The performance of the operational 4km resolution HIRLAM and UM runs at met.no

Thor Erik Nordeng

met.no R&D Dept.

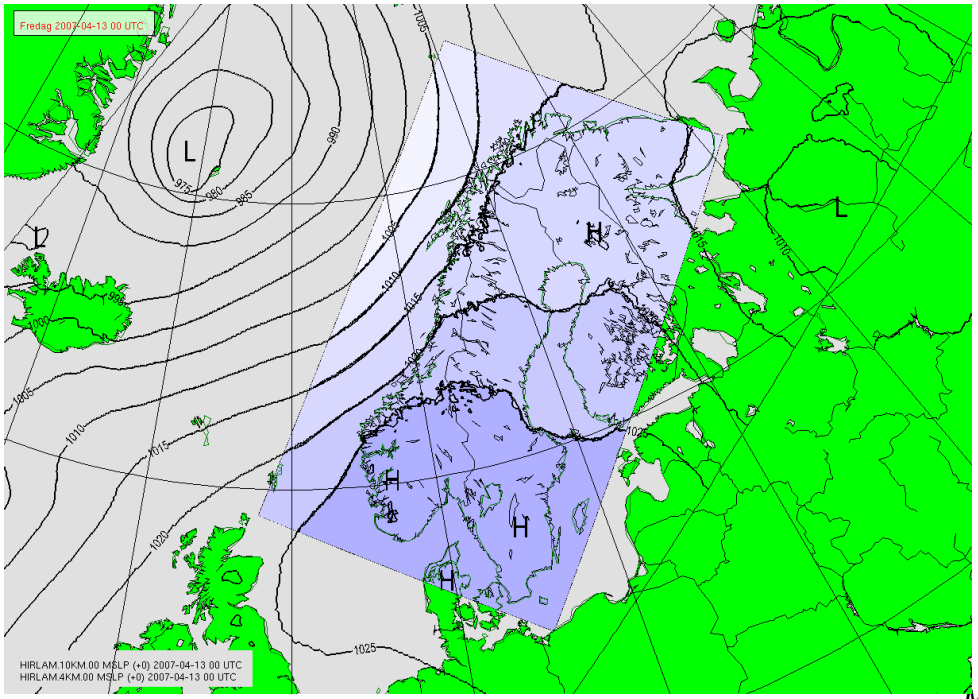
Outline

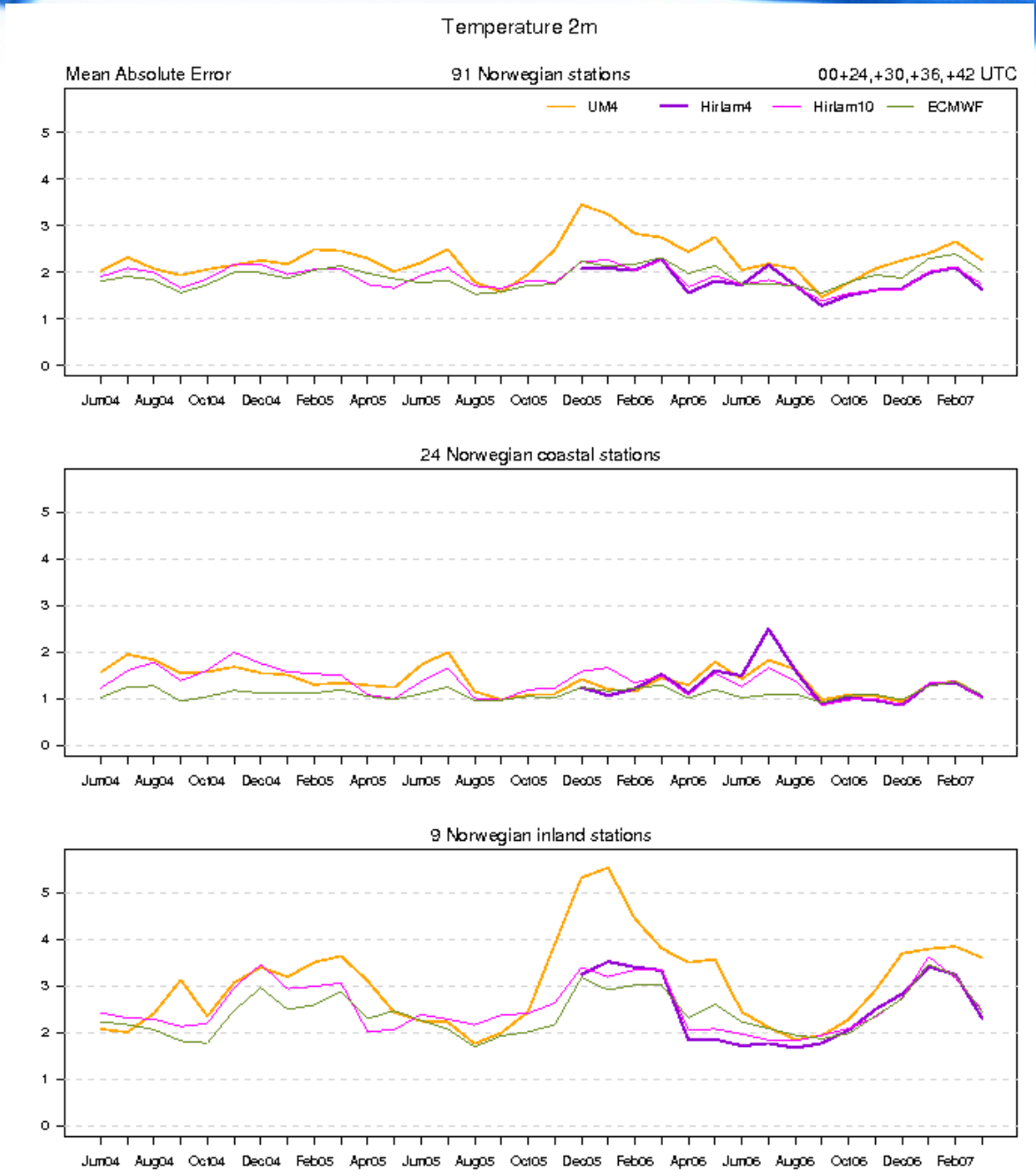
- Hirlam and UM set-up
- Long term performance
  - verification of **surface** temp, wind and precipitation
- Case studies
  - heavy precipitation events
  - snow melt

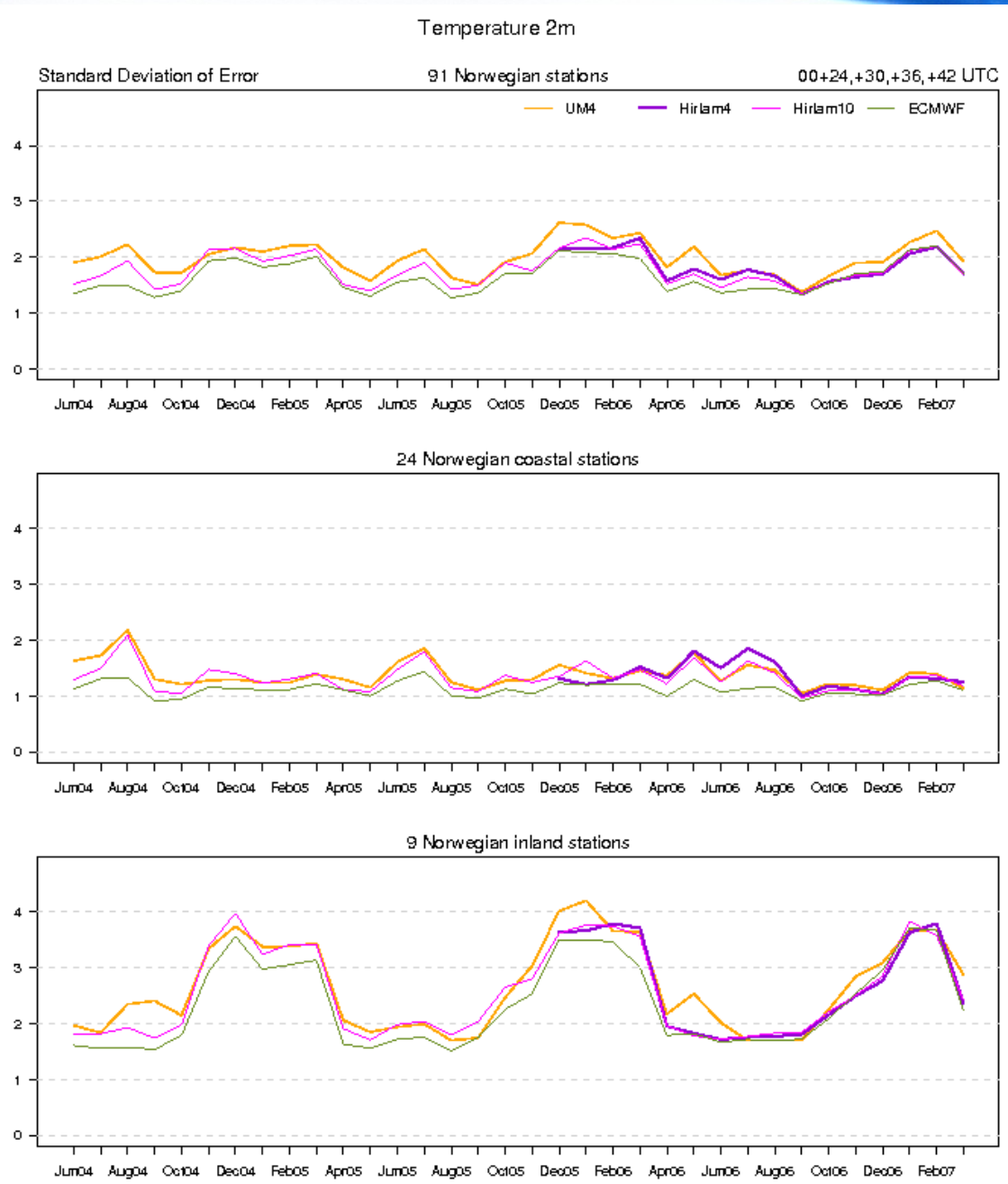
HIRLAM and UM set-up

- same area
- same topography
~ same climathology
- same horizontal grid

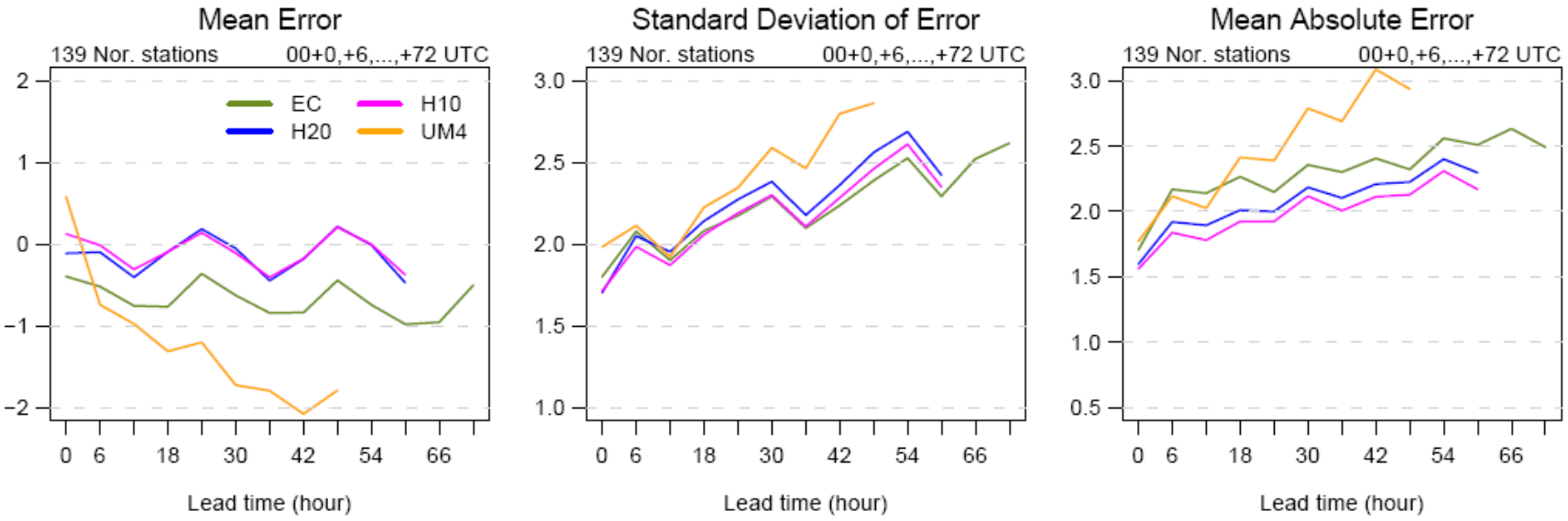
- different equations
  hydrostatic vs non-hydrostatic
  normalized pressure vs normalized height
- different vertical staggering (Lorenz vs. Charney-Phillips)
- different physics

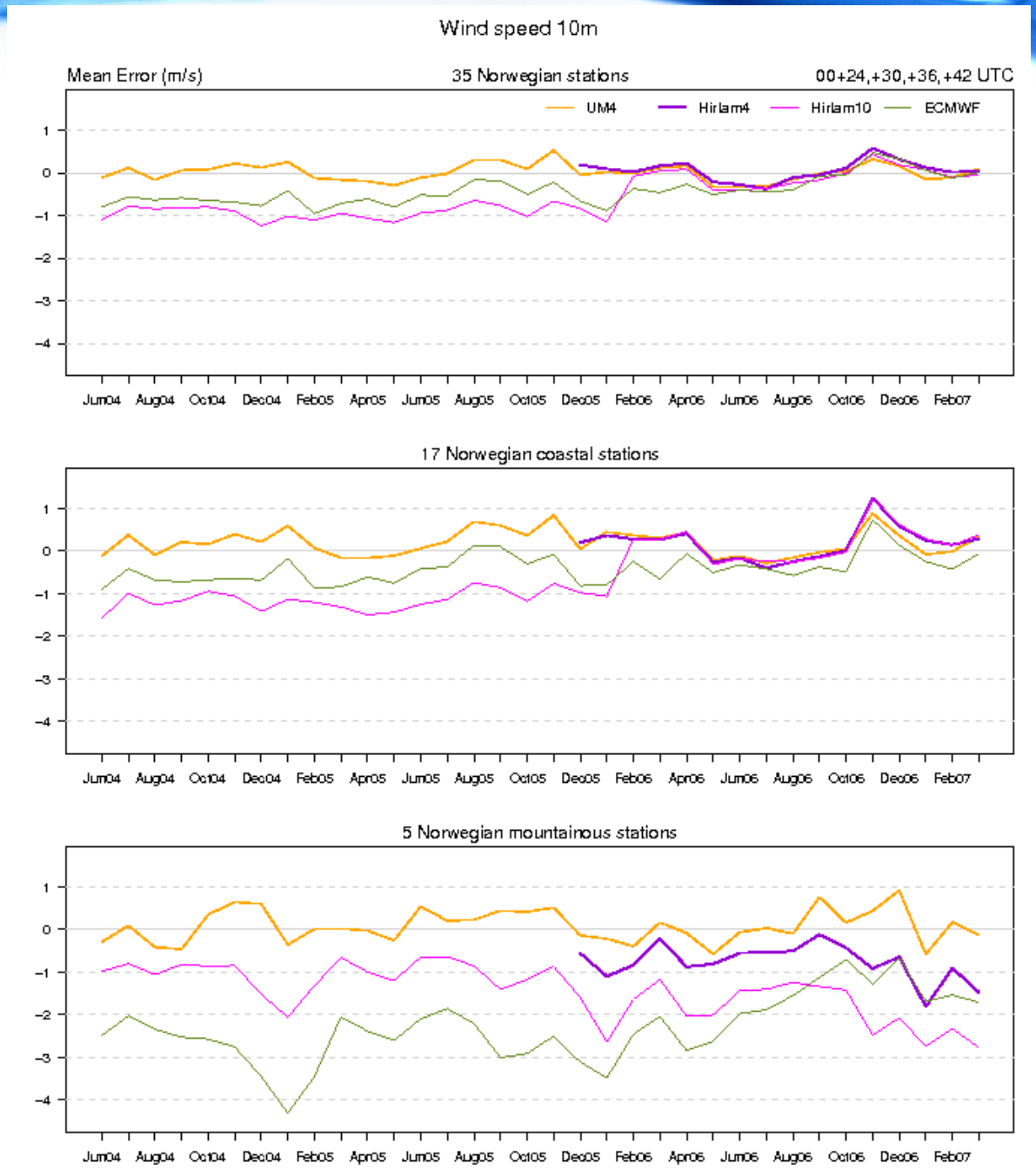


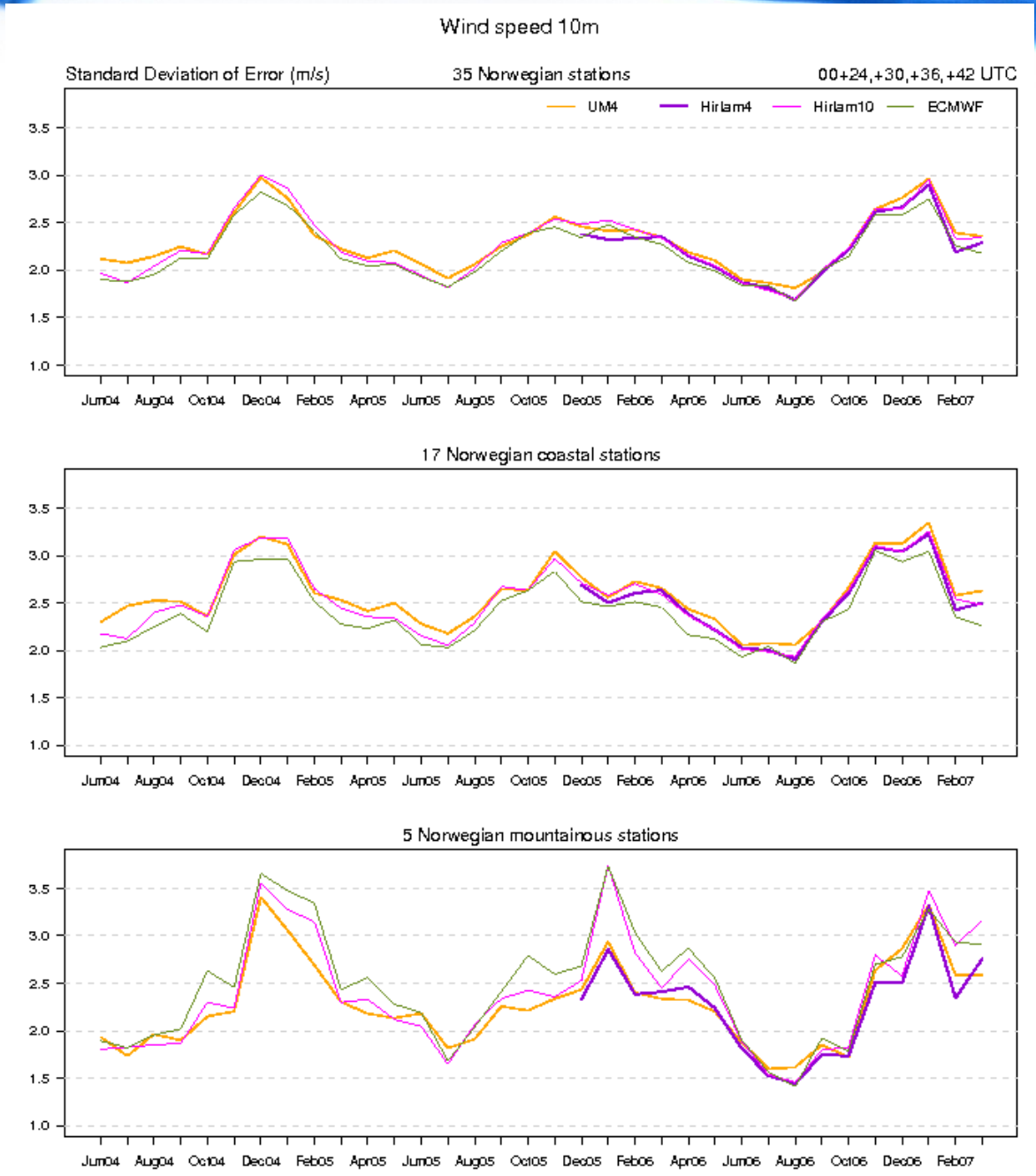

Temperature 2m
Mean Absolute Error
91 Norwegian stations
00+24,+30,+36,+42 UTC
UM4
Hirlam4
Hirlam10
ECMWF
0
1
2
3
4
5
Jun04
Aug04
Oct04
Dec04
Feb05
Apr05
Jun05
Aug05
Oct05
Dec05
Feb06
Apr06
Jun06
Aug06
Oct06
Dec06
Feb07
24 Norwegian coastal stations
9 Norwegian inland stations


