How to Adapt Standard Ice Loss Assessment Models to Local Conditions ?

Marie C. Pedersen and Morten L. Thøgersen
EMD International A/S

Winterwind 2025

February 3–5, Skellefteå, Sweden

Introduction

- Question: How to adapt standard ice loss assessment models to local conditions ?
- Why: in principles it can be applied at any location 🌍 👍

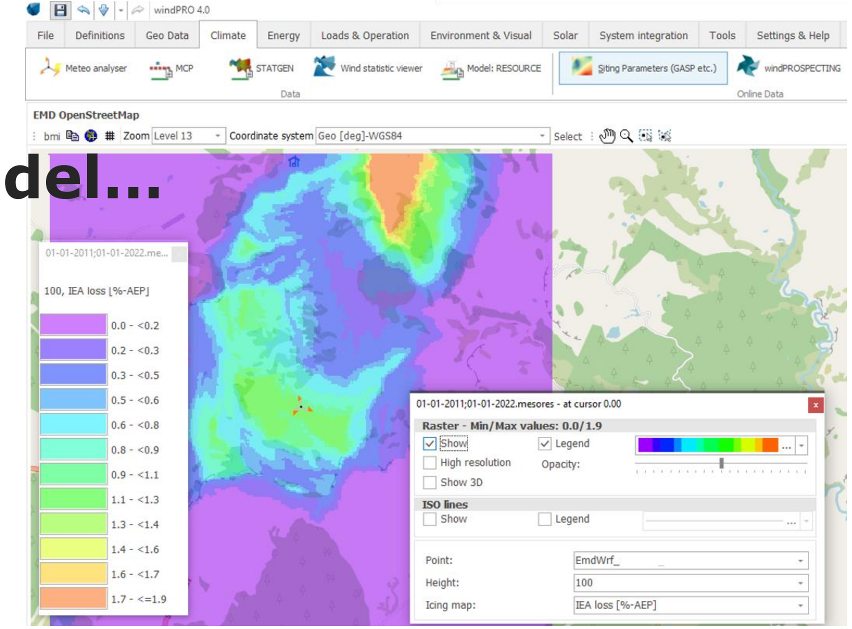
  ➡ some local conditions challenge the methodology… 😫

- Examples:
  - Complex terrain
    - Downscaling
    - Higher resolution modelling
    - Multipoint approach
    - Long-term corrections of icing variables
  - Light icing sites
    - Temperature bias corrections
  - “Out of bounds modelling” for extreme norths
    - Beneficial to use more and different datasets

windPRO

A so-called Standard Ice Loss Assessment Model...

- EMD-WRF On Demand Icing [1,2]
  - Relies on industry proven standards



Icing map seen in windPRO.

Atmospheric Data:

WRF + Thompson microphysics [3, 4]

Resolution: 3x3 km, 1 h

ERA5 global boundary conditions

→

Ice Model:

Standard cylinder-based ice model (ISO 12494) [5, 6]

- Ice growth rate, ice load and instru.+ meteo. icing hours

→

Production Loss Estimations:

Production loss estimates using:

IEA Ice Class system

(by IEA Task 19) [1]

↓

Downscaling to 30m using **CopernicusDEM**

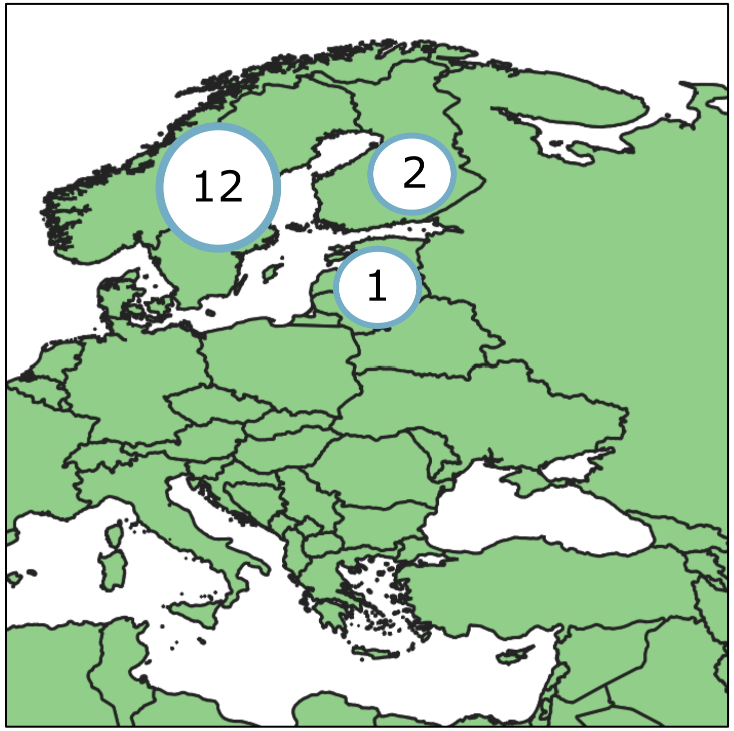
Scope of presentation – temperature bias sensitivity

Study the potential temperature bias:
→ mast vs. WRF

The effect on the modelled icing
- Instrumental icing
- Estimated losses

Case study with 15 masts

Focus on 5 masts



Masts shown as blue dots. The total masts cover: 19 in Sweden, two in Finland, one in Lithuania.

