GEOPHYSICAL RESEARCH LETTERS, VOL. 28, NO. 14, PAGES 2871-2872, JULY 15, 2001

Comment on "Changes in the Rates of North Atlantic Major Hurricane Activity During the 20th Century"

Christopher W. Landsea

NOAA/AOML/Hurricane Research Division, Miami, Florida.

Atlantic major hurricanes have a profound impact on human and natural environments. Understanding and predicting these storms' occurrence on daily, intraseasonal, interannual, multidecadal and climatic timescales can be of tremendous benefit and should be pursued vigorously. *Elsner et al.* [2000] (hereafter as EJN) address multidecadal changes of Atlantic basin major hurricanes - those tropical cyclones with maximum sustained surface winds of at least 50 m/s. However, aspects of EJN analysis are questionable because its treatment of the Atlantic major hurricane database may be erroneous, because its proposed link to the North Atlantic Oscillation is unsubstantiated, and because it fails to cite or acknowledge key earlier studies.

Treating the record of Atlantic major hurricanes since 1900 as trustworthy in its entirety is very questionable. The assumption that the records of major hurricane activity are complete before the advent of aircraft reconnaissance leads directly to the erroneous conclusion that major hurricanes became much more numerous starting in 1943. That year - not coincidentally - was the beginning of routine aircraft flights into hurricanes [*Sumner* 1944]. EJN state that "the observational bias is smallest for the strong storms considered here". It is unclear how the authors come to this conclusion. Major hurricanes typically stay at that intensity for an average of 2-3 days and have their 50 m/s or higher winds concentrated in the mesoscale (10s of km) eyewall [*Landsea* 1993; *Powell and Houston* 1998]. Before aircraft and satellite reconnaissance, it was simply not possible to detect such small transient features offshore consistently or reliably. *Holland* [1981] demonstrated that even when numerous ships and buoys are in a strong tropical cyclone, the actual intensity is likely to be drastically underestimated without aircraft or satellite data.

Another way to understand the problem is a comparison of the relationship between all major hurricanes to the subset that have hit the United States. (The latter should be sampled adequately back to the beginning of the 20th Century.) These two records are correlated at r=0.41 for the years 1943-99 (less than 17% of the variance) versus r=0.78 for 1900-1942 (over 61% of the variance). (These two correlation coefficients show a strong significant difference in a two-tailed test with a p-value of less than 0.03.) Since in nature the relationship should be relatively steady over time, one can conclude that before the mid-1940s, the Atlantic major hurricane records were less likely to include those that did not strike the United States. *Solow and Moore* [2000] come to similar conclusions as stated above by analyzing the ratio of landfalling U.S. hurricanes to all Atlantic basin hurricanes. The stratification of the entire period from 1900-42 into a quiet regime by EJN is primarily due to the incomplete record of Atlantic major hurricanes, not to an actual shift in activity.

EJN have failed to employ the bias-removal as suggested by *Landsea* [1993]. This correction is necessary for analyses of major hurricanes because of a consistent overestimation of their intensity during the mid-1940s through the late 1960s due to non-physical alterations in the wind-pressure relationship utilized. The lead author of EJN utilized the bias-removal in his earlier work [*Lehmiller et al.* 1997], but not here where it appears to be crucial in the analysis of multidecadal variations.

The multidecadal link that EJN attempt to make between the Atlantic major hurricanes and the North Atlantic Oscillation (NAO) is tenuous. EJN do not provide a significance test of the interdecadal differences in the Icelandic sea level pressures (half of the NAO) for the active versus quiet major hurricane regimes. The reader is left to wonder if there is a significant difference. Even if the statistical relationship is valid, EJN's physical interpretation is faulty: a westward and southward shift of the Bermuda High causes an increased meridional sea level pressure gradient and stronger tradewinds over the main development region, not a relaxation of the tradewinds. [See *Shapiro* [1982], *Gray et al.* [1993] and *Knaff* [1997] for details about sea level pressure variations and impacts on Atlantic tropical cyclones.]

Finally, EJN fail to acknowledge previous studies that advance the same thesis - that there are multidecadal shifts of Atlantic major hurricanes and that there has been a return of the active regime in recent years. There have been numerous conference papers presented, in which evidence was given that the years since 1995 have marked a substantial shift to a higher frequency of major hurricanes: *Gray and Sheaffer* [1996], *Goldenberg et al.* [1996a, b, 1997a, b, 1999], *Gray* [1999], *Goldenberg and Landsea* [1999]. While these papers are not refereed publications, they were presented at the most widely attended conferences in the field and are easily accessible. The one reference to *Landsea et al.* [1996] focuses upon the paper's analysis of linear trends in Atlantic major hurricanes. While that was the case for this particular paper, many other published papers [*Gray* 1990, *Landsea* 1993, *Gray et al.* 1997, and *Landsea et al.* 1999] have analyzed and extensively discussed the multidecadal nature of Atlantic major hurricanes. In a reading of EJN, one gets the distinct impression that only they (and *Wilson* [1997]) have done work on the multidecadal regimes of Atlantic major hurricanes despite there being an extensive previous literature on the phenomenon.

Overall, while EJN addresses an important topic, the paper has multiple crucial problems. It is hoped that EJN will

Paper number 2000GL012832.
0094-8276/01/2000GL012832$05.00

address these major issues of questionable data use and interpretation, lack of a substantial physical link to the NAO, and neglect of previous work in the field.

