Evaluation of field tests of different ice measurement methods for wind power

Focusing on their usability for wind farm site assessment and finding production losses
Confidentiality - None (C1)

2014/02/04

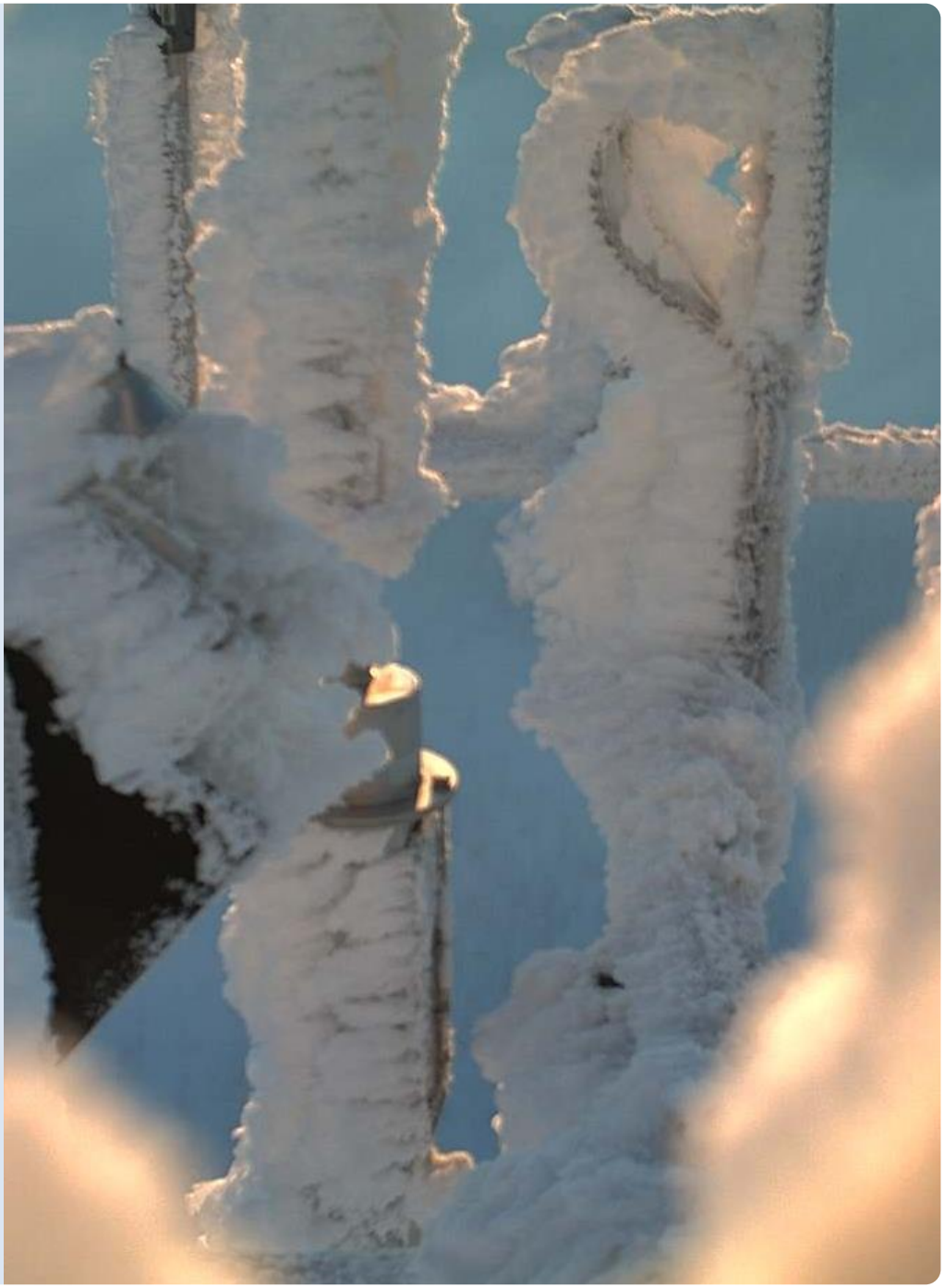
ICE DETECTORS

Evaluation of field tests of different ice measurement methods for wind power

Helena Wickman | 2014.02.04

AGENDA

- Background
- Objective
- Terminology
- Method
- Results and Discussion
- Conclusions
- Questions



BACKGROUND

Favorable wind recourses in many clod climate (cc) regions but...

- Wind power in cc can lead to:
  - Loss of energy production
  - Production stop
  - Fatigue loadings
  - Ice throws
  - Increased noise
- Important to include ice in site assessment
  - Modeling
  - Measurement

Urgent need for ice detectors adapted for wind power!

OBJECTIVE

- Increase the understanding of the detectors' abilities and limitations
- Compere the ice detectors' performances with each other
- See if it is possible to use the data for:
  - Site assessment
  - Predicting production loss during operation

TERMINOLOGY

- Meteorological icing periods
- Instrumental icing periods
- Production loss periods

METHOD

Given:

- Detector installations

Data processing:

