Norwegian
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met.no

Snow analysis in HIRLAM and HARMONIE

Kuopio, 24 March 2010

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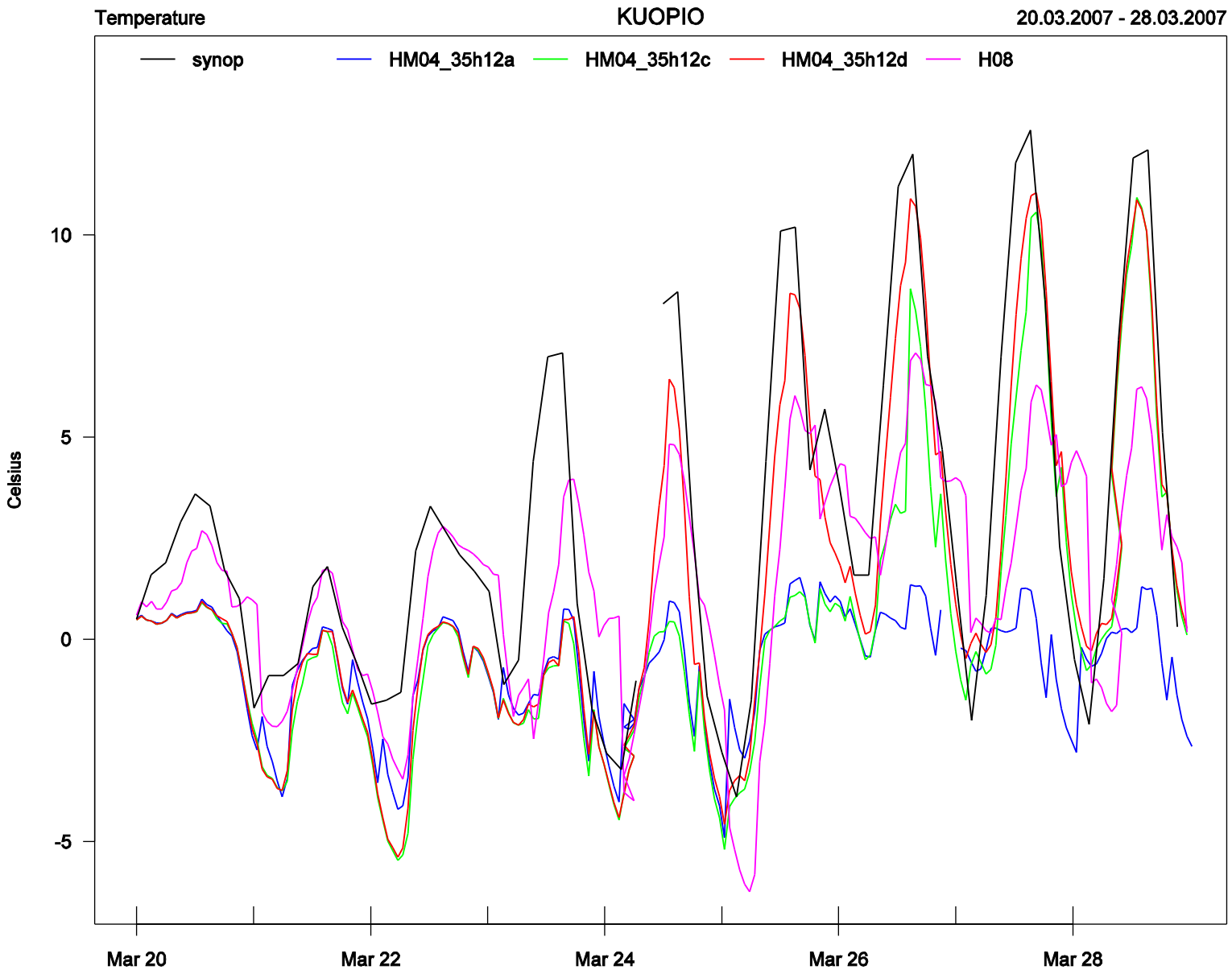
Outline

- Motivation:
  - the surface temperature depends on snow cover, in reality and in NWP
  - advanced snow schemes show larger sensitivity to snow, sometimes too large….
  - the NWP model benefits from both
    - realistic initial snow fields
    - realistic modeling of processes related to snow; melting, accumulation, albedo, emissivity, ..
- Snow analysis in HIRLAM
  - by Optimum Interpolation, introduced by A. Cansado (2004)
  - winter 2008/2009 snow were diagnosed thoroughly
    - as preparation for testing of CANARI snow analysis in HARMONIE
    - to understand why doesn't the OI analysis work as intended?
- CANARI snow analysis in HARMONIE
  - Experiments performed in cooperation with L. Tasseva and F. Taillefer, October 2009
  - introduced in HARMONIE at met.no 18 February 2010



HARMONIE experiments:

HM04_35h12a
cy35h1.2

HM04_35h12c
+ CANARI
+ blending

HM04_35h12d
+ tuning of parameters related to albedo

HIRLAM operational:
H08

Snow analysis in HIRLAM

- Optimum Interpolation (OI)
- Introduced in 2004 by Alberto Cansado, Spain

  A. Cansado, C. Martin and B. Navascues:

  'Optimum interpolation New Snow Depth Analysis in HIRLAM'

  HIRLAM Newsletter no. 45, 2004
- Based on Brasnett (1999) :

