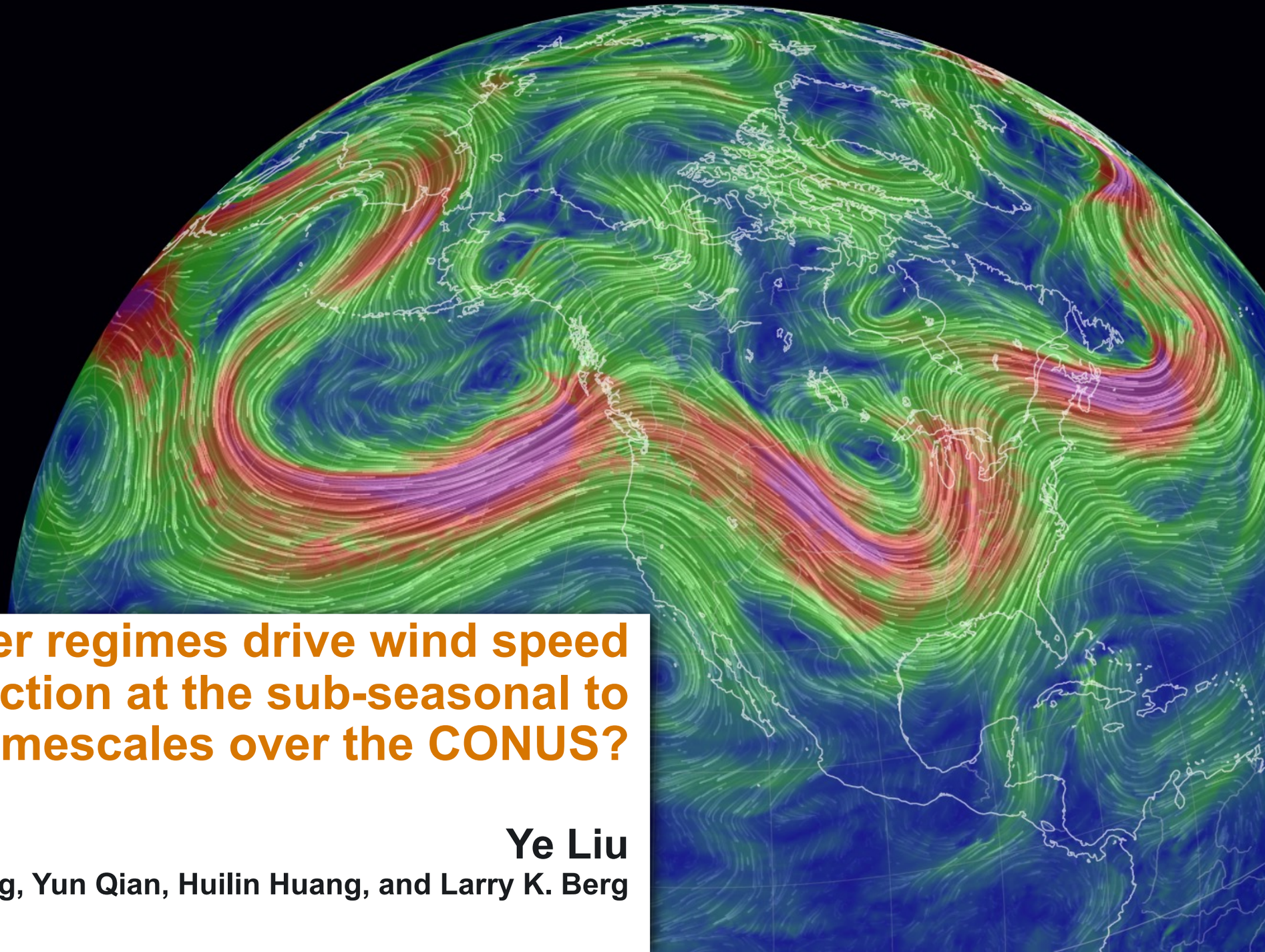


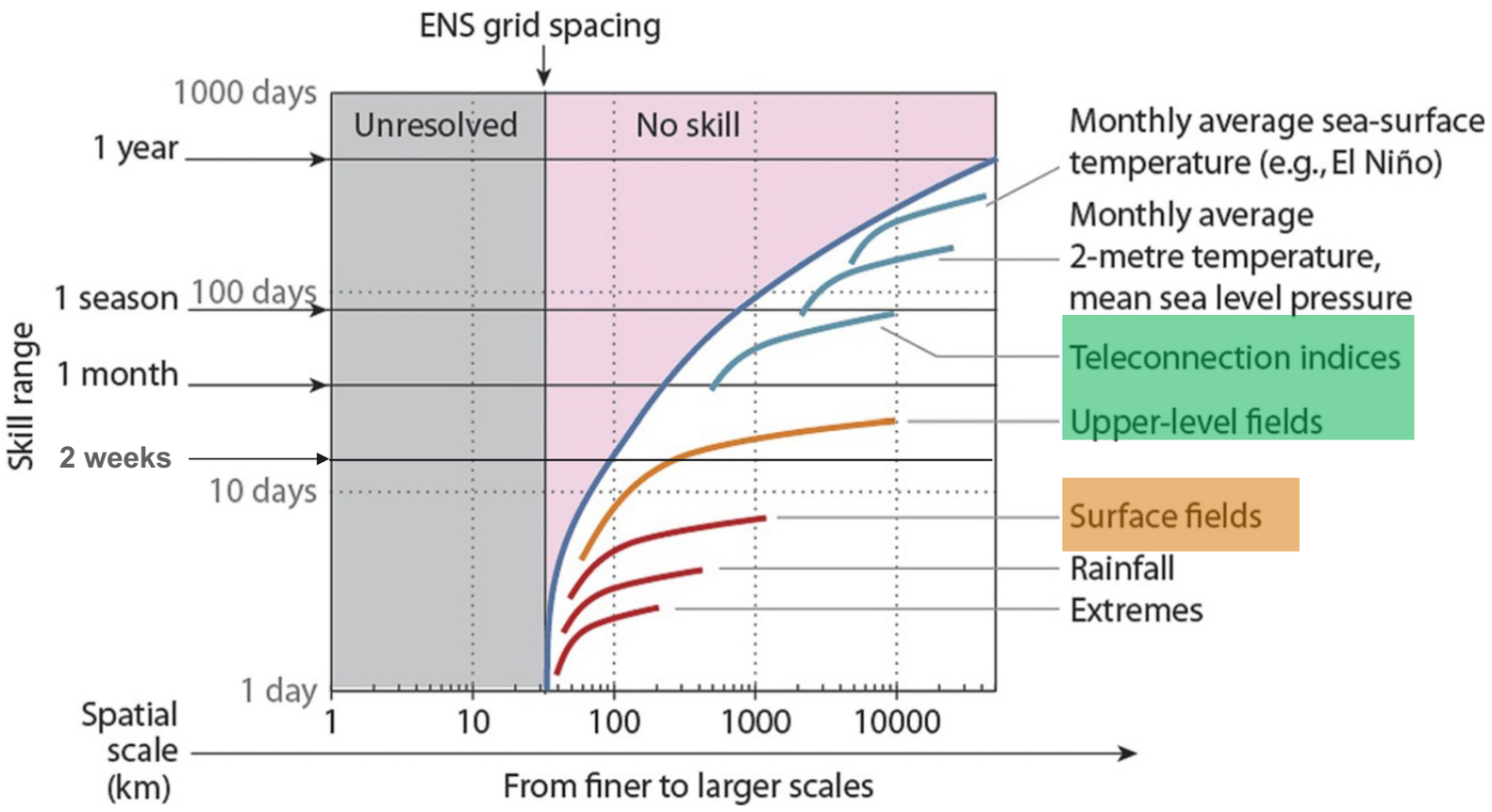
How do the weather regimes drive wind speed and power production at the sub-seasonal to seasonal timescales over the CONUS?

