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A case study of the variations in the upper ocean at Ocean Weather Ship Mike (66° N, 2° E) in the Norwegian Sea

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This paper investigates how short period variations in the upper ocean structure relates to meteorological changes. The one-dimensional, mixed layer model of Denman has been tested since it requires only routine ocean weather ship observations and no current measurements as input. Agreement between observations and model simulations is obtained on a weekly time scale. Rapid fluctuations (daily) in the depth and temperature of the mixed layer are observed but not successfully modelled. It is suggested that these rapid fluctuations are associated with frontal dynamics such as formations of meanders and eddies.

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1. INTRODUCTION

Since 1948 regular oceanographic observations have been carried out at Ocean Weather Ship (OWS) Mike (66° N, 2° E) in the Norwegian Sea. During these years an appreciable amount of data has been collected. These data have formed studies of the deep water and the Atlantic water in the Norwegian Sea such as by Mosby (1959, 1979). Furthermore, studies of the seasonal variations in the upper layer at OWS Mike from 1948–1958 have been carried out by Helland (1963), while Bøyum (1966) has studied the annual variations in the energy exchange across the air–sea interface over the same period. Recently Gammelsrød & Holm (1983) have looked for possible influence of advection on the upper ocean structure as opposed to atmospheric forcing over a period of nearly 30 years.

Few studies, however, exist which emphasize synoptic variations in the upper ocean structure in this region. This paper briefly describes the regional background in Sect. 2 and presents mean seasonal variations in the upper ocean structure based on 9 years of data from 1967 to 1975 in Sect. 3. The development of the mixed layer depth and temperature as derived from bathythermograms is examined during the 17 day period 5–22 March 1967 in Sect. 4. This period was selected because of frequent passages of cyclonic storms in the region, and also because the atmosphere gained heat from the sea. The observed behaviour of mixed layer is then simulated by using Denman's (1973) one-dimensional model in Sect. 5.

This model only requires standard marine meteorological parameters as input data. The model prediction of the mixed layer behaviour is compared with observed layer depths and temperatures, and areas of discrepancies are discussed in Sect. 6.

2. REGIONAL BACKGROUND

OWS Mike is located at 66° N, 2° E in the Norwegian Sea. This is in the western boundary region of the Norwegian Atlantic Current (N.A.C.) (Fig. 1). Colder water of Arctic origin is found to the west. The Atlantic water is confined to the upper 400 m at OWS Mike. According to Mosby (1970), the mean speed of the N.A.C. at OWS Mike is 0.03 m/s in a northward direction. Mosby also estimated the average temperature gradient in the Norwegian Sea to be 0.4° per degree latitude. The temperature change to be expected from advective effects would therefore be about 0.10° C in 10 days.

However, both Sælen (1963) and Mosby (1970) revealed from drawings of depth contours of isothermal surfaces that eddy-like features were occasionally present in the Atlantic current. Such features were first detected in the Norwegian Sea by Helland-Hansen & Nansen (1909) and given the name 'puzzling waves'. The scale of these waves appeared to be in the order of 50 km. Sælen (1963) observed that they could be stationary for several days or moving slowly or rapidly in a north easterly direction. Such eddy-like features within the Atlantic current can be associated with strong horizontal and vertical temperature gradients that may contribute significantly to synoptic variations in the temperature and depth of the mixed layer. This is further discussed in Sect. 6.

3. MEAN SEASONAL VARIATIONS

The mean seasonal variations in the temperature of the upper ocean at selected depths of 0, 50, 150, 200 and 250 m as derived from 9 years of hydrocast data from 1967 to

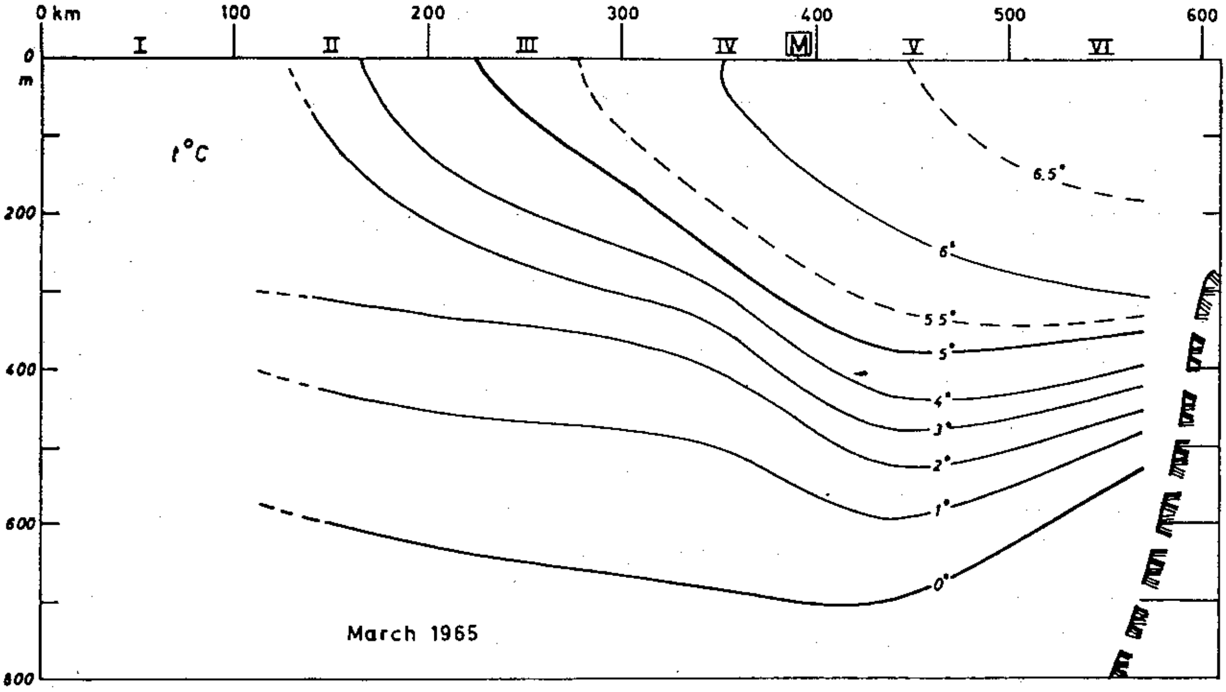

Fig. 1. Average temperature section through OWS Mike (after Mosby 1970).

1975 are presented in Fig. 2a. Based on these curves the active layer at OWS Mike is determined to have a lower limit at 200 m. Below this depth the annual temperature cycle is practically absent. The temperature at this depth varies no more than 1.5° C during the mean year, while the annual fluctuation of the sea surface temperature reaches nearly 6° C. The density variations in this active layer are almost entirely determined by temperature variations. For a more detailed discussion of the seasonal and annual variations of temperature, salinity and density in the upper layer (200 m), the reader is referred to Helland (1963) and Gammelsrød & Holm (1983).

The seasonal variations of the heat flux (q_s) across the ocean-atmosphere interface are presented in Fig. 2b. The heat flux (q_s) is the balance of solar radiation, short-wave reflection from the surface, long-wave radiation from the sky, back radiation and transfer of sensible and latent heat across the sea surface. The period of summer heating, when $q_s > 0$, lasts from May to August with an associated rapid increase in sea surface temperature. From the beginning of September to February the surface temperature decreases, corresponding to the seasonal cooling when $q_s < 0$.

During the ocean heating process the temperature difference between the sea surface

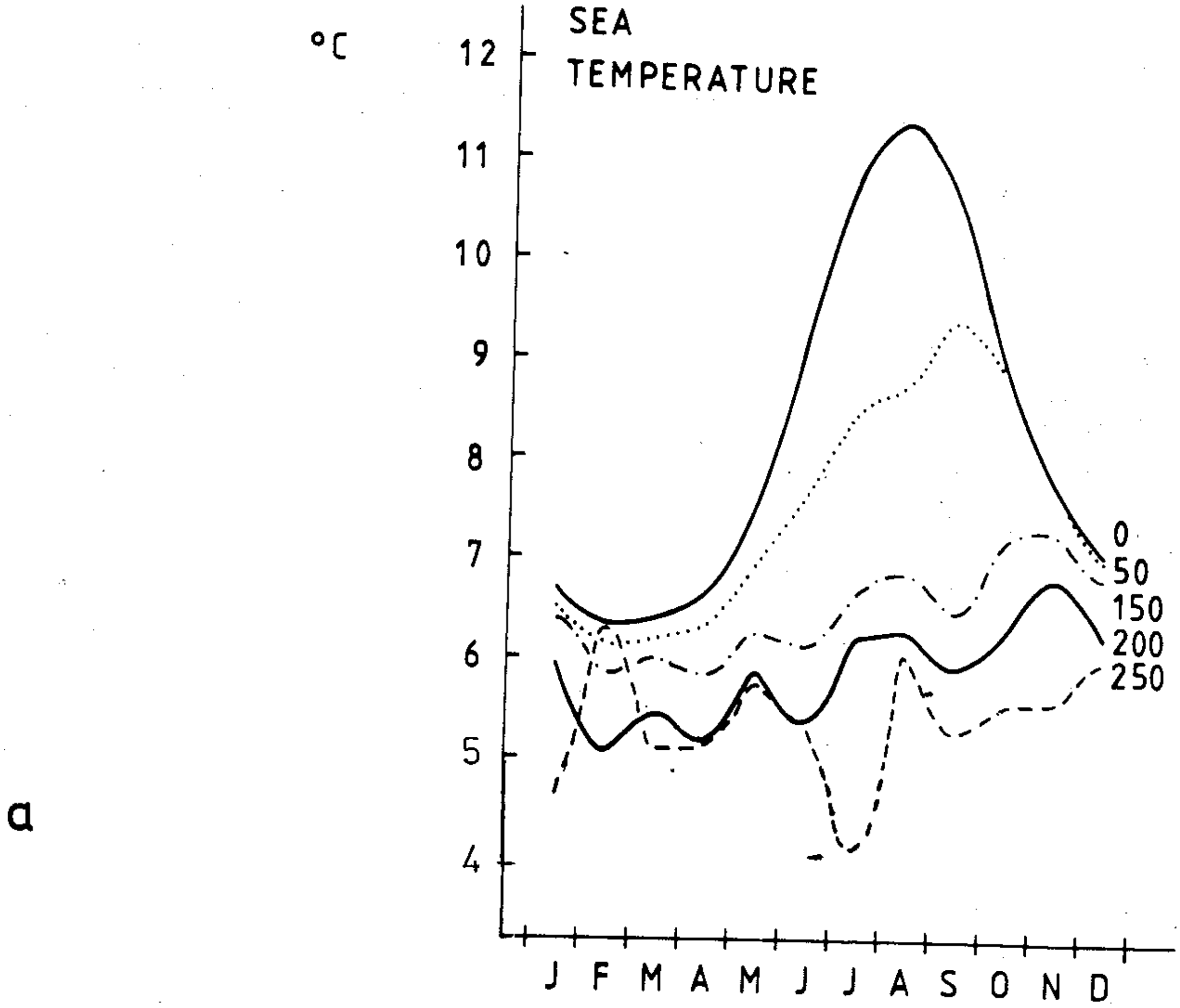

Fig. 2a. Mean seasonal temperature variations with depth for the upper 250 m.

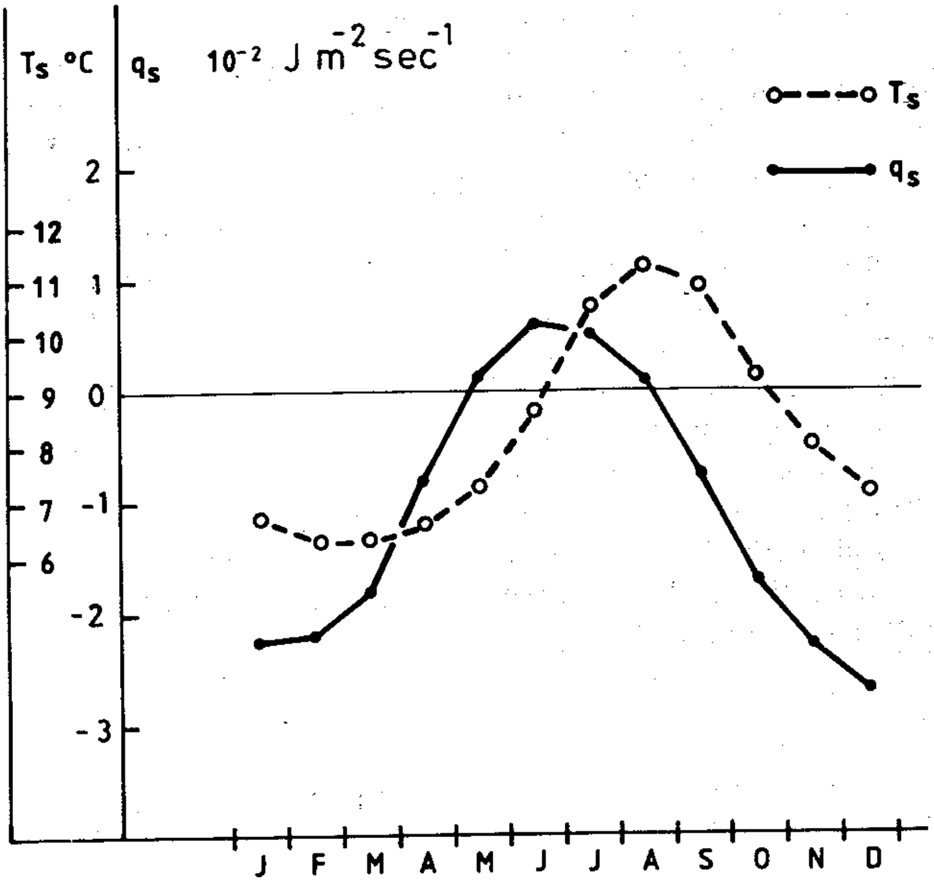

Fig. 2b. Mean seasonal variations of the heat flux q_s across the ocean atmosphere interface.

and the lower boundary of the active layer becomes so large that it starts to affect the thermal conditions of the active layer (Kitaigorodskii 1973). The formation of the new temperature gradient determined by this temperature difference can at some depth lead to complete dampening of the vertical transport of the wind-induced turbulent energy (forced convection). The associated mixing is thereby also dampened across this gradient zone. The seasonal thermocline formed at this depth separates the upper turbulent mixed layer from the remaining part of the active layer (Fig. 3). From the beginning of the autumn the vertical mixing is determined not only by the influence of the wind but also by convection due to heat loss from the ocean surface (free convection). In this period of free and forced convective mixing the summer thermocline weakens, and around February/March the

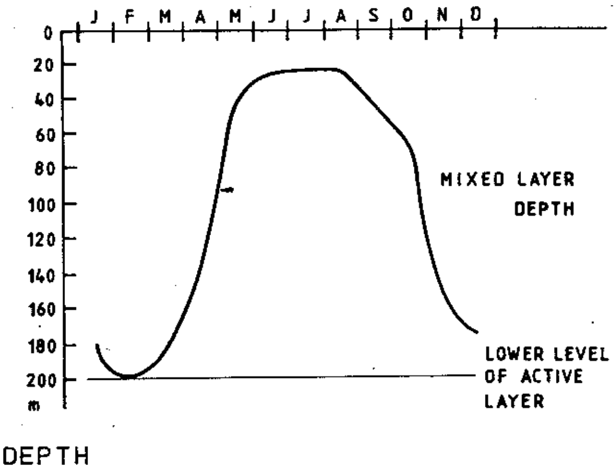

Fig. 3. Mean seasonal variations of the mixed layer depth.

entire active layer becomes nearly isothermal. It is such an event of free and forced convective mixing in the mixed layer that is examined and modelled for the period 5–22 March 1967 in the next sections.

4. CASE STUDY: 5–22 MARCH

During winter time there are frequent passages of low-pressure systems in the Norwegian Sea. The monthly means of the wind speed can reach 10 m/s at this time of the year, and it is therefore of interest to see how short period variations in the upper ocean structure relate to meteorological changes. The data base for this study consists of standard hourly marine meteorological observations, and somewhat less frequently sampled bathythermograph (BT) observations. Unfortunately, there are a few gaps where BT data are missing. The 17 day period 5–22 March 1967 was selected due to frequent passages of low-pressure systems in the region. In addition a net heat loss to the atmosphere from the sea surface occurred during this period.

The hourly observations of cloud cover, wind speed, air temperature (dry and wet) and sea surface temperature from 5–22 March 1967 are presented in Fig. 4. The mean wind speed during the 17 day period

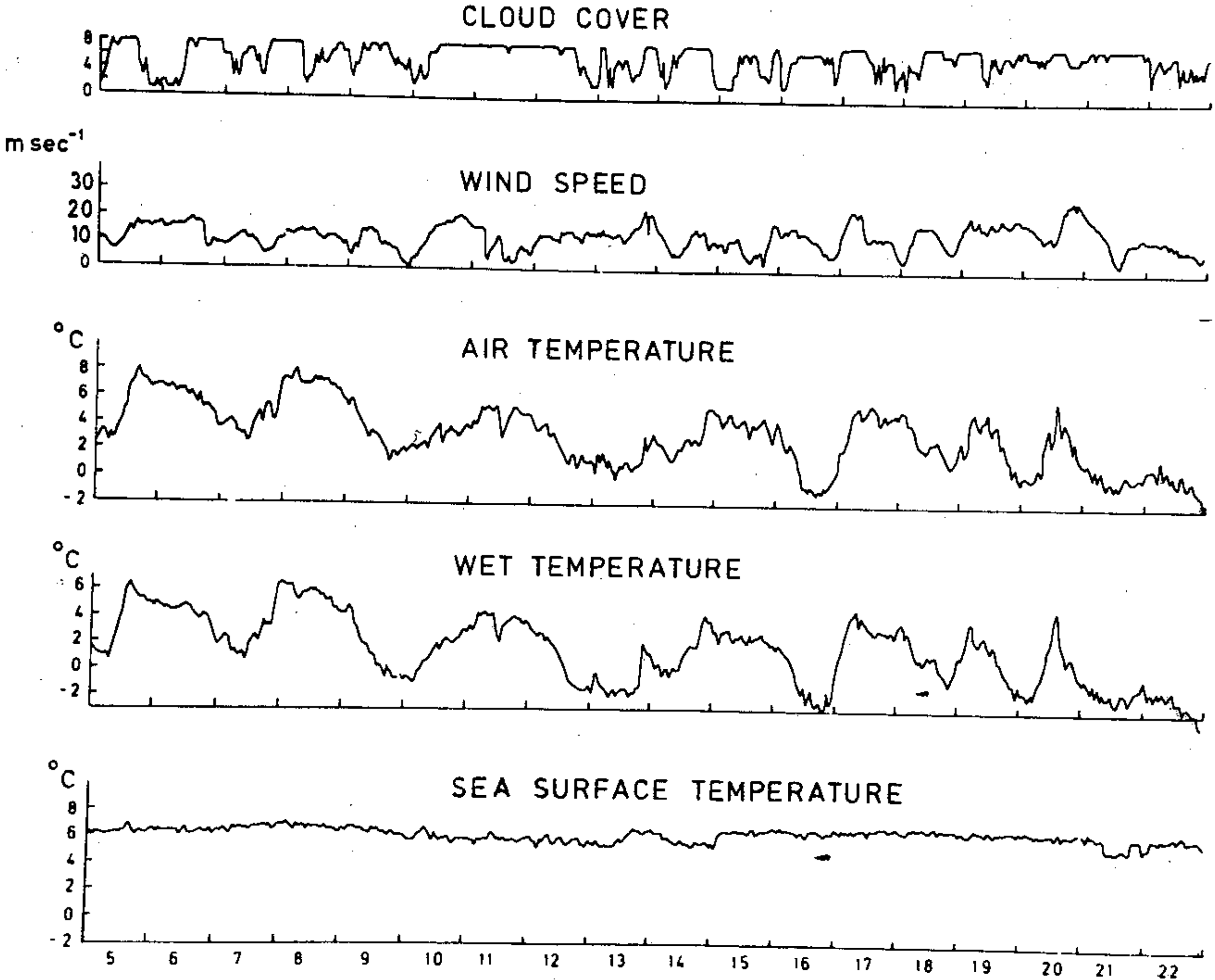

Fig. 4. Hourly meteorological observations of the cloud cover, the wind speed, the air temperature (dry and wet) and the sea surface temperature.

was about 10 m/s, but several storms with wind speeds up to 20 m/s or more were passing the area. The air temperature appears to vary between 0° C to 8° C over a period of 2 to 4 days. Similar variations are seen to take place for the wet bulb temperature. These variations are most likely associated with the passages of the cyclonic storms. The mean air temperature was about 4° C with a mean wet bulb temperature at about 1° C. During this period the sea surface temperature remained almost constant at 6° C. The atmospheric temperature fluctuations therefore appears to have negligible influence on the variations of the sea surface temperature. The air temperature was almost always less than that of the sea surface, causing a loss of sensible heat from the sea, as well as loss of latent heat.

The mixed layer depth (▲) and temperature (▲) are shown in Figs 5a and b. The mixed layer depth is here defined as the depth h to which the BT-temperature is 0.3° C less than the sea surface temperature for the same BT-cast. The temperature in the mixed layer is then set equal to the sea

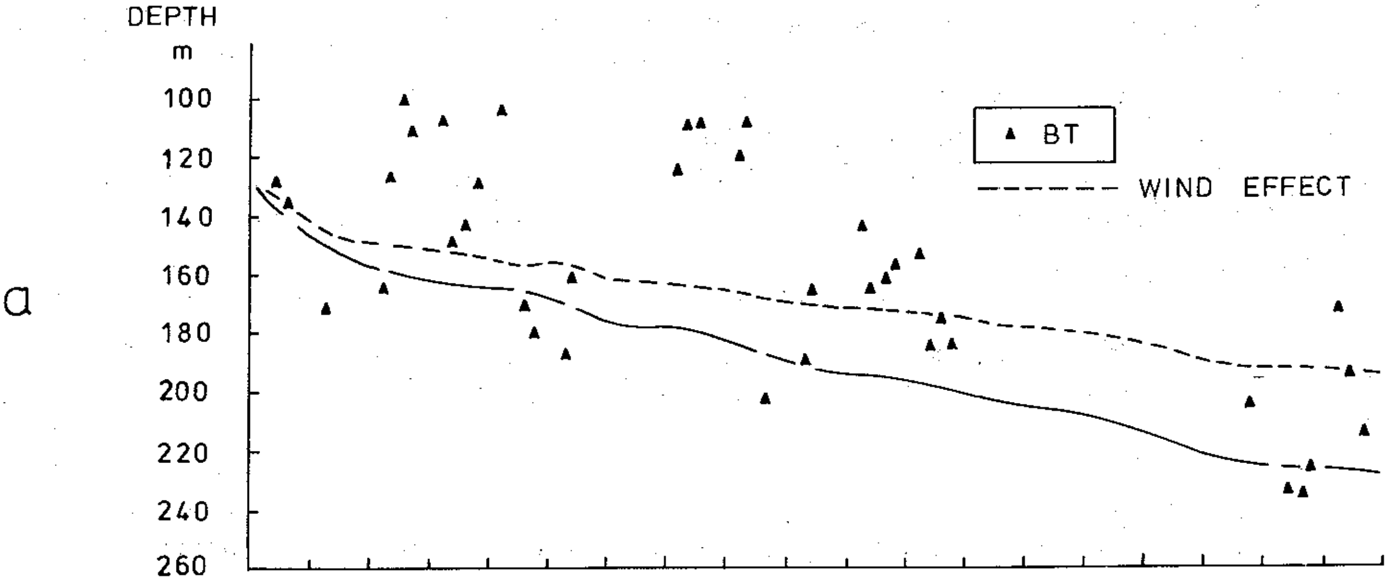

Fig. 5a. Predicted depth of the mixed layer. The observed depth (▲) are shown for comparison.

