Advanced methods for processing and improving metocean variables from remote, in-situ and numerical sources

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MARINE OFFSHORE RENEWABLE ENERGY LAB

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Objective and method

Motivations

- **Scarce** on-site **measurements availability**
- **High uncertainty** in ERA5 data

Objective

- Achieve **available** and **reliable** ERA5 data reducing the dependence on on-site measurements

Resource based uncertainty

			Locations					
			Bilbao Vizcaya		Cape Silleiro		Gulf of Cadiz		Cape Begur	
Metric	ORE	Variable	ERA5	CERA5	ERA5	CERA5	ERA5	CERA5	ERA5	CERA5
Occurrence error	-	Wave	37.34	13.18	34.71	9.91	33.03	17.54	15.31	10.86
	-	Wind	16.55	3.54	13.81	5.52	14.11	6.72	16.80	2.00
Flux error	-	Wave	10.30	0.09	8.25	0.02	23.29	0.00	**194.95**	0.65
	-	Wind	9.07	0.06	5.82	0.04	23.44	0.15	31.26	0.40
EDP	-	Wave	35.81	0.51	22.32	0.53	3.78	0.63	5.83	1.00
	-	Wind	19.85	1.11	6.68	0.91	8.81	2.18	14.99	3.45
Design uncertainty										
Production	WEC	AEP	**49.89**	8.88	24.92	0.57	4.47	0.87	**41.70**	0.02
	FOWT	AEP	28.85	1.55	3.50	1.32	3.55	1.07	4.19	0.03
FLS	WEC	$MOOR_{Fair}$	**1205.77**	**79.27**	**65.68**	28.27	10.63	**41.11**	4.41	25.57
		$MOOR_{Fair}$	**50.93**	10.86	**54.77**	23.09	10.51	**56.02**	5.00	**47.28**
	FOWT	TOW_{Base}	**67.97**	**65.46**	19.72	32.90	1.66	**41.32**	34.54	31.44
		BLA_{Root}	10.32	5.87	4.39	3.40	20.75	10.69	3.09	5.54
ULS	WEC	$MOOR_{Fair-Ten}$	27.37	20.70	31.17	3.85	1.27	2.53	2.78	0.66
		$MOOR_{Fair-Ten}$	**41.07**	5.88	24.29	0.39	3.20	0.27	3.39	0.76
	FOWT	TOW_{In-Ben}	25.36	6.01	22.46	0.13	2.65	2.62	15.13	5.08
		$TOW_{Out-Ben}$	**55.60**	11.07	3.81	7.67	0.50	5.60	**64.02**	3.38
		BLA_{In-Bun}	33.33	3.33	14.40	2.29	4.95	9.08	4.82	17.68
		$BLA_{Out-Ben}$	33.64	6.47	1.45	0.09	1.08	0.88	0.24	0.37
O&M	WEC	MWT	**58.68**	8.40	28.75	21.08	23.05	0.82	**45.93**	1.48

Note: $MOOR_{Fair}$ = Mooring fairlead; TOW_{Base} = Tower base; BLA_{Root} = Blade root;

[1] Martinez-Perurena et al., *On the Impact of Resource Uncertainties on the Design of Offshore Renewable Energy Technologies*, submitted to Applied Energy, 2026

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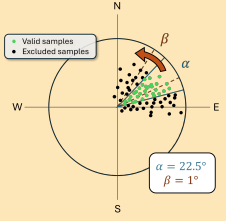
Bias Correction Model (*DAQM*)



Bounded optimization is applied to an objective function to find a set of correction factors[2]:

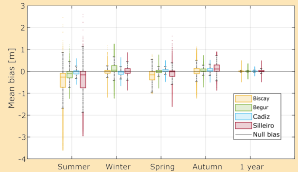
$$\begin{cases} y_{BC} = a(\theta_j, q_i) y_{SIM}{}^{b(\theta_j, q_i} + c(\theta_j, q_i) \\ min_{a,b,c}[\sum (y_i^{obs} - y_i^{BC})^2] \end{cases}$$

[2] Lemos et al., *On the need of bias correction methods for wave climate projections*, Global and Planetary Change, 2020

Results and developments

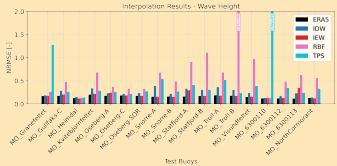
Temporal extrapolation

- **10 years** of data calibrated using only **3 months** for training[3]:



Spatial interpolation

- ERA5 data uncertainty only reduces in **a fraction** of test points[4]:



- Next step: turn towards physics-informed methods (such as **Machine Learning algorithms**) to evaluate bias spatial pattern and enable **large scale model calibration**

[3] Callea et al., *Resource assessment uncertainty reduction via bias correction: On the temporal and spatial sensitivity analysis*, Applied Ocean Research, 2025

 [4] Callea et al., *On the development of a spatially-transferable bias-correction framework: Assessing spatial uncertainty reduction in the North Sea*, EGU 2026

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Questions?

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