Evaluation of the Possibility of Hurricane for the Year 2022 in Galveston and Houston Using the Inland Rainfall Trends

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Abstract

Relationships between monthly average and total rainfall for Galveston and Houston, Texas were investigated for the current year and compared with the IKE hurricane year (July 2007 to June 2008). In both Houston and Galveston, the average monthly rainfall in 2022 correlates with the Hurricane year more than the Non-Hurricane year. In addition, for 9 months in Houston, the monthly rainfall rate compared well with both the Hurricane and non-Hurricane years. In Galveston, for 9 months, the monthly rainfall rate compared well with the non-Hurricane year.

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, 201,4 and 2008.

2. Objective

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

a) Investigate the monthly average rainfall pattern in the Years 2021/2022 (Current year) with 2013/2014 (Non-Hurricane year) and with the rainfall pattern in the IKE hurricane in 2007/2008.

b) Calculate the error values, mean error, and root means square deviation (RMSD) for the rainfall in the Years 2021/2022 (Current year) with respect to the year Hurricane and Non-Hurricane years.

3. Rainfall Analyses:

The study was performed by collecting precipitation data for the Houston and Galveston areas for the years 2022 and 2008. The data was obtained from the National Centers for Environmental Information (www.Ncds.noaa.gov) and analyzed to determine the correlation between hurricanes and rainfall.

(a) <u>Average Monthly Rainfall</u>

Figure 1 shows the variation of mean rainfall in the Houston and Galveston areas for one year period in the current year (July 2021-June 2022) & Hurricane year (July 2007-June 2008), and the current year (July 2021-June 202) & Non-Hurricane (July 2013-June 2014). The mean Error and RMSD of rainfall in 2022 compared to the Hurricane year is less than that in 2022 compared to the Non-Hurricane year in both areas as shown in Table 1.
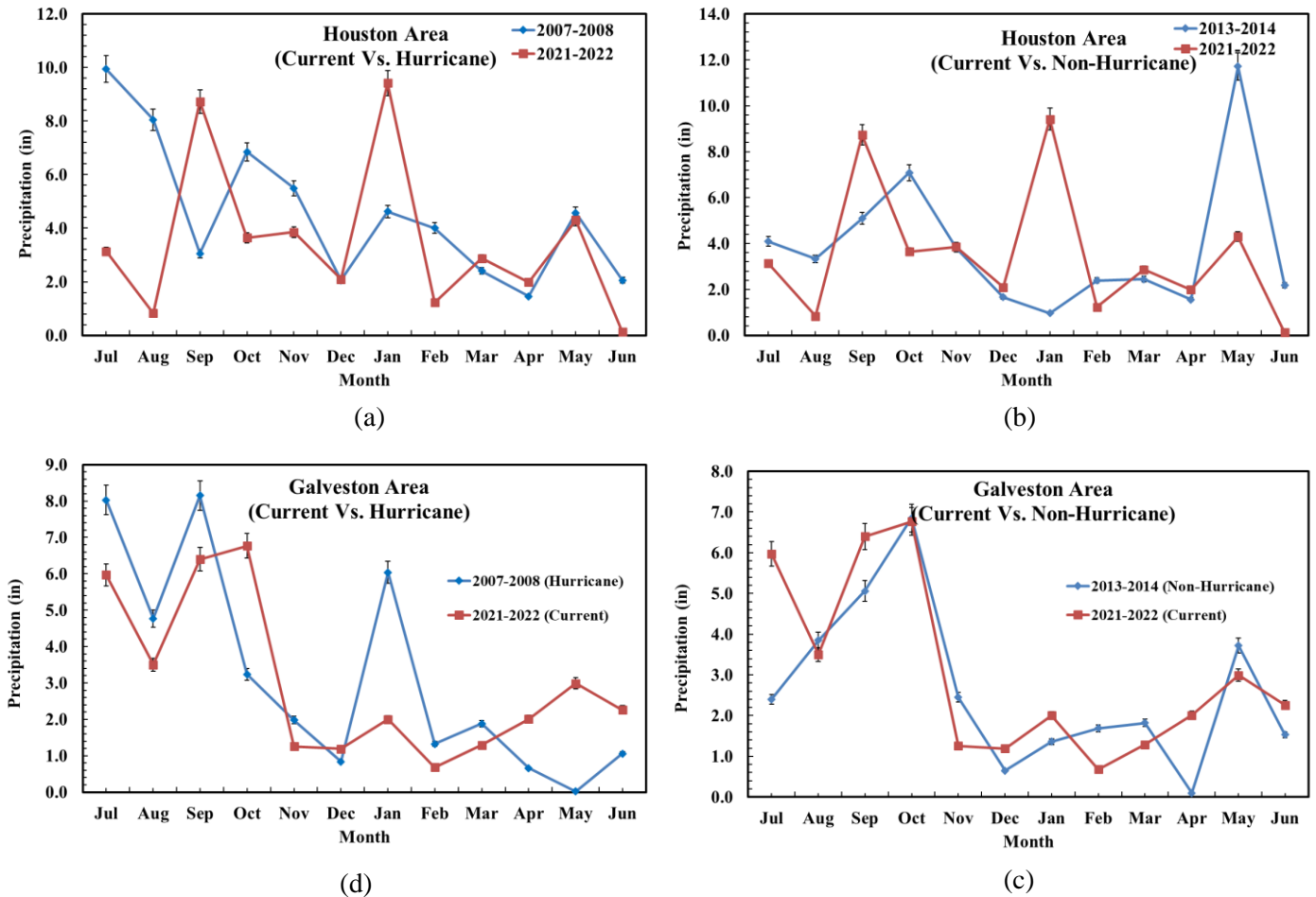

