

Texas Blackout Analysis

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Load libraries

```
# Load necessary libraries
library(here)
library(tidyverse)
library(sf)
library(stars)
library(tmap)
library(terra)
library(viridisLite)
```

Load in all data

Read in light raster data

```
# Load in light data before the blackout
light_before_1 <- read_stars(here("data", "VNP46A1", "VNP46A1.A2021038.h08v05.001.2021039064329"))

light_before_2 <- read_stars(here("data", "VNP46A1", "VNP46A1.A2021038.h08v06.001.2021039064329"))

# Load in light data after the blackout
light_after_1 <- read_stars(here("data", "VNP46A1", "VNP46A1.A2021047.h08v05.001.2021048091106"))

light_after_2 <- read_stars(here("data", "VNP46A1", "VNP46A1.A2021047.h08v06.001.2021048091106")
```

Read in road data

```
# Subset to only include highways
roads <- st_read(here::here("data", "gis_osm_roads_free_1.gpkg"),
query = "SELECT * FROM gis_osm_roads_free_1 WHERE fclass='motorway'", quiet = TRUE)
```

Read in building data

```
# Subset to only necessary building data
buildings <- st_read(here::here("data", "gis_osm_buildings_a_free_1.gpkg"),
query = "SELECT * FROM gis_osm_buildings_a_free_1 WHERE (type IS NULL AND name IS NULL) OR ty
```

Generate blackout mask

```
# Combine raster tiles for before the blackout
light_combined_before <- st_mosaic(light_before_1, light_before_2)

# Create bounding box for Houston
houston_bbox <- st_bbox(c(xmin = -96.5, xmax = -94.5, ymin = 29, ymax = 30.5), crs = st_crs(...))

# Crop area to Houston Texas
houston_before <- st_crop(light_combined_before, y = houston_bbox)

# Combine raster tiles for after the blackout
light_combined_after <- st_mosaic(light_after_1, light_after_2)

# Crop area to Houston Texas
houston_after <- st_crop(light_combined_after, y = houston_bbox)

# Plot light intensity before storm
houston_before_plot <- tm_shape(houston_before) +
  tm_raster(palette = viridis(9),
  style = "cont") + # Continuous scale
  tm_layout(legend.show = FALSE,
  title = "Houston Light Intensity Before Storm (Feb. 7th)",
```

```
    title.size = 0.7) +
tm_compass(position = c("right", "bottom"), size = 1) +
tm_scale_bar(position = c("left", "bottom"))
```

