Renewable Energy Analytics

Validation of turbine specific modelled ice losses

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Winterwind 2020, Åre

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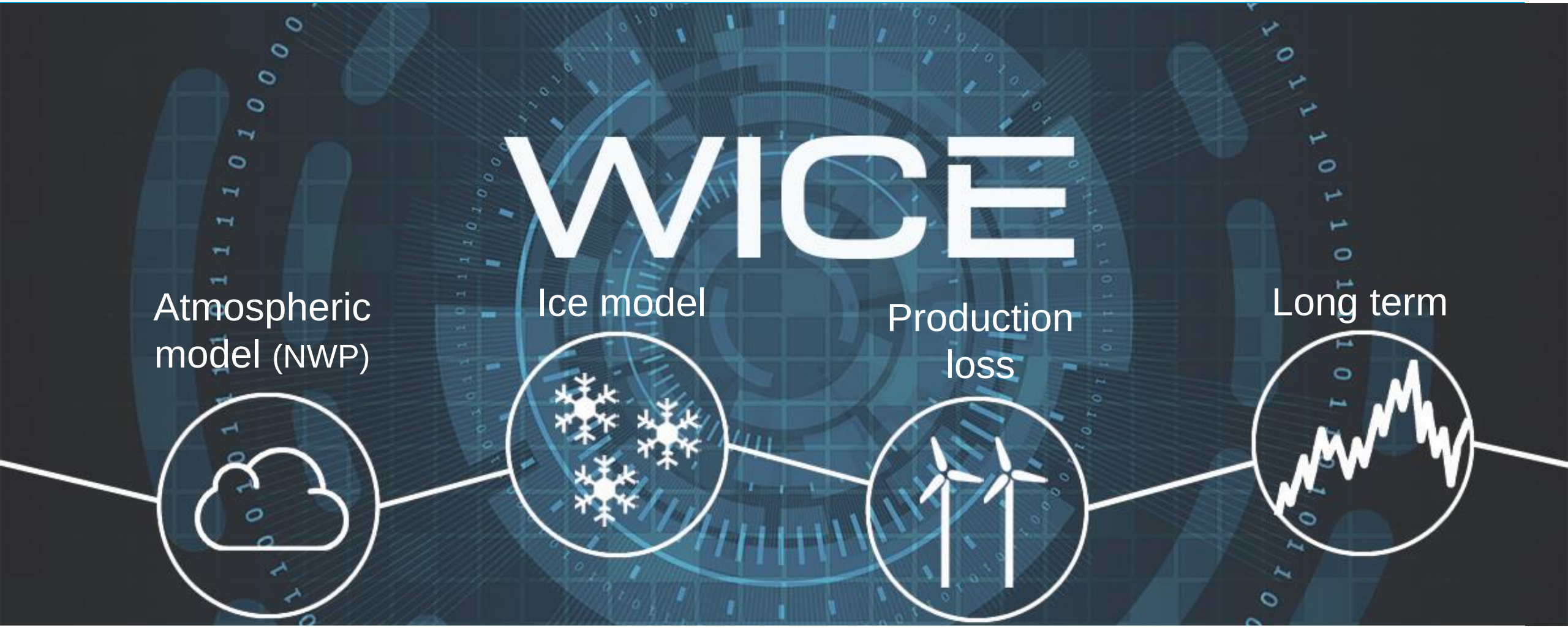
Contents

