**Global Warming Effects Stations**

**Directions:** Go to each station around the classroom. Research the effects that Global Warming will cause here on Earth. Then, respond to the questions below.

**Station 1 Effect: Extreme Weather**

Brief Summary:

- How are hurricanes linked to global warming?

- How will extreme weather affect humans?

**Station 2 Effect: Glacial Disappearance**

Brief Summary:

- How much have the glaciers retreated since the end of the 19th century?

- If glaciers melt, what environmental damages does this cause?

- How are the Hindu-Kush related to glaciers?

**Station 3 Effect: Sea Level Rise**

Brief Summary:

- What causes the sea level to rise?

- How high has the sea level rose since the Last Glacial Maximum 20,000 years ago?

- Why doesn't ice melt happen in a gradual and linear process?

- How does sea level rise affect humans and other organisms?
**Station 4 Effect: Ocean Acidification**

Brief Summary:

- How does the ocean become more acidic?

- Is the ocean a sink or source of carbon? Explain.

- What does ocean acidification do to coral reefs? Why is this an environmental problem?

- Why will the polar regions be more affected by this phenomenon?

**Station 5 Effect: Methane Release**

Brief Summary:

- How will methane be released from peat bogs?

- What is a methane hydrate? How is this linked to global warming?

- Why is methane a more “effective” greenhouse gas when compared to carbon dioxide?

**Station 6 Effect: Increase in Disease and Death**

Brief Summary:

- Why will hotter temperatures lead to more human deaths?

- Why will diseases increase with higher temperatures? Give examples.

- What diseases are likely to move into Europe, so says the WHO?

**Description of a Method to Reduce the Effect:**

**Station 7 Effect: Ecosystem Damage and Disruption**

Brief Summary:

- How are polar bears affected by global warming?

- How would marine invertebrates be affected?
-What did the 2002 Nature article reveal?

-What is up with the white possum?

### Global Warming Effect 1: Extreme Weather

Global warming may be responsible in part for some trends in natural disasters such as extreme weather.

Based on future projections of climate change, the IPCC (International Panel on Climate Control) report makes a number of predictions. It is predicted that over most land areas, the frequency of warm spells or heat waves will very likely increase. It is likely that:

- Increased areas will be affected by drought
- There will be increased intense tropical cyclone activity
- There will be increased incidences of extreme high sea level (excluding tsunamis)

Storm strength leading to extreme weather is increasing, such as the power dissipation index of hurricane intensity. Kerry Emanuel writes that hurricane power dissipation is highly correlated with temperature, reflecting global warming. However, a further study by Emanuel using current model output concluded that the increase in power dissipation in recent decades cannot be completely attributed to global warming. Hurricane modeling has produced similar results, finding that hurricanes, simulated under warmer, high-CO$_2$ conditions, are more intense, however, hurricane frequency will be reduced.

Worldwide, the proportion of hurricanes reaching categories 4 or 5 – with wind speeds above 56 meters per second – has risen from 20% in the 1970s to 35% in the 1990s. Precipitation hitting the US from hurricanes has increased by 7% over the twentieth century. The extent to which this is due to global warming as opposed to the Atlantic Multidecadal Oscillation is unclear. Some studies have found that the increase in sea surface temperature may be offset by an increase in wind shear, leading to little or no change in hurricane activity. Hoyos et al. (2006) have linked the increasing trend in number of category 4 and 5 hurricanes for the period 1970–2004 directly to the trend in sea surface temperatures.

Increases in catastrophes resulting from extreme weather are mainly caused by increasing population densities, and anticipated future increases are similarly dominated by societal change rather than climate change. The World Meteorological Organization explains that “though there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record to date, no firm conclusion can be made on this point.” They also clarified that “no individual tropical cyclone can be directly attributed to climate change.”