Ye Liu

Sha Feng, Yun Qian, Huilin Huang, and Larry K. Berg

PNNL is operated by Battelle for the U.S. Department of Energy

Forecasting skill varying with spatial and temporal scales



Weather regimes (WR) are recurrent and persistent weather patterns

Weather Regime

↕

Wind resource

Buizza et al., 2015

Outline

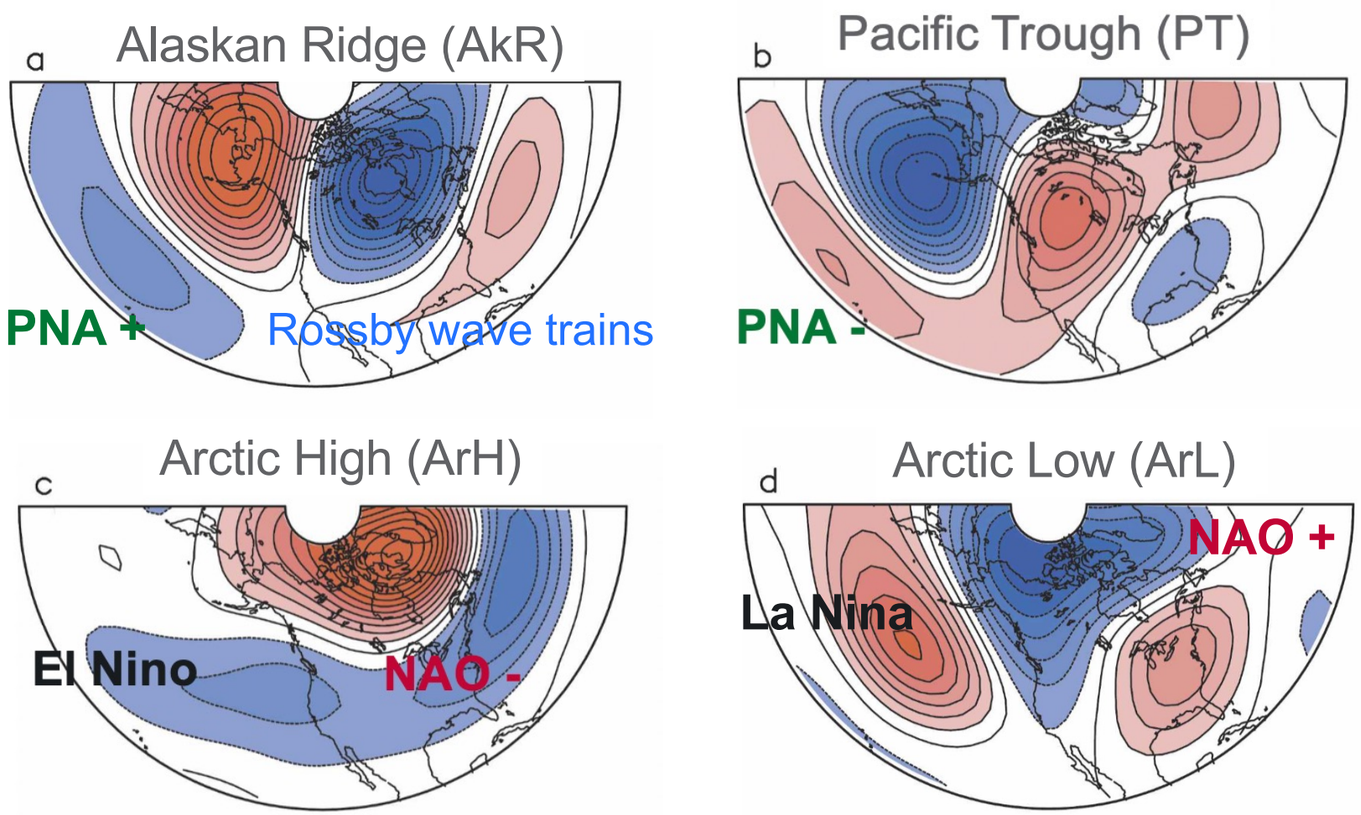
- What WRs affect CONUS?
- How are the WRs connected to wind speed?
- To what extent WRs explain the variability of wind speed?

