Sagsnr. 6154-00018B

EROSION

D1.1 Disdrometers in EROSION

Deliverable: D1.1 (Public)

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Publication: September, 2017

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Forsidefoto: Disdrometer Parsivel2from OTT
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Rekvireres: www.vindenergi.dtu.dk

Preface

This report describes the disdrometers in the EROSION project.

The project is funded by Innovation Fund Denmark and project partners. The project period is from April 1st, 2017 to March 31st, 2020 (3 years).

The aim of the project **EROSION – Wind turbine blade erosion: Reducing the largest uncertainties** is to create knowledge and methods to avoid blade erosion caused by rain and hail. The hypothesis is that by reducing the tip speed of the blades, during severe, but short, events of rain and hail causing severe blade erosion, a significant extension of blade lifetime can be obtained with reduced maintenance cost and negligible loss of production.

The key objective of EROSION is to enable longer lifetime of wind turbine blades at multi-MW machines. To achieve the objective the project work will include testing of specimen in the rain erosion tester and investigation and analysis of damage on leading edges of blades. Furthermore, the rain in real atmosphere will be investigated from ground-based instruments (disdrometers) and modelling of rain based on rain radar data. Finally a new prototype instrument will be developed in order to measure rain at wind turbines for making decision on control, to set 'erosion safe mode' with regulation of turbines. Much longer lifetime of wind turbine blades and reduced operation and maintenance costs are expected.

Project web-site is http://www.rain-erosion.dk/

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Executive summary

The disdrometers in the EROSION project will be used to measure rain drop size distribution and fall velocity at selected sites in Denmark and abroad. The measurements will be done with Parsivel2 instruments and the campaign is expected to last minimum one year.

1 Introduction

1.1 Why measure rain drop size distribution and fall velocity?

In the EROSION project the research hypothesis is that large rain drops cause significant erosion at the leading edges of wind turbine blades. The research hypothesis is sketched in Figure 1.

Figure 1. Sketch of the research hypothesis in the EROSION project.

In literature some documentation on the analysis of disdrometer data exists. These include New Jersey, USA with thunderstorms (Smith et al., 2009) and Malaysia with tropical rain and monsoon (Hong et al., 2015). Disdrometer data from Australia, Europe, Asia and America are analyzed and enable to distinguish between convective 'maritime' and convective 'continental' raindrop size distributions with the first being characterized by a smaller concentration of larger-sized drops as compared to the latter (Bringi et al., 2003).

Data on rain drop size distribution and fall velocity are not readily available at locations of interest in Denmark, at offshore wind farms and wind farms abroad. Thus in the EROSION project a measurement campaign involving several disdrometers are initiated, in order to collect data at relevant sites.

1.2 Selection of instrument

Based on experience by the Danish Meteorological Institute (DMI) a suitable instrument is the Parsivel^2 from OTT. Product details are available at http://www.ott.com/en-us/products/meteorological-sensors-26/ott-parsivel2-laser-weather-sensor-1536/ (OTT Parsivel² - Laser Weather Sensor).

1.3 Selection of locations

There were several aspects to consider for the selection of sites for the disdrometers in the EROSION project. The main aspects considered were 1) other available precipitation data, 2) representing various climate conditions in Denmark, 3) representing a suitable location for comparison to DMI radar stations, and 4) representing wind farms. Table 1 lists the selected sites and Figure 2 shows a map.

Table 1. Selected sites for disdrometers.

Location	**Operator**	**Specific aspects**
Voulund	DMI	Comprehensive precipitation measurement site
Thyborøn	DMI	Coastal site
Hvide Sande	DMI	Coastal site
DTU Risø Campus 1	DTU	Concurrent WindScanner lidar
DTU Risø Campus 2	DTU	Concurrent WindScanner lidar plus flexible locations
Horns Rev 3 platform	DTU/Vattenfall	Offshore wind farm
To be decided	DTU/E.ON	Offshore wind farms?

The two DMI weather stations along the west coast of Jutland, Thyborøn and Hvide Sande, offer meteorological data for validation of the disdrometer measurements, such as observations of weather type and precipitation.

