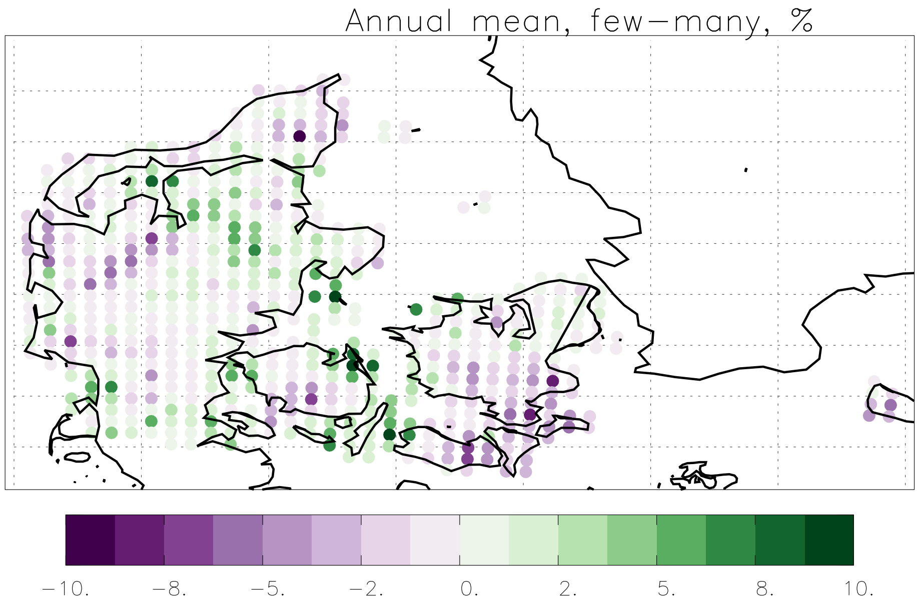
Danish Meteorological Institute
Ministry for Climate and Energy

Scientific Report 21–34

The sensitivity of gridded precipitation to the number of stations

Bo Christiansen, Flemming Vejen, Torben Schmith, Mikael Scharling, and Kim Sarup



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1. Abstract

Danish Meteorological Institute routinely grid precipitation measurements to a regular grid covering Denmark. However, there is a strong variation in the number of stations and in the homogeneity of the station net over time. In particularly, there was a strong reduction in the number of stations around 2010. Here we investigate the influence of the historical change in the station net using a simple inverse distance interpolation. We find that for spatial means over Denmark there is almost no impact of the reduced number of stations. This holds both for annual means and for daily time-scales. We find robust regional impacts but they are rarely above 10 % for annual means.

2. Introduction

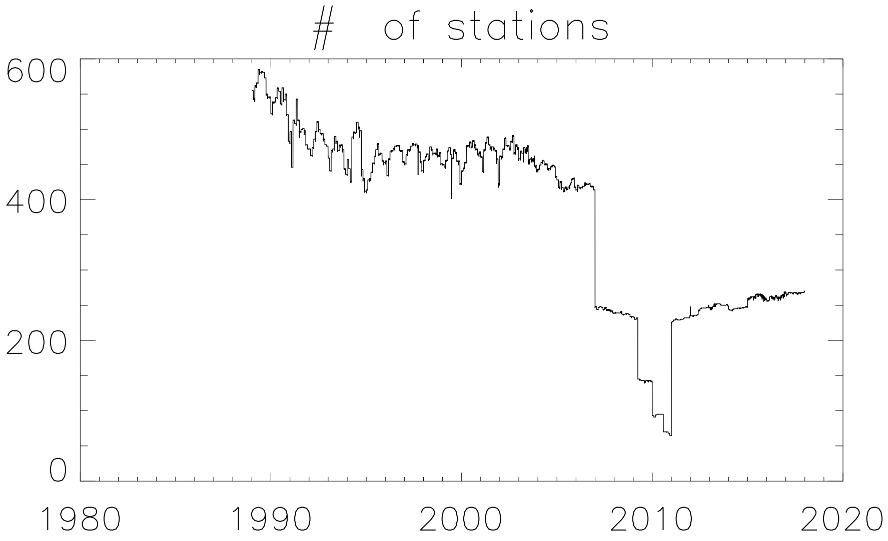

Figure 2.1: The number of stations providing data as function of time.

The number of precipitation stations has drastically decreased after 2010 compared to the years before 2005 (Fig. 2.1). The coverage has also become more spatially inhomogeneous (Fig. 2.2). The purpose of this note is to estimate how large an impact this change has on the gridded product. The sensitivity to the number of stations were also considered in Scharling (2006).

The official, gridded product, provided to Novana, is based on a rather convoluted gridding process (Riddersholm Wang and Scharling, 2010b). It is basically an inverse distance interpolation procedure working on the nearest eight neighbours selected so all directions are included if possible. The distance to the sea is also included in the weights. Furthermore, the gridding is done to a 1x1 km grid and thereafter softly smoothed and aggregated to a 10x10 km grid.

Here take the easy way out and choose a simple inverse distance procedure based on the nearest eight neighbors. Thus, no measure is taken to assure that different directions are included. Furthermore, we grid directly to the 10x10 km grid (609 grid pints). We will see that the difference to the full system is rather small. We therefore expect that the sensitivity to the data coverage in the simple system is representative for the operational system at least on large spatial and temporal scales.

