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Characterization of the Wind Power Resource in Europe and its Intermittency

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MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

ÉCOLE POLYTECHNIQUE ParisTech

EDF Fondation européenne pour les énergies de demain INSTITUT DE FRANCE

Pictures with the Courtesy of Vestas Wind Systems A/S

What are we going to talk about?

Step 1 - Meeting the Data;

Step 2 - Comparing and Contrasting with previous analysis: to which extent are our results valid?

Step 3 - A classic consideration : Capacity Factor;

Step 4 - One more exotic variable : introducing anticoncidence and its consequences;

Step 5 - Conclusion : some key points to keep in mind.

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Step 1 - Meeting the data

Modern-Era Retrospective Analysis for Research and Applications re-analysis data:

- Hourly data from 1979 to 2009:
- Spatial resolution of 1/2° by 2/3°;

Computations from the Boundary Layer Similarity Theory:

$$V_z = \left(\frac{u_*}{k}\right) log\left[\frac{(z-d)}{z_0}\right]$$

where u∗ stands for the friction velocity, d the displacement height and z_0 the roughness length.

$$P_z = \frac{1}{2}\rho V_z^3$$

where ρ stands for the air density.

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Step 2 - Comparing and Contrasting with previous analysis

Three major comparisons:

- Evaluation of global wind power by Archer and Jacobson (2005);
- Europe's onshore and offshore wind energy potential – An assessment of environmental and economic constraints by the European Environmental Agency (2009);
- European Wind Atlas developped by the Risø National Laboratory (1989).

Conclusions?

- Our results consistent with previous ones

  => our dataset is **reliable**!

- We have underlined some limits : NAO influence over year to be checked, **failure to capture high topographic variations influence** on wind power density profiles.

