Long-term correction: Facts and Fiction

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EMD International A/S
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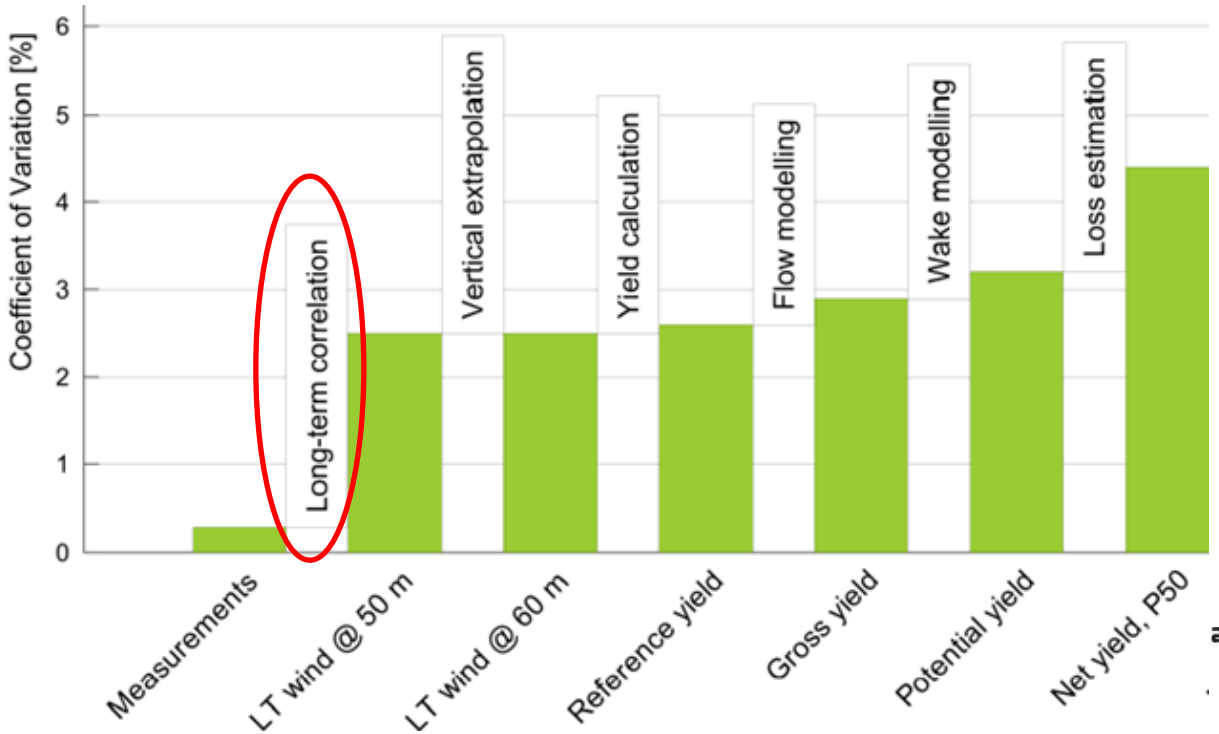
LT Long-term Correction

Challenges:

Nature: +/- 20% energy variation possible

Man-made: CREYAP 1 (blind test) indicated LT correction as biggest source of deviation between consultants



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Why?

A number of choices have to be made:

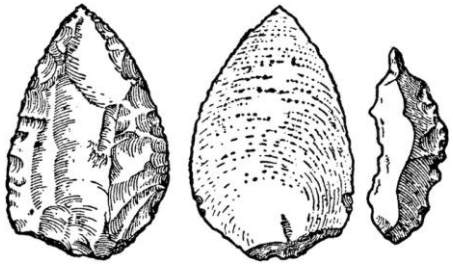
1. LT data source
2. MCP (measure-correlate-predict) method
   - Artificial time series: Linear Regression or Matrix Method
   - Scaling: Wind Index (or better said Energy Index)

But there is no guideline how to make a choice!

Common Consideration

Key parameter: Wind Speed Correlation Coefficient R

How well does the ST (short-term) data set correlate with LT data?



But:

Improved quality of meso-scale data (temporal and spatial resolution) allows far more sophisticated approaches.

