# The added value of regional climate simulations at kilometre-scale resolution to describe daily wind speed: the CORDEX FPS-Convection multi-model ensemble runs over the Alps María O. Molina | Claudia Gutiérrez | Enrique Sánchez | FPS-CONVECTION team

## **1. ABSTRACT**

The World Climate Research Program's Coordinated Regional Downscaling Experiments Flagship Pilot Studies (FPS) on convective phenomena encompasses a set of simulations driven by the ERA-Interim reanalysis for the period from 2000-2009 (hindcast). Most models feature a horizontal resolution of 2.2 to 3 km (ALP), nested in an intermediate resolution of 12-25 km (EUR). An extended Alpine domain is considered for the simulations, due to the complexity of the mountain system together with heavy precipitation events, a large observational network and the high population density of the area. This initiative aims to build firstof-its-kind ensemble climate experiments of convective-permitting models (CPRCMs) to investigate convective processes over Europe and the Mediterranean.

In this study, the **Distribution Added Value** metric is used to determine the improvement of the representation of all available FPS hindcast simulations for the daily mean wind speed. The analysis is performed on normalized empirical probability distributions (**PDF**) and considers station observation data (from HadISD) as a reference. The use of a normalized metric allows for spatial comparison among the different seasons. This approach permits a direct assessment of the added value between the higher resolution CPRCM simulations against their global driving simulations and respective coarser resolution Regional Model counterparts. Although the complexity of such simulations, those not always reveal an added value. In general, results show that models add value to their forcing reanalysis, but the nature and magnitude of the improvement on the representation of wind speed vary depending on the model, the spatial distribution and the season.

