



Mapping of icing in Sweden

The benefits of forecasting icing for energy production

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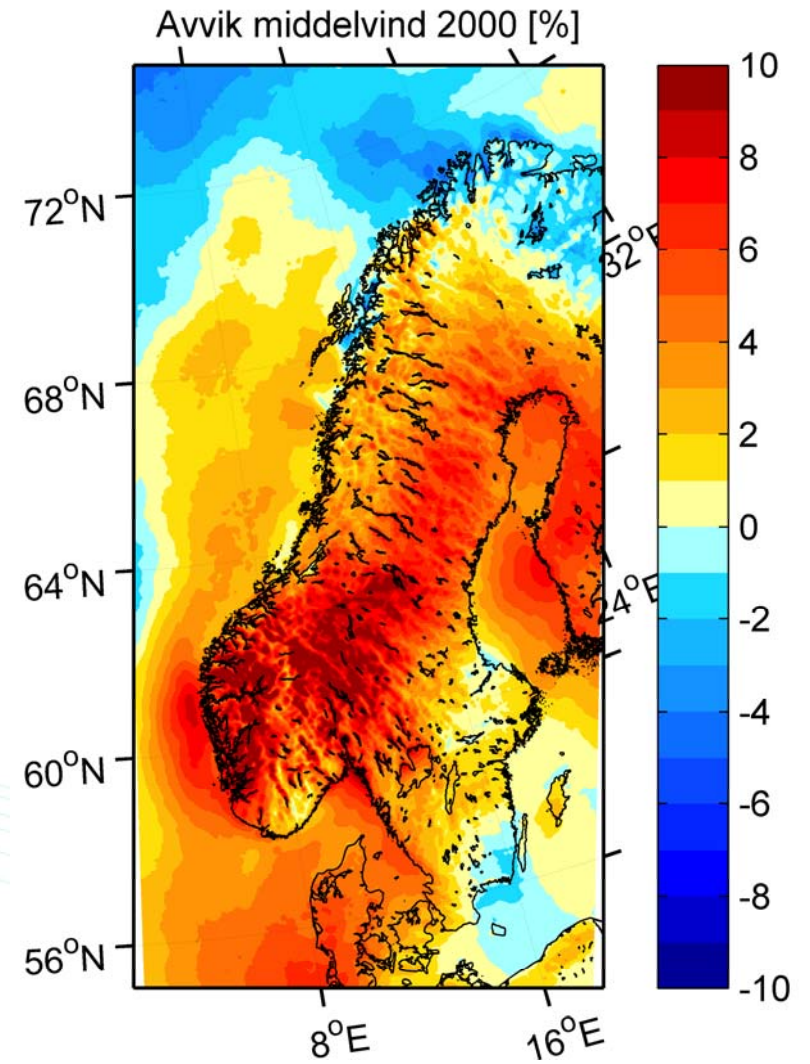
Wintewind 2012, Skellefteå 07.02.2012

Mesoscale model

- The meso-scale refers to the time and spatial scale of the features resolved by the model. The model resolves low-pressure systems and fronts.
- WRF – Weather Research and Forecasting
- The model describes the atmosphere dynamics (wind, temperature and humidity), and includes physical description of radiation, cloud formation, precipitation, snow, surface processes, etc.
- The model performs calculations in the time domain, no steady-state model
- Typical model resolution down to 1km x 1km

