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Evaluation of ERA5, COSMO-REA6 and CERRA in simulating wind speed along the French coastline for wind energy applications

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Analysis		D																							
Day	H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
D	0	A	+1	+2	+3	+4	+5	+6			+9			+12			+15			+18			+21		
D	3				A	+1	+2	+3	+4	+5	+6														
D	6							A	+1	+2	+3	+4	+5	+6											
D	9										A	+1	+2	+3	+4	+5	+6								
D	12													A	+1	+2	+3	+4	+5	+6			+9		
D	15																A	+1	+2	+3	+4	+5	+6		
D	18																			A	+1	+2	+3	+4	+5
D	21																						A	+1	+2

Figure S1. The analysis hours ("A") at each day (in red) and the forecasts chosen (in green) for ("A" +4, "A" +5, "A" +6) in the study for CERRA (From Jourdier et al., 2023).

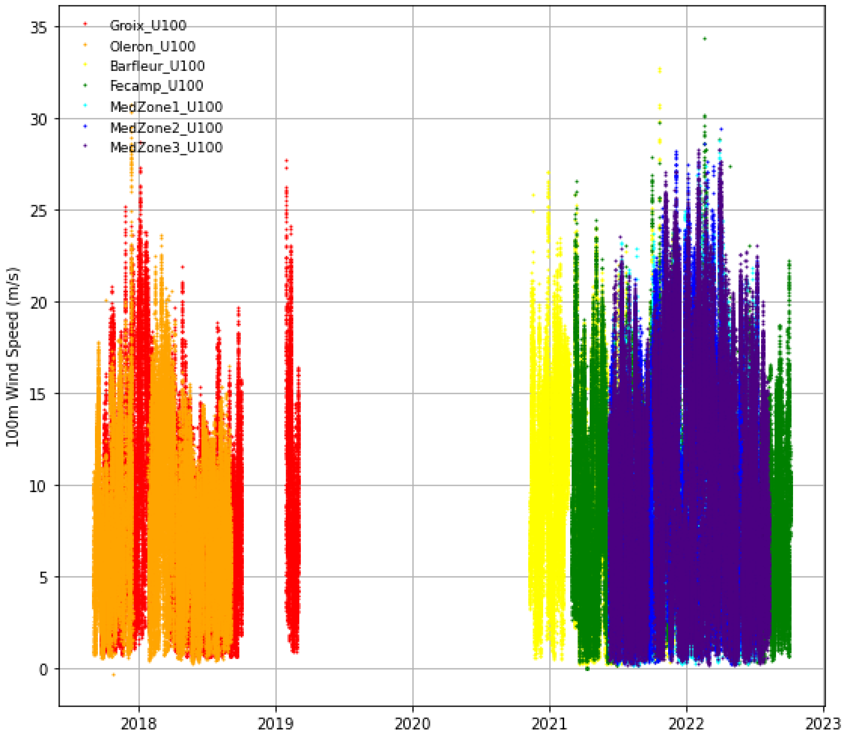

Figure S2. Time-series of LIDAR measurements at different stations

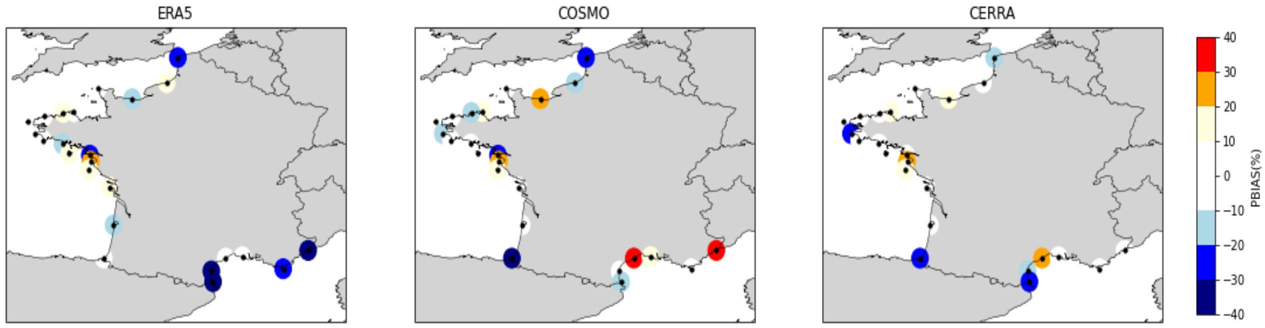

Figure S3. Maps showing percentage biases (PBIAS) for 10m wind speed from the reanalyses with compared to SYNOP measurements.

