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Uncertainty quantification for wind power forecasts in cold climates

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Contents

- Motivation
- Model setup
- Results
- Summary and future plans

Motivation

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- Forecasting wind power production taking icing into account involves using a chain of different models.
- Each step introduces uncertainties.
- Important to quantify these uncertainties.
- For the weather forecast we use a so called Ensemble Prediction System (EPS).
- Errors in the initial conditions and the weather models inability to take small-scale atmospheric processes into account, leads to forecast errors that increases with forecast lead time.
- Solution: Run several forecasts with different initial conditions and slightly adjusted model formulations.

Motivation

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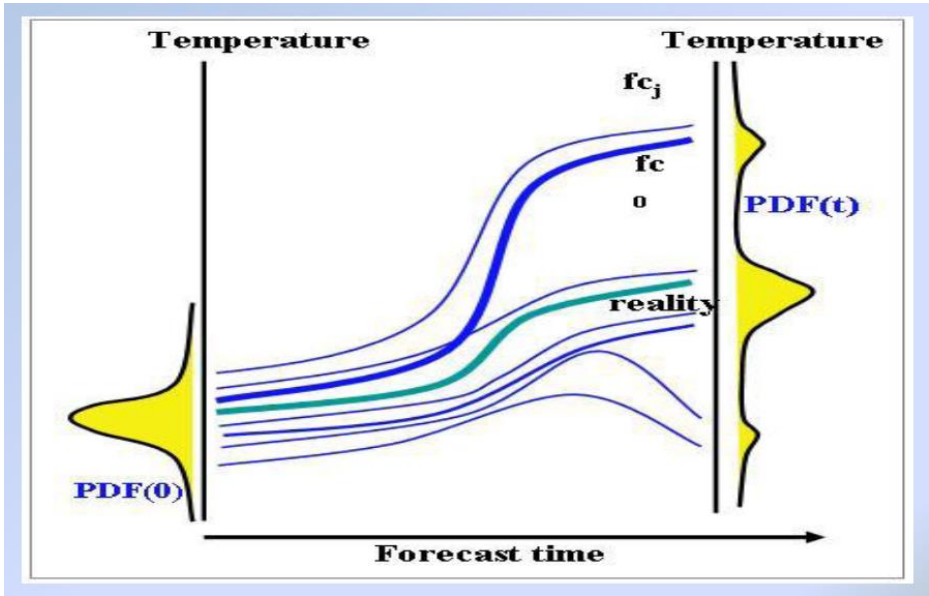

