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Medium range forecasting in India— An over view

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सार – मध्यम कालीन पूर्वानुमान का अभिप्राय 3 से 10 दिनों के परास में मौसम विज्ञान प्राचलों का पूर्वानुमान करना है। उत्तरवर्ती पचास में, भारत में मध्यम कालीन पूर्वानुमान का कार्य प्रारम्भ किया गया था और मध्यम कालीन पूर्वानुमान अनुसंधान के लिए एक विशेष एकक की स्थापना की गई थी। सबसे पहले आंकड़ों के आधार की तैयारी अपेक्षित थी। इस शोधपत्र में मौसम उप-खंडों के एक समूह के लिए पंच संयोजक (5 दिन) के वर्षा विसंगतियों की प्रागुक्ति के लिए विकसित सांख्यिक और सिनॉप्टिक सहित सांख्यिक तकनीकों की समीक्षा की गई है।

ABSTRACT. Medium range forecasting aims at predicting meteorological parameters with a validity ranging from 3 to 10 days. Work on medium range forecasting was taken up in India in the late fifties and a special unit was set up for medium range forecasting research. As a first step preparation of data base was required. Statistical and synoptic-cum-statistical techniques developed for prediction of pentad (5-day) and weekly rainfall anomalies for a group of sub-divisions are reviewed in the paper.

1. Introduction

Prediction of weather, particularly rainfall, is of considerable importance, because of its influence on the agriculture, water and energy management. In meteorological paralance weather forecasts can be classified as :

(*i*) *Short range forecasts* — Covering a period of a few hours to two days,

(*ii*) *Medium range forecasts* — Covering a period from 3 to 10 days,

(*iii*) *Long range forecasts* — Covering a period of a month or a season.

In south Asia and southeast Asia most of the rainfall is in association with the summer and winter monsoons. Over the Indian sub-continent the summer monsoon rainfall accounts for about 80-90% of the annual rainfall.

The pulsatory character of the summer monsoon is known to the meteorologists ever since the classical work of Eliot reported in the early part of the present century. However, in the last two decades, scientists have been able to discover the latent quasi-periodicities through the use of harmonic and spectrum analysis techniques. Periodicities ranging from four to six days up to 40-50 days in the monsoon field have been reported by various authors, *viz.*, Bhalme and Parasnis (1975), Sikka and Gadgil (1980). However, these variations in the different time scales and the variations in the different space scales produce a complex and at times a baffling picture of the rainfall distribution over the subcontinent. Variations in the weekly mean circulation anomaly for 1987, a drought year, and 1988, a good monsoon year, are shown in Fig. 1. The central problem in the medium range forecasting is to predict these intraseasonal fluctuations in the time scale of 3-10 days and link it with a known spatial domain.

Between the short range forecast covering a period of say, 24 hours and a climatic forecast which may span over a period of say, thousands of years, we have wide spectrum. In the last two to three decades the problem of medium range forecasting have received increased attention of the scientists.

2. Techniques of medium range forecasting

Early investigations in the field of medium range forecasting consisted of attempts to understand the physical or natural evolution of large scale meteorological systems and their influence on the weather over comparatively large areas of the globe. In order to filter out short period and local influences, mean circulation charts over large areas were prepared and studied. Since then, a large volume of work has been done on the problem of medium range forecasting, we may classify these into the following :

(*i*) *Statistical techniques* — These are based on statistical relationships without explicit analysis of physical reasoning,

(*ii*) *Synoptic cum statistical techniques* — These are based on empirical methods using synoptic analysis compositing etc. Use of statistics is secondary in nature,

(*iii*) *Dynamical and physical techniques* — These involve the use of NWP models specially developed for medium range weather prediction.

Now we shall elaborate a bit on these techniques and give details of the various investigations carried out in this respect in India. Work on medium range forecasting was taken up in India in the late fifties and a special unit was set up for medium range forecasting research. The broad approach followed in these investigations was statistical or synoptic cum statistical.