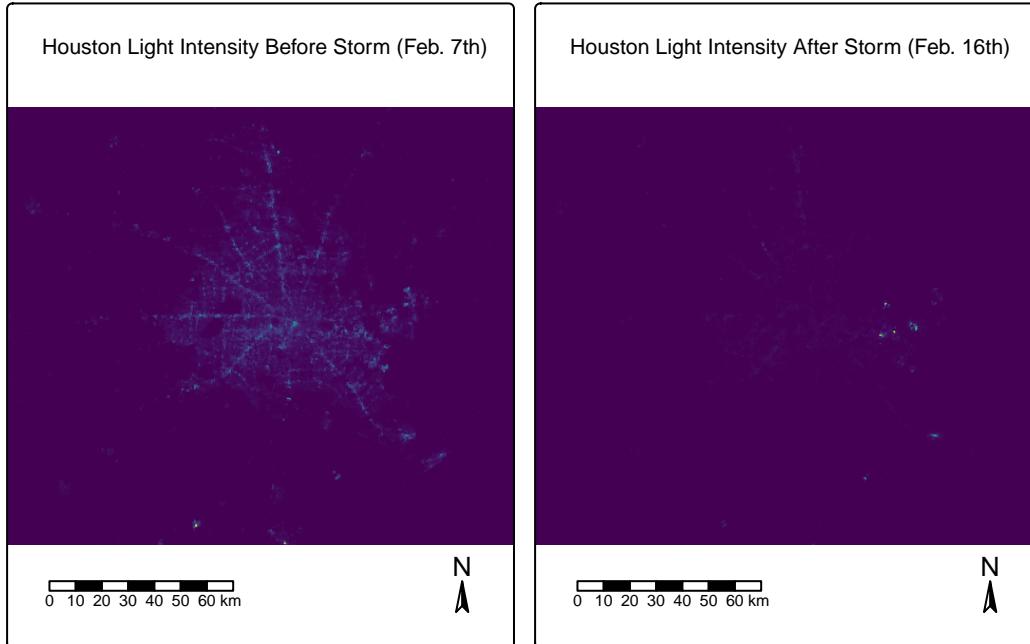
```
-- tmap v3 code detected -----
```

```
[v3->v4] `tm_raster()`: instead of `style = "cont"`, use col.scale =
`tm_scale_continuous()` .
i Migrate the argument(s) 'palette' (rename to 'values') to
`tm_scale_continuous(<HERE>)'
[v3->v4] `tm_layout()`: use `tm_title()` instead of `tm_layout(title = )` -
`tm_scale_bar()` is deprecated. Please use `tm_scalebar()` instead.
```

```
# Plot light intensity after storm
houston_after_plot <- tm_shape(houston_after) +
  tm_raster(palette = viridis(9), style = "cont") + # Continuous scale
  tm_layout(legend.show = FALSE, title = "Houston Light Intensity After Storm (Feb. 16th)", +
  tm_compass(position = c("right", "bottom"), size = 1) +
  tm_scale_bar(position = c("left", "bottom")))
```

```
[v3->v4] `tm_layout()`: use `tm_title()` instead of `tm_layout(title = )` -
`tm_scale_bar()` is deprecated. Please use `tm_scalebar()` instead.
```

```
# Arrange plots side by side
tmap_arrange(houston_before_plot, houston_after_plot, nrow =1)
```



```
# Create logical variable with true for areas with desired light intensity drop
light_difference <- (light_combined_before - light_combined_after) > 200

# Turn areas that did not meet drop condition into NA
light_difference[light_difference == FALSE] <- NA # Clipping approach

# Turn stars into simple feature to vectorize the raster
sf_light_diff <- light_difference %>%
  st_as_sf() %>%
  st_make_valid() # Fix geometries

# Crop area to Houston Texas
ht_light_diff <- st_crop(sf_light_diff, xmin = -96.5, xmax = -94.5, ymin = 29, ymax = 30.5)

# Reproject vector to EPSG:3083
if (st_crs(ht_light_diff) != 3083) {
  warning("coordinate reference systems do not match, transforming them to match")
  ht_light_diff <- st_transform(ht_light_diff, crs = 3083)
}
```

Warning: coordinate reference systems do not match, transforming them to match

Exclude highways from the cropped blackout mask

```
# Reproject roads vector to ht_light_diff crs
if (st_crs(roads) != st_crs(ht_light_diff)) {
  warning("coordinate reference systems do not match, transforming them to match")
  roads <- st_transform(roads, crs = st_crs(ht_light_diff))
}
```

Warning: coordinate reference systems do not match, transforming them to match

```
# Create buffer object
hw_buffer200m <- st_buffer(roads, dist = 200)
```

```
# Pull together geometry fragments
houston_hw_union <- st_union(hw_buffer200m)
```

```
# Return light intensity vector that is not in buffer
ht_light_diff_no_hw <- st_difference(ht_light_diff, houston_hw_union)
```

Identify the number of homes likely impacted by blackouts

```
# Reproject buildings vector to crs of ht_light_diff
if (st_crs(buildings) != st_crs(ht_light_diff_no_hw)) {
  warning("coordinate reference systems do not match, transforming them to match")
  buildings <- st_transform(buildings, crs = st_crs(ht_light_diff_no_hw))
}
```

Warning: coordinate reference systems do not match, transforming them to match

```
# Return buildings that intersect blackout mask
homes_in_blackout <- st_filter(buildings, ht_light_diff_no_hw, .predicate = st_intersects)
```

```
# Quiet autoscaling warnings
tmap_options(component.autoscale = FALSE)
```

```
# Plot overlapping homes in blackout area
```

