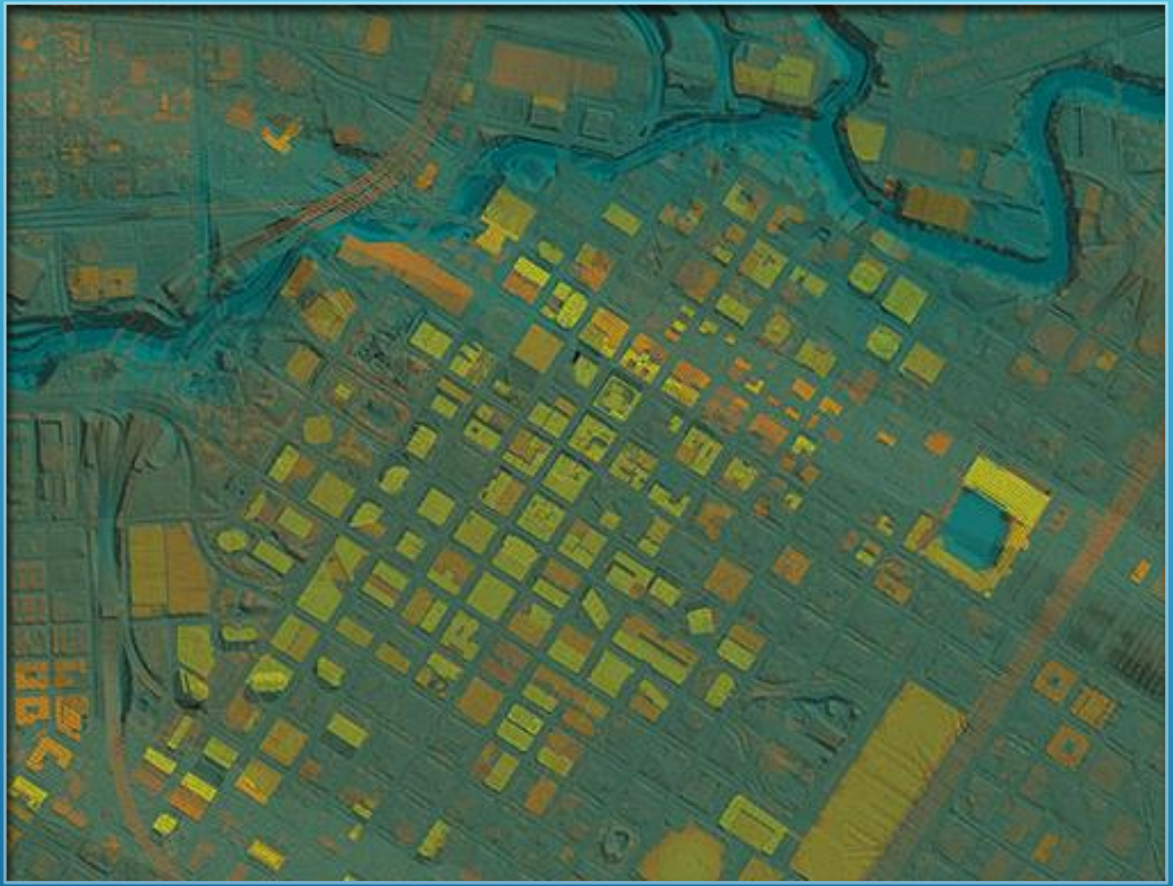


EXPLORING THE CORRELATION BETWEEN LAND SUBSIDENCE, URBAN DEVELOPMENT, IMPERVIOUS SURFACES, AND INUNDATION IN THE GREATER HOUSTON REGION USING REMOTE SENSING DATA

Thursday, July 16, 2020

GEOG 596A Capstone Proposal

Presenter: Brooks Andrews, Graduate Student, The Pennsylvania State University

Advisor: Karen Schuckman, Associate Teaching Professor, The Pennsylvania State University

