Measuring Air Liquid Water Content by Shadowgraph Image Analysis for Wind Turbine Icing Detection

Presentation of a Project at Mid Sweden University

By Staffan Rydblom

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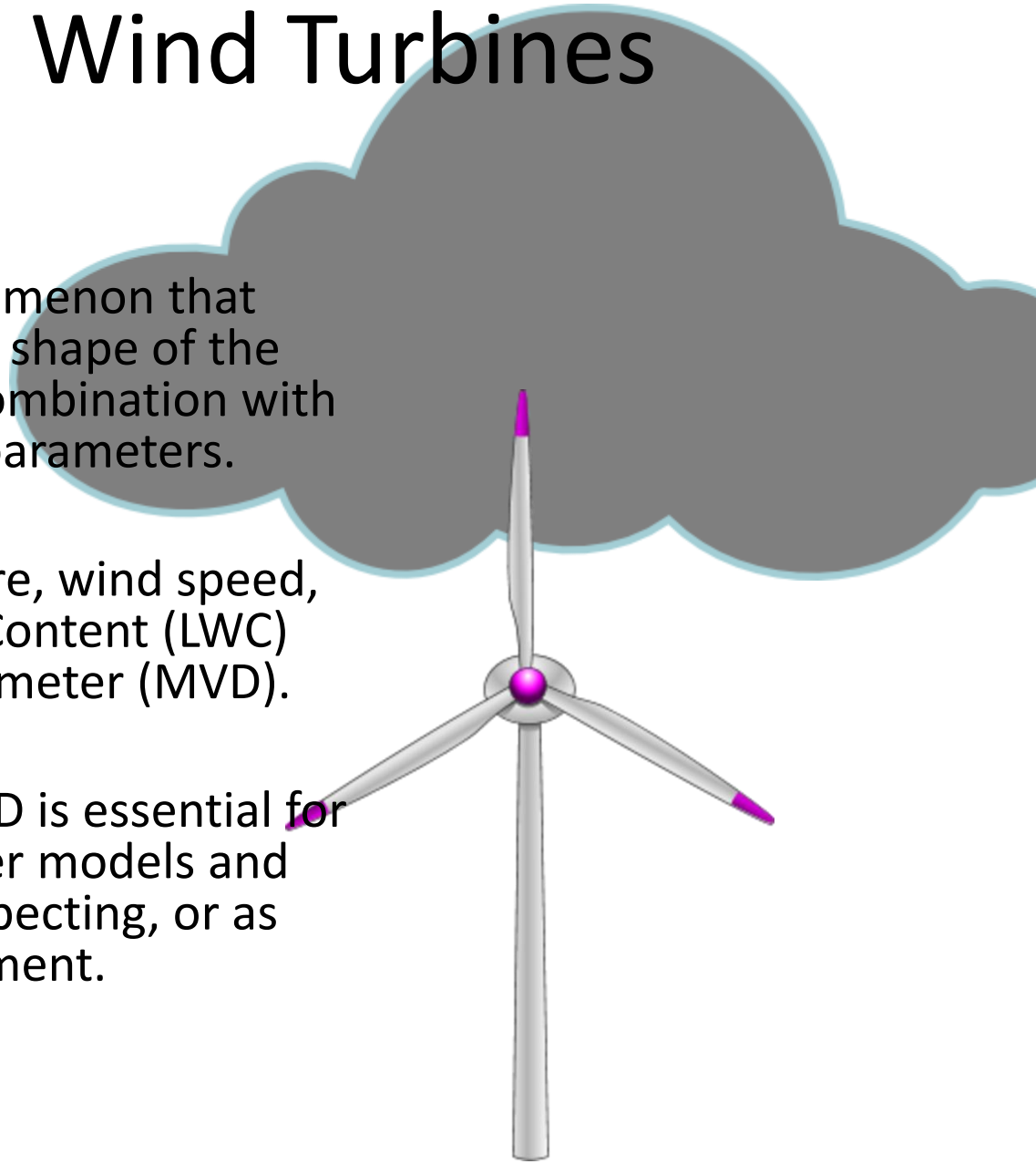
Icing or no Icing?

A new instrument is suggested to help predicting when icing will occur.

- Direct Methods – Measure Ice
- Indirect Methods – Measure Freezing Water

Icing on Wind Turbines

- Icing is a complex phenomenon that depends strongly on the shape of the structure, or airfoil, in combination with several meteorological parameters.
- Temperature, air pressure, wind speed, humidity, Liquid Water Content (LWC) and Median Volume Diameter (MVD).
- Measuring LWC and MVD is essential for creating input to weather models and wind farm location prospecting, or as input for de-icing equipment.



Indirect Measurement Method

- Our aim is to test the feasability of using modern imaging technique to measure both MVD and LWC during icing.
- Main interest is droplets with diameters between 10 µm and 30 µm.
- An instrument should measure near the highest point of the turbine.
- The instrument should be durable and cost efficient.
- Despite several techniques and instruments developed, there is still a need for an instrument that could meet the above criteria.

