factsheet 3

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Extreme weather events in Europe: preparing for climate change adaptation

Factsheet 3 Precipitation and floods

Key messages

The future magnitude and frequencies of floods are very uncertain, partly because information about the future evolution of the underlying causes is uncertain but also because of other confounding factors, including the effects of human intervention.

Damage from floods has increased in the past, but evidence linking this to changes in the physical conditions is weak, partly because of a lack of data and partly because of the role of past flood risk management. It seems that there has been a measure of adaptation but that vulnerability has increased economic losses because there is now more and higher-value stock at risk.

Future floods

Climate-driven changes in future flood frequency are projected to be complex, depending on the flood-generating mechanism, for example increasing flood magnitudes where floods result from heavy rainfall and decreasing magnitudes where floods are generated by snow-melt in areas with decreasing snow cover.

Owing to a large uncertainty of projections for the future, it is currently not possible to devise a scientifically sound procedure for redefining design floods, for example 100-year floods. Hence, for the time being, adjusting design floods using a 'climate change factor' is recommended. Because of this uncertainty, flood risk-reduction strategies should be reviewed on a regular basis, taking into account new information.

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Figure 1 The aftermath of flash flooding in Spain in 2012
Source: *The Observer.*

According to model-based projections for the future, intense precipitation will increase in much of Europe, accompanying the warming. However, model-based projections of intense precipitation are loaded with much uncertainty.

Past floods

A universal increase in flood maxima is not evident in Europe, and observations at individual river gauges in the region provide no conclusive and general proof as to how climate change has affected flood risk in Europe so far. There is evidence, however, that the number of large floods has increased (see Figure 2). Flood damage has risen strongly, but there are multiple factors explaining this. Flood risk and vulnerability tend to increase over many areas in Europe because of a range of climatic and non-climatic impacts whose relative importance is site-specific.

Globally, over the past 50 years, heavy precipitation events have increased for most extra-tropical regions, corresponding to a warmer Earth surface and lower troposphere. This includes widespread growth in the contribution to total annual precipitation from very wet days – days when precipitation amounts exceed the 95th percentile value – in many land regions.

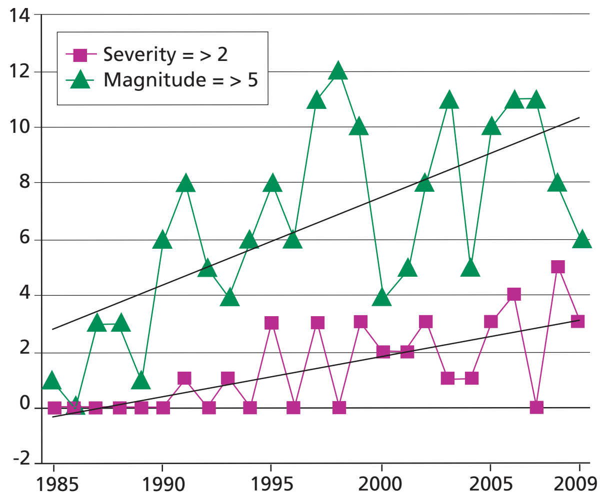
According to observations, heavy precipitation has increased in a warming climate in much of Europe. However, intense precipitation in the region exhibits complex variability and a lack of a robust spatial pattern. The principal seasonal effect is the increase of extreme precipitation in winter. Heavy precipitation events have become more frequent, even in regions with decreasing total precipitation amounts.

There has been an expanding body of evidence showing unequivocal warming of the atmosphere at all spatial scales. Corresponding precipitation changes have been less regular, but increases over land north of 30 °N over the period 1901–2005 and decreases over land between 10 °S and 30 °N after the 1970s have been observed.

Rainfall statistics in Europe are strongly influenced by inter-annual and inter-decadal variability. Seasonality and structure of precipitation is subject to change. Winter precipitation has increased over much of Europe, in particular in the north. Summer precipitation has decreased over much of Europe, particularly in the south. Short and temporally isolated rain events have been regrouped into prolonged wet spells.

