



Blind Icing Map Validation

07.02.2017

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on behalf of

IEA RD&D Wind Task 19: «Wind Energy in Cold Climates»

2 questions



How good is the IEA Ice Classification?

How good do icing maps predict the IEA Ice Class?

Warning



P A R E N T A L

A D V I S O R Y

E X P L I C I T C O N T E N T

Warning



SCIENTIFIC

ADVISORY

EXPLICIT UNCERTAINTY

IEA Task 19 site classification



From IEA T19 Recommended Practices Report, 2012 → NEW EDITION OUT NOW!

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

Create common language
Make sites comparable

Data base



- **Publicly available** data (proceedings, presentations)
- **Anonymous data provided by**
 - MeteoTest
 - DNV GL
 - Vattenfall
 - Kjeller Vindteknik
 - VTT
 - EDF Canada
 - AWS Truepower

Data base



- **A colorful mixture of methods for data assessment**
 - Iced anemometers
 - Webcam icing
 - Temperature & relative humidity
 - SCADA data: T19 IceLoss & others (→ rotor icing)
- **Different operational modes**
 - Unheated, operating whenever possible
 - Unheated, stopped when iced
 - Heating during operation
 - Heating during stand still
 - Automatic & manual restart

Data Base

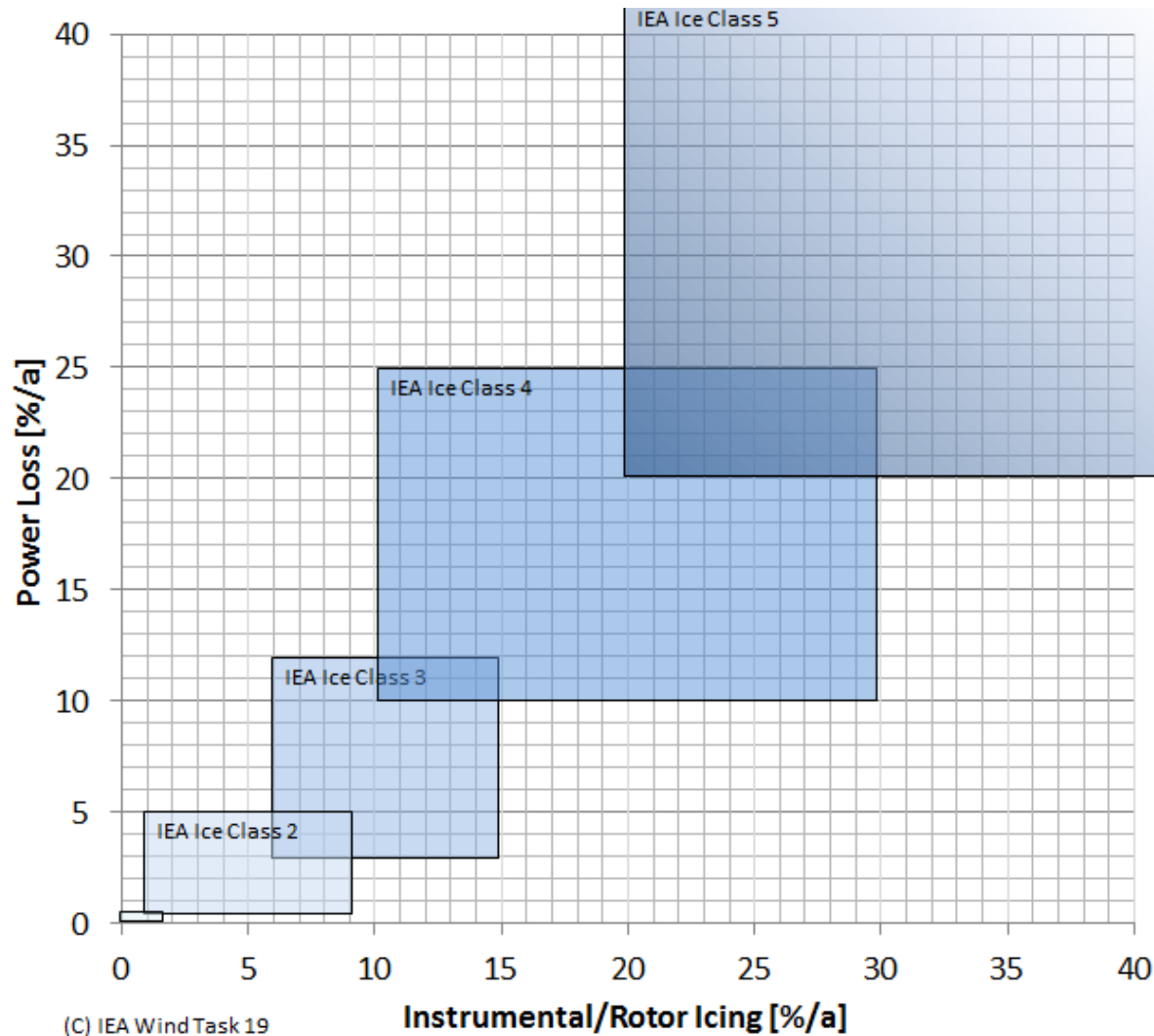


Instrumental & Rotor Icing versus Power Loss

54 / 30

values / sites

IEA Task 19 site classification



Instrumental & rotor icing (N=54)



