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Variability in Ice Protection System efficiency

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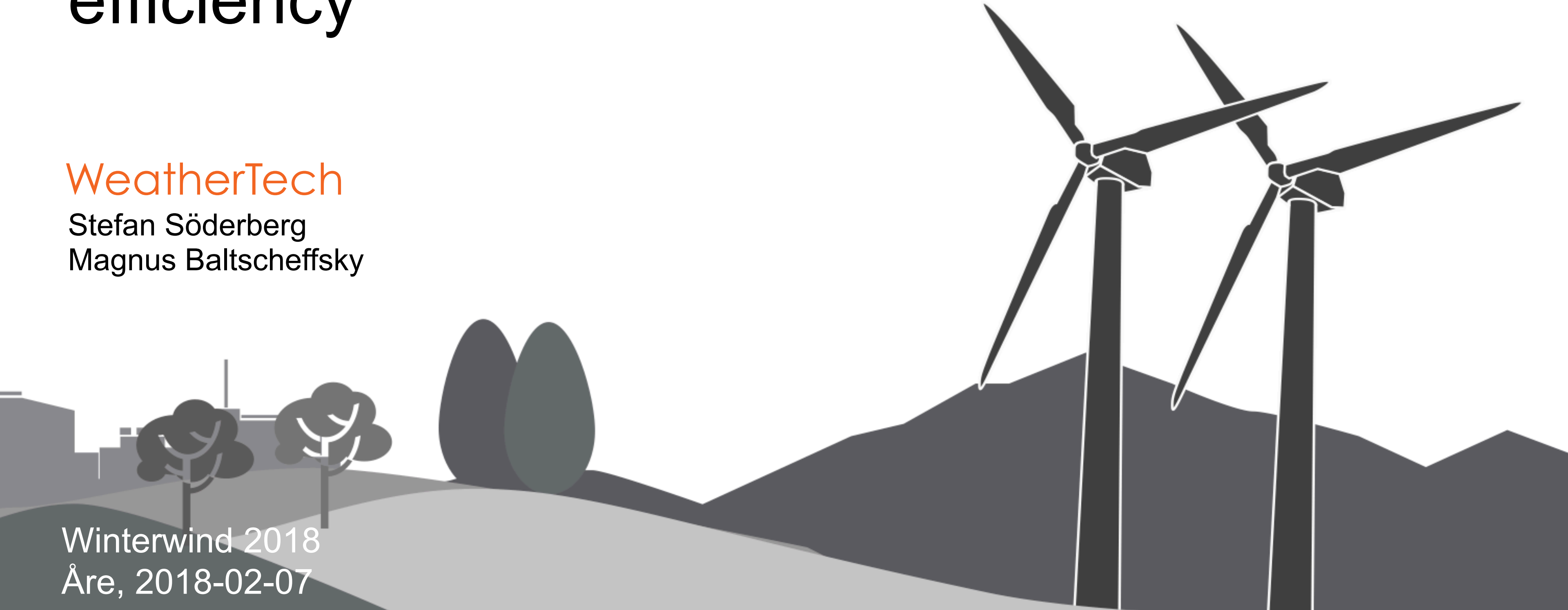

Winterwind 2018

Åre, 2018-02-07

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Business

- Atmospheric modelling
- Cold climate studies
- Weather Forecasts

Research

- Wind Power in Forests
- Farm-Farm Interaction
- NEWA
- Cold Climate

Model chain

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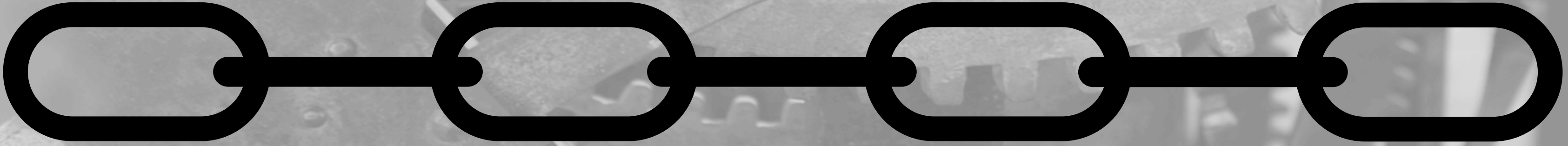
NWP — Ice model — Production loss — Long term



