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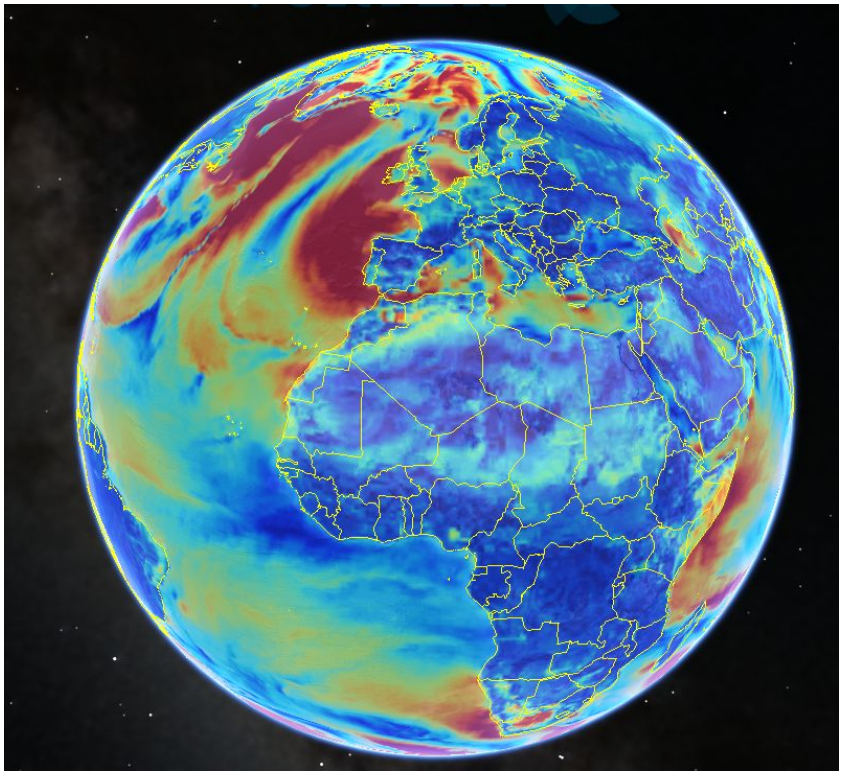
Wind Europe Resource Assessment 2017
Edinburgh, Scotland

In the next 12′ minutes

Articulating WRF models to reach the microscale

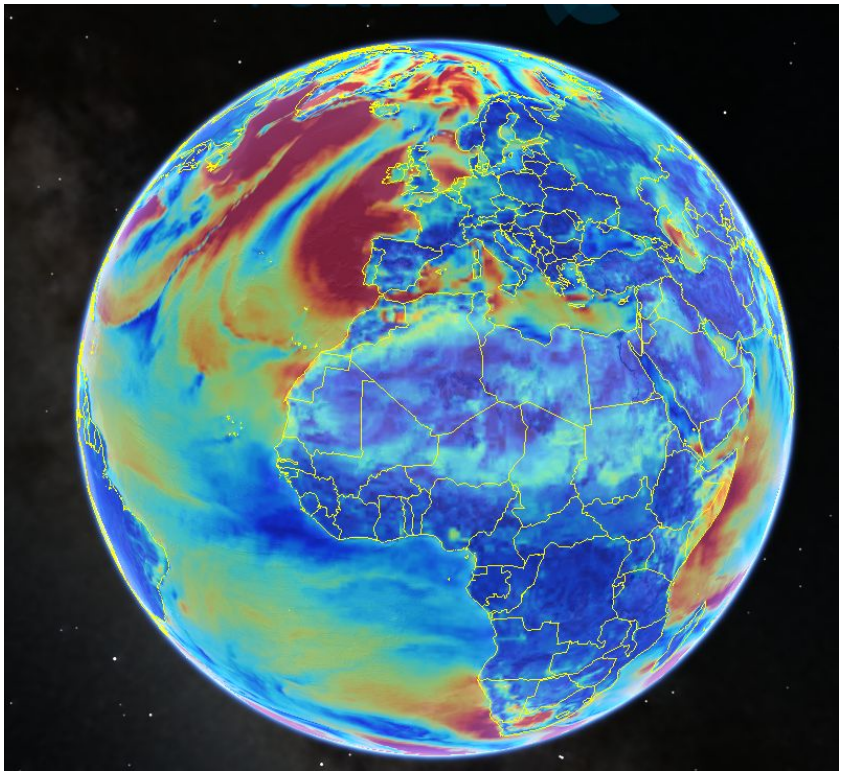
- Block 1: Mean Bias & Correlation
- Block 2: Shear
- Block 3: Site Classification
- Block 4: New Drivers, ERA5