(*i*) *Statistical method*

For many years purely statistical techniques have been adopted for weather prediction, however, the past

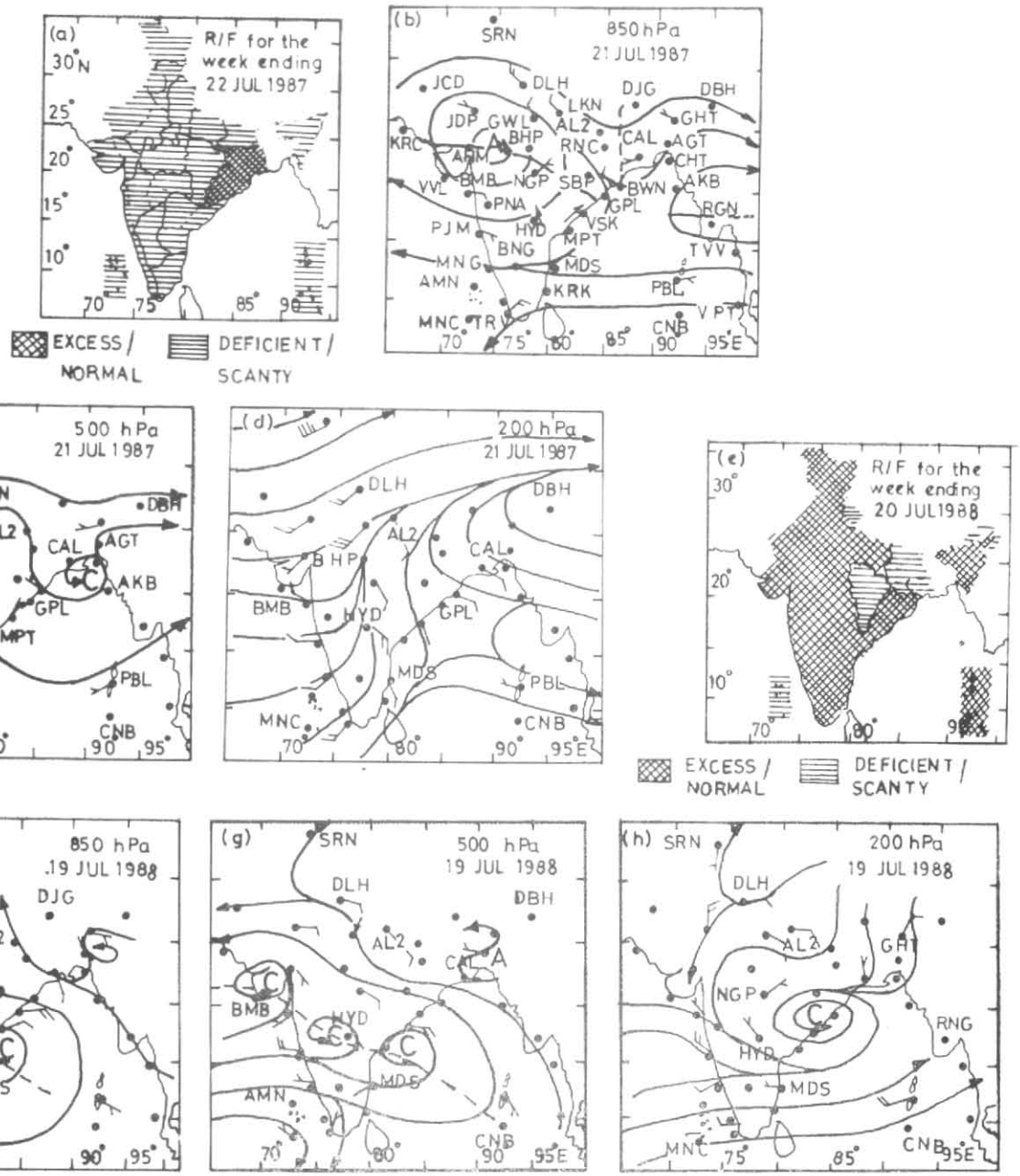

Fig. 1. Variations in the mean circulation anomaly 1987-88

two decades have witnessed a marked revival of interests in the use of statistical techniques for medium range forecasts, *e.g.*, De (1982), Singh *et al.* (1979). Multiple correlation regression technique, screening regression discriminant analysis and contingency techniques are some of the tools used for medium range prediction research in India, *e.g.*, Jagannathan and Ramamurti (1961), Pant (1965), Shukla and Suryanarayana (1967) and Singh *et al.* (1984). In these techniques the main variable called predictand was five-day, seven-day and ten-day rainfall total (or departures from normal) while the predictors were tropospheric circulation features at 850, 700 or 500 hPa levels. Fig. 2 shows a typical 7-day forecast for different groups of sub-division in India using multiple regression technique by Singh *et al.* (1979). An improved prediction equation can be obtained by using additional parameters in a regression equation of the type :

