Impacts of Weather on Electricity Reliability :

A case study for MA

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Why it matters

- Climate change is increasing the frequency of extreme weather
  - Extreme weather can cause power outages for thousands at a time

Major impacts of weather events on the electrical power delivery system in the United States

Stephen A. Shield [a, c], Steven M. Quiring [a], Jordan V. Pino [a], Ken Buckstaff [b]

- Health risks

Responses of a vulnerable Hispanic population in New Jersey to Hurricane Sandy: Access to care, medical needs, concerns, and ecological ratings

Joanna Burger [1 2], Michael Gochfeld [2], Taryn Pittfield [1], Christian Jeitner [1]

- Costs

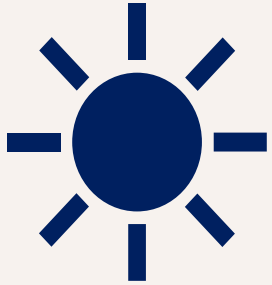
Case Studies of the Economic Impacts of Power Interruptions and Damage to Electricity System Infrastructure from Extreme Events

2020 | Sanstad, Alan H; Zhu, Qianru; Leibowicz, Benjamin; Larsen, Peter H; Eto, Joseph H

  - US economic production reduces by 1% because of electricity outages

Research Question

- What are the major reasons for outages?
- Is there statistical significance between weather and electricity reliability metrics of outages?
- Where are the top 20 most affected towns located in MA?



SAIDI(System Average Interruption Duration Index)

- A variety of indices for measuring electricity reliability are described in the IEEE 1366 standard

$$\text{SAIDI} = \frac{\text{Outage duration} * \text{Number of customers affected}}{\text{Number of customers served}}$$

- **Assumption:**

Number of customers served is approximated as total number of population of town.

Data

MA Power Outage Data:

Mass.gov aggregates energy company emergency response (ERP) reports. Dataset includes town/city of outage, duration, time, and reason. Biases include human error in outage reports

MA Weather Data:

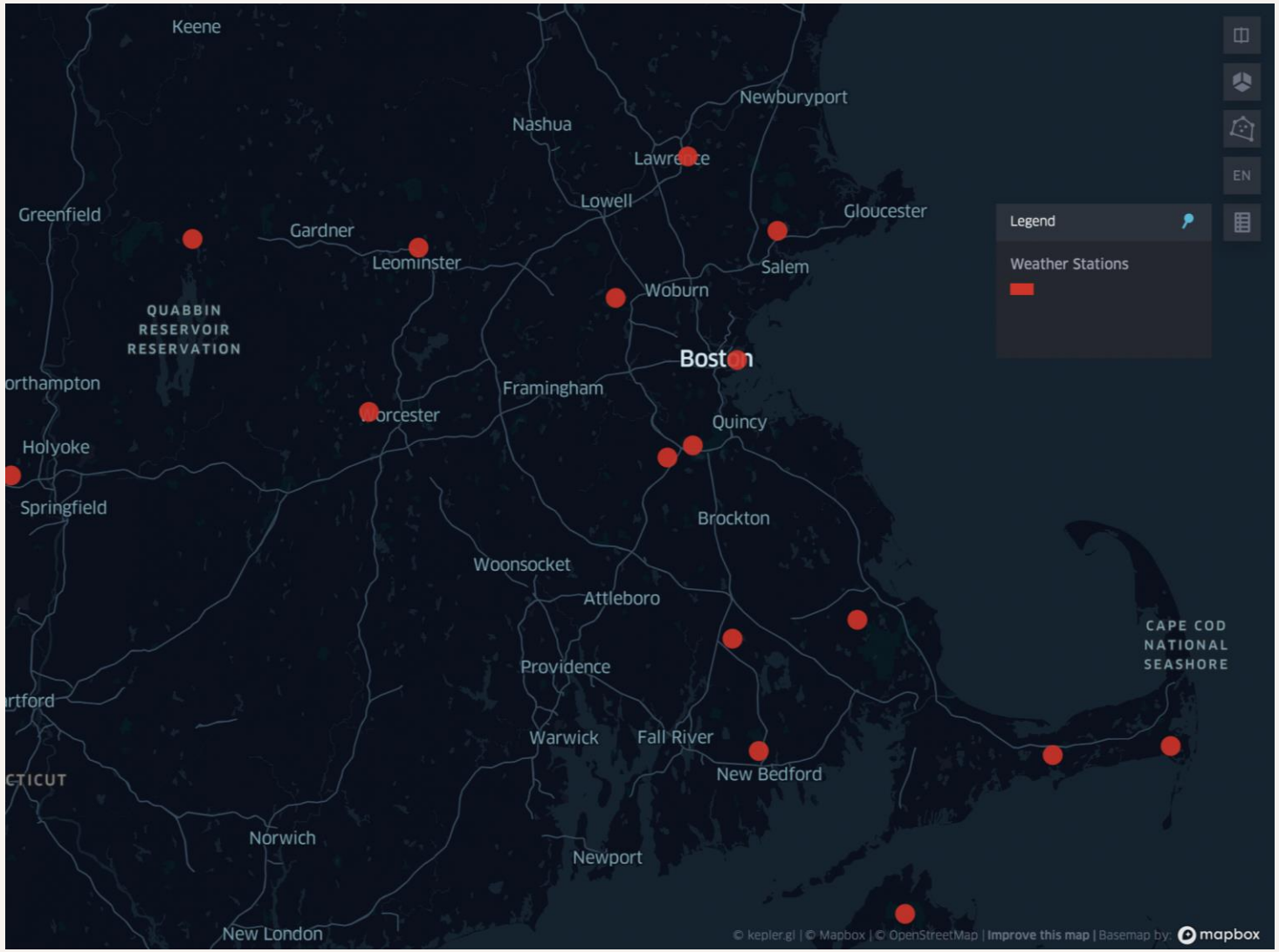
Dataset collected from National Ocean and Atmospheric Administration (NOAA) relies on local stations collecting weather data such as, wind speed (m/sec), temperature (Celsius), precipitation (mm), etc.