		3.	R	E	S	UI	Т	S	A	N			С	0	N	CL	<b>.</b> U	S		
<b>3.1. Yearly and seasonal analysis: full PDF</b> EUR vs ERA																				
			I									_1	1			I	1		I	I
	SON -	2.96	2.77	-9.98	-0.38	-4.56	4.99	6.52	-12.7	3 –7.8	37 5	5.43	-10.7	-6.71	-5.24	-7.54	-1.7	-1.2	0.09	4.53
c	JJA -	2.08	1.91	-12.6	-2.8	2.48	8.37	7.21	-2.44	4 1.5	7 4	.99	-8.02	4.95	-13.22	-13.08	-3.6	-1.75	-2.96	-1.66
Seaso	MAM -	0.67	0.26	-11.25	5 –2.62	-7.21	2.03	4.49	-18.2	2 –9.8	88 3	8.14	-14.34	-10.07	-5.55	-7.5	-3.57	-3.91	-2.36	2.25
	DJF -	-5.49	-5.27	-9.26	-1.82	-10.2	-2.44	-2	-21.0	5 –17.9	99 –	1.61	-15.79	-17.18	-1.76	-4.68	-2.62	-3.62	-1.38	-0.04
	Year -	7.75	7.55	-8.21	0.53	-1.29	8.21	9.79	-7.49	9 –2.9	94 8	3.83	-6.15	-1.41	-3.21	-6.44	-1.57	-0.16	2.01	6.14
		AUTH -	CCR1 -	CCR2 -	CERO -	BTU -	CMCC -	KIT -	CNRM -	ETHZ -	Ĺ		- ALLIN -	ICTP _	- 1a <sub>l</sub>	- <sup>1</sup> Sdı	KNIMI -	UCAN -	- HOHN	NEGC -
ALP vs ERA															_					
	SON -	_2	-2.52	-2.75	2.1	-0.53 -	-0.07 -	-0.89	-2.05 -	-2.63	6.99	-9.	81 –1.3	33 –0.5	9 0.85	1.12	-0.46	2.51	-2.75	5.51
	JJA -	-1.75	-2.03	-1.49	5.03	5.67	4.64	5.62	4.74	2.7	1.98	-1.	83 6.4	5 –2.0	4 0.05	5.06	3.42	5.18	-4.65	9.1
ason	MAM -	-3.77	-4.64	-4.82	1.15	-4.26 -	-3.37 -	-3.49	-6.13	-4.9	7.26	-13	.16 –4	.8 –1.4	5 –0.42	2 –0.29	) –1.18	1.44	-3.44	0.87
Se	DJF -	-3.55	-4.65	-4.61	-0.04	-5.47	-4.18 -	-7.53	-8.19 -	-9.12	5.52	-16	.71 –8. <sup>,</sup>	46 –1.5	9 –0.58	3 –1.32	2 -2.88	0.52	-2.46	-1.59
	Year -	0.06	0.01	0.18	5.4	1.52	2.82	1.09	1.14 -	-0.19	7.72	-6.	31 2.3	34 3.6 <sup>-</sup>	1 3.65	3.93	2.16	5.97	-0.61	8.74
		E	R1 -	CH2 -	RO -	<sup>2</sup> TU –		KIT -	RM -	_HZ _	- OW	LIM _	e di	- זמן	- 75c	- IWA	- NF	- HO	- J	HC -
		AL	BCC	BCC	CICE	Ч	CM		ζ Λ	교 I D ve		D HC	2		2	X	07	5	WE	MC
	Г	1							A			n 	I		1	1	I			
	SON -	-4.82	-5.15	8.03	2.49	4.23	-4.82	-6.96	6 12.25	5 5.69	) 1	.48	0.99	5.76	4.91	9.07	2.87	0.75	2.42	-6.97
	JJA –	-3.75	-3.86	12.71	8.06	3.11	-3.44	-1.48	3 7.36	1.11	_2	2.87	6.72	1.42	12.88	15.1	8.98	5.26	8.39	-3.04
Season	MAM -	-4.4	-4.89	7.24	3.87	3.18	-5.29	-7.64	14.79	9 5.53	3	4	1.37	5.87	4.34	7.65	3.4	2.84	3.9	-5.56
	DJF -	2.06	0.66	5.12	1.81	5.27	-1.78	-5.64	16.28	3 10.8	1 7	.24	-1.09	10.52	0.17	4.3	1.33	0.77	1.93	-2.42
	Year -	-7.14	-7.01	9.14	4.85	2.85	-4.98	-7.92	9.32	2.84	1 – <sup>-</sup>	1.02	-0.17	3.8	7.05	10.78	5.59	2.32	3.88	-6.36
	L	AUTH -	BCCR1 -	BCCR2	CICERO -	ΒΤυ -	CMCC -	KIT -	CNRM -	ETHZ -	R L		HCLIM -	ICTP -	- 1a <sub>1</sub>	- <sup>7</sup> Sdl	KWMI -	UCAN -	- HOHN	WEGC -
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		-4(	5	-3	JU.	-2	-0		-10		U		I	U	2	v	3	v		τU

#### **4. REFERENCES**

- Coppola, E., Sobolowski, S., Pichelli, E., Raffaele, F., Ahrens, B., Anders, I., Ban, N., Bastin, S., Belda, M., Belusic, D. et al. 231 (2020). A first-of-its-kind multi-model convection permitting ensemble for investigating convective phenomena over Europe and the Mediterranean. Climate Dynamics, 55, 3–34. - Soares, P. M. and Cardoso, R. M. (2018). A simple method to assess the added value using high-resolutions: application to the euro-cordex daily precipitation. International Journal of Climatology, 38, 1484–1498.

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- In the comparison of the CPRCMs with the RCMs, an added value is seen in the wind speed representation, with yearly DAV values between 2-10% in 11 out 18 of the models. This improvement is usually larger in winter than summer.

- Overall, larger DAV than those for the whole PDF are obtained in the EUR vs ERA and in the ALP vs ERA comparisons of the DAV values for the wind speed partial PDF regarding the wind speed bins above the p95 of the observations. The obtained DAV reflect that the AUTH, BCCR1, CNRM, HCLIM, ICTP and WEGC models represent better the high extreme winds at higher resolution. DAV are larger in summer than winter.