OVERVIEW

- Project Background
- Goals and Objectives
- Proposed Methodology
- Anticipated Results
- Limitations and Considerations
- Project Timeline
- Presentation Venues/Acknowledgements
- References

ABOUT ME

- GIS Program Manager at the Houston-Galveston Area Council (H-GAC)
  - Data Services GIS team
  - Employed at H-GAC since 2012
- Bachelor's of Science in Urban and Regional Planning from Texas State University-San Marcos in 2011
  - Certificate in Geographic Information Systems
  - Minor in Business Administration
- Greater Houston native and current resident
- Hobbies: running/exercise, wine, travel

Notre-Dame, Paris, France – June 2018
Photo Credit: Ashley Andrews

PROJECT BACKGROUND

- The problem: In recent years, the Greater Houston metro-statistical area with a growing population of 7.0 million residents have seen an increase in the number of major flooding events as well as the severity of flooding events (Greater Houston Partnership, 2019).
- This capstone proposal focuses on what humans might be doing to cause these flooding events to occur more frequently and with increased severity in the Greater Houston region.

Downtown Houston, Texas
Photo Credit: Ryan Conine

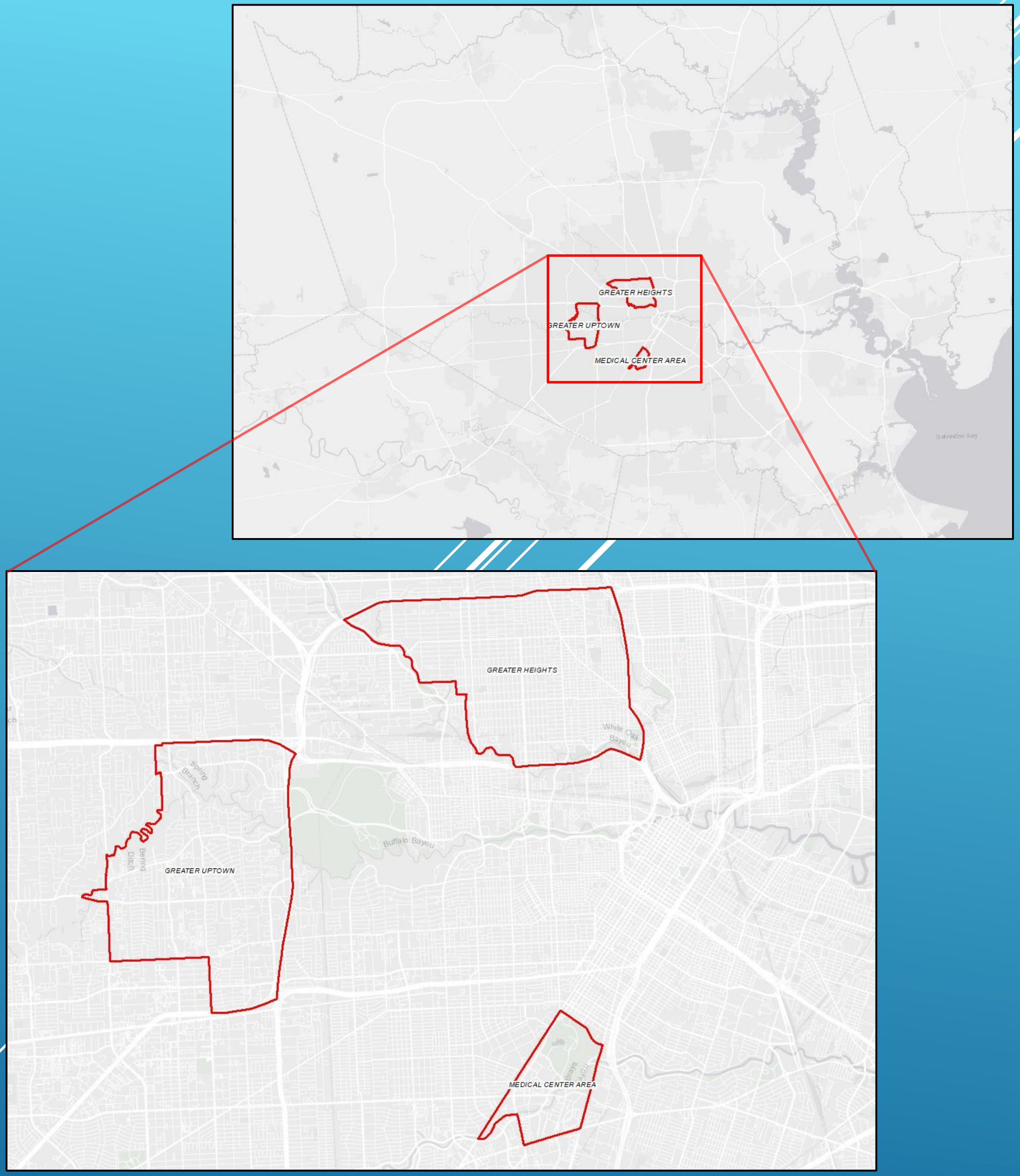
PROJECT BACKGROUND

- *"Category 4 landfalling hurricane Harvey poured more than a metre of rainfall across the heavily populated Houston area, leading to unprecedented flooding and damage. Although studies have focused on the contribution of anthropogenic climate change to this extreme rainfall event, limited attention has been paid to the potential effects of urbanization on the hydrometeorology associated with hurricane Harvey. Here we find that urbanization exacerbated not only the flood response but also the storm total rainfall."* (Zhang et al., 2018)

Flooding in Houston, Texas from Hurricane Harvey in 2017
Photo Credit: David J. Phillip, AP Photo

PROJECT BACKGROUND

- The proposal is a remote sensing-based analysis that is based on my own GEOG 481 final project from Spring 2019.
- The analysis methodology will utilize digital aerial orthoimagery and lidar data and derivatives to compare change in the bare earth and the built environment from 2008 to 2018 in the Greater Houston region.
