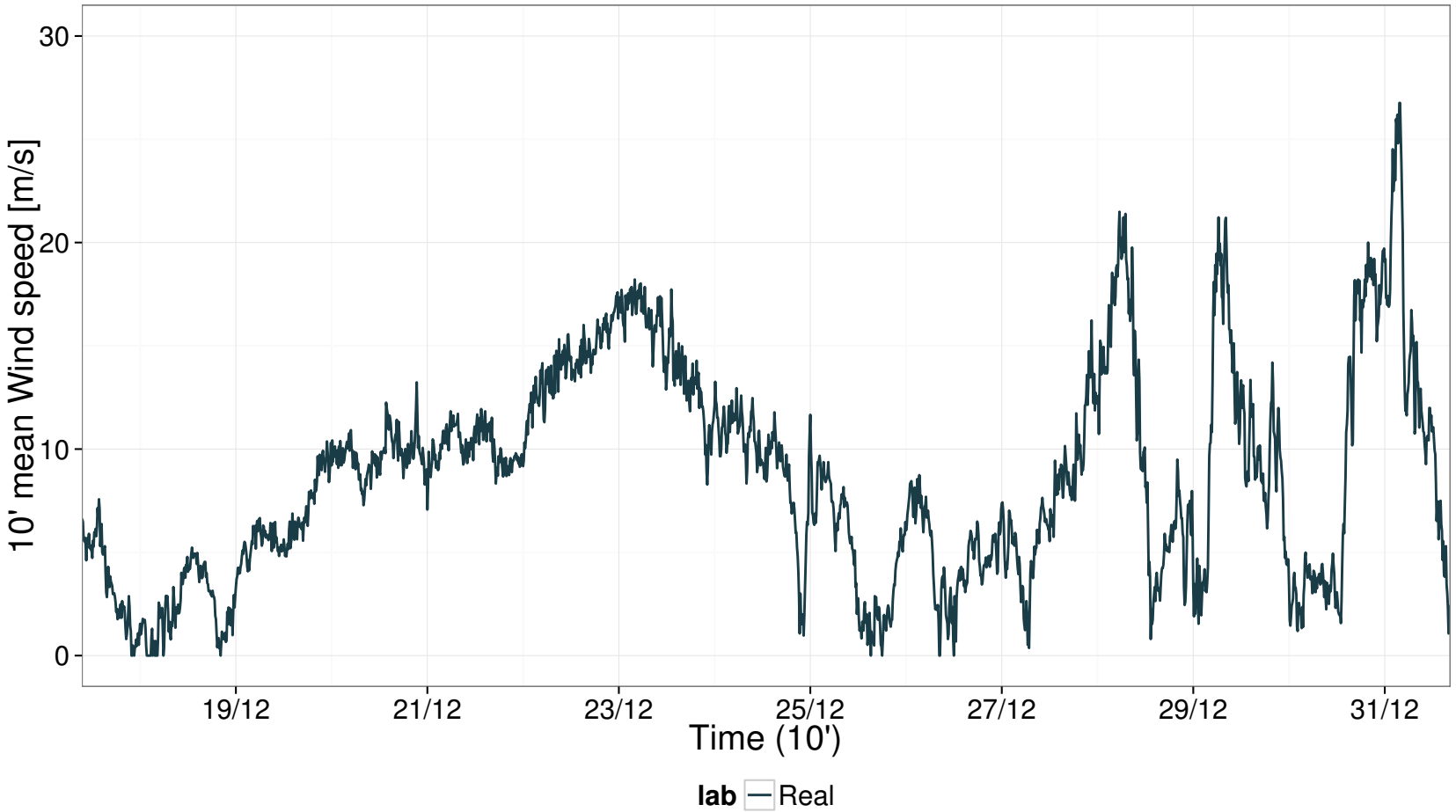
Is WRF-LES a suitable tool for realistic turbulence analyses in wind resource assessment applications?

A. Montornès[1] P. Casso[1] B. Kosovic[2] G. Lizcano[1]

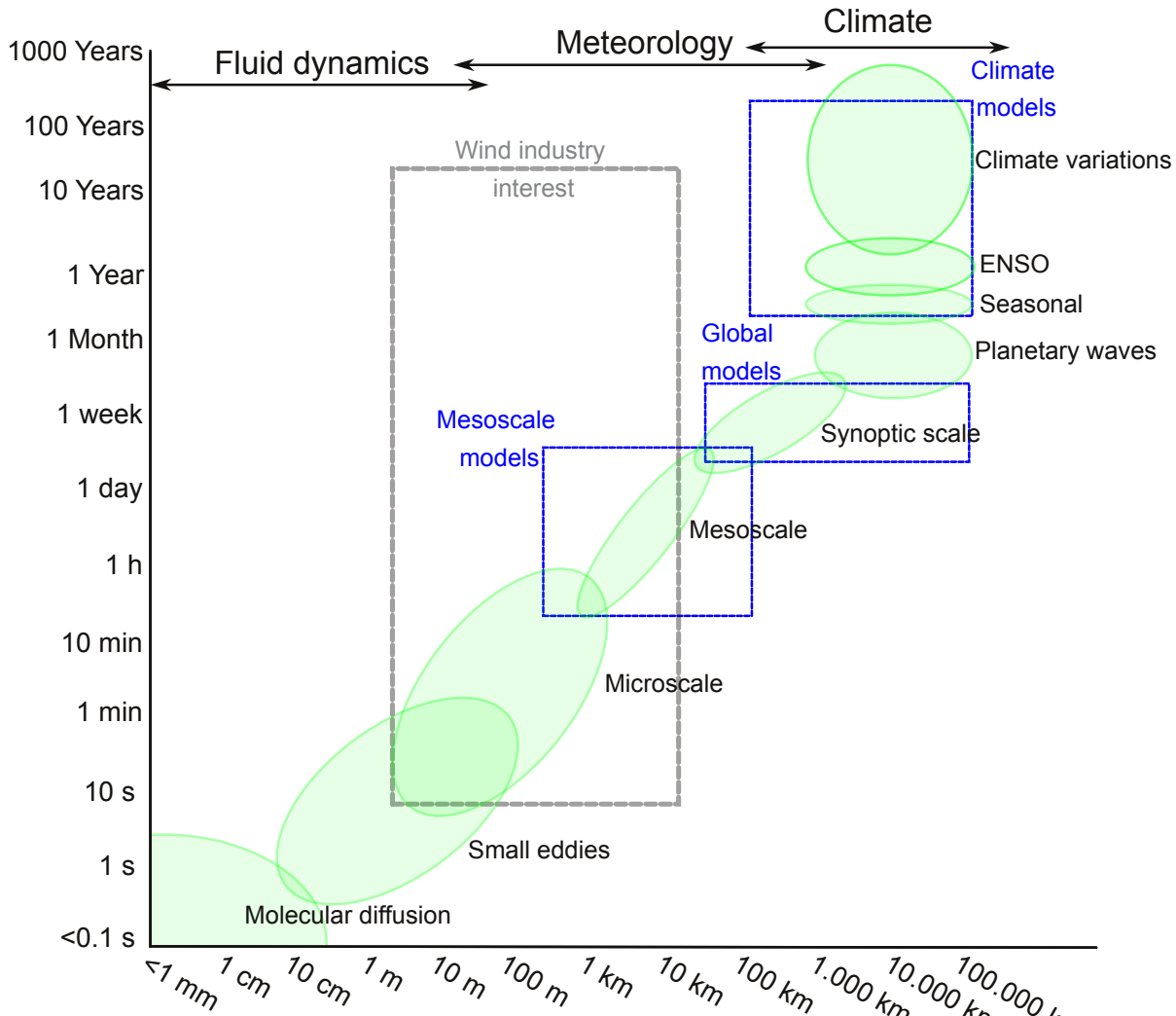
[1]Vortex, [2]NCAR–RAL

VORTEX

- **Experienced** Vortex started its technology development in 2005 by former Wind Site engineers, atmospheric physicists and computer experts in a unusual collaborative team of experienced professionals with active researchers.
- **Wind industry** Vortex provides wind resource maps and series oriented for wind resources assessment and forecasting purposes.


30
20
10
0
10' mean Wind speed [m/s]
19/12
21/12
23/12
25/12
27/12
29/12
31/12
Time (10')
lab
Real

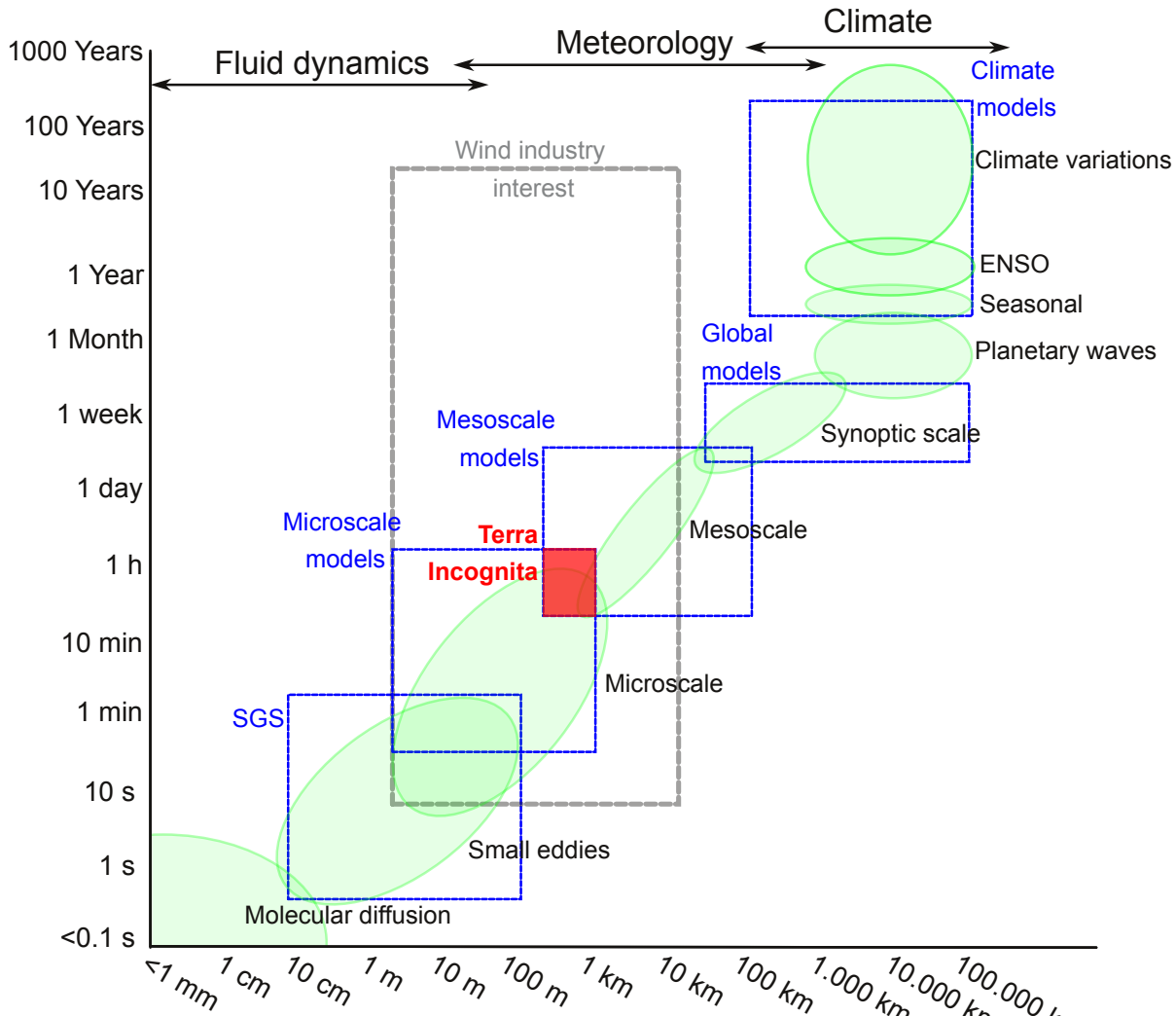
2000s - 2010s


Climate
Meteorology
Fluid dynamics
1000 Years
100 Years
10 Years
1 Year
1 Month
1 week
1 day
1 h
10 min
1 min
10 s
1 s
<0.1 s
Wind industry interest
Climate models
Climate variations
ENSO
Seasonal
Global models
Planetary waves
Synoptic scale
Mesoscale models
Mesoscale
Microscale
Small eddies
Molecular diffusion
<1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
10 km
100 km
1.000 km
10.000 km
100.000 km

