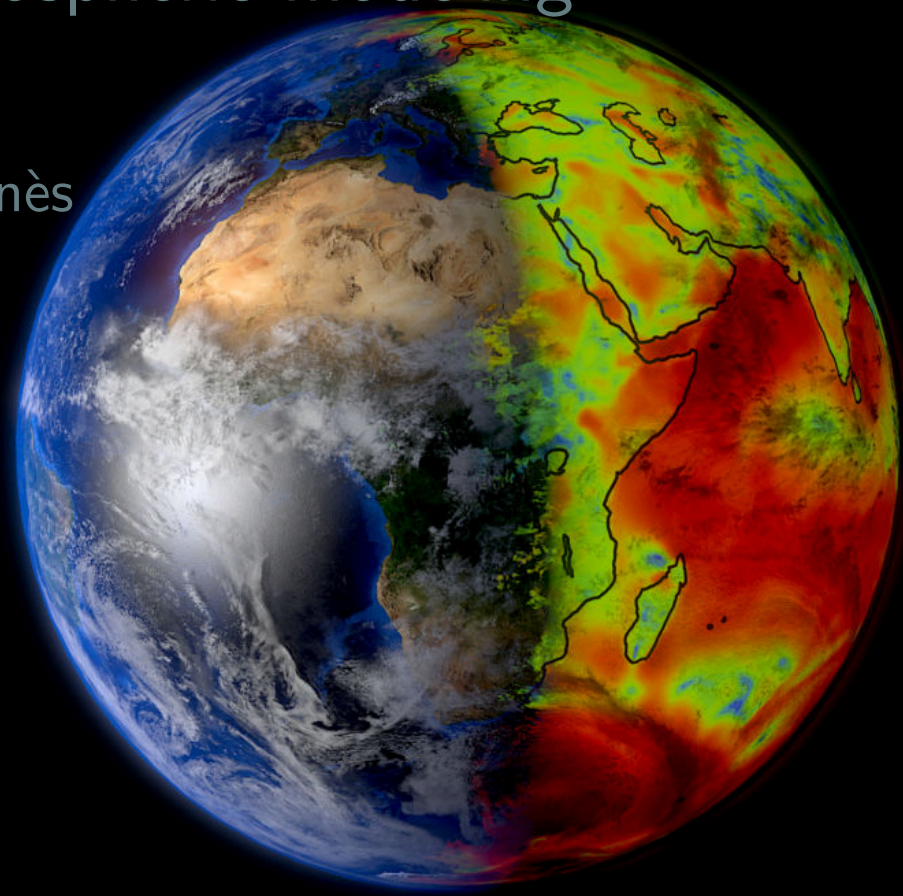
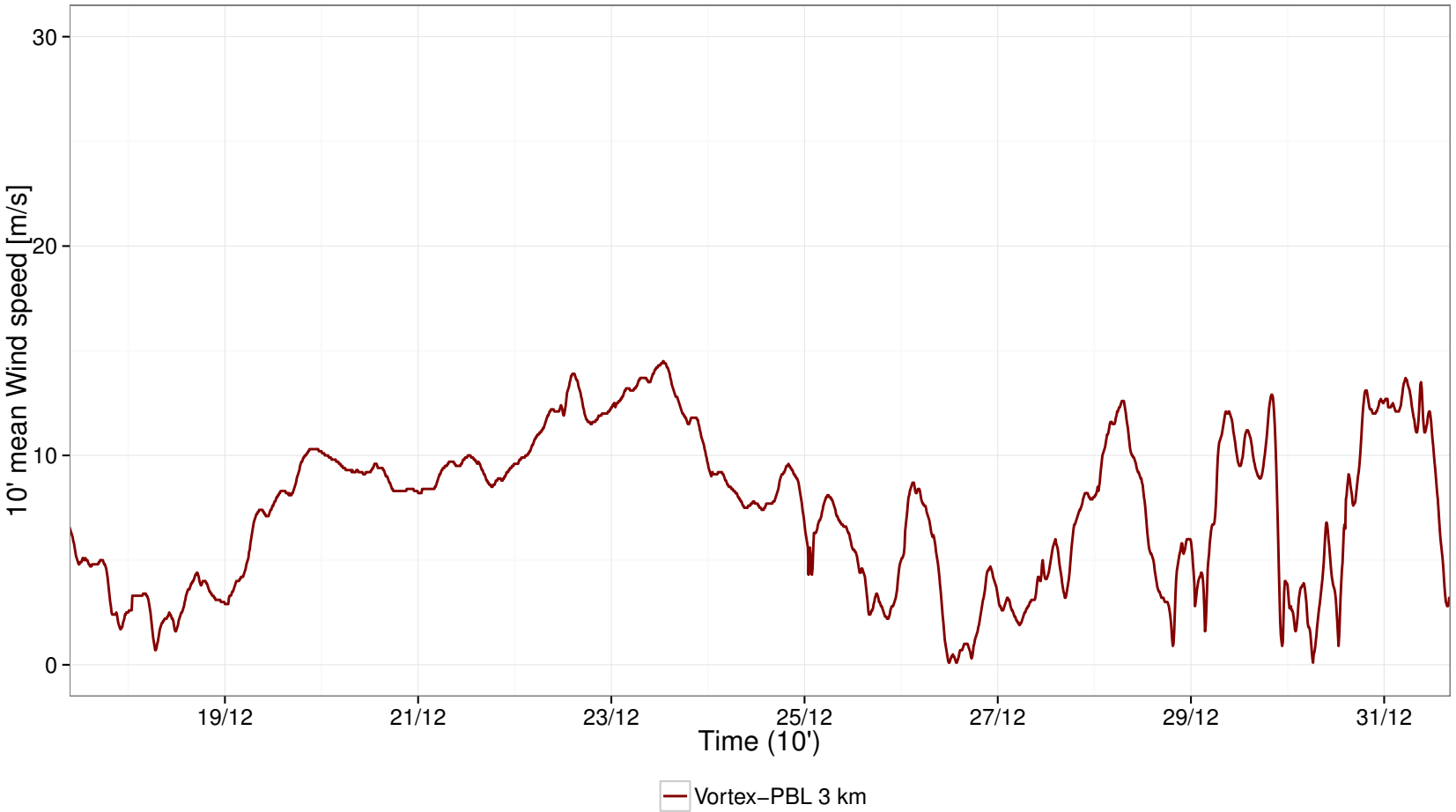
Mesoscale-Microscale coupling: A new time for the atmospheric modeling

