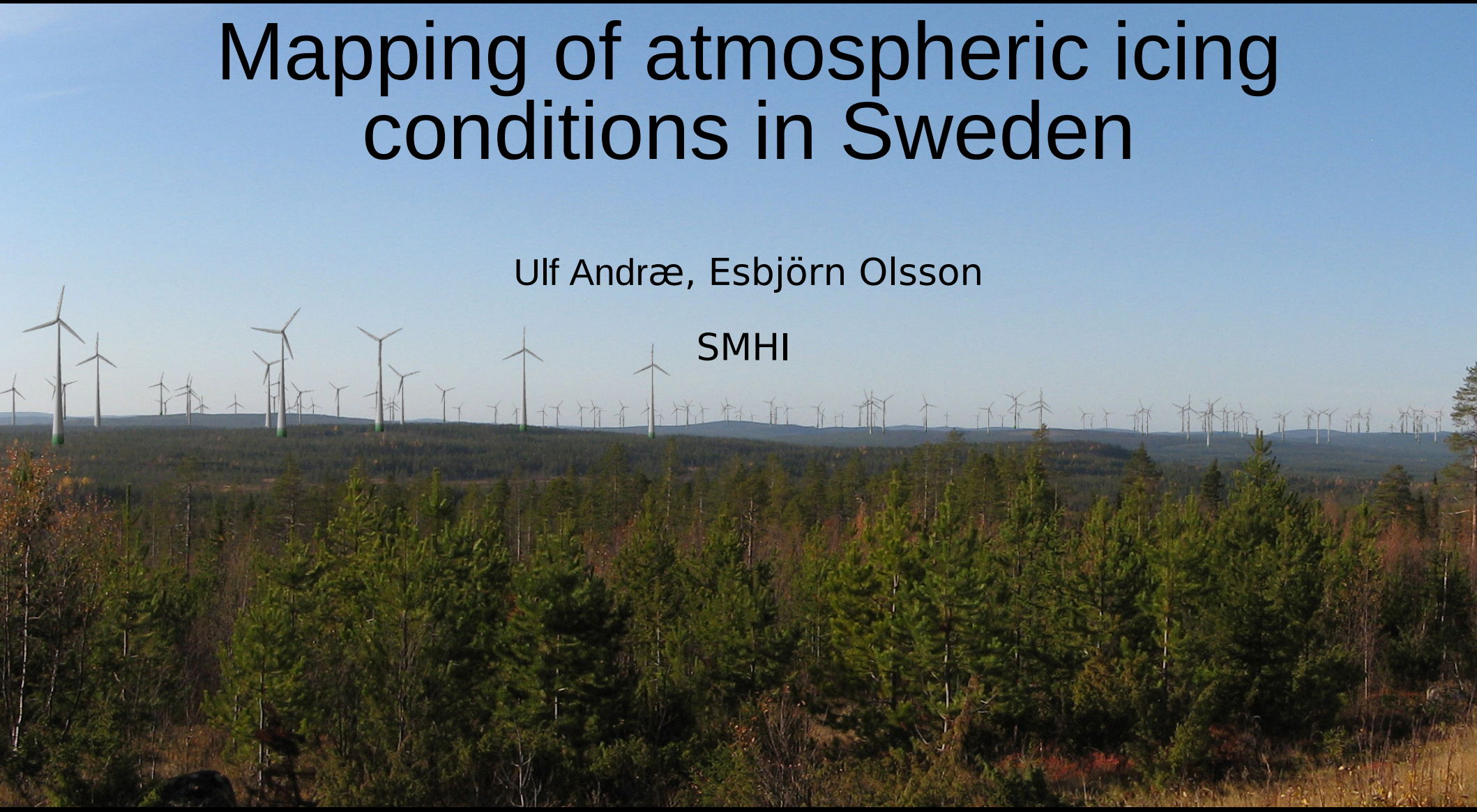
Mapping of atmospheric icing conditions in Sweden



Ulf Andræ, Esbjörn Olsson

SMHI

joint ASM 2010 and 20th ALADIN Wk, 13-16 April 2010, Cracow, Poland

The problem

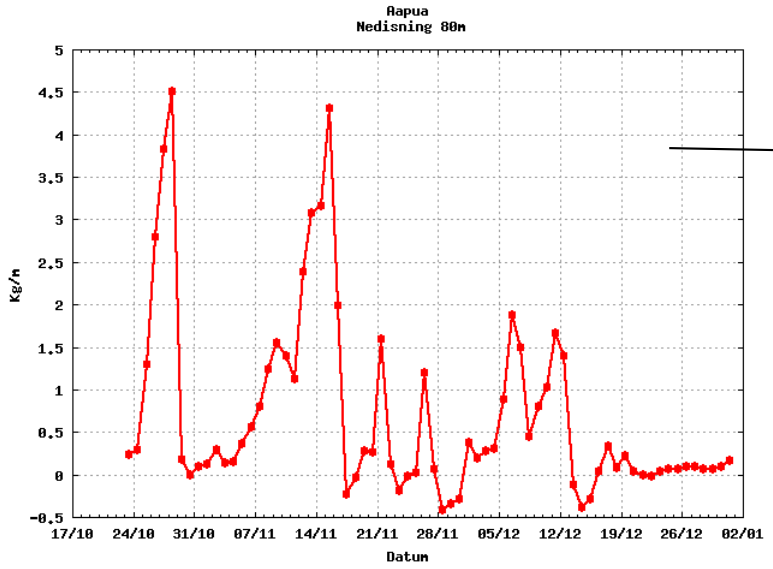
- Most parts of Sweden are effected by icing during the winter
- In the worst parts the down time may be up to 80% six months of the year.
- Sweden aim to produce 30TWh/Year windpower 2020. Today we have 2.5TWh

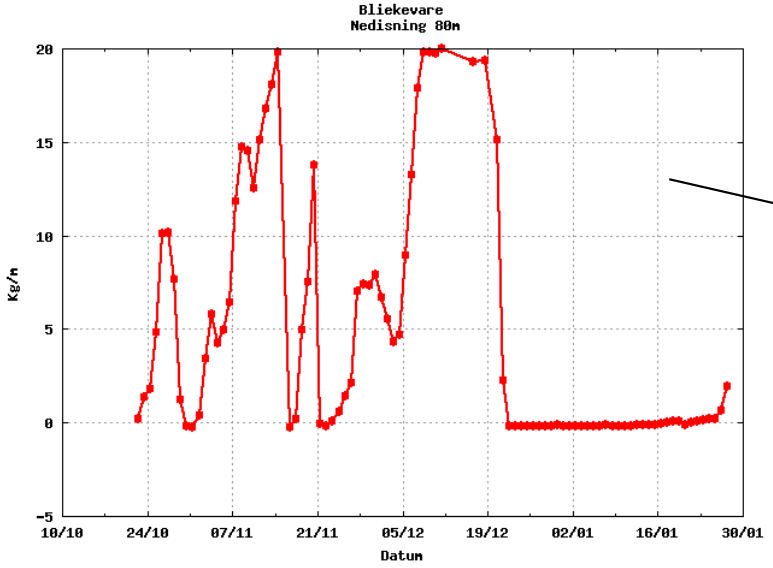
The project: A mission from the Swedish Energy Agency

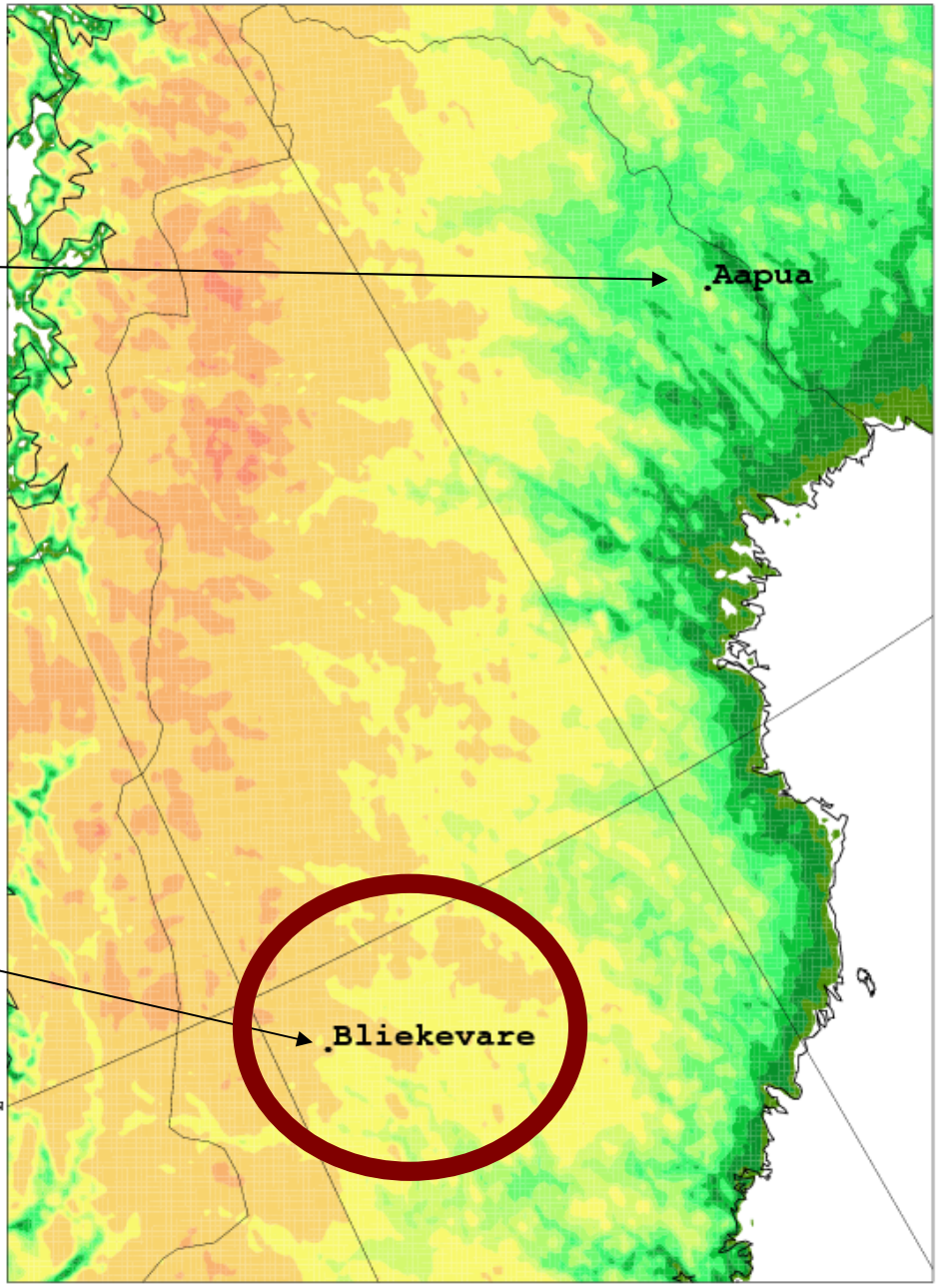
- Decrease the uncertainty in wind power production in areas with icing problems.
- Create a map of icing rates with 1km resolution over Sweden.
- Create measures of frequency and duration of icing