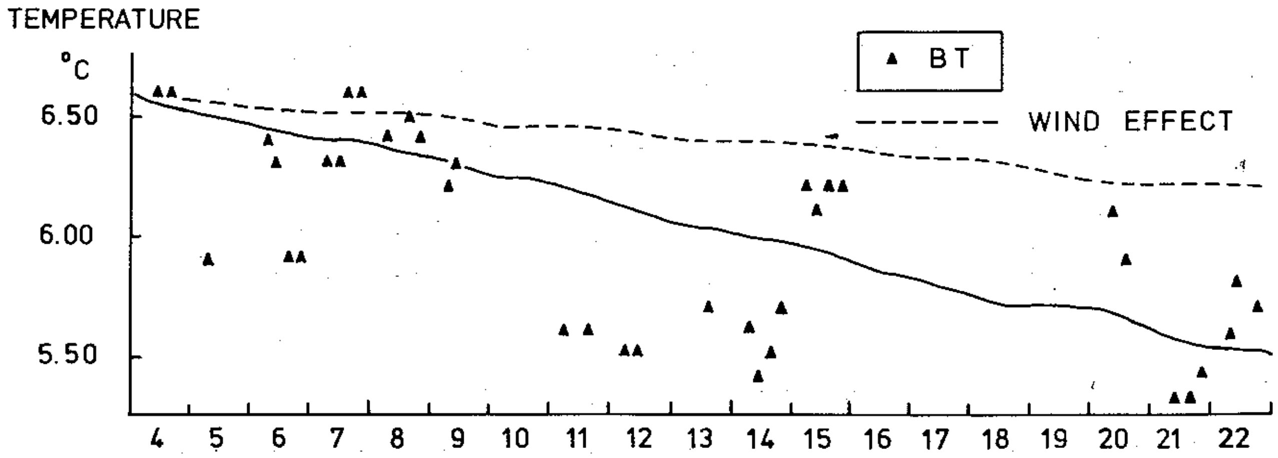

Fig. 5b. Predicted temperature of the mixed layer. The observed BT-temperature (▲) are shown for comparison.

surface temperature T_s. The most apparent feature in Fig. 5a is the rapid fluctuations of the mixed layer—sometimes as much as 100 m in less than one day. It is difficult to recognize any dominant period in these variations due to the gaps of missing data. However, a period of 2–4 days appears to exist in correspondence with the period of the weather disturbances. The variations in the mixed layer temperature are within 5° C to 6.6° C throughout the observations (Fig. 5b). The dominant period agrees with that of the mixed layer depth but appears out of phase. A deep mixed layer is thereby much of the time warmer than a shallow mixed layer. This suggests that the changes in the structure of the mixed layer are associated with horizontal displacement of the boundary of the N.A.C. rather than an interplay of free and forced convective mixing (see Fig. 1). This is further discussed in Sect. 6. However, the speculation is partly supported by the results of the simulation of the mixed layer structure presented below.

5. THE MODEL SIMULATION

Since the mixed layer at OWS Mike is measured only by a few conventional BTs a day and much less frequent bottle casts, we are limited in testing models. There are no direct current measurements. Denman's (1973) model can be applied since it requires no current measurements and is responsive to changes on time scales of the order of one day. It is a one-dimensional time dependent model of the upper mixed layer of the ocean driven by meteorological forcing. The model is sensitive to the rate of production of the turbulent energy by the wind stress, and to the rate of absorption with depth of the solar radiation. The available turbulent energy for mixing is assumed to be independent of depth. The temperature gradient at the base of the mixed layer has to be given. Only simple parameters available from routine meteorological measurements are required as input. For a full description of the model, see Denman (1973).

Later relevant works on one-dimensional mixed layer models, reviewed by Garwood (1979), are not taken into account, e.g. Elsberry et al. (1976) and Kim (1976), who added depth-dependent dissipation terms that helped to reduce unrealistic deepening, and De Szoeke & Rhines (1976) and Yun (1978), who added a term for the unsteadiness which became important in cases of very rapid deepening. Three-dimensional models, including horizontal and vertical advection of the mean fields such as described by Adamec et al. (1981), have also been omitted from our consideration. Such models yield more realistic simulations of the mixed layer structure in ocean areas influenced by current systems.

The deepening regime described by the dependent variables T_s, the temperature of the surface layer and h, the depth of the mixed layer, are expressed by two equations. These are

$$\frac{dT_s}{dt} = \frac{2}{\rho_0 h^2}\left\{-\frac{(G-D)}{\alpha g} + \frac{h}{C_p}(B + He + Hs)\right\} + \frac{R}{C_p}(h - \gamma^{-1} + \gamma^{-1} e^{-\gamma h}) \qquad (5.1)$$

$$\left\{w + \frac{dh}{dt}\right\} = \frac{2\left\{\frac{1}{\alpha g}(G-D) + \frac{R\gamma^{-1}}{C_p}(1 - e^{-\gamma h})\right\} - \frac{h}{C_p}\{B + He + Hs + R\,(1 + e^{-\gamma h})\}}{\rho_0\, h(T_s - T_h)} \qquad (5.2)$$

where the empirically derived variables are the surface heat fluxes of the back radiation (B), latent heat (He), sensible heat (Hs), the solar radiation (R) and the wind energy available for turbulent mixing (G − D). Other variables are the density ρ_0, the acceleration of gravity g, and the specific heat capacity C_p. The extinction length γ^{-1} is taken from Jerlov (1968) to be 2.5×10^{-1} m. The value of the coefficient of thermal expansion is $\alpha = 1.67 \cdot 10^{-4}\ C^{-1}$ for sea water of 10° C and 35‰. For the ratio of the potential energy increase of the water column to the downward transfer rate of turbulent energy by the wind stress, the value m = 0.0012, which Denman & Miyake (1973) found most suitable on the OWS Papa data, is employed. The amount of wind energy available for turbulent mixing is then expressed as

$$G - D = \rho_0 C_D m u^3 \qquad (5.3)$$

where u is the near surface wind speed and $C_D = 1.3 \times 10^{-3}$ is the drag coefficient.

The surface heat fluxes (latent and sensible) together with the back radiation are computed using empirical formulas (Malkus 1962 and Munn 1966) where the input data are shown in Fig. 3. The fluxes are presented in Fig. 6 along with the rate of solar radiation and the wind energy available for turbulent mixing derived by Eq. (5.3).

With these data given, Eqs (5.1) and (5.2) can be solved with regard to the mixed layer depth and temperature by numerical techniques. The vertical velocity w has been set equal to zero and the time step used is 12 hours. The result is given in Figs 5a and b (solid lines). During the period 5–22 March 1967 the predicted mixed layer depth (Fig. 5a) increased smoothly from 130 m to 220 m in correspondence to strong winds and release of heat to the atmosphere from the sea surface. Moreover, the entrainment of

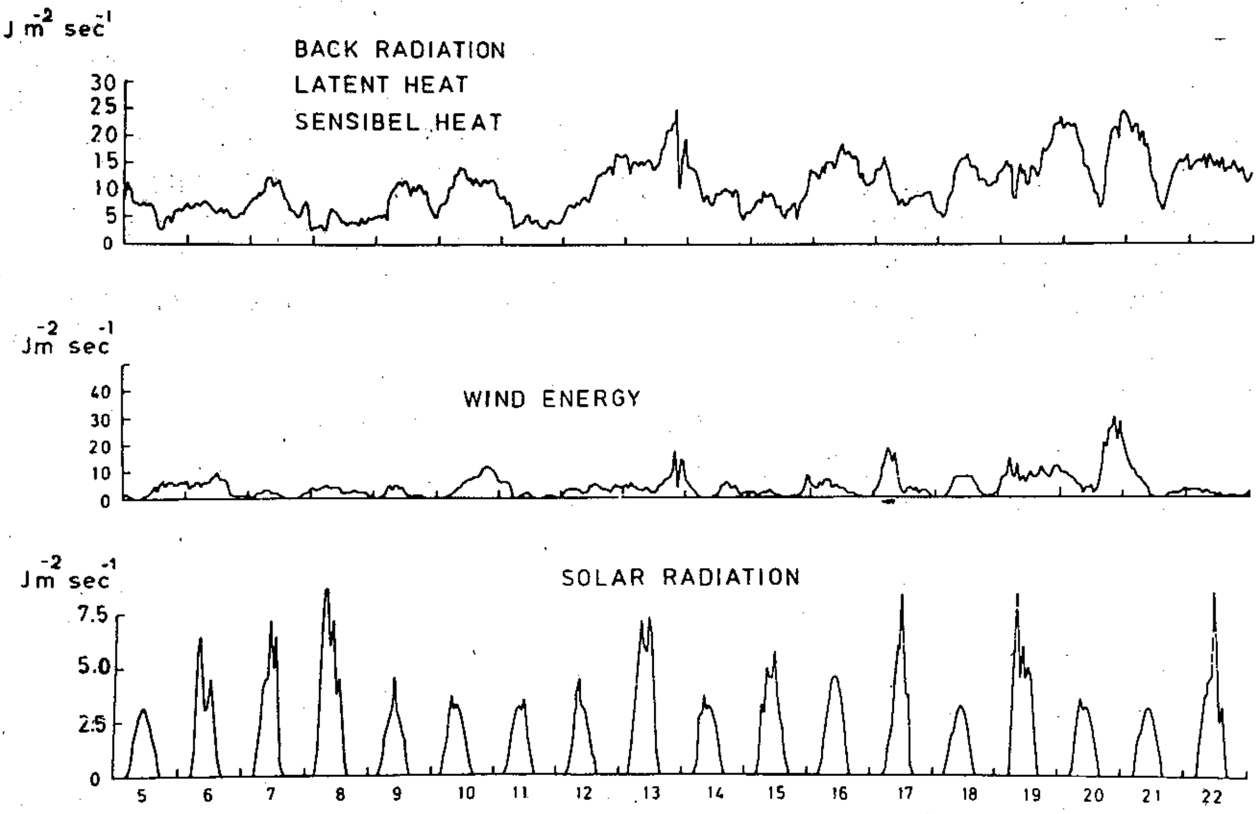

Fig. 6. Computed hourly values of the surface heat fluxes, the wind energy and the solar radiation.

cold water into the mixed layer, as well as the heat loss from the sea surface, reduced the mixed layer temperature from about 6.6° C to 5.5° C. Only a weak tendency towards more rapid increase of the mixed layer depth and decrease in the mixed layer temperature associated with the storm events can be seen.

The model can also be used to study the effect of wind mixing and free convection independently. One can assume heat balance by neglecting the radiative, latent and sensible heat transfer terms through the ocean-atmosphere interface. One can then study the growth of the mixed layer depth and decrease in the temperature due to the wind mixing. The result is seen in Figs 5a and b (dashed lines). Since the wind-induced turbulent energy available for mixing is independent of depth, as much as 60% of the increase in the mixed layer depth is accounted for by turbulent energy. Under the circumstances discussed here, with a mixed layer depth of 100–200 m, such an increase of 60% due to the wind is probably too high. The associated 20% decrease in mixed layer temperature is probably overestimated due to the same fact. However, the choice of temperature gradient at the base of the mixed layer will also have influence on this estimate. Thus, the heat loss at the surface appears to dominate the temperature decline in the mixed layer. This is in accordance with the present knowledge of the winter cooling and convection in the Atlantic Water of the Norwegian Sea.

6. DISCUSSION AND SUMMARY

The model simulation of the mixed layer depth and temperature is in agreement with the general trend in the BTs. This suggests that the model is capable of predicting variations in the mixed layer on a weekly time scale. However, the rapid fluctuations of up to 100 m of the mixed layer depth in less than one day, every so often, are not predicted by the model. In the following, some possible causes of the discrepancies between observations and simulation are discussed.

Over the wide range of wind speeds observed during this 17 day period, it is probably not correct to keep m—the ratio of the potential energy increase to the downward transfer of turbulent energy by the wind stress—constant. For example, Turner (1969) suggests that a considerably larger value of m (0.01) would be necessary to account for the rapid storm-induced deepening of the mixed layer. Other responses in the mixed layer to passages of weather disturbances can be generation of vertical motion. With a non-zero curl in the surface wind stress field, Ekman transports are set up in the upper layer with large scale divergences and convergences. The compensating vertical motion is likely to generate fluctuations in the mixed layer temperature and depth. The combined effect of a too small m and neglect of vertical motion in the model thereby reduces the applicability of the model to simulate the true behaviour of the mixed layer during passages of storm events. However, the amplitude of these rapid fluctuations of the mixed layer are probably too large to be caused by these effects alone.

As speculated above, the most likely causes of the drastic changes in the behaviour of the mixed layer are horizontal displacements of the boundary of the N.A.C. Such displacements of the boundary of the N.A.C. may be wind-induced or due to instabilities. This conjecture is indeed supported by the infrared (IR) imagery of the southern part of the Norwegian Sea obtained on 14 May 1980 (Fig. 7). As seen in the image, the N.A.C. consists of eddies on different scales.

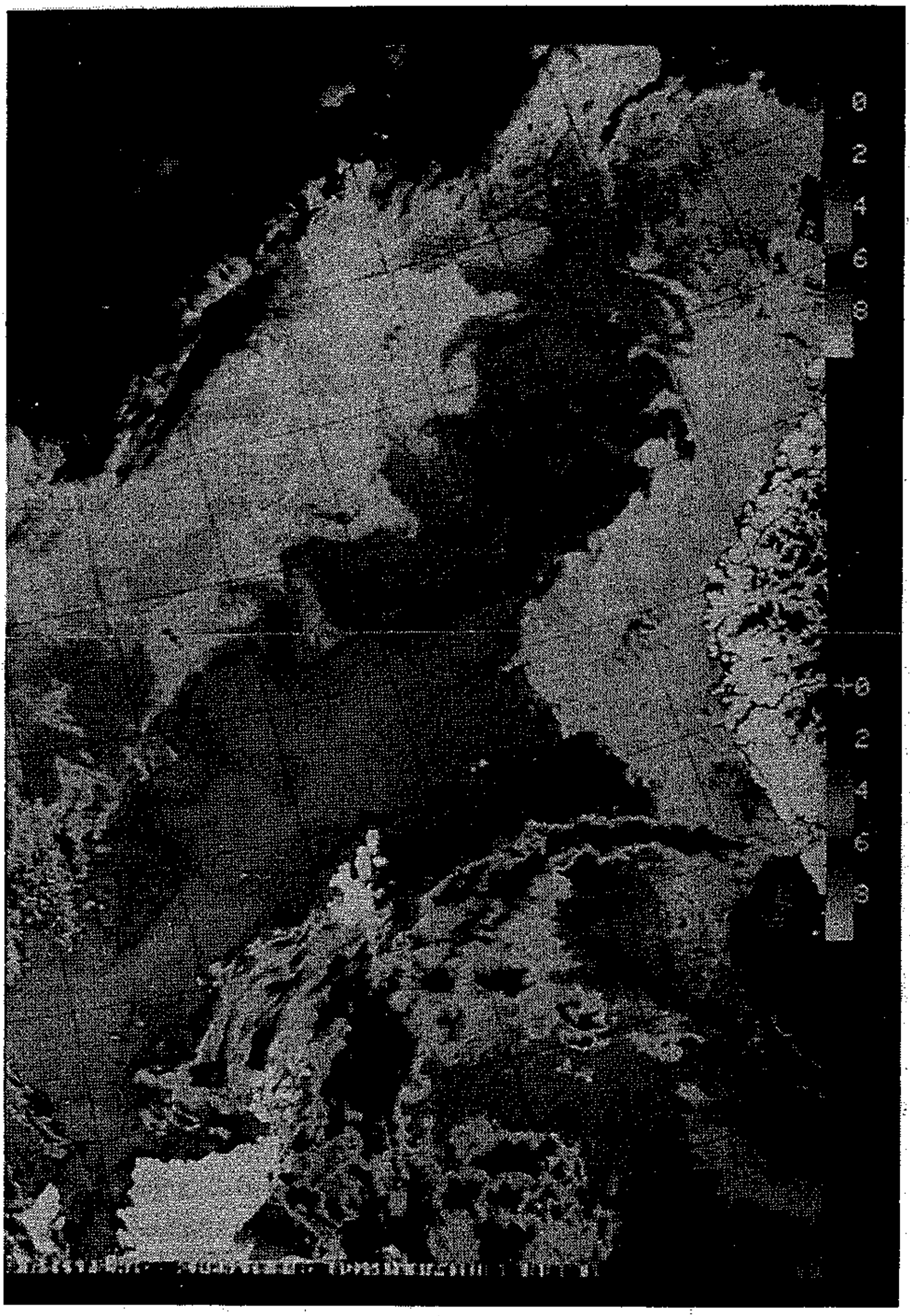

Fig. 7. IR imagery of the N.A.C. in the southern part of the Norwegian Sea obtained by TIROS-N satellite. Resolution is 1 km. (The image was produced at CMI.)

These eddies cause entrainment of colder water into the N.A.C. as well as dispersion of A.W. into the resident Norwegian Sea water and the coastal water off Norway.

The mean diameter of the eddies is in the order of the Rossby radius of deformation, which is approximately 10 km in this region. In addition, their propagation speed is limited by the maximum phase speed of Rossby waves, expressed by McWilliams & Flierl

(1979) as

$$C = \beta L^2 \quad (6.1)$$

where β is the variation in the Coriolis parameter with latitude, and L is the Rossby radius of deformation. This speed is about 0.01 m/s at this latitude, so the total speed of the eddies will be about 0.04 m/s. The travel time for an eddy to pass OWS Mike is then approximately 2–3 days. This compares well with the major period of fluctuations seen in the BTs in Figs 5a and b. The sharp boundaries' association with these warm and cold eddies may thereby very well be responsible for the rapid changes in the structure of the mixed layer.

The discussion above therefore suggests that an increase in m, the amount of turbulent energy available for mixing, together with incorporation of vertical and horizontal advection in the model, may not be sufficient to describe the rapid fluctuations in the depth and temperature of the mixed layer. These rapid fluctuations are better explained by an alteration of water masses due to the displacement of the western boundary of the Atlantic current. Such displacement may be due to frontal waves and eddies. The propagation of these eddies appear to have time scales which correspond to the period of the rapid fluctuations.

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Probability models in precipitation climate studies

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In section 2 precipitation intensity is considered as a random variable with time as a continuous parameter. Estimates of monthly averages of precipitation probability are obtained for 280 stations.

In sections 3–7 a 3rd. order Markov model has been applied to sequences of dry and wet days. Various schemes are applied to derive probabilities for (A) the number of wet days in n successive days, (B) the duration of dry and wet runs, (C) that no more than J successive dry (wet) days occur in n days.

Sections 8–9 present a model for the distribution of precipitation sums in n days.

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INTRODUCTION

Users of information on the precipitation climate of Norway have a need for estimates of probabilities of a great variety of precipitation events, and/or related statistical quantities. In this paper the primary goal has been to show how probability theory may be used to obtain these estimates, assuming that a few basic probability models are given.

The various events which have been considered are restricted to such that characterize the precipitation climate on isolated stations, thus excluding events expressing simultaneous precipitation conditions under widely different conditions throughout the country. In this case the general structures of the models which should come into consideration are fairly well known. Problems of a more difficult nature, however, arise when the models have to be specified in detail. The systematic search for optimal models is not a subject for study in the present paper. Accordingly, the specification of models in this work may seem, and is in fact to some extent, arbitrary. However, in spite of weaknesses in the models, they are considered good enough, for the interests of users, to compute model probabilities of some interesting events for a selection of stations. These results are tabulated in an Annex. However, with respect to more extensive results for these and other events in this article, users are asked to make specific requests.

1. THE BASIC PRECIPITATION RANDOM VARIABLE

Definitions

$\omega \equiv$ precipitation intensity as function of time: $t \rightarrow \omega(t)$; $t \in [0, \infty\rangle$; $\omega \in [0, \infty\rangle$

Sample space Ω:

$$\begin{aligned} &\Omega \equiv \{\text{all possible } \omega\text{'s}\} \\ &P \equiv \text{probability function on a} \\ &\quad\ \text{probability field of subsets of } \Omega. \end{aligned} \tag{1}$$

The first random variable defined on Ω to be considered is the precipitation intensity for an arbitrarily given t, symbolized by X:

$$X \equiv \omega(t) \tag{2}$$

This random variable has t as a parameter and takes values in $[0, \infty\rangle$. The distributions of X,

$$F(x) \equiv P(X \leqslant x) \tag{3}$$

have shapes as illustrated by the curve marked F in Fig. 1. The jump at $x = 0$ equals the non-zero probability of dry weather. Obviously

$$\Omega = \{\omega | \omega = 0 \text{ at time t}\} \\ \cup \{\omega | \omega > 0 \text{ at time t}\}$$

With a change in notation for the two r.h.s. disjoint subsets, this may be written more shortly

$$\Omega = \{X = 0\} \cup \{X > 0\} \tag{4}$$

Writing intersection of sets without the intersection symbol, we have

$$\{X \leqslant x\} \\ = \{X \leqslant x\}\Omega \\ = \{X = 0\}\{X \leqslant x\} \cup \{X > 0\}\{X \leqslant x\} \\ = \{X = 0\}(\{X = 0\} \cup \{0 < X \leqslant x\}) \cup \\ \{X > 0\}\{X \leqslant x\}$$

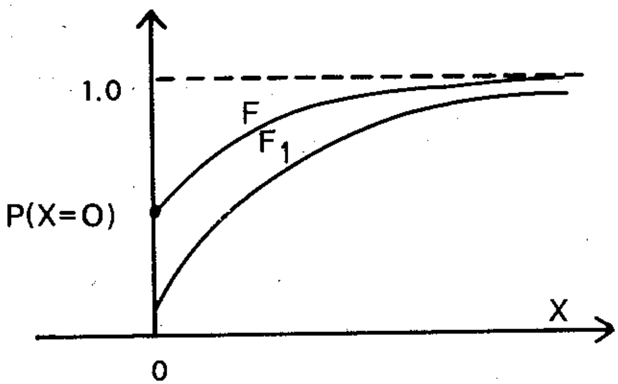

Fig. 1. A schematic illustration of probability distributions of precipitation intensity. F is the unconditional distribution and F_1 is the one relative to the subset $\{X > 0\}$.

$$= \{X = 0\} \cup \{X > 0\}\{X \leqslant x\}$$

The corresponding relation between probabilities becomes

$$P(X \leqslant x) = P(X = 0) + P(\{X > 0\}\{X \leqslant x\})$$

This relation may also be written

$$P(X \leqslant x) = P(X = 0) \\ + P(X > 0)P(X \leqslant x | X > 0) \tag{5}$$

introducing the probability of $\{X \leqslant x\}$ relative to the subspace $\{X > 0\}$. In terms of functions of x, Eq. (5) may be written

$$F(x) = p_0 + p_1F_1(x) \tag{6}$$

having written p_0 for $P(X = 0)$, p_1 for $P(X > 0)$, and $F_1(x)$ for $P(X \leqslant x | X > 0)$. Obviously

$$p_0 + p_1 = 1 \tag{7}$$

In view of this and because $F(0) = p_0$, $F(\infty) = 1$, we obtain $F_1(0) = 0$ and $F_1(\infty) = 1$ as illustrated in Fig. 1 by the curve marked F_1.

From eq. (6) we get a corresponding relation between expectations,

$$E[X] = p_1E[X | X > 0] \tag{8}$$

in which the r.h.s. expectation represents the expected value of precipitation intensity, not counting the cases when the intensity is zero. The fact that dry weather (zero precipitation intensity) has a non-zero probability is an essential feature of precipitation climate. As a consequence, the probability of many events, like for instance precipitation sums, will depend on the distribution of the lengths of dry and wet periods, as well as on the distribution of precipitation intensities during wet periods. Also the probability models become more complicated for the same reason.