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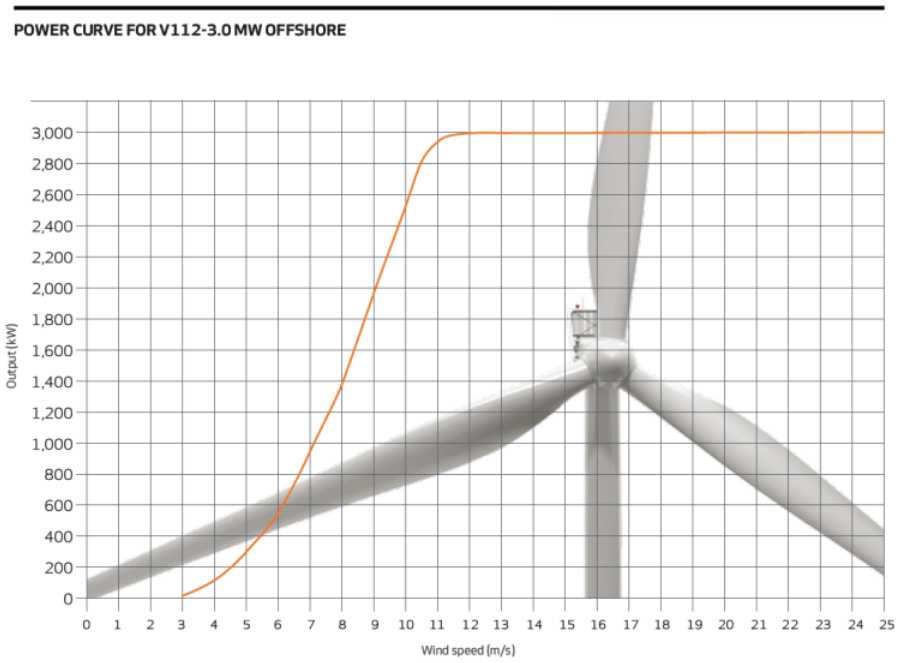
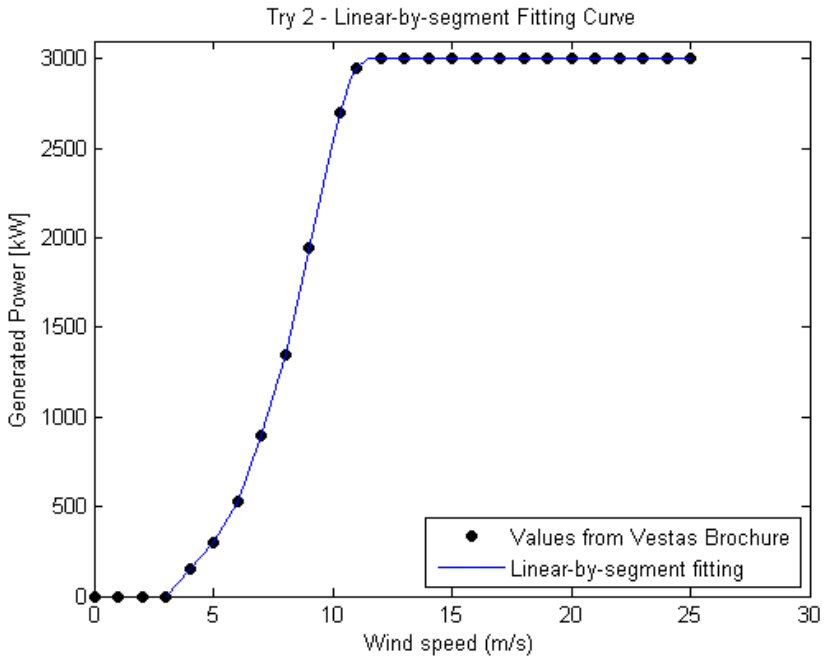
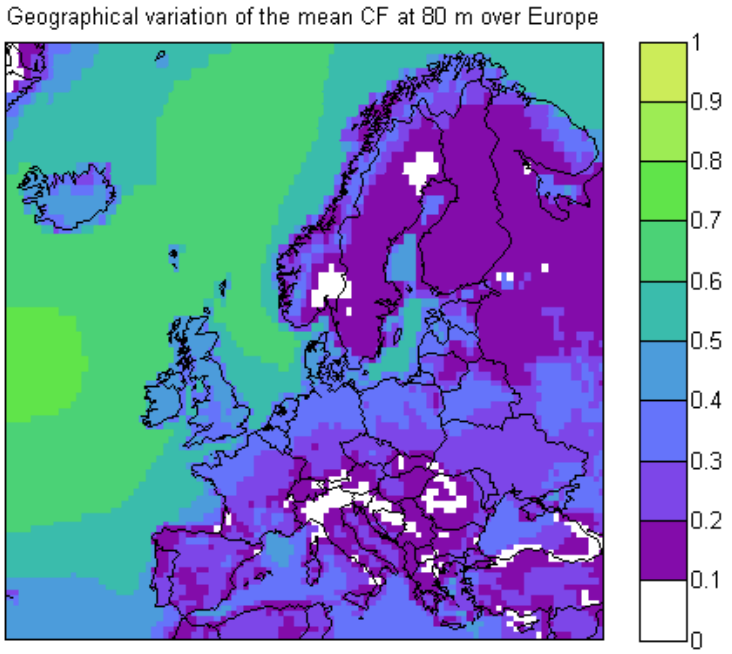
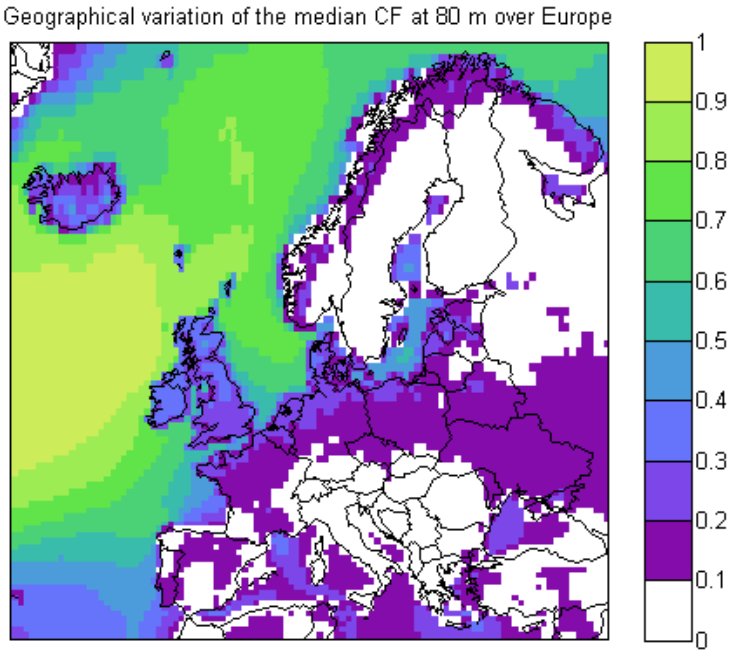
Step 3 - Some classic considerations : Capacity Factors Analysis (1/3)