Ice Class 1



0

Ice Class 2



9

Ice Class 3



24

Ice Class 4



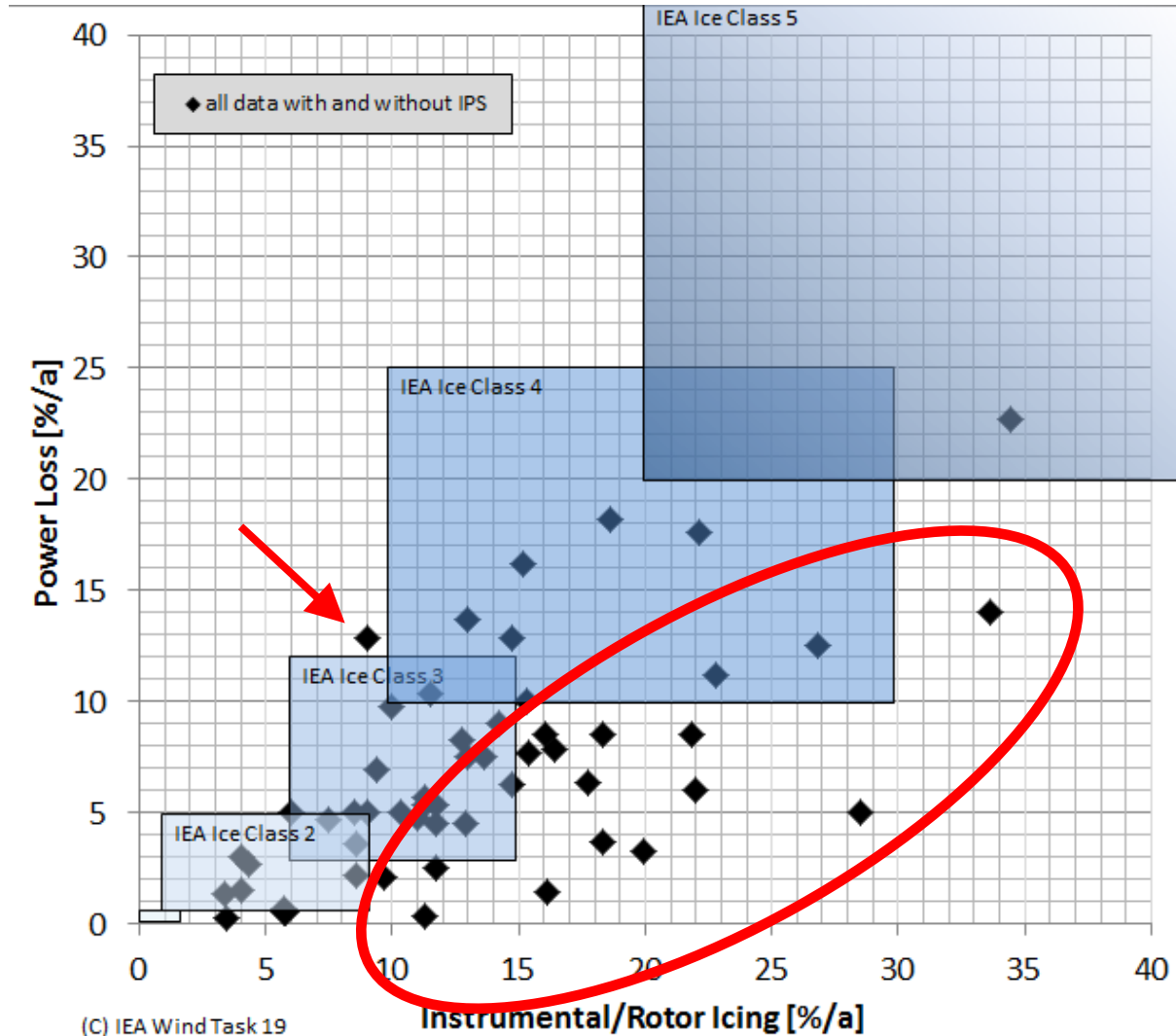
14

Ice Class 5



7

All available data pairs (N=54)



All data points (N=54)



