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

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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.
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What about the surface wind direction?
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2.- Experimental set up

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]

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

\[
MAE = \sqrt{\frac{\sum_{i=1}^{n} |\Delta d_i|}{n}}
\]
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The wind direction variability is a function of the wind speed.

Jofre and Laurila (1998)
Davies and Thomson (1999)
Mahrt (2011)
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

a) Wind speed > 0 m/s

b) Wind speed > 0 m/s

c) Wind speed > 3 m/s
Distribution of the differences II

Nearest grid point

Most representative

Wind speed > 3 m/s
Statistical corrections

A statistical correction based on simple linear regressions is applied to the positive/negative wind components.
Distribution of the differences III

Nearest grid point

Statistical correction

wind speed ≥ 3 m/s
Direction errors VS wind speed II

![Graph showing RMSE and MAE for different terrains and wind speeds.](image-url)
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.
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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

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