NASA/TP—2014–218199

On the Relationship Between the Length of Season and Tropical Cyclone Activity in the North Atlantic Basin During the Weather Satellite Era, 1960–2013

Robert M. Wilson
Marshall Space Flight Center, Huntsville, Alabama

August 2014

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LIST OF ABBREVIATIONS, ACRONYMS, AND DESIGNATORS

ACE	accumulated cyclone energy
<ACE>	mean seasonal ACE
AMO	Atlantic Multidecadal Oscillation (index)
CO_2	carbon dioxide
D(FSD)	difference between yearly observed and predicted LOS based on FSD
D(<MLCO2>)	difference between yearly observed and predicted LOS based on <MLCO2>
DOY	day of year
E	El Niño
ENY	El Niño year
fd(10-yma)	first difference of the 10-year moving average
FSD	first storm day
HISACE	Highest Individual Storm Accumulated Cyclone Energy
HISPDI	Highest Individual Storm Power Dissipation Index
L	La Niña
<LAT>	mean seasonal latitude
LISNSD	longest individual storm NSD
LNY	La Niña year
<LONG>	mean seasonal longitude
LOS	length of season
LP	lowest pressure

LIST OF ABBREVIATIONS, ACRONYMS, AND DESIGNATORS (Continued)

<LP>	mean seasonal LP
LSD	last storm day
MLCO2	Mauna Loa CO_2 (index)
<MLCO2>	mean seasonal Mauna Loa CO_2
NH	number of hurricanes
NHD	number of hurricane days
NMH	number of major hurricanes
NMHD	number of major hurricane days
NSD	number of storm days
<NSD>	mean seasonal NSD
NTC	number of tropical cyclones
NTCA	net tropical cyclone activity
NUSLFH	number of U.S. land-falling hurricanes
NY	neutral year
ONI	Oceanic Niño Index
PDI	Power Dissipation Index
<PDI>	mean seasonal PDI
PWS	peak wind speed
<PWS>	mean seasonal PWS
U.S.	United States

NOMENCLATURE

a	y-intercept
b	slope
cl	confidence level
na	number above median
nb	number below median
nra	number of positive runs
P	probability
r	coefficient of correlation
r^2	coefficient of determination
sd	standard deviation
se	standard error of estimate
t	t statistic for independent samples
x	independent variable
y	dependent variable
z	normal deviate for the sample results

TECHNICAL PUBLICATION

ON THE RELATIONSHIP BETWEEN THE LENGTH OF SEASON AND TROPICAL CYCLONE ACTIVITY IN THE NORTH ATLANTIC BASIN DURING THE WEATHER SATELLITE ERA, 1960–2013

1. INTRODUCTION

Officially, the North Atlantic basin tropical cyclone season runs from June 1 through November 30 of each year. During this 183-day interval, the vast majority of tropical cyclone onsets are found to occur. For example, in a study of the 715 tropical cyclones that occurred in the North Atlantic basin during the interval 1945–2010, it was found that about 97% of them had their onsets during the conventional hurricane season, with the bulk (78%) having had onset during the late summer-early fall months of August, September, and October and with none having had onset in the month of March.[1] For the 2014 hurricane season, it already has had the onset of its first named storm on July 1 (day of year (DOY) 182), Arthur, which formed off the east coast of Florida, rapidly growing into a category-2 hurricane with peak 1-minute sustained wind speed of about 90 kt and striking the coast of North Carolina as a category-2 hurricane on July 3. Arthur is the first hurricane larger than category-1 to strike the United States (U.S.) since the year 2008 when Ike struck Texas as a category-2 hurricane and there has not been a major hurricane (category-3 or larger) to strike the U.S. since Wilma struck Florida as a category-3 hurricane in 2005. Only two category-1 hurricanes struck the U.S. in the year 2012 (Isaac and Sandy, striking Louisiana and New York, respectively) and there were no U.S. land-falling hurricanes in 2013 (also true for the years 1962, 1973, 1978, 1981, 1982, 1990, 1994, 2000, 2001, 2006, 2009, and 2010).[2]

In recent years it has been argued that the length of season (LOS), determined as the inclusive elapsed time between the first storm day (FSD) and the last storm day (LSD) of the yearly hurricane season (i.e., when peak 1-minute sustained wind speed of at least 34 kt occurred and the tropical cyclone was not classified as 'extratropical'), has increased in length with the lengthening believed to be due to the FSD occurring sooner and the LSD occurring later and with both being related to global warming.[3–5] In this study, the relationship between the LOS and tropical cyclone activity and climate is examined for the weather satellite era, 1960–2013.[6–8] Estimates are also given for the LOS and LSD, as well as for the expected number of tropical cyclones (NTC), the total number of storm days (NSD), the total accumulated cyclone energy (ACE), and the net tropical cyclone activity (NTCA) index for the 2014 hurricane season.

2. RESULTS AND DISCUSSION

Figure 1 displays the yearly variation of the (a) LOS, (b) first-difference of the 10-year moving average (fd(10-yma)) of the LOS, and (c) distribution of the fd(10-yma) values for the weather satellite era, 1960–2013. In figure 1(a), the thin jagged line is the yearly seasonal value of the LOS; the thick smoothed line is the 10-yma of the LOS; and the letters E and L simply identify those years when the Oceanic Niño Index (ONI) was of value 0.5 ºC or higher and –0.5 ºC or lower, respectively, for at least 6 months of the year, used here as an indicator for classifying the year as being either an El Niño year (ENY) or a La Niña year (LNY). Years not identified with an E or L represent El Niño neutral years (NYs). The overall mean for the LOS is 133 days, having a standard deviation (*sd*) of 42 days. The longest LOS measures 235 days in 2003, an NY, while the shortest LOS measures 47 days in 1983, an ENY. Based on the E and L classification as employed in this study, 14 years are classified as ENY, 15 years as LNY, and 25 years as NY. On average, the 14 ENYs have a mean LOS of 110 days ($sd = 41$ days); the 15 LNYs have a mean LOS of 137 days ($sd = 25$ days); and the 25 NYs have a mean of 143 days ($sd = 48$ days). The difference in the means between those years classified as ENY and LNY is found to be statistically important ($t = –2.16$, confidence level $cl > 95\%$). Hence, if a year is predicted to be an ENY, one probably should expect its LOS to be shorter than the mean LOS (=133 days), whereas if a year is predicted to be a non-ENY, one probably should expect its LOS to be ≥133 days. For the 14 ENYs, 12 of the 14 years (86%) have had LOS <133 days, with the 2 years having LOS ≥133 days being the years 1972 (163 days) and 1997 (139 days). Twenty-five of the forty years (63%) not being classified as ENY have LOS ≥133 days.

