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Normal Maps of Accumulated Winter Precipitation For Southwestern Norway

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REPORT NO. 3/97 KLIMA

DNMI-REPORT

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ISBN 0805-9918

REPORT NO.
3/97 KLIMA

DATE
07.01.97

TITLE

Normal Maps of Accumulated Winter Precipitation For Southwestern Norway

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PROJECT CONTRACTOR

Statnett SF (Norwegian Power Grid Company)
DNMI (Norwegian Meteorological Institute)

Contract no. TE96/10186

SUMMARY

Three methods for establishing normal maps of accumulated winter precipitation (November - March) are tested and compared. One of the approaches was to apply an objective spatial interpolation method, kriging, on the winter precipitation. The other two methods utilizes the digitized maps of normal monthly precipitation 1961-90.

None of the three methods are ideal. The method based on the station normals underestimates the orographic effect, and is not reliable in areas with sparse station coverage.

The methods based on the normal monthly precipitation maps also have disadvantages. One approach establishing a linear terrain model between the contour lines in the normal maps gives an overestimated precipitation. The other method, merging the monthly maps together, results in a very generalized map. The latter is though the most credible map.

All three methods was carried out within a geographical information system (GIS).

SIGNATURES

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Contents.

1. Introduction

This short study was initiated by the Norwegian Power Grid Company; Statnett SF, who wished information on normal winter precipitation for southwestern Norway. Winter precipitation is defined as precipitation in the period November to March.

In this study a geographical information system (GIS) is used as a modelling tool to establish such maps. Three alternative methods are tested and compared. For readers not familiar with GIS-expressions and the ArcInfo world, a short explanation of the expressions used in this report is given. Then the three approaches used is presented and discussed.

2. Short introduction to Geographical Information Systems (GIS).

This chapter is meant to give an understanding of the expressions used in this report related to the use of ArcInfo GIS, and how spatial data are managed in such a system. GIS-expressions are typed in italics in this chapter.

Geographical information system is a system for retrieving, editing, storing, analysing and presenting geographically distributed data. GIS has also capabilities for spatial analysis and manipulation of the data.

The spatial data is stored as *coverages.* A coverage is a directory containing a number of files representing the features of geographical data set. Physical data can be represented as *points, lines (arcs)* or areas (*polygons*). When the spatial relations are created, *topology* is present. This way of representing the data is called vector-data.

Terrain models can be represented in two ways in ArcInfo, *TIN* and *GRID*. TIN is an abbreviation for Triangular Irregular Network, and the terrain model is built of triangular elements between *nodes* in a line or points. The gradient of the triangular surface determines the spatial variation, the level of the surface value. *Nodes* are the breaks on an arc.

GRID is a raster-GIS, and the data is allocated to regularly spaced cells. These cells contain a z-value, or *NODATA*. Different GRIDs can be overlaid using mathematical expressions creating new GRIDs.

TIN and *GRID* are modules in ArcInfo. Other modules are *ArcEdit*, the editing module, and *ArcPlot* that is used to display the data.

3. Data.

The Norwegian Meteorological Institute (DNMI) has two data sources for this analysis ,the station normals (Førland, 1993a) and the monthly precipitation maps (Førland, 1993b). Both data sets can easily be applied for such analysis, but the way they have to be considered introduces different uncertainties in the derived maps.

4. Methods.

4.1 Method I - station normals.

To establish maps using the station normals involves an interpolation routine to distribute normal precipitation into the areas between the points with defined normals. Such methods are included as options in most GIS-software. In this study ArcInfo is used, and the interpolation method applied is kriging.

The accumulated winter normal is calculated at the station as the sum of the months November to March. After that a standard point kriging was performed to establish rastermaps of the accumulated winter normal precipitation. The rastersize in the map is defined as 1 km in each direction. Figure 1 shows a map of the stations used in this calculation. The resulting map is shown in figure 2.

One disadvantage using this approach is the unbiased station network. There are few stations located at altitude levels above 1000 m.a.s.l. available. Since methods including the altitude in statistical interpolation not are implemented yet, altitude is not considered in the interpolation. Precipitation in high altitude areas will therefore be underestimated. The resulting map will though include all the inter-station variability.

