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Probabilistic forecasting of wind power production losses in cold climates

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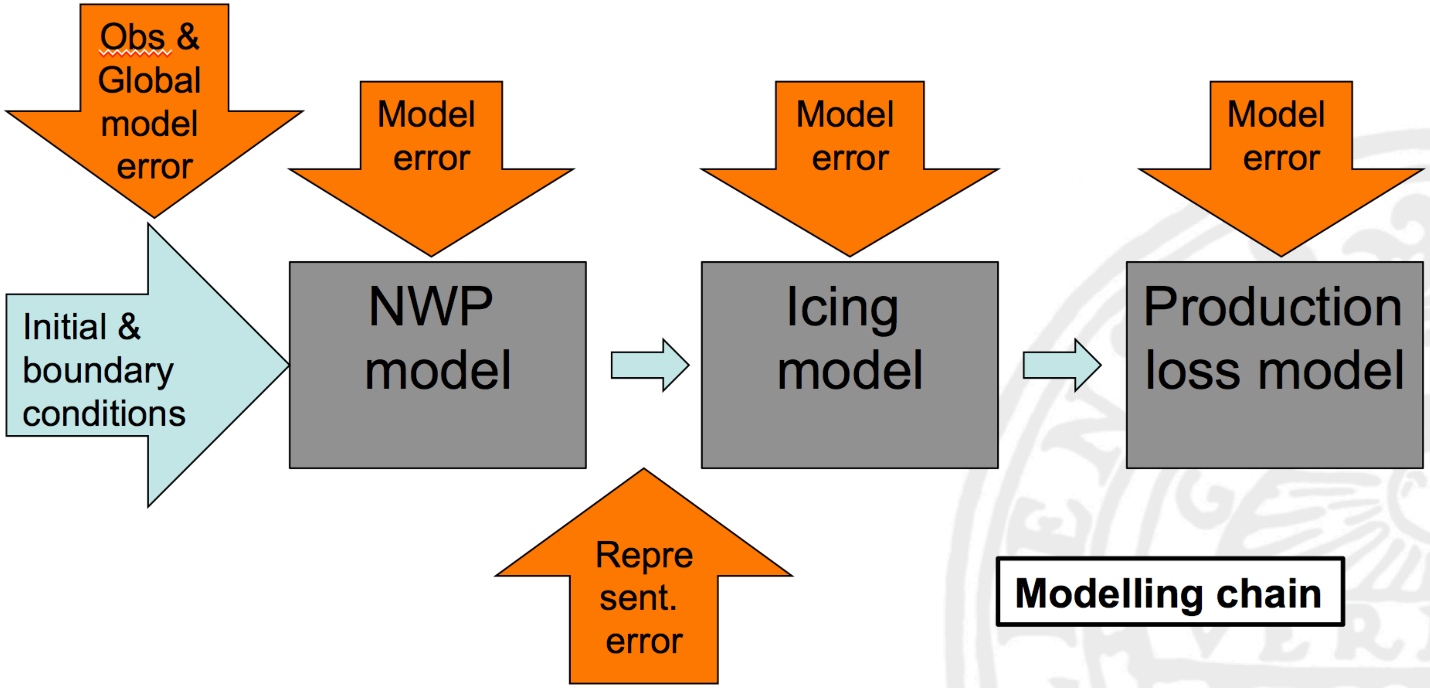
SMHI VATTENFALL WeatherTech

Introduction

- Icing causes production losses
- Short-range, next-day, forecasts are important for trading
- These forecasts are uncertain