Concerning the yearly variation of the LOS as described by its 10-yma, one finds that it appears to be trending upwards since about 1987, increasing from 118 days in 1987 to 157 days in 2008 (the last year having a 10-yma entry). Furthermore, a comparison of the two subintervals 1960–1994 and 1995–2013 indicates that the mean LOS has increased in length from about 122 days during the earlier subinterval to about 152 days in the more recent subinterval, with the difference in the means being statistically important ($t = –2.60$, $cl > 98\%$). Hence, the more recent subinterval is found to have an LOS about 30 days longer, on average, than the earlier subinterval. For the year 2013, its LOS measured 186 days. (The division of the overall interval 1960–2013 into two subintervals is predicated on the observation that the more recent subinterval is associated with the return of the warm phase as measured by the Atlantic Multidecadal Oscillation (AMO) index, a descriptor for the Atlantic Meridional Overturning Circulation, a density-driven, global circulation pattern of about 65–70 years in length that involves the movement of warm, salty equatorial waters to higher latitudes and the subsequent cooling and sinking of those waters into the deep ocean.[9–14])

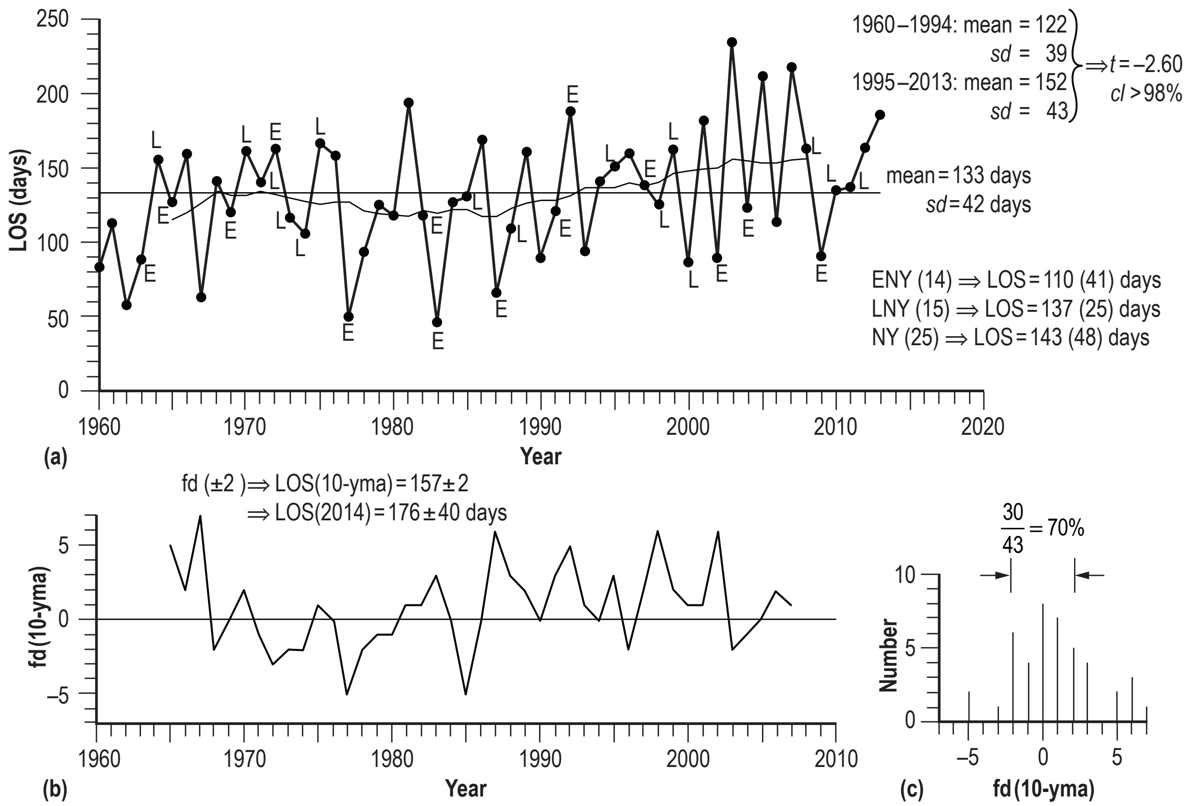

Figure 1. Variation of yearly (a) LOS, (b) fd(10-yma), and (c) distribution of fd(10-yma) for the interval 1960–2013.

In figure 1, (b) and (c), one observes that the fd(10-yma) values of the LOS has varied between fd(10-yma) = –5 and 7, having a central spread of about 0 ± 2 that captures 30 of the 43 yearly fd(10-yma) values (70%). Hence, one expects the next fd(10-yma) value for the year 2009 likely to be about 157 ± 2 days, which suggests that the LOS for the year 2014 should be expected to be about 176 ± 40 days, or LOS(2014) ≥ 136 days. Only 3 of the 43 years (7%) have had fd(10-yma) ≤ –3. Thus, one expects the LSD for the 2014 hurricane season to occur no earlier than DOY 318, or about November 14, 2014, based on the distribution of fd(10-yma) values. However, if fd(10-yma) = –3 for 2009, then the LOS for 2014 equals 176 ± 60 days, or LOS(2014) ≥ 116 days and the LSD would occur no earlier than DOY 298, or about October 25, 2014.

