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Advanced MCP for improved assessment of curtailment losses

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3E

Abstract

Long-term extrapolation methodologies rely on the assumption that MCP relationships between a site and a reference remain constant over time. But in reality, these vary as a function of atmospheric stability at the site and reference. This is an issue when the predicted long-term time series needs to represent the actual wind speed variations over time, such as when it is used to assess curtailment losses that apply at given times of the year or day.

In this work, MCP relationships between MERRA-2 reanalysis and site wind speeds were found to vary significantly as a function of solar elevation angle. MCP algorithms were therefore modified to establish separate relationships between reference and site wind speeds and directions for times when the sun is below or above the horizon.

The modified Matrix MCP method was found to improve the predictions of noise and/or bat curtailment losses at all 7 considered test sites, dividing the uncertainty associated with these losses by 2.

Objectives

3E selected 7 test sites located in Northern France, Belgium and the Netherlands, where curtailments apply (noise and/or bat-related). Curtailment parameters are listed below and include time of day for all sites. Therefore, if MCP relationships were found to vary as a function of time of day, then assessing losses from a long-term time series generated with a standard MCP method would bias the result.

3E investigated if it was the case, and if refining MCP methods could improve the prediction of curtailment losses. At each site, 2 years of site measurements are available, allowing the 1st year of measurements to be used for MCP training, and the 2nd one for comparison of curtailment losses computed from measurements or from a time series rebuilt through MCP.

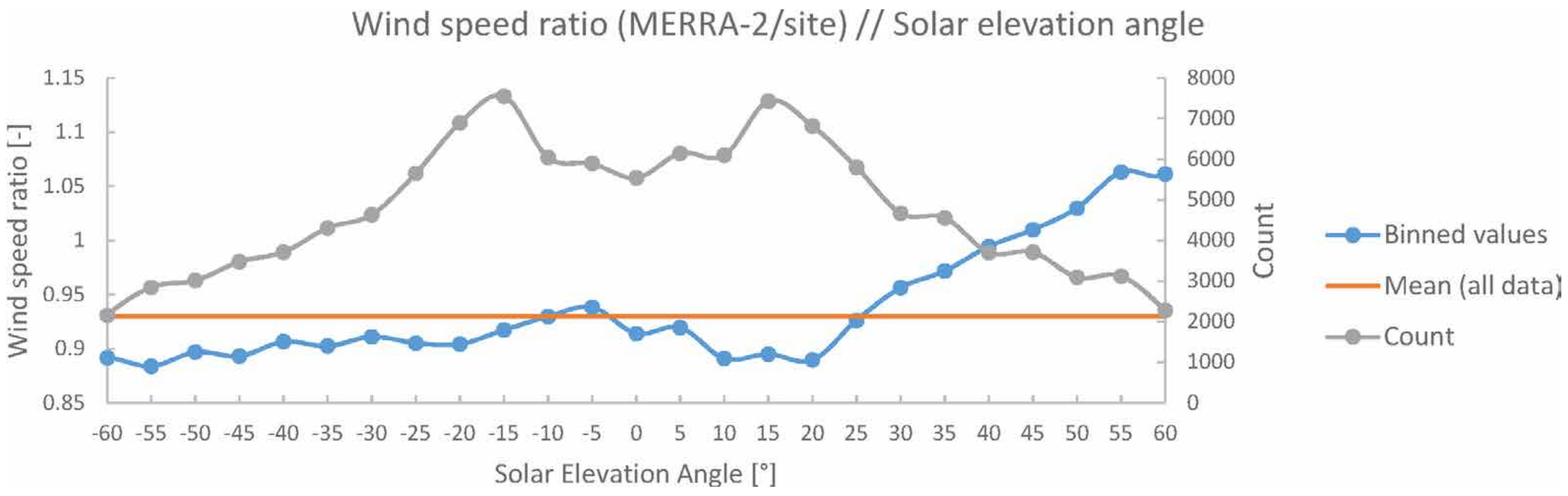
Site	Noise curtailment			Bat curtailment			
	Time of day	Wind speed	Wind direction	Time of year	Time of day	Wind speed	Temperature
#1	*	*	*				
#2	*	*	*				
#3	*						
#4	*	*		*	*	*	
#5	*						
#6				*	*	*	*
#7	*	*	*	*	*	*	*

