Windpower in cold climates – Vindforsk project V313

presented at

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Project goals

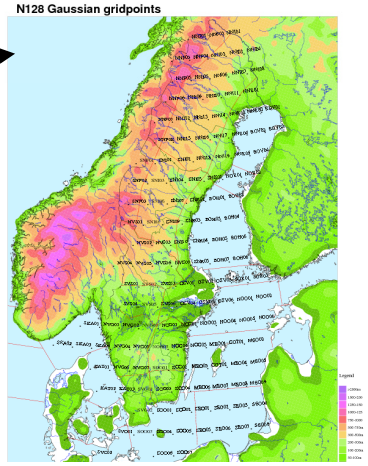
- Generally increase the knowledge on how wind power plants produce in areas with icing.
- Methods for producing an icing climatology with 1 km^2 over Sweden.
- The climatology should include information on frequency and duration of icing.

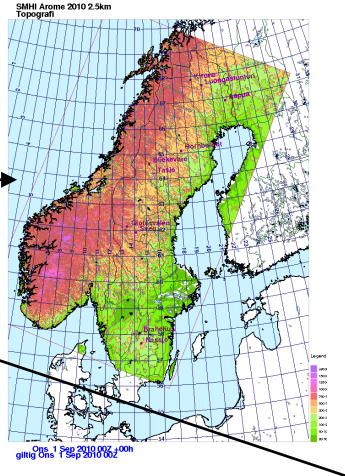
Tools

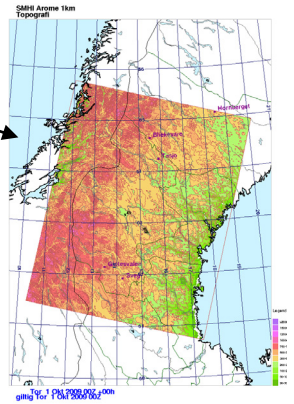
Models:

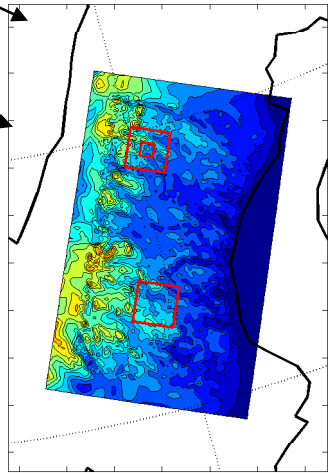
- ECMWF ERA-interim
  - ~ 80 km, 60 levels
- AROME (ECMWF/HIRLAM)
  - 1-2.5 km, 65 levels
- COAMPS (GFS)
  - 1-3 km, 40 levels
- WRF (GFS)
  - 1-3 km, 40 levels
- Makkonen ice model

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









Tools

Observations:

- Measurements in telecommunication masts and on wind power plants.
- Wind, temperature, humidity, pressure, visibility, cloud base and ice load.
- 3 places last winter, will be 11 this winter.

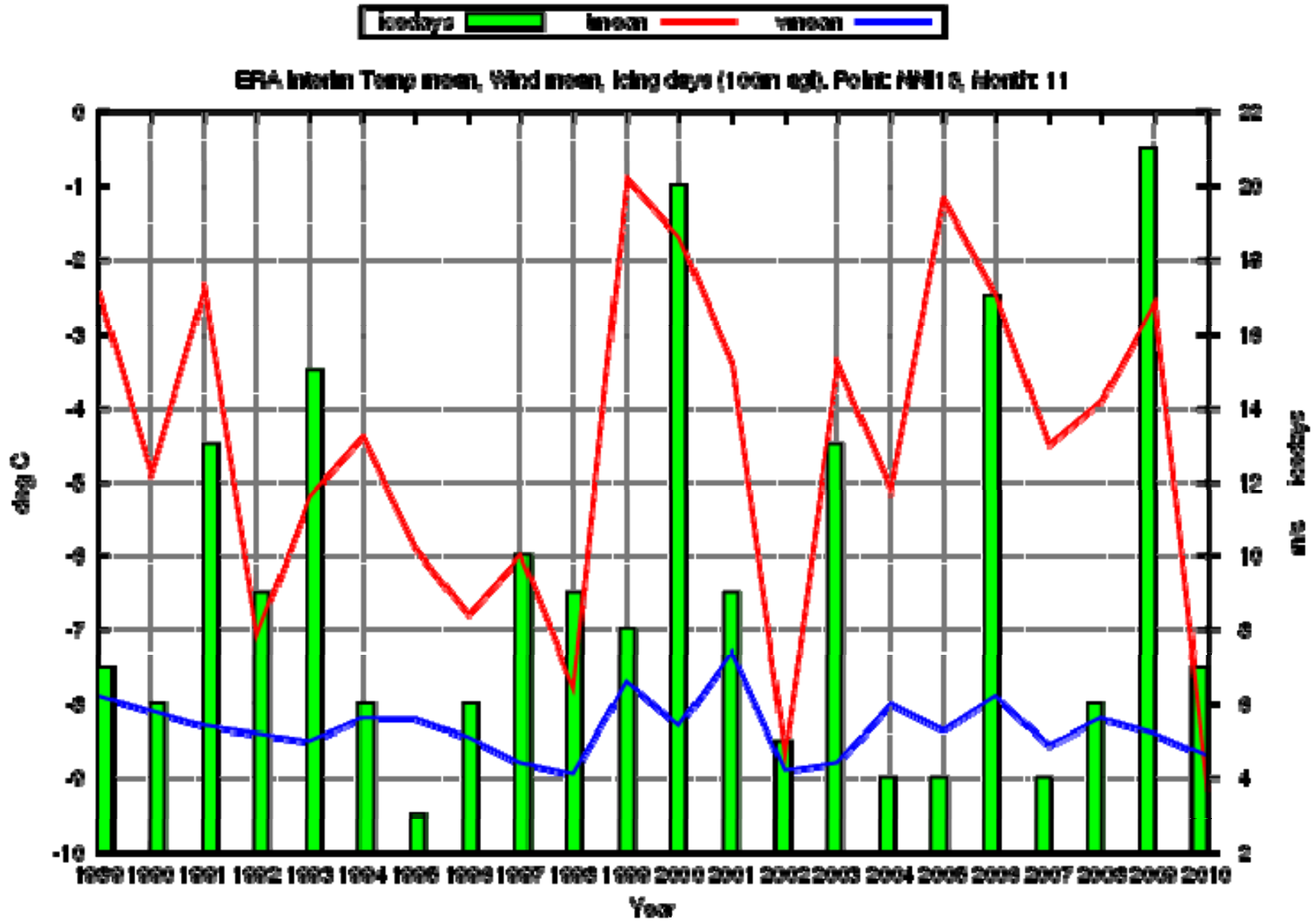
Saab Combitech and Holooptics ice measuring devices

ECMWF ERA-interim re-analysis
Global dataset 1989-today

- Will be used as lateral boundaries and initial conditions for high resolution model runs.
- Weather classification methods will be applied to find representative icing seasons or months.