Part 1: Introduction and Methodology

Icing study model chain



Internal Validation

- 10 sites
- Chosen to cover different regions
  - Sweden, Norway and Finland

SCADA

- 1-7 years per wind farm
- 263 turbines

Weather modelling

- WRF, in-house setup
- 1000m / 333m model grid resolution

- Method used to derive ice losses:
  - DNV GL internal

RES Blind Test

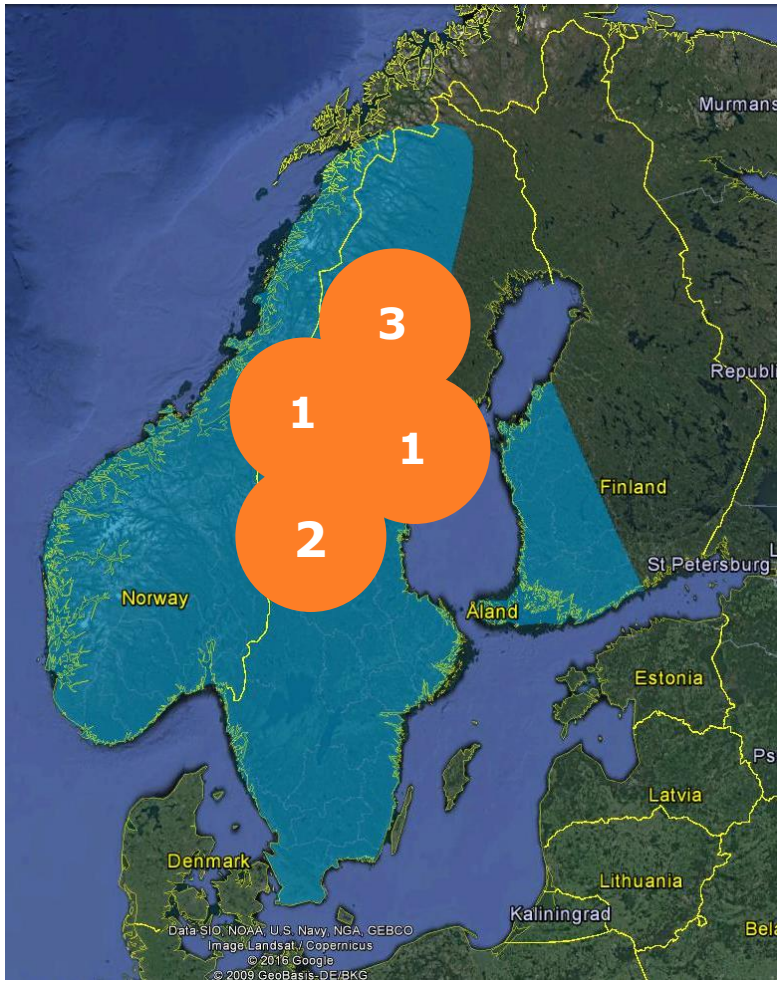
- 6 sites in Sweden chosen by RES

SCADA

- 1 year per wind farm
- 162 turbines

Weather modelling

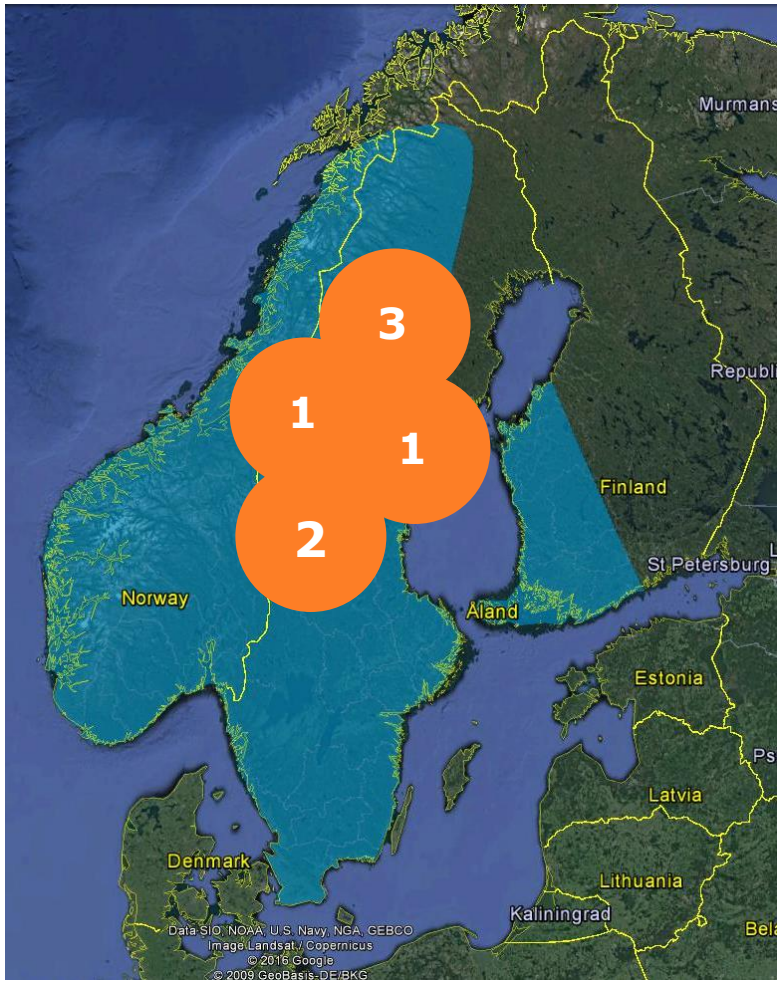
- WRF
- In-house setup
- 333m model grid resolution



