Brief Communications Arising

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Meteorology: Hurricanes and global warming

Christopher W. Landsea[1 (#a1)]

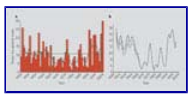
Abstract

Arising from: K. Emanuel **Nature 436, 686–688 (2005)** (http://dx.doi.org.offcampus.lib.washington.edu/10.1038/nature03906) ; K. Emanuel **reply** (/nature/journal/v438/n7071/full/nature04427.html) .

Anthropogenic climate change has the potential for slightly increasing the intensity of tropical cyclones through warming of sea surface temperatures[1 (#B1)]. Emanuel[2 (#B2)] has shown a striking and surprising association between sea surface temperatures and destructiveness by tropical cyclones in the Atlantic and western North Pacific basins. However, I question his analysis on the following grounds: it does not properly represent the observations described; the use of his Atlantic bias-removal scheme may not be warranted; and further investigation of a substantially longer time series for tropical cyclones affecting the continental United States does not show a tendency for increasing destructiveness. These factors indicate that instead of "unprecedented" tropical cyclone activity having occurred in recent years, hurricane intensity was equal or even greater during the last active period in the mid-twentieth century.

My first concern is that Emanuel's figures[2 (#B2)] do not match their description: his Figs 1–3 aim to present smoothed power-dissipation index (PDI) time series with two passes of a 1-2-1 filter, but the end-points — which are crucial to his conclusions — instead retain data unaltered by the smoothing; this is important because the last data point plotted in Emanuel's **Fig. 1** (#f1) is far larger than any other portion of the time series. Even after adding last year's busy hurricane season into the analysis and then properly using the filter, as described, the crucial end-point of the smoothed time series no longer jumps up dramatically in the last couple of years (**Fig. 1a** (#f1)). About one-third of the increase in Atlantic PDI in Emanuel's graph for the past ten years is incorrect owing to inappropriate plotting of the data, even if the active 2004 season is incorporated.

Figure 1: Derivation of Atlantic power-dissipation index (PDI).
(/nature/journal/v438/n7071/fig_tab/nature04477_F1.html)


(/nature/journal/v438/n7071/fig_tab/nature04477_F1.html)

a, Emanuel's bias-correction version[2 (#B2)] of PDI for the North Atlantic tropical cyclones for 1949–2004. PDI takes into account frequency, duration and intensity of tropical cyclones by cubing the winds during the lifetime of the systems while they are of at least tropical-storm force (18 m s^{-1}) and summing them up for the year. Values shown are multiplied by 10^{-6} in units of m^3 s^{-3}. Horizontal line, time-series mean of 10.8; black curve, data after smoothing with two passes of a 1-2-1 filter. b, Three versions of the smoothed PDI for the North Atlantic using: dashed line, Emanuel's applied bias-removal scheme; dotted line, 1993 version[3 (#B3)] of the bias-removal scheme; solid line, original hurricane database. All three versions are identical from 1970 onwards.

