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NORDKLIM – Nordic co-operation within climate

Analysis of extreme daily precipitation and return periods in Norway and NORDKLIM area

Report 13/2002

Solfrid Agersten

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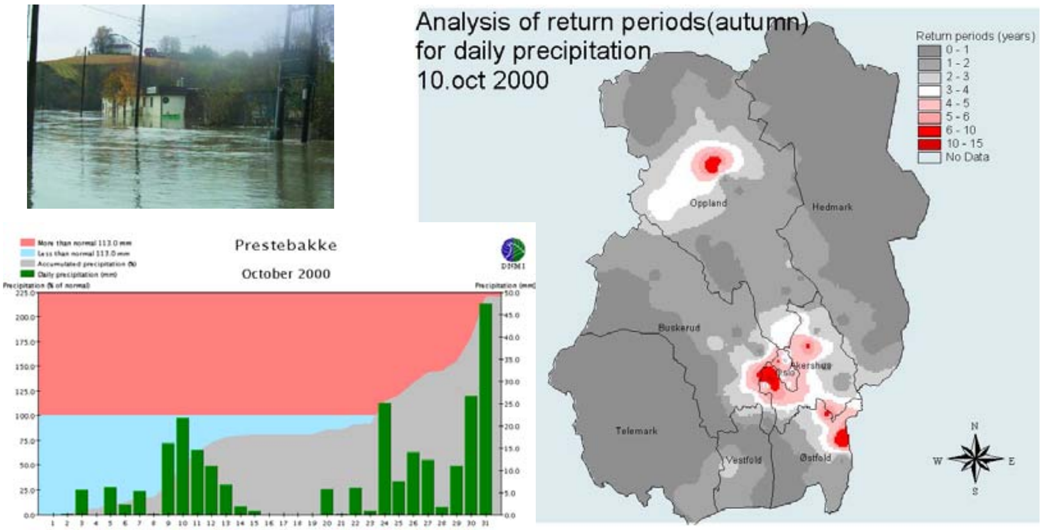

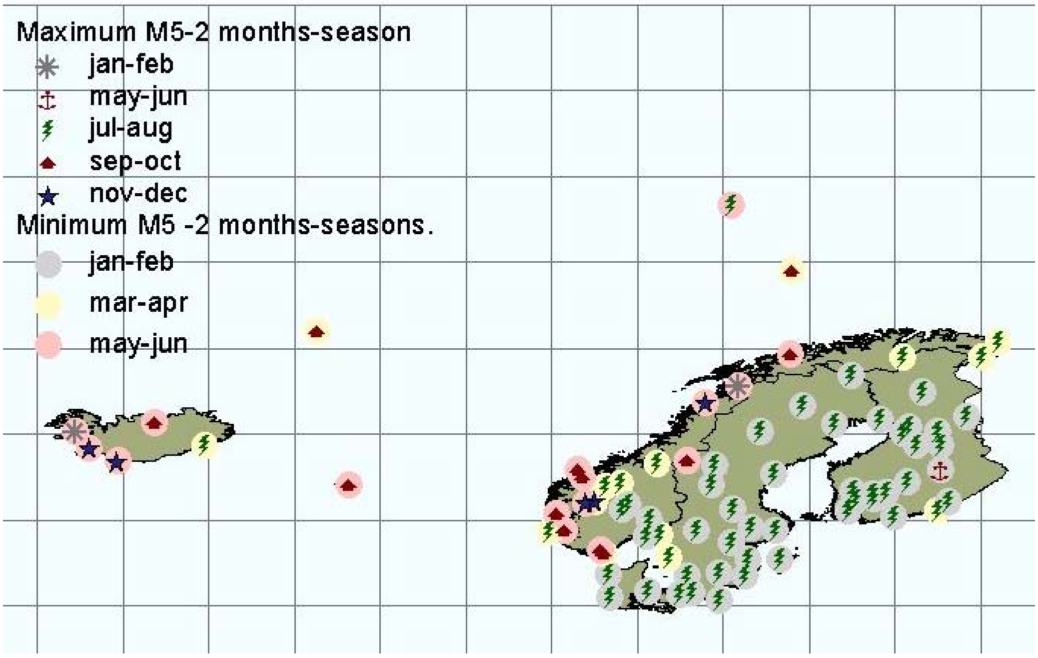

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Analysis of extreme daily precipitation and return periods in Norway and NORDKLIM area

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NORDKLIM/NORDMET on behalf of the National meteorological services in Denmark (DMI), Finland (FMI), Iceland (VI), Norway (met.no) and Sweden (SMHI)

SUMMARY:

This report is prepared under Task 2 in the Nordic NORDKLIM project: Nordic Co-Operation Within Climate Activities. The NORDKLIM project is a part of the formalised collaboration between the NORDic METeorological institutes, NORDMET.

This report gives a presentation of extreme daily precipitation and corresponding return periods for Norway and the NORDKLIM area. For Norway longer extreme precipitation episodes, as of 1-28-days duration, are analysed. A closer look at the seasonal differences for the probable extreme precipitation is done. The report also gives some trend analysis of annual series of 1-day precipitation extremes for selected stations. Through the report we see the power of using GIS tool for presenting climate information.

KEYWORDS:
extremes, daily precipitation, return period, spatial distribution, GIS, GUMBEL

SIGNATURES:

....

Eirik J. Førland
NORDKLIM Activity Manager

Bjørn Aune
Head of the met.no Climatology Division

Foreword

This report is prepared under task 2 in the Nordic NORDKLIM project: *Nordic Co-Operation Within Climate Activities*. The NORDKLIM project is a part of the formalised collaboration between the NORDic METeorological institutes, NORDMET.

The main objectives of NORDKLIM are:
1). Strengthening the Nordic climate competence for coping with increased national and international competition
2). Improving the cost-efficiency of the Nordic meteorological services (i.e. by improving procedures for standardized quality control & more rational production of standard climate statistics)
3). Coordinating joint Nordic activities on climate analyses and studies on long-term climate variations

The NORDKLIM project has two main tasks:

1. **Climate data** (Network design, Quality control, long-term datasets).
2. **Climate Applications** (Time series analysis, use of GIS within climate applications, mesoscale climatological analysis, extreme values and return periods).

A detailed description of the project is given by Førland et al. (1998).

An Advisory Committee, headed by an Activity Manager, coordinates NORDKLIM. A task manager heads each of the main tasks.

The Advisory Committee in NORDKLIM is presently consisting of:
Hasse Alexandersson, SMHI
Eirik J. Førland, met.no (**Activity Manager**)
Raino Heino, FMI
Trausti Jónsson, VI
Lillian Wester Andersen, DMI

The present task managers are:
Task 1: Caje Jacobsson (SMHI)
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A special thank to Eirik Førland (met.no), Ole Einar Tveito (met.no) and Hans Alexanderson (SMHI) for ideas, comments, feedback and corrections. Also thanks to my husband, Lewi Agersten, for reading through the report and correcting the language usage.

Analysis of extreme daily precipitation and return periods in Norway and NORDKLIM area

1 Introduction

The changes in annual precipitation during the last century are well documented. The normal precipitation for 1961-1990 in Northern Europe has increased compared to the 1930-1960 normal (Førland et al. 1996 [9]). For the NORDKLIM dataset we can see a trend in increasing annual precipitation during the 20th century (figure 8 in Tuomenvirta et al. 2001 [5]). Scenarios for Norway indicates a future increase in annual precipitation of 0.3-2.7 % per decade in different Norwegian regions up to 2050 (Hanssen-Bauer et al. 2001[1]). A connection between the large-scale atmospheric circulation and the occurrence and amounts of precipitation is also found (Tveito 2002 [11]).

For climate change impact studies extreme precipitation episodes are of interest. Further research has to be done regarding the connection between the increasing precipitation sum and the extreme short-term precipitation. Is there also an increasing frequency of extreme precipitation episodes? Are the episodes more extreme now? Or are the most extreme episodes clustered (Førland et al. 1998 [2] fig. 6.4) in some periods because of natural decadal variations?

Extreme amount of precipitation depends on duration of the episode and the geography. Some places as on Finnmarksvidda, north in Norway, an extreme daily precipitation episode is just a few tens of millimetres compared to the west coast of Norway where the daily precipitation amount can be larger than the total annual precipitation on Finnmarksvidda. Precipitation extremes are very important for flooding conditions, and in dimensioning hydroelectric power plants and for sewer systems in municipalities.

It is useful and common to use the term *return period,* which describes an average number of years between extreme precipitation episodes. Several times in this report we refer to the *M5 value*, which is the (calculated) *probable 1-day precipitation with 5 years return period*. Description of the calculation methods used is given in chapter 2.2. In this report we will look at return periods for extreme precipitation during one or more days for Norway and the NORDKLIM area. We will also look upon a concrete extreme precipitation episode and give a spatial analysis.

The programming framework is made quite general so that it is easy to give an analysis of a precipitation episode and corresponding return period, for points represented by stations and spatial distribution. GIS tools give a powerful way of distributing and visualizing the climate information. The spatial distribution of precipitation and corresponding return periods is a useful tool in planning, for example in construction, energy production and agriculture.

The NORDKLIM dataset (Tuomenvirta et al. 2001 [5]) includes the element maximum daily precipitation on monthly basis. Based on this dataset, return period and seasonal differences in extreme daily precipitation are given.

Some analysis of long-term variation of extreme daily precipitation during the last century is given in chapter 4. Further work and study will be done on this task later.

2 Meso-scale analysis of spatial distribution in extreme precipitation episodes

2.1 Examples of extreme episodes, Norway

This chapter presents examples of extreme 1 and 2 days episodes of precipitation in Norway. The episodes used are from autumn 2000 when unusual large amounts of precipitation fell in the southeastern part of Norway and parts of Sweden. Some of the episodes were extreme both in short timescale (some hours) as well as for large timescales (1-3 months), but in general we can say that the situation was most extreme for long timescales. Over the southeastern Norway both October and November had about 200 – 400 percent of the monthly normal (1961-1990).

Normally the low-pressure area has a westerly path causing the main amount of the precipitation to fall on the west side of the mountains. This extremely wet autumn in 2000 in the southeastern part of Norway, was caused by a low-pressure area, which had a much more southerly path than usual. A stable high-pressure area in Russia and a quite stable low pressure north of Great Britain caused the situation as seen from Figure 1. This circulation pattern dominated the weather situation in Scandinavia for about 3 months. The extreme precipitation in southeastern Norway was caused by orographic enhancement during southeasterly winds. This weather situation also gave an extremely dry autumn in the west and middle north of Norway on the leeward side of the mountains. The wet autumn in southeastern Norway could also be caused by anomalies in the Sea Surface Temperature (Benestad, Melsom 2001 [13]).

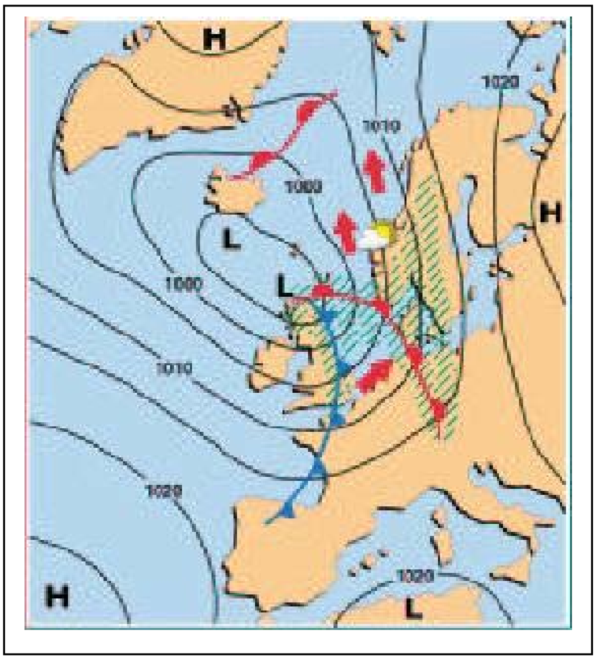

Figure 1. Mean weather situation in October and November 2000. Source NVE [6].

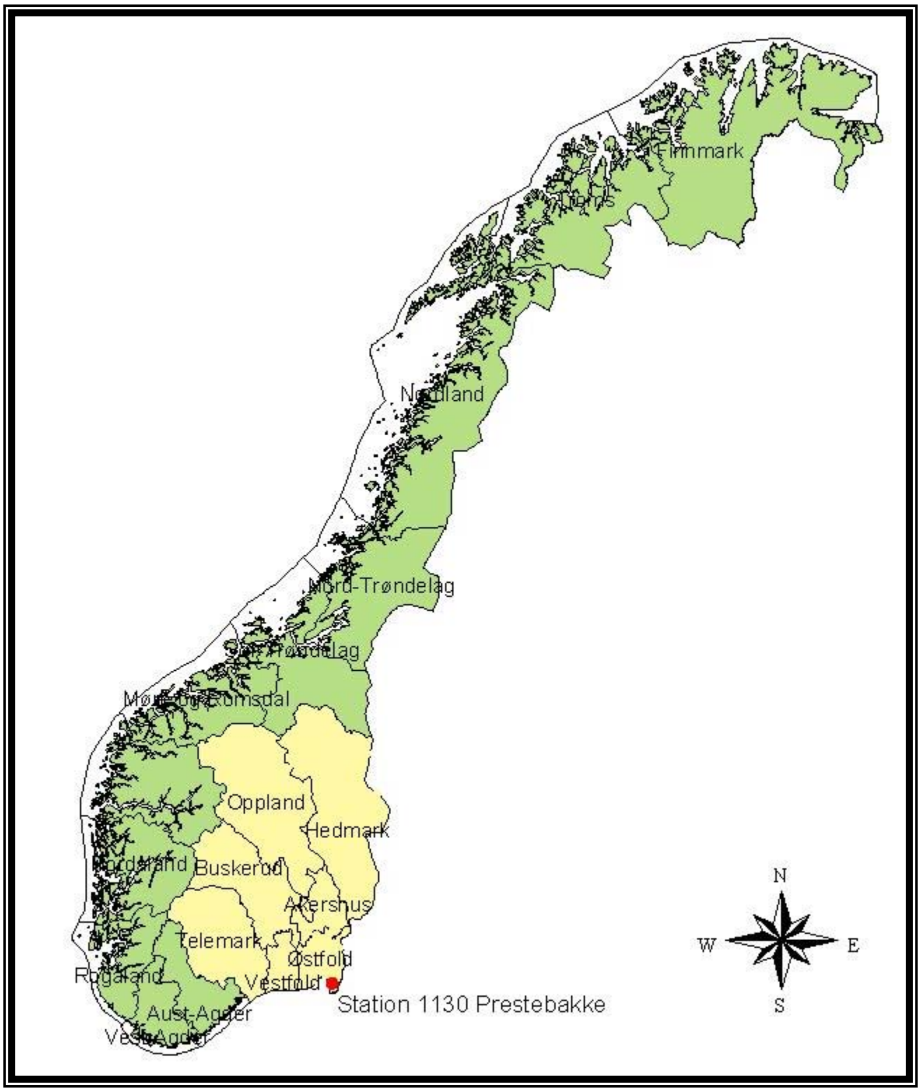

Figure 2. **Map of background for calculations of precipitation 31. Oct 2000**

In October 2000, the station 1130 Prestebakke, near the city Halden, had 249,4 mm of precipitation, ~221 % precipitation of normal, 113 mm, see Figure 3. The day with largest amount of precipitation was the 31. October when this station had 47,5 mm. In Norway a precipitation day is running from 06-06 UTC, and precipitation is dated on the day it is measured.

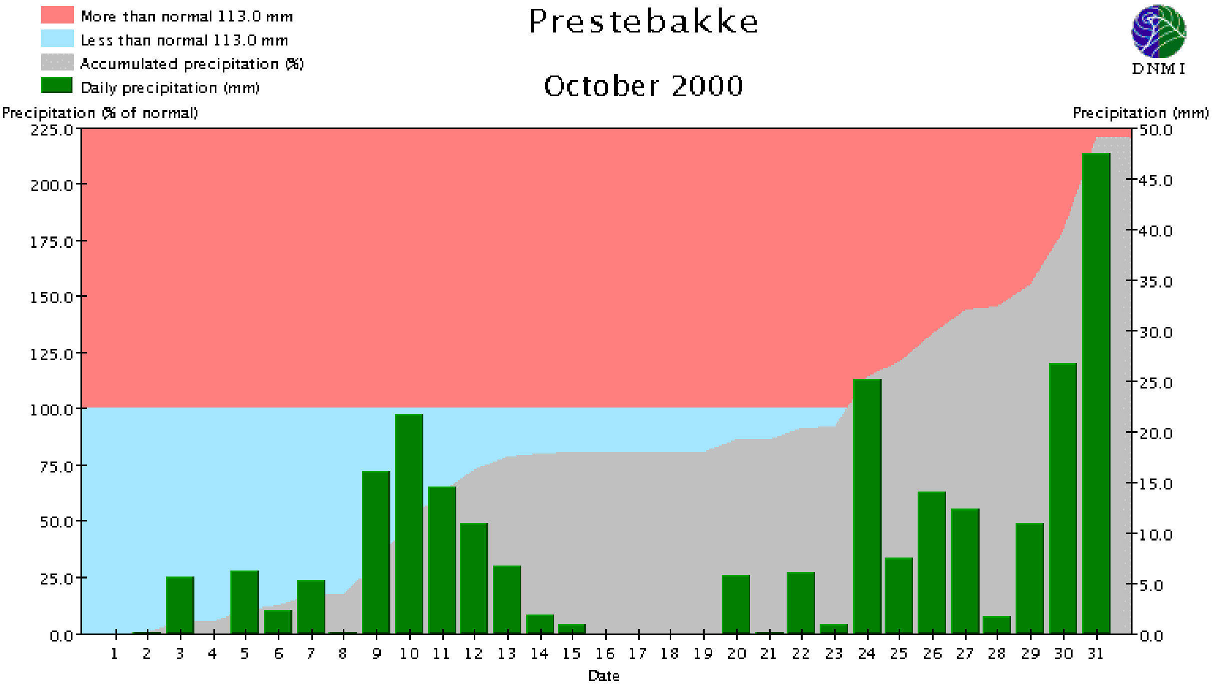

Figure 3. Precipitation in October 2000 for the station 1130, Prestebakke.

A daily precipitation amount of 47,5 mm at Prestebakke, happens very seldom. The station has most frequently extreme episodes in the summer, but also in the autumn. In Figure 4 (and also from Table 1) we can see that the daily precipitation 31.10.2000, is the third highest value since 1965, when precipitation measurements began at this station. The mean value for the annual maximum values is 26,9 mm (in the bottom of Table 2).

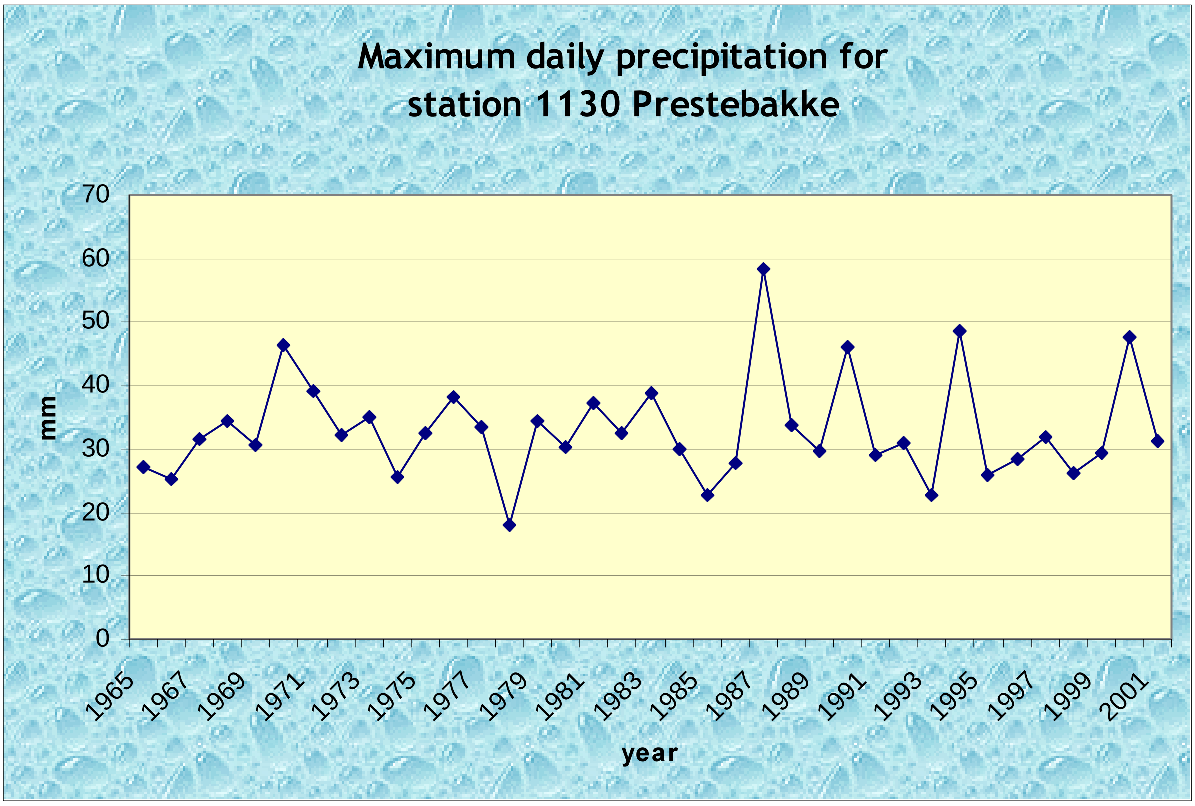

Figure 4. **Maximum daily amount of precipitation, annually for the station 1130 Prestebakke.**

1130 PRESTEBAKKE Probable return period for 47.5 mm, date 31.10.2000, in 1 precipitation day.					
	Annual	**Winter** **Jan, Feb, Dec**	**Spring** **Mar, Apr, May**	**Summer** **Jun, Jul, Aug**	**Autumn** **Sep, Oct, Nov**
Return period (year)	15	86	86	30	35

Table 1. **This table shows the calculated return period in years, for a station and given date, with given amount of precipitation.**

From Table 1 it is shown that this 1-day precipitation extreme has an annual return period of approximately 15 years. Table 2 is a standard report for met.no, Climatology division, showing amount of precipitation in mm for different return periods (years). The return periods are calculated with GUMBEL and NERC methods, see Chapter 2.2. The methods use the annual 1-day maximum for the different seasons to find the correct values. It is therefore very important to have long data series as a basis for the calculations. In the following examples it is used 30 or more years (from 1957) for every station in the calculations and maps. Table 1 has used the NERC calculation method in the "inverse" way, having the precipitation amount, finding the return period. This is a very useful table, and is also integrated in a standard report for met.no, Climatology division. The return period maps for this extreme precipitation episode are calculated this way.

Table 2:

DNMI

Extreme precipitation for seasons. Return periods.

a)

Stations						
Stnr	**Name**	**From**	**To**	**Masl**	**Municipality**	**County**
1130	PRESTEBAKKE	Aug 1965		157	HALDEN	ØSTFOLD

b)

1130 PRESTEBAKKE Basis for data: 1965-2001

Probable maximal precipitation (mm) in 1 precipitation day.

Return period (year)	Method	Annual	Winter Jan, Feb, Dec	Spring Mar, Apr, May	Summer Jun, Jul, Aug	Autumn Sep, Oct, Nov
5	GUMBEL	38	26	26	33	32
10	GUMBEL	43	30	30	39	36
25	GUMBEL	49	36	36	45	41
50	GUMBEL	54	40	40	50	45
100	GUMBEL	58	44	44	55	49
500	GUMBEL	68	53	54	66	59
1000	GUMBEL	73	57	58	71	63
5	NERC	38	26	26	33	32
10	NERC	43	30	30	38	37
25	NERC	52	36	36	45	44
50	NERC	59	42	42	52	51
100	NERC	67	48	48	60	58
500	NERC	91	68	68	81	80
1000	NERC	104	78	78	93	91
PMP	NERC	202	163	163	202	183
PMP	HERSHFIELD	178				

c)

10 max observed precipitation sums (mm) (independent episodes), for 1 precipitation day

	Annual	**Winter** **Jan, Feb, Dec**	**Spring** **Mar, Apr, May**	**Summer** **Jun, Jul, Aug**	**Autumn** **Sep, Oct, Nov**
1 max value	58,2	46,1	40,4	58,2	48,6
Median date	10.07.1987	01.02.1990	28.03.1987	10.07.1987	16.09.1994
2 max value	48,6	31,9	34,3	46,5	47,5
Median date	16.09.1994	28.02.2000	10.03.1979	30.06.1970	31.10.2000
3 max value	47,5	30,8	33,5	39,0	38,1
Median date	31.10.2000	03.12.1992	17.03.1977	14.08.1971	15.10.1976
4 max value	46,5	30,2	32,5	38,7	33,7
Median date	30.06.1970	18.12.1980	04.03.1982	25.06.1983	03.09.1988
5 max value	46,1	30,0	31,6	37,3	32,4
Median date	01.02.1990	29.12.1979	25.05.1973	30.06.1981	26.09.1975
6 max value	39,0	28,9	28,9	35,0	32,0
Median date	14.08.1971	13.02.1973	21.03.1968	09.07.1973	17.09.1997
7 max value	38,7	28,2	27,6	34,4	31,6
Median date	25.06.1983	03.12.1972	19.04.1999	15.08.1968	04.10.1967
8 max value	38,1	25,3	26,2	32,4	31,0
Median date	15.10.1976	14.01.1983	06.05.1997	30.07.1988	29.10.1987
9 max value	37,3	24,6	26,1	32,3	29,9
Median date	30.06.1981	06.12.1982	21.03.1989	19.06.1972	19.11.1973
10 max value	35,0	24,0	25,1	31,1	29,4
Median date	09.07.1973	23.12.1974	26.05.2000	08.06.2001	17.11.1999
Data loss (num days)	33				
Mean of max values	33,0	21,0	20,9	27,5	26,9
Standard deviation of max values	8,1	7,4	7,7	9,0	7,3

Generated: *04.12.2001*

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Table 2. a) Station information b) estimated amount of precipitation (mm) for different return periods based on GUMBEL, and NERC methods c) The 10 maximum daily precipitation sums in the observation period.

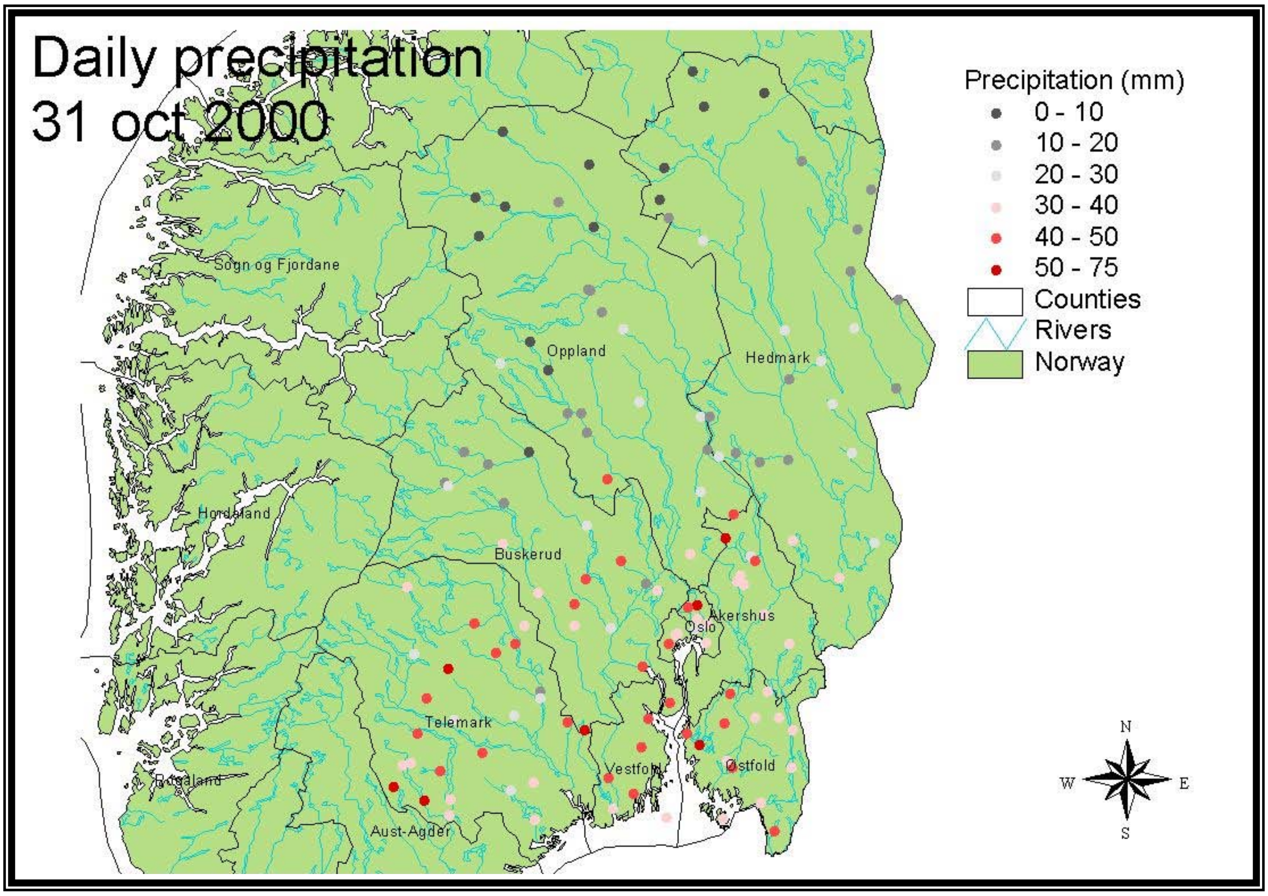


Figure 5. Amount of precipitation 31. Oct. 2000 for stations in the southeastern part of Norway.

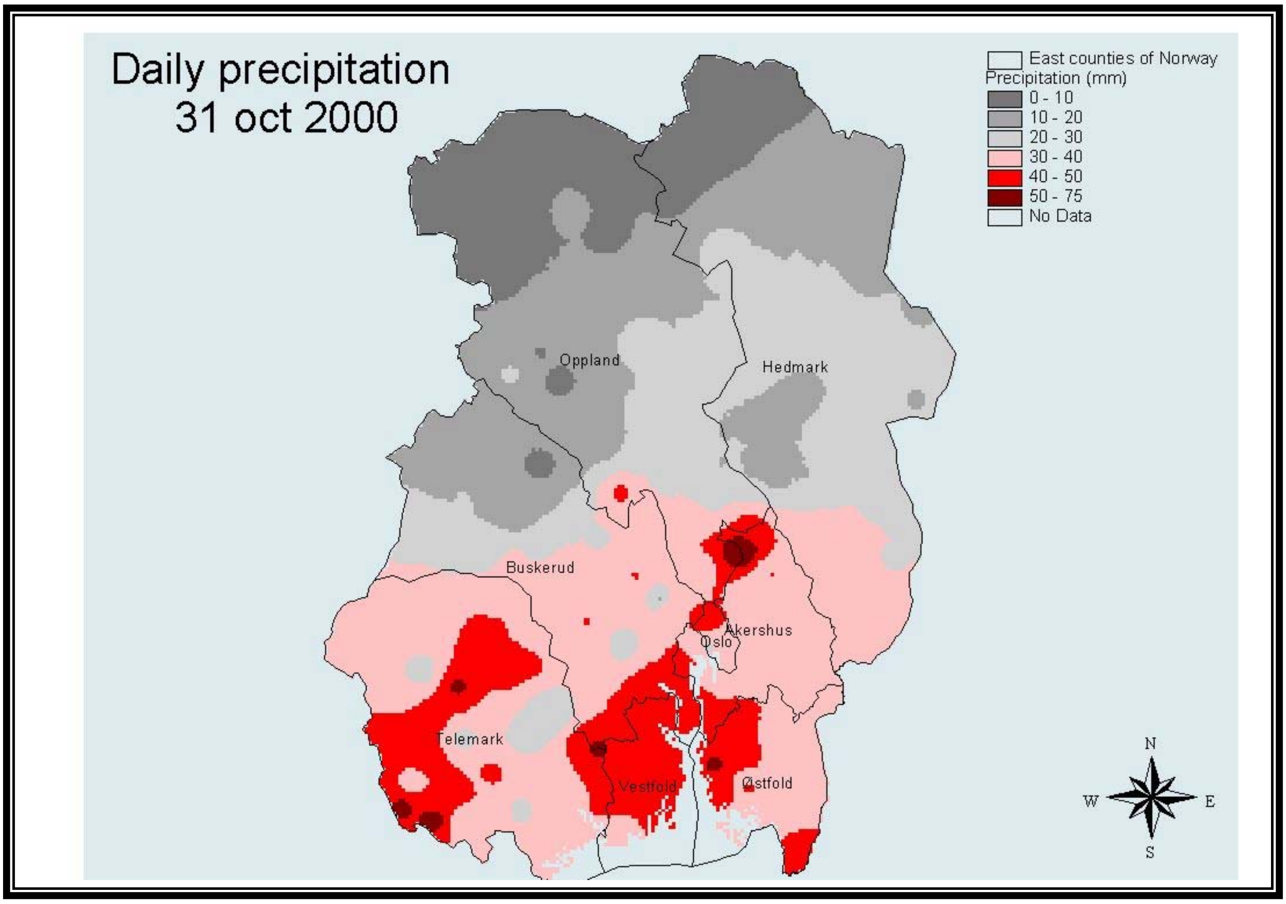


Figure 6. Spatial distribution of daily precipitation the 31. Oct. 2000.

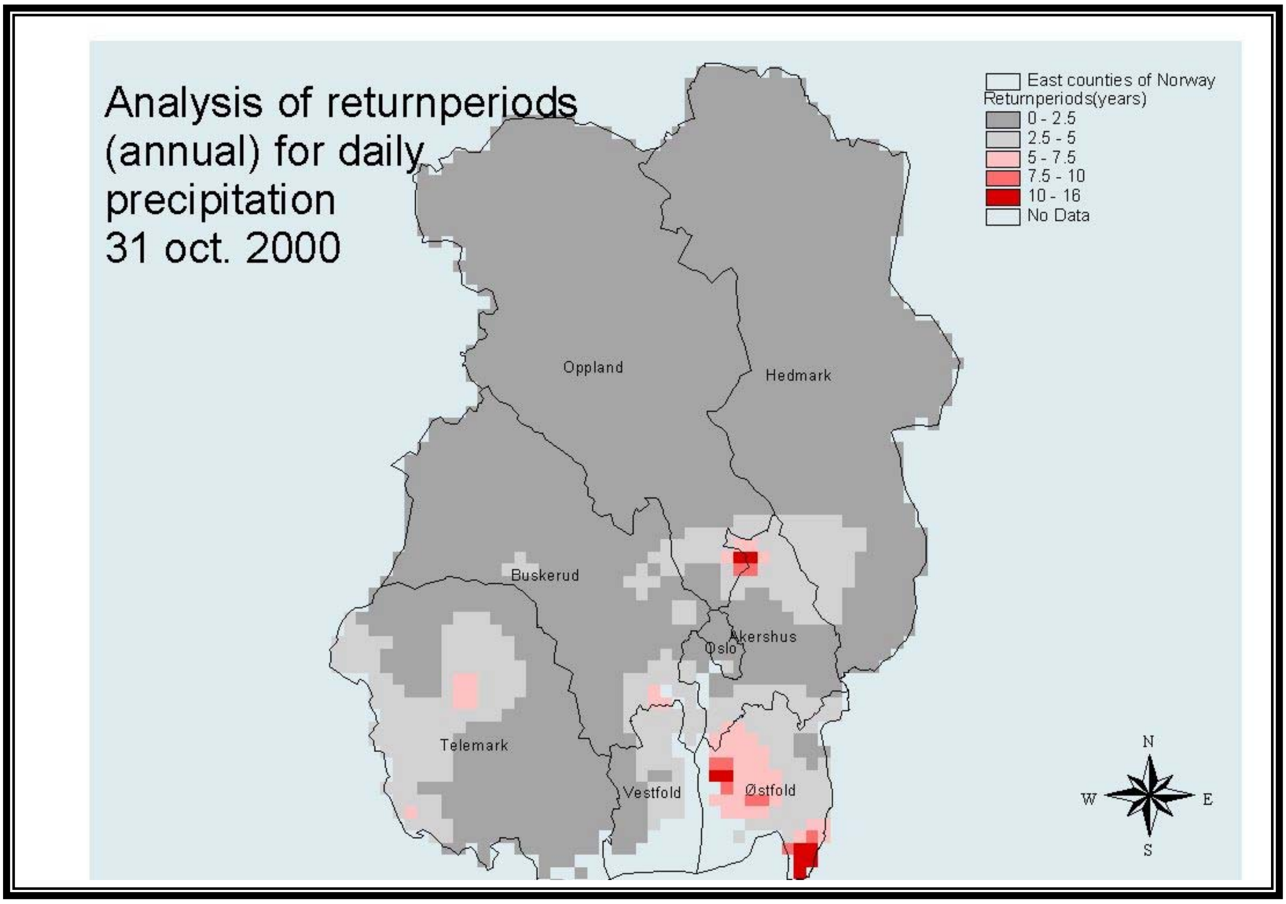


Figure 7. Annual return period for 1-day precipitation 31.10.2000 in the southeast counties of Norway.

Figure 5 - Figure 7 show the connection between how often extreme episodes occur and the extreme episode itself. From Figure 5 and Figure 6 we can see that the precipitation amount was above 40 mm in western parts of Telemark, in Vestfold, Oslo up north to Akershus and also some places in Østfold. A closer look at Figure 7 tells us that it is quite normal, annually, with these amounts of precipitation in Telemark and Vestfold, where the return periods are lower than 7.5 years. North in Akershus and in Østfold it is not so common, where the return period is about 15 years.

