S M R C

NEWSLETTER

Vol. 10 No. 1 **January - June 2003**

Theoretical Division

Research in numerical weather prediction

An advanced high resolution numerical weather prediction (NWP) model was earlier installed at the Bangladesh Computer Council (BCC) IBM facility with the technical support provided by the Florida State University, USA (Professor T.N. Krishnamurti's group). The model is being used for NWP research in SMRC. A few case studies have been carried out using data sets pertaining to a few cyclone cases in the Bay of Bengal. Job sequences for running the model in a regular mode have been designed. A PC based graphics software package GrADS for viewing the output products has been customized. Results of a typical case study for the well known supercyclone of October 1999, which hit Orissa coast in Bay of Bengal, are presented here as illustration.

The model comprises a Regional Spectral Model (RSM) nested with a Global Spectral Model (GSM). The vertical structure of the model is formulated in sigma coordinate system in the form $\sigma = p/p_s$ where 'p' is the pressure at the relevant level and 'p_s' is the surface pressure. The model has 14 sigma levels in the vertical for the dependent variables other than moisture, which is defined at 11 levels. These levels are unevenly spaced between approximately 10 and 1000 hPa. The present version of the model has two spectral resolutions of T106 and T126 (triangular truncation with 106 and 126 waves), which correspond to an approximate grid size of 1.49 and 0.95 degrees respectively near the equator. A nested regional spectral model within the global spectral model, formulated on a perturbation technique, provides forecasts at a horizontal resolution of about 50 km. The output products include the basic flow variables of the atmospheric circulation, viz., the mean sea level pressure, u and v components of wind, temperature, geopotential height and moisture variable, besides precipitation. The model is one of the best for tropical weather prediction.

Tropical cyclone 25-29 October 1999

This is the well known super cyclone of October 1999 which hit Orissa near Paradip. The initial analysis of 26 October, and the 48 hour and 72 hour forecasts of mean sea level pressure are shown in Fig. 1(a) to 1(c). The products in this case are from the T126 version. The experiment revealed that the initial analysed position of the cyclone vortex has a significant location error as is usually the case with numerical analyses in the case of tropical weather systems developing out in the sea due to paucity of data. The forecast track, however, almost matches with the observed track in the 48h and 72h forecasts and gives the landfall fairly close to the observed position. The 48h forecast shows a good intensification.

The experiments point towards the need for correcting the initial position of the cyclonic vortex by special means, viz., by use of a synthetic vortex and/or maximization of non-conventional data like ocean data buoys and satellite remote sensing observations in the cyclone field. Appropriate data assimilation methods also need to be developed. The intensity forecasting remains another important issue. Future research with NWP models in SMRC will be focused to address the above issues.

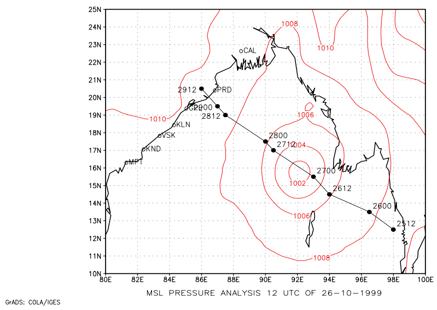

Fig. 1 (a)

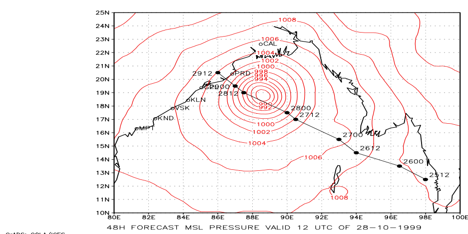

Fig. 1(b)

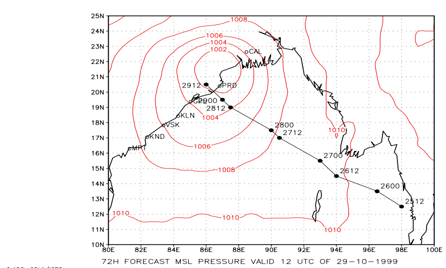

Fig. 1(c)

On some aspects of the monsoon rainfall and floods in Bangladesh

The summer monsoon rainfall in the Indian subcontinent is characterised by a large inter-annual variability. The most common tendency in the search for explanations for the year to year fluctuations in the seasonal rainfall, spatially averaged over a large area, say the country as a whole or a cluster of smaller geographical units, is to relate these fluctuations with the ENSO phenomenon and the slowly varying boundary conditions such as snow cover, soil moisture etc. Various studies carried out in respect of the Indian monsoon rainfall have suggested that the inter-annual variability, or the difference between the strong and the week monsoon or a good and a poor monsoon, is a manifestation of the duration and intensity of the ‘active’ and ‘break’ spells of precipitation within the season (intra-seasonal oscillations), which occur on a time scale of about two weeks. Such oscillations are believed to be the natural oscillations of the large scale monsoon circulation due to its inherent dynamics. Apart from these low frequency oscillations, there also exist shorter period fluctuations on the order of 5-7 days, associated with the passage of synoptic scale disturbances, which are mainly responsible for the active and weak spells of monsoon rainfall on day to day basis over specific areas. Suggestions have also been made as to the links between the active-break cycles of the monsoon to the 40-50 day Madden-Julian oscillations.

The present study is motivated by the need to further investigate the nature of these atmospheric intra-seasonal oscillations and their contribution to the inter-annual variability of monsoon rainfall in the countries of South Asia, SAARC region to be specific. With this end in view, a study has been taken up to gain an insight into the year to year variations in the monsoon rainfall of Bangladesh vis-a-vis the intra-seasonal fluctuations in the parameters of atmospheric circulation. Analysis is based on the daily rainfall data of Bangladesh synoptic stations, which were collected from the archives of Bangladesh Meteorological Department (BMD). Data for varying number of stations are available from 1948 onwards. The number of stations was comparatively much less in the earlier years. However, the number has been constantly increasing and in recent years about 30 stations' data are available. A number of P.C. based Fortran applications have been developed for computation of various parameters. The data were subjected to a visual inspection and message, before being used in the computations, to deal with the erroneous and missing entries, and each station's file was reconstructed.

For the purpose of this analysis we have constructed the country average rainfall on day to day basis. The daily country average rainfall was used as the basic element for constructing the long period averages of the pentad mean rainfall, and the monthly & seasonal rainfall for an analysis of the characteristics of monsoon. The above method of constructing the monthly and seasonal totals of country average rainfall using the daily country average rainfall as the basic element was considered superior as it obviates the need for artificial interpolations to fill the missing rainfall entries when individual station data are taken as the working elements. Such missing entries were substantially large in number in some cases and the interpolation procedures using graphical methods and/or substitution by long period averages, which are normally resorted to, have their own limitations. Results of analyses based on this methodology are briefly described below.

