Motivation

Data & Methods

Results

Conclusions

Assessment of the WRF topographic parameterization for the surface wind speed over Spain

R. Lorente-Plazas, P.A. Jiménez, J. Dudhia, J.P. Montávez, P. Jiménez-Guerrero, J.J. Gómez-Navarro and S. Jerez

University of Murcia

Motivation

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Bias of the surface wind speed between WRF and observational records.

- overestimation over the plains and valleys
- underestimation over the hills and mountains

Plausible explanation:

- The smoother topography used in the model

A Fix: A topographic parameterization. Concept:

- introducing a sink term in the momentum equations to represent the drag generated by subgrid-scale orography

Motivation

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Improving the Representation of Resolved and Unresolved Topographic Effects on Surface Wind in the WRF Model

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(Manuscript received 19 April 2011, in final form 13 October 2011)

Spatial and dynamical configuration

Motivation
Data & Methods
Numerical experiment
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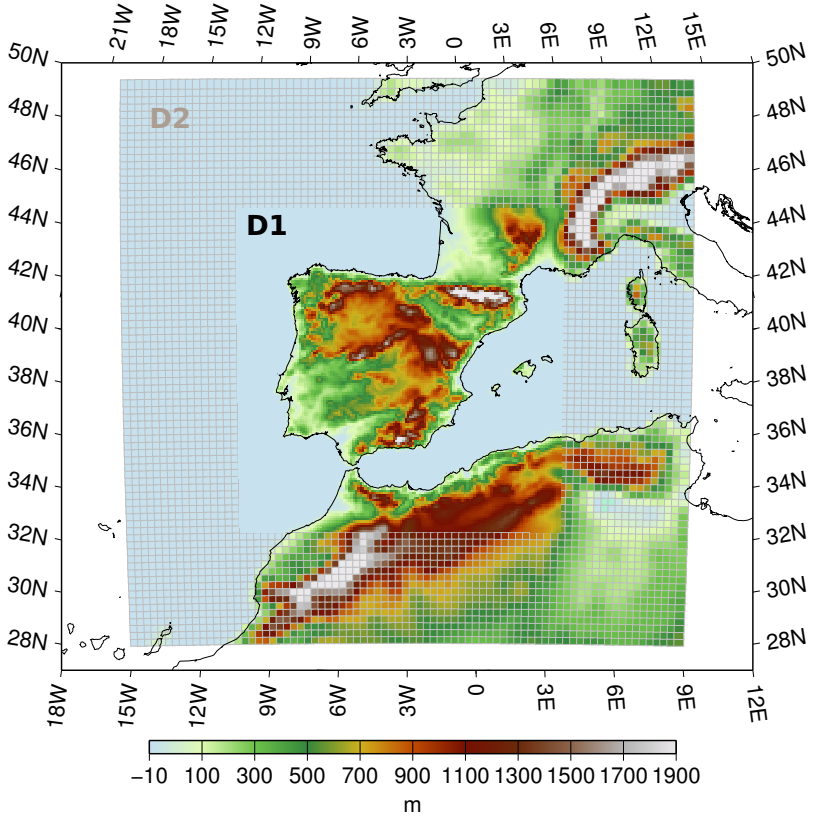
2 numerical experiment without and with topographic effects activated (Ref. and New)



- WRF 3.4 (modified to obtain wind at 2m)
- 2005 (1 month spin-up) July/Jan.
- two two way nested domain
- 10 km inner (30 km outer)
- 27 sigma-levels top 50mb
- SST update
- ERA interim

Physical configuration

Motivation
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Numerical experiment
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&physics
topo_wind = 0, 1, 0,

Microphysics	WSM6
LW rad	RRTM
SW rad	Dudhia
Surface Layer	MM5 similarity
Land-Surface	Noah
PBL	YSU
Cumulus	Kain-Fritsh

Table: The physical parameterization schemes employed within WRF.

Observational databases

Motivation

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Numerical experiment

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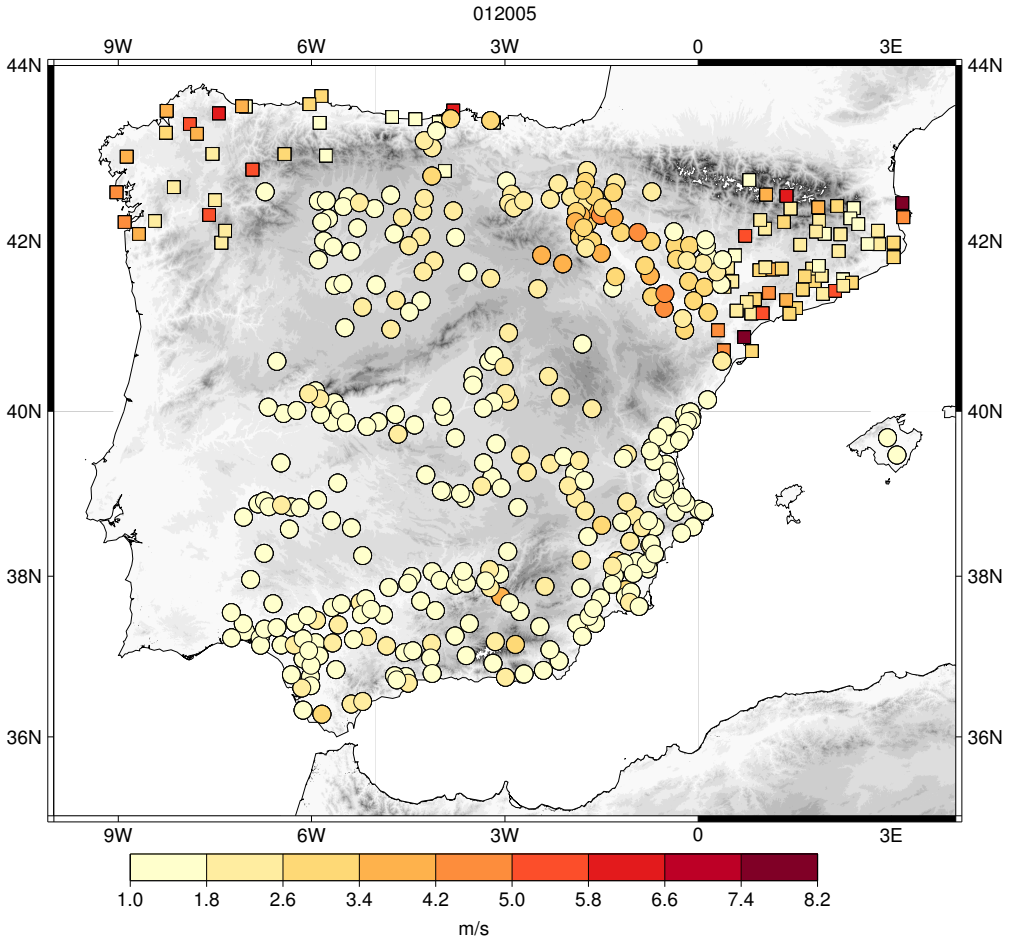

- 445 stations
- Period: 1999-2007
- Quality Control
- Sensor Height: 10 m (85) complex terrain y 2m (332) in valleys
- 1h temporal resolution
- Variables: wind speed and direction

Methodology

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Assessment of the simulation by comparison with observations considering

- Different sensor height separately
- July (thermally driven circulations) and January (large scale)
- Nearest and most representative grid point (lowest absolute bias)

Mean wind speed (2005)

