Connecting Urban Areas and Flood Risk: Forecasting Hydrometeorological Conditions that can Fuel Flood Events Around the Dallas-Fort Worth Area and the Influence of the Local Urban Heat Island Effect, Part One

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Introduction

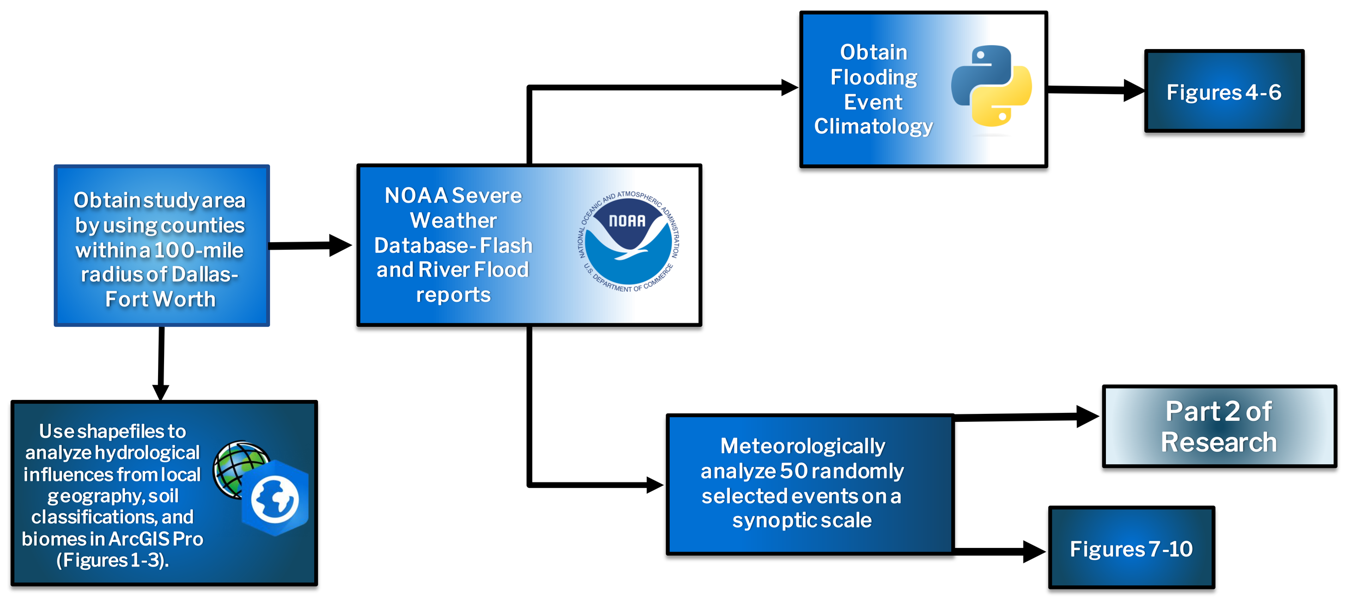
From August 21-22, 2022, widespread river and flash flooding occurred in the North Central Texas and Southern Oklahoma region. The bouts of heavy rainfall that spurred this event were difficult to forecast. In addition to the synoptic-scale weather pattern, the overperformance of the rainfall event may have seen some influence from the Urban Heat Island (UHI) effect given off by Dallas-Fort Worth (DFW).

Although previous studies have analyzed UHI-based impacts on heavy rainfall and subsequent flooding conditions, few have focused on the region surrounding DFW. This study combines several cases of river and flash flooding events from 2002-2022 for a GIS-based analysis. All these events occurred in counties within a 100-mile radius of the metropolitan area. The first part of this study aims to validate the climatological patterns and large-scale hydrological drivers within this region. The results from this study will be used to support the second part of this research, which will focus on separating urban influences from climatological drivers. It will then evaluate connections between the relative strength of the UHI effect to flooding within the study area.

