Efficient monitoring requires close cooperation between all centers concerned, as well as with the WMO Secretariat. To this end, WMO has developed plans which detail procedures and responsibilities for monitoring activities for data availability in real time and non-real time and for data quality.

Real-Time Monitoring Activities

Real-time monitoring contains activities carried out quickly enough to allow remedial action to be taken in time to be of value in day-to-day meteorological work. This requires swift exchange of information between centers concerned, e.g.:

1. Bulletins not received by the time specified;

2. Observations not received, or which are incorrect;

3. Inadequacies in receipt of processed information.

Non-Real-Time Monitoring Activities

Non-real-time monitoring activities are carried out over a specific time period at an agreed frequency, for instance once per year. Types of data to be monitored include observations such as TEMP, SYNOP, PILOT, AMDAR, CLIMAT, BATHY, TESAC which are marked for global exchange. WWW centers are invited to participate and provide their findings to the WMO Secretariat. The WMO Secretariat coordinates these activities and produces a summary of statistics and evaluates, as far as possible, the deficiencies.

Non-Real-Time Data Quality Monitoring

The monitoring of the quality of observational data is based on so-called "lead centers." For each type of observation, a lead center will be nominated which a view to taking a leading role in the coordination between participating centers of all monitoring aspects, including common methods and criteria to be used for compiling statistics. Such centers continuously carry out the monitoring activities and compile and distribute reports every six months. For monitoring on global level, the following centers act as lead centers:

1. Upper-air observations--ECMWF Reading;

2. Marine weather observations--RSMC Bracknell;

3. Satellite and aircraft observations--WMC Washington.

The plan for the monitoring the quality of surface observations is to seek lead centers on regional level for carrying out this task. Presently, RSMC Tokyo for Region II and WMC Melbourne for Region V have begun to monitor on regional level. Coordination to find other lead centers is ongoing in the remaining regions.

Coordination of Exchange of Software

Technical and procedural innovations have forced many Member countries, and in particular the developing ones among them, to look for computer support for handling improving their operations. Although, the computer industry offers higher hardware performance at lower cost, the actual benefit expected from the use of computers can only be attained through complex computer programs which are difficult to obtain, especially in developing countries. Meanwhile, progressing standardization made many basic meteorological functions that need to be performed at the various centers, similar or almost identical and programs for these functions are available in many centers. A free exchange will help others in obtaining software modules, design ideas, or development methodologies without "re-inventing the wheel" many times over and without big financial investment. In view of this, WMO has started to collect information on meteorological applications software which is offered and/or requested by Member countries for exchange, and published a catalogue on such data in early 1991. The main objectives of this activity are to:

1. Encourage and support the free exchange of application software among the WMO Members;

2. Provide an overview of applications software offered and requested by WMO Members.

Promotion of Suitable Standards

It is the view of CBS that the entire sector of software development and maintenance, including efforts to prot software between various hardware platforms could become much more cost-efficient if appropriate standards would be consequently applied. Although, CBS has not yet published firm recommendations it encouraged WMO Members to follow guidelines, such as:

1. The general use of UNIX;

2. The use of GKS in graphical applications;

3. The modular architecture of meteorological computer system with well-defined interfaces;

4. The separation of the telecommunications component from the applications component;

5. The preference of WMO binary formats, wherever this is possible.

Work is underway to look at graphical interfaces best suitable for a meteorological operational environment.

Data and Product Representation

Binary Formatting Systems

The use of bit-oriented formatting systems FM 92 GRIB and FM 94 BUFR is rapidly progressing in the meteorological community and their range of data representation is steadily expanding. Ten centers are presently capable of exchanging binary data, and this number will double in the near future.

It is the policy of CBS to further develop and promote the binary formats and, at the same time, maintain and improve the WMO character-oriented codes where this is necessary.