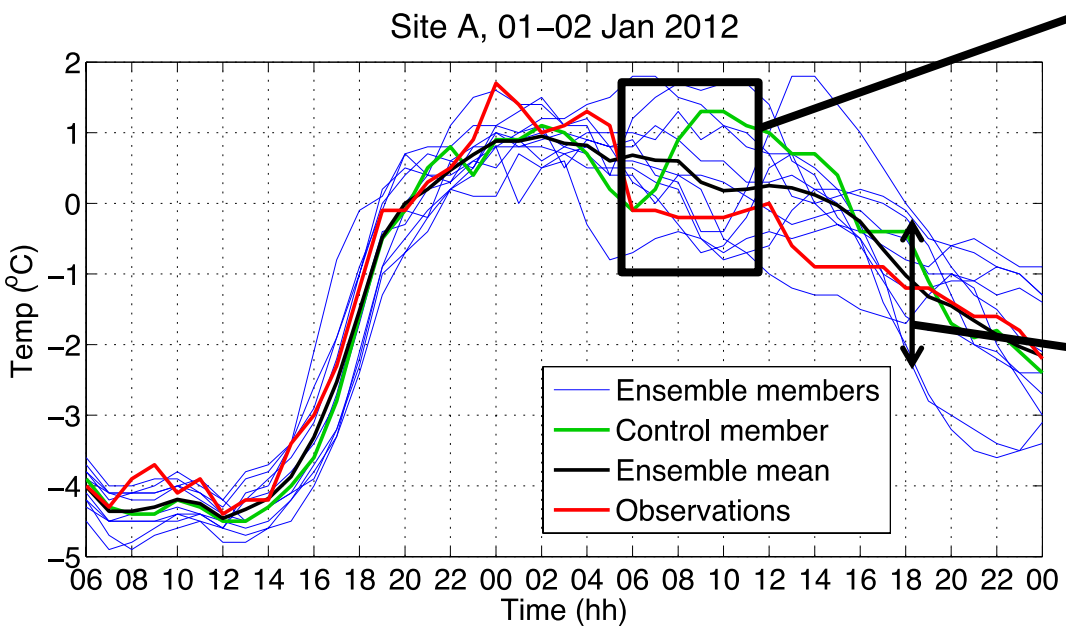

50 % chance of temp below freezing

Spread of ensemble gives the uncertainty

Motivation

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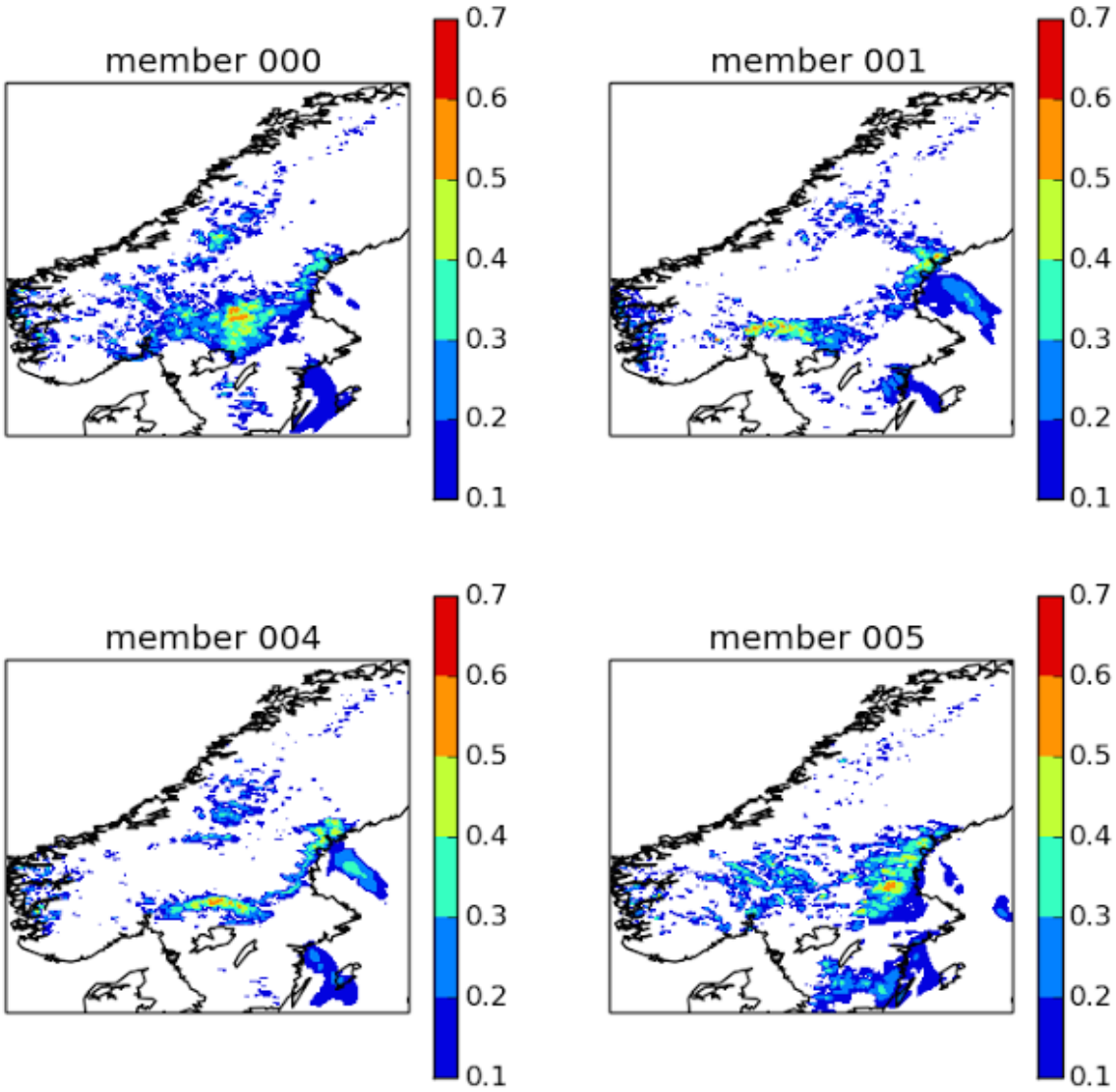
Cloud water
100 m height
(g/kg)



Motivation

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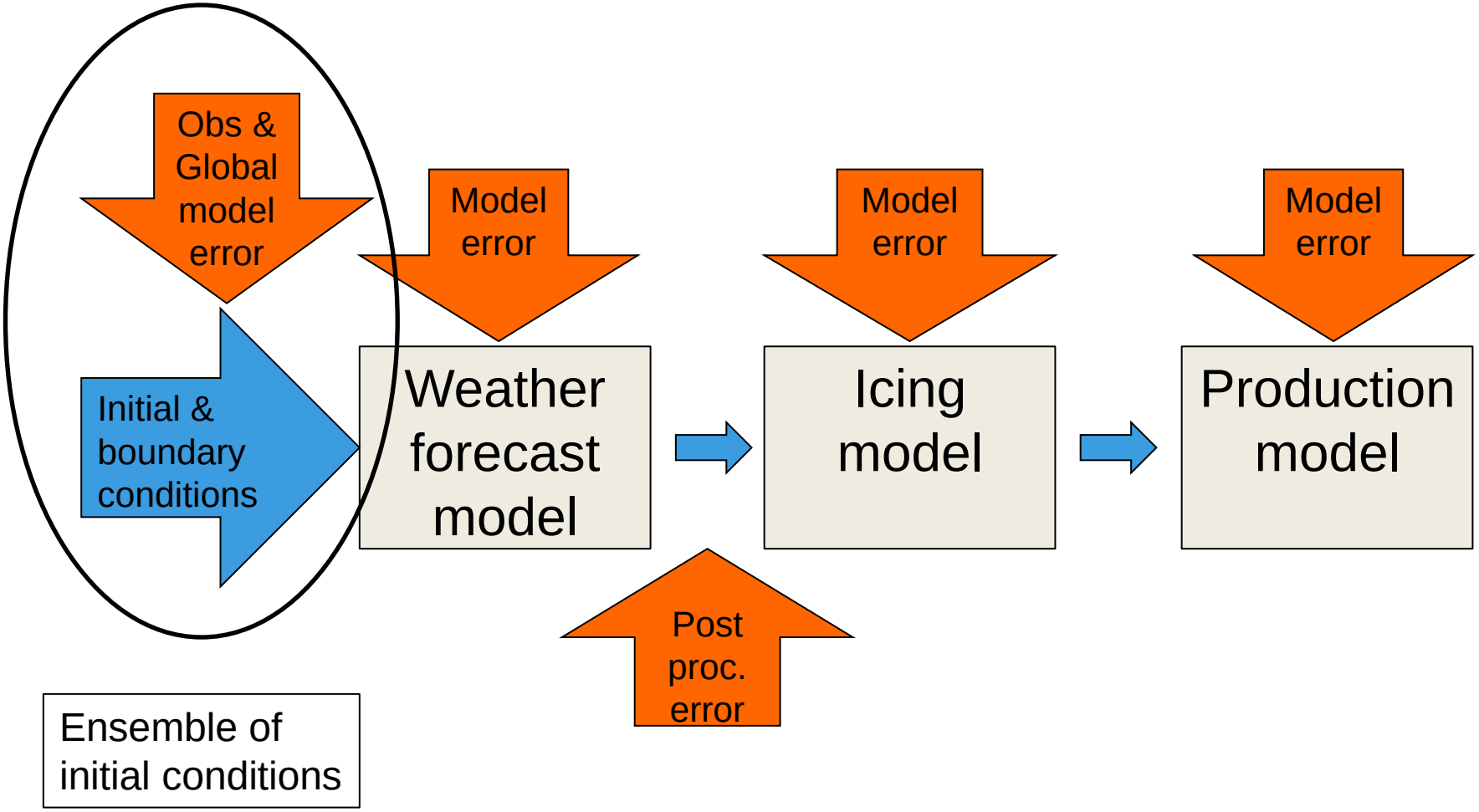
Modelling chain



