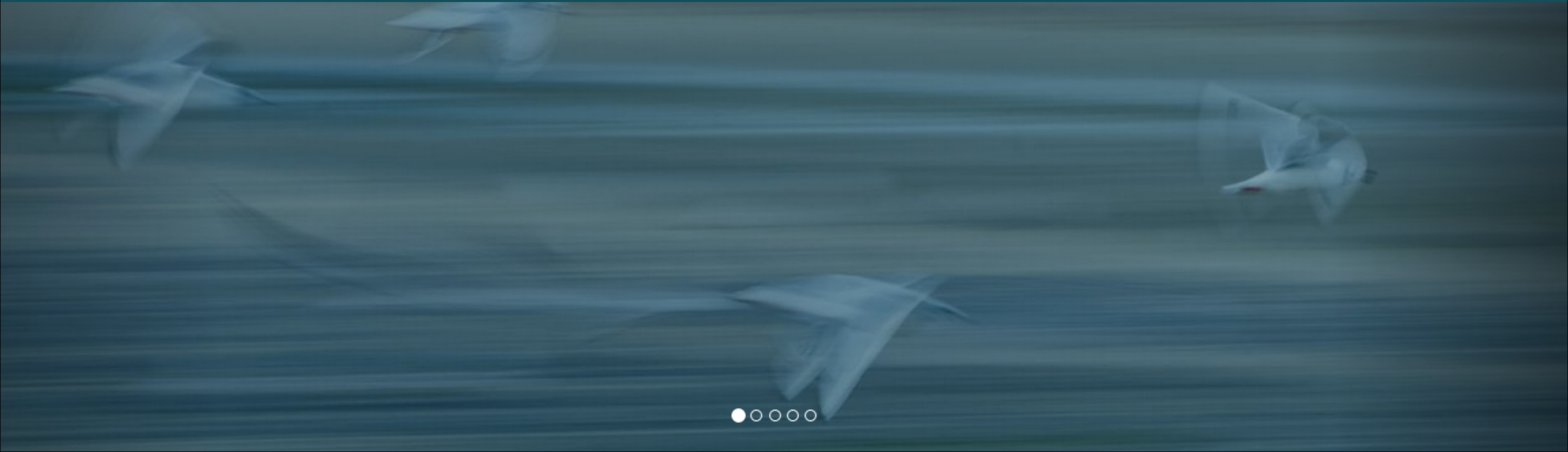
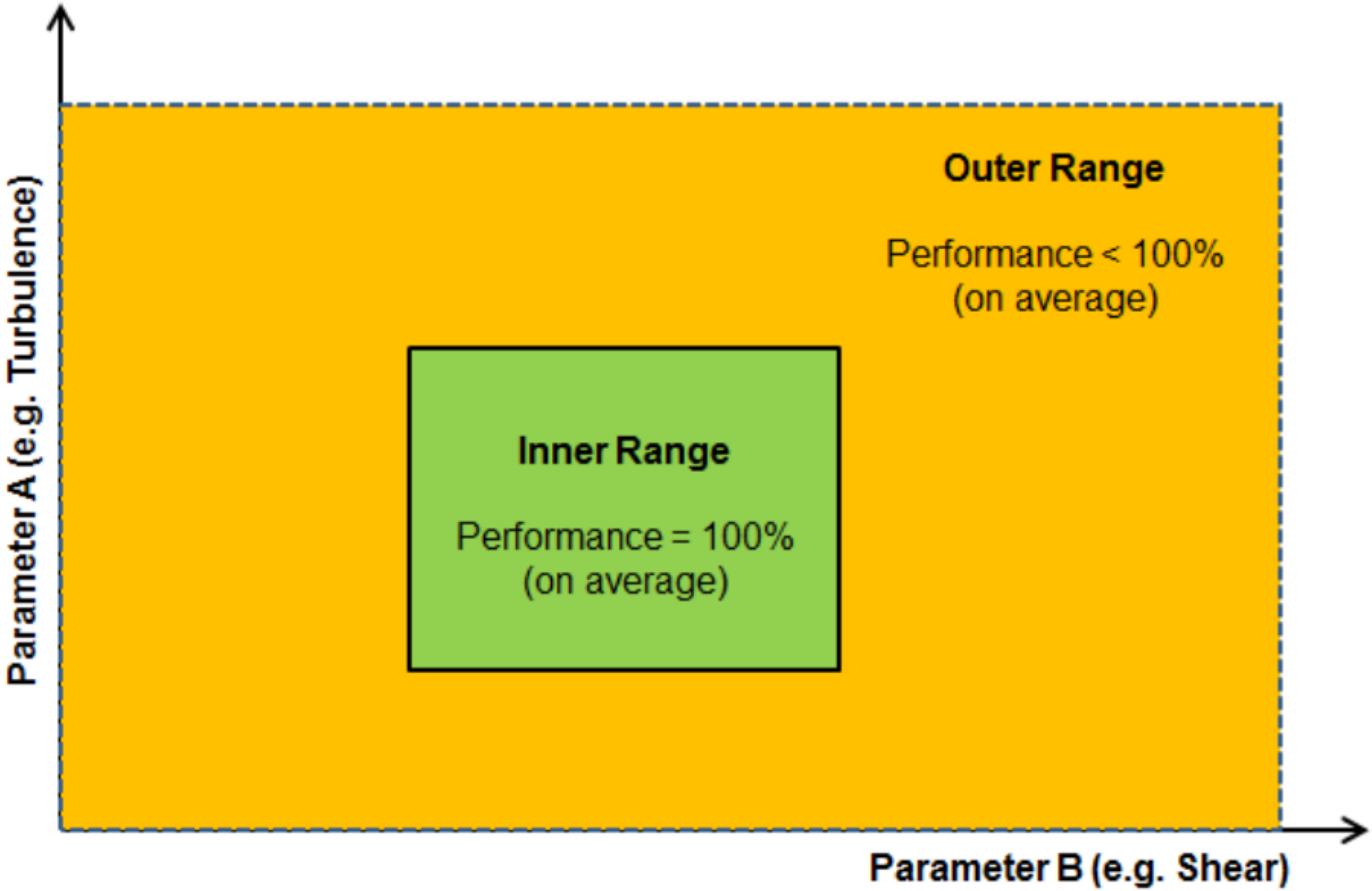
PCWG Meeting September 2015 NOLA

