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FOR ASIA AND THE PACIFIC

AND

WORLD METEOROLOGICAL ORGANIZATION

REPORT ON THE SECOND JOINT SESSION OF THE PANEL ON TROPICAL CYCLONES AND THE TYPHOON COMMITTEE

Phuket, Thailand
20 - 28 February 1997

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ORGANIZATION OF THE SESSION

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I. ORGANIZATION OF THE SESSION (Agenda item 1)

1. At the kind invitation of the Government of Thailand, the Second Joint Session of the Panel on Tropical Cyclones and the Typhoon Committee was held at Phuket, Thailand from 20 to 28 February 1997. The Session was co-sponsored by the World Meteorological Organization (WMO) and the Economic and Social Commission for Asia and the Pacific (ESCAP) of the United Nations.

Attendance

2. The Session was attended by 70 participants and 11 observers. They represented 6 (out of 8) Members of the Panel on Tropical Cyclones, namely, Bangladesh, India, Sultanate of Oman, Pakistan, Sri Lanka and Thailand and 12 (out of 13) Members of the Typhoon Committee, namely, Cambodia, China, Hong Kong, Japan, Lao PDR, Macau, Malaysia, Philippines, Republic of Korea, Singapore, Thailand and Vietnam.

3. Observers from Brunei Darussalam, Indonesia, Papua New Guinea, and the United States of America (USA) also attended the session. In addition, the President of the Regional Association II (Asia) of WMO and observers from the International Civil Aviation Organization (ICAO) and the WMO Commission for Atmospheric Sciences (CAS), and WMO, ESCAP and the Technical Support Unit (TSU) of the Panel on Tropical Cyclones and the Typhoon Committee Secretariat (TCS) also attended. The list of participants is attached as Appendix I.

Opening of The Session (Agenda item 1(a))

4. The Joint Session observed a minute of silence on the passing away of Mr Deng Xiaoping, a great leader of China.

5. The opening meeting was addressed by representatives of the host Government and the two sponsoring Organizations. Mr Smith Tumsaroch, Director-General of the Thai Meteorological Department (TMD), welcomed all participants. He expressed his appreciation to Prof. G.O.P. Obasi, the Secretary-General of WMO for his endeavours and close cooperation, and to WMO and ESCAP for their support during the past year. He mentioned that natural disasters such as tropical cyclones, floods and storm surges in the area of the Pacific Ocean and the Bay of Bengal are causing serious loss of human lives and damage to property every year. Thus, appropriate measures would be needed for prevention of and preparedness for the disasters caused by tropical cyclones. He added that the advancement of weather prediction relating to the movement of storms is one of the most beneficial and useful tools to the people and property. Mr Tumsaroch, said that it was a good opportunity for the participants to discuss and exchange their knowledge and experience and wished them success in their endeavours and a pleasant stay in Phuket.

6. Professor G.O.P. Obasi, Secretary-General of WMO, thanked the Government of Thailand for hosting the Second Joint Session of the Panel on Tropical Cyclones and the Typhoon Committee. He also expressed his appreciation to Mr Smith Tumsaroch, Director-General of TMD for the excellent arrangement made to ensure the success of the session. He extended a warm welcome to all the participants. He thanked the Government of the Philippines

and Thailand for hosting the two Secretariats and also thanked the Government of Bangladesh which hosted the TSU of the Panel from 1985 until its transfer to Bangkok in December 1996 and to the Governments of Japan and the Republic of Korea for the secondment of full-time hydrologists to the TCS. He also extended the thanks of WMO to ESCAP for its standing close cooperation and support to the activities of the Typhoon Committee (TC) and the Panel on Tropical Cyclones (PTC).

7. The Secretary-General complimented the Panel and the Committee for their past achievements. He highlighted the events of tropical cyclones that occurred recently in Asia. In this connection, he mentioned that within the context of the Tropical Cyclone Programme, a noticeable improvement in the warning systems had resulted in many parts of the world. Anyhow further improvements were still needed, such as, the accuracy and reliability of cyclone forecasts, particularly of unusual movements, sudden changes in intensity and long-range position forecasts. Additionally, the interaction between the National Meteorological and Hydrological Services (NMHSs) and the national agencies concerned with disaster prevention and preparedness has to be further strengthened. In this regard, a number of activities to be promoted in the context of the programmes of the Panel and the Typhoon Committee, among others, are the improvement of meteorological observing networks, upgrading of flood forecasting systems, development of numerical storm-surge models, and storm surge training. In closing, he wished the participants a very successful session.

8. The representative of ESCAP delivered the message of the Executive Secretary of the ESCAP of the United Nations. He welcomed the participants and expressed appreciation to the Government of Thailand for hosting the Second Joint Session. He recalled that ESCAP had played an important role in mitigating water-related natural disasters since its formation five decades ago. ESCAP had assisted in establishing both the TC and the PTC and would continue to work on water-related natural disaster reduction activities under the umbrella of the International Decade for Natural Disaster Reduction (IDNDR). In this connection, the participants were informed that ESCAP was organizing a Workshop on Guidelines and Manual on Land-Use Planning and Practices in Watershed Management and Disaster Reduction in Asia and the Pacific, at ESCAP Headquarters in Bangkok from 18 to 21 March 1997, and that a number of member countries of the PTC and the TC had been invited to attend.

9. Considering the number of meteorological and water-related natural disasters that continued to affect the region seriously, it was clearly underscored that the Members of the PTC and the TC had an enormous amount of work to do. They needed to enhance their cooperation in improving emergency facilities and early warning systems, flood protection measures, training programmes and technical cooperation among developing countries. This session provided another unique opportunity for the Members of the Panel and the Committee to exchange their experience over the last five years and improve regional cooperation on disaster mitigation. In this connection, the financial-support which had been provided by the United Nations Development Programme (UNDP) for the work of these two bodies was recalled with appreciation and the hope was expressed that, with the expanded cooperation that should result from the present Joint Session, this support would be revitalized. ESCAP acknowledged with gratitude the valuable support and cooperation of WMO in these important disaster mitigation efforts. Participation of the Secretary-General of WMO in this session was a reaffirmation of WMO's commitment to this productive partnership.

10. H.E. Mr Somsak Thapsuthin, Deputy Minister of Transport and Communications, welcomed all participants to Phuket. He recalled that the First Session was organized by the Meteorological Department in Pattaya, Chonburi, in 1992. He added that the objectives of the Second Session were to follow up its activities and recommendations including the exchange of knowledge and experiences among the agencies concerned, and to increase the capability of the Committee and the Panel in order to reduce the effects of natural disasters and to find some ways and means to protect against and avoid the damages caused by typhoons and tropical cyclones.

11. The Deputy Minister expressed his sincere thanks to all concerned in particular to WMO and UNDP for their kind support to the work of the Committee and the Panel. He wished the participants a successful session.

12. The Committee witnessed the awarding of the ESCAP/WMO Typhoon Committee Natural Disaster Prevention Award for 1996 to Mr Smith Tumsaroch, Director-General of the TMD. The award was presented by Dr Roman L. Kintanar, Chairman of the Typhoon Committee Foundation Incorporated (TCFI). The citation of the award read:

"In recognition of his outstanding services as Director-General of the Thai Meteorological Department, and of his tireless efforts in the promotion of people's awareness in reducing the impact of disasters caused by tropical cyclones in Thailand. Given on the occasion of the Second Joint Session of the Panel on Tropical Cyclones and the Typhoon Committee in Phuket, Thailand, on 20 February 1997".

13. Mr Smith Tumsaroch upon receiving the Award, made a short statement thanking the TCFI and informed the session that he decided that the cash awarded to him would be used to inaugurate a similar award supporting the Panel's activities. He announced that he was setting up *"The Smith Tumsaroch Foundation"* for this purpose by providing an additional amount as his own personal contribution.

14. The Session expressed its appreciation and support to Mr Tumsaroch for establishing the Foundation for the Panel.

Election of Officers (Agenda item 1(b))

15. Mr Smith Tumsaroch (Thailand) was unanimously elected as the Chairman and Mr Yan Hong (China) and Mr Shravan Kumar (India) as the Vice-Chairmen.

Adoption of the Agenda (Agenda item 1(c))

16. The Joint Session adopted the agenda as shown in Appendix II.

Application for Membership (Agenda item 1(d))

17. The ESCAP representative informed the session that the Government of Singapore, following the established procedure, had approached ESCAP for TC membership. ESCAP had circulated a communication to all Members of the Committee to this effect, and Singapore's application for membership received unanimous support. Accordingly, the TC welcomed

Singapore as a new Member from 20 February 1997.

18. The representative of the Sultanate of Oman expressed the wish of his Government to become a Member of the PTC. The Panel welcomed the Sultanate of Oman as a new Member from 20 February 1997.

Change of name of Member of ESCAP/WMO Typhoon Committee (Agenda item 1(e))

19. The TC was informed that with effect from 1 July 1997, Hong Kong will become a Special Administrative Region of the People's Republic of China. According to para. 36 and 37 of the Report of the 52nd Session of the ESCAP held in April 1996 and also Resolution 8 (EC-XI.VIII) of the 48th Session of the Executive Council of the WMO held in June 1996, in which it had been similarly decided that Hong Kong will continue its membership and will be listed as *"Hong Kong, China"* with effect from 1 July 1997. In consideration of the above, the membership of "Hong Kong" in the ESCAP/WMO TC will be changed to *"Hong Kong, China"* with effect from 1 July 1997.

Establishment of subcommittees (Agenda item 1(f))

20. Two Committees were established by the Joint Session: Committee A to discuss agenda items relevant to the Panel and Committee B to discuss items of interest to the TC. Mr Md. Sazedur Rahman (Bangladesh) was elected as the Chairman of Committee A (Panel), and Dr H.K. Lam (Hong Kong) as the Chairman of Committee B (Typhoon Committee). Dr J.T. Lim (Malaysia) was elected as the Chairman of the Drafting Committee.

Working arrangements (Agenda item 1(g))

21. The programme of work and the working arrangements, including hours of work were agreed upon.

II. ANNUAL PUBLICATIONS (Agenda item 2)

Typhoon Committee Annual Review and Typhoon Committee Newsletter (Agenda item 2 (a))

22. During the Session of the PTC and the TC, the Joint Session noted with satisfaction the publication of the eleventh edition of the *ESCAP/WMO Typhoon Committee Annual Review (1995)* through the commendable efforts of the Chief Editor provided by the TCS, the National Editors provided by the Members and the assistance of Hong Kong. The delegate from Hong Kong proposed that the TCS continue to prepare the Annual Review for the time being.

23. The eighth issue of the *Typhoon Committee Newsletter (1996)* was published by the TCS in September 1996.

Panel News (Agenda item 2(b))

24. The Joint Session was informed that *Panel News* had been issued eight times in the past 16 years. The ninth issue, prepared in the TSU recently transferred to Bangkok, was distributed

during the session. It was explained that its limited form was the result of there being insufficient time to obtain more material from Panel Members. The session welcomed the reappearance of Panel News and encouraged its Members to provide contributions of interest on national events to the TSU for inclusion in future issues. It thanked the Co-ordinator of TSU for his considerable effort in this connection and expressed its appreciation to the TMD for printing the latest issue.

25. It was noted that the TC issued two separate publications, the main one being an annual review of the preceding typhoon season which constituted a listing and invaluable record with detailed information on each tropical cyclone affecting its Members. A separate TC Newsletter reported on the annual session and also contained news items of general interest to Members.

26. The Panel decided to adopt a similar practice, thus making the publications compatible in the two adjacent tropical cyclone basins covered by their programmes. It further decided that each Member of the Panel should designate a national editor who would be responsible to prepare and send detailed information on the season's storms to the Regional Specialized Meteorological Centre (RSMC)-tropical cyclones New Delhi. TSU will do the necessary coordination in this regard. An offer by India to provide a chief editor for the annual review was warmly welcomed by the Panel. It was agreed that the annual review would be compiled by the chief editor in India, in camera-ready form and sent to the WMO Secretariat for printing and distribution in due course. The Panel expressed its appreciation to WMO for its offer to assume the cost of printing the review. Favourable comments were also made on the *"Report on Cyclonic Disturbances over North Indian Ocean during 1996"*, prepared by the RSMC-tropical cyclones New Delhi and distributed at the Joint Session. The present practice of submitting this report to the Panel Session will be continued.

27. Finally, the Panel confirmed that Panel News would continue to be issued once or twice a year and requested its TSU to coordinate and edit available contributions. It thanked Thailand for its offer to assist in the production of Panel News and instructed the TSU to use such resources as might be available to it through, for example, the host country or the Panel Trust Fund when it became adequately established.

III. REVIEW OF THE 1996 TROPICAL CYCLONE/TYPHOON SEASON (Agenda item 3)

Review of the 1996 Tropical Cyclone Season

RSMC-tropical cyclones New Delhi

28. The delegates of India presented the report of RSMC-tropical cyclones New Delhi.

29. During 1996, nine cyclonic disturbances formed over North Indian Ocean, six of which formed over the Bay of Bengal, two over the Arabian Sea and the remaining one was a land depression. The North Indian Ocean was very active during the post-monsoon season (October-December) with five systems. Two of these cyclones exhibited unusual southwestward movement. The Bay of Bengal cyclone from 28 November - 6 December displayed double-looping, which is uncommon. The Arabian Sea cyclone of 17-20 June crossed the Saurahtra coast near Diu. This was the first system to cross the Gujarat coast after a gap of more than a decade.

30. The Bay cyclone of 12-16 June formed at a very low latitude (11°N) which is also very rare. The Bay cyclone of 5-7 November crossed the Andhra coast about 50 km south of Kakinada causing extensive damage to life and property. The total loss of human lives was reported as 978. Estimated maximum winds of the order of 150 kmph, reaching 200 kmph in gusts, prevailed during cyclone landfall. The Bay cyclone of 28 November - 6 December had a very long life of 9 days which is a unique feature.

31. These cyclones were tracked by Indian Satellite (INSAT) imageries and the cyclone detection radars located along the east and west coasts of India.

32. Warnings issued during these cyclones were timely and adequate which was appreciated by the respective state Governments.

33. RSMC-tropical cyclones New Delhi issued 58 tropical cyclone advisories at 6-hourly intervals to the Panel members. The upper-air data and radar observations from Bangladesh during 7-8 May were very useful for the finalization of the track and severity.

34. A summary of the 1996 cyclone season over the North Indian Ocean, based on the RSMC-tropical cyclones New Delhi report provided to the session, is given in Appendix III.

RSMC Tokyo -Typhoon Center

35. The 1996 tropical cyclone season opened with the formation of a tropical storm towards the end of February. By the end of December, a total of twenty six tropical cyclones had developed, which is within the normal annual average of tropical cyclones in the Western North Pacific and South China Sea areas.

36. Four of these, 9604, 9607, 9611 and 9619 formed over the South China Sea or its marginal waters. Four of them made landfall in Indochina or southern China, while 9604 migrated over the waters south of Japan.

37. The remaining twenty two tropical cyclones developed over the sea east of the Philippines or the sea south of Japan. Two of them, 9601 and 9602 dissipated over Philippine land mass while one, 9622, dissipated over the South China Sea. Most of the others took a normal recurving track and migrated into the Western North Pacific. Two of the 1996 tropical cyclones, 9610 and 9615, exhibited unusual tracks.

38. Viet Nam had a very active season in 1996 with a total of 7 tropical cyclones crossing the country.

39. A tropical depression which was spawned in the South China Sea on 23 December 1996 made landfall on the state of Sabah in East Malaysia around 1800 Universal Time Coordinated (UTC), 25 December 1996. The disturbance inflicted enormous loss of lives and property, numbering 238 dead and monetary damage amounting to US$ 120 million. This is the first recorded event of Malaysia being struck by a tropical disturbance.

40. The RSMC Tokyo-Typhoon Center, Japan Meteorological Agency (JMA), had kindly provided the Session with a comprehensive summary of the 1996 typhoon season over the Western North Pacific Ocean and South China Sea. Details of this report are given in Appendix IV.

IV. NATIONAL REPORTS ON ACTIVITIES AND DEVELOPMENTS DURING 1996 UNDER THE REGIONAL COOPERATION PROGRAMMES (Agenda item 4)

41. The Session reviewed and evaluated in-detail the activities of the Members of the Panel and the Committee during the past year under the meteorological, hydrological, disaster prevention and preparedness, training, and research components of their programmes. Detailed reports are presented in Appendix V and, for the purpose of the Session, are only summarized.

42. The Session was informed that in 1996, the Members of the TC continued to devote considerable efforts to improving their observation facilities and operations necessary for the rapid and efficient collection and distribution of the required observational and processed information. A number of radars were established and upgraded during the year and it was noted that the Members continued to aim for faster speeds in telecommunications. Advances in computers, satellite systems, and limited-area numerical weather prediction models were also noted. The launching of Geostationary Meteorological Satellite (GMS-5) in mid-1995 ushered in a new era in satellite technology. It is equipped with two new sensors, the split-window channel, and the water-vapor channel, aside from the visible and infrared sensors of GMS-4. The Analyzing Forecasting Data - Processing Operational System (AFDOS) is now in operational use in China, Maldives and Myanmar in this region. The new version (version 5.0) of the system had been

developed recently with new technology such as: open retrieving technique, standard topographic color map, three kinds of projectional coordinate and multi-media technique.

43. In the area under the responsibility of the PTC, development in the installation or refurbishment of upper-air stations were noted in several countries including Bangladesh and Sri Lanka. Important improvements had been made in the storm warning radar network, India having installed new wind finding/storm warning radars replacing the old ones at 10 stations. Thailand has newly installed five X-band Doppler radars. Considerable efforts were made to complete essential telecommunication links or to upgrade the performance of existing circuits, including the New Delhi-Bangkok circuit.

44. India informed the Joint Session that some of the data products made available from INSAT, including cloud motion vectors are disseminated twice daily over the Global Telecommunication System (GTS). Products derived from processed satellite data comprise sea surface temperature, outgoing long wave radiation, quantitative precipitation estimates and vertical temperature profiles.

V. COORDINATION OF ACTIVITIES (Agenda item 5)

Coordination within the Tropical Cyclone Programme (Agenda item 5(a))

45. The WMO Secretariat made a presentation to the Joint Session on the WMO Tropical Cyclone Programme (TCP). The session expressed appreciation for the comprehensive report on the latest level of action implemented within the framework of the TCP. The Session noted with satisfaction the achievement and progress made during 1996 in both the general and regional components of the TCP, especially in association with IDNDR.

46. In response to the request of the Panel, a joint Seminar on Meteorological and Hydrological Risk Assessment was organized as part of the twenty-third session of the Panel. The Seminar took place at the India Meteorological Department from 16 to 19 March 1996. It was attended by 45 experts from the Panel and the TC Members, as well as from regional organizations concerned. Financial assistance for participants from Members of the Committee was provided from the Typhoon Committee Trust Fund (TCTF). The Session noted with satisfaction the publication in July 1996 of the proceedings of the Seminar, including a summary and recommendations, as a WMO Technical Document (WMO /TD-No. 761) in the TCP series (Report No. TCP-40).

47. The Session invited Members to make full use of reports in the TCP series, such as the recently issued "Global Perspectives on Tropical Cyclones" (TCP-38), the "Global Guide to Tropical Cyclone Forecasting" (TCP-31), "Papers presented at the workshop on storm surges for the Bay of Bengal" (TCP-35) and "Papers presented at Technical Conferences on Special Experiment Concerning Typhoon Recurvature and Unusual Movement (SPECTRUM)" (TCP-27, 29, 33 and 39), which provide guidance and information for tropical cyclone forecasters and researchers. It also invited Members to take advantage of relevant training events such as the biennial training courses on tropical meteorology and tropical cyclone forecasting, and on operational hydrological forecasting, organized by the USA in cooperation with WMO. The Session requested the Secretary-General of WMO to continue providing maximum support for the training courses to qualified candidates from the Panel and the Committee Members within the limits of available funding.

Coordination of activities common to the PTC and the TC (Agenda item 5(b))

48. The Session recalled the fact that the two tropical cyclone basins for which the PTC and the TC, respectively, are responsible are adjacent and linked by the common membership of Thailand. It was further noted that occasionally the same tropical cyclone may affect Members of both groups (e.g. Typhoon Gay in 1989). These circumstances created a situation that could conceivably call for common activities.

49. In past years, common activities had chiefly been training events such as seminars, workshops, etc., and mostly in technical subjects such as forecasting, radar, satellites and storm surges. Whilst there was a continuing need for training activities of this type, the Session felt that it would be possible to expand the scope of these events to give greater prominence to, for example, tropical cyclone disaster preparedness and prevention activities and that they should be conducted within the framework of the IDNDR. The Members of the Panel and the TC were requested to keep under review their requirements for training so that arrangements could be made to meet them to the greatest possible extent.

50. It was further observed that little had been done so far to encourage joint research projects between the two groups of Members. The representative of China suggested that improvement of the operational system should take priority although smaller, joint investigations of problems of common interest were to be encouraged. Mention was made of potential topics such as the frequency and preferred periods for tropical cyclones the tracks of which passed from the Committee's area of responsibility into that of the Panel. There might be a number of noteworthy features of such storms meriting further investigation. Members of the Panel and the TC were invited to forward their views on desirable topics for limited common research activities to the TSU and TCS for further consideration at forthcoming sessions of the two regional cyclone bodies.

Meteorological Component

Eleventh Session of WMO Regional Association II (Asia)

51. The Joint Session noted that the eleventh Session of WMO Regional Association II (Asia) (XI-RA II) was held in Ulaanbaatar, Mongolia from 24 September to 3 October 1996.

52. The Association adopted the text under "World Weather Watch Programme - Regional Aspects" for inclusion in the general summary of XI-RA II. Particular interest was expressed by the Joint Session in the following paragraphs of the text relevant to the programmes of the Panel and the Committee.

53. Global Data-Processing System (GDPS)

(i) The Association expressed appreciation to the Korea Meteorological Administration (KMA) for hosting a training seminar on the Use of GDPS Products and Presentation of Forecasts to the Public. (Seoul, 22 to 29 October 1996);

(ii) There are still large gaps in the data processing capabilities of some Members and further endeavours of major centres in co-sponsoring developing centres, system support activities and coordinated projects are needed so that all Members can receive and use the output of advanced GDPS centres.

54. WMO Satellite Activities

The Association emphasized the need for adequate coverage over the Indian Ocean and thanked the Russian Federation for the launch of Geostationary Operational Meteorological Satellite (GOMS). It noted with appreciation that the People's Republic of China planned to launch the meteorological satellite FY-2 in the first half of 1997 and install PC-based satellite receiving stations.

55. The Association also expressed its gratitude to Japan and the Russian Federation for their plans to launch new geostationary satellites - a Japanese Multifunctional Transport Satellite (MTSAT) which will replace GMS-5 in 1999, and the second Russian satellite Electro N2 in 1998-1999.

Eleventh Session of the Commission for Basic Systems (CBS)

56. The Joint Session noted that the eleventh Session of the CBS took place in Cairo, Egypt from 28 October to 7 November 1996. The Commission adopted the text for inclusion in the general summary of CBS-XI. The following paragraphs of the text relevant to the programmes of the Panel and the Committee were noted with interest by the Session. The major decisions and recommendations of the CBS are reflected in Appendix VI.

Implementation Coordination Meeting on the GTS in Region II

57. The Joint Session noted that an Implementation Coordination Meeting on the GTS in Region II was held in Phuket from 18 to 22 February 1997, in partial overlap with this Session. The following main outcome of the meeting was submitted to the Session on 22 February 1997 by the Chairman of the Coordination meeting as follows:

i) Status of implementation of the Regional Meteorological Telecommunication Network

A summary of the status of implementation of the Regional Meteorological Telecommunication Network (RMTN) in Region II is given in the attached Figure 1 on page 12. Most National Meteorological Centres (NMCs) are connected to the RMTN at present. However three NMCs (i.e. Phnom Penh, Sanaa and Vientiane) are not yet connected to the RMTN for the transmission and the reception of data. The meeting has considered this problem with a high priority. It agreed that the use of satellite based links such as two-ways Very Small Aperture Terminal (VSAT) is a cost-effective solution. The relevant technical project will be carried out by the Members concerned.

ii) Improvement of the RMTN

Although there are a lot of low speed circuits and old-fashioned circuits in the RMTN, Members have been trying to improve such circuits. Actually, there are many plans for upgrading the circuits, in particular by increasing the speed of transmission and introducing new communication techniques.

iii) Collection of national data

From the results of monitoring of the operation of the World Weather Watch (WWW), the meeting found out that a few countries were experiencing difficulties in the operation of their national data collection systems These difficulties are primarily due to the lack of national telecommunications infrastructure. Technical projects being developed to rehabilitate the national data collection systems in the People's Democratic Republic of Lao and in Cambodia have been studied. The meeting concluded that the use of Data Collection Platforms (DCPs) was a cost-effective and prompt solution.

iv) Replacement of HF broadcasts by satellite-based distribution systems

Some Members operating Regional Telecommunication Hubs (RTHs) stressed the

difficulties experienced in continuing the operation of their High Frequency (HF) broadcasts in the Region, in particular due to the high costs of maintaining these broadcasts. The meeting noted that satellite-based distribution systems advantageously replaced the HF broadcasts as they were considerably more cost-effective and fulfilled the requirements of WWW centres, which was not the case of the HF broadcasts. The meeting noted with satisfaction that five satellite-based distribution systems were already in operation and covered parts of Region II and that there were three other satellite-based systems which were planned or under consideration (see Appendix VII to this paragraph). There are therefore opportunities to overcome present deficiencies in the distribution of WWW data and products. The sub-group on regional aspects of the GTS in Region II would continue to study the replacement of HF broadcasts by satellite-based distribution systems. It is likely that each NMC in Region II will be in the zone of coverage of at least one, if not two, satellite-based distribution systems within the next two years.

v) Study of an improved RMTN

As requested by the last Session of Regional Association II, the sub-group on regional aspects of the GTS in Region II will carry out a study for an improved RMTN to overcome the remaining deficiencies of the GTS, such as the implementation of low speed point-to-point circuits and the lack of flexibility in the exchange of data between non-adjacent centres. The study will start with a compilation of the availability of new telecommunication techniques and services in RA II Member countries, such as managed data communication services.

vi) Radio frequencies for meteorological activities

For some years there has been a threat to meteorological radio-frequency bands. It is primarily caused by the pressure from the Mobile-Satellite Service Industry in expanding their frequency allocations. The meeting stressed that the coordination between Meteorological Services and their national telecommunication administrations was essential in the preparation for the world radio-frequency conference in November 1997.

58. The Session expressed its satisfaction on the above outcome of the meeting. It urged Members concerned and WMO to make all possible efforts towards the accomplishment of the Regional Meteorological Telecommunication Network (RMTN) for Region II (see Figure 1 on page 12).

Second TCP RSMCs Technical Coordination Meeting

59. The Joint Session noted that the Second TCP RSMCs Technical Coordination Meeting was held at the RSMC Miami-Hurricane Center from 13 to 19 November 1996. The Session reviewed the results of the meeting, in particular concerning the "Exchange of information between RSMCs and Numerical Weather Prediction (NWP) centres", "Tropical Cyclone Forecast Verification" and "Terminology".

60. Recognizing the importance of uniformity in standardizing terminology, at least for marine and aviation purposes, the Session invited the Commission for Marine Meteorology (CMM) and ICAO to consider the following definitions :

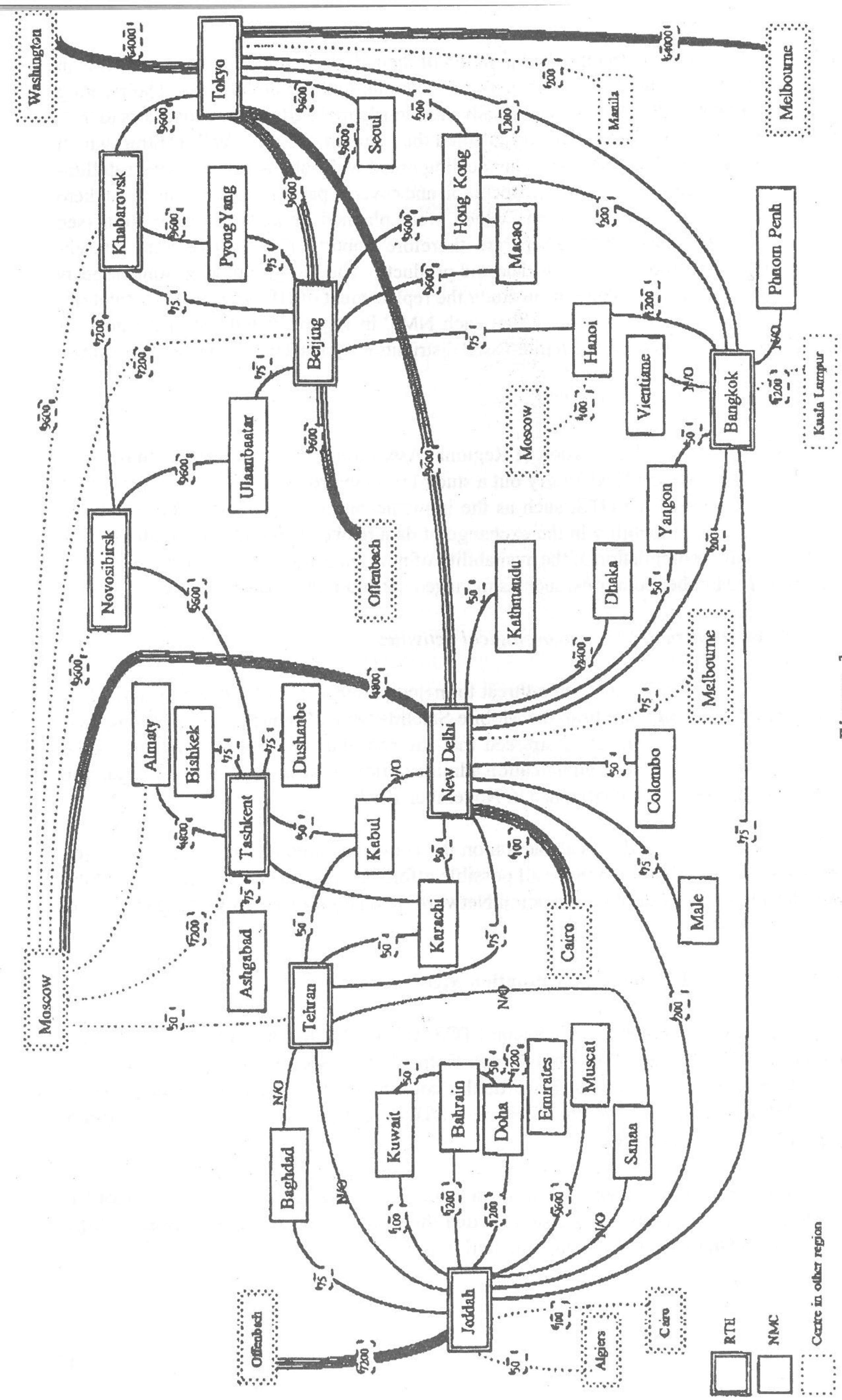

Figure 1

Regional Meteorological Telecommunication Network for Region II (Asia)
point-to-point circuits implementation (transmission speed in bit/s)

- "tropical depression winds" - up to 33 knots
- "tropical storm winds" - 34 to 63 knots
- "hurricane/typhoon winds" - 64 knots and above

Training Events-Meteorological Component

61. The Session recalled that at the first Joint Session in 1992, special attention had been given to the mutually beneficial training events and exchange of information between the Panel's TSU and the TCS.

62. The Session noted with satisfaction that since 1992, the following training events had been held with the participation of Members of the Panel and the Committee:

(i) Training Seminar on Tropical Cyclone Forecasting and Research, organized by China in cooperation with WMO at the Nanjing Institute of Meteorology from 27 October to 7 November 1992;

(ii) Workshop on Storm Surges for the Bay of Bengal, at the Thai Meteorological Department, Bangkok, from 14 to 19 November 1994;

(iii) Joint Seminar on Meteorological and Hydrological Risk Assessment, organized as part of the twenty-third Session of the Panel, which was held at the India Meteorological Department, New Delhi, from 16 to 19 March 1996.

63. The Panel at its twenty-third Session recognized the importance and benefits of further inter-regional coordination and cooperation between the Panel and the TC. The Session agreed that a Regional Workshop on Doppler Tropical Cyclone Radars should be organized by TCS and TSU in cooperation with WMO, in Hua Hin, Thailand, from 14 to 17 April 1998, possibly consecutively with the International Workshop on Tropical Cyclones (IWTC-IV) (Haikou, Hainan Province, China, tentatively between 21 to 30 April 1998).

64. The Joint Session was informed that in response to a United Nations Resolution on the Promotion of Women, WMO is organizing an International Technical Conference for Senior Female Forecasters, to be held in Thailand, from 9 to 12 December 1997. The Session endorsed the attendance of the TCS Meteorologist (Ms Nanette Lomarda) and the TSU Meteorologist (Dr Somsri Huntrakul) at the conference.

Hydrological Component

Activities of ESCAP

65. The Joint Session noted with satisfaction that ESCAP continued to provide support to the members in their endeavours on flood protection. The Joint Session noted that ESCAP had formulated and submitted a project proposal for a "Regional Seminar on Flood Risk Analysis and Mapping" to donors for funding. The venue of the seminar would be in Bangkok. The objectives of the project were to assist developing countries in flood risk analysis and mapping

which was one of the main elements required for systematic formulation and effective implementation of comprehensive flood loss prevention and management strategies, and to provide technology transfer in the field of flood risk analysis and mapping. The project when funded, in the first phase, was intended to benefit, Bangladesh, Cambodia, Lao PDR, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand and Viet Nam. This phase could be followed by a second phase covering other countries of Asia and the Pacific vulnerable to frequent flooding.

66. The Joint Session also noted with interest that ESCAP had also been undertaking activities on other aspects of hydrology and water resources, such as provision of guidelines for water pricing for irrigation and municipal water supply, investment promotion for the water sector, rehabilitation of contaminated rivers, promotion of women's role in water supply and sanitation, and assessment of water resources of its members. ESCAP also organized an exhibition and ceremony on the observance of World Water Day on 22 March of every year (on 21 March 1997, as 22 March will fall on Saturday).

Activities of WMO

67. The Session was informed of the most recent developments with respect to the new Management Overview of Flood Forecasting Systems (MOFFS). The participants were informed that in 1996, WMO published and distributed the Technical Report in Hydrology and Water Resources No. 55 "Development and use of the Management Overview of Flood Forecasting Systems (MOFFS)" which contained the third version of MOFFS.

68. The Session was also informed, that with the support of the WMO and the TCTF, a Workshop on MOFFS was planned to take place in the Republic of Korea, from 19 to 21 March 1997. Experts that are operationally involved with flood forecasting systems in this region had been invited. This workshop is a follow-up of the regional consultation meetings on the application of MOFFS held in Malaysia in 1992 and in Mexico in 1994.

69. The Session was informed of the role of the Hydrological Operational Multipurpose System (HOMS) in reference to technology transfer, and of the contribution of HOMS to the development of the Scientific Technology Exchange for Natural Disasters (STEND).

70. The Session recommended that Members encourage the activities of the Working Group on Hydrology of the Regional Associations, particularly those related to flood forecasting.

71. The Session recommended also that Members continue giving support to the activities related to flood forecasting in the region, including the application of MOFFS and the contribution of relevant components to HOMS.

Hydrologists' Meeting

72. The Typhoon Committee hydrologists met to review the activities of the Members, and implementation of the recommendations formulated during the previous session. The report of the hydrologists' meeting with the list of participants is presented in Appendix VIII. The hydrologists formulated a set of recommendations which were adopted by the Committee as reflected below :

(i) The Typhoon Committee Secretariat to evaluate the requirements of TC Members as soon as possible after the arrival of the new TC Hydrologist and formulate proposals for future activities under the hydrological component;

(ii) The meeting requested ESCAP to accord priority to the project on flood risk analysis and mapping in securing funds from donors;

(iii) Hydrologists will seek the means for the utilization of the TCTF to supplement Technical Cooperation among Developing Countries (TCDC) funds that may be available and to support attendance of TC hydrologists to relevant workshops and seminars to be organized in the region by various organizations;

(iv) To widen the scope of the activities of the TC Hydrologists, so as not to cope only with flood loss reduction, but also for the optimal use of the waters which become available;

(v) To assist in sending promotional materials to ESCAP and WMO for organization of the World Water Day and the IDNDR Day (March and October, respectively, every year).

73. The TC hydrologists unanimously agreed on the proceedings, decisions and recommendations of the Meeting, as it was closed.

Disaster Prevention And Preparedness Component

Activities of ESCAP

74. The Joint Session noted with appreciation that ESCAP continued to accord priority to its activities on natural disaster reduction. The project proposal on land use planning and practices in watershed management and disaster reduction had received funding from the Government of Netherlands. Accordingly, ESCAP informed that it was organizing a Workshop on Guidelines and Manual on Land-use Planning and Practices in Watershed Management and Disaster Reduction in Asia and the Pacific, at its Headquarters in Bangkok from 18 to 21 March 1997.

75. The primary objectives of the Workshop were :

(i) To assist the developing countries in formulation of appropriate land-use policies and implementation of effective land-use planning and practices for proper management and conservation of watersheds directly contributing to natural disaster reduction and sustainable development; and

(ii) To promote regional and international cooperation in the field of sustainable watershed development and management through exchange of expertise and information on appropriate land-use planning practices.

76. In the present phase of the project it was expected to receive participation from Bangladesh, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, the Philippines,

Sri Lanka and Viet Nam. Depending upon the success of the current project it might later be extended to cover other ESCAP members.

Activities of WMO

77. Seminar on Meteorological and Hydrological Risk Assessment

The Joint Seminar on Meteorological and Hydrological Risk Assessment was organized as part of the twenty-third session of the Panel at the India Meteorological Department, New Delhi, from 16 to 19 March 1996. Dr N. Sen Roy was director of the seminar. The focus of the seminar was the evaluation of tropical cyclone and flood hazards, vulnerability and risk assessment. It provided for exchange of information with the aim of improving mitigation of disasters caused by tropical cyclones and associated storm surges and floods within the context of the IDNDR.

Other activities

78. The Joint Session noted with interest tropical cyclone disaster prevention methods undertaken by the Cyclone Preparedness Programme (CPP) of Bangladesh.

Training Component

79. The Joint Session reviewed the involvement of their Members in the various education and training activities supported under UNDP, WMO Voluntary Cooperation Programme (VCP), regular budget and TCDC arrangements.

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

81. The Joint Session expressed appreciation for the number of training events and workshops which were organized in 1996, especially those events which were of direct relevance to tropical cyclones. The Session further noted that six training courses, seminars and workshops were planned for 1997.

82. The Panel and the Committee noted with satisfaction that thirty-seven fellows from their Members were under training in 1996 under various WMO programmes, and that 33 more were under consideration.

