

Regionalization of MERRA-2 50-m wind speed over the United States for Energy Applications

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Background and Objective

- As of July 2021, there were 69,166 wind turbines in the US with a total rated capacity of 124,550 MW (Fig. 1; source: US Wind Turbine Database)
- Many previous studies have characterized the wind resource over the US, which varies seasonally and regionally (Fig. 2)
- Variability in wind speeds has been linked to climate variability such as ENSO, NAO, PNA, but further work is needed to understand the regionality and seasonality of these links.

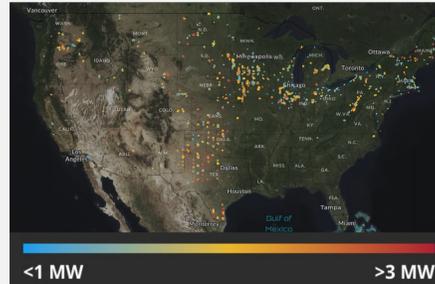


Fig. 1. Wind turbines in the US as of July 2021. Colors indicate capacity of the turbines. Source: U.S. Wind Turbine Database (Hoen et al. 2018)

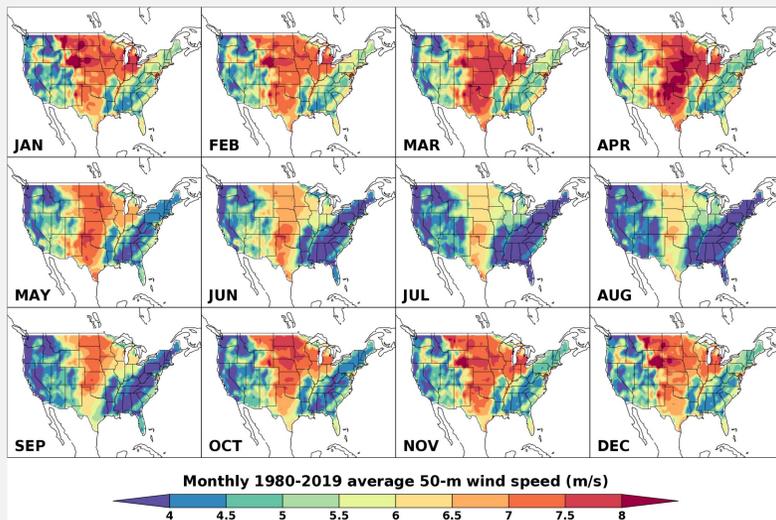


Fig. 2. Monthly-average 50-m wind speed over 1980-2019 from MERRA-2.

Objective: use climate regionalization to identify distinct regions in terms of 50-m wind speed over the US, to be used to determine spatial variation in drivers of inter-annual variability.

Results

- Regionalization is applied to each month separately – the optimal number of regions is determined by maximizing intra-regional correlations (homogeneous regions) and minimizing inter-regional correlation (distinct regions); example shown here for March.

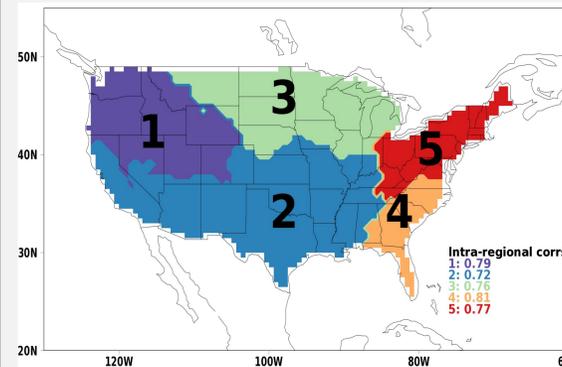


Fig. 3. Regions identified using regionalization on March 50-m wind speed over 1980-2019 from MERRA-2.

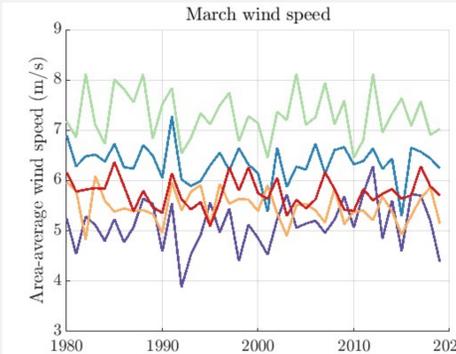


Fig. 4. Area-averaged March 50-m wind speed from regions shown in Fig. 3 over 1980-2019.

Inter-regional correlations				
	1	2	3	4
2	0.53			
3	0.45	0.28		
4	-0.10	0.24	-0.33	
5	0.11	0.38	0.29	0.36

Table 1. Inter-regional correlations between regions shown in Fig. 3.

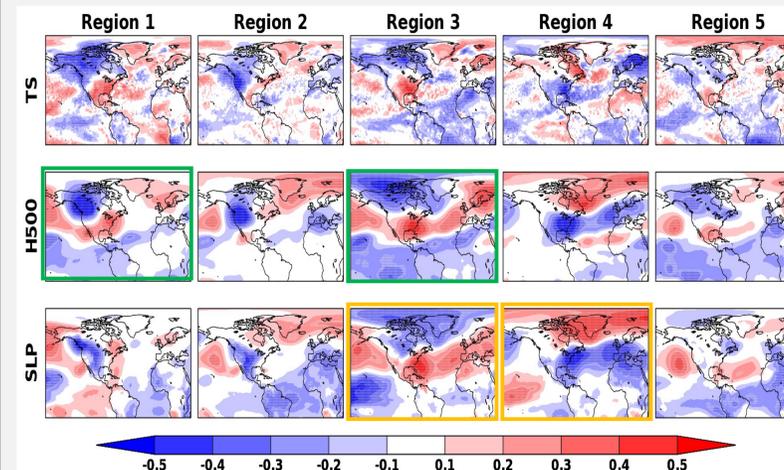


Fig. 5. Correlations between March area-averaged wind speed and March skin temperature (top), 500-hPa geopotential height (middle) and sea level pressure (bottom) for 1980-2019 from MERRA-2. White dots indicate correlations are significant at the 95% level ($R > 0.27$).

- Regions 1 and 2 are the most similar (inter-correlation is 0.53)
- Regions 3 and 4 are the most distinct (inter-correlation is -0.33).
- Correlations between area-averaged wind speed and climate variables indicate:
 - PNA-like pattern is negatively correlated with both Region 1 and Region 3
 - NAO-like pattern is positively correlated with Region 3 and negatively correlated with Region 4
 - ENSO correlations are weak in March, but other winter months (not shown) have significant negative correlation with ENSO.

Data and Methods

- Using the NASA Modern Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) 50-m wind speed (WS50m)
- Climate regionalization tool (HiClimR R package; Badr et al. 2015) is used to group grid points based on interannual variability in WS50m

Preliminary Conclusions

- The example shown here for March shows the value of climate regionalization in identifying unique drivers of interannual variability in WS50m
- This information can be useful for determining regions with both (1) adequate wind resource and (2) potential for prediction skill

Future work

- Group months into seasons based on similar regionalization results
- Repeat analysis with other reanalyses: are regions are similar or different?
- Explore S2S hindcasts of turbine-height wind speeds to identify seasons and regions with high prediction skill



References

- Badr et al. 2015, <https://doi.org/10.1007/s12145-015-0221-7>.
- Hoen, et al. 2018, <https://doi.org/10.5066/F7TX3DN0>.