Ensemble of initial conditions

Model setup

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The weather forecast model

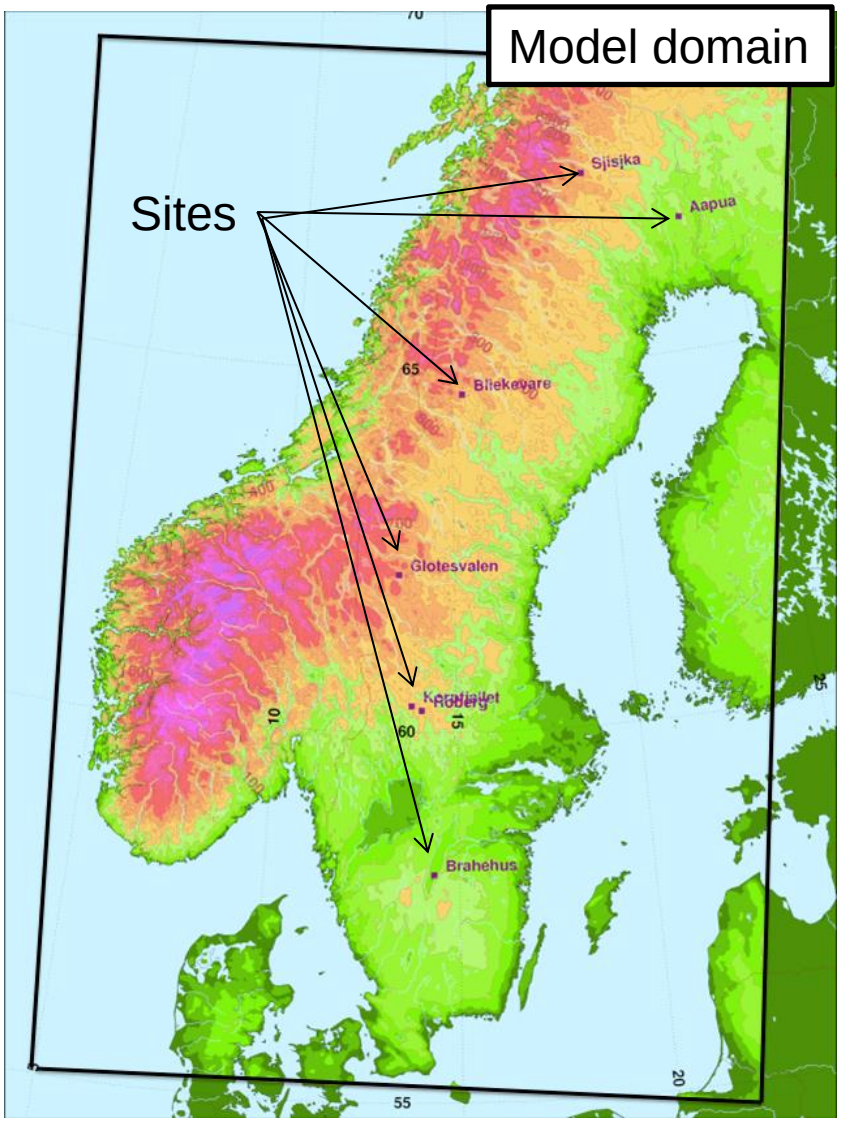
HarmonEPS

2.5 km and 65 levels

1 control member
10 perturbed members based on the ECMWF EPS

Period: 26/12-2011 - 8/1-2012

Forecasts 00,06,12,18 UTC (+42 h)



