Offshore Wind Potential in Brazil

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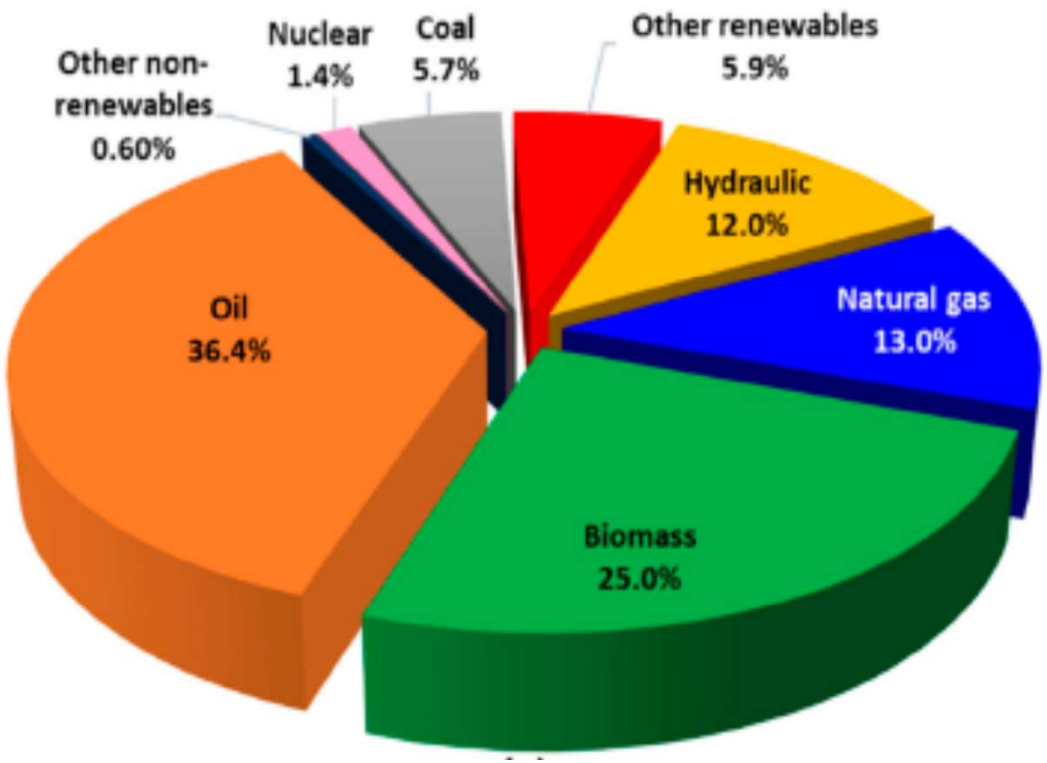
Offshore Wind Session

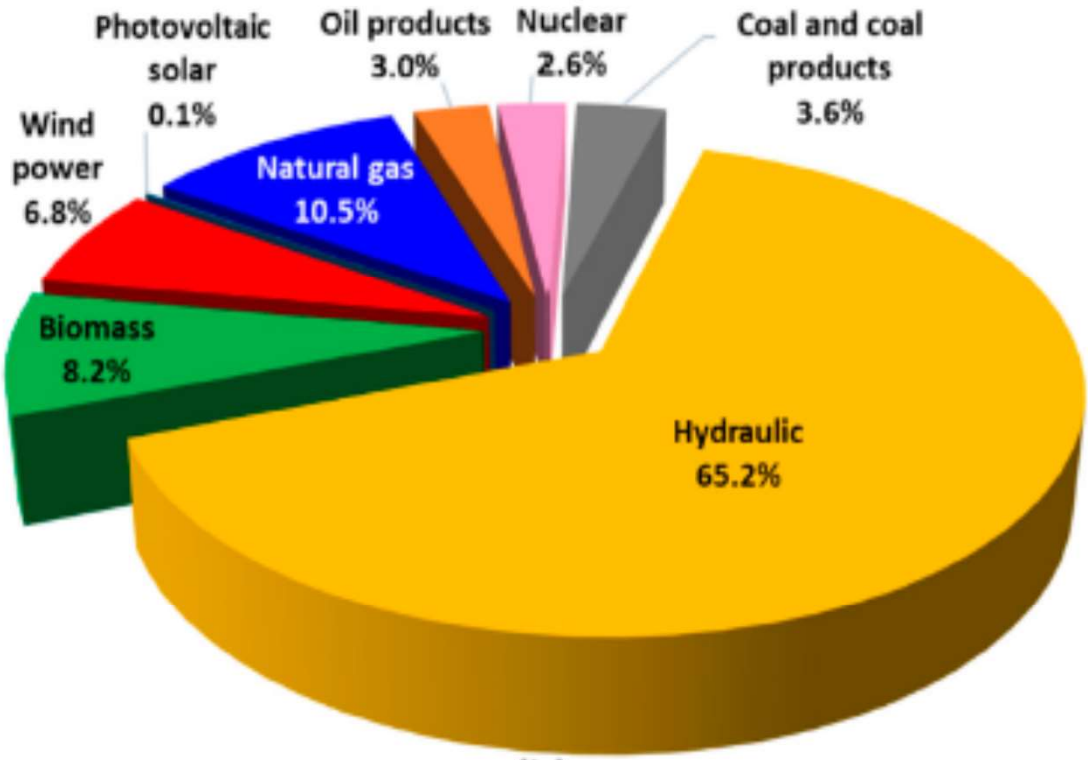
Conference on Brazilian-Norwegian Energy Research
28th October 2020

Contents

Brazilian Energy Supply and Electricity Matrix (2017)

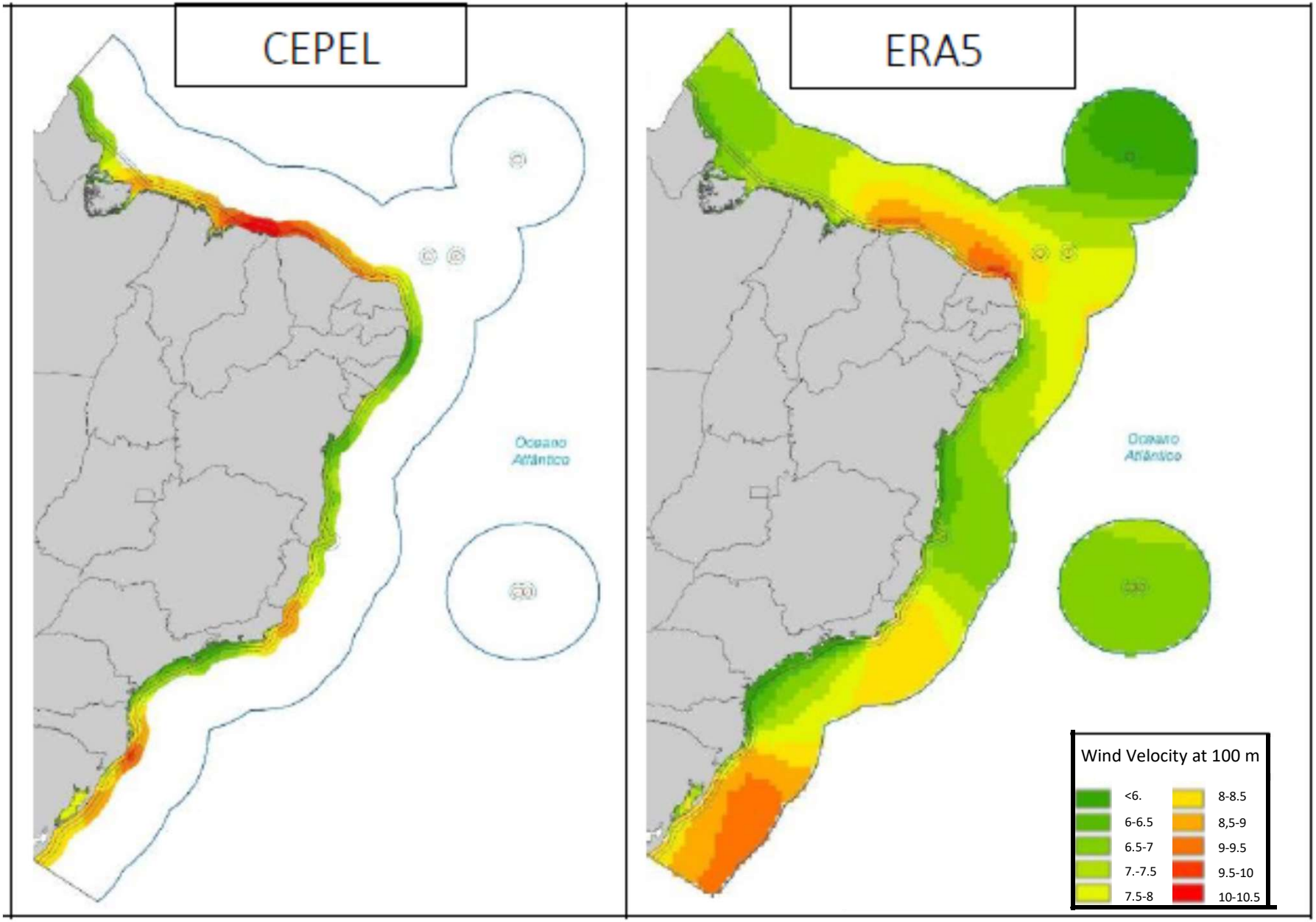


Energy Supply



Electricity Matrix

Agência Nacional de Energia Elétrica (ANEEL , 2017).



