

## RELATIONSHIPS BETWEEN INDIAN SUMMER MONSOON RAINFALL AND ICE COVER OVER SELECTED OCEANIC REGIONS

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### ABSTRACT

The variations in oceanic ice cover at selected polar regions during 1973 to 1987 have been analysed in relation to the seasonal Indian summer monsoon rainfall. The ice cover over the Arctic regions in June has negative relationship (correlation coefficient  $-0.53$ , significant at 5% level) with the Indian rainfall from June to September. Ice cover over the Barents Sea during January to June shows a negative relationship with the Indian rainfall, the correlation coefficient remaining above 0.5 throughout the period. Ice covers over two sectors of the Antarctic region in February have positive relationships with the subsequent Indian rainfall.

### INTRODUCTION

The global scale interaction of the Indian summer monsoon was understood by Walker (1924) who examined the relationships of Indian rainfall with several parameters, some of them observed at places far away from India, found significant correlation between some of the parameters and the Indian rainfall. Ramaswamy (1962) pointed out that both the northern and southern hemisphere circulations influence the summer monsoon circulation over India. Several investigators (Day and Bhanukumar, 1982; Hahn and Shukla, 1976 and Dickson, 1984) have observed that snow covers over the Himalayas and Eurasia have significant relationships with the Indian rainfall. Ramage (1971) suggested a possible relationship between ice cover of Sea of Okhotsk and Indian rainfall. Shukla (1987) pointed out the evidence of slowly varying boundary conditions such as sea surface temperature, soil moisture, snow cover and sea ice influencing the variability of the atmospheric parameters in the tropics.

The relationships between the oceanic ice cover over various Arctic and Antarctic regions and the Indian rainfall have not been investigated earlier. The results of such a study are presented in this paper.

### DATA AND METHODS

The sea ice which occurs at high latitudes, mostly close to the frozen watermass or enclosed bays, during the winter season of the hemisphere (Doronin and Kheisin, 1977). The data on sea ice cover were difficult to obtain till the advent of the remote sensing satellites. The data on satellite derived monthly ice cover over 6 Arctic and 6 Antarctic regions were obtained from the Climate Analysis Center, USA. The

details of the data processing and also space-time variability are given by Ropelewski (1983, 1985). The Indian summer monsoon rainfall data for the season were computed from the sub-divisional rainfall data obtained from India Meteorological Department. The data set covers the years from 1973 to 1987.

## RESULTS AND DISCUSSION

The total ice cover over the Arctic region in June has a negative relationship with the Indian rainfall. The computed correlation coefficient between them is  $-0.53$  and is significant at 5% level. However, no such relationship is observed between Indian rainfall and Antarctic ice cover as a whole.

The ice cover over a few regions of both Arctic and Antarctic in certain months has a significant correlation with the Indian rainfall. These are the Barents Sea between  $20^{\circ}\text{E}$  and  $60^{\circ}\text{E}$  longitudes in the Arctic, Indian Ocean Basin between  $20^{\circ}\text{E}$  and  $70^{\circ}\text{E}$  and South East Pacific Ocean between  $80^{\circ}\text{W}$  and  $130^{\circ}\text{W}$  both in the Antarctica. The ice cover of two regions of the Antarctic during the month of February is found to be related to the succeeding Indian rainfall.

The relationship between Indian Ocean ice cover and the Indian rainfall is less significant than in the relationship obtained between Indian rainfall and the south east Pacific Ocean ice cover. The correlation coefficient in the former case is  $+0.52$  (significant at 5% level) and in the latter case  $+0.68$  (significant at 1% level). These regions roughly represent the oceanic area in the Indian Ocean connecting the Atlantic and Pacific oceans, the region of heat exchange between the south Atlantic Ocean with the other oceans. The more ice cover in these regions in southern summer may indicate cooler than normal surface temperature resulting from less heat transport into the area during the previous season.