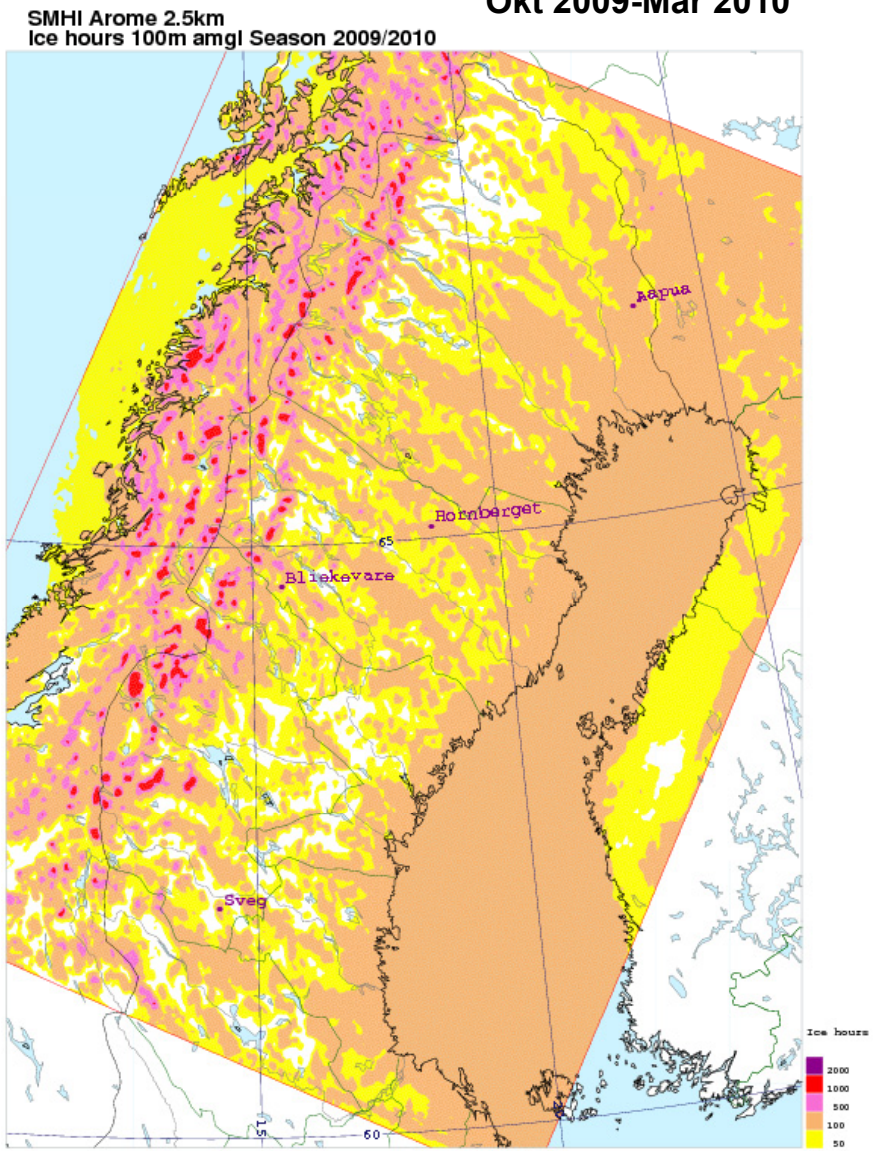
- What can ERA-interim data as it is combined with the ice model show us ?

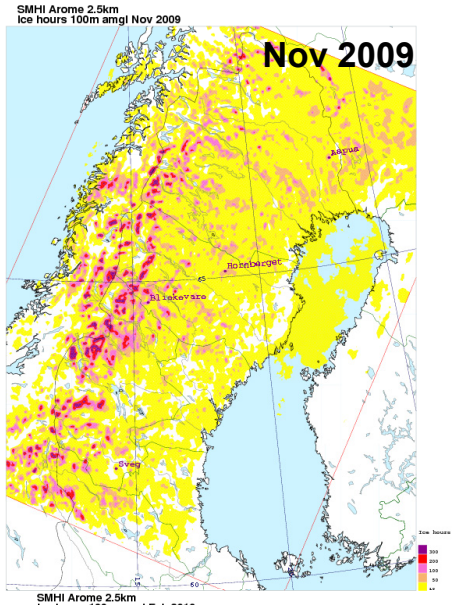
ERA-interim: number of NOVEMBER ice days, mean temperature and wind speed 100 m agl. Gridpoint in the middle of Västerbotten

