TIMES

TOWARDS THE ULTIMATE WIND TIME-SERIES: LONG-TERM AND HIGH-RESOLUTION, ALL TOGETHER

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Vortex FdC

VORTEX

TIMES

OUTLINE

Motivation

Methodology

Validation & Results

Key Takeaways

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TIMES Motivation

Goal is to create a long-term dataset that includes the benefits of microscale modeling without the excessive computational cost.

Mesoscale+Microscale

- 10min
- Cover a long period (decades)
- Reasonable cost
- Long Term Values and Interannual Variability
- Focus on wind distribution accuracy
- Includes local effects
- Turbulence Intensity

TIMES Deliverables

Lat=<LAT> Lon=<LON> Hub-Height=<HH> Timezone=<TZ> (file requested on <DATETIME> UTC0)
VORTEX (www.vortexfdc.com) - Computed at 333 m resolution based on ERA5 data

YYYYMMDD	HHMM	M(m/s)	D(deg)	SD(m/s)	T(C)	De(k/m3)	PRE(hPa)	RiNumber	RH(%)	RMOL(1/m)	VertM(m/s)
20030101	0000	7.30	32.4	0.16	1.9	1.24	975.7	0.14	59.3	0.0226	0.02
20030101	0010	6.68	37.2	0.51	1.9	1.24	975.9	-0.06	59.4	0.0365	0.02
20030101	0020	7.17	37.6	0.36	1.0	1.24	975.9	0.64	59.1	0.0479	-0.08
20030101	0030	7.24	42.2	0.49	2.0	1.24	975.9	0.28	58.8	0.0513	0.35
20030101	0040	7.13	37.4	0.42	1.5	1.24	975.8	-0.07	58.7	0.0489	-0.03
20030101	0050	7.95	39.0	0.34	0.8	1.24	975.8	0.64	58.7	0.0429	-0.16
20030101	0100	7.89	39.6	0.47	1.2	1.24	975.8	0.36	58.9	0.0295	-0.20
20030101	0110	8.22	38.8	0.15	1.6	1.24	975.7	0.12	59.2	0.0194	0.18
20030101	0120	8.34	35.5	0.42	1.0	1.24	975.8	0.82	59.4	0.0135	-0.02
20030101	0130	9.23	37.8	0.50	1.5	1.24	975.7	0.41	59.5	0.0103	0.00
20030101	0140	9.66	32.3	0.30	1.7	1.24	975.6	0.39	59.7	0.0088	-0.03

(...)

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TIMES Methodology

Atmospheric simulations using the Weather Research and Forecasting Model (WRF). Dynamical downscaling of the reanalysis.

Baseline WRF simulation

- Resolution: 300m
- Period: 20 years
- Explicitly solving microscale: NO
- Boundary conditions: ERA5
- Output frequency: 10min
- Affordable

WRF-LES simulation

- Resolution: 100m
- Period: 6 months
- Explicitly solving microscale: YES
- Boundary conditions: ERA5
- Output frequency: 10min
- Expensive

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TIMES Methodology

The LES Enhancement has three main targets:

1→ Wind Distribution

2 → Turbulence

3 → Sub-Hourly Variability

MLA is used to trespass LES modeling accuracy & microscale description into the long-term WRF baseline. Information from all meteorological variables is used.

