Danmarks Meteorologiske Institut

DMI Report 22-15
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Final scientific report of the 2021 National Centre for Climate Research Work Package 1.2.2, EkstremRegn

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1. Scientific summary

Short description

Cloudbursts are significant events which impact society and therefore often draw medial attention, in particular if cities are hit, whereas they pass unattended if they hit the countryside or smaller towns. This contributes to a possible skewed picture of the risk of cloudburst occurrence in different regions of Denmark. A further complication is that cloudburst events are often not recorded in the conventional rain gauge system because they often have a spatial scale of around 10 km, which is less than the typical distance between rain gauges.

Therefore, we need innovative thinking to reveal any geographical differences in cloud burst occurrence across Denmark. Here, we hypothesise that we can use time series of daily precipitation sums from climatic stations. They have a long record of almost 100 years and a quite dense network across Denmark. Their drawback is that they only have daily precipitation sums, but it seems likely that in the past, a cloudburst is more likely to have occurred on a day with a large daily sum.

We combine these data with data from synoptic stations in hourly resolution. Using logistic regression, we relate the probability of cloudburst occurrence to the daily precipitation sum. This relationship can then be used to estimate cloudburst occurrences at all the climate stations. More specifically, we use logistic regression, where the probability of exceeding a specified threshold in one-hour precipitation depends on the daily sum. The logistic regression model contains two parameters. These are estimated on basis of modern weather ('synoptic') observations, where we have both one-hour and daily precipitation sums. We then use data from each of the climate station as input to the logistic regression model to get a probability of cloudburst for each day. The total number of expected cloudbursts is the sum of these probabilities.

We validate the logistic regression model using cross-validation. Each of 10 synoptic stations with a long record of observations are in turn taken out and play the role of a 'pseudo' climate station. The logistic regression model is trained on the remaining synoptic stations and then applied on the pseudo climate station. Since we have hourly data for this station, we can calculate the true number of cloudburst to be compared with the number of cloudburst from the logistic regression model. This shows that our logistic regression model performs better than using the global average cloudburst rate.

Overall results

We applied the above method to more than 150 climatic stations which yielded a country-wide estimation of cloudburst rates (Figure 1).

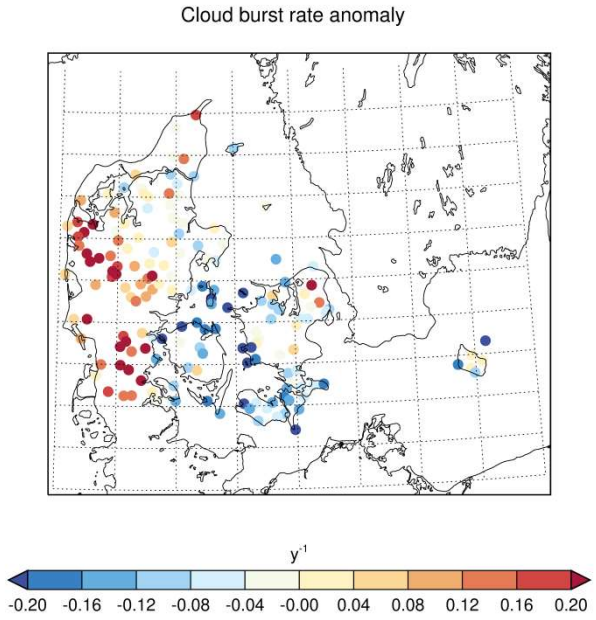

Figure 1 Anomalies of cloudburst rates obtained by applying the logistic regression model to daily precipitation sums from climatic stations.

We identify significant and coherent differences: In Southern and Western Jutland, cloudburst rates were up to 20% above average, in Northern Jutland/Fuen and Western Zealand, cloudburst rates were down to 20% below average. We applied statistical testing to see, whether these differences were likely to occur by chance. We used Moran's *I*, which is a spatial analogue of autocorrelation. By resampling the values of the cloudburst rates many times we could get significance limits on Moran's *I* under the null of no spatial correlations and this yielded that the spatial patterns seen were highly significant.

Next steps

Presently, a manuscript is in preparation, reporting on the above results. We expect it to be ready for submission within first half of 2022.

2. Scientific publication

A manuscript is planned for submission within first half of 2022.