GENERAL CHARACTERISTICS OF MONSOON RAINFALL IN BANGLADESH

The monsoon rainfall in Bangladesh is characterised by a large spatial variability, generally increasing from west to east and northeast, mainly influenced by orography. The cumulative seasonal rainfall from June to September varies from a little over 1100 mm in the western parts to as high as approximately 2800 mm in the northeastern parts (Sylhet).

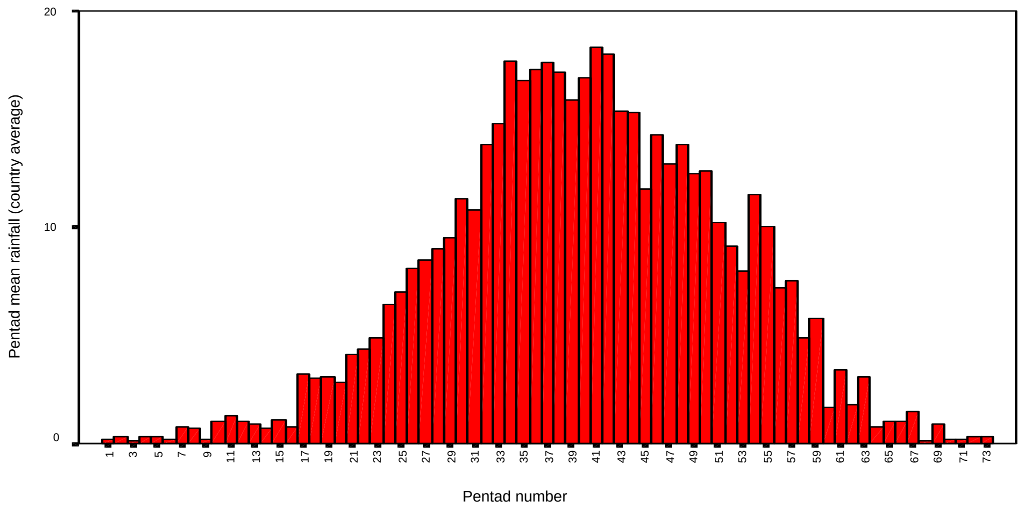

Fig. 2 : Pentad mean rainfall (long period average 1971-2000) over Bangladesh (country average)

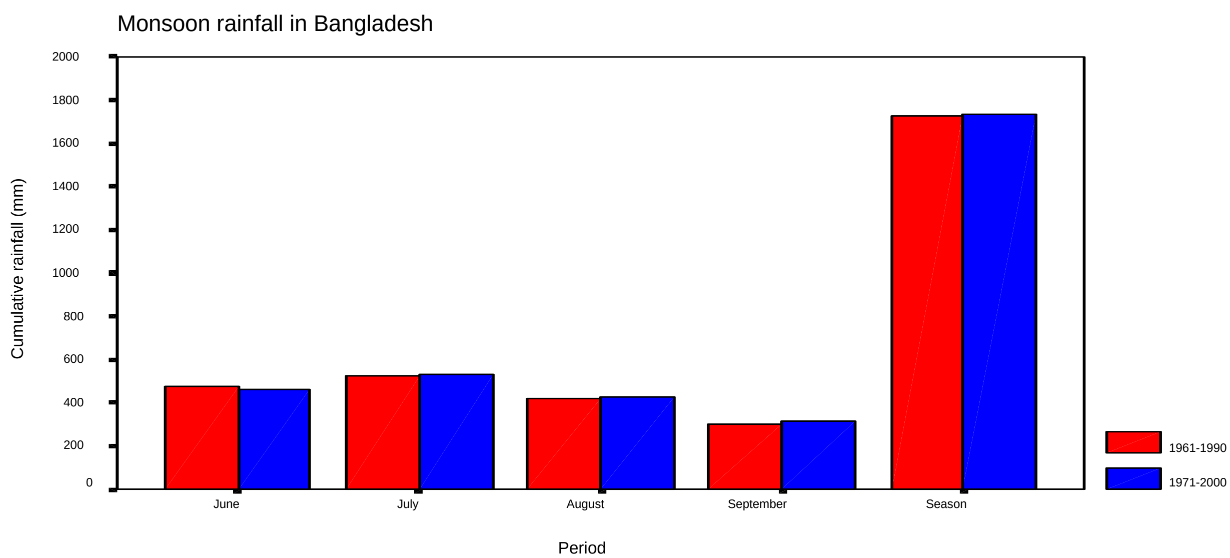

Fig. 3 : Long period average cumulative rainfall of Bangladesh (country average) for 1961-90 and 1971-2000

Taking the country as a whole, the seasonal rainfall is of the order of 1700 mm. In order to examine the distribution of rainfall with the progress of the season(s) pentad mean rainfall based on the country daily average data were worked out for each year. Normal (long period average 1971-2000) pentad mean rainfall for each pentad were then computed. Figure 2 shows the distribution of the normal pentad mean rainfall for the whole year (73 pentads). The picture shows a sudden increase of rainfall in the 17th pentad, i.e., during the last week of March, which marks the beginning of the pre-monsoon season. As the season progresses, rainfall keeps on increasing. A distinguishing feature seen here is that the pre-monsoon rainfall gradually merges into the monsoon rainfall and it is difficult to isolate the onset of monsoon, which should normally be associated with a distinct and sudden rise in the rainfall curve with the arrival of monsoon. The region comprising Bangladesh and neighbouring states of India are known for a widespread pre-monsoon thunderstorm activity (Nor'westers) which cause substantial rainfall. A closer examination though reveals that a comparatively larger change occurs in pentad 32, i.e. around 10 June, which may perhaps be considered as the date of onset of monsoon over Bangladesh, taking the country as a whole. The pentad rainfall curve peaks at pentad number 34 (around June 20), which signifies the stabilization of the monsoon rainfall. Rainfall continues at its maximum until pentad 42, i.e. till the end of July, and starts declining thereafter. The monsoon rainfall appears to continue till about the middle of October (pentad 63). It is interesting to see that the pentad mean rainfall (Fig. 2) exhibits fluctuations on the order of two to three weeks, even in the long period average.

In order to see if there is any change in the normal rainfall of Bangladesh with time, climatological means for two 30-year periods, 1961-1990 and 1971-2000, were computed. The plots for individual months June to September and the season are presented in Figure 3. No significant changes are noticed.

