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Re-determination of normal dates of onset of southwest monsoon over India

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सार – देश के विभिन्न भागों में दक्षिण–पश्चिम मानसून का आरम्भ मानसून की सामान्य तारीखों की तुलना में उससे पहले, समय पर अथवा उससे देर से हो सकता है। मानसून तेजी से अथवा धीमी गति से आगे बढ़ सकता है अथवा कभी कभी मानसून के आगे बढ़ने में बहुत लम्बी रूकावट आ सकती है कृषि क्षेत्र और जल आपूर्ति के क्षेत्र में मानूसन के आरम्भ के समय का बहुत अधिक महत्व है। इस समय मानसून के आरम्भ की जो जलवायविक सामान्य तारीखें उपलब्ध हैं वे 149 स्टेशनों से प्राप्त आँकड़ों के बहुत पुराने तरीकों (1901–1940) पर आधारित है। इस अध्ययन में भारत के विभिन्न भागों में ग्रीष्मकालीन मानसून के आगमन की जलवायविकी 1971–2000 तक समूचे देश में फैले 569 स्टेशनों के माध्य पेंटाड वर्षण आँकड़ों का उपयोग करके प्राप्त की गई हैं। यह देखा गया है कि मानसून के आरम्भ की संशोधित तारीख अंडमान सागर में 20 मई, केरल में 1 जून, पूर्वोत्तर भागों में 5 जून और समूचे देश में मानसून छा जाने की तारीख 15 जुलाई (मौजूदा तारीख के समान ही) है दक्षिण प्रायद्वीप और मध्य तथा समीपवर्ती पश्चिमोत्तर भारत के पश्चिमी भागों में मानसून के आरम्भ की मौजूदा और पुनः निर्धारित तारीखों में महत्वपूर्ण अंतर देखा गया है। पुनः निधारित तारीखें मानसून के आगमन की मौजूदा सामान्य तारीखों की तुलना में क्रमशः 1 से 3 दिन पहले रही और 10 से 15 दिन देर से रही। पुनः निर्धारित सामान्य तारीखों का मानक विचलन 7 से 14 दिनो का रहा जिसमें भारत के पश्चिमोत्तर और पश्चिम मध्य भागों तथा अंदरूनी प्रायद्वीपीय क्षेत्र के मान अधिक रहे।

ABSTRACT. The onset of southwest monsoon over various parts of the country can be early, timely or late as compared to a set of normal dates. Advance of monsoon could be either rapid or slow or sometimes there could be prolonged stagnation in the advance of monsoon. The timing of the monsoon onset is of vital importance to the agricultural sector and water replenishment. The climatological normal dates of onset which are being used at present are based on a much older data set (1901-1940) obtained from 149 stations. In this study, the climatology of the summer monsoon onset over different parts of India is derived using the mean pentad precipitation data of 569 stations spread all over the country, from 1971-2000. It has been observed that the revised dates of onset of monsoon over the Andaman Sea is 20 May, over Kerala is 1 June, over the northeastern parts is 5 June and the date of monsoon covering the entire country is 15 July (same as the existing dates). Considerable differences between the existing and the re-determined dates of onset are noticed over parts of south peninsula and western parts of central and adjoining northwest India where the re-determined dates are advanced by 1 to 3 days and delayed by 10 to 15 days respectively with respect to the existing normal dates of arrival of monsoon. The Standard Deviation of the re-determined normal dates ranges between 7 to 14 days with larger values over the northwest and west central parts and interior peninsular India.

Key words – Monsoon onset, Advance, Normal dates, Pentad rainfall.

1. Introduction

The economy of India has a close and vital link with the rainfall during the southwest monsoon season. The onset and advance of southwest monsoon over the country play a very crucial role during the sowing phase of agriculture. The timely onset of southwest monsoon over Kerala and its northward progress across the country is of vital importance to the agricultural operations all over India as well as for water replenishment and management.