Temperature 2m
Standard Deviation of Error
91 Norwegian stations
00+24,+30,+36,+42 UTC
UM4
Hirlam4
Hirlam10
ECMWF
0
1
2
3
4
Jun04
Aug04
Oct04
Dec04
Feb05
Apr05
Jun05
Aug05
Oct05
Dec05
Feb06
Apr06
Jun06
Aug06
Oct06
Dec06
Feb07
24 Norwegian coastal stations
9 Norwegian inland stations

UM4 has a problem related to temperature in winther




Wind speed 10m
Mean Error (m/s)
35 Norwegian stations
00+24,+30,+36,+42 UTC
UM4
Hirlam4
Hirlam10
ECMWF
1
0
−1
−2
−3
−4
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07
17 Norwegian coastal stations
1
0
−1
−2
−3
−4
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07
5 Norwegian mountainous stations
1
0
−1
−2
−3
−4
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07

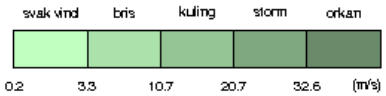

Wind speed 10m
Standard Deviation of Error (m/s)
35 Norwegian stations
00+24,+30,+36,+42 UTC
UM4
Hirlam4
Hirlam10
ECMWF
3.5
3.0
2.5
2.0
1.5
1.0
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07
17 Norwegian coastal stations
3.5
3.0
2.5
2.0
1.5
1.0
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07
5 Norwegian mountainous stations
3.5
3.0
2.5
2.0
1.5
1.0
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07

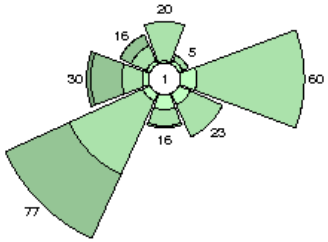
Wind speed and direction

Bodø

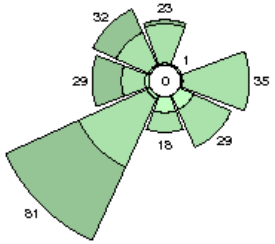
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 248

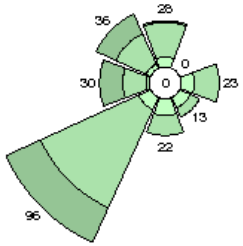




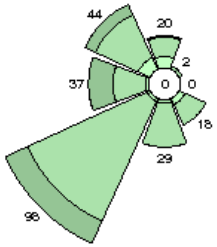
synop:00,...,21 /3



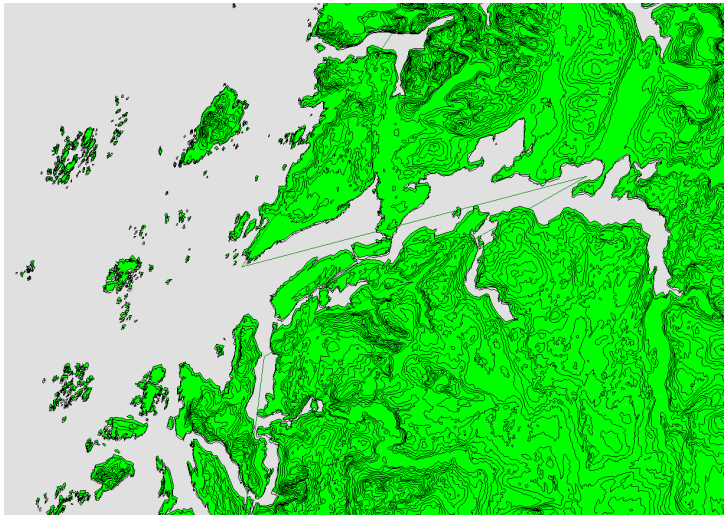
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



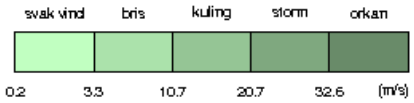
ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

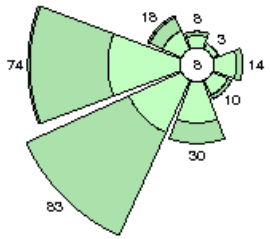


Bardufoss

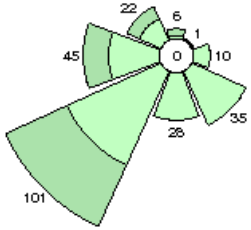
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 248

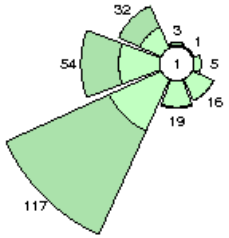




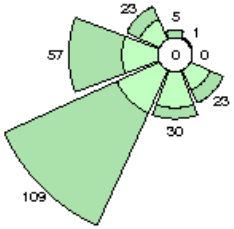
synop:00,...,21 /3



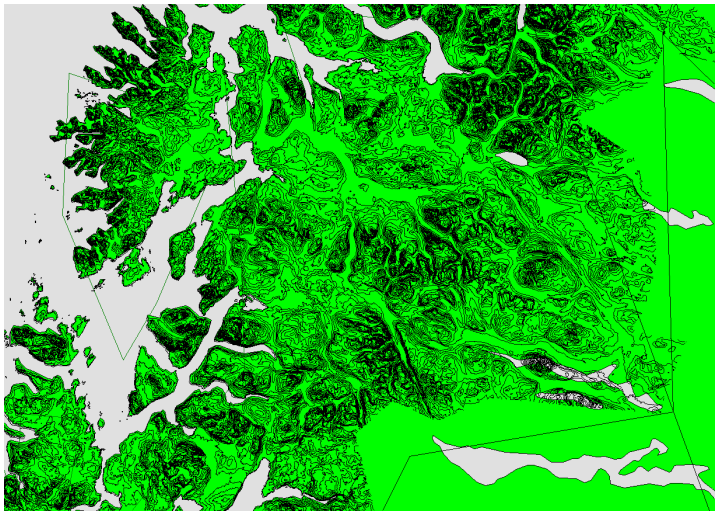
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



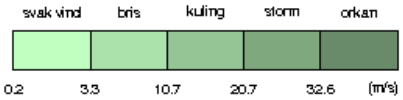
ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

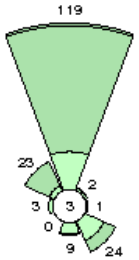


Byglandsfjord

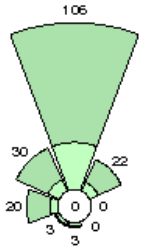
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 184

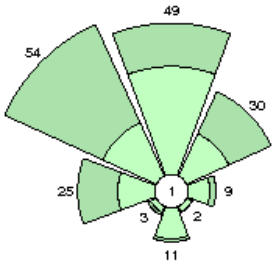




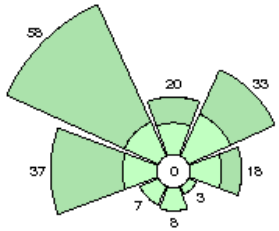
synop:00,...,21 /3



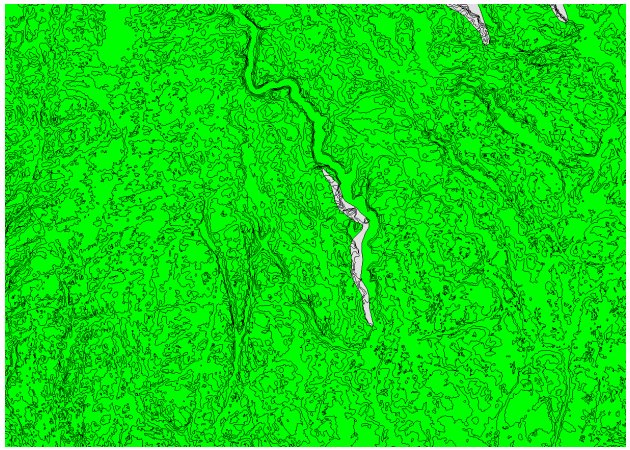
UM4HL:00+12,+15,+18 12+15,+18,+21



Hirlam4:00+12,+15,+18 12+15,+18,+21



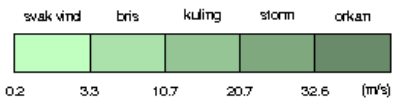
ECMWF:00+12,+15,+18 12+15,+18,+21

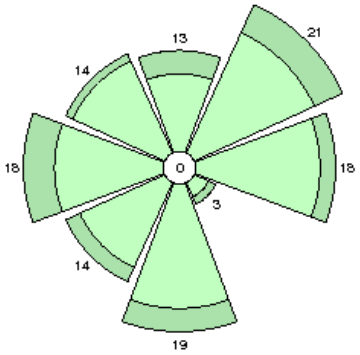


Sirdal

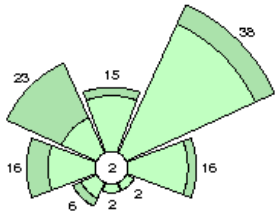
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 120

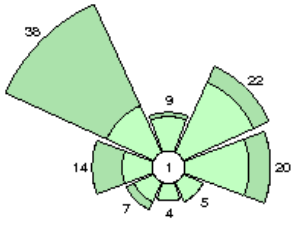




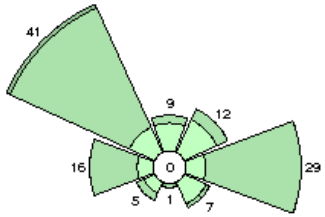
synop:00,...,21 /3



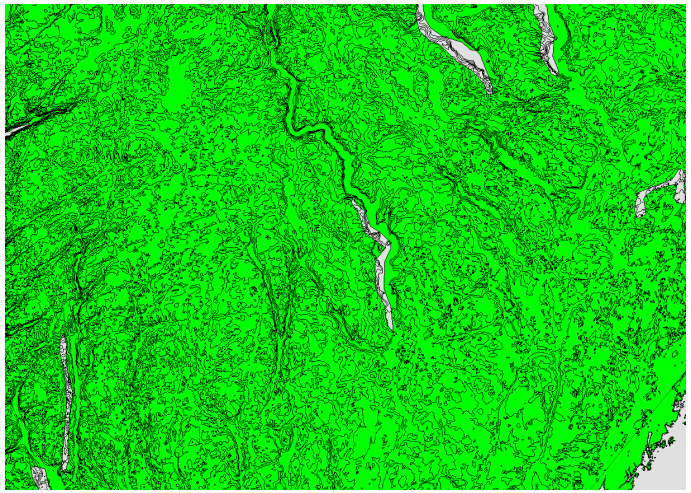
UM4HL:00+12,+18,+21 12+18



Hirlam4:00+12,+18,+21 12+18



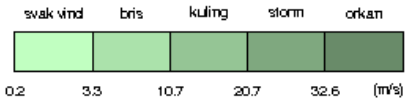
ECMWF:00+12,+18,+21 12+18

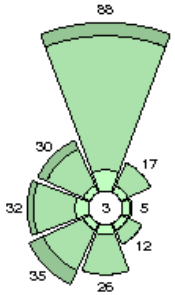


Færder

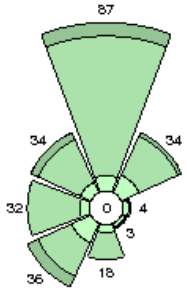
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 248

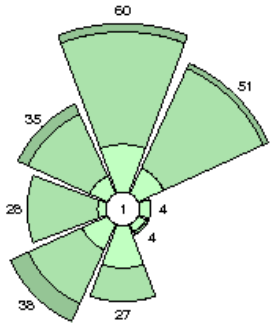




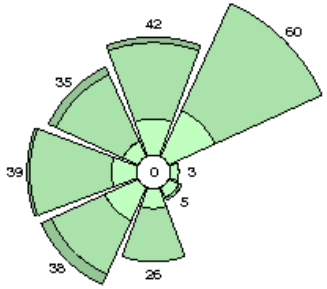
synop:00,...,21 /3



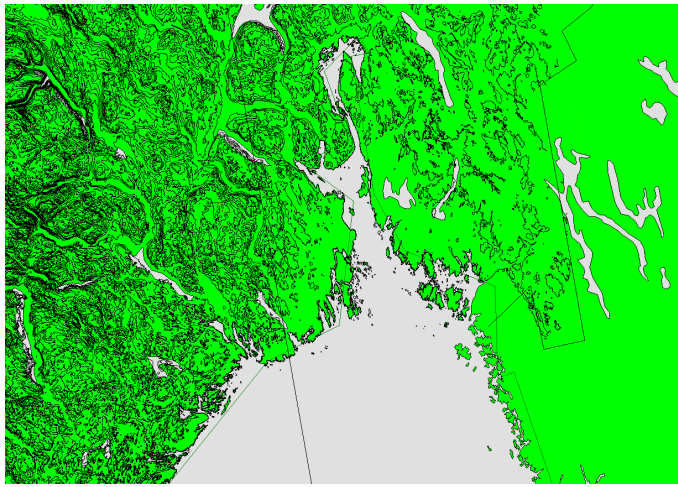
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21

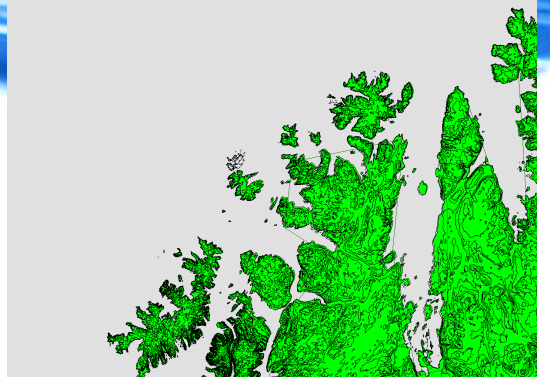


Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

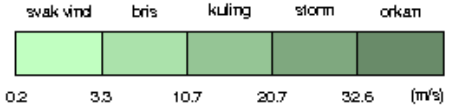


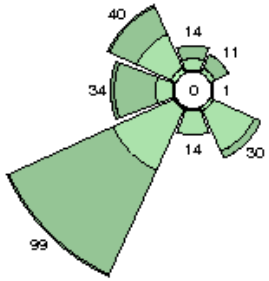


Fruholmen

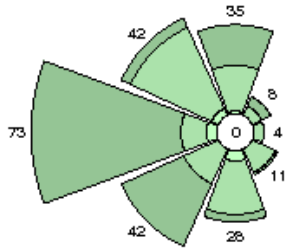
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 243

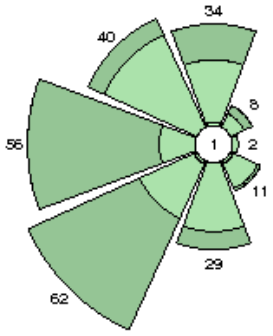




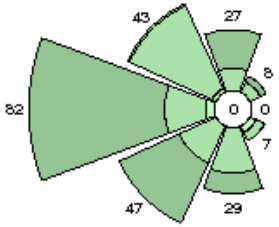
synop:00,...,21 /3



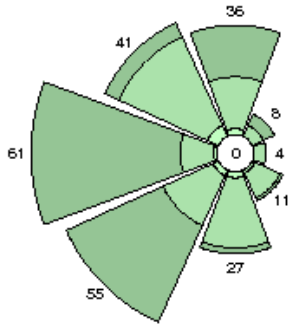
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



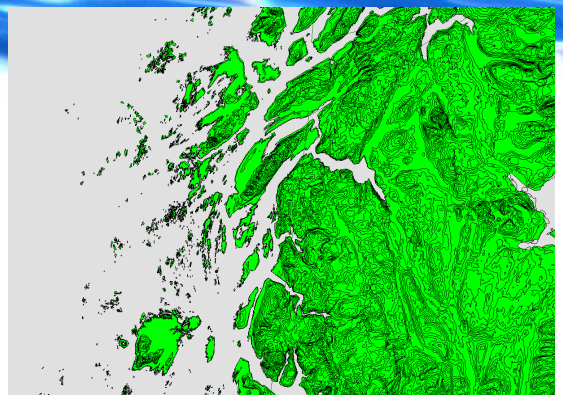
Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21