We work on the corrected daily data for the period 1989-2017. These are the same data used for the official, gridded product, except that we ignore any flags indicating troubled data. See Riddersholm Wang (2010) and Riddersholm Wang and Scharling (2010a) for discussions of the station data.

We note that the official gridding give reasonable results without any singularities, the right values close to stations etc. In this note we test the sensitivity of the gridding procedure to the less dense

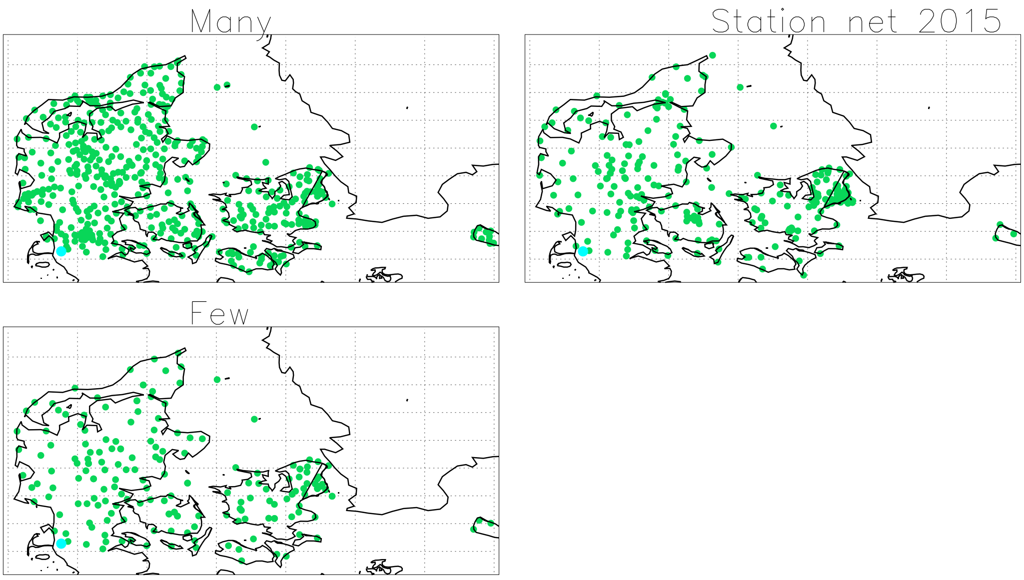

Figure 2.2: The position of the 472 stations providing data January 1st 1992 (top left) and the 252 stations providing data January 1st 2015 (top right). Bottom: The position of the stations in 1992 closest to the stations in 2005. As more than one of the stations in the 2015 set may map into the same station in the 1992 set, we get 193 unique stations. The blue dot shows the position of Møgeltønder.

and non-homogeneous station coverage after 2010, rather than testing the gridding procedure itself.

3. Method

In most of the note we focus on the year 1992. We grid the precipitation of this year based on the station coverage in 1992 itself and based on the station coverage in 2015.

In the beginning of 1992 we have 472 active stations, while there are 252 active stations in 2015. We select the stations active in 1992 that are closest to the 252 active stations in 2015. Some of these stations will be identical as there are regions where the station net in 2015 are denser than the net in 1992. Choosing only the unique stations we end with 193 stations. We refer to the large set as *many* and the smaller set as *few*. The *many* and *few* compilations are shown in the first and last panels of Fig. 2.2. In the following we grid all days in 1992 based on the two compilations. The comparison of these gridded values will give us an indication of the effect of the change of stations.

4. Spatial mean precipitation over Denmark

Figure 3.1 shows the daily spatial mean for 1992 of the gridded fields obtained with the *many* stations (left) and *few* stations (right). Also shown is the spatial mean calculated from the official, gridded product. Both *many*, *few*, and the official, gridded product give very similar results, and any differences are hardly recognized. In Fig. 4.1 we have plotted *many* and *few* against each other (left panel). The right panel in this figure is similar to the left, but now the spatial means are calculated as a simple mean over all stations. The almost perfect 1:1 relations show, that the gridding hardly affects the spatial average. The annual, spatial mean is 2.12 and 2.11 mm/day for *many* and *few*, respectively.

