

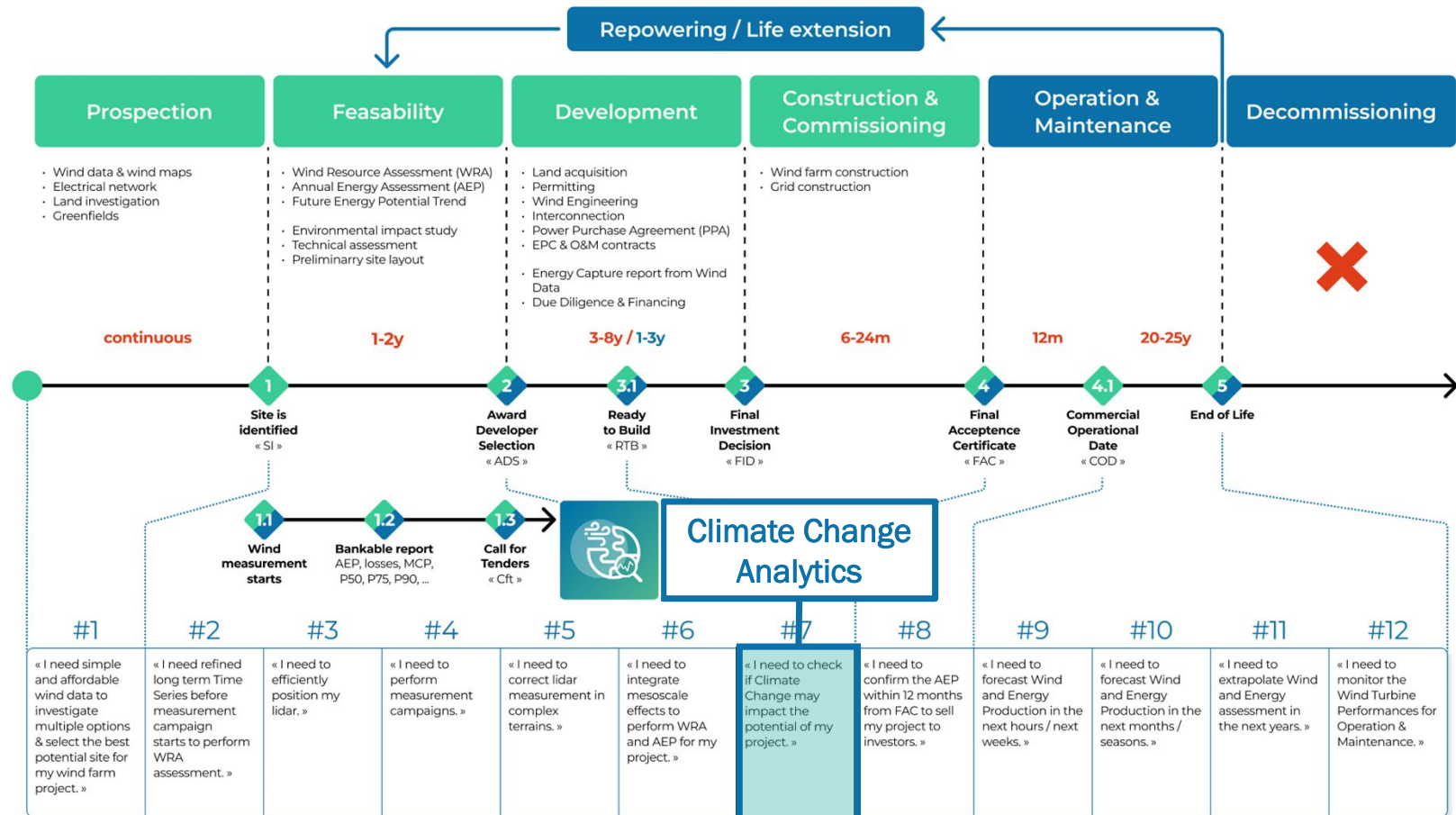


Regional impact of Climate Change on Annual Energy Production

Windenergietage 2025 – Potsdam, 12-14 November 2025

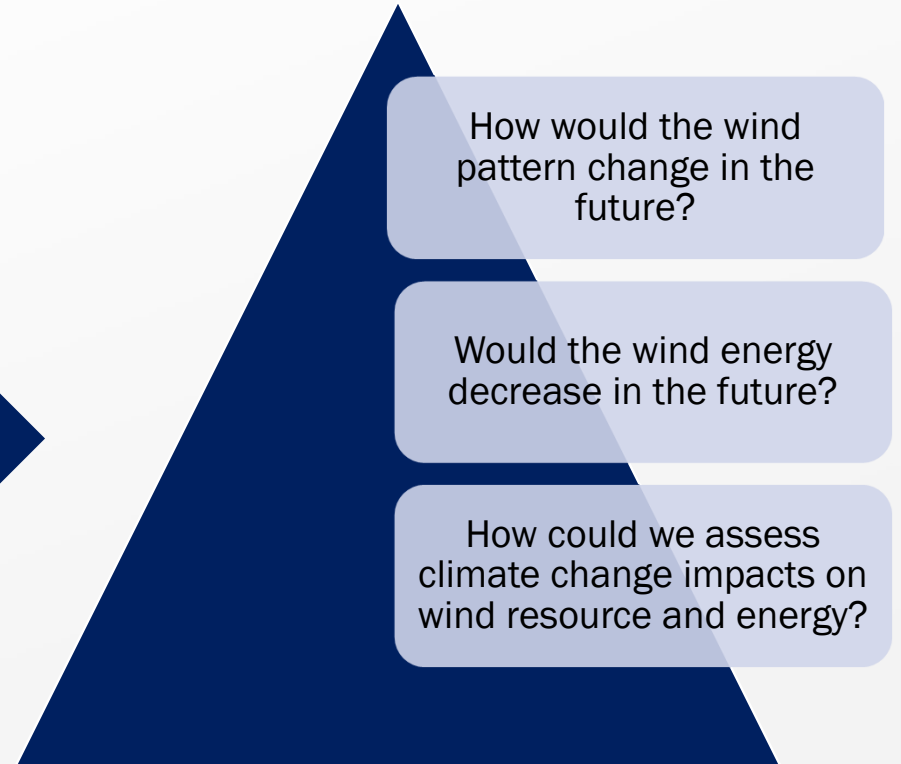
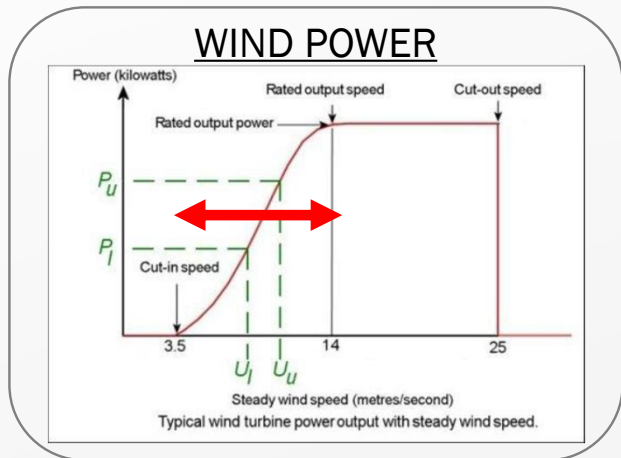
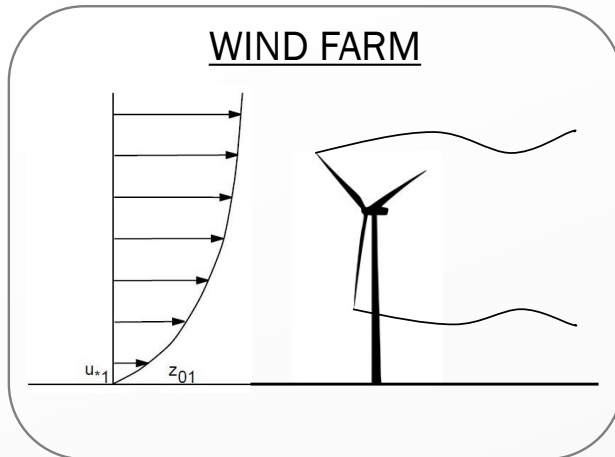
Eric TROMEUR, PhD – Director Research, Innovation, Service & Expertise

Wind Farm Life-Cycle





Context & Challenges





Context & Challenges

- Rising
 - Global T
 - Sea level
 - Ocean salinity
 - Extreme events freq. and strength
- Ecosystems disruption
- Agricultural impacts
- Water resource stress

What about future
wind speed tendency ?