The regularity of southwest monsoon is only in its annual recurrence. But its major features like onset, activity during the season, withdrawal etc., are subject to variations that sometimes are quite large. It is useful for the agriculturists, economists, engineers and the operational meteorologists to know the normal dates of onset and withdrawal of monsoon. Onset/advance of monsoon can be early, timely or can be late as compared to the normal dates. A late onset/advance of monsoon may have devastating effects on agriculture, even if the mean

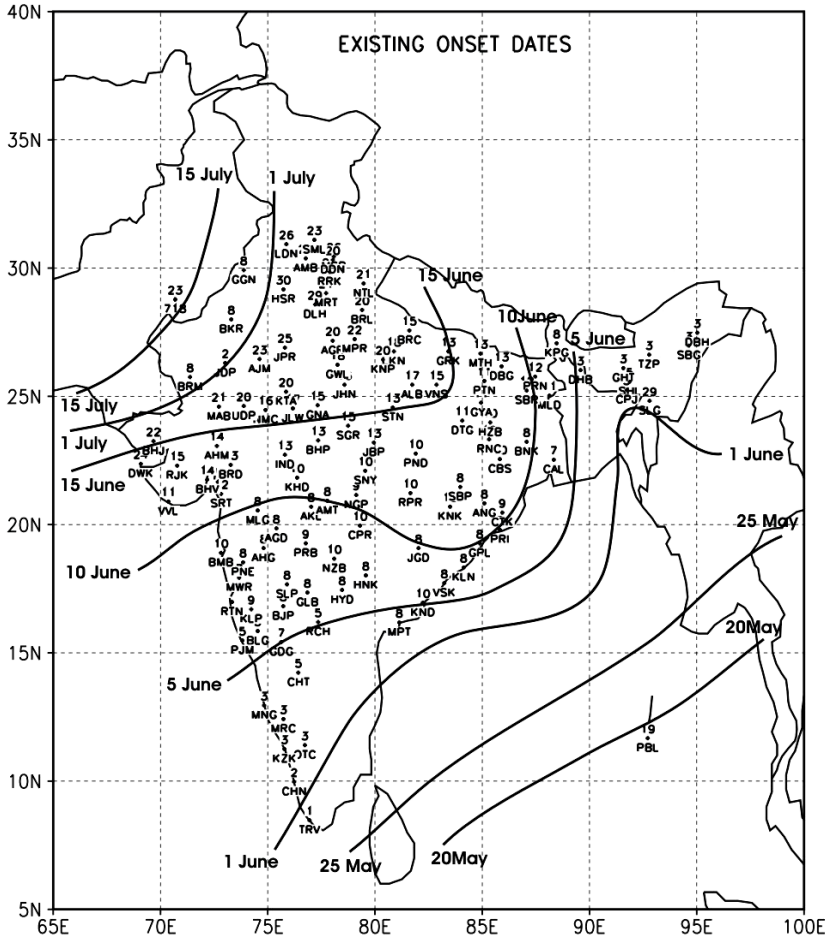

Fig. 1. Existing normal dates (based on rainfall data from 1901 to 1940) and isochrones of onset of southwest monsoon

annual rainfall is normal. It could also result in low levels in hydro-electric reservoirs, with a consequent reduction in the generation of hydro-electricity and the imposition of a power cut on the industry.

Considering the practical importance of the dates of onset and advance of monsoon, the need for a reliable set of climatological dates is essential to act as a base line for defining early or late onset and advance.

The set of normal dates currently existing and is being used by the India Meteorological Department (IMD) on operational basis is shown in Fig. 1. These were determined way back in 1943, based on the rainfall data as available during 1901-1940 (Climatological Atlas for Airmen, 1943). These dates have been derived from the 5-day normal of accumulated rainfall published by the IMD. The diagrams were prepared showing the normal rainfall at each station for successive 5-day periods in the year. The middle date of the 5-day period showing the characteristic rise in monsoon rainfall curve was taken as the date of onset of the monsoon.

A number of studies have been carried out subsequently by various authors including Bhuller (1952); Ramdas *et al*. (1954); Ananthakrishnan *et al*. (1967); Rao (1976); Subbaramayya and Bhanu Kumar (1978); Reddy (1977); Ananthakrishnan & Soman (1988); Chowdhury *et al*. (1990); Mazumdar *et al*. (2001) bringing out features of the onset of monsoon over various parts of the country.

