The Diurnal Variation of Precipitation Frequency over Weather Ship M

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ABSTRACT

The diurnal precipitation variation over northerly oceans is studied with the aid of the 3-hr synoptic observations from Weather Ship M at 66N, 02E during the 20-year period 1949–68. The precipitation frequencies possess a maximum in the morning during the whole year and a pronounced daytime minimum during the months March–September. The remaining months have a less pronounced diurnal variation and during September–April there is usually also an evening maximum. January and February even indicate a night minimum of precipitation frequency.

1. Introduction

The classic diurnal variation of precipitation thought to prevail over the seas is characterized by a night maximum. Due to the difficulties of getting representative observations, the evidence is scarce. Most avaliable observations originate either from small islands close to coasts which probably are affected by land and sea breeze circulations or from oceanic islands that due to their sizes themselves affect the precipitation conditions. Utilizing observations from weather ships, Kraus (1963) showed that maritime precipitation is significantly more frequent at night over middle latitude oceans during the warmer months. During winter the diurnal variation is less pronounced and the possibility of a slight daytime excess cannot be excluded. The most northerly ship used by Kraus was I at 59N, 19W. An investigation of the diurnal precipitation variation over Sweden (Andersson, 1969) showed a pronounced daytime maximum of precipitation amounts during winter over the northern Swedish mountains, which are situated close to the Atlantic.

The observations from M, which were not included in Kraus' study, permit an investigation of the diurnal variation of precipitation frequency over the northeastern Altantic.

2. Results and discussion

The frequencies of precipitation observations show an annual variation with a maximum during the winter. This winter maximum is especially pronounced for convective precipitation as shown in Table 1.

The diurnal march of the total precipitation frequencies is characterized by a maximum between 0300 and 0900 (local time) during all months (Fig. 1), usually including convective precipitation as well. During April–November the total frequencies possess a minimum between 1200 and 1800, and the daily variation is similar to that described by Kraus. The patterns during the period from September–March are more complicated since these months also show a maximum in the evening or early night. During January the evening maximum is even more pronounced than the morning one. Therefore, we cannot exclude the possibility of a semi-diurnal precipitation variation during the colder months. It is interesting to note that Brier and Simpson (1969) have found a semi-diurnal variation of precipitation and cloudiness over tropical oceans. They ascribed this phenomenon to the semi-diurnal solar tide. Even if this explanation holds in the tropics, it is probably not valid at M where the semi-diurnal solar tide is much weaker.

According to Kraus, evaporation from the tops of thin layer clouds due to solar heating reduces the rainfall likelihood during the day. This factor, in connection with increased condensation rates during the night caused by cooling of cloud tops through longwave radiation transfer, was considered responsible for the night precipitation maximum. These diurnal changes of condensation rates are negligible, however, for convective clouds due to the high condensation rates in the adia-

Table 1. Average number of precipitation observations as a percentage of the total number of observation at Weather Ship M for the period 1949–68.

	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
All types of precipitation	31	31	30	27	22	21	20	22	22	25	26	30
Convective precipitation only	18	18	15	13	10	8	7	9	7	11	11	16