SON -

JJA -





## **2. DATA AND METHOD**



**DATA:** HadISD observations, CPRCMs FPS-CONV models and ERA-Interim reanalysis.

**METHOD:** Distribution Added Value, **DAV** (Soares and Cardoso, 2018): 1. A score (S) between 0 and 1 is obtained as a measure of the common area between the high (hr) and low (lr) resolution model or the ERA-Interim data PDFs. 2. The daily wind speed DAV is obtained with the relative difference between the scores of the hr and Ir resolution model.

$$S = \sum_{1}^{n} min(Z_m, Z_o)$$
  $DAV = 100 * \frac{S_{hr} - S_{lr}}{S_{lr}}$ 

**ANALYSIS**: Yearly and seasonal PDF, full PDF and PDF section above the 95<sup>th</sup> percentile of the observations (extremes), composite of different station observations altitudes (orography dependence).

### **3.2. Yearly and seasonal analysis: upper-tail PDF**

300–400

• 500-1000

65       18.04       6.4       8.57       0.25       1.23       0.36       0.57       0.36       1.13       0.12       7.06       5.20       7.26       5.20       7.26       5.40       7.26       7.40       7.20       7.26       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       7.20       7.40       <								EU	R vs I	ERA								
55       -1634       64       6.57       0.25       -1.23       -0.36       -1.27       -7.06       5.2       7.26       8.4       8.5       8.4       -16.27         207       -1926       8.03       6.49       1.9       -0.57       1.49       -6.69       -0.14       1.27       -1.31       -7.05       7.44       7.83       7.69       7.6       7.28       -17.8         200       -1446       6.66       2.02       3.17       1.49       2.46       -6.56       3.25       -3.34       2.17       -5.79       3.48       3.72       4.47       3.44       4.09       -14.69         240       -6.5       2.57       1.59       -2.48       -2.01       -6.52       6.84       8.14       7.81       8.16       7.78       1.49         341       1.18       6.06       5.42       -2.69       -3.19       -3.62       1.08       4.65       5.36       9.24       9.34       6.35       9.24       9.34       6.35       9.24       9.34       6.35       9.24       9.34       6.35       9.24       9.34       6.35       9.24       9.35       6.57       0.55       1.64       5.55       2.46       2.15 <th>1</th> <th></th> <th></th> <th></th> <th></th> <th>I</th> <th></th>	1					I												
207       1926       8.03       6.49       1.9       -0.57       1.49       -6.9       -0.14       1.27       -1.31       -7.05       7.40       7.83       7.69	6.5	-16.94	6.4	8.57	0.25	-1.23	-0.36	-6.57	-0.35	-1.93	-1.27	-7.06	5.32	7.26	8.4	8.5	8.4	-16.22
4.44       1577       7.01       9.38       1.3       0.28       0.44       4.68       -0.1       -1.30       1       -5.66       6.21       7.97       9.48       9.42       9.70       16.88         2.09       -1445       4.56       0.22       -1.4       -0.26       -5.1       1.59       -2.48       -2.01       -6.50       8.48       3.14       7.81       8.46       7.81	9.07	-19.26	8.03	6.49	1.9	-0.57	1.49	-6.9	-0.14	1.27	-1.31	-7.05	7.44	7.83	7.69	7.6	7.28	-17.8