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

84. The Members of the Panel and the Committee were encouraged to make the maximum use of the training programmes relevant to their Regional Meteorological Training Centres

(RMTCs) Located in RA II/RA V and in neighbouring Regions.

85. The Joint Session expressed its appreciation to the Government of China for organizing a study tour for typhoon experts of Members of the TC which took place from 9 to 18 December 1996. The Session invited China to consider offering a similar study tour for tropical cyclone forecasters of the PTC to be formally confirmed by the Coordinator of TSU after consultation with the Panel Chairman.

86. The representative of India informed the Session that India is providing training facilities at its RMTC under the VCP. Panel and TC Members are encouraged to utilize these training facilities in General Meteorology, Telecommunication, Instrumentation, Agricultural Meteorology, NWP, etc., under bilateral arrangements and through WMO. These training courses are conducted at RMTC Pune and at New Delhi and are free of cost.

87. The Session noted that a revised edition of the publication WMO-No. 434 "Compendium of Lecture Notes in Marine Meteorology for Class III and Class IV Personnel" had been issued in Arabic and English languages during the inter-sessional period. It also appreciated that an updated computerized version of WMO-No. 240 "Compendium of Training Facilities for Meteorology and Operational Hydrology" is expected to be issued and distributed soon to Members. The Panel and the Committee urged their Members to make use of the facilities and holdings of the Training Library, in particular its audiovisual aids and Computer-Aided Learning (CAL) modules in their training programmes.

88. The Session emphasized the importance of the Manpower Development Programme, in particular to developing countries, and encouraged Members to make every effort to develop national plans for manpower development to become self-reliant in the basic training of meteorological and operational hydrological personnel. In this respect the Session noted with appreciation that the results of the 1994 survey of Members' training requirements for the twelfth financial period had been published as WMO/TD-No. 668.

89. The high priority training requirements were indicated during the Session as follows :

(a) High resolution mesoscale modelling and data assimilation techniques with specific emphasis on tropical cyclone and heavy rain forecasting.

(b) Training on techniques of information dissemination, such as TV presentation skills, ways and means to get forecasts and warnings as quickly as possible to the public and other users, techniques to handle and make use of the media, etc.

(c) "State-of-the-art technology in hydrological instruments and telemetric systems for flood forecasting and warning purposes".

(d) Development of flash flood forecasting techniques for steep-sloped rivers and urban rivers.

(e) Forecasting of river flood levels in the tidal reaches consequent to combined effects of heavy rain and tides.

Research Component

90. The Joint Session noted that the Twelfth Session of the WMO Congress (Cg-XII) had endorsed organization of the Fourth WMO/International Council of Scientific Unions (ICSU) IWTC-IV which is tentatively scheduled to be held in Haikou, Hainan Province, China between 20 April and 1 May 1998. It encouraged Members of the subregion to ensure adequate participation in the Workshop in order to further collaboration and exchanges between research and operational experts.

91. The Session was informed that a sub-committee of the CAS Working Group on Tropical Meteorology Research is continuing its investigation on the so-called "Drone Reconnaissance" for developing an observational system with unmanned aircraft.

92. Mr Gary Foley, CAS representative, presented the Session the following current activities within the CAS Tropical Meteorology Research Programme :

(i) The International Workshop on Tropical Cyclones (IWTC) Series;

(ii) Support for Field Programmes and Applied Research on Tropical Cyclones;

(iii) The Autonomous Aerosonde;

(iv) Statement on Climate Change and Tropical Cyclones;

(v) The South China Sea Monsoon Experiment.

93. The Session expressed its deep appreciation for his excellent presentation. Appendix IX contains a summary of his presentation.

94. The Session urged CAS/ICSU/WMO to issue a formal position statement on climate change and tropical cyclones for TCP regional bodies. This Statement will be used by Members of TCP regional bodies to respond to questions regarding the impact of climate change related to tropical cyclones.

95. The Session welcomed India's suggestion that suitable research projects on unusual features of tropical cyclones, such as looping, recurvature, etc. for systems of North Indian Ocean, which will be of great relevance to the Panel Members, be taken up similar to the "SPECTRUM" project organized for the Pacific.

96. The Session stressed the need for research initiatives with regard to the following specific topics :

(i) Intensity of rainfall associated with tropical cyclones;

(ii) Objective methods for determining the intensity of tropical cyclones;

(iii) Limited area model of tropical cyclones.

VI. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN AND THE TYPHOON COMMITTEE OPERATIONAL MANUAL (Agenda item 6)

Tropical Cyclone Operational Plan

97. The basic purpose of the Panel's Tropical Cyclone Operational Plan is to facilitate the most effective tropical cyclone warning system for the region with existing facilities. Recognizing the evolutionary nature of the Plan, the Panel Members discussed the changes necessary at the Second Joint Session with a view to issuing an updated 1997 version to replace the 1996 edition. It was noted that the inclusion of Sultanate of Oman as a new Member of the Panel would also call for a number of changes and additions. It was agreed that the Sultanate of Oman would send its contribution to be incorporated in the Plan to the WMO Secretariat by the end of April 1997.

98. The observer from ICAO welcomed the decision for extension of the area of responsibility of the RSMC-tropical cyclones New Delhi to cover the Arabian Sea including the Gulf of Aden up to 45°E. The Panel noted that the advisory information for the extended area is being disseminated by RSMC-tropical cyclones New Delhi.

99. The discussion revealed the need to update the Plan in a number of other respects and, notably, to meet proposals put forward by India for Chapter 4 and in the list of important addresses and telephone, facsimile and e-mail numbers. Since the revised information could not be provided during the Second Joint Session, the Panel instructed its Members to send it to the WMO Secretariat by 30 April 1997 so that the 1997 edition of the Plan may be issued expeditiously.

Typhoon Committee Operational Manual

100. The TC reviewed and approved with minor revisions the Typhoon Operational Manual-Meteorological Component (TOM) submitted by the rapporteur, Mr Yukio Takemura (Japan). The amendments to the Manual are attached as Appendix X.

101. The Members of the TC expressed their gratitude for the services of a rapporteur and appreciation for the offer of Japan Meteorological Agency (JMA) for the continued services of the rapporteur on TOM for the coming year as well. WMO assured the Members that an amended copy of the Manual will be made available by June 1997.

VII. REVIEW OF THE PROGRAMME FOR 1997 AND BEYOND (Agenda item 7)

International Decade for Natural Disaster Reduction and Other Activities (Agenda item 7 (a))

102. The Panel and the Committee Members continued their activities in line with the goals of the IDNDR. A summary of the reports of the individual Members on their activities related to the IDNDR during 1996 is included in Appendix XI.

Activities of ESCAP

103. The Joint Session noted that ESCAP continued its activities in support of implementation of the IDNDR in the region. In addition to what is reported under the Disaster Prevention and Preparedness Component (Agenda item 4 (c)), ESCAP organized the IDNDR Day in October 1996, together with an exhibit, prepared by utilizing the material contributed by WMO, the IDNDR Secretariat and the members of ESCAP.

104. The Joint Session also noted that ESCAP continued its cooperation with the Department of Humanitarian Affairs (DHA) and with the IDNDR Secretariat in Geneva.

Activities of WMO

105. The Joint Session noted that Cg-XII in June 1995 accepted the leading role that WMO should play in regard to disasters of meteorological and hydrological origin and emphasized once again that a major portion of the Organization's regular programme supports this. Examples of this support are the Joint Seminar on Meteorological and Hydrological Risk Assessment held in New Delhi in March 1996 under the auspices of the PTC and the TC and the completion of the project on the MOFFS. The revised WMO Plan of Action for the IDNDR identifies not only the longer-term projects which support this commitment but also the four special projects being undertaken in support of the Decade.

106. WMO actively supports the work of the bodies involved in the Decade and has been represented at all sessions of its Scientific and Technical Committee (STC) and Inter-Agency Working Groups. These bodies play a useful role in coordinating the work of the various United Nations agencies involved and in ensuring that their work is relevant to the wider aims of the Decade.

107. Realizing the vulnerability of human beings to natural and other hazards, Cg-XII agreed to provide meteorological and hydrological support to United Nations humanitarian and relief missions, and requested the Secretary-General to develop an appropriate mechanism for this purpose and in particular to strengthen collaboration with the United Nations DHA as the focal point within the United Nations system for humanitarian and relief efforts. The support of WMO would be of particular significance on the least developed and developing countries where sustainable development projects are underway.

Other discussion

108. The Coordinator of TCS informed the Session on the progress with regard to IDNDR. He indicated that in its last meeting in Paris, in January 1997, the IDNDR STC identified IDNDR national committees, United Nations specialized agencies and regional commissions, e.g. WMO and ESCAP, and regional bodies such as the PTC and the TC in this region as among the groups which can continue the efforts on natural disaster reduction after the termination of the IDNDR.

Panel's Coordinated Technical Plan (Agenda item 7(b))

109. The representative of WMO presented a document containing the Panel's regional cooperation programme and its implementation plan as adopted at the twenty-third session of the Panel held in New Delhi in March 1996, and invited Panel Members to review and revise the plan, considering each of the five components in turn, and deciding upon the changes and on the priorities to be assigned.

110. The WMO representative further reported in particular on the informal consultation meeting held in India (December 1996) to discuss the "storm surge project particularly for the Bay of Bengal and the northern part of the Indian Ocean" which had been supported by the twelfth WMO Congress. This decision had been reiterated by the forty-eighth session of the WMO Executive Council in June 1996 which recommended continued efforts by WMO, Intergovernmental Oceanographic Commission (IOC)/United Nations Educational Scientific and Cultural Organization (UNESCO) and United Nations Environment Programme (UNEP) in exploring ways of obtaining extra-budgetary funding for the project. The WMO representative further explained the programme and schedule for drawing up of a draft project proposal under the leadership of Prof. T.S. Murty (Australia). A final version of the draft proposal would be developed at an expert meeting tentatively scheduled to be held in New Delhi in October 1997.

111. The Panel was also informed that the international organizations would nominate experts who will compose a group and provide input to the project proposal within their area of competence. The Panel approved WMO's proposal to nominate Dr Somsri Huntrakul (Thailand/TSU) and Dr R.P. Sarkar (India) to the expert group. The representative of Bangladesh drew attention to the distinctive storm surge problems facing his country. To this end, the Panel agreed that Mr Md. Sazedur Rahman (Bangladesh) should have the opportunity to explain these problems to the other experts nominated. The Panel requested WMO to make the necessary arrangements for these consultations.

112. The Panel reviewed the Technical Plan, making numerous changes to bring it up-to- date. It was found impossible to revise the Hydrological Component at the Joint Session in the absence of hydrologists from Panel Members. It was accordingly agreed that it would be examined in depth at the next session of the Panel.

Typhoon Committee's Regional Cooperation Programme Implementation Plan (RCPIP) (Agenda item 7(c))

113. With respect to the activities included in the Typhoon Committee's Regional Cooperation Programme included in its RCPIP, the Members recognized its accomplishments and have further recognized that much work must be accomplished. After considerable deliberations, the Committee adopted the revised RCPIP. The Committee agreed to reformat the RCPIP, one part to reflect continuous activities of the Members and another for specific tasks.

VIII. SUPPORT REQUIRED FOR THE REGIONAL COOPERATION PROGRAMMES (Agenda item 8)

Arrangements for the Technical Support Unit (Agenda item 8(a))

114. The Panel reviewed the various aspects in relation to the TSU.

115. The Panel expressed its gratitude to the Government of Thailand for providing the host facilities in the TMD in Bangkok for the TSU. It welcomed Mr Smith Tumsaroch, Director-General of TMD to serve as the new Coordinator of the TSU. The Panel thanked the Coordinator for providing services of a full-time meteorologist, Dr Somsri Huntrakul and two supporting staff of TMD.

116. The Panel discussed a number of proposals put forward by the Coordinator of the TSU. A prime concern expressed by the Coordinator concerned funding for support of the TSU and for some of the Panel's programme activities. A number of Panel Members stated that they would need to consult their governments before any commitment to increase contributions to the Trust Fund could be made. In considering the possibility of obtaining funds from sources external to the Panel it was agreed that appropriate international organizations, the World Bank, the Asian Development Bank (ADB) and other potential donors be approached for financial support. It requested WMO and ESCAP to take early joint action for this purpose.

117. The Panel also considered the Coordinator's proposal for a study to determine the benefits or drawbacks of a gradual enhancement of joint activities between the Panel and the TC. In the absence of three Panel Members (Maldives, Myanmar and Pakistan), the Panel was not able to make a decision on the proposal.

118. The representative of ESCAP explained the ways in which his organization could assist the Panel Members, making particular reference to the arrangements possible through TCDC.

<u>Arrangements for the Typhoon Committee Secretariat (Agenda item 8(b))</u>

119. The Joint Session was pleased to note the following activities of the TCS in 1996:

i) TCS hosted the consultation meeting on the development of typhoon forecast and warning services in Cambodia, organized by WMO, from 22-25 July 1996. The Coordinator and Meteorologist of TCS were joined by the representatives from the Cambodian National Meteorological Service and an interpreter from the WMO Secretariat;

ii) The TCS Coordinator and Meteorologist joined the TC consultation mission team to Vientiane on the preparation of a UNDP national project proposal for the development of typhoon forecast and warning services in Laos, from 4 - 6 September 1996. A pre-mission coordination meeting was earlier conducted in Bangkok on 2 September;

iii) TCS, in cooperation with the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), held a meeting, on 11 September 1996, with a visiting British research team on the project related to High Winds in Densely Populated Urban Areas, funded by the United Kingdom Overseas Development Administration;

iv) The TCS Coordinator participated in the following :

_Seventh Session of the STC of the UN IDNDR held in Moscow, Russia, from 11 - 14 March 1996, in his capacity as Chairman of STC for the IDNDR; and

*Sixth Session of the RA V Tropical Cyclone Committee in Honolulu, Hawaii, from 9 - 16 October 1996 as observer.

v) TCS Hydrologist provided technical expertise on the following activities :

*Seminar/Workshop on Flood Loss Mitigation conducted jointly by PAGASA and the Japan International Cooperation Agency in Manila, Philippines from 28 February - 8 March 1996;

*Training in Operational Hydrology conducted by TCS and PAGASA for Nepalese trainees under TCDC arrangements, from 2 - 15 May 1996; and

*Joint Seminar on Meteorological and Hydrological Risk Assessment held in New Delhi, India, from 16 - 19 March 1996.

vi) The TCS Meteorologist participated in the following :

*Joint Seminar on Meteorological and Hydrological Risk Assessment held in New Delhi, India, from 16-19 March 1996.

*Study Tour in China for Typhoon Operational Forecasters of TC Members, from 8-19 December 1996.

vii) TCS continued its management of the TCFI. The Foundation presented the Typhoon Committee Natural Disaster Prevention Award for 1996 to Mr Smith Tumsaroch, Director-General of the TMD.

viii) TCS published the 8th issue of the TC Newsletter in September 1996.

ix) TCS published the 11th issue of the ESCAP/WMO Typhoon Committee Annual Review (TCAR) 1995 in December 1996.

120. The Committee expressed its gratitude to the Government of the Philippines for hosting the TCS and for providing a full time meteorologist, a part-time hydrologist and a part-time expert on disaster prevention and preparedness. The Committee was pleased to note that the Government of the Philippines would continue to facilitate the functioning of the TCS in Manila through a similar arrangement during the next period. The Committee likewise re-affirmed the necessity of a dedicated, pro-active and independent TCS to serve TC Members.

121. The Committee also expressed its appreciation to the Government of the Republic of Korea which will provide the services of a hydrologist to TCS this year.

Technical Cooperation (Agenda item 8 (c))

122. The Session reviewed the performance of the technical cooperation activities since the previous sessions, and the new proposed projects and initiatives that are being taken in support of the activities and the plans of the Panel and the TC.

123. The Session expressed its appreciation to the TCS for preparing the National UNDP project proposal for Cambodia and Lao PDR. The purpose of the project is to assist the National Meteorological and Hydrological Services in improving the national typhoon forecasting and warning services. The Session was also informed that the NMCs (Phnom Penh and Vientiane) are not yet connected to the RMTN for the transmission and the reception of data. In this connection the Session considered that there is an urgent need for assistance to Cambodia and Lao PDR and urged WMO, UNDP, ESCAP, neighbouring countries and other donors to provide the necessary assistance.

124. The Session held an informal discussion on the regional project proposal entitled *"Integrated System for the Mitigation of Typhoon, Flood and Environmental Disasters in the Western North Pacific Area"*. The Session expressed its appreciation to Mr Stephen Browne, (UNDP), Mr Andrei Iatsenia (World Bank), Mr Levy Amorei (WMO), and Dr William Bolhofer (Consultant to WMO), for the presentation of the project proposal and explanation of the Work Plan of the Project.

125. The representative of UNDP made a statement during the informal discussion as presented in Appendix XII.

126. The Session expressed its gratitude to UNDP and hoped that it would continue to support the activities of the National Meteorological and Hydrological Services in providing typhoon forecasting and warning services.

127. The Joint Session noted with satisfaction ESCAP's indication of strong interest and available capabilities to participate in the project formulated in the proposal, starting with the feasibility studies. ESCAP has been dealing with disaster reduction activities since its establishment fifty years ago and was a co-founder and one of the supporting agencies of the TC. Considering the ESCAP secretariat's proximity to the project area, the long years of relevant experience, and interest and available capabilities, it was agreed that ESCAP's participation in the project would contribute to its successful implementation.

128. The Joint Session expressed satisfaction to WMO for its efforts with the IOC/UNESCO and UNEP in exploring ways of obtaining extra-budgetary funding for the establishment of the project on storm surges for the Bay of Bengal and the northern part of the Indian Ocean, with the joint cooperation of WMO, IOC/UNESCO and UNEP.

129. The Joint Session was informed that ESCAP would continue to undertake activities in support of the PTC and the TC within the framework of its own programme of work. This might also include undertaking of projects on substantive issues relating to mitigation of damage from typhoons, floods and droughts in Asia and the Pacific, which would be drawn up in close consultation with TCS and TSU. The project proposal on flood risk analysis had been prepared and submitted to potential donor countries for funding consideration.

130. The Joint Session was pleased to note that ESCAP could provide advisory services on flood protection, drainage and other hydrological work through its Regional Adviser on Water Resources and that TCDC funding could be made available to support exchanges of experts among developing countries in the fields of hydrology and disaster prevention and preparedness.

131. The Joint Session welcomed ESCAP's efforts to acquire additional resources to undertake work on natural disaster reduction, and appealed to donor countries and agencies to provide additional manpower and adequate extra-budgetary support for implementation of activities on natural disaster reduction.

WMO VCP and WMO Fund

132. The Session expressed satisfaction that a number of requirements had been met under the WMO VCP. The Members were urged to take full advantage of this system and advised to update their requirements and send these to WMO.

133. The delegate of Japan mentioned that his Government would provide support to Members in light of the recommendations of the eleventh session of Regional Association II (Asia) which was held in Mongolia, September/October 1996. Priority will be given to upgrading upper air observations and strengthening the GTS links.

Bilateral Assistance

134. The Members from the Panel and the Committee recognized the importance of bilateral assistance from developed countries. Members expressed their thanks to the Government of Japan for the generous assistance provided to some Members of the Panel. In this connection, the delegate from Bangladesh informed the Session that Japan would provide his country with two additional weather-radars.

Trust Funds

(a) Panel on Tropical Cyclones Trust Fund

135. The Panel reviewed the financial report on the Trust Fund established by WMO (see Appendix XIII).

136. The Panel was pleased to note that Maldives and Myanmar had made their contributions and other Members are in the final stages of receiving approval from their Governments. The Panel strongly urged its Members to make their annual contributions in time. The Panel welcomed the contributions from neighbouring and donor countries as well as from national and international institutions. The Panel also encouraged and requested the National Meteorological Services of the Panel Members to coordinate with other agencies involved in tropical cyclone activities and private sectors.

137. The delegate from the Sultanate of Oman informed the Panel that his Government would provide its contribution to the Trust Fund soon.

138. Request for support from the Trust Fund would require the concurrence of both the TSU

Coordinator and the Chairman of the Panel in accordance with the rules of the Fund.

(b) Typhoon Committee Trust Fund

139. The Committee reviewed the financial report on the TCTF and the balance of the fund as of 31 December 1996 as shown in Appendix XIV.

140. The Committee was pleased to note that a certain degree of self-reliance had been achieved. The Committee urged its Members to continue and enhance their contributions to the TCTF.

141. The Committee agreed to the use of the TCTF for the following specific purposes from 1 March to 31 December 1997.

(i) Publishing the Typhoon Committee Newsletter No. 9 (about US$ 1,400);

(ii) Printing and Distributing cost of documents for the thirtieth session of the Committee (about US$ 1,700);

(iii) Printing and distribution cost of the publication of TCAR 1996 (500 copies) (about US$ 5,000);

(iv) Augmentation of travel funds for TCS staff mission, including attendance at TC-30 (US$ 15,000);

(v) Support for attendance of female senior typhoon forecasters at an International Technical Conference for Female Senior Forecasters (about US$ 20,000) (see Appendix XV); and

142. Any other emergency case that can be justified for the use of the TCTF, requiring the concurrence of both the TCS Coordinator and the Typhoon Committee Chairman.

143. The Committee requested the WMO Secretariat to prepare a more detailed breakdown of expenses of the TCTF for the next session.

<u>TCDC</u>

144. The Session noted the importance of TCDC as a means of promoting and strengthening collective self-reliance. It was pleased to note that a number of TCDC activities were carried out by its Members. The Session urged the Members of the PTC and TC to take an active part in this important activity.

IX. ELECTION OF CHAIRPERSONS FOR THE PANEL ON TROPICAL CYCLONES AND THE TYPHOON COMMITTEE (Agenda item 9)

145. The Panel on Tropical Cyclones unanimously elected Mr Md. Sazedur Rahman, Director of the Bangladesh Meteorological Department as Chairman until the next session of the Panel.

146. The Typhoon Committee unanimously elected Mr Smith Tumsaroch, Director-General of the Thai Meteorological Department as Chairman until the next session of the TC.

X. DATE AND PLACE OF THE TWENTY-FIFTH SESSION OF THE PANEL ON TROPICAL CYCLONES AND THE THIRTIETH SESSION OF THE TYPHOON COMMITTEE (Agenda item 10)

147. The Panel on Tropical Cyclones welcomed the offer of Bangladesh to hold its twenty-fifth session in Dhaka, from 24 February to 2 March 1998 subject to confirmation by the Government.

148. The Typhoon Committee welcomed the offer of Hong Kong to hold the thirtieth session in the then Hong Kong Special Administrative Region, People's Republic of China, from 25 November to 1 December 1997, to be preceded by the TC Hydrologists meeting on 24 November 1997.

XI. SCIENTIFIC LECTURES (Agenda item 11)

149. The following scientific lectures were presented :

(a) <u>Introduction of Natural Disaster Insurance System in Korea</u>
By: Mr Heung-Soo Cheong (Republic of Korea)

(b) <u>Unusual Features of Cyclonic Disturbances over North Indian Ocean in 1996</u>
By: Mr S.K. Subramanian (India)

(c) <u>A Numerical Simulation on the Impact of Asymmetric Thermodynamic Structure on Typhoon Motion</u>
By: Mr Qiu Guoqing (China)

(d) <u>Hydrological Investigation on the Flood Event in Keningau Area of Sabah due to Tropical Storm *Greg* on 26 December 1996</u>
By: Mr Chong Sun Fatt (Malaysia)

(e) <u>Typhoon Predictions with JMA's new NWP models and operationalization of their products at National Meteorological Services</u>
By: Dr Takeo Kitade (Japan)

(f) <u>Recent Progress in Research on Typhoon Prediction Models at KMA</u>
By: Dr Hyo-Sang Chung (Republic of Korea)

(g) Atmospheric Voyager - The Aerosonde Status Report
By: Mr Gary Foley (CAS)

(h) Diagnosis and Warning Platform for Typhoons: Introduction to a new version of AFDOS
By: Mr Wang Jizhi (China)

150. The Joint Session expressed its thanks to the lecturers.

XII. ADOPTION OF THE REPORT (Agenda item 12)

151. The report of the Second Joint Session of the Panel on Tropical Cyclones and the Typhoon Committee was adopted at its final meeting at 1120 hours on 28 February 1997.

XIII. CLOSURE OF THE SESSION (Agenda item 13)

152. One very significant accomplishment of this Joint Session, as gathered in the general comments made before the session ended, was the re-emphasis on the importance and benefits of inter-regional coordination and cooperation. The Joint Session closed at 1125 hours on 28 February 1997.

Appendix I

PARTICIPANTS

Joint Session of the Panel on Tropical Cyclones and the Typhoon Committee

Second Session
20 - 28 February 1997
Phuket, Thailand

MEMBERS OF TYPHOON COMMITTEE

CAMBODIA

Ms Vannareth Seth	Deputy Director Department of Meteorology

CHINA

Mr Yan Hong	Deputy Administrator China Meteorological Administration (CMA)
Mr Qiu Guoqing	Director-General National Meteological Centre (CMA)
Mr Fang Weimo	Consultant, Senior Engineer Operation Development and Weather Department (CMA)
Mr Xin Xianhua	Division Director International Cooperation Department (CMA)
Mr Sun Guihua	Deputy Chief Engineer, Water Information Center Ministry of Water Resources
Mr Wei Shangjin	Assistant consultant, Dept. of International Cooperation Ministry of Water Resources

HONG KONG

Dr H.K. Lam	Director, Royal Observatory Hong Kong
Ms Elaine Koo	Assistant Director, Royal Observatory Hong Kong

JAPAN

Dr Takeo Kitade	Director, Administration Division, Forecast Department Japan Meteorological Agency
Mr Katsumi Seki	Senior Officer, River Planning Division River Bureau Ministry of Construction

LAO PEOPLE'S DEMOCRATIC REPUBLIC

Mr Thongphou Vongsiprasom	Director-General Meteorological and Hydrological Department

MACAU

Mr O.F.V. Rasquinho	Director, Macau Meteorological and Geophysical Services (SMG)
Mr óscar Gomes Da Silva	Secretary-General Security Coordination Office
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AGENDA

1. ORGANIZATION OF THE SESSION:

   (a) Opening of the joint session
   (b) Election of officers
   (c) Adoption of the agenda
   (d) Application for membership
   (e) Change of name of member of ESCAP/WMO Typhoon Committee
   (f) Establishment of subcommittees
   (g) Working arrangements

2. ANNUAL PUBLICATIONS:

   (a) Typhoon Committee Annual Review and Typhoon Committee Newsletter
   (b) Panel News

3. REVIEW OF THE 1996 TROPICAL CYCLONE/TYPHOON SEASON

4. NATIONAL REPORTS ON ACTIVITIES AND DEVELOPMENTS DURING 1996 UNDER THE REGIONAL COOPERATION PROGRAMMES

5. COORDINATION OF ACTIVITIES:

   (a) Coordination within the Tropical Cyclone Programme
   (b) Coordination of activities common to the Panel and the Typhoon Committee

6. REVIEW OF THE TROPICAL CYCLONE OPERATIONAL PLAN AND THE TYPHOON COMMITTEE OPERATIONAL MANUAL

7. EVIEW OF THE PROGRAMME FOR 1997 AND BEYOND:

   (a) International Decade for Natural Disaster Reduction and other activities
   (b) Panel's coordinated technical plan
   (c) Typhoon Committee's regional cooperation programme implementation plan

8. SUPPORT REQUIRED FOR THE REGIONAL COOPERATION PROGRAMMES:

   (a) Arrangements for the Technical Support Unit
   (b) Arrangements for the Typhoon committee Secretariat
   (c) Technical cooperation

9. ELECTION OF CHAIRPERSONS FOR THE PANEL ON TROPICAL CYCLONES AND THE TYPHOON COMMITTEE

10. DATE AND PLACE OF THE TWENTY-FIFTH SESSION OF THE PANEL ON TROPICAL CYCLONES AND THE THIRTIETH SESSION OF THE TYPHOON COMMITTEE

11. SCIENTIFIC LECTURES AND TECHNICAL DISCUSSIONS

12. ADOPTION OF THE REPORT

13. CLOSURE OF THE SESSION

SUMMARY OF THE 1996 CYCLONE SEASON -
RSMC NEW DELHI

INTRODUCTION

This report consists of a review of the cyclonic disturbances and their associated features, that formed in the North Indian Ocean (The Bay of Bengal and the Arabian sea) during the year 1996. The classification of cyclonic disturbances followed in the report are given below:

	Weather system	Maximum sustained surface wind speed
1	*Low*	*Wind speed less than 17 kt. (31 kmph)*
2.	*Depression (D)*	*Wind speed between 17 and 27 kt .(between 31 and 49 kmph)*
3.	*Deep Depression (DD)*	*Wind speed between 28 and 33 kt (between 50 and 61 kmph)*
4.	*Cyclonic Storm [CS]*	*Wind speed between 34 and 47 kt (between 62 and 88 kmph)*
5.	*Severe Cyclonic Storm [SCS]*	*Wind speed between 48 and 63 kt between 89 and 117 kmph)*
6.	*Severe Cyclonic Storm with a core of Hurricane Winds. [SCS(H)]*	*Wind speed 64 kt or more (118 kmph or more)*

The term **'Cyclone'** used at times in the text, is to indicate all the three categories of cyclonic disturbances given above under S.N0. (4) to (6).

Following are the important features of cyclonic disturbances in the North Indian Ocean during 1996.

a) This year, like previous year, **eight** cyclonic disturbances formed over the Bay of Bengal and the Arabian sea against the average frequency of 13 to 14 per year. Six out of the eight disturbances formed over the Bay of Bengal and two over Arabian sea. Only **one** land depression formed in July. **Five** out of the **nine** systems attained the intensity of a cyclone.

(b) This year the Bay of Bengal and the Arabian Sea were very active from October to December as five systems formed during this period, which is almost equal to the average number of systems in this period.

(c) Two cyclones, one in the Arabian Sea and the other in the Bay of Bengal exhibited unusual movement. They came in the vicinity of the coast but instead of crossing or skirting it, they moved in a south westerly direction.

(d) The cyclone of 28 November to 6 December 1996 made one loop over central Bay of Bengal and other loop near Andhra Pradesh coast which is uncommon over the Bay of Bengal.

(e) This year only a deep depression crossed the coast of Bangladesh and Myanmar in May in place of a cyclone striking every year since 1990 except in 1993.

(f) This year, the east coast of India north of $18^{o}N$ was not affected by the depressions or cyclones.

(g) The movement of the cyclones this year was slower compared to those of the last year.

(h) This year the two systems had a very long life period of 7 to 9 days. Such cases are rare during the past years.

(i) Only one system formed as deep depression in May, against the average frequency of 1 to 2. One depression and one deep depression formed in the beginning and end of the October in Bay of Bengal

(j) Two cyclones formed in the month of June, one over the Bay of Bengal and the other over the Arabian sea during the Onset phase of the south-west monsoon, Both the systems helped in the northward progress of monsoon.

Thus the year of 1996 also had below normal cyclonic activity over North Indian Ocean like in the earlier years from 1993 to 1995.

The **First** system formed over the north Bay of Bengal as a depression in the morning of 7 May 1996 and moved in a north north easterly direction. It further intensified into a deep depression on 1800 UTC and moving in a north-easterly direction it crossed Bangladesh coast near Cox's Bazar by the early morning of 8 May.

The **Second** system formed over south-west Bay of Bengal as depression on the afternoon of 12 June when the southwest monsoon was advancing northward over India. It concentrated into a cyclonic storm and moved close to Indian Coast (14.0^{o}N/88.5^{o}E) on the morning of 14 June. At this time it took northerly course and moved in a north-north-easterly direction slowly. Maintaining its intensity as a cyclonic storm it crossed Andhra Pradesh coast close to Visakhapatnam by the forenoon of 16 June and weakened rapidly. Formation of a system in such a low latitude in the month of June is a history for the last 100 years.

The **Third** system formed over Arabian Sea as a depression on the afternoon of 17 June when the Arabian Sea branch of southwest monsoon was advancing further north, over India. Moving in a northerly direction, it further intensified into a deep depression on the morning of 18 June and by the same evening it concentrated into a cyclonic storm. Further intensification of this system continued and it attained the intensity of a Severe Cyclonic Storm by the midnight. The system crossed Saurashtra Coast near Diu in the early morning of 19th and weakened into a Cyclonic Storm. Moving almost in a northerly direction, it weakened into a depression over north Gujarat by the morning of 20 June.

The **Fourth** system formed as a land depression over Bihar Plateau and neighbourhood on the morning of 26 July. Moving in a westerly direction, it moved upto South Rajasthan as depression on 28 July and weakened there by the evening. No further cyclonic disturbance formed over the Bay of Bengal and Arabian Sea till the end of September 1996.

In the beginning of the post-monsoon season, the **Fifth** system formed as a depression on 1 October over west-central Bay of Bengal. Moving in a westerly direction it crossed Andhra Pradesh Coast near Ongole around the midnight of same day and weakened rapidly over North Interior Karnataka and neighbourhood by the morning of 2 October.

The **Sixth** disturbance formed over east-central Arabian Sea as a depression on the afternoon of 22 October 1996. It attained the intensity of a cyclonic storm on the afternoon of 23 October and moving in a northerly direction, it intensified into a Severe Cyclonic Storm by the morning of 24 October. It continued to move in a northerly direction and came close to the Gujarat coast within 150 km south of Veraval. At this point the system remained stationary and started disorganizing and weakened into a Cyclonic Storm by the morning of 26 October. It changed its course to south-westerly direction and weakened into a depression by the evening. By 27 October it weakened into a low pressure area over east-central Arabian Sea and moved westward till the morning of 31 October.

The **Seventh** system formed in the west-central Bay of Bengal as a depression on the morning of 27 October 1996. Moving initially in a north-westerly direction for sometime, it changed its course to north-easterly direction and intensified into a deep depression by the morning of 28 October. Moving further in a north-easterly direction, it crossed West Bengal coast near Indo-Bangladesh border in the afternoon of 28 October. After moving through Bangladesh it weakened into a depression over Assam region by the morning of 29th October and finally dissipated in the evening over northeast India.

The **Eighth** system also formed as a depression in the west-central Bay of Bengal on the morning of 5 November and moved slowly westwards. It intensified into a deep depression in the afternoon and into a Cyclonic Storm in the evening. It continued to move in a westerly direction and further intensified into a Severe Cyclonic Storm by the morning of 6 November. From this time it moved in a west-north-westerly direction and attained the intensity of a Severe Cyclonic Storm with a core of Hurricane Winds by the afternoon of 6 November and crossed Andhra Pradesh Coast near Kakinada in the evening of 6 November 1996. It rapidly weakened into a depression after crossing the coast.

The **Ninth** system formed as a depression in the south-east Bay of Bengal in the morning of 28 November and moved initially in a west-north-westerly direction and intensified into a deep depression in the morning of 29 November. At this point it changed its course to north-easterly direction upto the evening of 30 November and then moved south-eastward till the morning of 1 December. Thereafter, after orienting first loop, it moved in a westerly direction and intensified into a Cyclonic Storm by the morning of 2 December and Severe Cyclonic Storm by the morning of 3 December and by the evening into a hurricane. Moving westwards, it came close to the Andhra Pradesh coast, about 50 km south of Machilipatnam by the morning of 5 December. At this point the system made a second loop and moved in a south-westerly direction and weakened rapidly into a Severe Cyclonic Storm. It crossed Tamilnadu coast near Mahabalipuram on the evening of 6 December 1996.

The tracks of these 9 disturbances are given in Fig. *A-1, A-2,* and *A-3.*

Table 1A gives the monthwise formation of cyclonic disturbances in the Bay of Bengal and Arabian Sea and over land. It may be seen from the table that the number of systems in the pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-December) seasons of this year were 1, 3 and 5 respectively. Two cyclones and one land depression formed in the monsoon season against the normal frequency of 6 to 7 per year. This year the frequency of systems during monsoon season is better than that in 1994 and 1995, when only 2 and 1 depressions formed respectively.

The monthly distribution of cyclonic disturbances during the past 25 years (1971-1995) is given at the end of the Table 1A.

The Table 1B gives the important features of cyclonic disturbances formed during this year. Identification numbers are given to the systems of cyclone intensity only, in accordance with the para 2.3 of the TCP-21.

Tables (2 to 10) give the best track positions at 00, 03, 06, 12, and 18 UTC along with the other meteorological parameters for all the cyclones in the Bay of Bengal and the Arabian Sea.

Detailed account of all the systems are given in the following paragraphs. The locations of various stations referred to in this report are shown in Fig. *A-4*.

2. DETAILED DESCRIPTION OF CYCLONIC DISTURBANCES.

2.1 PRE-MONSOON SEASON (MARCH - MAY)

During the pre-monsoon season, only one system formed during the first week of May as a depression against the average frequency of 1 to 2 systems per year. Moving in a north to north-easterly direction it crossed Bangladesh coast.

2.1.1 Bay of Bengal Deep Depression (7 to 8 May 1996)

A well-marked low pressure area formed over north-west Bay of Bengal on the night of 6 May and concentrated into a depression with centre at 0300 UTC of 7 May near Lat. 19.0°N and Long. 89.0°E (about 400 km south of Calcutta). Moving in a north to north-easterly direction it intensified into a deep depression around mid-night of 7 May, and crossed Bangladesh coast near Cox's Bazar in the morning of 8 May 1996. The maximum intensity of this system was estimated as T-2.0 on Dvorak's scale from the imagery of 1800 UTC of 7 May 1996 (Fig. 1).

Under the influence of this system, the coastal areas of Orissa and West Bengal received widespread rains. As per the reports received from Bangladesh Meteorological Department (BMD), Dhaka, coastal districts of south-east Bangladesh also received widespread rainfall on 7 and 8 May. Some of the rainfall amounts were 6 cm at Khepupara, 5 cm at Chittagong and 4 cm at Sandwip on 7 May.

The system was also tracked by the Radar at Cox's Bazar. Spiral bands with cloud height of 16 to 18 km were reported in their observations of 1900 UTC to 2300 UTC of 7 May. Maximum wind speed was northerly 40 kt. and maximum pressure drop was 11.6 hPa recorded by Cox's Bazar at 0300 UTC on 8 May 1996.

2.2 SOUTH WEST MONSOON SEASON (JUNE-SEPTEMBER)

During the monsoon season two cyclones, one over the Bay of Bengal and the other over Arabian Sea and one land depression formed. First system formed on 12 June as a depression at a low latitude (11^{o}N) against the normal position between 18^{o}N and 20^{o}N. Moving initially in a north-westerly direction and intensifying into a cyclone, it recurved towards north-east along the Andhra Pradesh Coast and finally dissipated over North Andhra Pradesh on 16 June after making its landfall north of Visakhapatnam. The **second** system formed in the Arabian Sea on 17 June and intensified into a Severe Cyclonic Storm on 18 and finally crossed Gujarat Coast on the early morning of 19 June. The **third** system formed as a Land Depression towards the end of July and moved across the states of Bihar, Madhya Pradesh and Rajasthan.

