MEGAJOULE
Rethinking Energy Worldwide

iea wind

IEA Wind Task 11 - Topical Expert Meeting #111

End-user Perspective on the Usage of Wind Reanalysis

DTU, Copenhagen

25th April 2024

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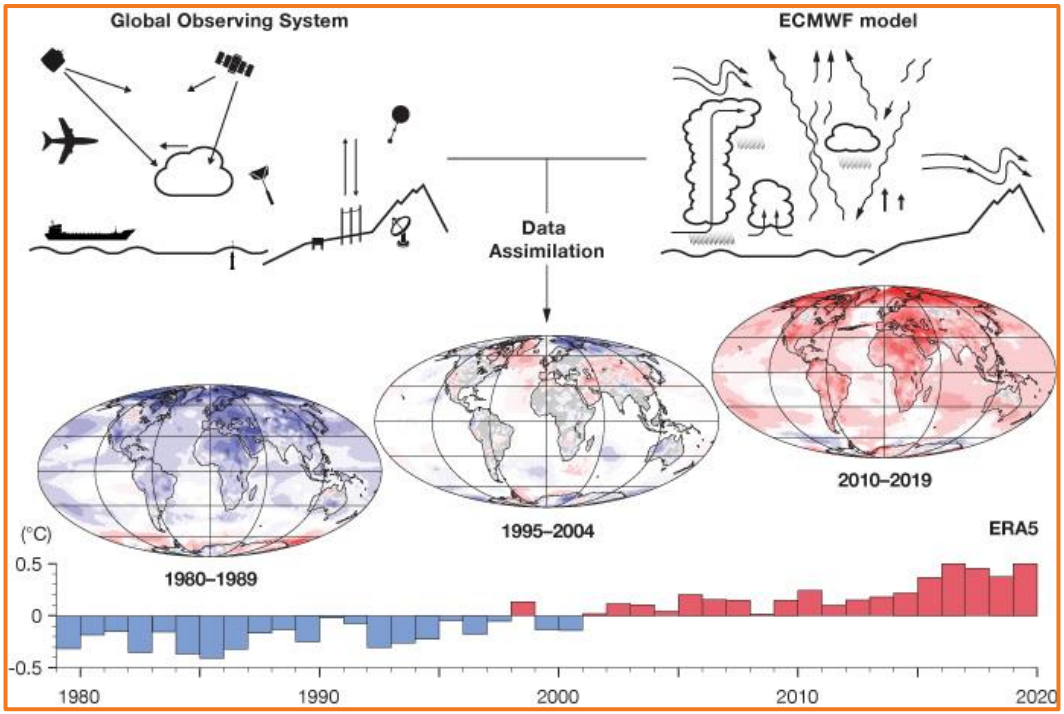
Climate Reanalysis

Climate Reanalysis

Climate reanalyses combines past observations with models to generate consistent time series of multiple climate variables **(wind speed and direction, temperature, relative humidity, absolute pressure)**. Reanalyses are among the most-used datasets in the geophysical sciences. They provide a comprehensive description of the observed climate.



Schematic of the reanalysis process [1]

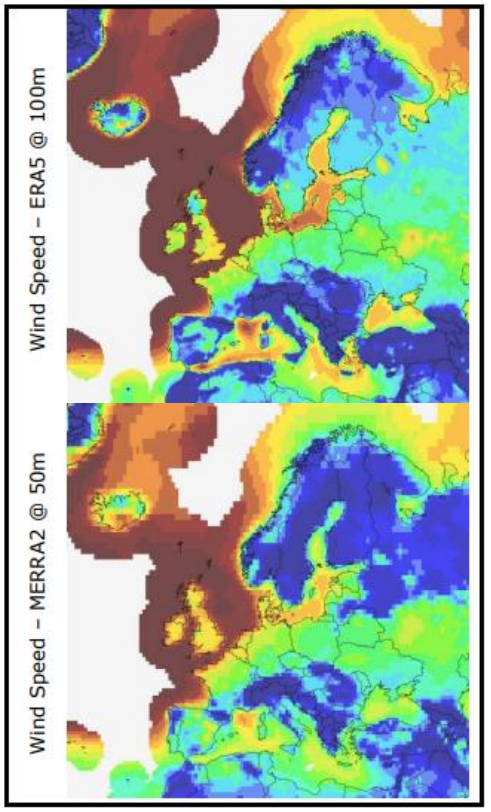
[1] – European Centre for Medium-Range Weather Forecasts, "Fact sheet: Reanalysis", https://www.ecmwf.int/

Most commonly used reanalysis in wind projects

ERA5: Public climate reanalysis produced by ECMWF, providing hourly data on many atmospheric, land-surface and sea-state parameter. Available from 1950 and with a latitude-longitude resolution of 31 km, ERA5 is the most used series in our studies. [2]

MERRA-2: Global atmospheric reanalysis produced by NASA GMAO. Available from 1980 and with a latitude-longitude resolution of 50 km. [3]

CFSv2: Global, high resolution reanalysis product, with a global atmosphere resolution of ~38 km. The period of records begins on April 1, 2011 and continues onward. [4]



European resource grid using ERA5 and MERRA2 Reanalysis [5]

[2] – Copernicus Climate Change Service , "Climate reanalysis", https://climate.copernicus.eu/climate-reanalysis

