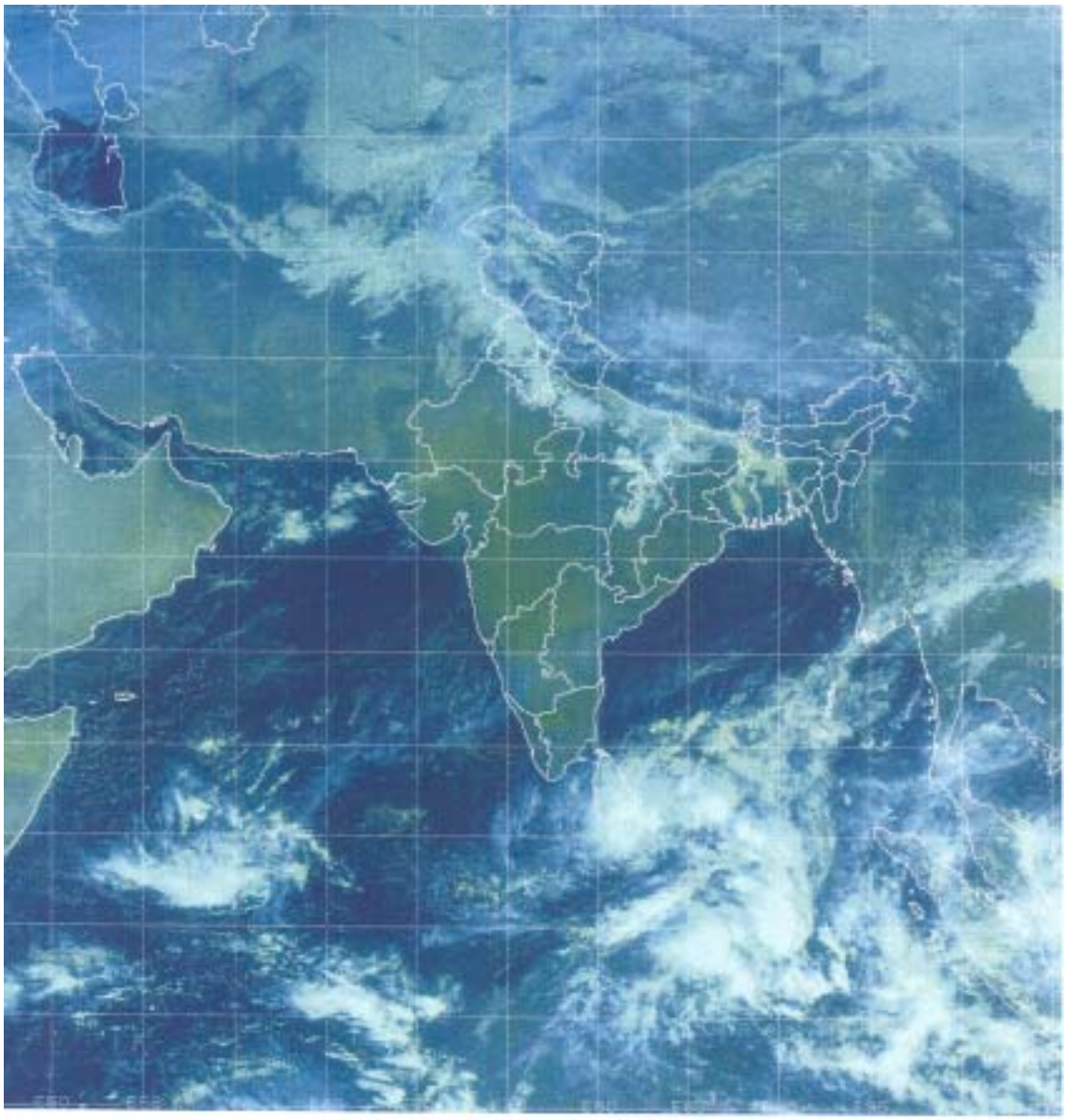
WMO / ESCAP
PANEL ON TROPICAL CYCLONES
ANNUAL REVIEW 2002



INSAT Imagery at 0600 UTC, December 24, 2002

WORLD METEOROLOGICAL ORGANISATION

UNITED NATIONS ECONOMIC & SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

N O T E

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PREFACE

The first publication of WMO/ESCAP Panel Annual Review was for the year 1997. This is the sixth publication of the Review. Efforts have been made to make it a useful document through which we can realise the scope for further improvement of our warning system. The World Meteorological Organisation (WMO) and the Economic and Social Commission for Asia and the Pacific (ESCAP) are given full credit for supporting and playing the major role in disaster mitigation efforts in Asia and the governments of the Member Countries which are extending their full participation in the programme. In our continuing efforts to improve the disaster warning system, further programmes would include not only an improved technical know-how and facilities but also enhanced public education in terms of knowledge and understanding of the nature and impacts of cyclones and floods, warning systems and appropriate disaster counter measures. The basic aim of the Panel is to improve the contents of cyclone warnings and to devise methods for quick dissemination of cyclone warning messages, flood advisories and to ensure their availability to the general public, so as to be of maximum benefit.

R. R. KelKar
Chief Editor
2002-2003

WMO, ESCAP AND THE WMO/ESCAP PANEL ON TROPICAL CYCLONES

WORLD METEOROLOGICAL ORGANIZATION (WMO)

The World Meteorological Organisation (WMO), of which 185 States and Territories are Members, is a specialised agency of the United Nations. The objectives of the organisation are:

- To facilitate international co-operation in the establishment of networks of Stations and Centres to provide meteorological and hydrological services and observations;

- To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;

- To promote standardisation of meteorological and related observations and ensure the uniform publication of observations and statistics;

- To further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;

- To promote activities in operational hydrology and to further close co-operation between Meteorological and Hydrological Services and

- To encourage research and training in meteorology and, as appropriate, in related fields and to assist in co-ordinating the international aspects of such research and training.

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC (ESCAP)

The Economic and Social Commission for Asia and the Pacific (ESCAP) aims to initiate and participate in measures for concerted action towards the development of Asia and the Pacific, including the social aspects of such development, with a view to raising the level of economic activity and standards of living and maintaining and strengthening the economic relations of countries and territories in the region, both among themselves and with other countries in the world.

The commission also

- Provides substantive services, secretariats and documentation for the Commission and its subsidiary bodies;
- Undertakes studies, investigations and other activities within the commission’s terms of reference;

- Provides advisory services to Governments at their request;

- Contributes to the planning and organisation of programmes of technical co-operations and acts as executing agency for those regional projects decentralised to it.

WMO/ESCAP PANEL ON TROPICAL CYCLONES

Colossal loss of human life, damage to property and unbearable sufferings of human beings caused by tropical cyclones in coastal areas in various parts of the globe are a regular feature. The disaster potential due to cyclones is particularly high in the North Indian Ocean comprising Bay of Bengal & Arabian Sea region, being associated with high storm surges which are, by far, the greatest killer in a cyclone. This region has the distinction of having experienced the world's highest recorded storm tide of 41 feet (1876 Bakherganj cyclone near Megna estuary, Bangladesh). Past records show that very heavy loss of life due to tropical cyclones have occurred in the coastal areas surrounding the Bay of Bengal. In the recent past, during the year 1998, the state of Gujarat in India experienced the impact of a very severe cyclonic storm which crossed coast north of Porbandar (42830) on June 9 and caused huge damage to public property near Kandla Port (42639). A Super Cyclonic Storm that crossed coast near Paradip (42976) in Orissa on October 29, 1999 took a toll of about 10,000 lives and caused huge damage to property in 12 districts of the state. Apart from causing large scale devastation to agriculture and plantation crops it also affected entire infrastructure on communications, power and transport. The storm surge of 5-6m height was experienced in areas close to and southwest of Paradip. This cyclone was century's most intense cyclone and its unusual feature was that it remained practically stationary after crossing coast and battered the State of Orissa for 36 hours.

Realising the importance of an effective cyclone warning and disaster mitigation machinery in the region, WMO/ ESCAP jointly established the Panel on Tropical Cyclones in 1972 as an inter- governmental body. Its membership comprises the countries affected by tropical cyclones in the North Indian Ocean. Originally its member countries were Bangladesh, India, Myanamar, Pakistan, Sri Lanka and Thailand. Later Maldives joined the panel in 1983 followed by Sultanate of Oman in 1997, raising the membership of the Panel to eight.

The Panel is one of the six regional tropical cyclone bodies established as part of the WMO Tropical Cyclone Programme (TCP) which aims at promoting and co-ordinating the planning and implementation of measures to mitigate tropical cyclone disaster on a world wide basis.

It also aims to initiate and participate in measures for concerted action toward the development of Asia and the Pacific including social aspects of such developments, with a view to raising the level of economic activity and standards of living and maintaining and strengthening the economic relations of countries and territories in the region, both among themselves and with other countries in the world.

The first session of WMO / ESCAP Panel on Tropical Cyclones was convened in Bangkok, Thailand in January 1973. The functions of the Panel are:

- To review regularly the progress in various fields of tropical cyclone damage prevention

- To recommend to the member countries plans and measures for the improvement
  of community preparedness and disaster prevention ;

- To promote, prepare and submit to member countries plans for co-ordination of research programmes and activities on tropical cyclones;

- To facilitate training of personnel from member countries in tropical cyclone forecasting and warning, flood hydrology and control within the region and arrange for training outside the region, as necessary;

- To promote, prepare and submit to participating member countries and other interested organisations plans for co-ordination of research programmes and activities concerning tropical cyclones;

- To prepare and submit, at the request and on behalf of the member countries requests for technical, financial and other assistance offered under the UNDP and by other organisations and contributors and

- To consider, upon request, possible sources of financial and technical support for such plans and programmes.

In carrying out these functions, the Panel on tropical cyclones committee maintains and implements action programmes under the five components of meteorology, hydrology, disaster prevention and preparedness, training and research with contributions and co-operation from its Members and assistance by the UNDP, ESCAP,WMO and other agencies.

The Panel at its twelfth session in 1985 at Karachi (Pakistan) adopted a comprehensive cyclone operational plan for this region. The basic purpose of the operational plan is to facilitate the most effective tropical cyclone system for the region with existing facilities. The plan defined the sharing of responsibilities among Panel countries for the various segments of the system and recorded the co-ordination and co-operation achieved. The plan also recorded the agreed arrangements for standardisation of operational procedures, efficient exchange of various data related to tropical cyclone warnings, issue of cyclone advisories from a central location having the required facilities for this purpose, archival of data and issue of a tropical weather outlook for the benefit of the region.

A technical plan aiming at the development and improvement of the cyclone warning system of the region has been drawn by the Panel. Implementation of some items under the technical plan would lead to strengthening of the operational plan.

The operational plan is evolutionary in nature. Its motivation is to update or raise the text of the plan from time to time by the Panel and each item of information given in the annexes to the plan be kept up to date by the member country concerned.

WMO/ESCAP PANEL ON TROPICAL CYCLONES

(2002 – 2003)

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INTRODUCTION

Publication of "WMO/ESCAP Panel on Tropical Cyclones – Annual Review" commenced with the review for the year 1997. This was as per the decision of the Second Joint Session of the WMO/ESCAP Panel on Tropical Cyclones and Typhoon Committee held at Phuket, Thailand 20-28, February 1997. Like the previous issues, the present Annual Review-2002 contains primary contribution from the Members.

Chapter 1 provides an overview of the activities of the Panel in 2002. It contains detailed information on national programmes and activities related to meteorology, hydrology, disaster prevention and preparedness, training and research as supplied by Panel Members. Technical and administrative support provided and activities undertaken by the Panel Secretariat during 2002 are also covered.

Based on the Members' post analyses of Tropical Cyclones and climatological data available at India Meteorological Department (IMD), India, special features of the 2002 tropical cyclone season are highlighted. A summary of the Tropical Cyclones in 2002 is given in the first part of chapter 2. Each tropical cyclone is identified by the geographical location of its genesis. Tropical disturbances are classified as per the practice recently introduced at Regional Specialised Meteorological Centre (RSMC) –Tropical Cyclones New Delhi as given in the following Table .The term "Cyclone" used in the present text is a generic indicating the four categories of cyclonic disturbances (S.N. 4 to 7) given below:

Table-1.1

Classification of low pressure systems at RSMC – Tropical Cyclones New Delhi

S.No.	Maximum sustained surface Wind Speed Knot (Kmph)	Nomenclature
1.	Less than 17 (< 31)	Low Pressure Area (L)
2.	17 to 27 (31-49)	Depression (D)
3.	28 to 33 (50- 61)	Deep Depression (DD)
4.	34 to 47 (62 –88)	Cyclonic storm (CS)
5.	48 to 63 (89 – 117)	Severe Cyclonic Storm (SCS)
6.	64 to 119 (118 –221)	Very Severe Cyclonic Storm(VSCS)
7.	120 and above (≥ 222)	Super Cyclonic Storm (SuCS)

The second part of chapter 2 contains a report on tropical cyclones affecting Panel countries. It contains detailed account of each tropical cyclone and the damages caused.

In the context of Chapter 2, sustained winds refer to wind speeds averaged over a period of 3 minutes. Kilometers per hour (kmph) are used for wind speed as well as speed of movement of tropical cyclones. The S.I. unit of hecta-Pascal (hPa) is used for atmospheric pressure. Reference time used in this chapter is primarily in Universal Time Coordinate (UTC). Whenever possible, station names contained in WMO Weather Reporting-Observing Stations (WMO-No.9 Volume A) are used for geographical reference.

Chapter 3 consists of contributed articles received from Members.

Chapter 4 outlines the activity of the WMO Tropical Cyclone Programme in 2002.

CHAPTER 1

WMO/ESCAP PANEL ACTIVITIES IN 2002

1.1 METEOROLOGY

Activities of the Panel member countries on Meteorology during the year 2002 were presented by them in the thirtieth session of the WMO/ESCAP Panel on Tropical cyclones which was held at the Holiday Inn Hotel, Islamabad, Pakistan from 4 to 10 March 2003. These are briefly summarized below:

BANGLADESH

Bangladesh Meteorological Department (BMD) informed the session that two tropical cyclonic disturbances affected their country in 2002. One of them was a tropical depression while the other one was a tropical cyclone. However, these disturbances did not cause any damaging effects to the country.

Reception of data (surface and upper air) remained unsatisfactory during storm period. The situation needs to be improved, Tropical cyclone advisories from RSMC New Delhi were appreciated but advisories were required to be regular and timely during the cyclone period. Electricity and link failures have been improved due to the establishment of local generator.

NOAA (HRPT), INSAT, GMS (S-VISSR), WAFS and SADIS Ground Stations have already been Installed at the BMD premises. They were very useful during the storm period of 2002. BMD maintained network of 35 surface observing stations, 10 Pilot Balloon Observing Stations, 3 Radiosonde Stations for upper air observations throughout the whole country. Out of 3 stations, 2 are obsolete and one is in partial operation due to shortage of necessary modern equipment and raw materials. Only one out of three RS-observatory is now operative in Dhaka. Due to financial constraints, RS-Dhaka is now taking observations twice a week. Instruments of Chittagong and Bogra are obsolete. Attempts had been made to replace these instruments but no response from any donor country. Observations of some PBOs had been suspended due to the want of chemicals and balloons. The surface observatories were equipped with conventional equipment. If it could be equipped with modern equipment, accuracy of observations would be high.

BMD stated that it did not have any shortcomings relating to cyclone forecasting. It was observed that their forecast landfall point and the track of the cyclone almost complied with actual landfall point and track. However, the quality of the forecast could be improved with the introduction of numerical weather prediction system in BMD. BMD observed that the tracks of the tropical cyclone transmitted form different agencies to the different organizations other than National Meteorological Services (NMSs) through internet/fax caused technical problems/confusions. In this context

BMD recommended that there should not be any scope for creation of such confusion by making tracks/forecasts available to the public by the organization other than the NMSs. However, the track/forecasts could be made available to the NMSs only through TCP/IP protocol with the username and password or through internet/fax.

Ships observations were scanty. Attempts had been made to develop the data reception but no improvement was found. However, data are being received by BMD through coastal radio stations at Chittagong via teleprinter.

INDIA

India Meteorological Department (IMD) installed a new server Origin-200 for Numerical Weather Prediction (NWP). Operational limited area analysis and forecast system was implemented on Origin-200 computer system. Implementation of GTS data decoders in Origin-200 was on test mode. A limited area Quasi Lagrangian Model (QLM) for cyclone track prediction was made operational. Current LAM analysis and 24 hours forecast products, daily weather bulletins and forecasts (texts) for all regions including special weather warnings such as tropical cyclones, heavy rainfall etc. were available on IMD web site (http://www.imd.ernet.in) in real time. A Global Spectral Model and a Regional Spectral Model were also installed in the computer system Origin – 200. Successful test runs were conducted up to 72 hrs forecast with NCMRWF analysis data. A storm surge model adapted from Indian Institute of Technology, Delhi for Indian coasts was installed and was currently being validated. A large volume of meteorological information, including the forecast tracks of tropical cyclones was being provided on IMD's Website.

With effect from February 1, 1999, IMD is providing full Global Maritime Distress and Safety System (GMDSS) service to the ships on the high seas under Met area VIII (N) with routine bulletins at 0900 and 1800 UTC daily and additional bulletins during cyclone period.

IMD informed that the 1680 MHz WBRTs are being replaced by state of the art solid state 1680 MHz Radiotheodolites at New Delhi, Lucknow, Guwahati, Kolkata, Nagpur, Mumbai and Jodhpur during 2003-2004. IMD is in the process of upgrading its upper air observation systems. For this purpose one new IMD-MKIV radio sonde has been designed & being produced in IMD workshop. For processing the data from this radiosonde a new computing system for automatic acquisition & processing on the PCs has been developed by M/s SAMEER, Research and Development (R & D) laboratory under ministry of Information Technology, Govt. of India. The system is under installation at 35 RS/RW stations in India.

12 INSAT-AWS systems have been deployed in the field units at Dwarka, Karaikal, Pune, Nasik, Delhi, Thiruvananthapuram, Goa, Ahmedabad and Mumbai. There is a proposal to deploy 100 AWS with the state of the art system in a phased manner and to establish an AWS Data Reception, Processing and Dissemination Centre at Pune.

10 more High Wind Speed Recorders (HWSR) have been installed at Chandbali, Balasore, Puri, Visakhapatnam, Karaikal, Machilipatnam, Ongole, Nellore, Pondicherry and Adiramapattinam during July, 2002. This is in addition to the ten that were installed during September, 2000.

A WP-RASS was installed at DCP Complex, Pashan. The systems record wind speed and wind direction up to 10 km and temperature up to 3 km. The system was made operational in June 2002. The data received are under evaluation and scrutiny.

MALDIVES

Maldives informed the session that they did not experience any cyclone in 2002. However, a severe disturbance in July in the form of a low-level circulation in the west of Huvadhu atoll caused widespread rain and thundershowers over the country. The same thing occurred in December when a trough of low pressure appeared over the Maldives. The southewest monsoon which was active for almost a week in June and in late September caused flooding in some of the islands.

No observations were made last year. The WF100 and WF33 wind finding radars with the hydrogen generators donated by United States and Britain under the Voluntary Cooperation Program (VCP) remained unserviceable for a long time and needed to be replaced. Upper air observations from south and central Maldives were important in the region. Hence, Maldives requested WMO and Panel members to provide necessary assistance to restart the upper air observations, at Gan (WMO # 43599) and Male' (WMO # 43555).