MA 2020 Census Tract:

Tiger/Line shapefiles from census bureau.

Weather data

- Data collected 2019 to 2021: https://www.ncdc.noaa.gov/cdo-web/search?datasetid=GHCND
- Total 19 stations are located recorded the data



Outage Data

- 3 electricity providers in Massachusetts
  - Unitil
  - Massachusetts Electric Company and Nantucket Electric Company
  - Eversource
- Collected data from 2019-2021 :https://www.mass.gov/info-details/power-outages#historic-power-outages-
- **Limitations:**
  - Unitil had no outage data for 2020
  - 18 rows had SAIDI values of infinity which we chose to remove

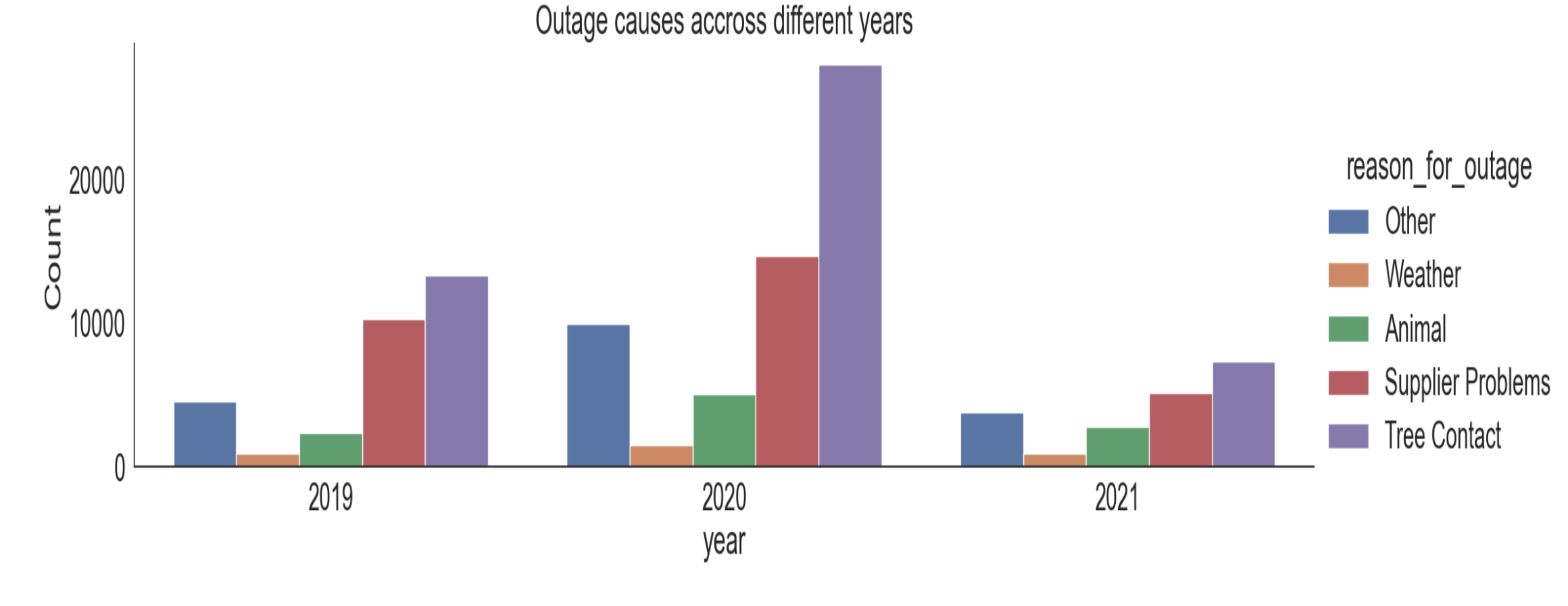
Data Merge & Clean

- Found the nearest towns located to weather stations using spatial join in ArcGIS Pro
- **Missing values :**

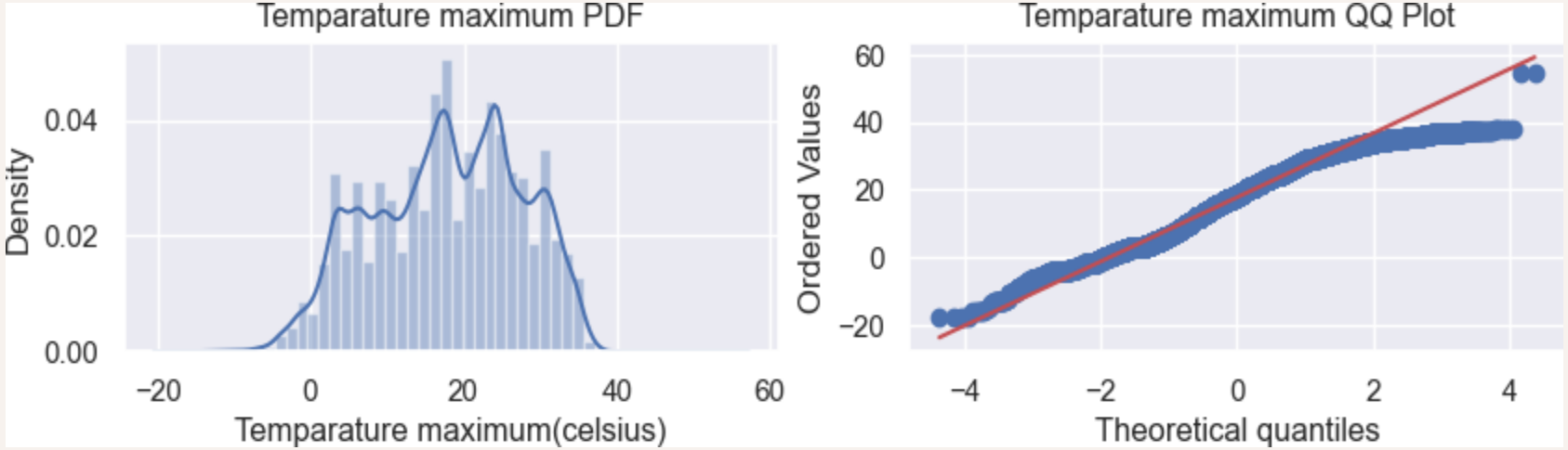
81% Snow values are filled based on month and year