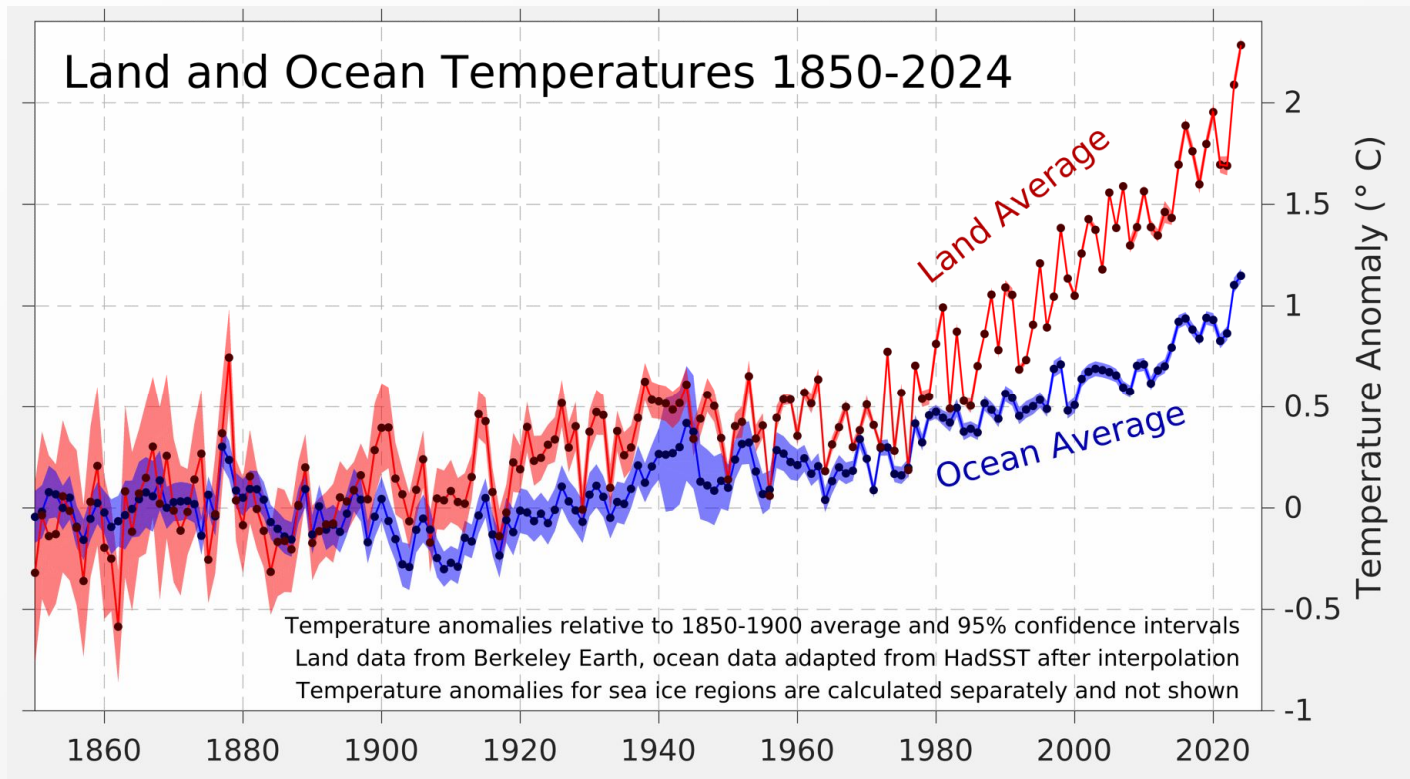
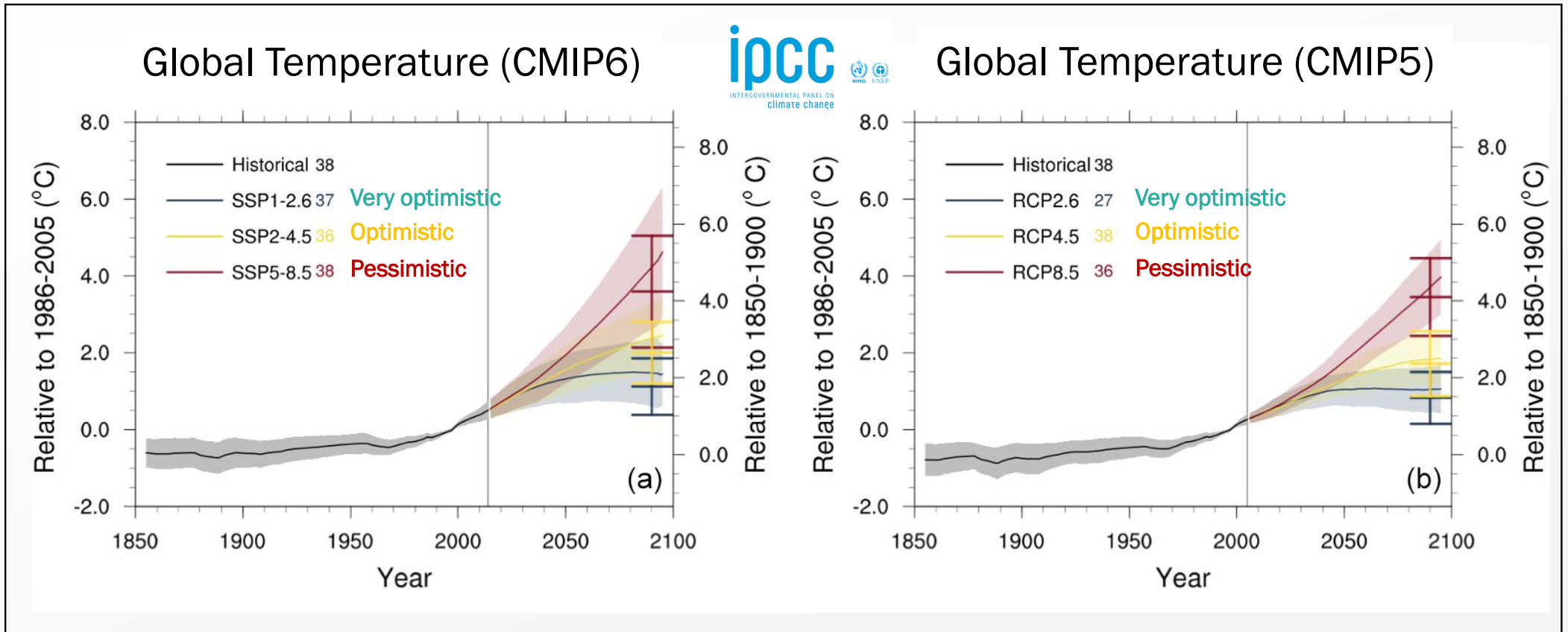