Regimes affecting North America in the previous studies

WR are recurrent and persistent weather patterns

Identify WRs by categorizing weather pattern

- Weather patterns: Z200/Z500
- K-Means clustering

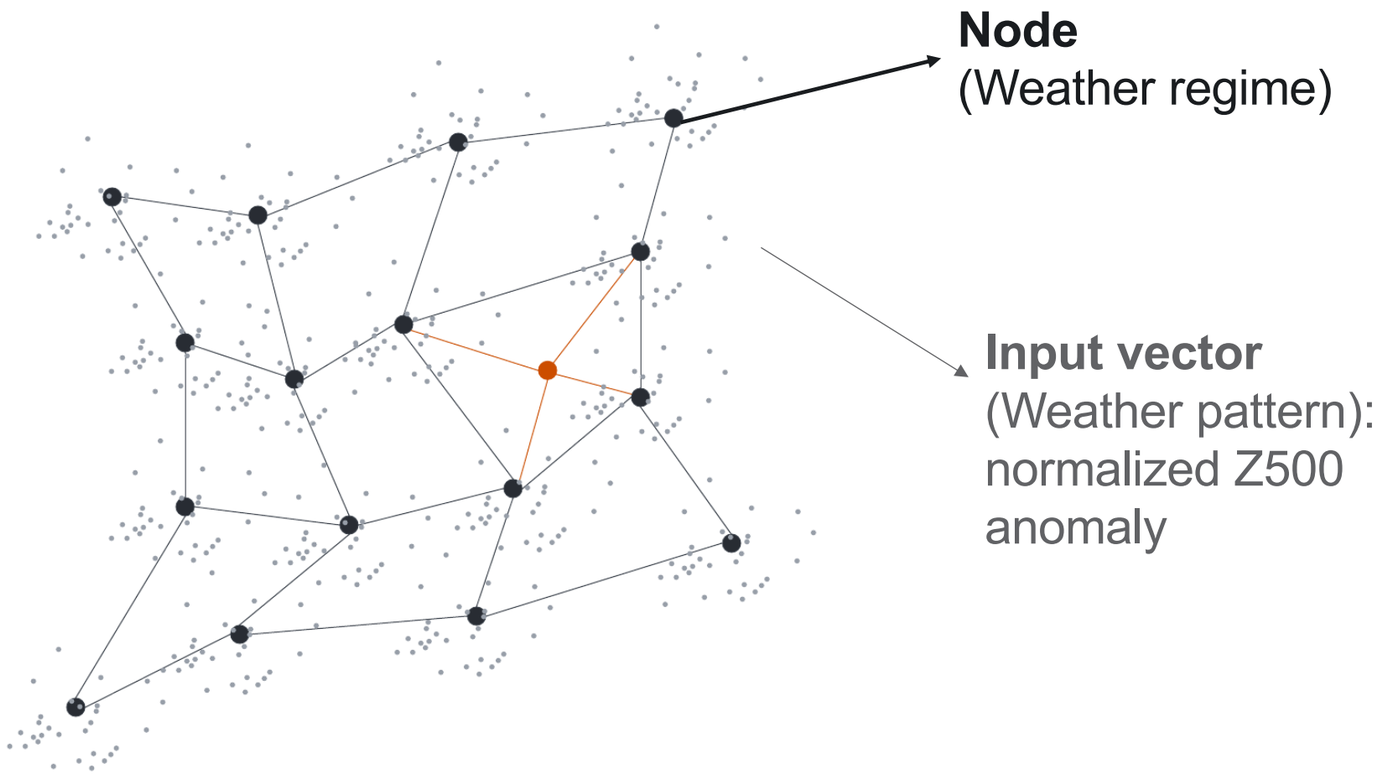


Straus et al., (2007)

Two-stage clustering method: SOM + K-Mean

SOM (self-organizing maps) and K-mean are both Euclidean distance-based clustering method

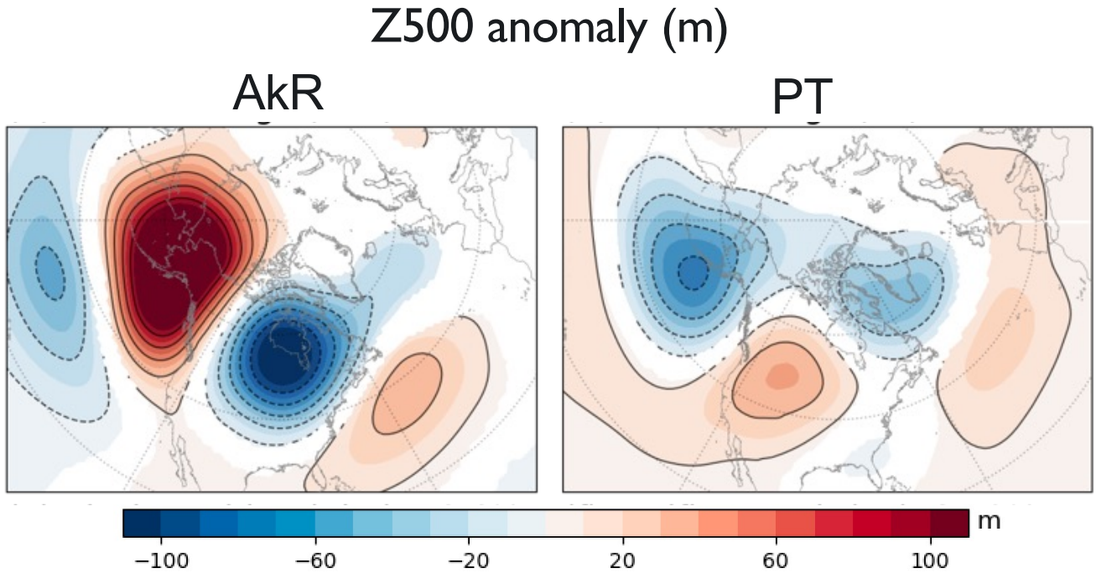
- K-mean is sensitive to the initial centroids and no connection between the nodes
- SOM keeps the topological relationship between the nodes, which is important in reconstruction
- Two-stage:
  - 8x8 prototypes using SOM
  - 4 clusters using K-mean