Definition of the indicator W

$$W{:}X \rightarrow W(X) = \begin{cases} 0 \text{ for } X = 0 \\ 1 \text{ for } X > 0 \end{cases} \tag{9}$$

For W we have

$$E[W] = p_1 \tag{10}$$

2. TIME EVOLUTION OF X. CONTINUOUS TIME PARAMETER

Taking into account that X depends on time t as a parameter, new random variables may be defined. We shall give three of them.

Definition

$$L \equiv \int_T W\,dt = \text{length of precipitation}$$

$$\text{time in a section T of time space}$$

We shall restrict ourselves to a study of the expectation E[L], for which we have

$$\begin{aligned} E[L] &= E[\int_T W\,dt] \\ &= \int_T E[W]dt = \int_T p_1\,dt \end{aligned} \tag{11}$$

We have estimated E[L]/T for calendar months, by the number of precipitation observations relative to the total number of observations at the main observing hours. At stations with observations at 06, 12, 18 GMT only, the estimates will be biassed during summer, when most land stations have a significant daily variation in p_1. However, this bias is small, as found already by H. Mohn (1888). Clearly, E[L]/T may also be looked upon as the monthly averages of daily averages of p_1, and therefore approximately as estimates of the daily averages of p_1 on mid-month days. The estimates are tabulated in Table 6 in the Annex.

Definition

$$\begin{aligned} D_1 &\equiv \text{time until a precipitation state first comes to a stop} \\ D_0 &\equiv \text{time until a non-precipitation state first comes to a stop.} \end{aligned} \tag{12}$$

Adopting a stationary Markov process for the wet and dry states we have

$$\begin{aligned} P(D_1 > d_1) &= e^{-d_1/E[D_1]} \\ P(D_0 > d_0) &= e^{-d_0/E[D_0]} \end{aligned} \tag{13}$$

It also follows that

$$\begin{aligned} &P(\{W(t) = 1\}\{W(t+\Delta t) = 0\}) \\ &\quad = p_0 p_1 (1 - e^{-\Delta t/p_0 E[D_1]}) \end{aligned}$$

Putting here $\Delta t = 6$ hrs., the joint probability on the l.h.s. has been estimated from observations 6 hrs. apart. Using the tabulated numbers for p_1 in Table 6, we may solve the above equation with respect to $E[D_1]$. These numbers are tabulated in Table 7. Substituted in the first of eq. (13), we obtain the distribution for D_1. We shall also note that when the Markov conditions above are strictly fulfilled, D_1 may also be interpreted as the lengths of precipitation "runs", i.e. the times from the last entrances into precipitating states to the first passages out of them. However, it remains to show how good an approximation the above Markov model is. This will be postponed to a later occasion, when continuous registrations of precipitation intensity will be investigated for the relatively few stations where series of such observations exist. Most likely the estimates are too high for summer months except for typical coastal stations. This is because a majority of summer showers of short duration are within the interval 12–18 GMT.

Definition

$$R \equiv \int_T X\,dt$$

We shall use this to get estimates of E[X].

$$E[R] = \int_T E[X]\,dt$$

$$= \int_T p_1 E[X|X > 0]\,dt, \text{ using (8)}$$

Under almost stationary conditions, this may be written

$$E[X|X > 0] \approx E[R]/E[L] \qquad (14)$$

Table 8 contains the estimated values of $E[X|X > 0]$ having used estimated values of E[R] for calendar months and the estimated values of E[L]/T in Table 6 using identical observation bases.

3. PRECIPITATION VARIABLES IN DISCRETE TIME

The archives of precipitation variables in Norway are essentially of three kinds:

(A) Continuous registrations of accumulated precipitations amounts for a few stations
(B) Observations of precipitation conditions at fixed hours for a relatively large number of stations
(C) Daily precipitation sums for a still higher number of stations (around 600)

Accordingly, for events connected with sequences of dry and wet days, and precipitation sums for an integer number of days, one has to use observation category (C) in order to obtain a satisfactory geographical coverage. Also it is possible that this may be a more rational way of studying events defined for periods of one day or more, rather than basing the studies on observations of time scales much less than 24 hrs.

Following up what is said above, we consider, in this and the following sections, time space as a union of successive 24 hr. intervals, which we agree to label with successive integers n. Also we now redefine the random variable X to mean:

Definition

$$X \equiv \text{precipitation sum in 24 hrs.} \qquad (15)$$

This random variable depends on the parameter n. In analogy with the results of section 1, we get:

$$\Omega = \{X = 0\} \cup \{X > 0\}$$

$$P(X \leq x) = P(X = 0) + P(X > 0) \times P(X \leq x|X > 0),$$

or with a change in notation

$$F(x) = P(A) + P(B)FB(x)$$

$$E[X] = P(B)E[X|B] \qquad (16)$$

A model for FB(x) will be studied in section 8.

Definition of W

$$W: X \rightarrow W(X) = \begin{cases} 0 \text{ for } X = 0 \\ 1 \text{ for } X > 0 \end{cases} \qquad (17)$$

We have

$$E[W] = P(B) \qquad (18)$$

4. MARKOV MODELS FOR STUDYING EVENTS DEFINED FROM SEQUENCES OF DRY AND WET DAYS

Let C denote either A or B on an arbitrary day. An arbitrary sequence of A and B's for n successive days may then be written as the intersections

$$C_1C_2 \ldots C_n = \{C_1C_2 \ldots C_{n-1}\}C_n$$

The corresponding relations between probabilities then becomes

$$P(C_1C_2\ldots C_n) = P(\{C_1C_2\ldots C_{n-1}\}C_n)$$
$$= P(C_1C_2\ldots C_{n-1})$$
$$\times P(C_n|C_1C_2\ldots C_{n-1})$$

Here $P(C_n|C_1C_2\ldots C_{n-1})$ formally expresses the probabilities of $C = A$ or $C = B$ on the n-th day as depending on a knowledge of the distribution of dry and wet days on the previous $n - 1$ days. When no such dependence exists, we have

$$P(C_n|C_1C_2\ldots C_{n-1}) = P(C_n) \text{ for any } n$$

When there is a dependence on history, we shall assume that it is of the following kind:

$$P(C_n|C_1C_2\ldots C_{n-1})$$
$$= P(C_n|C_{n-k}C_{n-k+1}\ldots C_{n-1}) \qquad (19)$$

for fixed k and any value of n (Markov model of order k). We note that

$$P(A_n|C_{n-k}\ldots C_{n-1}) + P(B_n|C_{n-k}\ldots C_{n-1}) = 1$$

Therefore, there are altogether 2^k independent transition probabilities on any day n. In Table 1 we give estimates of $P(A_n)$ and the particular transition probabilities $P(A_n|A_{n-k}\ldots A_{n-1})$ for $k = 1, 2, 3$ at a station in SE-Norway. The estimates are based upon 82 years of observations.

In this paper orders higher than 3 will not be considered, Eidsvik (1979), Bjørgum (1945), Bjørgum & Fjordholm (1946). As a general rule, the shorter the periods from which the events are defined, the better will the Markov model work.

Table 1

Transition probabilities $P(A_n|A_{n-k}\ldots A_{n-1})$ for sequences of dry and wet days as function of order k of Markov chain at a station in south-eastern Norway.

Month	Indep.	k = 1	k = 2	k = 3
March	.7400	.8334	.8453	.8588
August	.5651	.7114	.7411	.7617

5. THE NUMBER L OF PRECIPITATION DAYS IN N SUCCESSIVE DAYS

This random variable may be written $L = \sum_{i=1}^{N} W_i$. Hence

$$E[L] = \sum_{i=1}^{N} E[W_i] = \sum_{i=1}^{N} P(B_i) \qquad (20)$$

Under almost stationary conditions, this may be written

$$E[L] \approx NP(B) \qquad (21)$$

In order to derive the distribution $f(l, N) \equiv P(L = l)$, $l = 0, 1, \ldots, N$, we shall adopt a 3rd order Markov model for sequences of precipitation and non-precipitation days. We have

$$\Omega = A_{i-2}A_{i-1}A_i \cup A_{i-2}A_{i-1}B_i$$
$$\cup A_{i-2}B_{i-1}A_i \cup A_{i-2}B_{i-1}B_i$$
$$\cup B_{i-2}A_{i-1}A_i \cup B_{i-2}A_{i-1}B_i$$
$$\cup B_{i-2}B_{i-1}A_i \cup B_{i-2}B_{i-1}B_i \qquad (22)$$

and

$$\Omega = A_i \cup B_i \qquad (23)$$

the latter having been used already in section 3.

A consequence of (19) is

$$P(Z_{n-1}C_n)$$
$$= P(Z_{n-1})P(C_n|C_{n-3}C_{n-2}C_{n-1}) \qquad (24)$$

if

$$Z_{n-1} = (\bigcup_J (C_1C_2\ldots C_{n-4})_J)$$
$$\times C_{n-3}C_{n-2}C_{n-1} \qquad (25)$$

in other words, if Z_{n-1} is defined on the first $n - 1$ outcomes, but such that the three last intervals have a given sequence, $C_{n-3}C_{n-2}C_{n-1}$, of outcomes.

Let Z represent an arbitrary non-empty subset of Ω. Then

$$\begin{aligned}
Z\,A_{n-1}A_nA_{n+1} &= Z\,A_{n-2}A_{n-1}A_nA_{n+1}\\
&\cup Z\,B_{n-2}A_{n-1}A_nA_{n+1}\\
Z\,A_{n-1}A_nB_{n+1} &= Z\,A_{n-2}A_{n-1}A_nB_{n+1}\\
&\cup Z\,B_{n-2}A_{n-1}A_nB_{n+1}\\
Z\,A_{n-1}B_nA_{n+1} &= Z\,A_{n-2}A_{n-1}B_nA_{n+1}\\
&\cup Z\,B_{n-2}A_{n-1}B_nA_{n+1}\\
Z\,A_{n-1}B_nB_{n+1} &= Z\,A_{n-2}A_{n-1}B_nB_{n+1}\\
&\cup Z\,B_{n-2}A_{n-1}B_nB_{n+1} \qquad (26)\\
Z\,B_{n-1}A_nA_{n+1} &= Z\,A_{n-2}B_{n-1}A_nA_{n+1}\\
&\cup Z\,B_{n-2}B_{n-1}A_nA_{n+1}\\
Z\,B_{n-1}A_nB_{n+1} &= Z\,A_{n-2}B_{n-1}A_nB_{n+1}\\
&\cup Z\,B_{n-2}B_{n-1}A_nB_{n+1}\\
Z\,B_{n-1}B_nA_{n+1} &= Z\,A_{n-2}B_{n-1}B_nA_{n+1}\\
&\cup Z\,B_{n-2}B_{n-1}B_nA_{n+1}\\
Z\,B_{n-1}B_nB_{n+1} &= Z\,A_{n-2}B_{n-1}B_nB_{n+1}\\
&\cup Z\,B_{n-2}B_{n-1}B_nB_{n+1}
\end{aligned}$$

where, in consequence of (22) the union of the eight left members equals Z.

That the sets above are identical is easily recognized by using $A_{n-2} \cup B_{n-2} = \Omega$. The probabilities of the events on the left sides of eq. (26) are obtained by adding the probabilities of the events on the right sides. Let now as a special case $Z = Z_{l,n+1} \equiv$ union of all sample points with exactly l precipitation days in the n + 1 first intervals. Then in the r.h.s. members of eq. (26), $Z_{l,n+1}$ may be replaced by $Z_{l,n}$ in the relations ending with a non-precipitation day, and with $Z_{l-1,n}$ in the relations where an additional precipitation day in the interval n + 1 adds to the previous number l − 1 in the first n intervals. We define $f_k(l, n)$, $p_kA(n)$, and $p_kB(n)$ by

$$\begin{aligned}
f_1(l, n) &\equiv P(Z(l, n)A_{n-2}A_{n-1}A_n)\\
f_2(l, n) &\equiv P(Z(l, n)A_{n-2}A_{n-1}B_n)\\
p_1A(n) &\equiv P(A_{n+1}|A_{n-2}A_{n-1}A_n)\\
p_1B(n) &= 1 - p_1A(n)\\
p_2A(n) &\equiv P(A_{n+1}|A_{n-2}A_{n-1}B_n)\\
p_2B(n) &= 1 - p_2A(n)
\end{aligned}$$

Then, by applying eq. (24) to the right members of eq. (26), we get:

$$\begin{aligned}
f_1(l, n+1) &= p_1A(n)f_1(l, n)\\
&+ p_5A(n)f_5(l, n)\\
f_2(l, n+1) &= p_1B(n)f_1(l-1, n)\\
&+ p_5B(n)f_5(l-1, n)\\
&\vdots \qquad\qquad\qquad\qquad (27)\\
f_8(l, n+1) &= p_4B(n)f_4(l-1, n)\\
&+ p_8B(n)f_8(l-1, n)
\end{aligned}$$

$$f(l, n) = \sum_{k=1}^{8} f_k(l, n);\ l = 0, 1, \ldots, n.$$

Equations (27) represent an iteration scheme from which f(l, n) may be obtained for any n, given the initial fields $f_k(0, 0)$ and the transition probabilities $p_kA(i)$; i = 1, 2, . . . N. We have

$$\begin{aligned}
f_1(0, 0) &= P(A_{-2}A_{-1}A_0)\\
f_2(0, 0) &= P(A_{-2}A_{-1}A_0)\\
&\vdots \qquad\qquad\qquad (28)\\
f_8(0, 0) &= P(B_{-2}B_{-1}B_0)
\end{aligned}$$

Table 9 contains for N = 30 computed values of $F(l, n) \equiv \sum_{j=0}^{l} f(j, N)$ for selected values of

1 for 33 stations. More extensive tables may be obtained on request.

6. DURATION OF PRECIPITATION RUNS

Given that a precipitation run has started, the probability that it will last at least d days is given by

$$G(d) \equiv P(D1 \geqslant d) = P(A_0B_1B_2 \ldots B_d)/P(A_0B_1) \qquad (29)$$

In our model, this equation becomes:

$$G(d) = \{P(A_0) \cdot P(B_1|A_0) \cdot P(B_2|A_0B_1) \cdot P(B_3|A_0B_1B_2) \cdot P(B_4|B_1B_2B_3) \ldots P(B_d|B_{d-3}B_{d-2}B_{d-1})\}/P(A_0B_1)$$

giving

$$\begin{aligned} G(1) &= 1 \\ G(2) &= P(B_2|A_0B_1) \\ G(3) &= G(2)P(B_3|A_0B_1B_2) \\ G(d) &= G(3)\prod_{n=4}^{d} P(B_n|B_{n-3}B_{n-2}B_{n-1});\ d > 3 \end{aligned} \qquad (30)$$

Under almost stationary conditions this may be written more simply as

$$\begin{aligned} G(1) &= 1 \\ G(2) &= P(B|AB) \\ G(d) &= G(2)P(B|ABB) \times [P(B|BBB)]^{d-3};\ d \geqslant 3 \end{aligned} \qquad (31)$$

For non-precipitation run D0, the corresponding equations are, in the stationary case,

$$\begin{aligned} F(1) &= 1 \\ F(2) &= P(A|BA) \\ F(d) &= F(2)P(A|BAA) \times [P(A|AAA)]^{d-3};\ d \geqslant 3 \end{aligned} \qquad (32)$$

where $F(d) \equiv P(D0 \geqslant d)$.

We note that

$$P(d_1 \leqslant D1 < d_2) = G(d_1) - G(d_2) \qquad (33)$$

$$P(d_1 \leqslant D0 < d_2) = F(d_1) - F(d_2) \qquad (34)$$

In order to exemplify the use of the above formula, for two stations, whose locations may be found from List B, we have computed $100 \cdot F(D_0 \equiv d)$ for $d = 1$ up to 15 days, as tabulated in Table 2.

7. THE EVENT Z_n, THAT THE NUMBER OF SUCCESSIVE DRY DAYS IN n SUCCESSIVE DAYS DOES NOT EXCEED J

This is an event which may cause considerable harm to activities for which a minimum number of successive dry days within periods of given lengths is essential. For large values of J, the complementary events $\bar{Z}_n$ defined by $Z_n \cup \bar{Z}_n = \Omega$, represent outcomes of serious drought within periods of given lengths.

In the following we shall develop an iterative scheme to derive $P(Z_n; J)$ for increasing values of n. The probability of the complementary events, that at least J + 1 successive days occur in a period of n days, is next found from $P(\bar{Z}_n; J) = 1 - P(Z_n; J)$. We note that $P(Z_n) = 1$ when $n \leqslant J$, whereby n may be taken as $n \geqslant J + 1$.

Let i represent the number of days we have to go back from day n in order to find the first wet day. With $\Omega^{(i)}$ symbolizing the corresponding events we find

$$\begin{aligned} \Omega^{(0)} &= B_n \\ \Omega^{(1)} &= B_{n-1}A_n \\ \Omega^{(2)} &= B_{n-2}A_{n-1}A_n \\ \Omega^{(J)} &= B_{n-J}A_{n-J+1} \ldots A_n \end{aligned} \qquad (35)$$

Obviously

$$\Omega = \bigcup_{i=0}^{J} \Omega^{(i)} \cup \left(\bigcup_{i=J+1}^{\infty} \Omega^{(i)} \right)$$

Table 2. Model probability estimates that the total lengths of unbroken periods of dry days are equal to or greater than 2, 3, . . . , 15 days for stations 1252 and 5056 in List B in the Annex, respectively. Unit: 1/1000.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15
J	68	47	37	29	23	18	14	11	9	7	5	4	3	3
F	72	52	42	35	29	24	19	16	13	11	9	7	6	5
M	75	59	51	43	37	32	28	24	20	17	15	13	11	9
A	76	61	51	43	36	30	25	21	18	15	13	11	9	7
M	69	51	43	36	30	25	20	17	14	12	10	8	7	6
J	66	48	38	31	25	20	17	13	11	9	7	6	5	4
J	63	44	33	25	19	14	11	8	6	5	3	3	2	2
A	61	42	32	25	19	14	11	8	6	5	4	3	2	2
S	63	47	37	29	22	17	14	11	8	6	5	4	3	2
O	66	46	37	29	23	18	14	11	9	7	6	4	3	3
N	66	45	36	29	23	18	15	12	9	7	6	5	4	3
D	64	44	35	27	21	16	13	10	8	6	5	4	3	2

J	57	39	29	22	16	12	9	7	5	4	3	2	2	1
F	60	42	31	23	17	13	9	7	5	4	3	2	2	1
M	60	43	33	25	19	15	11	8	6	5	4	3	2	2
A	60	40	28	20	14	10	7	5	4	3	2	1	1	1
M	66	46	35	27	21	16	12	9	7	6	4	3	2	2
J	56	39	30	23	18	14	11	8	7	5	4	3	2	2
J	55	38	27	19	14	10	7	5	4	3	2	1	1	1
A	57	37	26	19	14	10	7	5	4	3	2	1	1	1
S	56	32	22	15	10	7	5	3	2	2	1	1	0	0
O	55	36	24	16	11	7	5	3	2	1	1	1	0	0
N	54	35	24	16	11	7	5	3	2	2	1	1	0	0
D	57	38	27	19	13	9	7	5	3	2	2	1	1	1

Using $Z_n = Z_n\Omega$ and denoting $Z_n\Omega^{(i)}$ by $Z_n^{(i)}$, we obtain

$$Z_n = \bigcup_{i=0}^{J} Z_n^{(i)} \cup \text{empty set}, \qquad (36)$$

since Z_n according to its definition is disjoint to $\bigcup_{J+1}^{\infty} \Omega^{(i)}$. Furthermore we see that

$$\begin{aligned} Z_{n+1}^{(0)} &= Z_n^{(0)} B_{n+1} \cup \ldots \cup Z_n^{(J)} B_{n+1} \\ Z_{n+1}^{(1)} &= Z_n^{(0)} A_{n+1} \\ &\vdots \\ Z_{n+1}^{(J)} &= Z_n^{(J-1)} A_{n+1} \end{aligned} \qquad (37)$$

The probability relations corresponding to (37) and (36) become in a 3rd order Markov model:

$$\begin{aligned} P_{n+1}^{(0)} &= P_n^{(0)} \cdot P(B_{n+1}|B_n) \\ &\quad + P_n^{(1)} \cdot P(B_{n+1}|B_{n-1}A_n) \\ &\quad + P_n^{(2)} \cdot P(B_{n+1}|B_{n-2}A_{n-1}A_n) \\ &\quad + \sum_{i=3}^{J} P_n^{(i)} \cdot P(B_{n+1}|A_{n-2}A_{n-1}A_n) \\ P_{n+1}^{(1)} &= P_n^{(0)} \cdot P(A_{n+1}|B_n) \\ P_{n+1}^{(2)} &= P_n^{(1)} \cdot P(A_{n+1}|B_{n-1}A_n) \\ P_{n+1}^{(3)} &= P_n^{(2)} \cdot P(A_{n+1}|B_{n-2}A_{n-1}A_n) \\ P_{n+1}^{(i)} &= P_n^{(i-1)} \cdot P(A_{n+1}|A_{n-2}A_{n-2}A_n); \\ &\qquad i = 4, 5, \ldots J \end{aligned} \qquad (38)$$

$$P_n = \sum_{i=0}^{J} P_n^{(i)} \qquad (39)$$

Eq. (38) represents an iteration scheme from which the values of $P_n^{(i)}$ for any n may be obtained, knowing their initial values, and given estimates of the transition probabilities appearing in the equations. Since Z_n is certain when $n \leqslant J$, the initial n may be taken to be J + 1, for which we have the initial set of probabilities:

$$\begin{aligned} P_{J+1}^{(0)} &= P(B_{J+1}) \\ P_{J+1}^{(1)} &= P_{J+1}^{(0)} \cdot P(A_{J+1}|B_J) \\ P_{J+1}^{(2)} &= P_{J+1}^{(1)} \cdot P(A_{J+1}|B_J) \\ P_{J+1}^{(3)} &= P_{J+1}^{(2)} \cdot P(A_{J+1}|B_{J-1}A_J) \\ P_{J+1}^{(i)} &= P_{J+1}^{(i-1)} \cdot P(A_{J+1}|A_{J-2}A_{J-1}A_J); \\ &\qquad i = 4, 5, \ldots J \end{aligned} \qquad (40)$$

Statistics of the above kind may be obtained on request for arbitrary values of J and n (within certain limits), for a number of stations. Below we include, by way of example, a few results in Tables 3 and 4.

8. THE DISTRIBUTION OF PRECIPITATION SUMS, R

$$R \equiv \sum_{i=1}^{n} X_i \qquad (41)$$

Decomposing Ω into

$$\Omega = \{L = 0\} \cup \{L = 1\} \cup \ldots \cup \{L = n\},$$

we obtain

$$\begin{aligned} \{R \leqslant r\} = \Omega\{R \leqslant r\} &= \{L = 0\} \cup \{L = 1\} \\ &\quad \times \{R \leqslant r\} \cup \ldots \cup \{L = n\}\{R \leqslant r\} \end{aligned}$$

Taking probabilities of these events, gives

$$\begin{aligned} P(R \leqslant r) &= P(L = 0) + \sum_{l=1}^{n} P(L = l) \\ &\quad \times P(R \leqslant r | L = l), \end{aligned}$$

or in terms of functions of l and r

$$F(r; n) = f(0, n) + \sum_{l=1}^{n} f(l, n) F_l(r; n) \qquad (42)$$

Since $F(\infty; n) = 1$, $F(0; n) = f(0, n)$ and

Table 3

Model probability estimates that no more than J successive dry days occur in n days on Station 2780, List B. October. Unit: 1/1000.

n	J = 1									
2–10		455	353	277	217	170	133	104	82	64
11–20	50	39	31	24	19	15	12	9	7	6

n	J = 2									
3–10			582	506	430	368	315	270	231	198
11–20	169	145	124	106	91	78	67	57	49	42
21–30	36	31	26	22	19	16	14	12	10	9

n	J = 3									
4–10				676	616	557	497	447	402	361
11–20	324	292	262	235	211	190	171	153	138	124
21–30	111	100	90	81	72	65	59	53	47	42
31–40	38	34	31	28	25	22	20	18	16	15

$\sum_{l=0}^{n} f(l,n) = 1$ we obtain $F_l(0;n) = 0$ and $F_l(\infty;n) = 1$. The point probabilities $f(l,n)$, as demonstrated in section 5, may be found from the 3rd-order Markov model described earlier. With regard to the distributions F_l we now adopt the model

$$F_l(r;n) = \mathrm{Gam}(r;\alpha_{l,n},\beta_{l,n}) \equiv \int_0^{r/\beta_{l,n}} \frac{U^{\alpha_{l,n}}}{\alpha_{l,n}!} e^{-U}\,dU; \qquad l = 1, 2, \ldots, n \tag{43}$$

as an approximation. This hypothesis is supported by observations for those values of l and n where observation series are long enough to permit a significant testing of the model. For large values of n it would, however, be impossible to estimate all 2n parameters from available observation series. In this case it is therefore essential that the number of parameters, by further development of the model, should be reduced drastically. In what follows we shall describe how this may be accomplished.