For instance, recent improvements of GRIB included:

1. Identification of high precision and mixed precision pressure and sigma layers;

2. Accommodation of vertical coordinate parameters and quasi-regular grids;

3. Revision of the definition of the Mercator grid revised to allow for more precision in the grid length specification;

4. Definition of a space view or "perspective" map projection, with satellite needs in mind;

5. Representation of a matrix of values at each grid point with the freedom to specify the coordinates of the matrix; second order packing can now be done either on a row-by-row basis or by selecting various points in the data to start, or restart, the second order packing. The latter is a variant of "run-length encoding."

BUFR was recently expanded to include:

1. Many new descriptors for aviation, radar, surface observations, radiation, satellites, ship reports, wind profilers, etc.

2. A set of new descriptors to describe information about quality control, replaced values, retained values, the original values, statistics of the measurements, etc; it will now become possible to handle quality control information in BUFR.

3. A feature which allows splitting of large binary data entities into smaller ones, thus facilitating more convenient handling of such data sets at GDPS centers and also allowing transmission of binary data sets that would otherwise exceed the maximum size of a message on the GTS.

WMO Character Codes

WMO maintains a spectrum of 45 character codes which are needed to represent observational data and products stemming from meteorological, climatological, aeronautical, and oceanographic sources. These codes are published in the WMO Manual on Codes Vol I and Vol II (WMO-No. 306) and kept up-to-date by the Sub-group on Codes.

Given the co-existence of both data representation standards and the adherence to the principle that one and the same should not be exchanged on a given link on the GTS in both formats, it is obvious that some kink of interface is needed between both representation forms. Standardized techniques are being sought for the transformation between bit-oriented and character-oriented formate, e.g., to:

1. Facilitate the human legibility (visualization) of binary coded data;

2. Allow for exchange on those parts of the GTS where centers are not automated or where telecommunication capabilities are insufficient;

3. Overcome the inflexibility inherent to character codes.

At present, two proposals are being discussed, namely the IGOSS Flexible Code (IFC) and the BUFR Tabular Form (BTAB). This is done with a view towards developing a flexible character code which are best described as character codes analog to BUFR in that they share many of the advantages of BUFR, but can be transmitted on low-speed communication lines.

Extension of DM Principles to Other WMO Programs

Other WMO programs (e.g., World Climate Program, and in particular the Global Climate Observing System (GCOS), the Global Atmospheric Water, Hydrology and Water Resources Program, the Environmental Program, etc.) will progressively take advantage of the basic services of the WWW systems in order to establish efficient and consistent data handling procedures across the programs. There are, for instance, growing requirements for the use of climatological data in near real time. Such requirements lead to requests from other WMO programs for a timelier, more reliable exchange of growing data volumes. There is a need to include oceanographic data, radioactive radiation data, volcanic activity data, satellite data archives, etc., in the WWW data handling. In this respect, consultations and cooperation are being sought with the relevant WMO technical commissions with other intergovernmental and international organizations.

Summary

The integration of the core elements of the WWW system is seen as an essential prerequisite for an efficient operation and should enable the WWW system to cope with the rapid evolution of meteorological requirements and techniques and should ensure that proper WWW data and products subsets are available to Members in a timely and convenient fashion. k The WWW Data Management concept is expected to bring about this important level of integration. The various data-management functions will be introduced progressively over a period of years and all aspects and experiences gained will be closely monitored.