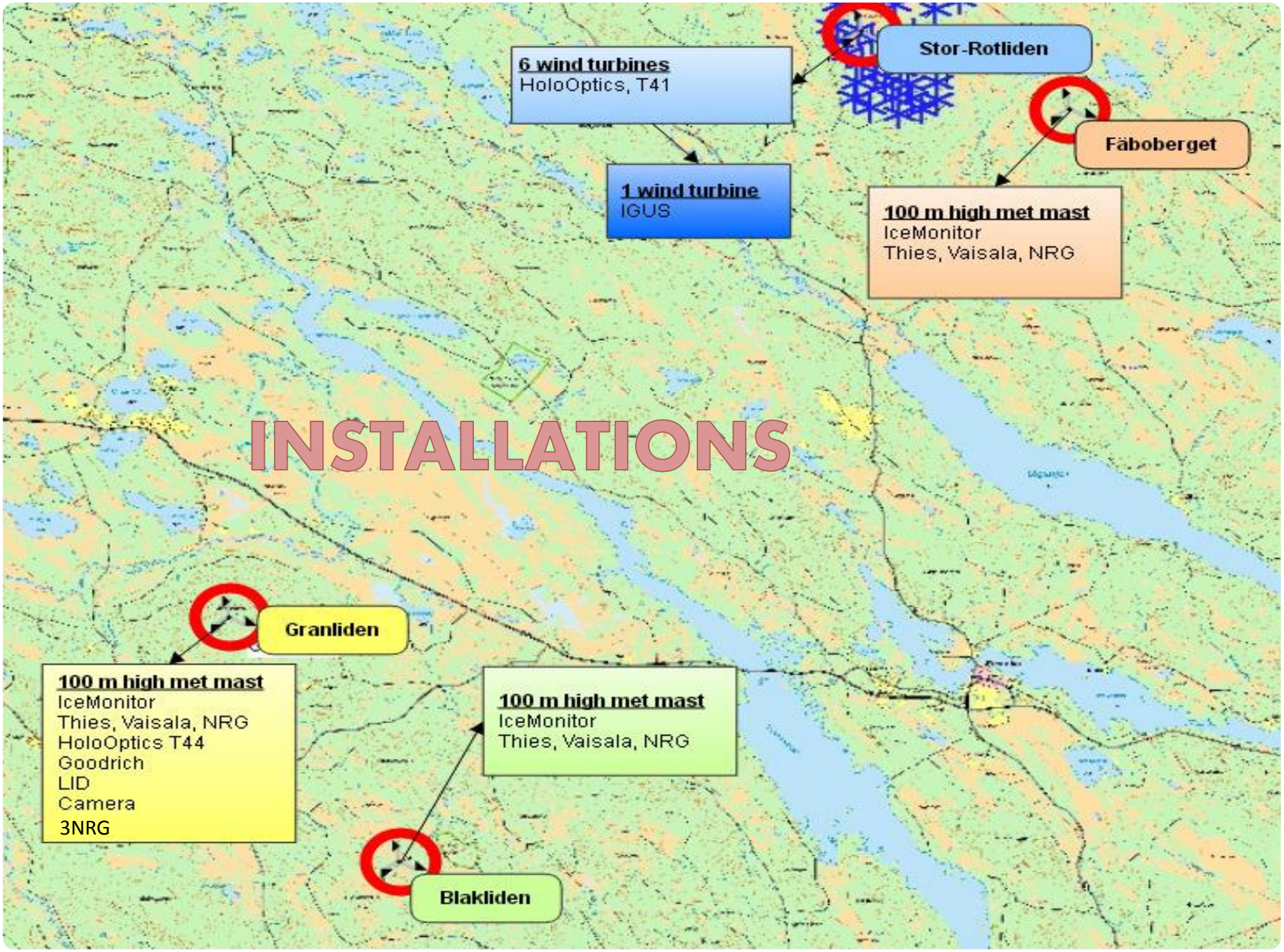
- Data cleaning
- Data characteristics

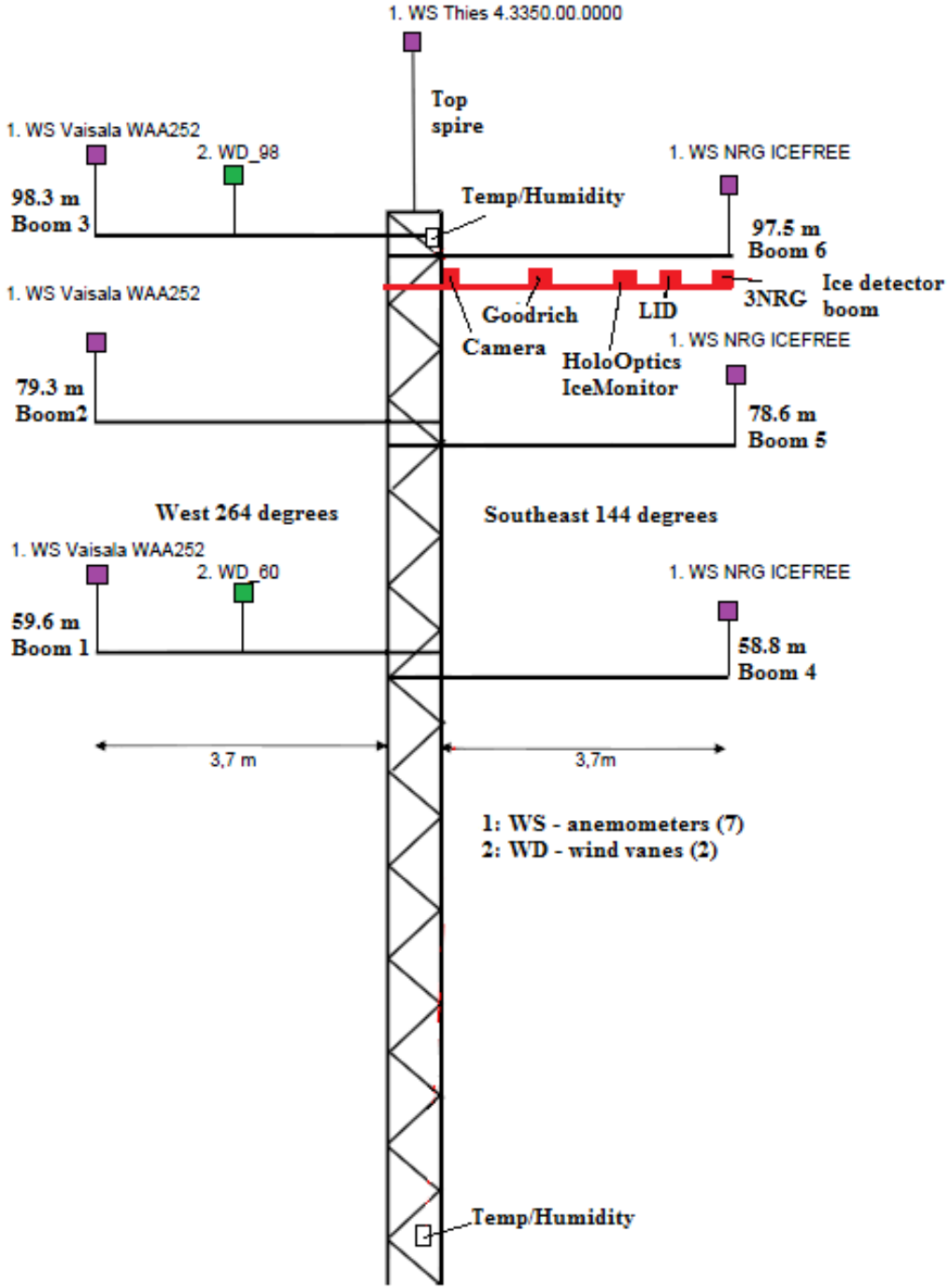
Finding concurrent indications:

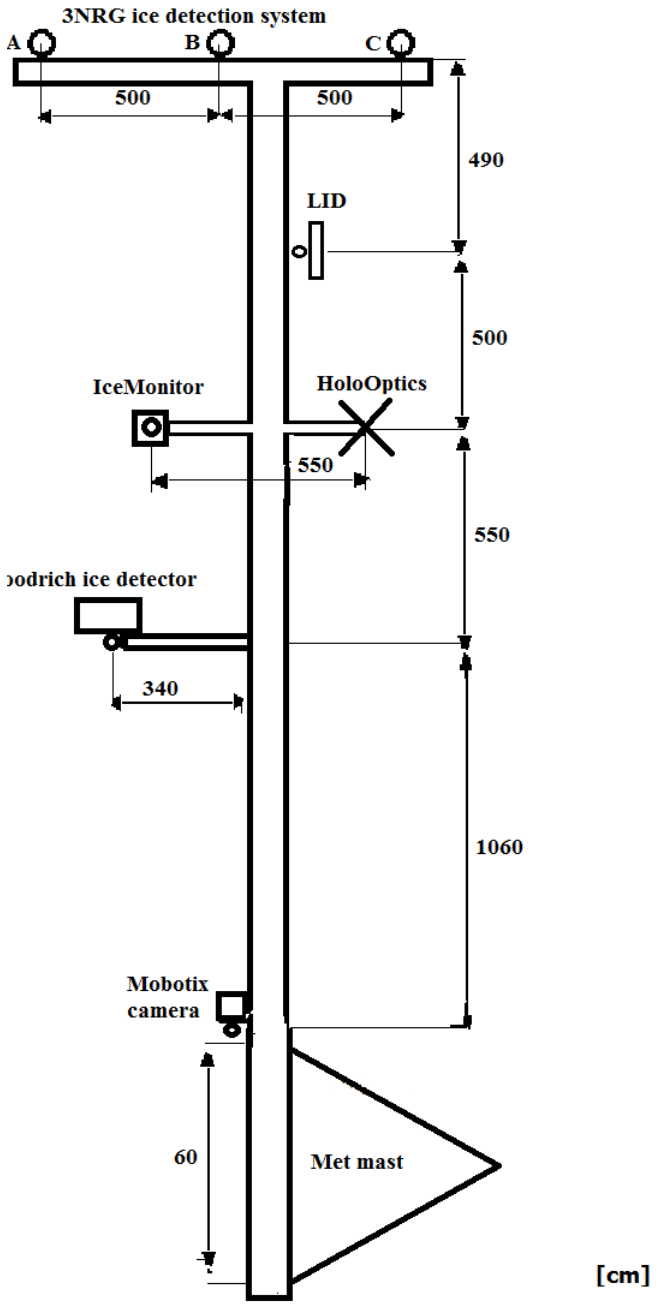
- Meteorological icing
- Instrumental icing
- Production loss

