On the reproducibility of the surface wind direction over complex terrain by the WRF model

Pedro A. Jiménez (CIEMAT)

Jimy Dudhia (NCAR)

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Outline

1.- Background and motivation
2.- Experimental set up
3.- Results
4.- Conclusions

Motivation:

- Investigate the ability of WRF to reproduce the surface wind direction over complex terrain.

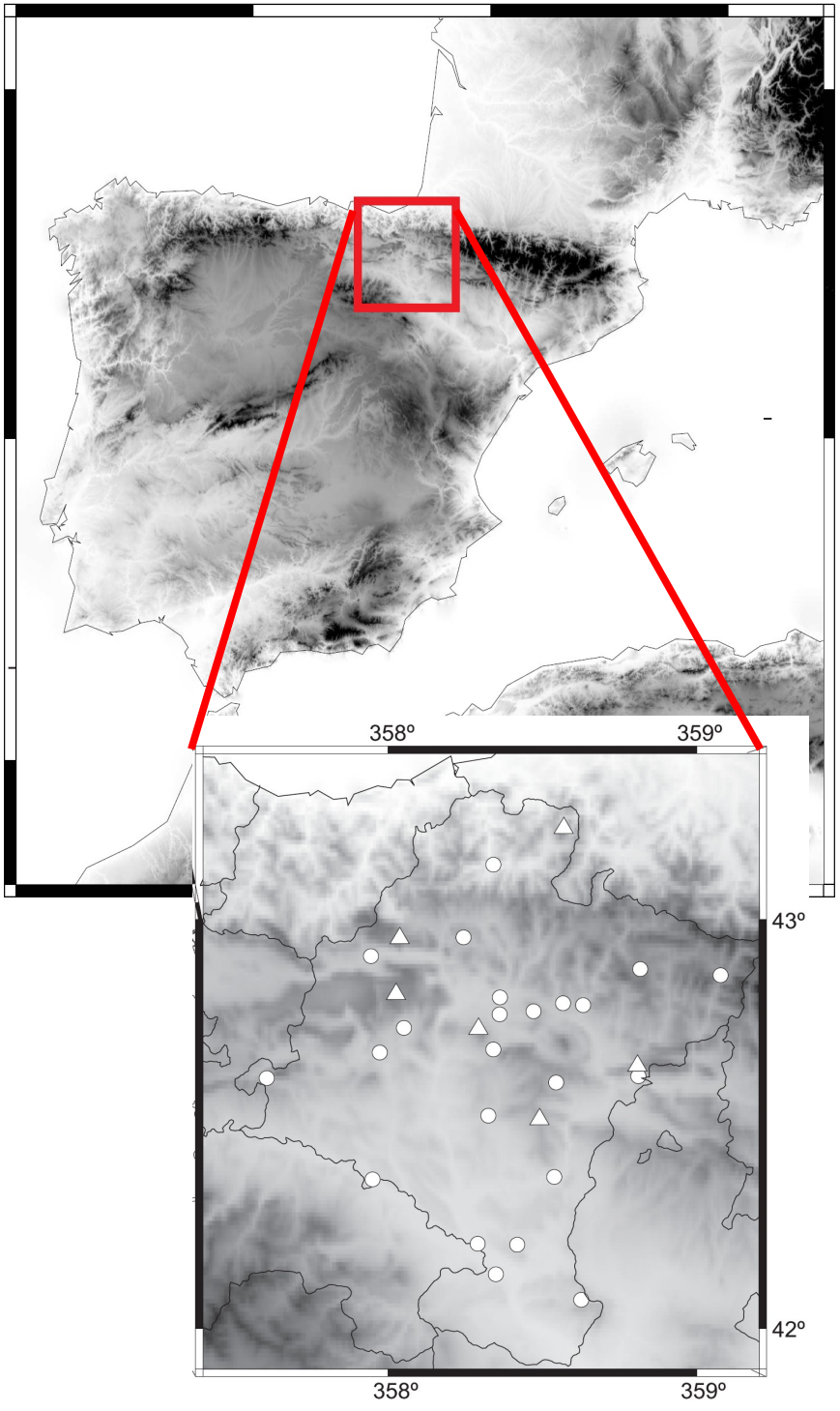
Wind speed biases

The high (low) wind speed bias that WRF presents over the plains (mountains) is corrected using a **parameterization** of the effects of the **subgrid scale orography**

Jiménez and Dudhia JAMC 2012

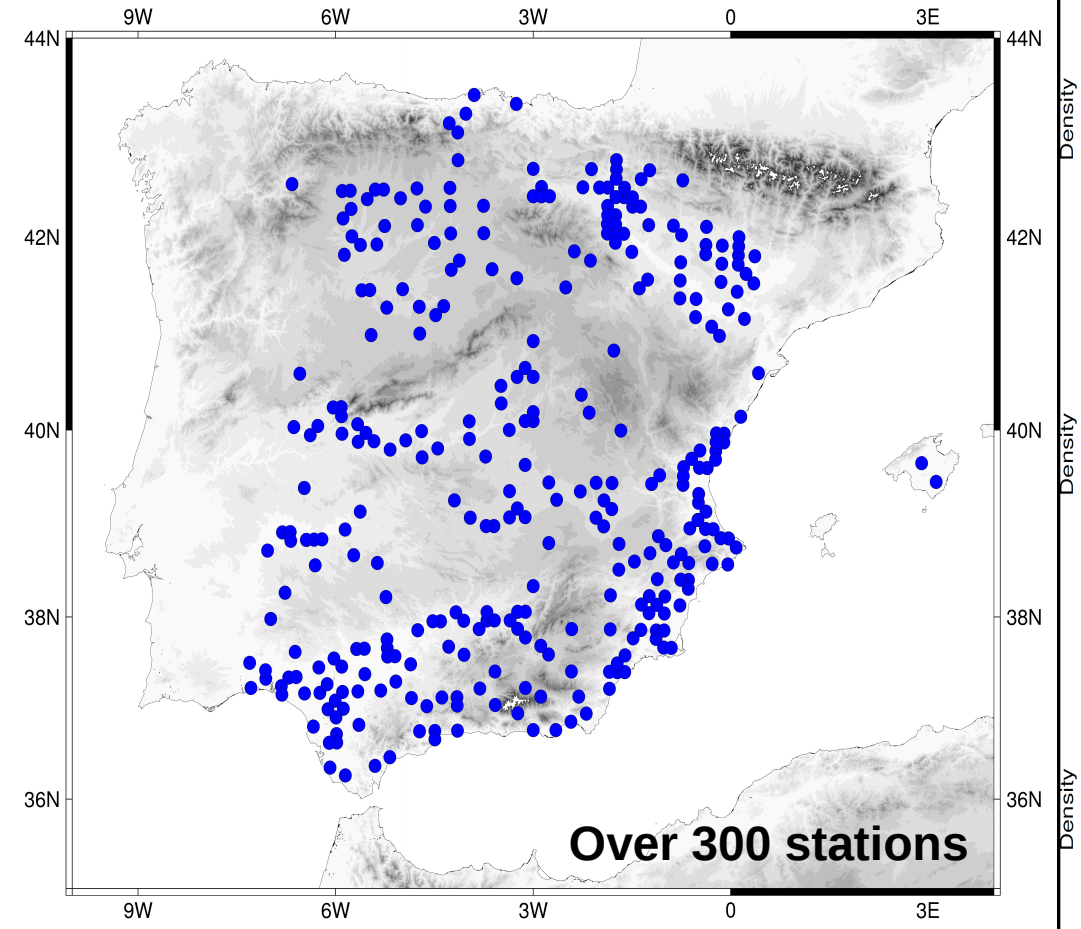
Importance of using **representative grid points** in the comparison with observations.

