EWGLAM/SRNWP 2013

National presentation from DMI

Development of operational Harmonie at DMI

Since Jan 2013 DMI updated HARMONIE-Denmark suite to CY37h1 with a 3h-RUC cycling and 57h forecast, 8 times a day, on a 800*600*65 grid mesh with 2.5 km grid spacing. The suite is configured with "asynoptic time", each centered 1h ahead of 'regular' synoptic time, i.e., 02, 05, 08, 11, 14, 17,20,23 UTC, which enables a much earlier delivery of forecast products to end users. The 3-hourly RUC has been found to resulting in forecast with reduced moisture spin-up. As backup, each of the HARMONIE forecast is run 6h longer, which is designed to provide product backup in case of cycle interuption. Work is currently under way to migrate the suite to that of CY38h1 with assimilation of new types of observation such as radar, ATOVS, ASCAT, AMV, GNSS and GPSRO, as well as Mode-S data.

Table 1: Operational schedule for 3-hourly cycled DKA37 at DMI
(all time given in UTC)

Base time	Nominal cycle	ObsData window	Obs cutoff	EC BC cycle	Launch	Forecast length	Delivery time
02	03	00:30 – 03:30	03:15	18	03:15	58h	04:45
05	06	03:30 – 06:30	06:15	00	06:15	58h	07:45
08	09	06:30 – 09:30	09:15	00	09:15	58h	10:45
11	12	09:30 – 12:30	12:15	06	12:15	58h	13:45
14	15	12:30 – 15:30	15:15	06	15:15	58h	16:45
17	18	15:30 – 18:30	18:15	12	18:15	58h	19:45
20	21	18:30 - 21:30	21:15	12	21:15	58h	22:45
23	00	21:30 – 00:30	00:15	18	00:15	58h	02:45