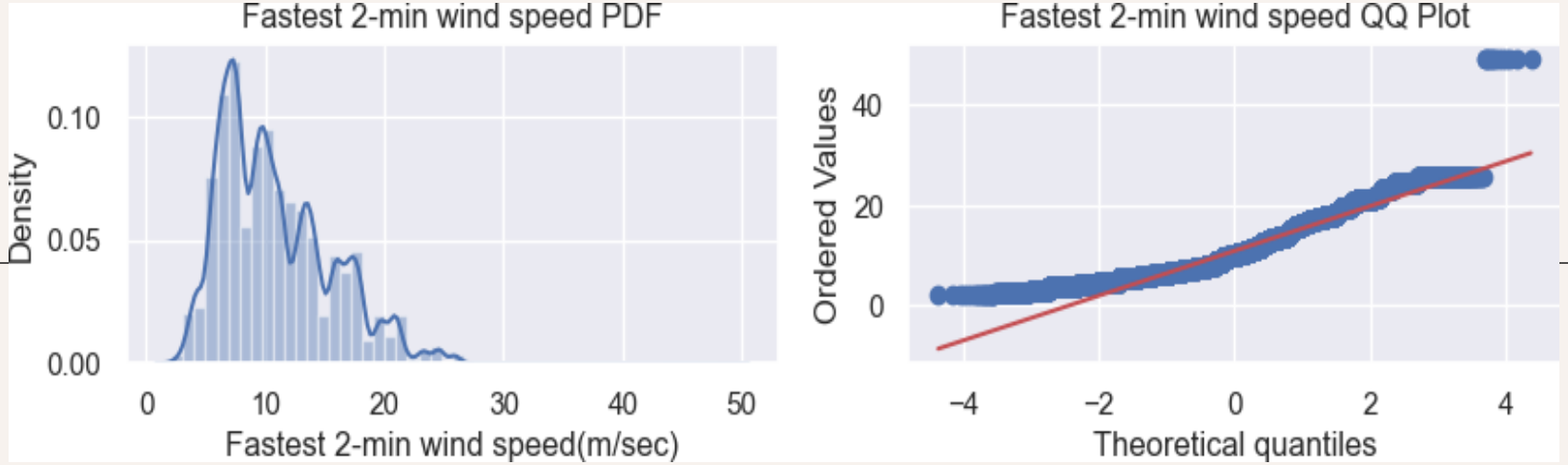
Removed 4% missing data

Reasons for outage



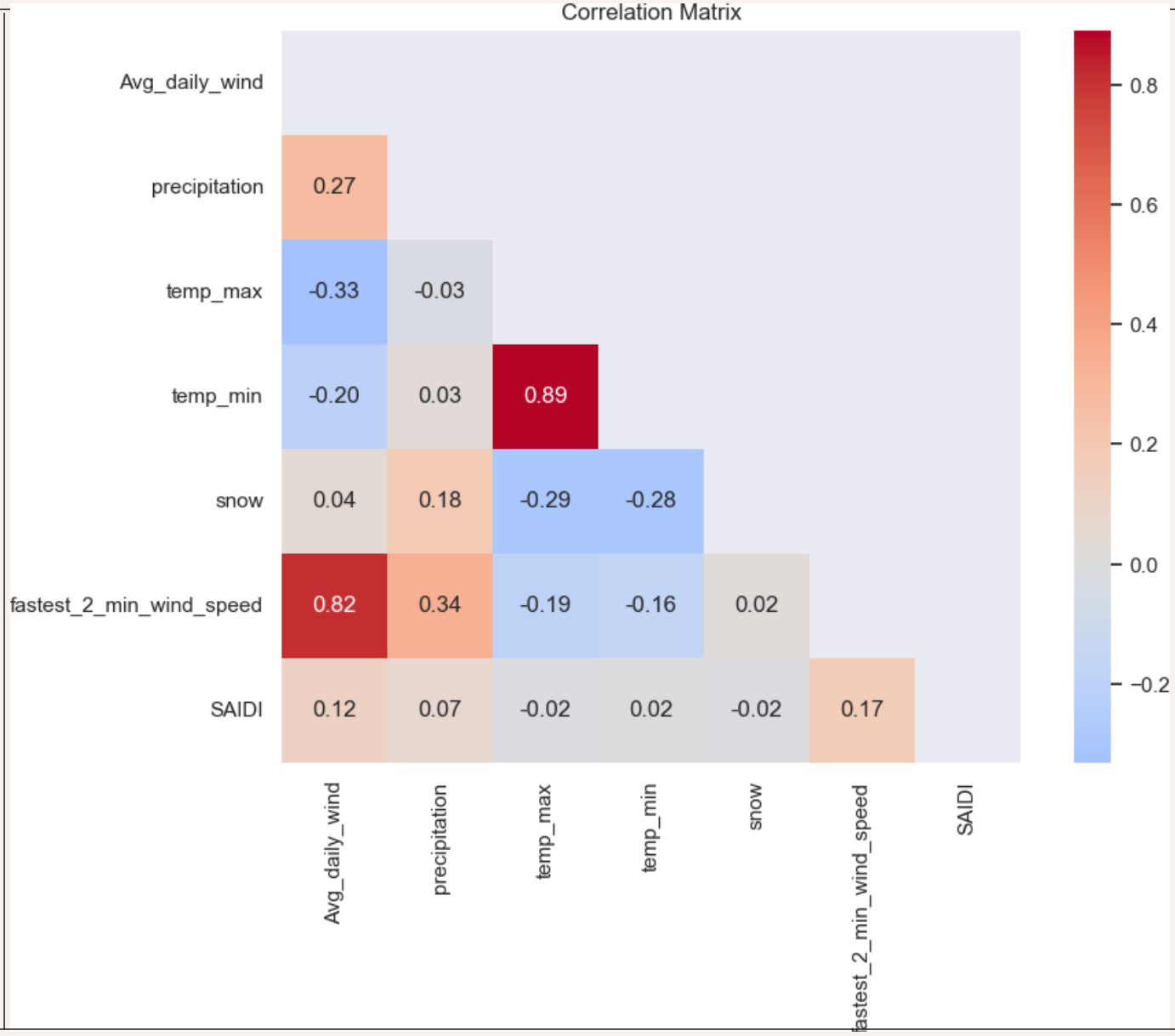
Normality Check





Correlation Matrix

- Fastest 2 min wind speed is highly correlated to daily average wind speed
- Temp minimum is highly correlated to
  Temp maximum



Exploratory analysis

- All weather variables are statistically significant
- Adjusted R-squared value is too low

OLS Regression Results

Dep. Variable:	SAIDI	R-squared:	0.030
Model:	OLS	Adj. R-squared:	0.030
Method:	Least Squares	F-statistic:	862.8
Date:	Sat, 10 Dec 2022	Prob (F-statistic):	0.00
Time:	22:33:58	Log-Likelihood:	-66735.
No. Observations:	111212	AIC:	1.335e+05
Df Residuals:	111207	BIC:	1.335e+05
Df Model:	4		
Covariance Type:	nonrobust		

