An Apparent Relationship between Eurasian Snow Cover and Indian Monsoon Rainfall

DOUGLAS G. HAHN

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, N.J. 08540

J. SHUKLA

Geophysical Fluid Dynamics Program, Princeton University, Princeton, N.J. 08540

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ABSTRACT

A short record of year-to-year variations of summer monsoon rainfall over India is compared with that of winter snow cover over Eurasia as derived from satellite data. An inverse relationship between these two quantities is indicated, i.e., winters with extensive (little) snow cover over Eurasia tend to be followed by summers with less (more) rainfall over India.

In a simulation study of the South Asian monsoon circulation Hahn and Manabe reported (1975, 1976) that some aspects of the monsoon simulation differed substantially from one model year to the next. One interesting difference is that Indian monsoon rainfall was substantially less during the last summer of model integration. At first, this was somewhat surprising, since the external forcing for their global model of the atmosphere remained essentially unchanged during the 2-year integration. Additional analysis of the model results also revealed that surface temperatures were lower over Eurasia and snow cover was more extensive over Eurasia during the last model winter. From these numerical results, it was thought that the amount of Indian summertime rainfall may be related to, and negatively correlated with, the extent of Eurasian snow cover during the previous winter season. A similar idea was earlier developed in two observational studies by Blandford and Walker (Walker, 1910), which suggested a tendency for negative correlation between summertime rainfall over India and winter snow accumulations in the mountains to the northwest of India. Both of these ideas are not inconsistent with paleoclimatological evidence which indicates that colder periods, with more snow and ice, are characterized by reduced monsoon rainfall (Bryson, 1975).

The studies of Blandford and Walker used localized

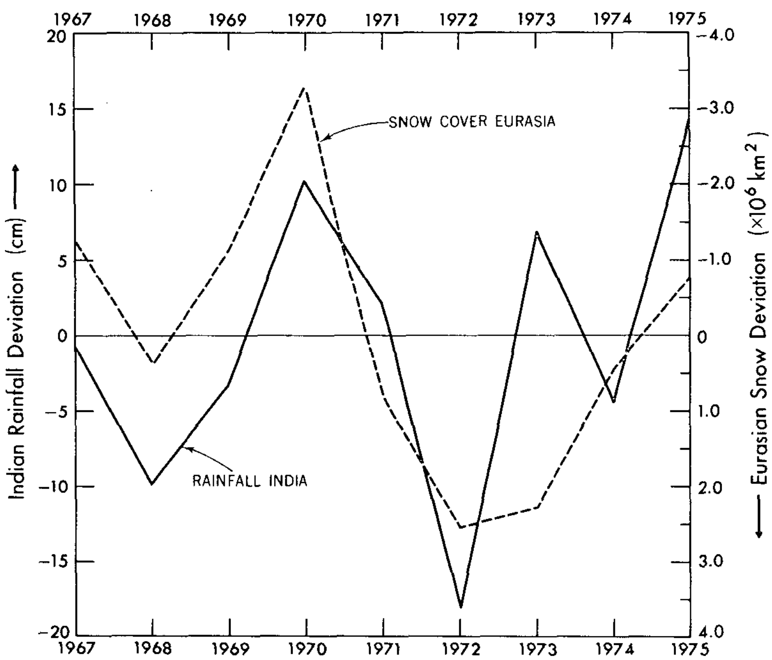

FIG. 1. Graphs of year-to-year variation of winter snow cover departure over Eurasia south of 52°N, and the corresponding variation of summertime area mean rainfall departure for India.

snow measurements and qualitative reports on the intensity and extent of snowfall. Since their studies in the late 1800's and early 1900's, the quality and extent of wintertime snow cover estimates have been substantially upgraded. This observational study, which is an update of their earlier work, uses estimates of winter snow cover by Wiesnet and Matson (1975) as derived from photo interpretation of satellite imagery. According to Wiesnet and Matson, "this satellite record of the past 9 years is the most complete record of hemispheric snow cover available." The rainfall data used in this study is obtained from the Indian Meteorological Department.

Fig. 1 shows the year-to-year variations in winter snow cover departure for Eurasia south of 52°N. The snow cover departure for each year is obtained by averaging the December, January, February and March deviations from their 9-year means. Along with these winter snow cover departures, Indian summertime rainfall departure is also plotted as a function of year. For each year, Indian rainfall departure is the area-weighted mean of all Indian meteorological subdivisions' (except Bay Island and Arabian Sea Islands) departure from mean precipitation for the months of June, July, August and September. For 7 out of 8 cases, the year-to-year tendency in Eurasian snow cover is opposite to that of Indian monsoon rainfall, i.e., except for the year 1973, winter snow cover estimates over Eurasia appear to be negatively correlated with the amount of rainfall over India during the following summer season.

The distribution of Indian monsoon rainfall is not very uniform. Therefore, a correlation coefficient between Eurasian winter snow cover and the summertime rainfall anomaly of each meteorological subdivision of India was computed. Although the values of the individual correlation coefficients were mostly negative, the largest negative correlations found were for 10 subdivisions lying between 13° and 22°N (Vidarbha, Saurashtra and Kutch, Konkan, Madhya Maharashtra, Marathwada, Coastal Andhra Pradesh, Telangana, Rayalaseema, Coastal Mysore and North Interior Mysore). Monsoon depression tracks and the monsoon trough tend to lie north of this region.

The time series presented here are very short. It is quite possible that the negative correlation will not be preserved in a much longer record. Nevertheless, it is hoped that this note will encourage continued monitoring of snow cover and stimulate further investigations of the various snow cover feedback mechanisms.

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