THE IMPACT OF LIQUID WATER CONTENT ON THERMAL ICE PROTECTION SYSTEMS EFFICIENCY

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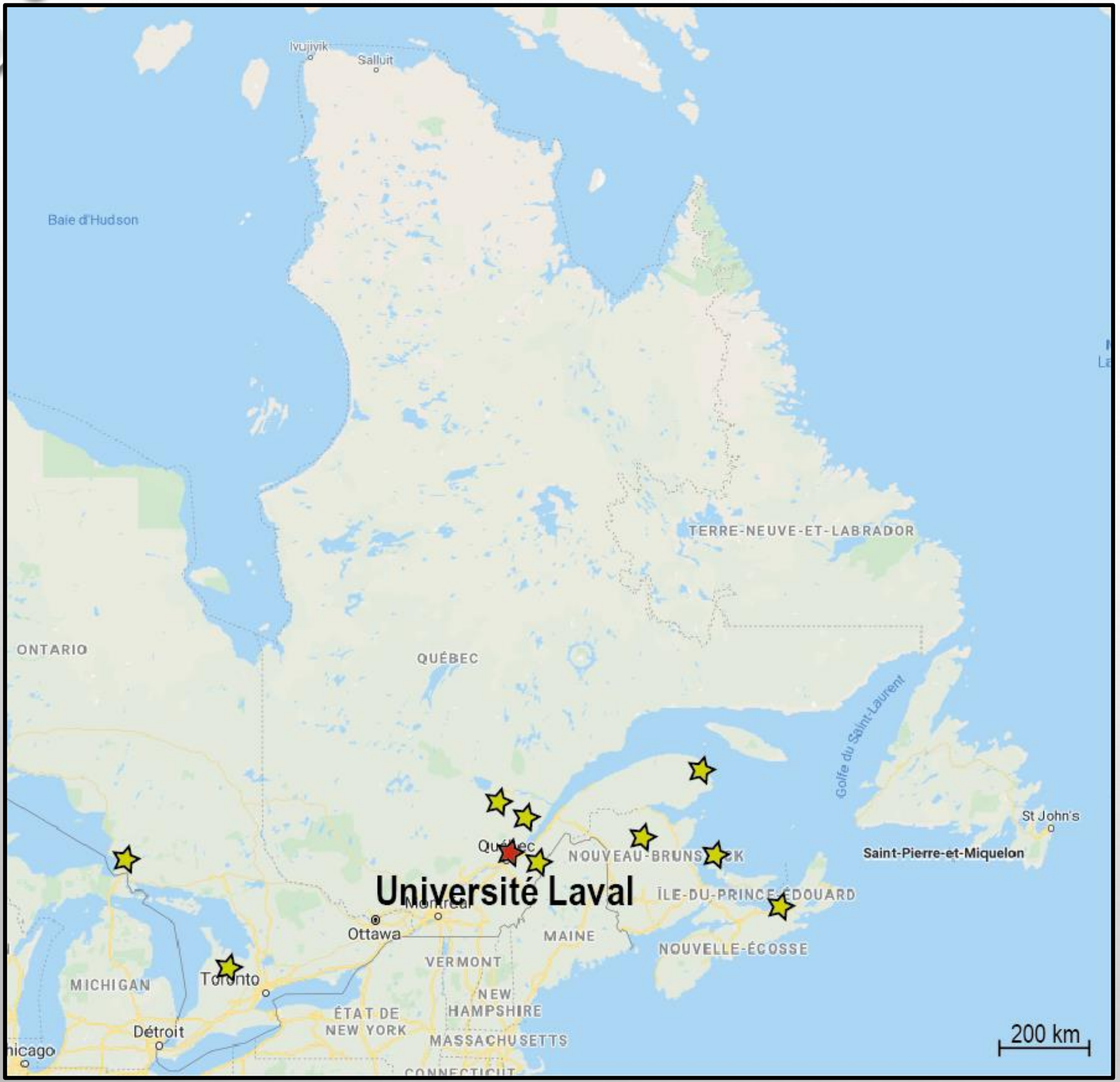
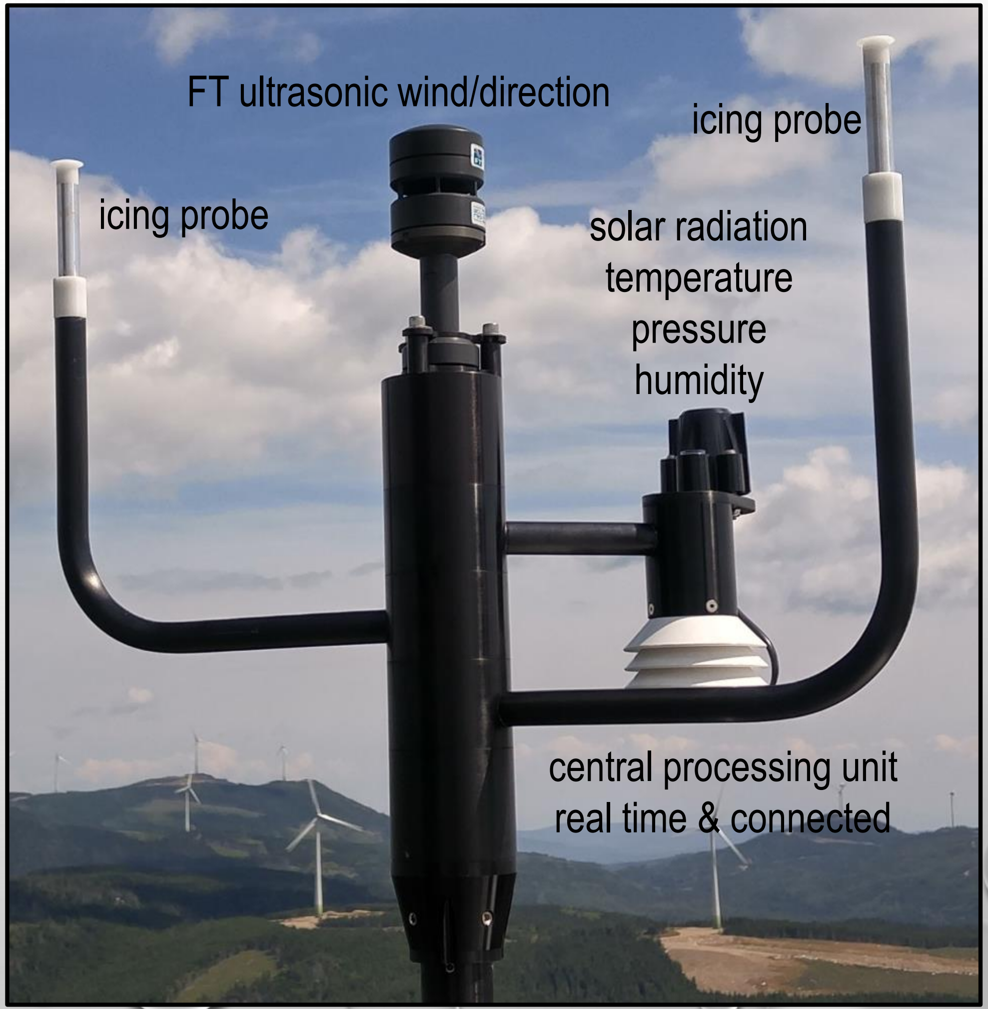
Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

