The impact of time series length and temporal resolution on wind resource assessment: a comparative analysis of wind speed distributions

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1. INTRODUCTION

- Preliminary wind assessments are crucial for identifying economically viable turbine sites. These assessments often rely on wind characteristics derived from fitting wind distribution to a certain amount of data. However,

Varying time series length/temporal resolutions → **Variations** in distribution characteristics → **Differences** in parameters → **Biased** assessment outcomes

This study aims to:

quantify uncertainty in wind resource estimation resulting from variations in distribution parameters due to differences in the lengths and resolutions of time series data.

2. METHODS

Data we used: 1-hourly and daily 10 m wind speed data for nine year (2009, 2015, 2017-2023) (78,727) for station SN38140 was used. The average percent of missing values in hourly and daily dataset is 0.17% and 1.4% per year.

Methods:

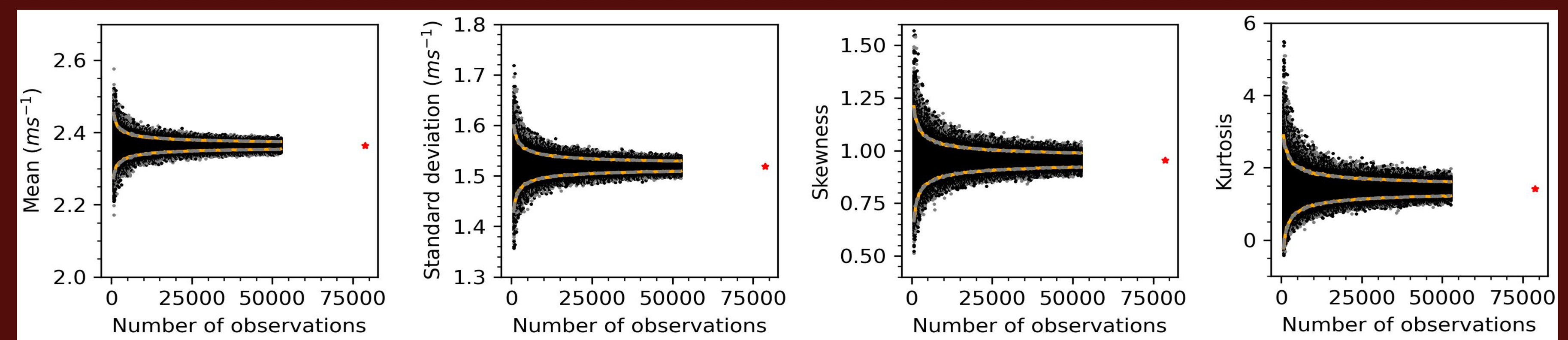
Maximum likelihood estimation
Coefficients of determinations

- Two parameter Weibull probability density function: $p(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} e^{-\left(\frac{v}{c}\right)^k}$

v is wind speed, k is shape parameter, c is scale parameter

Question 1

➢ Sample randomly selected (√) OR diurnal cycle retained?