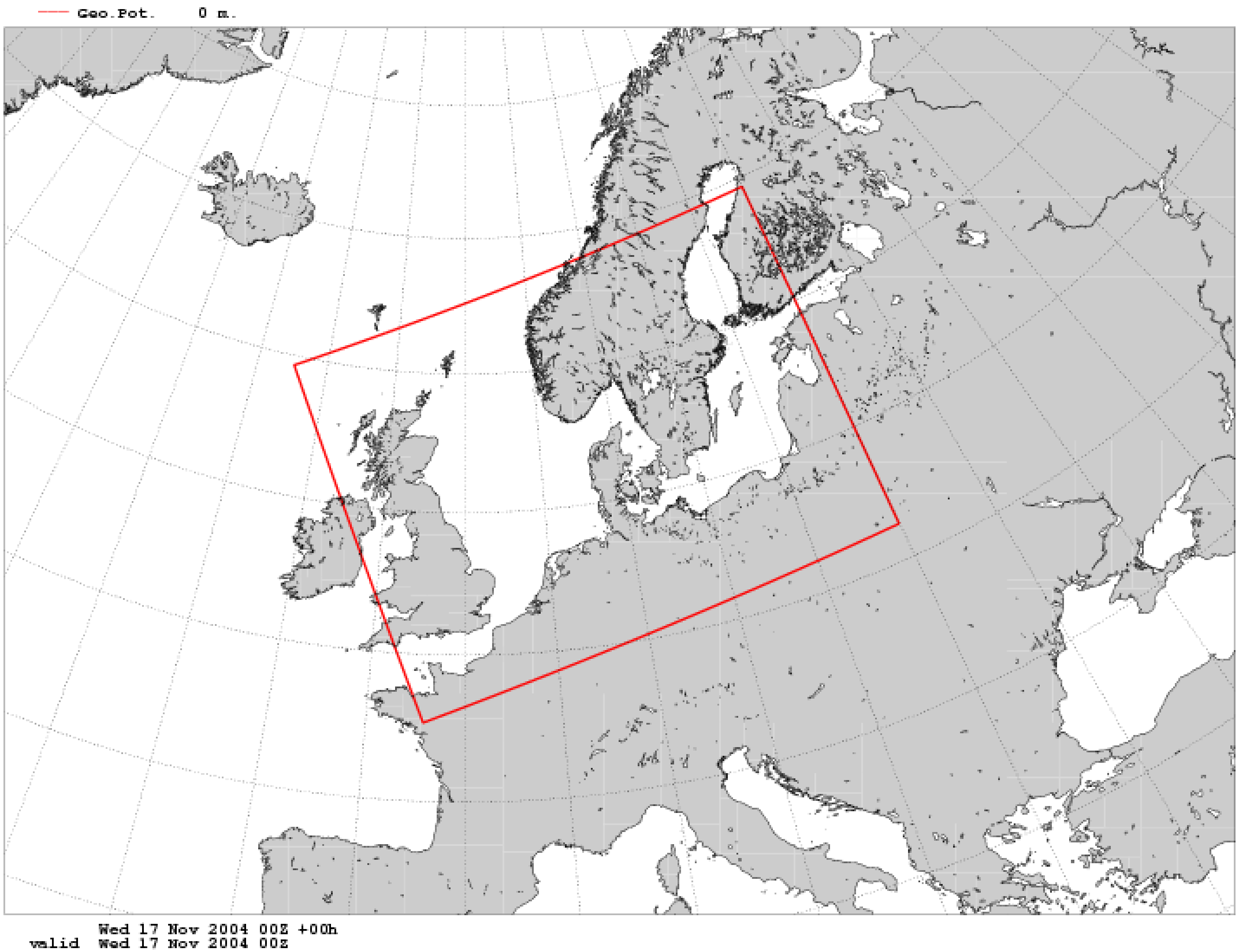


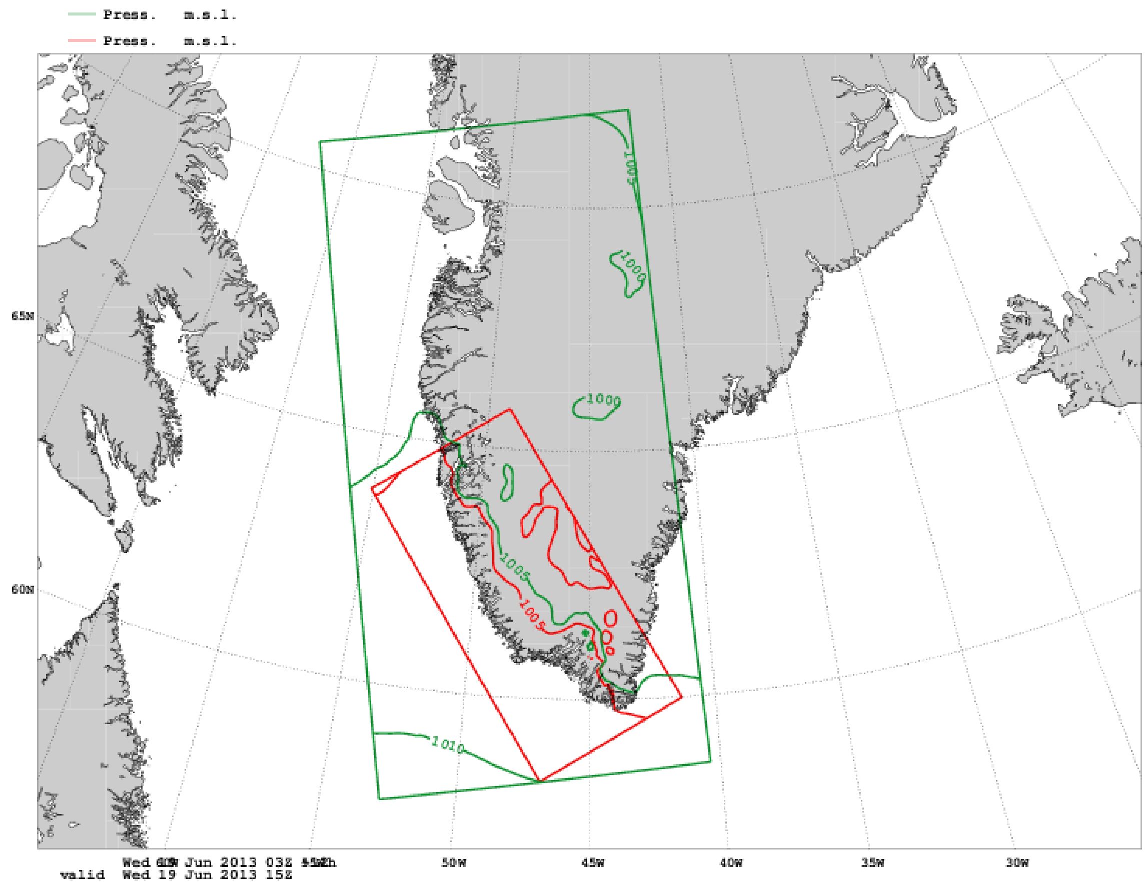
Fig.1 Operational Harmonie area `DKA-37´ around Denmark

Harmonie setup for Southwest Greenland

HARMONIE-Greenland has been updated to a domian with 800x400x65 with 2 km grid-spacing, which covers now better the south western Greenland with over 80% of local population. The forecast has been found to be especially popular for end users due to its superior capability to predict catabatic winds in coastal Greenland.