VORTEX

The Potential to Use Mesoscale Models to Predict the Turbine Specific Frequency of Outer Range Conditions

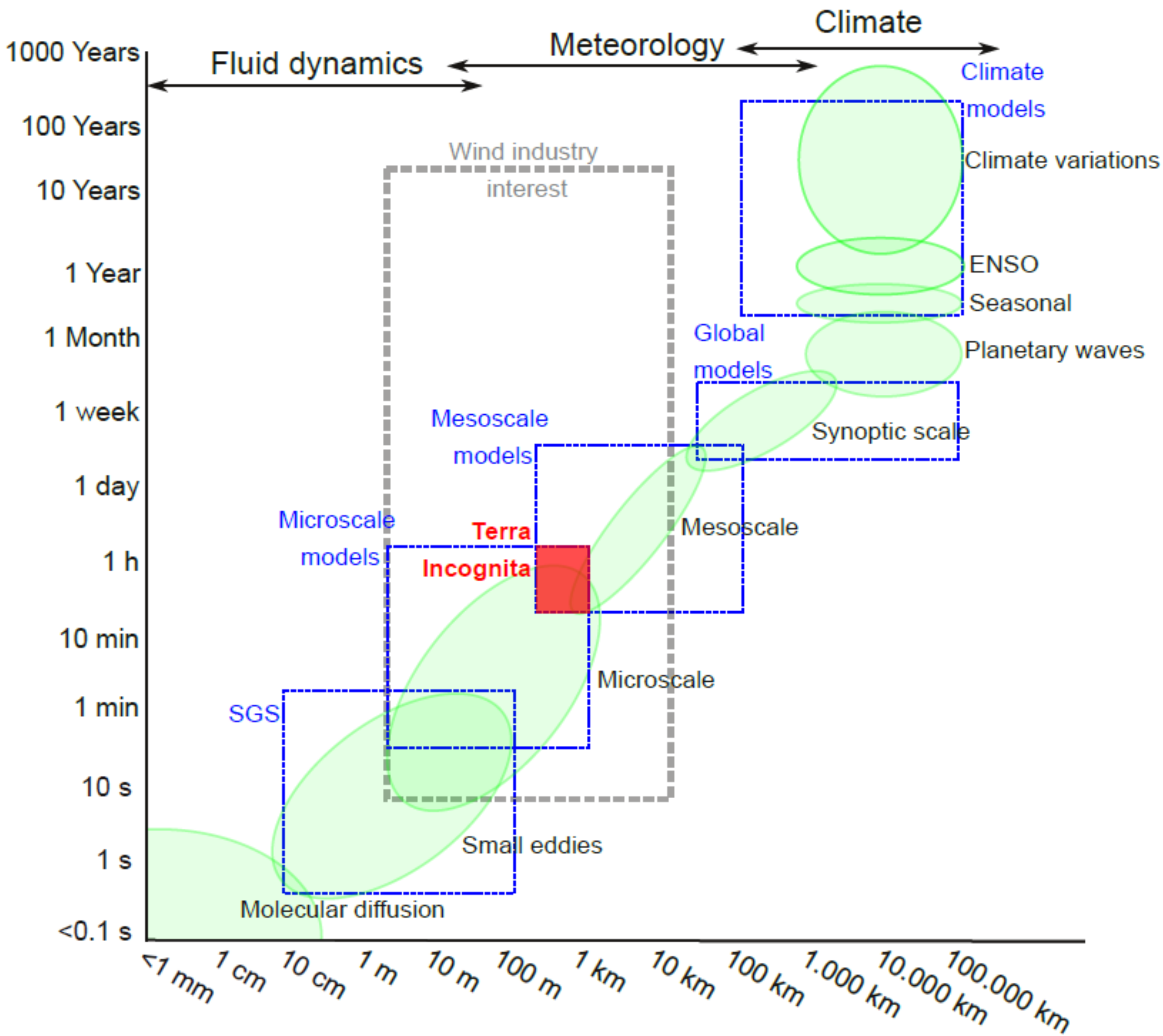
Gil Lizcano




Outer Range
Performance < 100%
(on average)
Inner Range
Performance = 100%
(on average)
Parameter A (e.g. Turbulence)
Parameter B (e.g. Shear)

2015 RoadMap:

- Develop methods for applying corrections for non-standard conditions;
- Power Deviation matrix methods relies upon knowledge of outer region "space" mapping (joint frequency distribution of shear/intensity of turbulence …);
- Current assumption: Mest-Mast data applies to all turbine locations


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
models
Terra
Incognita
Microscale
SGS
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

Mesoscale (*Multiscale)* Modeling:

- ❑ Can Mesoscale model help to map the inner/outer region ?
- ❑ Is feasible for an industry approach ?
- ❑ How reliable? How consistent ? How efficient ? How accurate ?

Background: Why Mesoscale Modeling?

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DYNAMIC: 4D vision (x,y,z time)
REAL conditions (radiation, clouds, surface...)
LONG-TERM retrospective scan
High RELIABILITY capturing the mean flow features

Background: Why Mesoscale Modeling?