Under the influence of these three systems, southwest monsoon advanced over the country and caused widespread rainfall with heavy to very heavy falls at a few places in the south Indian States.

2.2.1 Bay of Bengal Cyclonic Storm 12-16 June 1996 (BOB 96 01 06 14 16)

2.2.1.1 The Life History of the Cyclone.

The satellite imagery of 0500 UTC of 12 June showed the formation of a vortex near Lat. 10.0°N/ Long. 87.5°E. Subsequently, it organised and intensified into a depression at 0900 UTC [Fig. 2] and its centre was located near Lat. 11.0°N/Long. 86.0°E at 1200 UTC. Moving in a north-westerly direction, it further concentrated into a deep depression on 13th morning and continued to move in a northwesterly direction up to 0300 UTC of 14th, when it was located near Lat. 14.0°N/ Long. 80.5°E with intensity of cyclonic storm (about 100 km east of Nellore) [Fig 3]. At this point the system changed its course from north-westerly to north-easterly direction and moved along the coast of Andhra Pradesh up to 16 June, when it was located at 0300 UTC near Lat. 17.5°N/ Long. 83.5°E (about 50 km south-east of Visakhapatnam). It crossed Andhra Pradesh coast close to Visakhapatnam between 0600 UTC to 0700 UTC on 16 June, 1996.

2.2.1.2 Salient Features of the Cyclone

Some of the important features of this cyclone were:-

i. It formed at a very low latitude (11°N) and intensified into a cyclonic storm close to the coast near Lat. 14°N. It is a rare case in the history of the cyclones, when a system has formed and intensified into a cyclone in the month of June at such a low latitude.

ii. The system had a recurvature close to the coast and moved along the Andhra Pradesh coast from Lat. 14°N to 18°N. Such movement of the cyclone in the month of June is unusual.

iii. The system formed at the leading edge of southwest monsoon current and weakened rapidly after crossing the coast near Visakhapatnam.

iv. Under its influence, Chennai recorded 35 cm rainfall on 14 June which is a record for the last 100 years for 24 hrs rainfall in the month of June.

v. The system initially moved at a speed of 10 to 12 kt. but later at 5 to 7 kt.

2.2.1.3 Monitoring and Tracking

Initially the system was detected and tracked with the help of INSAT cloud imageries. Later on, it was continuously monitored by the CDRs located at Karaikal, Chennai, Machilipatnam, Visakhapatnam and Paradip. Spiral bands were observed by CDRs Chennai and Visakhapatnam [Fig.4 (a), (b), (c), (d)].

2.2.1.4 Movement

As the system was located in the southern sector of upper air anticyclone at 200 hpa on 12 and 13 June, it moved in a north-westerly direction. Gradually, as it moved northward it came under the influence of weak winds of the western sector of upper air anticyclone and as such moved in a north-easterly direction.

2.2.1.5 Meteorological Features and Weather Caused

2.2.1.5.1 *Pressure*

By considering the highest intensity of the system T-3.0 on Dvorak's scale from 0700 UTC of 15 June to 0000 UTC of 16 June and corresponding pressure defect 10 hPa, the central pressure was calculated as 982 hPa. The lowest surface pressure of 987.5 hPa was observed by Visakhapatnam at 0000 UTC. Thereafter, the pressure showed rising tendency and indicated the weakening of the system before crossing the coast.

2.2.1.5.2 *Wind*

The estimated maximum surface wind corresponding to T-3.0 is 45 kt. The maximum surface wind observed at Waltair (43150) and Visakhapatnam

(43149) was 30 kt. at 0040 UTC of 16th June. The reversal of wind direction was observed between 0340 UTC and 0540 UTC of 16 June [Fig.5]. This indicated that the system crossed coast around 0500 UTC.

2.2.1.5.3 *Rainfall*

As the cyclone formed at the leading edge of Bay of Bengal branch of southwest monsoon, it caused widespread rainfall with heavy to very heavy falls in the coastal districts of Andhra Pradesh which were in the south-west sector of the system. The isohyetal map of cumulative rainfall during the period 12-17 June is shown in Fig. 6. Rainfall of the order of 30 cm and above have occurred in these areas. A station Koida in Khammam district recorded rainfall of 68 cm on 17 June.

2.2.1.5.4 *Damages*

The post cyclone survey shows that the system affected and caused extensive damages in Chittur, Nellore, East Godavari and Visakhapatnam districts of Andhra Pradesh. The damages were mainly due to breach of tanks and reservoirs. No extensive damage due to winds or storm surge was reported. A total loss of human lives was reported 68 which occurred mainly due to floods caused by breaches of reservoirs/tanks. The property loss was estimated to be about Rs. 81 crores in Coastal Andhra Pradesh. As the system strengthened the monsoon activity, monsoon became vigorous over Karnataka, Kerala and Tamilnadu. Details of damages in these states are given below.

a) Damage Report from Andhra Pradesh.
(*as per the available information from local Govt.*)

1. Districts affected	:	13
2. Death	:	68 *(Districtwise : Chittur 37, East Godavari 16, Krishna 5, Nellore 5, Guntur 3, Visakhapatnam 2).*
3. Houses Damaged	:	Fully : 1985 Partly : 3109
4. Damage to Crops	:	13,378 hect.
5. Rail/Roads/Canals	:	3833 Canals damaged.
6. No. of families evacuated	:	3517
7. Loss of property/ Infrastructure.	:	Rs.82 Crores.

b) Damage Report from Tamilnadu
(Based on information received from local state Govt.)

1. Death	:	44
2. Boats affected/ missing:		18

c) Damage Report from Karnataka
(Based on information received from local state Govt.)

1. Death	:	53

d) Damage Report from Kerala
(based on information received from local state Govt.)

1. Districts affected	:	Thiruvananthapuram, Ernakulam, Idukki, Alappuzha, and Kozhikode.
2. Loss of human lives	:	14

2.2.2 Arabian Sea Severe Cyclonic Storm 17-20 June 1996 (ARB 96 02 06 18 20)

2.2.2.1 The Life History of the Cyclone

A broad scale circulation in the lower level formed over the east-central Arabian Sea on 16 June. Under its influence a low pressure area formed on the morning of 17 June and concentrated into a depression by the afternoon with its centre near Lat. 18.5°N/ Long. 69.5°E [Fig. 7]. Moving initially in a north-easterly direction with a speed of 6 kt, it intensified into a deep depression at 0300 UTC of 18 June near Lat. 19.0°N/ Long. 70.5°E (230 km south of Veraval). It attained the intensity of cyclonic storm at 0900 UTC with its position at 1200 UTC near Lat. 20.0°N/ Long. 70.5°E [Fig. 8]. Moving almost in a northerly direction, it crossed south Gujarat coast between Veraval and Diu (Junagarh District) in the early morning (around 2200-2300 UTC) of 19 June [Fig.9]. At 0300 UTC it was centred about 100 km south-east of Rajkot (Lat. 21.5°N/Long. 71.5°E) [Fig.10] as a Severe

Cyclonic Storm. Thereafter, it weakened into a cyclonic storm by 0900 UTC and its position at 1200 UTC was Lat. 22.5°N/Long. 72.0°E (about 70 km south-west of Ahmedabad) [Fig.11]. Moving in a north-north-easterly direction, it weakened into a depression by the evening of 20 June and into a low pressure area over southwest Rajasthan by the morning of 21 June.

2.2.2.2 Salient Features of the System

This cyclone had some significant features as given below.

(i) One of the main features is that this cyclone formed in the Arabian Sea in the month of June and crossed Junagarh district of Gujarat after a gap of 50 years. The earlier case was in June 1920 when a similar cyclone crossed Junagarh District. The two cyclones which formed in June, 1961 & 1964 crossed Kutch District of Gujarat. Thus, this is the fourth cyclone during the period 1891-1996 which formed in the month of June and affected Gujarat coast.

ii. This system rapidly intensified into a Severe Cyclonic Storm from the depression stage (within 32 hours).

iii. It moved in a northerly direction at a speed of 3 to 5 kt.

iv. As the cyclone formed at the leading edge of Arabian Sea branch of southwest monsoon, most of the clouds with the system were in the west and southern sector. Spiral band structure, with bands almost closing around the centre, was continuously observed.

2.2.2.3 Post Cyclone Survey Report

a). Survey team estimated the height of storm surge 5 to 6 meter near Bharuch.

b). Maximum winds were estimated as 42 kt. with direction 200° from 0600 to 0900 UTC of 18 June at Bhavnagar.

c). Cyclone crossed between Diu and Kodiar near the village Sarkhadi around 2300 UTC of 18 June 1996.

d). Isohyetal map of 19-20 June indicated that the heavy rainfall had occurred in the western sector of the system (Fig.12).

2.2.2.4 Monitoring and Tracking

Initially the system was tracked with the help of INSAT cloud imageries, ship observations and ONGC RIGS observations. From 1200 UTC of 18 June, Cyclone Detection Radar (CDR) Mumbai and CDR Bhuj tracked the system continuously. A diffused open 'eye' was first seen at 1400 UTC of 18 June by CDR Mumbai. After the cyclone crossed the coast, CDR Bhuj recorded open 'eye' at 1000 UTC and 1200 UTC of 19 June [Fig.13(a)&(b)].

2.2.2.5 Movement

The system moved almost in a northerly direction parallel to the west coast of India. After crossing the coast and reaching up to south Rajasthan, it weakened into a well marked low pressure area and recurved to north-east under the influence of a Westerly Trough moving along 30^{o}N latitude.

2.2.2.6 Meteorological Features and Weather Caused

2.2.2.6.1 *Pressure*

As the highest intensity of the system was T-3.5 on Dvorak's scale at 1800 UTC onward of 18 June, the corresponding pressure defect is taken as 20 hPa and outer closed isobar as 992 hPa. The central pressure was estimated as 972 hPa. The lowest pressure 974.4 hPa was recorded by Veraval at 2200 UTC of 18 June.

2.2.2.6.2 *Wind*

The maximum surface wind, associated with the intensity of T-3.5, was taken as 60 kt. The maximum winds recorded at Veraval were 340^{o}/46 kt. at 2300 UTC of 18 June.

2.2.2.6.3 *Rainfall*

During its northerly movement, the system caused widespread rain with heavy to very heavy falls at a few places over coastal districts of north Maharashtra and Gujarat during 18 to 21 June.

2.2.2.6.4 *Storm surge*

As per the survey report, the surge height was estimated as 5 to 6 meters near Bharuch. It appears that the coastal areas surrounding Gulf of Cambay were affected by storm surge of height 3-5 meters.

2.2.2.6.5 *Damages*

Damage reports based on post cyclone survey report and information received from local state Govt. of Gujarat are given below:

A) Damage Report from Gujarat

1. No. of Districts affected	:	19
2. No. of Talukas affected	:	161
3. No. of Villages affected	:	5573
4. Population affected (In Lakhs)	:	22.83
5. Area affected (In Lakhs Hectare)	:	2.02
6. No. of Deaths to Human	:	33
7. No. of Deaths to Cattle	:	2082
8. Damage to Agricultural Crops. Area (In Lakhs Hectare)	:	0.08
9. Damage to Pucca Residential Houses No.of Residential Units	:	27964
10. Damage to Huts Completely Destroyed No. of Residential Units	:	2930
11. Damage to Huts Partially Destroyed No. of Residential Units.	:	38643
12. No of persons evacuated	:	3228
13. Total estimated loss in Lakhs	:	Rs.1803.52

Some photographs of damages are given in Fig. 14.

b) Damage Report from Maharashtra.

1. No. of Districts Affected	:	4 (Mumbai Upnagari, Ratnagiri, Thane, & Satara.)
2. No. of Villages Affected	:	142
3. No. of Population Affected	:	2472
4. No. of Human deaths	:	14
5. No of Cattle deaths	:	31
6. No of Houses damaged	:	1611
7. No of Cattle sheds damaged	:	90
8. Loss of Public Property	:	Rs.1.34 Crore
9. Total Loss	:	Rs.1.58 Crore

2.2.3 Land Depression (26-28 July 1996)

A well-marked low pressure area over northwest Bay of Bengal moved in a northwesterly direction and concentrated into a depression over land near Daltonganj at 0300 UTC on 26 July. Associated cyclonic circulation was extending upto mid-tropospheric level. It moved in a westerly direction across central parts of India on 27 July and weakened into a low pressure area over south Rajasthan by the evening of 28 July. It finally merged with the seasonal monsoon trough by 29 July.

Under its influence widespread rains with scattered heavy fall occurred over Madhya Pradesh, Maharashtra, Rajasthan and Gujarat State.

2.3 POST MONSOON SEASON (OCT. - DEC., 1996)

The season began with the formation of a depression over west-central Bay of Bengal on the morning of 1 October and crossed South Andhra Pradesh coast in the evening. It weakened into a well marked low pressure area on 2 October. Four more cyclonic disturbances formed in the Bay of Bengal and Arabian Sea during this season. Thus, North Indian Ocean was quite active during this period. Only one system out of five formed in the Arabian Sea on 22 October and moved northward. It moved upto Gujarat coast and intensified into a severe cyclonic storm but it showed erratic behaviour near the coast and instead of crossing the coast, it weakened and moved initially southwards and later in a south-westerly direction. Similarly, one cyclone out of the three which formed in the Bay of Bengal during this period showed an unusual behaviour and made two loops over Bay of Bengal and later moving westward came close to the Indian coast. At this point, instead of crossing the coast of Andhra Pradesh, it moved south-westward and made landfall in Tamilnadu on 6 October 1996. This system had a very long life of 9 days. This is a rare phenomenon over North Indian Ocean.

One cyclone (5-7 November) moved in a west to west-north-westerly direction and crossed Andhra Pradesh coast on the late evening of 6 November. Though this system had a narrow core but caused heavy damage in East & West Godavari districts of Andhra Pradesh.

2.3.1 Bay of Bengal Depression (1-2 October 1996)

The first system of post-monsoon season formed on the morning of October 1, with centre at 0300 UTC near Lat. 15°N/Long. 87°E (Fig.15). Moving westward it crossed South Andhra Pradesh coast near Ongole around mid-night of 1 October. It weakened into a well marked low over North Interior Karnataka and neighbourhood by the evening of 2 October. Thereafter, it moved in a northerly direction upto 4 October and then in a north-easterly direction and finally dissipated over Central Himalayas by the evening of 5 October.

Under its influence wide spread rain with scattered heavy to very heavy fall occurred over South Andhra Pradesh, North Tamilnadu and Karnataka.

2.3.2 Arabian Sea Severe Cyclonic Storm 22-28 Oct., 1996 (ARB 96 03 10 23 28)

2.3.2.1 The Life History of the cyclone

The remnant of a well marked low pressure area, which formed over the Bay of Bengal and crossed south Andhra Pradesh coast near Nellore, emerged into east-central Arabian Sea off north Karnataka coast on the morning of 21 October. Satellite imagery of 0300 UTC of 21 October (Fig.16) indicated the formation of a vortex around Lat. 14°N/Long. 70°E with intensity T-1.0. It moved north-westward and intensified into a depression with centre at 0900 UTC of 22 October near Lat 14.0°N/Long. 69.0°E (Fig.17). Moving in a north-north-easterly direction, it intensified into a cyclonic storm in the afternoon of 23 October with centre near Lat. 15.5°N/Long. 70.5°E (Fig.18). Thereafter, it moved in northerly direction and further intensified into a Severe Cyclonic Storm at 1800 UTC of 23 October near Lat. 17.0°N/Long. 70.5°E (Fig.19). Moving further in a northerly direction, it was centered at 0900 UTC of 24 October near Lat. 18.5°N/Long. 70.5°E and at 1200 UTC near Lat 19.0°N/Long. 70.7°E. Moving slowly northward, it weakened into a cyclonic storm with centre near Lat. 20.0°N/Long. 70.0°E. Moving further north, it rapidly weakened into a depression with centre at 1200 UTC of 25 October near Lat. 20.5°N/Long. 70.5°E (Fig.20) (about 50 km south of Veraval). At this point, the system remained practically stationary for six hours and then moved in a southerly direction. By the afternoon of 27 October, it was centered near Lat. 18.5°N/Long. 69.0°E (Fig.21) as a depression. Later moving south-westwards, it weakened into a well marked low by the morning of 28 October and moved west-south-westward thereafter. By the morning of 30 October, its central region was located near Lat. 14.5°N/Long. 63.0°E and by the evening of 31 October near Lat. 13.5°N/Long. 55.0°E. Thereafter, it dissipated close to north Somalia Coast by 1 November.

2.3.2.2 Monitoring and Tracking

The system was continuously tracked with the help of INSAT, CDR, Mumbai and later by CDR, Bhuj. Ship observations and ONGC RIGS observations also helped in locating the system. Centre of this system was determined with the help of spiral and open eye from 2100 UTC of 23 October to 1300 UTC of 24 October by CDR Mumbai (Fig.22).

2.3.2.3 Significant Features of the Cyclone

Some of the important features of the cyclone are given below:-

i. The system continuously intensified from Depression to Severe Cyclonic Storm and moved in a northerly direction. Near Lat. 20.0°N, it started weakening and disorganizing and its CDO lost its circularity and compactness from the evening of 24 October.

ii. The system retraced its track back near the Saurashtra coast and then moved in a south-westerly direction.

iii. The system almost remained stationary close to the coast from 25/1200 UTC to 27/0300 UTC.

iv. The system did not cross the coast inspite of no significant change in the upper air flow pattern prevailing over the area. It appears that this system weakened due to the unfavourable environment such as cold sea surface temperatures and dry winds.

v. There is no parallel of this system in the history of the cyclone. In this month, the cyclones have either crossed Gujarat coast or skirt the coast and moved westward.

2.3.2.4 Meteorological Features and Weather Caused

2.3.2.4.1 *Pressure*

The maximum intensity of this system was observed T-4.0 on Dvorak's scale at 0600 UTC of 24 October. The corresponding wind speed and pressure defect were taken as 65 kt. and 20 hPa respectively. The estimated central pressure was 984 hPa. The actual lowest pressure was recorded 999.8 hPa by a ONGC RIG PN-3 at 1700 UTC of 24 October located at Lat. 19.4°N/Long. 71.2°E in the periphery of cyclone.

2.3.2.4.2 *Wind*

The maximum surface wind associated with T-4.0 was 65 kt. The highest wind speed recorded by ONGC RIG was south-easterly 45 to 55 kt. gusting to 60 kt. on the evening of 24 October.

2.3.2.4.3 *Rainfall*

Under its influence Konkan and Goa received widespread rainfall with isolated heavy falls on 24 and 25 October. The coastal districts of Gujarat also received widespread rain with isolated heavy falls on 26 and 27 October.

2.3.2.4.4 *Damage*

As the system did not cross the coast no significant damage was reported. 11 fishing boats were missing off Veraval Port and about 50 boats were stranded in the high seas due to strong wind.

2.3.3 Bay of Bengal Deep Depression 27-29 October, 1996

On the morning of 27 October a depression formed over west-central Bay of Bengal and was centered at 0300 UTC near Lat. 15°N/Long. 86°E. It moved initially in a northwesterly direction and then recurved to north-easterly direction by the early morning of 28 October. It intensified into a deep depression around mid-night with its centre near Lat. 17.0°N/Long. 86.5°E at 1800 UTC of 27 October. Moving in a north-north-easterly direction, it crossed coast near West Bengal-Bangladesh border around mid-night of 28 October (Fig.23) and moved northward across Bangladesh. It weakened into a well marked low pressure area over Assam and neighbourhood by the morning of 29 October.

2.3.3.1 Rainfall

Under its influence widespread rain with heavy to very heavy falls occurred at one or two places in Gangetic West Bengal on 28 and 29 October. Chief amounts of rainfall (in cm) recorded on 28 October were Contai-20, Canning Town-15, Digha-12, Diamond Harbour-10 and on 29 October at Rampurhat-11 and Canning Town-10.

2.3.3.2 Damages

About 16000 people were affected due to floods caused by the breaches in Ichamati and Kalindi River in north 24-Parganas districts. Calcutta city life was paralysed. As per the news report, 14 human lives were lost and 2090 injured and 100 fishermen were missing in Bangladesh. A news paper reported storm Surge of 3 meter height and wind speed 80 kmph in Bangladesh.

2.3.4 Bay of Bengal Severe Cyclonic Storm with a Core of Hurricane Winds 05-07 November 1996 (BOB 96 04 11 05 07)

2.3.4.1 Life History of Cyclone

The INSAT Imagery of 0600 UTC of 4 November indicated the formation of a vortex near Lat. 16.5°N/Long. 91.0°E. By the evening, it further organised and was classified as a Depression on the early morning (0000 UTC) of 5 November 1996 (Fig. 24), when it lay centered at Lat. 16.0°N/Long. 87.0°E, about 650 km east of Machilipatnam. It moved westwards and in a very rapid and dramatic development, it intensified into a Deep Depression and then into a Cyclonic Storm on the afternoon (0900 UTC) of 5 November when it was centered near Lat. 16.0°N/Long. 86.0°E, about 530 km east of Machilipatnam. The system continued to move in a westerly direction and intensified further into a Severe Cyclonic Storm by the morning (0300 UTC) of 6 November centered near Lat. 16.0°N/Long. 83.8°E, about 300 km east of Machilipatnam. It further intensified into a Severe Cyclonic Storm with a Core of Hurricane Winds by the afternoon (0900

UTC) [Fig.25], of 06 November when it lay centered near Lat. 16.4°N/Long. 83.0°E about 220 km east-north-east of Machilipatnam.

Moving in a west-north-westerly direction, it crossed Andhra Pradesh coast about 50 km south of Kakinada on the night (around 1600 UTC) of November 6. Continuing to move in a west-north-westerly direction, the system weakened into a deep depression, centered near Khammameth in Andhra Pradesh on 7 morning and then into a low pressure area over Telangana by the evening before fading out.

2.3.4.2 Monitoring and Tracking

When the system was out in the high seas beyond the detectable range of cyclone detection radars at Machilipatnam and Visakhapatnam, it was mainly tracked by INSAT cloud imageries and conventional observations. It came under the surveillance of Visakhapatnam Radar from 0300 UTC of November 6. The hourly observations from these radar stations and from the coastal observatories were very useful in locating the centre of the system accurately.

2.3.4.3. Significant Features of the Cyclone

Some of the important features of the cyclones are given below:-

i. The system intensified rapidly from 0600 UTC of 5 November. Intensification of this system was very significant from 0000 UTC to 0800 UTC of 6 November, during which period T-number was increased by 1.5 (Fig.26).

ii. The highest intensity attained by the system was T-4.5 at 0800 UTC of 6 November (Cover page).

iii. At 0400 UTC of 6 November, the Satellite imagery indicated an asymmetric eye inside the CDO. The eye became regular and more distinct at 0800 UTC.

iv. CDR Machilipatnam reported eye from 0600 UTC of 6 November to 0000 UTC of 7 November with fair confidence. Diameter of the eye was observed initially 64 km at 0600 UTC of 6 November and it decreased to 17 km at 1900 UTC of 6 November. The height of eye wall ranged from 15 km to 18 km. Radius of Maximum Reflectivity (R.M.R) was between 8 to 20 km. The Radar track is given in Fig.27.

v. The polar diagrams of CDR Visakhapatnam are given in Fig.28 (a), (b), (c) & (d).

vi. The overall size of the cyclone was only about 450 km in diameter as revealed in satellite cloud imageries which is relatively small.

vii. The system moved rather slowly (10 kmph or less) in westerly direction on 5th. From 6th morning, the movement changed to west-north-westerly direction with an average speed of about 5 to 6 kt.

viii. Following features are based on post cyclone survey report:

a) The cyclone crossed over I. Polavaram Mandal of East Godavari district (Lat. 16.6°N/Long. 82.2°E) in Andhra Pradesh and moved in-land with hurricane intensity about 100 km inside the land.

b) Tidal waves of the order 2-3 meter above normal tide affected the coastal belt of length about 60 km and breadth 5 km in land.

c). The estimated maximum winds were/ of the order of 150-180 kmph reaching 200 kmph in gusts 150 to 180 kmph. This is based on the evidence (i) Blown off CWDS equipments and anemometer at Yanem (ii) Collapsed microwave tower at Ravulapalen and (iii) Several 220 KV L.T. Towers and uprooted several big trees.

d) Heavy to very heavy rain caused extensive floods in East & West Godavari districts. Amalapuram recorded 39 cm rainfall.

e) Maximum wind speed recorded by the Cargo Ship was 130°/ 60 kt. at 1610 UTC on 6 November by KAPITAN SHANTSUBURG at Kakinada Port.

2.3.4.4 Meteorological Features and Weather Caused

2.3.4.4.1 *Pressure*

After considering the pressure defect corresponding to highest intensity T-4.5 as 30 hPa and peripheral isobars 1004 hPa, estimated central pressure was 974 hPa. Lowest pressure recorded was 995.9 hPa at Kakinada at 1500 UTC of 6 November.

2.3.4.4.2 *wind*

The estimated maximum wind speed corresponding to peak intensity of T-4.5 is 77 kt. The maximum wind speed recorded at Kakinada was south-easterly 32 kt. at 1800 UTC of 6 November.

2.3.4.4.3 *Rainfall*

Widespread rain with heavy to very heavy falls occurred in the coastal districts of East & West Godavari on 6 and 7 November. Some of the chief amounts of rainfall:- Amalapuram-39 cm, Karapa-29 cm, P.Gannavaram-27cm, Samarlakota-27 cm, Peddapuram-27 cm.

2.3.4.4.4 *Damages*

The cyclone caused widespread damages in East and West Godavari districts of coastal Andhra Pradesh. Following reports are based on the information given by the state Govt.

1.	Loss of lives	....	978
2.	No of missing persons	......	1375
3.	Village affected	......	1380 in 80 Mandals.
4.	Loss of Paddy crop.	.....	1.74 lakh hectares.
	Other crops	.....	67.802 hectares.
5.	No of Boats lost	.....	6464
6.	Four cargo ship ran aground.		
7.	Breach of several canals and drains.		
8.	Several electric tower collapsed.		

9.	Micro-Wave tower used for telecommunication collapsed. The tower was 100 meter height and made up of 2cm thick angular steel.		
10.	Heavy damages to roads.		
11.	House damaged	.....	647554
12.	One anemometer blown off at Yanam and one CWDS antenna dislodged from concrete base.		
13.	No. of families evacuated	.....	2.25 lakh
14.	Estimated total loss	.....	Rs.2150 Crores

Some of the photographs of damages are given in Fig.39.

2.5 BAY OF BENGAL SEVERE CYCLONIC STORM WITH A CORE OF HURRICANE WINDS, 28 NOVEMBER TO 6 DECEMBER (BOB 96 05 11 2806)

2.5.1 Life History of Cyclone

A well marked low pressure area formed on 27 October over south-east Bay of Bengal with central region near Lat. 9.0°N/Long. 81.5°E. Moving north-westward, it concentrated into a depression on the morning of 28 November near Lat. 11.5°N/Long. 86.5°E at 0300 UTC. Initially it moved north-westward and then northward and further intensified into a deep depression near Lat. 13.0°N/Long. 85.5°E at 0300 UTC of 29 November. At this point, system recurved north east and weakened into a depression by the evening of 30 November (Fig.30). Thereafter it took a looping motion and moved in a south-easterly direction on 1 December (Fig.31) and lay centered near Lat. 14.5°N/Long. 89.0°E at 0300 UTC. The system intensified again into a deep depression by the evening and moved in a westerly direction. It attained the intensity of cyclonic storm at 0000 UTC of 2 December, when it was centered near Lat. 14.0°N and Long. 87.0°E (Fig.32). Moving in a westerly direction, it further intensified into a severe cyclonic storm at 0300 UTC of 3 December (Fig.33) with centre near Lat. 14.0°N/Long. 84.5°E. It further intensified into a severe cyclonic storm with a core of hurricane winds at 1200 UTC of 3 December and lay centered near Lat. 14.5°N/ Long. 83.5°E. It moved in a west-north-westerly direction till the evening of 4 December and moved close to the Andhra Pradesh coast (Lat. 15.3°N/Long. 81.3°E) at 0000 UTC of 5 November (Fig.34). At this point, the system showed signs of disorganization and weakening on the night of 4 December. It appears that the upper portion of the system moved inland and the lower portion moved southward. As such the system was relocated with its centre near Lat. 14.5°N/Long. 82.0°E (Fig.35) as a severe cyclonic storm at 0300 UTC of 5 December. It remained practically stationary up to the evening of 5 December and then moved in a south-westerly direction and lay centered at 0300 UTC of 6 December near Lat. 13.7°N/Long. 81.1°E (Fig.36). Moving slowly in a south-westerly direction, it came close to Chennai in Tamilnadu by the evening of 6 December. It finally crossed coast between Chennai and Pondicherry near Mahabalipuram between 1600 and 1700 UTC of 6 December and rapidly weakened into a well marked low pressure area by the morning of 7 December (Fig.37).

2.5.2 Monitoring and Tracking

The system was initially tracked with the help of INSAT and later by CDR Machilipatnam and CDR Chennai. CDR Machilipatnam observed the system from 0700 UTC of 3 December to 0000 UTC of 6 December and CDR Chennai tracked it from 2300 UTC of 3 December to 1200 UTC of 6 December. The system could not be observed by CDR Chennai from 0800 UTC of 4 December 1996 to 0500 UTC of 5 December 1996. Fairly defined spiral bands were seen from 2300 UTC of 3 December to 0700 UTC of 4 December. Well defined spiral bands were seen again at 0600 UTC of 5 December. Partial eyewall was seen at 2100 UTC 5 December. Radar fixes were given with confidence fair to good [Fig. 38 (a), (b), (c) & (d)].

2.5.3 Significant Features

i. The system created a unique history in its movement. There is no parallel in the past when a cyclone behaved in such an unusual way in the Bay of Bengal.

ii. The system made first loop motion over central Bay of Bengal near Long. 87.0°E and later had a sudden change of direction near the Andhra Pradesh coast on the night of 4 December.

iii. The system maintained its intensity of severe cyclonic storm and its structure during its south-westerly movement from 5 December.

iv. The system had a very long life of 9 days which is also a unique feature.

2.5.4 Weather Caused and Damages

The system caused fairly widespread rainfall with isolated heavy falls in the coastal districts of south Andhra Pradesh from 5 to 8 December. As the system did not cross Andhra Pradesh coast, no significant damages were reported. As the system crossed Tamilnadu coast in the evening of 6 December the impact of the cyclone was felt in the coastal belt of north Tamilnadu in the form of gale force wind exceeding 100 kmph over Chennai city and its suburbs on the evening of 6 December. As the convective cloud mass associated with the system weakened considerably during its south-westerly movement, no major damage to life and property in Tamilnadu was caused by this system. (Based on the information from local State Govt.).

3. DYNAMICAL ASPECTS

3.1 VERTICAL SHEAR

It is known that the development of a disturbance is favoured when the vertical wind shear is small over the disturbance. In order to see the contribution of this parameter for the development of cyclonic disturbances in the North Indian Ocean in 1996, vertical shear of the zonal winds between 200 and 850 hPa were computed in few cases of cyclones. Computations were made by utilizing the winds at 850 and 200 hPa from the land stations and 2.0° Lat/Long. grid point forecast winds available over the ocean areas from the Limited Area Model of RSMC, New Delhi.

The analysis of the vertical wind shear charts for the cyclones of 1996 indicated the prevalence of minimum vertical wind shear over the area of disturbance (Fig.39).

3.2 TRACK PREDICTION MODELS

Storm track prediction is made operationally by RSMC New Delhi by utilizing several models based on climatology, persistence and the combination of climatology and persistence (CLIPER). These models were run for all the cyclonic disturbances (depression onward). The track prediction was also made based on Analogue techniques. Such forecasts were made for cyclonic disturbances of tropical storm intensity and above. Mean forecast position errors on the basis of climatology, persistence and CLIPER models for cyclones are given in Table 11. Mean forecast position errors for the cyclones based on Analogue are given in Table 12. The forecast skill relative to CLIPER and Limited Area Model for cyclones is given in Table 13.

The forecast skill relative to CLIPER model is expressed as percentage and calculated by using the formula given below :

$$\text{FORECAST SKILL} = \frac{\text{CLIPER (PE)} - \text{OM (PE)}}{\text{CLIPER (PE)}} \times 100$$

CLIPER (PE) = Position errors based on CLIPER Model,

OM (PE) = Position errors based on other models such as persistence, climatology, Analogue etc.

The data reveals the following facts:

a. In general the forecast position errors were more with time, particularly beyond 24 hours.

b. The forecast errors based on Analogue model were less than the error based on other models. The Forecast skill in comparison to CLIPER indicates that the forecast based on Analogue model for 24 hours forecast was better than CLIPER by 27% (Fig.40).

c. The forecast position errors for 24 hours based on Analogue model were least (within 100 km).

d. The forecast position errors were very high in the case of cyclones having recurvature or loop motion.

3.3. THE LIMITED AREA FORECAST MODEL OF RSMC, NEW DELHI.

The limited area forecast model adapted from Florida State University, U.S.A. is also being run by RSMC, New Delhi on an experimental basis. The details of the model are given in R.S.M.C. report of the year 1993.

3.3.1. Results from Model for Cyclones - 1996

The Limited Area forecast model used by RSMC was run for all the cyclones of 1996. Some of the initial and predicted vorticity field at 850 hpa are given in Fig.41 and Fig.42. Table-12 gives the 24-hrs model forecast error for each cyclone along with the forecast error based on Analogue and CLIPER. The 24-hr forecast errors for the cyclone (2-6 Dec.'96) were less than 100 km in a few cases. The 24-hr forecast error in respect of the other cyclones were between 200 to 300 km. The overall average for all 24-hr forecast was 261 km.

4. DISSEMINATION OF WARNINGS

Cyclone warnings were issued and disseminated to the general public, Central and State government officials and other user organizations in India through high priority telegrams, T/P, Telephone and Telex. The electronic and print media were also used extensively for this purpose. Particularly, timely cyclone warnings issued to the public and the State governments of Gujarat, Maharashtra, Andhra Pradesh and Tamilnadu in connection with the severe cyclones of June and November were helpful in minimizing the loss of life and public property to a great extent. The services provided by India Meteorological Department were appreciated by the high ranking officials of State Government. Cyclone warnings in different local languages were communicated directly by India Meteorological Department (IMD)'s Cyclone Warning Centres to the affected coastal populations through the satellite based communication system known as the Cyclone Warning Dissemination System (CWDS).

5.COOPERATION AMONG PANEL COUNTRIES

As in the previous years, the Regional Specialized Meteorological Centre (RSMC) New Delhi, issued this year 58 (Fifty Eight) Tropical Cyclone advisories to all the member countries of WMO/ESCAP Panel on Tropical Cyclones during the cyclone period at the six hourly interval. Besides this, Tropical Weather Outlooks for the north Indian Ocean were issued daily at 0600 UTC as a routine to the member countries of the Panel.

Cloud Motion Vectors based on 0000 UTC and 1200 UTC observations are regularly disseminated over GTS for the area covering the Bay of Bengal, the Arabian Sea and the Indian Ocean upto 30°S. 0000 UTC IR full frame satellite picture is transmitted on Radio Facsimile for international use.

Bangladesh Meteorological Department provided some valuable information on upper wind data and radar observations from the coastal Cyclone Detection Radars (CDRs) in connection with the system of 7-8 May, 1996. These were very useful in finalizing the track and the intensity of the system at the time of crossing the Bangladesh coast on May 8.

6. CONCLUDING REMARKS

Unlike the previous years, 1993 and 1994, North Indian Ocean was very active, particularly during the post-monsoon months (October to December) of this year 1996, as five out of total nine systems formed over this region. The cyclones exhibited an unusual behaviour like loop motion etc. which is very rare in this region. One cyclone of hurricane intensity had a small core but caused severe damage to life and property in Andhra Pradesh. On the other hand, a cyclone had a long life of nine days and attained the intensity of hurricane but changed its course near the coast and instead of crossing, it moved in a south-westerly direction.

Thus, the year 1996 had cyclones of unusual behaviour which needs more investigation and study. Some cyclones have surpassed earlier records in the history of cyclones over Indian Seas.