Table 4

Probability that at least J + 1 successive dry days occur in n days. Station 2780, List B. Unit: 1/1000.

March–April	
n	J = 29
30	6,1
59	32,9

June–July	
n	J = 22
23	2,5
55	14,1

From the model representation of $F_l(r;n)$ we obtain

$$\beta_{l,n}(\alpha_{l,n} + 1) = E[R|L = l] \tag{44}$$

$$\beta^2_{l,n}(\alpha_{l,n} + 1) = VAR[R|L = l] \tag{45}$$

Now, R is the sum $X^{(1)} + X^{(2)} + \ldots + X^{(l)}$ of l daily precipitation sums without any ordering relative to the n different days. We may therefore write

$$E[R|L = l] = lE[X|B, L = l] \tag{46}$$

$$VAR[R|L = l] = VAR[X|B, L = l] \cdot (1 + Q) \tag{47}$$

where

$$Q = 2 \sum_{d=1}^{n-1} P(W_i = 1, W_{i+d} = 1 | L = l) \cdot (n-d) \cdot \text{cor}[X_i X_{i+d} | W_i = 1, W_{i+d} = 1, L = l] \quad (48)$$

At first sight the estimation problem has now become much worse, when using the r.h.s. expressions in (46), (47). For, as we shall soon see, $E[X|B, L = l]$ and $VAR[X|B, L = l]$ have a real dependency on l. This alone gives 2n quantities to be estimated as before. Furthermore, whereas the conditional joint probability function, at least in theory, is determined from our model for sequences of dry and wet days, we have in addition got conditional correlations to be estimated for $d = 1, 2, .. n-1$ for each $l = 2, .. n$, i.e. altogether $2(n-1)^2$ correlations. In the subparagraphs (A)–(C) below, we shall show how a real reduction in the numbers of quantities to be estimated may be accomplished, without having to make the model too unrealistic.

(A) *Stratification of wet days*

We introduce 3 types of wet days, B_1, B_2, B_3, as shown below:

$$AB_1A, AB_2B \text{ or } BB_2A, \text{ and } BB_3B \quad (49)$$

We shall then find that the means and standard deviations of daily precipitation amounts differ systematically for these 3 types. For station 2370 we find, for instance, the following estimates in the month of October

$$E[X|B_1] = 5.87\,\text{mm};$$
$$E[X|B_2] = 8.00\,\text{mm};$$
$$E[X|B_3] = 11.94\,\text{mm} \quad (50)$$
$$SD[X|B_1] = 6.97\,\text{mm};$$
$$SD[X|B_2] = 9.47\,\text{mm};$$
$$SD[X|B_3] = 12.00\,\text{mm}$$

The same ordering with respect to the magnitudes of these quantities has been found in all months at all 33 stations except one, station 165. Assuming that the first and second moments of X, given the B_k, are not influenced by a further knowledge of the numbers L_k of B_k we obtain

$$E[X|B, L = l] = \sum_{k=1}^{3} M_k E[X|B_k] \quad (51)$$

$$E[X^2|B, L = l] = \sum_{k=1}^{3} M_k E[X^2|B_k] \quad (52)$$

where the weight M_k is the expected value of the number L_k of wet days of type k relative to the total number l of wet days in the subset,

$$M_k = E[L_k|L = l]/l = \sum_{l_1+l_2+l_3=l} l_k \times P(L_1 = l_1, L_2 = l_2, L_3 = l_3)/l \quad (53)$$

The point probabilities of exactly l_1 wet days of the first kind, l_2 of the second, and l_3 of the third in n days may be found using an iteration scheme of a type completely analogous to the one used in Section 5. The corresponding expression for $VAR[X|B, L = l]$ is found from

$$VAR[X|B, L = l] = E[X^2|B, L = l] - E^2[XB, L = l]$$

after substituting from (51), (52):

$$VAR[X|B, L = l] = \sum_{k=1}^{3} M_k E[X^2|B_k] - \left(\sum_{k=1}^{3} M_k E[X|B]\right)^2 \quad (54)$$

Using the estimates in (50), and the computed values of M_k for $l = 1, 2, \ldots 30$, with $n = 30$ found from a 3rd order Markov model, we obtain the results in Table 5.

Obviously with increasing l, the chances increase that there will be more wet days of type 3 relative to the number of wet days of type 2 and 1, and more wet days of type 2 relative to the number of wet days of type 1. This, taken together with the ordering relations in (50), in short explains the reasons behind the result why $E[X|B, L = l]$ and $SD[X|B, L = l]$ increase for increasing values of l.

(B) *Simplification of* $P(W_i = 1, W_{i+d} = 1 | L = l)$ *in Eq.* (48)

The expression for Q in eq. (48) implies that stationarity is assumed within our subsets. The subscripts i and i + d indicate two different days picked out at random. We now assume, as an approximation, that the joint probability in question is independent of d, in which case

$$P(W_i = 1, W_{i+d} = 1 | L = l) = \frac{l}{n} \cdot \frac{l-1}{n-1} \qquad (55)$$

(C) *Simplification of the correlation function*

The correlation function appearing in (48) is next assumed to be independent of l:

$$\mathrm{cor}[X_i X_{i+d} | W_i = 1, W_{i+d} = 1, L = l] = \mathrm{cor}[X_i X_{i+d} | W_i = 1, W_{i+d} = 1] \qquad (56)$$

Although we do not see any obvious reason why this function should depend strongly on l, we do best in not considering (56) as an exact relation. What is important in our connection is the fact that (56) taken together with (55) simplifies the estimation problem drastically. By substituting from (55), (56) into (48), we get

$$Q = l(l-1) \cdot \sum_{d=1}^{n-1} (n-d) \times \mathrm{cor}[X_i X_{i+d} | W_i = 1, W_{i+d} = 1] \cdot \frac{2}{n(n-1)} \qquad (57)$$

where the sum is now just a parameter, C, independent of d and l:

$$C \equiv \sum_{d=1}^{n-1} (n-d) \mathrm{cor}[X_i X_{i+d} | W_i = 1, W_{i+d} = 1] \cdot \frac{2}{n(n-1)} \qquad (58)$$

Then (47) assumes the form:

$$\mathrm{VAR}[R|L = l] = \mathrm{VAR}[X|B, L = l] \times (1 + l(l-1)C) \qquad (59)$$

Table 5

Model estimates of expectations and standard deviations of daily precipitation amounts on days of precipitation in subsets of l wet days out of 30. Station 2370, List B. October. Unit: 1/1000.

l	$E[X\|B, L = l]$									
1–10	61	68	72	75	78	80	82	84	86	88
11–20	89	91	92	93	95	96	97	99	100	101
21–30	103	104	105	107	109	110	112	114	116	119

l	$SD[X\|B, L = l]$									
1–10	73	82	87	90	93	95	97	99	100	102
11–20	103	104	105	106	107	108	109	110	111	111
21–30	112	113	114	115	116	117	117	119	119	121

For the unconditional variance of the precipitation sums of n days we have

$$\begin{aligned} \mathrm{VAR}[R;n] &= \sum_{l=1}^{n} f_l E[R^2|L=l] \\ &\quad - \left(\sum_{l=1}^{n} f_l E[R|L=l]\right)^2 \\ &= \sum_{l=1}^{n} f_l (\mathrm{VAR}[R|L=l] \\ &\quad + E^2[R|L=l]) - \left(\sum_{l=1}^{n} f_l E[R|L=l]\right)^2 \end{aligned} \tag{60}$$

Therefore this variance depends linearly on C. Instead of estimating C directly from the expression in (58), which would be very difficult, we may therefore estimate C by taking a value for it that will make the value of VAR[R; n] as obtained from (60) equal to its directly estimated value from observations.

In conclusion, in addition to the parameters in the Markov model for sequences of dry and wet days, we have to estimate the six parameters in (50) and the variance VAR[R; n] to get estimates of $E[R|L = l]$ and $\mathrm{VAR}[R|L = l]$ from which the parameters of the subset Gammadistributions are obtained, using (44), (45).

9. REMARKS ON THE USE OF THE MODEL IN SECTION 8

In estimating the parameters for the model of the previous section, observations have been grouped in twelve groups, one for each calendar month, and no attempt has been made to distinguish between observations belonging to the same group.

This implies that the climatological trends within calendar months have been considered as sufficiently small to justify considering conditions as quasi-stationary within periods of the lengths of months. However, in order to eliminate as much as possible influences from the trends, which, although small, do exist, the results obtained for the probability distributions of precipitation sums should be interpreted as valid for periods centered around mid-month days. Results for other periods may then be obtained by interpolation.

The distribution function F(R; n) may then be computed for calendar months for values of $n \leq$ length of calendar month, and for selected values of R, as desired. In this article we shall just reproduce F for $n = 30$ and for values of R given by $100 \cdot R/E'[R] = 2, 5, 10, 15, 25, 30, 50, 75, 100, 150, 200, 250, 300$, and 400, where $E'[l]$ is an estimate of E[R; 30]. The numbers are tabulated in Table 10 in the Annex.

In Fig. 2, points (F, R/E′[R]) for the above values of R as found for station 3845 have been plotted and connected with unbroken lines. In the same figure crossmarks give a selection of corresponding points as obtained by frequency countings from 82 years of observations.

The degree of correspondence between model and observations for the main frequency range, which one finds by visual inspection of the above curves, is typical for all 32 stations in List B. A closer inspection shows that there is also satisfactory correspondence for the extremely high values of R, with no clearcut systematic difference, when all 32 × 12 distributions are considered.

However, the model seems to underestimate somewhat the risks of very dry events, approximately $R/E[R] \leq 0.15$, for a majority of months and stations in Southern Norway, whereas in Northern Norway this tendency is less obvious. The correction transformation

$$F^* = 0.01 \cdot \left(1 - e^{-\frac{R}{E[R] \cdot 0.05}}\right) + 0.99\, F(R/E[R]) \qquad (61)$$

$$R^* = \frac{R}{0.99}$$

may be used to correct the tabulated values for n = 30, as a preliminary measure, until more is known about the reasons for the mentioned discrepancy.

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Note added in proof. According to observing practices at Norwegian meteorological stations, the numbers in Table 6 express the probabilities that precipitation is falling within the time it takes to make the full set of observations, approx. a quarter of an hour. As compared with instantaneous precipitation probabilities and intensities, the numbers in Tables 6 and 8 will therefore be somewhat too large and small, respectively, and the numbers in Table 7 too large.

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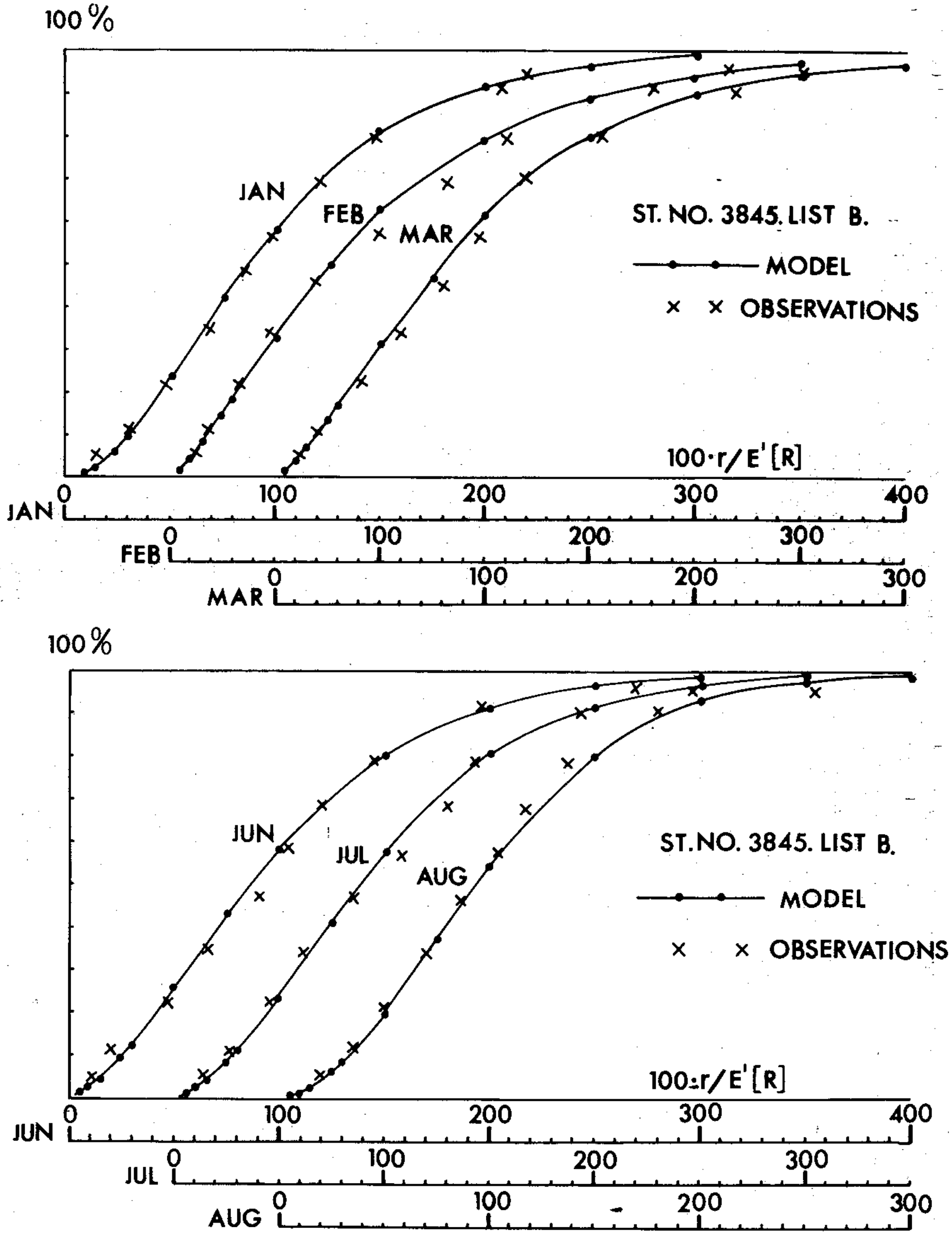

Fig. 2. These diagrams represent examples of probability distributions of 30 day precipitation sums as percentages of estimates of the corresponding expectances. Dotted points represent values computed from model, while crosses are frequencies obtained by direct counting from observation series. The diagrams are drawn in order to give a visual impression of the typical goodness of the model in the main frequency range.

Station List A. A station number referred to in the text corresponds with its sequence number in the station list, which for convenience is arranged in groups of ten and ten stations, headed by the first and last numbers of each group. The first column contains the official archive numbers of the stations, the next three their geographical coordinates, latitudes, longitudes in degrees and minutes, and heights above sea level in meters, respectively.

```
      ST.NO   1 -  10
0020 6120/1215/ 356
0070 6153/1203/ 672
0113 5900/1132/ 157
0140 5909/1134/ 114
0290 5959/1207/ 150
0307 5920/1054/  34
0315 5919/1103/  57
0341 5930/1117/ 141
0398 5942/1118/ 154
0478 6012/1105/ 202
      ST.NO  11 -  20
0487 6004/1116/ 247
0493 6006/1123/ 162
0565 6013/1201/ 175
0604 6037/1201/ 184
0701 6110/1127/ 240
0755 6122/1123/ 262
0825 6137/1054/ 303
0871 6153/1009/ 739
0885 6202/1047/ 485
0960 6218/1045/ 483
      ST.NO  21 -  30
1040 6234/1123/ 628
1103 6009/1127/ 152
1150 6042/1052/ 264
1209 6044/1106/ 153
1218 6048/1112/ 200
1255 6046/1048/ 128
1264 6105/1029/ 271
1266 6106/1029/ 226
1354 6135/0947/ 249
1355 6136/0946/ 241
      ST.NO  31 -  40
1367 6131/0923/ 865
1431 6144/0933/ 285
1460 6152/0906/ 371
1469 6149/0858/ 746
1536 6142/0817/ 674
1554 6152/0827/ 378
1572 6154/0752/ 712
1655 6204/0908/ 643
1660 6207/0917/ 952
1661 6207/0917/ 972
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      ST.NO  81 -  90
3450 5900/0913/  67
3586 5838/0909/   4
3620 5824/0848/  12
3656 5839/0838/ 169
3723 5902/0831/ 252
3814 5820/0831/   6
3904 5812/0805/  12
3910 5804/0803/   9
3917 5810/0759/  22
3969 5840/0748/ 212
      ST.NO  91 - 100
3971 5840/0749/ 206
4014 5906/0730/ 443
4090 5938/0726/ 920
4111 5803/0727/ 138
4166 5815/0719/ 260
4177 5759/0703/  13
4216 5807/0634/  14
4280 5840/0642/  57
4334 5826/0554/  63
4350 5833/0621/ 196
      ST.NO 101 - 110
4408 5839/0533/  24
4432 5848/0538/  14
4456 5853/0538/   8
4464 5857/0544/  72
4590 5911/0604/   1
4651 5950/0659/1079
4661 5939/0622/   5
4691 5929/0545/  64
4720 5909/0515/   7
4730 5918/0453/  55
      ST.NO 111 - 120
4790 5951/0600/  24
4833 5955/0504/  15
4949 6019/0639/  12
4991 6034/0656/  60
5013 6013/0559/   1
5030 6024/0555/ 408
5046 6016/0521/  50
5050 6018/0513/  48
5054 6023/0520/  39
5056 6024/0519/  41
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```
      ST.NO 161 - 170
6537 6325/0804/  30
6595 6351/0828/  28
6610 6320/0939/ 300
6670 6250/1001/ 424
6671 6250/1001/ 441
6683 6237/1015/ 543
6817 6325/1026/ 113
6830 6312/1107/ 197
6886 6325/1027/ 127
6907 6319/1056/ 671
      ST.NO 171 - 180
6910 6328/1056/  12
6936 6325/1146/ 218
6995 6348/1112/  76
7036 6340/1201/ 251
7085 6410/1229/ 195
7091 6415/1225/ 127
7155 6342/0936/   9
7165 6351/0944/   4
7199 6424/1027/  18
7214 6413/1113/  85
      ST.NO 181 - 190
7285 6436/1216/  22
7347 6427/1336/ 403
7349 6427/1343/ 462
7541 6448/1033/  33
7560 6506/1142/  47
7632 6528/1213/   5
7650 6552/1211/   6
7719 6551/1312/   4
7742 6511/1325/ 339
7765 6537/1402/ 380
      ST.NO 191 - 200
7795 6553/1318/ 634
7940 6616/1359/  31
7948 6619/1410/  51
7980 6630/1514/ 549
8010 6624/1237/  10
8070 6649/1359/  39
8145 6710/1501/ 793
8162 6658/1518/  26
8180 6634/1521/ 680
8208 6715/1523/  14
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      ST.NO 241 - 250
9371 6901/2304/ 330
9390 6845/2332/ 382
9426 7041/2340/  69
9450 7106/2400/  13
9470 7104/2614/  33
9489 7027/2513/  12
9490 7027/2513/  10
9535 7004/2459/   5
9543 7004/2507/  35
9640 7105/2814/   8
      ST.NO 251 - 260
9680 7024/2812/   9
9708 6954/2625/ 112
9725 6928/2530/ 129
9735 6922/2426/ 286
9840 7042/3005/   9
9855 7022/3106/  14
9870 7005/3006/   6
9915 6951/2925/   8
9937 6944/2954/  89
9953 6910/2915/  54
      ST.NO 261 - 265
9971 7431/1901/  16
9972 7630/2504/   6
9979 7804/1338/   7
9986 7813/1535/  37
9995 7056/0840/  10
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      ST.NO  41 -   50
1715 5923/1047/   40
1729 5926/1036/   12
1785 5940/1047/   95
1870 5957/1043/   94
1895 5959/1041/  514
1940 5954/1037/   10
1948 5954/1031/   59
1971 5951/1026/  154
2036 6012/1019/  192
2124 6047/1012/  159
      ST.NO  51 -   60
2167 6056/1007/  485
2316 6055/0918/  634
2350 6107/0904/  525
2354 6114/0856/  822
2483 6033/0910/  369
2487 6034/0908/  165
2496 6043/0857/  542
2559 6031/0813/  810
2561 6032/0813/  768
2573 6031/0752/  988
      ST.NO  61 -   70
2584 6036/0730/1224
2590 6037/0725/1300
2648 5953/0954/   58
2689 5944/1012/    5
2723 5919/1031/   31
2735 5914/1017/   76
2741 5909/1027/   43
2745 5914/1021/   26
2747 5912/1016/   90
2750 5902/1032/    6
      ST.NO  71 -   80
2836 5940/0939/  171
2880 5954/0932/  288
2977 6025/0827/  871
3161 5951/0804/  948
3197 5951/0840/1828
3210 5923/0911/   26
3242 5933/0825/  614
3243 5933/0825/  655
3306 5927/0800/   77
3412 5852/0936/   12
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      ST.NO 121 -  130
5159 6039/0630/  125
5167 6041/0645/  560
5230 6050/0556/  104
5253 6045/0443/   20
5286 6102/0523/   39
5310 6110/0639/   51
5413 6104/0731/   36
5516 6130/0742/   27
5523 6131/0754/2062
5535 6126/0725/  484
      ST.NO 131 -  140
5543 6140/0717/  324
5578 6111/0652/   53
5584 6126/0646/   10
5718 6128/0551/   41
5775 6134/0448/   10
5776 6134/0448/    9
5807 6147/0611/   51
5870 6156/0714/  201
5880 6156/0606/   71
5910 6202/0459/   38
      ST.NO 141 -  150
5958 6222/0600/   30
5961 6206/0535/   41
5971 6212/0608/   35
5980 6220/0516/   38
6020 6218/0648/   84
6050 6214/0725/    8
6065 6218/0714/   50
6083 6230/0641/   26
6099 6234/0607/   22
6104 6236/0619/   13
      ST.NO 151 -  160
6115 6237/0710/   49
6177 6214/0822/  621
6249 6252/0632/    8
6265 6258/0709/   26
6330 6224/0834/  869
6350 6233/0906/  195
6390 6218/0936/  885
6426 6307/0745/   48
6458 6250/0831/    3
6510 6312/0900/    9
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      ST.NO 201 -  210
8229 6716/1422/   11
8240 6724/1354/   14
8312 6750/1447/    6
8370 6803/1602/   60
8479 6828/1730/   32
8490 6826/1805/  512
8524 6819/1539/   20
8538 6809/1439/   11
8578 6753/1303/   31
8590 6730/1204/    8
      ST.NO 211 -  220
8595 6725/1153/   18
8626 6821/1358/   10
8652 6839/1517/   23
8676 6838/1428/   12
8710 6919/1607/    5
8711 6918/1609/   10
8735 6846/1612/   36
8742 6856/1641/   45
8779 6835/1635/    7
8800 6845/1749/   20
      ST.NO 221 -  230
8868 6933/1755/    9
8890 6921/1805/   12
8935 6903/1833/   76
8980 6901/1917/   78
8995 6847/1943/  228
9008 6920/1854/   22
9020 6915/1914/   22
9028 6938/1801/    2
9045 6939/1856/  100
9049 6941/1855/    8
      ST.NO 231 -  240
9080 7015/1930/   21
9126 6934/2014/    3
9133 6915/1959/   37
9135 6923/2018/   46
9175 6945/2102/    4
9235 6950/2153/    6
9270 7020/2128/   10
9314 6959/2322/    3
9330 6935/2332/  374
9370 6900/2302/  306
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Station List B. Stations measuring 24 hr. precipitation amounts. Columns as for Station List A.