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Too DISSIPATIVE: features $< \Delta x$ are unresolved
PBL PARAMETERIZATIONS: turbulence not resolved
SCALE: effects smaller than Δx cannot be described

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SUB-GRID process
RESOLVE turbulence ("larger" than a scale)
SCALE: higher resolution

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LARGE EDDY SIMULATIONS

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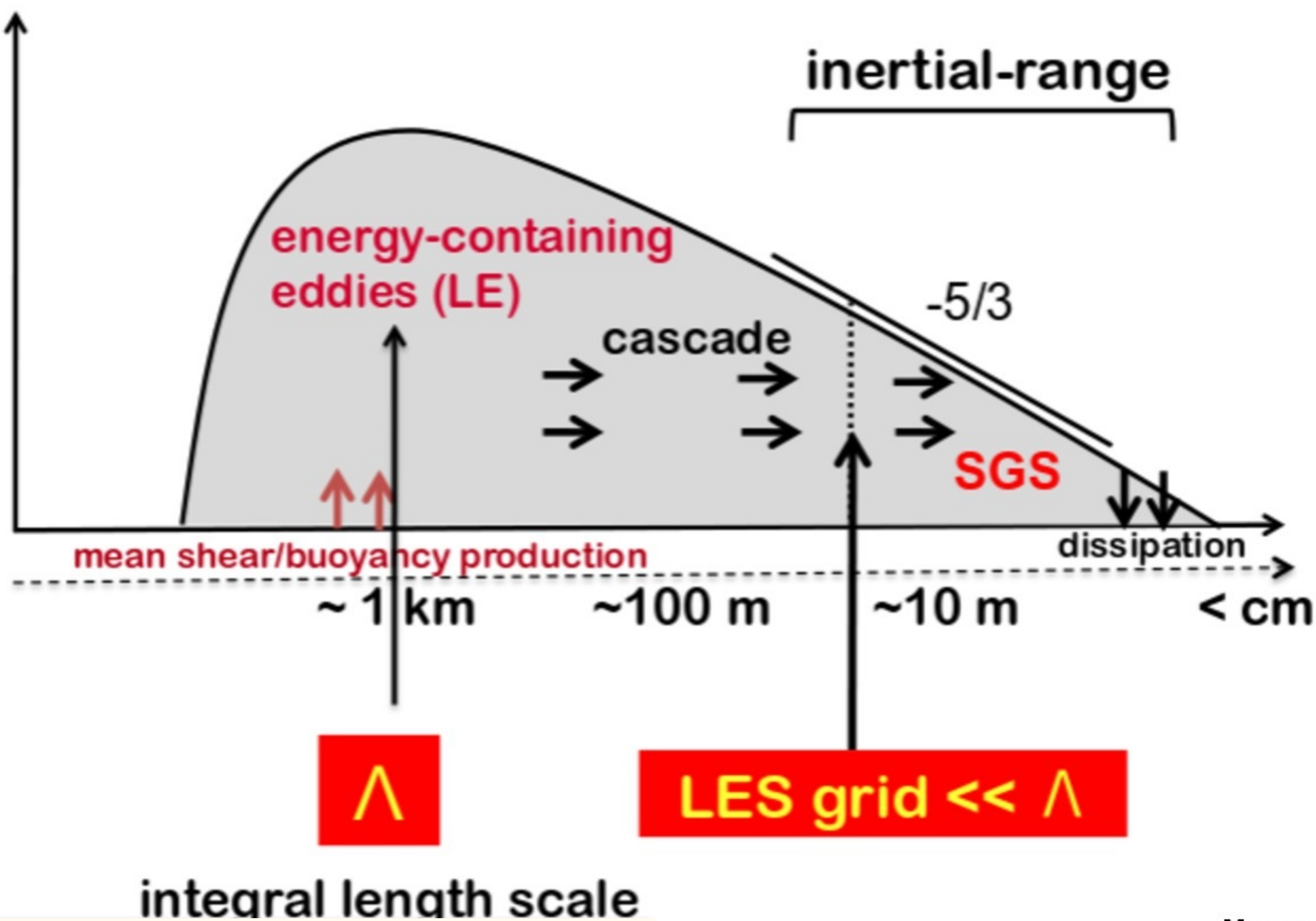
Turbulent flow = Resolved large eddies + Unresolved small eddies

LES SGS



Moeng (WRF workshop, 2011)

