PO.221

Generation and Validation of Spatial Distribution of Hourly Wind Speed Time-Series

Fabio Veronesi & Stefano Grassi
ETH Zurich – Chair of Geoinformation Engineering
www.gis.ethz.ch

geoinformation engineering
ikg eth zurich

Abstract

Wind resource assessment is crucial for wind farms' planning, and it is generally performed with numerical wind flow models. These may be very accurate, but also extremely time-consuming and computationally expensive. For this reason recent research has been dedicated to the use of statistical techniques for wind mapping. In contrast to numerical wind flow models, **statistical wind resource assessment** is computationally fast and efficient, meaning that it can be employed to increase the spatial resolution of current wind atlases.

In this research we present a statistical wind resource assessment approach, based on machine learning, to accurately estimate the spatio-temporal pattern of the wind resource. Moreover, statistical methods are perfectly able to assess the local accuracy of the wind map, meaning that for each location we provide a detailed spatio-temporal uncertainty estimation.

Methods

We collected 10 min average wind speed data over 5 years from 161 stations of the network of the Federal Office of Meteorology and Climatology of Switzerland. The wind speed measurements were correlated with around 8'000 predictors, consisting of environmental and climate data, with different time and spatial resolutions, covering Switzerland [1].

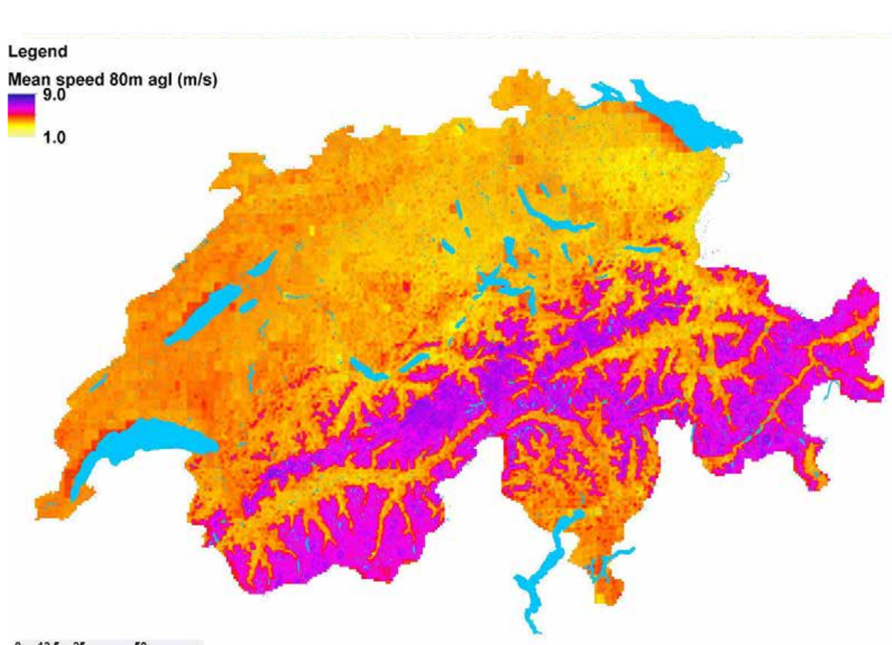
This research employed the wind resource assessment method, based on machine learning, developed by Veronesi et al. [2]. This method was developed with a case study in the UK, obtaining an **accuracy of 0.7 m/s** (RMSE), comparable with the model in use by the MET Office. It is extremely flexible and can be used to estimate both the long-term pattern of the wind resource, or its time variability.