RES Blind Test

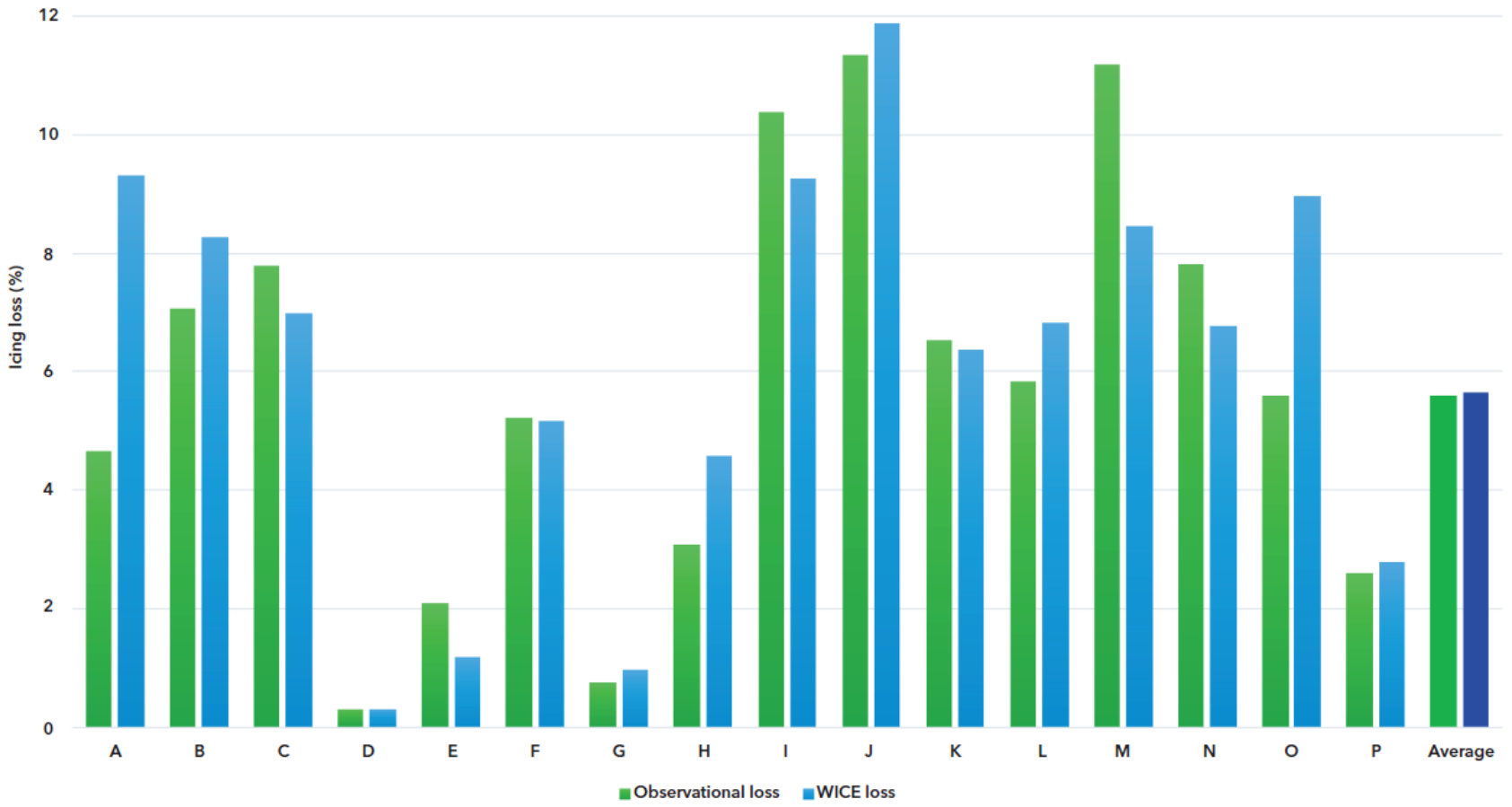
- DNV GL provided hourly times series for each individual turbine
- RES evaluated the model results

