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

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ABSTRACT

According to previous works, the Weather Research and Forecasting (WRF) model introduces a bias for the surface wind speed. To overcome this drawback, a new parameterization has been developed by Jimenez and Dudhia (2012). This new scheme parametrizes the subgrid scale orographic effects over momentum. In this work, we assess the improvements of this scheme in the wind speed representation over Spain for July and January. With this aim, two simulations have been performed with and without the resolved topographic effects activated. The simulations are validated by comparison with an observational wind data base for stations with the wind records located at 2 m and 10 m above the ground level. The preliminary results show a bias reduction when the new parameterization is introduced albeit with some exceptions in stations located in some areas where the terrain is especially complex. The topographic scheme promotes more spatial variability for the wind speed. This implies more sensitivity in the selection of the suitable grid point for the wind representation. The use of the new parameterization and the appropriate selection of the most representative grid points involves an important bias reduction for the surface wind speed in the target region.

Motivation

Biases 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

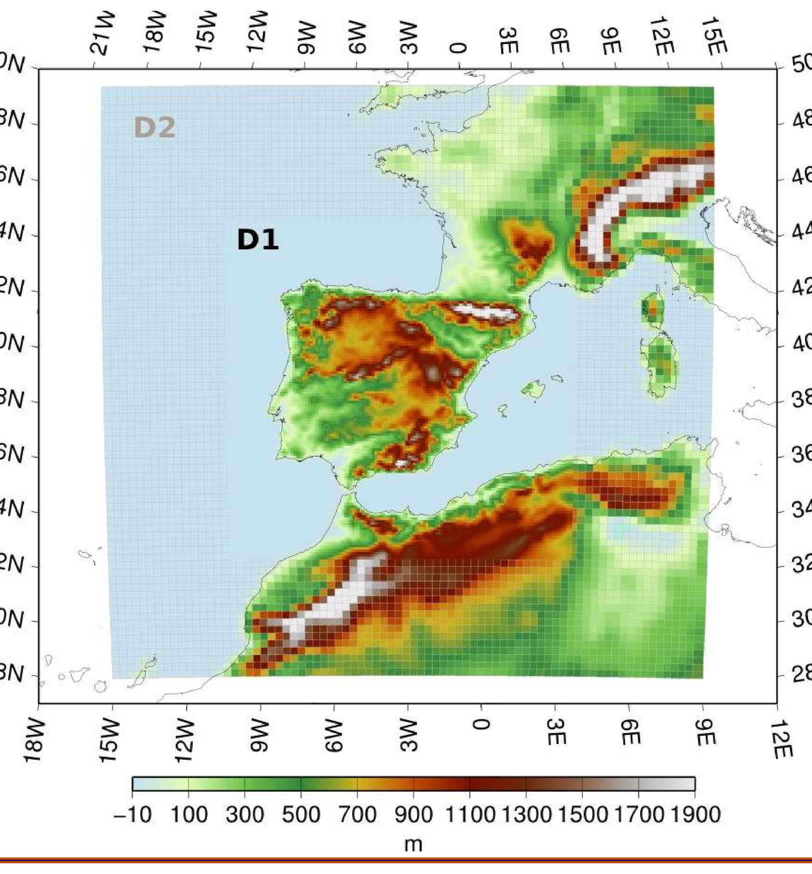
A Fix:
- A new topographic parameterization.
Jiménez and Dudhia (2012)

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

Data & Methods

Numerical experiments

Two numerical experiment have been performed
- ***Ref.*** without the topographic effects activated
- ***New*** with the topographic effects activated