Motivation

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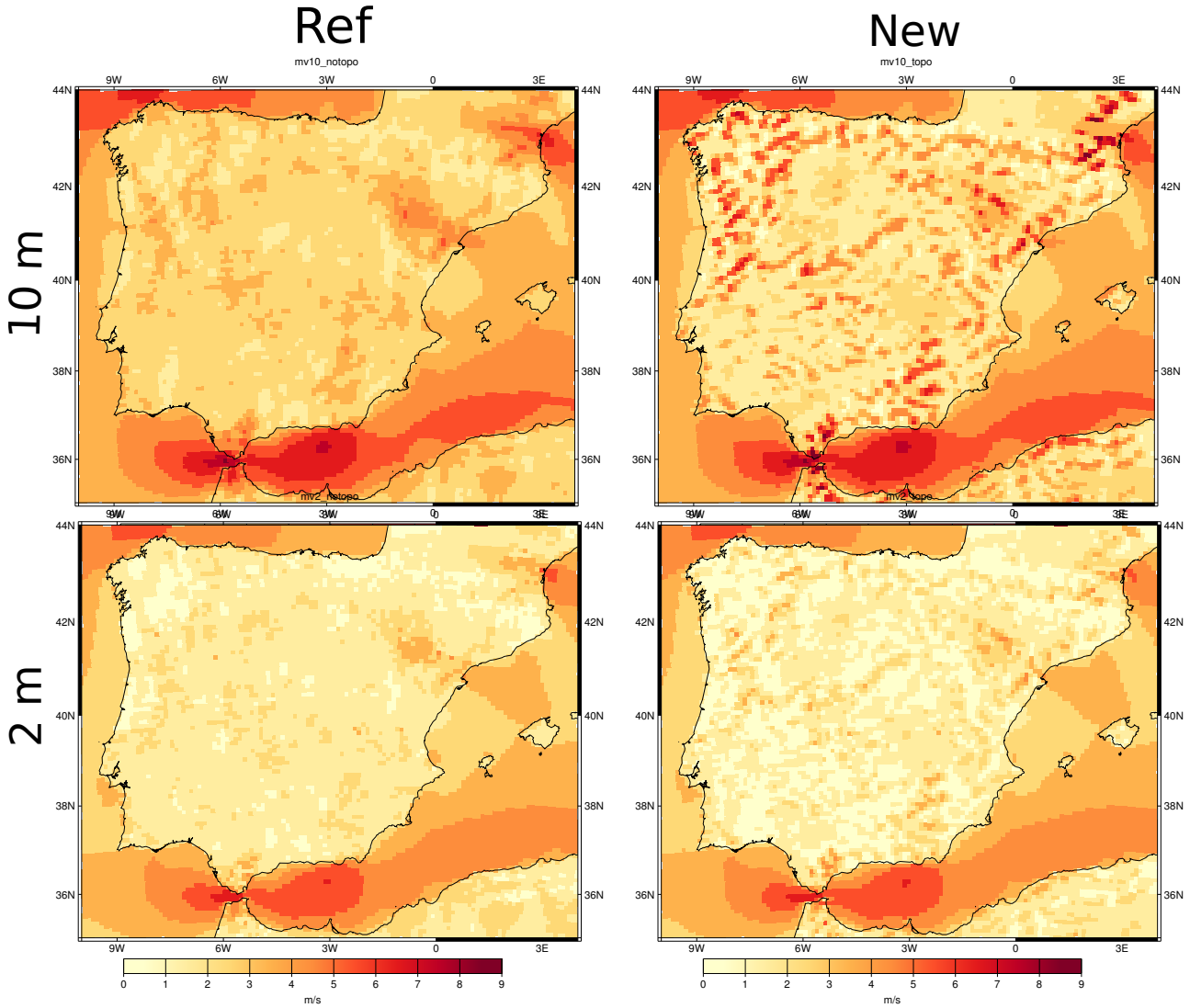
Nearest grid point

Most representative grid point

Conclusions

The new scheme increases the wind speed spatial variability



Wind Biases (new-ref)

Motivation

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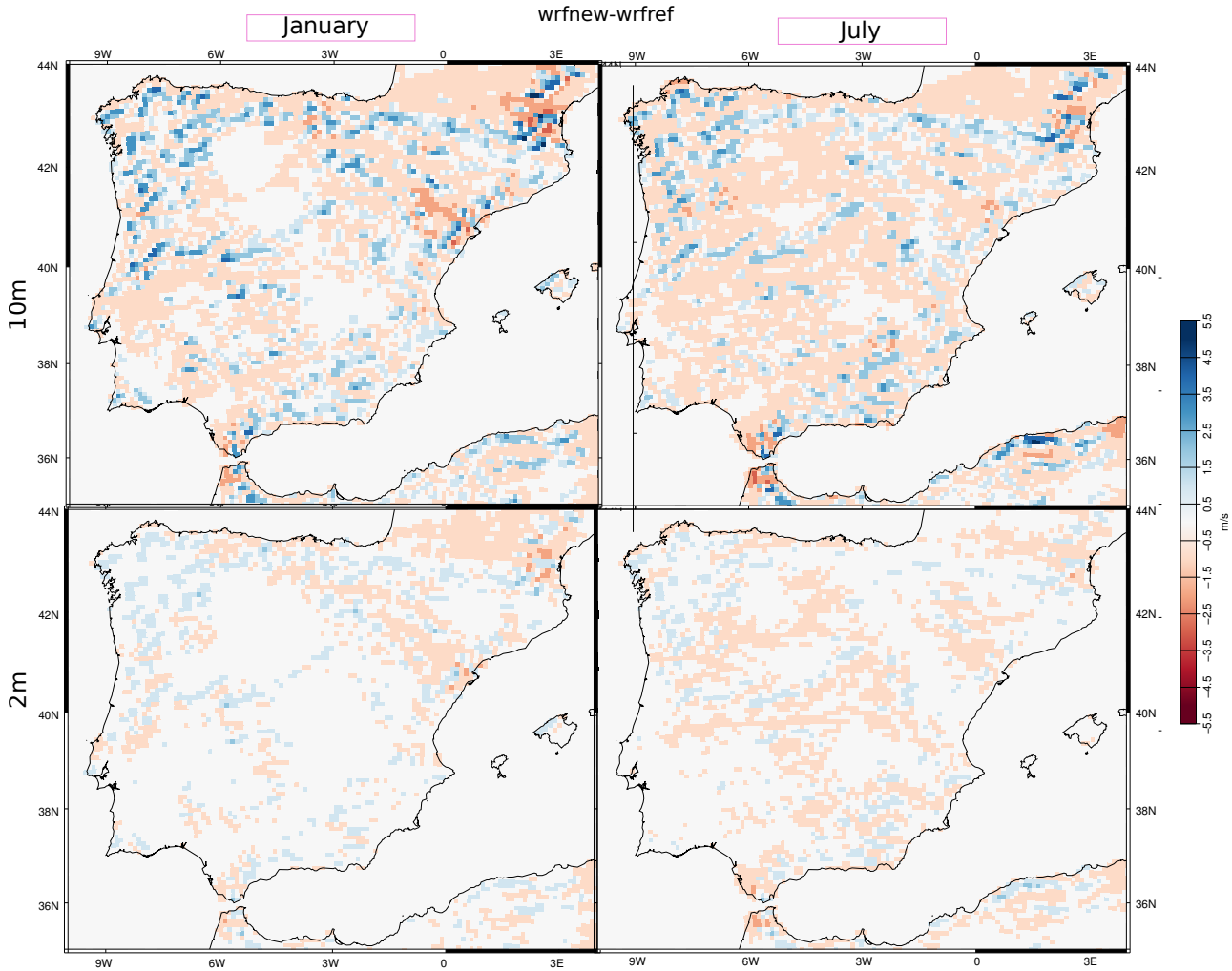
Domain

Nearest grid point

Most representative grid point

Conclusions

Similar spatial patterns July and Janr.



Nearest grid point: WRF-OBS (2m)

Motivation

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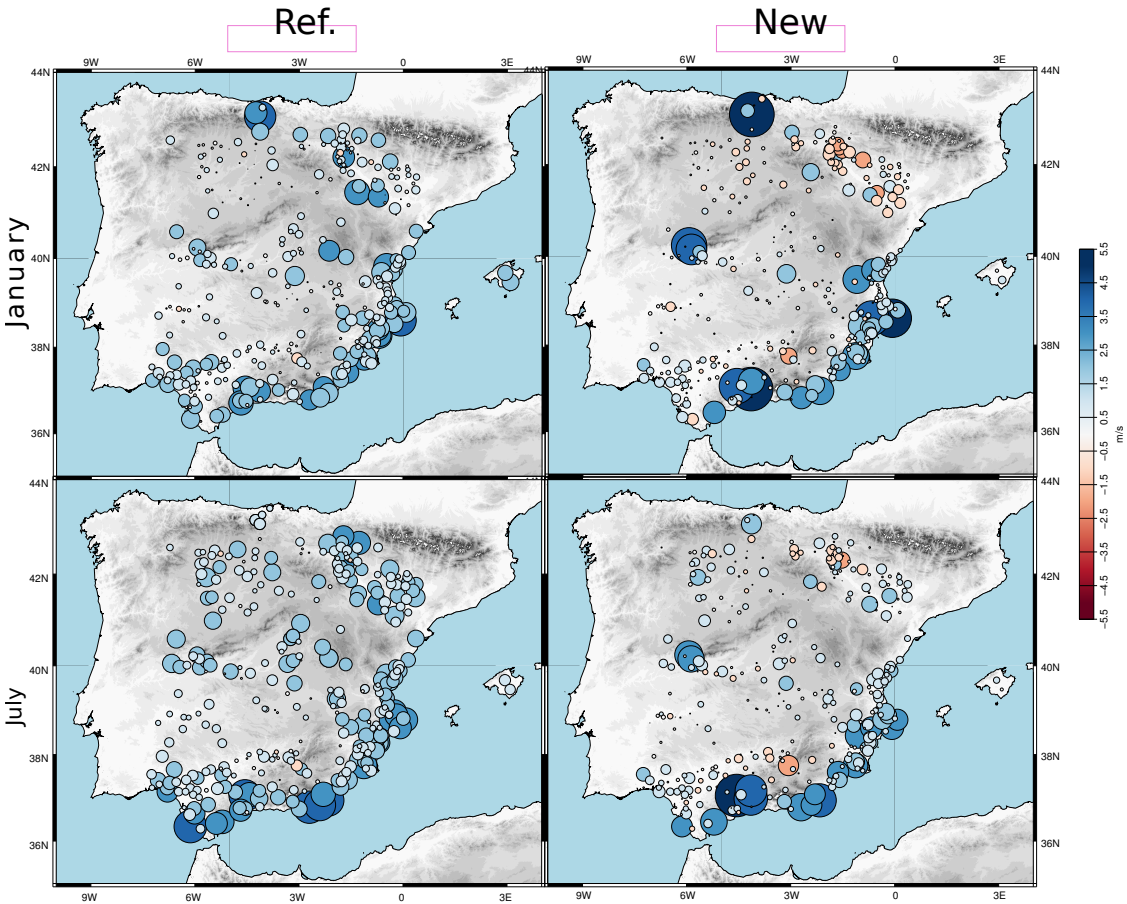
Domain