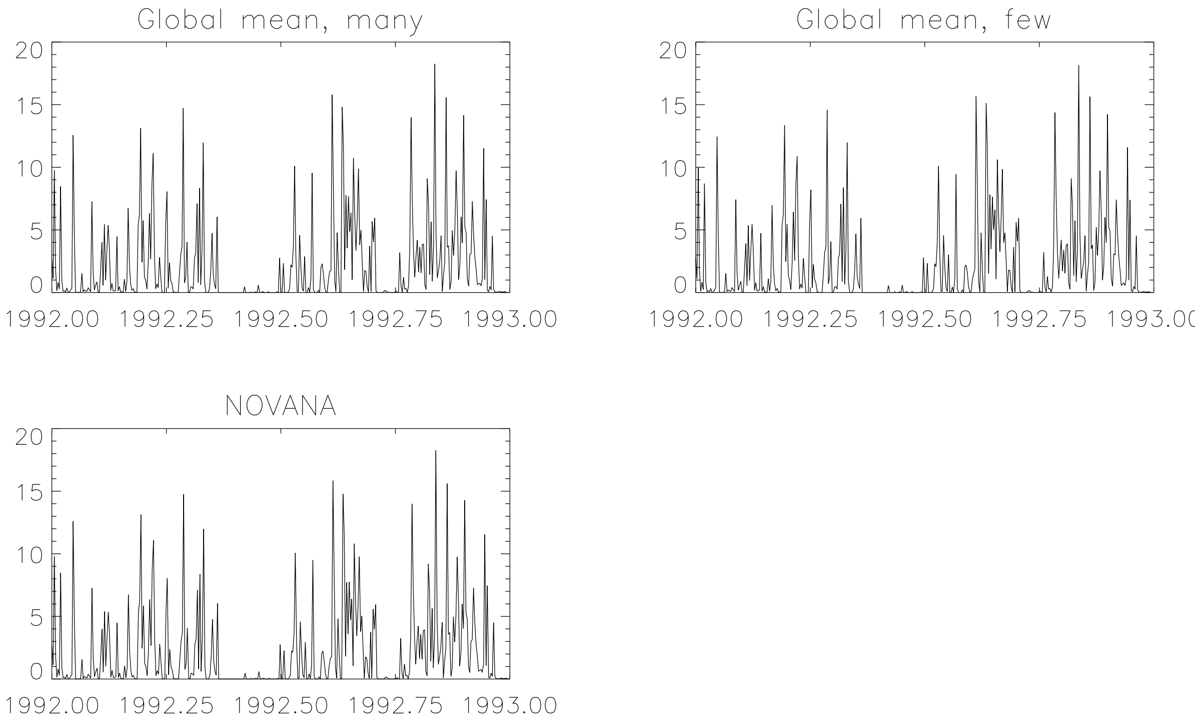

Figure 3.1: Spatial (country-wide) mean precipitation [mm/day] as function of time for 1992. Top left and top right are from gridded results with our simple method based on *many* stations (left) and *few* stations (right). Bottom panel shows the spatial mean from the gridded product delivered to Novana.

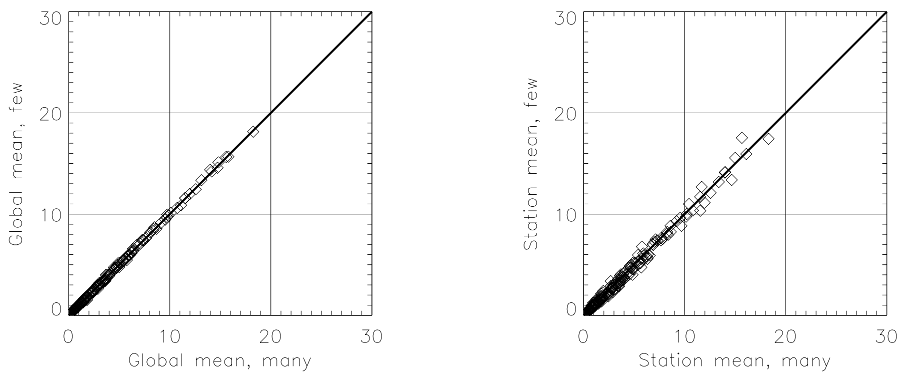

Figure 4.1: Spatial (country-wide) mean precipitation [mm/day] for 1992. Results from *few* plotted as function of results from *many*. Left: based on results from our simple gridding procedure. Right: based on simple means over stations. Different points correspond to different days.

5. Geographical distributions

5.1 Annual means

Figure 5.1 shows the geographical distribution of the 1992 annual mean. Both *many* and *few* as well as the Novana product agree well on both the pattern and the magnitude of the precipitation. Differences between *many* and *few* are rarely larger than 5 – 10 %. Note, that the pattern of the differences is rather patchy (stripy) with both negative and positive differences (mean almost 0 mm/day as noted in the previous section). The largest differences are found on Bornholm, probably because of the absence of inland stations in *few*. The differences are also shown as histograms in Fig. 5.2.

Both the pattern and the magnitude of the differences are systematic and also found in other years than 1992. The southern part of Jutland, for example, shows a consistent overestimation the precipitation in *few*. Such systematic differences will occur in a region where the density in *few* is lower than in *many* and the climatology has a gradient.