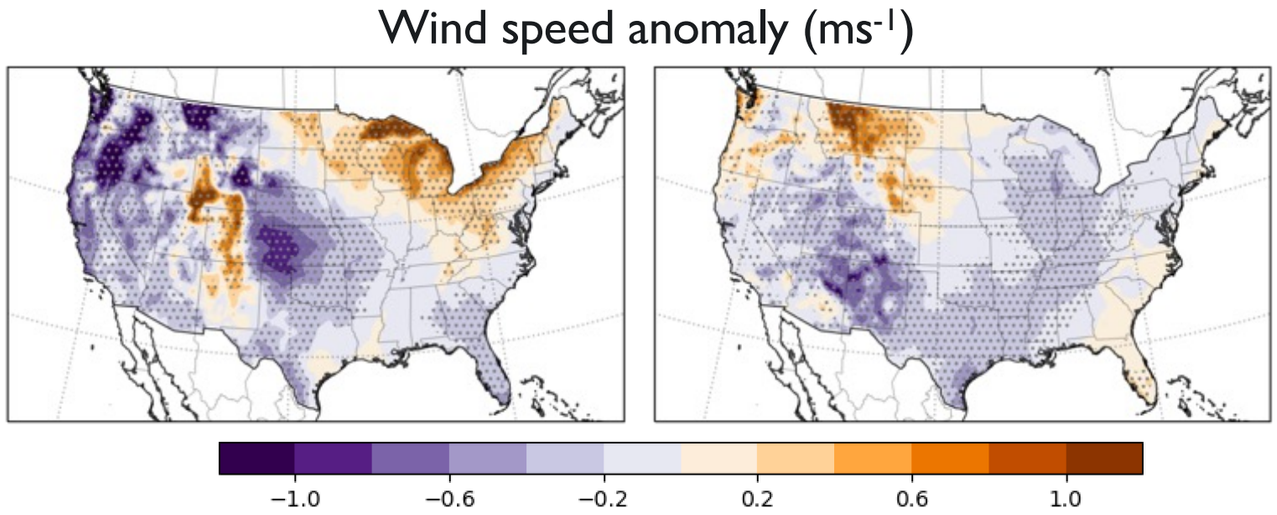


AkR & PT slow down large-scale winds

- **AkR regime:** Slows down the large-scale wind speed over the western United States and Great Plains, but increases over the east slope of Rocky Mountains and Midwestern US

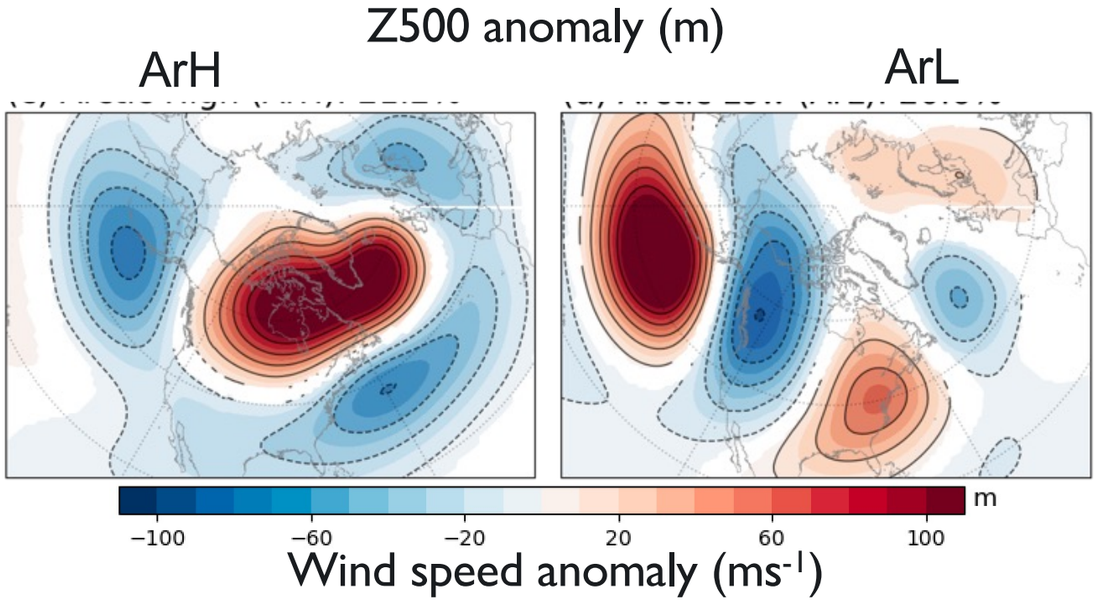
- **PT regime:** Drives decreased wind speed across the CONUS except for the northern US