Which Marks I would give to WRF



- ❑ A+
- ❑ A
- ❑ B
- ❑ C
- ❑ D

Which Marks I would give to WRF

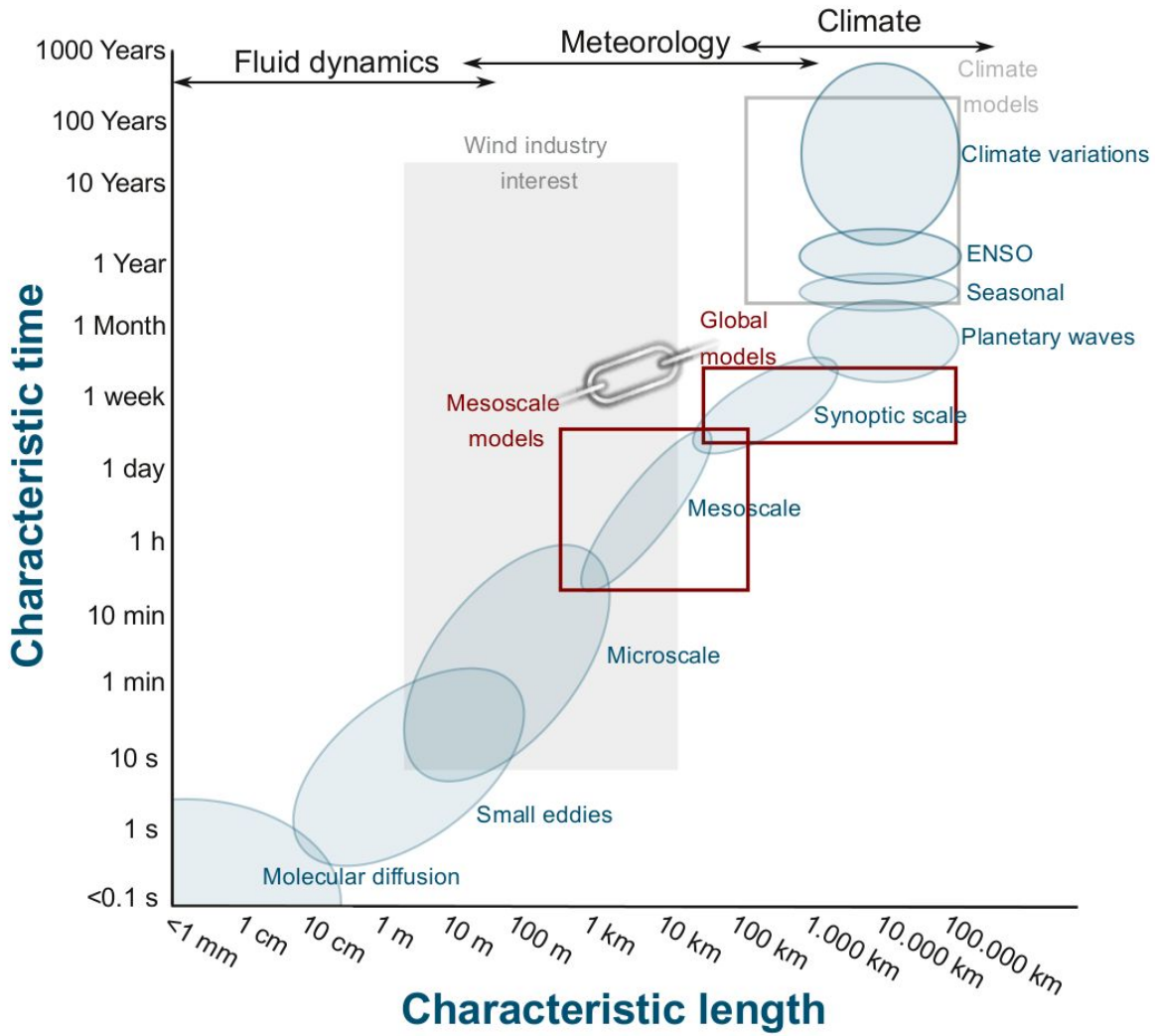


- Good enough when there is a lack of information
- Very good as LT reference

- Moderate to high Bias
- Missing micro turbulence

- Multiscale capabilities
- Model & observations

Articulating WRF to reach the microscale



Bias reduced as scales are represented

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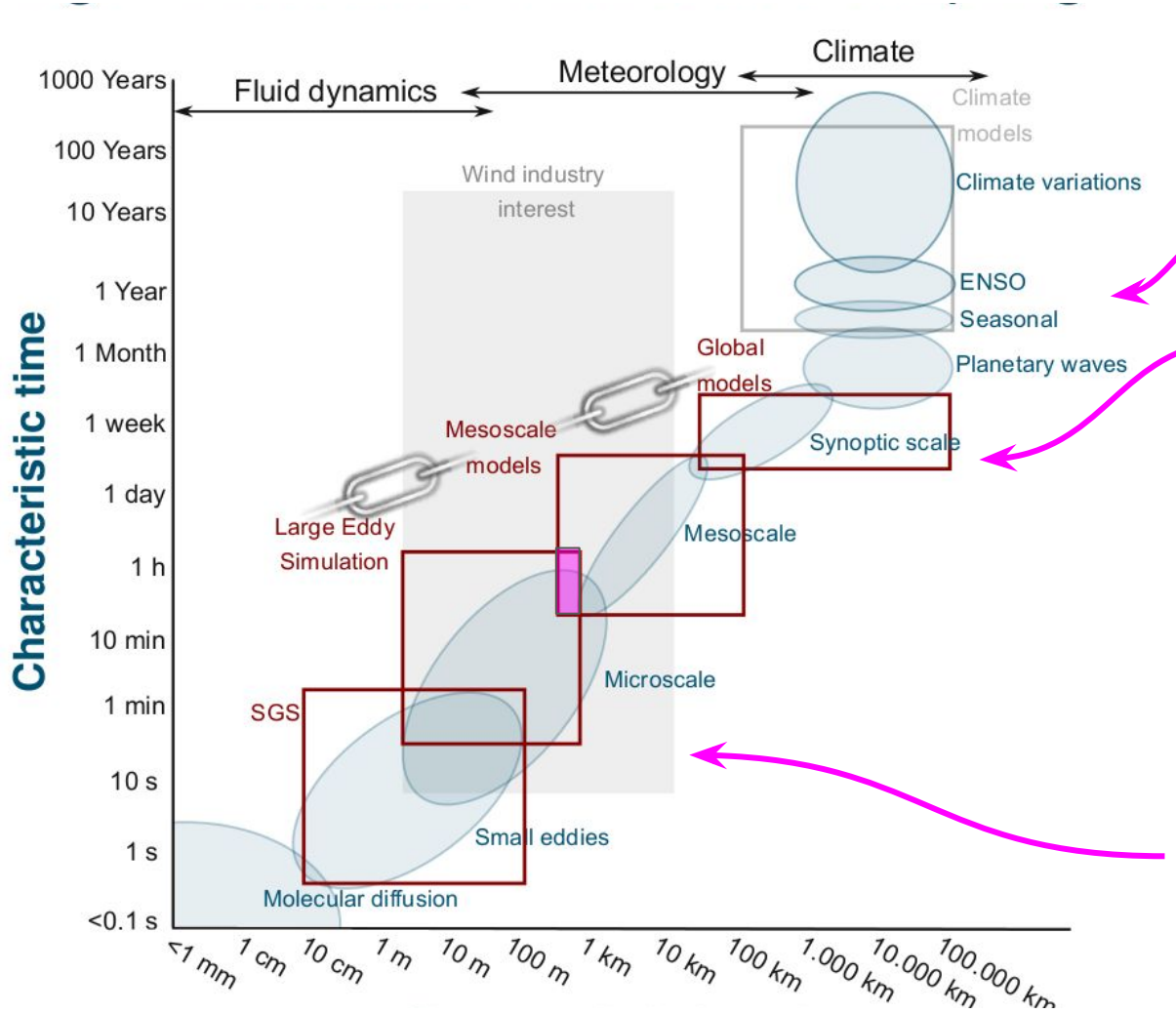
Articulating WRF to reach the microscale