- Three flood-prone neighborhoods within the City of Houston have been identified for the analysis.
    - Greater Heights neighborhood (7.32 sq. mi.)
    - Greater Uptown neighborhood (8.24 sq. mi.)
    - Medical Center Area neighborhood (1.67 sq. mi.)



GOALS AND OBJECTIVES

- The goal: Utilize the data, technology, and analysis methodology identified to explore a possible link between increases in land subsidence, urban development, and impermeable surfaces and how they have impacted flooding frequency and severity in the Greater Houston region in the decade between 2008 and 2018.
- The analysis will produce results relating to the changes in land subsidence, urban development, and impermeable surfaces while existing literature will be used to link the results to extreme flooding.

Flooding in Houston, Texas from the Memorial Day Flood in 2015
Photo Credit: Thomas B. Shea, Houston Chronicle

GOALS AND OBJECTIVES

- The data: The following data will be acquired from the Houston-Galveston Area Council and the City of Houston.
  - Lidar Data
    - 2018 Lidar (Harris County Flood Control District Extent)
      - LAS Point Cloud (LAS 1.4)
    - 2008 Lidar
      - LAS Point Cloud (LAS 1.1)
  - Aerial Orthoimagery Data
    - 2018 Aerials 6 Inch
      - MrSID and GeoTIFF formats
    - 2008 Aerials 6 Inch
      - MrSID and GeoTIFF formats
  - Boundary Data
    - City of Houston Super Neighborhoods
      - 15-Greater Heights, 21-Greater Uptown, 33-Medical Center

Houston-Galveston Area Council

Source: Houston-Galveston Area Council

Source: City of Houston

GOALS AND OBJECTIVES

- The technology: The following desktop GIS programs will be used for data processing and analysis.
  - Esri's ArcGIS Pro
    - Version 2.5.1
    - Uses: Aerial orthoimagery analysis, visualizations and cartographic outputs
  - Esri's ArcGIS Desktop
    - Version 10.6.1
    - Uses: Data processing, raster processing tools, visualizations and cartographic outputs
  - GeoCue Group's LP360
    - Version 2019.1.30.5, 64-bit
    - Uses: Data processing, lidar analysis and derivative production

