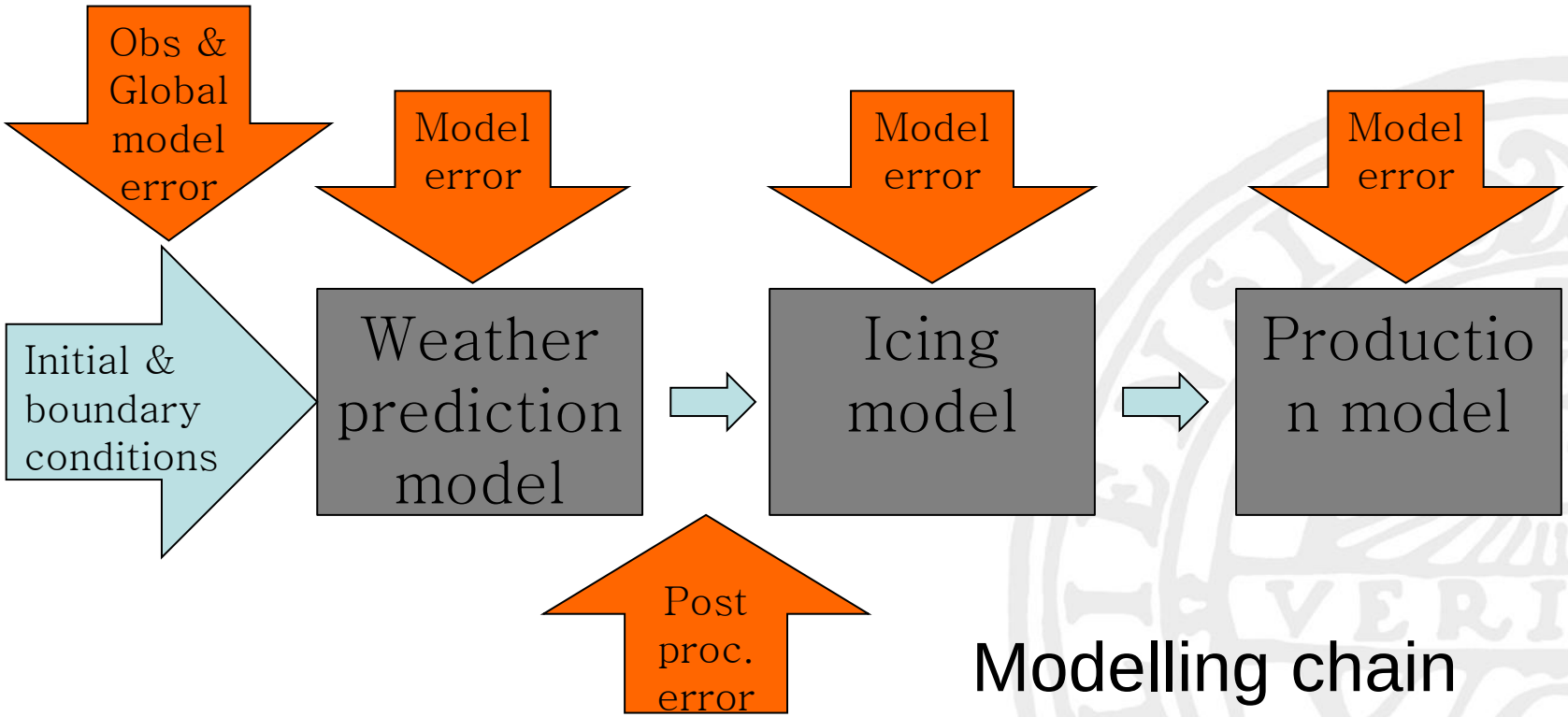
Probabilistic forecasting of icing and production losses

Jennie Persson Söderman, Heiner Körnich, Björn Stensen, Esbjörn Olsson, Hans Bergström & Anna Sjöblom

Acknowledgements to the Swedish Energy Agency (Energimyndigheten) for funding the project

Why do we need probabilistic forecasting?