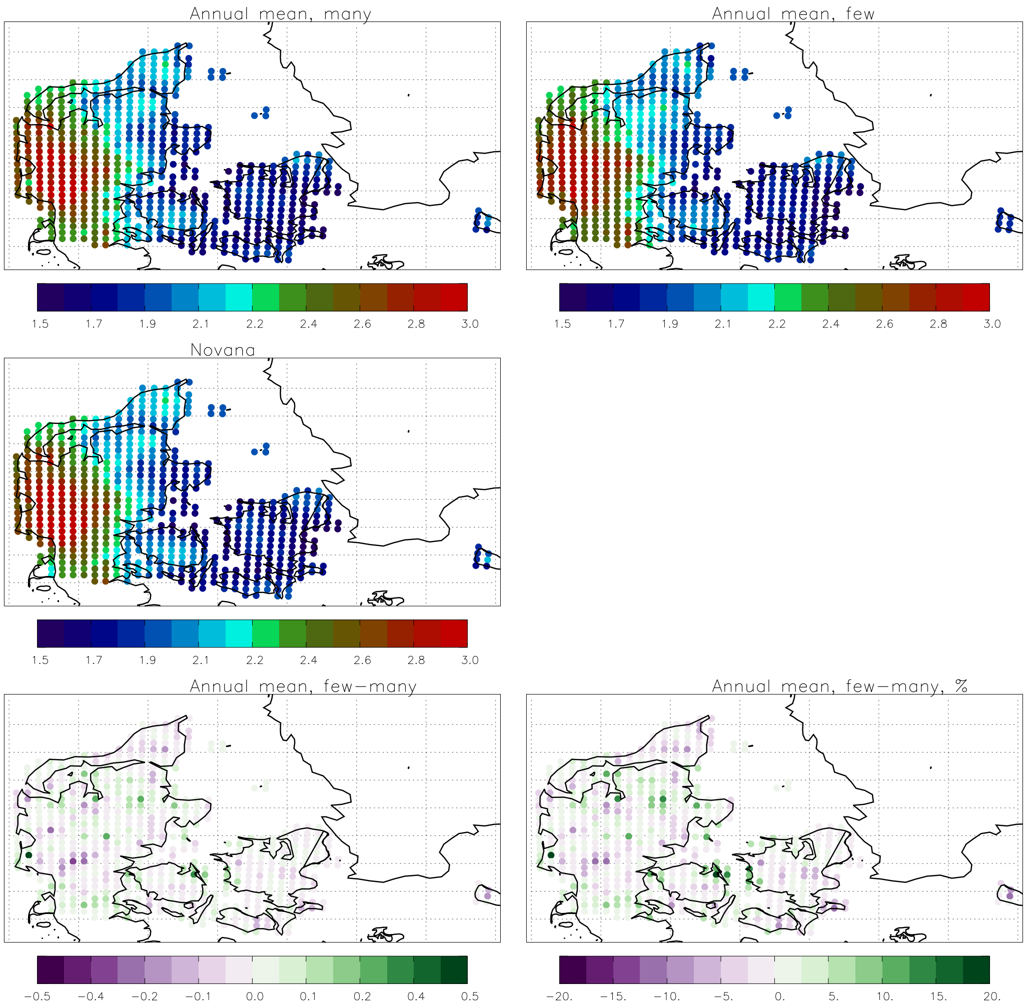

Figure 5.1: Maps of annual mean precipitation for 1992 [mm/day]. Top *many* and *few*. Middle: Novana. Bottom: Difference between *few* and many (absolute and %).

5.2 Daily and monthly means

Figure 5.3 shows the situation for a single grid point in southern Jutland near Møgeltønder (marked with blue bullet in Fig. 2.2), where *few* overestimates the precipitation as shown in Fig 5.1 (lower panel).

Some differences are seen between *many* and *few* in particular for daily values while the difference is smaller for monthly values.

Figures 5.4 and 5.5 show maps of January mean and January 1st precipitation. The differences are shown as histograms (%) in Fig. 5.6. For monthly means differences are not often larger than 20 %.

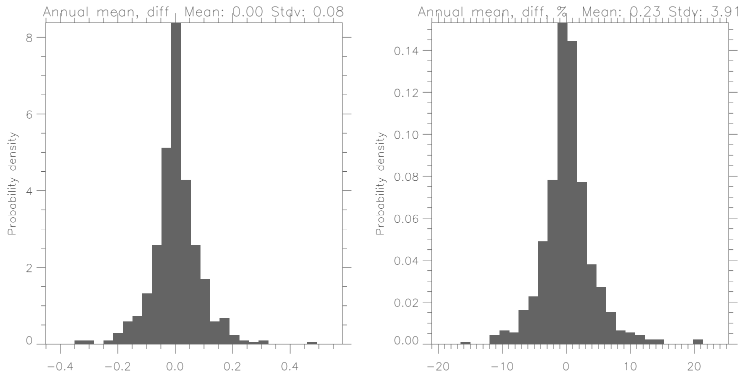

Figure 5.2: Histograms of differences, *few* - *many*, of annual means [mm/day] over the grid point. Absolute (left) and % (right).

Larger differences are seen for daily values but here the percentage may be misleading due to low values of precipitation.