4.2 Method II - precipitation maps.

Førland (1993b) has derived maps for normal monthly precipitation 1961-90. All these maps are digitized as thematic maps in ArcInfo coverages with polygon topology at the Norwegian Mapping Authority (Statens Kartverk). The principle of method II is to add the maps of November to March together into one map. The advantage using these maps as data is that the topography is encountered in the procedure producing the maps. One disadvantage is that the maps are generalized.

When data are represented as polygons, is the value constant in each polygon. In the maps of monthly normal precipitation, the value is defined as FTEMA, representing an interval of precipitation, e.g., 100 - 150 mm/month. If these maps are presented as three-dimensional surfaces, they will look like terraces, as shown in figure 3. There are two possible ways to go further.

One is to keep the constant value of the polygons, as the median value of the polygon, e.g., 125 mm/month in the 100-150 mm/month polygon, and then add all these polygons together to create a winter season map. This is the easiest procedure, and is carried out in this study mostly as a control against the other two methods. We call this approach method II_a. The polygon coverage is transformed into a grid using the *POLYGRID* command in ArcInfo, and precipitation values are defined according to the classvalue FTEMA. Then the grids of the months November to March are merged together into a winter season grid. This grid is shown in figure 4.

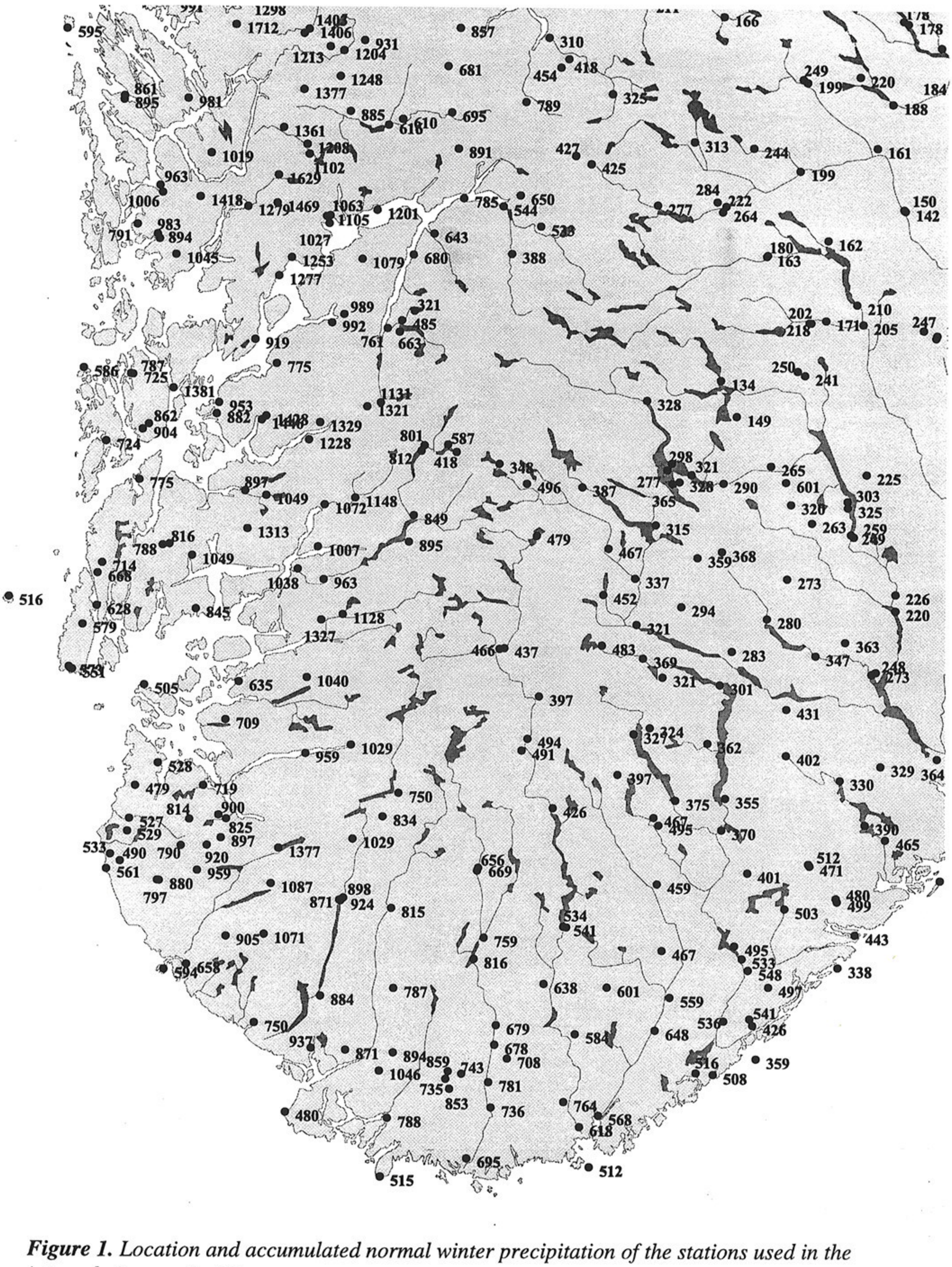


Figure 1. Location and accumulated normal winter precipitation of the stations used in the interpolation, method I.