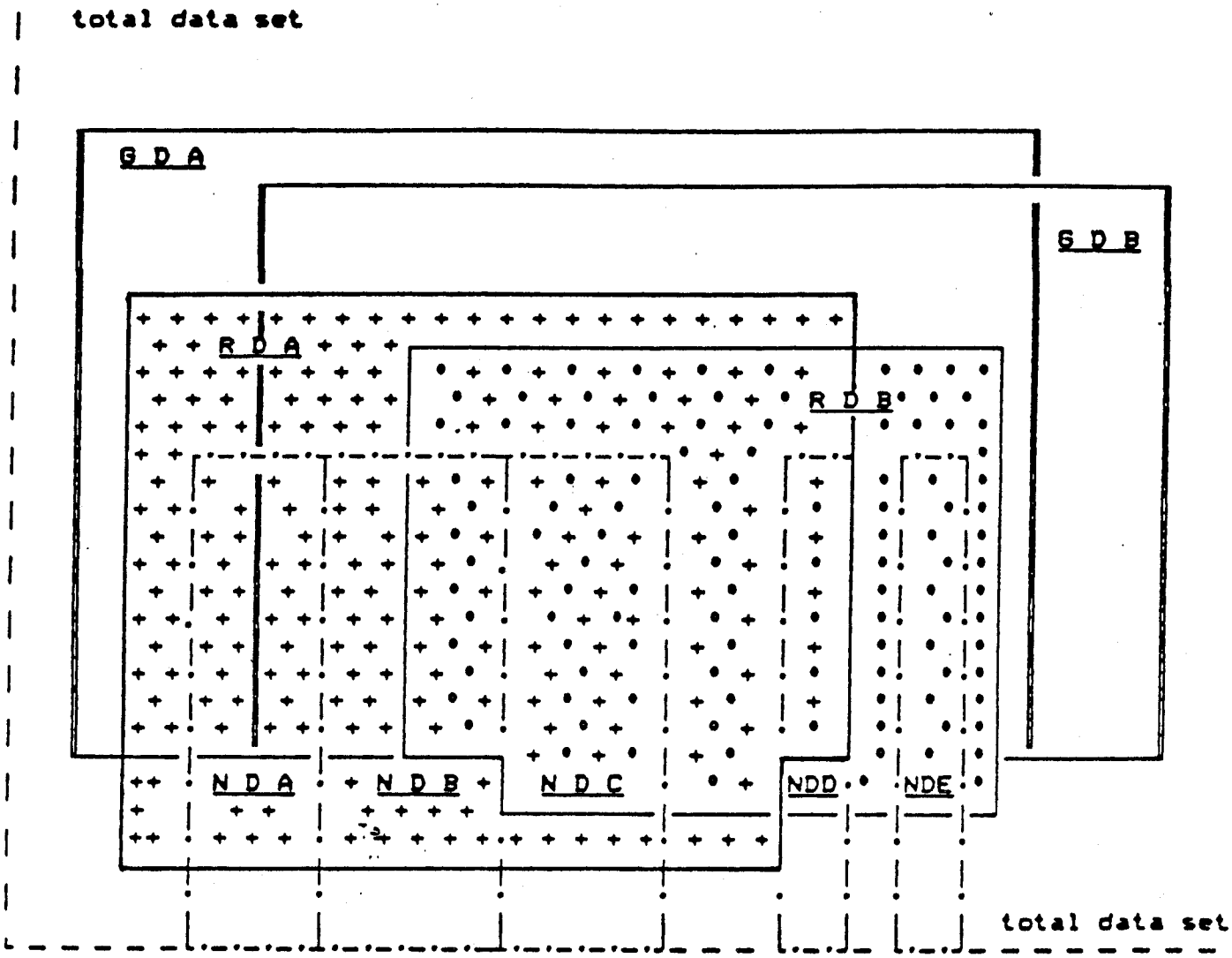
References

Cg-X 1987: Tenth WMO Congress, Geneva, 4-18 May 1987, Abridged Final Report with Resolutions; WMO-No. 681.

SLTP 1987: The World Weather Watch Programme 1988-1997, Second Long-Term Plan, Part II, Vol. 1; WMO-No. 691.

CBS-IX 1988: Commission for Basic Systems, Abridged Final Report of the Ninth Session, Geneva, 25 Jan - 5 Feb 1988; WMO-NO. 699.