The Department of Meteorology issued timely and accurate severe weather or tropical cyclone warnings and disseminated them to the public through mass media. It helped immensely to minimize the damages to property and loss of life due to floods/ landslides, risks to fishing vessels or passenger boats countering stormy weather in the open seas. These warnings were greatly appreciated by the community.

MYANMAR

Myanmar informed the session that of the five tropical depressions which developed in the Bay of Bengal none crossed the Myanmar coast. Those that had formed though close to the coast brought widespread monsoon rains along the coastal areas of the country.

There are two ground receiving systems for meteorological satellites. The newly installed ground satellite receiver donated by CMA is capable of receiving High Resolution VISSR pictures from GMS-5. Although INSAT sub-satellite location is much closer to Myanmar than GMS-5, INSAT MDD receiver is not available. Myanmar is keenly interested to receive images and charts on regular basis by using INSAT MDD systems for forecasting and warning of tropical cyclones. All the meteorological, hydrological and seismological data of the DMH are stored in DOS version G06 Software and Microsoft EXCEL. It is urgently necessary to rescue and

save the old data. Therefore, the CLICOM software version 3.1 has been installed and Climate Data Rescue Project VCP (4/1/1) has been successfully completed in DMH from 14 to 25 May 2001, under the VCP of WMO. Record section of DMH is solely responsible section of DMH for partial implementing the ASEAN Project on "Updating of the ASEAN Climate Atlas and Compendium of Climate Statistics". In the case of Myanmar, this will involve the preparation of the data set for the period commencing January 1965 to December 2000 with 30 stations including WWW stations chosen for this project.

Due to the shortage of consumables, only half of the listed stations could take observations at 0000 UTC. Although 6 stations are listed in WMO as Radiosonde / Radio wind stations, 5 stations did not operate due to the shortage of airborne transmitter from the factory. DIGI CORA II at Mandalay in the Central Myanmar was partly operational. No wind data could be obtained due to the ceased OMEGA signal world wide. Myanmar was eager to carry out regular observation for the benefit of the region, if equipment and consumables could be made available under VCP/Bilateral Programme. WMO monitoring result showed that Myanmar TEMP report to GTS percentage was zero.

After review of above existing telecommunication facilities in DMH, Myanmar, it can be noted that most of the telecommunication and electronic related instruments are more than 10 and 25 years old. Although they are aged, they can fairly fulfill the national, regional and WWW requirements. Conventional telecommunication equipments were out of tune to the updated equipment and protocol. A number of changes in meteorological telecommunication and dissemination method of data and product are required, in order to get cost effective, more reliable and high volume of information in short period using modern technologies.

SULTANATE OF OMAN

Oman informed the session that a cyclonic storm, ARB01A, made landfall on the morning of 10 May 2002 at the Governorate of Dhufar, which is in the southern region of the Sultanate. The storm caused severe thunderstorms, strong winds and rough sea conditions. The lowest pressure recorded during the storm was 996 hPa at the coastal station of Mina, Salalah while the highest recorded mean wind speed was 43 knots with gusts of up to 57 knots at Salalah. The region was flooded due to heavy rainfall. The storm left 9 people dead and several others injured. In addition, the storm also caused a great deal of social, economic, infrastructure and environmental damages. Oman proposed that RSMC New Delhi improve the regularity of their issuance of advisories during the cyclone period.

The Sultanate of Oman operates two upper air-observing stations. One flight is launched from each of these stations in a day.

Ship Weather Reports are received through GTS as well as from Muscat Coastal Radio Station. In addition, ship reports are also received from the Royal Oman Navy. One wave measurement station was installed offshore Sohar and the collected data is

inserted on the GTS every three hours. Two more stations will be repaired and or replaced at Muscat and Salalah. One additional station is planned for Qalhat (Sur).

The number of synoptic land stations being inserted into the GTS still remained at 23 stations. Numerical weather products are received via MOD, GTS and Internet from Bracknell, Toulouse, Offenbuch and Washington. A local Oman Regional Model (ORM) was established with the kind co-operation of the National Weather Service of Germany (DWD).

In order to meet ICAO recommended practices and to fulfill the requirements for aviation, the Department installed a SADIS workstation as early as 1996. Effective last year, the Department 'started to pay to the UK Met Office the annual contributions for obtaining SADIS data and products. In addition, all the SADIS data and products are also received thru an FTP server from UK as a back up. A new service was also established last year for the provision of en-route flight folders for all airlines operating in the Sultanate to be accessed on our web site.

PAKISTAN

No cyclone affected Pakistan during the year 2002.

WMO has recently proposed index numbers in respect of four new synoptic observatories established during the year. Allotment of index numbers to meteorological observatory, Gwadar and class-I surface observatory at Upper Atmospheric Research Station (UARS), Peshawar, established during 2001, are still awaited.

On account of financial constraints, all the six Radiosonde /Rawin (RS) stations and some of the upper air stations were partially operational during the year 2002. However, synoptic data of all the 13 GTS stations (portion-I), 11 stations of RBSN (portion-II) and 16 stations of RBSN (portion-III) along with available pilot data, was collected by PMD's NMCC Karachi and transmitted to RTH New Delhi and other international links on 3 and 6 hourly intervals round the clock. All the transmitted data was monitored immediately by Internet facility at the NMCC. With the revival of national economy, government had provided funds in PMD's budget for the year 2002-2003 for the procurement of radiosondes for the RS stations and consumables for the pilot stations for which tenders have been floated. Consequently, it is hoped that transmission of met data would significantly improve during the later half of 2003 subject to the materialization of tendered consumables.

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SRI LANKA

Sri Lanka was not affected by any cyclone during the year 2002. However, heavy rain associated with lower tropospheric cyclonic circulations in the vicinity of the Island, caused severe flooding in the Eastern Province during the cyclone period of October to December. There were two such spells of heavy rain in the East during the period 20-23 October and 19 -20th December, which caused widespread flooding. About 14,400 families, mainly in the eastern part of the country, were affected by floods and the government expenditure for welfare amounted to approximately Rs. 28.5 million (US $ 0.3 million). Another notable feature was the development of an eastward moving shallow low pressure area to the south of Sri Lanka which was observed in December.

Radiosonde observations at Colombo were made three times a week at 1200 UTC. India continued to supply Radiosonde transmitters, accessories and consumables for these observations. Radar wind observations were done at 0600 UTC and 1200 UTC using 100g and 350g balloons at Colombo through out the year. Pilot balloon observations were done as usual at Colombo at 0001 UTC and at 0600 UTC and 1200 UTC when the radar was defective. The pilot balloon observations at Hambantota, Puttalam and Trincomalee were continued at 0001, 0600 and 1200 UTC. Ships weather reports were received through the coastal radio station "Colombo Radio" and sent to the National Meteorological Centre (NMC) in the Meteorological Department via telephone or fax. During the Non Real Time Monitoring Period 01 -05 October 2002, none of the report was received.

The high gust anemometer at Trincomalee on the East coast, worked satisfactorily during the year 2002.

THAILAND

Thailand reported that no tropical cyclones made landfall in 2002. They were however affected by one cyclone, three tropical depressions and three tropical storms. Five of these weather systems activated the southwest monsoon which brought heavy to very heavy rains and caused flooding in some areas.

The Panel expressed its appreciation to the RSMC-tropical cyclones New Delhi for the valuable contribution it was making to its Members.

Besides 19 stations where Automatic Weather Observation System (AWOS) had been installed previously, 5 sets of the system were installed in the following provinces: Nakhon Phanom, Mae Sot, Phetchabun Phitsanulok and Phrae, bringing the number of AWOS to 24.

TMD produced graphic products of wind and significant wave height forecasts in the Gulf of Thailand and the Andaman Sea areas for marine services through the TMD's web browser (http://www.tmd.go.th).

Aeronautical Meteorological Division improved the Opmet Data Bank System which facilitates airline operators through various means of acquisition. With data from RAFC end WAFC, the new server can disseminate storm warnings to automated Fax; the division's website and work stations at the office at the Don Mueng Airport. All of them can be accessed by the operators' demands.

The medium and the long-range weather forecast messages have been issued to the concerned government offices, private sectors and public media. The distribution of weather forecasts (containing information in both texts and graphics), together with warnings of tropical cyclones expected to have effects on the weather of Thailand or neighboring countries, through Thai Meteorological Department's (TMD) website and by mail for some local areas has been improved . TMD has produced graphic products of wind and significant wave height forecasts in the Gulf of Thailand and the Andaman Sea areas for marine services through the TMD's web browser (http://www.tmd.go.th).

To extend the H.R.H. Princess Maha Chakri Sirindhorn's concerns in the quality of children's lives in remote areas in particular, the Royal Support Project for Education was initiated Iand has been pursuing consistently not only for Thai citizens but also for the neighboring communities, such as Cambodia. The main objective is to equip the school children with basic knowledge applicable to their daily' activities, particularly focusing on the socio-sciences, environment-friendly life, culture-oriented behaviors, health improvement, and other general sciences.

The Numerical Weather Prediction (NWP) System in Thailand contains the supercomputer system and NWP models covering a number of domains; global (100 km resolution), Southeast Asia (48 km resolution), Thailand (17 km resolution), and Bangkok (5 km resolution). These models are all based on the Unified Model. The Global, the Southeast Asia, and the Thailand models are usually run for 84, 72 and 36 hours forecasts, respectively. At present, TMD runs the Global, the Southeast Asia and the Thailand models as a part of its operation.

The IBM RS/6000 SP supercomputer consists of six wide nodes (Power 2 SC 135 MHz).Each wide node has 512 Mb of memory and 4.5 Gb storage. For thin nodes, each of them has 128 Mb of memory and 2.2 Gb storage. The total system (containing 32 nodes altogether) has the peak performance of 12.96 GFLOPS (LINPACK TPP). The two RS/6000 model 595 computers (POWER 2 SC 135 MHz) are used as high availability control workstations for the system.

With the development in numerical weather prediction, the tropical cyclone prediction in both intensity and track can be produced 3 days in advance with high satisfaction.

TMD has received daily marine meteorology data (such as wind speed and direction, wave height as well as period, and pressure, etc.) from the Global Telecommunication System (GTS) and Unocal platform via message switching and internet network, respectively, for monitoring sea state and supporting marine services. TMD has also received Merged Geophysical Data Record (MGDR) from the

TOPEX/Poseidon Mission Generation B and monitored climatological wave height in both the Gulf of Thailand and the Andaman Sea. Though this is still in the experimental stage, it can significantly enhance TMD's capacity in forecasting wave height as well as warning in the Gulf of Thailand and the Andaman Sea.

TMD has already used ocean Wave Forecast Model (W AM) to forecast wave height. This model has been operated at the Marine Meteorological and the Upper-air Observations Sub- divisions where products from such model will later be forwarded to the Forecast Division

1.1.2 COORDINATION WITH OTHER ACTIVITIES OF THE WMO TROPICAL CYCLONE PROGRAMME

The Panel expressed its appreciation for the detailed information provided by the WMO Secretariat the implementation of the WMO Tropical Cyclone Programme (TCP). It noted with satisfaction the developments and progress made in both the general component and the regional component of the TCP since the twenty-ninth session of the WMO/ESCAP Panel on Tropical Cyclones (Yangon, Myanmar, 12 to 18 March 2002).

The Panel noted with appreciation that the Second WMO Regional Technical Conference on Tropical Cyclones, Storm Surges and Floods which will be held in late 2004. The said conference will not only provide a forum for the exchange of views and experience on improving tropical cyclone, storm surge and forecasting but also strengthen cooperation and coordination between TC regional bodies having common interests, in particular, the Panel and the Typhoon Committee.

The Panel was informed that the TCP published the "Annual Summary of Global Tropical Cyclone Season 2001" (WMO/TD-No. 1132) (TCP-48) was published in August 2002 and that the next issue of the annual summary is under preparation and will be published in August 2003.

The Panel was pleased to note that the Fourth Tropical Cyclone RSMCs Technical Coordination Meeting was successfully held in Nadi, Fiji, from 26 to 29 November 2002, prior to the IWTC-V. With a view to further harmonizing the activities of the Regional Specialized Meteorological Centers (RSMCs) with activity specialization in tropical cyclones, the coordination meeting was attended by Directors of the six TC RSMCs (Honolulu, La Reunion, Nadi, New Delhi, Miami and Tokyo) a representative of the Australian Tropical Cyclone Warning Centres (TCWCs Brisbane, Darwin and Perth) and TCWC Wellington, and observers from WMO's Commission on Atmospheric Systems (CAS) and Commission on Basic Systems (CBS). The four-day meeting formulated future plans and activities of the TC RSMCs and TCWCs, assessed their requirements and worked on standardizing procedures related to tropical cyclone tracking and forecasting and stressed the need for enhanced coordination and closer collaboration between the RSMCs and TCWCs and the importance of strengthening the existing symbiotic relationship between the national warning centres and their

respective RSMCs. The meeting also submitted a list of non-prioritized recommendations to the IWTC-V.

The Panel was pleased to note that two storm surge experts from Bangladesh and Myanmar undertook a two-week training (19 to 30 August 2002) at the India Institute of Technology (lIT, Kharagpur) in the implementation and running of a PC-based high- resolution storm surge model. The Panel expressed its appreciation to IIT for this valuable " contribution to the Panel's activities and requested that WMO make similar arrangements: with the IIT for the year 2003 for the attachment of a storm surge expert from Pakistan and Thailand.

The Panel was pleased to note that in response to a request made during last years session, arrangements are being made for the participation of six tropical cyclone/storm surge experts from four Panel Members to the Second South China Sea Storm Surge Workshop "A Hands-on Ocean Forecast Training Laboratory for the South China Sea" (Kuantan, Malaysia, July 2003).

The Panel was informed that a meeting of international experts was convened in Nadi, Fiji (30 November) and Cairns, Australia (7 December) which was tasked to formulate TCP Sub-Project 23: *Combined Effects of Storm Surges and River Floods in Low-Lying* Areas. The experts, composed of meteorologists and hydrologists alike delved into current knowledge on the effects of combined storm-surge/river flooding, the deficiencies, studies made, new developments, operational storm-surge/river flooding forecasting techniques and systems and provided useful guidance on how to develop improved forecasting techniques and risk mapping tailored to the needs of those in coastal or low-lying areas.

1.1.3 REVIEW OF THE CO-ORDINATED TECHNICAL PLAN AND CONSIDERATION OF THE WORK PROGRAMME FOR THE NEXT TWO YEARS

Dr Somsri Huntrakul (Thailand), Chairperson of the Working Group tasked to carry out a detailed review of the Coordinated Technical Plan was unable to attend the session but submitted a report for the Panel’s consideration. Concerned Members involved in the Storm Surge Project, except for India and Pakistan, were again urged to take expeditious action in submitting their national project proposals to WMO for the Secretariat to complete the regional framework for the storm surge project and find funding for its national components.

India reported to the Panel that it is proceeding with national efforts related to the storm surge project. National Institute of Ocean Technology (NIOT) Chennai has developed an operational model based on fine element method for prediction of storm surges along the east coast of India. The model has been calibrated using past cyclone data and digitized coastal area maps (1: 25,000 scale with 0.5 m contour interval) for inundation studies. The inundation model has also been bench marked with international software MIKE 21 (a) modeling system for estuaries, coastal waters and

seas). Efforts are underway to transfer the model to the respective coastal states of India for operational use.

1.1.4 INFRASTRUCTURAL FACILITIES

Meteorological Observing and Telecommunications Systems

The Panel Members were invited to present reports on the current progress in dealing with problems encountered and on programmes for the modernization of observing and telecommunication networks and forecasting systems, aiming at further improvements in tropical cyclone monitoring, forecasting and warning services. The Panel reviewed the activities under the meteorological component of the Members during the past year.

Monitoring Results

The annual global monitoring of the operation of the World Weather Watch provides information on the level of operation of the observing and telecommunications systems. The October 2002 monitoring results show that:

a) The availability of SYNOP reports received during these periods from RBSN of Members of Panel on Tropical Cyclones increased for Bangladesh and Pakistan, constituting an average of 71 and 52 per cent respectively. The percentage of reports received from Thailand remained the highest in the region, constituting 99 per cent of expected reports. The availability of data from India, Oman and Sri Lanka was slightly varied, constituting an average of 81, 91 and 52 per cent respectively. The percentage for Myanmar decreased from 57 to 41 percent.

(b) Availability of TEMP reports during the same SMM period in 2002 has shown some positive trends. In particular, the percentage of reports increased for Bangladesh and Oman, constituting an average of 25 and 41 per cent respectively. Availability of reports slightly increased for Pakistan (from 8 to 14per cent). While providing the highest availability of reports in the region (80 percent), India, however, had experienced some problems in producing TEMP reports, decreasing their availability from 90 to 79 percent. Like in the previous years, 6 upper- air stations in Myanmar continued to be silent during the whole period with the exception of monitoring results in July, when 9 per cent of the availability had been registered. The percentage of reports received from Thailand actually remained unchanged during SMM constituting an average of 49 per cent.

The Panel was also informed that the implementation of point-to-point circuits required for the connection of the countries to the GTS had made significant progress but there were still shortcomings:

(a) RTHs Bangkok and New Delhi were linked to other RTHs in Region II by 64 Kbps circuits using the TCP/ IP protocol; NMC Karachi was also connected to RTH New Delhi by a 64 kbits/s circuits using the TCP/IP protocol;

(b) NMC Dhaka was linked to RTH New Delhi by a 2.4 Kbits/s circuit;

(c) Three NMCs had connections to the GTS operating at low speeds (50 or 75 Bauds): Colombo, Male and Yangon.

The reception of data and products on the GTS point-to-point circuits was complemented by the reception of satellite distribution systems. EUMETSAT MDD receiving systems were installed in Oman and Pakistan. INSAT MDD receiving systems were installed in Bangladesh, Maldives and Sri Lanka.

The Panel felt that the deficiencies described in the monitoring results above, as before, arose largely due to lack of consumables because of the high cost of radiosonde spare parts and trained staff in some Member countries. It urged Members to take necessary action to ameliorate the implementation of the observational programme and exchange.

In recognizing the importance of the availability of data from the Panel Region in order to improve tropical cyclone forecasts and warning services, the Panel urged Member concerned to make every effort to maintain and upgrade the observation programme particularly upper air observations.

The Panel was informed of the outcome of a Training Seminar on Information Communication Technology for the GTS that was held in Bangkok in September 2002. The meeting recommended:

(a) that the RTHs in Region II develop plans to upgrade the circuits connecting the RTHs in Region II to allow the transmission of data at a minimum speed of 64 Kbits/s using TCP/IP procedures;

(b) that the RTHs in Region II develop plans to implement the procedures for observation data collection using E-mail via Internet recommended by the Implementation- Coordination Team on Information Systems and Services (ICT/ISS);

(c) that RTHs Bangkok, Beijing, New Delhi and Tokyo be invited to carry out a Virtual Private Network (VPN) pilot project for Region H and that RTH New Delhi be invited to co-ordinate the pilot project;

(c) the use of satellite distribution systems to complement the point-to-point circuits, such as United Kingdom Satellite Facilities/World Weather Watch (UKSF/WWW) for which a pilot project was being carried out and to pay

specific attention to the development of satellite-based digital audio broadcast systems, such as the project of RTH New Delhi.

Bangladesh

BMD exchanges meteorological data, forecasts, warnings and other relevant information with RTH New Delhi on routine basis through WMO's GTS system. All the observatories of BMD are connected with NMCC Dhaka by TP, telephone, SSB, etc. At present, BMD is using Centralized Message Switching System (CMSS) for HP-UNIX Workstation for telecommunication purposes. In case of the disruption of the Dhaka-Delhi line, data are received through RTT/ lnternet. Data are also received through Kalpana-1 (INSAT) telecommunication system. If the proposed Dhaka-Bangkok RTT line would be restored which will be more beneficial. Dhaka-New Delhi X.25 GTS link operating at 2400 bps may be upgraded to 64 kbps speed at the time of introduction of WP in the BMD. RTH New Delhi has offered for upgradation of the link to TCP/IP at speed of 64 kbps.