Methodology (1/3)

On-site data:

- 10 sites with 80m measurement masts in Turkey
- All mast IEC compliant
- All anemometer MEASNET calibrated
- All excellent recovery rate – 1 year of data

Methodology (2/3)

LT data:

- EMD ConWx
- Vortex
- Merra

MCP Methods (all using default in WindPRO):

- Linear Regression
- Matrix
- Wind Index (which is an energy index)

Methodology (3/3)

Total of 90 results (10 sites, 3 LT data sets, 3 methods)
How to compare?

Each LT data set/method results in a LT corrected wind speed

- Correction factor wind speed $C_{ws} = WS_{LT}/WS_{ST}$
- Correction factor wind energy $C_{we} = 1+(C_{ws}-1)^2$

All results have been normalized to the C_{we} from LT data set
From 90 results:

- Averages as measure of bias
- Standard deviations as measure of uncertainty

Results (1/3)

How much do the results vary for a specific site?

- Despite high correlation: significant variations
- For a specific site the results from different methods and sources span on average 15%
- All data sets/methods industry accepted

	Deviation from Normalised Energy Correction Factor		
	Average	Min	Max
10 sites	15%	7%	31%

Results (2/3)

Dependency on LT data set and method? Focus "Average" (bias)

- around 6% difference between methods
- Wind Index positive bias - Matrix negative bias
- EMD ConWx and Vortex comparable
- Merra: positive bias in all methods

		Deviation from Normalised Energy Correction Factor		
		Wind Index	Lin. Regression	Matrix
all LT data	Average	5%	2%	-1%
	Std Dev			
EMD ConWx	Average	5%	0%	-3%
	Std Dev			
Vortex	Average	4%	1%	-3%
	Std Dev			
Merra	Average	8%	4%	4%
	Std Dev			

Results (2/3)

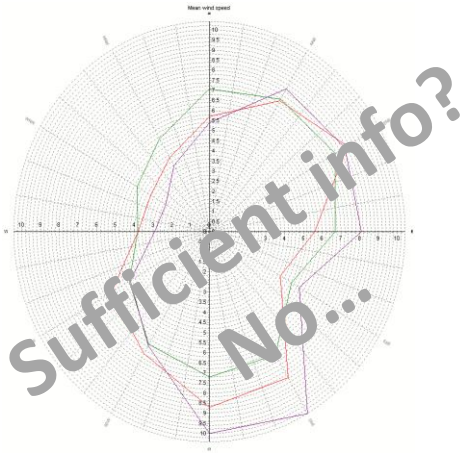
Dependency on LT data set and method? Focus "std dev" (uncertainty)

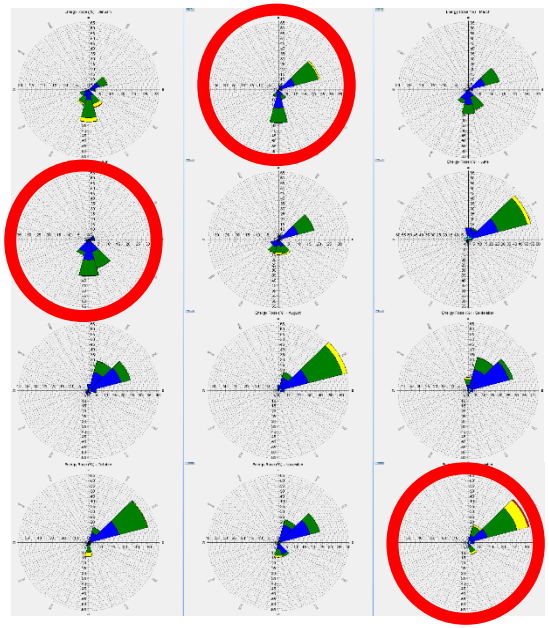
- No significant difference between methods
- Slightly lower for Vortex for Lin. Regr. and Matrix

		Deviation from Normalised Energy Correction Factor		
		Wind Index	Lin. Regression	Matrix
all LT data	Average	5%	2%	-1%
	Std Dev	7%	6%	7%
EMD ConWx	Average	5%	0%	-3%
	Std Dev	6%	6%	6%
Vortex	Average	4%	1%	-3%
	Std Dev	6%	4%	3%
Merra	Average	8%	4%	4%
	Std Dev	9%	7%	7%