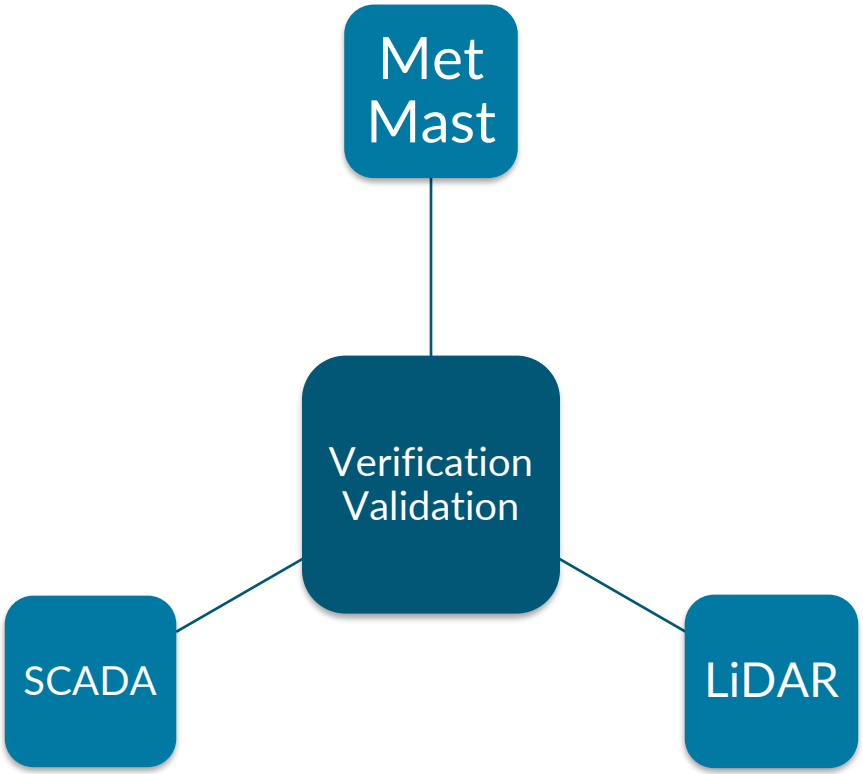
[3] – National Aeronautics and Space Administration, "Modern-Era Retrospective analysis for Research and Applications, Version 2", https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

[4] – windPRO Wiki, "CFS- and CFSR Data", https://help.emd.dk/mediawiki/index.php/CFS-_and_CFSR_Data

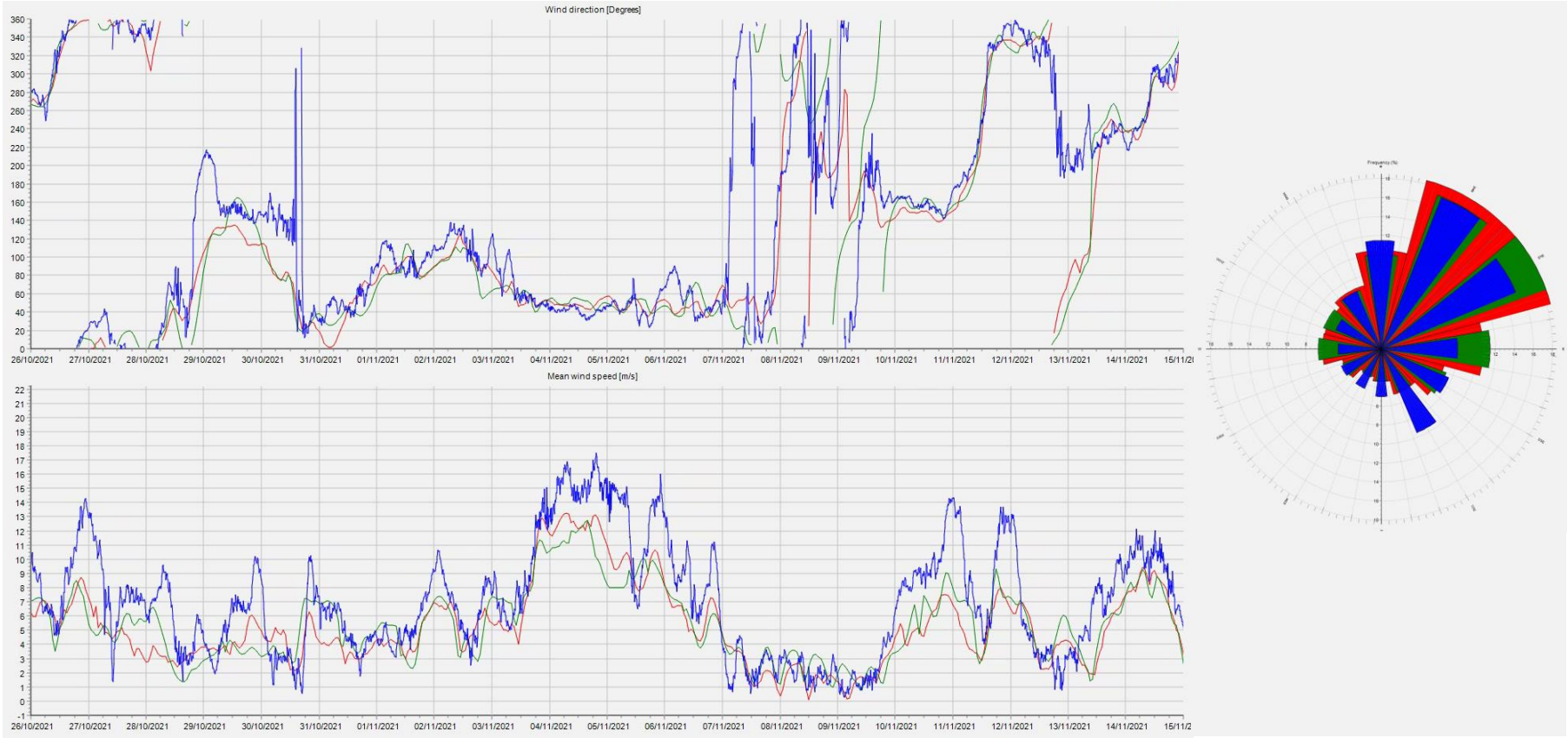
[5] – EMD International A/S, "Release note: ERA5–The (Not So) Long Term Reference Wind Data – years 2010-2016"