- SMHI
  - Esbjörn Olsson,
  - Ulf Andrae,
  - Per Unden
- University of Uppsala
  - Hans Bergström
- Weathertech Scandinavia
  - Stefan Söderström
- 2010-2012

Measurements of icing during 2009-2010





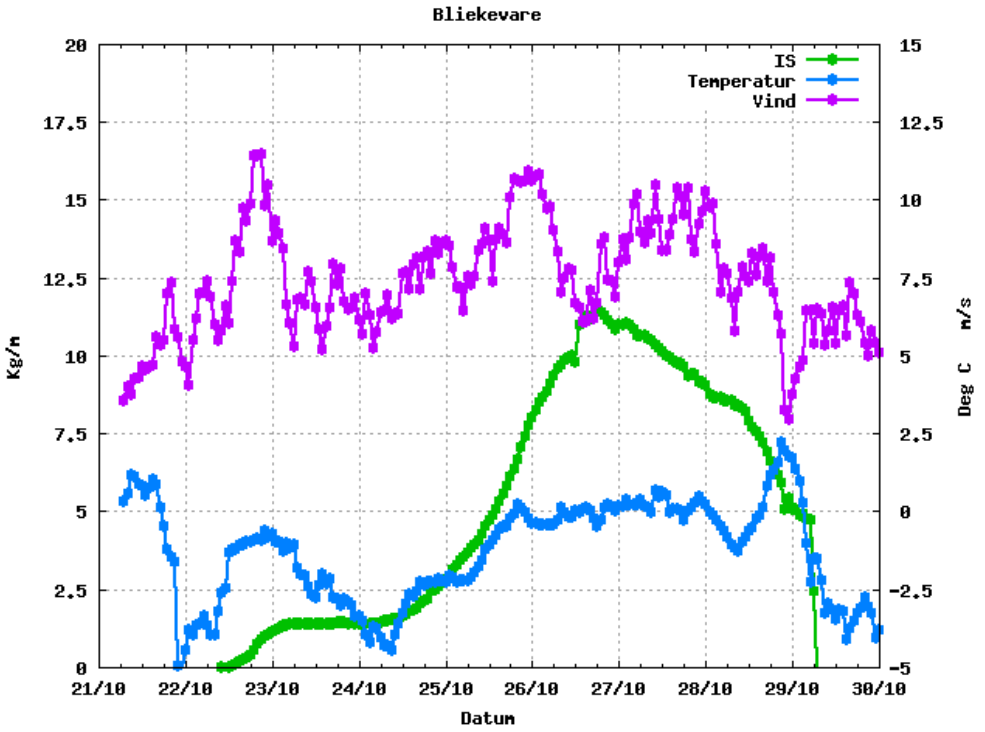


Modelling of atmosperic icing

L. Makkonen 2001, B.E. Nygaard et.al. 2009

$$\frac{DM}{dt} = \alpha_1 \alpha_2 \alpha_3 w * A * \vec{V} - Q$$

$$Q = Q_h + Q_e + Q_r$$



Assume a free rotating cylinder

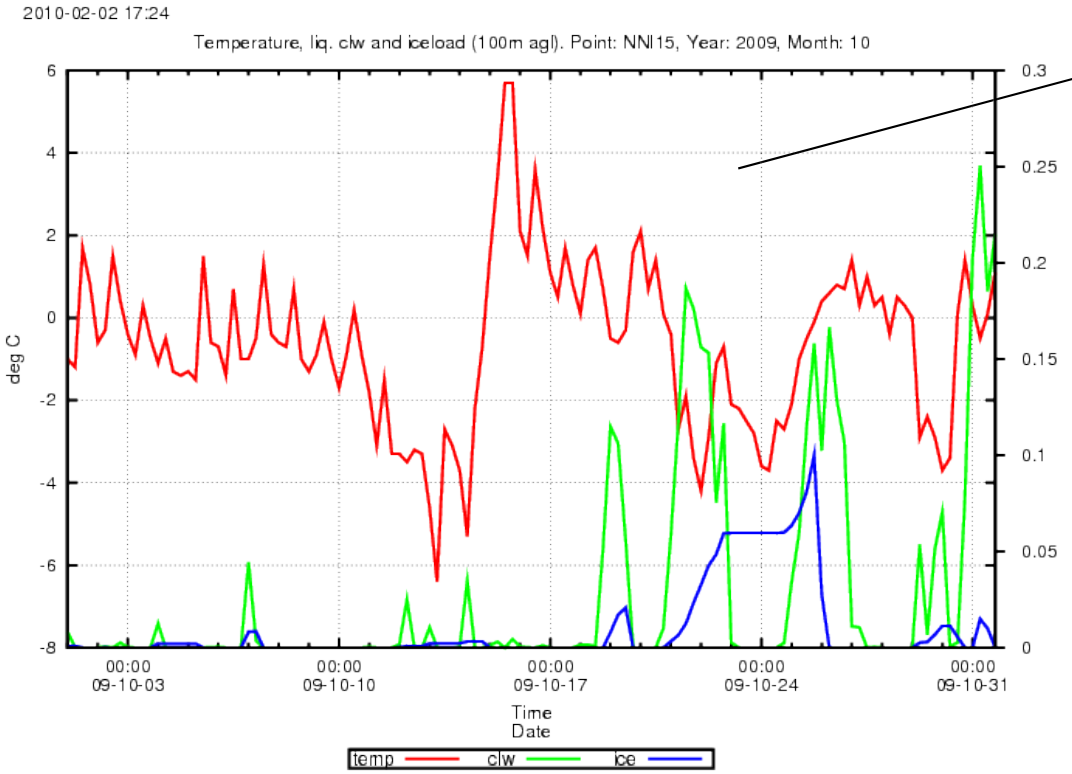
- Growth
  - α_1 collision
  - α_2 sticking
  - α_3 accretion
  - wAV the amount of cloud water passing the cylinder
- Melting
  - Qh conduction
  - Qe evaportaion
  - Qr radiation

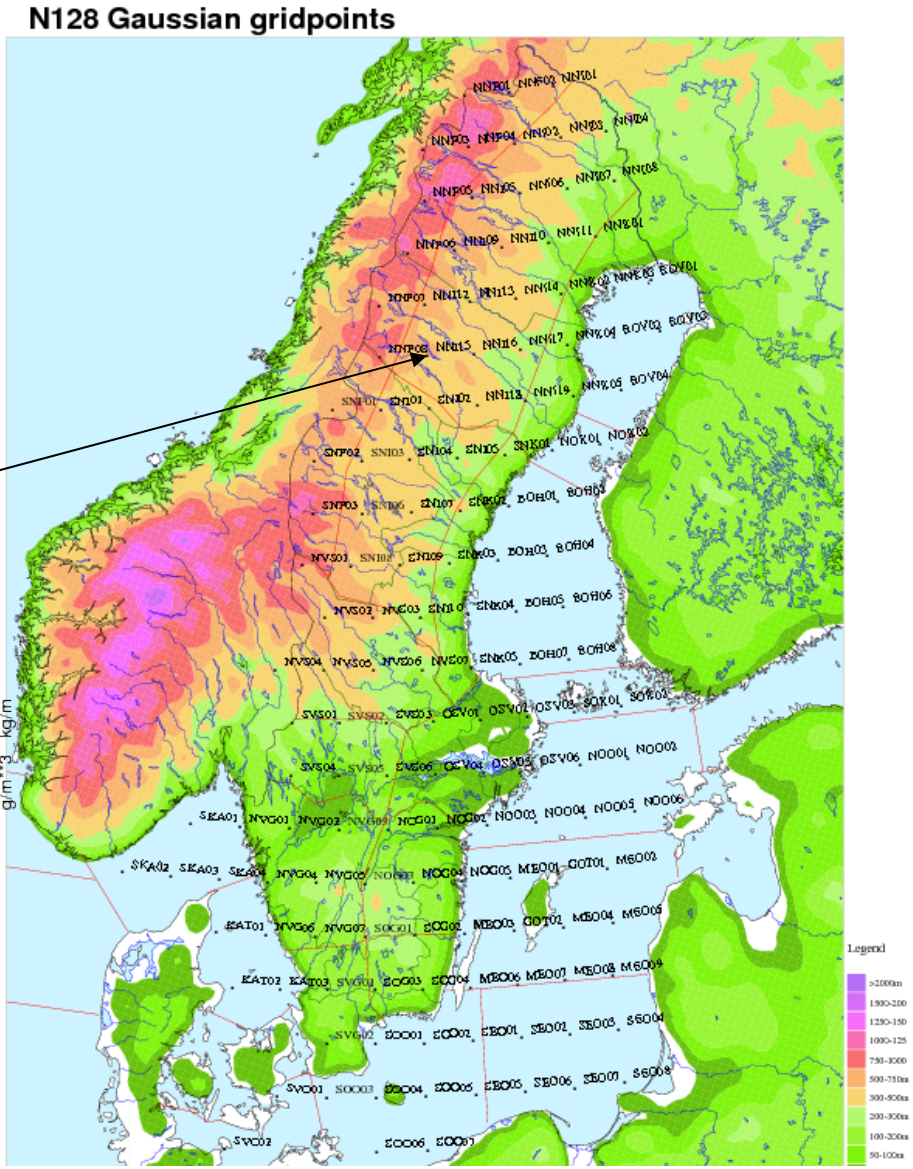
dM/dt = F(U,T,P,CW)

Strong dependence on assumptions about droplet concentrations

What can ERA interim data tell us?