Image: berkeleyearth.org





Climate Scenarios & Horizons



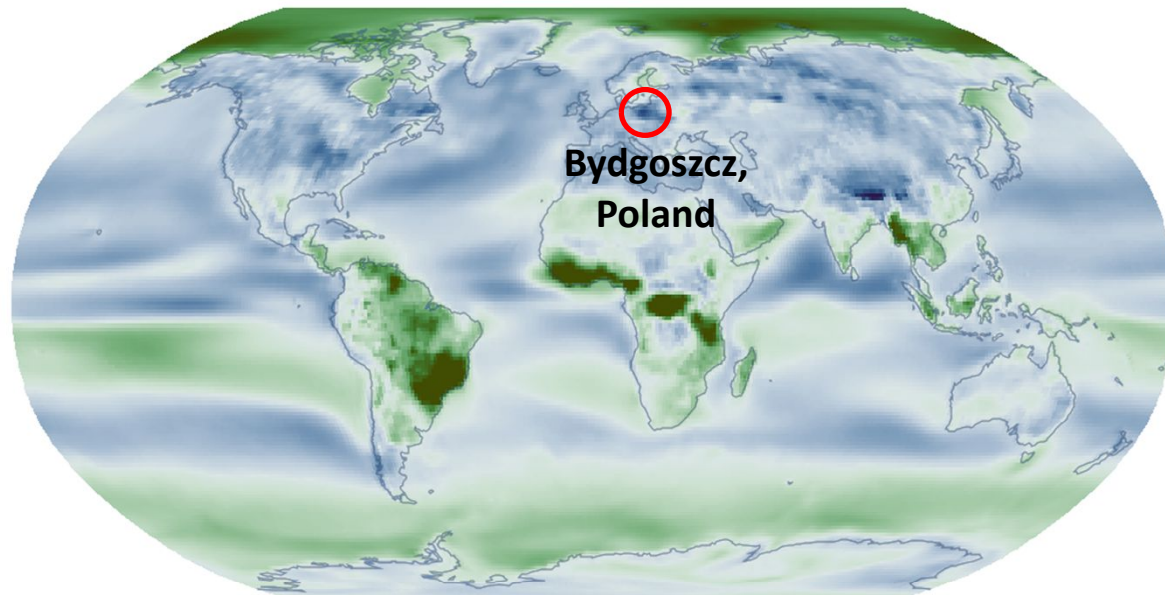
Tebaldi et al, Earth Syst. Dynam., 12, 253–293, 2021, <https://doi.org/10.5194/esd-12-253-2021>