200       -14.0       456       2.92       3.10       1.49       2.46       -5.56       3.25       -3.94       2.17       -5.70       3.46       3.72       4.47       3.44       4.00       -14.88         548       -15.49       6.55       6.55       6.26       -2.46       -2.40 <t< th=""><th>4.44</th><th>-15.77</th><th>7.01</th><th>9.38</th><th>1.3</th><th>0.28</th><th>0.44</th><th>-4.88</th><th>-0.1</th><th>-1.93</th><th>1</th><th>-5.66</th><th>6.21</th><th>7.97</th><th>9.48</th><th>9.42</th><th>9.37</th><th>-15.69</th></t<>	4.44	-15.77	7.01	9.38	1.3	0.28	0.44	-4.88	-0.1	-1.93	1	-5.66	6.21	7.97	9.48	9.42	9.37	-15.69
548       -1549       6.85       7.81       -0.22       -1.44       -0.26       -5.11       1.59       -2.48       -2.01       -6.32       6.84       8.14       7.81       8.16       7.70       -15.12         6       6       6       6       6       6       6       6       6       6       6       6       6       6       6       6       6       6       6       7.81       6.16       7.70       5.81       6       6       6       7.81       6       6       7.81       6       6       6       6       7.81       6       6       6       6       7.81       6       6       6       7.81       6       6       6       6       7.81       6       6       6       7.81       6       6       6       6       6       7.81       6       6       6       7.81       6	2.09	-14.45	4.56	2.92	3.17	1.49	2.46	-6.56	3.25	-3.94	2.17	-5.79	3.48	3.72	4.47	3.44	4.09	-14.68
a       a	5.48	-15.49	6.85	7.81	-0.22	-1.44	-0.26	-5.1	1.59	-2.48	-2.01	-6.32	6.84	8.14	7.81	8.16	7.78	-15.12
A       A       A       B       B	Hior	BCCR1 -	BCCR2 -	ICERO -	BTU -	CMCC -	KIT -	CNRM -	ETHZ -	REMO -	HCLIM -	ICTP _	- זמו	- Isal	KNMI -	UCAN -	- HOHN	WEGC -
1       1		ALP vs ERA																
1       1.13       6.06       5.42       -2.69       -3.19       -3.82       -1.11       -1.63       -0.05       1.08       4.6       2.72       7.73       5.61       5.41       6.03       -1.45       5.43         23       1.63       8.74       11.08       0.13       0.95       -3.43       -0.74       -0.59       -3.41       1.87       6.45       5.36       9.24       9.34       9.63       10.89       0.08       8.64         49       1.55       3.94       2.46       0.01       -3.58       -0.09       2.15       1.34       -9.72       2.55       3.46       0.37       3.54       3.82       3.07       3.24       -0.83       5.16         17       2.49       7.03       6.32       -1.39       -0.98       -0.55       0.16       -6.43       1.79       6.21       5.5       7.66       7.13       6.89       6.99       0.7       5.97         17       2.49       7.03       6.32       -1.39       -0.98       -0.55       0.16       -6.43       1.79       6.21       5.5       7.66       7.13       6.89       6.99       0.7       5.97         181       2.187       -0.63				<b>-</b>	0.00	0.40							0 7 -					<b>- - - - -</b>
3       1.63       8.74       11.08       0.13       0.95       -3.43       -0.74       -0.59       -3.41       1.87       6.45       5.36       9.24       9.34       9.63       10.89       0.08       6.64         1       3.14       6.56       5.81       -2.41       -2.88       -2.87       -0.21       -1.87       -5.4       2.19       5.56       2.9       8.43       6.54       5.95       6.67       -0.83       5.16         163       3.94       2.46       0.01       -3.58       -0.09       2.15       1.34       -9.72       2.55       3.46       0.37       3.54       3.82       3.07       3.24       -0.83       5.16         17       2.49       7.03       6.32       -1.39       -0.09       -2.08       -0.55       0.16       -6.43       1.79       6.21       5.5       7.66       7.13       6.89       6.99       0.7       5.97         163       2.18       -0.33       -2.9       -2.93       -1.99       -3.47       5.84       -1.28       4.21       2.38       12.55       -2.47       0.44       -2.49       -2.86       -2.18       17.63         183       2.68       6.	