Wind Gust Climatology

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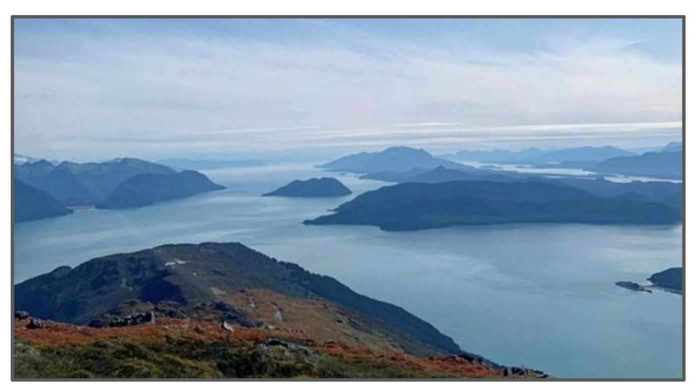
Question

Will statistical analysis and an increased observation density improve wind gust forecasts across the complex terrain of Southeast Alaska?

Background

Southeast Alaska is home to a widely diverse landscape, comprising numerous fjords, thousands of islands, and roughly 35,138 square miles of land (almost as large as the entire state of Indiana). This complex terrain often influences damaging high wind events, providing the Juneau WFO with the important task of conveying future risks to its community of approximately 72,373 people.



West Peak Mountain facing south towards the Gastineau Channel and Admiralty Island. Photo courtesy of Cody Moore.

The office recently moved from using a flat 1.2 gust multiplier model to a more region specific prediction method that also accounts for direction, based on the work of Hollings Scholar Kimberly Clinch[1]. With over 4 years of new data and a wider network of stations, the office aims to improve wind gust forecasts through a research experiment.

Prediction

After witnessing the predicting power of a power model, it is evident that a higher gust multiplier is more effective for lower wind speeds. Following the success of Kimberly's findings, it is **expected** that a **higher observation density** will lead to **more refined equations** and ultimately **more accurate forecasts**.

Materials

- Access to Python and R
- Data pulled from 97 unique observation sites throughout SE AK using three primary databases
  - Alaska Ocean Observing System (AOOS)
  - Synoptic Data - MesoWest
  - National Data Buoy Center (NDBC)
- Separated into 27 zones based on location