```
0060 6151/1151/  696
0165 5918/1140/  113
0535 6023/1134/  147
0655 6103/1153/  513
1010 6231/1101/  788
1252 6047/1058/  205
1835 5956/1045/   83
2012 6007/1024/  442
2188 6102/0931/  679
2780 5912/0958/   31
3490 5916/0846/  464
3845 5831/0821/   85
3922 5813/0754/  151
4289 5849/0643/  475
4448 5841/0559/  263
4480 5849/0555/  230
4645 5950/0650/  393
5035 6028/0554/  370
5056 6024/0519/   41
5147 6039/0614/  319
5711 6126/0513/  162
5896 6200/0639/  340
6522 6316/0900/  133
7210 6415/1112/   86
7380 6441/1339/  376
7785 6522/1416/  500
8020 6623/1312/  110
8190 6708/1605/  142
8350 6748/1559/   76
8685 6849/1448/    3
9175 6945/2102/    4
9330 6935/2332/  374
9560 7019/2533/   10
```

Table 6

Estimates of precipitation probabilities based upon observations on the main observing hours, 00, 06, 12, 18 GMT or 06, 12, 18, GMT, and averaged for calendar months Jan., . . . , Dec. The numbers are arranged horizontally according to months, and vertically in 10 and 10 stations according to Station List B. Unit: 1/1000.

J	F	M	A	M	J	J	A	S	O	N	D
ST.NO 1 - 10											
228	188	154	190	159	131	172	147	152	198	281	246
184	166	164	164	135	139	151	129	125	149	187	188
217	159	145	133	101	71	88	71	111	157	216	183
190	185	125	178	140	117	165	194	167	226	271	234
165	137	104	135	122	106	128	110	132	167	202	166
175	133	99	125	126	100	113	102	133	179	233	179
167	126	104	99	86	87	86	80	104	147	171	135
150	94	92	76	82	71	86	58	95	141	145	118
223	184	145	160	140	137	143	140	187	206	260	235
286	230	165	164	139	109	135	119	148	202	261	257
ST.NO 11 - 20											
250	185	154	159	112	98	113	110	145	192	244	230
182	156	118	123	100	90	107	101	107	153	190	167
205	179	123	136	112	83	101	100	112	151	219	213
154	111	81	103	86	86	98	84	97	114	148	143
144	101	88	102	109	97	132	101	117	129	170	148
261	177	147	127	135	103	113	94	150	197	213	220
183	165	112	129	122	88	122	129	107	152	233	233
209	174	173	184	134	120	141	109	138	161	222	224
165	144	131	146	133	109	142	118	124	139	202	182
183	135	111	111	104	106	139	103	97	123	178	195
ST.NO 21 - 30											
243	225	199	218	146	143	165	135	177	196	252	263
167	159	89	117	102	94	120	113	122	137	228	212
185	151	122	125	97	96	123	101	117	150	191	194
122	103	81	100	98	81	117	100	95	112	144	129
161	150	102	142	140	113	154	127	136	156	244	211
196	145	116	129	108	103	126	108	123	143	199	196
206	145	161	117	106	143	132	90	137	161	197	173
174	153	104	136	141	108	146	129	139	175	228	207
167	90	91	79	56	83	102	67	86	83	139	120
151	156	97	103	132	139	191	182	133	135	206	246
ST.NO 31 - 40											
135	61	79	97	53	70	106	67	70	73	128	102
90	51	57	48	60	117	129	68	100	86	111	82
171	113	90	82	98	98	111	90	108	124	180	174
268	174	145	123	90	130	135	87	123	148	213	245
121	112	126	81	121	125	129	112	146	154	144	134
168	89	110	90	90	117	184	106	193	139	177	177
276	208	191	119	108	124	129	104	205	196	253	305
183	166	149	142	121	150	157	140	149	174	198	202
181	191	158	127	142	141	168	139	129	167	205	230

ST.NO 81 - 90											
269	204	152	132	109	79	105	106	117	173	243	221
213	174	134	110	103	78	83	90	111	157	206	190
255	196	153	136	116	97	98	107	145	182	235	230
293	210	171	141	122	74	99	81	136	207	238	212
265	191	158	146	136	113	140	135	165	199	258	224
251	183	156	129	108	80	95	97	117	167	226	227
309	255	199	158	140	103	107	105	145	192	280	284
254	209	172	141	121	95	106	108	146	183	255	251
221	170	149	137	110	77	95	102	114	147	228	210
410	298	226	173	132	97	132	94	163	213	307	305
ST.NO 91 - 100											
243	163	139	136	151	103	127	144	144	196	242	253
437	321	290	239	233	211	237	226	356	312	407	394
217	113	132	103	44	72	81	73	167	140	169	188
223	171	168	141	119	93	112	119	138	199	238	229
473	364	325	233	228	169	183	161	275	304	400	397
266	213	185	151	137	113	126	135	186	213	294	263
229	185	160	146	128	114	121	129	161	206	248	224
212	167	196	167	177	160	171	175	190	249	254	247
229	174	152	153	145	113	123	113	209	223	270	232
452	368	328	285	239	211	228	177	353	328	386	387
ST.NO 101 - 110											
217	174	150	165	140	148	143	147	171	212	238	224
122	90	94	92	92	86	83	97	92	140	153	137
223	193	182	175	163	165	157	156	201	224	264	230
206	169	150	143	154	138	135	147	190	209	261	236
238	190	198	193	177	203	189	195	265	268	307	279
423	333	326	317	198	242	270	202	400	419	454	378
311	257	278	230	216	219	213	226	310	341	380	356
261	203	214	188	152	170	179	147	245	235	318	290
182	156	130	132	125	122	118	129	186	188	220	192
217	190	163	145	129	126	142	136	190	210	248	231
ST.NO 111 - 120											
245	215	226	211	189	204	228	222	243	297	248	260
194	171	158	128	123	141	126	133	196	199	249	212
256	193	215	184	153	179	181	151	279	274	298	315
213	173	223	153	126	142	176	132	250	223	270	316
269	233	243	208	182	187	192	183	283	272	320	323
293	260	279	228	187	238	224	220	311	309	342	346
207	182	204	178	152	184	163	146	237	220	253	255
257	233	213	200	168	184	188	177	225	245	274	275
268	239	233	212	182	200	205	185	259	275	276	276

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                    ST.NO  41 -  50
236 194 153 130 114  96 100  95 120 171 223 195
197 132 126 135 110  81  85  92 122 153 202 145
163 125 115 114  90  75 105  80  99 133 165 132
254 199 161 161 136 109 129 111 145 168 241 220
192 157 148 149 131 100 136 105 132 158 219 195
255 206 146 141 116  96 121 105 123 173 223 210
319 230 210 160 123 113 145 119 147 206 223 194
192 177 121 135 115  90 126  97 122 152 212 174
159 119  97 113 101  90 125 110 118 135 207 178
212 165 131 130 118 117 129 114 130 152 218 208
                    ST.NO  51 -  60
191 157 137 144 122 124 129 108 131 150 184 168
137 114 114 110  67  75  93  88 106 115 142 135
215 165 156 137 142 116 122 118 157 161 212 205
304 212 222 154 161 157 153 121 196 218 233 254
174 149 123 137 135 120 142 119 147 123 253 216
156 122  92  98 100 102 123  98 113 121 186 173
151 113  99 106 101 104 131 105 125 109 142 137
298 218 196 174 127 113 164 112 183 187 267 256
119 135  97  97  90  87 126 118 111 129 193 154
287 228 231 192 168 151 158 151 221 239 305 311
                    ST.NO  61 -  70
426 379 361 273 197 187 216 210 353 335 473 452
287 286 301 215 208 261 258 251 330 355 325 329
247 191 140 143 126 107 119 108 145 182 232 218
297 187 139 133 113  74 103  74 127 190 244 148
215 161 122 156 125 115 106 113 133 181 240 210
237 196 120 131 116  93 101 113 112 171 264 228
231 165 126 117  91  67  94  65 114 159 192 149
218 184 124 122  94  73  91  86 100 152 222 181
265 198 145 128 110  92  98  92 119 172 243 215
195 165 119 114  95  75  83  91 106 158 193 160
                    ST.NO  71 -  80
244 194 139 143 122  97 135 109 142 179 238 205
244 186 147 159 133 109 142 121 141 175 246 229
108  83  78  76  65  68  92  72  92 106 146 123
325 250 211 205 207 161 175 145 242 242 319 278
195 175 136 137 179 146 168 163 159 161 247 205
194 154 112 120 105  93 127 112 135 174 203 167
351 266 186 203 181 120 147 122 170 171 263 254
351 262 190 203 181 117 147 125 173 171 256 258
272 213 160 132 129  95 133 115 157 179 244 228
240 176 126 128 111  90 105 102 125 182 243 203
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                    ST.NO 121 - 130
290 236 234 189 164 172 191 151 290 300 369 330
243 221 237 192 177 243 247 238 329 303 314 287
317 285 284 229 187 233 229 198 311 336 336 340
294 255 238 206 176 171 178 189 267 293 326 313
282 247 243 214 177 226 230 198 291 303 314 317
126 116 102  75  63  88  98 105 170 171 162 156
158 125 143 122 136 162 173 163 226 202 193 203
182 143 143  91 108 120 125 112 210 194 201 220
318 290 279 273 254 238 248 240 286 320 378 346
213 210 220 151 142 140 157 137 208 266 227 238
                    ST.NO 131 - 140
179 124 167 110 107 131 137 117 210 208 210 224
212 199 189 138 123 152 154 143 232 231 232 238
303 262 268 197 173 209 213 195 313 345 329 356
304 256 309 200 182 217 219 211 344 366 364 368
452 366 347 269 199 244 252 242 394 454 551 519
254 242 235 218 167 185 182 185 218 249 267 281
214 148 173 129 103 138 135 140 232 220 256 255
191 179 164 148 112 136 158 129 217 216 203 227
320 304 286 219 214 217 235 203 292 316 271 329
228 187 178 158 121 138 155 139 188 231 228 246
                    ST.NO 141 - 150
315 295 336 221 194 245 299 202 315 375 345 361
294 259 261 243 213 233 258 220 373 340 370 334
188 201 209 144 110 154 171 151 246 233 256 236
272 246 236 189 170 202 214 190 291 290 311 309
145 175 194  98  85  95 122  76 160 164 164 196
210 201 186 180 129 169 170 168 236 234 226 265
173 192 207 119  90 114 145 108 171 198 179 224
238 241 229 214 161 184 216 175 305 280 282 282
203 191 169 163 134 173 176 154 233 227 223 233
142 156 155 147 123 107 161 129 222 188 228 210
                    ST.NO 151 - 160
196 188 183 158 141 165 170 151 220 230 182 213
 86 167 108 111  65 111 140 108 175 121 125 145
213 202 192 174 117 151 183 142 212 232 223 261
224 209 206 190 144 197 202 163 250 273 249 284
249 261 222 177 109 119 129 107 173 196 248 329
171 174 169 152  89 107 119 102 143 156 148 203
210 179 145 167 129 100 194 129 100 129 217 226
212 222 185 202 154 184 194 146 254 267 232 267
220 239 223 183 167 206 202 177 231 218 183 218
259 234 236 214 170 212 208 191 283 278 254 281
```

Table 6—*continued*

ST.NO 161 - 170											
260	252	248	208	143	179	202	194	296	306	292	294
224	233	202	171	143	191	186	131	204	228	215	254
239	232	219	347	168	200	206	167	283	306	294	392
202	216	185	152	150	173	191	179	200	161	170	181
132	156	140	194	108	131	156	99	162	174	174	199
169	160	167	167	114	132	146	137	133	138	168	174
226	251	222	233	151	196	198	170	267	305	256	280
223	227	203	210	168	195	195	166	223	229	207	272
158	181	171	113	100	147	110	113	157	145	147	142
183	197	172	198	155	200	216	166	236	205	191	204
ST.NO 171 - 180											
185	193	177	188	151	168	177	146	209	216	181	209
251	248	241	177	164	174	149	149	206	199	197	242
139	125	135	98	83	100	97	77	129	153	121	146
173	168	170	165	136	159	143	144	207	203	162	189
208	196	189	148	112	138	126	111	174	199	175	226
234	250	221	197	139	175	179	136	219	277	218	306
192	203	174	174	128	159	180	137	220	231	199	206
204	207	211	187	143	169	159	140	243	265	226	247
253	243	240	226	138	160	184	164	262	288	267	284
234	219	223	219	129	153	156	132	215	275	233	285
ST.NO 181 - 190											
282	256	250	206	137	189	154	171	268	295	250	296
229	220	254	141	111	137	113	123	167	187	190	247
156	139	129	147	94	108	134	102	167	166	159	211
227	219	194	171	161	196	141	126	200	226	187	243
245	245	255	212	174	223	223	188	278	306	241	265
195	168	159	140	101	125	133	115	171	188	153	188
251	225	214	173	142	168	178	163	239	276	251	264
198	196	237	184	131	158	177	165	288	290	267	282
228	230	223	189	118	136	149	149	233	263	267	290
303	311	329	273	187	227	265	206	303	387	300	374
ST.NO 191 - 200											
233	228	201	213	172	227	230	210	309	318	242	238
251	237	236	190	134	144	169	169	231	304	281	290
354	332	273	232	151	217	185	162	262	308	292	343
294	335	316	273	187	175	172	183	275	355	378	374
178	157	154	114	104	110	130	106	120	161	139	161
237	233	217	213	177	242	236	216	272	324	261	261
272	283	257	238	194	217	257	224	294	326	258	284
149	172	161	133	87	113	166	113	160	198	167	207
342	243	301	250	204	233	226	194	300	426	328	329
235	206	211	164	144	191	202	138	233	246	182	197
ST.NO 241 - 250											
136	138	104	100	79	89	94	86	104	118	116	106
181	154	146	142	125	130	137	142	168	181	184	191
194	214	212	196	181	196	168	180	201	217	204	192
289	285	276	225	185	184	151	168	199	262	271	279
323	310	281	249	199	186	157	198	249	318	313	320
177	169	136	126	104	111	111	136	141	176	137	118
112	109	132	113	99	97	87	105	114	143	126	106
183	158	151	133	114	118	118	146	144	162	181	178
113	93	97	102	104	111	125	134	126	129	119	112
229	222	230	209	167	175	143	167	191	208	203	212
ST.NO 251 - 260											
161	174	175	133	112	109	88	105	143	156	143	149
129	130	162	156	99	102	74	87	85	132	147	119
154	131	123	133	103	105	90	92	113	129	157	137
179	158	164	192	117	126	139	124	162	207	193	207
217	236	243	236	192	164	137	181	220	231	222	201
247	240	206	184	153	143	116	143	183	195	191	222
137	146	129	106	99	81	76	92	104	135	118	118
196	205	205	212	154	162	97	171	162	194	214	189
206	210	168	171	135	139	110	144	169	200	238	220
187	196	151	164	133	130	105	139	155	177	200	188
ST.NO 261 - 265											
241	277	264	249	192	203	188	220	241	272	300	265
203	220	215	207	255	203	192	205	254	316	301	241
229	227	202	182	198	172	197	192	211	231	228	234
160	193	171	127	141	96	113	133	153	173	185	177
321	311	318	286	261	229	238	281	320	348	387	358

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                  ST.NO 201 - 210
222 220 194 183 140 178 206 163 214 278 229 227
256 256 252 198 145 227 236 200 290 339 269 294
119 126 110 109  72 103 111  95 123 171 129 120
169 137 167 154 131 144 140 132 179 228 160 148
175 183 173 158 114 137 144 132 163 219 167 176
344 354 366 325 265 290 237 233 300 348 294 273
215 213 247 193 145 187 197 134 204 318 256 219
247 230 208 178 132 151 149 143 190 272 241 270
331 316 311 250 173 222 213 192 300 369 338 362
174 153 159 136  82 113 114 107 126 179 142 177
                  ST.NO 211 - 220
213 196 167 153  95 138 150 120 165 217 194 226
177 171 164 143  94 125 129 104 143 196 188 181
331 341 318 276 220 241 252 240 313 393 349 343
228 234 219 196 151 171 188 160 221 275 253 248
207 199 194 167 125 152 138 106 187 251 223 189
216 235 217 215 158 181 194 180 215 274 242 229
234 243 216 192 143 127 157 159 219 240 227 250
165 199 181 183 113 170 219 206 177 226 193 204
255 272 253 213 195 225 237 229 270 296 241 261
153 210 200 180 138 138 151 155 176 234 196 196
                  ST.NO 221 - 230
188 221 185 183 144 170 185 185 227 258 258 242
240 236 250 179 144 154 167 134 215 253 235 247
247 263 217 207 168 181 194 175 209 275 223 245
183 225 187 178 157 158 181 173 223 248 223 202
104 120  77  81 101 113 139 121 113 118 110  90
226 261 258 243 155 177 194 206 220 316 245 232
355 316 161 167  97 167 161 194 200 226 300 226
202 187 188 155 147 191 174 165 203 223 180 152
295 285 276 264 208 232 224 230 290 320 286 272
254 291 256 231 185 194 193 217 256 334 294 282
                  ST.NO 231 - 240
194 193 181 149 136 171 233 163 167 217 207 195
175 209 207 164 126 128 151 158 167 243 186 185
212 213 226 226 154 167 189 208 231 278 240 228
117 115  89  58  34  58  39  67  80 103  82  75
287 315 278 249 237 251 241 244 276 277 264 264
152 172 159 148 120 140 136 166 149 200 180 144
258 259 241 187 169 181 151 195 226 247 203 220
183 177 169 123 103 107  91 110 138 162 188 176
236 215 208 250 200 180 149 198 221 258 261 241
124  94  97  98 108 102 124 127 112 122 136 129
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Table 7

Estimates of the expected values of the total lengths of unbroken precipitation periods averaged for calendar months. The numbers are obtained from a stationary Markov model combined with estimates of precipitation probabilities and joint precipitation probabilities 6 hours apart on main observing hours. The accuracy of the Markov model is not tested (see Section 2). Unit: 0.1 hr. Month and station arrangements as in Table 6.

J	F	M	A	M	J	J	A	S	O	N	D
ST.NO 1 - 10											
90	85	75	99	70	64	56	54	68	77	109	110
84	75	99	77	92	61	66	66	66	80	93	96
59	92	70	66	42	44	36	44	50	69	81	72
100	112	89	78	68	58	57	85	93	109	120	127
73	89	77	83	72	61	64	69	79	89	86	67
96	100	86	78	73	76	70	65	58	103	108	126
81	75	61	56	41	53	53	43	52	68	74	66
78	65	68	39	61	58	66	46	54	53	65	70
110	83	83	79	77	68	68	71	65	78	96	125
128	102	87	91	63	52	52	56	56	88	98	115
ST.NO 11 - 20											
106	101	90	86	64	64	58	59	68	92	103	106
76	68	69	71	52	53	56	60	42	79	87	72
79	71	87	66	56	46	48	56	55	70	89	88
63	54	48	66	56	50	51	48	50	62	61	68
80	84	71	82	55	55	57	59	60	78	74	94
102	83	62	69	78	61	43	41	54	75	74	115
103	100	82	83	57	62	49	59	54	76	111	133
110	90	97	81	66	65	51	50	71	90	93	87
89	73	74	69	67	63	56	46	66	59	71	83
45	36	38	41	49	51	42	43	36	45	45	51
ST.NO 21 - 30											
57	67	70	63	49	51	52	45	53	61	71	67
85	79	83	88	57	62	56	61	61	59	113	121
83	77	83	77	55	53	52	59	48	74	85	102
95	84	71	63	63	51	76	62	62	69	73	102
77	82	76	78	73	64	64	65	58	75	89	117
92	95	68	77	52	52	50	54	59	76	84	107
115	80	110	78	65	77	72	67	61	126	103	87
92	95	66	76	62	49	43	44	75	65	101	123
79	28	48	56	57	48	35	46	56	54	78	65
95	108	73	69	59	59	75	82	75	80	91	118
ST.NO 31 - 40											
70	53	74	59	30	44	49	57	47	71	75	57
73	43	77	38	57	77	62	49	82	69	74	49
74	55	54	56	53	41	46	50	48	67	64	69
110	46	72	49	51	58	51	42	46	56	64	65
66	54	66	40	57	48	48	40	54	64	40	68
92	48	60	47	54	78	78	62	77	74	67	71
87	64	67	49	42	47	53	53	60	61	76	100
62	65	61	59	52	56	46	53	57	62	72	72
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST.NO 81 - 90											
139	109	94	67	69	58	52	65	73	81	120	101
97	97	89	61	60	52	50	42	52	86	87	78
112	93	92	73	57	49	58	59	53	82	83	94
126	102	97	80	71	50	52	62	64	100	90	99
137	121	103	85	90	87	78	92	95	100	129	129
121	91	83	74	67	63	69	66	62	68	97	99
109	93	92	76	75	64	54	51	58	80	84	93
79	78	75	70	66	54	56	52	58	75	81	90
88	84	77	67	66	68	61	56	58	66	92	101
149	120	96	76	59	46	66	52	62	98	106	109
ST.NO 91 - 100											
97	71	72	76	58	52	58	61	69	63	85	110
194	167	128	112	123	115	85	108	158	135	174	174
110	78	93	90	43	67	59	84	93	85	76	98
74	77	68	64	68	58	71	52	69	73	64	71
175	151	125	88	99	77	76	61	82	109	125	130
69	79	64	66	57	50	56	53	58	70	72	73
67	68	59	62	58	47	55	50	53	66	61	67
101	73	75	82	85	73	78	59	72	75	64	106
66	62	67	77	65	43	63	55	64	70	70	69
122	120	96	101	96	81	98	67	113	110	94	110
ST.NO 101 - 110											
64	45	57	66	43	46	50	50	58	47	56	65
55	37	43	46	35	51	51	43	52	52	57	69
57	51	59	65	60	56	51	46	57	57	56	60
92	85	65	75	83	86	72	70	79	82	75	108
79	69	74	77	86	80	62	71	89	93	94	82
115	110	136	99	82	97	118	94	154	143	127	95
141	103	131	98	101	103	96	75	111	124	131	162
83	61	67	79	43	76	61	58	77	69	79	78
63	51	41	53	59	45	45	48	56	44	54	54
57	47	52	54	55	49	49	44	52	50	54	49
ST.NO 111 - 120											
90	87	81	76	87	87	73	70	80	87	80	107
53	54	50	41	55	60	53	50	57	52	66	60
82	85	93	82	73	71	68	71	92	93	95	131
78	76	110	71	56	72	66	49	76	79	108	107
88	107	84	65	79	77	65	72	88	92	102	128
94	99	102	70	94	94	83	80	111	111	104	131
65	72	78	78	86	83	83	71	86	87	78	86
66	66	64	65	63	67	65	52	59	68	68	74
68	73	69	69	70	70	69	58	64	79	72	75