Finding explanations

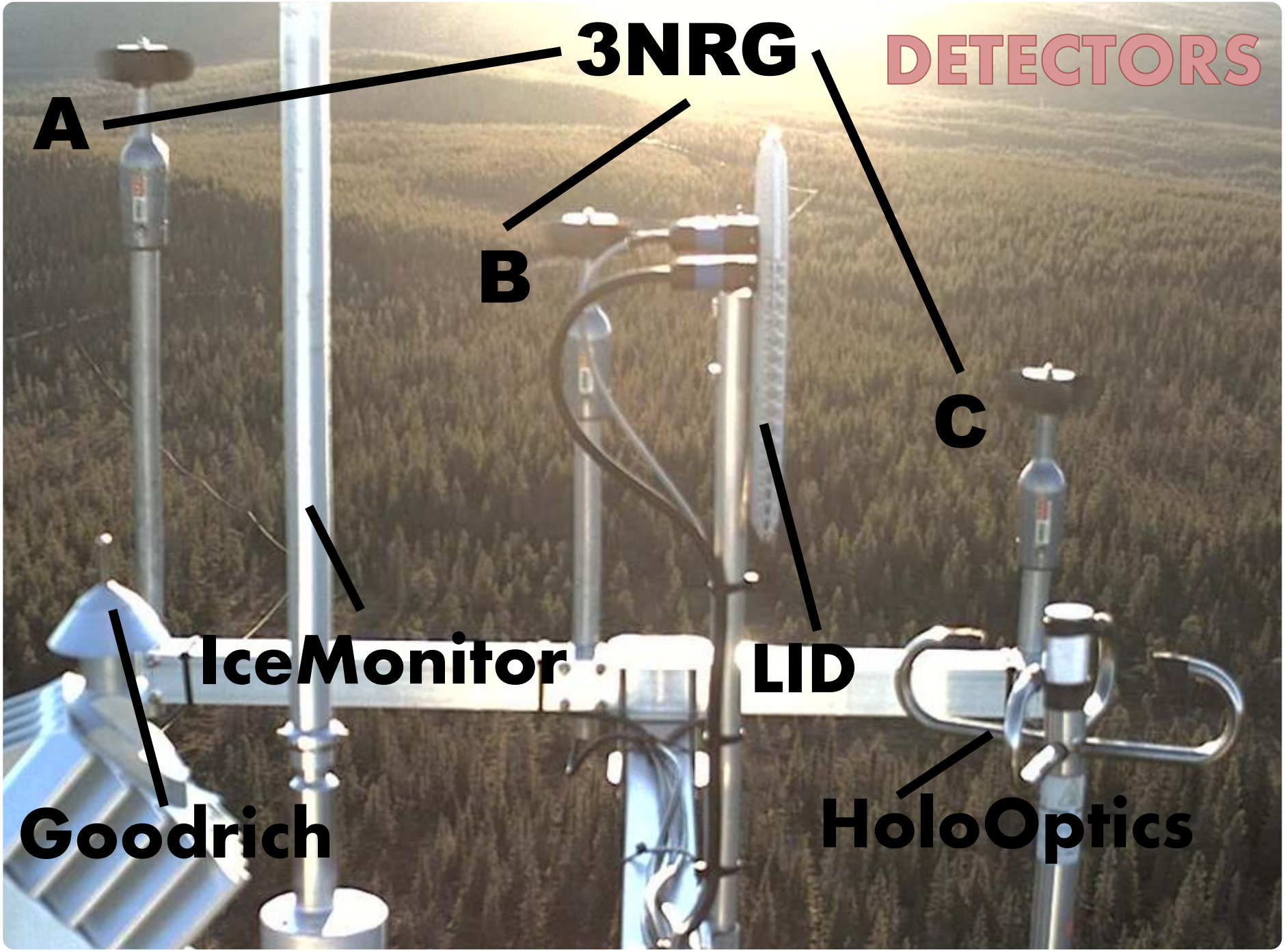
- Met mast camera
- Temperature
- Wind speed
- Wind directions


Stor-Rotliden
6 wind turbines
HoloOptics, T41
1 wind turbine
IGUS
Fäboberget
100 m high met mast
IceMonitor
Thies, Vaisala, NRG
INSTALLATIONS
Granliden
100 m high met mast
IceMonitor
Thies, Vaisala, NRG
HoloOptics T44
Goodrich
LID
Camera
3NRG
100 m high met mast
IceMonitor
Thies, Vaisala, NRG
Blakliden


1. WS Thies 4.3350.00.0000
Top spire
1. WS Vaisala WAA252
2. WD_98
98.3 m Boom 3
Temp/Humidity
1. WS NRG ICEFREE
97.5 m Boom 6
Ice detector boom
3NRG
LID
Goodrich Camera
HoloOptics IceMonitor
1. WS Vaisala WAA252
79.3 m Boom2
1. WS NRG ICEFREE
78.6 m Boom 5
West 264 degrees
Southeast 144 degrees
1. WS Vaisala WAA252
2. WD_60
59.6 m Boom 1
1. WS NRG ICEFREE
58.8 m Boom 4
3,7 m
3,7m
1: WS - anemometers (7)
2: WD - wind vanes (2)
Temp/Humidity


3NRG ice detection system
A
B
C
500
500
490
LID
500
IceMonitor
HoloOptics
550
550
oodrich ice detector
340
1060
Mobotix camera
60
Met mast

[cm]


3NRG
DETECTORS
A
B
C
IceMonitor
LID
Goodrich
HoloOptics

METHOD

Given:

- Detector installations

Data processing:

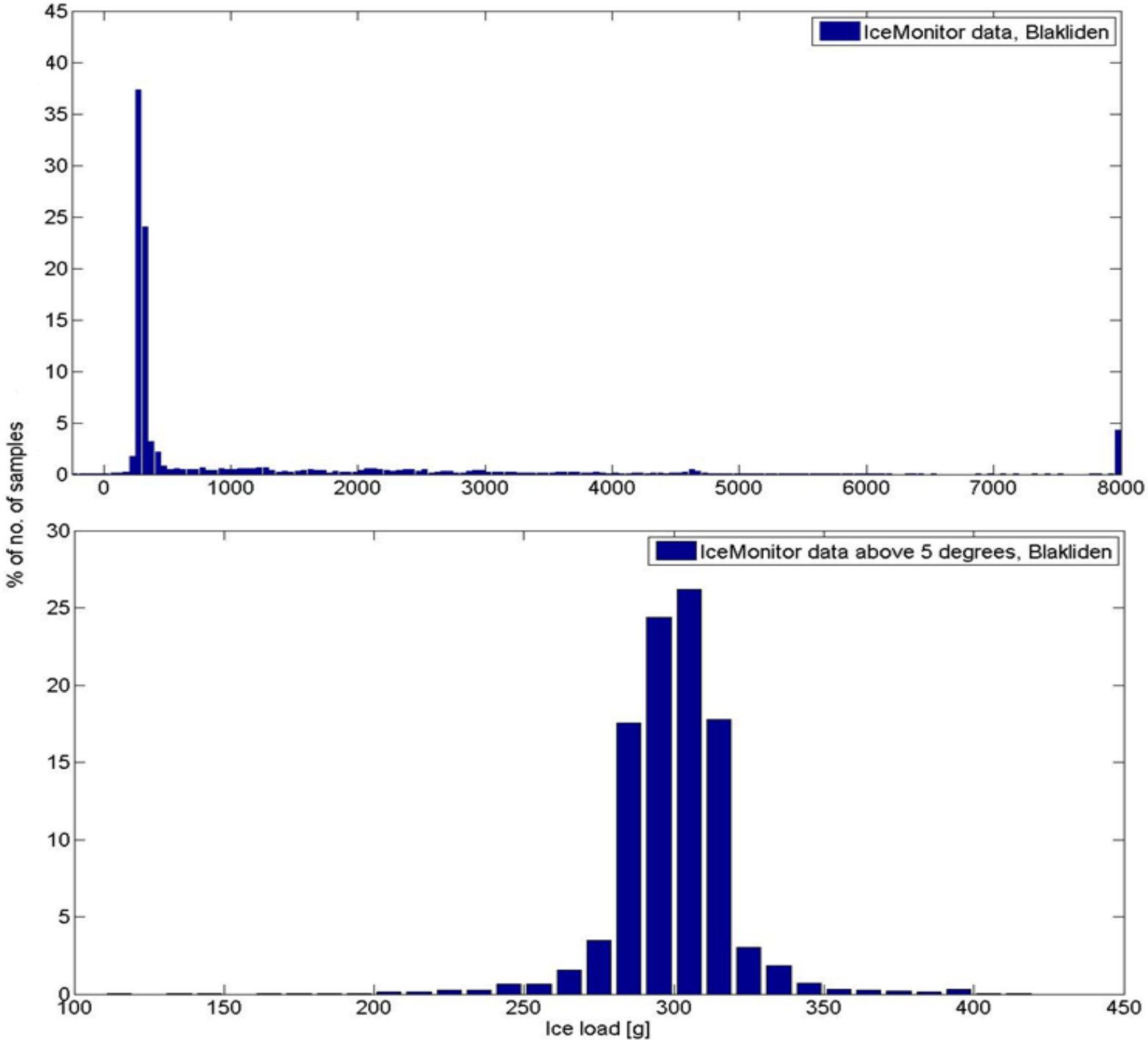
- Data cleaning
- Data characteristics

Finding concurrent indications:

- Meteorological icing
- Instrumental icing
- Production loss

Finding explanations

- Met mast camera
- Temperature
- Wind speed
- Wind directions


IceMonitor data, Blakliden
IceMonitor data above 5 degrees, Blakliden
% of no. of samples
Ice load [g]

METHOD

Given:

- Detector installations

Data processing:

- Data cleaning
- Data characteristics

Finding concurrent indications:

- Meteorological icing
- Instrumental icing
- Production loss

Finding explanations

- Met mast camera
- Temperature
- Wind speed
- Wind directions

RESULTS & DISCUSSION

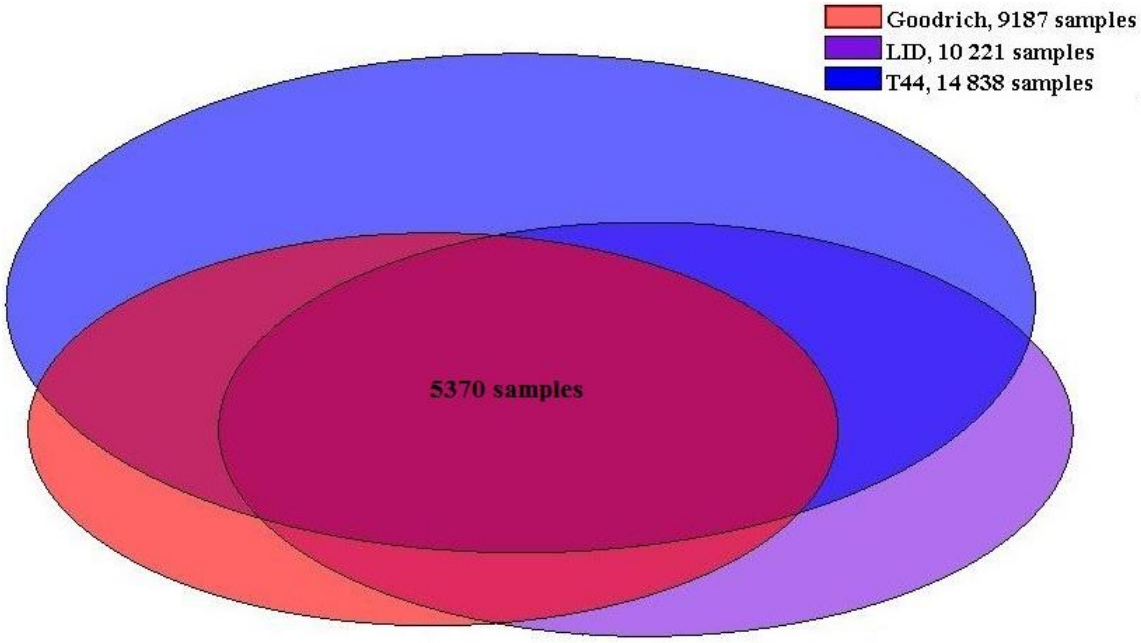
Concurrent indications:

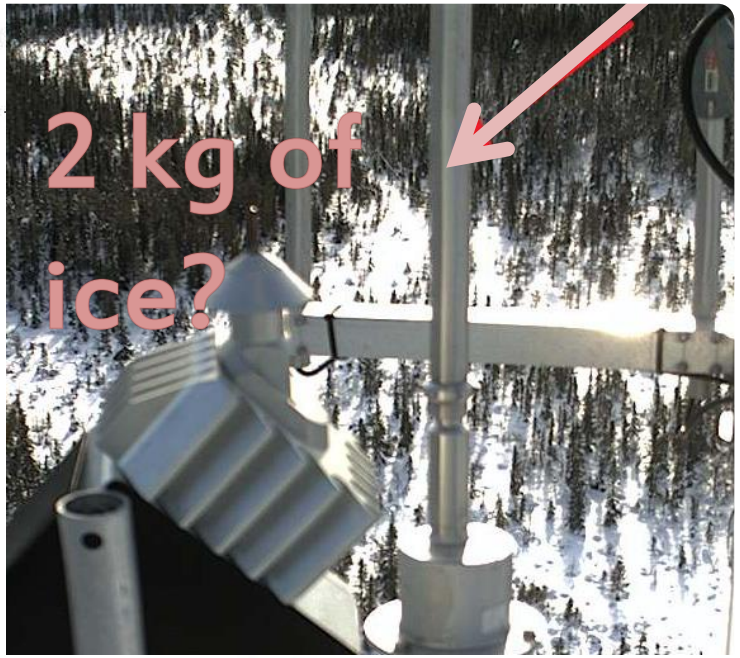
- Instrumental icing

  Possible
- Meteorological icing

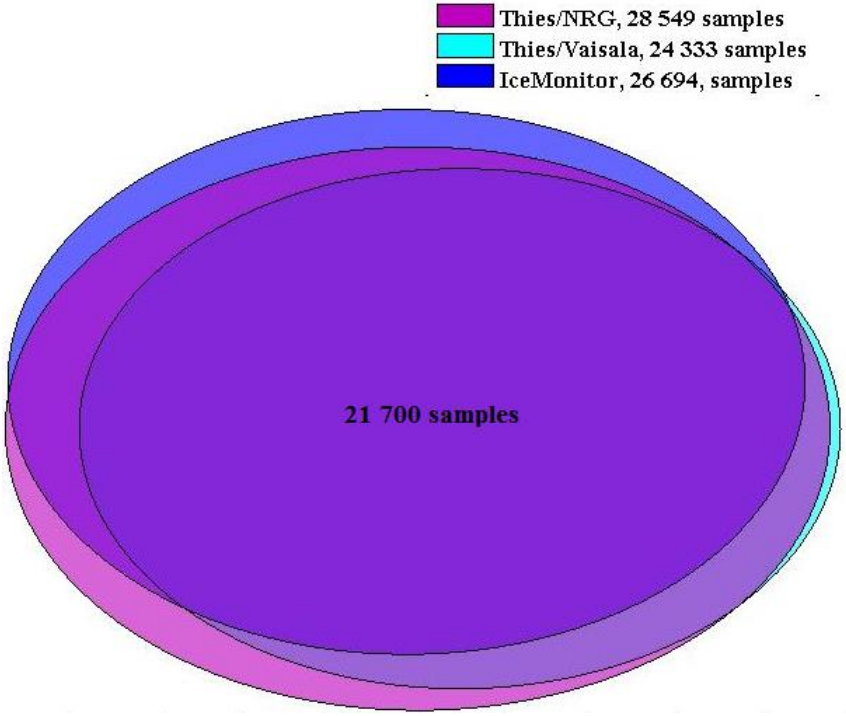
  Hard
- Production loss

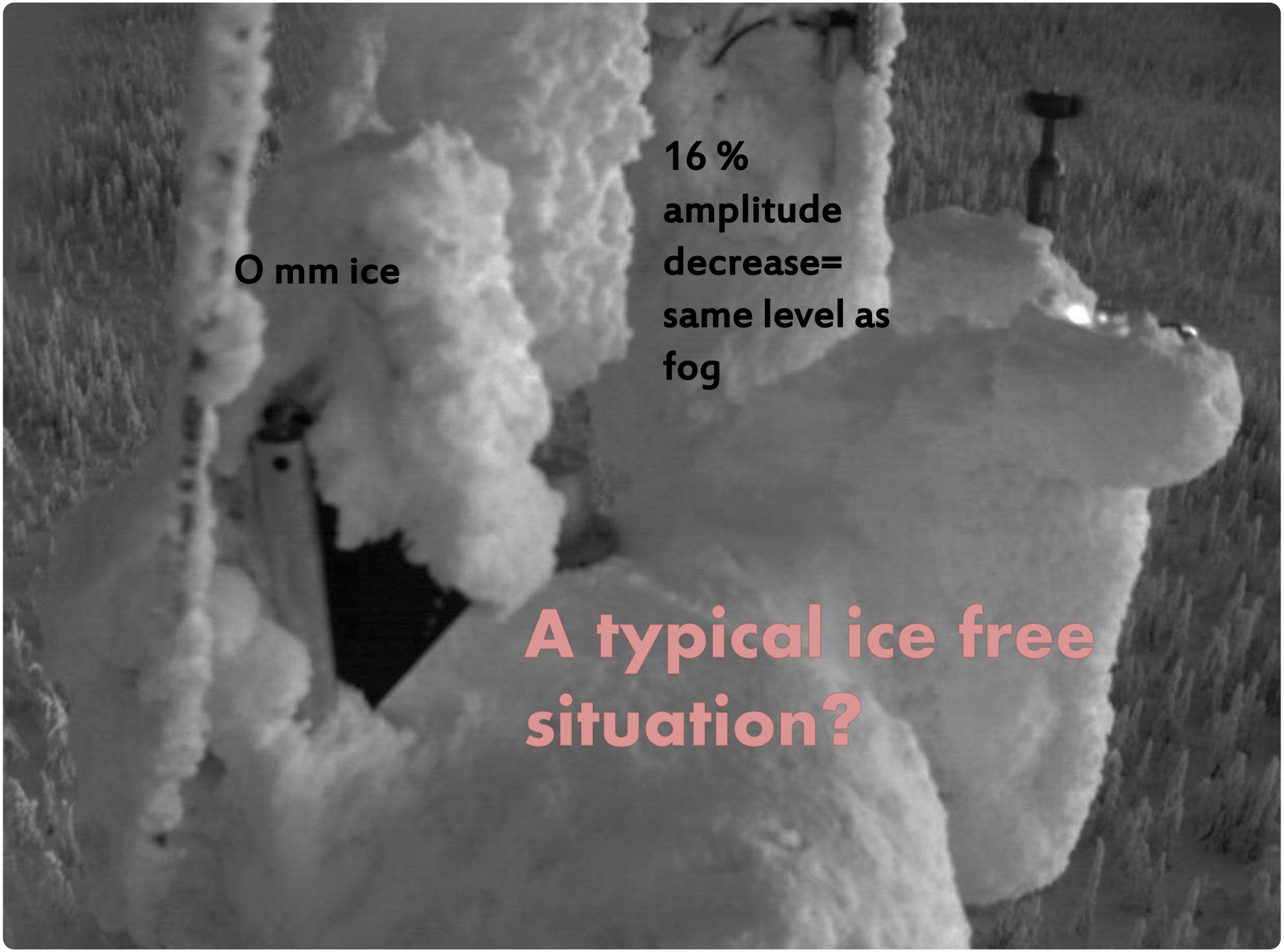
  Very hard


Goodrich, 9187 samples
LID, 10 221 samples
T44, 14 838 samples
5370 samples

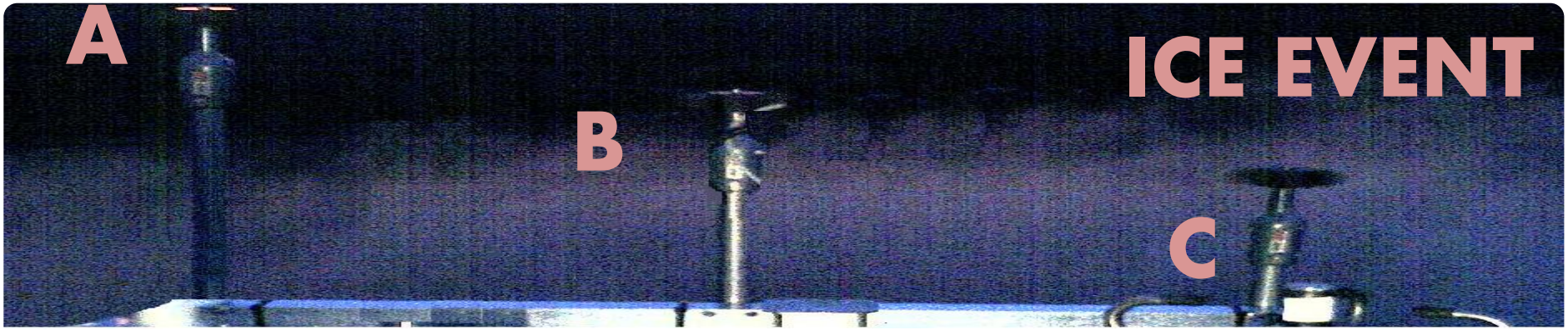

2 kg of
ice?