RECENT FLOODS VIS-A-VIS RAINFALL ANOMALIES IN BANGLADESH AND NEIGHBOURING STATES OF INDIA

The years 1987, 1988 and 1998 have witnessed extreme floods in Bangladesh. While 1987 and 1998 were characterised by significantly excess rainfall in Bangladesh, the anomaly in 1988 was not so abnormal (Figs. 4 & 5). Floods in Bangladesh result from not only due to the excess rainfall within the country, but also the heavy inflow of river discharge from the upstream regions comprising the northeastern states of India, particularly Arunachal Pradesh, Assam & Meghalaya, Sub-Himalayan West Bengal & Sikkim (the Brahmaputra, Teesta basins) as also north Bihar (Bihar Plains) which contribute substantially to the flow in Ganga. The occurrence of floods in Bangladesh has therefore to be seen in light of the rainfall anomalies of the entire region. With this end in view, rainfall anomalies during the monsoons of 1987, 1988 and 1998 in respect of the above meteorological sub-divisions of India were examined. We considered only the months of July and August, which provide the bulk of the monsoon rainfall. The percentage departures of rainfall in the above met. subdivisions of India and Bangladesh are given in Table 1 below.

Table 1 Percentage departures of monsoon rainfall in Bangladesh and adjoining met. sub-divisions of India
(source: MAUSAM published by India Met. Dept.) during major flood years

	1987		1988		1998	
	July	August	July	August	July	August
Bangladesh	49	54	-05	15	40	43
Arunachal Pradesh	89	45	05	179	14	58
Assam & Meghalaya	32	-14	45	38	24	22
Sub-Himalayan West Bengal & Sikkim	12	84	17	66	28	50
Bihar Plains	48	86	09	-04	49	17

It would thus be seen that the highly positive anomalies of rainfall during 1987 and 1998 were synonymous in Bangladesh and the adjoining northeastern states of India, thus covering a large area. During 1988, however, no significant anomaly was seen in the rainfall of Bangladesh. The 1988 floods, therefore, can be attributed to the contribution from upstream – the anomaly of 179% in the month of August in Arunachal Pradesh is outstanding and noteworthy in this regard.

Another feature that is apparent from this analysis is the fact that the anomaly of rainfall over Bangladesh seems to go in tune with those over the northeastern regions of India. We find this feature in the deficit monsoon years also as reflected in Table 2. This indirectly suggests that the large scale synoptic setting that determines the rainfall distribution in northeastern region of India, seems to be controlling the rainfall distribution in Bangladesh also. The heavy rainfall in northeastern region occurs with the seasonal monsoon trough passing close to the sub-montane regions of eastern Himalayas, coupled with a strong southerly inflow of moist air mass from the Bay of Bangal. It thus appears that Bangladesh, which lies at the eastern end of the monsoon trough, receives heavy rainfall during the periods of the trough passing across northern latitudes. A prolonged or quasi-stationary position of the monsoon trough in a northerly latitude would give rise to persistent heavy rainfall activity, resulting in anomalous rainfall with a high positive departure. Table 2

Percentage departures of monsoon rainfall in Bangladesh and adjoining met. sub-divisions of India (source: MAUSAM published by India Met. Dept.) during deficit monsoon years

	1992		1994	
	July	August	July	August
Bangladesh	-18	-28	-33	-15
Arunachal Pradesh	-27	-41	-53	-19
Assam & Meghalaya	-14	-12	-35	-22
Sub-Himalayan West Bengal & Sikkim	06	-22	-50	-26
Bihar Plains	-14	-28	-32	-14

INTER-ANNUAL VARIABILITY vs. ENSO

The monsoon rainfall of Bangladesh is subject to large inter-annual variability. This is reflected in Figures 4 & 5, which depict the percentage departures of monsoon rainfall from its long period average for the season as a whole (Fig. 4) and for the months of July and August (Fig. 5), which are the main monsoon months. In order to verify as to how far the ENSO events impact the monsoon variability, the years with warm episodes and cold episodes are identified in the picture by coloured bars. It emerges that the years of excess rainfall and deficit rainfall vis-a-vis the warm episodes and cold episodes are evenly distributed, indicating thereby that the monsoon rainfall of Bangladesh appears to be indifferent to ENSO episodes. It is interesting to see that the year 1987, which was a significant El Nino year, stands out as the year of maximum excess rainfall. In sharp contrast, 1987 was a severe drought year in India (country as a whole). Likewise 2002, which was also a warm episode and a severe drought year in India, turned out to be an year of significantly positive departure of rainfall in Bangladesh. 1997, which was one of the warmest episodes, turned out to be a normal monsoon (departure on the positive side). 1998 was another year of excess rainfall. This year happened to be a cold episode. It appears that while the ENSO events do have an impact on monsoon systems on large sub-continental scales such as those of India as a whole, the relationships are ill defined when we downscale to smaller geographical areas like Bangladesh.

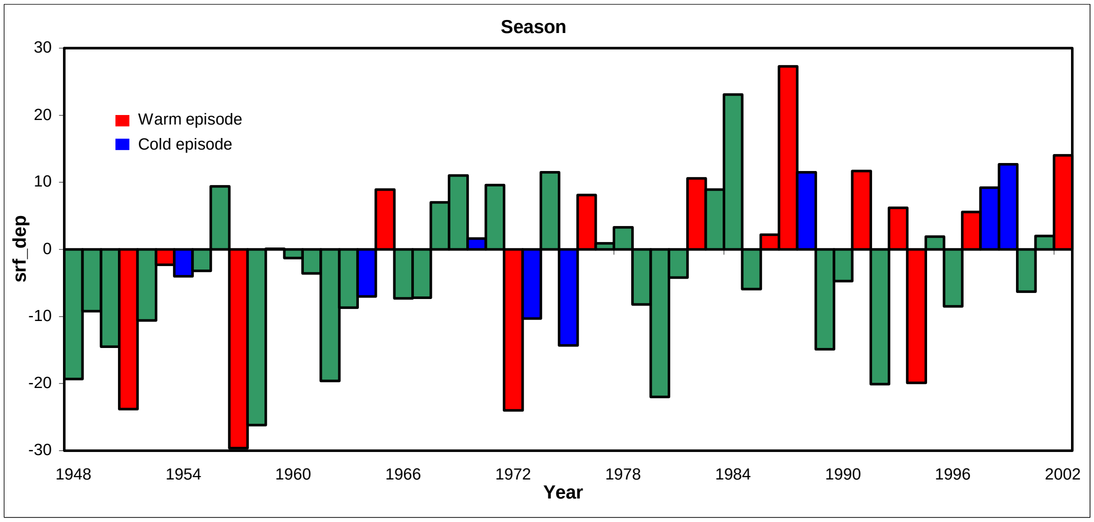

Fig. 4 : Percentage departure (from long period average 1971-2000) of monsoon season rainfall of Bangladesh (country average); The years of warm episodes of ENSO events are shown by red coloured bars and those of cold episodes by blue.