NWP

- WRF model
- High resolution
- Microphysics

2013
2016

Ice model

- Makkonen
- Turbine blade
- IPS

2013
2014

Production loss

- WICE
- SCADA

EWEA 2013 VIENNA
EUROPE'S PREMIER WIND ENERGY EVENT
4 - 7 FEBRUARY

2013

Long term

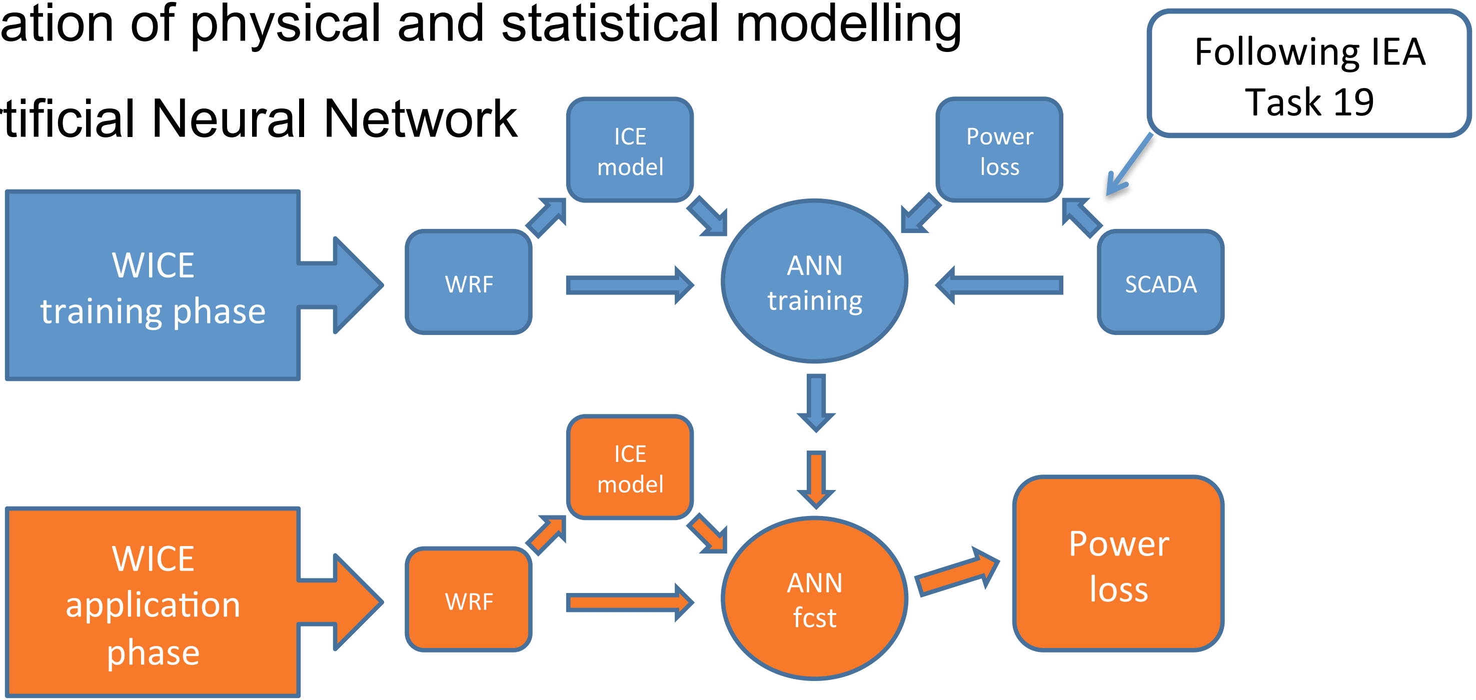
- 30yrs
- Condensates

2012
2015
2017

Production loss model - WICE

A combination of physical and statistical modelling

ANN – Artificial Neural Network



Anti/De-icing

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A novel model study of Ice Prevention Systems

Objective of presentation:

- a principal understanding of how an IPS can reduce production losses

Anti/De-icing

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1. How much can production losses be reduced using an IPS
2. Sensitivity to detection limits and system limitations
3. Anti-icing vs. de-icing
4. Site and seasonal variability

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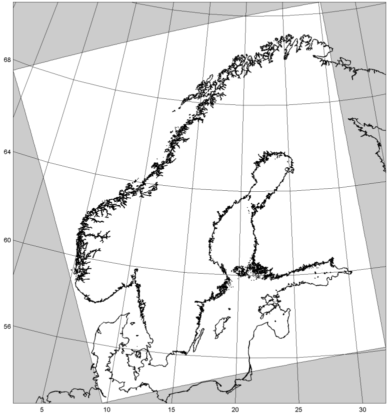
Basis for the study

Atmospheric data from high resolution WRF model runs

- $1x1\ km^2$ ($333x333\ m^2$) model grid resolution
- 1 full year modelled and long-term corrected to +30 years
- Hourly data of wind speed, temperature, cloud water etc.
- 78 sites in Finland, Sweden and Norway



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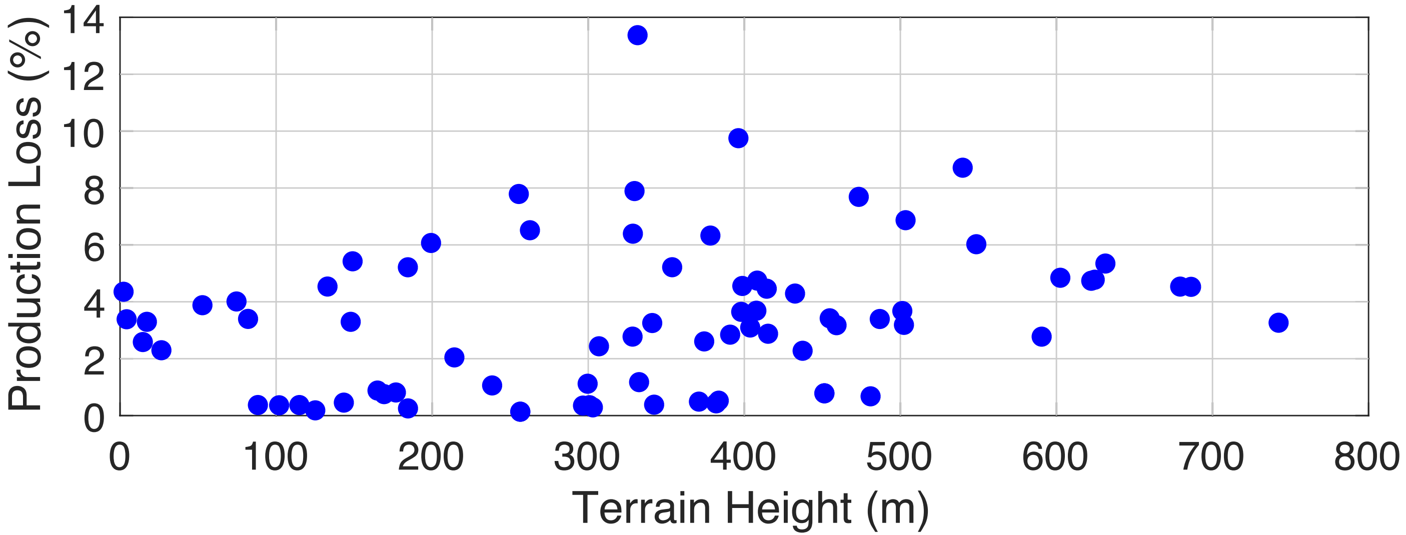
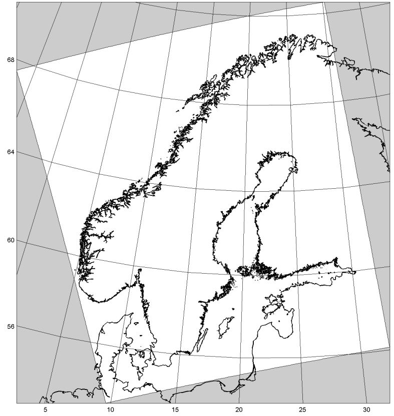
Modelled Production Losses