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Inside IEA Ice Class

67%

Outside IEA Ice Class

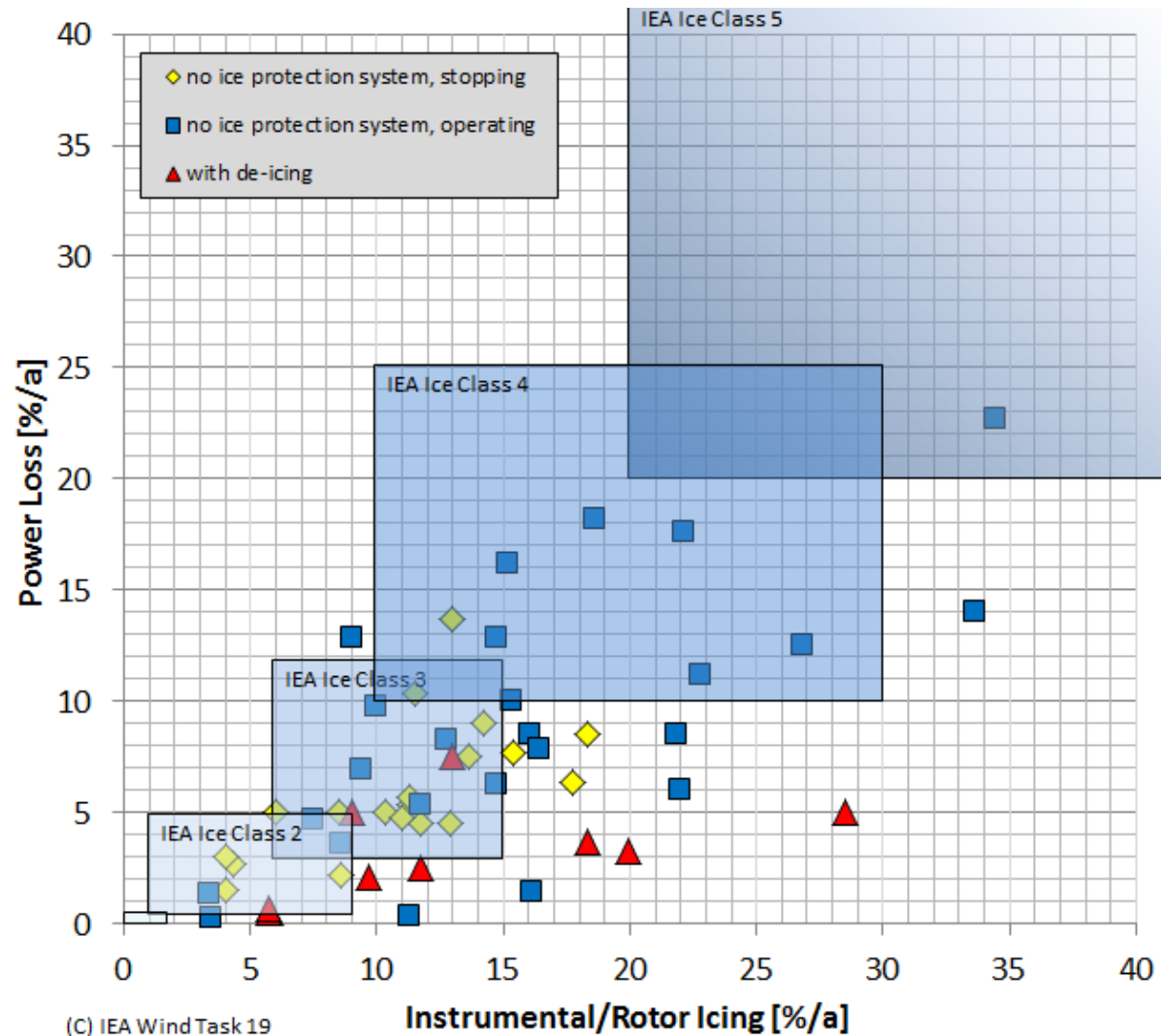
33%

3 operational modes



1. **No** Ice Protection System (IPS)
Stopping when iced
2. **No** Ice Protection System (IPS)
Operating whenever possible
3. **With** Ice Protection System (IPS)

Different operational modes (N=54)



(C) IEA Wind Task 19

Inside IEA Ice Class (N=54)