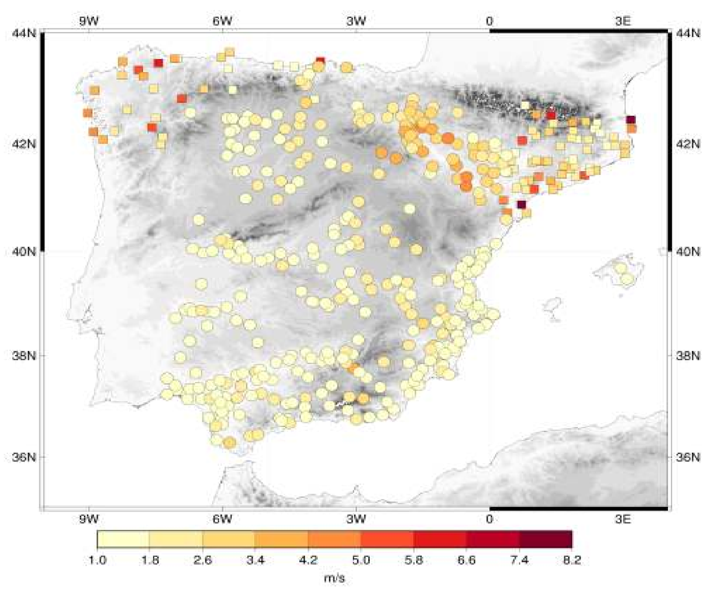
WRF 4.3 Skamarock, 2008 (modificated to obtain the wind speed at 2m)
ERA interim
SST update
No nudging

Spatial configuration
- Two two way nested domain
- 10 km inner (30 km outer)
- 27 sigma-levels top 50mb

Physical configuration
&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

Observational Database

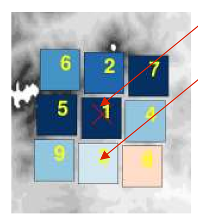


The database is formed by:
- 445 stations that have overcome a Quality Control (Jiménez et. al 2010b)
- encompassing 1999-2007
- hourly temporal resolution

Employed data:
- 85 stations at 10 m (square symbols) and 332 at 2m (circle symbols)
- 2005 because less missing value

Methodology

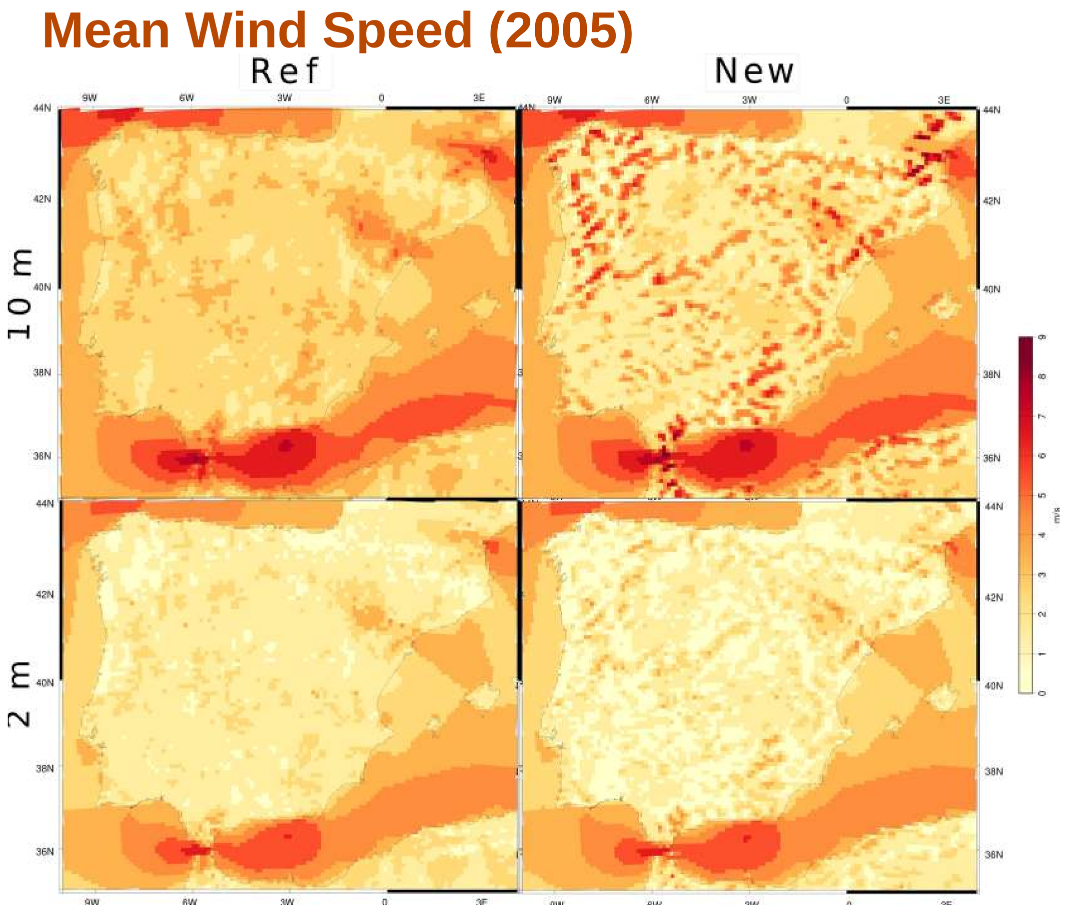
Assessment of the simulation by comparison with observations considering
- Different sensor height separately
- July (thermally driven circulations) and January (large scale)
- Nearest and the most representative grid point
  most representative=min(|bias$_i$|) i=1,9 nearest points



