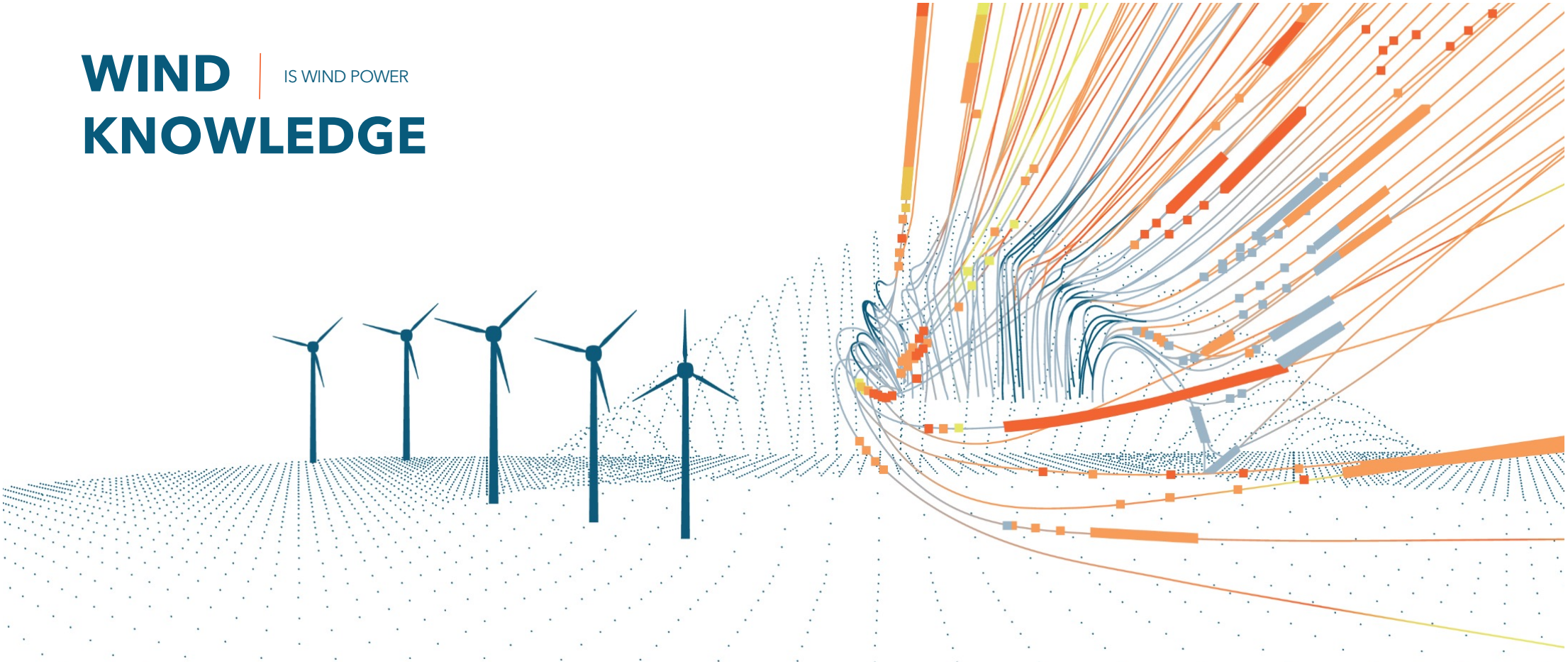
WIND IS WIND POWER
KNOWLEDGE



WindSim User Meeting 2024

windsim

Time Series Versus Frequency Distributions

Presented by:
Arne R. Gravdahl

windsim

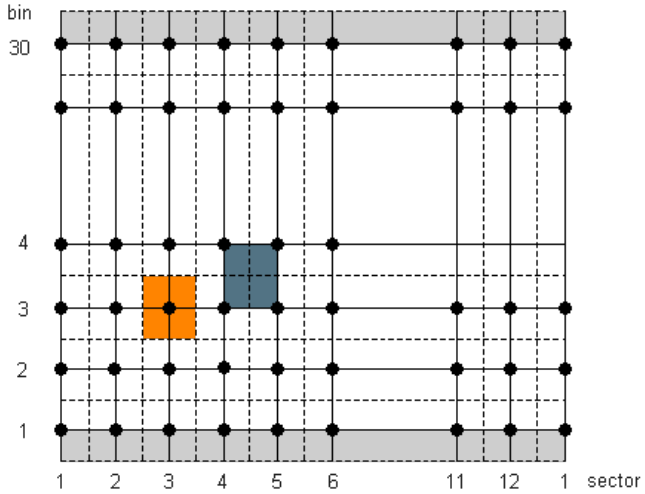
Why CFD – Increased profitability?