EPE – Roadmap, Eólica Offshore Brasil, 2020.

South and Southeast Regions

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journal homepage: www.elsevier.com/locate/energy

Assessment of the offshore wind technical potential for the Brazilian Southeast and South regions

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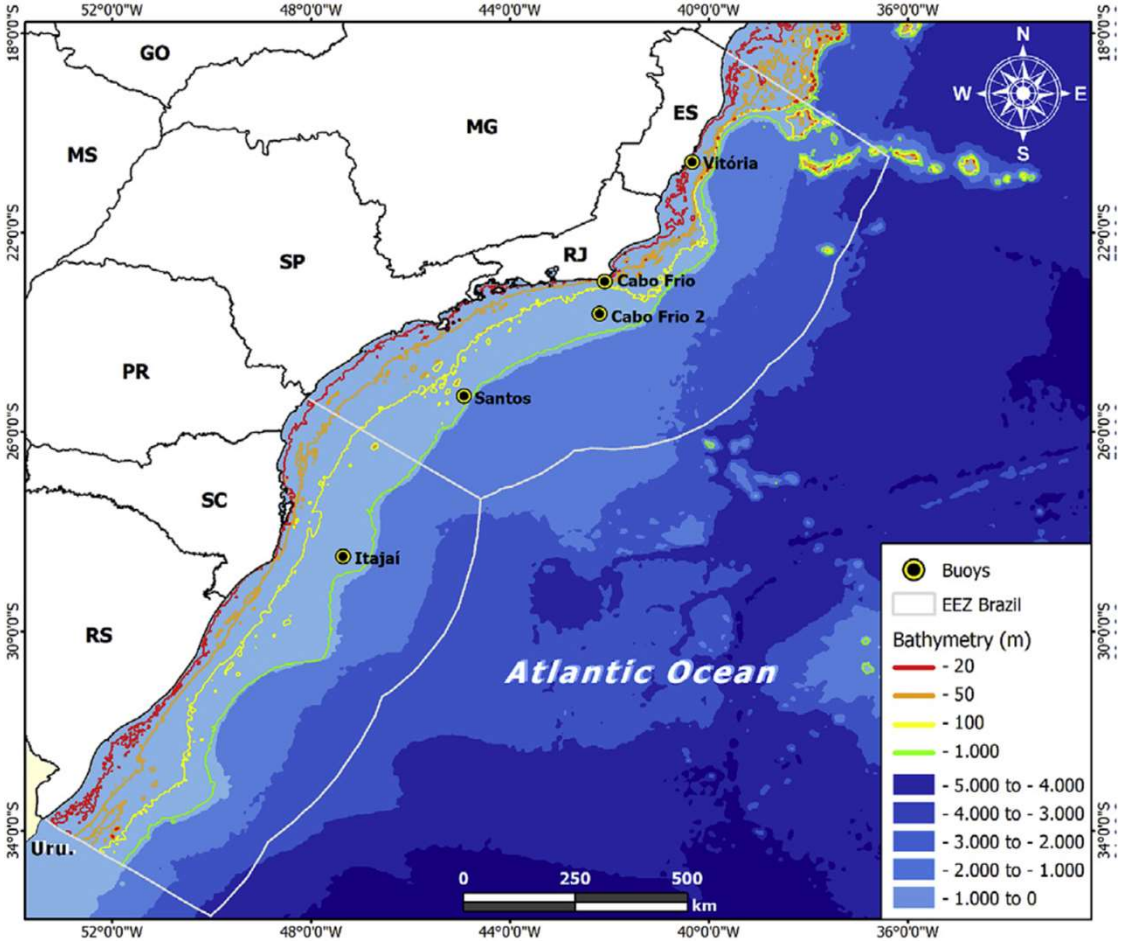
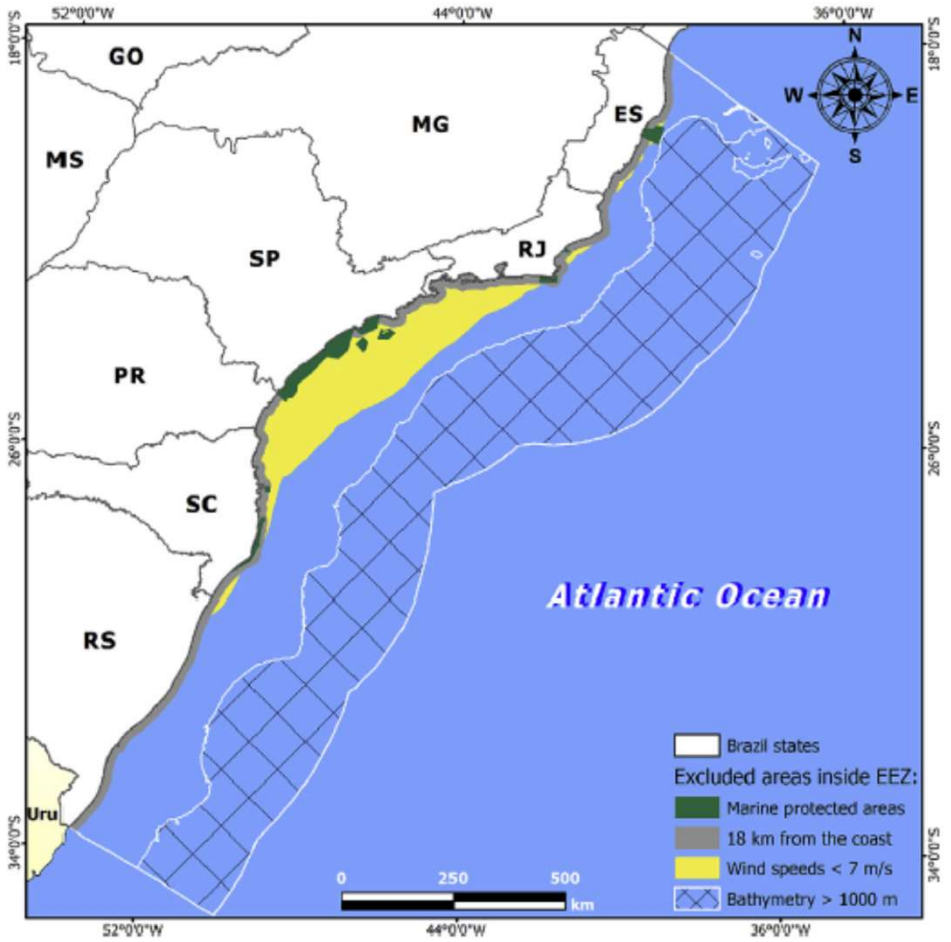