TABLE-1A

Monthly distribution of cyclonic disturbances (depressions and cyclones) over North Indian Ocean (The Bay of Bengal and the Arabian Sea) during 1996

System	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Bay of Bengal													
Depression	-	-	-	-	1	-	-	-	-	2	-	-	3
Cyclonic storm	-	-	-	-	-	1	-	-	-	-	-	-	1
Severe cyclonic storm	-	-	-	-	-	-	-	-	-	-	-	-	-
Severe cyclonic storm with a core of hurricane winds	-	-	-	-	-	-	-	-	-	-	2	-	2
Land depression	-	-	-	-	-	-	1	-	-	-	-	-	1
Arabian Sea													
Depression	-	-	-	-	-	-	-	-	--	-	-	-	-
Cyclonic storm	-	-	-	-	-	-	-	-	-	-	-	-	-
Severe cyclonic storm	-	-	-	-	-	1	-	-	-	1	-	-	2
Severe cyclonic storm with a core of hurricane winds	-	-	-	-	-	-	-	-	-	-	-	-	-
Total (North Indian Ocean)	-	-	-	-	1	2	-	-	-	3	2	-	8
No. of Cyclonic systems during 1971-1995	3	0	1	5	24	34	25	47	36	51	58	22	306

TABLE-1B

S.No.	Cyclonic Disturbance	Peak Intensity T.No.	MSSW (kt)	Duration Time(UTC) /Date	Place and time of crossing the coast	Loss (human life)	Peak storm surge height (m)
1.	Bay of Bengal deep depression 7-8 May, 1996	T2.0	30	03/7 May to 03/8 May	Near Cox's Bazar, early morning of 8 May.	-	-
2.	Bay of Bengal cyclonic storm 12-16 June, 1996 (BOB 96 01 06 1416)	T2.5	40	12/12 Jun to 12/16 Jun	Close to VSK between 0500 and 0600 UTC of 16 June.	68	-
3.	Arabian Sea severe cyclonic storm 17-20 June, 1996 (ARB 96 02 06 1820)	T3.5	60	09/17 Jun to 03/20 Jun	Crossed near Diu between 2200 and 2300 UTC of 18 June.	33	2
4.	Bay of Bengal depression 1-2 October, 1996	T1.5	25	03/1 Oct. to 12/2 Oct.	Close to Ongole around 1700 UTC of 1 October.	-	-
5.	Arabian Sea severe cyclonic storm 22-28 Oct, 1996 [ARB 96 03 10 2325]	T3.5	60	12/22 Oct. to 03/28 Oct.	Weakened 50 km south of Veraval and moved SW-ward	-	-
6.	Bay of Bengal deep depression 27-29 Oct, 1996	T2.0	30	03/27 Oct. to . 12/29 Oct	Crossed near border between W. Bengal and Bangladesh around 1500 UTC of 28 Oct.	-	-
7.	Bay of Bengal severe cyclonic storm with a core of hurricane winds 5-7 November, 1996 [BOB 96 04 11 0507]	T4.5	77	03/5 Nov. to 12/7 Nov.	Crossed Andhra Pradesh coast 50 km south of Kakinada around 1600 UTC of 6 November.	978	2
8.	Bay of Bengal severe cyclonic storm with a core of hurricane winds 28 Nov.-6 Dec., 1996 [BOB 96 05 12 0206]	T4.5	77	03/28 Nov. to 03/7 Dec.	Crossed near Chennai (MDS) around 2100 UTC of 6 December.	1	-

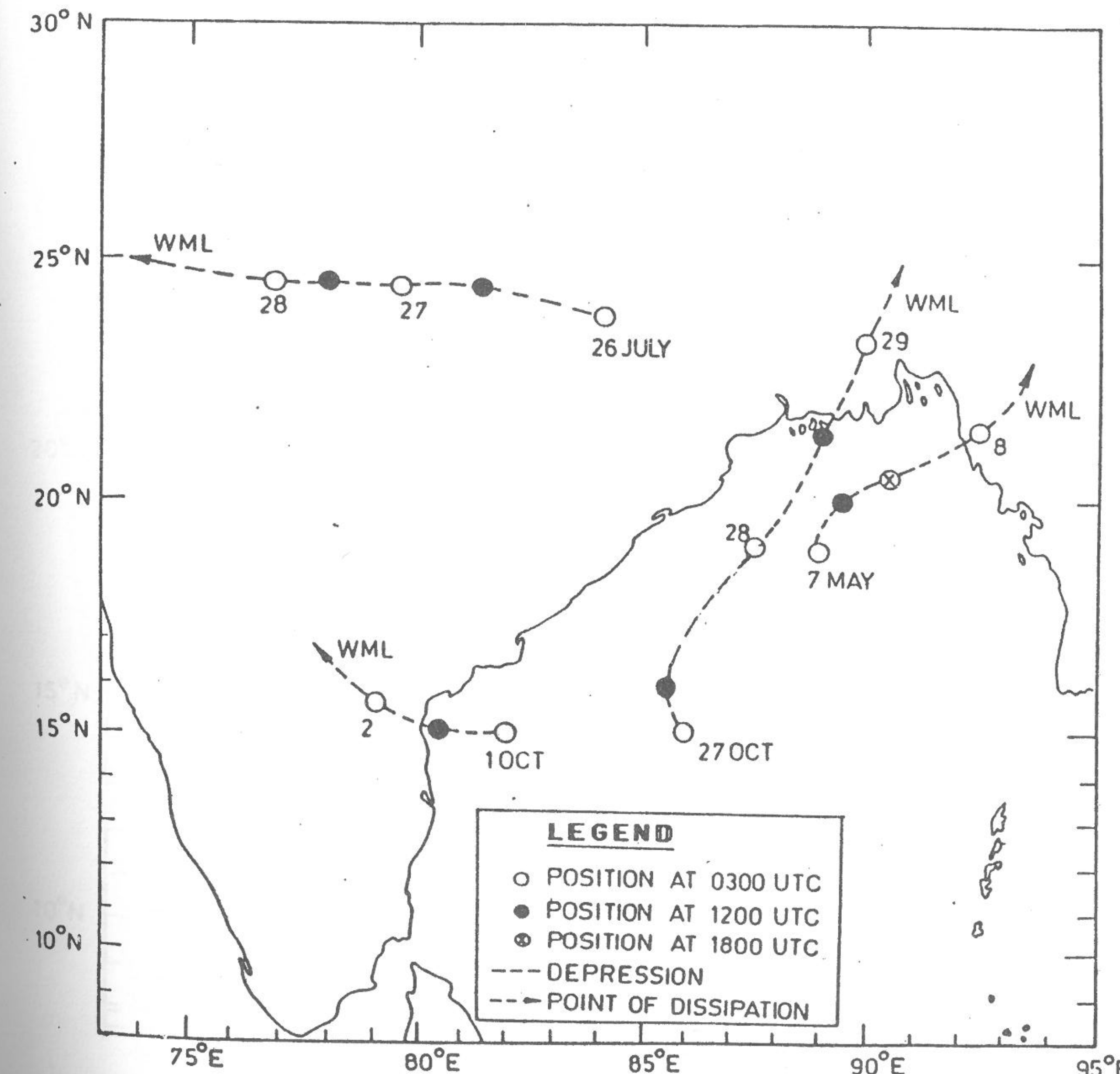

30° N
25° N
20° N
15° N
10° N
75°E
80°E
85°E
90°E
95°E
WML
28
27
26 JULY
WML
29
WML
8
28
7 MAY
WML
2
1 OCT
27 OCT
LEGEND
POSITION AT 0300 UTC
POSITION AT 1200 UTC
POSITION AT 1800 UTC
DEPRESSION
POINT OF DISSIPATION

FIG. A1

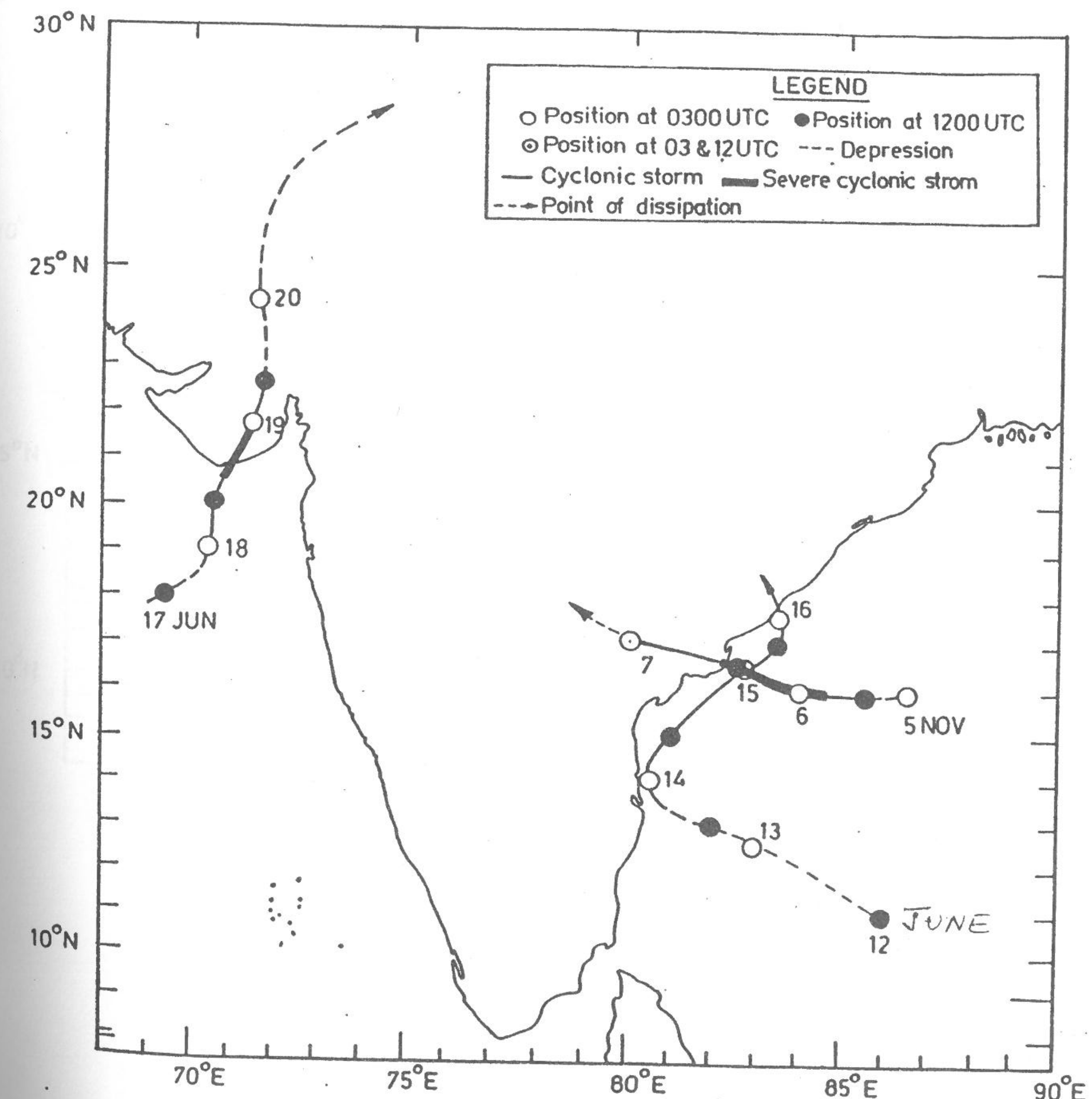

30° N
25° N
20° N
15° N
10° N
70°E
75°E
80°E
85°E
90°E
LEGEND
Position at 0300 UTC
Position at 1200 UTC
Position at 03 & 12 UTC
Depression
Cyclonic storm
Severe cyclonic strom
Point of dissipation
20
19
18
17 JUN
16
7
15
6
5 NOV
14
13
12
JUNE

FIG. A2

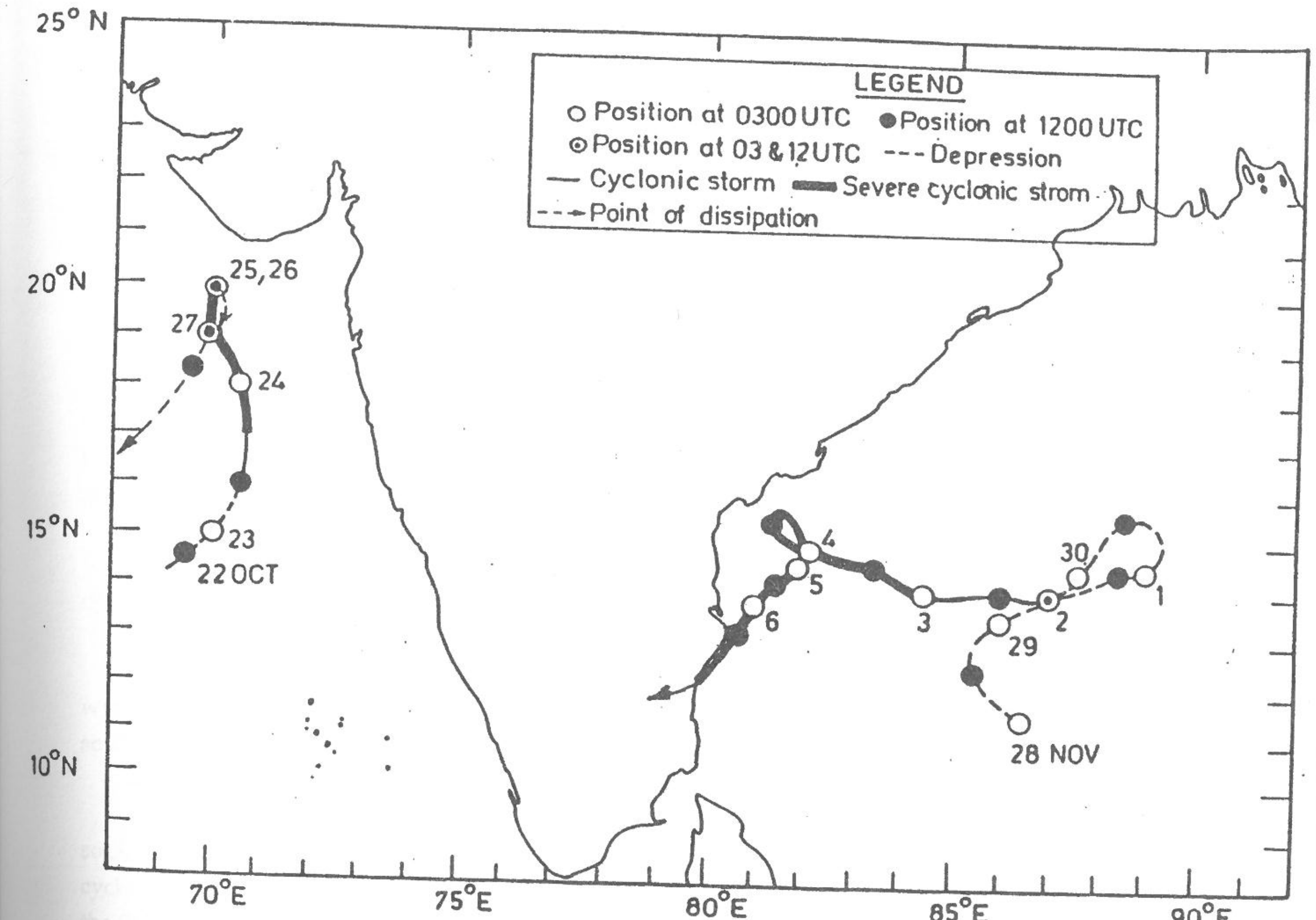

LEGEND
Position at 0300 UTC
Position at 1200 UTC
Position at 03 & 12 UTC
Depression
Cyclonic storm
Severe cyclonic strom
Point of dissipation
25° N
20°N
15°N
10°N
70°E
75°E
80°E
85°E
90°E
25,26
27
24
23
22 OCT
4
5
6
3
2
1
30
29
28 NOV

FIG. A3

SUMMARY OF THE 1996 CYCLONE SEASON - RSMC TOKYO

SUMMARY

In late 1995, the Walker circulation in the tropical Pacific was still intense as had been since August of the year. Dominant easterly anomalies of the low-level winds prevailed over the western and central tropical Pacific. The negative anomalies of monthly mean sea surface temperatures (SST) over the eastern tropical Pacific reached its maximum in December 1995 as indicated by spreading area over -1.0 C around 140 W near the equator. Intense negative SST anomalies over these waters persisted until February 1996. Positive anomalies of SST had been also predominant over the western tropical Pacific during the period.

Though the negative SST anomalies over the eastern tropical Pacific diminished in March 1996, the positive anomalies over the western tropical Pacific remained still evident. The positive anomalies lasted longer than a year over these waters. This was the first since 1949 when JMA had started the analysis of SST. The Walker circulation was still strong in autumn. A La Nina-like SST pattern has persisted in the equatorial Pacific.

The first tropical cyclone in 1996 formed in the end of February. The formation of tropical cyclones this year was twenty-six by the end of December, which is normal in number.

Four of them, 9604, 9607, 9611 and 9619, formed over the South China Sea or its marginal waters. Three of them landed on Indochina or southern China, while 9604 migrated for the waters south of Japan.

Other twenty-two tropical cyclones formed over the sea east of the Philippines or the sea south of Japan. Two of them, 9601 and 9602, dissipated in the Philippines. Other five tropical cyclones, 9608, 9609, 9613, 9616 and 9625 landed on Indonesia or China and one, 9622 dissipated in the South China Sea. Most of the others took normal recurving tracks and migrated for the western North Pacific, while 9610 and 9615 took unusual tracks.

TS 9601 (9601)

The first tropical cyclone in 1996 formed as a tropical depression (TD) over the Palau Islands about 300 km southeast of Koror (91408) at 00 UTC on 27 February. Momentary intensification of the subtropical anticyclone at 300 hPa level over the Mariana Islands drove the TD west-northwestward. It developed into a tropical storm (TS) 9601 closely east of Mindanao at 00 UTC on 29 February.

The minimum pressure of 998 hPa and the maximum winds of 35 knots were estimated near the center. TS 9601 had crossed the central region of the Philippines without further intensification by 00 UTC on 1 March when it weakened into TD. The lifetime as a tropical cyclone with TS intensity or higher was only 24 hours. The TD dissipated in the Sulu Sea by 00 UTC on 2 March.

TS 9602 ANN (9602)

A systematic organization of the cloud clusters developed into TD over the Caroline Islands, about 220 km northeast of Woleai (91317) at 12 UTC on 1 April. Initially the TD moved slowly in the weak steering flow. The intensification of the subtropical anticyclone at 300 hPa level over the Mariana Islands after 3 April favored the westward migration of the TD. The TD developed into TS ANN (9602) about 600 km east of Mindanao at 18 UTC on 5 April. ANN moved west-northwest and affected the Philippines taking a similar track as TS 9601 had done.

The minimum pressure of 10 0 hPa and the maximum wind of 35 knots were recorded. Without further intensification, ANN weakened into TD at 00 UTC on 8 April over the Sibuyan Sea and dissipated in the western vicinity of Panay Island by 12 UTC on 10 April.

TY 9603 BART (9603)

BART (9603), which attained the typhoon (TY) intensity first in 1996, formed as TD over the Caroline Islands, about 200 km southeast of Yap (91413) at 18 UTC on 8 May and reached TS intensity at 06 UTC on 10 May in the western vicinity of Yap. Initially BART was in the southern periphery of the significant subtropical ridge around 20 N and moved west. Abrupt retreat of the subtropical anticyclone over the South China Sea on 12 April caused the dissolution of the ridge and led BART for northward migration.

BART acquired the severe tropical storm (STS) intensity at 06 UTC on 12 May and further developed into TY at 00 UTC on 13 May about 600 km east of Luzon Island. The minimum pressure of 930 hPa and the maximum wind of 95 knots were estimated from 14 to 15 May while it began to recurve over the sea about 300 km east of Luzon.

BART was evidently in the northern periphery of the subtropical ridge on 15 May and the southern branch of the westerlies lay along 25 N in latitude. Thus, after 16 May BART moved constantly northeast over the sea about 800 km south of the Japan Islands incessantly decreasing its intensity into STS at 06 UTC on 17 May and into TS at 06 UTC on 18 May. It degenerated into an extratropical cyclone over the sea east of the Ogasawara Islands at 00 UTC on 19 May and dissipated near the international date line by 18 UTC on 20 May.

TS 9604 CAM (9604)

A tropical depression formed over the South China Sea at 06 UTC on 18 May and moved slowly northeast in absence of significant steering flow. It developed into TS CAM (9604) at 12 UTC on 20 May about 500 km west of Luzon. The minimum pressure of 994 hPa and the maximum wind of 40 knots were estimated.

In the north of CAM, there blocked up the subtropical ridge over the northern South China Sea. CAM slowly cut a distressing route of northeastward migration and reached the southern branch of the mid-tropospheric westerlies on 23 May over Bashi Channel where CAM started the constant migration to the east-northeast.

CAM weakened into TD about 300 km south of Naha (47936) at 18 UTC on 23 May. The TD, after degenerated into an extratropical cyclone at 12 UTC on 24 May, dissipated over the sea about 200 km west of Chichijima (47971) by 06 UTC on 26 May.

TY 9605 DAN (9605)

No tropical cyclone with TS intensity or higher formed in June 1996.

DAN (9605) formed at 00 UTC on 5 July as a tropical depression in the Mariana Islands, about 350 km east of Maug (91234) in the southern periphery of the subtropical anticyclone over the western North Pacific. Moving west, it attained TS intensity at 12 UTC on 6 July. DAN further developed into STS at 06 UTC on 7 July and into TY at 00 UTC on 8 July. The minimum pressure of 970 hPa and the maximum wind of 65 knots were estimated.

Retreat of the subtropical ridge on 8 July over the sea south of Japan allowed DAN to recurve to the north and to rush into the northern periphery of the subtropical ridge. Downgraded into STS at 06 UTC on 9 July, DAN migrated direct to the north approaching the eastern Islands of Japan. Over the northern Sea of Japan, there lay an polar cutoff low with upper cold air. DAN reached the northeastward steering flow along the eastern periphery of the polar low and was switched its movement to the northeast on 10 July.

Downgraded into TS at 21 UTC on 10 July about 150 km east from the coast of the Islands of Japan, DAN moved northeast and reached the Kuril Islands where it was merged with the polar low and degenerated into an extratropical cyclone at 06 UTC on 12 July. Finally the extratropical cyclone reached the Aleutian Islands and left the responsible area of the Center by 18 UTC on 17 July.

TY 9606 EVE (9606)

EVE (9606) formed as a tropical depression over the sea near the Mariana Islands, about 150 km west of Pagan (91222) at 06 UTC on 13 July. Soon after the formation it attained TS intensity at 06 UTC on 14 July. Rapid intensification led EVE to STS intensity at 00 UTC on 15 July and further to TY intensity at 12 UTC that day. Initially EVE moved northwest along the steering flow around the subtropical anticyclone over the Ogasawara Islands. The minimum pressure of 940 hPa and the maximum wind of 85 knots were recorded on 16 July.

Constant northwestward migration led EVE to a trifling col in the subtropical ridge in the east of another anticyclone over the East China Sea. From 17 to 18 July, EVE was just located in the midst of the ridge, where it gradually recurved to the north.

EVE landed on Kyushu Island at 04 UTC on 18 July. Tracking over the western Islands of Japan, it weakened into STS at 09 UTC on 18 July and further into TS at 15 UTC that day. In the northern periphery of the subtropical ridge, EVE turned to the east and wakened into TD at 06 UTC on 19 July.

While the subtropical anticyclone over the Ogasawara Islands decreased its intensity, another anticyclone over the East China Sea remained dominant, which signified that the subtropical anticyclone over the sea south of Japan shifted rather west. Then the tropical depression moved east-southeast along the steering flow in the eastern periphery of the subtropical anticyclone and left the Islands of Japan to the south. On 23 July, sudden intensification of the subtropical ridge, especially of the dominant anticyclone over the western North Pacific, pushed the tropical depression again to the north. After the extratropical transformation at 12 UTC on 24 July, it reached the Aleutian Islands where it left the responsible area of the Center by 06 UTC on 27 July.

STS 9607 FRANKIE (9607)

A tropical depression formed in the South China Sea at 06 UTC on 20 July and developed into TS FRANKIE (9607) at 00 UTC on 22 July. FRANKIE moved constantly to the northwest along the steering flow in the southeastern periphery of the subtropical anticyclone over the East China Sea. During the constant migration, it passed over Hainan Island late on 22 July. Slight intensification led FRANKIE into STS at 06 UTC on 23 July just west of Hainan Island. The minimum pressure of 975 hPa and the maximum wind of 50 knots were recorded during the migration over the Gulf of Tongkin on 23 July.

Gradual split of the subtropical high over the East China Sea drove its western faction into the inland of China. FRANKIE moved west in the southern periphery of the subtropical anticyclone over the central China and landed on Vietnam at 18 UTC on 23 July when it weakened into TS. It further weakened into TD at 18 UTC on 24 July. Forced to migrate into the mountainous region of southern China, it dissipated by 00 UTC on 26 July.

TY 9608 GLORIA (9608)

GLORIA (9608) formed as a tropical depression over the sea east of the Philippines, about 700 km east of Samar Island at 06 UTC on 21 July. It moved along the southeastern periphery of the subtropical anticyclone over the East China Sea as FRANKIE (9607) had done, except that GLORIA moved near the center of the anticyclone. Moving northwest it developed into TS at 12 UTC on 22 July.

GLORIA moved constantly to the northwest. It developed into STS at 12 UTC on 23 July and further into TY at 06 UTC on 24 July recording the minimum pressure of 965 hPa and the maximum wind of 65 knots from 24 to 26 June when it was over the waters near north of Luzon.

On 25 July, the subtropical anticyclone over the East China Sea began to split west and east. GLORIA was led to the col of the subtropical ridge among the anticyclone over the sea south of Japan and one over the central China. Thus it turned slightly to the north and passed very close to Taiwan on 26 July. It weakened into STS at 12 UTC that day and landed on the southern coast of China without further northward migration.

GLORIA weakened into TS at 00 UTC on 27 July and further into TD at 06 UTC that day. Moved into the inland of southern China, it dissipated by 00 UTC on 29 July.

TY 9609 HERB (9609)

A tropical depression developed over the sea east of the Mariana Islands, about 800 km east of Tinian (91232) at 00 UTC on 23 July. It initially moved along the steering flow in the southwestern periphery of the subtropical anticyclone over the western North Pacific and developed into TS HERB (9609) at 00 UTC on 24 July. Rapid intensification of the subtropical ridge over the sea south of Japan hindered HERB from migrating further to the north. Moving constantly to the west, HERB developed into STS at 18 UTC on 25 July and further into TY at 12 UTC on 26 July.

The subtropical ridge weakened on 28th July and retreated to the north over the Yellow Sea. HERB turned to the northwest and recorded the minimum pressure of 925 hPa and the maximum wind of 95 knots on 31 July when it was over the southern Ryukyu Islands.

The subtropical ridge intensified again over the Yellow Sea and HERB gradually turned to the west to pass over the island of Taiwan on 31 July. Shortly after landing on the coast of China on 1 August, HERB weakened into STS at 06 UTC on 1 August and further into TS at 12 UTC that day. It moved deep in the continent of central China and weakened into TD at 06 UTC on 2 August and dissipated by 18 UTC on 4 August over the northern China.

STS 9610 JOY (9610)

JOY (9610) originated as a tropical depression about 200 km north of Marcus Island at 00 UTC on 30 July. Born in the midst of the subtropical ridge, it moved slowly to the north and developed into TS at 18 UTC on 31 July. Meandering east and west, JOY moved north and developed into STS at 06 UTC on 2 August. The minimum pressure of 980 hPa and the maximum wind of 55 knots were reported on 3 August. Shortly after, JOY weakened into TS at 12 UTC on 3 August and further into TD at 12 UTC on 4 August.

The TD escaped the stagnancy on 5 August when it reached the northward steering flow in the eastern periphery of the polar low migrating over the Sea of Okhotsk. Rapid northward movement led the tropical depression to the sea east of the Kuril Island where it performed extratropical transition at 06 UTC on 6 August. Moving further to the north, it dissipated over the sea east of Kamchatka by 18 UTC 6 August.

TS 9611 LISA (9611)

The cloud system over the South China Sea developed into TD at 06 UTC on 5 August and further developed into TS LISA (9611) at 18 UTC that day. An upper cold low was migrating slowly to the west over the inland of the southern China. This cold low could be traced back to the upper cold trough moving to the south over the western Islands of Japan on 30 July. The trough moved south along the eastern periphery of the subtropical anticyclone over the Yellow Sea and then migrated westward in the southern periphery of the anticyclone until it reached the inland of China.

Initially LISA moved northeast directed by the steering flow in the eastern periphery of the cold low. The minimum pressure of 996 hPa and the maximum wind of 40 knots were reported from 5 to 6 August.

Without further intensification, LISA landed on the southern coast of China and weakened into TD at 18 UTC on 6 August. Hindered by the significant anticyclone over the central China and induced to the cold low over the inland of central China, the TD turned to the north and then to the west before it dissipated by 18 UTC on 9 August.

TY 9612 KIRK (9612)

A tropical depression formed over the sea off south of the Islands of Japan, about 550 km south-southeast of Minamidaitojima (47945) at 18 UTC on 3 August. The subtropical ridge lay from the Islands of Japan to the Mariana Islands. Initially the TD moved north along the steering flow of the western periphery of the subtropical ridge until it approached Naze (47909) in the island of Amami on 5 August. At the time, the southern branch of westerlies was predominant at 300 hPa level over the western Islands of Japan and a trifling col hindered the TD from migrating further to the north of 28 N in latitude. Here the TD developed into TS KIRK (9612) at 18 UTC on 5 August.

Abrupt conversion of the upper flow over the western Islands of Japan caused the intensification of northerlies in the eastern periphery of the subtropical anticyclone over the central China at 12 UTC on 5 August. KIRK located too west to escape the northerlies and began to be pushed back to the southeast until it reached again about 250 km east-southeast of Minamidaitojima on 7 August. Though momentary retreat of the subtropical anticyclone over the central China allowed KIRK to move northwest on 8 August, the restoration of the subtropical anticyclone on 9 August suppressed the further northward migration of KIRK again. KIRK moved slowly to the west and developed into STS at 00 UTC on 9 August. Reaching near 130 E KIRK developed into TY at 06

UTC on 10 August and stayed there for a day.

The subtropical ridge suddenly weakened on 12 August and there appeared a distinct col in the ridge over the western Islands of Japan. To the west of the col, the upper trough approached from the northern China. Thus the northeastward steering flow grew influential over the Sea of Japan. KIRK began to move slowly to the north and soon afterward was led for typical recurving track. On 13 August, KIRK recorded the minimum pressure of 955 hPa and the maximum wind of 75 knots.

In the beginning of 14 August, KIRK landed on the island of Kyushu and, after crossed over the western Islands of Japan, it left for the Sea of Japan where it weakened into STS at 09 UTC that day. KIRK passed again over the northern Islands of Japan on 15 August and weakened into TS at 09 UTC that day over the sea near east of the northern Islands. Constantly moving to the northeast in the eastern periphery of the upper trough, KIRK regenerated into an extratropical cyclone at 00 UTC on 16 August in the southern vicinity of the Kuril Islands. It further moved northeast and left the responsible area of the Center over the sea near the Aleutian Islands by 18 UTC on 18 August.

Large eye at the center of cyclone was a characteristic of KIRK. Naha (47936) on the island of Okinawa had been in the midst of the eye during 9 hours on 12 August when KIRK passed over the island.

TY 9613 NIKI (9613)

During the event of KIRK (9612), retreated the subtropical ridge which lay over the regions from the central China to the Islands of Japan. A tropical depression formed at 00 UTC on 17 August over the sea east of the Philippines, about 800 km north-northwest of Yap (91413) in the southern periphery of the dominant subtropical ridge relocated over the seas south of Japan, i.e., from the southern East China Sea to the Ogasawara Islands. Swiftly migrating west, the TD developed into TS NIKI (9613) at 06 UTC on 18 August. Upgraded into STS at 12 UTC on 19 August, NIKI passed over the island of Luzon. It further developed into TY at 06 UTC on 21 August over the South China Sea. The minimum pressure of 970 hPa and the maximum wind of 65 knots were recorded.

Passing over Hainan Island, NIKI weakened into STS at 12 UTC on 22 August over the Gulf of Tongkin. After landing on Vietnam on 22 August, it weakened into TS at 00 UTC on 23 August and further into TD at 06 UTC that day. It dissipated over the inland of Indochina by 18 UTC on 23 August.

TY 9614 ORSON (9614)

A tropical depression formed over the sea between the Mariana Islands and the Ogasawara Islands, about 250 km northwest of Pagan (91222) at 18 UTC on 20 August. Slowly moving to the north, it was hindered from further northward migration on 23 August by the subtropical anticyclone located south of the Islands of Japan. The TD developed into TS ORSON (9614) at 00 UTC on 23 August during the stagnancy. Then, successive intensification Of the subtropical ridge over the Mariana Islands led ORSON for eastward migration. It developed into STS at 06 UTC on 24 August and further into TY at 00 UTC on 25 August. The minimum pressure of 955 hPa and the maximum wind of 75 knots were estimated on 25 August.

ORSON fell into stagnancy again on 27 August prohibited by intensifying subtropical anticyclone located over the sea off east of Japan. During the stagnancy ORSON weakened into STS at 06 UTC on 28 August. Then it moved northwest directing for a trifling col in the ridge and further weakened into TS at 18 UTC on 29 August.

ORSON passed over the subtropical ridge on 1 September. To the north of ORSON there lay a dominant steering flow in the eastern periphery of the upper trough locating over the Sea of Japan. During the period of recurvature, ORSON experienced temporal restoration into STS from 06 UTC on 31 August to 06 UTC on 1 September. After the recurvature, swift migration led ORSON for the sea east of the Kuril Islands where it degenerated into an extratropical cyclone at 12 UTC on 3 September. The cyclone kept on northeastward migration and left the responsible area of the Center by 18 UTC on 4 September.

TS 9615 PIPER (9615)

PIPER (9615) formed as a tropical depression about 750 km northeast of Marcus Island (47991) at 18 UTC on 22 August and developed into TS at 12 UTC on 23 August. It moved north along the steering flow in the western periphery of the upper anticyclone located over the sea south of the Aleutian Islands. The minimum pressure of 996 hPa and the maximum wind of 40 knots were estimated on 25 August.

Swift migration led PIPER to the sea east of the Kuril Islands where it weakened into TD at 06 UTC on 26 August. Merged into the polar cut-off low migrating over the Sea of Okhotsk, it dissipated by 12 UTC that day.

TY 9616 SALLY (9616)

SALLY (9616) formed as a tropical depression off east of the Philippines, about 880 km north of Koror (91408) at 00 UTC on 5 September. Initially in the stagnant air off south of the subtropical ridge, it moved slowly to the west-northwest. Rapid intensification led SALLY into TS status at 00 UTC on 6 September and then into STS status at 12 UTC that day. Abrupt intensification of the subtropical ridge along 28 N in latitude on 7th led SALLY for swift west-northwestward migration. SALLY developed further into TY at 06 UTC on 7 September and recorded the minimum pressure of 940 hPa and the maximum wind of 85 knots over the South China Sea on 8 September.

Constant migration led SALLY to land on the southern coast of China on 9 September. It weakened into STS at 06 UTC on 9 September, and further into TS at 18 UTC that day. Over the inland of southern China, it weakened into TD at 00 UTC on 10 September and dissipated by 00 UTC on 11 September.

TY 9617 VIOLET (9617)

A tropical depression formed over the sea about 900 km east of Luzon Island at 06 UTC on 11 September. Dominant subtropical anticyclone located over the sea east of Marcus Island and another one over the sea south of Japan. The TD began to move northwest along the weak steering flow in the southwestern periphery of the latter. During the northwestward migration, it developed into TS VIOLET (9617) at 00 UTC on 13 September and into STS at 12 UTC that day. VIOLET further developed into TY at 12 UTC on 14 September. To the north of VIOLET there lay a significant subtropical ridge stretching west from the anticyclone over the sea south of Japan, which hindered VIOLET from migrating further to the northwest.

Temporary retreat of the subtropical anticyclone over the sea south of Japan switched the movement of VIOLET to the east-northeast. When VIOLET was over the sea about 600 km east of Bashi Channel, the minimum pressure of 935 hPa and the maximum wind of 90 knots were estimated on 16 September.

After east-northeastward migration, VIOLET was in the midst of the subtropical ridge over the sea east of the Ryukyu Island on 19 September. Significant trough in the westerlies approached from the west and located over the western Islands of Japan on 20 September. VIOLET turned to the north and migrated along the steering flow in the eastern periphery of the trough. Constant northeastward migration over the sea south of the Islands of Japan led VIOLET to approach the eastern Islands of Japan on 22 September keeping the TY intensity. Then it weakened into STS at 18 UTC on 22 September over the sea near east of Japan. After degenerated into an extratropical cyclone at 12 UTC on 23 September over the Kuril Islands, it left the responsible area of the Center by 12 UTC on 27 September.

TY 9618 TOM (9618)

A tropical depression formed over the sea in the eastern vicinity of the Mariana Islands, about 400 km east-northeast of Tinian (91232) at 00 UTC on 12 September. Initially it moved northwest in the western periphery of the subtropical anticyclone over the sea near Marcus Island. It developed into TS TOM (9618) at 06 UTC on 13 September. TOM fell in stagnancy and developed into STS at 06 UTC on 14 September. Retreat of the subtropical anticyclone favored northeastward migration of TOM. TOM further developed into TY at 12 UTC on 15 September and the minimum pressure of 965 hPa and the maximum wind of 70 knots were estimated till 17 September.

The same day, the significant upper trough approached from west over the western Islands of Japan. TOM gradually escaped the subtropical ridge and was accelerated northeast along the steering flow in the eastern periphery of the trough.

Downgraded into STS at 12 UTC on 18 September, TOM reached over the sea off east of Japan where it degenerated into an extratropical cyclone at 12 UTC that day. Gradually turned to the north, the extratropical cyclone dissipated in the south of Kamchatka by 06 UTC on 22 September.

STS 9619 WILLIE (9619)

WILLIE (9619) formed as a tropical depression at 18 UTC on 15 September over the Gulf of Tongkin. It took an unusual track going round the Hainan Island.

Initially affected by the weaksubtropical anticyclone at 500 hPa level over the southern Indochina, it moved southeast over the sea in the southern vicinity of Hainan Island. It developed into TS at 06 UTC on 18 September. Then it was affected by the ridge extending between the southern China and the Philippines. WILLIE turned to the north over the sea in the eastern vicinity of Hainan Island where it developed into STS at 12 UTC on 19 September.

WILLIE reached the southern periphery of the subtropical ridge extending east and west at 300 hPa level over the southern China and turned to the west over the sea in the northern vicinity of the Island. It recorded the minimum pressure of 985 hPa and the maximum wind of 55 knots on 20 September.

WILLIE reached again over the Gulf of Tongkin on 21 September and weakened into TS at 06 UTC that day. Crossed over the Gulf, it landed on Vietnam on 22 September and weakened into TD at 12 UTC that day. It moved further west and dissipated over the inland of Indochina by 18 UTC on 23 September.

TY 9620 YATES (9620)

A tropical depression formed over the Marshall Islands, about 100 km north of Enewetak (91250) at 00 UTC on 21 September. It moved west-northwest in the southern periphery of the dominant subtropical anticyclone over the western North Pacific. Abrupt intensification of the subtropical ridge extending west of the anticyclone formed another center of the subtropical anticyclone over the sea off south of Japan, which hindered the TD from further northward migration. The TD developed into TS YATES (9620) at 03 UTC on 23 September over the sea east of the Mariana Islands and further into STS at 12 UTC that day. It developed into TY at 00 UTC on 24 September. The minimum pressure of 935 hPa and the maximum wind of 90 knots were estimated on 26 September.

Retreat of the subtropical anticyclone off south of Japan again led YATES for northwestward migration. YATES was located over the sea west of the Mariana Islands and in the midst of the col of the subtropical ridge on 28 September. It began to recurve to the north.

Another significant typhoon ZANE (9621) migrated over the Ryukyu Islands 1,200 km west of YATES. Fujiwara effect, a mutual interaction between tropical cyclones adjacent to each others, disturbed the tracks of both typhoons during 18 hours from 12 UTC on 29 September. Consequently, YATES experienced the abrupt acceleration of the northward migration, while ZANE was kept back to the south.

Rapid northward migration lead YATES for the southern periphery of the westerlies over the Islands of Japan. Downgraded into STS at 06 UTC on 30 September, it gradually turned to the east. During swift eastward migration, it degenerated into an extratropical cyclone at 12 UTC on 1 October over the sea off east of Japan. Gradually turning to the northeast, it reached south of the Aleutian Islands and left the responsible area of the Center by 06 UTC on 3 October.

TY 9621 ZANE (9621)

ZANE (9621) formed as a tropical depression over the sea about 450 km west of Guam (91217) at 18 UTC on 23 September. Intensification of the ridge extending west of the subtropical anticyclone over the western North Pacific forced the TD to take a westward track. ZANE developed into TS at 00 UTC on 25 September in the east of the Philippines and further into STS at 12 UTC that day.

Gradual retreat of the subtropical ridge ahead allowed ZANE to migrate northward. ZANE developed into a typhoon at 00 UTC on 26 September. On 28 September, ZANE was on its way of constant recurving over the Ryukyu Islands.

Another significant typhoon YATES (9620) located 1,200 km east of ZANE. From 12 UTC on 29 to 06 UTC on 30 September, Fujiwara effect disturbed both of the typhoons. While ZANE swung YATES to the north, ZANE was kept back to the south and stayed over the Ryukyu Islands. Though ZANE had already reached the southern periphery of the westerlies over the East China Sea and had been directed for the Islands of Japan, this kink on the tracks suppressed further northward migration. ZANE was kept over the sea about 500 km south of the Islands and forced for eastward migration. During stagnancy over the Ryukyu Islands, ZANE recorded the minimum pressure of 950 hPa and the maximum wind of 80 knots on 29 September.