Figure 2 depicts the yearly variation of (a) FSD and (b) the Mauna Loa CO_2 (<MLCO2>) index for the overall interval 1960–2013. These particular parameters have previously been shown to have some predictive ability regarding determination of the LOS.[4,5,7,8] In figure 2(a), the thin jagged line is the yearly seasonal FSD; the thick smoothed line is the 10-yma of the FSD; and the letters E and L have the same meanings as in figure 1(a). The overall mean of the FSD is DOY 180 (about June 29) and the *sd* = 33 days. The latest FSD occurred in 1967 (DOY 242), an NY, and in 1977 (DOY 242), an ENY, while the earliest FSD occurred in 2003 (DOY 110), an NY. On average, the years classified as ENY have an FSD occurring about DOY 190 (about July 9), while those years classified as LNY or NY have an FSD occurring about DOY 180 (about June 29) or DOY 174 (about June 23),

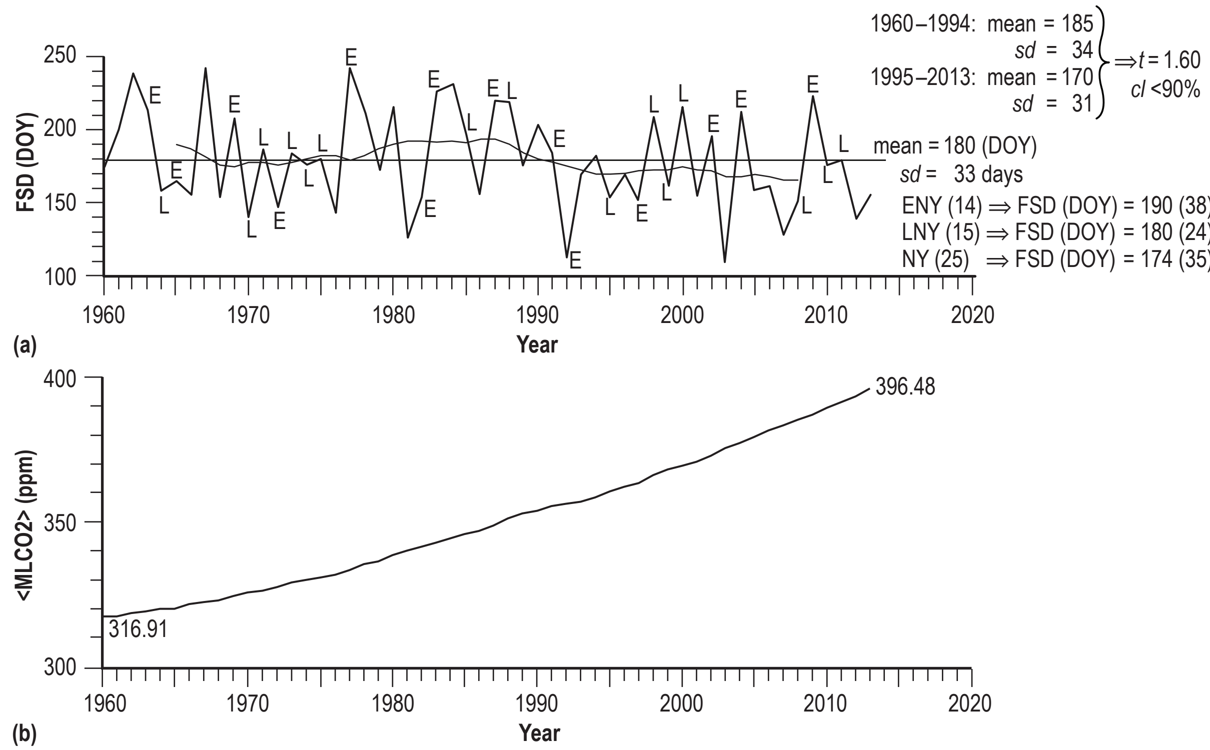

Figure 2. Variation of yearly (a) FSD and (b) <MLCO2> for the interval 1960–2013.

respectively. Statistically speaking, the difference in the means between ENY and LNY is not statistically important ($t = 0.85$, $cl < 90\%$). Also, the difference between the means for the two subintervals 1960–1994 and 1995–2013 is found not to be statistically important ($t = 1.60$, $cl < 90\%$). Hence, while the FSD for the more recent subinterval is about 15 days, on average, earlier than that for the earlier subinterval, the difference is not statistically meaningful. Also, the mere observation that the FSD occurs either later or earlier than the mean provides no definitive information for classifying the year as ENY, LNY, or NY, although 25 of the 30 years (83%) having FSD <DOY 180 are noted to be classified as non-ENY. (Of the 24 years having FSD ≥ DOY 180, 9 years were ENY, 7 years were LNY, and 8 years were NY; of the 30 years having FSD < DOY 180, 5 years were ENY, 8 years were LNY, and 17 years were NY.)

Based on the distribution of the fd(10-yma) values of FSD (not shown), one finds that 27 of 43 years (63%) had fd(10-yma) = 0 ± 2 and 36 of 43 years (84%) had fd(10-yma) = 0 ± 3, suggesting that the 10-yma value of FSD for 2009 should be about DOY 167 ± 2 or 3, respectively, and that the FSD for the year 2014 should be about DOY 169 ± 40 or 60, respectively. Arthur, the first named storm of the 2014 hurricane season, had its FSD on July 1 (DOY 182), thereby setting the 10-yma value of FSD for 2009 to be DOY 168.

Figure 2(b) shows the yearly variation of the <MLCO2>, which is observed to be continually rising from year to year. It measured 316.91 ppm in 1960 and 396.48 ppm in 2013, suggesting an average rate of increase in the <MLCO2> of about 1.5 ppm yr^{-1}. However, the rate of increase actually has been higher of late than earlier, being about 1.98 ppm yr^{-1} since 1995 as compared to about 1.25 ppm yr^{-1} between 1960 and 1995 (a rate of increase about 58% faster since 1995 than before 1995). Hence, one expects the <MLCO2> for 2014 to measure about 398.46 ppm and to exceed 400 ppm in 2015. (The Mauna Loa CO_2 index is a measure of the amount of atmospheric concentration of CO_2, as determined by the Mauna Loa Observatory in Hawaii, located in a barren lava field of an active volcano at an altitude of 3,397 m above mean sea level.[15–21])

Figure 3 depicts the scatterplots of LOS versus (a) <MLCO2> and (b) FSD. From figure 3(a), one finds that the LOS is inferred to be directly related to the <MLCO2> as expressed by the linear regression $y = -76.959 + 0.598x$, having a coefficient of correlation $r = 0.338$, a coefficient of determination $r^2 = 0.114$ (meaning that about 11.4% of the variance in the LOS can be explained by the variation in the <MLCO2> alone), a standard error of estimate $se = 40$ days, and $cl > 98\%$. Based on Fisher's exact test for 2×2 contingency tables (where the vertical and horizontal lines in the scatterplot represent the parametric medians), the probability P of obtaining the observed result, or one more suggestive of a departure from independence (chance), is $P = 13.8\%$. Since the expected value of the <MLCO2> for 2014 will be greater than the median <MLCO2> value (348.28 ppm), based on the overall interval 1960–2013), one expects the LOS for 2014 likely to be greater than the median value for the LOS (131 days). Of the 27 years when the <MLCO2> exceeded 348.28 ppm, 16 years had LOS ≥ 131 days (59%). Presuming <MLCO2> = 398.46 ppm for the year 2014, one infers (from the regression) LOS = 161 ± 40 days (the ±1 standard error of estimate *se* prediction interval), or LOS ≥ 121 days. (In this scatterplot and all succeeding scatterplots, the years marking the extremes for the parameters are identified.)