Figure 2: model domain of GLA (old area) vs GLB (new area)

Figure 3 : scatter plots comparing 10m wind forecast accuracy of ECMWF (Fig.3a) to the corresponding GLB forecast accuracy (Fig.3b). The colors indicate number of cases



Press. m.s.l.
Press. m.s.l.
65N
60N
50W
45W
40W
35W
30W
1005
1000
1000
1005
1005
1010
valid Wed 19 Jun 2013 15Z

Fig 2

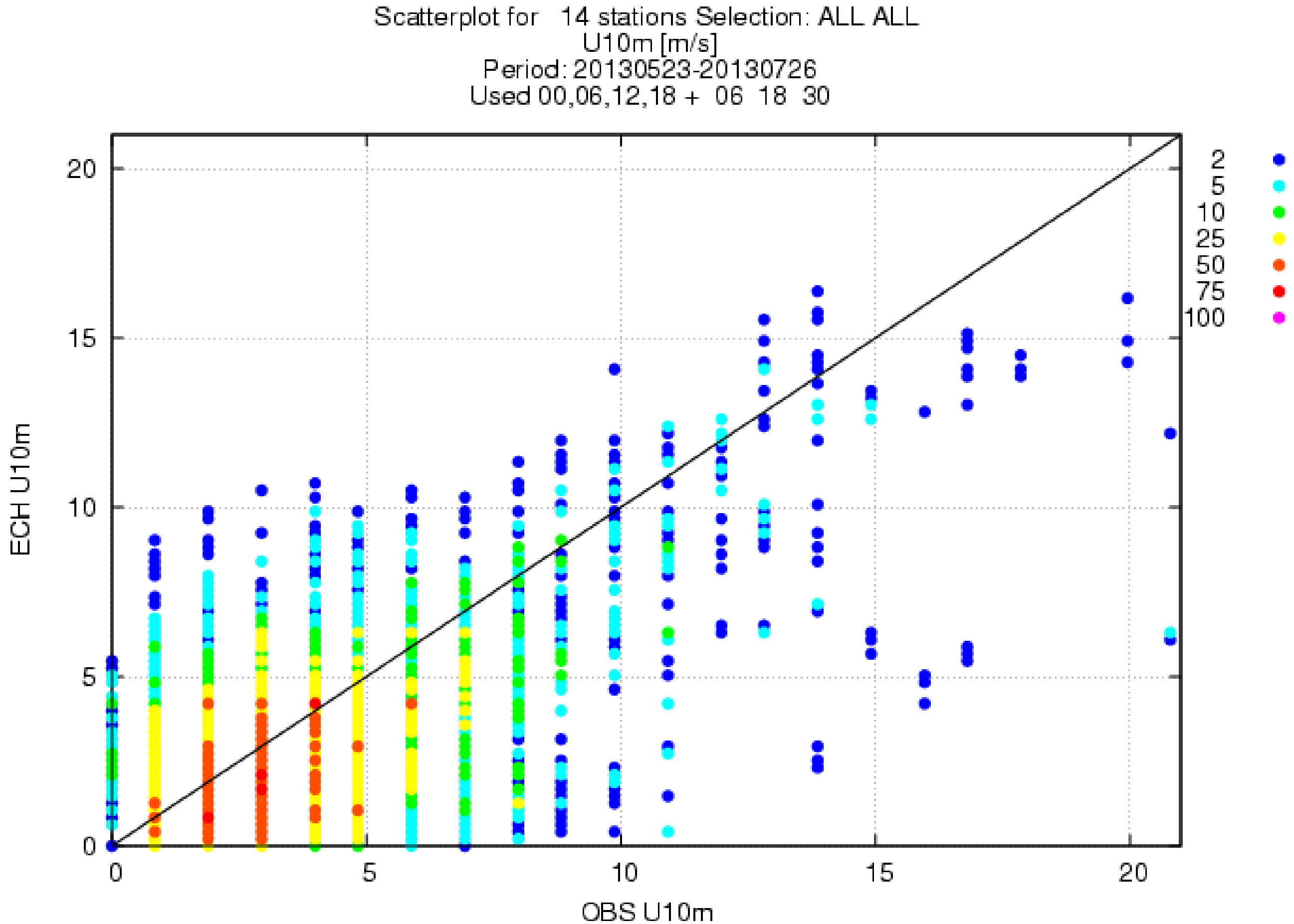
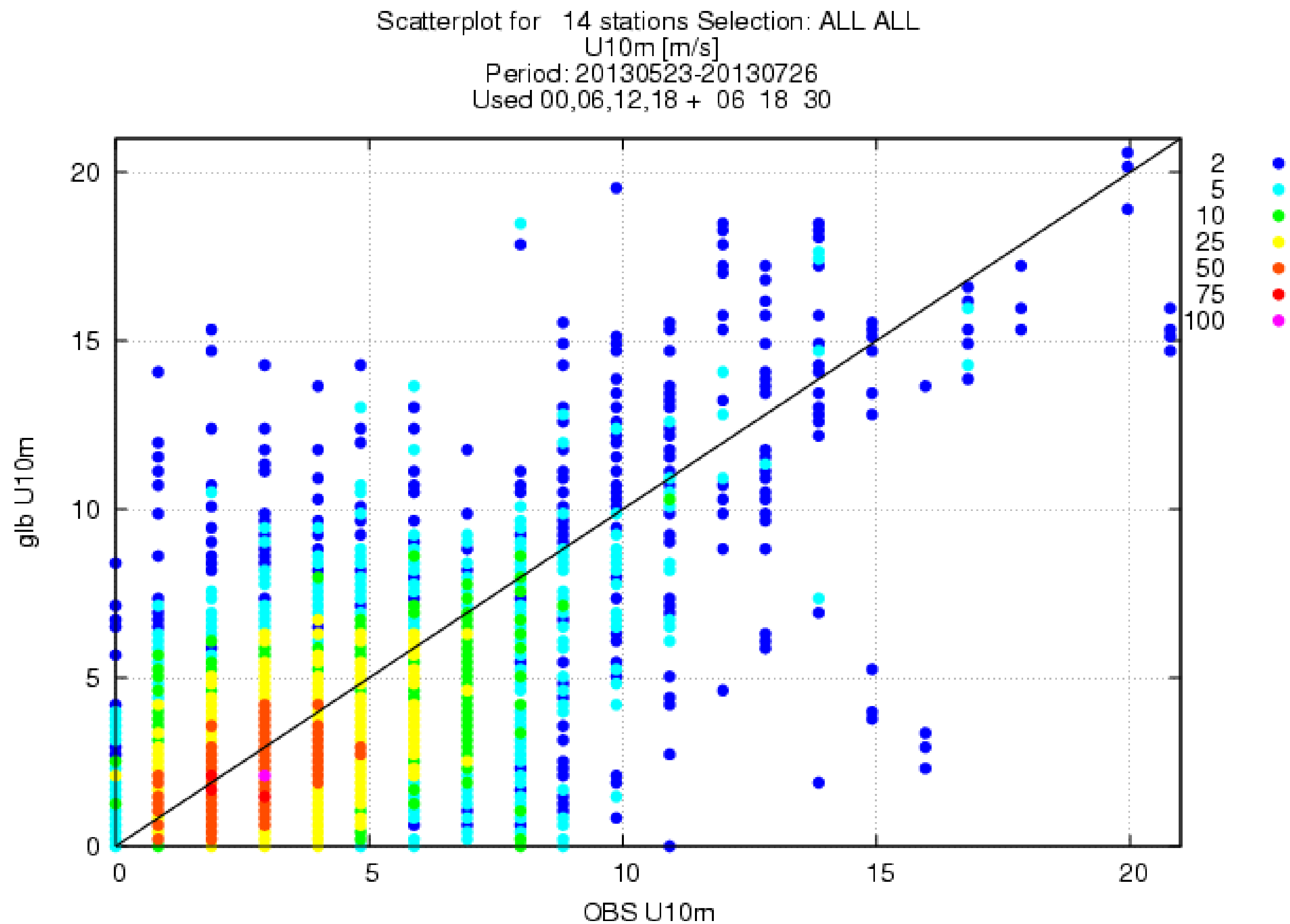