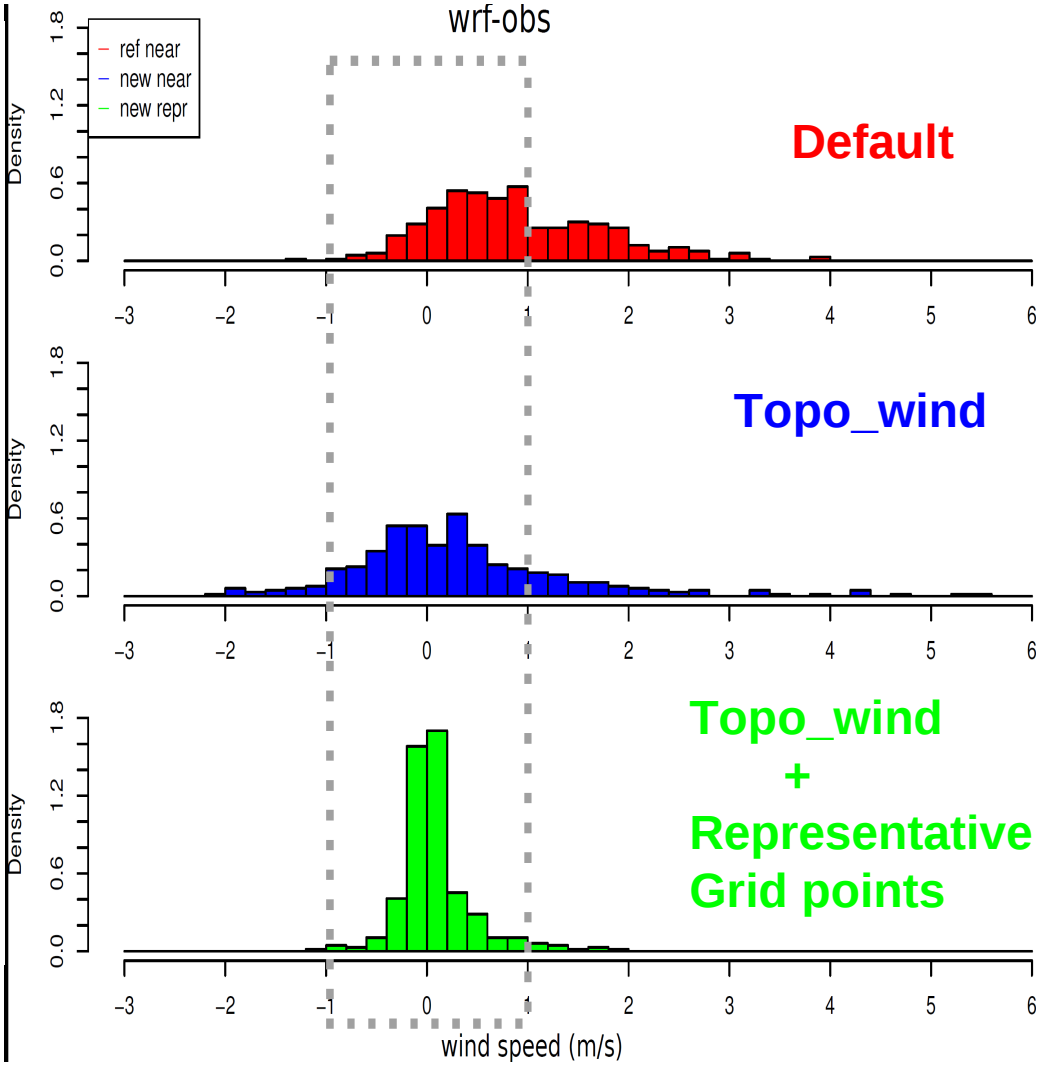
The **parametrization** and the use of **representative grid points** can reduce the MAE of the wind speed from 1.85 m/s to 0.72 m/s.



Further testing

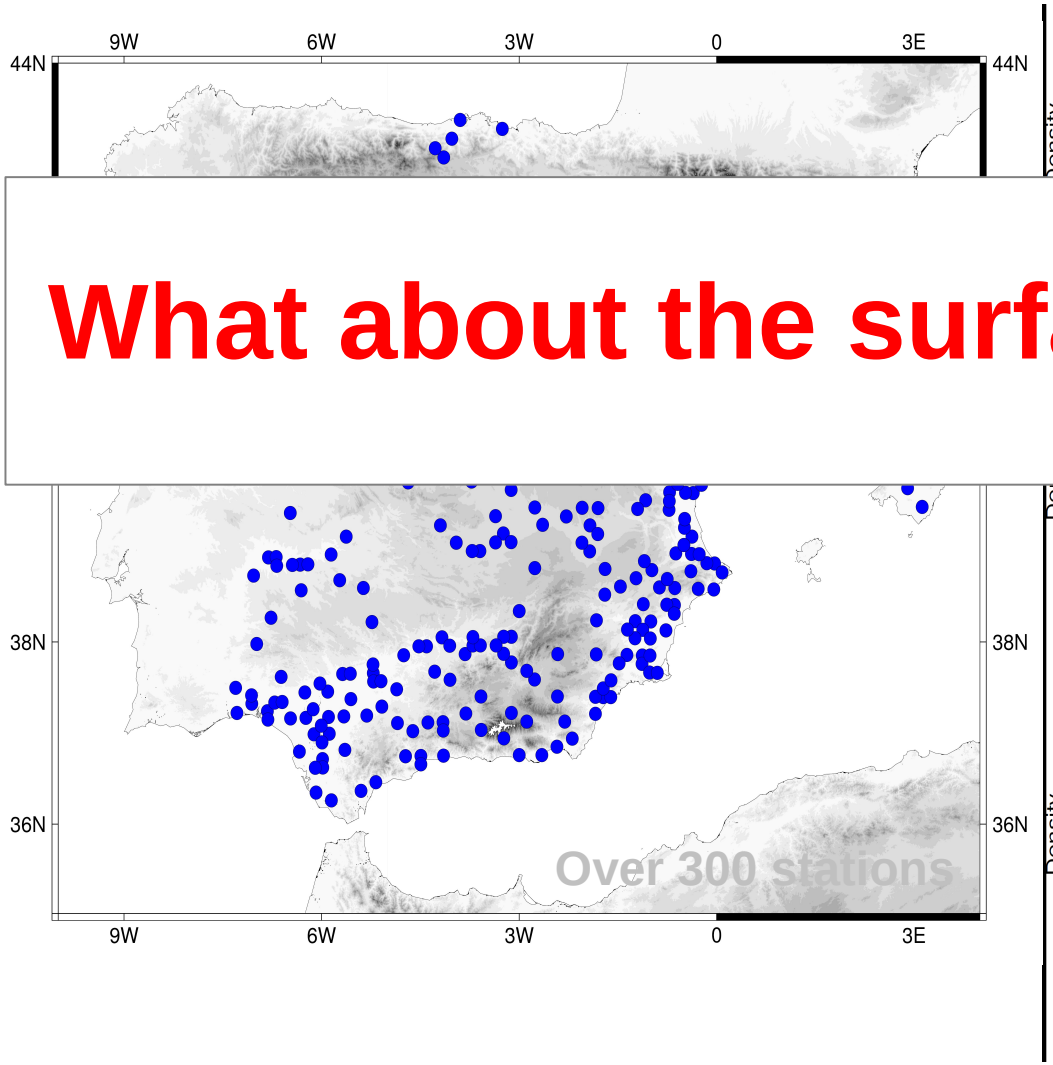
The parameterization of the effects that the topography exerts over the surface wind improves the simulation of the surface wind speed over the Iberian Peninsula.