Åre, Sweden, February 3-5, 2020

MY RESEARCH INTERESTS

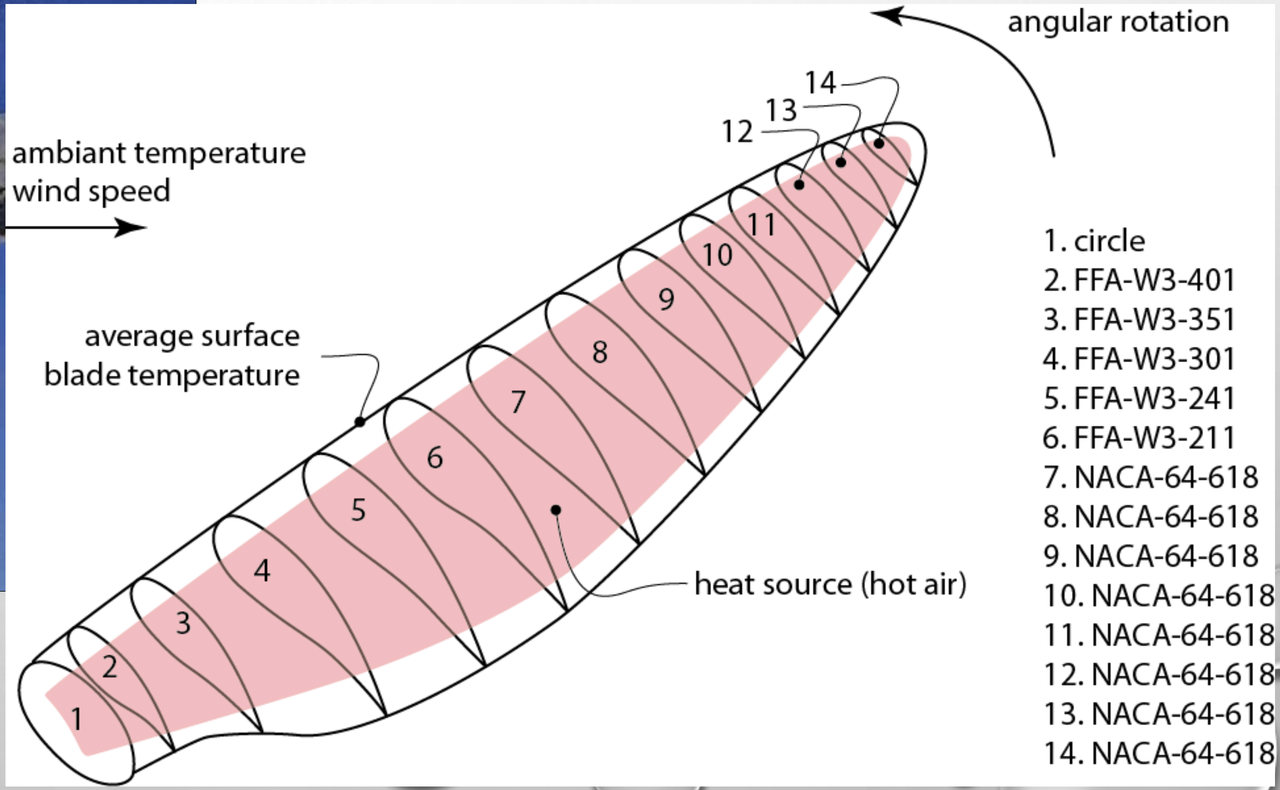


Meteorological Conditions Monitoring Station (MCMS)

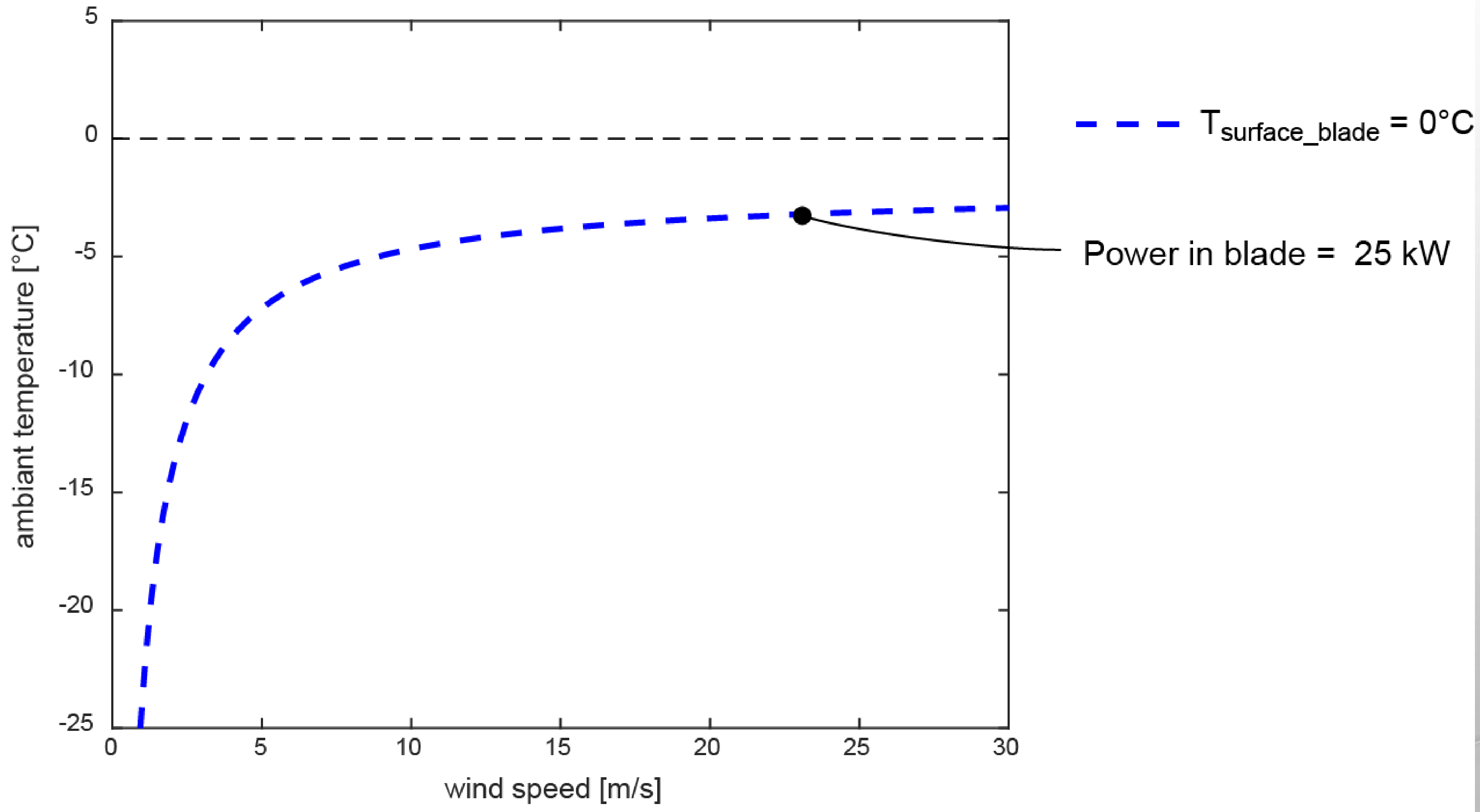


THROWBACK TO WINTERWIND 2018

Bégin-Drolet *et al.* (2018) *The importance of accurate detection for turbine ice prevention systems.* Winterwind 2018