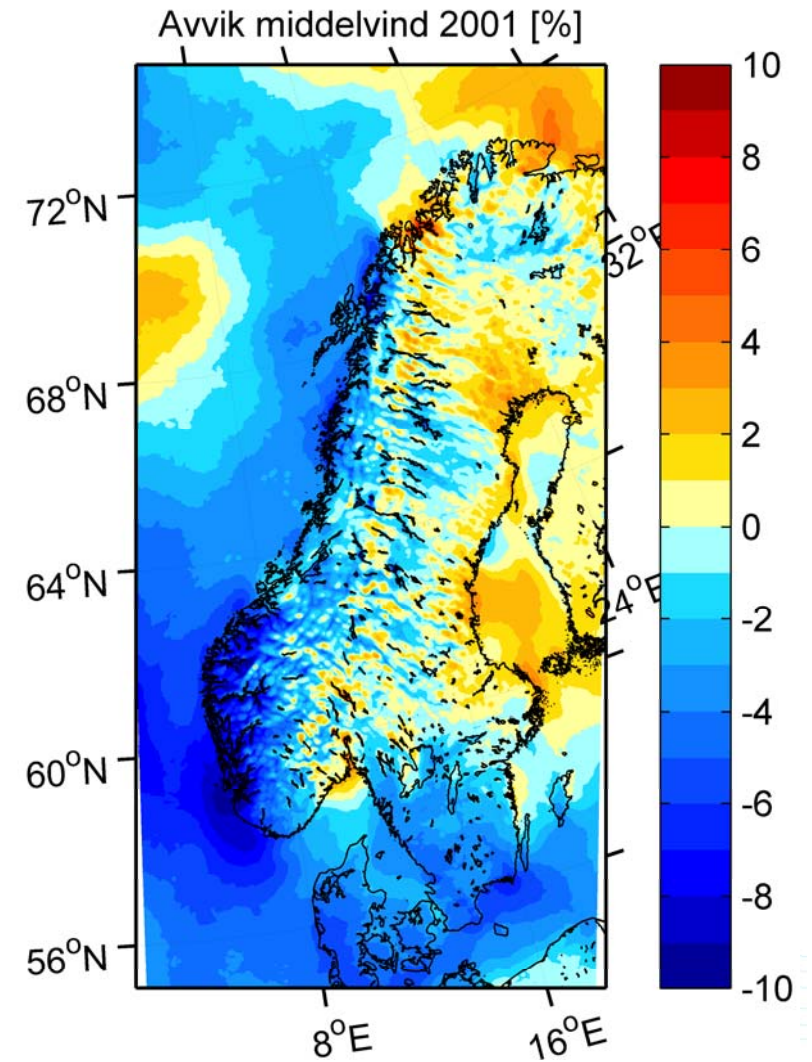
Mesoscale wind index

2000



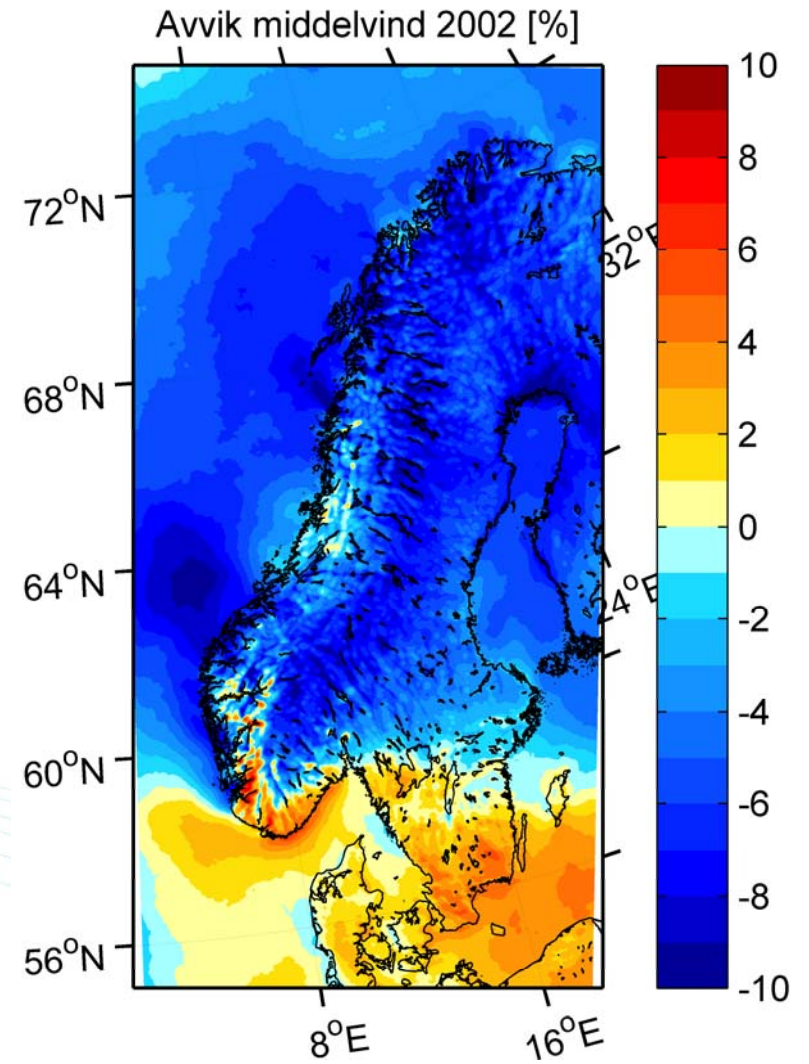
Mesoscale wind index

2001



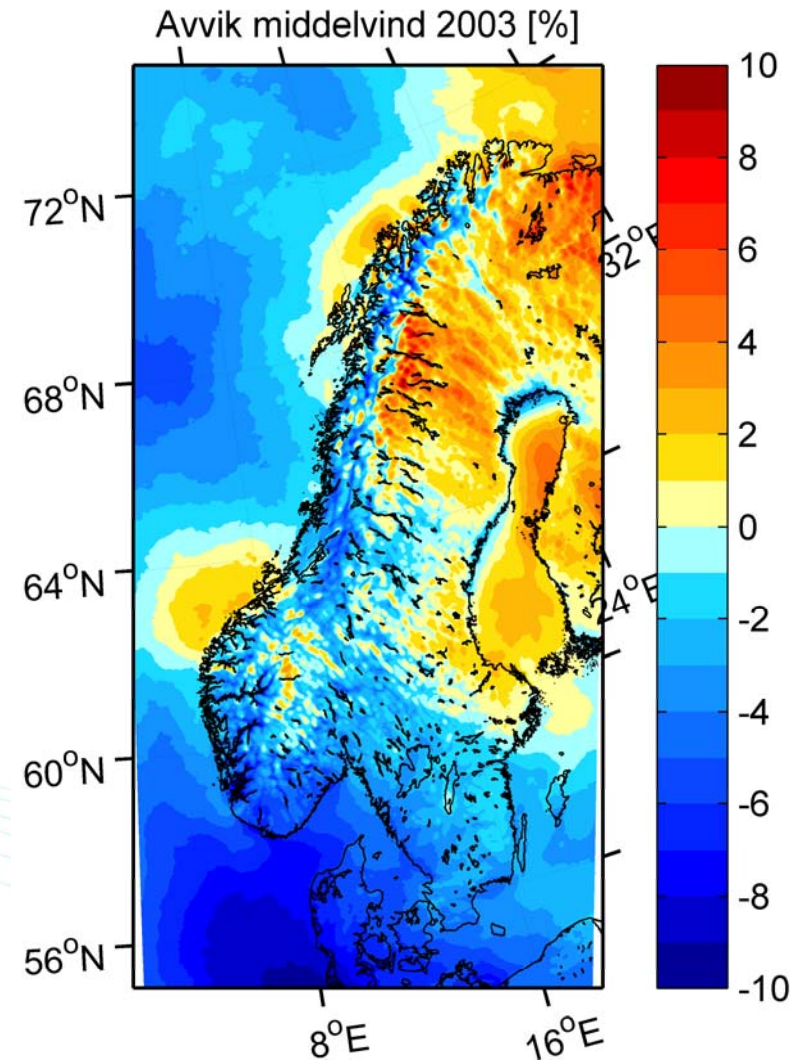
Mesoscale wind index

2002



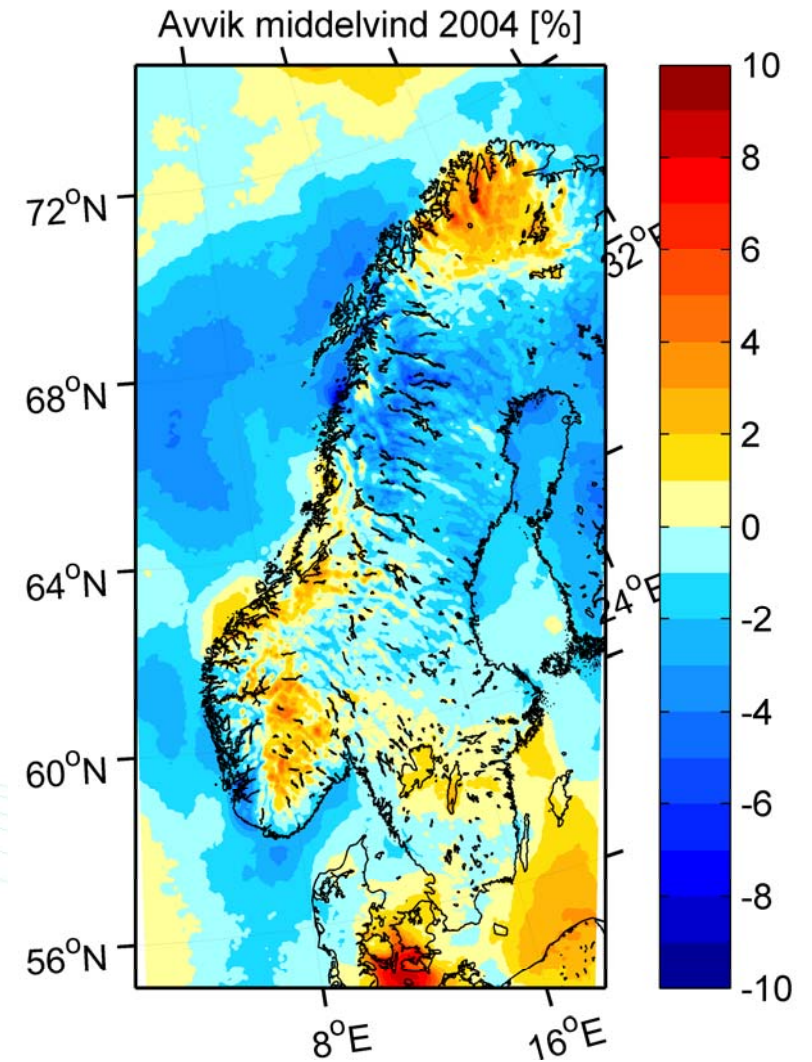