The objective of this study is to re-determine the normal onset dates of southwest monsoon based on more recent rainfall data from a denser network of rain gauge stations. The existing normal onset map is based on the data of 149 stations. Daily rainfall of 569 stations is considered in this study. Thus, by considering a denser network of stations, a well-defined spatial distribution of onset dates could be derived and the latest changes in the

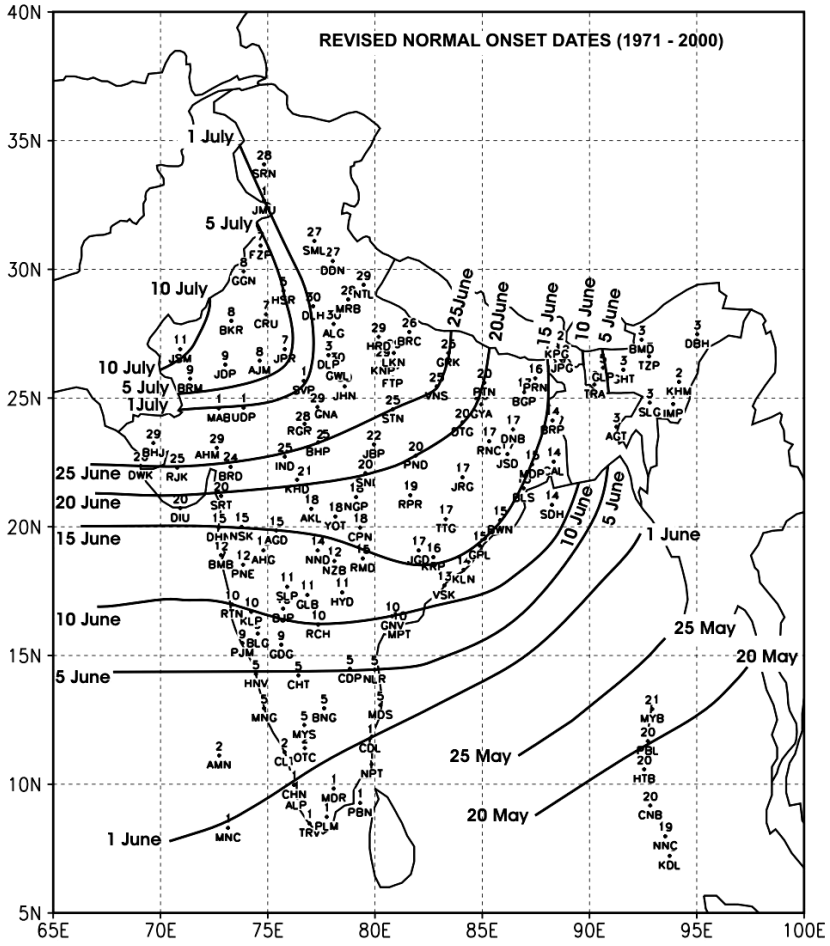

Fig. 2. Re-determined normal dates of onset/advance of southwest monsoon (1971-2000)

monsoon onset dates, if any, could be captured more accurately.

A period of 30 years (1971-2000) has been selected for study in order to bring out climatic signal, if any, in keeping with guidelines provided by the World Meteorological Organisation. The 30 years period of 1971 - 2000 has been considered to examine the change in dates of onset, if any, in the recent period.

2. Data and methodology

The daily rainfall data were collected for 569 stations well distributed across India from the archives of National Data Centre, IMD, Pune for the period 1st May to 31st July from 1971-2000.

The actual onset dates of southwest monsoon over the country are determined by the India Meteorological Department every year on the basis of a thorough meteorological analysis, which include not only a sudden increase in the rainfall but also various other factors, *viz*., satellite derived Outgoing Long wave Radiation (OLR), precipitable water, wind speed and direction, prognosis of the synoptic systems as whether those features are conducive for the sustenance of the rainfall, spatial continuity of the region etc. These dates are re-analysed on a delayed mode with the help of additional rainfall data by the Office of Additional Director General of Meteorology (Research), Pune. These are further vetted by the forum of Annual Monsoon Review, comprising the field forecasters representing various regions as well as other experts in the field. The same are then published in MAUSAM. Station wise average dates of onset are derived from the frequency distribution (Mazumdar *et al*., 2001). The set of onset dates thus obtained, are referred to as 'average actual onset dates' in the present study.