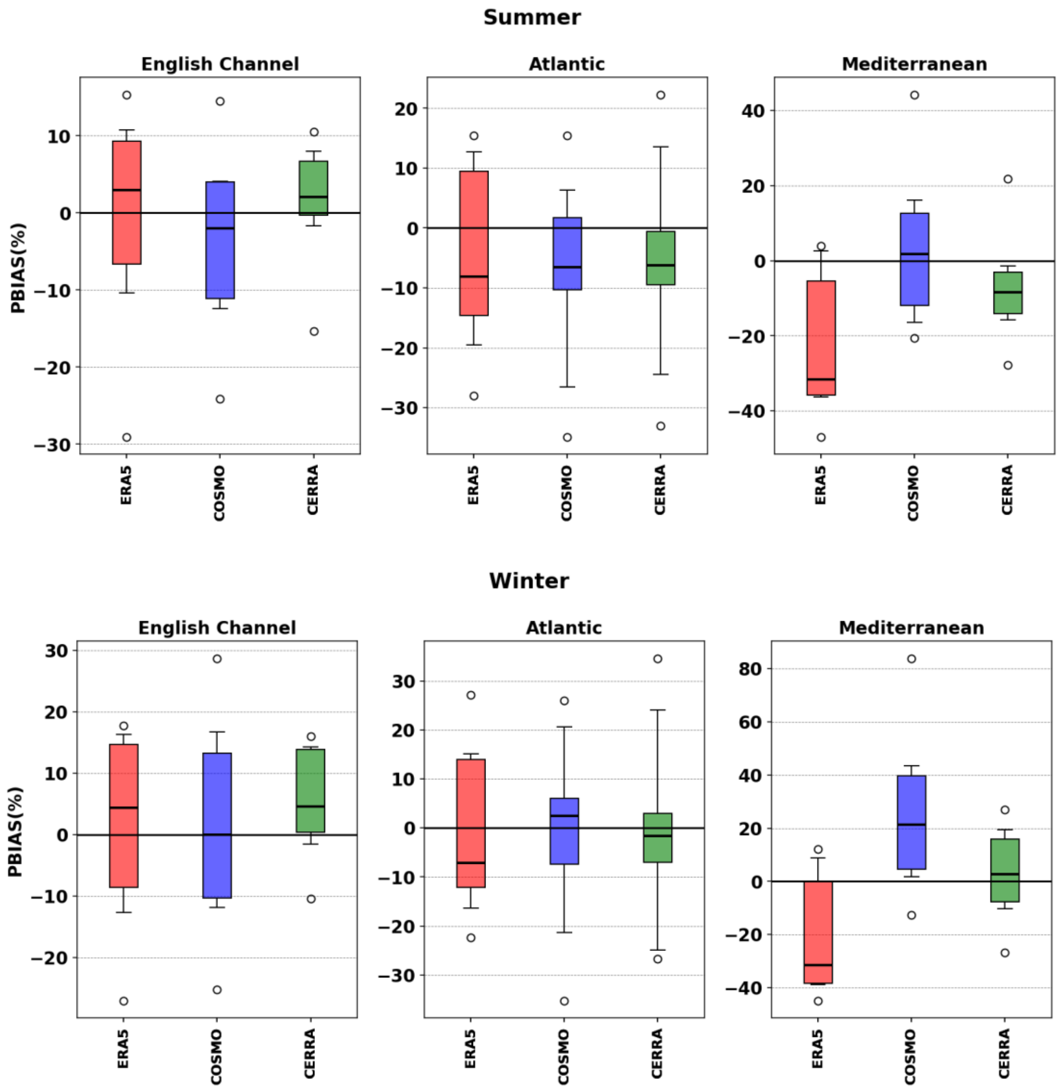

Figure S4. Box–Whisker plots for the bias distribution over the stations for 10 m wind speed from the reanalyses with compared to SYNOP. Same as Figure3, but just including summer: June-August (above) and winter: December-February (below) months.

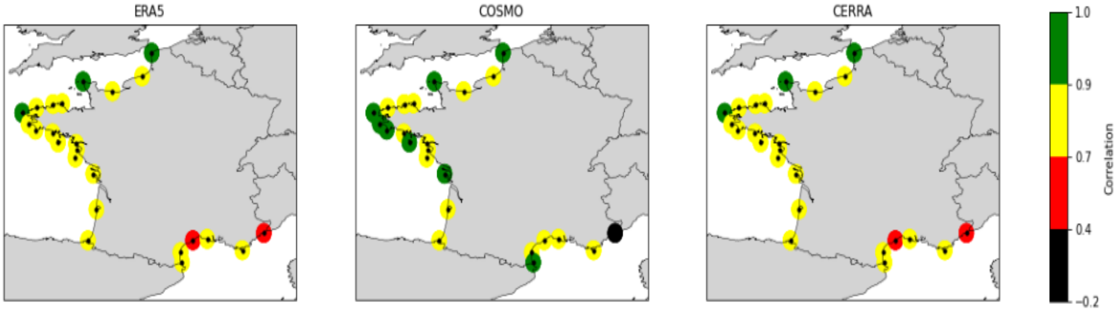

Figure S5. Maps showing Pearson correlation coefficient for 10 m wind speed from the reanalyses and SYNOP measurements. This is using hourly time series at common time steps between reanalyses and measurement.