India

India Meteorological Department Karachi- New Delhi circuit has been upgraded to 64 kbps w.e.f. 03 – 10 - 2002. Response from Colombo to upgrade New Delhi-Colombo circuit to 2400 bps is awaited. Action to upgrade Dhaka circuit from 2400 to 9600bps is in progress.

Maldives

The computer based telecommunication system between the local Meteorological Offices and the National Meteorological Centre (NMC), was upgraded and worked very well during last year.

The 75- baud GTS link between Male' and New Delhi did not operate satisfactorily. To overcome problems with speed and reliability of the ageing 75 Baud circuit, DMM is now looking into establishing a TCP/IP GTS link via the internet. The Analyzing, Forecasting, Data-processing and Operating System (AFDOS) functioned efficiently during the year 2002.

Myanmar

Myanmar informed the meeting that WMO had suggested that the communication speed of 50 baud on the GTS circuit Bangkok-Yangon and New Delhi-Yangon is no longer adequate or cost effective. Negotiations are now underway with Bangkok to upgrade the link to at least 200 bauds. India was also approached on this matter but no reply has been received so far.

Oman

Sultanate of Oman informed that all the meteorological stations operated by the Meteorological Department are connected to the MSS computer located at the Central Forecasting Office at Seeb International Airport by a reliable dial-up telephone link.

The MSS which was connected to RTH Jeddah at 9600 bps was upgraded last November to 64 kbps based on TCP/IP protocol. In addition to this, a 128 kbps Internet leased line has been established as well as an e-mail and FTP server all of which are protected by a firewall.

A Bilateral Internet Circuit, which was established between New Delhi and Muscat for the exchange of meteorological data, has proved to be very effective and useful. Another bilateral circuit link was also established between Abu Dhabi and Muscat for the exchange of meteorological data.

Pakistan

Pakistan informed the meeting that the meteorological data exchange circuit between Karachi and RTH New Delhi has been upgraded to a high speed of 64 kbps leased data circuit using TCP/IP protocol. The hardware and software installation was completed on 3 October 2002, followed by a series of successful tests; the data exchange has begun since 14 October 2002. Locally designed TCP Server/Client applications along with necessary hardware are working to exchange the data with RTH New Delhi as per WMO/IP Socket procedures. Before the new high-speed link, the data received was insufficient for plotting, analysis and other research work. Not only a rich amount of data is now being received but it can also be utilized in meteorological plotting/ analysis/ forecasting as well as in numerical weather predictions.

Establishment of a 64 kbps circuit between NMCC Karachi and RTH Tehran is in the initial stages. All the procedural information regarding equipment and its relevant software/hardware to be used has been provided to RTH Tehran for their facilitation.

Thailand

Thailand reported that the circuit between Bangkok and Vientiane (Laos PDR) has been opened with the speed of 64 Kbps, FTP protocol. The circuit between Bangkok and Kuala Lumpur (Malaysia) has also been upgraded from asynchronous speed of 1200 bps into frame relay speed of 16 Kbps.

The Panel recommended that all point-to-point circuit between NMCs of the Member countries and RTH New-Delhi to be upgraded to 64 kbps. In this respect, the Panel requested WMO and Pakistan Meteorological Department to formulate a project proposal for the Panel Members.

Cyclone Detection Radar

Bangladesh

Bangladesh informed that it is operating four 10cm S-band radars at Dhaka, Cox's Bazaar, Khepupara and Rangpur.Dhaka, Cox's Bazaar and Khepapura radars are linked with the Storm Warning Centre by microwave and that of Rangpur is linked by V-SAT reception and animation. Cox's Bazaar and Khepapura radars are old and need

to be replaced. Radar composite system has been installed. Composition of four radar images is being carried out with this system. It has become fully operational. The Panel requested WMO to look into the matter and give it high priority.

India

India has imported from M/S Gematronik, Germany Two numbers of S-band Doppler Weather Radars (DWRs) which have been installed, commissioned and made operational at Chennai and Kolkata w .e. f 21-02-2002 and 29-01-03 respectively replacing the conventional S-band Cyclone Detection Radar. The indigenous DWR developed by Indian Space Research Organisation (ISRO) under IMD-ISRO collaboration has been installed and made operational at SHAR center, Sriharikota (Andhra Pradesh) w.e.f. 29-12-02. It is planned to replace 5 more existing S-band conventional CDRs out of remaining 8 radars by state of the art S-band Doppler Weather Radars during the 10^{th} five year plan (2002-2007) in a phased manner.

Myanmar

Myanmar informed the Panel that one storm detection radar is located at Kyaukpyu and now it is partially operational due to the absence of preamplifier and DVIP function. Although the lack of above mentioned units, the radar can detect storm position except for true intensity and amount of rainfall. Since Kyaukpyu radar is the only radar in Myanmar, there is a gap of storm detection radar coverage in the region of Deltaic- Mon, Tanintharyi coast and it is necessary to install storm detection radar at Yangon to fill the gap of radar coverage for better tracking and warning of the tropical cyclone in the region.

Sri Lanka

Sri Lanka informed the Panel that due to technical reasons, the cyclone radar at Trincomalee was not operational during the cyclone season 2002.

Meteorological Satellites

The Panel noted with appreciation the latest detailed information on the reports on the operational meteorological satellite systems that are presently providing or having the potential to provide the data to Members in the Bay of Bengal and the Arabian Sea.

Bangladesh

Bangladesh informed the session that it is now receiving GMS-5 imageries hourly basis. Imageries from NOAA (HRPT) and Kalpana-1 are also received on a regular basis.

India

India had launched in September 2002 a geo-stationary Meteorological Satellite (METSAT) over the Indian Ocean and placed it over the equator over 74° E longitude .It has payloads purely for the meteorological purpose and is providing imagery in VIS, IR and WV channels. In addition it also carried DRT transponder for relaying the DCP data. It will be followed by another geo-stationary satellite INSAT-3A and the meteorological payload will be identical to those of INSAT –II E. METSAT has been recently renamed as KALPANA -I.

Maldives

Maldives informed the session that the Satellite Division of the India Meteorological Department arranged an expert mission which assessed the extent to which Meteorological Data Distribution (MDD) geostationary satellite receiving system had deteriorated structurally and functionally, and performed the necessary repair work bringing back the MDD system on line. Although the Indian Satellite (INSAT) receiving system is now operational still it has experienced significant periods of non-reception. Imageries from METEOSAT and satellite winds available on the internet are used daily for weather forecasting and analyzing.

Myanmar

Myanmar informed the session of the recent installation of the ground receiver donated by the China Meteorological Administration. It is capable of receiving high resolution Visible Infrared Spin-Scan Radiometer (VISSR) pictures from GMS 5.

Oman

Oman informed the session that the department installed ground-receiving for intercepting high resolution images from polar orbiting satellites operated by NOAA as well as from geostationary satellites operated by European Organization for the exploitation of Meteorological Satellites (EUMETSAT).

Sri Lanka

Sri Lanka informed the session that the reception of High Resolution Picture Transmission (HRPT) Pictures from NOAA series of Satellites were satisfactory. The meteorological data receiving system including the INSAT cloud imagery provided by India under Indo-Sri Lanka Joint Commission is operating well. Cloud imageries from various Websites are also received for operational purposes.

Thailand

Thailand reported to the session that the existing satellite receiving system (GSC- REALPAK) at the head office has been upgraded in order to obtain more

NOAA series satellite data and was preparing to receive data from MTSAT (Japan). It will be ready for MTSAT processing when MTSAT is in its orbit in the end of this year as scheduled by JMA.

Panel's view

The Panel expressed its appreciation that at CGMS-XXX (November 2002, Bangalore, India), WMO informed CGMS members that during the twenty-ninth session of the WMO/ESCAP Panel on Tropical Cyclones for the Bay of Bengal and the Arabian Sea held in Yangon, Myanmar from 12 to 18 March 2002, India had informed the Panel that a meteorological geostationary meteorological satellite (METSAT) has been launched in September 2002. This would be followed by another geostationary satellite INSAT -3A shortly after and the meteorological payload will be identical to those of INSAT -2E. In this regard, the WMO/ESCAP Panel Members had requested that India may supply the specifications for the satellite ground receiving station required to receive the signal broadcast from the satellite once it becomes fully operational. In response to this, one of the action items that were agreed upon and will be reported on at CGMS-XXXI to be held in November 2003 is for all CGMS Members to report on planned geostationary and low earth orbiting satellite coverage to support the WMO's Tropical Cyclone program, including distribution mechanisms for those data.

The Panel expressed its appreciation to the EUMETSAT for agreeing to keep METEOSAT 5 in its present position until 2005 and again requested that it may continue to do so beyond 2005.

1.1.5 Tropical Cyclone Names

The Panel expressed its appreciation on the excellent work done by Mr Ahmed Hamoud Mohamed AI-Harthy (Oman), Rapporteur on the Naming of Tropical Cyclones for the Bay of Bengal and the Arabian Sea.

The Panel agreed that the implementation of the name list couldn't be started during the coming cyclone season as India has yet to submit their list of names. In this regard, the Panel urged India to take part in this programme and submit a list of tropical cyclone names for the Panel's consideration. However, RSMC-Tropical Cyclones New Delhi continues to have its strong reservation against adoption of the names for Tropical Cyclones forming in the North Indian Ocean.

The Panel also agreed that during the session an audio recording of how the names are pronounced locally is to be made with the help of the local secretariat staff. The recording can be accessed in a password restricted page within the TSU website. Members who were not able to attend the session were requested to forward an audio tape recording of their proposed tropical cyclone names to the TSU as soon as possible.

The Panel requested that Mr AI-Harthy continue his assignment as Rapporteur on the Naming of Tropical Cyclones for the Bay of Bengal and the Arabian Sea.

1.2 HYDROLOGICAL COMPONENT

Under the hydrological component, the Panel reviewed the activities of its Members, UNESCAP and WMO. The representatives of the Members reported the activities of their respective countries as reflected in Appendix VII. In general, during the past year, several improvements had been made in several Panel Members, particularly with respect to real-time monitoring of water level and rainfall, risk mapping and participation of stakeholders in flood warning systems, such as in Bangladesh, India, Maldives, Oman, Pakistan and Sri Lanka.

The Panel was informed about good cooperation among the concerned Members in the exchange of hydrological data aiming at improving flood forecasting services in the international river basins. The Panel urged that these Members continue this kind of cooperation and inform the Panel of developments including specific details to enhance the visibility of achievements.

Likewise, a concept document has been developed for the establishment of a flood information system in the Mekong river basin in collaboration with the Mekong River Commission (MRC) which is currently reviewed before discussion with the member countries in the Mekong river basin (Cambodia, Lao, Thailand, Vietnam). This initiative is planned to be implemented as a regional WHYCOS component aiming to aid the implementation of the Flood Management Strategy of the MRC. Here, linkages have also been established with Members of the Typhoon Committee.

1.2.1 Activities of Panel Members

BANGLADESH

Bangladesh Water Development Board (BWDB) is the only national agency, which is responsible for collection, storing, retrieving, management and development of hydrological data of Bangladesh. Processing and Flood Forecasting Circle of Hydrology is the key centre for processing, analyzing, storing and retrieving all sorts of hydrological data. The real time hydrological data is collected by 67 SSB wireless and by telephone from the BWDB network. Water level data from 81 stations and rainfall from 55 stations are collected. Water level is collected 5 times daily at 3 hours interval in the day time. Very limited water level and rainfall data and forecast from Indian stations are also collected through BMD teleprinter link and also point to point data transmission arrangement. Flood Forecasting and Warning Centre (FFWC) is only the authority of issuing flood forecast of Bangladesh. They normally issue 24, 48 and 72 hours basis flood forecast. They use rainfall estimation from the satellite pictures, weather forecast, surface charts etc. supplied by BMD. At present, FFWC has taken 3 projects for dissemination of forecast and awareness building among the people.

INDIA

IMD has established 10 Flood Meteorological Offices (FMO's) located at Ahmedabad, Asansol, Agra, Bhubaneswar, Guwahati, Hyderabad, Jalpaiguri, Lucknow, New Delhi and Patna in the flood prone areas.

These Offices cater their services to meet requirements of flood forecasting for the rivers like Yamuna, Ganga, Narmada, Tapti, Mahi, Mahanadi, Brahmaputra, Barak,Godavari, Krishna,Teesta etc. After crossing India Ganga and Brahmaputra rivers enter Bangladesh. During the flood season-2002, 2361 Quantitative Precipitation Forecasts (QPF) were issued. These QPFs are used by Flood forecasting Division (FFD) of Central Water Commission (CWC) for issuing flood forecasts. In addition to QPFs , FMOs also provide following information.

- Prevailing Synoptic Situation
- Heavy rainfall warning
- Catchmentwise / sub-catchmentwise areal precipitation that occurred during the past 24 hours

Design storm studies are being conducted to study rainfall magnitude and its time duration for use as main input for the design engineers in estimation of flood for hydraulic structure, irrigation projects, dams etc. on various rivers. The probable maximum precipitation values are also evaluated for optimum utilisation of water resources.

Real time monitoring of district wise daily rainfall is one of the important functions of IMD. A network comprising a large number of raingauge stations is utilised under the Districtwise Rainfall Monitoring Scheme (DRMS).

Based on the real time daily rainfall data, weekly districtwise, sub-divisionwise and statewise rainfall distribution, summaries are prepared as a routine activity of Rainfall Monitoring Unit (RMU). Rainfall statistics are prepared in the form of rainfall tables and maps. The tables contain districtwise and sub-divisionwise actual, normal and percentage departures of rainfall. Maps showing weekly and cumulative rainfall figures in 35 meteorological divisions are also prepared to present a pictorial distribution of rainfall. Areas of excess, normal, deficient and scanty rainfall are depicted in different colours. Updated weekly, monthly and seasonal rainfall distribution summaries are also prepared regularly.

Districtwise and sub-divisionwise rainfall statistics provide important information useful to the agriculture scientists, planners and decision makers. This information is supplied to various government agencies for official use.

This unit provides design estimates of short duration rainfall in different sub-zones of the country for the purpose of railway and road bridge construction. Hydrometeorological data for a number of river catchments are analysed for probable

maximum storms, return periods of very heavy rainfall and run-off relationship. The study in respect of 24 sub-zones (out of 26) has so far been completed and the flood estimate report for the 6 sub-zones has been revised. The flood estimation report for lower Narmada and Tapti basins has also been revised during 2001. In these studies, representative network of rainguage stations and hydro-meteorological observatories are being maintained for collection of data.

HYDROLOGY PROJECT

IMD is one of the Nodal Agency in this World Bank Aided Hydrology Project for enhancing the physical infrastructure of Hydrological and Hydro-meteorological activities in India. IMD components pertain to;

- Re-designing raingauge and climatological network.
- Procurement of testing, calibration and installation of meteorological instrument.
- Annual inspection of about 2500 raingauges.
- Imparting hydrometeorological data banks at state level for monitoring evaluation of quality control of hydromet data for archival and dissemination to users.

MYANMAR

A total of 43 flood warnings and 106 river bulletins with a time advance of 1 to 5 days have been issued by the Hydrological Division of DMH to the public and the authorities concerned with, respect to the floods in 2002.

PAKISTAN

On account of below to largely below normal monsoon rains during the summer season 2002, water flow in all the rivers remained very low. In order to increase the storage capacity of the Mangla Dam reservoir, government has approved its raising by 50 feet. Necessary constructional work is under progress.

SRI LANKA

Hydrological Division of the Irrigation department is the only organization which collects, stores and analyses surface hydrological data in an island -wide basis. Hydrological division at present collects hourly water levels and calculates daily river discharges from 55 stream gauging stations situated in 17 major river basins. These 17 river basins account for over 60% of the total basin area in the island. The hydrological data thus collected is made available for water resource planning and research work. The division collects daily rainfall values from 20 rain gauges it has established, mostly in conjunction with the stream gauging stations. It also maintains 10 evaporation pans and collects daily evaporations values. The division also operates a floods warning systems for Kelani Ganga for Colombo using a computer model. For

this purpose several upstream river gauging and rainfall stations are connected to the Hydrology division by a UHF radio network. These provide real-time data enabling the division to operate the flood model and forecast the river level near the city.

SULTANATE OF OMAN

One of the roles of the Ministry of Water Resources (MWR) is to act as the flood information authority of Oman. As well as collecting storm and flood data in its nation wide hydrological network, it provides a service of information on historic storms and floods, flood risk maps, flood frequencies, design storm rainfall intensities and frequencies, design flood and drainage rates. It is also involved in tidal flooding aspects.

These services are used by various Ministries and the public in the course of planning any housing infrastructure and other developments that may involve wadis in any way, either as wadi crossings, or any structure within wadis or flood plains. They are also used for general drainage design.

THAILAND

TMD has launched the first phase of the Telemetering System Project since late September 1999. The project is established by TMD with the purpose to collect real time data, related to flood monitoring, flood forecasting and warning. The system is comprised of the hydro-meteorological forecast center, workstations, PCs and other peripherals. The first phase of project is divided into 2 parts as follows:

- Establishment of 50 automatic rainfall stations in Bangkok Metropolis and its vicinity for rainfall and temperature data measurement**.**

- Installation of 18 automatic hydro-meteorological stations as master stations in 8 river basins, namely Yom, Nan, Pasak, Chi, Mune, Prachin Buri, Tapi and Klong U- Tapao for measuring rainfall, water level, temperature, wind direction and speed, air pressure and relative humidity data.

The first phase of project was completed since 50 automatic rainfall stations and 18 automatic hydro-meteorological stations were installed already. For the second phase, it is under implementation in 3 main river basins in the South of Thailand: the Phetburi, the Prachuap Khirikhan, and the Tapi River Basins. Under this phase, 43 automatic rainfall/hydro-meteorolgical stations are planned to be completely installed in these river basins in 2003.

Technical Advancement

The Management Overview of Flood Forecasting System (MOFFS) version 2C was replaced by MOFFS version 3.

Flood Forecasting and Warning (basins in operation)

The flood forecasting and warning systems in the three designated river basins, namely: Nan, Pasak and Prachin, Buri River Basin are monitored on a routine basis. The three models currently used for flood forecasting and warning systems are as follows:

- Discrete Linear Cascade Model (DLCM), software received from the World Meteorological Organization (WMO). It is one of HOMS Components.
- Antecedent Precipitation Index (API)
- MIKE 11 Modeling System was installed in November 1995 (applied in Nan River Basin).

Comprehensive Flood Control Measures

The Royal Irrigation Department is responsible on flood prevention and flood control in irrigated areas countrywide. Its work plan was separated into 3 stages:

1) Before flood time

- Investigating rainfall / runoff situations for effective water management.
- Bewaring of the discharge of the main .rivers for the warning purpose.
- Dredging and clearing weeds In Irrigation canals.
- Depleting stored water in the reservoirs as well as the retarding fields for flood volume and rainfall in responsible areas.
- Inspecting the irrigation structures, i.e., embankments, regulators, and pumping stations.
- Arranging machines and equipment, i.e., movable pumps; generators; backhoes; dredgers; tractors; and sandbags, etc., in both central and provincial areas in ready to-use condition.
- Establishing flood control centers, in both central and provincial areas, to closely investigate the situation as well as concerning reports in order to command the assistance in time.