Mesoscale wind index

2003



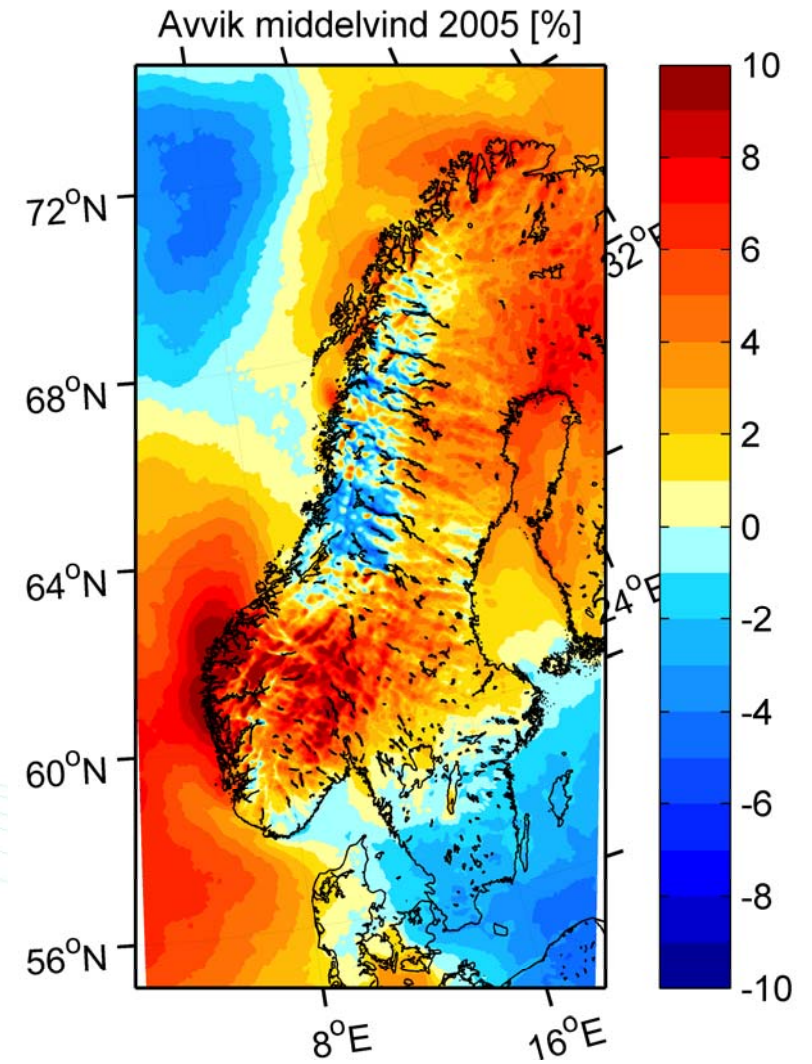
Mesoscale wind index

2004



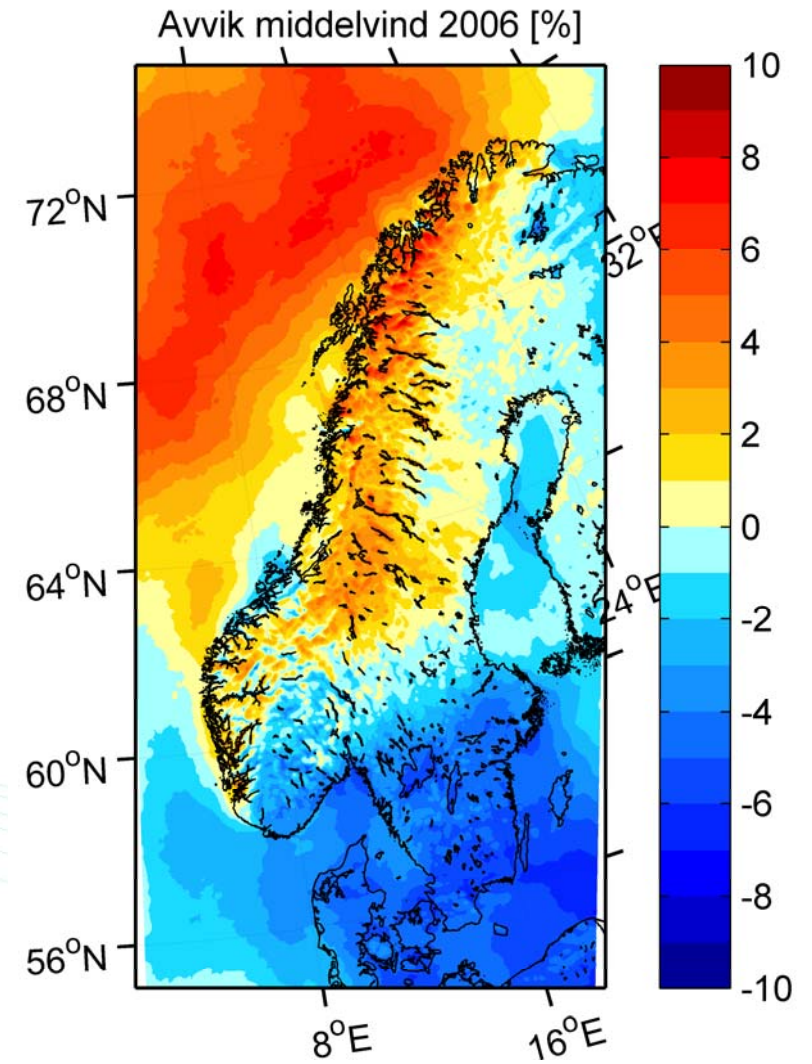
Mesoscale wind index

2005



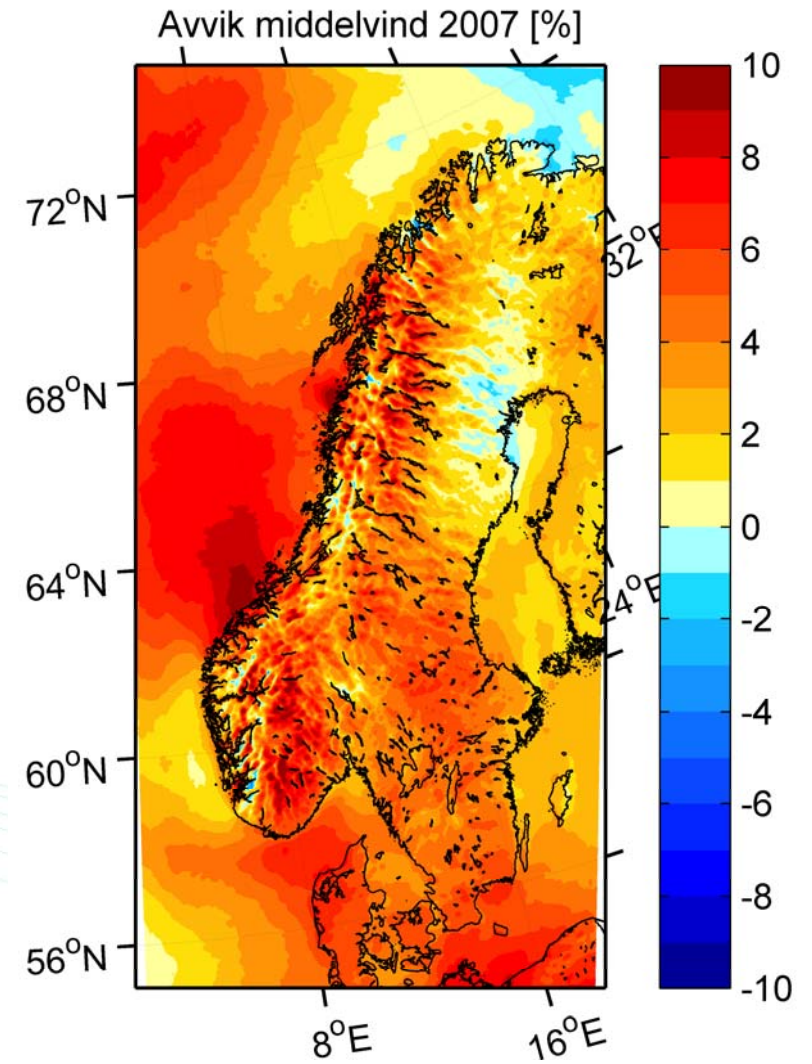