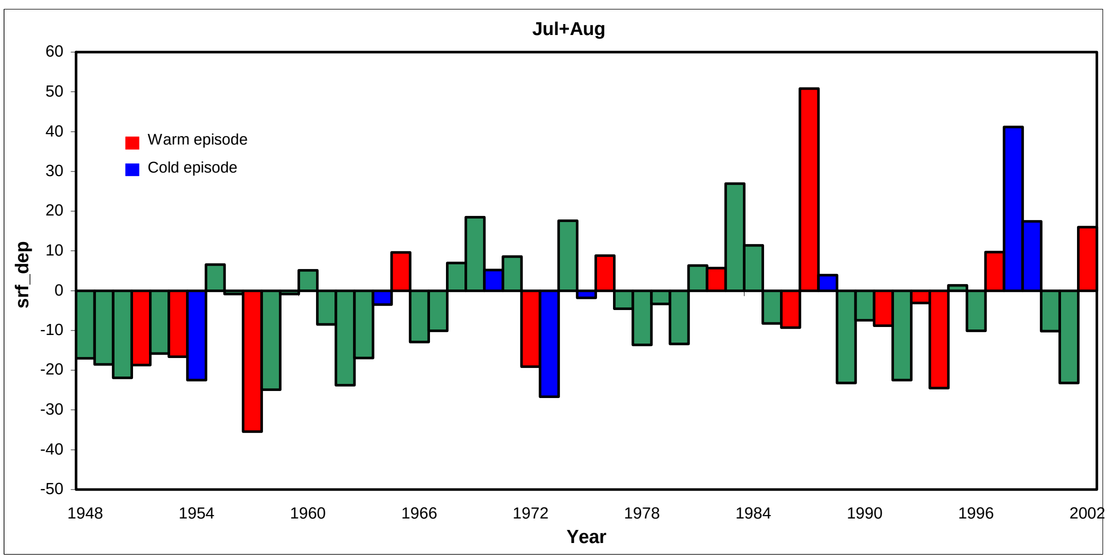

Fig. 5 : Percentage departure (from long period average 1971-2000) of July+August rainfall of Bangladesh (country average); The years of warm episodes of ENSO events are shown by coloured bars and those of cold episodes by blue.

INTER-ANNUAL VARIABILITY vs. INTRA-SEASONAL OSCILLATIONS OF MONSOON CIRCULATION

The problem of inter-annual variations in monsoon rainfall of Bangladesh needs an in-depth study of the atmospheric circulation features and anomalies on the inter-annual and intra-seasonal time scales to find a plausible explanation for the phenomenon. As pointed out earlier, the total quantum of seasonal rainfall depends to a large extent on the behavior of rainfall within the season – the intra-seasonal oscillations. The intra-seasonal oscillations, in turn, are determined by the nature of atmospheric disturbances that are responsible for day to day rainfall. In order to understand the nature of these atmospheric disturbances and to isolate the modes of variability in monsoon circulation in the extreme years of rainfall, we decided to apply the techniques of power spectrum analysis to various atmospheric parameters. To begin with, we have chosen the mean sea level pressure (MSLP) of stations within Bangladesh for analysis. Surface pressure is the single most important parameter, which reflects the atmospheric circulation features in its totality. The study makes use of the power spectrum analysis approach to identify and isolate the oscillations on various time scales. Daily data of mean sea level pressure (averaged for the day) of individual stations have been subjected to spectrum analysis. For this purpose the basic data used for analysis are the time series of the departures of daily values of mean sea level pressure from their pentad normals. The pentad normals were computed for each individual station as long period average (LPA) for each of the 73 pentad means in respect of each year from the daily MSLP data of the 30-year base period 1971-2000. The time series were sampled for the monsoon period 1 June to 30 September every year, containing 122 to 123 data elements. The obvious advantage of dealing with the pressure departure series constructed in the above manner over that of the original MSLP values is the inherent absence of the seasonal trend component in the time series, which would otherwise have to be removed before further analysis.

Power spectrum analysis was carried out via the autocorrelation function. A lag period of 40 days, which is about one-third of the length of the time series, was chosen. Spectral curves were drawn for the individual stations and individual years. The main objective of this study was to examine the behaviour of intra-seasonal oscillations vis-a-vis the performance of monsoon rainfall from year to year over the country as a whole. Power spectra in respect of Dhaka for some of the contrasting years during recent times, viz., 1984, 1987, 1998, which were significantly excess rainfall years, and 1992, 1994, which were deficit rainfall years, are presented here for illustration (Fig. 6-10). The abscissa shows the period in days on a log scale and ordinate the product of power and frequency. This kind of representation has been suggested as preferable since it brings out the spectral peaks in a better way when the spectral power is localised. The 95% and 99% confidence limits are drawn alongside the observed spectral curve. Analyses were carried out for all the synoptic stations for which unbroken records were available. It was found that the spectra in respect of all the stations exhibited similar behaviour. This indicates that the entire country falls under homogeneous synoptic regime.