2) During flood time

- Additional plan when flood hazard is going to happen and the plan before flood time could not handle the flooding situation, i.e., heightening the embankment and closing the flood way, etc.

3) After flood time

- Surveying the damaged areas.
- Surveying the damages of irrigation system and repairing it back to the normal condition.
- Distributing free seeds of the second rice and/or short-lived field crops to the farmers to grow, using water still available in their fields.
- Supporting movable pumps both in and out of the irrigation areas, up to the potential of the available water.

Measures in The lower Chao Phraya River Basin

The Chao Phraya River Basin covers about 28 % of the total country area and claims high importance to Thailand's economics. The present flood prevention systems are comprised of embankments, regulators, and pumping stations to protect the inner area of Bangkok Metropolis and drain flood water out of such area to the sea with the drainage capacity about 65.2 mcm./day on the eastern field, and about 34.5 mcm./day on the western one. The work plan for flood management mainly is H. M. the King's Royal initiation while the Royal Irrigation Department and the Bangkok Metropolitan Administration are the main concerning agencies. The projects having been conducted in 2002 are listed below:

- The Monkey's Cheeks Project "Khlong Maha Chai -Sanam Chai", construction of regulator of 6 x 12.50 m., pumping station of 12 x 3 cm, and dike.

- Two pumping stations, "Chol Han Phichit 2" -20 pumps x 3 cm. and "Bang Pia" -20 pumps x 3 cm. to increase the drainage capacity of 10.4 mcm./day.

- The Khlong 14 Project, to drain flood above the Chao Phraya Dam, in Chainat province. The flood water can be drained from the left side of the Chao Phraya River through the former drainage system to the Bang Pakong River and the sea, respectively, via a pumping station named "Chol Han Phichit", with the drainage capacity of 4.0 mcm./day.

- The Khlong Lat rho Project, cutoff the Chao Phraya River, 65 m. wide x 600 m.long, with regulator of 4 x 14 m. and the bridge. This project can reduce the water level of the Chao Phraya River through Bangkok by 5 -7 cm.

- Hydrodynamic flow measurement project to study the relationship between the tidal and the flood flows through Bangkok. The principle components are the telemetering system of the discharge observation at 8 stations, the movable current meters, and the Chao Phraya River mathematical model from Bang Sai district, Ayutthaya Province up to the river mouth. The situation of the Chao Phraya River can continuously be observed in real time and can be forecasted for effective water management. This project is the cooperation among the Royal Irrigation Department, the Bangkok Metropolitan Administration, the Public Works Department, and other agencies. The project was planned for conducting during 2001 -2004.

Other river basins

The telemetering system for flood forecasting and flood warning is the main measure for flood prevention and flood control. The concerning projects having being conducted in 2002 can be listed as following:

- Tha tapao (Thasae -Rubro) Project, in Chumporn Province for urban flood mitigation in the town of Chumporn Province, is made up of the drainage system and the diversion system.

- The flood mitigation project for Chanthaburi Province, to provide systematic operation plan and drainage system. It is expected to be complete in 2003. The telemetering system for flood forecasting was under the process of tender bids and will be finished in 2004.

- U Tapao River Basin, Hat Yai District, Songkhla Province, under the process of tender bids and will be ready to full function in 2003.

- The lower Tha Chin River Basin, under the process of tender bids and should be finished in 2003. .The regulator "U-thok Vipa Cha Prasit", Nakhon Si Thammarat Province, additional part has been being under the study and design stage and will be complete in 2003.

1.2.2 ACTIVITIES OF ESCAP/ WMO

ESCAP

In the area of water resources management, UNESCAP completed Phase II of the project on "Capacity-building in strategic planning and management of natural resources in Asia and the Pacific" in 2002.

In Phase II, five sub regional workshops were held including the one for South-East Asia, jointly organized by the Mekong River Commission and UNESCAP in July 2002 and for South Asia, jointly hosted by the Interim National Water Authority of Sri

Lanka, the International Water Management Institute (IWMI) and UNESCAP in September 2002. Myanmar and Thailand took part in the Workshop for South-East Asia and Bangladesh, India, Maldives, Pakistan and Sri Lanka participated in the Workshop for South Asia. Preparation is currently being made to implement Phase III of the project in 2003 and 2004. In connection with regional efforts in strategic planning and management, UNESCAP continues the joint FAO-UNESCAP pilot project on the formulation of national water visions to action into the second phase. In this phase, efforts are being made to focus on the least developed countries in South-East Asia. Discussion on detailed implementation of related activities in the Union of Myanmar was held in February 2003. A national workshop to discuss the case study on the formulation of national water vision to action for Myanmar is scheduled to be held in Yangon in May 2003. The findings of the studies on strategic planning and management of water resources, and the three case studies on the formulation of national water vision to action and publications would be distributed widely to the UNESCAP members. As requested by the Panel at its last session, UNESCAP distributed a set of questionnaires to all Members of the Panel, as part of the survey to identify priorities and opportunities to enhance effectiveness of regional cooperation. A brief analysis of the seven responses from four members of the Panel would be presented for discussion at the 30th session.

The Panel Members were urged to make use of the advisory services which could be made available by UNESCAP to developing countries in the region on various aspects of water resources planning and management and to contribute their experiences, especially best practices, and research results related to water resources management to be published in the Water Resources Journal of UNESCAP for dissemination to developing countries in the region.

WMO

The Panel was informed that the "Associated Programme on Flood Management" (APFM) which is implemented jointly by WMO and the Global Water Partnership (GWP) has geared up its activities in the development of a pilot project focusing on “Community Approaches to Flood Management". The primary objective of this pilot project is to improve the management and adaptation capacity of communities in flood prone regions within the context of Integrated Flood Management (IFM). Currently the first phase of this project is implemented in selected communities in small river basins in Bangladesh, India and Nepal. Once the results of the initial phase of this pilot project are published in April 2003, Panel Members will be invited to examine whether the results and approaches are useful for hydrological activities in the Panel on Tropical Cyclones.

Aiming to establish a flood information system in the Hindu Kush Himalayan region in the framework of WMO's World Hydrological Cycle Observing System (WHYCOS) programme, a draft project proposal has been developed in collaboration with the International Centre for Integrated Mountain Development (ICIMOD). The proposal will be discussed in a high-level meeting in Kathmandu, Nepal from 10-13 March 2003. The pilot project will focus on the technical feasibility for real-time

hydrological and meteorological observations and the transmission of data. It is expected that the following countries will further collaborate in the planning and implementation of the project: Bangladesh, Bhutan, China, India, Nepal, Pakistan with Afghanistan and Myanmar as observers at this stage of the project development. Funding has been secured to implement a pilot project in the context of the planned project.

Likewise, a concept document has been developed for the establishment of a flood information system in the Mekong river basin in collaboration with the Mekong River Commission (MRC) which is currently reviewed before discussion with the member countries in the Mekong river basin (Cambodia, Lao, Thailand and Vietnam). This initiative is planned to be implemented as a regional WHYCOS component aiming to aid the implementation of the Flood Management Strategy of the MRC. Here, linkages have also been established with Members of the Typhoon Committee.

1.3 DISASTER PREVENTION AND PREPAREDNESS COMPONENT

The Panel reviewed the activities of its Members, WMO and UNESCAP. The representatives of the Members reported the situations on disaster mitigation and related disaster management activities of their respective countries in the past year as follows:

In general, the situation of cyclone-related disasters in the Panel Area in 2002 was not serious, except floods in Maldives, southern part of Oman, and Sri Lanka (especially in the last three months) and high waves in Oman. The Panel was also informed that the tropical cyclones in 2002 had caused beneficial effects in filling the reservoirs in Pakistan and Sri Lanka after suffering the long and serious drought period during the past five years.

Bangladesh

Bangladesh reported that it continued to improve its cyclone warning system, which had contributed importantly to reducing loss of lives and damage to properties, especially in 2002. Several training, seminars and rallies on disaster preparedness were conducted in 2002 at the national and local levels.

India

India reported that Government of India, under the Ministry of Agriculture constituted a high power committee (HPC) to review the Disaster Management machinery in the country and to formulate a comprehensive model plan for disaster mitigation at National, State and District levels. As per the recommendation of the HPC a National Disaster Management (NDM) was constituted under Ministry of Home Affairs to review and draw up fresh contingency plan like supply of essential goods, timely availability of medical assistance and medicine etc. with various departments of Central and State Governments. Similarly mitigation committees are

also formed at all the maritime states under the chairmanship of Chief Secretary and at all the district levels under the district collector respectively.

In addition to this various training programmes are conducted by both Government and Non Governmental Organizations (NGOs) with regard to cyclone mitigation management. As a pre cyclone measure IMD and State Government authorities take all necessary steps for better reception and dissemination of warnings.

Maldives

Maldives informed that timely warnings on flood and landslides had been issued as in previous years, which had contributed to minimize damage in 2002. In addition, the Department of Meteorology also continued to issue severe weather warnings to help minimize the risks to fishing vessels and passenger boats encountering stormy weather conditions in the open seas. An awareness programme on disaster preparedness was also conducted.

Myanmar

Myanmar informed the Panel that it had conducted lectures to residents and local government authorities of storm prone areas concerning weather related disasters. A special workshop aimed at bridging the gap between the weather warning providers and various users was organized by Department of Meteorology and Hydrology for the first time. There were more than 30 participants in the workshop including some staff from five agencies under the Ministry of Transport.

Oman

Oman reported that disaster prevention and preparedness activities in their country are undertaken by the Directorate General of Civil Defense of the Royal Oman Police. There is a very good coordination and cooperation between the Directorate General of Civil Defense and the Meteorological Department. Aside from disseminating warnings and advisories to the public, the Civil Defense also conducts disaster awareness programs, roving workshops, rehabilitation programs, etc. In 2002, heavy rainfalls caused floods in several wadis.

Pakistan

Pakistan reported that the country was frequently affected by natural disasters such as tropical cyclones, hill torrents causing flash floods, floods, earthquakes, droughts etc causing heavy losses of life and severe damage to property, infrastructure and crops. In the case of floods, a flood forecasting manual for formulating strategy to be adopted during flood, pinpointing exact agencies with their responsibilities and an extensive communication layout plan for quick dissemination of flood forecasts, warnings and advisories at the federal and provincial levels, already exist. A comprehensive guideline regarding cyclone relief operations at the local level has also

been formulated. For better coordination among the local administration and rescue and relief agencies, UNDP in consultation with the Emergency Relief Cell (Cabinet Division) has recently undertaken formulation of a national disaster management programme. The National Disaster Management Plan was scheduled to be presented to the Government on 31 March 2003 and a programme would be drafted and finalized in April 2003.

Sri Lanka

Sri Lanka reported that the National Disaster Management Plan had been finalized. The National Disaster Counter Measure Act is still to be enacted by the Parliament to provide legal framework for effectively implementing disaster activities. It had conducted the following: 14 Disaster Management Certificate Courses, two community-based Disaster Management National Training Courses, one-day Training Course on Disaster Information System, and 18 Disaster Management Workshops.

Thailand

Thailand informed that because of the severe damage brought by flash floods in remote, mountainous areas, and the great capacity of radar in capturing the rain type and intensity, Thai Meteorological Department (TMD) has installed 19 radar stations in many parts of Thailand to detect rain features, particularly heavy rain in flood-risk areas. Rain intensities will be monitored and analyzed at TMD and Regional Meteorological Centers of those regions before disseminating warnings to people of flood-risk villages. With the integration of the Village Meteorological Volunteers and Watch and Ward measures, TMD hopes that people in remote, flash flood-risk areas will receive flood warnings that are much more accurate in terms of the degree of severity and more timely. Most importantly, this integrative task will promote natural disaster awareness amongst villagers for the benefit of their own communities.

ACTIVITIES OF WMO

The Panel was pleased to note that WMO is currently a member of the Inter-Agency Task Force for the ISDR, and plays a prominent role in implementation of the strategy by providing assistance with science and technology and the operational activities of NMHSs. In the Inter-Agency Task Force, there are four Working Groups (WGs). The first WG on Climate and Disasters is chaired by WMO. The second WG on Early Warnings is chaired by UNEP. The third WG on Risk, Vulnerability and Impact Assessment is chaired by UNDP. The fourth WG on Wild Land Fires is chaired by the Global Fire Monitoring Centre located in Freiburg, Germany. The first WG on Climate and Disasters has taken over the responsibilities of the UN Task Force on EI Nino with an expanded mandate to consider all climate-related aspects of disasters. WMO actively participates in all WGs. It is encouraged that NMHSs contribute to the work of ISDR because there would be considerable advantages for NMHSs in developing close relationship with the groups. For example, Joint projects may be planned at regional level to mitigate the effects of natural disasters.

In this connection, the Panel noted that WMO closely worked with ISDR to publish "Living with Risk, a global review of disaster reduction activities." "Living with Risk" was released before the World Summit on Sustainable Development (WSSD) in 2002. It has been elaborated with a strong collaboration of WMO and the Asian Disaster Reduction Center (ADRC). Following the feedback to the preliminary version, a revision will be released in 2003.

The Panel was pleased to take note of another remarkable achievement of WMO in concluding with the Government of Ecuador a Memorandum of Cooperation to develop the activities of the International Centre for the Research on EI Nino Phenomenon in Guayaquil. Ecuador (CIIFEN). The centre functions as a regional and international facility to foster EI Nino research. It is highly recommended for associated NMHSs to participate in the activities of the centre.

The Panel was informed that the World Bank has launched the Pro-Vention Consortium. It is a global coalition of governments, international organizations, academic institutions, the private sector, and civil society organizations. It aims at reducing disaster impacts in developing countries. WMO is a member of the Consortium and represented in the Consortium Steering Committee. More active collaboration between WMO and the Consortium is expected in 2003. The main objectives of the Consortium, which may be associated with NMHSs, are as follows:

i. To promote a culture of safety through education and training among leaders and citizens of developing countries;

ii. To support public policy that can reduce the risk of natural and technological disasters within developing countries;

iii. To support pilot projects and to disseminate information about "best practices" that have been proven to mitigate the scope and frequency of disasters;

iv. To develop governments' ability to minimize disasters and to respond effectively when they occur; and

v. To forge links between public and private sectors, between the scientific community and policy makers, between donors and victims so that all stake holders work together to strengthen the economy, reduce pain and suffering and promote the common good.

To achieve these objectives there are two main vehicles for leveraging resources and knowledge: the Consortium's clearinghouse for capacity and information sharing; and the support of pilot or demonstration projects and other new activities.

The Panel was informed that WMO participated in the International Symposium on Landslide Risk Mitigation and Protection of Cultural and Natural Heritage held in Kyoto, Japan in January 2002 in view of the fact that landslides are actual killers during

and after heavy precipitation. International experts in the field of landslide such as landslide risk mitigation and protection agreed to establish an "International Consortium on Landslides (ICL)". The consortium aims at promoting landslide research and capacity building. A Memorandum of Understanding between WMO and ICL was signed in October 2002. NMHSs' cooperation with and contribution to ICL are highly expected.

It was also pleased to note that WMO had played a key role during the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa where the disaster management issue became a key topic in its main outcomes. Natural disaster prevention and mitigation were included in WSSD's Plan of Implementation as essential elements for a safer world in the 21st century. The Summit agreed that actions were , required to improve surface-based monitoring systems and to increase the use of satellite data. The goal is to improve early warning systems.

In 2002, the following WMO Programmes were particularly important in contributing to global capabilities in the detection, forecasting and early warning of hazards, and providing effective means and procedures to minimize their adverse consequences through the application of science and technology:

- The World Weather Watch Programme promoted upgrading of infrastructures **to** exchange real-time data, forecasts, warnings and advisories for the public and the international community. GDPS through its Regional Specialized Meteorological Centres provided weather forecasts and advisories on tropical cyclones or other specialized risks associated with the atmosphere or having global implications such as volcanic plumes, fire haze and drought.

- The Public Weather Services Programme provided assistance to NMHSs to develop their capability to communicate adequate warning messages to both the public and the emergency management community. This assistance has been provided through training activities and the publication of guidelines on media issues, the use of internet and the use of new technologies and research. Specific guidelines on warning process and accuracy, timeliness, language content and credibility of the sources of warning messages were also developed. The exchange of warnings between neighboring countries has been promoted. Hong Kong, China accepted to develop a pilot Website for tropical cyclone warnings in the western North Pacific, in the first instance. A link to this Website is already active in WMO Web page.

- The Tropical Cyclone Programme coordinated actions at International, regional and national levels, to provide upgraded and more effective warnings of tropical cyclones and associated floods and storm surges, and to strengthen related community preparedness through workshops and seminars. The Southwest Indian Ocean Tropical Cyclone Warning System was upgraded with the establishment of the Regional Specialized Meteorological Centre in La Reunion and the realization of training events.

- The World Climate Programme provided assistance through its Climate Information and Prediction Services (CLIPS) to countries for the application of climate information and knowledge in the prediction and early warning of climate- related natural disasters. Taking into account the increasing value in the field of disaster preparedness that could accrue from early warnings on longer time- scales derived from seasonal to inter-annual climate predictions, sub-regional forums were regularly convened to develop seasonal outlooks and provide an excellent opportunity for co-operation between NMHSs and user communities.

- The World Weather Research Programme contributed to promote research on cost-effective and improved techniques for the forecast of high-impact weather such as tropical cyclones, sand and dust storms, and heavy rainfall that can provoke severe flooding.

- The Hydrology and Water Resources Programme (HWRP) assisted NHSs with strengthening and updating their observation networks by adopting modern data collection and transmission technologies by developing their data management capabilities.

- HWRP also promoted through the provision of technical guidance and the establishment of technical co- operation projects, flood risk assessment and forecasting water-related hazards focused on major floods and droughts. WMO through HWRP and The Global Water Partnership launched a joint project, APFM (Associated Program on Flood Management), in the context of integrated water resources management, which considers both negative and positive aspects of floods.

The Panel was informed that WMO's Inter-Department Disaster Reduction, Emergency and Disaster Response Group (EDRG) were renovated in 2002. The goal is for the WMO Secretariat to take quick and effective actions in case of excessive disasters in developing countries. The task of EDRG is to collect and provide detailed disaster information when necessary so that the WMO Secretariat could make a decision on further assistance to the affected NMHSs. In order to support this activity, the Government of Japan advised by the Japan Meteorological Agency (JMA) kindly seconded a Junior Professional Officer in February 2002.

ACTIVITIES OF UNESCAP

The Panel was informed that the UNESCAP continued its work on disaster prevention and preparedness with emphasis on water-related disasters reduction, particularly for flood mitigation and preparedness. In this connection, the project on "Strengthening Capacity in Participatory Planning and Management for Flood Mitigation and Preparedness in Large River Basins" was implemented. Apart from the completion of four country case studies, including India (Panel member) and an earlier regional workshop, UNESCAP prepared a set of guidelines on participatory planning

and management for flood mitigation and preparedness in 2002. The publishing of the guidelines together with compilation of related materials are expected to be completed soon for dissemination in the region.

In pursuance of the request of the Panel at the 29th session, UNESCAP mobilized support from the Ministry of Land, Infrastructure and Transport (MLIT) of Japan to sponsor participants from the Panel to take part in the Regional Workshop on Integration of Risk Analysis and Management of Water-related Disasters into Development Process in Manila in July 2002. Due to communication difficulties, participants from Bangladesh, Myanmar and Pakistan only took part in the four-day workshop. On the basis of the findings and recommendations of the workshop, the Department of Meteorology and Hydrology of Myanmar organized a national workshop to enhance public participation in flood forecasting and flood risk mapping. Efforts are being made to mobilize resources to further support these national activities. In addition, in response to the participation of the Coordinator of TSU of the Panel, financial support from MLIT was also secured to sponsor the participation of representatives of two Panel Members, one from Bangladesh and the other from India, in the Third World Water Forum to be held in Kyoto from 18 to 20 March 2003.