Scatterplot for 14 stations Selection: ALL ALL
U10m [m/s]
Period: 20130523-20130726
Used 00,06,12,18 + 06 18 30
ECH U10m
OBS U10m
0
5
10
15
20
2
5
10
25
50
75
100

Fig. 3a


Scatterplot for 14 stations Selection: ALL ALL
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Period: 20130523-20130726
Used 00,06,12,18 + 06 18 30
glb U10m
OBS U10m
0
5
10
15
20
2
5
10
25
50
75
100

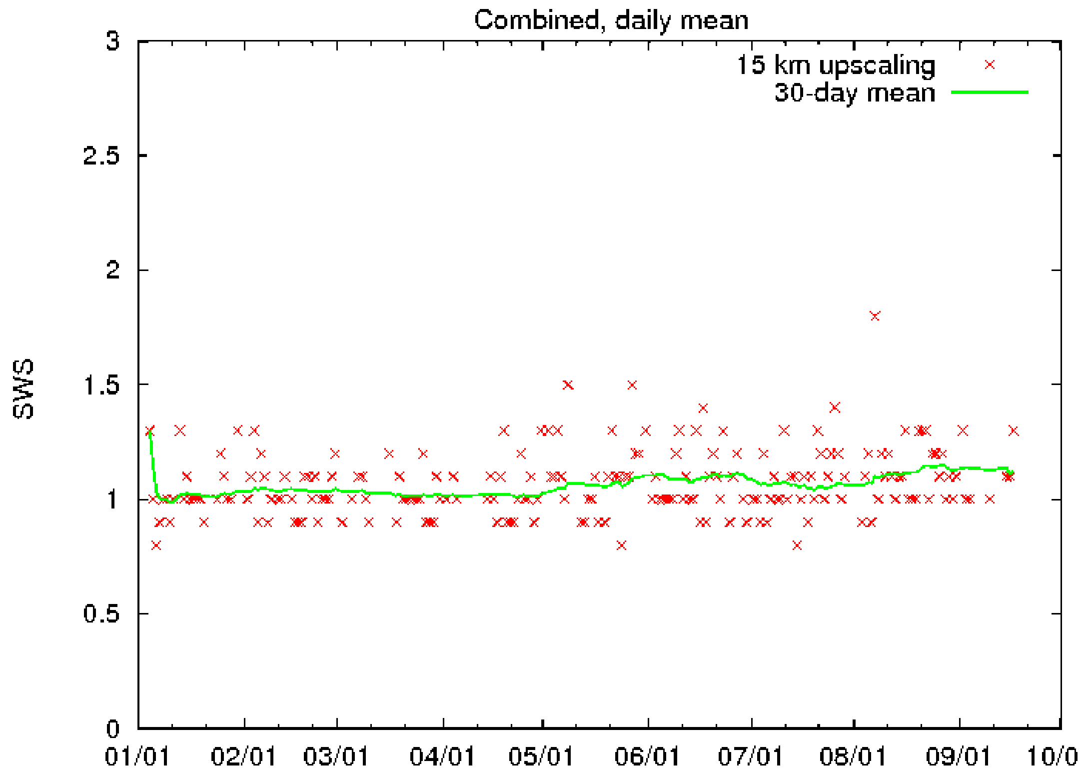
Fig. 3b

New spatial verification measure SWS (`**S**ignificant **W**eather **S**core´)

The recently developed verification scheme to measure added value of a fine resolution model relative to that of coarser resolution one, especially for high impact weather, Significant Weather Score [1] , has been introduced into the regular monitoring of NWP models run at DMI. Work is on the way to incorporate SWS into NWP indexing to monitoring long term quality trend of the operational NWP system.

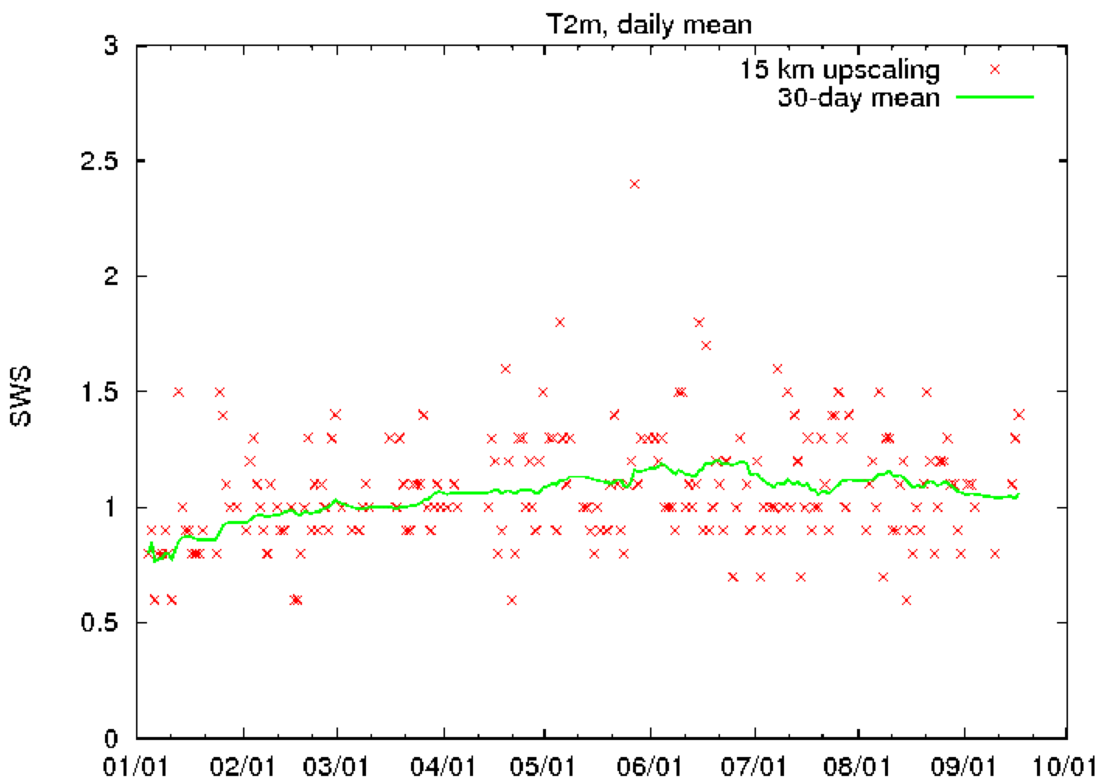
Figures show SWS total scores between January and September with HARMONIE versus ECMWF. Values above 1 implies better score for Harmonie compared to ECMWF. Results apply to Danish station list. Fig.4a represents average for 2m temperature, 10m wind and accumulated precipitation. Fig.4b shows result for 2m temperature, Fig.4c and Fig.4c apply to 10m wind and accumulated precipitation (over 12 hours), respectively.