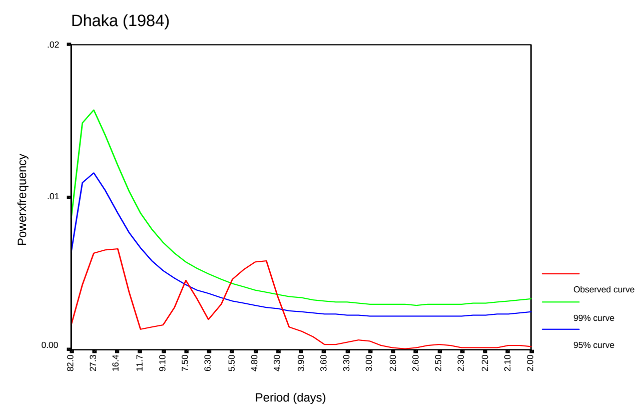

Fig. 6

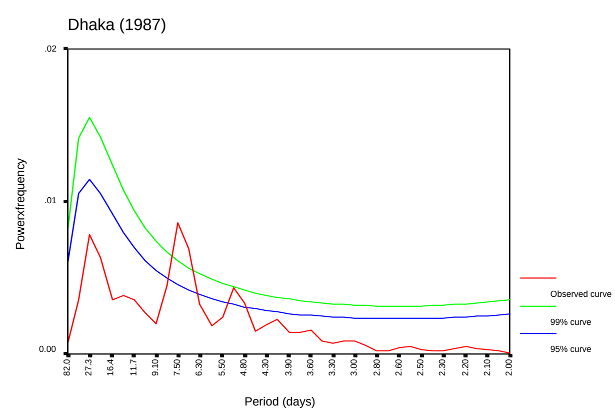

Fig. 7

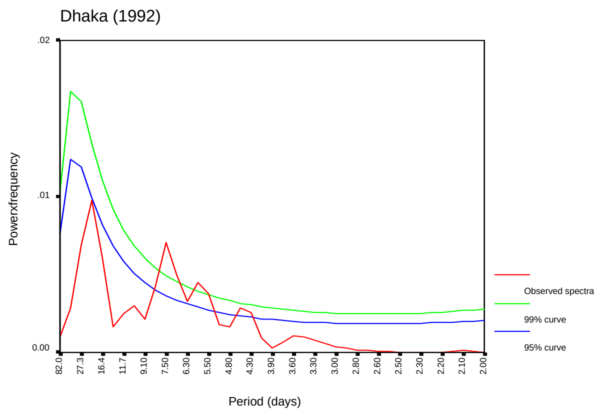

Fig. 8

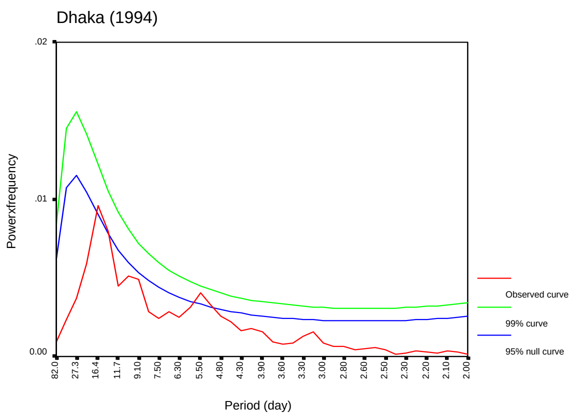

Fig. 9

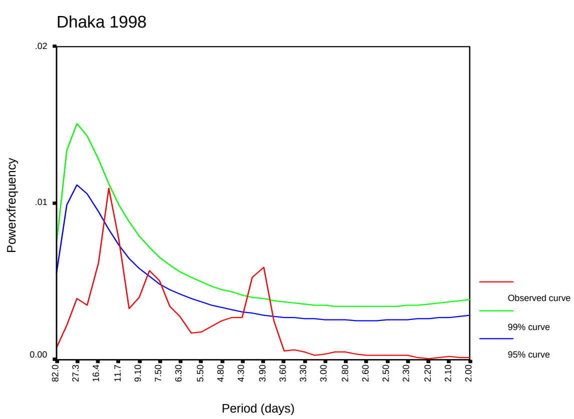

Fig. 10

The shape of the power spectra varies widely from year to year though they do have some features in common. The analyses show spectral peaks both in the low frequency range, beyond 10 days, as also the peaks in the short period range of 4 to 7 day range, which has already been a known fact in the Indian monsoon system. The analysis shows that the spectral curves in the years with excess rainfall, viz., 1984, 1987 and 1998 contain prominent and significant (at 99%) spectral peaks in the short period range of around 4 days. The 1994 (deficit monsoon) curve shows no such significant peaks - neither in the high frequency part of the spectrum nor in the low frequency range. 1992 (also a deficit monsoon) curve does show significant peaks in the 5 to 7 day period range.

It appears from the above preliminary analysis that there is a year to year variation in the intra-seasonal modes of atmospheric variability in this part of the monsoon region. One can not generalize the existence of any particular mode(s) of oscillation in the monsoon season as a matter of rule. The interaction and superimposition of various scales of atmospheric perturbations seems to be a determining factor in the overall performance of monsoon. For example, as we have seen in the earlier section, the pattern of monsoon rainfall departure is in tune with that occurring over the neighbouring states of India in the vicinity of the foothills of Himalayas. The monsoon activity in this region is controlled by the position of the seasonal monsoon trough. It appears that as the monsoon trough over runs this region in a quasi-stationary mode, the pressure within the trough fluctuates due to high frequency oscillations, which may either be propagating or some kind of standing waves. This aspect needs further investigation via the technique of cospectrum and cross spectrum analysis with neighbouring stations. A study of the nature of synoptic scale disturbances, which account for the fluctuations in the surface pressure field on short time scales is also a subject of further investigation. Prima facie, these fluctuations can not be explained by the activity of cyclogenesis over Bay of Bengal in terms of the number of monsoon lows and depressions. Fluctuations in the monsoon trough and its latitudinal migration and/or the westward passage of low pressure waves, which are not always possible to detect on the conventional synoptic charts, may apparently contain the mechanism for these fluctuations.

The interactions and phase relationships between different scales also needs to be investigated for a better understanding of the inter-annual variability of monsoon rainfall in different regions of the Indian subcontinent.

General

Dr. K. Prasad joined SMRC on 3rd January 2003 as Head, Theoretical Division. Dr. Prasad is a former Deputy Director General of Meteorology, India Meteorological Department, New Delhi, India.

Dr. Prasad holds a Master's degree in Statistics from Agra University, India. He obtained his Ph.D. degree from Meerut University on the thesis "Synoptic and Statistical Studies of Tropical Weather Systems for Rainfall Prediction in India".

Dr. Prasad joined the Indian Meteorological Service in 1964. He has worked in various disciplines of Meteorology, which include Agricultural Meteorology, Flood Meteorology, Aviation Meteorology, and World Weather Watch, mainly as an operational synoptic forecaster for the greater part of his career in the India Meteorological Department. In the later years he worked in the field of numerical weather prediction and computerised data processing in the headquarters office of India Meteorological Department, New Delhi. He has also been actively associated with various bodies of the World Meteorological Organization (WMO) in various capacities, such as Member of the Working Group on the Global Data Processing Systems, Chairman of the Regional Association II (Asia) Working Group on Planning and Implementation of World Weather Watch, and as a WMO Consultant for modernization of the Weather Services of Ethiopia and Nigeria.

Bangladesh

Special Weather Events that Took Place in Bangladesh During the Period of January-June 2003

One pre-monsoon cyclonic storm (09-20 May '03) formed in the Bay of Bengal which crossed Myanmar coast south of Akiyab. One monsoon depression formed in June 21-22, 2003 over the Bay of Bengal which moved over Bangladesh and caused heavy rainfall all over the country.