Objectives

- Analyze which counties within a 100-mile radius of Dallas-Fort Worth experienced the most flooding events
- Pinpoint the type of weather phenomenon which contributes to the greatest number of flooding events in the region
- Identify the time(s) of year in which flooding events most commonly occur
- Identify the common synoptic-scale meteorological features from 50 randomly-chosen cases
  - *Determine a possible influence on these patterns from ENSO*
- Establish baseline hydrological conditions

Process



STUDY REGION

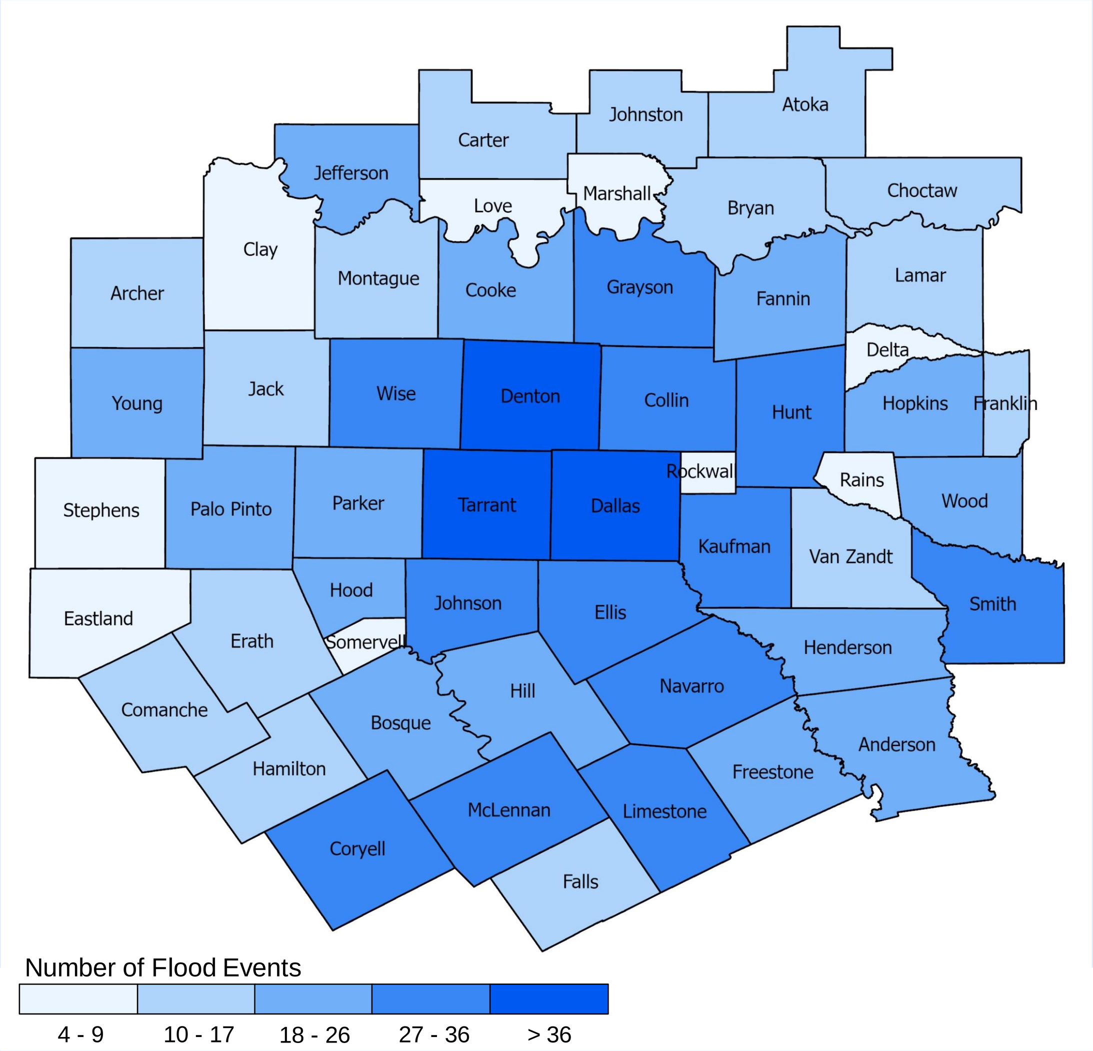


Figure 1 - Number of Flood Events Reported per County (2002-2022)