Resolution ~120km



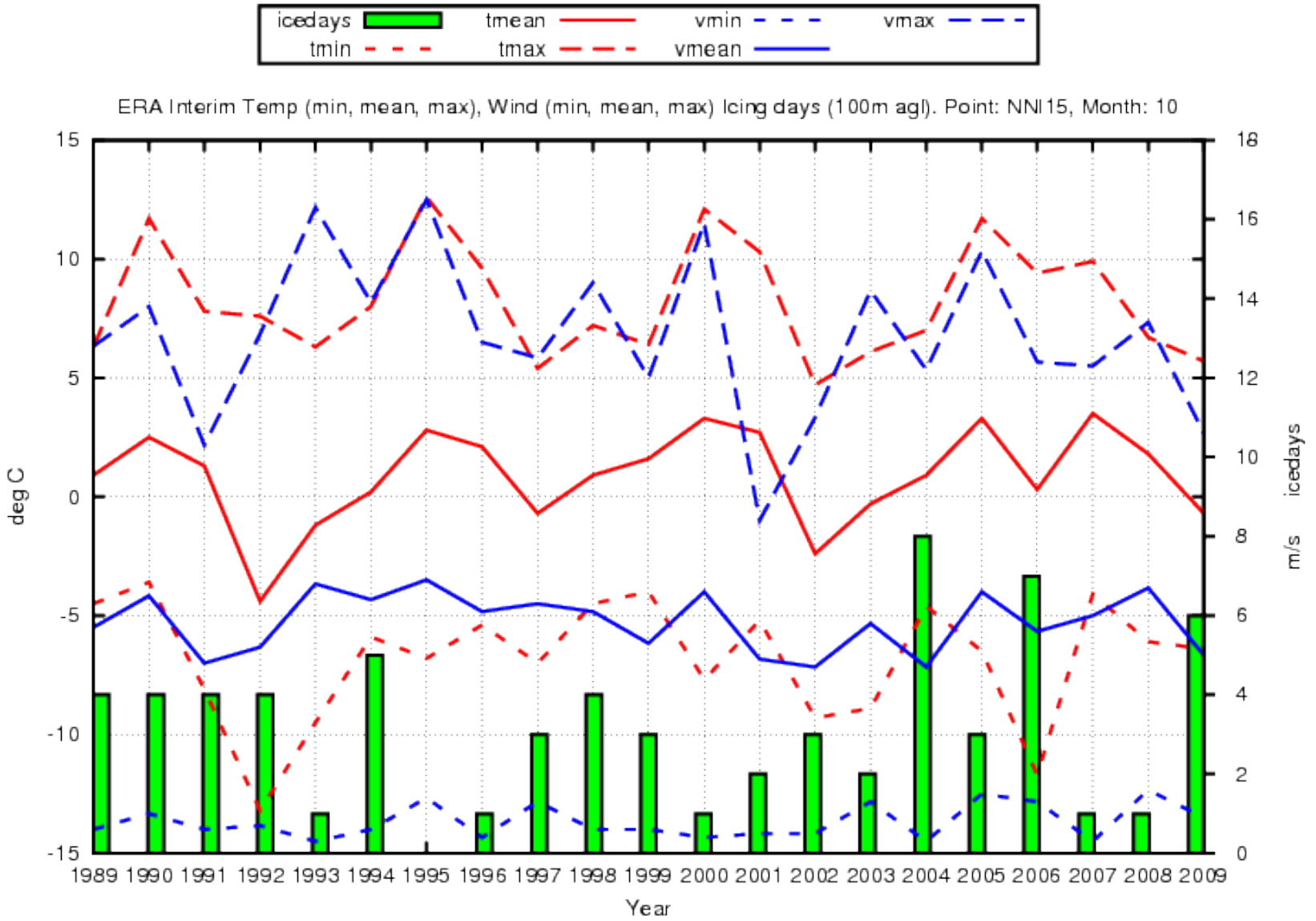


How to create a climatology without running AROME for 30 years

- Like Kjeller vindteknikk
  - Run one year and say that it represents any year
- Like FMI
  - Find typical months (for wind)
- Find typical icing months

- The idea is to (if possible) use the results of EURO4M for downscaling

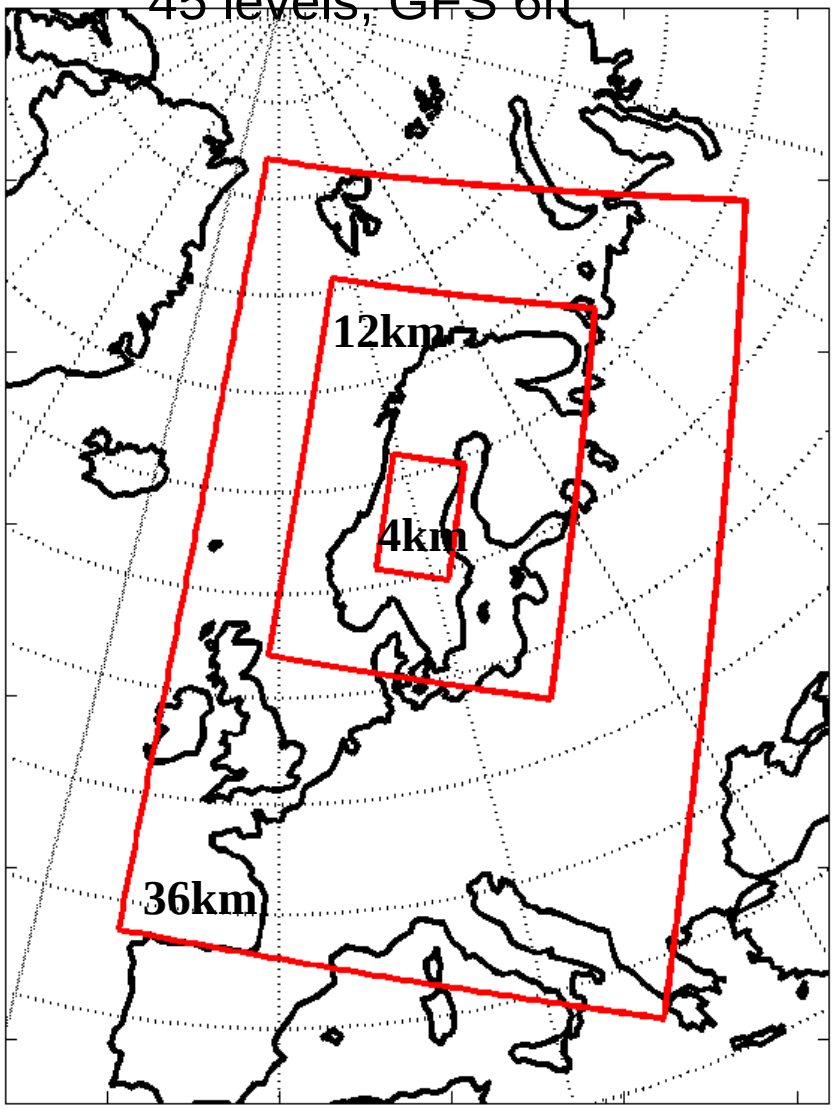
Icing climatology in Bliekevare for October1989 – 2009 according to ERA interim