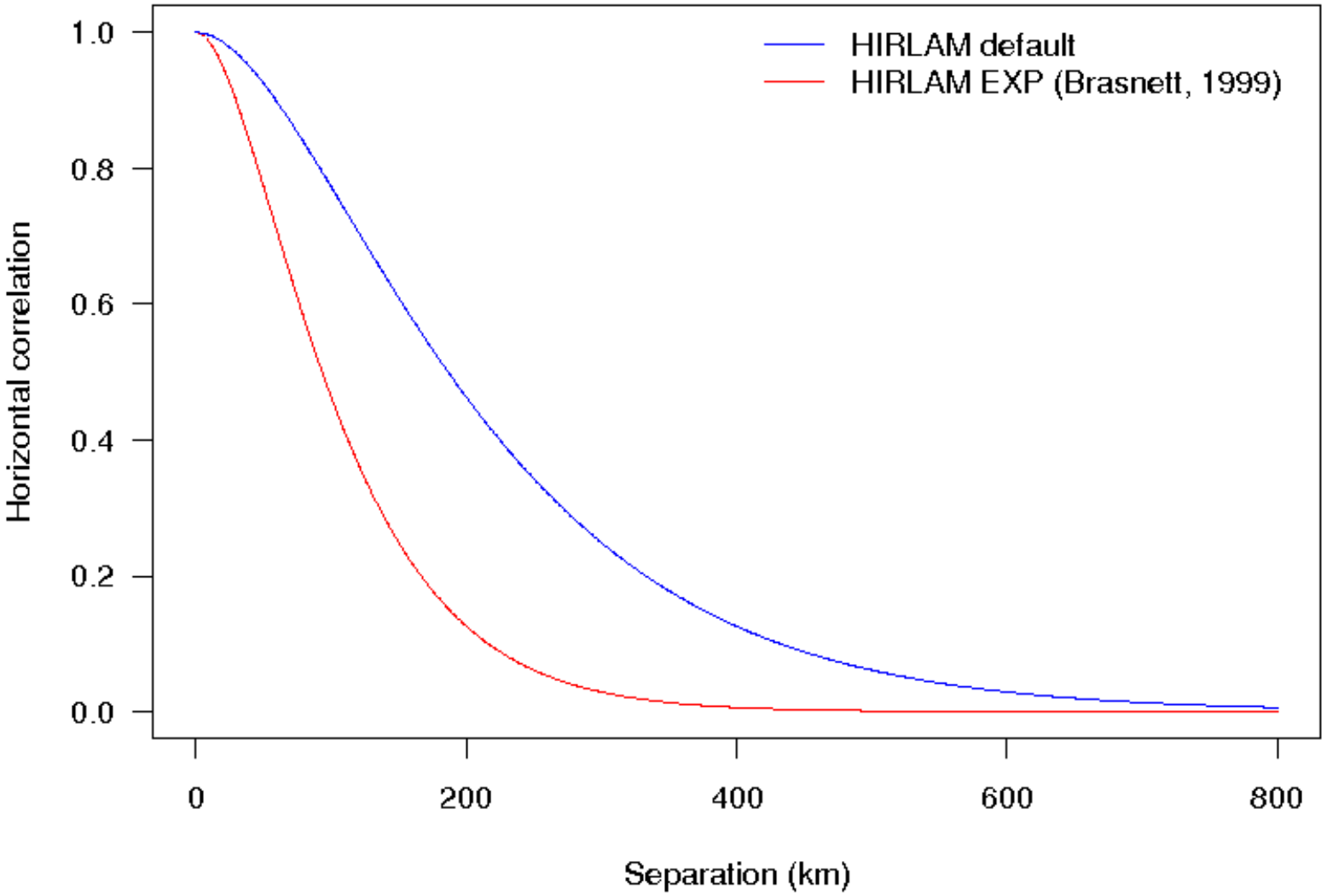
  'A Global Analysis of Snow Depth for Numerical Weather Prediction', J. Appl. Meteor.
- NWP model: snow water equivalent in tonn/m2 ←→

  Observations: from synop of snow depth in cm

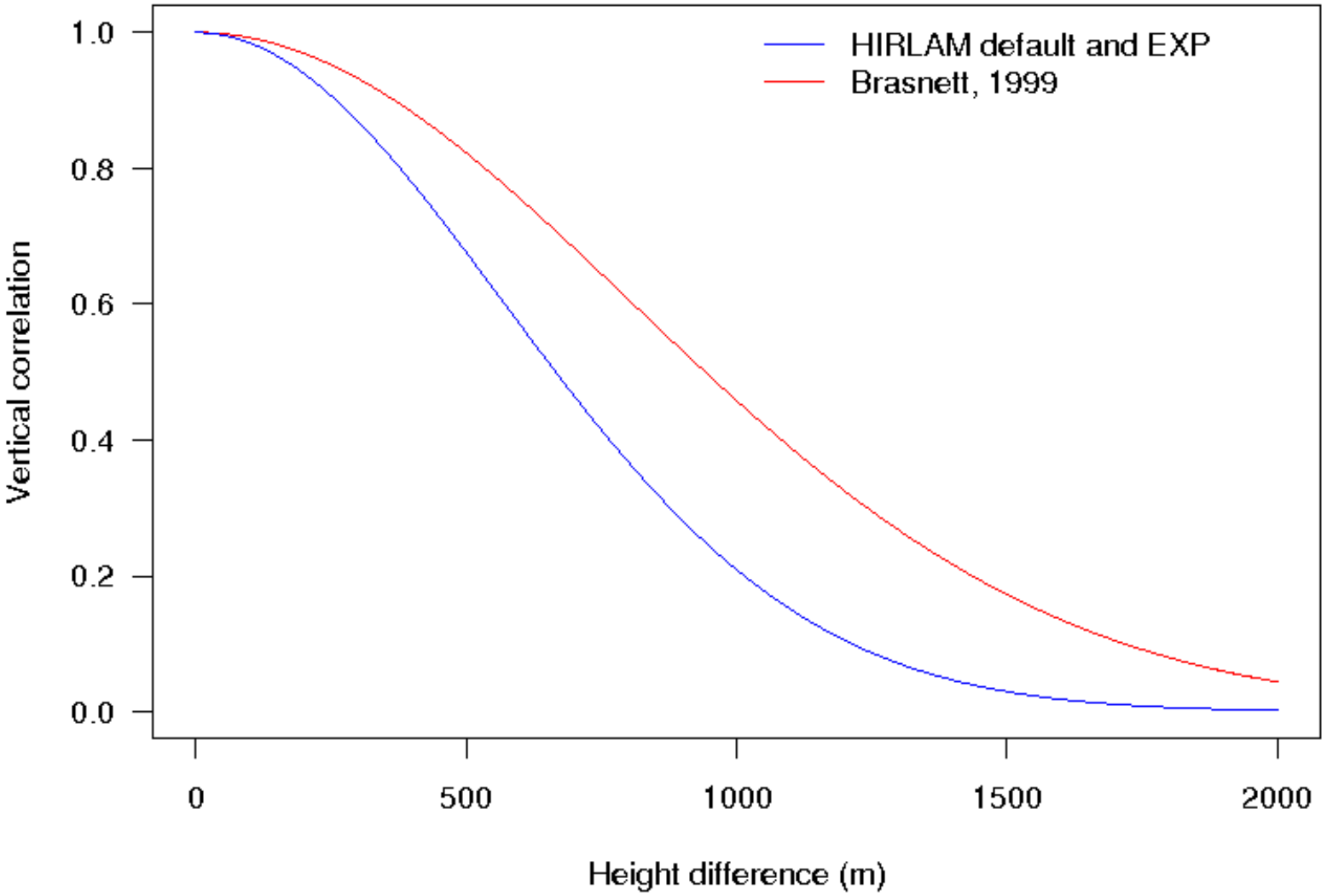
Snow analysis in HIRLAM, cont.