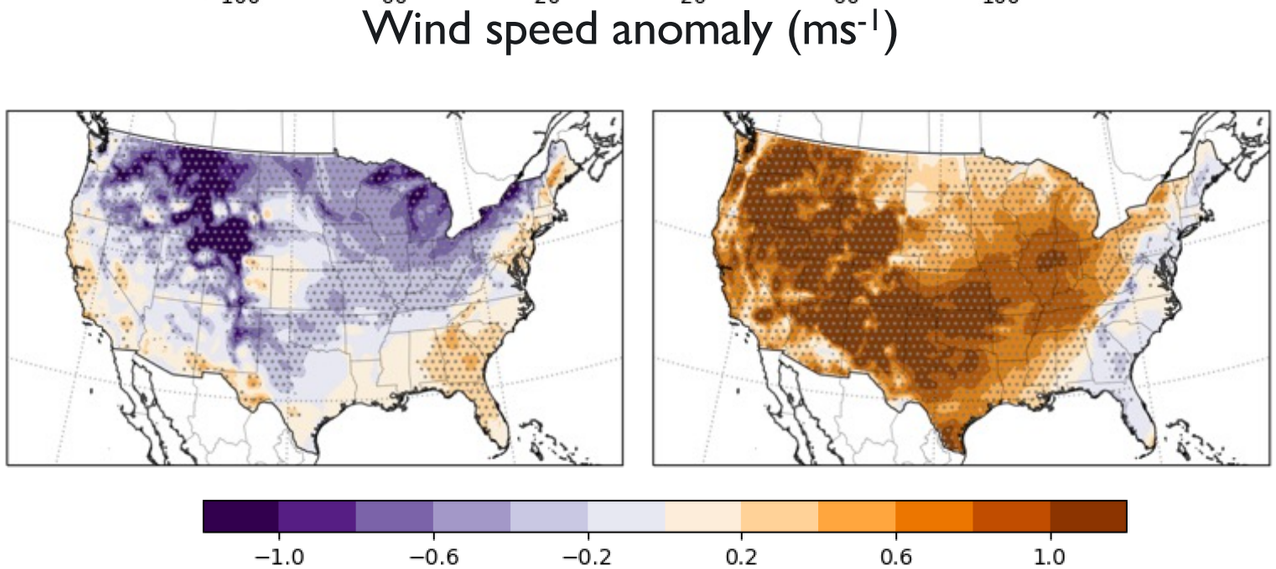




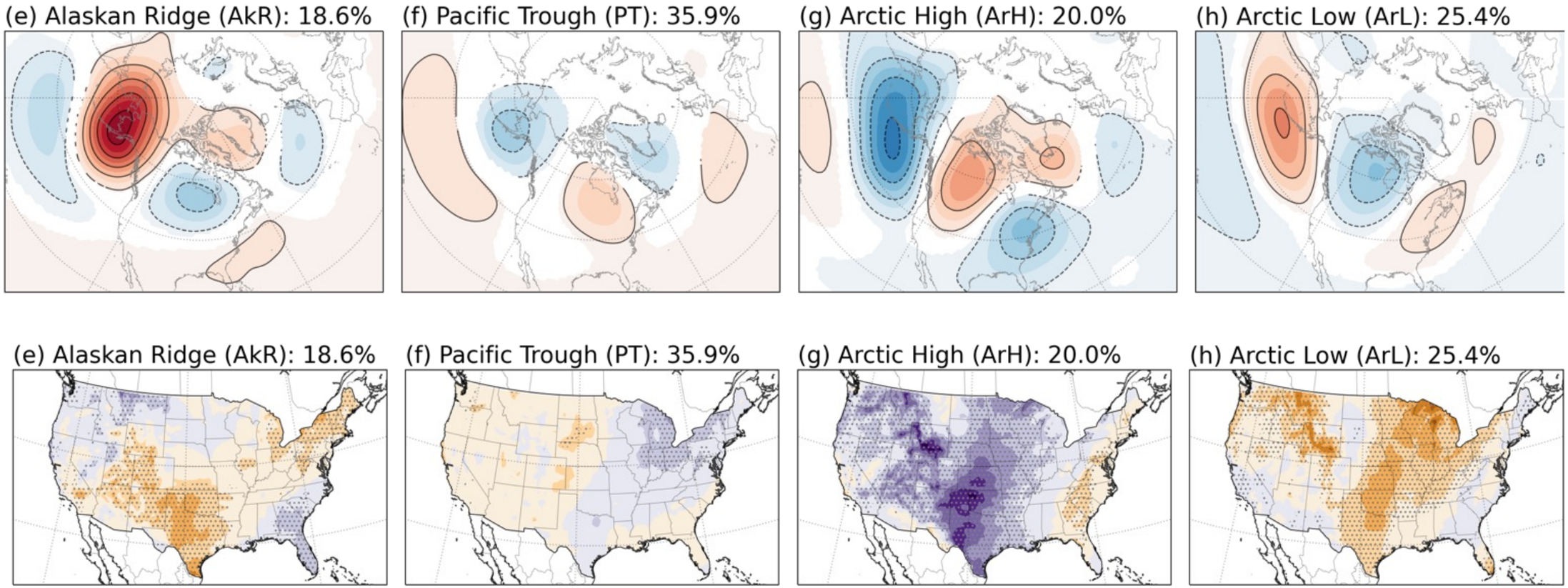
ArH & ArL affects most of the CONUS

- **AH regime:** lower wind speed across most of the CONUS
- **AL regime:** faster wind speed across most of the CONUS