Methodology

Ground truth:

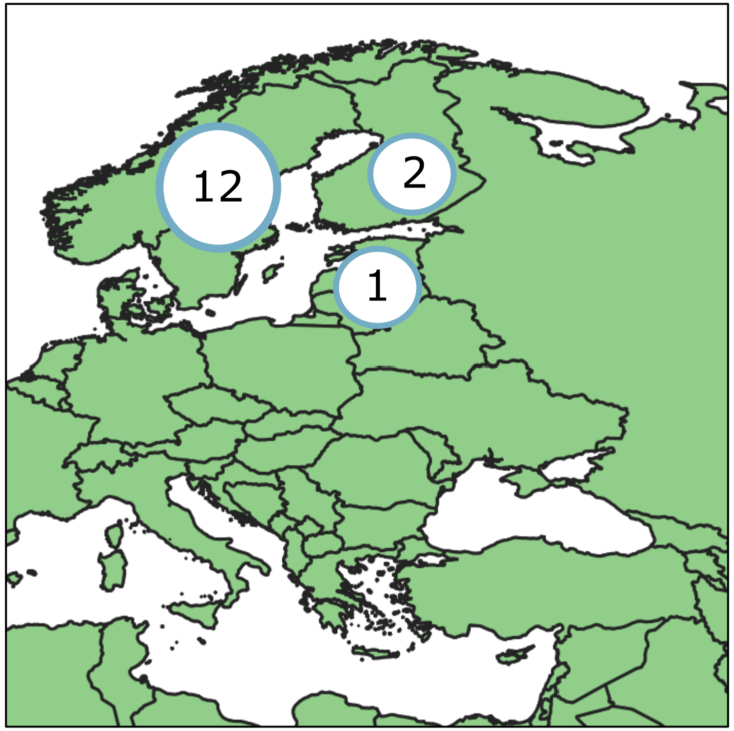
- We have used 15 meteorological masts, 26 icing seasons
  - (filtered, cleaned, quality checked)
- From met masts
  - Measurements of temperature, wind speed and wind direction
  - Extracted instrumental icing using windPRO [2] [3]

Model:

- Run EMD-WRF OD ICING [1]
  - Modelled timeseries of weather and icing
  - Estimates of losses due to icing (% of AEP)

Approach:

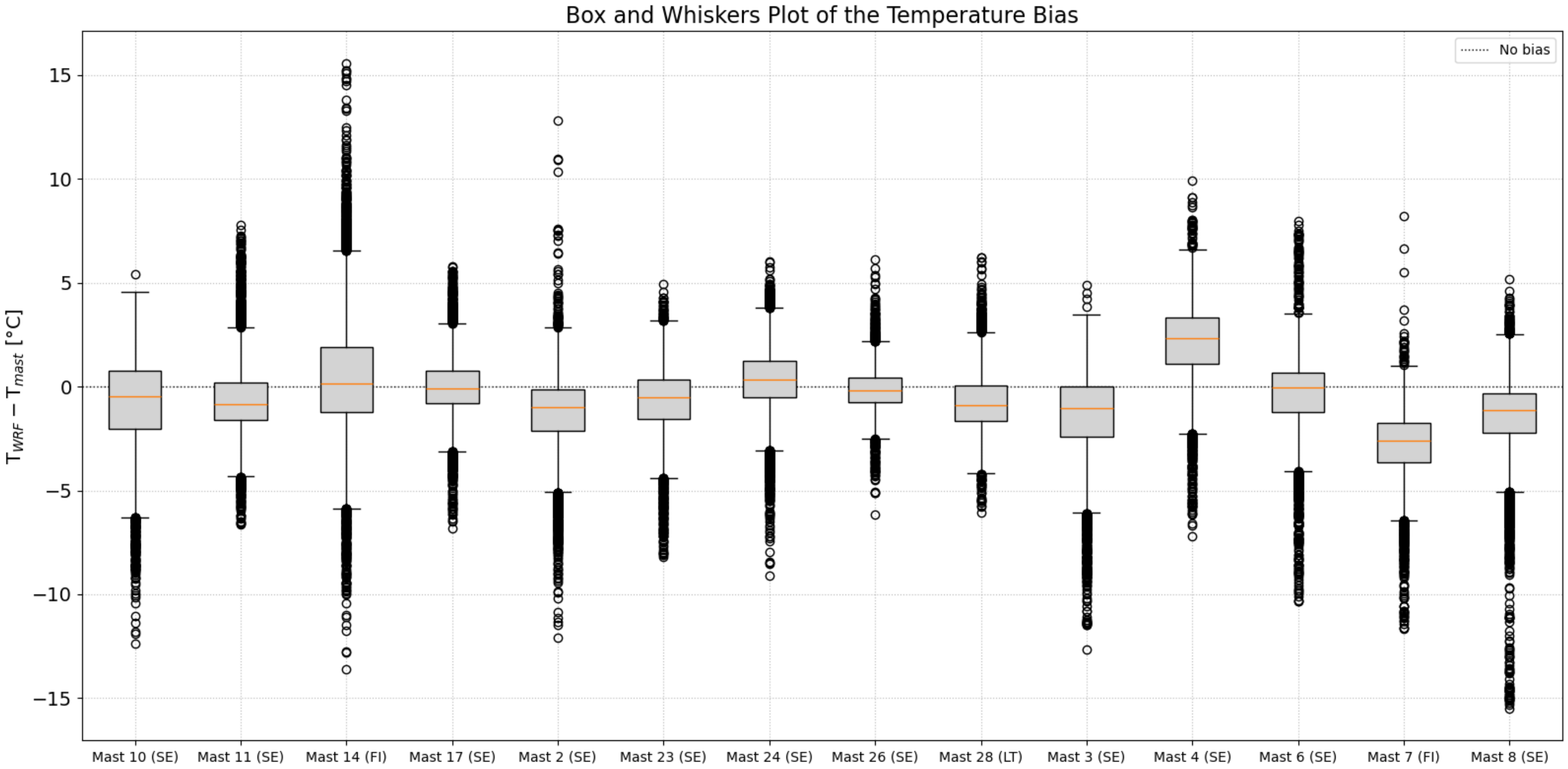
- Join mast and model data
- Compare at mast height during mast measurement periods