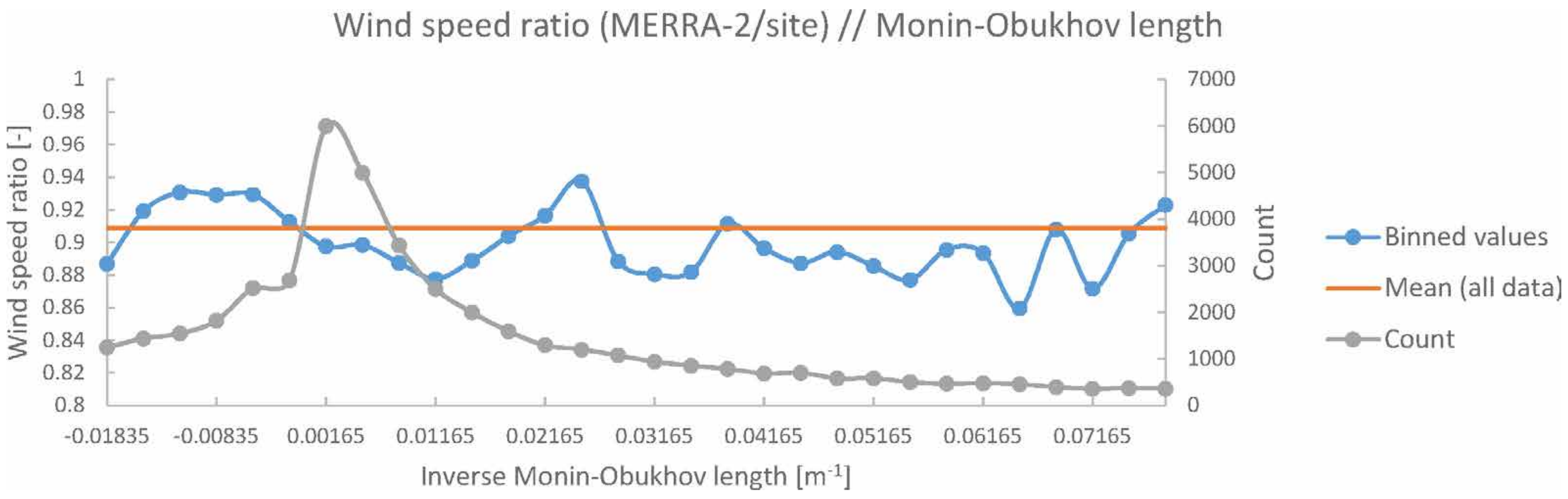
Methods

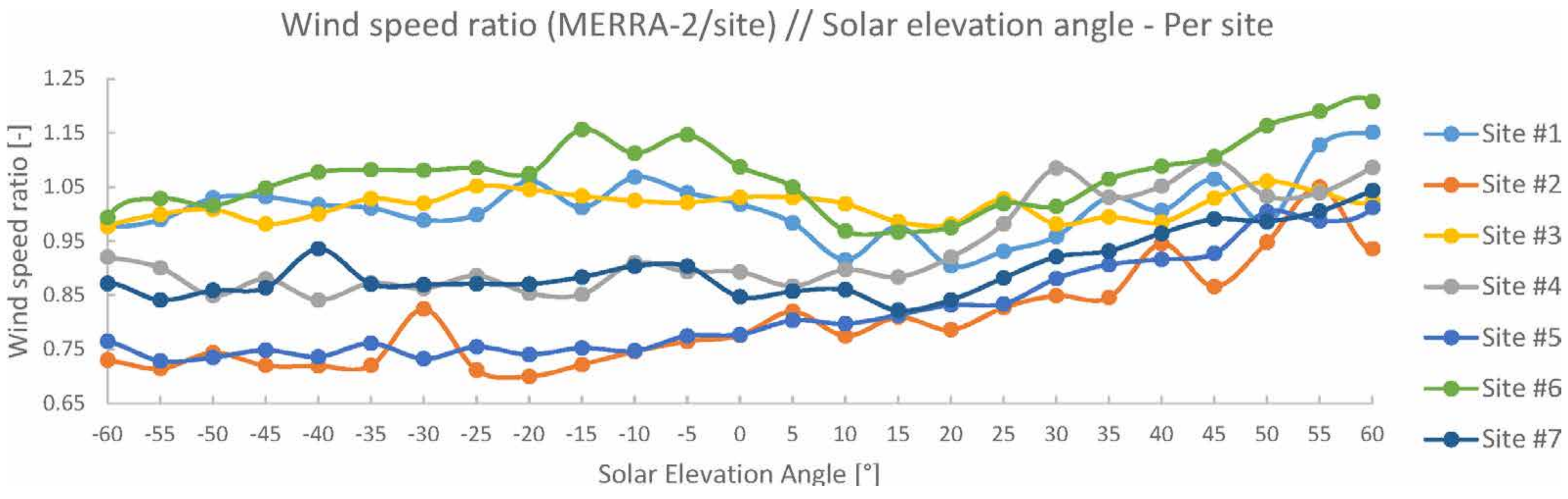
Variations in wind speed ratio between site measurements and MERRA-2 at the closest grid point were analyzed, as a function of 2 