Bathymetry



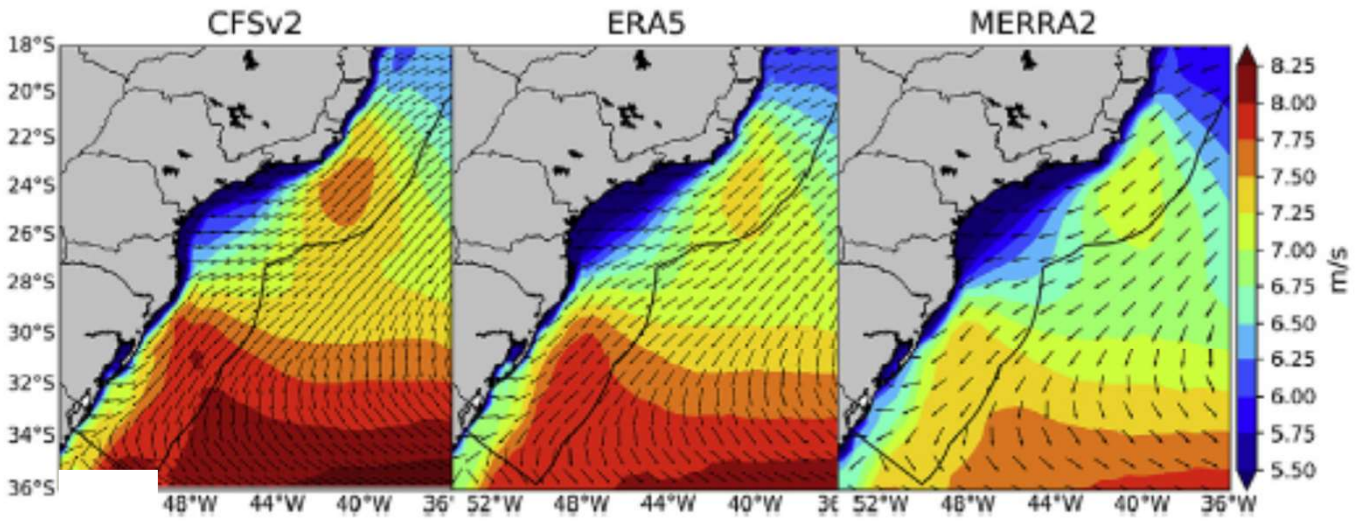
Excluded Areas

Data from PNBOIA Program

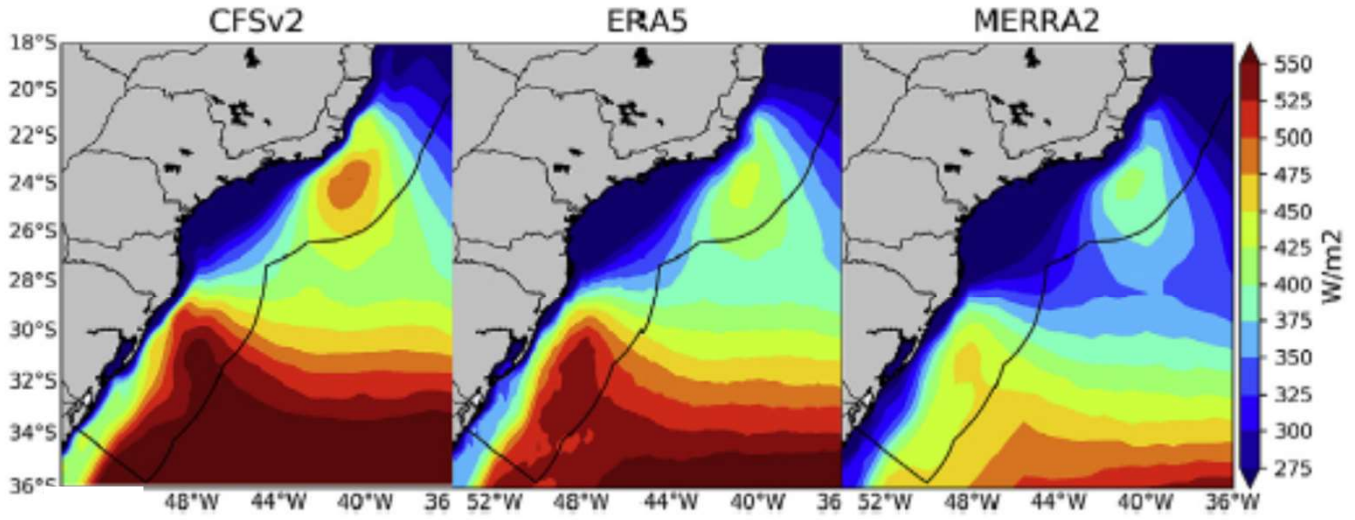
Buoy	Latitude	Longitude	Period	N	Bathymetry
Itajaí	28.50° S	47.36° W	2011/02/17 to 2018/10/25	41,299	202 m
Santos	25.28° S	44.93° W	2011/04/12 to 2018/09/30	58,528	244 m
Cabo Frio 2	23.63° S	42.20° W	2016/07/20 to 2018/09/30	8639	307 m
Cabo Frio	22.98° S	42.10° W	2012/03/13 to 2013/05/23	2528	54 m
Vitória	20.58° S	40.34° W	2015/10/13 to 2017/07/23	15,561	15 m

Atmospheric Reanalysis Database

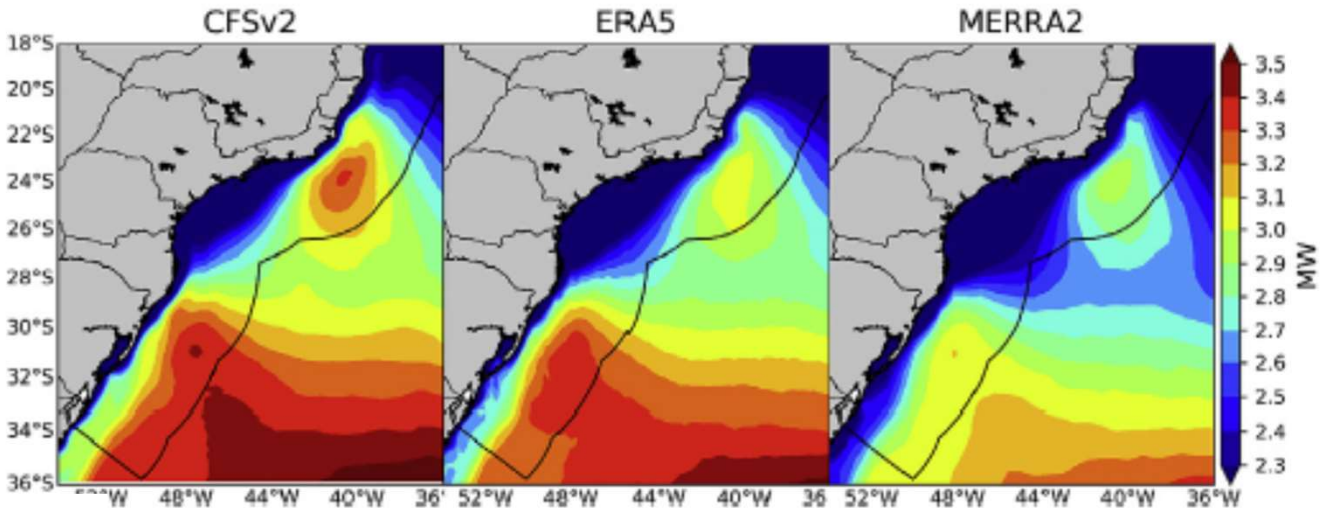
Reanalysis	Period	Horizontal resolution	Vertical resolution	Temporal resolution
CFSv2	2011 to 2018	$0.205^{\circ} \times 0.204^{\circ}$	64 levels	Hourly
ERA5	2011 to 2018	$0.25^{\circ} \times 0.25^{\circ}$	137 levels	Hourly
MERRA2	2011 to 2018	$0.5^{\circ} \times 0.625^{\circ}$	72 levels	Hourly



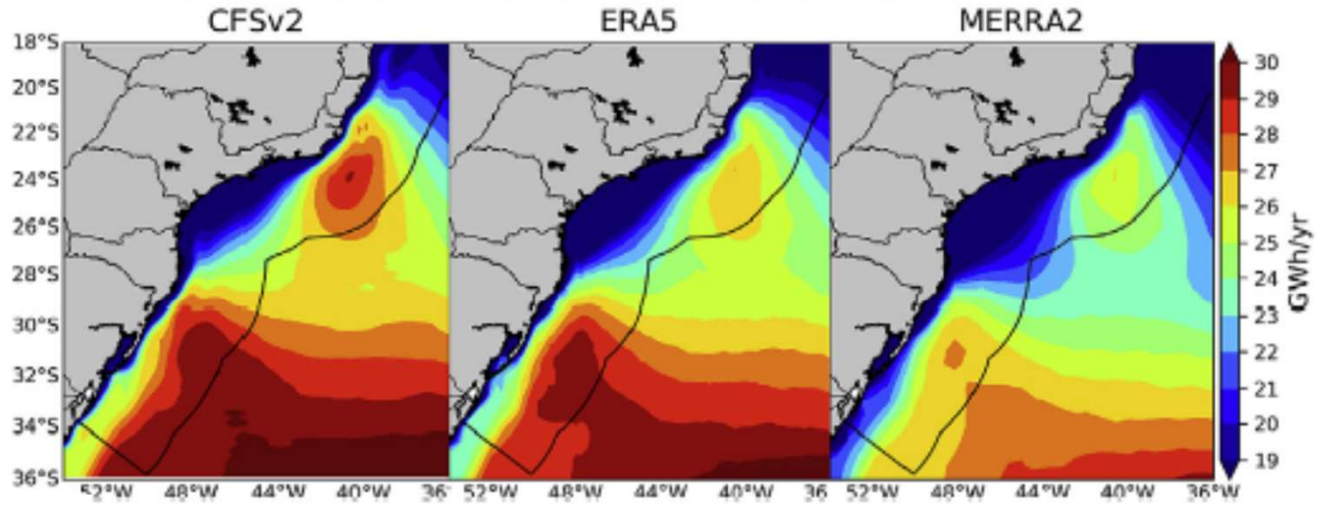
Wind Velocity (m/s) and Direction at 10 m Height