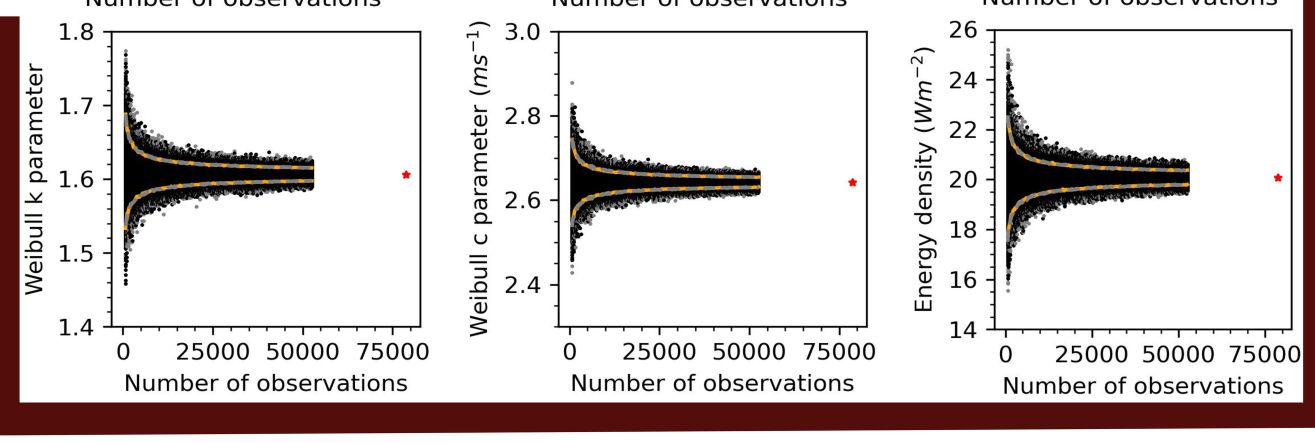


Fig. 1 For 1000 iterations spanning observation numbers from n=720 (30 days) to 65,700 (6 years). Red asterisks denote the value for the entire dataset (78,727). Black dots indicate uniform number from four time intervals (0-5, 6-11,12-17, 18- 23), and orange line shows 90% confidence interval (CI). While light grey dots and line signify random selection of samples.

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wind energy

3. RESULTS

Question 2:

How many hourly data points are required to capture the population parameters effectively?

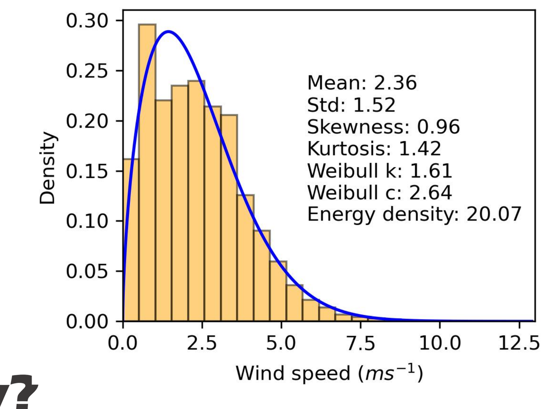

Fig. 2 The probability density and Weibull distribution of SN38140 calculated using the entire hourly dataset.

Weibull wind power density:

$$E = \frac{1}{2}\rho c^3 \Gamma\left(1 + \frac{3}{k}\right)$$

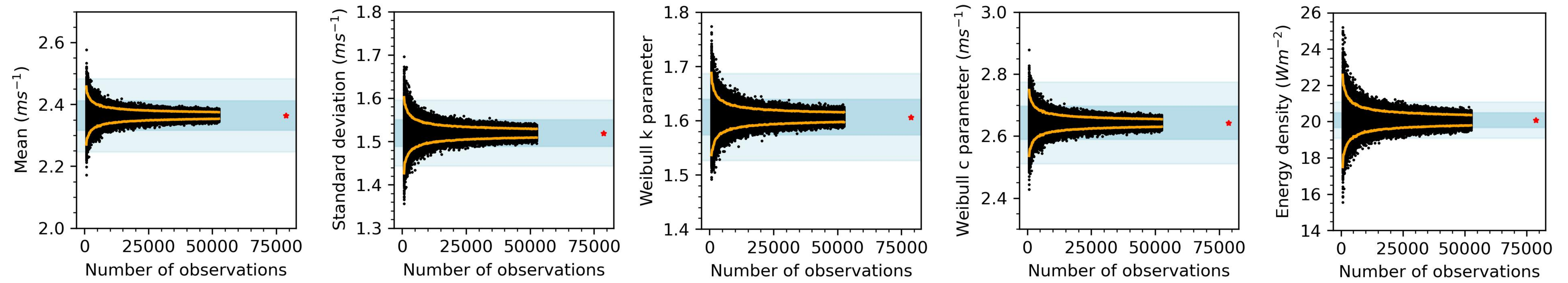

Fig. 3 For 1000 iterations for hourly data spanning observation numbers from n=720 (30 days) to 65,700 (6 years). Red asterisks denote the value for the entire hourly dataset (78,727), while dark and light blue areas indicate ±2% and ±5% ranges relative to the dataset values.

➢ **Finding #2: To achieve a 2% error, mean, standard deviation, Weibull parameters (*c* and *k*) require only hourly data spanning less than 7 months, while energy density necessitates 2.5 years of hourly data.**

Table. 1 The number of randomly distributed observations (unit: days) needed to achieve an estimate of the parameters within ± 1 and 2%.

