Validation of a LIDAR ice detection method

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Introduction

According to BTM, nearly 100 GW of wind power is currently installed in low temperature and icing climates making it one of the largest “non-standard” markets in the world today [1]. Ice accretion on wind turbines is a problem when operating in cold climates and icing conditions. Icing causes production losses and falling ice from turbines is a potential safety hazard. Ice detection is therefore an important aspect of cold climate wind. Ice detection is often done using sensors mounted on meteorological masts or wind turbines.

LIDAR is a remote sensing measurement device that uses laser to measure wind speed and wind direcation. The typical range of the land-based LIDARs used in wind energy is up to 300 meters above ground. Using LIDARs for wind speed measurement makes it possible to make wind speed measurements from multiple heights at the same time using one portable measurement device without necessarily requiring a mast.

Approach

VTT has developed a method to use a LIDAR as an ice detector. This method makes remote sensing of icing conditions possible by utilizing the existing and unmodified LIDAR hardware. Ice detection with LIDAR has the same benefits as wind speed measurement with LIDAR: portable device, remote sensing, multiple heights, no expensive construction required. The method produces an icing alarm from all (on typical device up to ten) different heights, making it possible to create an icing profile for the measurement site. [2] It has also the benefit of being used in an increasing number of wind resource assessment studies. And it is of great interest to be able to use the data from these sensors for a wider range of applications.

In this study the LIDAR-based ice detection method is compared to mast measurements on two different sites from Norway and Germany. The accuracy of the LIDAR-based approach is compared to measurements collected using ice sensors and webcam images from the sites. The validation is done by identifying the icing events based on the different measurement methods and seeing how well they correlate to each other.

Main body of abstract

The basic principle behind LIDAR-based ice detection is to use the LIDAR to detect the presence of clouds in the measurement area. Ice formation requires liquid water and sub-zero temperatures. Clouds contain some amount of super-cooled liquid water even when air temperature is below zero, when these water droplets hit a cold surface, ice is formed.

The goal of the LIDAR ice detection method is to detect these cloud water droplets. This is done by analyzing the strength of the signal reflected back from particles in the air. This backscatter signal is stronger if the target it is reflected from is denser. A stronger backscatter signal is therefore an indicator of cloud at that height. This information is further combined with temperature measurements to create icing alarms.

Data is collected from two locations, one in Norway, one in Germany during multiple winters. The Norwegian site is a rather severe icing site, while icing at the German site is from light to moderate in terms of severity.

The icing output of LIDAR based method is compared to output of conventional icing sensors using statistical methods to determine the accuracy of the LIDAR-based method.

Conclusion

The icing events observed by the ice detector are registered by the LIDAR is detector algorithm as well. There are, however, events that are visible in the LIDAR data but not in the ice sensor. The LIDAR based method also suffers from data availability issues; there are gaps in the LIDAR data. There are differences in timing as well: starting and ending times of the events are not detected identically by the different methods. However in general, the LIDAR based method is able to detect meteorological icing and thus can be used for example in the resource assessment phase of a potential site to evaluate the icing risks. There is also a potential to use the Lidar based ice detection methodology in the operational phase for turbine control eg preventive shutdown to mitigate ice risks or controlling active blade de- or anti-icing systems.

Learning objectives

Important objectives here are the significance of the cold climate market and the issue of blade icing when operating in cold climates. Most important takeaway form this work is the possibility of using remote sensing equipment for ice detection in all stages of a wind power project, in assessment and during operation.

References:

[1] Navigant Research, "World Market Update 2012," Navigant Research, ISBN: 978-87-994438-4-0, Copenhagen, Denmark, 2013

[2] Antikainen, P. and Vignaroli, A. and Peltola, E. Arrangement and method for icing detection, 2015, EP2726851