The Panel was also informed that a Regional Workshop on Management strengthening Capacity Building of the National Meteorological Services of Least Developed Countries in Asia, including Bangladesh and Maldives, was jointly organized by WMO and UNESCAP in October 2002, with the aim to assist these countries in identifying priorities for capacity building in cyclone-related disasters mitigation and preparedness.

UNESCAP, in cooperation with the United Nations Office for Outer Space Affairs, organized a “United Nations Regional Workshop on the Use of Space Technology for Disaster Management in Asia and the Pacific” in November 2002 to promote better exchange of information and experiences in disaster preparedness and mitigation. Several senior officials from Bangladesh, India, Pakistan and Thailand took part in the workshop.

The Panel took note of the activities of UNESCAP in organizing a special event to commemorate the International Day for Natural Disaster Reduction on 9 October 2002 at the United Nations Conference Centre in Bangkok. The event included two major activities:

1.2 An exhibition of achievements and ongoing efforts of various international agencies and national agencies in the region on this subject

2.2 The UNESCAP - Asian Disaster Preparedness Centre (ADPC) Forum on Disaster Reduction addressed major issues on “Disaster Reduction for Sustainable Mountain Development and Emerging Trends of Floods and Flood Management in Countries in Asia and the Pacific”. The Forum moderated by the Director of the Environment and Sustainable Development Division, UNESCAP, included a keynote speech by the Executive Director of the ADPC and lectures by the distinguished experts from

Thailand and the region: Secretary General of the Royal Development Projects Board; Director General, Department of Town and Country Planning, Ministry of Interior; Director General, Meteorological Department of Thailand, Royal Thai Government; and Forestry Sector Analysis Specialist, Regional Office for Asia and the Pacific of FAO.

ACTIVITIES OF ADRC

The Panel took note of the most recent and on-going activities of the ADRC which were presented by the observer from the center. The representative of ADRC also made a presentation on the centers' role in information sharing for effective disaster management during the technical conference.

The Panel expressed its appreciation to ADRC for the CD-ROM copies of "Living with Risk (A global review of disaster reduction initiatives)" which were distributed to the participants during the session.

1.4 TRAINING

The Panel reviewed the involvement of its Members in the various education and training activities supported under UNDP, WMO Voluntary Co-operation Programme (VCP), regular budget and TCDC arrangements.

Since its last session, the Panel had benefited from WMO's education and training activities, relating to the award of fellowships, relevant training courses, workshops, seminars, the preparation of training publications, and the provision of advice and assistance to Members.

The Panel expressed appreciation for the number of training events and workshops, which were organized in 2002

The Panel noted that 25 fellows from the Panel Member countries have completed their training during 2002.

The Panel expressed appreciation to Members which offered their national training facilities to other Members under bilateral arrangements. These co-operative efforts by the Panel Members have been found by the recipient countries to be very useful, and the Panel strongly recommended that such endeavours should continue in the future and strengthened.

The Panel expressed appreciation to the continuing development of the WMO Training Library (TLB) particularly its website component, the Virtual Training Library (VTL) and the Virtual Laboratory for Education and Training in Satellite Meteorology, which provide an efficient operational service to Members using the latest and most suitable available training material through Internet. The Panel urged its Members to make use of this new development where possible.

The Panel requested WMO to arrange for a training seminar/workshop in satellite meteorology for the Members.

The Panel also requested RSMC New Delhi to arrange for the attachment of tropical cyclone forecasters from the Panel Members in their Centre during the cyclone season.

Bangladesh

Bangladesh informed the Panel that 5 meteorologists and one assistant meteorologist have done post graduate courses on meteorology and satellite meteorology in the Philippines, India and Egypt under WMO's Voluntary Cooperation Programme. Two meteorologists are now undergoing post-graduate courses on satellite meteorology in India. Bangladesh requested WMO to provide assistance for two of its staff to undertake post- graduate course in Meteorology (i.e. Masters in Meteorology).

India

India informed the Panel that assistance is needed for officer/s from the Central Water Commission to undergo training. Under the programme of Technical Cooperation among the Developing Countries (TCDC) and Voluntary Cooperation Programme (VCP), IMD organizes training courses as a WMO Regional Meteorological Training Centre for its own personal and trainees from other RA-II countries. Training for class IV, III, II & I levels is imparted.

Table 1.2

Number of Candidates Trained in India during 2002

Level of WMO training	No.of Departmental trainees.	No. of Non-Departmental Trainees	No. of foreign trainees
Class I	**Nil**	**Nil**	**Nil**
In between Class I and class II	**24**	**6**	**1**
Class III	**25**	**Nil**	**2**
Class IV	**73**	**Nil**	**Nil**

In all the above training programmes, emphasis is given to Tropical Meteorology and Tropical Cyclones and the subjects are covered as per WMO stipulated syllabus. For Class I and Class II level, a separate subject on ‘Numerical Weather Prediction Models’ is also included.

Maldives

Maldives requested WMO and Panel Members to render necessary assistance to train their staff in the meteorological service. The department urgently needs to train staff in the field of marine meteorology, equipment maintenance. Training on AFDOS, INSAT, CLICOM and SADIS are also required.

Myanmar

Myanmar informed the Panel that in 2002, 27 of their staff participated in overseas training in meteorology, hydrology and seismology while 14 attended WMO organized meetings. It also reported that a special training course and workshop on Marine meteorology was held in Yangon from 17 to 21 February 2003. .

Oman

Oman informed the Panel that 17 of their staff participated in overseas training and study while at least 20 were trained locally.

Pakistan

Pakistan informed the Panel that the Director General, Meteorological Services, during his visit to China to attend the Regional Coordination Meeting on Capacity Building followed by the Regional Seminar on Cost Recovery and Administration in RA II held in Nanjing, China in 2001, conducted useful deliberations with the authorities of the Institute of Atmospheric Physics (lAP), Chinese Academy of Sciences, Beijing, China for providing facilities of research, education and training in the field of Weather and Climate Prediction to PMD Scientists. This resulted to a Memorandum of Understanding on Cooperation for Research, Education and training in the field of Weather and Climate Prediction between the lAP and PMD. It had already been approved by the Ministry of Defence and will be submitted to the Cabinet for approval.

Sri Lanka

Sri Lanka informed the Panel that 9 of their staff participated in overseas training with financial assistance from WMO. It thus expressed its sincere thanks to the WMO for providing opportunities for participating in the above meetings, seminars and workshops etc. during the year and also thanked the IPCC, UNDP, KOICA and the Government of India for providing various kind of training assistance.

1.5 RESEARCH

The Panel was pleased to note that the Fifth WMO International Workshop on Tropical Cyclones (IWTC-V) was successfully held in Cairns, Australia from 3 to 12 December 2002 and that the Panel was represented by the following at the workshop: Mr Samarendra Karmakar (Bangladesh), Dr Akhilesh Gupta (India), Mr S.R. Kalsi

(India), Dr Oamar-uz-Zaman Chaudhry (Pakistan), Mr Ethige Sunil Silva (Sri Lanka) and Mr Kriengkrai Khovadhana (Thailand).

The Panel was informed that the final report of IWTC-V is being published and will soon be distributed to all concerned.

The Panel was pleased to note that as recommended by IWTC-V, the Global Guide to Tropical Cyclone Forecasting which is seen as a valuable forecast reference is currently undergoing revision and that the revised Guide will be published by WMO primarily as a Web version, with limited Hard Copy and a CD ROM version. It was further pleased that it may even be available soon in other languages.

The Panel was likewise pleased to note that a forecaster's website will soon be established within the WMO TCP website on which operational studies, forecasting rules, and other relevant material could be posted.

The Panel was informed that as recommended by IWTC-V, a Science Working Group for the International Tropical Cyclone Landfall Programme (ITCLP) was established and chaired by Dr Gary Foley (Australia).

Bangladesh

Bangladesh requested WMO to provide assistance to the establishment of a research cell in their meteorological department.

Myanmar

Myanmar informed the session that most of the research work done lately at the DMH was focused on the improvement of long range forecasts and climate prediction.

Pakistan

Pakistan informed the Panel that a research unit will be established under its Drought Monitoring and Early Warning Centre, Islamabad. It will carry out research in drought related issues such as the climatological conditions leading in the occurrence of droughts and would develop statistical models for improved drought forecasts.

Sri Lanka

Sri Lanka informed the Panel that a Meteorologist of the Department of Meteorology continue his research project, leading to a Ph.D, on rainfall estimate using remote sensing satellite data at the International Institute of Aerospace Survey and Earth Sciences (ITC), Netherlands and the International Water Management Institute (IWMI), which was funded by the Netherlands Remote Sensing Board through ITC. A research on identification of areas of water Stress using remote sensing technology in the Department of Meteorology is carried out by a group of Meteorologists.

Thailand

Thailand reported that their ongoing research activities include

"The analyses of rainfall and temperature over Thailand related to ENSO phenomenon", “The Southwest Monsoon Onset over Thailand during GAME- T lOP by using MM5 Model”, “Geographic and hydrological studies following the August 2001 devastating flash floods in Nam Kor and Nam Chun, Phetchabun areas” and “Meteorological and geographical research for implementing flood warning system in flood prone areas”.

1.6 PUBLICATIONS

Publications issued under the programmes of the Panel fall into two categories (a) Panel News, and (b) the Annual Review of the Tropical Cyclones affecting the Bay of Bengal and the Arabian Sea. Information on the current status of each is presented below:

(a) Panel News

Panel News No.16 was published by TSU in February 2002 Panel News No.17 (Jubilee Issue) was published by TSU in November 2002

(b) Annual Review

The Panel on Tropical Cyclones Annual Review (PTCAR) for the year 2000 which was consolidated and finalized by the Chief Editor, Dr R.R. Kelkar (India) with contributions from the National Editors was published by WMO in 2002. Annual Review for the years 2001 and 2002 are under publication. In this regard, the Panel expressed its appreciation to the Chief Editor and the National Editors of the Review.

It was reported by IMD that brochure entitled “Damage Potential of Tropical Cyclones” has been published by the India Meteorological Department during the year 2002.

1.7 TECHNICAL SUPPORT UNIT (TSU)

The Panel expressed its gratitude to the Government of Pakistan for hosting the TSU and appreciated the services being rendered by Dr Qamar-uz-Zaman Chaudhry, Director-General of Pakistan Meteorological Department (PM D) in his capacity as the coordinator and Mr Umar Hayat Ghalib as the TSU Meteorologist.

The Panel was briefed by the TSU Meteorologist on the activities of TSU during the past year. The Panel expressed its satisfaction with the work of the TSU. TSU informed the meeting that it circulated to the Members in July 2002 an abridged copy of the action sheet on the decisions and recommendations of the 29th session of the Panel which was circulated by WMO in May 2002.

The Panel was informed that TSU published the 17th issue of the Panel News as silver Jubilee Issue of the TSU", which was circulated during November 2002 and that the 18th issue, was under process.

Panel Members had been requested to contribute information for inclusion in the documentation for the 30th Session to the WMO Secretariat under intimation to the TSU by 20th January 2003. In this regard, only Myanmar, Maldives and Sri Lanka responded.The Panel was informed that TSU has ultimately succeeded in contacting Mr Smith Tumsaroch, Chairman, Board of Governors of Smith Tumsaroch Fund (STF) during January 2003 regarding approval of the guidelines for its operation and award. However, having no opportunity to coordinate with the host country of the forthcoming Panel's session, he has intimated to defer the award for 2003 pending further consideration of the future of the fund. The Panel requested the Coordinator of TSU to formalize with Mr Tumsaroch the arrangement regarding the STF award for the Panel.

The Panel was pleased to note that in response to a request from the Members during the 29th session, the PTC website was launched in 15 January 2003 and can be accessed on http//www.tsuptc.org. For feedback and inputs, the website can be logged in through;

User ID = tsu
Password = 123

The Panel commended the TSU for the well constructed and user-friendly website and noted with appreciation that it is the first tropical cyclone regional body to have its own website. The Panel was informed that the WMO TCP website had been linked to the PTC website since 14 February 2003.

The Panel was informed that the Coordinator of TSU attended the Fifth International Workshop on Tropical Cyclones (IWTC-V) held in Cairns, Australia from 3-9 December 2002

The Panel was informed that with financial assistance from the Panel's Trust Fund the Coordinator of TSU will participate in the forthcoming 3rd World Water Forum, scheduled to be held in Kyoto, Japan from 16-24 March 2003.

TSU provided the Panel with a detailed breakdown of its expenses incurred by the TSU during the Inter- sessional period.

The Panel requested the Coordinator of TSU to prepare the draft institutional arrangements for acceptance of any award by the Panel.

The Panel agreed to establish an award for the Panel. It requested the Coordinator to draft the guidelines, including the name of the award, the criteria, in consultation with WMO, UNESCAP and Pane! Members. In this regard, the Coordinator is requested to submit this in the next session for the Panel's consideration.

1.8 TECHNICAL DISCUSSIONS

A one-day technical conference on "Tropical cyclone-related disasters and poverty alleviation in the Panel area" was held in conjunction with the 30th session of the Panel.

The Panel expressed its deep appreciation to the lecturers/presenters for their informative and scientific presentations. Some of the conclusions and recommendations were incorporated within this report under their related agenda items.

The Panel decided to organize a similar technical conference during the next session and requested the Chairman of the Panel in consultation with the Members to select a suitable theme for the conference.

DATE AND PLACE OF THE THIRTIETH SESSION

The representatives of Sri Lanka informed the panel that their countries would be willing to host the thirty first session in March 2004, subject to the approval of their government. The Panel requested its Chairman in consultation with Sri Lanka, WMO, ESCAP and TSU to arrange for convening the session.

CLOSURE OF THE SESSION

The Panel expressed its sincere appreciation to the Government of Pakistan, the host country, for providing excellent facilities, the venue, other arrangements and its warm hospitality for this year's session. The Panel also expressed its deep appreciation to Dr Qamar-uz-Zaman Chaudhry, the Chairman of the Panel and Coordinator of TSU, for the successful conduct of the session. The Panel wished to express its gratitude to Mr Zia-ud-Din Khan, Conference Coordinator/Chairman of the Local Organizing Committee and his able staff for their hard work in producing a session report, which is definitely of high quality.

The Panel expressed its gratitude to Pakistan Meteorological Department for arranging the visit to the Khewra Salt Mines and to Marree.

The 30th session of the Panel was concluded on 10 March 2003 at 1000 hours.

CHAPTER II

TROPICAL CYCLONES IN 2002

2.1 OVERVIEW

This was the second successive year of below average cyclone activity over the North Indian Ocean (six against an average of 13 to 14}. Some of the salient features of the cyclogenesis during this year are given below:

- North Indian Ocean was completely devoid of any cyclone activity during the monsoon season (June-September).

- Only one system out of four which formed during the post -monsoon months in the Bay of Bengal attained the intensity of Severe Cyclonic Storm for a very short duration close to coast and subsequently weakened into cyclonic storm just before crossing the coast. The remaining systems (two Cyclones dissipated over the sea area itself).

- The last system of the year (Cyclonic Storm 21-25 December) developed close to the equator and had an unusual track toward Northeast.

Like the previous year, during 2000 also the North Indian Ocean witnessed development of four cyclonic storms and two depressions. Out of the four cyclones, three developed in the Bay of Bengal and only one in the Arabian Sea. The cyclonic storm of 10 May caused extensive damage in Oman and 9 people lost their lives. No damage to life and property was caused due to cyclones in other Panel member countries other than India. Even in India the damage to life and property was much less compared to some other years in the recent past. Except for the severe cyclonic storm over the Bay of Bengal in the month of November, the remaining three cyclones were marginal ones. Two cyclones that developed over the Bay of Bengal weakened over the sea itself.

Like the previous two years, convective activity was generally subdued over the Bay of Bengal during the month of October except over a part of southwest Bay of Bengal. This is evident from the mean Outgoing Long - wave Radiation (OLR) field (Fig. 2.1). During November convection maxima was located over central parts of south Bay of Bengal that was seen shifted to the south of 5^0 N in December. For the season as a whole, the convection maxima were located over the sea area south of 5^0 N.

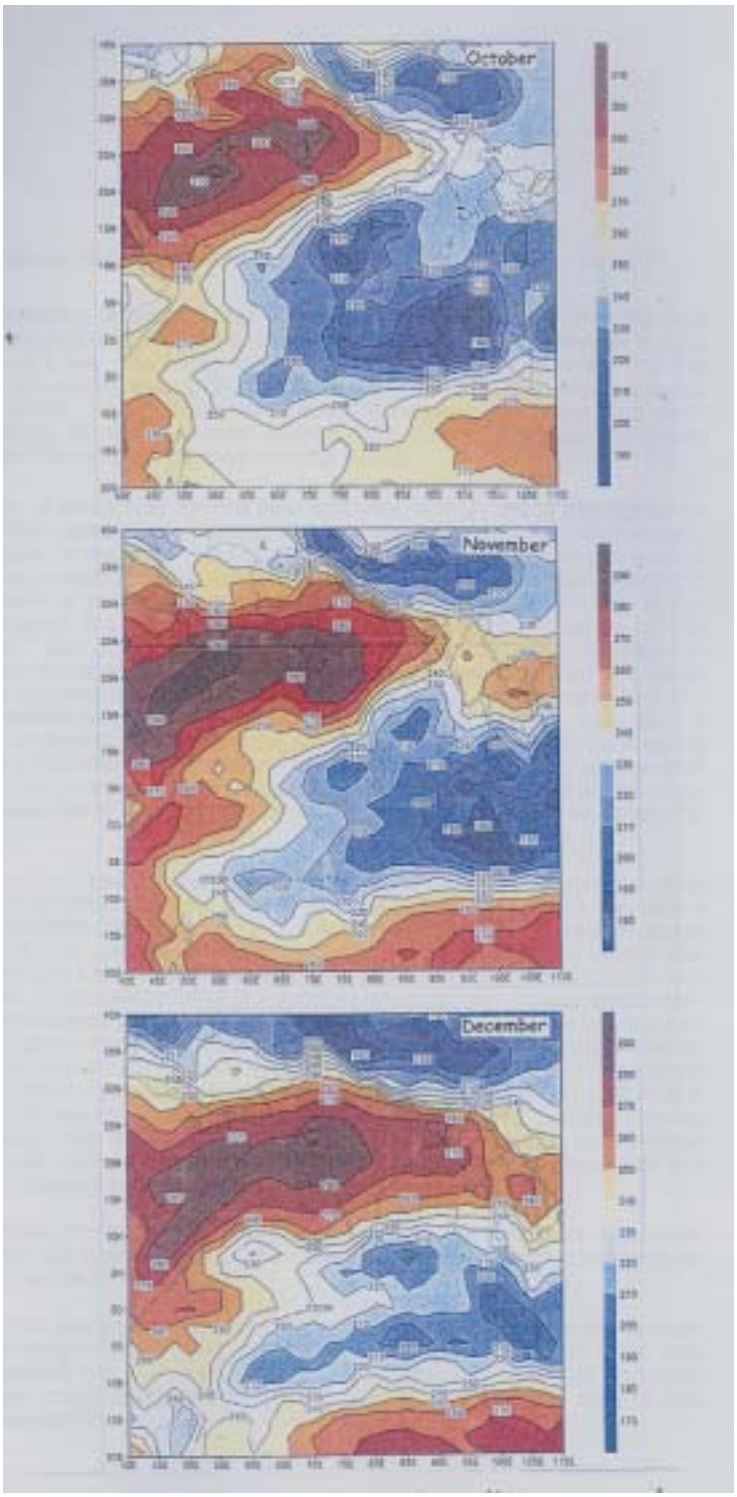

Fig. 2.1 Mean Outgoing Long wave Radiation (OLR) in Watts / m^2 during post monsoon season of 2002

The Regional Specialised Meteorological Centre (RSMC)–Tropical Cyclones New Delhi mobilised all its resources, both technical and human, to track the tropical disturbances evolving in the North Indian Ocean and issued advisories to WMO / ESCAP Panel countries.