Droplet Sizing by Imaging Challenges

- Size range
- Concentration range
- Diffraction

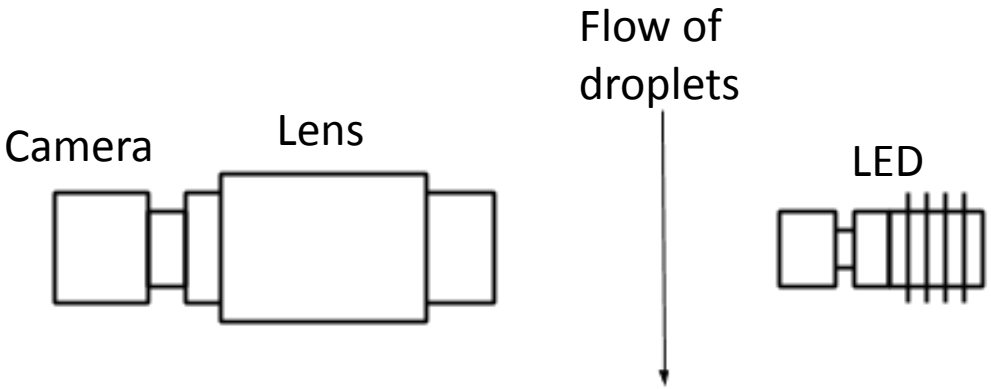
Pros

- Simple and robust hardware
- Relatively inexpensive
- LWC and MVD is measured simultaneously

Cons

- Concentration is sensitive to size measurement with a power to three
- The equipment needs to be where the measurement is – difficult environment
- Only very small volumes can be measured

Materials in our Pre-Study

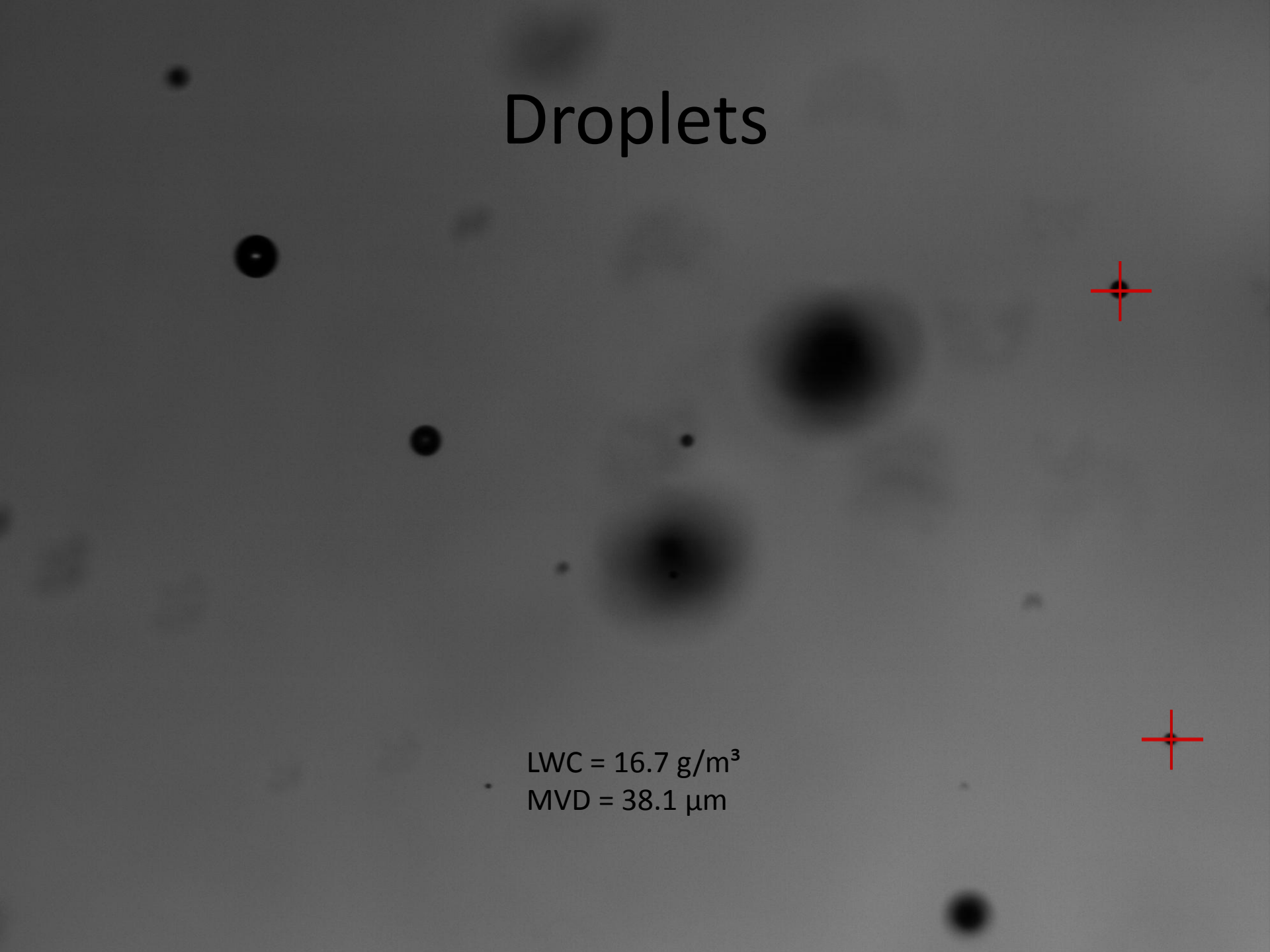


- 4MP CMOS camera with a telecentric 4x magnifying lens
- LED flash illumination with collimating optics
- PC with Matlab for image processing and analysis.