Model setup

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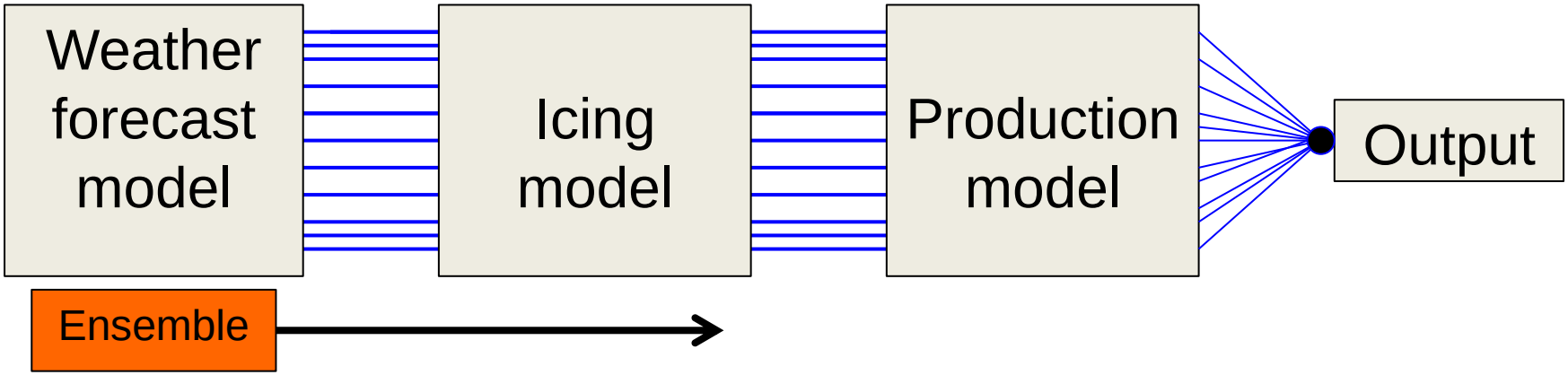