Masts shown as blue dots. The total masts cover: 19 in Sweden, two in Finland, one in Lithuania.

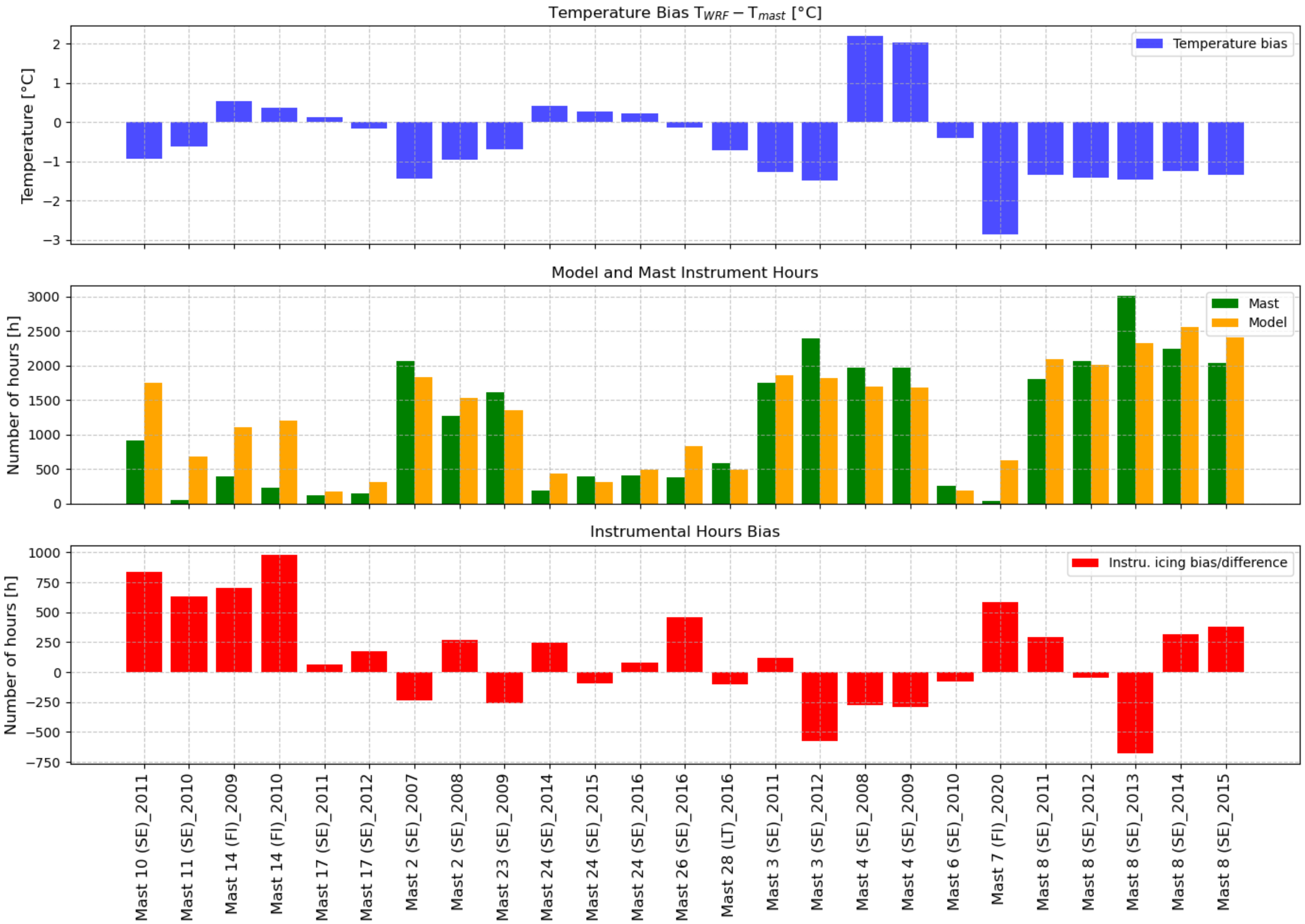
Case study – introduction

- Temperature bias overview
- Plotted for each masts ($T_{WRF} - T_{mast}$)



