

Houston Annual Precipitation and Temperature Predictions using Artificial Neural Networks

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Abstract: In this study, the annual precipitation and annual minimum, annual average and annual maximum temperatures with occurrence of tropical storms and hurricanes in the Houston area was studied. In this study, the annual precipitation, annual maximum, average and minimum temperature data for a period of 50 years from 1968 to 2018 during July to June every year was considered. The values of precipitation and temperatures are analyzed for a total of six tropical storms and hurricanes which include Hurricane Rosa (1994), Rita (2005), Ike (2008), Harvey (2017) and tropical storms Allison (2001) and Grace (2003). The average annual precipitation for period 1968 to 2018 is 53.9 inches and average temperature is 70.2 °F. The temperature behavior for Houston area for the period of 1968 to 2018 is predicted using artificial neural network. The average temperature for year 2019 was predicted to be 72 °F, about 1.8 °F greater than the 50 year average.

1. Introduction:

Tropical cyclones are among the deadliest and most destructive form of natural disasters causing widespread damage and destruction in their path. Hurricane Katrina was the costliest natural disaster in the USA, resulted in at least 1,833 deaths and costing US\$160 billion in damages (all dollars adjusted to 2017) along the Gulf Coast of the USA in August 2005. A close second is hurricane Harvey, which stalled over the Houston metropolitan area in August 2017, causing record flooding. The hurricane Harvey caused the second largest loss of over \$125 billion compared to Katrina in 2005. Hurricane Harvey, a category 4 storm that hit Texas on August 25, 2017 caused about \$125 billion in damage affecting about 13 million people from Texas through Louisiana, Mississippi, Tennessee, and Kentucky [1]. The rainfall amounts across the Houston area ranked as roughly a 1,000-year event. This does not mean that it will be 1,000 years before the next flood of this magnitude will occur. With climate change shifting the odds in favour of extreme rainfall events, return period calculations like this are becoming less useful to civil engineers who must design infrastructure to withstand historical floods. In total, the hyperactive 2017 Atlantic hurricane season caused at least US\$265 billion in damages and 251 fatalities, probably a staggering underestimate owing to crippled communications and infrastructure in Puerto Rico, which meant that many hurricane-related deaths were unconfirmed [2]. To improve the resiliency to these tropical events, it is critical to understand the drivers of tropical cyclone variability and change. A new study, published by the National Energy Research Scientific Computing Center, reports that climate change intensified the rains of Hurricane Katrina, Hurricane Irma and Hurricane Maria by between 4 and 9 percent. The researchers predict that future warming could increase rainfall totals for the most extreme hurricanes and tropical cyclones by up to 30 percent [2]. The average annual rainfall in 2017 was 74.74 inches, 20.56 inches above 50 year average. The annual average temperature was 71.8 °F, 1.6 °F greater than 50 year annual average temperature. The purpose of this study is to advance our understanding of influences on tropical cyclones by quantifying the impact of climate change so far, and in the future, on the precipitation and temperature increase. An ANN model was used to predict average temperature for 50 year period. A data set of about 50 points was used to train the network.

- Objective:** The main objective was to investigate the dependence of tropical events on the past precipitation and temperature and also to predict average annual temperature using artificial neural network.

3. Method:

The study was performed by collecting precipitation and temperature data for the Houston area for the past 50 years from 1968 to 2018. The data was obtained from the NOAA National Centers for Environmental Information.

4. Results and Discussion:

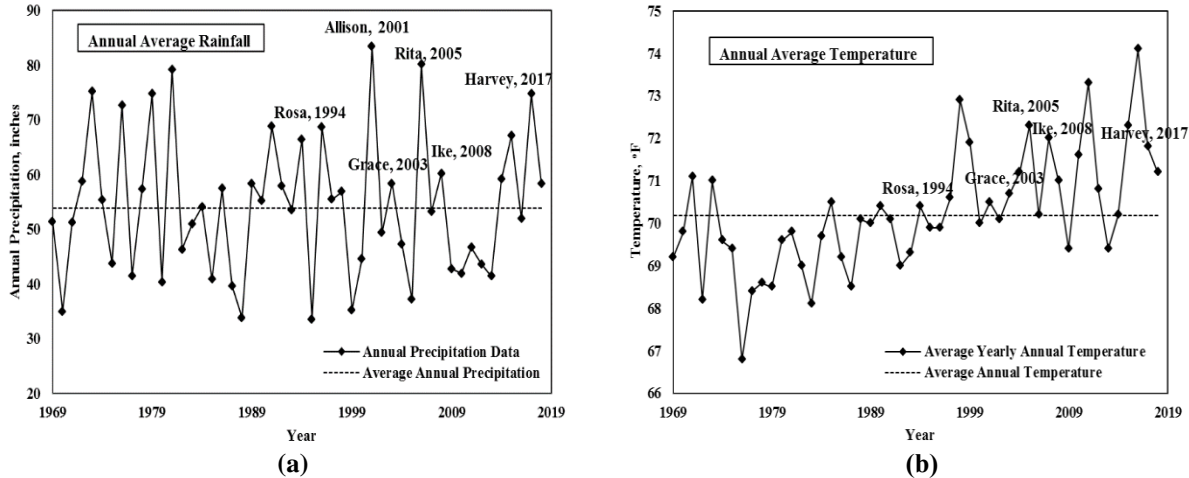


Figure 1: Houston area past 50 years (1968 to 2018) (a) Annual Precipitation Data, (b) Annual Average Temperature. Rainfall