A. Montornès



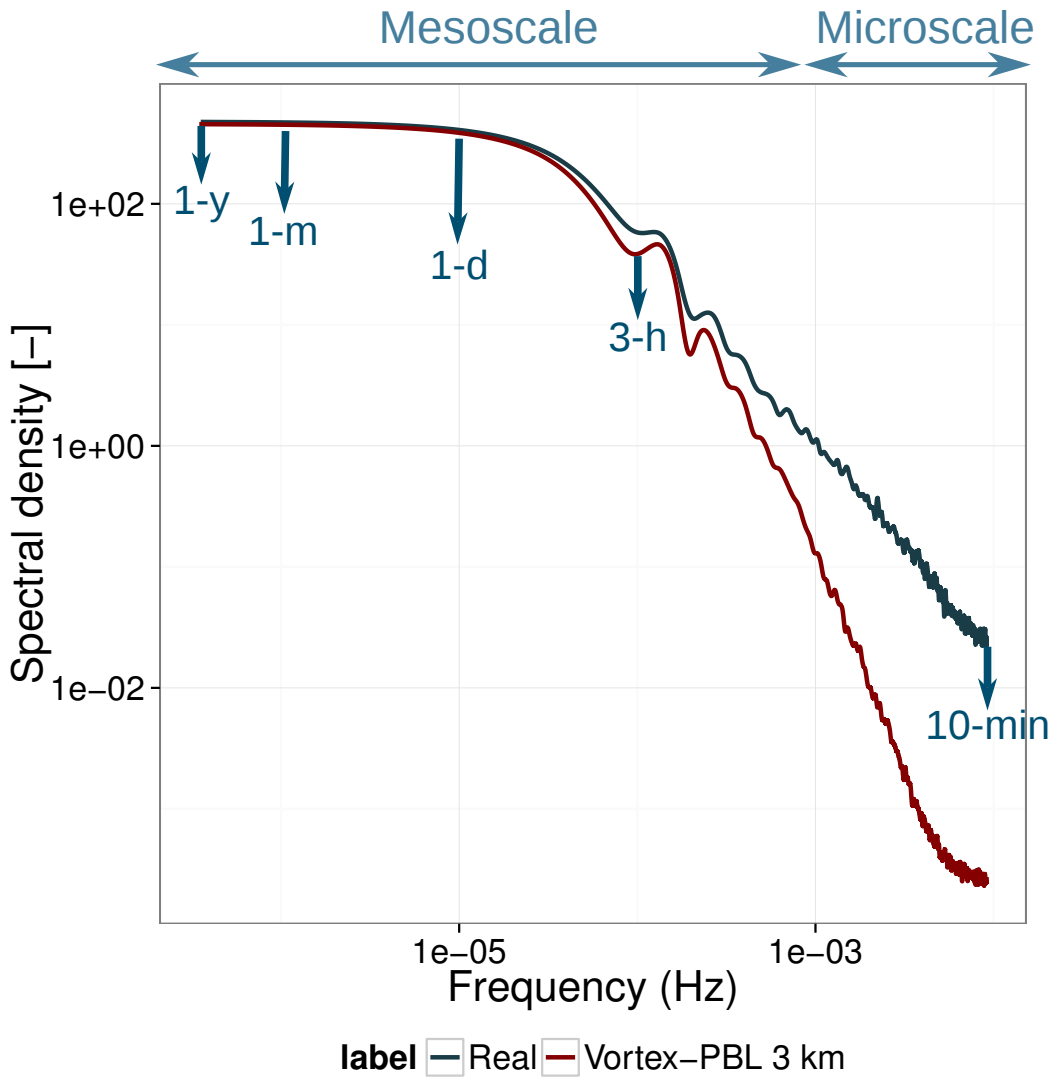
VORTEX

80 m above ground

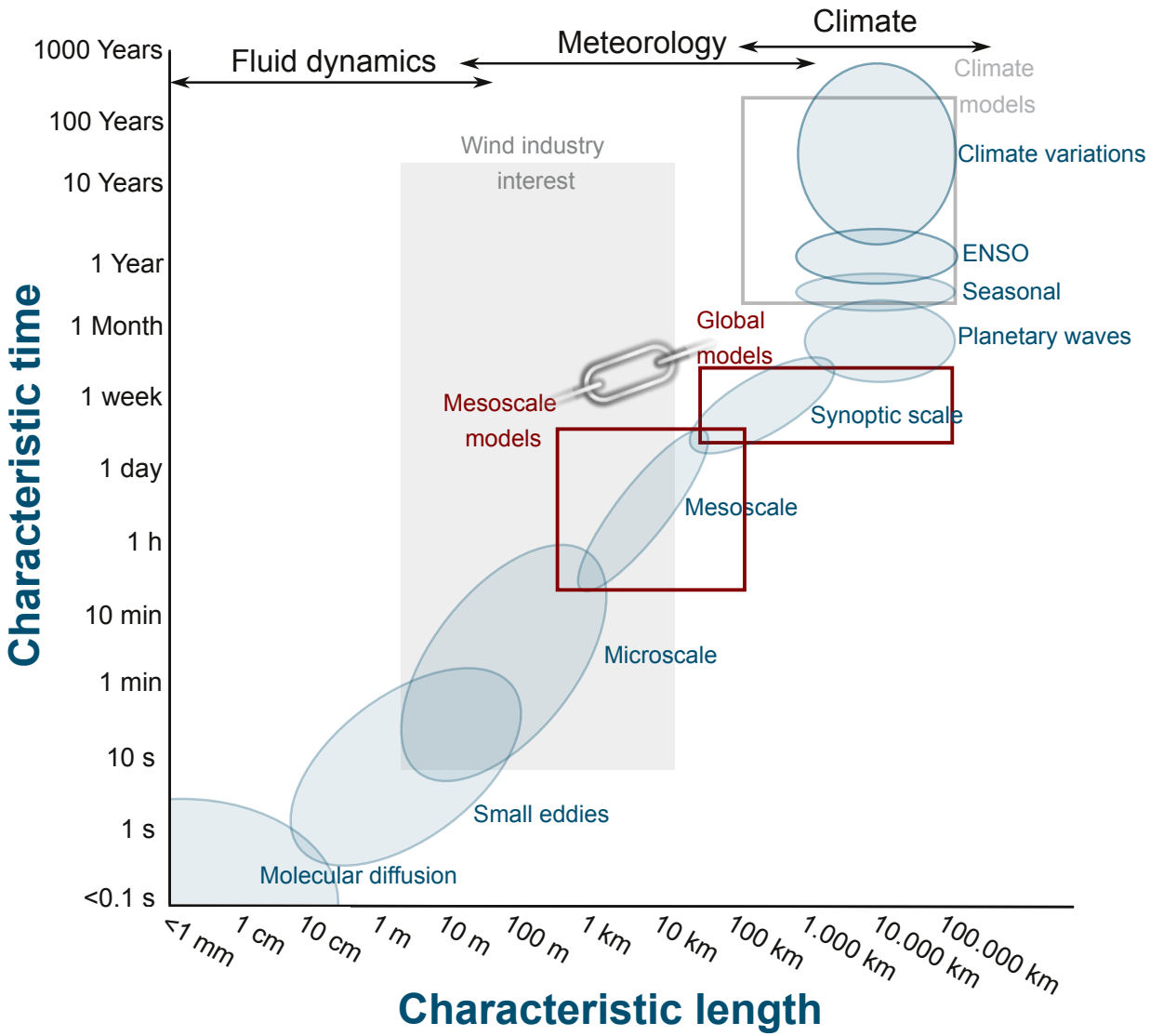


80 m above ground

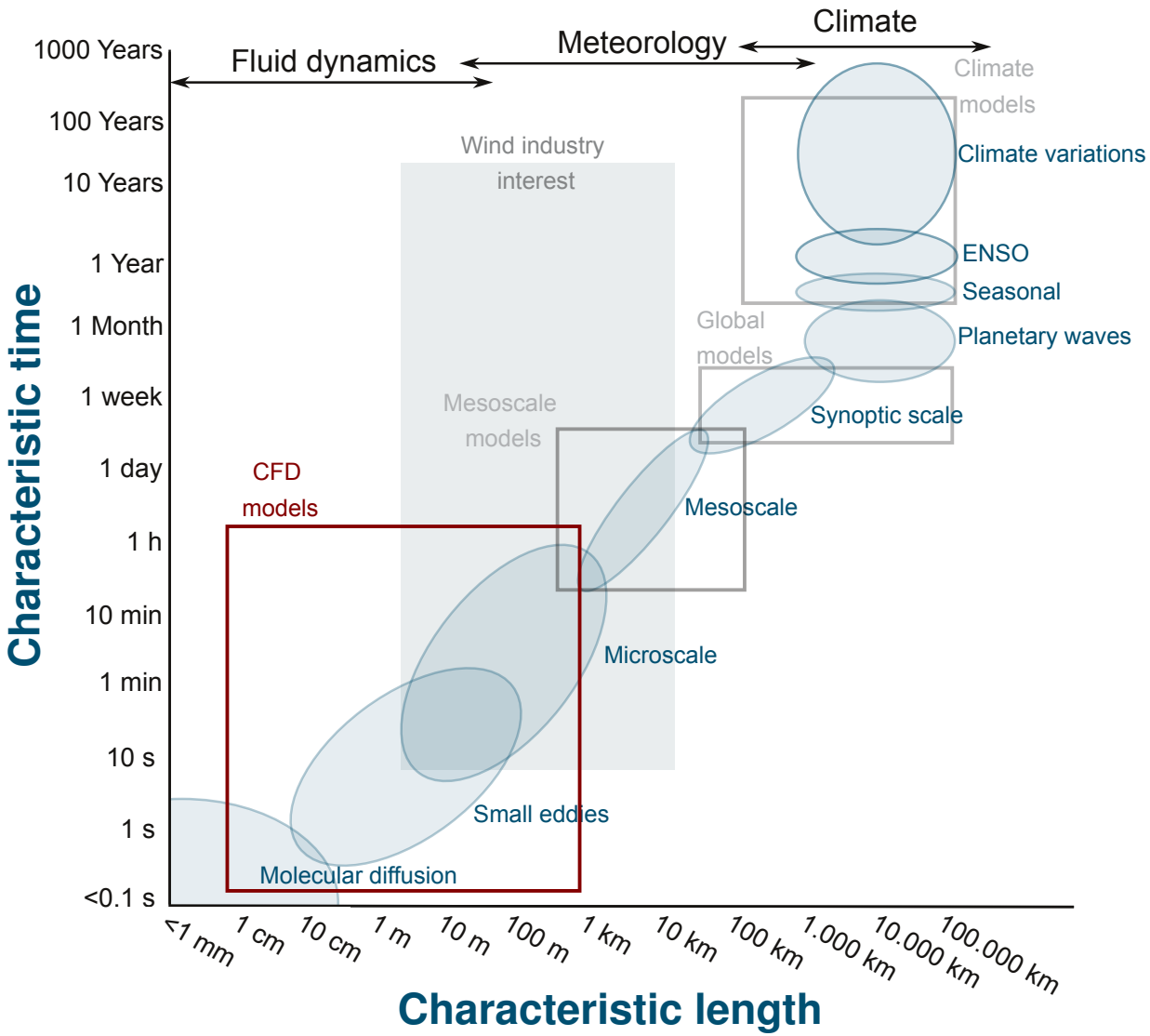
80 m above ground: 1 year analysis

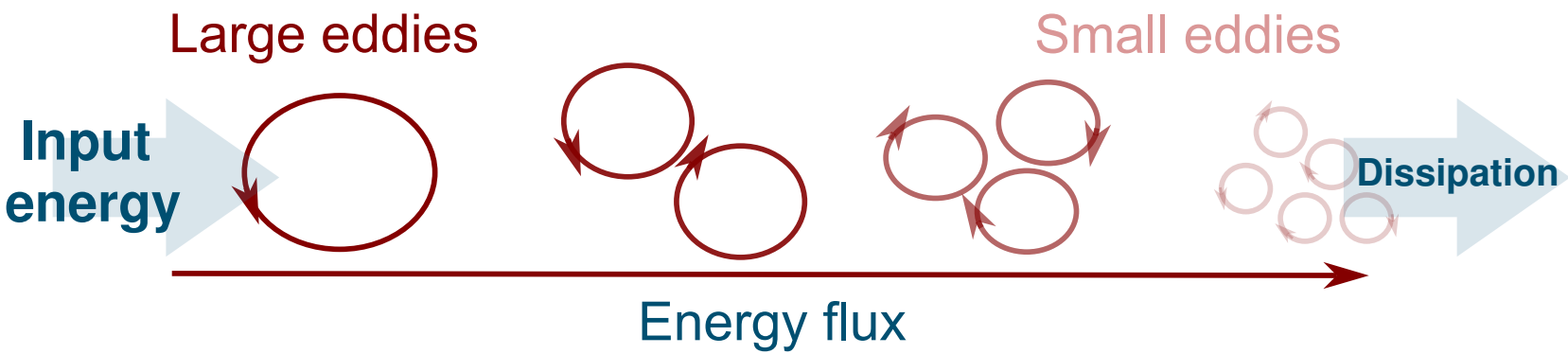


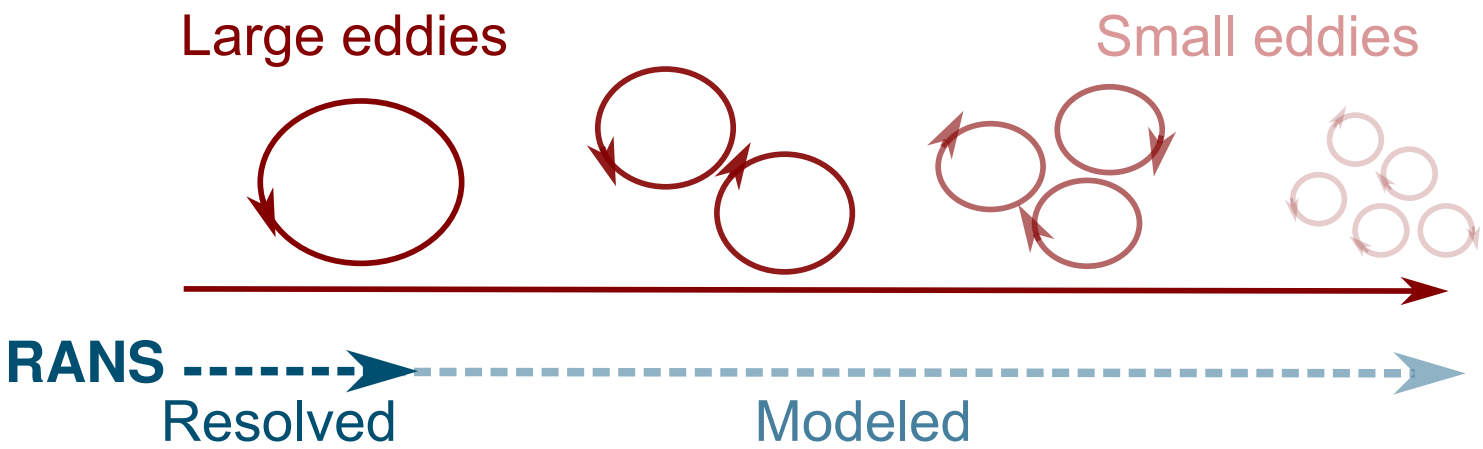
Wind resource assessment approach: mesoscale models



