The growing impact and dangers of global warming

Bryan Dyne
27 November 2012

Climate change, and a clear understanding of its impact on all aspects of life, has taken on acute importance in the past several months. The extreme weather events—the historic drought conditions over large parts of the world, the flash melting of Greenland's surface ice and the intensity of Hurricane Sandy—are examples of the changes to global weather patterns that can be expected from an overall rise in Earth's surface temperature.

This temperature is determined by the incoming solar energy—how much sunlight is reflected into space by the atmosphere, the energy of light that is re-radiated from the surface, and how much of the re-radiated light is captured by the atmosphere.

If the Earth, which reflects an average of 30 percent of incoming sunlight, absorbed all light that struck its surface and re-emitted that light at the same frequencies, the planet would have a surface temperature of approximately -18º C. This is well below the actual global average surface temperature, which NASA estimates to be 14º C. The atmospheric mechanism that accounts for this difference is the "greenhouse effect."

When the surface of the Earth is struck by radiation from the Sun, the surface then re-radiates the light. However, as the Earth is much colder than the Sun, what is re-emitted is mostly infrared light—heat. Unlike visible light, infrared light is readily absorbed by the Earth's atmosphere. It is then re-radiated in all directions, including towards the surface, creating a warmer environment, in a process called the greenhouse effect.

The four major greenhouse gases, in order of their contribution to the greenhouse effect, are water vapor, carbon dioxide, methane and ozone.

Cloud cover plays a dual role in the greenhouse effect. The amount of cloud cover, along with ice coverage, largely determines the reflectivity of Earth. A change in the extent of either clouds or ice means that the surface of the Earth is hit with more or less energy. On the flip side, clouds absorb and emit infrared radiation from the surface.

Global warming is the term given to the anthropogenic (human-induced) intensification of the greenhouse effect. Since the beginning of human agriculture, and more sharply since the beginning of the industrial era, the human race has caused the average global surface temperature to rise. This is primarily caused by putting more carbon dioxide (CO2) into the atmosphere through the burning of fossil fuels and mass deforestation.

The combination of putting more CO2 into the atmosphere and taking away the Earth's ability to remove it has greatly increased the amount in the atmosphere, especially in the past fifty years. The Earth System Research Laboratory (ESRL) records from Mauna Loa, Hawaii reveal that since 1961 the amount of CO2 in the atmosphere has increased from 318 parts per million (ppm) to 392 ppm. This is 27 percent higher than pre-industrial levels and much higher than any level found in the past 650,000 years.

Similar data can be found for rising methane levels, caused by landfills, livestock and oil and gas facilities. In 1750, the atmospheric methane count was 700 parts per billion (ppb). In 2008, the levels had risen to 1,800 ppb. Over a century, methane is 72 times as prevalent a greenhouse gas as CO2.

The inevitable impact of more greenhouse gases in the atmosphere is an increase in the heat from the Sun that is trapped in the atmosphere, and thus higher global temperatures. It is true that natural processes cause the global temperature and greenhouse gas levels

to fluctuate—oscillations in oceanic temperatures, the carbon cycle, etc. However, data collected over the past century reveal that underlying the periodic changes in global temperature is an increase in the global temperature that can be attributed only to the increase of greenhouse gases caused by human activities.

The best measurements from the past century show that global surface temperatures have increased by 0.8º C. While that amount seems small, if the surface air of the Earth is taken to be just the air within ten meters of the ground, the increase in the average global temperature is an energy input of $5x10^{18}$ joules into the atmosphere. This is saying that energy equivalent to more than a third of the electrical energy produced by the US is milling about in the atmosphere.

If this energy were evenly spread throughout the atmosphere, global warming would be a minor problem. But energy is the measure of motion, in this case the wholly non-uniform motion of atmospheric particles. The increased motion of the atmosphere causes extreme weather—massive flooding, powerful hurricanes, longer and hotter droughts—to become more and more common.

What is most troubling, however, are the positive feedback mechanisms of global warming—the abrupt global climate changes that have begun occurring with greater frequency over the past four decades, and possible long-term consequences of the increased global temperature.

Positive feedback is a term signifying that the first process causes the second, the second causes the first, the first causes more of the second, ad infinitum. A major positive feedback mechanism is the slow degradation of Arctic ice. Ice is one of the most highly reflective substances known, and any decrease in its coverage of Earth means that the atmosphere is able to absorb more light from the Sun, raising the atmosphere's temperature.

The first change in the global climate, and what first alerted climatologists to the possibility of global warming was in 1977. Records from 1950 onwards showed no change in land surface temperatures, despite the CO2 levels rising from 310 to 332 ppm. However, in 1977, the mean surface temperature began to rise at its current rate of 2º C per century.

In 1982 and 1997, global droughts occurred that lasted far longer than normal atmospheric oscillations would have provided for. In 1998, 2005 and 2007, dry and hot weather led to the Amazon rainforests nearly igniting on a mass scale. Sea levels have already begun to rise, caused by the warming of the oceans and the expansion of water that occurs when its temperature rises, as well as the melting of glacial ice.

The rise in ocean sea levels directly contributed to the amount of water that flooded into New York City during Sandy. The sea level recorded at the Battery in lower Manhattan has risen twelve inches in the last century, which translates into higher storm surge than what an equivalent hurricane would have produced 100 years ago.

Beyond local phenomena, there is a very real risk of a global catastrophe if global warming is left unchecked. Examples include: oceanic acidification leading to the mass death of coral and plankton, the basis of the Earth’s food chain; the total collapse of the tropical rainforests; an ice sheet of the size of Greenland or Antarctica falling into the ocean, causing a near instantaneous rise in worldwide sea levels of at least five meters.

Any one of these scenarios is most likely still decades away. Yet solutions to such a vast problem require decades to take effect. Instead of working towards such a goal, global capitalism has been unable to seriously address the crisis. In fact, countries and corporations are making billions of dollars from global warming by means of carbon trading schemes. Nations have begun looking to exploit new Arctic trade routes opened by the melting of the ice.

Humanity has the technological capability to surmount the challenges posed, but it cannot do so while constrained by the current socio-economic system. Only once society has undergone a revolutionary transformation in which the approach to such pressing matters are determined not by private profit but social need can the issues raised by global warming begin to be seriously addressed.