How Global warming has affected cyclonic activity

This story map will discuss how global warming has changed the intensity, number of and location of hurricanes over the years.

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Overview

Cyclones or hurricanes are one of the most powerful and destructive natural disasters to occur on Earth. These storms form over very warm ocean water (80 degrees plus) and feature strong winds, heavy rainfall, and widespread damage. Hurricanes end up costing the US billions of dollars in damages per year. As global temperatures rise, there is likely to be an increase in storms as well as an increase in the intensity and poleward extension of these storms. This story map will dive into the research behind this.

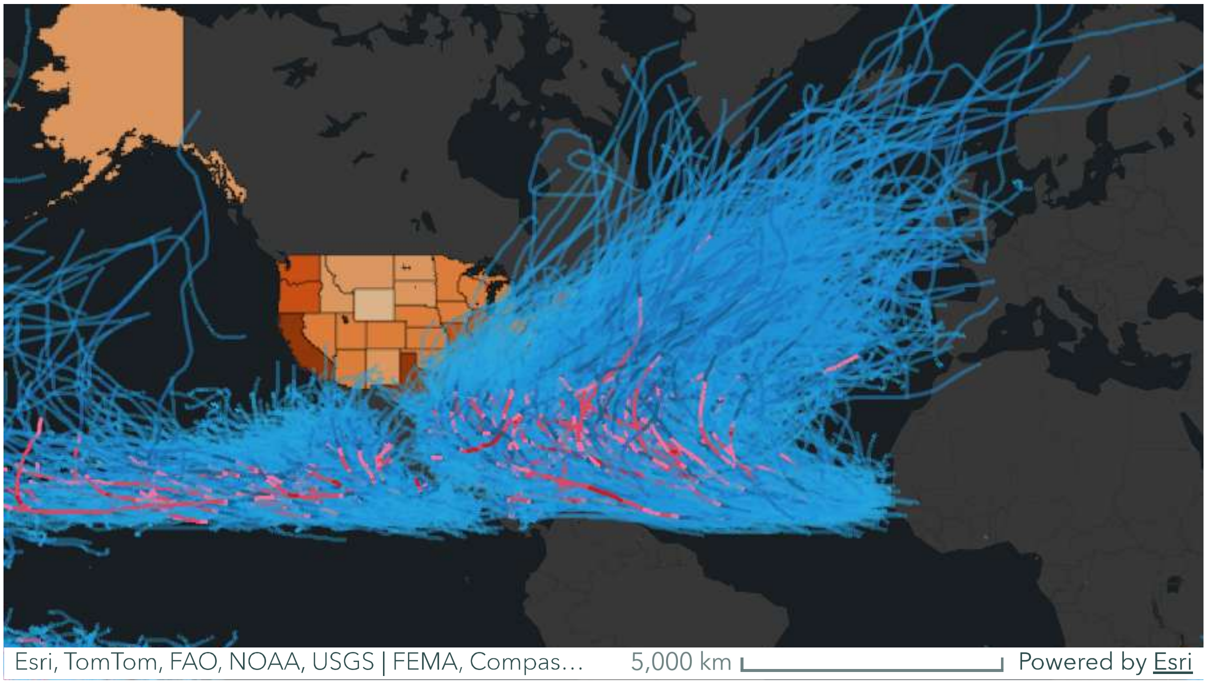

Fig 1: Hurricane tracks vs. National expected loss to show the economic impact of hurricanes

This map shows that the areas that have the highest national expected loss are areas that frequently deal with hurricanes which can indicate that hurricanes are an important disaster for the United States and this shows encouragement toward research in this field.