indicators of atmospheric stability:

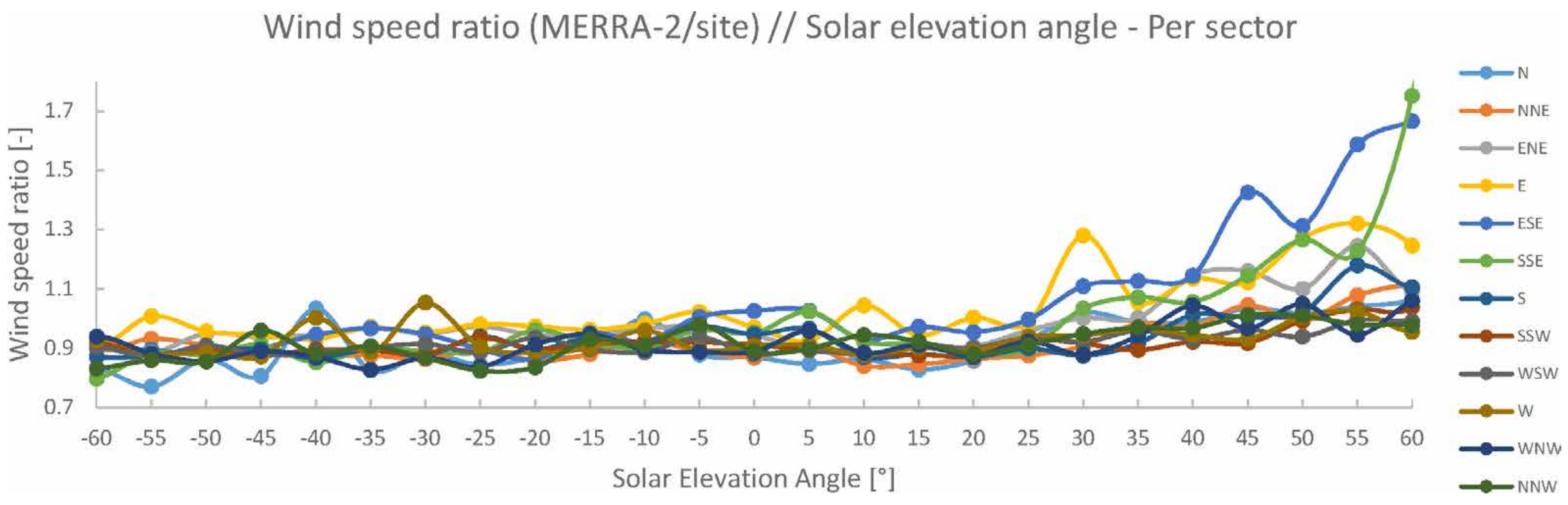
- Solar Elevation Angle (SEA)
- Monin-Obukhov length (L) from a state-of-the art WRF mesoscale run at the closest grid point to each site.