In the present study, the long term rainfall data are examined to determine the date at which a sudden and persistent increase in rainfall sets in. Making use of the

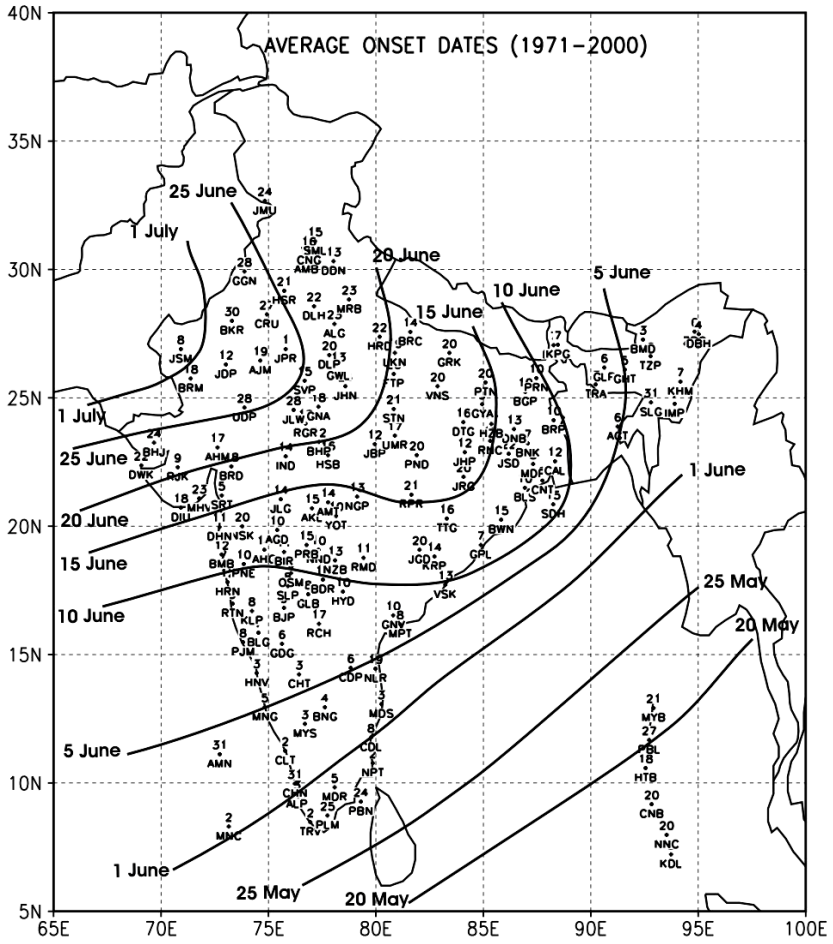

Fig. 3. Average of actual dates of onset/advance of southwest monsoon (1971-2000)

daily rainfall data mentioned above, moving averages of 3 days rainfall, 5 days rainfall and 7 days rainfall were computed. Along with this, the number of continuous rainy days, number of rainy days during each of 3 days, 5 days and 7 days groups were also computed.

A preliminary analysis of the rainfall data indicated that it may not be feasible to prescribe a common methodology which could be applied for every station/ region. Hence, the onset dates of southwest monsoon were picked up from each of the 3 days, 5 days and 7 day moving averages for the period 1971-2000, making use of the following criteria (IMD, 1990).

(a) Middle date of the seven day moving average period is selected as onset day satisfying one of the four conditions, *viz*.,

(*i*) If the two consecutive moving averages are increasing with at least four continuous rainy days in a seven day moving average OR

(*ii*) If the two consecutive moving averages are increasing with at least four rainy days in a seven day moving average OR

If the two consecutive moving averages are not increasing then

(*iii*) If continuous number of rainy days is at least four in a seven day moving average OR

(*iv*) If the number of rainy days are at least four in a seven day moving average.