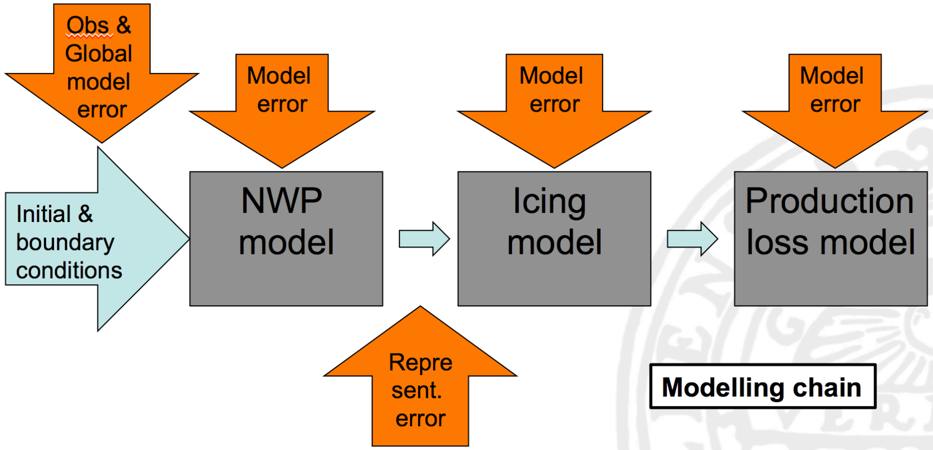
  ⇒ **The Aim of the study:** Using probabilistic forecasting to improve the forecast skill and get estimations of the uncertainty



Method: Probabilistic forecasting

Ensemble forecasting

- Representing uncertainties in the initial conditions



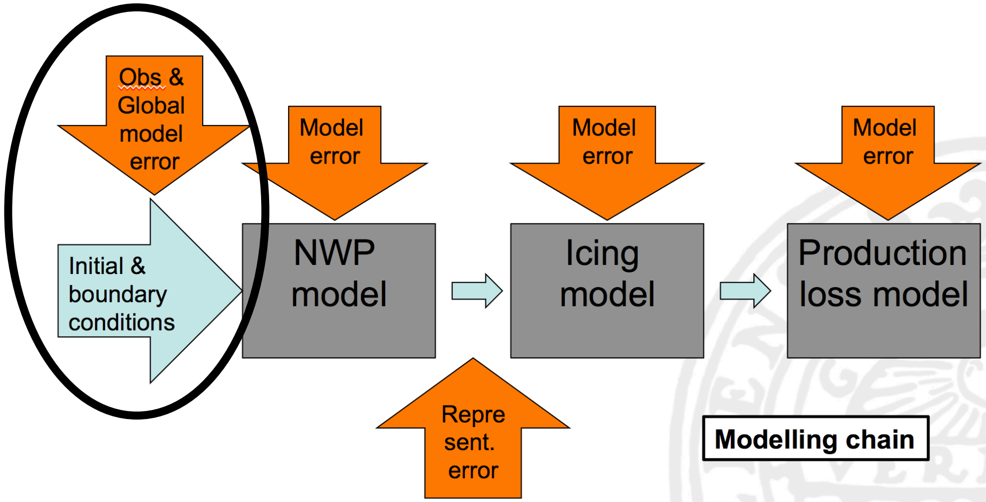
The neighbourhood method

- Using the 25 nearest grid points as equally likely forecast
- Represent the horizontal error in the representativeness of the wind turbines

Method: Probabilistic forecasting

Ensemble forecasting

- Representing uncertainties in the <u>initial conditions</u>



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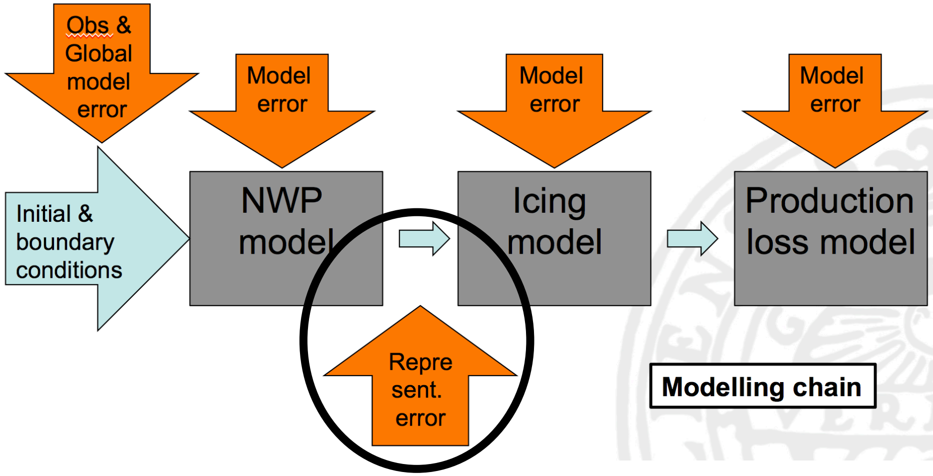