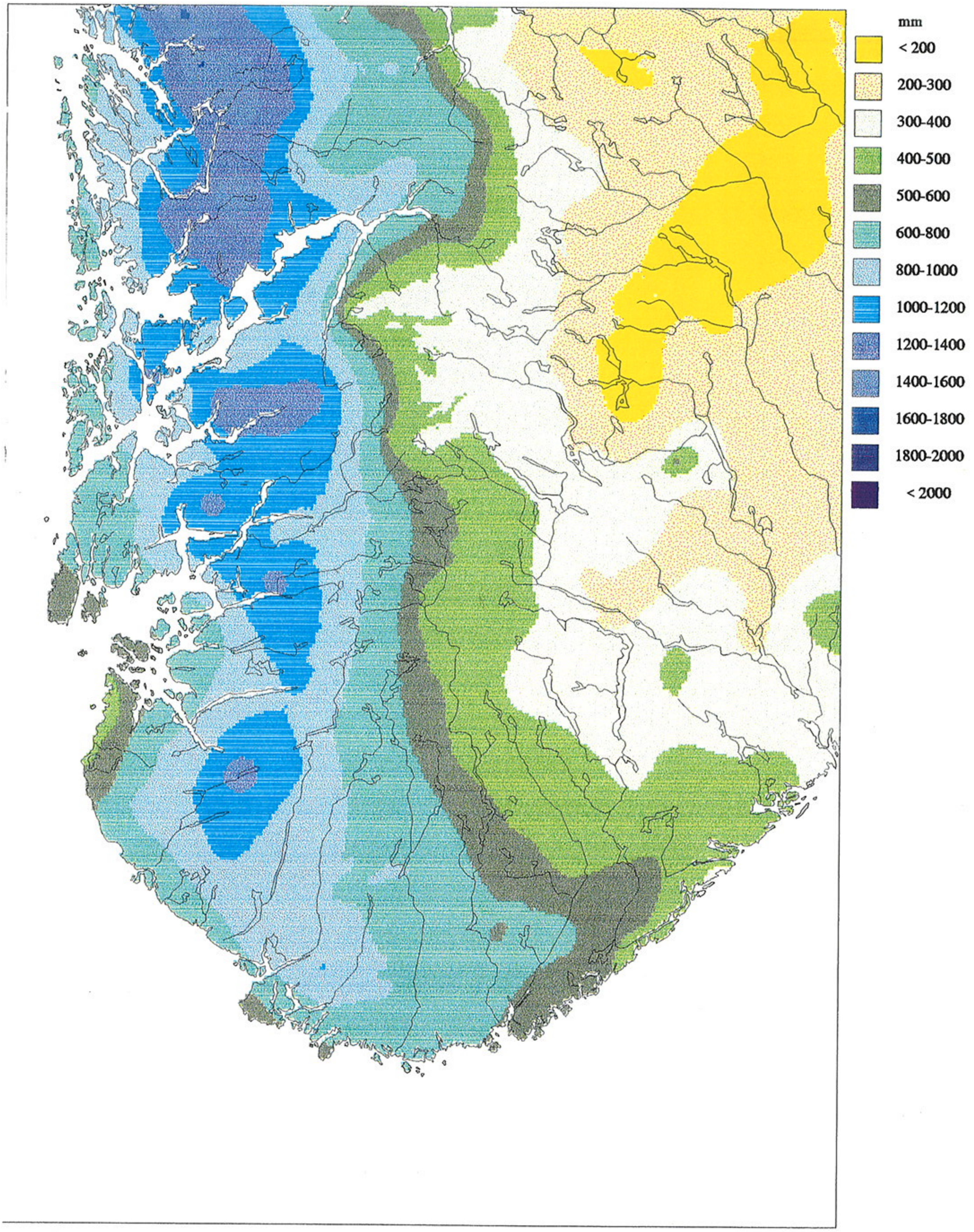


Figure 2. *Map of accumulated normal winter precipitation by method I.*

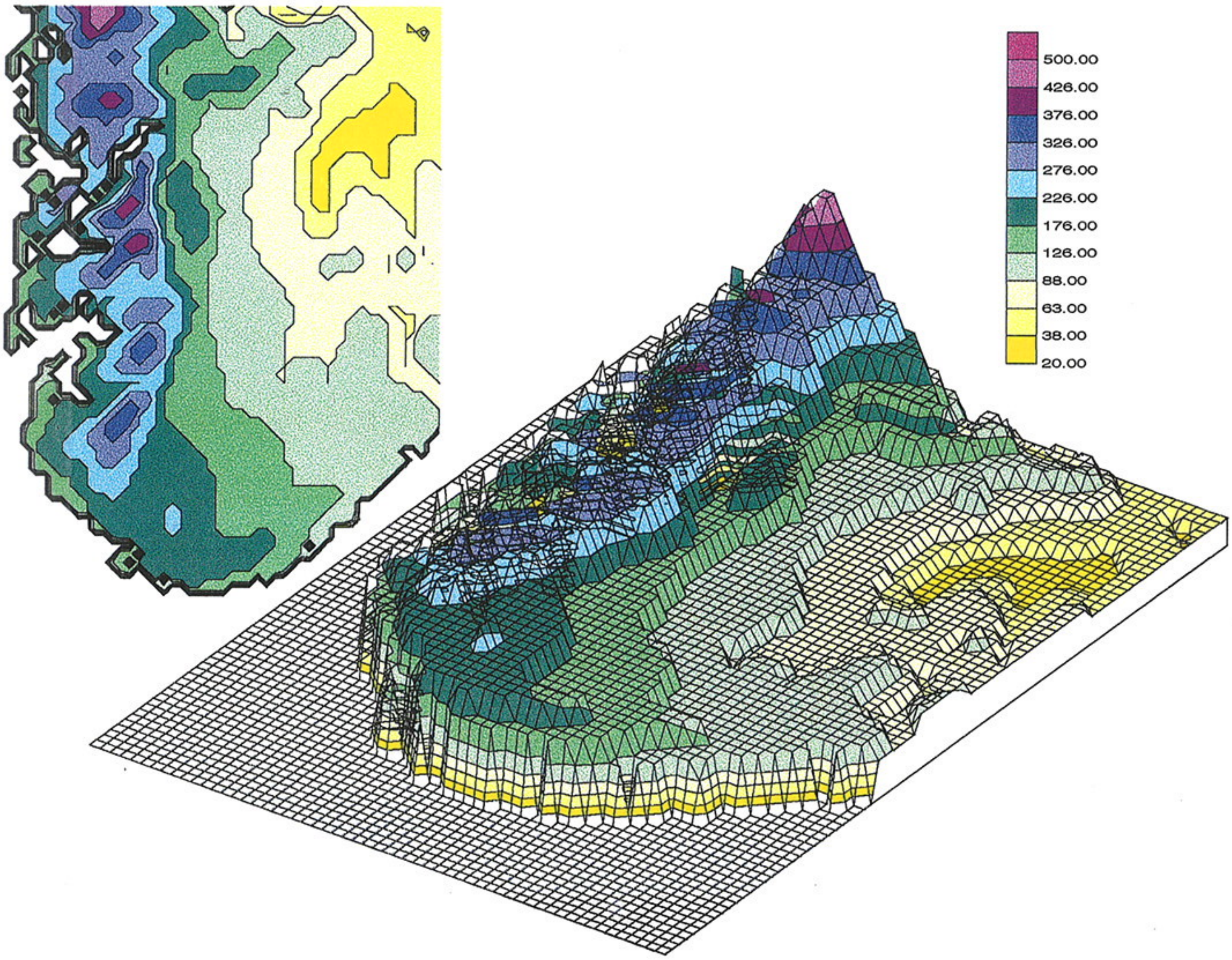


Figure 3. *Terrace effect in a polygon representation of precipitation. This map is the normal monthly precipitation for November (1961-90). For presentation purposes, the map is generalized and gridded with cellsize 5×5 km. The figure shows both the contour map and the terraces in a 3D-view.*