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                     ST.NO  41 -  50
   89   86   84   68   67   54   47   48   51   71   89   88
   91   82   73   70   60   58   55   54   53   84   87   76
   79   75   74   71   52   58   64   56   46   67   80   77
  116  109   88   71   56   52   57   60   47   68  107  120
   83   79   94   70   62   58   50   50   60   57   95  105
   99  100   88   76   64   53   49   53   51   71   83  101
  115  130   89   69   56   49   54   47   51   87   88   79
  109  129   93   76   66   53   66   60   49   78  104   97
  119   74   62   58   57   54   54   75   54   80  105  108
  112   90   85   78   68   59   48   58   62   81  100  110
                     ST.NO  51 -  60
  100   97   90   80   73   56   51   52   65   83   84  122
   87   93   71   64   50   42   50   41   57   90   76   77
  101   79   78   70   83   66   52   51   68   78   95  106
  106  118  131   87   76   79   70   73   74   88   98  113
   86   93   61   44   53   50   44   49   69   58  112  100
  101   83   65   57   63   48   48   50   59   76  102  109
   83   95   68   57   57   44   57   53   52   69   80   82
  145  117   91   95   65   57   91   71   81  109   98  101
   69  109   64   44   57   59   72   56   51   65   88   82
  108   87   79   68   73   58   63   53   91   94   94  102
                     ST.NO  61 -  70
  124  150  160   99   96   99   90   98  102  131  144  155
  109   90  132   91   86  131  100   81  110  107  113  113
  132  127   99   77   74   53   53   70   73  103  127  147
  114  127   69   88   68   46   56   64   58  113   94   99
  104   82   68   65   77   64   47   60   61   88   94  117
  106  107   94   67   71   46   56   51   61   82  104  101
   84   97   73   68   53   42   47   51   56   84   81   68
  104  110   94   65   66   63   50   53   55   71  105   86
  104   96   92   63   64   55   59   47   65   75  105   85
   80   87   78   64   63   58   52   52   52   66   70   77
                     ST.NO  71 -  80
  145  108   90   74   61   50   53   60   74   90  133  104
  122  125  101   69   68   54   63   83   66  110  118  113
   63   45   49   37   40   47   57   46   56   70   63   65
  108   79   99   81   91   75   71   71   87   99   99  108
   70   74   56   50   61   59   58   62   56   70   80   79
  105   88   72   62   61   57   60   57   79   82  109   93
  252  118   83  121  105   55   63   56   76   57  101  119
  245  122   88  117  102   57   61   54   73   57  105  121
  147  140  119   73   69   58   62   58   71   85  104  103
  103   97   92   75   74   60   67   50   63   81   97   90
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                     ST.NO 121 - 130
   72   86   89   62   69   61   65   58   78  108  101   81
  118  102  113   75   72   95  100   87  115  136  130  130
   98   97  127   99   78   80   83   72  108  124  104  121
   72   72   73   75   68   71   69   77   74   71   79   83
  114   97   88   81   73   91   90   68  116  107  102  115
   58   80   60   42   43   46   45   45   58   61   59   70
   70   59   72   43   56   51   44   55   70   60   80   77
   76   70   53   46   64   42   47   37   62   56   71   87
   83   87   92   78   89   79   70   77   76   80   91   88
   90  100   90   73   69   76   59   58   72   99  103  106
                     ST.NO 131 - 140
   63   67   92   59   53   58   75   64   58   60   77   88
   73   80   91   65   58   55   50   50   70   84   81   87
  131  106  128   80   79  100   83   74  101  119  121  164
  113  106  117   86  100   97  106   97  124  133  128  159
  138  133  116   71   77   86   74   93  119  157  163  136
   68   60   66   72   64   62   63   53   65   60   71   64
   72   38   63   60   50   75   68   66   82   72   74   84
   78   79   56   50   59   55   52   44   59   69   80   80
  109  110  106   83   83   89   67   57   79   80  106  139
   58   61   54   53   52   53   51   52   56   58   53   61
                     ST.NO 141 - 150
  147  104  133   91  114  136  100   76   98  116  134  130
  101  111   95   79   72   76   62   67   88   87   87   75
   89   82   83   71   71   60   61   54   82   84   88   86
   62   63   75   53   60   72   62   57   68   67   59   66
   56   68   74   37   55   48   60   40   55   75   65   58
   96   93  111   89   69   64   64   61   78   87   99  117
   69   72   85   70   61   54   52   45   54   71   78   82
   92   85   73   71   68   67   66   64  101   84   73   84
   42   51   44   44   55   50   45   48   51   56   52   47
   44   55   42   55   69   37   48   51   57   58   50   41
                     ST.NO 151 - 160
   67   62   76   68   47   60   51   50   66   67   72   72
   21  148   70   36   29   36   31   30   78   54   38   61
   67   69   57   49   52   65   64   51   72   70   54   66
   62   64   66   59   70   66   68   55   66   74   68   80
   95  114  125   84   47   44   39   55   69   97   93  118
   88  107  102   71   49   60   48   46   62   65   81  118
   87   92   67  110   54   82    0   35   82   35   66   66
   59   53   60   58   50   68   54   51   63   60   66   64
   83   82   93   78   68   68   64   56   63   74   90   98
   94   71   84   70   65   69   62   54   66   67   67   85
```

Table 7—*continued*

```
                         ST.NO 161 - 170
 82   77   67   49   55   72   64   61   71   84   73   72
 55   64   59   57   62   82   73   48   49   59   53   61
 94   92  153  122   84   72   85   54  139  103   86  123
 80   81   99   79   66   64   75   63   57   76  109   99
 60   68   91   63   70   47   57   50   64   56   78   89
 66   60   77   59   53   78   56   51   50   52   67   70
 82  103   86   75   68   71   61   60   75   78   71   81
 65   93   83   77   84   64   61   47   69   59   62   83
 42   67   67   57   36   64   39   46   38   41   55   44
 64   73   72   79   77   81   77   59   82   74   63   64
                         ST.NO 171 - 180
 56   67   68   65   60   65   55   51   53   56   55   63
 59   89   97   86   68   68   52   68   85  101   80   80
 48   49   64   45   38   53   37   30   36   47   42   34
 46   55   56   57   44   52   37   33   49   44   50   53
 64   69   70   52   46   48   52   45   55   54   53   61
 93   90   99   84   59   72   54   59   79   85   57   64
 56   54   54   61   49   65   54   49   48   53   62   52
 76   59   72   61   59   60   49   51   66   65   80   67
 93  105   95   68   52   60   85   64   73   92   71   96
 97   77  108   77   54   49   54   47   64   81   57   77
                         ST.NO 181 - 190
105  100  112   77   73   92   64   71   99   97   90  109
 55   75   74   40   50   37   50   35   46   53   69   54
 65   53   60   52   45   51   66   45   68   46   62   87
 58   58   66   70   67   51   46   50   62   64   52   63
 72   68   96   78   72   72   76   63   70   78   68   79
 55   61   56   51   52   48   46   61   53   45   49   62
 74   67   68   63   65   58   67   65   79   83   70   66
 82   75   90   87   62   72   68   67  100   91   98  104
104  102  105   53   51   64   59   68   87   87   75   98
108  113   96   78   60   81   68   65   98  118  101  113
                         ST.NO 191 - 200
 78   70   72   79   75   83   80   75   92   97   80   73
 86   85   83   83   65   76   57   57   76   93   85   80
118  113  117   91   60   82   60   59   89  111  112  130
108  131  135   89   95   81   57   95   63  102  119  121
 62   52   61   47   54   51   60   46   42   57   54   51
 86   84   86  102   86   92   95   70   90  115  117  120
116  108  115  101   89   89  111   92  115  124   99  120
 66   69   70   49   37   50   41   43   49   56   65   80
162  105  120  101   67   68  102   72   91  156   96   94
 90   74   78   72   58   64   61   53   83   78   70  108
```

```
                         ST.NO 241 - 250
 64   52   58   52   54   39   51   57   49   57   47   71
 54   58   64   56   48   50   46   47   56   62   59   68
 47   52   59   54   55   58   64   63   53   59   59   51
 61   57   60   58   58   59   55   65   54   56   59   64
 89   73   79   82   77   74   63   79   73  106   89   99
 59   51   48   46   31   36   40   74   50   43   57   44
 40   38   47   31   36   55   35   34   32   44   52   24
 48   48   51   54   53   54   45   63   53   49   47   53
 44   44   36   51   48   44   44   56   47   43   42   38
 52   47   49   49   51   55   53   57   48   54   59   52
                         ST.NO 251 - 260
 34   49   56   46   39   44   36   43   52   42   45   36
 48   46   67   66   57   50   39   54   41   49   57   45
 42   45   47   50   43   51   40   36   40   43   55   54
 66   69   56   63   59   69   57   43   51   76   74   73
 80   93   74   76   62   64   60   59   76   78   69   75
 49   54   54   47   45   56   49   49   52   49   53   54
 42   45   49   64   47   39   40   48   52   48   39   26
 53   71   59   79   59   50   31   55   50   64   65   57
 52   54   49   55   50   54   52   48   49   53   68   60
 51   67   48   55   48   48   42   54   54   54   72   61
                         ST.NO 261 - 265
 51   51   55   52   48   49   52   65   56   52   49   55
 55   60   72   68   81   61   52   67   59   63   62   62
 78   72   65   70   70   69   66   70   65   66   77   73
 59   88   71   62   60   59   51   59   42   63   68   80
 74   67   74   70   74   62   63   68   76   70   83   76
```

```
                     ST.NO 201 - 210
  64  63  58  68  59  55  64  48  55  72  60  60
  65  88  69  77  48  70  67  59  75  70  71  76
  56  46  45  53  36  40  48  54  45  72  50  39
  78  53  57  76  55  49  59  68  62  65  74  58
  59  72  53  67  55  47  46  45  45  77  60  62
 134 121 172 107  94  88  66  61  98 117 112 106
  75  62  64  85  74  54  55  65  45  75  60  67
  57  55  52  59  55  54  54  49  55  74  55  64
  76  78  91  76  73  66 104  80  82 108  86  84
  47  41  54  53  48  48  60  41  43  52  36  61
                     ST.NO 211 - 220
  53  41  54  54  49  53  57  40  52  59  44  48
  56  49  46  60  47  53  51  47  45  66  54  52
 127 141 154 125 106  96 101  99 116 154 129 147
  61  54  66  64  55  59  62  47  61  70  50  58
  53  58  59  62  58  60  50  53  65  62  56  54
  53  58  60  61  55  56  58  59  54  64  51  47
  82  77 103  61  48  52  54  52  67  74  60  66
  57  64  63  50  63  61  56  48  47  83  57  48
  82  67  81  74  75  86  67  78  75 110  78  91
  74  82  76  65  68  50  63  49  67  89  81  74
                     ST.NO 221 - 230
  52  56  59  62  56  47  47  46  42  53  53  53
  83  92  89  88  63  56  71  55  54  71  76  74
  83  85  72  74  62  55  59  58  56  76  67  83
  93  99  79  75  59  64  73  69  79  86  83  95
  59  49  38  42  53  54  74  70  64  63  50  34
  84 104  89 115  79  55  60  58  57  86  87  81
 112  84  93  39  82 110   0  28  27  75 106  51
  42  50  38  60  54  62  63  53  64  53  57  37
  92 100  73 102  71  61  76  70  67 102  85  84
  78  95  98  87  72  71  64  72  64  94  78  87
                     ST.NO 231 - 240
  52  45  51  48  55  59  92  63  47  61  51  50
  82  97 107 125  62  56  63  57  74  72  90  92
 118 108 103 125  67  82  77  59  70  91  98  91
  66  72  53  45  34  38  28  41  51  64  77  65
 130 126 128  95  92  66  73  77  79 100 101 132
  64  69  64  57  64  53  57  69  60  84  66  55
 134 107 115  80  87  91  81 102  75 107  98 106
  50  53  68  46  45  38  40  46  35  48  50  50
  89  60  48  74  75  62  54  54  70  59  76  72
  56  44  64  53  61  56  56  47  55  62  58  60
```

Table 8

Estimates of the expected values of precipitation intensities greater than zero, averaged for calendar months. Unit: 0.01 mm hr⁻¹. Month and station arrangements as in Table 6.

J	F	M	A	M	J	J	A	S	O	N	D
ST.NO 1 - 10											
19	23	25	31	53	88	82	81	79	59	34	28
20	17	19	23	38	61	81	76	65	38	31	25
39	37	49	52	77	115	116	114	127	82	67	50
47	36	32	39	59	86	77	87	63	67	47	44
37	35	40	45	64	82	90	100	86	59	52	41
43	43	46	46	66	86	82	123	86	83	60	49
49	51	55	65	94	108	121	140	119	91	79	65
53	70	64	82	86	133	112	150	149	92	85	69
30	33	38	44	66	76	87	84	78	73	48	31
29	29	36	43	59	90	96	101	87	66	53	37
ST.NO 11 - 20											
0	0	0	0	0	0	0	0	0	0	0	0
29	30	34	42	66	93	103	94	97	63	49	37
22	23	27	37	63	91	103	101	92	58	41	26
31	36	43	48	78	94	117	111	97	70	54	38
48	50	50	59	73	101	96	94	89	77	59	54
28	32	28	34	65	89	118	95	74	49	42	32
22	20	27	34	51	86	107	80	87	58	34	24
19	17	17	18	40	75	91	82	57	44	27	21
15	17	19	22	43	88	85	71	65	47	26	19
12	13	16	16	35	69	71	67	66	36	19	16
ST.NO 21 - 30											
17	18	20	15	25	53	57	56	36	27	20	20
34	32	43	45	75	98	101	98	89	85	45	35
27	24	27	34	54	82	93	93	74	55	43	28
38	36	31	36	51	90	80	84	81	58	43	37
30	26	31	29	51	66	66	69	61	56	32	28
25	26	29	35	52	80	83	88	69	59	39	25
36	35	39	44	59	70	86	89	72	52	46	36
35	30	37	43	58	78	85	95	75	69	48	41
22	19	22	25	55	79	90	69	65	50	33	23
19	15	19	16	34	49	51	50	53	47	23	17
ST.NO 31 - 40											
40	45	43	33	92	124	107	97	90	70	50	40
29	23	28	27	63	77	71	70	57	44	37	31
16	20	18	15	35	60	65	58	50	39	20	20
19	20	20	15	37	64	80	60	50	33	30	24
42	32	36	27	37	50	55	63	52	57	36	41
17	19	10	8	19	38	39	34	17	23	21	23
25	22	28	12	28	37	45	47	38	41	34	34
20	21	19	12	30	47	51	46	36	33	24	24
24	21	22	19	29	55	53	59	45	31	19	22
ST.NO 81 - 90											
43	39	38	56	75	114	117	118	131	97	79	53
48	40	47	62	78	87	113	132	111	90	75	48
41	37	41	50	64	74	87	101	88	76	69	44
56	51	60	63	85	126	121	138	149	94	94	62
36	36	38	47	71	84	94	109	97	74	69	45
62	59	59	72	98	120	124	154	151	119	100	62
55	46	47	58	81	94	117	154	130	104	88	57
60	53	52	60	73	86	99	131	110	97	87	58
85	78	60	72	106	131	142	171	178	137	115	87
37	35	41	51	77	98	90	126	119	75	83	47
ST.NO 91 - 100											
58	66	54	63	84	119	112	130	131	109	94	64
29	30	28	30	50	49	46	62	55	54	45	35
57	69	54	56	104	98	103	108	97	87	105	78
87	83	68	79	101	117	129	149	156	115	113	84
42	37	42	44	61	72	72	102	100	79	77	55
52	50	50	62	67	73	91	106	87	80	70	52
51	44	50	63	72	75	94	110	110	84	85	60
85	97	73	74	82	96	102	113	143	132	104	91
76	63	77	65	62	76	98	89	94	79	95	73
60	52	56	52	61	74	73	100	106	97	115	79
ST.NO 101 - 110											
62	61	65	58	70	76	94	102	121	91	91	72
97	117	96	92	99	133	135	199	204	156	114	119
49	45	46	40	56	63	80	100	104	78	71	59
57	60	65	53	61	83	97	108	113	94	82	63
56	61	65	49	56	64	78	76	86	81	75	68
30	25	29	22	32	50	48	57	68	58	44	34
83	78	72	58	63	82	77	89	104	100	94	85
98	86	92	73	90	95	112	131	158	122	141	110
80	73	79	73	74	90	97	111	113	99	102	85
58	54	57	65	66	79	71	106	100	81	81	63
ST.NO 111 - 120											
123	127	142	92	95	143	124	128	165	173	150	134
70	63	68	75	76	88	98	107	110	103	90	82
59	60	62	41	44	52	62	64	78	86	72	69
78	83	75	52	55	72	76	78	95	111	89	93
105	94	114	76	83	107	109	112	152	147	137	121
116	110	105	87	98	119	112	125	150	158	131	122
105	113	95	89	96	116	126	150	151	143	133	103
71	69	72	63	69	90	94	104	131	113	101	82
0	0	0	0	0	0	0	0	0	0	0	0

```
                        ST.NO  41 -  50
 34   29   36   46   67   84  104  118  108   78   59   44
 33   36   41   44   71  100  110  120  106   80   64   47
 39   38   41   52   89  117  104  136  125   93   72   52
 27   25   32   37   50   79   93   99   78   66   46   33
 55   47   42   54   75  116  124  150  126   94   73   53
 23   22   30   40   57   89   91   99   87   59   47   29
 31   28   43   43   53   78   99   79   80   50   61   38
 44   39   45   56   74  110  103  139  114  103   76   53
 31   33   37   44   69  104   96   97   78   74   45   34
 28   25   30   37   59   81   93   97   87   67   45   32
                        ST.NO  51 -  60
 35   31   38   40   56   90   90   80   88   66   49   42
 37   31   32   34   86  122  124  105   83   70   53   40
 25   22   22   22   45   72   84   76   51   48   33   24
 32   21   23   21   41   73   82   76   45   30   39   25
  0    0    0    0    0    0    0    0    0    0    0    0
 23   20   19   21   49   72   84   73   73   59   36   25
 31   27   36   32   47   80   84   68   67   66   44   36
 24   23   30   27   43   62   67   58   54   52   39   31
 40   30   33   33   58   89   82   97   72   73   42   46
 26   26   23   22   34   49   67   60   45   43   29   30
                        ST.NO  61 -  70
 26   16   20   18   33   48   64   69   51   40   35   29
 35   33   31   28   30   44   57   56   50   50   28   37
 28   26   28   39   56   82   89  104   75   69   53   35
 36   38   39   43   66   97   81  119  103   71   59   47
 36   36   35   48   66   87   87  124  109   96   64   36
 53   50   53   70   82  111  131  149  141  122   89   63
 39   39   47   54   75   96  103  135  117   70   79   51
 54   47   56   68   94  117  118  150  145  112   89   64
 37   35   43   58   84   99  110  144  127   99   79   49
 37   30   40   51   65   85   90  111   98   77   67   49
                        ST.NO  71 -  80
 32   29   36   43   61   90   91  103   81   75   54   38
 30   28   32   36   57   83   96   95   86   71   52   34
 39   38   35   39   64  100  109  111   78   67   44   41
 23   23   21   22   38   57   70   73   59   41   28   26
 81   76   83   83   68   95  106   90   99   93   80   99
 34   32   42   42   72   91   96  106   96   68   60   41
 28   29   26   39   51   92   92  114   94   84   51   33
 30   32   30   43   54  102   98  114   97   89   55   37
 29   29   32   44   68   91   94  109   95   77   58   39
 48   47   57   56   69   82   95  115  104   88   75   54
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                        ST.NO 121 - 130
 48   45   47   35   47   59   59   65   81   71   67   60
 64   57   59   39   49   62   58   65   84   74   72   72
108   93   95   79   82   98   95  120  134  134  130  121
 52   50   50   52   48   52   68   76   80   71   68   59
138  121  123  101  103  109  102  124  170  166  158  147
 92   81   93   83   94  101  102   99  110  108   99   98
 28   23   20   14   21   29   38   36   36   43   32   30
 44   41   40   29   43   55   60   71   57   62   49   46
 44   41   35   32   32   43   56   60   54   46   40   46
 70   62   62   40   53   77   65   73   76   82   69   75
                        ST.NO 131 - 140
 96   96   82   59   82   76   72   98  102  104  112  102
 53   43   48   33   41   48   50   63   70   70   61   59
 76   68   68   54   56   64   66   80   95   89   85   81
 90   79   89   67   65   76   82   82  118  103  109  104
 50   48   45   45   53   56   64   70   76   57   59   50
 85   82   76   77   72   86   97  109  124  135   94   94
 70   69   59   54   63   61   67   73   89   87   97   96
 71   70   70   39   53   58   65   70   80   80   73   82
 75   77   76   63   51   66   65   65   87   99   80   84
 63   62   57   56   60   82   87   99  107   88   93   73
                        ST.NO 141 - 150
 56   63   62   55   50   68   61   79  101   92   70   78
 70   66   63   59   55   62   69   89  112   93   99   93
123  122  112  110   93  100   96  121  153  144  127  147
 27   27   25   31   33   37   43   53   48   45   43   30
 97   94   83   88   79   91   83  121  112  127  120  128
 54   53   51   37   39   39   48   51   59   59   62   61
 81   82   78   83   68   62   60   79  101  108  110  105
 75   78   81   64   57   68   64   88   96   99   90   98
 62   61   64   61   54   60   67   86   98   98   90   73
 73   71   66   75   68   99   96  130  119  142  116  108
                        ST.NO 151 - 160
 74   69   66   50   53   61   78   78   87   82   82   79
 44   30   23   19   22   41   54   47   48   35   62   30
 59   47   53   53   51   57   64   76  100   89   82   74
 63   65   56   54   50   54   62   79   91   82   76   70
 34   33   41   23   33   47   63   66   46   41   28   34
 54   50   51   40   47   60   67   63   59   62   62   59
 15   12   18   12   14   57   51   58   25   30   20   13
 56   53   57   46   47   55   66   78   81   79   63   66
 58   54   66   51   50   63   73   81   91   83   64   60
 72   77   69   64   55   66   66   75   90   92   79   87
```

Table 8—*continued*

ST.NO 161 - 170

46	41	41	42	40	48	59	55	68	66	61	60
49	45	48	44	35	41	45	56	57	68	56	58
76	60	50	52	68	52	57	80	93	85	77	75
41	43	41	34	36	57	60	67	58	46	40	36
52	46	49	34	50	67	77	70	62	70	54	60
22	25	21	19	36	68	70	56	66	46	28	25
36	32	34	29	36	42	48	42	56	50	39	43
34	34	35	32	43	58	62	71	60	53	41	34
66	59	59	51	64	75	79	84	94	85	59	65
48	53	59	58	55	72	76	78	74	72	58	55

ST.NO 171 - 180

42	41	40	35	45	62	64	67	73	66	54	48
42	44	38	38	41	64	71	71	65	65	43	41
55	59	58	43	72	78	90	97	90	81	66	53
48	47	43	45	55	74	91	80	80	73	59	56
47	45	43	44	52	80	96	98	81	67	52	51
56	49	50	37	38	51	75	69	74	56	50	54
58	51	54	45	55	64	61	72	84	77	68	68
51	53	44	44	44	58	62	63	65	66	54	54
37	32	32	33	39	44	52	50	53	53	43	39
70	74	52	50	51	67	75	71	96	79	80	79

ST.NO 181 - 190

67	62	60	47	50	64	72	64	74	74	66	68
34	27	18	21	29	57	89	69	55	48	39	33
56	49	39	31	41	70	81	82	61	53	48	52
45	38	43	36	32	39	38	61	57	53	52	42
70	58	57	53	47	57	59	77	80	77	73	70
90	91	99	79	76	101	110	118	125	138	105	106
53	47	54	48	50	60	61	71	75	73	60	54
113	95	95	73	76	71	74	85	90	100	91	92
67	58	54	44	54	67	86	75	84	70	59	65
49	37	46	30	28	32	51	37	48	53	40	47

ST.NO 191 - 200

0	0	0	0	0	0	0	0	0	0	0	0
67	66	63	51	62	68	75	87	89	77	67	73
64	63	55	37	44	60	62	56	75	87	61	64
41	38	31	23	29	33	54	49	42	40	39	46
85	87	86	85	72	92	90	122	143	130	118	105
106	106	98	70	65	67	82	90	122	115	106	114
0	0	0	0	0	0	0	0	0	0	0	0
60	57	52	35	41	58	65	73	77	70	58	58
20	20	23	14	26	23	47	41	30	31	21	20
61	48	51	44	48	55	68	63	69	88	66	61

ST.NO 241 - 250

18	20	18	16	39	47	66	72	56	22	29	20
15	14	12	14	26	48	67	60	32	23	15	13
47	47	44	35	35	40	46	51	58	52	47	50
42	40	36	33	32	35	42	44	47	43	43	44
34	38	33	27	26	31	36	35	33	30	32	34
35	37	37	25	31	57	59	63	50	44	38	36
51	54	45	38	51	66	88	83	77	53	52	57
13	17	13	14	21	42	61	58	36	27	17	15
33	40	32	32	32	50	67	70	58	42	36	37
27	25	22	19	25	30	39	42	41	39	36	29

ST.NO 251 - 260

33	29	24	22	27	47	80	70	50	38	33	36
15	18	14	18	18	30	71	64	52	30	20	18
16	16	14	14	29	62	101	93	48	31	18	18
12	12	14	11	25	41	61	68	36	21	18	12
31	31	23	18	25	34	49	50	45	37	32	37
25	25	22	19	26	41	53	51	44	37	32	28