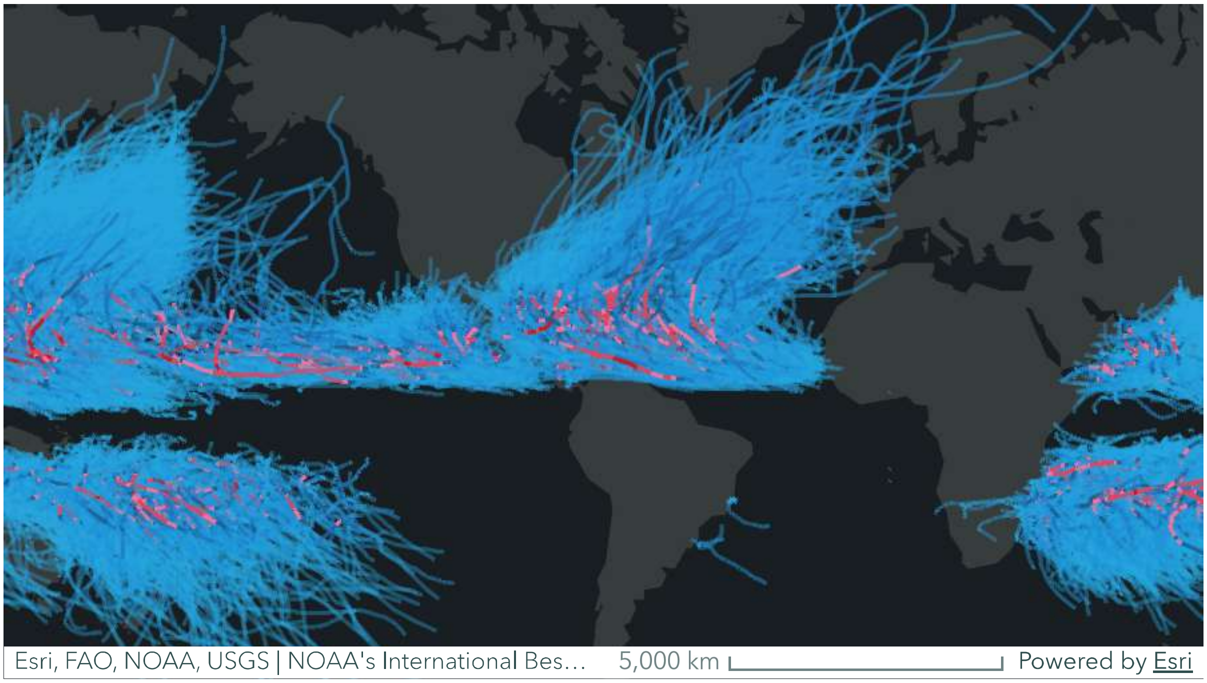

Fig 2: 1981-2010 average Sea surface temperatures vs. historical hurricane paths (red is 80 degrees and above) to show how specific sea surface temperatures affect where cyclones develop and how intense they get.

This map shows that hurricanes occur more frequently and stronger in the area where temperatures are very warm (80 degrees and above). I also noticed from this map that storm do occur in colder waters as well but do not get to higher strengths which is important to note for how warmer temperatures effects hurricane intensity as well as frequency for the relationship between temperature and frequency of cyclones.

How does Global Warming affect Hurricanes Intensity and Wind Speeds?

The way global warming affects cyclones in terms of rainfall intensity and wind speeds is it increases rainfall intensity and increases wind speeds. The reason rainfall intensity increases is because warmer air can hold more moisture leading to an increase in evaporation from the ocean and higher atmospheric water vapor content.

The reason it increases wind speeds is because warmer oceans will cause more energy for the storm to form and gain strength.

This is being shown by many climate organizations. According to the American Mediological Society, “The mean intensity and size were projected to increase by 6.4% and 1.5% for a 2°C warming, respectively. We found that tropical cyclones embedded in historically warmer oceans and more stable atmospheres intensified more than the others, while historically wetter and windier environments promoted larger size growth. Our results suggest that certain tropical cyclones can exhibit a greater increase in intensity and size in a warmer climate under favorable environmental conditions.”(Emanuel et al., 2008). Research by Emmanual also indicates that warmer sea surface temperatures enhance the hydrological cycle, which causes higher moisture levels which lead to more intense and higher levels of precipitation. (Mendelsohn et al., 2012). Another study by Knutson projects that there will be a 10-15 percent increase in precipitation rates for tropical cyclones if the world warms by 2 degrees Celsius. Wind speeds are also projected to increase by 1-10%. (Sirutis et al., 2015). A third study by the American Geoscience Institute showed us that windspeeds are projected to increase by 3-5 percent for every degree Celsius of warming as well as category 5 hurricanes increasing in frequency by about 4-5% per degree Celsius. These studies all align with the fact that Global warming does indeed increase rainfall intensity and wind speeds.