From figure 3(b), one finds that the LOS is inferred to be inversely related to the FSD as given by the linear expression $y = 321.587 - 1.052x$, having $r = -0.828$, $r^2 = 0.686$, $se = 24$ days, and $cl > 99.9\%$. Furthermore, based on Fisher's exact test for 2×2 contingency tables, one finds that the probability P of obtaining the observed result, or one more suggestive of a departure from independence, is $P = 0.045\%$. Because the FSD is now known for the year 2014, one finds from Fisher's exact test that the LOS is about 3 times more likely to be <131 days (and highly likely to be <167 days) than ≥131 days. From the regression equation, one infers that LOS = 130 ± 24 days (the ±1 *se* prediction interval), or LOS <154 days, for the year 2014 (i.e., the yearly hurricane season for the year 2014 is expected to end before December 2).

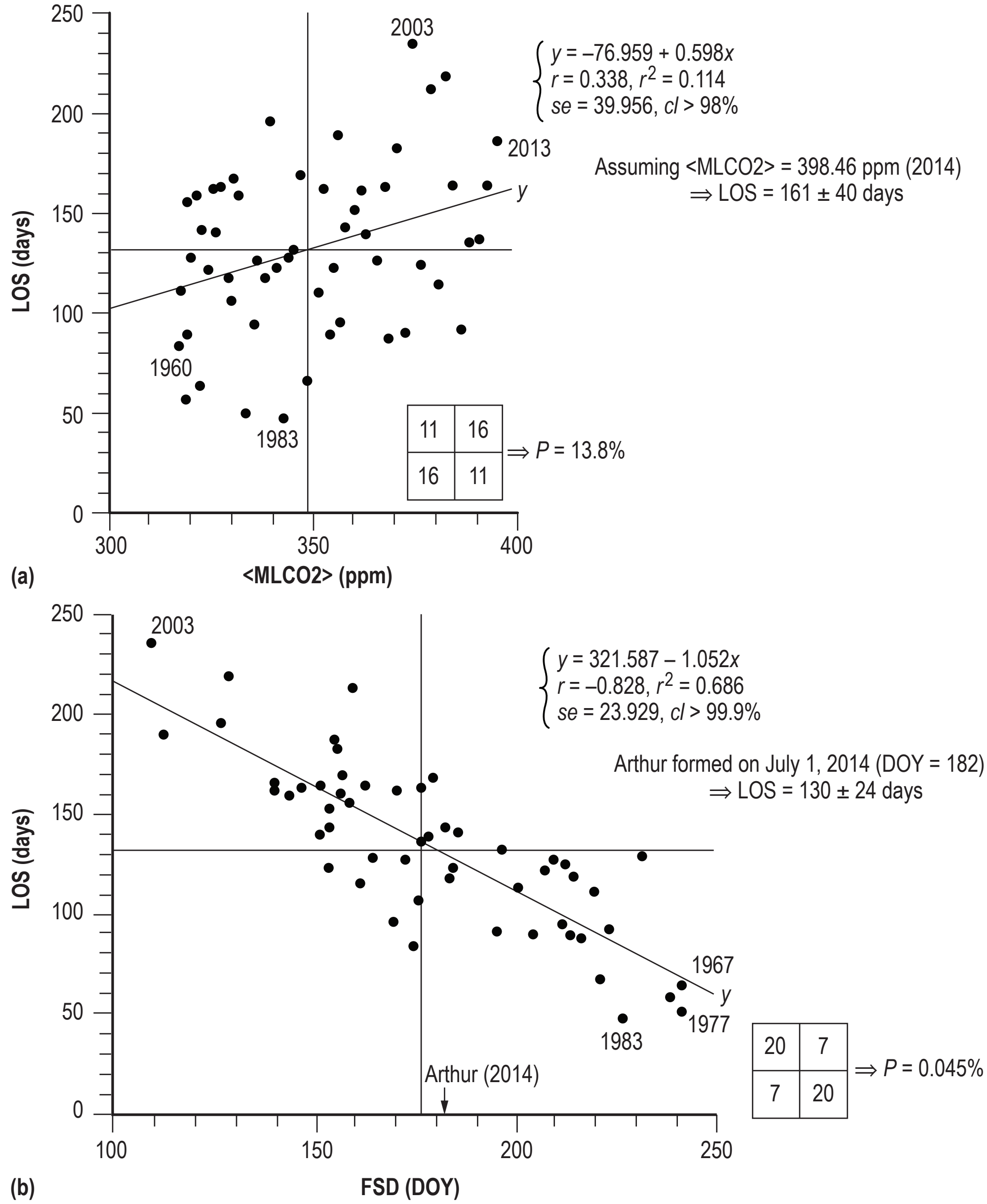

Figure 3. Scatterplots of (a) LOS versus <MLCO2> and (b) LOS versus FSD.

Figure 4 shows the yearly variation of (a) the difference (observed minus expected) LOS, based on the linear fit of LOS versus FSD, D(FSD) and (b) the difference LOS, based on the linear fit of LOS versus <MLCO2>, D(<MLCO2>). Runs-testing yields the normal deviate for the sample results $z = 1.06$ and 0.02, respectively, meaning that the differences appear to be distributed randomly. Based on FSD, 16 years (30%) have had D(FSD) within ±10 days, 33 years (61%) have had D(FSD) within ±20 days, and 45 years (83%) have had D(FSD) within ±30 days. Based on <MLCO2>, 12 years (22%) have had D(<MLCO2>) within ±10 days, 19 years (35%) have had D(<MLCO2>) within ±20 days, and 30 years (56%) have had D(<MLCO2>) within ±30 days. Obviously, knowledge of the FSD for a hurricane season provides the best indicator as to how long one should anticipate the hurricane season to last. (In figure 4, *na* refers to the number of differences above zero, *nb* refers to the number of differences below zero, and *nra* refers to the number of positive-valued runs.)