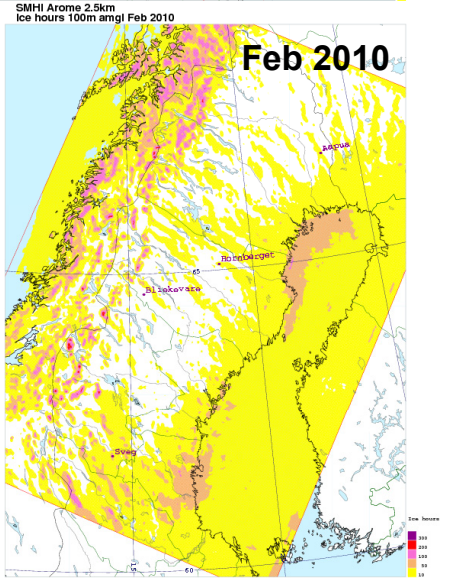


Results from last winter:
Hours with icing (>10g/hour) according to AROME 2.5 km

Okt 2009-Mar 2010







Uppsala University Weathertech Scandinavia SMHI

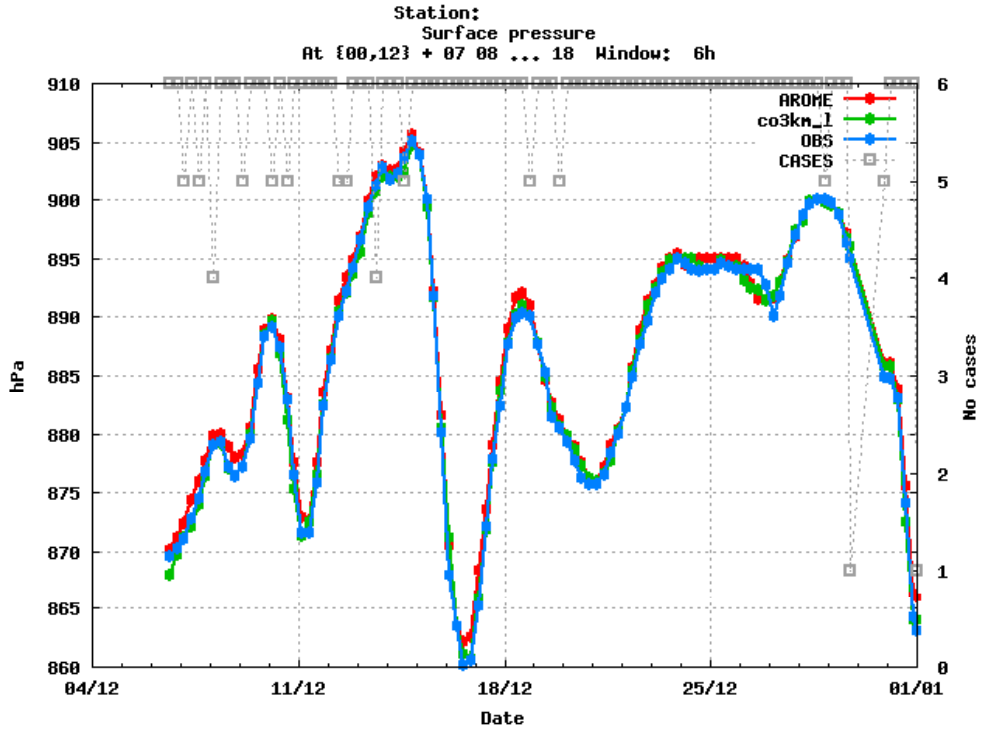
Model results

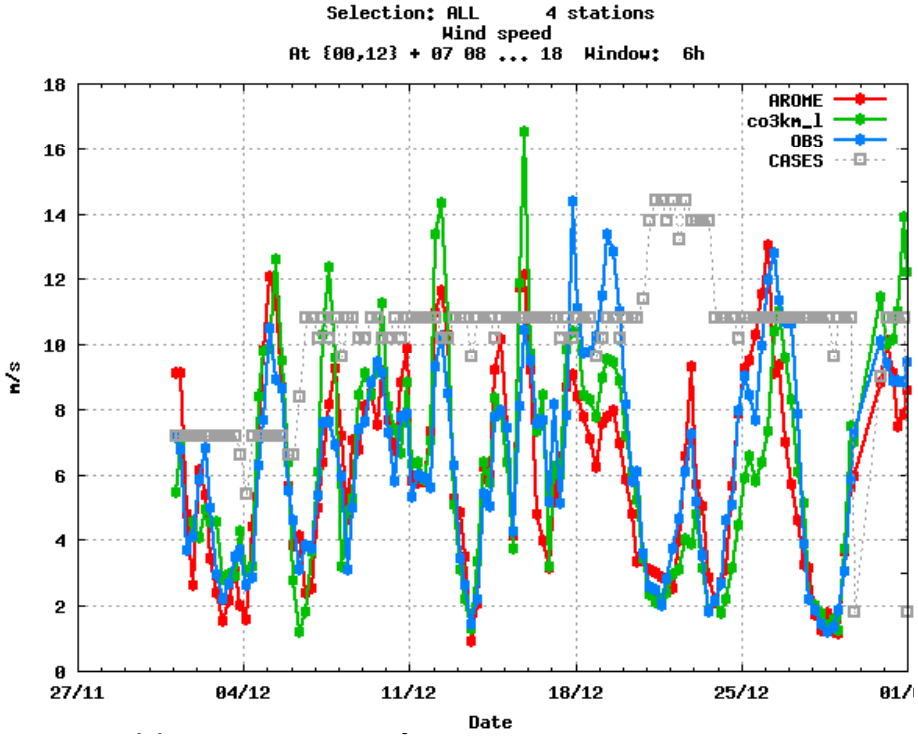
AROME (2.5 km, ECMWF)

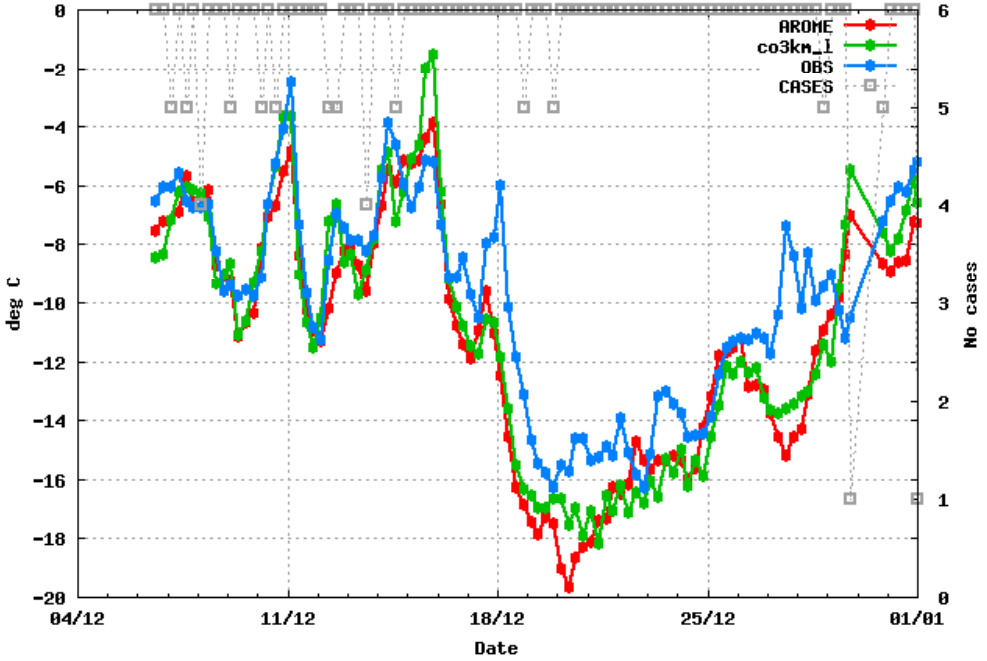
COAMPS (3 km, GFS)