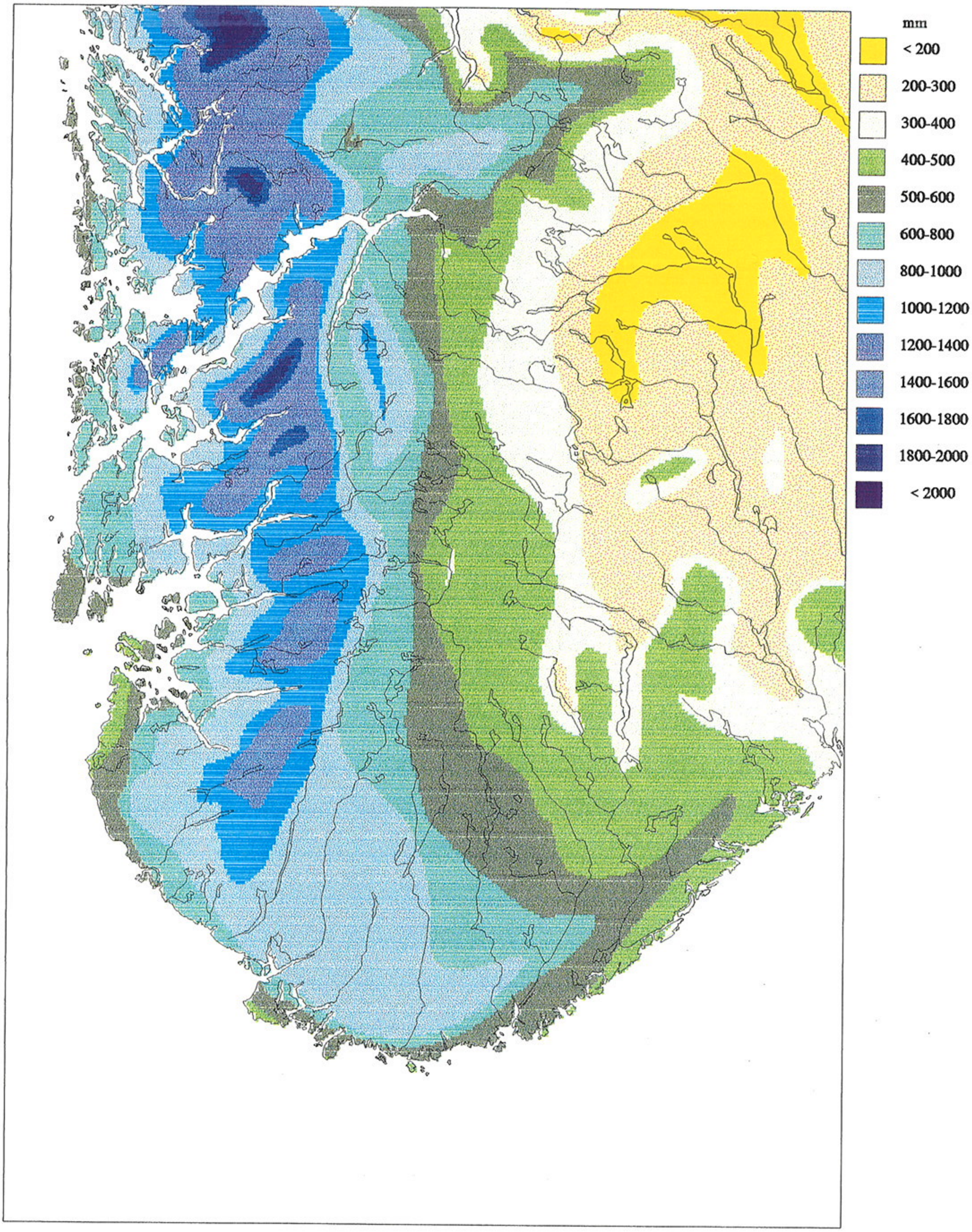