Mesoscale wind index

2006



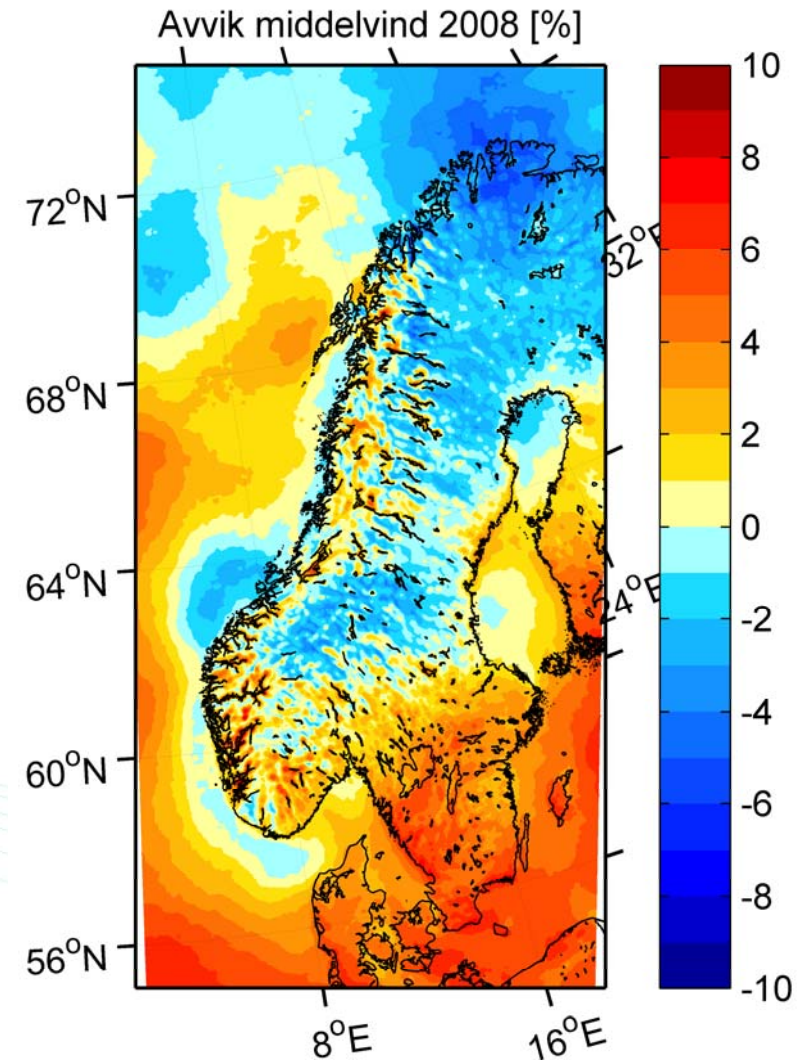
Mesoscale wind index

2007



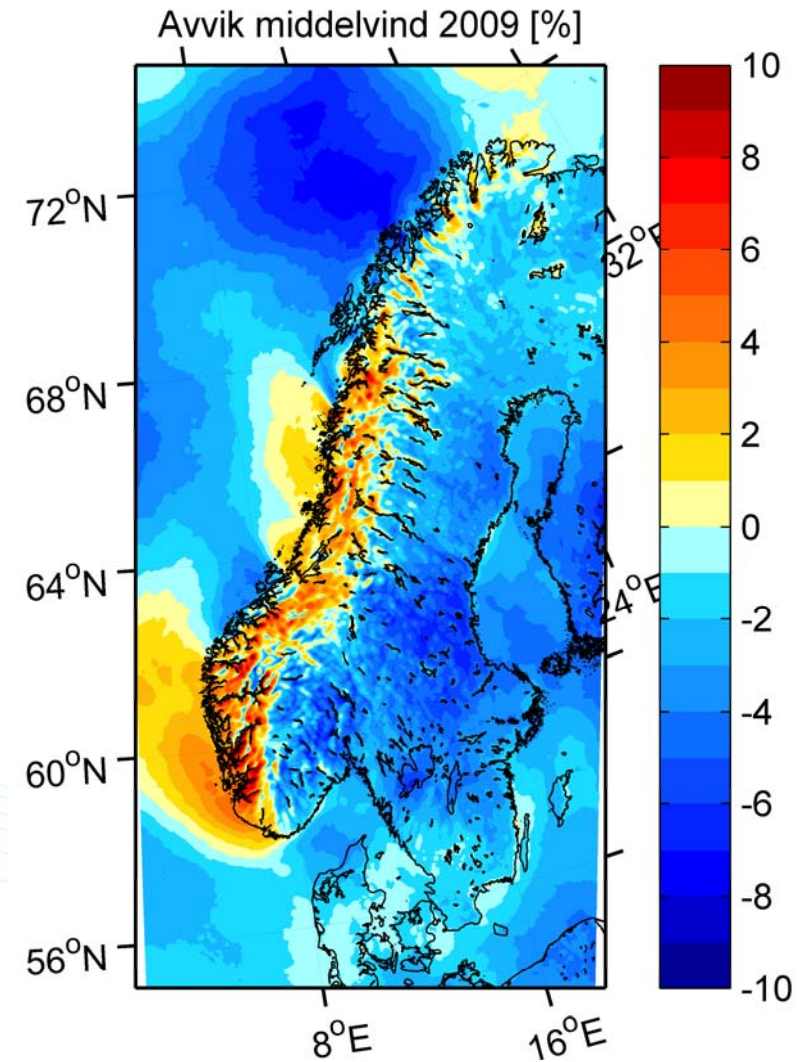
Mesoscale wind index

2008



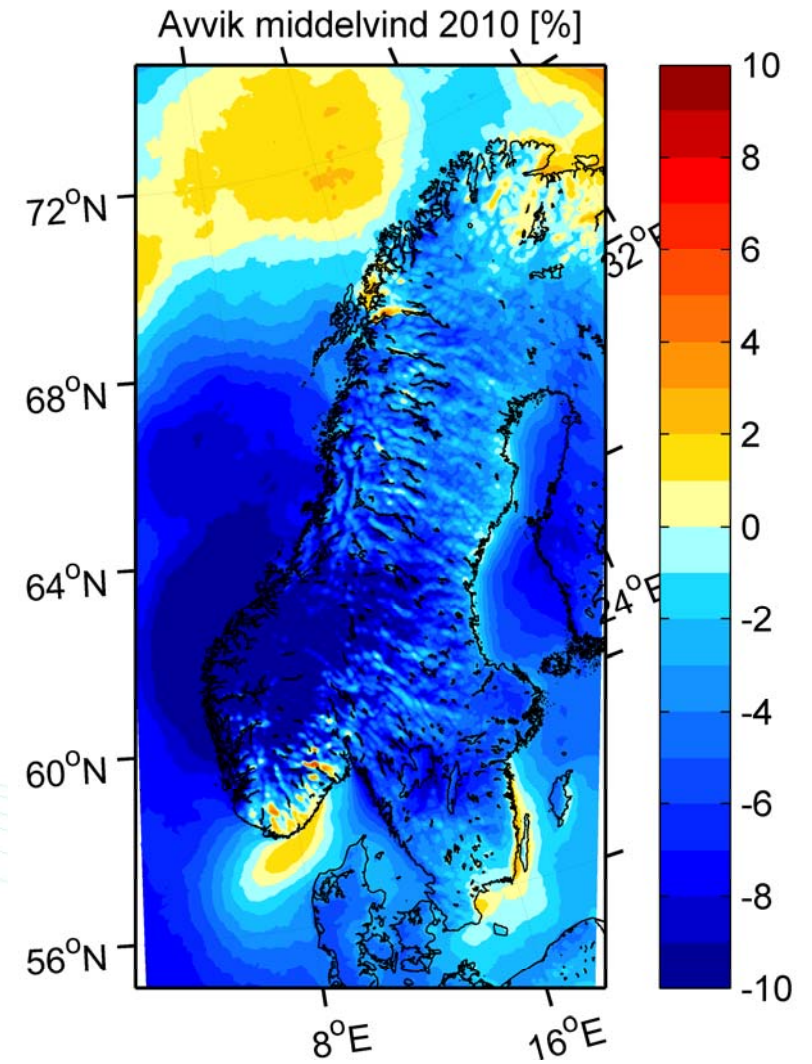
Mesoscale wind index