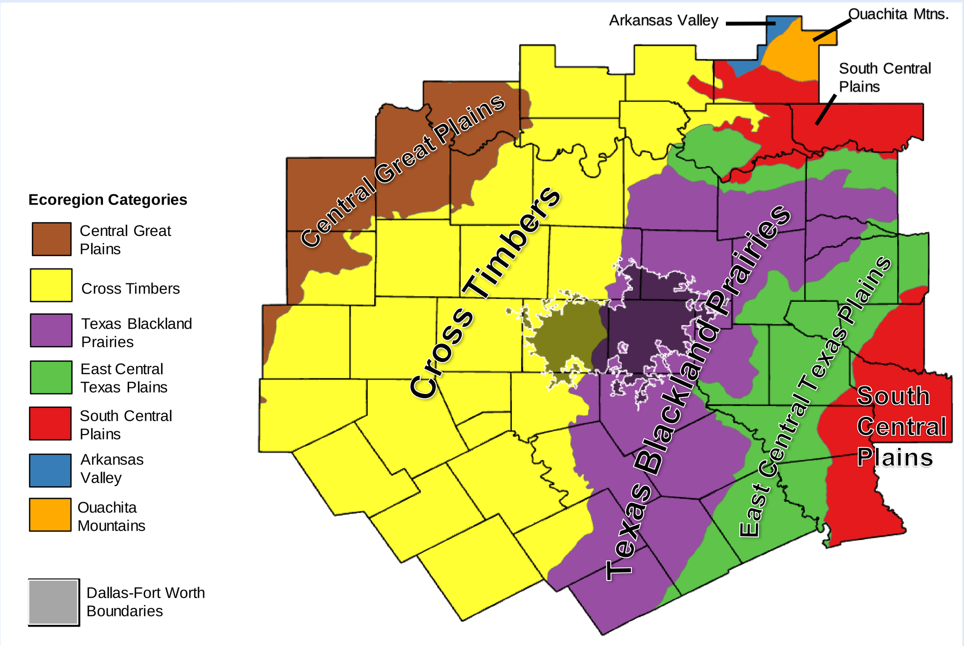


Figure 2 - Ecoregions with DFW Boundaries

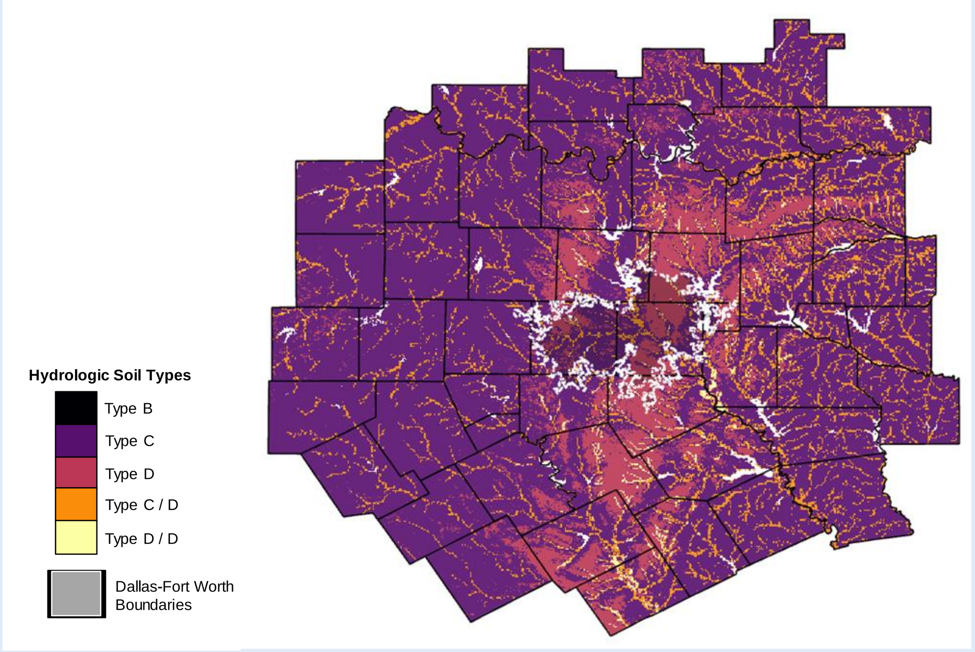


Figure 3 - Hydrologic Soil Classifications with DFW Boundaries

Figures 1, 2, and **3** display the number of flood events captured in the study area along with the physical characteristics of the region. The cities of Dallas and Fort Worth, Texas are at the center of this study area.

FLOODING CLIMATOLOGY

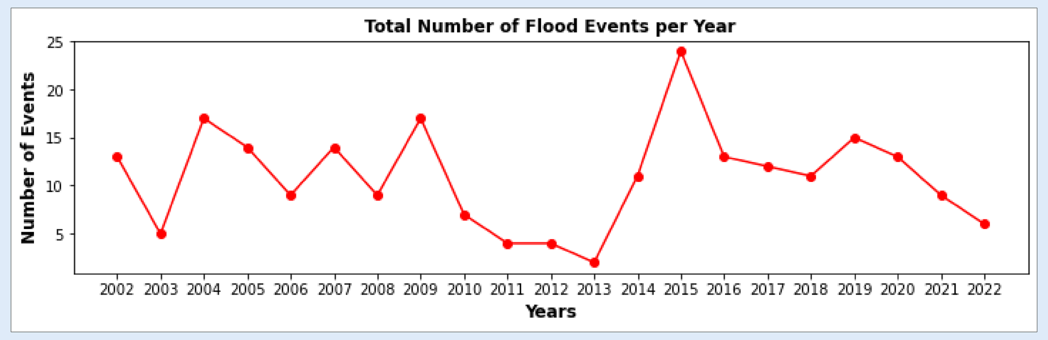