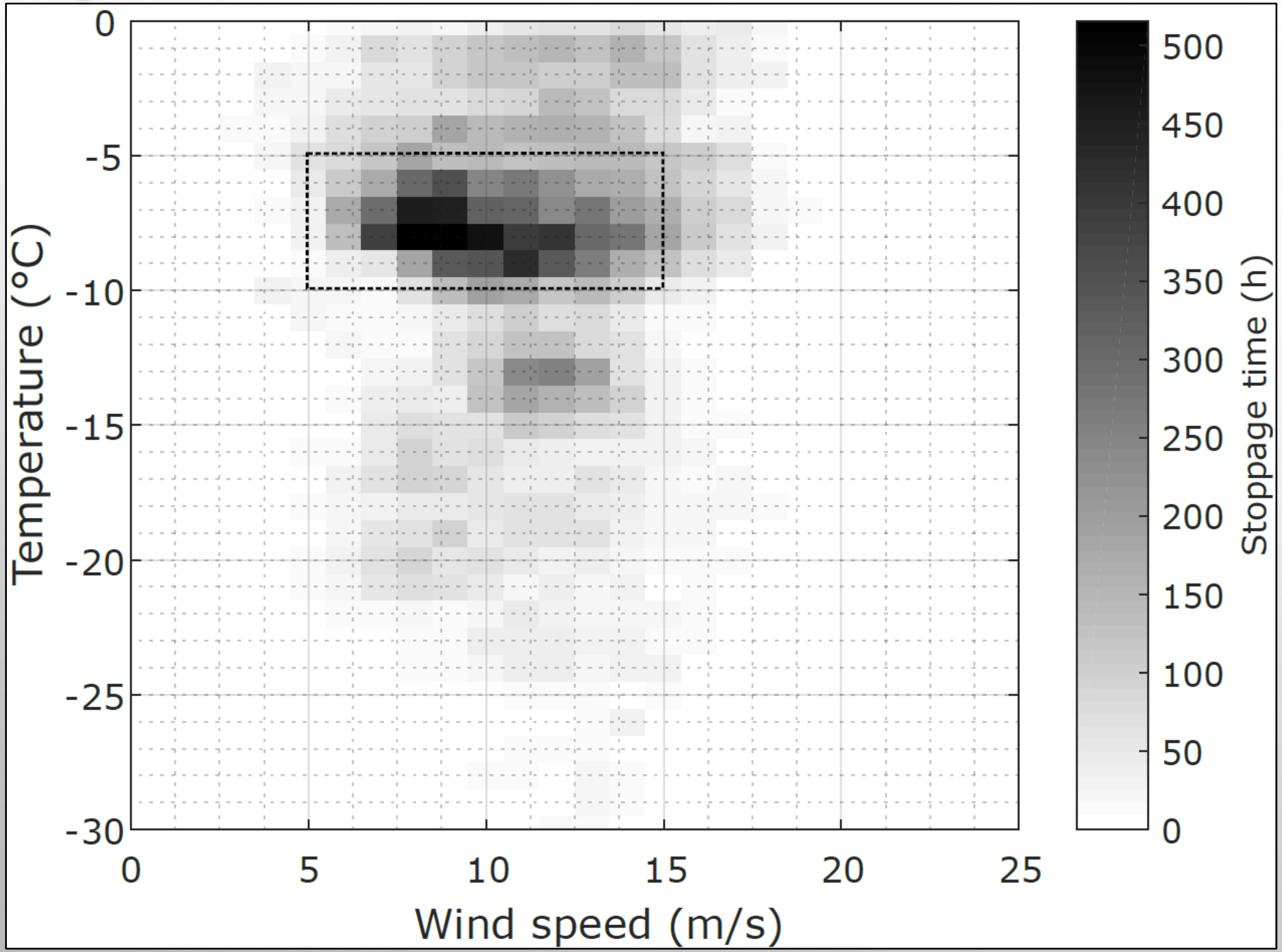


THROWBACK TO WINTERWIND 2018



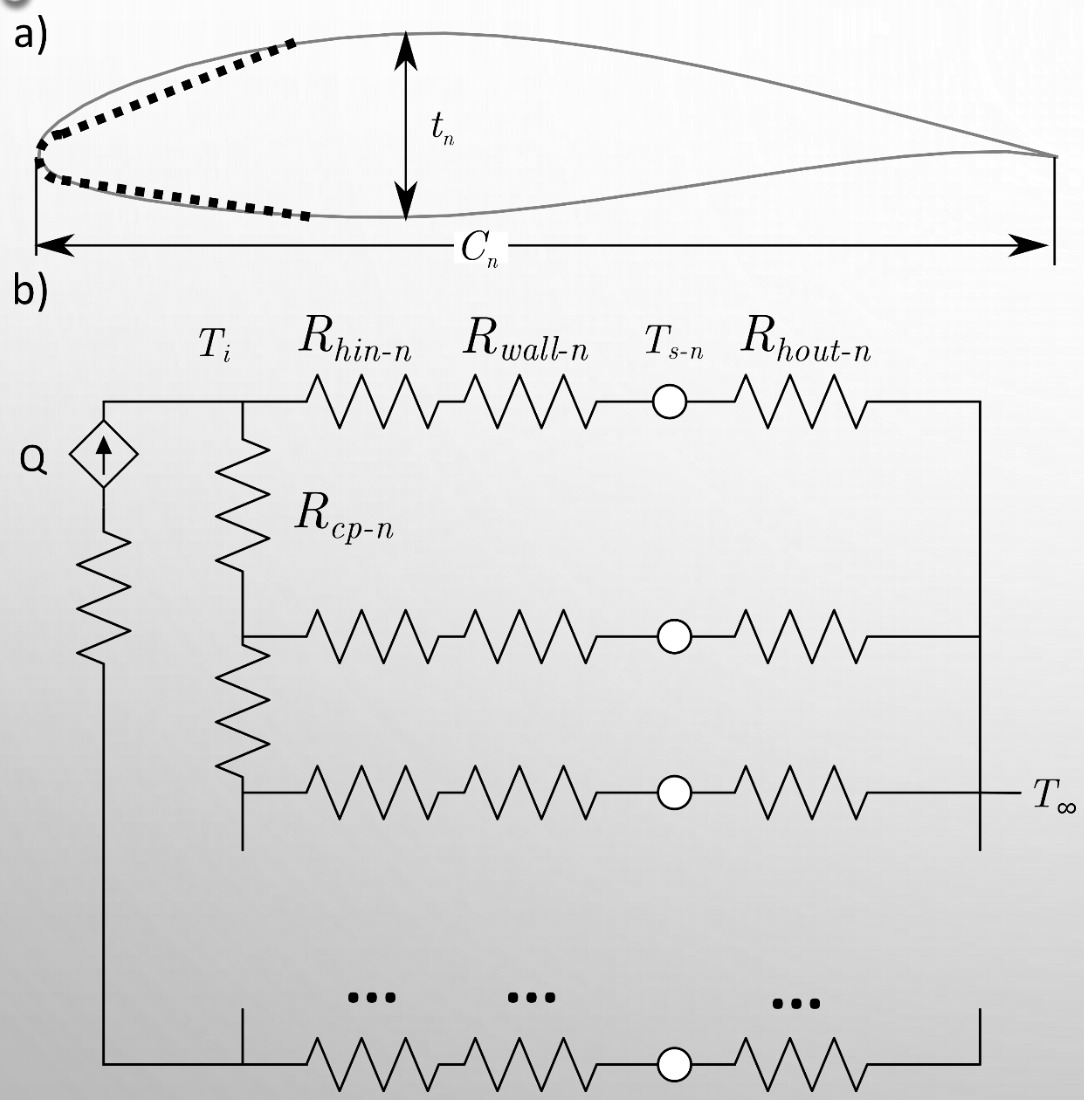
THROWBACK TO WINTERWIND 2019

Bégin-Drolet *et al.* (2019) *How efficient is your blade heating?* Winterwind 2019,



study of 80+ turbines
turbine stoppages = 12521
total downtime = 27185h

BLADE HEATING MODEL



- Based on a simple 1D blade heating model;
- Thermal resistance approach;
- Blade broken into 14 sections of different profiles;
- Does not take into account LWC;
- Accounts for rotation rate (higher convection at the tip).

