Assessing the Potential for a Hurricane in Houston during Year 2023 Based on the Inland Rainfall Patterns

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Abstract: The study compares the monthly average rainfall and total rainfall in Houston, Texas, to the Hurricane IKE year from July 2007 to June 2008 and non-hurricane year 2014. In 2023, the monthly average and total rainfall in Houston show a stronger correlation with the Non-Hurricane year compared to the Hurricane year. Additionally, for seven months in Houston, the monthly rainfall rate aligns well with the non-Hurricane years.

1. Introduction:

Atlantic hurricane activity has largely increased in frequency and intensity since 1995 (Landsea et al., 1996). For the year 2008, there were 16 named storms with 8 of them reaching hurricane intensity including Hurricane IKE which had a landfall in Galveston, Texas (Williams 2010). Since hurricanes cause widespread devastation to daily operations and properties, prediction is very important to reduce the losses and evacuate people to safer places (Sattler et al., 2000). While hurricanes remain difficult to predict, hurricane forecasting has become more important nowadays (Sai Anudeep Reddy et al., 2019; Broad et al., 2007).

The recent increase in the Atlantic hurricane activity has fueled a debate on the role of rainfall in the increase (Ariramand et al., 2016). By looking at annual variations in various climate parameters, forecasts can make predictions about the overall number and intensity of hurricanes that will occur in a given season. In this paper, the total rainfall analysis of the Houston and Galveston areas has been carried out for the years 2022, 2014, and 2008.

2. Objective:

The overall objective was to compare the trend for the average and total rainfall in Houston. The specific objectives of this study are the following:

a) Investigate the monthly average rainfall pattern in the Years 2022/2023 (Current year) to 2013/2014 (Non-Hurricane year) with the rainfall pattern in the IKE hurricane in 2007/2008 (Reference).

b) Compare the mean rainfall difference, and root means square difference (RMSD) for the Year 2022/2023 (Current year) to the Hurricane year (2007/2008) and Non-Hurricane year (2013/2014).

3. Rainfall Analyses:

The investigation involved gathering precipitation data for the Houston region during the years 2023, 2014, and 2008. The data was acquired from the National Centers for Environmental Information (www.Ncds.noaa.gov) and subjected to analysis in order to establish the relationship between hurricanes and rainfall.

(a) Average Monthly Rainfall

Figure 1 illustrates the changes in average rainfall in the Houston region over a one-year period in the current year (July 2022-June 2023) and the Hurricane year (July 2007-June 2008), as well as the current year (July 2022-June 2023) compared to the Non-Hurricane year (July 2013-June 2014). Table 1 displays the mean Error and RMSD (Root Mean Square Deviation) of rainfall in 2023 when compared to the Non-Hurricane year, indicating lower values compared to the Non-Hurricane year in the Houston area.
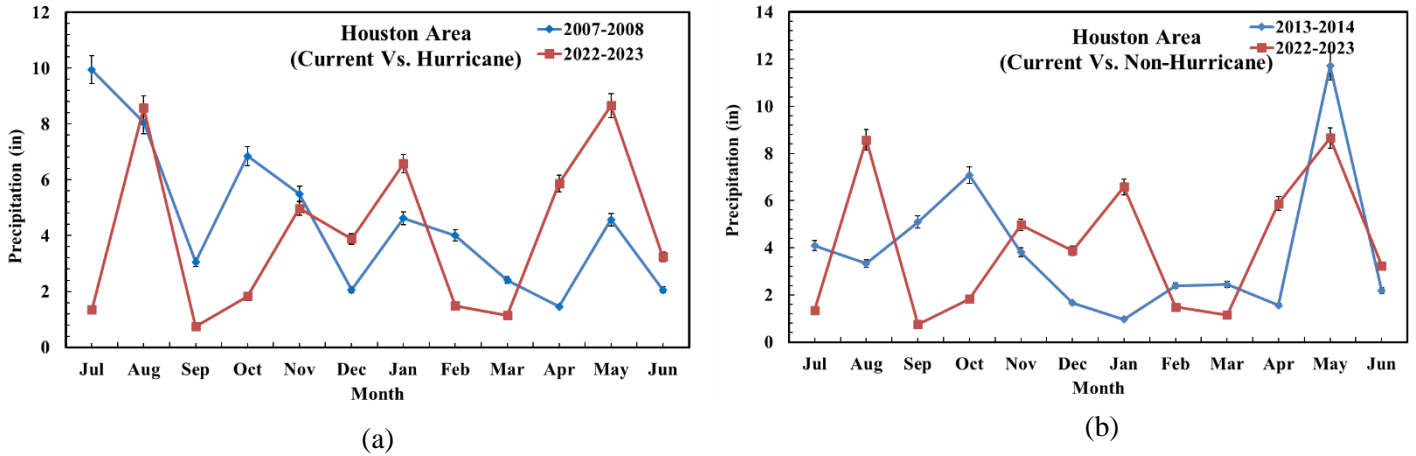
(a)

(b)

Figure 1: Variation of mean rainfall per month.

Table 1. Calculated mean difference and root mean square difference for average rainfall in the current year (2023) compared to the non-Hurricane year and the Hurricane year in the Houston area.