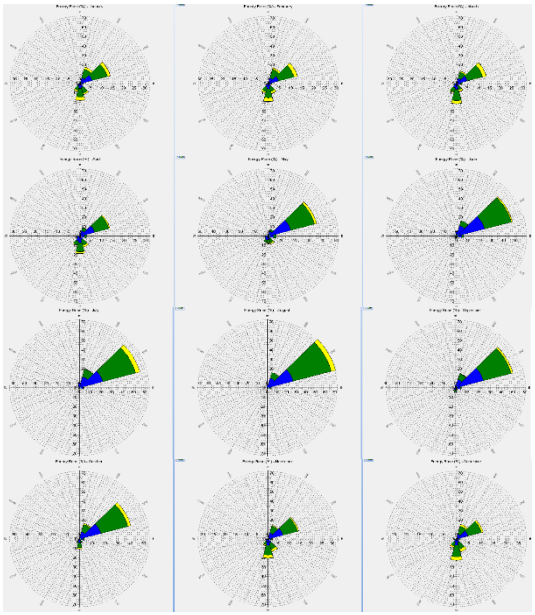
Reasons (1/2)

1. Wind direction:
- Annual rose hides too much
- Look at monthly level





Monthly energy roses local data

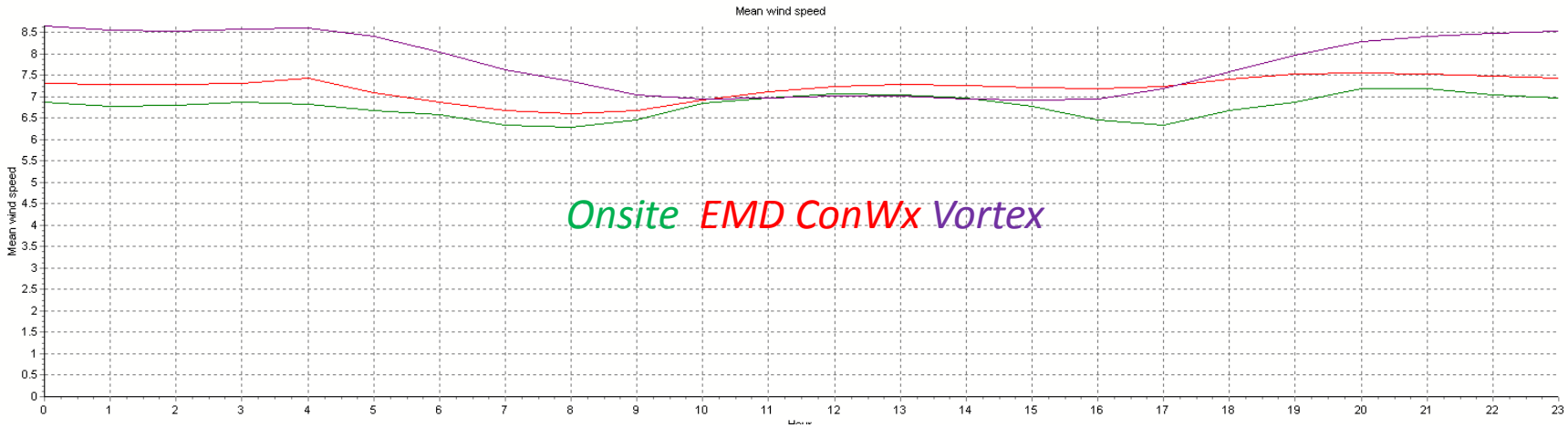


Monthly energy roses reference data concurrent with local data

Reasons (2/2)

2. Get the timing right:

- If you generate artificial time series (lin reg or Matrix) check diurnal variations



Recommendation

- There is no “perfect” method.
- Show comparison concurrent **energy** rose, not only frequency rose or mean wind speed rose of concurrent period
- Go into **detail** and check if the wind rose is representative (monthly basis), it is important to get it right **how much** and **when** it is blowing from **what** direction
- Check **seasonal** and **diurnal** variations
- If artificial time series is generated, do **quality control** and compare artificially generated energy rose with measured one for concurrent period