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CONVERSATIONS

Climate Change: the Science

Robert Watson*

There is no doubt that the earth's climate is changing on all scales, from local to global—in large measure due to human activities, primarily the combustion of fossil fuels and large-scale deforestation. Climate change undermines economic growth, poverty alleviation, and the livelihoods of the poor; and threatens socio-economic sectors (food and water security, for example), ecological systems, human health, and personal and national security.

The major indirect drivers of climate change are primarily demographic, economic, sociopolitical, technological, cultural, and religious. These drivers are clearly changing; for example, the world's population is projected to increase from just over 7 billion people today to 9–10 billion people by 2050. There will likely be an accompanying increase in the global economy by a factor of three or four. Increasingly, developing countries will drive global economic growth. These projected increases in population and the economy are certain to result in increased demand for energy.

There is no doubt that the composition of the atmosphere and the earth's climate has changed since the industrial revolution; and it is inevitable that these changes will continue—regionally and globally. The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide are higher than at any time in the past 800,000 years; and the atmospheric concentration of carbon dioxide, the major anthropogenic greenhouse gas (GHG), recently exceeded 400 parts per million by volume (ppmv). Each of the past three decades has been warmer than the previous decade. The global mean surface temperature has already increased by about 1 °C relative to pre-industrial levels. The low emissions scenario projects that the global mean surface temperature will increase by 0.3–1.7 °C by 2100; the high emissions scenario projects that it will increase by 2.6–4.8 °C. The greatest increases are projected for land areas in the high northern latitudes.

Changes in temperature and precipitation are causing, and will continue to cause, other environmental changes. Such changes include rising sea levels; retreating mountain glaciers; melting of the Greenland and Antarctic ice sheets; shrinking Arctic Sea ice; increasing frequency of extreme weather events, such as heat waves, floods, and droughts; and intensification of cyclonic events, such as hurricanes in the Atlantic. The sea level has risen by about 0.2 metres

* Strategic Director of the Tyndall Centre, University of East Anglia.

since 1900, and is projected to increase by an additional 0.3–0.6 metres by 2100 in the low emissions scenario or by 0.5–1.0 metre in the high emissions scenario. Annual Arctic sea ice extent has decreased by 3.5–4.1 per cent per decade during the past three decades, and summer Arctic sea ice minimum extent has decreased per decade by 9.4–13.6 per cent, with further reductions projected in September of 43–94 per cent by 2100. The rate of ice loss from the Antarctic ice sheet between 2002 and 2011 increased significantly compared to the rate between 1992 and 2001.

Enhanced atmospheric concentrations of carbon dioxide cause, and will continue to cause, ocean acidification, which poses risks to fish, especially shell fish and marine ecosystems, especially coral reefs.

Working Group I of the Intergovernmental Panel on Climate Change (IPCC) in 2013 concluded that the human influence on the climate system is clear, and that it is '*extremely likely*' that human activities have been the cause of more than 50% of the observed warming (0.6–0.7 °C) since the mid-20th century. The IPCC considers it likely that anthropogenic activities have influenced the global water cycle; such influence includes global-scale changes in precipitation over land and intensification of heavy precipitation over land regions with sufficient data.

Every government in the world recognized the danger associated with human-induced climate change and signed the Paris Agreement in 2016, though the US has since withdrawn. Under the agreement, governments pledged to hold the increase in global average temperature well below 2 °C (above pre-industrial levels), and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. To realize these targets, a rapid transition to a low-carbon economy is required, which involves unprecedented global cooperation and a dramatic transformation in energy systems.

Governments acknowledged that achieving the Paris Agreement goals requires balancing anthropogenic emissions by sources and removals by sinks (the oceans and terrestrial biosphere) in the second half of the 21st century. In reality, most models require negative emissions beyond 2050 to achieve these targets. As part of the Paris Agreement, 162 voluntary non-binding pledges were submitted to the United Nations Framework Convention on Climate Change (UNFCCC); these were from 189 countries and accounted for about 98 per cent of global GHG emissions.

While these pledges demonstrate a real increase in commitment to reduce GHG emissions, they are far from sufficient to put the world on a pathway to meet the 2 °C goal—let alone the aspirational goal of 1.5 °C. Without the Paris Agreement, global emissions of carbon dioxide-equivalent are projected to increase from the current level of 54 gigatons to 65 gigatons by 2030, but these will have to be reduced to about 42 gigatons for the global average temperature to stay below 2 °C. However, even if all pledges were fully implemented, global emissions would remain at about their current level, and result in an increase in global mean temperature of between 3°C and 4°C above preindustrial levels. Therefore, without significantly stronger pledges to reduce GHG emissions, the Paris Agreement goals will not be met. Indeed, the 2 °C goal could be reached between 2050 and 2060 and the 1.5 °C goal could be reached by the early 2030s.