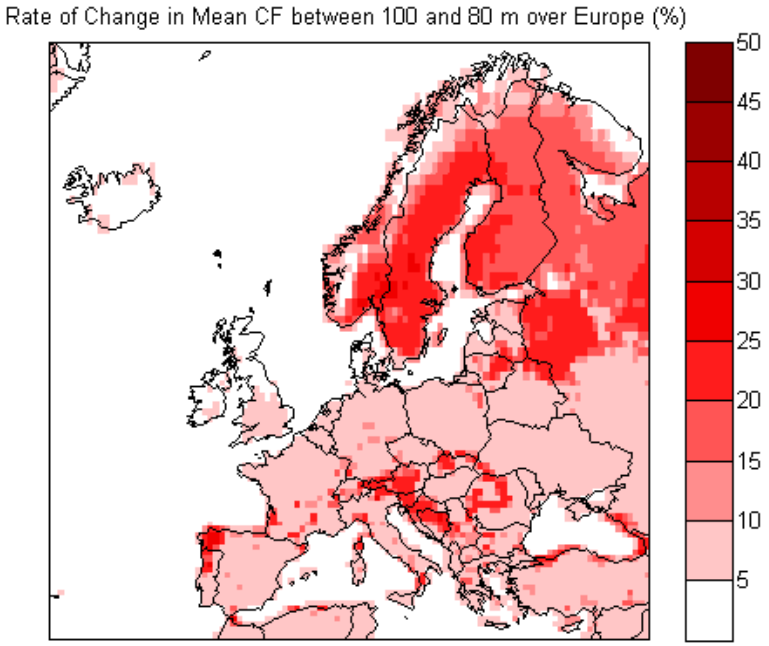
Step 3 - Some classic considerations : Capacity Factors Analysis (2/3)

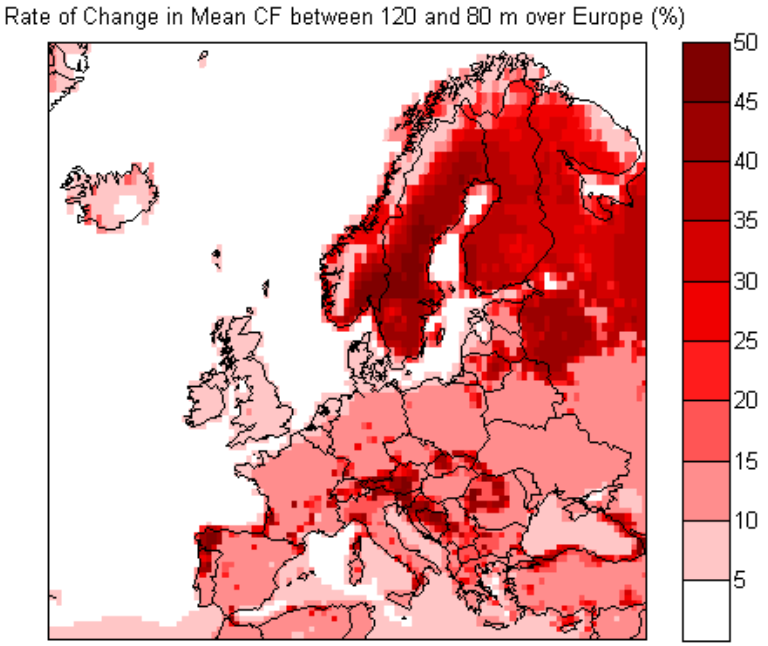




First step to assess wind power that could be really harvested.
Iceland, Ireland, United Kingdom and Denmark confirmed to be high wind potential areas.