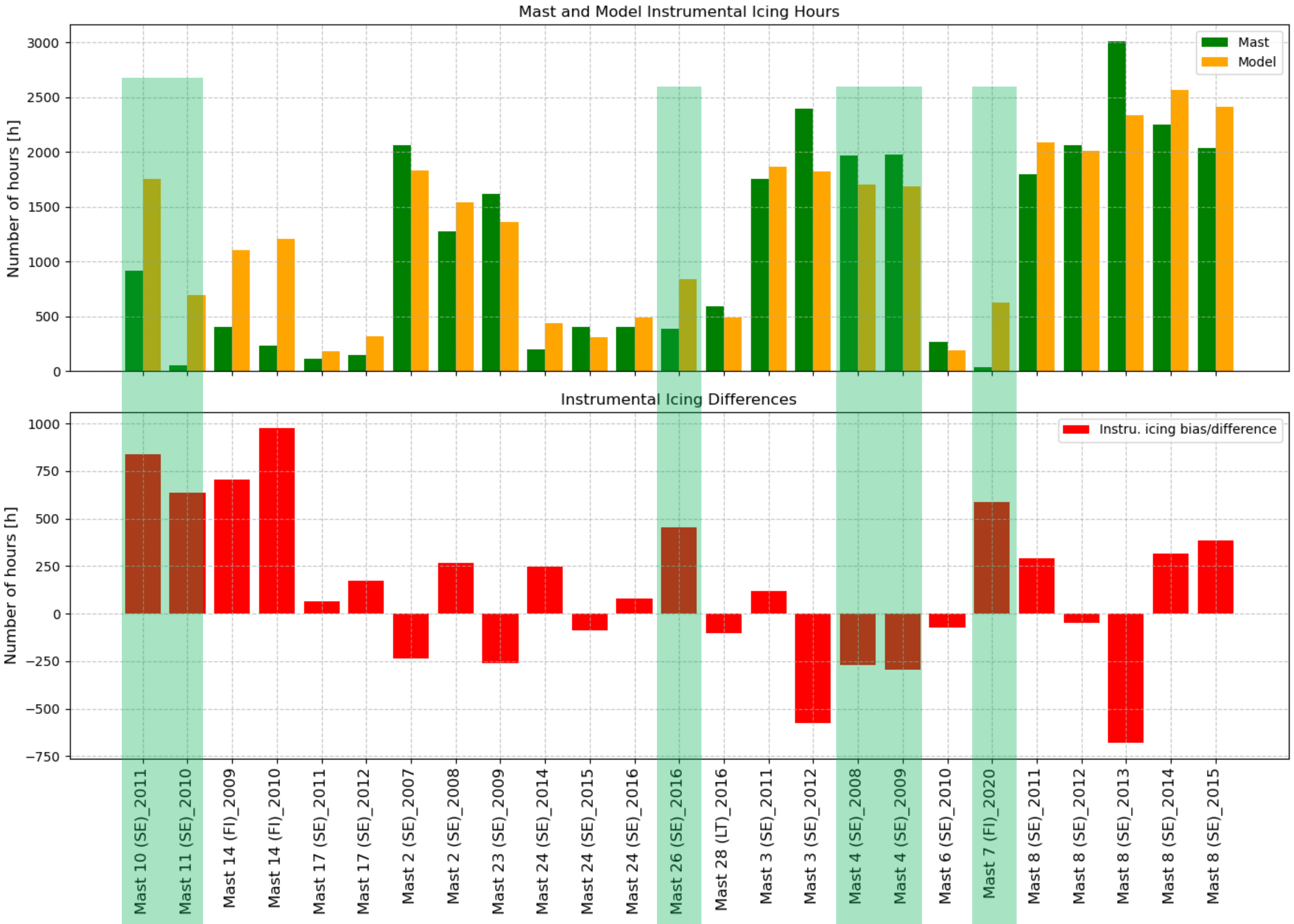
Case study: overview per season

- Temperature bias
- Instrumental icing
- Instrumental icing “bias”