List of cyclonic disturbances during 2002 are given below in chronological order**:**

1. **Cyclonic Storm over the Arabian Sea (06-10 May)**
2. **Severe Cyclonic Storm over the Bay of Bengal (10-12 November)**
3. **Cyclonic Storm over the Bay of Bengal (23-28 November)**
4. **Cyclonic Storm over the Bay of Bengal (21- 25 December)**

Tracks of these cyclonic disturbances are given in Fig. 2.2.

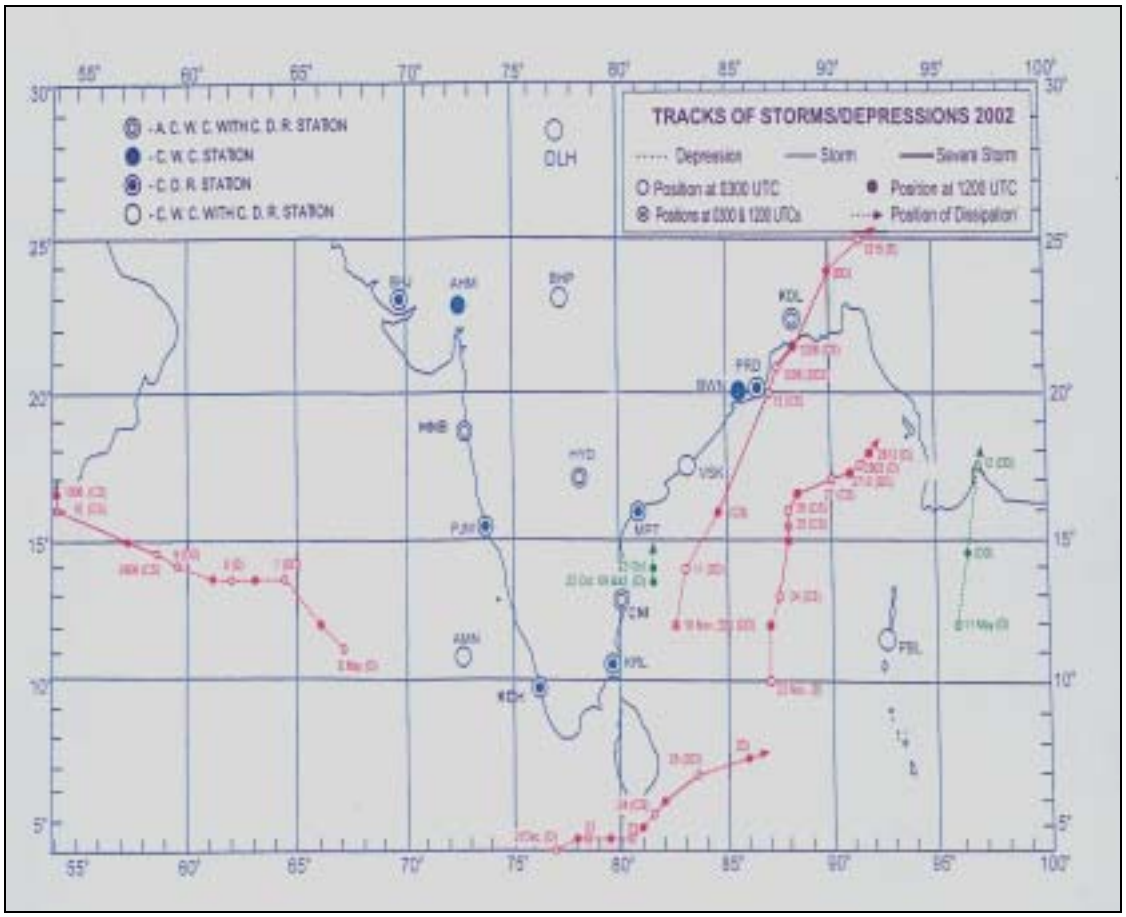

Fig. 2.2 Track of storm and Depressions during the year 2002

2.2 BRIEF DESCRIPTION OF TROPICAL CYCLONES WHICH AFFECTED MEMBERS OF WMO/ESCAP PANEL COUNTRIES.

2.2.1 Cyclonic Storm over the Arabian Sea 06-10 May 2002

A depression developed over southeast Arabian Sea on 6 May. Moving north-westwards it intensified into a deep depression in the morning of 7 May. Thereafter it moved in a westerly direction till the evening of 8 May. Moving in a west-north-westerly direction it intensified into a cyclonic storm by the noon of 9 May. Continuing to move in a west- north-westerly direction it crossed Arabian coast close to and south of Salalah Port (Sultanate of Oman) around noon of 10 May.

A low pressure area formed over southeast Arabian Sea in the vicinity of Lakshadweep Islands. Signature of the low pressure area was also seen in the INSAT infra-red cloud imagery of 041200 UTC in the area bounded by longitudes 65 deg. E and 70 deg. E around latitude 10 deg. N in the form of the development of two small curved cloud bands hooking into each other at the leading edge of the deep layer convection spreading from Arabian Sea to the south-west Bay of Bengal. In the sub-sequent 3-hourly cloud pictures the convection increased around the centre and decreased to its east and south indicating ongoing development of a system. At 051200 UTC a ship near 10.0^0 N / 67.7^0 deg. E reported wind ENE/25 Kt. At 060000 UTC, a ship near 13.0^0 N / long. 68.5^0 E, reported wind SE/25 Kt. Thus the low pressure area deepened gradually and a depression formed in the morning of 6 May and was centred at 060300 UTC near lat. 11.0^0 N / long. 67.0^0 E. The associated cloud mass was to the west of the cloud system centre. In the morning of 6 May the sub-tropical ridge line at 200 hPa level was running across the Arabian Sea around 13 deg. N latitude.

The system moved in a north-westerly direction and became deep at 070300 UTC near lat.13.5^0 N / long.64.5^0 E. Thereafter it moved in a westerly direction till the evening of 8 May. At 080300 UTC the system centre was located 1.5 degree away from the main convective cloud mass. The system was down graded to a depression at 080300 UTC. It continued to move in a westerly direction. The system was again upgraded to a deep depression at 081200 UTC when it was located near lat. 13.5^0 N / long. 61.0^0 E. In the morning of 9 May the curvature of the cloud band around the system centre increased showing strengthening of the system. Continuing to move in a west-north-westerly direction the system further intensified into a cyclonic storm at 090600 UTC near lat. 14.5^0 N / Long.58.5^0 E. It continued its west-north-westerly movement till 100300 UTC when it was located near lat. 16.0^0 N/ long. 54.0^0 E. It moved slightly northwards and was located at 100600 UTC near lat. $16.5^{0\,N}$/ long 54.0^0 E. The cyclonic storm crossed Arabian coast close to and south of Salalah Port (Sultanate of Oman) by the noon of 10 May.

The track of the system is given in Fig. 2.2. A few INSAT cloud imagery of the system are given in Fig. 2.3.

Historical data shows that only a few cyclones that develop in the Arabian Sea in the month of May could track westwards up to the Arabian Coast. This had happened in the years 1886, 1889, 1911, 1916, 1919, 1927, 1959, 1960, 1963 and 1970. The cyclonic storm of May 1959 had also crossed Arabian coast close to and south of Salalah Port.

Weather realized
(Source: Sultanate of Oman, Ministry of Transport and communication)

The storm was associated with severe thunderstorms rain and strong winds. Salalah was flooded by rain waters. Significant amount of rainfall (in cm) are given below:

Salalah (41316)	5.9	Thamrait (41314)	2.4
Mina Salalah (41312)	6.7	Qairoon (41315)	25.1

Storm Surge

The storm surge caused rough sea conditions raising wave height upto 4 meters at the coast of Oman.

Damage

The system caused a great deal of social, economic, infrastructure and environmental damage. Nine people died and several others injured at the vicinity of the Governorate of Dhofar, Oman.

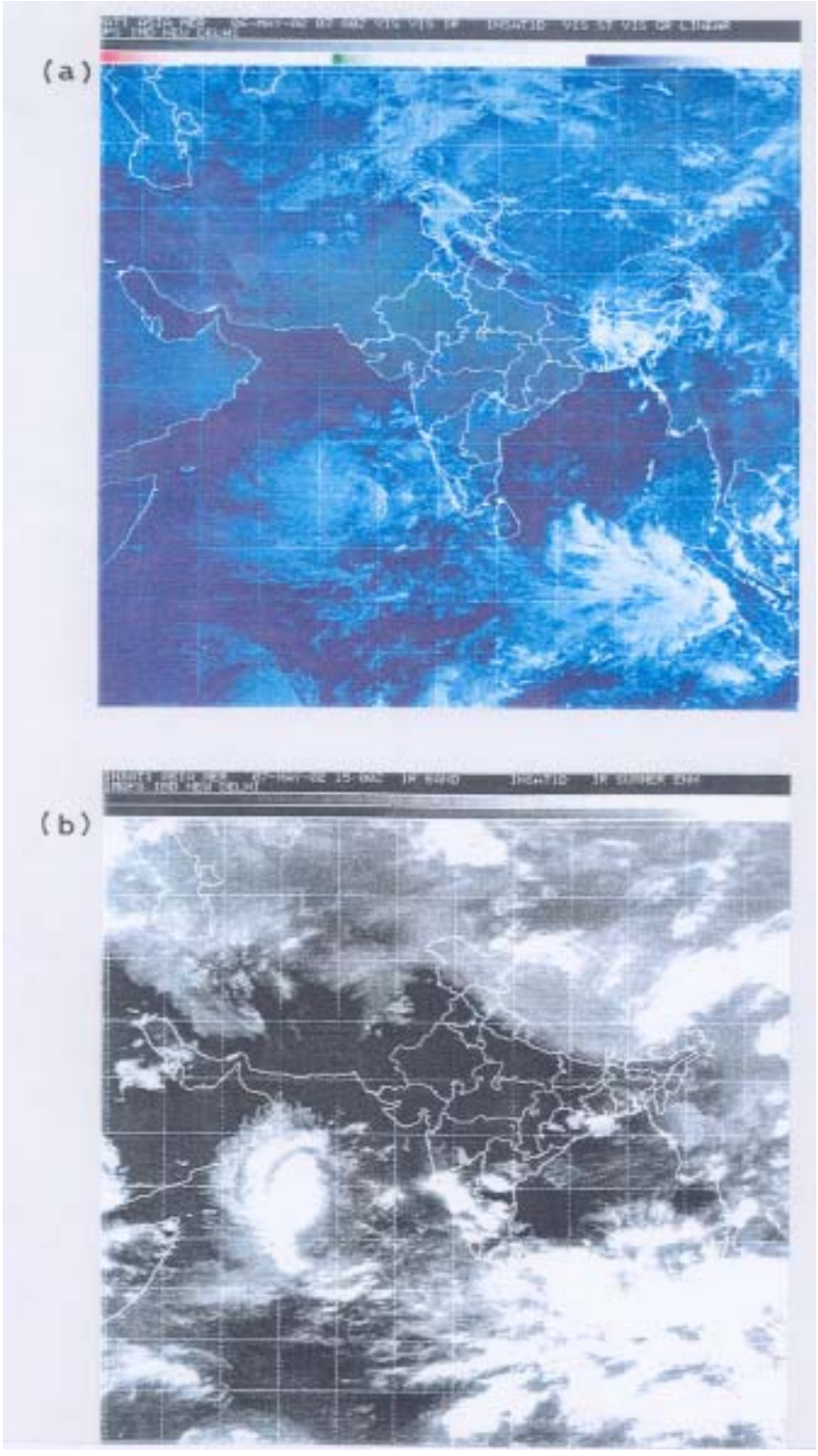

Fig. 2.3 Satellite pictures showing cloudiness associated with (a) a depression Over South Arabian Sea on 6 May and (b) a well developed comma shaped cloud when the system had deepened into a deep depression on 7 May.

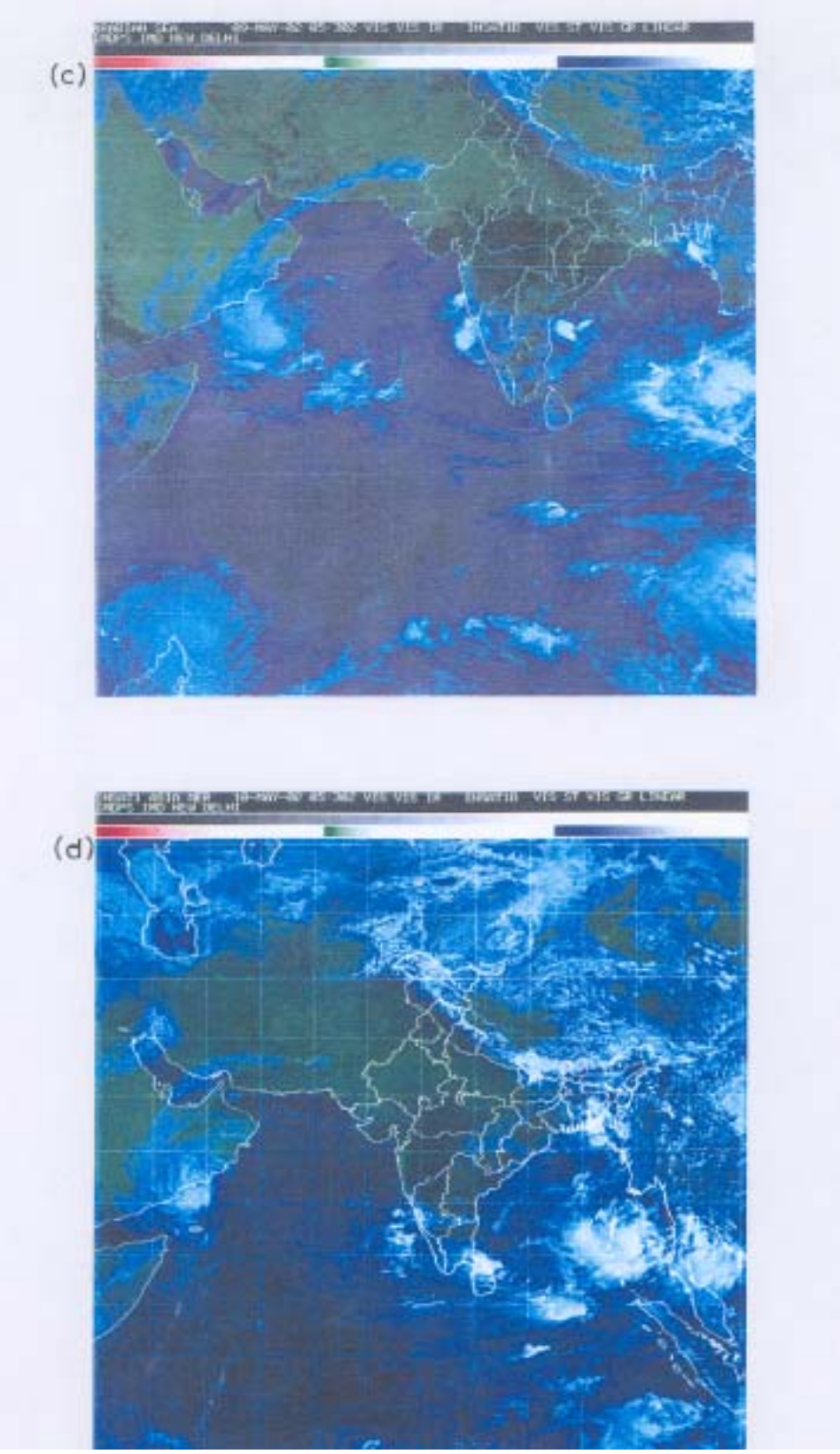

Fig. 2.3 (Contd) (C) satellite picture showing the cyclonic storm over west central Arabian Sea on 9 May and (d) when the cyclonic storm was close to Arabian Coast on 10 May. Also seen in the picture is a developing system over north Andaman Sea

2.2.2 Severe Cyclonic Storm over the Bay of Bengal (10-12 November 2002)

A depression formed over southwest Bay of Bengal in the morning of 10 November and lay centred near lat. 12.0^{0} N / long. 82.5^{0} E at 0300 UTC. Remaining practically stationary, it intensified into a deep depression at 1200 UTC on the same day. Moving in a north-north-easterly direction it further intensified into a cyclonic storm at 1200 UTC near lat. 16.0^{0} N / long. 84.5^{0} E. At this time the system had come close to the 200 hPa ridge line. The system remained practically stationary during the night of 11 November. Thereafter it came under the influence of a mid-latitude westerly trough and moved rather fast and lay centred near lat. 20.0^{0} N / long.87.0^{0} E at 0300 UTC of 12 November. Continuing to move in a north-north-easterly direction the system further intensified into a severe cyclonic storm at 120600 UTC and lay centred near lat. 21.0^{0} N /long. 87.5^{0} E. At this stage a banding type eye was seen by the Doppler Weather Radar (DWR) at Kolkata . At the next synoptic hour i.e. at 0900 UTC it again weakened into a cyclonic storm and crossed West Bengal coast south of Kolkata around that time. Moving in a north-easterly direction the system further weakened into a depression over Bangladesh in late night of 12 November.

The track of the system is given in Fig 2.2. . A few INSAT cloud imageries of the system are given in Fig.2.4. Cloud picture of the cyclone, taken by Doppler Weather Radar, Kolkata is given in Fig.2.5.

Weather realised

Under the influence of the system widespread rainfall with scattered heavy falls occurred over Orissa coast.

Damage caused

In Orissa, two trawlers collided head to head due to cyclonic storm and 18 inmates of the trawlers died and their dead bodies were seen floating near Dhamra port in Bhadrak district. Two trawlers were reported missing in Orissa. Two Persons died in West Bengal.