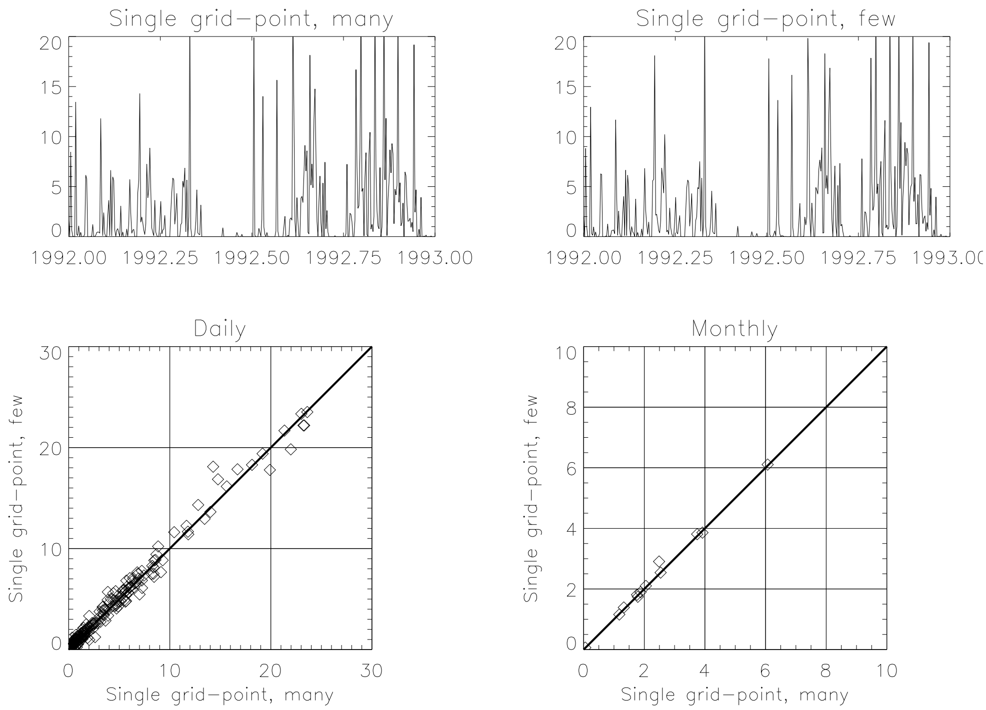

Figure 5.3: Precipitation for 1992 in a single grid point (near Møgeltønder marked with blue bullet in Fig. 2.2). Top: time-series for *many* and *few*. Bottom: Results from *few* plotted as function of results from *many*. Unit: [mm/day].

6. Conclusions

- The simple interpolation scheme applied in this note compares sufficiently well to the official scheme that we believe we can use if for sensitivity studies.
- For spatial means over Denmark there is almost no impact of the reduced number of stations. This holds both for annual means and for daily time-scales.

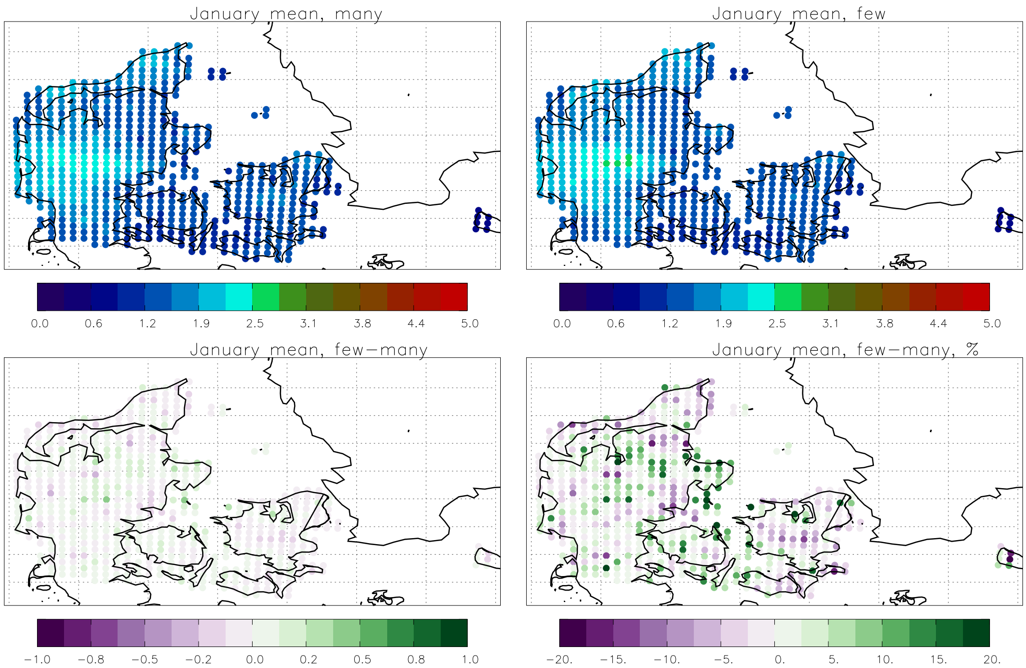

Figure 5.4: Maps of mean precipitation for January 1992 [mm/day]. Top *many* and *few*. Bottom: Difference between *few* and *many* (absolute and %).