Thomas Knutson and Robert E. Tuleya of NOAA stated in 2004 that warming induced by greenhouse gas may lead to increasing occurrence of highly destructive category-5 storms. In 2008, Knutson et al. found that Atlantic hurricane and tropical storm frequencies could reduce under future greenhouse-gas-induced warming. Vecchi and Soden find that wind shear, the increase of which acts to inhibit tropical cyclones, also changes in model-projections of global warming. There are projected increases of wind shear in the tropical Atlantic and East Pacific associated with the deceleration of the Walker circulation, as well as decreases of wind shear in the western and central Pacific. The study does not make claims about the net effect on Atlantic and East Pacific hurricanes of the warming and moistening atmospheres, and the model-projected increases in Atlantic wind shear.

A substantially higher risk of extreme weather does not necessarily mean a noticeably greater risk of slightly-above-average weather. However, the evidence is clear that severe weather and moderate rainfall are also increasing. Increases in temperature are expected to produce more intense convection over land and a higher frequency of the most severe storms.
Global Warming Effect 2: Glacier Retreat and Disappearance

In historic times, glaciers grew during a cool period from about 1550 to 1850 known as the Little Ice Age. Subsequently, until about 1940, glaciers around the world retreated as the climate warmed. Glacier retreat declined and reversed in many cases from 1950 to 1980 as a slight global cooling occurred. Since 1980, glacier retreat has become increasingly rapid and ubiquitous, and has threatened the existence of many of the glaciers of the world. This process has increased markedly since 1995.

Excluding the ice caps and ice sheets of the Arctic and Antarctic, the total surface area of glaciers worldwide has decreased by 50% since the end of the 19th century. Currently glacier retreat rates and mass balance losses have been increasing in the Andes, Alps, Pyrenees, Himalayas, Rocky Mountains and North Cascades.

The loss of glaciers not only directly causes landslides, flash floods and glacial lake overflow, but also increases annual variation in water flows in rivers. Glacier runoff declines in the summer as glaciers decrease in size, this decline is already observable in several regions. Glaciers retain water on mountains in high precipitation years, since the snow cover accumulating on glaciers protects the ice from melting. In warmer and drier years, glaciers offset the lower precipitation amounts with a higher melt water input.

Of particular importance are the Hindu Kush and Himalayan glacial melts that comprise the principal dry-season water source of many of the major rivers of the Central, South, East and Southeast Asian mainland. Increased melting would cause greater flow for several decades, after which "some areas of the most populated regions on Earth are likely to ‘run out of water’" as source glaciers are depleted. The Tibetan Plateau contains the world's third-largest store of ice. Temperatures there are rising four times faster than in the rest of China, and glacial retreat is at a high speed compared to elsewhere in the world.

According to a Reuters report, the Himalayan glaciers that are the sources of Asia's biggest rivers—Ganges, Indus, Brahmaputra, Yangtze, Mekong, Salween and Yellow—could diminish as temperatures rise. Approximately 2.4 billion people live in the drainage basin of the Himalayan Rivers. India, China, Pakistan, Bangladesh, Nepal and Myanmar could experience floods followed by droughts in coming decades. In India alone, the Ganges provides water for drinking and farming for more than 500 million people. It has to be acknowledged, however, that increased seasonal runoff of Himalayan glaciers led to increased agricultural production in northern India throughout the 20th century.

The recession of mountain glaciers, notably in Western North America, Franz-Josef Land, Asia, the Alps, the Pyrenees, Indonesia and Africa, and tropical and sub-tropical regions of South America, has been used to provide qualitative support to the rise in global temperatures since the late 19th century. Many glaciers are being lost to melting further raising concerns about future local water resources in these glaciated areas. In Western North America the 47 North Cascade glaciers observed all are retreating.

Despite their proximity and importance to human populations, the mountain and valley glaciers of temperate latitudes amount to a small fraction of glacial ice on the earth. About 99% is in the great ice sheets of polar and subpolar Antarctica and Greenland. These continuous continental-scale ice sheets, 3 kilometers (1.9 mi) or more in thickness, cap the polar and subpolar land masses. Like rivers flowing from an enormous lake, numerous outlet glaciers transport ice from the margins of the ice sheet to the ocean.

Global Warming Effect 3: Sea level rise

Sea level has been rising 0.2 cm/year, based on measurements of sea level rise from 23 long tide gauge records in geologically stable environments.