2009



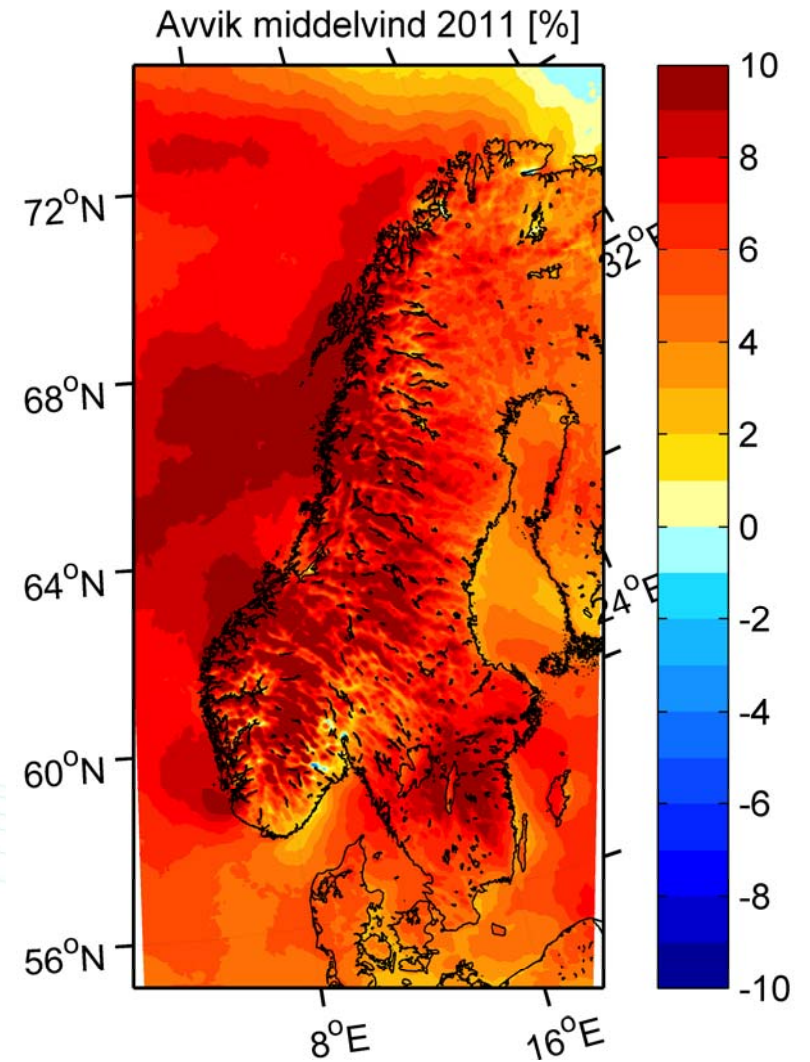
Mesoscale wind index

2010



Mesoscale wind index

2011



Calculation of in-cloud icing

- We calculate icing on a standard body following Makkonen. 1m cylinder with diameter 30mm:

$$\frac{dM}{dt} = \alpha_1 \alpha_2 \alpha_3 \cdot w \cdot A \cdot V$$

α_1 - collision efficiency, $\alpha_1=f(V,d,D)$

α_2 - sticking efficiency, $\alpha_2 \approx 1$

α_3 - accretion efficiency, $\alpha_3=f(V,d,w,T,e,D,\alpha_1)$

w – cloud liquid water content

A – collision area, perpendicular to flow

V – Wind speed

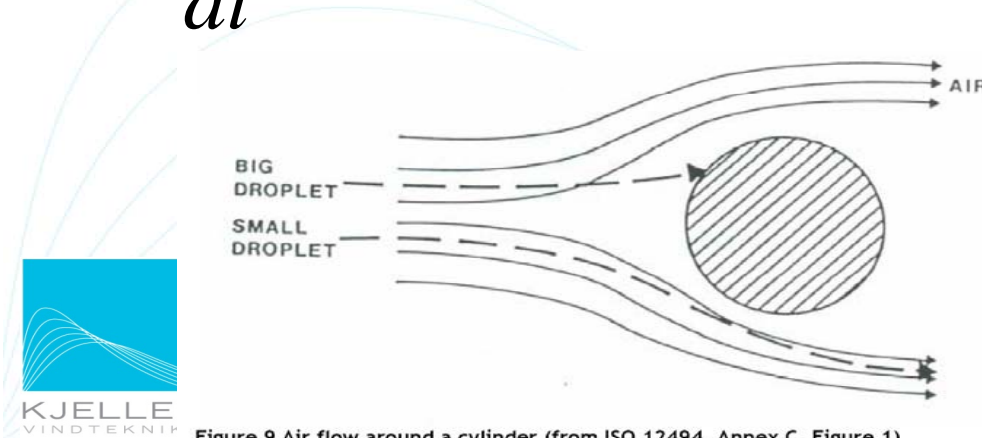
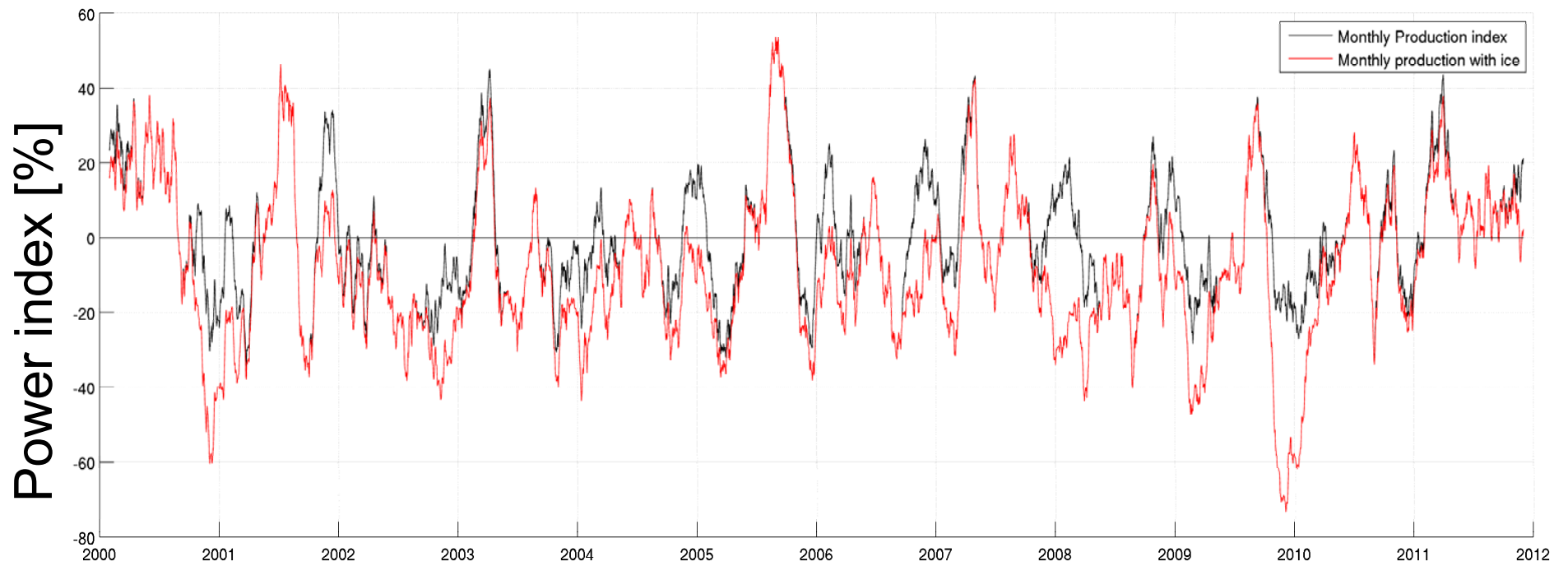
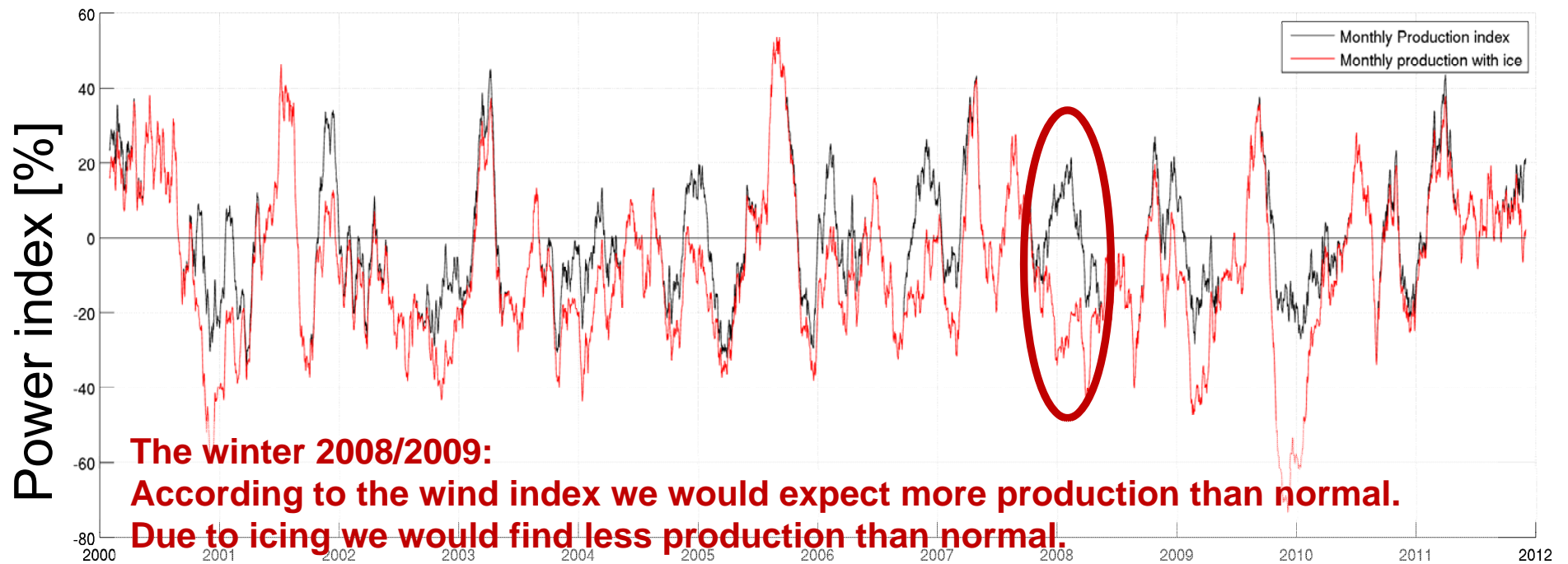


Figure 9 Air flow around a cylinder (from ISO 12494, Annex C, Figure 1)