OBSERVATIONS

- Observed pressure, temperature, and wind speed at Site A are quite well captured by the models





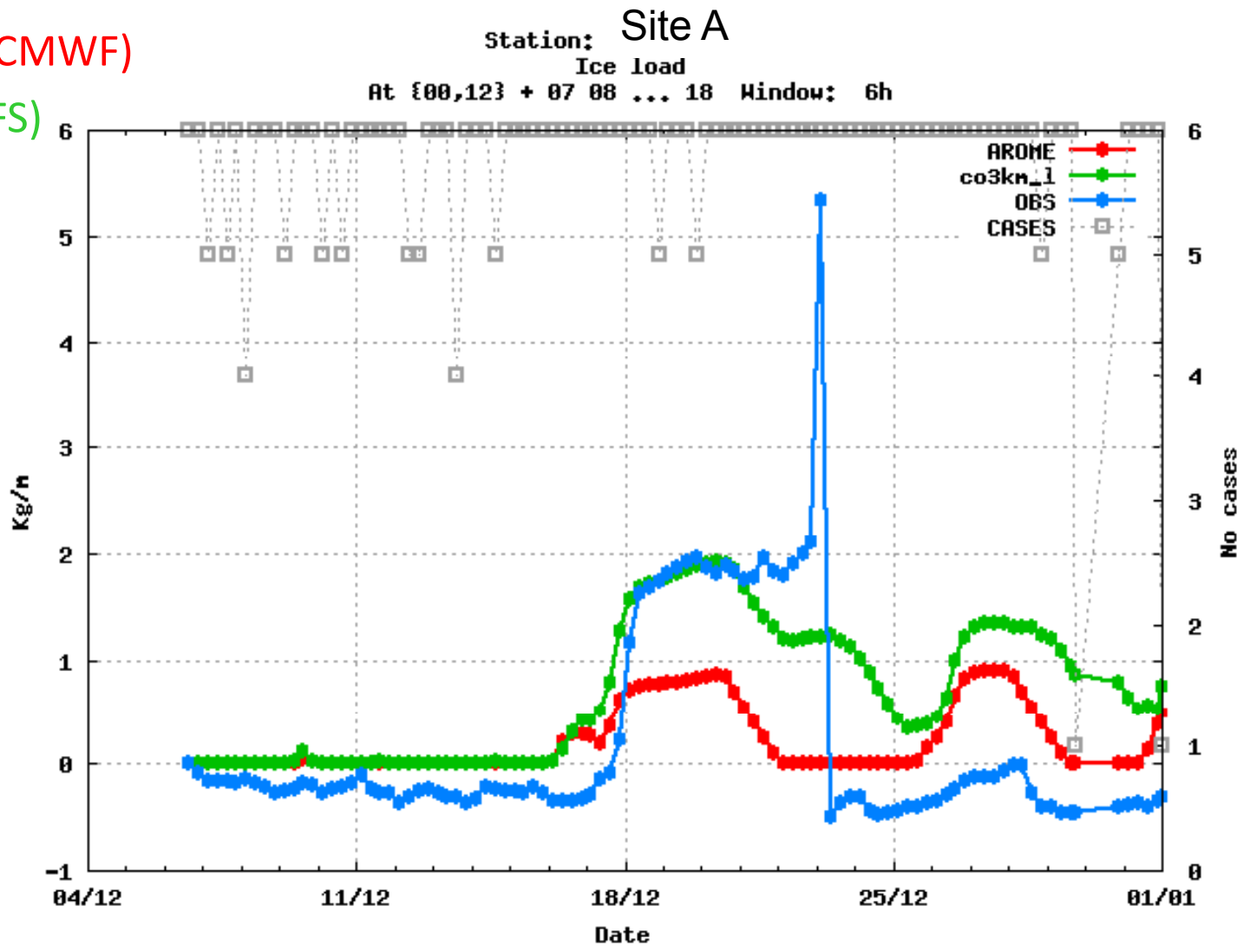


Model results: Ice load at Site A

AROME (2.5 km, ECMWF)

COAMPS (3 km, GFS)