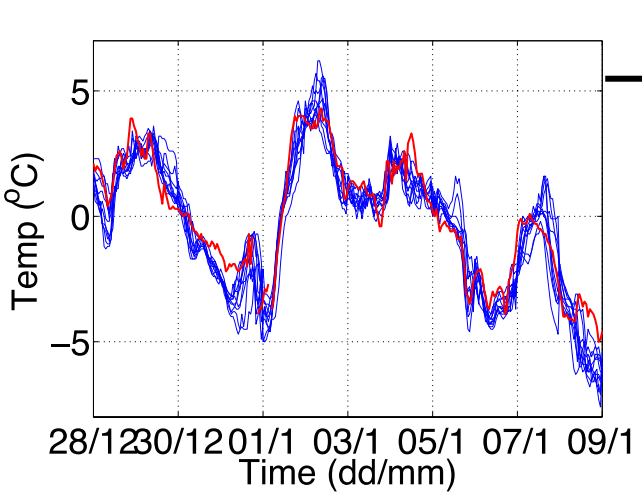

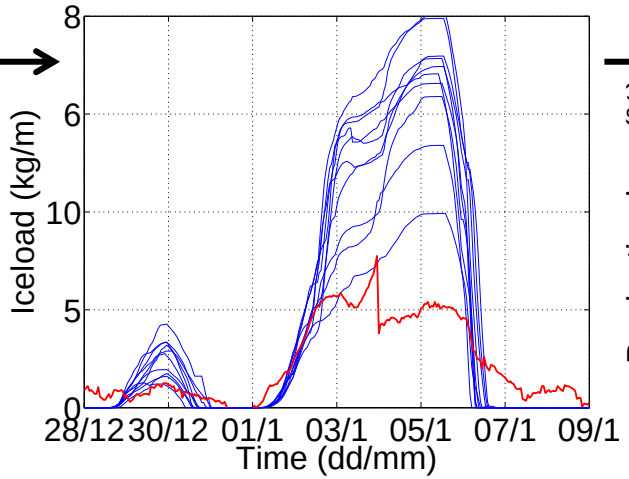

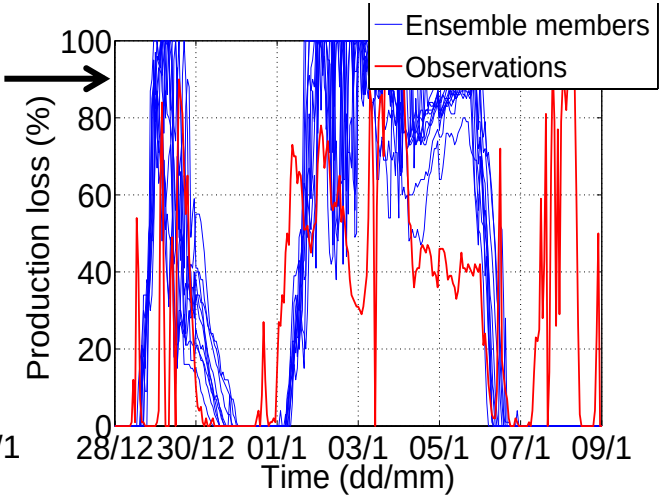

Model setup

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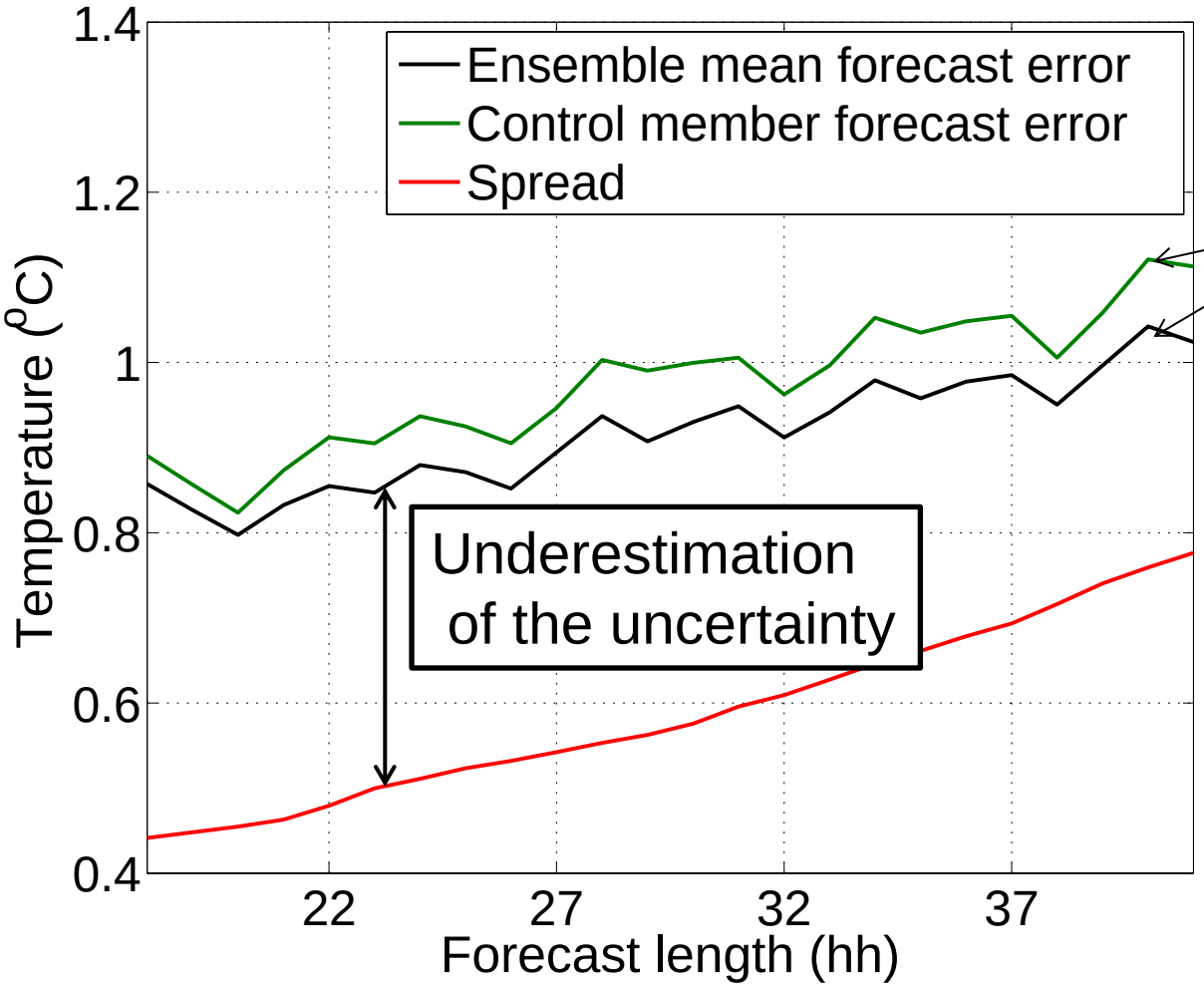
Spread/skill of the ensemble



The ensemble mean reduces the forecast error

Ideally:
Spread of ensemble= Forecast error of ensemble mean

Model setup

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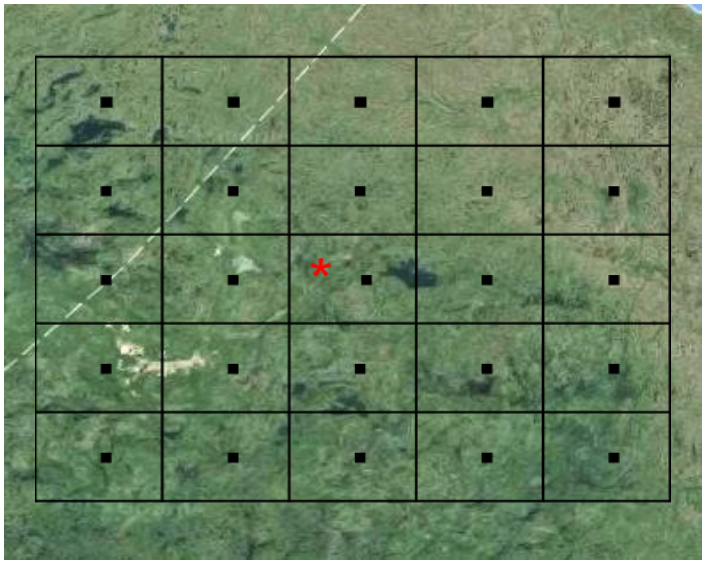
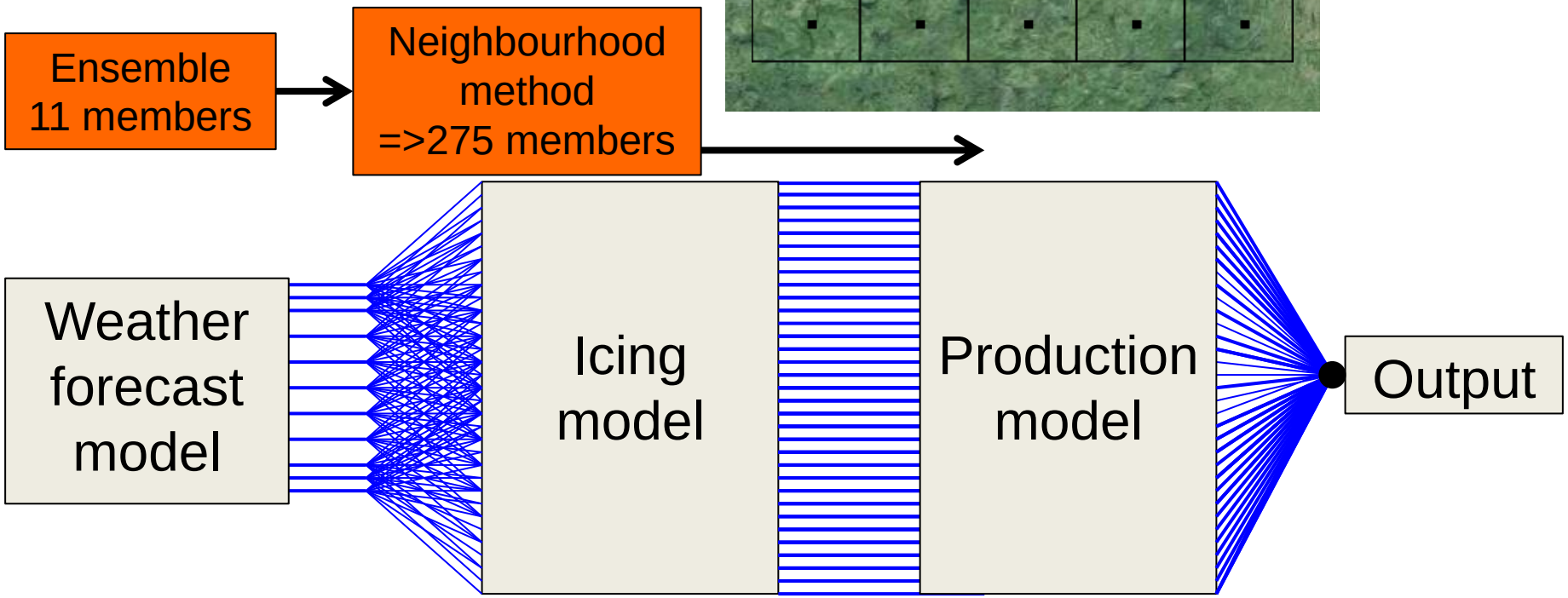
Neighbourhood method