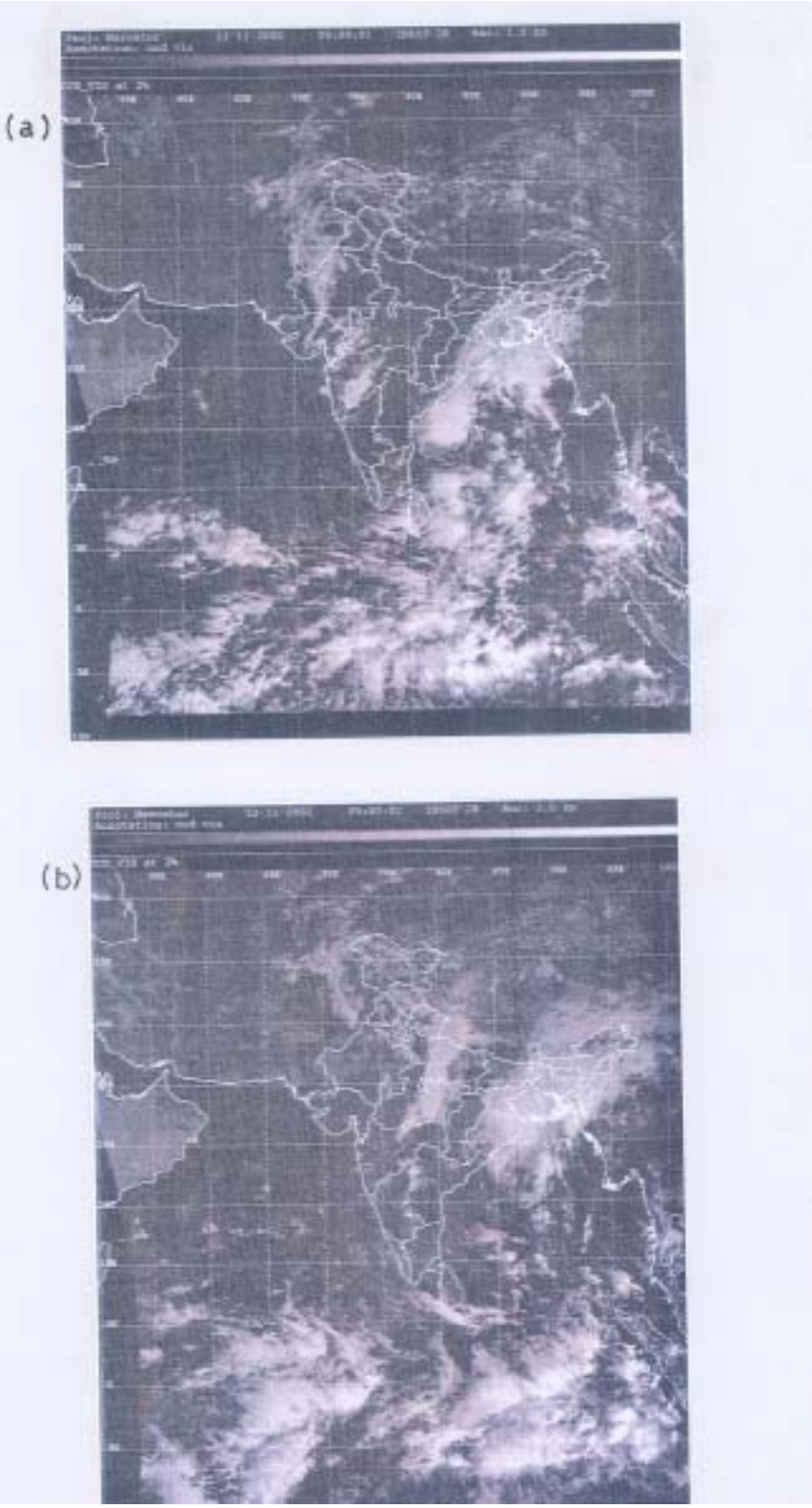

Fig. 2.4 Satellite cloud imagery showing cloudiness in association with (a) a deep depression over west central Bay of Bengal on 11 November (b) a cyclonic storm when it was close to West Bengal coast on 12 November. Also seen in the picture is cloudiness over central and north India in association with a westerly trough.

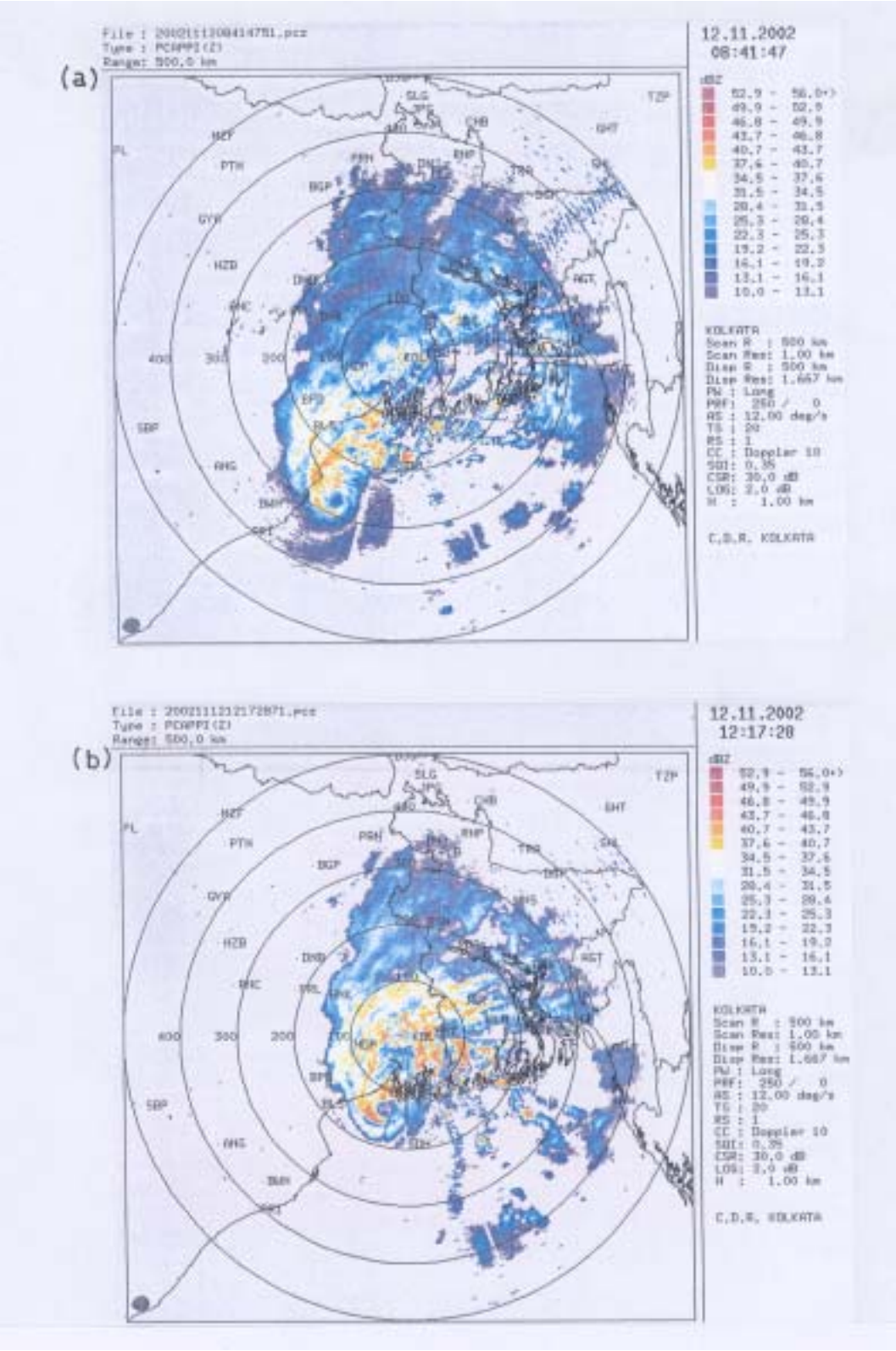

Fig. 2.5 Cloud Pictures of the cyclone taken by Doppler Weather Radar, Kolkata at (a) 08:41:47 and (b) 12:17:28 hours of 12 November 2002.

2.2.3 Cyclonic Storm over the Bay of Bengal (23 – 28 November 2002)

The equatorial trough was active in the Bay of Bengal in the week beginning from 21 November. In this active equatorial trough a low pressure area formed over south-east Bay of Bengal in the morning of 22 November at 0300 UTC. Moving in a north-westerly direction the low pressure area concentrated into a depression in the morning of 23 November and was located at 0300 UTC near lat. 10.0^{0} N / long .87.0^{0} E. Moving in a northerly direction It intensified into a deep depression at 1800 UTC near lat. 12.5^{0} N / long. 87.0^{0} E. It further intensified into a cyclonic storm on 24 November at 0300 UTC near lat.13.0^{0} N / long. 87.5^{0} E. The system moved slowly north-north-eastwards for the next 24 hours. Once again it showed north-eastward movement between 0300 and 1200 UTC of 26 November and took east-north-easterly course thereafter. It weakened into a deep depression on 27 November at 1200 UTC near lat. 17.2^{0} N / long. 91.0^{0} E. Moving very slowly north-eastwards it further weakened into a depression at 1800 UTC near lat. 17.5^{0} N / long. 91.0^{0} E. It moved in the same direction and maintained its intensity as a depression till 1200 UTC of 28 November. It further weakened into a low pressure area over sea itself.

The track of the system is given in Fig. 2.2. A few INSAT cloud imageries of the system are given in Fig. 2.6.

Weather realised

As the system remained far away from the coast, the east coast line of India was not affected.

Damage

No loss of life and damage to property was reported.

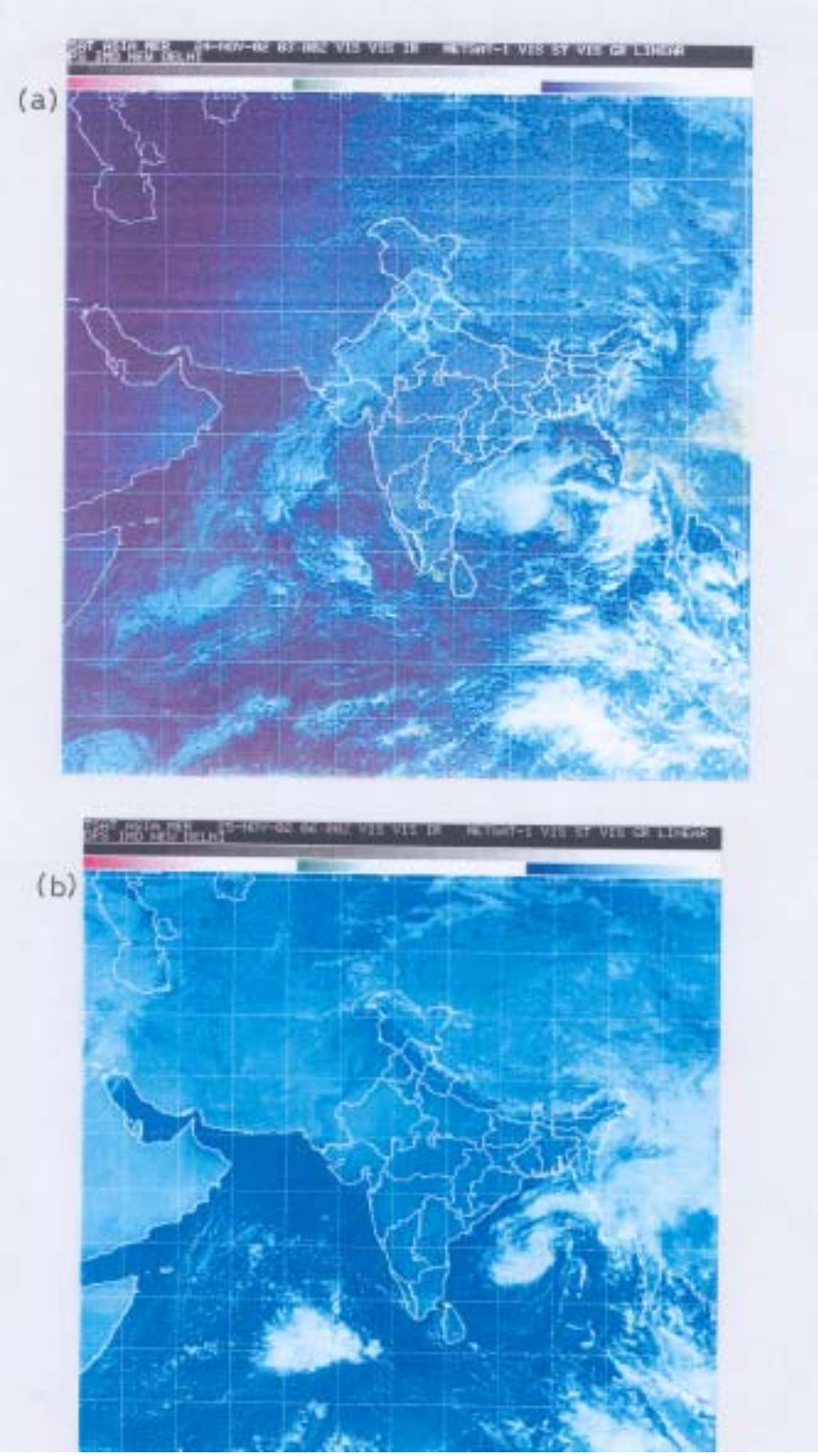

Fig. 2.6 Satellite pictures showing cloudiness associated with (a) Cyclonic storm on 24 November. Cumulus cloud lines clearly defining the centre outside the convection over central parts of Bay of Bengal and (b) cyclonic storm on 25 November. Sharp boundary of the convection could be seen in eastern and southern sectors.

2.2.4 Cyclonic Storm over the Bay of Bengal (21-25 December 2002)

In an active equatorial trough a depression formed off southwest coast of Sri Lanka over extreme northern parts of equatorial Indian Ocean in the morning of 21 December and lay centred near lat. 4.0^0 N/ long. 77.0^0 E. The system almost tracked eastwards till 0300 UTC of 23 December when it was centred near lat. 4.5^0 N/ long. 80.5^0 E. Under the influence of the steering flow of equatorial westerlies associated with a developing circulation close to the equator but south of it. The system continued to strengthen and intensified into a deep depression at 231800 UTC near at. 5.0^0 N / 81.0^0 E. Moving north-eastwards it further intensified into a cyclonic storm at 240300 UTC near lat. 5.5^0 N/ long. 81.5^0 E. Moving in a north-easterly direction the system maintained its intensity upto 250000 UTC and lay centred near lat.7.0^0 N/ long. 83.5^0 E. The system started weakening over southwest Bay of Bengal and moving in a north-easterly direction it weakened into a deep depression and was located at 250300 near lat. 7.0^0 N / long. 83.5^0 E. Moving east-north-eastwards the system further weakened into a depression and was located at 251200 UTC near lat. 7.5^0 N / long. 86.0^0 E. It weakened into a low pressure area at 251800 UTC over the southwest and adjoining southeast Bay of Bengal.

The track of the system is given in Fig.2.2. A few INSAT cloud imageries of the system are given in Fig.2.7.

Weather realised

As the system was away from the Indian coast line, no weather was experienced over the Tamilnadu coast line of India.

Damage

No damage to life and property were reported.

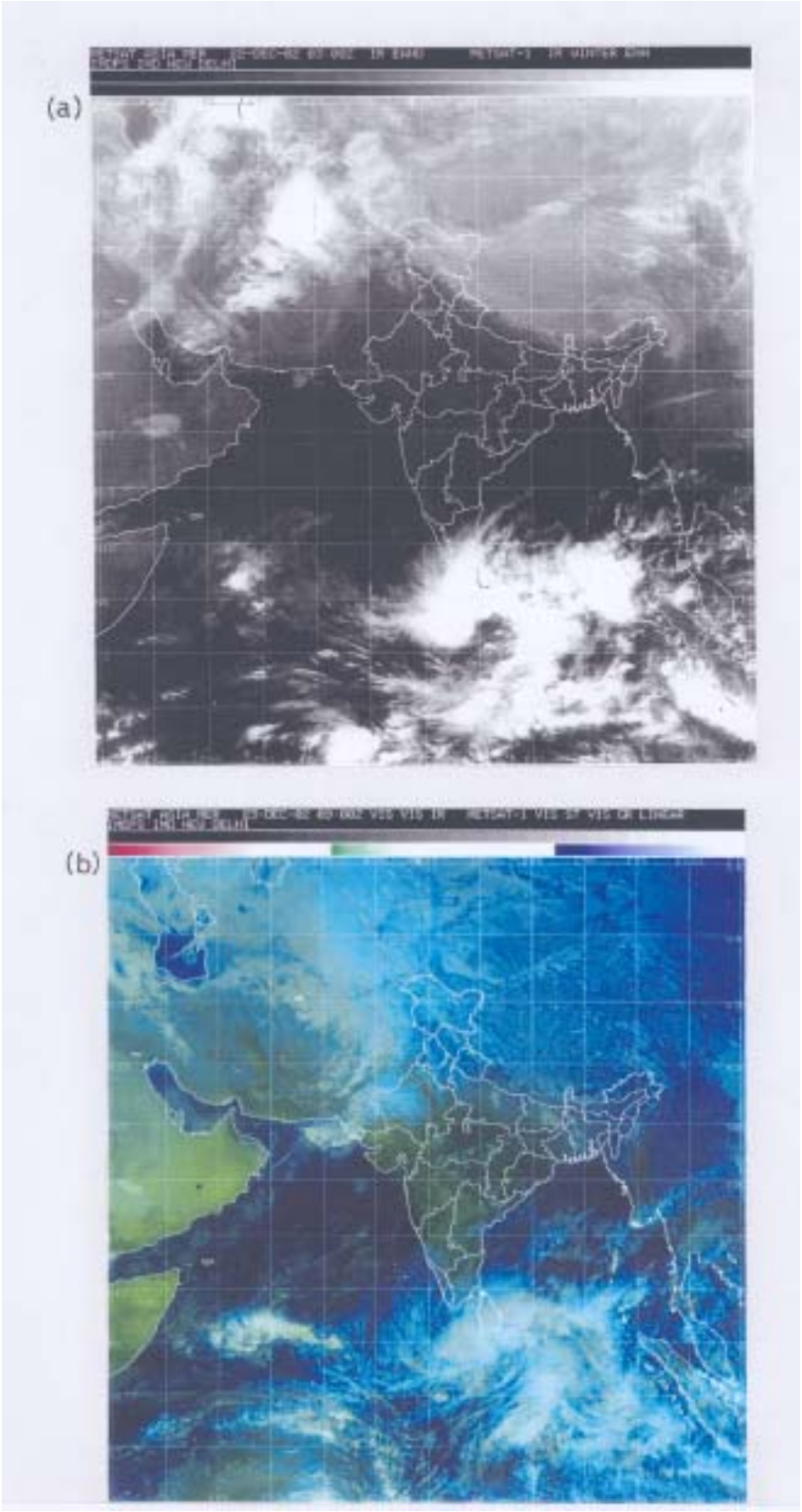

Fig. 2.7 Satellite cloud imagery showing cloudiness associated with a depression southwest of Sri Lanka and very close to equator (a) on 22 December and (b) on 23 December.