(b) Middle date of 5 day moving average period is selected as onset day under one of the four criteria, *viz*.,

(*i*) If the two consecutive moving averages are increasing with at least three continuous rainy days in a five day moving average OR

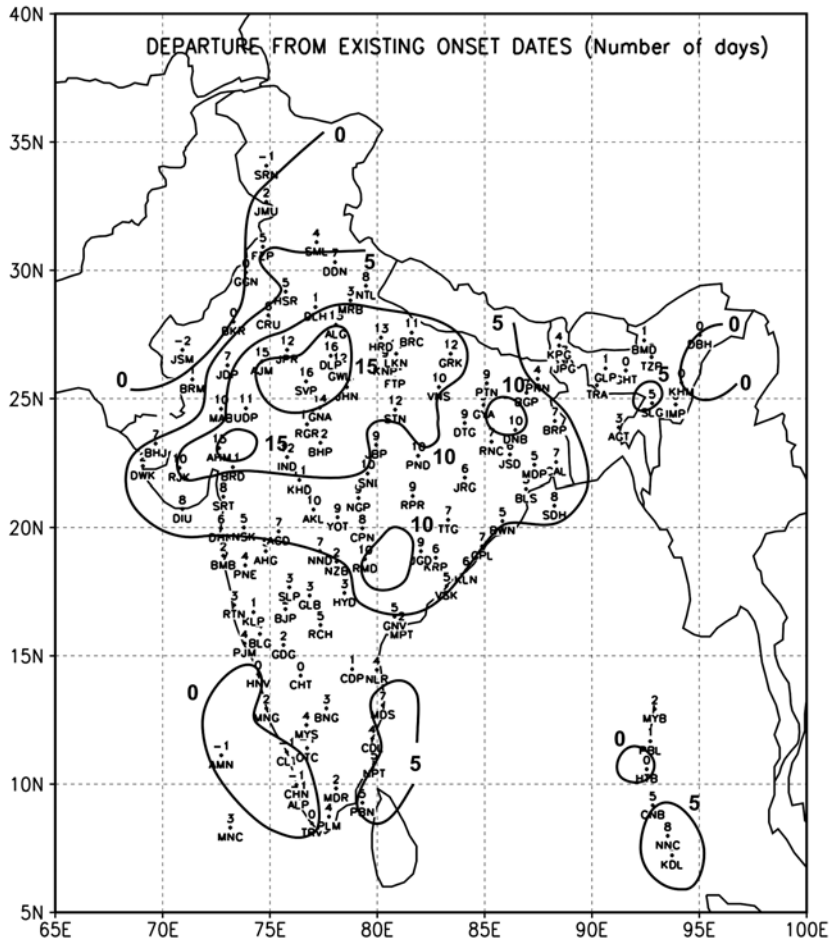

Fig. 4. Departure (number of days) of re-determined onset dates from the existing onset dates (Re-determined-Existing)

(*ii*) If the consecutive moving averages are increasing with at least three rainy days in a five day moving average OR

If the two consecutive moving averages are not increasing then

(*iii*) If three continuous rainy days are there in a five day moving average OR

(*iv*) If the number of rainy days are at least three in a five day moving average.

(c) Middle date of three day moving average period is selected as onset day from one of the following, *viz*.,

(*i*) If the two consecutive moving averages are increasing with at least two continuous rainy days in a three day moving average OR

(*ii*) If the two consecutive moving averages are increasing with at least two rainy days in a three day moving average OR

If the two consecutive moving averages are not increasing then

(*iii*) If there are at least two continuous rainy days in a three day moving average OR

(*iv*) If at least two rainy days are present in a three day moving average period

The above analysis was carried out using a systematically formulated objective method. Thus a set of tentative onset dates are determined.