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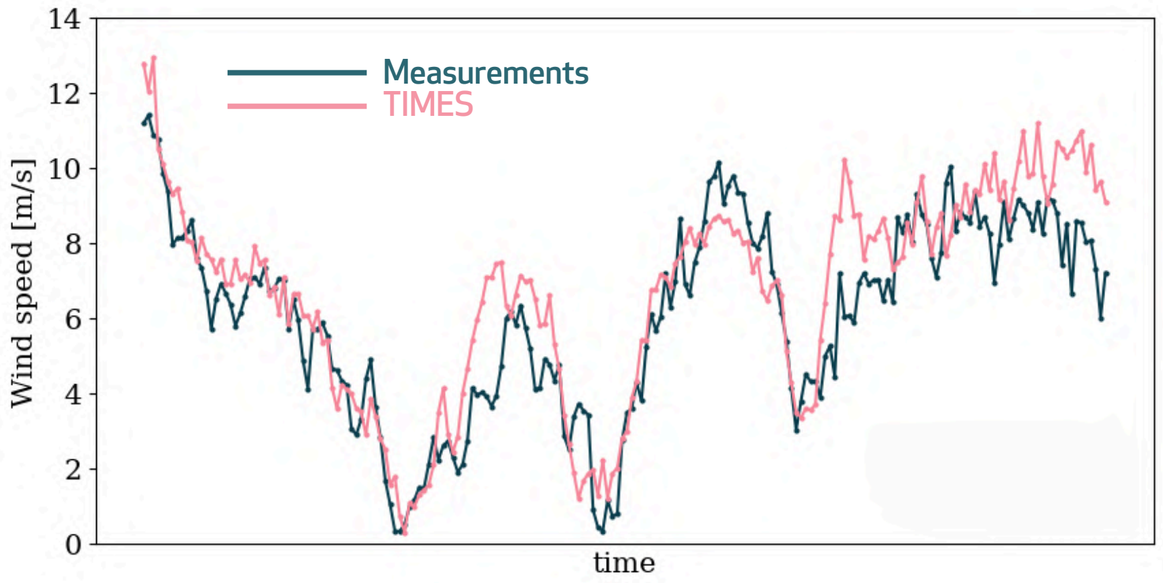
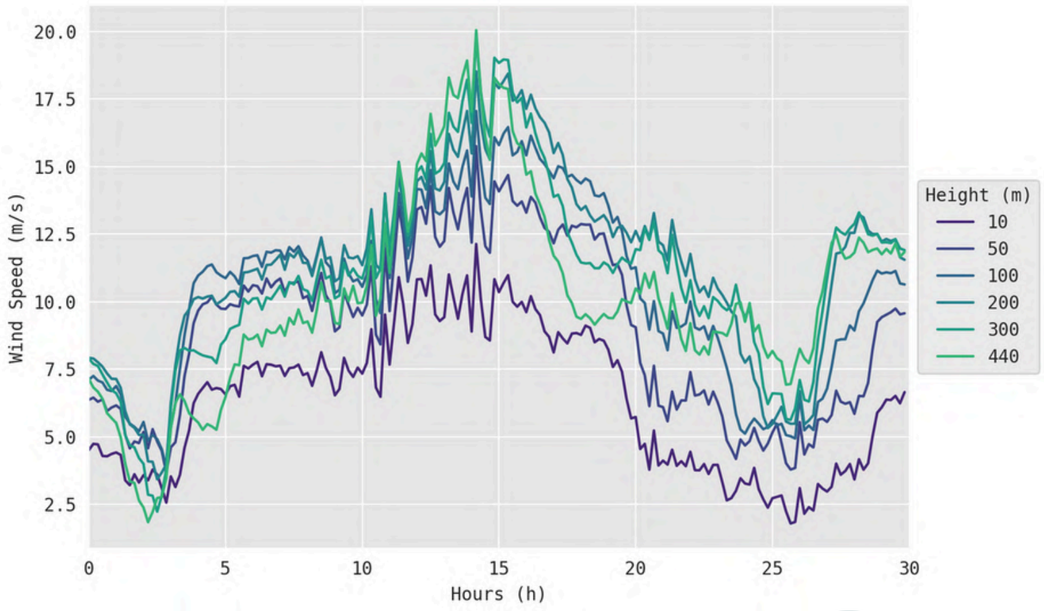
TIMES Methodology

Example of series daily variability:

Wind Speed for one day



Model Wind Speed (m/s)for several heights



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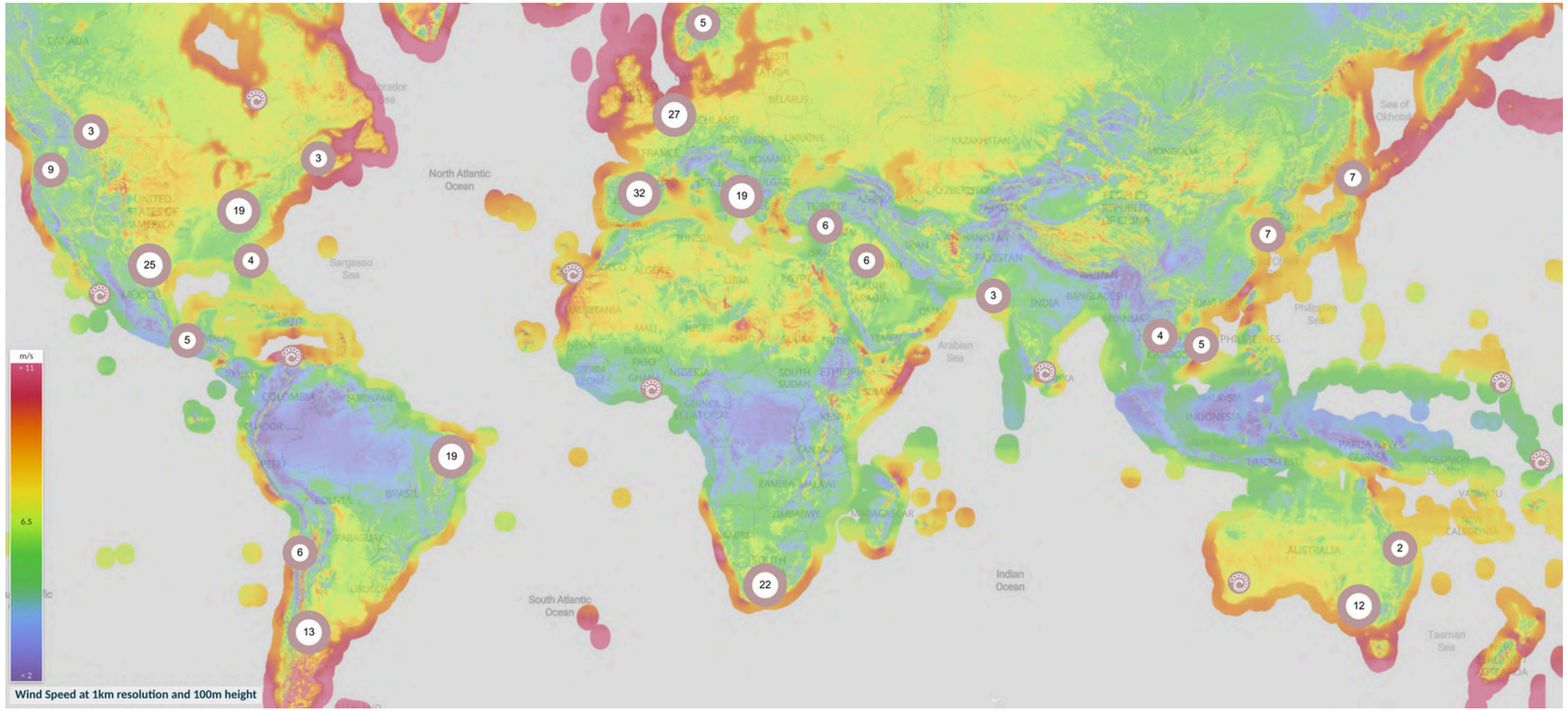
TIMES Validation

272 Sites Worldwide



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TIMES Validation

Benefits of the long-term TIMES dataset compared to reanalysis:

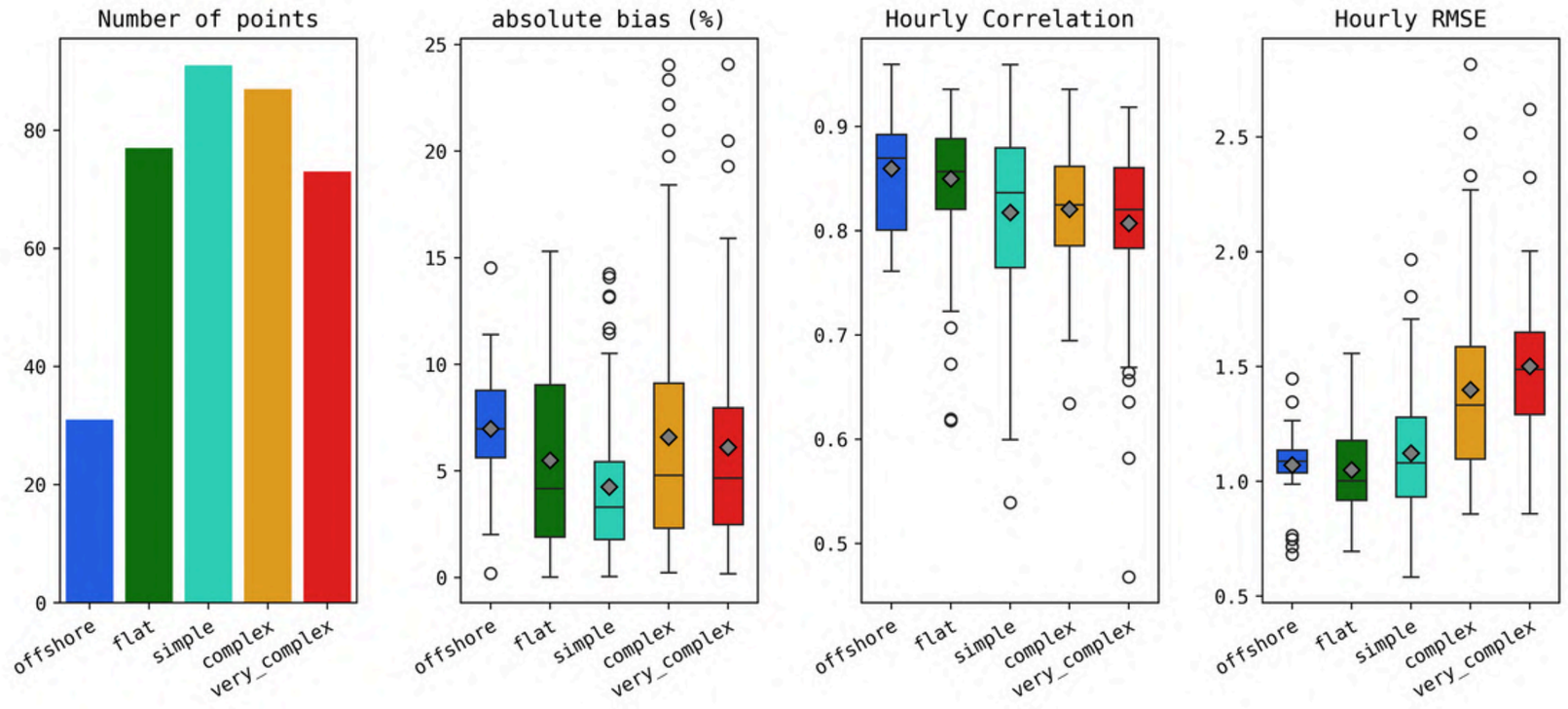
- It is microscale: better accuracy, describes the local effects at the site
- It is 10-min
- With multiple heights
- It contains many variables

TIMES Validation

	World (272 sites)
Mean Wind Speed Absolute Bias (%)	5.71 ± 4.72
Mean Wind Speed Bias (%)	0.003 ± 7.393
10-min Wind Speed RMSE (m/s)	2.04 ± 0.47
10-min Wind Speed Correlation	0.70 ± 0.09

TIMES Validation

Metrics by Terrain Complexity World (272 sites)



Terrain Complexity is a metric derived from the range and maximum values of terrain height and slope for the surrounding area of the point.

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TIMES Validation

Benefits of the long-term TIMES dataset compared to reanalysis:

- **It is microscale**
- **It is 10-min: realistic texture, extreme wind speeds**
- **With multiple heights**
- **It contains many variables**

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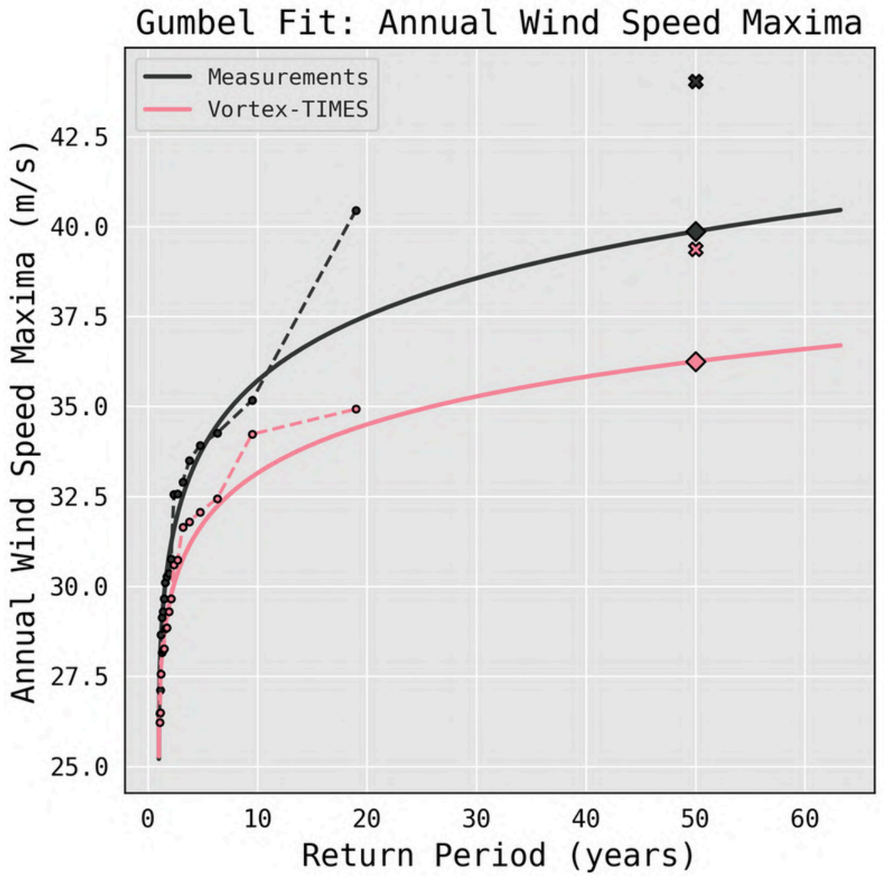
TIMES Validation