- Why CFD?
  - Request from the customer
  - Request from the bank
  - We are a well reputed company, and we know how to run CFD simulations
  - …….
  - CFD – checked 
- Increased profitability?
  - Deliver wind fields and derived post-processing results with highest possible accuracy to increase the profitability of a wind project

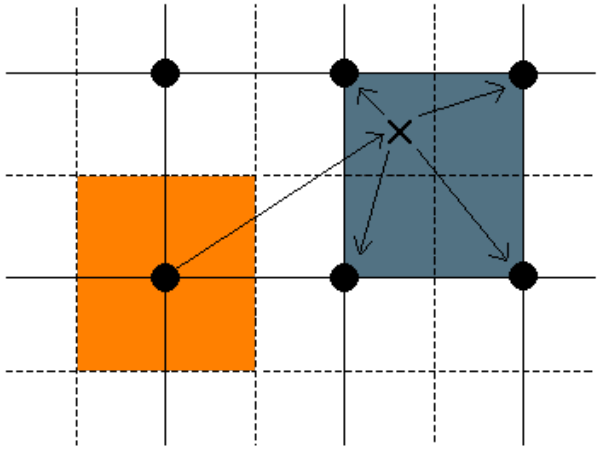
- In this presentation we will look at how to increase the accuracy of the Annual Energy Production (AEP) estimates by using time series (.tws) instead of frequency distributions (.wws)

Climatology transfer as frequency distribution or time series

- A frequency distribution represents a discrete representation of the measurements, where all measurements within a certain direction- and speed-interval is lumped into one point with a given direction and speed
- When transferring a frequency distribution from the measurement mast to any other location by applying a directional shift and a speedup factor, the associated re-distribution imposes a smoothing of the frequency distribution
- The same errors will not appear if time series are used due to their continuous representation of the measurements



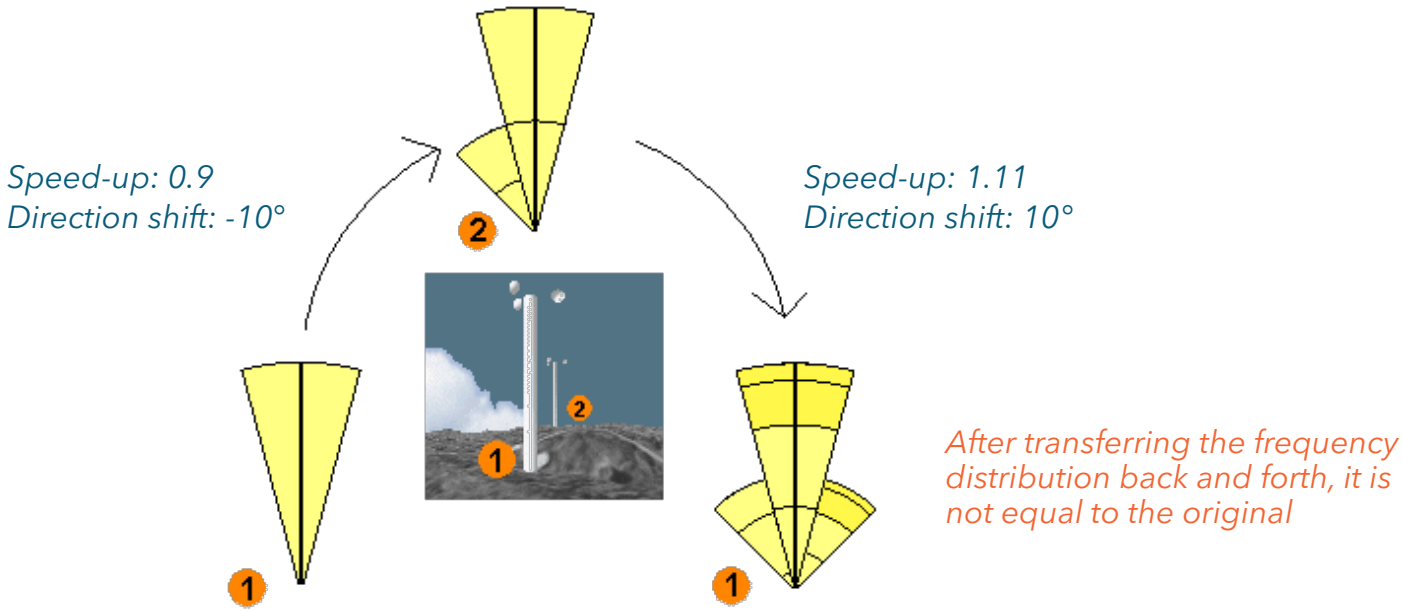
Frequency distribution, a discrete representation of the measurements