81	1.18	6.06	5.42	-2.69	-3.19 -	-3.82 –	1.11 –	1.63 –6	5.05 1.0	08 4.0	6 2.7	2 7.7	′3 5.81	5.4	6.03	-1.45	5.43
<ul> <li>1 3.14 6.56 5.81 -2.41 -2.48 -2.87 -0.21 -1.87 -5.4 2.19 5.56 2.9 8.43 6.54 5.95 6.67 -0.68 6.08</li> <li>1.55 3.94 2.46 0.01 -3.58 -0.09 2.15 1.34 -9.72 2.55 3.46 0.37 3.54 3.82 3.07 3.24 -0.83 5.16</li> <li>2.49 7.03 6.32 -1.39 -0.99 -2.08 -0.55 0.16 -6.43 1.79 6.21 5.5 7.56 7.13 6.89 6.99 0.7 5.97</li> <li>2.49 7.03 6.32 -1.39 -0.99 -2.08 -0.55 0.16 -0.49 9.72 2.55 3.46 0.37 5.5 7.56 7.13 6.89 6.99 0.7 5.97</li> <li>2.59 6.5 1.5 -1.5 -1.5 -1.5 -1.5 -1.5 -1.5 -1.</li></ul>	23	1.63	8.74	11.08	0.13	0.95 –	-3.43 –	0.74 –(	0.59 –3	3.41 1.8	37 6.4	5 5.3	6 9.2	24 9.34	9.63	10.89	0.08	8.64
<ul> <li>40</li> <li>1.55</li> <li>3.94</li> <li>2.46</li> <li>0.01</li> <li>-3.58</li> <li>0.09</li> <li>2.15</li> <li>1.34</li> <li>-3.72</li> <li>2.55</li> <li>3.46</li> <li>0.37</li> <li>3.54</li> <li>3.82</li> <li>3.07</li> <li>3.24</li> <li>-0.80</li> <li>5.16</li> <li>-1.4</li> <li>-1.4</li> <li>-1.4</li> <li>-1.2</li> <li>-1.2</li> <li>-1.4</li> <l< td=""><th>.1</th><td>3.14</td><td>6.56</td><td>5.81</td><td>-2.41</td><td>-2.88 -</td><td>-2.87 –</td><td>0.21 -</td><td>1.87 –</td><td>5.4 2.*</td><td>19 5.5</td><td>6 2.9</td><td>8.4</td><td>13 6.54</td><td>5.95</td><td>6.67</td><td>-0.58</td><td>6.08</td></l<></ul>	.1	3.14	6.56	5.81	-2.41	-2.88 -	-2.87 –	0.21 -	1.87 –	5.4 2.*	19 5.5	6 2.9	8.4	13 6.54	5.95	6.67	-0.58	6.08
17 2.49 7.03 6.32 -1.39 -0.98 -2.08 -0.55 0.16 -6.43 1.79 6.21 5.5 7.66 7.13 6.89 6.99 0.7 5.97	49	1.55	3.94	2.46	0.01	-3.58 -	0.09 2	2.15 1	.34 –9	).72 2.	55 3.4	6 0.3	7 3.5	54 3.82	3.07	3.24	-0.83	5.16
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	17	2.49	7.03	6.32	-1.39	-0.98 -	-2.08 –	0.55 0	.16 –6	6.43 1.7	79 6.2	21 5.8	5 7.6	6 7.13	6.89	6.99	0.7	5.97
ALP vs EUR         93       21.81       -0.33       -2.92       -2.93       -1.99       -3.47       5.84       -1.28       -4.21       2.38       12.55       -2.47       0.44       -2.4       -2.86       -2.18       17.63         10       25.87       0.65       4.31       -1.73       1.53       -4.85       6.62       -0.45       -4.63       3.22       14.52       -1.94       1.31       1.53       1.88       3.37       21.75         68       22.45       -0.42       -3.26       -3.15       -3.33       4.91       -1.77       -3.54       1.18       1.189       -3.12       0.42       -2.69       -3.17       -2.48       1.78         105       18.7       -0.45 <t< th=""><th></th><th>BCCR1</th><th>BCCR2 -</th><th>CICERO -</th><th>BTU -</th><th>CMCC -</th><th>KIT -</th><th>- MANO</th><th>ETHZ-</th><th>HCLINA</th><th>ICTP _</th><th>- Taj</th><th>- <sup>IS</sup>dl</th><th>KNMI</th><th>UCAN -</th><th>- HOHN</th><th>WEGC -</th><th>MOHC -</th></t<>		BCCR1	BCCR2 -	CICERO -	BTU -	CMCC -	KIT -	- MANO	ETHZ-	HCLINA	ICTP _	- Taj	- <sup>IS</sup> dl	KNMI	UCAN -	- HOHN	WEGC -	MOHC -
