How will the occurrence of extreme rainfall events in the UK change by the end of the 21st century?

This information sheet is one in a series describing how the frequency and intensity of extreme weather events may change by the end of the 21st century in response to global warming. The regional information presented here was obtained using state-of-the-art climate modeling and regional downscaling techniques developed during the STARDEX European Union-funded research project. These methods and the STARDEX approach are described in an accompanying overview information sheet.

Extreme rainfall in the UK

Extreme rainfall can cause large damage to property from flooding. The Cumberland News reported that the floods in Cumbria (Fig. 1) in January 2005 caused over £500 million in damage. Over 6,000 people were displaced from their homes, many of whom have still not been able to return. The Environment Agency estimates that at least 5 million people live in areas with a high risk of flooding in England and Wales. Therefore, it is vital that we ascertain the likelihood of such events recurring.

Fig. 1: Floods in Cumbria, 2005.

Past changes in extreme rainfall

STARDEX examined how extreme rainfall changed in the latter half of the twentieth century. We examined a network of stations in southeast and northwest England and found in both regions a tendency towards wetter conditions in winter and drier conditions in summer. In winter this included an increase in the heavy rainfall threshold (pq90) and the number of heavy rainfall days (pnl90) and a corresponding decrease in the longest dry period (pxcdd). Trends in the maximum winter 5-day rainfall are shown in Fig. 2, with all stations except three in the northwest showing an increase.

STARDEX also found a tendency towards less heavy rainfall in summer, with a corresponding increase in the longest dry period. While this might mean there has become less risk of flooding during this season, it also means there has become less available water during the driest season. This has important consequences for water storage requirements.

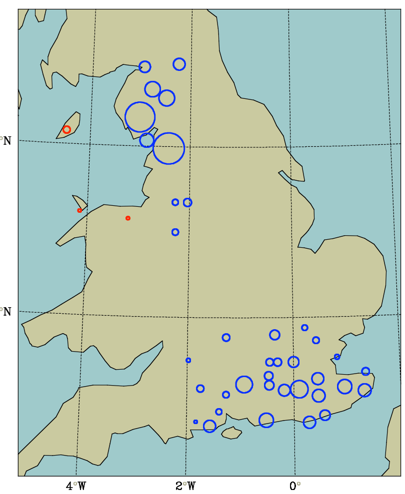

Fig.2: Trend in maximum 5-day rainfall for DJF from 1958-2000. Blue represents an increase and red is a decrease. The largest circles are an increase of about 11mm/decade.

A Europe-wide study was carried out (Haylock and Goodess 2004) to determine the cause of the observed changes in winter heavy precipitation. We found that trends in the North Atlantic Oscillation (NAO), which represents the difference in pressure between the high pressure centre over the Azores and the low pressure centred near Iceland, was the cause for the observed large-scale trends in heavy precipitation. Whether the observed trends in the NAO are caused by human-induced climate change is still undecided.

Future changes in extreme rainfall

Global Climate Models (GCMs) are our most important tool in determining the likely climate under scenarios of greenhouse gas emissions. However there is a discrepancy between the scale at which GCMs provide output (several hundred km) and the scale at which we need data for impacts studies (usually at stations or within rainfall catchments). Downscaling provides the tools to determine the climate of GCMs at the local scale.

STARDEX compared the output of six downscaling models when applied to the network of stations in southeast and northwest England under GCM experiments forced by two scenarios of greenhouse gas emissions. The six downscaling methods included four statistical methods (which statistically relate station rainfall to large-scale climate forcing) and two dynamical models (which are high resolution numerical climate models). We found that, while the models generally agree to the sign of the change (i.e., wetter or drier), there is large uncertainty as to the magnitude of the change. In many cases the variability between the models is at least as large as the variability between emissions scenarios. Fig. 3 shows an example of the proportional change in the winter precipitation indices for Oxford. There is agreement amongst the models that there is likely to be an increase in total and heavy rainfall and a decrease in the longest dry period (similar to what has been observed in recent decades). However there is no clear grouping of the model results according to the emissions scenario.

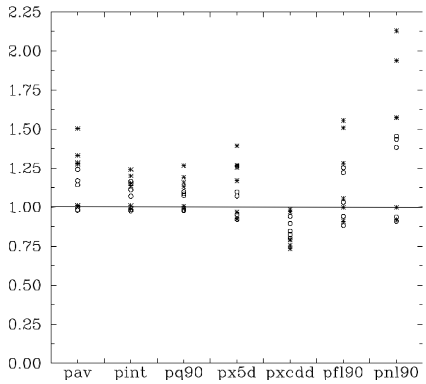

Fig. 3: Proportional change in winter precipitation indices for Oxford under A2 (asterix) and B2 (circle) emissions scenarios.

Also of note is that there is differing uncertainty in future projections depending on the rainfall index. While the spread amongst the models and scenarios is relatively small for the average wet-day rainfall (pint) and the longest dry period (pxcdd), the spread for the number of heavy rainfall days (pnl90) is much larger.

Not all models are equal however. As part of STARDEX, we compared the models in their ability to reproduce past observed heavy rainfall variability. Some models performed better than others which gives us more confidence in their ability to model heavy rainfall in the future. The performance of the models also depends on the season and rainfall index being considered. The models generally performed better in winter compared with summer and did a better job reproducing total rainfall than extreme rainfall. This is understandable since summer rainfall and extreme rainfall are generally more localised and less governed by the large-scale circulation, which is what the GCMs are reproducing. A consequence of this is that we find that the indices and seasons that are better modelled are also the ones that give a lower spread amongst the models for future projections.

Combining all the models, scenarios and stations gives us a spread of likely changes for each index (Fig. 4). The figure shows that we are confident that in winter both average and extreme rainfall are likely to increase by a factor of 1 to 1.25 in both southeast and northwest England with a corresponding decrease in the longest dry period. In summer we are less confident but the models indicate more of a decrease in average and extreme rainfall.

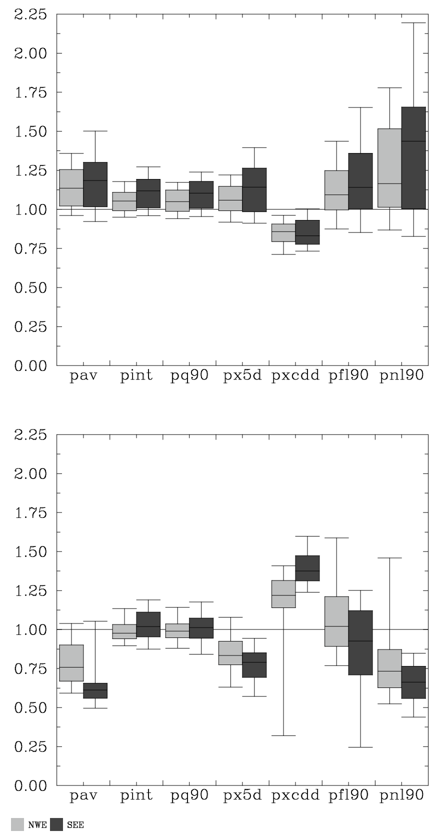

Fig. 4: All-model all-scenario change in indices for DJF (top) and JJA (bottom).

References and further reading

Haylock, M. and C.M. Goodess, 2004: Interannual variability of European extreme winter rainfall and links with mean large-scale circulation. *International Journal of Climatology*, **24,** 759-776.

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