OBSERVATIONS

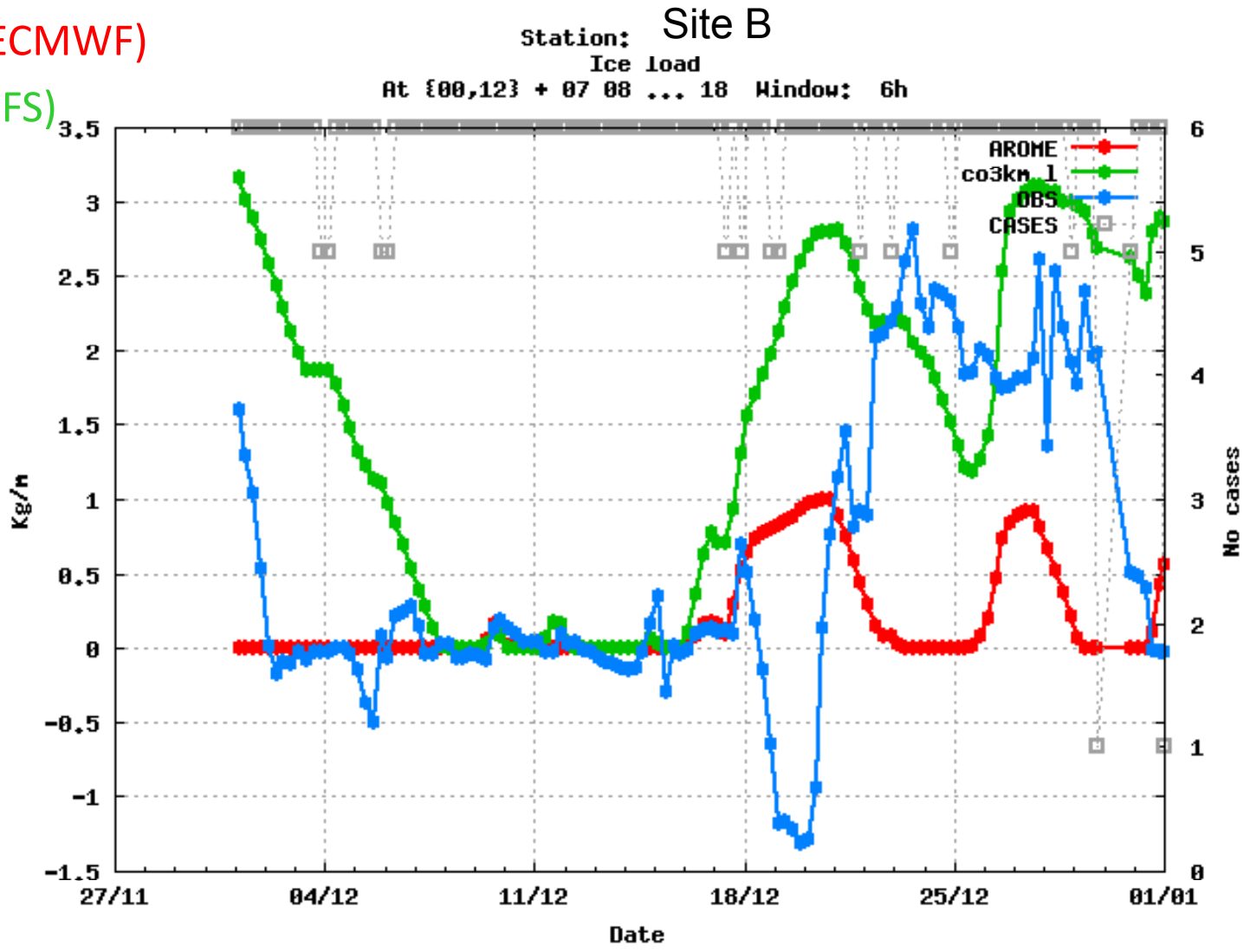


Model results: Ice load at Site B

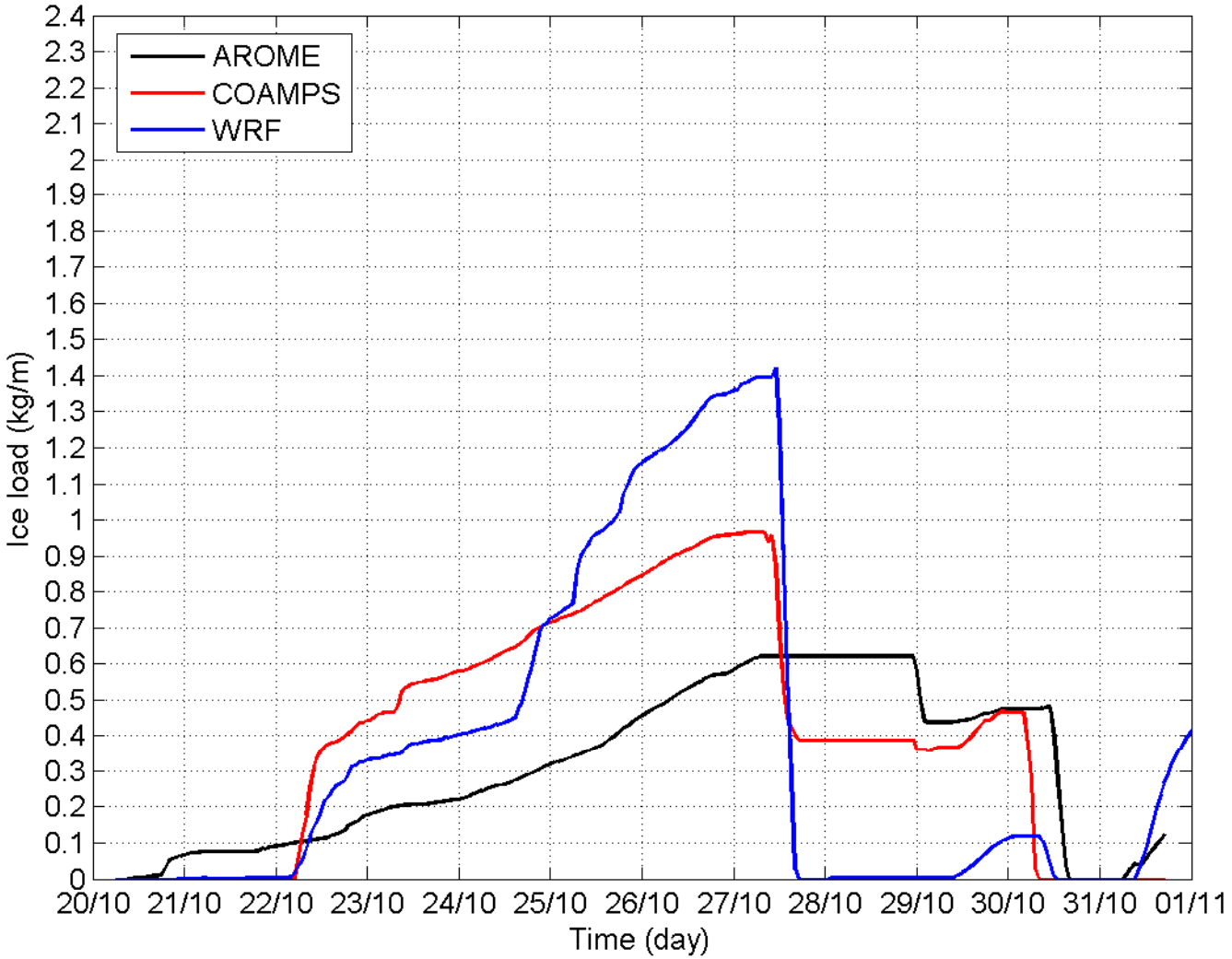
AROME (2.5 km, ECMWF)