Figure 4 displays the number of Flood Events per Year. Quite a few of the years with higher flood event numbers can also be correlated with fairly strong El Nino anomalies. In particular, the year 2015 served as inspiration to investigate ENSO influences on North Central Texas flooding events.

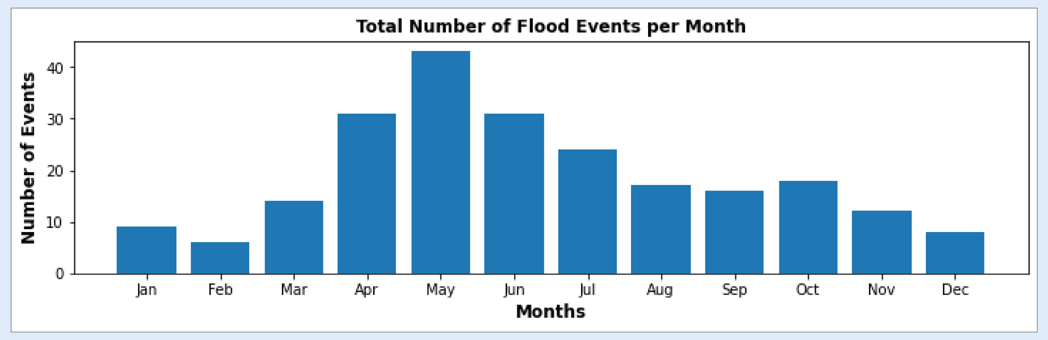


Figure 5 displays the number of Flood Events per month, tallied up from all the years. This chart follows the expectations held for the likelihood of flooding to be strongest from April to July. A smaller, secondary peak in October also somewhat followed expectations, yet caught interest.