Modeling Chain	
Benchmark	**New**
ERAI MERRA CFS	ERA5 MERRA2
WRF Model (standard)	WRF Model (standard)
WRF Model (standard)	WRF with LES
Subgrid	Subgrid

Complex passage : Terra Incognita

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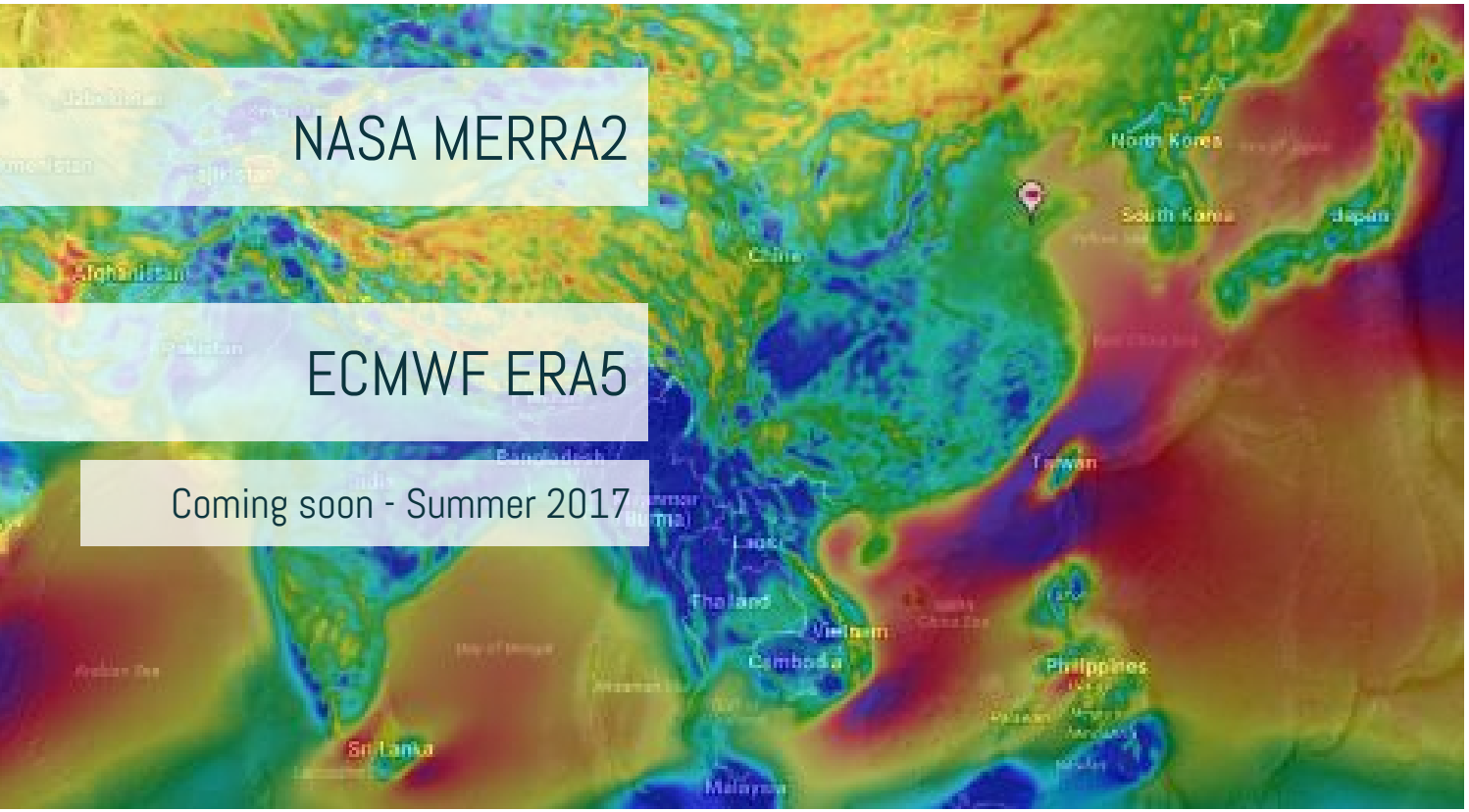
Backends: Large scale drivers