- One approach to increase the ensemble and get a more realistic spread.
- Treats neighbouring grid points (10x10 km, 25 grid points) as equally likely forecasts.



▪ - Grid point
* - Site



Model setup

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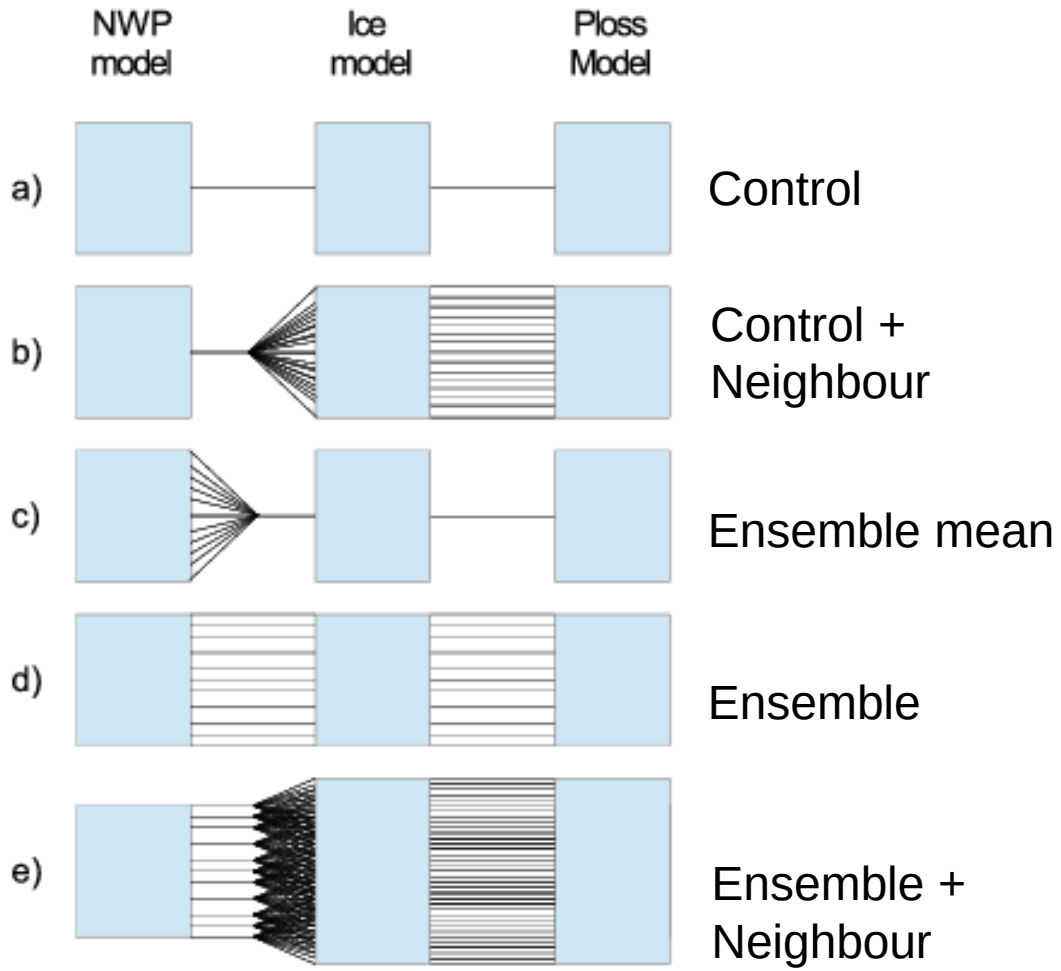
Different icing/power production loss calculation options