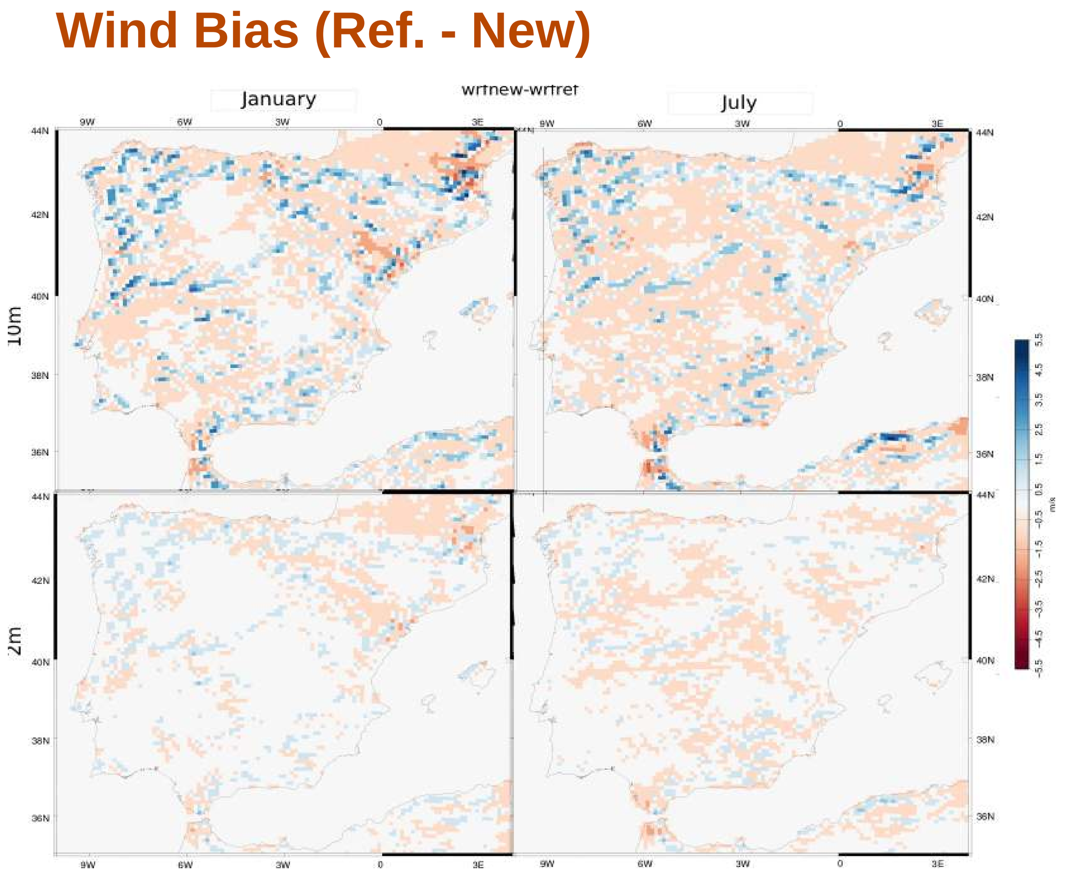
Results

a) Domain

Mean Wind Speed (2005)