Vref50: Maximum Wind Speed for 50-year return period

Validated at 30 points in the world (with more than 8 years of data)

	Vref (30 points)
Vref50 Absolute Bias (%)	11.09 ± 6.72
Vref50 Bias (%)	-6.98 ± 11.05

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TIMES Validation

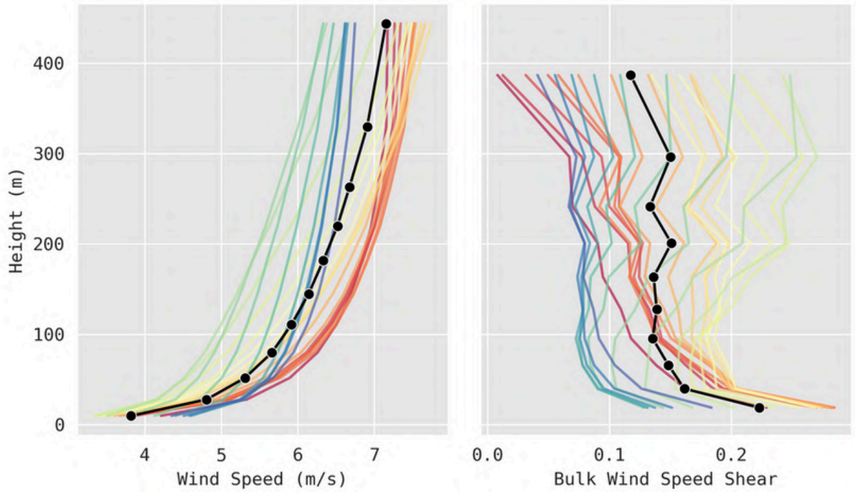
Benefits of the long-term TIMES dataset compared to reanalysis:

- It is microscale
- It is 10-min
- With multiple heights: easier vertical extrapolation, shear and veer analysis
- It contains many variables