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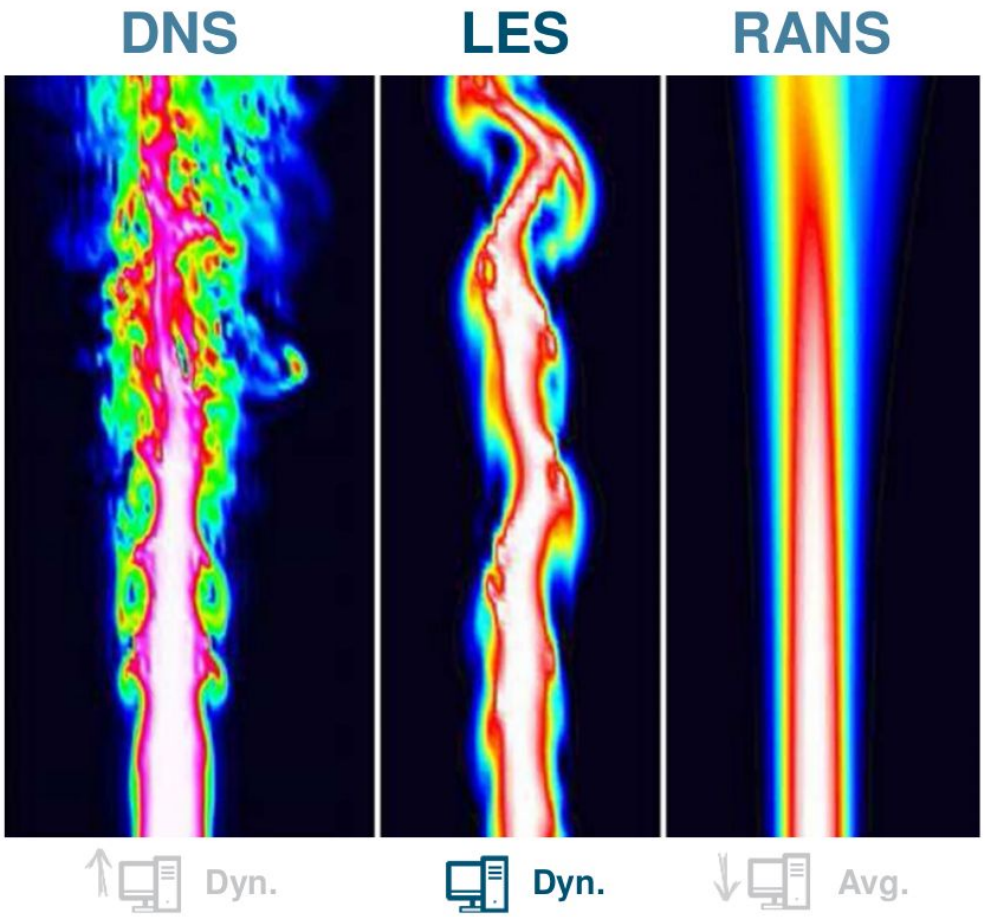
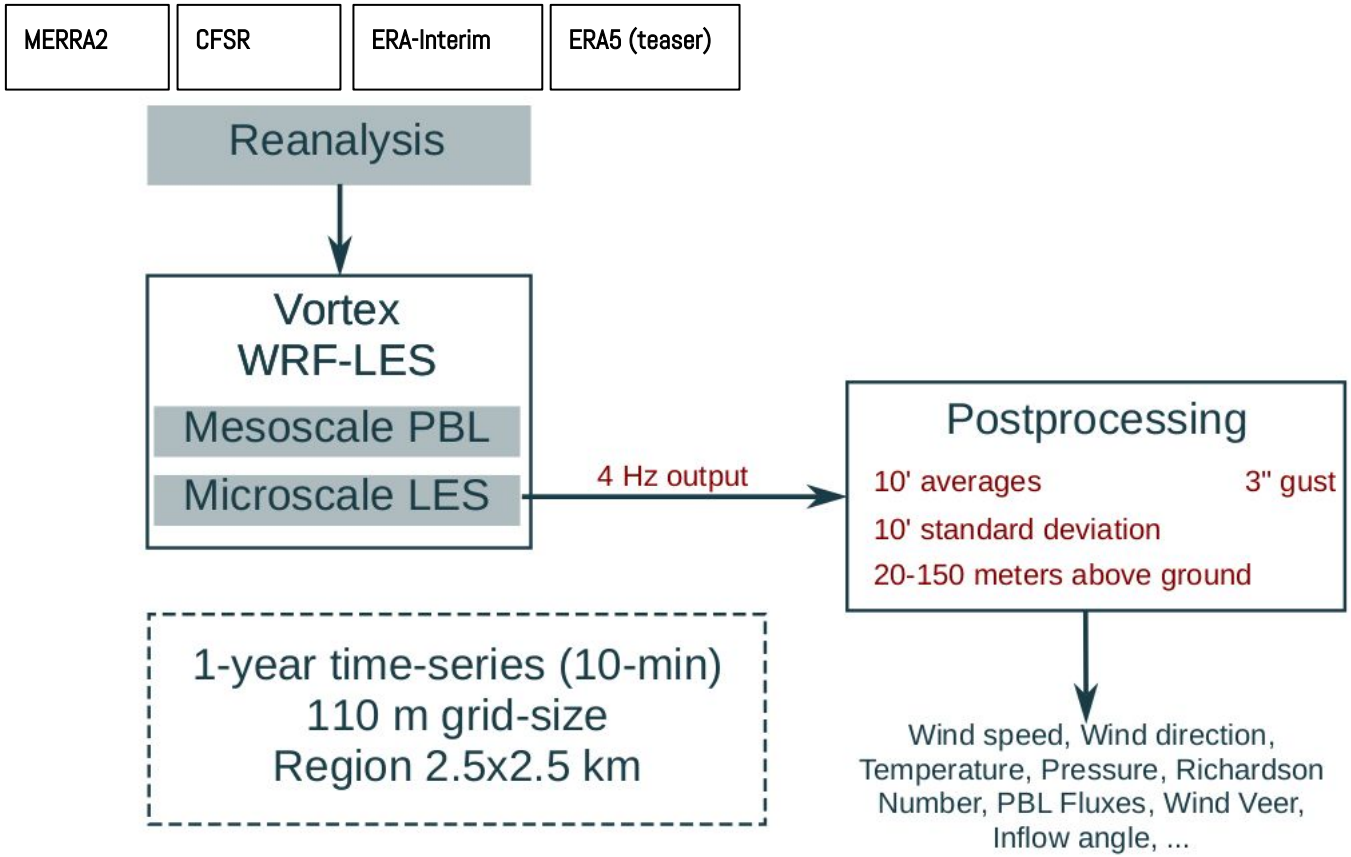
Backends: High resolution