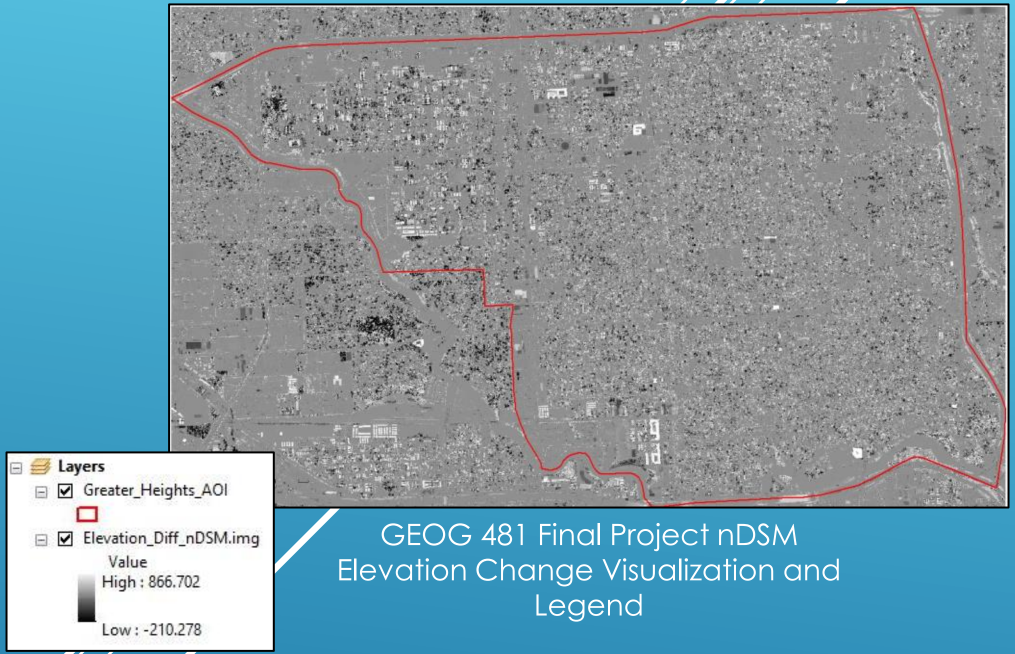
Source: Esri

Source: Esri

Source: GeoCue Group

PROPOSED METHODOLOGY

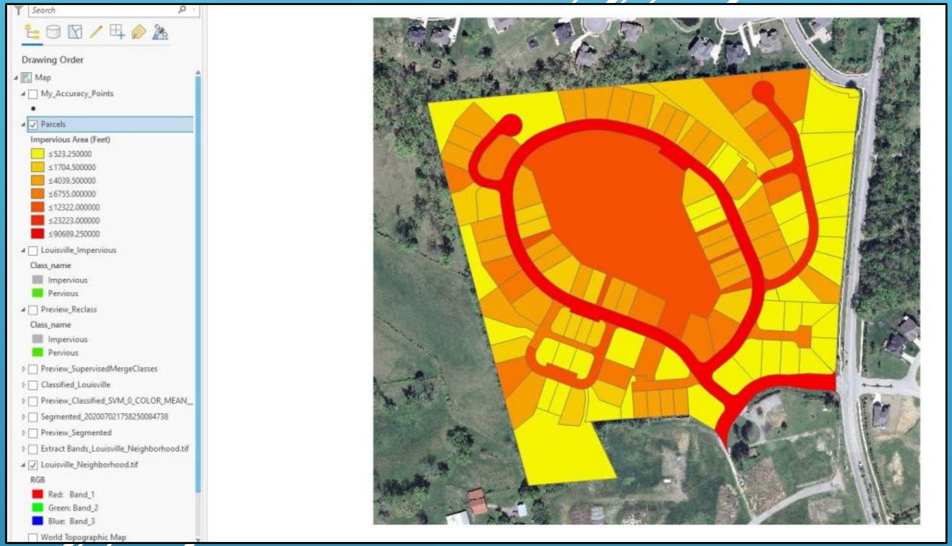
- Lidar analysis and methodology
  - Digital elevation models (DEMs) and digital surface models (DSMs) from 2008 and 2018 will be produced and used to compare the change in the bare earth
  - Normalized digital surface models (nDSMs) will then be generated for both years to compare the changes above the ground in the built environment
  - Using raster processing tools, elevation change surfaces for both the bare earth and the built environment will be produced to summarize the detected changes in all three neighborhoods from 2008 to 2018
  - The result is six elevation change visualizations displaying the changes in land subsidence and urban development