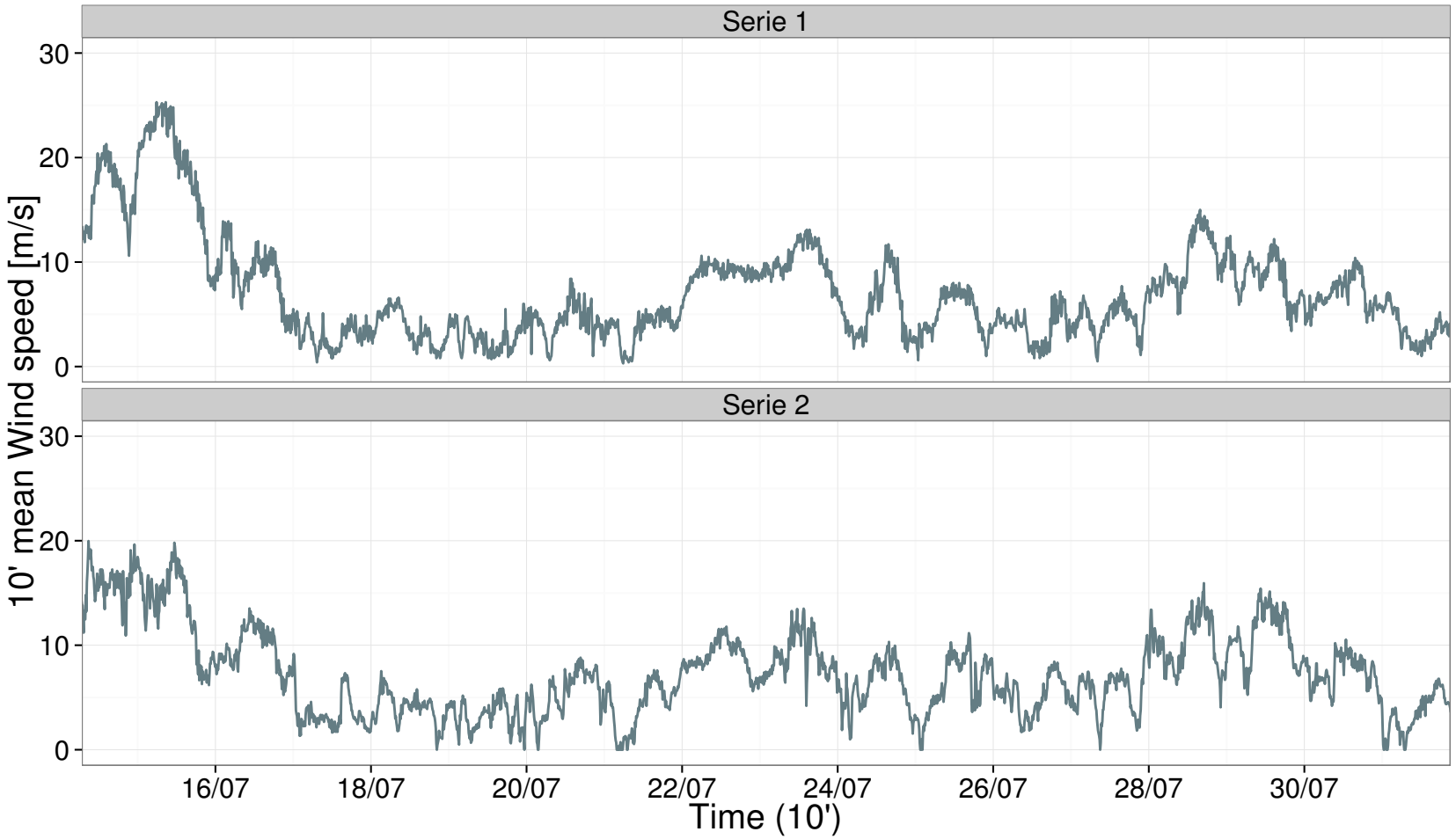
2000s - 2010s

30
20
10
0
10' mean Wind speed [m/s]
19/12
21/12
23/12
25/12
27/12
29/12
31/12
Time (10')
lab
Real
Vortex−PBL 3 km

2016: Microscale is here



2016: Real or model?



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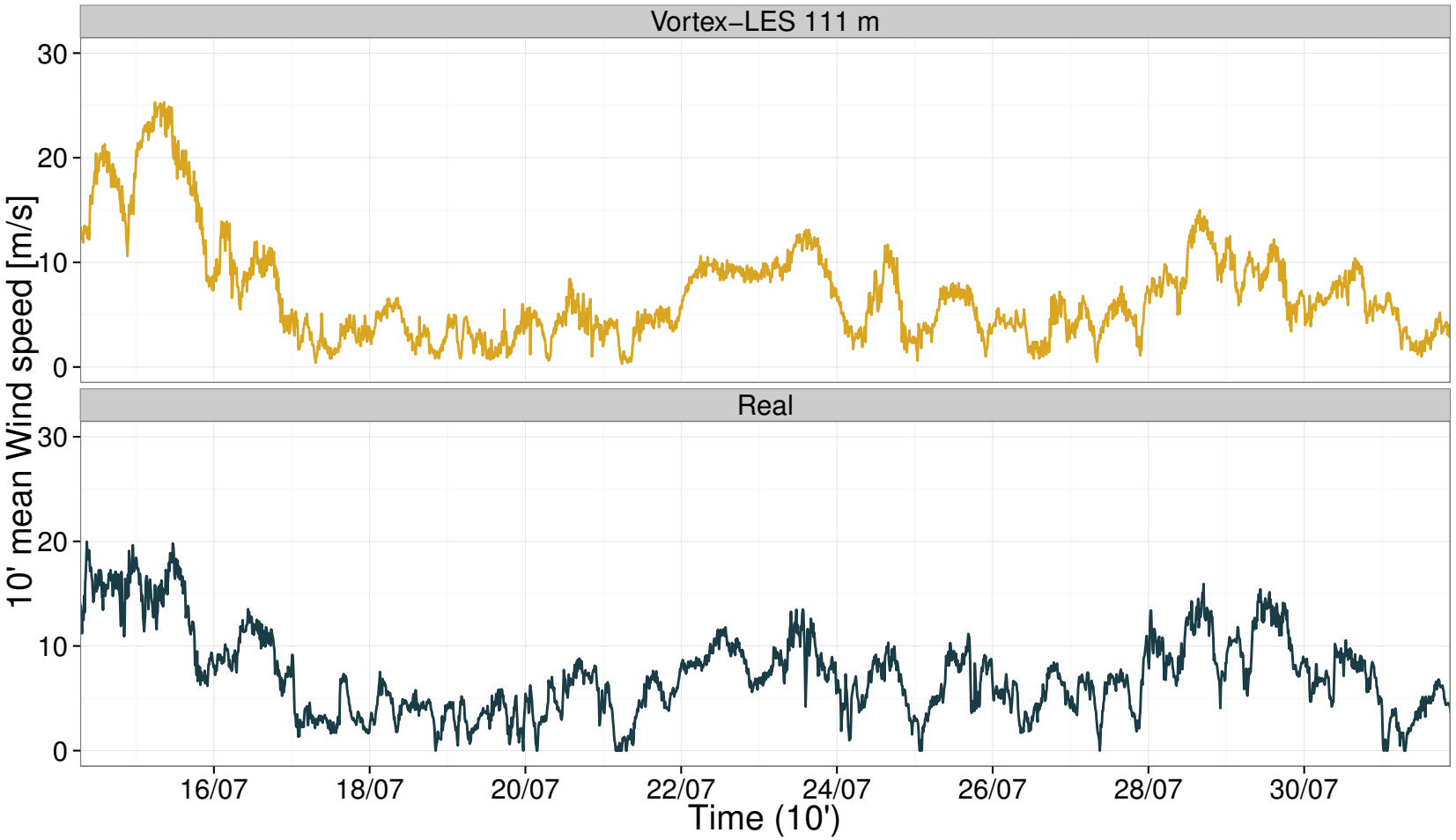
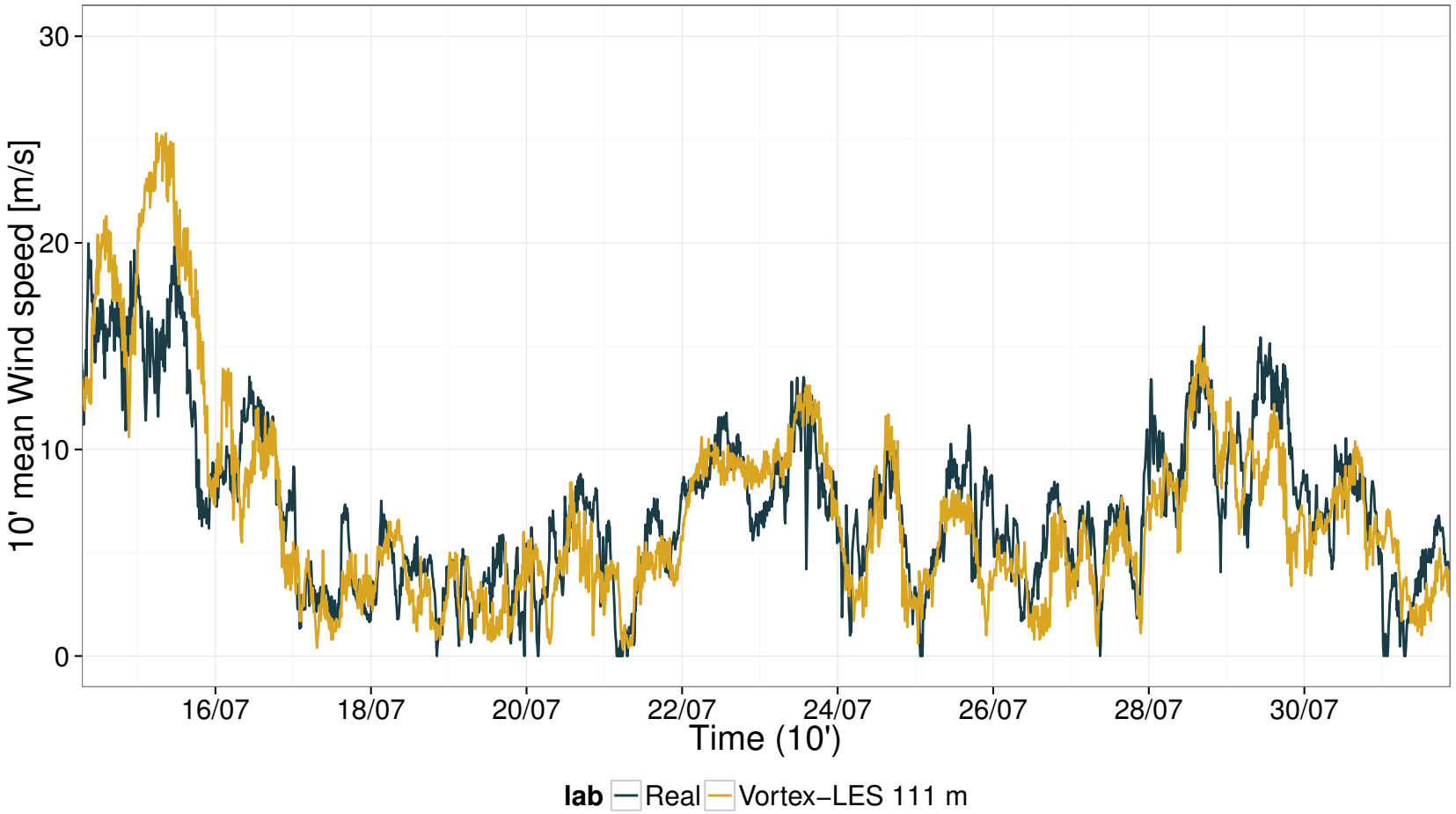
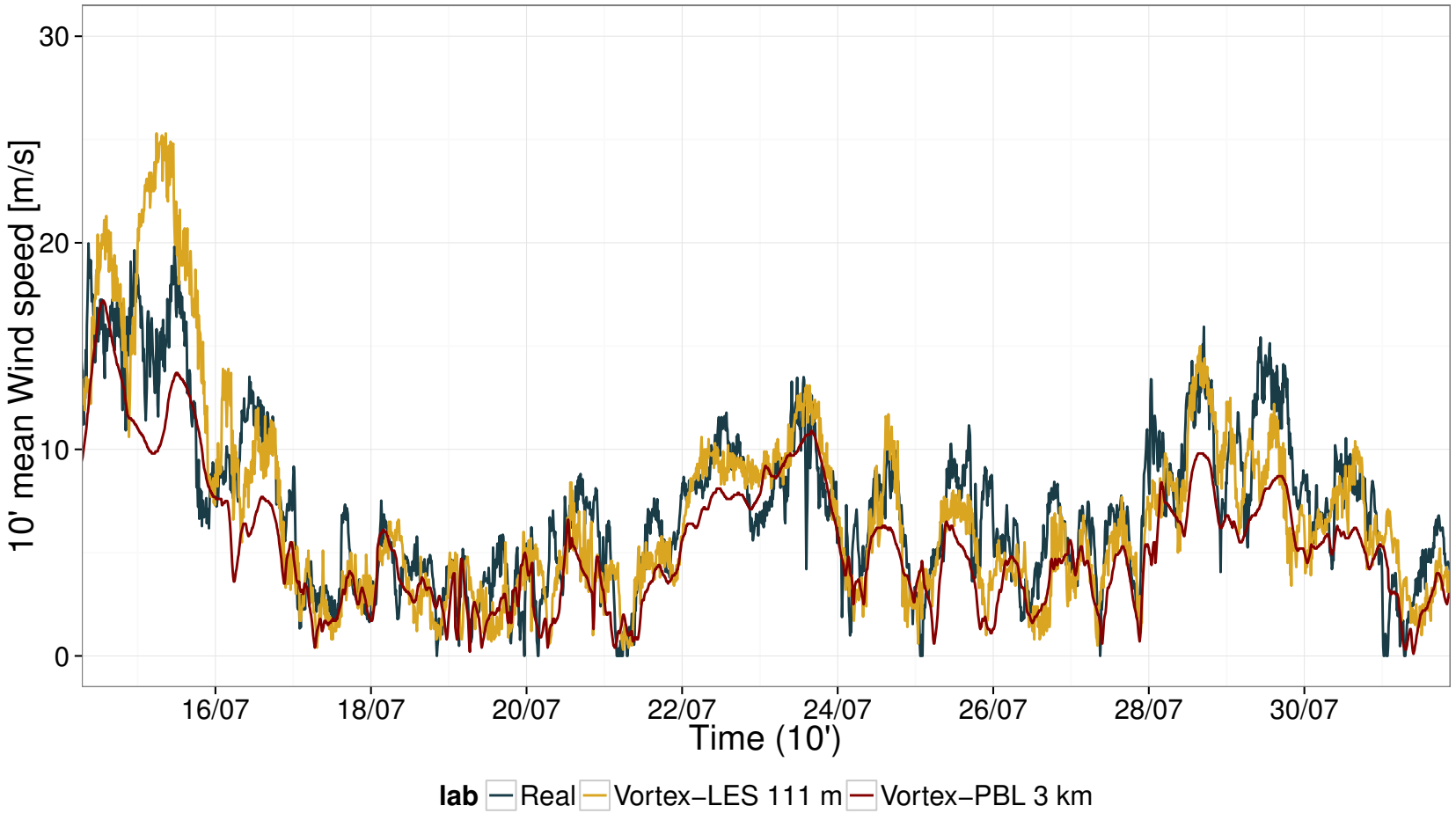