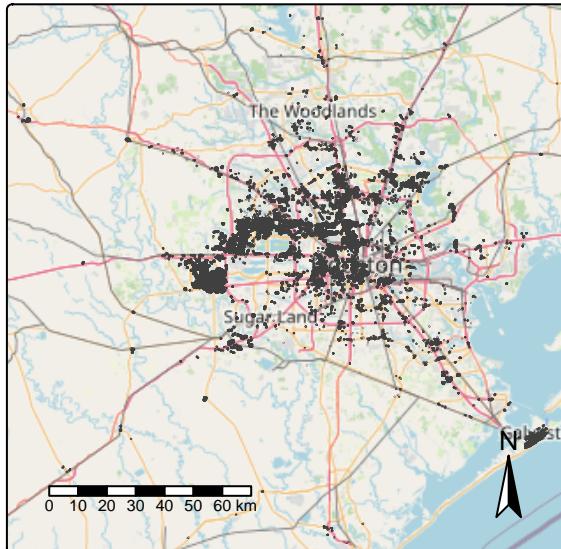
```

homes_in_blackout_plot <- tm_shape(homes_in_blackout) +
  tm_polygons() +
  tm_title("Houston Buildings Blackout due to 2021 Storm") +
  tm_basemap("OpenStreetMap") +
  tm_compass(position = c("right", "bottom"), size = 2) +
  tm_scalebar(position = c("left", "bottom"))

homes_in_blackout_plot

```

Houston Buildings Blackout due to 2021 Storm



```

# Calculate number of buildings in blackout mask
print(paste0("There were ", nrow(homes_in_blackout), " homes that experienced a blackout"))

```

```
[1] "There were 157410 homes that experienced a blackout"
```

```

# Check available layers in census geobatabase
layers_info <- st_layers(here::here("data", "ACS_2019_5YR_TRACT_48_TEXAS.gdb"))

```

```

# Read in census socioeconomic data
census_income <- st_read(here::here("data", "ACS_2019_5YR_TRACT_48_TEXAS.gdb"),
  layer = "X19_INCOME", quiet = TRUE)

```

```

# Read in geometry of census tracts
census_geom <- st_read(here::here("data", "ACS_2019_5YR_TRACT_48_TEXAS.gdb"), layer = "ACS_2019_5YR_TRACT_48_TEXAS")

# Left join income attribute onto census tract geometry
census_income_geom <- left_join(census_geom, census_income, by = c("GEOID_Data" = "GEOID"))

# Crop census tract to only contain Houston
census_income_geom = st_crop(census_income_geom, xmin = -96.5, xmax = -94.5, ymin = 29, ymax = 32)

# Reproject census tracts to crs of ht_light_diff
if (st_crs(census_income_geom) != st_crs(ht_light_diff_no_hw)) {
  warning("coordinate reference systems do not match, transforming them to match")
  census_income_geom <- st_transform(census_income_geom, crs = st_crs(ht_light_diff_no_hw))
}

Warning: coordinate reference systems do not match, transforming them to match

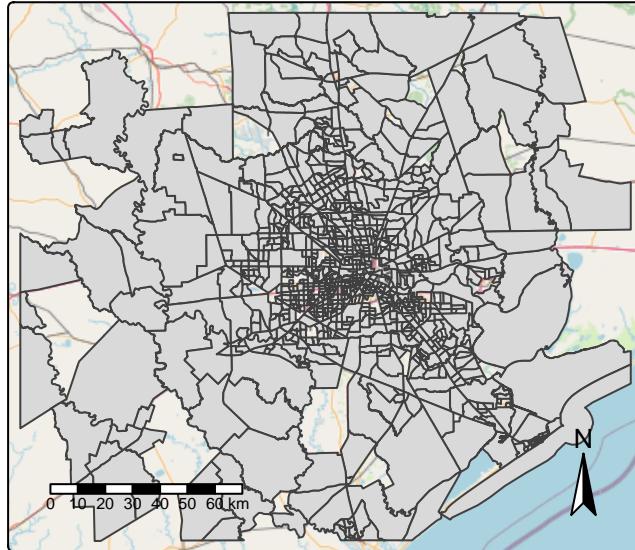
# Find census tracts within the blackout zone
tract_in_blackout <- st_filter(census_income_geom, ht_light_diff_no_hw, .predicate = st_intersects)

# Plot census tracts in blackout zone
tract_in_blackout_plot <- tm_shape(tract_in_blackout) +
  tm_polygons() +
  tm_title("Houston Census Tract Blackout Due to 2021 Storm") +
  tm_basemap("OpenStreetMap") +
  tm_compass(position = c("right", "bottom"), size = 2) +
  tm_scalebar(position = c("left", "bottom"))

tract_in_blackout_plot

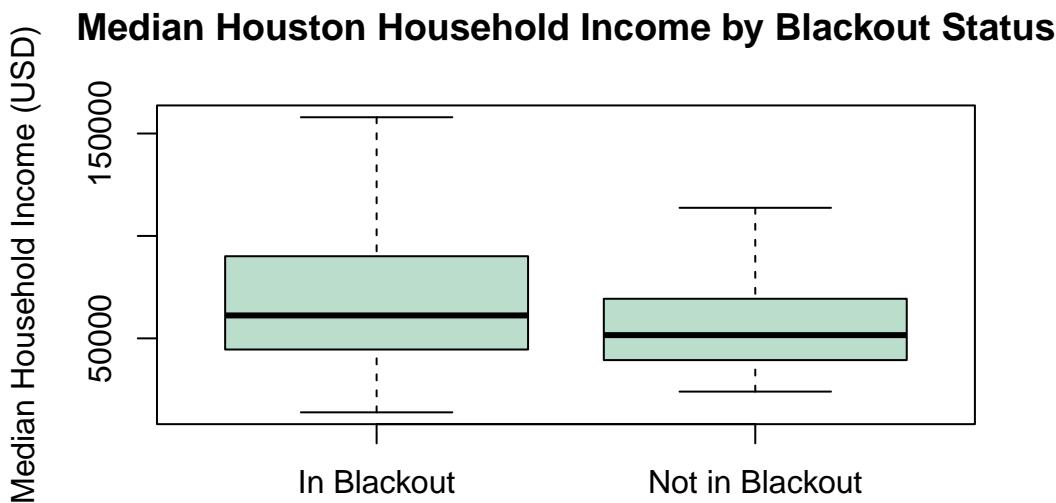
```