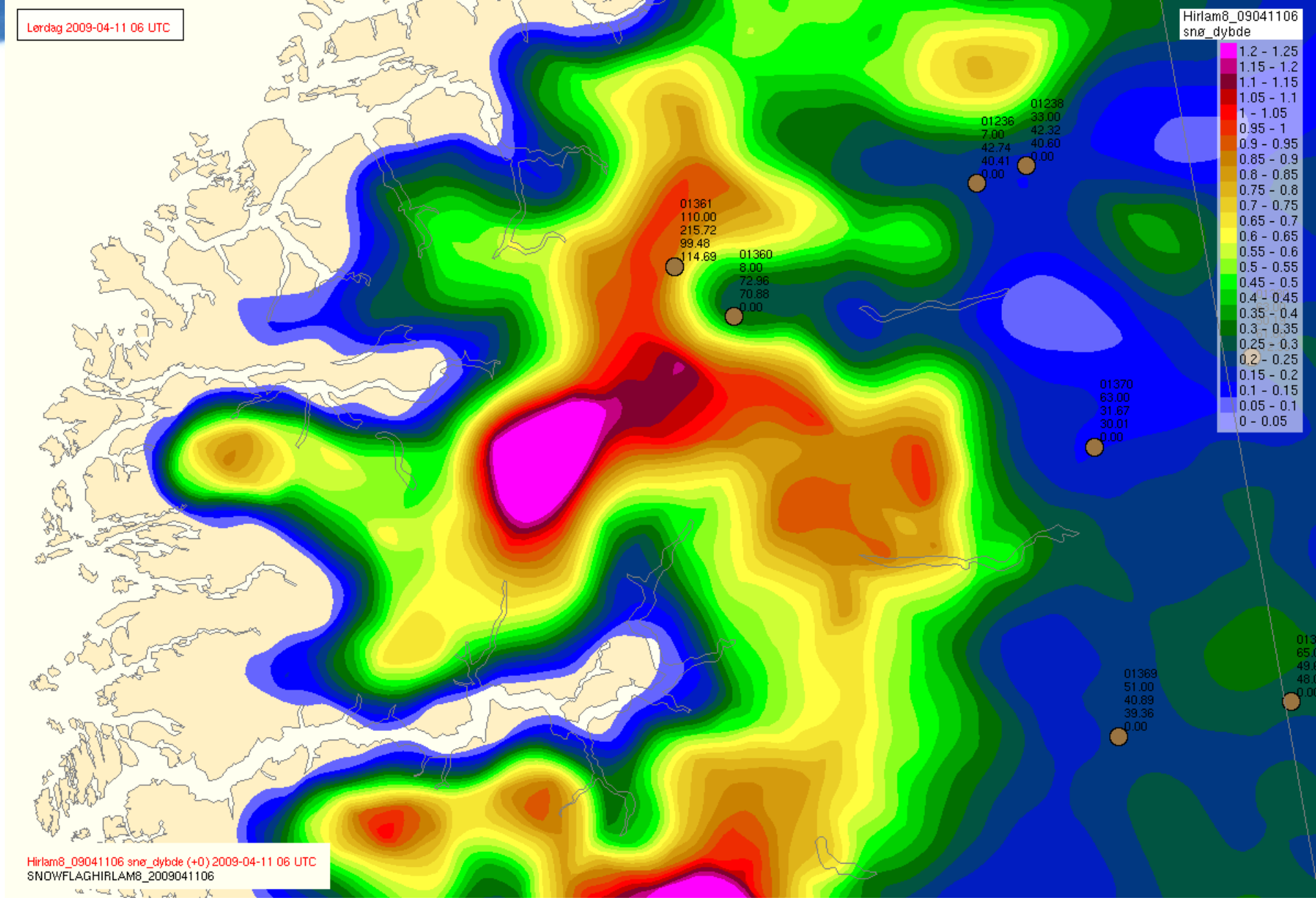
- $x_a = x_b + BH^T\left(R + HBH^T\right)^{-1}\left(y - H(x_b)\right)$
- observations are supposed to be uncorrelated
- error statistics:
  - synop - std = 3.3 (2.45 in Brasnett)
  - 1.guess - std = 3.1 (3.16 in Brasnett)
  - Horizontal correlation - Second Order Autoregressive:
    (1+cc*r)*exp(-cc*r), where cc=0.009 km^-1 (0.018 in Brasnett)
  - Vertical correlation - Gaussian function:
    exp(-0.5*(dH/565)^2) (800 in Brasnett)
- Bias correction – only at stations with observations more often than daily (in the way it is implemented…)
- HIRLAM's snow analysis had a separate 1. guess with much slower melting rate than the forecast.