For the 2 days precipitation sum 10-11 Oct in Figure 8, we can see the same structure. The most extreme return periods in Figure 9 make a “belt” across the map, showing that the weather situation has an unusual direction. There are large mountain areas in the west and in the north of the “belt”.

Taking a look at the station at the border between Akershus and Oppland, Jeppedalen, where the red area is, we can see from Figure 10, that this precipitation sum was the maximum ever since observations began in 1965.

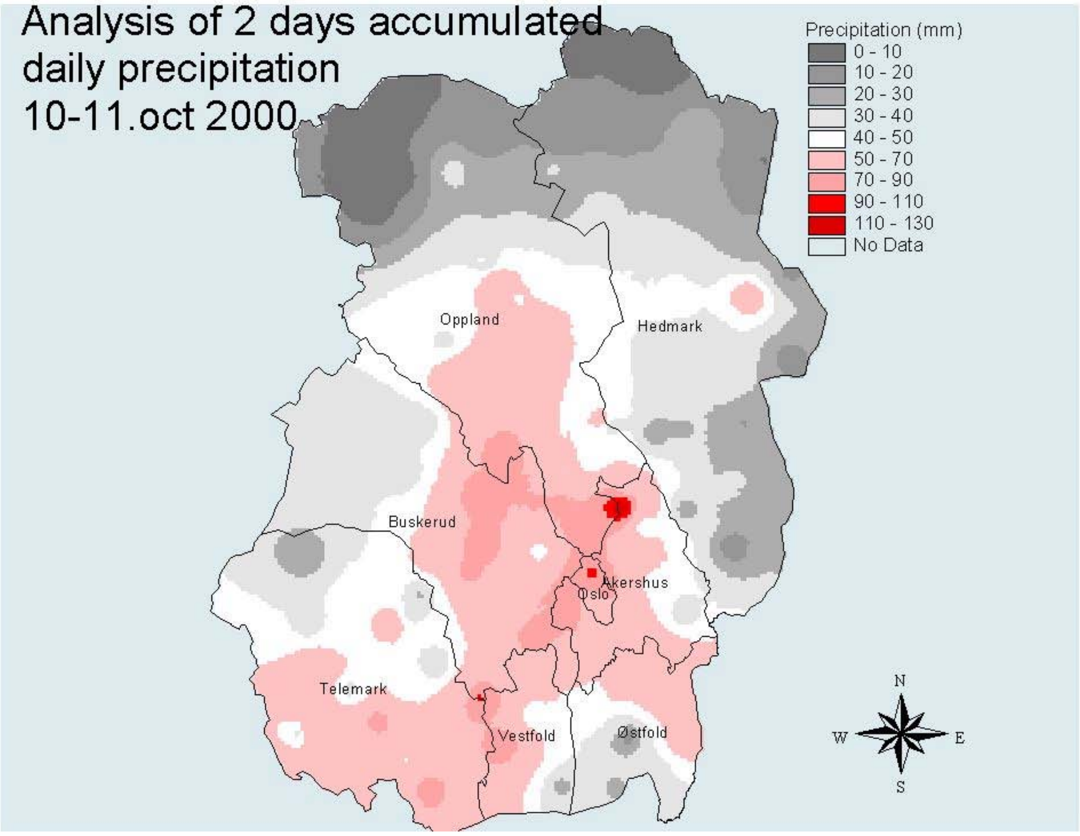


Figure 8. Map showing 2 days precipitation sum 10-11 Oct. 2000.

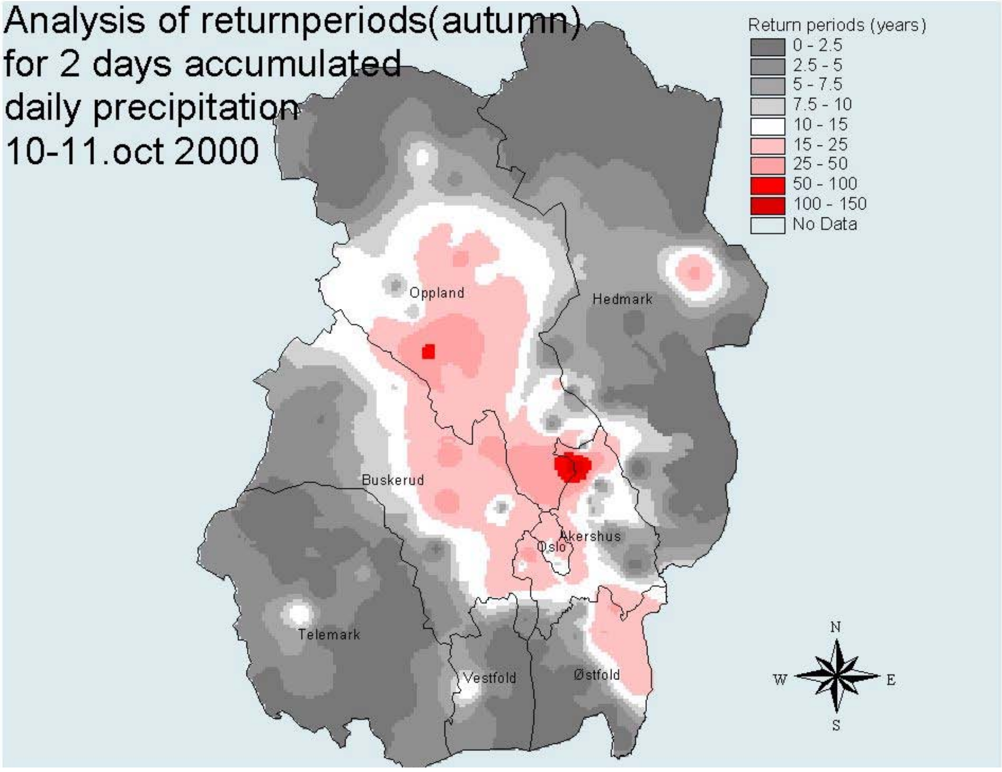


Figure 9. Map showing the return periods for 2 days precipitation sum 10-11 Oct. 2000.

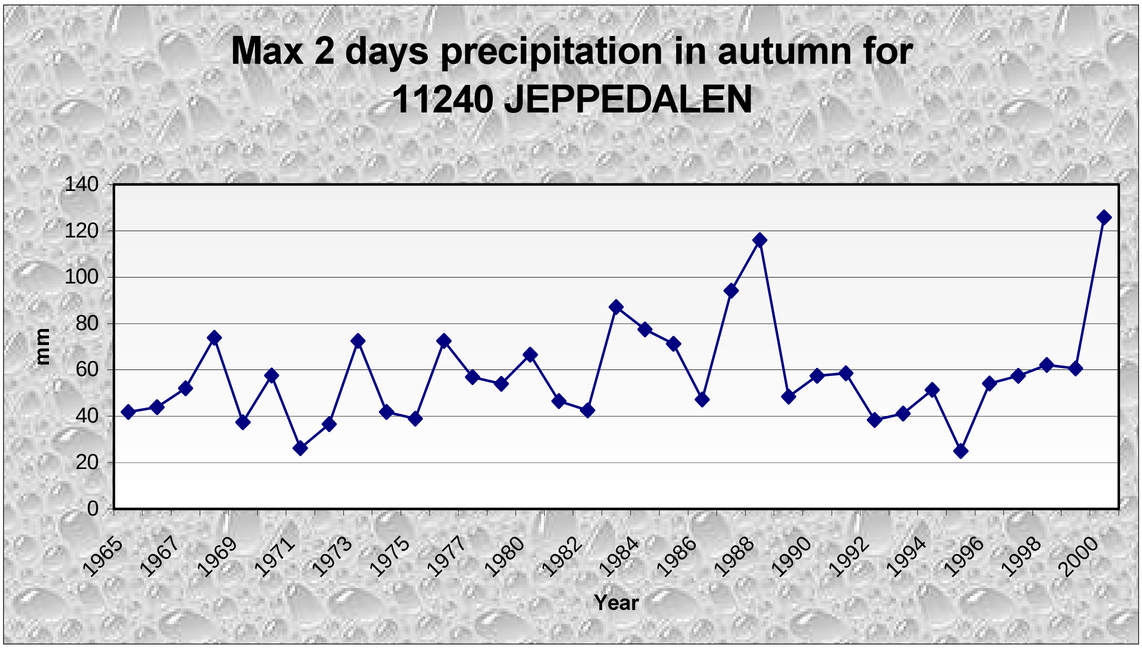


Figure 10. **Distribution of the 2 days maximum precipitation amounts in autumn for the station, Jeppedalen.**

Figure 11. **Leira in Akershus 12. October 2000. Photo Øyvind Høydal, NVE [6].**

Figure 12. **Frogner in Akershus 12. October 2000. Photo Øyvind Høydal, NVE [6].**

As seen from the pictures in Figure 11 and Figure 12, the extreme 2 days precipitation episode 10-11 October resulted in a flood in the Akershus area, east of Oslo. There were many rivers and lakes that were flooded 1 to 3 times, during October and November with large flood-return periods from 5 to 100 years (Drageset, NVE 2000 [6]).

2.2 *General analysis for return periods for daily precipitation*

The calculation methods used in this report are based on the Norwegian manual for calculation of probable precipitation values (E. Førland 1992 [7]). The methods have been a standard way of calculate return periods for extreme daily precipitation and is widely used for dam dimensioning. In the NORDKLIM countries we are using slightly different methods. More details on methods for extreme value analysis used in the Nordic countries are given in H.Alexandersson et.al 2001 [8].

Procedure for calculations:

1. Stations were selected with daily precipitation series of 30 years or more in the period 1957-2000. This gave almost 500 stations in Norway, which were pretty well geographical distributed. See Figure 13.
2. Annual and seasonal MAX daily (or N days) precipitation sum, each year, for each station were found.
3. Mean and standard deviation values of these maximum values were calculated.
4. Mean and standard deviation values were used to calculate GUMBEL values.

X(T) is the value exceeded every T’th year.

GUMBEL* equation:

$$X(T) = Xmean - (\mathrm{sqrt}(6)/pi) *\{ 0.577 + \ln(-\ln((T-1)/T)) \}* Xstdev$$

5. **The GUMBEL(X(5)=M5) values are used to find NERC-values(X(T)) for different return periods T(year):**

NERC equation, solved for X (mm):

$$X(T) = M5 * \mathrm{EXP}\{ C* [\mathrm{LN}(T-0.5) -1.5]\}$$

C = 0.165 + 0.0236*LN(**M5**)	where 2< **M5** <= 10	(mm)
C = 0.219	where 10< **M5** <= 15	(mm)
C = 0.300 - 0.0294*LN(**M5**)	where 15< **M5** <= 25	(mm)
C = 0.3584 - 0.0473*LN(**M5**)	where 25< **M5** <= 350	(mm)
C = 0.167 - (0.0145)^LN(**M5**)	where 350< **M5** <=1000	(mm)

6. **The NERC equation is solved for T, to find the return period for different NERC values, X(T) - precipitation amount. The same methods are used to calculate C.**

NERC equation, solved for T (years):

$$T(X) = EXP\{(1/C)*(LN(X/M5)) + 1.5\} + 0.5$$

PMP NERC equation, solved for X (mm). The same methods are used to calculate C.

$$X(T) = M5 * EXP\{ C* [LN(T-0.5) -1.5]\}$$

T = 36000 (year) where **M5** <=45 (mm)
T = 47829 - 262.9***M5** (year) where 45 < **M5** <= 125 (mm)
T = 22503 - 62.4***M5** (year) where 125 < **M5** <= 200 (mm)
T = 10000 (year) where **M5** > 200 (mm)

The NERC method, is an empirical method and the C-coefficient is based on the climatical and geographical conditions in Great Britain and may thus give smaller return period values in continental parts of Scandinavia. For Norway, the method gives good results (Førland 1992 [7], Alexandersson et al 2001 [8]).

* The **GUMBEL** function, is derived from the Generalised Extreme Value Distribution Function $F(x)=P(X<x)=EXP\{-EXP[-a(x-b)]\}$ where $a=1.281/Xstdev$ and $b=Xmean-0.45*Xstdev$.
(Alexandersson et al 2001 [8] and Tveito et al. 1998 [12].)

Production of maps:

- Point values are interpolated by using IDW (inverse distance method, pure mathematical method, based upon nearest 12 stations). This is one of the most used methods for interpolation of climate and atmospheric elements. (Dobesch et.al 2001 [3])
- Grid size about 9 km for Norwegian country maps
- Grid size about 1,8 km for East counties of Norway maps
- Map scale ~ 1 : 2 000 000

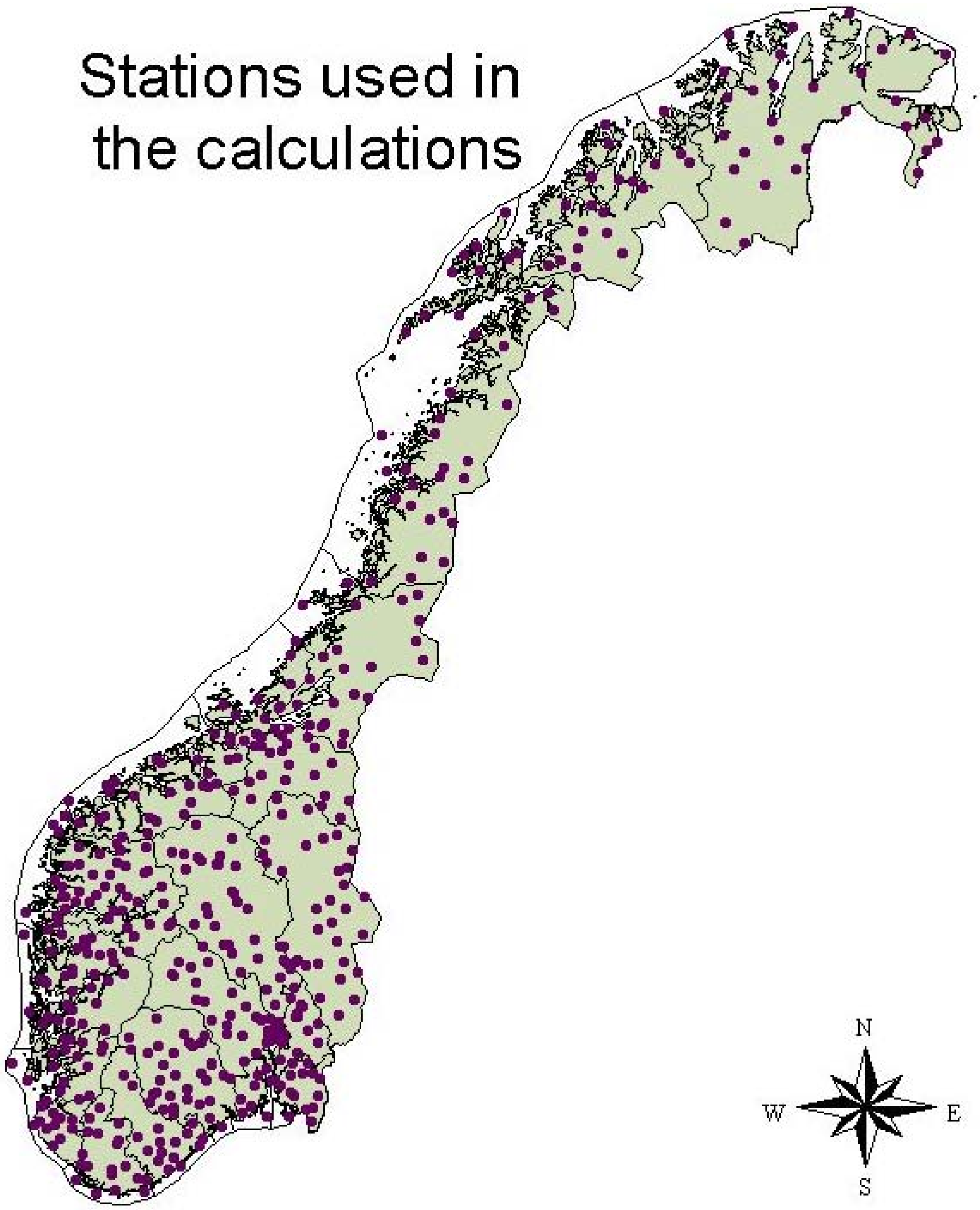


Figure 13. **Stations, with at least 30 years of daily precipitation data in the years 1957-2000, used in the return period calculations.**

3 Spatial distribution of return periods for extreme precipitation

3.1 Estimate of 1-day precipitation values with 5 years return period, seasonal, Norway

The next 4 figures, Figure 14 - Figure 18, show the GUMBEL calculated, probable 1-day precipitation extreme values for 5 years return period (M5 value), spatially distributed, for the 4 seasons in Norway. The same legend is used for the four seasons. Generally the amount of extreme 1-day precipitation is less in spring and summer than in autumn and winter. In the southeast of Norway, it is more probable to get a heavy 1-day precipitation episode in the summer, than the other seasons, due to the convective effect, often with thunder. Winter season is the season with smallest extreme precipitation episodes in the north and the southeast, were it is typical inland climate, as seen from Figure 28. Autumn and winter give heaviest precipitation episodes along the west coast, Figure 27. Relatively large catch deficiency in the precipitation gauges may occur during winter episodes with snowfall and strong winds, but it is not so important in the scope of extreme precipitation.

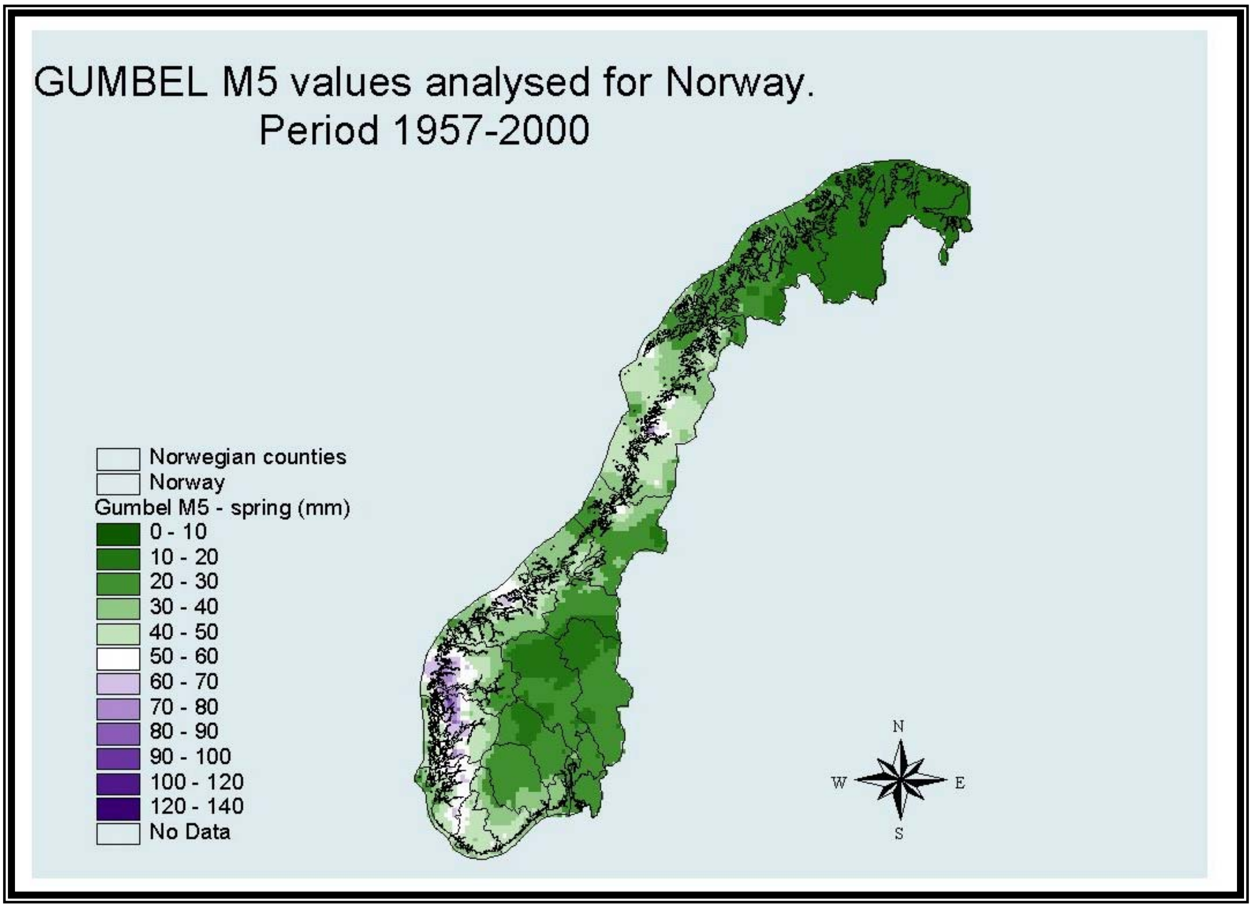


Figure 14. Estimated 1-day precipitation values with 5 years return period, for the spring months March, April and May.

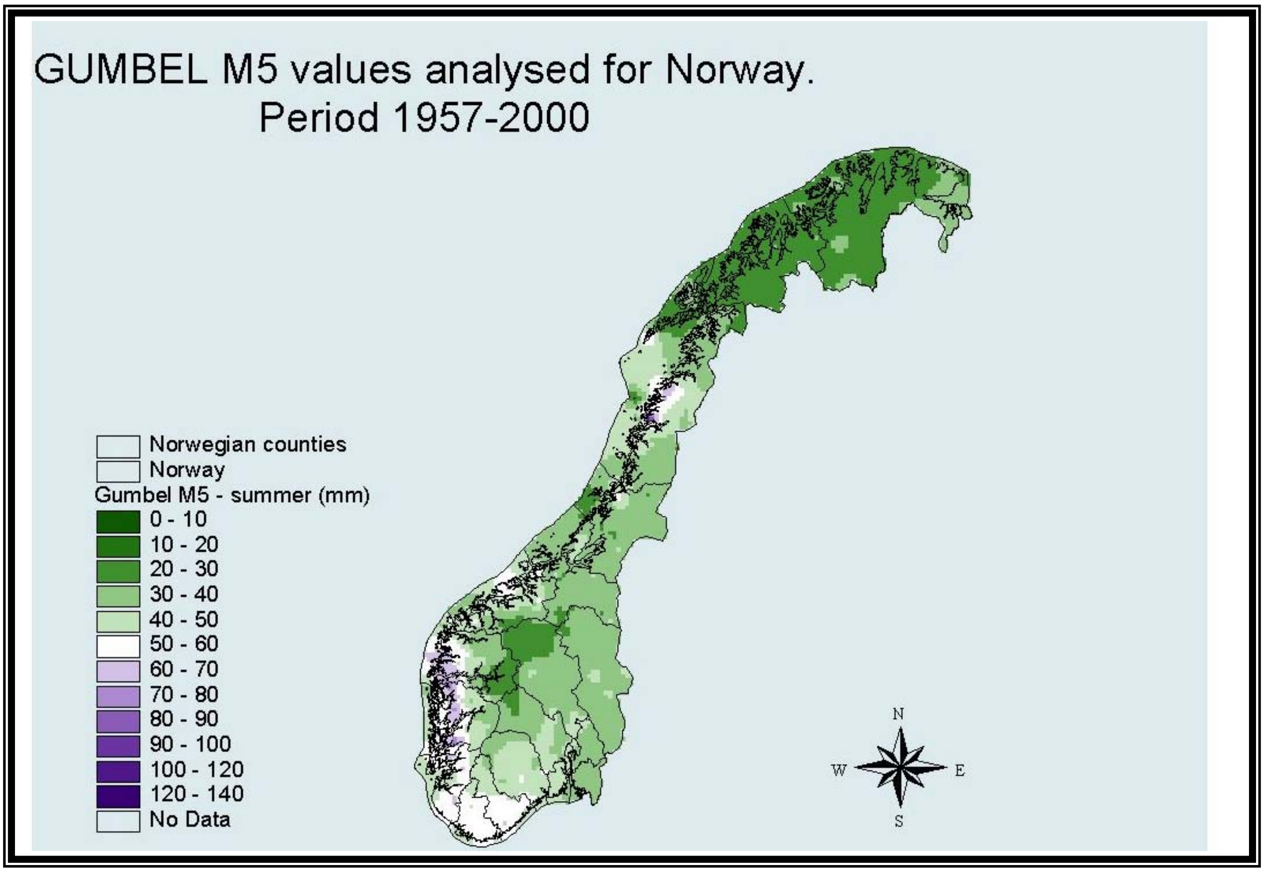


Figure 15. **Estimated 1-day precipitation values with 5 years return period, for the summer months June, July and August.**

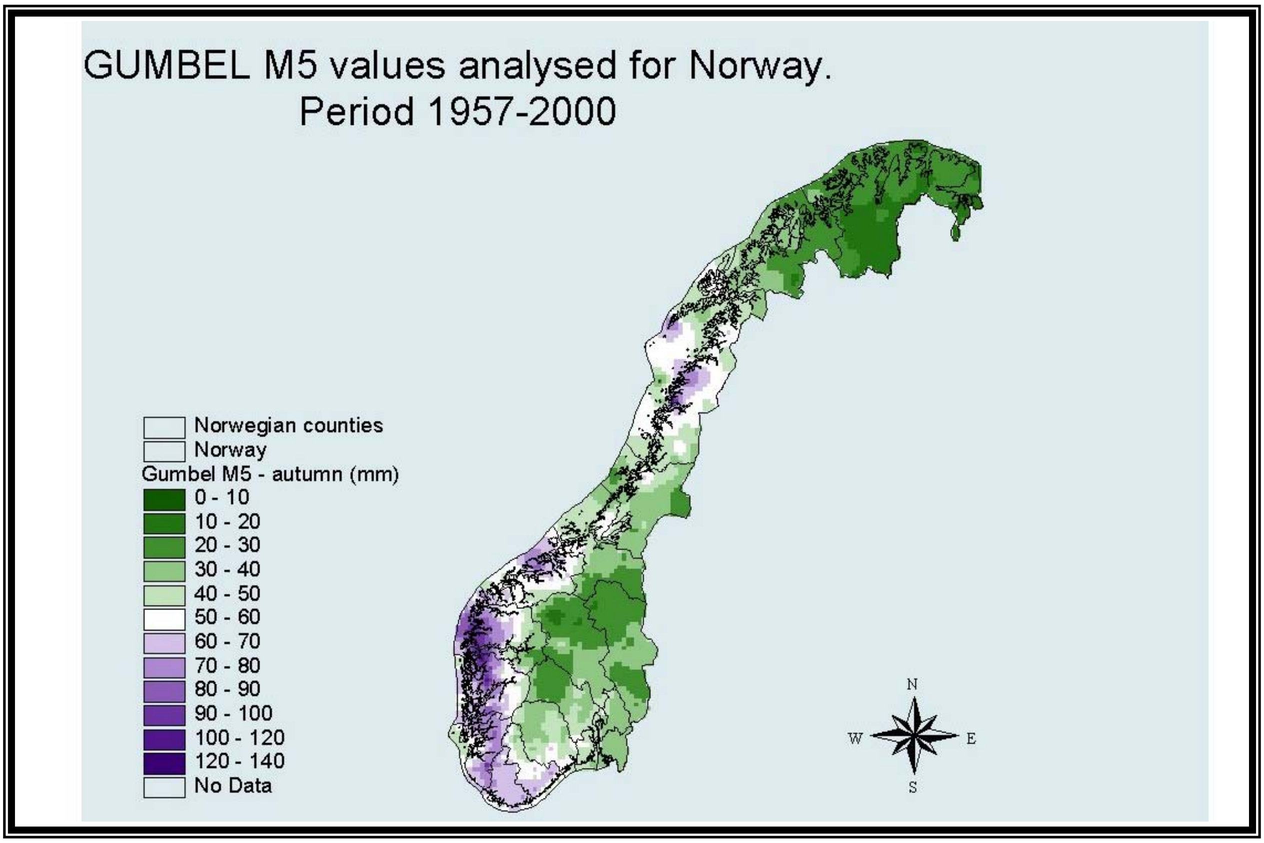


Figure 16. **Estimated 1-day precipitation values with 5 years return period, for the autumn months September, October and November.**

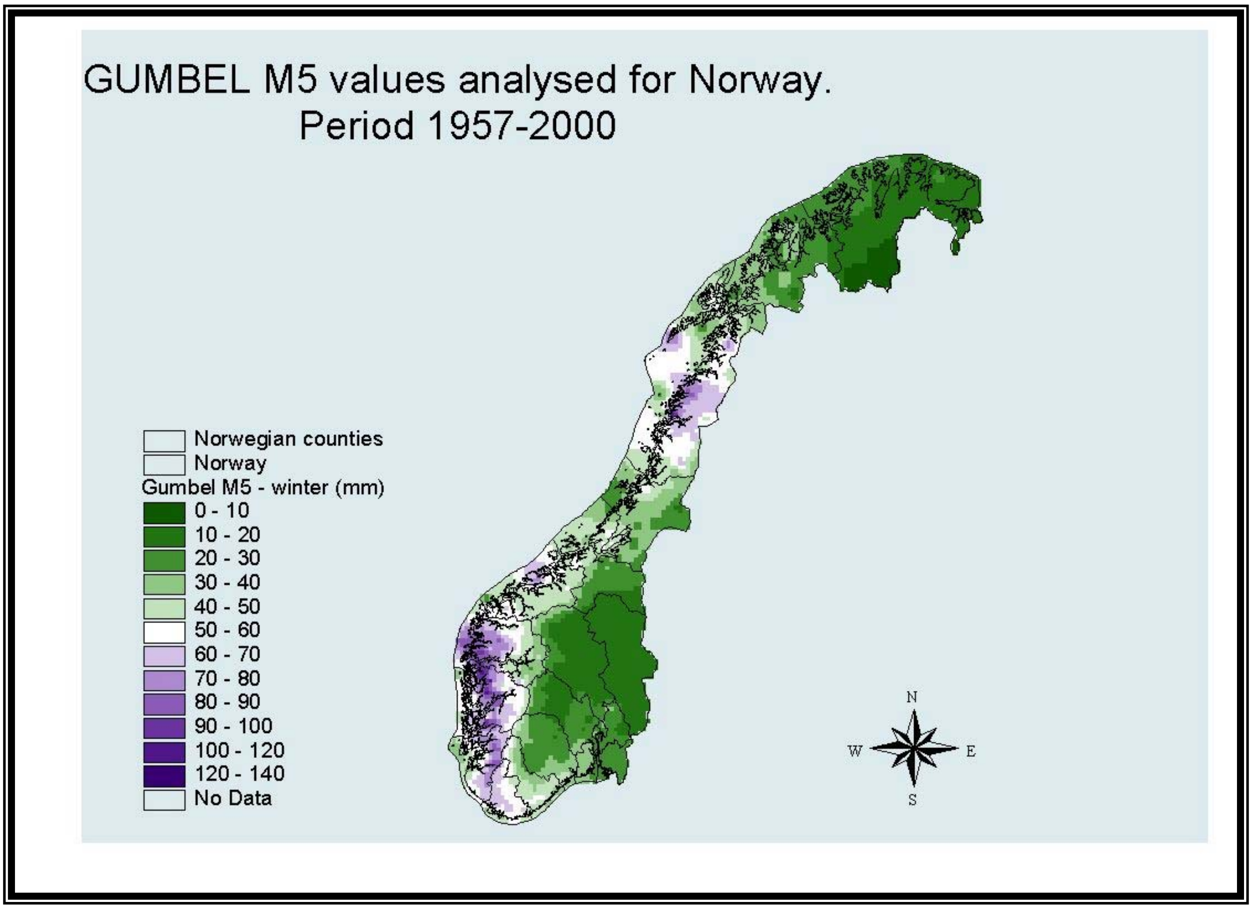


Figure 17. Estimated 1-day precipitation values with 5 years return period, for the winter months December, January and February.

Maps of 5 years return period values for Norway are also presented by Alexanderson et.al, 2001 [8]. They will differ a little bit because of the period used. In this section stations with at least 30 years with precipitation observations after 1957 (where the data have been through a quality check) until year 2000 are used. In these calculations we use the precipitation day compared to the generalized 24 hours precipitation in the Figure 3.1 in Alexanderson et.al, 2001[8].

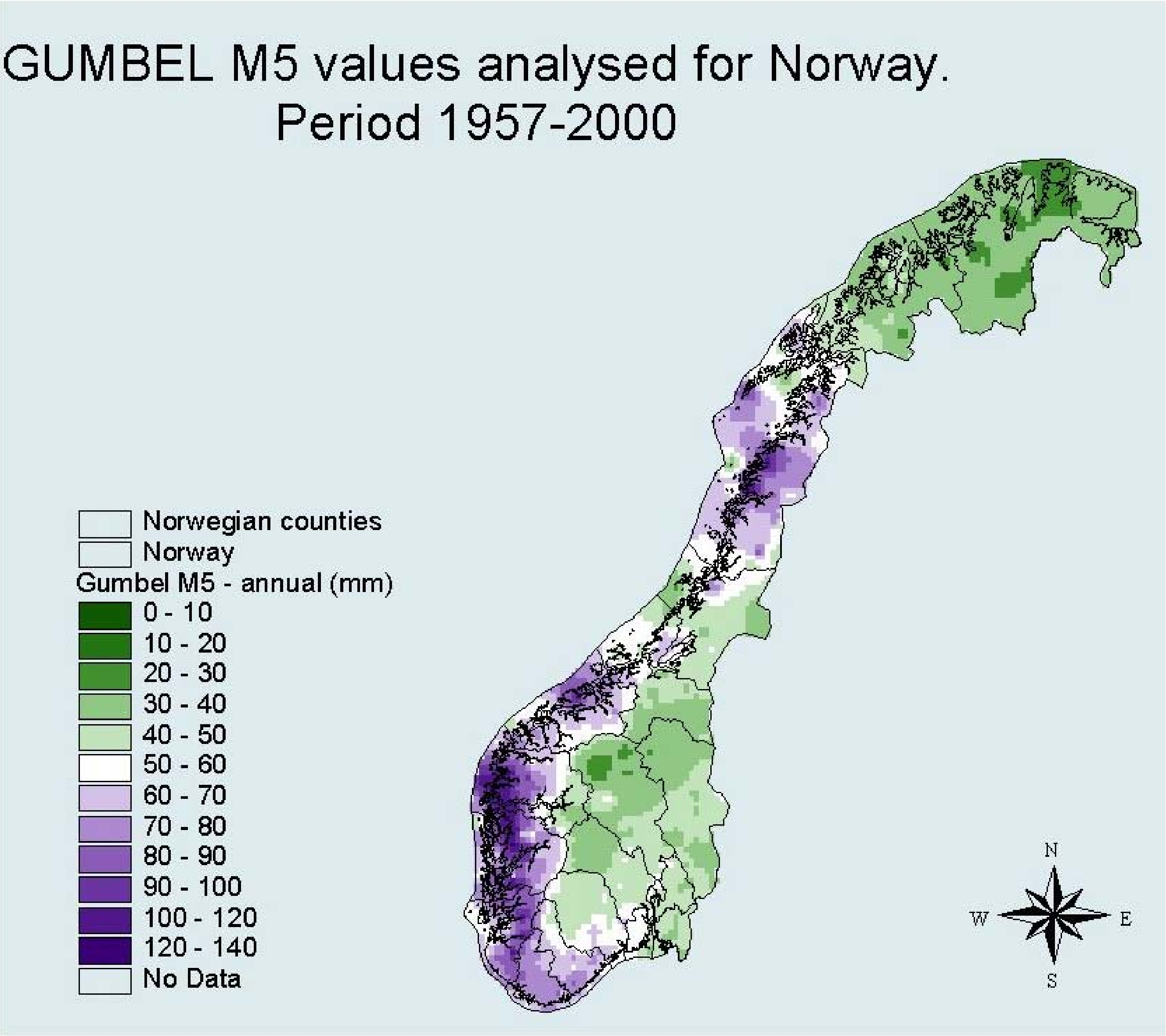


Figure 18. **Estimated 1-day precipitation values with 5 years return period, annually.**

From Figure 18 we can see that the M5 value is above 120 mm along the west coast, but is only a few tens of millimeters in the eastern and more continental parts of Norway.

The map in Figure 18 differs a little bit from the corresponding map given in Figure 7, Tveito and Førland, 1996 [4]. This is because of a different station net and different period is used as the basis for the calculations of isolines in a map. The interpolation is based upon these hand drawn isolines and digitized afterwards. The legend and the interpolation method used are also different. The map used in this report is therefore more accurate and updated.

3.2 Estimate of X-day precipitation values with N years return period, Norway

The following maps show annual return period for different duration of the precipitation. NERC calculation is used. The stations have data series with at least 25 years with precipitation observations after 1957 (where the data have been through a quality check) until year 2001. This gives some more stations (about 30) than what is used in the last calculation in Figure 13.