I. THE CYCLONIC STORM OF 09-20 MAY' 2003:

The well marked low over Southeast Bay and adjoining area concentrated into a depression over the same area at 1200 UTC of 10 May 2003. The depression moved northwestwards and intensified into a deep depression over the same area at 11, 0000 UTC. Then it moved northwestwards and rapidly concentrated into a cyclonic storm over Southwest Bay and adjoining area at 11, 0600 UTC. The Cyclonic storm moved west-northwestwards and concentrated into a severe cyclonic storm over the same area at 1200 UTC of 11 May. After that it continued to move northwestwards and weakened into a cyclonic storm over Southwest Bay and adjoining area 14, 1200 UTC. The system then moved northwards over the same area and weakened into a deep depression at 14, 1200 UTC. Then it continued to move northwards over the same area and further weakened into a depression at 17, 1200 UTC. It moved northwards and further weakened into a well-marked low over West Central Bay and adjoining area at 18,0000 UTC. Then it continued to move northeastwards and intensified into a depression over East Central Bay and adjoining North East Bay at 19,0600 UTC. Then it moved northeastwards and rapidly concentrated into a deep depression over the same area at 19,0900 UTC. The system further moved northeastwards and rapidly concentrated into a cyclonic storm over the same area at 19,1200 UTC. Finally it crossed Myanmar coast near south of Akyab and weakened into a depression at 2100 UTC of 19 May. Then it moved northeastwards and weakened gradually and became unimportant eventually.

ii. **The land depression of 21-22 June' 2003:**

The low over Northwest Bay and adjoining Bangladesh-West Bengal coast concentrated into a well-marked low at 1200 UTC of 20 June 2003. It moved northwards and concentrated into a land depression over Bangladesh at 06 UTC next day. Finally the system moved northwestwards and weakened slowly by giving heavy precipitation all over the country during 21-22 June 2003.

Under the influence of the land depression, very heavy rainfall of 175 mm, 115 mm, 114 mm, 126 mm, 129 mm and 106 mm at Chittagong, Rangamati, Comilla, Feni, Teknaf and Bhola respectively on June 21, 2003. On the following day very heavy rainfalls of 141 mm, 203 mm, 122 mm, 91 mm, 169 mm, 136 mm, 221 mm, 132 mm and 124 mm at Chandpur, Maijdi Court, Feni, Hatiya, Cox's Bazar, Kutubdia, Teknaf, Syedpur and Patuakhali respectively. Monthly rainfall in June 2003 was 47% above normal due to this depression.

Cold Wave:

West and northwestern part of the country and the regions of Srimangal went under the grip of moderate to severe cold wave during 09-27 January '03. The lowest minimum temperature of 3.4°C was recorded at Rajshahi on 23 January of 2003 which was below normal by -7.3°C. It was the lowest minimum temperature of Rajshahi during last 53 (Fifty-three) years and also the 2nd lowest minimum temperature of the country of the same period.

Heat Wave:

West and northwestern part of the county experienced moderate to severe heat wave during 26-30 May '03. The highest maximum temperature of 41.4°C was recorded at Rajshahi on 28 May of 2003 that was above normal by 7.0°C.

Pakistan

Election to the executive council of the world meteorological organization (wmo)

Dr. Qamar-uz-Zaman Chaudhur, Director-General, Meteorlogical Sevices was elected as the Member of the Executive Council of the WMO by securing 122 votes out of 146 WMO Member countries.

30TH SESSION OF WMO/ESCAP PANEL ON TROPICAL CYCLONES

The 30th session of the WMO/ESCAP Panel on Tropical Cyclones was held at Islamabad from 4th to 10th March 2003. The session was attended by the representatives of six out of eight member countries of the Panel namely Bangladesh, India, Maldives, Oman, Pakistan and Sri Lanka. The session was also attended by the observers from Nepal, Asian Disaster Reduction Centre (ADRC), International Civil Aviation Organization (ICAO) and the representatives from WMO, ESCAP & TSU.

SIGNIFICANT WEATHER EVENTS FOG OVER PUNJAB & ADJOINING AREAS

Fog formed over Punjab and adjoining areas for a number of days during the months of January and February 2003. The foggy weather prevailed over for 27 days in January 2003 which was the longest spell in the record of Lahore; the lowest minimum temperature was recorded –13.5°C at Kalam on 8th February 2003.

HEAVY RAINS IN FEBRUARY, 2003

A low-pressure system over southeast Iran with its trough extending to west Balochistan was located on 14-02-2003. Next day, it got intensified into well-marked low pressure area over there. It persisted over there for two day picking moisture from Persain Gulf and Gulf of Oman.

Although record of rainfall amounts were not broken at ayes number of stations in upper parts of country, it was record breaking in relation to duration, storm occurrence and hydro meteorological perspective for more than two decades.

The National Weather Centre, Islamabad reported this event as the wettest spell during the last three decades. New record formed from 16th to 21st February 2003 at a number of stations in terms of precipitation amount, intensity and duration of spell as indicated in the following table.

Station Name	Rainfall (mm)			Heaviest Rainfall during last 24 hours	
	Normal February Rainfall	Total Rainfall Feb. 16th to 21st Spell	Previous Record	Previous Record	Current
Gilgit	6.0	31.5	30.7 (in 1971)	15.5 on (4-2-1972)	25.7 on (19-2-2003)
Kotli	99.1	266.9	231.3 (in 1976)	119.4 on (1-2-1972)	154.9 on (19-2-2003)
Muzaffarabad	134.7	283.9	Previous record holds	73.0 on (20-2-1979)	113.9 on (18-2-2003)
Balakot	153.5	268.5	Previous record holds	80.8 on (18-2-1988)	113.0 on (18-2-2003)
Dir	Normal for the month is 172.6 mm whereas 171 mm has been received during this spell		Previous record holds	81.0 on (20-2-1979)	98.0 on (18-2-2003)
Jhelum	50.0	170.6	117.3 (in 1966)	86.9 on (20-2-1979)	93.0 on (19-2-2003)
Murree	145.0	314.0	Previous record holds	112.0 on (19-2-1984)	122.0 on (18-2-2003)
Sialkot	43.09	163.3	Previous record holds	74.4 on (28-2-1971)	82.5 on (19-2-2003)
Hyderabad	3.9	106	55.1 (in 1906)	37.8 on (2-2-1888)	71.0 on (18-2-2003)
Chhor	2.0	20.1	Previous record holds	17.5 on (2-2-1940)	17.3 on (18-2-2003 (2nd highest record)
Quetta	49.0	83.0	Previous record holds	49.0 on (3-2-1986)	54.0 on (17-2-2003)

Heavy rain was received in the catchments areas of reveres Indus, Jhulam, Chenab, Ravi and even Sutlej which was quite abnormal during this part of the season and unprecedented during the last many years. The inflow in the reservoirs of all the abovementioned rivers increased. At Mangla, the inflow rose from 6500 cusecs on 17-02-2003 to 315568 cusecs on 18-02-2003, thus raising the dam level from 1040 ft to 1096 ft in two days, which has not been observed in the recent history of the dam. Similarly water inflow at Marala in River Chenab rose and registered 316524 cusecs on 19-02-2003, which is very high flood position. River Indus also contributed a large amount of water in Tarbela where the dam level rose from 1376 feet on 17-02-2003 to 1389 feet on 26-02-2003.