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

REAL WORLD applications



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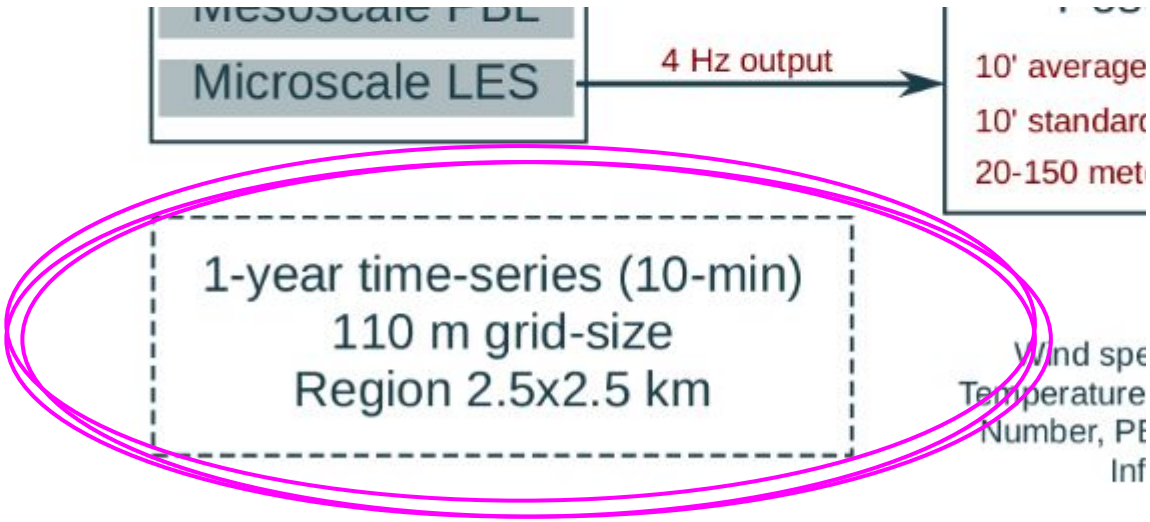


Rationale:

- **Enduser backend:** Resolution/domain vs commercial timings
- **Developers backend:** Increase resolution doesn't solve all the gaps
  - Land surface model
  - Lateral Boundary Conditions
  - Terra incognita passage

REAL WORLD applications

5% Off-shore **40% Flat Terrain** **25% Complex Terrain** **30% Forest**

Anemometers Height: **15% 20-50m** **70% 50-100m** **15% 100-110m**

Simulations spanned over **one complete year**
96 masts employed for bias & correlation assessment
56 masts for turbulence validation
Very few mast with more than one height