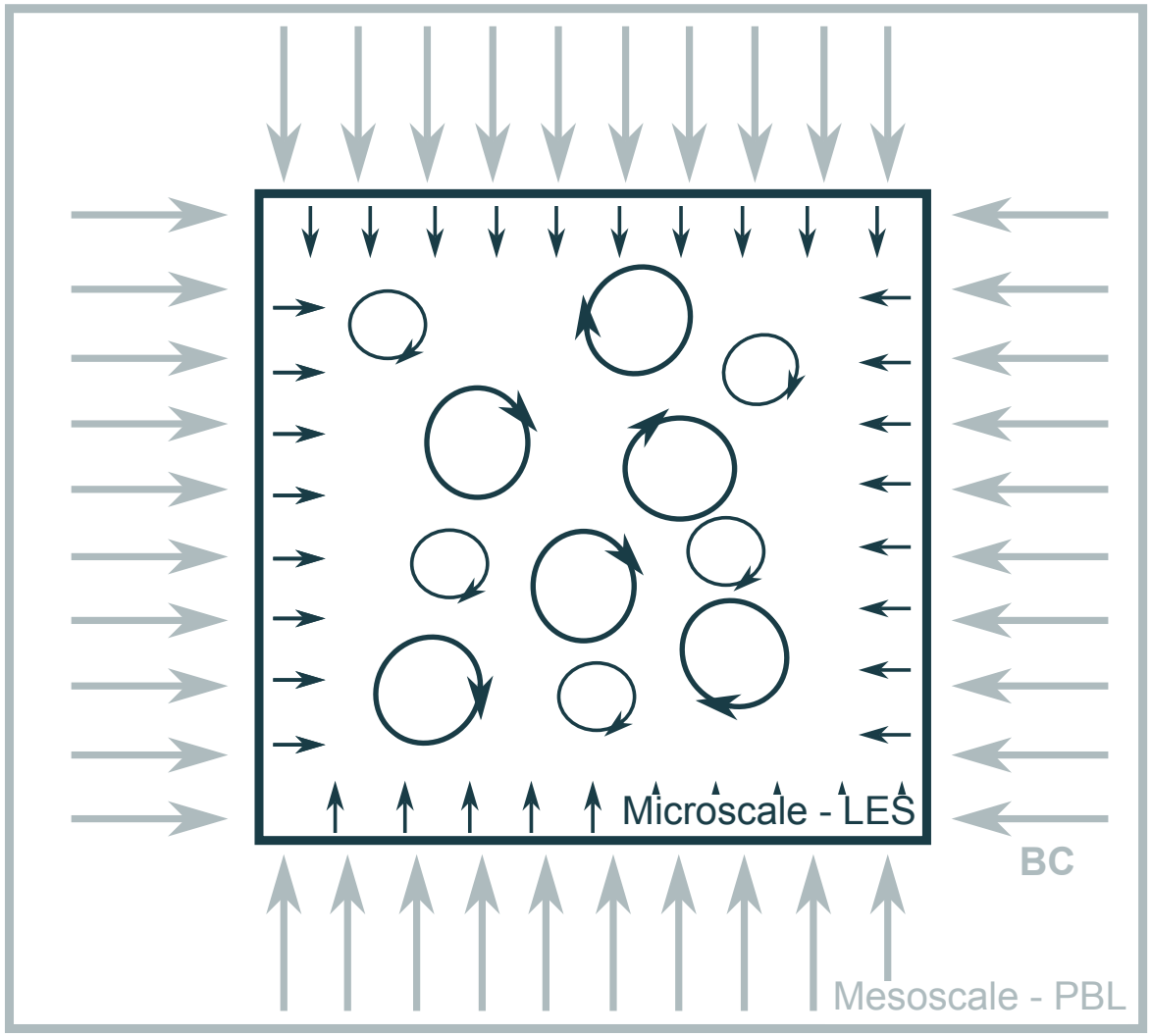
2016: Real or model?



