Cross spectral characteristics of modelled and measured sets of spatially distributed wind in the Faroe Islands

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Introduction

NWP data in the Faroe Islands are validated, with a focus on its spectral characteristics. The Faroe Islands is a small country located in the northeast of the Atlantic Ocean, ~300 km away from the nearest adjacent land. It is a mountainous group of 18 islands separated by fjords with a windy climate.

Aim

The aim is to compare auto- and cross-spectral characteristics of sets of modelled and measured data. The results will give an insight on the value of NWP derived data for grid integration studies in a region with complex topography.

Motivation

There is a political goal that the electrical power system in the Faroe Islands should be running entirely on renewable resources by 2030. This is expected to be mainly achieved by implementing a considerable amount of wind power [1].

As a tool for future wind power integration in the Faroe Islands, a WRF model has been used to simulate meteorological data for the region. However, models are simplified versions of the reality, and validations are thus of great importance.

WRF setup [2]

- Model version: v3.8.1
- Vertical levels: 51
- 3 domains
  Innermost domain: Covers the entire Faroe Islands
  Innermost horizontal resolution: 500m x 500m
- Temporal resolution: 1 hour
- ERA5 reanalysis data was used to drive the WRF model
- WRF schemes: Thompson scheme for microphysics, Mellor-Yamada-Janjik scheme for boundary layer mixing and NOAH scheme for surface.