With increasing average global temperature, the water in the oceans expands in volume, and additional water enters them which had previously been locked up on land in glaciers and ice sheets. The Greenland and the Antarctic ice sheets are major ice masses, and at least the former of which may suffer irreversible decline. For most glaciers worldwide, an average volume loss of 60% until 2050 is predicted. Meanwhile, the estimated total ice melting rate over Greenland is 239 ± 23 cubic kilometers.
(57 ± 5.5 cu mi) per year, mostly from East Greenland. The Antarctic ice sheet, however, is expected to grow during the 21st century because of increased precipitation. Under the IPCC Special Report on Emission Scenario (SRES) A1B, by the mid-2090's global sea level will reach 0.22 to 0.44 m (8.7 to 17 in) above 1990 levels, and is currently rising at about 4 mm (0.16 in) per year.

The sea level has risen more than 120 meters (390 ft) since the Last Glacial Maximum about 20,000 years ago. The bulk of that occurred before 7000 years ago. Global temperature declined after the Holocene Climatic Optimum, causing a sea level lowering of 0.7 ± 0.1 m (28 ± 3.9 in) between 4000 and 2500 years before present.[6] From 3000 years ago to the start of the 19th century, sea level was almost constant, with only minor fluctuations. However, the Medieval Warm Period may have caused some sea level rise; evidence has been found in the Pacific Ocean for a rise to perhaps 0.9 m (2 ft 11 in) above present level in 700 BP.

In a paper published in 2007, the climatologist James E. Hansen et al. claimed that ice at the poles does not melt in a gradual and linear fashion, but that another according to the geological record, the ice sheets can suddenly destabilize when a certain threshold is exceeded.

Sea level rise due to the collapse of an ice sheet would be distributed non-uniformly across the globe. The loss of mass in the region around the ice sheet would decrease the gravitational potential there, reducing the amount of local sea level rise or even causing local sea level fall. The loss of the localized mass would also change the moment of inertia of the Earth, as flow in the Earth's mantle will require 10–15 thousand years to make up the mass deficit. This change in the moment of inertia results in true polar wander, in which the Earth's rotational axis remains fixed with respect to the sun, but the rigid sphere of the Earth rotates with respect to it. This changes the location of the equatorial bulge of the Earth and further affects the geoids, or global potential field. A 2009 study of the effects of collapse of the West Antarctic Ice Sheet shows the result of both of these effects. Instead of a global 5-meter sea level rise, western Antarctica would experience approximately 25 centimeters of sea level fall, while the United States, parts of Canada, and the Indian Ocean, would experience up to 6.5 meters of sea level rise.

**Global Warming Effect 4: Ocean Acidification**

Ocean acidification is an effect of rising concentrations of CO₂ in the atmosphere, and is not a direct consequence of global warming. The oceans soak up much of the CO₂ produced by living organisms, either as dissolved gas, or in the skeletons of tiny marine creatures that fall to the bottom to become chalk or limestone. Oceans currently absorb about one ton of CO₂ per person per year. It is estimated that the oceans have absorbed around half of all CO₂ generated by human activities since 1800 (118 ± 19 pentagrams of carbon from 1800 to 1994).

In water, CO₂ becomes a weak carbonic acid, and the increase in the greenhouse gas since the Industrial Revolution has already lowered the average pH (the laboratory measure of acidity) of seawater by 0.1 units, to 8.2. Predicted emissions could lower the pH by a further 0.5 by 2100, to a level probably not seen for hundreds of millennia and, critically, at a rate of change probably 100 times greater than at any time over this period.

There are concerns that increasing acidification could have a particularly detrimental effect on corals (16% of the world's coral reefs have died from bleaching caused by warm water in 1998, which coincidentally was the warmest year ever recorded) and other marine organisms with calcium carbonate shells.
In November 2009 an article in *Science* by scientists at Canada’s Department of Fisheries and Oceans reported they had found very low levels of the building blocks for the calcium chloride that forms plankton shells in the Beaufort Sea. Fiona McLaughlin, one of the DFO authors, asserted that the increasing acidification of the Arctic Ocean was close to the point it would start dissolving the walls of existing plankton: "[the] Arctic ecosystem may be risk. In actual fact, they'll dissolve the shells.” Because cold water absorbs CO2 more readily than warmer water the acidification is more severe in the Polar Regions. McLaughlin predicted the acidified water would travel to the North Atlantic within the next ten years.