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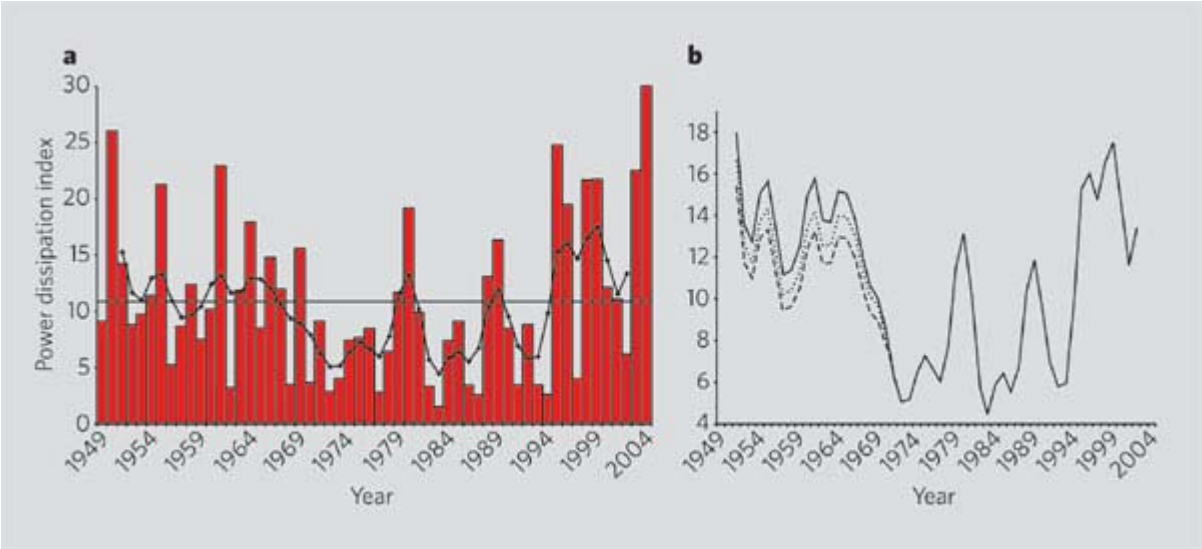

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High resolution image and legend (30K)
(/nature/journal/v438/n7071/fig_tab/nature04477_F1.html)

A second concern is the bias-removal scheme used to alter the data for the Atlantic for 1949–69. Emanuel can demonstrate "unprecedented" activity in the past ten years only by markedly reducing the tropical-cyclone winds for the first two decades of the time series. He attempts to use a bias-removal scheme[3] (#B3) that recommends reduction of the tropical-cyclone winds by 2.5–5.0 m s^{-1} for the 1940s–60s because of an inconsistency in the pressure–wind relationship during those years compared with subsequent (and presumably more accurate) data. However, the function used by Emanuel to reduce the winds in the earlier period goes well beyond this recommendation, as the bias removal used continued to increase with increasing wind intensity and reached a reduction of as much as 12.2 m s^{-1} for the strongest hurricane in the 1949–69 original data set.

In major hurricanes, winds are substantially stronger at the ocean's surface[4,] (#B4) [5,] (#B5) [6,] (#B6) [7] (#B7) than was previously realized, so it is no longer clear that Atlantic tropical cyclones of the 1940s–60s call for a sizeable systematic reduction in their wind speeds. It is now understood to be physically reasonable that the intensity of hurricanes in the 1970s through to the early 1990s was underestimated, rather than the 1940s and 1960s being overestimated[8] (#B8). To examine changes in intensity over time, it is therefore better to use the original hurricane database than to apply a general adjustment to the data in an attempt to make it homogenous.

Figure 1b (#f1) shows Emanuel's bias-removed smoothed curve and the substantially larger PDI values in the original hurricane data set; the latter indicates that amplitudes for 1949–69 are comparable to those for the most recent decade. This is consistent with earlier work[9,] (#B9) [10] (#B10), emphasizing the large multidecadal oscillations in activity. It is also likely that values of PDI from the 1940s to the mid-1960s are substantially undercounted owing to the lack of routine aircraft reconnaissance and geostationary satellite monitoring of tropical cyclones far from land.

A third concern is that it is difficult to separate out any anthropogenic signal from the substantial natural multidecadal oscillations with a relatively short record of tropical-cyclone activity. One way to extend the PDI analysis back to include several additional decades of reliable records is to examine only those tropical cyclones that made landfall along populated coastlines[11,] (#B11) [12] (#B12). **Figure 2** (#f2) shows that tropical-cyclone activity in the United States was generally extremely busy between the 1930s and 1960s, but fell below average between the 1970s and early 1990s. Despite the extreme value for 2004, the most recent decade has a PDI that is near-average for the United States, rather than showing an increase in the overall number and intensity of hurricane strikes.