Wind Power Density (W/m^2) at 10 m Height

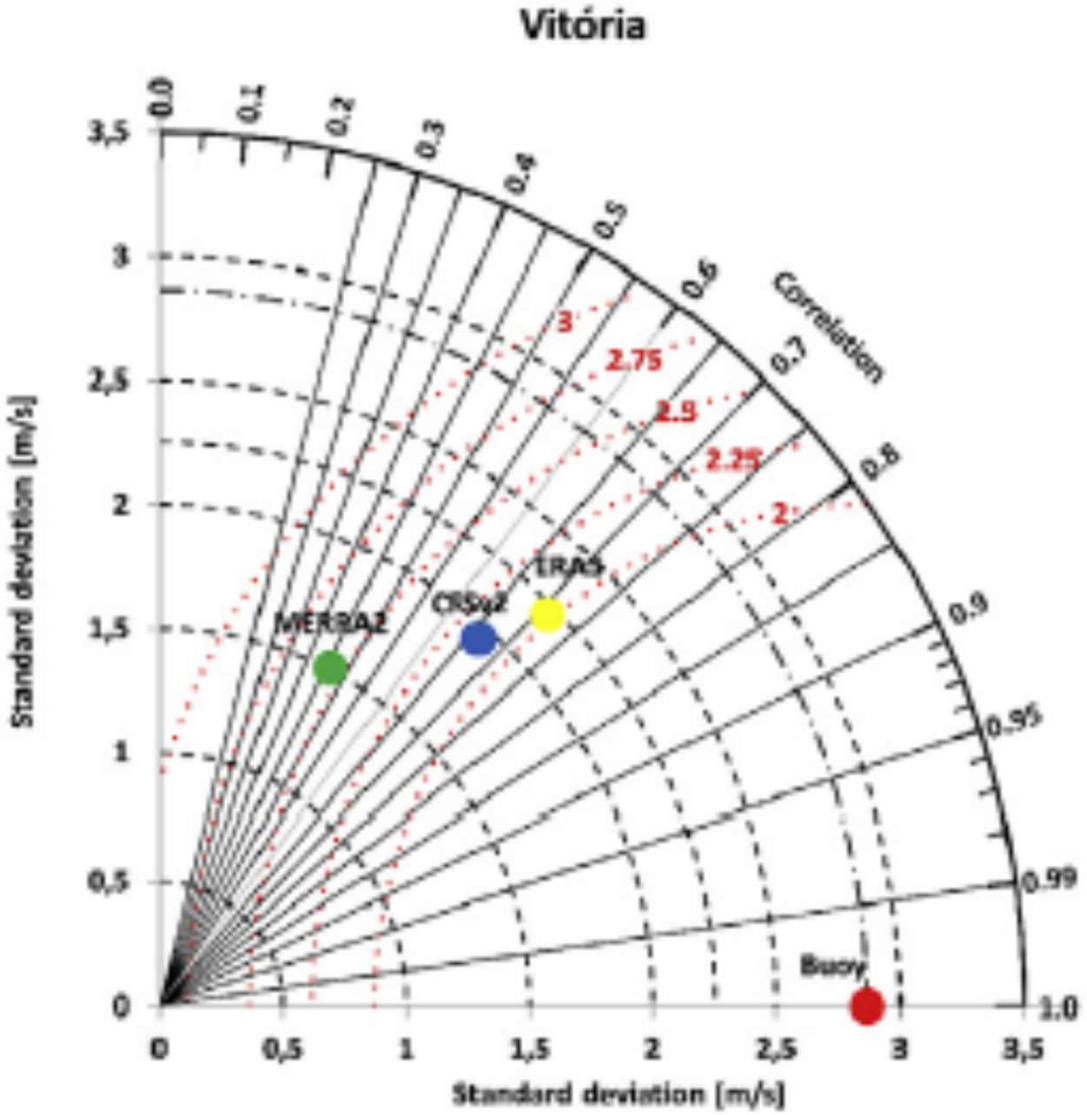


NREL-6MW Turbine Output Power (MW) – 2011-2018



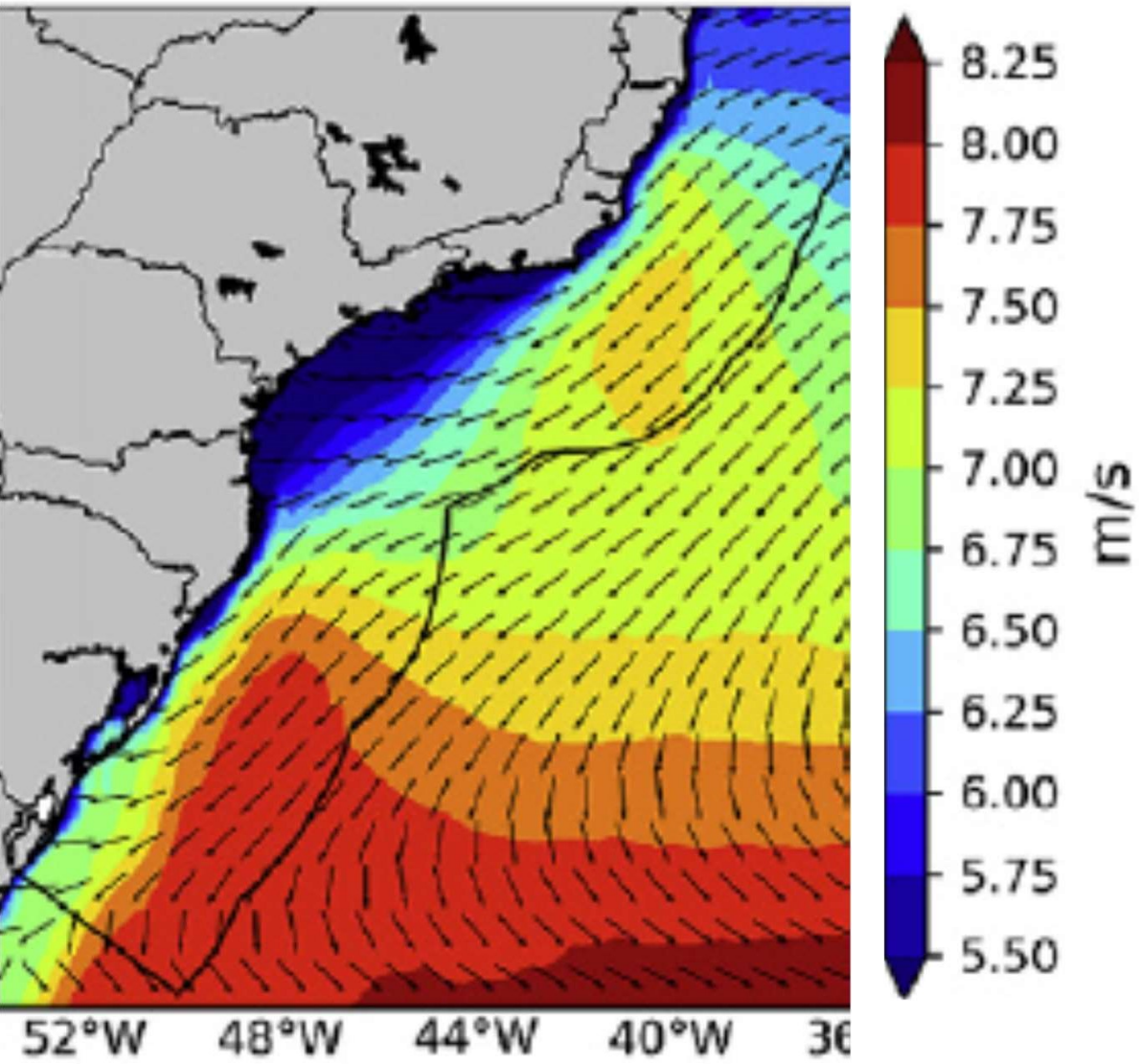
NREL-6MW Annual Power Production (GWh/yr) – 2011-2018

Taylor Diagram



- Correlation with 5 buoys from the Program PNBOIA.
- ERA5 presented the best correlation with experimental data.

Wind Velocity and Direction at 100 m – ERA5 (2011-2018)

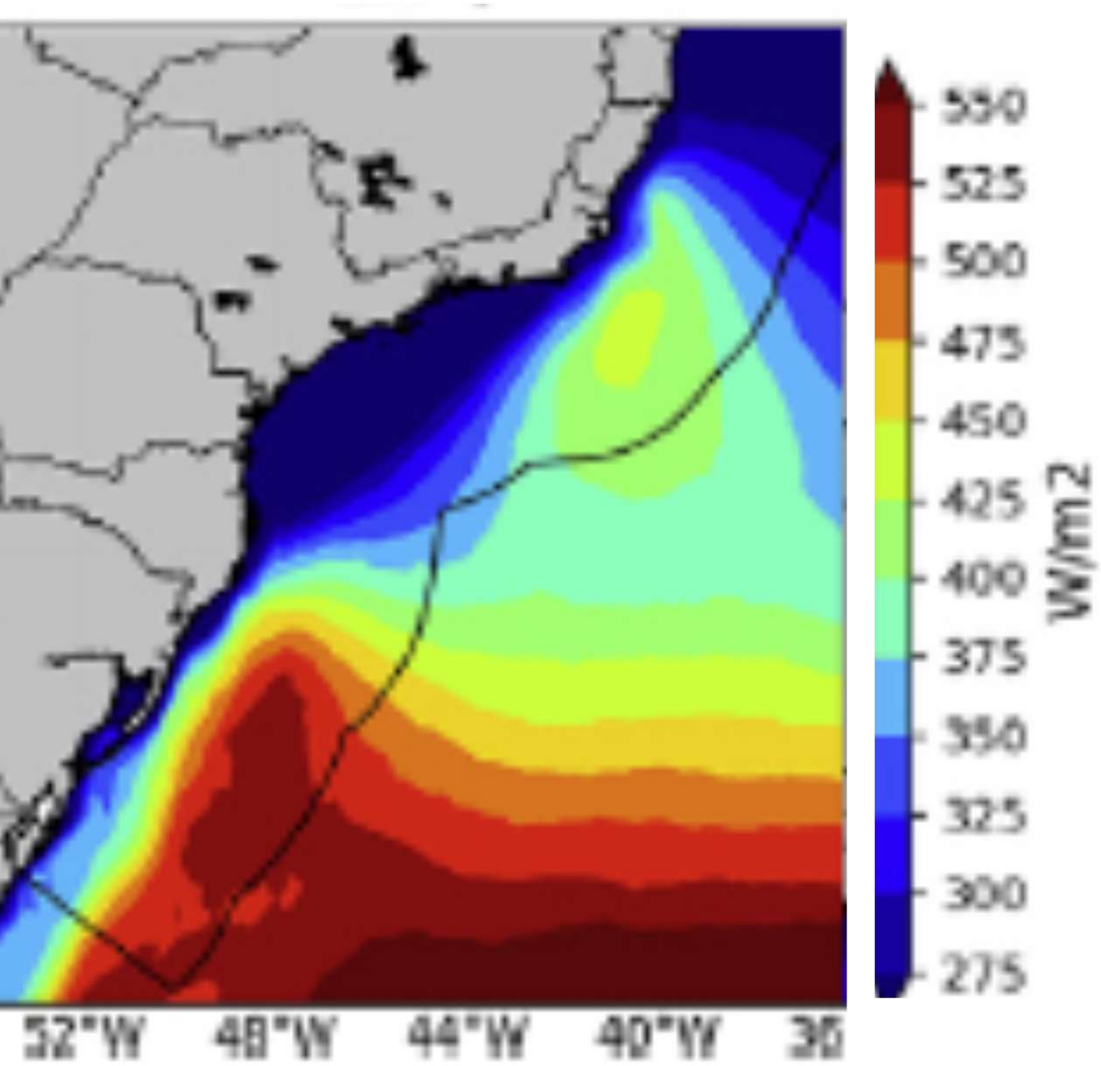


Two regions to be highligted in the EEZ:

- **Offshore Rio de Janeiro State**
  Vmax = 9 m/s; 100 < WD < 1500 m.