GEOG 481 Final Project nDSM Elevation Change Visualization and Legend

PROPOSED METHODOLOGY

- Aerial orthoimagery analysis and methodology
  - Digital aerial orthoimagery at six-inch resolution from 2008 and 2018 will be segmented by pixels to make image classification more accurate
  - Once segmented, supervised classifications based on land use will be preformed to classify the imagery
  - Once classified, impervious surfaces will be calculated using the spectral content and classification of the imagery
  - Using raster processing tools, impervious change surfaces for the built environment will be produced to summarize the detected changes in all three neighborhoods from 2008 to 2018
  - The result is three impervious change visualizations displaying the impervious surface changes



Result from Esri's Calculate Impervious Surfaces from Spectral Imagery Online Training

PROPOSED METHODOLOGY

1. Acquire raw data and technology licenses
2. Pre-process data (i.e. clip to boundaries, ensure coordinate systems, datums, and linear units, etc.)
3. Lidar: Export rasters for both DEM and DSM models for 2008 and 2018 for all three AOIs
4. Lidar: Import surfaces into ArcGIS Desktop to further clip to the bounding rectangle of all three AOIs to avoid edge effects caused by LP360 exporting
5. Lidar: Use clipped DEMs and DSMs to create nDSMs for both 2008 and 2018 for all three AOIs
6. Lidar: Subtract 2008 DEMs from 2018 DEMs to show total elevation gained/lost in the bare earth for the decade in all three AOIs
7. Lidar: Subtract 2008 nDSMs from 2018 nDSMs to show total elevation gained/lost in the built environment for the decade in all three AOIs