Wind Reanalysis: Applications in Wind Studies

Data Verification & Validation

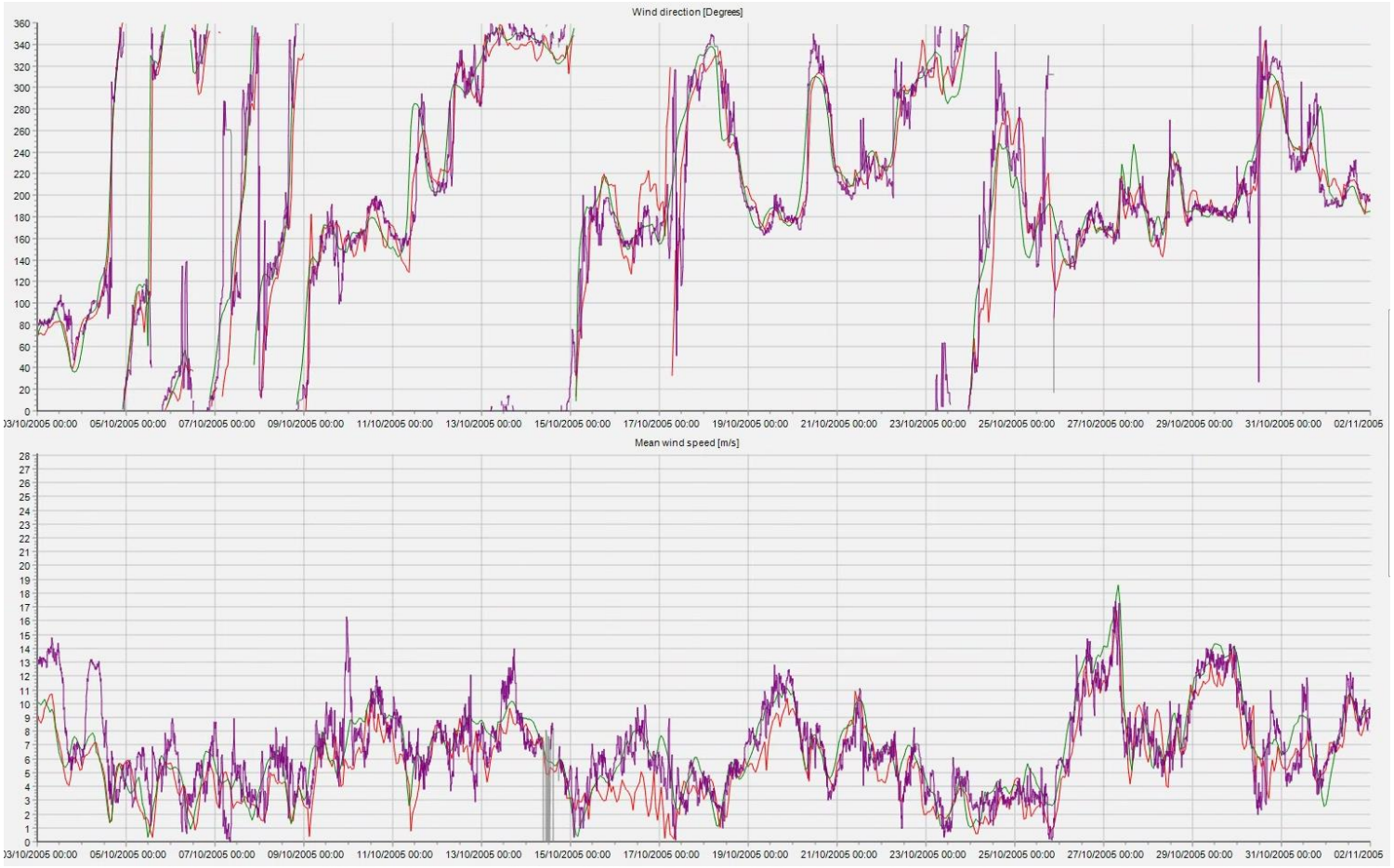