However, there are problems with the availability of precipitation data, in general, and with data homogeneity and accuracy, in particular in less developed countries, worldwide. These

Figure 2 Large floods in Europe (with severity at least 2 and magnitude at least 5)
For explanation of severity and magnitude, see 'Definitions'.
Source: Kundzewicz *et al.*, 2013.



problems with data are even more severe for heavy precipitation.

Description

The observed significant increase in water vapour amount in the warmer atmosphere is consistent with the fact that the capacity of the atmosphere to hold water vapour increases with rising temperature.

The greater atmospheric moisture feeds the storms on all spatial scales with more water vapour, and if the storm precipitation efficiency – defined as the ratio of the mass of water falling as precipitation to the influx of water vapour mass into the storm – is kept unchanged, the precipitation increases.

The strength and position of the Northern Atlantic polar front and the associated tracks of synoptic-scale cyclones are crucial for the winter-time precipitation in Northern Europe. However, there is still a substantial degree of uncertainty about historic changes in the storm tracks and the question of whether storm activity has changed over time.

In summer, the situation does not depend on transported moisture to the same extent, but rather on the occurrence and strength of convective storms.

Atmospheric convection is a basic mechanism for vertical transport of heat, humidity and momentum from the boundary layer throughout the troposphere. The extreme manifestations of moist atmospheric convection are the deep convective clouds morphologically classified as the cumulonimbus genus. Such clouds can signal convective storms, which may have different horizontal and vertical extent and updraft speed.

The larger-scale conditions necessary for the formation of severe convective storms include an initiating mechanism and moist buoyant air in the atmospheric boundary layer, which is able to form vigorous updrafts in a deep, unstable environment. The occurrence of summer cold fronts represents a typical European environment where severe convective storms develop.

Basic quantitative measures that characterise the severe storm environments are the convective available potential energy (CAPE) and the magnitude of the vertical wind shear. Strong updrafts in storms occur in environments of large CAPE, which are able to support the growth of large hailstones and generally produce large rainfall rates.

Climate modelling indicates a small increase in favourable severe environments for most locations resulting from an increase in the joint occurrence of high CAPE and high deep-layer shear. However, the analyses of severe storm environments provide little information about how and whether deep convective clouds initially form. This lack of information about storm initiation prevents any claim about what will happen to the number of severe storms.

The strong internal organisation of severe convective storms causes several types of extreme hazardous phenomena that may occur during storm development. These are heavy local rainfalls with the hydrological response of flash flooding, large hail causing local but pronounced damage to crop and property, and strong wind and wind gusts, sometimes in the form of tornadoes or downbursts.

Climatological studies indicate an increase in reports about hazardous convective events. However, this increase can also be related to greater recent awareness due to more information sources and the significantly higher quality and extent of remote sensing techniques.

Definitions

Figure 2 shows a trend in the number of large floods in Europe, which are characterised by two indices – severity and magnitude.

These two indices were proposed by researchers at the European Floods Observatory Archive in order to compare individual flood events.

Severity is a discrete index and not an exact descriptive statistic. It uses expert judgements to translate news reports such as ‘largest flood in 50 years’, or ‘as large as the flood of 2002’ into approximate numerical estimates of how unusual the flood was.

Three flood severity classes were defined as follows:

- Severity class 1 includes large flood events, often causing significant human and economic damage, with an estimated, commonly from news reports, mean return period – recurrence interval – of the order of 10–20 years.
- Severity class 1.5 contains very large events whose return period is greater than 20 years but less than 100 years.
- Finally, severity class 2 includes truly extreme events with an estimated return period equal to or greater than 100 years.

The mean return period is the average interval between two events with magnitude equal to or greater than the level concerned. It is estimated from reports, for example in newspapers, of significant floods.

Flood magnitude is defined as a function that takes account of severity as defined above, the duration of the flood and the flooded area. The index is the product of duration in days, severity as given above and the area affected in square kilometres. It is given a logarithmic scale similar to the Richter scale for earthquakes. Flood magnitudes of 7, 8 or 9 represent very large magnitude events.

For details of these indices, see Choryński *et al.*, 2012.

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