Nearest grid point

Most representative grid point

Conclusions

- Ref.: systematic overestimation (Medit.)
- New: no systematic overestimation
- New: bias reduction with exceptions (84.94% Jan. and 80.42%)



Nearest grid point: WRF-OBS (2m)

Motivation

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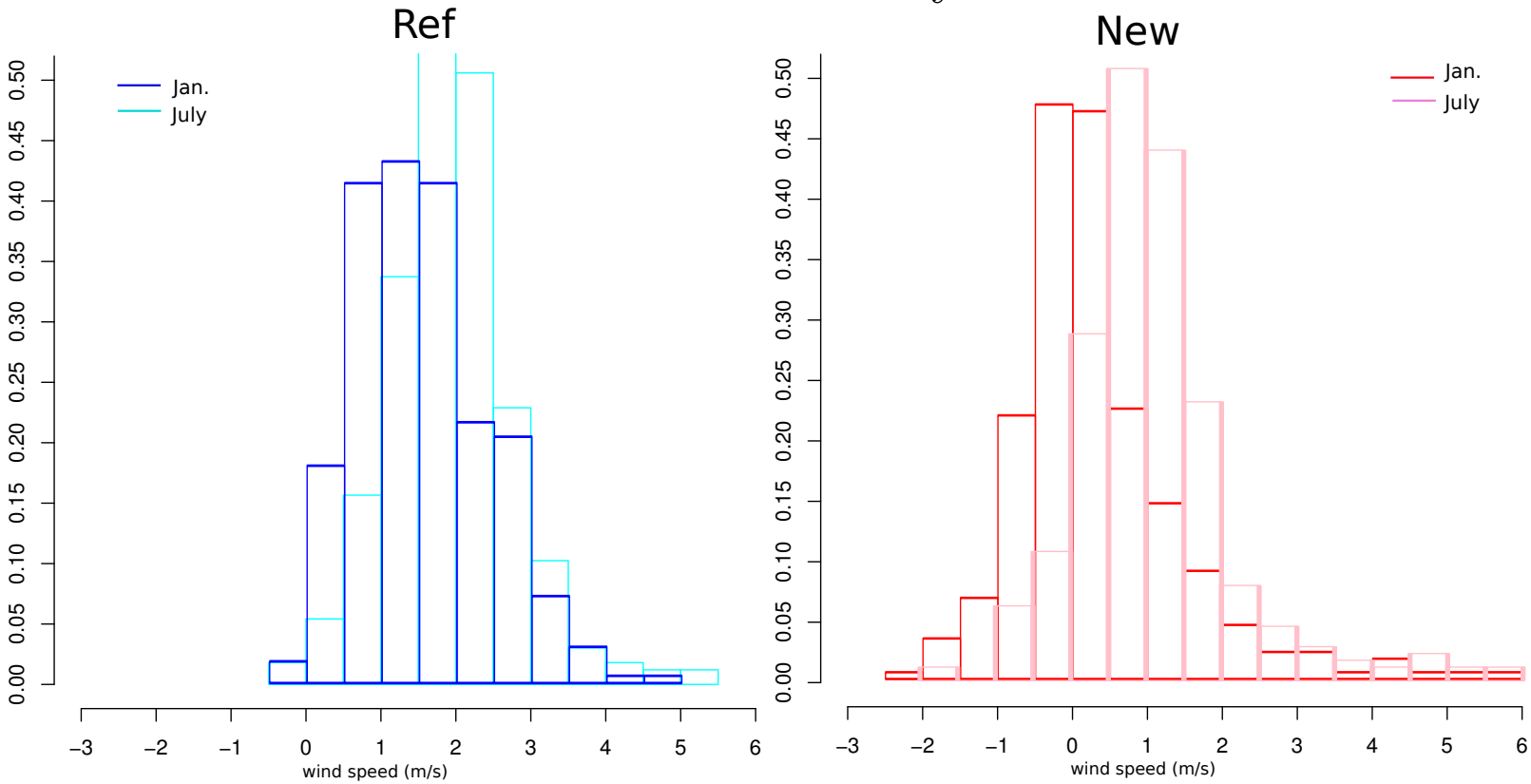
Domain

Nearest grid point

Most representative grid point

Conclusions

- New scheme increases the variance
- New scheme maximum of probability closer to cero
- More overestimation in July (ref and new)
- More underestimation in January in new scheme



Most representative grid point

Motivation

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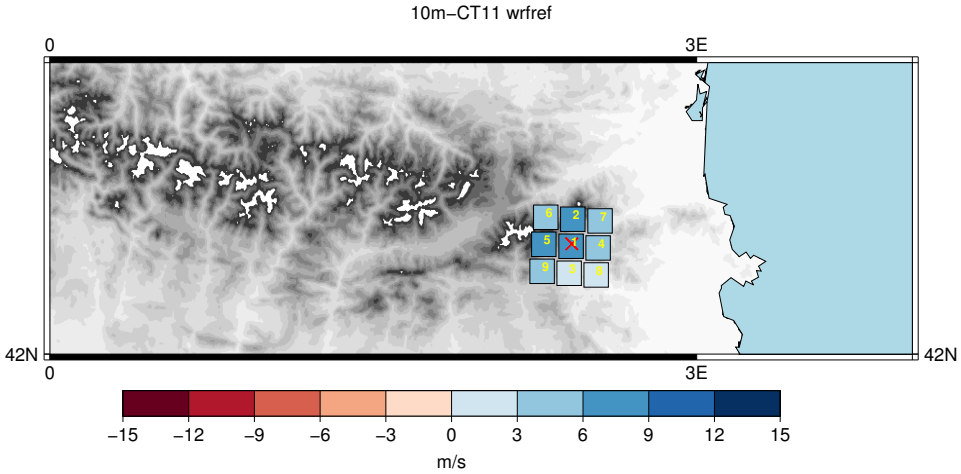
Domain

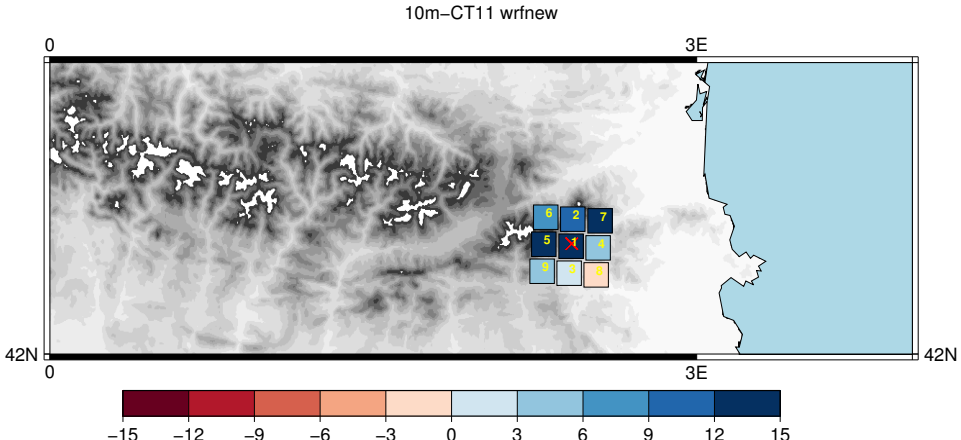
Nearest grid point

Most representative grid point

Conclusions

More spatial variability involves more sensitivity in the selection of the grid point