CMIP : Coupled Model Intercomparison Project

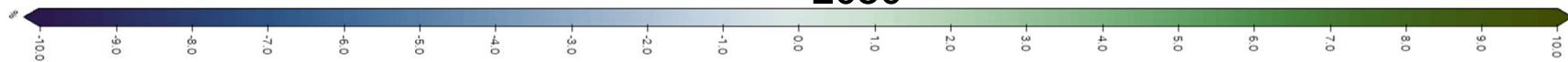




Climate Change | Case Study



2050



Surface wind - Tendency (%)
Medium Term (2041-2060) (SSP5-8.5) (rel. to 1986-2005)
CMIP6 - Annual (31 models)



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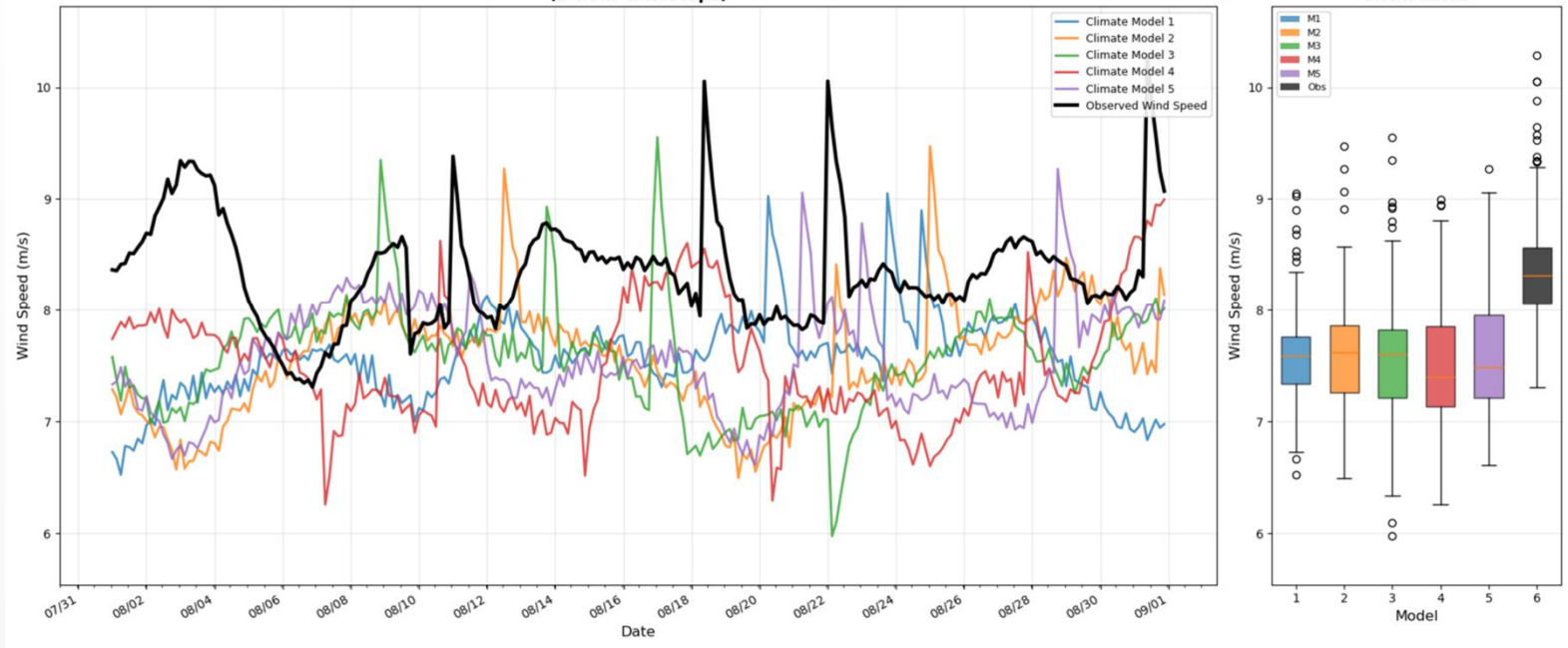
Multimodel Projection Challenges

- Traditional approach:
Equal model weights
- Similar RMSE across models
- Unable to discriminate best performers
- Large projection uncertainties

Need for better selection methods

Assess climate model quality

Climate Model Comparison: Synthetic Wind Speed Time Series (3-hour timesteps)





New Statistical Method for Model Selection

- Advanced performance metrics
- Multiple validation criteria
- Clear model ranking system
- Some models significantly better



Improved projection confidence !