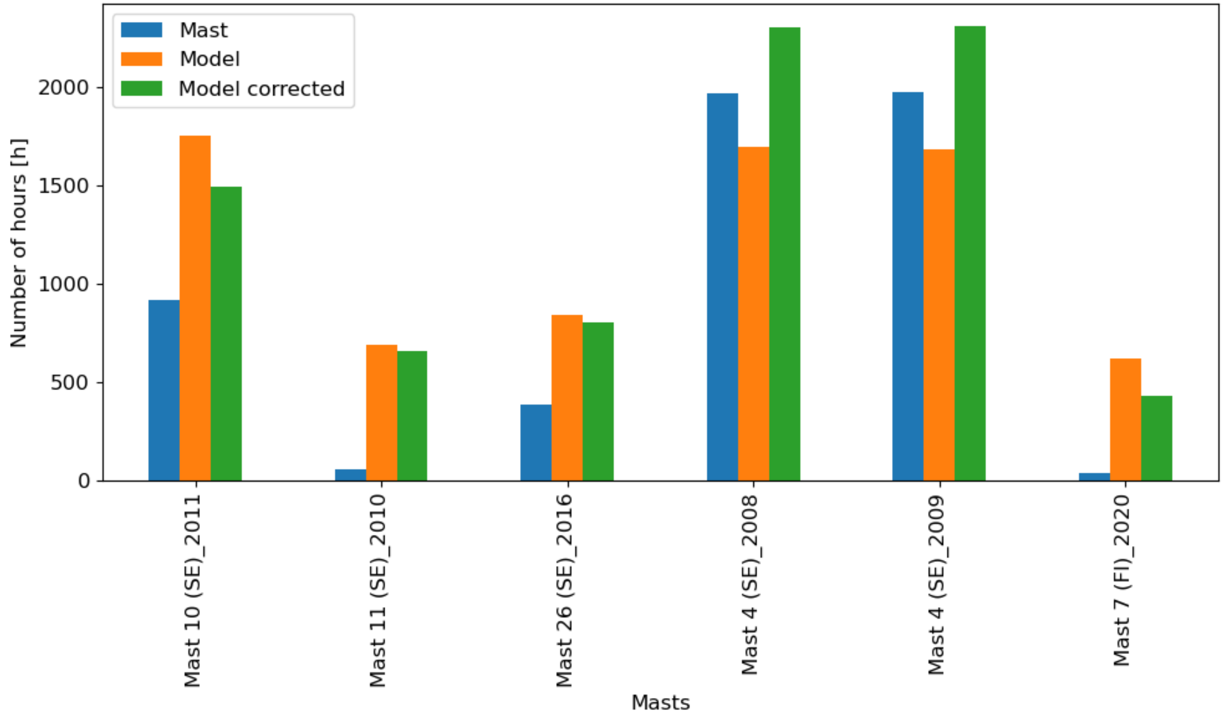
Case study – 5 sites for temp. bias correction

- 5 sites chosen for more investigation



Case Study – instrumental icing

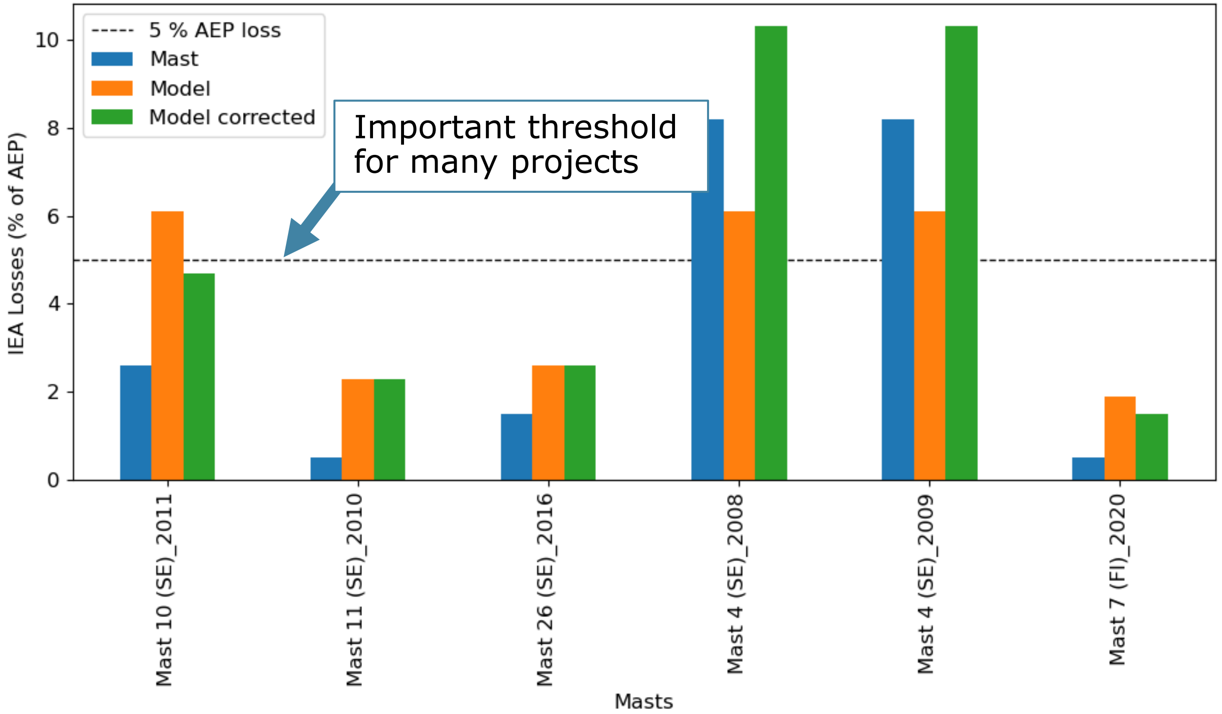
- Correcting using the exacts bias
  - Improvements yes – not perfect
  - Because we are on this mast/season level