Most representative grid point

Motivation

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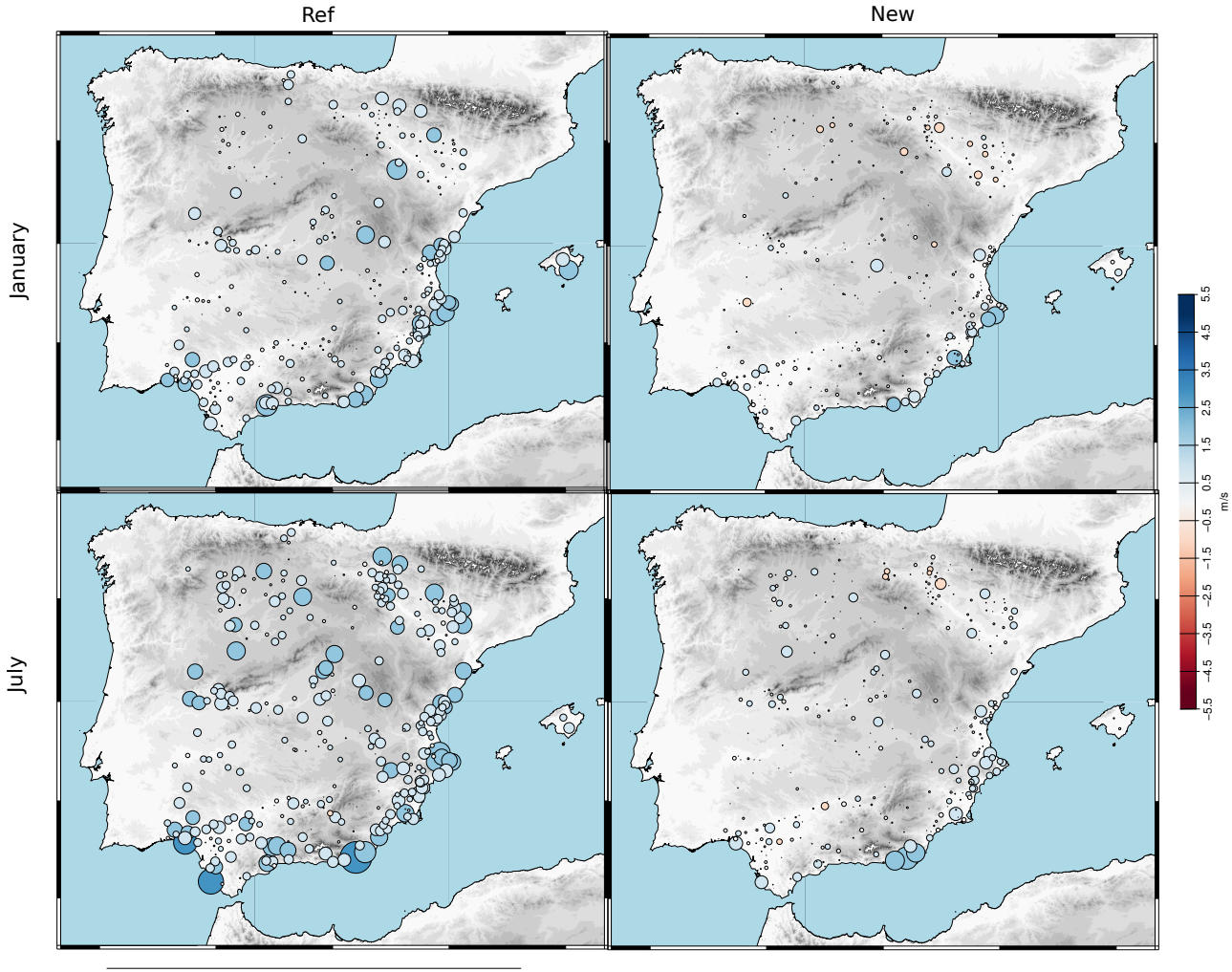
Nearest grid point

Most representative grid point

Conclusions

Most representative = min($|bias_i|$) for i=1,9 nearer points

(72.58% Janr. and 84.64 % July)



Nearest vs Repre. point: PDF

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Nearest grid point

Most representative grid point

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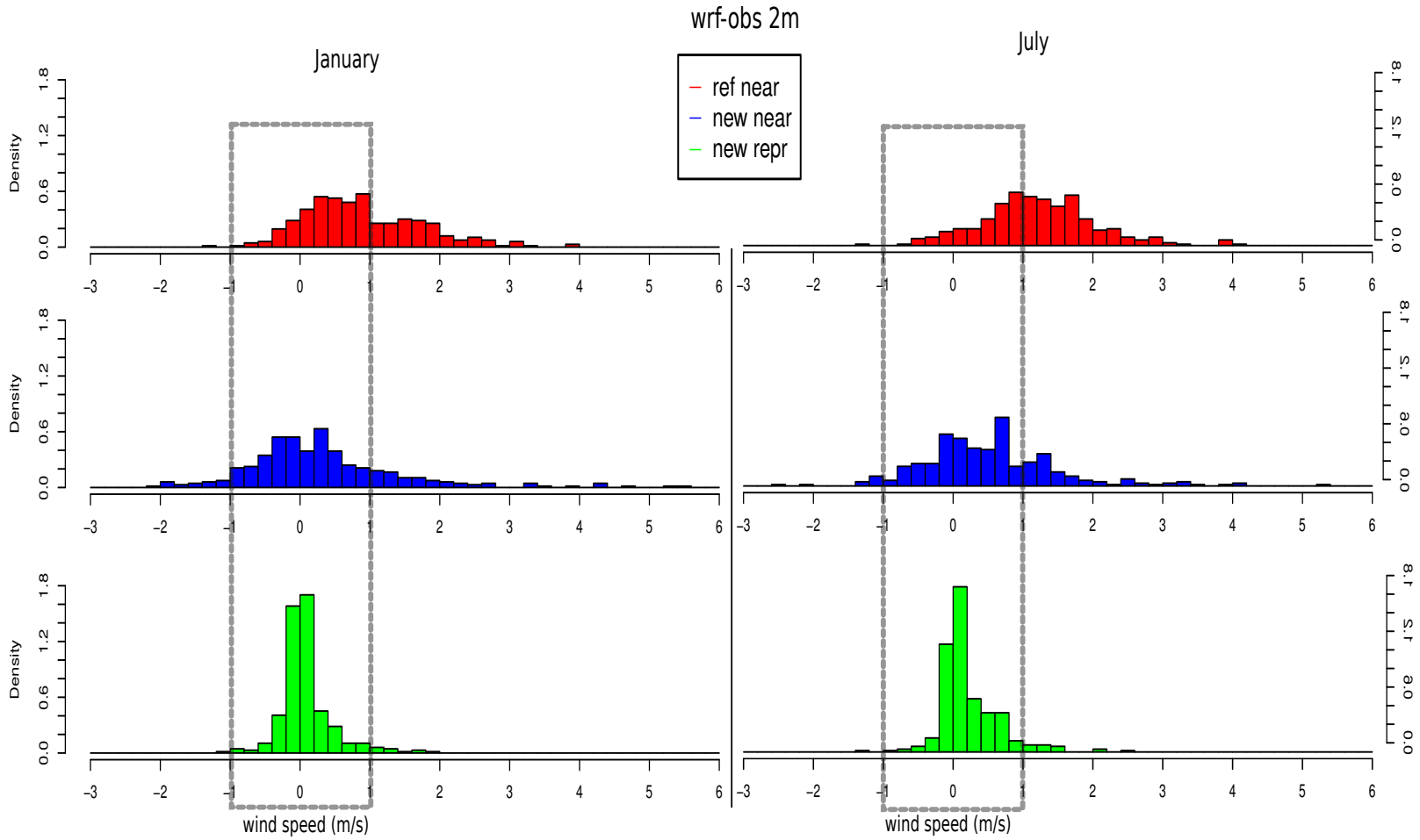

Nearest vs Repre. point: MAE

Motivation

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Nearest grid point

Most representative grid point

Conclusions

- MAE ref > MAE new
- MAE July > MAE January
- MAE Near > MAE Rep.