Mesoscale models

COAMPS

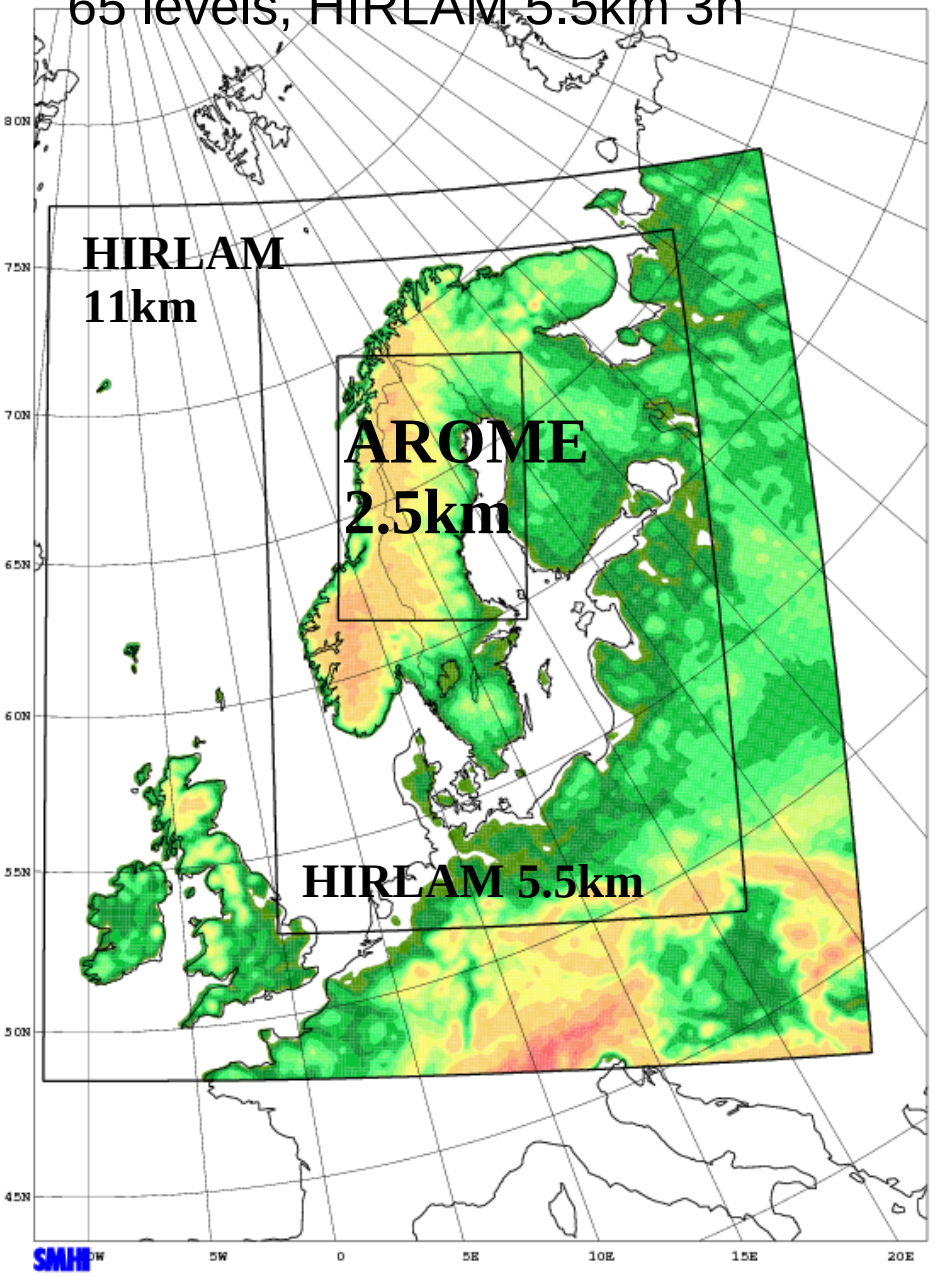
45 levels, GFS 6h



COAMPS

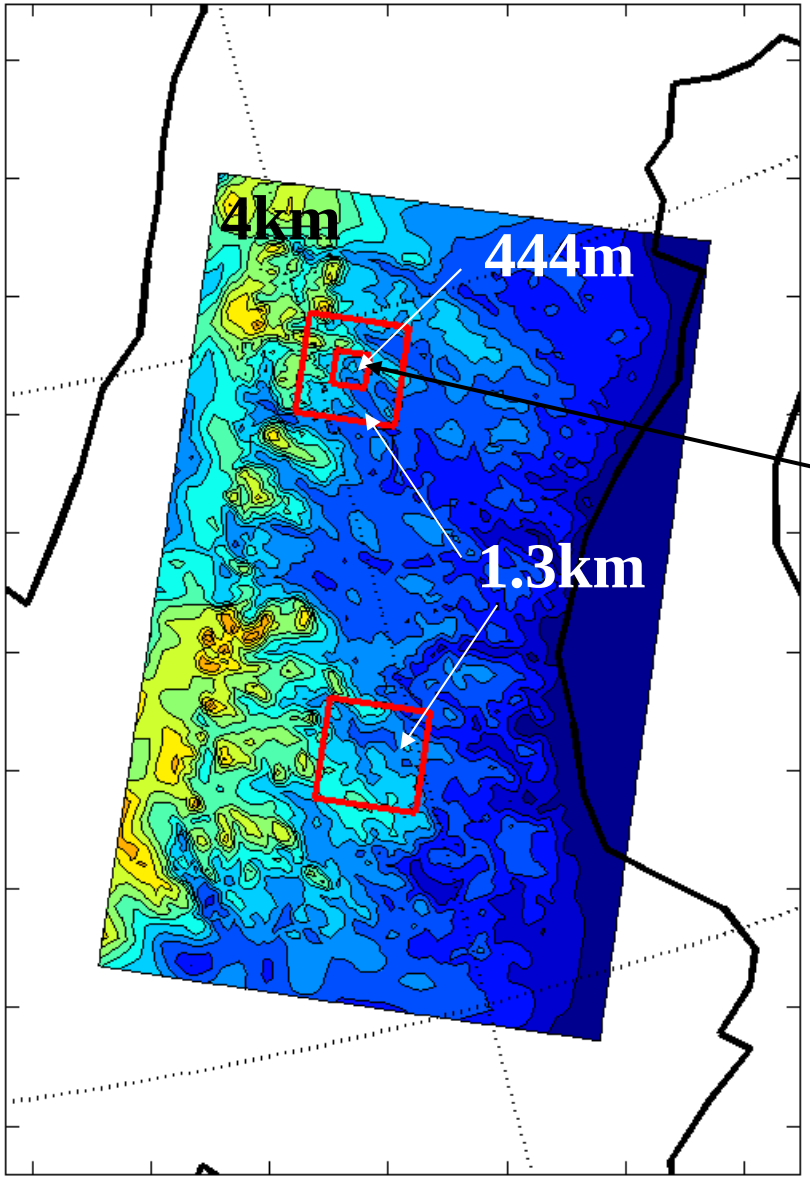
AROME

65 levels, HIRLAM 5.5km 3h

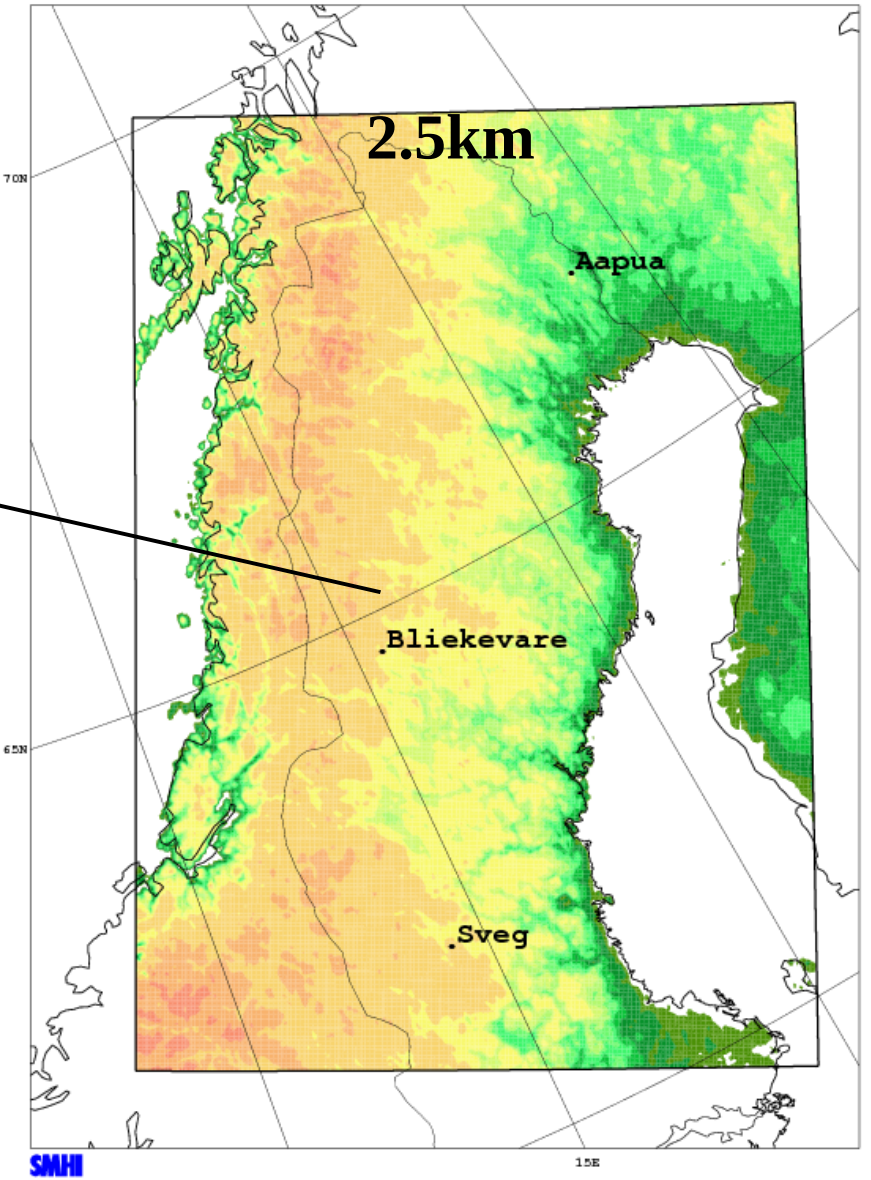


High resolution domains