93       21.81       -0.33       -2.9       -2.93       -1.99       -3.47       5.84       -1.28       -4.21       2.38       12.55       -2.47       0.44       -2.4       -2.86       -2.18       17.63         31       25.87       0.65       4.31       -1.73       1.53       -4.85       6.62       -0.45       -4.63       3.22       14.52       -1.94       1.31       1.53       1.88       3.37       21.75         68       22.45       -0.42       -3.26       -3.67       -3.15       -3.3       4.91       -1.77       -3.54       1.18       11.89       -3.12       0.42       -2.69       -3.17       -2.48       17.93         59       18.7       -0.59       -0.45       -3.06       -4.99       -2.49       9.33       -1.86       -6.02       0.37       9.81       -3       -0.17       -0.62       -0.36       -0.81       16.23         68       21.27       0.17       -1.38       -1.17       0.47       -1.83       4.79       -1.41       -4.05       3.88       13.37       -1.26       -0.45       -0.63       -1.17       -0.74       18.63         74 $\frac{6}{28}$ $\frac{6}{2}$ $6$								AL	.P vs E	EUR								
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	03	21.81	0.33	2.0	2 03	1 00	3 47	5.84	1 28	1 01	2 28	12 55	2 / 7	0.44	2.4	2.86	2 18	17.63
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	.90	21.01	-0.00	-2.5	-2.95	-1.55	-0.47	5.04	-1.20	-4.21	2.00	12.00	-2.47	0.44	-2.4	-2.00	-2.10	17.05
68       22.45 $-0.42$ $-3.26$ $-3.67$ $-3.15$ $-3.3$ $4.91$ $-1.77$ $-3.54$ $1.18$ $11.89$ $-3.12$ $0.42$ $-2.69$ $-3.17$ $-2.48$ $17.93$ 59 $18.7$ $-0.59$ $-0.45$ $-3.06$ $-4.99$ $-2.49$ $9.33$ $-1.86$ $-6.02$ $0.37$ $9.81$ $-3.5$ $-0.17$ $-0.62$ $-0.36$ $-0.81$ $16.23$ 06 $21.27$ $0.17$ $-1.38$ $-1.17$ $0.47$ $-1.83$ $4.79$ $-1.41$ $-4.05$ $3.88$ $13.37$ $-1.45$ $-0.45$ $-0.63$ $-1.17$ $-0.74$ $18.63$ $V_{B}$ </td <th>.31</th> <td>25.87</td> <td>0.65</td> <td>4.31</td> <td>-1.73</td> <td>1.53</td> <td>-4.85</td> <td>6.62</td> <td>-0.45</td> <td>-4.63</td> <td>3.22</td> <td>14.52</td> <td>-1.94</td> <td>1.31</td> <td>1.53</td> <td>1.88</td> <td>3.37</td> <td>21.75</td>	.31	25.87	0.65	4.31	-1.73	1.53	-4.85	6.62	-0.45	-4.63	3.22	14.52	-1.94	1.31	1.53	1.88	3.37	21.75
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	.68	22.45	-0.42	-3.26	-3.67	-3.15	-3.3	4.91	-1.77	-3.54	1.18	11.89	-3.12	0.42	-2.69	-3.17	-2.48	17.93
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	.59	18.7	-0.59	-0.45	-3.06	-4.99	-2.49	9.33	-1.86	-6.02	0.37	9.81	-3	-0.17	-0.62	-0.36	-0.81	16.23
$-\frac{1}{40}$	.06	21.27	0.17	-1.38	-1.17	0.47	-1.83	4.79	-1.41	-4.05	3.88	13.37	-1.26	-0.45	-0.63	-1.17	-0.74	18.63
-40 -30 -20 -10 0 10 20 30 40		BCCR1	BCCR2	CICERO_	BTU -	CMCC -	KIT -	CNRM -	ETHZ -	REMO	HCLIM -	ICTP -	- <i>1</i> qı	- <sup>1</sup> Sal	KNMI -	UCAN -	- HOHN	WEGC -
-40 $-30$ $-20$ $-10$ $0$ $10$ $20$ $30$ $40$	1								ç	%								
	-40	-40 -30			-20 -10					0	10		20		3	80	2	40



#### HIGHLIGHTS

CPRCMs and RCMs tend to represent the wind peed better than ERA-Interim as height ncreases up to 400 m, and then the DAV lecreases with altitude. In the CPRCMs vs CMs comparison, DAV are positive for the ange of altitudes lower than 100 m and etween 300-500 m in the yearly PDF.



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