Validation of pulsed Lidar as ice detector

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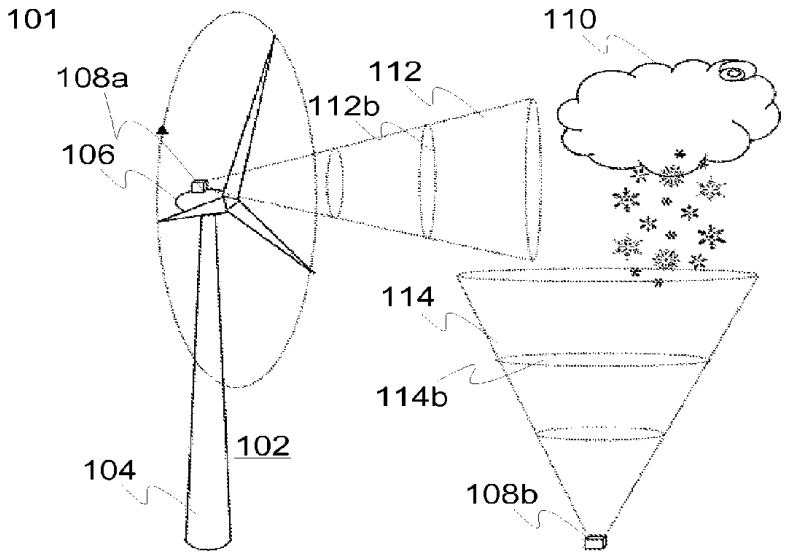
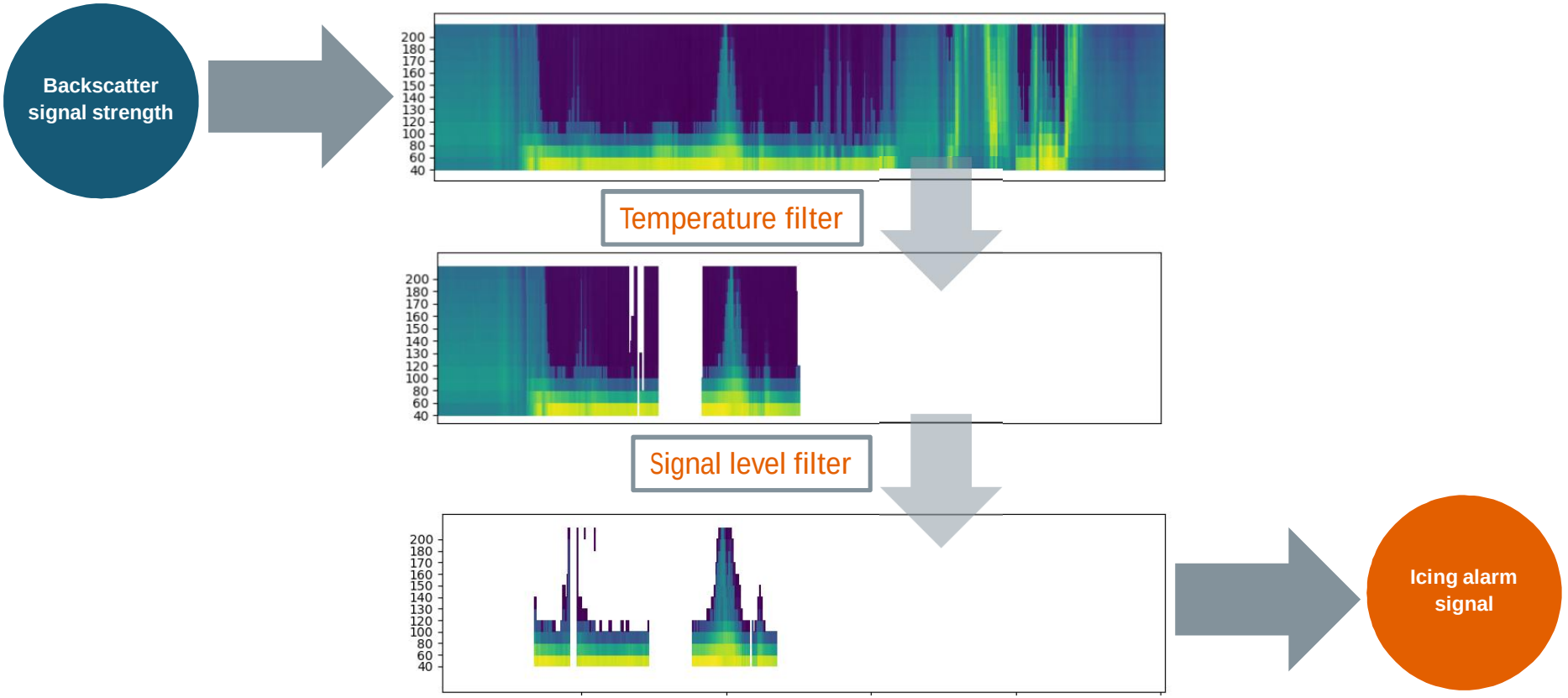
Contents