Mast	Temp bias	Instru. diff	After corr.
Mast 4 (SE)	2.12	-289	332
Mast 7 (FI)	-3.06	624	434
Mast 10 (SE)	-0.94	839	577
Mast 11 (SE)	-0.61	635	603
Mast 26 (26)	-0.14	455	419

Case Study – IEA losses

- The effect on estimated IEA loss
  - Improvements yes – not perfect
  - What about IEA loss from that mast instrumental icing?
  - Underlines the importance of treating icing as an extremely interannual phenomena!



Mast	Temp bias	IEA Loss corrected	IEA Loss Mast
Mast 4 (SE)	2.12	10.3 (6.1)	8.2
Mast 7 (FI)	-3.06	1.5 (1.9)	0.5
Mast 10 (SE)	-0.94	4.7 (6.1)	2.6
Mast 11 (SE)	-0.61	2.3 (2.3)	0.5
Mast 26 (26)	-0.14	2.6 (2.6)	1.5

windPRO

Case Study – IEA losses interannually

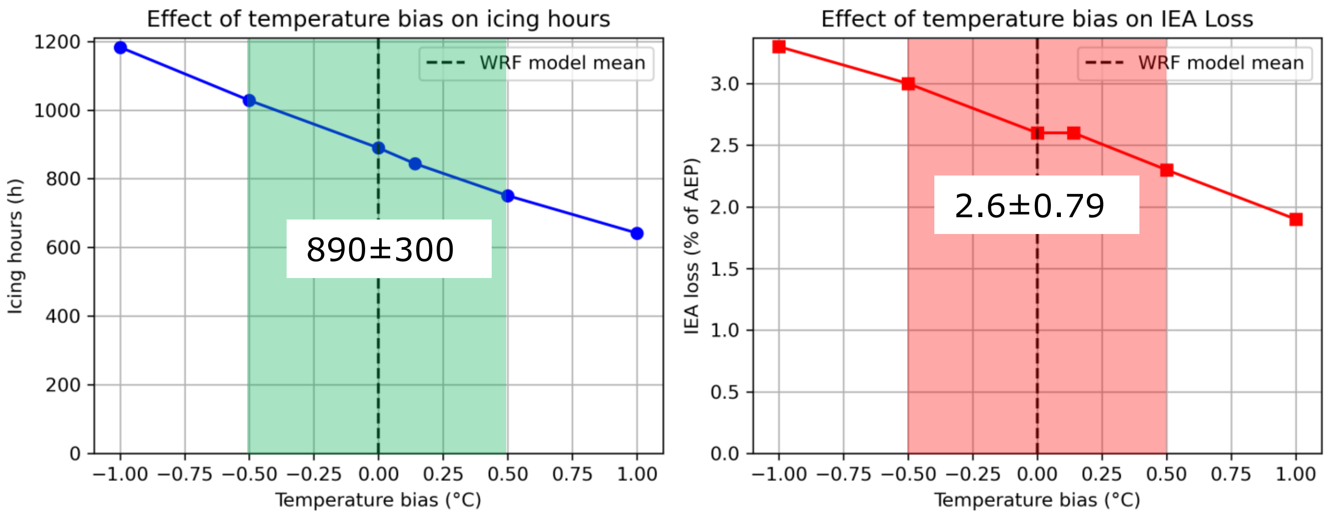
- Modelled results for mast 10 (temp. bias corrected)

Seasons	Instr. hours	IEA ice class	IEA loss (% AEP)
2009-2010	1886	3.5	7.5
2010-2011	1569	3.2	5.4
2011-2012	1494	3.1	**4.7**
2012-2013	1762	3.4	6.8
2013-2014	1756	3.3	6.1
2014-2015	1869	3.5	7.5
2015-2016	1852	3.5	7.5
2016-2017	1584	3.2	5.4
2017-2018	1879	3.5	7.5
2018-2019	1315	2.9	3.6
Mean	1696.6	3.31	**6.2**

