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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 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.

## **Vocabulary bank**

**meteorologist** - *noun* a specialist who studies processes in the earth's atmosphere that cause weather conditions

**rampant** - *adj.* (of a plant) having a lush and unchecked growth; unrestrained and violent

**climate** - *noun* the weather in some location averaged over some long period of time; the prevailing psychological state

**predict** - *verb* make a prediction about; tell in advance; indicate by signs

**atmosphere** - *noun* the mass of air surrounding the Earth; the envelope of gases surrounding any celestial body; the weather or climate at some place; a particular environment or surrounding influence; a distinctive but intangible quality surrounding a person or thing; a unit of pressure: the pressure that will support a column of mercury 760 mm high at sea level and 0 degrees centigrade

**region** - *noun* the extended spatial location of something; a large indefinite location on the surface of the Earth; the approximate amount of something (usually used prepositionally as in 'in the region of'); a part of an animal that has a special function or is supplied by a given artery or nerve; a knowledge domain that you are interested in or are communicating about

**accuracy** - *noun* the quality of being near to the true value; (mathematics) the number of significant figures given in a number

**data** - *noun* a collection of facts from which conclusions may be drawn

**precipitation** - *noun* an unexpected acceleration or hastening; the act of casting down or falling headlong from a height; the falling to earth of any form of water (rain or snow or hail or sleet or mist); the process of forming a chemical precipitate; the quantity of water falling to earth at a specific place within a specified period of time; overly eager speed (and possible carelessness)

**humidity** - *noun* wetness in the atmosphere

**forecast** - *noun* a prediction about how something (as the weather) will develop; *verb* predict in advance; judge to be probable; indicate by signs

**chaotic** - *adj.* lacking a visible order or organization; completely unordered and unpredictable and confusing; of or relating to a sensitive dependence on initial conditions

**disturbance** - *noun* the act of disturbing something or someone; setting something in motion; a disorderly outburst or tumult; an unhappy and worried mental state; a noisy fight; activity that is an intrusion or interruption; electrical or acoustic activity that can disturb communication; (psychiatry) a psychological disorder of thought or emotion; a more neutral term than mental illness

**turbulent** - *adj.* (of a liquid) agitated vigorously; in a state of turbulence; characterized by unrest or disorder or insubordination

**parameter** - *noun* a constant in the equation of a curve that can be varied to yield a family of similar curves; a quantity (such as the mean or variance) that characterizes a statistical population and that can be estimated by calculations from sample data; any factor that defines a system and determines (or limits) its performance

**constraint** - *noun* the act of constraining; the threat or use of force to control the thoughts or behavior of others; the state of being physically constrained; a device that retards something's motion

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**periodic** - *adj.* recurring or reappearing from time to time; happening or recurring at regular intervals; recurring at regular intervals

**minor** - *adj.* limited in size or scope; inferior in number or size or amount; lesser in scope or effect; not of legal age; of a scale or mode; of your secondary field of academic concentration or specialization; of lesser importance or stature or rank; of lesser seriousness or danger; warranting only temporal punishment; *noun* a young person of either sex

**drought** - *noun* a shortage of rainfall; a prolonged shortage

**universal** - *adj.* adapted to various purposes, sizes, forms, operations; applicable to or common to all members of a group or set; of worldwide scope or applicability; *noun* a behavioral convention or pattern characteristic of all members of a particular culture or of all human beings; (logic) a proposition that asserts something of all members of a class; (linguistics) a grammatical rule (or other linguistic feature) that is found in all languages; coupling that connects two rotating shafts allowing freedom of movement in all directions