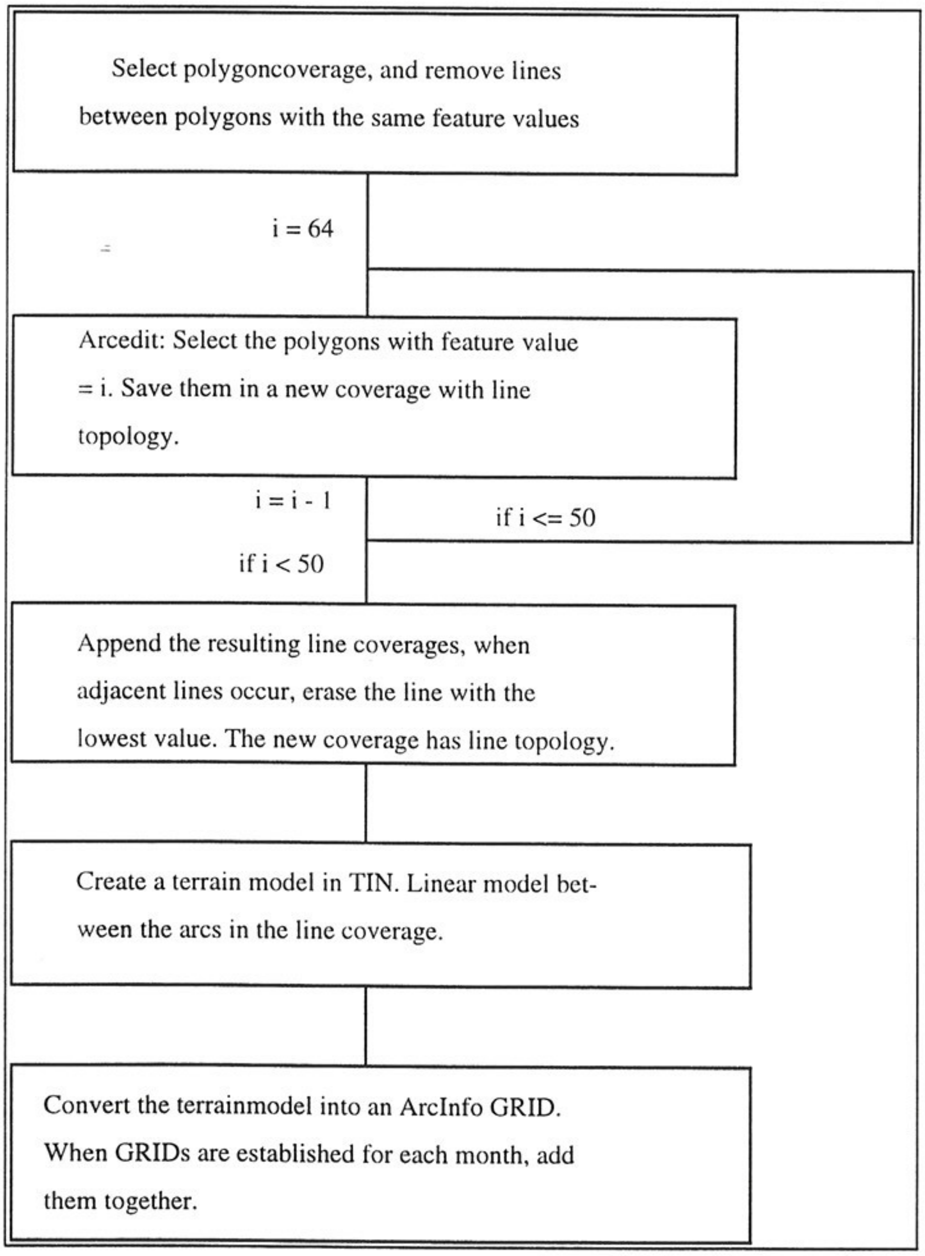