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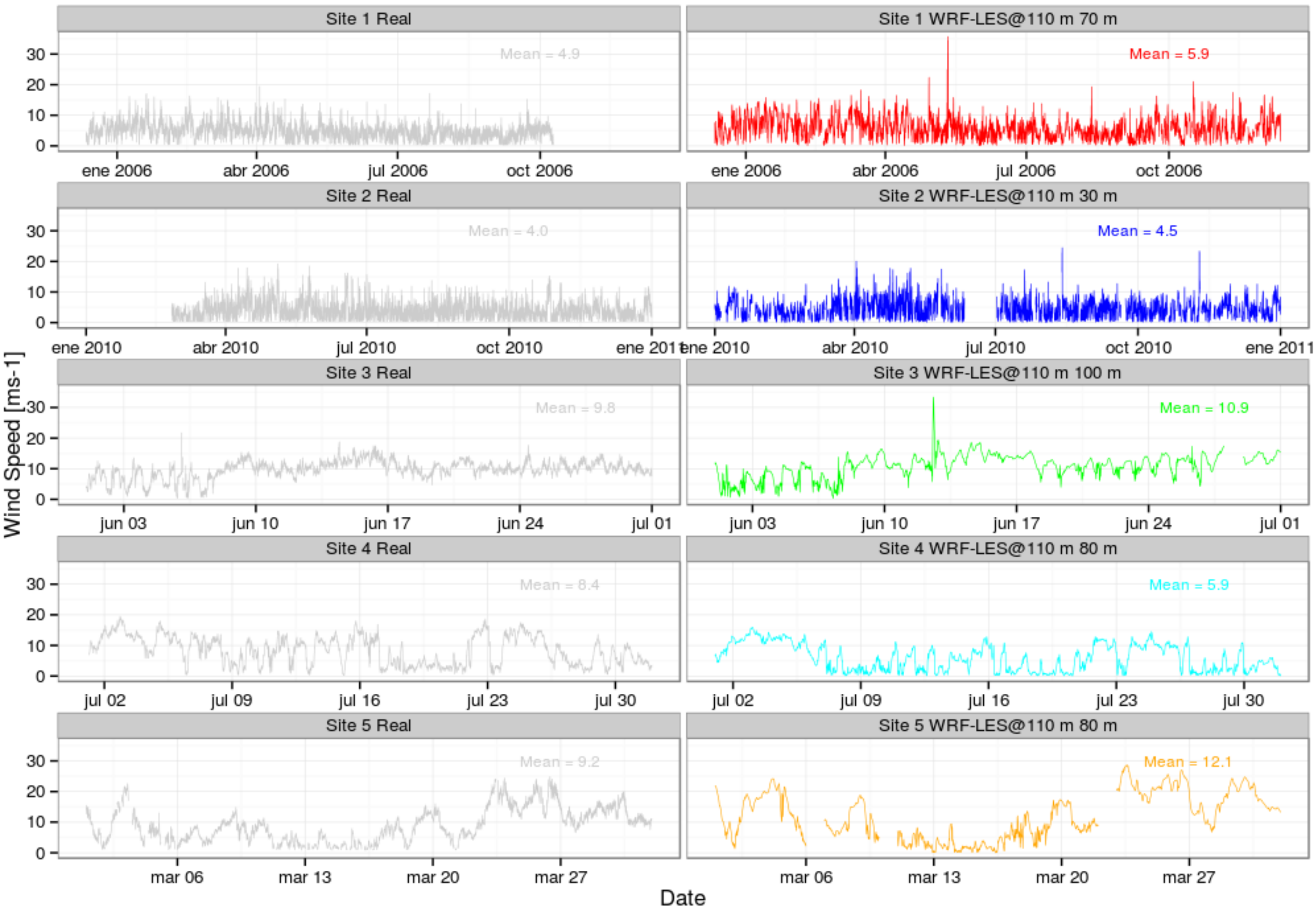