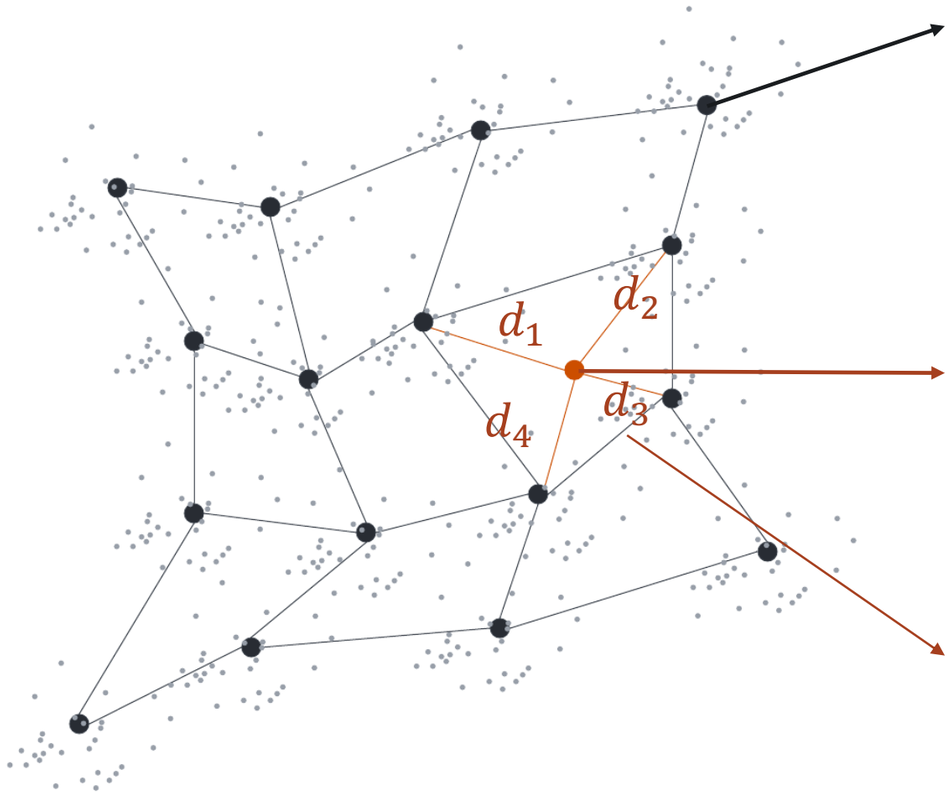
Weaker anomalies in warm months



500-hPa geopotential height anomaly

Only values significant at 0.05 confidence interval are shown

Reconstruct wind speed & power production



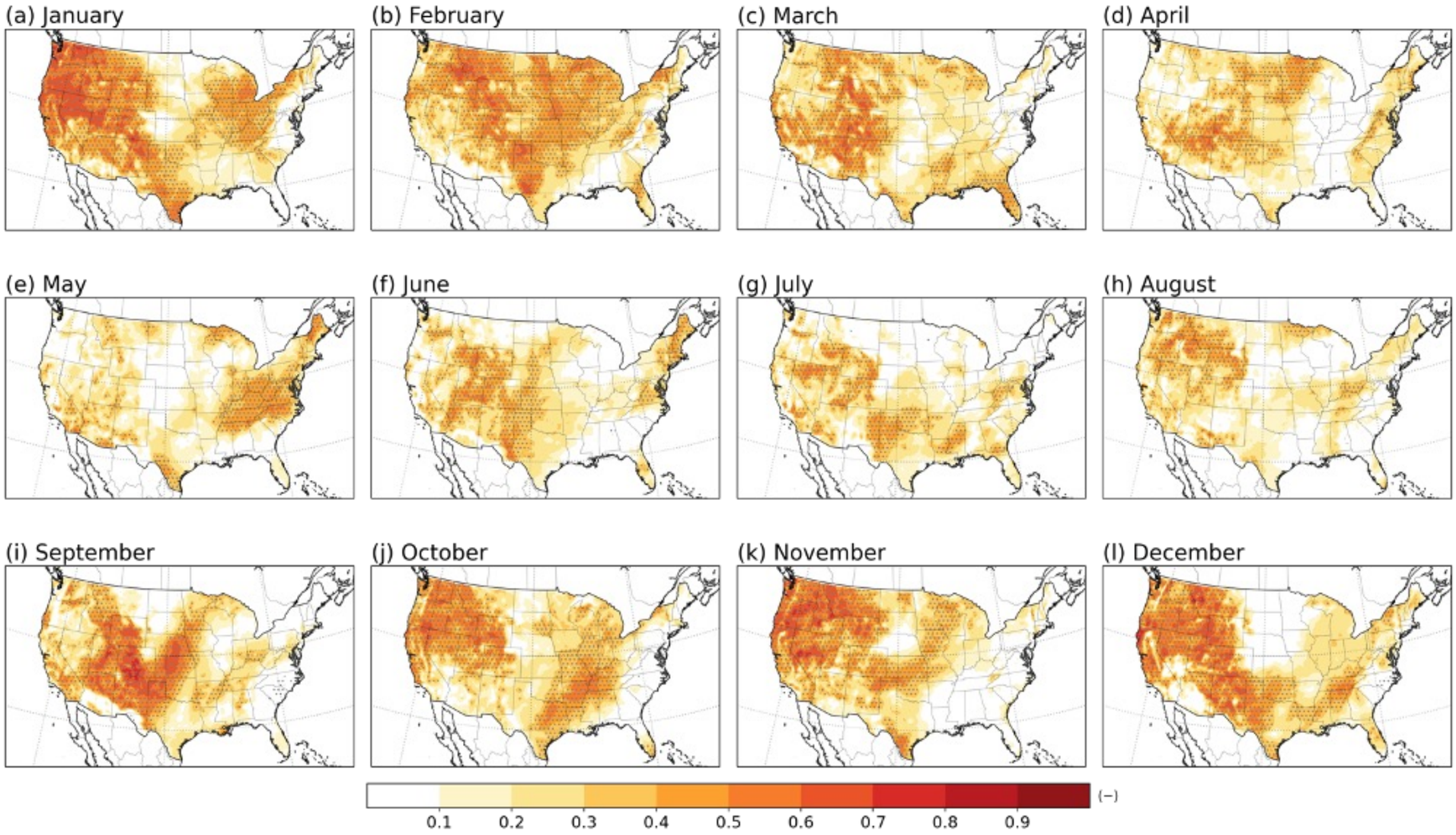
1. Weather Regime/Impact
- Prototypes (Z500)
- Impact on wind speed/power production