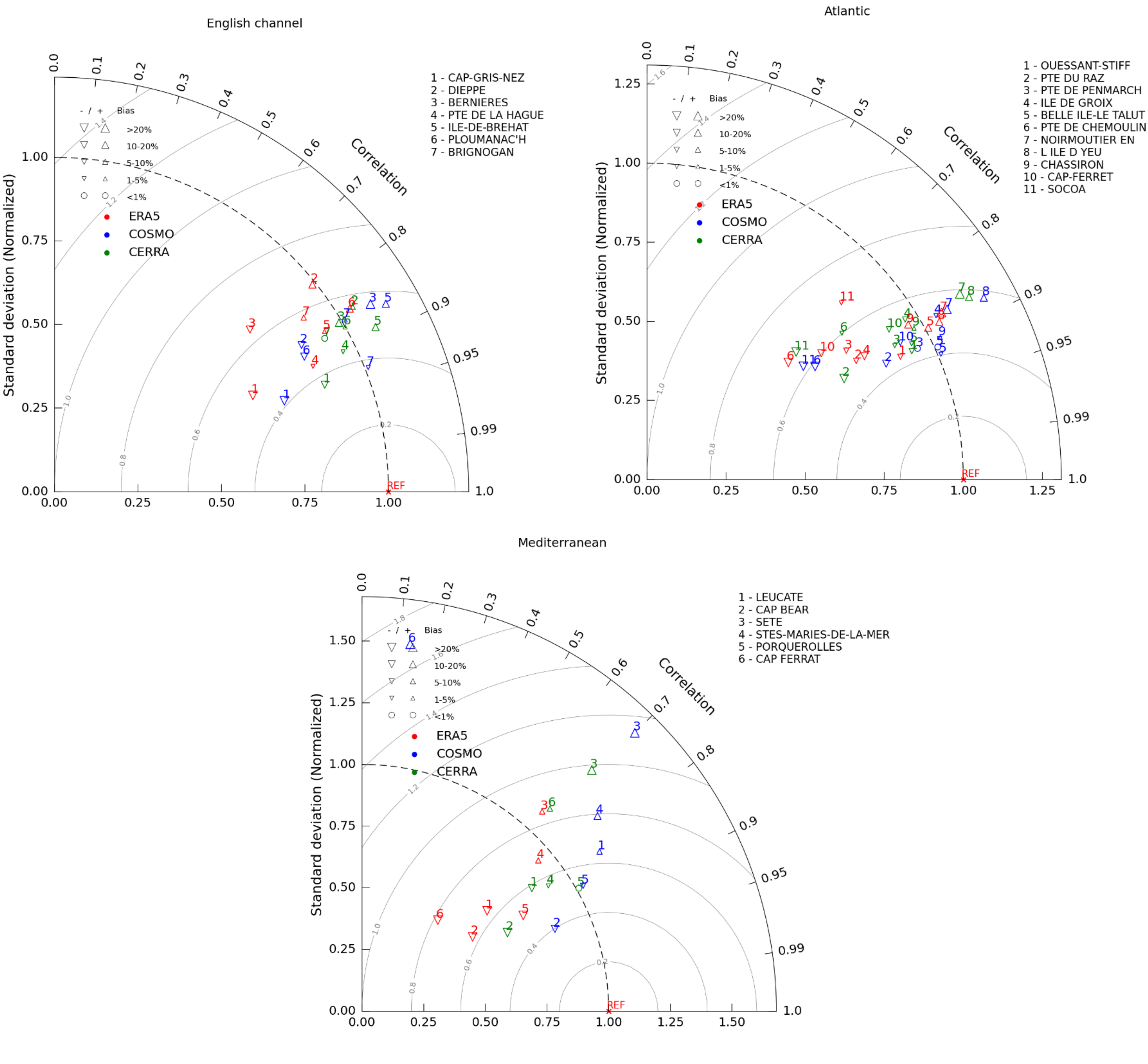

Figure S6. Taylor diagram including Pbias values (in %) of each station at the 3 french coasts.