ZANE migrated constantly to the east decreasing its intensity into STS at 18 UTC, 1 October and further into TS at 06 UTC on 3 October. It degenerated into an extratropical cyclone at 18 UTC that day and left the responsible area of the Center by 12 UTC on 5 October.

STS 9622 BETH (9622)

BETH (9622) formed as a tropical depression over the waters about 50 km south of Saipan at 12 UTC on 11 October. Initially blocked by the dominant ridge of subtropical anticyclone along 25 N, it moved constantly to the west. Except for the brief northward excursion during temporal retreat of the ridge on 15 October, it moved further to the west after the restoration of the ridge on 16 October. After long duration of immaturity as TD, it developed into TS at 00 UTC on 16 October over the waters about 500 km east of Luzon.

After that, it developed satisfactorily into STS at 12 UTC on 16 October. BETH recorded the minimum pressure of 975 hPa and the maximum wind of 60 knots. After the passage over Luzon from 17 to 18 October, it weakened into TS at 00 UTC on 20 October over the South China Sea. It further weakened into TD at 00 UTC on 21 October and dissipated over the waters in the vicinity of Viet Nam at 06 UTC on 22 October.

TY 9623 CARLO (9623)

CARLO (9623) formed as a tropical depression over the waters about 700 km east of Saipan at 00 UTC on 20 October. Initially it moved to the northwest toward a col in the ridge between subtropical anticyclones over the western North Pacific and the sea south of Japan. After developed into TS at 18 UTC on 21 October, CARLO moved west blocked by the anticyclone migrating east over the waters off south of Japan. CARLO developed into STS at 00 UTC on 23 October, while this anticyclone began to retreat. Dominant anticyclone over the western North Pacific led CARLO for constant northward migration along its western periphery.

Further developed into TY at 00 UTC on 24 October, CARLO recorded the minimum pressure of 965 hPa and the maximum wind of 70 knots. It decayed into STS at 00 UTC on 25 October and into TS at 00 UTC on 26 October. Further decaying into TD at 12 UTC that day over the waters south of Kuril Islands, it dissipated at 18 UTC the same day.

TY 9624 DALE (9624)

A tropical depression formed over the waters to the north of Truk Islands at 18 UTC on 3 November. Along 25 N, there stretched the dominant ridge of subtropical anticyclone and an easterly trough with upper cold air migrated westward along 20 N. The TD located to the south of the cold trough where the easterlies of the subtropical anticyclone are locally canceled by the westerlies of the cold trough. The TD stayed in stagnancy almost for three days where it had formed. The TD developed into TS DALE (9624) at 18 UTC on 5 November.

The cold trough left for west on 6 November, which allowed DALE to migrate northwestward along the northwestern periphery of the anticyclone. DALE developed into STS at 12 UTC on 6 and into TY at 12 UTC on 7 November. Except for brief stagnancy on 7 November, it kept constant westward migration to reach the southern Mariana Islands on 8 November. Sudden retreat of subtropical ridge over the Ryukyu Islands led DALE for northwestward migration. DALE further developed and recorded the minimum pressure of 930 hPa and the maximum wind of 90 knots on 9 November.

DALE took fair recurving track in the western periphery of the subtropical anticyclone gradually retreating for east. It directed north on 11 November and northeast on 12 November. During the period of recurvature, another TS ERNIE (9625) migrated over the waters of Bashi Channel. DALE affected the northwestward movement of ERNIE to trace it back to the southeast for northern vicinity of Luzon. Though DALE, itself, sustained its normal recurving track, it never experienced any reduction in the speed of movement which is often the case with ordinary recurving tropical cyclones.

After the recurvature, the westerlies over the Islands of Japan flowed rather zonally to the east and led DALE for east-northeastward migration suppressing its northward penetration. On 13 November, the westerly trough deepened over the Sea of Japan and DALE moved rather to the northeast in its eastern periphery. DALE weakened into STS at 18 UTC on 12 November and degenerated into an extratropical low at 12 UTC on 13 November. The low developed again and left the responsible area of the Center at 00 UTC on 15 November.

TS 9625 ERNIE (9625)

A tropical depression formed over the waters about 300 km east of Luzon at 12 UTC on 7 November. Initially it moved to the northwest in the western periphery of gradually retreating subtropical ridge along 25 N. Moving across the Island of Luzon, it developed into TS ERNIE at 12 UTC on 9 November over the northern waters of the South China Sea. ERNIE recorded the minimum pressure of 992 hPa and the maximum wind of 40 knots on 11 November.

At the same time, another typhoon DALE (9624) located about 1,200 km to the east of ERNIE migrating to the northwest over the waters east of the Philippines. On 11 November, ERNIE was swung back to the southeast for near north of Luzon, where ERNIE found its way in the eastern periphery of another developing anticyclone over Indochina. After 12 November, ERNIE turned to the southwest across the South China Sea and decayed into TD at 12 UTC on 14 November. Landing on Indochina, it dissipated at 18 UTC on 16 November.

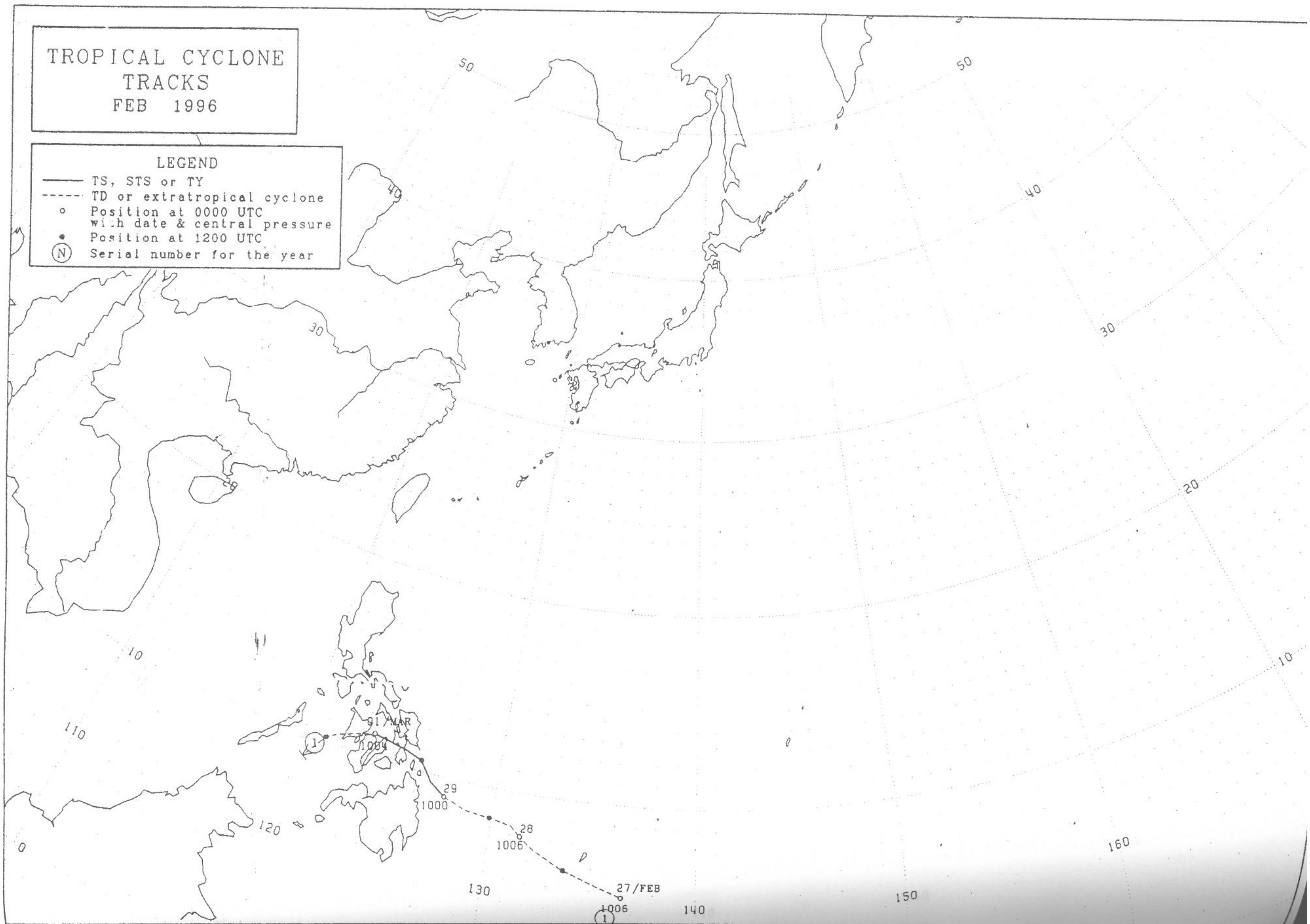
STS 9626 FERN (9626)

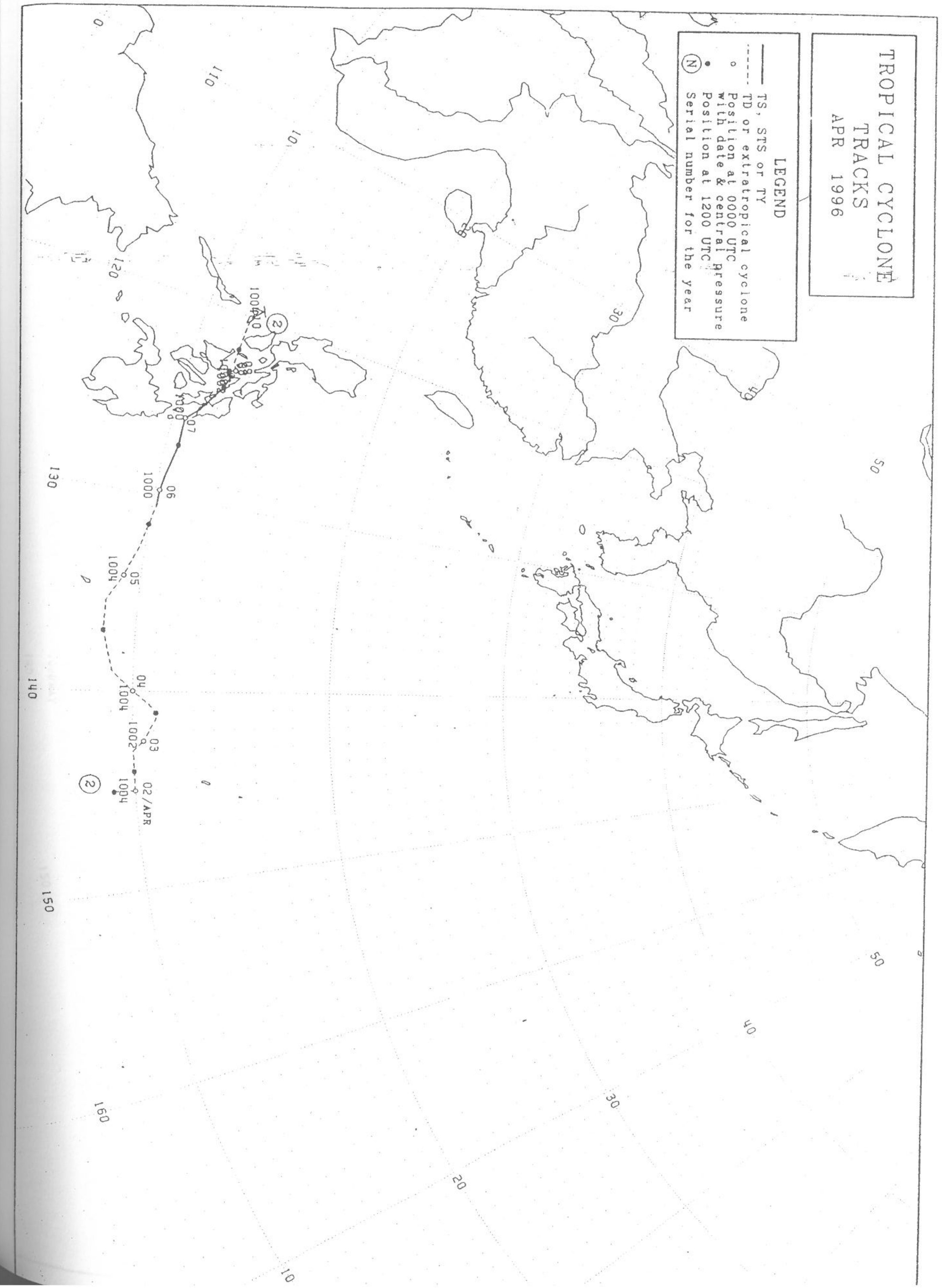
FERN (9626) formed as a tropical depression over the waters of Calorine Islands about 320 km southeast of Yap (91413) at 00 UTC on 21 December. Initially moving west or north within the southern periphery of subtropical ridge around 15 N, it developed into TS 9626 FERN at 18 UTC on 22 December. It further moved to the west and attained the STS intensity at 12 UTC on 24 December in the vicinity of Yap.

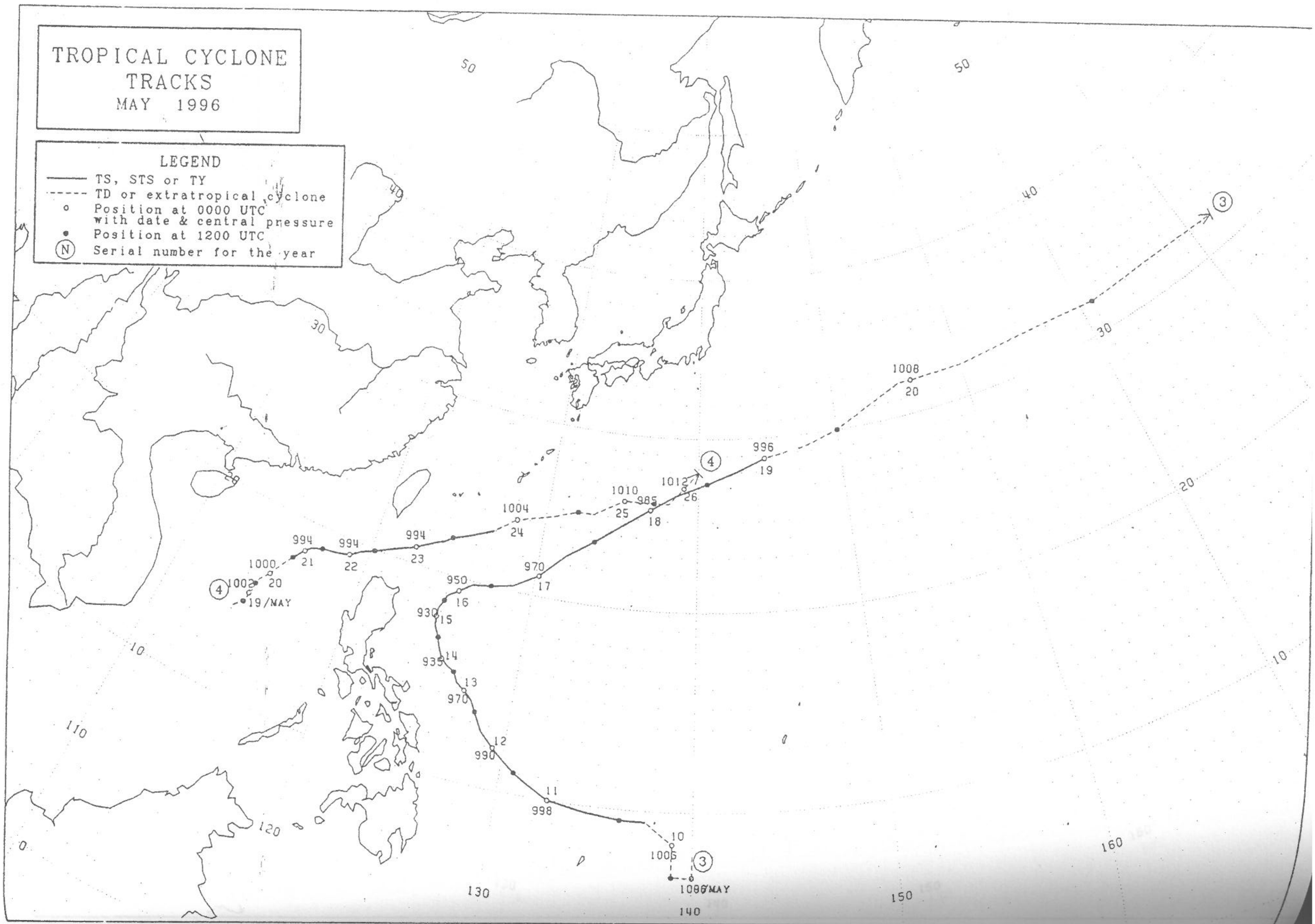
The upper trough in the southern periphery of westerlies approached from the southern China and formed a col within the subtropical ridge over the waters east of the Philippines. On 25 December, FERN turned to the north towards the col. It recorded the minimum pressure of 975 hPa and the maximum wind of 60 knots on 26 December. After reaching the westerlies on 28 December, it further turned to the northeast and weakened into TS at 18 UTC on 29 December. It accelerated to the east and transformed into an extratropical cyclone at 00 UTC on 30 December and dissipated by 18 UTC on 30 December over the waters to the west of Wake (91245).

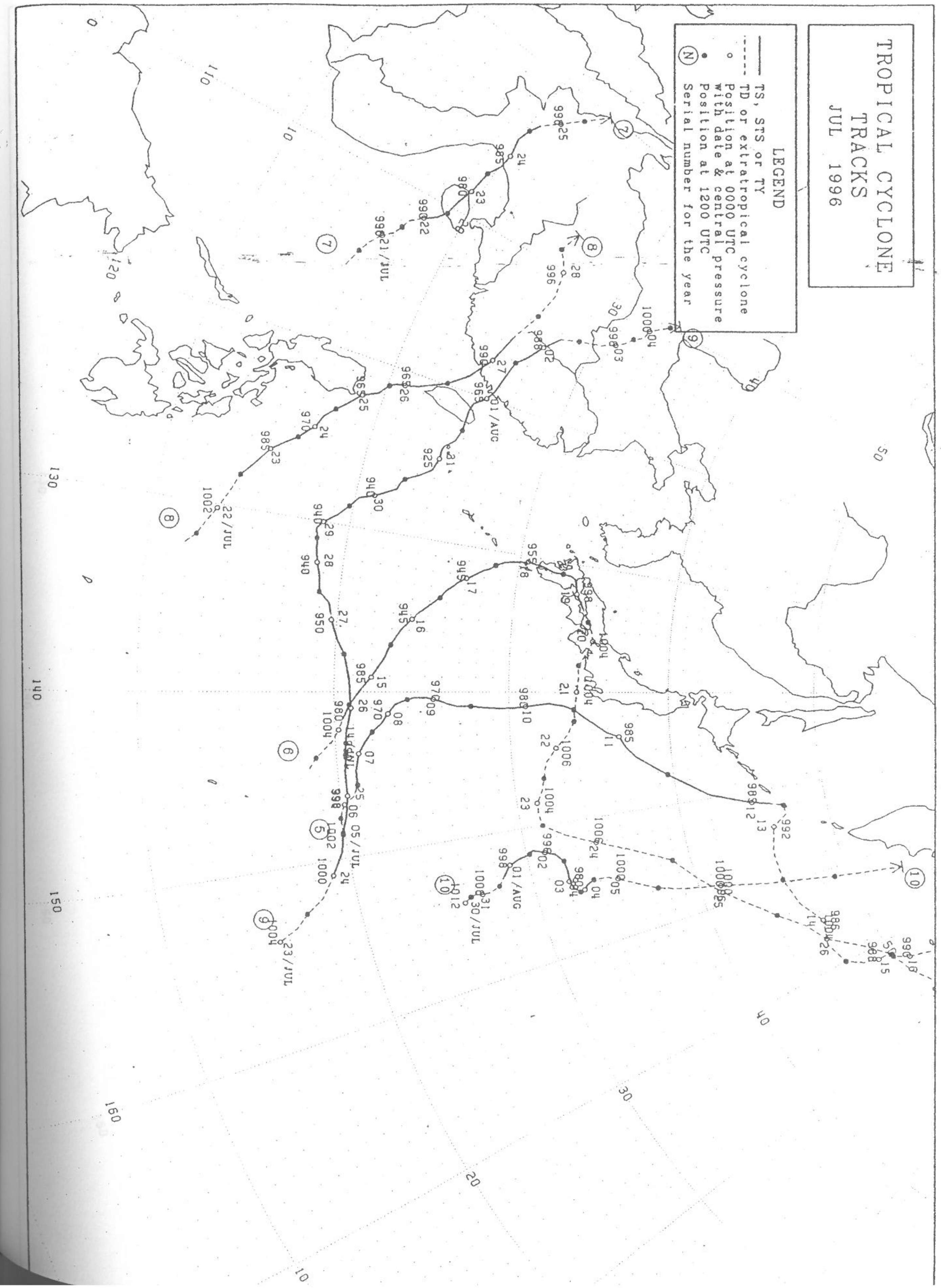
List of tropical cyclones generated in 1996

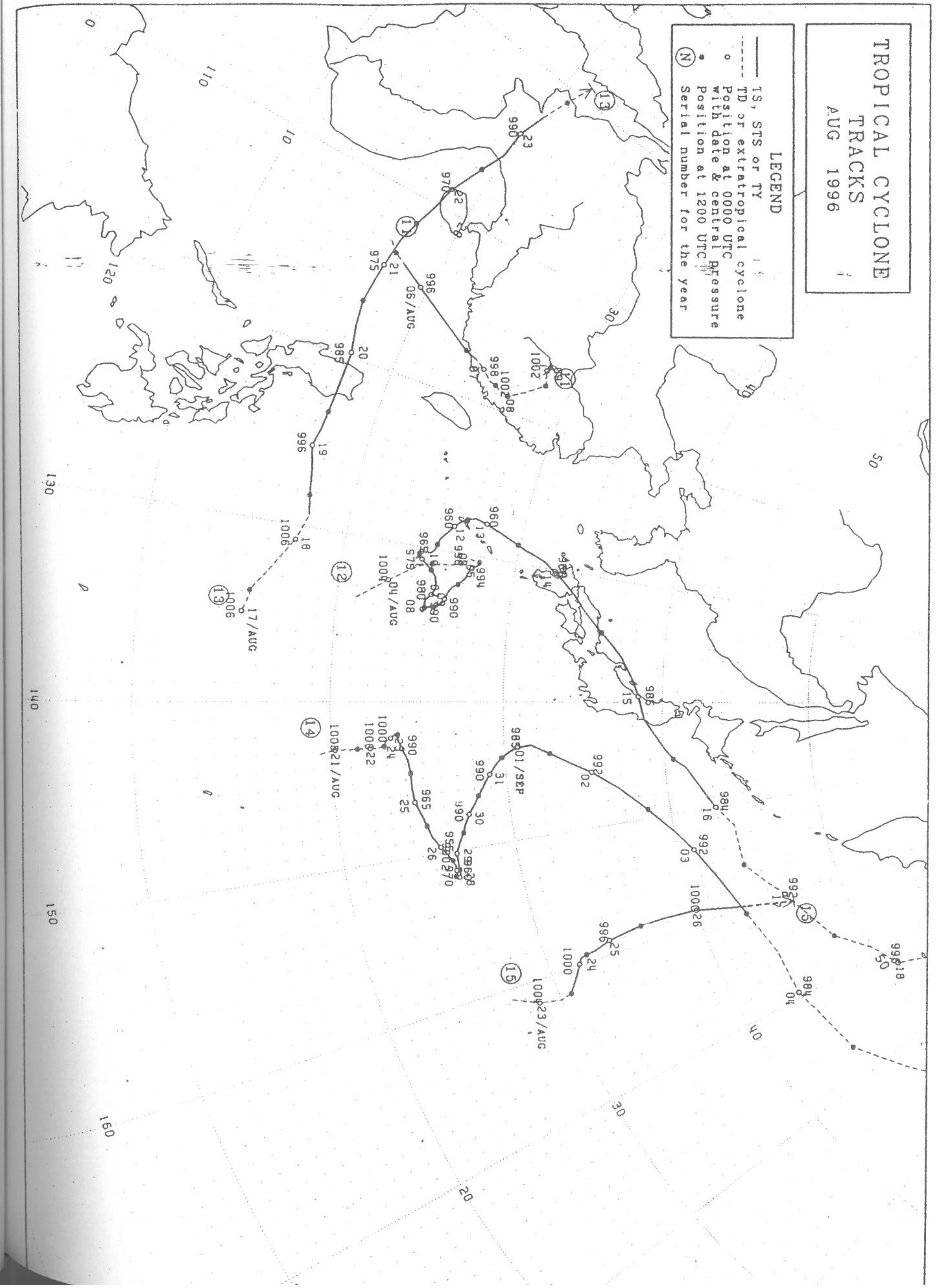
Tropical Cyclone			Duration of TS intensity or higher (UTC)					Minimum Central Pressure Date/Time (UTC)		Location (°N)	(°E)	Pressure (hPA)	Maximum Sustained Wind (kt)
TS	9601		290000	Feb	-	010000	Mar	290600	Feb	9.6	126.7	998	35
TS	9602	ANN	051800	Apr	-	080000	Apr	051800	Apr	10.2	130.5	1000	35
TY	9603	BART	[illegible]	May	-	190000	May	140600	May	16.2	125.4	930	95
TS	9604	CAM	201200	May	-	231800	May	201800	May	18.2	116.2	994	40
TY	9605	DAN	061200	Jul	-	120600	Jul	080000	Jul	22.9	141.4	970	65
TY	9606	EVE	140600	Jul	-	190600	Jul	160300	Jul	24.4	134.9	940	85
STS	9607	FRANKIE	220000	Jul	-	241800	Jul	230600	Jul	19.6	108.0	975	50
TY	9608	GLORIA	221200	Jul	-	270600	Jul	240600	Jul	17.3	124.0	965	65
TY	9609	HERB	240000	Jul	-	020600	Aug	301800	Jul	23.2	126.0	925	95
STS	9610	JOY	311800	Jul	-	041200	Aug	021200	Aug	32.1	152.9	980	55
TS	9611	LISA	051800	Aug	-	061800	Aug	051800	Aug	18.3	113.9	996	40
TY	9612	KIRK	051800	Aug	-	160000	Aug	130900	Aug	29.3	128.4	955	75
TY	9613	NIKI	180600	Aug	-	230600	Aug	210600	Aug	17.5	112.7	970	65
TY	9614	ORSON	230000	Aug	-	031200	Sep	251200	Aug	24.9	148.1	955	75
TS	9615	PIPER	231200	Aug	-	260600	Aug	250000	Aug	34.0	158.9	996	40
TY	9616	SALLY	060000	Sep	-	100000	Sep	080600	Sep	19.9	117.9	940	85
TY	9617	VIOLET	130000	Sep	-	231200	Sep	160000	Sep	20.0	126.4	935	90
TY	9618	TOM	130600	Sep	-	201200	Sep	151800	Sep	21.9	145.0	965	70
STS	9619	WILLIE	180600	Sep	-	221200	Sep	200000	Sep	20.5	110.4	985	55
TY	9620	YATES	230300	Sep	-	011200	Oct	261200	Sep	17.3	142.4	935	90
TY	9621	ZANE	250000	Sep	-	031800	Oct	291200	Sep	27.6	126.8	950	80
STS	9622	BETH	160000	Oct	-	210000	Oct	170600	Oct	17.5	123.3	975	60
TY	9623	CARLO	211800	Oct	-	261200	Oct	240600	Oct	23.8	145.0	965	70
TY	9624	DALE	051800	Nov	-	131200	Nov	091800	Nov	15.7	135.2	930	90
TS	9625	ERNIE	091200	Nov	-	141200	Nov	110600	Nov	19.8	118.5	992	40
STS	9626	FERN	221800	Dec	-	300000	Dec	261200	Dec	12.1	138.4	975	60

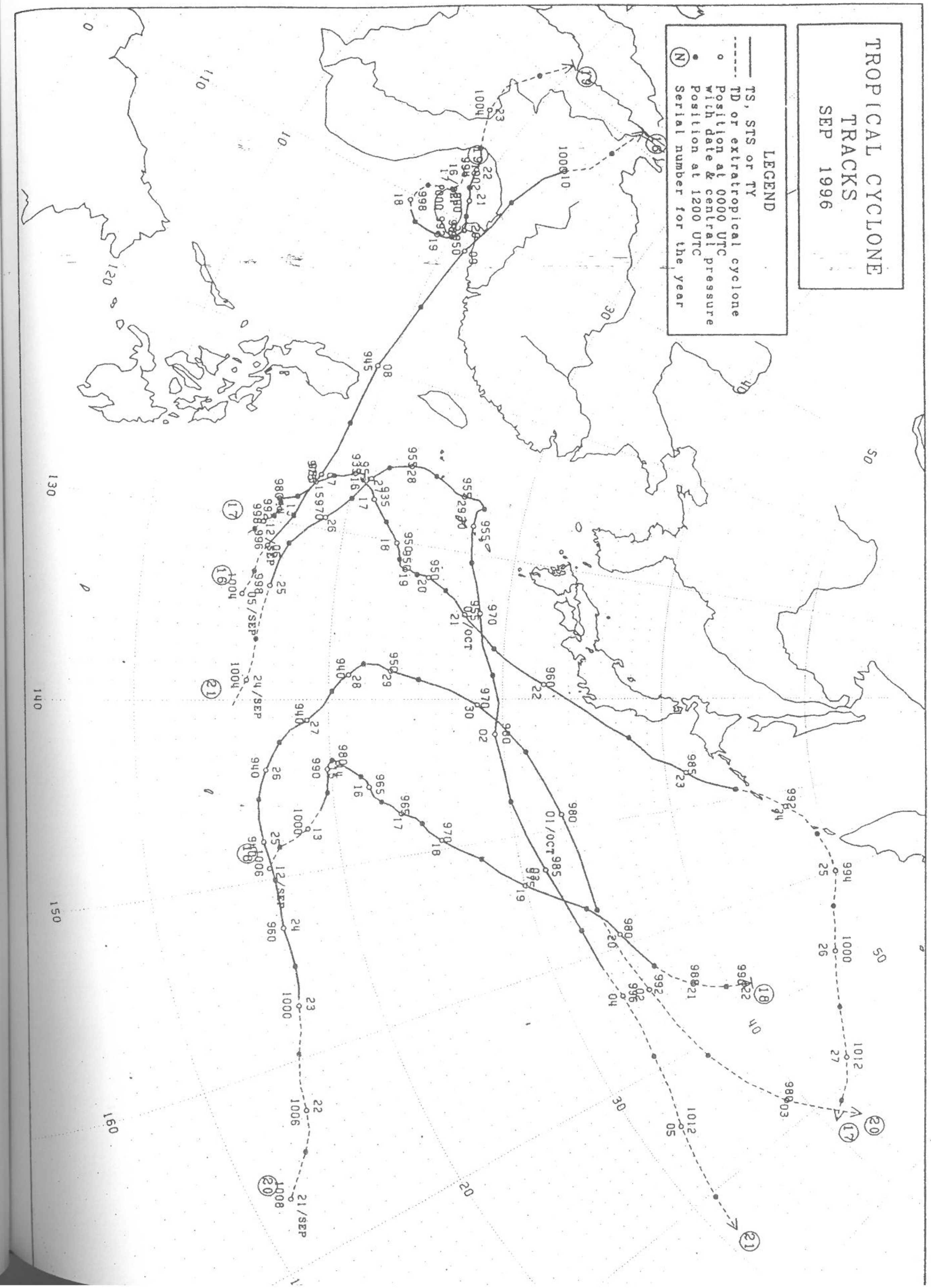

TROPICAL CYCLONE
TRACKS
FEB 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
N Serial number for the year
01/MAR
1004
29
1000
28
1006
27/FEB
1006
1

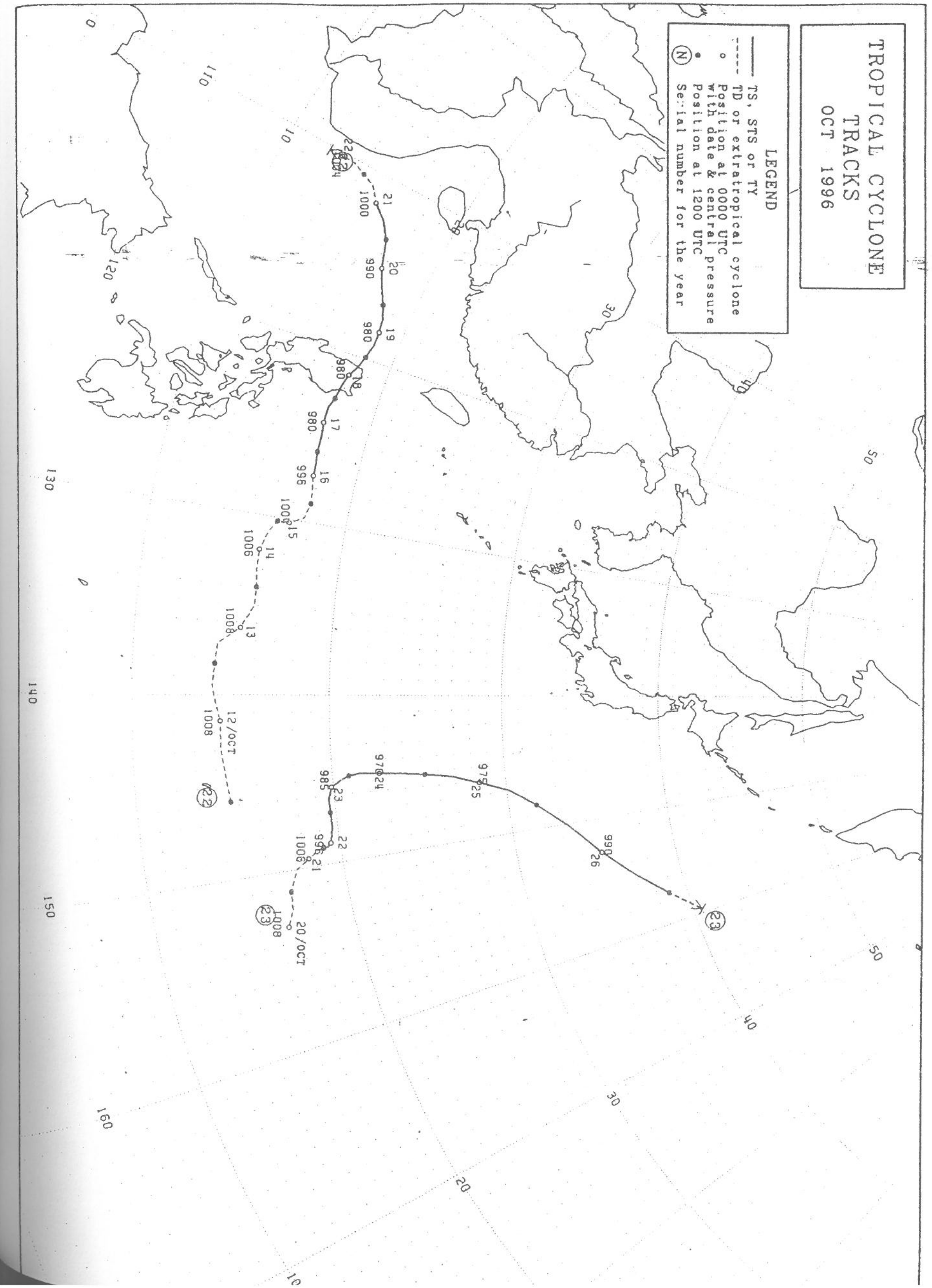

TROPICAL CYCLONE
TRACKS
APR 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
(N) Serial number for the year

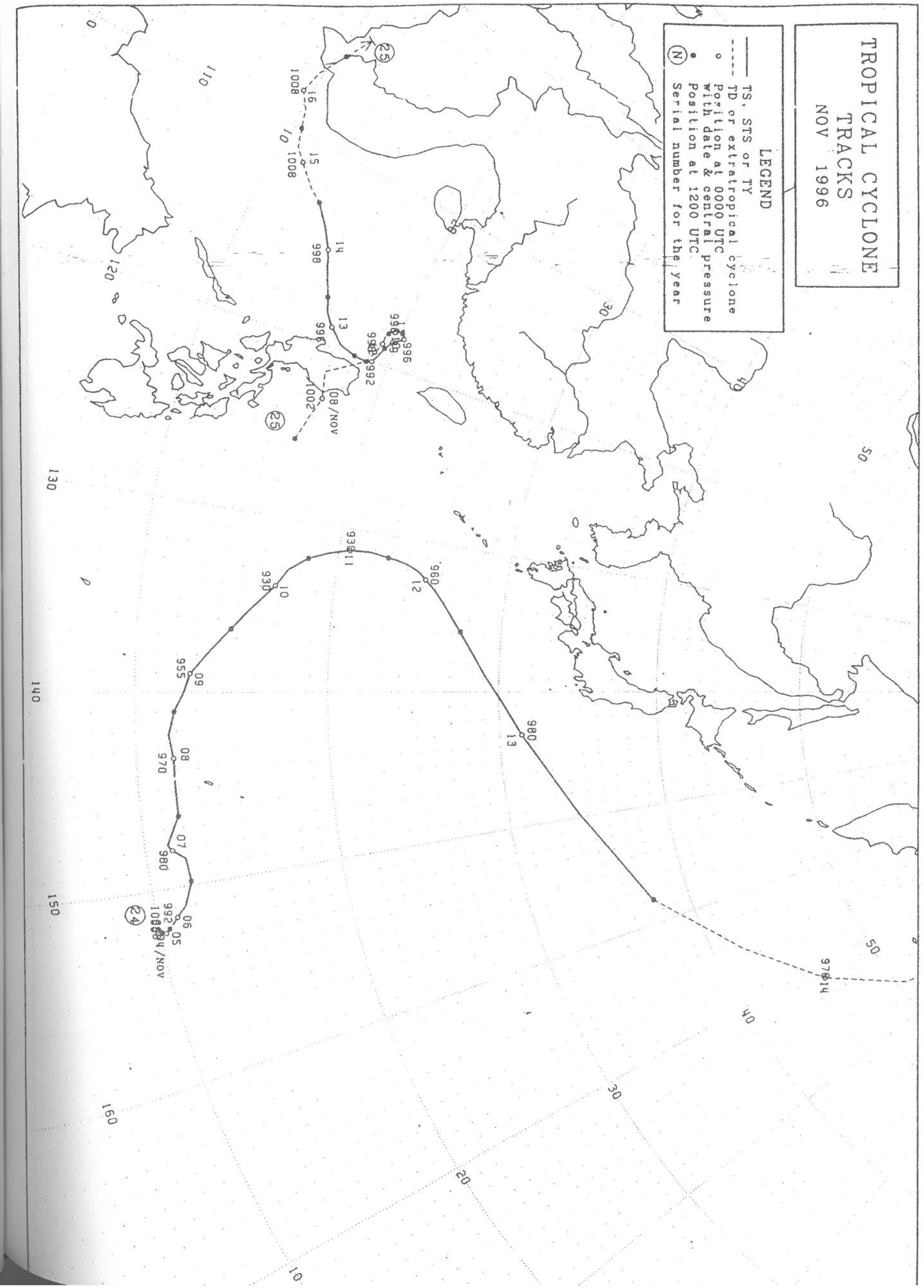

TROPICAL CYCLONE
TRACKS
MAY 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
(N) Serial number for the year
(3)
(4)
19/MAY
1008/MAY
1006
10
998
11
990
12
970
13
935
14
930
15
950
16
970
17
985
18
996
19
1008
20
1002
20
1000
994
21
994
22
994
23
1004
24
1010
25
1012
26
110
120
130
140
150
160
10
20
30
40
50