- Methods used to derive ice losses:
  - RES Smart
  - IEA-Task 19, v2.0.2
  - IEA-Task 19, v2.2.2



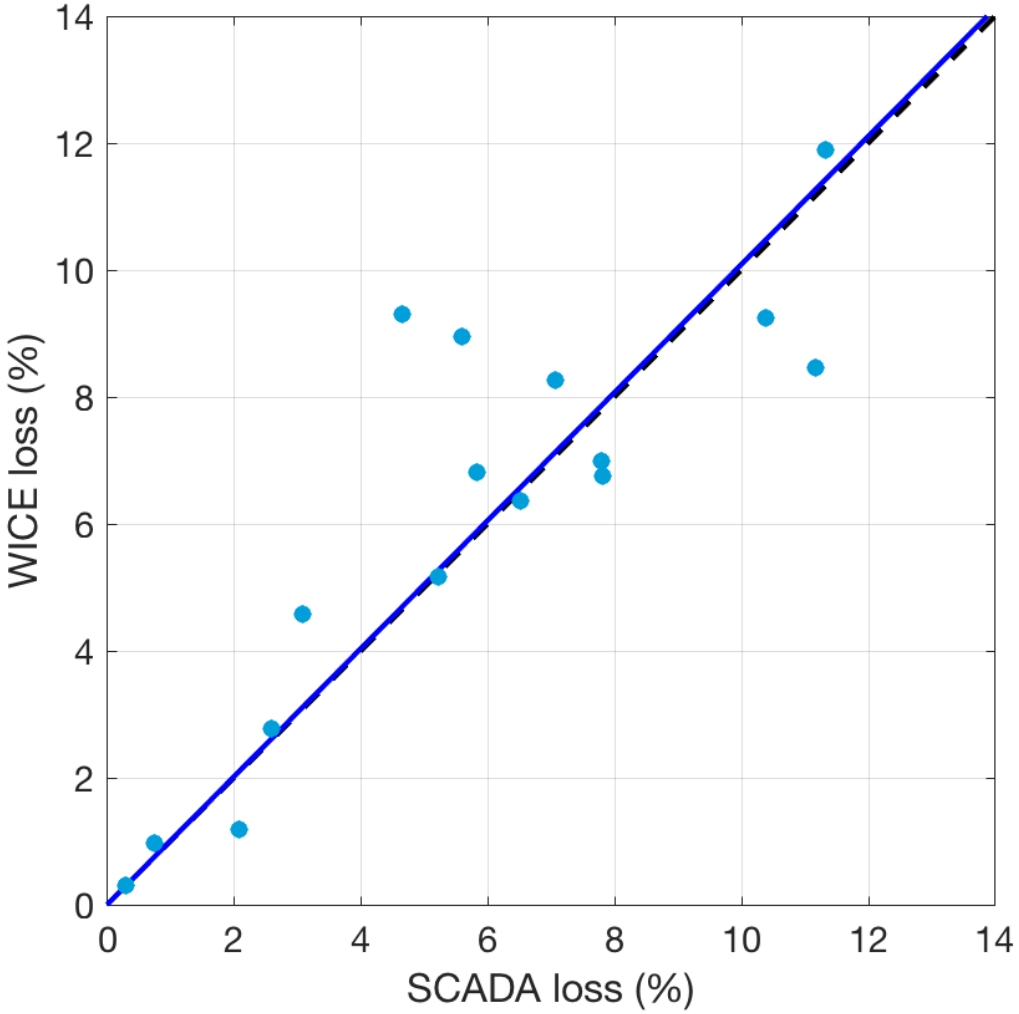
Part 2: Validation of modelled ice losses – Wind Farm level

Internal Validation and RES Blind Test – modelled wind farm ice losses



Internal Validation and RES Blind Test – modelled wind farm ice losses

- Total wind farm ice loss validation
- Increased from 10 to 16 sites (of which 6 are from a blind test)
  - slope: 1.0087
  - std dev: 1.77
  - corr: 0.87