January

	Nearest		Repre.		
Reg.	Ref	New	Ref	New	#sta.
Lev.	2.08	1.64	1.18	0.95	68
Tajo	1.59	1.38	0.98	0.87	67
Guaq	1.74	1.39	1.03	0.87	57
CasL	1.33	1.10	1.02	0.97	43
LEbr	2.18	1.45	1.41	0.69	7
HEbr	1.91	1.41	1.24	1.20	34
CanC	2.73	2.79	1.39	1.41	5
MEbr	1.87	1.35	1.11	1.04	21
NPy	2.99	2.20	1.54	1.14	3
Gal	2.91	1.47	1.70	1.27	1
Gib	2.35	1.97	1.38	1.05	15
Inst.					
CA	2.73	2.79	1.39	1.41	5
DGDR	1.81	1.44	1.11	0.95	310
RI	1.52	1.20	1.10	1.22	6

July

	Nearest		Repre.		
Reg.	Ref	New	Ref	New	#sta.
Lev.	2.26	1.67	1.24	1.28	67
Tajo	1.94	1.47	1.20	1.15	67
Guaq.	2.03	1.46	1.25	1.22	57
CasL	1.87	1.29	1.17	1.05	43
LEbr	2.07	1.33	1.44	1.01	7
HEbr	2.08	1.29	1.27	1.18	35
CanC	1.72	1.44	0.96	1.18	5
MEbr	2.52	1.59	1.33	1.09	21
Npy	2.57	1.68	1.38	1.31	3
Gal	1.50	1.32	1.21	1.36	1
Gib	3.03	2.15	1.63	1.79	15
Inst.					
CA	1.72	1.44	0.96	1.18	5
DGDR	2.14	1.51	1.26	1.21	310
RI	1.30	1.03	0.97	0.99	6

Nearest vs Repre. point

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Most representative grid point

Conclusions

How often the the best is the nearest?

pos.	ref 10m	new 10m	ref 2m	new 2m
January				
1	9.41	8.24	7.53	9.64
2	7.06	12.94	10.84	13.25
3	4.71	9.41	10.84	11.75
4	10.59	10.59	10.84	12.65
5	9.41	14.12	10.84	7.53
6	12.94	7.06	15.36	11.14
7	14.12	12.94	8.13	10.54
8	16.47	14.12	9.94	12.95
9	15.29	10.59	15.66	10.54
July				
1	8.24	9.41	7.83	11.45
2	5.88	11.76	10.54	10.54
3	15.29	16.47	11.45	11.45
4	5.88	10.59	13.25	13.86
5	16.47	5.88	12.05	9.94
6	11.76	9.41	14.46	11.14
7	7.06	12.94	7.23	10.24
8	17.65	12.94	12.35	9.34
9	11.76	10.59	10.84	12.05

Nearest vs Repre. point

Motivation

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Nearest grid point

Most representative grid point

Conclusions

How significant are the differences between the best and the nearest?

	Jan.				July			
pos.	ref 10m	new 10m	ref 2m	new 2m	ref 10m	new 10m	ref 2m	new 2m
$\|bias_i\| \leq \|bias_{rep}\| + 0.1 * \|bias_{rep}\|$								
1	9.41	10.59	13.55	11.14	11.11	8.89	18.98	13.55
2	10.59	15.29	15.06	15.6627	10.00	12.22	19.28	14.16
3	8.24	14.12	15.06	12.35	20.00	18.89	19.58	12.05
4	16.47	12.94	15.06	13.25	14.44	11.11	23.19	16.27
5	11.76	14.12	16.27	9.64	20.00	7.78	19.28	11.45
6	14.12	7.06	19.88	13.8554	14.44	11.11	23.19	13.25
7	16.47	12.94	10.84	11.45	12.22	12.22	13.25	10.84
8	21.18	15.29	13.55	14.4578	23.33	15.56	19.88	10.84
9	17.65	12.94	17.17	12.35	18.89	14.44	18.37	13.85
$\|bias_i\| \leq \|bias_{rep}\| + 0.5 * \|bias_{rep}\|$								
1	29.41	14.12	30.72	18.67	44.44	22.22	49.40	23.80
2	23.53	17.65	32.53	25.30	35.56	24.44	50.90	23.19
3	27.06	22.35	34.64	18.67	38.89	24.44	49.10	19.88
4	29.41	18.82	32.23	21.39	30.00	22.22	47.89	26.51
5	22.35	16.47	32.83	16.57	35.56	17.78	45.78	18.37
6	25.88	14.12	32.83	17.77	32.22	15.56	49.70	20.78
7	31.76	18.82	24.40	17.77	34.44	21.11	46.99	18.98
8	34.12	22.35	28.31	22.29	42.22	23.33	47.89	20.48
9	35.29	16.47	33.73	18.98	37.78	20.00	46.69	19.88
$\|bias_i\| \leq \|bias_{rep}\| + 0.8 * \|bias_{rep}\|$								
1	37.65	21.18	46.39	25.90	54.44	34.44	65.06	32.23
2	32.94	24.71	43.07	29.82	45.56	27.78	62.95	30.42
3	32.94	28.24	45.18	22.59	50.00	27.78	61.75	28.61
4	31.76	22.35	39.76	25.00	46.67	26.67	59.94	30.72
5	31.76	22.35	42.17	21.08	44.44	23.33	60.54	25.30
6	32.94	16.47	40.66	21.99	42.22	23.33	61.14	27.41
7	41.18	23.53	34.94	21.08	46.67	30.00	58.13	25.60
8	41.18	25.88	36.44	25.90	46.67	28.89	61.45	25.30
9	41.18	18.82	42.47	21.99	45.56	22.22	58.73	25.60

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Most representative grid point

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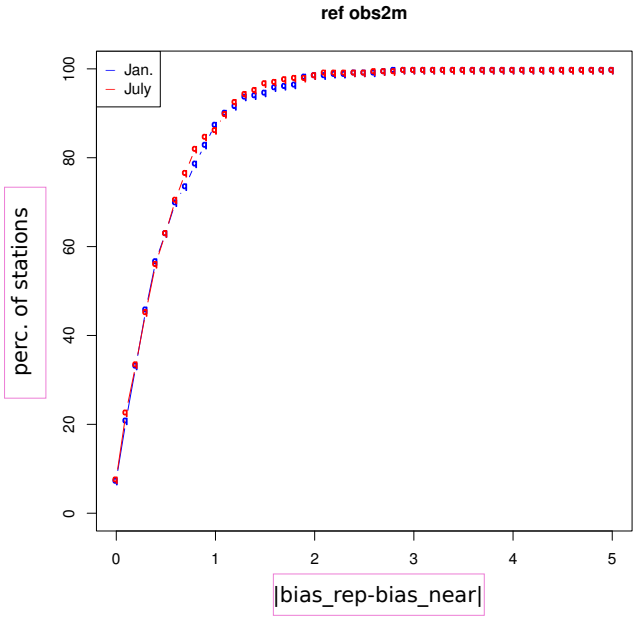