Re-distribution (interpolation) errors, due to the discrete representation of the measurements

Re-distribution or smoothing errors – A simple example

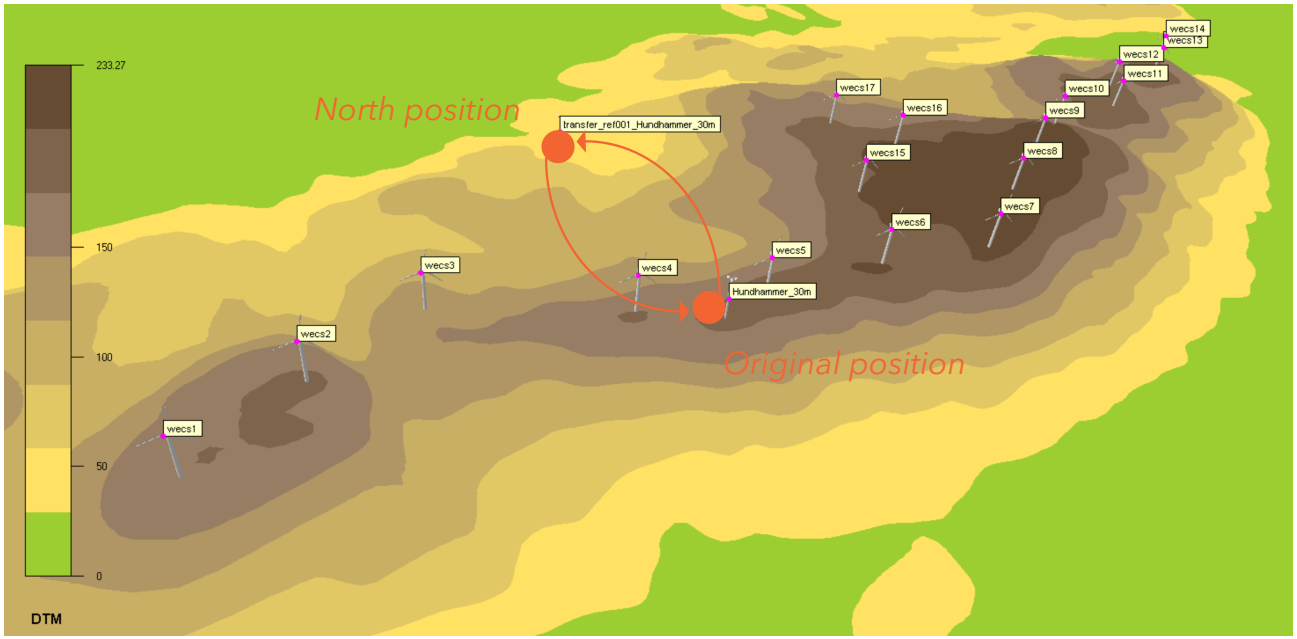
- The discrete representation of a climatology as a frequency distribution (.wws) introduces interpolation or re-distribution errors while transferring to new positions
- Let's examine a simplified case where a climatology is transferred from position 1 to position 2 and then back again to position 1.
- We expect the final climatology to be equal to the original, but this is not the case



After transferring the frequency distribution back and forth, it is not equal to the original

