factsheet 2

Extreme weather events in Europe: preparing for climate change adaptation

Factsheet 2 Wind storms

Key messages

There is some evidence that **synoptic winter storms** over Northwestern Europe have increased during the past 60 years, with a maximum of activity in the 1990s. However, controversy remains about longer-term changes since the middle of the 19th century, as results seem to depend on the dataset used. Assuming there is no adaptation to climate change, simulations for a future climate suggest an increase in damage in Northern and Central Europe, this increase being 30–100 % in Central Europe. In Southern Europe, it is expected that there will be fewer storms of this kind.

The data available for **convective, summer storms** are not sufficiently harmonised at present to provide a reliable assessment of recent trends. However, analysis suggests that in future there will be more occasions when conditions are favourable to the development of convective storms.

Future windstorms

Climate models used to estimate the future of windstorms calculate the future climate by assuming a range of different greenhouse-gas emission scenarios, typically the scenarios developed by the Intergovernmental Panel on Climate Change (IPCC). There is, however, a difference of opinion in the scientific community about whether climate models are able to account for all the key aspects of importance for storm activity statistics.

At the surface, the zonal mean temperature gradient between poles and equator becomes less in all global warming scenarios. Consequently, the total number of storms is reduced but there is a tendency for the remaining storms to become more intense. This is partly because more

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energy is released as water vapour condenses to form cloud droplets from a warmer atmosphere, and partly because of regionally enhanced temperature differences. However, models also show that the zonal mean temperature gradient in the upper troposphere becomes larger with global warming, which would increase storm activity. This difference in trends lends uncertainty to future trends in storm activity. State-of-the-art climate model simulations indicate a significant increase in risk of windstorms over Northwest Europe. Correspondingly, the extreme wind speeds in these regions are expected to increase under future climate conditions, leading to higher storm damage when there is no adaptation. Over Southern Europe the number of severe storms and the damage caused by them are projected to decline. However, there are indications that the seasonal patterns of synoptic storms may change with winter storminess increasing and summer storminess decreasing. This is important because, whilst winter storms give rise to damage, summer storms may also give relief from heat.

In general, an increase in damage of the order of 30–100 % is projected for Central Europe when maintaining present day wind-loss relations and societal conditions for possible future climates, assuming that there is no adaptation to change.

Although direct evidence of past trends is ambiguous because of shortcomings in the data record, physical preconditions for convective storms are changing in a way that suggests an increase in convective events in future.

Past windstorm patterns

Analysis of data from around 1950 indicates an upward trend in Central, Northern and Western Europe, which peaked in the 1990s. Insurance data also show a strong increase in storm damage during recent decades, which is, however, influenced by an increase in wealth and economic values, and is further affected by changes in vulnerability.

Calculations of the windstorms over the North Sea region based on surface pressure differences, corroborated by independent data, cover a period starting in the late 19th century. Recent evaluations distinguishing winter and summer storms show a rising trend in winter, with a maximum in the 1990s. This is in line with the increasing trend found in the recent reanalysis of 20th century data, but there are also studies questioning these results. The evolution of windstorms during the past 150 years remains controversial, therefore. An unequivocal relationship between windstorms, climate change and damage in Europe cannot currently be deduced on the basis of the available data.

The assessment of trends in convective storm patterns is limited by the quality of data available. A unified system for reporting and collecting information on severe storms has been in operation in Europe only since 2002, when the European Severe Weather Database came under the control of the European Severe Weather Laboratory. Early indications are that this will provide important information on trends in due course. At this stage, however, there is little direct evidence of significant trends.

Description of the phenomenon

Windstorm tracks are regions of frequent storms, which normally reach the coasts of Northwestern Europe; however, from time to time they can also hit other European countries.

Any intensification of depressions produces large pressure gradients, mostly south of the track of the core, leading to strong winds. Other cyclones have their origin closer to the European continent. Particular areas of cyclogenesis relevant for North and Central Europe are located in the vicinity of Greenland, whereas most of the systems affecting Southern Europe develop locally, for example the Genoa cyclone. A significant proportion of the depressions affecting Europe have their genesis region over North America, but usually there is either an intensification of the cyclone close to Europe or the development of a secondary low-pressure system.