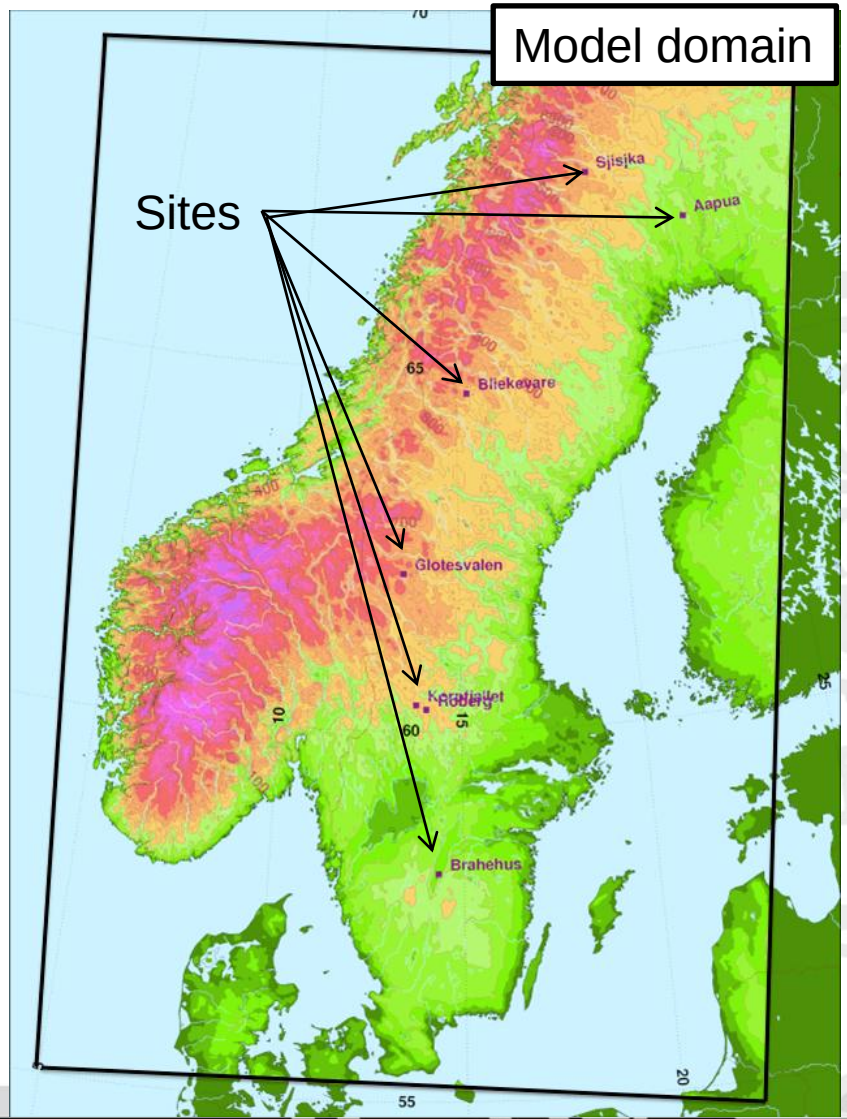
Better forecast with uncertainties



Modelling chain

The weather prediction model

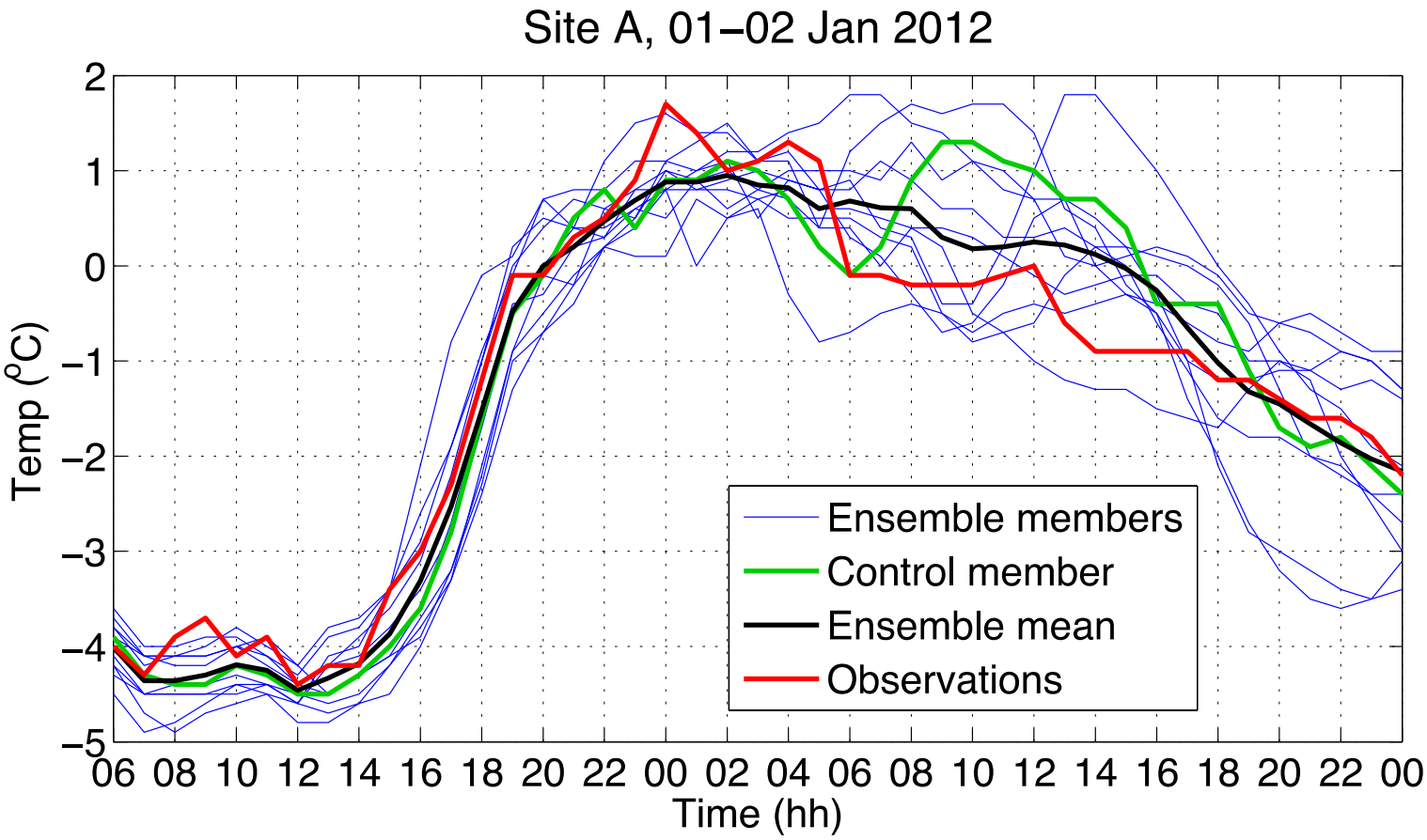
- HarmonEPS
- 2.5 km and 65 levels
- 1 control member
- 10 perturbed members based on the ECMWF EPS
- Period: 26/12-2011 - 8/1-2012
- Forecasts 00,06,12,18 UTC (+42 h)