[1] `A verification score for high resolution NWP , *Hirlam Tech. Rep. No. 69, December 2012* , 27 pp
[available from www.hirlam.org]



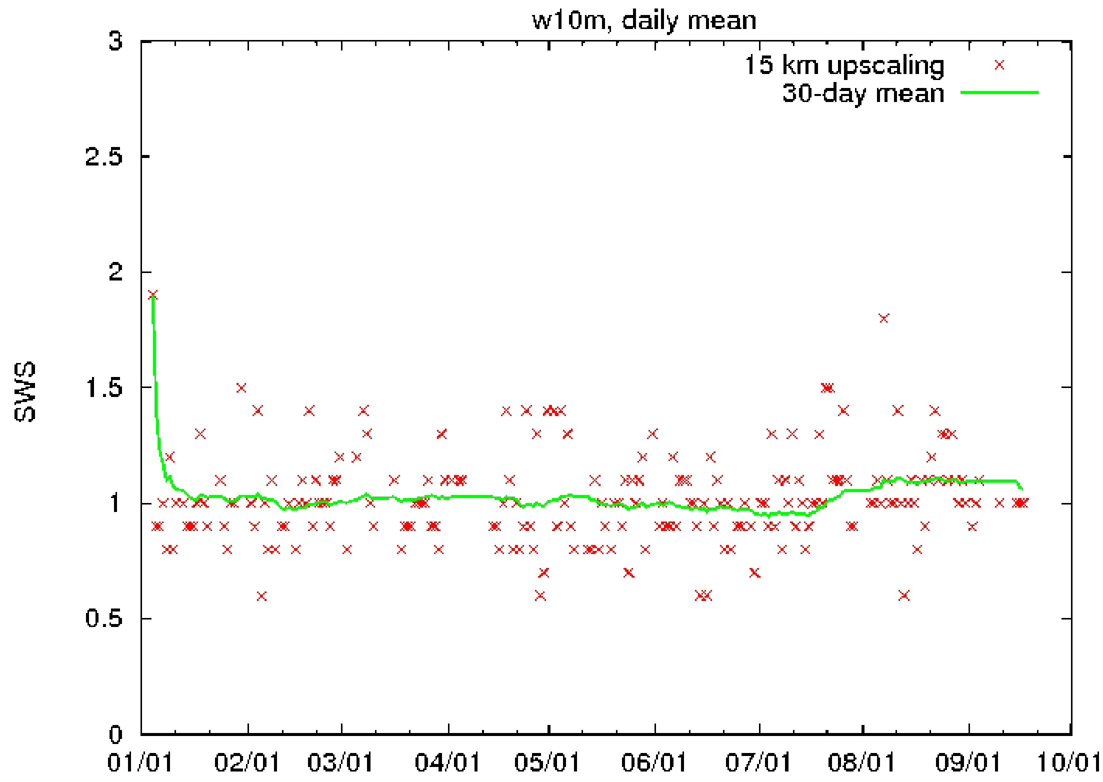
Combined, daily mean
15 km upscaling
30-day mean
SWS
3
2.5
2
1.5
1
0.5
0
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01