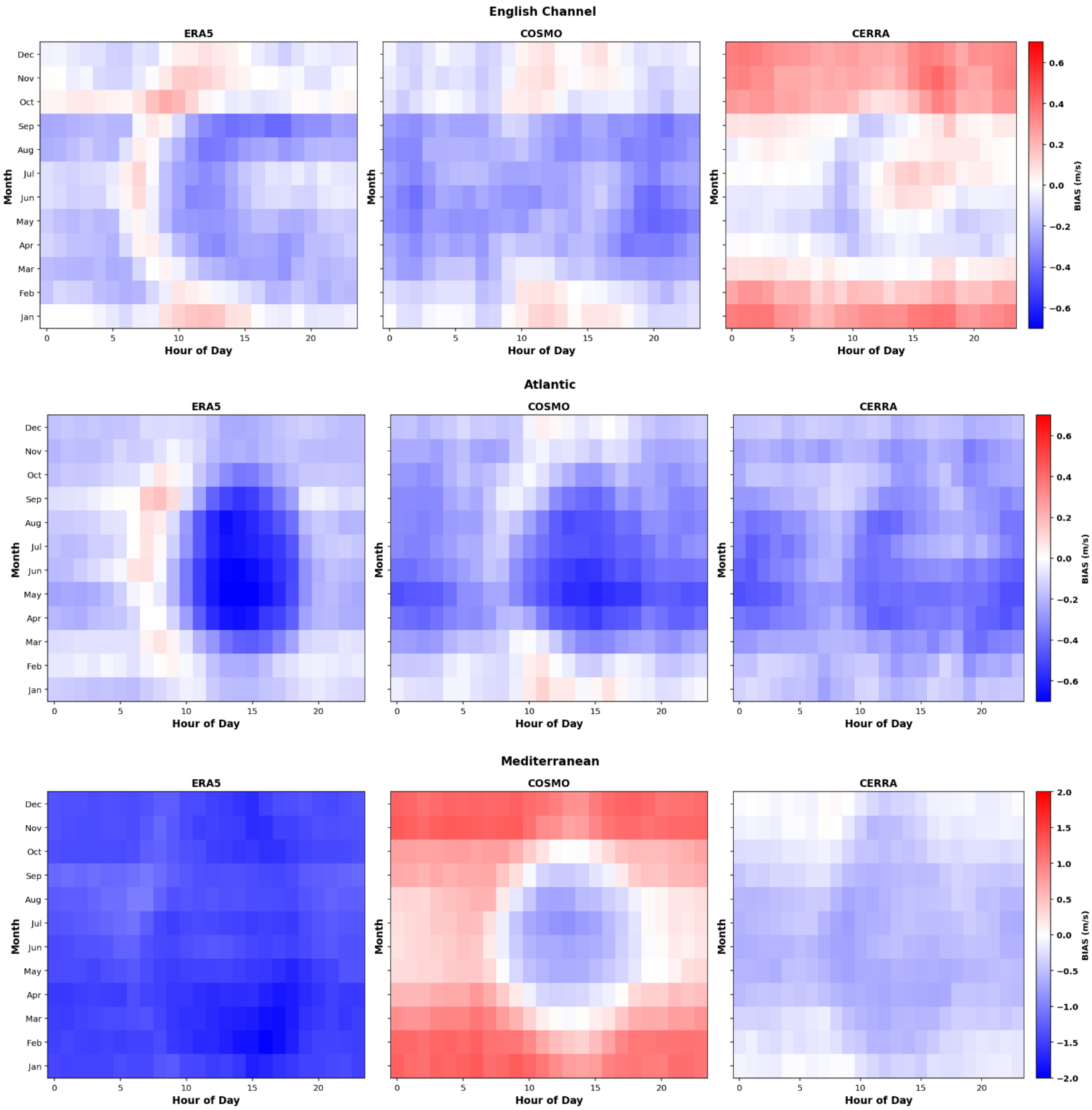

Figure S7. Monthly and hourly surface wind speed error with relative to the observation during 1995-2018.

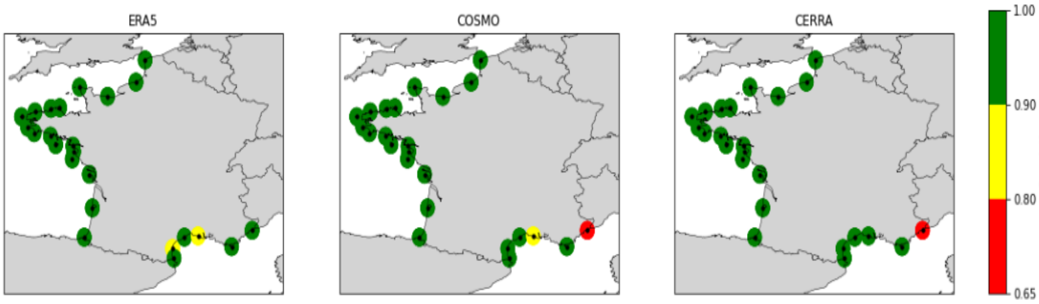

Figure S8. Maps showing Pearson correlation coefficient between seasonal cycles from the reanalyses and SYNOP measurements (10m wind speed).

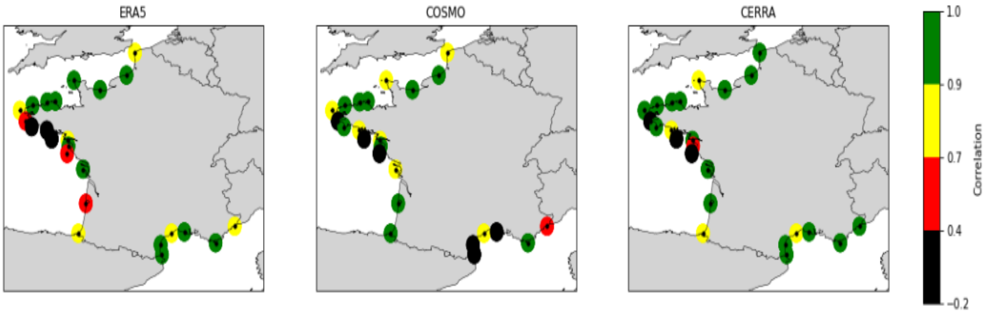

Figure S9. Maps showing Pearson correlation coefficient between diurnal cycles from the reanalyses and SYNOP measurements (10m wind speed).