UPPSALA UNIVERSITET

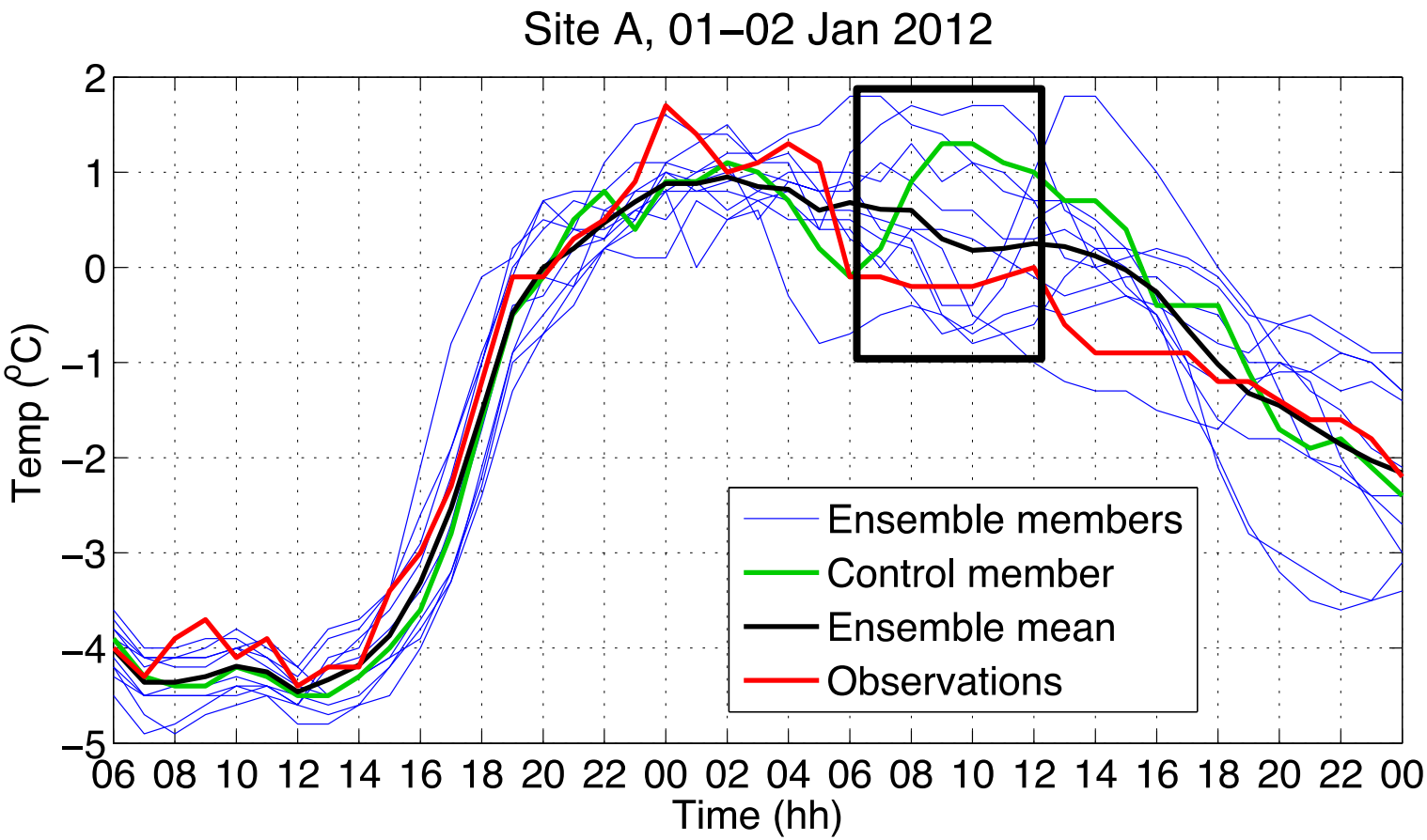
Method: Ensemble forecasting

Several simulations with e.g., different initial conditions



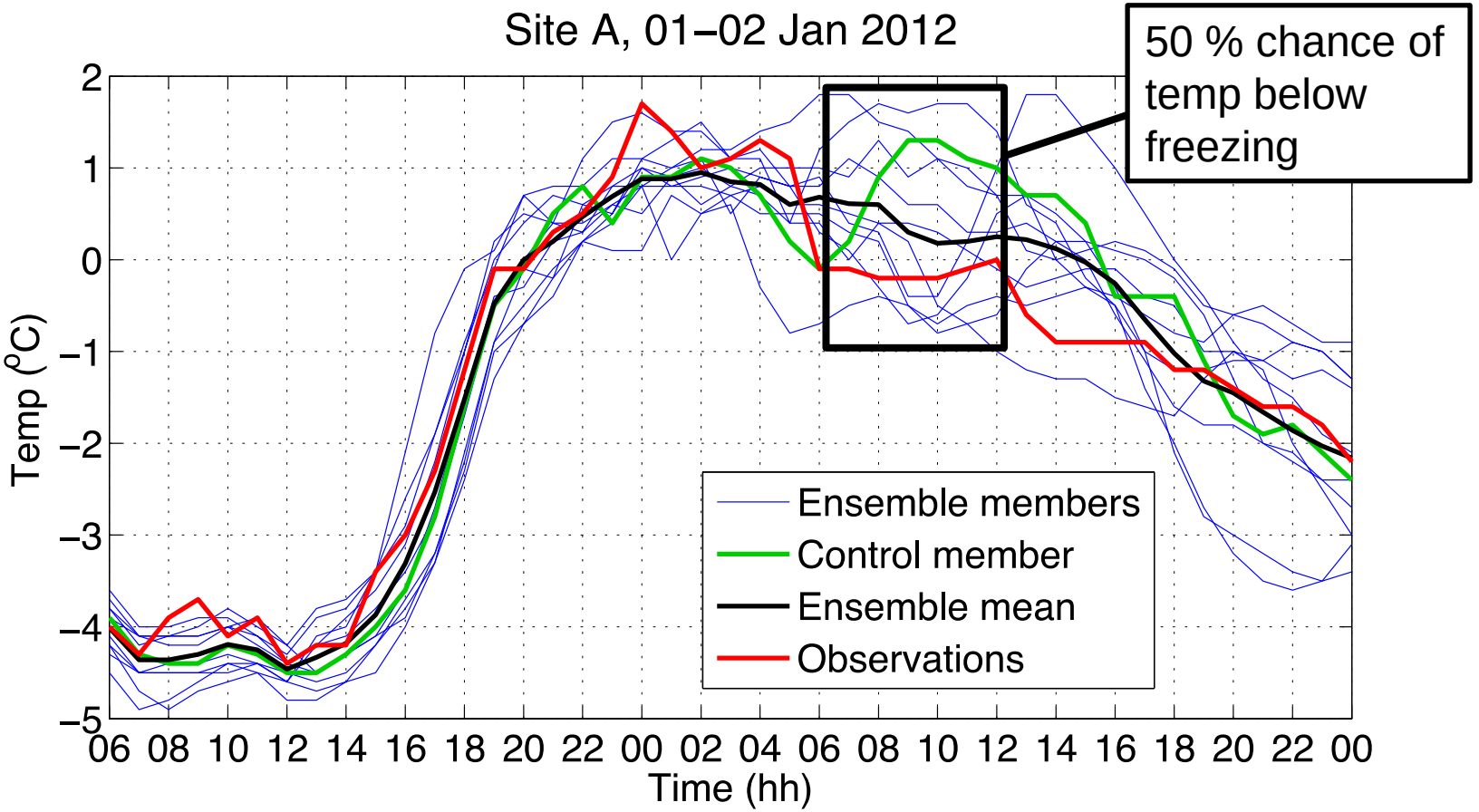