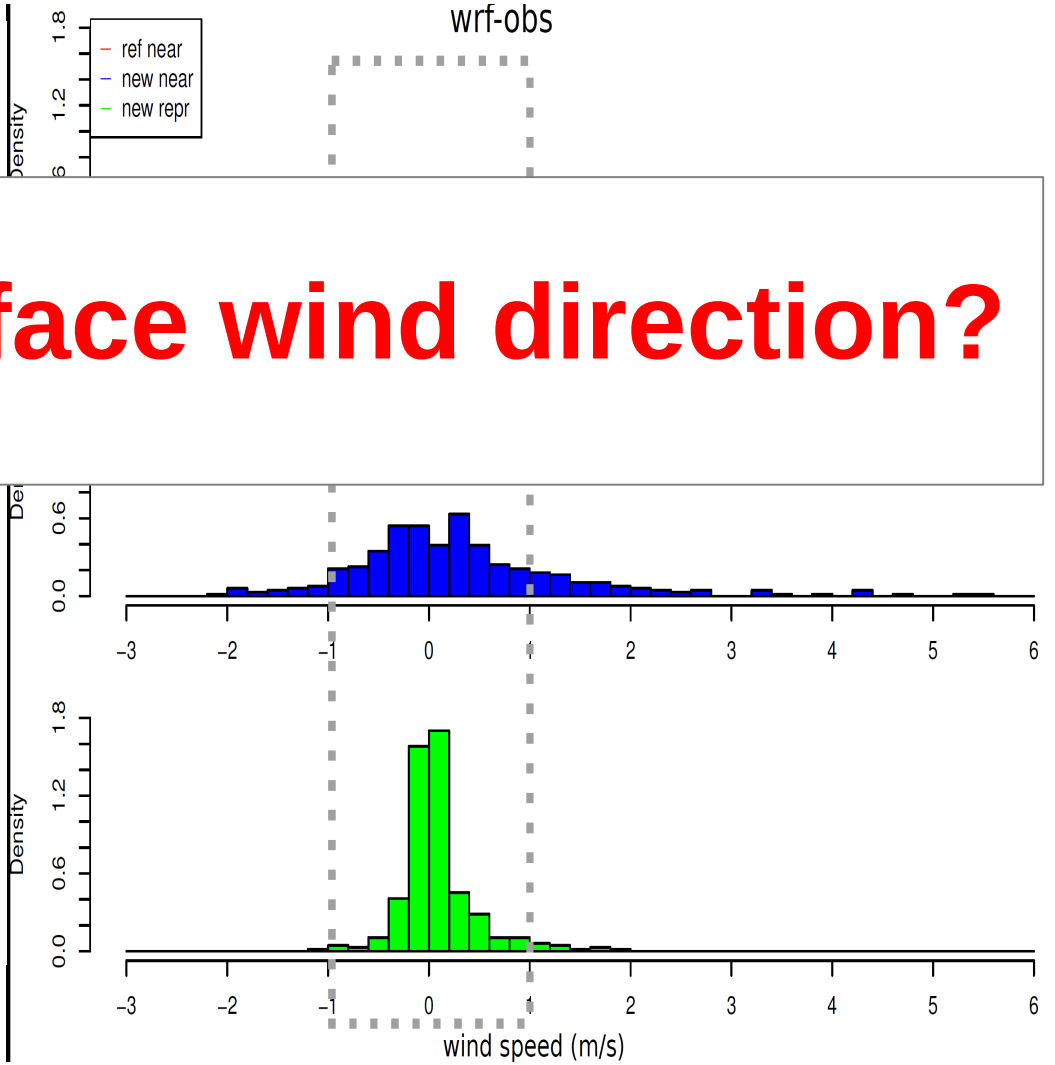


Further testing

The parameterization of the effects that the topography exerts over the surface wind improves the simulation of the surface wind speed over the Iberian Peninsula.



What about the surface wind direction?



Outline

1.- Background and motivation

2.- Experimental set up

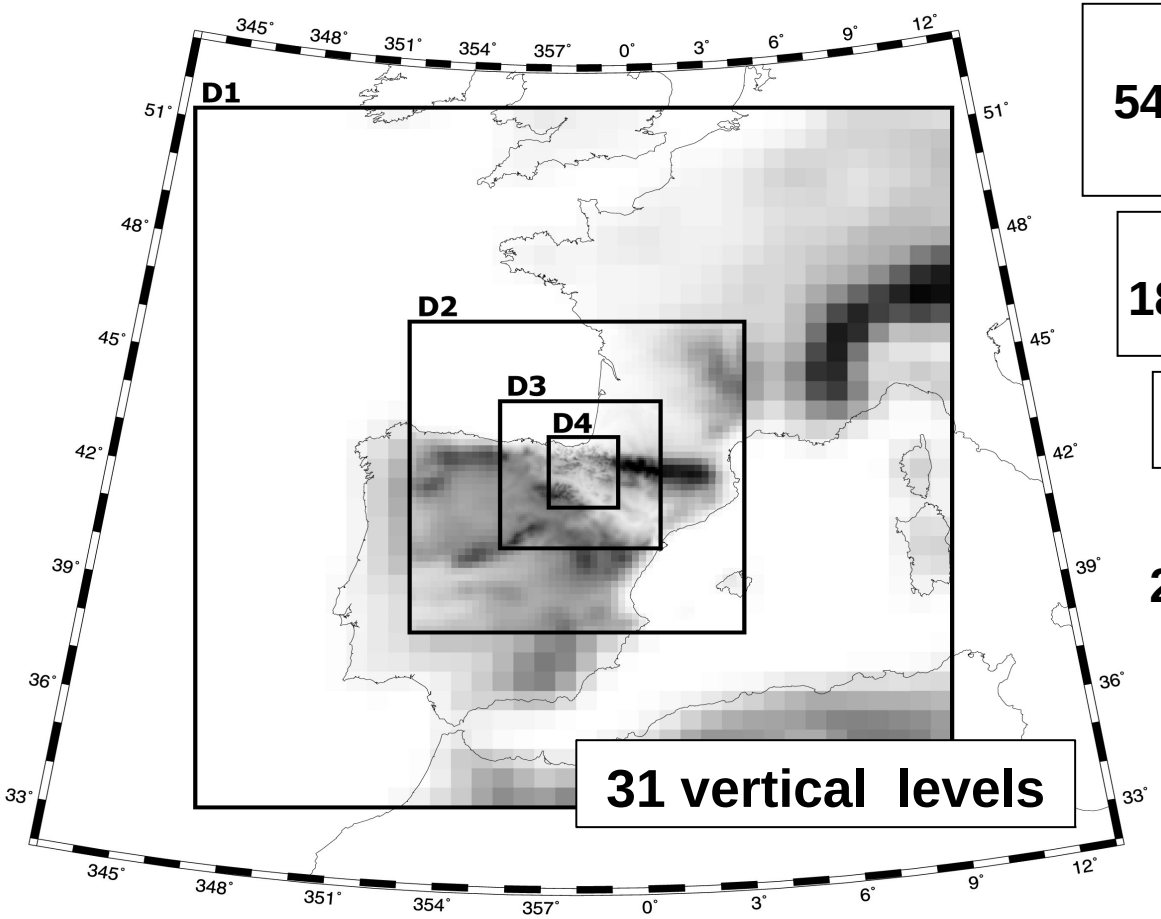
3.- Results

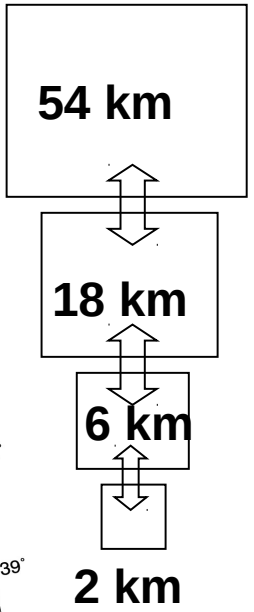
4.- Conclusions

Motivation:

- Investigate the ability of WRF to reproduce the surface wind direction over complex terrain.

2.- Experimental set up





WRF 3.1.1

Skamarock, 2008

Two way nesting

Initial and boundary conditions every 6 hours from the final NCEP Analysis

The simulation of Jimenez and Dudhia (2012) is used in the evaluation. The simulation spans the **winter of 2001/02** (December, January and February) and parameterizes the topographic effects. Output every hour.

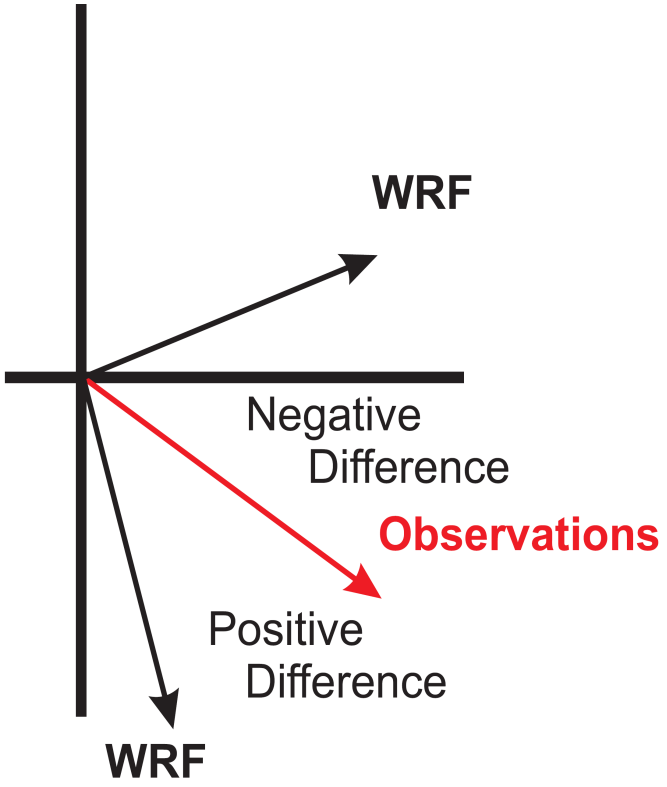
Jiménez and Dudhia *JAMC*, 2012

Evaluation

Wind direction requires a **circular variable**

$$\Delta d = \begin{cases} d_{WRF} - d_{obs} & \text{if } d_{WRF} - d_{obs} < |180| \\ d_{WRF} - d_{obs} - 360 & \text{if } d_{WRF} - d_{obs} > 180 \\ d_{WRF} - d_{obs} + 360 & \text{if } d_{WRF} - d_{obs} < -180 \end{cases}$$