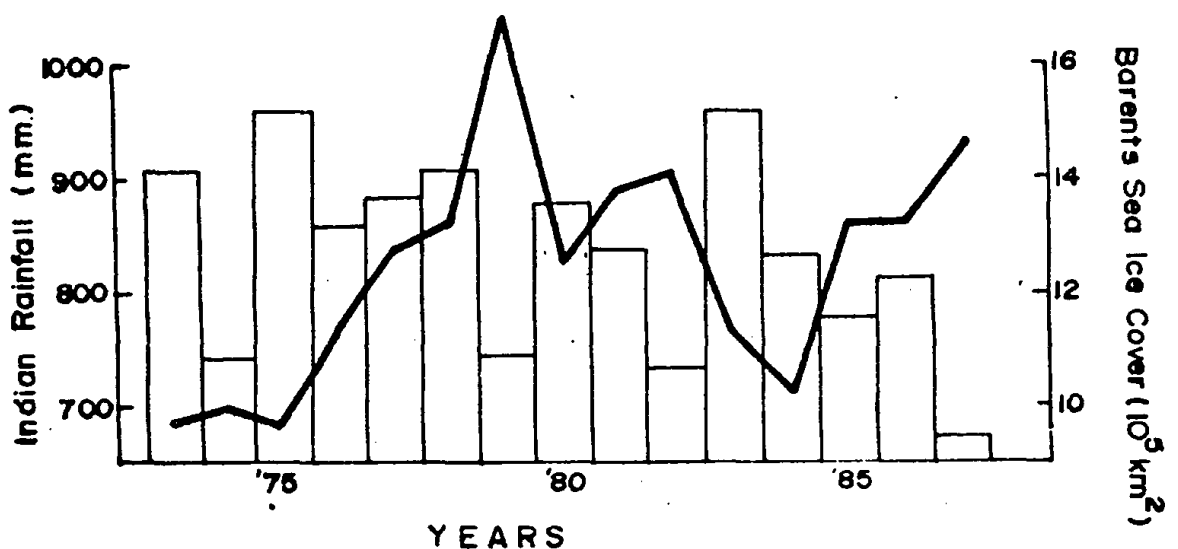


Fig. 1. The variations in the mean ice cover over Barents Sea from January to May and the Indian summer monsoon rainfall during 1973 - 1987.

The most important and persistent relationship is found between ice cover over the Barents Sea and Indian rainfall. The correlation between monthly ice cover and the Indian rainfall is significant at 5% level throughout the period from January through June, though consistently negative relationship is observed throughout the period from January to October. An interesting, but less important positive relationship exists between the Indian rainfall and the ice cover over the Beaufort Sea, an area just on the opposite side of the Barents Sea in the same hemisphere. The Beaufort Sea is between 120°-160°W longitudes in the Pacific Ocean.

It may be noted that Barents Sea area represents the heat sink region of the north Atlantic Ocean. Less ice cover in the region means a warmer sea due to more heat transport to the north polar regions of Atlantic Ocean during the previous season. The negative relationship obtained between the ice cover and the Indian rainfall is also applicable to the adjoining Greater Greenland Sea in the north Atlantic Ocean. The ice cover in these areas together in June has a correlation coefficient of  $-0.61$  with the Indian rainfall. It is significant at 1% level.

The relationship between the monthly mean ice cover over the Barents Sea between January and May and the Indian summer monsoon rainfall is shown in Fig 1. The negative relationship is seen especially after 1978. The correlation coefficient between the parameters for the 15 years is  $-0.60$ , but for the 11 years after 1978, is  $-0.75$ .

## CONCLUSIONS

The ice covers over the south Indian Ocean basin and south east Pacific Ocean of the Antarctic region in February have significant positive relationships with the Indian rainfall.

The ice cover over the Barents Sea and the Greater Greenland Sea in the Arctic region from January to June is negatively related to the Indian rainfall. The mean ice cover over the Barents Sea between January to May has a correlation coefficient of  $-0.6$  with the Indian rainfall.

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