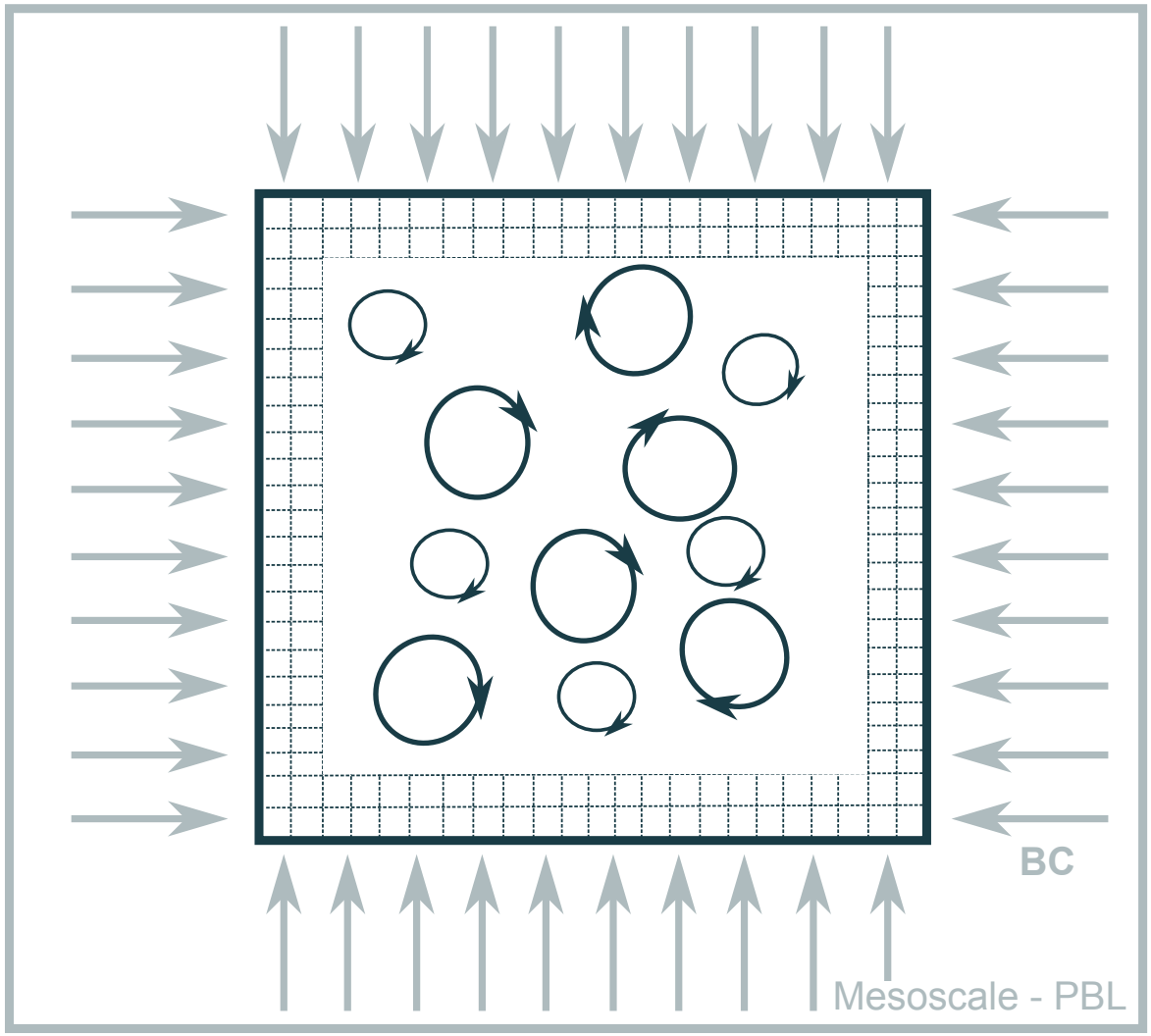
2016: Real or model?



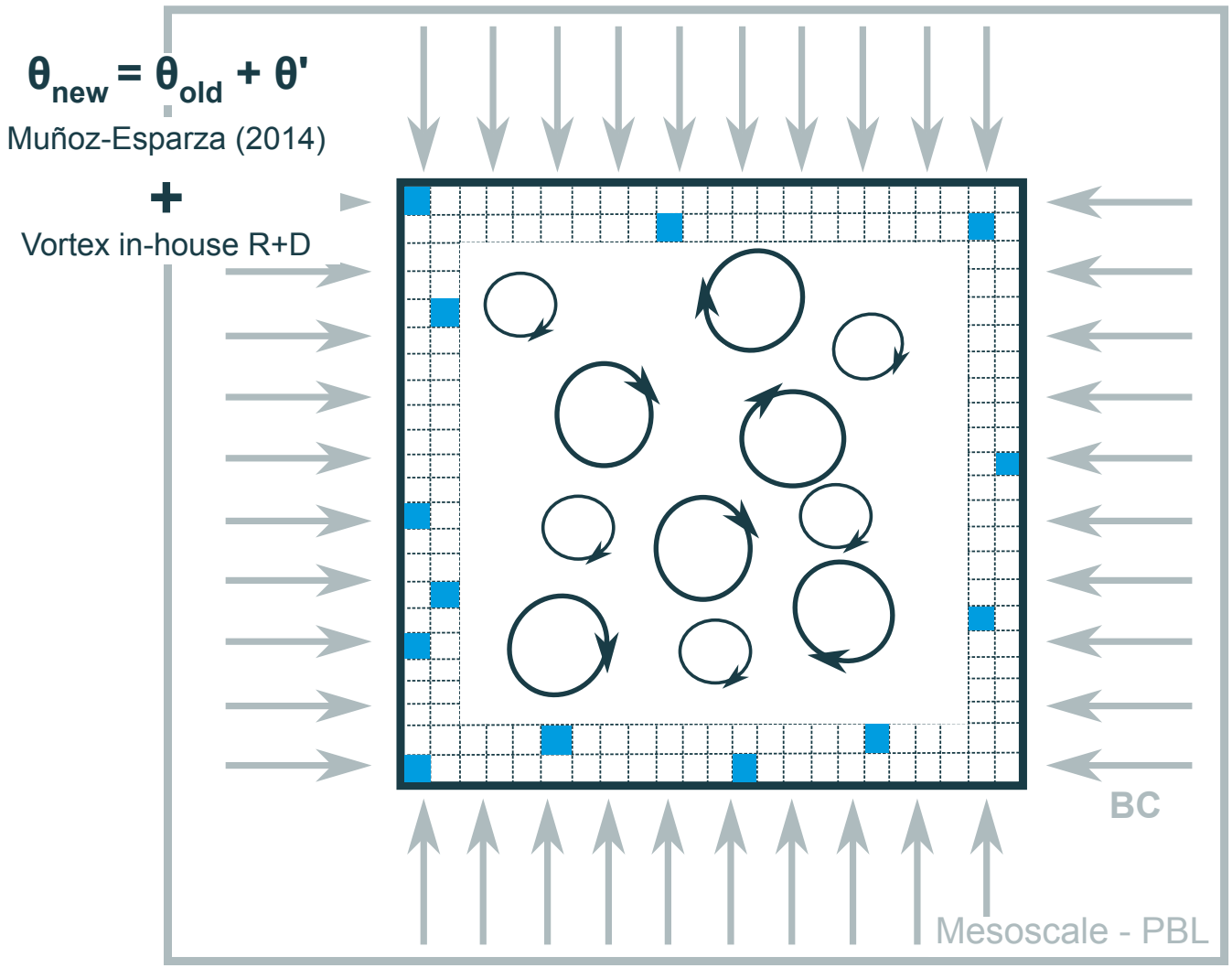
Limitations in real simulations



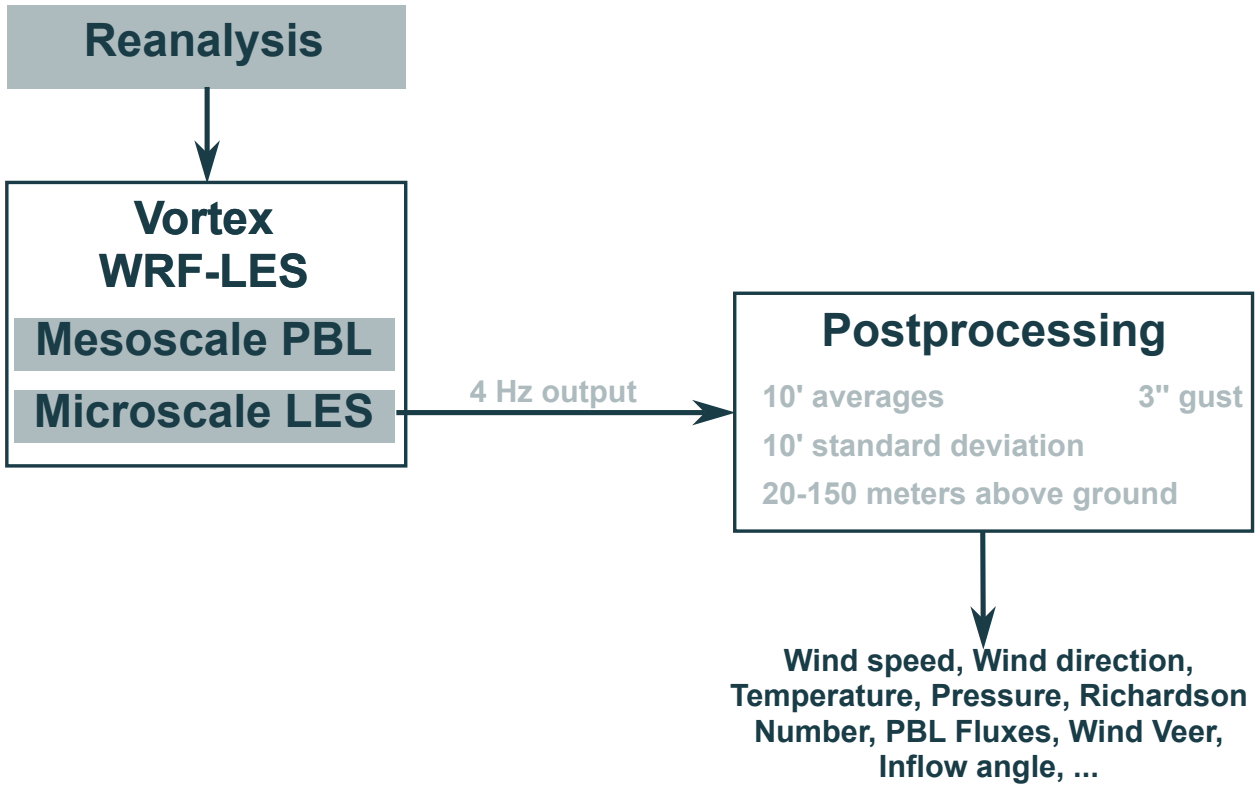
Limitations in real simulations



Limitations in real simulations

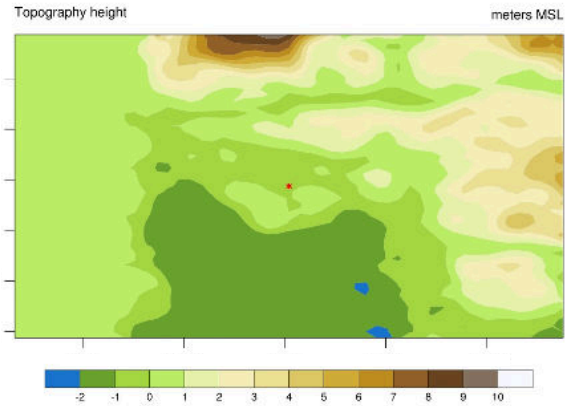


Vortex approach

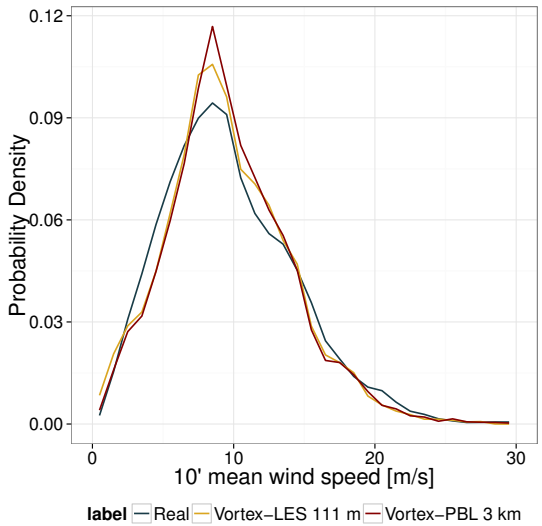


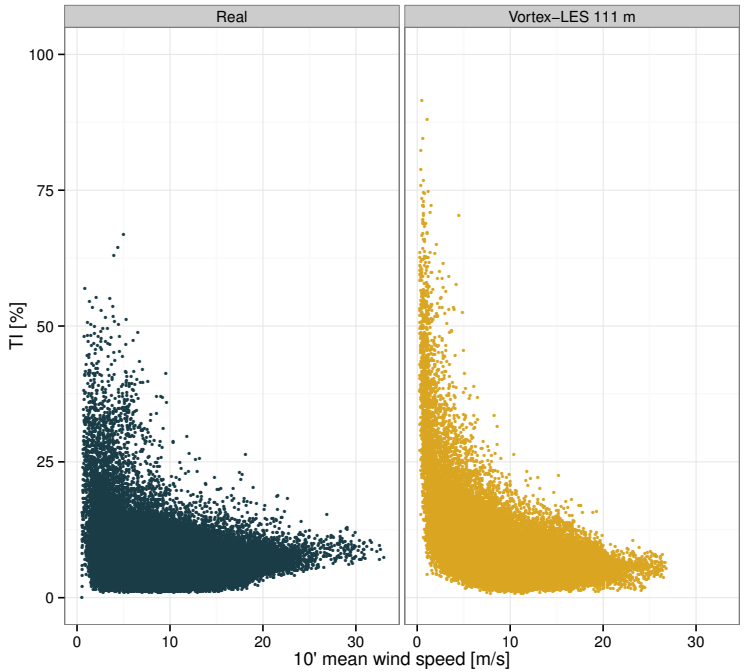
Site 1

Metmast: 60 m
Period: 1-year



	$Bias_{10'}$	$RMSE_{10'}$	R^2_{hourly}	R^2_{daily}
Vortex-3 km	1.0 ms^{-1}	1.7 ms^{-1}	0.87	0.95
Vortex-111 m	1.0 ms^{-1}	1.7 ms^{-1}	0.86	0.94