Figure 2: The continental United States PDI at the time of impact for the reliable-period record of 1900–2004.
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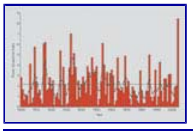
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This is computed from the best estimate of the peak sustained (1 min) surface (10 m) winds to have affected the US coastline for all tropical storms, subtropical storms and hurricanes causing at least gale-force (18 m s^{-1}) winds. Values shown are multiplied by 10^{-5} in units of m^3 s^{-3}. Horizontal line, time-series mean; black curve, data after smoothing with two passes of a 1-2-1 filter. For the

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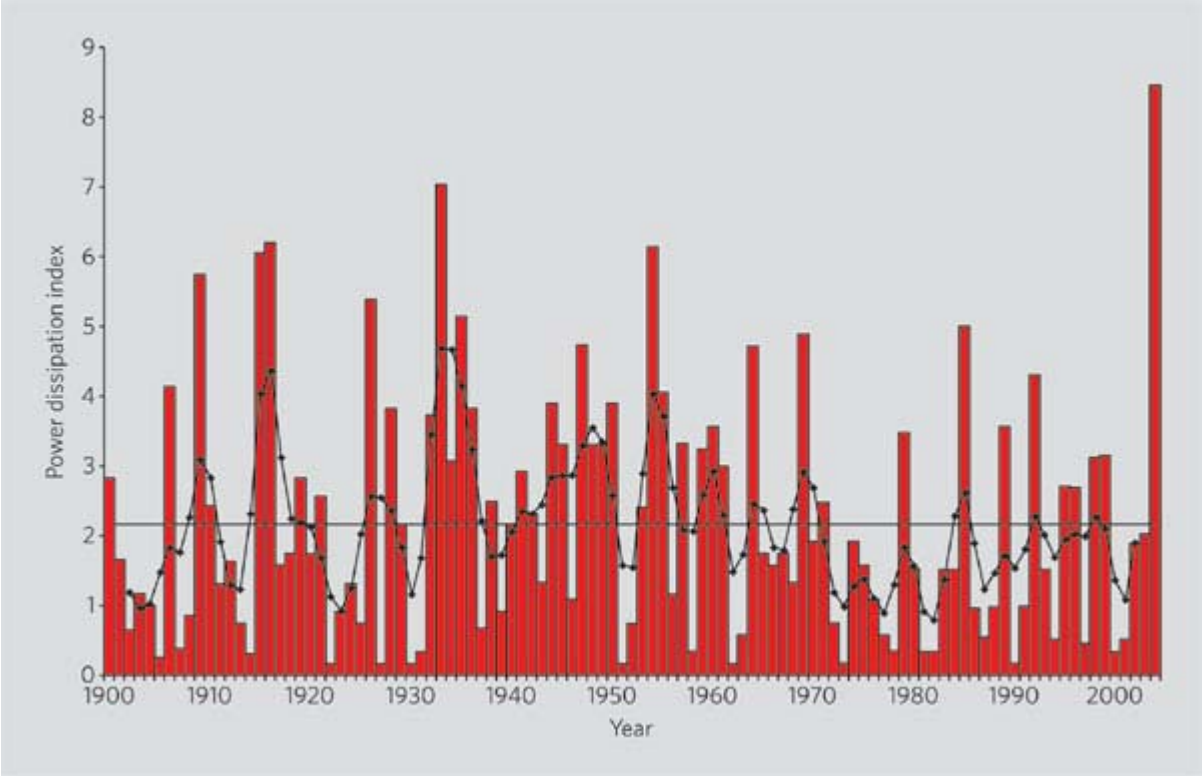

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High resolution image and legend (42K)
(/nature/journal/v438/n7071/fig_tab/nature04477_F2.html)

Despite these problems, Emanuel's study illustrates the pressing need for a completion of the storm-by-storm reanalysis of the Atlantic hurricane database[8, (#B8) 11 (#B11)], which will provide a more homogeneous time series of tropical-cyclone intensities and so avoid the application of arbitrary bias-removal schemes. But, on the basis of the evidence I present here, claims to connect Atlantic hurricanes with global warming are premature. The Atlantic hurricane basin is currently seeing enhanced, rather than "unprecedented", storminess that is comparable to, or even less active than, that seen in earlier busy cycles of activity.

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