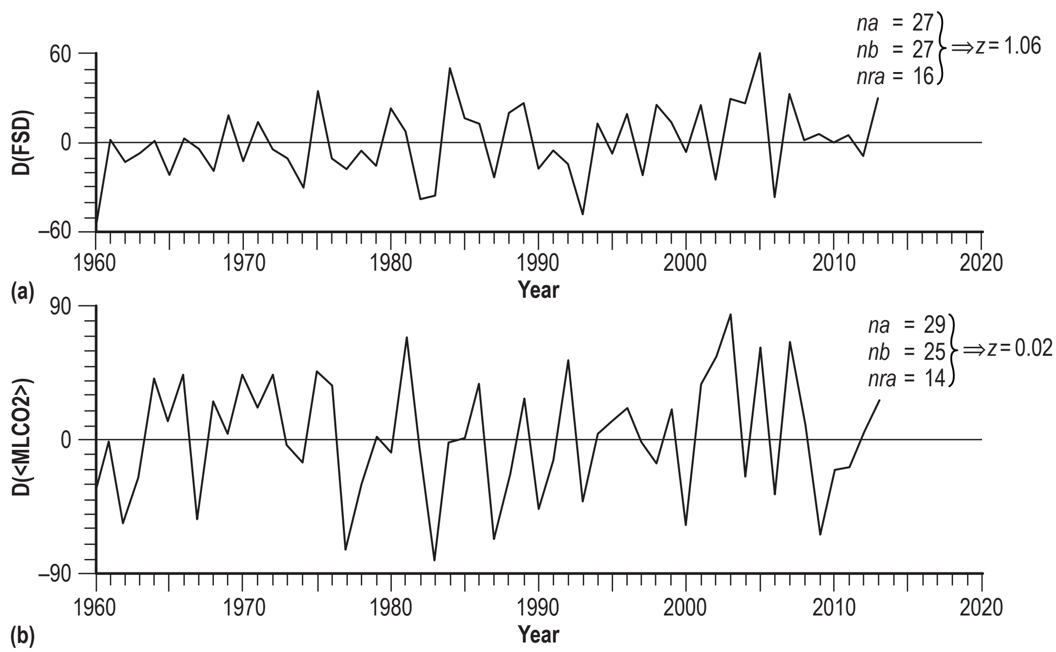

Figure 4. Variation of yearly (a) D(FSD) and (b) D(<MLCO2>) for the interval 1960–2013.

Table 1 gives the statistics (*a*, *b*, *r*, r^2, *se*, and *cl*, where *a* is the *y*-intercept and *b* is the slope) using FSD and LOS as the independent variables for the prediction of specific tropical cyclone parametric values. The listing of parameters,[7,8] in addition to those called out in the Introduction, includes NH (number of hurricanes), NMH (number of major hurricanes), NUSLFH (number of U.S. land-falling hurricanes), <LAT> (mean seasonal latitude), <LONG> (mean seasonal longitude, PWS (peak wind speed), <PWS> (mean seasonal PWS), LP (lowest pressure), <LP> (mean seasonal LP), <ACE> (mean seasonal ACE), HISACE (highest individual storm ACE), <PDI> (mean seasonal power dissipation index), total PDI, HISPDI (highest individual storm PDI), <NSD> (means seasonal NSD), LISNSD (longest individual storm NSD), total NHD (total number of hurricane days), and total NMHD (total number of major hurricane days). When the inferred correlation has $cl > 95\%$ it is marked with * and when the inferred correlation has $cl > 98\%$ it is marked **. Examination of the table reveals that the only correlation involving FSD to be marked * or ** is the one between LOS and FSD. Regarding the correlations against LOS, those marked * or ** include FSD, LSD, NTC, NH, total ACE, total PDI, total NSD, and NTCA.

Table 1. Summary of tropical cyclone statistics against FSD and LOS.

	FSD						LOS					
Parameter	***a***	***b***	***r***	***r*²**	***se***	***cl***	***a***	***b***	***r***	***r*²**	***se***	***cl***
FSD	–	–	–	–	–	–	266.031	–0.652	–0.828	0.686	19.009	>99.9%**
LSD	320.587	–0.052	–0.073	0.005	23.528	<90%	265.031	0.348	0.620	0.384	19.158	>99.9%**
LOS	321.587	–1.052	–0.828	0.686	23.768	>99.9%**	–	–	–	–	–	–
NTC	16.032	–0.026	–0.190	0.036	4.517	<90%	4.851	0.049	0.462	0.213	4.116	>99.9%**
NH	6.834	–0.004	–0.044	0.002	2.861	<90%	3.483	0.020	0.308	0.095	2.711	>95%*
NMH	2.907	–0.003	–0.046	0.002	1.926	<90%	0.973	0.011	0.253	0.064	1.827	>90%
NUSLFH	1.833	–0.002	–0.048	0.002	1.486	<90%	0.258	0.009	0.254	0.065	1.449	>90%
<LAT>	24.147	–0.009	–0.090	0.008	3.359	<90%	22.645	–0.001	–0.010	–	3.432	<90%
<LONG>	67.954	–0.025	–0.144	0.021	5.740	<90%	63.740	–0.002	–0.016	–	5.728	<90%
PWS	107.174	0.095	0.145	0.021	21.818	<90%	119.840	0.033	0.065	0.004	22.091	<90%
<PWS>	67.373	0.031	0.119	0.014	8.596	<90%	72.769	0.001	0.006	–	8.837	<90%
LP	944.825	–0.043	–0.065	0.004	23.580	<90%	949.501	–0.093	–0.179	0.032	21.609	<90%
<LP>	983.629	–0.016	–0.069	0.005	7.934	<90%	981.806	–0.008	–0.044	0.002	8.471	<90%
<ACE>	7.740	0.005	0.043	0.002	3.687	<90%	7.792	0.006	0.070	0.005	3.743	<90%
Total ACE	123.257	–0.127	–0.071	0.005	59.607	<90%	40.092	0.456	0.326	0.106	56.427	>98%**
HISACE	37.208	–0.035	–0.073	0.005	15.222	<90%	22.010	0.067	0.176	0.031	16.007	<90%
<PDI>	6.191	0.004	0.036	0.001	3.946	<90%	5.986	0.007	0.079	0.006	3.933	<90%
Total PDI	98.214	–0.091	–0.054	0.003	56.166	<90%	28.755	0.401	0.304	0.092	53.559	>95%*
HISPDI	36.174	–0.030	–0.049	0.002	20.356	<90%	20.386	0.079	0.165	0.027	20.045	<90%
<NSD>	5.104	–0.001	–0.022	0.001	1.391	<90%	4.544	0.003	0.094	0.009	1.354	<90%
LISNSD	12.481	–0.004	–0.036	0.001	3.770	<90%	10.650	0.008	0.095	0.009	3.840	<90%
Total NSD	80.850	–0.127	–0.130	0.017	32.547	<90%	24.522	0.254	0.330	0.109	30.839	>98%**
Total NHD	23.054	0.004	0.008	–	14.701	<90%	13.714	0.075	0.218	0.048	14.449	<90%
Total NMHD	7.025	–0.008	–0.046	0.002	5.880	<90%	1.223	0.033	0.238	0.057	5.712	>90%
NTCA	135.062	–0.142	–0.078	0.006	61.109	<90%	47.280	0.470	0.328	0.107	57.901	>98%**