Lidar ice detection method

- Detect cloud cover from signal strength
- Use unmodified Lidar
- Tunable software solution
- Postprocessing of data or real time

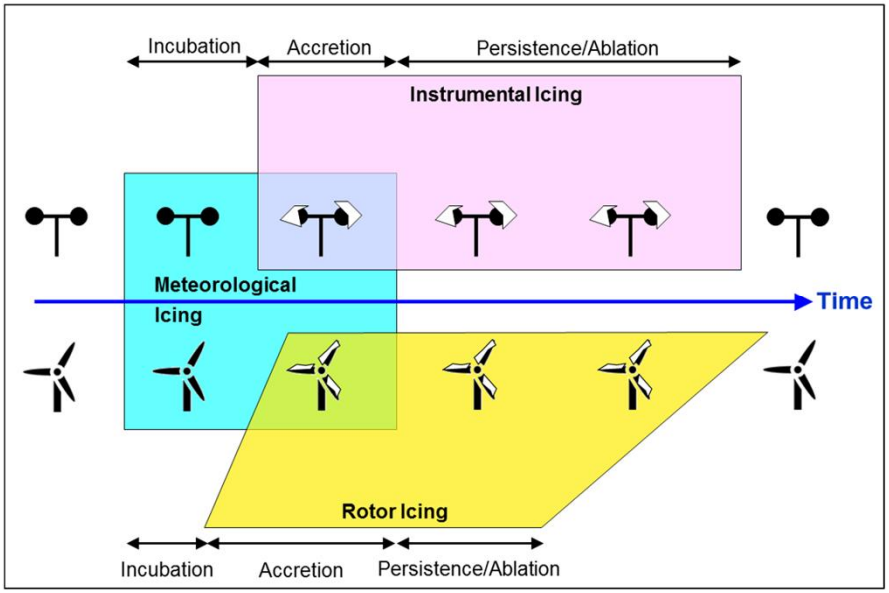


Ice detection method



Icing definitions*

- Lidar detects icing conditions i.e. meteorological icing
- Most sensors measure some variation of instrumental icing
- Need an apples-to-apples comparison