If storms increase in rainfall intensity and wind speeds, do overall storms increase? Do intense storms increase?

The frequency of overall storms won't necessarily increase. According to the American Mediological Society, "Storm frequency decreases in the Southern Hemisphere and north Indian Ocean, increases in the western North Pacific, and is indeterminate elsewhere."(Emanuel et al., 2008). Another article from the same journal also backs this up by saying "Historical and observational data on

Hurricanes and tropical cyclones are relatively robust, it is clear that storm frequency has not tracked recent tropical climate trends. Research on possible future changes in hurricane frequency due to global warming is ambiguous, with most studies suggesting that future changes will be regionally dependent, and showing a lack of consistency in projecting an increase or decrease in the total global number of storms"(Landsea et al.,2005) However there will be an increase in intense storms and out of the storms that do happen they are more likely to be intense than before. According to the Business of Global Warming "In the latter half of the 20th century, the Atlantic Ocean averaged one Category 5 hurricane every three years; this century, it has averaged more than one per year."(NewsRx, 2008). This shows that the high-intensity storms are increasing. According to In this journal, it then goes on to quote the IPCC and says that they predict more intense hurricanes. (NewsRx, 2008). A projection by the Representative Concentration Pathways 8.5 (RCP8.5) in the future climate (2074–2100) scenarios also shows that this is not going to get better as time progresses. "In the warmer climate, the LMI of very intense TCs in WNP are projected to be stronger. Such an increase in intensity is statistically significant and can be primarily explained by an enhanced intensification rate. Meanwhile, TCs among the top 5% in LMI can reach higher intensities which cannot be attained in the current climate. After downscaling, the probability of WNP TCs reaching Category 4–5 increases by 6.5 percentage points in the late 21st century. This increase is 1.7 percentage points higher than the increase projected exclusively by HiRAM. Moreover, for TCs among the top 5% in LMI, a 233-km and 300-km westward shift of LMI locations is identified in the late 21st century for simulations with and without the downscaling approach, respectively."(Chand et. al., 2022). Below is an interactive map to show hurricanes over the 150 years or so to show how hurricane activity has changed over time as the earth has warmed to give you a visual representation.

