Wind Speed Variability and Adaptation Strategies in Coastal Regions of the Pacific Northwest
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Research Objectives
1. Determine if correlations exist between Pacific Northwest wind speed distributions (i.e., quantiles), Pacific Ocean climate indices, and monitoring station-specific attributes (e.g., elevation, geographic location, data source); and
2. Assess the robustness of relationships for forecasting wind speeds within the study area; and
3. Identify adaptation strategies to reduce wind damage and convey in a manner easily understandable by a wide (potentially non-technical) audience.

Methods (continued)
Hierarchical Cluster Analysis (HCA) - Looks for commonalities among time series and groups the respective stations accordingly. Useful explanatory tool for early data exploration. However, HCA does not provide physical process explanations of groupings; left to the researcher to determine.

Context
As coastal communities expand their vulnerability to severe windstorms may increase if changing climate conditions and risks are ignored. Previous attempts to forecast wind speeds in the Pacific Northwest have been limited in scope and had varying results. However, a link between Pacific Ocean climate indices (e.g., PDO & PNA) and wind speeds has been proposed. This type of connection could allow forecasts from dynamic climate models (GCMs) to be locally applied and result in better decision making and adaptation actions.

Methods
Quantiles instead of Mean or Max/Min - A focus solely on mean or max/min values may underestimate, overestimate, or fail to distinguish real nonzero changes in response-explanatory relationships. This is especially true for distributions, such as those typical of wind speeds, which display strong skew and/or exhibit unequal variance across the magnitudes of observations. Quantiles can better summarize strongly skewed (versus normally distributed) data to provide a more robust statistical starting point.

Linear Mixed-Effects (LME) Model
- Fixed (population) effects – e.g., influence of PDO on wind speeds across the region; Random (location-specific) effects – e.g., how a valley location may have a different wind speed response to PDO versus a mountain location;
- Appropriate for climate data because LME can incorporate repeated measurements over time at permanent monitoring stations, temporal correlation (e.g., time-series), heterogeneous variance (non-normal distributions), or non-stationary (trending) data.

$Y_{ij} = X_{ij} \cdot \beta + Z_{ij} \cdot b_j + e_{ij} \quad \quad b_j \sim N(0, D) \quad e_{ij} \sim \eta_j - (\beta \cdot e_{ij-1}) \quad \eta_j \sim N(0, \Sigma_j)$

Next Steps
Additional fixed effect factors, such as re-analysis SST and SLP calculated values, upper air measurements, or GIS topographic features could be used to better forecast PNW wind speeds. A Quantitative Decision Analysis focusing on wind damage adaptation options available to resource managers would likely help future planning.

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