Example: Validation



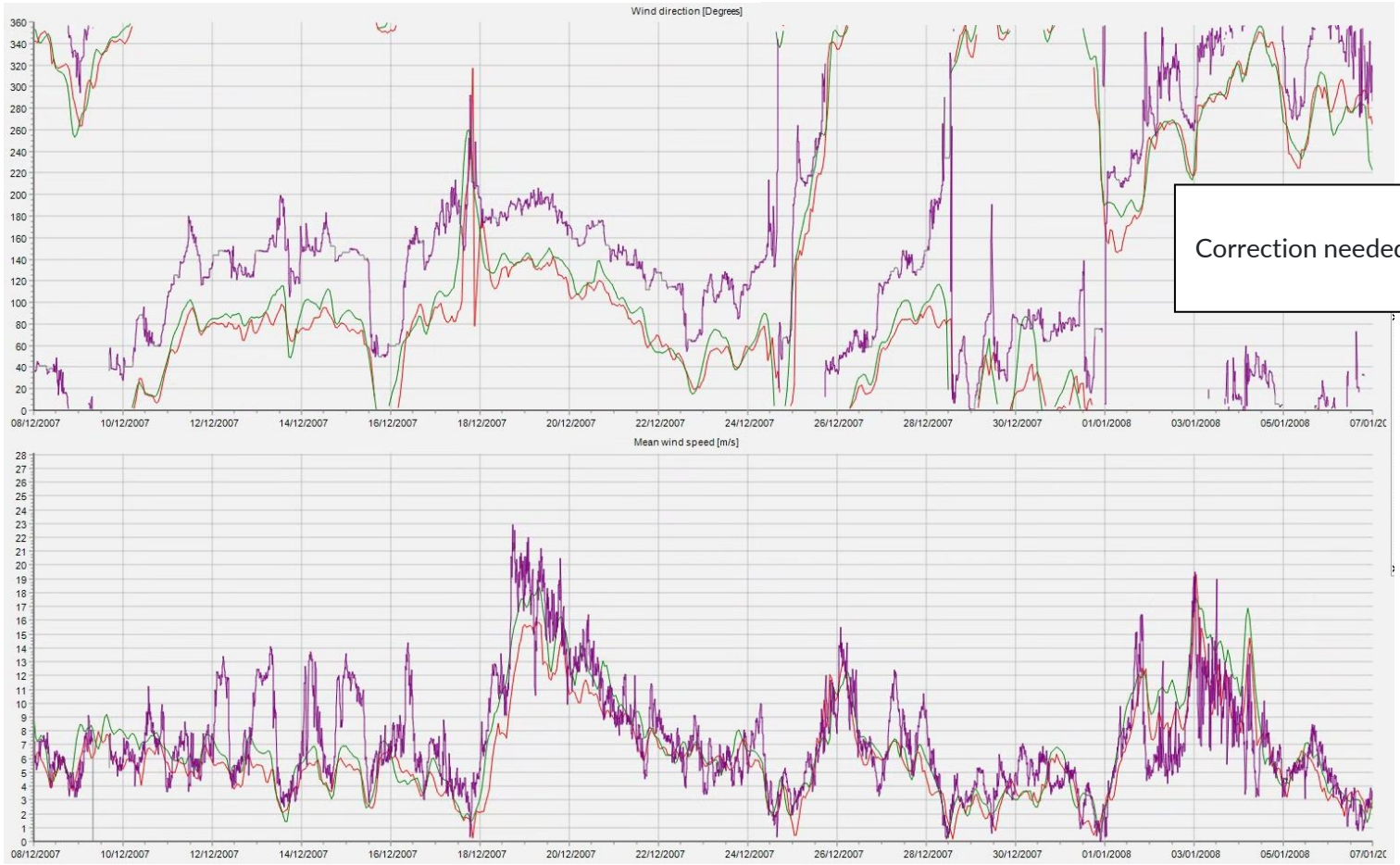
- ERA5 - 100m
- MERRA2 - 50m
- Met Mast – 102.5 m

