

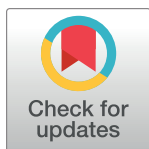
OPINION

Links between climate change and hurricanes in the North Atlantic

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There is no doubt that global warming is altering weather patterns and climatic trends all over the world, yet how Earth's changing climate is affecting hurricanes is still not fully understood. Hurricanes are powerful tropical cyclones (TCs) that develop in the warm waters of our planet's oceans. They are known as typhoons in the West Pacific and cyclones in the Indian Ocean. Hurricanes are mostly powered by warm tropical waters, and it is well established that ocean temperatures in areas where TCs form have been rising since the mid-20th century [1].

In recent years we have witnessed powerful hurricanes that have exhibited record-breaking, rapid intensification. They have produced extreme rainfall that has led to flash floods and landslides, and have caused severe storm surges that have impacted many coastal environments and communities. Over the past three decades the Caribbean in the North Atlantic basin has been particularly affected by hurricanes, creating hazardous conditions and putting water resources in jeopardy.

Many studies have examined the relationship between climate change and hurricane frequency and intensity in the North Atlantic basin. The results of these analyses suggest that warmer sea surface temperatures (SSTs) associated with climate change are a major factor in the increased frequency of hurricanes [2]. Several studies have found that the total number of major hurricanes in the North Atlantic is increasing [3] and that this is associated with higher SSTs and more humid environments [4].

However, other researchers have found that the increase in the total number of hurricanes may be associated with an undercounting of storms in the pre-satellite era [5] and that it may also be related to teleconnections like the El Niño Southern Oscillation (ENSO) and the Atlantic Multidecadal Oscillation (AMO), which promote changes in vertical wind shear and SSTs that could enhance or suppress TC development [6]. A recent study has found an increase in the total number of off-season TCs [7], that could be associated with climate change.

The latest research suggests that both climate change (higher ocean heat, sea surface temperature and cloud cover moisture) and climatic variability (ENSO and AMO) might explain the increase in the total number of tropical cyclones and major hurricanes in the North Atlantic (Fig 1A), with climate change factors being more statistically significant [4]. Even though recent research has found that the total number of tropical cyclones has increased in the North Atlantic, it is still not clear how much of that increase in activity and intensity can be attributed to climate change.

Researchers have found that the increase in hurricane intensity in the Atlantic basin is strongly correlated with an increase in the late summer / early fall SSTs that have been attributed to climate change [8]. When researchers examined the total power dissipation and accumulated cyclone energy (ACE) by TCs, they found that storm intensity (Fig 1A) in the latter

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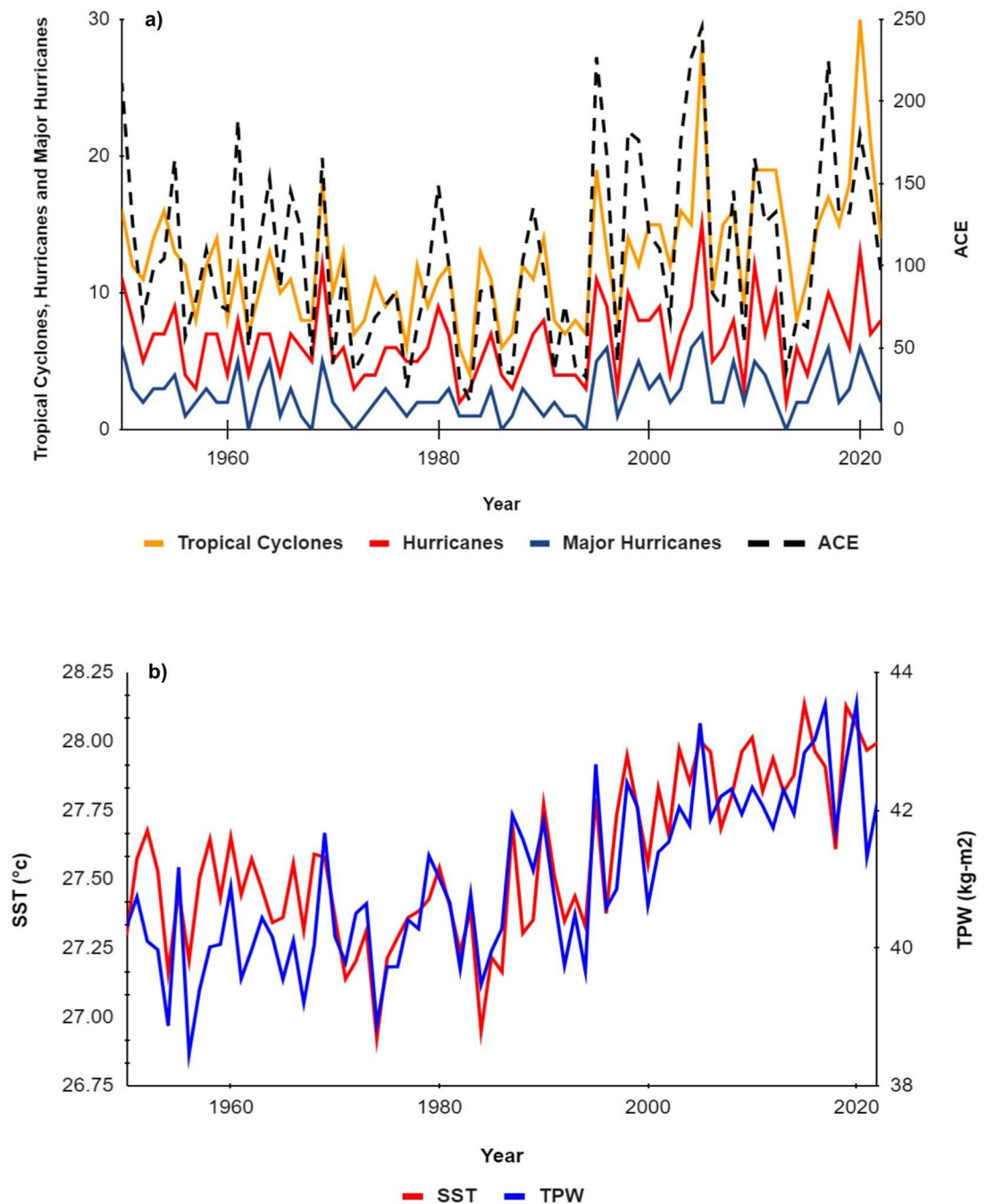