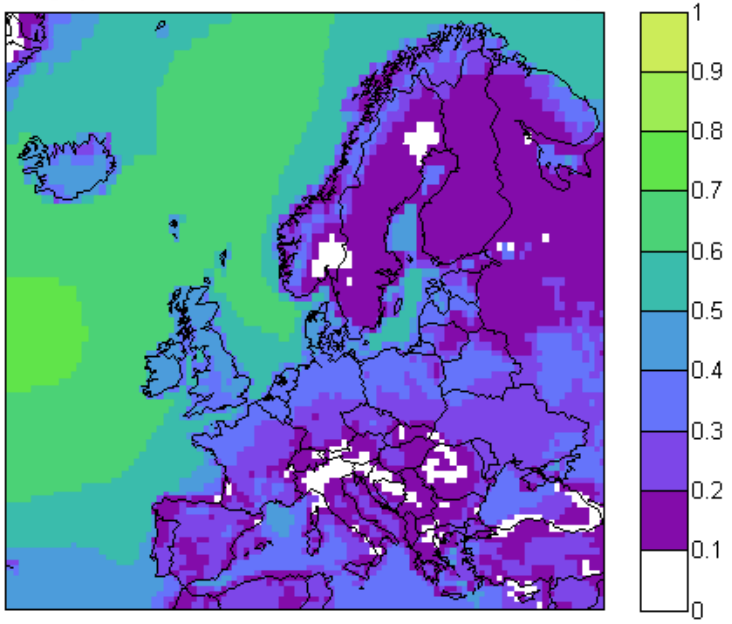
Step 3 - Some classic considerations : Capacity Factors Analysis (3/3)



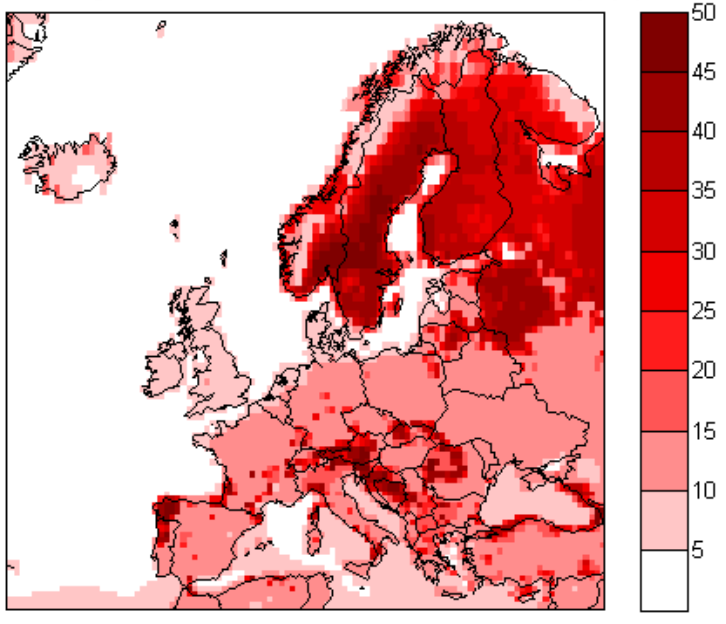


Step 3 - Some classic considerations : Capacity Factors Analysis (3/3)

Geographical variation of the mean CF at 80 m over Europe



Rate of Change in Mean CF between 120 and 80 m over Europe (%)