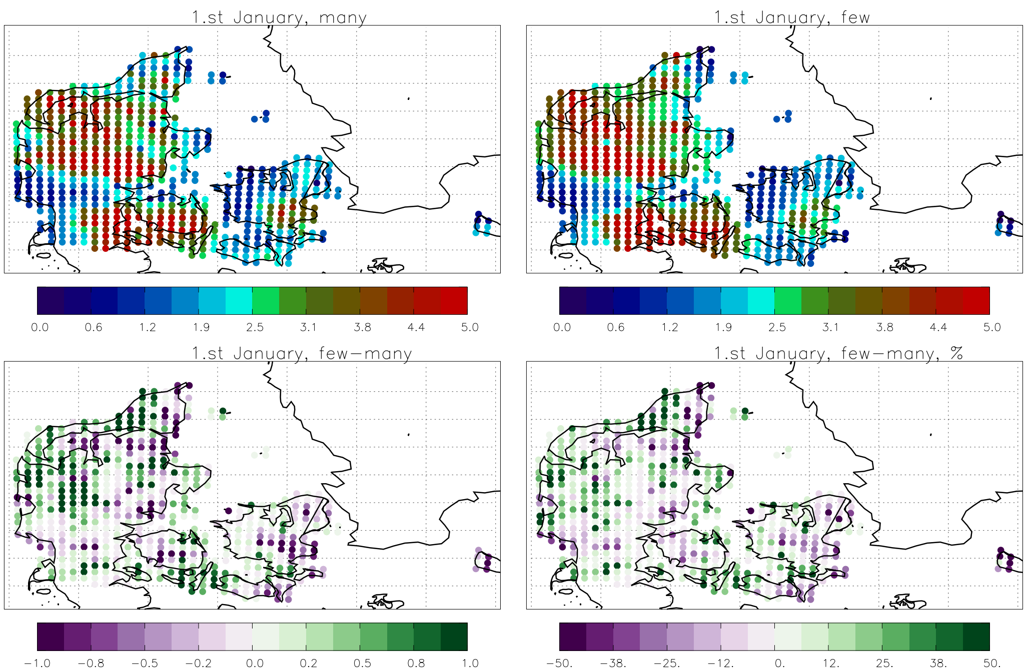

Figure 5.5: Maps of precipitation for 1st of January 1992 [mm]. Top *many* and *few*. Bottom: Difference between *few* and *many* (absolute and %).

- For annual mean in single grid-points the difference is only rarely above 10 % These values are distributed around 0 with standard deviation of 0.1 mm/day corresponding to 5 %.
- For monthly means in single grid-points the difference is only rarely above 20 % In this case values are distributed around 0 with standard deviation of 0.21 mm/day corresponding to 14 %.
- We have focused on 1992 in this note but results for other years are similar. Figure 6.1 show the annual mean difference averaged over all years 1990-2009.

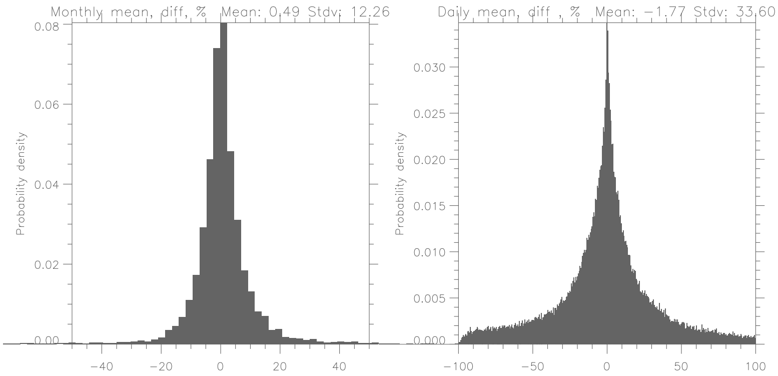

Figure 5.6: Histograms of differences in precipitation of monthly means (left) and daily values (right). All 12 months (365 days) and grid-points. In % of *many*.

- The regional differences are robust and also found for other years (Fig. 5.1). So, e.g, in the southernmost part of Jutland precipitation is systematically overestimated in *few*, whereas other regions are underestimated.
- The sum of the regional overestimations is matched by a corresponding sum for regional underestimations, resulting in a country-wide sum which is almost equal for gridding using *few* and *many*.

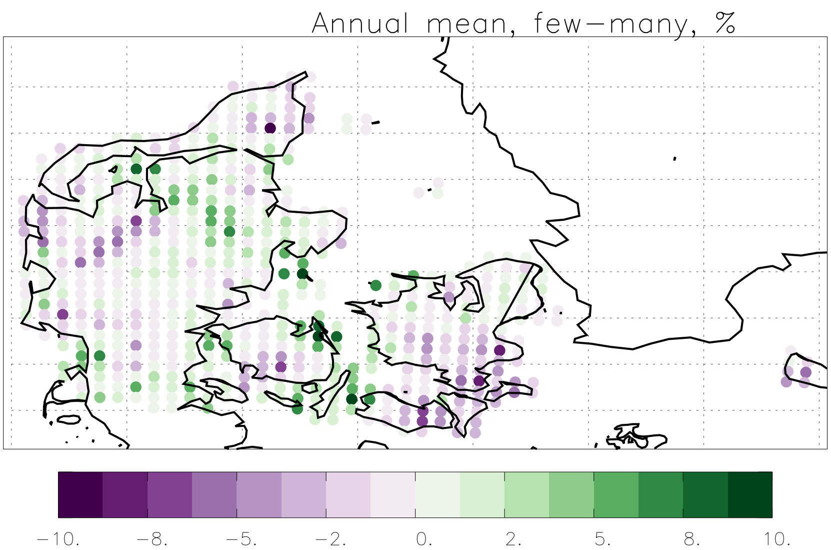

Figure 6.1: Map of difference between *few* and *many* in annual mean precipitation [%]. This is the average over 1990-2009. Compare with Fig. 5.1 (lower right panel) which shows the difference for a single year, 1992.

A. Appendix

In this appendix we present some additional figures. Figure A.1 shows the annual mean precipitation difference as in Fig.5.1, but now the reduced grid is based on 2010 instead of 2015. The year 2010 year is the year we the lowest number of stations (Fig. 2.1). The differences are somewhat larger than for 2015 but the pattern is almost the same as expected.