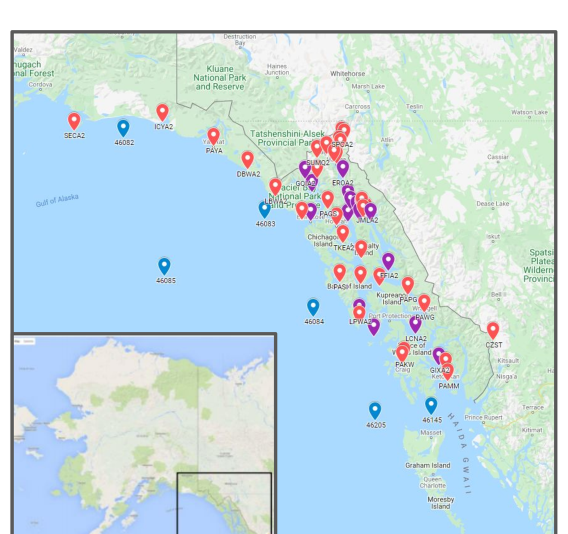
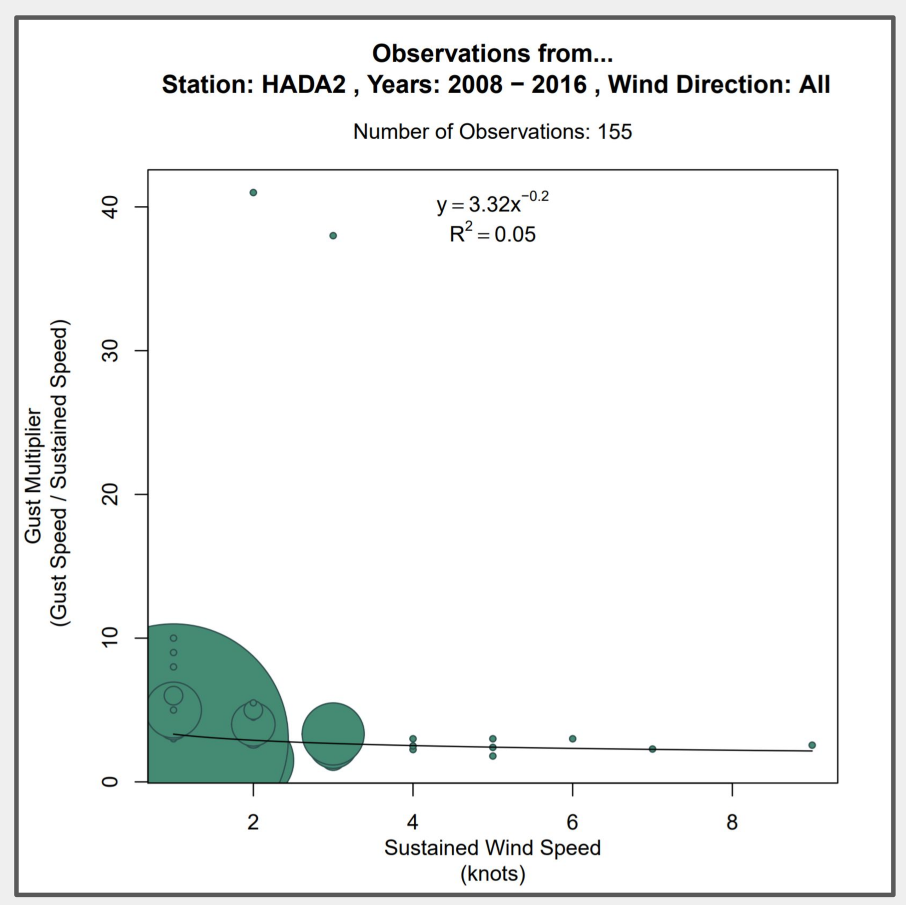


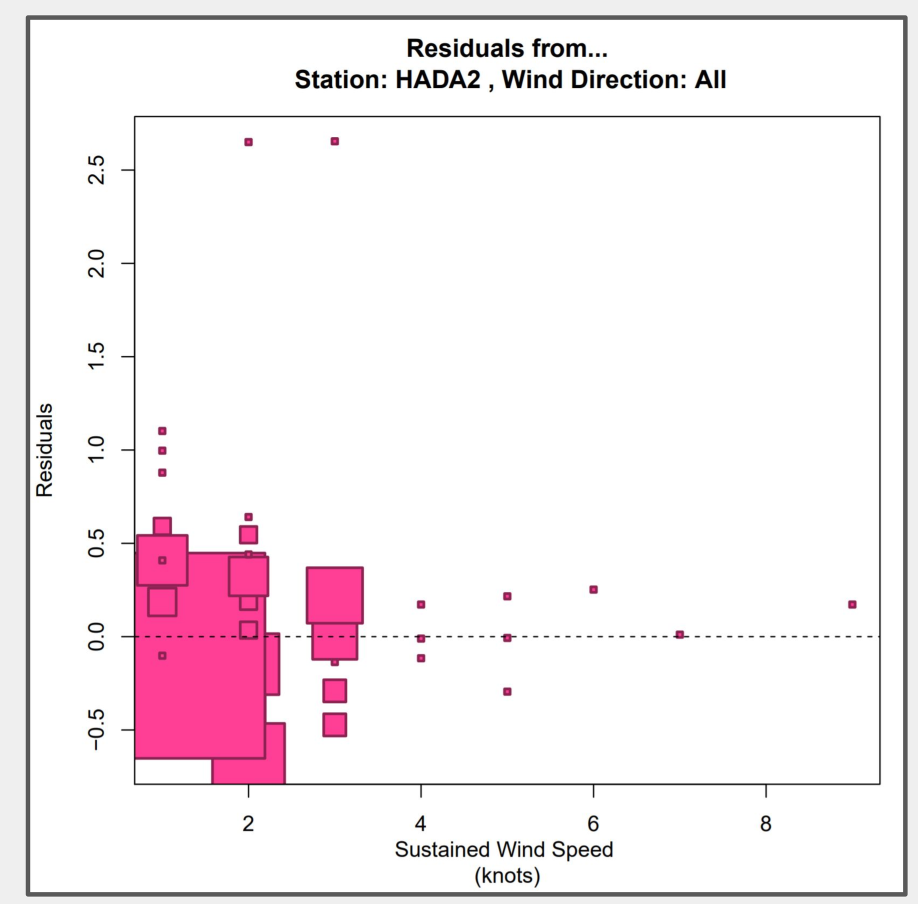
Image illustrates 57 of the observations sites in SEAK. Red indicates land-based sites, purple indicates channel-based, and blue indicates gulf-based.