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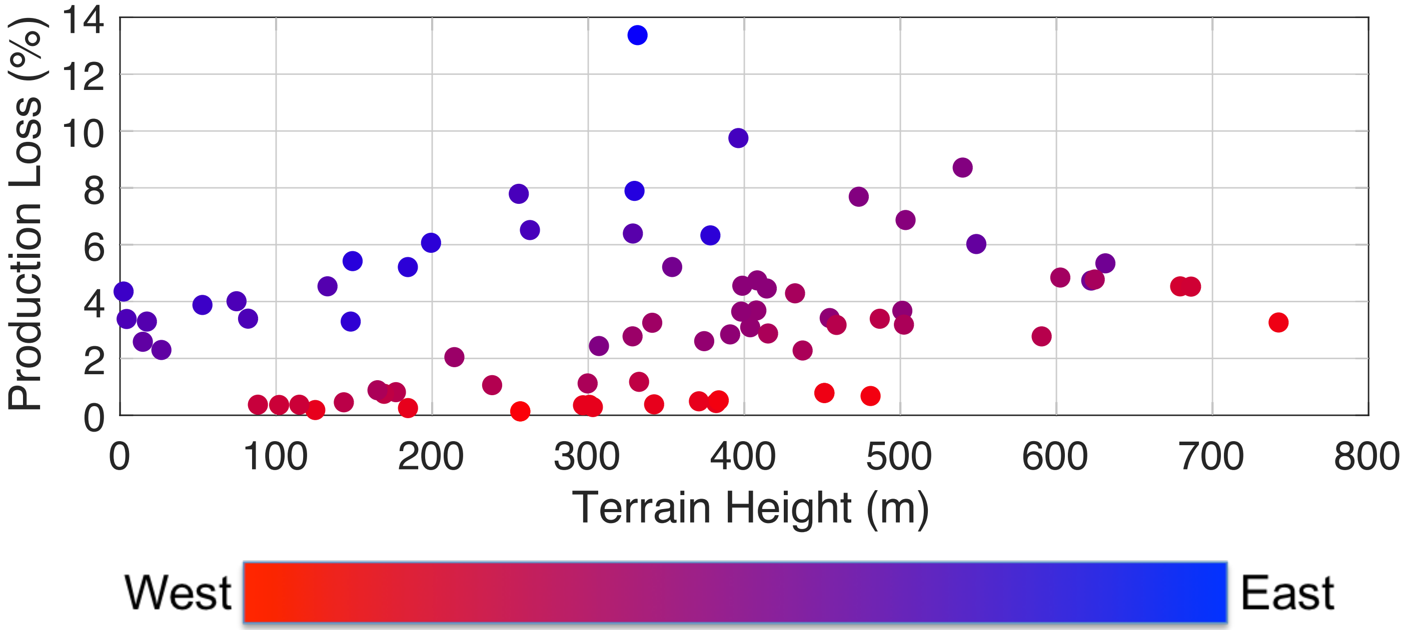
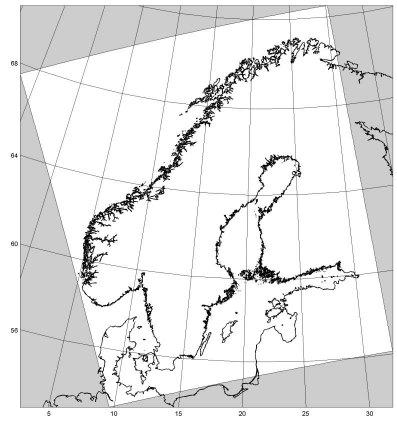
Modelled Production Losses





Ice Prevention Systems

Simplified models of Ice Prevention Systems

- Anti-icing and De-icing

Assumptions

- No overheating of blades
- No shortage of power for running IPS
- No stand stills for health and safety reasons

Ice Prevention Systems

De-icing IPS

- Trigger: production losses >30%
- Cycle length: 2 hours, assuming 100% losses during cycle
- Environmental conditions: T > -15 ^{o}C, U < 15 m/s

Ice Prevention Systems

Anti-icing IPS

- Triggers: production losses >10% or ice growth > 10 g/hr on a ISO standard cylinder at hub height
- Cycle length: 1 hour, assuming 10% losses during cycle
- IPS mean power: 80 kW, included in production loss estimates
- Environmental conditions: T > -10 ^{o}C
- In T from -10 ^{o}C to -15 ^{o}C, acts as the De-icing IPS.