Horizontal correlation

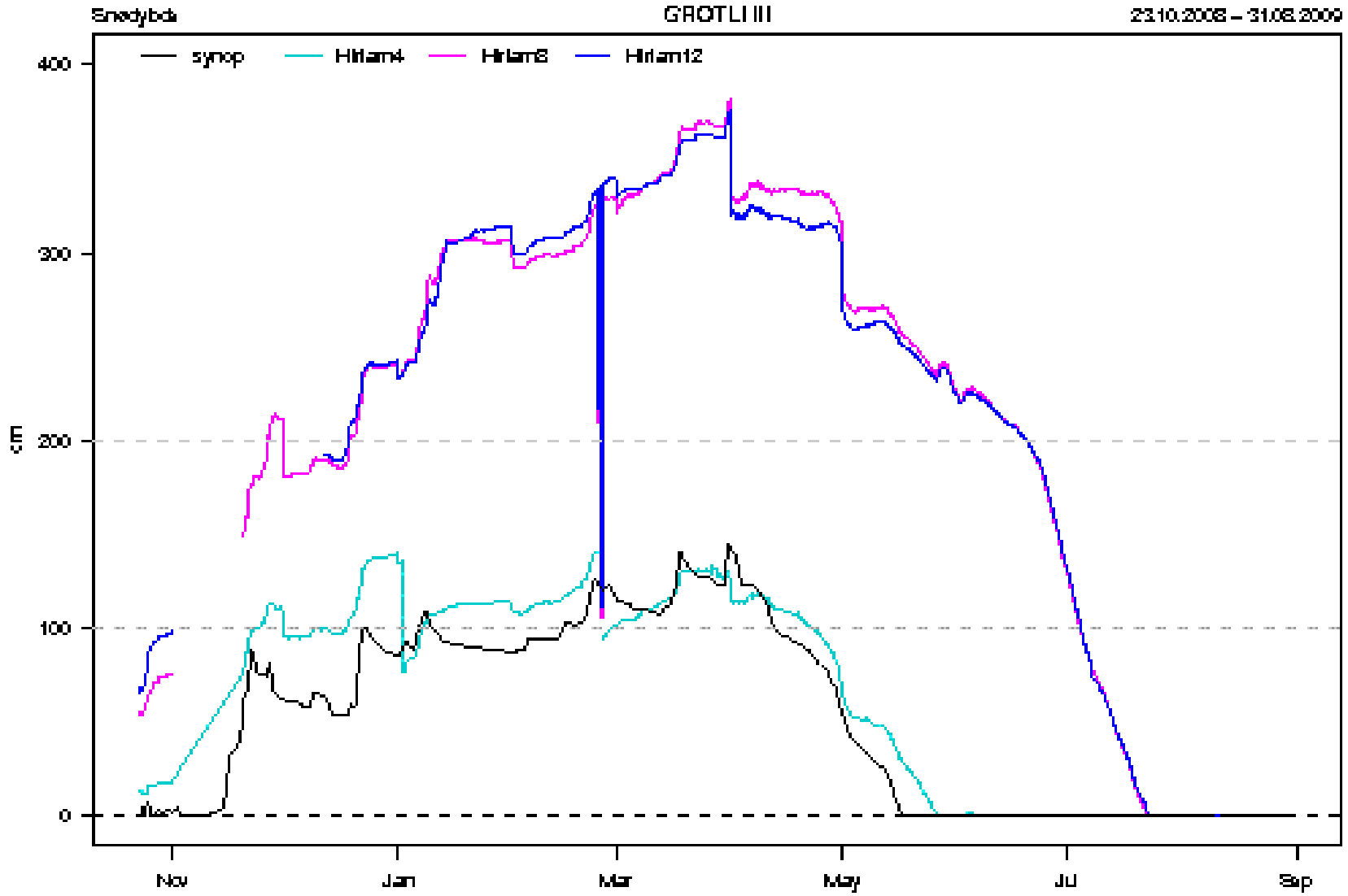


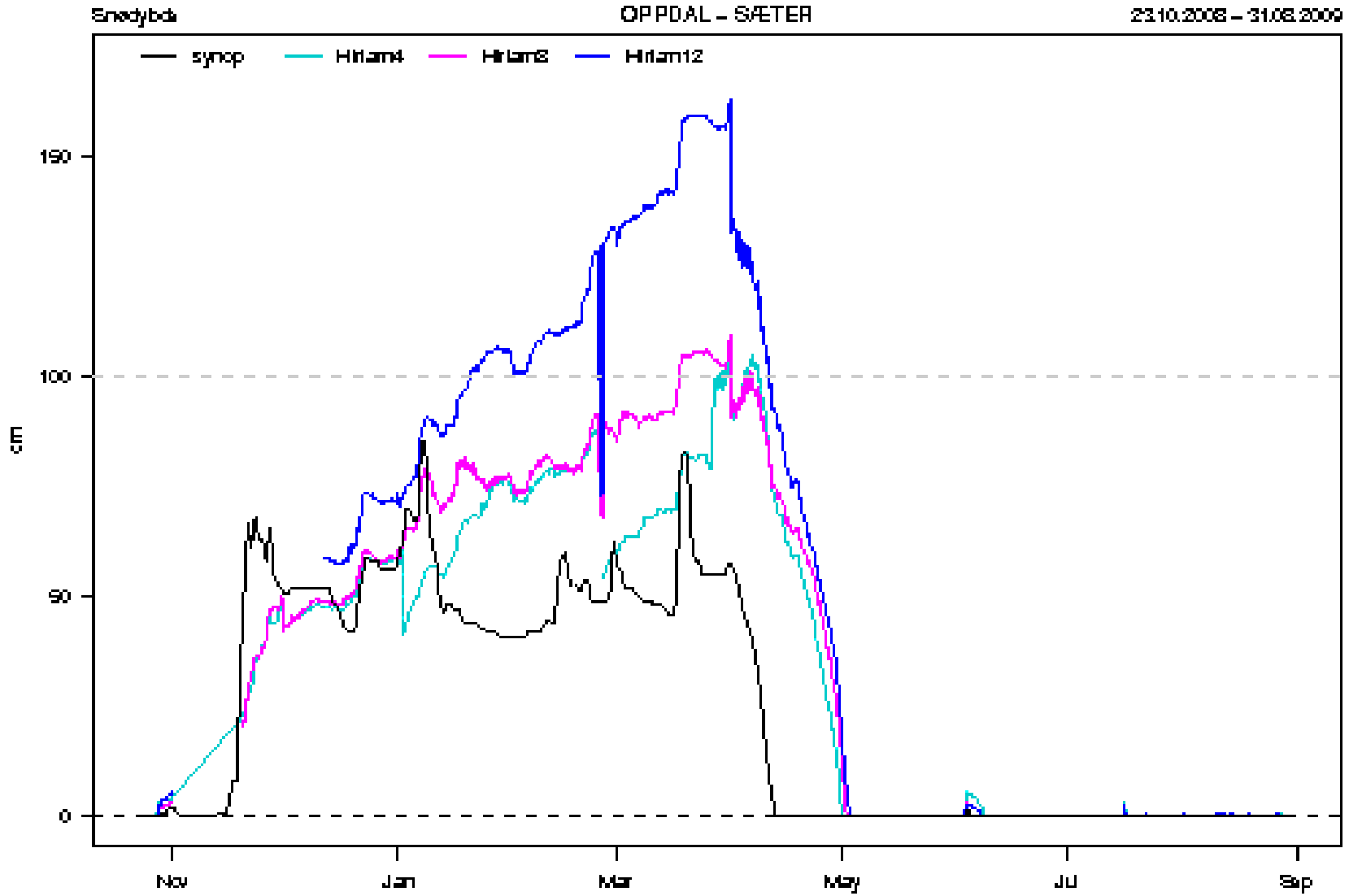
Vertical correlation





Hirlam8 snow (tonn/m2) – 11 April 2009


Snødybde
GROTLI III
23.10.2008 – 31.08.2009
synop
Hirlam4
Hirlam8
Hirlam12
400
300
200
100
0
cm
Nov
Jan
Mar
May
Jul
Sep


Snødybde
OPPDAL – SÆTER
23.10.2008 – 31.08.2009
synop
Hirlam4
Hirlam8
Hirlam12
190
100
90
0
cm
Nov
Jan
Mar
May
Jul
Sep