Wind Speed Change compared to historical period (m/s)

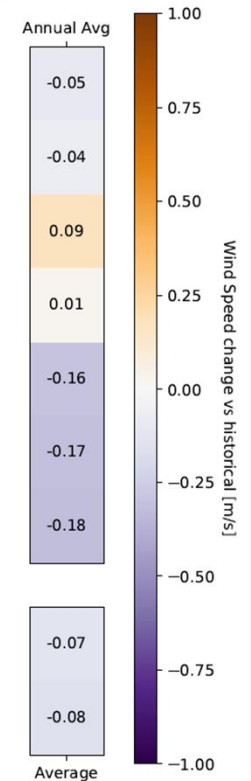
2035

Site : Bydgoszcz, Lon : 17.997 Lat : 53.123, scenario : RCP4.5, Period 1989-2002 vs 2025-2045

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Model 1	0.06	0.00	0.28	-0.10	-0.17	-0.03	-0.33	0.12	-0.06	-0.30	-0.02	-0.08
Model 2	-0.40	0.11	-0.10	-0.06	-0.22	0.02	0.17	-0.07	-0.36	0.15	0.38	-0.09
Model 3	0.11	-0.28	0.09	-0.07	-0.01	0.02	0.30	-0.26	0.25	0.22	0.02	0.79
Model 4	-0.35	-0.56	-0.01	-0.05	0.14	-0.00	0.22	0.03	0.27	0.15	-0.01	0.44
Model 5	-0.36	-0.14	-0.42	0.02	-0.26	-0.08	-0.30	-0.01	-0.08	0.28	-0.37	-0.16
Model 6	-0.42	-0.22	-0.38	-0.03	-0.16	-0.02	-0.41	-0.32	0.03	0.31	-0.15	-0.19
Model 7	-0.56	-0.27	-0.54	-0.00	-0.32	0.08	-0.22	0.16	0.07	0.25	-0.40	-0.30

Multimodel Average	-0.28	-0.19	-0.15	-0.04	-0.14	-0.00	-0.08	-0.05	0.02	0.15	-0.08	0.06
Meteodyn Average	-0.38	-0.22	-0.19	-0.03	-0.14	0.00	-0.10	-0.04	0.01	0.15	-0.04	0.05

Quality increase	41.2%	0.0%	8.5%	12.8%	0.0%	0.0%	4.4%	12.4%	0.0%	0.0%	9.6%	6.3%
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New Statistical Method for Model Selection

Site : Bydgoszcz, Lon : 17.997 Lat : 53.123, scenario : RCP4.5, Period 1989-2002 vs 2025-2045