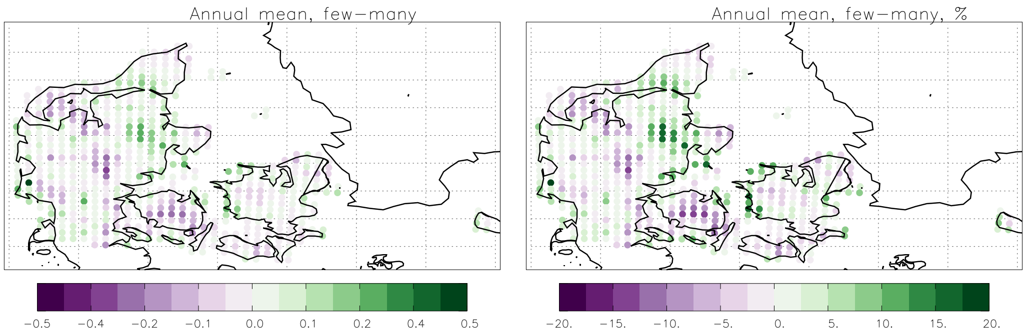

Figure A.1: As the two last plots in Fig. 5.1 but now the reduced grid (few) is based on 2010.

Figures A.2 and A.3 show some results based on the station net for 1992 and 2015. There is nothing new here compared to Fig. 2.2.

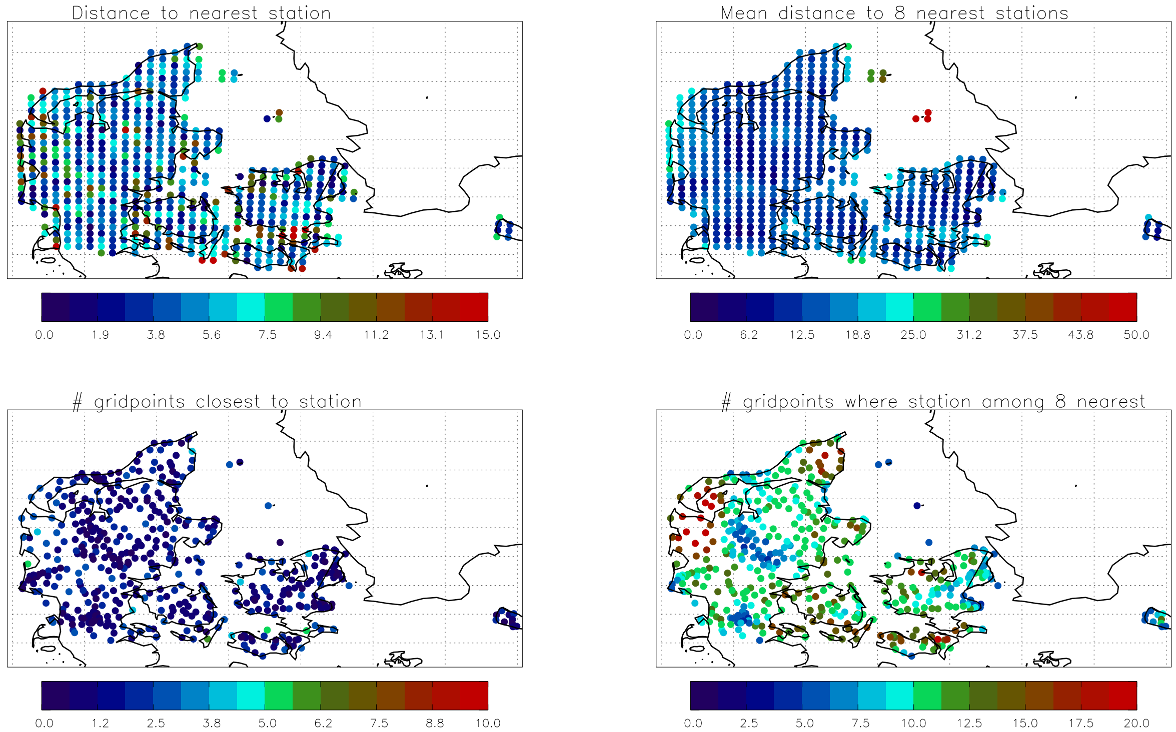

Figure A.2: Upper left: The distance [km] from grid-points to the nearest station. Upper right: The average distance [km] from grid-points to the 8 nearest stations. Lower left: For each station we show the # of grid-points which are closest to that station. Lower right: For each station we show the # grid-points which have this station among the nearest 8 stations. All for 1992.