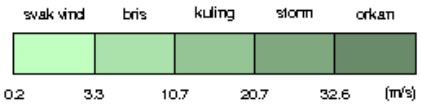
UM1:00+12,+15,+18,+21 12+12,+15,+18,+21

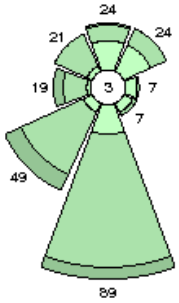


Sandnessjøen – Stokka

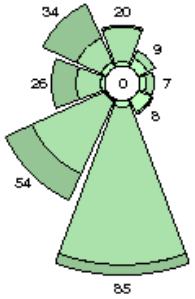
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 243

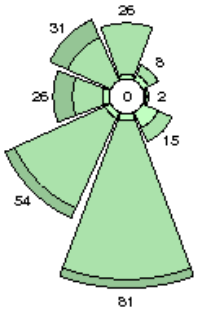




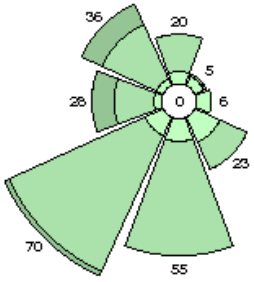
synop:00,...,21 /3



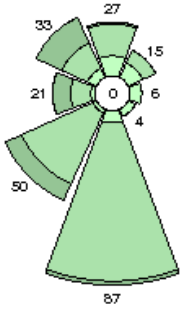
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

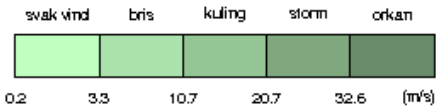


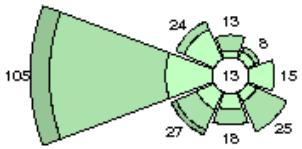
UM1:00+12,+15,+18,+21 12+12,+15,+18,+21

Sognefjell

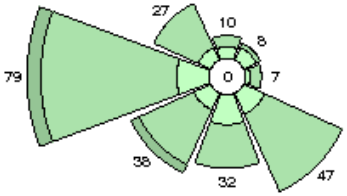
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 248

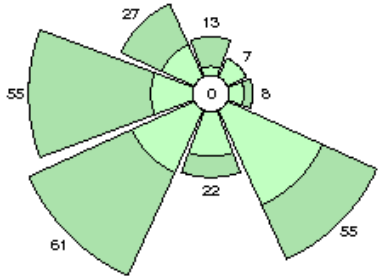




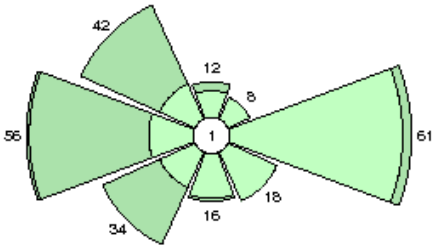
synop:00,...,21 /3



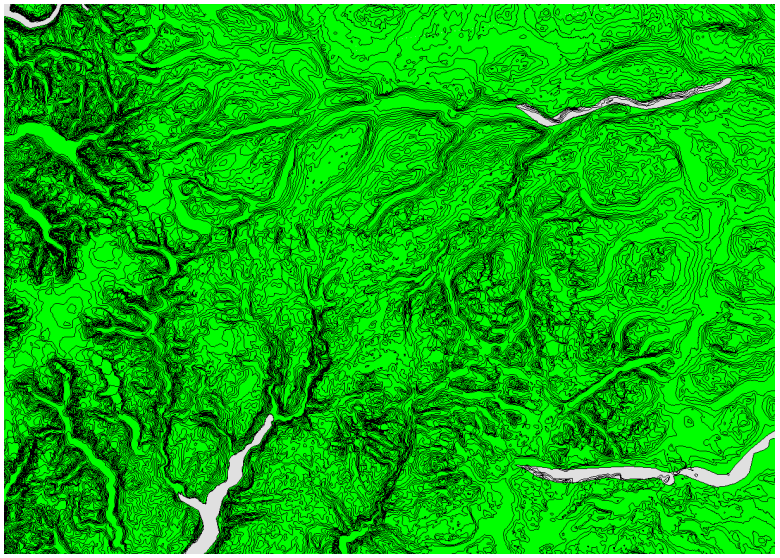
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21

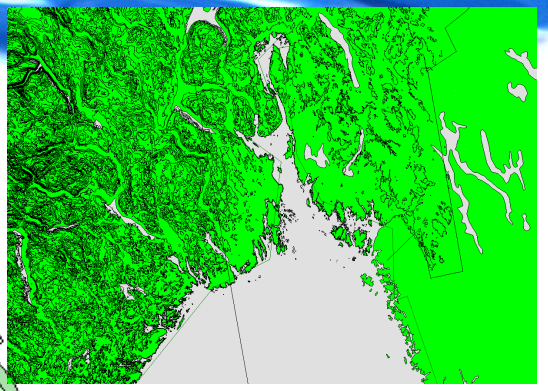


Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

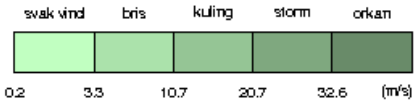


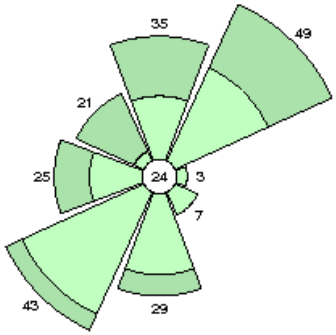


Oslo

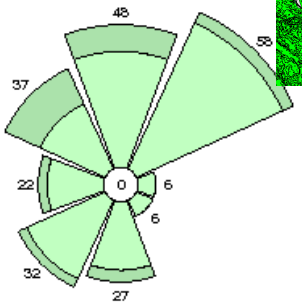
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 236

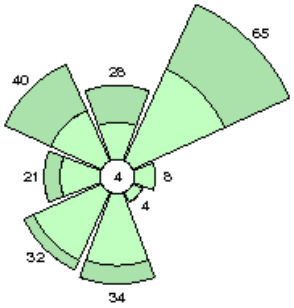




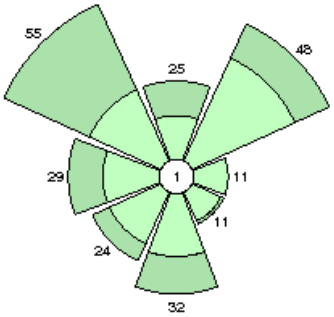
synop:00,...,21 /3



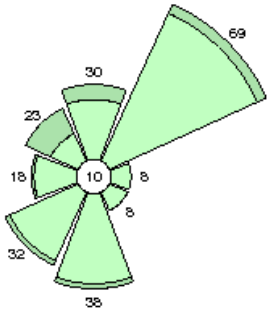
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



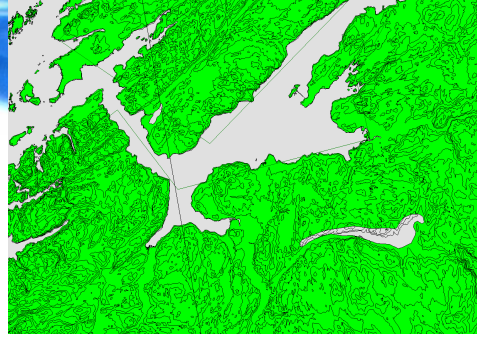
Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21



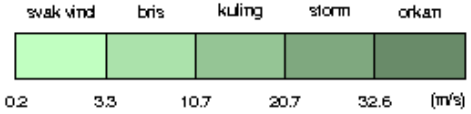
UM1:00+12,...,+33 /3

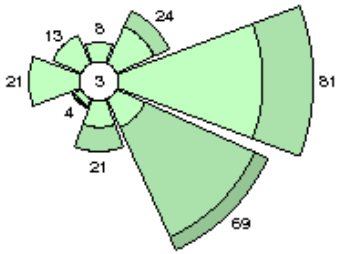


Trondheim

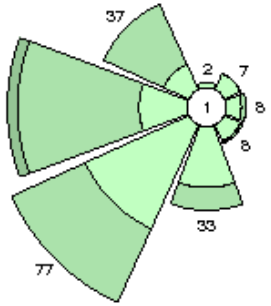
Tidsrom: 20.03.2007 – 20.04.2007

Antall tilfeller: 244

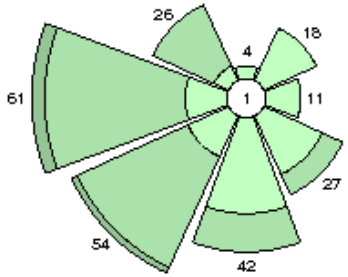




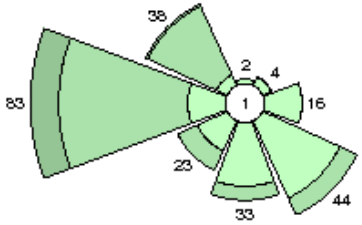
synop:00,...,21 /3



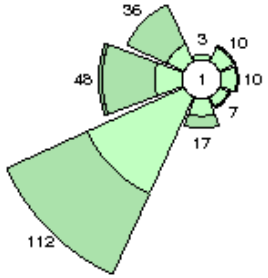
UM4HL:00+12,+15,+18,+21 12+12,+15,+18,+21



Hirlam4:00+12,+15,+18,+21 12+12,+15,+18,+21



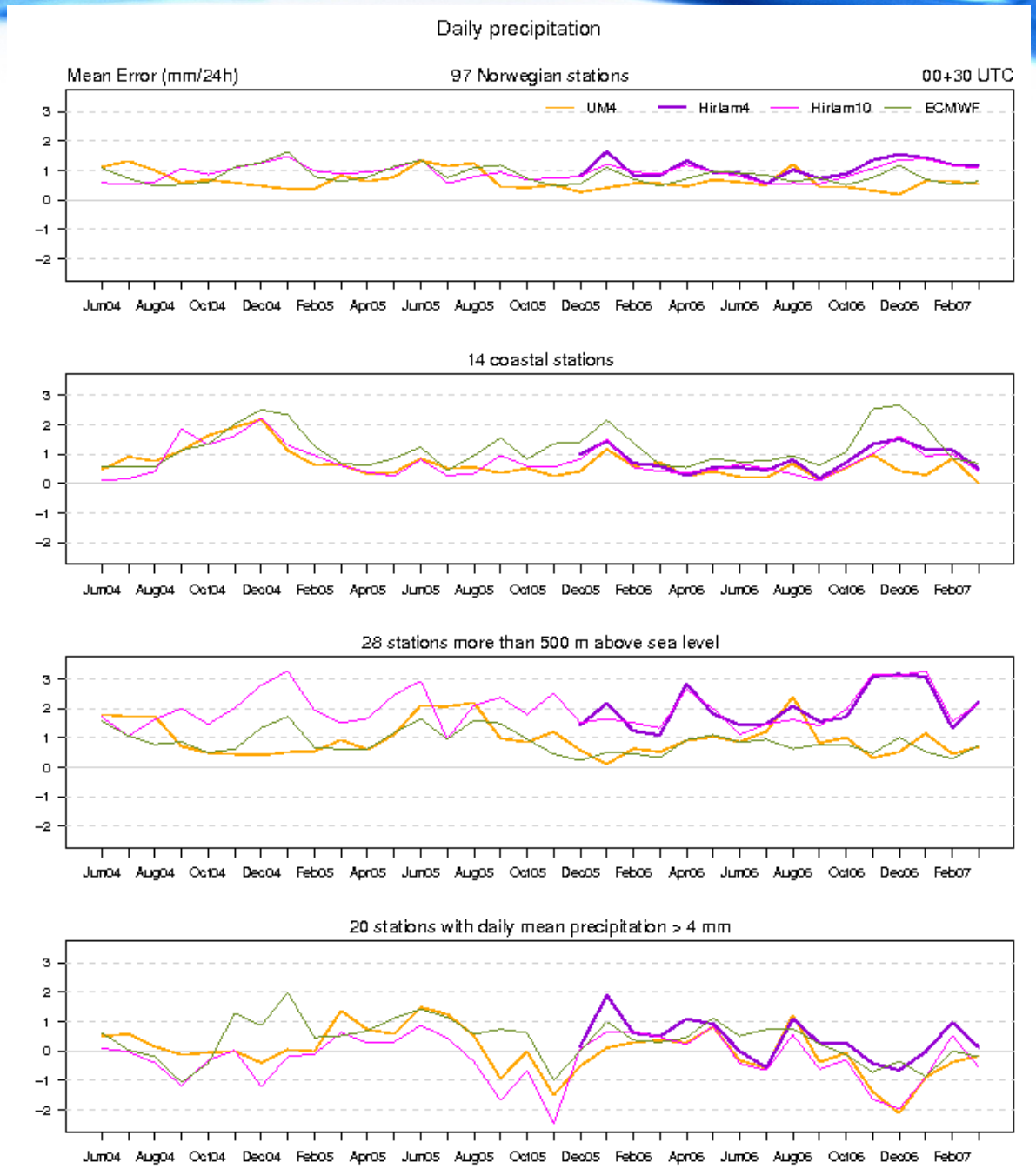
ECMWF:00+12,+15,+18,+21 12+12,+15,+18,+21

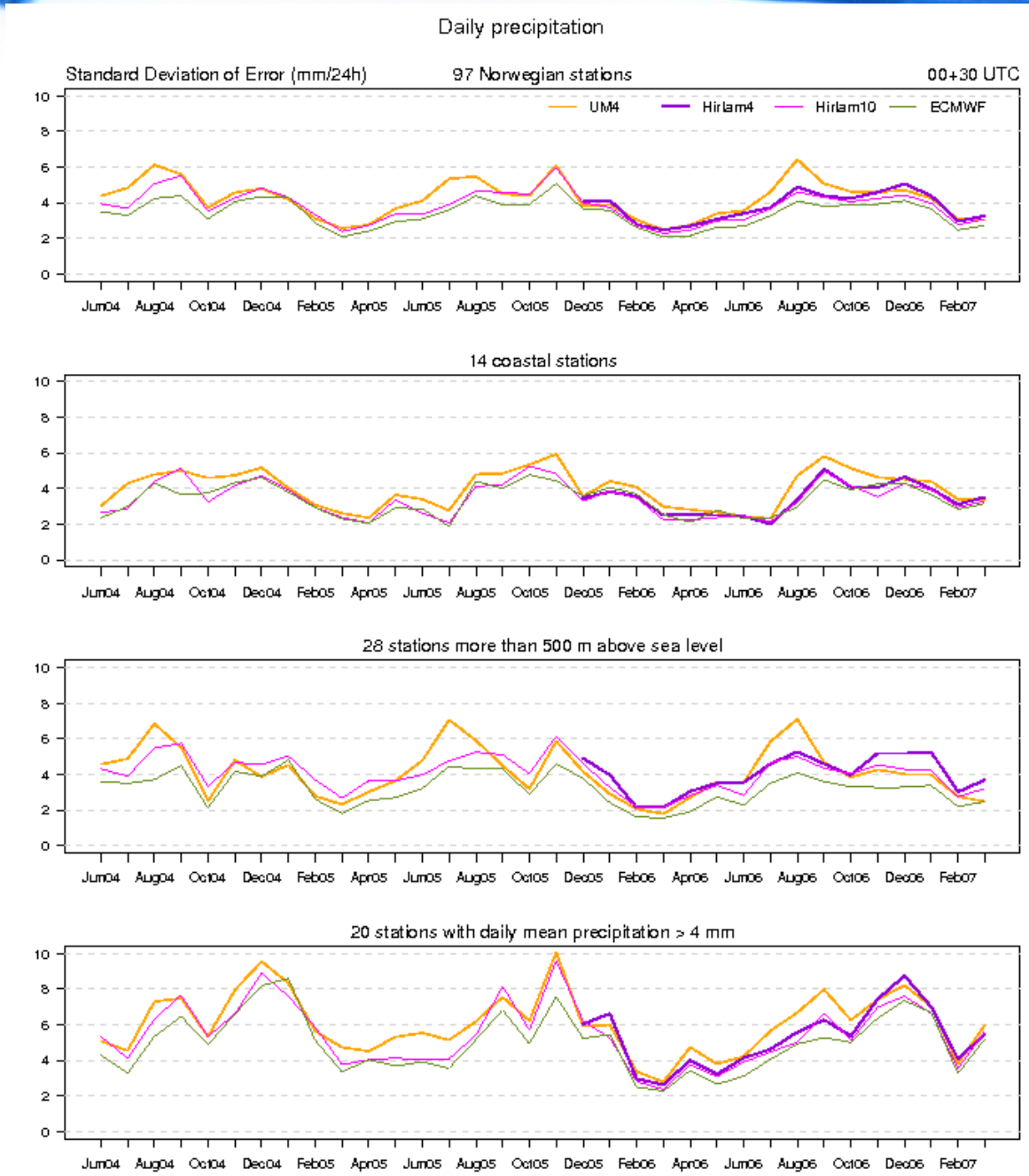


UM1:00+12,...,+33 /3

Wind

UM better than HIRLAM for speed as well as direction


Daily precipitation
Mean Error (mm/24h)
97 Norwegian stations
00+30 UTC
UM4
Hirlam4
Hirlam10
ECMWF
14 coastal stations
28 stations more than 500 m above sea level
20 stations with daily mean precipitation > 4 mm
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07


Daily precipitation
Standard Deviation of Error (mm/24h)
97 Norwegian stations
00+30 UTC
UM4
Hirlam4
Hirlam10
ECMWF
14 coastal stations
28 stations more than 500 m above sea level
20 stations with daily mean precipitation > 4 mm
Jun04 Aug04 Oct04 Dec04 Feb05 Apr05 Jun05 Aug05 Oct05 Dec05 Feb06 Apr06 Jun06 Aug06 Oct06 Dec06 Feb07

