Enhancing ERA5 wind speed time series variability through ramp events detection and correction

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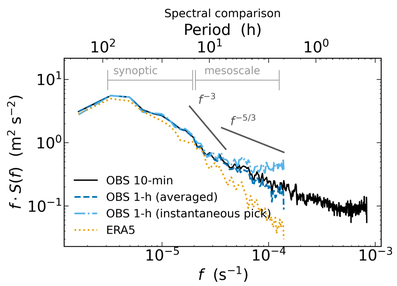
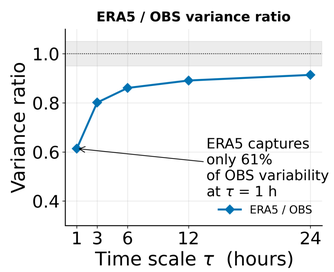
Background and Motivation

- ERA5 underrepresents variability in wind speed time series, as shown in the energy deficit in mesoscale range of the spectra (left), and ERA5 has lower variability when compared to the observation data (right).

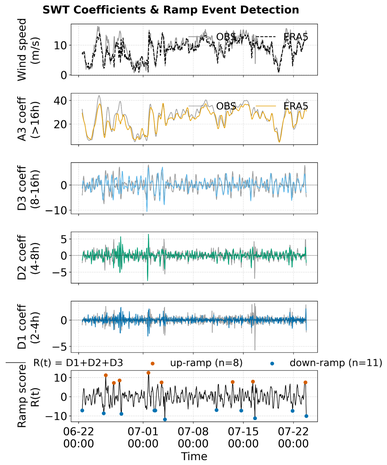




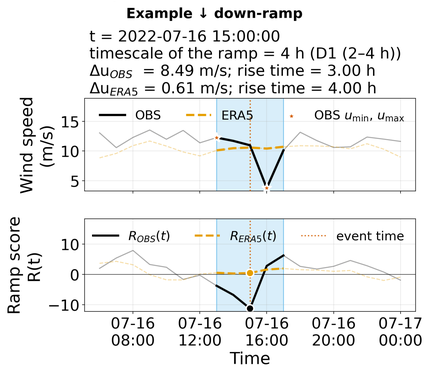
- **Aim of the study**
  - To recover periods of high variability that must have been presented in the ERA5 wind speed time series

The Concept: Wavelet-based Ramp-Event

- **Discrete Stationary Wavelet Transform**



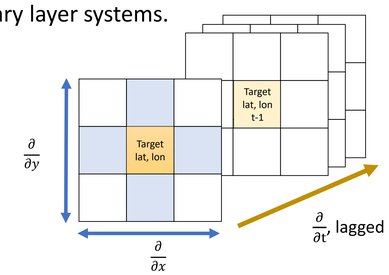
- **Example of ramp event detected by wavelet-based ramp score**



Similar methods: Gallego et al., 2013, Hannesdóttir and Kelly, 2019, Pichault et al. 2021

Data and Feature Engineering

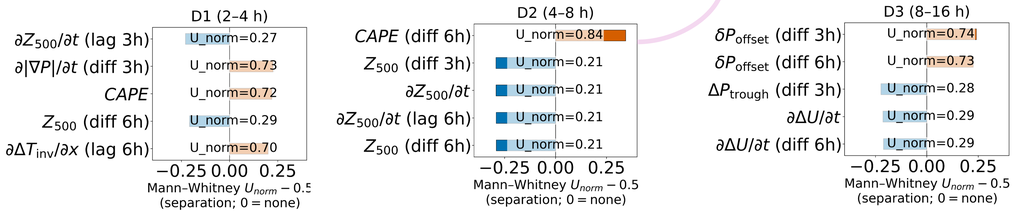
- **100 m Wind Speed:**
  - OBS: Floating LIDAR system
  - ERA5: u100 and v100
  - Baltic Sea (54.9944°N, 14.3547°E)
  - 1 December 2021 to 30 November 2022
- Predictors**: >50 ERA5-derived atmospheric variables** including synoptic, frontal, convective, shear, and boundary layer systems.