The 50 year average annual precipitation for Houston area is 53.9 inches with a standard deviation of 0.3 inches. The maximum value of yearly precipitation of 83.41 inches occurred in 2001 and marked occurrence of tropical storm Allison. Houston area recorded a precipitation of 66.43 inches marking occurrence of Hurricane Rosa, a precipitation of 58.39 inches was recorded in 2003 which includes tropical storm Grace, a precipitation of 80.12 in 2005 which includes hurricane Rita, 2005, a precipitation of 60.2 inches in 2008 which includes hurricane Ike and a precipitation of 74.74 inches in 2017 which includes Hurricane Harvey. It is evident that occurrence of tropical event is leading to increase in precipitation by 4.5 inches above average. (Fig. 1(a)).

Temperature

The annual average temperature of Houston area for 50 year period was 70.2 °F (Fig. 1(b)).

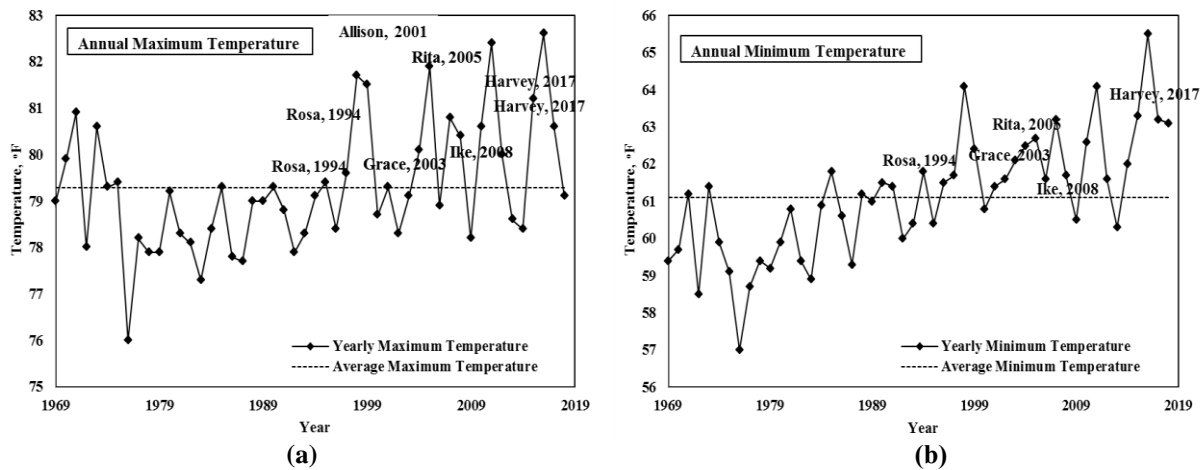


Figure 2: Houston area 50 year (1968-2018) (a) Yearly Maximum Temperature, (b) Yearly Minimum Temperature.

The 50 year average maximum temperature was 79.3 °F and average minimum temperature was 61.1 °F for a period from 1968 to 2018. The occurrence of tropical storms and hurricanes were identified to be in year with annual average temperature above the 50 year average by atleast 0.5 °F. The yearly maximum temperature in 1968 was 77.9 °F while it is 79.1°F in 2018, a 1.5% increase. The yearly minimum temperature in 1968 was 59.7 °F while it was 63.1 °F in 2018, a 5.7% increase. (Fig. 2(a) & 2(b))

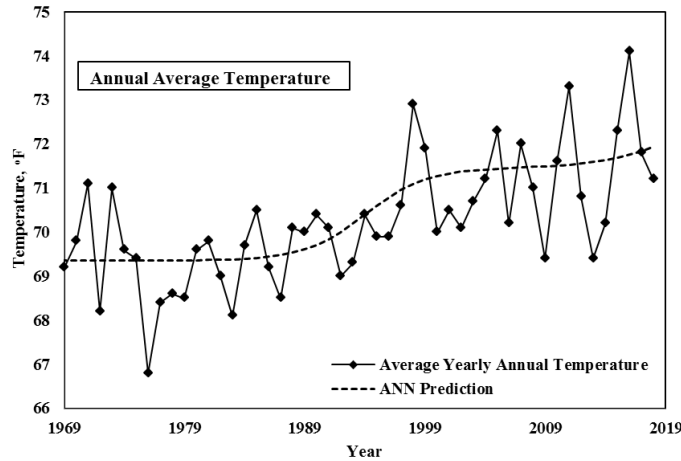


Figure 3: Artificial Neural Network prediction of average temperature for Houston area for 50 year period (1968-2018). The yearly average temperature was 68.8 °F in 1968 while it was 71.2 °F in 2018, a 3.5% increase. Artificial Neural Network was used to predict the annual average temperature. The RMSE for ANN prediction was 1.06 °F. ANN predicted the average temperature in 2019 to be 72 °F.

5. Conclusion:

The 50 year average annual precipitation for Houston area is 53.9 inches. Occurrence of tropical event is leading to increase in precipitation by 4.5 inches above average. The yearly average temperature was 68.8 °F in 1968 while it was 71.2 °F in 2018, a 3.5% increase. The occurrence of tropical storms and hurricanes were identified to be in year with annual average temperature above the 50 year average by atleast 0.5 °F. ANN predicted the average temperature in 2019 to be 72 °F.

6. Acknowledgements:

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7. References:

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