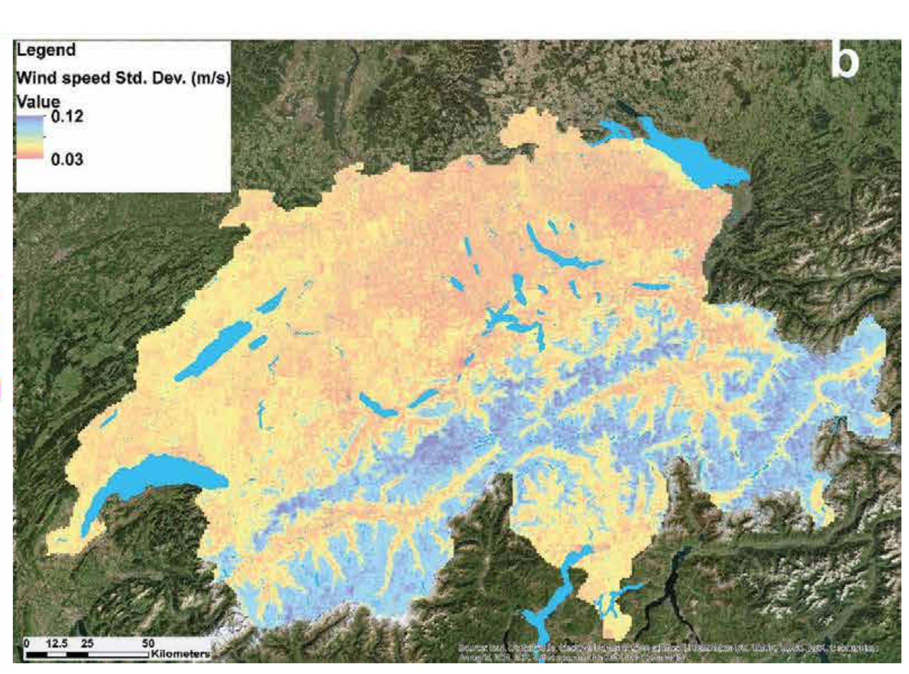
Here we present the results we obtained in applying this statistical wind resource assessment to Switzerland.

Long-Term Wind Pattern

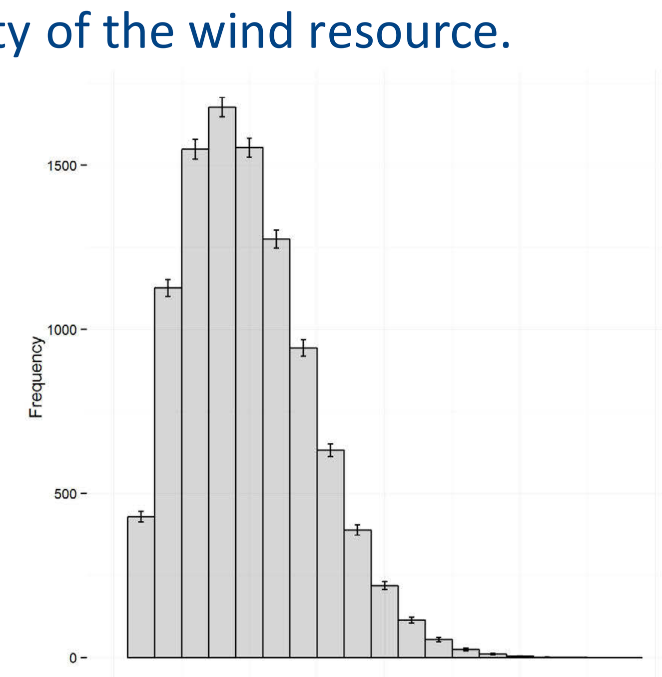
Using the Weibull parameters calculated from the weather data, and correlating them with several thousand environmental predictors, we were able to generate the map presented below. These represent the long-term wind speed pattern at 1 km of resolution (RMSE: 0.8 m/s).

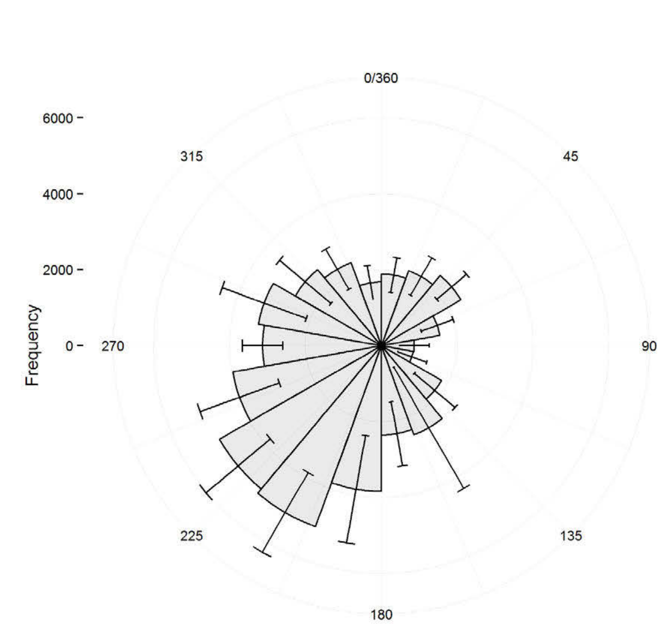
Figure b represents the standard deviation of the wind resource, which is proportional to the uncertainty of the map in each location.