***Figure 4.** Map of accumulated normal winter precipitation established by method II_a.*

The nature does however not behave like terraces, the variations are more random. The digitized versions of the maps are produced for presentation, and the way the precipitation is represented in the coverage is not direct applicable for analysis. Therefore a routine to transform the data from ArcInfo polygon coverage to ArcInfo GRID format is developed. This is called method II_b. The standard ArcInfo command *POLYGRID* cannot be used, due to the terrace effect (fig. 3). The principle of the procedure is that there is a linear variation between the lines defining the borders of the polygons. In its original form, the maps were established as a contour line map, and now these have to be reestablished. The procedure can be described as follows:



The resulting map is presented in figure 5.

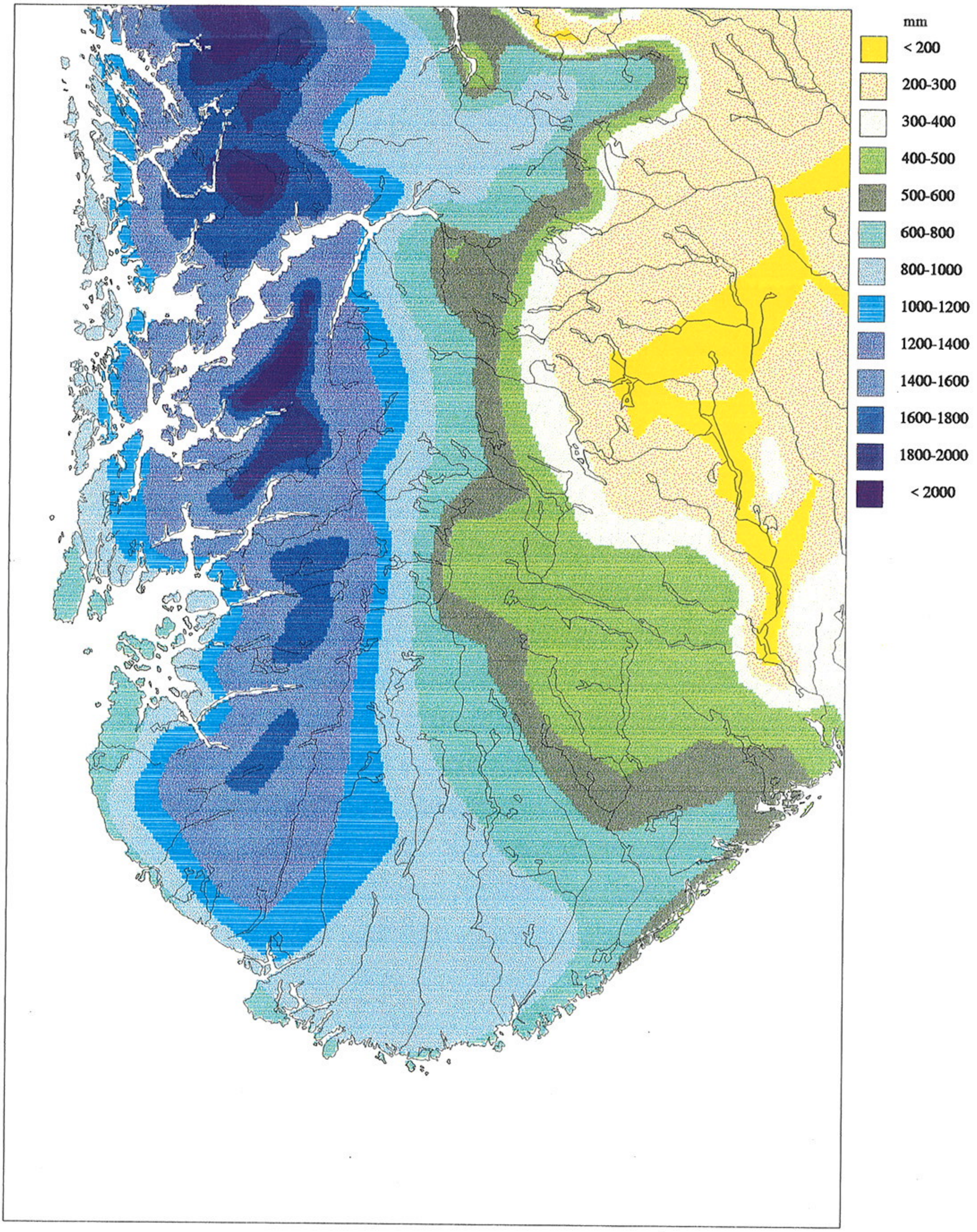


Figure 5. *Map of accumulated normal winter precipitation established by method II_b.*

One disadvantage using this approach is that each line represents two values, the borders of two polygons with different values. In this algorithm the highest value is kept, since this represents the real value on the line. The lines are assigned the lowest value of the interval. There will however be problems in areas with local minima. These will act as islands in a surrounding polygon, and will by this approach be erased.