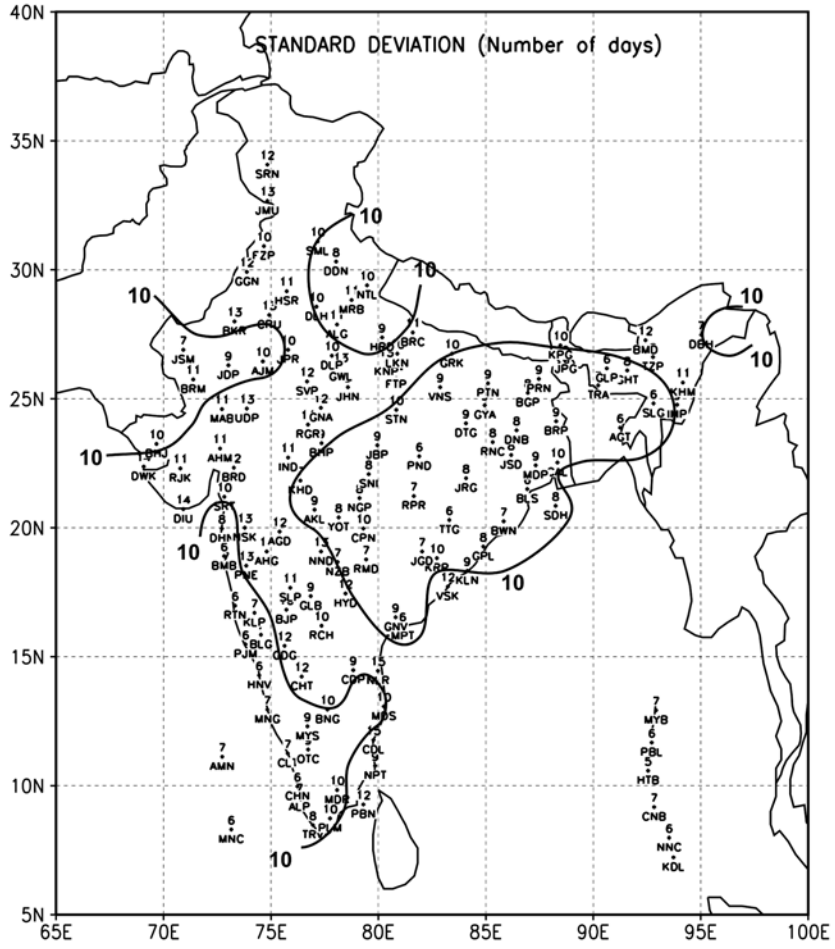

Fig. 5. Standard deviation (number of days) of the re-determined onset dates

3. Results and discussion

The mean onset dates along with their standard deviations and deviations from the normal dates are calculated. Since there was no large difference noticed between the results obtained from the 3 day, 5 day and 7 day moving averages, only the results of 5-day analysis are presented in this study for brevity. One more reason for selecting the 5-day moving average is that the methodology followed will be in conformity with that of the existing normal (Fig. 1).

Fig. 2 depicts the map of re-determined normal dates of onset/advance of southwest monsoon. Fig. 3 shows the average actual onset dates for the period 1971-2000. (Mazumdar *et al*., 2001). Fig. 4 shows the difference of re-determined and existing dates and Fig. 5 depicts the standard deviation of onset dates. Table 1 summarizes the dates of onset of southwest monsoon over some of the major cities as per the 3 different sets of values.

There is no major change noticed in the date of arrival of monsoon current over the Andaman Sea and also in the date of its setting in over the southern tip of the mainland. A recent study (Htway & Matsumoto, 2010) making use of the mean pentad data of 29 stations from 1968 to 2000 shows the climatological summer monsoon onset over the southern and central Myanmar as 18 May. This is in agreement with the presently determined onset date over the Andaman Sea. Major parts of northeast India are covered by 5 June, central and east central parts by 25 June, the northwestern parts and thus the entire country by 15 July.

Areas where major changes observed are parts of south Peninsula, western parts of central India and adjoining northwest India. Over the south Peninsula the re-determined dates are advanced and adjoining northwest India the redetermined dates show a delayed advance by 8 to 10 by 1 to 3 days and over the western parts of central and days when compared to the existing normal dates.