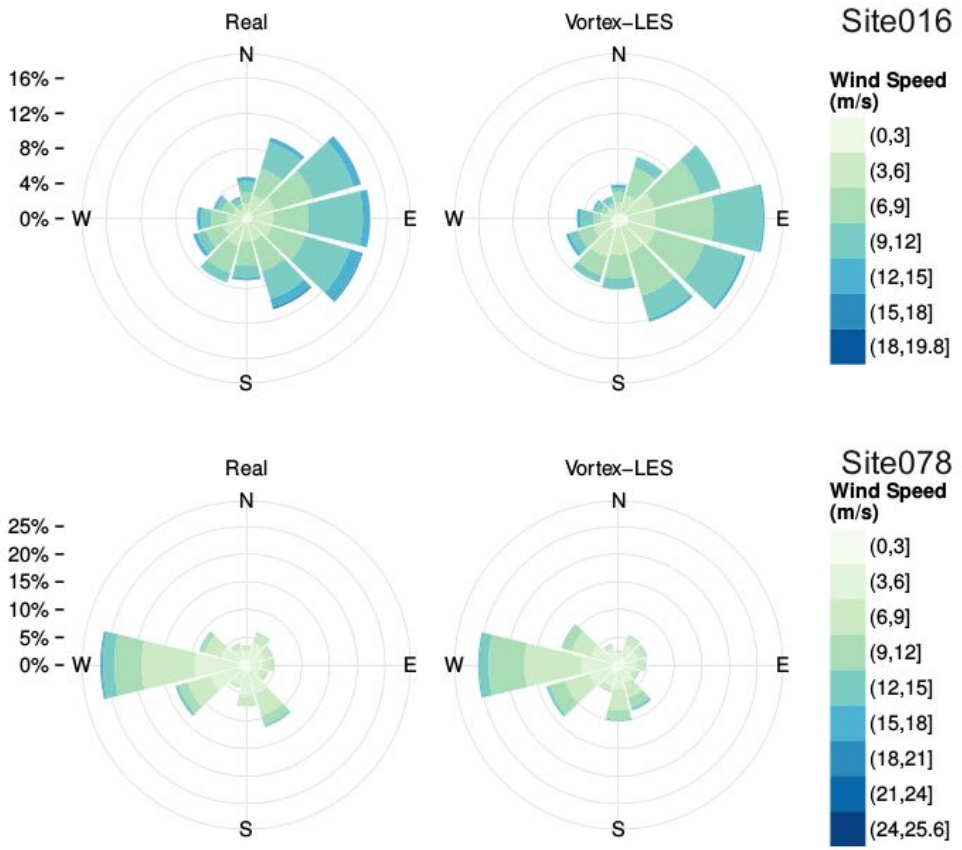
REAL WORLD applications: Bias & Correlation

Average aggregated values across sites		Average Bias (%)		RMSE		Correlation R^2 Hourly - Daily	
		Standard	WRF-LES	Standard	WRF-LES	Standard	WRF-LES
All	100%	2.7	2.4	3.9	2.5	0.62 - 0.75	0.63 - 0.80
Offhsore	5%	0.9	0.4	2.9	1.8	0.75 - 0.85	0.85 - 0.93
Flat	40%	-4.1	-3.4	3.2	2.4	0.61 - 0.76	0.62 - 0.81
Complex	25%	1.5	0.5	12.4	7.2	0.60 - 0.73	0.62 - 0.79
Forest	30%	1.2	0.4	9.5	6.8	0.63 - 0.74	0.69 - 0.80

- Bias signal is more systematic in flat terrain while more noisy in complex
- Notion of "flat & complex" should be revisited (complex flow) & localized
- Same bias tendencies in both standard and less configurations
- Less variability across sites
- Improvement in correlation (daily cycle low & high tails)

REAL WORLD applications: Bias & Correlation

		Bias (deg)	MAE (deg)
All (100%)	10-min	3	35
Offshore 5%	10-min	-2	18
Flat 30%	10-min	0	34
Complex 25%	10-min	2	34
Forest 30%	10-min	10	31



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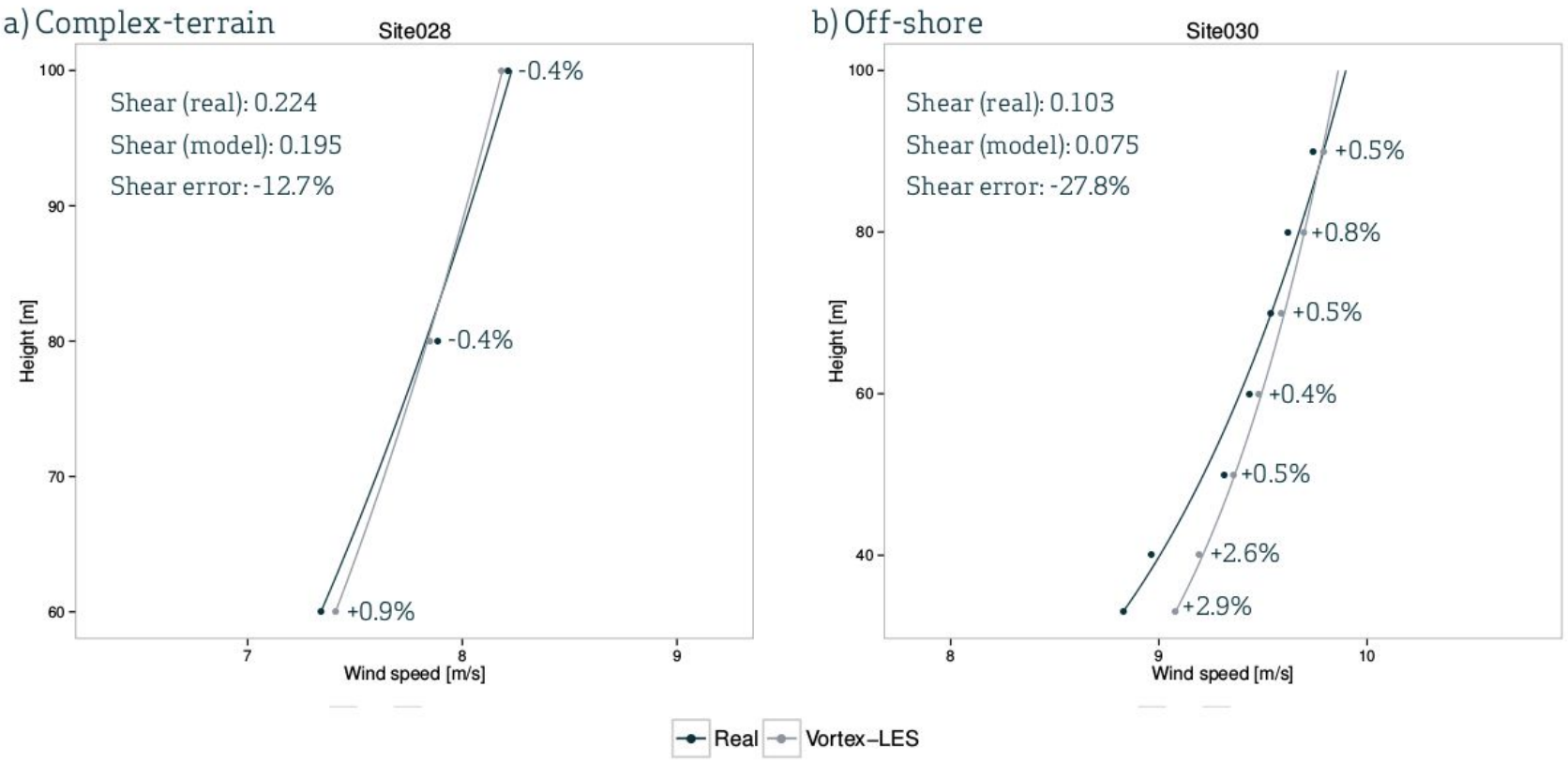
REAL WORLD applications: Shear