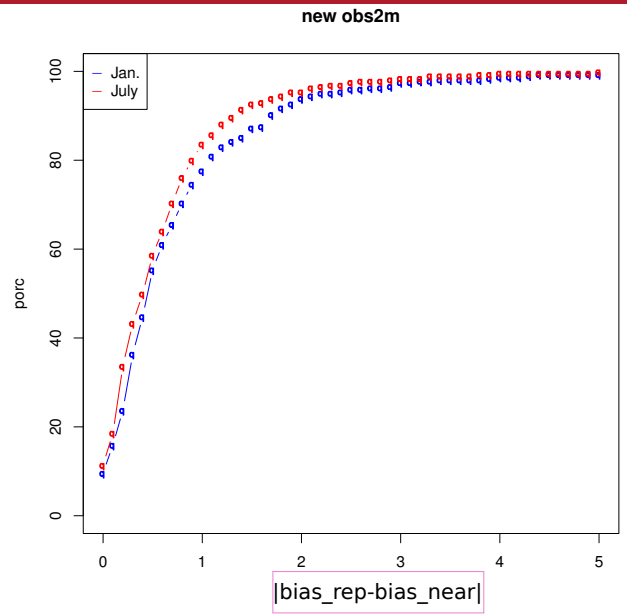

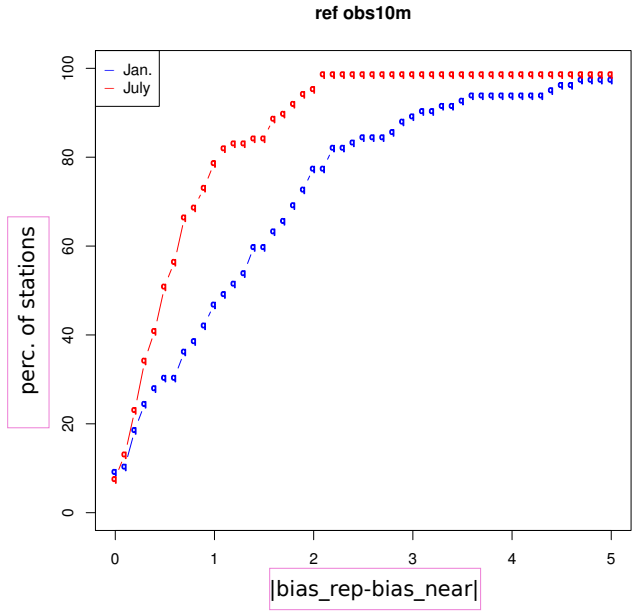

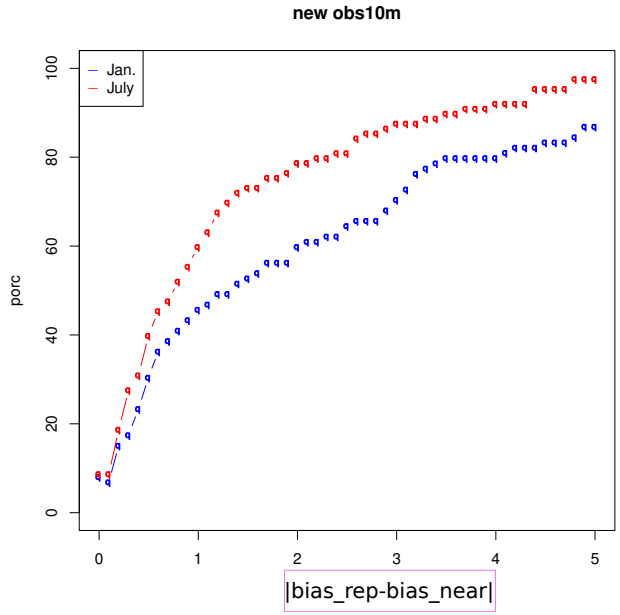

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Conclusions

Is the best grid point the same point in January and July?

	ref	new
2m	33.23	23.56
10m	42.86	22.62

17.66% of the stations at 2 m (8.24% at 10m) the best is the same for New y Ref.

Conclusions

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- Ref. vs New numerical experiment (2 m)
  For the New parameterization
  - more wind speed spatial variability
  - disappearance of systematic overestimation
  - wind speed bias reduction with exceptions
  - decrease MAE for the considered regions
- July vs. January
  - In July greater overestimation in Ref.
  - In Jan. greater underestimation in New
  - In July greater MAE (all cases)
- Repr. vs Nearest grid point
  - More variability implies more sensitivity in the selection of the point
  - Repr. plus new scheme $\Rightarrow$ improvement in the wind bias
  - Representative $\neq$ Nearest

Thank you for your attention

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	Jan.				July			
pos.	ref 10m	new 10m	ref 2m	new 2m	ref 10m	new 10m	ref 2m	new 2m
$\lvert bias_i\rvert \leq \lvert bias_{rep}\rvert + 0.5 * \varepsilon_r(\lvert bias_i\rvert)$								
1	17.6471	4.70588	35.241	14.1566	24.4444	7.77778	45.1807	19.2771
2	16.4706	7.05882	32.5301	19.5783	20	6.66667	46.988	18.9759
3	15.2941	8.23529	36.1446	11.747	23.3333	14.4444	45.4819	17.7711
4	23.5294	8.23529	31.9277	14.4578	20	11.1111	43.9759	19.2771
5	14.1176	8.23529	34.6386	10.5422	27.7778	3.33333	42.1687	15.9639
6	15.2941	2.35294	32.5301	11.4458	22.2222	8.88889	45.1807	17.1687
7	17.6471	4.70588	28.3133	11.1446	22.2222	6.66667	40.6627	15.0602
8	28.2353	5.88235	27.4096	12.9518	26.6667	13.3333	41.2651	15.6627
9	23.5294	14.1176	28.9157	18.3735	27.7778	15.5556	36.1446	18.3735
$\lvert bias_i\rvert \leq \lvert bias_{rep}\rvert + \varepsilon_r(\lvert bias_i\rvert)$								
1	30.5882	9.41176	57.2289	29.5181	50	17.7778	70.1807	35.8434
2	30.5882	8.23529	56.6265	34.6386	42.2222	13.3333	69.8795	36.1446
3	30.5882	14.1176	54.5181	28.3133	38.8889	17.7778	68.9759	34.9398
4	31.7647	12.9412	54.8193	31.9277	42.2222	17.7778	68.0723	33.1325
5	24.7059	10.5882	56.6265	28.3133	42.2222	13.3333	66.8675	33.1325
6	27.0588	5.88235	53.9157	26.8072	41.1111	11.1111	67.1687	31.6265
7	31.7647	7.05882	53.9157	27.7108	40	12.2222	66.2651	29.8193
8	35.2941	7.05882	55.4217	28.012	44.4444	15.5556	67.4699	33.1325
9	30.5882	15.2941	41.8675	20.783	33.3333	16.6667	52.4096	22.8916
$\lvert bias_i\rvert \leq \lvert bias_{rep}\rvert + 2 * \varepsilon_r(\lvert bias_i\rvert)$								
1	55.2941	32.9412	78.3133	53.3133	64.4444	41.1111	84.6386	61.4458
2	55.2941	36.4706	80.1205	59.6386	60	33.3333	85.241	63.253
3	54.1176	36.4706	76.8072	52.1084	60	43.3333	87.3494	62.3494
4	54.1176	37.6471	77.4096	57.5301	62.2222	40	84.9398	62.0482
5	51.7647	27.0588	79.8193	58.7349	61.1111	35.5556	84.6386	63.253
6	55.2941	30.5882	80.4217	59.9398	64.4444	38.8889	85.5422	62.3494
7	57.6471	29.4118	77.7108	59.3373	61.1111	35.5556	85.241	63.8554
8	56.4706	31.7647	78.9157	57.8313	60	41.1111	84.9398	65.0602
9	38.8235	17.6471	51.8072	27.7108	46.6667	22.2222	66.8675	31.3253

Table: Percentage of stations whose absolute bias is less than a threshold related with the absolute minimum bias of the nine points. The subindex i indicates one of the nine points. The

Bias vs. RMS Jan. 2m Nearest

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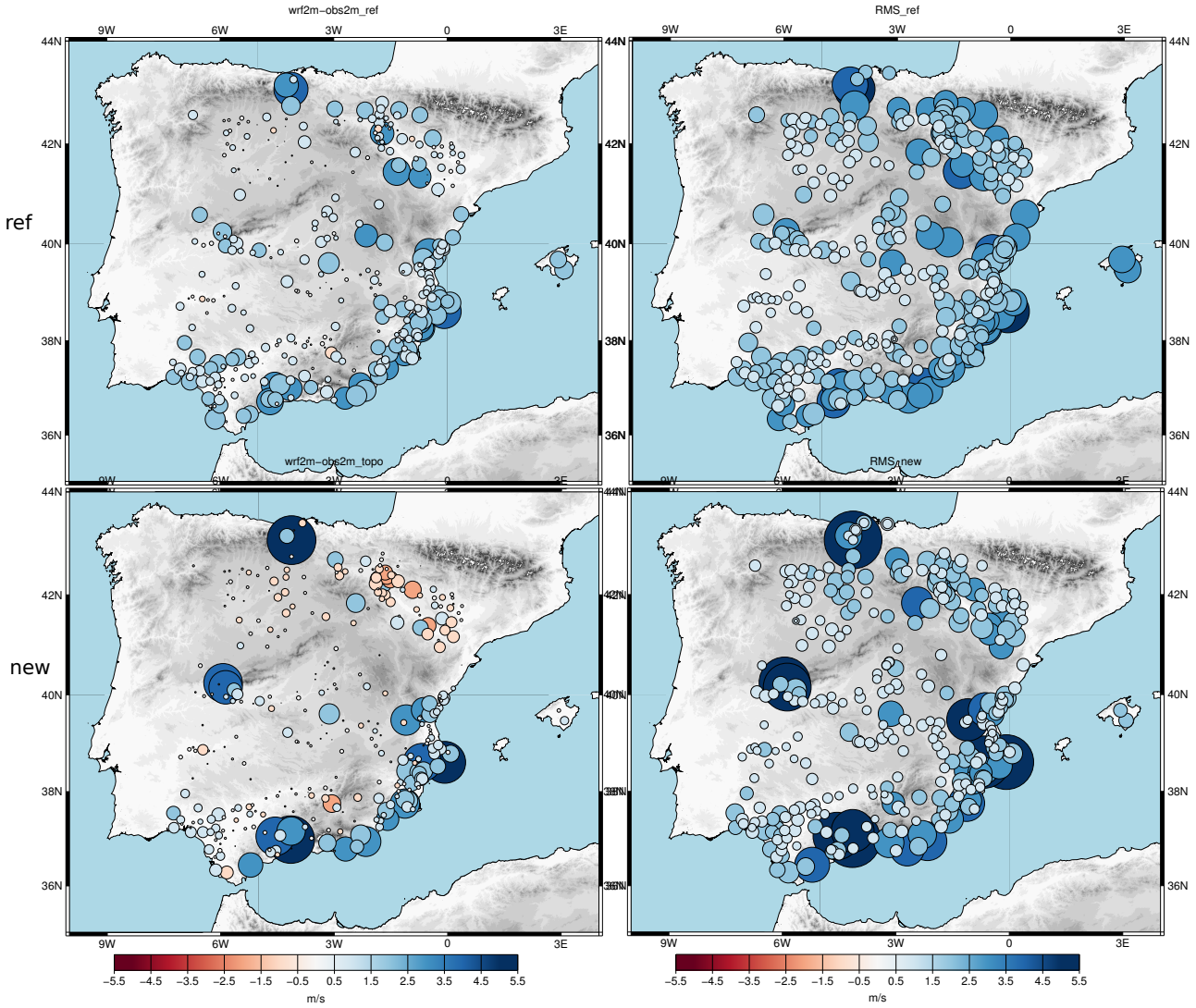

