Preliminary results of the COTUR project (COherence of TURbulence)

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Remote sensing of offshore wind turbulence for wind turbine design

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Mast 1

What is the coherence of turbulence?

The coherence tells about the spatial correlation of the eddies.

«The coherence can be thought as a correlation in the frequency space» [1]

It governs the wind load on a large structure

[1] Ropelewski, C. F., Tennekes, H., & Panofsky, H. A. (1973). Horizontal coherence of wind fluctuations. *Boundary-Layer Meteorology*, *5*(3), 353-363.



What is the coherence of turbulence?



Coherence estimation without masts but with lidars







Data availability from August to November



Case study: LOS scan on 25-10-2019



Case study: 25-10-2019



Range gate: r = 1975 m from each lidar

Case study: 25-10-2019



Range gate: r = 1975 m from each lidar

Misalignement issue with LidarS



LidarW = WLS40 LidarS = WLS34

LidarN = WLS37

Co-coherence estimates (LidarN and LidarW)



Co-coherence estimates (WLS37 and WLS40)

$$\gamma_{uu}(f,d_y) \approx \exp\left(-\frac{f}{\overline{u}}\sqrt{[C_xd_x]^2 + [C_yd_y]^2}\right)\cos\left(\frac{2\pi dx f}{\overline{u}}\right)$$



Dependency of the decay coefficients on the scanning distance

$$\gamma_{uu}(f, d_y) \approx \exp\left(-\frac{f}{\bar{u}}\sqrt{[C_x d_x]^2 + [C_y d_y]^2}\right)\cos\left(\frac{2\pi dx f}{\bar{u}}\right)$$



We can explore more than the coherence of turbulence

«Pseudo-profile» of mean wind speed



«Pseudo-profile» of Turbulence intensity (I_{v_r})



Conclusion

The COTUR campaign can provide valuable information on turbulence, at altitudes relevant to wind-turbine design. Such data are needed to overcome the first grand challenge in wind energy [2].

The coherence of turbulence, wind speed profiles, turbulence intensity profiles, and velocity spectra can be studied.

The influence of the coastline on the flow charateristics may not be negligible.

[2] Veers, Paul, et al. "Grand challenges in the science of wind energy." Science 366.6464 (2019): eaau2027.

Thank you

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