UPPSALA UNIVERSITET

Method: Ensemble forecasting



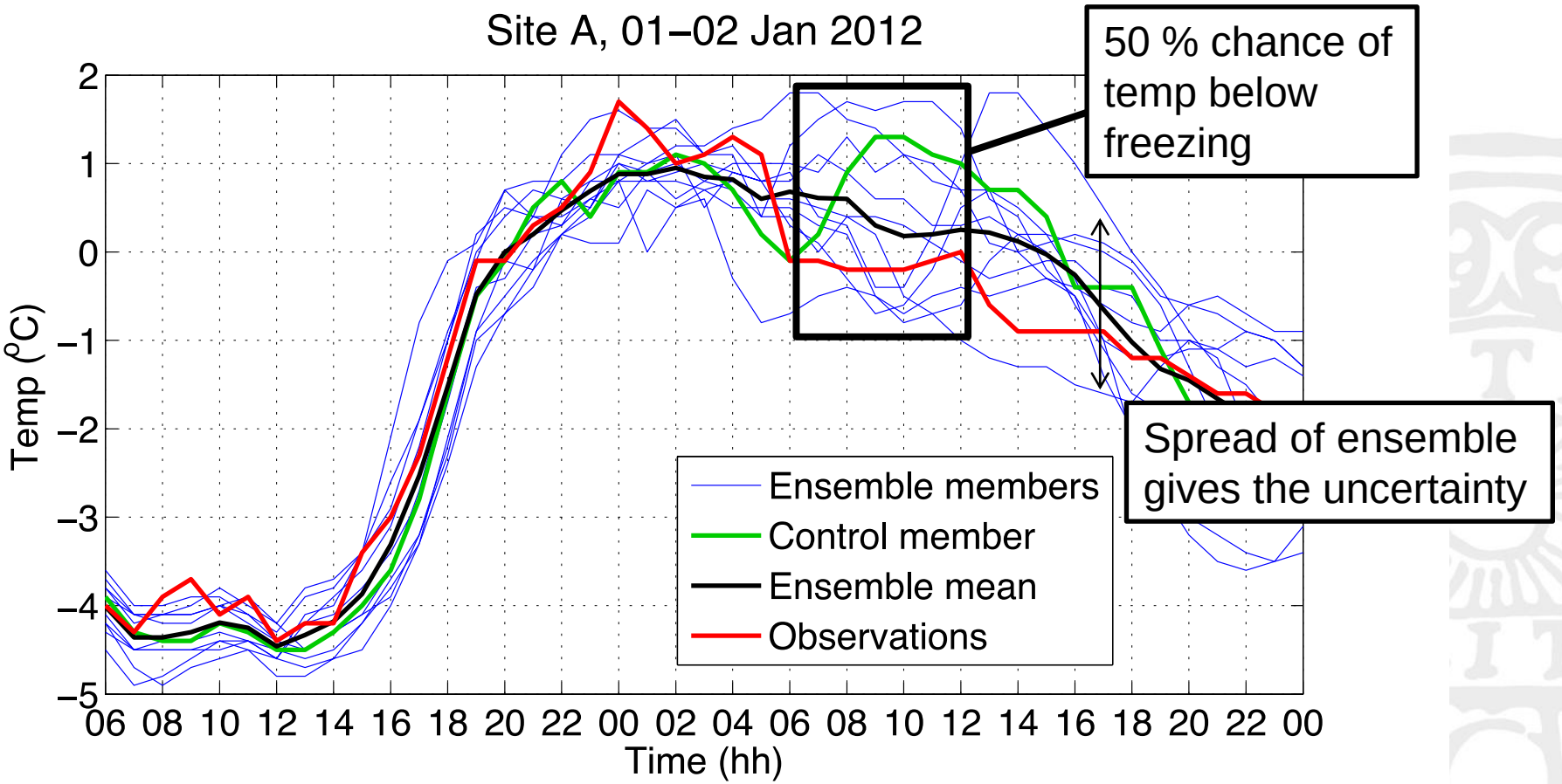
UPPSALA UNIVERSITET

Method: Ensemble forecasting

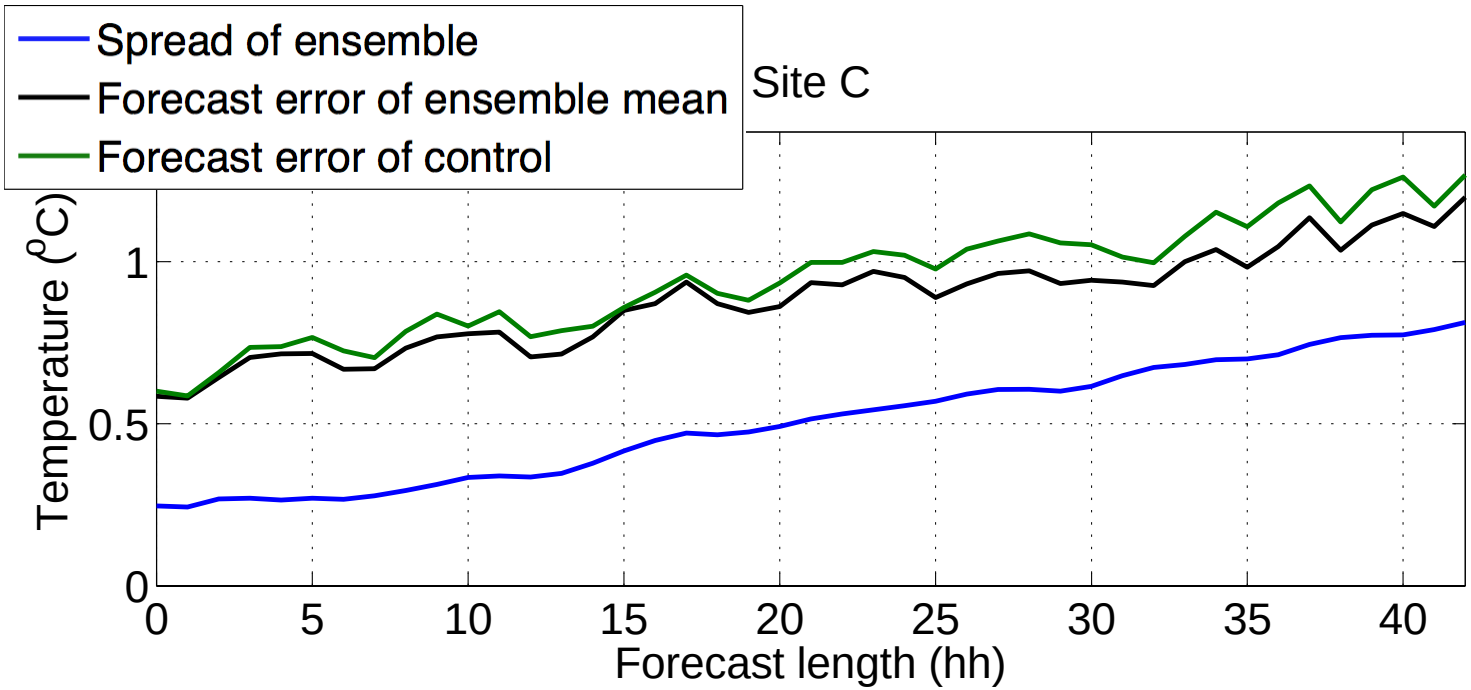