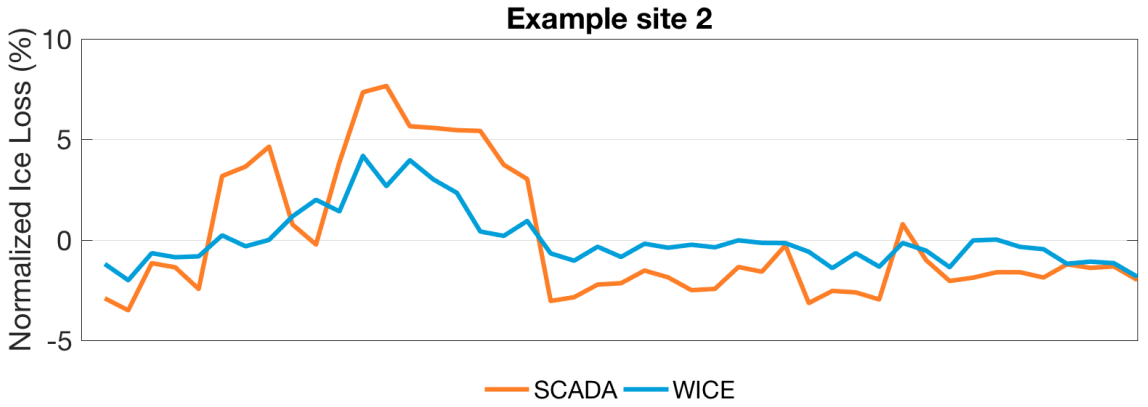


WARNING!
Using different methods to derive ice losses can increase/decrease the ice loss by ~20%