TABLE 1

Dates of onset of southwest monsoon over some major cities

S. No.	Station name	Southwest monsoon onset dates			Difference (No. of days)	
		Re-determined	Existing	Average of actual (1971-2000)	(Re-determined-Average actual)	(Re-determined-Existing)
1	Thiruvananthapuram	1 June	1 June	2 June	-1	0
2	Kochi	1 June	2 June	31 May	+1	-1
3	Imphal	1 June	1 June	7 June	-6	0
4	Bangalore	5 June	2 June	4 June	+1	+3
5	Chennai	5 June	29 May	3 June	+2	+7
6	Guwahati	3 June	3 June	5 June	-2	0
7	Agartala	3 June	31 May	6 June	-3	+3
8	Panjim	9 June	5 June	8 June	+1	+4
9	Hyderabad	11 June	8 June	10 June	+1	+3
10	Mumbai	12 June	10 June	12 June	0	+2
11	Pune	12 June	8 June	10 June	+2	+4
12	Visakhapatnam	13 June	8 June	13 June	0	+5
13	Bhubaneshwar	15 June	10 June	15 June	0	+5
14	Kolkata	14 June	7 June	12 June	+2	+7
15	Kalimpong	12 June	8 June	7 June	+5	+4
16	Akola	18 June	8 June	15 June	+3	+10
17	Nagpur	18 June	9 June	13 June	+5	+9
18	Raipur	19 June	10 June	21 June	-2	+9
19	Jamshedpur	17 June	11 June	22 June	-5	+6
20	Ranchi	17 June	10 June	18 June	-1	+7
21	Gaya	20 June	11 June	9 June	+11	+9
22	Patna	20 June	11 June	20 June	0	+9
23	Bhopal	25 June	13 June	12 June	+13	+12
24	Jabalpur	22 June	13 June	12 June	+10	+9
25	Varanasi	25 June	15 June	20 June	+5	+10
26	Gorakhpur	25 June	13 June	20 June	+5	+12
27	Ahmedabad	29 June	14 June	17 June	+12	+15
28	Jhansi	30 June	16 June	24 June	+6	+14
29	Kanpur	29 June	20 June	20 June	+9	+9
30	Lucknow	29 June	18 June	19 June	+10	+11
31	Nainital	29 June	21 June	23 June	+6	+8
32	Dehra Dun	27 June	20 June	13 June	+14	+7
33	Simla	27 June	23 June	15 June	+12	+4
34	New Delhi	30 June	29 June	22 June	+8	+1
35	Chandigarh	30 June	30 June	16 June	+14	0
36	Srinagar	28 June	29 June	24 June	+4	-1
37	Jammu	1 July	29 June	24 June	+7	+2
38	Gwalior	30 June	18 June	13 June	+17	+12
39	Mussoorie	5 July	26 June	24 June	+11	+9
40	Jaipur	7 July	25 June	1 July	+6	+12
41	Sriganganagar	8 July	8 July	28 June	+10	0
42	Bikaner	8 July	8 July	30 June	+8	0
43	Jaisalmer	11 July	13 July	8 July	+3	-2

There is not a remarkable difference in the dates of onset of monsoon over Kerala, whereas there are large differences [of the order of 10-15 days] over central and parts of north-west India. The delay in the arrival of monsoon over these regions could be attributed to hiatus in advance of monsoon and often these regions not receiving rainfall from the monsoon spell causing onset over Kerala.

The onset of Monsoon over Kerala is a much watched phenomenon among all sectors of society, as it signifies the entry of the monsoon over the main land of India. Every year, the planning of various operations related to agriculture, water resources management and economy, in general, is based on a large extent on the existing date of onset of monsoon over Kerala and its further advance over various parts of the country. In the light of the fact that, there is a marginal difference in the re-determined dates of onset of monsoon over Kerala but a substantial difference over central and parts of north west India, it becomes all more essential to adopt the re-determined dates of onset of monsoon, in order that planning based on the same yields fruitful results for various activities.

Examination of the differences in the re-determined and the actual onset dates over major cities (Table 1) shows large positive values over many cities of north and central India. This could be due to the fact that the actual dates are determined based on rainfall and other meteorological conditions, like, circulation features, OLR, continuity of the advance, etc. whereas the re-determined dates are based on only rainfall data. And often actual onset dates over these places are determined with shorter rain spells but these spells are associated with other favourable meteorological conditions.

The Standard Deviation of the re-determined normal dates ranges between 7 to 14 days with larger values noticed over the northwest and west central parts and interior peninsular India.

4. Conclusion

A detailed analysis of the normal onset dates (1971-2000) reveals that in some regions, more than a week's difference exists in the present scenario when compared to the existing normal. A consistent change is noticed in the onset dates over the central parts of the country. As a systematic change of more than one standard deviation (7 days) was noticed in the present day onset dates and also since the revised dates are based on a denser data set and thereby resulting in closer isochrones, it is suggested to adopt the revised onset map presented in this study. Also it is proposed that such a revision need to be carried out periodically, henceforth, as is being done for the rainfall and other meteorological elements.

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