Bias vs. RMS July 2m Nearest

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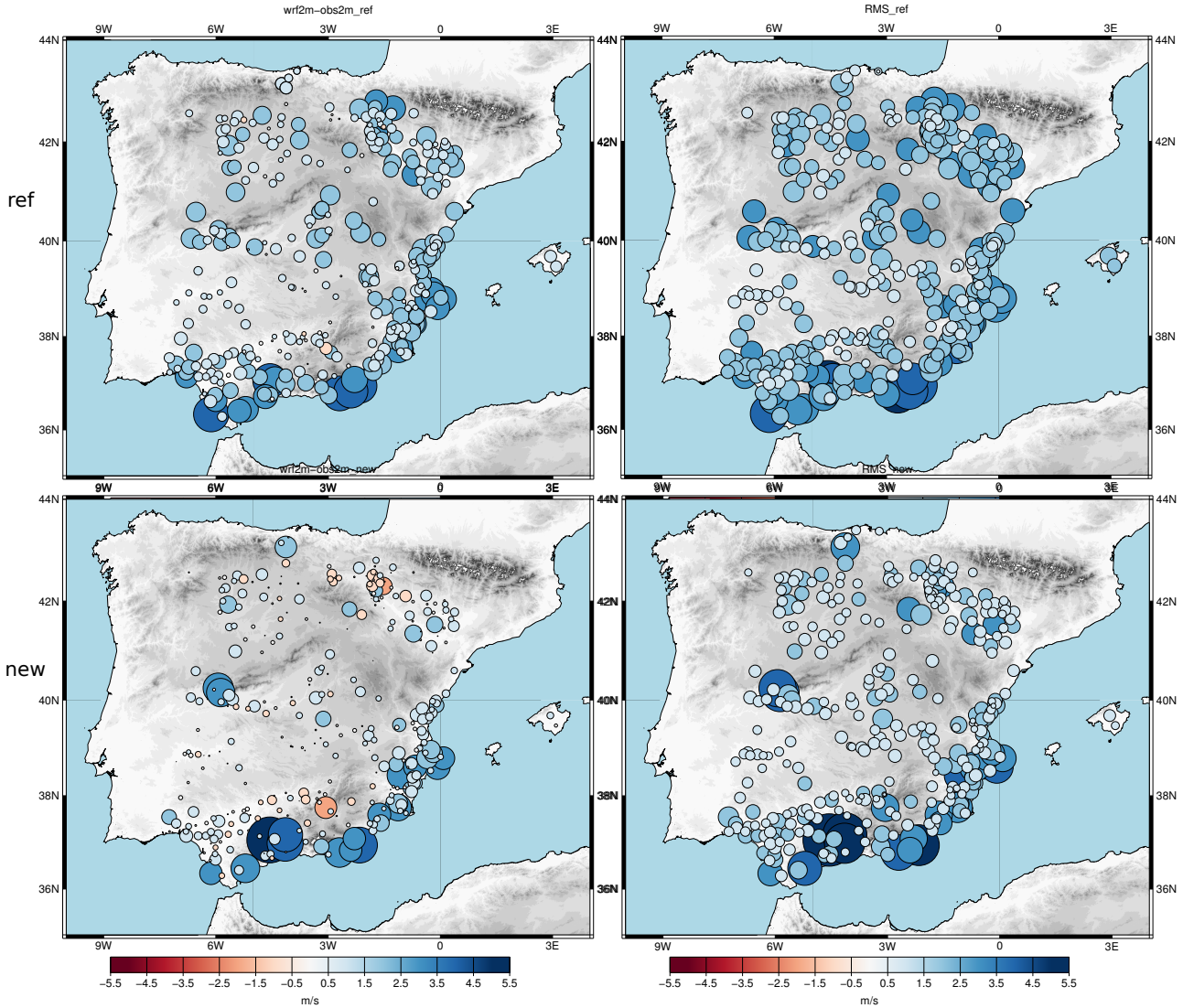

Bias vs. RMS Jan. 2m Rep.

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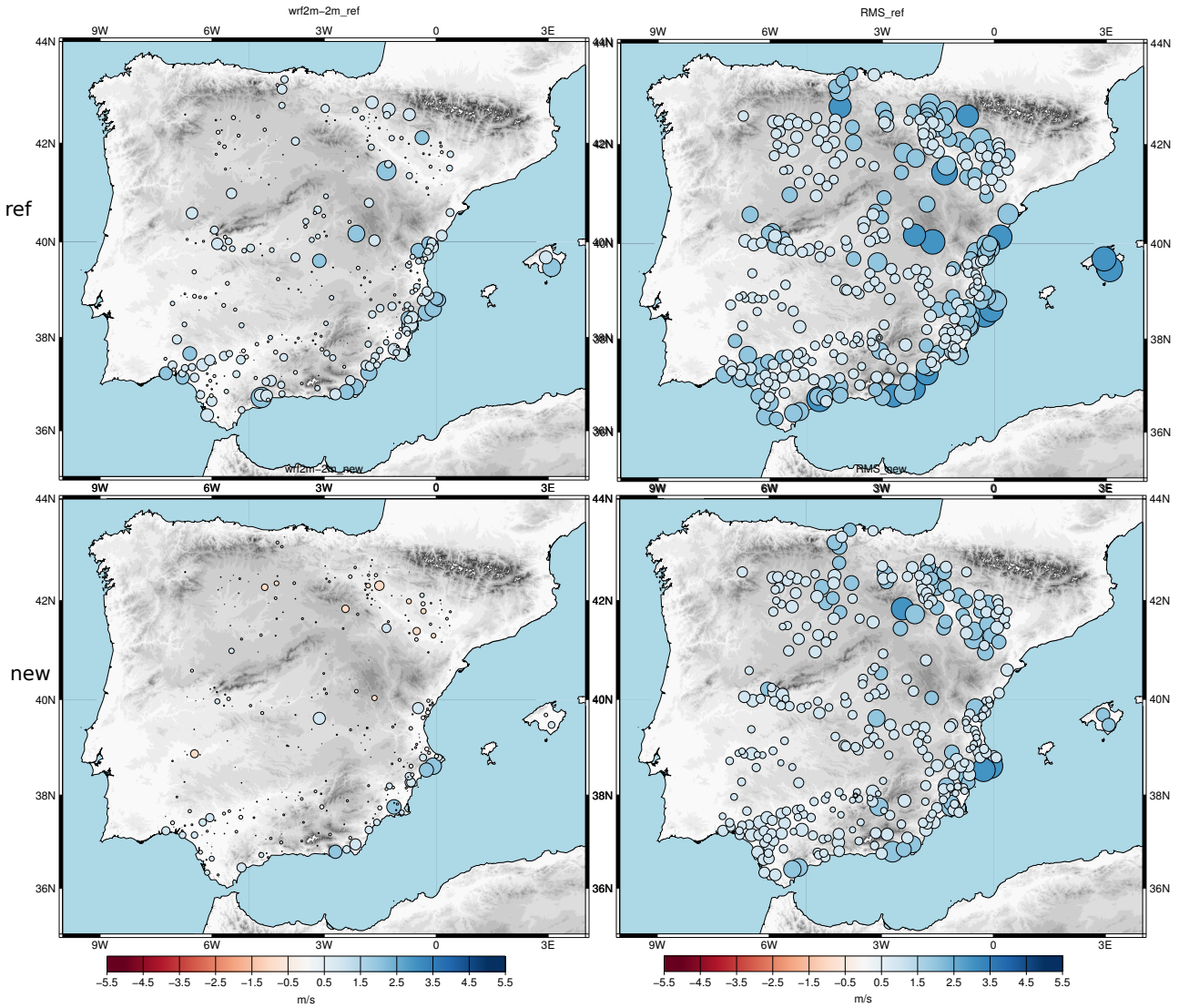

Bias vs. RMS July 2m Rep.