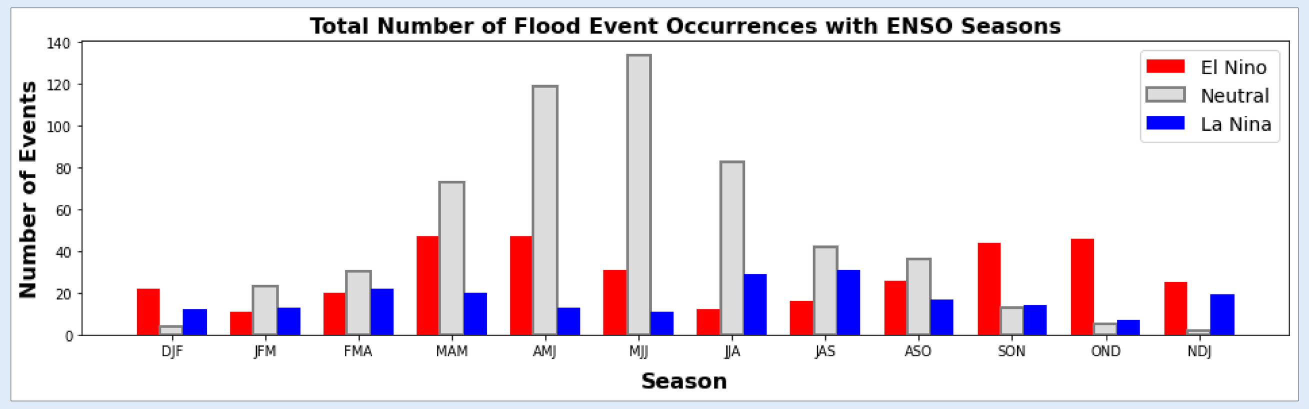
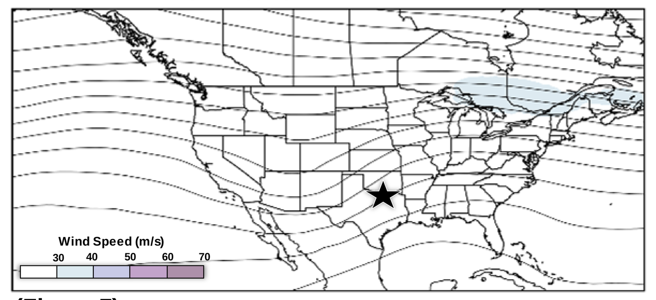


Figure 6 displays the total number of flooding events within a 3-month ENSO season, separating the total events ENSO anomaly type. It appears that a neutral period follows the primary peak in Figure 5. This figure also indicates that the ENSO anomalies can not only determine flood frequencies, but also when the greatest flooding events occur.

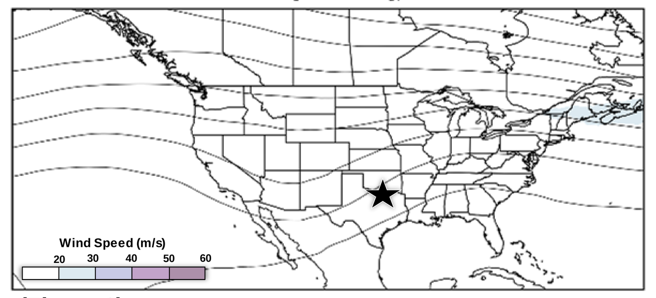
Synoptic Scale Meteorology

Average Geopotential Height (m) and Wind Speed (m/s) at 300 hPa, 12 UTC



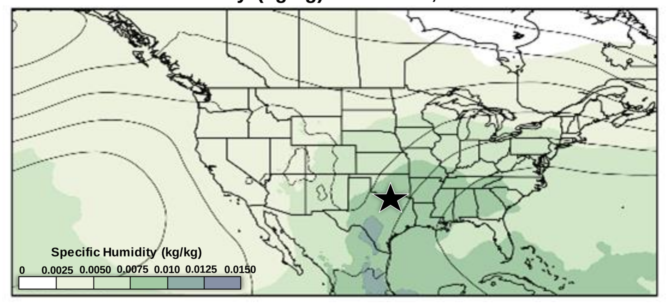
(Figure 7)