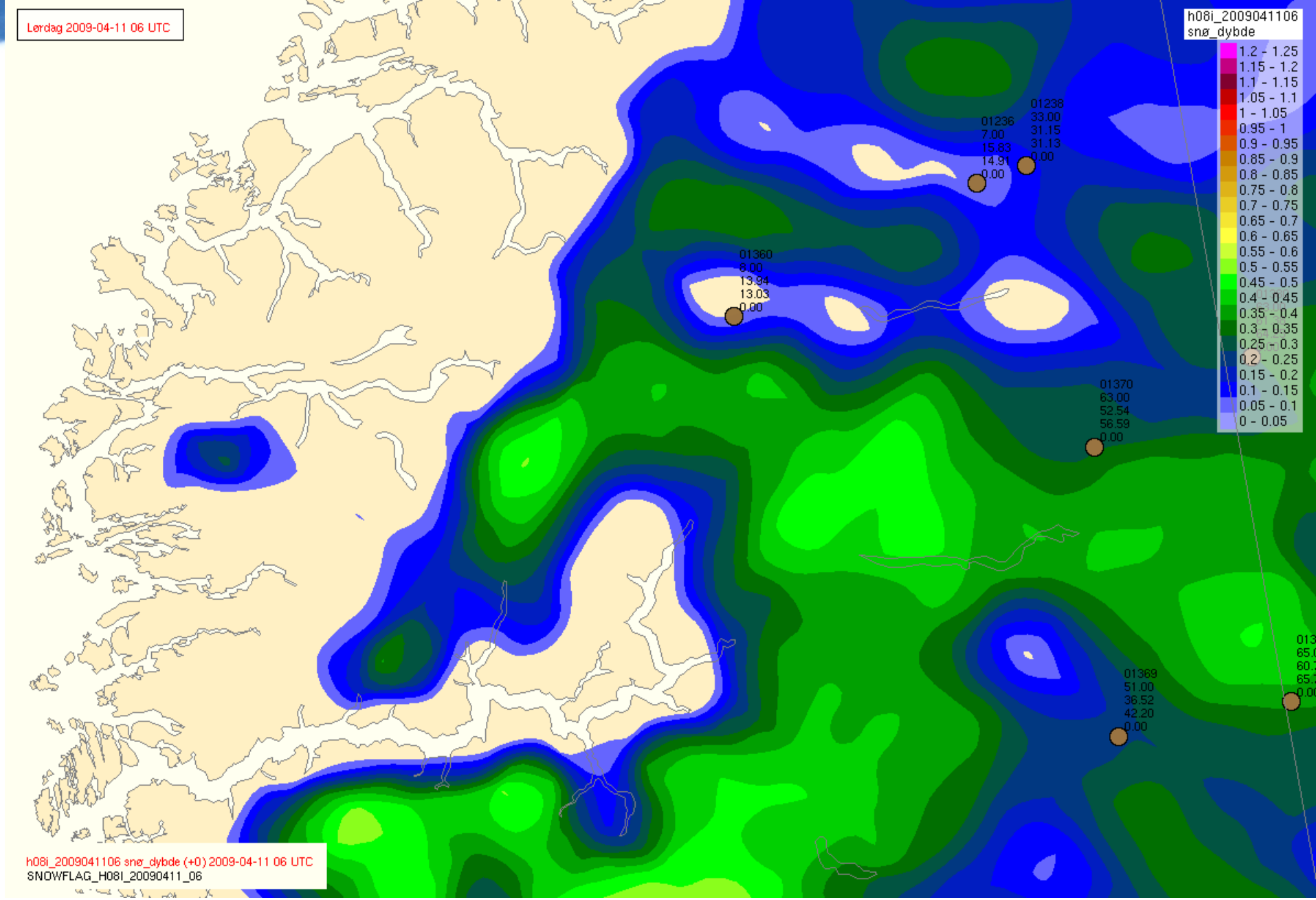
Snow analysis in HIRLAM

Diagnostics winter 2008/2009:

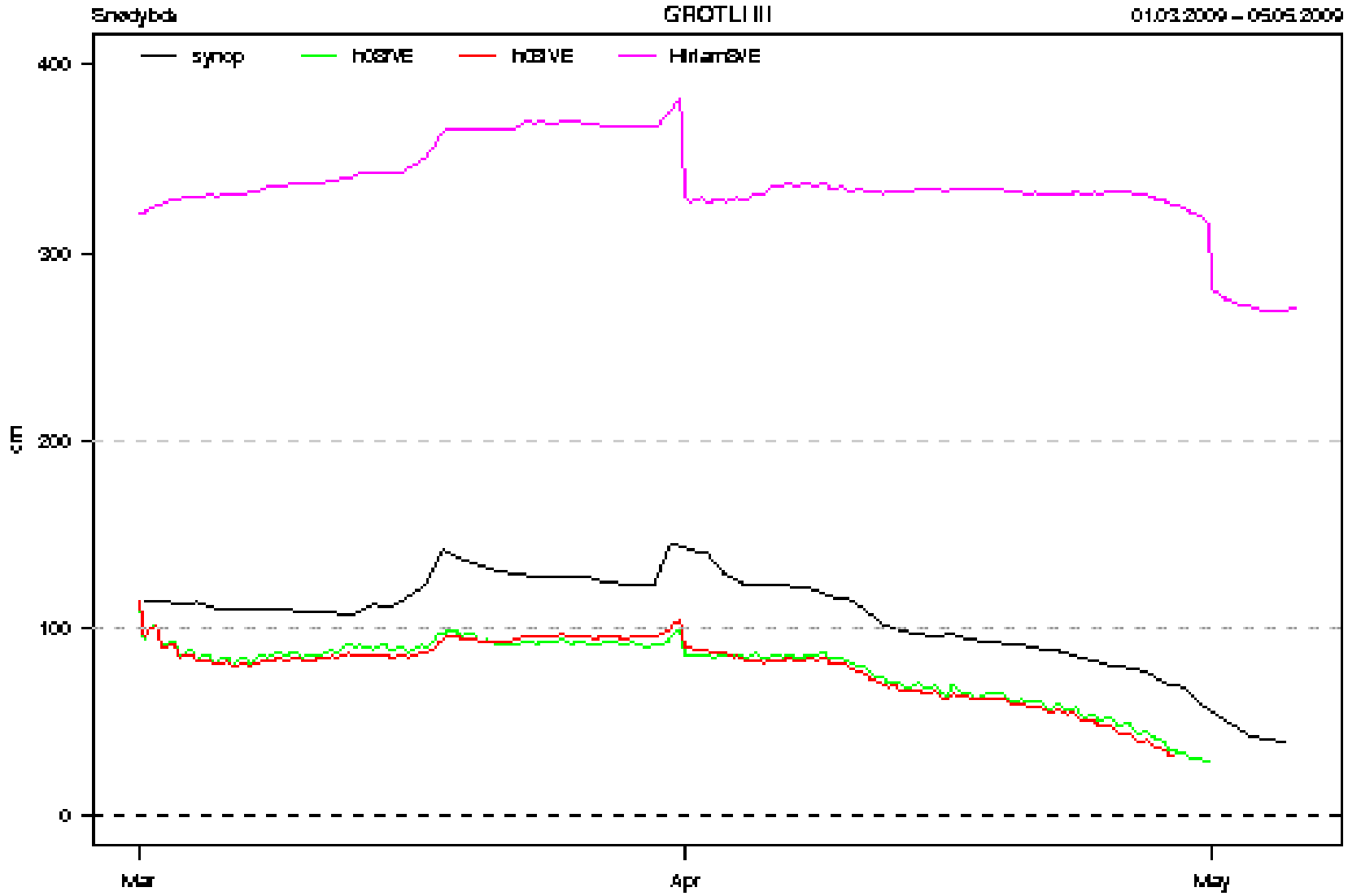
- Accumulates large amounts of snow in central areas,
  max. values in the end of March, f.ex.:
  - Hardangerjøkulen (which cover Finse) ~ 6m
  - Grotli ~ 4m (observed 1.5m, with 1.5m bias correction)
- Snow disappears too late in the spring
- Large influence from observations, might lead to snow over large and snow free domains in spring and summer

