Global Warming Does Not Lead to More Typhoons

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Introduction

Particularly since the devastation of New Orleans caused by Hurricane Katrina in 2005, many people believe that global warming could lead to more frequent occurrences of intense hurricanes like Katrina. This conclusion seems to be intuitively obvious. Global warming not only leads to increases in air temperature, but the ocean temperatures will rise as well. A warmer ocean will cause more evaporation of ocean water into the atmosphere. The energy that is absorbed by the water molecules going into the atmosphere will subsequently be released through condensation of the water vapour. Because tropical cyclones (called typhoons in Asia and hurricanes in the Atlantic) are huge cloud systems over the ocean, more evaporation, and subsequently more condensation, means that more energy is available for the tropical cyclones to develop. Thus, it seems obvious that under a global warming scenario, not only should the frequency of occurrence of tropical cyclones increase, but they should also become more intense.

However, such a conclusion is inaccurate – at least for typhoons that affect Asia. The reason for this counter-intuitive statement is because of the incorrect and overly simplistic understanding of what causes a tropical cyclone to develop and become more intense. The following article describes the causes of typhoons and explains why, contrary to much public opinion, global warming does not lead to more frequent or severe typhoons. The more likely causes for variations in the frequency of typhoons are then discussed, together with possible implications for the insurance industry.

What causes the formation of a typhoon?

All tropical cyclones form over warm, tropical oceans. They begin as a large group of heavily-raining clouds, known as a cloud cluster. In these clusters, moist air rises rapidly upwards and condenses, forming the clouds. The condensed water droplets merge until they are too heavy for the rising air to support, and will fall as rain. The void created by the rising air will have to be replaced by air from the surroundings of the cluster. If the cluster exists in an environment in which the air is rotating in a counter-clockwise direction (for situations in the Northern Hemisphere), the air flowing into the cluster will bring in this rotation towards the centre of the cluster. As the air moves closer to the centre, it will have to spin faster to maintain its speed, and hence a tropical cyclone forms. As the rising air spirals to the upper part of the atmosphere, it will flow back to the air outside of the tropical cyclone. In doing so, it will spin slower to the point where the rotation becomes clockwise. An environment that has a clockwise rotation in the upper part of the atmosphere therefore facilitates the outgoing air to turn clockwise. Lastly, in the middle of the cyclone, the winds at the upper part must not be too much stronger than those near the ocean surface (the difference between the winds at the two levels is known as "vertical wind shear") to maintain the vertical integrity of the cloud, or else the vertical circulation will get "sheared." A smaller vertical wind shear is therefore also important.

Based on this simple description, it follows that for a tropical cyclone to form, several conditions must be met. These conditions can be grouped into two main categories: (i) those conditions related to heat energy and moisture (thermodynamic factors) and (ii) conditions related to winds (dynamic, or kinematic, factors). We need a warm ocean to provide the moisture and thus the clouds. But this is not enough. If the cloud cluster does not reside in an environment with sufficient counter-clockwise rotation, the cluster will not rotate fast enough and no tropical cyclone will form. Furthermore, the vertical wind shear near the centre of the cloud cluster must not be too large. If global warming is to bring about more frequent or severe tropical cyclones, it must not only produce a warmer ocean so that more moisture is available in the atmosphere (thermodynamic factors), it must also cause the atmosphere (a) to have a greater counter-clockwise rotation near the ocean surface in the regions where the cloud clusters form and (b) not to have a larger vertical wind shear than that in the present-day climate. The thermodynamic factors have indeed been found to become more favourable. However, no study has found an increase in counter-clockwise rotation under any global warming scenario. Some computer simulations also show that the vertical wind shear actually increases. Thus, although global warming can provide more heat energy to the atmosphere, this alone cannot produce more frequent or severe tropical cyclones since the dynamic factors may not provide the right environment. The thermodynamic factors therefore could be seen as the necessary conditions, while the dynamic factors are the sufficient ones.

In fact, no trend can be identified in the annual number or intensity of tropical cyclones in the Western North Pacific Ocean during the past 60 years, even while the water temperature in this ocean basin continues to climb – particularly in the past 30 years (as a result of global warming).