```
                     ST.NO 201 - 210
 52  44  52  39  44  50  63  70  81  75  60  57
 40  30  34  29  31  31  47  41  50  51  44  36
 87  66  75  65  78  91 116 115 126 118  99  94
 68  67  53  49  49  62  80  70  85  91  68  74
 57  51  41  41  43  63  75  86  75  74  52  54
 34  29  22  21  21  37  48  44  47  51  32  33
 54  53  57  49  42  47  68  79  83  73  60  69
 34  33  35  34  35  43  52  54  61  57  51  43
 68  59  57  56  52  48  65  66  79  92  75  65
 55  51  53  42  45  52  63  47  82  73  72  63
                     ST.NO 211 - 220
 37  32  37  28  38  32  45  47  51  47  44  39
 85  76  77  64  62  59  76  85 107 103  99 100
 54  54  47  40  35  39  45  51  64  70  62  54
 47  47  46  42  36  45  55  64  74  73  58  56
 50  48  48  42  44  47  50  57  68  65  50  55
 41  40  41  34  37  37  38  54  61  60  55  51
 44  44  41  33  29  44  40  54  54  58  56  46
 64  52  61  40  39  41  52  54  69  64  58  62
 36  35  31  26  24  28  38  42  41  45  40  39
 59  51  40  37  36  47  63  72  66  62  59  56
                     ST.NO 221 - 230
 61  64  53  40  42  43  52  65  70  65  65  60
 47  46  38  36  34  47  47  67  61  61  51  49
 35  34  27  20  19  32  41  47  45  37  36  35
 30  37  28  25  22  41  48  50  41  46  36  39
 21  19  15  12  20  35  55  54  37  30  21  21
 38  46  35  31  20  46  58  57  52  42  40  42
 57  49  47  22  55  56  76  45  57  78  77  58
 61  54  49  39  45  49  55  59  70  76  63  65
 43  44  40  31  30  37  45  49  53  53  49  45
 36  44  38  31  30  37  50  54  54  50  46  41
                     ST.NO 231 - 240
 52  46  45  38  47  42  30  53  68  58  51  51
 44  51  41  36  23  45  57  57  45  46  55  50
 28  34  23  19  21  41  44  49  35  37  31  32
 37  32  29  22  55  56 113  73  54  48  44  42
 27  25  24  17  21  27  34  38  34  36  31  28
 25  27  30  18  26  35  56  45  42  34  26  30
 39  41  40  36  41  48  59  64  60  59  52  42
 20  20  22  19  24  50  86  64  40  31  20  23
 15  17  15  11  17  36  63  48  29  20  17  16
 13  13  10  12  24  60  85  73  41  35  17  15
```

Table 9

Monthly model estimates of probabilities that the number of wet days in 30 days is less or equal to 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, and 29, arranged horizontally. Calendar months Jan., . . . , Dec. are arranged vertically. Station numbers are according to Station List B. Unit: 1/1000.

60

0	3	28	123	327	601	834	958	995	***	***
0	9	65	216	461	718	896	976	997	***	***
0	20	119	330	595	813	937	986	998	***	***
1	30	159	406	676	868	961	992	999	***	***
1	25	127	340	605	823	944	989	999	***	***
0	9	55	177	386	633	836	951	992	***	***
0	2	18	82	231	463	713	895	978	998	***
0	2	20	91	254	499	748	914	984	999	***
0	8	52	182	407	665	863	964	995	***	***
0	11	70	226	469	719	892	973	996	***	***
0	4	41	160	380	638	844	954	992	999	***
0	2	21	103	293	561	803	942	991	999	***

165

1	27	129	323	564	776	912	976	996	***	***
4	67	240	484	717	877	960	991	999	***	***
7	94	297	552	771	908	972	994	999	***	***
7	98	309	572	790	920	977	996	999	***	***
5	89	299	571	797	928	981	997	***	***	***
4	65	244	507	752	907	976	996	***	***	***
2	41	175	408	666	859	959	992	999	***	***
2	35	155	375	631	835	948	990	999	***	***
2	44	174	392	635	828	939	985	998	***	***
2	38	148	341	570	771	905	971	994	***	***
1	17	85	232	447	672	848	948	989	999	***
0	12	69	207	422	657	844	949	990	999	***

535

0	16	96	281	536	770	918	981	997	***	***
2	46	197	441	690	868	958	991	999	***	***
4	72	260	521	755	904	972	994	999	***	***
4	66	244	504	747	903	973	995	***	***	***
2	44	183	419	674	862	959	992	999	***	***
1	22	112	300	547	772	916	979	997	***	***
0	10	64	207	437	687	872	966	995	***	***
0	8	55	191	424	683	875	969	996	***	***
0	14	83	251	497	738	900	975	996	***	***
0	19	104	283	520	742	893	968	994	***	***
0	12	77	230	457	690	863	957	991	999	***
0	8	58	197	426	676	865	961	994	***	***

1835

1	32	153	372	623	823	938	985	998	***	***
4	67	243	497	735	893	969	994	999	***	***
6	84	277	535	764	909	974	995	***	***	***
5	73	258	518	755	905	974	995	***	***	***
2	56	223	476	721	886	966	993	999	***	***
1	33	154	374	626	826	940	986	998	***	***
0	13	82	252	502	745	906	978	997	***	***
0	7	58	207	460	727	906	980	998	***	***
0	14	89	272	536	779	927	985	998	***	***
1	26	129	326	572	784	918	978	997	***	***
1	24	117	297	528	741	889	965	993	999	***
0	19	104	282	519	741	892	968	994	***	***

2012

0	11	56	164	340	555	757	900	973	997	***
1	23	102	259	475	695	862	955	991	999	***
2	37	156	366	610	811	931	983	997	***	***
2	48	195	433	679	859	954	989	999	***	***
2	40	168	387	629	821	934	983	997	***	***
1	18	93	253	478	703	870	959	992	999	***
0	8	46	151	339	574	788	926	985	999	***
0	7	42	137	312	543	764	915	982	999	***
1	12	61	179	373	603	803	930	985	999	***
0	11	64	192	394	622	813	932	984	998	***
0	6	44	150	333	558	764	904	974	996	***
0	5	37	126	289	504	718	878	964	995	***

2188

1	19	105	292	541	768	913	977	997	***	***
2	41	176	402	646	834	941	985	998	***	***
3	58	217	454	689	859	951	988	998	***	***
3	65	244	503	743	898	970	994	999	***	***
2	50	207	456	705	877	962	992	999	***	***
1	16	82	231	449	679	855	953	991	999	***
0	2	17	73	208	426	675	871	970	998	***
0	2	17	78	222	453	706	892	978	998	***
0	15	81	236	465	701	874	963	994	***	***
1	30	137	336	575	783	914	976	996	***	***
1	19	94	256	482	707	872	960	992	999	***
0	11	68	210	434	677	861	959	993	***	***

```
    655
0   12   74 231 471 715 887 969 995 *** ***
1   24  129 336 589 799 925 980 997 *** ***
1   36  173 411 662 848 948 987 998 *** ***
2   41  185 430 686 868 959 991 999 *** ***
1   33  149 364 617 822 939 986 998 *** ***
1   16   84 237 459 689 862 957 992 999 ***
0    6   43 147 335 571 785 923 983 999 ***
0    6   42 145 335 576 793 930 986 999 ***
0   12   68 207 426 665 852 954 992 999 ***
0   13   79 234 462 694 866 957 991 999 ***
0    8   58 193 413 655 844 950 990 999 ***
0    6   49 174 392 644 845 954 992 999 ***

   1010
0    1    6  32 112 283 535 787 944 995 ***
0    1   10  54 176 393 654 862 968 997 ***
0    2   24 104 278 524 762 917 983 999 ***
0    8   56 187 406 653 847 954 992 999 ***
0   10   66 208 433 677 862 960 993 *** ***
0    4   32 122 302 545 774 923 985 999 ***
0    1    9  49 161 367 626 847 964 997 ***
0    1    6  36 129 317 577 817 955 996 ***
0    1    9  48 162 373 637 855 967 997 ***
0    0    7  43 154 370 640 861 970 998 ***
0    0    4  25 103 279 544 801 952 996 ***
0    0    4  22  86 236 481 750 933 994 ***

   1252
1   34  159 386 643 841 949 989 999 *** ***
4   80  281 547 776 915 976 996 *** *** ***
9  135  398 675 864 957 990 998 *** *** ***
9  133  398 680 872 962 992 999 *** *** ***
5   75  266 530 767 913 977 996 *** *** ***
1   30  136 339 588 801 930 984 998 *** ***
0   14   80 239 477 720 890 972 996 *** ***
0   12   77 238 484 731 899 976 997 *** ***
1   21  110 302 557 784 924 983 998 *** ***
1   32  144 351 598 804 929 982 997 *** ***
1   30  139 341 585 792 921 979 997 *** ***
1   24  122 322 573 791 925 982 997 *** ***
```

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   2780
2   35  155 372 621 821 937 985 998 *** ***
5   74  253 501 732 887 964 992 999 *** ***
9  109  325 582 792 918 976 995 999 *** ***
9  116  347 614 820 935 983 997 *** *** ***
5   84  295 572 803 933 984 998 *** *** ***
2   41  187 441 706 888 971 996 *** *** ***
1   20  110 310 576 807 939 988 999 *** ***
1   17   93 268 516 753 910 979 997 *** ***
1   25  113 291 527 749 900 973 996 *** ***
1   27  118 294 524 741 891 968 994 *** ***
1   19   98 265 496 723 883 965 994 *** ***
1   18   99 276 517 746 900 973 996 *** ***

   3490
0    9   51 154 329 547 752 898 973 997 ***
1   24   99 242 439 646 817 927 981 998 ***
2   34  137 314 531 731 876 956 990 999 ***
2   35  151 357 596 797 921 978 996 *** ***
1   28  130 329 579 793 925 981 997 *** ***
1   14   80 232 459 695 870 962 993 *** ***
0    6   41 145 333 570 785 924 984 999 ***
0    5   33 118 285 512 738 898 976 998 ***
0    7   42 133 298 516 733 892 973 997 ***
0    7   40 129 291 507 723 884 969 996 ***
0    4   27 101 252 470 699 873 966 996 ***
0    3   25  99 252 473 703 877 967 996 ***

   3845
0    2   17  68 187 381 615 822 948 994 ***
0   10   57 167 346 563 762 902 973 997 ***
1   20   93 244 454 671 842 943 986 998 ***
1   25  116 295 526 742 892 967 994 *** ***
1   27  128 321 560 772 910 975 996 *** ***
1   20  104 277 509 731 887 966 994 *** ***
0   11   59 182 385 623 824 943 990 999 ***
0    7   37 122 284 509 737 903 980 999 ***
0    6   34 108 248 446 663 845 954 995 ***
0    4   25  84 200 374 581 775 913 983 998
0    1    8  38 117 268 483 713 890 979 998
0    0    5  27  96 245 476 726 909 987 999
```

Table 9—*continued*

3922

0	1	6	30	100	246	469	715	901	985	999
0	5	30	103	245	448	668	848	954	993	999
1	13	67	191	385	609	802	926	982	998	***
1	22	98	255	475	700	869	961	993	***	***
2	28	116	289	517	737	892	970	996	***	***
1	23	108	285	522	747	900	973	996	***	***
0	10	65	208	438	687	872	965	995	***	***
0	4	29	111	284	527	764	920	985	999	***
0	3	18	70	186	377	610	818	947	994	***
0	2	14	52	139	292	499	717	889	979	998
0	1	5	25	83	206	405	644	853	971	997
0	0	2	12	52	159	359	624	857	977	998

4289

0	4	21	66	157	304	496	701	871	972	997
1	13	51	133	267	443	635	805	924	985	998
1	15	70	188	368	579	770	903	973	996	***
1	18	89	241	458	683	855	952	990	999	***
1	24	111	279	499	711	867	954	989	999	***
1	18	89	240	452	670	840	942	986	998	***
0	5	36	132	316	555	776	920	982	998	***
0	2	17	72	203	416	661	858	964	996	***
0	5	27	85	200	373	580	775	915	984	998
0	8	36	98	207	363	548	732	879	969	996
0	3	18	61	152	301	497	705	874	972	997
0	1	9	38	109	244	445	673	866	974	997

4448

0	5	23	69	157	298	481	677	847	958	994
1	9	41	113	238	410	604	782	911	980	997
0	10	48	139	292	491	695	858	954	993	999
1	12	58	168	345	561	762	903	974	997	***
1	13	65	181	363	579	773	907	975	997	***
0	8	43	132	290	498	709	872	962	995	***
0	3	17	65	173	351	575	787	929	989	999
0	1	9	38	110	246	447	675	867	974	997
0	3	13	43	109	226	399	607	808	950	993
0	3	13	41	101	208	368	569	774	936	991
0	1	8	27	77	175	334	546	768	938	992
0	2	9	32	88	197	367	581	793	945	993

0	3	13	42	105	217	382	584	783	934	989
0	4	19	63	152	299	492	697	867	969	997
0	3	20	72	183	361	580	786	927	989	999
0	4	24	85	211	404	628	824	946	993	999
0	6	33	102	234	424	637	822	941	991	999
0	6	30	96	222	407	621	812	938	991	999
0	3	16	59	157	324	542	760	917	988	999
0	1	6	27	84	202	393	628	842	968	997
0	0	3	15	50	132	282	499	741	929	990
0	0	3	12	41	111	246	455	702	912	987
0	0	2	12	41	113	253	466	715	919	989
0	1	5	20	60	147	296	505	736	921	988

5147

1	8	34	91	192	340	521	706	862	963	994
1	13	51	131	261	434	624	794	917	982	998
1	16	66	172	338	539	732	879	963	995	***
1	20	82	208	395	606	791	916	978	997	***
1	19	80	203	384	590	775	904	973	996	***
1	11	50	143	301	504	710	870	962	995	***
0	3	19	70	183	367	594	803	939	993	***
0	1	7	33	103	243	454	692	884	980	998
0	1	8	32	94	214	401	626	832	961	995
0	3	14	46	118	244	427	640	834	960	995
0	4	18	57	138	274	461	670	853	967	996
0	5	23	67	154	294	477	677	852	964	995

5711

0	4	17	49	112	219	372	559	751	912	984
0	5	24	69	155	290	466	658	830	950	993
0	4	22	72	174	334	536	737	893	977	997
0	5	27	87	206	386	599	794	927	988	999
1	8	38	113	249	438	647	827	942	991	999
0	7	34	106	240	431	644	827	944	992	999
0	3	18	64	165	333	549	762	916	986	999
0	2	9	35	99	222	409	634	838	965	996
0	1	7	27	75	171	326	534	756	931	990
0	1	5	19	58	141	286	492	724	916	987
0	0	3	13	45	121	263	474	716	915	986
0	1	6	22	63	147	291	491	715	907	984

```
   4480
0    5   26   79  180  334  526  722  879  971  996
0    8   39  113  247  432  637  816  935  989  999
0    8   41  128  287  502  720  885  971  997  ***
0    9   48  150  330  558  772  916  982  999  ***
1   12   62  178  365  587  785  918  980  998  ***
0   10   52  155  328  544  750  898  973  997  ***
0    3   22   81  209  409  640  837  954  995  ***
0    1    8   36  113  263  484  723  903  986  999
0    1   10   37  103  229  419  643  844  967  997
0    3   15   49  120  243  419  625  820  955  995
0    3   15   47  118  241  418  627  823  957  995
0    3   15   50  125  256  440  650  839  961  996

   4645
1   13   51  133  267  445  638  809  928  987  999
2   27   91  209  376  565  743  878  959  993  999
2   30  113  266  468  676  840  941  986  999  ***
2   35  138  323  550  757  898  969  994  ***  ***
3   42  159  351  575  770  900  968  993  999  ***
2   27  112  273  488  700  860  951  989  999  ***
0    7   41  133  304  531  751  905  978  998  ***
0    3   18   68  183  372  605  815  946  994  ***
0    6   29   87  199  367  571  767  912  984  998
1    9   39  109  233  407  605  787  918  984  998
0    5   26   87  208  393  609  804  934  990  999
0    4   24   81  197  377  594  795  931  990  999

   5035
0    5   25   74  167  311  496  691  857  964  996
0    8   36  102  221  391  589  775  912  983  999
1   10   46  133  285  488  699  866  961  995  ***
1   12   57  166  344  562  765  906  976  997  ***
0   12   58  163  332  540  739  885  966  995  ***
0    7   37  111  248  440  651  832  946  993  ***
0    3   17   61  157  321  538  758  918  990  999
0    2   10   39  111  246  446  676  871  977  998
0    2   11   39  108  233  419  636  833  960  995
0    2   12   42  113  241  427  643  837  961  995
0    2   12   42  114  246  439  661  854  969  997
0    3   15   50  128  263  453  666  851  966  996
   5056
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   5896
1   12   46  116  230  387  567  742  881  968  996
1   12   49  127  256  427  614  785  909  978  997
1   10   50  142  297  496  698  857  952  992  999
1   14   67  187  375  594  788  917  978  997  ***
1   20   86  220  415  629  810  927  982  998  ***
1   15   67  180  355  563  757  896  970  996  ***
0    6   32  101  233  423  636  820  939  990  999
0    3   16   56  145  296  498  712  883  976  997
0    3   16   52  130  263  449  659  846  965  996
0    4   19   61  149  293  485  692  867  971  997
0    4   23   74  176  337  539  742  897  979  998
0    7   33   93  203  364  558  747  894  976  997

   6522
1   12   48  124  247  412  597  769  900  975  996
1   13   51  132  263  434  620  787  910  977  996
1   12   54  146  295  484  678  837  940  988  998
1   12   56  156  318  520  718  870  958  993  999
0   10   48  141  301  507  714  873  962  995  ***
0    5   30  104  251  463  689  867  965  996  ***
0    2   16   67  185  384  624  832  954  995  ***
0    1   10   42  123  277  495  727  902  984  999
0    1    9   37  103  228  415  637  838  964  996
0    3   15   51  130  267  456  667  851  965  996
0    5   26   82  192  358  560  756  902  980  998
0    9   39  111  236  409  605  785  914  982  998

   7210
0    4   18   57  134  262  436  634  817  947  992
0    4   21   66  155  296  481  679  849  959  994
0    5   27   86  201  374  580  774  914  983  998
0    7   36  113  255  453  667  844  952  993  999
0    7   36  115  261  464  681  856  958  995  ***
0    4   26   95  236  446  678  863  964  996  ***
0    2   17   68  189  389  630  837  956  995  ***
0    1    9   39  116  260  469  699  883  978  998
0    1    5   20   61  151  305  519  750  929  989
0    1    4   16   50  127  270  480  723  922  989
0    1    7   26   77  181  352  576  801  955  995
0    2   13   45  116  242  424  637  832  961  995
```

Table 9—*continued*

7380

0	7	46	150	329	550	754	896	970	995	***
0	7	46	146	318	532	737	886	966	995	999
0	6	44	152	344	578	787	920	981	998	***
0	9	64	211	445	691	870	962	993	999	***
1	16	91	259	497	728	888	967	994	***	***
1	16	78	214	419	644	829	940	987	999	***
0	9	47	141	303	514	725	883	969	997	***
0	6	33	104	237	428	640	823	941	991	999
0	5	29	95	221	405	615	802	928	987	999
0	3	21	84	217	420	647	836	949	992	999
0	2	18	87	247	486	729	899	976	998	***
0	3	28	120	305	550	774	918	981	998	***

7785

1	15	64	169	334	536	733	881	964	995	***
1	17	70	185	362	572	766	903	974	997	***
1	19	85	225	430	652	832	941	987	999	***
1	27	120	300	532	747	895	969	994	***	***
2	31	135	332	575	788	921	980	997	***	***
1	19	94	261	498	732	895	972	996	***	***
0	8	46	150	335	571	785	924	984	999	***
0	4	24	85	212	408	636	831	950	994	***
0	3	18	68	177	357	584	796	937	992	***
0	3	19	75	202	407	649	851	963	997	***
0	4	28	105	265	496	732	901	979	998	***
0	9	46	143	313	532	744	896	973	997	***

8020

0	3	16	57	143	285	474	678	851	960	994
0	3	16	53	132	267	452	659	842	960	995
0	3	18	59	148	297	495	706	878	974	997
0	4	23	79	195	376	595	796	931	989	999
0	4	22	78	199	390	618	820	946	993	***
0	2	13	51	143	307	532	761	923	991	999
0	1	8	33	99	230	432	670	873	979	998
0	1	6	26	78	185	358	583	804	954	995
0	1	5	19	59	144	294	506	740	927	990
0	1	4	15	50	130	276	492	738	931	991
0	1	6	24	75	182	359	588	810	955	994
0	2	12	46	125	265	461	676	857	965	995

9175

3	40	149	332	551	749	888	963	992	999	***
3	44	151	324	531	725	869	953	989	999	***
4	55	185	384	603	788	910	972	994	***	***
2	45	186	419	667	852	952	989	999	***	***
1	34	165	406	672	865	960	992	999	***	***
2	40	176	411	666	855	954	990	999	***	***
2	42	168	380	619	813	931	982	997	***	***
1	23	103	261	477	694	859	953	990	999	***
1	14	68	191	381	600	793	920	980	998	***
2	29	113	267	471	678	841	941	986	998	***
4	61	203	411	632	810	922	976	995	***	***
4	59	204	423	651	828	934	981	997	***	***

9330

0	1	12	76	251	526	789	942	992	***	***
0	2	18	85	247	494	747	915	984	999	***
0	3	30	121	305	553	783	928	986	999	***
0	5	44	173	404	668	866	965	995	***	***
0	6	56	210	467	732	906	979	997	***	***
0	8	61	210	453	709	889	972	996	***	***
0	6	44	158	368	622	834	951	992	***	***
0	2	18	83	238	481	736	912	985	999	***
0	1	9	47	161	376	647	867	974	999	***
0	1	11	58	183	402	663	871	973	998	***
0	2	18	90	259	511	761	922	986	999	***
0	1	16	94	290	571	819	952	993	***	***

9560

0	9	57	187	403	648	844	953	992	999	***
0	10	61	190	402	644	840	951	992	***	***
1	15	84	243	479	719	889	971	996	***	***
0	14	89	272	534	776	925	984	998	***	***
0	8	69	246	519	775	928	985	998	***	***
0	7	62	228	494	754	916	982	998	***	***
0	8	57	195	422	672	862	961	994	***	***
0	4	30	109	267	491	721	890	974	998	***
0	2	13	58	169	364	610	829	955	996	***
0	3	22	87	233	457	702	886	975	998	***
0	9	58	191	411	660	855	959	994	***	***
0	12	75	233	472	716	888	970	996	***	***

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    8190
1   19   87 223 415 622 798 915 975 996 ***
1   17   77 203 387 596 780 907 973 996 ***
2   29  117 282 495 703 860 950 988 999 ***
2   39  153 351 584 785 915 976 996 *** ***
1   25  116 296 533 753 901 973 996 *** ***
0   12   73 227 459 698 873 963 994 *** ***
0    8   57 189 406 647 839 947 989 999 ***
0    4   30 109 268 490 716 883 969 996 ***
0    1   11  48 146 326 566 794 939 993 ***
0    2   18  71 195 398 639 842 958 995 ***
0   13   70 206 415 645 830 940 986 999 ***
1   24  116 290 511 720 871 954 989 999 ***

    8350
1   14   62 165 327 524 715 864 953 991 999
1   16   67 172 333 529 720 868 956 993 999
1   23   96 238 437 649 824 933 983 998 ***
1   25  116 297 534 755 902 973 996 *** ***
1   18   93 257 491 722 886 968 995 *** ***
0   10   60 186 393 631 828 944 989 999 ***
0    5   35 124 297 530 756 910 980 998 ***
0    1   13  58 170 364 608 823 951 995 ***
0    1    6  30 101 250 475 721 904 986 999
0    2   15  58 159 329 549 765 917 986 999
0    9   51 150 316 524 725 876 961 994 999
1   15   73 197 382 591 775 903 970 995 999

    8685
0    2   13  46 117 243 424 634 827 956 994
0    2   12  42 110 232 411 621 818 951 992
0    3   19  62 153 302 498 705 873 971 996
0    6   30  94 217 400 612 803 931 988 999
0    7   38 116 258 456 670 846 952 993 999
0   10   49 145 308 518 725 882 967 996 ***
0   10   52 155 326 542 748 896 973 997 ***
0    4   24  82 199 381 598 796 930 989 999
0    0    3  15  54 147 316 549 787 949 994
0    0    1   6  26  85 215 434 703 920 989
0    1    6  25  75 177 346 566 788 946 993
0    3   15  52 130 265 453 664 848 965 996
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Table 10

Monthly model estimates of probabilities that 30 day precipitation sums R are less or equal to 0.05, 0.10, 0.15, 0.30, 0.50, 0.75, 1.00, 1.50, 2.00, 2.50, 3.00 times expected values of R, arranged horizontally. Months and stations are arranged as for Table 9. The numbers for extremely small values of R may be systematically somewhat too small. See section 9 for a possible correction formula.