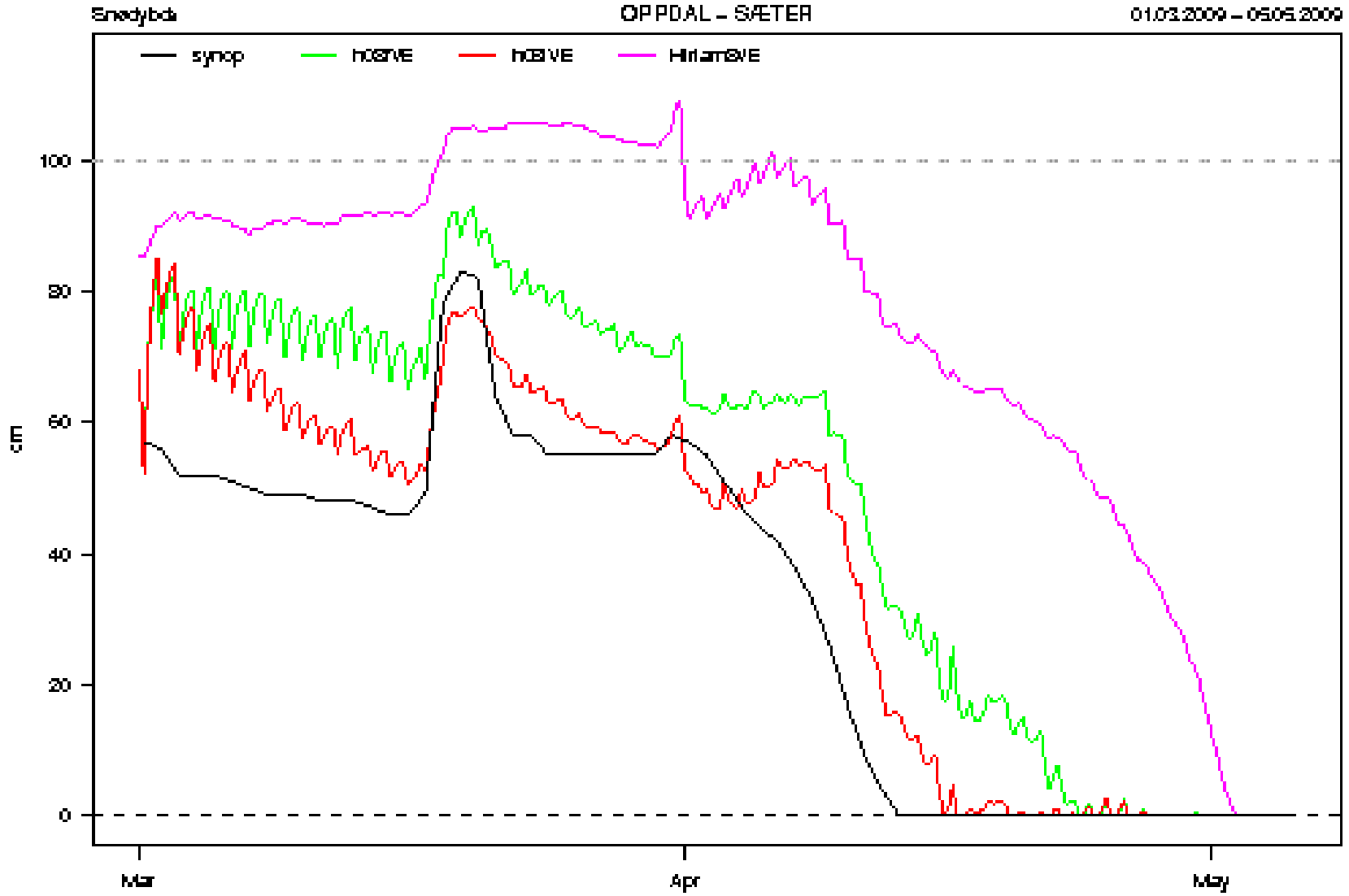
Changes tested in parallel experiments and introduced in operational Hirlam12/8/4 models 8. September 2009:

- revised limits in quality control
- NO bias correction
- reduced influence radius
- increased melting in 1. guess



h08i snow (tonn/m2) – 11 April 2009


Smedybda
GROTLI III
01.03.2009 – 06.05.2009
synop
hCEVE
hCEVE
HirlamCVE
400
300
200
100
0
cm
Mar
Apr
May


Snødybde
OPPDAL – SÆTER
01.03.2009 – 05.05.2009
synop
hclrVE
hclrVE
HirlamVE
100
80
60
40
20
0
cm
Mar
Apr
May

Snow analysis in CANARI

- introduced in CANARI and tested in ALADIN and ARPEGE in 2000/2001
- by Lora Taseva and Françoise Taillefer (Gaytandjieva,2000/2001)
- the snow analysis as introduced in CANARI and HIRLAM are similar
  - analysis method is Optimum Interpolation (OI)
  - background error correlation includes a horizontal and a vertical term
  - use only synoptic observations which are supposed to have uncorrelated error
- the snow analysis in HARMONIE with CANARI where tested during one week in October 2009 at Météo-France
- CANARI snow analysis in HARMONIE at met.no since 18 February 2010

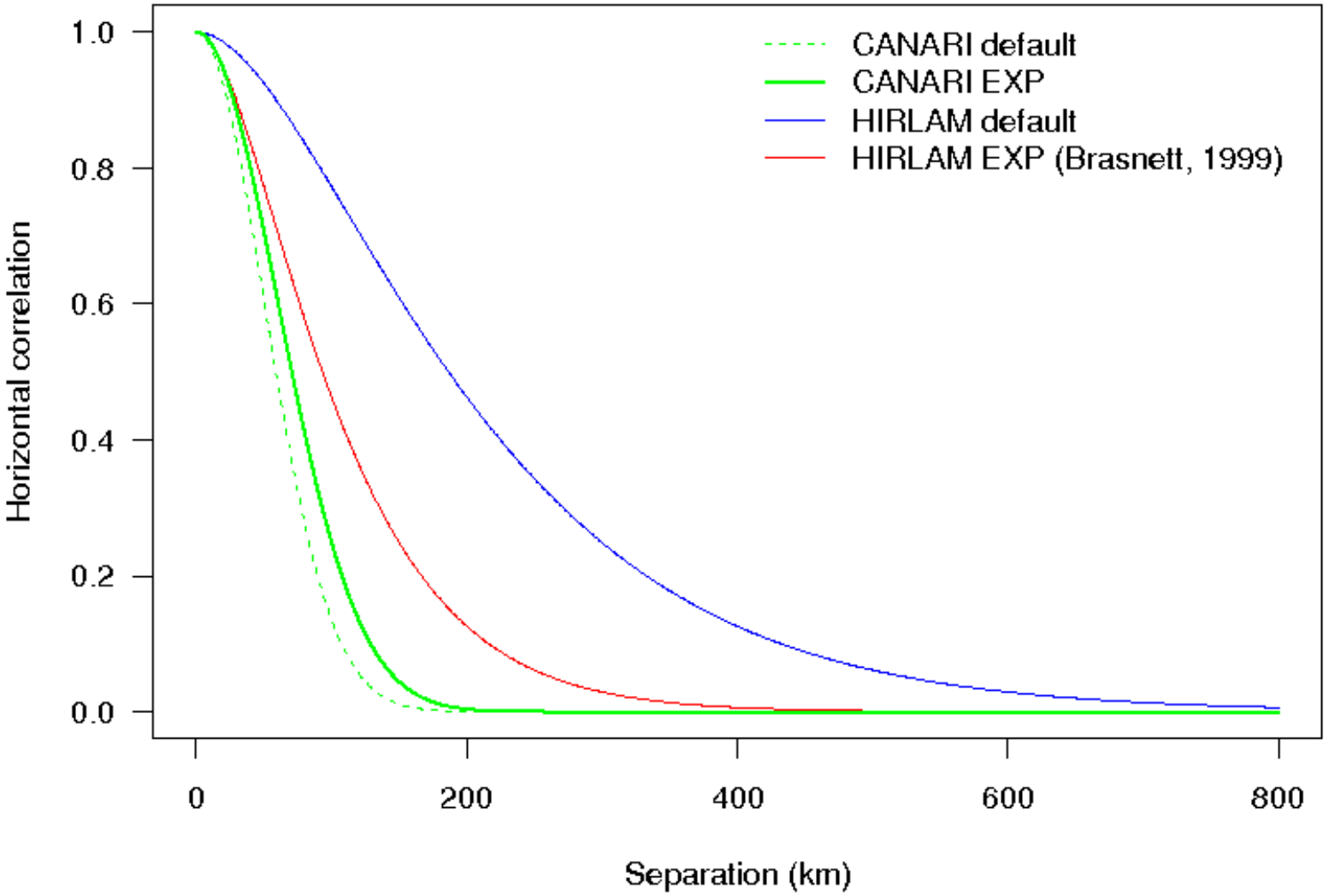
Snow analysis experiments with CANARI in HARMONIE – cy35h12 – period: 1-9 March 2009