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Variability between sites

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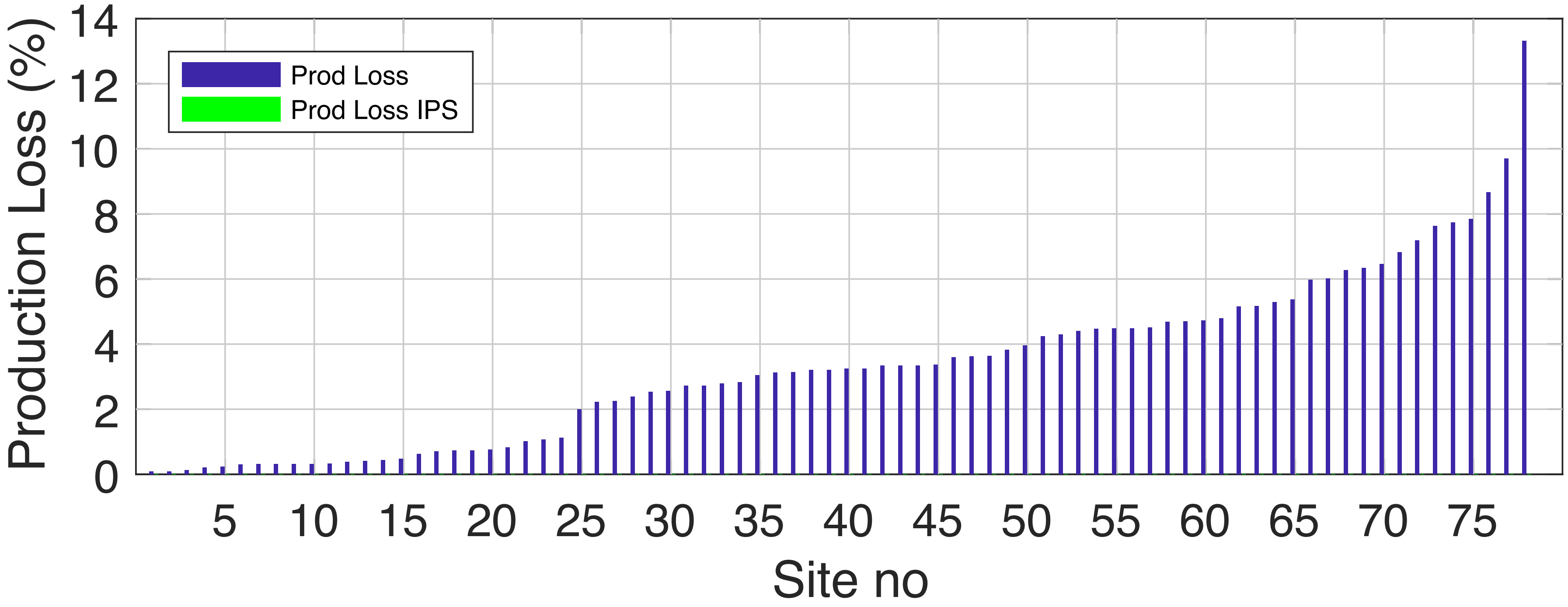
De-icing: Ploss lim 10%



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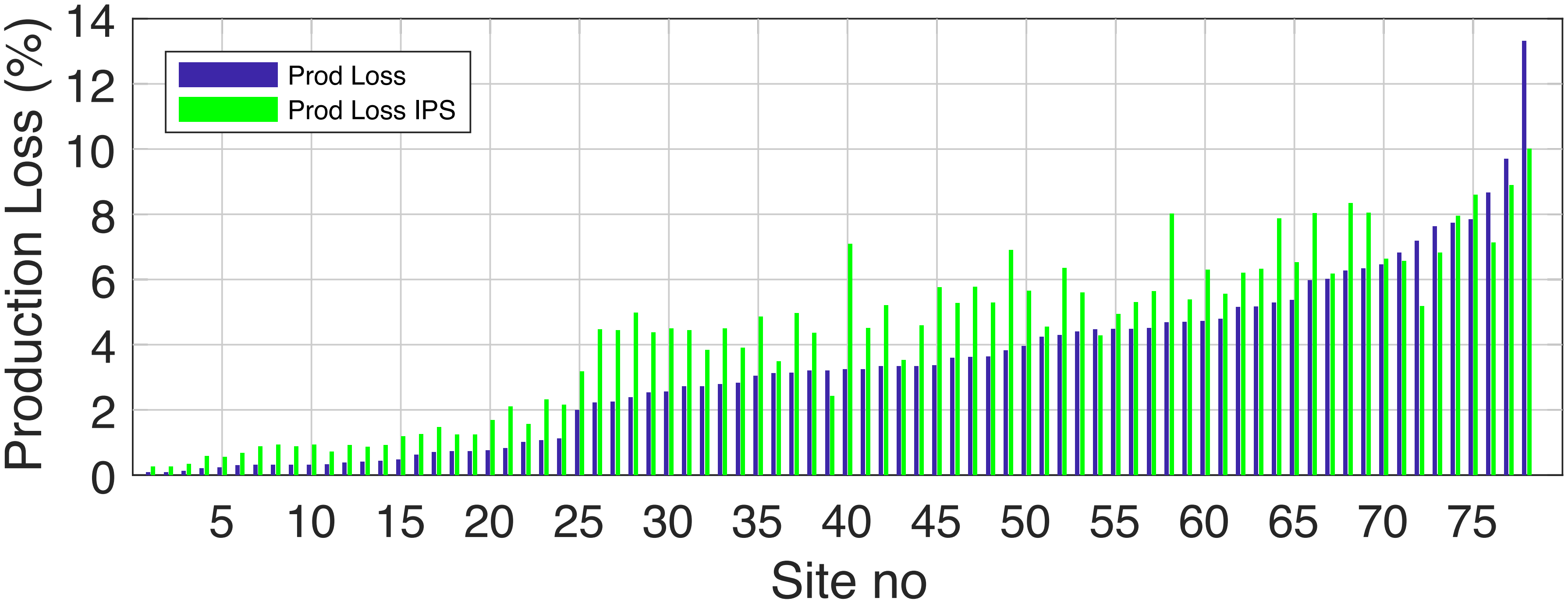
De-icing: Ploss lim 10%