60

1	4	10	56	177	377	570	829	942	982	995
1	4	9	40	136	331	550	860	971	995	999
7	18	34	103	236	423	593	825	934	977	992
6	15	29	95	225	410	581	816	929	975	991
8	16	27	79	187	362	543	816	943	986	997
2	5	11	50	153	341	541	830	951	988	998
1	2	5	32	125	327	561	879	979	998	***
1	3	8	42	145	342	552	843	958	991	998
3	9	18	73	199	398	587	840	948	985	996
3	10	21	80	209	400	578	820	932	976	992
1	5	11	53	165	364	567	845	957	990	998
0	2	5	29	115	304	527	853	970	996	***

165

3	8	16	65	182	374	564	828	944	984	996
11	23	38	103	226	408	583	829	942	983	996
14	29	47	124	258	434	590	806	915	965	986
11	21	34	88	196	366	543	816	945	988	998
10	19	31	84	194	369	550	822	947	988	998
9	19	32	92	213	393	566	812	930	976	992
4	9	17	60	163	348	548	840	959	992	999
4	8	16	59	166	354	551	833	952	989	998
8	17	30	94	223	412	588	826	936	978	993
5	13	24	82	204	389	565	811	928	975	992
2	6	13	53	161	362	575	866	971	995	999
2	6	13	53	159	352	556	845	960	992	999

535

3	10	22	85	217	408	583	818	929	974	991
6	15	26	83	200	380	556	811	932	978	994
15	29	46	114	234	403	564	801	923	974	992
10	20	33	90	202	373	545	804	932	980	995
9	17	29	80	187	358	538	812	942	986	997
5	12	21	69	176	355	543	821	947	987	997
2	5	11	46	142	328	537	846	966	995	999
2	6	12	53	162	355	556	838	954	989	998
3	9	18	66	179	370	566	842	956	990	998
5	13	24	82	201	384	561	816	936	981	995
3	9	18	66	181	375	575	856	965	994	999
2	7	16	69	193	387	571	822	936	979	993

1835

4	12	25	88	218	404	575	810	923	971	989
19	40	64	154	290	454	594	787	893	947	975
20	37	57	133	258	422	572	789	905	960	984
12	23	38	98	211	381	550	804	931	980	995
8	19	33	95	213	388	559	809	932	979	994
7	14	25	76	184	361	544	819	945	987	997
2	5	10	45	143	331	539	844	963	993	999
1	4	9	46	153	350	557	842	956	990	998
5	13	26	88	217	408	587	829	939	980	994
5	13	25	84	206	386	557	801	921	971	990
6	16	30	98	230	420	596	835	942	982	995
5	14	29	99	235	423	590	817	926	972	990

2012

5	13	25	87	212	397	572	816	931	977	993
10	23	41	115	248	425	584	804	916	966	987
15	33	56	142	279	449	596	798	905	957	981
11	24	41	113	240	415	576	805	922	971	990
9	19	32	91	205	378	550	808	935	982	996
5	12	23	74	184	360	539	808	936	982	996
2	5	11	47	148	338	543	839	959	992	999
3	8	15	59	167	355	549	829	949	987	997
9	21	38	108	239	421	587	819	930	976	992
5	15	29	97	226	405	568	797	913	965	986
6	17	34	111	252	440	604	823	928	973	990
3	11	25	92	226	415	585	816	926	972	990

2188

3	9	20	76	201	393	575	824	937	979	994
10	22	38	107	234	412	576	807	922	971	990
14	28	47	122	252	425	583	805	919	969	989
12	24	39	104	224	397	564	810	932	979	994
11	23	39	106	229	403	567	803	922	972	990
4	9	17	57	152	321	510	810	949	990	999
0	1	4	25	110	308	544	870	976	997	***
1	4	10	51	165	368	573	848	957	990	998
5	12	23	81	208	406	594	848	953	988	997
6	15	29	94	220	401	570	806	923	971	990
5	11	22	74	190	377	563	827	945	985	996
3	9	19	74	198	389	569	818	933	977	993

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   655
  2   6   13   59 179 379 573 834 945 984 995
  5  12   23   77 192 375 557 820 941 984 996
 11  23   40  110 238 415 579 810 925 973 991
  6  14   26   83 201 384 563 819 939 982 995
  7  14   24   71 173 343 525 808 943 987 997
  3   8   15   55 153 332 530 832 959 993 999
  1   4    8   40 135 329 548 862 973 996 ***
  2   5   11   50 156 350 556 845 960 991 998
  2   7   15   61 175 371 569 844 956 990 998
  3   9   19   72 190 377 561 821 940 982 995
  2   5   12   54 166 365 572 855 963 993 999
  1   4    9   47 154 354 562 846 958 990 998

  1010
  1   4   10   57 181 383 575 832 943 982 995
  1   4   12   63 192 396 586 837 945 983 995
  2   7   16   65 181 374 566 832 947 985 996
  3   9   20   79 206 396 572 814 929 975 991
  6  14   25   78 191 371 554 823 945 986 997
  1   5   12   53 161 351 547 826 947 986 997
  0   1    4   28 119 320 549 864 972 995 999
  1   2    6   37 138 343 565 864 969 994 999
  0   2    5   29 118 316 547 870 977 997 ***
  0   2    5   34 133 334 554 855 966 993 999
  0   2    6   40 147 346 552 836 952 988 997
  1   4   11   62 190 390 577 826 937 979 993

  1252
  6  15   29   92 218 399 567 804 921 971 990
 11  22   36   96 213 388 561 815 938 982 996
 27  48   72  158 289 453 595 796 904 956 981
 19  38   60  139 265 427 573 788 906 961 985
 13  25   41  103 218 386 551 800 926 976 993
  8  17   30   87 200 376 552 812 937 982 995
  2   6   12   49 149 336 542 844 963 993 999
  4  11   21   76 195 382 564 820 937 981 994
  6  14   24   77 191 375 564 837 955 990 998
  6  14   26   81 195 371 546 804 931 979 994
  7  18   35  113 255 442 603 817 922 967 987
  4  11   22   82 210 402 581 824 935 978 993
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  2780
  7  18   33  105 239 422 586 810 921 968 988
 16  32   54  137 273 445 595 800 908 959 982
 26  52   81  184 330 494 627 805 900 950 974
 23  40   59  131 249 410 563 794 918 972 991
 11  22   36   96 210 384 557 816 940 984 996
  5  13   23   73 181 358 541 815 942 985 997
  4  11   20   66 172 353 544 826 950 989 998
  3  10   21   80 207 398 577 821 934 978 993
  8  18   31   95 222 411 591 837 946 984 996
  5  13   26   87 212 397 570 812 928 974 991
  5  15   28   96 233 426 601 833 938 979 993
  6  17   35  114 253 435 591 803 910 960 983

  3490
  5  14   28   96 228 412 579 810 922 970 989
 13  30   51  137 277 451 601 805 911 961 983
 14  33   57  148 290 462 607 803 906 957 980
 15  32   53  136 268 438 587 796 907 960 983
  5  13   25   85 207 390 564 810 928 975 992
  4  10   19   66 174 353 537 812 940 984 996
  3   9   18   71 190 377 560 817 936 980 994
  3  11   24   92 227 417 586 815 925 971 989
  6  15   28   91 218 405 581 825 937 980 994
  4  11   23   85 212 399 571 810 926 973 991
  4  12   25   90 224 414 586 820 930 975 991
  3  10   23   89 224 413 583 814 925 971 990

  3845
  4  13   28   99 236 423 589 814 923 970 989
 21  48   80  189 334 495 623 795 891 942 969
 22  46   73  171 312 477 615 802 903 953 978
 13  29   49  130 262 433 585 799 911 963 985
 11  24   40  110 235 411 574 807 923 972 990
  7  16   28   84 195 367 541 804 933 981 995
  6  14   26   84 204 385 558 805 925 974 992
  4  12   25   90 221 407 576 809 923 971 989
  7  18   33  100 228 413 584 821 933 977 993
  5  13   26   89 216 399 568 806 923 972 990
  2   9   20   81 213 409 588 830 939 980 994
  4  15   31  108 247 428 586 802 911 962 984
```

Table 10—*continued*

3922

2	7	17	74	204	402	585	830	940	980	994
11	28	52	144	290	465	611	808	909	958	981
11	27	47	128	266	445	601	814	920	968	988
8	18	30	88	204	382	560	822	943	985	997
10	21	34	93	208	384	558	814	937	982	995
6	13	23	71	176	352	537	816	945	987	998
4	12	24	82	202	384	557	804	925	974	991
2	6	13	58	171	362	552	820	940	982	995
3	7	15	58	166	353	548	829	950	988	997
2	6	12	53	160	350	548	831	951	988	997
1	5	12	59	180	383	582	846	954	988	997
1	5	14	69	198	395	579	825	936	979	993

4289

4	11	22	81	208	397	574	816	930	976	992
12	28	48	131	268	445	600	811	918	966	987
31	67	104	220	363	511	628	786	877	929	959
6	15	29	93	221	408	582	823	935	978	993
7	18	33	101	230	410	575	806	922	971	990
3	9	18	66	175	359	551	831	953	989	998
1	4	9	47	154	352	559	846	959	991	998
1	4	9	47	155	352	556	837	952	988	997
2	5	12	54	165	359	558	835	951	988	997
6	14	26	80	196	379	561	823	942	984	996
1	5	11	49	153	349	558	852	964	993	999
3	10	21	83	216	410	588	827	936	978	993

4448

5	14	26	86	212	401	578	822	936	979	994
7	18	34	106	242	429	597	823	930	975	991
14	32	55	144	284	455	600	798	903	955	979
4	9	18	67	179	368	561	836	953	989	998
7	18	33	99	227	410	580	817	931	976	992
2	5	11	43	131	305	510	832	964	995	999
1	4	10	45	145	338	547	844	961	992	999
1	3	7	38	137	335	548	846	961	992	999
2	5	10	46	147	345	560	861	970	995	999
3	8	17	65	182	377	569	835	949	986	997
0	2	4	21	91	275	522	886	987	999	***
2	6	13	57	174	378	581	854	960	991	998

5147

6	16	30	95	223	406	574	809	924	972	990
13	31	54	141	281	455	605	810	915	964	985
24	52	84	192	336	493	620	791	887	939	968
9	22	39	112	243	423	584	809	921	969	989
7	16	30	92	216	397	568	811	928	975	992
5	11	19	58	151	322	519	832	964	995	***
1	3	8	40	137	331	544	846	962	993	999
1	2	6	30	115	305	534	865	976	997	***
1	3	7	37	131	327	549	862	972	996	999
3	10	20	79	210	408	592	838	945	983	995
2	5	10	43	137	324	537	850	968	995	999
7	18	33	101	233	420	592	825	935	978	993

5711

5	13	24	83	206	391	566	813	930	976	993
8	21	39	114	249	430	591	813	923	971	989
11	28	51	142	285	460	606	805	908	958	981
3	11	22	84	215	408	586	826	936	978	993
7	17	32	102	235	418	584	811	923	971	989
2	6	13	52	154	337	536	828	952	989	998
3	10	21	82	212	404	581	822	933	977	992
2	5	11	50	155	348	550	838	955	990	998
1	3	7	38	136	335	554	856	967	994	999
2	5	10	48	156	359	572	861	967	994	999
0	2	4	25	104	296	533	874	980	998	***
2	7	16	66	187	382	571	830	944	984	996

5896

9	20	36	105	233	412	577	807	921	970	989
11	27	49	137	279	455	605	809	913	962	984
15	35	60	153	295	462	602	794	897	950	976
5	15	31	107	250	439	602	818	922	968	987
7	15	26	81	198	382	562	818	937	981	995
5	13	26	86	210	394	567	811	928	975	992
1	4	10	50	160	357	558	835	951	987	997
1	4	9	40	133	322	539	852	968	995	999
1	4	8	39	132	327	549	866	975	997	***
4	10	20	72	194	391	584	845	953	988	997
2	5	11	49	150	337	538	829	952	989	998
7	17	31	98	228	412	581	814	927	973	991

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  4480
4   9  18  67 183 375 567 835 949 987 997
5  14  27  93 224 415 591 829 938 980 994
7  19  37 114 251 430 586 800 909 961 983
3   8  17  64 177 368 562 835 951 988 997
3   9  18  67 181 369 557 823 942 983 995
3   8  15  54 149 327 528 833 964 995 999
1   4   8  38 128 314 531 850 969 995 999
1   2   5  33 128 328 549 854 966 994 999
1   2   6  32 123 322 550 866 973 996 ***
3   8  15  56 163 356 560 847 961 992 999
1   2   4  22  88 265 511 891 990 *** ***
3   7  14  55 162 359 567 857 966 994 999
```

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   4645
 9  21  37 109 239 416 575 798 912 964 986
20  40  63 151 287 456 603 805 912 962 984
36  73 112 229 371 517 632 787 876 928 958
11  24  41 114 245 424 585 810 922 970 989
11  26  45 124 259 434 589 801 911 962 984
 7  15  25  74 178 350 534 817 948 989 998
 2   5  12  56 170 364 559 829 946 985 996
 1   4   8  36 124 311 532 856 972 996 ***
 2   6  13  58 174 374 574 845 955 989 998
 6  16  31  98 228 414 584 817 929 975 991
 2   7  15  62 178 373 567 835 949 987 997
 7  19  36 115 254 437 596 811 918 966 987
```

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   5035
 5  13  26  87 212 397 570 812 929 975 992
13  32  56 150 297 475 619 815 915 962 983
18  43  72 175 319 481 613 792 890 943 971
 8  22  41 125 267 448 603 811 916 964 985
 9  25  46 133 274 449 598 801 907 958 982
 3   9  18  64 174 359 549 824 946 986 997
 3   9  20  80 209 399 575 816 929 975 991
 1   4  10  45 147 342 552 847 961 992 999
 2   5  11  49 155 352 561 851 963 993 999
 2   8  17  70 194 392 581 838 948 985 996
 1   3   7  36 125 313 534 856 972 996 ***
 6  16  32 105 243 431 597 821 928 973 990
```

```
   6522
10  23  41 115 248 426 586 808 919 968 988
 9  22  40 117 252 433 594 816 925 972 990
13  30  51 136 271 441 589 794 904 957 981
 5  14  28  97 233 421 590 819 928 974 991
 4  10  20  71 188 375 561 824 942 983 996
 2   5  12  54 166 360 558 833 949 987 997
 1   3   7  40 142 341 556 852 964 993 999
 1   3   8  42 146 345 556 848 961 992 998
 1   4   9  42 139 330 543 848 965 994 999
 3  10  20  77 203 401 589 844 951 987 997
 3  10  21  77 199 384 561 809 928 976 992
13  31  53 142 281 454 602 804 909 960 983
```

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   7210
 3   8  18  72 194 387 572 827 941 982 995
 3   9  18  68 186 377 565 828 944 984 996
11  28  51 140 282 455 602 801 906 957 981
 4  12  24  83 206 392 569 818 934 979 994
 2   6  12  50 149 333 534 830 955 990 998
 2   6  12  50 153 342 546 840 959 992 999
 1   4   9  43 142 335 548 850 965 994 999
 1   2   5  29 110 297 526 864 977 997 ***
 1   4   9  45 150 347 554 843 958 991 998
 1   3   8  41 144 347 566 863 969 994 999
 1   4  10  52 165 361 557 828 945 984 996
 5  13  25  89 221 412 587 825 935 978 993
```

```
   7380
 3  10  22  87 220 410 583 817 929 974 991
 4  14  30 107 247 429 586 801 910 961 983
 6  23  47 146 298 473 614 799 897 948 973
 1   3   7  42 151 353 559 839 952 987 997
 3   8  15  59 170 362 561 841 956 990 998
 2   6  11  43 133 313 524 845 968 996 ***
 2   5  11  48 148 338 547 847 963 993 999
 2   7  14  53 154 343 550 853 969 995 999
 0   2   5  33 131 336 556 854 963 992 999
 1   4   9  51 167 373 580 854 960 990 998
 0   2   7  47 161 359 555 823 940 981 995
 1   5  14  72 208 410 592 830 936 978 992
```

Table 10—*continued*

7785

8	21	39	117	252	428	583	798	909	961	984
15	36	61	156	298	467	606	797	899	951	976
33	72	112	233	377	523	636	788	876	926	956
22	53	89	203	351	506	627	789	881	932	961
8	17	31	90	207	385	559	813	935	981	995
4	9	17	60	164	351	552	843	961	993	999
2	4	10	43	140	333	550	858	970	995	999
1	4	8	37	127	317	539	862	974	996	***
1	3	7	35	125	319	546	867	975	997	***
2	6	14	65	190	388	576	828	940	981	994
3	9	19	78	203	390	564	806	923	971	990
15	39	68	173	321	487	620	798	895	946	972

8020

4	11	22	78	199	388	572	829	944	984	996
3	8	16	64	179	371	562	830	946	985	996
6	15	28	91	217	404	579	822	935	978	993
2	6	14	63	184	383	576	837	948	985	996
3	9	18	62	166	345	533	815	944	986	997
2	7	15	69	196	392	576	826	938	980	994
5	15	31	108	247	430	590	806	915	964	986
4	11	23	85	213	400	574	815	929	975	992
0	1	4	24	106	303	543	877	980	998	***
1	3	8	39	141	347	571	873	974	996	***
1	4	10	49	154	344	543	826	948	987	997
4	10	21	74	193	383	570	832	947	986	997

8190

8	22	42	121	256	430	583	796	908	960	984
7	18	35	109	243	424	585	806	918	967	987
18	40	66	161	301	466	604	793	896	949	975
15	35	60	153	295	464	605	796	899	950	976
7	18	35	110	243	420	575	790	903	956	981
2	6	13	58	173	372	573	847	957	990	998
2	6	14	60	174	367	560	830	946	985	996
1	3	7	40	141	340	555	852	964	993	999
0	2	6	40	146	346	553	837	953	988	997
3	9	20	80	213	410	591	832	940	980	994
5	14	29	99	230	410	572	797	911	963	985
12	29	50	135	271	445	596	805	913	963	985

9330

1	8	20	88	229	422	589	811	919	966	986
6	21	43	135	282	460	606	802	904	955	979
2	7	17	77	208	403	581	821	932	976	992
2	6	13	55	162	351	549	834	953	989	998
4	14	30	104	240	421	580	797	908	960	983
2	5	11	48	154	355	570	866	971	995	999
2	7	16	65	181	371	559	822	940	982	995
1	3	7	36	131	325	542	851	966	994	999
0	1	4	27	114	309	535	854	968	995	999
1	4	9	50	164	367	571	845	955	989	997
0	2	4	27	113	311	547	879	981	998	***
0	2	6	40	150	359	572	853	960	990	998

9560

2	5	11	49	152	340	543	837	957	991	998
3	10	21	81	209	401	578	820	932	976	992
4	11	22	74	191	378	563	825	942	984	996
5	13	26	89	217	405	580	821	933	977	993
2	6	14	57	168	357	550	826	946	986	997
1	4	10	47	152	349	560	854	965	994	999
4	11	22	82	210	402	581	826	937	980	994
1	3	8	37	128	315	533	851	968	995	999
0	2	5	31	123	321	544	855	967	994	999
2	5	10	46	148	349	571	876	978	997	***
1	5	11	51	161	358	559	836	950	987	997
2	8	17	66	184	376	568	835	950	987	997

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  8350
14  32  54 137 270 439 587 794 905 959 983
 7  18  35 107 240 420 581 805 918 967 988
17  38  64 158 299 468 609 801 903 954 979
18  41  68 164 304 468 605 794 897 949 976
 6  15  29  94 219 399 565 800 918 968 988
 3   8  16  65 184 380 573 839 951 987 997
 2   5  11  49 151 339 538 827 950 988 997
 1   3   8  46 158 358 561 836 950 986 997
 0   1   5  33 130 327 542 840 957 990 998
 4  11  24  88 223 419 596 833 939 980 994
 4  12  23  77 193 373 552 812 935 981 995
 8  19  35 104 232 410 576 812 928 975 992

  8685
 1   5  11  48 151 344 550 843 960 992 999
 1   3   7  38 134 332 551 858 969 995 999
 2   6  12  52 159 356 565 854 964 993 999
 4  10  19  71 189 382 573 837 950 987 997
 2   7  14  57 166 355 550 828 948 986 997
 4  11  20  68 178 368 566 848 962 993 999
 6  15  28  87 206 387 561 813 933 979 994
 2   7  15  61 175 364 553 821 941 983 995
 0   1   2  19  92 282 522 868 978 997 ***
 0   2   5  32 133 344 573 873 973 995 999
 0   2   4  30 122 322 546 857 968 994 999
 3   6  12  47 140 324 537 853 970 996 ***

  9175
10  22  39 110 238 412 571 796 913 965 986
11  24  41 114 245 422 581 803 915 966 987
17  38  64 160 304 473 613 801 902 952 977
 8  17  29  84 198 379 562 831 951 989 998
 5  12  23  78 194 375 555 815 937 982 995
 8  16  27  80 193 376 565 840 957 991 999
 7  17  31  96 225 411 583 818 930 975 992
 3   8  15  59 164 351 548 836 957 991 998
 3   7  14  52 149 332 536 841 963 994 999
 7  18  32  99 230 420 596 834 942 982 995
10  22  37 101 220 396 568 821 942 985 997
21  38  58 136 265 436 592 811 922 971 990
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