[-180, 180]



$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (\Delta d_i)^2}{n}}$$

$$MAE = \sqrt{\frac{\sum_{i=1}^{n} |\Delta d_i|}{n}}$$

Outline

1.- Background and motivation
2.- Experimental set up
3.- Results
4.- Conclusions

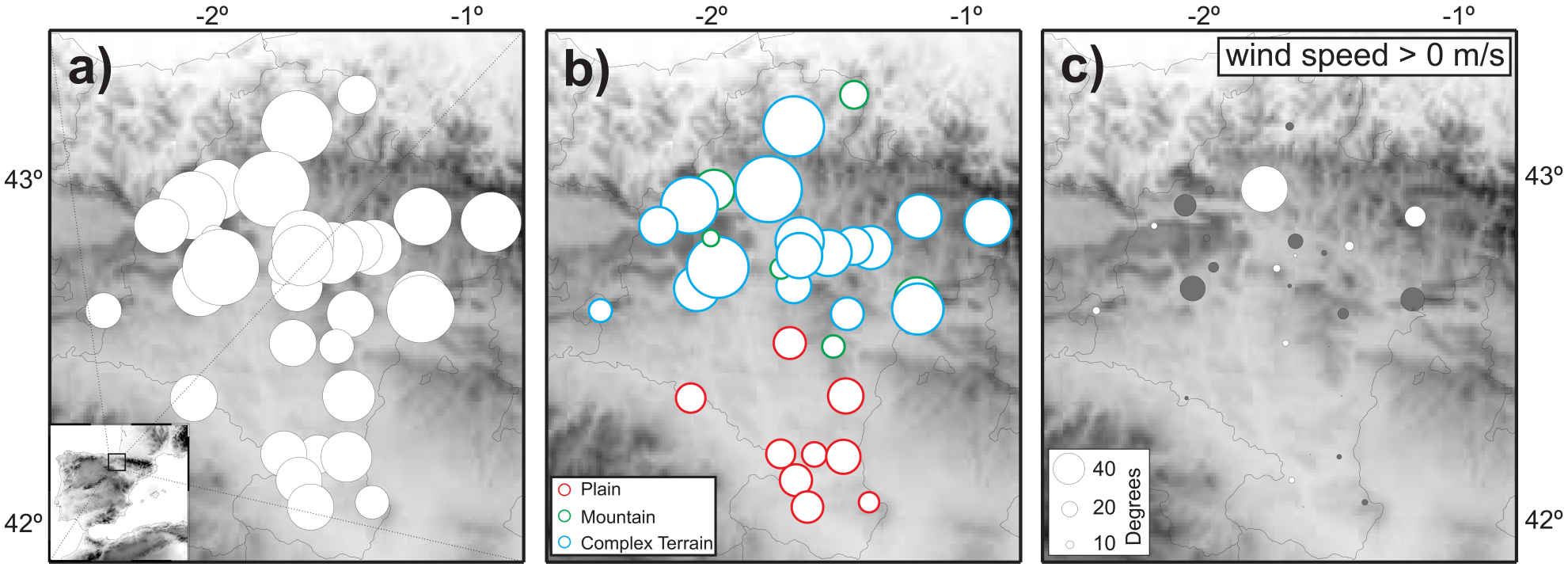
Motivation:

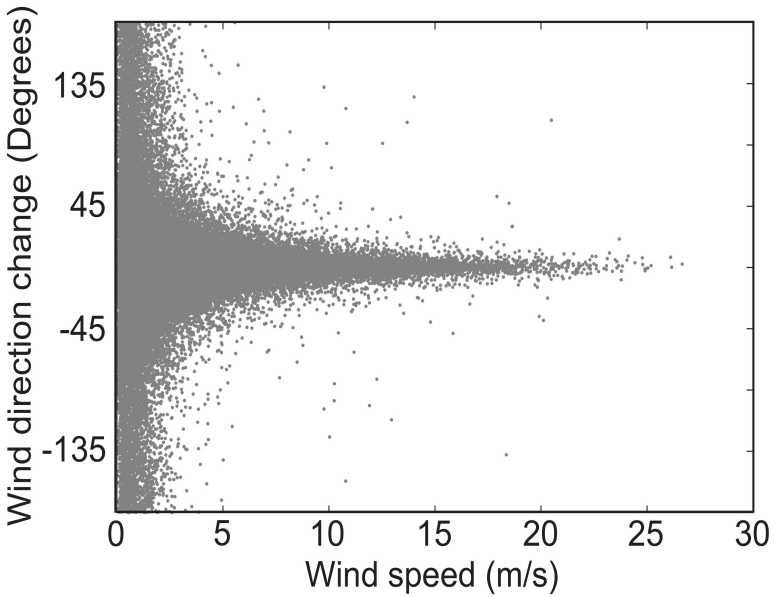
- Investigate the ability of WRF to reproduce the surface wind direction over complex terrain.

RMSE

MAE

Median Differences



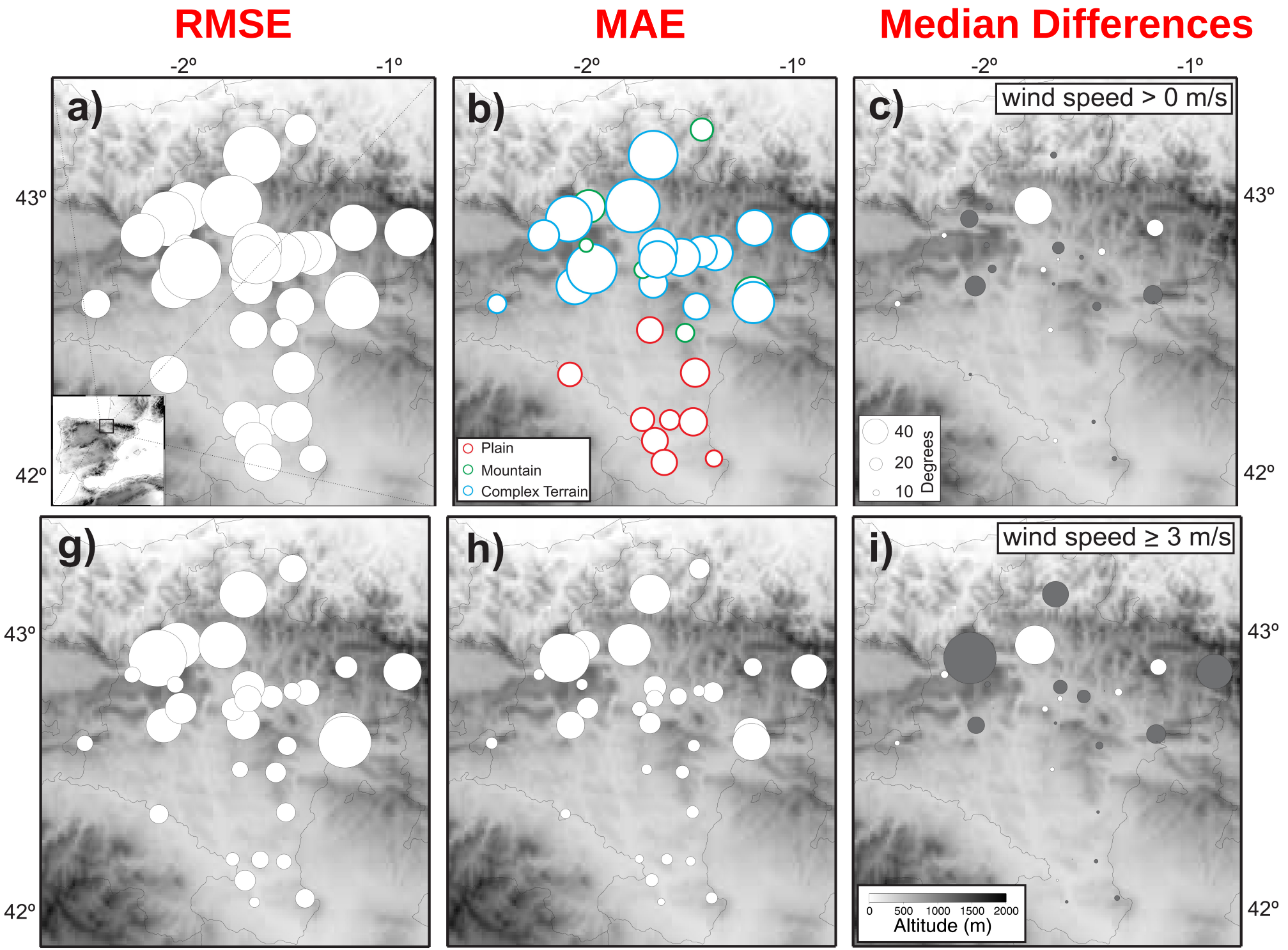


The wind direction variability is a function of the wind speed.

