Temporally resolved wind field downscaling over complex terrain using machine learning: The Swiss Alps and their potential for wind energy as case study

After the Fukushima disaster in 2011 Switzerland initiated an ambitious plan for phasing out of its nuclear power program. This plan aims at replacing the 40% of domestic electricity production provided by the rather centralized nuclear fleet with a more distributed renewable electricity generation. Certainly, photovoltaic panels will ensure a big part of it but wind energy has specific advantages that should also be exploited. Most of the wind energy potential is located in the Swiss Alps, which offer higher average wind speeds because of higher elevation as well as more site-specific enhanced wind speeds induced by local climates and orographic effects.

To install a distributed fleet of wind turbines in the mountains we must first identify the locations that hold a high potential. On one hand, measurement stations offer a reliable but sparse source of information. Standard interpolation techniques fail to capture correctly what happens in between those stations because of the high heterogeneity of the terrain and induced variations of the climate variables. On the other hand, Numerical Weather Prediction (NWP) models offer long time series of spatially distributed data. Those wind fields are however averages over the resolution of the model grid, which is always too coarse to capture local phenomena.

We are taking advantage of the strengths of both measurement data and model output by merging them in a new statistical downscaling scheme. We are currently developing a novel machine learning model that extracts the local wind patterns at 184 automatic measurement stations located in the Swiss Alps, given the local topography and larger scale wind patterns provided by the 1-km resolution Cosmo-1 NWP model. After the model has learned the relevant relationships between topography, mesoscale climate and local climate, it can predict the wind speed at any point with a better accuracy than standard interpolation techniques. High-resolution wind field time series can then be generated and used to optimize wind energy scenarios.

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Refreshments and Meet the Speaker at 3:00pm