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Recent studies in medium range forecasting for agromet advisory service

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सार – भारत मौसम विज्ञान विभाग ने कुछ राज्यों में कृषि संबंधी प्रचालनों के लिए कृषि मौसम विज्ञान सलाहकार सेवा शुरु की है। इस शोध पत्र में सिनॉप्टिक एवं सांख्यिकी आधार पर भारत में विभिन्न उप-सम्भागों में वर्षा के माध्य परिसीमा पूर्वानुमान के क्षेत्र में चल रहे शोध-कार्य का वर्णन किया गया है। यह विधि आसंग तकनीक पर आधारित है तथा इस विधि को पूर्वी एवं पश्चिमी मध्य प्रदेश, विदर्भ, मध्य महाराष्ट्र, मराठवाड़ा एवं तमिलनाडु में सप्ताह में होने वाली वर्षा असंगति के सफलतापूर्वक पूर्वानुमान के लिए उपयोग में लाया गया है।

ABSTRACT. The Agrometeorological Advisory Service for agricultural operations has been started by the India Meteorological Department in a few States. The paper describes the ongoing research work in the field of Medium Range Forecasting of rainfall for various sub-divisions in India on a synoptic *cum* statistical basis. The method is based on a contingency technique which has been used to successfully forecast the weekly rainfall anomaly over East and West Madhya Pradesh, Vidarbha, Madhya Maharashtra, Marathwada and Tamil Nadu.

1. Introduction

Weather affects almost every aspect of human activity from agriculture to aviation and from space flight to sports. It is well known that agriculture in our country largely depends upon the performance of monsoon whose vagaries are too well-known. From sowing to harvesting, weather plays a dominant role and determines the yield of the crops. The Meteorological Department commenced issuing weather bulletins for the farmers in 1945. Recently, an agrometeorological advisory scheme for agricultural operations in a few States has been started. One of the main components of this scheme is the medium range forecasting unit. The main purpose of this unit is to design methods by which forecasts can be made of important weather elements 3-7 days in advance for every State where the agrometeorological advisory service is functioning.

2. Technique for medium range forecasting

It is well known that during the monsoon season there are spells of active and weak or break monsoon. A thorough understanding of the morphology and dynamics of large-scale flows during and prior to these epochs is a pre-requisite to medium range forecasting in these parts. Several studies were taken up by the research unit in the office of the Deputy Director General of Meteorology (Weather Forecasting) to acheive this end. Alexander *et al.* (1978) studied the circulation anomalies associated with spells of strong and weak monsoon. The studies showed that in the pentad prior to the pentad of strong monsoon an anomaly trough is extending from south Peninsula to Thailand and further east in the lower and mid-troposphere. In the upper troposphere prior to and during strong monsoon epoch there is generally more northerly component of wind over northwest and central parts of India.

In the pentad prior to the break an anomaly ridge extends from south Peninsula to southeast Asia in the lower tropospheric and the upper tropospheric flow over northwest India shows more southerly component. From these contrasting features it is possible to get some clue for medium range forecasting. Till the time numerical models in the tropics can be used with reasonable success on the time scale of 3-7 days, a statistical *cum* synoptic approach is necessary for medium range forecasting. A similar analysis of the composite anomaly charts prior to excess and deficient rainfall over Tamil Nadu during the northeast monsoon was made by Pant *et al.* (1980). The study showed that before spells of excess rainfall over Tamil Nadu meridional flow over Madras and Visakhapatnam at 500 mb was more southerly while it was more northerly before a spell of weak rainfall activity. These features were discernable 1 or 2 days before the

TABLE 1

Values of (10.000 + log R'_{ij})

Predictor	Class (mps)	Predictand EN	Predictand DS
Central India (East Madhya Pradesh + West Madhya Pradesh + Vidarbha) based on data for 1965-1970			
Madras-Nagpur zonal shear anomaly 700 mb, one day before	≥−5.0 <−5.0	10.0829 9.8489	9.8906 10.1241
Madras-Nagpur zonal shear anomaly 850 mb, one day before	≥ 0.0 < 0.0	10.1160 9.8534	9.8277 10.1160
Port Blair-Calcutta zonal shear 850 mb, one day before	≥−5.0 <−5.0	10.0984 9.8377	9.8534 10.1366
Visakhapatnam-Calcutta Zonal shear anomaly 850 mb, one day before	≥−0.5 <−0.5	10.0813 9.8395	9.8759 10.1283
New Delhi meridional anomaly, 200 mb, two days before	≥−0.0 <−0.0	9.8420 10.1009	10.1334 9.8495
Allahabad - Jabalpur surface pressure gradient, anomaly, 3 days before	≥−1.0 <−1.0	10.1582 9.7874	9.7144 10.1534
Tamil Nadu based on data for 1965-1970			
Madras meridional wind anomaly 500, mb, one day before	≥+1.0 <+1.0	10.1351 9.8723	9.8028 10.0986
Madras meridional wind anomaly 500 mb, two days before	>−1.0 ≤−1.0	10.1008 9.8897	9.8625 10.0919
Vizag meridional wind anomaly 500 mb, two days before	≥−2.0 <−2.0	10.1930 9.8557	9.8985 10.1151
Vizag meridional wind anomaly 700 mb, three days before	≥−1.0 <−1.0	10.0924 9.8148	9.7143 10.1351
Trivandrum zonal wind anomaly, 200 mb, two days before	≥0.0 <0.0	9.8717 10.0873	10.1085 9.8768
Vizag-Madras surface pressure gradient anomaly, one day before	≥0.5 mb <0.5 mb	10.1406 9.8073	9.7736 10.1406