[Figure 1]--Domains for one data set



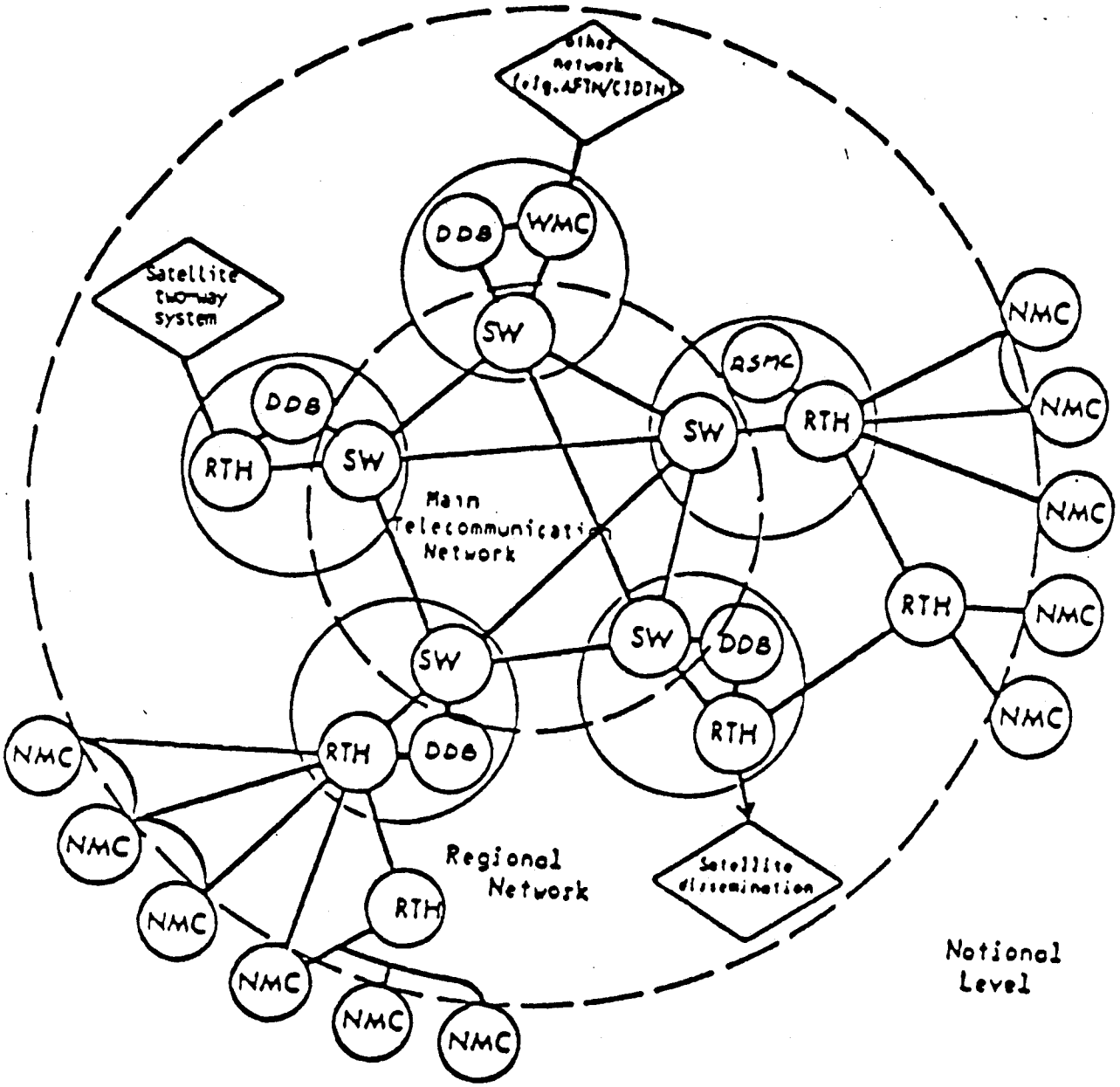
N = National Domain: Includes all national data and the subsets received from other national, regional, and global data centers

R = Regional Domain: Includes data collected from national domains and required sets or subsets from other regional centers and from global centers

G = Global Domain: Includes all required data from global and regional exchange

Note: Required data are those data needed by centers routinely served plus data needed to provide alternate (backup) service in emergency.

Structure of GTS



[**Figure 2**]--Switching Node (included in fuctions of RTHs on the MTN)