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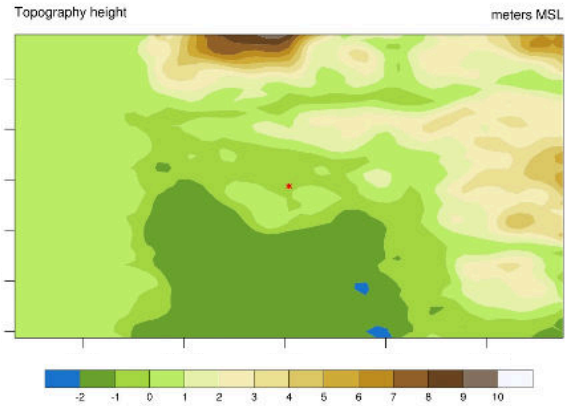

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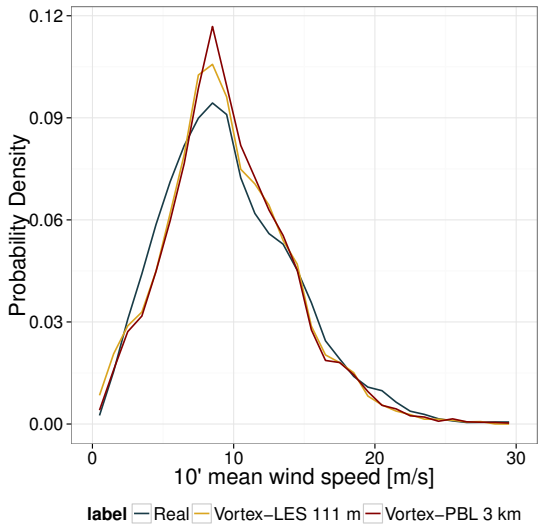

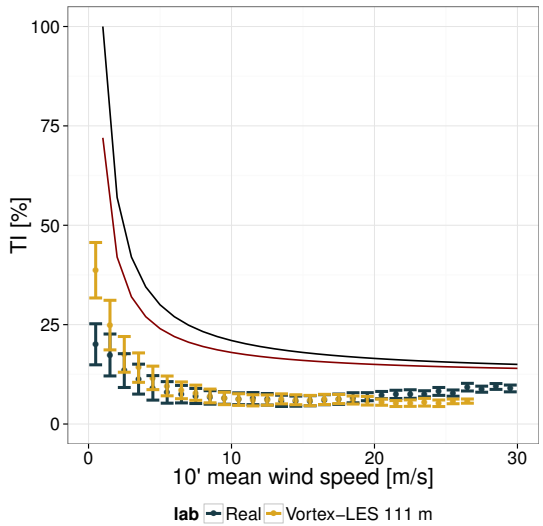

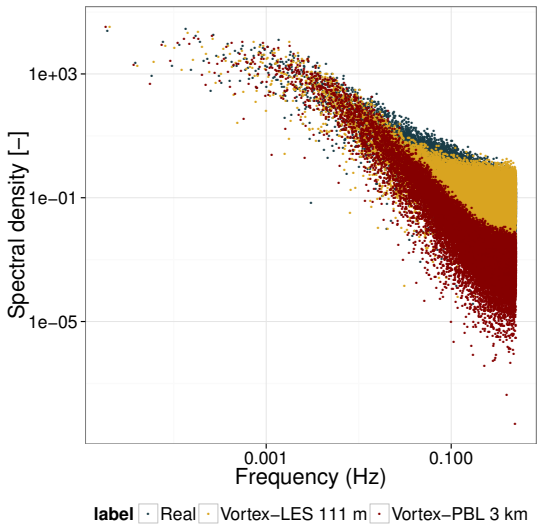

Site 1

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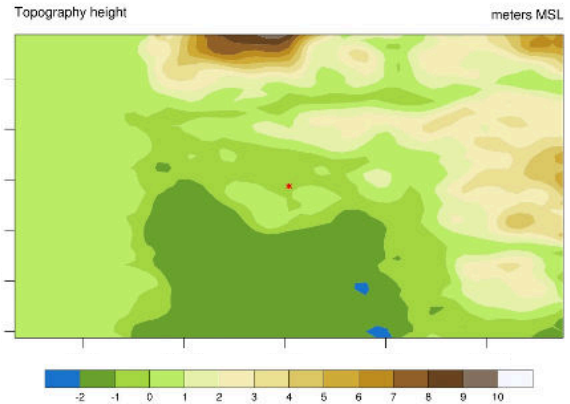
Period: 1-year



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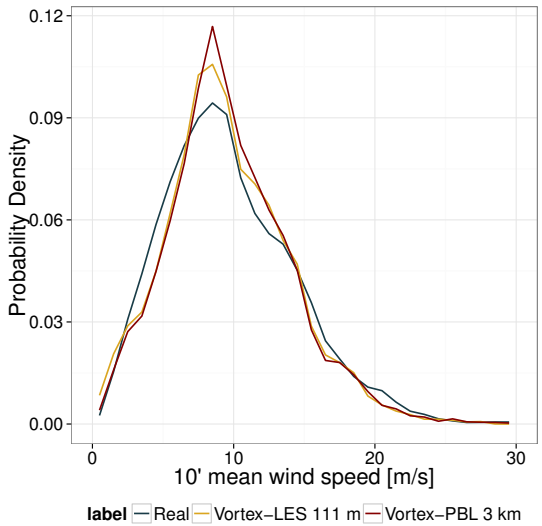
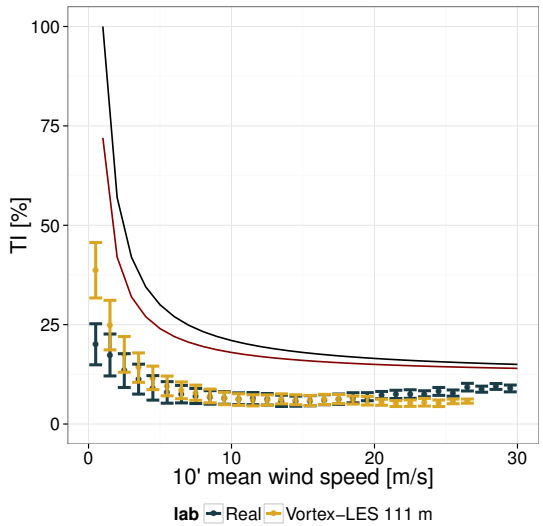
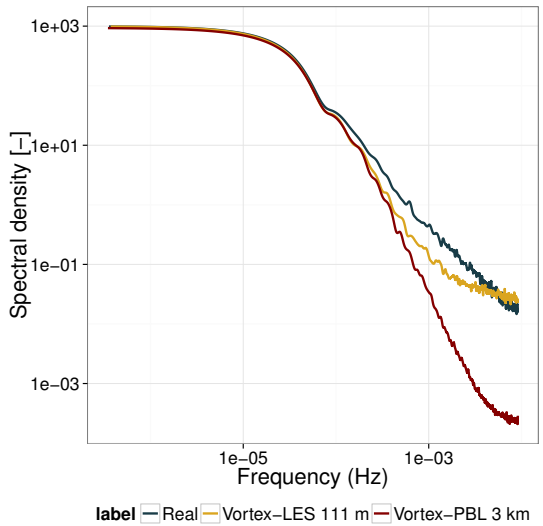
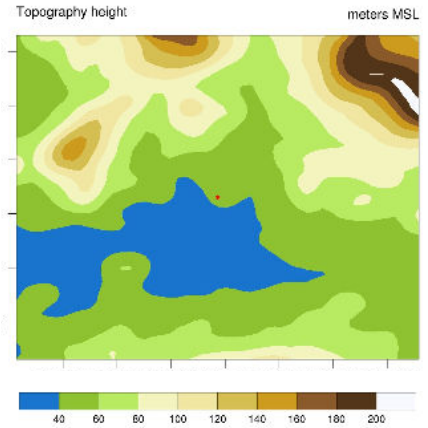