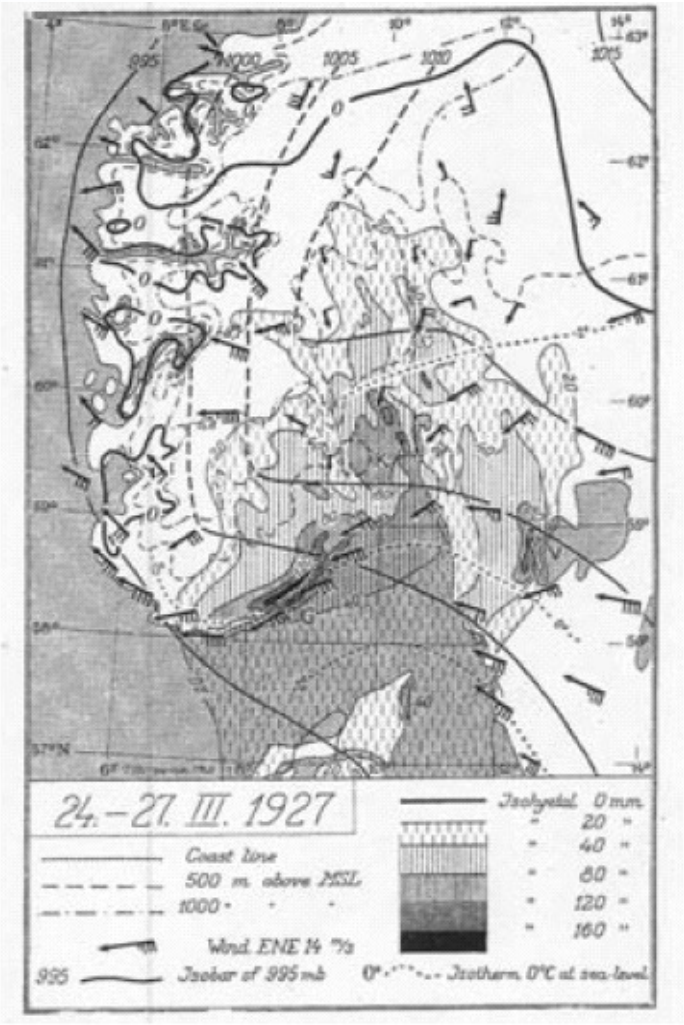
precipitation

UM best on precipitation

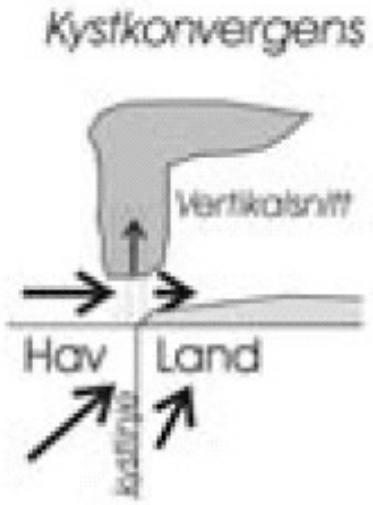
Particularly for inland stations

Case studies (precipitation)

the February 2007 snowstorm on Sørlandet

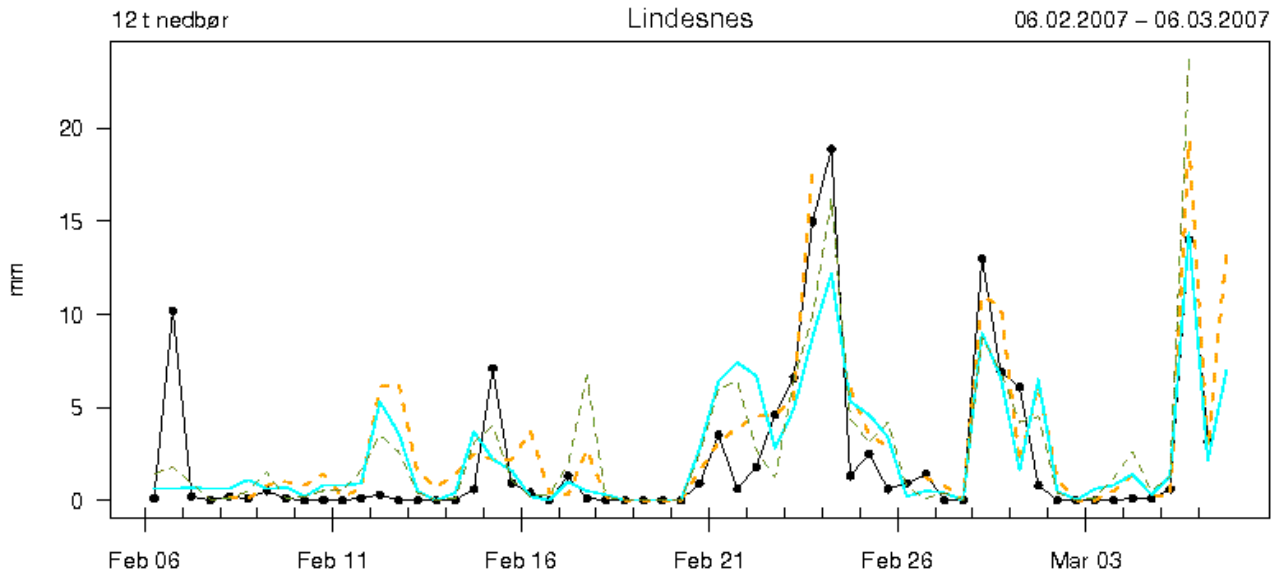


c)



Bergeron (1949)

Pointwise verification

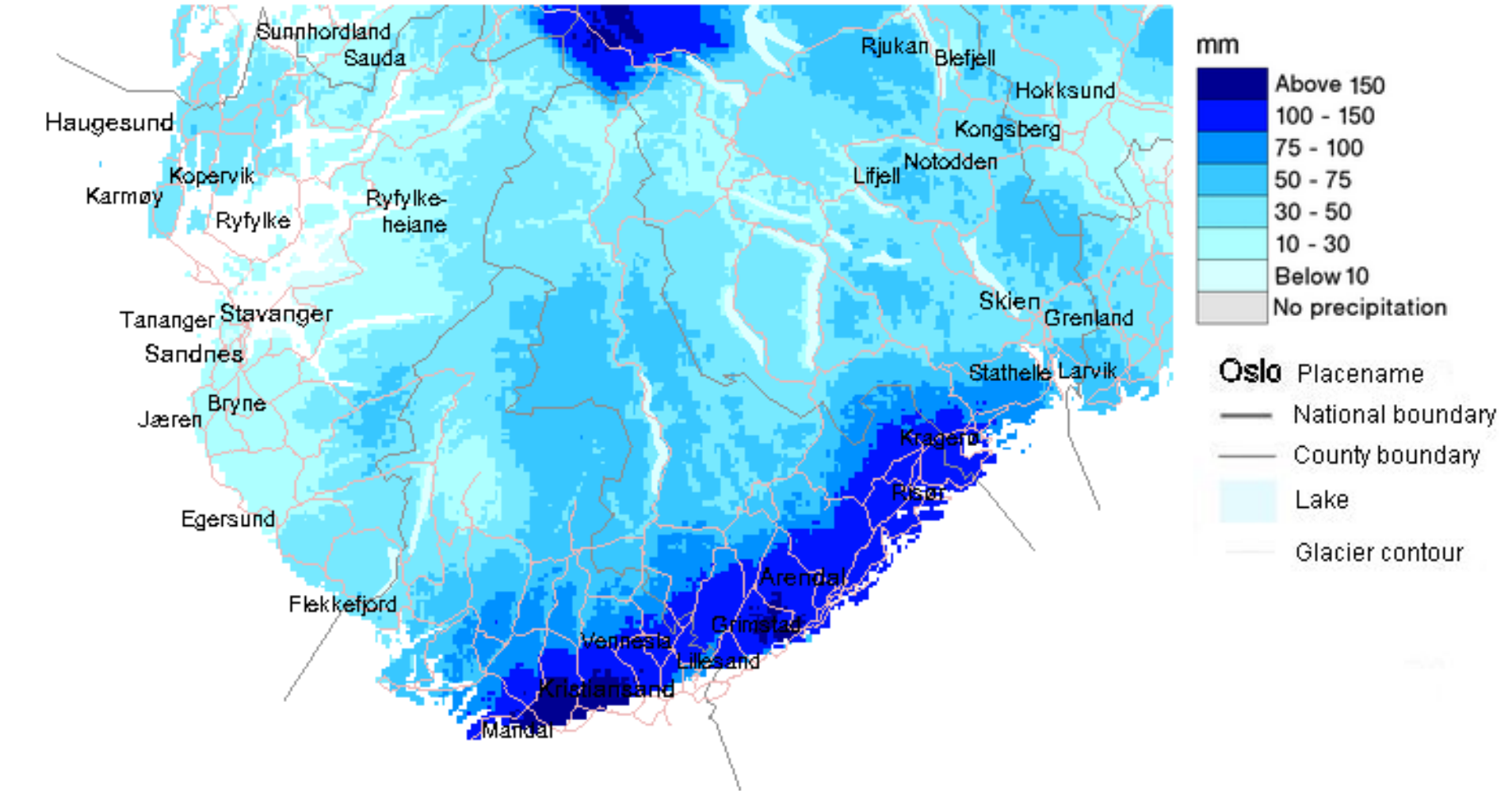


	Min	Middel	Maks	Stdl	N
synop: 06,18	0	2.2	18.9	4.3	57
UM4HL: 00+18 12+18	0	3	19.4	4.3	53
Hirlam4: 00+18 12+18	0	2.5	14.4	3.3	58
ECMWF: 00+18 12+18	0	2.7	23.7	4.2	56
UM1:					0

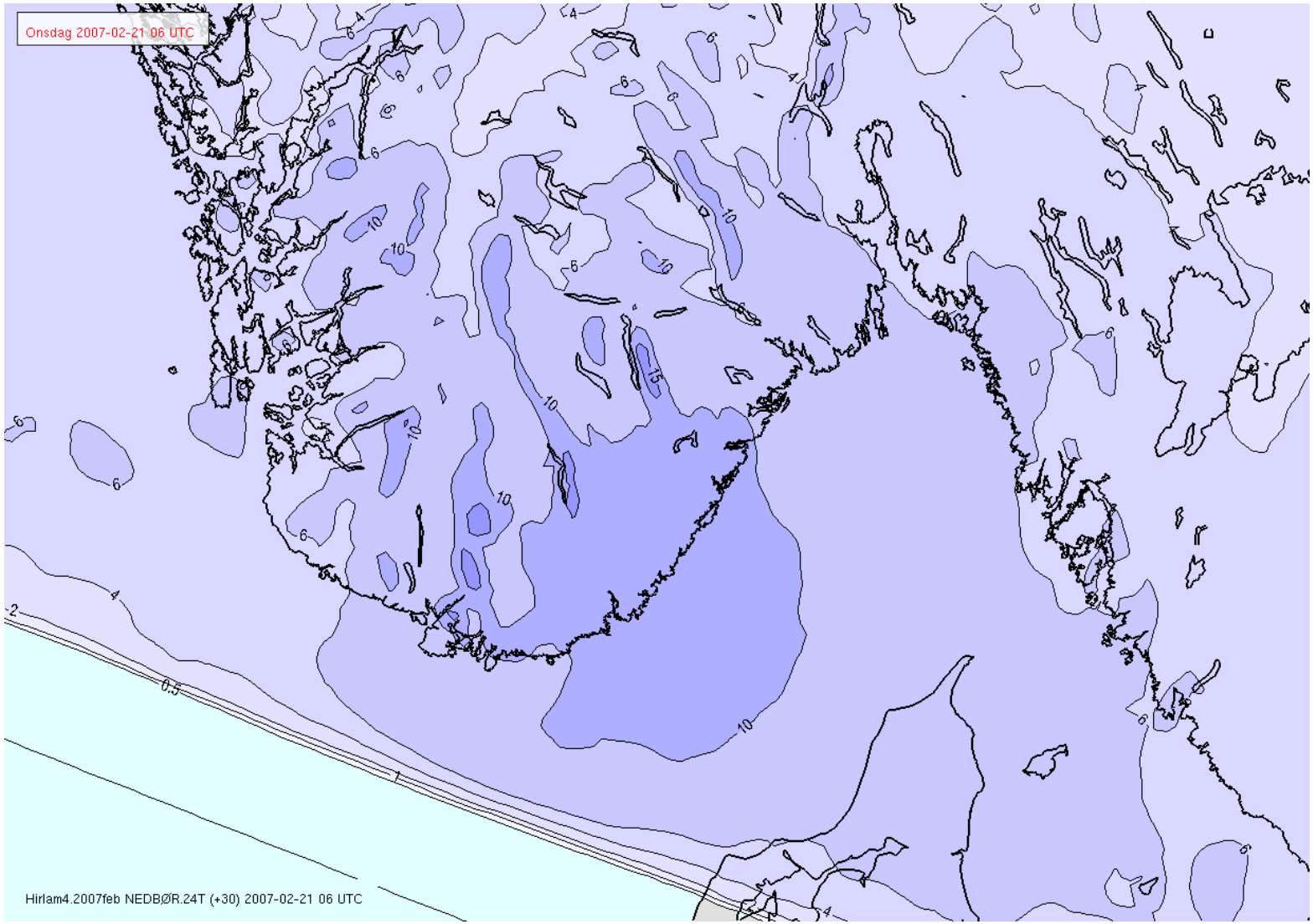
	Middelfeil	Stdl.feil.	RMSE	MAE	Maks.abs.feil	N
UM4HL – synop	0.8	2.6	2.7	1.7	10.1	52
Hirlam4 – synop	0.2	2.8	2.8	1.7	9.6	57
ECMWF – synop	0.5	2.7	2.7	1.6	9.7	56

Observed precipitation (standard – in situ)

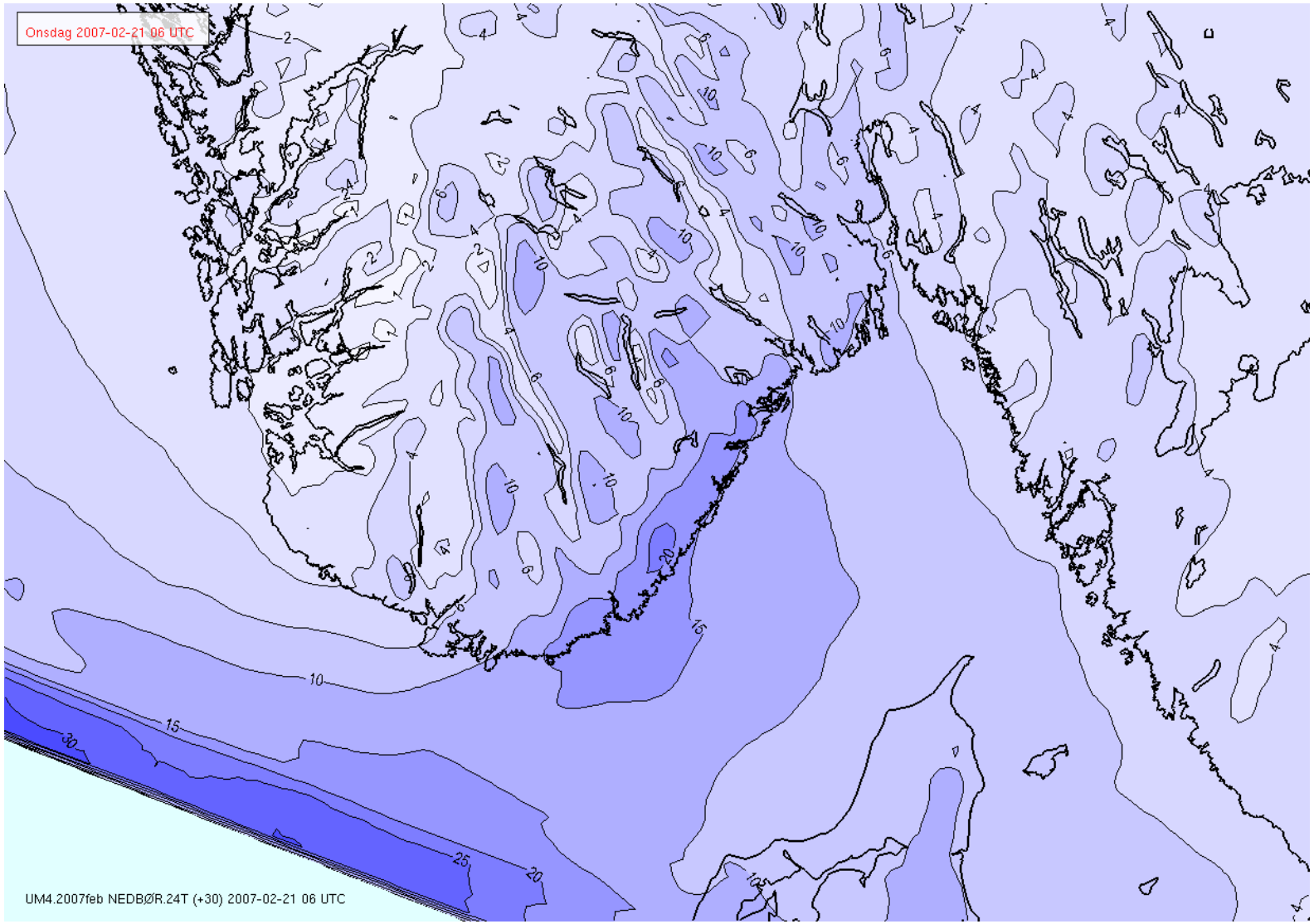
Precipitation previous week (01.03.2007)