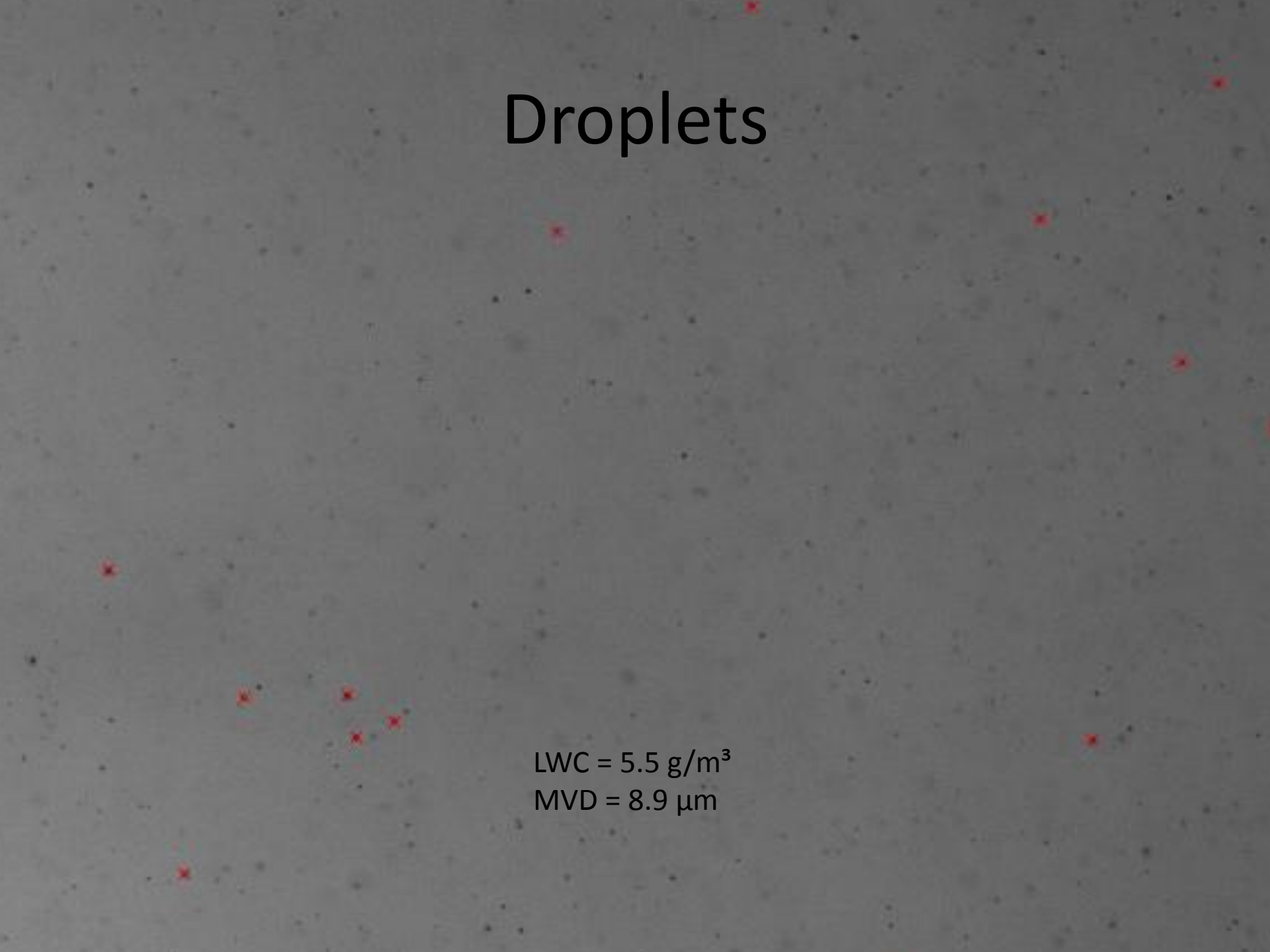
Early Results of our Pre-Study

- LWC and MVD can be derived directly from images of the water droplets using a shadowgraph system.
- The imaging system functionality is verified in laboratory conditions.

Droplets



Droplets



Coming Study

- Coming experiments will investigate the system applied first in a climate chamber and then real world winter condition.
- A reference instrument (e.g. the FM-120 from DMT) will be used for comparison.

Thank you!

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