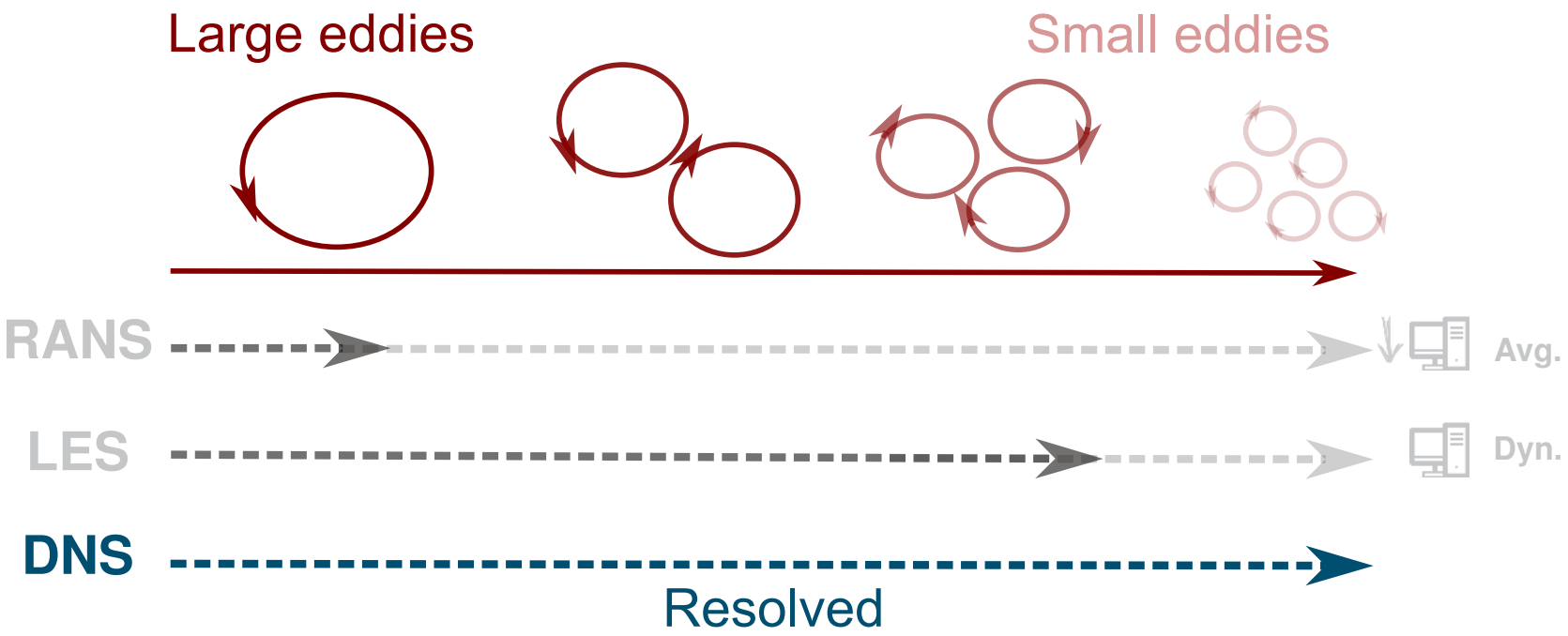
A new age: CFD


Fluid dynamics
Meteorology
Climate
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
Characteristic time
Wind industry interest
Climate models
Climate variations
ENSO
Seasonal
Planetary waves
Global models
Synoptic scale
Mesoscale models
Mesoscale
CFD models
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
Characteristic length