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ELSEVIER

Field analysis, modeling and characterization of wind turbine hot air ice protection systems

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Icing
Cold climates
Anti-icing
De-icing
Icing measurements

ABSTRACT

In the rapidly expanding market of wind energy, sites in cold climates are becoming popular because of their high wind potential. However, several challenges are associated with energy production in those sites. Such challenges not only include low temperature and high winds, but also multiple icing events. To cope with the negative impacts of icing, wind turbine manufacturers nowadays include ice protection systems (IPS) to their products. It has been observed that the performances of those systems can be greatly influenced by the ambient conditions. In many occasions, under harsh conditions, turbines IPS may not able to prevent ice formation on the blades nor to remove ice that is already formed. Multiple numerical analysis were made on the IPS performance but none of them relies on actual field data. In this paper, the relationship between the turbine stoppage time, wind speed and ambient temperature was studied on a wind farm of over 80 turbines in eastern Canada. The test site is subject to harsh weather and long recovery time and can therefore provide interesting data on icing events. A simplified 1-D heat transfer model of the blades during recovery time has been developed and then

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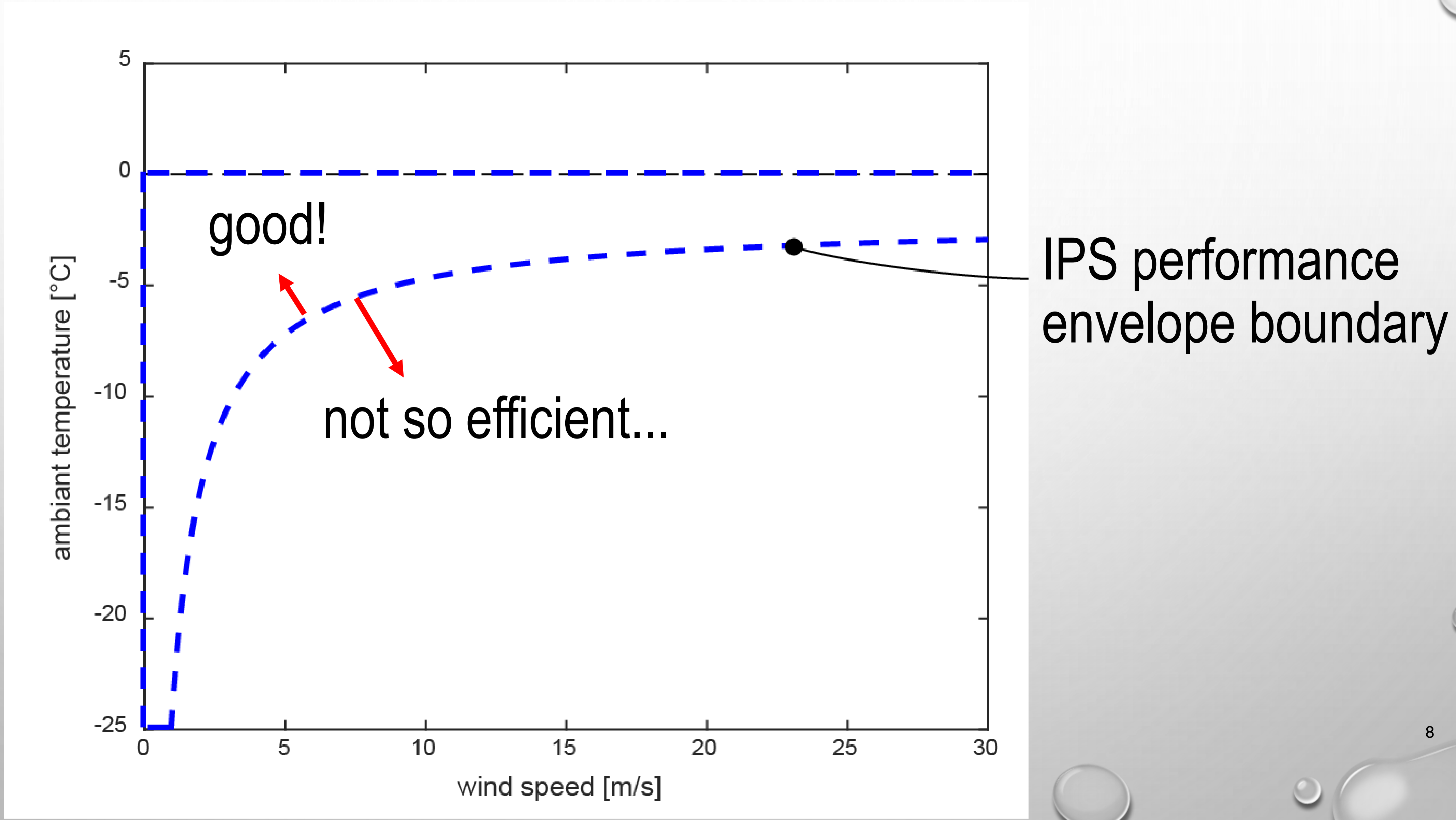
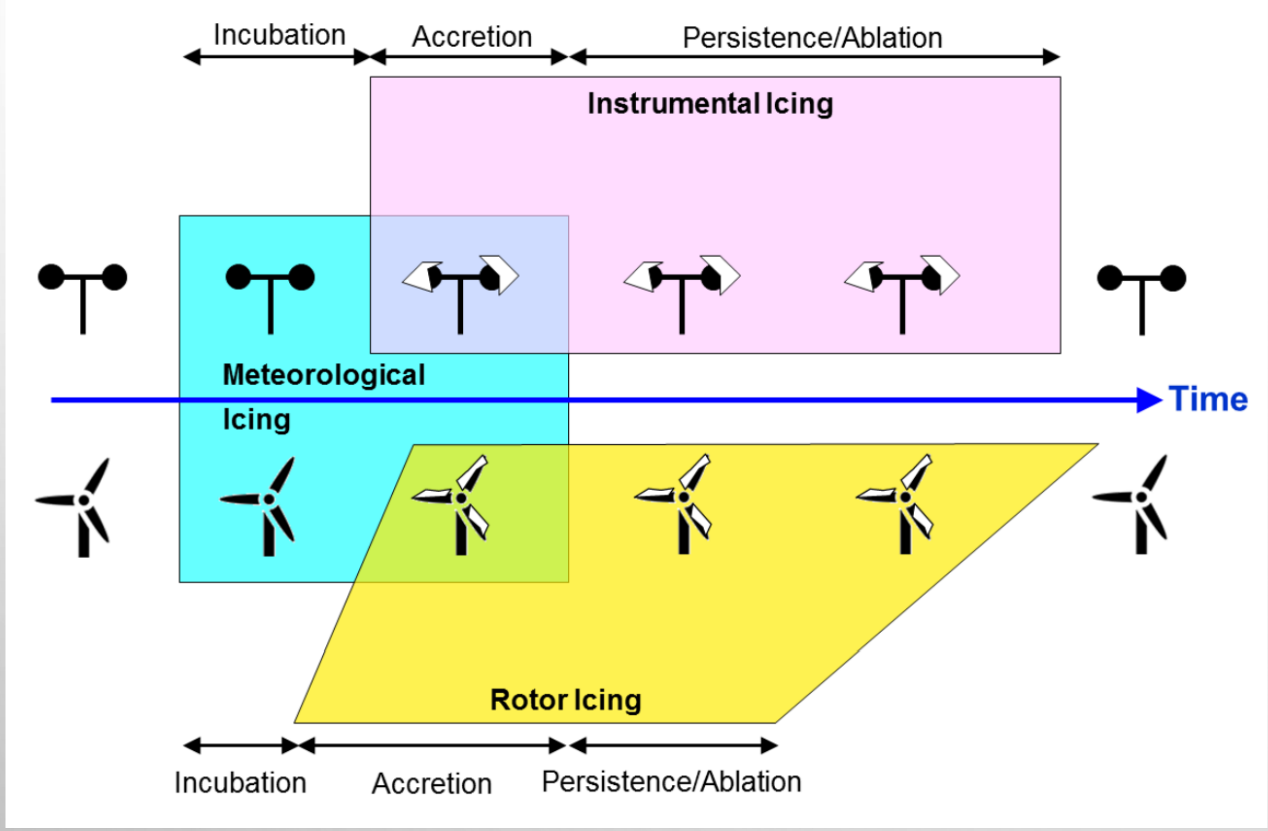
IPS PERFORMANCE ENVELOPE