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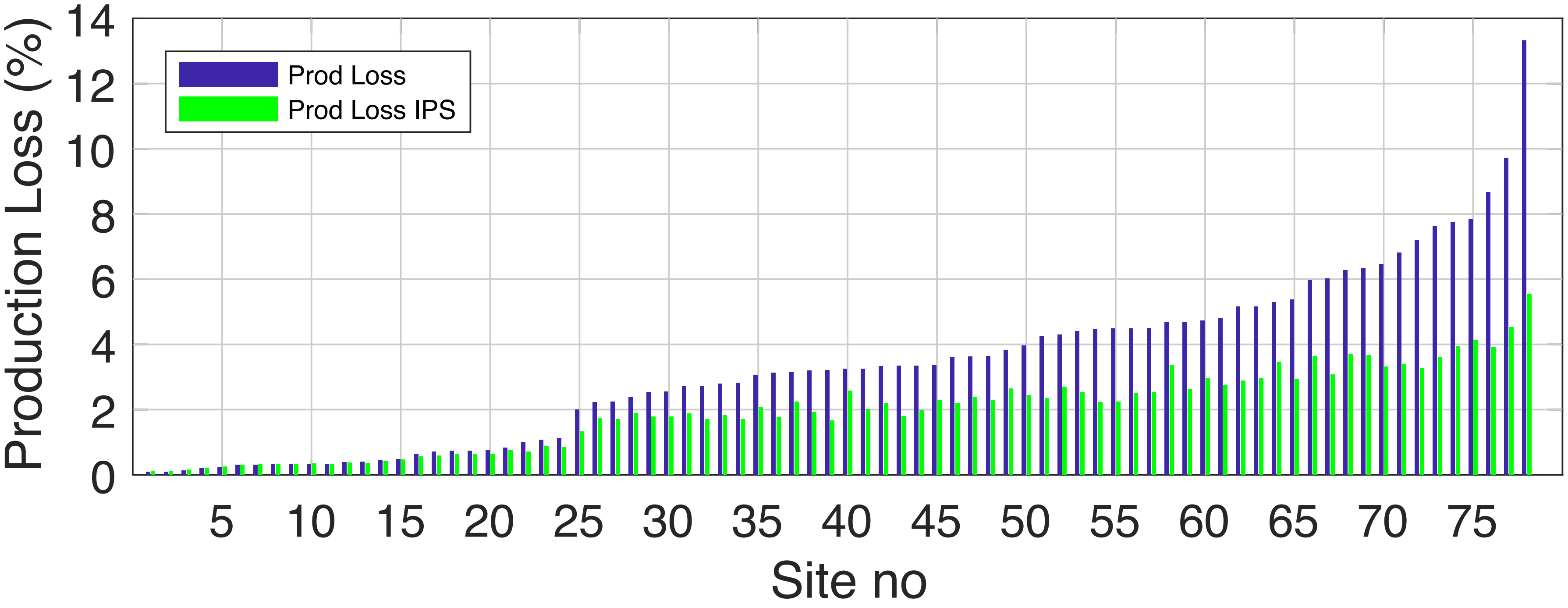
De-icing: Ploss lim 30%



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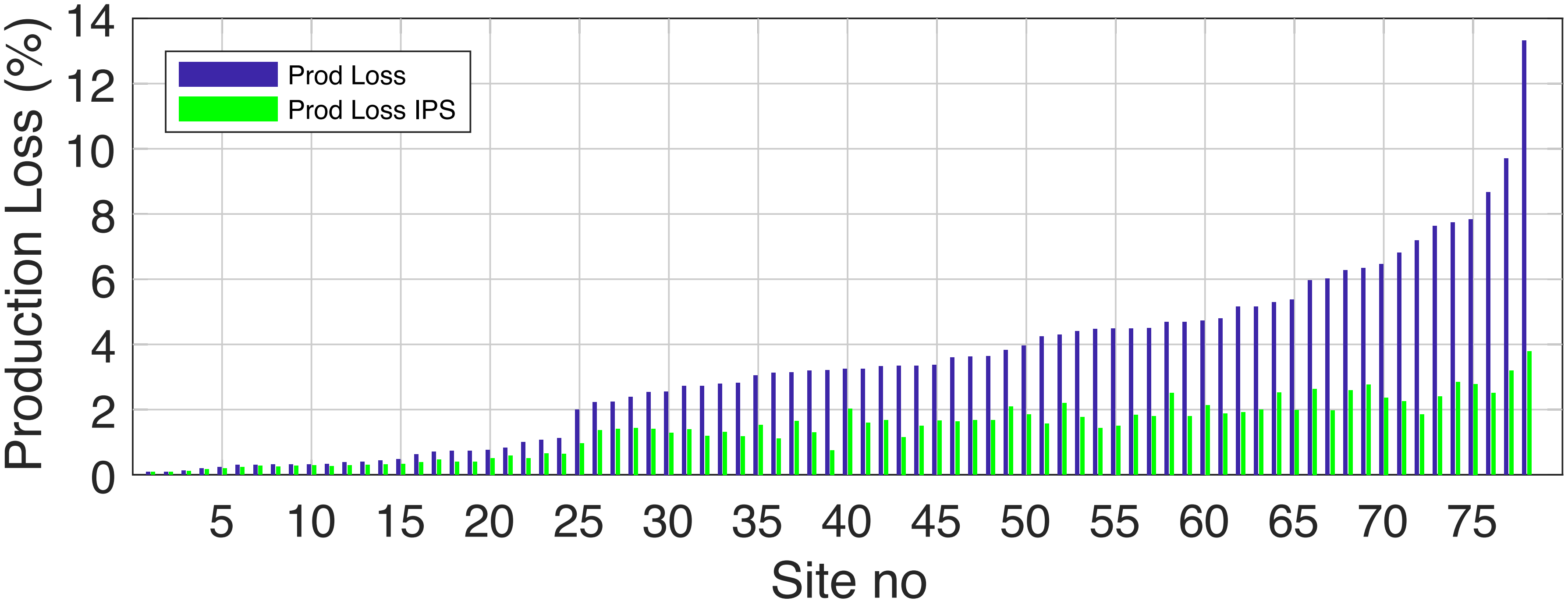
Anti-icing: Ploss lim 10%