(a)

(b)

(d)

(c)

Figure 1: Variation of mean rainfall per month.

Table 1: Calculated mean errors, and root means square deviations for average rainfall in the current year (2022) compared to the non-Hurricane year and the Hurricane year in Houston and Galveston areas.

Area	Error Type	Year	Rainfall
Houston	Mean Error	2021-2022 Compared to Hurricane year	1.00
	RMSD		0.80
	Mean Error	2021-2022 Compared to Non-Hurricane year	1.92
	RMSD		1.26
Galveston	Mean Error	2021-2022 Compared to Hurricane year	3.00
	RMSD		1.30
	Mean Error	2021-2022 Compared to Non-Hurricane year	4.17
	RMSD		1.55

(b) Cumulative Rainfall

Figure 2 shows the annual cumulative rainfall in the Houston and Galveston areas for one year period. When IKE Hurricane hit Houston, the total annual rainfall was 54.5 inches, while it was 43.9 in the Non-Hurricane year and 42.2 inches in the current year. In Galveston, the total annual rainfall was 37.9 inches in the Hurricane year, while it was 39.9 in the Non-Hurricane year and 36.3 inches in the current year.

The p-q model was used to predict the cumulative precipitation for all concerned years as the following:

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

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.
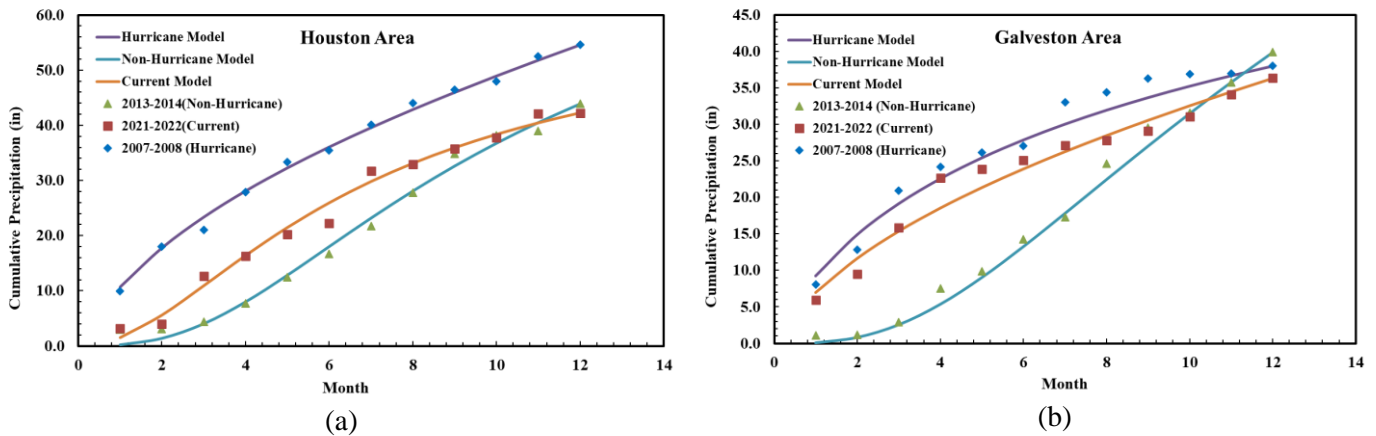

Figure 2: Cumulative rainfall trends in (a) Houston and (b) Galveston.

Table 2: Model Parameter for Houston and Galveston.

Parameter	Area	2007-2008	2013-2014	2021-2022
q=Es/Ei	Houston	0.30	0.44	0.24
P		4.00	0.15	0.11
p+q		4.30	0.59	0.35
R^2		0.99	0.99	0.98
RMSE		0.95	1.42	1.58
q=Es/Ei	Galveston	0.20	0.60	0.30
P		0.45	0.20	2.00
p+q		0.65	0.80	2.30
R^2		0.96	0.99	0.96
RMSE		1.77	1.24	1.74

(c) Monthly Rainfall Rate

Monthly rainfall was grouped into different classes from less than 1 inch to more than 10 inches as seen in Figure 3. In the years (2008&2022) and years (2014&2022), the monthly rainfall in Houston for both groups of years can be considered uniformly distributed. It was noted that 4 months in both groups of years have the same rainfall of 3-5 inches and 2 months of 2-93 inches. In general, for 9 months in the Houston area, the monthly rainfall compared well with both the Hurricane and non-Hurricane years.