* Means inferred correlation is statistically significant at *cl* >95%.
** Means inferred correlation is statistically significant at *cl* >98%.

Figure 5 depicts the scatterplots of (a) FSD, (b) LSD, and (c) NTC versus LOS. Figure 5(a) is simply a replot of figure 3(b), but now using LOS as the independent variable rather than FSD. Clearly, the two parameters are highly correlated (inversely). If one assumes an LOS(2014) = 131 days (the median), one infers that the FSD(2014) should be about DOY 181 ± 19 days, or that it would likely occur no earlier than about DOY 162 (about June 11) and no later than about DOY 200 (about July 19). In actuality, the FSD for the 2014 season is now known to have occurred on DOY 182 (July 1).

In figure 5(b), assuming LOS(2014) = 131 days, one infers that the LSD(2014) should be about DOY 311 (November 7) ± 19 days, or that it likely will occur no earlier than DOY 292 (October 19) and no later than DOY 330 (November 26). Should the actual LOS(2014) be <131 days, this would tend to make the LSD(2014) $<$ DOY 310, while LOS(2014) $>$ 131 days would tend to make LSD(2014) $>$ DOY 310.

In figure 5(c), assuming LOS(2014) = 131 days, one infers that the NTC(2014) should be about 11 ± 4, which is essentially the long-term average for the 1960–2013 interval. Based on Poisson statistics, it has been shown[7] that the probability of obtaining NTC(2014) = 11 ± 4 is about 83%. Should the year turn out to be classified as ENY, the probability of obtaining NTC(2014) = 9 ± 2 is about 60%. On the other hand, if the year 2014 turns out to be classified as non-ENY, the probability of obtaining NTC(2014) = 13 ± 2 is about 60%. It has also been shown[8] (1) that the NTC is closely related to the yearly <AMO> index, such that it is about 3 times more likely that the NTC ≥ 11 when the <AMO> is in its warm (positive) phase, which it now is and has been since about 1995 and should remain so for at least another decade or more, and (2) that the NTC is strongly related to the <MLCO2>, such that the NTC ≥11 is more than twice as likely when the <MLCO2> ≥ 348.28 ppm, which it now is and has been since 1987. (The <MLCO2> is expected to measure about 398.46 ppm for the year 2014.)