Example: Correction



- ERA5 - 100m
- MERRA2 - 50m
- SCADA – 85 m

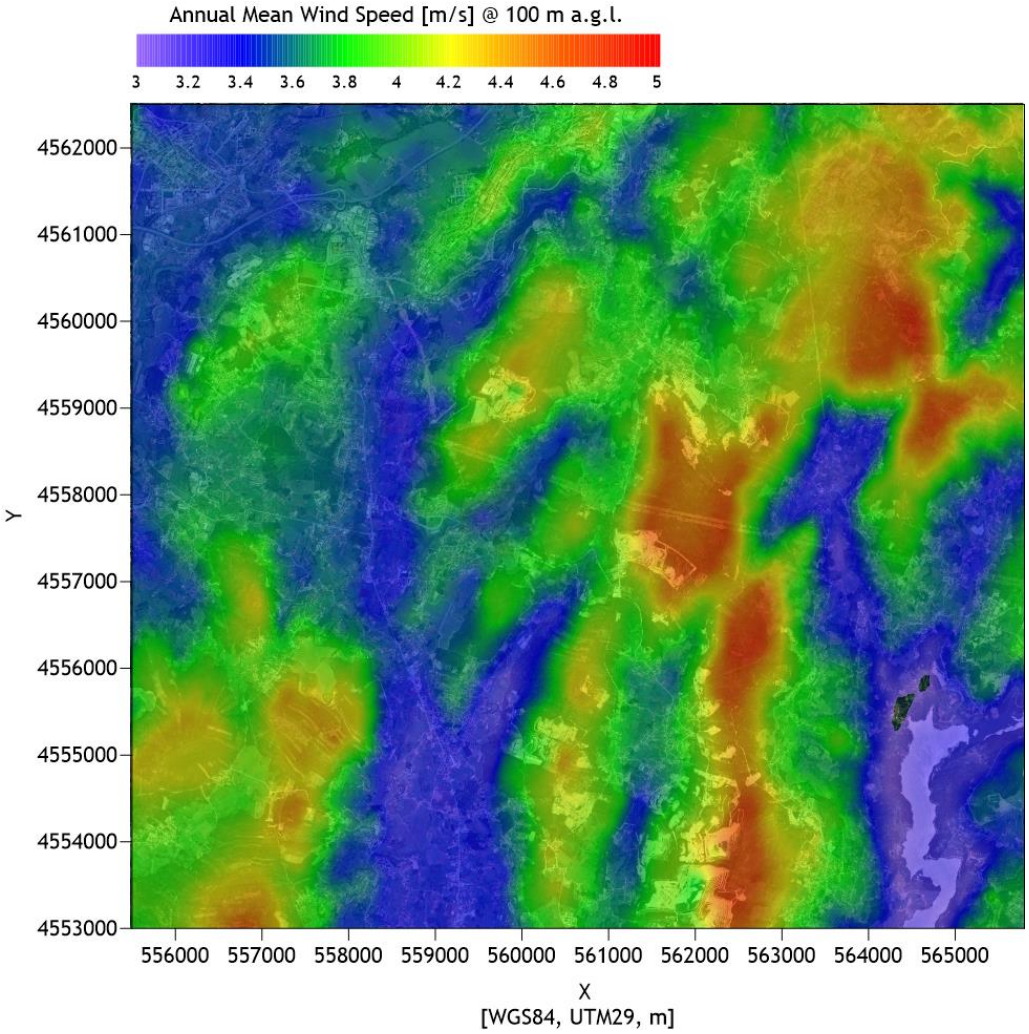
Example: Correction



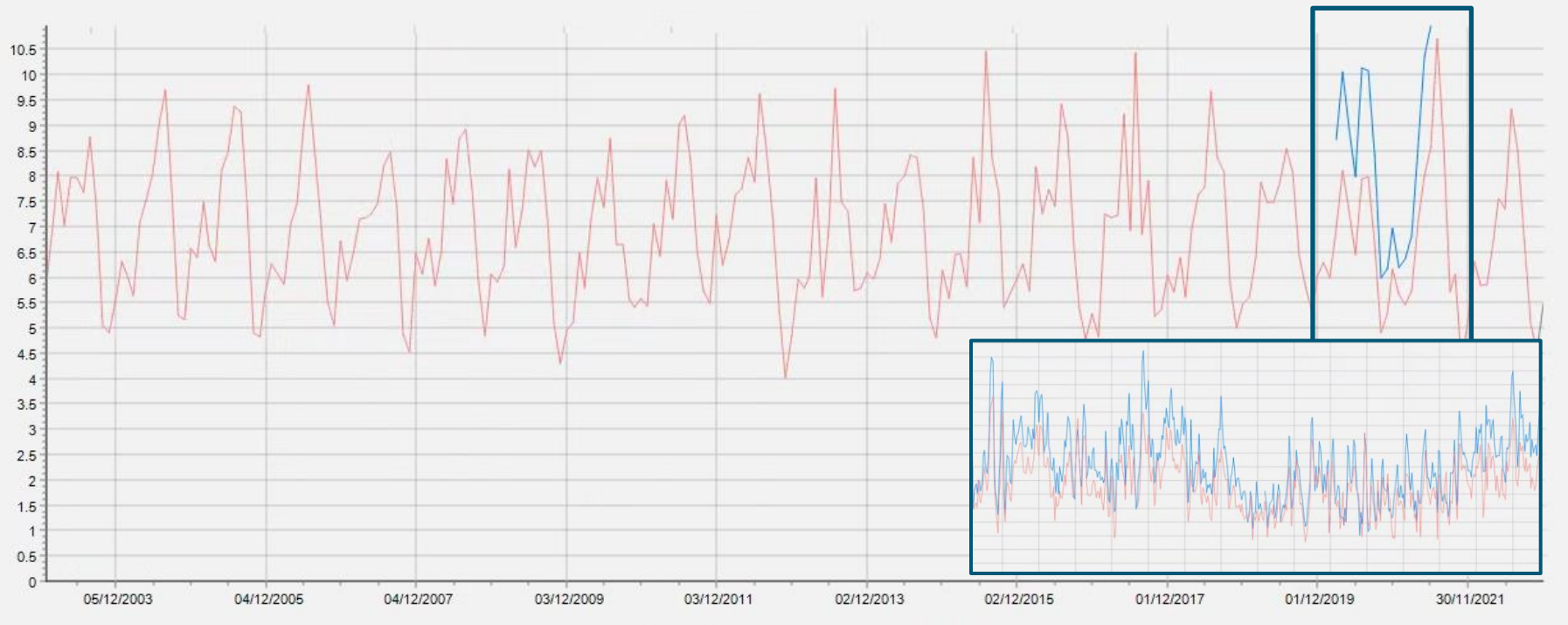
Correction needed: ≈40°

- ERA5 - 100m
- MERRA2 - 50m
- SCADA – 85 m

Resource Grids