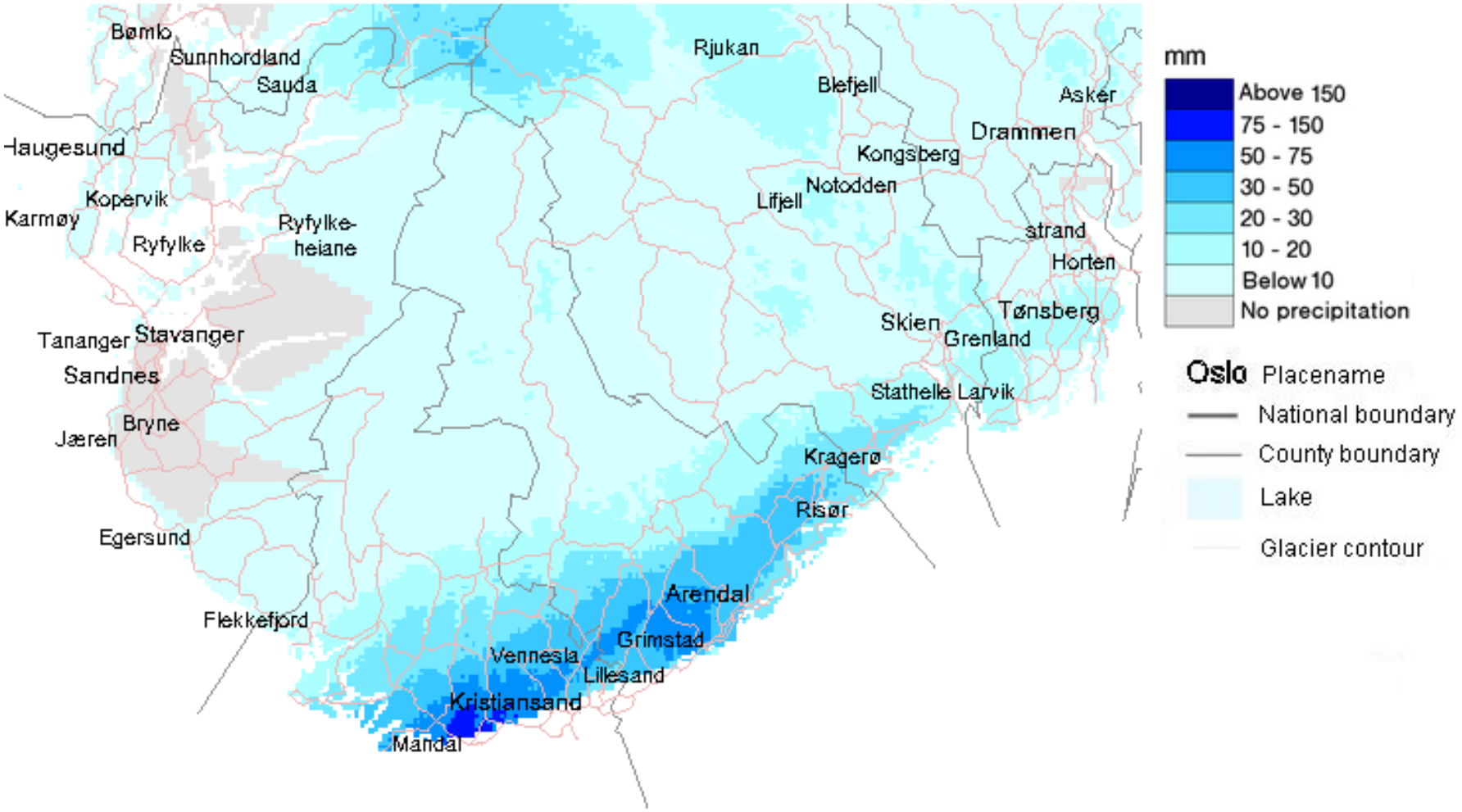
Accumulated precipitation HIRLAM4



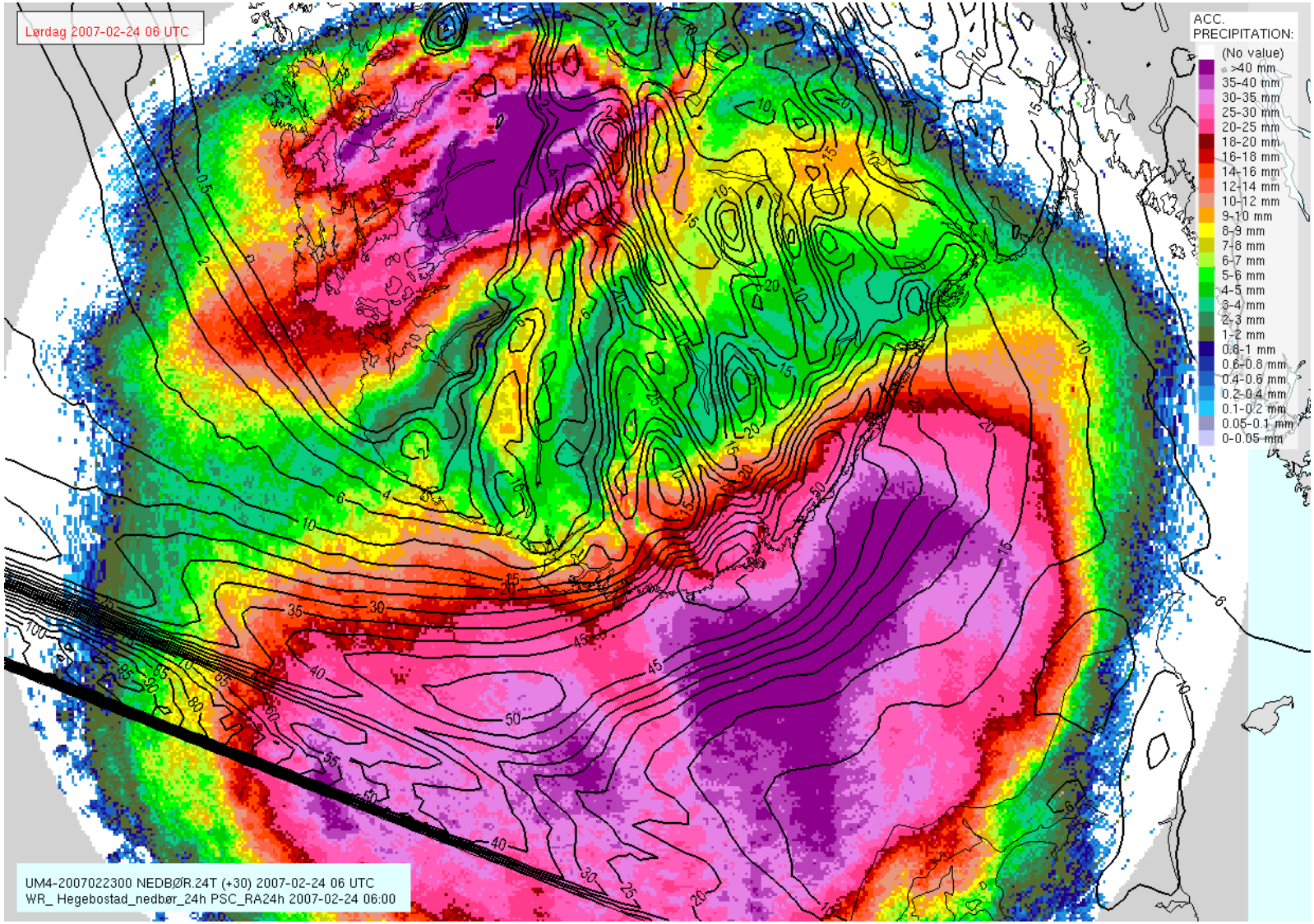
Accumulated precipitation UM4



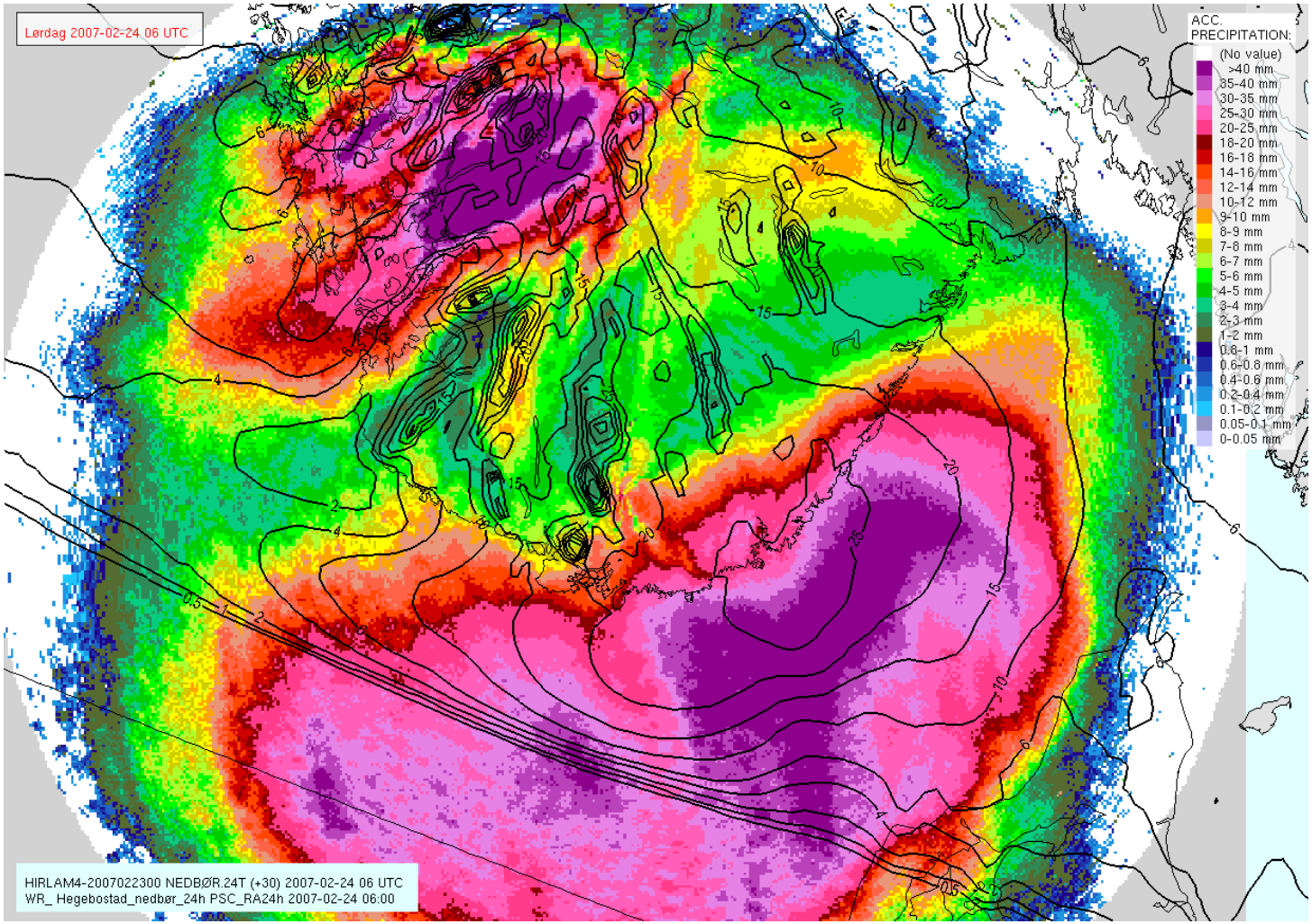
The extreme event, 23-24 February



UM4 prec 23/2-06 to 24/2-06



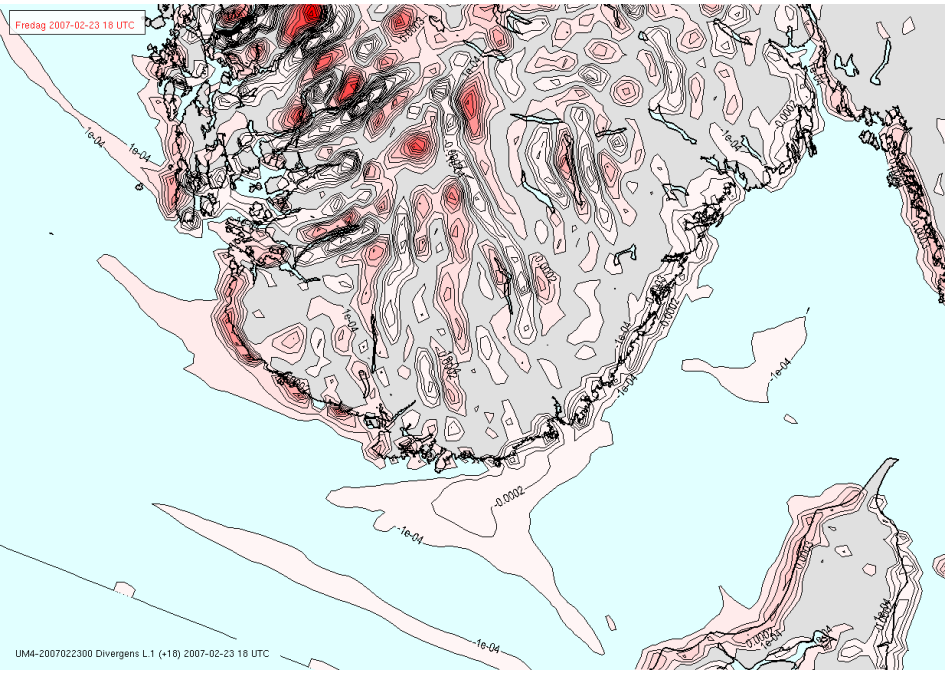
HIRLAM4 prec 23/2-06 to 24/2-06

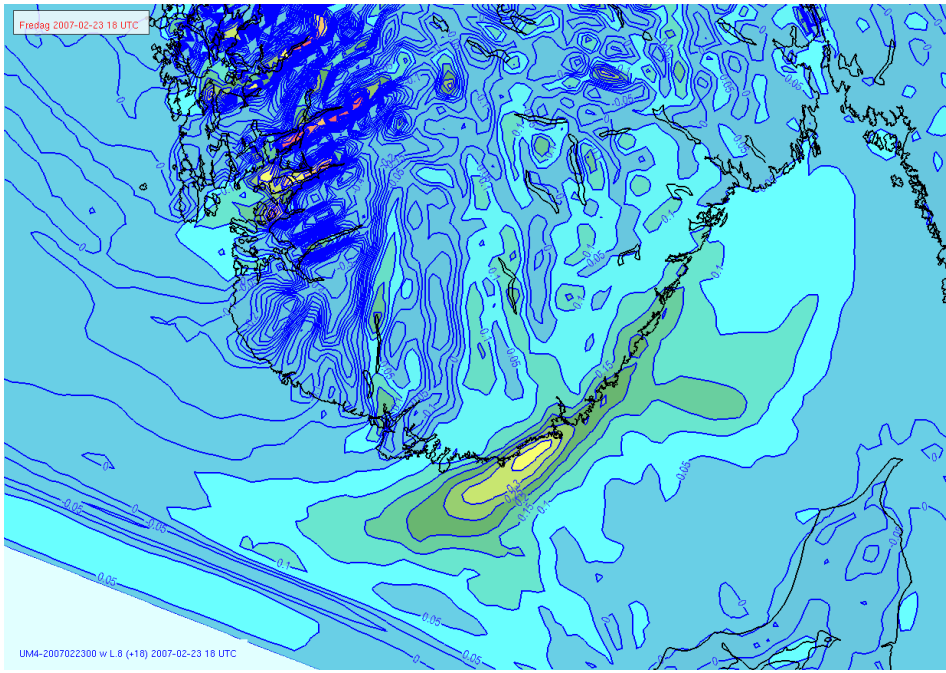


Possible explanations for the difference between HIRLAM and UM for this case

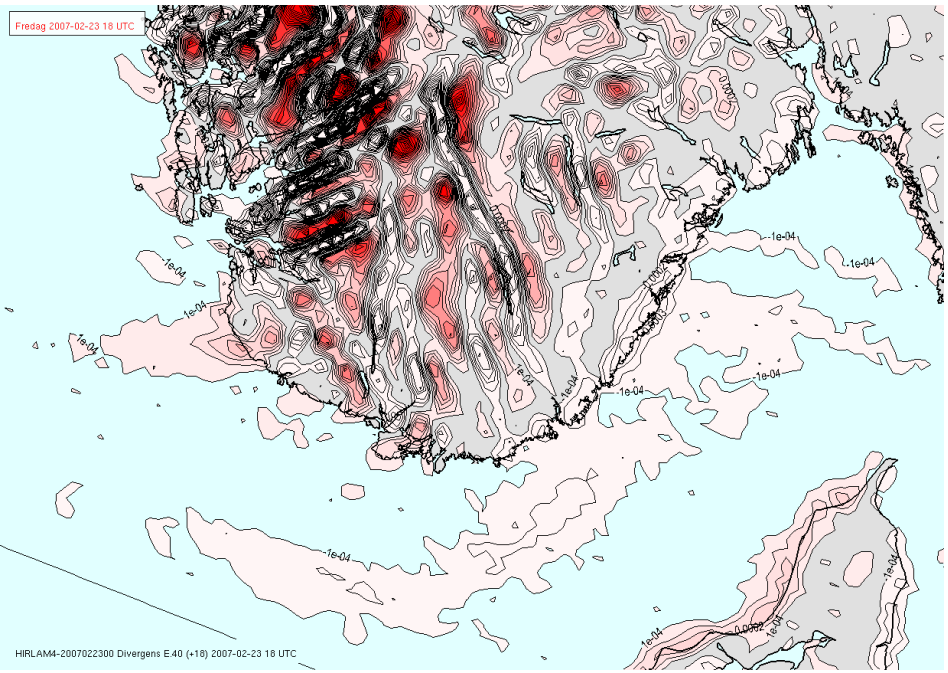
1. land-sea definition, climatological preset fields, e.g. land/sea contrast
2. non-hydrostatic effects
3. Parameterisation of condensation /precipitation

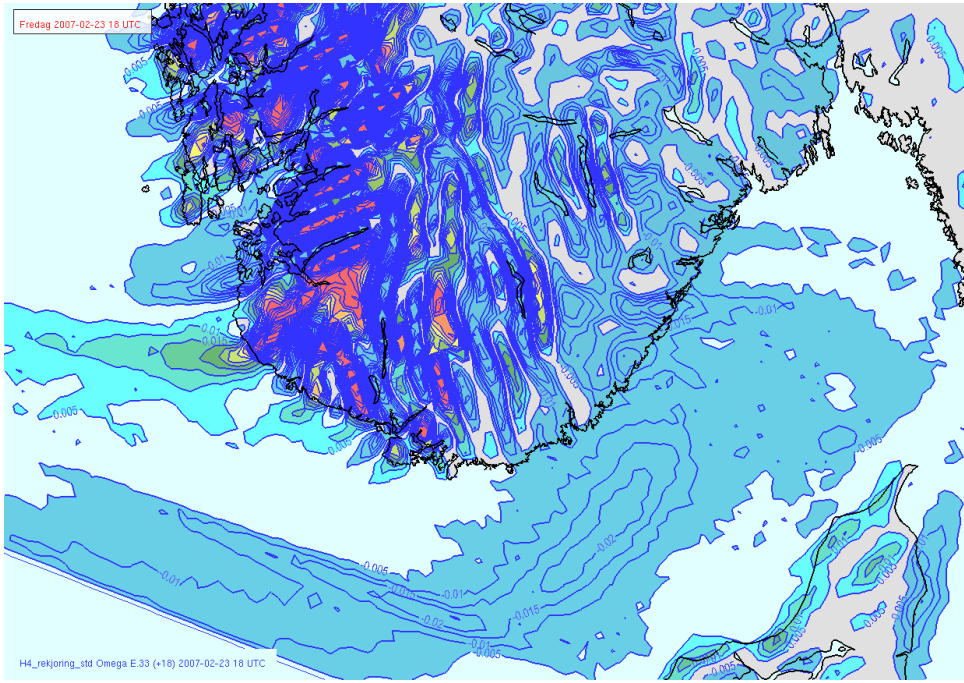
Coastal convergence and vertical velocity in UM