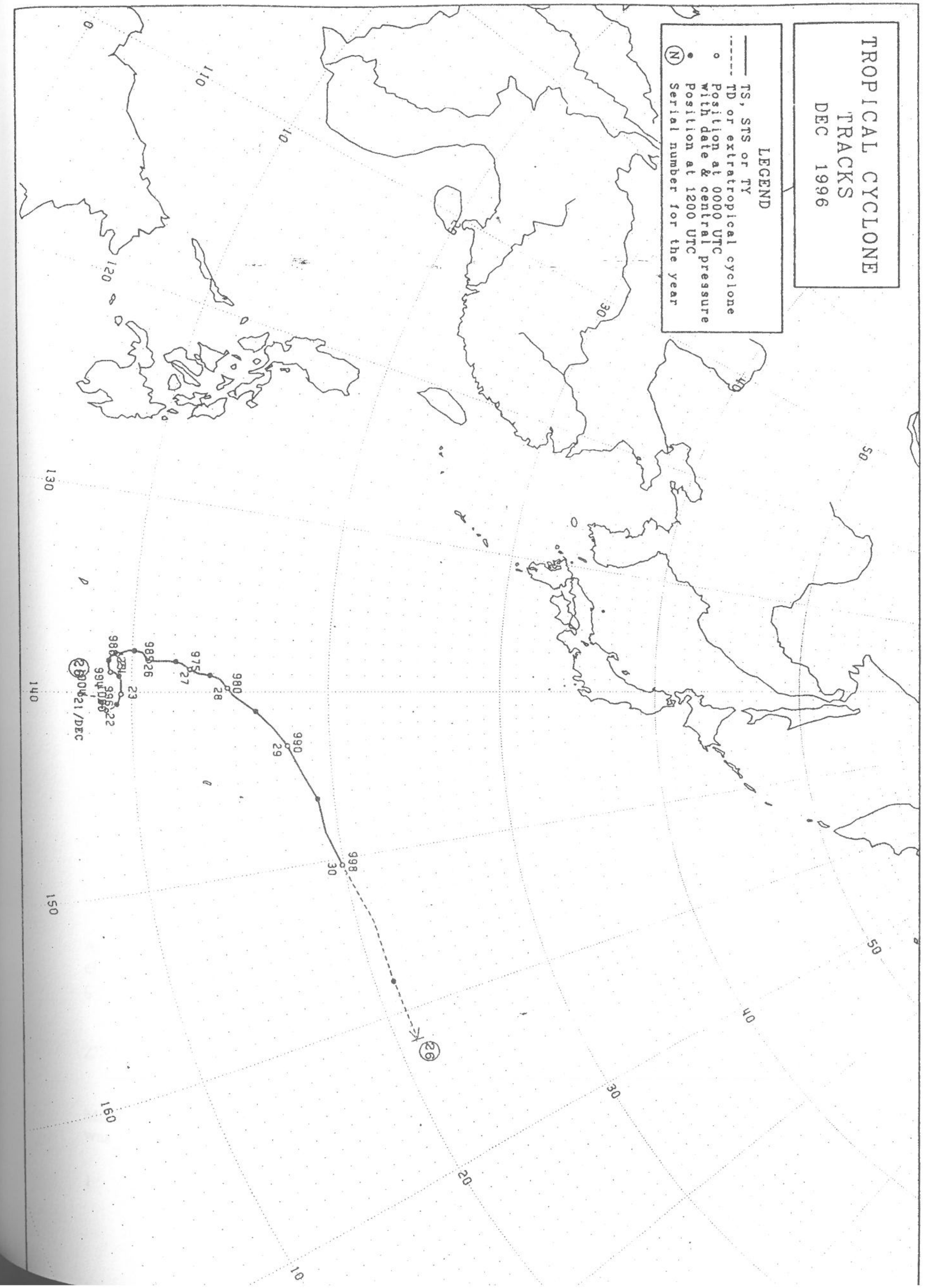

TROPICAL CYCLONE TRACKS
JUL 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
Serial number for the year


TROPICAL CYCLONE
TRACKS
AUG 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
Serial number for the year
06/AUG
04/AUG
17/AUG
21/AUG
23/AUG
01/SEP


TROPICAL CYCLONE TRACKS
SEP 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
Serial number for the year


TROPICAL CYCLONE
TRACKS
OCT 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
Serial number for the year


TROPICAL CYCLONE TRACKS
NOV 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
Serial number for the year


TROPICAL CYCLONE
TRACKS
DEC 1996
LEGEND
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
Serial number for the year
2600 21/DEC
990
22
23
24
25
988 26
975 27
980 28
990 29
998 30
26

NATIONAL REPORTS ON ACTIVITIES AND DEVELOPMENTS DURING 1996 UNDER THE REGIONAL COOPERATION PROGRAMMES

A. METEOROLOGICAL COMPONENT

In **Cambodia,** the National Weather Forecasting Section uses synoptic charts it receives from Bangkok, Japan and Australia as guidance materials in the preparation of its daily weather forecast. In the formulation of its seasonal outlook it utilizes the Southern Oscillation Index (SOI) from Darwin, Australia.

In **China,** the radars in Fuzhou and Shantou stations were replaced by Doppler weather radars. The radar at the Shantou station was moved to a new location (23° 17'N, 116° 44'E, with the antenna elevation of 196.7 meters above sea level. Also in 1996, a new C-band radar for upper-air sounding was installed in Zhengzhou station.

About 97 percent of the observatories at the prefectural level established computer information network systems during the past year while approximately 72 percent of county stations had with the use of pc terminals established links with the meteorological information service.

In the first quarter of 1996, 86GB of disk space was added to the Cray C92. It also acquired a Cray J90 4 CPU system and a Storage Tek automatic tape library with a capacity of 1000 tapes. The local area network was also upgraded to a hierarchical FDDI-based one.

To date, the Computer Telecommunication Network has taken over the old Meteorological Telegraph Communication system. All provincial Meteorological Bureau had established its Local Area Networks (LANs), which is currently being gradually expanded to the Wide Area Network. The Meteorological Supplementary Telecommunication Network (VHF telecommunication) is likewise undergoing development in terms of automation.

With regard to NWP models, the Model for Typhoon Track Prediction (MTTP was put in operation on 15 May 1996. The high resolution limited area forecasting system (HLAFS), typhoon forecasting system and the regional NWP system for the North China region was also operationalized in 1996. In the near future, the T106L19 which is an updated version of the T63L16 will be put in operation to improve the accuracy of the NWP products.

The Analyzing, Forecasting and Data-processing Operational System (AFDOS), an integrated display system of weather charts, prognostic products, radar and satellite imageries had been installed for operational use in China, Maldives, Myanmar, Mongolia and Nigeria. A new version of the AFDOS software (version 5.0) was developed recently utilizing a second generation of the Windows, UNIX operating system and YLW-WINDOWS interface technique.

On 16 August 1996, a Center of Meteorological Services was set up by the China Meteorological Administration to provide meteorological services for government decision making. The center has effectively established a meteorological information network link between the meteorological services and government decision-making bodies at the national, provincial, prefectural (cities) and county level.

A Marine Meteorological Warning System was put into operation at Putuo, Zhoushan County, Zhejiang Province on 1 January 1996 to enhance the marine meteorological service in the region.

In **Hong Kong**, a new ground station for receiving satellite pictures from the Geostationary Meteorological Satellite (GMS-5) was put into operation in early 1996. A boundary layer wind profiler was installed near the Hong Kong International Airport for wind shear detection and two automatic weather stations (AWS) were set up in the Pearl River estuary area also in 1996. Late last year, an FDDI backbone was installed to enhance the capacity of the computer network. A new computer graphics system was implemented on the Observatory's own television studio which enabled presenters to incorporate the display of temperature and rainfall distributions as well as animation and perspective views of radar and satellite cloud pictures.

A home page of the Observatory was set up on the Internet in early 1996 to enable local public and those from overseas to acquire real-time weather information. A "Friends of the Observatory" was also set up during the year as a channel to improve liaison with the general public.

Plans are at hand to install a second Doppler radar at Tai Mo Shan to secure unimpeded detection of severe weather in all directions.

High resolution numerical products from the Japan Meteorological Agency (JMA) became available during 1996. With the agreement of JMA, a spectral limited area model with potentially finer time resolution is being adapted for use in Hong Kong. The Observatory also gained access to semi-operational model products from the Geophysical Fluid Dynamics Laboratory (GFDL), U.S.A., for tropical cyclone prediction. Both JMA and GFDL products proved to be very useful reference to weather forecasters.

In **Japan**, GMS-5, launched on 18 March 1996, started operating on 13 June 1996. Improvements to the Radar Echo Digitizing and Disseminating System (REDIS) are underway so that radars can be remotely controlled at Tokyo by 1997. A new model of rawinsonde (RS2-91) will commence at Ishigakijima (47918) in February 1997 replacing RS2-80. This will be the completion of the deployment of RS2-91 at the upper-air stations of JMA.

JMA made five cruises in 1996 with its three meteorological observation vessels to monitor seasonal-to-interannual variations of the oceanographic structure in the western tropical Pacific waters. In addition, JMA made marine meteorological observations as well as observations of the sub-surface layer in seas south of Okinawa in August and September 1996 with Keifu Maru.

In addition to 73 tide stations, JMA installed 11 new tide gauges in March 1996 to intensify the capability to observe tsunamis from the central Pacific at an early stage and to monitor the sea level fluctuation due to climate change.

In March 1996, JMA upgraded the Computer System for Meteorological Services (COSMETS) by replacing the whole computer system for telecommunications and numerical weather predictions.

JMA started providing the Members of the Typhoon Committee with grid point values for the globe with a resolution of 2.5° x 2.5° through the RSMC Data Serving System in March 1996. JMA provided grid point values with the resolution of 1.25° x 1.25° for the area of 60°N~20°S, 80°E~160°W from March 1996. Seven Members were registered for the access to the System as of October 1996, and Viet Nam will be registered as a user of the System soon.

The telecommunications circuit between Tokyo and Melbourne was upgraded in March 1996, and the circuit between Tokyo and Washington was upgraded in June 1996. The speed of the both circuits was increased from 9600bps to 64Kbps.

JMA conducted in February 1996 a survey on the transition of the short wave broadcast of facsimile charts and teletype messages to the satellite broadcast for RTHs in Region II in response to a request aired during The Implementation Co-ordination Meeting on the GTS in Region II (New Delhi, 13-17 November 1995).

A new Typhoon Model (TYM) with 40km horizontal grids and 15 vertical levels currently makes 78-hour predictions for up to two target typhoons from 0600/1800UTC.

The operational wave model with the resolution of 381km for the western North Pacific was replaced by the global wave model with the resolution of 2.5° x 2.5° on the spherical plain. The fine mesh wave model with the resolution of 127km grid interval was replaced by the Japan-area wave model with the higher resolution of 0.5° x 0.5° on the spherical plain. The forecast periods of the Japan-area wave model and coastal wave model predictions were extended from 48 hours to 72 hours.

The RSMC Tokyo-Typhoon Center has increased the frequency and the valid time of its guidance products for forecast of typhoons since 1 March 1996. The guidance is now issued four times a day up to 84 hours with GSM and 78 hours with TYM, respectively.

In **Lao P.D.R.,** the Department of Meteorology and Hydrology performed routine but highly critical activities mandated to them. Although almost all activities are still suffering from lack of equipment and trained manpower it had managed to maintain its credibility in the service of the general public especially the agriculture sector.

In **Macau,** the Meteorological Information Software (METIS 2000) was installed on the Weather Forecasting Centre and put into operational use. The high resolution satellite receiving system were delivered by the end of 1995 and will be installed and operated in the beginning of 1996.

An objective analysis application which was jointly develop with Nanjing Meteorological Institute of China using Optimal Interpolation Method is in operational use as well as one using Cressmam's Succession Corrections Method with Institute of Meteorology of Portugal.

The SMG in 1996 conducted tests on the access of the JMA RSMC DSS System by Internet.

A Doppler Weather Radar was installed in the last quarter of 1996.

In **Malaysia,** owing to some teething problems, the meso-scale observation network consisting of 38 automatic meteorological stations in the state of Selangor and Federal Territory of Kuala Lumpur is expected to be operational only in 1997.

Malaysian Meteorological Service (MMS) has successfully implemented in 1996 a Radar Integration Project centralizing the radar data from Butterworth, Subang, Kluang, Kuantan and Kota Bahru to the MMS HQ to composite the echo maps for the whole of Peninsular Malaysia and to redistribute them to the relevant Regional Forecast Offices.

MMS has completed the enhancement of computing resources and wide-area connectivity at six Regional Forecast Offices. In addition, computing and local-area networking resources at four divisions in MMS HQ have been established and enhanced.

MMS has acquired a sophisticated meteorological observation, processing and display system for the Kuala Lumpur International Airport. The System, consisting of a terminal Doppler weather radar, a GMS receiving system, a satellite distribution system, an interactive radar integrated system and a meteorological data processing system will be operational by September 1997.

In the **Philippines,** the Japan-assisted Meteorological Telecommunication System Development Project (MTSDP) continued to operate and maintain all meteorological telecommunication facilities since its turn-over to PAGASA in March 1995. Phase B of the MTSD Project has been proposed to do improvement works on some telecommunication lines, particularly in the Southern Philippines to correct significant interferences due to the proliferation of cellphones and other similar telecommunication devices.

Under the France Financial Protocol Agreement, the Enhancement of Meteorological Delivery System to the Countryside (EMDSC) Project of PAGASA was implemented between 1992 to 1995. As of 30 June 1996, the main contractor (SOFREAVIA) has completely supplied and delivered the commissioned equipment and systems. On the part of PAGASA, the installation and deployment of these equipment is almost complete (96%), except in some airports which are currently undergoing rehabilitation or improvement works..

Operational weather and flood forecasting as well as researches have greatly been benefited with the establishment of a dedicated line in the retrieval of RSMC Tokyo grid data (GPV).

In the **Republic of Korea,** the Korea Meteorological Administration (KMA) partially replaced 30 Automatic Meteorological Observation Systems(AMOS) and newly installed three AMOS in 1995. After the installation of the Automatic Weather Stations (AWS), KMA implemented a project to improve the operational deficiencies of the system. The major improvement includes a change in the data collection and analysis frequency from one hour to a few minutes. This system will be further enhanced by incorporating information from satellite and radars. It is also envisioned that the system could be used for very short-range forecasting in the near future.

KMA launched in 1995 'Installation of Ocean Buoys' which is a four-year project which involves the installation of 5 medium-size buoys and a large-size buoy around the Korean peninsula. In 1996, two medium-size buoys were installed and these are now on operational status at Duckjuk Is. and Chilbal Is. in the West Sea(Yellow Sea).

Eight coastal watching systems was established in 1996 for real-time monitoring of sea state through high-resolution CCTV. The installation of 10 additional systems will be completed by the end of 1999.

A new computer system named KMA Meteorological Analysis and Prediction System(KMAPS) commenced operation on March 23, 1995. The system consists of a mainframe supercomputer (Fujitsu VPX-220), a server (SUN Center 2000), and other peripherals. Currently, the Regional Data Assimilation and Prediction System (RDAPS) is run in the VPX 220 while the Global Data Assimilation and Prediction System(GDAPS) runs in the CRAY-C90 which KMA continuous to share with the System Engineering Research Institute.

KMA has completed the upgrading of its domestic meteorological telecommunication network in 1996 from 9600bps to 512Kbps.

KMA has opened its home page on the Internet on 01 July 1996 to promote high-level service to the public. It consists of an Introduction to KMA, weather information, climate information, etc. both in Korean and English.

KMA has adapted the Global Spectral Model (GSM) from Japan Meteorological Agency (JMA) to support limited area model operation and medium-range forecast system in KMA. The GSM with horizontal resolution of T106L21 has been running operationally since 1996.

KMA published in 1996 a revised edition of the Typhoon White Book (1904-1995).

In **Singapore,** although there has been no tropical storms or typhoons which has affected the country on record, the Singapore Meteorological Service (SMS) continues to closely monitor intensification and development of storms in the southern part of the South China Sea as there are some which develop in or move into its designated area of responsibility for shipping.

The SMS is in the process of acquiring a new radar to replace the existing EEC radar. This should be operational either late 1997 or early 1998.

They have adapted and operationally run the Global Spectral Model (GSM), a limited area fine-mesh model (FLM) and a limited area very fine mesh-model (VFM). These models are found to be useful tools for weather forecasting as well as monitoring of storm activity over the South China Sea.

In 1996, Singapore has adopted a new TV weather forecast format wherein satellite pictures and some 3-D graphics are used which has drawn positive feedbacks from the public.

In addition to the existing dial-a-weather forecast they have also in 1996 implemented the Automatic Rain Announcing System. In this system, radar rainfall data are processed by personal computers which has a voice capability to give the names of some 35 areas where rain is being experienced. The public can then make telephone calls to find out where it is are currently raining.

In the **Socialist Republic of Viet Nam,** three sets of automatic weather observation are under installation, 59 observational stations have been equipped with new barometers and 99 automatic gauges were put into operation, three sets of automatic weather observation system have been installed in 3 cities where three sets of ozone spectrophotometer were also set up.

A network of 120 old wind observational instruments on island and coastal stations (where are frequently affected by tropical cyclones) have been replaced by the new digital anemometers EL1 manufactured by China. Twenty digital pluviographs and 60 digital thermometers have been installed.

The Hanoi-Bangkok telecommunication channel was upgraded to 1200 bps in 1996. A facsimile receiving system was also established in 5 regional centers. The year also saw the completion of a project on a new message switching system together with enhancement of the computer local area network at the National Center for Hydrometeorological Forecasting.

In **Thailand,** a mobile X-Band Doppler weather radar at the Head office became operational in October 1996, while four sets of X-Band Doppler weather radars will commence to operate in January 1997.

The existing satellite receiving system (GSC-METPAK) at the Head office is being currently being upgraded. Eleven domestic communication satellite stations connected to the existing National Meteorological Telecommunication Network commenced operation in December 1996. A set of 10 KW-HF transmitter of RTH radio broadcasts was be installed at the Regional Telecommunication Hub-Bangkok in June 1996.

A WSAS at Chaing Mai International Airport is now in operation.

Two sets of Brewer Ozone Spectrophotometer was be set up at the Head Office and Songkhla-Regional Meteorological Center in 1996 while a set of OPMET Data Bank was installed at the Aeronautical Meteorological Division.

B. HYDROLOGICAL COMPONENT

In **Cambodia,** due to the political upheaval in the country, hydrological activity was almost nonexistent inspite of foreign assistance in the 1980's. But with the establishment of the Mekong Committee a rehabilitation project of the country's hydro-meteorological network was conducted in the early 1990's and is still going.

A three-year project "Improvement of the Hydrological network" commenced in April 1996. This project is funded by Government of Japan and implemented by the Mekong River Committee (MRC) Secretariat. To date 8 hydrological station has been rehabilitated, 3 floating gauges has been installed , a number of river flow measurements have been obtained and one combined training on Operational Hydrology, Hygrometry and Data Processing has been held.

The Hydrology Section of the GDIMH currently conducts 24-h, 48-h and 72-h water level prediction daily, by using the data collected from five operational station in Cambodia and three other upstream station in Lao PDR, transmitted to GDIMH headquarters in real-time by radio transceivers.

In **China,** the National Hydrological Information System is changing from the integrated data processing to the distributed data processing with the structure of Client/Server and 2 LET36 Ethernet exchangers (transfer rate: 100 Mbps). The data base system has been upgraded from Sybase 10 to Sybase 11.

Now, the National Hydrological System allows 25 water management authorities to transmit real-time hydrological information through CHINAPAC of Ministry of Posts and Telecommunication.

The Interactive Flood Forecasting System, imported from USA with the World Bank credit and the Huaihe River prototype of the Interactive Flood Forecasting System which was developed under the cooperation between USA and China, were used in the flood event which occurred in the Huaihe River Basin in 1996.

Fifteen flood forecasting and warning systems, 13 repeated stations and 259 telemetering stations were established and put into operation in the five provinces in 1996.

Serious storm and flood disasters occurred in the river basins of Pearl, Yangtze, Yellow, Huaihe and Haihe as well as Zhejiang Province and Xinjiang Uygur Autonomous Region in 1996. The hydrological departments provided 2.76 million telegrams of timely and correct rainfall and flood information and issued about 3000 flood forecasts. According to the initial statistics, economic losses were decreased by 40 billion Yuan (RMB).

Four Chinese hydrologists visited Malaysia from May 5 to 15 May 1996 while 4 more were on a study tour in the Philippines from 4 to 17 June 1996. In an exchange visit, 4 hydrologists from the Philippines was in China on 1 to 14 September 1996.

Three research projects obtained the awards of science and technology progress in the Ministry of Water Resources, PRC in 1996, of which 2 are on the second grade and 1 is on the third grade.

The National Flood Control Computer WAN Workshop was held by the Water Resources Information Center, MWR in Beijing during 8-20 January, 1996.

The Storm Surge Forecasting Workshop was held in Hehai University in Nanjing during 9-20 April, 1996.

In **Hong Kong,** a new rainfall station has been incorporated into the Automatic Water-level Reporting System (AWRS) which was set up to monitor heavy rain and water levels in the northern part of Hong Kong. The System presently receives data in real-time from a total of 14 field stations.

The Drainage Services Department, the department in Hong Kong Government responsible for flood management and control, was sent a copy of MOFFS Version 3 for their possible application.

A consultancy study on land drainage and flood control strategy for five major flood prone basins in Hong Kong was completed in 1993. In addition to deriving major improvement to the primary drainage system in these basins, this consultancy study also recommended Hong Kong Government to proceed with seven Drainage Master Plan Studies to resolve secondary and local drainage problems in all flood prone areas in Hong Kong, as well as a Sedimentation Study to determine the appropriate methodology for maintenance dredging and disposal of sediments in tidal river channels.

In **Japan**, the Ministry of Construction and JMA issue flood forecasts for specified rivers. When the flood forecast began in 1955, 17 river systems were subject to the forecast. The number of the specified rivers has increased since then. Fifty nine river systems are selected at present, including twelve systems that were newly designated on 22 March 1996.

In **Malaysia,** the Department of Irrigation and Drainage Malaysia (DID) to date has installed about 150 telemetric stations in 26 river basins for real time collection and monitoring of hydrological data (rainfall and water level). As part of local flood warning systems, 60 flood warning boards and 56 flood warning sirens have been established in flood prone areas throughout the country.

Under the Seventh Malaysia Plan (1996 - 2000), 10 more river basins are expected to be equipped with telemetric system. In addition, existing VHF telemetric stations located at strategic points will be backed up with telephonic telemetry or satellite equipment. Data transmission via satellite is currently being tested at some problematic remote radio based telemetric stations where telephonic infrastructure is not available. Under the 7th Malaysia Plan, existing forecasting models will be recalibrated and new forecasting models will be developed for selected rivers.

To provide real time flood forecasting service in the Kelantan River basin, a telemetric network was been established which consists of 6 rainfall stations and 4 water level stations.

For this North-East monsoon season, the Flood Forecasting Center (FFC) carried out real-time flood forecasting operation from 15 October 1996 through 15 January 1997.

The performance of the flood forecasting system for the Kelantan River basin continued to be evaluated using MOFFS. The performance of the system for 1996 is found to be satisfactory.

Since the 1970's, several studies had been conducted with regard to the flooding problems of Kelantan river basin. However, to date there is still practically no structural measures being implemented. Currently a more comprehensive feasibility study on the possibility of implementing an integrated flood mitigation project is in progress.

In the **Philippines,** the flood forecasting and warning operations resulted in the issuance of 131 flood bulletins for the monitored 4 river basins, nine flood bulletin/information and one flood situationer for Metro Manila. During the first quarter of 1996, the Flood Forecasting Branch started issuing flood advisories to non-telemetered river systems in the country.

As a consequence of the flood of July 1996, a project called ***5-Year Pangasinan Flood Control Project (1997-2001)*** was drafted involving the PAGASA and several government agencies. The project aims to identify the best mix of structural and non-structural measures with emphasis on bio-engineering to address the perennial flooding in Pangasinan.

To enhance the hydrological database system called TELEDATA, computers were provided in the 3 subcenters. Recognizing the need for a cost effective maintenance of flood forecasting facilities, a software is being developed to convert the Apollo real-time database computing system into the IBM PC environment.

A seminar/workshop on Flood Loss Prevention and Mitigation was conducted in February 1996 in coordination with the Japan International Cooperation Agency (JICA) and the Typhoon Committee. The seminar was attended by twenty-four (24) local and foreign participants. Also in February 1996, a seminar/workshop was carried out in collaboration with the University of Tokyo experts on disaster mitigation and the application of GIS and RS technologies in hydrologic modeling for the Agno river basin. Another training/workshop involving three (3) Nepalese in the field of operational hydrology was conducted in April 15 - 26, 1996.

In the **Republic of Korea,** to improve the hydrologic data collection network for flood forecasting and warning system, the Ministry of Construction and Transportation(MOCT) had established the plan for installation of 148 rainfall and river stage gauge stations from 1994 to 1998. This plan includes the construction and the remodeling of rainfall and river stage gauge stations and the formation of hydrological data collection systems using commercial satellites.

The MOCT constructed an on-line system for 5 major river flood control centers. This system is more effective for flood forecaster to decide the present flood condition because it can offer graphic results, compared with past digital ones. The MOCT also is carrying out the feasibility study for the radar rainfall observation plan for the Imjin River basin.

The Han River Flood Control Center is implementing a one-year project of comprehensive flood management system development. This covers modular system construction, augmentation of the runoff models, flood risk analysis, and data collection using satellite.

The characteristics of 1996 precipitation show serious regional imbalance in rainfall amounts. Two series of heavy storms during July 26 to 28 of 1996 were concentrated mainly on the Imjin River basin. Significant heavy rainfall was concentrated in the Imjin River in the northern region of South Korea which caused extensive damage to rail roads, dams and embankments. This flood event caused a total of 89 fatalities and property losses of more than US$660 million. The number of people temporarily evacuated from their inundated houses exceeded 35,000.

The flood hydrograph at Kunman showed that the peak flow exceeded the 100-years design flood stage(31.8 m) by 1.4 m, while that at Cheongok far exceeded the 80-years design flood stage(31.7 m) by 1.4 m. These exceedings of the design floods resulted in the levee overtopping and breakage at several places along the rivers and the failure of a small hydropower dam built across the Hantan River.

Viewing the damage aspect of the recent flooding in Korea, the small basins (basin area : 1000-1500 km^2) by local heavy storms are more severe than the large basins covered by a flood forecasting system. MOCT is planning to expand the flood forecasting system to small basins. After the Imjin River large flood, A comprehensive flood loss prevention plan in the Imjin River basin is being made a steady progress now.

The Ministry is funding a comprehensive flood management system for the Han River, the flood forecasting model calibration for the Geum River and the Nakdong River, respectively, and a study on impact of the Nakdong and the Yoengsan estuary barrage in flood forecasting system in 1996. MOCT finished the study on improvement of a discharge observation system and developed the hydro-information system for effective management and use of water data.

The Flood Control Center has conducted practical job training twice a year for field officers. Researchers of the Korea Institute of Construction Technology participated in a FLDWAVE model workshop and a training course offered by the National Weather Service Flood Forecasting System of America.

In the **Socialist Republic of Viet Nam,** a plan is underway to establish telemetric systems to some small river basins and dam areas. With this upgrading, the loss of data, specially during the monsoon and tropical cyclone season is expected to be minimal.

a) The Viet Nam HMS with the assistance from some overseas companies is developing an integrated hydrological information system which began in 1996 and will be carried out in the period of 1997-2000. The Project on improvement of rainfall, flood and inundation forecasts for the main rivers in the Central Viet Nam was completed in 1996. Operational flood forecast models have been applied to several major river basins using microcomputer system.

b)

Flood Flows forecasts with a good accuracy for a period of 1 to 5 days were made for some rivers in the Lower Mekong Delta. A number of investigations and surveys for comprehensive flood loss prevention and management purpose were also carried out.

Many flood mitigation reservoirs were built on small and moderate-sized rivers in the mountainous regions. For large floods, like the floods in 1995 and 1996 in the Cuu Long River Delta in the South Viet Nam, evacuations were realized in pre-flood phase and during flooding.

In **Thailand,** 5 hydrometeorological stations were established in 1996.

The Management Overview of Flood Forecasting System (MOFFS) has already applied to the flood forecasting system for Prachin Buri river basin.

The establishment of flood forecasting models for Thailand was carried out under the agreement between the Government of Denmark and the Royal Thai Government (RTG) Since August 1993. Computer hardwares and softwares of flood modeling and flood forecasting techniques using the MIKE11 modeling system were transferred to the six institutions in November 1995.

C. DISASTER PREVENTION AND PREPAREDNESS COMPONENT

In **China,** in 1996, the China Central TV included "Popular Meteorological Science" and "Disaster Prevention and Mitigation" as part of its Television Weather Forecasting Program, so as to further increase the public awareness of the role of meteorological services in natural disaster reduction and the benefit derived from the meteorological services provided for the social and economic activities.

Jointly sponsored by Chinese Disaster Prevention Association, Shanghai Disaster Prevention Association, Shanghai Science and Technology Association and Shanghai Normal University, the First National Workshop on the Risk Assessment of Disasters was held from 16 to 18 October 1996 in Shanghai East China Normal University.

Nine tropical cyclones made landfall on the southeast coast of China from September 1995 to August 1996. Total death toll was 1135 and direct economic loss amounted to US$8592.86 million.

In **Hong Kong,** in co-operation with the Guangdong Meteorological Bureau, the Observatory established two automatic weather stations respectively on the Tuoning and Neilingding islands in Chinese waters in 1996. These became the first stations of an Integrated Observing Network on Hazardous Weather for the Pearl River delta established under an agreement among the Guangdong Meteorological Bureau, the Servicos Meteorologicos e Geofisicos Macau and the Observatory.

The Observatory's Dial-a-Weather service was further publicized through regular announcements over the radio. Members of the public were encouraged to obtain the latest forecast and warnings from this automatic answering service rather than calling the forecaster. This would enable forecasters to concentrate on their weather watch duties.

An area of heavy rain and thunderstorms affected Hong Kong on 30 April 1996 resulting in 14 reports of flooding in Kowloon and the New Territories. Torrential downpours on 14 September 1996 triggered a landslide in Tai Hang Road on Hong Kong Island where 43 people in a nearby residential block had to be evacuated. Seven other landslides and 24 cases of flooding were also reported across the territory.

In **Macau,** several activities were carried out during the period under review in order to improve the public awareness regarding natural disasters and capabilities of all the government and private bodies involved in the field of "Disaster prevention and preparedness".

Tropical storm "SIBYL" affected Macau on the 3rd October 1995 flooding the area close to the Inner Harbour. Accommodation and assistance were provided to 158 affected inhabitants.

A Contingency Plan for Nuclear Accidents was enforced and a booklet giving instructions and advising the residents in case of a nuclear accident was published. The Contingency Plan for tropical storms named "TAI FONG", was revised and updated in the beginning of 1996 and the emergency response exercise was held on the 3rd of May. A Contingency Plan, named " FEI KEI", was enforced with the purpose of coordinating several rules, procedures and measures to be implemented in case of a civil aviation disaster. An exercise was held with the purpose of testing the procedures and rules governing the use of all the ambulances belonging to the public and private organizations of Macau.

In **Malaysia,** in order to enhance disaster preparedness, the Malaysian Government has continuously carried out public education on disaster prevention to the people living in flood prone areas with the ultimate objective of protecting human lives and properties, as well as avoiding or minimizing social disruption and economic loss. Civic education and practical training in life saving techniques are also conducted in the natural disaster prone areas. In addition, presentations on life-saving during floods have been made and pamphlets on disaster prevention targeted at children in flood prone areas during the monsoon season were also circulated.

Agencies such as the Malaysian Red Crescent Society and Civil Defence Department have also played their part in educating the public especially children and how to protect themselves against the danger of flood.

In the **Philippines,** the National Disaster Coordinating Council (NDCC) through its executive secretariat, the Office of the Civil Defense (OCD) has carried out its programs and activities in 1996 along the line of disaster preparedness, response, prevention and mitigation. It provided guidance to local government units (LGUs) in the organization and training of disaster coordinating councils and preparation of disaster plans and such other similar activities that could enhance their capacity to operate accordingly during the occurrence of disasters or untoward incidence.

As of November 1996, OCD has monitored, reported and compiled 238 disaster incidents (90 on natural and 148 on others). A total of 790 requests for financial assistance coming from different local and national units/officials as well as NGOs were acted upon.

The Local Government Academy undertook the Disaster Preparedness Training Program for Local Government Units in the Philippines.

In the **Republic of Korea,** in order to reduce the loss of life, property damage, and economic disruption caused by natural disasters such as floods, windstorms etc. during the rainy season, the Korean government has annually designated the period from March to May as "Disaster Preparedness Period

A total of 102,654 staff members were trained from February 24 to March 31 in 1996 to enhance their ability to deal with natural disasters. The program included planning and managing critical situations, reporting damage, working on recovery plans, and studying relevant laws.

To take quick action during disaster situations exercises under computer-simulated disaster conditions, comprehensive exercise for disaster prevention and practice emergencies specific to each region were carried out during the period from April 15 to May 25 in 1996.

To mitigate disasters which are getting varied and larger in scale, the government has established The Basic Five-Year Disaster Prevention Plan and The Yearly Disaster Prevention Action Plan. Compared to the Fourth Basic Disaster Prevention Plan (1992-1996) which directed investment amounting to US$8625 million to 17 key items such as flood control, disaster prevention, technology development, etc. the Fifth Basic Disaster Prevention Plan (1997- 2001) will pursue three goals and ten strategies based on the idea of "Life Free from Disasters".

Korea had chosen 416 sites most vulnerable to inundation, collapse, and isolation by typhoons and floods, and labeled them as Disaster Prone Areas. A total US$1,713 million will be invested in three areas for full improvement from 1996 to 2005. A total of US$263 million was invested to improve 23 disaster prone areas in 1996.

Over the next 22 years (1995 to 2016), US$7,375 million is earmarked for the improvement of 27,056 small rivers in Korea which are vulnerable to overflow and are the main causes of flooding. In 1996, the "Manual for the Improvement of Small Rivers" was published and 130 small rivers was refurbished at the cost of US$723 million.

In 1996, there were 11 disasters, including the floods and typhoons of mid-June and the flood of Kyungki and Kangwon Provinces during late July, which resulted in 133 casualties and US$559 million property damages. It is worthy of note that, as a result of continued application of the Prearranged Evacuation Plan the loss of human lives decreased by up to 36% compared to the average death toll during the last ten years.

In the **Socialist Republic of Viet Nam,** disasters occurred in 48 of 61 provinces of Viet Nam in 1996 due mainly to tropical cyclones and floods. Seven tropical cyclones either landed or directly affected the country within a period of 3 months (from the end of July to the beginning of November). About 26 tornadoes or hail storms occurred in many provinces or cities in Viet Nam during 1996. A total of 46 people were reported killed, 24 were injured and 64 were missing. Total economic loss, according to primary estimation was more than US$15 million.

In **Thailand,** as a part of the Eight National Economic and Social Development Plan (1997-2001) emphasis was placed on Disaster Prevention Programs. In the area of Flood Prevention a subway flood way and flood control channel was constructed, the river bank along the Chaopraya River was reinforced, the drainage plans to ensure that new development will not increase runoff, divert flows to another property, or cause backwater to pond onto property was reviewed, and a comprehensive regional study to analyze to identify locations and facilities that are presently at risk from flooding was prepared.

The Department of Local Administration (DOLA) which acts as the office of Civil Defense Secretariat (CDS) arranged seminars on “Disaster Management” for civil defence directors in regional and local level.

D. TRAINING COMPONENT

In **Cambodia,** a training course on Operational Hydrology, Hygrometry and Disaster Prevention" was held at the GDIMH in Phnom Penh from 16-20 December 1996.

In **China,** co-sponsored by WMO, the International Training Course on Tropical Meteorology was held in the WMO Regional Meteorological Training Center Nanjing, China from 9 September to 8 October 1996. Altogether 34 students from all over the world attended the course, among them 5 Trainees were from the Typhoon Committee Members.

Eleven experts from nine TC Members, TCS and WMO participated in the study tour for typhoon operational forecasters of Typhoon Committee Members from 9 to 18 December 1996, with a view to exchanging experience and knowledge in operational typhoon forecasting and increasing the capability of operational forecasts using the results of recent studies.

In **Hong Kong,** the Royal Observatory organized several in-house meteorological training courses in 1996. A total of 31 meteorological personnel of WMO class I, II and III attended these courses. They were:

a) Training Course on the New GMS Satellite Reception System
b) Applied Meteorological Course for Forecasters (AMCF)
c) Initial Training Course for Scientific Assistant (ITC)
d) Meteorological Course for Aviation Forecasters (MCAF)

A total of 14 Royal Observatory officers attended 8 training courses abroad, 1 was on a training attachment to Japan Meteorological Agency (JMA), 3 attended training seminars, 2 participated in international workshops and 1 participated in the "Study Tour for Typhoon Operational Forecasters" at the China Meteorological Administration in December 1996.

In **Japan,** JMA continues the endeavor to expand the technical co-operation in the field of training and secondment of experts. After the 28th session, JMA conducted training courses of the numerical prediction and telecommunications for Members of the Typhoon Committee. It also seconded an expert to China on numerical typhoon prediction, announcement of warnings and prediction of heavy rainfall from 9 to 19 June 1996.

In **Macau,** 47 SMG staff were trained on various meteorological courses during the year. A total of 9 officers were sent abroad for training.

The Tenth Seminar of Hazardous Weather was held in Macau in 18 and 19 December 1995. Twenty-seven meteorologists from the Guangdong Meteorological Bureau, Royal Observatory Hong Kong and Macau Meteorological and Geophysical Services participated in the seminar with technical presentations on heavy rains and tropical cyclones. Meanwhile, experiences of hazardous weather warnings were exchanged. There were also discussions on improvements of the observations network which links the AWS of the Pearl River Delta to monitor hazardous weather conditions in the region.