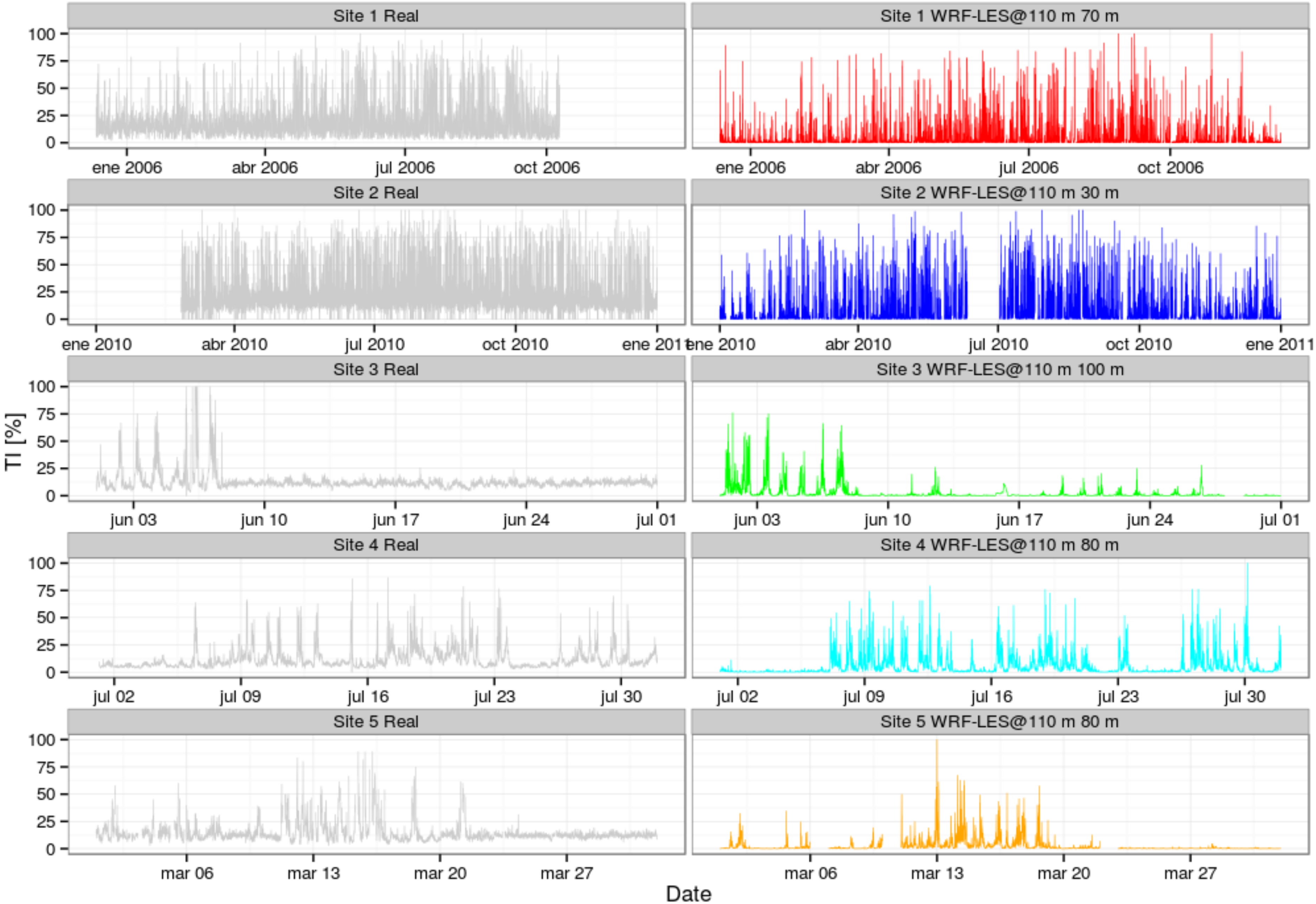
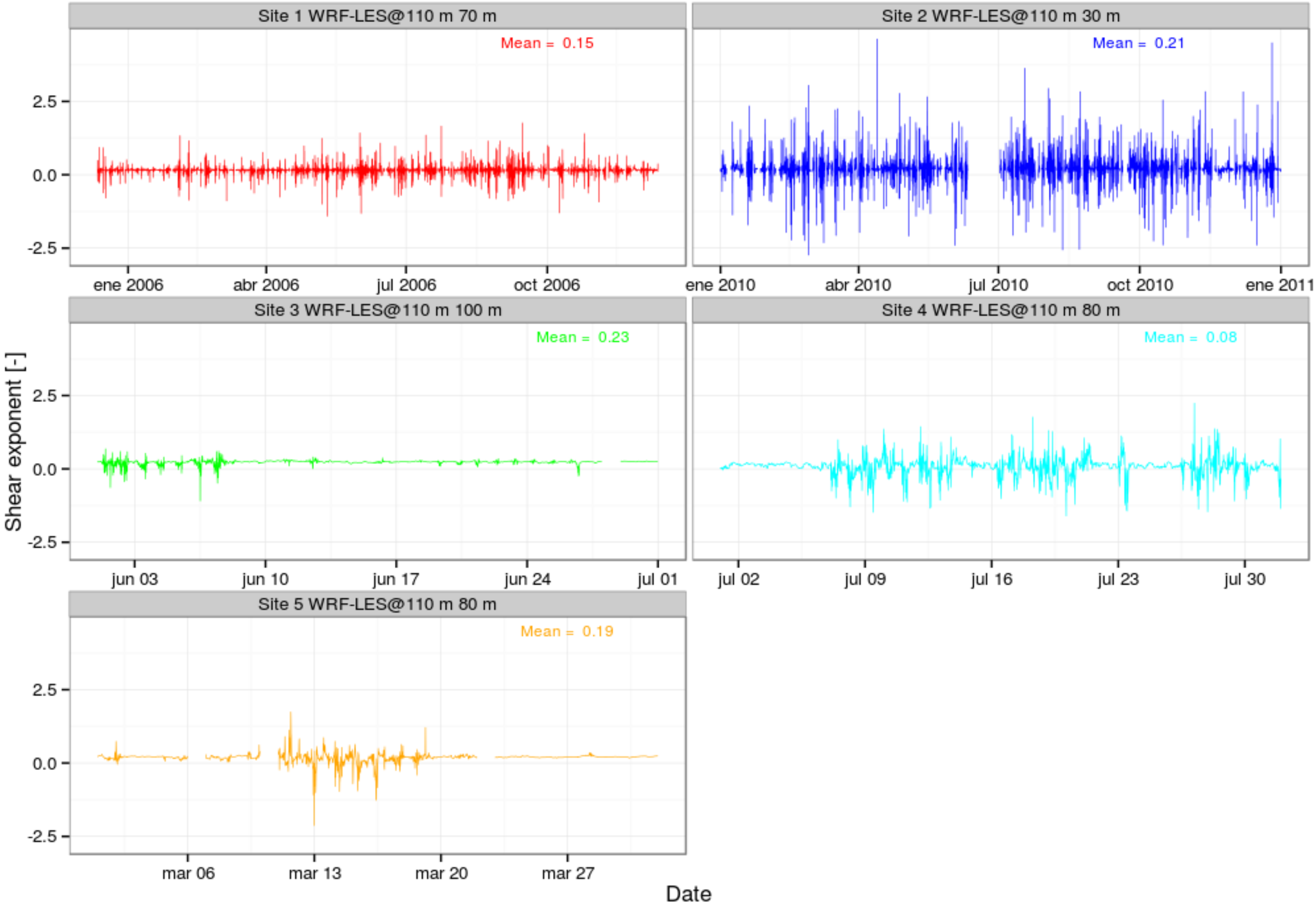