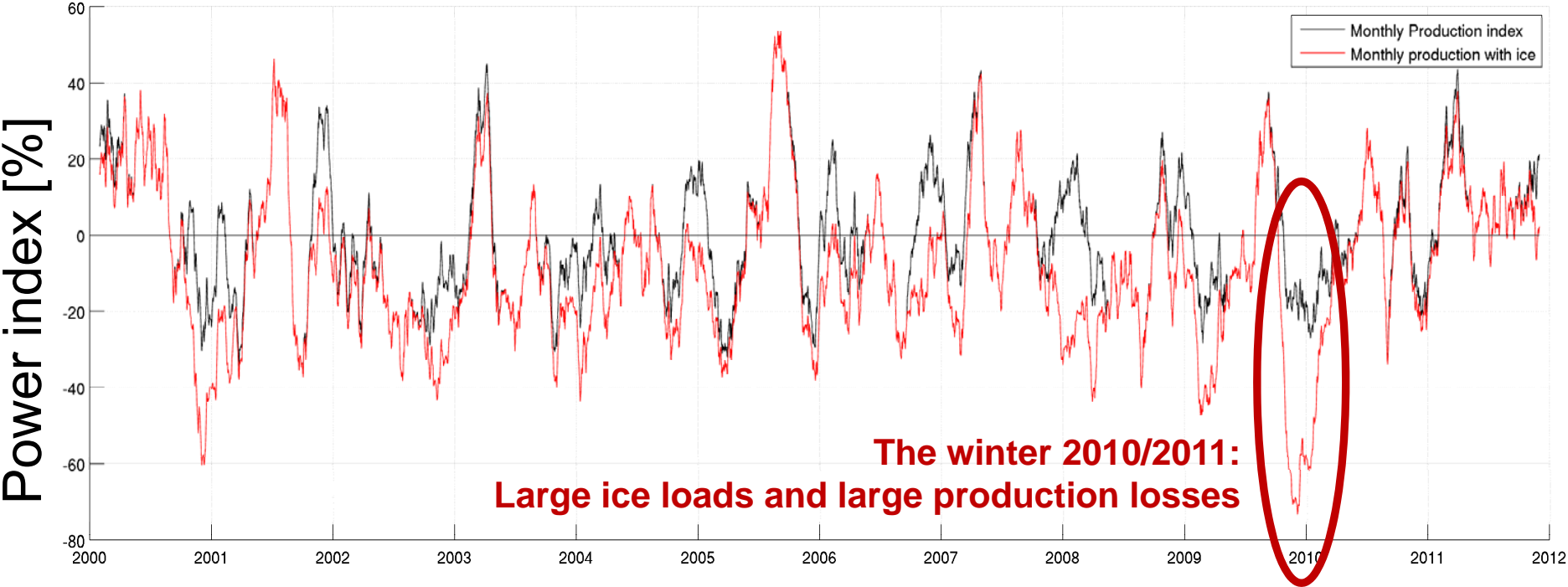
Power production index



Power production index

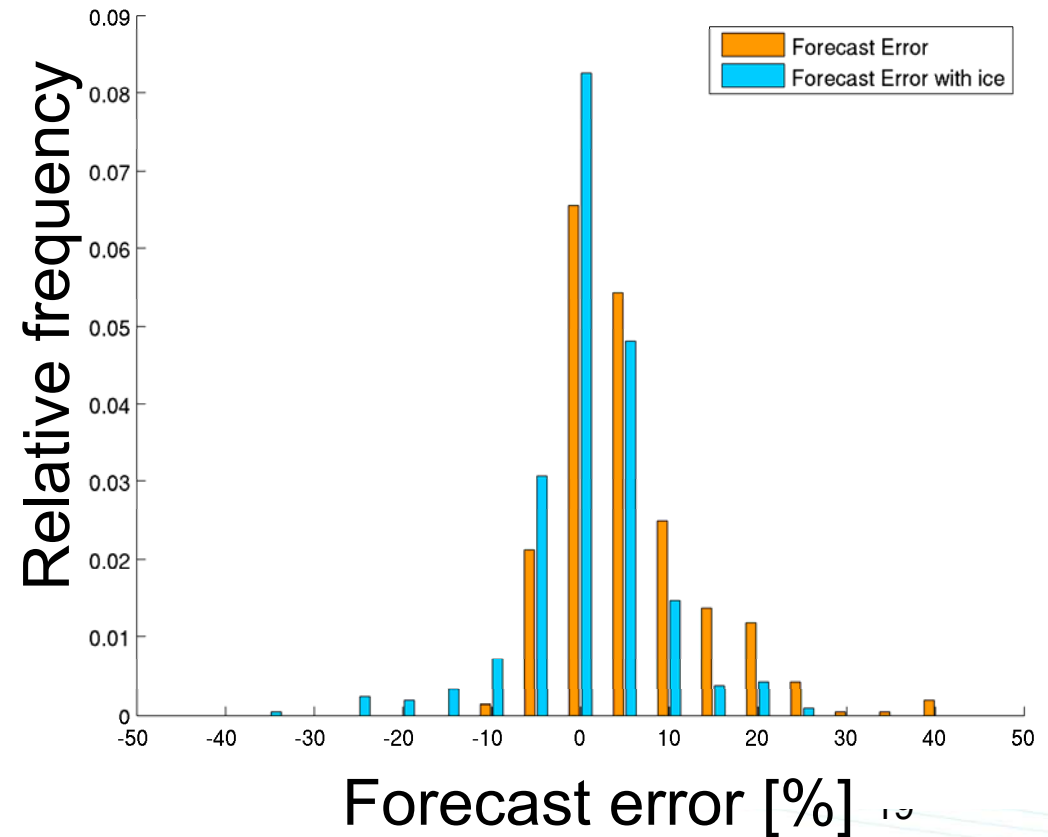


Power production index



Production forecasts

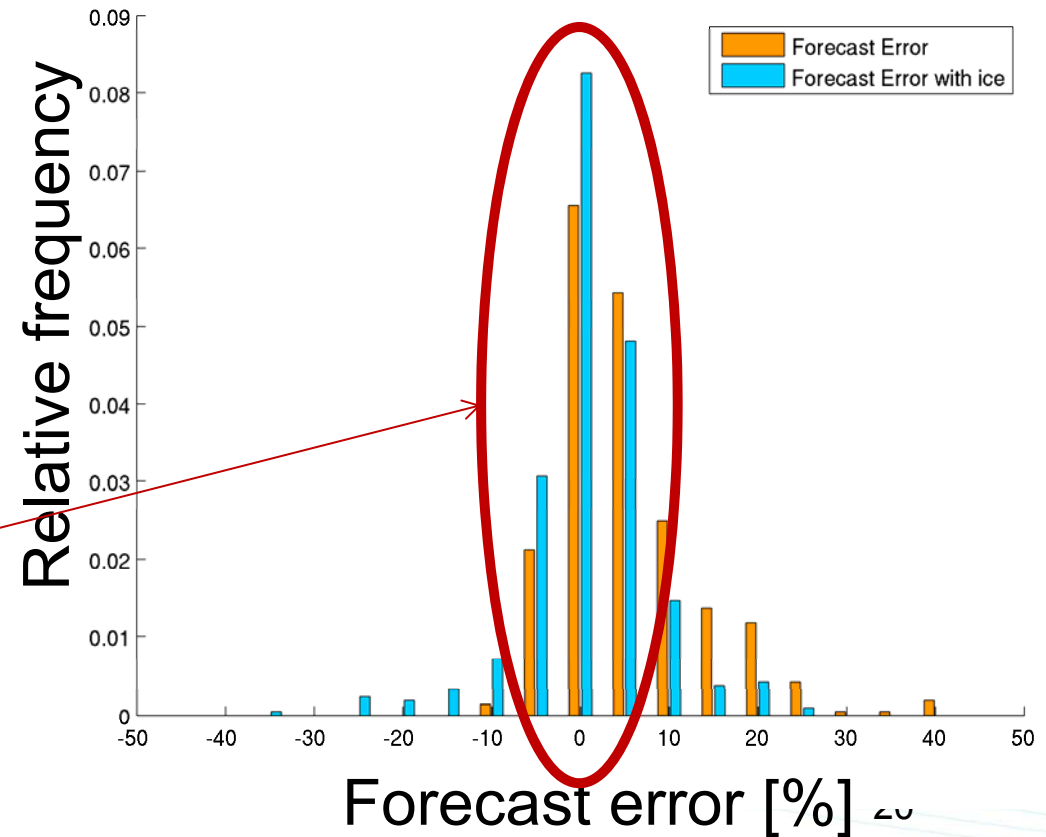
The analysis is based on 3 years of operational data from a wind farm in Sweden