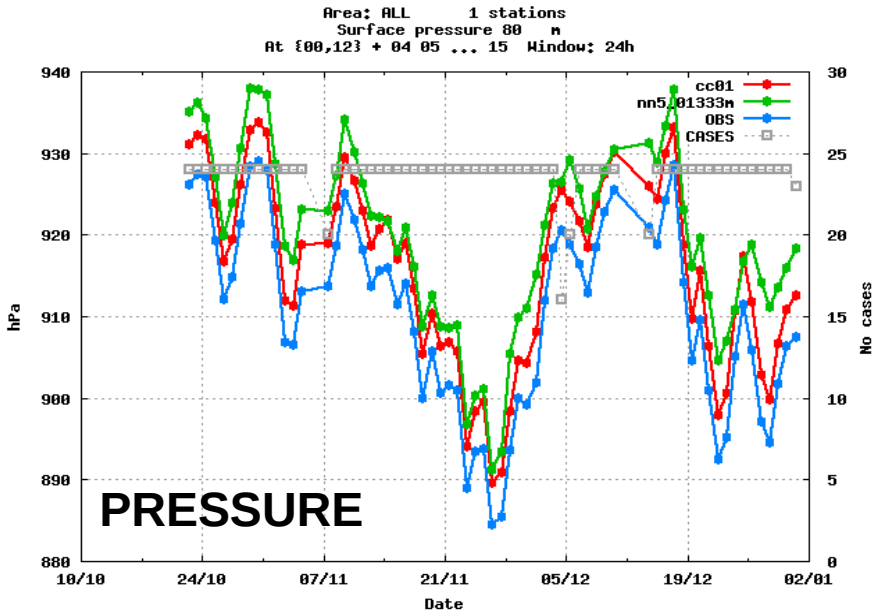
COAMPS



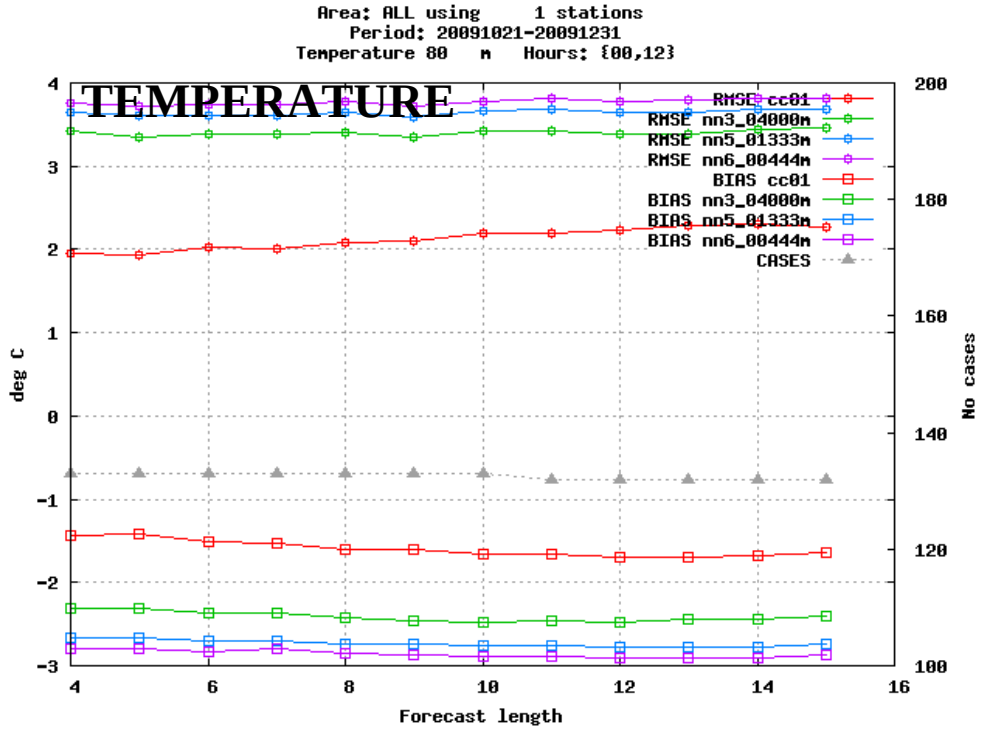
AROME

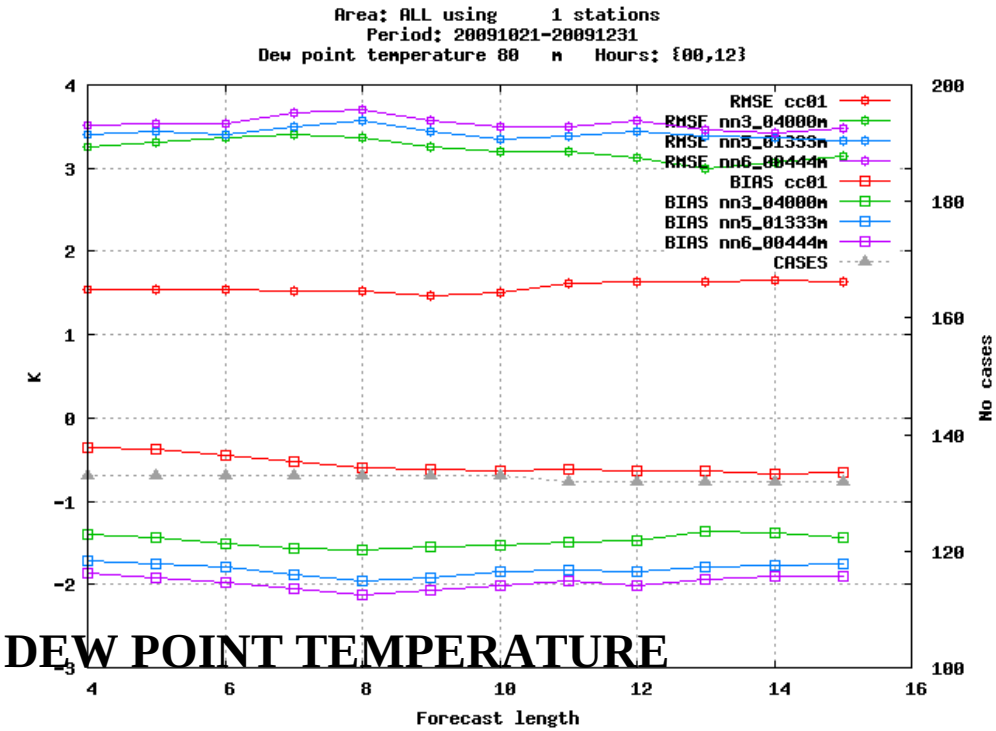


- Daily runs at 00/12UTC + 15h during October-December 2009
- AROME cold started every cycle
- COAMPS cycling surface properties