Setup of first experiments

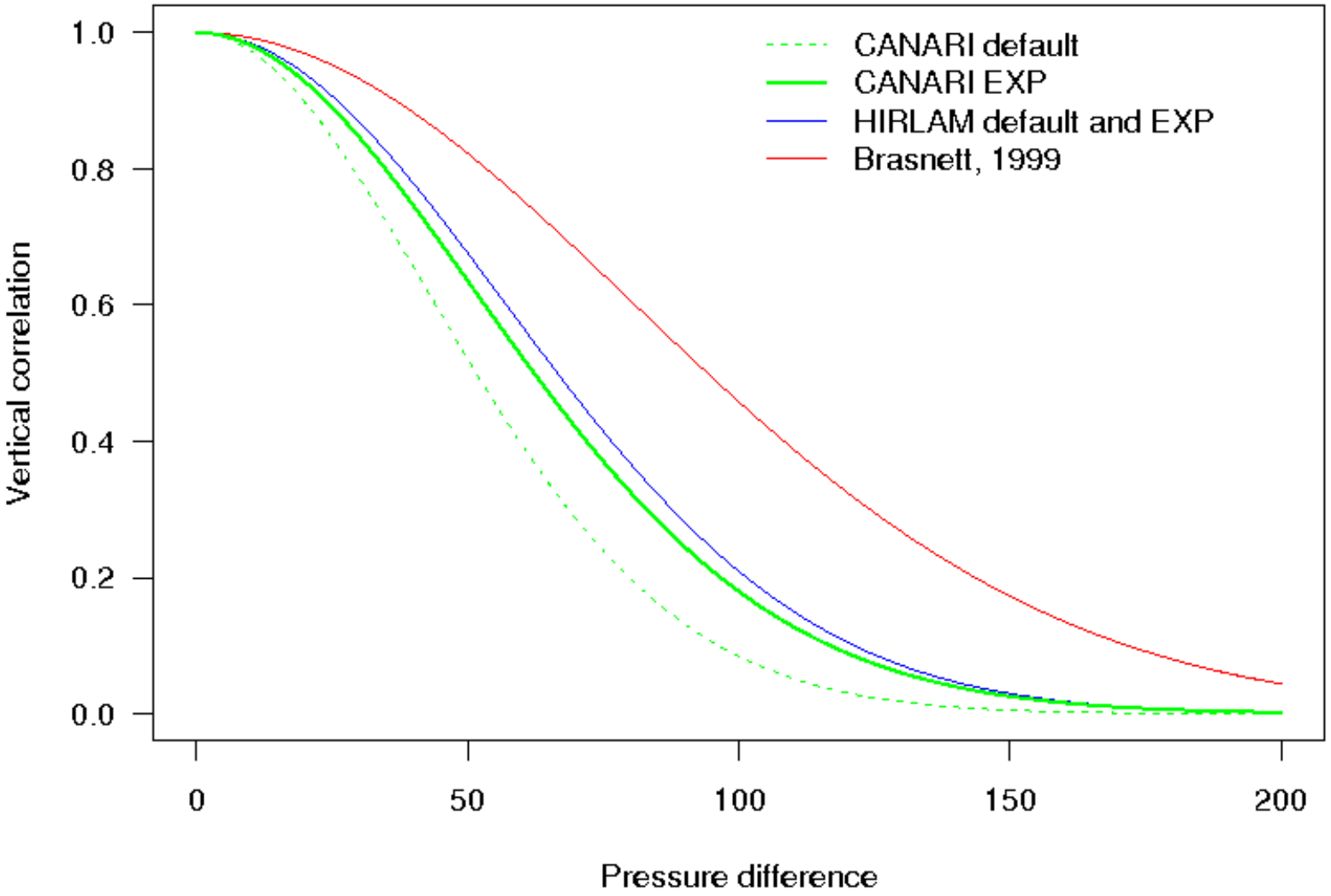
- no relaxation
- limits of quality control increased to include all available observations, default limits lead to rejection of most observations
- scales of background error correlations increased from 500 to 600 km for the horizontal and from 0.05 to 0.06 for the vertical part, to be closer to experimental HIRLAM settings
- standard deviations of observation and background errors are by default 5 kg/m2, have not been changed
- first guess from 6 h forecast, the preprocessing taking real and model orography into account has not been tested
- monthly mean values for snow density introduced in the experiment, replace the value 100 kg/m3

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
kg/ m3	222	233	240	278	312	312	312	143	143	161	182	213