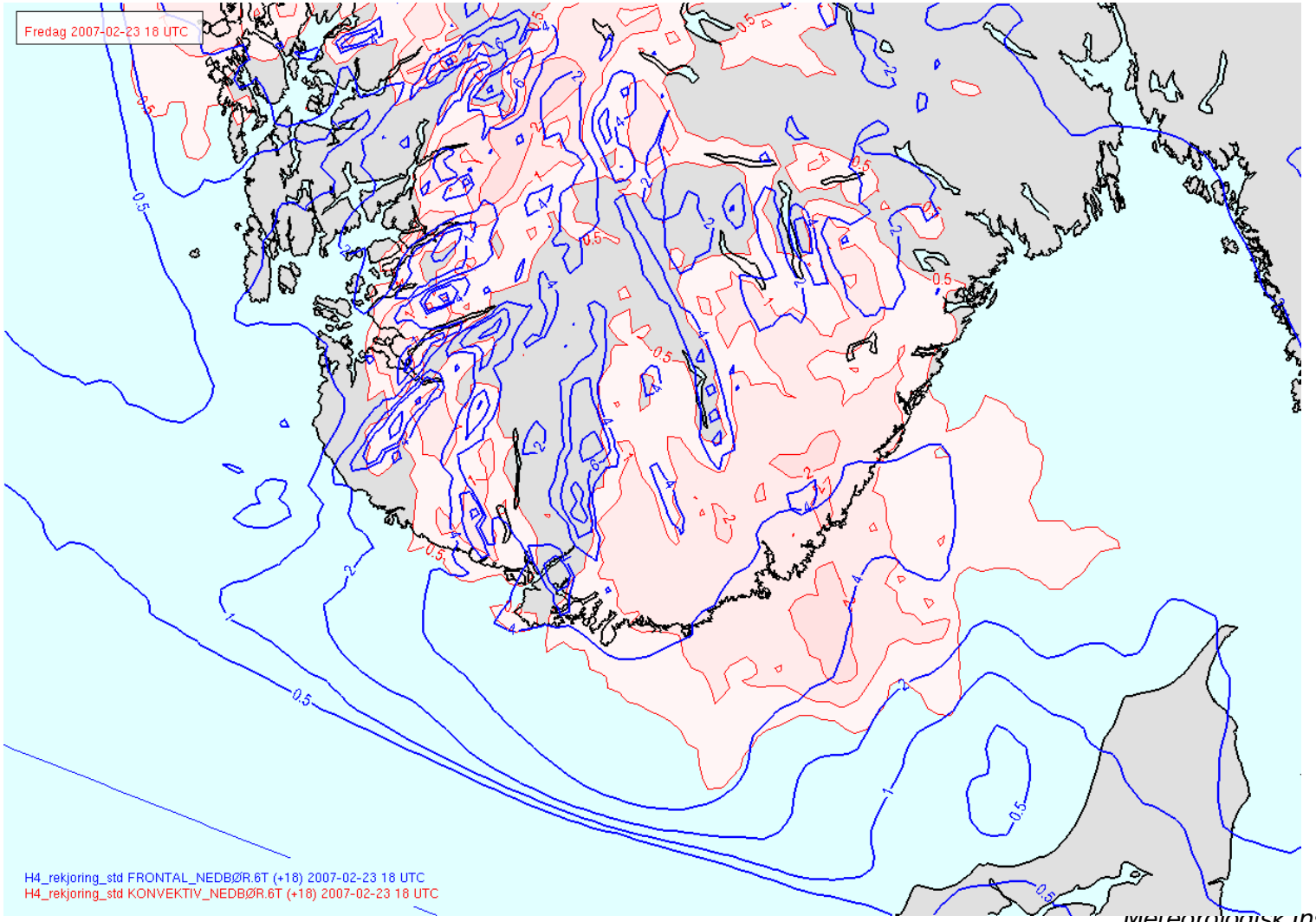


Coastal convergence and vertical velocity in HIRLAM

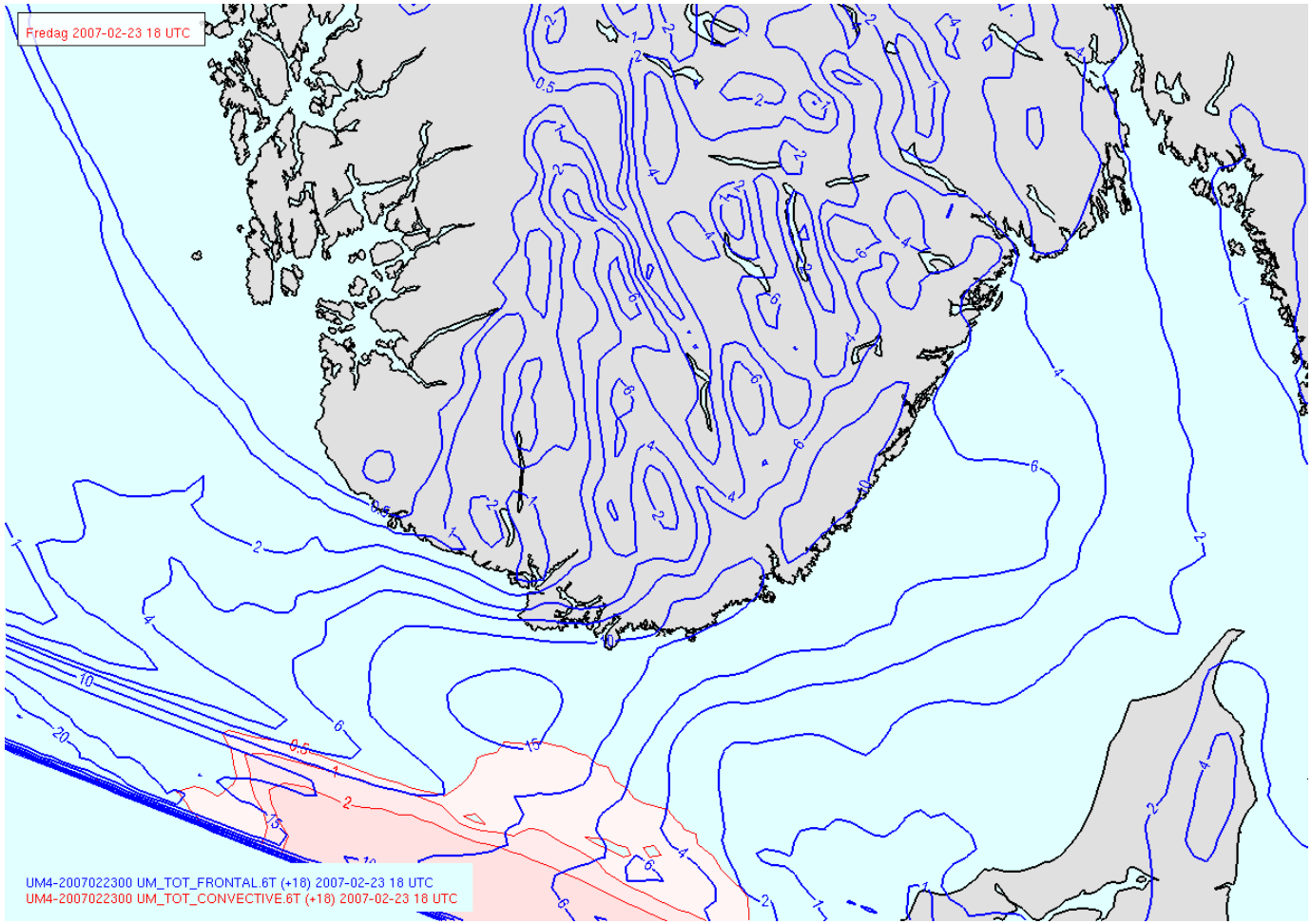




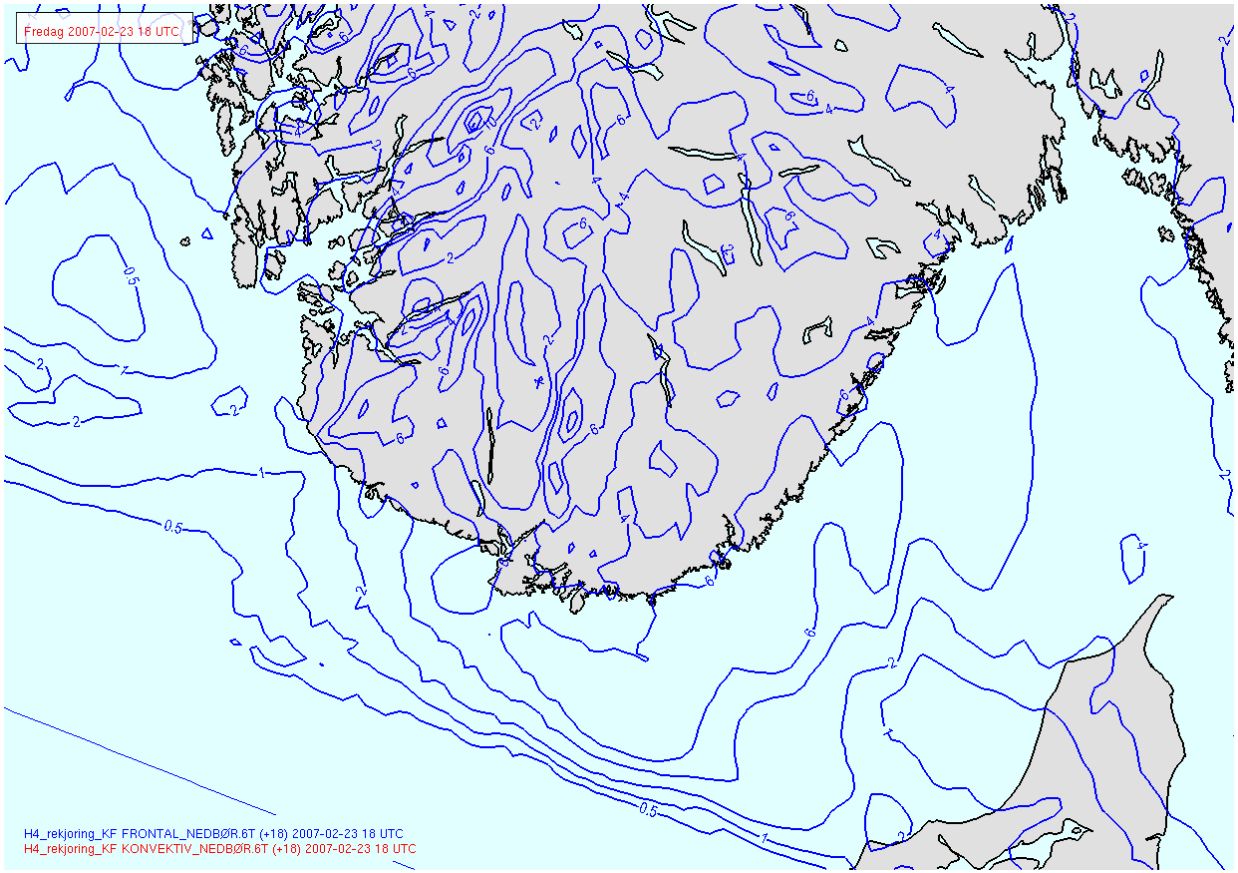
HIRLAM -stratiform precip.
HIRLAM-convective precip.



UM -stratiform precip
UM-convective precip



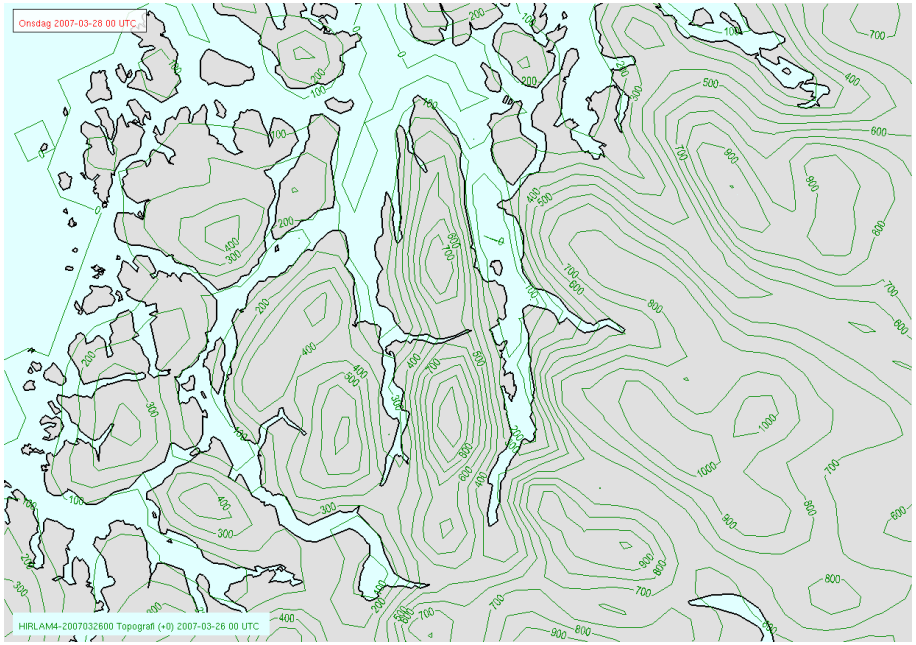
HIRLAM -Stratiform precip (Rasch/Kristjansson)
HIRLAM-convective precip (Kain/Fritsch)

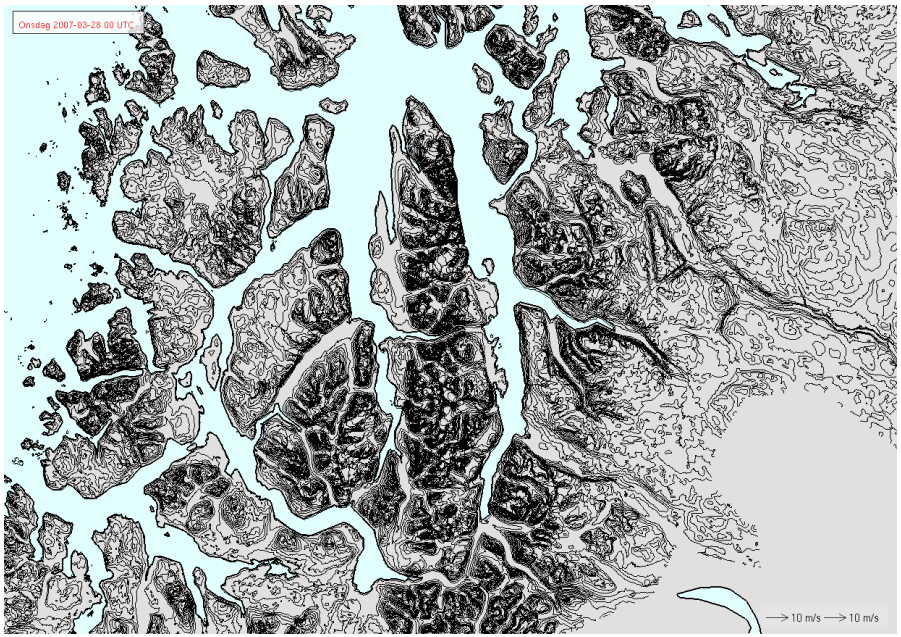


Why is there a difference?