Predictor	Class	Predictand EN	Predictand DS
Madhya Maharashtra based on data for 1968-1975			
Calcutta 700 mb, zonal anomaly, one day before	≥1.0 mps <1.0 mps	9.7848 10.1301	10.1378 9.8233
Nagpur 850 mb *vs* Nagpur 500 mb zonal anomaly one day before	Area A Area B	10.1633 9.7959	9.7683 10.1277
Nagpur 500 mb *vs* Visakhapatnam 500 mb zonal anomaly, one day before	Area A Area B	10.1456 9.7932	9.7932 10.1341
Madras 850 mb *vs* Visakhapatnam 500 mb zonal anomaly one day before	Area A Area B	10.1202 9.8573	9.8435 10.0886
Bombay 850 mb *vs* Nagpur 850 mb zonal anomaly, one day before	Area A Area B	10.1392 9.7627	9.8026 10.1479
Marathwada based on data for 1968 - 1975			
Nagpur 850 mb zonal anomaly one day before	≥0.0 mps <0.0 mps	9.6901 10.1754	10.1660 9.7353
Bombay 850 mb *vs* Nagpur 850 mb zonal anomaly one day before	Area A Area B	10.1899 9.7335	9.7103 10.1775
Visakhapatnam 500 mb *vs* Nagpur 500 mb zonal anomaly, one day before	Area A Area B	10.1453 9.8172	9.8172 10.1132
Nagpur 850 mb *vs* Nagpur 500 mb zonal anomaly, one day before	Area A Area B	10.1679 9.7901	9.76[illegible]7 10.1256
Hyderabad 850 mb zonal anomaly one day before	≥0.0 mps <0.0 mps	9.8274 10.1222	10.1155 9.8445

E : ≥ 20%, N:−19 to 19%, D:<−20 & >−59% and S : <−60% of the normal weekly rainfall in the sub-division.

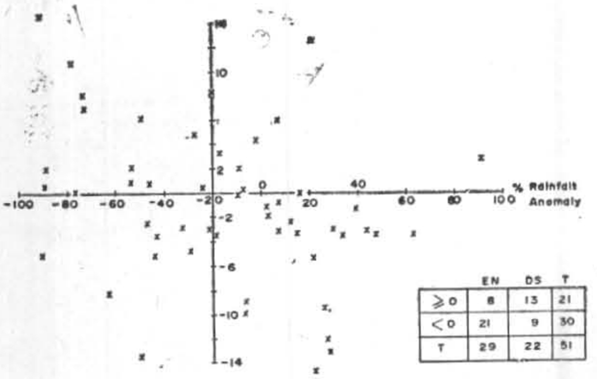

Fig. 1. Central India (New Delhi) N component anomaly, 2 days before

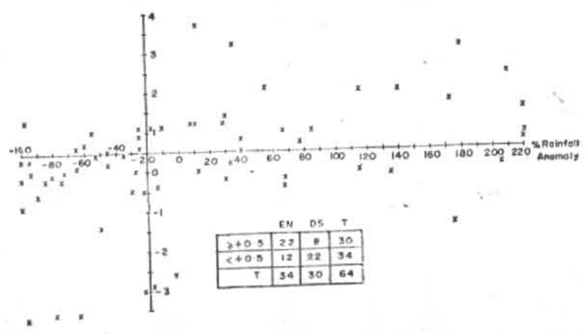

Fig. 2. Tamil Nadu (VSK-MDS) horizontal pressure gradient anomaly, one day before

