Meteorological icing condition detection with ceilometer

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In cold climates, wind turbine icing is a severe safety risk at wind farms due to the possibility of ice throw. Wind power production losses due to the wind turbine icing are costly for wind farms, as the ice gathered on the wind turbine blades decreases the power output of the turbines. Therefore, it would be crucial to identify meteorological icing conditions in real-time to help wind power operators with their decision-making. Wind turbine icing usually occur during in-cloud situations and precipitation events.

Ceilometers are widely used in airport applications around the world to report cloud base heights. Here, the ceilometer backscatter information is used to identify meteorological conditions affecting wind turbine icing. We have analysed wind turbine SCADA data, meteorological mast data and ceilometer data during winter season 2016 – 2017 from a wind farm located in the Northeast US. Wind power produced by several wind turbines was analysed and icing situations were identified based on the difference between the theoretical power output and true power output from each turbine, and wind turbine icing faults. The results were compared to simultaneous ceilometer backscatter profiles, air temperature and wind data measured at the site.

The attenuated backscatter profiles reveal the cloud base height and give indication of precipitation events. Additional air temperature data helps to identify possible super-cooled liquid clouds and precipitation type. The backscatter profiles and additional temperature information at hub height give repeatable indicator of meteorological icing conditions when compared to the wind turbine data, however, future improvements are needed to understand the effect of precipitation events.