Weather Hazards: Global Atmospheric Circulation

Transcript

Narrator: Why is it that some parts of the world are warmer than others, even when they are approximately the same distance from the equator? For example, in the Scilly Isles that lie off the coast of Cornwall in Southwest England, January temperatures are generally very mild, frosts are extremely rare, and snow even more so. Average daytime temperatures are about 10 degrees Celsius; and nighttime, about 5. Yet cross the Atlantic to the city of St. John's in Newfoundland, Canada, and the situation is very different. In January, there's an average 18 days of snow cover and minimum temperatures at night average minus nine degrees. That's a 15-degree difference between those two locations even though they are at a similar latitude.

One important factor is the Gulf Stream, a warm stream of surface water that circulates around the Atlantic Ocean. The North Atlantic drift is an offshoot that circulates warm water around the Scillys, so the sea surface temperature almost never falls below 11 degrees in winter. In St. John's at the same time, the sea temperature is 0.5 degrees. The Gulf Stream is partly caused by the circulation of ocean waters but is mainly driven by winds. The earth's climate, ocean currents, and global atmospheric circulation or large scale winds are interconnected.

At any one time, there are many different weather systems creating localised conditions around the globe. While storms are raging in the North Atlantic in February, in the Southern Hemisphere, Central Australia can be suffering intense heat and heavy tropical rains might be falling in the Amazon rainforests. The global circulation model explains the earth's atmospheric circulation. Heating and cooling effects around the globe are driven by wind. The starting point of this model is heat from the sun.

Energy from the sun is short-wave light radiation and not actually heat. The heat we feel comes from light absorbed on the earth's surface which is converted into long-wave radiation that we feel as heat. So on a warm day, the heat we feel comes from the earth's surface heating the air around it. Our location on earth plays a major part in determining the amount of heat we feel. In the Sahara during the hottest months, air temperatures can rise above 50 degrees Celsius. Over the course of one year, the intensity of solar radiation or insolation is greatest over the equator because the sun is directly overhead. At the polar caps, the sun hits the earth's surface at a much lower angle, so the same amount of energy is spread over a much larger area, which means it's cooler. Polar ice sheets also reflect most of the sunlight that does reach the surface.

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There is an excess of heat at the equator and a deficit at the poles. The different levels of insolation across the earth result in different heat levels, which helps to set up atmospheric circulation. Winds play a vital role in making the earth habitable by redistributing that heat. Without winds, the equator would become unbearably hot and the poles intensely cold.

Let's look at the difference in heat levels between land and sea. Land heats quickly at the surface in summer but also cools quickly in winter. By heating the air above, the air expands and becomes lighter. As it rises, it forms extensive areas of low pressure over large land masses. At sea, some of the light is reflected from the surface but some is also absorbed to about 30 metres depth, so it takes the sea longer to heat and longer to cool. That's why the sea is warmer at the end than the start of summer. In summer, air over the sea remains cooler and denser, forming areas of high pressure.

The atmosphere is always trying to equalise air pressure so the air moves from high to low pressure, which creates wind. Wind moves in a circular pattern because of the earth's rotation. It is known as the Coriolis Effect. Large scale circulation of wind moves heat from the tropics towards the poles and cool air towards the tropics. The tilt of the Earth's axis, about 23 degrees, creates the seasons and also impacts global atmospheric circulation or wind patterns.

The global circulation model is made up of three cells in each hemisphere: the Hadley, Ferrel, and Polar cells, mirrored north and south of the equator. These cells exist due to the heating and cooling air circulating around the Troposphere, creating high and low pressure systems. The Troposphere is the lowest part of the atmosphere and where the weather conditions are most active. It extends about 15 kilometres above the earth's surface.

The Hadley cell extends from the equator, north and south, to around 30 degrees latitude. Because so much solar energy hits the equator, the land, water, and air are all warm. The belt of warm air at the equator creates large areas of low surface pressure that are drawn together in what's known as the Intertropical Convergence Zone or ITCZ. Due to the convergence of northeast trade winds from the northern hemisphere and southeast trade winds from the southern hemisphere in the ITCZ, the winds are calm and weak and have no prevailing direction.

Warm, moist air is pushed up into the Troposphere as the cooler, heavier surface air comes from the north to fill the low pressure system. This creates a convection current in the cell. Water vapour in the warm, moist air changes to liquid water as it condenses in the clouds. This leads to thunderstorms and the release of latent heat due to the condensation process, creating more warm and moist air.

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In tropical and subtropical regions, intense rainfall occurs seasonally during what is known as the monsoon. The rising warm air from the ITCZ gets trapped below the stratosphere, cools, and becomes denser as it flows toward the poles. At about 30 degrees latitude, the build-up of cool, dense air in the upper Troposphere causes it to sink. This increases surface pressure, creating a belt of subtropical high pressure. The sinking air is dry with little cloud or precipitation, producing tranquil weather.

High pressure systems cover dry regions and deserts, including the Sahara in North Africa. The return flow of cool air at low altitude from north to south in the Northern Hemisphere, combined with the Coriolis Effect creates the north-easterly trade winds. These winds were well known to sailors who relied on the wind to propel their vessels in the days before steamships. The Hadley cell has the most predictable pattern of air movement, producing extreme wet weather at the equator and extreme arid conditions on the deserts.

From approximately 30 degrees latitude to 60 degrees in both hemispheres is the Ferrel cell. Warm surface air flows towards the poles in winds that are known as the Prevailing Westerlies. As it meets the cool, dense polar air around the 60-degree latitude mark, the warmer subtropical air is forced upwards at the polar front. Above this in the upper Troposphere, there is a polar jet stream, which generally flows from west to east. The polar jet stream is strongest in winter when there is a greater contrast in temperature and air pressure. The winds are strong enough to make an eastward flight on an aeroplane from North America to Europe anything up to 1.5 hours shorter than the reverse journey because the jet streams act as a tail wind.

In the northern hemisphere, the polar front occurs around the latitudes of the UK, often creating unsettled weather conditions and high rainfall. The air cools at higher latitudes as it flows back toward the tropics where it meets the cooler air from the Hadley cell. It sinks to fill the low pressure created by warmer air. As we see, the Ferrel cell moves in the opposite direction to the other cells. The Polar cells extend from approximately 60 degrees latitude to the poles. These are the smallest and weakest cells. The cold, high pressure polar air flows across the surface towards the equator. At about 60 degrees latitude, it meets the Ferrel cell. The warm, lower pressure air disperses and rises before flowing back to the pole. The air moves from high to low pressure, creating winds and the Polar cells that are known as the Prevailing Easterlies.

These cells in the global atmospheric circulation model determine the prevailing winds around the globe. The winds in turn influence ocean currents that circulate around land masses and have an impact on average temperatures, particularly in coastal locations.