Note: Mest Mast data as proxy for REAL
(*"who knows what is real"* T. Blodau)

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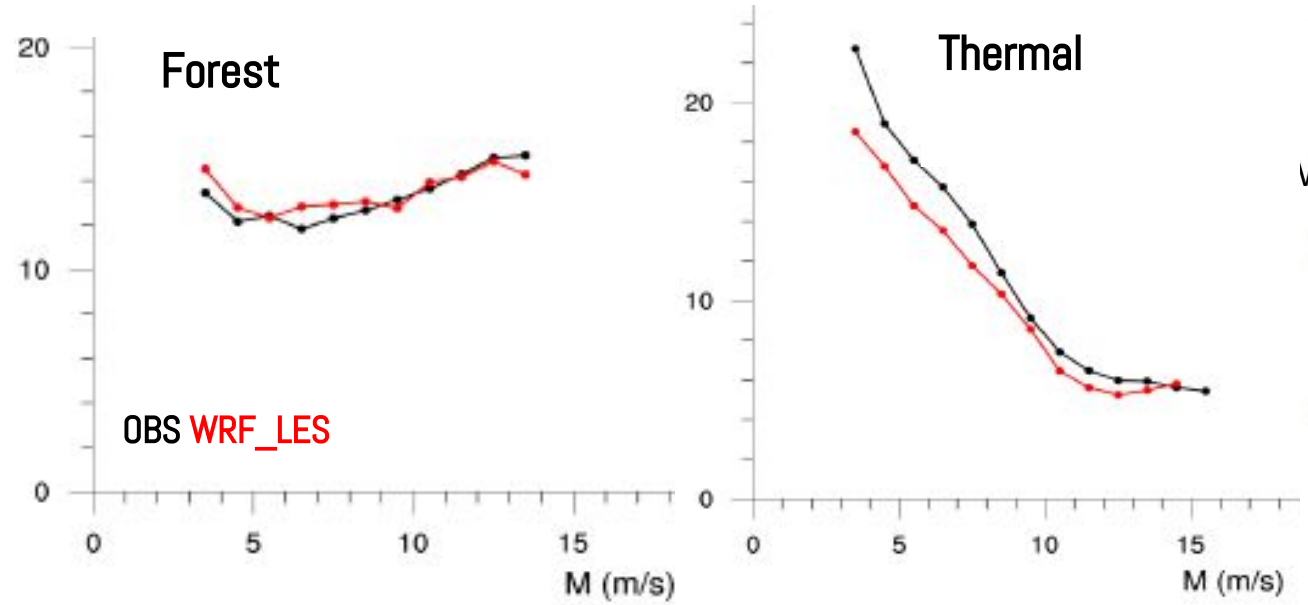
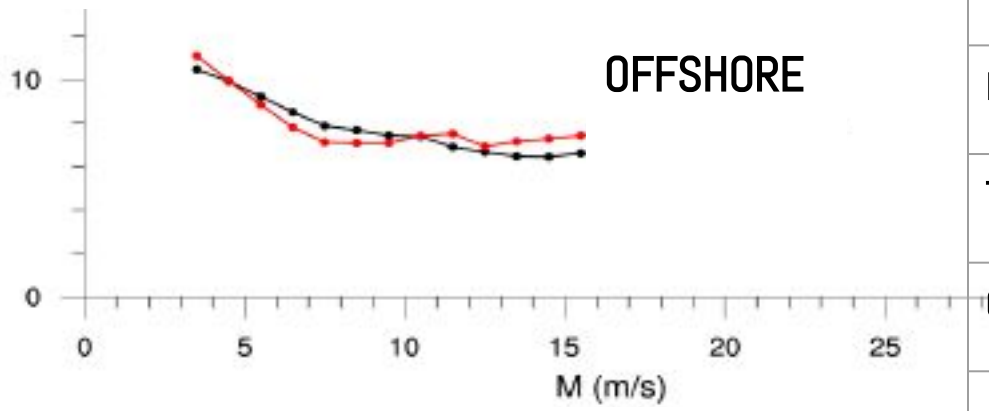
REAL WORLD applications: Turbulence