COAMPS (3 km, GFS)

OBSERVATIONS

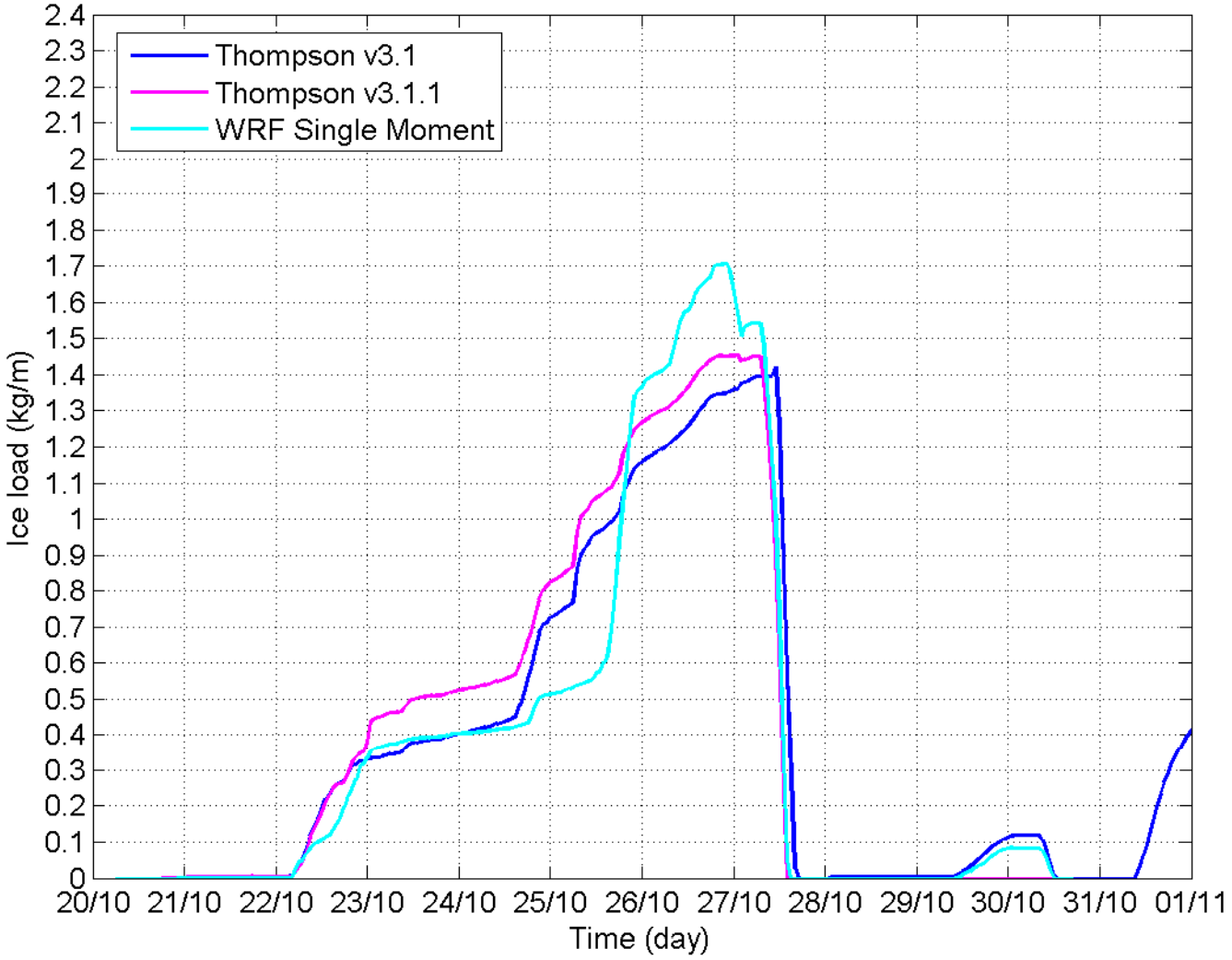


Bliekevare Ice load modelled by 3 different models



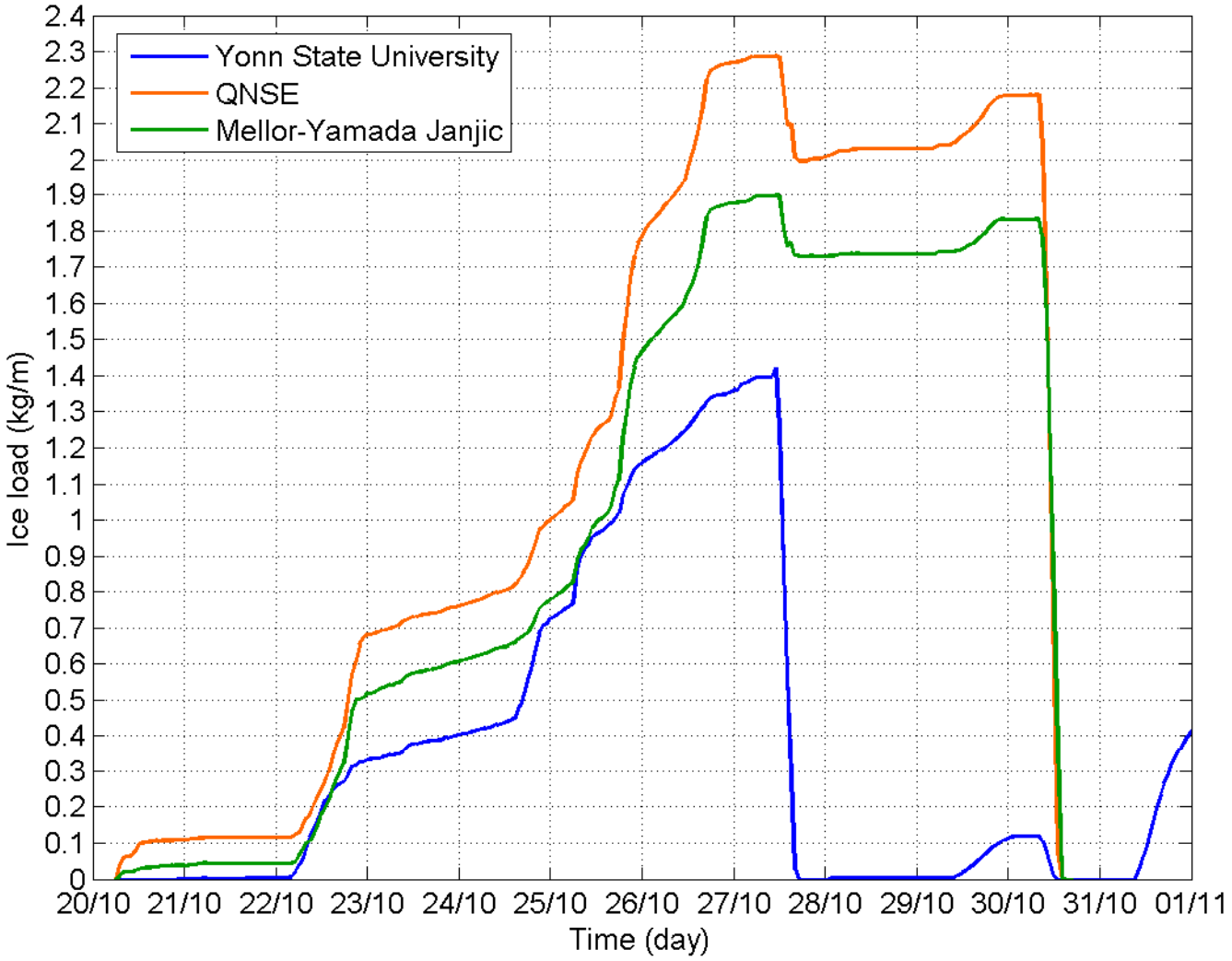
2009

WRF: Ice load with 3 different microphysics schemes