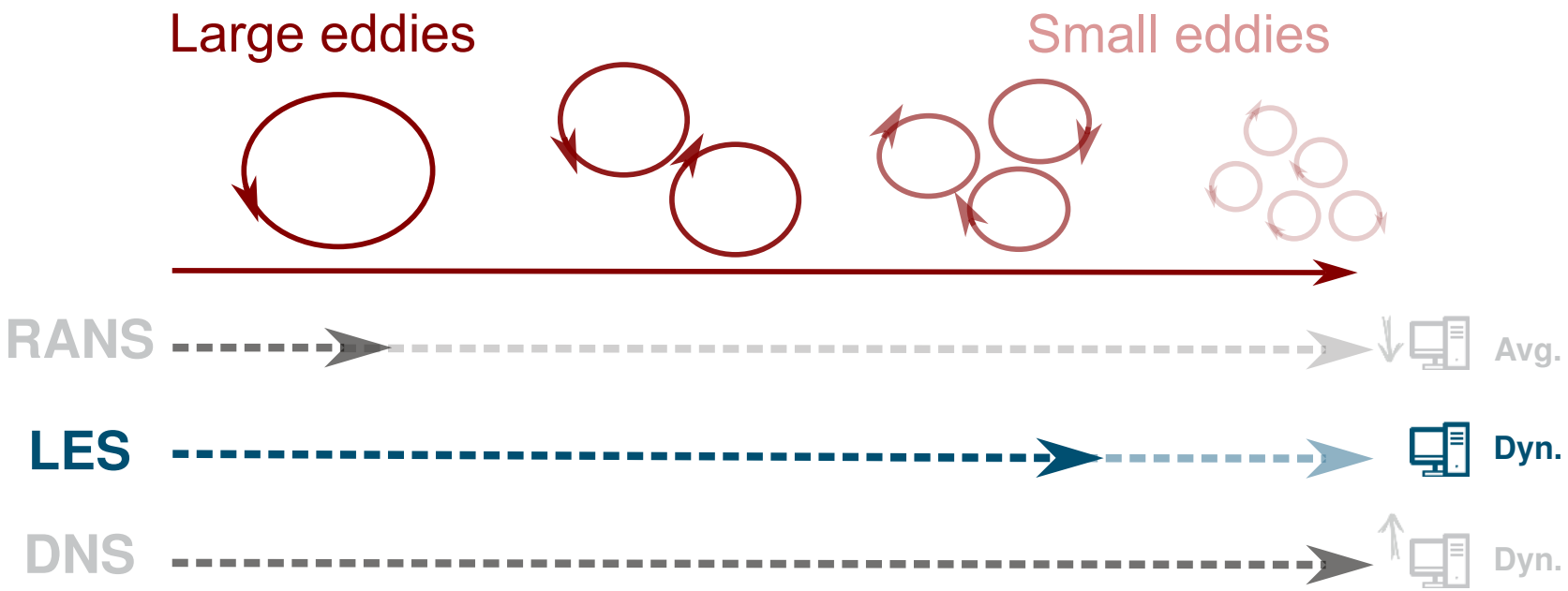

Large eddies
Small eddies
Input energy
Dissipation
Energy flux

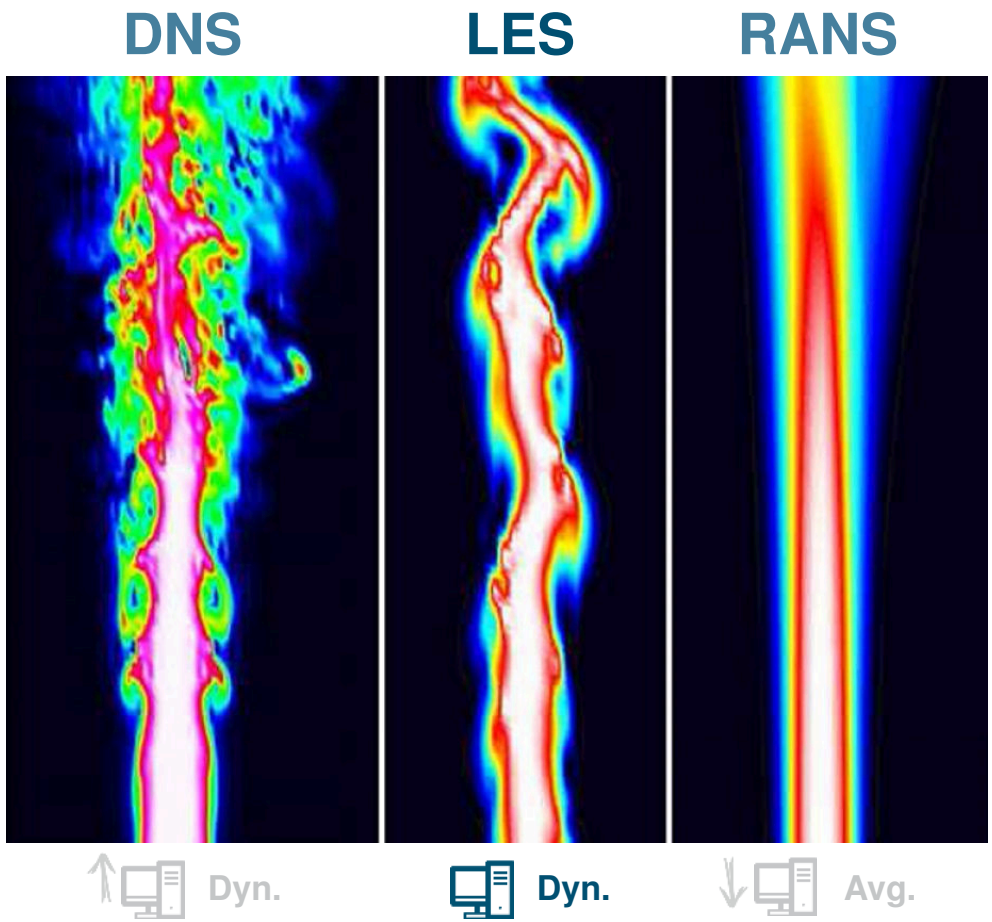


Average

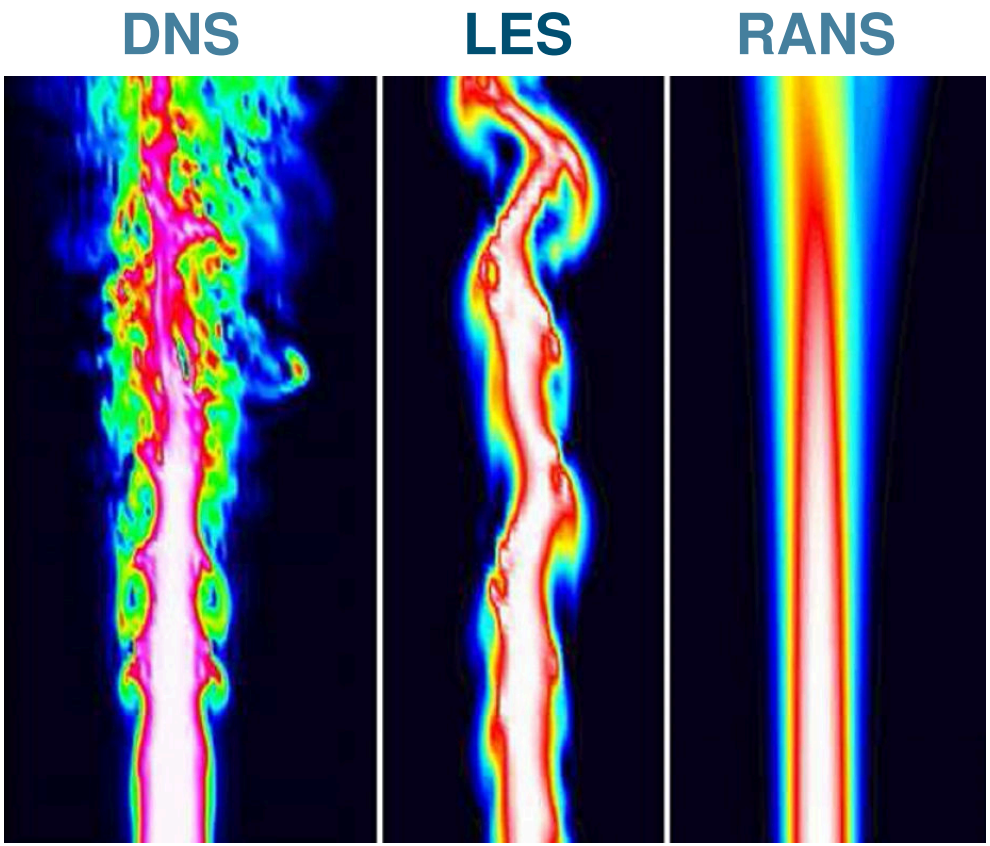


Dynamic


Large eddies
Small eddies
RANS
Avg.
LES
Dyn.
DNS
Dyn.

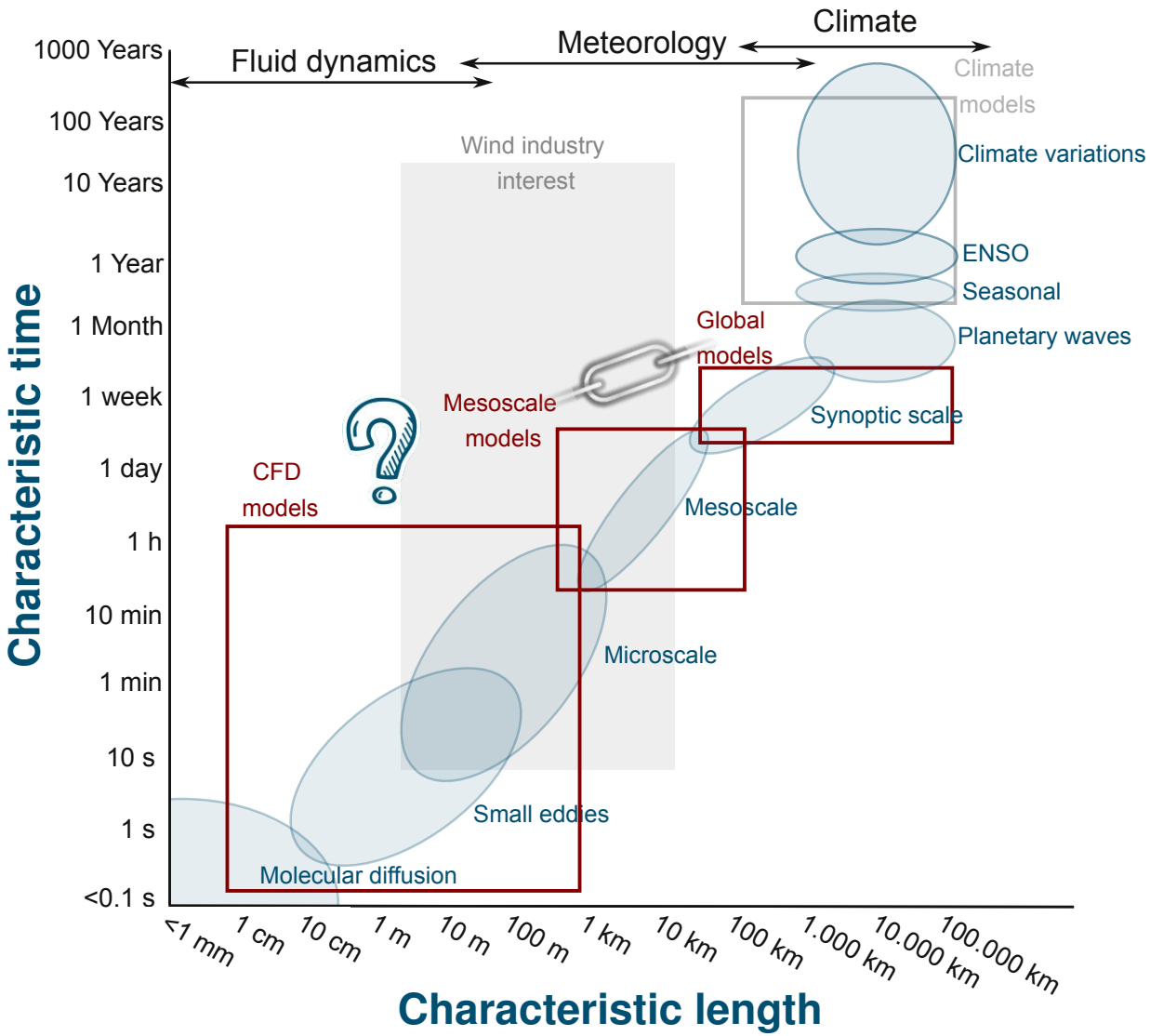


Adapted from Maries, A., Haque, M. A., Yilmaz, S. L., Nik, M. B., Marai, G. E.: New Developments in the Visualization and Processing of Tensor Fields, Springer, pp. 137-156, D. Laidlaw, A. Villanova. 2012



Different tools for different applications

A new age: Mesoscale-Microscale coupling



Coupling mesoscale-LES: Challenges

- Lateral boundary conditions
- Surface layer and Land Surface Model
- Terra-Incognita