Results

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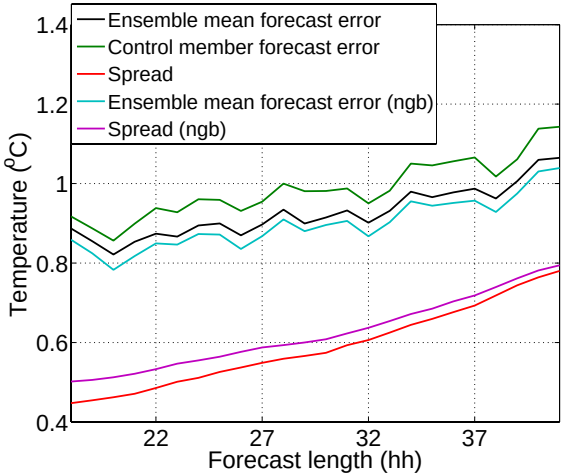
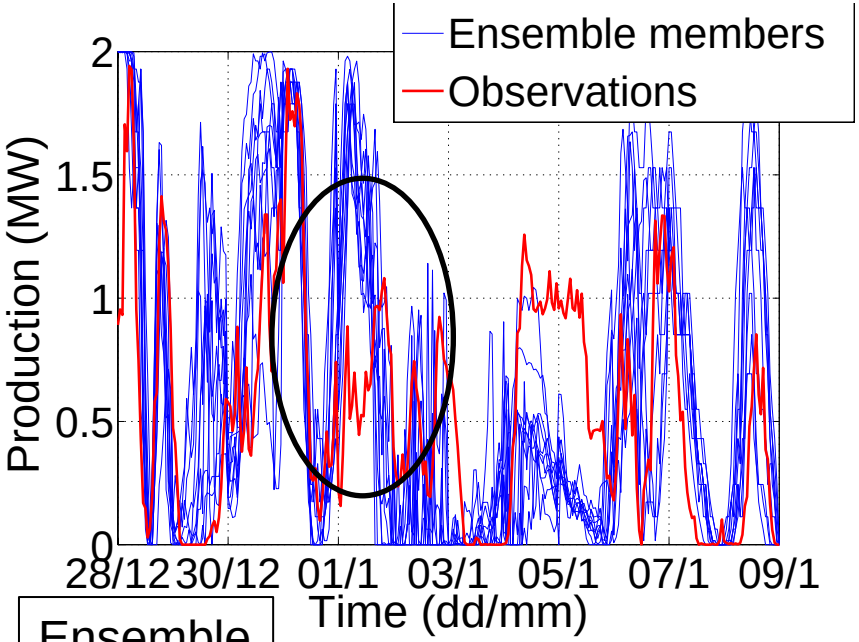
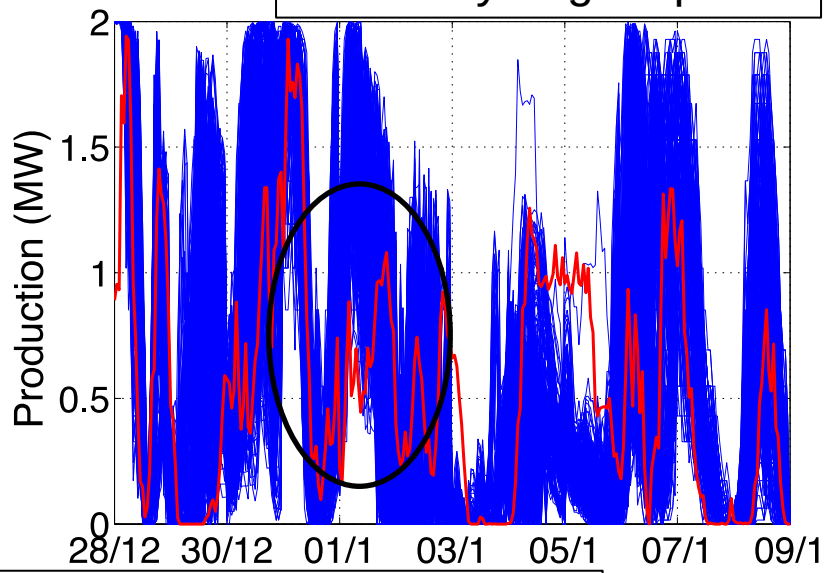
Ensemble vs Ensemble + Neighbourhood





