Cyclone Amphan: link with climate change

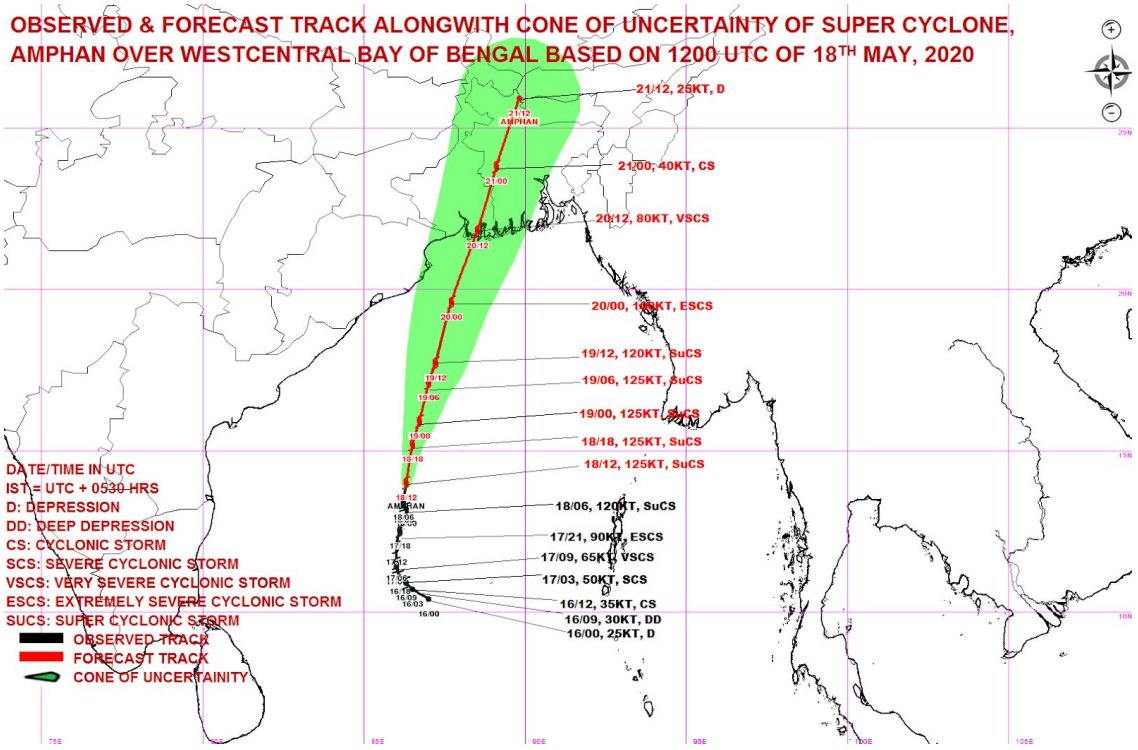
A record-breaking storm, Cyclone Amphan, is forecast to land in India and Bangladesh on Wednesday 20 May in the late afternoon local time (see track forecast below and live tracking here). Amphan is now the strongest storm on record in the Bay of Bengal, with sustained wind speeds of 270kmh, making it stronger than a 1999 super cyclone, and the joint-strongest on record in the North Indian Ocean.

Climate change is increasing the damage that cyclones like Amphan cause in several ways, including:

- Increasing sea surface temperatures which raises the maximum potential energy that a storm can reach
- Increasing the rainfall that drops during the storm,
- Raising sea levels, which increases the distance inland that storm surges reach,
- Causing storms to gain strength more quickly.

Reductions in air pollution across South Asia because of the Covid-19 restrictions may also have influenced the storm.

Cyclone Amphan Forecast Track - Source: Indian Meteorological Department



How climate change influences cyclones

The strongest cyclones have become more common across the world and scientists project that climate change will continue to make the strongest cyclones more powerful. The strength of cyclones affecting the countries bordering the North Indian Ocean has been increasing as the planet has warmed, according to multiple studies.

Climate change is increasing the danger from cyclones in several ways:

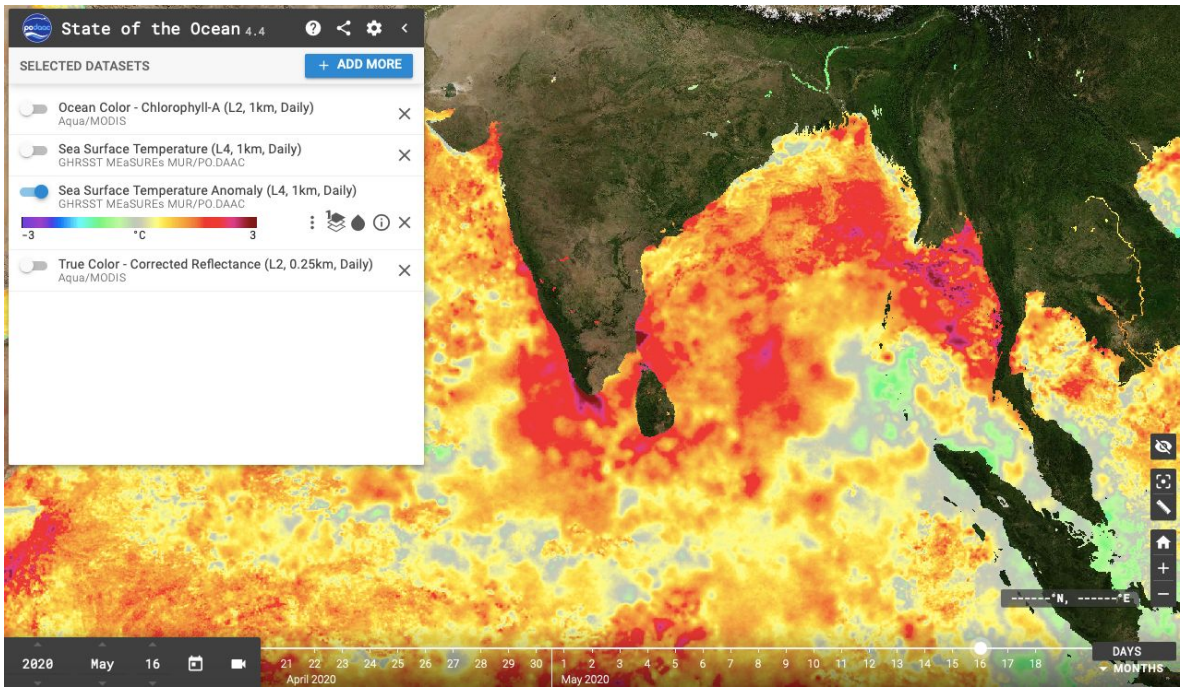
Temperature and storm strength

Cyclones are fueled by available heat. Warming seas can make cyclones more powerful, by increasing the potential energy available to them, effectively increasing their power ceiling or speed limit. Higher

sea-surface temperatures mean that cyclone wind speeds can increase. Globally, ocean temperatures have increased as a result of climate change - and there has been a global increase in the observed intensity of the strongest storms over recent decades. A study published the same week as Cyclone Amphan confirmed this trend, finding that the proportion of the strongest storms is increasing about 8% a decade.

Water in the Bay of Bengal was at record temperatures in May, driven by climate change (see quote by Dr Roxy Mathew Koll, below). These higher sea-surface temperatures increased the energy available to the storm:

Sea surface temperatures in the Bay of Bengal; colours show difference between long-term average temperatures and temperatures on 16 May, as Cyclone Amphan developed (see image above for location of Amphan on that date). Source: NASA



More intense rainfall

The planet's atmosphere is warming as a result of carbon emissions. A warmer atmosphere can hold more water, driving extreme rainfall during cyclones, which increases the threat of flooding. Scientists have directly linked the increase in atmospheric moisture with human-caused climate change. The number of record-breaking rainfall events globally has significantly increased in recent decades, as a result of global warming, and scientists predict that rainfall from cyclones will increase with continued climate change.

Scientists have linked particular cyclones and periods of heavy rainfall with climate change, using attribution studies. For example:

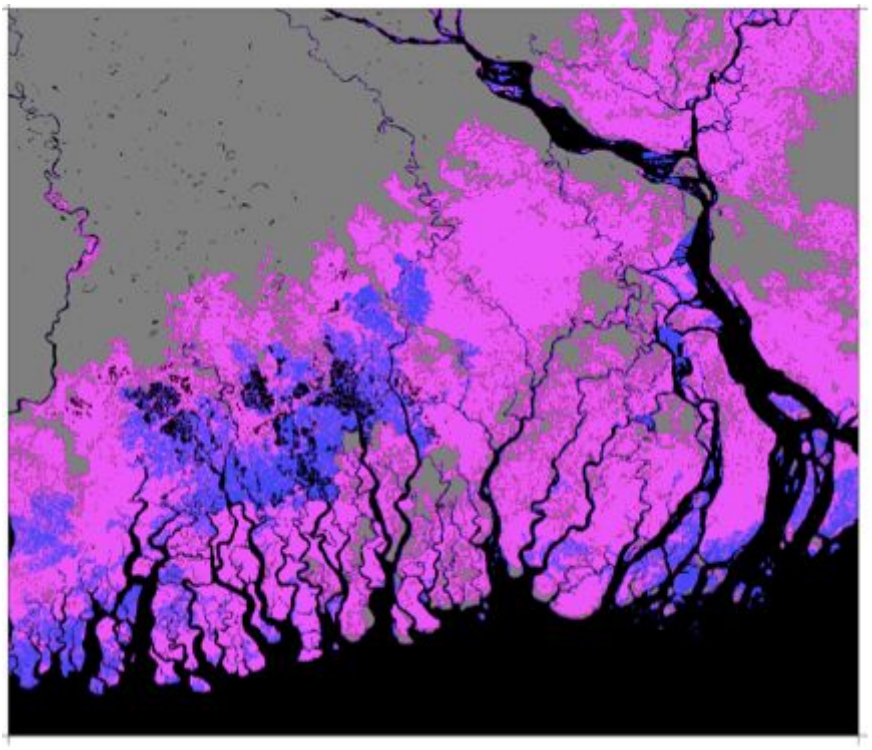
- Heavy pre-monsoon rain in Bangladesh in March 2017, which led to flooding, was made twice as likely by climate change.
- Hurricane Harvey, a major storm that caused catastrophic flooding in Texas in 2017, could not have produced as much rain as it did without human-caused climate change.
- The amount of rainfall in three major US hurricanes, Katrina, Irma and Maria, was increased as a result of human-caused climate change.
- The strong 2015 cyclone season in the Western North Pacific was mainly caused by high sea surface temperatures in the eastern and central Pacific, which was made "substantially" more likely by human-caused climate change.

Increased storm surges

The potential storm surge from Amphan may be among the most dangerous threats from the storm. Increases in storm surge related to climate change can be due to rising sea levels, increasing size, and increasing storm wind speeds. Global sea levels have already increased about 23cm as a result of human carbon emissions - dramatically increasing the distance that storm surges can reach. Sea levels in the North Indian Ocean have risen more quickly than other places in recent years.

India and Bangladesh could experience dramatic annual coastal flooding by 2050 (see map below), affecting 36 million people in India and 42 million in Bangladesh, according to a major 2019 study in the journal Nature.

Projected coastal flooding in Bangladesh by 2100 under a high-emissions scenario, affecting 42 million people. Source: Climate Central/Nature



Rapid intensification

A growing proportion of tropical cyclones are developing quickly, known as rapid intensification, according to multiple studies - these changes are linked with climate change. Warm ocean waters are one factor driving rapid intensification so higher ocean temperatures, caused by human greenhouse gas emissions, make it more likely.

Rapid intensification of a storm occurs if maximum sustained wind speed increases by 30 kts (approx 55kmh) in 24 hours. Cyclone Amphan intensified at more than twice this rate - between 1800 UTC 16/5/20 and 1800 UTC 17/5/20, intensity increased from 45 kts to 115kts (70 kts increase).

Rapid intensification is a threat because it makes it harder to forecast how a storm will behave and so to prepare before it makes landfall.

Rapid intensification is expected to continue to become much more frequent this century with continued climate change. One study found that intensification rates that happen once a century now could happen every 5-10 years by 2100.

Relationship with air pollution

There is a complex relationship between air pollution and cyclones and it is possible that reductions in air pollution in the region, due to the Covid-19 restrictions, may have influenced Cyclone Amphan.

Aerosols, from human-caused air pollution, can partly reduce the strength of cyclones in various ways (see Dr V Vinoj quote, below). One factor is that aerosols reduce the amount of sunlight reaching the Earth's surface, cooling it slightly. Reductions in air pollution may have slightly increased sea surface temperatures in the Bay of Bengal, adding to the effect of climate change. These factors suggest that reductions in air pollution would tend to increase cyclone strength.

But another factor that influences cyclone strength, wind shear, has the opposite relationship with air pollution. Higher air pollution tends to reduce wind shear, which generally allows stronger cyclones to form. So reduced air pollution could, in this respect, limit cyclone strength.