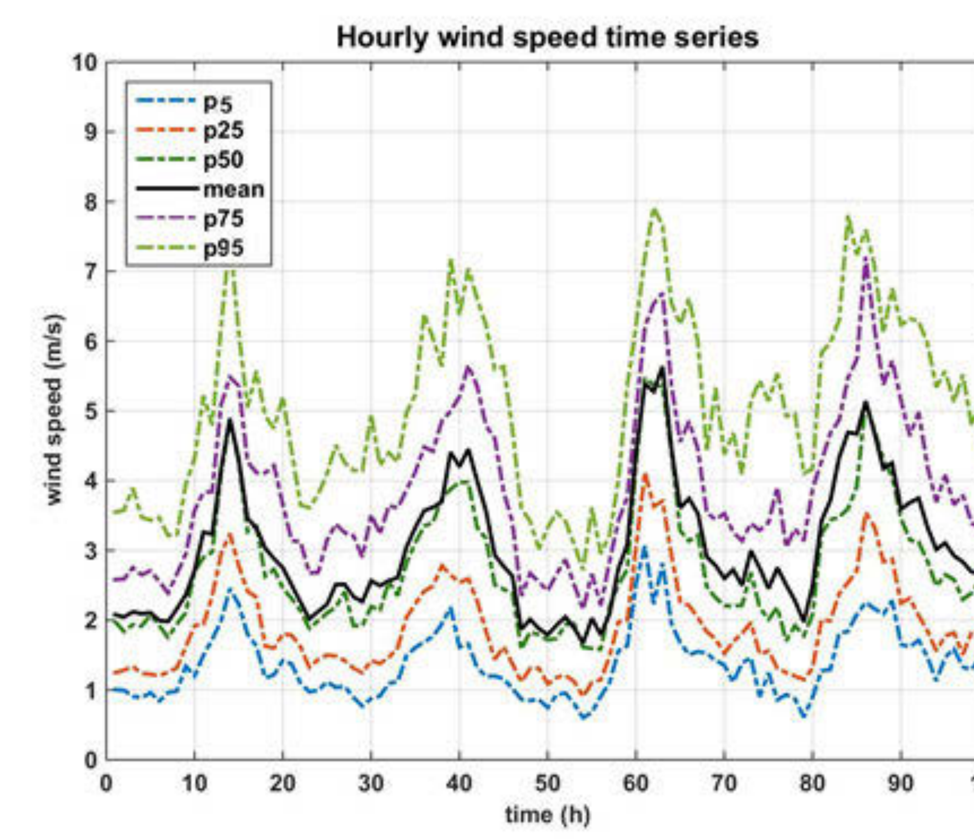
For each 1 km cell we are able to provide practitioners with the distribution of wind speed and direction, each with error bars to assess the long-term variability of the wind resource.