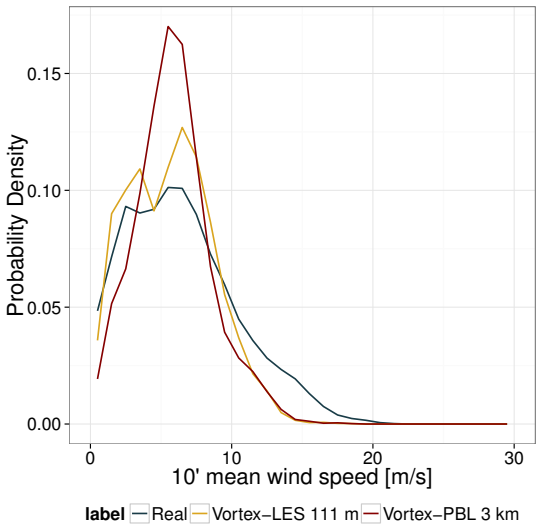


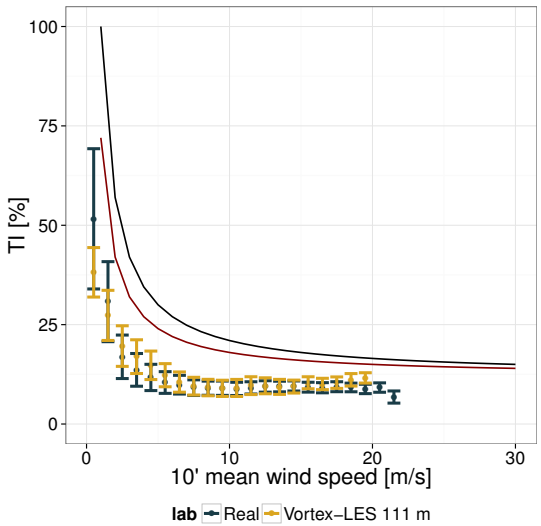
Site 2

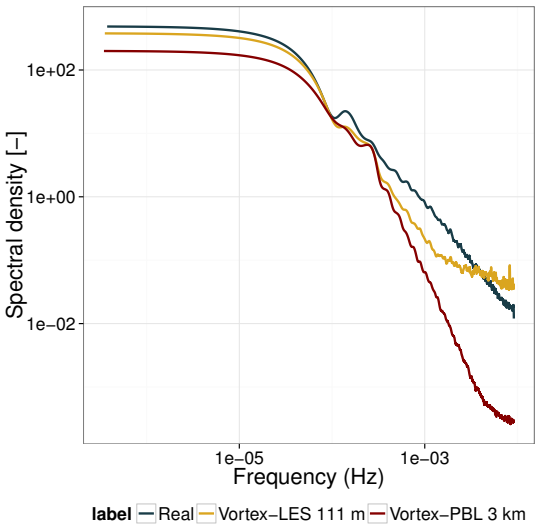
Metmast: 70 m
Period: 1-year



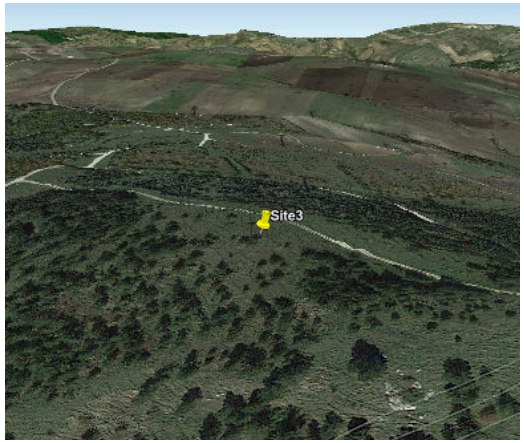
	$Bias_{10'}$	$RMSE_{10'}$	R^2_{hourly}	R^2_{daily}
Vortex-3 km	-0.5 ms^{-1}	2.9 ms^{-1}	0.51	0.70
Vortex-111 m	-0.7 ms^{-1}	2.6 ms^{-1}	0.62	0.80







Site 3 70 m

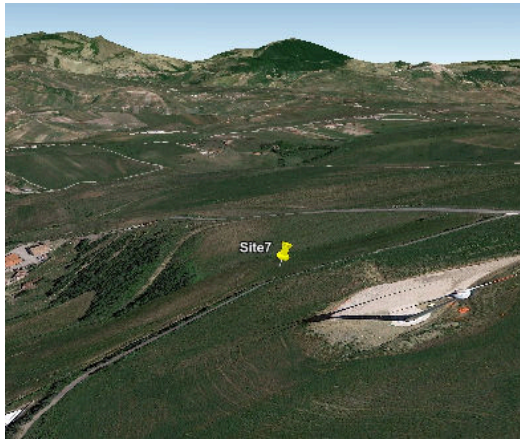


Site 4 60 m

Site 5 90 m

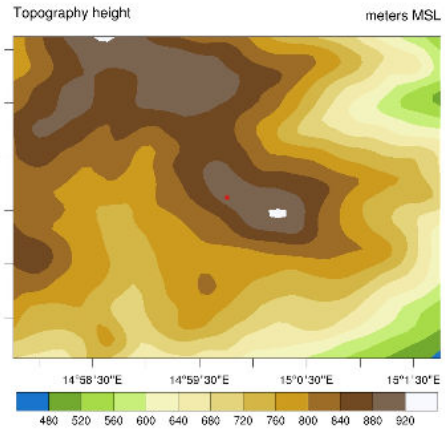
Site 6 97 m

Site 7 30 m

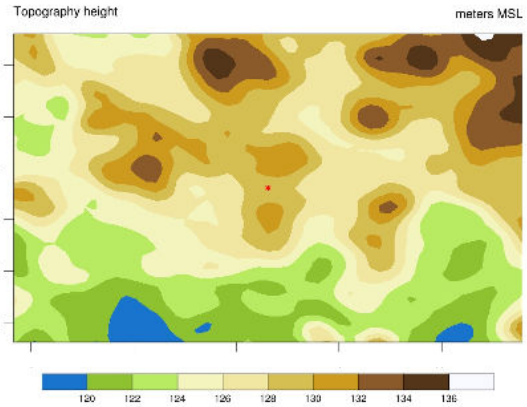


Site 8 60 m

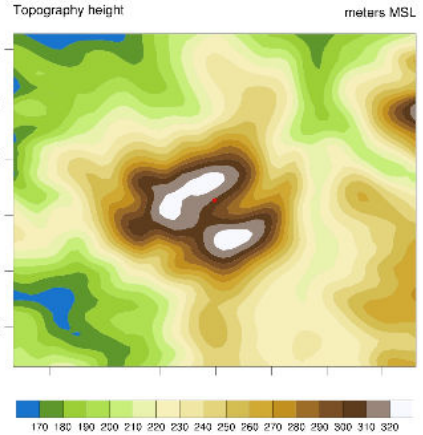
Site 3 — 70 m



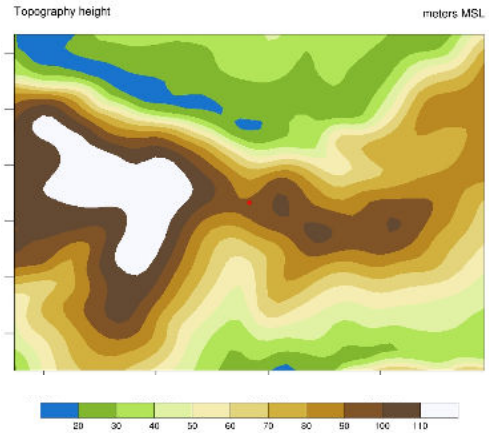
Site 4 — 60 m



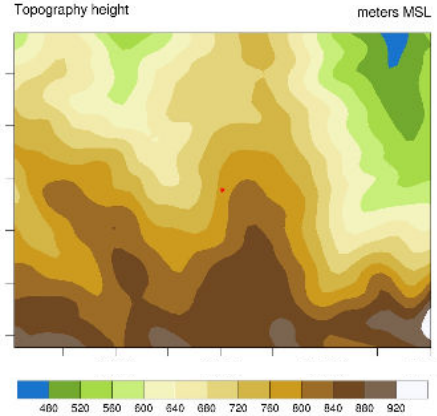
Site 5 — 90 m



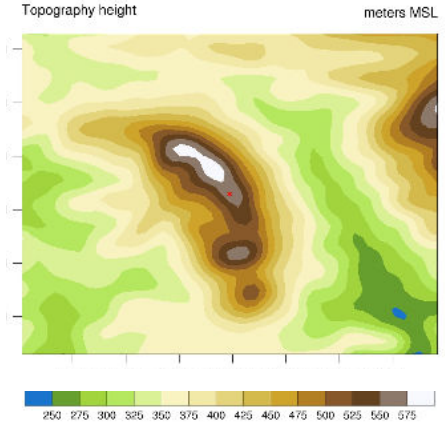
Site 6 — 97 m



Site 7 — 30 m



Site 8 — 60 m

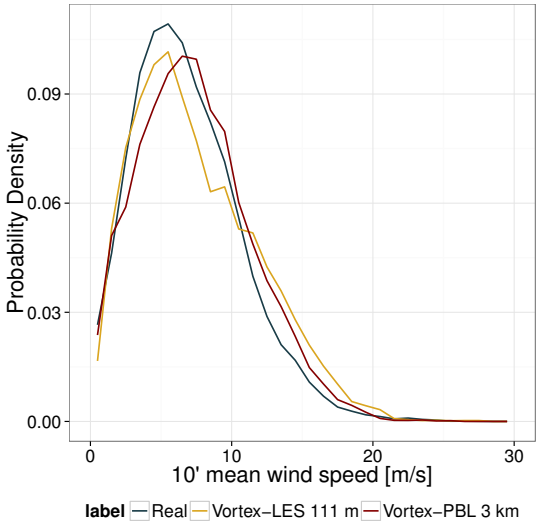


Metrics summary

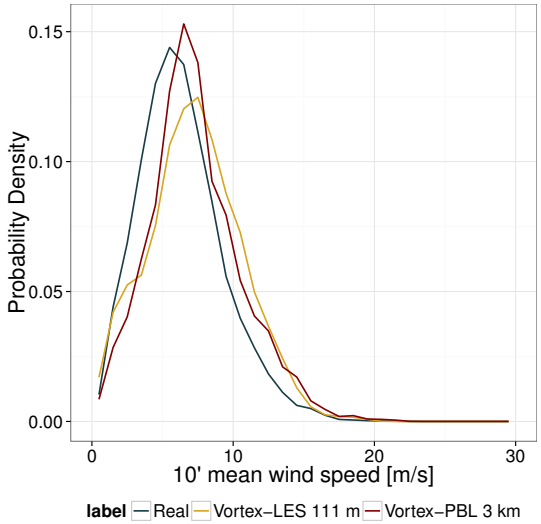
Averaged values **8 sites**

	$Bias_{10'}$	$RMSE_{10'}$	R^2_{hourly}	R^2_{daily}
Vortex-3 km	0.3 ms^{-1}	2.6 ms^{-1}	0.64	0.81
Vortex-111 m	0.3 ms^{-1}	2.3 ms^{-1}	0.68	0.84