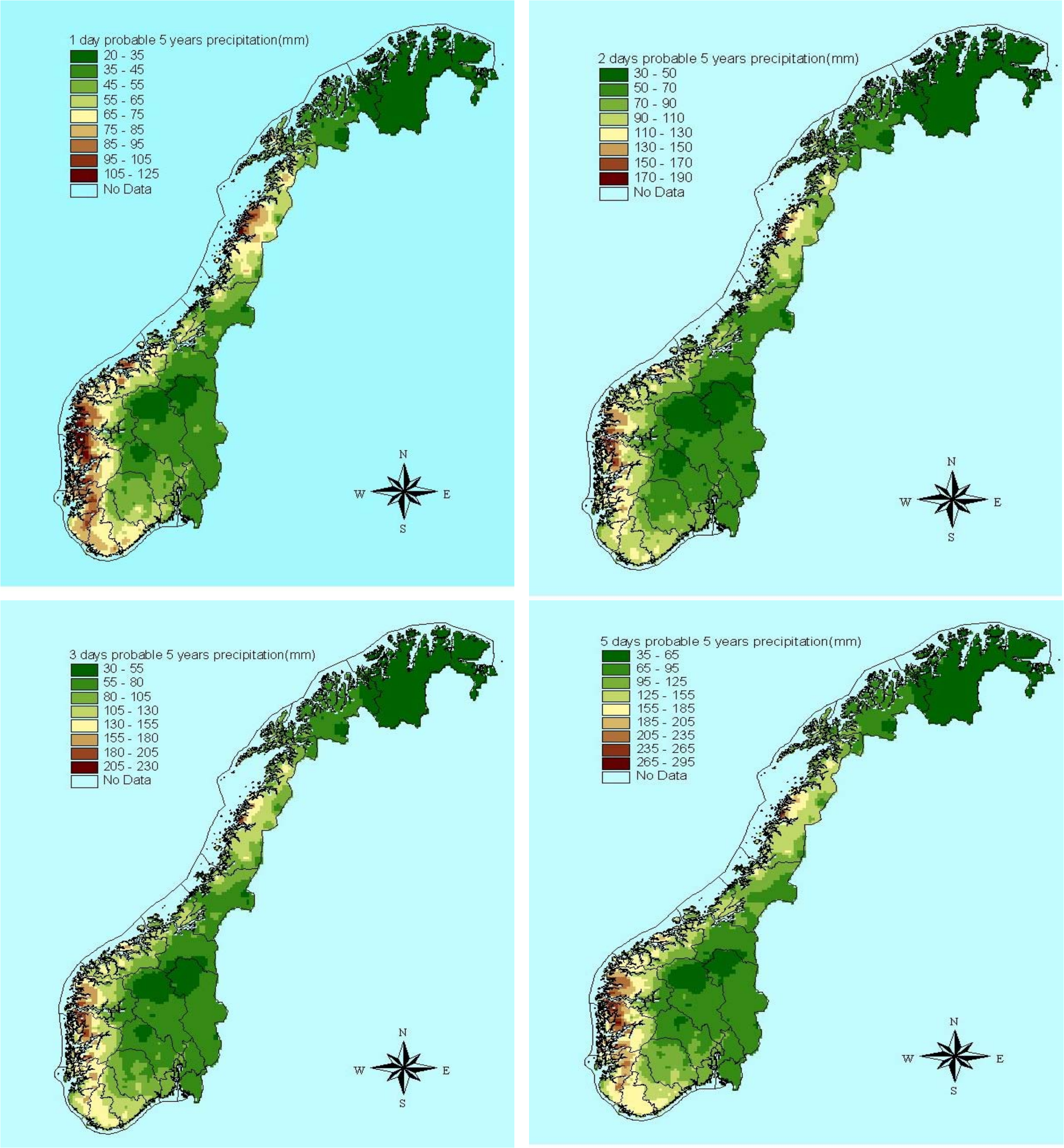


Figure 19. Precipitation amount for 5 years return period for different durations: 1, 2, 3 and 5 days.

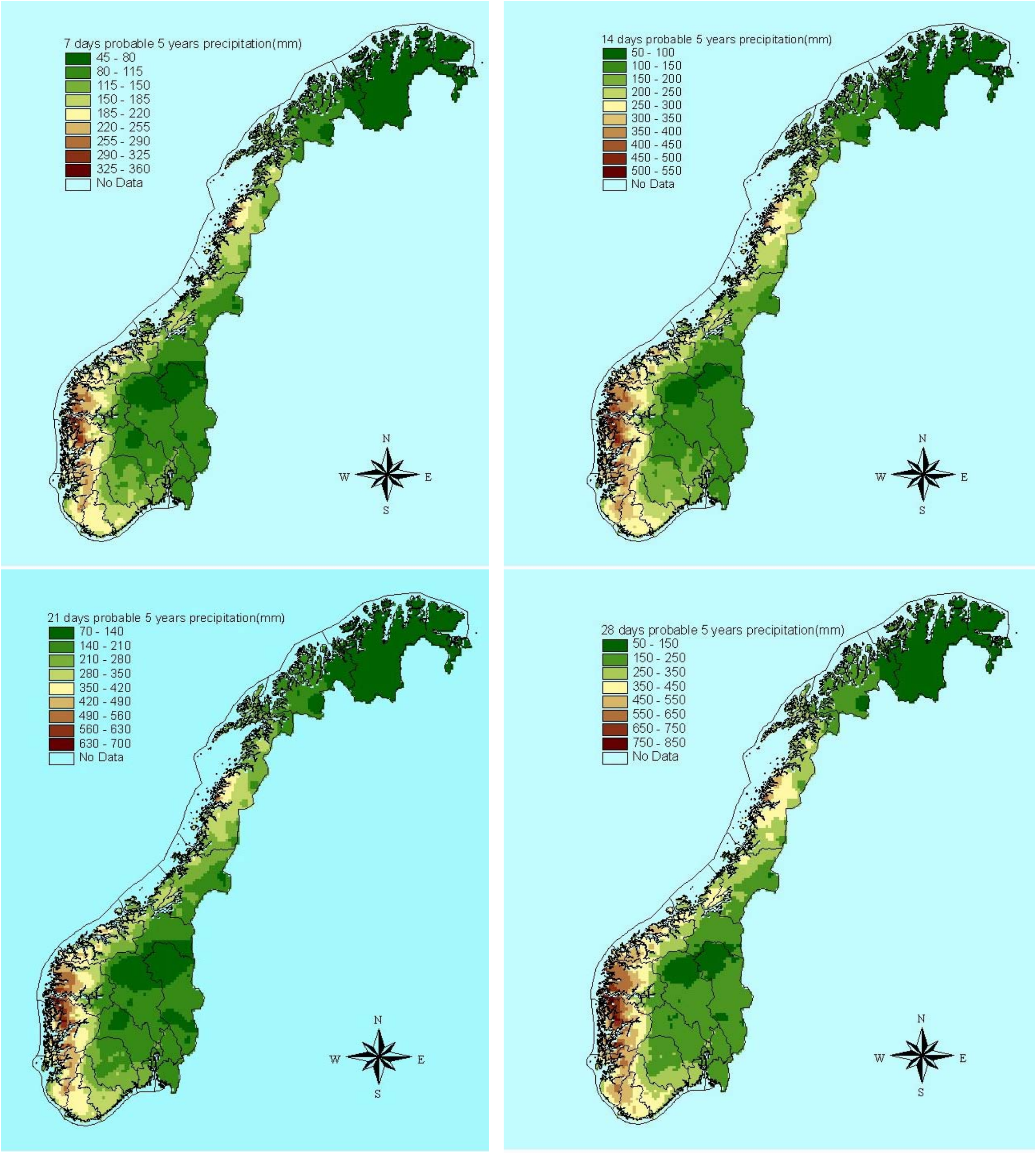


Figure 20. Precipitation amount for 5 years return period for different durations: 7, 14, 21 and 28 days.

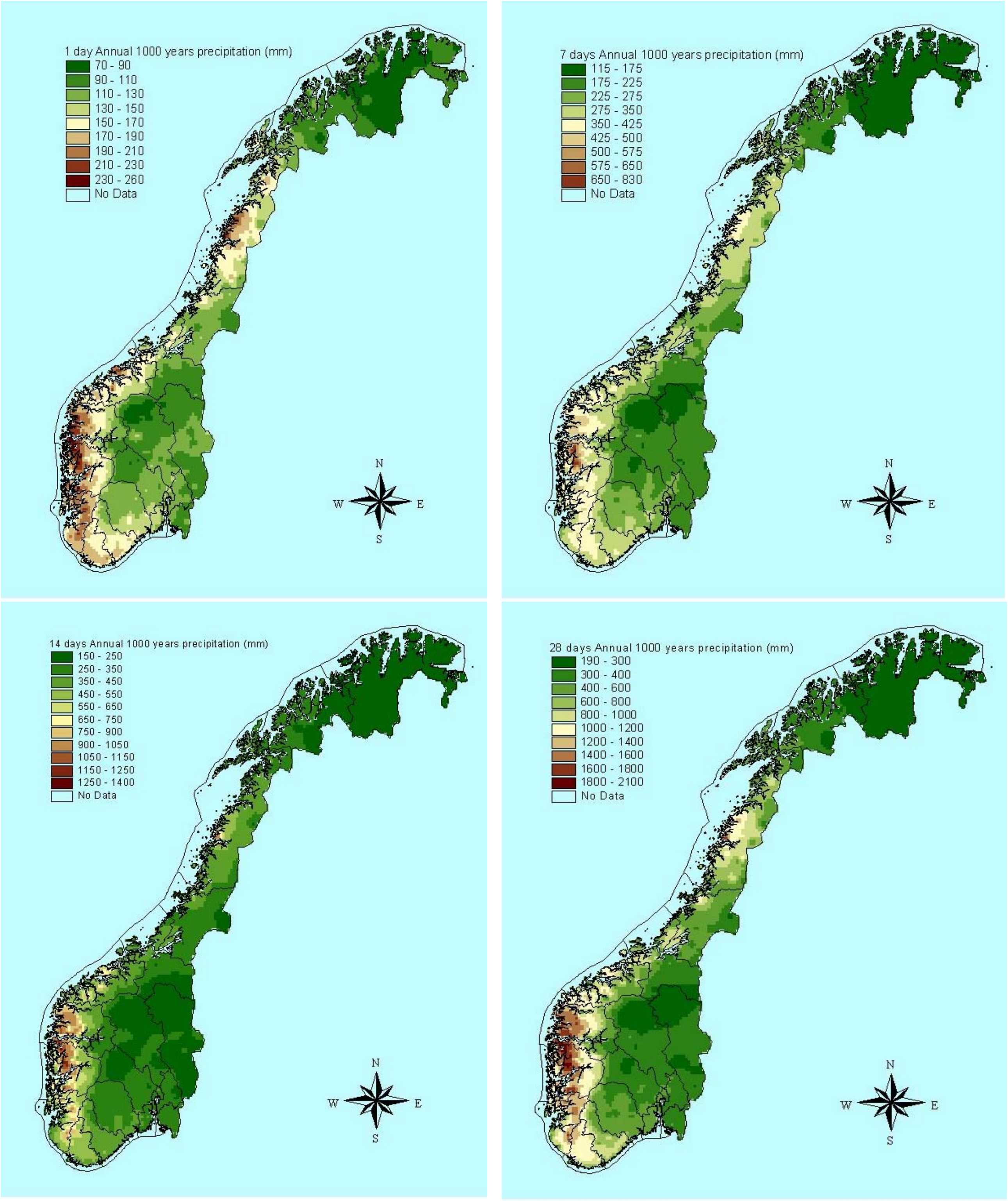


Figure 21. **Precipitation amount for 1000 years return period for different durations; 1, 7, 14 and 28 days.**

Figure 19 - Figure 21 show that different durations do not give much difference in the spatial distribution of neither the precipitation amount nor the return period. We can see that the west coast and a smaller area in the middle north, *Nordland,* underneath the mountain and the glacier *Svartisen* have the heaviest N-days rainfall. Least extreme episodes are in the inland at the east and north side, in the leeward side of the large mountain area, and in the northeast at *Finnmarksvidda.*
The intervals in the legend make it complicated to see the effect of the convective heavy rainfall in the Norwegian inland and southeast during summer time, but the effect is still there between 1 and 3 days duration, as we also will see of the seasonal graphs in Figure 23.
Figure 21, shows that for T=1000 years, a 1-day precipitation at the west coast with about 250 mm is higher than the 28 days precipitation value in northeast! From this we can derive that a precipitation episode will probably last for more days in the west (generally where the episodes are heavier) than in northeast (generally where the episodes are smaller). In Figure 23 we can see the same connection; the *Samnanger* curve is much steeper (the precipitation episode "grows" heavier every day) than the *Karasjok* curve. *Samnanger* has generally much rain because of the Icelandic-low and the frontal-systems hitting the west coast.

3.3 Seasonal differences during N-days precipitation, Norway

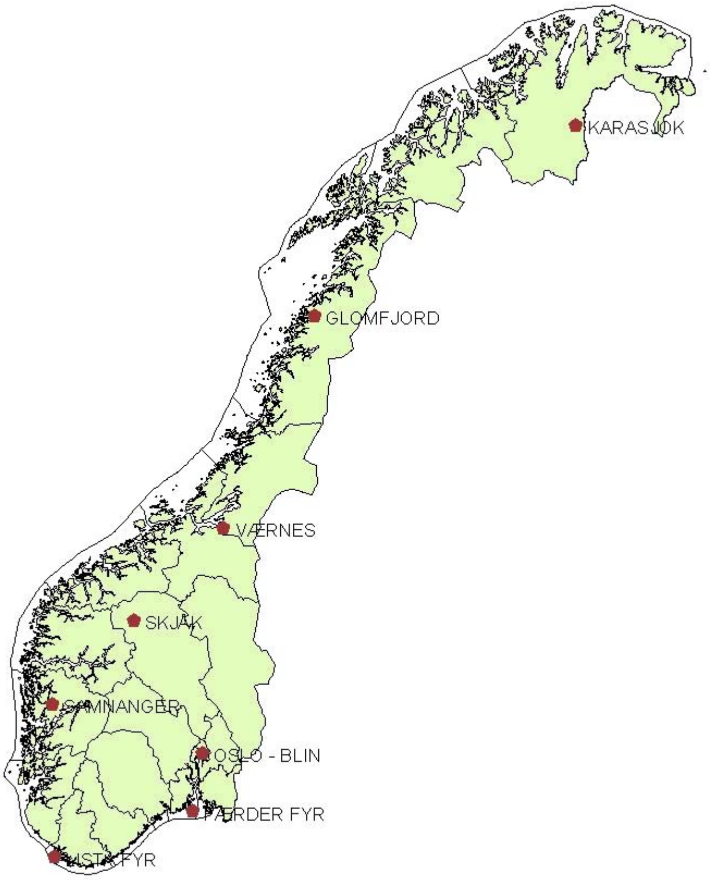
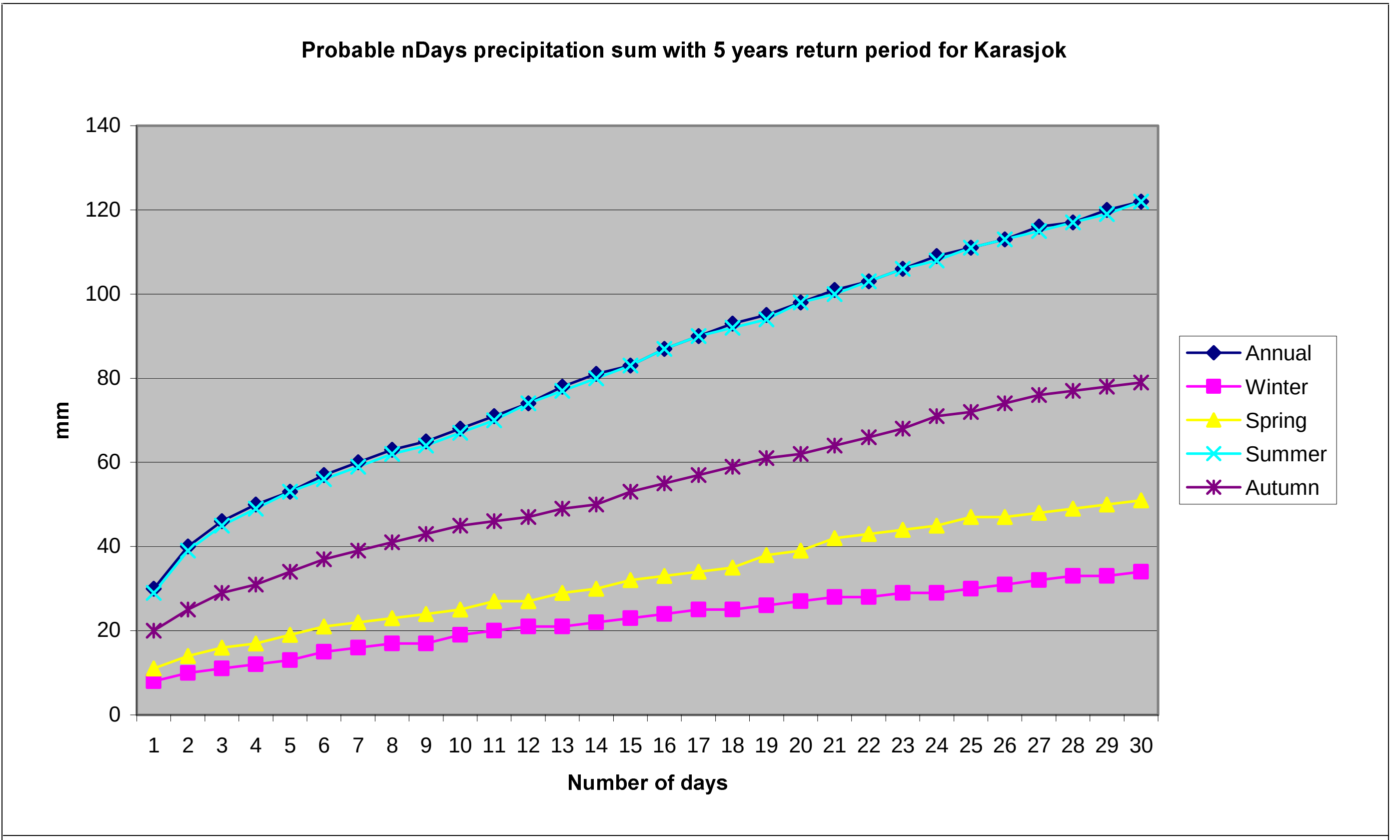
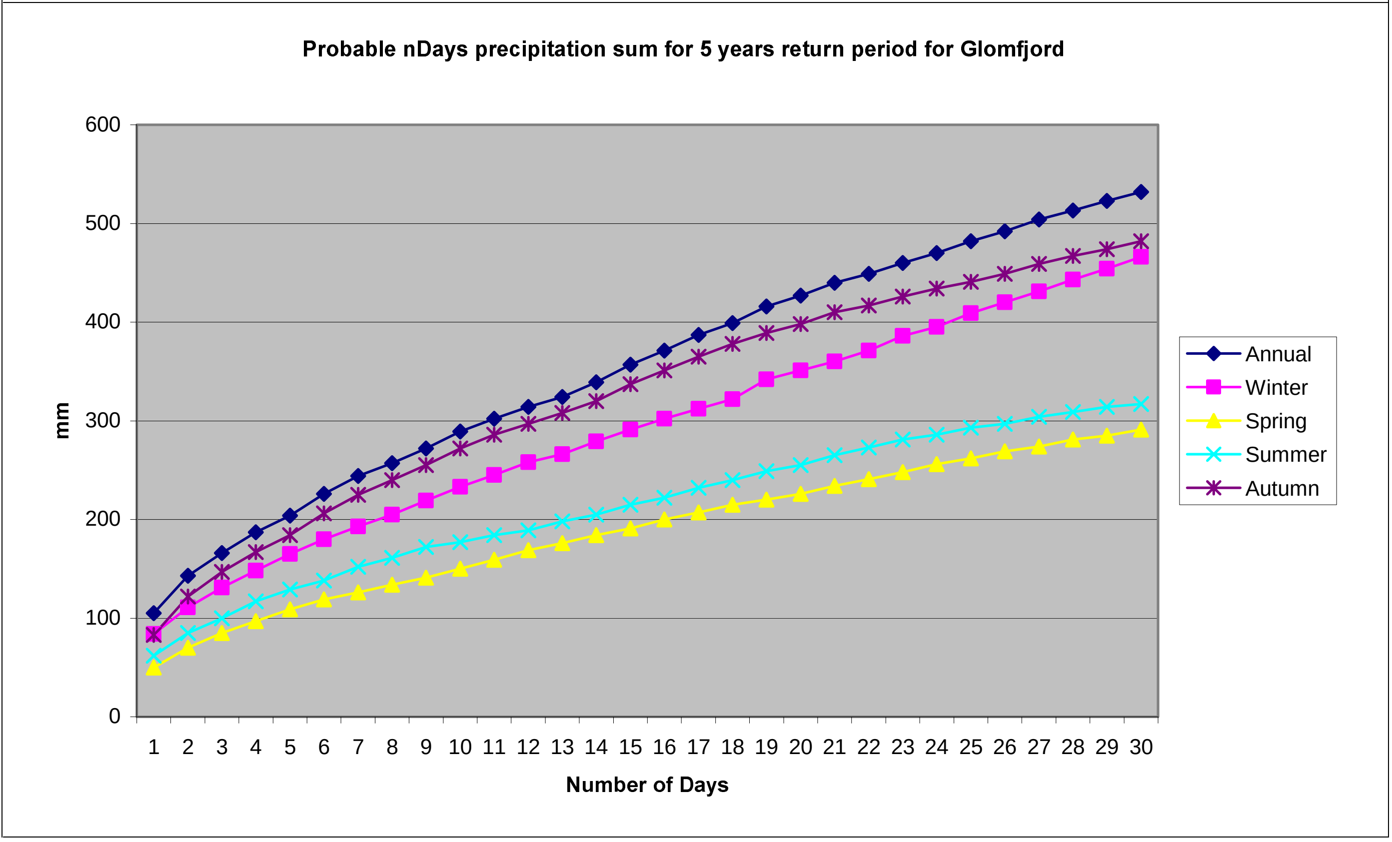
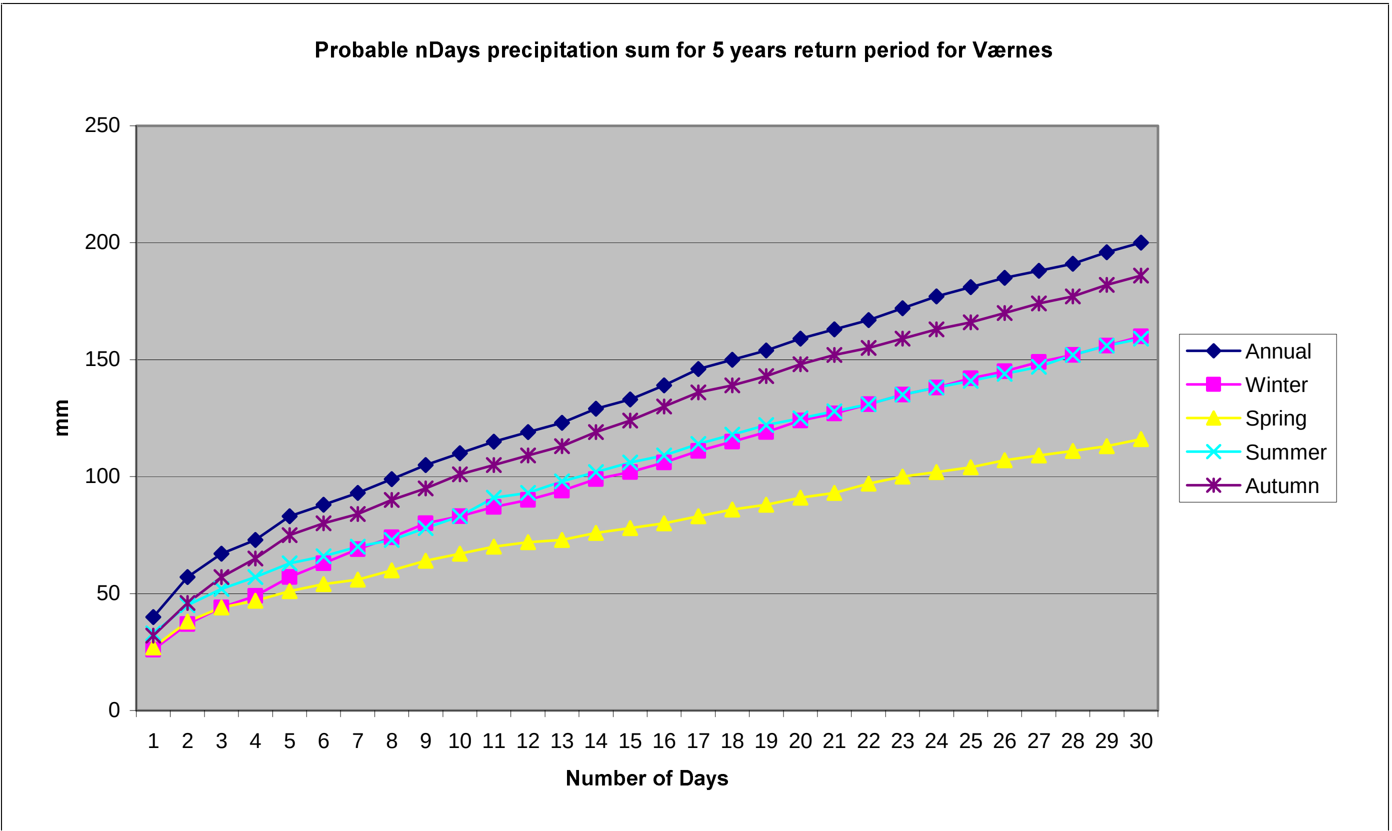
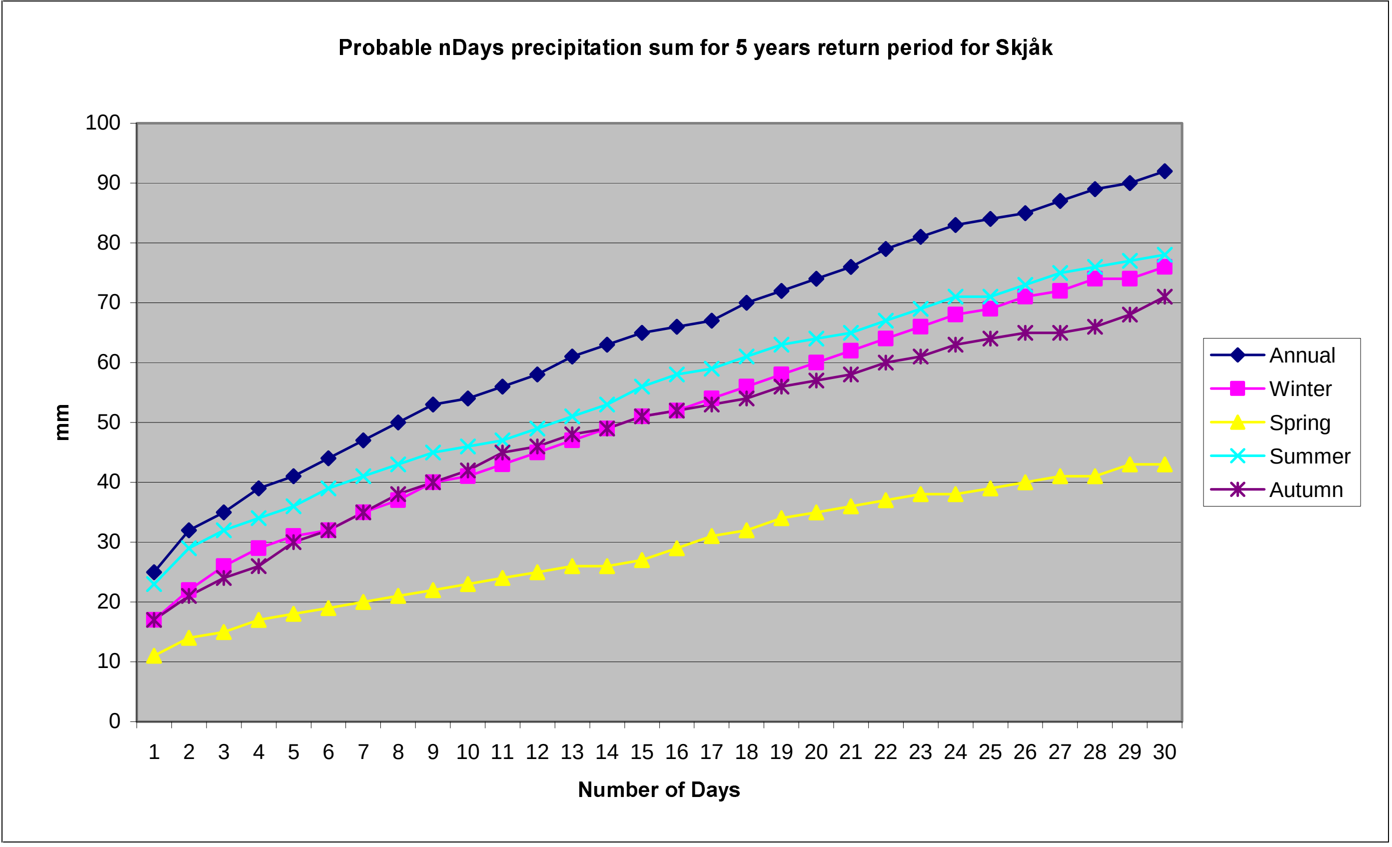


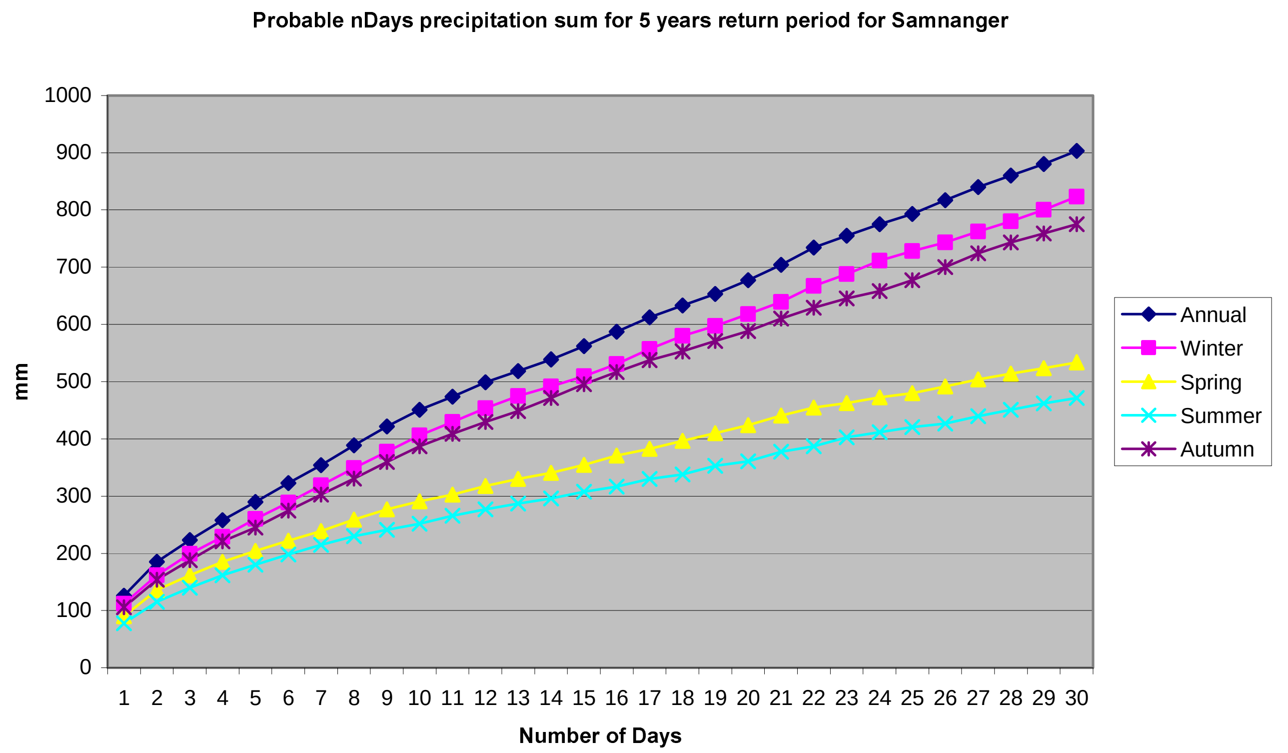
Figure 22. **Map showing stations in the seasonal analysis.**

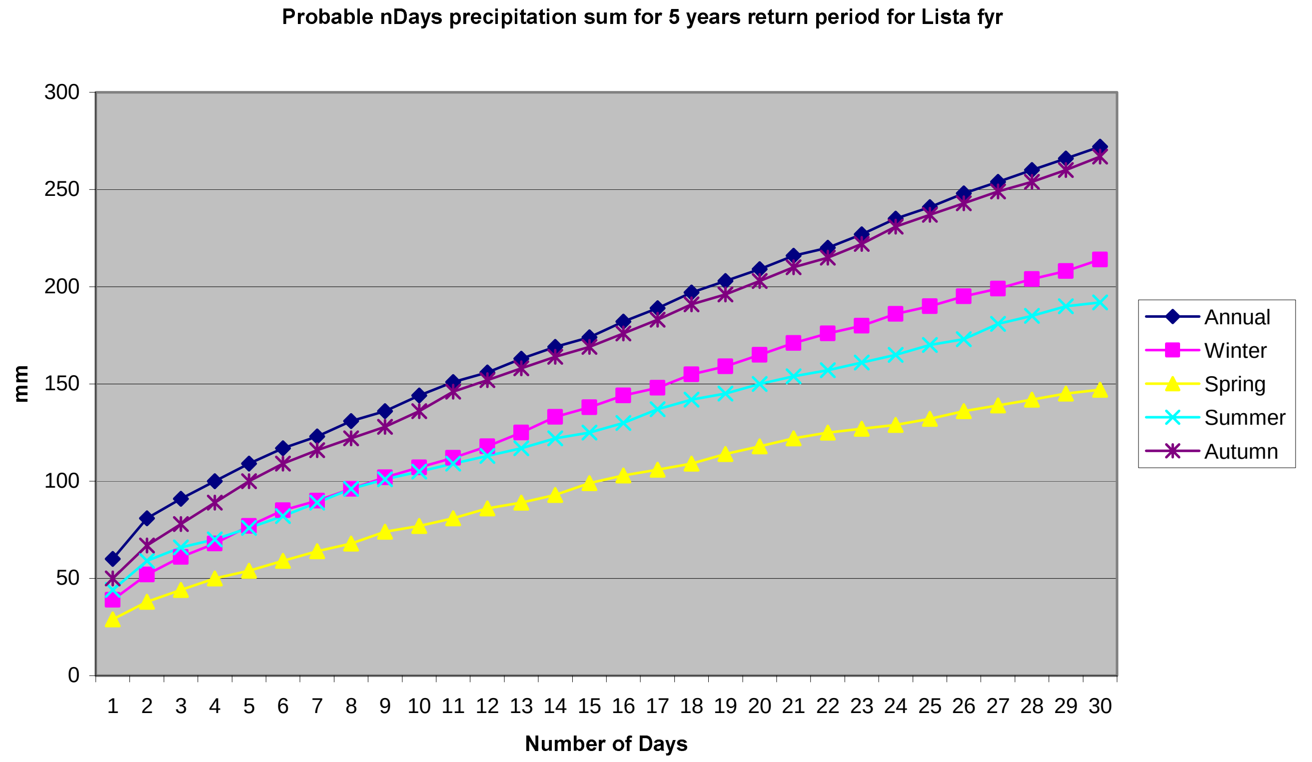

Probable nDays precipitation sum with 5 years return period for Karasjok
mm
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of days
Annual
Winter
Spring
Summer
Autumn

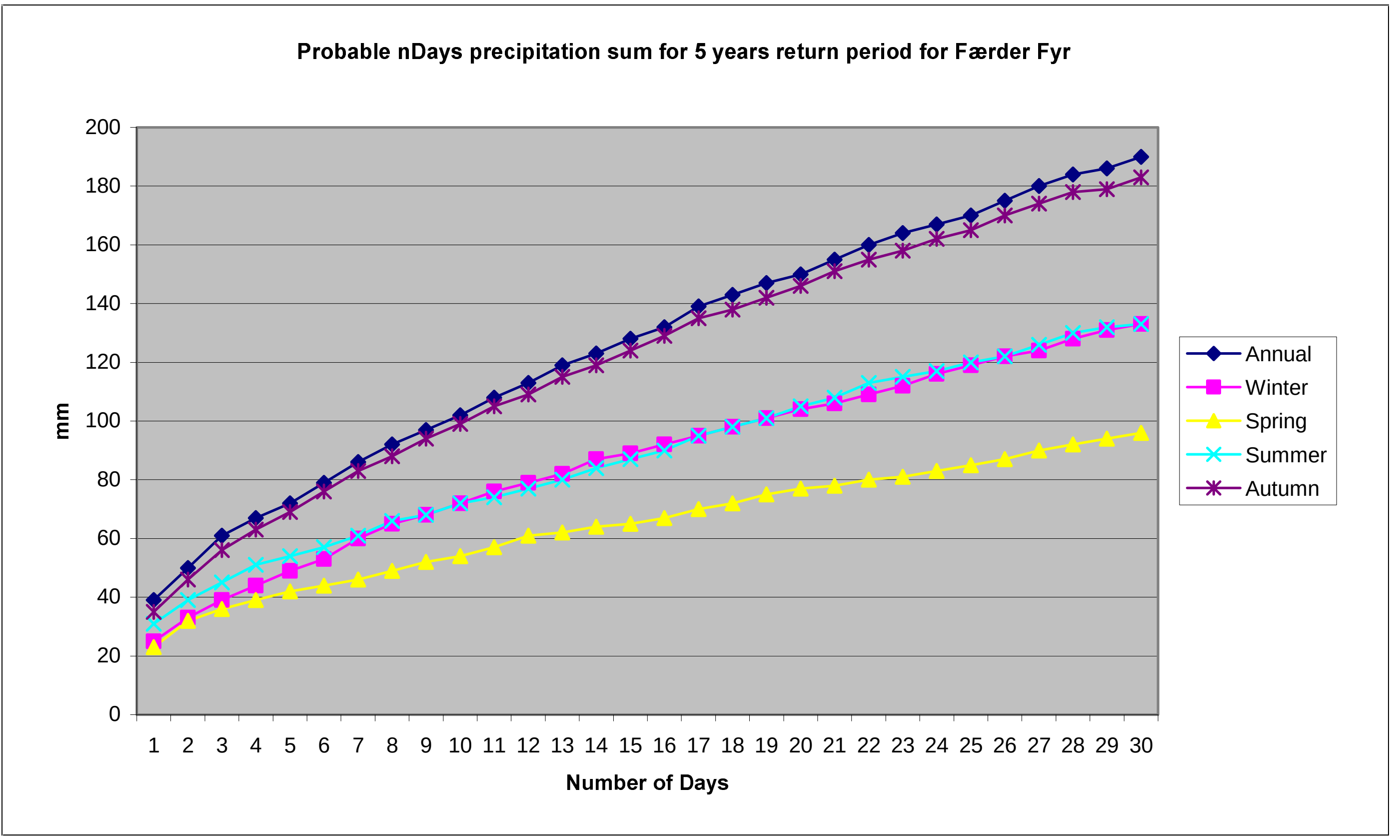

Probable nDays precipitation sum for 5 years return period for Glomfjord
mm
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of Days
Annual
Winter
Spring
Summer
Autumn


