Climate Change

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The certainty of climate change remains a public controversy despite the consensus among approximately 97% of active climate researchers, who not only agree that the Earth's climate is changing but also state that this change is intensified by human activity, predominantly carbon emissions 1. The disconnect between the public and the experts is partly due to poor understanding of the mechanisms involved in climate change as well as the differences among essential concepts such as weather and climate. Climate versus Weather Localized atmospheric conditions in a region over a short period of time, such as temperature and precipitation, are described as the weather. Climate involves these same conditions, however when measured over extended periods of time. Therefore, when scientists talk about the global climate, they refer to the statistical measures of climate data collected across the entire Earth. One prominent global climate measure is the global average temperature, which is the average of the temperatures recorded across the planet. Monitoring Climate Change Scientists study changes to the global climate over time and much of the research in climate change is based on the physical sciences, such as meteorology, geography, and oceanography. Further, computer scientists model the predicted effects of events such as polar ice melting causing sea level rise and increasing temperatures. These studies are imperative for biological research because climate change affects a myriad of species that have varied abilities to tolerate different climates. A major component of climate change is global warming, defined as an increase in global average temperature of the atmosphere. Climate researchers recognize that increases in greenhouse gases raise global average temperatures. This is because greenhouse gases absorb infrared radiation transmitted from the sun and re-emit it as heat into the atmosphere. Subsequently, this heat is distributed throughout the different layers of the atmosphere and Earth's surface. While heat radiates in all directions from greenhouse gas molecules, the surface of the Earth absorbs some of the heat that had radiated downward, which leads to increased surface temperatures and trapping of the heat energy in the lower atmosphere. This trapping of heat at the Earth's surface due to the atmosphere is called the greenhouse effect. Four major gases contribute to the greenhouse effect on Earth: water vapor, CO2, methane, and ozone. However, a particularly important greenhouse gas that plays a significant role in global warming and climate change is carbon dioxide (CO2). While CO2 has always been found in the Earth's atmosphere, human-related activities such as fossil-fuel burning are increasing its abundance significantly. In the past 800,000 years, CO2 levels fluctuated without human-intervention between 180 parts per million (ppm) to 270 ppm in the atmosphere. In 2016 the concentration rose above 400ppm, which is staggeringly high considering historical fluctuations 2. Predicting the Future A prominent consequence of climate change is the sea level rise. As the climate warms, glacial ice melts due to a phenomenon known as the albedo effect. Albedo is a measure of reflected solar radiation as a proportion of total solar radiation received and ranges from 0 to 1. Albedo value depends on snow quality; dirtier or melted slow has a low albedo, whereas fresh and white snow has a high albedo. Antarctic snow generally has an albedo of around 0.8. As the temperature warms and the snow begins to melt, the albedo value gets lower, which means the snow reflects less of the radiation as heat and melts more, resulting in a positive feedback loop. Positive feedback loops occur when a perturbation to a system increases

the magnitude of the response to the perturbation. So, the more the snow/ice melts due to warmer temperatures, the more it will melt due to its weakened ability to reflect solar radiation and the more heat is absorbs, causing it to melt further. This melting of ice causes the sea levels to increase. At present, the large ice sheets contain mass equivalent to almost 70 meter (m) of global sea-level rise, of which approximately 60 m mass equivalent is stored in Antarctic ice and nearly 7 m in Greenland 3. Smaller bodies of ice, such as glaciers and ice caps contain much less water, however, melting of these ice reservoirs dominated over larger ice sheets in the last decades because they respond quicker to a given climate forcing due to their smaller size 3. Sea level rise is a critical threat to human wellbeing due to its potential in destroying properties near the coast, affecting coastal communities, and mediating ocean temperatures. The economic costs of sea level rise are vast; if the ocean level rises by just 1 meter, a sizable portion of Florida's coastline would be under water, affecting 1.2 million people's homes 4. Currently the Greenland ice sheet is thinning and if it were to be eliminated the sea levels would rise an estimated 5-7 meters, affecting millions more 3. As the climate changes, it becomes important to track species distributions to see if these are also changing. Species are found across a geographical area known as their range. Scientists study the changes in the historical ranges of organisms, known as range shifts, in relation to a variety of environmental variables to predict whether species will be able to keep up with changes in temperature, precipitation and other weather patterns. Studying range shifts is important because if species cannot move to new areas and their current habitats become unsuitable, they will go extinct. For slow-growing organisms like plants and corals, it is nearly impossible to adapt to a quickly changing climate. Corals naturally inhabit clear, shallow reefs, and if they move deeper they will not be able to get the light they need for their photosynthetic symbiotic algae. As the water warms, symbiotic algae called zooxanthellae leave the corals which causes the corals to bleach and die. Surveys on the Australian Great Barrier Reef in 2016 show that up to 67% of corals have died in specific regions due to bleaching 5. Human-induced carbon emissions contribute significantly to the levels of CO2 in the atmosphere, which in turn increases global temperature. In addition to this rise in global temperature, ocean acidification is also a direct result of increased CO2. The oceans absorb about a quarter of the CO2 in the atmosphere each year. When CO2 is absorbed by seawater, it is converted to carbonic acid (H2CO3), which in turn causes the seawater to become more acidic and reduce the availability of carbonate ions. Decreases in carbonate ions can hinder building and maintaining calcium carbonate structures of bivalves, sea urchins, and corals 6. Together with the rise of ocean temperatures, the acidification of the oceans can be detrimental for the aquatic ecosystems. 6 It is imperative to mediate the effects of climate change. Many scientists have begun researching what is currently called the Holocene Extinction, commonly known as the "Sixth Extinction" 7. There have been five major extinction events in the past, however, the rate of extinction in the past century has been 1000 times greater than expected "background extinction rates". Habitat loss and climate change both play large roles in species extinction, making it important to maintain consideration of the environment in management decisions 7. References William R. L. Anderegg, James W. Prall, Jacob Harold, and Stephen H. Schneider. Expert credibility in climate change. PNAS. 2010, Vol. 107, 27 (12107-9). Richard A. Betts, Chris D. Jones, Jeff R. Knight, Ralph F. Keeling & John J. Kennedy. El NinÌp3 (Bo and a record CO2 rise. Nature Climate Change. 2016, Vol. 6, (806-10). Milne, Glenn. How the climate drives sea-level changes. Astronomy & Geophysics. 2008, Vol. 49, 2 (2.24-2.28). Williams, S. Jeffress. Sea-Level Rise Implications for Coastal Regions. Journal of Coastal Research. 63 (184-96). Terry P Hughes, James T Kerry, Mariana AÌp1(Blvarez-Noriega, Jorge G AÌp1(Blvarez-Romero, Kristen D Anderson, Andrew H Baird, Russell C Babcock, Maria Beger, David R Bellwood, Ray Berkelmans, Tom C Bridge, Ian R Butler, Maria Byrne, Neal E Cantin, Steeve Comeau, Se. Global warming and recurrent mass bleaching of corals. Nature. 2017, Vol. 543, 7645 (373). F. Prada, E.

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