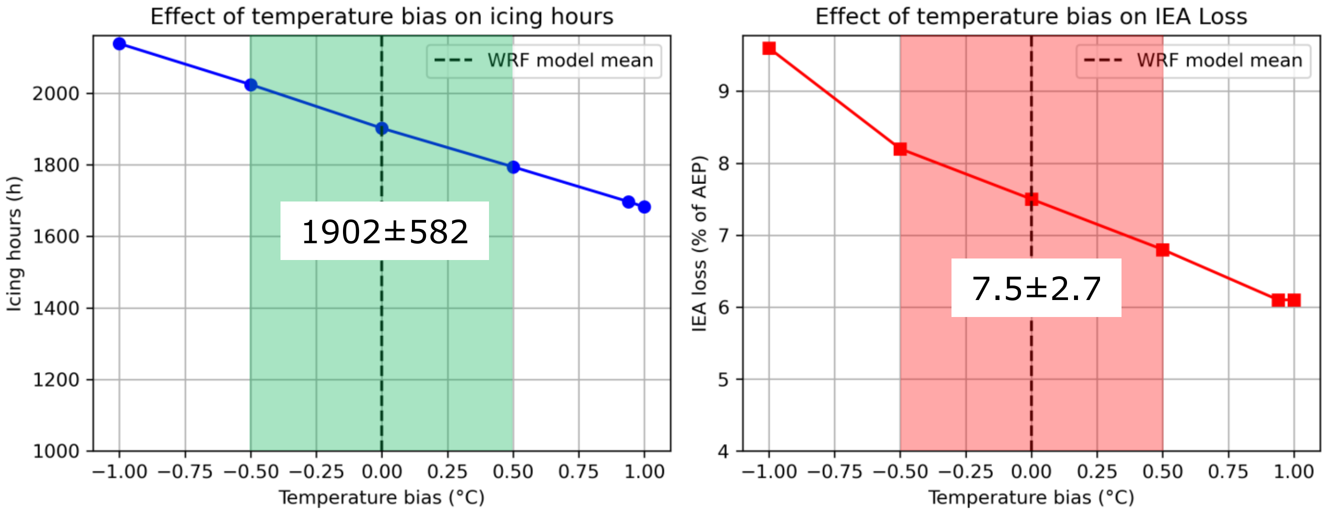
Case Study results – final note

- Case study – study of the effect of temperature correction
  - Modelled instrumental icing
  - Estimated IEA Ice loss
- Especially important for light icing sites
- Using a temp. bias band would provides even more information
  - Especially when masts are not available
  - (modelled mean over 10 seasons)
- The question…

Mast 26



Mast 10



Niels Jernes Vej 10
9220 Aalborg, Denmark
Tel: +45 69164850
E-mail: emd@emd.dk

EMD.DK

visit our website to learn more

References

[1] https://help.emd.dk/mediawiki/index.php?title=EMD-WRF_On-Demand_ICING

[2] M. C. Pedersen, T. Ahsbahs, W. Langreder, M.L. Thøgersen, *"On the modelling chain for production loss assessment for wind turbines in cold climates,"* Cold Regions Science and Technology, Volume 216, 2023, 103989, ISSN 0165-232X, https://doi.org/10.1016/j.coldregions.2023.103989.

[3] M. C. Pedersen, T. Ahsbahs and M.L. Thøgersen, *"Validation Study of Modelled Icing using Met Mast data and SCADA data"*, winterwind 2022, Skellefteå, https://windren.se/WW2022/09_3_15_Pedersen_Validation_study_of_modelled_icing_using_met_mast_data_and_SCADA_data_Pub_v2.pdf

windPRO

Methodology

Met mast data prepared using **windPRO**

- Abnormalities in the data
  (wind vane, double anemometry, T<0°C)