In **Malaysia,** on-the-job trainings on the maintenance and repair of hydrological instruments were organized by the Hydrological Division of DID for the State hydrology personnel throughout the year. Besides, the DID also participated in a training seminar held in the Philippines and organized the visit of 4 China flood forecaster from 5-15 May 1996.

The Malaysian Meteorological Service (MMS) conducted various training courses which was attended by 207 of its personnel and 4 from Brunei Darussalam (BD) in 1996. Six MMS personnel participated in various overseas training/seminar/workshop also in 1996.

In the **Philippines,** PAGASA conducted local training courses on meteorology and hydrology for Class I, Class II and Class III personnel, and Computer Literacy Program among others. Sixteen personnel also attended several training courses seminars, workshops abroad. In 1996, PAGASA supported 5 foreign and 16 local scholars to the University of the Philippines post graduate program in meteorology, under the VCP arrangement with the World Meteorological Organization (WMO).

In the **Republic of Korea,** a total of 119 staff of KMA were sent abroad for training and to attend seminars in 1996. One expert from CMA visited KMA from November 3 to 17 1996 on the field of radar meteorology. Dr. Hong Peng presented several seminars and technical notes and discussions to KMA staff on the topics of application of radar meteorology to weather analysis and nowcasting of severe weather phenomena.

The Flood Control Center conducted two practical job training courses in 1996 for field officers. Researchers of the Korea Institute of Construction Technology participated in a FLDWAVE model workshop and training course offered by the National Weather Service Flood Forecasting System of America.

In the **Socialist Republic of Viet Nam,** 37 HMS personnel attended seminars, 16 participated in workshops, 8 attended postgraduate studies, 8 underwent short-term training and 25 participated in study tours.

In **Thailand,** 5 personnel attended training courses, seminars and workshops abroad.

E. RESEARCH COMPONENT

In **Cambodia,** a research project which aimed at establishing an integrated agricultural development master plan in the Mekong River Region was conducted by some personnel of the CMHS and a team of JICA experts in 1996.

In **China,** some new ideas and concepts on the relations between unusual motion and flow field, inner asymmetric structure, effects and underlying surface impact, were put forward. A study (Luo, et al. 1996) on the impact of asymmetric structure of tropical cyclone on its motion expanded the quasi-uniform flow theory from barotropic to baroclinic atmosphere. Numerical simulation shows that typhoon would recurve when dense contour area moves from NE octant to SW octant (Xu 1996).

Through analyzing TCM intensive data, the asymmetric flow field around tropical cyclone and its environment could be obtained. Motion simulation indicates that simulated tracks of SPECTRUM target typhoons Abe and Flo were much more agreeable to the observed tracks with asymmetric flow field than those with symmetric field (Xu 1996).

The other numerical experiment shows that tropical cyclone tends to move towards a strong instability stratification area in the outer region of typhoon where strong connective and ascending motion occur. Strong instability distribution, in fact, is a sort of thermal asymmetric structure of tropical cyclone (Chen 1996). Both laboratory model simulation and numerical experiments are applied to show the unusual track features and dynamic causes when typhoon passes over an island topography (Meng, et al. 1996). A developed bogussing technique using potential vorticity could be effectively applied to numerical models to study the interaction between typhoon vortex and environmental baroclinic atmosphere, and consequently improve the adjustment ability of the model initial field (Kang, et al. 1996).

Numerical and diagnostic analysis methods are applied in the study of the mechanism of the impact of typhoon environmental flow, topography and ocean on the sudden change of typhoon structure and intensity, as well as the interaction between typhoon and its environmental field, between typhoon structure and ocean underlying surface thermodynamic process (Lin, et al. 1996, Qing, et al. 1996). On the other hand, tropical cyclone would decrease its intensity when it moves upon a cold trail which arises from the former tropical cyclone and increases its intensity if sea surface temperature increases (Qin 1996; Zhu 1996; Duan 1996).

With regard to the research on the typhoon torrential rainfall sudden enhancement, in previous researches, there are few systematic studies on the mechanism of extraordinary torrential rain and its sudden enhancement through numerical simulations. Through many case studies, some results of theoretical significance are obtained: the coupling theory of low level jet, upper level jet and vertical circulation are extended to typhoon study; three kinds of effects of mesoscale systems or structure related to typhoon torrential rain are identified from numerical studies (Dang, et al. 1996).

Satellite data is an important source to improve the analysis of cyclone initial field on its mesoscale structure and moisture asymmetric distribution. Using integrated satellite data in PSU/NCAR MM4 model, the strength and distribution of typhoon rain (8209) are simulated in a good agreement with the observed one.

In **Hong Kong,** during the year the Observatory carried out research into the relationship between environment winds and tropical cyclone recurvature. The effect of tropical cyclones in the South China Sea on the subtropical ridge over south China during the summer months was also studied.

Research papers on tropical cyclone and heavy rain completed are in progress at the Royal Observatory since August 1995. Six tropical cyclone research projects are also performed at the City University of Hong Kong.

In **Japan,** JMA proposed that T9019 (Flo), which was subject to the intense observations during SPECTRUM, be used as the third case of the Comparison of Mesoscale Prediction And Research Experiment (COMPARE) project under WMO-CAS/JSC-WGNE. The Project Steering Committee of the project adopted the proposal, and numerical experiments will be carried out in 1997 and 1998.

Radar observations of nineteen typhoons that passed in the vicinity of Japan showed that there were four kinds of structures of the precipitation band other than clouds near the eye of typhoon. When T9617 (Violet) passed close east of Japan, observations of its structure were made with two Doppler radars and omega sondes. It brought record-breaking precipitation and strong winds in the Tokyo metropolitan area, and the structures of the precipitation band and the strong winds are being analyzed.

The efficiency in analyzing typhoons with new water vapor and split window sensors equipped in GMS-5 was studied during the SPECTRUM period. One of these studies suggests that the drop of sea surface temperature is larger in the right side of the direction after the typhoon's passage.

In **Macau,** two research projects currently underway are Analysis of the Trajectory of Typhoon Kent (9508) and A Comparison of ECMWF"s Prediction and the Actual Measurement.

In **Malaysia,** the large-scale effects of Typhoon Ryan (9514) and the rare direct hit of Tropical Storm Greg (9627) had created significant impact over northwestern states of Peninsular Malaysia on 17 September 1995 and over Sabah on 26 December 1996 respectively. Both cases have opened up a new venue for local meteorologist to probe further into their possible mechanisms. New and enhanced studies to capture the range of forcing conditions, environmental conditions and physical process representations continue to be carried out. However, there is a need to break down the complexity of the problems as represented by the above-mentioned forcings into its essential elements, perhaps using simple theoretical models, with the view of improving our understanding as well as operational forecasting.

In the domain of flood hydrology, DID with few other agencies are embarking on a project (1997 - 1999) to evaluate the use of GIS and remote sensing technology to monitor and evaluate floods. DID also leads an urban hydrology study (1995 - 1998) with an objective to determine experimentally the runoff coefficients and concentration times of different urban conditions.

In the **Philippines,** In line with the national thrust on disaster impact reduction and hazard mitigation, PAGASA continued to undertake researches on various meteorological and hydrologic concerns. It completed 11 research projects on tropical cyclones and floods in 1996. Currently there are 29 on-going researches on various topics ranging from weather related health disorders to regional mesoscale weather forecasting technique.

In the **Republic of Korea,** most research activities related to tropical cyclones in KMA have been concentrated on the improvement of their numerical typhoon forecast model. Some of the research projects currently underway are:

- Forecasting of Typhoon Motion Using Water Vapor Images
- Estimation for Total Energy of Kinetic, Potential Energy and Sensible, Latent Heat On Typhoon Robyn(9307)
- Sea Surface Temperature and the Maximum Intensity of Typhoon

The MOCT is funding a comprehensive flood management system for the Han River, the flood forecasting model calibration for the Geum River and the Nakdong River and a study on impact of the Nakdong and the Yoengsan estuary barrage in flood forecasting system in 1996. MOCT finished the study on improvement of a discharge observation system and developed the hydro-information system for effective management and use of water data.

In the **Socialist Republic of Viet Nam,** 6 researches concerning tropical cyclones were carried out during 1996. Two of these were "Establishing a model for computing the wind fields of tropical cyclone over the East Viet Nam Sea areas" and "Study of vertical structure variation of geopotential height and temperature field over Hanoi region under the influence of tropical cyclone landing at the Northern part of the Vietnamese coastline".

In **Thailand,** the Meteorological Department had established a working group with the closed coordination of the scientists from various research institutes aiming to develop models of Numerical Weather Prediction. It had also devised some Objective Techniques for Investigation of the Thai People's Attitudes toward Meteorological Work. In hydrology, a comparative study of water Inflow and Storage by Dam (Rainfall Caused by Tropical Cyclones Passing Thailand) is on-going.

BANGLADESH

(a) Progress

(i) new rawinsonde equipment had been installed at Bogra. Observations were being made there and at Chittagong at 00 UTC from March to May and from October to December. At other periods observations are made twice a week.

(ii) An 35 Bangladesh Meteorological Department (BMD) Stations are now connected to the Dhaka NMC. Radar Station at Cox's Bazar are linked to Dhaka by microwave.

(iii) The Dhaka-New Delhi link now operating at 2400 bps is to be upgraded to 9600 bps when NWP is introduced.

(b) Problems

(I) Communications need improvement in order to provide more data when tropical cyclones occur.

(ii) More frequent advisories are desirable from RSMC New Delhi during cyclone periods. Similarly, improvement of fax charts needs to be improved.

(iii) Financial constraints limit upper-air observations.

(iv) Training on storm surge forecasting is needed.

(a) The India Meteorological Society (IMS) in collabortion with Andhra University, Visakhapatnam, India Meteorological Department (IMD) and other Scienticfic Organisations Organised a national symposium with the theme "Meteorology and natural disaster""TROPMET-96" at Vishakapatnam in which large number of scientists from different disciplines of Meteorology and allied sciences participated. Various aspects of natural disaster were discussed during the seminar.

(b) As a part of pre-cyclone exercise meetings were organised with chief secretary, chief port officers, AIR, Doordarshan etc at state and district levels by the Area cyclone warning centres and cyclone warning centres in different maritime states of the country before commencement of cyclone season. Publicity through posters, booklets, films and Radio and TV talks were undertaken as a part of pre-cyclone excerise to increase the public awareness about cyclones.

(c) One senior scientist attended the crisis management group meeting organised by Ministry of Agriculture to review the cyclone situation in Andhra Pradesh.

(d) A Scientist from RSMC New Delhi participated in a workshop which was organised by IAS Academy Mussoori, with an aim to prepare a Blue book on the actions to be taken before, during and after the natural disasters for the benefit of administrators.

(e) 58 cyclone advisories were issued to the members of panel countries of WMO/ESCAP.

(f) A close coordination was kept with the media, TV etc during cyclonic situations and wide coverage was given, to the public for the cyclones in Indian Seas during 1996.

(g) A critical review of cyclones during 1996 was made in Annual Cyclones Review meeting held at Calcutta. Various decisions were taken to improve the cyclone warning system in the region.

(h) Cloud motion vectors (CMVs) based on three consecutive INSAT imageries centered at 00 and 12 UTC were derived daily and disseminated over GTS. CMVs are also being derived at 0600 UTC daily using visible imageries on an experimental basis.

(i) Processed satellite imagery multiplexed with meteorological data and weather facsimile charts were disseminated through INSAT for reception at field stations in India and neighbourhood (Maldives).

(j) The AVHRR data contained in the five channels and TOVS (TIROS Operational Vertical Sounder) data transmitted by U.S. Polar Orbiting Meteorological Satellites TIROS-N (NOAA-12 & 14) are being received and processed at INSAT Meteorological Data Processing System (IMDPS), New Delhi. The upper air sounding data derived from TOVS are being archived. A new HRPT data receiving station has been commissioned at Chennai (Madras) for reception and processing of AVHRR & TOVS data from the NOAA series of satellites. In addition, the following products are also being derived from processed satellite data:-

(i) Sea Surface Temperature (SSTs) - four times a day for each 1 deg. latitudelongitude

grid (free from cloud contamination) on an experimental basis using INSAT data and polar orbiting NOAA satellite data, twice daily over 1 deg. latitude/longitude grid using multichannel algorithms.

(ii) Outgoing Longwave radiation (OLR) on daily/weekly/monthly basis over a 2.5 x 2.5 deg latitude/longitude grid.

(iii) Quantitative Precipitation Estimates (QPE) on daily/weekly/monthly basis over a 2.5 x 2.5 deg. latitude/longitude grid using the standard temperature thresholdtechnique.

(iv) Vertical Temperature profiles-twice a day from NOAA TOVS data.

(k) 10 multipurpose wind finding/Storm Warning radars (x band) have been mistalled as replacement of the old equipments.

(l) V-SAT communication facility is being used extensively for exchange of meteorological data and cyclone warning messages

.

(m) Action is in progress for installation of Doppler Radars at three locations along the east coast of India.

(n) The Speed of New Delhi-Bangkok circuit has been upgraded to 200 bauds from May 96.

(o) Action is in progress for upgradation of New Delhi-Colombo circuit to 75 bauds.

Oman

(a) Progress

(i) Two main objectives to upgrade the service of the Oman Meteorological Department (OMD) are being implemented: firstly to provide the forecasters with all possible advance forecasting tools and facilities. In early 1996 HRPT, PDUS and MDD were installed at the main forecast centre. Secondly, to provide the public, government and private sectors with accurate and timely weather forecast and warning. To achieve this we have instituted a voice mail system in Arabic and English. Weather forecasts and warnings, and satellite images are transmitted regularly to the national TV Centre using an advanced graphic system.

(ii) Warnings for the Arabian Sea, and Oman in particular are received over the GTS thanks to the RSMC-tropical cyclones, New Delhi.

(iii) Appreciation is expressed to the China Meteorological Administration for providing a forecaster from OMD to attend a training course on Tropical Meteorogy.

(iv) SADIS came into operation in 1996, Oman being amongst the first to install a receiving system.

(v) WAFS products are available in the forecast centre in Oman

(b) Difficulties

(i) As a new member of the Panel, more training/workshop, are needed as part of our involvement in the Panel activities.

For the Bay of Bengal and the Arabian Sea: Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand

February 1997

No. 9

STOP PRESS, STOP PRESS, STOP PRESS, STOP PRESS

Oman joins Panel

On the first morning of the Second Joint Session of the WMO/ESCAP Panel on Tropical Cyclones and the Typhoon Committee *Oman* became the eighth member of the Panel when its application was accepted by acclamation. *Panel News* joins Members in welcoming Oman to the Panel and looks forward to a valuable new contribution on storms affecting the Arabian Sea area. As the Chairman was quick to point out, the contribution of Oman to the Trust Fund is also eagerly awaited (as long as it is not less than US$ 1,000................. and preferably more!)

Honour for TSU Co-ordinator

At a ceremony on 20 February TSU Co-ordinator Smith Tumsaroch became the recipient of the 1997 ESCAP/WMO Typhoon Committee Natural Disaster Prevention Award. In presenting the award, Dr Roman Kintanar, Chairman of the Typhoon Committee Foundation Incorporated (TCFI), quoted the citation on the plaque forming part of the award "in recognition of his outstanding services as director-general of the Thailand Meteorological Department, and his tireless effort in the promotion of people's awareness in reducing the impact of disasters caused by tropical cyclones in Thailand." .

In accepting the award, Mr Smith thanked the Typhoon Committee for honouring him in this way. He stated that he had decided to use the monetary portion of the award (US$ 4,000) to set up a foundation to make a similar award for Members of the Panel on Tropical Cyclones. To help in establishing the fund for the award, he was contributing an additional US$ 5,000 from his own pocket. *"The Smith Tumsaroch Foundation"*, if successful, could later be used in support of other Panel activities.

Phuket, Thailand

1.2 Eleventh session of CBS

1.2.1 The eleventh session of the Commission for Basic Systems (CBS) took place in Cairo, Egypt from 28 October to 7 November 1996.

1.2.2 The Commission adopted the text for inclusion in the General summary of CBS-XI. The following paragraphs of the text which are relevant to the programmes of the Panel and the Committee, are extracted from the report:

OMEGA Radio-navigation System

1.2.3 The Commission noted that in the past three years, WMO constituent bodies, Members and the Secretariat had undertaken considerable efforts to secure continued operation of the OMEGA Radio-navigation System for upper-air wind finding, on which about 25 per cent (247 stations) of the world-wide network depended, until such time as a feasible alternative was found. These efforts had resulted in the continuation of the OMEGA system for at least three years. However, the Commission noted with great concern that despite WMO's strong appeal to the International OMEGA Technical Commission (IOTC) Meeting in Melbourne in April 1996, the IOTC members had agreed to promptly advise relevant Government agencies and principle user organizations in their respective countries that the system would be terminated by 30 September 1997.

1.2.4 In considering the need for immediate action to limit the loss of upper-air data after September 1997, the Commission noted with appreciation that the Secretary-General had provided the 79 Members concerned with guidance material regarding alternative systems developed by the CIMO Working Group on Upper-Air Measurements. It also noted the preliminary results of a survey conducted by the Secretariat providing information on the location of OMEGA-based wind-finding systems, the relevant monitoring results on performance and on the plans of 34 of the Members concerned for the replacement by alternative systems. These showed that there was a reasonable expectation of up to 40% of the OMEGA-based stations being converted to alternative systems by September 1997. (see map attached)

1.2.5 It was further noted that an additional ten countries operating a total of 25 upper-air stations would be prepared to operate replacement systems if funds could be found for their conversion and several were already seeking assistance in this regard. The Commission expressed its serious concern that with less than one year remaining until the termination of the OMEGA system, 47 countries covering 131 stations had not provided information on their future plans which left a large degree of uncertainty in the assessment of the overall impact of the termination on the GOS and on NWP operations in particular.

1.2.6 The Commission considered that the situation was extremely serious as it seemed likely that a significant number of upper-air stations would cease to operate after 30 September 1997, at least for a period of several months before additional National Meteorological Services were in a position to select alternative systems, obtain budgetary approval and effect the necessary up-grading. The Commission strongly urged all Members concerned to make every effort to ensure that any reduction in observations was kept to a minimum for the shortest possible time.

1.2.7 The responses to the survey had also indicated that a number of Members were conducting trials with the use of alternative systems, particularly the Global Positioning System (GPS), and the Commission urged that the results of these trials be exchanged between the Members concerned. From additional information provided at the session, it was felt that GPS would be the most suitable long-term alternative yielding high quality measurements, but the higher operating costs was likely to pose problems for some countries.

1.2.8 To add to these concerns, the Commission noted the critical erosion of the upper-air network encountered in the Russian Federation because of problems in the national production of instruments and consumables and the grave economic difficulties in maintaining station staffing, particularly in remote locations. It was feared that this situation could lead to a great loss of upper-air observations over the Russian Federation for an extended period of time.

1.2.9 In the medium term, the constraints expected in the availability of radio frequencies will further compound the threats to the global upper-air network because many Members may be forced to offset the higher cost of deploying radiosondes with a narrower radio frequency bandwidth and the associated ground stations equipment by a reduction in the density of their station network and/or reduced observing programmes.

1.2.10 The Commission agreed that studies needed to be carried out as a matter of urgency to assess the impact of the loss of individual or groups of upper-air stations and/or the changes in the observation programmes of upper-air stations in some countries, on the WWW forecasting operations. The Commission was informed by the USA of initial studies that had been carried out. The results of such studies were seen as being fundamental for Members to develop plans for restructuring their upper-air networks to meet their requirements for observational data with reduced costs and higher effectiveness.

1.2.11 The studies were also needed urgently to develop guidance as regards the identification of the most critical areas and stations in order to achieve the maximum benefit from the limited available resources for bilateral or VCP aid projects. With respect to the latter, the Commission noted with appreciation that some donor countries had already initiated projects to assist in replacing OMEGA-dependent upper-air systems. The Commission requested the Secretary-General to provide for a forum to compare and consolidate the various study results through an expert meeting. The Commission recognized that the COSNA workshop on GOS impact studies planned for April 1997 should provide a valuable opportunity to consolidate the results of such studies.

1.2.12 The Commission felt, however, that it would not be possible to complete such studies in time for the informal meeting of major VCP donors in February 1997. The chairman of the Working Group on Data-processing was therefore requested to form a Task Team to work mainly by correspondence to provide expert views, based on all available relevant information for the VCP donors to take into account prior to their February meeting.

Study on the impact of Internet

1.2.13 As a first step in the study of the Internet requested by EC-XLVIII (see paragraph 4.10 to 4.12), the Commission reviewed with interest a consultant report on the extent to which the World Wide Web components of the Internet actually has the potential to be used to exchange meteorological information. The report included the results of a survey of the meteorological data and products posted by World Wide Web servers, and identified the technical and implementation attributes of the Internet.

1.2.14 The survey indicated that about 170 sites hold meteorological data or products and another 200 sites contain pointers only. Of this 170 sites identified, approximatively 30% provide access to observations, 70% to products and 40% to meteorological imagery, mainly from satellites. Of the 50,000 weather-related documents posted on the Internet approximately 37% are posted by universities, 32% by NMHSs, 22% by commercial services, 5% by military or other government agencies and 4% by others (including international organizations). About 85% of the meteorological documents identified by standard Internet search services were located in North America, 7% in Europe, 3% in Australia and 5% in the rest of the world.

1.2.15 The Commission noted that, as the Internet relies on the telecommunication infrastructure, some areas of the developed world have very high-capacity (greater than 45 megabits/second) while most of the developing world has no or only very limited connections. Internet traffic vary by time of day with even high-capacity lines or sites becoming congested at peak hours. However, the needs of many users can be accommodated by voice grade communication lines using slow/medium speed modems. This method of operation is encouraged in locations where only low-speed communication lines exist. There is a vast amount of information available over the Internet but there are no guarantees regarding the quality of information posted. Security is an area of serious concern, since a server on the Internet can be open to attack by computer hackers. However, technical solutions exist which can reduce substantially these problems. The report also identified a special application, the Unidata Internet Data Distribution (IDD) system, providing for the real-time distribution of meteorological data files over the Internet for a consortium of universities in North America. The system has proved to be efficient in the North American Internet environment.

1.2.16 The Commission felt that for the study to progress more information was needed concerning the actual use by Members and other identified users of the Internet. It requested the Secretariat to carry out a technical survey; to this end, a questionnaire was developed by an ad-hoc group. The Commission requested the Secretariat to promptly inform all Members of the analysis of the responses to the questionnaire which will be undertaken by the ad-hoc Task Group.

1.2.17 As the Internet supports the use of both the File Transport Protocol (FTP) for the exchange of large files and the World Wide Web browsers (for http presentations), it can provide for significant data exchange and availability, which can enhance the meteorological services and should be considered as a new component of those services. The Commission recognized that it must develop CBS guidance on server construction and DDB file naming standards for all member countries of WMO. It was also noted by the Commission that there is a continuing need for a dedicated Intranet (private Internet, i.e., enhanced GTS using the Internet technology) as an additional capability of the GTS for reliable and secure data exchange in support of critical hydro-meteorological data needs for the production of numerical forecast models and the protection of life and property.

Study on the use of Internet

1.2.18 EC-XLVIII requested CBS also to address the question of data and products exchanged through the Internet, including all its possible ramifications, in the context of Res. 40 (Cg-XII), and furthermore, to consider setting up an ad hoc group to study the impact of Internet on NMSs. (see also agenda sub-item 6.4). The Commission, on the one hand, welcomed the various benefits from the effective use of the Internet, such as the potential to assist in increasing the visibility of a NMS in its country and the quality of end-user oriented services it can provide through direct and cost-effective information exchange with end users, and the potential to raise the level of scientific knowledge and public awareness of meteorological matters.

1.2.19 On the other hand, the Commission recognized the concerns over the potential issues that should be solved with regard to the Internet, specifically attribution of sources of data and products, capacity of the system, its operational drawbacks, and the associated costs of the system. The Commission recognized that the Internet is an open network of communication links on a global scale. In view of this, the content of meteorological data and products on servers connected to this environment should be consistent with Resolution 40 (Cg-XII). Also, the Commission noted that special consideration must be taken on the content of the data made available openly on servers, in view of a possible negative impact on some NMSs. The information on these servers should include, among other things, recognition of the suppliers of the data and products as the national or international official scientific voice, and the status of the information.

1.2.20 The Commission noted with appreciation that the CBS/AWG had started to discuss these matters and had, as a first step, carried out a study on the extent to which the Internet actually has the potential to be used to exchange meteorological information (see agenda sub-item 6.4). As the next step, it agreed to establish an ad hoc Task Group as proposed by the Executive Council. The Commission agreed that the best approach was to determine from the beginning the range of issues the Task Group should investigate, being fully aware that studying all possible ramifications of the Internet in the context of Res. 40 (Cg-XII) would likely exceed the resources and capabilities of this Commission. The Commission requested the Task Group to address the technical and operational aspects involved and their possible ramifications on the implementation of Resolution 40 (Cg-XII) but to set aside, for further consideration by the Executive Council, other relevant questions. The Commission agreed on the terms of reference and composition of the Task Group as given in the annex to this paragraph.

1.2.21 Finally, the Commission noted with satisfaction that EC-XLVIII had agreed that the president of CBS be invited as observer to the forthcoming session of the EC Advisory Working Group on the Exchange of Meteorological and Related Data and Products. It invited the president to present a progress reports to that group both on development of mechanisms and formats for reporting, collecting and handling the information related to "additional" data and products and on the then available results on the Internet question, and also to provide an update on the technical aspects of the status of implementation of Resolution 40 (Cg-XII).

Public Weather Services Programme

1.2.22 The Commission noted with appreciation that optimum use had been made of the modest resources available to the PWS Programme. This, in a great measure, had been due to the assistance provided by those Members with well-developed PWS to the less developed ones through expert meetings and training workshops. In addition the initiative had been taken to coordinate PWS training activities with those of other WMO Programmes. Such arrangements had been successfully made with the TCP and GDPS.

1.2.23 The Commission noted with satisfaction that two expert meetings on PWS (Geneva, 1994 and 1995) had helped to refine the goals of the programme and implement one of the primary objectives namely, the preparation of a preliminary Guide on Public Weather Services Practices. This publication, which is based on available information, would be developed into a full Guide through soliciting contributions and inputs from Members. The Commission urged Members to provide examples of national PWS practices for inclusion in the Guide. In this respect, the Commission encouraged members to provide information on positive feedback from Services.

1.2.24 The Commission noted with appreciation that the Training Workshops on PWS (Singapore, 1995, for RA II/V and Republic of Korea, 1996 for RA II), were most important for furthering the PWS capabilities of the NMSs. A presentation on PWS had also been given at a workshop in Nairobi in 1994 for meteorologists from eastern and southern parts of Africa.

A Training Workshop on Communication Techniques and Improved Media Relations (Costa Rica, May 1996 for RAs III/IV) addressed the coordination between NMSs, disaster coordinators and the media. In addition the Commission noted the Expert Meeting on PWS and Hurricane Disaster Preparedness (Trinidad and Tobago, 1995) for participants from Region IV, had discussed the use of seasonal forecasting techniques in relation to disaster mitigation and preparation of warnings for hurricanes. The Commission expressed its appreciation to Singapore, the Republic of Korea, Kenya , Costa Rica and Trinidad and Tobago for hosting those events.

1.2.25 The Commission was pleased to note that as a response to the concerns regarding the proliferation of weather forecasts from different sources in the media, and in particular, international television broadcasts by satellite, discussions had been held with producers and disseminators of those forecasts with a view to agreeing on a "best practice". Initial discussions had been fruitful and demonstrated willingness by international broadcasters to continue working with WMO on this subject. This issue was also addressed by the Expert Meeting on Operational Matters of GDPS Centres (Geneva, December 1995). The Commission noted the summary results of that meeting and agreed that WMO, through the PWS Programme should continue to be involved in future discussions on issues associated with media communication. In particular, the Commission expressed several specific comments as given in the Annex to this paragraph.

1.2.26 The Commission noted the actions coordinated in response to the request by Congress as regards provision of meteorological and hydrological information in support of the UN humanitarian and relief missions. In this connection the Commission referred to paragraph 6.3.18 and Annex II to draft Resolution 6.3/1.

1.2.27 Congress had requested CBS to consider establishing an open working group on PWS with a rapporteur from each regional association as core members of the group. The Commission decided to establish that working group and adopted Resolution 7/1 (CBS-XI).

1.2.28 As regards areas of future work, the Commission requested its Working Group on Public Weather Services to address the PWS issues identified by Congress and, in particular:

- Develop the preliminary Guide on Public Weather Services Practices into a full Guide and keep it under review with the aim of incorporating updates as necessary;

- Develop plans and recommendations for PWS training events, such as regional workshops and seminars with contents suitably tailored to deal with subjects of special concern and interest for each Region;

- Develop practices for the production and dissemination of severe weather warnings through addressing the sensitive issue of exchange of such warnings among neighbouring countries, in coordination with the Working Group on Data Processing;

- Prepare materials aimed at raising the level of public response to warnings of severe weather as part of the disaster preparedness and prevention;

- Develop proposals to: (a) improve relationships between NMSs, the media, and the private sector; and (b) provide better coordination between NMSs, disaster coordinators and media as part of efforts to provide high quality services to the public;

- Develop guidance material on how to improve the presentation of weather information through various media including the issuance of forecasts and warnings in multiple languages;

- Develop procedures on the issuance of guidance for extra-tropical storms based on the approach used in WMO's Tropical Cyclone Programme;

- Develop guidance material on practice of quality monitoring of the accuracy and utility of forecast information to the public, and exchange information on the practices and results;

- Develop practice to deal with public weather service broadcast which cover several countries simultaneously;

- Promote and develop outreach programmes with the intent to enhance the understanding of meteorology and weather forecasting by the public, particularly for use in all levels of educational institutions.

Appendix VII

SATELLITE-BASED DISTRIBUTION SYSTEMS

The following satellite-based distribution systems covered or will cover parts of Region II:

(a) The system operated by China already integrated into the RMTN;

(b) The system operated by India;

(c) The system planned to be operated by Japan via the multifunctional transport satellite (MTSAT) which will be launched in 1999 to replace GMS-5;

(d) The system operated by Russian Federation (TV-Inform-Meteo) ;

(e) The system operated by Thailand;

(f) The MDD system operated by EUMETSAT;

(g) The SADIS system offered by ICAO to be used to distribute WWW data and products in addition of WAFS data and products;

(h) The system proposed by UK using spare capacities of the UK satellite-based system; the UK satellite-based system also supports the application SADIS.

REPORT OF THE MEETING OF HYDROLOGISTS FROM TYPHOON COMMITTEE MEMBERS

1. INTRODUCTION

1.1 The meeting of the hydrologists from the Typhoon Committee Members was convened by ESCAP and WMO, and was atttended by representatives of the TC members from China, Japan, Malaysia, Republic of Korea, Thailand and Vietnam.

The hydrologists noted the satisfactory completion of the term of Mr. Toshio Okazumi as the TCS Hydrologist, and expressed their thanks to Mr. Okazumi for his excellent services and gratitude to the Government of Japan for making his services available. The hydrologists also expressed their gratitude to the Government of Philippines for assigning Ms. Margaret Bautista as part-time TCS Hydrologist during the interim period.

The group of hydrologists welcomed with appreciation the decision of the Government of Korea to assign a hydrologist to the TCS, who is expected to report for duty soon.

2. RECENT ACTIVITIES OF EACH TC MEMBER

2.1 The TC members reported their recent activities in the country reports during the main session.

ESCAP reported on their activities related to hydrology and water resources, particularly on the workshop on land use planning and practices for natural disaster reduction and increased crop production scheduled to be held in Bangkok from 18 to 21 March 1997.

3. REVIEW OF RECOMMENDATIONS MADE DURING THE LAST PRE-SESSION MEETING

3.1 As a result of the continuing efforts of the Typhoon Committee, TCS and ESCAP, dispatching of a hydrologist to TCS had been secured, as mentioned above.

3.2 Evaluation of the requirements of the TC Members could not be carried out by TCS due to departure of the TCS Hydrologist.

3.3 Financial support from the TC Trust Fund had been secured for attendance of hydrologists from TC Members to the Second Expert Meeting on MOFFS which will be held from 19 to 21 March 1997, in Seoul, Republic of Korea.

4. RECOMMENDATIONS FROM THE MEETING OF HYDROLOGISTS

The meeting deliberated on problems concerning the implementation of flood loss prevention programme and other matters. Future activities were also discussed and a set of recommendations were drawn up as follows.

1. The Typhoon Committee Secretariat to evaluate the requirements of TC Members as soon as possible after the arrival of the new TCS Hydrologist and formulate proposals for future activities under the hydrological component.

2. The meeting requested ESCAP to accord priority to the project on flood risk analysis and mapping in ...

3. Hydrologists will seek the means for the utilization of the TC Trust Fund to supplement TCDC funds that may be available and to support attendance of TC hydrologists to relevant workshops and seminars to be organized in the region by various organizations.

4. To widen the scope of the activities of the TC Hydrologists, so as not only to cope with flood loss reduction, but also for the optimal use of the waters which become available.

5. To assist in sending promotional materials to ESCAP and WMO for organization of the World Water Day and the IDNDR Day (March and October, respectively, every year)

5. CLOSING OF THE MEETING

The TC Hydrologists unarimously agreed on the proceedings, decisions and recommendations of the Meeting, as it was closed.

HYDROLOGISTS MEETING
List of Participants

Name	Country/Organization
Sun Guihua	China
Wei Shangjin	China
Katsumi Seki	Japan
Chong Sun Fatt	Malaysia
Wang Oo Rhee	Rep. of Korea
Thada Sukkhapunnaphan	Thailand
Jaray Thongduang	Thailand
Rungsan Sirayayon	Thailand
Le Bac Huynh	Vietnam
Cengiz Ertuna	ESCAP
Katsuhiro Abe	WMO

TROPICAL CYCLONE ACTIVITIES INTHE WMO-CAS TROPICAL METEOROLOGY RESEARCH PROGRAM: REPORT TO THE JOINT SESSION OF THE ESCAP/WMO TYPHOON COMMITTEE AND THE WMO PANEL ON TROPICAL CYCLONES, PHUKET, THAILAND, FEBRUARY 1997

Dr. Greg Holland
Chairman, Working Group on Tropical Meteorology Research

1. INTRODUCTION

The CAS Tropical Meteorology Research Program continues to strongly promote tropical cyclone research activities and applications, especially those that can help with operations. Within the Working Group on Tropical Meteorology Research we have an energetic Rapporteur on Tropical Cyclones, Professor Russell Elsberry, who has worked with the Tropical Cyclone Program over the past decade on several tropical cyclone projects. These have included the highly successful SPECTRUM/ Typhoon 90/TCM-90, TCM-92 and TCM-93 series of field experiments and related research activities.

Professor Elsberry apologises for being unable to attend this meeting of the Typhoon Committee. The Chairman of the WMO/CAS International Committee on Tropical Cyclones, Gary Foley, is representing the TMRP and will report in detail on the plans for IWTC-IV and the Aerosonde.

2. CURRENT ACTIVITIES

Current activities within the TMRP are summarised below.

2.1 The International Workshop On Tropical Cyclone Series

There have been three of these quadrennial workshops, each dedicated to bringing researchers and forecasters together in a workshop environment to discuss mutual problems and potential solutions. A major outcome of each of the past workshops has been a reference book and a forecast manual. *The Global View of Tropical Cyclones*, was written following IWTC-I with Professor Elsberry as the editor and subsequently was substantially updated after IWTC-III as *Global Perspectives on Tropical Cyclones*. *The Global Guide to Tropical Cyclone Forecasting* was written following IWTC-II under the editorial direction of Dr. Holland and with support from the TCP. All of these books have been distributed to forecast offices around the globe.

The next Workshop, IWTC-IV, is scheduled for early 1998 in China. The chairman of the International Program Committee, Gary Foley, will provide a full brief to the meeting and will be seeking comment and feedback on the workshop plans.

2.2 Support For Field Programs And Applied Research On Tropical Cyclones

The WGTMR has actively promoted programs likely to help with forecast improvement.

One example is the Decade-long Tropical Cyclone research Initiative supported by the US Office of Naval Research and focussed in the western North Pacific. This program provided the funding for the first Global View reference book, and has conducted joint international programs in the western Pacific.

We have also strongly supported the series of SPECTRUM research meetings, organised under the Typhoon Committee. We also co-sponsored the ICSU/WMO Tropical Cyclone Disasters Symposium in Beijing in 1992, which produced a book on the multi-disciplinary topics covered.

2.3 The Autonomous Aerosonde

A major initiative over the past several years has been the development of the Aerosonde, a small, autonomous aircraft designed to enable observations of a wide range of atmospheric systems at a very economical cost. The early support provided to the Aerosonde by the Typhoon Committee and by the New Delhi meeting of the IDNDR was pivotal in the establishment of a development program that is leading to the first operational system being available in 1998. Mr Foley will present a detailed brief on the current status and development plans to the meeting.

Initial typhoon reconnaissance trials are planned for September 1997 out of Guam, to be followed by further tests from northwestern Australia. If these are successful, we shall be actively canvassing the potential for establishment of an international reconnaissance facility to provide economical direct measurements of the intensity, location and near environment of tropical cyclones. We would be pleased to receive comment and advice from the meeting on this objective.

2.4 Statement On Climate Change And Tropical Cyclones

One outcome of IWTC-III was a community view on tropical cyclone aspects of climate change, developed under the leadership of Sir James Lighthill and published in the Bulletin of the American Meteorological Society. A further detailed statement has now been prepared by a committee of prominent scientists headed by Professor Ann Henderson-Sellers. This statement is still in the review stage, but will be issued as a formal WMO/CAS position statement on this important topic. Mr. Foley will provide an informal brief on its major points.

2.5 The South China Sea Monsoon Experiment

This major initiative for eastern Asia will have its field phase in April-June 1998 and is being co-sponsored by WMO/CAS through the TMRP. Whilst not directed specifically at tropical cyclones, we see this as an excellent continuation of our already well-established involvement in Asian research and development programs.

3. SUMMARY

As outlined by the few examples in this brief report, the CAS Tropical Meteorology Research Program continues its active role in supporting improvements to operations through workshops and support for research and development activities.

The quadrennial meeting of the Working Group on Tropical Meteorology Research is meeting in Jakarta in the week following the joint session of the Typhoon Committee and the Panel on Tropical Cyclones. This meeting will establish our major objectives for the next 4-8 years and feedback and suggestions would be very welcome. In particular comment would be appreciated on the 4th International Workshop on Tropical Cyclones and on the potential establishment of an Aerosonde reconnaissance program for tropical cyclones.