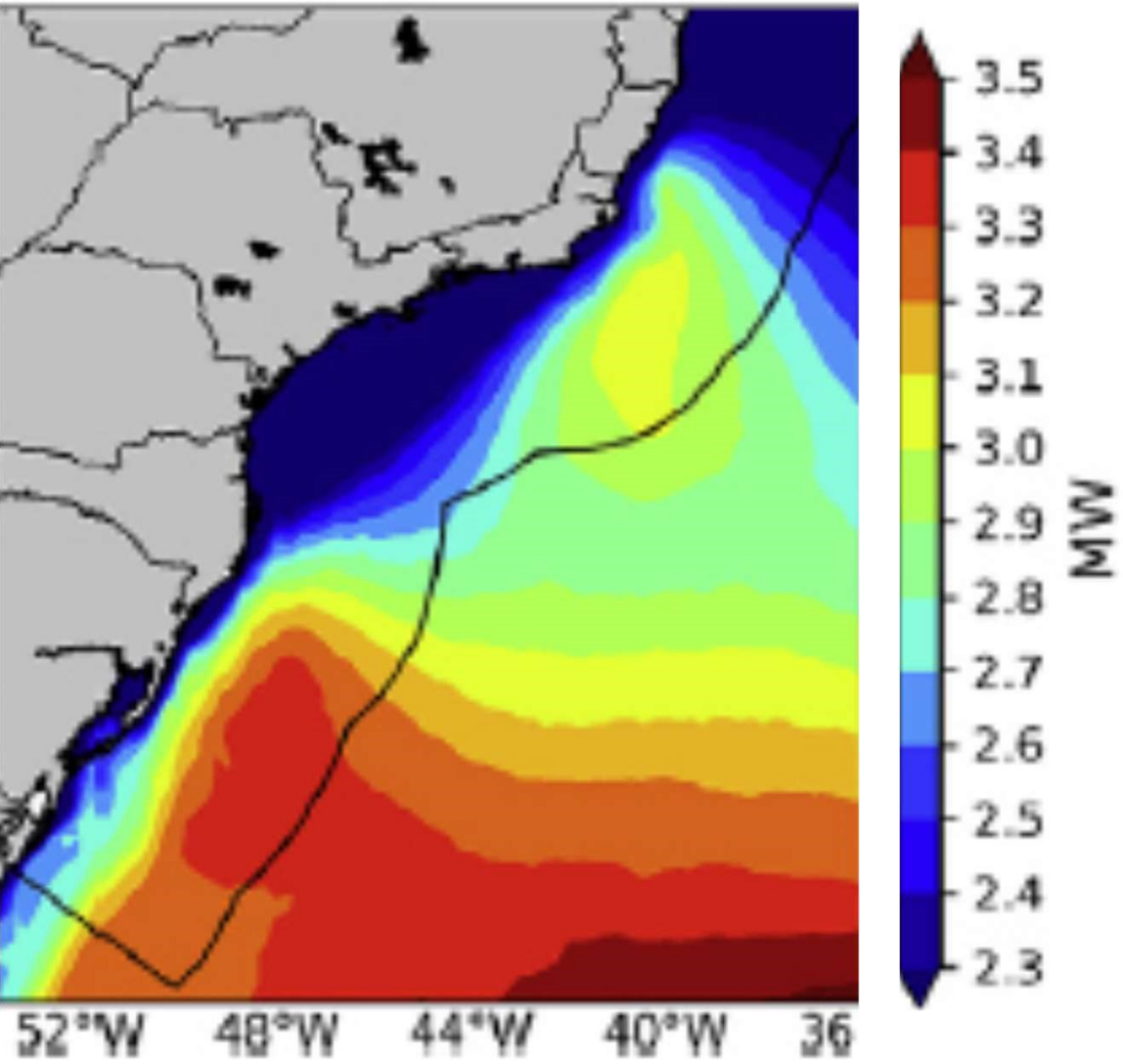
- **Santa Catarina and Rio Grande do Sul States – along the coast and and across the South Atlantic Ocean.**
  Vmax = 9.5 m/s; 50 < WD < 3000 m.

Wind Power Density (W/m²) at 100 m – ERA5 (2011-2018)



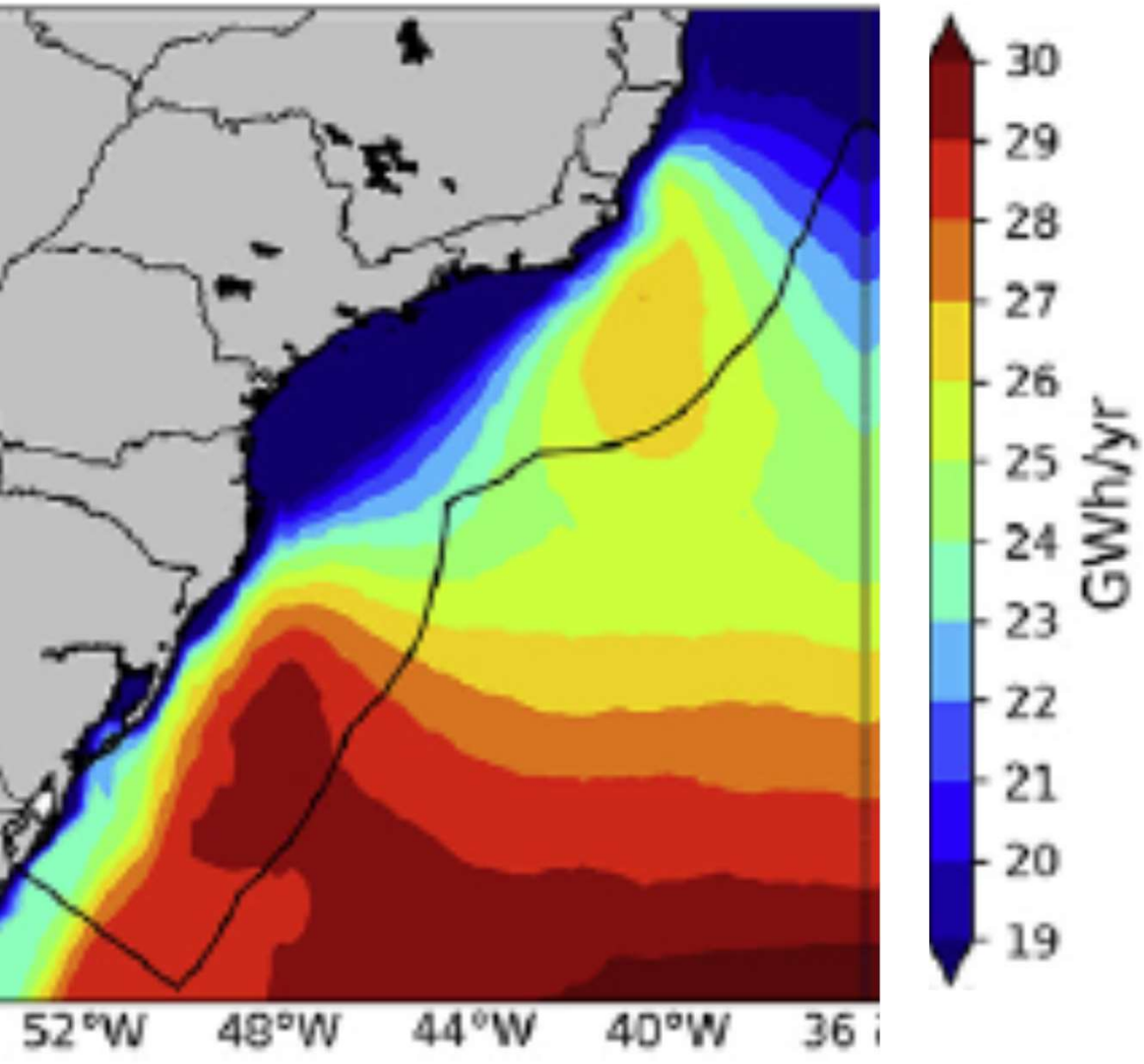
- **Southeast: WPD max = 450 W/m²**
- **South: WPD max = 525 W/m²**

NREL-6MW Turbine Output (MW) at 100m – ERA5 (2011-2018)