UPPSALA UNIVERSITET

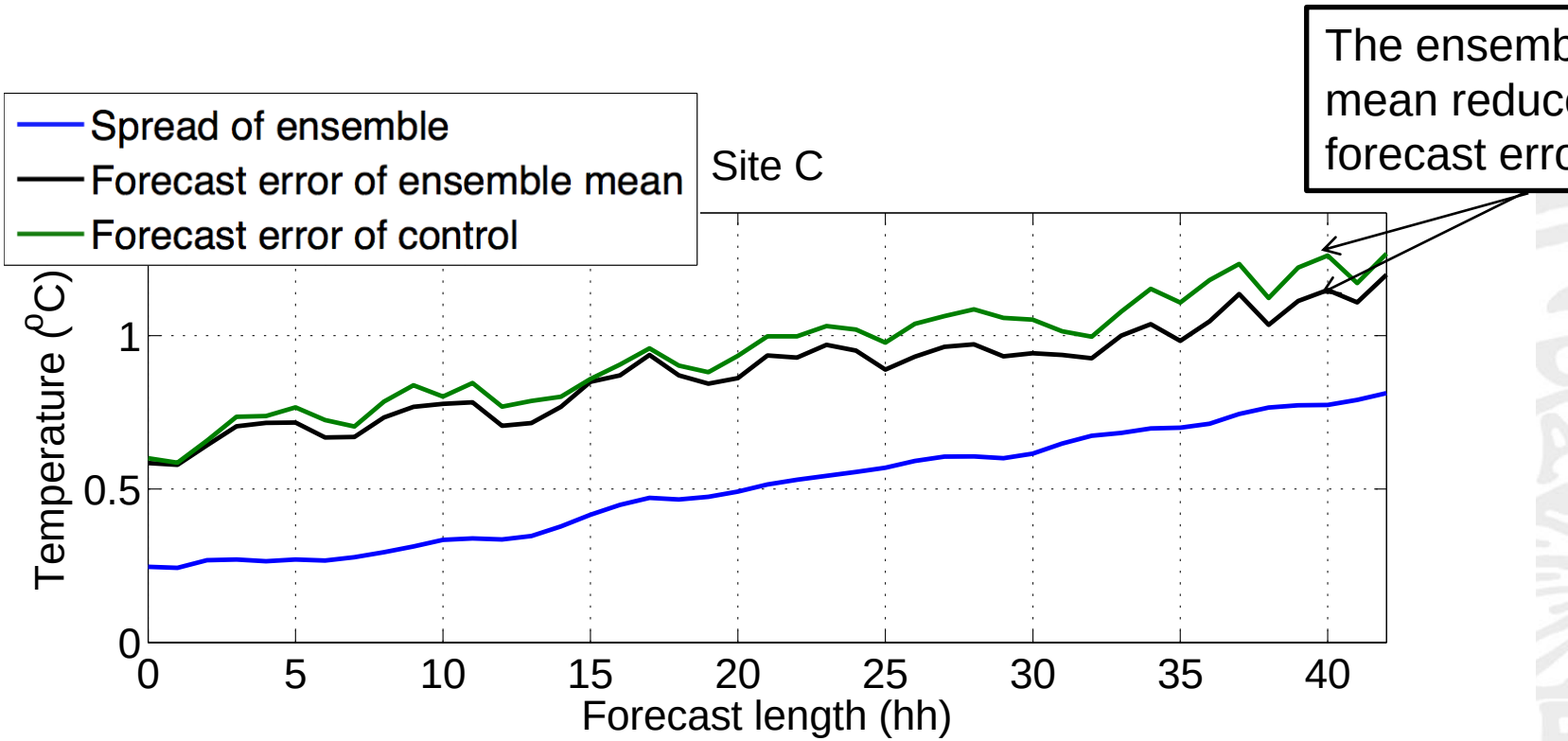
Method: Ensemble forecasting



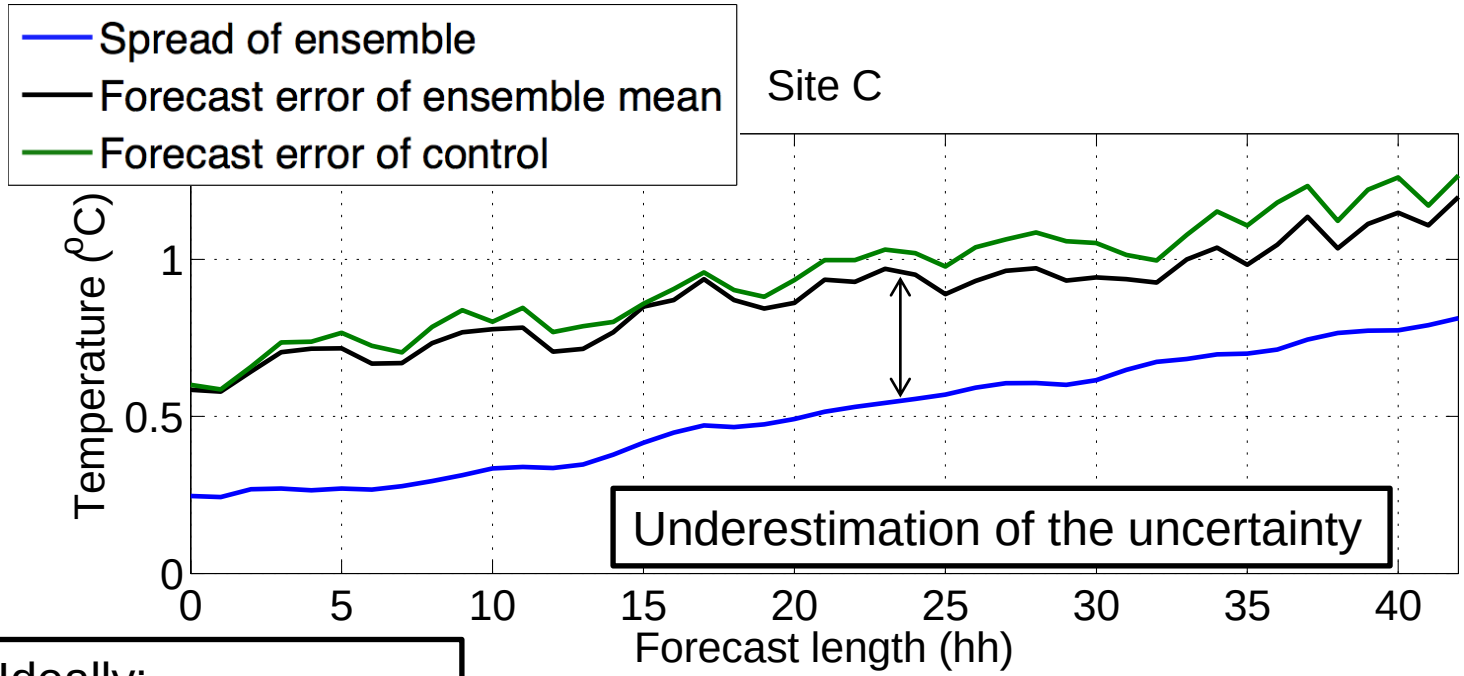
Weather forecast: Spread/skill of the ensemble



