Experts predict that as the surface of the Earth warms due to climate change, even more extreme weather events will occur. A recent study by Niklas Boers and co-workers has shown that extreme rainfall events across the world are also more significantly connected than we first thought. They believe that there are rainfall teleconnections.

Why worry about predicting the weather?

Human beings love to talk about the weather. We avidly watch the weather forecast and it has an enormous influence on our lives. Should we put our washing out? Should we take an umbrella? Or perhaps we should even cancel the boat trip? For centuries we collected weather wisdom, seeking guidance from the behaviour of animals or the appearance of clouds. Few people believed that a forecast could be made to predict the weather beyond the next hour. Then in 1854, Admiral Robert Fitzroy (Charles Darwin’s captain on HMS Beagle) established what we now call the Met Office. For over 150 years, meteorologists (scientists who study the weather) have built up their understanding of the Earth’s climate and weather patterns. They collect data including temperature, atmospheric pressure and wind speed and direction in weather stations to help them make short- and long-range forecasts. Accurate forecasting of the weather has often played a pivotal role in history. Most notable was when D-Day was delayed by 24 hours to make the most of a predicted break in the stormy weather on the 6th June 1944.

How accurate are weather forecasts?

On 15th October 1987, just a few hours before a ‘Great Storm’ broke, the weather forecaster Michael Fish famously said, ‘Earlier on today, apparently, a woman rang the BBC and said she heard there was a hurricane on the way. Well, if you’re watching, don’t worry, there isn’t!’ In fact, the Great Storm was the worst seen in decades in the UK with gusts of wind recorded at up to 115 mph and an estimated 15 million trees were lost in one night. Although, such huge mistakes with weather forecasting are rare and the accuracy is improving, inaccurate forecasts can be devastating.

Today, calculating a weather forecast is extremely complicated and involves super computers running simulations using data from around the globe (gathered from weather stations, satellites and special weather balloons). The computers will use real temperature data to predict how much evaporation of water will take place and hence how much cloud formation. Meanwhile, air pressure can be used to calculate the direction and speed of winds because air particles rush from areas of high pressure (high concentration) towards areas of low pressure (low concentration). Weather systems can extend over large distances, up to a few thousand kilometres, depending on the time of year. If we look at the weather forecast on television, we can see clouds extending over large distances (Figure 1). You can read about the formation of clouds in I bet you didn’t know... There is lightning at the edge of the Solar System.
How is climate change effecting the weather?

In recent times, we have experienced extreme weather in the UK. In February 2020, many areas suffered from severe flooding caused by three consecutive winter storms (Storms Ciara, Dennis then Jorge). Internationally, 2019 is recorded as the second hottest year ever. Could this have influenced conditions which resulted in Australia experiencing one of its worst wildfires ever with 15 million acres burned? Many scientists believe that throughout the world, global warming is intensifying extreme weather such as hurricanes, typhoons, droughts and floods. Records to track the weather have indicated that the strongest storms globally have occurred in the last few years. For example, Hurricane Dorian (2019) caused massive destruction in The Bahamas, USA and Canada; it was one of the strongest landfalling Atlantic hurricanes with winds reaching speeds of 185 mph (Figure 2). In the same year, tropical cyclone Idai was recorded as the third deadliest southern hemisphere cyclone on record.

Questions to discuss with children:
- What do you know about the water cycle?
- What will happen if we have very heavy rainfall?
- Do you know why it rains?
- If we add more heat to the surface of the Earth how will this affect the water cycle?
- What is a teleconnection? Can you work out its meaning?
- From the images of clouds in Figures 1 and 2, can you work out how big can a weather system can be?

Does weather in one region affect the weather in other countries?

Boers and their team have identified a distance of up to 2,500 km for regional weather systems to link with each other, but more importantly they have found that global weather events are also more closely linked than first thought and this could have implications for the extreme weather events. For example, they have found that the monsoon systems of south-central Asia, east Asia and Africa are significantly synchronised (this means that they happen at the same time). How did they work this out? First, they analysed satellite data to determine rainfall patterns and in particular extreme rainfall events. Second, they used a mathematical technique called network analysis to determine how strong the connections were between these patterns. We can see an example of their results in Figure 3. Based on rainfall events in south central Asia, the regional impacts are shown in red but the longer-range connections are the shaded blue areas and so we see that extreme rainfall events in south east Asia can have an impact on rainfall events across the globe at the same time. The scientists believe that extreme rainfall events in Europe could sometimes be linked to those in Tibet.

How is this possible?

The researchers suggested that it is caused by something called Rossby waves at around 10 km in altitude (height) in the atmosphere which link weather systems together. Imagine an ocean of gases swirling around the planet. Rossby waves (also called planetary waves) occur in both the Earth’s liquids (oceans) and gases (atmosphere). The waves are a result of the Coriolis effect (which occurs because of the rotation of the Earth) combining with temperature and pressure differences across the planet. You may have heard of the Gulf Stream or jet stream which are the results of Rossby waves.

By understanding the teleconnections between the weather in different regions better, the scientists hope that they will become more accurate when predicting extreme weather in the future. As global warming is likely to increase the power of extreme weather, this will be a very useful skill.
Figure 3. The teleconnections of extreme rainfall events occurring in southern central Asia (north-eastern Pakistan and northern India), which lead to regions in Europe and China as part of the 'Silk Road' Teleconnection pattern, but also to more remote regions in South-Eastern Asia, the West-African Monsoon Domain, as well as the Caribbean and the eastern coast of the US. The red area represents the regional weather system of South-Central Asia, while the blue areas represent the teleconnections connecting this region to remote regions on the planet. Landmass is white, oceans are pale blue.

The Teacher Guide which accompanies this article describes:

- details of how children could make weather stations to monitor weather patterns in their environment
- a practical investigation looking at which surfaces allow water to drain away quickly
- a demonstration of the forces which can be generated by differences in air pressure
- an activity to demonstrate the Coriolis effect
- a demonstration of how energy can be transferred from one system to another over large distances

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The paper that inspired this work was:
Complex networks reveal global patterns of extreme-rainfall teleconnections.
By Niklas Boers,1, 2 Bedartha Goswami,2 Alijoscha Rheinwalt,3 Bodo Bookhagen,3 Brian J. Hoskins1,4 and Juergen Kurths,2,5,6
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6. Saratov NG Chernyscevskil State University, Saratov, Russia.

All these researchers are from Europe, so why would they be interested in weather across the world?

GLOSSARY

climate change
a long-term change in the average weather patterns on Earth

Coriolis effect
the rotation of the Earth on its own axis causes fluids (gases in the atmosphere and water in the oceans) to turn to the right as they move in the northern hemisphere and to the left in the southern hemisphere

Gulf Stream
strong ocean current which brings warm water from the Gulf of Mexico into the Atlantic Ocean

jet stream
strong westerly winds

monsoon
a seasonal change in the direction of the wind bringing rain or a dry season

Rossby waves
waves occurring in rotating fluids (liquids and gases)

teleconnections
a causal connection between weather or environmental systems which occur a long distance apart