Probable nDays precipitation sum for 5 years return period for Værnes
mm
0
50
100
150
200
250
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of Days
Annual
Winter
Spring
Summer
Autumn


Probable nDays precipitation sum for 5 years return period for Skjåk
mm
0
10
20
30
40
50
60
70
80
90
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of Days
Annual
Winter
Spring
Summer
Autumn


Probable nDays precipitation sum for 5 years return period for Samnanger
mm
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of Days
Annual
Winter
Spring
Summer
Autumn


Probable nDays precipitation sum for 5 years return period for Lista fyr
mm
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of Days
Annual
Winter
Spring
Summer
Autumn



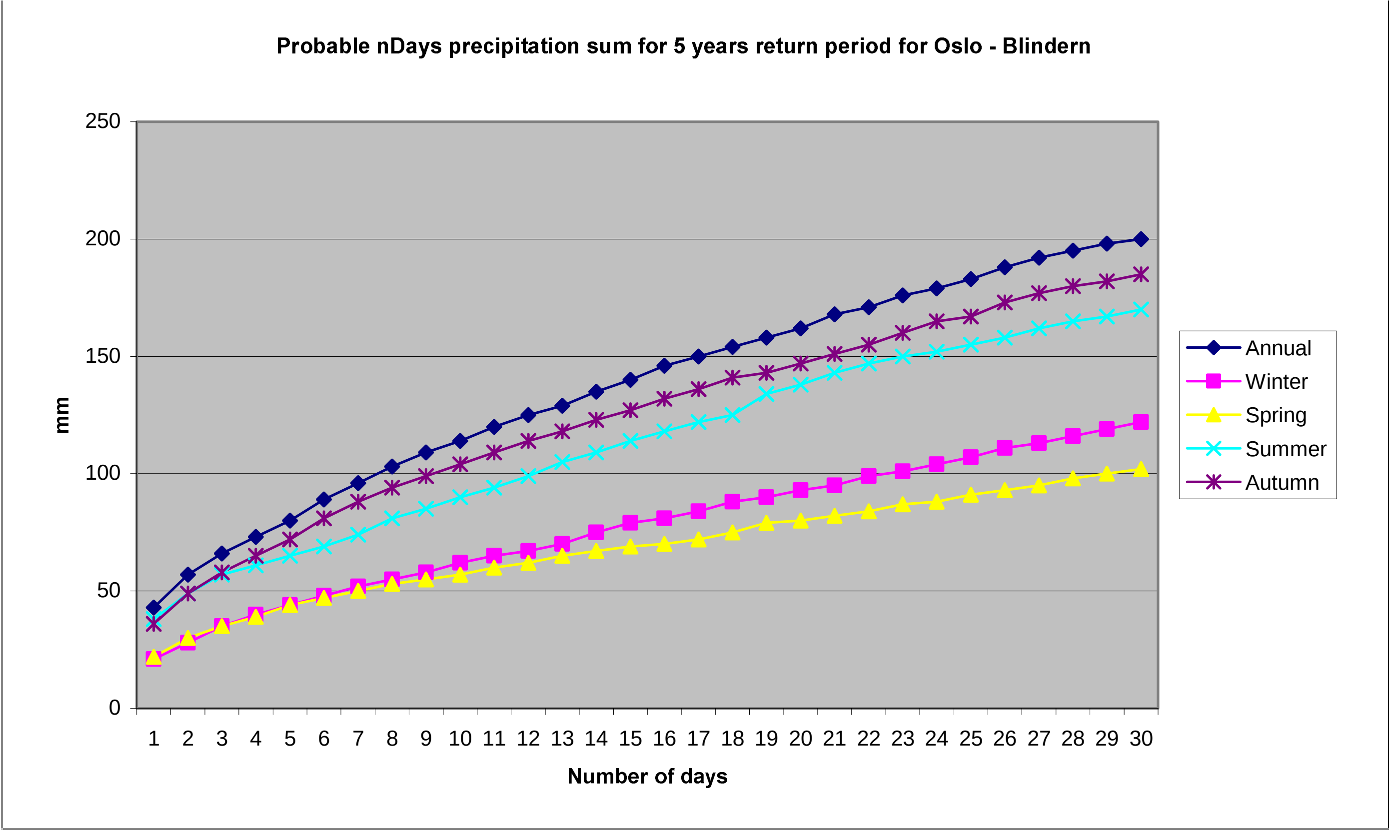


Figure 23. **Seasonal graphs for 5 years return period for N days precipitation amount.**

From Figure 23 we can see that the lowest extreme values are found during spring (yellow line) in most of Norway except in Western Norway (*Samnanger),* where they occur in summer, and inner parts of Finnmark (*Karasjok)* where the lowest values are found in winter.

In southeast and middle North (*Oslo-Blindern, Færder Fyr, Lista Fyr, Værnes, Glomfjord)* it is more probable that a 5 years return period precipitation episode should occur in the autumn than the other seasons.

Along the west coast, in *Samnanger*, the heaviest precipitation episodes are found in winter, but also in autumn. This gives a lot of snow in the mountains but also very wet along the coastline because the ocean causes a warm coast climate.

At the typical inland stations *Skjåk* and *Karasjok*, the heaviest rainfall is in summer. For *Karasjok* the summer curve follows the annual curve directly, telling that if a heavy precipitation episode will occur, not depending of duration, it will happen during summer time. The heavy convective summer rain in the southeast can be seen from the graph for *Oslo-Blindern*; the summer curve follows the autumn curve until 3-days precipitation. For *Værnes* the spring and winter curves cross each other at day 3, telling that it is more common with extreme precipitation episodes lasting for more days in winter than in spring.

When the curve is flat it shows that it is not usually raining continually so much during many days, the extreme precipitation height for 4-days is almost as high as the 28-days extreme precipitation episode. Opposite, if the curve is steep it tells that it is common with heavy precipitation episodes during many days.

The summer curve for *Karasjok* graph is steep up till 4 days; it will therefore seldom have a heavy precipitation episode lasting more than 4 days in the summer. In winter it will seldom fall so much precipitation, it will fall as snow or not fall any precipitation at all, because of the low temperatures. In *Karasjok* it is probable to have a 5 years return period episode giving ~30 mm precipitation during 30 days in winter and ~30 mm during 1 day in summer!

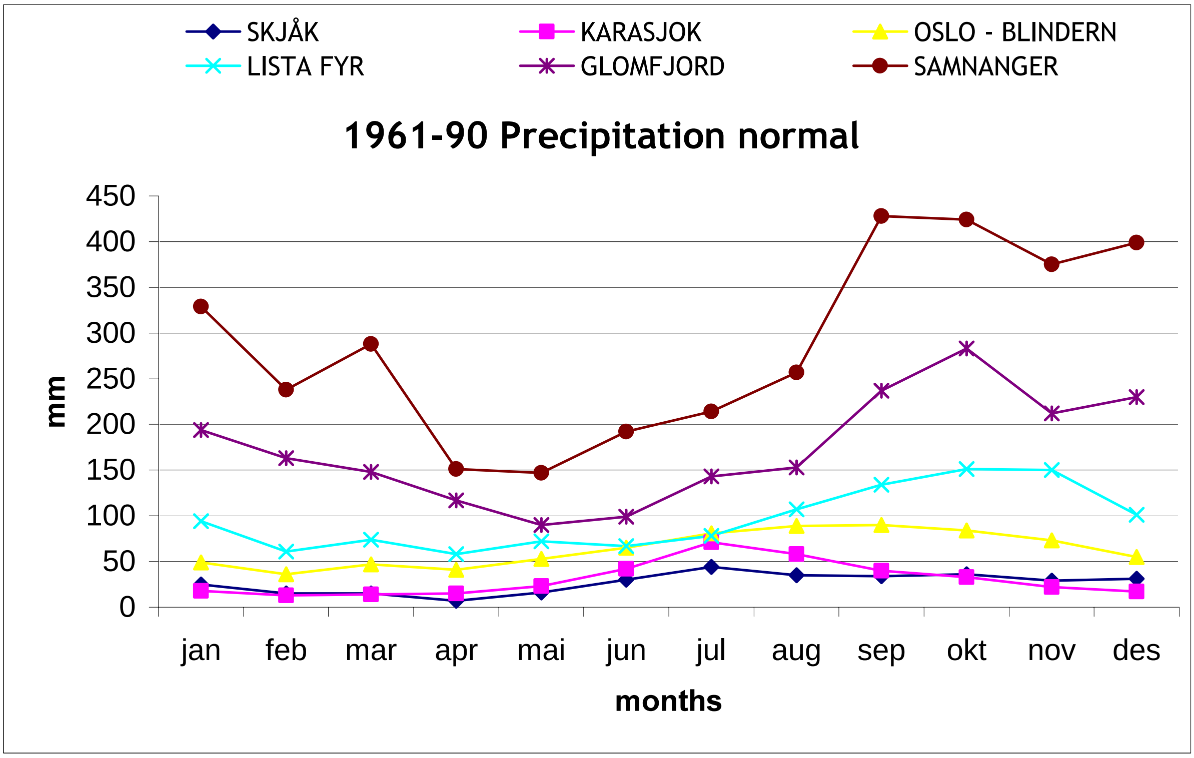


Figure 24. Monthly precipitation sum for the normal period 1961-1990 for the stations: ***Skjåk, Karasjok, Oslo-Blindern, Lista Fyr, Glomfjord, Samnanger***

The monthly normal graph in Figure 24 states more or less the same result as given above. The west coast of Norway, with *Samnanger,* has most precipitation in autumn and winter. Typical inland stations have most precipiation in summer and least in winter. This shows therefore a relation between monthly precipitation amount and seasonal distribution of extreme 1-N-days precipitation episode, though this is not an analysis of that.

A closer look at the seasonal distribution of the M5 value for 1-day precipitation is given in Figure 25 and Figure 26.

Maximum 1-day precipitation in:

a) Autumn is found in 264 of the 511 stations. These 264 stations are found spread over the country, mainly along the coast from southeast, south, west and northwest, and also some places more or less between the summer and wintertime dominated parts. *
b) Winter is found in 69 of the 511 stations, mostly on the west coast from south to north, actually some kilometres from the coast in the mountain area.
c) Spring is found nowhere.
d) Summer is found in 178 of the 511 stations, mainly in the southeastern and northeastern parts of Norway, with typical inland climate and convective rainfall during summertime.

Minimum 1-day precipitation in:

a) Autumn is found in 1 of the 511 stations on Hopen, in the Barents Sea, not showed in this map.
b) Winter is found in 164 of the 511 stations in the southeastern and northeastern parts of Norway, typical the stations with maximum precipitation episode in summer.
c) Spring is found in 235 of the 511 stations, from south to north along the coast more or less the same stations with maximum M5 value during autumn.
d) Summer is found in 111 of the 488 stations along the west coast from southwest to middle north. These are more or less the same stations that have maximum M5-value during winter.

Remark: The calculation of the max and min value is taken in this priority order: autumn, winter, spring, summer. This means that if a station had the same max value in both autumn and summer, autumn is taken.

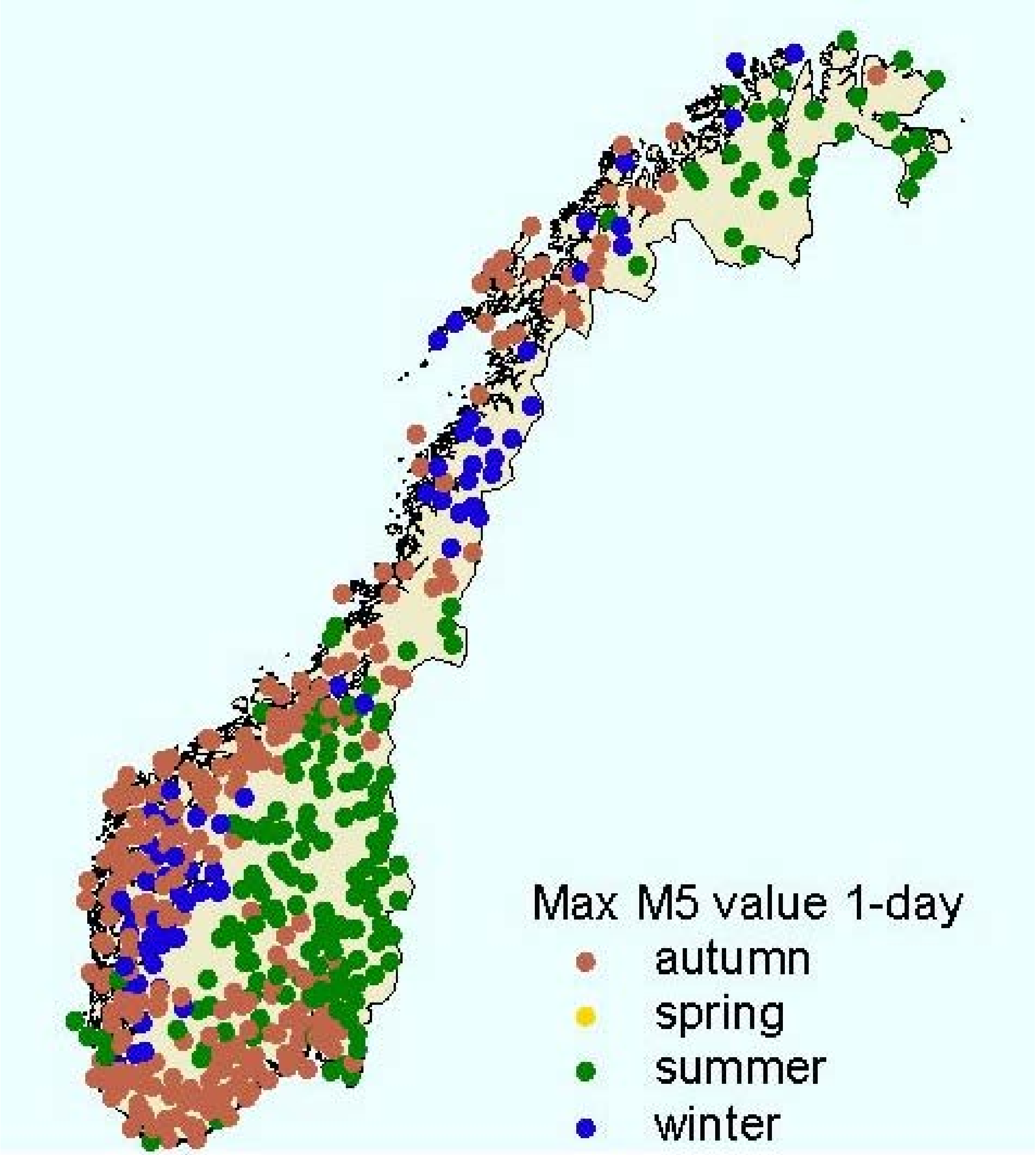


Figure 25. Seasonal distribution of maximum M5 value, the 1-day probable extreme precipitation with 5 years in return period.

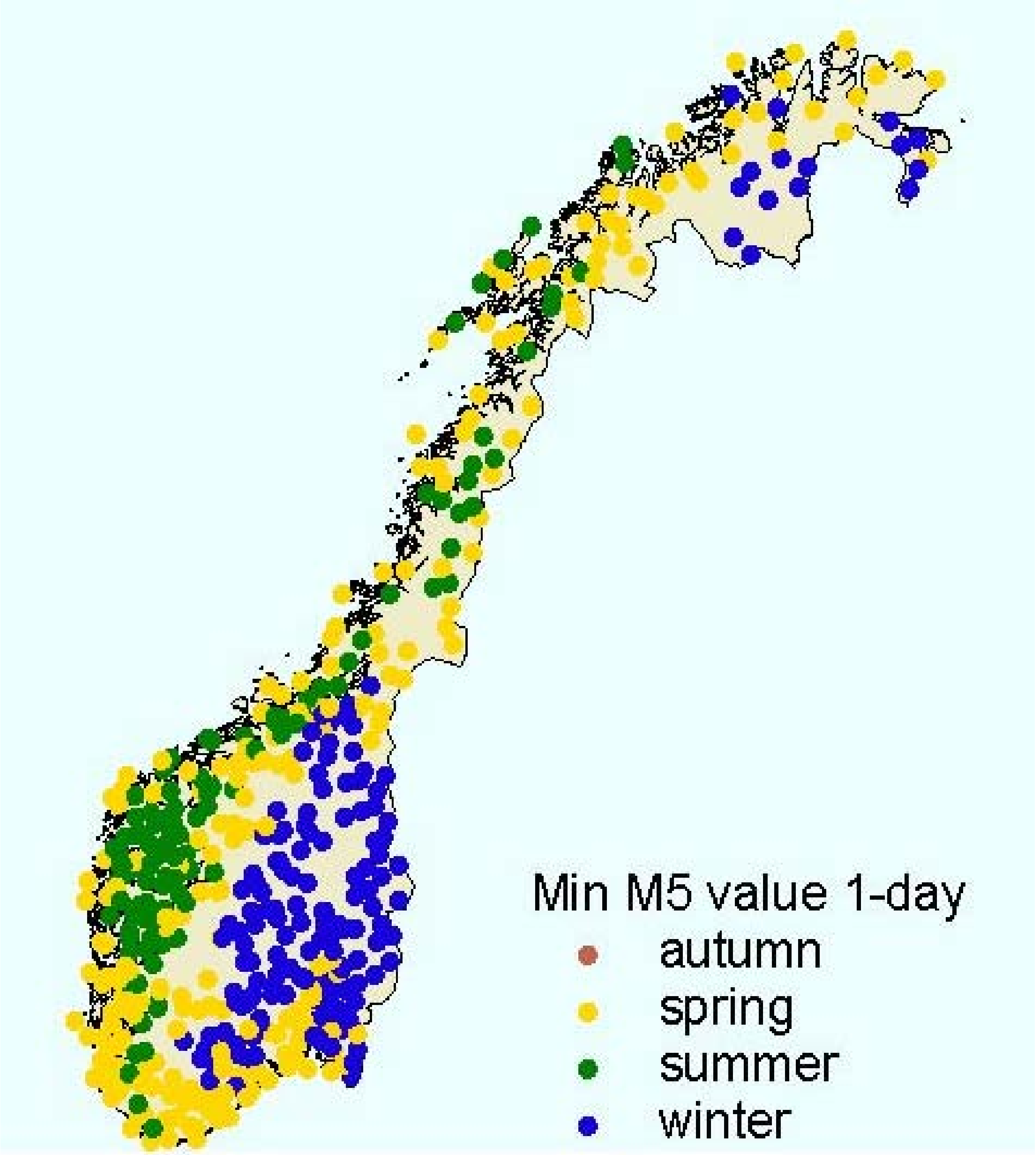


Figure 26. Seasonal distribution of minimum M5 value, the 1-day probable extreme precipitation with 5 years in return period.

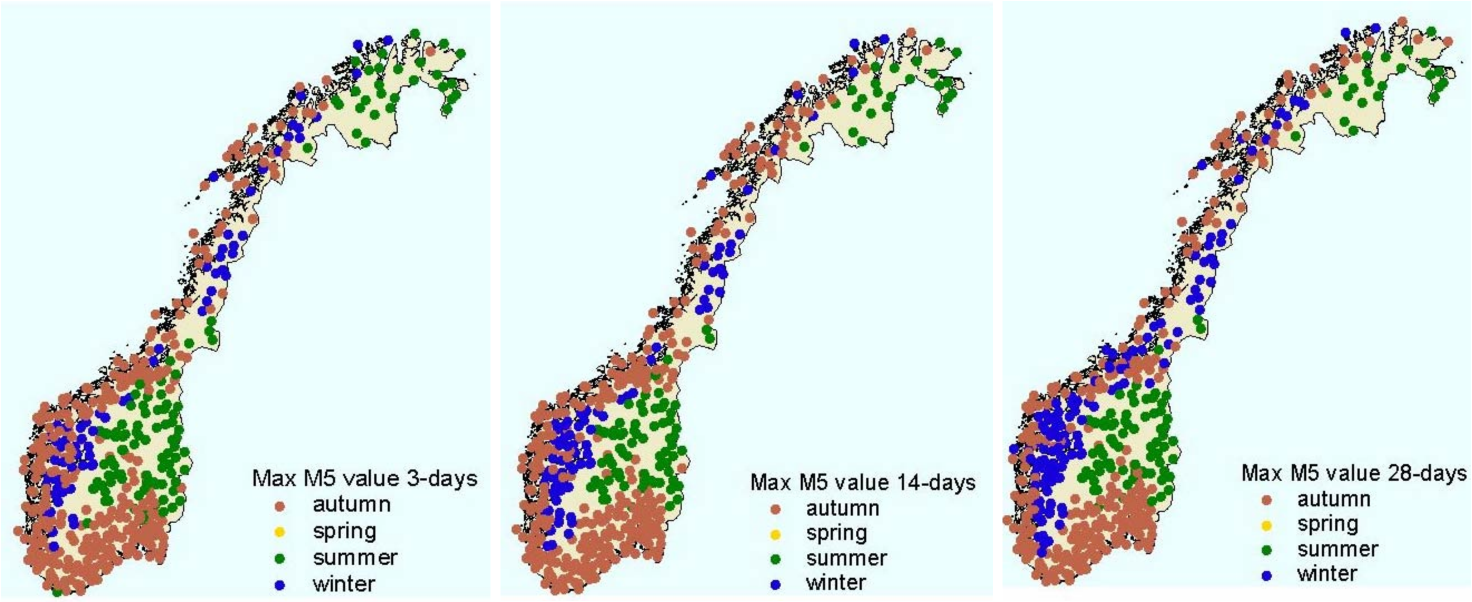


Figure 27. **Seasonal distribution of maximum M5 value, for 3-days, 14-days and 28-days probable extreme precipitation with 5 years in return period.**

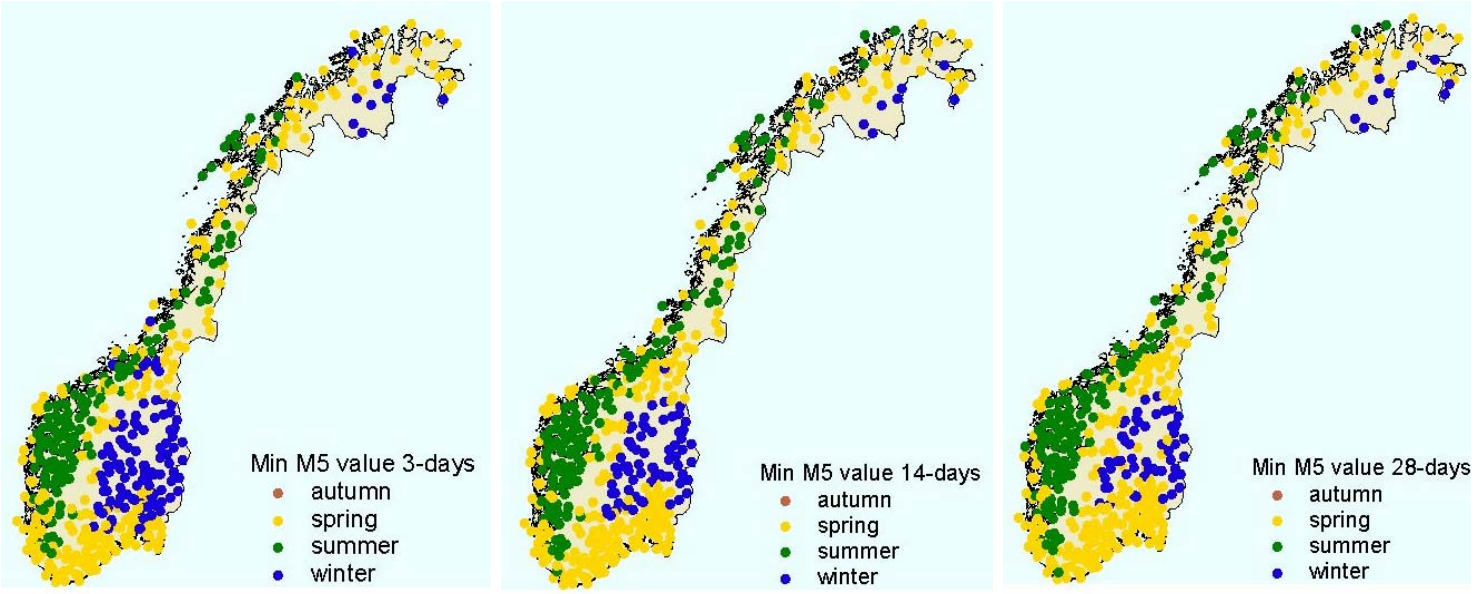


Figure 28. **Seasonal distribution of minimum M5 value, for 3-days, 14-days and 28-days probable extreme precipitation with 5 years in return period.**

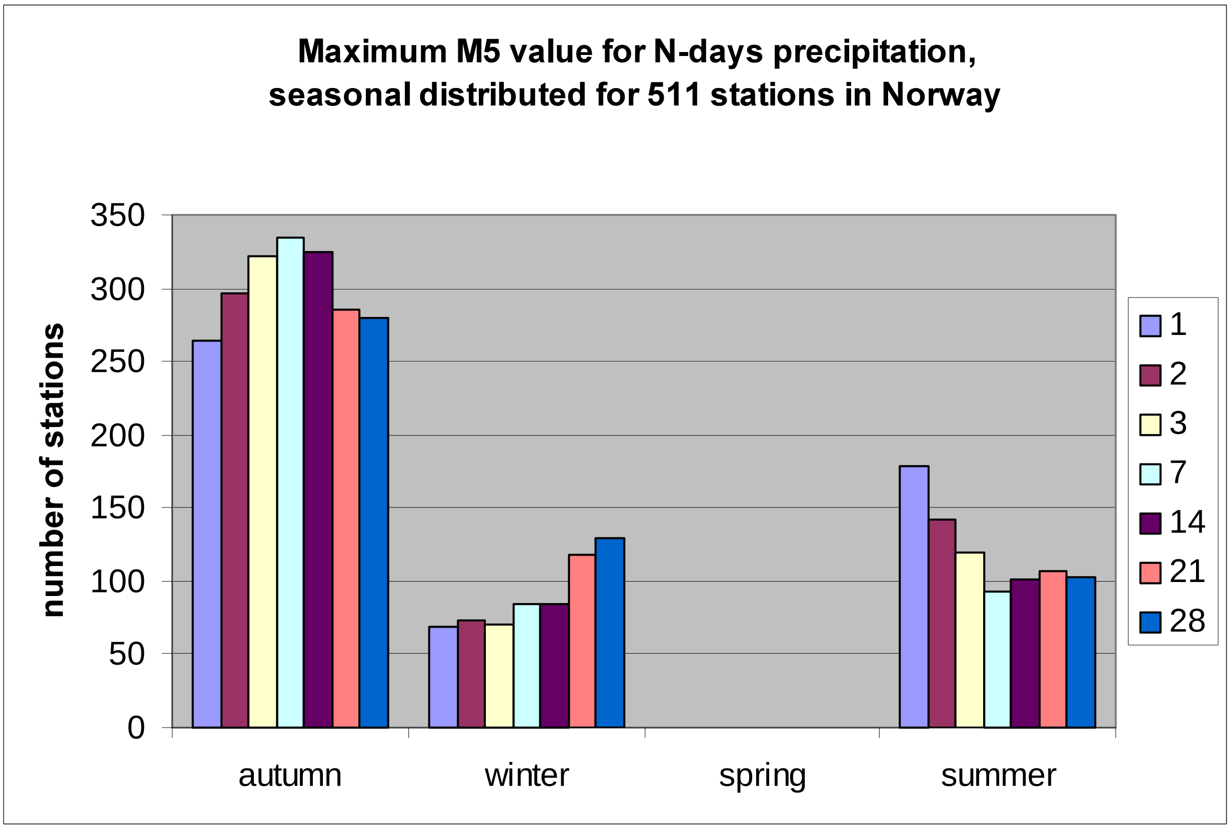


Figure 29. **Maximum M5 value seasonal distributed for number of stations.**

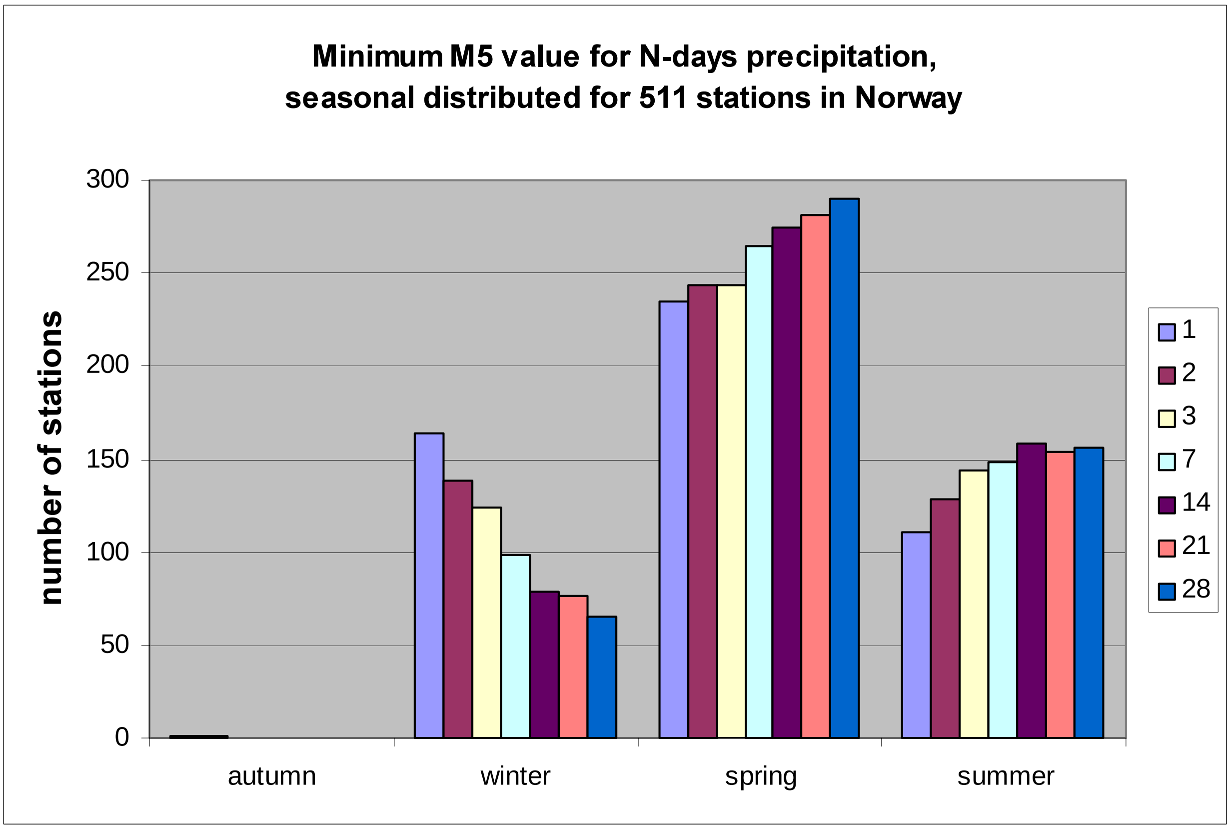


Figure 30. **Minimum M5 value seasonal distributed for number of stations.**

Figure 27 and Figure 28 gives a spatial overview of the maximum and minimum M5 value for the seasons. As we can see there is no big difference between the seasonal distribution of 1-day and 28-days probable extreme precipitation. The differences are better seen from Figure 29 and Figure 30, where the bars give number of stations with observed maximum M5 and minimum M5, respectively, in the different seasons.

a. In autumn, extreme precipitation episodes of intermediate duration (3-14 days) are more common than extreme precipitation episodes of short duration (1-2 days) or long duration (more than 14 days). There is only found one station with minimum M5 value during autumn.
b. In winter it is more and more common to have extreme precipitation episode (maximum M5 value) with longer duration. Corresponding to that, we see that there are less stations having minimum M5 value for 28-days extreme precipitation than for 1 day.
c. In spring no stations have maximum M5 value and there are more stations having minimum M5 value for 28-days extreme precipitation than for 1-day.
d. In summer more stations experience heavy precipitation episodes during 1-day than 2-days, due to the convective rainfall. Number of stations decrease with increasing number of days. There are more stations having minimum M5 value for 28-days extreme precipitation than for 1-day.

Remark: The calculation of the max and min value is taken in this priority order: autumn, winter, spring, summer. This means that if a station had the same max value in both autumn and summer, autumn is taken.

3.4 Estimate of 1-day precipitation values with N years return period, NORDKLIM area

The NORDKLIM dataset has the element *p602*, that *is the maximum 24 hours precipitation during a month*. These data is the background for the calculations of the following maps, showing spatial distribution of precipitation amount for different return periods. Most of the data series has more than 100 years with data, which give high quality estimates of the return periods.

As we can see from the maps, from Figure 31 to Figure 36, the spatial distribution of the precipitation is much the same for the different return periods, the pattern do not differ so much between the maps, because the calculation method, NERC, for the probable precipitation, is based upon the M5 value. The division of the intervals in the legend in the map causes some differences.

An extreme daily precipitation episode in the north has generally a moderate amount of precipitation. Going southwards in Sweden or Finland we will have more extreme precipitation. Along the Baltic-sea there exists places that will probably have even greater extreme precipitation episodes. The southwest coast and middle north of Norway will get the greatest daily extreme precipitation. In the middle south of Norway we can see that the values are differing quite a lot because of the large mountains in that region. Iceland will get heavy precipitation episode in southern costal areas and smallest amounts in the north.

Figure 37 shows the distribution of the mean value of the annual maximums for the *p602* element. The map shows a quite good connection between the mean value and the probable precipitation amount for the different return periods e.g. the map for 100 years return period in Figure 35.

Figure 38 shows the distribution of the standard deviation for the annual maximums for the *p602* element, max precipitation sum during 24 hour in a month. This map also gives more or less the same pattern, apart from a bit more complex pattern in the southeastern part of Sweden and Finland, with more variations in the standard deviation value, than it was for the mean value. This is probably caused by large inter-annual variations in occurrences of heavy convective precipitation episodes during summer.

Table 3 gives a list of the NORDKLIM stations, with the *p602* element as basis, with calculated annual probable precipitation amounts for different return periods.

Remark: Be aware that the following maps show only a few selected stations and may not be representative for a larger area. For more precise information about climatic extremes, contact the national meteorological services. See also Tveito et al 1998 [12].