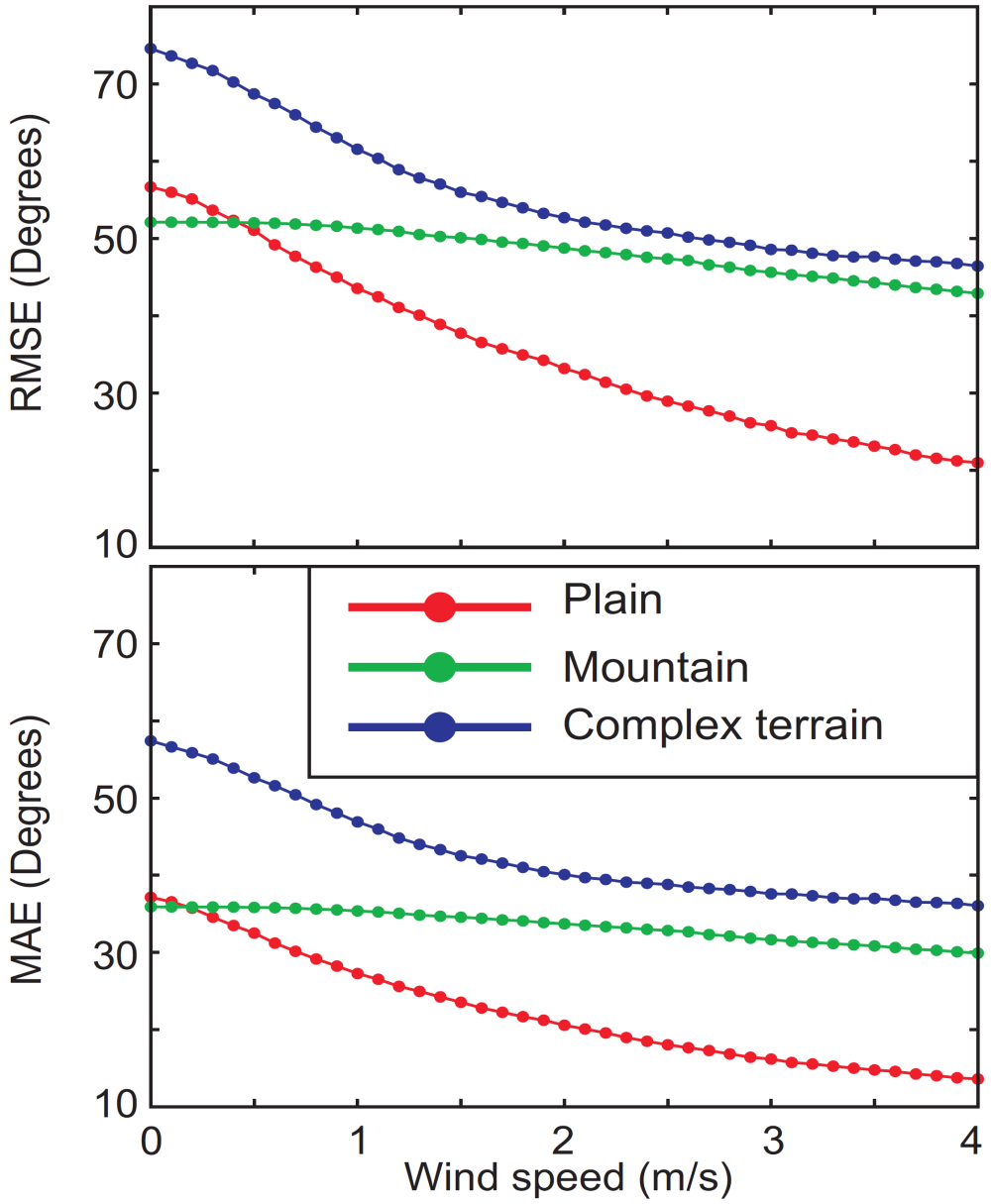
Jofre and Laurila (1998)

Davies and Thomson (1999)

Mahrt (2011)

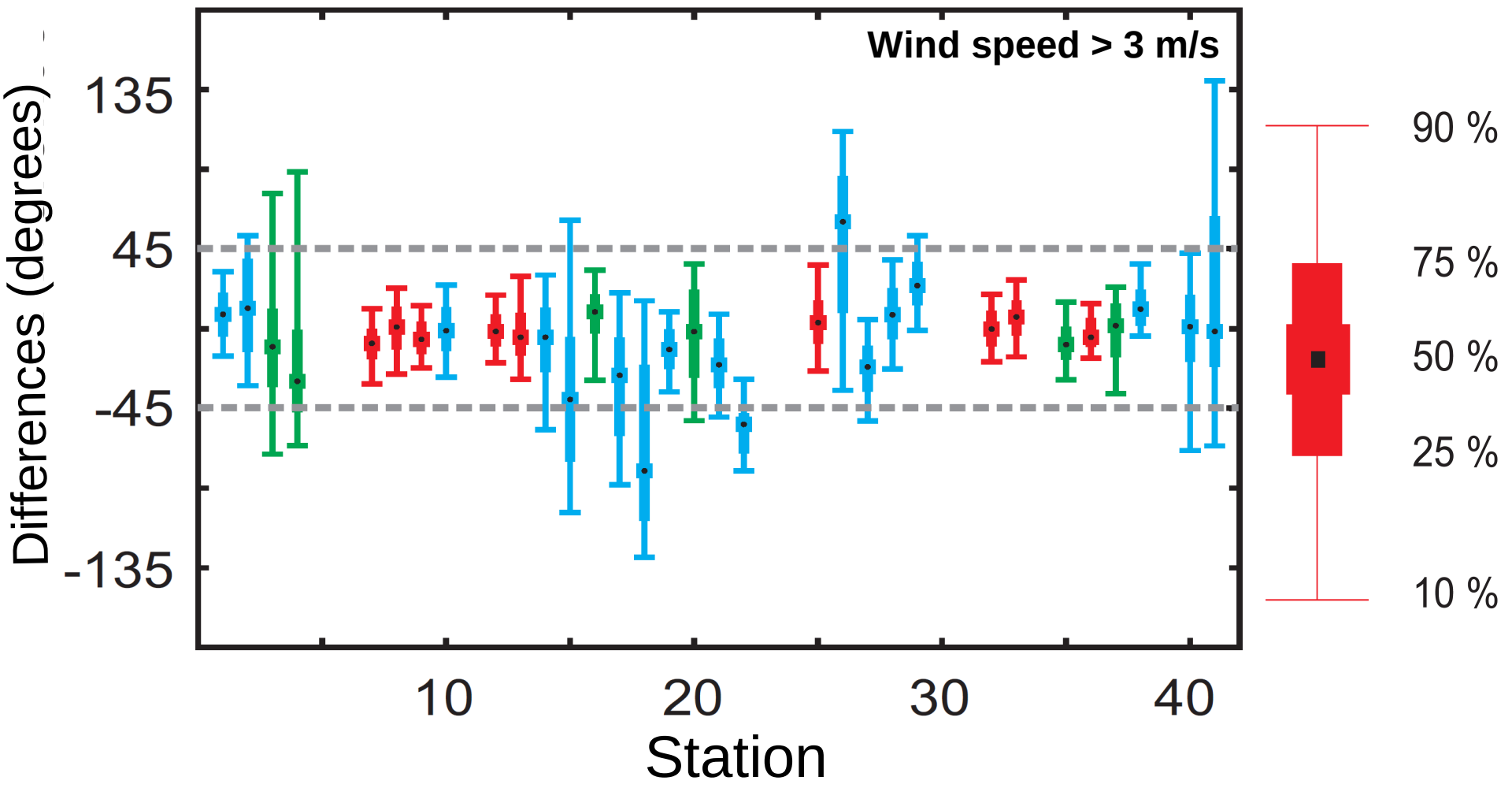

RMSE
MAE
Median Differences
-2º
-1º
43º
42º
a)
b)
c)
wind speed > 0 m/s
Plain
Mountain
Complex Terrain
40
20
10
Degrees
g)
h)
i)
wind speed ≥ 3 m/s
0
500
1000
1500
2000
Altitude (m)