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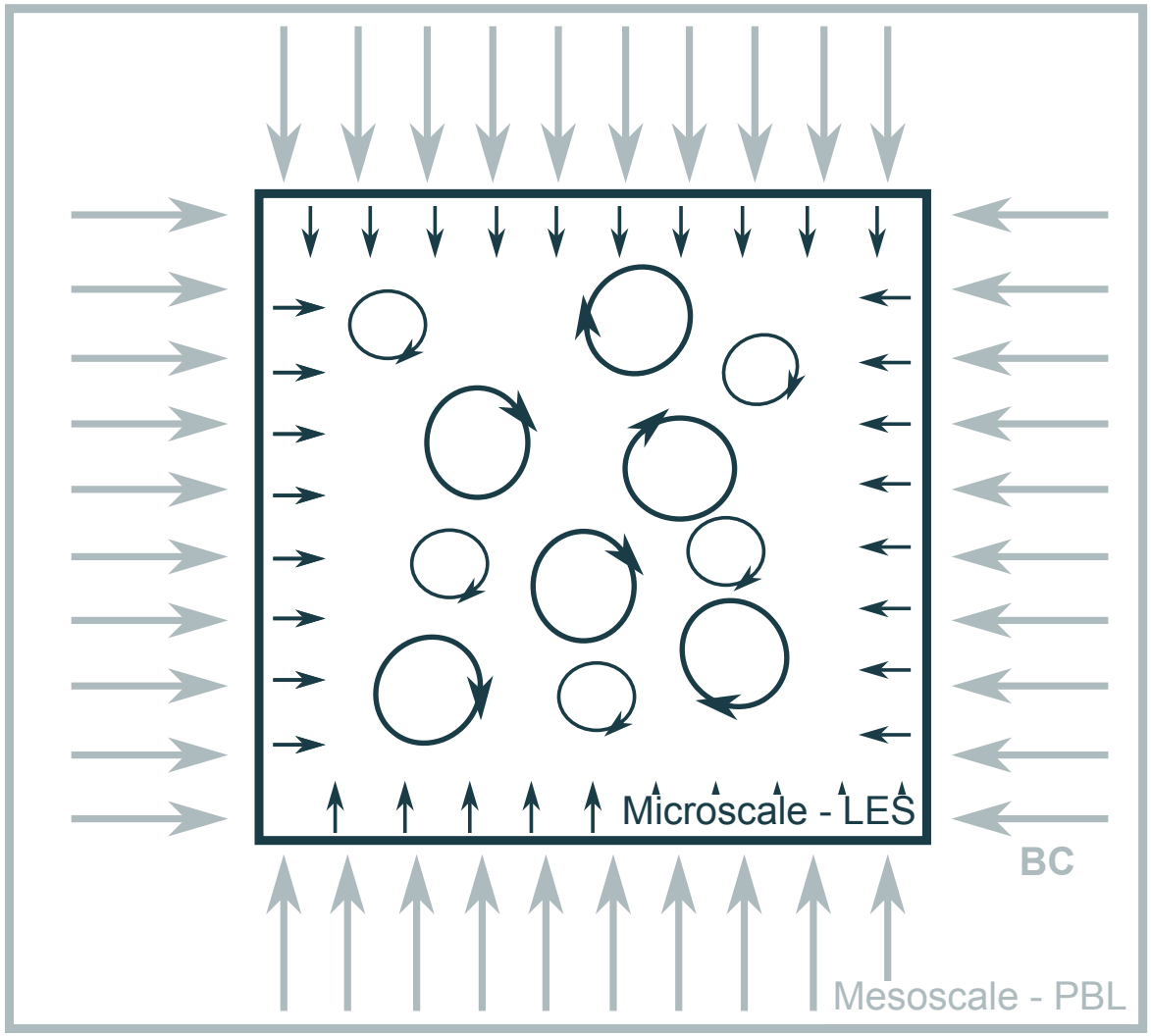
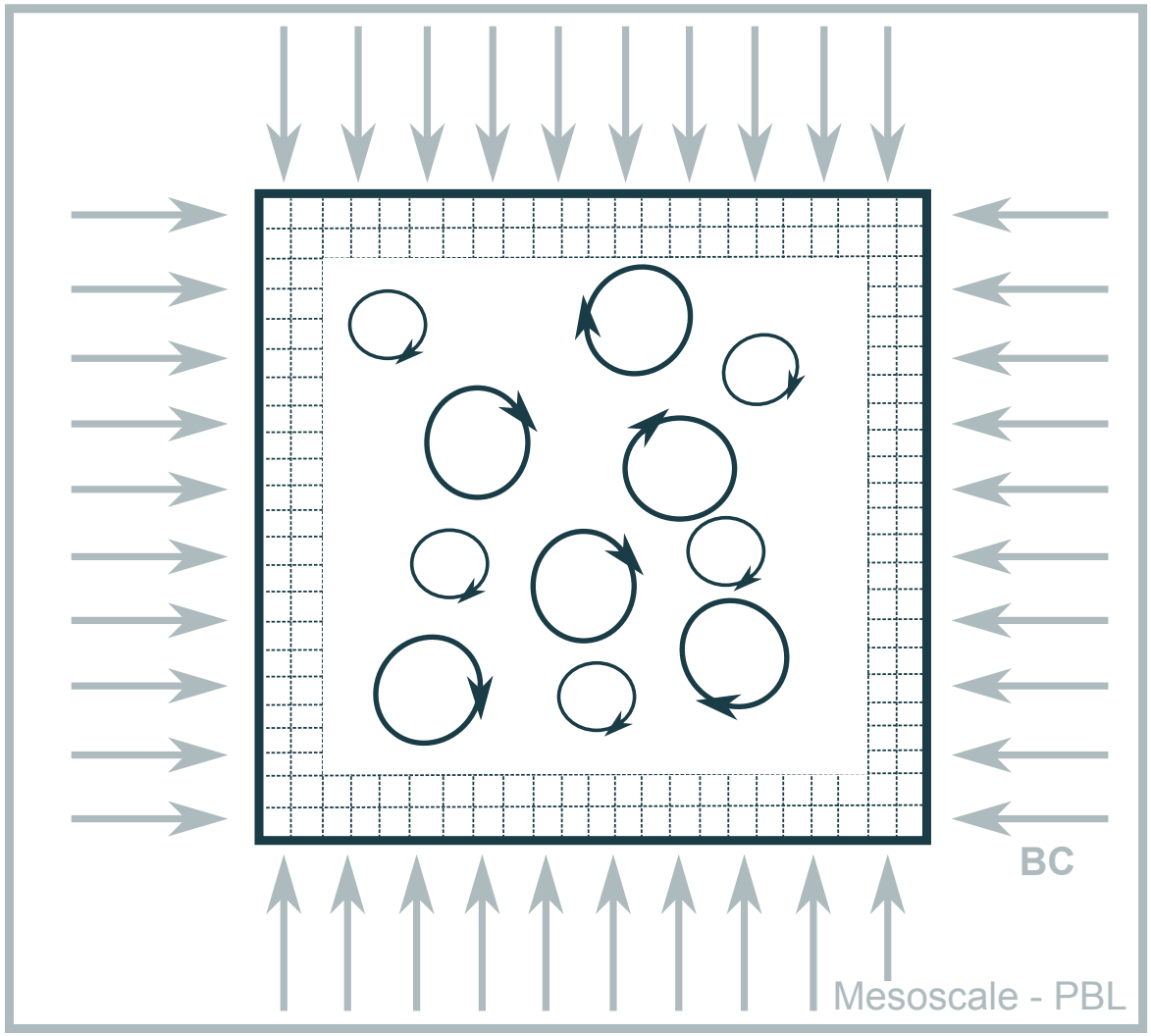
Lateral boundary conditions



Lateral boundary conditions



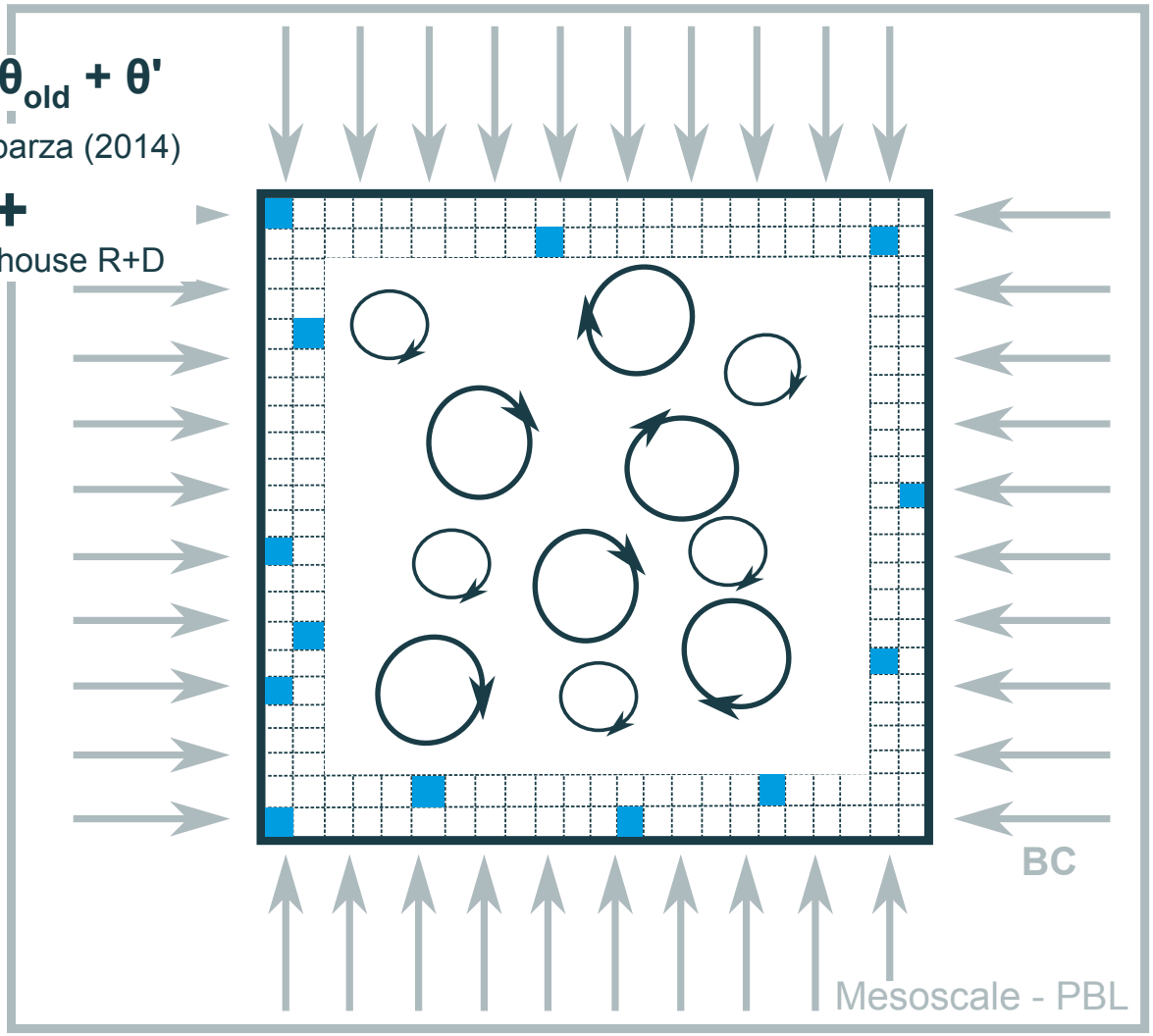
Lateral boundary conditions

$\theta_{new} = \theta_{old} + \theta'$

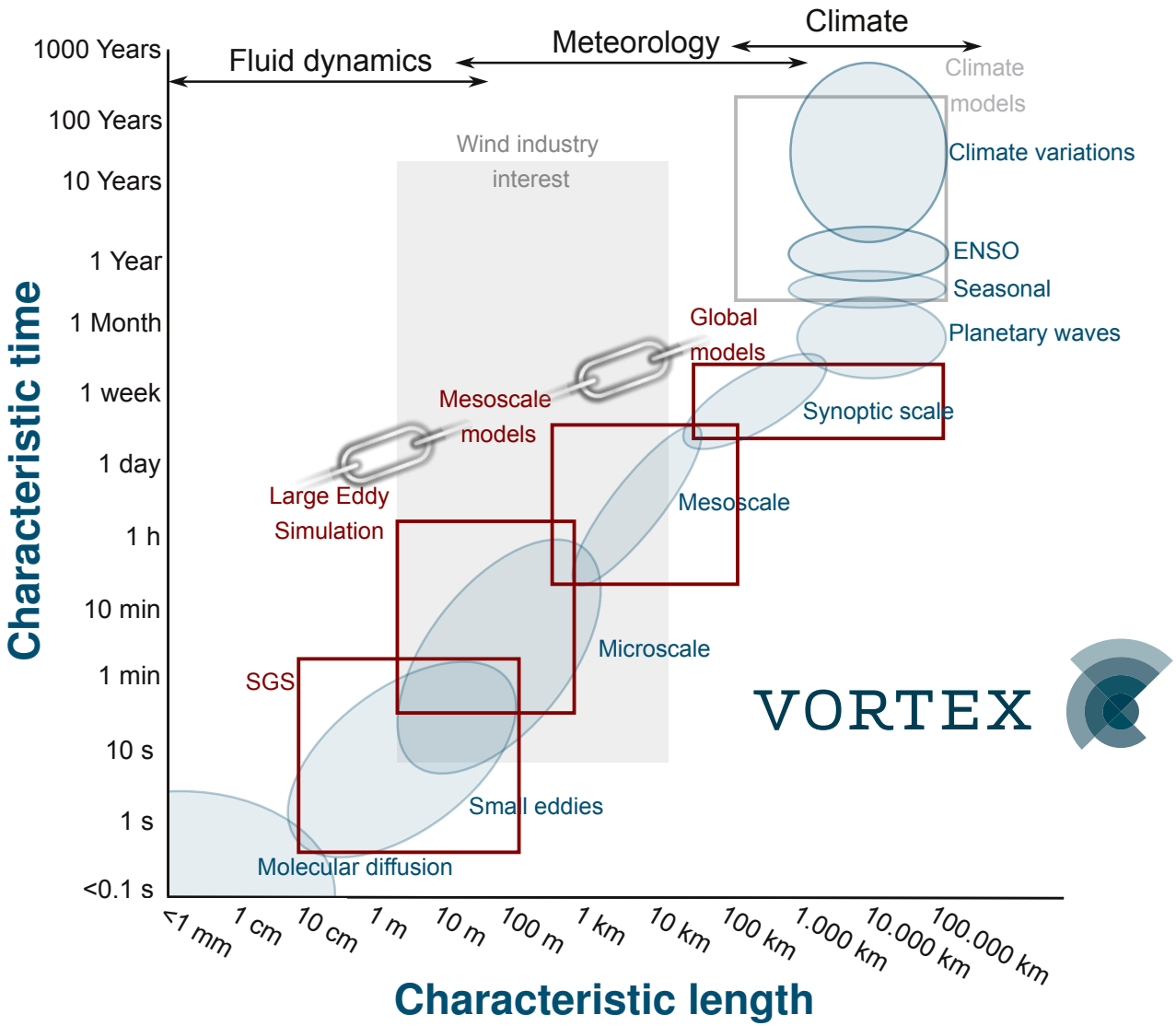
Muñoz-Esparza (2014)