Some cyclones may develop into severe storms under particular conditions, such as a strong meridional temperature gradient (called 'baroclinicity') or a high latent heat content. The seasonal distribution of the number of

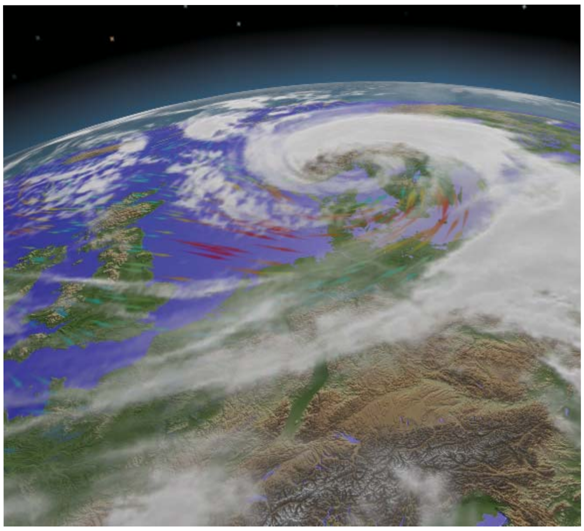

Figure 1 Example of a synoptic (large)-scale storm
The wind storm on 3 December 1999 was named 'Anatol' in Germany, 'Desemberorkanen' in Denmark and 'Carolastormen' in Sweden. The coloured lines indicate the maximum wind speed.
Source: MSG2 and ECMWF ERA-40 winds.

European winter storms shows a maximum in January, when the meridional temperature gradient in the mid-latitudes is largest.

Statistically, the occurrence of European windstorms is related to the state of the North Atlantic Oscillation (NAO), which indexes the pressure difference between Iceland and Portugal. A high NAO index indicates an extensive low pressure in the vicinity of Iceland. Central European windstorms are more frequent at moderately positive phases of the NAO index. However, there are also storm occurrences during the negative NAO phase. Physically, a strong NAO contributes to an enhanced westerly mean flow over the eastern North Atlantic and the European continent, adding to the mostly westerly winds in the storms themselves. At the same time, the positive NAO contributes to enhanced baroclinicity, as it leads to an intensification of airflows bringing cold air from the north and warm air from the south to the eastern North Atlantic.

Small-scale gusts are embedded within the large-scale wind anomalies and occur most often at the frontal systems of a storm cyclone. Gusts significantly exceed the mean wind speeds, and are the main cause of damage in a windstorm field. As they are not resolved satisfactorily in weather forecast models, approaches for estimating their strength have been developed, basically assuming that wind energy from higher levels is transported downward to the surface.

Windstorms can be identified based on their meteorological characteristics (surface winds) or their consequences (damage). For Germany, wind speeds higher than or equal to Beaufort force 8 (sustained wind speeds greater than 17.2 metres per second) roughly define a windstorm or gale. This value, which is based on the experience of the insurance industry, is approximately equivalent to the 98th percentile of the wind speed over the low-lying areas of northern Germany. Other approaches identify windstorms based on sea level pressure. They use pressure differences between measurement stations or temporal tendencies, because barometric measurements are less influenced by spatial inhomogeneities than wind measurements.

Windstorms in Europe cause monetary losses comparable to those produced by earthquakes, floods or hurricanes. They cause more than half of the economic loss resulting from natural disasters in Europe.

Definitions

European windstorms are large-scale, intense and mobile cyclones associated with large areas of low atmospheric pressure. They occur most frequently during winter months. These windstorms at the surface are steered by

Figure 2 Example of a convective summer storm
Note the small scale compared with the synoptic-scale storm 'Anatol' pictured in Figure 1.
Source: http://www.eumetsat.int/website/home/Images/ImageLibrary/DAT_IL_12_05_10.html.

associated waves, with troughs and ridges in the upper troposphere. Europe finds itself geographically downstream of the main storm tracks located over the Eastern Atlantic.

Convective storms are smaller in scale (kilometres to tens of kilometres) and of relatively short duration (hours). They can also be more intense and occur typically in the summer months. They are often described as thunderstorms as they are associated with heavy rain, thunder and lightning as well as high winds.

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