DUST STORMS OVER PUNJAB

A number of dust storms hit the plain areas of Punjab during May and June 2003. A sever dust-storm with maximum wind speed of 122 km/hour was recorded at Lahore on 29th June 2003 which caused heavy loss of property in Lahore city and the surrounding areas.

Another severe dust storm hit Islamabad and Rawalpindi on 17th June, 2003 which also caused heavy loss of property.

CLIMATE EXTREMES DURING THE YEAR 2002

Hottest day (53.0°C) was July, 3rd 2002 at Turbat.

Coldest day (-15.6°C) was January 19th , 2002 at Astore.

Heaviest rainfall in 24 hours (159.0 mm) at Mureee June 24th, 2002.

Heaviest rainfall in a month.

359.8 mm during August, 2002 at Islamabad.

351.0 mm during August, 2002 at Risalpur.

Sri Lanka

It is very clearly seen in the rainfall isohyetal map of 17th May, that most of the rainfall during this spell was over the river catchments of Kalu ganga, Nilwala ganga and Gin ganga. The total estimated average area rainfall over these catchments on 17th May were, Nilwala ganga –233.0 mm, Gin ganga -227.0 mm, Kalu ganga - -219.0 mm equivalent to rainfall volumes of 288, 211 and 597 million cubic meters respectively.

Foods in Sri Lanka-May 2003:

A spell of extremely heavy rain in south-western Sri Lanka on 17th May 2003, associated with the onset of the Southwest Monsoon caused severe flooding in the districts of Ratnapura, Galle, Matara, Kalutara and Hambantota during third week of May 2003. Severe flooding at places over 20 feet high, inundated large areas completely devastating agriculture, house and property and causing an immense strain on the economy of Sri Lanka. Intensity of rain reaching 130 mm $hour^{-1}$ at places, caused many of the slope areas already identified as vulnerable to earth-slips in these districts and near-by, to give away in massive earth-slips burying a number of houses together with their inmates and property within. The total number of deaths reported were 236 while 19 people were missing. Most deaths have been reported from the hilly district of Ratnapura (122 deaths) while 64 deaths reported from Matara district. A total of 9,136 houses were completely devastated and 30,385 houses were reported as partially damaged due to floods/earth-slips which affected a total of 138,973 families.

Low pressure systems which form in the Bay of Bengal and the Arabian Sea close to Sri Lanka in May/June often result in the sudden setting-in of the Southwest Monsoon. Cyclonic circulations round the centre of these systems causes a strengthening of the westerly winds and gives rise to a rapid deterioration in the weather over limited areas of Sri Lanka. The resulting rain is usually heavy but is orographically confined to the southwest quarter of the island. On 7th May 2003 a similar tropical disturbance was noticed approximately 900 kilometers to the east of Sri Lanka which initially moved in a northwest direction while deepening. By 11th May it developed into a cyclonic storm to be named TCO1B and thereafter lied practically stationary or wobbling around approximately the same place for over a day before suddenly regenerating on the 16th and moving eastward to bring about very intense and heavy rain in southern Sri Lanka due to the formation of an intense feeder-band. With this system, the Southwest Monsoon flow was established over Sri Lanka on 13th May approximately ten days ahead of schedule.

The most intense and heaviest rain during this spell was confined to a relatively smaller area over the southern slopes of the Sabaragamuwa hills on 17th May; 24-hour rainfall isohyet of 100 millimeters encompassing about eight per cent of the land area of Sri Lanka. The highest total rainfall recorded during the spell was 730.0 millimeters at Deiyaya (08º33'40" East, 06º20'10" North) between 0600 hours on the 17th to 1030 hours (SLST) on the 18th. The temporal break-down of the rain at Deniyaya show, 195.0 mm between 17/0600 to 17/1030; 150.0 mm between 17/1030 to 17/1400; 174.0 mm between 17/1400 to 17/1730; 150.0 mm between 17/1730 to 17/2230 and 61.0 mm between 18/0600 to 18/1030 hours. The other major 24-hour rainfalls recorded on the 17th were, 521.8 mm at Kudawa (080º25' E 06º 26'N), 402.9 mm at kalawana (080º24'E, 06º 32'N), 345.2 mm at Ratnapura (080º24'E, 06º32'N) and 328.0 mm at Morawaka (080º 30'E, 06º15'N). It is noteworthy here to mention that the recorded rainfall of 521.8 mm at kudawa is the highest since observation began 22 years previously and the fall of 345.2 mm at Ratnapura is the third highest 24-hour rainfall recorded since the start of the observations in 1869. The higher falls recorded at Ratnapura prior to this episode been 394.4 mm on 15th July 1942 and 392.5 mm on 8th June 1996.

As indicated earlier, the most intense rainfall during this spell was confined to a relatively smaller area. As the rain fell over an area where a number of rivers and streams originate, downstream areas of these water paths were inundated due to the enormous amount of water. It is very clearly seen in the rainfall isohyetal map of 17th May, that most of the rainfall during this spell was over the river catchments of Kalu ganga, Nilwala ganga and Gin ganga. The total estimated average areal rainfall over these catchments on 17th May were, Nilwala ganga -233.0 mm; Gin ganga -227.0 mm; Kalu ganga -219.0 mm equivalent to rainfall volumes of 228, 211 and 597 million cubic meters respectively.

Maldives

Special weather events January-June 2003 Maldives

Severe weather commenced on 08 January 2003 with a severe thunderstorm over Faafu atoll. Lightning strikes caused destructions to many audio/video appliances and refrigerators.

During late April, pre-monsoon rain caused havoc over southern atolls. The meteorological office in Kadhdhoo (WMO # 43577) reported as many as 107.2 mm of rain on 27 April 2003.

Fresh to strong south-westerly winds started prevailing from 5th May till 12 May and 20-23 June 2003. During this strong monsoon period frequent gusts exceeding 45 mph were experienced throughout the country. Uprooting of trees and several other damages to properties and vessels were reported.

DEVELOPMENTS:

The official website of this Department www.meteorology.gov.mv Was launched on the World Meteorological Day 23 March 2003. Forecasts, warnings for the Maldives and various meteorological reports/charts for aviation sector are currently available on this web page. The website was launched by the Minister of the President's Office Honorable Abdulla Jameel.

Fig. (a)

Fig. (b)

Fig. (c)

Nepal

The main highlights in the weather condition over Nepal for the period from January to June 2003 are briefed here, along with the Severe Cold Wave conditions in the month of January.