+

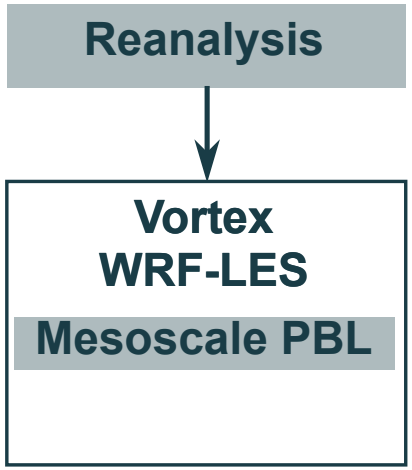
Vortex in-house R+D



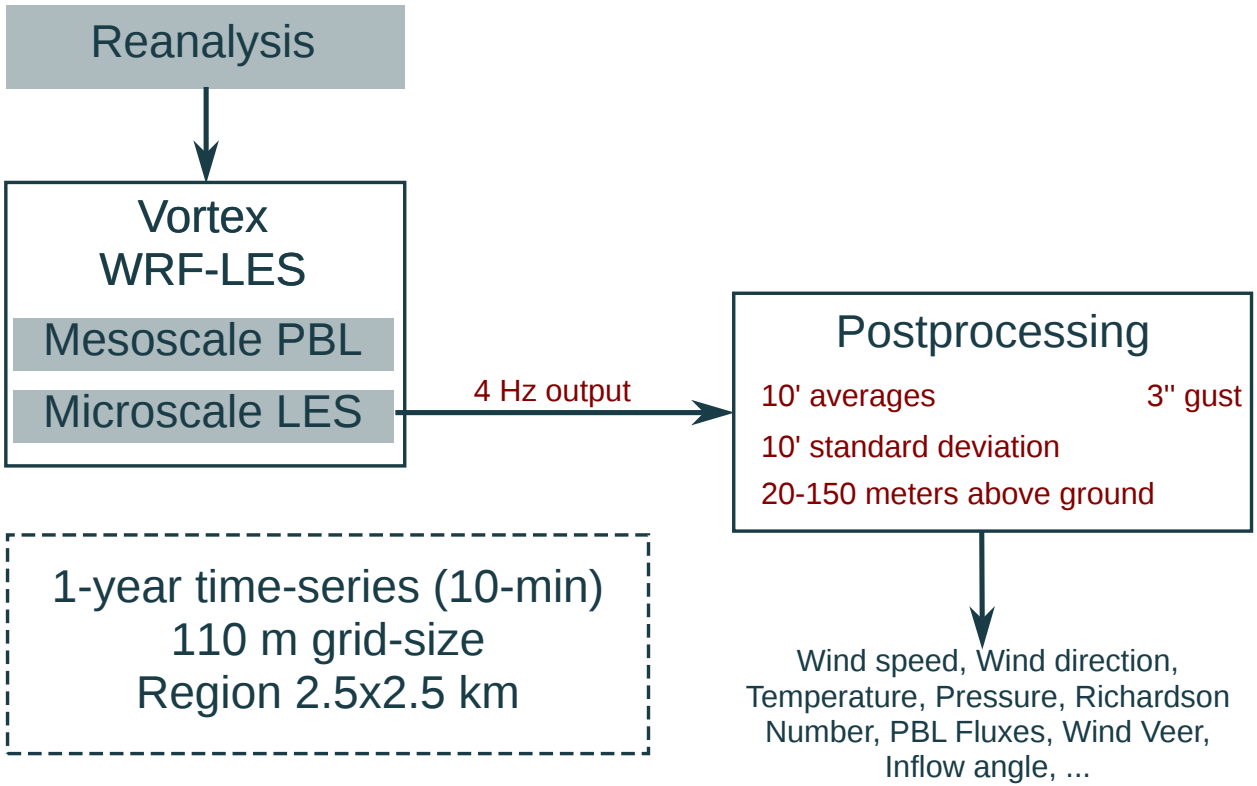
A new age: Mesoscale-Microscale coupling



Vortex approach



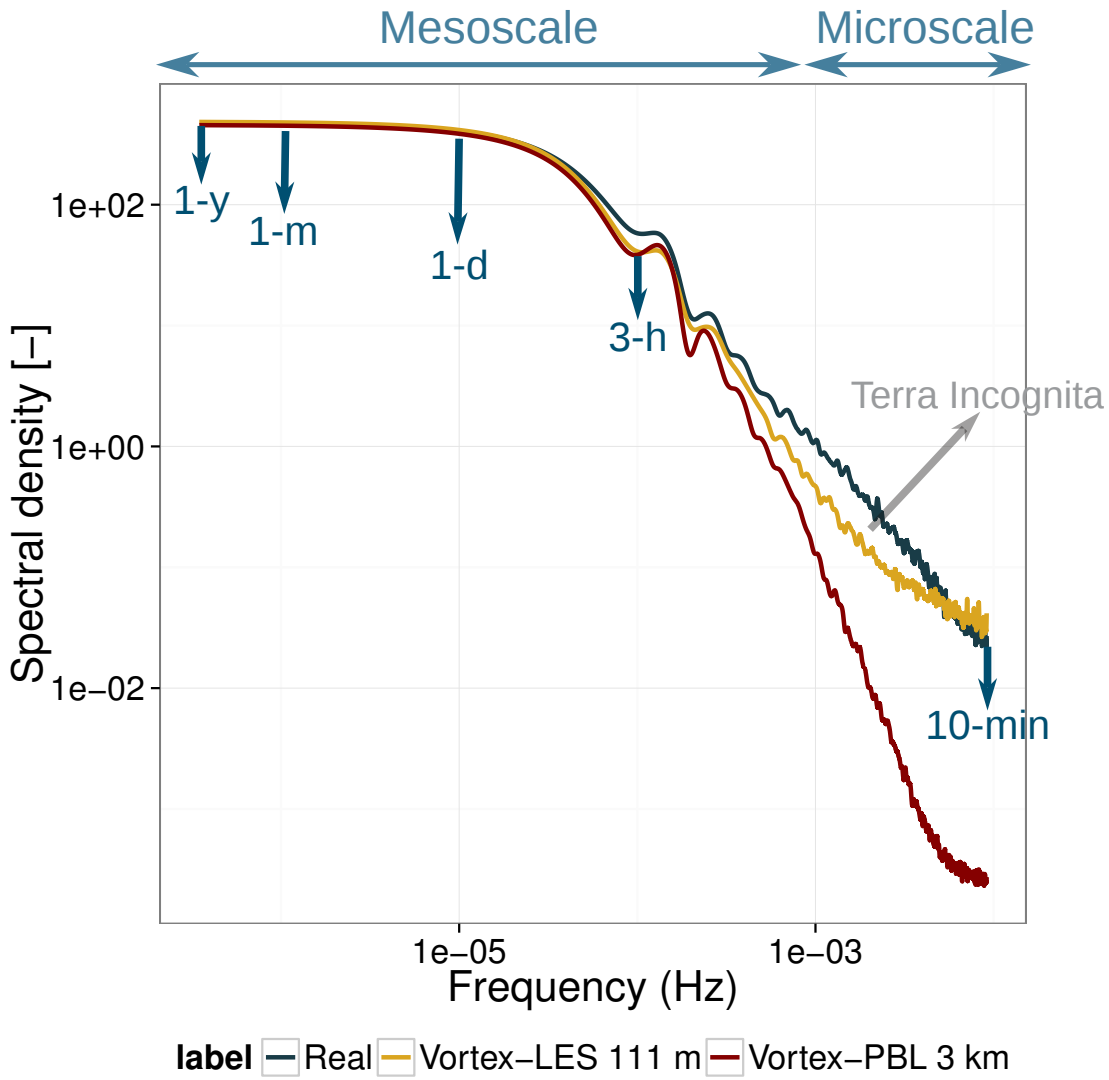
Vortex approach



80 m above ground

80 m above ground

80 m above ground: 1 year analysis



Validation exercise

3.1% Off-shore **41.7%** Flat terrain **25.0%** Complex terrain **30.2%** Forest

Anemometers: **18.1%** 20-50 m **68.1%** 50-100 m **13.8%** 100-150 m

1-year validation
Wind speed validated at 96 sites at different mest-mast heights
Turbulence validated at 56 sites at different mest-mast heights