Site 1 Real
Mean = 4.9
Site 1 WRF-LES@110 m 70 m
Mean = 5.9
ene 2006
abr 2006
jul 2006
oct 2006
Site 2 Real
Mean = 4.0
Site 2 WRF-LES@110 m 30 m
Mean = 4.5
ene 2010
abr 2010
jul 2010
oct 2010
ene 2011
Site 3 Real
Mean = 9.8
Site 3 WRF-LES@110 m 100 m
Mean = 10.9
jun 03
jun 10
jun 17
jun 24
jul 01
Site 4 Real
Mean = 8.4
Site 4 WRF-LES@110 m 80 m
Mean = 5.9
jul 02
jul 09
jul 16
jul 23
jul 30
Site 5 Real
Mean = 9.2
Site 5 WRF-LES@110 m 80 m
Mean = 12.1
mar 06
mar 13
mar 20
mar 27
Wind Speed [ms-1]
Date
0
10
20
30

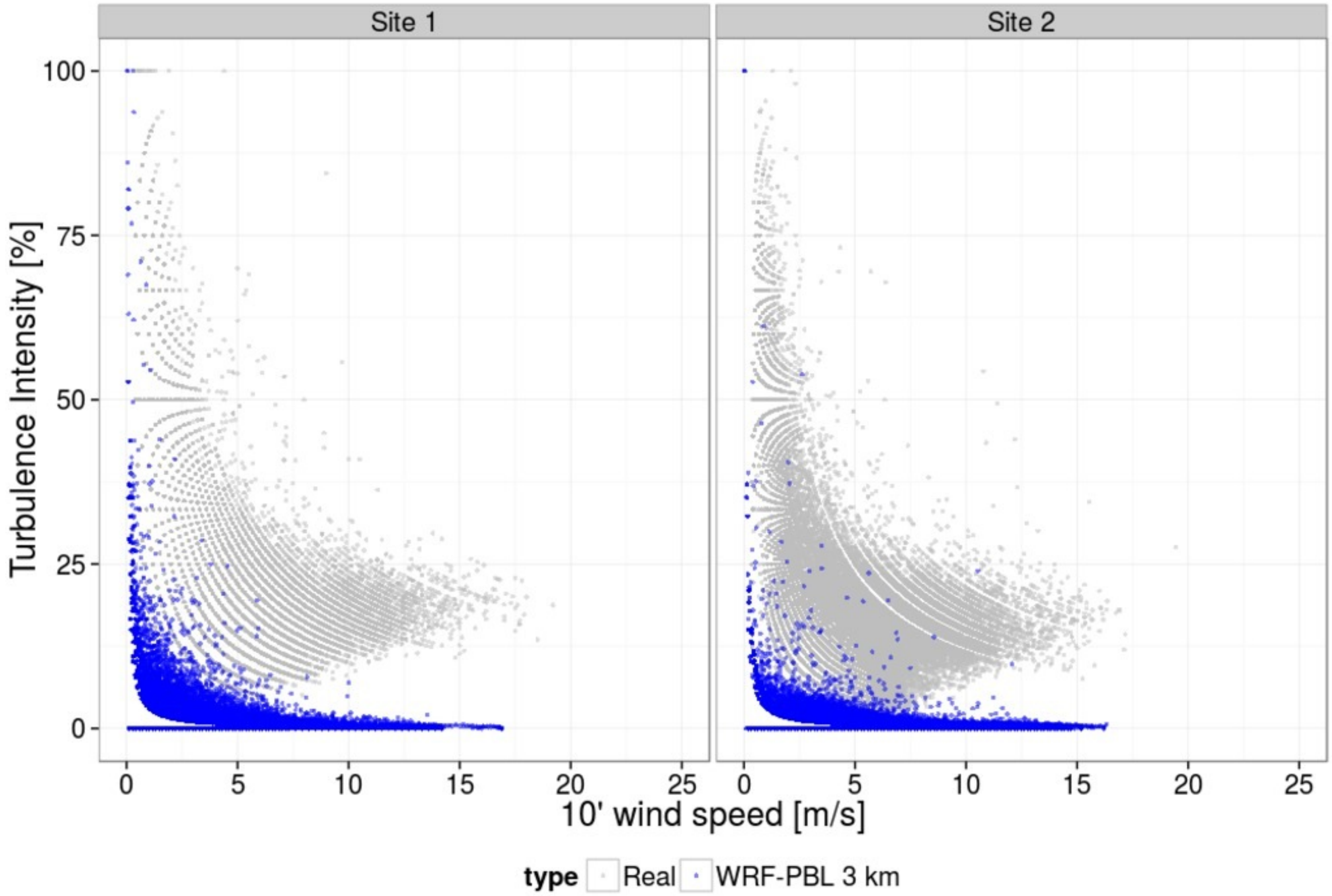


Site 1 Real
Site 1 WRF-LES@110 m 70 m
Site 2 Real
Site 2 WRF-LES@110 m 30 m
Site 3 Real
Site 3 WRF-LES@110 m 100 m
Site 4 Real
Site 4 WRF-LES@110 m 80 m
Site 5 Real
Site 5 WRF-LES@110 m 80 m
100
75
50
25
0
ene 2006
abr 2006
jul 2006
oct 2006
ene 2010
abr 2010
jul 2010
oct 2010
ene 2011
jun 03
jun 10
jun 17
jun 24
jul 01
jul 02
jul 09
jul 16
jul 23
jul 30
mar 06
mar 13
mar 20
mar 27
TI [%]
Date