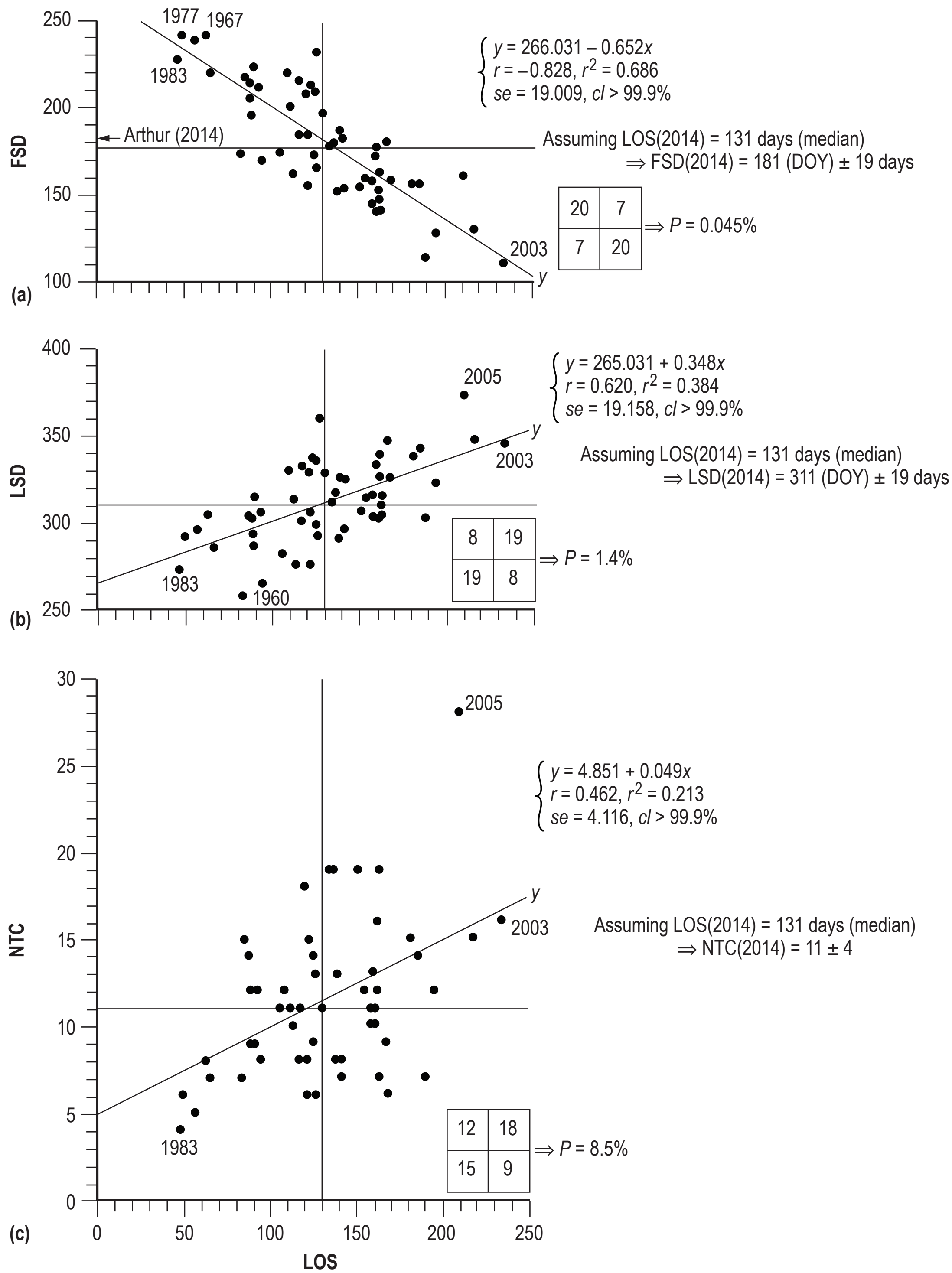

Figure 5. Scatterplots of (a) FSD, (b) LSD, and (c) NTC versus LOS.

Figure 6 shows the scatterplots of (a) total ACE and (b) total NSD versus LOS. Again, assuming an LOS(2014) = 131 days, one infers that the total ACE(2014) should be about 99.8 ± 56 (in units of 10^4 kt^2) and the total NSD(2014) should be about 58 ± 31 days. Based on the <AMO> being in the warm (positive) phase, one infers that the total ACE(2014) and total NSD(2014) are more than twice as likely to be ≥88 and ≥52 days, respectively. Based on the expected <MLCO2> value for the year 2014 (398.46 ppm), one expects the total NSD(2014) = 87 ± 29 days, or ≥58 days.

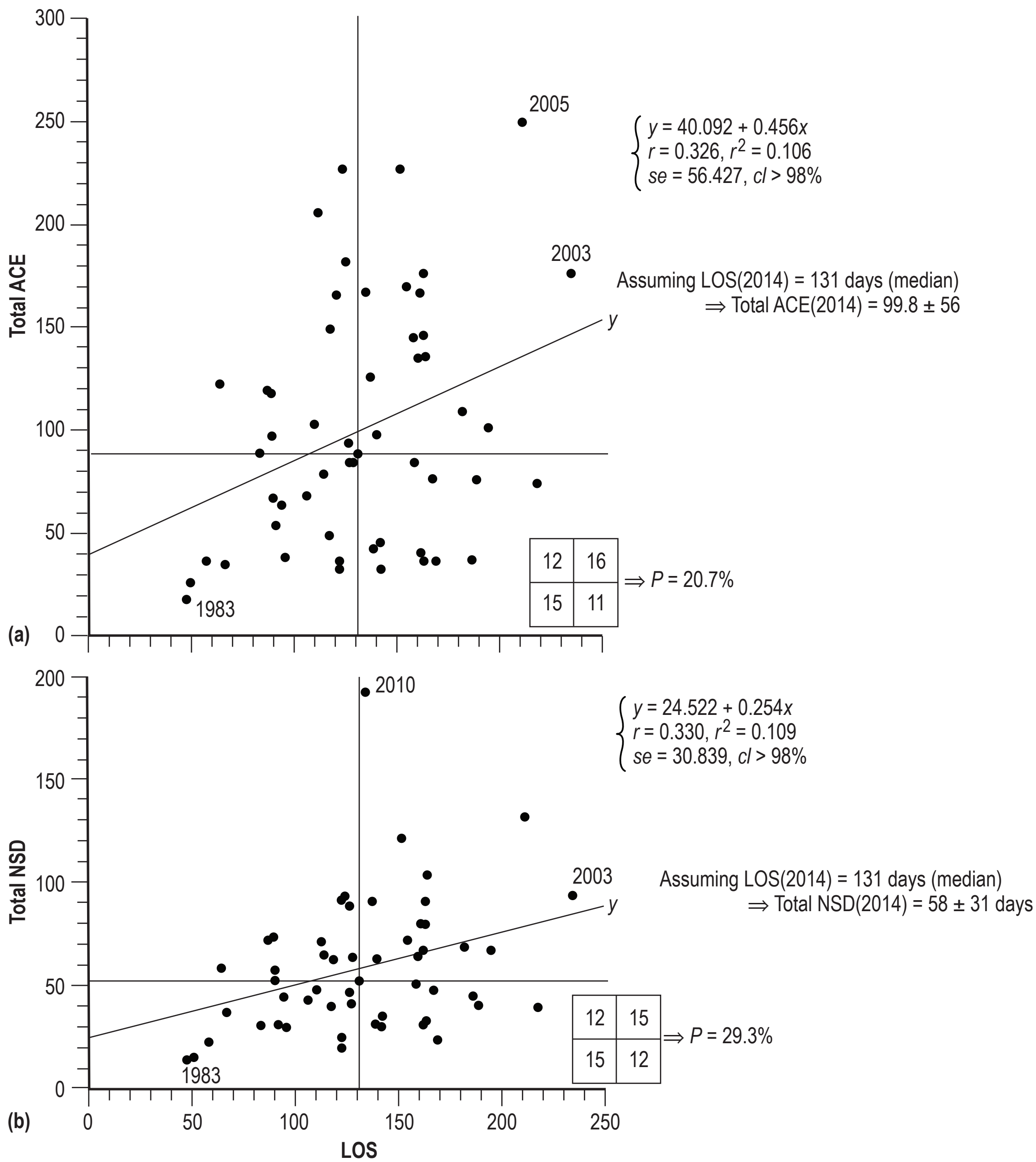

Figure 6. Scatterplots of (a) total ACE and (b) total NSD versus LOS.

Figure 7 displays the scatterplot of NTCA versus LOS. Assuming LOS(2014) = 131 days, the NTCA(2014) is estimated to be about 108.9% ± 57.9%, or ≥51%. Based on <AMO> being in the warm (positive) phase, one infers that the NTCA(2014) is more than twice as likely to be ≥98.8%.