Percent error	Mean	Standard deviation	Skewness	Kurtosis	Weibull k	Weibull c	Energy density
±1%	373	774	26,426	545,804	553	388	3,698
±2%	93	196	6,058	122,299	140	97	914

Question 3:

Can daily data replace hourly data for distribution fitting? What issues might arise from doing so?

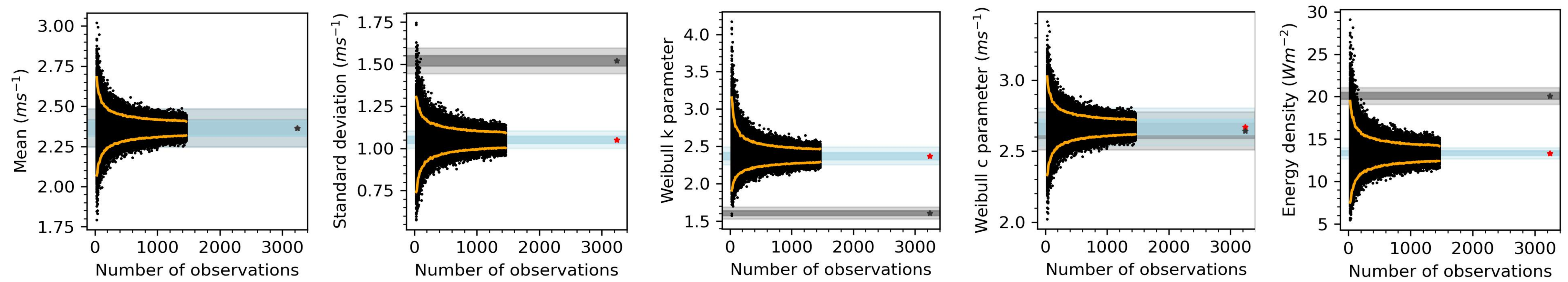

Fig. 4 For 1000 iterations for daily data spanning observation numbers from n=30 to 1,460 days (4 years). Red asterisks denote the value for the entire daily dataset (3,241), and dark and light blue areas indicate ±2% and ±5% ranges relative to the dataset values. While grey areas and asterisk indicate the ±2% and ±5% ranges relative to the hourly dataset values.

➢ **Finding #3: Despite similar mean and scale parameters (±1%), the wider range of hourly data yields a significantly larger standard deviation, causing a notable difference (+48%) in the Weibull k (shape) parameter, leading to an underestimation (-34%) of esimated energy density.**

4. WHAT'S NEXT?

❑ **How to consider the impact from the seasonality characteristic and interannual variations of wind speed?**

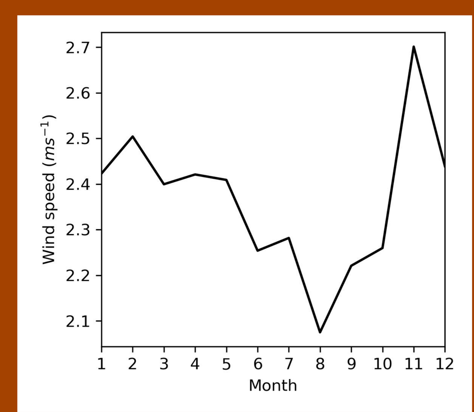

Fig. 5 Average wind speed for each month calculated using the entire hourly dataset (SN38140).

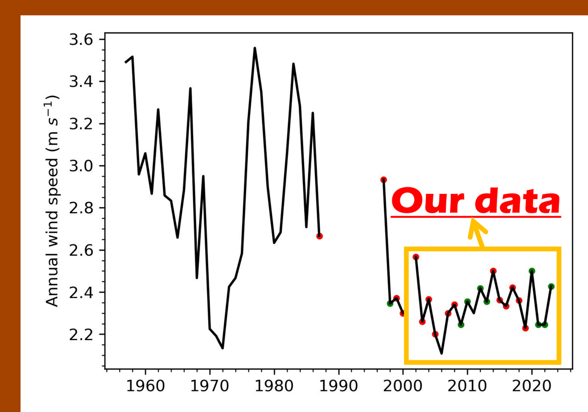

Fig. 6 Annual wind speed time series for SN38140. Green dots indicate 11-month data, while red dots represent less than 11 months. No data was available between 1988 and 1996.

Abstract Link