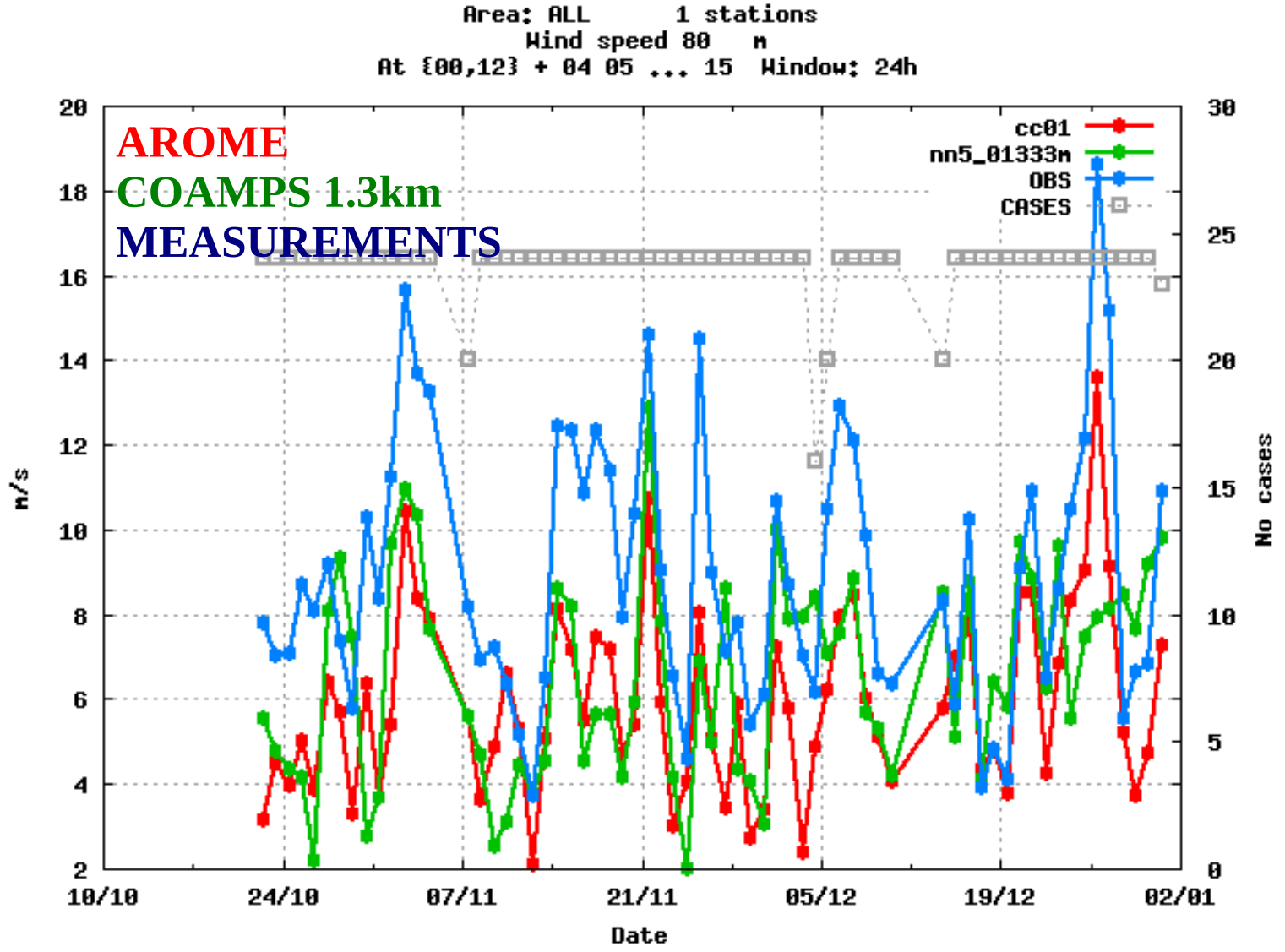


AROME 2.5km
COAMPS 4km
COAMPS 1.3km
COAMPS 0.4km

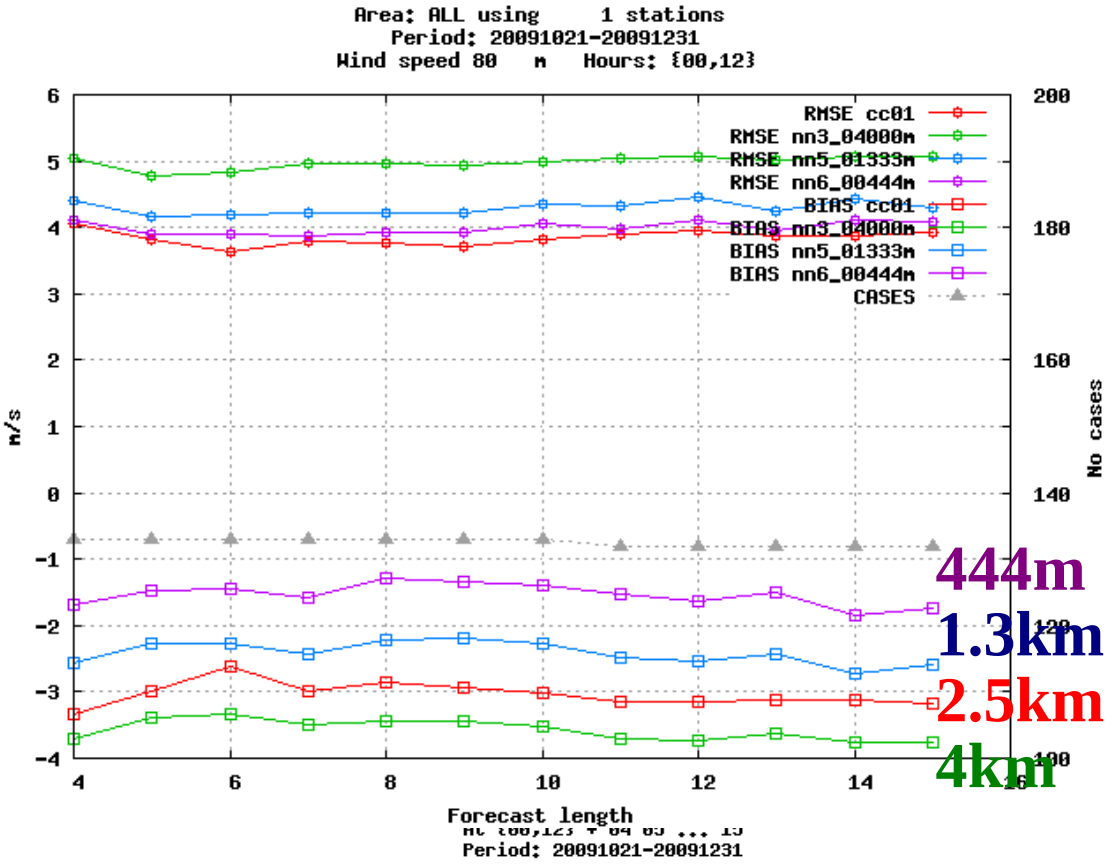


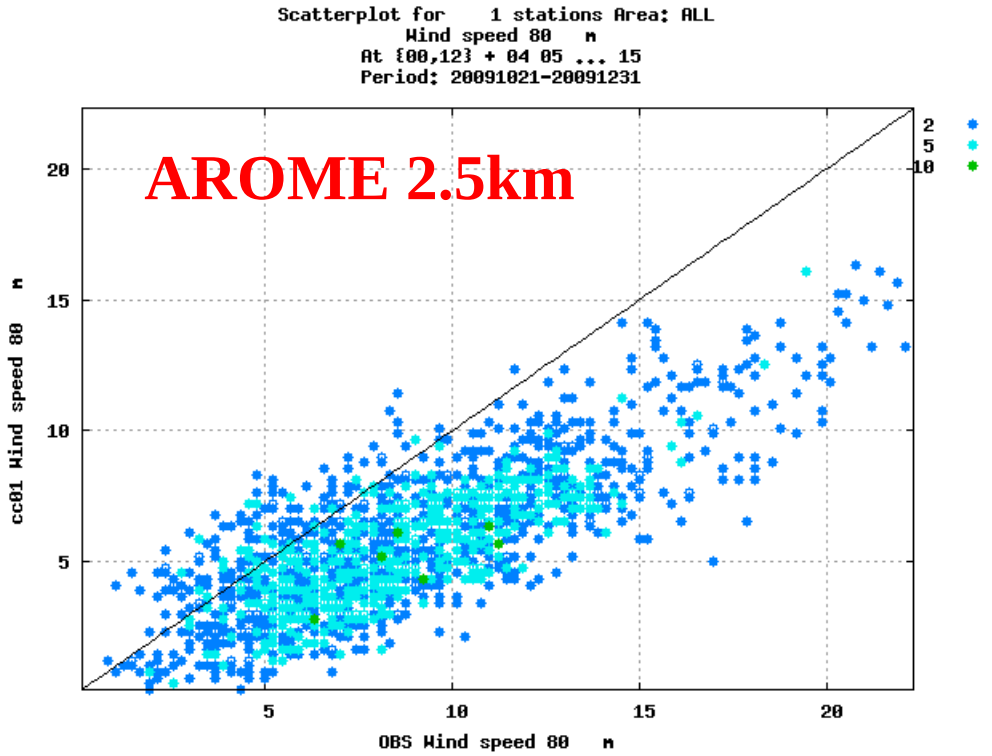


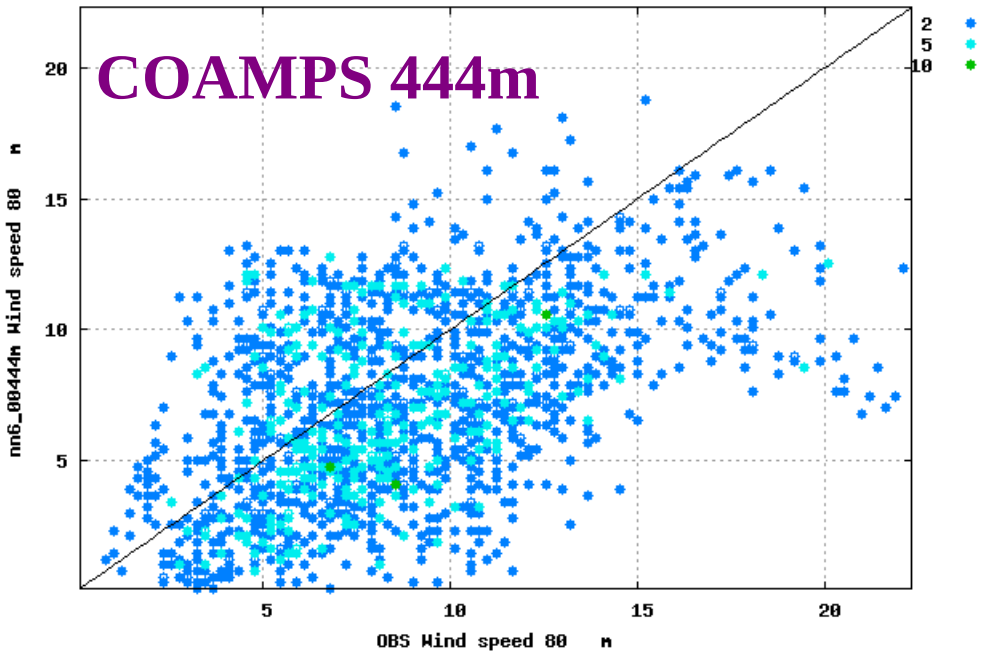
Wind at Bliekevare (80 magl)



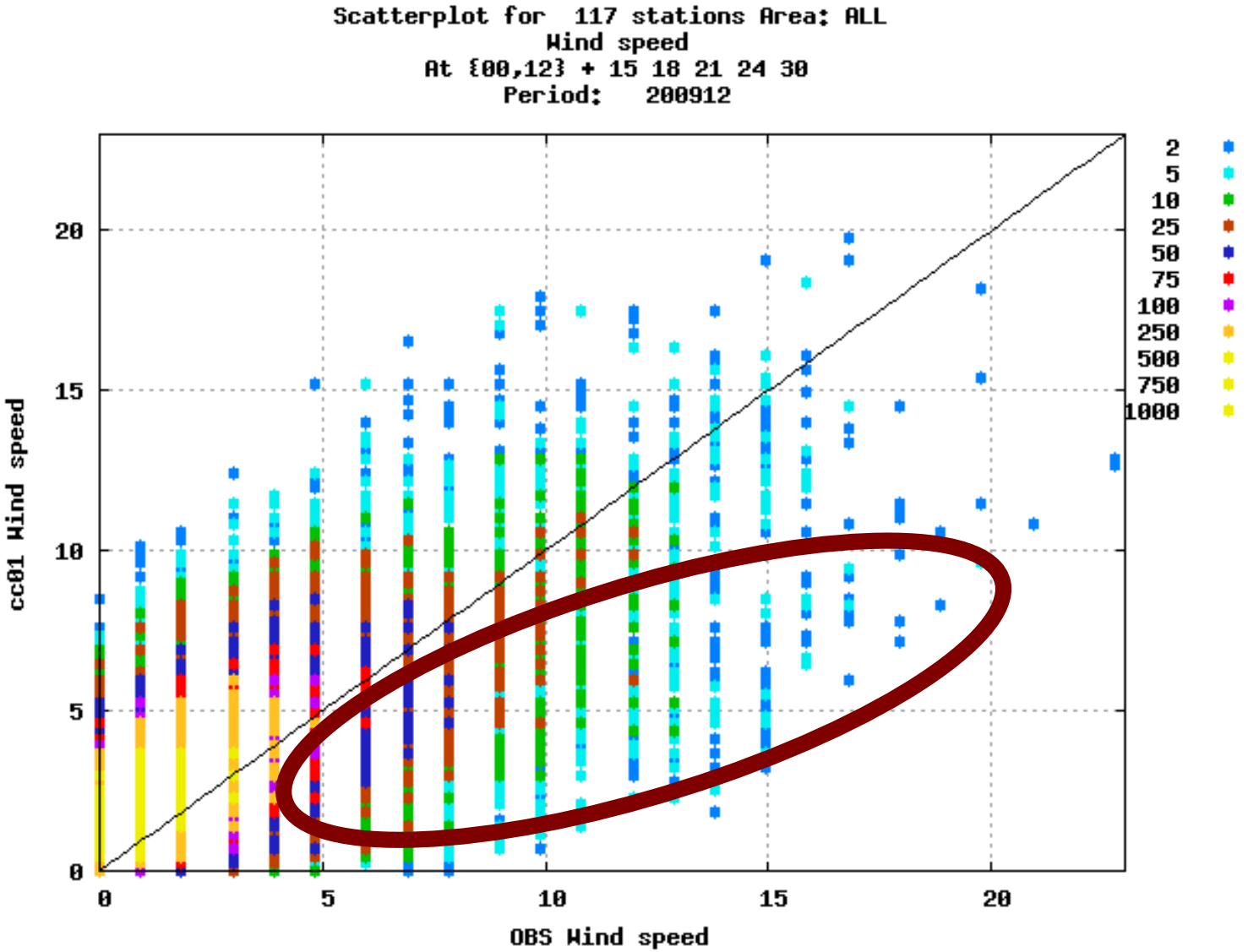
- Good response to resolution in wind error
- AROME typically underestimates the mountain wind
- COAMPS has smaller bias but larger rms





