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Monsoon Definitions*

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ABSTRACT. While mariners have, for long, associated monsoon with winds, description of monsoonal circulations over land has invariably been designed to explain primarily their rainfall effects. A rainfall oriented definition of monsoon has several limitations. An attempt has been made in this presentation to define monsoon by some consistent low level circulation feature which will have universal application, irrespective of place and time.

1. Introduction

The term 'Monsoon' implies a steady wind, over a length of time, characterised by its regularity and constancy and caused by differential heating between continental areas and oceans, as a result of the zenithal march of the sun. It is a modification of the Arabic word 'mawsim' and according to Hobson-Jobson it is "the name given to the periodical winds of the Indian Seas and of the seasons which they affect and characterise".

The relative heating of land areas in summer and corresponding cooling in winter result in an almost complete reversal in the prevailing wind flow in the lower atmosphere. However, in the near equatorial regions, such seasonal changes occur twice annually owing to the double traversal of the thermal equator over these areas. Seasonal changes of wind of a semi-permanent nature and occurring on a large scale are possible only where comparatively intense gradients of temperature occur as a result of differential heating caused by the march of the sun. The monsoons are, therefore, most conspicuous in the tropical and equatorial regions of Africa and south Asia. The monsoon currents associated with other continental masses are less well developed although seasonal wind changes occur in north Australia, the southern United States and possibly in South America. Of the above monsoon regimes, the Asiatic Summer Monsoon (the Indian Southwest Monsoon and the Burma Monsoon) has been best known, probably owing to the rainfall associated with it. As Simpson (1921) remarked in India, when we speak of 'the monsoon' we have almost invariably meant the rain which falls during the period June to September. On the other hand, the mariners normally associated the monsoon with winds.

2. Present concepts and their limitations

The association of monsoon with rainfall has led to practical difficulties, since the rainfall effect over land is not always synchronous with changes in circulation in the lower troposphere. So far, available definitions and descriptions of monsoonal circulations over land have been designed to explain primarily their rainfall effects. Terms such as 'onset', 'withdrawal', 'pulsation of monsoon rainfall' etc have come to be frequently used as a result of a rainfall oriented definition of monsoon. Meteorologists assembled here are well aware of the limitations of these concepts. It has, therefore, become necessary to define monsoon not by the rainfall effect on land but by some consistent circulation feature, which will have universal application, irrespective of place and time. Since differential heating between land and sea is most pronounced in the lower layers of the atmosphere, it seems

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rational to evolve a monsoon definition in terms of low level circulation features. The exclusion, from the scope of monsoon definition, of wind circulations in the upper troposphere and further aloft would enable the problem to be tackled in a simple and practical way so as to be useful in day-to-day work.

3. Parameter used and its application

Of all parameters that go to describe low level monsoon circulation, wind flow and its steadiness appear fundamental. Wind at 1·5 km (which is above the frictional layer), if its direction remains constant for at least five days, could be regarded as representing a seasonal condition. A study was made of variation of 1·5 km wind at 15 stations in India along 78°E during two representative years 1956 and 1959. The study revealed that at the southernmost station, Colombo, wind direction changed to west by mid-April or early May and thereafter continued west. Similar changes took place progressively in time and space at more northern latitudes up to about 23°N. In the region of the summer heat trough, the variability of wind direction was high and persistence small. Again, to the north of the seasonal trough, winds were steady.

The broad inference that one draws from the above study is that the heat low first appears at the extreme south of the Indian Peninsula and thereafter gradually shifts northwards, with the march of the sun, to stabilise itself along the Indo-Gangetic Plain. While the progression northward of the heat low is manifested by a persistent westerly wind along 78°E, it should be expected that the changes along the west and east coasts of India will display a transitional phase before stabilising as westerlies in response to the established heat low referred to above. Such transition will be most marked over those land areas where the thermal equator traverses twice annually with a sufficient time interval between the two traverses. Until such time as the appropriate 'monsoon' direction (*i.e.*, direction of wind in response to the stabilised heat low) is established south of the peripheral continental low, it appears reasonable to designate the circulation over Peninsular India as a 'transition period' or 'spring monsoon'. Similar circulation characteristics obtain in the corresponding latitudinal belts over Africa, Thailand and China. The circulation over India as a whole when the heat low stabilises itself at its *northernmost position* may well be termed the 'summer monsoon'.

Analysis of Indian Ocean charts in IMC during this year showed two features. The transition period heat trough over the Indian Peninsula had embedded vortices in it. Secondly when the heat trough stabilised itself in its summer position, a number of vortices were embedded in it, from Somalia in the west to the Philippines in the east, with the trough line running through the Gulf of Oman, West Pakistan, the Indo-Gangetic Plain, Upper Burma and Thailand.

It is also expected that other parameters, say march of maximum temperature northwards may give indications of the northward shift of the heat low.