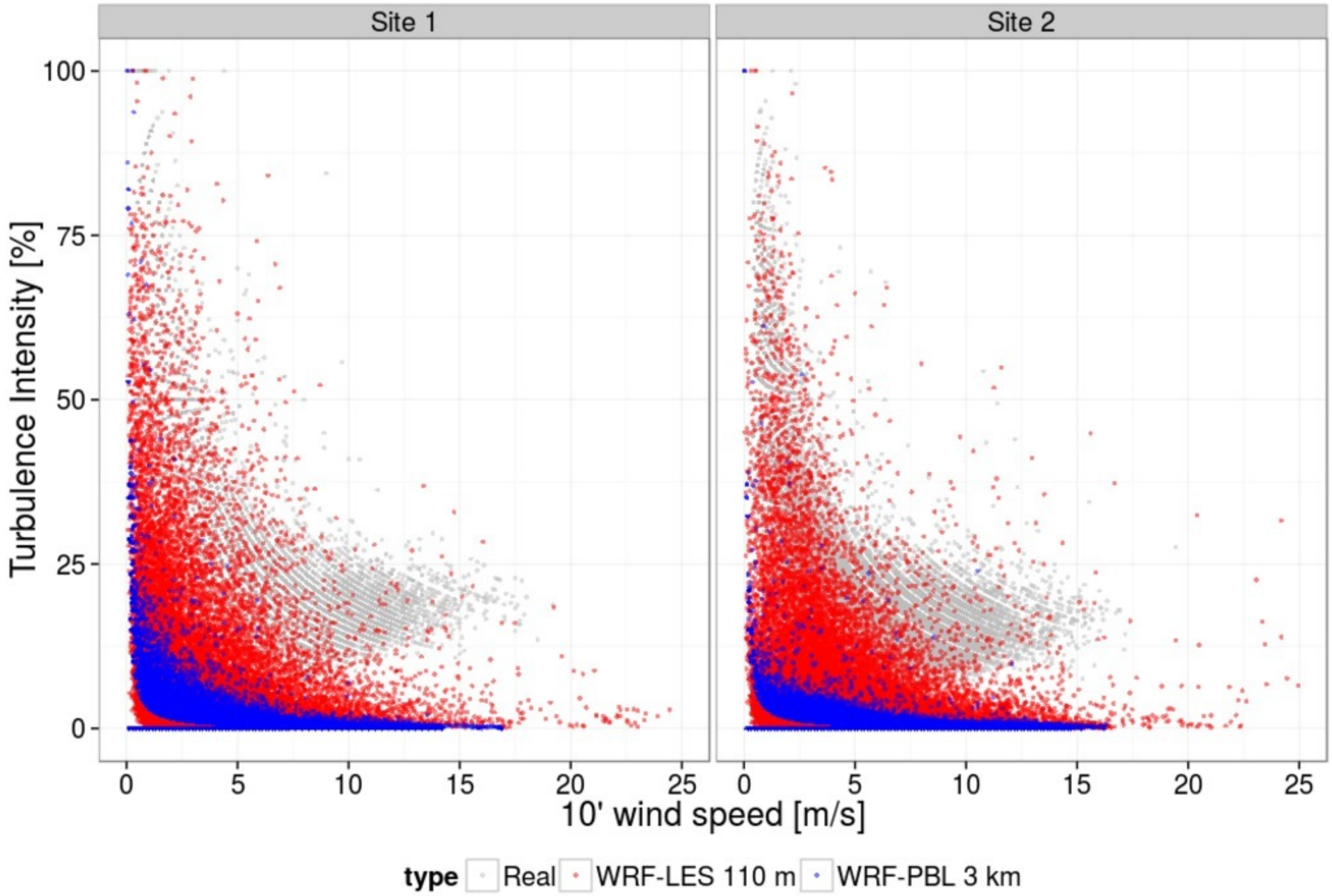
Site 1 WRF-LES@110 m 70 m
Mean = 0.15
Site 2 WRF-LES@110 m 30 m
Mean = 0.21
Site 3 WRF-LES@110 m 100 m
Mean = 0.23
Site 4 WRF-LES@110 m 80 m
Mean = 0.08
Site 5 WRF-LES@110 m 80 m
Mean = 0.19
Shear exponent [-]
2.5
0.0
-2.5
ene 2006
abr 2006
jul 2006
oct 2006
ene 2010
abr 2010
jul 2010
oct 2010
ene 2011
jun 03
jun 10
jun 17
jun 24
jul 01
jul 02
jul 09
jul 16
jul 23
jul 30
mar 06
mar 13
mar 20
mar 27
Date

Experiments: Results



Experiments: Results

- WRF-LES 110 m improves the TI-WS relationship for low and mid wind speeds
- WRF-LES 110 m tends to produce laminar flows at high wind speeds



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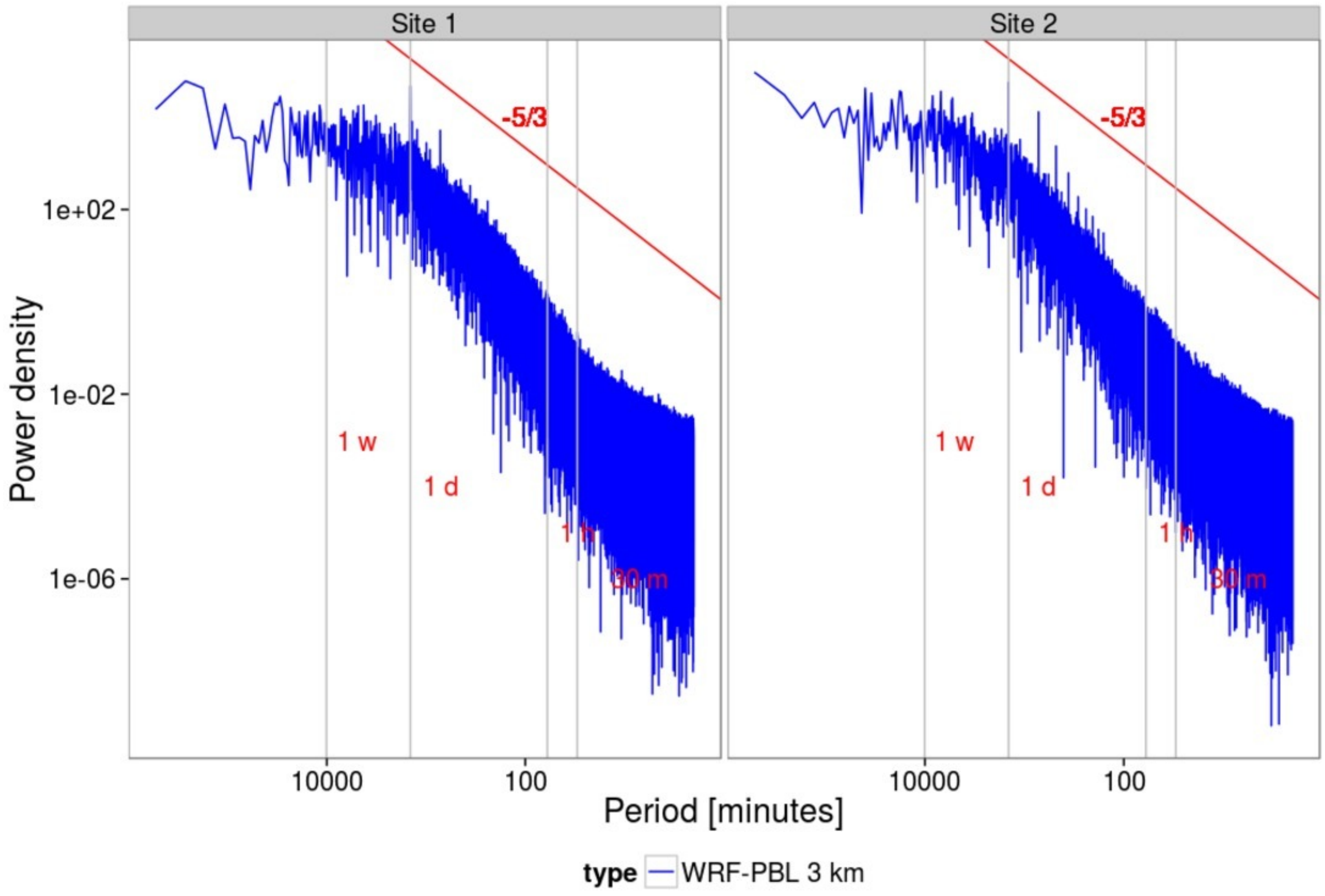
- WRF-PBL 3 km underestimates the energy of the eddies faster than 1-2 hours