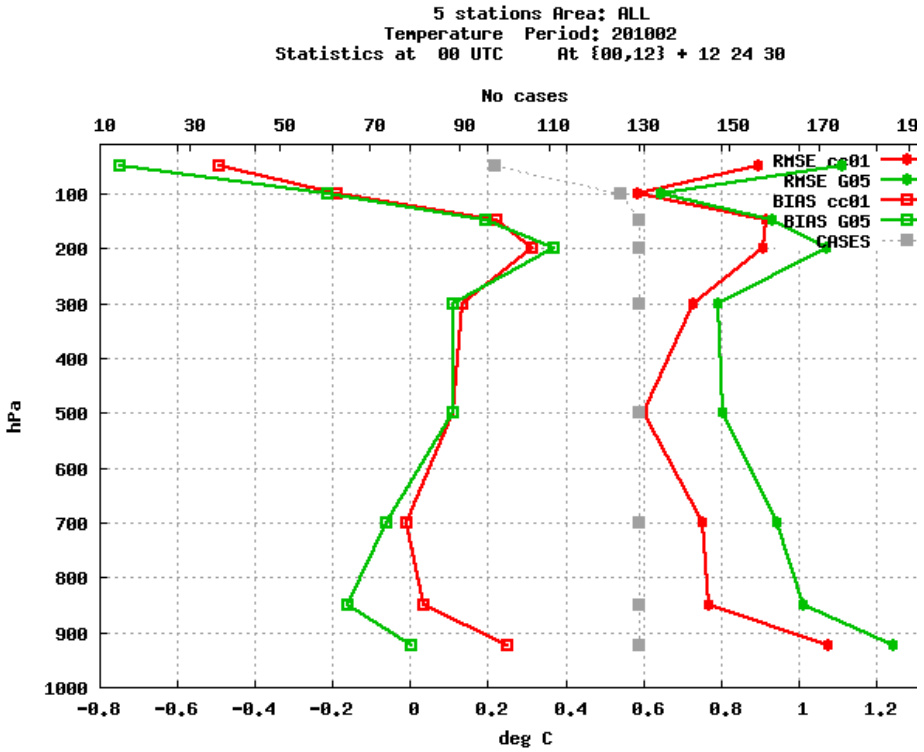


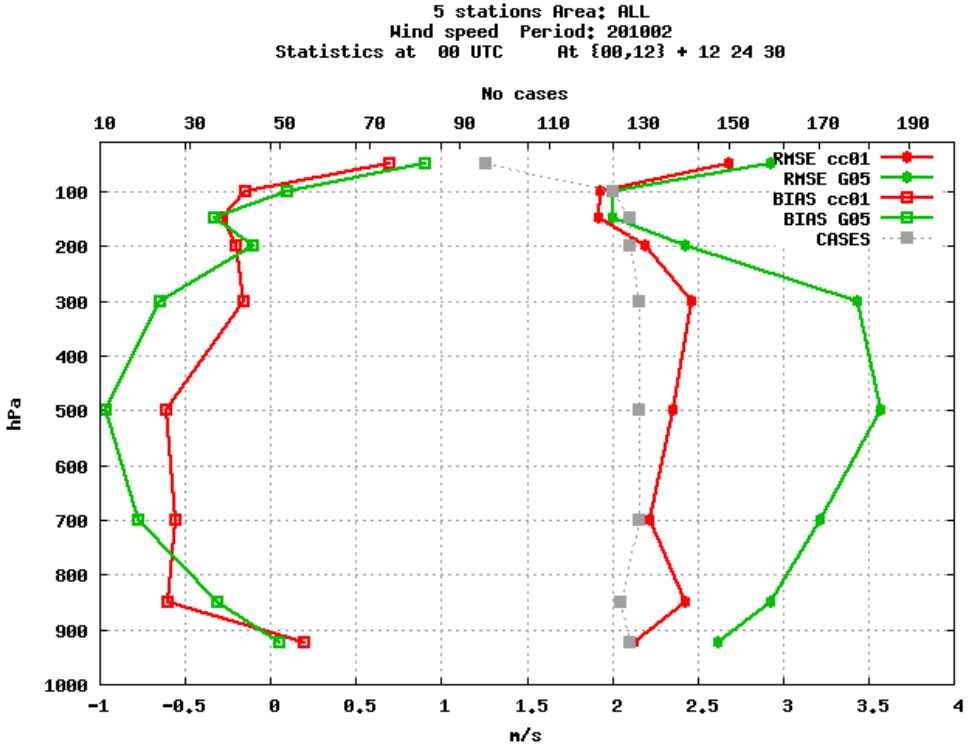
AROME U10m scatter for the full domain



Improvements
HIRLAM 5.5km -> AROME 2.5km

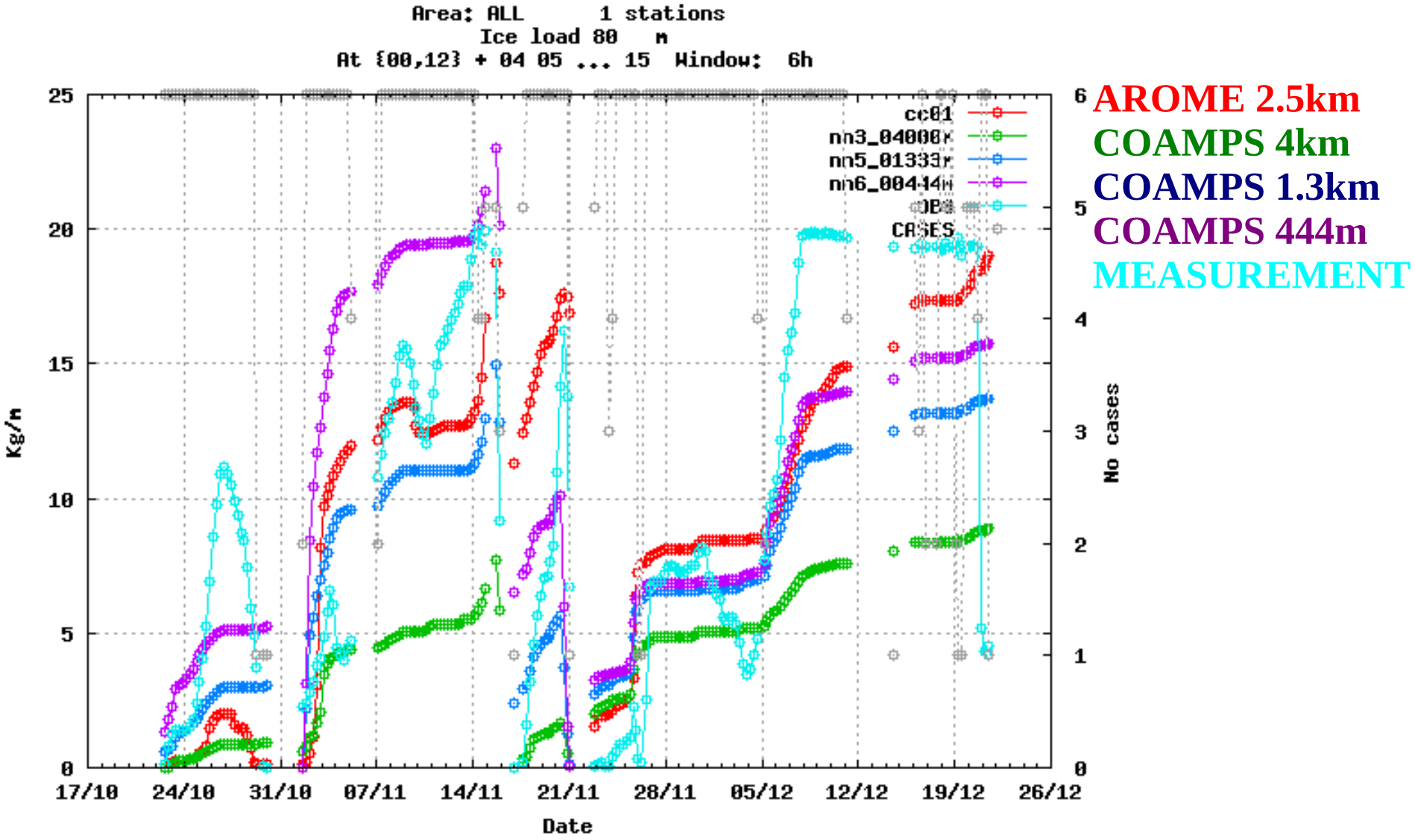
AROME **HIRLAM**





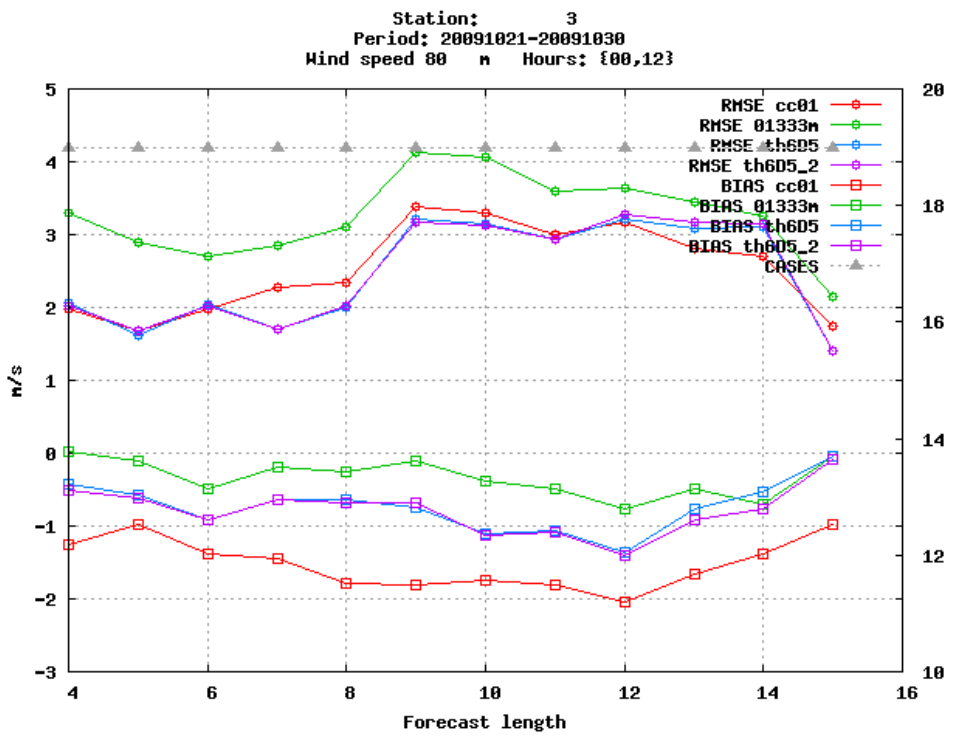
TEMPERATURE **WIND**

Measured and modelled icing 21st of Oct – 21st of Dec 2009

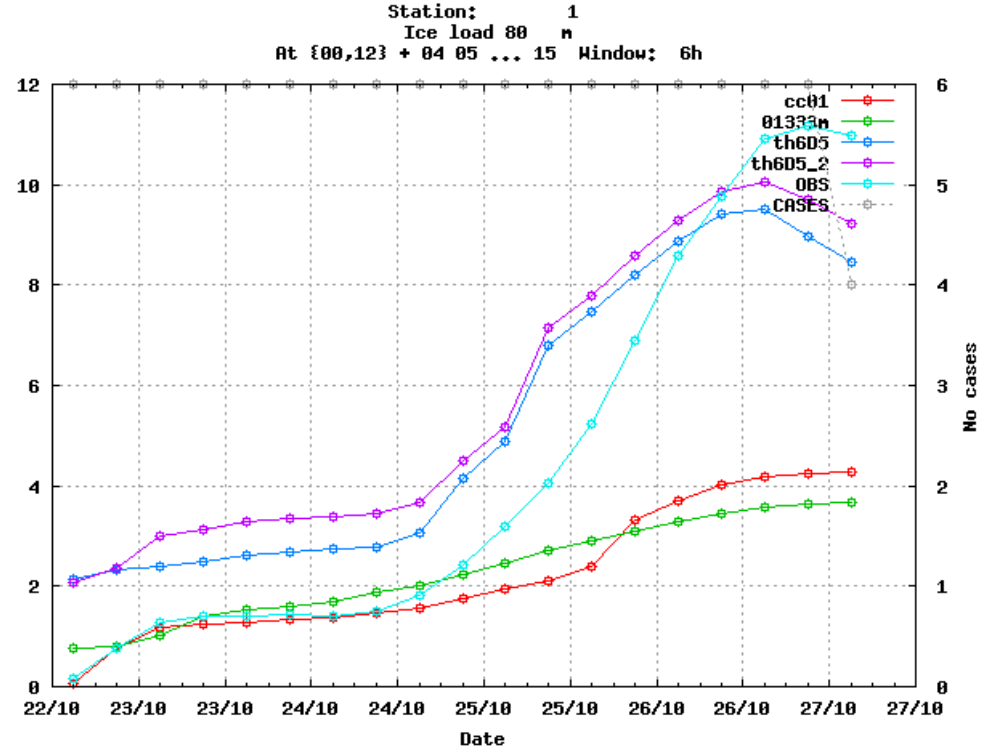


How does AROME compare with WRF at 1.3km?

Wind verification



Icing

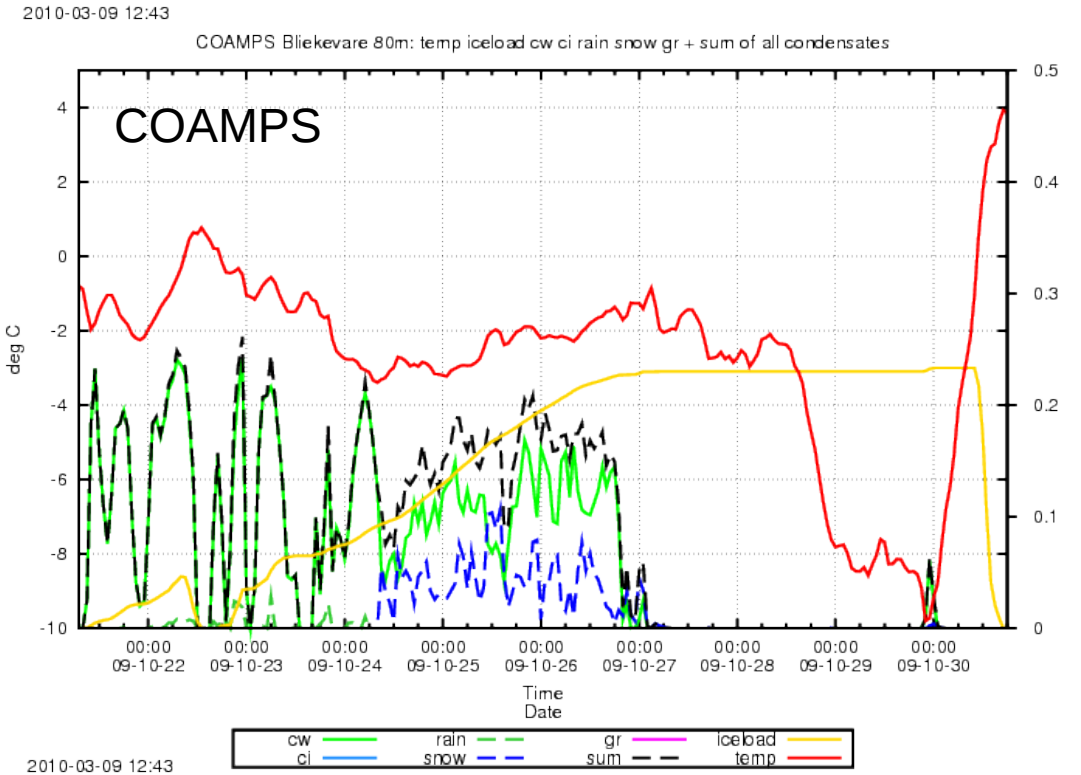


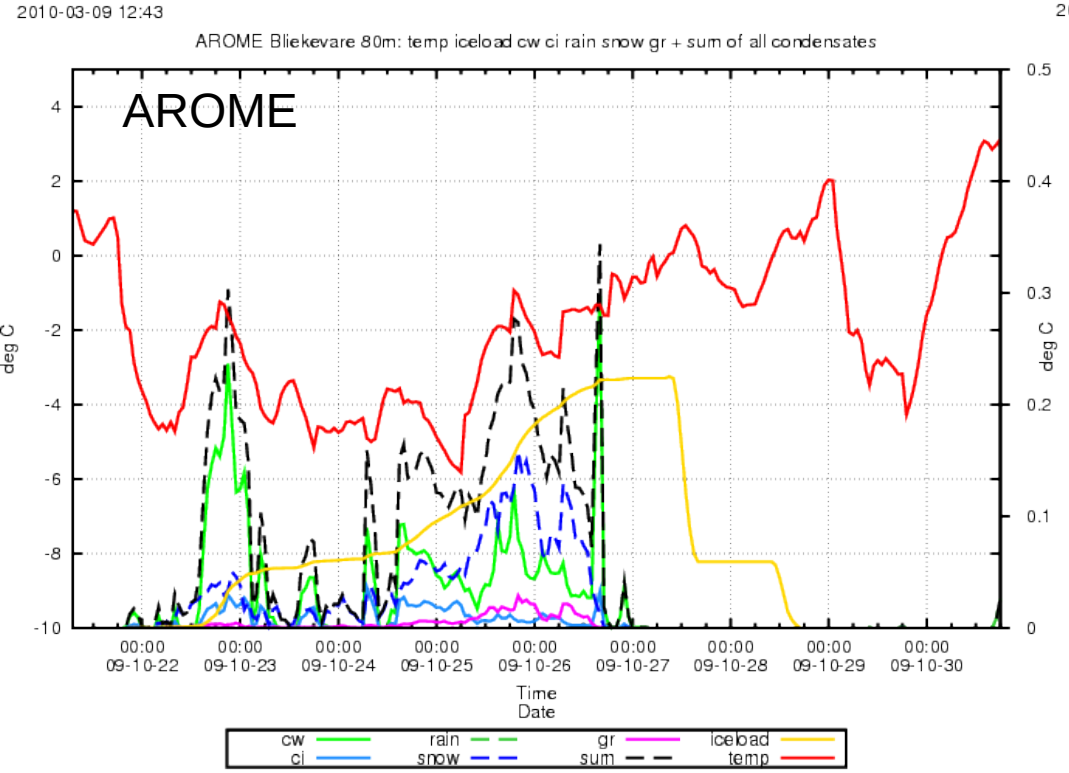