As an illustration of the application of the above 'monsoon' definition, variation of 1·5 km wind along 78°E during May-June 1956 is shown in Fig. 1. It will be seen that westerlies establish themselves south of 7°N by mid-May and extend progressively to 22°N by the first week of June. However, it is not before the commencement of the third week of June that the circulation stabilises itself in response to the heat low over north India and westerlies extend to the northernmost latitude. Perhaps, it would be appropriate to designate the circulation after say 16 June as the "genuine summer monsoon circulation". The circulation south of the demarcation line from 1 May to 15 June may be appropriately termed 'spring monsoon'. The circulation to the north of this demarcation line would represent a winter/transition period. An approach somewhat on the above lines, will avoid difficulties in monsoon descriptions on occasions when the first advance of 'monsoon rains' (associated with tropical storms) is not maintained, especially

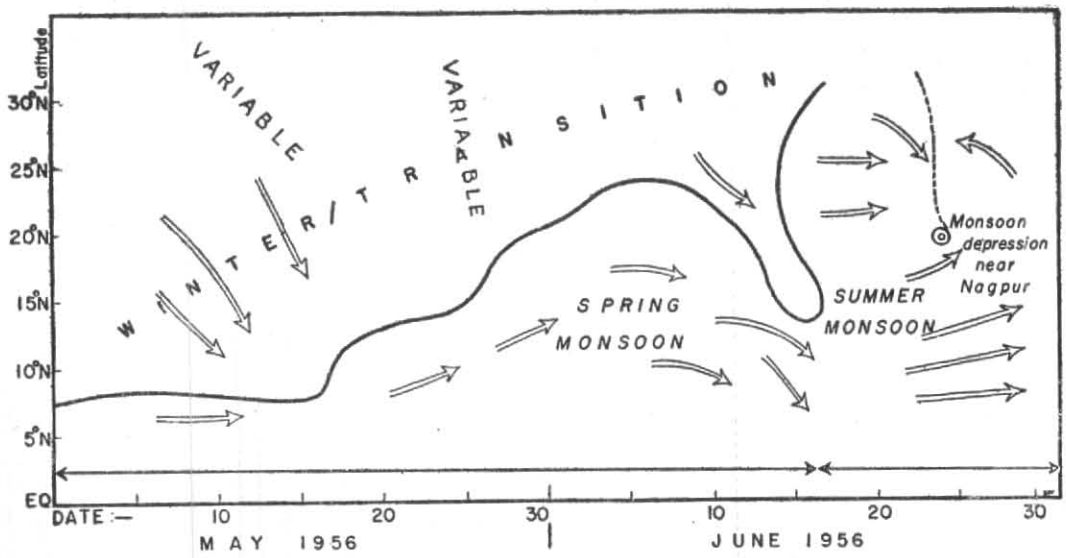

Fig. 1. Schematic illustration of 5000 ft wind flow in May-June 1956 over India

in May/June, when we have temporarily to 'withdraw' the monsoon.

4. Implications of definition and further extension

The two basic implications of this definition are (*i*) that the circulation feature is separated from the rainfall effect; (*ii*) 'monsoon' does not 'withdraw' once it establishes itself until reversal takes place with the southward march of the seasonal low.

It is proposed to extend the above study to other regions in Africa and south Asia where monsoon regimes prevail and also to study the rainfall distribution within the framework of this definition.

REFERENCE

Simpson, G. C. 1921 *Quart. J.R. met. Soc.*, **47**, pp. 151-172.

Discussion

RAMAGE (C. S.): I think it has been obvious today and it is obvious every time we have a map discussion at IMC that the monsoon is a very personal phenomenon. Everyone has his own definition, and although this is fine, it does tend to cause confusion. For the past few weeks four of us have looked for a possible monsoon definition which will apply not only to India, and not only to the summer in India, but more generally.

DESAI (B. N.): I think the way in which Mr. Raman has tried to explain the monsoons is very interesting. But what I personally feel is that it might be unwise to accept what satisfies the technical man. As far as the general public is concerned and the layman is concerned, there is an age old tradition associated with monsoons. And I don't know whether even the

Government has considered the monsoon as different from the standpoint of rainfall. The prosperity of the country depends upon the rains which we get, because 90 per cent of the population is agricultural. I wonder if this is a sound approach for the average man in the street; in fact it will make the task of the forecaster fairly easy. He will avoid associating precipitation and rain when talking of monsoon weather and he could say that he meant wind! But the man in the street associates with a heavy monsoon, a downpour in the region where you say the monsoon has been vigorous. So I don't know whether at the present stage of our knowledge of the monsoon when we do not know much about the monsoon, we should go after defining what the monsoon should be. I think this should be left to a stage where we know many conditions which govern the monsoon current and then think of a definition.

RAMAGE : I suppose it is all right if the scientists remain confused; this seems to be the real problem!

PISHAROTY (P. R.) : We have Elliot's hand book of cyclonic storms. This was my initial text book and it started my career. He has maintained that as far as the establishment of the monsoon is concerned, it did not become established over Port Blair before June 15. So while we have all of the dates of the monsoon represented by rainfall criteria, he has made a remark that before that it should be called a "chotta monsoon" and the monsoon normally establishes itself over Port Blair only on the 15th of June.