This analysis reveals a noticeable change in wind speed ratio with SEA. Such a behavior is observed at all sites and in all sectors. On the other hand, no relationship could be identified between wind speed ratio and L.









3E then adapted standard state-of-the art Matrix and Linear regression MCP methods, to allow relationships to be established not only as a function of wind speed and direction, but also as a function of SEA.

For each site, curtailment losses computed from the 2nd year of measurements, were compared to curtailment losses computed from data rebuilt through MCP, establishing relationships for sectors and SEA bins of various numbers and sizes.

Results

The most consistent improvement of curtailment losses predictions was obtained by simply establishing separate MCP relationships for times when the sun is below or above the horizon.

In this scenario, the Matrix method proves to improve the prediction of curtailment losses in all 7 test cases (compared to 5 cases out of 7 for the Linear regression MCP).

Overall, the uncertainty associated with curtailment losses is halved.

Additionally, 3E investigated the benefit in terms of the representation of monthly wind farm production profiles. However, this benefit was found to be marginal for the test sites under consideration.

Site		From measurements	From Matrix MCP		From Linear regression MCP	
			Standard	Advanced (SEA<0/SEA≥0)	Standard	Advanced (SEA<0/SEA≥0)
#1	Curtailment loss [%]	11.1	9.1	10.4	9.1	10.4
	Absolute error [%]		17.6	6.2	17.5	6.2
	Error reduction [%]			64.9		64.6
#2	Curtailment loss [%]	4.7	5.0	4.6	4.5	4.6
	Absolute error [%]		5.7	1.0	3.1	1.9
	Error reduction [%]			82.8		38.6
#3	Curtailment loss [%]	3.0	2.9	3.0	2.9	3.0
	Absolute error [%]		3.3	0.1	3.3	0.3
	Error reduction [%]			96.4		90.2
#4	Curtailment loss [%]	0.9	0.8	0.9	0.8	0.9
	Absolute error [%]		4.7	0.4	2.7	4.1
	Error reduction [%]			92.2		-49.8
#5	Curtailment loss [%]	2.4	2.8	2.5	2.8	2.6
	Absolute error [%]		13.6	4.1	13.8	4.7
	Error reduction [%]			69.7		66.3
#6	Curtailment loss [%]	1.9	2.2	2.1	2.1	2.0
	Absolute error [%]		13.7	7.6	11.6	6.2
	Error reduction [%]			44.1		46.6
#7	Curtailment loss [%]	8.9	9.1	8.8	9.0	8.5
	Absolute error [%]		2.1	1.0	0.8	3.9
	Error reduction [%]			53.3		-365.2
Portfolio	Curtailment loss [%]	4.7	4.6	4.7	4.5	4.6
	Absolute error [%]		3.3	1.8	4.4	2.4
	Error reduction [%]			45.5		46.0
Uncertainty associated with losses predictions [%]			11.1	4.4	10.5	4.7

Conclusions

MCP relationships between MERRA-2 reanalysis and site wind speeds were found to vary significantly as a function of solar elevation angle, for the 7 test cases under consideration located in Northern France, Belgium and the Netherlands, where curtailments apply (noise and/or bat-related).

Curtailment parameters include time of day. Therefore, assessing losses from a long-term time series generated with a standard MCP method under the assumption that MCP relationships between a site and a reference remain constant over time would result in a biased estimate.

MCP algorithms were therefore modified to establish separate relationships between reference and site wind speeds and directions for times when the sun is below or above the horizon. The modified Matrix MCP method is found to improve the predictions of noise and/or bat curtailment losses at all 7 considered test sites, reducing the uncertainty associated with these losses by 2.

References

1. MERRA-2
2. Skamarock, W.C., Klemp, J.B., Dudhia, J., Gill, D.O., Barker, D.M., Wang, W., Powers, J.G., 2008. A description of the advanced research WRF version 3, NCAR Technical Note TN-468+STR. National Center for Atmospheric Research, Boulder, CO.