ANALYSIS OF A SINGLE WIND TURBINE



Source: Lehtomäki *et al.* (2018) Available Technologies for Wind Energy in Cold Climates - report. IEA Wind Task 19.

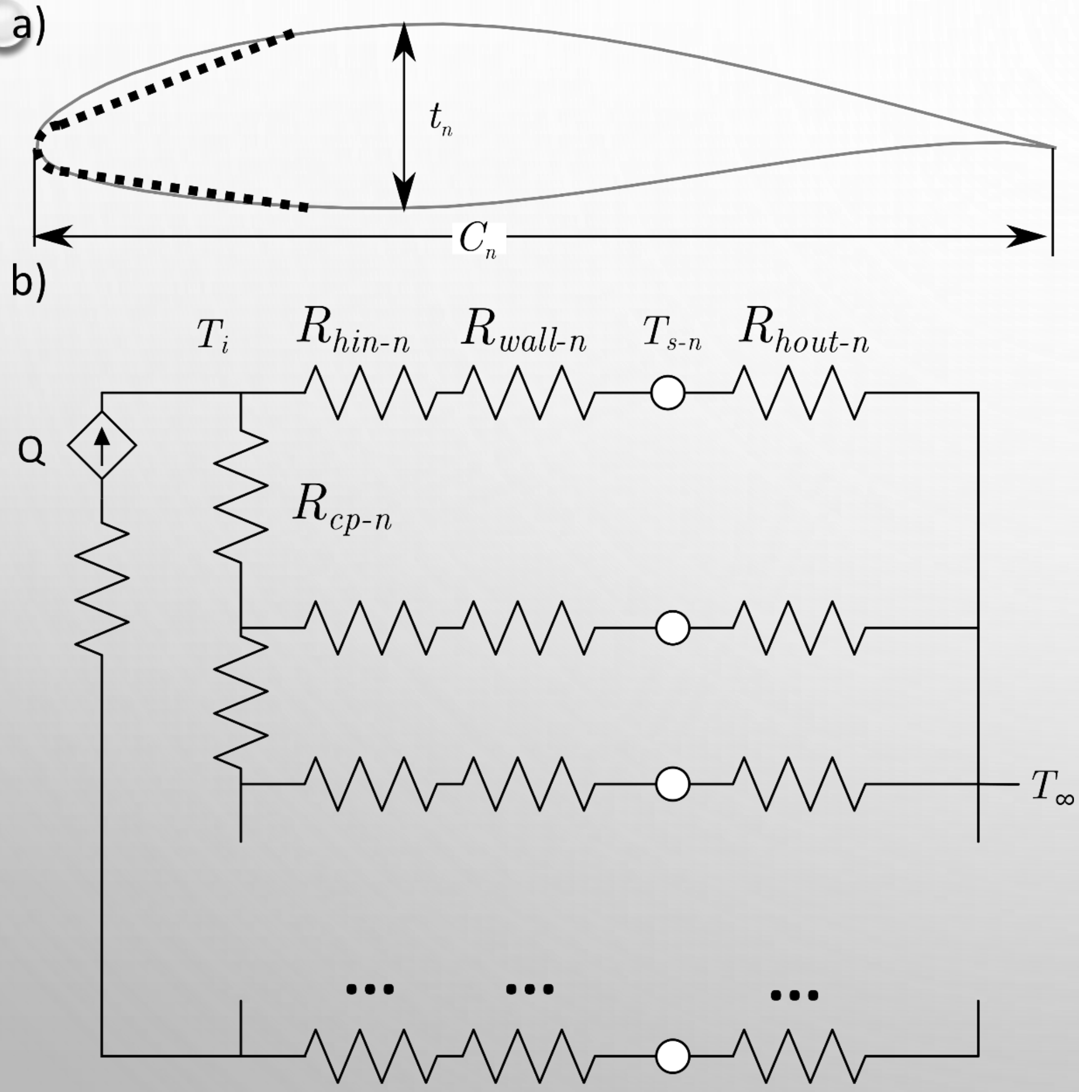
WEC type: confidential
IPS system: hot air
Location: confidential
Operator: confidential
Dates: september 2018 to june 2019

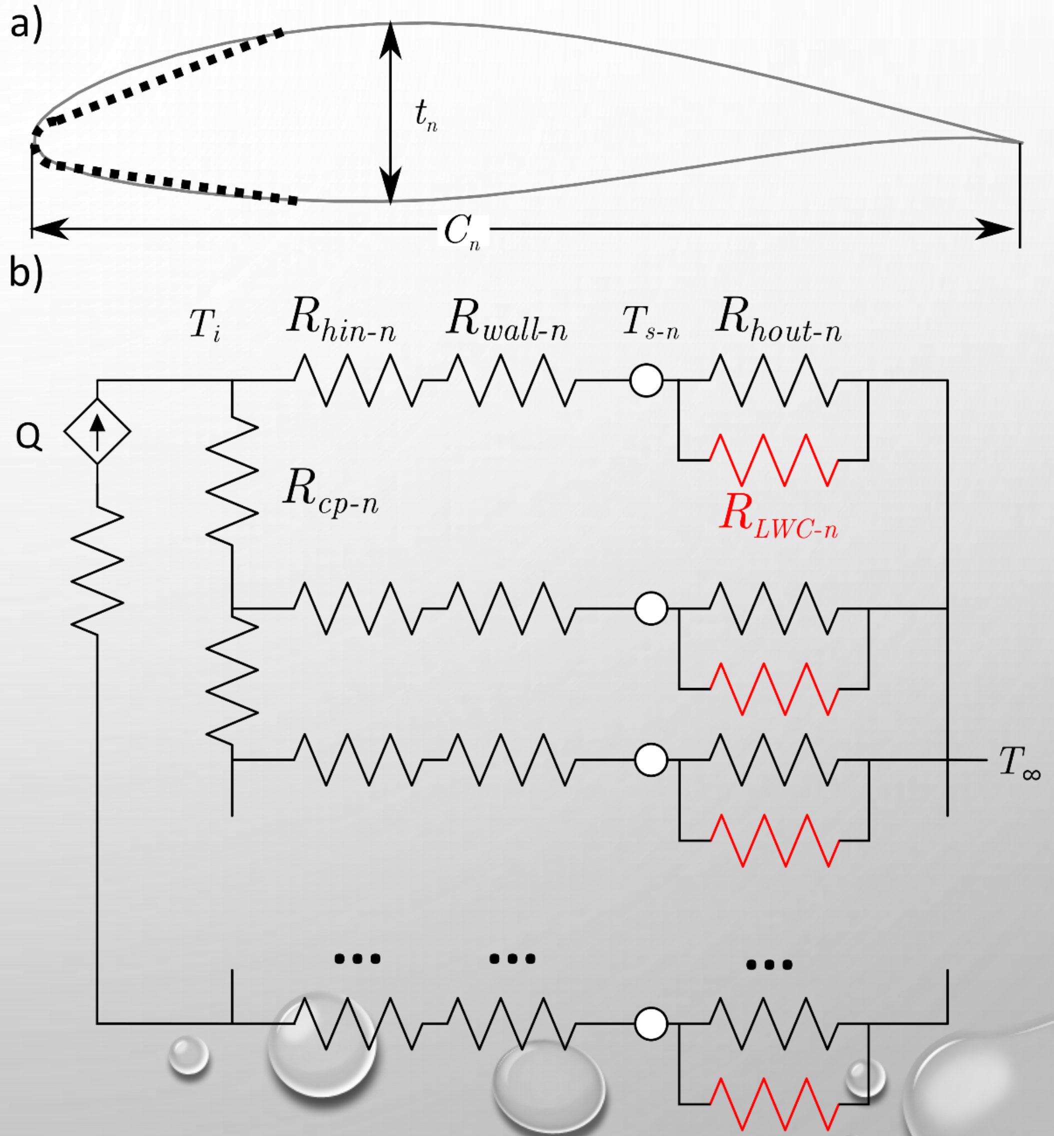
ICING DATA:

- 27 icing episodes
- Meteorological icing: 385 h
- Rotor incubation: 80 h
- Rotor accretion: 305 h
- Persistance/ablation time: 76 h
- Rotor icing: 381 h
- Total icing time: 461 h

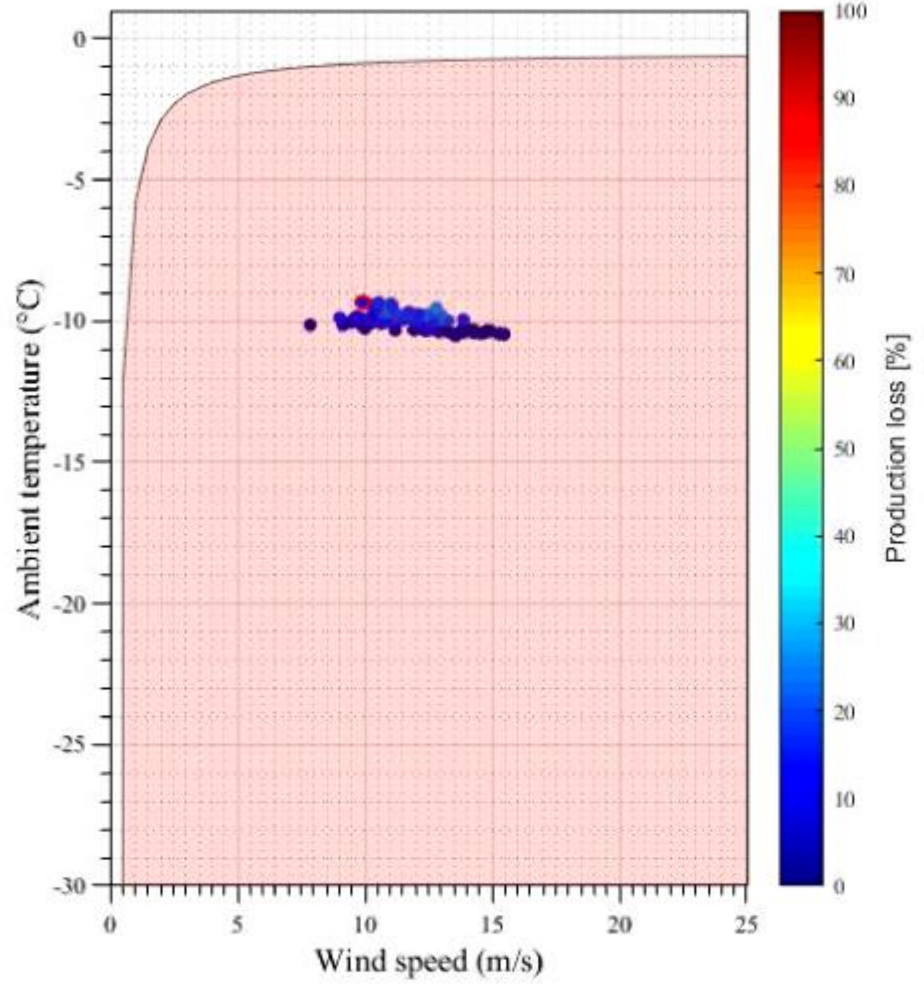
IEA ICE CLASS 3

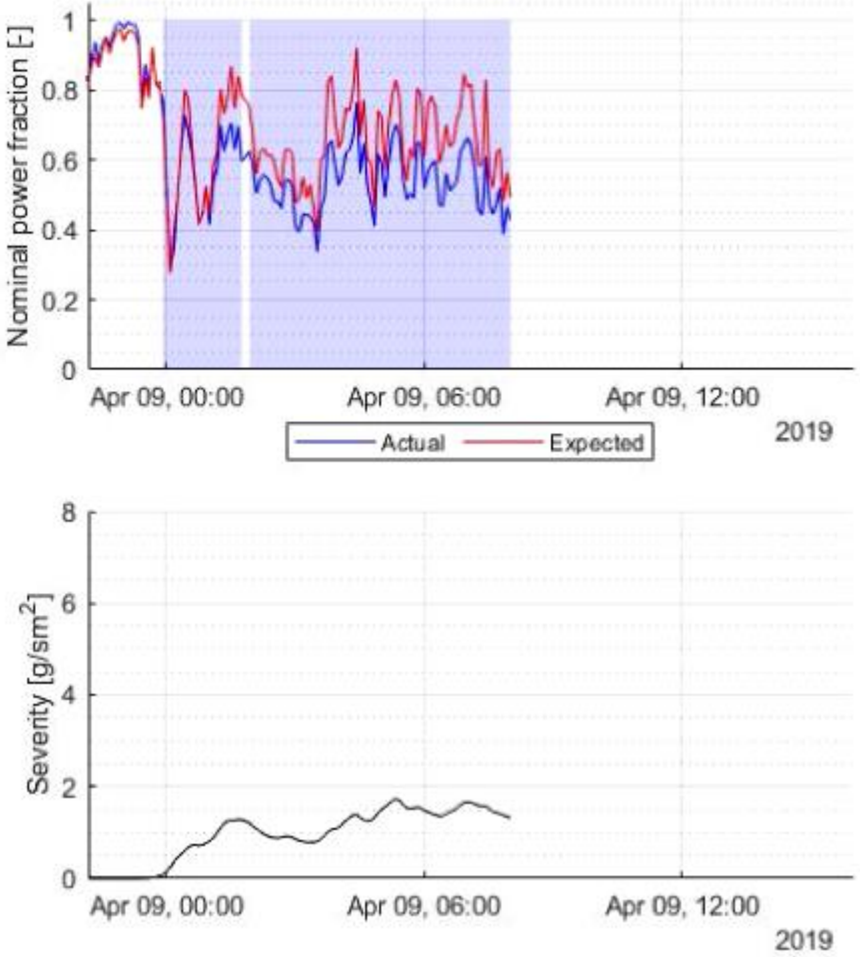
HOW TO ACCOUNT FOR LWC?