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No IPS
Stopping

84%

No IPS
Operating

68%

With IPS

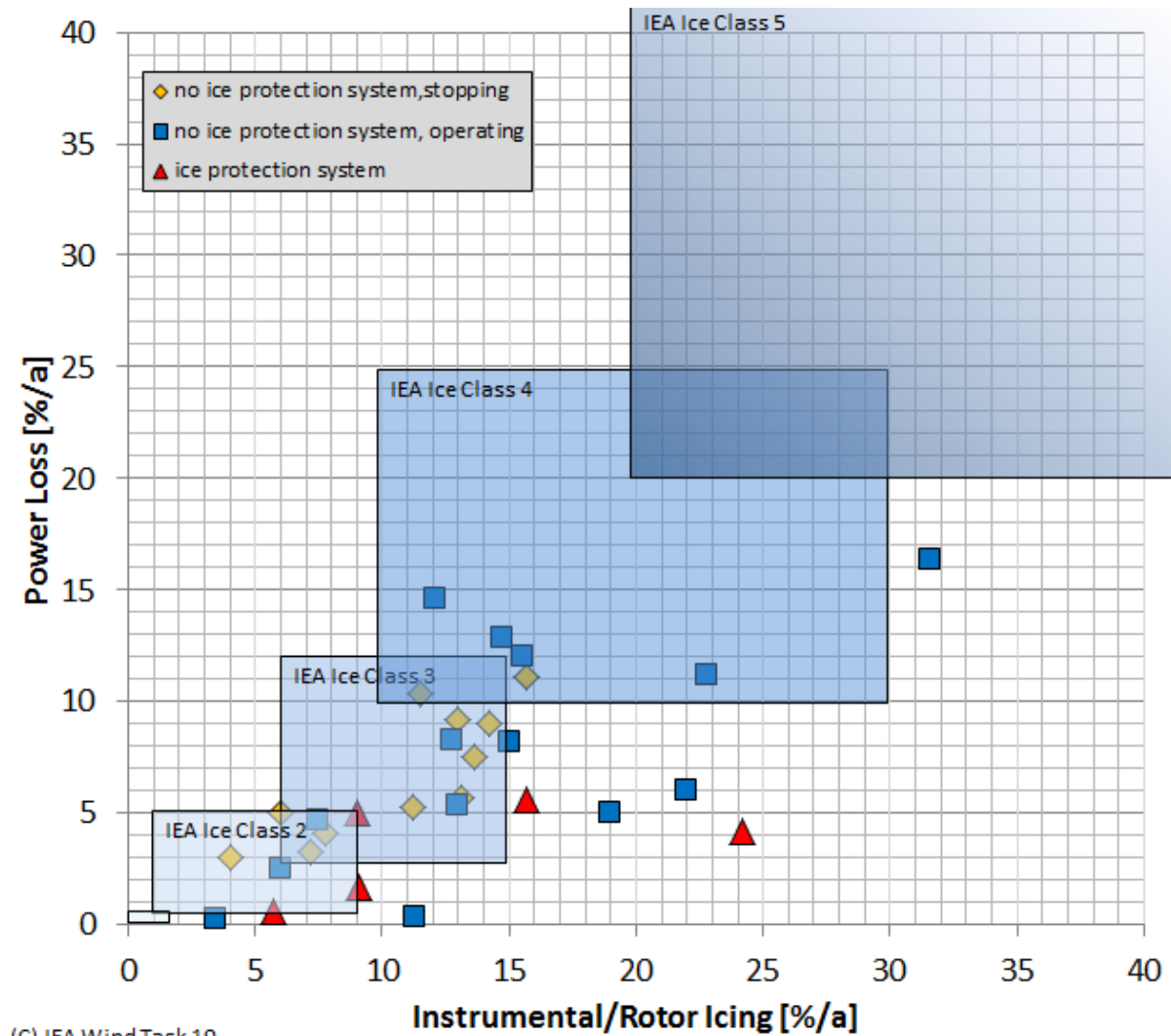
40%

Time period



1. **Single years**
2. **«Long term averages»**

«Long term averages» (N=30)



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Inside IEA Ice Class (N=30)



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No IPS
Stopping

100%

No IPS
Operating

57%

With IPS

20%

Wrap up I



- IEA Ice classification **is robust and rather conservative**
- **Only one case** with **higher power loss** than predicted
- It is a **long term classification**, **single years** do not necessarily fit in
- **Good match** for turbines **without Ice Protection System (IPS) stopping** when iced
- **Lower power loss** when turbine keeps **operating**
- **Even lower power loss with Ice Protection System (IPS)**
- **Hardly any** validation data for **IEA Ice Class 5**
- **More detailed understanding** of icing versus power loss needed for **site assessment**

Question



- How good are **icing maps** for pre-assessment?
- Focus: **IEA Ice Class**: «measured versus modelled»

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Data Base



Instrumental & Rotor
Icing versus Power Loss

54 / 30
values / sites



IEA Ice Class
Measured versus Mapped

48
sites

Icing Atlases



- **WiceAtlas** (global): Cloud base height & temperature
45 samples
- **Kjeller Vindteknikk icing maps** (SWE, NO, FIN): WRF
13 samples
- **DNV GL Ice Atlas** (SWE): Power Loss from SCADA data
7 samples
- **Swiss Icing Map**: COSMO
2 samples
- **Czech Icing Map**: icing measurements
2 samples
- **FMI Ice Atlas** (FIN): AROME
2 samples
- **German Ice Atlas**: Icing measurements
1 sample