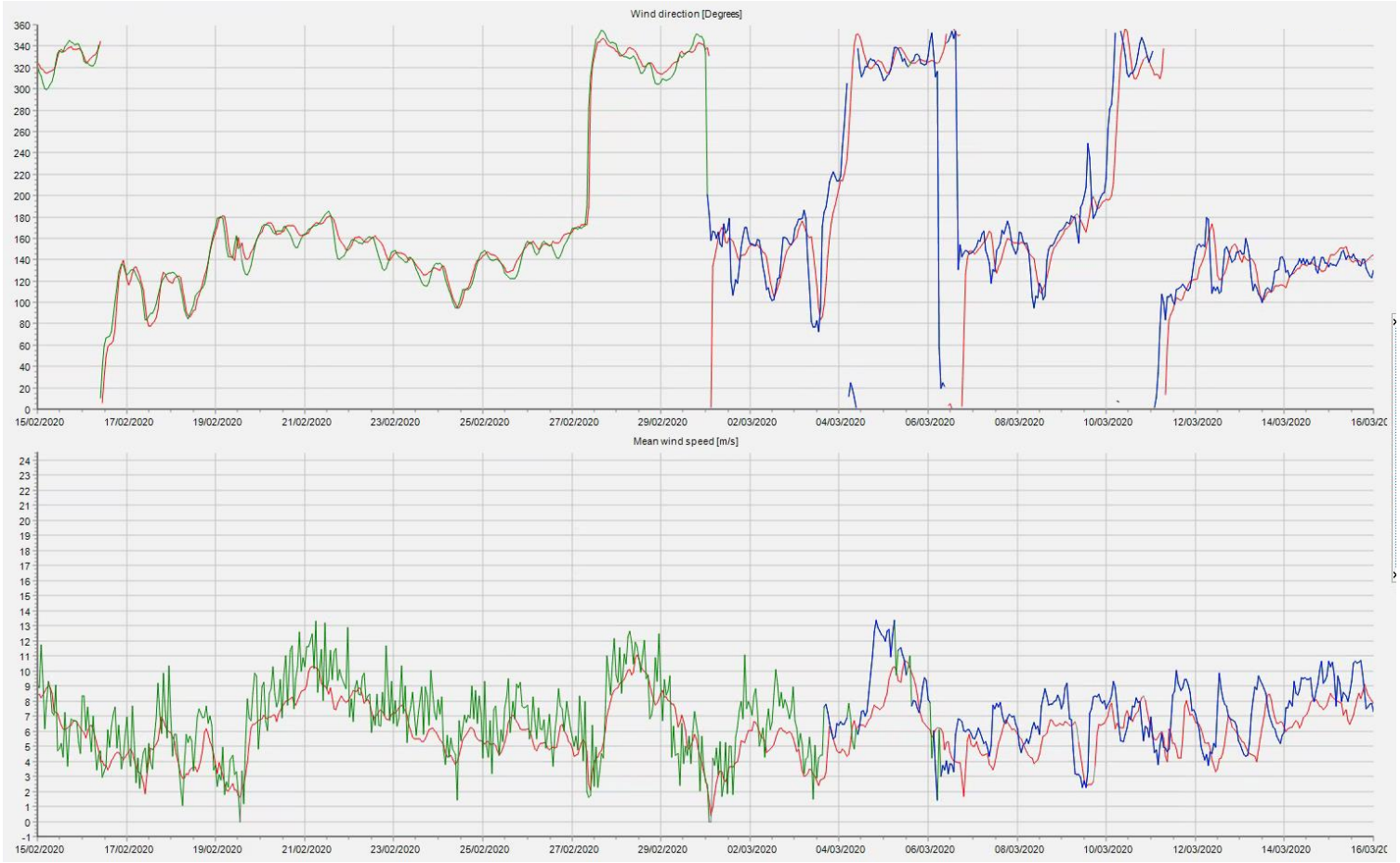


Long-term historical reference data



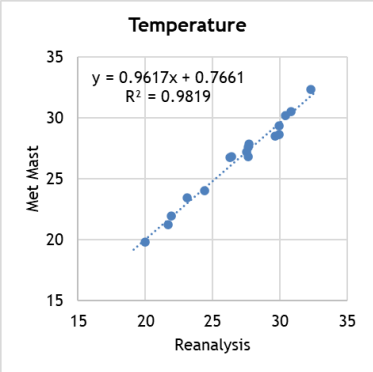
- Local measurements (site data) - 100m
- Long-term reference (ERA5) - 100m

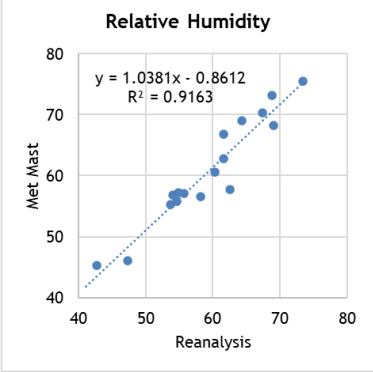
Long-term adjustment (Wind Speed & Wind Direction)