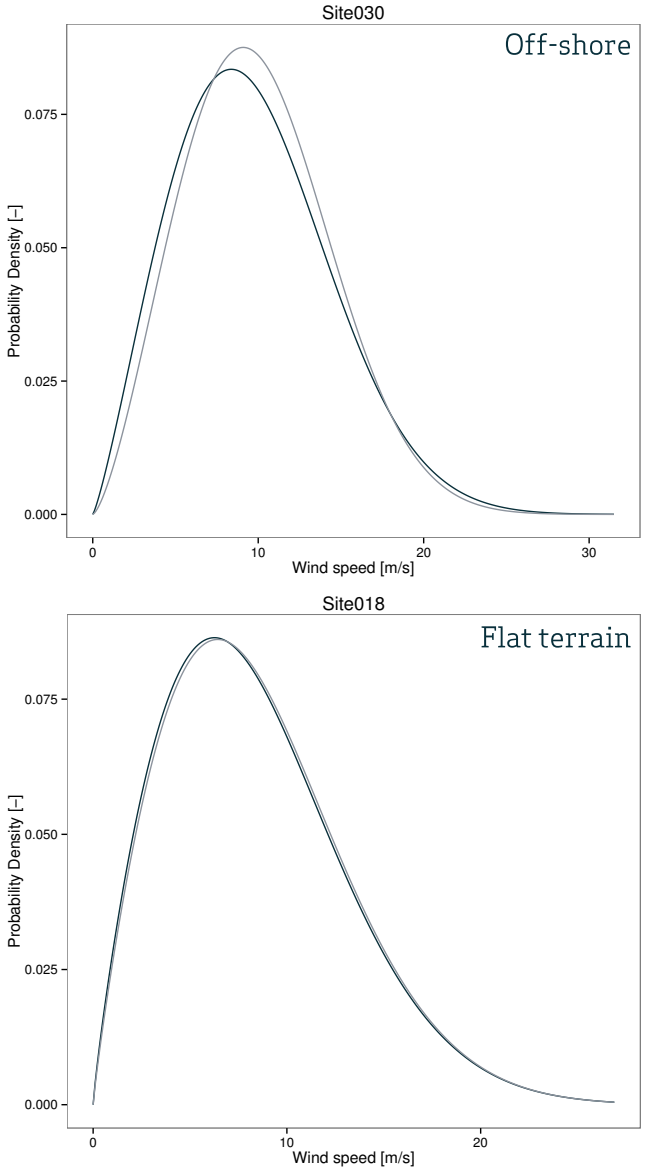
Wind speed: Metrics

		Bias (%)	RMSE (ms-1)	R^2
All (100%)	10-min	2.4	2.6	0.605
	Hourly		2.5	0.637
	Daily		1.7	0.807
Off-shore (3.1%)	10-min	0.4	1.9	0.837
	Hourly		1.8	0.855
	Daily		1.1	0.937
Flat (41.7%)	10-min	-3.4	2.5	0.593
	Hourly		2.4	0.625
	Daily		1.6	0.811
Complex (25.0%)	10-min	0.5	7.1	0.590
	Hourly		7.2	0.623
	Daily		7.1	0.790
Complex Forest (30.2%)	10-min	0.4	6.6	0.610
	Hourly		6.8	0.646
	Daily		6.9	0.805

Wind speed: Weibull

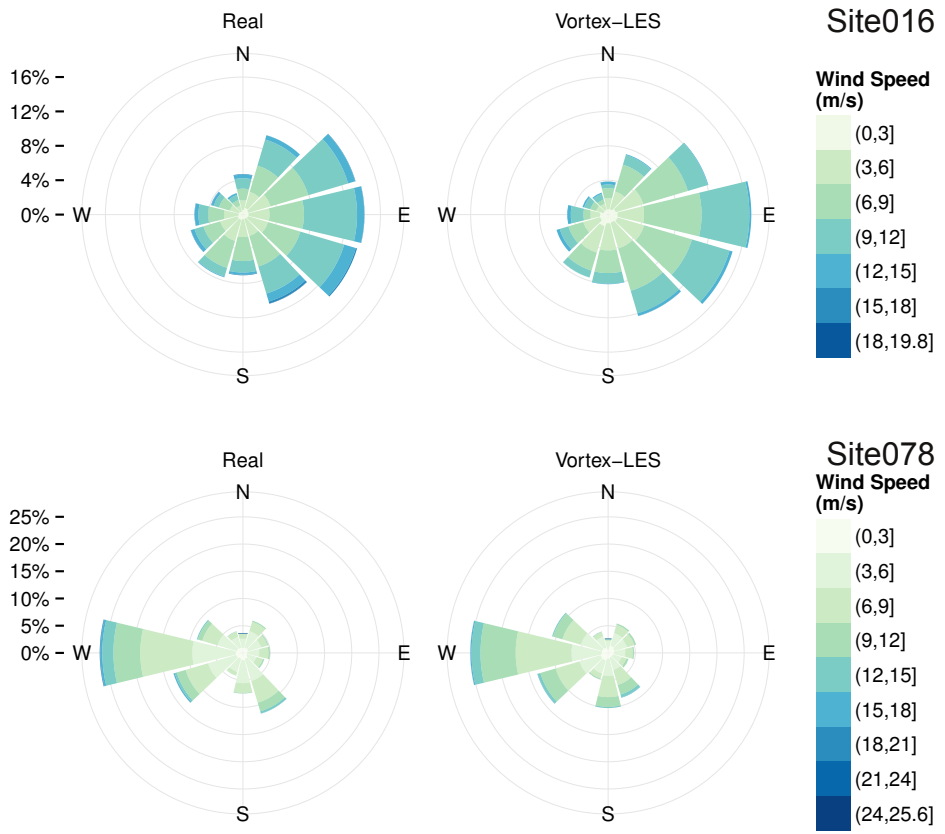
		A (%)	k (%)	Freq. (sm^{-1})
All (100%)	10-min	2.8	2.3	0.015
Off-shore (3.1%)	10-min	0.3	8.3	0.007
Flat (41.7%)	10-min	-3.2	1.0	0.018
Complex (25.0%)	10-min	8.0	7.7	0.014
Complex Forest (30.2%)	10-min	6.8	-2.9	0.014

$$f(x) = \frac{k}{A}\left(\frac{x}{A}\right)^{k-1} \exp\left(-\left(\frac{x}{A}\right)^{k}\right)$$

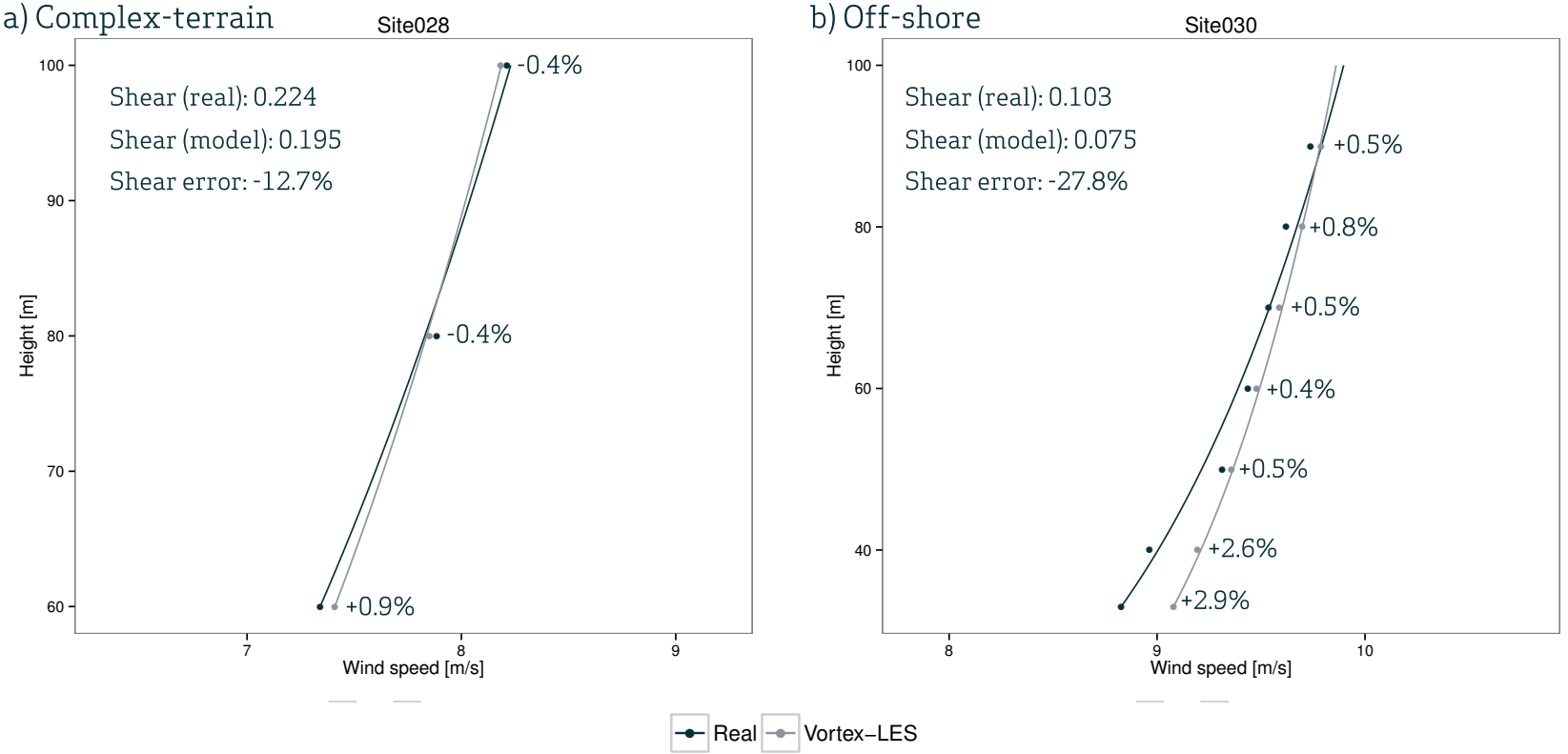


Wind direction: Metrics and rose

		Bias (deg)	MAE (deg)
All (100%)	10-min	3	34
Off-shore (3.1%)	10-min	-2	18
Flat (41.7%)	10-min	0	34
Complex (25.0%)	10-min	2	34
Complex Forest (30.2%)	10-min	10	31