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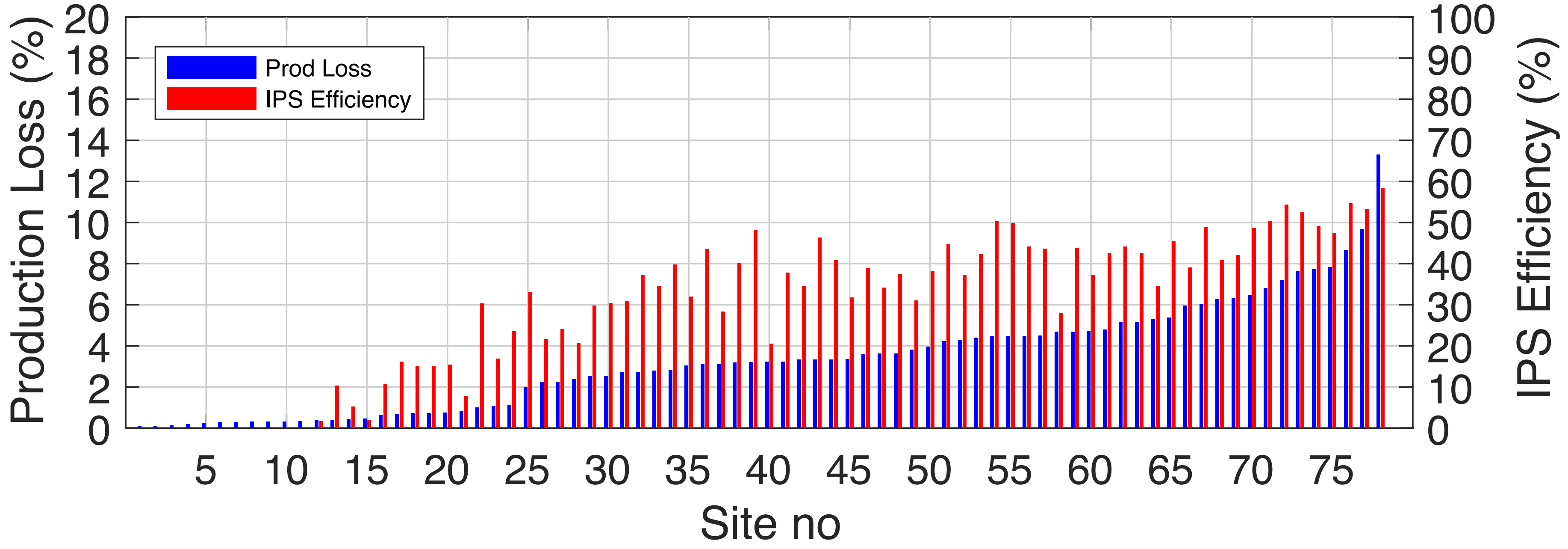
De-icing: Ploss lim 30% efficiency



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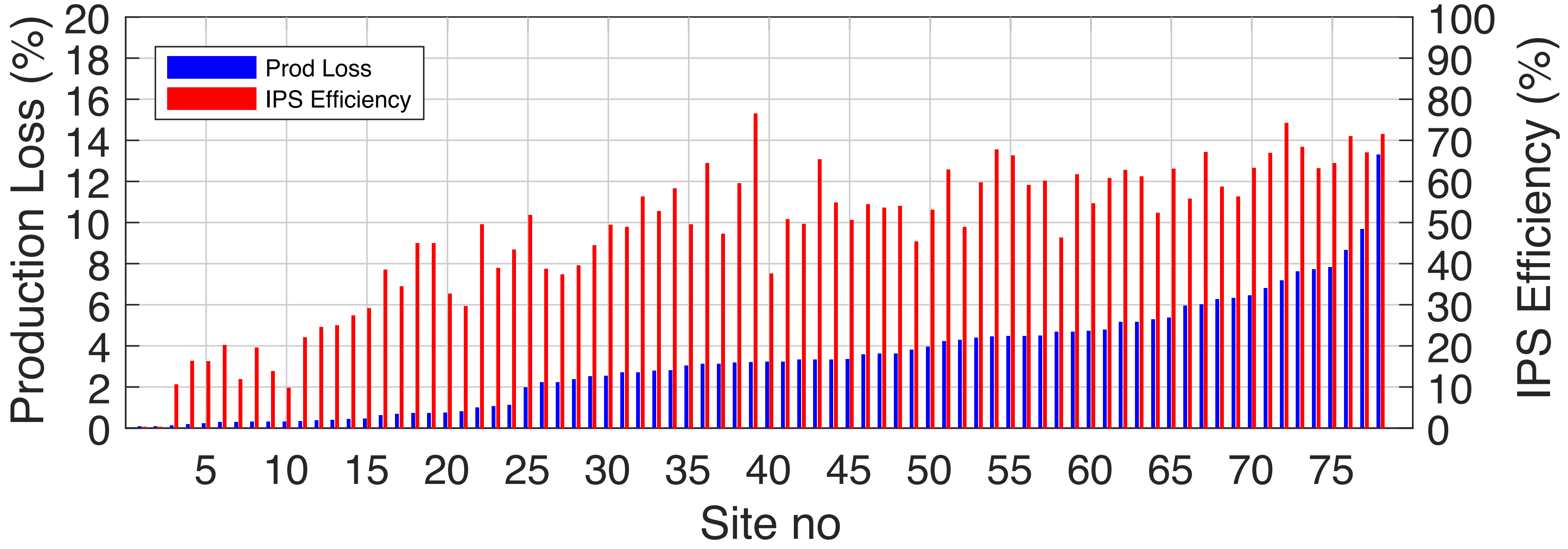
Anti-icing: Ploss lim 10% efficiency