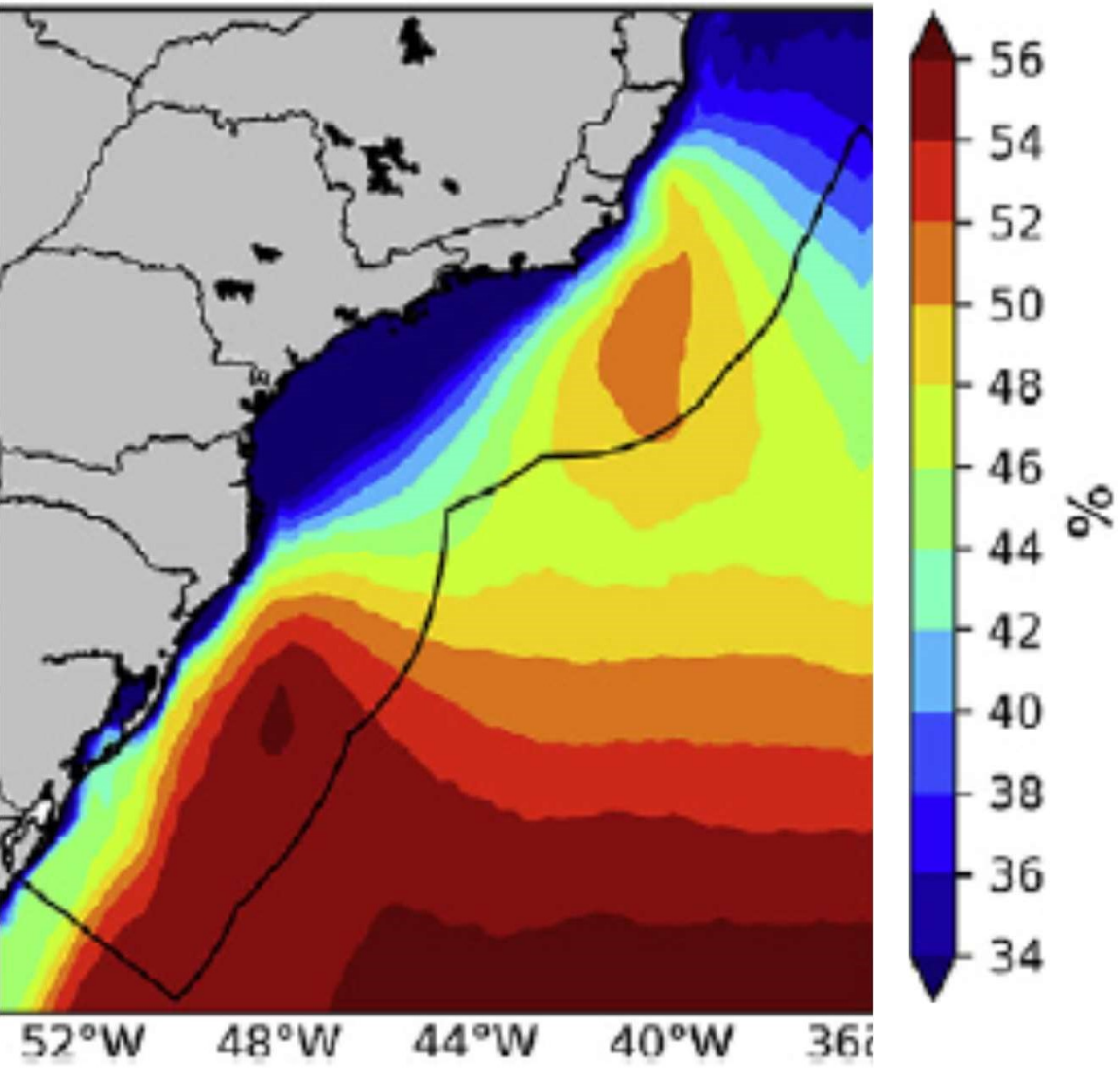
- **Southeast: Tp max= 3 MW**
- **South: Tp max = 3.5 MW**

Annual Energy Production at 100m (GWh/yr) – ERA5 (2011-2018)



- **Southeast: AEPmax = 26 GWh/yr**
- **South: AEPmax = 30 GWH/yr**

NREL-6MW Capacity Factor at 100 m – ERA5 (2011-2018)



- **Southeast: 48 < CF < 52 %**
- **South: 48 < CF < 56 %**

Usable Area on the Sea Surface – Approach I (2011-2018 – ERA5 Database)

Approach I : EEZ

	Southeast	South	Total
Area [km^2]	483,776	415,489	899,265
Number of turbines	241,888	207,745	449,633
Nameplate capacity [GW]	1451	1246	2698
Average output [GW]	578	592	1170
AEP [TWh/yr]	5063	5186	10,249
Production-to-demand ratio [%]	2173	6101	3223

Usable Area on the Sea Surface – Approach II (2011-2018 – ERA5 Database)

Approach II : **Areas excluded due to technical and environmental restrictions**

		Area [km^2]	Number of turbines	Nameplate capacity [GW]	Average output [GW]	AEP [TWh/yr]	Productionto-demand ratio [%]
Up to 20 m	Southeast	1979	990	6	2	18	8
	South	3413	1707	10	4	35	41
20- 50 m	Southeast	18,900	9450	57	20	175	75
	South	16,612	8306	50	21	184	216
50–100 m	Southeast	16,481	8241	49	20	175	75
	South	45,440	22,720	136	61	534	628
100–1000 m	Southeast	74,836	37,418	225	83	727	312
	South	93,851	46,926	282	133	1165	1371
Up to 1000 m	Southeast	112,196	56,098	337	125	1095	470
	South	159,316	79,658	478	219	1918	2256

Northeast and North Regions

North and Northeast Brazil Offshore Wind Power

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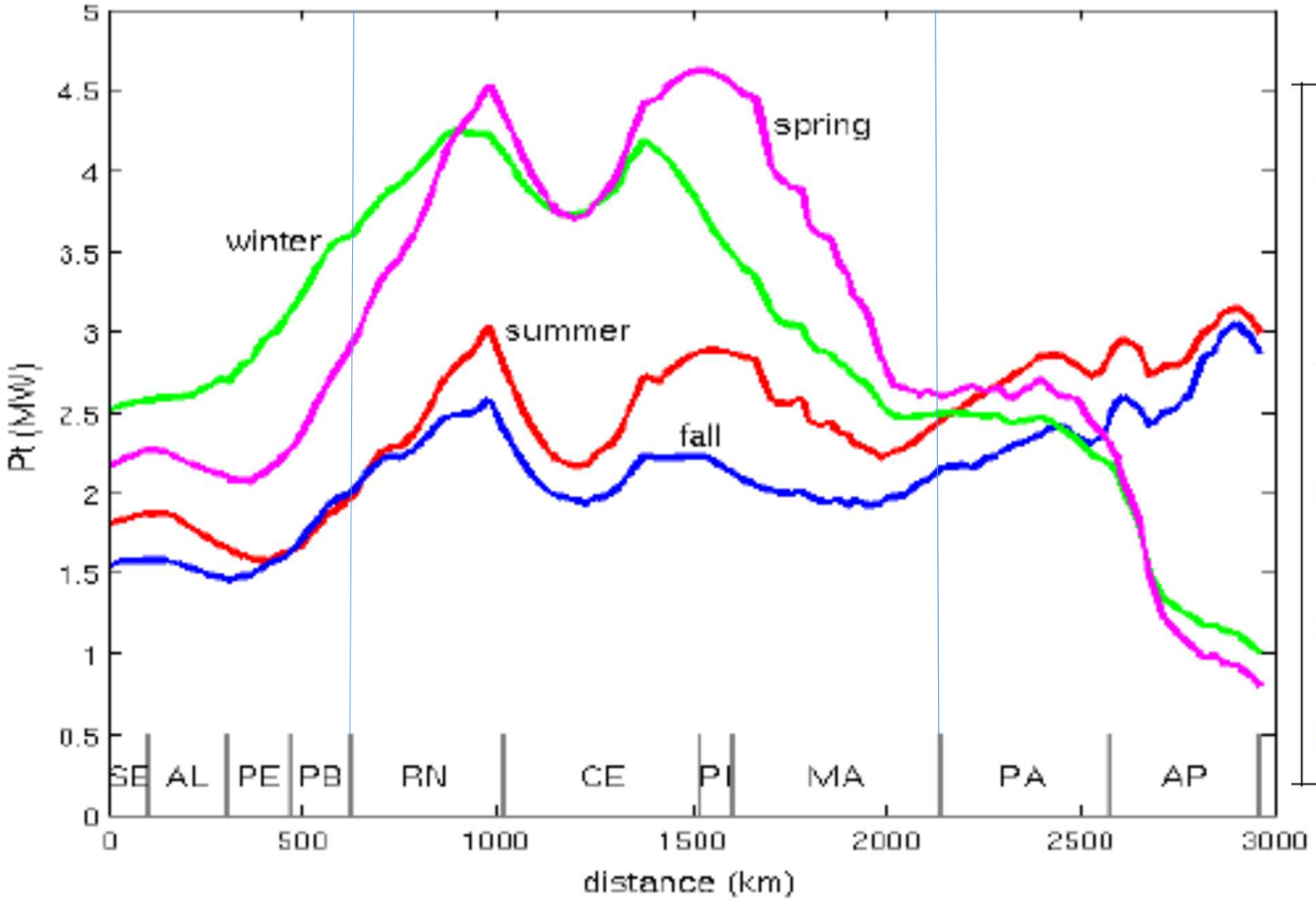
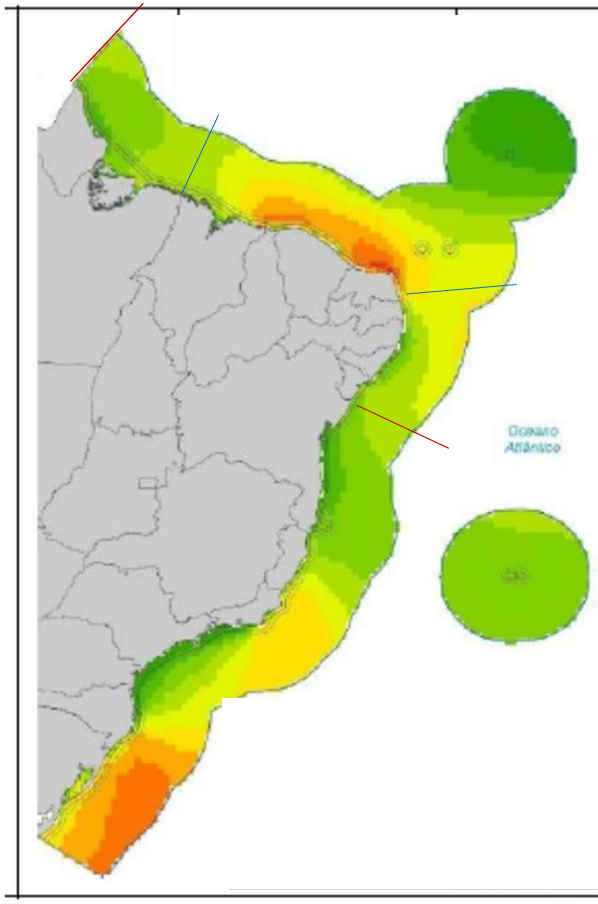
1) Universidade Federal do Rio Grande do Norte (UFRN)
2) Universidade de Brasília (UNB)