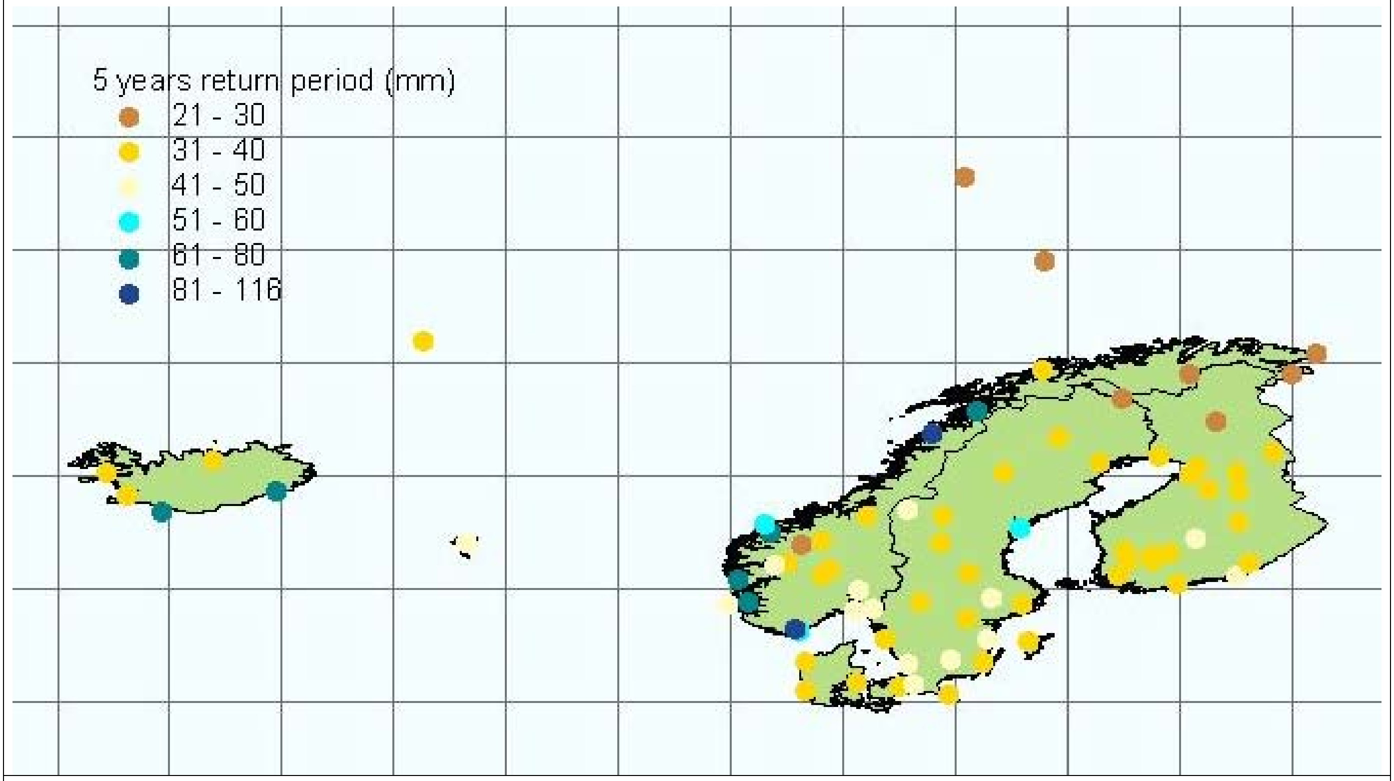


Figure 31. **Daily precipitation with 5 years annual return period for the NORDKLIM area.**

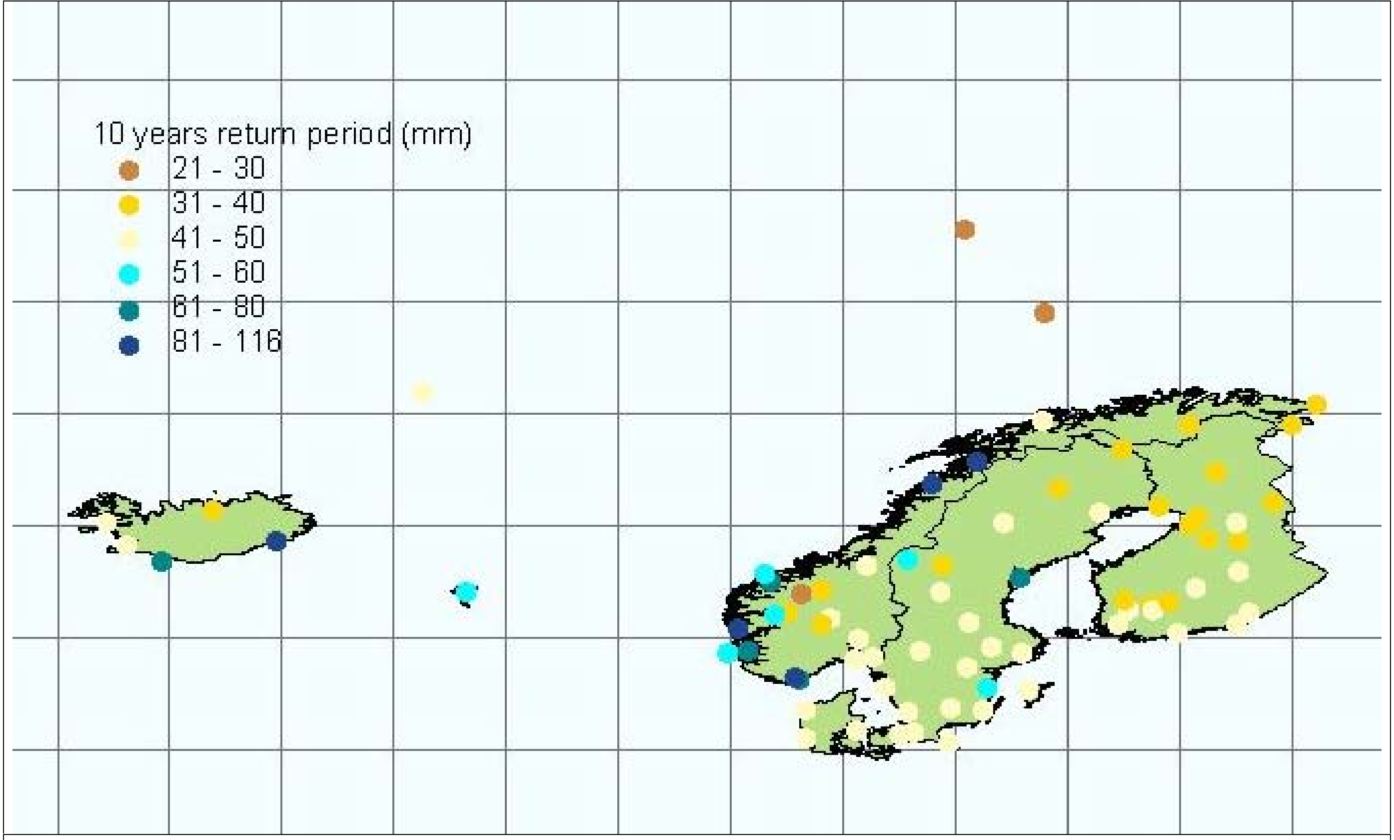


Figure 32. **Daily precipitation with 10 years annual return period for the NORDKLIM area.**

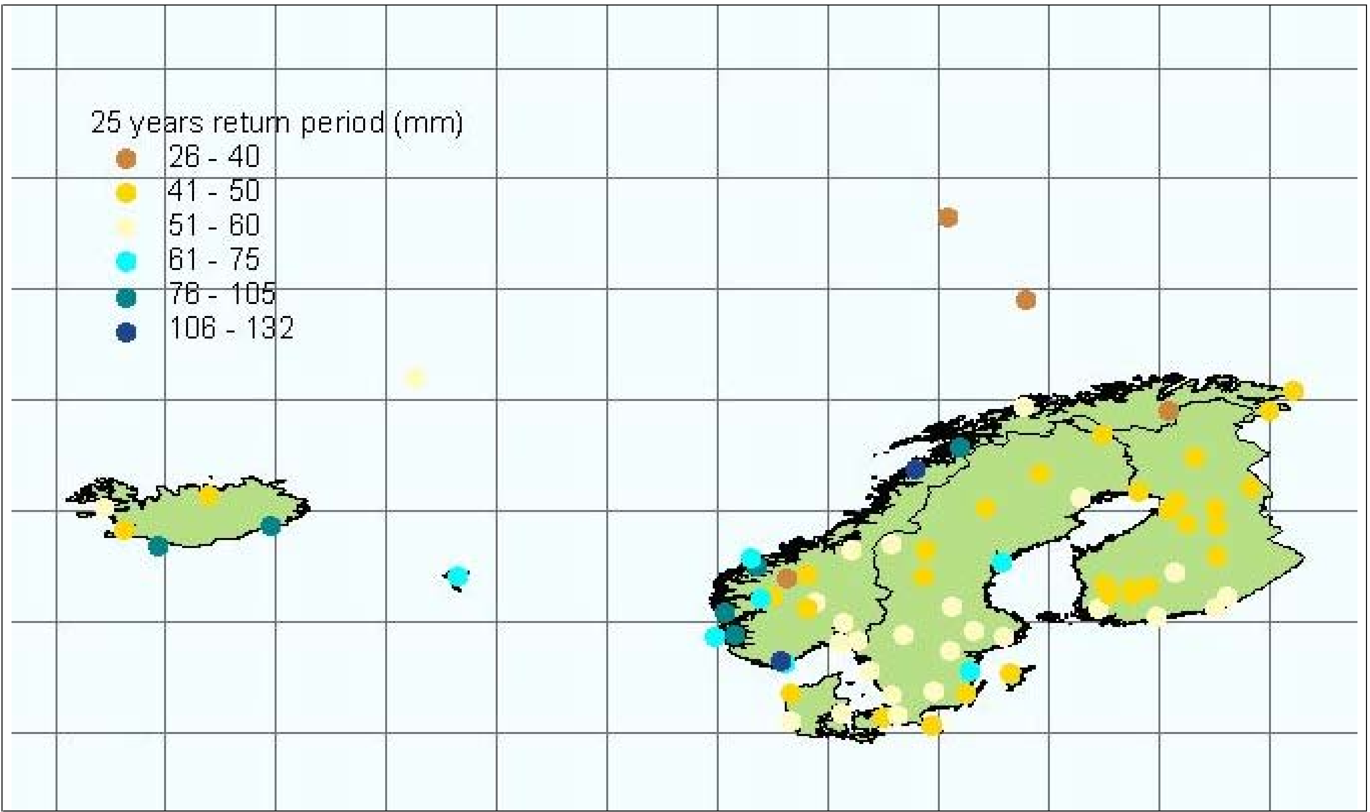


Figure 33. **Daily precipitation with 25 years annual return period for the NORDKLIM area.**

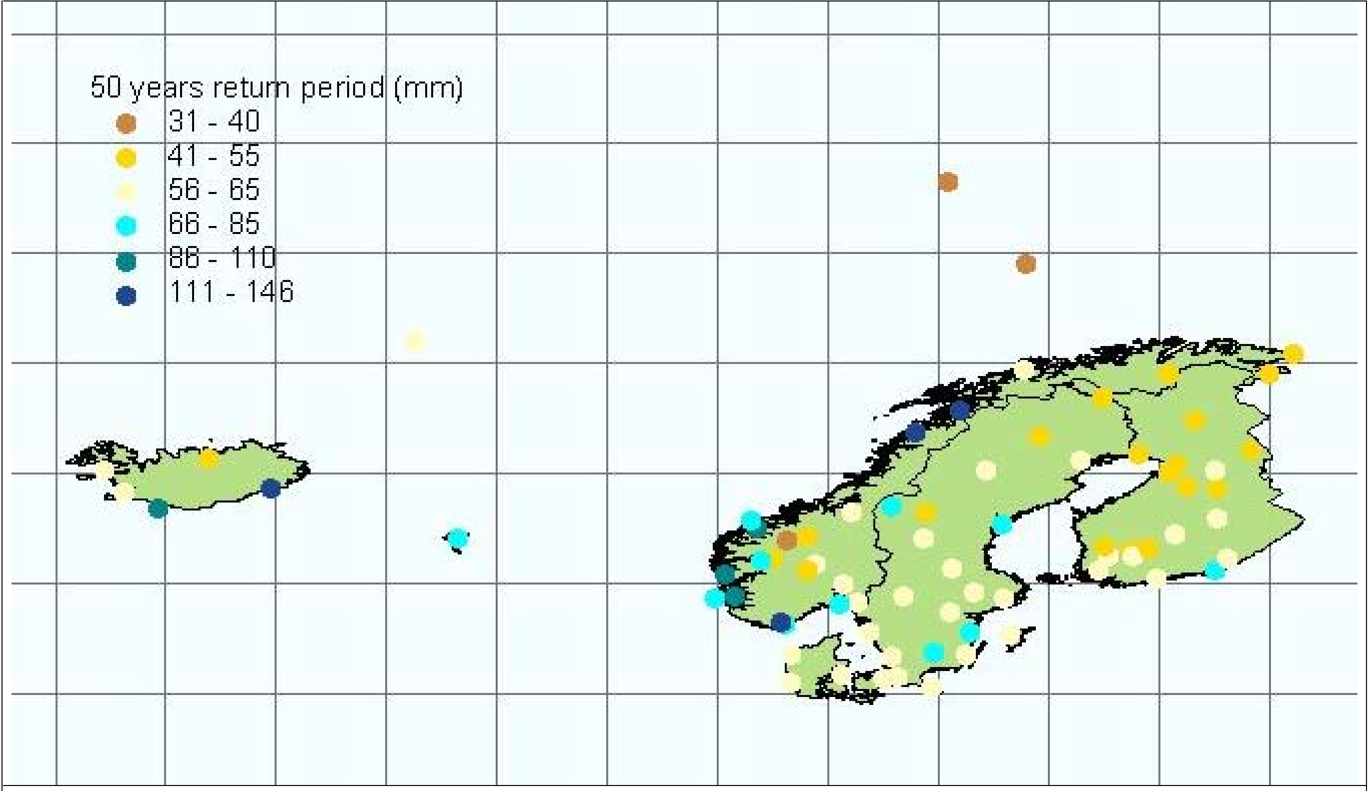


Figure 34. **Daily precipitation with 50 years annual return period for the NORDKLIM area.**

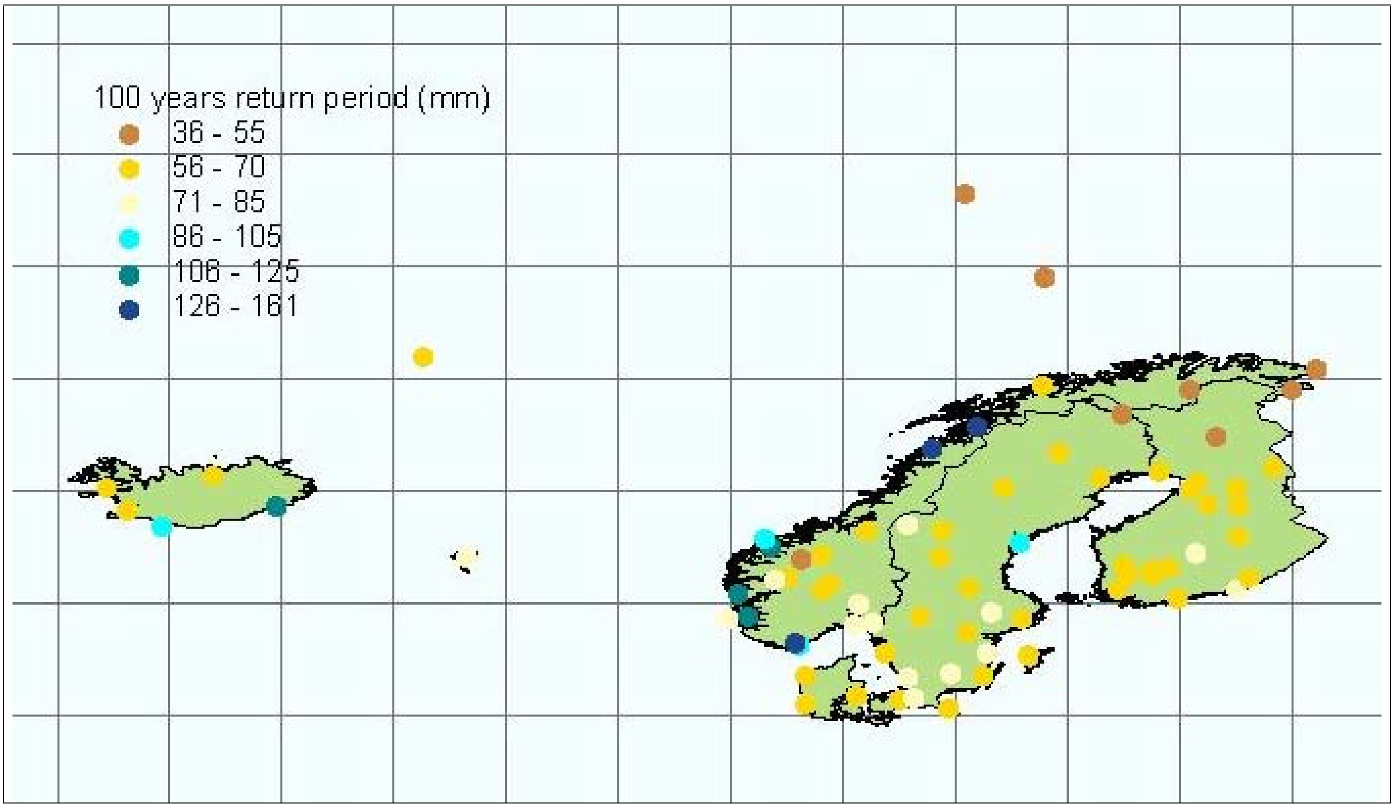


Figure 35. Daily precipitation with 100 years annual return period for the NORDKLIM area.

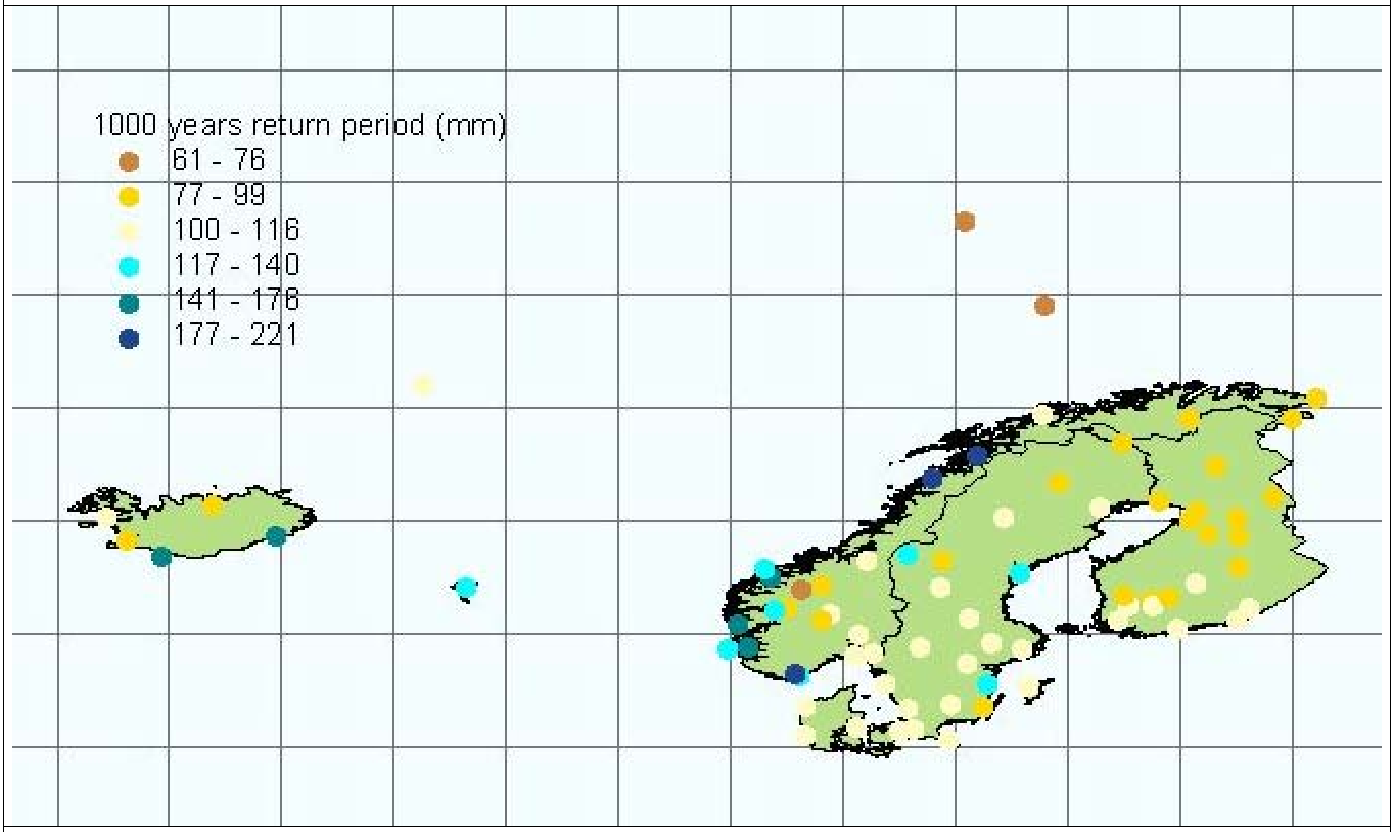


Figure 36. Daily precipitation with 1000 years annual return period for the NORDKLIM area.

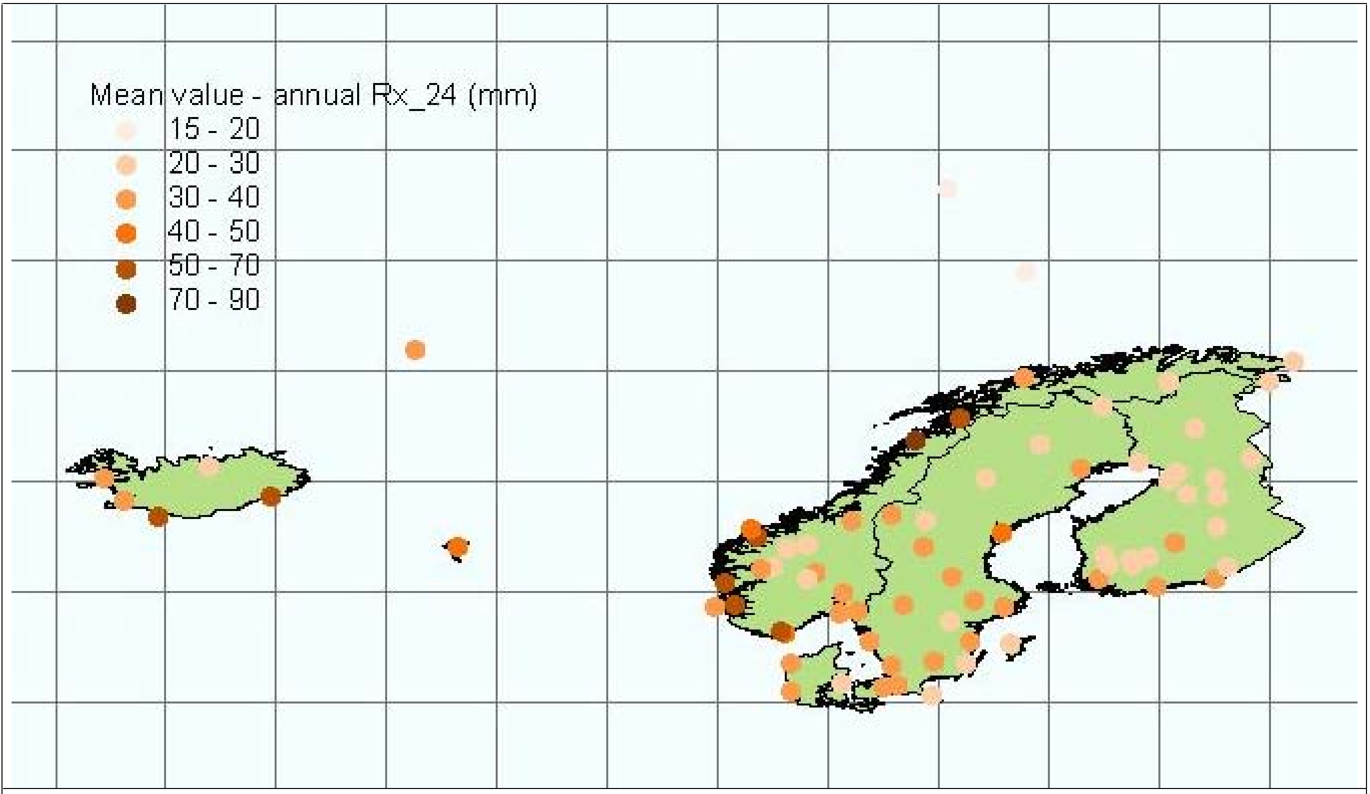


Figure 37. **Mean value of annual maximum daily precipitation** *(p602)* **values for the NORDKLIM area.**

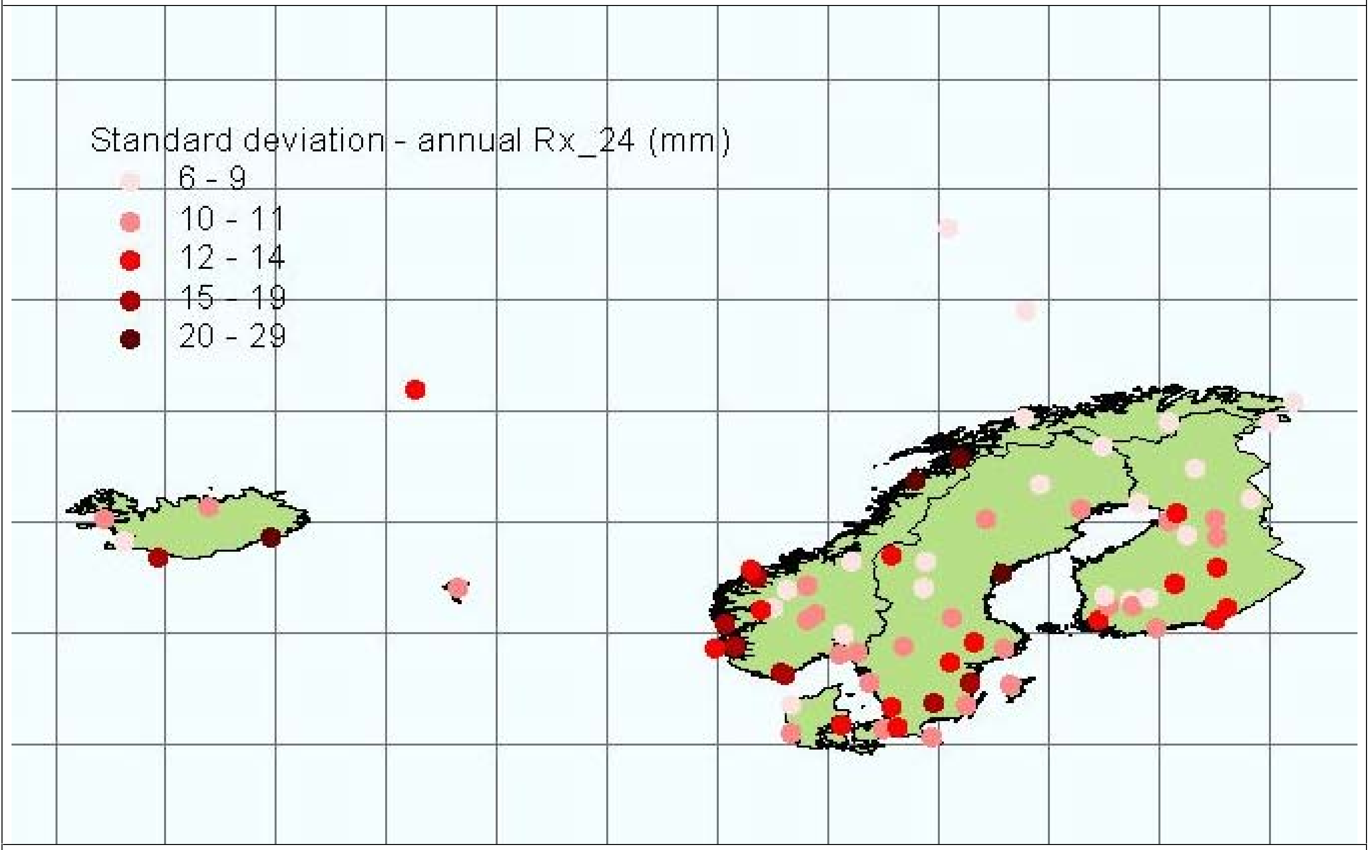


Figure 38. **Standard deviation of annual maximum daily precipitation** *(p602)* **values for the NORDKLIM area.**

Annual:

Stnr.	Name	From	To	Mean	St.dev.	5y	10y	25y	50y	100y	250y	500y	1000y
6193	Hammerodde Fyr	1890	1995	29.62	10.74	37	42	50	58	66	78	89	102
21100	Vestervig	1890	1995	31.41	8.63	37	42	50	58	66	78	89	102
25140	Nordby	1890	1995	32.41	11.14	40	45	54	62	70	83	95	108
27080	Tranebjerg	1890	1995	29.71	12.58	38	43	52	59	67	80	91	104
30380	Köbenhavn	1890	1995	30.84	9.54	37	42	50	58	66	78	89	102
304	Helsinki	1882	1999	31.45	9.52	38	43	52	59	67	80	91	104
1101	Turku	1891	1999	31.28	12.48	40	45	54	62	70	83	95	108
1103	Huittinen	1894	1997	29.56	10.63	37	42	50	58	66	78	89	102
1202	Tampere	1891	1999	27.59	8.74	33	38	45	52	60	71	81	93
1601	Virolahti	1894	1999	33.31	14.01	43	49	58	66	75	88	100	114
1701	Lappeenranta	1886	1999	29.68	11.97	38	43	52	59	67	80	91	104
2104	Lavia	1903	1999	28.28	8.76	34	39	47	53	61	73	83	95
2211	Virrat	1909	1999	30.48	9.87	37	42	50	58	66	78	89	102
2306	Orivesi	1891	1999	28.33	9.29	35	40	48	55	63	75	85	97
2425	Jyvaeskylae	1891	1999	32.15	12.74	41	47	55	63	72	85	97	110
3602	Kuopio	1891	1998	28.22	12.12	36	41	49	56	64	76	87	99
4509	Kestilä	1909	1999	26.15	7.66	31	35	43	49	56	68	78	89
4601	Kajaani	1886	1999	27.75	10.38	35	40	48	55	63	75	85	97
5404	Oulu	1891	1996	26.64	10.61	34	39	47	53	61	73	83	95
5407	Yli-Ii	1912	1999	27.18	11.53	35	40	48	55	63	75	85	97
5605	Pudasjärvi	1909	1999	29.65	10.12	36	41	49	56	64	76	87	99
6801	Kuusamo	1908	1999	25.66	7.82	31	35	43	49	56	68	78	89
7501	Sodankylae	1908	1999	25.58	7.28	30	34	41	48	55	66	76	87
6011	Torshavn	1890	1999	41.16	11.09	49	55	65	74	84	98	111	125
4013	Stykkisholmur	1890	1999	32.82	10.28	40	45	54	62	70	83	95	108
4030	Reykjavik	1924	1999	30.88	8.39	36	41	49	56	64	76	87	99
4048	Vestmannaeyar	1890	1999	51.53	17.90	64	72	84	94	105	122	137	153
4063	Akureyri	1925	1999	24.59	10.90	32	37	44	51	58	69	80	91
4092	Teigarhorn	1890	1999	62.17	20.70	77	86	99	111	123	142	158	176
1230	Halden	1895	1999	35.94	9.77	42	48	57	64	73	87	98	112
15660	Skjåk	1896	1999	21.00	6.58	25	29	35	40	47	57	65	75
16740	Kjøremsgrendi	1890	1999	26.47	9.57	33	38	45	52	60	71	81	93
18700	Oslo-Blindern	1890	1999	34.37	9.31	41	47	55	63	72	85	97	110
22840	Reinli	1895	1997	31.80	10.08	39	44	53	60	69	82	93	106
24880	Nesbyen	1897	1999	28.28	10.19	35	40	48	55	63	75	85	97
27500	Ferder Fyr	1890	1999	36.05	10.46	43	49	58	66	75	88	100	114
39100	Oksøy Fyr	1890	1999	45.87	14.74	56	63	74	83	94	110	123	138
39220	Mestad	1900	1999	69.59	19.05	83	92	106	118	131	151	167	186
47020	Nedstrand	1895	1999	59.82	16.94	72	80	93	104	116	134	150	167
47300	Utsira Fyr	1920	1999	40.10	12.36	48	54	64	73	82	97	109	123
50540	Bergen-Florida	1890	1999	64.37	17.07	76	85	98	109	122	140	156	174
54120	Lærdal	1890	1996	27.38	8.98	33	38	45	52	60	71	81	93
54900	Vetti	1895	1996	38.63	11.94	47	53	63	71	81	95	107	121
60800	Ørskog	1895	1999	56.12	17.34	68	76	89	99	111	128	143	160
62480	Ona	1919	1999	42.47	13.20	51	58	68	77	87	101	114	129
68330	Lien I Selbu	1895	1999	32.74	9.11	39	44	53	60	69	82	93	106
69100	Værnes/Trondheim	1890	1999	36.48	12.23	45	51	60	69	78	92	104	118

80700	Glomfjord	1990	1999	89.89	21.01	105	116	132	146	161	183	201	221
83500	Kråkmo	1895	1999	64.91	21.45	80	89	103	115	127	146	163	181
90450	Tromsø	1890	1999	32.52	8.89	38	43	52	59	67	80	91	104
97250	Karasjok	1890	1999	23.45	7.87	29	33	40	46	53	64	74	85
98550	Vardø	1893	1999	24.62	8.24	30	34	41	48	55	66	76	87
99450	Bjoernsund	1895	1999	24.31	8.22	30	34	41	48	55	66	76	87
99710	Bjoernøya	1926	1999	18.64	6.15	23	26	32	37	43	53	61	70
99840	Svalbard Lufthavn	1957	1999	15.59	7.97	21	24	30	34	40	48	56	65
99950	Jan Mayen	1922	1999	30.75	12.24	39	44	53	60	69	82	93	106
5343	Lund	1885	1999	32.45	12.23	41	47	55	63	72	85	97	110
6240	Halmstad	1885	1999	34.27	12.13	42	48	57	64	73	87	98	112
6452	Växjö	1873	1999	32.49	16.90	44	50	59	67	76	90	102	116
6641	Kalmar	1885	1999	29.21	10.55	36	41	49	56	64	76	87	99
7147	Göteborg	1881	1999	33.42	10.08	40	45	54	62	70	83	95	108
7647	Västervik	1885	1999	36.29	15.97	47	53	63	71	81	95	107	121
7840	Visby	1879	1999	29.48	11.05	37	42	50	58	66	78	89	102
8524	Linköping	1885	1999	30.34	12.04	39	44	53	60	69	82	93	106
9322	Karlstad	1881	1999	32.59	11.01	40	45	54	62	70	83	95	108
9635	Västeraas	1885	1999	32.18	14.27	42	48	57	64	73	87	98	112
9821	Stockholm	1873	1999	31.71	10.33	39	44	53	60	69	82	93	106
10537	Falun	1875	1999	32.01	10.37	39	44	53	60	69	82	93	106
12402	Sveg	1885	1999	31.08	8.64	37	42	50	58	66	78	89	102
12738	Härnösand	1879	1999	42.39	20.58	57	64	75	85	95	111	125	140
13411	Östersund	1875	1999	27.60	9.47	34	39	47	53	61	73	83	95
15772	Stensele	1885	1999	29.87	10.38	37	42	50	58	66	78	89	102
16179	Piteaa	1885	1999	31.59	11.26	39	44	53	60	69	82	93	106
16395	Haparanda	1873	1999	27.20	7.88	32	37	44	51	58	69	80	91
16988	Jokkmokk	1882	1999	27.18	7.76	32	37	44	51	58	69	80	91
19283	Karesuando	1885	1999	24.23	8.24	30	34	41	48	55	66	76	87
4210	Upernavik	1949	1986	24.56	11.997	33	38	45	52	60	71	81	93
4250	Nuuk	1921	1998	49.28	19.94	63	71	83	93	104	121	135	151
4270	Narsarsuaq	1890	1999	68.98	28.884	89	99	114	126	139	160	177	196
4320	Danmarkshavn	1949	1999	15.35	7.1718	20	23	28	33	38	46	54	62
4339	Ittoqqortoormiit	1949	1999	31.91	11.857	40	45	54	62	70	83	95	108
4360	Tasiilaq	1897	1999	51.58	20.042	66	74	86	96	108	125	140	156

Table 3. Probable extreme 1-day precipitation, total in year, calculated with the NERC-method for the stations in the NORDKLIM dataset for return periods 5, 10, 25, 50, 100, 250,500 and 1000 years. The calculation is based on mean and standard deviation of absolute max-values each year in the observation period found from the element *p602*.