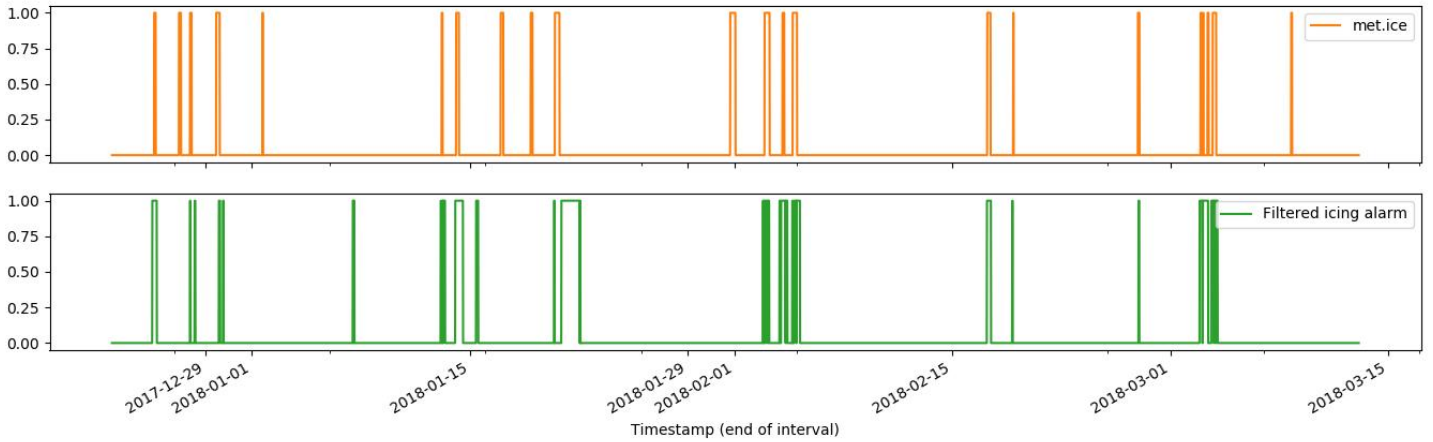


*Source: IEA Wind Task 19 Available Technologies report of Wind Energy in Cold Climates (2016 edition): http://www.ieawind.org/task_19.html

Experiment

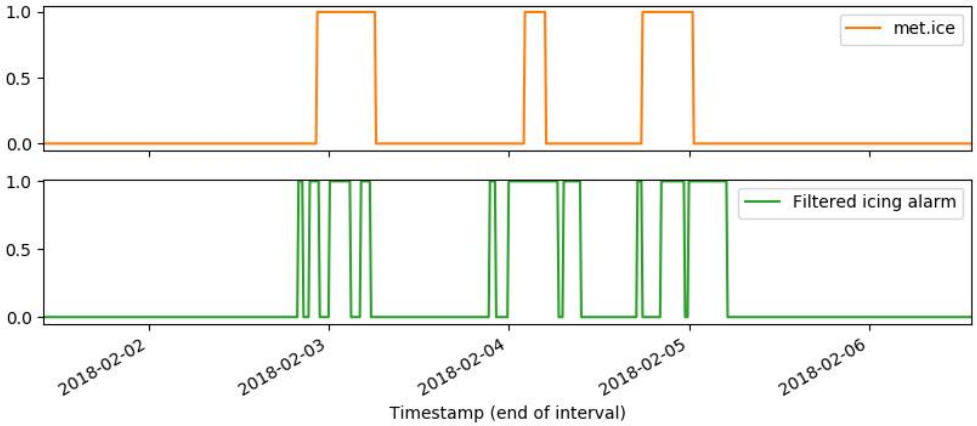
- Results calculated from the data provided by Verbund
- The reference used is the Webcam-based meteorological icing signal
  - Assumption is that it is the most reliable/most relevant reference available
- Use alarm and filtering settings for the LIDAR ice detector that are known to be somewhat good in the past.

Icing alarms from LIDAR vs reference



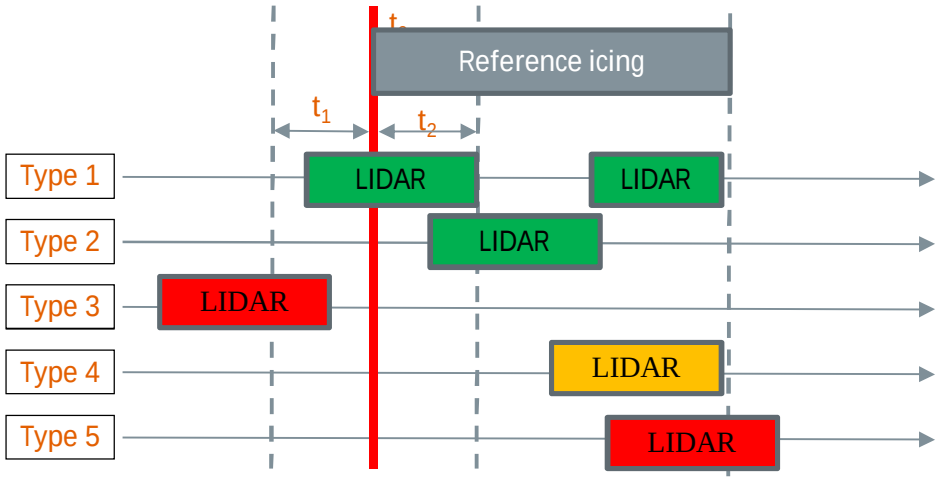
Example of icing alarm

- Timing is not excact between the methods
  - Reference (orange)
  - Lidar (green)
- Lidar-based alarms tend to trigger on and off during a reference icing event



Criteria for correct detection

§ Events marked as green on the Figure on right are considered correct
  - t1, incubation time
  - t2, delay
  - Event needs to start within t1 of the start of the reference event, but no later than after a delay of t2