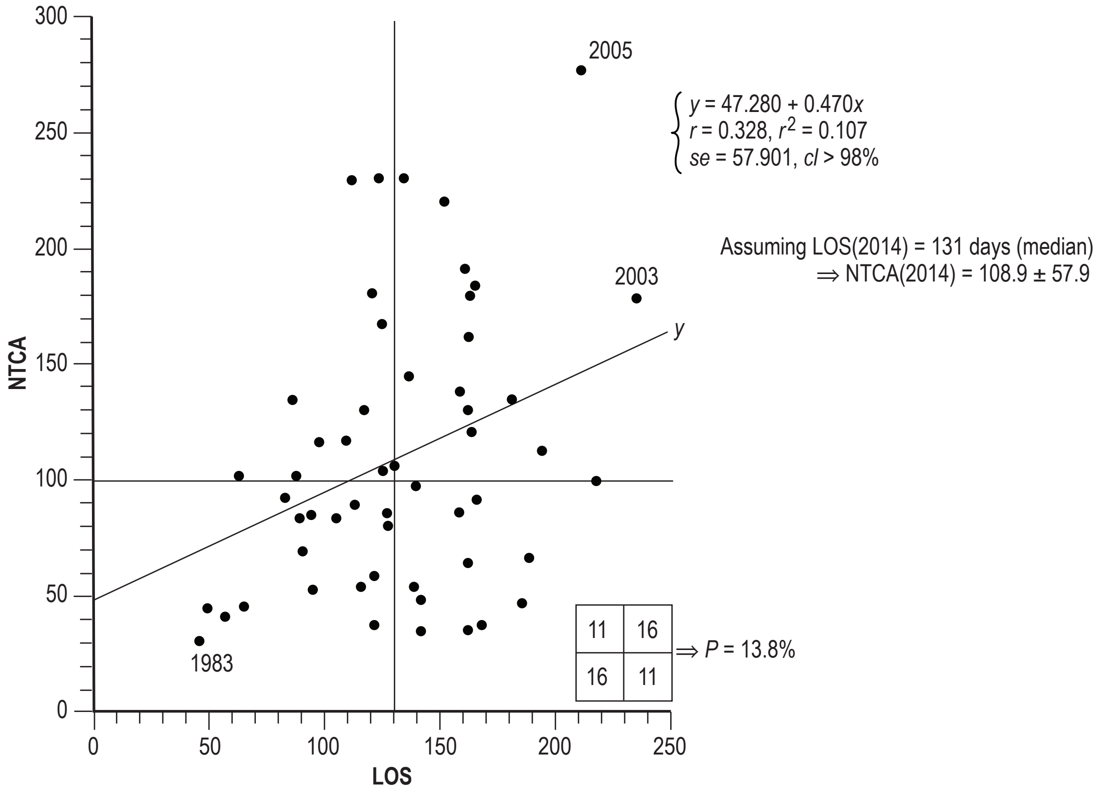

Figure 7. Scatterplot of NTCA versus LOS.

3. SUMMARY

The LOS of the yearly hurricane season is reckoned inclusively from FSD to LSD, averaging about 133 days in length and spanning 47 (1983) to 235 (2003) days during the weather satellite era (1960–2013). During the subinterval 1960–1994, the LOS averaged about 122 days, while during the more recent subinterval 1995–2013, it has averaged about 152 days. Incorporating the phasing of the El Niño-Southern Oscillation, the LOS is found to usually be somewhat shorter during an ENY (about 110 days, on average), while being somewhat longer during a non-ENY (about 141 days, on average). The LOS is found to correlate strongly against both the <MLCO2> and FSD, especially, the latter. For the 2014 North Atlantic basin hurricane season, the increased level of CO_2 suggests that the LOS might be longer than 133 days (as does the current continuing warm phase of the AMO, which began about 1995). In contrast, because the FSD for the 2014 hurricane season occurred on July 1 (DOY 182), this suggests that the LOS for the 2014 hurricane season likely will be less than 133 days (the mean; actually it is likely to be less than the median LOS, which equals 131 days). The inferred regression of LOS against FSD (having $r = -0.828$, $se = 24$ days) suggests that the LOS for the 2014 hurricane season likely will be about 130 ± 24 days, inferring that the LSD will come no earlier than October 15 (DOY 288) and no later than December 2 (DOY 336).

Presently, the Climate Prediction Center and the International Research Institute for Climate and Society are predicting the chance for El Niño forming during the Northern Hemisphere this summer to be about 70% and to be about 80% during the fall and early winter.[22] If the months of July–December each have ONI monthly values of 0.5 ºC or more, then following the definition of ENY as employed in this study, the year 2014 will be classified as an ENY and would be expected to have LOS < 133 days (about 110 ± 40 days, inferring LSD no earlier than September 9, or DOY 252, and no later than November 28, or DOY 332). (The ONI monthly values for January–May 2014 are –0.6, –0.6, –0.5, –0.1, and 0.2 ºC, respectively.[23])

Assuming that the year 2014 will have LOS < 133 days and that it will be classified as ENY, one expects LSD before DOY 299 ± 18 days, or before November 13 and after October 8. Also, one expects NTC = 11 ± 4, probably <11; total ACE = 101 ± 56, probably <101; NSD = 58 ± 30 days, probably <58 days; and NTCA = 110 ± 58%, probably <110%.

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14. ABSTRACT

During the weather satellite era (1960–2013), the yearly length of the hurricane season has increased by about 30 days, from 122 days, on average, during the subinterval 1960–1994 to 152 days, on average, during the subinterval 1995–2013. For the overall interval 1960–2013, the mean length of season is 133 days, having a range of 47 days (1983) to 235 days (2003) and standard deviation of 42 days, with El Niño years tending to be of shorter average length (110 days, on average) and non-El Niño years tending to be of longer average length (141 days, on average). The length of season is inversely correlated with the occurrence of the first storm day, such that when the first storm day occurs before (after) day of year (DOY) 177 (about June 26, the median), the length of season is about 3 times more likely to be longer (shorter) than 131 days (the median). For the 2014 hurricane season, the first storm day occurred on DOY 182 (July 1), inferring that the 2014 length of season likely will be about 130 ± 24 days (the ±1 standard error of estimate prediction interval) and that the last storm day should occur after DOY 288 (October 15) and before DOY 336 (December 2).

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