MEC583 - project A
Observed winds in the boundary layer

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Jordi Badosa, jordi.badosa@lmd.polytechnique.fr,
Filippo Agnelli, filippo.agnelli@polytechnique.edu,
Riwal Plougonven, riwal.plougonven@lmd.polytechnique.fr,
Ecole Polytechnique, Palaiseau.

The purpose of this project is to analyze the winds at low levels using observations from SIRTA (Site Instrumental de Recherche par Télédétection Atmosphérique) on the campus of Ecole Polytechnique. We are fortunate to have many observations (in situ measurements at two altitudes, remote sensing measurements with two instruments) with time series covering several years. For this specific site it will be possible to investigate some of the common assumptions made about the wind in the wind energy sector.

More specifically we suggest to address the following questions as starting points for your investigations:

1. how does the surface wind vary (wind at 10, 30 m)? In time (daily variations, seasonal variations)?

2. how does the surface wind decorrelate in time[1]? Are there preferred frequencies for its variations?

3. how does the wind vary with atlitude?

4. To what extent are the usual assumptions on vertical wind profiles justified (log profile, power law)? In individual profiles? In time-averaged profiles?

5. can you improve the vertical extrapolation of the wind by decomposing the dataset into different categories (daytime / nighttime, seasons, westerly wind, southerly wind...)?

6. The wind is often summarized by a Weibull distribution: how does that fit here? At different heights? In different seasons? Does it vary from year to year?

7. Instead of extrapolating individual profiles in the vertical, can you extrapolate the parameters of the Weibull distribution? How do you expect them to change? Is this consistent with the observations?

[1] In other words, if you know the wind at a given time t_0, how much does it tell you about the wind to come?

1 Suggested outlines

The purpose of the first sessions will be to establish **a climatology of the wind** near the surface from observations available from SIRTA. You will emphasize quantities that are most relevant for estimating the wind energy potential and pay particular attention to the assumptions frequently used in this framework.

Below we propose three directions in which the project can go. Depending on the level of detail and depth of the investigation, one, two or three directions can be explored. However, we recommend carrying out a detailled analysis for at least one direction (rather than a superficial examination of the three).

1.1 Vertical extrapolation

The wind is presented, in wind energy textbooks, as varying in the vertical with a log profile or as a power law. In both cases, there is one constant to determine, then an amplitude which varies with time. Knowledge of the wind at a low level supposedly allows to extrapolate the value of wind at a typical height of wind turbines. Below are several suggested steps:

1. for individual profiles, set up the calculation which obtains the best fit with either the log profile or the power law.

2. how much do the *constants* vary in time? Is there any systematic variation (season, day/night, orientation)?

3. carry out the extrapolation for a subset of the observations, having determined from the rest of the observations what the *constant* (e.g. roughness length) should be. How large are the errors? How do they compare between the different methods?

4. If instead of considering instantaneous profiles you consider time averaged profiles (e.g. over 6 hours), are the results improved?

1.2 Variability in time

The **variability of the wind at different timescales** can be explored in the data sets from the different instruments:

1. the diurnal cycle and its variation with altitude;

2. the annual cycle.

1.3 Statistical characterization

The wind distribution is often summarized by a Weibull distribution. Explore whether this is justified.

1. set up a procedure to identify the best fit to a Weibull distribution for a given subset of measurements of wind.

2. evaluate the Weibull distributions describing the wind in different subsets of the observations: at different heights, in different seasons, at night or during the day...

3. a path that can be explored for vertical extrapolation consists in extrapolating the parameters of the Weibull distribution instead of the wind in individual profiles.