$$y = a_0 + a_1 x_1 + a_2 x_2 + \ldots\ldots + a_k x_k$$

where, $a_0, a_1, a_2 \ldots\ldots a_k$, are regression coefficients determined by least square. Often a screening procedure is adopted to select from a large set of possible predictors only those few which contribute significantly to the predictand. In the multiple correlation regression approach success was moderate and one major difficulty was to identify many parameters which had prediction value, furthermore, the formulae developed related to a specific months or season and related to different sub-divisions or groups of sub-divisions. Consequently, a large amount of effort was needed for developing multiple regression technique. Yet another approach using statistical method is the use of contingency relationship between the predictor and predictand. This method can take care of relationship between these two variables statistically even though it may be non-linear. In order to get reliable results from statistical techniques, the predictors should be independent of each other as far as possible and a

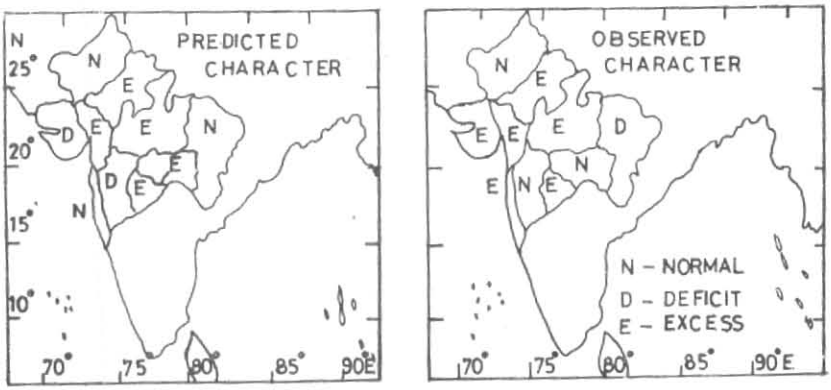

Fig. 2. Typical 7-day forecast using multiple regression equation

large part of the variance of the predictand should be associated with the selected predictors. These two conditions are often difficult to satisfy and hence there was limited success in purely statistical approach.

(*ii*) *Synoptic cum statistical method*

These methods are based on the combined use of synoptic climatology and statistics in arriving at a forecast technique. Some of the variations of this approach are :

(*a*) Typing method,

(*b*) Analogue method and

(*c*) Mean circulation method.

Of these methods the mean circulation method consists of the study of five-day mean circulation charts, circulation anomaly charts and their association with the concurrent as well as anticipated weather anomalies over a region. Often a stepwise study is required to identify :

(*i*) the concurrent relationships,

(*ii*) prediction of circulation anomalies over a period of 3 to 10 days and

(*iii*) use the predicted mean circulation anomalies in terms of weather through concurrent relationships identified earlier.

Study of mean circulation charts at various tropospheric levels have been made by Alexander *et al.* (1978) over India for the summer monsoon season. The study brought out the role of the circulation anomalies in different phases of the monsoon activity. It also showed that the anomalies in the circulation (both zonal and meridional) could be used as a predictive tool for weekly rainfall departures. Following this investigation De *et al.* (1978) worked out a contingency technique for predicting rainfall anomaly over central India (consisting of three sub-divisions, *i.e.*, east Madhya Pradesh, west Madhya Pradesh and Vidarbha).

De (1982) has summarised the results of the investigations following this line of approach. Table 1 summarises the verification of the forecast trends. Study of antecedent mean circulation parameters for predicting active and break or weak monsoon spells have been done by De *et al.* (1984) and Singh *et al.* (1984).

At present, medium range forecasts are issued by some countries only on a routine basis. In India weekly outlook of weather and medium range forecasts for

TABLE 1

Verification of forecasts using MRF predictors

	Observed class	Predicted class EN	Predicted class DS	Predicted class Total	Skill score
(1) Central India	EN	27	7	34	
	DS	12	20	32	0.42
	Total	39	27	66	
(2) Tamil Nadu	EN	18	7	25	
	DS	7	28	35	0.53
	Total	25	35	60	
(3) Madhya Maharashtra	EN	23	6	29	
	DS	10	24	34	0.53
	Total	33	30	63	
(4) Marathwada	EN	21	7	28	
	DS	10	23	33	0.43
	Total	31	30	61	
(5) Orissa	EN	23	5	28	
	DS	1	8	9	0.61
	Total	24	13	37	
(6) Gangetic West Bengal	EN	21	8	29	
	DS	2	10	12	0.49
	Total	23	18	34	