Fig.4a



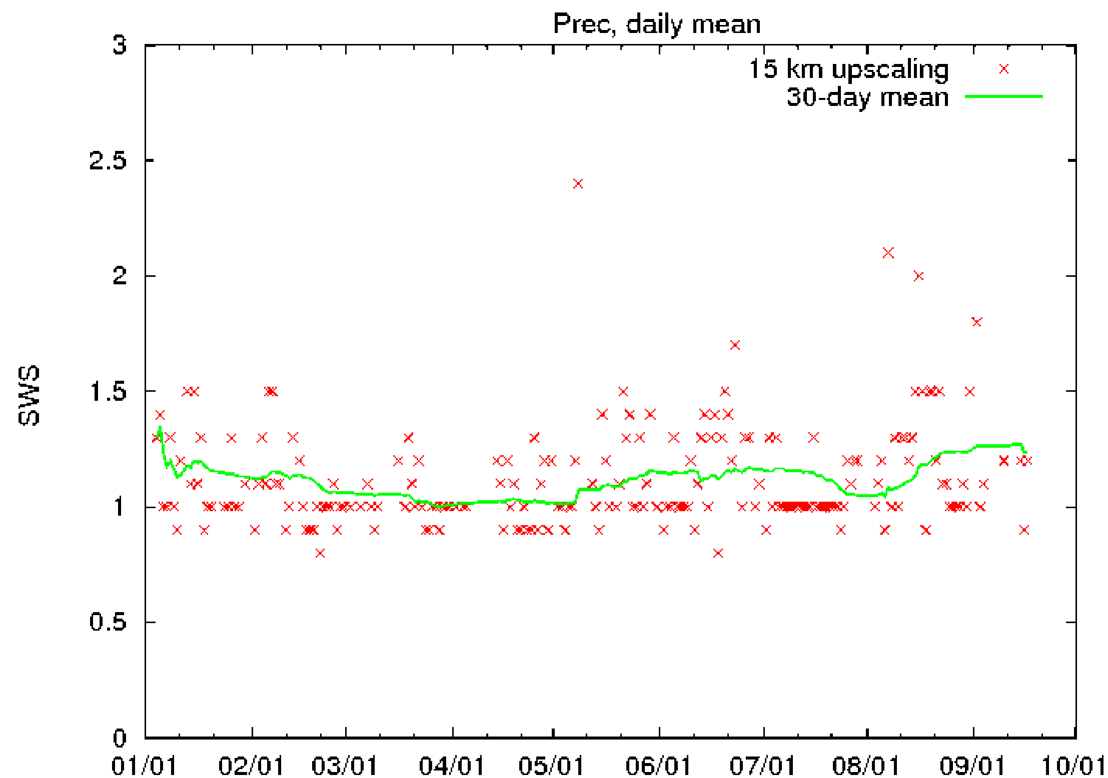
T2m, daily mean
15 km upscaling
30-day mean
SWS
3
2.5
2
1.5
1
0.5
0
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01

Fig.4b



w10m, daily mean
15 km upscaling
30-day mean
SWS
3
2.5
2
1.5
1
0.5
0
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01

Fig.4c



Prec, daily mean
15 km upscaling
30-day mean
SWS
3
2.5
2
1.5
1
0.5
0
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01

Fig.4d

Nowcasting

Basic information about current model setup

- **Based on HIRLAM 3 km grid**
- **Rapid update cycles every hour**
- **Assimilation is a combination of 3D-VAR and a new nudging scheme for assimilating clouds and hourly precipitation analysis based mainly on radar data**
- **Monitoring and corrections of radar data not representing precipitation**
- **Nudging scheme is modifying divergent wind in a conceptual approach implying also modification of temperature and humidity**
- **Setup has been run daily for about 9 months in test mode**

BASIC CHALLENGES

- **The significant precipitation phenomena we want to describe and forecast occur partly on very small horizontal scales down to ~1 km which operational models currently cannot properly resolve (*)**

- **Small scale convergent/divergent wind fields connected with small scale precipitation phenomena should ideally be analysed**

- **Difficult to analyse thermodynamic variables consistent with the 3-dimensional wind field. Inconsistencies can easily show up in degraded precipitation forecasts at very short forecast ranges**

- **Data-assimilation and forecast need to run fast due to time constraints.**

[*We may define \`Nowcasting´ based on NWP to involve forecasts up to 3 or even 6 hours ahead]