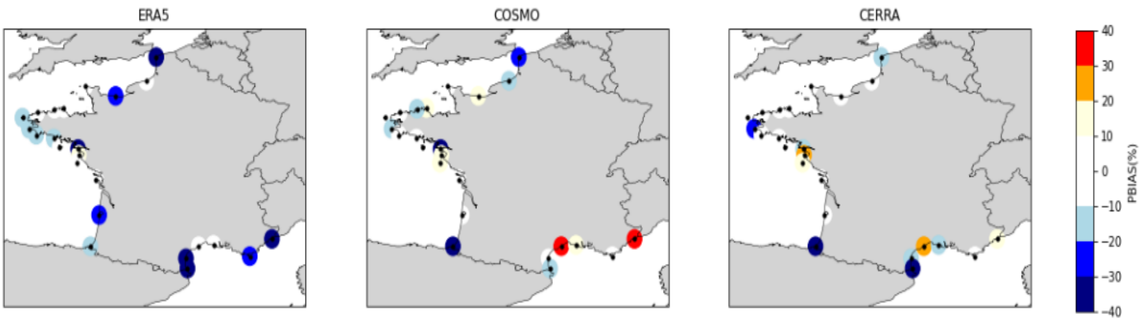

Figure S10. Maps showing percentage biases (PBIAS) in 95th Percentiles for 10m wind speed from the reanalyses with compared to SYNOP measurements.

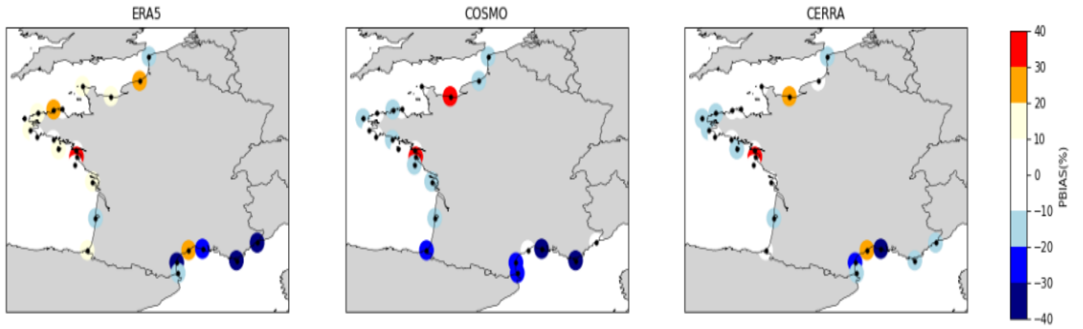

Figure S11. Maps showing percentage biases (PBIAS) in 5th Percentiles for 10m wind speed from the reanalyses with compared to SYNOP measurements.