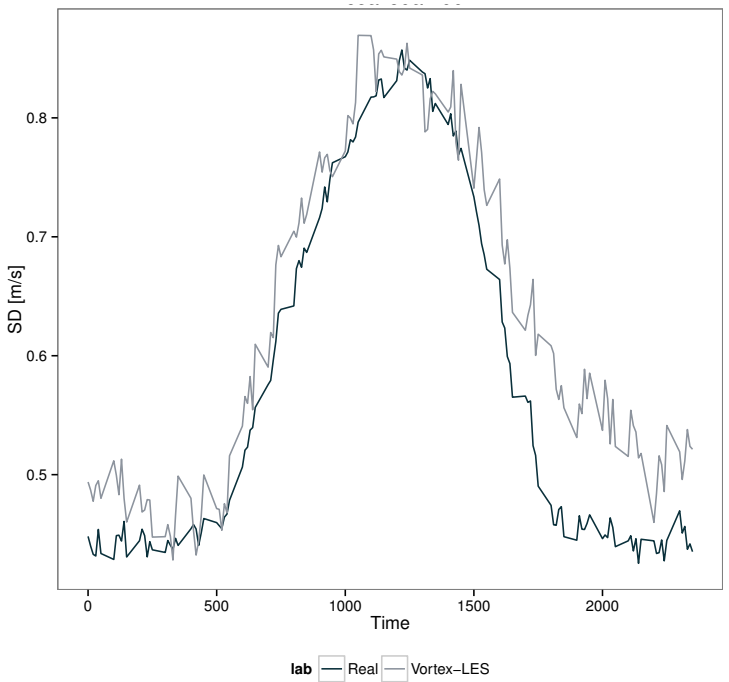


Wind speed: Vertical profiles

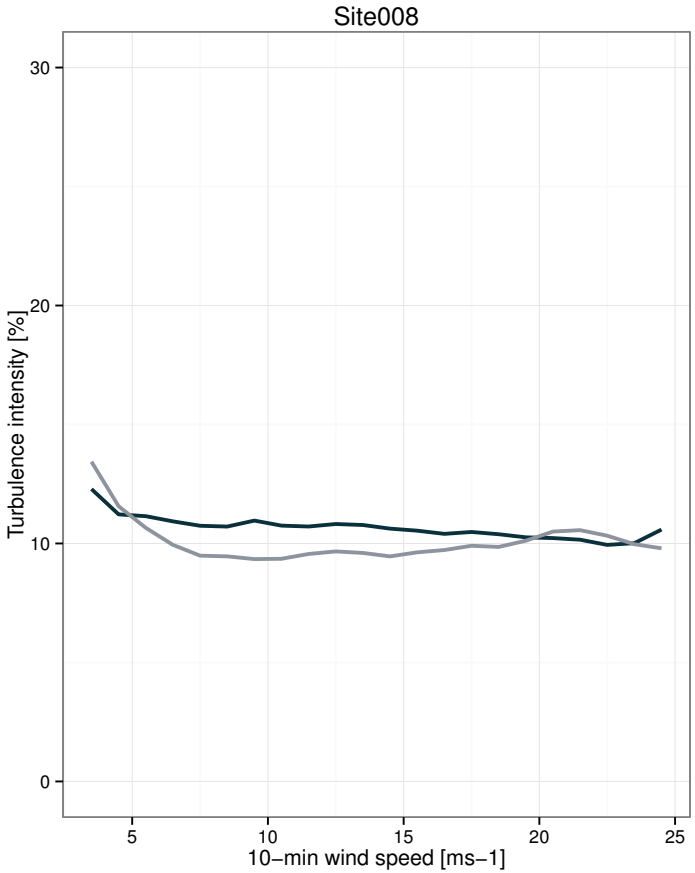


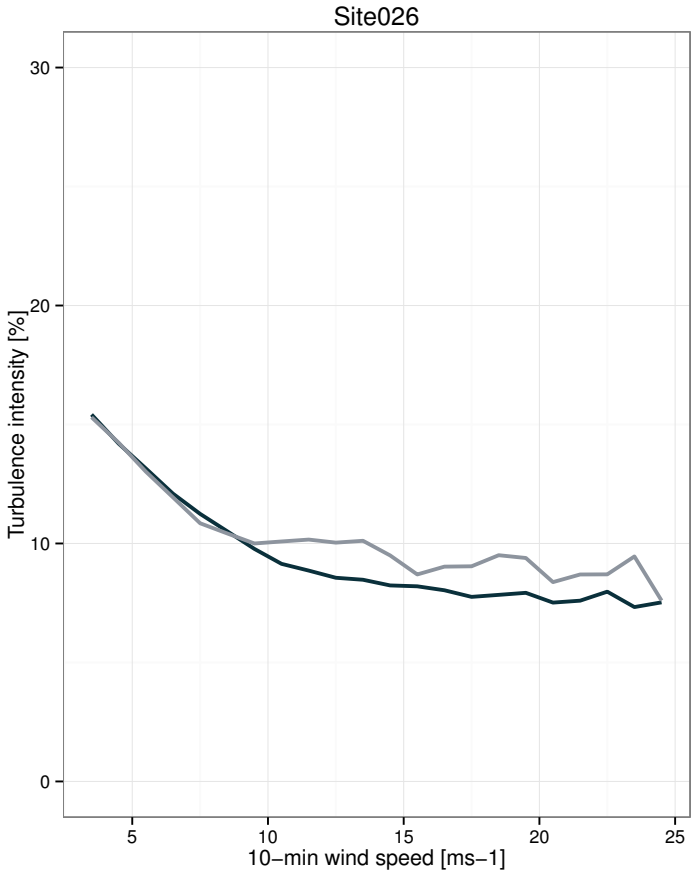
Wind standard deviation: Metrics

	Bias (ms^{-1})	RMSE (ms^{-1})	R^2 (-)
All (100%)	-0.05	0.5	0.278
Rainfed croplands (16.4%)	-0.1	0.4	0.223
Cropland (50-70%) Vegetation (20-50%) (10.9%)	0.0	0.5	0.171
Vegetation (50-70%) Cropland (20-50%) (10.9%)	0.0	0.4	0.251
Deciduous forest (40%, >5m) (9.1%)	-0.1	0.5	0.261
Evergreen forest (40%, >5m) (10.9%)	-0.1	0.6	0.309
Forest (50-70%) Grassland (20-50%) (7.3%)	-0.1	0.5	0.416
Grassland (50-70%) Forest (20-50%) (1.8%)	-0.1	0.6	0.260



Turbulence intensity





$$TI = 100\frac{\delta_{ws}}{<ws>}$$

Real

Vortex−LES

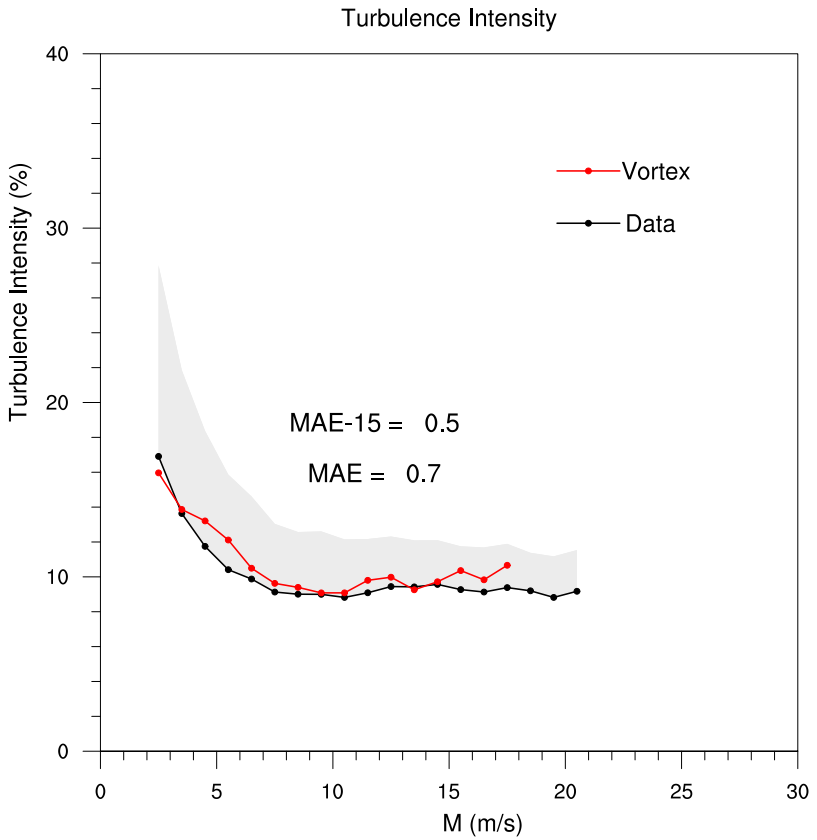
Turbulence Intensity

TI(%) validated at **58 sites**

Which metric to use?

1. MAE between TI-model against TI-obs weighted by bin-ocurrence
2. MAE at 15 m/s bin

	Average	Std Dev
MAE	1.8	0.9
MAE-15	1.9	1.1



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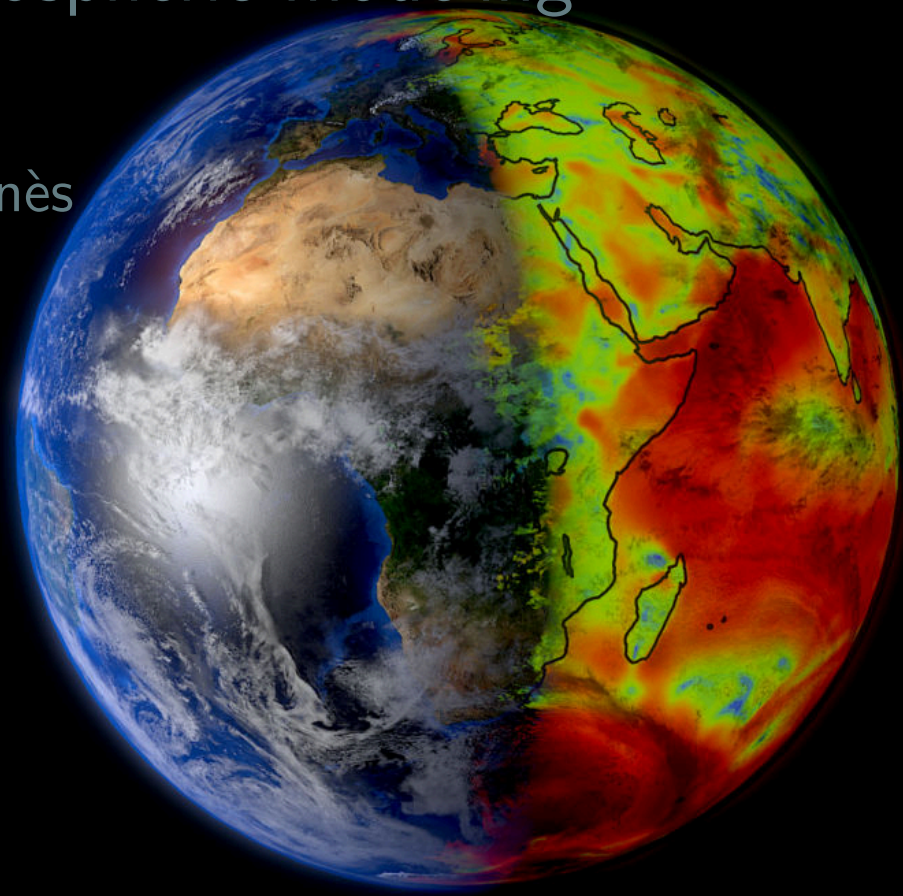

VORTEX