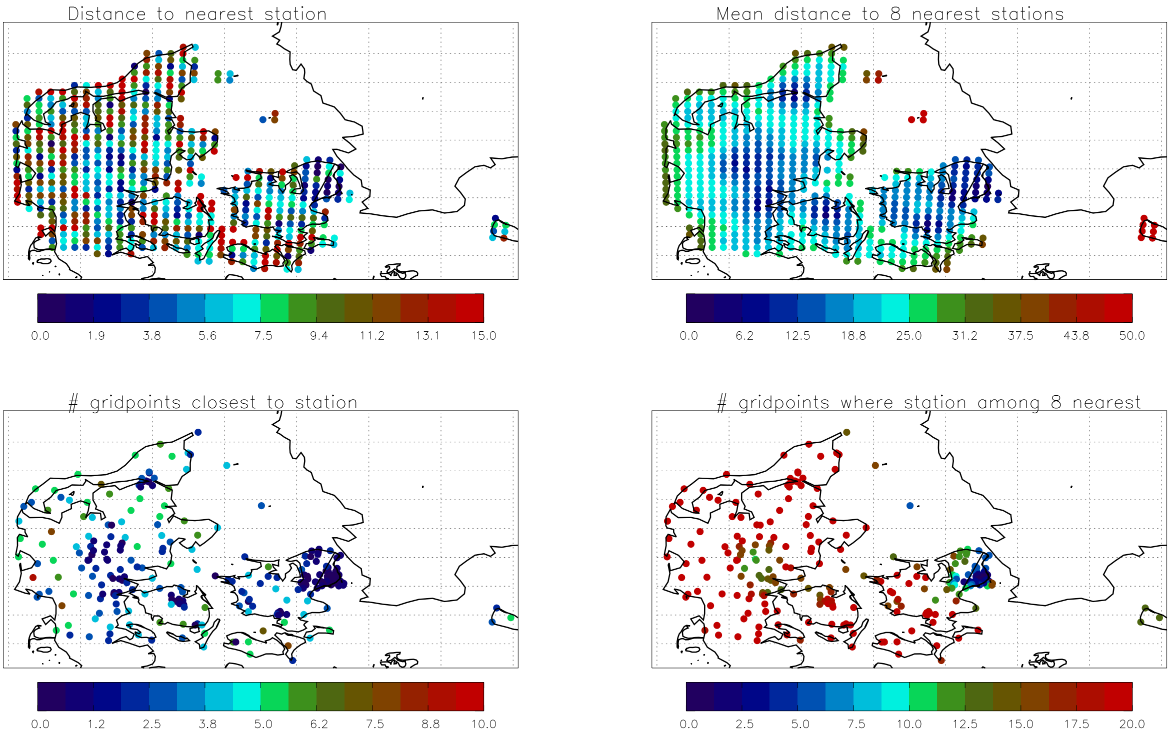

Figure A.3: As previous figure but for 2015.

Figure A.4 shows cross-sections of the upper two figures in Fig. 5.1 for different latitudes. Do not be tempted to focus too much on details as these might be different for the operational gridding procedure, which is more sophisticated than just nearest neighbors.

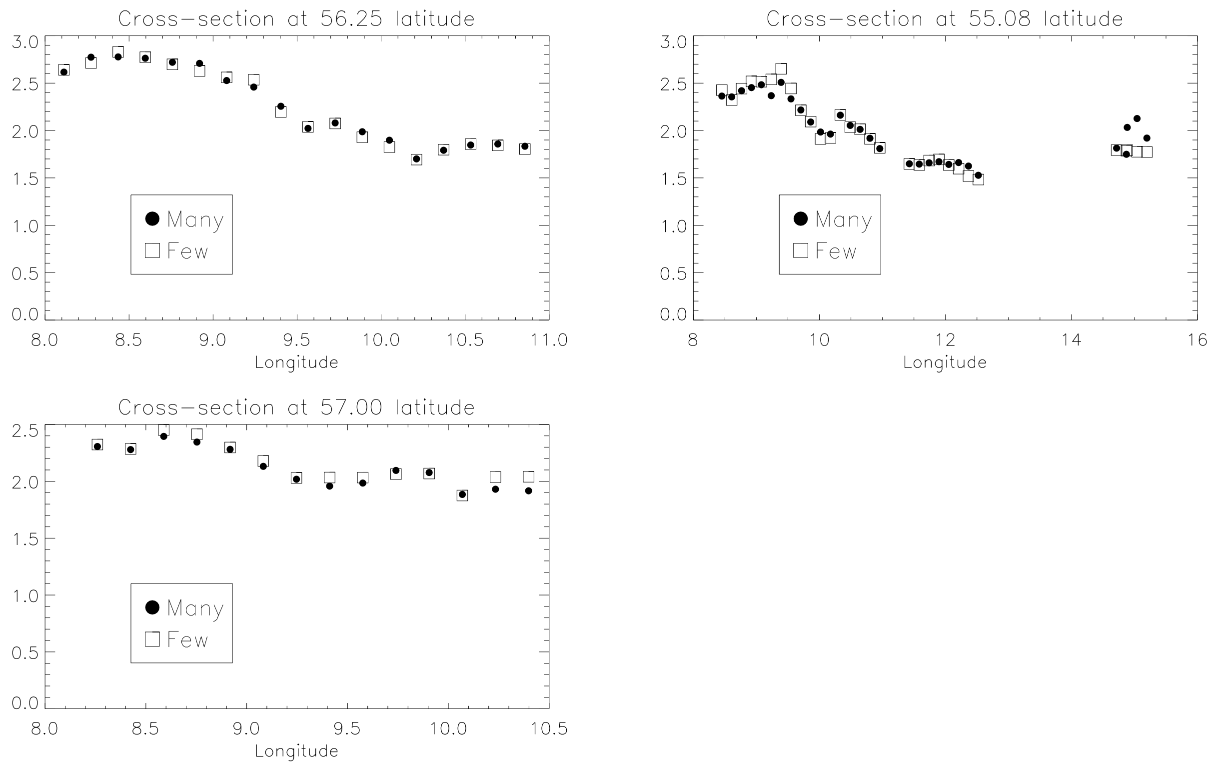

Figure A.4: Cross-sections from the upper two figures in Fig. 5.1, i.e., the annual mean precipitation [mm/day] for 3 different latitudes.

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