AMENDMENTS TO TOM

Proposals for updating of the Typhoon Committee Operational Manual - Meteorological Component

Page	Line	Present description	Proposal for amendments
CHAPTER 2			
7	4	··· included ···	··· registered ···
7	32	··· upper-wind ···	··· upper-air ···
7	35	··· four ascents on ···	··· four ascents per day on ···
7	35	··· All these ···	··· All data of these ···
8	2	··· Japanese weather ships ···	··· JMA's meteorological observation ships ···
8	3	··· JGHQ ···	··· JGQH ···
8	6	··· JGHQ ···	··· JGQH ···
8	10	··· A new function was installed on all the buoys to make hourly observations automatically whenever wind speed there exceeds 35 knots.	··· The observation is usually carried out every three hours. When wind speed exceeds 35 knots buoys changes the function automatically to hourly observation.
8	17	··· every three hours ···	··· every six hours ···
CHAPTER 5			
21	11	[Table 5.1: 3. Regional circuit / Bangkok - Hong Kong] Satellite, 200 bit/s	Cable/satellite
21	22	[Table 5.1: 3. Regional circuit / Tokyo - Hong Kong] Cable/satellite, 200 bit/s	Cable/satellite, 200 bit/s; Cable, ISDN 64kbit/s
22	18	··· and FXPQ21 RJTD	··· through FXPQ25 RJTD
Appendix 2-C			« REPLACE the figure by Annex 1. »
Appendix 2-E			
3	7	[NAME OF STATION 'Hong Kong'] Antenna elevation [right column] 584	Antenna elevation [right column] 583
3	11	Sensitivity minimum of receiver [right column] -110	Sensitivity minimum of receiver [right column] <-110
3	16	Detction range	Detection range
3	16	Detection range [right column] 500	Detection range [right column] 512

Page	Line	Present description	Proposal for amendments
Appendix 2-E			
4	9	[NAME OF STATION 'Sapporo/Kenashiyama'] Wave length 5.66	Wave length 5.65
5	9	[NAME OF STATION 'Akita'] Wave length 5.66	Wave length 5.68
5	17	Detction range	Detection range
7	3-4	NAME OF STATION Hiroshima/ haigamine	NAME OF STATION Hiroshima/ Haigamine
7	17	Detction range	Detection range
8	9	[NAME OF STATION 'Ishigaki/Omotodake'] Wave length 5.66	Wave length 5.70
8	17	Detction range	Detection range
9	17	Detction range	Detection range
11	17	Detction range	Detection range
13	17	Detction range	Detection range
14	17	Detction range	Detection range
15	17	Detction range	Detection range
16	17	Detction range	Detection range
Appendix 2-F, Annex			
1	12-15	satellite, while the data transmission rate ··· of the satellite. This fixed scheme ··· at MDUS.	satellite. « DELETE ', while the data transmission rate ··· of the satellite. This fixed scheme ··· at MDUS' »
2	1	Less than 1 Mbps (Around 880 Kbps is expected)	660 Kbps
Attachment			
2			« REPLACE Fig. 2-F. 5 by **Annex 2.** »

Page	Line	Present description	Proposal for amendments
Appendix 3-A			
1-2			« REPLACE the full description on pages 1 - 2 by **Annex 3.** »
Appendix 3-B			
5	2-14	[Name of the method = Dynamical space mean method]	« DELETE; no longer in use »
5-6			« INSERT the following method before [Name of the method = Persistence and climatology method] »

ITEM	METHOD	TYPE OF OUTPUT
Name of the method	Climatology-Persistence Technique (CLIPER)	24, 48 and 72 -hr movement forecasts
Description of the method	The CLIPER technique forecasts tropical cyclone movement based on stepwise regression on a set of predictors comprising storm position and speed, time of year and storm intensity. Independent variables: Present storm position, current Julian date, past 12- and 24-hour meridional and zonal speeds, and storm intensity. Historical variables: Best tracks of all tropical cyclones of tropical storm strength or above in the western North Pacific and the South China Sea during the period 1946 - 1980. Frequency of forecast: 4 times a day Reference: Xu, Y-M, and C.J. Neumann, 1985: A statistical model for the prediction of western North Pacific tropical cyclone motion. NOAA Technical Memorandum NWS NHC 28,30 pages.	

Page	Line	Present description	Proposal for amendments
Appendix 5-A			
1	23-32	[Centre = Hong Kong]	« REPLACE the full description in the column as follows. »

Centre	Mailing address	Telex/cable telephone and fax numbers
Hong Kong		
Public Weather Service Royal Observatory (Attn: B.Y. Lee)	134A Nathan Road Tsim Sha Tsui Kowloon Hong Kong	Telex: 54777 GEOPH HX Tel.: (+852)2926 8361 (office hours) (+852)2926 8474 (24 hours) (+852)2368 1944 (24 hours) Fax: (+852)2721 5034 (24 hours)

Page	Line	Present description	Proposal for amendments
Appendix 6-A			
1	15	RQRPT SNPH...	AHD SNPH...
Appendix 7-A			
1	20	... by 1.875° × 1.875° ...	... by 1.25° × 1.25° ...
2			« REPLACE the whole description on page 2 by **Annex 4.** »

SUMMARY OF REPORTS OF MEMBERS ON ACTIVITIES RELATED TO IDNDR

In China, to support the activities of 1996 International Day on Disaster Reduction "Urbanization and Disaster", the China IDNDR Committee held a "Workshop on Urban Development and Disaster Mitigation in China" on 26-29 September 1996 in Beijing. Government leaders, officials and experts responsible for disaster management from several cities and related departments of the central government attended the Workshop. Discussions on issues of impacts of urban disaster on social and economic sustainable development, and of policy on comprehensive urban disaster reduction were conducted during the Workshop. The participants are of the view that with the rapid national economic development since the founding of the People's Republic of China, China's urbanization process has been accelerated. The congested urban population, highly intensified economy and technology, the accumulation of properties, along with the irrational production and living activities and the gradually deteriorated ecological environment have increased vulnerability of cities to disasters. In this aspect, the strengthening of comprehensive urban disaster mitigation activities and response strategies in Chinese cities is an important support to the social and economic sustainable development in China.

Faced with the threat of severe urban disasters, a proposal on the Development Strategy of Urban Disaster mitigation was adopted, which put forward some specific suggestions on the following aspects: building up an overall management system of urban disaster reduction, increasing input to disaster reduction activities, establishing a sound disaster preparedness system, setting up pilot public communities for disaster mitigation, strengthening the administrative, scientific, technological and legal construction on comprehensive disaster reduction, bringing in the role of insurance in urban disaster reduction process and paying close attention to education of middle and primary school students in such fields.

In Beijing, Tianjin, Shijiazhuang, Jinan, Zhengzhou, Nanjing, Shanghai, Fuzhou, Hefei, Wuhan, Kunming, Xian and Lanzhou, public education campaign on disaster prevention was conducted on the occasion of the International Day for Natural Disaster Reduction.

On 12-14 December 1996, a meeting of disaster management focal points sponsored by the China IDNDR Committee was held in Fuding county, Fujian Province. The future work of the China IDNDR Committee was the main topic of the meeting. The meeting also put forward some suggestions on major measures to be taken in the future.

During the meeting, the participants visited the comprehensive disaster reduction projects in the region.

Entrusted by the China IDNDR Committee, and with the support of the United Nations Development Program (UNDP), the China Meteorological Administration co-sponsored the China Workshop on Management of Disaster Reduction from 25 November to 5 December 1996 at the Center of Asian Institute Technology (AIT Center) in Thailand.

The major objective of the workshop is to further enhance the management capability of the key personnel from the meteorological service and the related departments to promote the continuous development of disaster reduction in China and further strengthen international exchanges and cooperation. All the participants have the view that such training workshop is really rewarding. Through the training, they have learned modern knowledge of disaster management and the relevant updated scientific achievements. The training will no doubt produce far-reaching and positive impacts on China's disaster management.

In **Japan,** a research study on reduction of typhoon damage will be conducted from 1997 to 1999 one of a series of investigations in support of the activities of the IDNDR.

In **Macau,** Mr Chan Koc Io (Felix) participated the IDNDR Internet Conference during from 2 September to 25 October 1996.

As a member of UN, **Malaysia** fully supports and participate in the UN's efforts in the reduction of natural disasters by observing the UN sponsored International Day for Natural Disaster Reduction on October 13th, aimed at enhancing public awareness on the effect of natural disasters and undertaking various activities towards reducing natural disasters.

In the **Republic of Korea,** May 25 was designated as "National Disaster Prevention Day" to promote the public participation and awareness of disaster prevention. The main events on "National Disaster Prevention Day" are as follows:

- Inspection of disaster prevention facilities and equipment
- Drill and campaign for disaster prevention
- Photo display of disaster-struck areas and their recovery process
- Contest for disaster prevention posters
- Select one of the five major river basins in Korea and carry out a comprehensive exercise for disaster prevention with the participation of responsible authorities.

As part of the observance of National Disaster Prevention Day, the Ministry of Home Affairs carries out various public awareness programs through the mass media.

In the **Socialist Republic of Viet Nam,** efforts are being made to improve the sustainability of the forecasting and warning systems operated by HMS and the Committee for Flood and Storm Control. For forecasting, a sectoral support mission conducted by the WMO in December 1994 sought to assess the status and determine the needs of hydrometeorological observation network and services in Vietnam by:

* Improving the accuracy and effectiveness of the hydrometeorological observing networks by equipping key hydrometeorological stations with modern equipment; establishing a limited number of Data Collection Platforms in mountainous and coastal areas; and establishing a hydrometeorological instrument repair and calibration facility.

* Establishing a national databank for processing and disseminating to users the existing and future data acquired by hydrometeorological observational network.

* Strengthening the forecast and early warning capacity for floods and typhoons by establishing a network of weather radars and high resolution meteorological satellites.

*Upgrading the Aeronautical Meteorological Service at national and international airports.

* Providing training to meteorologists and hydrologists through both local and international fellowships, workshops and seminars.

Additional initiatives are required to improve the typhoon and flood warning systems: (1) a more secure telecommunication system is required to withstand the effects of water related disasters; (2) the telephone and broadcasting systems are required to improve the district and village level warning systems; and (3) solutions such as sirens based on water levels, are required in mountainous and remote regions.

For attaining a sustainable flow of information of water related disasters the following steps should be undertaken:

*Improving information exchange will require several strategies. Firstly, the Disaster Management Unit as discussed above has already been established. One of the mechanisms to be set up and managed by the DMU will be a centralized database, with regional links on disaster - management issues, projects, statistics, etc.

* The centralized database will be the basis for providing bulletins, newsletters, technical reports, and information notes to the international relief community in a timely manner.

* Secondly, a new policy is expected to be promulgated which will require the executing agencies to provide reasonable access to the information collected and/or generated by the project. One of the roles of the DMU will be the monitoring and disseminating this information.

International Decade for Natural Disaster Reduction and other activities

In Sri Lanka major disaster occure due to Cyclones, floods, landslides and droughts. Every year large sums of money is spent by the government of Sri Lanka. In 1996 the government spent about US$ 500,000/- for relief work due to floods and wind damages and about US$ 800,000/- for drought relief measures. The actual losses are many times the relief provided by the government.

Sri Lanka has an effective system for relief, rehabilitation and reconstruction in the event of disasters. This has been demonstrated several times in the past and united Nation, bilateral and multilateral donors have highly commended the performance of Sri Lanka an these activities.

A draft legislation mamely "Sri Lanka Disaster Counter Measures Bill" is ready to be submitted is parliament and a National Disaster Management Plan is being prepared Sri Lanka Disaster Counter Measures Bill provides inter alia for:-

(a) Establishment of National Disaster Management Council Chaired by H.E. the president of Sri Lanka.

(b) Establishment of National Disaster Management Centre to assist the Council

(c) Establishment of Advisory Committee an National Disaster Management

(d) Declaration of State of Disaster in the event by disasters in potential an affected areas by disasters.

(e) Establishment of Provincial, District, Divisional and Village level of disaster Management Committees.

This will satisfy to a great extend the need for legel and institutional framework. to counter disasters.

/THPHOON

TYPHOON COMMITTEE'S REGIONAL CO-OPERATION PROGRAMME IMPLEMENTATION PLAN

PART A. CONTINUING TASKS

	1. Meteorological Component	TIME SCALE 97	98	99	00	BY WHOM	RESOURCES	REMARKS
1.1	*Support to Meteorological Observing Systems and Facilities*							
1.1.1	Establishment of a communication line to RSMC data system via Internet or ISDN for distribution of RSMC Tokyo grid point data	↔	↔	↔	↔	TC Members, WMO and ESCAP	National/External	Continuous activities
1.1.2	Expansion of observational programme: *With stress on radiosonde observations*	↔	↔	↔	↔	Members	National/External	Continuous activities
1.1.3	Maintaining services specified in the Operational Manual, including intensified observations (surface, upper-air and radars)	↔	↔	↔	↔	Members	National	Continuous activities
1.1.4	Provision of automated observation facilities and real-time telemetry of meteorological parameters, e.g., winds, rainfall, pressure, etc., by replacing with automatic instruments	↔	↔	↔	↔	Members	National	Continuous activities
1.1.5	Establishment of AMedas, ASDAR, anemometer, tide gauge and water recorder networks	↔	↔	↔	↔	Members	National	Continuous activities
1.1.6	Establishment/upgrading of satellite equipment (GMS/TIROS-N)	↔	↔	↔	↔	Members	National	Continuous activities
1.1.7	Establishment of a WWW data user system for the reception of FAX and GPV data INTERNET or ISDN	↔	↔	↔	↔	Members	National	Continuous activities
1.1.8	Establishment/upgrading of weather radars	↔	↔	↔	↔	Members	National	Continuous activities
1.2	*Support to Meteorological Telecommunication Systems and Facilities*							
1.2.1	Maintaining:							
	• Services and facilities for the real-time exchange of data and products	↔	↔	↔	↔	Members	National	Continuous activities

	PART A. CONTINUING TASKS	TIME SCALE				BY WHOM	RESOURCES	REMARKS
1.	Meteorological Component	97	98	99	00			
	• Monitoring of data exchange	↔	↔	↔	↔	RTHs Bangkok, Beijing and Tokyo	Members concerned	Continuous activities
		↔	↔	↔	↔	RTH Bangkok, Vientiane-Hanoi Bangkok-Vientiane-Ho Chi Minh	Members concerned	Continuous activities
1.2.2	Improvement of facilities and their operation as necessary for the rapid and reliable collection and distribution of the required observational and processed information	↔	↔	↔	↔	Members	National	Continuous activities
1.2.2.1	Improvement of data completeness and quality, including use of real-time and non real-time monitoring results for this purpose	↔	↔	↔	↔	Members	National	Continuous activity
1.2.2.2	Review of existing arrangements for dissemination of typhoon warnings with a view of introducing improvements where necessary	↔	↔	↔	↔	Members	National	Continuous activity
1.2.2.3	Improvement of national data collection and retransmission to associated RTHs	↔	↔	↔	↔	Member	National/External	Continuous activity
1.3	*Requirements Specifically for Tropical Cyclone Forecasting and Warning*							
1.3.1	Continuing provision and dissemination of processed information, advisories and other products needed by TC Members for their forecasting and warning systems, archival of information on typhoon data in accordance with the TC Typhoon Operational Manual	↔	↔	↔	↔	RSMC Tokyo	Japan	Continuous activity
1.3.2	Exchange of forecasts including products of different objective methods in accordance with the TC Typhoon Operational Manual	↔	↔	↔	↔	Members	National	Continuous activity
1.3.3	Enhancement of cooperation in typhoon monitoring, forecasting and warning	↔	↔	↔	↔	Members	National	Continuous activity

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
1.	Meteorological Component	97	98	99	00			
1.3.4	Establishment of a regional computer network					Members	National and external assistance	
1.3.5	Installation of a computer processing system in view of integrating satellite, radar and rainfall data so as to provide spatial distribution of rainfall amount over a large region	↔	↔	↔	↔	Member	National and external assistance	TCDC, technical consultancy and assistance from external sources would be required
1.3.6	Setting up of electronic equipment maintenance and repair workshops	↔	↔	↔	↔	Members	National and external assistance including TCDC	Continuous activities
1.3.7	Promotion of development at the interface between the meteorological warning services and the users of warnings for increasing the impact and effectiveness of these services					Members	National and external assistance in conjunction with IDNDR	Continuous activities

	PART A. CONTINUING TASKS	TIME SCALE				BY WHOM	RESOURCES	REMARKS
2.	Hydrological Component	97	98	99	00			
2.1	*Flood Forecasting and Warning*							
2.1.1	Installation and operation networks of observing stations required for flood forecasting systems	↔	↔	↔	↔	Members	National	Continuous activity
2.1.2	Establishment and operation of flood forecasting and warning system	↔	↔	↔	↔	Members	National	Continuous activity
2.1.3	Establishment of flood forecasting and warning systems for dam operations	↔	↔	↔	↔	Interested Members	National and external assistance	
2.1.4	Establishment of flood forecasting and warning systems for inundation from storm surges	↔	↔	↔	↔	Members concerned	Members concerned and external assistance including TCDC	Includes interaction of river floods and storm surges
2.1.5	Monitoring of/and reporting on performance of existing flood forecasting systems	↔	↔	↔	↔	Members	National and external assistance including TCDC and with support of TCS and WMO	Coordinated by WMO, using MOFFS
2.1.6	Further improvement of existing flood forecasting and warning systems, making use, where appropriate, of the results of TOPEX	↔	↔	↔	↔	Members	Members concerned and external assistance including TCDC	Includes catchment modeling
2.1.7	Implementation of recommendations of mission by experts to provide technical guidance on items 2.1.1 to 2.1.6	↔	↔	↔	↔	Members	External assistance, Missions to be organized by WMO and ESCAP	Using, where appropriate, technology available through HOMS
2.1.8	Exchange of technical visits among flood forecasters	↔	↔	↔	↔	Members	National and external assistance	Coordinated by WMO
2.1.9	Development and application of guidance on hydrological technology models for tropical cyclone regions	↔	↔	↔	↔	Members	External assistance with WMO	On the basis of OHP (HOMS)
2.1.10	Development and use of improved techniques for Quantitative Precipitation Forecast (QPF) taking advantage of data provided by satellite and radar	↔	↔	↔	↔	Members	National and external assistance	WMO to assist in development and promulgation of improved techniques

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
2.	Hydrological Component	97	98	99	00			
2.2	*Comprehensive Flood Loss Prevention and Management*							
2.2.1	Establishment of pilot area for comprehensive flood loss prevention and management	↔	↔	↔	↔	Members	Bilateral or multilateral support if available	Detailed programme will be established by respective Members
2.2.2	Investigation and survey including:					Members	National	ESCAP and WMO to assist in organizing investigations and surveys
	• Determination of flood-prone areas subject to heavy damages	↔	↔	↔	↔			
	• Determination of magnitude and corresponding frequency of floods in each flood-prone area	↔	↔	↔	↔			
	• Assessment of potential flood damage in each area for various flood magnitudes	↔	↔	↔	↔			
	• Preparation of flood risk maps	↔	↔	↔	↔			
2.2.3	Application of the manual and guidelines for/and dissemination of techniques for comprehensive flood loss prevention and management	↔	↔	↔	↔	Members	National and external assistance	With assistance of ESCAP and WMO
2.2.4	Implementation of selected aspects of comprehensive flood loss prevention and management	↔	↔	↔	↔	Members	National and external assistance	With assistance of ESCAP and WMO
2.2.5	Mission of experts to provide technical guidance to Members on items 2.2.1 to 2.2.4 above	↔	↔	↔	↔	Members	UNDP, TCDC and bilateral, multi-lateral support if available	With assistance of ESCAP and WMO
2.2.6	Preparation and application of a manual and guidelines for integrated river system development and management with reference to comprehensive flood loss prevention and management	↔	↔	↔	↔	Members	National and external assistance	With assistance of ESCAP and WMO
2.2.7	Preparation of guidelines for the formulation of a comprehensive master plan for urban flood loss prevention and mitigation	↔	↔	↔	↔	Members	National and external assistance	With assistance of ESCAP and WMO
2.2.8	Storm surge prediction and risk analysis	↔	↔	↔	↔	Members	National and external assistance	With assistance of ESCAP and WMO

PART A. CONTINUING TASKS	TIME SCALE				BY WHOM	RESOURCES	REMARKS
2. Hydrological Component	97	98	99	00			
2.2.9 Improvement of dam water release operation system	↔	↔	↔	↔	Members	National and external assistance	With assistance of TCS, ESCAP and WMO

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
3.	Disaster Prevention and Preparedness	97	98	99	00			
3.1	*Public Awareness*							
3.1.1	Improvement of public awareness on typhoon and flood threat and preparedness coupled with studies of human response to warnings	↔	↔	↔	↔	Members	National and external assistance in conjunction with IDNDR	With advice and assistance of DHA/IFRC/WMO and other agencies concerned
3.1.2	Production of materials (audio-visual aids, pamphlets and booklets) related to public information and education	↔	↔	↔	↔	Members	National and external assistance	Work under the WMO TCP projects 12 and 14 is also revenant
3.2	*Disaster Management*							
3.2.1	Establishment/upgrading of national disaster prevention and preparedness plans	↔	↔	↔	↔	Members	Bilateral or multilateral support if available	With advice, and if possible, support from ESCAP
3.2.2	Strengthening national coordination and cooperation between departments and agencies involved in DPP activities	↔	↔	↔	↔	Members	National	
3.2.3	Improvement in the timely dissemination of warnings of typhoons, floods and storm surges with particular attention to remote areas	↔	↔	↔	↔	Members	National	
3.2.4	Improvement of communication systems for warning dissemination and relief operations	↔	↔	↔	↔	Members	Bilateral or multilateral support if available	
3.2.5	Improvement of damage assessment and reporting	↔	↔	↔	↔	Members	Multilateral support if available	With advice from ESCAP roving mission
.2.6	Development and exchange of information and guidance materials on structural and non-structural measures for mitigation of disasters	↔	↔	↔	↔	Members	External assistance	With guidance from international agencies, such as, DHA, IFRC, ESCAP and WMO
2.7	Conducting case studies of response to major disasters	↔	↔	↔	↔	Members	External Assistance	With advice from DHA, IFRC, and WMO
2.8	Compilation of annual information on loss of life and damage caused by typhoons, floods and storm surges including damage to houses, public facilities, agricultural products, and so on	↔	↔	↔	↔	Members	External Assistance	With advice from DHA in co-operation with ESCAP

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
3.	Disaster Prevention and Preparedness	97	98	99	00			
3.2.9	Where appropriate, implementing the recommendations of joint missions and seminars to evaluate DPP procedures and to provide advice on local problems	↔	↔	↔	↔	Members	Bilateral or multilateral support if available	
3.2.10[1]	Production of material related to public information and education on the Typhoon Committee activities, particularly storm warning and DPP	↔	↔	↔	↔	Members	External Assistance	With support of ESCAP, WMO and TCS

[1] External assistance in conjunction with IDNDR

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
4.	Training Component	97	98	99	00			
4.1	*Meteorology*							
4.1.1	Training on engineering application of tropical cyclone climatological data	↔	↔	↔	↔	Members	External assistance	Conferences, seminars and overseas training programmes, including roving missions and arrangements
4.1.2	Training on applications of radar and satellite data in tropical cyclone tracking, forecasting and very short-range precipitation forecasts	↔	↔	↔	↔	Members	External assistance	
4.1.3	Training in calibration, maintenance and repair of electronic meteorological instrumentation	↔	↔	↔	↔	Members	National and external assistance	Coordinated by WMO
4.1.4	Training on utilization of software for integrating satellite/radar/rainfall data	↔	↔	↔	↔	Members	Short-term fellowships with external support	Coordinated by WMO
4.1.5	Training of quantitative precipitation forecast (QPF) models	↔	↔	↔	↔	Members	Short-term fellowships with external support	Coordinated by WMO
4.1.6	Training of personnel through fellowships on tropical cyclone forecasting	↔	↔	↔	↔	Members	UNDP, WMO and other international organizations concerned	Coordinated by WMO
4.1.7	Other courses and seminars organized WMO and Members	↔	↔	↔	↔	Members	UNDP, WMO and other international organizations concerned	Coordinated by WMO
4.1.8	Group training courses in meteorology	↔	↔	↔	↔	Members	JICA	Japan International Cooperation Agency
4.1.9	Exchange of forecaster(s) between tropical cyclone forecasting and warning centers	↔	↔	↔	↔	Members	External assistance	Through TCDC arrangement
4.1.10	Training on observing technology	↔	↔	↔	↔	Members	External support	Seminars
4.1.11	Exchange of meteorological experts between Members other than 4.1.9 above	↔	↔	↔	↔	Members	Bilateral or TCDC arrangements	

	PART A. CONTINUING TASKS	TIME SCALE				BY WHOM	RESOURCES	REMARKS
4.	Training Component	97	98	99	00			
4.1.12	Training on storm surge and wave prediction	↔	↔	↔	↔	Members	Short-term fellowships with external support	
4.1.13	Training in message-switching, wave forecasting, numerical weather prediction and cloud physics, through attachments	↔	↔	↔	↔	Members	External assistance	TCDC arrangements
4.1.14	Training personnel through fellowships on maintenance of electronic meteorological and hydrological equipment	↔	↔	↔	↔	Members	External assistance	
4.2	*Hydrology*							
4.2.1	Training on repair and maintenance of electronic equipment used in flood forecasting and warning	↔	↔	↔	↔	Members	WMO, UNDP and other sources	Roving seminars to be organized by WMO
4.2.2	Training on advanced techniques for flood forecasting and warning associated storms, including hardware and software	↔	↔	↔	↔	Members	WMO, UNDP and other sources	Courses and seminars to be organized by WMO
4.2.3	Training in hydrology with emphasis on flood forecasting	↔	↔	↔	↔	Members	WMO, UNDP and other sources	Courses and seminars to be organized by WMO
4.2.4	Training on personnel through fellowships on flood loss prevention	↔	↔	↔	↔	Members	WMO, UNDP and other sources	Courses and seminars to be organized by WMO
4.2.5	Training on appropriate topics relating to flood loss prevention and management	↔	↔	↔	↔	Members	ESCAP, UNDP and other sources	Seminar to be organized by ESCAP
4.2.6	Group training courses on river engineering	↔	↔	↔	↔	Japan	Japan International Cooperation Agency (JICA)	At the request of TC
4.2.7	Exchange of flood forecasting experts	↔	↔	↔	↔	Members	WMO, UNDP and other sources	TCDC requirements
4.3	*Disaster Prevention and Preparedness*							
4.3.1	Training of disaster managers and volunteer leaders	↔	↔	↔	↔	Members	National and external assistance	With advice from international agencies

TYPHOON COMMITTEE'S REGIONAL CO-OPERATION PROGRAMME IMPLEMENTATION PLAN

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
4.	Training Component	97	98	99	00			
4.3.2	Test exercises	↔	↔	↔	↔	Members	National and external assistance	With advice from international agencies
4.3.3	Training in Disaster Prevention and Preparedness (DPP)	↔	↔	↔	↔	Members	External assistance	Regional seminars organized by TCS with help of DHA, IFRC, ESCAP and WMO
4.3.4	Exchange of information on the socio-economic impact of disaster	↔	↔	↔	↔	Members	DHA, IFRC	Seminars organized by DHA, IFRC and WMO
4.3.5	Training on disaster vulnerability and risk assessment	↔	↔	↔	↔	Members	DHA, IFRC	Courses and seminars organized by DHA, IFRC and ESCAP
4.3.6	Group training courses on technology for disaster prevention	↔	↔	↔	↔	Japan	JICA	At the request of TC
4.3.7	Exchange of DPP personnel	↔	↔	↔	↔	DHA, IFRC, TCS and ESCAP	DHA, IFRC, ESCAP and other sources	TCDC arrangement organized by DHA, IFRC, TCS and ESCAP

PART A. CONTINUING TASKS 5. Research Component	TIME SCALE 97	 98	 99	 00	BY WHOM	RESOURCES	REMARKS
5.1 *Meteorology*							
5.1.1 General studies on:							
5.1.1.1 Interaction between typhoons and the environmental circulation	↔	↔	↔	↔	Members or regionally coordinated programme	National	
5.1.1.2 Typhoon climatology in relation with anomalies in regional circulation	↔	↔	↔	↔	Members or regionally coordinated programme	National	
5.1.1.3 Forecasting storm surge and heavy rainfall	↔	↔	↔	↔	Members or regionally coordinated programme	National	
5.1.1.4 Tropical cyclone related rainfall and intensity rates aimed at detection of possible relationship to global climate change							
5.1.2 Utilization of TOPEX, SPECTRUM, TCM-90 and TYPHOON-90 data set in tropical cyclone numerical and physical modeling, with the aim of improving existing methods of predicting formation, development and steering	↔	↔	↔	↔	Members or regionally coordinated programme	National	Need for short-term attachment of experts to advanced centers in the typhoon region
5.1.2.1 Establishment and operation of a tropical cyclone data bank for the northwestern Pacific and East Asia with software exchanges between Members	↔	↔	↔	↔	RSMC Tokyo	Japan	According to the procedure described in TOM
5.1.2.2 Development of an operational NWP model for typhoon movement and development	↔	↔	↔	↔	Members or regionally coordinated programme	National	
5.1.2.3 Irregular tropical cyclone behavior, such as, sudden turning of tracks, sudden increase/decrease of intensity, rainfall and storm surge	↔	↔	↔	↔	Members or regionally coordinated programme	National	
.1.2.4 Air-sea interactions associated with the occurrence of typhoons, with emphasis on wave and storm surge generation	↔	↔	↔	↔	Members or regionally coordinated programme	National	
.1.2.5 Study on typhoon-related wind climatology					Members	National	

PART A. CONTINUING TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
5.	Research Component	97	98	99	00			
5.1.2.6	Study on climatology of precipitation extremes	↔	↔	↔	↔	Members	National	Counts on discussion
5.1.2.7	Encourage participation in the works of the CAS working group	↔	↔	↔	↔	Member	National	
5.1.2.8	Encourage members to provide the CAS Committee on Climate Change Aspects of Tropical Cyclones relevant data sets for their consideration	↔	↔	↔	↔	Members	National	
5.2	*Hydrology*							
5.2.1	Application of meteorological inputs to flood forecasting	↔	↔	↔	↔	National or regionally coordinated programmes	National	In cooperation with ESCAP
5.2.2	Study of effects of deforestation, urbanization and changing land use on the hydrology of the catchment and on the intensity of floods	↔	↔	↔	↔	Members	National	In cooperation with ESCAP
5.3	*Disaster Prevention and Preparedness*							
5.3.1	Studies on the socio-economic impact of typhoon and flood disasters	↔	↔	↔	↔	Members	National	With advice and possible support of DHA, IFRC, ESCAP and WMO
5.3.2	Vulnerability and risk assessment of disaster-prone areas	↔	↔	↔	↔	Members	National	With advice and possible support of DHA, IFRC, ESCAP and WMO
5.3.3	Socio-economic implication of availability and quality of typhoon and flood forecasts and warnings	↔	↔	↔	↔	Members	National	With advice and possible support of DHA, IFRC, ESCAP and WMO
5.3.4	Disaster impact modelling	↔	↔	↔	↔	Members	National	With advice and possible support of DHA, IFRC, ESCAP and WMO
5.3.5	Natural Disaster Insurance System		↔	↔	↔	National or Regionally Coordinated Programme	National	With advice and possible support of UNDP, WMO and other international organizations concerned

	PART B. SPECIFIC TASKS	TIME SCALE				BY WHOM	RESOURCES	REMARKS
1.	**Meteorological Component**	97	98	99	00			
1.1	***Support to Meteorological Observing Systems and Facilities***							
1.1.1	CAS aerosonde field development and testing (typhoon reconnaissance by unmanned aerial vehicles) in the western North Pacific region as a Typhoon Committee Project	↔	↔	↔	↔	Possible Regional Consortium/Individual countries	Base facilities, cost of UAV, staff training	Subject to successful trials in 1997
1.2	***Support to Meteorological Telecommunication Systems and Facilities***							
1.2.2.1	Establishment of regional telecommunication links							
	• Bangkok - Cambodia					Thailand and Cambodia	National and external assistance	
	• Bangkok - Vientiane					Thailand and Lao DPR	External assistance	
	• Seoul - Pyongyang					ROK and DPRK	National	Depending on bilateral discussion
1.2.2.2	• Upgrading of telecommunication circuit linking Hanoi and Bangkok from 75 bauds to 1200 - 9600 or 200 bauds	↔	↔	↔	↔	Vietnam	National and external assistance	Continuous activity
	• Establishment of telecommunication circuit between Hanoi and Beijing with speed of 2400 bauds					Vietnam	National and external assistance	Speed is under negotiation

PART B. SPECIFIC TASKS 2. Training Component		TIME SCALE 97	98	99	00	BY WHOM	RESOURCES	REMARKS
2.1	*Meteorology*							
2.1.1	Satellite meteorology		↔			China	China	
2.1.2	Regional Workshop on Doppler Tropical Cyclone Radars		↔			Thailand	Thailand	Organized by TCS and TSU in cooperation with WMO
2.1.3	International Training Seminar on Tropical Cyclones	↔	↔	↔	↔	Japan	Japan	Includes on-the-job training and study tour
2.1.4	Training of Class II meteorologists in Applied Meteorolos	↔	↔	↔	↔	Hong Kong	TC members may be waive of tuition subject to availability of space	
2.15	On-the-Job Training for operational forecasters	↔	↔	↔	↔	China	China	One month on-the-job training during the typhoon season in NMC or RMC

PART B. SPECIFIC TASKS		TIME SCALE				BY WHOM	RESOURCES	REMARKS
		97	98	99	00			
3.	**Research Component**							
3.1	*Meteorology*							
3.1.1	Encourage members to participate in the "model-inter comparison experiment for typhoon in research project COMPARE under WGNE of CAS	↔	↔			Members	National Assistance	

Technical Cooperation UNDP Statement by Stephen Browne, 24 February 1997

As many people attending this session probably know, UNDP has supported both national and regional meteorological projects in this region over many years. We believe that the Panel on Tropical Cyclones and the Typhoon Committee, which have been the beneficiaries of our assistance in the past, are excellent examples of practical regional cooperation.

Our particular interest in this Second Joint Session is to participate in the discussions on the proposed WMO project on the Integrated System for the Mitigation of Typhoon, Flood and Environmental Disasters in the Western North Pacific Area. As confirmation of this interest, UNDP has contributed US$ 200,000 to the financing of the preparation of the project document and we look forward to further involvement in the project during the implementation phases.

In line with UNDP's interests, I would make three comments of a general nature on the project:

1. Obviously, the project should build links to the Typhoon Committee which is the best existing cooperative mechanism. Nearly all the countries expected to be involved in the project are members of the Committee.

2. There are many long-term environmental concerns which the project seeks to address, in addition to those of a disaster mitigation nature. It is important that the project helps to build capacity in what the document describes as "fully integrated environmental observation systems". The reliable measurement of marine and air pollution and their movements across borders are critical to the mitigation of long-term environmental damage into potentially global impact.

3. The project should be seen in the general context of the capacity, of each participating country to respond to naturally determine disasters. It is one thing to develop high quality data. It is also important that the data be utilized effectively through timely dissemination to potentially affected populations and areas. We interpret the term "integrated" in the title of the project to mean, first that in addition to the hydrological and meteorological services, other national planning and development authorities will be involved in the project; second, that local organizations and the general public are seen to be beneficiaries and that there is an effective public information and dissemination component. A primary purpose of the project is to save lives, so people should know how best to help themselves on the basis of a easily assimilated and comprehended information.

Now I would like to come to the role of UNDP in this project. As already mentioned, we have been pleased to fund the start-up phase. Further funding is also envisaged. Linked to that, is our intended role as a partner during the implementation phases. In that regard, let me refer to seven specific roles and functions of UNDP which can prove advantageous to all the partners in the project:

1. We are a flexible funding mechanism and we can mobilize our own funds at short notice;

2. We can also assist- as we are increasingly doing - in the mobilization of additional resources from a varieties, of sources: individual donors and Governments, multilateral organizations and private session;

3. As a organization, we have a strong vocation in regional cooperation and inter-countries activities.

4. We have offices in many countries, including almost all those to be covered by the project. We have a presence in DPR of Korea, for example.

5. The head of each UNDP office (the Resident Representative) also acts as the UN resident coordinator in his/her country, with responsibility for UN system and, often, wider donor coordination.

6. Each of our offices maintains close links to our Government counterparts and can therefore help to support different aspects of implementation.

7. Related to the above, UNDP and its offices have wide experience in helping with procurement, identifying trainees, issuing contracts, and so on.

These are some of the ways in which UNDP can be a close and reliable partner in all facts of the project.

PANEL ON TROPICAL CYCLONES TRUST FUND

As at 31 December 1996

	$	$
Balance of fund as at 1 January 1996	1,000	
Advances received	2,000	
Other Revenue	61	
Total revenue		3,061
Less: Expenditure		Nil
Balance at 31 December 1996	$	3,061
Represented by:		
Cash at Bank	$	3,061

Contributions received

	1,996
Myanmar	1,000
Maldives	1,000
Total	2,000

ESCAP/WMO TYPHOON COMMITTEE TRUST FUND

As at 31 December 1996

	$	$	$
Balance of fund as at 1 January 1996	323,800		
Adjustment for cancellation of prior period obligations	358		
		324,158	
Advances received	84,000		
Other income	15,363		
		99,363	
Total revenue			423,521
Less: Expenditure			
Sessions of Committee		1,600	
Administration Costs - Local		25,721	
Administration Costs - WMO		1,808	
Spectrum Technical Conference		50	
Consultative Meeting on Cambodia in Manila		13,786	
Support Study Tour in China		13,166	
Publications and Reports		1,400	
Missions		29,006	
Total Expenditure			86,537
Balance at 31 December 1996		$	336,984

Represented by:

Cash at Bank	$	336,984

Contributions received

	1,996
China	12,000
Hong Kong	12,000
Japan	12,000
Korea Rep. of	12,000
Macau	12,000
Malaysia	12,000
Thailand	12,000
Total	84,000

DRAFT

Request for temporary support under the ESCAP/WMO Typhoon Committee Trust Fund

Reference No:
(To be completed by WMO)

Request made by: 1)

Your reference:

Activity/facility to which the request is related: Financial assistance for attendance of female typhoon forecasters at an International Technical Conference for Female Senior Forecasters (tentatively Thailand, 4 days in December 1997)

Name and address of supplier:

Item No.	Period/ Quantity	Description of Services/ Merchandise	Rate/ Unit Price	Estimated cost: Currency and amount
		Travel and DSA for:		
1.	2	Female typhoon forecasters from China		
2.	10	Female typhoon forecasters from (one each) other Typhoon Committee Members		
3.	1	TCS Meteorologist (Ms Nanette Lomarda)		
				US$ 19,900

Total amount of temporary support is not to exceed (currency and amount) US$ 20,000

Name and address to which payment is to be made (after receipt of certified invoices if other than that given above:

Signature:

Representative of member government to the Typhoon Committee
or ESCAP
or Co-ordinator, TCS

1) Member of Typhoon Committee or ESCAP or Coordinator, TCS.