Houston Census Tract Blackout Due to 2021 Storm



```
# Return SF dataframe for census tracts not in blackout zone
tract_not_in_blackout <- census_income_geom[!census_income_geom$TRACTCE %in% tract_in_blackout]

# Create Boxplot Showing Difference in Median Household Income Between Blackout/No Blackout
boxplot(
  tract_in_blackout$B19013e1,
  tract_not_in_blackout$B19013e1,
  names = c("In Blackout", "Not in Blackout"),
  main = "Median Houston Household Income by Blackout Status",
  ylab = "Median Household Income (USD)",
  col = c("#BDC", "#BDC"),
  outline = FALSE
)
```



Analysis

In February 2021, much of Texas experienced a winter storm that left millions of Texans without power. This analysis focuses on the impacts of this storm on Houston, Texas. The boxplots show a higher median household income for houses that were affected by the blackout compared to houses that weren't. However, according to “Community-scale big data reveals disparate impacts of the Texas winter storm of 2021 and its managed power outage” by Cheng-Chun Lee et al., low-income communities were disproportionately affected by this blackout. The discrepancy between this research and my analysis may be because we could not obtain income figures for individual buildings, so we had to rely on census tract income, which generalizes income across tracts.

Citation:

Lee CC, Maron M, Mostafavi A. Community-scale big data reveals disparate impacts of the Texas winter storm of 2021 and its managed power outage. *Humanit Soc Sci Commun*. 2022;9(1):335. doi: 10.1057/s41599-022-01353-8. Epub 2022 Sep 24. PMID: 36187845; PMCID: PMC9510185.

OpenStreetMap Contributors (2025). OpenStreetMap database. Retrieved from <https://www.openstreetmap.org>. Distributed by Geofabrik GmbH, Karlsruhe, Germany. Available at <https://download.geofabrik.de/>

U.S. Census Bureau. (2020). TIGER/Line Shapefiles and American Community Survey 2019 (5-Year Estimates), Texas — Census Tract Level (ACS_2019_5YR_TRACT_48_TEXAS) [Data set]. U.S. Department of Commerce. Available from <https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-data.html>