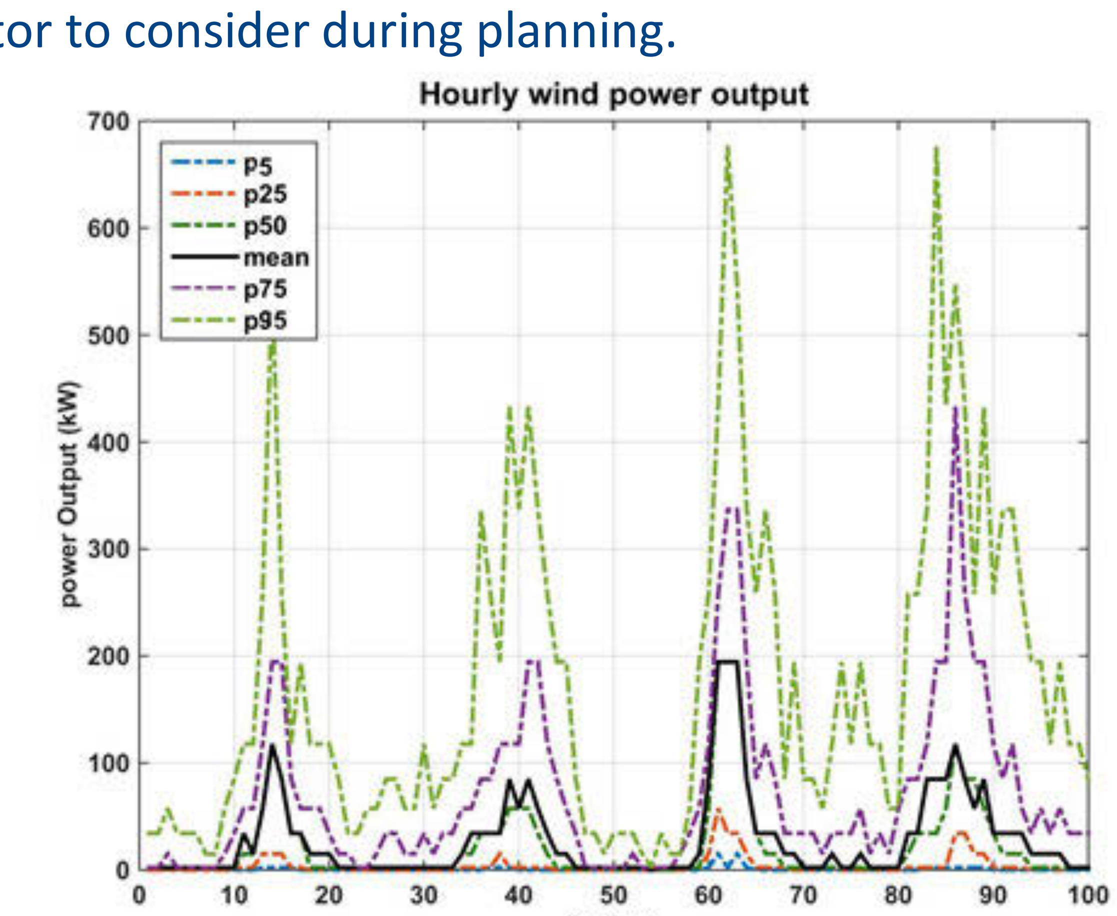


Hourly Time-Series

For this experiment, we used the weather data over the entire 5 years period to estimate the hourly variability of the wind speed. The innovative aspect of statistical wind resource assessment, compared with numerical weather predictions, is that it can assess its own accuracy. For time-series analysis this means that this method is not only able to provide the average speed for each hour, but also accurate confidence intervals. These allow the precise estimation of the wind variability on an hourly bases, for each 1 km cell we estimated in the log-term experiment. Thus, time-series like the excerpt below are available for the entire Switzerland.



To demonstrate the effect of the wind variability on the electricity production we estimated the energy output on a single 2.3 MW turbine. From the image below is clear that even in hours of high average speed, its variability is an important factor to consider during planning.



Conclusions

This research is an example of the use of statistical algorithms for estimating the wind resource, including a detailed uncertainty assessment. Estimating the wind resource at high spatio-temporal resolution using statistical methods is certainly much faster than with traditional methods based on numerical weather predictions, and this makes this method useful for the industry. In fact, being able to provide practitioners with hourly confidence intervals at high spatial resolution can be advantageous not only for planning but also for wind farms operations.

References

1. Veronesi, Fabio, Grassi Stefano, and Raubal. Martin. 2015. "Satellite data to improve the accuracy of statistical models for wind resource assessment." in EWEA. Paris.
2. Veronesi, F., S. Grassi, and M. Raubal. 2016. "Statistical learning approach for wind resource assessment." Renewable & Sustainable Energy Reviews 56:836-50.

Contacts

Fabio Veronesi
f.veronesi@gmail.com
www.fabioveronesi.net