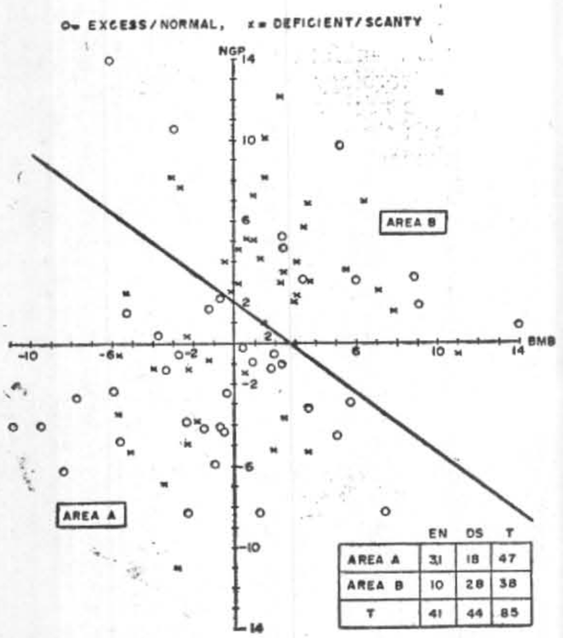

Fig. 3. Madhya Maharashtra (Bombay *vs* Nagpur) zonal anomaly 850 mb, one day before

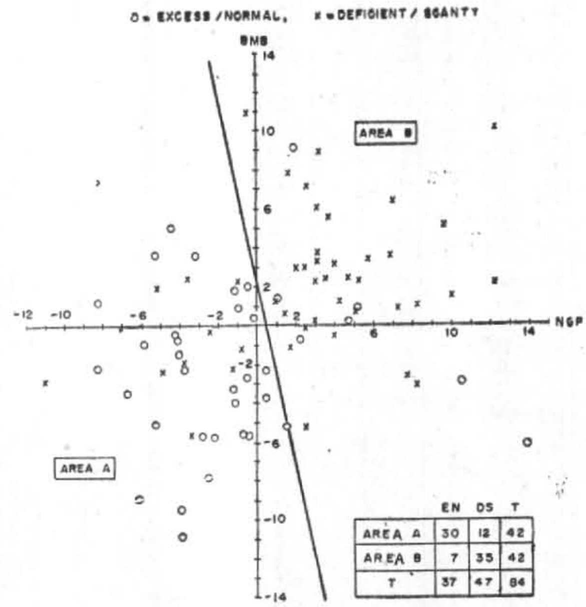

Fig. 4. Marathwada (Bombay *vs* Nagpur) zonal anomaly 850 mb, one day before

contrasting weekly rainfall spells. Joshi *et al.* (1981) have studied the behaviour of weekly spells of rainfall occurring during the southwest. monsoon season. It was seen that spells of excess, normal, deficient or scanty rainfall occur in a group or groups of sub-divisions simultaneously. On the other hand there is a group of sub-divisions where opposite type of distribution prevails. These factors could also be used in medium range forecasting. More quantitative relationships are to be established in this direction.

3. Statistical tests and selection of predictors

From the study of the anomaly charts several predictors were chosen and scatter diagrams, Figs.1-4 were prepared. The final choice of predictors for the contingency tables were made by following the technique of Lund and Whal (1955) which has also been utilised by De *et al.* (1978). Details of this are, therefore, not presented in this paper.

Table 1 gives the various predictors chosen for predicting the weekly rainfall over the central India, Tamil Nadu, Madhya Maharashtra and Marathwada.

4. Verification of forecast

Using the predictors developed this method of forecasting was tested for 66 weeks in central India, 60 weeks in Tamil Nadu, 63 weeks in Madhya

Maharashtra and 61 weeks in Marathwada. The performance is given below :

	Observed class	Predicted class		
		EN	*DS*	*Total*
Central India	EN	27	7	34
	DS	12	20	32
	Total	39	27	66
Tamil Nadu	EN	18	7	25
	DS	7	28	35
	Total	25	35	60
Madhya Maharashtra	EN	23	6	29
	DS	10	24	34
	Total	33	30	63
Marathwada	EN	21	7	28
	DS	10	23	33
	Total	31	30	61

In all these cases the percentage of correct forecast was about 75 per cent or more. The skill score given by Heidke "chance" skill score was also around 0.4 to 0.5.

$$\text{Skill score} = \frac{C - E}{T - E}$$

where C is the number of correct forecasts, E is the number of correct forecasts on chance and T is total number of forecasts made.

5. Conclusion

(*i*) The work of medium range forecasting on statistical *cum* synoptic lines shows promising results. The method is easy to operate on weekly basis once the predictors are identified and the values of $\log_{10} \pi_j$ are tabulated.

(*ii*) The predictors selected for the study are readily available from the Pilot and surface charts at forecasting offices and the anomalies can be computed without much elaborate computations.

(*iii*) The predictors for all the different areas are taken to represent the surface, lower, middle and upper tropospheric circulation features which are based on a synoptic study carried earlier by the Medium Range Forecasting Unit.

(*iv*) The percentage of correct forecasts in all the cases was 75 or more and the skill score ranged between 0.40 and 0.50.

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