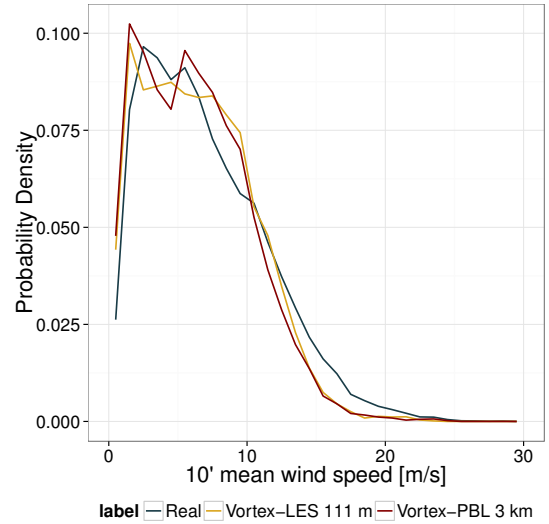
Site 3 — 70 m



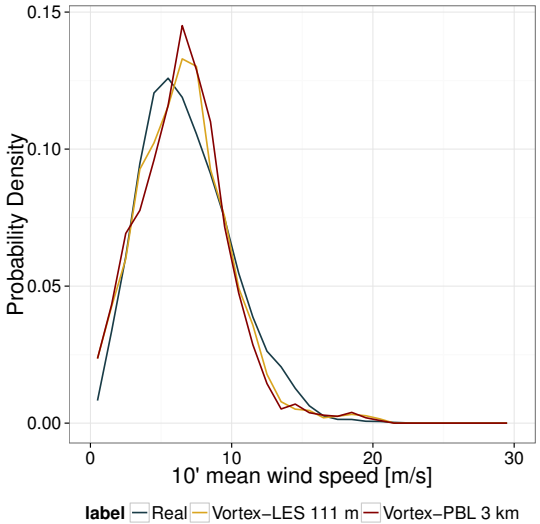
Site 4 — 60 m



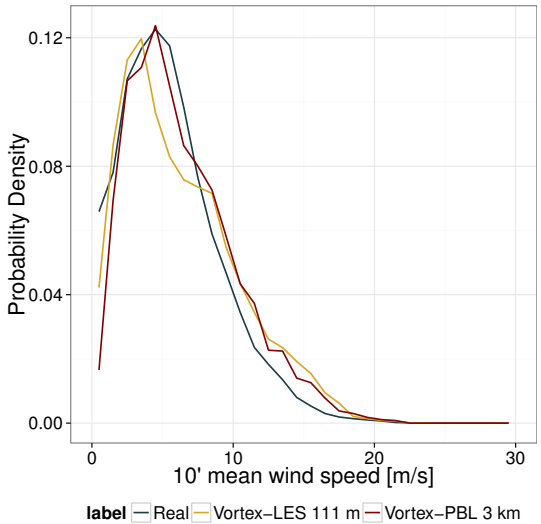
Site 5 — 90 m



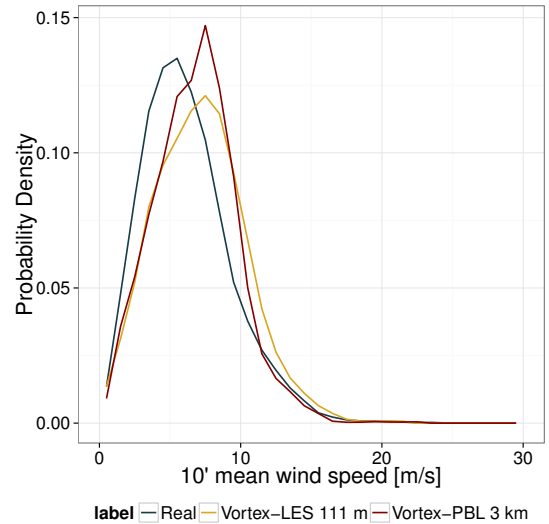
Site 6 — 97 m



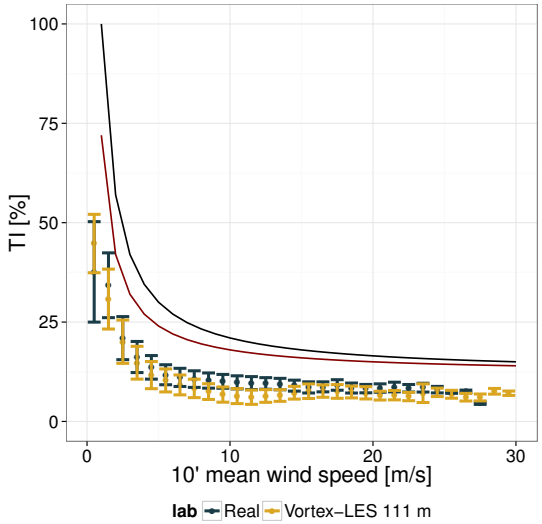
Site 7 — 30 m



Site 8 — 60 m



Site 3 — 70 m



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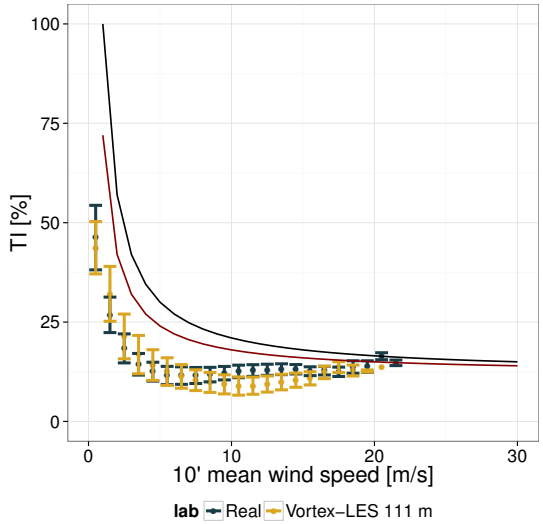

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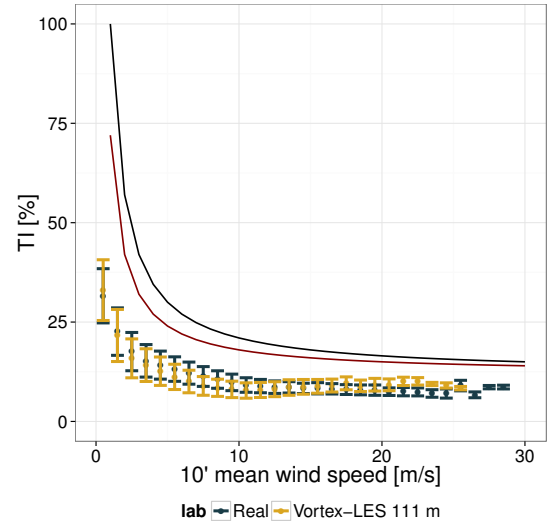
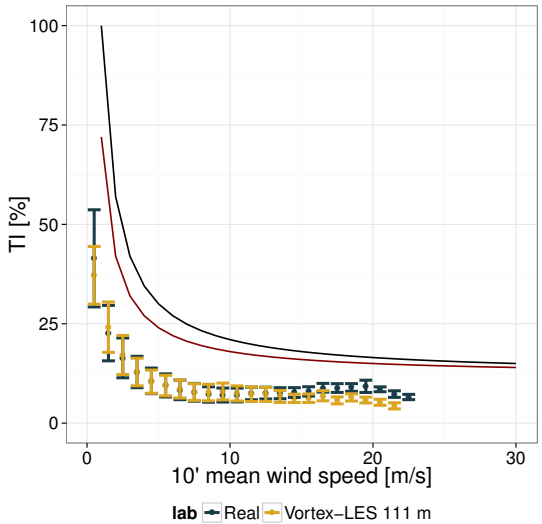
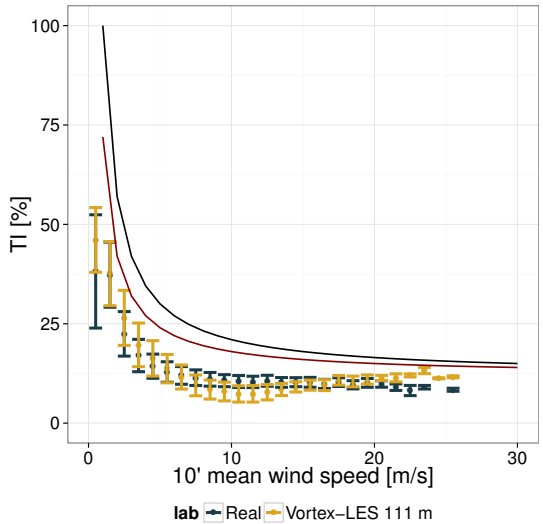