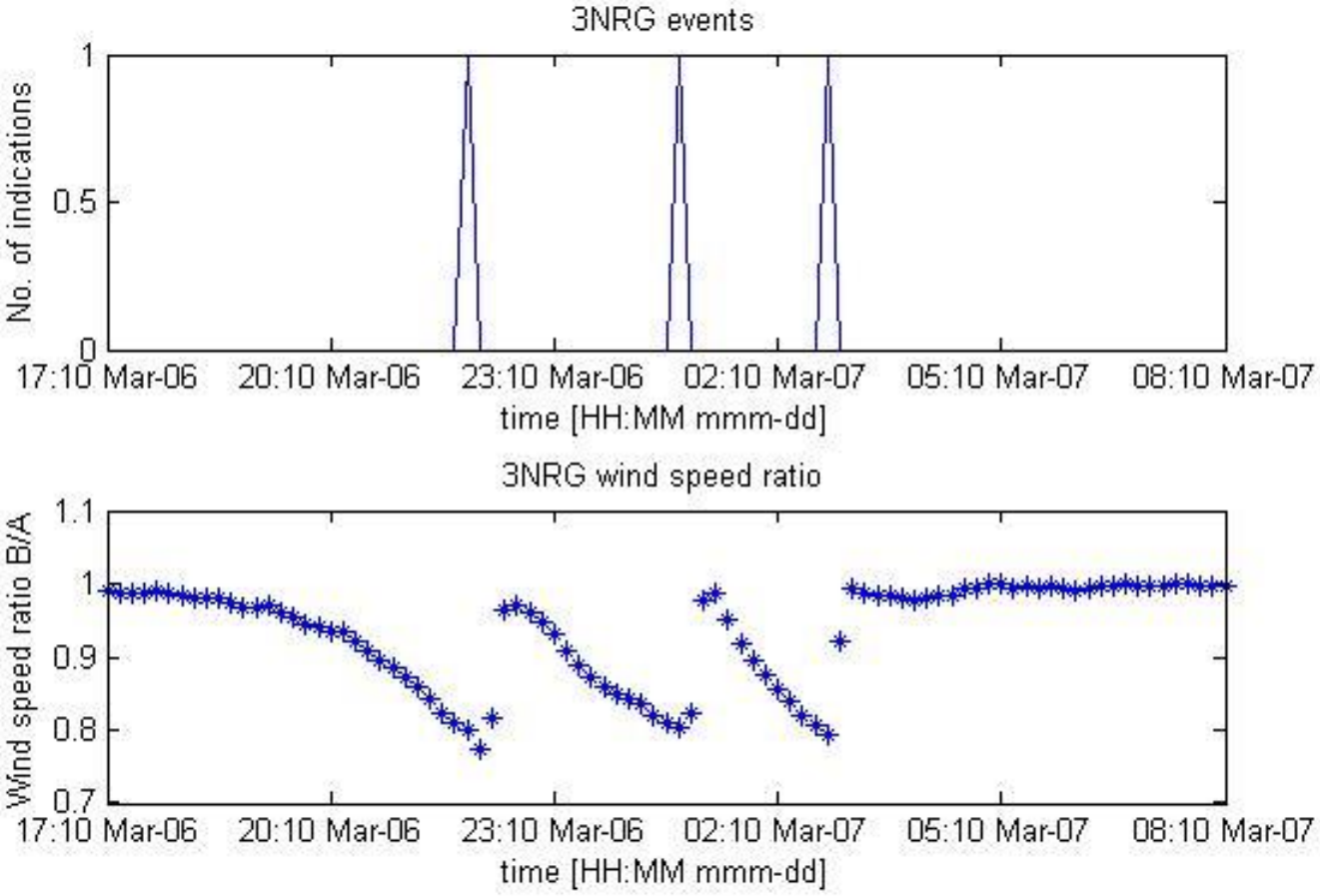

Igloo !

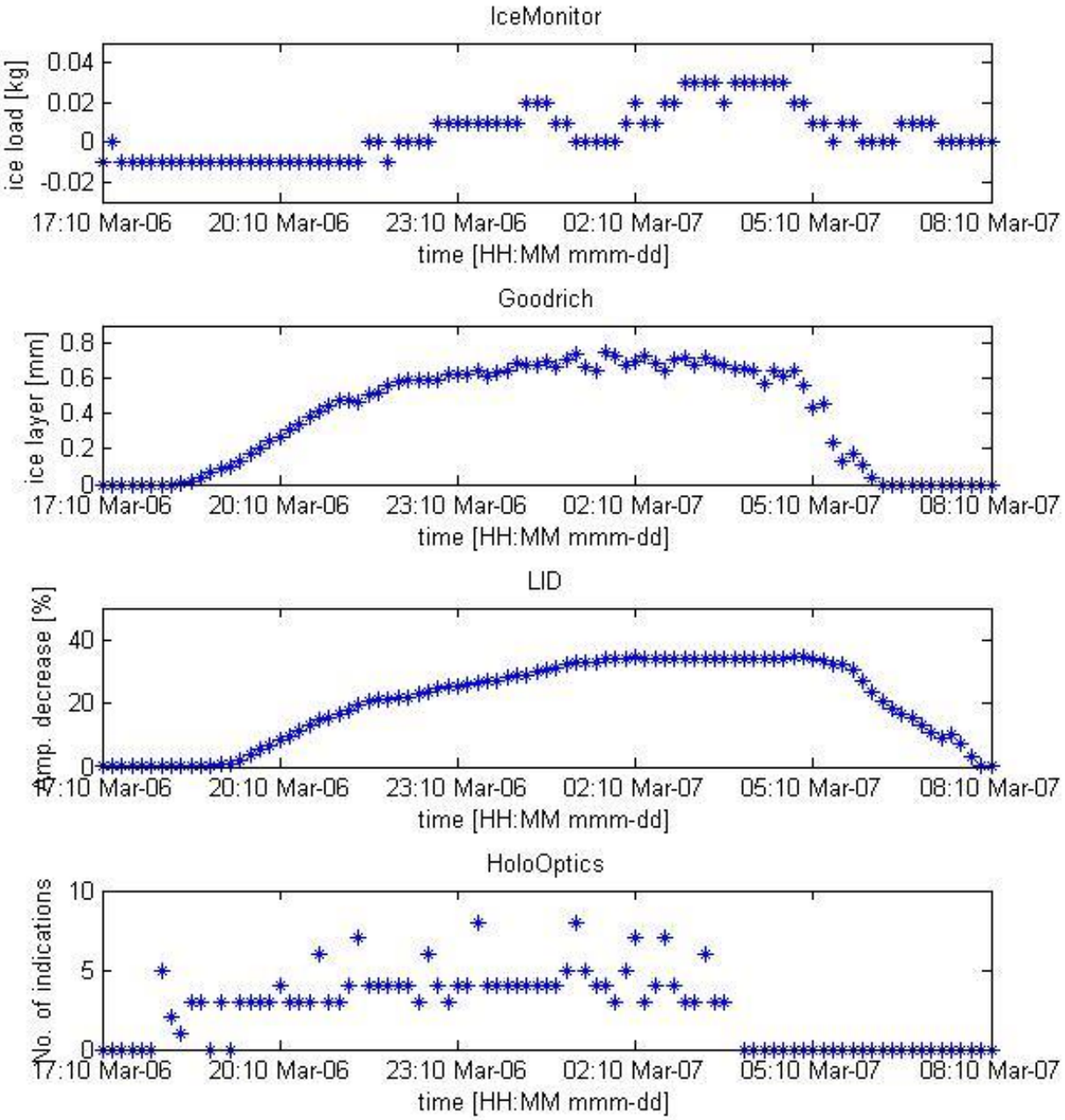

Thies/NRG, 28 549 samples
Thies/Vaisala, 24 333 samples
IceMonitor, 26 694, samples
21 700 samples