**Global Warming Effect 5: Methane release from melting permafrost peat bogs**

Western Siberia is the world's largest peat bog, a one million square kilometer region of permafrost peat bog that was formed 11,000 years ago at the end of the last ice age. The melting of its permafrost is likely to lead to the release, over decades, of large quantities of methane. As much as 70,000 million tons of methane, an extremely effective greenhouse gas, might be released over the next few decades, creating an additional source of greenhouse gas emissions. Similar melting has been observed in eastern Siberia. Lawrence et al. (2008) suggest that a rapid melting of Arctic sea ice may start a feedback loop that rapidly melts Arctic permafrost, triggering further warming.

**Methane release from hydrates**

Methane clathrate, also called methane hydrate, is a form of water ice that contains a large amount of methane within its crystal structure. Extremely large deposits of methane clathrate have been found under sediments on the sea and ocean floors of Earth. The sudden release of large amounts of natural gas from methane clathrate deposits, in a runaway global warming event, has been hypothesized as a cause of past and possibly future climate changes. The release of this trapped methane is a potential major outcome of a rise in temperature; it is thought that this might increase the global temperature by an additional 5° in itself, as methane is much more powerful as a greenhouse gas than carbon dioxide. The theory also predicts this will greatly affect available oxygen content of the atmosphere. This theory has been proposed to explain the most severe mass extinction event on earth known as the Permian–Triassic extinction event, and also the Paleocene-Eocene Thermal Maximum climate change event. In 2008, a research expedition for the American Geophysical Union detected levels of methane up to 100 times above normal in the Siberian Arctic, likely being released by methane clathrates being released by holes in a frozen 'lid' of seabed permafrost, around the outfall of the Lena River and the area between the Laptev Sea and East Siberian Sea.

**Global Warming Effect 6: Increase in Disease and Death**

Climate change currently contributes to the burden of disease and premature deaths. Economic development will affect how effective adaptation to climate change will be. According to the IPCC report, it is likely that:

- climate change will bring some benefits, such as reduced cold deaths.
- the balance of positive and negative health impacts will vary from one location to another.
- adverse health impacts will be greatest in low-income countries.
- the negative health impacts of climate change will outweigh the benefits, especially in developing countries. Some examples of negative health impacts include increased malnutrition, increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts, and increased frequency of cardio-respiratory diseases.

The most direct effect of climate change on humans might be the impacts of hotter temperatures themselves. Extreme high temperatures increase the number of people who die on a given day for many reasons: people with heart problems are vulnerable because one's cardiovascular system must work harder to keep the body cool during hot weather, heat exhaustion, and some respiratory problems increase. Global warming could mean more cardiovascular diseases, doctors
warn. Higher air temperature also increases the concentration of ozone at ground level. In the lower atmosphere, ozone is a harmful pollutant. It damages lung tissues and causes problems for people with asthma and other lung diseases.

Rising temperatures have two opposing direct effects on mortality: higher temperatures in winter reduce deaths from cold; higher temperatures in summer increase heat-related deaths. The net local impact of these two direct effects depends on the current climate in a particular area. Palutikof et al. (1996) calculate that in England and Wales for a 1 °C temperature rise the reduced deaths from cold outweigh the increased deaths from heat, resulting in a reduction in annual average mortality of 7000, while Keatinge et al. (2000) “suggest that any increases in mortality due to increased temperatures would be outweighed by much larger short term declines in cold related mortalities.” Cold-related deaths are far more numerous than heat-related deaths in the United States, Europe, and almost all countries outside the tropics. During 1979–1999, a total of 3,829 deaths in the United States were associated with excessive heat due to weather conditions, while in that same period a total of 13,970 deaths were attributed to hypothermia. In Europe, mean annual heat related mortalities are 304 in North Finland, 445 in Athens, and 40 in London, while cold related mortalities are 2457, 2533, and 3129 respectively. According to Keatinge et al. (2000), “populations in Europe have adjusted successfully to mean summer temperatures ranging from 13.5°C to 24.1°C, and can be expected to adjust to global warming predicted for the next half century with little sustained increase in heat related mortality.”