This year the terai region reported dense foggy weather resulting in severe cold condition for the long period from the last December 2002 till 24th January 2003 with the intervals of few days of slightly warmer temperature. During this adverse weather, the maximum temperature dropped rapidly by 8-10°C than the previous days or week, but the minimum temperature remained almost unchanged creating not so much different from maximum to minimum temperatures. In the day-time the hilly regions were considerably much warmer than that of the terai region (southern plain terrace). Even Jumla situated at the elevation of 2300m reported 21.3°C day-time temperature on 19th January, on the same day Nepalgunj (western terai) recorded 10.4°C. The sun was completely obstructed by the dense fog (in vertical) preventing the sun's ray from reaching the ground. The early morning's temperature could not rise up to its day's maximum value which resulted in severe cold condition throughout the day-time. In the western and central terai the day's maximum temperature plummeted 6-7°C below the normal maximum and in the eastern terai it was below by 4^{0}C. The most affected areas of prevailing cold wave were western and central terai, where as the eastern terai was less affected. This year, most parts of the terai regions marked coldest January breaking all the previous records. According to the press reports this severe cold spell was responsible for the death of nearly 100 people in the terai region.

Active westerly disturbances brought widespread rains in the month of February. Pokhara, Simara and Kathmandu reported the highest monthly rainfall (84mm, 57mm and 60mm respectively) breaking the past recorded values. Intensive thunderstorm was marked in the third week of this month.

In the months of March, April and May scattered thundershowers, sometimes accompanied by hailstorms and strong gales occurred over the country. According to the press reports the thunderbolt injured many persons and claimed around 15 lives, meanwhile hailstorms brought a big damage in the winter and seasonal crops at different places of the kingdom. Similarly strong gales disrupted electricity and communications. Pre-monsoon activity in May was weak in this year.

Monsoon-2003 commenced into the country on 16th June after a delay of 6 days. Usually the monsoon advances into the kingdom on 10th of June.

Active monsoon in the last week of June brought heavy torrential rain over the country leading floods and landslides at various parts of the country. According to press reports three persons were killed in floods and landslides, while intensive thunderstorms claimed four lives in the first week of this month.

India

<u>Membership/Assignment</u>

1. Dr. S.K. Srivastav, Additional Director General of Meteorology & P.R. of India with WMO has been elected as a Member of the Executive Council of the World Meteorological Organization (WMO) for the period 2003-2007. The election was held during 14th WMO Congress at Geneva, Switzerland in May, 2003.
2. On the request of Government of Sri Lanka, Dr. S.K. Dikshit, Additional Director General of Meteorology (Research), was deputed to Sri Lanka,

as a Consultant to implement the study to modernize the Meteorological Department, Sri Lanka from 19 February to 13 March, 2003.

3. Long Range Forecast for Monsoon Rainfall in India during June to September 2003:

This year, IMD has introduced several new models for the Long Range Forecast of the South-West Monsoon rainfall. With this, it has become possible to issue the long range forecast in two stages: first in mid-April using data upto March and an update in mid-July using data upto June.

The first forecast for the 2003 South-West Monsoon season rainfall (June-September) for the country as a whole using newly adopted power regression and probabilistic models were issued on 16 April. Detail of the forecasts is as follows:

3.1 Power Regression Model:

This is an 8-Parameter Power Regression Model which indicates that the 2003 South-West Monsoon rainfall (June-September) for the country as a whole is likely to be 96% of the Long Period Average (LPA) with a model error of ±5%.

3.2 Probabilistic Model:

The new 8-parameter Probabilistic Model indicates the following probabilities:

21% probability of drought (rainfall less than 90% of LPA)

39% probability of below normal rainfall (90 to 97% of LPA)

14% probability of near normal rainfall (98 to 102% of LPA)

23% probability of above normal rainfall (103 to 110% of LPA)

3% probability of excess rainfall (more than 110% of LPA)

3.3 Second Stage Forecast:

The South-West Monsoon forecast for the country as a whole was updated on 9th July 2003 and the models indicate the following:

(a) Power Regression Model:

The rainfall for the country as a whole is likely to be 98% of the Long Period Average (LPA) with a model error ±4%.

(b) Probabilistic Model:

The updated probabilistic forecast for the country as a whole is:

6% probability of drought (rainfall less than 90% of LPA)

28% probability of below normal rainfall (90 to 97% of LPA)

43% probability of near normal rainfall (98 to 102% of LPA)

17% probability of above normal rainfall (103 to 110% of LPA)

6% probability of excess rainfall (more than 110% of LPA)

Over the three broad homogeneous regions of the country, rainfall for the South-West Monsoon is likely to be 97% of LPA over North-West India, 100% of LPA over North-East India and 99% of LPA over the Peninsula, all with a model error of ±8%.

4. Extreme Weather Events:

4.1 Cold wave conditions over India during Winter Season of 2003:

Severe cold wave conditions prevailed over northern and eastern parts of country during firs t three weeks of January. During the period, most parts of northern India were under thick fog, usually continuing till afternoon caused maximum temperature drop below normal.

Fig. 1 shows Seasonal Minimum Temperature departure during winter season of 2003.

Mean seasonal (Jan-Feb 03) minimum temperature departures (°C)

4.2 Heat wave condition over India during Pre-monsoon Season of 2003:

Severe heat wave conditions prevailed over some parts of Andhra Pradesh, West Uttar Pradesh, Chhatisgarh and Tamil Nadu during second half of May & first half of June. Over Andhra Pradesh, maximum temperatures were generally above normal (more than 4°C) during the second half of May.

Hundreds of human lives were lost in Andhra Pradesh due to the severe heat wave conditions.

Fig. 2 shows Seasonal Maximum Temperature departure during pre-monsoon.

Mean seasonal (Mar-May 03) maximum temperature departures (°C)

4.3 Rainfall over India during Winter and Pre-monsoon season of 2003:

During winter season, the rainfall for the country as a whole was on the positive side of the normal as country received 131% of its Long Period Average value.

5. Onset and advance of Southwest Monsoon over India during 2003:

Southwest monsoon set in over Kerala on 8 June, almost a week behind its normal date. It advanced over the central Arabian Sea, most parts of Tamil Nadu and Karnataka by 11 June. Monsoon, thereafter, steadily progressed both north and eastwards. Southwest Monsoon advanced over the northern Arabian Sea, Gujarat region, Saurashtra & Kutch, North Bay of Bengal by 19 June covering parts of Madhya Pradesh, Chhatisgarh and Sub-Himalayan West Bengal. Monsoon onset was delayed by 7 to 10 days over most parts of country except Rajasthan.

Fig. 3 shows onset and advance of southwest monsoon over India.

Onset and advance of southwest monsoon 2003

SMRC Newsletter is published half yearly by the Director, SAARC Meteorological Research Centre (SMRC) Abhawa Bhaban (7th floor) Agargaon, Dhaka-1207, Bangladesh. **Phone**: **8111670, 9124508, Fax: 880-2– 8111670, E-mail: smrc@bol-online.com**

20