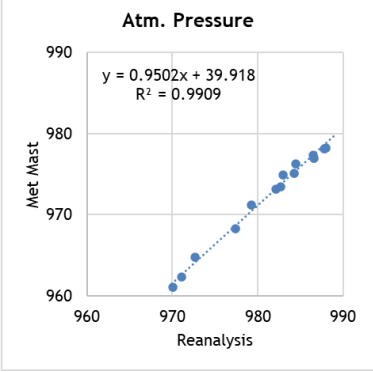


- ERA5 - 100m
- Met Mast – 100m
- Long Term corrected wind data - 100m

Long-term adjustment (Site Air Density)







LT	25.8	TEMP	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MM	26.6	January	19.9	20.5	19.7	19.9	19.1	20.2	18.8	20.3	20.1	19.2	19.6	19.2	19.1	20.6	21.0	19.1	20.7	19.9	19.8	20.2
		February	22.2	21.1	21.8	22.1	23.3	19.1	21.5	22.0	21.2	20.8	20.9	20.2	21.3	20.7	21.1	21.3	22.1	21.0	21.9	21.2
Slope	0.962	March	23.8	24.5	24.9	24.0	24.4	23.7	23.9	25.6	24.0	23.0	23.7	23.9	24.1	25.4	25.0	24.3	23.8	23.4	26.7	24.6
Offset	0.766	April	27.6	28.2	27.3	27.0	28.2	27.5	27.4	28.8	26.8	27.5	27.1	27.8	27.9	27.8	27.9	27.3	26.8	27.6	27.8	28.4
		May	29.8	29.9	29.1	30.1	29.8	28.8	30.6	30.1	29.9	28.8	30.4	29.1	29.7	30.3	28.9	29.1	30.1	30.2	29.3	30.2
		June	31.5	30.9	30.4	29.4	30.3	31.8	30.4	30.8	29.9	30.9	31.9	30.8	32.1	30.2	31.8	31.1	31.3	32.3	30.5	30.0
		July	29.8	27.6	28.2	28.8	29.6	28.8	31.3	29.6	27.9	27.8	27.7	28.9	28.3	27.8	28.1	28.2	29.8	28.5	26.8	28.1
		August	27.7	26.1	27.4	26.8	27.6	26.7	28.5	28.0	27.9	27.5	27.5	27.4	28.3	27.2	28.2	27.9	28.3	28.6	26.5	28.1
		September	26.9	25.6	26.3	27.3	27.8	26.5	27.5	27.2	28.7	28.0	27.0	27.2	28.1	26.8	26.8	26.2	27.9	27.2	28.7	27.1
		October	26.0	26.0	25.4	26.1	25.6	25.7	26.1	27.1	25.9	26.3	26.7	26.9	27.8	26.0	26.9	25.9	26.6	26.8	26.7	26.0
		November	24.6	24.4	23.9	24.0	24.2	23.4	24.2	23.9	23.7	23.8	24.0	24.7	25.0	23.9	24.1	25.4	25.0	24.0	24.5	24.7
		December	21.4	21.4	21.2	20.9	21.8	19.4	22.6	20.5	20.1	22.4	20.8	21.2	21.2	22.7	20.8	21.8	22.5	21.2	22.0	22.7

LT	60.9%	RH	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MM	60.8%	January	56.1	67.9	55.7	58.2	56.2	60.7	54.7	53.4	62.5	56.2	56.7	58.1	57.3	56.5	52.4	48.6	62.8	59.4	45.3	57.8
		February	61.7	52.5	65.1	66.6	61.8	46.8	61.7	64.3	52.7	55.4	59.7	54.3	59.6	45.9	58.4	54.8	58.6	58.8	55.8	50.4
Slope	1.038	March	61.7	43.1	57.6	56.4	57.8	43.3	56.0	43.5	43.1	50.8	57.3	63.2	63.6	69.6	61.4	57.7	49.4	57.7	46.1	49.2
Offset	-0.861	April	59.8	62.5	54.3	59.6	55.0	55.7	57.3	53.0	63.8	60.1	62.4	54.5	54.1	54.1	52.9	64.9	59.1	68.3	57.1	58.7
		May	59.5	50.9	59.5	56.0	63.9	66.9	53.1	65.1	61.3	64.5	58.5	64.5	64.1	63.5	69.5	65.6	58.1	62.8	69.0	49.6
		June	54.3	54.1	61.1	67.9	66.0	46.2	59.1	60.9	64.3	55.6	41.8	57.6	53.3	65.1	55.0	58.2	61.2	55.2	57.2	66.2
		July	59.9	66.3	63.9	60.4	60.0	62.3	53.0	60.4	67.1	67.4	69.1	64.0	68.8	68.8	70.9	67.0	62.7	73.2	75.5	70.1
		August	64.3	69.1	63.3	71.0	68.9	69.3	64.4	63.7	66.2	68.7	66.9	68.8	68.0	68.9	68.3	66.3	67.0	66.8	74.8	68.0
		September	66.0	75.5	72.4	69.1	65.5	71.3	66.1	66.4	60.4	66.6	67.4	71.8	70.4	70.7	74.6	71.5	70.9	70.3	68.7	73.8
		October	61.6	60.3	55.9	67.6	57.1	65.9	62.6	63.0	62.9	61.2	63.2	64.1	66.3	63.1	64.7	68.5	66.1	56.5	66.7	65.1
		November	61.5	63.2	61.5	66.2	62.2	59.1	60.6	47.3	76.4	63.0	64.6	58.1	62.8	57.3	58.7	67.6	64.1	60.6	54.3	66.0
		December	61.8	59.6	58.2	63.2	57.3	42.1	63.0	49.6	49.4	63.5	50.5	51.7	58.5	55.0	50.6	57.7	69.4	56.8	58.6	58.5