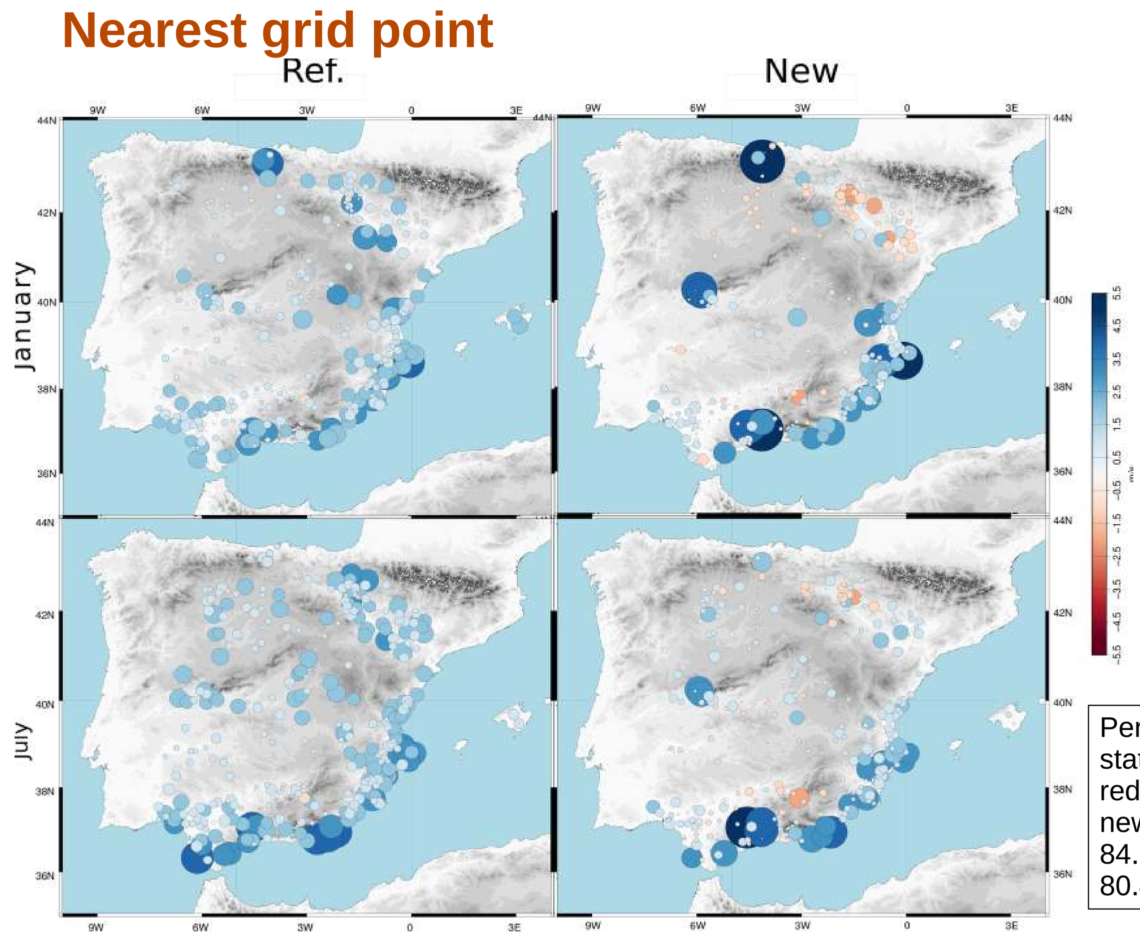


Wind Bias (Ref. - New)