3.5 Estimate of 1-day precipitation values, seasonal, NORDKLIM area

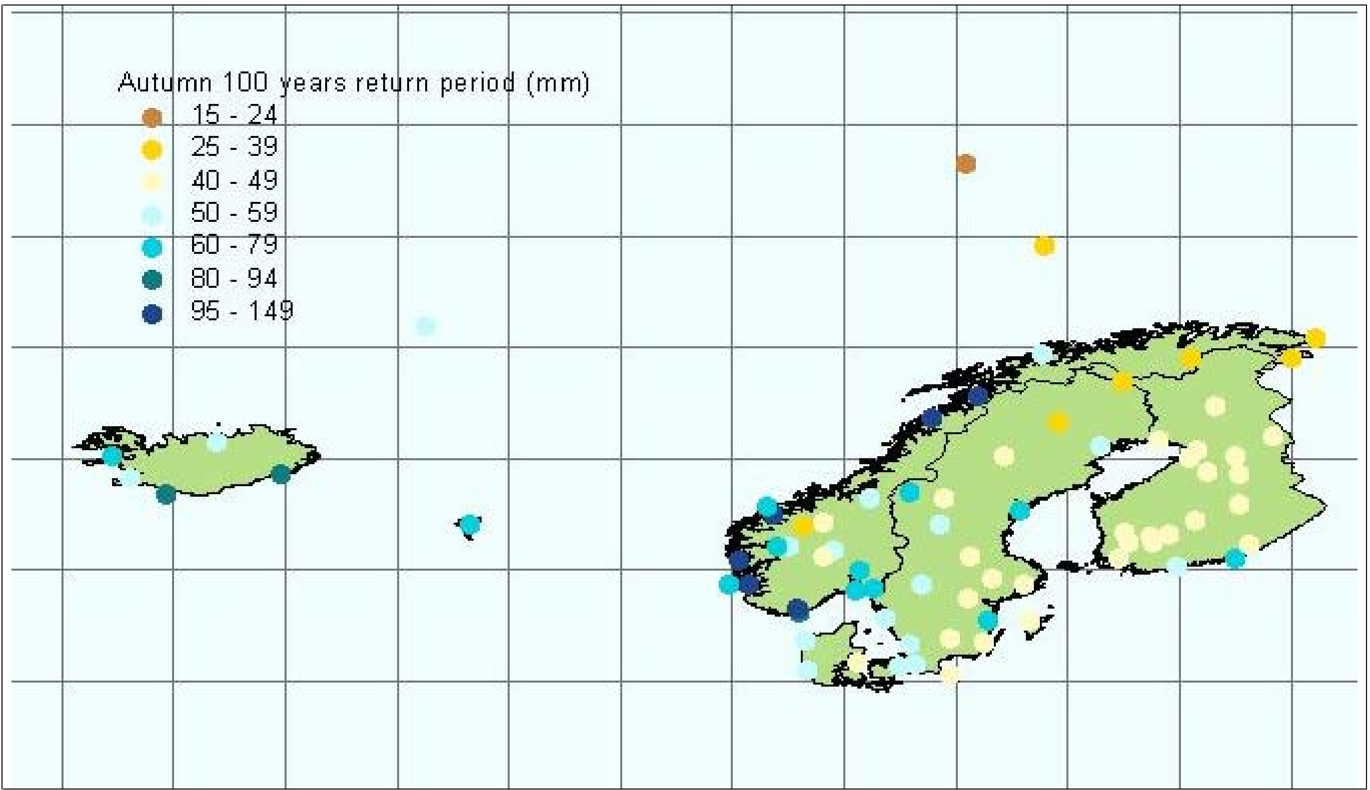


Figure 39. **Probable 24 hours precipitation in autumn (September, October, November) with 100 years return period for the NORDKLIM area.**

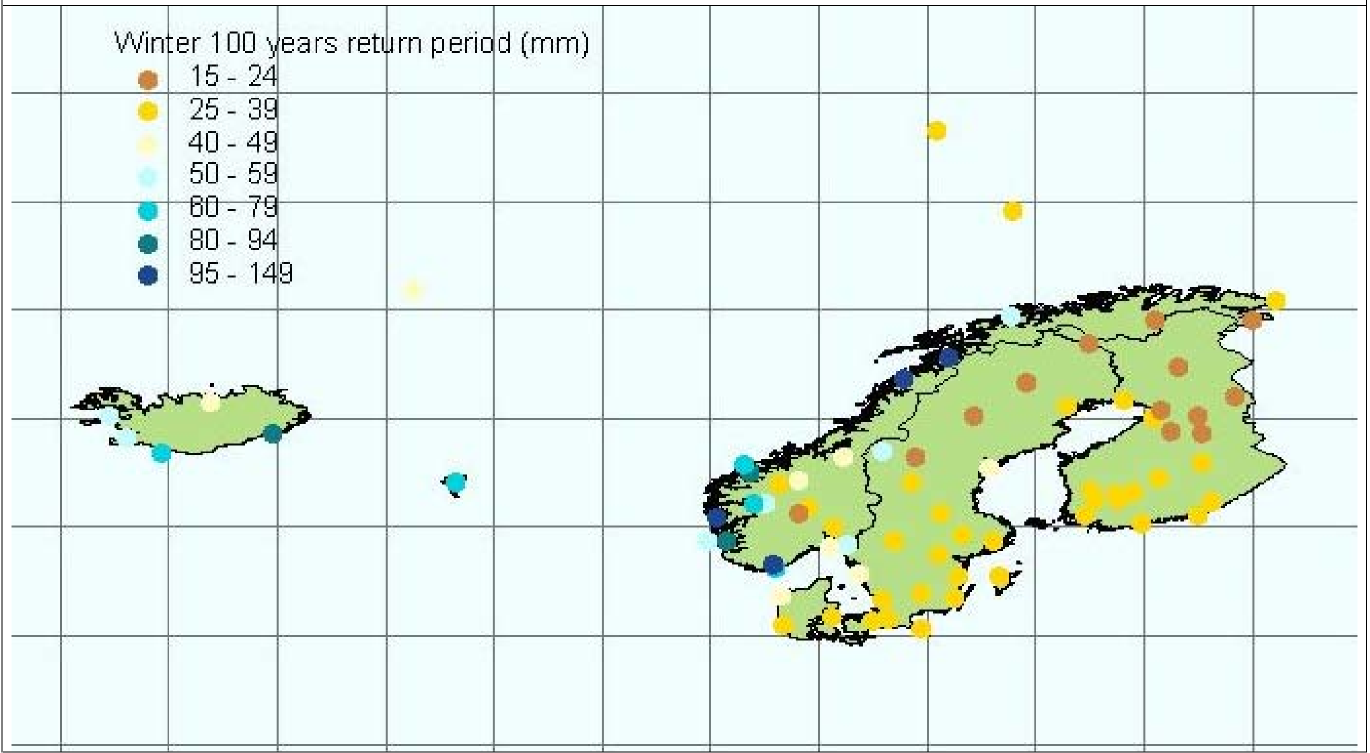


Figure 40. **Probable 24 hours precipitation in winter (December, January, February) with 100 years return period for the NORDKLIM area.**

Autumn:

Stnr.	Name	From	To	Mean	St.dev.	5y	10y	25y	50y	100y	250y	500y	1000y
6193	Hammerodde Fyr	1890	1995	20.74	7.35	26	30	36	42	48	59	68	78
21100	Vestervig	1890	1995	25.33	8.92	31	35	43	49	56	68	78	89
25140	Nordby	1890	1995	25.15	9.57	32	37	44	51	58	69	80	91
27080	Tranebjerg	1890	1995	20.06	8.29	26	30	36	42	48	59	68	78
30380	Köbenhavn	1890	1995	22.57	10.12	29	33	40	46	53	64	74	85
304	Helsinki	1882	1999	23.90	8.26	29	33	40	46	53	64	74	85
1101	Turku	1891	1999	21.36	6.93	26	30	36	42	48	59	68	78
1103	Huittinen	1894	1997	18.47	6.48	23	26	32	37	43	53	61	70
1202	Tampere	1891	1999	18.05	5.97	22	25	31	36	42	50	58	68
1601	Virolahti	1894	1999	25.35	12.74	34	39	47	53	61	73	83	95
1701	Lappeenranta	1886	1999	18.91	5.80	23	26	32	37	43	53	61	70
2104	Lavia	1903	1999	19.54	6.12	23	26	32	37	43	53	61	70
2211	Virrat	1909	1999	19.26	7.19	24	28	34	39	45	55	63	73
2306	Orivesi	1891	1999	18.23	8.01	23	26	32	37	43	53	61	70
2425	Jyvaeskylae	1891	1999	19.70	8.52	25	29	35	40	47	57	65	75
3602	Kuopio	1891	1998	17.73	6.18	22	25	31	36	42	50	58	68
4509	Kestilä	1909	1999	16.98	5.97	21	24	30	34	40	48	56	65
4601	Kajaani	1886	1999	17.21	6.90	22	25	31	36	42	50	58	68
5404	Oulu	1891	1996	17.35	6.84	22	25	31	36	42	50	58	68
5407	Yli-Ii	1912	1999	17.75	6.41	22	25	31	36	42	50	58	68
5605	Pudasjärvi	1909	1999	19.18	7.76	24	28	34	39	45	55	63	73
6801	Kuusamo	1908	1999	16.85	6.66	21	24	30	34	40	48	56	65
7501	Sodankylae	1908	1999	17.60	6.34	22	25	31	36	42	50	58	68
6011	Torshavn	1890	1999	34.31	11.24	42	48	57	64	73	87	98	112
4013	Stykkisholmur	1890	1999	26.24	11.02	34	39	47	53	61	73	83	95
4030	Reykjavik	1924	1999	24.05	8.24	29	33	40	46	53	64	74	85
4048	Vestmannaeyar	1890	1999	41.81	19.71	55	62	73	82	92	108	121	137
4063	Akureyri	1925	1999	20.51	10.46	28	32	39	45	52	62	72	82
4092	Teigarhorn	1890	1999	44.21	15.07	55	62	73	82	92	108	121	137
1230	Halden	1895	1999	27.30	8.21	33	38	45	52	60	71	81	93
15660	Skjåk	1896	1999	14.11	6.39	18	21	25	30	35	42	49	57
16740	Kjøremsgrendi	1890	1999	16.28	9.28	22	25	31	36	42	50	58	68
18700	Oslo-Blindern	1890	1999	26.27	9.46	33	38	45	52	60	71	81	93
22840	Reinli	1895	1997	24.02	9.73	31	35	43	49	56	68	78	89
24880	Nesbyen	1897	1999	18.58	8.07	24	28	34	39	45	55	63	73
27500	Ferder Fyr	1890	1999	28.46	9.62	35	40	48	55	63	75	85	97
39100	Oksøy Fyr	1890	1999	37.05	14.48	47	53	63	71	81	95	107	121
39220	Mestad	1900	1999	57.17	21.12	72	80	93	104	116	134	150	167
47020	Nedstrand	1895	1999	49.77	17.52	62	70	81	91	102	119	133	149
47300	Utsira Fyr	1920	1999	31.49	11.09	39	44	53	60	69	82	93	106
50540	Bergen-Florida	1890	1999	56.03	17.90	68	76	89	99	111	128	143	160
54120	Lærdal	1890	1996	21.48	8.94	27	31	38	43	50	60	70	80
54900	Vetti	1895	1996	29.65	9.74	36	41	49	56	64	76	87	99
60800	Ørskog	1895	1999	47.75	17.35	60	67	79	89	99	116	130	146
62480	Ona	1919	1999	36.98	13.41	46	52	62	70	79	93	106	119
68330	Lien I Selbu	1895	1999	23.29	8.33	29	33	40	46	53	64	74	85
69100	Værnes/Trondheim	1890	1999	27.57	11.67	35	40	48	55	63	75	85	97
80700	Glomfjord	1990	1999	70.07	29.83	91	101	116	128	142	163	180	199

83500	Kråkmo	1895	1999	48.13	18.23	61	68	80	90	101	117	132	148
90450	Tromsø	1890	1999	26.93	8.17	32	37	44	51	58	69	80	91
97250	Karasjok	1890	1999	14.72	6.61	19	22	27	31	36	44	51	60
98550	Vardø	1893	1999	16.39	5.87	20	23	28	33	38	46	54	62
99450	Bjoernsund	1895	1999	15.05	6.66	19	22	27	31	36	44	51	60
99710	Bjoernøya	1926	1999	14.56	5.41	18	21	25	30	35	42	49	57
99840	Svalbard Lufthavn	1957	1999	8.19	3.60	10	11	14	16	19	24	28	32
99950	Jan Mayen	1922	1999	24.22	11.56	32	37	44	51	58	69	80	91
5343	Lund	1885	1999	21.58	8.13	27	31	38	43	50	60	70	80
6240	Halmstad	1885	1999	23.96	9.52	30	34	41	48	55	66	76	87
6452	Växjö	1873	1999	19.68	6.80	24	28	34	39	45	55	63	73
6641	Kalmar	1885	1999	19.66	8.24	25	29	35	40	47	57	65	75
7147	Göteborg	1881	1999	24.53	8.54	30	34	41	48	55	66	76	87
7647	Västervik	1885	1999	25.03	12.20	33	38	45	52	60	71	81	93
7840	Visby	1879	1999	20.04	7.36	25	29	35	40	47	57	65	75
8524	Linköping	1885	1999	20.61	8.38	26	30	36	42	48	59	68	78
9322	Karlstad	1881	1999	22.79	7.12	27	31	38	43	50	60	70	80
9635	Västeraas	1885	1999	19.96	7.65	25	29	35	40	47	57	65	75
9821	Stockholm	1873	1999	21.11	7.26	26	30	36	42	48	59	68	78
10537	Falun	1875	1999	20.91	8.19	26	30	36	42	48	59	68	78
12402	Sveg	1885	1999	21.63	7.79	27	31	38	43	50	60	70	80
12738	Härnösand	1879	1999	29.59	12.07	38	43	52	59	67	80	91	104
13411	Östersund	1875	1999	16.37	7.62	21	24	30	34	40	48	56	65
15772	Stensele	1885	1999	17.02	7.82	22	25	31	36	42	50	58	68
16179	Piteaa	1885	1999	22.43	9.35	29	33	40	46	53	64	74	85
16395	Haparanda	1873	1999	21.45	6.87	26	30	36	42	48	59	68	78
16988	Jokkmokk	1882	1999	16.18	6.56	20	23	28	33	38	46	54	62
19283	Karesuando	1885	1999	15.12	6.90	20	23	28	33	38	46	54	62
4210	Upernavik	1949	1986	18.52	12.99	27	31	38	43	50	60	70	80
4250	Nuuk	1921	1998	34.50	16.81	46	52	62	70	79	93	106	119
4270	Narsarsuaq	1890	1999	53.57	25.92	72	80	93	104	116	134	150	167
4320	Danmarkshavn	1949	1999	9.03	6.55	13	15	18	21	25	31	36	42
4339	Ittoqqortoormiit	1949	1999	24.04	12.18	32	37	44	51	58	69	80	91
4360	Tasiilaq	1897	1999	40.44	17.91	53	60	70	79	89	105	118	133

Table 4. Probable extreme 1-day precipitation, in autumn (Sep., Oct., Nov.), calculated with the NERC-method for the stations in the NORDKLIM dataset for return periods 5, 10, 25, 50, 100, 250,500 and 1000 years. The calculation is based on mean and standard deviation of absolute max-values each year (in autumn) in the observation period found from the element *p602*.

Winter:

Stnr.	*Name*	*From*	*To*	*Mean*	*St.dev.*	*5y*	*10y*	*25y*	*50y*	*100y*	*250y*	*500y*	*1000y*
6193	Hammerodde Fyr	1890	1995	14.47	5.55	18	21	25	30	35	42	49	57
21100	Vestervig	1890	1995	17.32	5.88	21	24	30	34	40	48	56	65
25140	Nordby	1890	1995	16.49	5.32	20	23	28	33	38	46	54	62
27080	Tranebjerg	1890	1995	13.99	5.21	17	20	24	28	33	40	47	54
30380	Köbenhavn	1890	1995	14.54	4.73	17	20	24	28	33	40	47	54
304	Helsinki	1882	1999	16.43	5.91	20	23	28	33	38	46	54	62
1101	Turku	1891	1999	14.29	5.41	18	21	25	30	35	42	49	57
1103	Huittinen	1894	1997	11.69	4.33	14	16	20	23	27	33	39	45
1202	Tampere	1891	1999	11.29	4.22	14	16	20	23	27	33	39	45
1601	Virolahti	1894	1999	15.77	6.28	20	23	28	33	38	46	54	62
1701	Lappeenranta	1886	1999	13.29	5.06	16	18	23	27	31	38	44	52
2104	Lavia	1903	1999	12.11	5.68	16	18	23	27	31	38	44	52
2211	Virrat	1909	1999	11.82	3.76	14	16	20	23	27	33	39	45
2306	Orivesi	1891	1999	11.15	3.40	13	15	18	21	25	31	36	42
2425	Jyvaeskylae	1891	1999	12.33	4.45	15	17	21	25	29	36	42	49
3602	Kuopio	1891	1998	12.68	3.97	15	17	21	25	29	36	42	49
4509	Kestilä	1909	1999	10.58	3.28	12	14	17	20	23	28	33	39
4601	Kajaani	1886	1999	9.62	3.32	12	14	17	20	23	28	33	39
5404	Oulu	1891	1996	11.08	3.82	13	15	18	21	25	31	36	42
5407	Yli-Ii	1912	1999	9.67	3.04	11	12	15	18	21	26	30	35
5605	Pudasjärvi	1909	1999	9.96	3.56	12	14	17	20	23	28	33	39
6801	Kuusamo	1908	1999	8.59	3.17	10	11	14	16	19	24	28	32
7501	Sodankylae	1908	1999	8.29	2.56	10	11	14	16	19	24	28	32
6011	Torshavn	1890	1999	32.34	10.59	39	44	53	60	69	82	93	106
4013	Stykkisholmur	1890	1999	25.03	10.89	32	37	44	51	58	69	80	91
4030	Reykjavik	1924	1999	22.60	7.85	28	32	39	45	52	62	72	82
4048	Vestmannaeyar	1890	1999	37.70	10.70	45	51	60	69	78	92	104	118
4063	Akureyri	1925	1999	17.31	6.21	21	24	30	34	40	48	56	65
4092	Teigarhorn	1890	1999	42.25	16.95	54	61	72	81	91	106	120	135
1230	Halden	1895	1999	21.82	9.34	28	32	39	45	52	62	72	82
15660	Skjåk	1896	1999	11.35	5.94	15	17	21	25	29	36	42	49
16740	Kjøremsgrendi	1890	1999	15.05	9.00	21	24	30	34	40	48	56	65
18700	Oslo-Blindern	1890	1999	15.70	5.63	19	22	27	31	36	44	51	60
22840	Reinli	1895	1997	13.83	5.39	17	20	24	28	33	40	47	54
24880	Nesbyen	1897	1999	9.64	3.15	11	12	15	18	21	26	30	35
27500	Ferder Fyr	1890	1999	19.20	6.72	24	28	34	39	45	55	63	73
39100	Oksøy Fyr	1890	1999	30.02	12.48	38	43	52	59	67	80	91	104
39220	Mestad	1900	1999	50.43	18.04	63	71	83	93	104	121	135	151
47020	Nedstrand	1895	1999	44.81	12.83	54	61	72	81	91	106	120	135
47300	Utsira Fyr	1920	1999	24.74	8.33	30	34	41	48	55	66	76	87
50540	Bergen-Florida	1890	1999	49.05	15.53	60	67	79	89	99	116	130	146
54120	Lærdal	1890	1996	20.02	10.08	27	31	38	43	50	60	70	80
54900	Vetti	1895	1996	31.69	14.12	41	47	55	63	72	85	97	110
60800	Ørskog	1895	1999	38.41	15.49	49	55	65	74	84	98	111	125
62480	Ona	1919	1999	29.47	11.79	37	42	50	58	66	78	89	102
68330	Lien I Selbu	1895	1999	19.16	9.81	26	30	36	42	48	59	68	78
69100	Værnes/Trondheim	1890	1999	23.70	9.83	30	34	41	48	55	66	76	87

80700	Glomfjord	1990	1999	63.96	26.56	83	92	106	118	131	151	167	186
83500	Kråkmo	1895	1999	50.78	23.09	67	75	87	98	109	127	142	158
90450	Tromsø	1890	1999	25.46	9.37	32	37	44	51	58	69	80	91
97250	Karasjok	1890	1999	7.19	4.39	10	11	14	16	19	24	28	32
98550	Vardø	1893	1999	14.63	6.94	19	22	27	31	36	44	51	60
99450	Bjoernsund	1895	1999	9.02	3.85	11	12	15	18	21	26	30	35
99710	Bjoernøya	1926	1999	12.18	5.86	16	18	23	27	31	38	44	52
99840	Svalbard Lufthavn	1957	1999	10.90	6.67	15	17	21	25	29	36	42	49
99950	Jan Mayen	1922	1999	19.66	9.54	26	30	36	42	48	59	68	78
5343	Lund	1885	1999	14.97	5.30	18	21	25	30	35	42	49	57
6240	Halmstad	1885	1999	16.41	5.36	20	23	28	33	38	46	54	62
6452	Växjö	1873	1999	14.24	4.87	17	20	24	28	33	40	47	54
6641	Kalmar	1885	1999	12.77	5.24	16	18	23	27	31	38	44	52
7147	Göteborg	1881	1999	19.10	6.86	24	28	34	39	45	55	63	73
7647	Västervik	1885	1999	15.29	6.61	20	23	28	33	38	46	54	62
7840	Visby	1879	1999	14.02	4.45	17	20	24	28	33	40	47	54
8524	Linköping	1885	1999	12.97	5.05	16	18	23	27	31	38	44	52
9322	Karlstad	1881	1999	14.74	5.60	18	21	25	30	35	42	49	57
9635	Västeraas	1885	1999	11.99	4.54	15	17	21	25	29	36	42	49
9821	Stockholm	1873	1999	13.43	5.04	17	20	24	28	33	40	47	54
10537	Falun	1875	1999	12.19	3.93	15	17	21	25	29	36	42	49
12402	Sveg	1885	1999	14.38	6.02	18	21	25	30	35	42	49	57
12738	Härnösand	1879	1999	20.01	8.96	26	30	36	42	48	59	68	78
13411	Östersund	1875	1999	8.44	3.48	10	11	14	16	19	24	28	32
15772	Stensele	1885	1999	9.26	3.31	11	12	15	18	21	26	30	35
16179	Piteaa	1885	1999	12.67	5.42	16	18	23	27	31	38	44	52
16395	Haparanda	1873	1999	12.69	4.81	16	18	23	27	31	38	44	52
16988	Jokkmokk	1882	1999	8.49	3.28	10	11	14	16	19	24	28	32
19283	Karesuando	1885	1999	7.56	3.02	9	10	13	15	17	21	25	29
4210	Upernavik	1949	1986	7.74	5.67	11	12	15	18	21	26	30	35
4250	Nuuk	1921	1998	19.86	12.81	29	33	40	46	53	64	74	85
4270	Narsarsuaq	1890	1999	42.98	31.21	65	73	85	95	107	124	138	155
4320	Danmarkshavn	1949	1999	9.00	6.97	14	16	20	23	27	33	39	45
4339	Ittoqqortoormiit	1949	1999	18.49	8.94	24	28	34	39	45	55	63	73
4360	Tasiilaq	1897	1999	35.71	19.73	49	55	65	74	84	98	111	125

Table 5. Probable extreme 1-day precipitation, in winter (Dec., Jan., Feb.), calculated with the NERC-method for the stations in the NORDKLIM dataset for return periods 5, 10, 25, 50, 100, 250,500 and 1000 years. The calculation is based on mean and standard deviation of absolute max-values each year (in winter) in the observation period found from the element *p602*.

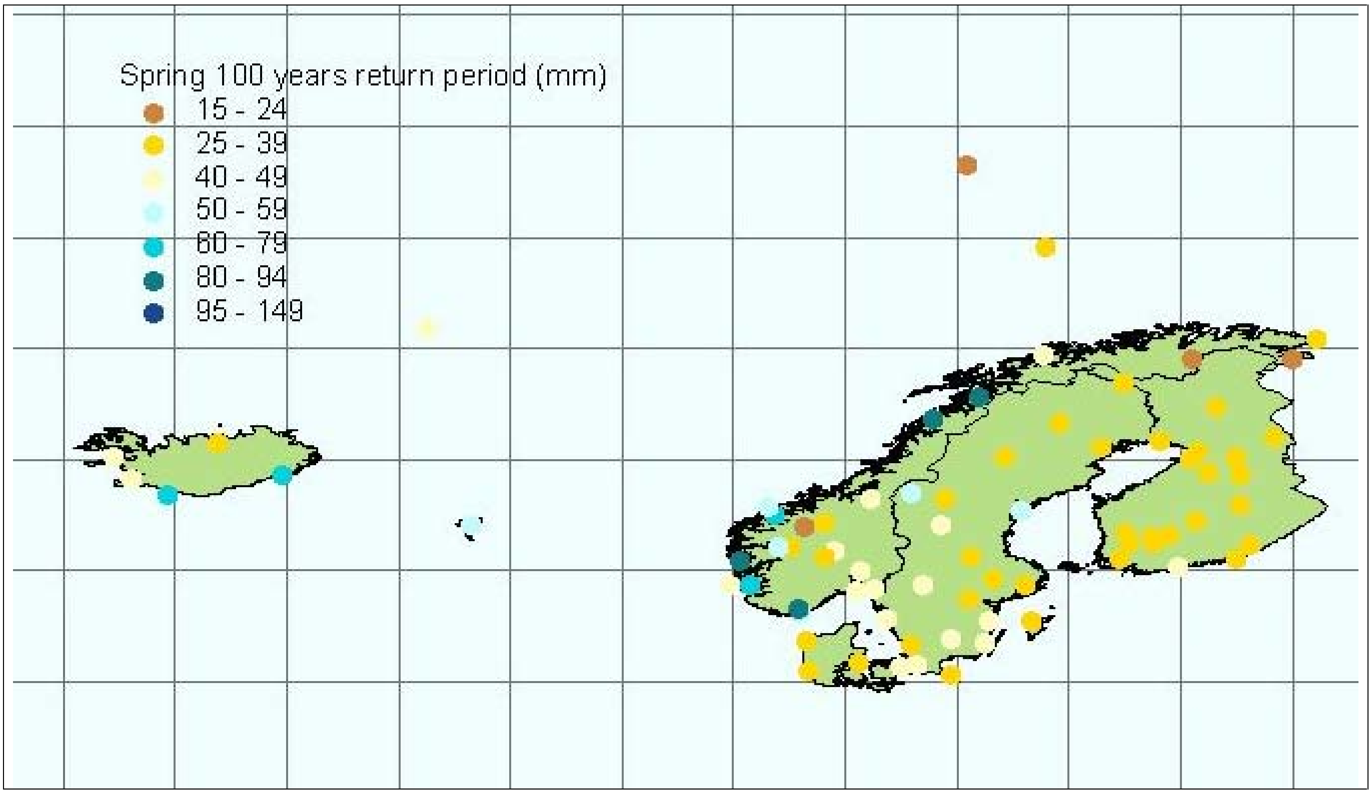


Figure 41. **Probable 24 hours precipitation in spring (March, April, May) with 100 years return period for the NORDKLIM area.**

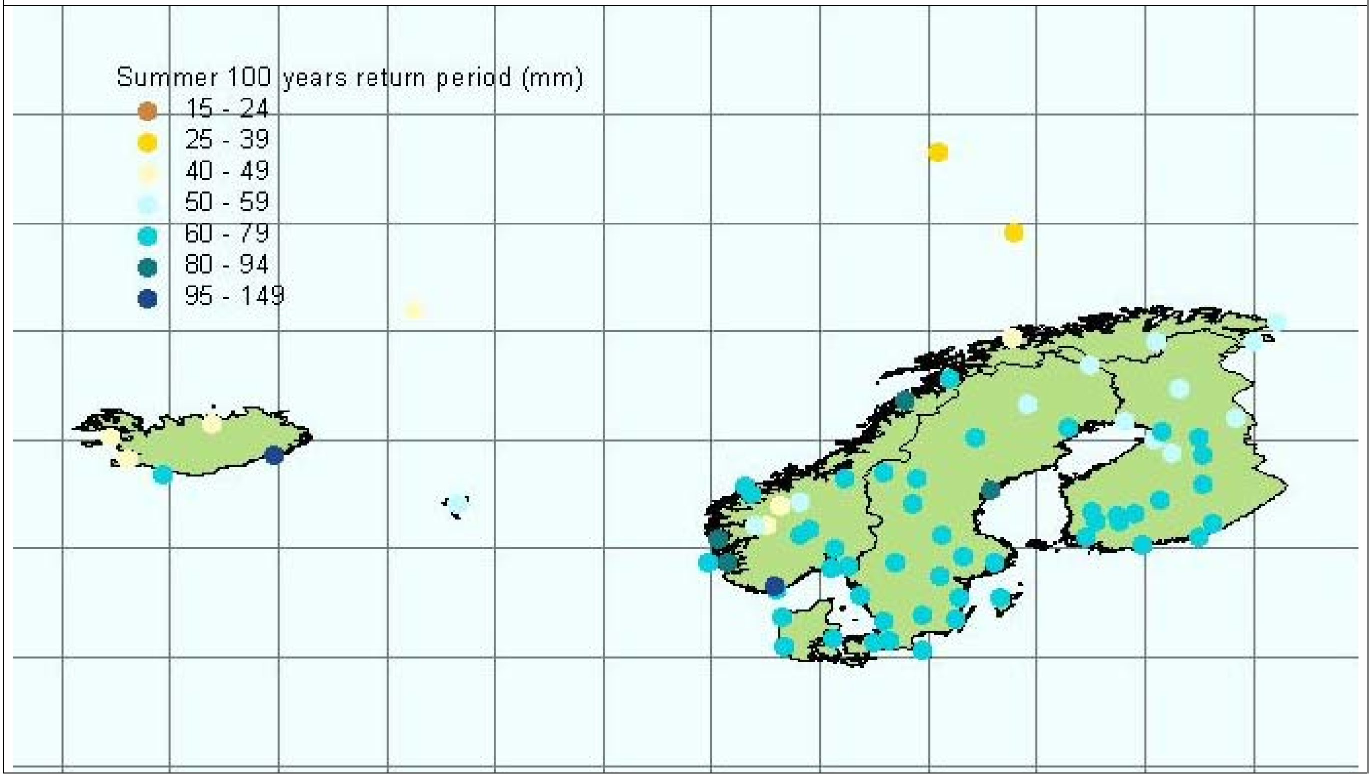


Figure 42. **Probable 24 hours precipitation in summer (June, July, August) with 100 years return period for the NORDKLIM area.**

Spring:

Stnr.	Name	From	To	Mean	St.dev.	5y	10y	25y	50y	100y	250y	500y	1000y
6193	Hammerodde Fyr	1890	1995	15.17	6.58	19	22	27	31	36	44	51	60
21100	Vestervig	1890	1995	16.76	5.21	20	23	28	33	38	46	54	62
25140	Nordby	1890	1995	16.08	6.25	20	23	28	33	38	46	54	62
27080	Tranebjerg	1890	1995	15.75	6.32	20	23	28	33	38	46	54	62
30380	Köbenhavn	1890	1995	17.05	7.22	22	25	31	36	42	50	58	68
304	Helsinki	1882	1999	16.82	6.44	21	24	30	34	40	48	56	65
1101	Turku	1891	1999	15.17	6.25	19	22	27	31	36	44	51	60
1103	Huittinen	1894	1997	13.64	5.55	17	20	24	28	33	40	47	54
1202	Tampere	1891	1999	14.71	5.32	18	21	25	30	35	42	49	57
1601	Virolahti	1894	1999	16.10	6.60	20	23	28	33	38	46	54	62
1701	Lappeenranta	1886	1999	15.55	7.26	20	23	28	33	38	46	54	62
2104	Lavia	1903	1999	15.59	6.31	20	23	28	33	38	46	54	62
2211	Virrat	1909	1999	14.14	6.93	19	22	27	31	36	44	51	60
2306	Orivesi	1891	1999	14.21	5.00	17	20	24	28	33	40	47	54
2425	Jyvaeskylae	1891	1999	14.62	6.85	19	22	27	31	36	44	51	60
3602	Kuopio	1891	1998	14.62	5.95	18	21	25	30	35	42	49	57
4509	Kestilä	1909	1999	14.49	5.03	18	21	25	30	35	42	49	57
4601	Kajaani	1886	1999	13.01	6.41	17	20	24	28	33	40	47	54
5404	Oulu	1891	1996	13.50	5.40	17	20	24	28	33	40	47	54
5407	Yli-Ii	1912	1999	13.47	5.53	17	20	24	28	33	40	47	54
5605	Pudasjärvi	1909	1999	13.59	5.65	17	20	24	28	33	40	47	54
6801	Kuusamo	1908	1999	12.52	5.25	16	18	23	27	31	38	44	52
7501	Sodankylae	1908	1999	11.75	4.72	15	17	21	25	29	36	42	49
6011	Torshavn	1890	1999	25.75	9.48	32	37	44	51	58	69	80	91
4013	Stykkisholmur	1890	1999	17.38	8.21	23	26	32	37	43	53	61	70
4030	Reykjavik	1924	1999	19.58	8.68	25	29	35	40	47	57	65	75
4048	Vestmannaeyar	1890	1999	34.49	13.59	44	50	59	67	76	90	102	116
4063	Akureyri	1925	1999	14.85	7.11	19	22	27	31	36	44	51	60
4092	Teigarhorn	1890	1999	35.64	15.77	46	52	62	70	79	93	106	119
1230	Halden	1895	1999	18.63	7.39	23	26	32	37	43	53	61	70
15660	Skjåk	1896	1999	8.48	4.70	11	12	15	18	21	26	30	35
16740	Kjøremsgrendi	1890	1999	11.41	6.14	15	17	21	25	29	36	42	49
18700	Oslo-Blindern	1890	1999	18.12	6.26	22	25	31	36	42	50	58	68
22840	Reinli	1895	1997	17.10	6.76	21	24	30	34	40	48	56	65
24880	Nesbyen	1897	1999	12.93	6.44	17	20	24	28	33	40	47	54
27500	Ferder Fyr	1890	1999	20.28	7.95	25	29	35	40	47	57	65	75
39100	Oksøy Fyr	1890	1999	24.24	9.94	31	35	43	49	56	68	78	89
39220	Mestad	1900	1999	41.93	16.82	54	61	72	81	91	106	120	135
47020	Nedstrand	1895	1999	35.18	13.31	44	50	59	67	76	90	102	116
47300	Utsira Fyr	1920	1999	20.00	6.37	24	28	34	39	45	55	63	73
50540	Bergen-Florida	1890	1999	38.73	15.42	49	55	65	74	84	98	111	125
54120	Lærdal	1890	1996	12.67	6.89	17	20	24	28	33	40	47	54
54900	Vetti	1895	1996	19.72	10.60	27	31	38	43	50	60	70	80
60800	Ørskog	1895	1999	31.82	13.82	41	47	55	63	72	85	97	110
62480	Ona	1919	1999	23.76	10.51	31	35	43	49	56	68	78	89
68330	Lien I Selbu	1895	1999	18.55	8.62	24	28	34	39	45	55	63	73
69100	Værnes/Trondheim	1890	1999	19.96	10.64	27	31	38	43	50	60	70	80

80700	Glomfjord	1990	1999	39.07	13.19	48	54	64	73	82	97	109	123
83500	Kråkmo	1895	1999	35.81	19.40	49	55	65	74	84	98	111	125
90450	Tromsø	1890	1999	19.62	6.53	24	28	34	39	45	55	63	73
97250	Karasjok	1890	1999	8.87	4.10	11	12	15	18	21	26	30	35
98550	Vardø	1893	1999	12.75	6.51	17	20	24	28	33	40	47	54
99450	Bjoernsund	1895	1999	9.32	4.16	12	14	17	20	23	28	33	39
99710	Bjoernøya	1926	1999	9.29	5.53	13	15	18	21	25	31	36	42
99840	Svalbard Lufthavn	1957	1999	8.07	5.63	12	14	17	20	23	28	33	39
99950	Jan Mayen	1922	1999	17.55	9.32	24	28	34	39	45	55	63	73
5343	Lund	1885	1999	16.82	8.43	22	25	31	36	42	50	58	68
6240	Halmstad	1885	1999	16.15	5.84	20	23	28	33	38	46	54	62
6452	Växjö	1873	1999	16.56	8.36	22	25	31	36	42	50	58	68
6641	Kalmar	1885	1999	16.08	6.89	21	24	30	34	40	48	56	65
7147	Göteborg	1881	1999	17.51	5.97	21	24	30	34	40	48	56	65
7647	Västervik	1885	1999	17.43	7.49	22	25	31	36	42	50	58	68
7840	Visby	1879	1999	14.77	5.83	18	21	25	30	35	42	49	57
8524	Linköping	1885	1999	15.55	6.18	19	22	27	31	36	44	51	60
9322	Karlstad	1881	1999	17.17	7.02	22	25	31	36	42	50	58	68
9635	Västeraas	1885	1999	15.24	5.92	19	22	27	31	36	44	51	60
9821	Stockholm	1873	1999	15.34	7.18	20	23	28	33	38	46	54	62
10537	Falun	1875	1999	15.81	6.93	20	23	28	33	38	46	54	62
12402	Sveg	1885	1999	17.37	5.84	21	24	30	34	40	48	56	65
12738	Härnösand	1879	1999	21.74	9.81	28	32	39	45	52	62	72	82
13411	Östersund	1875	1999	13.00	6.11	17	20	24	28	33	40	47	54
15772	Stensele	1885	1999	13.24	4.84	16	18	23	27	31	38	44	52
16179	Piteaa	1885	1999	14.92	5.81	19	22	27	31	36	44	51	60
16395	Haparanda	1873	1999	14.11	5.56	18	21	25	30	35	42	49	57
16988	Jokkmokk	1882	1999	12.32	5.78	16	18	23	27	31	38	44	52
19283	Karesuando	1885	1999	10.25	4.79	13	15	18	21	25	31	36	42
4210	Upernavik	1949	1986	9.30	9.44	16	18	23	27	31	38	44	52
4250	Nuuk	1921	1998	22.60	18.29	35	40	48	55	63	75	85	97
4270	Narsarsuaq	1890	1999	36.80	19.62	50	56	67	75	85	100	113	127
4320	Danmarkshavn	1949	1999	8.49	5.96	12	14	17	20	23	28	33	39
4339	Ittoqqortoormiit	1949	1999	15.02	8.76	21	24	30	34	40	48	56	65
4360	Tasiilaq	1897	1999	30.83	17.86	43	49	58	66	75	88	100	114

Table 6. Probable extreme 1-day precipitation, in spring (Mar., Apr., May), calculated with the NERC-method for the stations in the NORDKLIM dataset for return periods 5, 10, 25, 50, 100, 250,500 and 1000 years. The calculation is based on mean and standard deviation of absolute max-values each year (in spring) in the observation period found from the element *p602*.