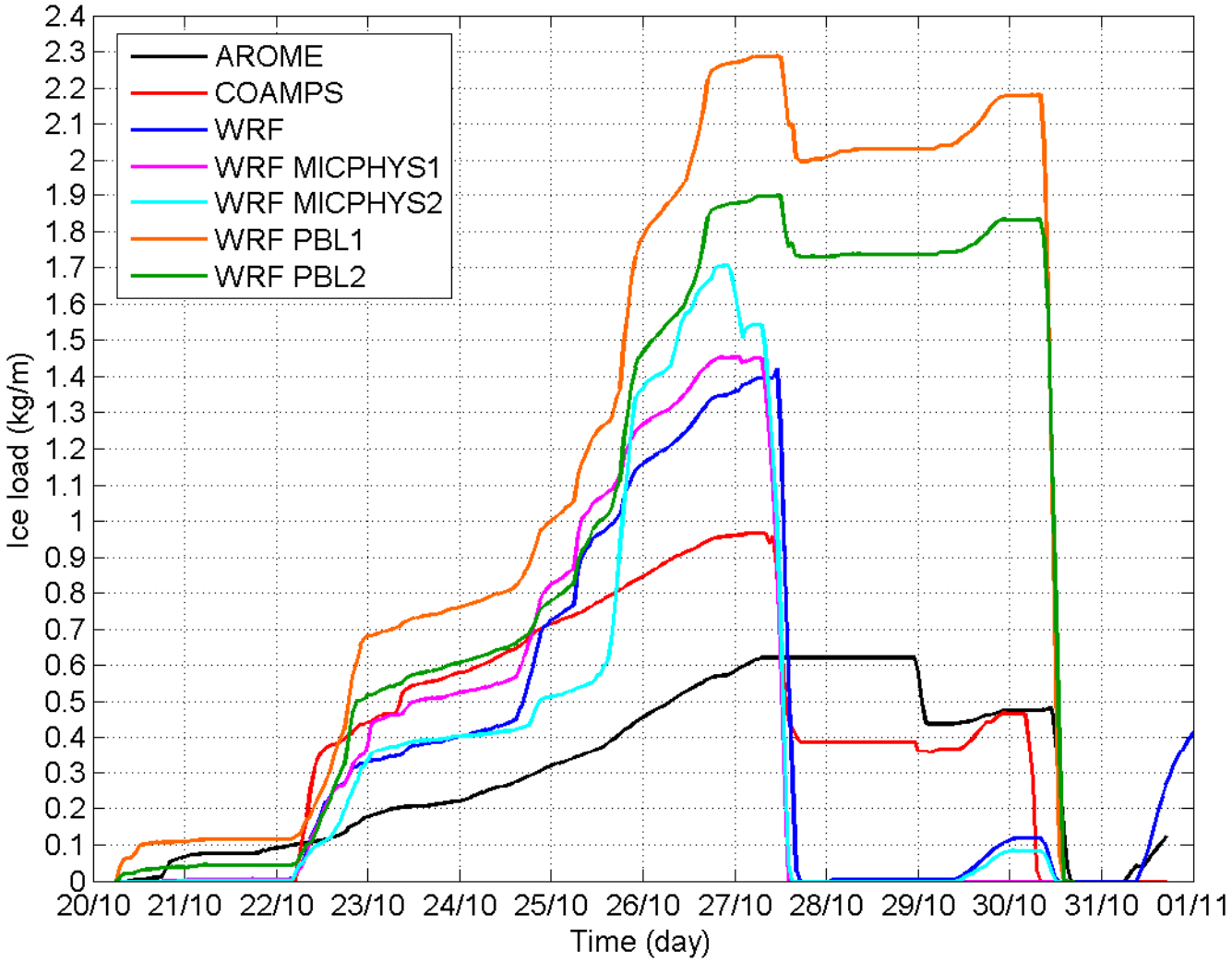
2009

WRF: Ice load with 3 different turbulence schemes



2009

Ice load: 3 models, 1 model with different physics options



2009

Where do we stand?