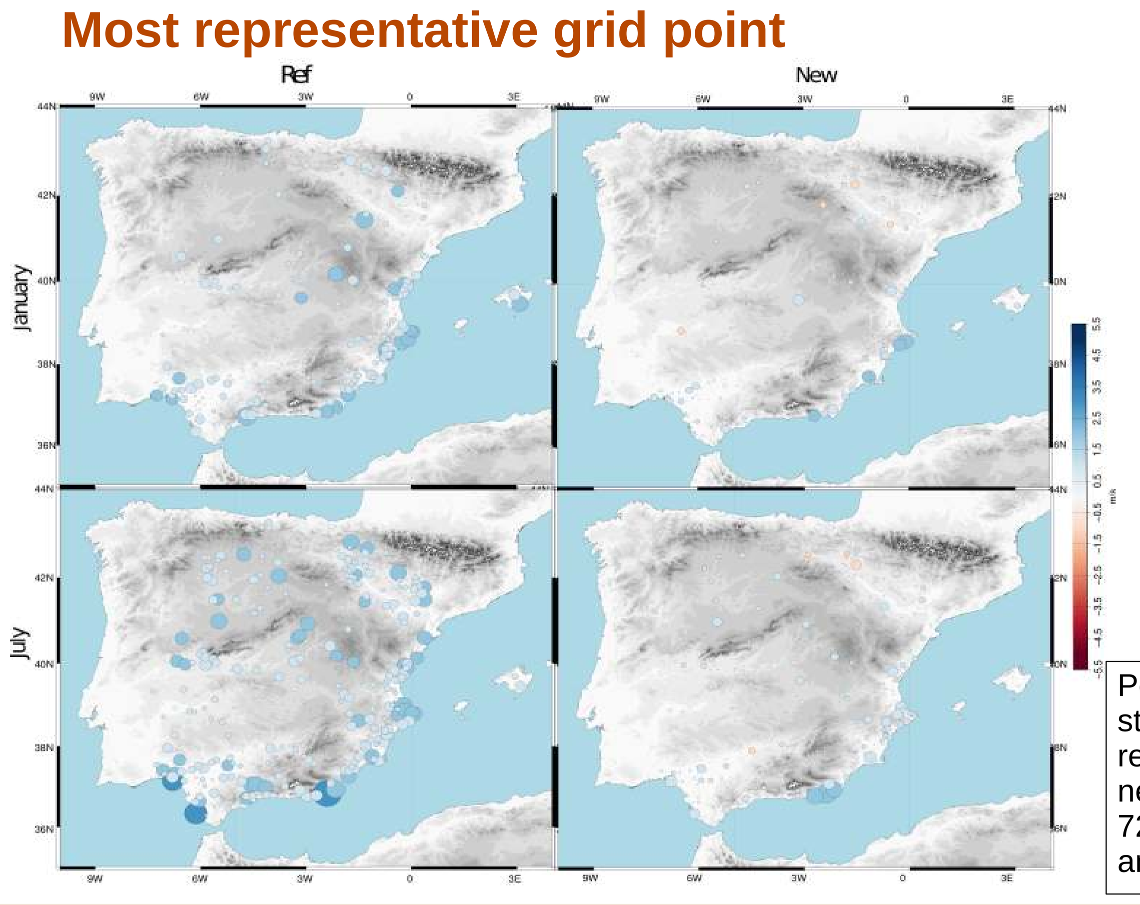
b) Wind Bias: WRF-OBS (2m)

Nearest grid point



Percentage of stations with bias reduccion with new scheme 84.94% Janr. and 80.42 % July