Acknowledgments. I am grateful to S. Goldenberg, P. Hebert, H. Willoughby and an anonymous reviewer for providing suggestions on an earlier version of this Comment.

References

Elsner, J. B., T. Jagger, and X. Niu, Changes in the rates of North Atlantic major hurricane activity during the 20th Century, *Geophys. Res. Lett.*, **27**, 1743-1746, 2000.

Goldenberg, S. B., and C. W. Landsea, Relationships between decadal-scale fluctuations in vertical shear from NCEP/NCAR reanalysis data and Atlantic basin tropical cyclone activity, *Preprints of the 23rd Conference on Hurricanes and Tropical Meteorology*, 1089-1091, 1999.

Goldenberg, S. B., C. W. Landsea, and G. D. Bell, Summary of the 1999 Atlantic hurricane season: A climatic perspective, *Proceedings of the Twenty-Fourth Annual Climate Diagnostics and Prediction Workshop*, 1-4, 1999.

Goldenberg, S. B., L. J. Shapiro, and C. W. Landsea, The hyperactive 1995 Atlantic hurricane season, Part II: Just a "spike" or a harbinger of things to come? *Minutes of the 50th Interdepartmental Hurricane Conference*, A-35, 1996a.

Goldenberg, S. B., L. J. Shapiro, and C. W. Landsea, The hyperactive 1995 Atlantic hurricane season: Just a "spike" or a harbinger of things to come? *Proceedings of the Twenty-First Annual Climate Diagnostics and Prediction Workshop*, 9-12, 1996b.

Goldenberg, S. B., L. J. Shapiro, and C. W. Landsea, Are we seeing a long-term upturn in Atlantic basin major hurricane activity related to decadal-scale SST fluctuations? *Preprints of the 7th Conference of Climate Variations*, 305-310, 1997a.

Goldenberg, S. B., L. J. Shapiro, and C. W. Landsea, Mounting evidence for a decadal-scale upturn in Atlantic basin tropical cyclone activity, *Preprints of the 22nd Conference on Hurricanes and Tropical Meteorology*, 507-508, 1997b.

Gray, W. M., Strong association between West African rainfall and US landfall of intense hurricanes, *Science*, **249**, 1251-1256, 1990.

Gray, W., On the causes of multi-decadal climate change and prospects for increased Atlantic basin hurricane activity in the coming decades, *Preprints of the 23rd Conference on Hurricanes and Tropical Meteorology*, 378-381, 1999.

Gray, W. M., C. W. Landsea, P. W. Mielke, Jr., and K. J. Berry, Predicting Atlantic basin seasonal tropical cyclone activity by 1 August, *Wea. Forecasting*, **8**, 73-86, 1993.

Gray, W. and J. Sheaffer, Prospects for increased Atlantic basin intense hurricane activity during the next 10-20 years, *Minutes of the 50th Interdepartmental Hurricane Conference*, A-36, 1996.

Gray, W.M., J.D. Sheaffer, and C.W. Landsea, Climate trends associated with multidecadal variability of Atlantic hurricane activity, in *Hurricanes: Climate and Socioeconomic Impacts,* edited by H. F. Diaz and R. S. Pulwarty, pp. 15-53, Springer-Verlag, New York, 1997.

Holland, G. J., On the quality of the Australian tropical cyclone data base, *Aust. Met. Mag.*, **29**, 169-181, 1981.

Knaff, J. A., Implications of summertime sea level pressure anomalies in the tropical Atlantic region, *Mon. Wea. Rev.*, **10**, 789-804, 1997.

Landsea, C. W., A climatology of intense (or major) Atlantic hurricanes, *Mon. Wea. Rev.*, **121**, 1703-1713, 1993.

Landsea, C. W., N. Nicholls, W. M. Gray, and L. A. Avila, Downward trends in the frequency of intense Atlantic hurricanes during the past five decades, *Geo. Res. Letters*, **23**, 1697-1700, 1996.

Landsea, C.W., Pielke, Jr., R.A., Mestas-Nunez, A.M., Knaff, J.A., Atlantic basin hurricanes: Indices of climatic changes, *Climatic Change*, **42**, 89-129, 1999.

Lehmiller, G. S., T. B. Kimberlain, and J. B. Elsner, Seasonal prediction models for North Atlantic basin hurricane location, *Mon. Wea. Rev.*, **125**, 1780-1791, 1997.

Powell, M. D., and S. H. Houston, Surface wind fields of 1995 Hurricanes Erin, Opal, Luis, Marilyn, and Roxanne at landfall, *Mon. Wea. Rev.*, **126**, 1259-1273, 1998.

Shapiro, L. J., Hurricane climatic fluctuations. Part II: Relation to large-scale circulation. *Mon. Wea. Rev.*, **110**, 1014-1023, 1982.

Solow, A. R., and L. Moore, Testing for a trend in a partially incomplete hurricane record, *J. Climate*, **13**, 3696-3699, 2000.

Sumner, H. C., 1944: North Atlantic hurricanes and tropical disturbances of 1944, *Mon. Wea. Rev.*, **72**, 237-240.

Wilson, R. M., Comment on 'Downward trends in the frequency in the Atlantic basin during the past 5 decades,' by C. W. Landsea et al., *Geophys. Res. Lett.*, **24**, 2203-2204, 1997.

C. W. Landsea, NOAA/AOML/Hurricane Research Division, 4301 Rickenbacker Causeway, Miami, FL 33149. (email: landsea@aoml.noaa.gov)

(Received January 5, 2001; accepted February 27, 2001.)