Global warming may extend the favorable zones for vectors conveying infectious disease such as dengue fever, West Nile virus, and malaria. In poorer countries, this may simply lead to higher incidence of such diseases. In richer countries, where such diseases have been eliminated or kept in check by vaccination, draining swamps and using pesticides, the consequences may be felt more in economic than health terms. The World Health Organization (WHO) says global warming could lead to a major increase in insect-borne diseases in Britain and Europe, as northern Europe becomes warmer, ticks—which carry encephalitis and Lyme disease—and sandflies—which carry visceral leishmaniosis—are likely to move in.

Global Warming Effect 7: Ecosystem Damage and Extinction

Unchecked global warming could affect most terrestrial ecosystems. Increasing global temperature means that ecosystems will change; some species are being forced out of their habitats (possibly to extinction) because of changing conditions, while others are flourishing. Secondary effects of global warming, such as lessened snow cover, rising sea levels, and weather changes, may influence not only human activities but also the ecosystem. Studying the association between Earth climate and extinctions over the past 520 million years, scientists from the University of York write, “The global temperatures predicted for the coming centuries may trigger a new ‘mass extinction event’, where over 50 per cent of animal and plant species would be wiped out.”

Many of the species at risk are Arctic and Antarctic fauna such as polar bears and Emperor Penguins. In the Arctic, the waters of Hudson Bay are ice-free for three weeks longer than they were thirty years ago, affecting polar bears, which prefer to hunt on sea ice. Species that rely on cold weather conditions such as gyrfalcons, and Snowy Owls that prey on lemmings that use the cold winter to their advantage may be hit hard. Marine invertebrates enjoy peak growth at the temperatures they have adapted to, regardless of how cold these may be, and cold-blooded animals found at greater latitudes and altitudes generally grow faster to compensate for the short growing season. Warmer-than-ideal conditions result in higher metabolism and consequent reductions in body size despite increased foraging, which in turn elevates the risk of predation. Indeed, even a slight increase in temperature during development impairs growth efficiency and survival rate in rainbow trout.

Rising temperatures are beginning to have a noticeable impact on birds, and butterflies have shifted their ranges northward by 200 km in Europe and North America. Plants lag behind, and larger animals' migration is slowed down by cities and roads. In Britain, spring butterflies are appearing an average of 6 days earlier than two decades ago.

A 2002 article in Nature surveyed the scientific literature to find recent changes in range or seasonal behavior by plant and animal species. Of species showing recent change, 4 out of 5 shifted their ranges towards the poles or higher altitudes, creating “refugee species”. Frogs were breeding, flowers blossoming and birds migrating an average 2.3 days earlier each decade; butterflies, birds and plants moving towards the poles by 6.1 km per decade. A 2005 study concludes human activity is the cause of the temperature rise and resultant changing species behavior, and links these effects with the predictions of climate models to provide validation for them. Scientists have observed that Antarctic hair grass is colonizing areas of Antarctica where previously their survival range was limited.

Many species of freshwater and saltwater plants and animals are dependent on glacier-fed waters to ensure a cold water habitat that they have adapted to. Some species of freshwater fish need cold water to survive and to reproduce, and this
is especially true with Salmon and Cutthroat trout. Reduced glacier runoff can lead to insufficient stream flow to allow these species to thrive. Ocean krill, a cornerstone species, prefer cold water and are the primary food source for aquatic mammals such as the Blue Whale. Alterations to the ocean currents, due to increased freshwater inputs from glacier melt, and the potential alterations to thermohaline circulation of the world’s oceans, may affect existing fisheries upon which humans depend as well. The white lemuroid possum, only found in the mountain forests of northern Queensland, has been named as the first mammal species to be driven extinct by man-made global warming. The White Possum has not been seen in over three years. These possums cannot survive extended temperatures over 30 °C (86 °F), which occurred in 2005. A final expedition to uncover any surviving White Possums is scheduled for 2009.