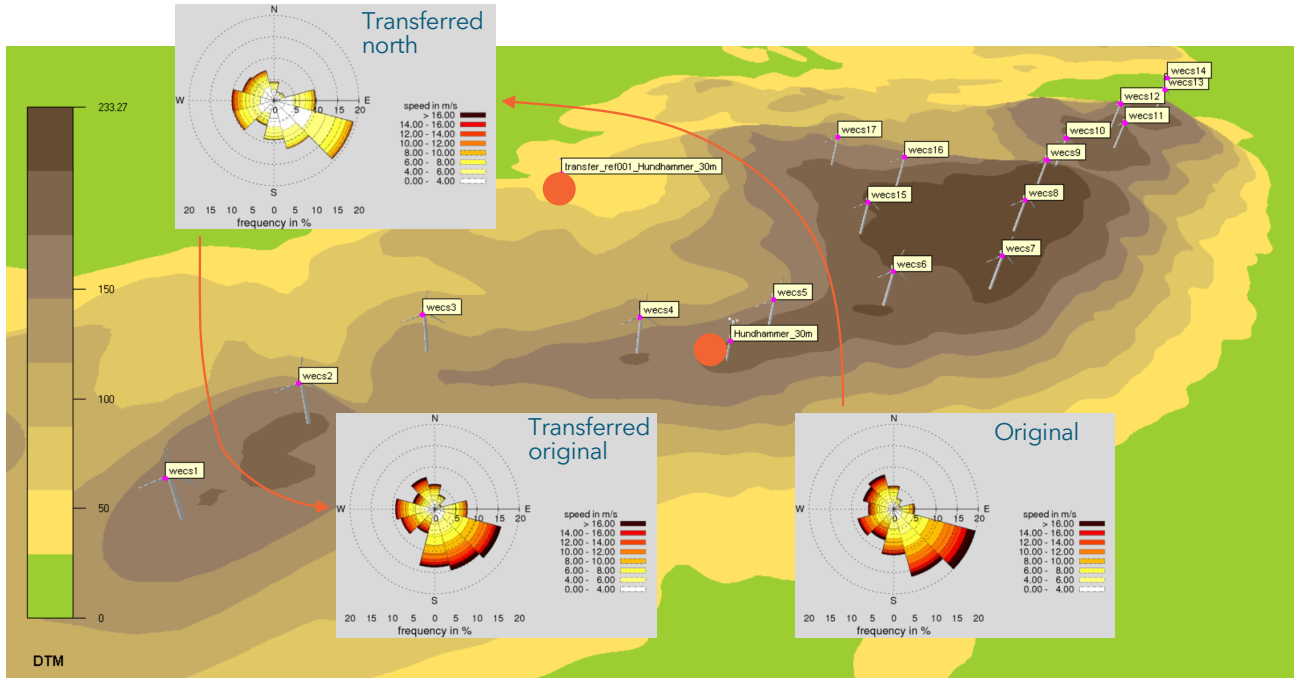
Re-distribution or smoothing errors – A real case example

- Measurements can be introduced in WindSim both as a time series (.tws) and as frequency distributions (.wws)
- In our Hundhammer demo we have measurements for a period of 2 years
- These measurements have been transferred arbitrarily 1 kilometer towards north, then it is transferred back to its original position. We have examined the changes both in the measurements itself and its derived AEP estimates when the measurements have been transferred both as frequency distributions and as time series



Re-distribution or smoothing errors – A real case example

- Transferring the measurements as a frequency distributions (.wws)

