CLIMATE COMMISSION

Climate Commission Summary Statement: Was Hurricane Sandy Influenced by Climate Change?

Hurricane Sandy has been causing devastation across the eastern United States in recent days with flooding and widespread power blackouts. The massive size of the storm has prompted many in the public and the media to ask the Climate Commission about the influence of climate change on Hurricane Sandy.

This document provides a summary of what we know about why Hurricane Sandy was so devastating, the links between climate change and Hurricane Sandy, and the influence of climate change more generally on tropical cyclones (called hurricanes in the North Atlantic) now and into the future.

What has made Hurricane Sandy so devastating?

Hurricane Sandy has caused significant damage in New York City and along the Mid-Atlantic coast with flooding reported from Maine to Virginia. Millions were without power and heavy snow fell from western Maryland down to Tennessee and North Carolina.

The size of the storm coupled with the vulnerability of much infrastructure along the US East Coast are the primary reasons there has been so much damage.

There are several links between Hurricane Sandy and climate change.

First, Hurricane Sandy was the most intense (as measured by barometric pressure) tropical storm on record to make landfall along the US east coast north of North Carolina. This was likely no accident as the storm developed in very unusual conditions. Before reaching land, it was feeding off exceptionally warm surface waters in the Atlantic Ocean. The temperature of the surface waters from which Sandy drew energy were 3-5^{o}C warmer than average (NOAA, 2012).

Climate change has contributed to the observed long-term rise in surface water temperatures of the world's oceans.

Second, the massive flooding caused by Sandy was caused by a storm surge – a wall of water pushed onto the coast by a storm out to sea – coincident with a high tide, in this case a very high tide associated with a full moon. Added to that is the fact that the base sea level itself has risen by about 20 cm over the past century, and has risen at a higher rate over the past two decades. Sea level will continue to rise for centuries into the future due to greenhouse gas emissions from fossil fuel burning. A rise of 20 cm may seem modest, but even small rises like this lead to a large increase in the probability of damaging floods. The primary reason for rising sea levels around the world is climate change, which warms and thus expands the oceans and adds more water to the ocean by melting glaciers and ice caps.

All the evidence suggests that climate change exacerbated the severity of Hurricane Sandy.

What do we know about the influence of climate change on tropical cyclones?

Global temperature has now increased by around 0.8 degrees Celsius. This global shift has already had a range of impacts including rising sea levels, increased moisture content of the air and increased air and sea surface temperatures. These basic features of the climate system provide the background conditions for all weather that we see around the world every day, including extreme events like tropical storms. The shifts in this background state toward a more energetic climate system – higher temperatures and more moisture in the air – are becoming the "new normal" and are influencing the nature and intensity of weather patterns around the world.

Although the extent to which any particular weather event is influenced by climate change is difficult to assess given the complex meteorological interactions that make up a storm, a fire or a heatwave, there is little doubt that they are being influenced by changes in the background state of the climate. A good example is the behaviour of tropical cyclones (hurricanes) such as Hurricane Sandy, which are affected by a range of factors associated with the state of the climate system.

Rising sea-level and storm surges

Climate change has played a significant role in the observed sea-level rise over the past century and will be the dominant driver of sea-level rise for decades and centuries into the future.

Currently global sea level rise is tracking close to the upper range of the Intergovernmental Panel on Climate Change predictions of just a few years ago. Most experts agree that a rise in sea level of 50-100 cm above 1990 levels is likely by 2100. However, depending on the stability of the major ice sheets in Greenland and Antarctica, a sea-level rise of over 100 cm is a distinct possibility. For low lying cities, like New York, New Orleans and Cairns and many of the major cities of Asia, this poses a substantial risk. Hurricane Sandy has graphically illustrated the damage that can be cause by very high storm surges.

Sea-level rise exacerbates the flooding caused by storm surges by increasing the average level of the oceans. Relative small rises in sea level can cause surprisingly high increases in the probability of coastal flooding, particularly in low lying coastal regions.