Flow chart continues to next slide…

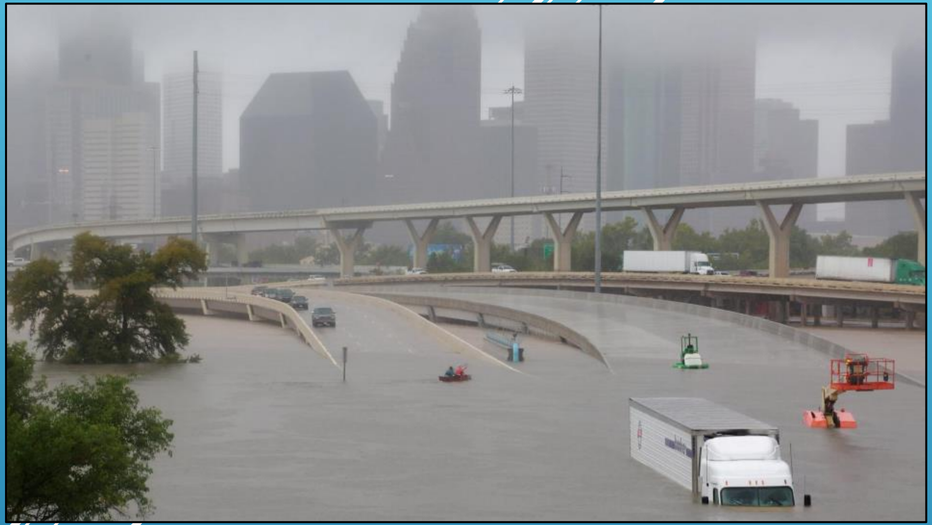
PROPOSED METHODOLOGY

Flow chart continues from previous slide…

1. Lidar: Test final DEM and nDSM elevation change surfaces at know test locations
2. Aerials: In ArcGIS Pro, segment 2008 and 2018 imagery by pixels for various tiles for all three AOIs
3. Aerials: Used supervised classifications based on land use to classify tiles for all three AOIs
4. Aerials: Use spectral content and classifications of tiles to create impervious surface outputs for various tiles for all three AOIs
5. Aerials: Subtract 2008 impervious surfaces from 2018 impervious surfaces to show total gain/loss in the built environment for the decade in all three AOIs
6. Aerials: Symbolize and display the resulting impervious change visualizations for all three AOIs
7. Import all final analysis change visualizations into ArcGIS Desktop or Pro to create final change detection maps for final report

ANTICIPATED RESULTS

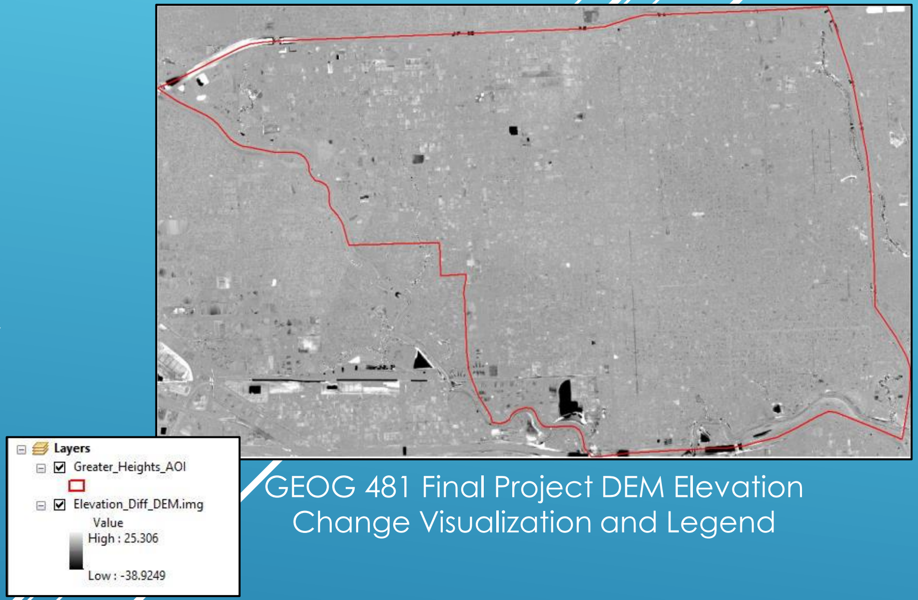
- Change in both the bare earth and the built environment especially are expected
- Given the likely increase in all three phenomena for all three AOIs in the decade identified, a link can be drawn between this and the increases in both flooding frequency and flooding severity
- Pre-selected, peer reviewed literature from this capstone proposal will be linked to reinforce the analysis results
- The analysis results and literature should show that…
  - Increases in land subsidence has lowered the base flood elevation in the region
  - Increases in urban development and impervious surfaces have decreased the permeable surfaces for water to recede in the region



Flooding in Houston, Texas from Hurricane Harvey in 2017
Photo Credit: Richard Carson, Reuters