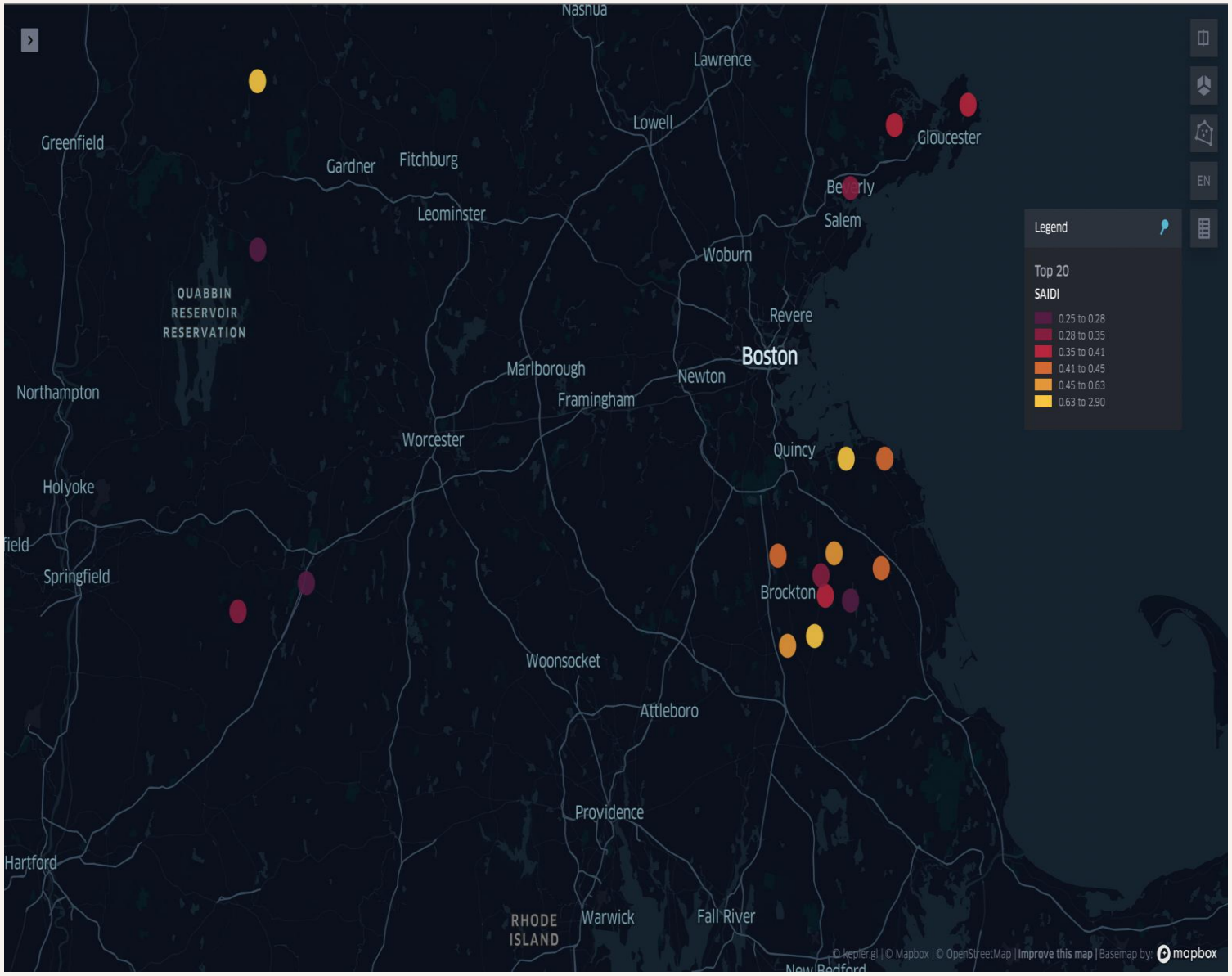
	coef	std err	t	P>|t|	[0.025	0.975]
precipitation	0.0006	0.000	5.745	0.000	0.000	0.001
temp_min	0.0019	0.000	11.991	0.000	0.002	0.002
snow	-0.0003	6.59e-05	-4.407	0.000	-0.000	-0.000
fastest_2_min_wind_speed	0.0162	0.000	52.183	0.000	0.016	0.017
Intercept	-0.0969	0.004	-24.489	0.000	-0.105	-0.089

Omnibus:	245118.145	Durbin-Watson:	1.419
Prob(Omnibus):	0.000	Jarque-Bera (JB):	2925004633.528
Skew:	20.057	Prob(JB):	0.00
Kurtosis:	796.485	Cond. No.	72.0

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Spatial Analysis

- Top 20 located based on mean of SAIDI for each town for all 3 years.
- Most of the towns are clustered around the area of Brockton.



Conclusion

Tree contact is the major reason for power outages

Weather variables are statistically significant to outage metrics

Most of the towns clustered around the area of Brockton experience more outages.

Policy Implementations

Tree Trimming

Underground transmission lines

Improving utility maintainence methods

Thank You

Project pitch is taken from prof. Sunter class of Data Science for sustainability(DSS)

Working on this project with 4 of my other teammates from DSS class

References

- Shield, S. A., Quiring, S. M., Pino, J. V., & Buckstaff, K. (2021). Major impacts of weather events on the electrical power delivery system in the United States. Energy, 218, 119434.
- Burger, J., Gochfeld, M., Pittfield, T., & Jeitner, C. (2017). Responses of a vulnerable Hispanic population in New Jersey to Hurricane Sandy: Access to care, medical needs, concerns, and ecological ratings. Journal of Toxicology and Environmental Health, Part A, 80(6), 315-325.
- Sanstad, A. H., Zhu, Q., Leibowicz, B., Larsen, P. H., & Eto, J. H. (2020). Case studies of the economic impacts of power interruptions and damage to electricity system infrastructure from extreme events.
- "IEEE Guide for Electric Power Distribution Reliability Indices," IEEE Std. 1366-2012, 2012.