Direction errors VS wind speed



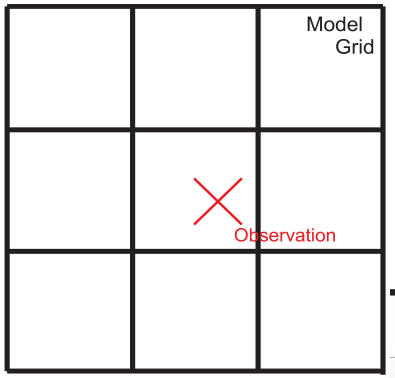
Lower reduction of the error for high wind speeds over complex terrain

Distribution of the differences

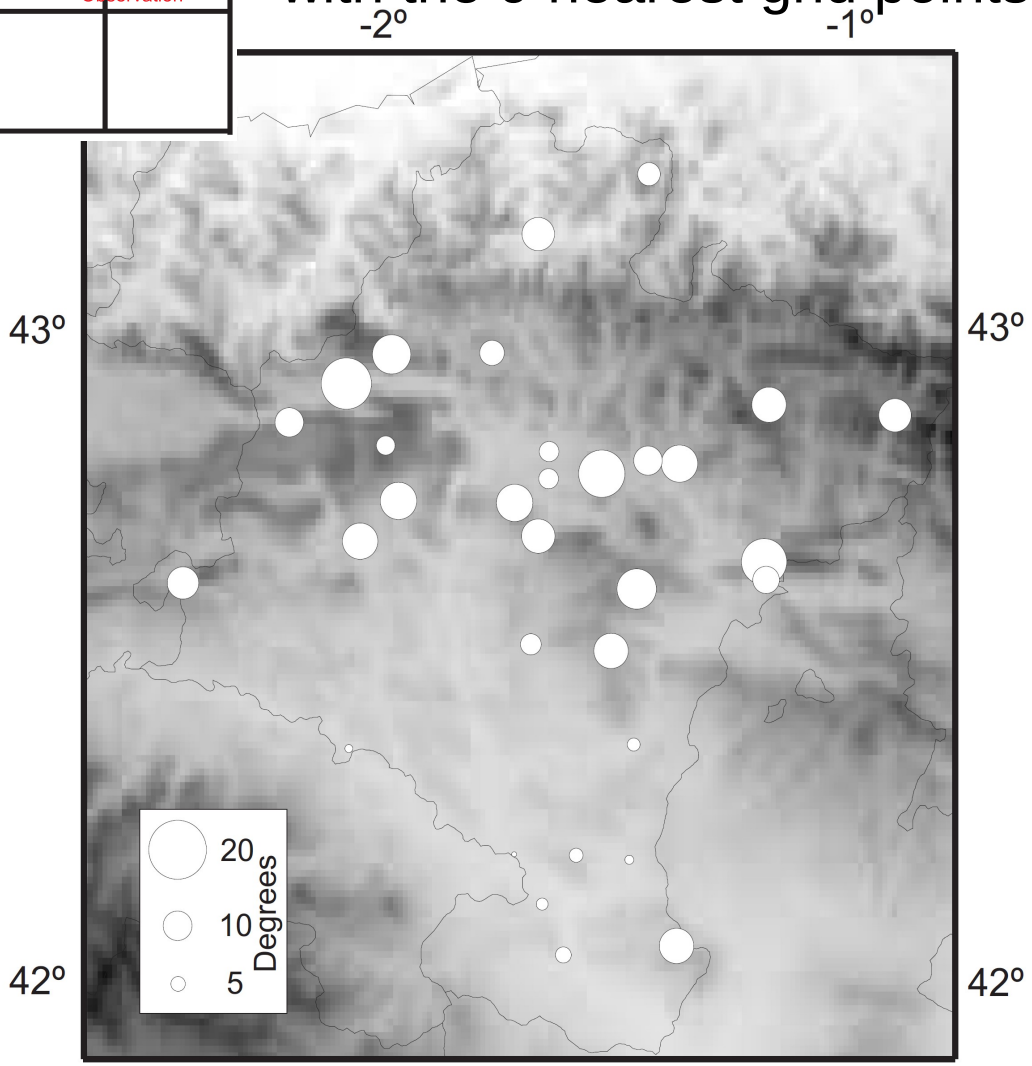


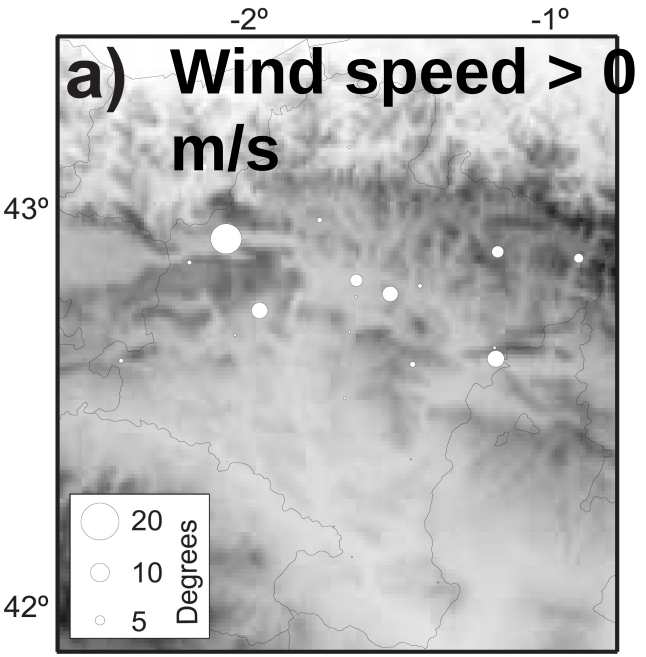
How important are the representativeness errors as a result of using the nearest grid point in the comparison?