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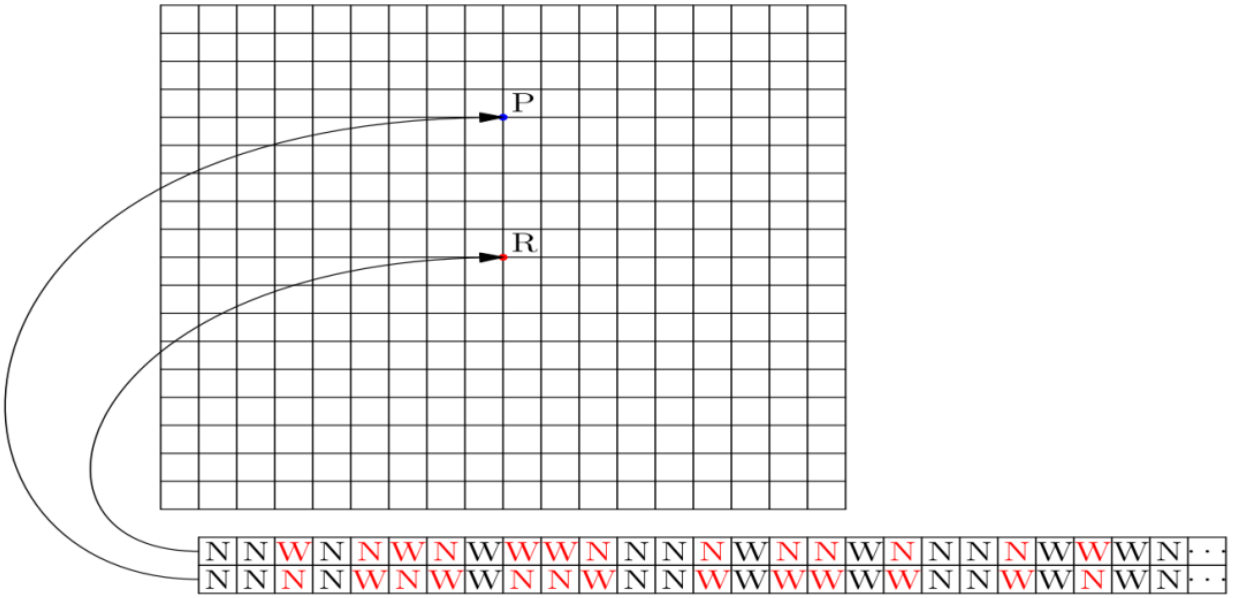
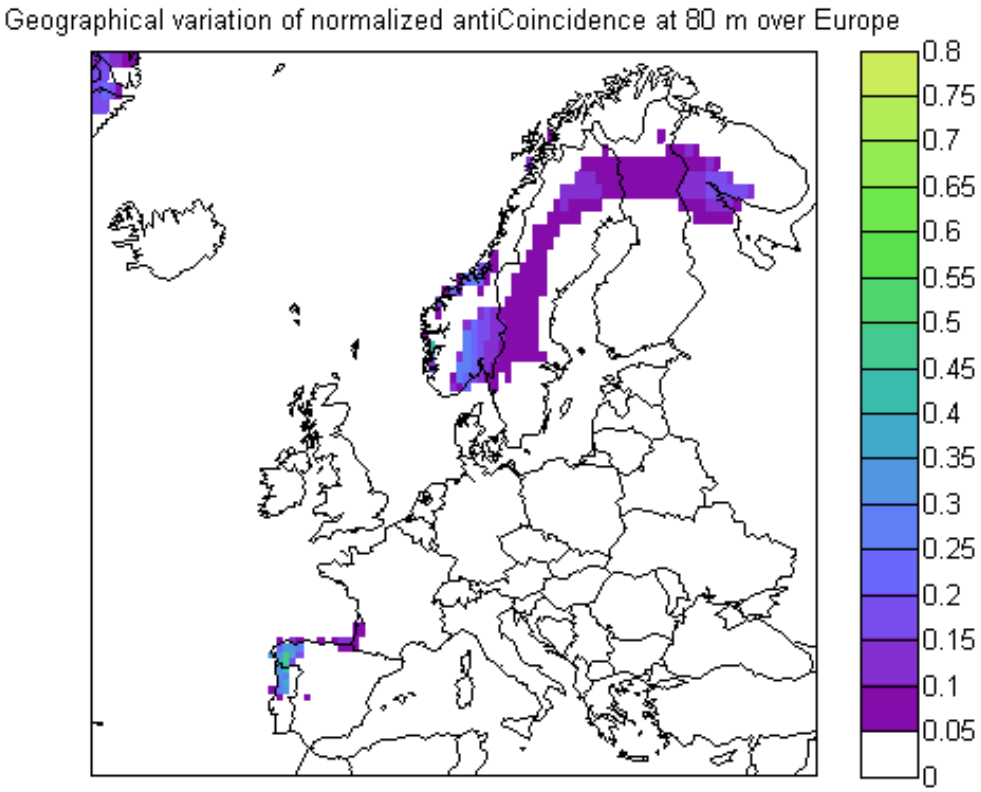
Step 4 - More exotic variables (1/2): introducing anticoncidence…

Instances when P and R have wind (ie WPD above 200 W.m^{-2}) but not at the same time are counted and if the count is at least 50% of the total length of the time series, the two points are said to be anti-coincident.



Step 4 - More exotic variables (2/2): … ans its consequences over Europe.



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Step 5 - Conclusion : Key points

- ✓ Further research needs to be done to confirm tendencies:
  - especially about anticoincidence (different-size boxes need to be experimented, for instance);
  - work with restrained territories as EEA did to be able to assess accurately actual wind power that could have been harvested in Europe;
  - etc.

- ✓ Nevertheless, correlation of wind episodes seems to be an major issue over Europe:

Step 5 - Conclusion : Key points

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  - especially about anticoincidence (different-size boxes need to be experimented, for instance);
  - work with restrained territories as EEA did to be able to assess accurately actual wind power that could have been harvested in Europe;
  - etc.

- ✓ Nevertheless, correlation of wind episodes seems to be an major issue over Europe:

- ✓ Are we heading towards this →

?

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Thank you for your attention.
Any questions?

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