

## Comments on “Monitoring and Understanding Trends in Extreme Storms: State of Knowledge”

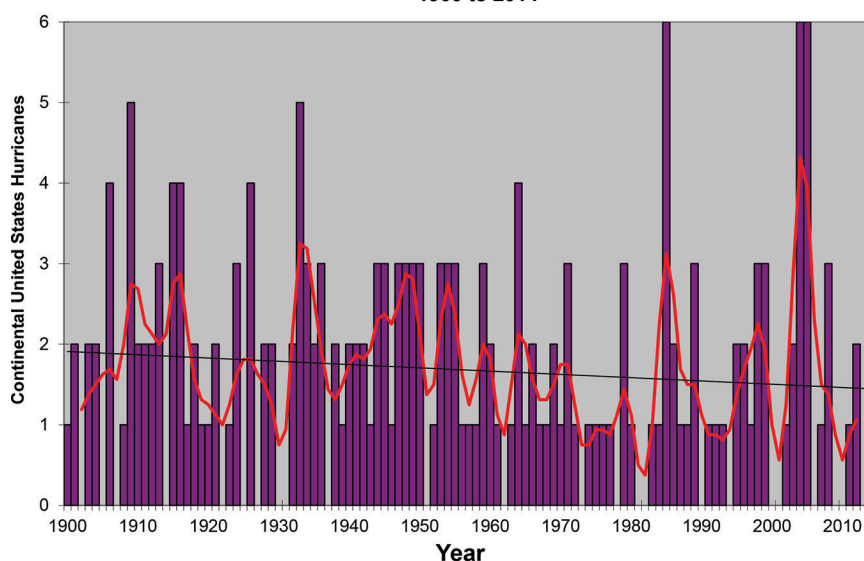
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Kunkel et al. (2013) reviewed the state of the science with regards to long-term changes and trends of various extreme storms that impact the continental United States. In particular, they addressed severe convective storms, precipitation, snowstorms, and—of interest to this comment—hurricanes. All of the analyses presented in Kunkel et al. (2013) (their Figs. 1–7 and Tables 1 and 2) were focused on observations taken over the continental United States, with the notable exception of hurricanes. Instead, their Fig. 5 provided data (updated from Kossin et al. 2007) for the entire North Atlantic and northwestern Pacific basins going back only to 1970 in the form of power dissipation index (PDI). They did reference one study on U.S. hurricane activity (Landsea 2005) and mentioned that it indicated no significant long-term trends. That paper, however, is now dated because of the passing of a decade of new

observations as well as revisions being made to the first half of the twentieth century U.S. hurricane record through the Atlantic hurricane database project (Landsea et al. 2008, 2012, 2014; Hagen et al. 2012). Given that Kunkel et al.’s (2013) goal was to “present a clear record . . . about what is known and unknown and why about . . . extreme weather and climate types affecting the United States” (p. 499), this comment examines the most up-to-date record of U.S. hurricanes and the associated century time-scale trends.

Hurricanes striking the continental United States compose a sizable percentage (23%) of all Atlantic basin hurricanes since 1972, the first year for reliable all Atlantic basin hurricane frequency owing to the invention of Dvorak satellite intensity technique (Dvorak 1975) coupled with available satellite imagery for the basin. The rather lengthy coastline of the United States tends to experience more hurricane strikes in busy seasons, but not

### Continental United States Hurricanes 1900 to 2014



**FIG 1. Continental U.S. hurricanes from 1900 through 2014. The time series is derived from the updated format of the Atlantic hurricane database (HURDAT2; Landsea and Franklin 2013) with results from the reanalysis (Landsea et al. 2008, 2012, 2014; Hagen et al. 2012) incorporated through 1955. The red curve provides a 1–2–1 filter applied twice to smooth interannual variability. The black line provides the linear trend.**

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every active year causes more U.S. landfalls because of variability in genesis locations and steering flow. The linear correlation coefficient of U.S. hurricanes with all Atlantic basin hurricanes is 0.49 for the years 1972–2014 (statistically significant beyond the 99.8% level after accounting for serial correlation). Thus, while the sample size per season of U.S. hurricanes is substantially smaller than for all Atlantic basin hurricanes, the U.S. hurricane time series reflects some of the same variability as seen in the whole basin.

Figure 1 provides an analysis of U.S. hurricanes from 1900 through 2014. The record begins at the start of the twentieth century as it was approximately at that time that enough coastal communities were established along the U.S. Gulf of Mexico and Atlantic Ocean coasts to ensure a relatively complete monitoring of all U.S. hurricanes (Landsea et al. 2004). Before about 1900, some hurricanes making landfall in parts of relatively unpopulated Texas, Louisiana, and Florida would have been underestimated in their intensity and considered tropical storms (or even missed completely), making the U.S. hurricane record incomplete. The figure shows that there has been a small, statistically insignificant downward trend in the frequency of U.S. hurricanes in this century-long time series. Instead, the record is dominated by interannual- to decadal-scale variability, with the busiest periods occurring in the 1910s, the 1930s to the 1950s, the mid-1980s, and the mid-2000s, while the quietest periods are seen during the 1920s, the 1970s to the early 1980s, the early 1990s, around 2000, and the last few years.

This U.S. hurricane record then puts the results of Kunkel et al. (2013) for Atlantic basinwide activity showing a sizeable increase in activity since 1970 into perspective. The long U.S. landfall record is an indication that this recent upward phase of activity in the Atlantic basin was preceded by quiet and active periods of similar magnitude. Furthermore, because of the use of over 100 years of reliable U.S. hurricane records, one can conclude that there has been no long-term century-scale increase in U.S. hurricane frequencies.

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