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



	OBS (m/s)	WRF_LES (m/s)	TI bias 1 (%)	TI bias 2 (%)
Forest	6.4	6.9	0.6	0.5
Thermal	7.9	7.7	1.5	1.5
Offshore	10.2	10.1	06	0.8
All	-	-	1.9	1.8

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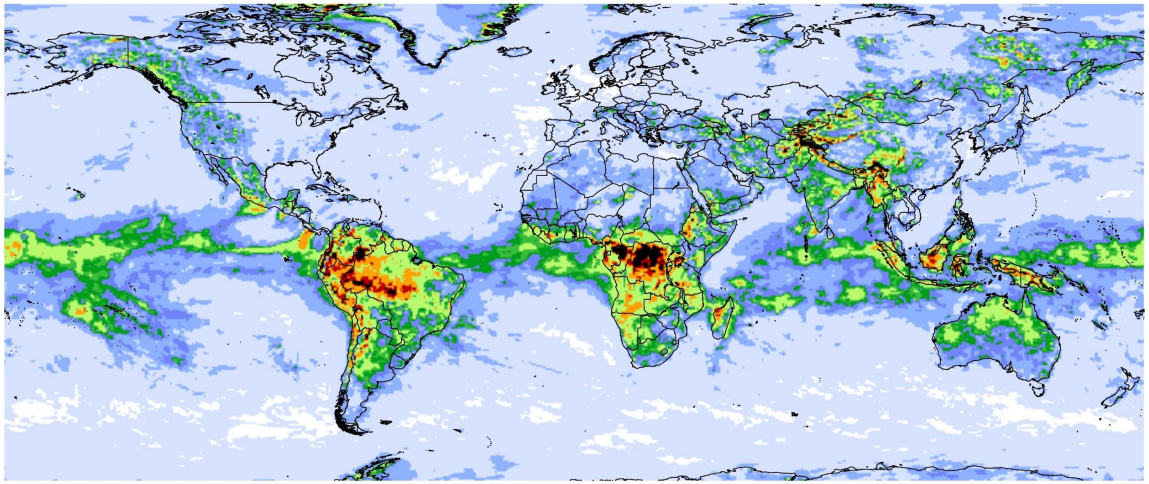
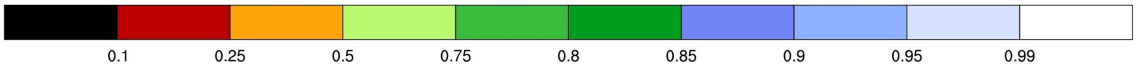
REAL WORLD applications: ERA5

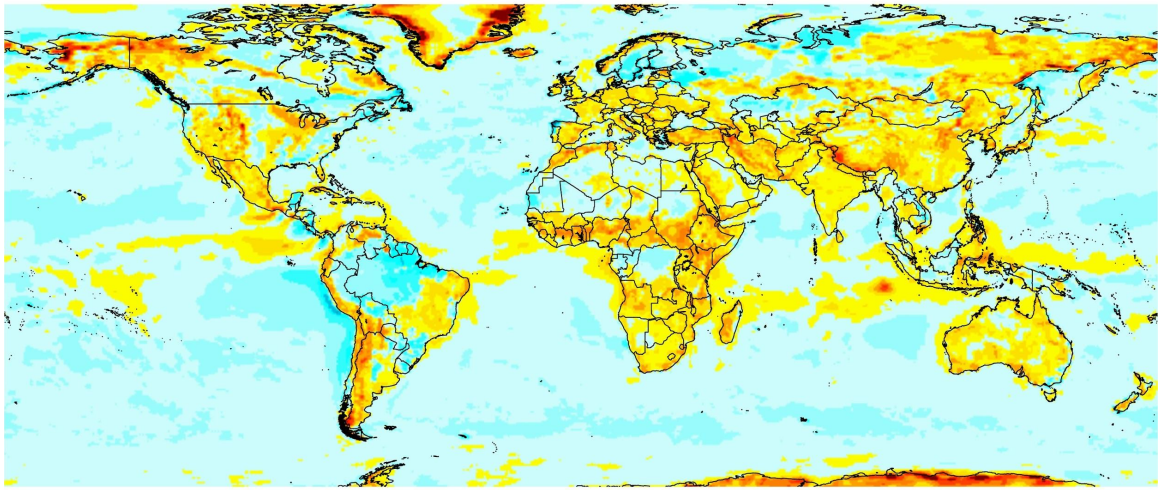
10m daily R2

MERRA2-ERA5





MERRA2-ERAI Diff



26 SITES	Jan-Feb 2016	
	WRF-CFSR (3KM)	WRF-ERA5 (3km)
R2 Hourly	0.59	0.68 (+
R2 daily	0.79	0.86
RMSE (m/s)	2.66	2.37
MAE (%)	13.9	13.1

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Comments

Same bias trends, lower aggregated values	WRF-LES
More compact & robust results (lower RMSE)	
Increase accuracy on the tails (higher correlation)	
Fair enough turbulence representation (site classes)	
ERA5 teaser promising	Drivers

Superman model is not here yet

Models are getting more complex, efficient and accurate

Are sites getting more complex as well ?

Large windfarm | Tall Towers | Offshore | Low winds

Extreme climates | Typhoons | Tropics & Subtropics

Complex Sites 2.0

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