Global weather extremes and climate change

The global average temperature at the Earth’s surface has risen by more than 1 °C since the pre-industrial era*. This measure of warming is useful for mitigation targets but masks bigger changes on regional or shorter-term scales. Extreme weather events have severe impacts on society and ecosystems in our current climate, and pose an increasing threat as climate changes. Building future resilience to extremes requires continued development in attribution science and forecasting skill.

Some types of weather extremes have increased globally

Global observations show an increase in certain types of extreme weather since 1950. The number of warm days and nights have increased, whilst the number of cold days and nights have declined. Heatwaves have become more frequent. Met Office research shows extreme summer temperature events in Europe are now 10 times more likely than they were in the early 2000s. The number of heavy rainfall events over land has increased in more regions than it has decreased.

Understanding long-term changes in many weather-related extremes including droughts, floods, cyclones and wildfires can be difficult because of natural variability and limitations in observational records. Assessing the vulnerability of human populations and ecosystems to future weather-related threats depends on continued monitoring efforts and improved, higher resolution climate models.

Is climate change responsible?

The science of determining how much of a role human influence has played in an extreme weather or climate event, known as attribution science, has advanced rapidly in response to increasing risks from climate change. The Met Office Hadley Centre is working with partners to pioneer the development of an event attribution system to provide regular and reliable assessments of recent extremes.

Current attribution science shows:

**Temperatures**: Global records reveal large increases in warm extremes and decreases in cold extremes worldwide since 1950, which can be confidently attributed to human influences on climate as global mean surface temperature has risen unequivocally. The likelihood of the European heatwave of 2003 was at least doubled by human influence.

**Rainfall**: As temperatures rise, the capacity of the atmosphere to hold moisture increases, and heavier rainfall can be expected. At the same time, higher rates of evaporation mean drought conditions can be exacerbated in some regions. Confidence in attributing these types of event to human influence can be more difficult in some cases as there is high regional natural variability in rainfall extremes. As understanding and climate modelling capabilities continue to improve, confidence in the attribution of these events is rapidly advancing.

**Storms**: Severe storms, hurricanes and typhoons can also be difficult to attribute as they are strongly influenced by atmospheric circulation and the impacts of climate change are less well understood.

*Pre-industrial is defined here as the 1850–1900 average.
Further extremes are likely as emissions continue

As global average surface temperature rises, it is virtually certain hot temperature extremes over most land areas will be more frequent on daily and seasonal timescales.\(^1\) Under a medium/high emissions scenario, temperatures endured in Europe during the heatwave of 2003 could be considered cooler than average by the end of the century.\(^3\)

Extreme rainfall over mid-latitude land masses and wet tropical regions is expected to become more intense and more frequent.\(^1\) Predicting the frequency and intensity of extreme rainfall events will be invaluable for countries across the world as they make plans to adapt to more flooding.

Met Office scientists have pioneered the use of very high-resolution (1.5km-scale) regional climate models which can simulate hourly rainfall extremes far more realistically than coarser models typically used for projections.\(^8\)-\(^10\) Projections of future UK rainfall already indicate that wetter winters and more intense summer downpours are likely under a medium/high emissions scenario, both raising the risk of future flooding.

Monthly to decadal forecasting for early warning of extreme weather events

Advance warning of an increased risk of extreme weather events associated with particular climate regimes, such as El Niño, allows vital time to prepare, thereby reducing potential impacts on life and property. The Met Office has been at the forefront of work in this area — applying its expertise to regions around the world.

Using the latest Met Office initialised climate predictions, Met Office scientists have demonstrated skilful prediction of the winter North Atlantic Oscillation (NAO) more than a year ahead.\(^11\) The NAO has a profound influence on European and North American weather patterns, and reliable forecasts on seasonal to interannual timescales are hugely valuable in planning for winter variability and the heightened risk of hazardous weather.

Continued improvement in monthly, seasonal, and decadal forecasting will help with disaster risk reduction in the UK and across the world. The Met Office is involved in a number of projects with this goal, funded through the European Union’s Horizon 2020 programme:

**EUPORIAS**
(European Provision of Regional Impacts Assessments on Seasonal and Decadal Timescales) links seasonal-decadal climate predictions with climate impacts and policy, and addresses key knowledge gaps and vulnerabilities in sectors such as water, energy, transport, food security, and health.

**SPECS**
(Seasonal to Decadal climate Prediction for the improvement of European Climate Services) aims to deliver a new generation of European climate forecast systems for reliable, local climate information over land at seasonal to decadal time scales.

**EUCLEIA**
(European Climate and Weather Events: Interpretation and Attribution), seeks to understand the extent to which weather and climate extremes in Europe have changed due to human influences on climate, and identify types of events where further research is needed to robustly attribute risk.

References:
\(^1\)IPCC AR5, 2013; \(^2\)Herring et al., 2015; \(^3\)Christidis et al., 2015; \(^4\)Donat et al., 2013; \(^5\)WIREs Clim Change 2016; \(^6\)Stott et al., 2016; \(^7\)Stott et al., 2004; \(^8\)Chan et al., 2014; \(^9,10\)Kendon et al., 2014, 2016; \(^11\)Dunstone et al., 2016

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