The neighbourhood method

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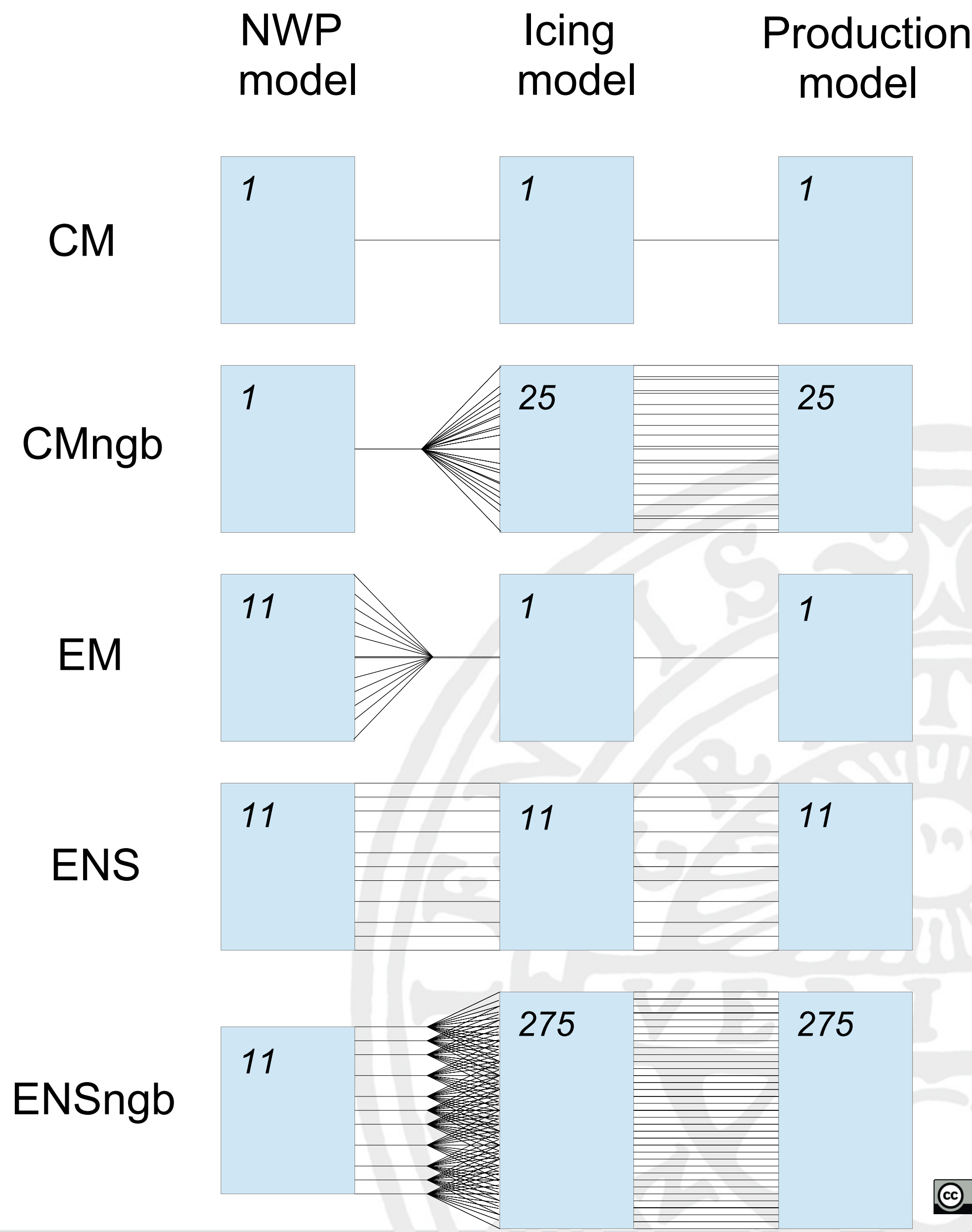
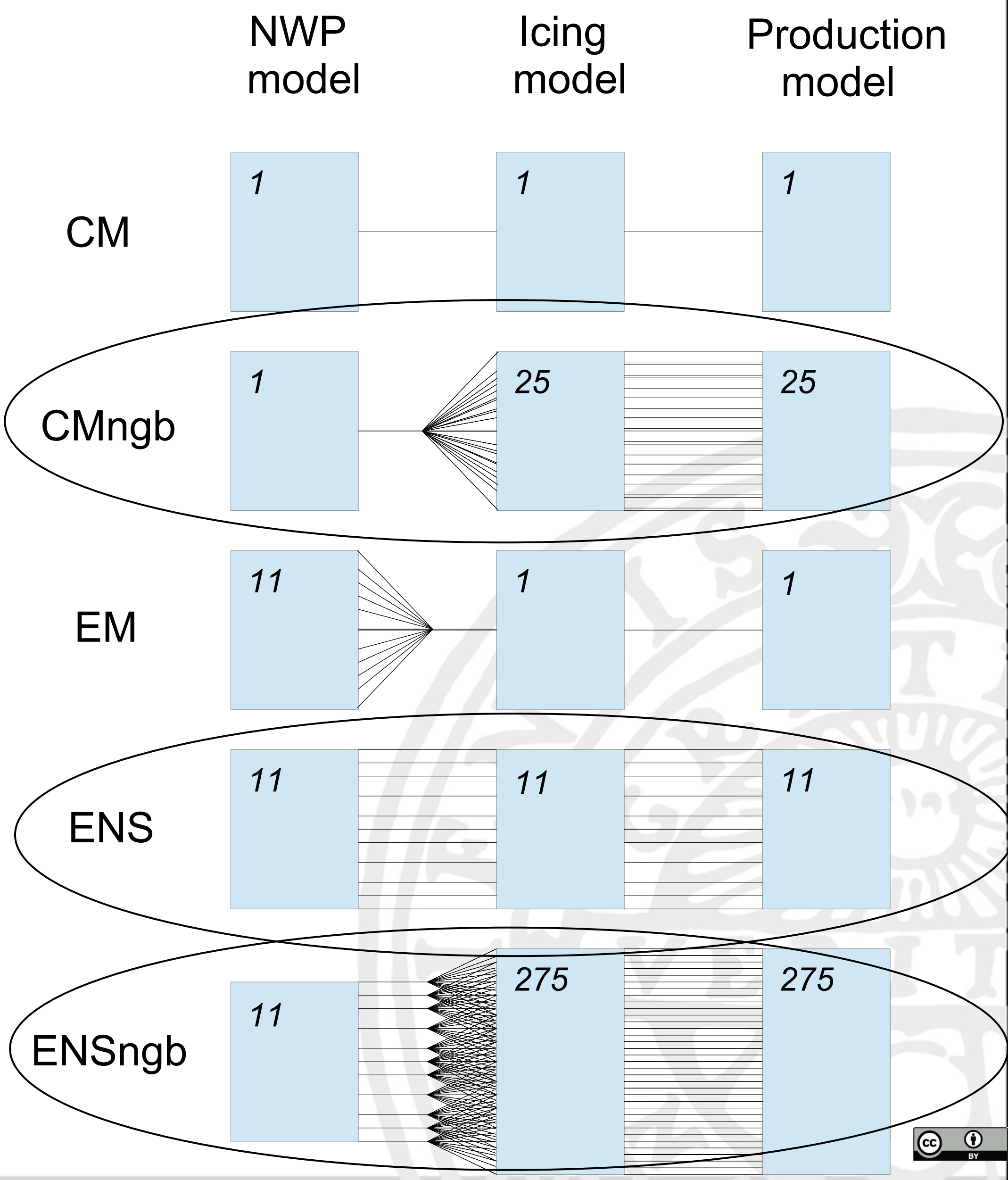
Different approaches