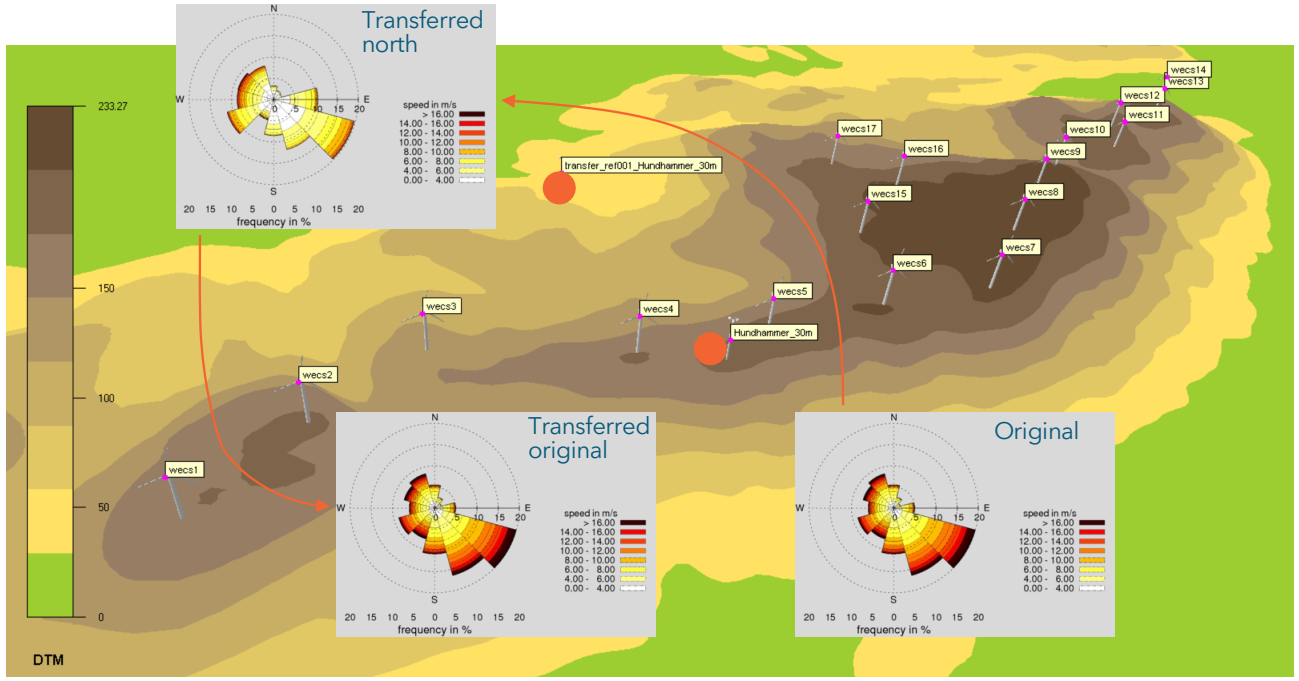


Climatology	Average Wind Speed (m/s)	AEP (GWh/y)
Original	7.89	133.7
Transferred north	4.47	126.3
Transferred original	7.54	127.7

After transferring the frequency distribution back and forth, it is not equal to the original, the AEP estimate has changed 4.5%

Re-distribution or smoothing errors – A real case example

- Transferring the measurements as a time series (.tws)



Climatology	Average Wind Speed (m/s)	AEP (GWh/y)
Original	7.89	133.7
Transferred north	4.47	133.9
Transferred original	7.88	133.6

After transferring the frequency distribution back and forth, it is almost equal to the original, the AEP estimate has changed 0.1%

Re-distribution or smoothing errors – A real case example

- Transferring the measurements as a time series (.tws), extract from time series.

```
version            : 48
site name          : HUNDHAMMER_30
measurement period : 27/04/2006 20:06 - 30/04/2008 23:56
site position      : 326703.8 7185926.0
coordinate system  : 3
measurement height : 30.0
```

Original

rec nr:	year:	mon:	date:	hour:	min:	dir:	speed:
1	2006	4	27	20	6	353.6	9.03
2	2006	4	27	23	56	0.8	5.7
3	2006	4	28	0	6	0.8	6.03
4	2006	4	28	0	16	237.7	6.27
5	2006	4	28	0	26	125.3	5.51

Transferred north

rec nr:	year:	mon:	date:	hour:	min:	dir:	speed:
1	2006	4	27	20	6	347.3	5.83
2	2006	4	27	23	56	354.9	3.73
3	2006	4	28	0	6	354.9	3.95
4	2006	4	28	0	16	245.7	4.11
5	2006	4	28	0	26	115.3	2.98

Transferred original

rec nr:	year:	mon:	date:	hour:	min:	dir:	speed:
1	2006	4	27	20	6	353.6	9.03
2	2006	4	27	23	56	0.8	5.70
3	2006	4	28	0	6	0.8	6.04
4	2006	4	28	0	16	237.7	6.27
5	2006	4	28	0	26	125.3	5.51

Minor changes in the transfer of time series due to abbreviation errors

Summary

- In this presentation we have looked at how to increase the accuracy of the Annual Energy Production (AEP) estimates by using time series (.tws) instead of frequency distributions (.wws)
- Transferring climatologies as frequency distributions could introduce significant re-distribution errors, the errors are proportional to the changes in wind speed and direction between the start and end location of the transfer
- Transferring climatologies as time series introduce minor abbreviation errors

Thank you!

WindSim AS
Tollbodgaten 22
3111 Tønsberg
Norway
Tel.: +47 33 38 18 00

WindSim China
No. 101 Shaoyang Beili, Chaoyang District
1000029 Beijing
China
Tel.: +86 186 1029 1570