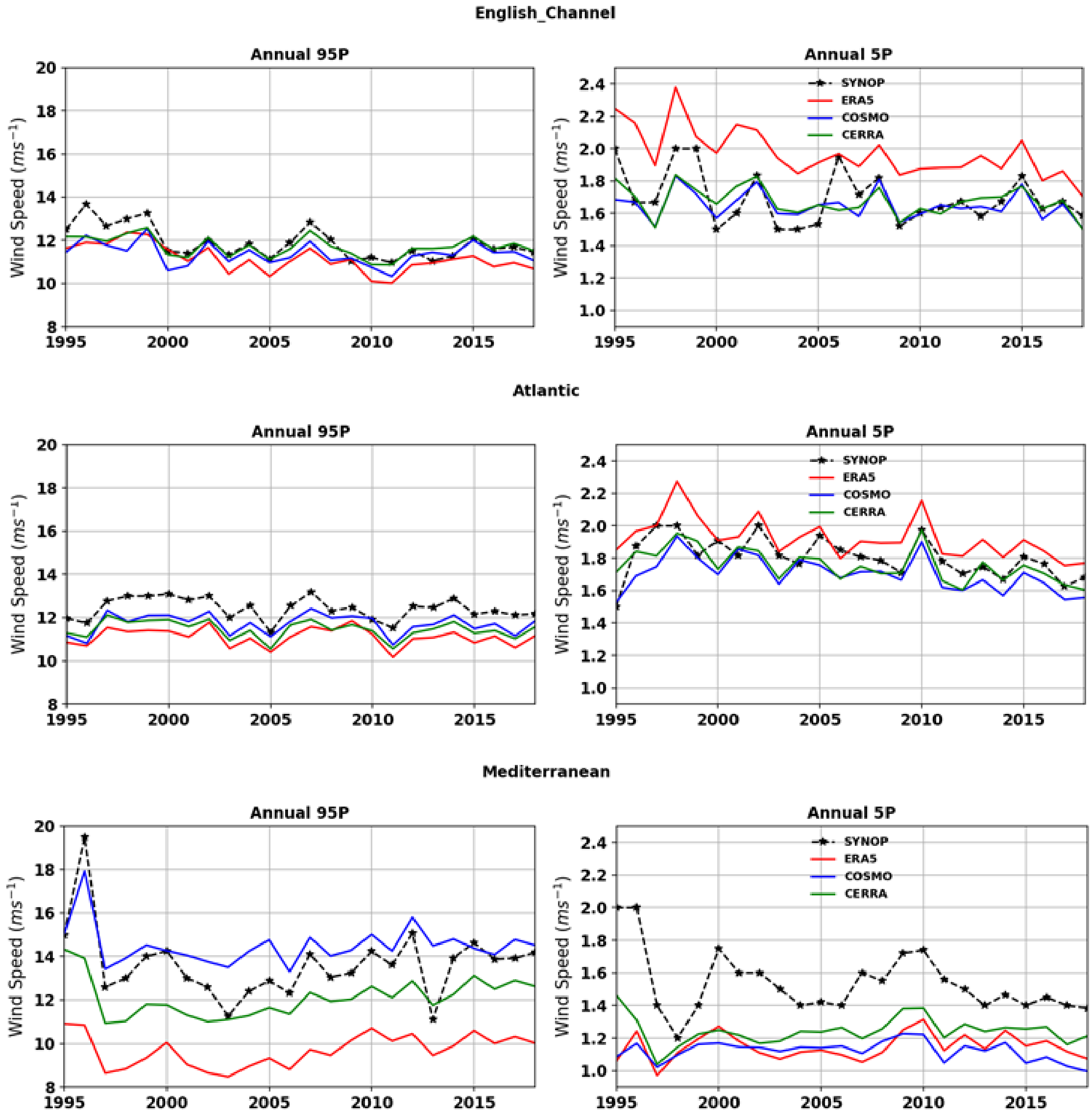

Figure S12. Interannual variability of the 95th percentile (left column) and 5th percentile (right column) wind speed (mean over the stations for each coastline)

Scores in English Channel	ERA5				COSMO				CERRA			
	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR
Station	[%]	[%]	[]	[]	[%]	[%]	[]	[]	[%]	[%]	[]	[]
CAP-GRIS-NEZ	-27,78	10,21	0,66	0,90	-24,93	8,97	0,74	**0,93**	**-13,13**	**6,43**	**0,87**	**0,93**
DIEPPE	14,04	7,36	**0,99**	0,78	-10,15	**5,65**	0,86	**0,86**	**9,72**	6,06	1,05	0,85
BERNIERES	-11,66	8,66	0,76	0,77	22,74	8,86	1,1	**0,86**	12,5	**7,2**	**0,99**	**0,86**
PTE DE LA HAGUE	-4,13	3,6	0,86	0,90	**-1,4**	**3,15**	**1,01**	**0,93**	-2,43	3,52	0,96	0,90
ILE-DE-BREHAT	**3,6**	**6,97**	**0,94**	0,86	11,73	8,04	1,14	0,87	12,83	7,47	1,08	**0,89**
PLOUMANAC'H	16,15	6,63	1,04	0,85	-11,38	5,44	0,85	**0,88**	**3,26**	**5,23**	**1**	0,87
BRIGNOGAN	9,03	6,78	0,91	0,82	5,54	5,98	1,01	0,86	**0,19**	**5,67**	0,93	**0,87**
Seafront mean	**12,3**	**7,17**	**0,9**	**0,8**	**12,6**	**6,6**	**1,0**	**0,9**	**7,7**	**5,9**	**1,0**	**0,9**
Seafront best score	**1/7**	**1/7**	**2/7**	**0/7**	**1/7**	**2/7**	**1/7**	**5/7**	**4/7**	**4/7**	**3/7**	**6/7**