Rainfall

A warmer atmosphere holds more moisture: around 7% more for every 1 degree Celsius of warming. 2012 is likely to be one of the hottest years on record (NOAA). This means that the risk is rising of unusually heavy rainfall associated with tropical storms such as Hurricane Sandy. This adds to the risk of unusally high and damaging flood levels. In general, it is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase this century over many parts of the globe (IPCC, 2012).

Meteorologist Greg Holland of the National Center for Atmospheric Research said in the Guardian newspaper, "I have no equivocation in saying that all heavy rainfall events, including this one (Hurricane Sandy), have an element of climate change in them, and the level of that contribution will increase in the future."

Cyclone intensity

The Intergovernmental Panel on Climate Change has found that cyclones are likely to increase in intensity, although the total number of cyclones may become less frequent (IPCC, 2012). This means it is likely that there will be more category 4 and 5 cyclones and fewer category 1 and 2 events (IPCC, 2012 p 11). Thus, the cyclones that do occur are likely to be stronger and thus pose a larger risk to people, infrastructure and ecosystems.

In addition to becoming more intense, it is likely that the tracks of tropical cyclones will extend polewards in both hemispheres. This means that in the southern hemisphere tropical storms are likely to reach further south, while in the northern hemisphere tropical storms are likely to reach further north (IPCC, 2012). The track of Hurricane Sandy is consistent with this trend. In Australia there may be an increase in cyclones affecting regions of southeast Queensland (Abbs, 2012).

Sea surface temperatures

Warmer oceans now and into the future are likely to influence the intensity of cyclones. A recent study summarised this as follows:

> "We find that warm years in general were more active in all cyclone size ranges than cold years. The largest cyclones are most affected by warmer conditions and we detect a statistically significant trend in the frequency of large surge events (roughly corresponding to tropical storm size) since 1923. In particular, we estimate that Katrina-magnitude events have been twice as frequent in warm years compared with cold years ($P < 0.02$)".[1]

Over the past 60 years the oceans, like the atmosphere, have been steadily warming. Sea surface temperatures off the east coast of the US have been very high in recent months. The globally-averaged ocean temperature tied with 1997 as second highest for September, just behind 2003, at 0.55°C above the long-term average.

Ocean temperature is expected to continue to rise, and consequently this increases the risk of more intense cyclones.

The Future

Hurricane Sandy provides several insights into how climate change is altering the nature of the risks that we face now and will face in the future.

Extreme events are occurring in a warmer, wetter atmosphere over warmer surface ocean waters. This influences their nature, their intensity, and their impact.

The expected trend towards more intense tropical cyclones and heavier rainfall events will expose the vulnerability of existing infrastructure, much of which has not been designed for the overheated climate we are increasingly experiencing. Communities and ecosystems will be profoundly impacted by these trends, to which they are currently not well adapted and often ill-prepared.

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[1] Aslak Grinsted, John C. Moore and Svetlana Jevrejeva, Homogeneous record of Atlantic hurricane surge threat since 1923 *PNAS 2012 ; published ahead of print October 15, 2012*

The costs of Hurricane Sandy are and will be massive. Hurricane Sandy highlights the costs of extreme weather events. Australia has also been hit by recent extreme weather events, including cyclone Yasi and the 2010-2011 Queensland floods, which highlight the risks to Australia of very costly extreme weather events. The Queensland floods of 2010-2011 are estimated to have caused over 1B$ in damage with a reduced GDP of around 30B$.

The extent to which climate change accelerates into the future is directly tied to the decisions we make today on fossil fuel burning and other activities that raise the levels of greenhouse gases in the atmosphere. In the future, devastating storms such as Hurricane Sandy and Cyclone Yasi will become much more common unless carbon dioxide levels are stabilised in the atmosphere at safe levels. This requires urgent action on carbon dioxide emissions.

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