RMSE summed over the period 1989-2002 for each month

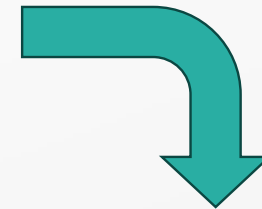
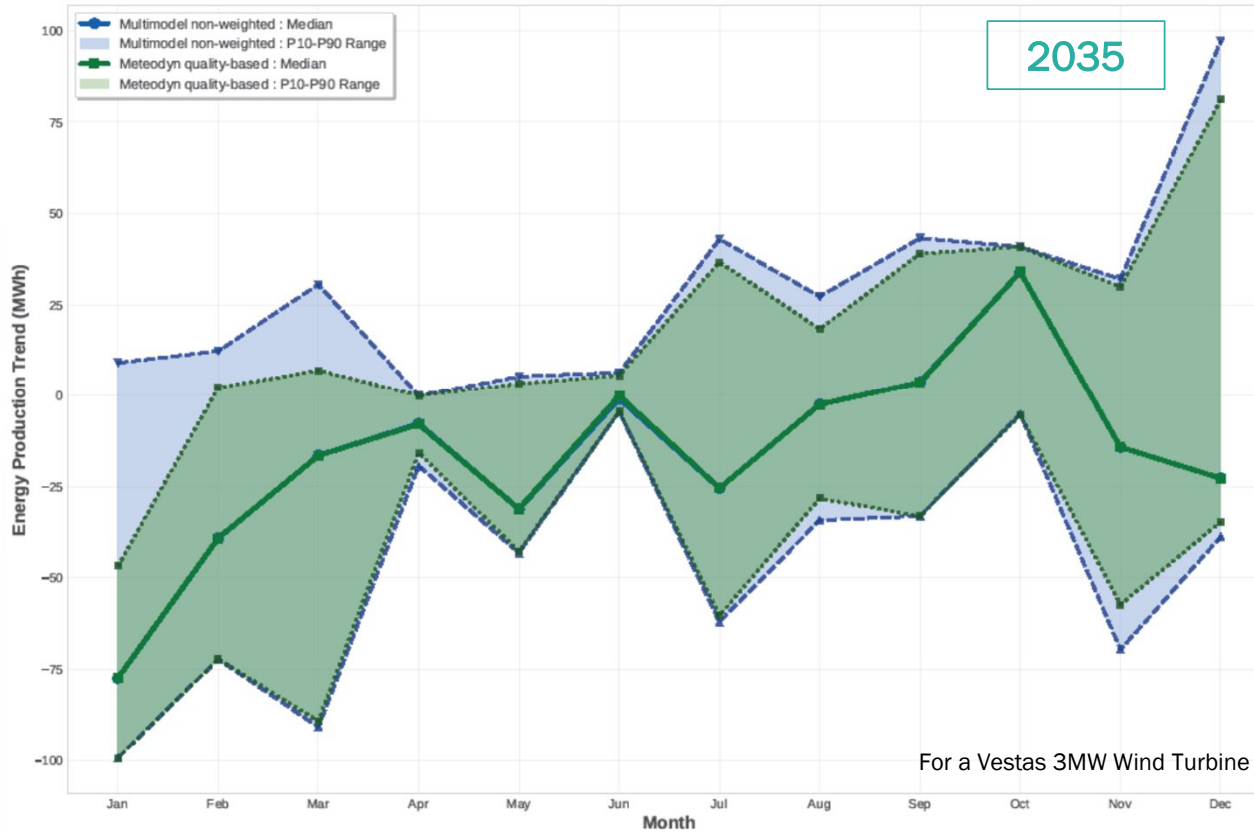




Multimodel Agreement Increasing Confidence

Monthly Energy Production Trend (100m)

Comparison of non-weighted and weighted distributions for the scenario RCP4.5, Period 1989-2002 vs 2025-2045

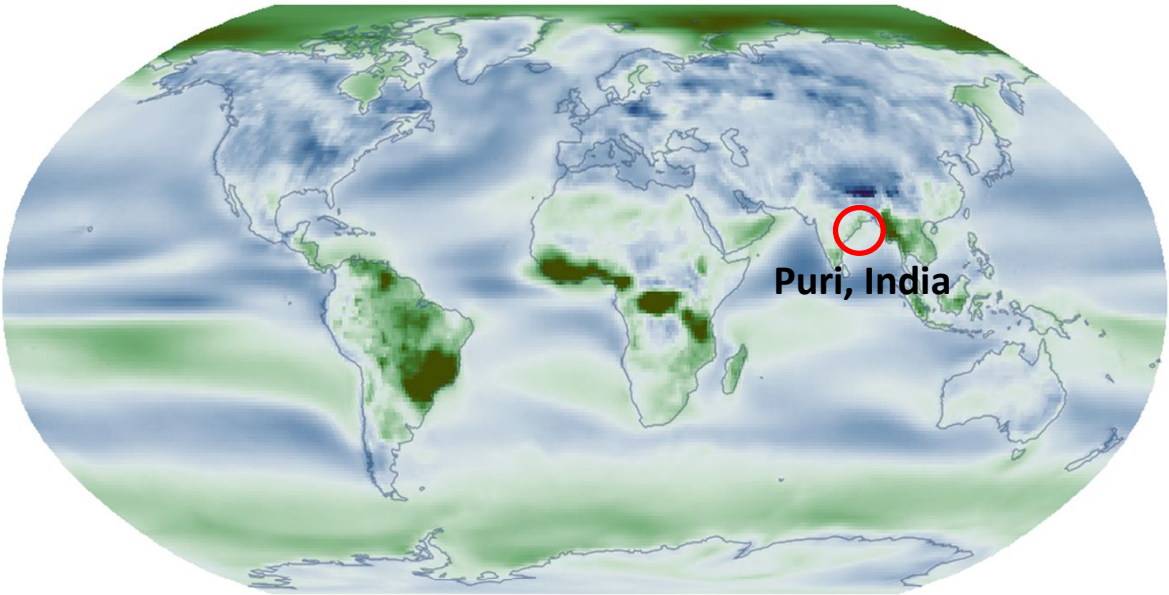


- Agreement reduces uncertainty
- Robust signal identification
- Enhanced decision-making