Scores in Atlantic Ocean	ERA5				COSMO				CERRA			
	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR
Station	[%]	[%]	[]	[]	[%]	[%]	[]	[]	[%]	[%]	[]	[]
OUESSANT-STIFF	-6,51	4,99	0,89	0,90	**-3,05**	**4,64**	**1,01**	**0,92**	-7,59	5,18	0,93	0,90
PTE DU RAZ	**-9,83**	6,79	0,76	0,87	-12,47	**6,30**	**0,84**	**0,90**	-26,36	8,78	0,70	0,89
PTE DE PENMARCH	-8,12	7,44	0,75	0,84	-0,90	**5,68**	**0,95**	**0,90**	-4,83	6,36	0,89	0,88
ILE DE GROIX	-17,44	6,29	0,79	**0,87**	**-2,18**	**5,45**	1,05	**0,87**	-5,55	5,67	**0,96**	0,85
BELLE ILE-LE TALUT	12,76	6,88	**1,01**	0,88	**0,84**	**5,28**	**1,01**	**0,91**	-4,58	5,87	0,94	0,89
PTE DE CHEMOULIN	-24,12	9,15	0,58	0,77	-23,48	8,34	0,64	**0,83**	**-4,50**	**7,21**	**0,77**	0,80
NOIRMOUTIER EN	22,23	7,41	**1,07**	**0,87**	**20,76**	**7,31**	1,09	**0,87**	29,48	8,87	1,15	0,86
L ILE D YEU	**10,79**	**2,70**	**1,05**	**0,88**	13,50	3,14	1,21	**0,88**	19,34	3,39	1,17	0,87
CHASSIRON	12,70	6,42	0,96	0,86	4,62	**5,35**	**1,03**	**0,90**	**3,81**	5,75	**0,97**	0,87
CAP-FERRET	-16,69	6,10	0,68	0,81	-6,68	**4,52**	**0,91**	**0,88**	**-5,48**	4,86	0,90	0,85
SOCOA	**-2,27**	**7,00**	0,83	0,74	-34,61	8,29	0,61	**0,81**	-28,36	8,08	0,62	0,76
Seafront mean	**13,04**	**6,47**	**0,85**	**0,84**	**11,19**	**5,85**	**0,94**	**0,88**	**12,72**	**6,37**	**0,91**	**0,86**
Seafront best score	**2/11**	**2/11**	**3/11**	**3/11**	**4/11**	**8/11**	**6/11**	**11/11**	**3/11**	**1/11**	**3/11**	**3/11**

Scores in Mediterranean Sea	ERA5				COSMO				CERRA			
	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR
Station	[%]	[%]	[]	[]	[%]	[%]	[]	[]	[%]	[%]	[]	[]
LEUCATE	-36,86	12,10	**0,65**	0,78	6,63	9,03	1,16	**0,83**	-13,69	**8,51**	0,85	0,81
CAP BEAR	-36,58	12,79	0,54	0,83	-16,42	**7,20**	**0,85**	**0,92**	-27,26	10,09	0,67	0,88
SETE	**6,88**	**8,52**	**1,09**	0,67	31,33	12,56	1,58	**0,70**	25,42	10,71	1,35	0,69
STES-MARIES-DE-LA-MER	5,99	8,88	0,94	0,76	14,58	10,90	1,24	0,77	**-4,66**	**7,34**	0,91	**0,83**
PORQUEROLLES	-27,75	9,81	0,76	0,86	-6,49	7,48	1,03	**0,87**	**1,00**	**7,29**	**1,01**	**0,87**
CAP FERRAT	-45,01	10,45	0,48	0,64	65,20	19,81	1,50	0,13	**6,99**	**8,77**	**1,12**	**0,68**
Seafront mean	**26,51**	**10,43**	**0,74**	**0,76**	**23,44**	**11,16**	**1,23**	**0,70**	**13,17**	**8,79**	**0,99**	**0,79**
Seafront best score	**1/6**	**1/6**	**2/6**	**0/6**	**0/6**	**1/6**	**1/6**	**4/6**	**3/6**	**4/6**	**2/6**	**4/6**

Table S1. Error metrics at the coastal stations (Figure 1) for 10m wind speed during 1995-2018 for the 3 French coasts. The best scores are indicated in bold and are highlighted in green. The last 2 lines present respectively the average of all stations for each score (note: for the PBIAS, it is the average of the absolute values that is calculated), and the number of stations (out of total stations) for which the reanalysis obtains the best score.

Station	Lon	Lat	Percentage of missing data (%)
BELLE ILE-LE TALUT	-3.2183	47.2943	12.67
BERNIERES	-0.4306	49.3340	29.45
BRIGNOGAN	-4.3310	48.6765	4.43
CAP BEAR	3.1350	42.5166	13.52
CAP FERRAT	7.3283	43.6833	54.88
CAP-FERRET	-1.2520	44.6306	17.28
CAP-GRIS-NEZ	1.5828	50.8696	58.66
CHASSIRON	-1.4116	46.0468	4.95
DIEPPE	1.0900	49.9328	5.18
ILE DE GROIX	-3.5023	47.6523	4.81
ILE-DE-BREHAT	-3.0045	48.8551	38.41
L ILED YEU	-2.3301	46.6936	9.09
LEUCATE	3.0596	42.9173	8.84
NOIRMOUTIER EN	-2.2571	47.0046	0.47
OUESSANT	-5.0570	48.4733	4.84
PLOUMANAC'H	-3.4731	48.8258	12.65
PORQUEROLLES	6.2268	43.0000	55.91
PTE DE CHEMOULIN	-2.2985	47.2336	25.46
PTE DE LA HAGUE	-1.9398	49.7251	17.66
PTE DE PENMARCH	-4.3748	47.7975	8.83
PTE DU RAZ	-4.7320	48.0388	8.84
SETE	3.6921	43.3973	13.03
SOCOA	-1.6865	43.3945	9.53
STES-MARIES-DE-LA-MER	4.4233	43.4483	38.11

Table S2. Percentage of missing SYNOP data (hourly, 10 m wind speeds) per station for the period 1995-2018.