Ensemble

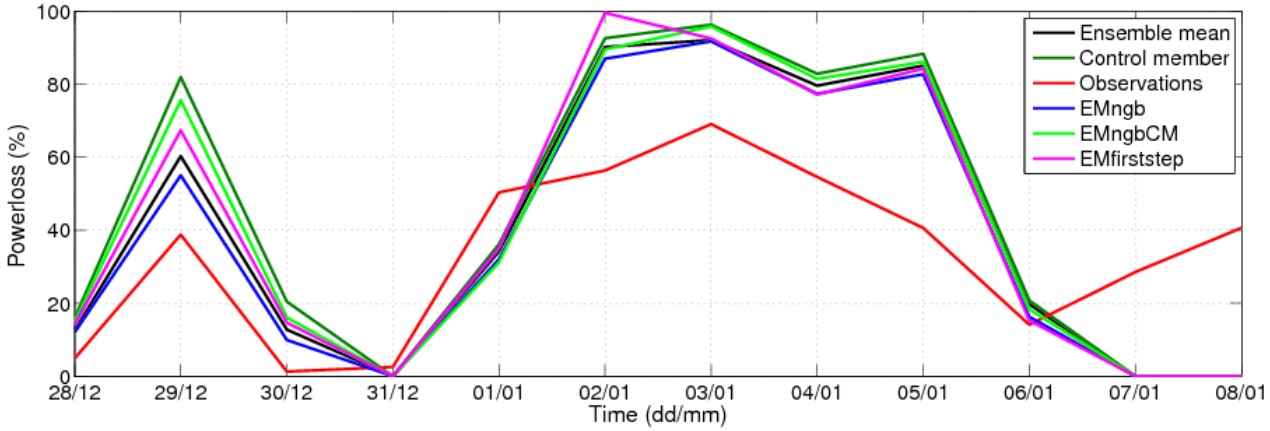
Generally larger spread



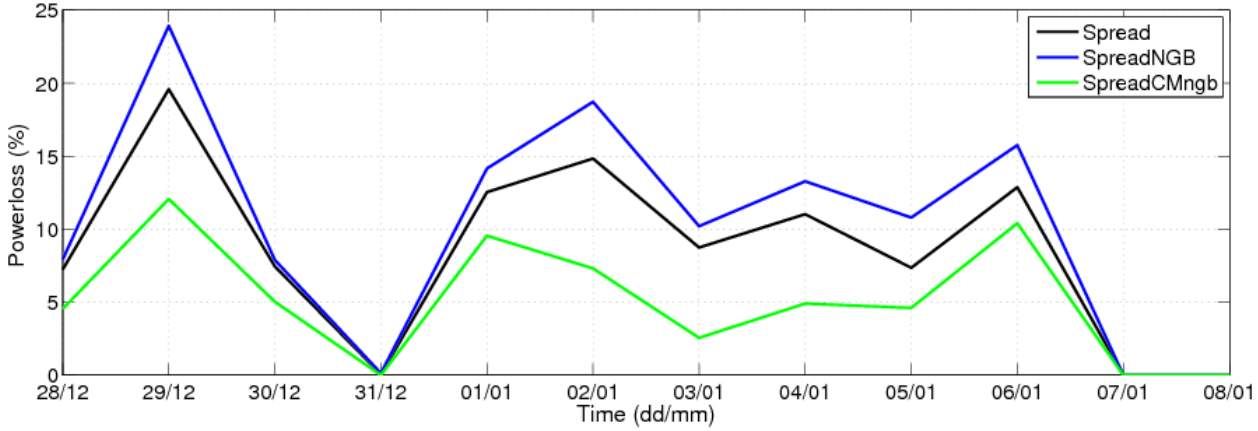
Ensemble + neighbourhood

Results

Daily power production loss forecasts, one site



Forecasts and observation of actual power production losses



Forecast spread for three of the methods

Results

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The greatest reduction in the forecast error is achieved using all the 11 members combined with the neighbourhood method.

	RMSE ploss mean(%)	RMSE power mean (MW)
CM	36	0.81
EM first step	35	0.78
EM	32	0.75
CM ngb	34	0.78
EM ngb	31	0.74
	Reduction compared to CM ploss (%)	Reduction compared to CM power (%)
EM first step	3	4
EM	11	8
CM ngb	5	4
EM ngb	14	9

Summary and future plans

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- Uncertainties in the power production forecast chain need to be addressed in order to get a measure of the forecast quality.
- For the weather forecast model the spread of high-resolution ensembles seems to provide a good uncertainty measurement.
- Ensemble + Neighbourhood method provides even better estimations of uncertainty and better ensemble mean
- Future plans
  - Introduce a probabilistic approach for the entire modelling chain (Ice model and Production model)

Summary and future plans

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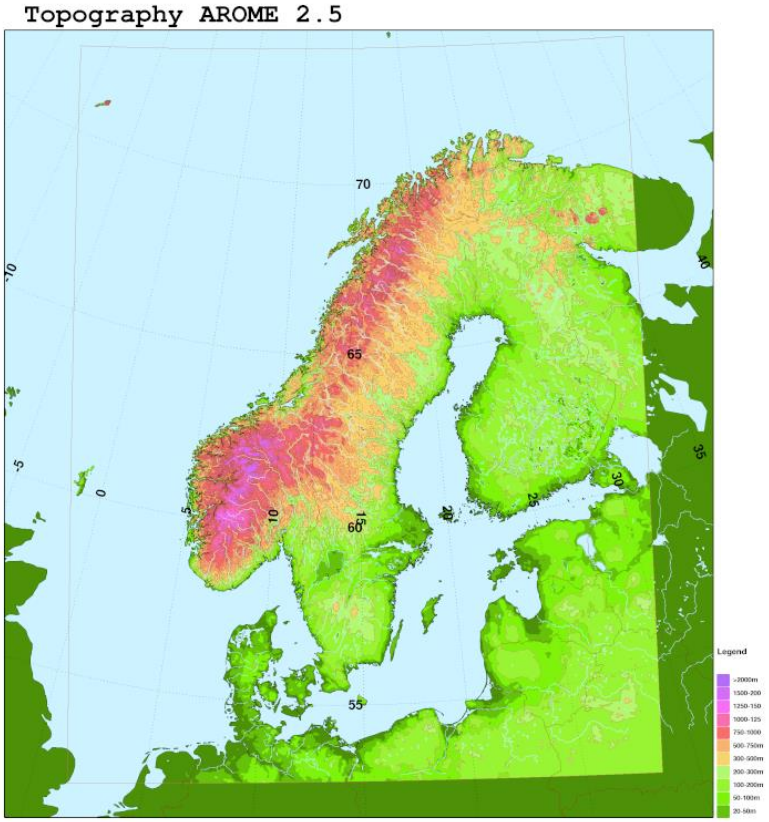
HarmonEPS: Sweden – Norway MetCoOp

- 2.5 km horizontal resolution
- 2 control members (Alaro and Arome)
- 8 Arome members
- Control runs +66 hours, members +36 hours.
- 4 times per day.
- Daily test runs starting within a month.
- Operational before summer.



Thank you!

Any questions?