Summer:

Stnr.	Name	From	To	Mean	St.dev.	5y	10y	25y	50y	100y	250y	500y	1000y
6193	Hammerodde Fyr	1890	1995	26.04	11.85	34	39	47	53	61	73	83	95
21100	Vestervig	1890	1995	26.44	9.61	33	38	45	52	60	71	81	93
25140	Nordby	1890	1995	27.25	11.78	35	40	48	55	63	75	85	97
27080	Tranebjerg	1890	1995	25.60	14.29	35	40	48	55	63	75	85	97
30380	Köbenhavn	1890	1995	25.90	10.01	33	38	45	52	60	71	81	93
304	Helsinki	1882	1999	27.44	10.72	35	40	48	55	63	75	85	97
1101	Turku	1891	1999	28.36	13.73	38	43	52	59	67	80	91	104
1103	Huittinen	1894	1997	27.63	11.64	36	41	49	56	64	76	87	99
1202	Tampere	1891	1999	26.44	9.47	33	38	45	52	60	71	81	93
1601	Virolahti	1894	1999	29.08	12.44	38	43	52	59	67	80	91	104
1701	Lappeenranta	1886	1999	27.08	13.16	36	41	49	56	64	76	87	99
2104	Lavia	1903	1999	26.09	9.65	33	38	45	52	60	71	81	93
2211	Virrat	1909	1999	28.27	10.94	36	41	49	56	64	76	87	99
2306	Orivesi	1891	1999	26.32	9.48	33	38	45	52	60	71	81	93
2425	Jyvaeskylae	1891	1999	29.66	13.47	39	44	53	60	69	82	93	106
3602	Kuopio	1891	1998	26.56	12.87	35	40	48	55	63	75	85	97
4509	Kestilä	1909	1999	25.03	7.84	30	34	41	48	55	66	76	87
4601	Kajaani	1886	1999	26.35	11.06	34	39	47	53	61	73	83	95
5404	Oulu	1891	1996	24.83	10.97	32	37	44	51	58	69	80	91
5407	Yli-Ii	1912	1999	24.90	12.44	33	38	45	52	60	71	81	93
5605	Pudasjärvi	1909	1999	27.62	10.89	35	40	48	55	63	75	85	97
6801	Kuusamo	1908	1999	23.63	8.15	29	33	40	46	53	64	74	85
7501	Sodankylae	1908	1999	23.88	7.88	29	33	40	46	53	64	74	85
6011	Torshavn	1890	1999	25.69	9.78	32	37	44	51	58	69	80	91
4013	Stykkisholmur	1890	1999	17.22	7.15	22	25	31	36	42	50	58	68
4030	Reykjavik	1924	1999	19.58	7.79	25	29	35	40	47	57	65	75
4048	Vestmannaeyar	1890	1999	33.58	12.08	42	48	57	64	73	87	98	112
4063	Akureyri	1925	1999	16.52	8.36	22	25	31	36	42	50	58	68
4092	Teigarhorn	1890	1999	48.81	23.32	65	73	85	95	107	124	138	155
1230	Halden	1895	1999	29.88	11.20	37	42	50	58	66	78	89	102
15660	Skjåk	1896	1999	17.86	7.57	23	26	32	37	43	53	61	70
16740	Kjøremsgrendi	1890	1999	21.98	9.44	28	32	39	45	52	62	72	82
18700	Oslo-Blindern	1890	1999	29.86	10.30	37	42	50	58	66	78	89	102
22840	Reinli	1895	1997	29.41	10.50	36	41	49	56	64	76	87	99
24880	Nesbyen	1897	1999	25.68	10.29	33	38	45	52	60	71	81	93
27500	Ferder Fyr	1890	1999	28.40	12.43	37	42	50	58	66	78	89	102
39100	Oksøy Fyr	1890	1999	33.52	14.48	43	49	58	66	75	88	100	114
39220	Mestad	1900	1999	46.57	17.21	58	65	76	86	97	113	127	142
47020	Nedstrand	1895	1999	44.51	15.06	55	62	73	82	92	108	121	137
47300	Utsira Fyr	1920	1999	31.60	14.20	41	47	55	63	72	85	97	110
50540	Bergen-Florida	1890	1999	42.85	12.57	51	58	68	77	87	101	114	129
54120	Lærdal	1890	1996	18.02	8.49	24	28	34	39	45	55	63	73
54900	Vetti	1895	1996	22.56	7.98	28	32	39	45	52	62	72	82
60800	Ørskog	1895	1999	35.34	14.83	46	52	62	70	79	93	106	119
62480	Ona	1919	1999	27.10	11.39	35	40	48	55	63	75	85	97
68330	Lien I Selbu	1895	1999	27.92	9.06	34	39	47	53	61	73	83	95
69100	Værnes/Trondheim	1890	1999	26.34	11.07	34	39	47	53	61	73	83	95
80700	Glomfjord	1990	1999	43.02	17.96	55	62	73	82	92	108	121	137

83500	Kråkmo	1895	1999	27.44	12.32	36	41	49	56	64	76	87	99
90450	Tromsø	1890	1999	21.01	7.44	26	30	36	42	48	59	68	78
97250	Karasjok	1890	1999	22.29	8.18	28	32	39	45	52	62	72	82
98550	Vardø	1893	1999	21.12	8.53	27	31	38	43	50	60	70	80
99450	Bjoernsund	1895	1999	22.88	8.78	29	33	40	46	53	64	74	85
99710	Bjoernøya	1926	1999	13.30	5.60	17	20	24	28	33	40	47	54
99840	Svalbard Lufthavn	1957	1999	10.14	7.14	15	17	21	25	29	36	42	49
99950	Jan Mayen	1922	1999	18.71	11.06	26	30	36	42	48	59	68	78
5343	Lund	1885	1999	28.34	13.26	37	42	50	58	66	78	89	102
6240	Halmstad	1885	1999	31.09	12.75	40	45	54	62	70	83	95	108
6452	Växjö	1873	1999	29.44	17.42	41	47	55	63	72	85	97	110
6641	Kalmar	1885	1999	25.30	12.01	33	38	45	52	60	71	81	93
7147	Göteborg	1881	1999	29.67	11.14	37	42	50	58	66	78	89	102
7647	Västervik	1885	1999	29.48	17.15	41	47	55	63	72	85	97	110
7840	Visby	1879	1999	26.19	12.48	35	40	48	55	63	75	85	97
8524	Linköping	1885	1999	27.38	13.06	36	41	49	56	64	76	87	99
9322	Karlstad	1881	1999	29.54	12.13	38	43	52	59	67	80	91	104
9635	Västeraas	1885	1999	29.60	15.39	40	45	54	62	70	83	95	108
9821	Stockholm	1873	1999	29.25	11.61	37	42	50	58	66	78	89	102
10537	Falun	1875	1999	29.55	11.06	37	42	50	58	66	78	89	102
12402	Sveg	1885	1999	28.52	9.80	35	40	48	55	63	75	85	97
12738	Härnösand	1879	1999	35.31	21.82	51	58	68	77	87	101	114	129
13411	Östersund	1875	1999	25.79	10.09	33	38	45	52	60	71	81	93
15772	Stensele	1885	1999	28.51	11.04	36	41	49	56	64	76	87	99
16179	Piteaa	1885	1999	27.36	12.38	36	41	49	56	64	76	87	99
16395	Haparanda	1873	1999	23.40	9.11	29	33	40	46	53	64	74	85
16988	Jokkmokk	1882	1999	25.91	8.30	31	35	43	49	56	68	78	89
19283	Karesuando	1885	1999	22.84	8.34	28	32	39	45	52	62	72	82
4210	Upernavik	1949	1986	15.06	8.23	20	23	28	33	38	46	54	62
4250	Nuuk	1921	1998	37.56	18.53	50	56	67	75	85	100	113	127
4270	Narsarsuaq	1890	1999	42.97	24.94	60	67	79	89	99	116	130	146
4320	Danmarkshavn	1949	1999	9.72	5.62	13	15	18	21	25	31	36	42
4339	Ittoqqortoormiit	1949	1999	21.88	13.08	31	35	43	49	56	68	78	89
4360	Tasiilaq	1897	1999	27.38	12.59	36	41	49	56	64	76	87	99

Table 7. Probable extreme 1-day precipitation, in summer (Jun., Jul., Aug.), calculated with the NERC-method for the stations in the NORDKLIM dataset for return periods 5, 10, 25, 50, 100, 250,500 and 1000 years. The calculation is based on mean and standard deviation of absolute max-values each year (in summer) in the observation period found from the element *p602*.

The seasonal differences of the probable extreme precipitation episodes are shown in Figure 39 - Figure 42 for 100 years return period. The autumn map, Figure 39, looks more or less the same as the annual map in Figure 35 telling that it is most probable to get the heaviest rainfall during autumn for most places. During wintertime heavy 24 hours precipitation episodes will seldom occur.

In summer we see that the 100 years return period gives about 60-79 mm for 24 hours precipitation over most of eastern Norway, Denmark, Sweden and Finland. In the west coast it can be even wetter than that and in north even drier. For Iceland the 1-day probable extreme precipitation episodes is larger in the south than in the north and northwest.

The spring map, Figure 41, gives a more complex picture of the 1-day precipitation, but we see smallest M5-value in the North, in middle Norway (leeward side of the mountains) and in the inland of Finland, Sweden, Denmark and Norway. The spring map shows larger differences in extreme precipitation amount between inland and coast, (also the south coast in Norway and Iceland), than the summer map when the convective precipitation dominates in the inland area.

Figure 43 shows the distribution of which season has the largest and smallest M5 1-day value. This is already discussed a bit, but it is really clear that in Finland and Sweden the M5 value is smallest in winter and largest in summer. For the west coast of Iceland and Norway autumn gives the heaviest rainfall and spring gives the smallest.

Figure 44 shows the 2 months distribution of the minimum and maximum M5 value, stating that the maximum 1-day precipitation occurs during July in summer time in the large inland areas in Finland and Sweden. The maximums in autumn occur during September and October.

In large areas in Sweden and Finland the minimum M5 value is found during wintertime in January and February and in the more coastal areas, during March to June. The minimum M5 value is never found in the months July to December!

Remark: The calculation of the max and min value is taken in this priority order: autumn, winter, spring, summer. This means that if a station had the same max value in both autumn and summer, autumn is taken.

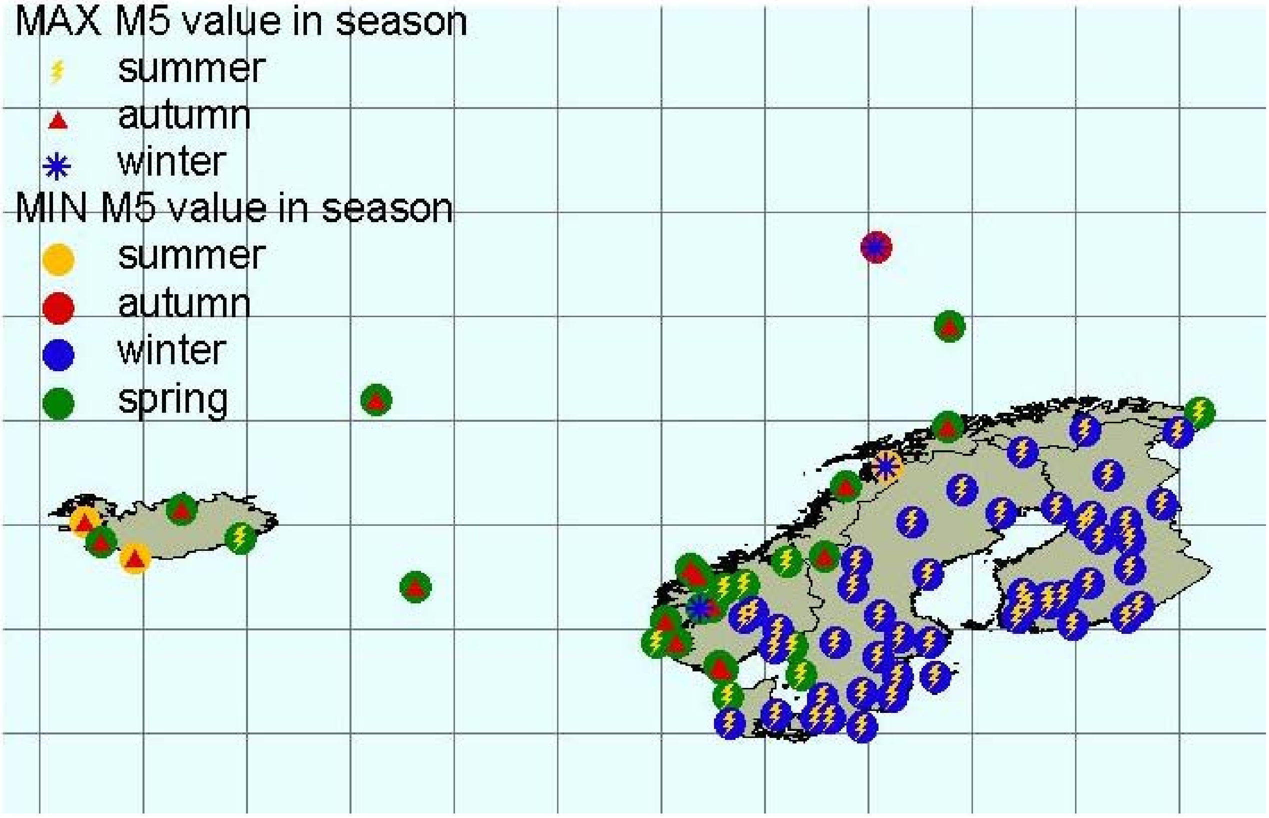


Figure 43. **Lowest and highest 1-day M5 value seasonal in NORDKLIM area.**

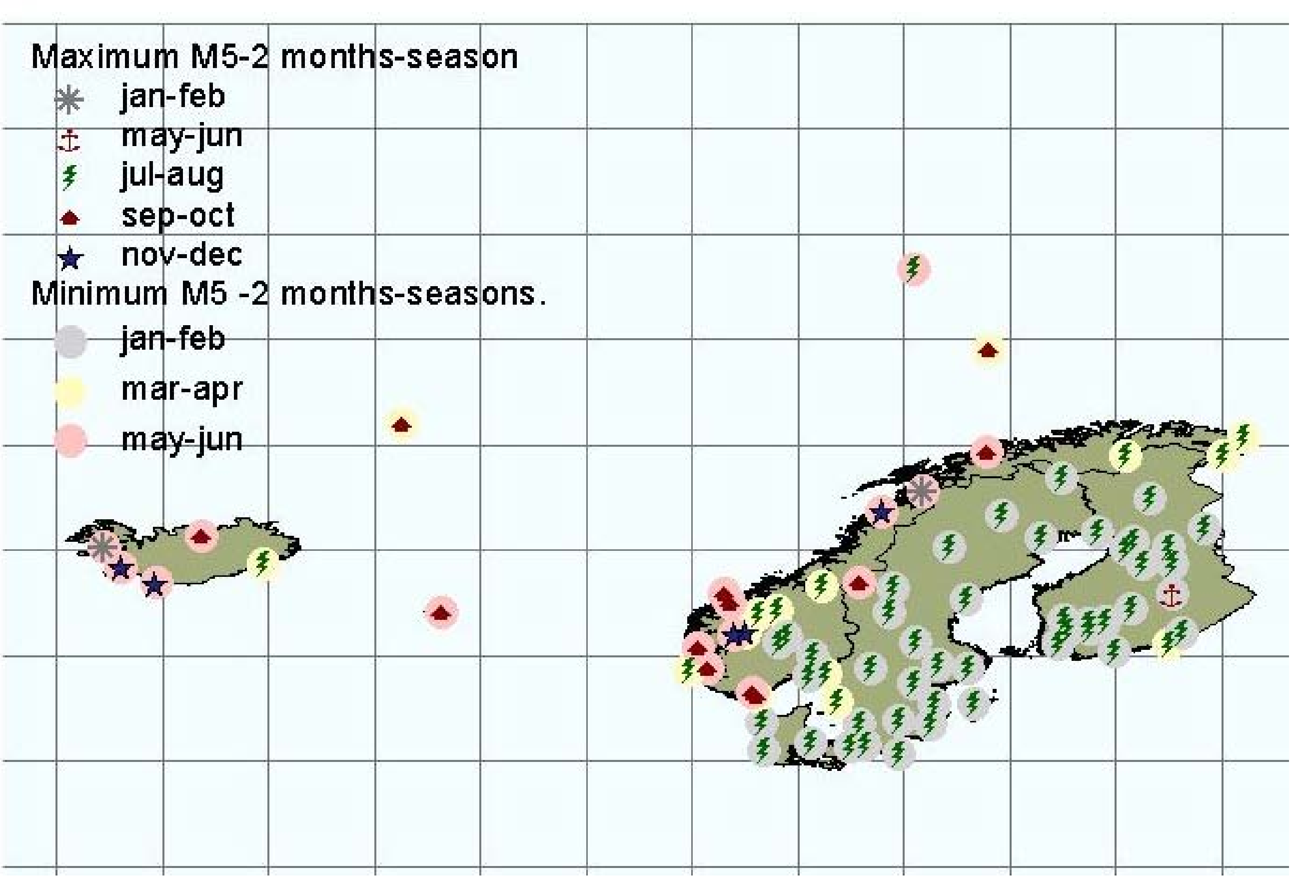


Figure 44. **Maximum and minimum 1-day M5 value distributed for two and two months in the NORDKLIM area.**

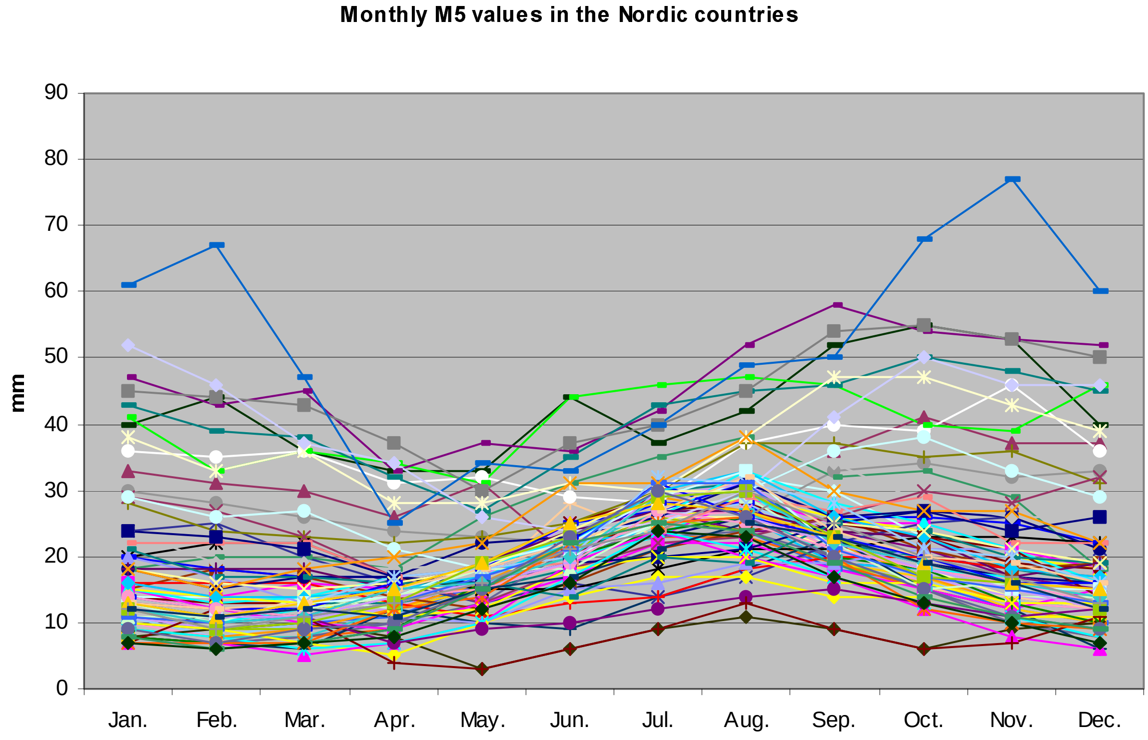


Figure 45. Monthly distribution of M5 value for all the stations in the NORDKLIM dataset.

Figure 45 shows that for most of the stations in the NORDKLIM dataset the maximum M5-value is in July, as stated before. The maximum blue curve with a top in November is *Glomfjord*, Norway nearby the glacier *Svartisen*, also seen in the middle of Norway with a star (Nov.-Dec.) for the maximum M5value in Figure 44.

Figure 46 gives monthly distribution of M5-value for some of the stations in the different countries, and we can see large differences between the stations.

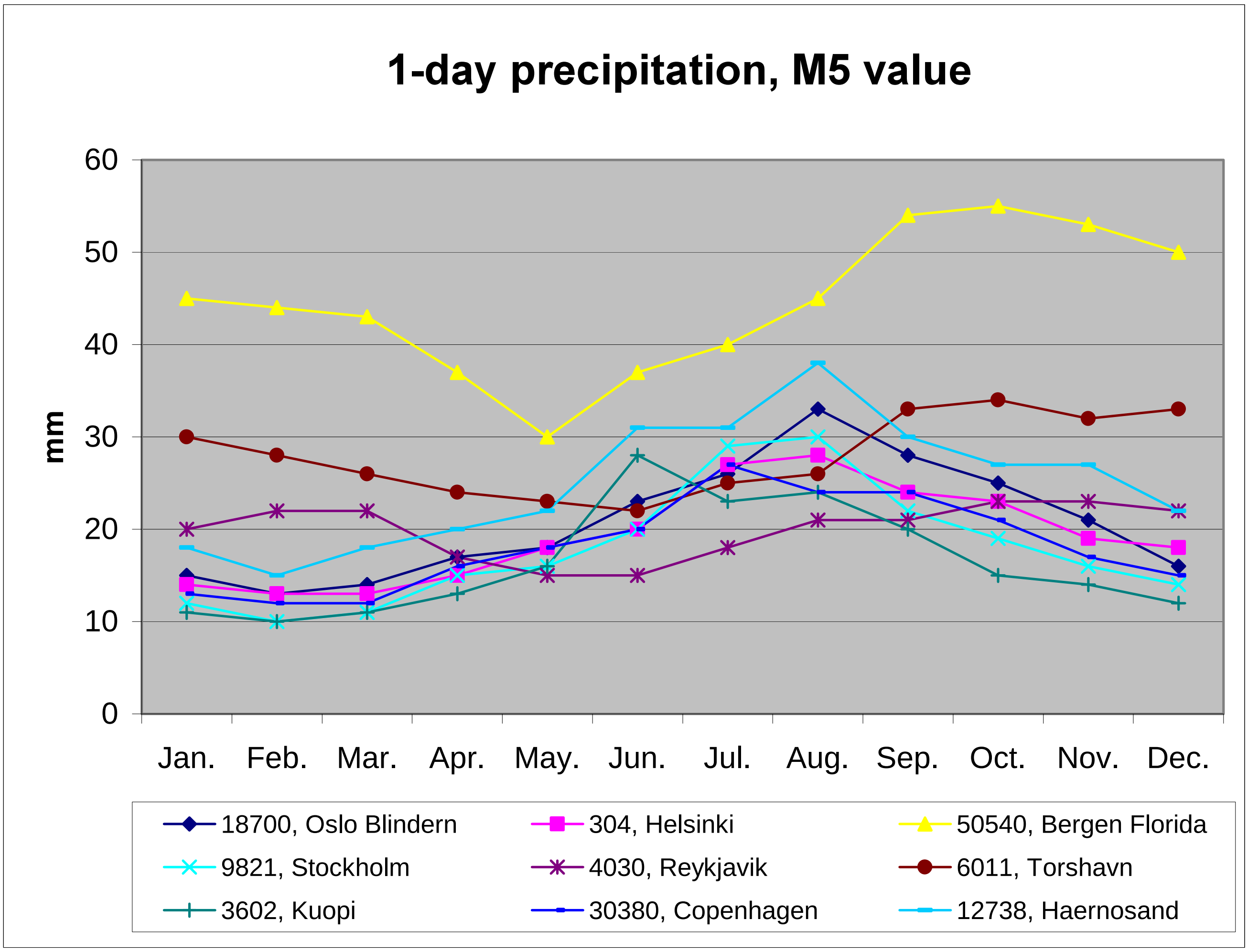


Figure 46. **Monthly distribution of the M5 value for selected stations in the NORDKLIM dataset.**

4 Trends in maximum 1-day precipitation in the NORDKLIM area

The next graphs, Figure 47 - Figure 60, show the daily precipitation maximum (element p602 in the NORDKLIM dataset), annually for some chosen stations in the NORDKLIM region. The graphs include also linear trends. As we can see it is very little or no trend in these series. *Reykjavik, Helsinki, Stockholm, Linköping,* and *Karasjok* give no trend at all. *Copenhagen, Göteborg, Bergen, Værnes (Trondheim)* and *Færder Fyr* have slightly negative trends. *Torshavn, Oslo-Blindern, Kuopio* and *Oksøy Fyr* have slightly positive trends. Of the station selection in NORDKLIM area done here, there are two stations having "largest" trends. *Færder Fyr* south in Oslo fjord has a negative trend and *Oksøy Fyr*, further south on the Norwegian coast, has a positive trend, even though they are almost in the same area with same climate conditions. No more conclusion than that we can have large locally effects of extreme precipitation, can be drawn here.

In "Climate of Europe", Tank, 2002 [10] the conclusion is "The dominant-warming trend between 1946 and 1999 was generally accompanied by a slight increase in wet extremes. However there are large trend differences between nearby stations and only about 20% of the station trends are significant at the 5% level."

Read more about trends in maximum 1-day precipitation in the Nordic region in Førland et al. 1998 [2].

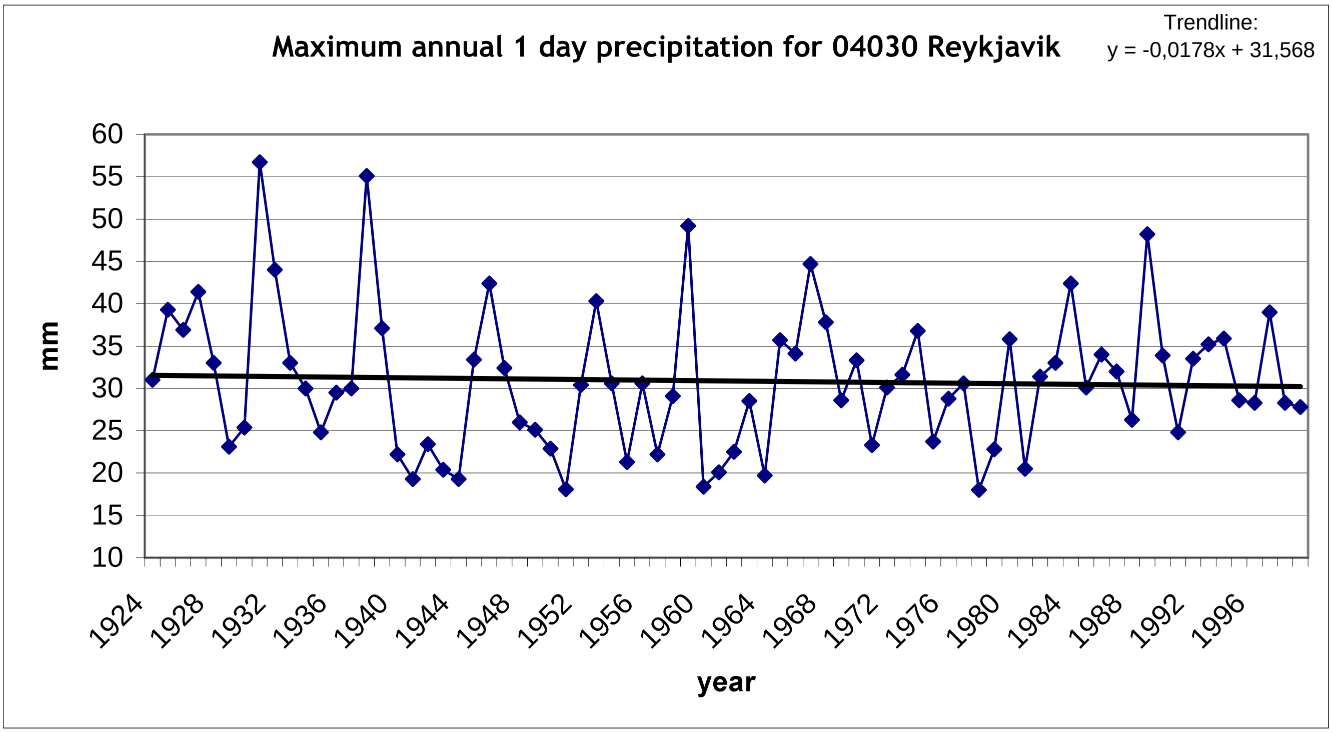


Figure 47. Daily precipitation maximum ***(p602)*** **every year and linear trend for Reykjavik, ICELAND.**
*** Maximum value 57.7 mm in 1931 with 41 years return period.**

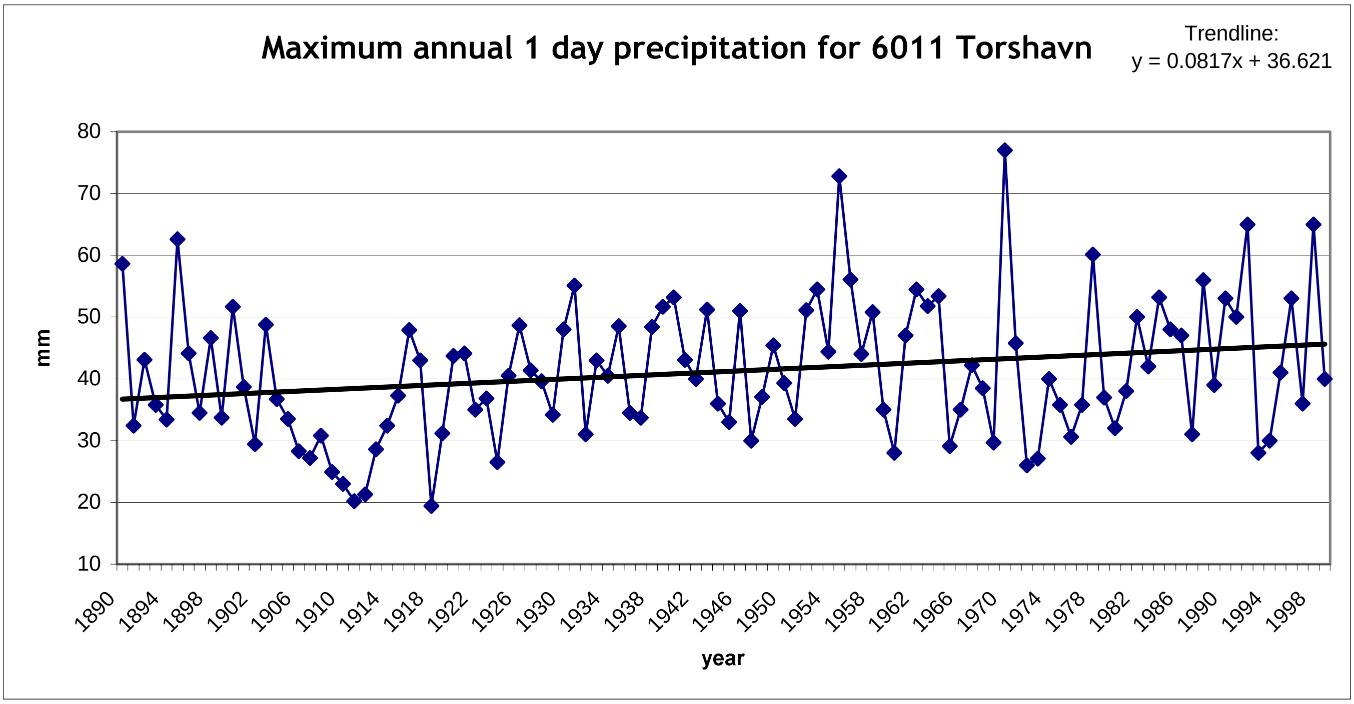


Figure 48. **Daily precipitation maximum** *(p602)* **every year and linear trend for Torshavn, Faeroe Islands**

*** Maximum value 77.0 mm in 1970 with 59 years return period.**

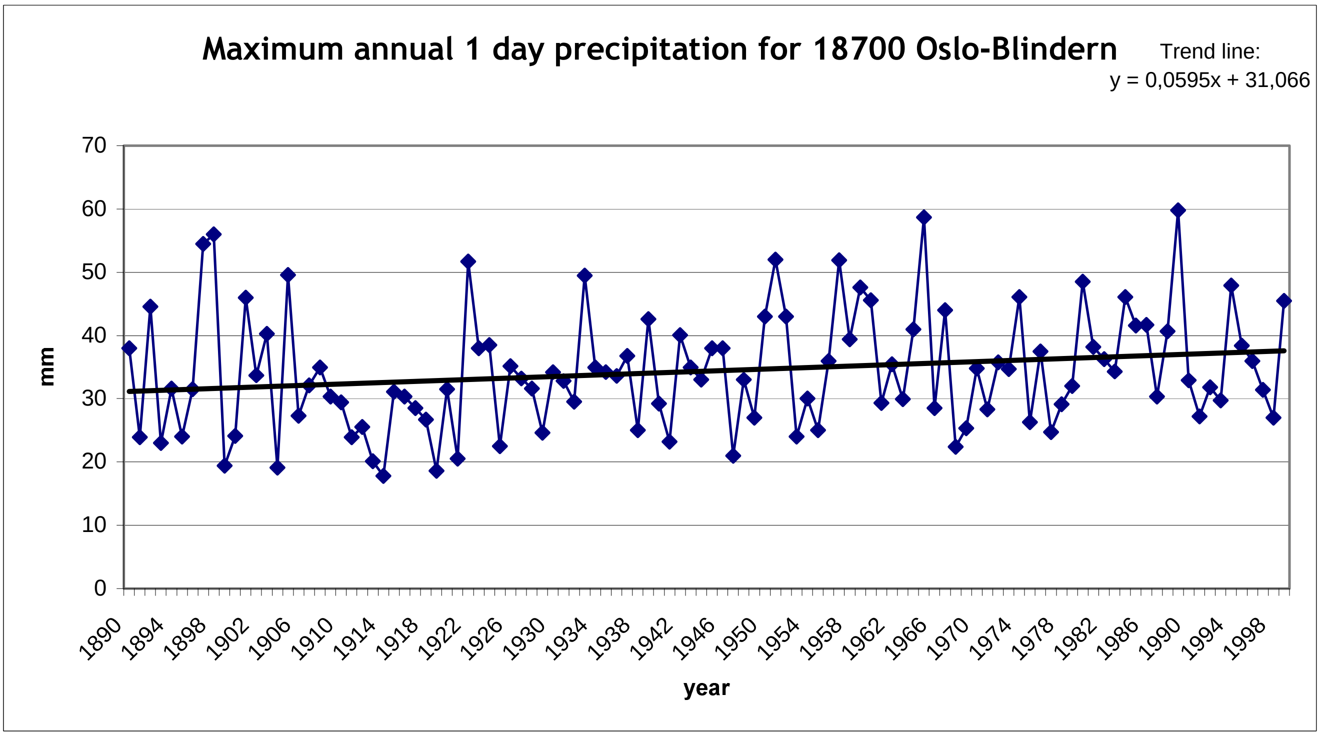


Figure 49. **Daily precipitation maximum** *(p602)* **every year and linear trend for Oslo-Blindern, Norway**

*** Maximum value 59.8 mm in 1989 with 35 years return period.**

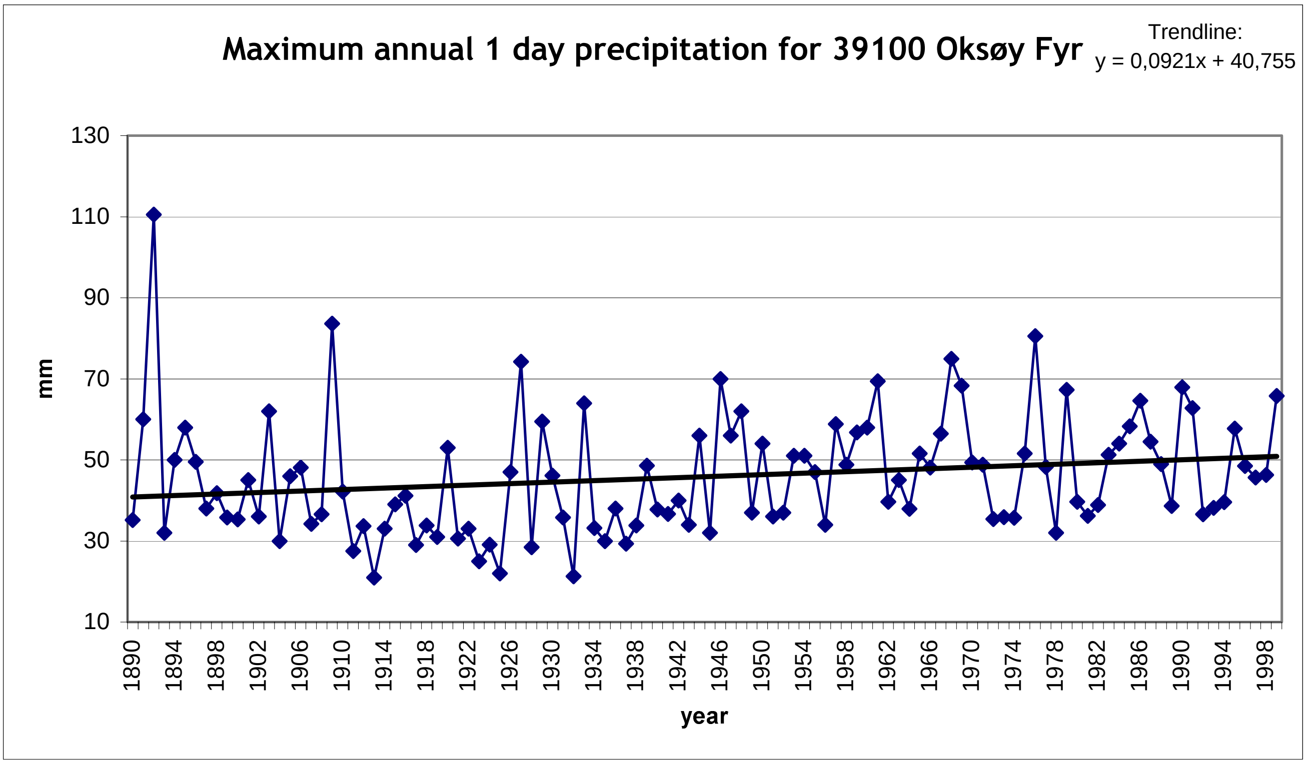


Figure 50. **Daily precipitation maximum** *(p602)* **every year and linear trend for Oksøy Fyr, south of Norway in Skagerak**