Fig 1. Total number of tropical cyclones, hurricanes, major hurricanes and accumulated cyclone energy from 1950 to 2022 in the Atlantic Ocean (a). Area average sea surface temperature (SST) and total precipitable water (TPW) for August-September and October from the ERA 5 reanalysis dataset for the tropical and subtropical Atlantic for the 1950–2022 period (b), the graph shows an increasing trend in both SST and TPW during the most active months of the hurricane season.

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half of the 20th century was strongly correlated with higher SSTs during the most active months (Aug/Sep/Oct) of the hurricane season [2].

Another major study on the topic found that climate change is likely responsible for warming trends since the mid-1950s in the tropical waters of the North Atlantic [9] and that, in addition, aerosol cooling during the same period has prevented even more powerful

hurricanes from developing and intensifying [10]. A review examining the relationship between hurricanes and climate change found that modeling studies project an increase of 2–1% in the global average TC intensity by 2100, yet on the other hand, the same analysis estimates a 6–34% decrease in storm frequency [11].

A more recent study on the topic found that seasons with many major hurricanes, like the 2017 season, had ideal conditions (weaker wind shear, higher ocean heat content) that were enhanced by both climate variability factors like AMO and climate change [12] (Lim et al. 2018). The latest research shows that the main contribution of climate change to increasing Atlantic TC activity comes from increasing potential intensity [13] (Emmanuel, 2021).

An area of tropical cyclone research that has been garnering much attention from atmospheric scientists who focus on the Caribbean is the role that climate change plays in the extreme rainfall produced by hurricanes. Since hurricanes are an essential part of Earth's energy transport and cooling system, we can expect that the excess heat will also lead to higher moisture levels (Fig 1B) and eventually more cooling via extreme precipitation accumulations.

Recent studies on the subject have found that climate change is enhancing the atmospheric and oceanic conditions that are making hurricanes produce record-breaking extreme rainfall [14]. Warmer ocean waters, fueled by the excess heat trapped by greenhouse gases, are causing an acceleration of the hydrologic cycle in the areas where hurricanes form, which then leads to higher precipitable water rates in the atmosphere.

Researchers examining powerful hurricanes like Hurricane Maria (2017) have found that climate change made the rainfall associated with the storm more extreme than usual [15]. Recent work on the most active hurricane season on record (2020) has found that climate change was a major factor behind the record-breaking 30 tropical cyclones and the total hurricane rainfall in the North Atlantic basin [4]. However, more research is needed to determine how much of the increase in extreme precipitation associated with hurricanes can be attributed to climate change.

So, what are scientists telling us about the relationship between hurricanes and climate change in the North Atlantic?

First, there is still no agreement on whether climate change is producing or will produce a higher number of storms. However, one point on which the experts do agree is that climate change is a major factor when it comes to trends in TC intensity. Scientists are also starting to find common ground regarding the role that climate change plays in the extreme precipitation associated with hurricanes (Hurricanes Maria, Fiona etc.). Recent research suggests that climate change is enhancing the conditions that will promote higher rainfall accumulations from hurricanes in the North Atlantic. Further research will help us understand how climate change continues to affect hurricane frequency and intensity, as well as rainfall.

Author Contributions

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