- COAMPS (GFS), WRF(GFS), and AROME(ECMWF) capture observed pressure temperature, and wind
- Different models give different iceloads
- Altering PBL-schemes in WRF can result in larger differences in iceload than using different models
- We capture the events, however, we still have some issues with the magnitude of the iceload
- New methods to model icegrowth?

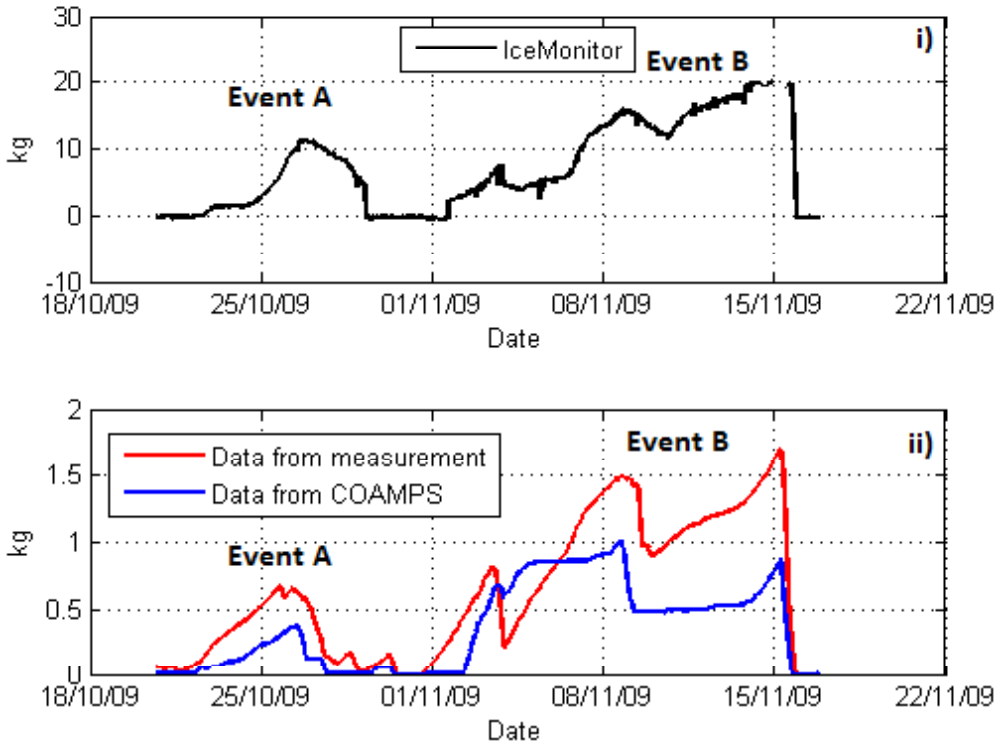
Validation of icing measurements

- Compare the measurements with modelled ice loads
- Could modelled ice loads be used as a complement to icing measurements?

Calculating the ice load from measurements

- Ice load is modelled with $\frac{dM}{dt} = EwVD$
- A simple estimation of *w* was used
- Some parameters were measured, *T*, *WS*
- Some parameters were assumed, N_c

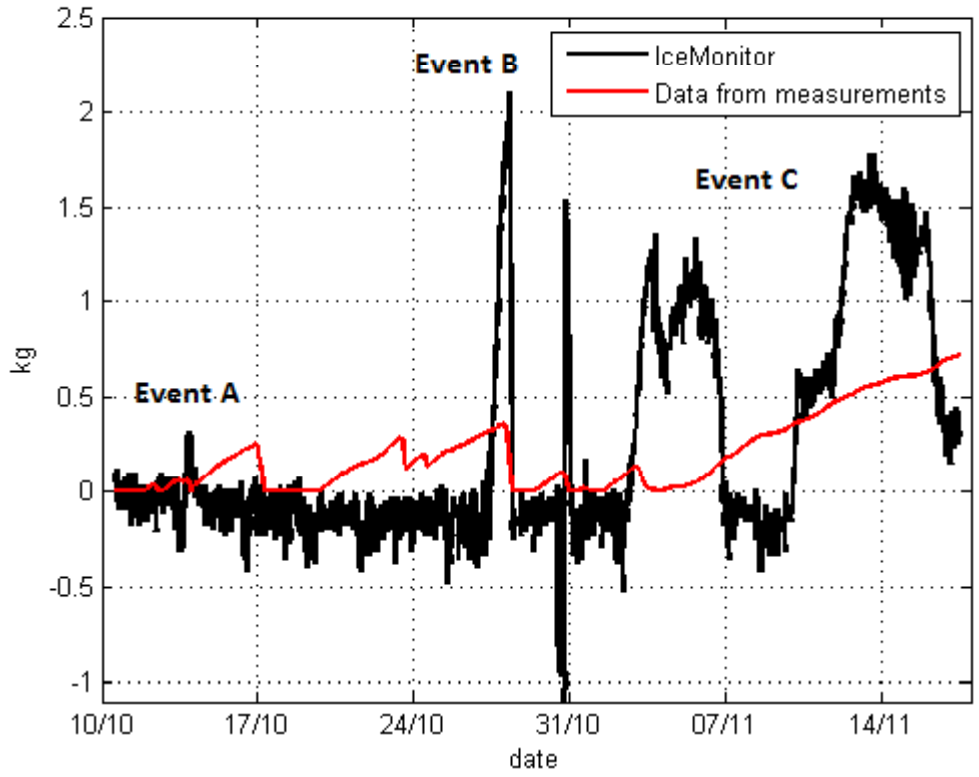
The results, Bliekevare 2009/2010



Event A: The modelled ice load capture the shape of this event quite well
Event B: The shape of the event is captured well, note that the icing instrument reaches its limit

The icing events are captured well, but the ice load is underestimated

The results, Bliekevare 2010/2011



Event A: The model captures some of the event
Event B: The ice melts/falls off about the same time as the measured ice load
Event C: The gap in the measured ice load could be a fall off of the ice, the modelled ice load seems to perform rather well

Ice load not as severely underestimated, but accretion shape not captured as well

Conclusions

- Modelling icing from meteorological measurements needs to be evaluated more
- Could be used as a compliment to ice load measurements