Weather forecast: Spread/skill of the ensemble

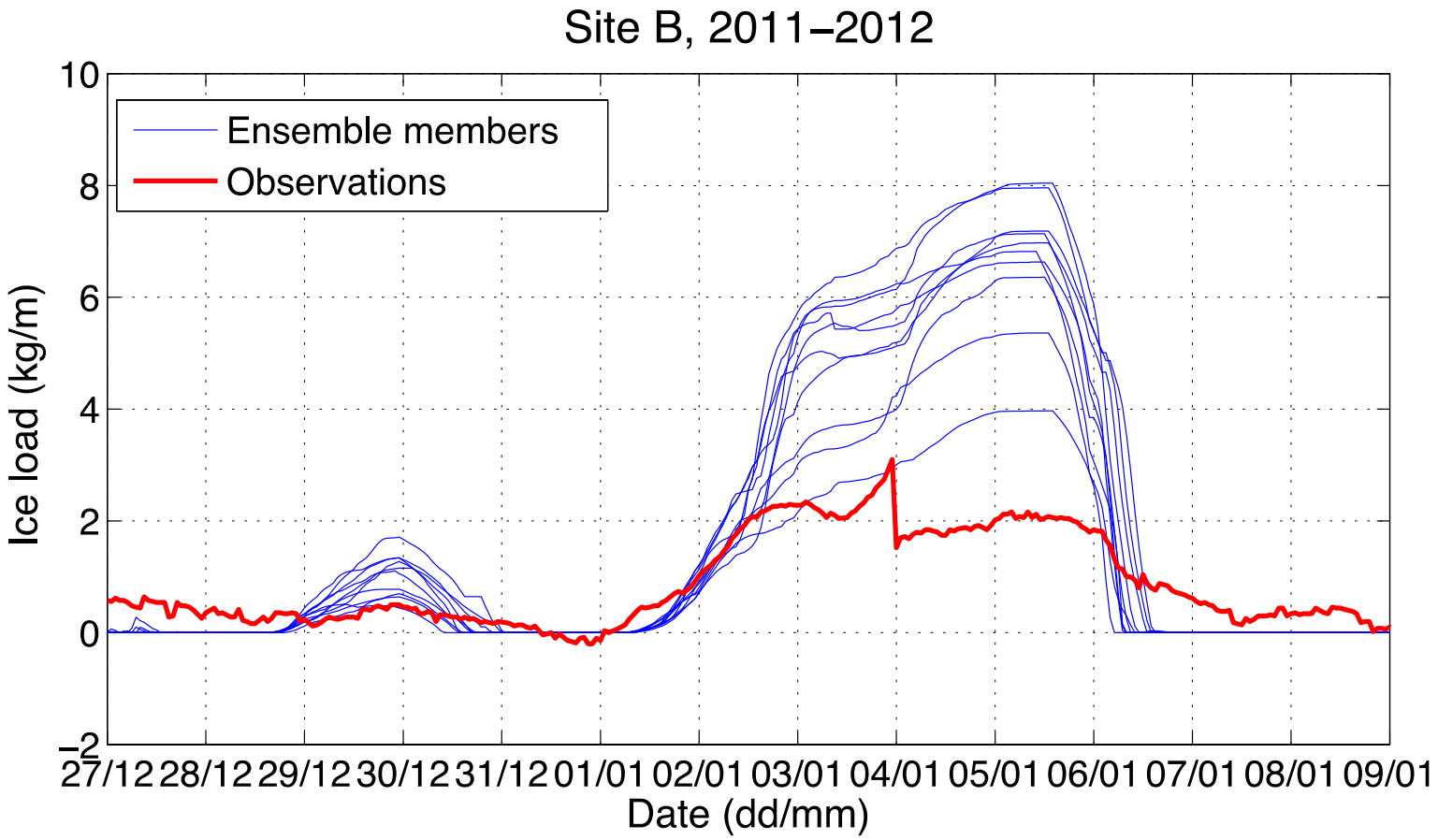


Weather forecast: Spread/skill of the ensemble

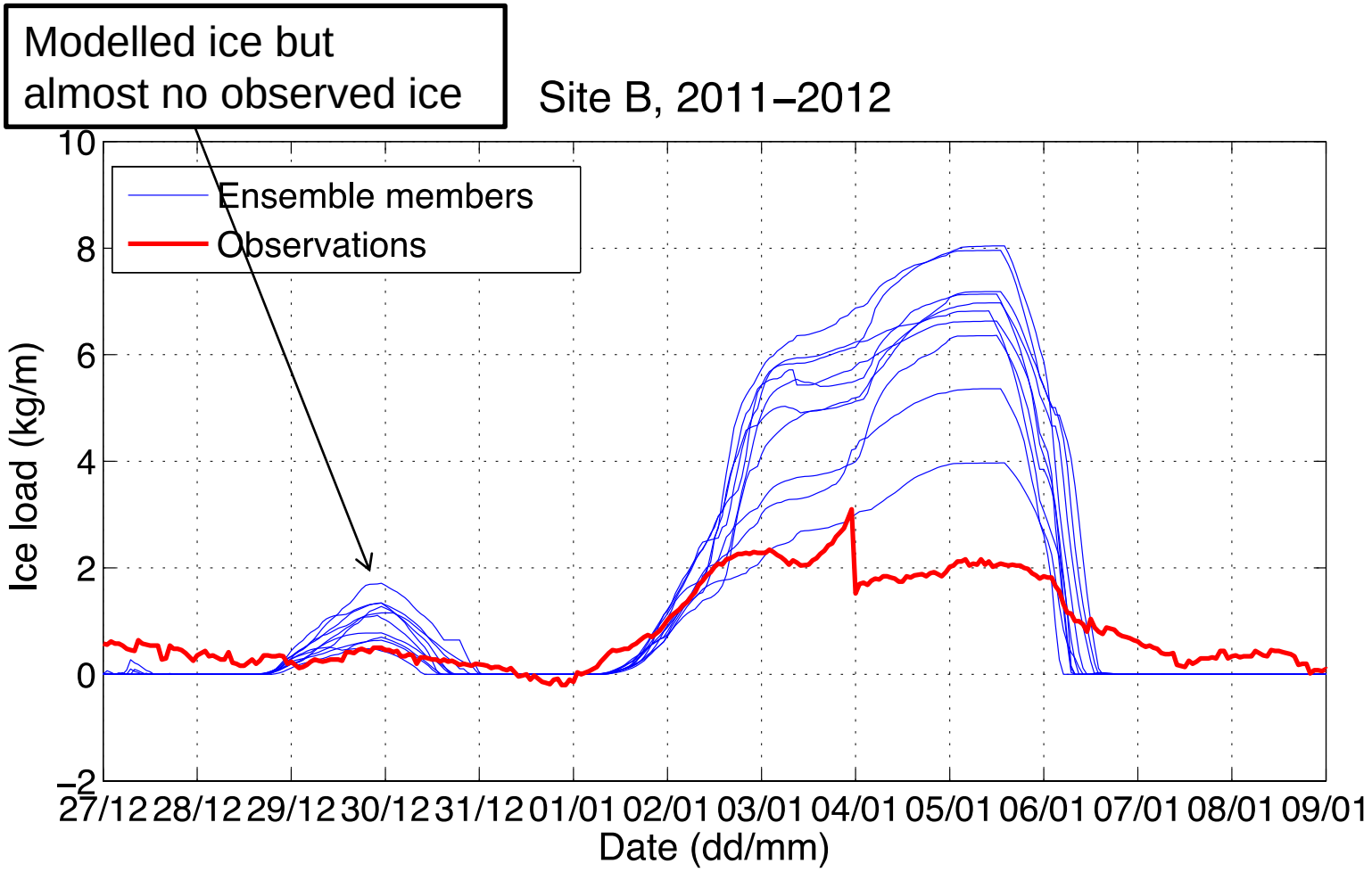