Production forecasts

The analysis is based on 3 years of operational data from a wind farm in Sweden

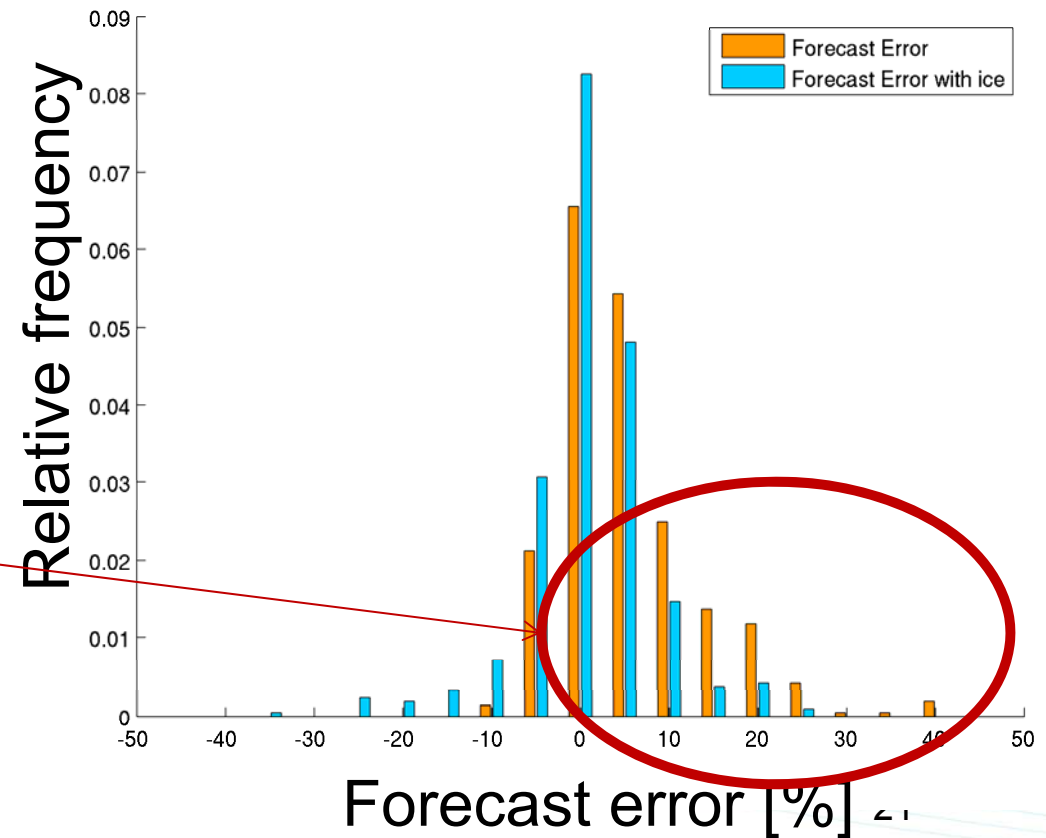
The overall forecast errors are reduced by including forecasts of ice



Production forecasts

The analysis is based on 3 years of operational data from a wind farm in Sweden

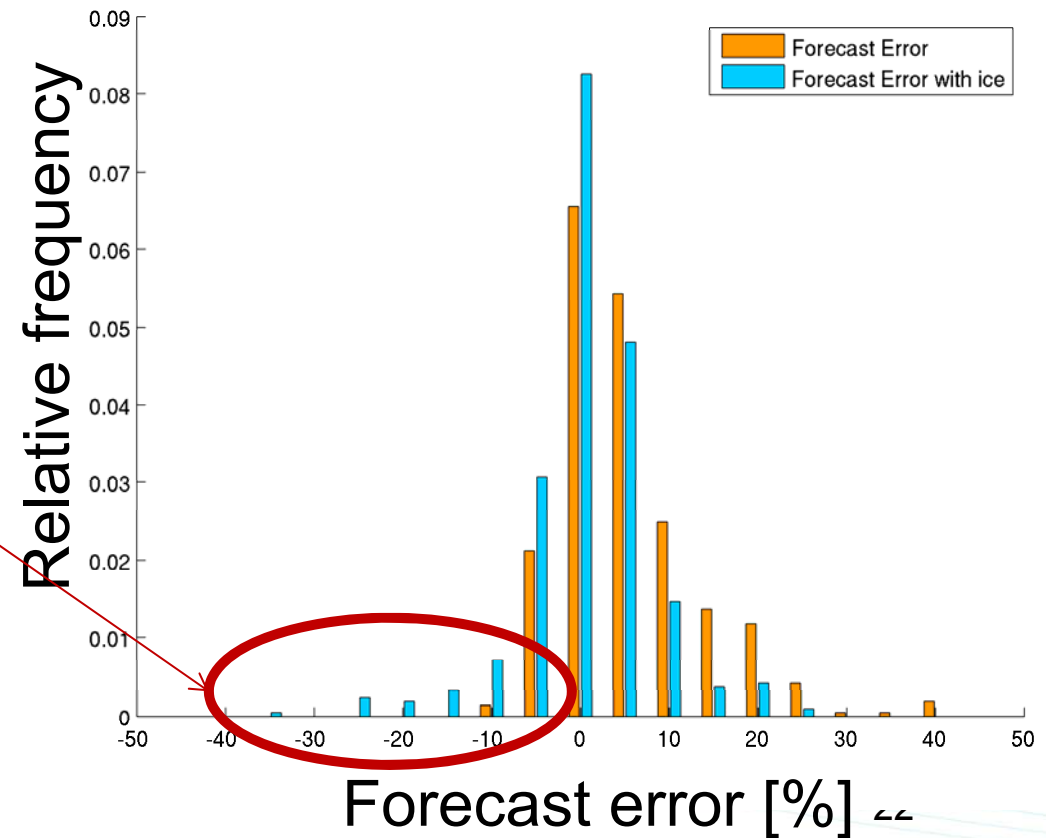
With the current model we particularly reduce the number of cases when the production is overpredicted



Production forecasts

The analysis is based on 3 years of operational data from a wind farm in Sweden

We get an increase of the number of cases when we underpredict production



Conclusions

- For a large number of sites the variability in icing from year to year will dominate over the variability in wind in the production index.
- An improvement in the energy production forecasts can be achieved by including the effects of icing

Thank you!

Wind and icing map are now available for Sweden:

www.vindteknikk.no