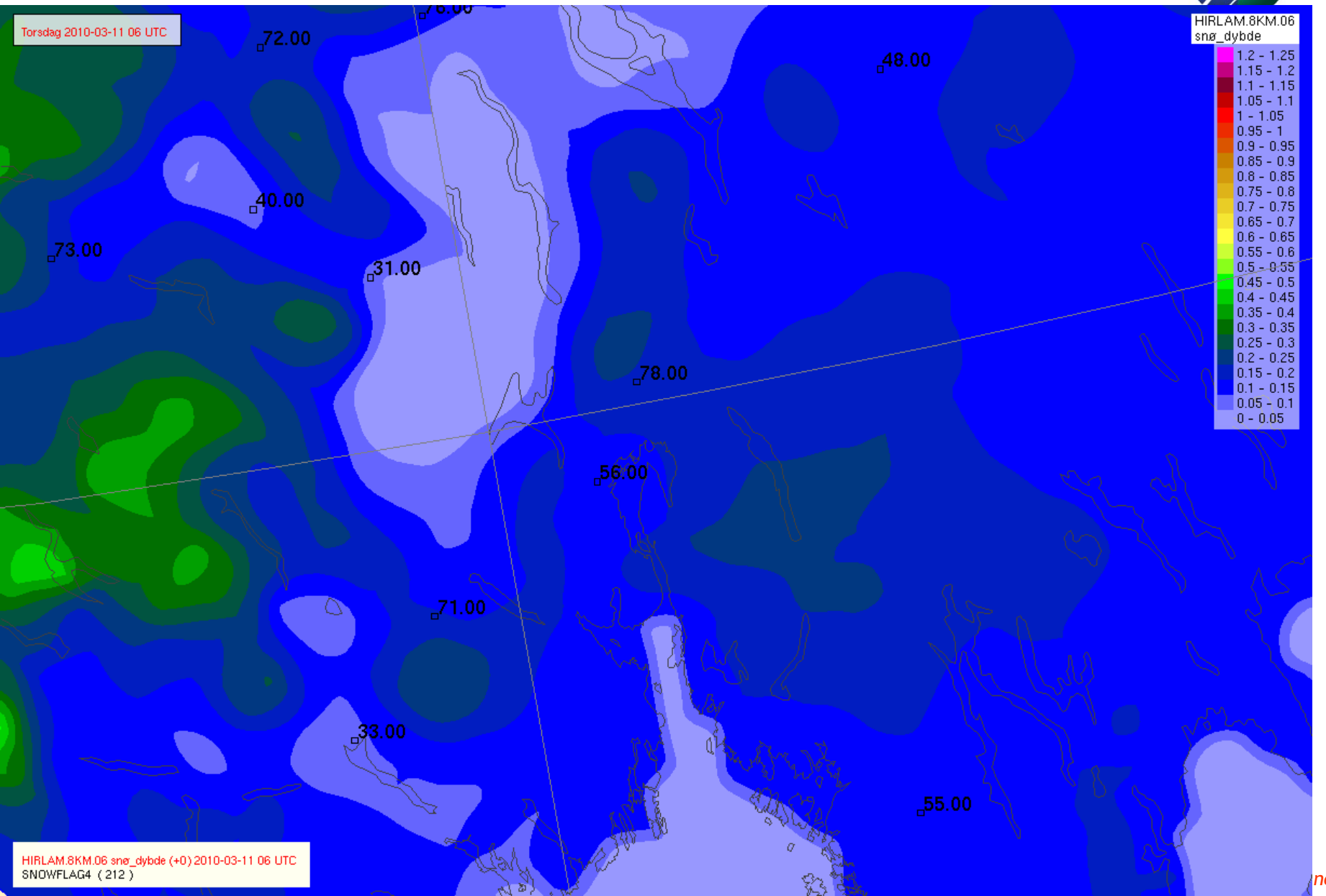
Horizontal correlation



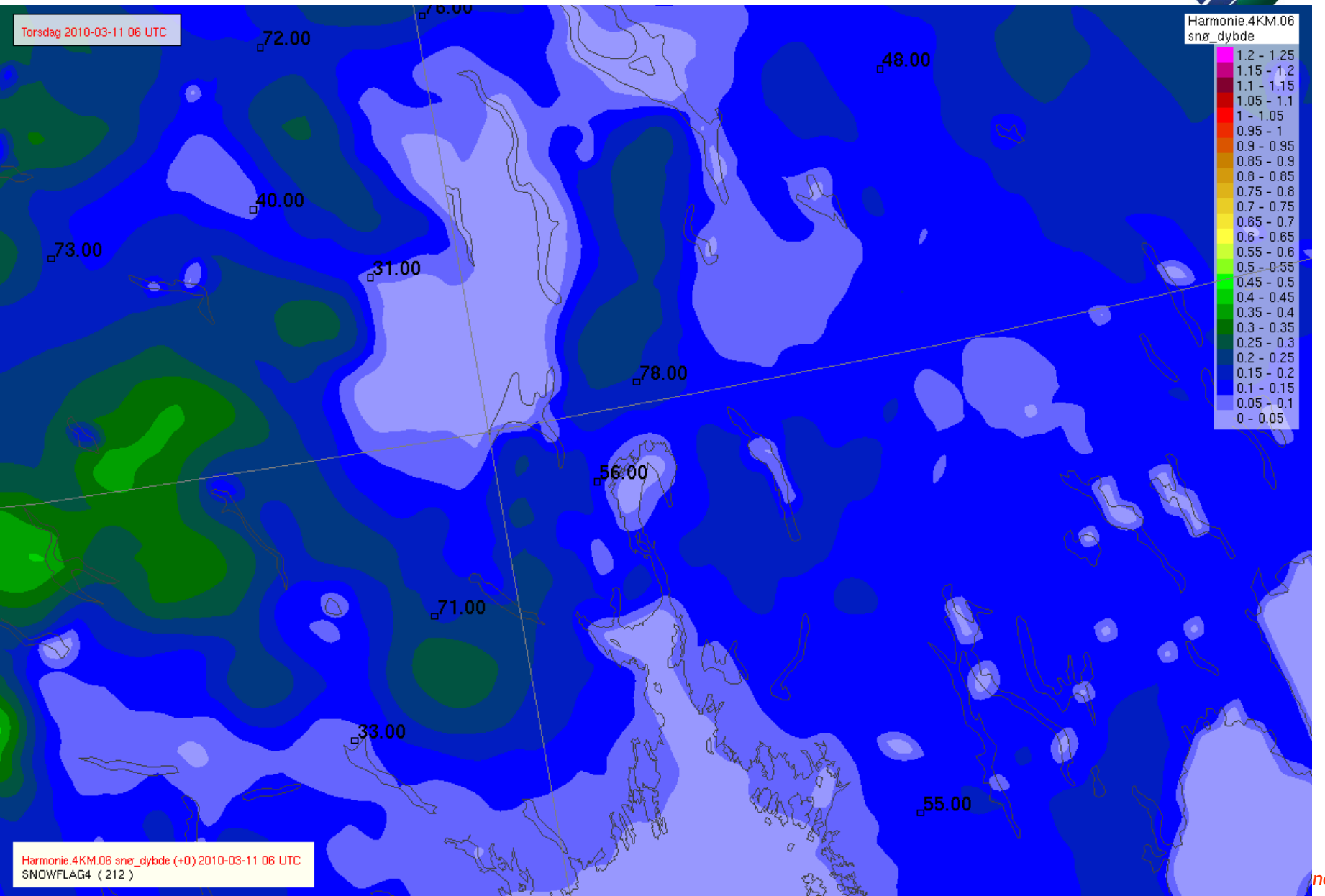
Vertical correlation



Hirlam8 – snow analysis 11 March 2010 06 UTC



HM04 – snow analysis 11 March 2010 06 UTC



HIRLAM and HARMONIE snow analysis status March 2010

- Optimum Interpolation
- SYNOP observations
- Experiments with satellite data by Kalle Erola, Suleiman Mostamandy and Laura Rontu

Monitoring is important!

Thank you!

Photos Jan Erik Haugen

Snow depth first guess for OI analysis in HIRLAM

- separate 1. guess for snow analysis,
  with much slower melting rate than the forecasts
- Estimates a snow density field to transform
  HIRLAM's snow water equivalent (tonn/m2) to snow depth (cm)

Snow density field, based on Brasnett (1999)

- increase due to aging, asymptotic value 300kg/m3, 210 kg/m3 in needle leaf
- when T>0°, increase with 0.5 kg/K/h until 550 kg/m3

Snow mass field

- when T>0°, remove mass with 0.15*T mm/h
- when T<0°, add precipitation as snow

Snow density constants used in 'old' HIRLAM versions (with succ. corr.):

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
SCAS NOW	450	430	416	360	320	320	320	700	700	620	550	470
kg/ m3	222	233	240	278	312	312	312	143	143	161	182	213