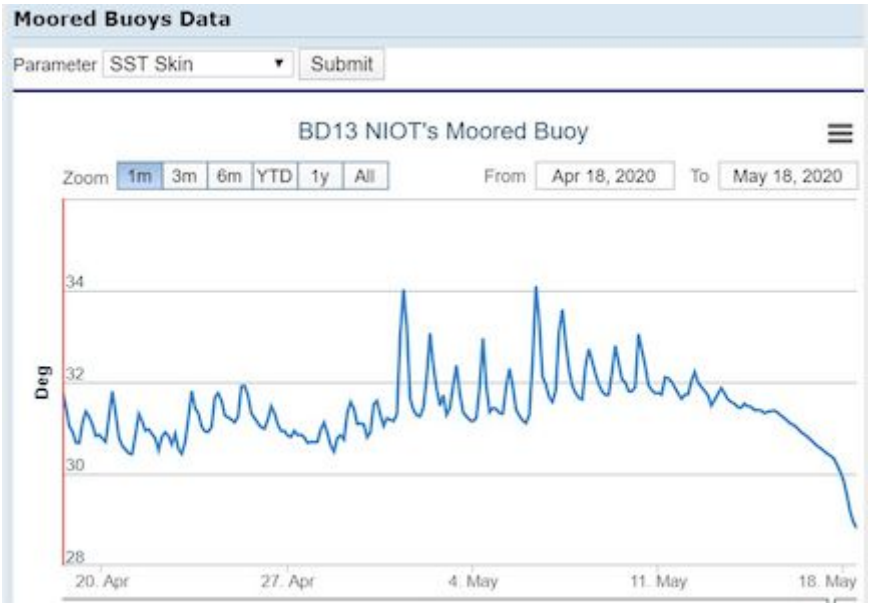
So while there may be a relationship between the reduction in air pollution, due to the Covid-19 restrictions, and Cyclone Amphan, it is too soon to say exactly what influence cleaner air has had on the storm. As governments continue to lower emissions and air pollution decreases in pursuit of Paris Agreement targets, it will be vital to understand this potential interplay, and consider its role in adaptation and resilience planning. It is understood however, that without lowering emissions rapidly, sea levels will continue to rise and severe storms can become more frequent, intense and dangerous.

Experts quotes

Dr Roxy Mathew Koll, Scientist, Indian Institute of Tropical Meteorology, Lead Author, IPCC Oceans and Cryosphere

"Our research shows that high ocean temperatures are conducive for rapid intensification of cyclones in the north Indian Ocean. In the current case, Bay of Bengal has been particularly warm, which may have had some role in the rapid intensification from a depression to a cyclone and then to a super cyclone in a very short time. For example, some of the buoys in the Bay of Bengal registered maximum surface temperatures of 32-34°C consecutively, for the first two weeks of May. These are record temperatures driven by climate change— we have never seen such high values until now. These high temperatures can super charge a cyclone since tropical cyclones primarily draw their energy from evaporation at the ocean surface.
The high sea surface temperatures were recorded by the INCOIS/NIOT moored buoys in the Bay of Bengal (attached). The temperatures drop once the depression/cyclone is formed."

"Cyclone Amphan intensified from a category-1 to category-5 in a short span of 18 hours"



Dr V Vinoj, Assistant Professor, School of Earth, Ocean and Climate Sciences, Indian Institute of Technology, Bhubaneswar:
"Global warming is leading to an increase in the heat content of the upper oceans around the globe. This is also true for the oceanic regions around the Indian region. This is one of the causes of the increasing number of cyclonic activities in our region during pre-monsoon times.

“However, what is different now than the past is the world's largest covid-19 lock-down in the south Asian region led by India. This lockdown has significantly reduced human emissions into the atmosphere. This decrease means that surface warming due to the removal of human-made aerosols has increased and atmospheric warming (due to those absorbing aerosols such as Black Carbon) has decreased significantly during this time. This surface warming extends over the waters in the Bay of Bengal. Therefore, the global warming effect which tends to increase the strength of cyclones, if any, is now amplified due to this human-induced lockdown effect. This may be the reason why Amphan has strengthened into a super cyclone, a second one only to the 1999 super cyclone.

“Overall, I feel lockdown may have strengthened this cyclone due to the additional warming of the ocean waters over the Bay of Bengal. This will need to be investigated in the future."

Simon Wang, Professor of Climate, Utah State University
“Last year set several new records for Indian Ocean cyclones. Was this an outlier year or a year that portends things to come? We can’t yet know. But we do know that the Indian Ocean is warming, and we know that warm ocean water is the first, and perhaps the key, ingredient for the formation of tropical cyclones, so the system is primed for more storms.”

“In our paper on Fani [in 2019], which was a terribly destructive cyclone, we noted that warming temperatures in the air and ocean surface have significantly intensified cyclones in the Bay of Bengal. And what we’re seeing now is that abnormally warm sea surface temperatures were present in the case of Amphan, too.”

Dr Saleemul Huq, Director of the International Centre for Climate Change and Development, Independent University Bangladesh

“Cyclone Amphan which is about to hit Bangladesh is going to compound the COVID19 pandemic as well as lockdown and social distancing measures. While Bangladesh has an enviable system of cyclone warning and cyclone shelters, it will be almost impossible to practice social distancing in those shelters.”