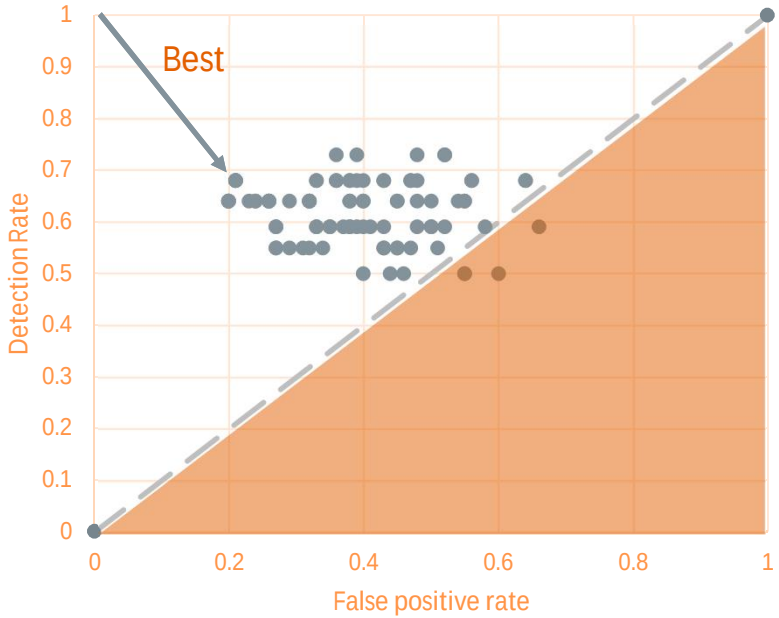


Detection accuracy

- Detection accuracy is combination of Correct detection rate and False positive rate
- Run multiple cases with different tuning parameters, lead times and delay times
- Count detection rate and false positive rate for each case

Detection accuracy

- Optimal case is closest to the top left corner
- Correct detection means that the start of an icing event detected correctly within the time limits specified
- False positive means that lidar gave an alarm that did not coincide with an alarm in the reference



Detection accuracy

Share of correctly detected events increases with incerese in lead time and delay.

Optimal case would be to maximise accuracy with minimal lead time and delay

Cases closest top top left corner:

Lead time	Detection delay	Detection rate	False positive rate	Timing error
3	3	68 %	21 %	16 %
3	3	64 %	19 %	9 %

Condition estimates

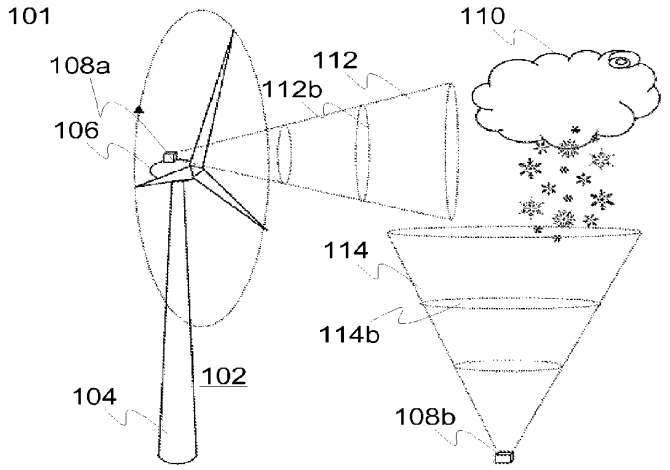
Icing time over the reference period was ~10 % higher when calculated from LIDAR.

- This would give a pretty similar view of the icing conditions on site regardless of the detection accuracy
- The accuracy is roughly on the level that ice class is correct

IEA Ice Class	Duration of Meteorological Icing [% of Year]	Duration of Instrumental Icing [% of Year]	Production Loss [% of AEP]
5	>10	>20	>20
4	5-10	10-30	10-25
3	3-5	6-15	3-12
2	0.5-3	1-9	0.5-5
1	0-0.5	<1.5	0-0.5

Conclusions

- Lidar-based method is detecting icing conditions
- False positive rate high, method is quite sensitive
- There is a timing issue in real time detection
- Results are promising, accurate enough to be useful



Next steps

Repeat the test for additional datasets

Sensitivity analysis of the algorithm

Performance differences at different sites and locations