Even though the Voulund site is placed in the heart of Jutland far from offshore environment, it offers good opportunities for various disdrometer experiments. Voulund is an experimental field with a variety of meteorological measurements, e.g. high resolution data from a Thiess disdrometer and meteorological data collected over a long time period. The Voulund site is a hydrological test field owned by the hydrological research project HOBE, a hydrological observatory and exploratorium run by national universities and DMI.

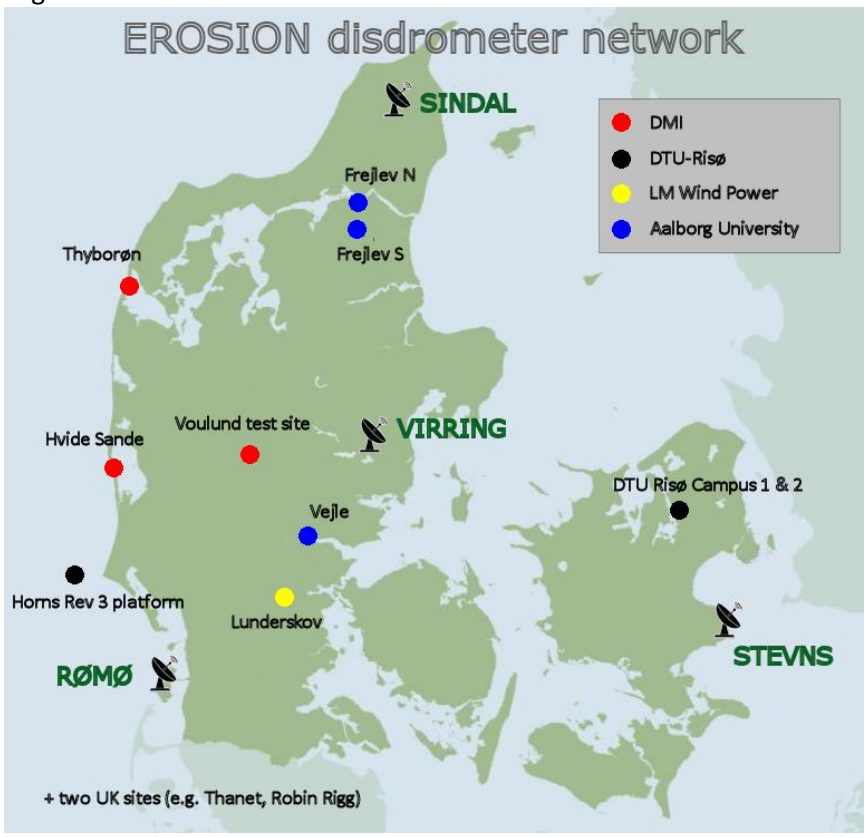

Figure 2. MAP of disdrometer locations. It is possible to get access to data from three disdrometer stations owned by Aalborg University. LM Wind Power has planned to install a disdrometer in Lunderskov. It is being investigated to locate two disdrometers at UK sites - Thanet and Robin Rigg platforms have been proposed.

2. Expectation for the disdrometer data

2.1 Campaign

The data collection is due to commence October 2017 and to last one year minimum with possible extension beyond this period. Thus one year of 1 minute samples are expected at each site. The data will be stored at DTU and DMI and shared between partners.

2.2 Analysis

The analysis of the collected disdrometer data will include quality control and regular checks on data streaming. A database will be established.

The data analysis of the collected disdrometer data will be on episodes, duration and rain intensity during time. The wind speed and wind direction at the same times will be investigated to understand how frequently heavy rain coincides with strong winds.

Furthermore disdrometer data collected in Denmark at earlier times with different types of disdrometers will be included in the analysis to estimate variability in the parameters for more than one year. Most notably is the disdrometer data collected by DMI at Voulund since year 2012.

Another part of analysis will relate the disdrometer data to other types of precipitation data collected in Denmark. This analysis will allow estimates of more than 10 years back in time.

Last but not least, disdrometer data will be used for comparison to the DMI rain radar observations. The radar data is important for spatial characterization of rain events and for forecasting.

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