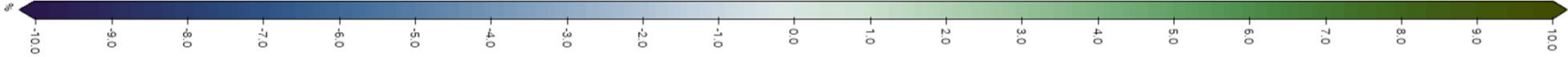




Climate Change | Case Study



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CMIP6 - Annual (31 models)



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Multimodel Agreement Increasing Confidence

2035

Energy production change compared to historical period*

Site : WestIndia, Lon : 85.829 Lat : 19.804, scenario : RCP4.5, Period 1980-1999 vs 2025-2045

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Multimodel Average	-9	23	119	118	63	37	31	11	17	2	-12	-34
Meteodyn's Average	-0	21	137	104	63	58	33	27	42	4	19	-12
Quality increase	40.9%	31.9%	33.6%	36.7%	9.6%	0.0%	8.5%	6.8%	12.5%	0.0%	20.4%	15.5%

AEP Tendency

366
494

Energy production change vs historical [MWh]

-170
449
1218

Standard Deviation [MWh]

452
313

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
P10	-14	-4	93	78	-12	-40	-84	-24	-30	-42	-44	-46
Median	-1	22	129	106	73	45	42	22	23	3	3	-19
P90	13	40	180	161	146	185	140	67	140	48	81	17

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Standard Deviation	46	41	82	98	95	112	118	57	91	40	92	46
Meteodyn's Deviation	10	18	44	38	73	100	91	43	66	37	50	23

*For one Vestas 3MW Wind Turbine

Meteodyn quality-based approach :

- Go beyond standard analysis !
- + 494 MWh/year for a 3 MW wind turbine
- + 164 hours/year at nominal power
- + 128 MWh/year compared to a non-weighted approach
- Annual uncertainty reduced by more than 30%





Wind Data Portal | Climate Change Analytics (CCA)



Climate Change Analytics (CCA)

Statistical trends

Secure your projects by reducing risks and improving the profitability of your investments with our CCA.

Access our accurate, localized climate projections, tailored to your project, based on IPCC scenarios and available worldwide for all heights from 10 to 300 meters.

Go beyond conventional analyses with our innovative statistical approach based on high-quality climate model analysis.

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HOME > SHOP > CLIMATE CHANGE ANALYTICS (CCA)

Climate Change Analytics (CCA)

Why is the CCA important for securing your projects?

In the wind energy sector, the wind resource assessment studies for a project are based on historical data without projections. Is there a risk of underproduction related to climate change? Does my project have additional repowering potential? Similarly, comfort analysis in the urban sector is based on past microclimate data. To what extent should my urban project evolve in order to adapt to climate change?

Thanks to our climate projections, the CCA—based on IPCC scenarios and available worldwide—provides accurate, localized seasonal and monthly data tailored to your project. The CCA helps reduce risks and improve the profitability of your investments.

Climate projections for your projects

Technical details

- **Deliverables:** Statistical trends
- **Variables:** Wind speed, AEP (annual energy production)
- **Available period:** 2030-2050 and 2090
- **Delivery time:** 24 heures
- **Horizontal resolution:** 11-44 km (depending on the area)
- **Temporal resolution:** Monthly
- **Heights:** 10-300 meters
- **Format:** CSV
- **Compatibility:** Excel, Python

[Order](#) [Go back to the store](#)

[Need other climate variables or a comprehensive study? Contact us.](#)

Define the location of your project

Point 1

Latitude (deg) * Longitude (deg) *

Must be in the blue zone Must be in the blue zone

Please enter a number from -90 to 90 Please enter a number from -180 to 180

Height (m) * Climate Horizon *

2030

Please enter a number from 10 to 300

Option

Projections of annual energy production* +300,00 €

*For one Vestas 3MW Wind Turbine. For another wind turbine type, please contact us.

[Add a point](#)

Total 0,00 €

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Thank you!

Eric TROMEUR, PhD

Director Research, Innovation, Service & Expertise

eric.tromeur@meteodyn.com

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