*** Maximum value 110.5 mm in 1892 with >200 years return period.**

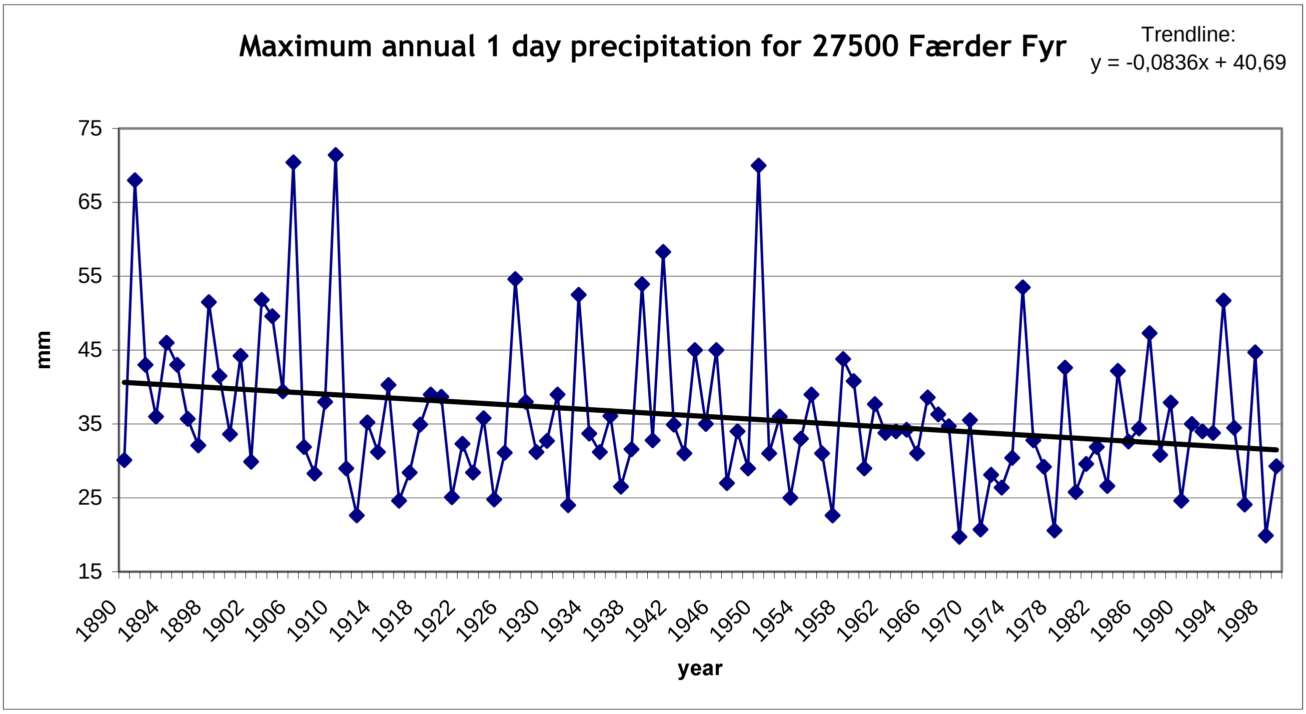


Figure 51. **Daily precipitation maximum** *(p602)* **every year and linear trend for Færder Fyr, Oslo fiord, Norway**

*** Maximum value 71.4 mm in 1910 with 70 years return period.**

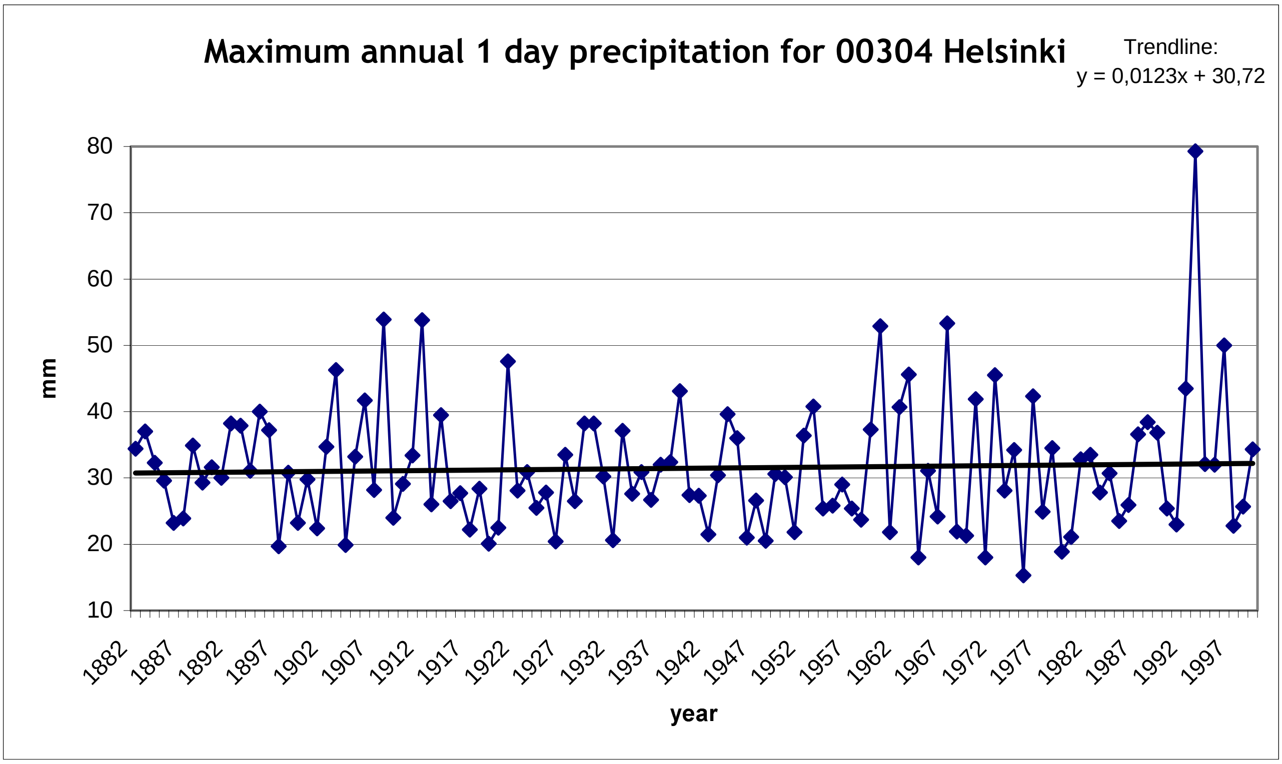


Figure 52. **Daily precipitation maximum *(p602)* every year and linear trend for Helsinki, Finland**
*** Maximum value 79.3 mm in 1993 with >200 years return period.**

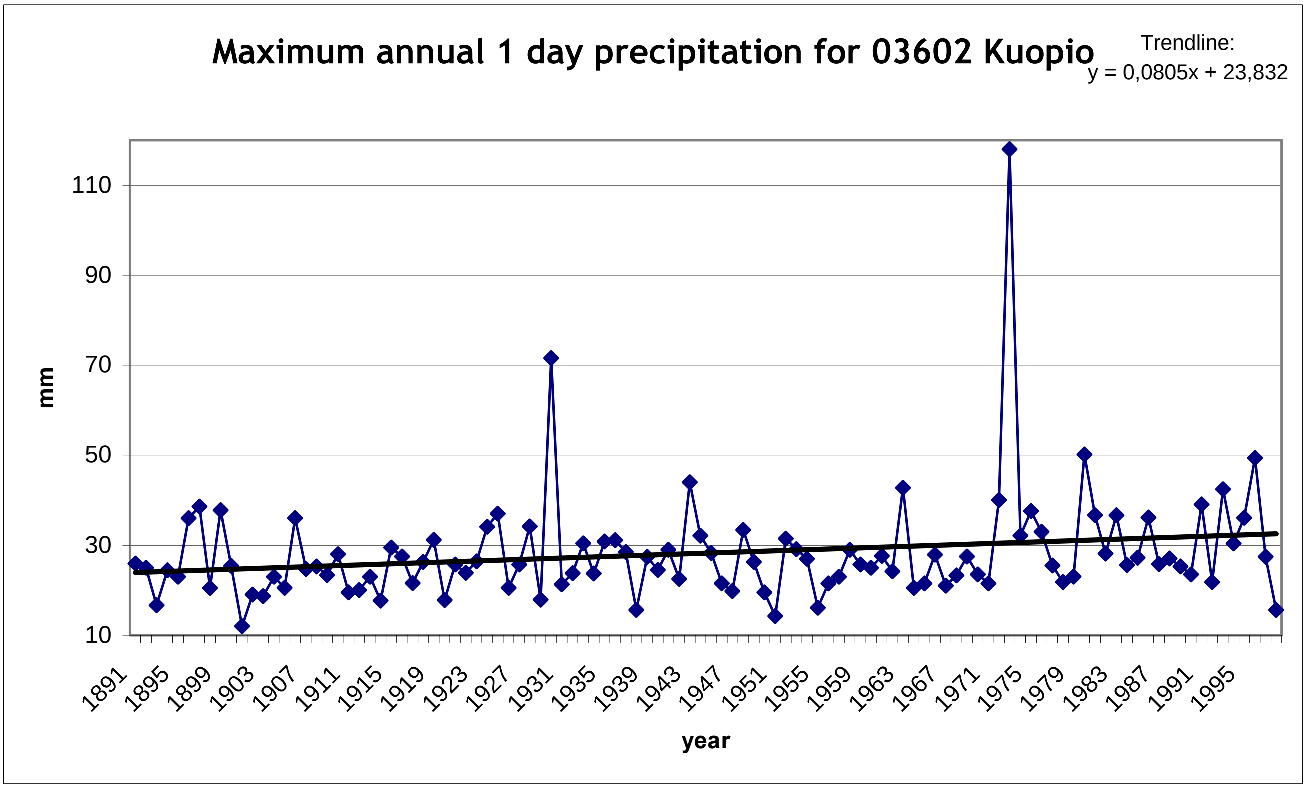


Figure 53. **Daily precipitation maximum *(p602)* every year and linear trend for Kuopio, Finland**
*** Maximum value 118.0 mm in 1973 with >1000 years return period.**

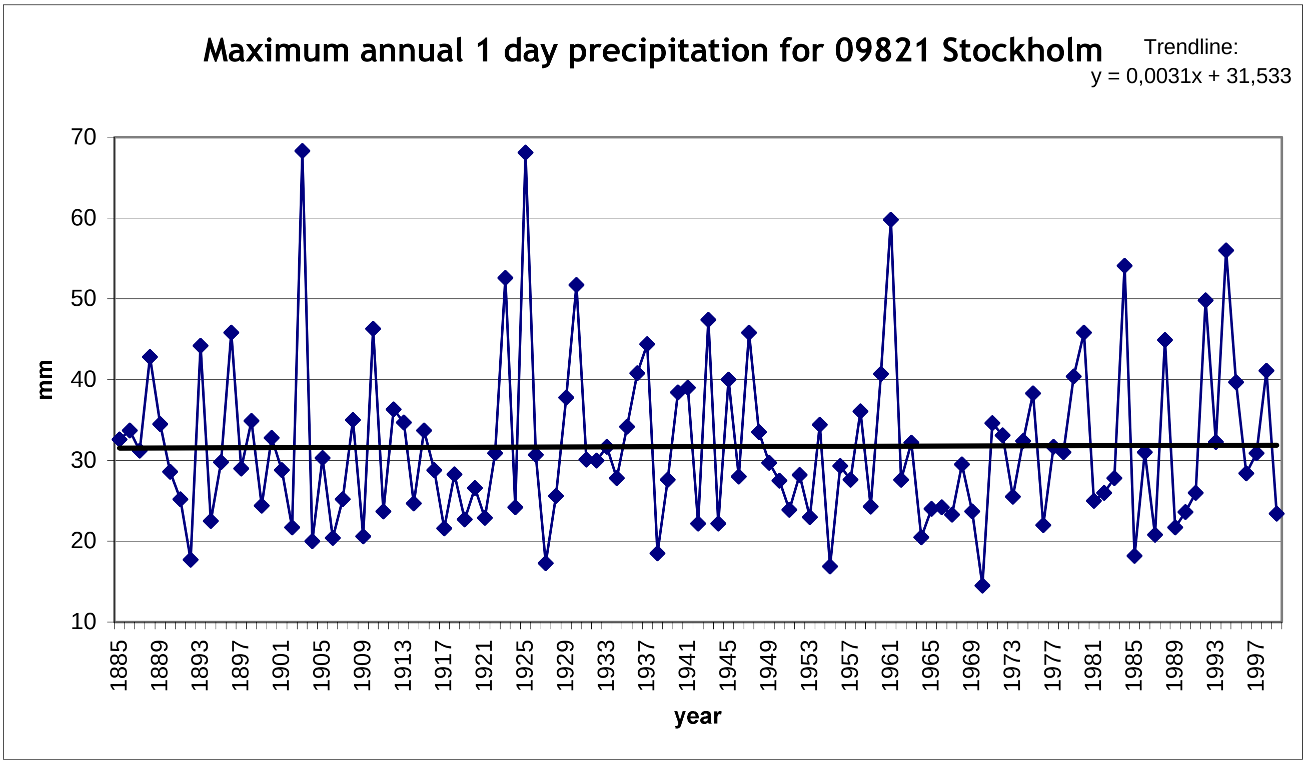


Figure 54. **Daily precipitation maximum** *(p602)* **every year and linear trend for Stockholm, Sweden**
*** Maximum value 68.3 mm in 1989 with 91 years return period.**

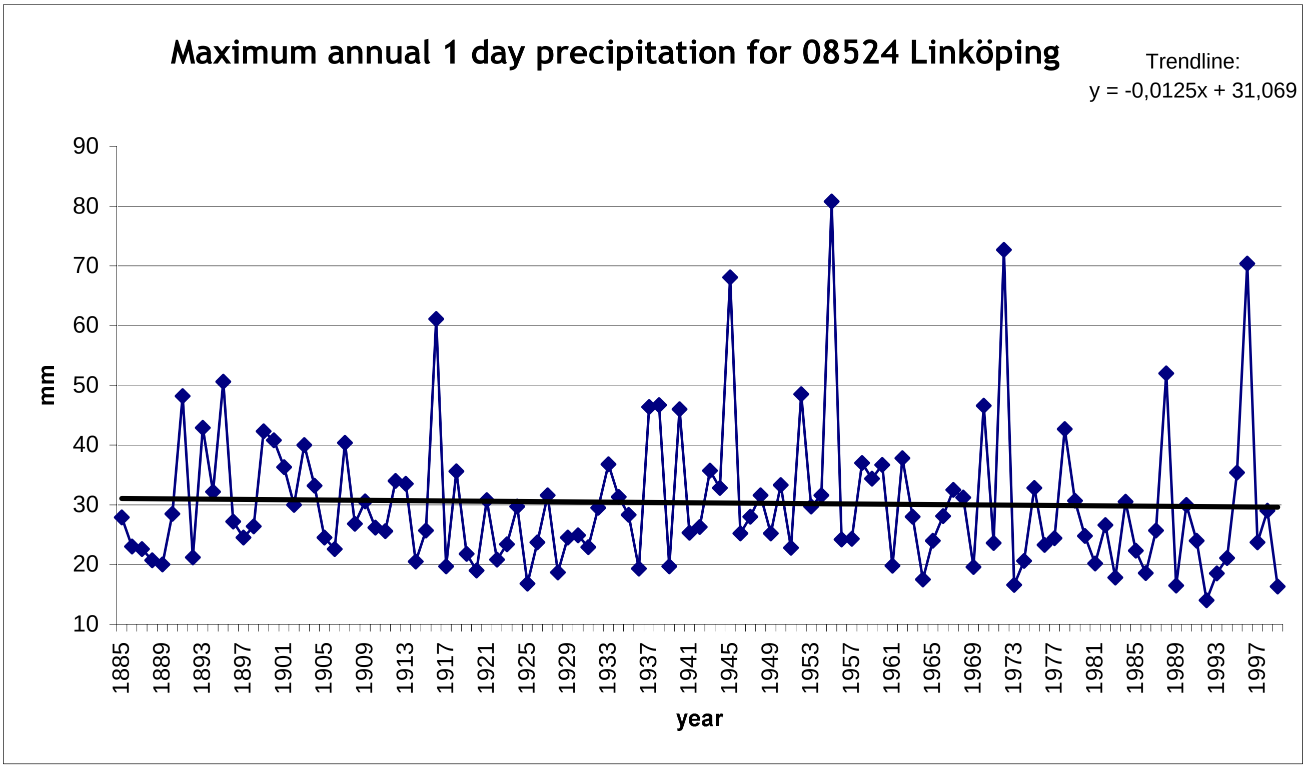


Figure 55. **Daily precipitation maximum** *(p602)* **every year and linear trend for Linköping, Sweden**
*** Maximum value 80.8 mm in 1955 with >200 years return period.**

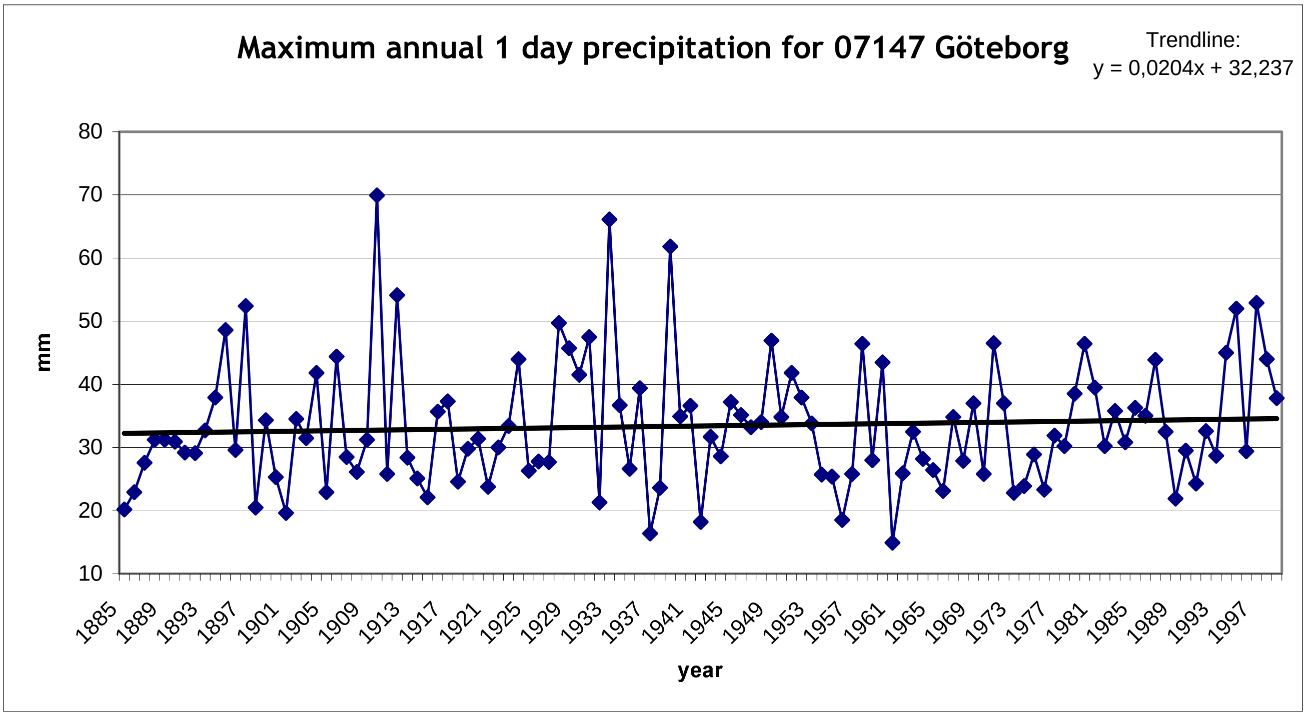


Figure 56. **Daily precipitation maximum** *(p602)* **every year and linear trend for Göteborg, Sweden**
*** Maximum value 69.9 mm in 1910 with 86 years return period.**

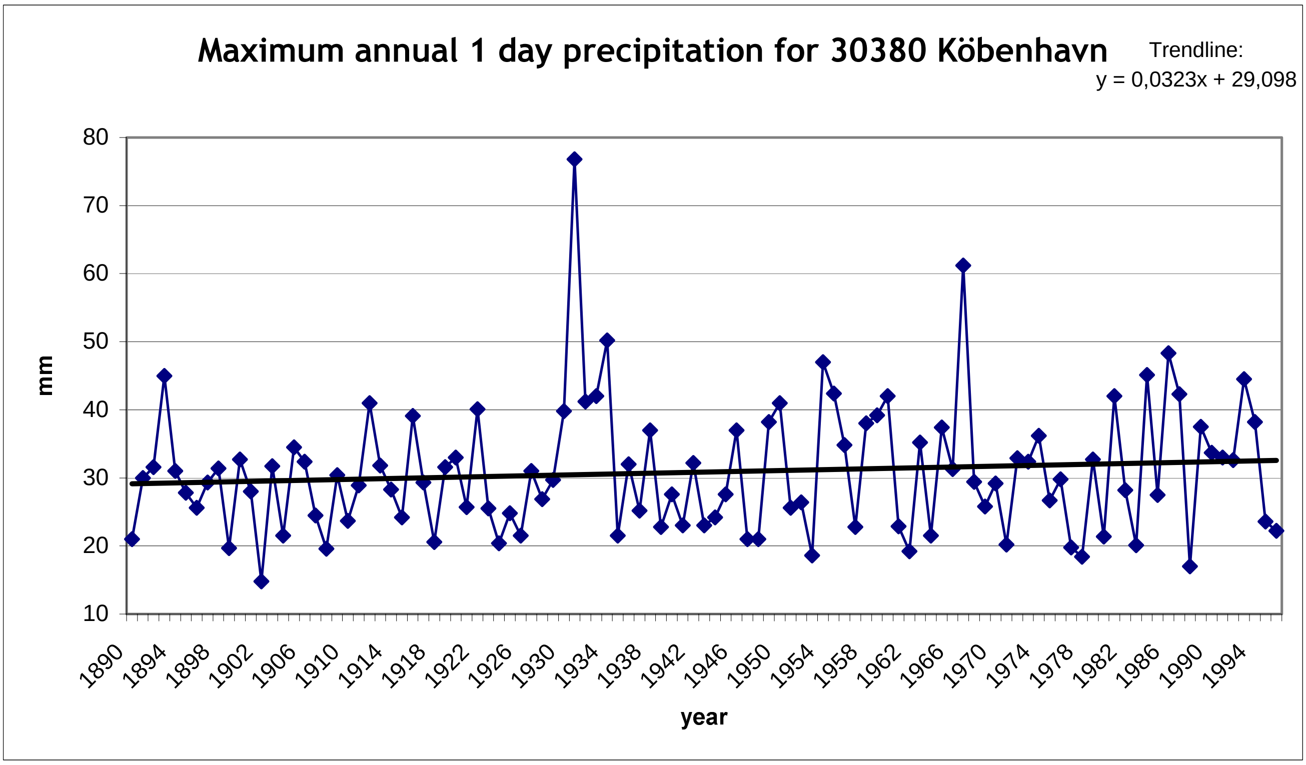


Figure 57. **Daily precipitation maximum** *(p602)* **every year and linear trend for Köbenhavn, Denmark**
*** Maximum value 76.8 mm in 1931 with >200 years return period.**

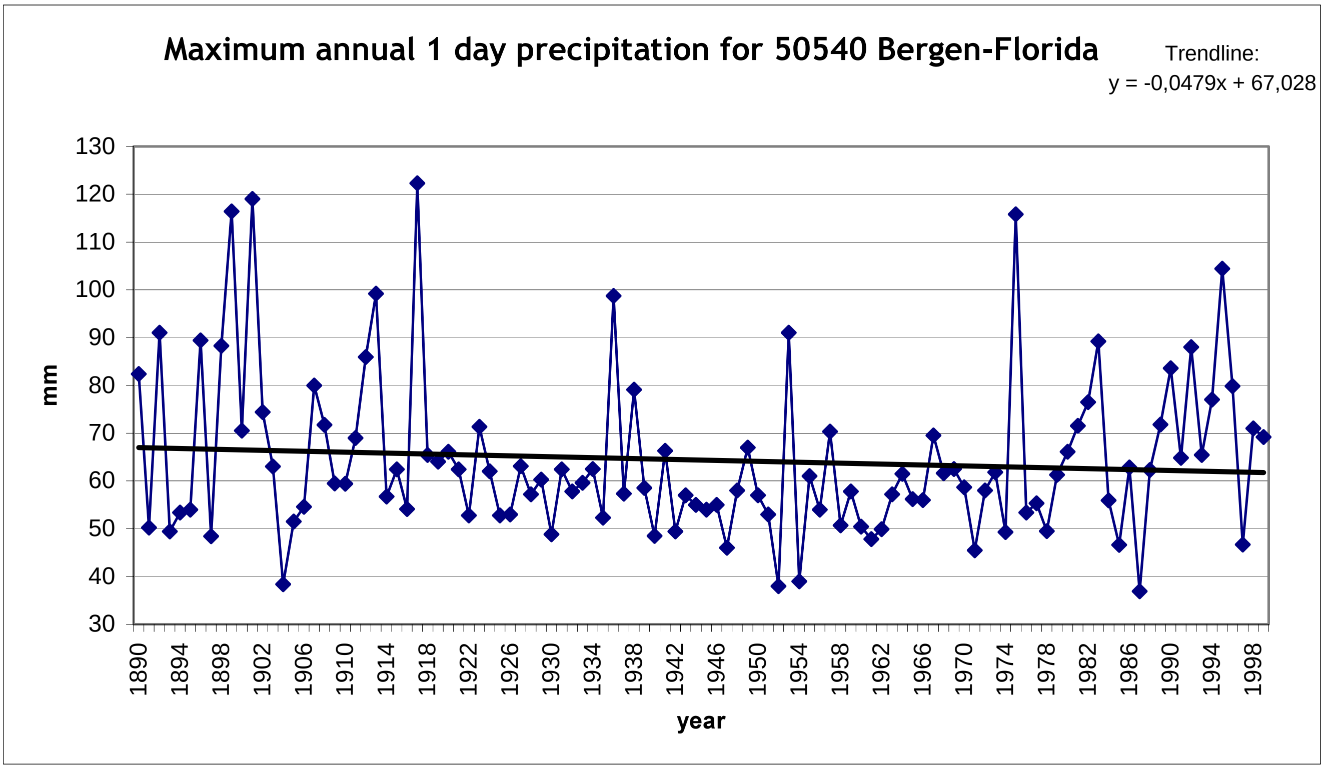


Figure 58. **Daily precipitation maximum** ***(p602)*** **every year and linear trend for Bergen, Norway**
*** Maximum value 122.3 mm in 1917 with 94 years return period.**

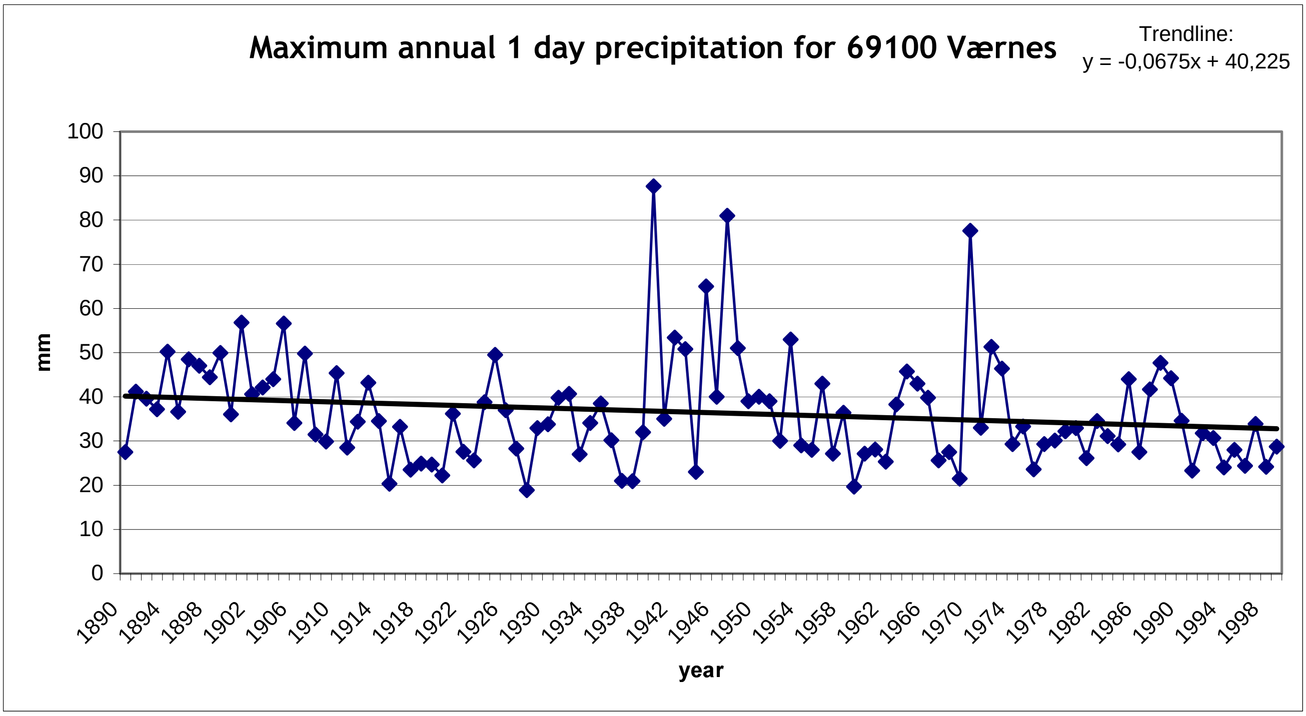


Figure 59. **Daily precipitation maximum** ***(p602)*** **every year and linear trend for Værnes (Trondheim), Norway**
*** Maximum value 87.6 mm in 1940 with ~180 years return period.**

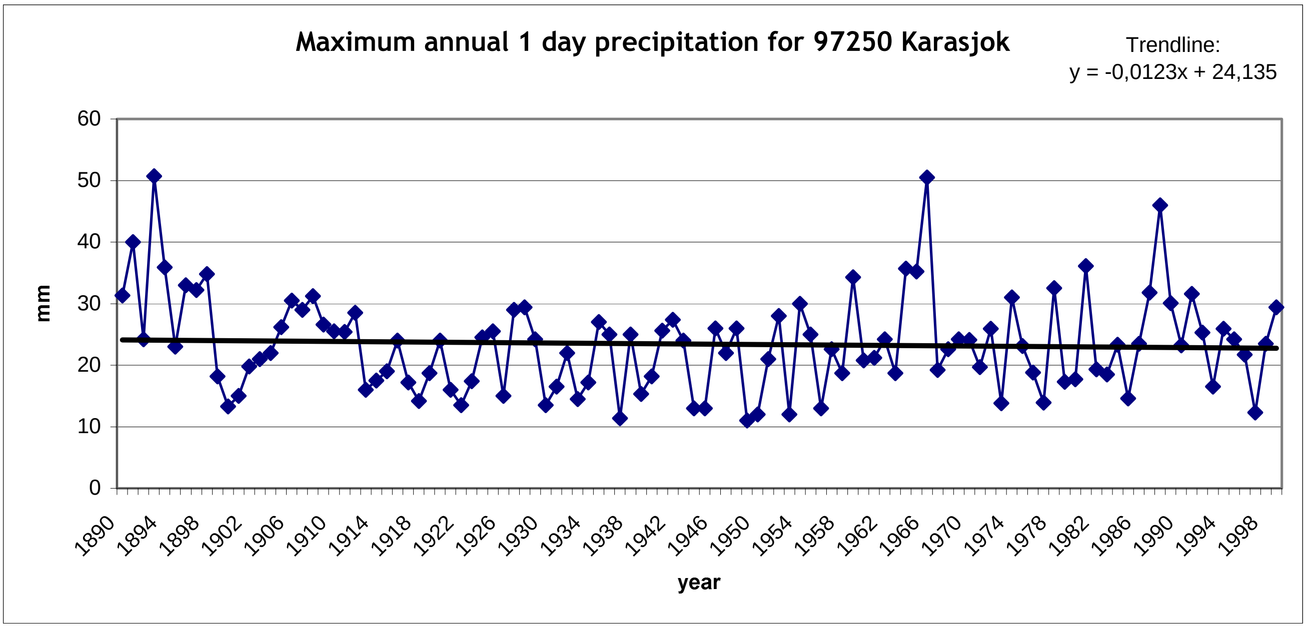


Figure 60. Daily precipitation maximum *(p602)* **every year and linear trend for Karasjok, Norway**
*** Maximum value 50.7 mm in 1893 with 73 years return period.**

The graphs, Figure 47 - Figure 60, show large differences from station to station, in precipitation amount and corresponding return period value. Some of the stations have experienced really heavy 1-day precipitation with above 200 years return period.
The mean value and standard deviation for these extreme series can be found in Table 3.

Absolute maximum value for 1-day precipitation in the NORDKLIM dataset (used in this report) is:

1. 187,3 mm June 1908 in Härnösand, Sweden
2. 171,7 mm January 1964 in Kråkmo, Norway
3. 155,7 mm June 1994 in Teigarhorn, Iceland

A survey of Nordic climatic extremes is given by Tveito et.al 1998[12]. In this report the highest observed 24 hours precipitation was:

Country	**Location**	**Value (mm)**	**Date**
Iceland	Kvísker	242,7	01.10.1979
Norway	Indre Matre	229,6	26.11.1940
Finland	Espo, Lahnus	198,4	21.07.1944
Sweden	Fagerheden	198	28.07.1997
Denmark	Marstal	168,9	09.07.1931

Contact the National Meteorological Institutes for further information about extremes in the Nordic countries.

5 Summary and conclusions

The examples of the extreme precipitation and return periods for Norway and the Nordic countries show that GIS tools are really useful in the climate analysis. When an extreme precipitation episode occur we can easily realize the spatial distribution of precipitation amount and the return period for the episode. The example from the extreme precipitation episode in south east of Norway, autumn 2000, showed that there is not necessary a connection between the spatial distribution of extreme precipitation amounts and the return periods for that episode.

Maps showing probable precipitation amount in a given season during N days for X years in return period are also presented. Assumption is then a dense station network with long time series for daily precipitation.

For Norway maximum 1-day precipitation episode was most common in autumn, mainly along the coast from south to northwest. In southeast and northeast, maximum M5 was found during summer with typical inland climate and convective rainfall. Some stations, mostly on the west coast, from south to north, some kilometres inland from the coast where orographic enhancement is strongest, has maximum 1-day precipitation episode in winter.

Minimum 1-day precipitation is found in winter, typical where maximum was in summer, and found in summer where maximum was in winter, and spring where maximum was in autumn. Some differences in the seasonal distribution of maximum and minimum M5 value for N-days were found, more seldom with long-duration extreme episodes in summer and more often in winter.

As expected we can see little difference in the spatial distribution pattern of extreme precipitation in Norway and the NORDKLIM area during 1 to 30 days. Seasonal differences exist. In the inland the convective precipitation in summer time dominates for 1-day extreme precipitation episodes. In autumn the NORDKLIM area are dominated by frontal activity. At the west coast the extreme episodes occur during autumn time. Winter is a relatively dry season in the Nordic countries, and extreme episodes are very rare, only common in the west coast of Norway. Minimum M5 value was found during springtime in Iceland, and along the west coast of Norway, in late spring. In early spring also inland stations had minimum M5 value in spring. No stations had the most extreme episode during spring.

Trend analysis for selected series of annual 1-day precipitation maximums in the NORDKLIM area gave us no trend. Only small linear trends in the graphs of the maximums for different stations in the area were found. The examples showed that some of the stations had experienced 1-day extreme precipitation with above 200 years return period during the observation period.

6 References

[1] I. Hanssen-Bauer, O.E. Tveito, E.J. Førland: ”Precipitation Scenarios for Norway: Empirical Downscaling from the ECHAM4/OPYC3 GSDIO integration” 2001, DNMI Report No. 10/01

[2] Eirik J. Førland, Hans Alexanderson, Achim Drebs, Inger Hanssen-Bauer, Haldo Vedin and Ole Einar Tveito: “Trends in maximum 1-day precipitation in the Nordic region”1998, DNMI Report No. 14/98

[3] H.Dobesch, O.E Tveito, P. Bessemoulin ”Geographic Information Systems in Climatological Application” 2001, DNMI Report No. 13/01

[4] Ole Einar Tveito, Eirik J. Førland ”Regionalisering av klimastatistikk” 1996 DNMI Report No. 13/96

[5] H. Tuomenvirta, A. Drebs,E. Førland,O.E. Tveito,H. Alexandersson, E. Vaarby Laursen and T. Jónsson ”Nordklim dataset 1.0 - description and illustrations” 2001, DNMI Report No. 08/01

[6] NVE, Hydrologisk månedsoversikt Mars 2002, Turid –Anne Drageset “Flommen på Sør- og Østlandet høsten 2000”

[7] Eirik J. Førland “Manual for beregning av påregnelige ekstreme nedbørverdier”, DNMI Report No. 21/92

[8] H.Alexandersson, E.J. Førland, J. Helminen, N. Sjöblom and O.E. Tveito “Extreme value analysis in the Nordic countries” NORDKLIM, DNMI Report No. 03/01

[9] E.J. Førland et.al “Changes in ‘Normal’ Precipitation in the North Atlantic region” NACD, DNMI Report No. 07/96

[10] Albert Klein Tank, Janet Wijngaard and Aryan van Engelen “Climate of Europe. Assessment of observed daily temperature and precipitation extremes.” European Climate Assessment (ECA), 2002

[11] O.E.Tveito ”An objective comparison of observed and forecasted 24-hour precipitation, a spatial analysis,” 2002 met.no REPORT Klima, in. prep

[12] O.E.Tveito, R.Heino, H. Vedin “Nordic Atlas of Climatic Extremes” 1998, DNMI Report No. 15/98

[13] Rasmus Benestad, Arne Melsom “Is there a link between the unusually wet autumns in the southeastern Norway and SST anomalies?” 2001 Submitted to Climate Research 06.06.2002