This paper was prepared for presentation during the 13th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, August 26-29, 2013.

- Basic wind data obtained from satellite - Blended Sea Winds (NOOA)
- Wind power production estimated by the turbine Repower-6 MW
- Resolution 0.25º (27.5 km) at 10 m height – Data period: 1987 to 2011
- Correlation with 5 offshore buoys (Tropical South Atlantic)

Turbine Power Seasonal Variation





Offshore Wind Velocity - North and Northeast (except Bahia) [100 m]

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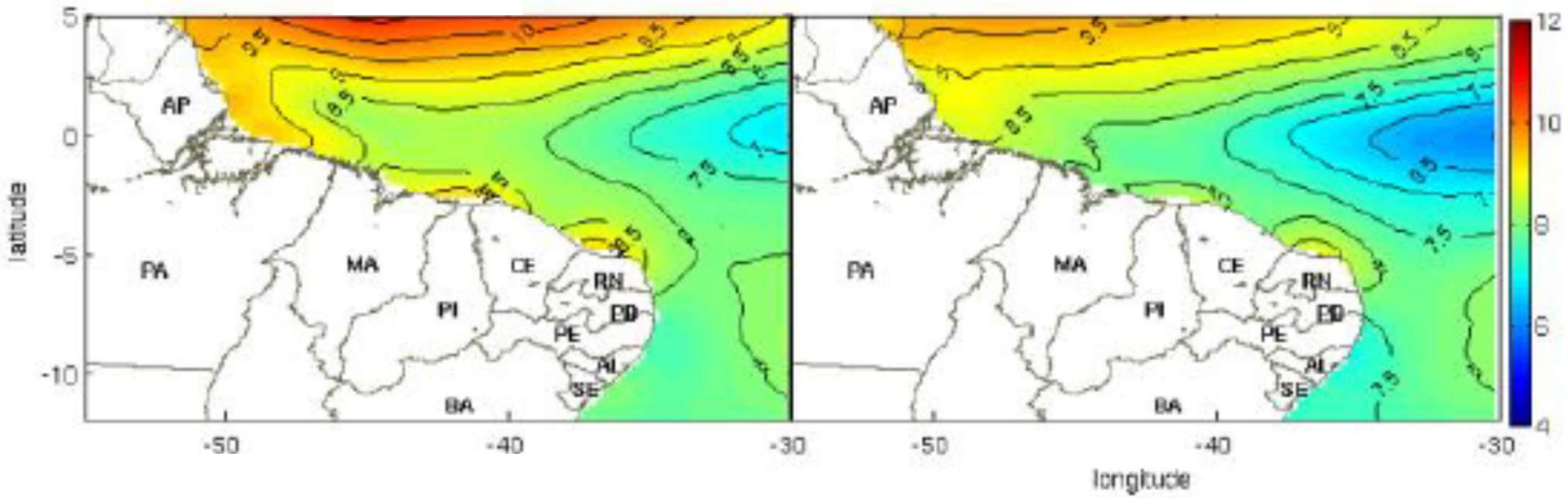
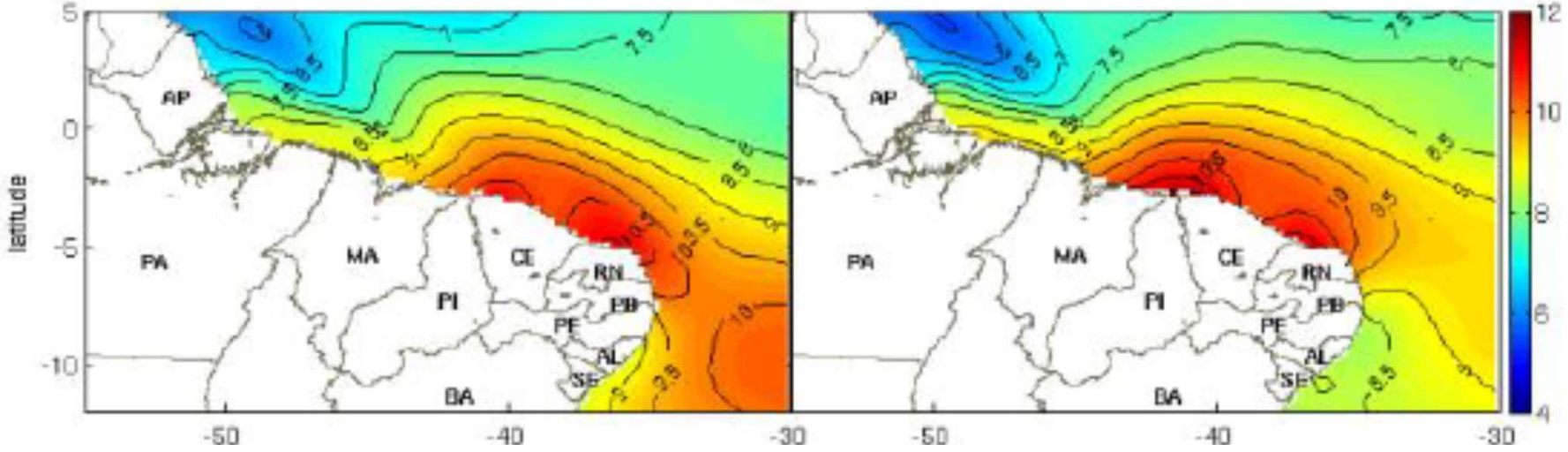
SUMMER

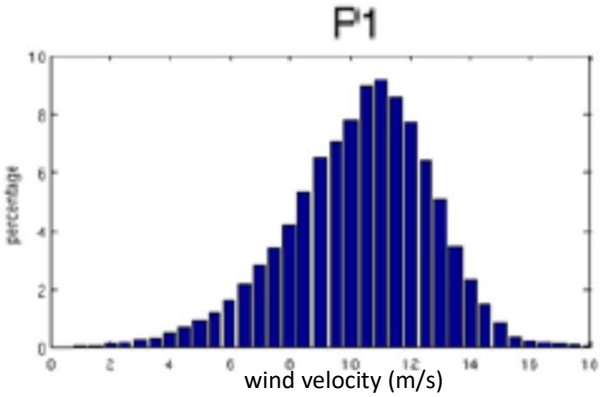
FALL

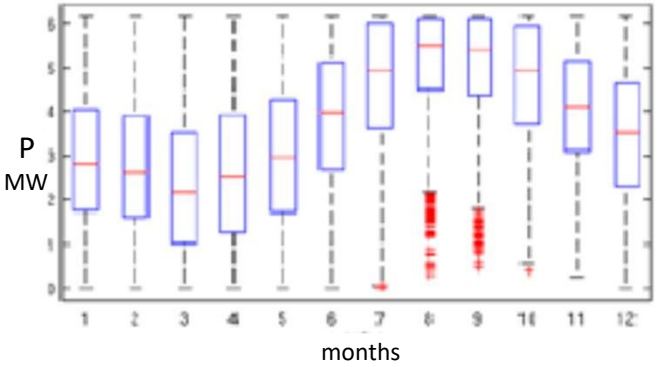


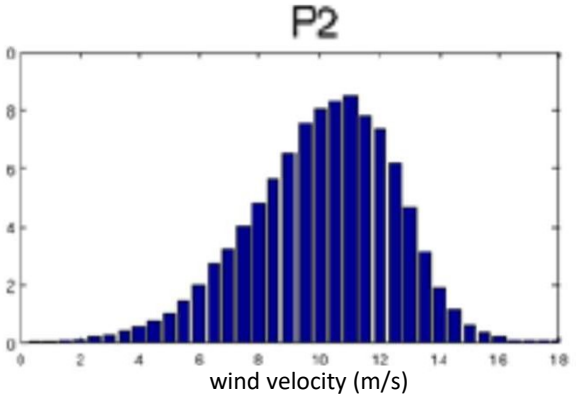
WINTER – Vmax = 10 m/s

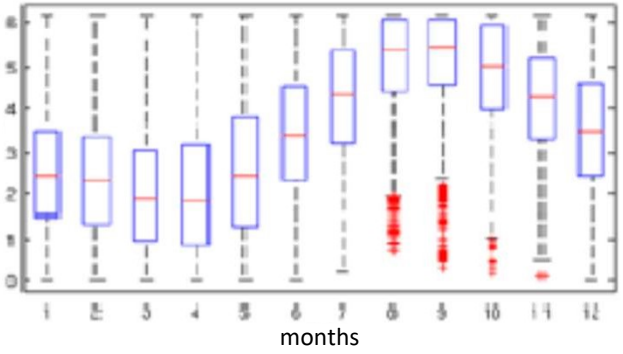
SPRING - Vmax = 12 m/s (CF = 65%)