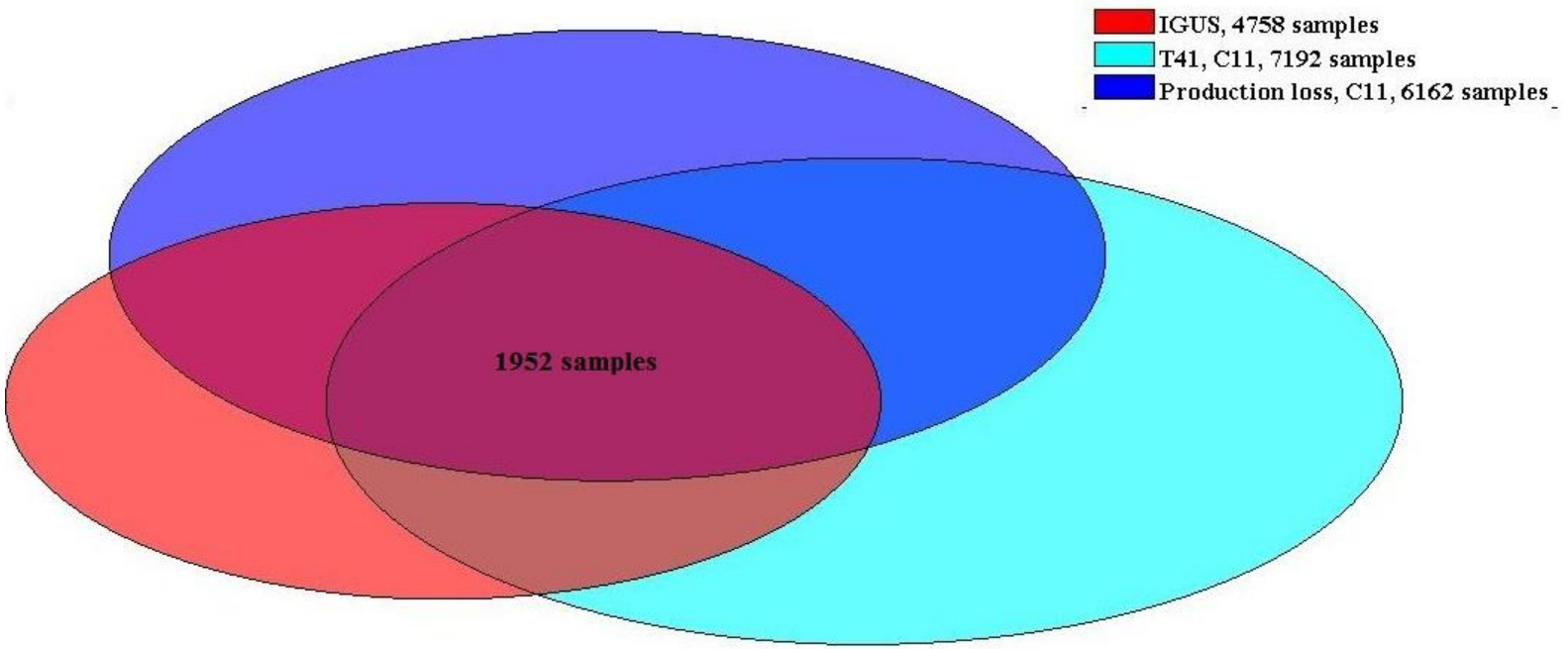

O mm ice
16 %
amplitude
decrease=
same level as
fog
A typical ice free
situation?

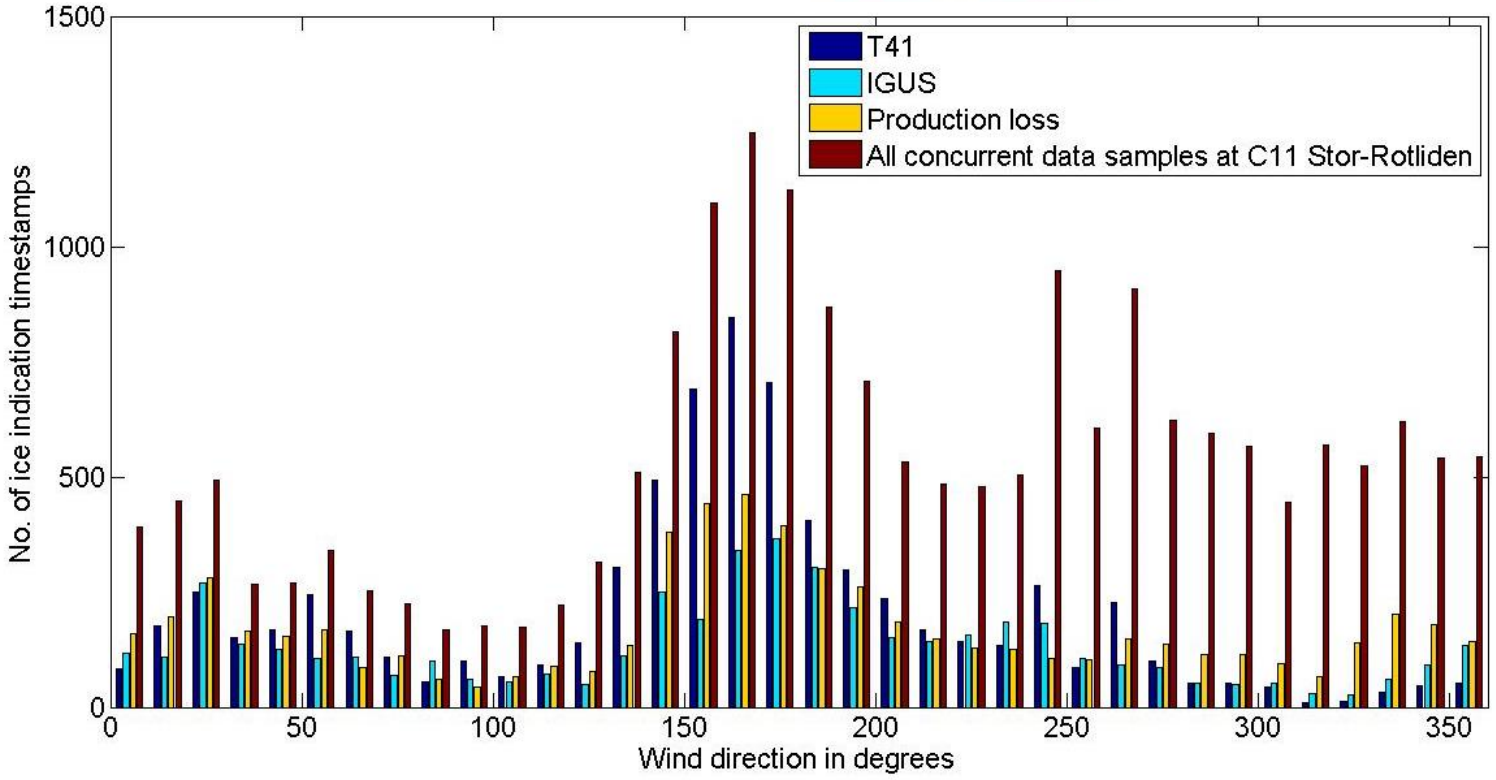

106 days...
LID: 31 days
IceMonitor: 55 days
Goodrich: 15 days
HoloOptics: 106 days


A
B
C
ICE EVENT


3NRG events
No. of indications
1
0.5
0
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]
3NRG wind speed ratio
Wind speed ratio B/A
1.1
1
0.9
0.8
0.7
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]


IceMonitor
ice load [kg]
0.04
0.02
0
-0.02
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]
Goodrich
ice layer [mm]
0.8
0.6
0.4
0.2
0
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]
LID
Amp. decrease [%]
40
20
0
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]
HoloOptics
No. of indications
10
5
0
17:10 Mar-06
20:10 Mar-06
23:10 Mar-06
02:10 Mar-07
05:10 Mar-07
08:10 Mar-07
time [HH:MM mmm-dd]


IGUS, 4758 samples
T41, C11, 7192 samples
Production loss, C11, 6162 samples
1952 samples