Ideally:
Spread of ensemble= Forecast error of ensemble mean

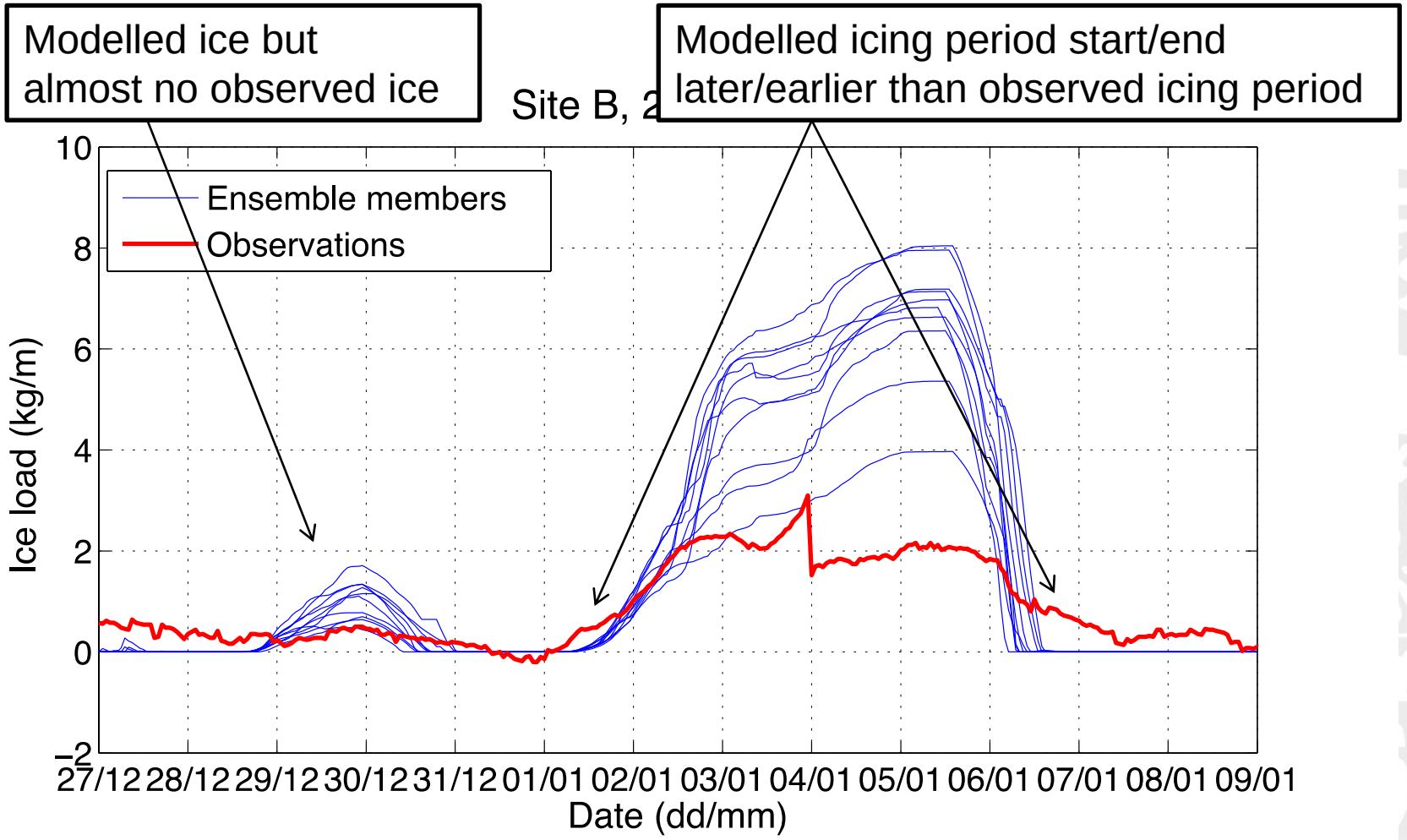
Forecasted ice load: Observations vs. ensemble