Similarly in Galveston, 3 months in both groups of years have the same rainfall of 1-2 inches. In general, for 9 months in Galveston, the monthly rainfall compared well with the non-Hurricane year. In addition, for 6 months in Galveston, the monthly rainfall compared well with the Hurricane year.

4. Conclusions

Houston and Galveston areas have a lower mean error and RMSD of rainfall in the current year of interest (2022) compared to the hurricane year (2008) than the Non-Hurricane year (2014). Annual rainfall in the Houston area in the year 2022 was similar to both the Hurricane and Non-Hurricane years, while in the Galveston area was close to the Non-Hurricane year. Based on the analyses, it has been found that there are 9 months in both groups of years (2008&2022) and years (2014&2022) that have the same monthly rainfall rate in the Houston area. From this, it can be predicted that there is a high chance of having a hurricane in the Houston area than Galveston area in the year 2022.

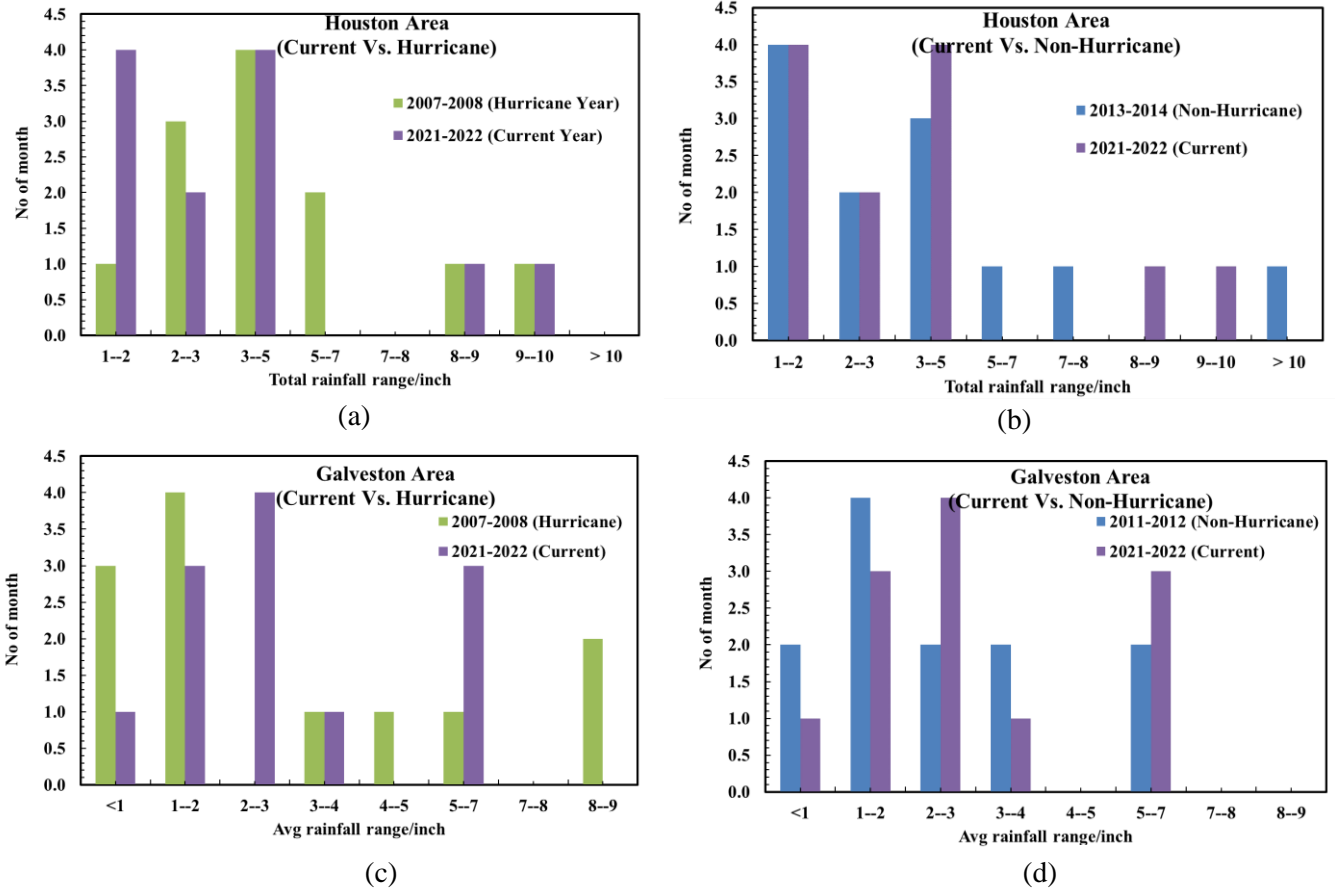## 5. Acknowledgments

(a)

(b)

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(d)

Figure 3 Monthly rainfall rate in (a) Houston and (b) Galveston.

6. References

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