2. Weather pattern:
- Normalized Z500 anomaly averaged over a certain timescale (1-90 days)

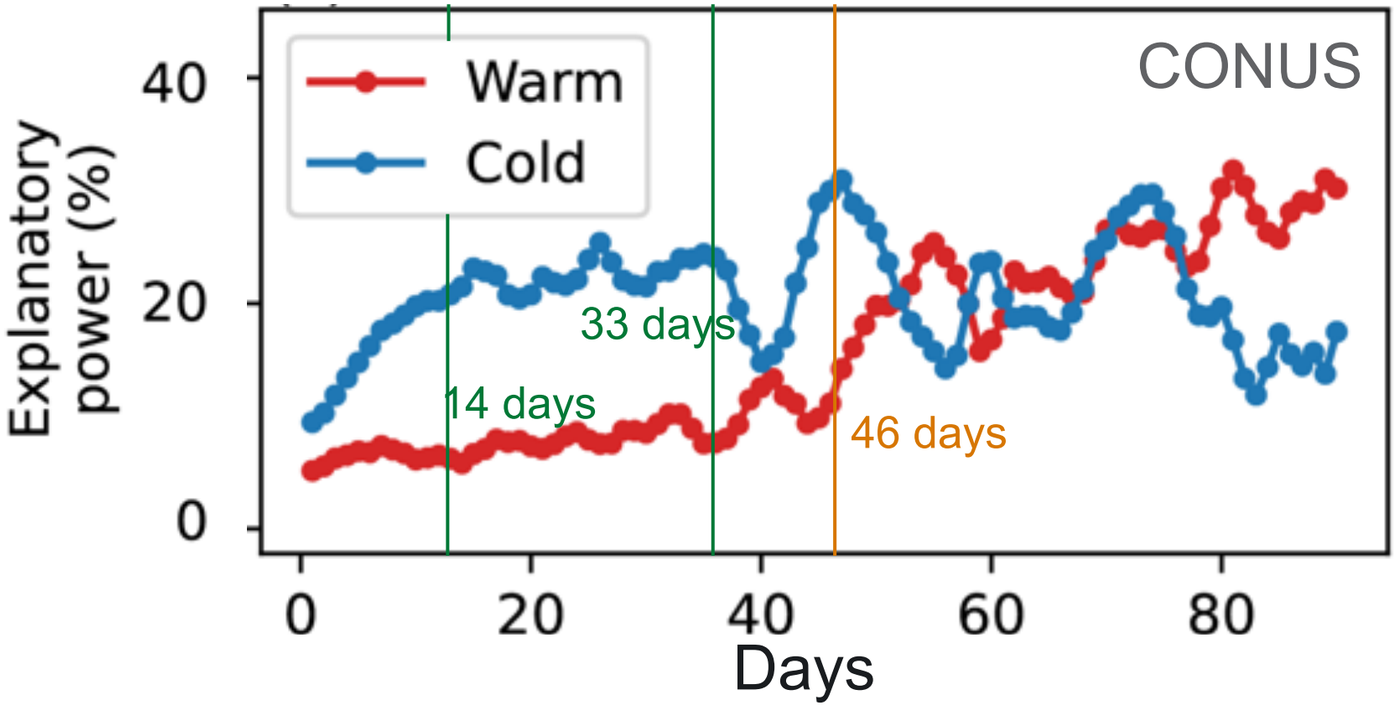
3. Reconstructed wind/power
- Weighted average of WR impact from the nearest 4 WRs using inversed Euclidean distance

- WR related wind speed/power production at different timescale from one day to one season

Temporal correlation (timing of the perturbation)



Explanatory power at different S2S timescales



- **In cold season**
  - Increasing rapidly from 1-day to 2-week
  - Stable from 2-week to 1-month
  - Fluctuation beyond 1-month
- **In warm season**
  - Low in 1-day to 50-day
  - Increasing rapidly over 50-day to 90-days

Similar patterns in CAISO, ERCOT, MISO, West (non-ISO) and WFIP2, which account for 80% of the power capacity

Summary

- Four weather regimes are identified which resemble the Rossby wave trains and the NAO patterns.
- Cold season WRs correspond to significant wind speed anomalies; warm season WRs' impacts are much weaker
- The explanatory power of WRs to the power production increase with the increase of timescale from 1 to 30 days in cold season to a range of 50 to 90 days in warm season.

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Thank you

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