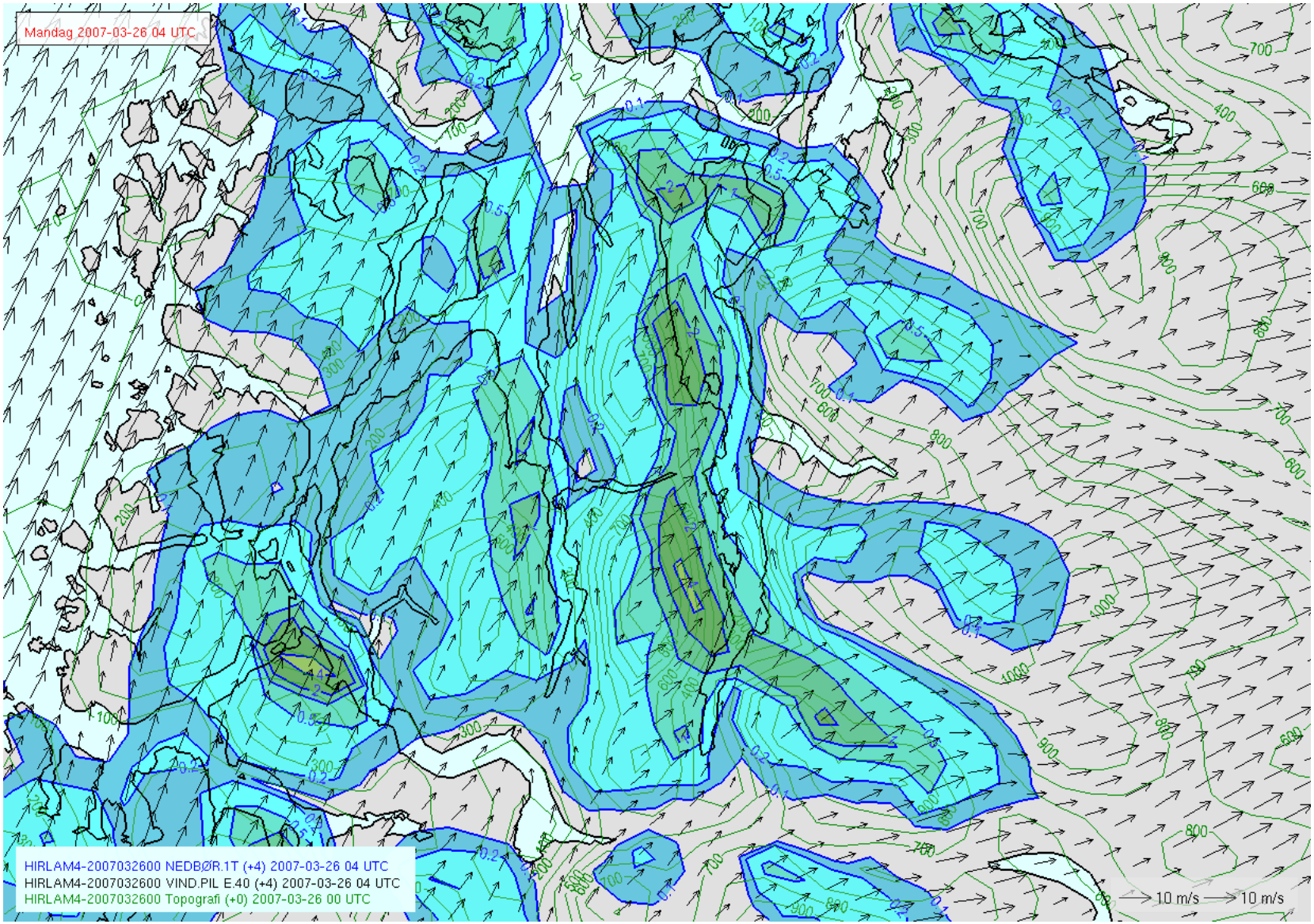
1. Land/sea contrast
   - UM has land or sea, HIRLAM has fractional land
   - The coastal convergence is slightly stronger in UM
   - The vertical velocity along the coast is stronger and more organised in UM
2. Parameterisation of microphysics and precipitation
   - HIRLAM (std) has significant amounts of convective precip
   - HIRLAM (KF) has stratiform condensation only (small improvement)
   - UM with modified micro physics (= further improvements)
3. Non-hydrostatic effects
   - not likely? (stable stratification, gentle topographic slope…)

Lyngsalpene

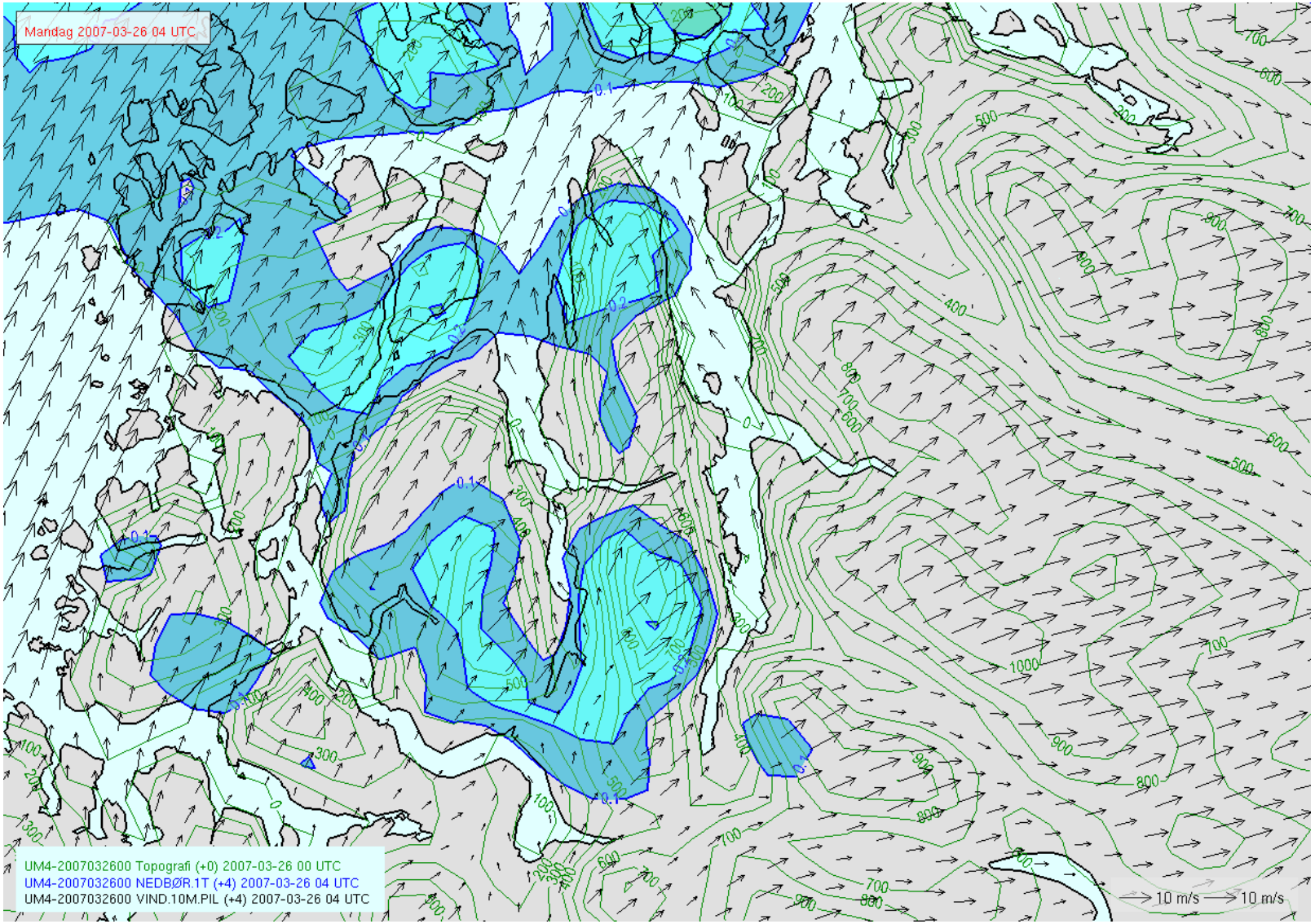




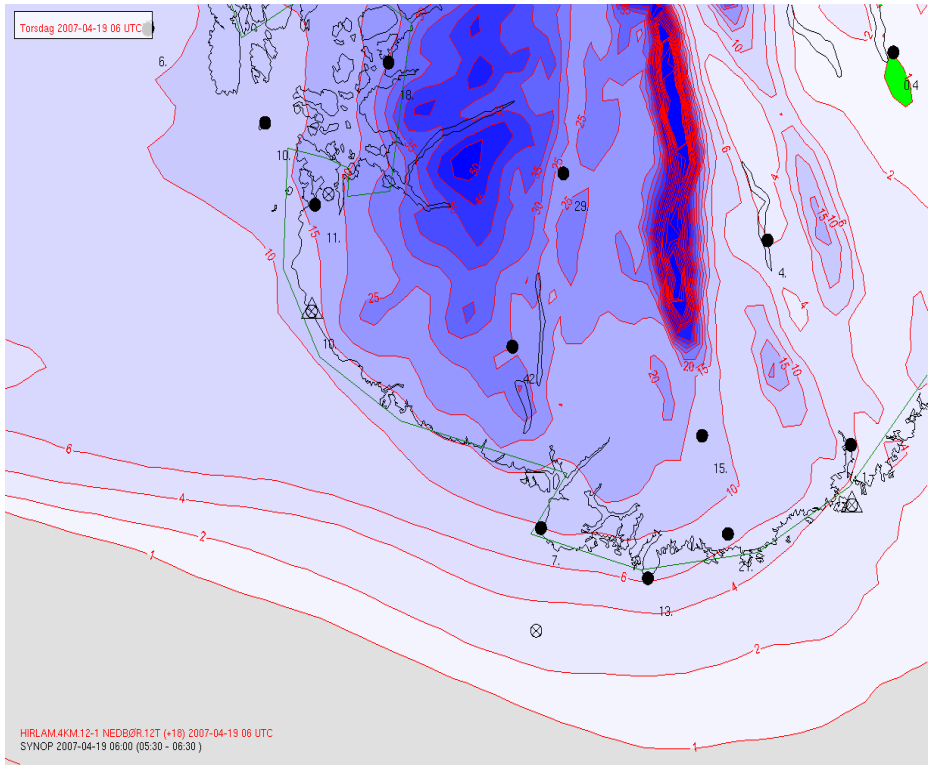
HIRLAM4-1h acc prec



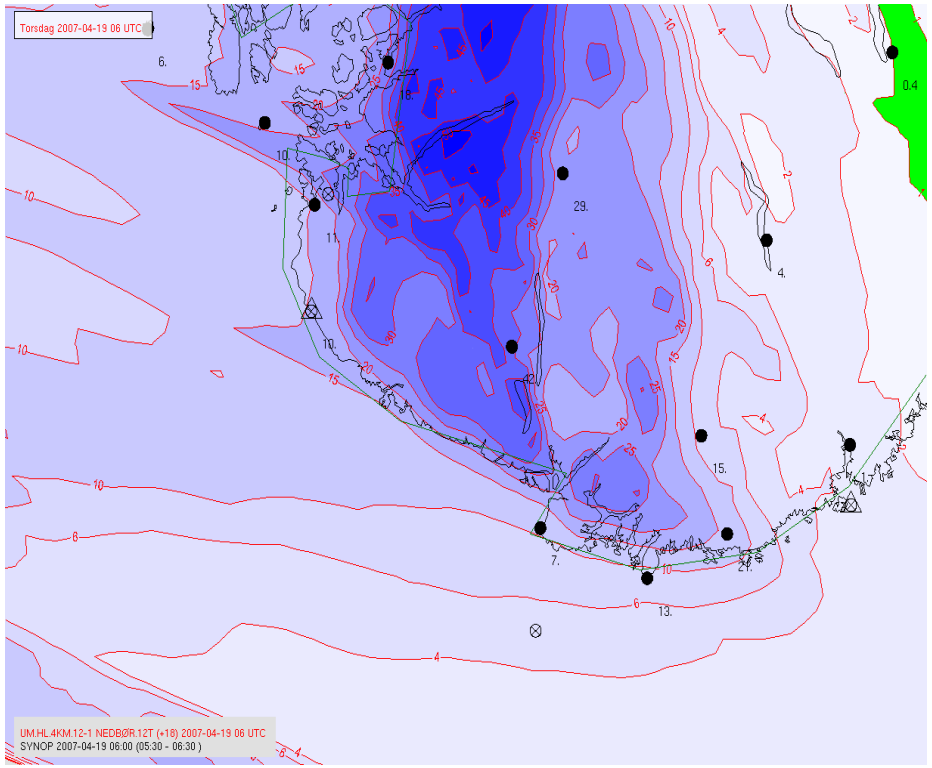
UM4-1h acc prec



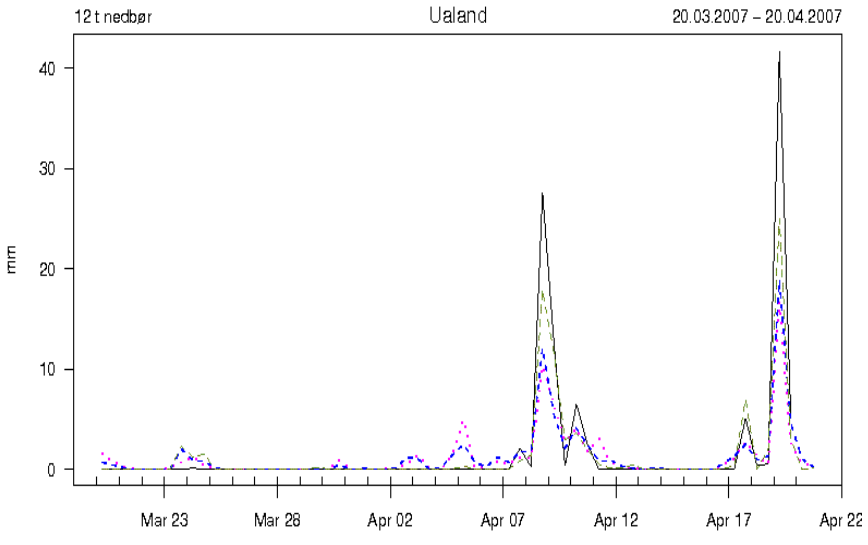
12 h acc precip valid at 19 April 2007 06 UTC



HIRLAM4

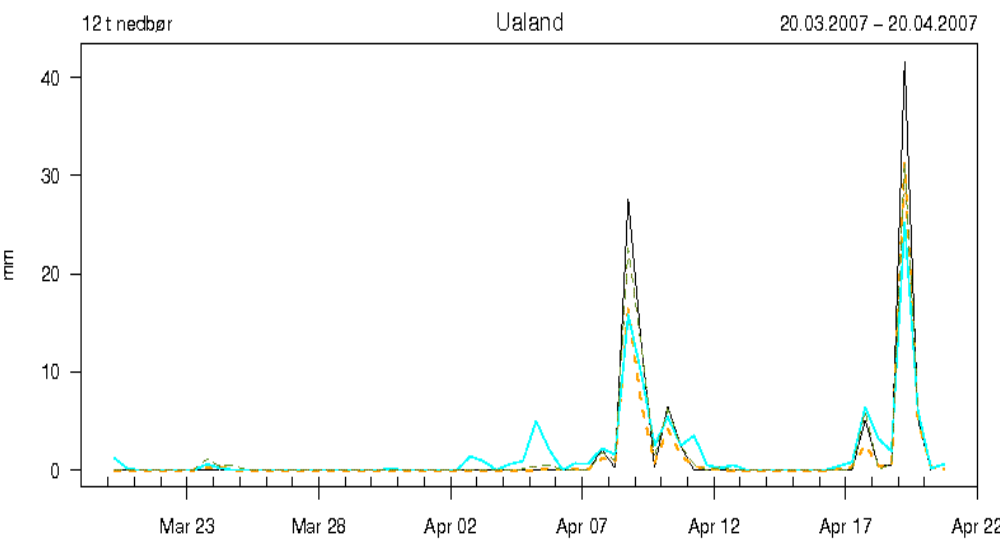


UM4



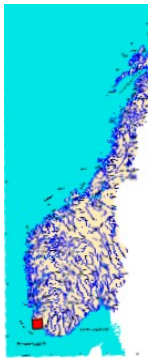
	Min	Middel	Maks	Stdl	N
synop: 06,18	0	1.7	41.7	6.5	62
Hirlam10: 00+30,+42	0	1.2	16.7	2.6	64
Hirlam20: 00+30,+42	0	1.2	18.9	2.9	64
ECMWF: 12+42,+54	0	1.3	25	4.1	64

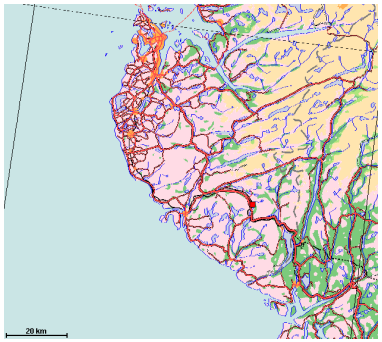
	Middelfeil	Stdl.feil.	RMSE	MAE	Maks.abs.feil	N
Hirlam10 – synop	-0.5	4.1	4.1	1.3	25	62
Hirlam20 – synop	-0.5	3.7	3.7	1.2	22.8	62
ECMWF – synop	-0.3	2.6	2.6	0.8	16.7	62



	Min	Middel	Maks	Stdl	N
synop: 06,18	0	1.7	41.7	6.5	63
UM4HL: 00+18 12+18	0	1.2	31.2	4.5	64
Hirlam4: 00+18 12+18	0	1.6	25.2	4	64
ECMWF: 00+18 12+18	0	1.6	31.2	5.2	62
UM1:					0

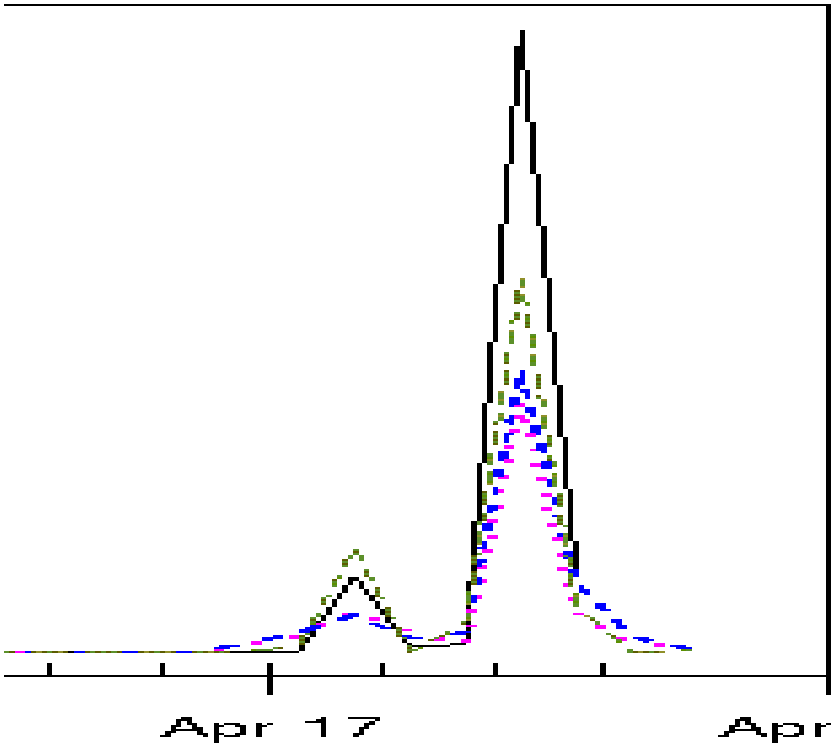
	Middelfeil	Stdl.feil.	RMSE	MAE	Maks.abs.feil	N
UM4HL – synop	-0.5	2.1	2.2	0.6	11.2	63
Hirlam4 – synop	0	2.8	2.8	1	16.5	63
ECMWF – synop	-0.1	1.5	1.5	0.4	10.5	62