- Minimum 80% data availability

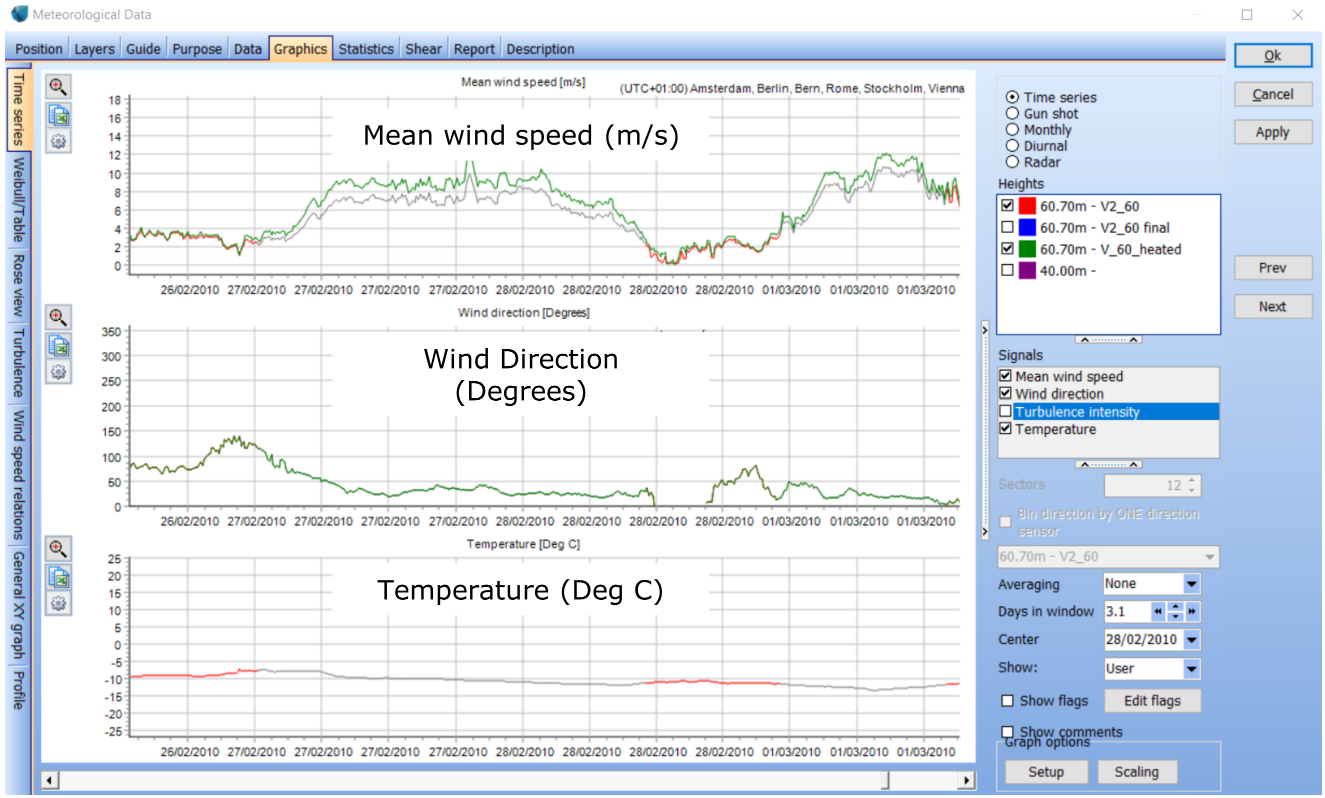
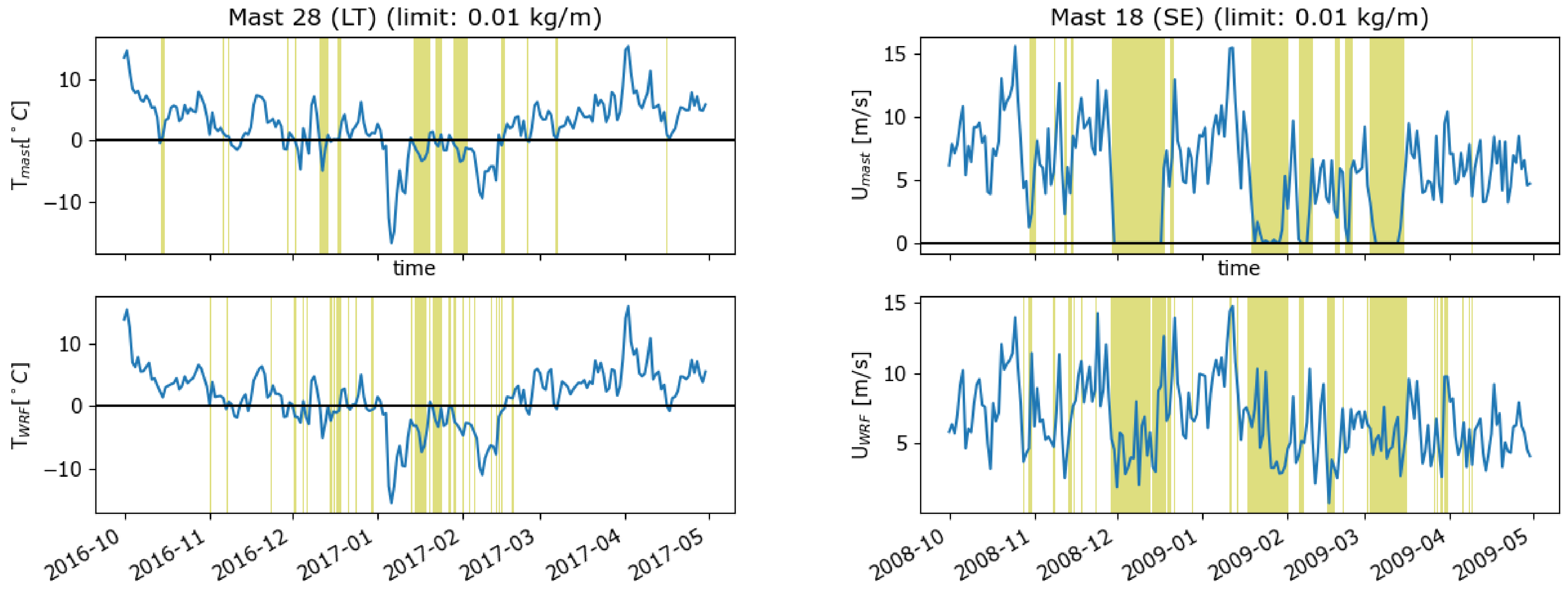


Figure A1: Example of filtering/cleaning data in windPRO.

Do we model seasonal icing well ?

When does instrumental icing start?

- Ice mass over cylinder > 10 g for a 1-m-high standard cylinder



Figures A2: Hourly comparison of mast instrumental icing and modelled instrumental for Mast 28 (LT) and Mast 18 (SE).