TABLE 2

Sub-division	No. of correct forecasts	Percentage	Skill score
(a) Persistence forecasts			
Madhya Maharashtra	54	62	0.21
Marathwada	59	69	0.35
Gangetic West Bengal	51	61	0.13
Orissa	54	64	0.26
(b) Persistence — Climatology forecasts			
Madhya Maharashtra	47	55	0.10
Marathwada	56	65	0.31
Gangetic West Bengal	56	67	0.20
Orissa	53	62	0.21

Agromet advisory schemes are issued. The methods are either synoptic climatological or statistical/empirical. The success achieved is moderate. The percentage accuracy varies between 60 & 70 for summer monsoon rainfall prediction. It must be added that, at present, there are no suitable set of techniques available to predict rainfall 5 to 10 days in advance for the whole country for the different seasons in an objective manner. The available statistical cum synoptic climatological techniques though better than climatology or persistence (Table 2 a & b) may not be adequate to fulfil the increasing and continued demand for improved medium range forecasts. However, statistical techniques are still very useful for preparing forecasts of specific weather elements as needed by the users.

In recent years many investigators have hinted the possible use of "30-50 day" mode for medium range forecasting. However, Rama Sastry *et al.* (1986) and De and Vaidya (1987) found their potential to be rather limited. This was in fact due to the variable period of these modes from one year to the other, and low variance associated with it.

(iii) Dynamical and physical techniques

A very substantial improvement has taken place in the quality of the numerical weather prediction specially for the extra-tropics since the first numerical forecast was made nearly 40 years ago. The improvements are essentially in two respects : more accurate short range forecasts and an extension in the range of the forecasts. One of the major objectives of the GARP was to improve the prediction capabilities in the tropics.

When one attempts to integrate the governing equations of a numerical models for a longer period, the assumption made for short range prediction (integration) cannot be taken for granted. Diabatic effects due to radiation, cumulus heating, cloud radiation interaction etc are to be incorporated in the model equations. The problems are quite complex. When numerical integration of even simple models for period up to 96 to 120 hr were attempted in the sixties, the success was limited. In brief, one can list the important limitations in this approach as follows :

(*i*) imperfections in the model,
(*ii*) lack of data for specifying the initial state,
(*iii*) truncation errors in the Numerical Integration scheme,
(*iv*) incomplete representation of the various physical processes at work in the atmosphere and
(*v*) limitations imposed by the predictability of the atmosphere.

Later workers, therefore, studied superior hierarchal models, specially the primitive equation models with improved data inputs for obtaining longer period time integrations.

Miyakoda and his collaborators in 1972 carried out long term integration extending up to 10 days. These forecasts show average positive skill which was small beyond 3 to 4 days. The last decade has witnessed a rapid development in the use of numerical models for medium range forecasting and success in solving, albiet partially, the problems connected with data assimilation, parameterisation and computational stability in long term integration. These developments culminated in the establishment of European Center for Medium Range Weather Forecast (ECMWF) in U. K. To start with, a grid point model was used. Daily forecasts are being issued by ECMWF since 1 August 1980. The model was changed to a spectral model for gaining better cost-benefit ratio. These forecasts show positive skill compared to climatology and persistence for the period up to ten days. At present the average skill of the ECMWF forecast for winter is 5 to 6 days. These are considered to be significant improvements upon the results obtained by Miyakoda nearly 12 years ago, at least in predicting the large scale motion of the atmosphere. The skill of ECMWF operational model is, however, low for the tropics (Heckley 1985). Considerable work is in progress to improve the model physics and resolution to get better forecasts for the tropical areas.

The tropical medium range forecasts have immense practical use. Thus, improvements in the medium range forecasts are very essential. While the development and improvement of numerical models for medium range forecasting is very necessary for the monsoon areas, such an improvement, however, does not necessarily produce similar improvements in weather forecasts. Further development is needed to interpret the numerical forecasts into weather and into consumer oriented useful products. Efforts in both these areas are needed for achieving the desired level of success in medium range forecasting. Establishment of the National Centre for Medium Range Weather Forecasting is in progress to achieve these goals in our country.

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