: met. Towers
: WRF data
X : site names

Site H

Site S

H

S

20 km

m a.s.l.
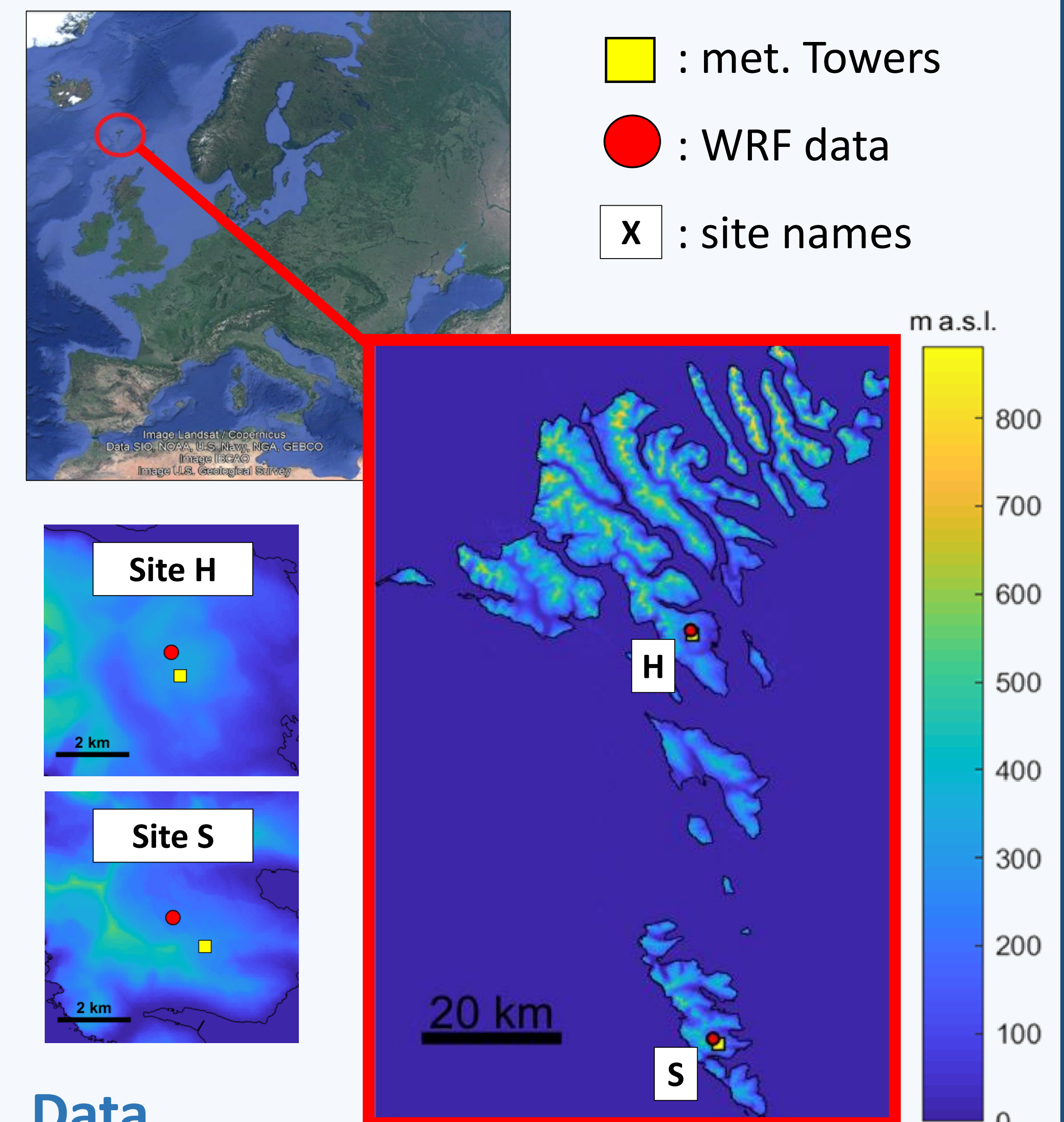
Data

- Empirical wind speed data from met masts
- WRF model data

Time period: 21 July 2016 to 30 June 2018

Both the empirical and the WRF model data are obtained from the local power company in the Faroe Islands, SEV. The authors' contribution is the analysis of these data sets.

Method

Empirical and WRF model wind speed data at two sites are compared (see map). Two heights are considered separately (50 m and 70 m a.g.l.). The meteorological masts measure wind speed at approximately these heights. However, the WRF model wind speed data are interpolated to these heights using the power law considering the closest adjacent wind speed heights (being 36.6, 60.9 and 85.3 m a.g.l.).