LT	971.9	BAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MM	971.1	January	979	977	979	979	981	978	979	980	977	978	979	979	980	979	979	978	980	979	978	978
		February	976	978	977	977	976	980	977	977	976	977	978	977	977	979	979	977	978	979	977	977
Slope	0.950	March	975	976	976	975	975	974	975	976	975	976	975	975	976	975	975	975	976	976	975	975
Offset	39.918	April	973	972	974	972	973	972	973	973	972	972	972	973	973	974	973	972	974	975	973	972
		May	970	968	970	969	969	969	969	969	970	970	969	970	971	970	971	970	971	971	969	969
		June	964	965	964	965	962	963	967	965	964	964	963	965	964	966	964	964	965	965	965	964
		July	962	963	963	963	963	962	962	962	962	962	962	963	964	963	963	962	962	962	964	962
		August	965	964	964	965	964	964	965	964	963	964	964	965	966	965	964	963	964	961	965	964
		September	968	970	968	969	967	969	969	968	967	968	968	968	970	968	969	970	968	968	967	968
		October	974	975	974	975	974	974	974	972	973	974	973	974	974	973	973	975	973	973	973	974
		November	977	977	977	976	976	977	976	976	975	976	976	977	976	977	977	977	976	977	976	977
		December	979	978	978	979	978	979	978	977	979	977	979	979	979	978	979	979	978	978	979	978

Curtailments, Uncertainties & Others

Curtailments

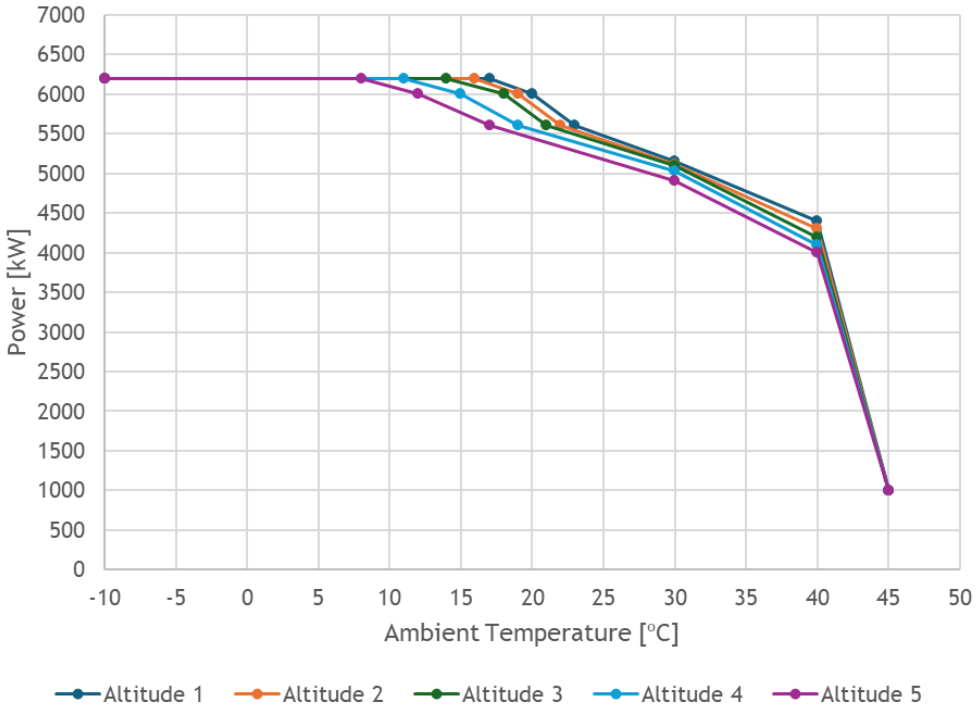
- Temperature Derating
- Grid Curtailment

Uncertainties

- Interannual Variability
- Climate Change Assessment

Others

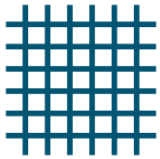
- Power Series
- Hybridization Scenarios



Example of temperature derating plan

Possibilities for the Future

Reanalysis Future - Possibilities



Better Resolution & Precise Models

Wind speeds with very good correlation and no ‘suspicious’ of inconsistency

Complex Terrain

Better resolution in complex areas and more relaxed is less complex areas

Worldwide Masts

Mast system contribution for Reanalysis improvement

(with emphasizes in wind studies: ≈100m a.g.l.)

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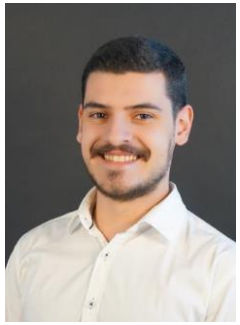
Thank you!



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