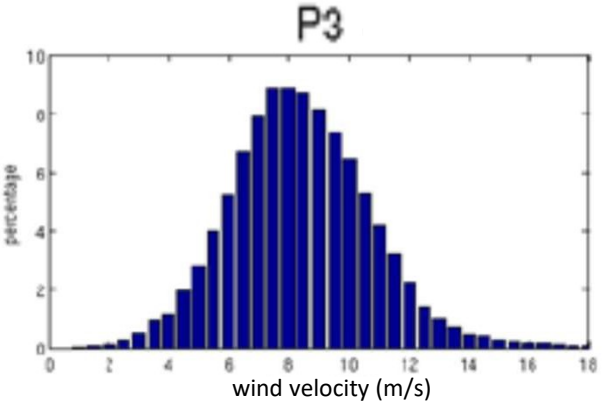


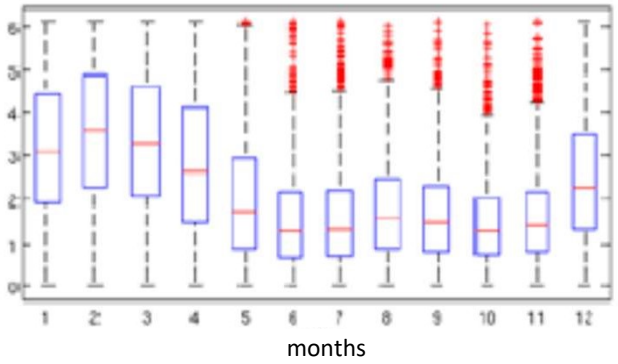

P1
percentage
wind velocity (m/s)

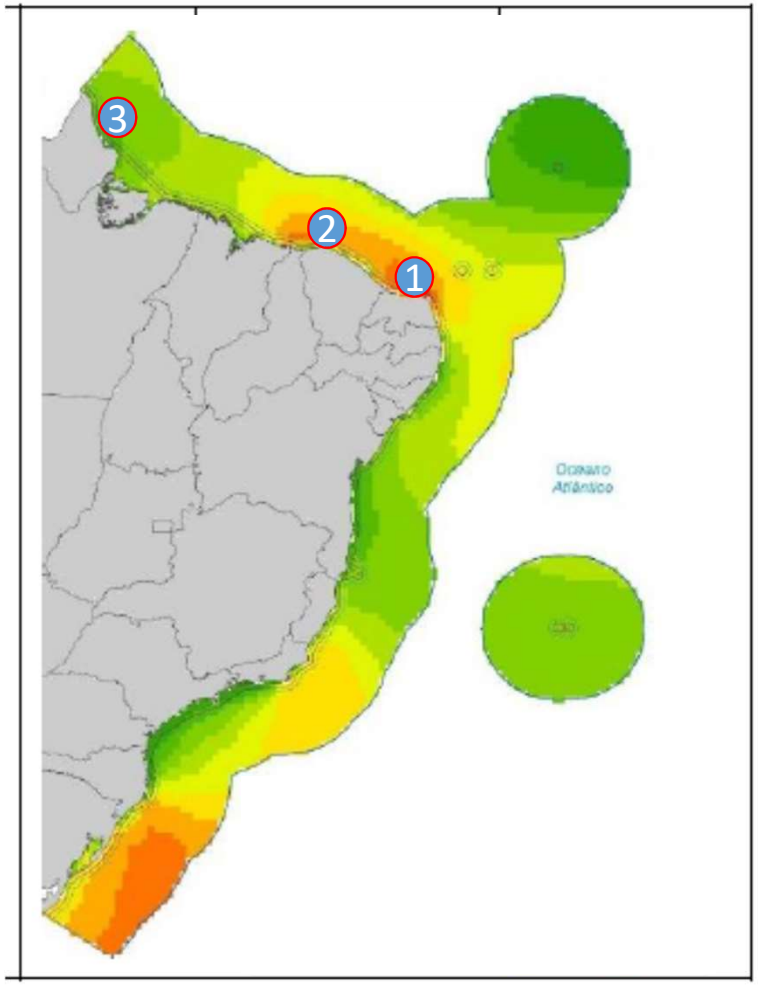

P
MW
months


P2
wind velocity (m/s)


months


P3
percentage
wind velocity (m/s)


months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Oceano Atlântico

Predictive System for Energy Generation and Structural Integrity of Wind Parks

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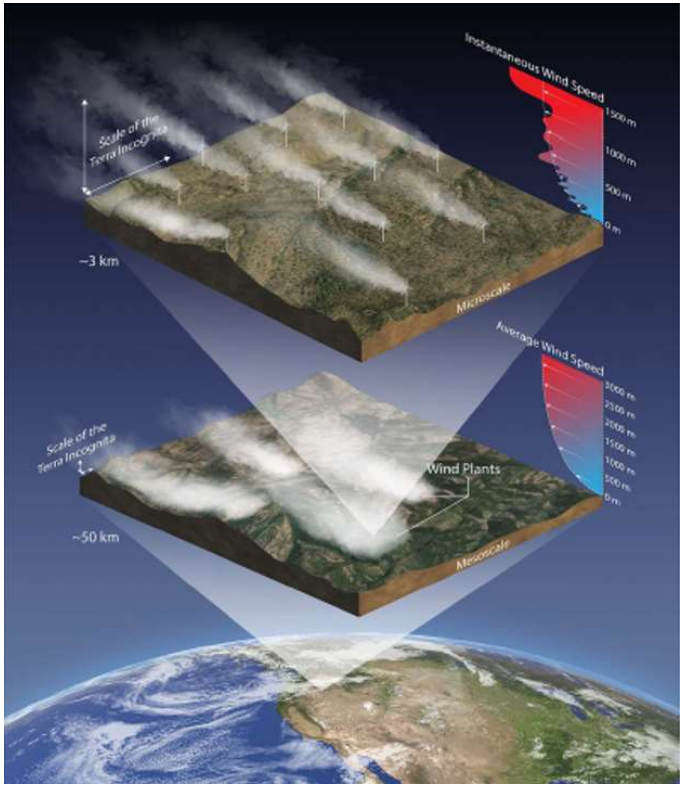
COPPE
UFRJ

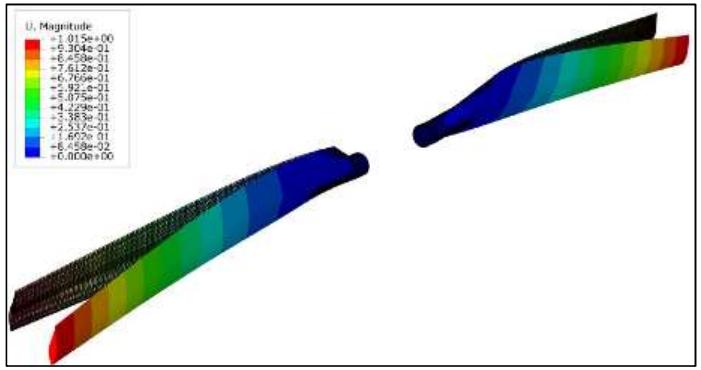
WRF-LES



CFD

Techno-Economic Potential
Layout Optimization
Extreme Conditions
Energy Production

FEA – Structural Integrity



Structural Response to Extreme Loads
Failure Modes (tower/blades)
Life Cycle Integrity
O & M

Conclusions

- Brazil presents an important technical potential for offshore wind power.
- The best regions for the installation of offshore wind parks are located in the Northeast Region **[CF up to 65%]** (Rio Grande do Norte, Ceará, Piauí and Maranhão) and South Region **[CF up to 56%]** (Santa Catarina and Rio Grande do Sul).
- An offshore area of North of Rio de Janeiro and South of Espirito Santo States also present very good technical potential **[CF up to 52%]**.
- Offshore wind power associated with the technical potential is **22 times** the demand for Southeast and South Regions.
- AEP in Southeast and South Regions is **88% higher** than the equivalent Brazilian oil&gas prodution (2018).

Thank you!

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