Tropical cyclones: global decline in frequency

Article

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TROPICAL CYCLONES

Global decline in frequency

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Quantifying historical trends in tropical cyclone activity has proven difficult, but a new reconstruction reveals a clear global decline over the last century, driven by an increasingly cyclone-hostile environment in the troposphere.

Tropical cyclones, including hurricanes and typhoons, rank among the costliest natural hazards. Understanding how—and why—tropical cyclone activity is changing globally in warming climate is profoundly important. However, the large natural variability of tropical cyclone frequency, combined with only a few decades of reliable, satellite-era observational data, make quantifying long-term historical trends and attributing trends to natural versus anthropogenic factors substantial scientific challenges. Writing in *Nature Climate Change*, Savin S. Chand *et al.*[1] reconstruct a global, long-term record of tropical cyclone frequency stretching back to 1850 and identify significant downward trends over the twentieth century. Their analysis shows the global tropospheric environment has become increasingly hostile to tropical cyclone formation over the last century, driving this decline.

Tropical cyclones are born from 'seeds'—tropical waves or rotating clusters of individual thunderstorms—over a period of hours to weeks. This occurs at low latitudes over warm tropical oceans and, usually, at least a thousand kilometres from the equator, where planetary rotation is sufficient to aggregate convective activity into a coherent vortex. Once formed, tropical cyclones typically move westward and poleward before reaching the midlatitudes, where a cooler ocean surface weakens them, or they transform into frontal weather systems.

Climate change is expected to affect the thermodynamic conditions that engender tropical cyclones, altering the frequency[2,3], intensity[4-6], spatial distribution[5,7,8], and seasonality[4,9] of these storms. Quantifying historical trends and projecting changes over the coming decades remain subjects of intense research. Globally, researchers have identified poleward shifts in the latitude at which tropical cyclones form[10] and reach their maximum intensity[5], and an increasing proximity of storms' maximum intensity to coastal regions[8]. Therefore, geographical shifts in where tropical cyclone landfall can occur may be already spreading risks to regions previously seldom hit. The proportion of intense tropical cyclones has increased over recent decades[2,6,11], and the number of North Atlantic tropical cyclones reaching the midlatitudes may also be rising[12]. When Hurricane Sandy struck the greater New York metropolitan area in 2012, it brought the human and economic implications of tropical cyclone changes into sharp focus.

Longer-term trends in tropical cyclone frequency, however, are uncertain[3,4]. Most studies address just the last few decades because tropical cyclone records and other observational data are less reliable prior to the satellite era[3,13-15] (since 1979). Pre-satellite observations were made from restricted aerial or ship-based reconnaissance, and storms are missing from official records[15]. These data issues hinder delving back into pre-industrial decades, but *reanalyses*, globally consistent climate datasets created by combining observational data with a physical weather-forecast model, offer a way forward[12,16]. To examine long-term trends, Chand *et al.*[1] use twentieth-century reanalyses, based on sea-level meteorological quantities that are relatively well observed over the last century. Historical changes in the global observational network, which may introduce spurious trends, are therefore minimised. Tropical cyclone data were extracted from a recent reanalysis using objective detection algorithms, creating a proxy reconstruction of activity over time.

Chand *et al.*[1] find a global decrease in tropical cyclone frequency of around 13% over the twentieth century compared with the pre-industrial (1850–1900) baseline. A steeper decline is seen after 1950, coinciding with recent accelerated warming. An exception is the North Atlantic, where activity has declined since 1850, but increased since the 1960s. Although questions remain about the reliability of pre-satellite (and certainly pre-1900) data, these results place the observed global decrease since 1990[2], which is dominated by North Pacific trends, into a longer-term context. Chand *et al.*[1] also find evidence for multiannual to decadal variability superimposed onto secular trends. The La Niña–dominated climate state over recent decades has likely suppressed Pacific and favoured Atlantic tropical cyclone activity[2]. In the Southern Indian Ocean, influence of the Pacific Decadal Oscillation, a long-lived, El Niño-like pattern of Pacific climate variability, is seen on tropical cyclone numbers. In the North Atlantic, the persistent warm (positive) phase of Atlantic Multidecadal Variability, alongside reduced aerosol forcing, have contributed to the increase in this basin. Overall, global downward trends remain robust after accounting for the effects of natural climate variability, but the regional details are important.

Is there a human fingerprint on falling tropical cyclone counts? Chand *et al.*[1] address this by examining two large ensembles of climate model experiments: historical simulations (including natural and anthropogenic climate forcing) are compared with pre-industrial control simulations (including only natural forcing). Models simulate a decline in tropical cyclones when anthropogenic factors are included, consistent not only with the reconstruction but also a wealth of existing modelling studies[4] (with a median decrease of 13 % for a 2 °C increase in global-mean surface temperature), although increases have also been projected[17]. Although the models analysed do not reproduce the reconstructed decline in North Indian Ocean tropical cyclones, an example of where model biases obscure the drivers of regional climate trends, the global similarity of reconstructed and model-simulated declines is compelling. However, a key limitation of current, 'high-resolution' global climate models (and reanalyses) is that typical resolutions (around 0.5 º) do not resolve the mesoscale processes that are important for tropical cyclone genesis and intensification. Research with state-of-the-art, storm-resolving models (km-scale) is needed to explore how these processes influence global and regional trends and deepen our understanding.

With these limitations in mind, Chand *et al.*[1] attempt to explain the reconstructed decline by analysing the large-scale environmental factors that reanalyses and models are able to capture. Three environmental quantities—vertical wind shear (which inhibits tropical cyclone development), mid-tropospheric mass flux (an indicator of deep convection), and saturation deficit (mid-tropospheric dryness)—were combined into a single measure of environmental favourability for tropical cyclones. This novel composite index shows a global decline since 1850, providing evidence that the tropospheric environment has become increasingly unfavourable for tropical cyclone formation. Chand *et al.*[1] hypothesise that the observed weakening of the two major global atmospheric circulations, the Walker and Hadley circulations, is reducing tropical deep convection and mid-tropospheric humidity—both hostile to tropical cyclones.

Improvements in models' ability to resolve cyclone processes across spatial scales will offer opportunities to test these ideas. Also needed are studies comparing multiple indices of environmental change and efforts to estimate observational uncertainty in the pre-industrial and early twentieth century. In looking at the last century, Chand *et al.*[1] raise questions about how well we understand complex tropical cyclone changes and how models may complement flawed observations. By continuing in this direction, we may advance our ability to attribute change to anthropogenic warming and refine projections for the next century.

Figure suggestion

- A simple time series of (i) global TC count and (ii) global composite environment index, with a caption making use of text from the penultimate paragraph of my draft text. If Chand et al. can provide their raw data files (either text files of netcdf), I can make this figure. I would only need the global-average data, so just two data series.

Competing interests

The author declares no competing interests.

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