Data Base



Instrumental & Rotor
Icing versus Power Loss

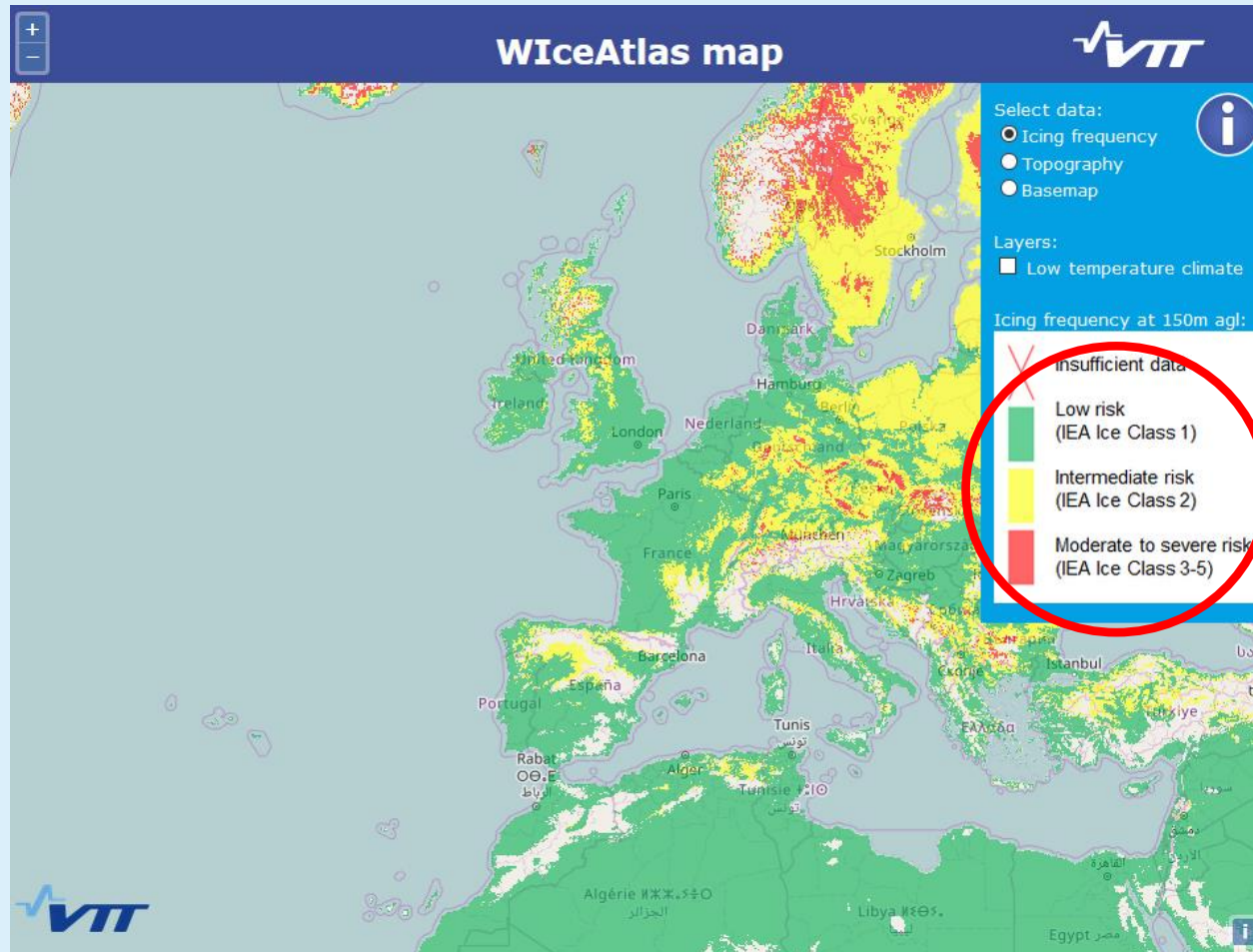
54 / 30
values / sites



IEA Ice Class
Measured versus Mapped

48 / 72
sites / samples

IEA Ice Classes



→ IEA Ice Class 3 to 5 summarized in one Ice Class

Measured IEA Ice Class (N=45)



IEA Ice Class 1



False positive?

4%

IEA Ice Class 2



33%

IEA Ice Class 3 to 5



63%

IEA Ice Classes (N=72)



Mapped Ice Class	3-5	1	33	
	2	17	17	
	1	2	2	
		1	2	3-5
		Measured Ice Class		

All icing maps (N=72)



Icing map

Reference



19

26.4%

**Ice class predicted
too low**

Icing map

Reference



52

72.2%

**Ice class predicted
correctly**

Icing map

Reference



1

1.4%

**Ice class predicted
too high**

WlceAtlas only (N=45)



Icing map

Reference



7

15.6%

Ice class predicted too low

Icing map

Reference



37

82.2%

Ice class predicted correctly

Icing map

Reference



1

2.2%

Ice class predicted too high

Wrap up II



- **Robust agreement** between measurements and icing maps
- Underestimation of IEA Ice Class in some cases
- Only one overestimation
- **False positive cannot be validated**
- **Large uncertainties**, especially for reference values
- More thorough validation required

- **Icing maps useful for:**
 - **Early warning of potential icing losses (pre-assessment)**
 - **Planning of site measurement campaign**

Take away messages



- **IEA Ice Classification is robust**
- **It is rather conservative**
- **Icing maps can predict IEA Ice Class**
- **Mapped IEA Ice class useful for pre-assessment**
- **Thorough site assessment required afterwards**
- **More data & validation needed (false positive)**
- **Share more data!**

Thanks for your attention!



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