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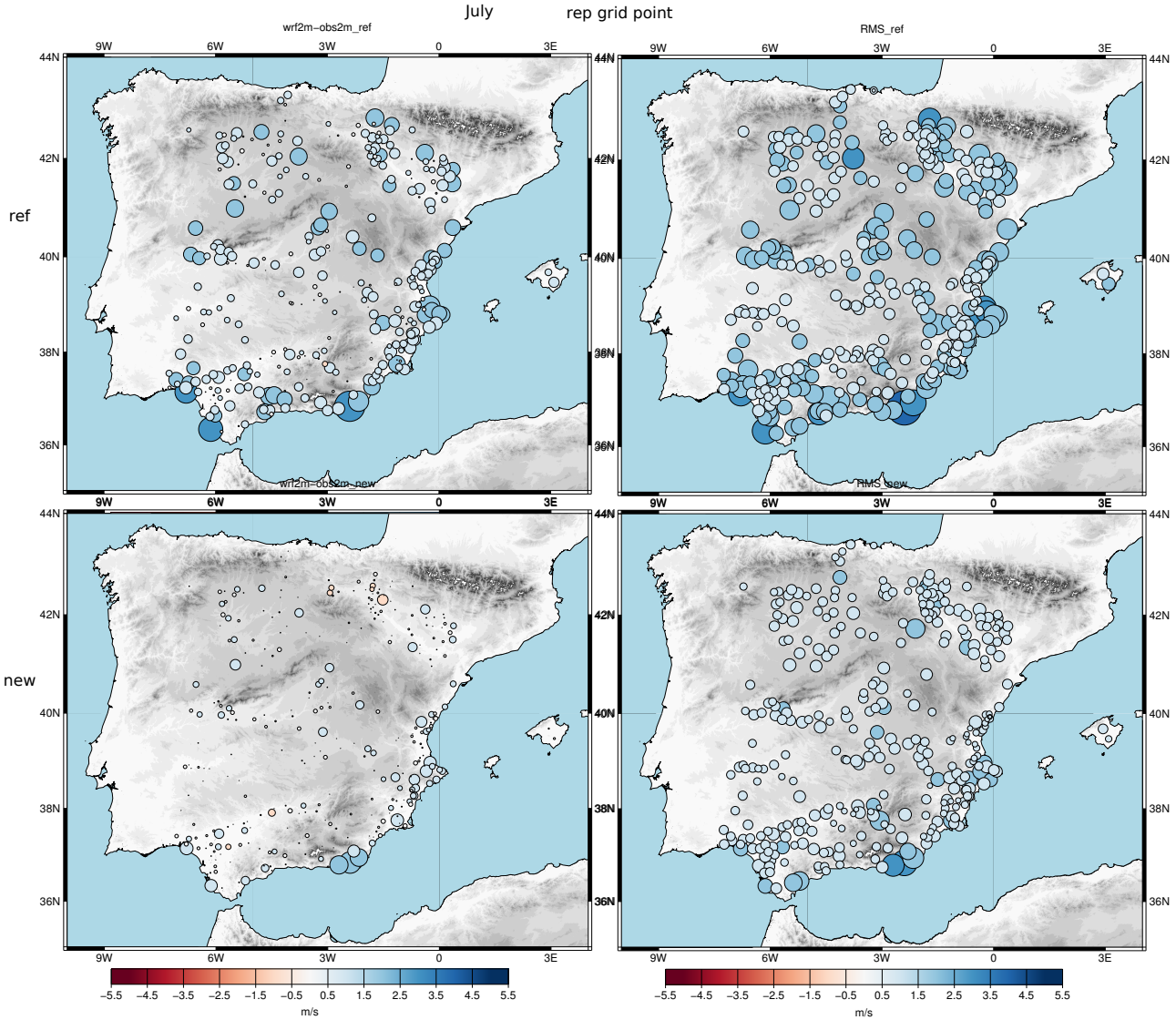

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pos.	ref 10m	new 10m	ref 2m	new 2m
January				
1	9.41	8.24	11.45	12.65
2	10.59	12.94	9.04	10.84
3	5.88	14.12	10.24	11.45
4	14.12	14.12	12.35	9.93
5	7.06	11.76	8.13	10.84
6	8.24	8.24	15.66	11.75
7	14.12	10.59	9.04	7.53
8	16.47	12.94	10.84	15.06
9	14.12	7.06	13.55	9.94
July				
1	10.00	7.78	7.53	14.16
2	11.11	13.33	10.54	11.45
3	10.00	8.89	9.64	10.84
4	7.78	10.00	15.06	12.95
5	14.44	12.22	12.65	10.24
6	10.00	11.11	15.36	9.64
7	12.22	20.00	7.23	9.04
8	12.22	7.78	12.65	12.35
9	12.22	8.89	9.34	9.34

Table: Percentage of stations of the best vs the distance to the observational point. 1 is the nearest grid point.

pos.	ref 10m	new 10m	ref 2m	new 2m	ref 10m	new 10m	ref 2m	new 2m
	Jan.				July			
$RMS_i \leq RMS_{rep} + 0.1 * RMS_{rep}$								
1	36.2637	31.7647	37.0482	39.4578	35.5556	30	34.3373	37.65
2	38.4615	28.2353	34.0361	40.6627	42.2222	30	34.3373	35.54
3	35.1648	28.2353	35.8434	37.3494	32.2222	26.6667	31.3253	29.22
4	36.2637	30.5882	36.747	32.8313	35.5556	27.7778	32.8313	31.33
5	36.2637	23.5294	30.7229	31.6265	35.5556	22.2222	29.8193	26.81
6	32.967	21.1765	31.0241	28.6145	27.7778	21.1111	34.6386	29.52
7	32.967	22.3529	26.2048	29.5181	24.4444	27.7778	25.9036	26.81
8	38.4615	23.5294	30.1205	32.8313	35.5556	13.3333	29.8193	25.60
9	32.967	20	29.8193	28.6145	36.6667	24.4444	28.3133	25.90
$RMS_i \leq RMS_{rep} + 0.5 * RMS_{rep}$								
1	57.1429	64.7059	85.5422	82.2289	88.8889	71.1111	85.5422	79.8193
2	62.6374	62.3529	81.3253	76.8072	86.6667	65.5556	82.2289	76.506
3	52.7473	60	81.9277	76.2048	81.1111	65.5556	83.1325	74.3976
4	57.1429	52.9412	79.2169	72.8916	78.8889	57.7778	81.6265	71.3855
5	46.1538	52.9412	72.5904	68.6747	83.3333	63.3333	77.7108	65.0602
6	56.044	51.7647	73.494	65.0602 6	74.4444	51.1111	78.3133	63.5542
7	53.8462	58.8235	70.7831	62.3494	80	60	78.3133	63.253
8	58.2418	58.8235	68.6747	65.0602	84.4444	62.2222	75.6024	64.759
9	56.044	50.5882	71.3855	61.4458	75.5556	51.1111	75.3012	60.5422
$RMS_i \leq RMS_{rep} + 0.8 * RMS_{rep}$								
1	69.2308	71.7647	94.2771	88.8554	95.5556	78.8889	96.0843	88.253
2	72.5275	70.5882	90.6627	82.8313	97.7778	75.5556	93.9759	84.9398
3	69.2308	65.8824	90.3614	82.5301	91.1111	74.4444	94.2771	84.6386
4	72.5275	60	90.6627	79.5181	90	71.1111	93.3735	79.8193
5	59.3407	57.6471	84.6386	75	87.7778	75.5556	92.7711	77.4096
6	67.033	60	84.9398	71.988	86.6667	64.4444	91.5663	73.494
7	67.033	67.0588	84.6386	70.1807	92.2222	72.2222	91.2651	69.8795
8	72.5275	67.0588	84.3373	74.6988	96.6667	73.3333	92.1687	75.9036
9	70.3297	57.6471	84.3373	71.988	88.8889	65.5556	90.6627	70.7831