Conclusions
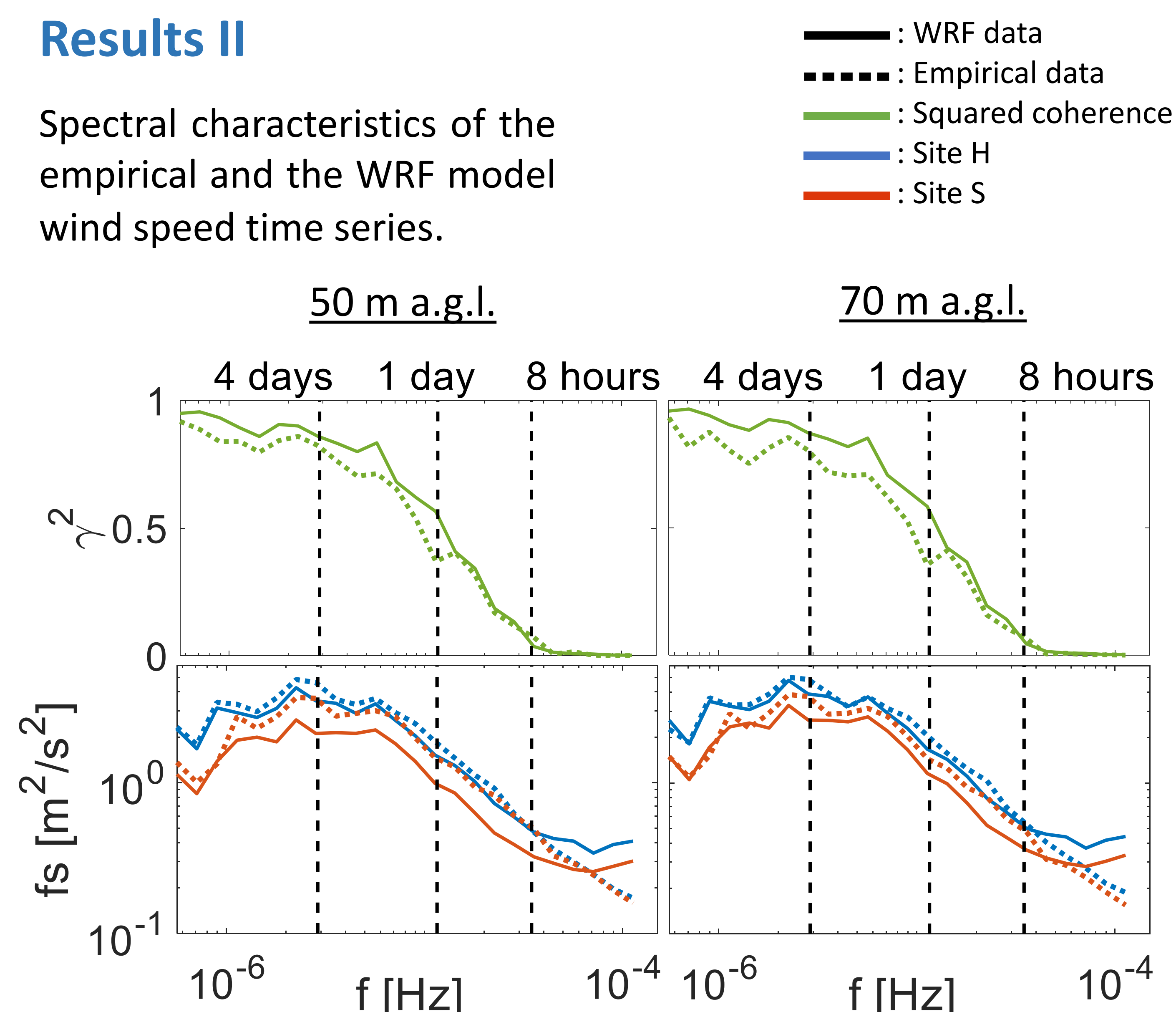
- The same patterns are seen for both measuring heights.
- The WRF model wind speed time series predict the average wind speeds well for the examples analyzed, with biases in between -0.7 m/s and 0.4 m/s.
- For frequencies higher than ~1/8h, the spectra of the WRF model wind speeds start to overestimate the fluctuations. This could be an effect of aliasing.
- For frequencies lower than ~1/8h, the spectral shapes of the WRF model wind speeds are resembling the spectral shapes seen for the empirical wind speeds. However, the values are in general somewhat lower, as could be expected from the standard deviation of the time series.
- The shapes of the coherence functions of the WRF model wind speeds are similar to the ones seen from the empirical wind speeds. However, for the lower frequencies, the WRF model overestimates the coherence between the considered sites.

Results I

Statistical values from the empirical and the WRF model wind speed time series.

Data height		50 m a.g.l.		70 m a.g.l.	
Site		H	S	H	S
μ [m/s]	Empirical	10.0	9.7	10.3	10.0
	WRF	10.1	9.0	10.8	9.9
σ [m/s]	Empirical	5.6	4.8	5.7	4.9
	WRF	5.3	4.1	5.6	4.6
r^2		0.90	0.85	0.89	0.87
Bias [m/s]		0.08	-0.71	0.43	-0.13
RMSE [m/s]		2.4	2.6	2.6	2.5

μ and σ are the mean and standard deviation, respectively, of the given time series. r^2, bias and RMSE are the correlation coefficients, bias and root mean square between model and emperical time series.

Results II

Spectral characteristics of the empirical and the WRF model wind speed time series.

: WRF data
: Empirical data
: Squared coherence
: Site H
: Site S

50 m a.g.l.

70 m a.g.l.

4 days   1 day   8 hours

[1] Hansen, H., Nielsen, T., Thomsen, B., and Andersen, K., 2018, Energilagring på Færøerne, Teknisk opsamlingsrapport. Dansk Energi.
  (see http://www.os.fo/media/1187/1-teknisk-opsamlingsrapport-energilagring-paa-faer-erne.pdf)
[2] Faroe Islands – Detailed wind maps, Report number: KVT/ASH/2019/R032, Kjeller Vindteknikk.
  Availability: limited to client.

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