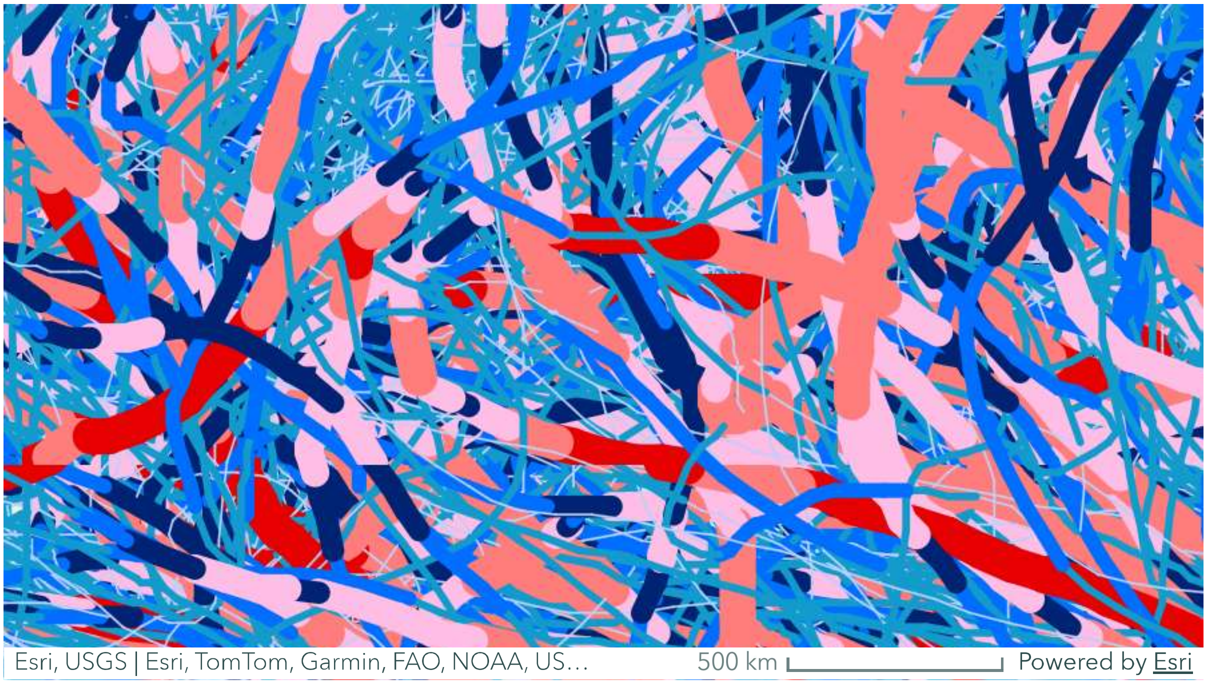

Fig 3: Hurricanes over time in 17 year phases to show how hurricanes paths number and intensity has progressed in a warming world

As you can tell from this map, the number of cyclones was relatively steady over time with some decades being higher than others but no clear trend of increasing or decreasing cyclones. However, the higher intensity cyclones became more and more common as time went on with the highest intensity cyclones becoming more common as well.

Figure 2 also backs up this claim by showing average sea surface temperature versus hurricane paths and it shows that when water temperatures are 50 degrees and above (green is 50 degrees) storm will form. It is also important to note that areas with 50 degree water didn't have significantly fewer cyclones than areas with 80-degree water. Showing that if sea surface temperatures are increasing due to global warming it won't necessarily affect the number of cyclones per season (particularly in areas already hit by cyclones that have sea surface temperatures like this year round). However, in areas with higher sea surface temperatures (80 degrees and above) hurricanes increased in intensity significantly. This proves that if sea surface temperatures rise the number of storms per season won't increase but the intensity in those areas will and it may even cause poleward expansion of hurricanes due to warm waters becoming more common in areas that would not normally see these warm waters.

How has Global Warming affected the poleward expansion of cyclones? How does this effect vulnerable communites?

Global Warming can lead to a poleward extension of cyclone activity including their extension of maximum intensity which essentially means that hurricanes are becoming more common at places further away from the equator and are stretching farther and farther away from the equator. This has been proven by DJF storm tracking densities where they say “Looking at the two oceanic storm tracks individually, an apparent poleward shift of the storm track is seen in the North Pacific”(Chih et al.,2024). It also means that hurricanes are hitting maximum intensity farther away from the equator than ever before. This can cause a huge impact on vulnerable populations that would not have had an impact if it weren’t for global warming. This is extremely problematic because these people are especially vulnerable because these areas are not prepared to handle cyclones. Some impacts on people who are lower income are in homes that don’t have as well-built infrastructure so they can’t withstand the impacts of hurricanes as much. This leads to higher rates of damage, displacement, and loss of life. The extension of cyclonic activity also impacts access to clean water and sanitation, exacerbating effects on the elderly. Another effect is threats to culture and way of life because hurricanes can damage areas important to culture. A thing to also consider is repeated vulnerability. When homes get damaged by hurricanes, especially in hurricane hotspots, and don’t have the time to recover, this can lead to even worse damage the second time around because of damage left the first time making the impact a lot worse and the recovery a lot longer. Also, worse damage in poorer communities leads to problems with aid distribution from damage and infrastructure bottlenecks. (Yamada et al.,2017). In order to understand exactly how poleward expansion affects the vulnerable we must show how hurricanes have impacted the vulnerable in the past. The map below shows us what low-income areas are hit by hurricanes frequently as well as what low-income areas are hit by strong storms frequently.