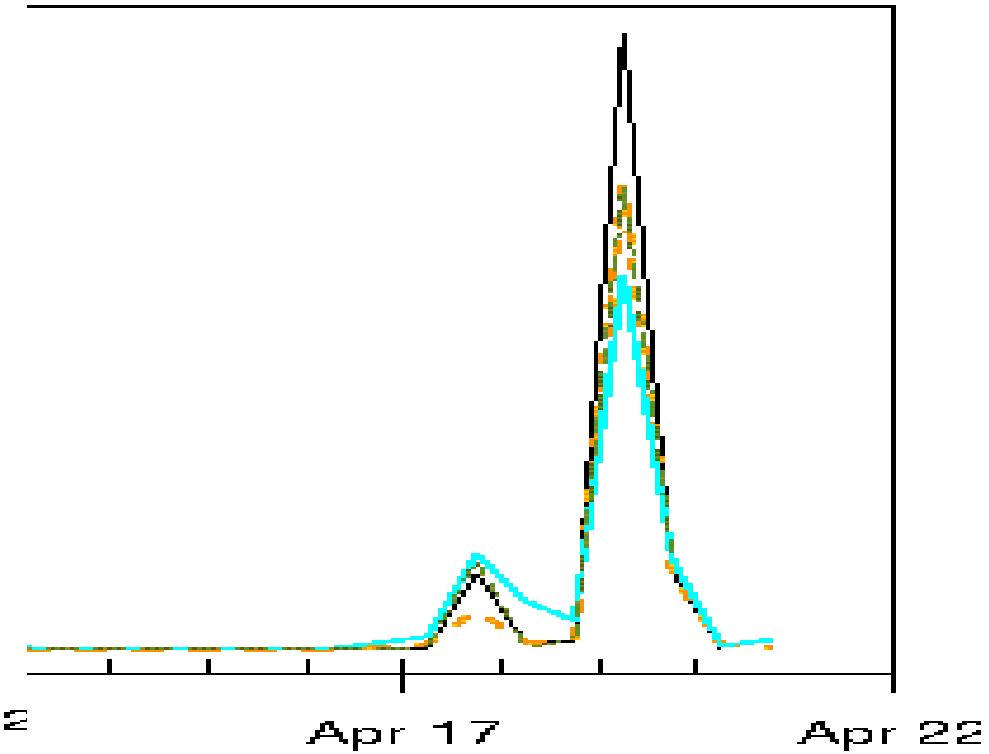




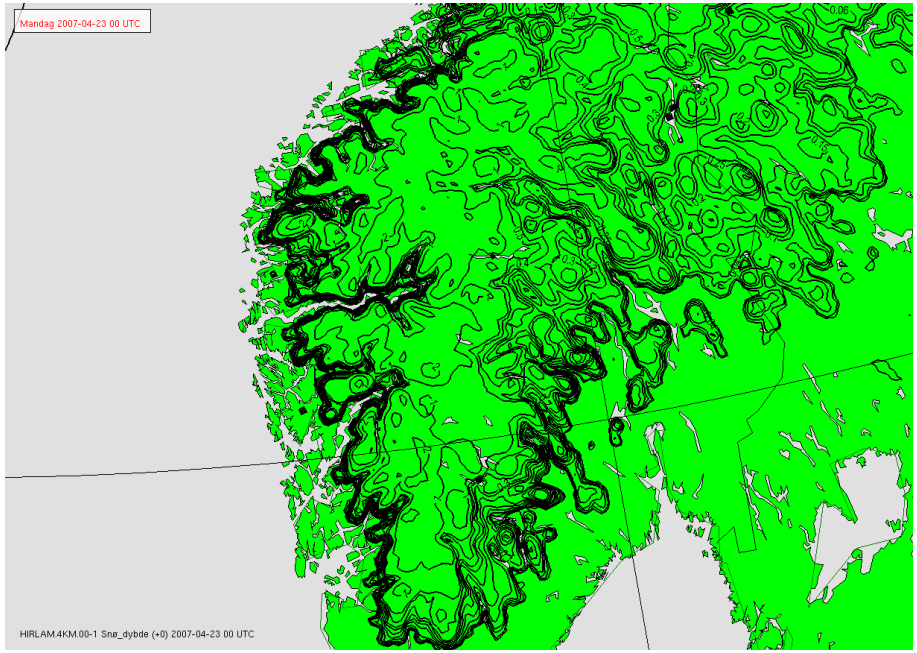
Comparison between large scale precipitation (H10,H20, ECMWF) and fine scale precipitation (H4,UM4) for synop station Ualand in South west Norway

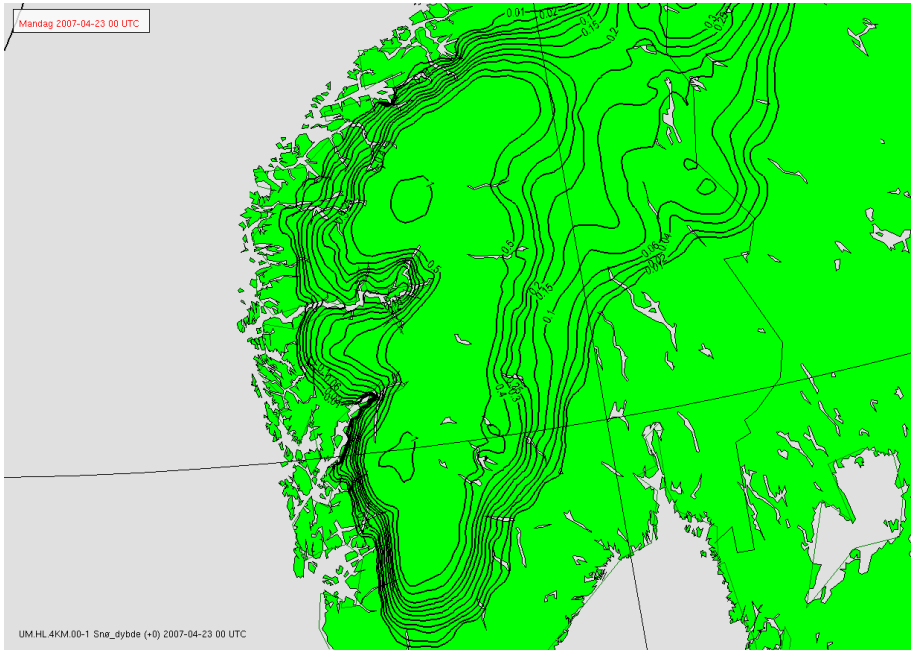
Left: H10 (light blue), H20 (blue) and ECMWF (red)
right: H4 (light blue) and UM4 (yellow)



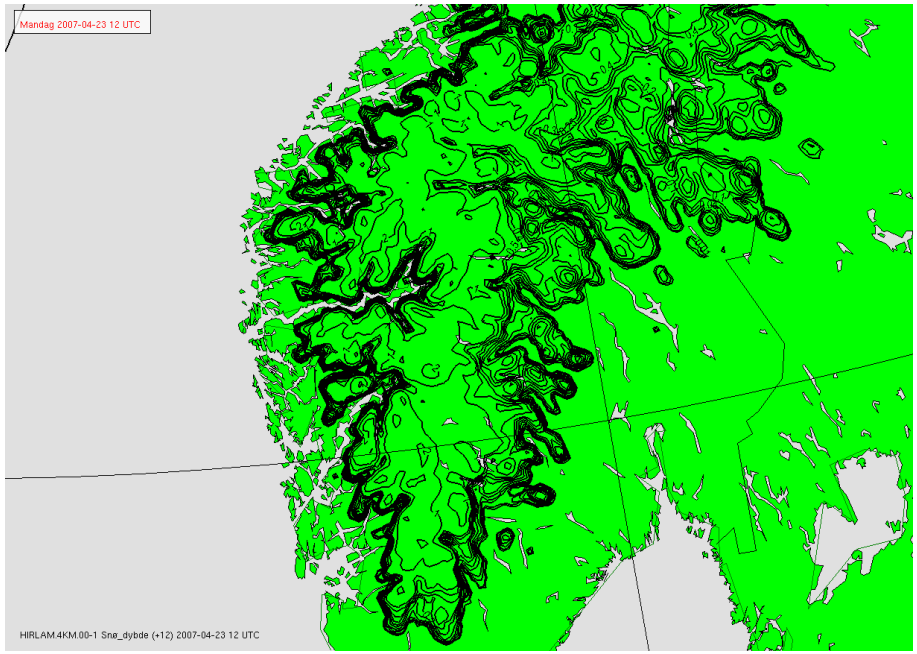


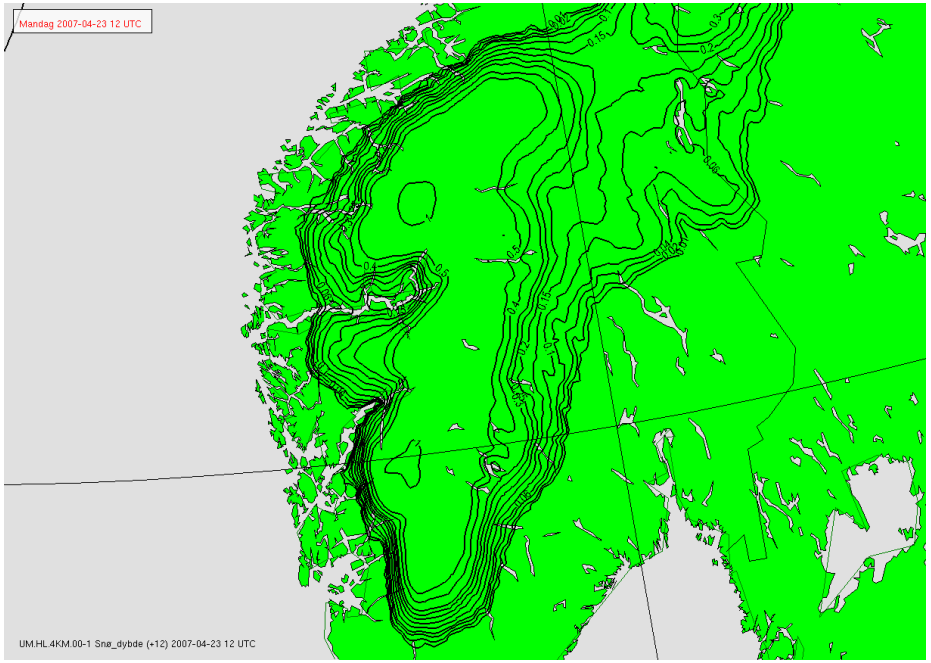
Snow depth
23 April 00 UTC



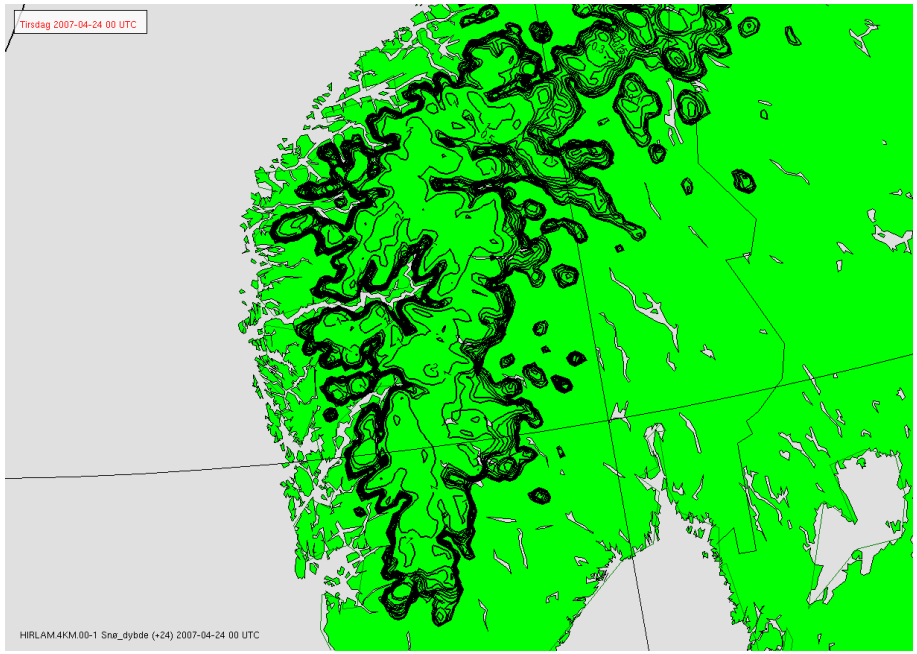


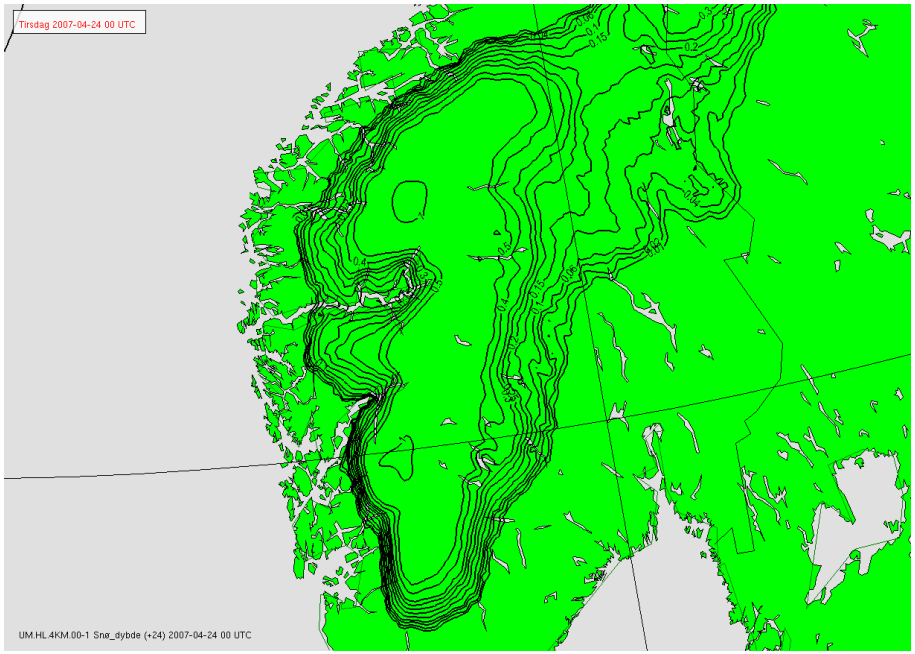
Snow depth
23 April 00 UTC +12



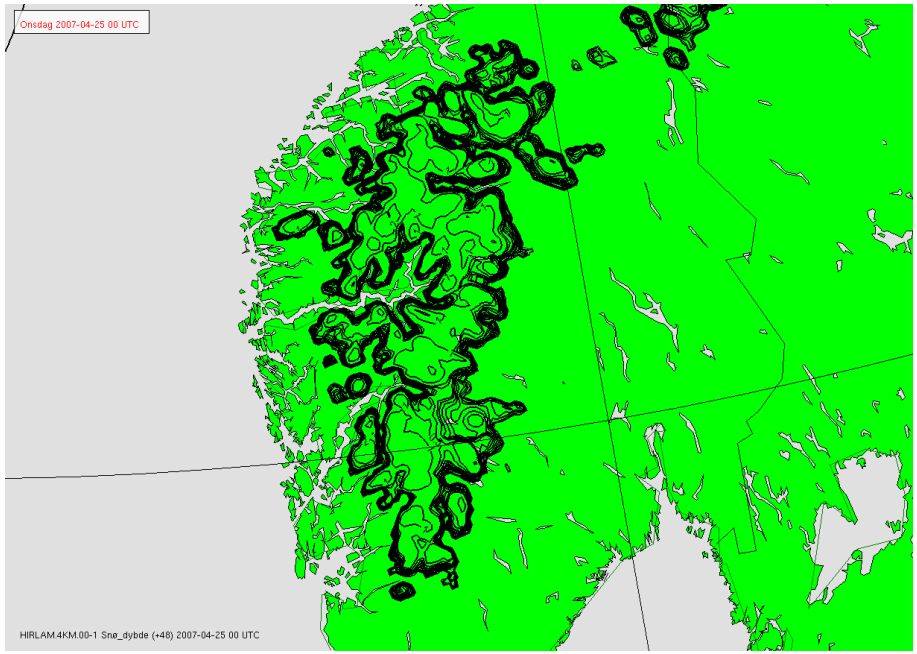


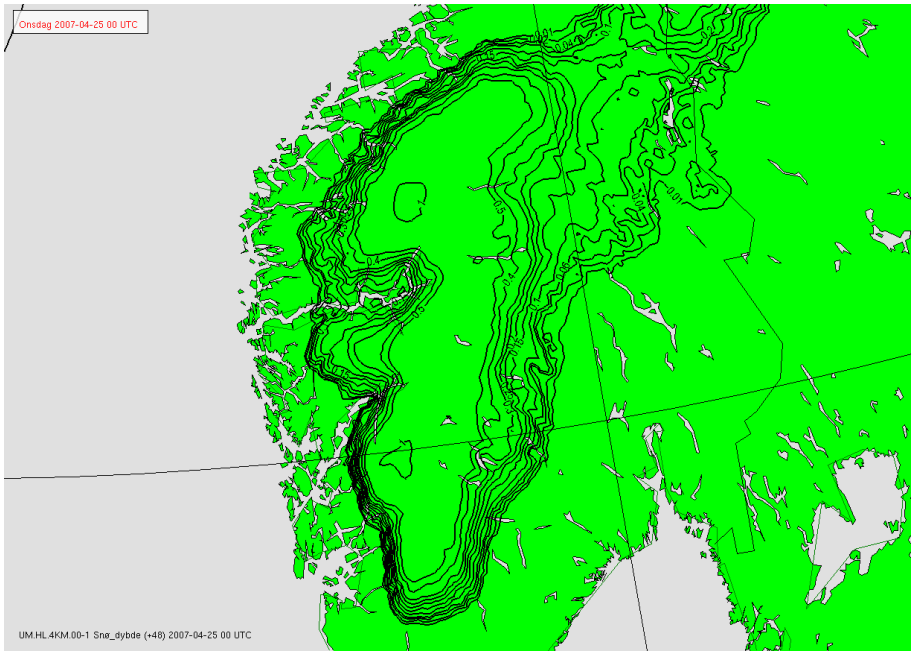
Snow depth
23 April 00 UTC +24





Snow depth
23 April 00 UTC +48





Conclusions based on duty forecasters subjective opinion and objective verification

Precipitation: UM4 best in limiting precipitation extent
Sometimes peculiar precipitation distribition in HIRLAM

Wind: UM4 best in describing local off-shore winds (drainage flow) out fjords and valleys. Also best for winds steered by orography. Able to forecast strong winds in mountains. HIRLAM4 also good at coasts (wind speed).

Screen temperature: HIRLAM4 best, particularly in winther

Snow: Too rapid snowmelt, particularly in HIRLAM4

Polar lows: Both models are pretty good. OK strength but some displacements errors.

Thank you for your attention!