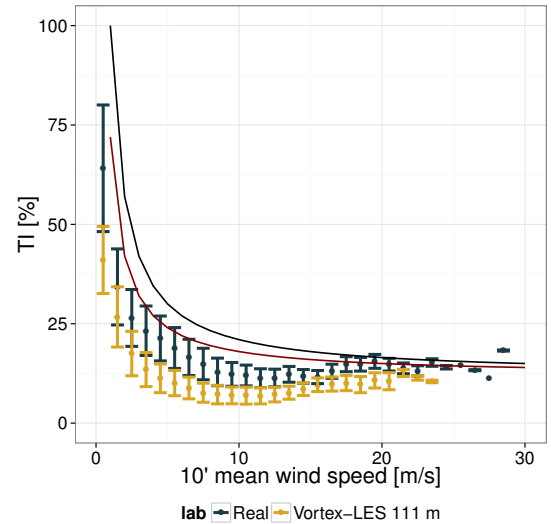
Site 6 — 97 m

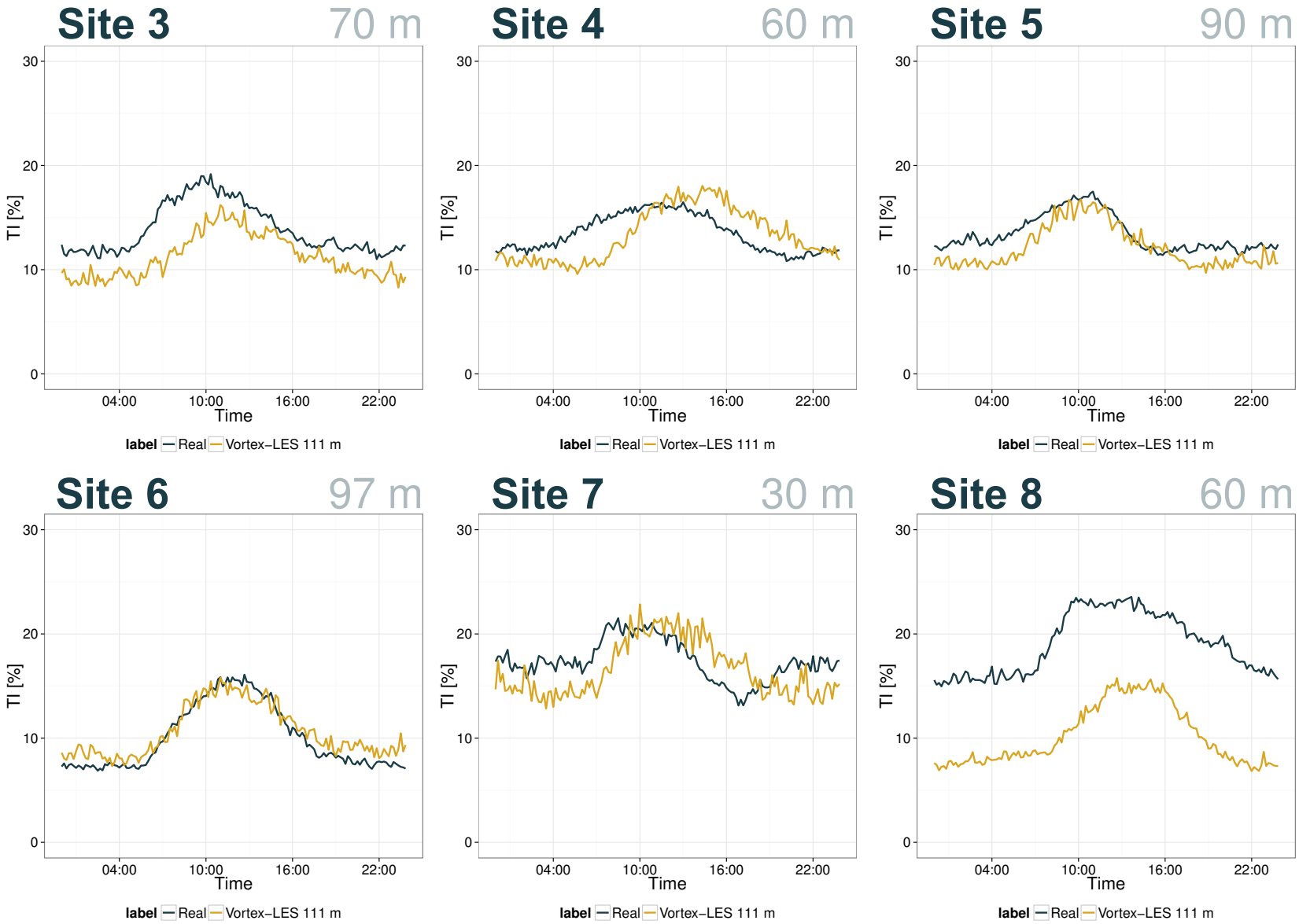


Site 7 — 30 m

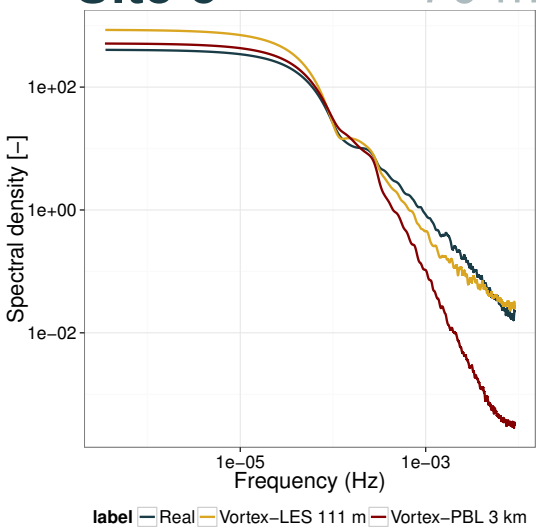


Site 8 — 60 m

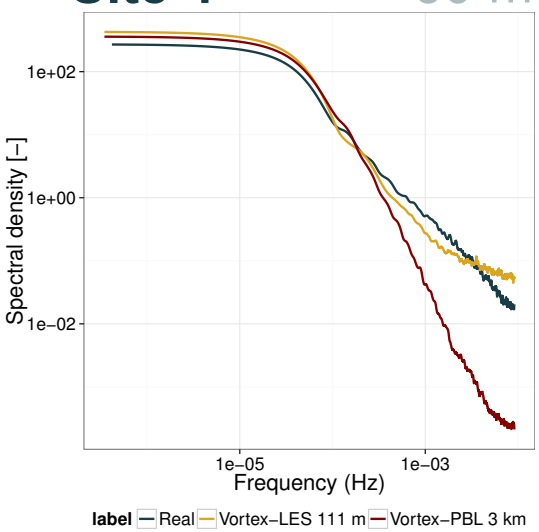



Site 3
70 m
Site 4
60 m
Site 5
90 m
Site 6
97 m
Site 7
30 m
Site 8
60 m
TI [%]
Time
04:00
10:00
16:00
22:00
0
10
20
30
label
Real
Vortex−LES 111 m

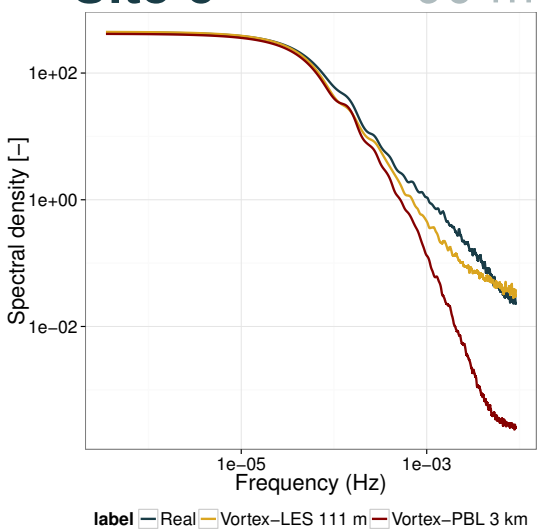
Site 3 — 70 m



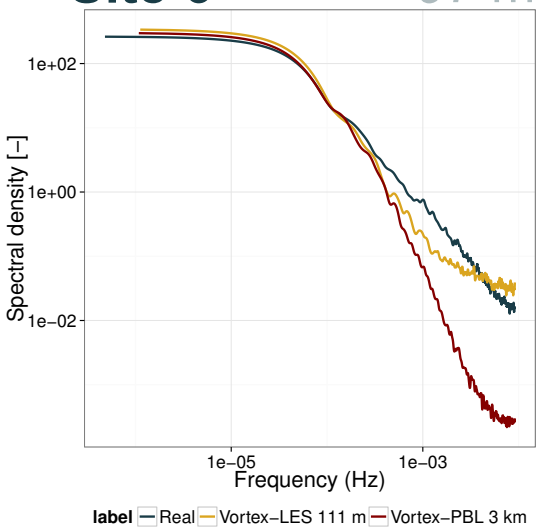
Site 4 — 60 m



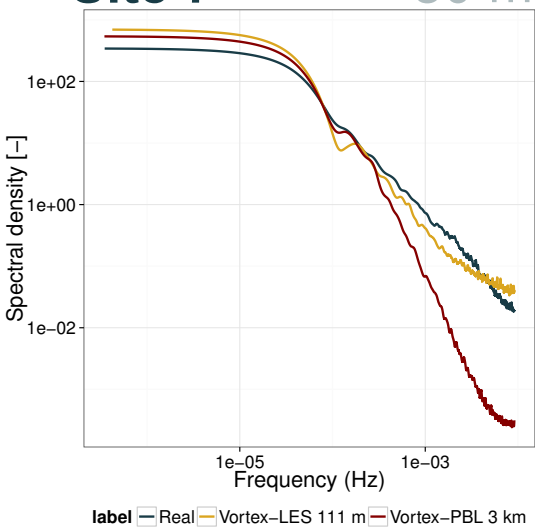
Site 5 — 90 m



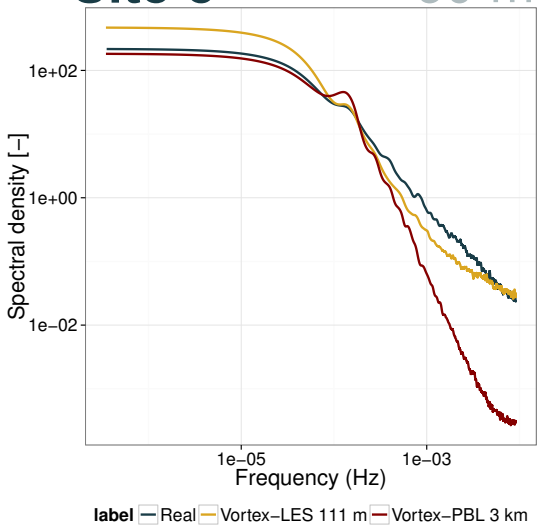
Site 6 — 97 m



Site 7 — 30 m



Site 8 — 60 m

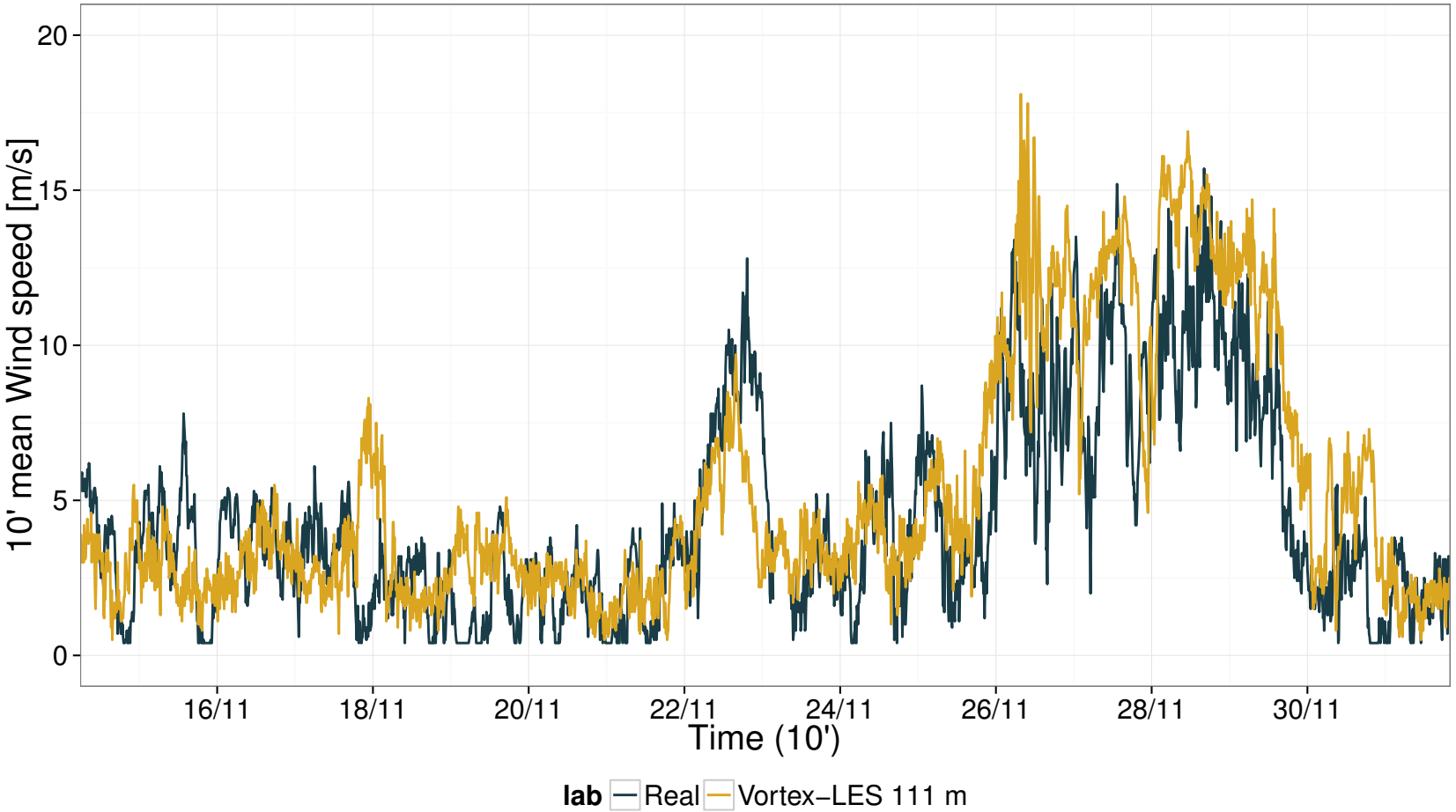


WRF-LES Challenges

- Energy cascade in the terra-incognita is underestimated.
- Surface processes must be improved.
- Unaccurate results when real turbines are installed.
- The tail in the TI-WS can be improved.

Conclusions

- **Vortex-LES** based on WRF produces accurate results with respect to the current mesoscale outputs.
- **WRF-LES** generates realistic turbulence.
- **WRF-PBL** underestimates the energy for motions with a characteristic time scale lower than 16 h (it is a mesoscale model!)
- **WRF-LES** improves the energy cascade for motions ranging from 10-min to 16 h.
- **WRF-LES** provides reliable and accurate turbulent time series for the wind energy industry.


10' mean Wind speed [m/s]
20
15
10
5
0
16/11
18/11
20/11
22/11
24/11
26/11
28/11
30/11
Time (10')
lab
Real
Vortex–LES 111 m

Is WRF-LES a suitable tool for realistic turbulence analyses in wind resource assessment applications?

A. Montornès[1] P. Casso[1] B. Kosovic[2] G. Lizcano[1]

[1]Vortex, [2]NCAR–RAL