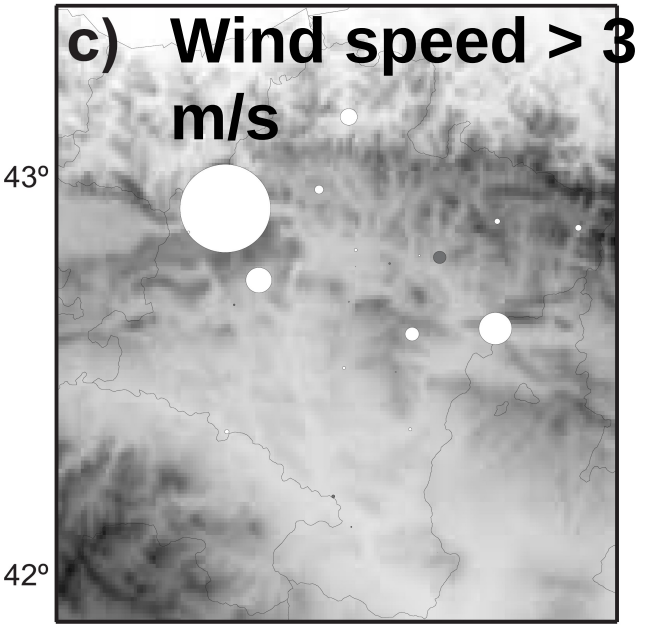
Representativeness Errors



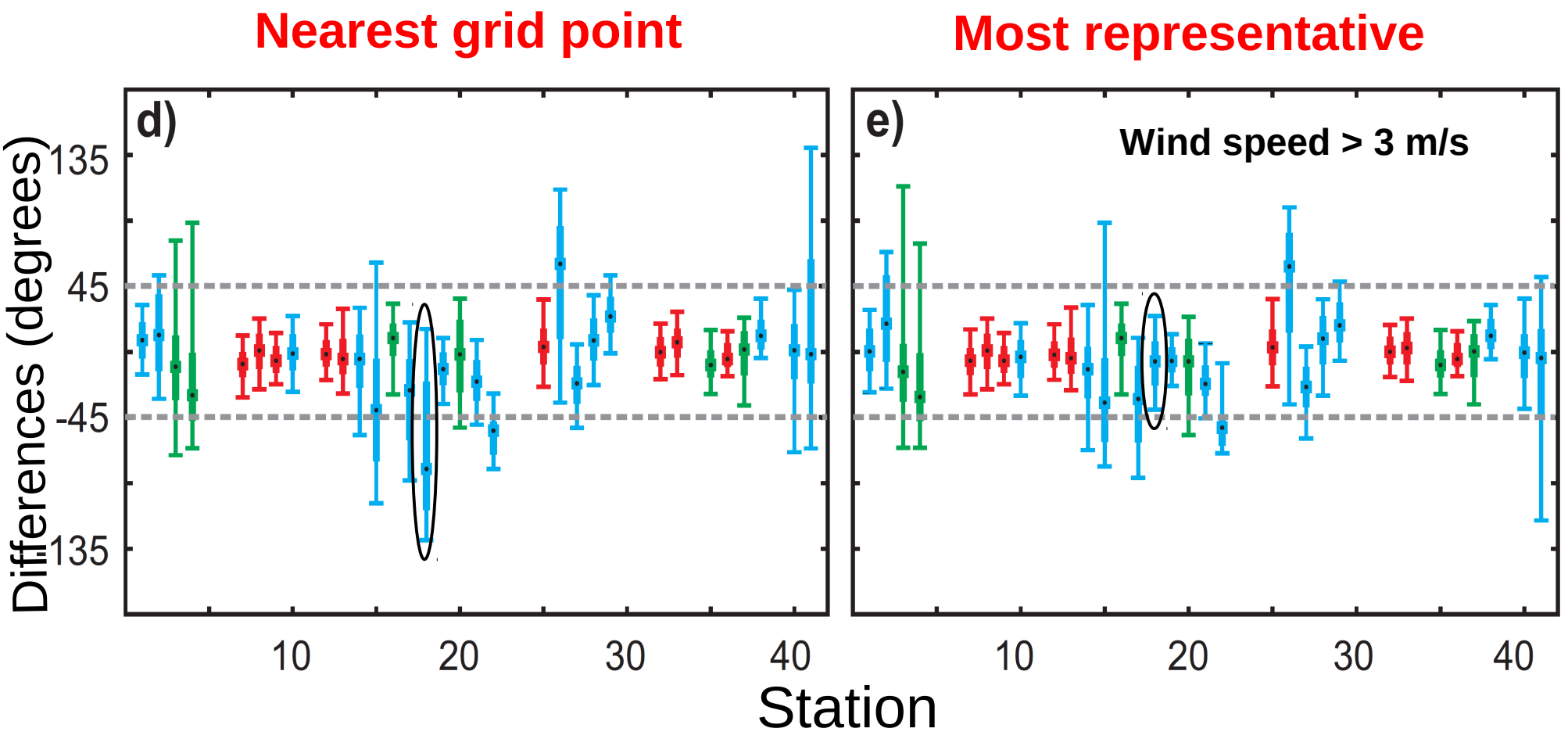
Difference between the maximum and minimum RMSE calculated with the 9 nearest grid points