Scores at locations (100 m)	ERA5				COSMO				CERRA			
	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR	PBIAS	NRMSE	STD ratio	CORR
Station	[%]	[%]	[]	[]	[%]	[%]	[]	[]	[%]	[%]	[]	[]
BARFLEUR	**-3,18**	**5,16**	0,95	**0,94**								
FECAMP	**-1,92**	**5,51**	0,97	**0,94**								
MED Zone 1	-13,1	9,47	0,89	**0,9**								
MED Zone 2	-8,92	**7,95**	0,9	**0,92**								
MED Zone 3	-7,91	**8,64**	0,91	**0,91**								
GROIX	-3,25	**5,79**	**0,99**	**0,94**	-1,94	6,42	1,04	0,93	**0,39**	5,95	**1,01**	**0,94**
OLERON	-5,65	6,5	0,91	0,89	-6,19	6,47	**0,99**	0,89	**-1,37**	**6**	0,98	**0,9**

Table S3. Error metrics at Lidar stations for 100m wind speed during common availability period. The best scores are indicated in bold and are highlighted in green.

Stations	ERA5	COSMO-REA6	CERRA
	Distance (km)		
CAP-GRIS-NEZ	14.54	4.39	1.28
DIEPPE	9.87	1.39	1.59
BERNIERES	10.62	2.25	1.44
PTE DE LA HAGUE	5.14	1.33	2.59
ILE-DE-BREHAT	11.71	3.11	2.26
PLOUMANAC'H	8.67	2.53	0.85
BRIGNOGAN	10.12	2.03	1.28
OUESSANT-STIFF	5.15	1.6	2.3
PTE DU RAZ	4.53	1.25	2.12
PTE DE PENMARCH	10.73	2.19	3
ILE DE GROIX	10.87	2.86	2.62
BELLE ILE-LE TALUT	5.48	1.24	2.56
PTE DE CHEMOULIN	4.09	3.4	1.33
NOIRMOUTIER EN	0.75	2.91	1.09
L ILE D YEU	8.76	3.1	0.18
CHASSIRON	8.59	2.55	1.82
CAP-FERRET	13.29	2.98	3.13
SOCOA	12.82	2.91	2.52
LEUCATE	10.41	1.65	2.11
CAP BEAR	9.62	2.12	1.86
SETE	12.35	1.25	1.92
STES-MARIES-DE-LA-MER	8.45	1.6	2.82
PORQUEROLLES	1.89	1.26	3.29
CAP FERRAT	9.74	2.83	0.81

Table S4. Distance of SYNOP locations from nearest reanalyses grid. Red, blue, green colors are for English Channel, Atlantic and Mediterranean coast, respectively.

Metrics	English Channel	Atlantic	Mediterranean
PBIAS	**CERRA (3.26, -1.12, 11.11)**	**CERRA (-4.83,-6.57,-0.34)**	**CERRA (-1.83, -11.43, 5.49)**
Correlation	**CERRA (0.87,0.865, 0.895)**	COSMO (0.88,0.87,0.9)	**CERRA** (0.81, 0.725, 0.85)
NSTD	**CERRA (0.99,0.94,1.02)**	COSMO (1.01,0.88,1.04)	**CERRA (0.96,0.87,1.09)**
Seasonal cycle (PBIAS)	**CERRA (3.26, -1.12,11.10)**	**CERRA (-4.83,-6.59,-0.32)**	**CERRA (-1.82,-11.43,5.48)**
Seasonal cycle (Correlation)	**ALL (1.00,0.98,1.00)**	**ALL (0.99,0.97,0.99)**	**CERRA (0.98,0.96,0.99)**
Diurnal Cycle (PBIAS)	**CERRA (3.26, -1.12,11.13)**	**CERRA (-4.83,-6.57,-0.35)**	**CERRA (-1.83,-11.43,5.54)**
Diurnal cycle (Correlation)	**ALL (0.97,0.95,0.98)**	COSMO (0.88,0.58,0.92)	**ALL** but COSMO (0.95,0.92,0.97)
Distribution	**ALL**	**ALL**	**CERRA**
95th Percentile (PBIAS)	**CERRA (1.28, -2.88,3.13)**	**CERRA (-8.12,-12.95,-0.64)**	**CERRA (-8.36,-16.61,12.29)**
5th Percentile (PBIAS)	**CERRA (-1.29,-10.93,0.67)**	**CERRA (-7.15,-13.35,-1.51)**	**CERRA (-16.46,-22.53,-14.32)**

*Table S5. Same as Table2, but with the scores (Median, 25th Percentile, 75th Percentile). In case of **ALL** (: to imply 3 reanalyses), the scores correspond to CERRA (correlation values close to 1 for each reanalysis).*