If no trend exists, then what is causing the record number of typhoons (i.e.,10) that hit Japan in 2004: the devastating typhoons Rusa and Maemi that hit the Korean Peninsula in 2002 and 2003 and typhoon Saomai, which hit East China in 2006? Are there trends in the number of landfalling typhoons in some locations? The answer is again negative. Instead, the frequency of typhoons, intense typhoons or landfalling typhoons at a particular location goes through large variations (or cycles) on time scales ranging from several years to decades. Such variations can be explained by similar variations in the atmospheric circulation or the ocean conditions, one of which is discussed below.

The effects of El Niño

El Niño is an ocean phenomenon that occurs in the equatorial Pacific Ocean. In a normal year, ocean temperatures in the western side of this ocean, along the equator, are warmer than those in the eastern side. Every few years, this situation reverses – generally around Christmas time, thus leading to the naming of this phenomenon as El Niño (the Spanish term for "the [Christ] Child"). An opposite situation also occurs every few years in which the ocean temperatures in the eastern side are much colder – a phenomenon now known as La Niña, the Spanish term for "the girl." Because a warmer ocean will cause more clouds and rain, as well as subsequent changes in the atmospheric circulation, the occurrence of an El Niño or La Niña lead to changes in winds not only along the equator, but in many places around the world.

For the Western North Pacific Ocean, changes in the atmospheric flow patterns during an El Niño lead to stronger counter-clockwise rotation in the southeastern part of the ocean basin, and hence more typhoons form in that region. Because they are farther away from land, they have more time to develop and can become more intense. In addition, typhoons have an inherent tendency to move northwest in the Northern Hemisphere. Therefore, in an El Niño year, more typhoons tend to make landfall in northern Asia (such as Korea and Japan). During a La Niña year, the opposite will occur, with more typhoons forming in the northwestern part of the ocean. Because they are closer to land, they have less time to develop, and so the number of intense typhoons in a La Niña year tends to be smaller. They also tend to make landfall in the southern part of East Asia, such as the Philippines, southern China and Vietnam.

Thus, variations in the frequency of typhoons, intense typhoons or landfalling typhoons at a particular location on time scales of a few years can largely be explained by the occurrence of the El Niño or La Niña phenomenon. Causes of variations on time scales of decades are still not known.

Implications for the insurance industry

Given the inconclusive result of the impact of global warming on typhoon activity, the insurance industry should not be overly concerned in projecting such activity under different global warming scenarios. However, even if typhoon activity is not continuously increasing, the rainfall intensity associated with typhoon events is likely to be higher because more water vapour is available in the atmosphere to be "squeezed out." Therefore, an important focus must be on the possible impact of flooding related to the landfalling typhoons. Indeed, in most places in Asia, damages from typhoons mostly come from flooding (due to heavy rain and storm surge) rather than wind destruction of properties. More studies must be carried out to identify possible trends in, as well as to make better predictions of, the amount of rainfall and rainfall intensity. Better tools to estimate flood potential arising from typhoon landfalling events should also be developed.

Because of the importance of the El Niño phenomenon in determining typhoon activity, a better prediction of the phenomenon would be useful. Unfortunately, even the most sophisticated computer models cannot make accurate predictions of El Niño more than six months in advance.

Conclusion

Arguably, global warming does not lead to more frequent or severe typhoons. Typhoon development does not depend simply on the amount of heat energy provided by the ocean to the atmosphere, but also on the amount of rotation in the atmosphere, which has not been shown to have increased under global warming. Thus, focus should be on the variations of typhoon activity on time scales of a few years that are largely governed by the occurrence/absence of the El Niño/La Niña phenomenon. Causes for longer-time variations are still not known, and more research is required.

About Guy Carpenter Asia-Pacific Climate Impact Centre

The Guy Carpenter Asia-Pacific Climate Impact Centre was established in June 2008 with the mission to become a leading centre in the Asia-Pacific region in research on climate-related perils. Since its inception, the Centre has been conducting research activities that focus four main areas: typhoons/tropical cyclones, monsoons, general climate, and air pollution studies. Apart from research papers and forecasts, the Centre also delivered numerous presentations in conferences worldwide and appeared in various media to address climate-related issues.

Major reports and articles from the Centre can be found on Guy Carpenter's intellectual capital website - GCCapitalIdeas.com

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