Seasonal variability

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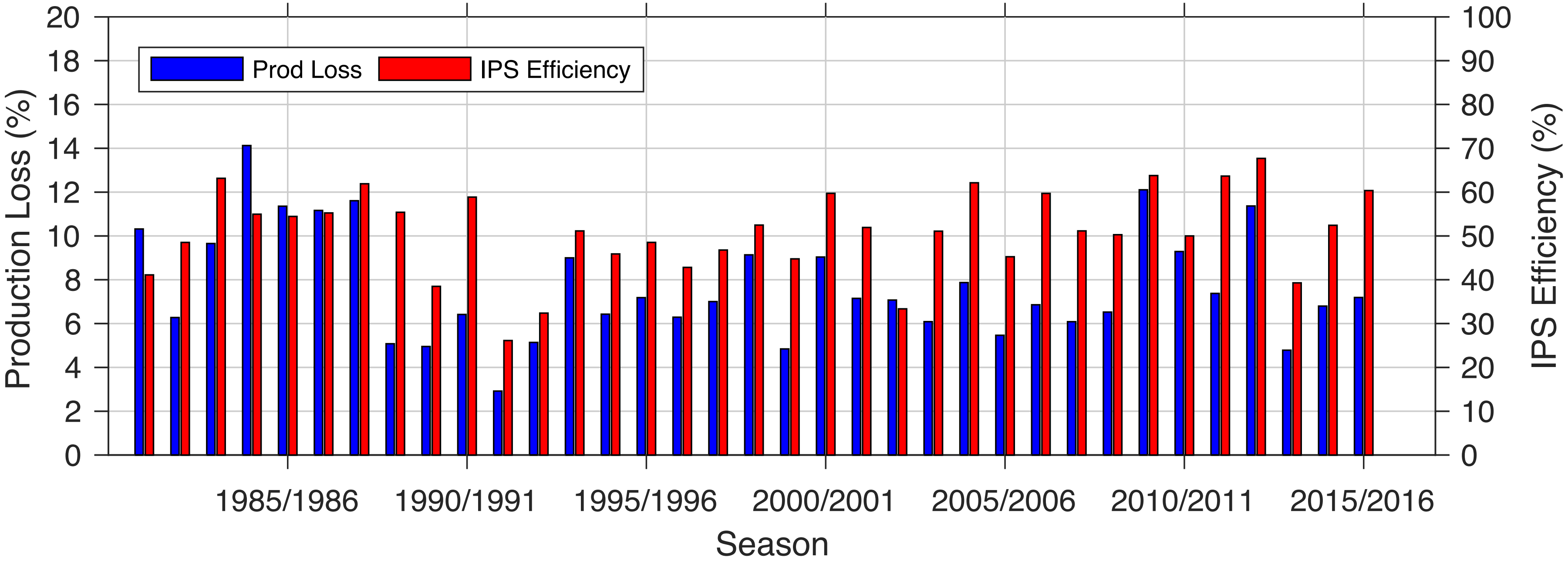
De-icing: Seasonal efficiency site A



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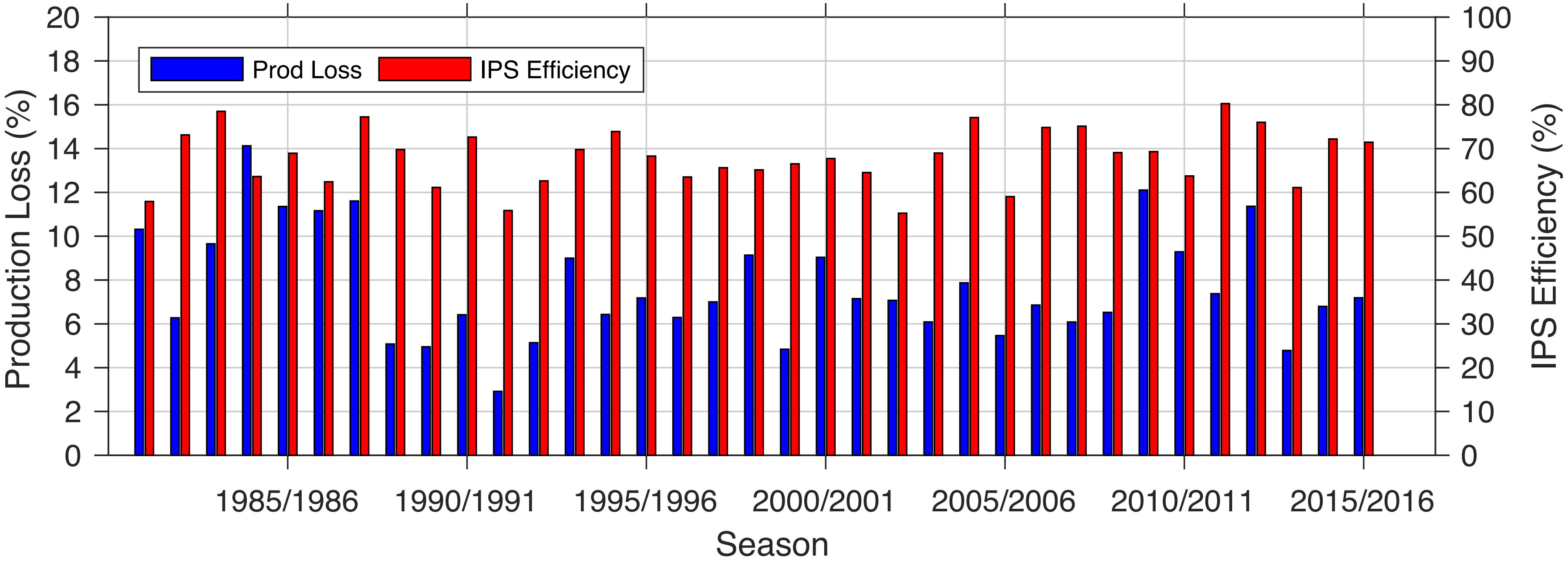
Anti-icing: Seasonal efficiency site A