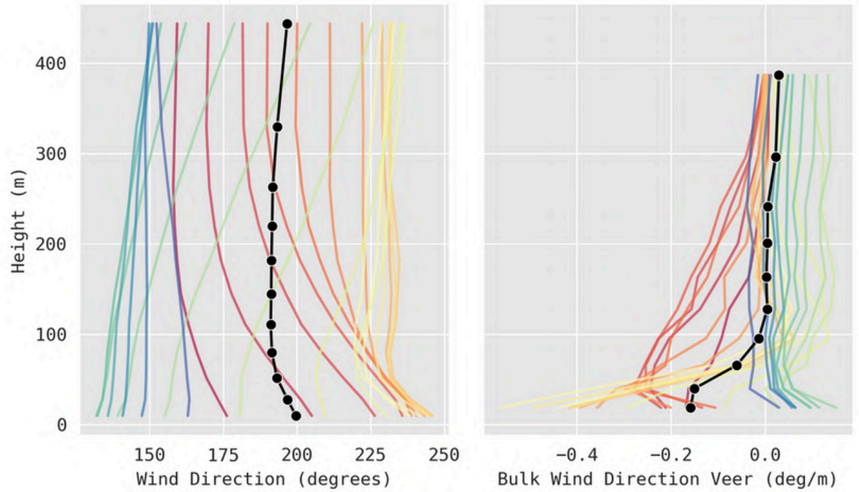
TIMES Validation

Mean Vertical Profiles

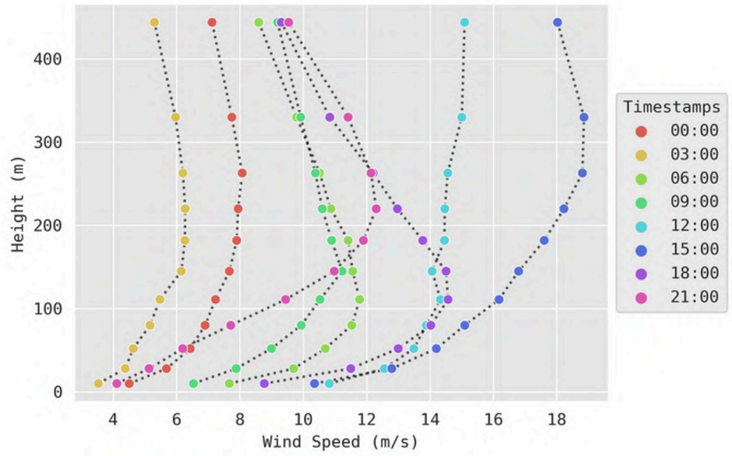
Wind Speed and Shear



Wind Direction and Veer



Wind Speed Vertical Structure



Black: Full mean
Colors: Profile for each hour

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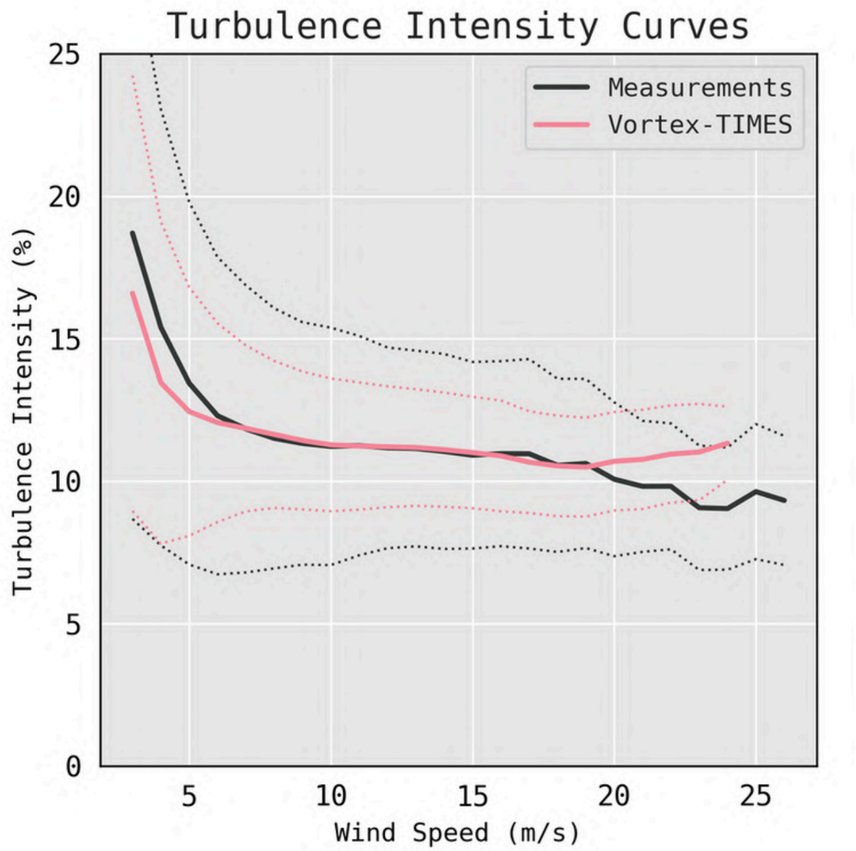
TIMES Validation

Benefits of the long-term TIMES dataset compared to reanalysis:

- It is microscale
- It is 10-min
- With multiple heights
- It contains many variables: can study long-term turbulence intensity, atmospheric stability, etc.