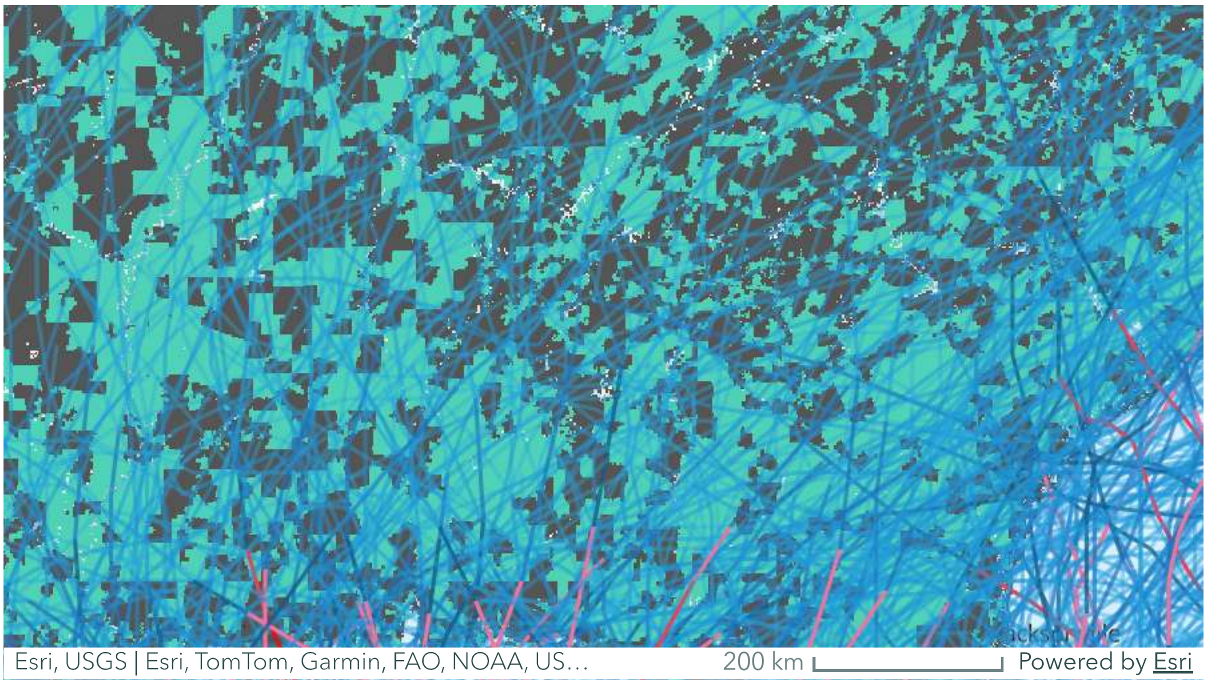

Fig 4: Hurricane Paths versus low income communities to show which low income areas are hit the hardest by hurricanes.

The reason I included this map is because it shows us where we can direct our aid and build hurricane-resistant infrastructure so that low-income areas aren't impacted as badly as they usually are since poleward expansion will likely cause these areas that are already hit by cyclones to get hit by stronger more dangerous cyclones as the globe continues to warm. Now we can talk about targeted mitigation strategies aimed at helping these communities.

Some things we can do that address these impacts on vulnerable communities include building hurricane-resistant infrastructure, being better prepared for these disasters, improving response systems, and ensuring equitable distribution of aid. The way that we would do this would require both national and international funding. It would also be helpful if we got private sector involvement through private-public partnerships to increase funding as well as get new ideas. Another thing we could do which might be more cost-effective is to use nature-based solutions in these areas. This could include restoring mangroves and wetlands which provide natural barriers to storm surge and flooding. According to Narayan et al. (2016), "Using an extensive database of property exposure, the regional study shows that wetlands avoided $625 Million in direct flood damages during Hurricane Sandy. The local study combines these models with a database of synthetic storms in Ocean County and estimates a 16% average reduction in annual flood losses by salt marshes with higher reductions at lower elevations."(Narayan et al., 2016). This proves that we can significantly reduce the economic impact of hurricanes as well as other coastal hazards. Doing this as well as the other measures I mentioned above can have a significant impact on protecting these communities.

Conclusion

If we want to stop these effects we have to do everything we can to stop the warming so the cyclones are less intense and less damage is done. If we want to prevent this in vulnerable communities we have to give funding to create assistance to these communities when disaster hits so they can recover with the rest of the population.

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