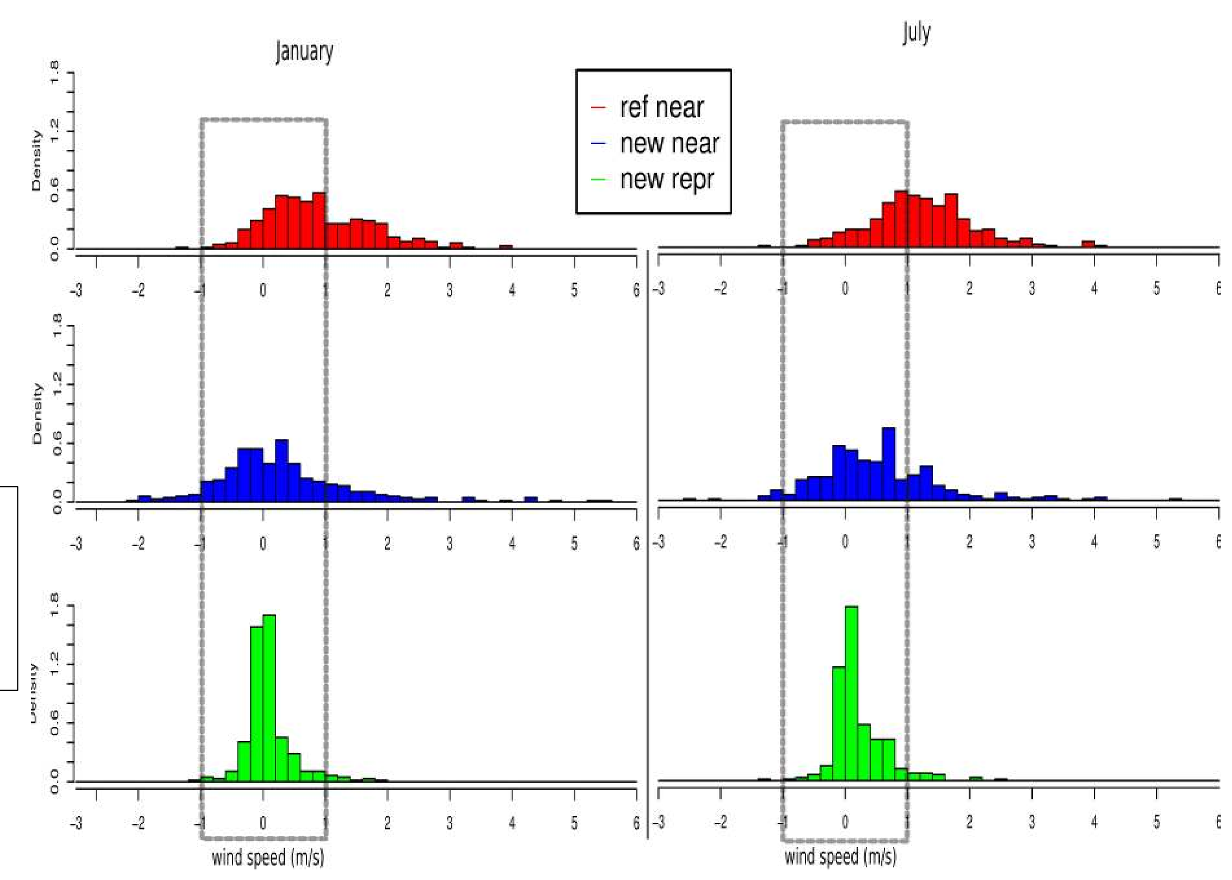
Most representative grid point



Percentage of stations with bias reduccion with new scheme 72.58% Janr. and 84.64 % July

- Ref.: systematic overestimation
- New: no systematic overestimation
- New: bias reduction with exceptions
- 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



c) Most representative *vs* Nearest

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

How often is another station better than the nearest one?

$\|bias_{near}\| > \|bias_i\| + \epsilon * \|bias_{rep}\|$					
ϵ		ref 10m	new 10m	ref 2m	new 2m
January					
0	Near	5.88	1.18	5.72	3.31
	Other	94.12	98.82	94.28	96.69
0.2	Near	10.59	1.18	15.36	3.92
	Other	89.41	98.82	84.64	96.08
0.5	Near	24.71	1.18	28.01	7.23
	Other	75.29	98.82	71.99	92.77
1	Near	34.12	2.35	44.88	12.05
	Other	65.88	97.65	55.12	87.95
5	Near	81.18	57.65	80.42	55.12
	Other	18.82	42.35	19.58	44.88
July					
0	Near	2.22	1.11	6.93	4.52
	Other	97.78	98.89	93.07	95.48
0.2	Near	11.11	1.11	25.60	8.43
	Other	88.89	98.89	74.40	91.57
0.2	Near	36.67	3.33	47.59	14.16
	Other	63.33	96.67	52.40	85.84
1	Near	46.67	7.78	69.28	22.59
	Other	53.33	92.22	30.72	77.41
5	Near	77.78	57.78	90.06	62.35
	Other	22.22	42.22	9.94	37.65

Is the best grid point the same point in Jan. and July?

	ref	new
2m	33.23	23.56
10m	42.86	22.62

Is the best grid point the same point in Ref. and New?

2m 17.66%
10m 8.24%

CONCLUSIONS

New vs Reference simulation
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 ⇒ improvement in the wind bias
- Representative≠ Nearest

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- Skamarock, W.C., and Coauthors, 2008: A description of the Advanced Research WRF version 3. NCAR Tech.Rep. TN-475+STR, 113 pp.

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