Average Geopotential Height (m) and Wind Speed (m/s) at 500 hPa, 12 UTC



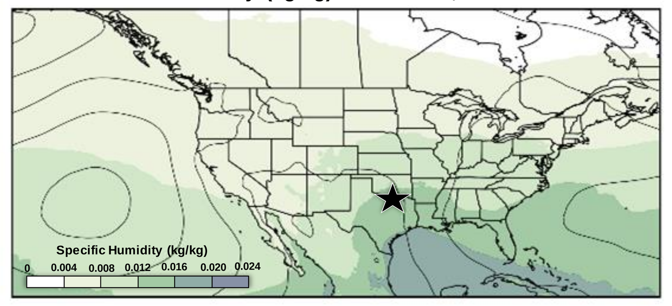
(Figure 8)

Average Geopotential Height (m) and Specific Humidity (kg/kg) at 850 hPa, 12 UTC



(Figure 9)

Average Geopotential Height (m) and Specific Humidity (kg/kg) at 1000 hPa, 12 UTC



(Figure 10)

- Datasets with various atmospheric measurements were taken from the NOAA North American Regional Reanalysis archive.
  - *- **Figures 6-7** display averages of geopotential heights and wind speed measurements taken from the 50 randomly selected events.*
  - *- **Figures 8-9** show averages of geopotential heights and specific humidity measurements taken from the 50 randomly selected events.*
- These maps also follow overall expectations regarding general synoptic-scale conditions prior to flooding events in the study region. In addition, an overwhelming majority of these events were spurred on by convective precipitation.
  - *-Height falls were present over the state of Texas, with height rises both east and west of the interpolated low pressure system. Atmospheric height rises are often attributed with slowing a low pressure system, which is a necessary ingredient for flood-inducing precipitation events.*
  - *-As a given, ample moisture is also vital. Separate figures illustrating lower atmospheric levels show the presence of a tighter gradient of geopotential heights. It can be interpolated that a steady low level jet is present and advecting moisture into the region.*

Future Steps into Part Two

- Conduct meteorological analysis on the mesoscale, using ASOS network data, ArcGIS Pro, and Python
  - *- Randomly select 50 cases from main flooding dataset*
  - *- Analyze precipitation by using river forecast center Quantitative Precipitation Estimates QPE), CoCoRAHs observations, and NEXRAD Level II Data*
  - *- Randomly select 20 cases of heavy precipitation without flooding for meteorological analysis*
  - *- Investigate urban influences on local precipitation*
- *Analyze antecedent hydrological conditions of selected flooding cases*
  - *- Use various satellite imagery*
  - *- Obtain Soil Moisture indices (observations preferred)*
  - *- Use Elevation data*
- *Investigate underreporting of flood impacts by cross-validating against river gauge data*
- *Improve synoptic analysis code to further analyze upper-level pressure system movement and evolution*

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REFERENCES:

Ross, C.W., L. Prihodko, J.Y. Anchang, S.S. Kumar, W. Ji, and N.P. Hanan, 2018: Global Hydrologic Soil Groups (HYSOGs250m) for Curve Number-Based Runoff Modeling, Version 1. ORNL DAAC, accessed 19 September 2023, https://doi.org/10.3334/ORNLDAAC/1566

United States Environmental Protection Agency, 2013: Level III Ecoregions of the Continental United States, Unknown Version, United States Environmental Protection Agency, accessed 05 October 2023, https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

United States Census Bureau, 2012: 2010 TIGER/Line Shapefiles, Unknown Version, United States Census Bureau, accessed 06 January 2024, https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.2010.html#list-tab-790442341

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