5. Evaluation of the maps.

All three methods used here have disadvantages. They do also act different due to their purpose.

The map established by method I is the most correct with respect to spatial variability. The major objection against this method is the lack of consideration of topography. This results in a map with underestimated precipitation. Figure 2, showing the map established by method I confirmes this. It is also seen that this map contains more detailed information than the other maps. In areas with small orographic effects and good station coverage is this map credible.

The map of method II_a is the most hazardous method from a scientific perspective. It is probably quite acceptable for presentation purposes. The map (fig. 4) coincides quite well with the kriged map (fig. 2) along the coast line. This gives confidence to the map. In the mountainous region it gives higher values than the kriged map, which is expected.

Method II_b results in a map giving the general highest precipitation values. The values are probably overestimated due to the problems of "two value" lines and elimination of local minima islands.

6. Conclusions.

Method I is the most powerful and promising method. The method will be further developed to take topography and other parameters (e.g., distance to coast) explaining the spatial variability of climatological elements into account. One serious problem with the existing result is underestimation of orographic precipitation. The method is vulnerable to not representative input data.

Method II_a is probably the most credible map, despite its rugged definition of precipitation level. It takes care of all the variations in the original maps of monthly precipitation.

The map of method II_b should ideally give the best result. Due to the problems of "two value"-lines and local minima islands, the overestimation is probably considerable.

As a conclusion, the map of method II_a (fig. 4) is the most credible. Method I will be further developed, and an elaborated version of this method will be applied in the future.

7. References

Førland, E.J. (1993a) Nedbørnormaler normalperiode 1961-90, *DNMI Klima rapport 39/93 (in Norwegian).*

Førland, E.J. (1993b) Månedsnedbør 1:7mill, Nasjonalatlas for Norge, kartblad 3.1.2, *Statens kartverk 1993 (in Norwegian).*

Appendix.

Order form

Statnett

BESTILLING

Vår ref. (Bestillingsnummer)	Dato	Side
TE96/10186	04.11.96	1

Det norske meteorologiske institutt
Postboks 43 Blindern
0313 OSLO

Vår saksbehandler / adm.enhet / tlf.nr.
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Deres ref.
Eirik Førland

NB: Alle dokumenter og forsendelser merkes med bestillingsnummer. Faktura sendes i duplo.

Vi bestiller herved:

Antall	Spesifikasjon	Nettobeløp
	KARTFREMSTILLING AV NEDBØRDATA FOR SETESDALEN OG SØRVESTLANDET	

METEOROLOGISK INST.
Saksnr. 2559 Dok nr. 2
Saksb. KL Arkiv 004.4
Innk. 5/11-96 Eksp.

Vi viser til Deres tilbud av 1996.10.31 og bestiller kartfremstilling av nedbørdata for vintersesongen (november - mars), justert for hovedtrekk i topografien.

Statnetts andel av utviklingskostnader:
Maksimalt 20 timer a kr 420,-, eller ca. kr 8 000,-.

Samlet netto kjøpesum
NOK 8000,00
(ekskl. mva.)

Leveringstidspunkt	:	Desember 1996
Vareadresse	:	Statnett SF, v/Svein Fikke, Boks 5192 Maj., 0302 Oslo
Varemerking	:	
Leveringsvilkår	:	- Incoterms 1990
Betalingsvilkår	:	Pr. 30 dager etter at levering og faktura med avtalte bilag er mottatt.
Øvrige vilkår	:	AIS-89 (Alminnelige innkjøpsvilkår for statlige kjøp av handelsvarer)

Kontonr. : TK5139K1	Underskrift Statnett SF	Parafent
	Bjørn Dag Evensen	Svein M. Fikke

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