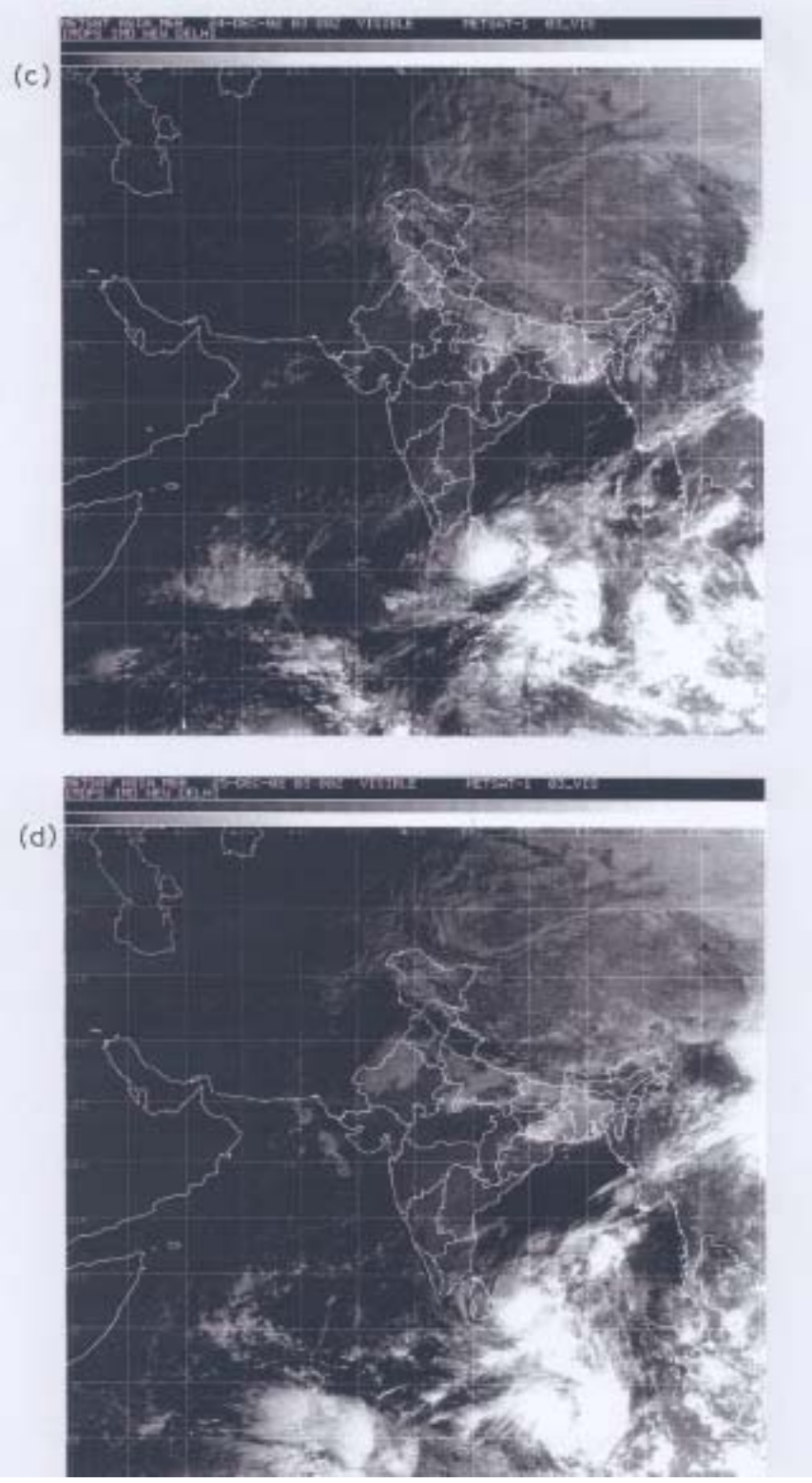

Fig. 2.7 – (Contd) © Satellite cloud imagery showing the system as a cyclonic storm south of Sri Lanka on 24 December and (d) on 25 December when the system had weakened into a deep depression.

2.3 Track Prediction

2.3.1 Track prediction Models

Track prediction is made operationally at RSMC- Tropical cyclones New Delhi by utilizing limited Area Forecast Model (LAM) .Quasi-lagrangian model (QLM), Climatology, persistence and combination of both (CLIPER) and Analogue.

2.3.2 Track prediction by Numerical Models

During the season LAM and QLM outputs such as initial development of the system and model predicted track forecasts were provided for the depression and cyclonic storms which formed during the year 2002. The QLM model was run to produce track forecasts based on the initial conditions of each day at 00 UTC and 12 UTC when the disturbance was in cyclonic storm stage, where as the LAM forecasts were produced regularly at 00 UTC and 12 UTC for day-to-day operational use. A Quantitative assessment of the performance of forecast model was made by computation of track prediction errors. TWO types of prediction errors have been computed. Direct position errors have been calculated by taking the geographical distance between the predicted position in each case of forecast and the corresponding observed position. The second type of error is the angular deviation between the observed and predicted track vectors starting from a given Initial position of the storm. While the former gives a measure of the absolute error of prediction, latter provides an indication of the closeness of the predicted direction of movement and the observed direction.

As the cyclones during November 2002 were either very fast moving or very slow moving, the model showed higher mean forecast track errors. Forecasts generated by other operational models also gave conflicting signals and no realistic and useful outputs could be achieved in respect of these cyclones. Table 2.1 contains the verification statistics of the mean position errors (km) and the angular deviation of the predicted tracks from the observed track (degrees), in respect of the two remaining cases. The mean position errors for 24H forecast by OLM ranges between 100 and 200 km. The overall average position error for the two cases works out to 150 km for 24 H forecast and 115 km for 36 H forecast.

The angular deviations varied from 50 to 150 in respect of 24 H forecast with average angular deviation of 10^0 for 24 H forecast and 12^0 for 36 H forecast.

Table 2.1
TRACK PREDICTION ERRORS (QLM)

Period	24 H		36 H	
	Position Error (km)	Angular Deviation (Deg)	Position Error (km)	Angular Deviation (Deg)
06-10 May (Arabian Sea)	200	05	120	07
21-25 December (Bay of Bengal)	100	15	110	17
Mean of above two cases	150	10	115	12

2.3.3 Track Prediction by other Models

The errors in the predicted positions from Persistence, Climatology, and Climatology & Persistence (CLIPER) models for the tropical cyclones in North Indian Ocean during 2002 are given in table 2.2. As the cyclone of 10-12 November 2002 displayed very fast movement (from a moderate speed of 15 Kmph in its initial stages to more than 30 Kmph on 11^{th} and 12^{th}), the statistics of the same is not included in Table 3.2. On an average Persistence performed better for 12 Hrs forecast with a mean error of 109 Km, Climatology performed better in 24 Hrs and 48 Hrs forecasts with mean error of 130 Km and 293 Km respectively and CLIPER performed better in 36 Hrs forecast with an average error of 236 Km.

Table 2.2

Forecast position errors (km) for Tropical Cyclones in the Bay of Bengal and the Arabian Sea in 2002 based on CLIMATOLOGY (C), PERSISTENCE (P) and CLIPER (CLIP) Models.

Date	12 Hours			24 Hours			36 Hours			48 Hours		
	P	C	CLIP	P	C	CLIP	P	C	CLIP	P	C	CLIP
06-10 MAY,2002	142	155		313	63	251	451	--	329	790	--	533
23-28 NOV ,2002	88	121	127	122	198	115	158	278	143	146	293	155
21-25 DEC,2002	97	--	--	139	--	--	131	--	--	205	--	--
Mean for three cases	109	138	118	191	130	183	246	278	236	380	293	344

CHAPTER 3

CONTRIBUTED PAPERS

CYCLONES & DEPRESSIONS

3.1 Cyclones and depressions over north Indian Ocean during 2001
V.Thapiyal, A.B.Mazumdar,V.Krishnan,
Meteorological Office Pune-411005
Published in "Mausam" Vol.53, No. 3 July 2002, pp 265---270

3.2 Post Monsoon Season (October-December 2001)
V.Thapiyal, A.B.Mazumdar,V.Krishnan,
Meteorological Office Pune-411005
Published in "Mausam" Vol.53, No. 4 November 2002, pp 543---558

3.3 Hot Weather Season (March to May -2001)
Thapliyal, V. Desai D.S., Krishnan V. Meteorological Office Pune-411005
Published in "Mausam" Vol.53, No.2 April 2001, pp 249-264

3.4 Development of super cyclone of Orissa and its impact,
Kalsi, S.R., Roy Bhowmik, S.K., Gupta, D.C. and Nath, S.M.,
Meteorological Office, New Delhi
Proceedings of the national symposium TROPMET-2001,
Indian Meteorological Society, Mumbai, February, 2001, pp. 60-67.

3.5 On forecasting cyclone movement using TOVS data
R. SURESH and S. RENGARAJAN,
Regional Meteorological Centre, Chennai -600 006
Published in "Mausam" Vol.53, No.2 April 2002, pp 215-224

3.6 Mean wind distribution around a typical cyclonic storm of the North Indian Ocean
Jayanthi N. Meteorological Office Pune, India Meteorological Department
Published in "Tropmet-2002" 11-14 Feb. at Bhubaneswar, India.

3.7 Orissa Super Cyclone-1999
Mahapatra. M., Gupta D.C., Chanchalani N.K. & Dastidar S.K. Meteorological Office Bhubaneswar, India Meteorological Department
Published in Volume VI, No.II, April 2002 Issue of "The Journal of Indian Geo-Physical Union"

3.6 A forecasting aspect of Thunderstorm over Calcutta and its paramaterialisation during pre-monsoon season
Basu G.C., Meteorological Office, Kolkata, India
Published in Mausam Vol. 5.3, No. 3, July 2002

CHAPTER 4

WMO TROPICAL CYCLONE PROGRAMME NEWS

4.1 Programme Activities of the Panel on Tropical cyclones in 2002

The thirtieth session of the WMO/ESCAP Panel on Tropical Cyclones was held at the Holiday Inn Hotel in Islamabad, Pakistan from 4-10 March 2003. The opening ceremony commenced at 10.05 a.m. on Tuesday, 4 March 2003 at the Holiday Inn Hotel, Islamabad, Pakistan. Dr Qamar-uz-Zaman Chaudhry, the Director-General of Pakistan Meteorological Department welcomed all the participants. He mentioned that the weather phenomenon like tropical cyclones, storm surges, floods, and droughts have no political frontiers. In this regard, he gave the historical background of how the Pane! was founded thirty years ago. He recognized that highly respected scientists, namely, Dr P.K. Das of India and Mr M Samiullah of Pakistan had taken part in the establishment of the intergovernmental body to be named WMO/ESCAP Panel on Tropical Cyclones. Dr Chaudhry was very pleased to hold the 30th session in Islamabad. He said that the meteorological community of the region had made a lot of achievement and has been making effective steps for implementing the agreed programmes of actions important to all nations. He wished the participants a pleasant stay in Pakistan.

On behalf of Prof. G.O.P. Obasi, Secretary-General of WMO, Mr Eisa H. AI-Majed the representative of the WMO Secretariat, welcomed all participants to the session and expressed the appreciation of WMO to the Government of Pakistan for hosting the session and for the excellent arrangements made. He mentioned that WMO's Tropical Cyclone Programme had already made significant strides in improving tropical cyclone warning systems. In addition, the rapid advancement in technology and development of the application of the atmospheric and related sciences had contributed to improved forecast of tropical cyclones with effective dissemination of warnings and wide awareness and preparedness of vulnerable population in most developing countries like Bangladesh which led to an impressive reduction of loss of life and property damage. Added to this is the effective role of the TC RSMCs and improved public awareness. Mr AI-Majed highlighted the expectations from the technical conference, which would be held in conjunction with the session. He assured the session that WMO would continue making every effort to support the Panel's work to the extent possible.

The Executive Secretary of UNESCAP, in his message transmitted by Mr Ti Le-Huu as representative of UNESCAP, expressed his appreciation to the Government of Pakistan for hosting this session in Islamabad and particularly for hosting the Technical Support Unit and providing the services of a coordinator and a meteorologist to support the activities of the Panel since 2000. He also expressed appreciation of the valuable contribution of India to the work of the Panel, especially through the forecasting services of the Regional Specialized Meteorological Centre at New Delhi. He pointed that the UNESCAP Commission, at its fifty-eighth session held in May 2002, noted with appreciation the achievements and the activities of the Panel and its

contribution to disaster reduction and preparedness measures through the excellent cooperation among its members. It expressed particular appreciation for the improvement in data exchange among several member countries of the Panel to enhance the effectiveness of flood forecasting in international river basins, and urged that such cooperation be further strengthened. He commended the Panel for its decision to establish a Working Group to Review the Coordinated Technical Plan and to adopt the theme "Tropical cyclone-related disasters and poverty alleviation in the Panel area" for the Panel's thirtieth session in 2003. He pointed out that, according to a recent study, Asia and the Pacific is the region most severely affected by water-related disasters, especially by floods which affected over 1,500 million people and caused a total flood damage of over US$ 110 billion during the last decade and that the people most severely affected by annual disasters are the poor. He noted that Asia, especially South Asia, is the region where the majority of the World's poor live and therefore emphasized the fact that the most important challenge in regional cooperation would be to mitigate the impacts of these natural disasters and to create opportunities to synergize national efforts for economic development in this sub region to contribute to poverty eradication. He assured the session that UNESCAP would continue to undertake activities in support of the Panel within the framework of its own programme of work and available resources.

In his inaugural address, His Excellency, Mr Rao Sikandar Iqbal, Federal Minister of Defence, extended a warm welcome to all the participants. He mentioned that meteorology had gained tremendous importance and recognition for their services with time by the public, aviation, agriculture, disaster mitigation agencies and others. In this regard, he noted the increased accuracy of weather forecasts and warnings by the Pakistan Meteorological Department. The Minister expressed the appreciation for the joint efforts of WMO and UNESCAP in capacity building of National Meteorological and Hydrological Ser:vices of Panel Members that is aimed at strengthening the regional cooperation and coordination of activities for mitigation of tropical cyclones and poverty alleviation. Mr Rao Sikandar Iqbal also appreciated the work of the Panel on Tropical Cyclones. Furthermore, he encouraged the Members to strengthen their coordination in order to mitigate the disastrous effects of natural disasters and contribute to sustainable development and poverty alleviation. The Minister declared the session open and wished the participants a pleasant and fruitful stay.

4.2 Review of the Tropical Cyclone Operational Plan

The basic purpose of the operational plan is to facilitate the most effective tropical cyclone warning system for the region with existing facilities. In doing so the plan defines the sharing of responsibilities among Panel countries for the various segments of the system and records the coordination and cooperation achieved. The plan records the agreed arrangements for standardization of operational procedures, efficient exchange of various data related to tropical cyclone warnings, archival of data and issue of a tropical weather outlook for the benefit of the region, from a central location having the required facilities for this purpose, that is RSMC-tropical cyclones New Delhi, as agreed upon by the Panel.

The operational plan contains an explicit formulation of the procedures adopted in the Bay of Bengal and the Arabian Sea region for the preparation, distribution and exchange of information and warnings pertaining to tropical cyclones. Experience has shown that it is a great advantage to have an explicit statement of the regional procedures to be followed in the event of a cyclone and this document is designed to serve as a valuable source of information to be readily available for reference by the forecaster and other users, particularly under operational conditions.

The observer from ICAO presented to the Panel a working paper on the communication aspects of the tropical cyclone advisories and warnings for aviation. He stressed on the fact that tropical cyclone advisories and warnings for aviation (TCAs and TC SIGMETs) are part of the operational meteorological (OPMET) information. According to Annex 3/WMO No. 49, Technical Regulations (C.3.1), p. 11.1.10, " The telecommunication facilities used for the exchange of the operational meteorological information should be the Aeronautical Fixed Service (AFS). In particular, AFTN links shall be used by TCAC New Delhi and the MWOs in the Panel area of responsibility for distribution of their products -TCAs and SIGMETs, in accordance with the ICAO ASIA/PAC and MID ANP/FASIDs. In order to provide clear instruction on the dissemination of the TCAs and SIGMETs, the ICAO observer proposed that the Operational Plan for the Bay of Bengal and the Arabian Sea should be amended. as shown below:

WMO headers for the exchange of tropical cyclone advisories for aviation and SIGMET

TC advisories		
Country	Abbreviated heading	Area
India	FKIN xx VIDP FKINyy VIDP	Bay of Bengal Arabian Sea
SIGMET for tropical cyclones		
Country	Abbreviated heading	Area
Bangladesh	WCBWxx VGDC	Dhaka
India	WCINxx VECC	Calcutta
Maldives	WCMVxx VRMM	Male
Myanmar	WCBMxx VYYY	Yangon
Oman (Sultanate of)	WCOMxx OOMS	Muscat
Pakistan	WCPKxx OPKC	Karachi
Sri Lanka	WCSBxx VCCC	Colombo
Thailand	WCTHxx VTBB	Bangkok

Notes:

1 TCAC New Delhi shall send the TC advisories to the MWO through AFTN. In addition to the MWOs listed above , the advisories shall be sent to all MWOs in the are of responsibility of TCAC New Delhi according to ICAO ASIA/PAC and MID Regions FASIDs.

2 TCAC New Delhi shall send the TC advisories to Singapore OPMET Data Bank- AFTN address WSSSYMYX

3 The MWOs listed above, shall send their SIGMETs for tropical cyclones through AFTN to the MWOs responsible for the adjacent FIRs and to Singapore OPMET Data Bank- AFTN address WSSSYMYX.

In this regard, the communication centres of the Panel Member countries should decide on the bulletin numbers, provisionally indicated in the proposal as "xx", to be used for the TCAs and SIGMETs bulletins.

The ICAO observer informed the meeting that the MET Divisional Meeting held in September 2002, Montreal, Canada, conjointly with the XII Session of the WMO Commission for Aeronautical Meteorology (CAeM) expressed serious concern on the non-implementation of the ICAO Annex 3/WMO No. 49 (C.3.1) provisions related to the issuance of TC advisories for aviation. In this regard, the MET Divisional Meeting adopted Recommendation 1/21, which requests the tropical cyclone advisory centre Provider States/Members to implement, as a matter of urgency, the issuance of tropical cyclone advisories for aviation in the format specified by ICAO. On request by the meeting the ICAO observer provided a briefing on other important outcomes from the MET Divisional Meeting, 2002. He also encouraged the Panel Members to strengthen the liaison with their national Civil Aviation Administrations to ensure timely receipt of all correspondence and documentation related to aeronautical meteorology distributed by ICAO.

The Panel submitted to WMO the changes necessary with a view to issuing an updated version of the Operational Plan to replace the 2002 edition. The Panel invited VMO to issue the year 2003 edition as soon as possible.

4.3 Support for the Panel's Programme

The Panel was briefed on the activities of the WMO's Technical Cooperation Programme (TCP). The Pane! Expressed its appreciation to the WMO Secretariat for its continued support to its Members by providing support through VCP and implementing projects. It urged its Members to increase their support and give priority to the WMO/TCP and Technical Cooperation among Developing Countries (TCDC).

The Panel was pleased to note with appreciation the continued activities implemented by the various Panel Members under the TCDC.

The Panel Members were encouraged to use the Strategic Plan for the enhancement of National Meteorological Services (NMSs) in Regional Association II (Asia) for the period 2001-2004 for the development of assistance programmes and projects. The Panel was informed of some activities undertaken by WMO within the framework of the Strategic Plan.

The Panel encouraged its Members to approach the various national economic sectors in the effort to mobilize resources for the Panel's activities.

The Panel noted with appreciation that WMO and UNESCAP would continue to undertake activities in support of the Panel on Tropical Cyclones.

The Panel was informed that a regional project is being formulated for the use of PC clusters in Numerical Weather Prediction between the Republic of Korea and WMO. The Panel urged WMO to finalize the document of the project and to submit it to the Members for consideration and appropriate participation.

The Panel was pleased to note that the Pakistan Meteorological Department (PMD) had recently introduced Data Switching System in its services. The Panel requested PMD and WMO to formulate a project for Panel Members who are in need of such facilities within the framework of the implementation of the Strategic Plan for Enhancement of NMSs in Asia.

The Panel was informed by WMO that its Members had made voluntary cash contributions to the Trust Fund. The Panel expressed its appreciation to all Members for their contributions, in particular, Sri Lanka, which had increased their contributions to USD 2000 for the year 2003 as, agreed upon at the twenty-ninth session. Oman would consider paying its contribution at US$2,000 for 2003. Furthermore, the Panel welcomed any additional contributions by its Members.

The Panel approved to meet from the Trust Fund the running cost of the TSU, the printing of the Pane! News, running cost of its website and monthly honorarium for the TSU Meteorologist with an overall amount of US$4,000 for 2003.

The Panel also approved to meet from the Trust Fund a maximum amount of US$4,000 for important activities of the Panel during the inter-sessional period. Such expenditures will be subject to the approval of the Chairman of the Panel in his capacity as Coordinator of TSU and the vice-Chairman of the Panel. This should be in accordance with Trust Fund rules.

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