WRF1 WRF2 AROME COAMPS

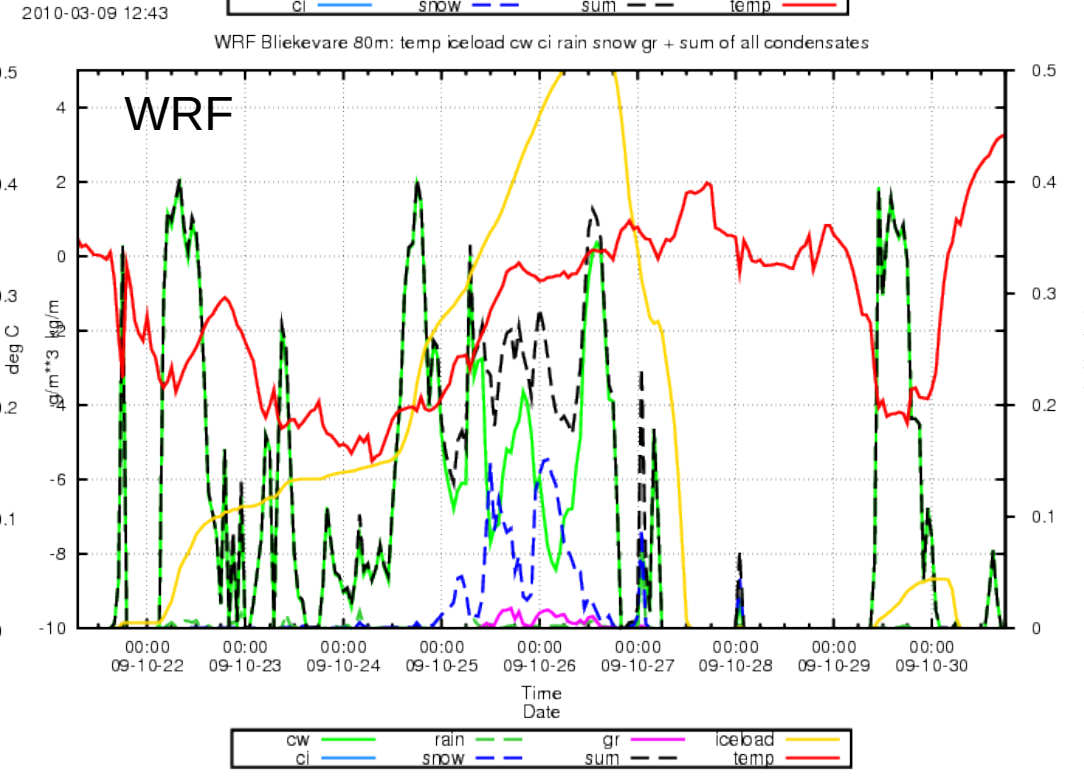
Distribution between cloud condensates in different models

What's the reality?

CW CI SNOW GRAUPEL TOTAL







Conclusions and continuation

- We are able to model the ice dynamics (growth/melting)
- Uncertainties in cloud particel distribution
- Underestimation of mountain winds

- Evaluate different methods of downscaling
- Better understanding the cloud processes
  - Is the distribution correct?
- Improve mountain winds in AROME (representation or model)
- Go to higher resolution with AROME