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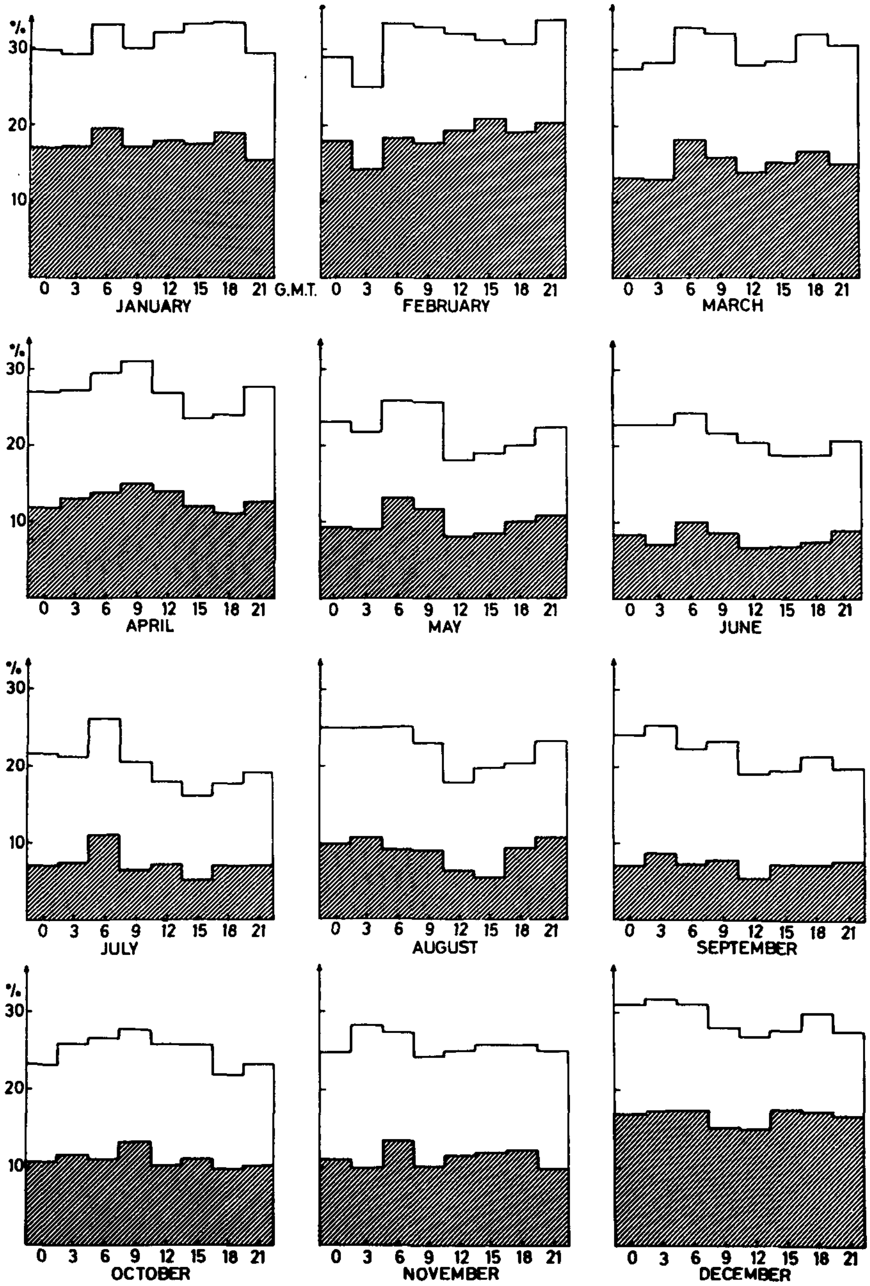

FIG. 1. Frequencies of precipitation observations at Weather Ship M (66N, 02E) for the period 1949–68. Hatched areas give the frequencies of convective precipitation.

batically rising air forming the clouds. Therefore, the process suggested by Kraus should be most effective during summer when the convective activity is at a minimum. This is confirmed by the observations. At M, however, the morning maximum also appears during winter when the sun barely reaches above the horizon, giving rise to very small diurnal changes in condensation rates caused by radiative transfer; at the same time the convective activity is at a maximum. It is also remarkable that at M, as well as at the weather ships studied by Kraus, the morning maximum appears at approximately the same hour of the day during all the warmer months. If solely caused by the processes suggested by Kraus, it ought to appear earlier during the midsummer months since sunrise is earlier then.

Although the process suggested by Kraus seems to be a very likely one, it is perhaps only one link in a very complicated mechanism. In fact Kraus himself noted that during winter the diurnal variation of precipitation is different from that during the summer even where

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radiative conditions also have a pronounced daily variation during winter.

Observations from Sweden (Andersson, 1969) show that over the northwestern Swedish mountains there is a pronounced daytime maximum of precipitation amounts during winter. Also over the northern mainland a higher percentage of the winter precipitation amounts falls during the daytime than over southern and middle Sweden.

The processes discussed here cannot explain the diurnal variation of precipitation over northerly latitudes or over the seas during winter. Admittedly, the data are fairly sparce, but they show a puzzling diurnal variation of winter precipitation.

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