Power models are an **improved predictor** for **wind gust** values in Southeast Alaska.

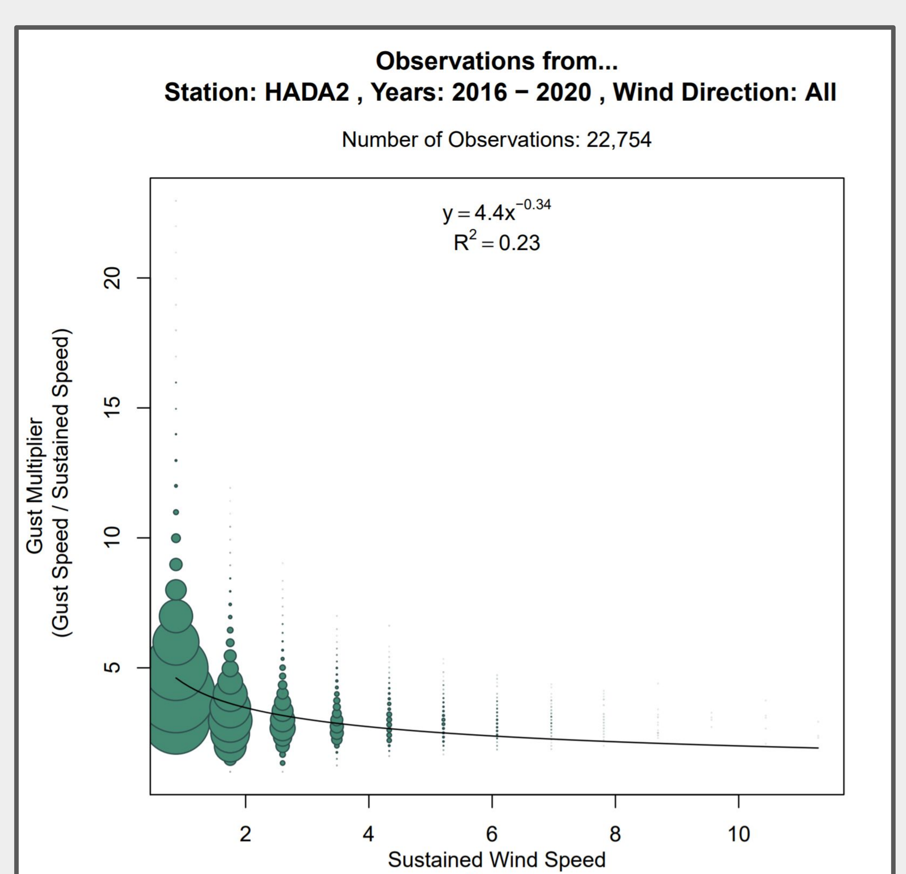
Results

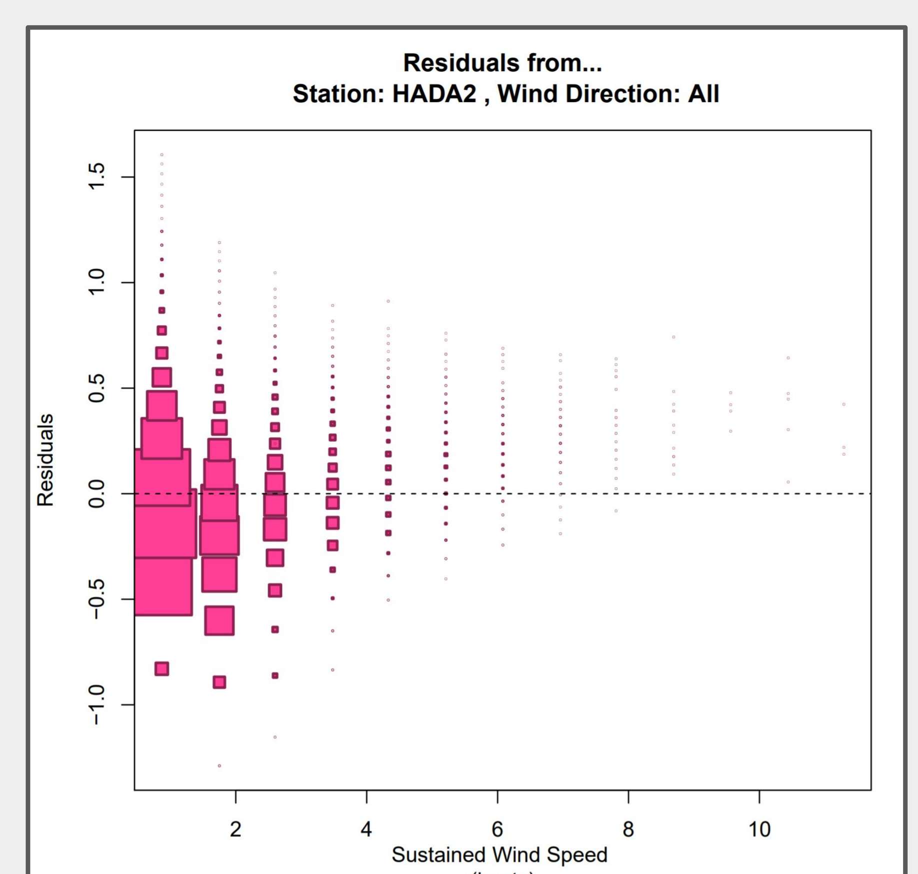
2016 Study: Initial Power Model





2020 Study: Updated Power Model (with more data)





Procedure

1. **Obtain sustained wind speed and wind gust data from AOOS, MesoWest, and NDBC for each station.**
2. **Clean/Convert the data using Python**
   a. Calculate the gust factor from the recorded sustained wind speed and gust wind speed values.

      Gust Multiplier = Gust Wind Speed / Sustained Wind Speed

   b. Sort the data by wind direction and create 9 separate files
      i. One file for each cardinal direction and one file containing all of the converted data for each observation site.
3. **Analyze the data in R**
   a. Fit the data for each site (all nine direction files) to a power model (showing the relationship between gust multiplier values and sustained wind speed values).
      i. Find *a* and *b* such that *y = ax^b* best fits the data
         1. Transform the power function by taking the logarithm of each side
         2. Use linear regression to find appropriate values of the coefficients
         3. Use the R-squared value to assess goodness of fit
4. **Update a wind gust predictor Python tool**
   a. Uses statistically significant variables to estimate gust factors based on a sustained wind speed forecast.

Conclusions

- The computed power models will provide the foundation for a **more expansive and overall more accurate** wind gust forecasts upon implementation.
- The **average number of observations** was **increased** from **52,481.4** to **101,827.5** indicating a **more reliable study** (less independence and more random).
- The 897 models provided a **wide range of R^2 values** (*0.00027* to *0.96686*), however there was an **average increase of 3.61%** from the stations that were analyzed in Kimberly's study compared to the equations derived in this project (excluding the Gulf values).
- **Future work** could be done to create models based on **specific wind speed ranges**.

References

1. Clinch, K., and Caffrey, B.. Improving Wind Gust Forecasts in Southeast Alaska. 2016.

Acknowledgements

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