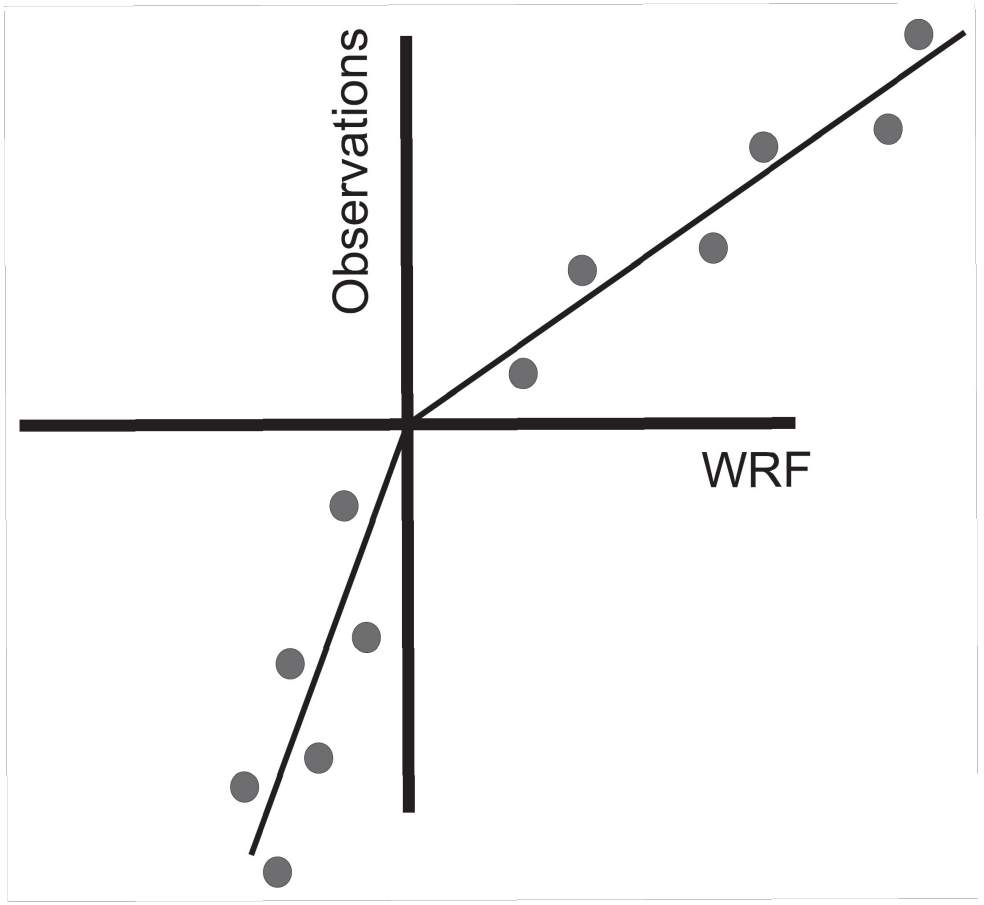


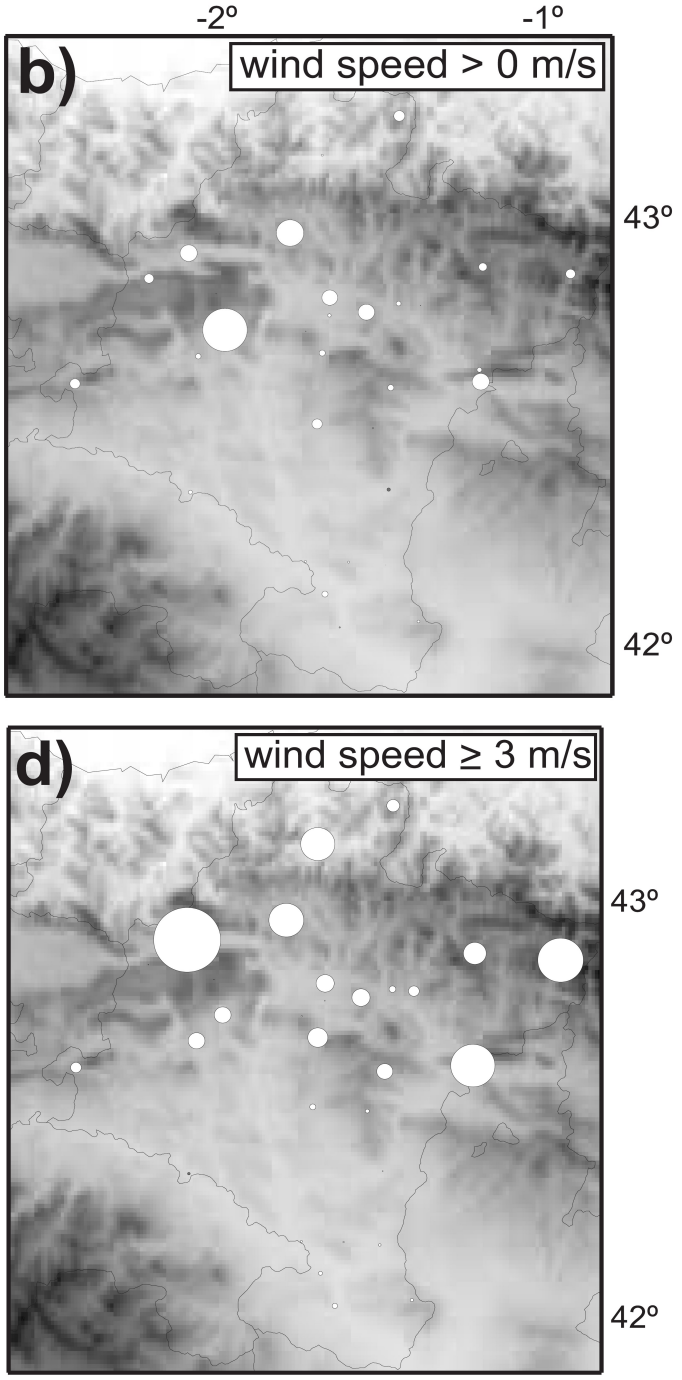
Distribution of the differences II



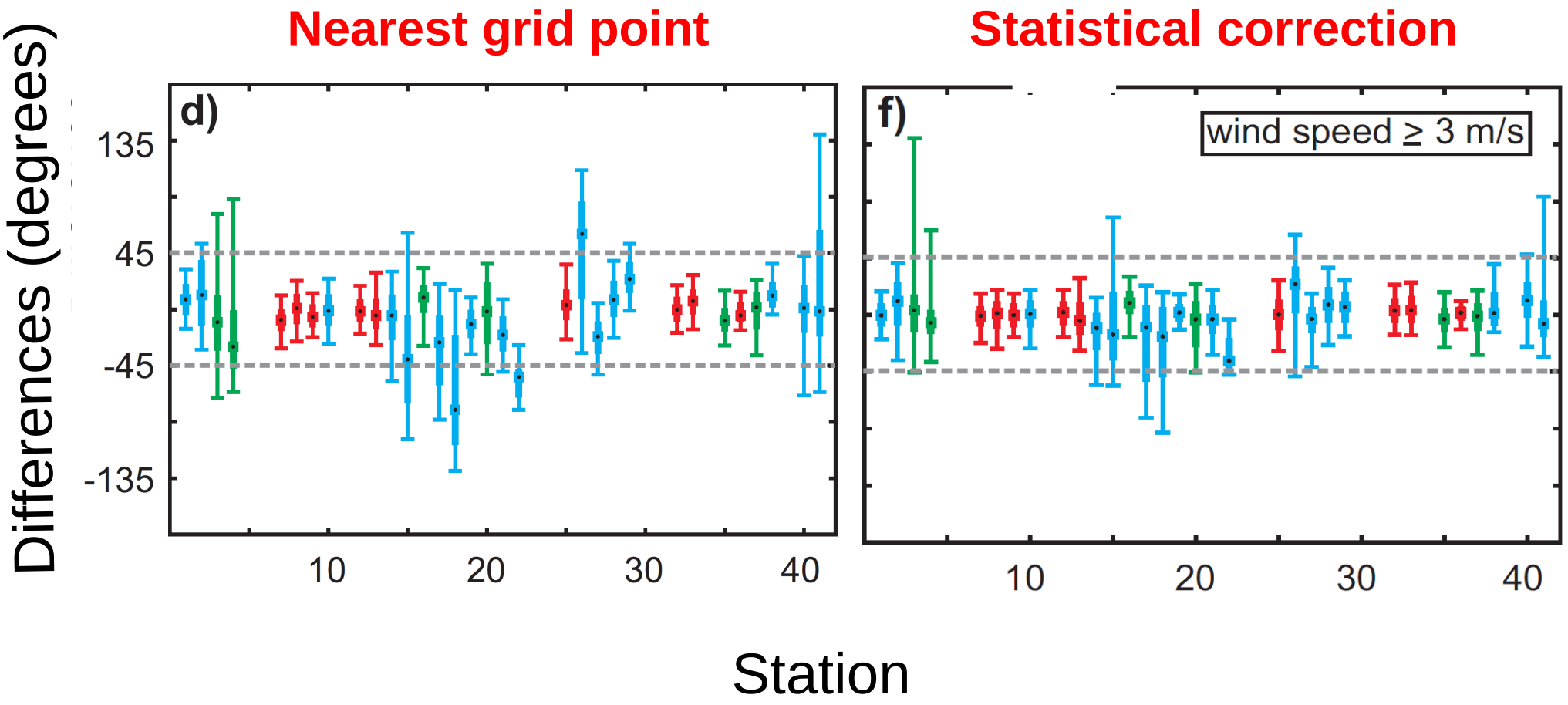
Statistical corrections

A statistical correction based on simple linear regressions is applied to the positive/negative wind components

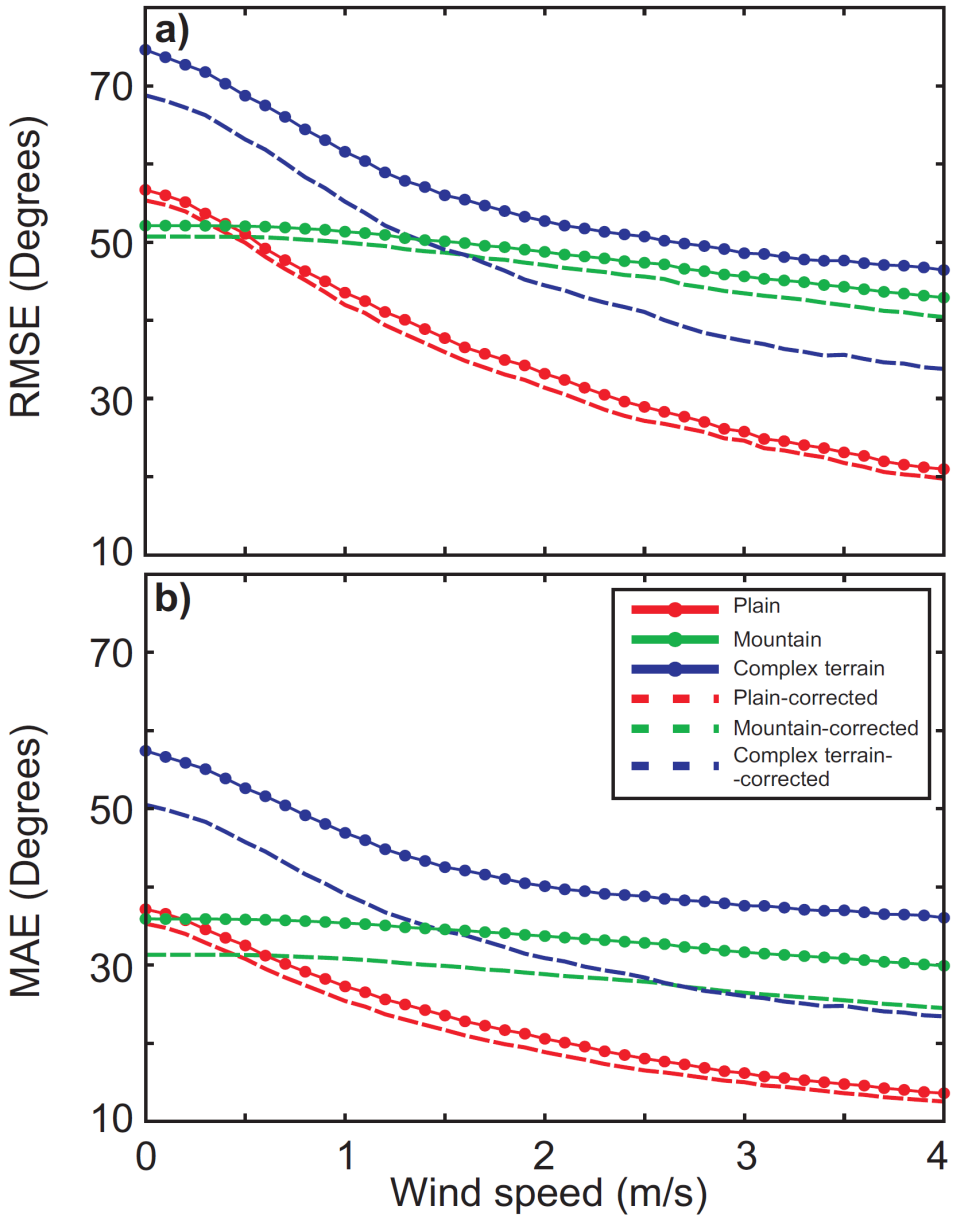




Distribution of the differences III



Direction errors VS wind speed II



Conclusions

1.- The reproducibility of the surface wind direction is a function of the wind speed.

2.- Areas of more complex terrain tend to show larger errors which can present a systematic behavior even at large wind speeds.

3.- The representativeness errors are more important over complex terrain.

4.- A statistical correction can be used to provide better estimations of the wind direction.

Workshop Land-Atsmophere Interactions

8-10 October 2012 Madrid

http://events.ciemat.es/web/egu

Madrid 2012

Land atmosphere interactions

1st Day: fundamental processes
- T. Foken
- C. van Heerwaarden
- E. Patton
- J. Vila-Guerau de Arellano

2nd Day: Modelling
- J. Dudhia
- P. Viterbo
- A. Martilli

3rd Day: Applications
- J. P. Montavez
- E. Davin
- J. F. Gonzalez-Rouco

Email: jimenez@ucar.edu