Deterministic forecast

Probabilistic approaches



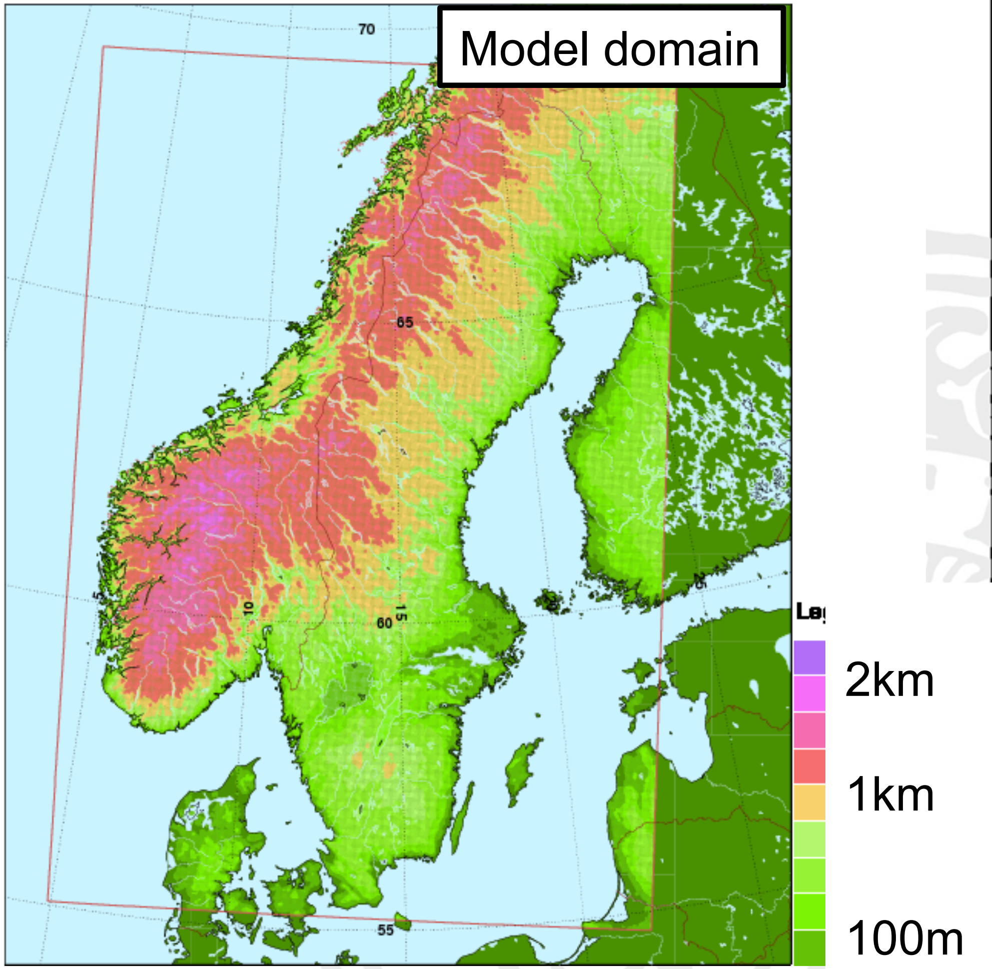
Different approaches



Three of the approaches give uncertainty estimations for each forecast step through spread

The NWP model

- Harmon-EPS
- HARMONIE-Arome cy38h1.2
- 2.5 km and 65 levels
- 1 control member, 3DVar, 3h-RUC
- 10 perturbed members based on the ECMWF EPS



The icing and production loss model

Icing model:

- Based on Makkonen Model (2000)
- Developed for ice accreation due to cloud water on cylinder

  Additions:
  - Ice accretion due to cloud ice, snow and rainwater
  - Sublimation, melting, shedding
  - Wind erotion

Production loss:

- Empirical relationship of modelled ice growth, ice load and wind speed

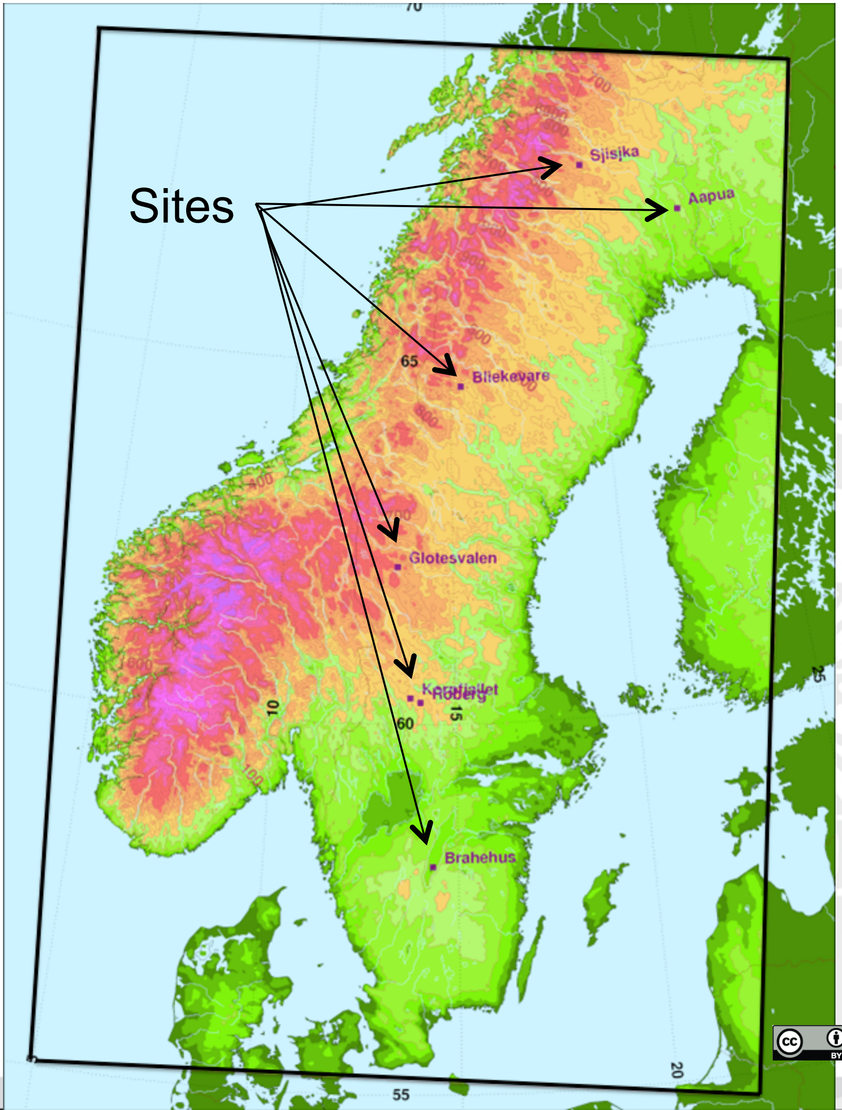
Production:

- Seasonally varying effect curves for each turbine from observed wind speed and power production.

(Developed by Esbjörn Olsson, SMHI)