TIMES Validation



Turbulence Intensity Curve (101 points)

Mean TI Curve	Absolute Bias (%)	13.96 ± 8.17
	Correlation	0.51 ± 0.36
	RMSE (% of TI)	1.70 ± 0.80

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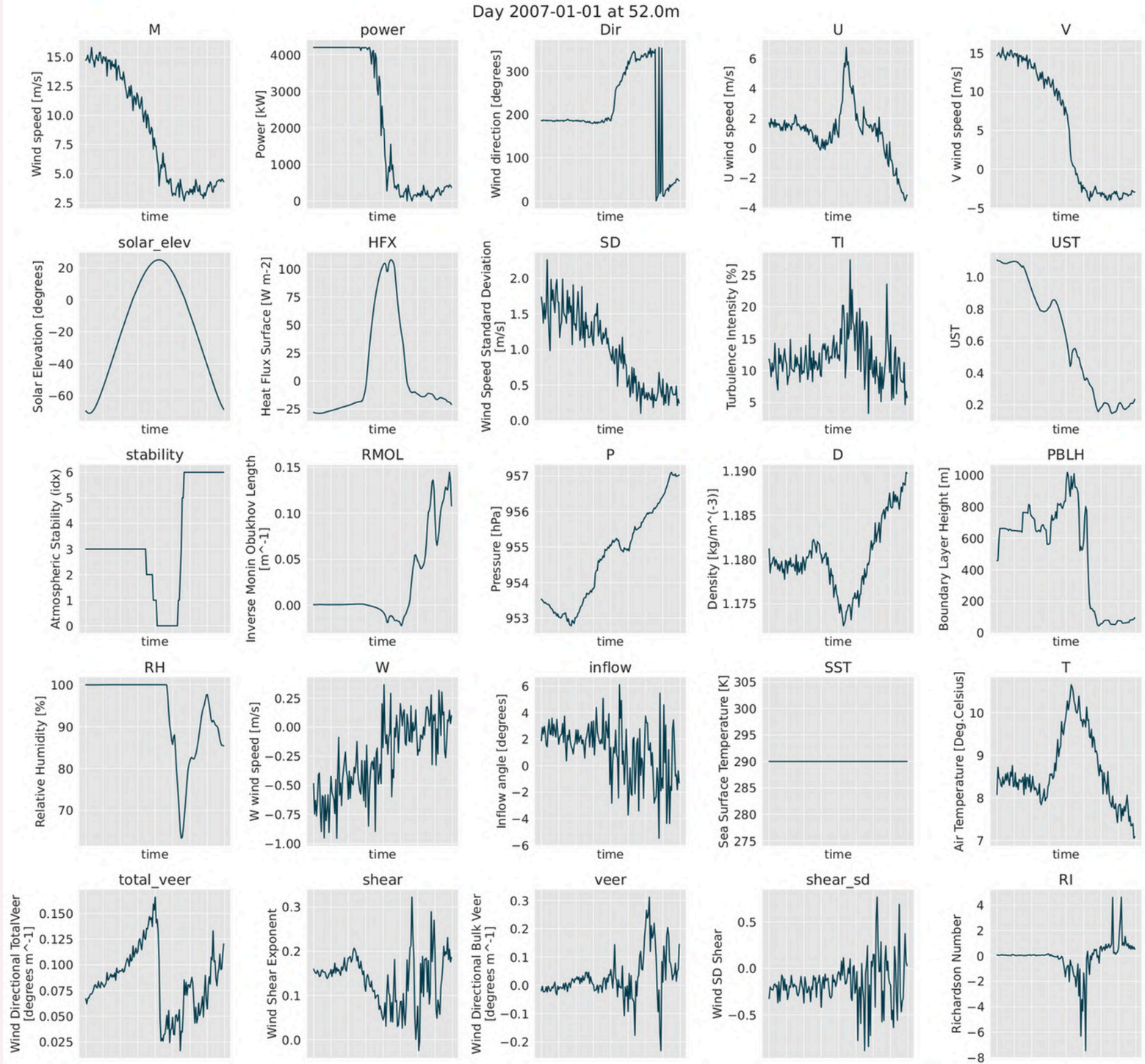
Some Plots

- Daily evolution of model variables at a glance.
- We can check the consistency and physicality of results.

X-axis: 10-min timestamps for one day



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Key Takeaways

- **Long-term 10-min high resolution time series are useful for a complete wind resource assessment study at a site.**

- **The methodology of using a short WRF-LES simulation to enhance a baseline WRF simulation has been proven to be robust and accurate.**

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TIMES Remodeling

- A calibration tool is available: TIMES-Remodeling.
- Allows the use of measurements to calibrate the long-term modeled dataset.
- Based on our own MCP focusing on the time-domain.
- Wind speed, wind direction and turbulence are calibrated.

Thank you for your attention!

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