LIMITATIONS AND CONSIDERATIONS

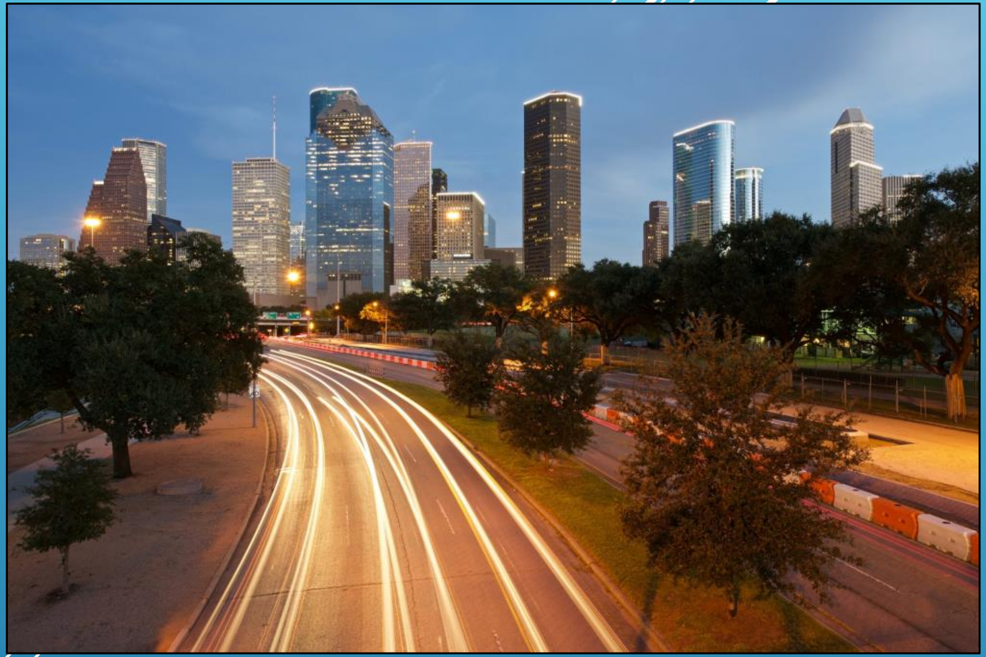
- Scale Limitation
  - Scalability will likely be issue for the aerial orthoimagery analysis
  - Analysis per one imagery tile at a time will prove cumbersome for both time and computing power (Viswambharan, 2020)
- Time Limitation
  - As noted, the aerial orthoimagery analysis will take far more time than allowed for this capstone project
  - 4.04 .sq mi. imagery tiles will need to be carefully selected to show accurate change in impervious surfaces for each neighborhood
- Data Size Limitation
  - The size of the lidar data and derivatives could possibly overwhelm the computing power of my current machine



GEOG 481 Final Project DEM Elevation Change Visualization and Legend

LIMITATIONS AND CONSIDERATIONS

- Title Change Consideration
  - For succinctness and accuracy, a project title change might be appropriate
  - *Exploring the Relation Between Urban Growth and Flooding in the City of Houston Using Remote Sensing*
- Future Study Considerations
  - This capstone is not indented to solve the issue of flooding, but rather highlight the consequences of unmanaged urban growth and how it affects flooding severity and frequency.
  - This capstone can provide the base for future studies going forward to explore other flooding concerns (i.e. climate change and weather patterns).



Downtown Houston, Texas
Photo Credit: Matt Nielsen

PROJECT TIMELINE

- July 2020
  - Proposal completion and presentation; end of GEOG 596A
- August 2020
  - Data acquisition and processing; start of capstone project analysis
- February 2021
  - End of capstone project analysis; compile results
- March 2021
  - Start of GEOG 596B; final report and presentation development
- April/May 2021
  - Final report completion and presentation; end of GEOG 596B

PRESENTATION VENUES/ACKNOWLEDGEMENTS

- Presentation Venues
  - American Association of Geographers Annual Meeting
    - April 7-11, 2021 in Seattle, WA
  - Conference of Latin American Geographers
    - May 20-22, 2021 in Tucson, AZ

- Acknowledgements
  - Karen Schuckman, Associate Teaching Professor, The Pennsylvania State University
  - Larry Nierth, Geographic Information Officer, City of Houston
  - Bill Bass, Geospatial & Analytics Senior Manager, Houston Advanced Research Center (HARC)

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THANK YOU!

QUESTIONS?

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