Part 3: Validation of modelled ice losses – Turbine by turbine

Validation of modelled ice losses – Turbine by turbine

Normalized Ice Loss = Turbine Ice Loss – Wind farm Ice Loss



Validation of modelled ice losses – Turbine by turbine

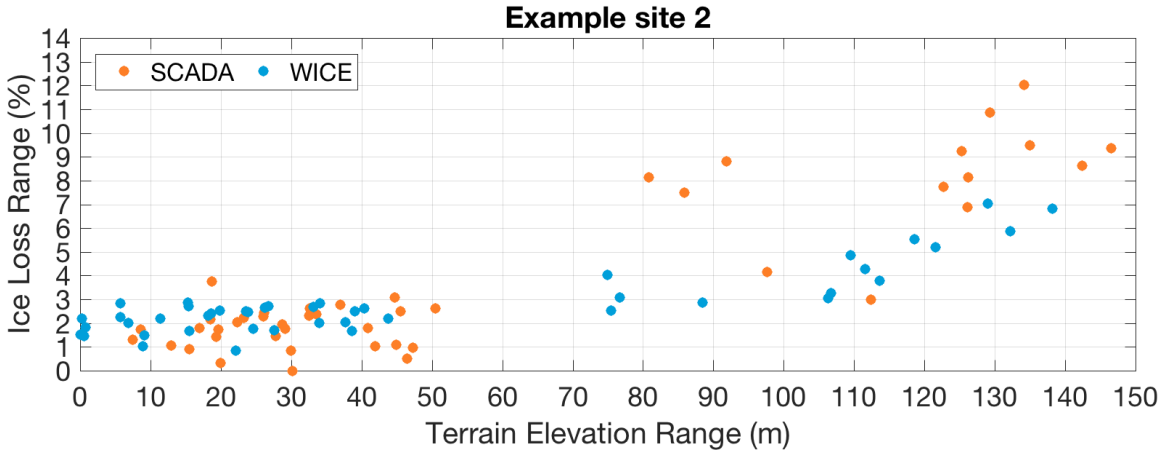
Results from RES blind test

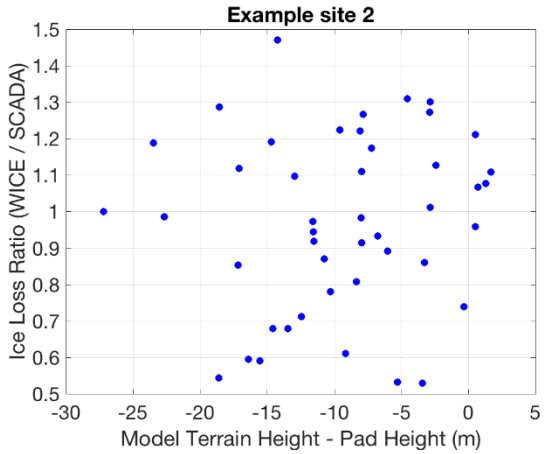
- Spatial variation of icing loss within wind farms
  - DNV GL icing model performs well in reflecting icing loss variation across turbines
  - SCADA data shows icing loss spikes for some turbines

Name	Correlation
Site 1	0.59
Site 2	0.78
Site 3	0.55
Site 4	0.71
Site 5	0.75
Site 6	0.24

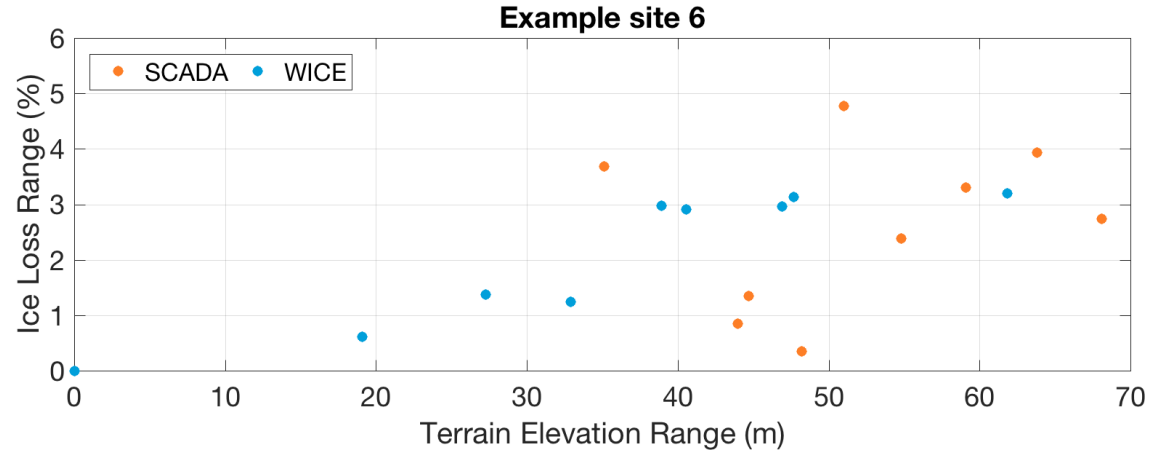
Validation of modelled ice losses – Turbine by turbine

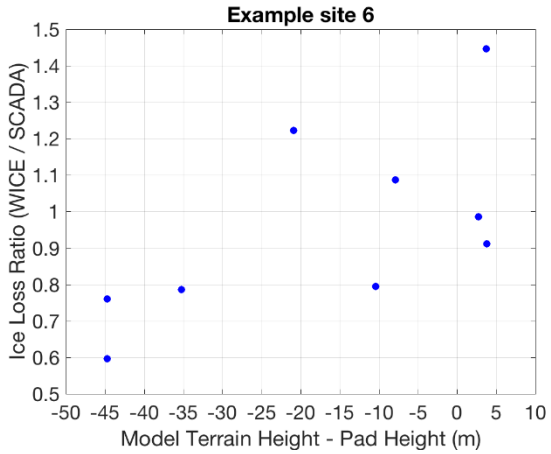
Can differences between model and real terrain elevations be used to improve model performance?





No strong relation between terrain height differences and ice loss ratios





Large spread in SCADA losses vs height. Other factors?

Part 4: Summary

Summary

- Internal and external validation show an overall good agreement between WICE and SCADA-derived losses
  - increased from 10 to 16 sites (6 from a blind test)
- WICE model estimated well the relative icing loss variations within wind farms
  - Can we use this to design wind farms better
    - IPS at certain turbines
    - layout design
- How can we improve the model further to bring more value to wind farm design
  - model grid resolution to better represent the local terrain (scale aware turbulence scheme needed)
  - better or more SCADA data sets to train the ice loss model

Thanks for listening

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