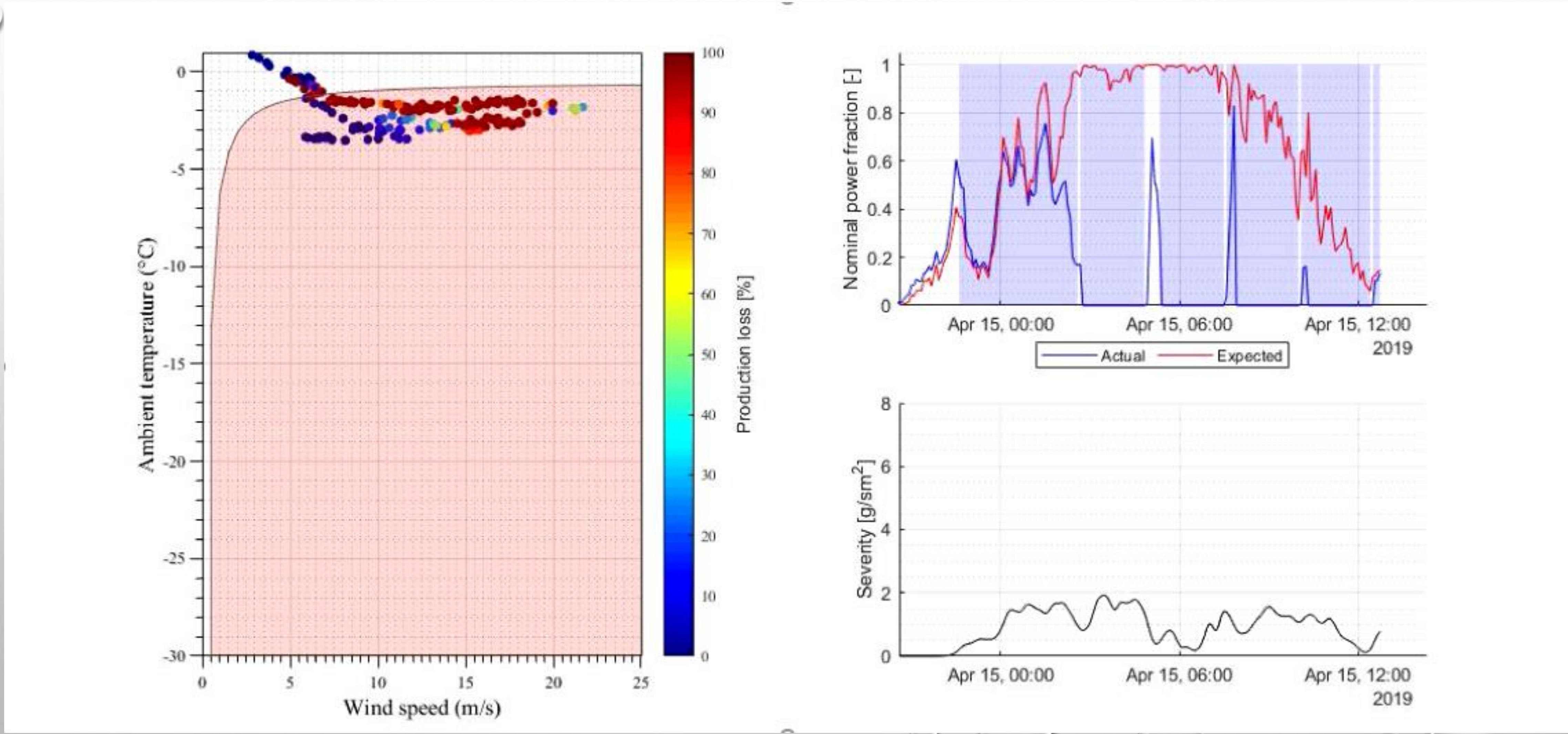


2019-04-09


Ambient temperature (°C)
Wind speed (m/s)
Production loss [%]
0
-5
-10
-15
-20
-25
-30
0
5
10
15
20
25
100
90
80
70
60
50
40
30
20
10
0

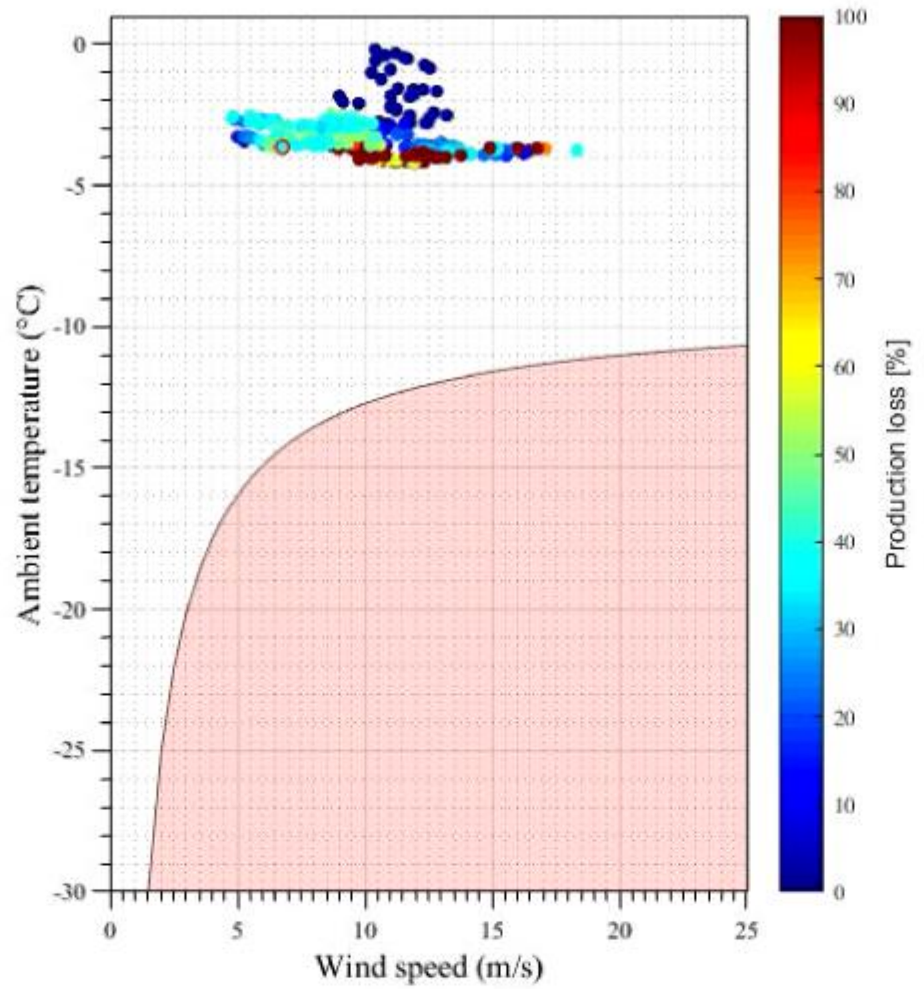

Nominal power fraction [-]
1
0.8
0.6
0.4
0.2
0
Apr 09, 00:00
Apr 09, 06:00
Apr 09, 12:00
2019
Actual
Expected
Severity [g/sm^2]
8
6
4
2
0
Apr 09, 00:00
Apr 09, 06:00
Apr 09, 12:00
2019