Area		Difference	Year	Rainfall (in.)
Houston		Mean	2022-2023 Compared to Hurricane year	0.52
		RMSD		1.05
		Mean	2022-2023 Compared to Non-Hurricane year	0.17
		RMSD		0.95
	Remark			The non-Hurricane year closed

(b) Cumulative Rainfall

Figure 2 presents the yearly accumulation of rainfall in the Houston area over a one-year period. During the occurrence of Hurricane IKE in Houston, the total annual rainfall measured 54.5 inches, while it amounted to 43.9 inches in the Non-Hurricane year and 48.3 inches in the current year. The Vipulanandan p-q model was utilized to forecast the cumulative precipitation for all the relevant years, yielding the following results:

$$\frac{Y}{Y_f} = \left[\frac{\frac{t}{t_f}}{q + (1-p-q)\frac{t}{t_f} + p\left(\frac{t}{t_f}\right)^{\frac{p-q}{(p)}}} \right] \tag{1}$$

where. Y is the cumulative precipitation, Y_f is the maximum cumulative precipitation, t is the time period, t_f is the time at the maximum cumulative precipitation, p, and q are model parameters. The model parameters for are presented in Table 2.
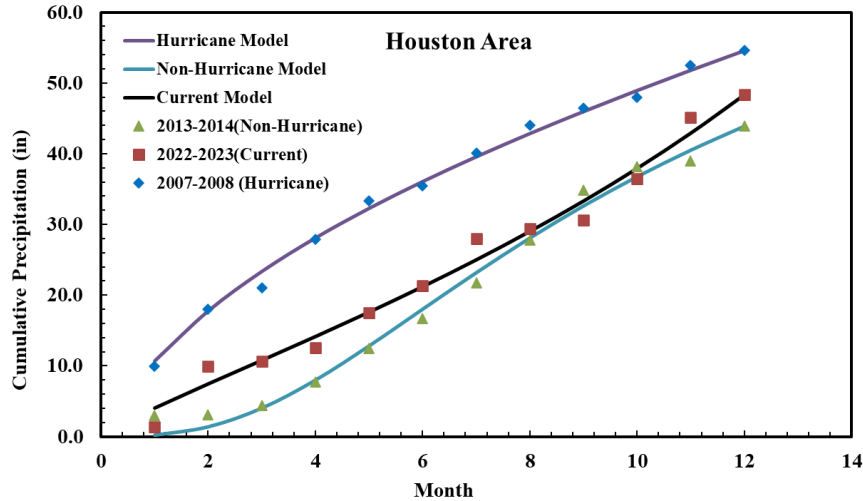
Figure 2. Cumulative rainfall trends in Houston.

Table 2. Model Parameter for Houston.

Parameter	Area	2007-2008	2013-2014	2022-2023
q=Es/Ei		0.30	0.44	0.70
P		4.00	0.15	1.47
p+q	Houston	4.30	0.59	2.17
R^2		0.99	0.99	0.98
RMSE		0.95	1.42	1.80

(c) Monthly Rainfall Rate

Figure 3 displays the categorization of monthly rainfall into various classes, ranging from less than 1 inch to over 10 inches. In both the years 2008&2023 and 2014&2023, the distribution of monthly rainfall in Houston can be considered fairly uniform across the respective year groups. Notably, three months in both year groups exhibit the same rainfall range of 3-5 inches. Furthermore, one month in the first-year group (2008&2023) and four months in the second year group (2014&2023) have identical rainfall values of 1-2 inches. Overall, for a span of seven months in the Houston area, the monthly rainfall compares favorably to both Hurricane year and the non-Hurricane years.
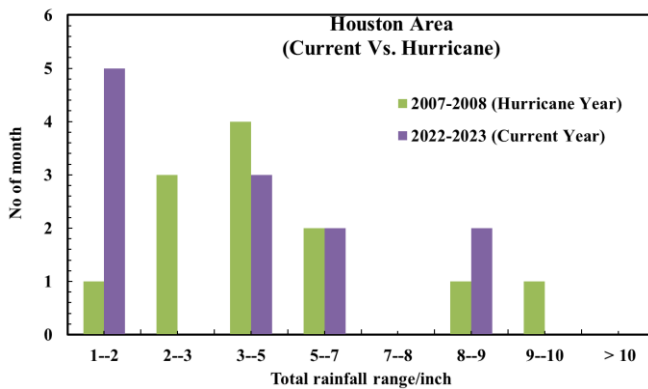
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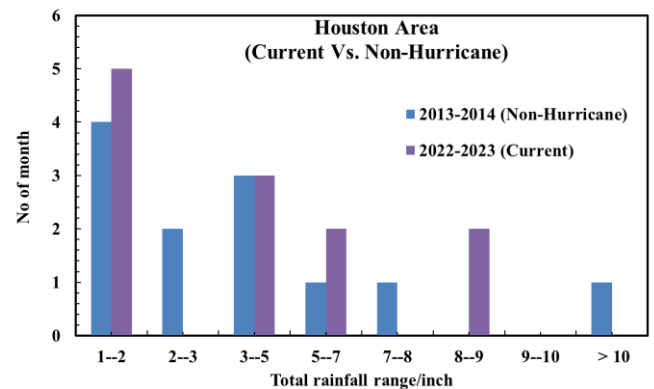
(b)

Figure 3. Monthly rainfall rate in Houston (a) Current year Vs Hurricane year and (b) Current year Vs Non-Hurricane year.

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4. Conclusions:

The Houston area exhibits a lower mean error and RMSD (Root Mean Square Deviation) of rainfall in the current year of interest (2023) when compared to the Non-hurricane year (2014), in contrast to the Hurricane year (2008). The annual rainfall in the Houston area for the year 2023 closely resembles that of the Non-Hurricane year. Through the analysis, it has been observed that there are seven months shared by the year group (2008&2023) and eight months with the year group (2014&2023) of monthly rainfall rates in the Houston area. Based on these findings, it can be predicted that the likelihood of a hurricane occurring in the Houston area in the year 2023 is relatively low.

5. Acknowledgments:

6. References:

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