Experiments: Results

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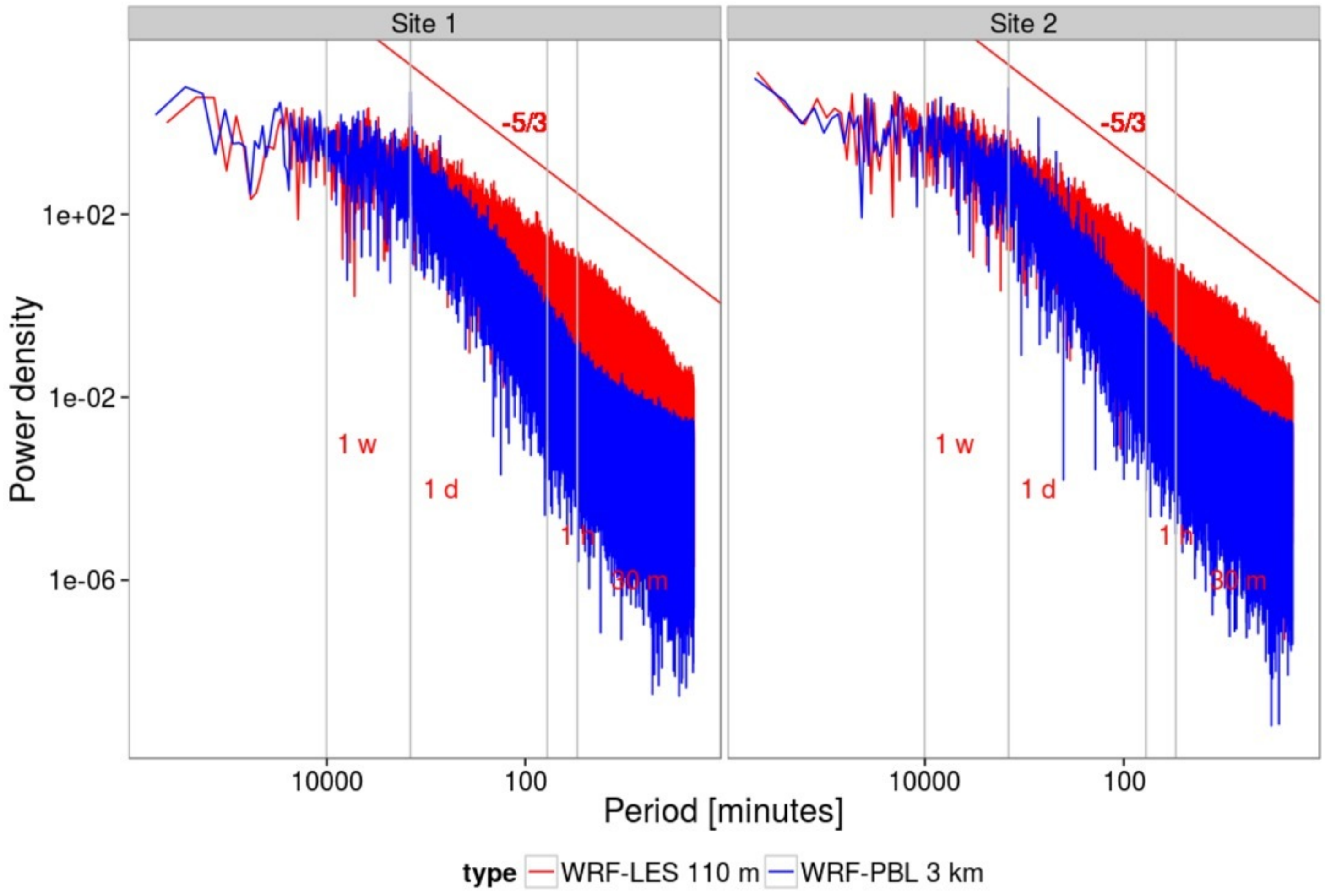
- WRF-PBL 3 km underestimates the energy of the eddies faster than 1-2 hours
- WRF-LES 110 m follows the expected 5/3 slope at all scales of the inertial range



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Some Notes

- Mesoscale (Multiscale) Modeling n is improving at the near-windfarm effective resolution

- 4D information of the wind condtions where:
  - 10' Turbulence is now enable
  - Shear follows atmospheric stability
  - known and uknown underprediction (missing energy)

- Working on Real Conditions (topography, for instance)
- CPU is not that constraining

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Some Notes

- Use in conjuction with observations
- Remodeling with observed power performance data

- Scenario analysis → risk assessment
- Laboratory to apply Matrix correction methods

- Sharing data initiative