From 2016 to 2019, **meteorologists** saw **record-breaking heat waves** around the globe, **rampant wildfires** in California and Australia, and **the longest run of** category 5 tropical cyclones on record.

The number of **extreme weather events** has been increasing for the last 40 years, and current **predictions** suggest that the **trend** will continue. But are these **natural disasters** simply bad weather? Or are they **due to** our changing climate?

To answer this question we need to understand the differences between **weather** and **climate**—what they are, how we **predict** them, and what those predictions can **tell us**.

Meteorologists **define** weather **as the conditions of** the **atmosphere** at a particular time and place. Currently, researchers can predict a region's **weather for the next week** with **roughly 80% accuracy**. Climate describes a region's average atmospheric conditions **over periods of** a month or more. Climate predictions can forecast average temperatures **for decades to come**, but they can't tell us what specific weather events to expect.

These **two types of predictions** give us such different information because they're **based on different data**. To forecast weather, meteorologists need to measure the atmosphere's **initial conditions**. These are the current levels of **precipitation, air pressure, humidity, wind speed, and wind direction** that **determine** a region's weather.

Twice every day, meteorologists from over 800 stations around the globe **release balloons into** the atmosphere. These balloons carry **instruments** called radiosondes, which **measure** initial conditions and **transmit their findings to** international weather centers. Meteorologists then **run the data through** predictive physics models that **generate the final weather forecast**.

Unfortunately, there's something stopping this **global web of data** from producing a perfect prediction: weather is a **fundamentally chaotic** system. This means it's **incredibly sensitive** and impossible to perfectly forecast without **absolute knowledge** of all the system's elements. In a period of just ten days, even incredibly small **disturbances** can **massively impact** atmospheric conditions—making it impossible to **reliably** predict weather **beyond two weeks**.

Climate prediction, on the other hand, is far less **turbulent**. This is partly because a region's climate is, by definition, the average of all its weather data. But also because climate forecasts **ignore what's currently happening** in the atmosphere, and **focus on the range of** what could happen. These **parameters** are known as **boundary conditions**, and as their name suggests, they **act as constraints on** climate and weather.

One example of a boundary condition is **solar radiation**. By analyzing the **precise distance** and **angle between** a location and the sun, we can determine **the amount of heat** that area will receive. And

since we know how the sun **behaves** throughout the year, we can **accurately** predict its **effects** on temperature. Averaged across years of data, this reveals **periodic patterns**, including seasons.

Most boundary conditions have **well-defined values** that change slowly, if at all. This allows researchers to **reliably predict** climate **years into** the future. But here's where it **gets tricky**. Even the **slightest** change in these boundary conditions represents **a much larger shift** for the **chaotic** weather system. For example, Earth's surface temperature has warmed by **almost 1 degree Celsius** over the last 150 years. This might seem like **a minor shift**, but this 1-degree change has added the energy **equivalent of roughly** one million **nuclear** warheads into the atmosphere. This massive **surge of energy** has already led to a dramatic increase in the number of **heatwaves, droughts**, and **storm surges**.

So, is the increase in extreme weather **due to** random chance, or changing climate? The answer is that— while weather will always be a **chaotic system— shifts in our climate** do increase the **likelihood** of extreme weather events. Scientists are **in near universal** agreement that our climate is changing and that human activity is **accelerating** those changes. But fortunately, we can **identify** what human **behaviors** are **impacting** the climate most by **tracking** which boundary conditions are shifting. So even though next month's weather might always be a **mystery**, we can work together to protect the climate **for centuries to come**.