2019-04-14

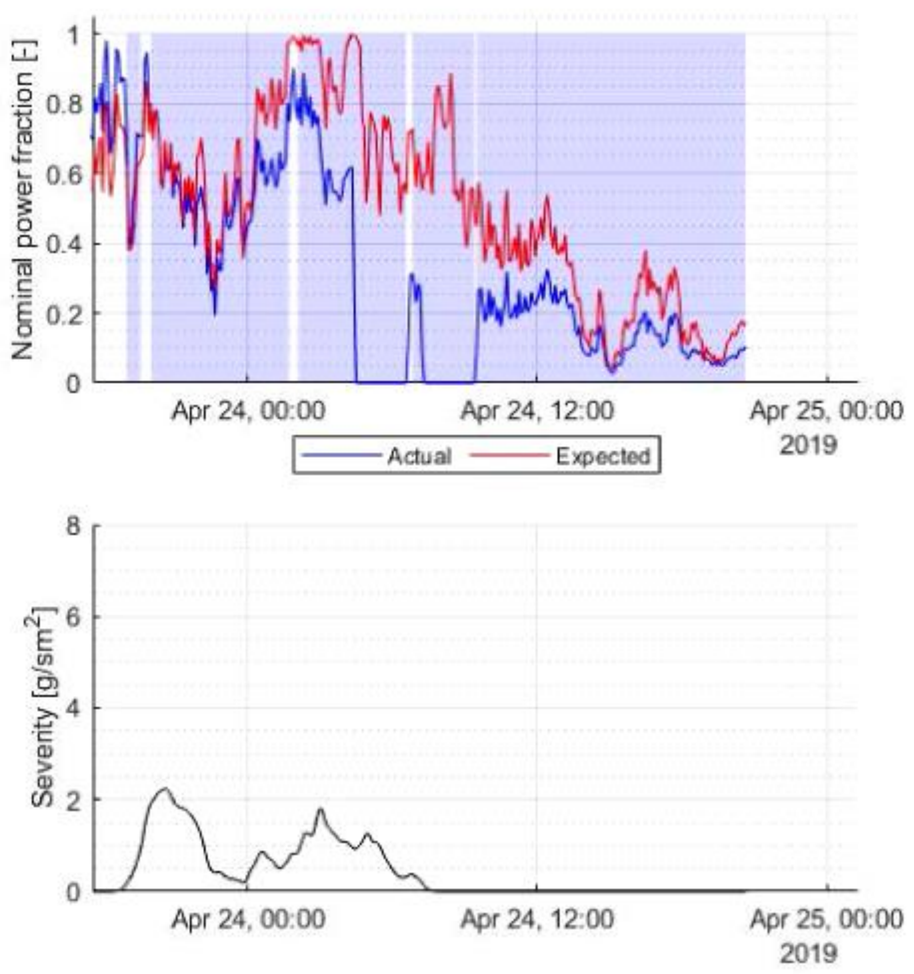


Ambient temperature (°C)
Wind speed (m/s)
Production loss [%]
Nominal power fraction [-]
Actual
Expected
Apr 15, 00:00
Apr 15, 06:00
Apr 15, 12:00
2019
Severity [g/sm²]

2019-04-23



Ambient temperature (°C)
Wind speed (m/s)
Production loss [%]



Nominal power fraction [-]
Apr 24, 00:00
Apr 24, 12:00
Apr 25, 00:00
2019
Actual
Expected
Severity [g/sm^2]

CONCLUSION AND PERSPECTIVES

- The importance Industry/academia partnerships and the benefits for all parties.
- IPS performance envelopes are a simple and efficient way to analyze and explain power losses.
- We need to gather more data to improve our blade heating model.

Contact information

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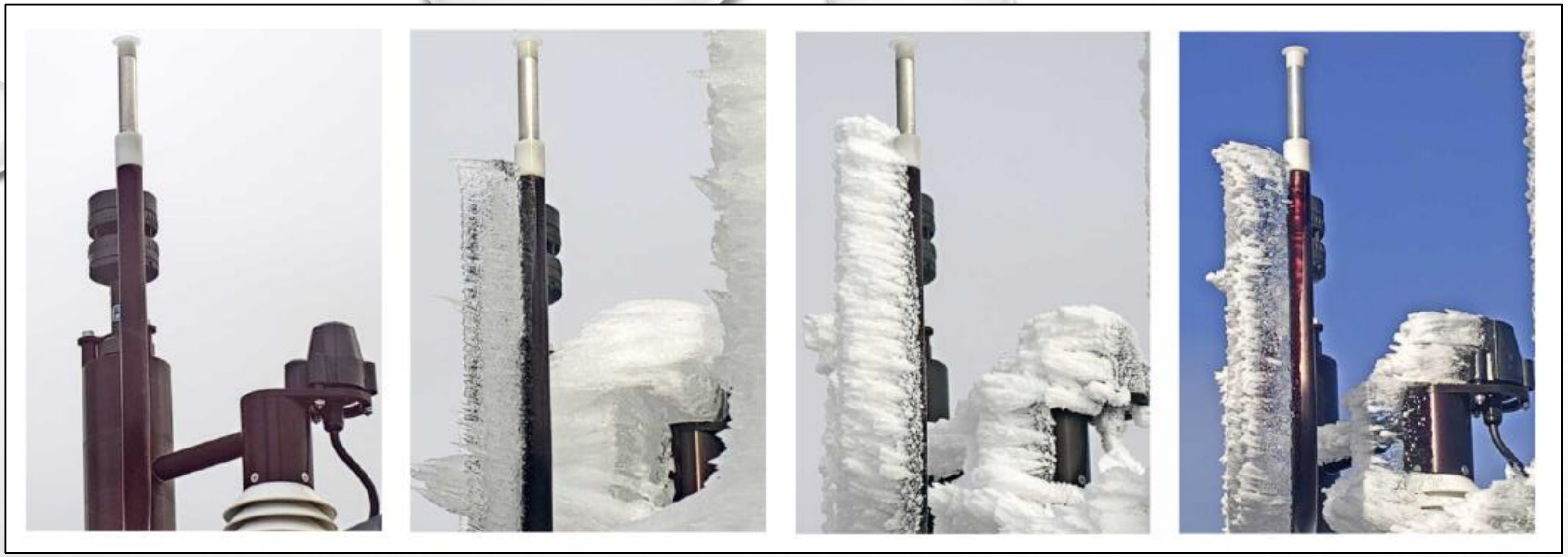
MERCI
THANK YOU
TACK

Meteorological Conditions Monitoring Station (MCMS)



Measurements		
Wind speed	0 to 50 m/s	± 0.5 m/s (0 to 15 m/s) ± 4 % (>15 m/s)
Wind direction	0 to 360°	± 4°
Temperature	-40 to 60 °C	± 0.1°C (-18°C to 30°C) ± 0.5°C (else)
Relative humidity	0 to 100 %	± 3 % RH
Barometric pressure	30 to 110 kPa	± 0.1 kPa
Solar radiation	0 to 1800 W/m^2	± 5 %
Liquid water content[2]	Typ. 0 to 1 g/m^3	
Icing severity[2]	Typ. 0 to 10 $g/(sm^2)$	
Ice accumulation[2]	mm	
Icing type[2]	glaze, soft rime, hard rime	
Precipitation	on/off	
Meteorological icing	on/off	
Instrumental icing	on/off