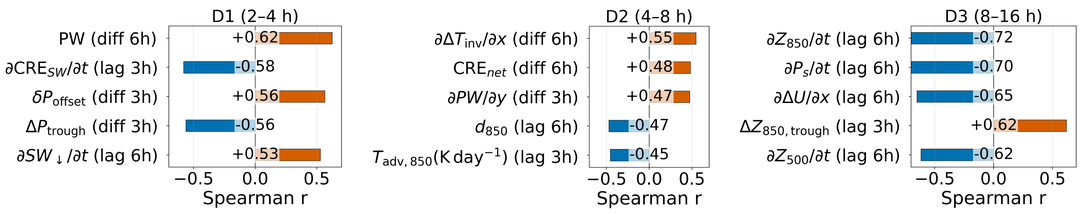
Results

- **A. Key Drivers of Ramp Detection**
  - Assessing feature separation between Ramp and Non-Ramp events

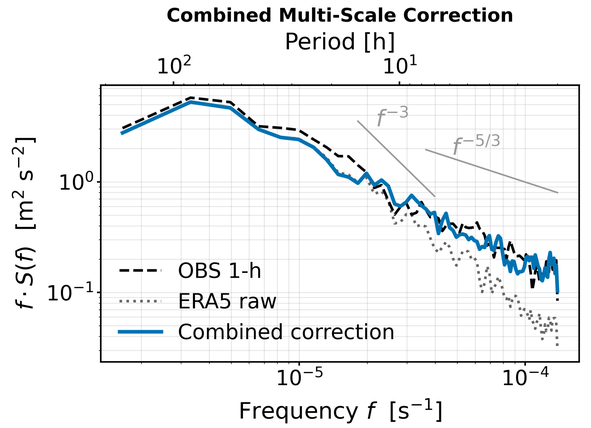
A U_norm of 0.8 means the predictor is significantly higher for the "ramp event" group.
If it's 0.2, the predictor is significantly higher for the "non ramp event" group.

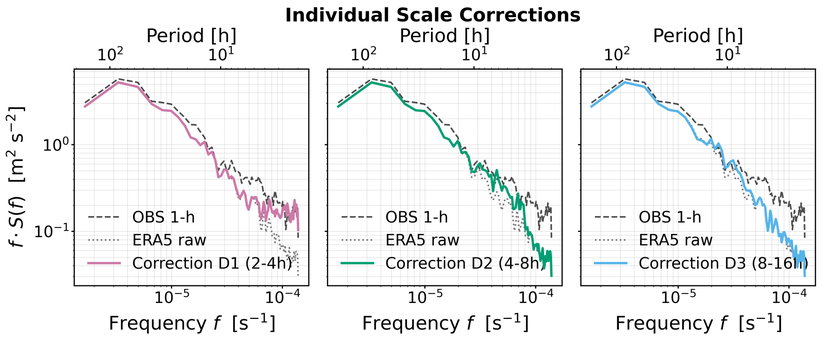


- **B. Predictor Screening for the Correction Model**
  - Analyzing correlations between predictors and the uncaptured signal (OBS-ERA5 wavelet coefficient residuals $|D_{OBS}| - |D_{ERA5}|$).



- **C. The Correction Model**
  - Two stages:
    - **Classification**: Predict the ramp event timestamps (when ramp event is happening) using variables with largest separation (Result A)
    - **Correction**: at the detected timestamp, correct the wavelet coefficients of the ERA5 at each decomposition level using variables that has high correlation with the uncaptured signal (Result B)
  - The correction model partially recovered the energy deficit in the mesoscale range, with attributable atmospheric variables.





Future work

- Using multiple sites
- Using longer time series, such as the FINO archive (≥15 y)

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