Experimental period and available data

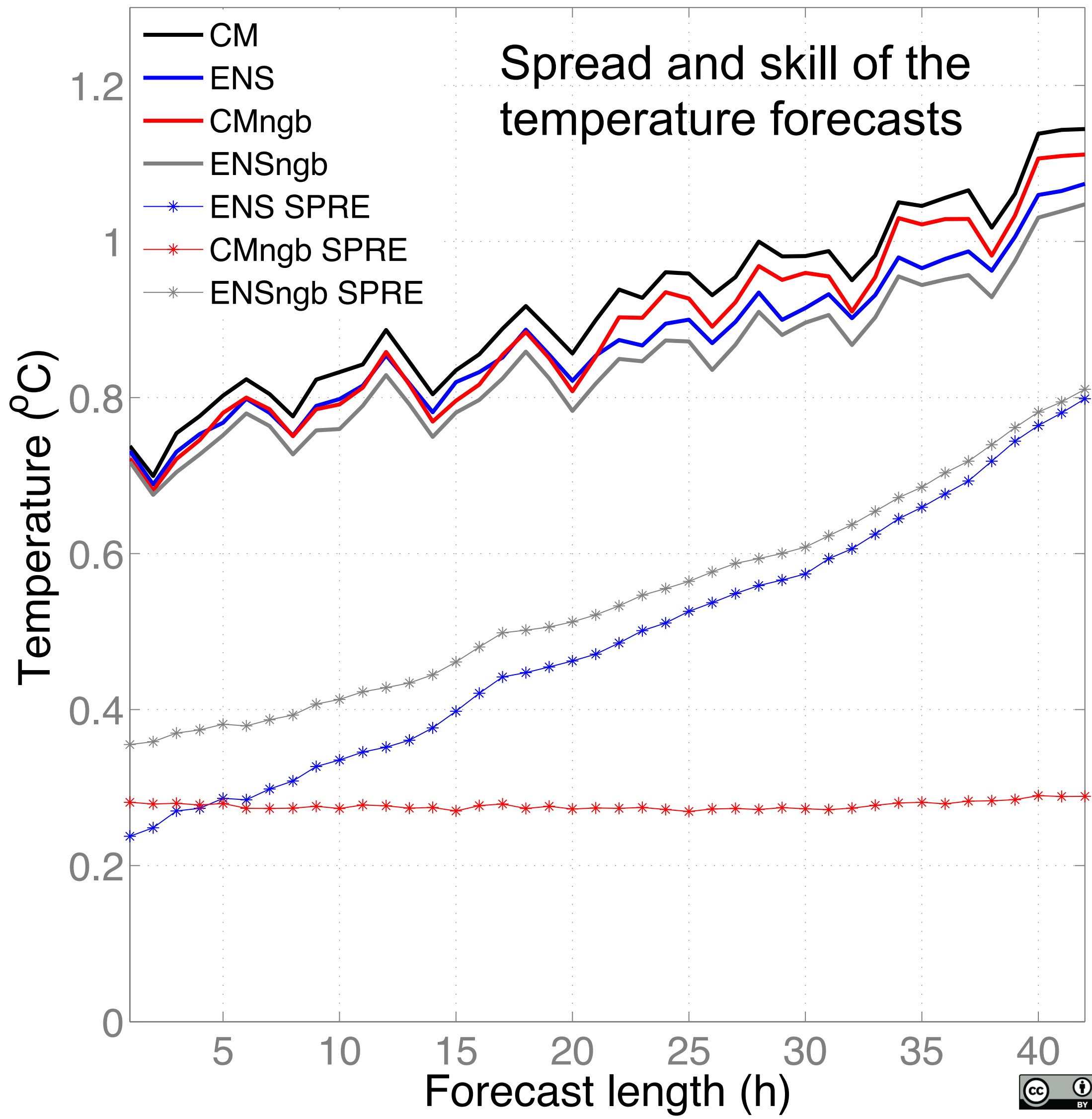
- Two weeks: 26/12-2011 to 8/1-2012
- Forecasts initialized 00,06,12,18 UTC (+42 h)
- Next-day forecasts: 06 UTC (+18-42 h)
- Observations:
  - 10 wind park sites in Sweden with meteorological measurements
  - From 3 of the sites also power production data



Results: Meteorological performance

Unbiased forecast error of the ensemble mean and ensemble spread

- ENSngb has the lowest forecast error
- ENS better than ngb method
- All approaches are underdispersive



Results: Meteorological performance

Average spread/skill ratio over all forecast lengths

Approach	Temperature	Wind speed	Relative humidity
CMngb	0.30	0.31	0.27
ENS	0.64	0.54	0.63
ENSngb	0.70	0.61	0.67

Results: Meteorological performance

In a "perfect" ensemble forecast spread/skill ratio = 1

ENS+ngb:

⇒ Best uncertainty estimation

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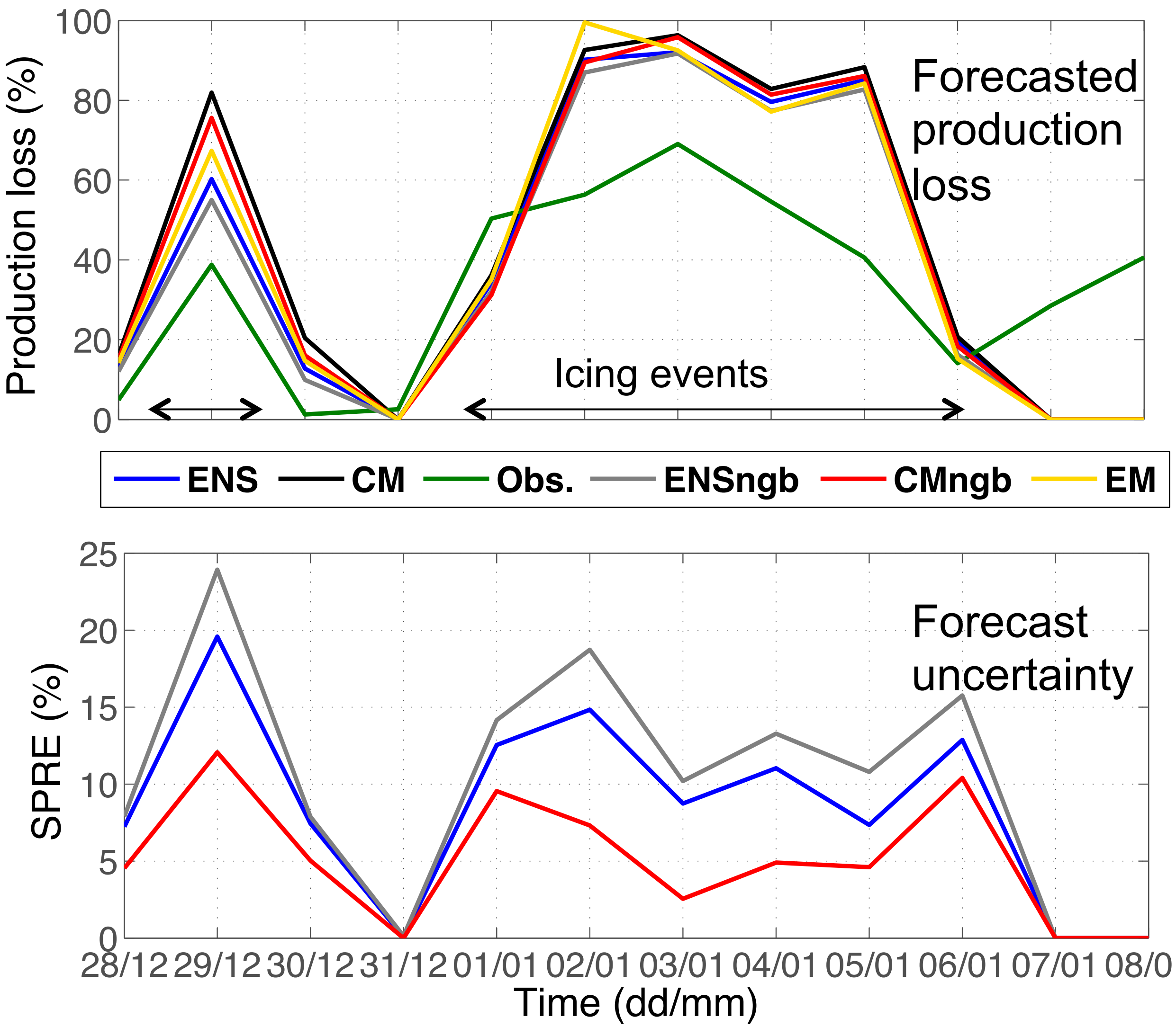
Results: Production loss

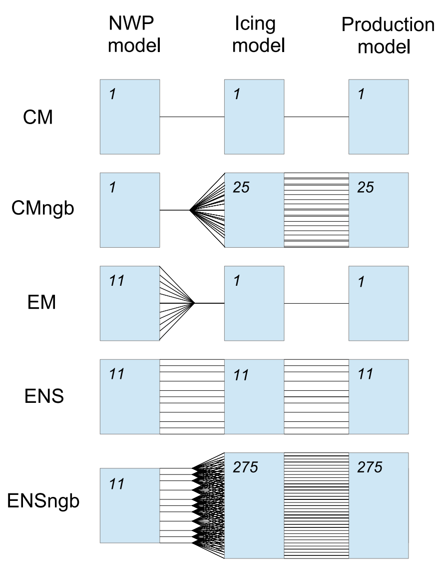
Forecasted daily mean production loss at one site

- ENSngb: Best agreement with observations and largest spread
- Forecasted uncertainty during icing events



Result: Production loss

RMSE **for production and production loss forecasts averaged over 3 sites**



Approach	Prod (MW)		Prod loss (%)
CM	0.81	Better	36
CMngb	0.78		34
EM	0.78		35
ENS	0.75		32
ENSngb	0.74		31

Summary

- Forecasting wind power in cold climates has been addressed using probabilistic forecasting.
- Probabilistic forecasting improves the forecast skill in all steps of the modelling chain.
- Combined ensemble and neighbourhood method provides best forecast.

Future plans:

- Improve ensemble spread.
- Take into account ice and production model uncertainty.

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Thank you!