Forecasted ice load: Observations vs. ensemble

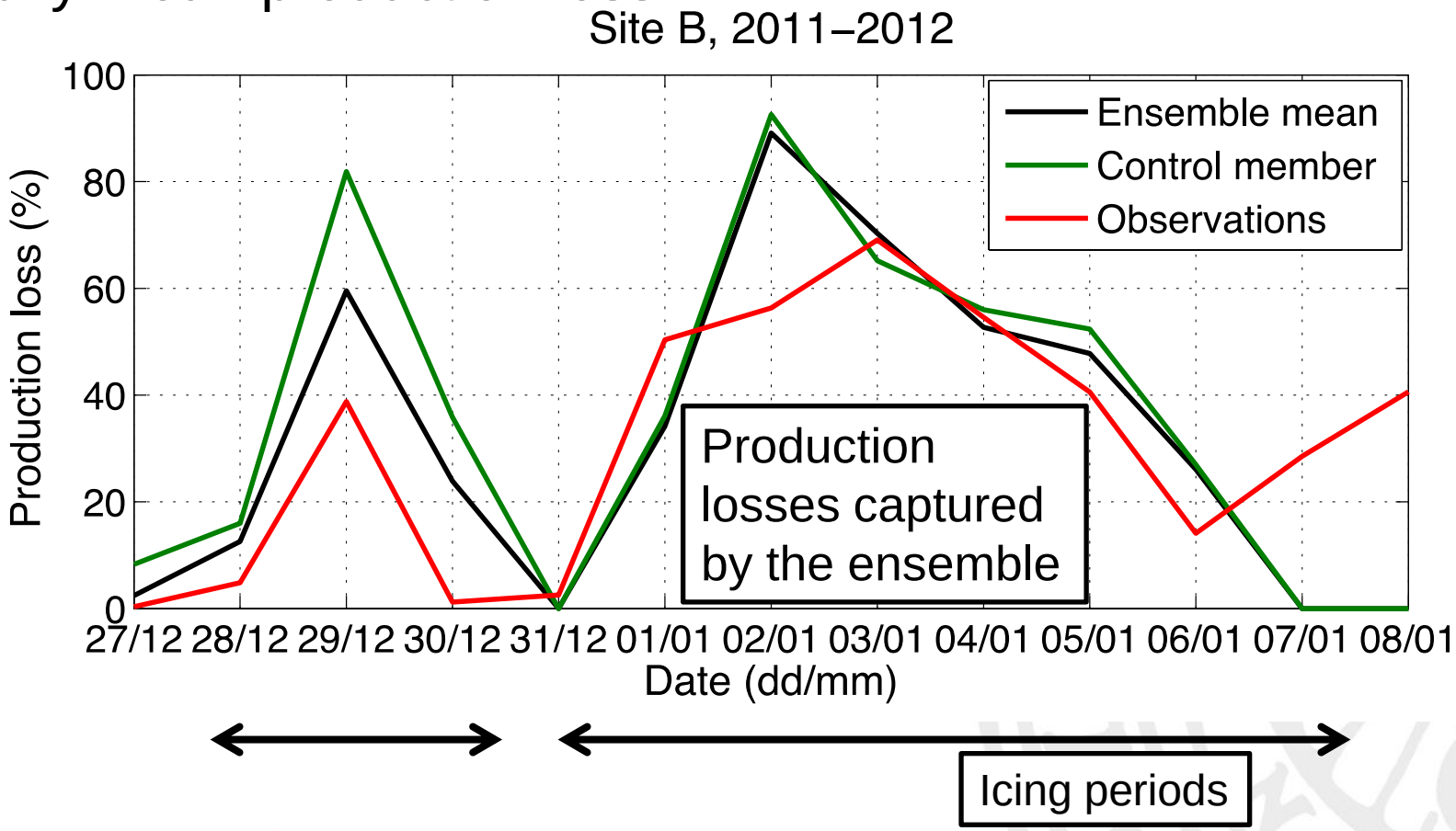


Forecasted ice load: Observations vs. ensemble



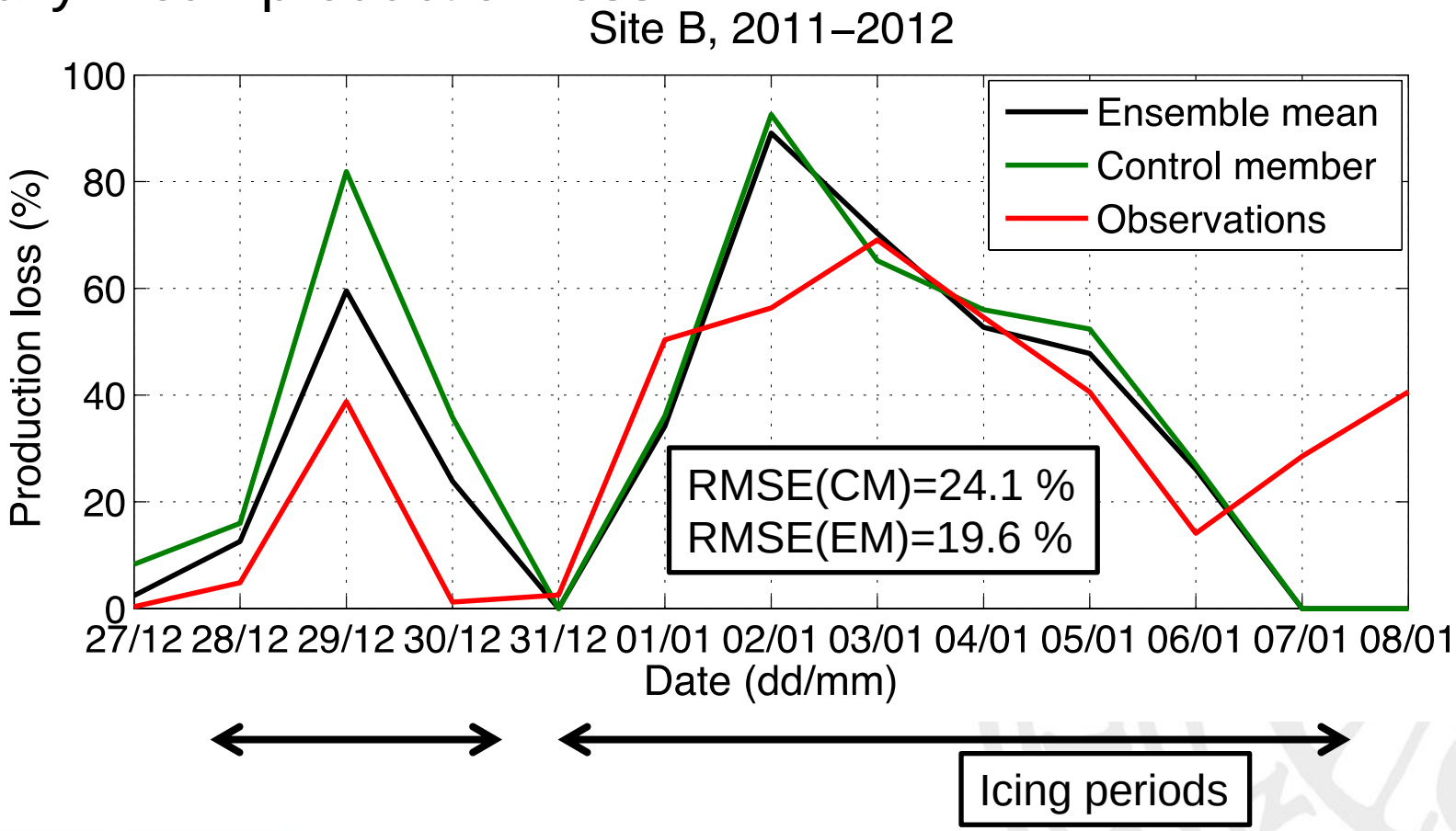
Forecasted production losses: Observations vs. ensemble

Daily mean production loss



Forecasted production losses: Observations vs. ensemble

Daily mean production loss



Summary & future plans

- Probabilistic forecast of icing and production losses were produced for a 2-week period using ensemble forecasts
- Ensemble spread provides uncertainty estimations
- Meteorological forecast uncertainty is underestimated
- Ensemble mean is consistently better than the control member

Future plans

- Extend database of ensemble forecasts
- Optimize probabilistic forecast over entire modelling chain

UPPSALA UNIVERSITET

Thank you!

UPPSALA UNIVERSITET

Modelling iceload

- Makkonen Model (2000)
- Developed for ice growth on cylinder
- Additionally:
  - flux of precipitation
  - Sublimation, melting
  - shedding

$$\frac{Dm}{dt} = \alpha_1 \alpha_2 \alpha_3 wAV - Q$$

α_1 = collision efficiency.
α_2 = sticking efficiency.
α_3 = accretion efficiency
***w*A*V* = Flux of water droplets**

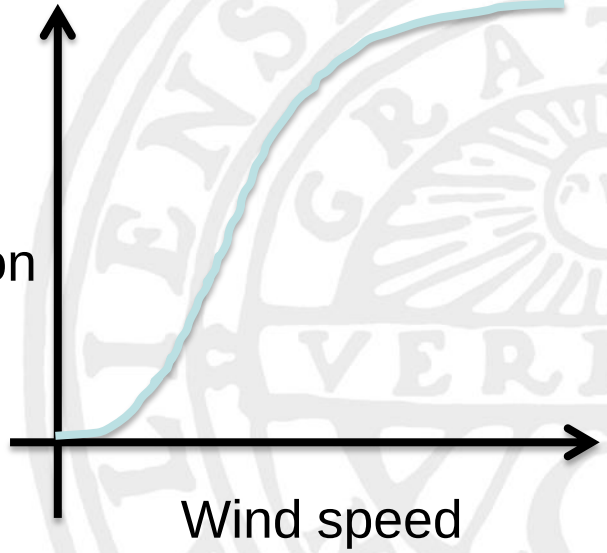
Modelling production losses

- Empirical relationship of modelled ice growth, ice load, and wind speed.
- Seasonally varying effect curves for each turbine from observed wind speed and power production.
- +18h- to +42h-forecast data from 06UTC-runs

Wind speed

Ice growth

10	**5**	**0**
50	25	10
100	100	90



HarmonEPS

More about HarmonEPS:

- Harmonie cycle 38 h1.2 (the latest version, used at SMHI)

- News in cycle 38h1.2:
  - New land use data (ECOCLIMAP2.2)
  - Improved statistical cloud scheme
  - Use different cloud droplet number concentration depending on land/sea/town
  - Mixed phase clouds and saturation with respect to water
  - Improved short wave radiative fluxes