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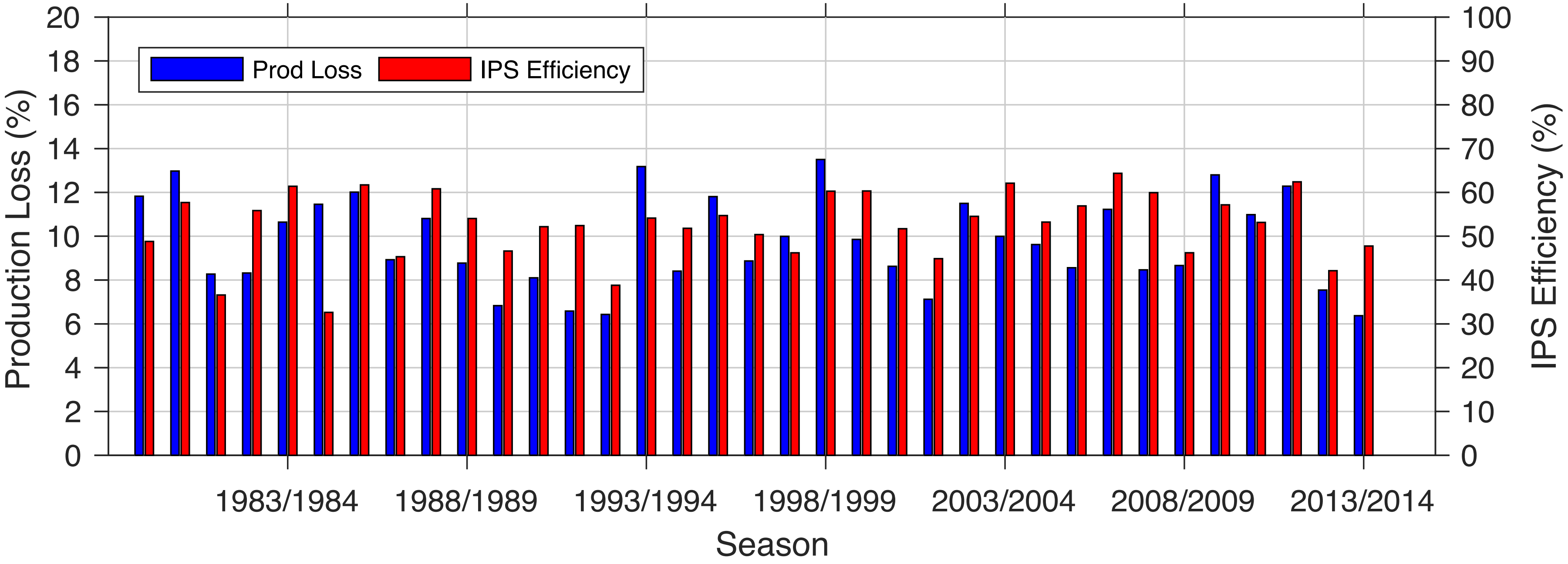
De-icing: Seasonal efficiency site B



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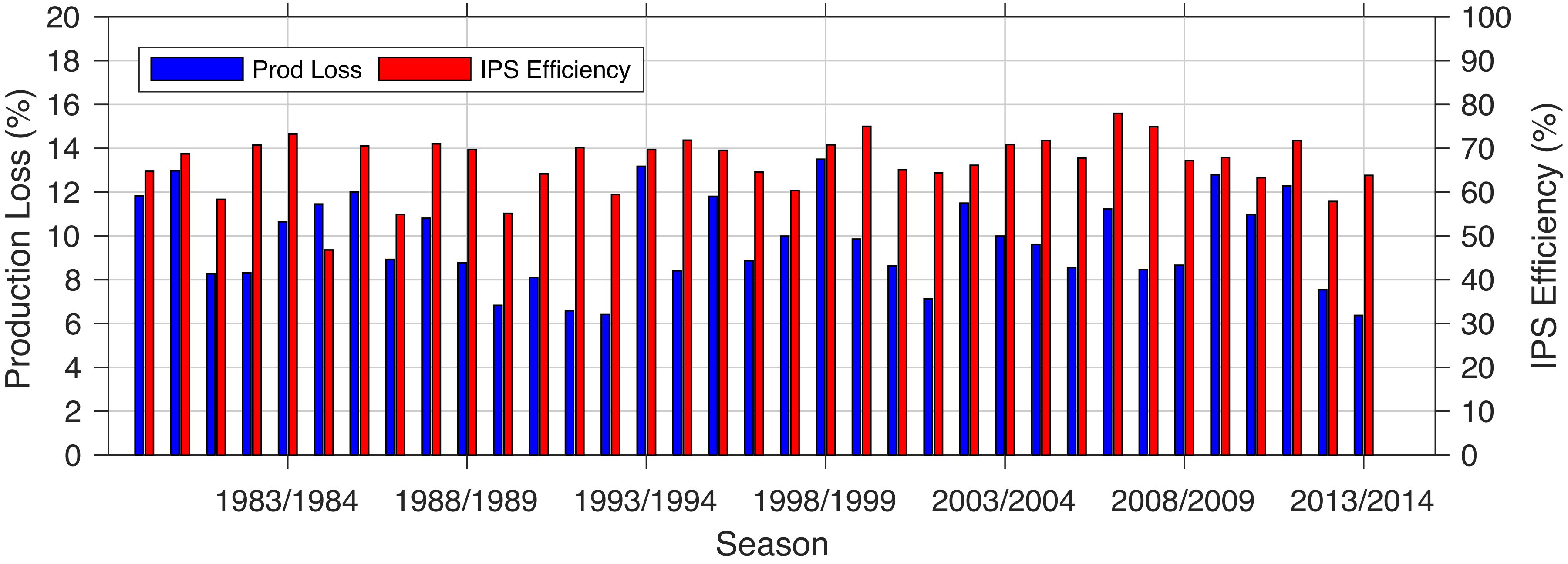
Anti-icing: Seasonal efficiency site B



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Summary

1. IPS efficiency sensitive to detection limits
2. IPS efficiency varies plenty between sites
3. IPS efficiency has some correlation with production loss
4. IPS efficiency varies plenty from year to year => important for measuring

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Thank you!

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