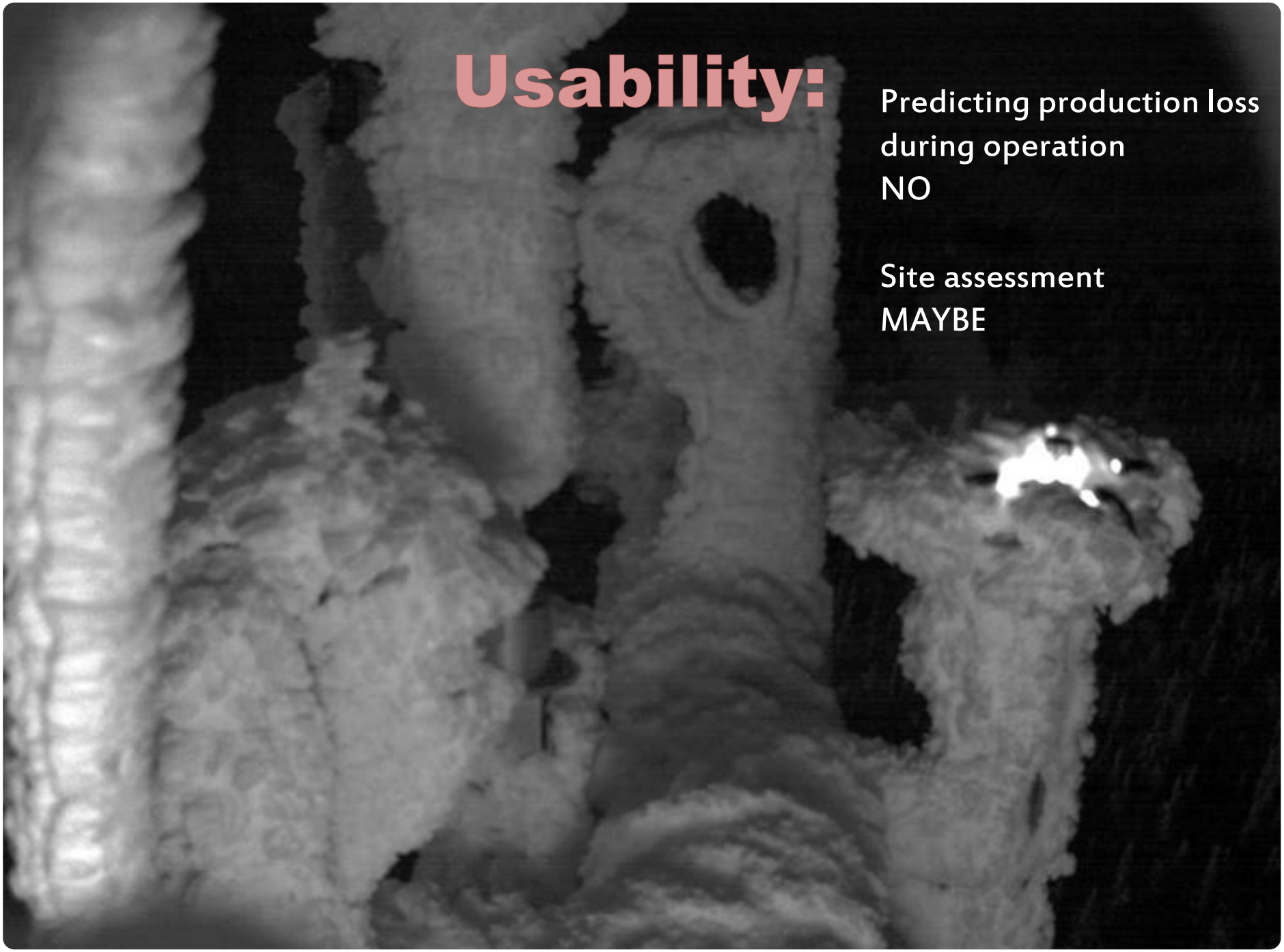

T41
IGUS
Production loss
All concurrent data samples at C11 Stor-Rotliden
No. of ice indication timestamps
Wind direction in degrees
0
500
1000
1500
0
50
100
150
200
250
300
350

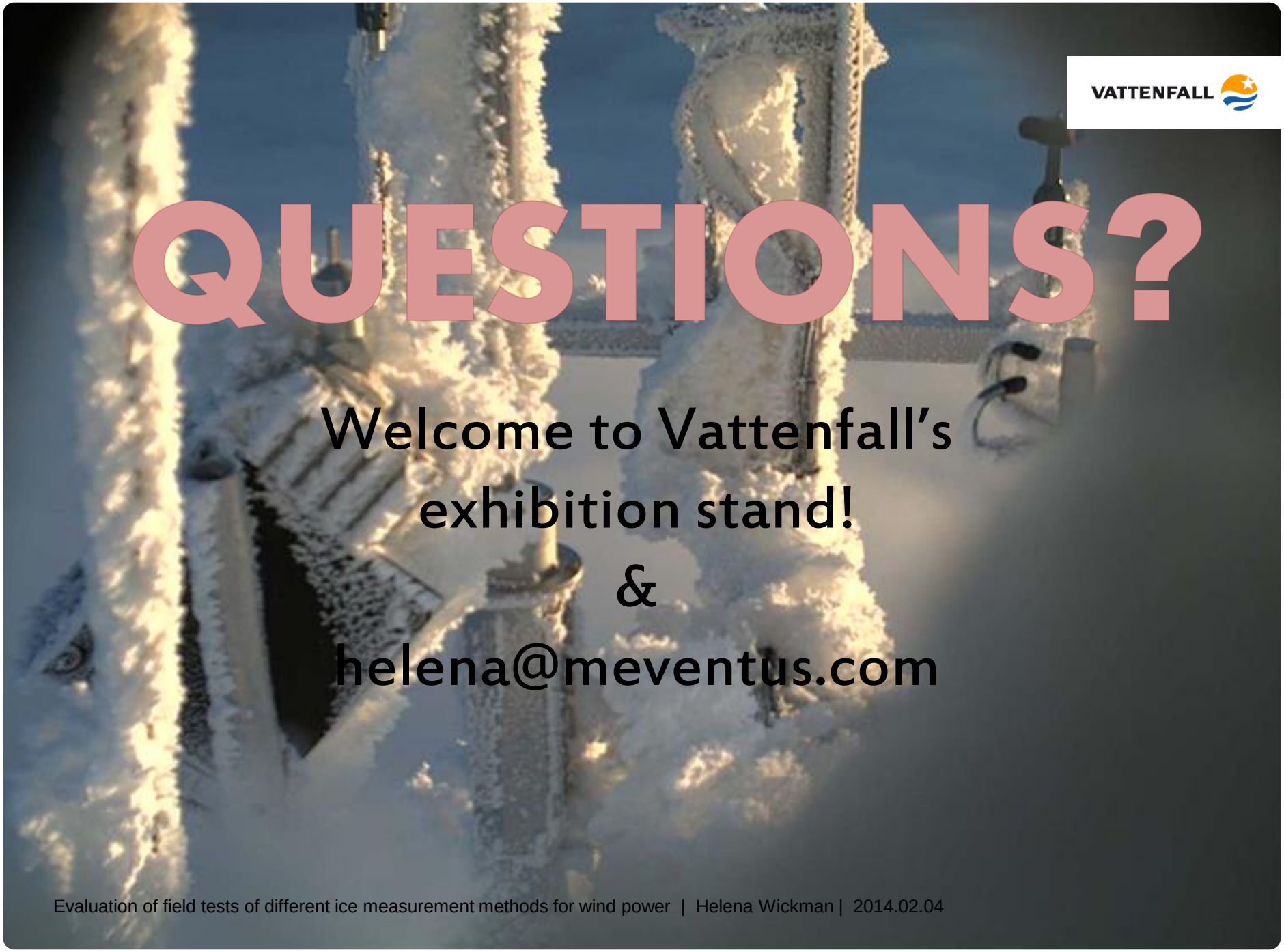
CONCLUSION

- None of the detectors perform satisfactory
- Instrumental icing periods can be found with reasonable precision
- Metrological icing periods are difficult to find
- Production loss periods are very difficult to find

But...the test area suffers from very sever ice events ...

- All detectors show ok result for less extreme ice events, especially Goodrich and LID
- BUT…comparing 10min timestamps might not be the best method
- It would be interesting to test the detectors in a less harsh icing climate
- Install the detectors on a heated boom and keep the boom free from other equipment


Usability:
Predicting production loss during operation
NO
Site assessment
MAYBE


VATTENFALL
QUESTIONS?
Welcome to Vattenfall's
exhibition stand!
&
helena@meventus.com