Statistical Models for U.S. Electricity Grid Renewable Production

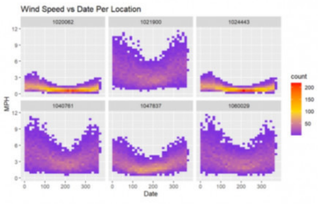
Created a simulation of future wind speeds in Northeastern U.S And Southeastern Canada in R

Mission of the project

Optimize the placement of renewable power plants to create a reliable green grid

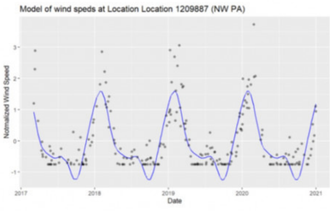
Preprocessing

1. Combined data across several large files From the NSRDB (National Solar Radiation Database)
   - Using a custom -made R script
2. Metadata
   - 31 locations over 24 years
   - Predictors – Wind Speed
   - 13,000,000 records
3. Preprocessing
   - Calculated daily average speed for each location
     - Captures the wind speed for each day
     - Differences are more meaningful
   - Randomly selected 15% of the data per location
     - Minimizing error isn't the main objective
4. Scaled and Centered the data
   - Better Performance and normal error distribution
5. Visualized Data



Model Fitting

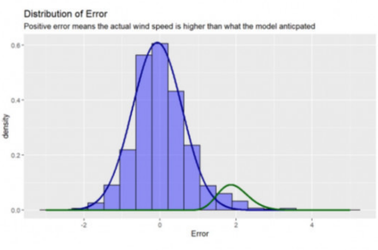
- Purpose
  1. Model behavior across complex systems
  2. Determine the locations that are most influential
  3. Comparison of different scenarios to Determine the ideal locations
- Need to capture randomness to find general trends
  1. Not Anomalies



General Sinusoidal Model

$$A_1 \times \left(\cos\left(\frac{\pi * days}{182.5}\right)\right) + A_2 \times \left(\cos\left(\frac{\pi * days}{91.25}\right)\right) + A_3 \times \left(\cos\left(\frac{\pi * days}{45.65}\right)\right) + A_4 \times \left(\sin\left(\frac{\pi * days}{182.5}\right)\right) + A_5 \left(\sin\left(\frac{\pi * days}{91.25}\right)\right) + A_6 \left(\sin\left(\frac{\pi * days}{45.625}\right)\right) + C$$

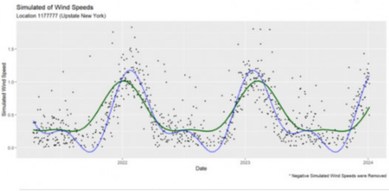
Data Simulation



Model Error

- Model Objective
  - Objective to select a combination of coeffects to minimize error
- Simulation Objective
  - Appropriately model error to apply randomness to the simulation
  - $f'(x) - f(x) + \epsilon$

Simulated Windspeed

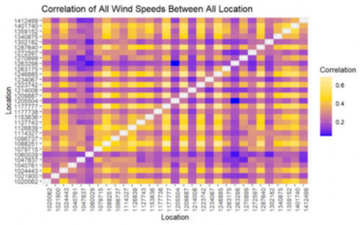


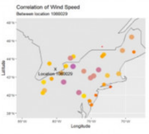
- The next 1000 days of wind speeds
  - Error distribution add the randomness
- Random Error
  - Still simulated lower than expected wind speed
  - Predict peak wind days

Results

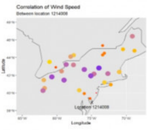
Correlation

- Low Correlation Benefit
  - Locations with little correction could power each other
  - i.e. with less correlation, if one location has little wind, then another location is more likely to have stronger winds
- Several locations are poorly correlated with most other locations
  - Can supply more locations power on still days

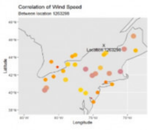




- Southern Canada
  - Large body of water
  - Canadian Lowlands



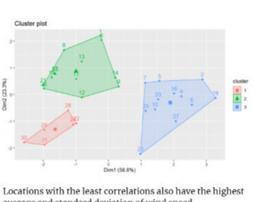
- North Coast of the Delaware Bay
  - Large body of water
  - Flat costal planes across the bay



- Montréal
  - Small body of water
  - Middle of the large St. Lawrence River Valley

Trends and Takeaways

Combination of proximity to a body of water and geographical features



Locations with the least correlations also have the highest average and standard deviation of wind speed