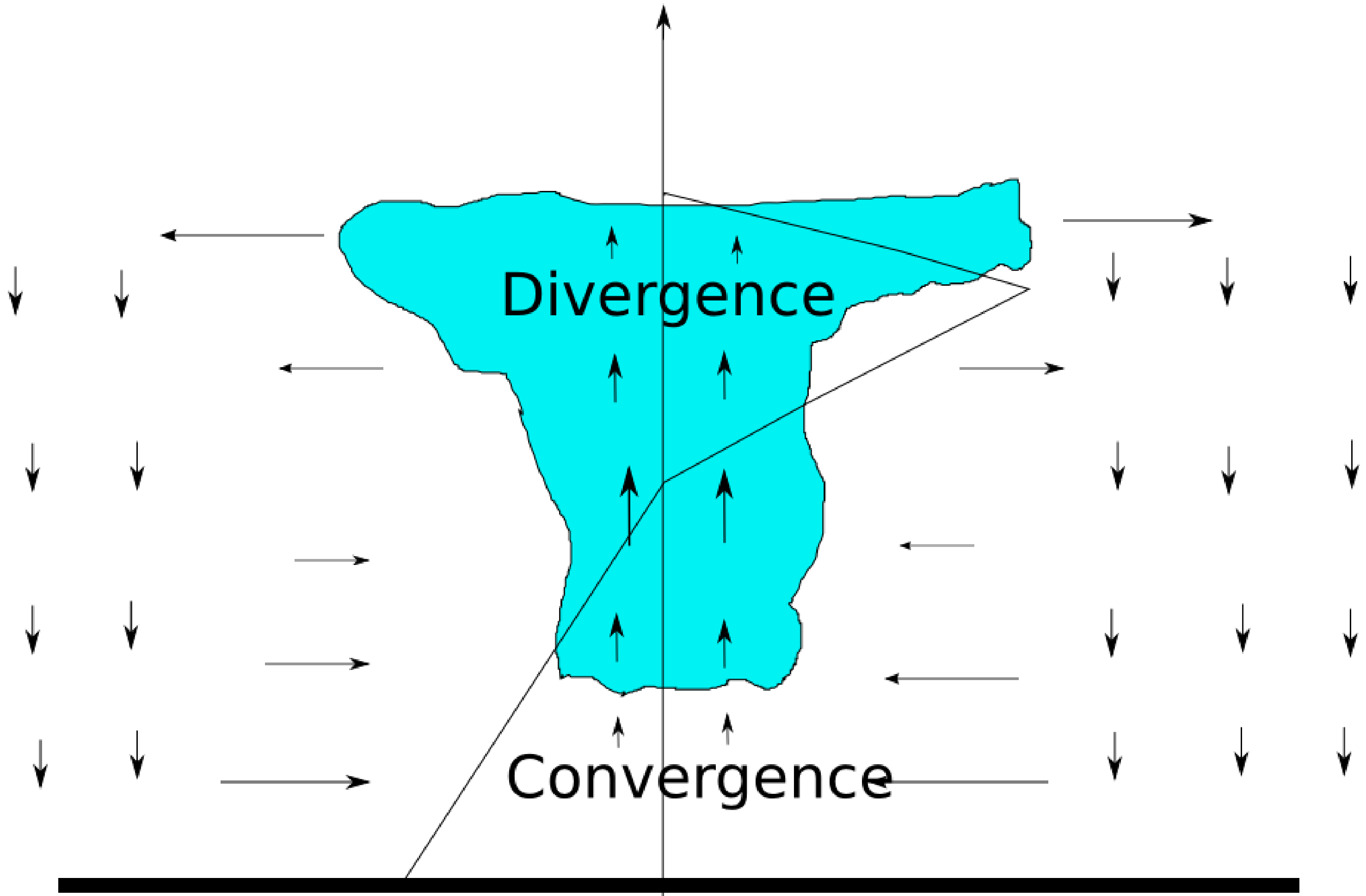
Fast method adapted to Nowcasting purposes

- Adjustment of wind field to precipitation (new method developed at DMI)

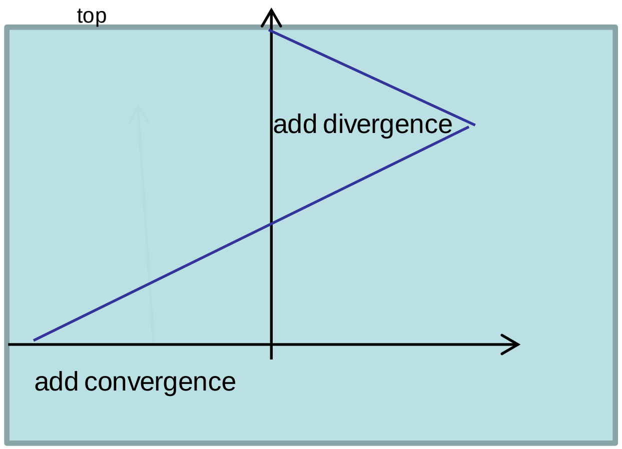
This method also adjusts model state according to differences between forecast precipitation intensity and observed of analysed intensity `continuously´ during some assimilation period. In contrast to Latent heat nudging both temperature, humidity variables and wind field are adjusted searching for better model consistency.

The developed method has been presented at the annual EGU (European Geophysical Union) meeting in Vienna 2013.

Assimilation of radar data Increase precipitation



adjustment procedure



The vertical integral of added convergence and divergence is zero implying no surface pressure change as a result of extra precipitation. This is based on an observational experience that surface pressure changes are small as a result of precipitation release

Higher humidity at low levels compared to humidity a high levels implies that the method is able to supply a net source of moisture for generation of additional precipitation The picture is consistent with a classical conception of convection with convergence at low elevations and divergence at high elevations.

$$\int_{bot}^{top} q(z)\, \delta D(z) = K\,(Pm - Pa)$$

Adjustment Nomenclature

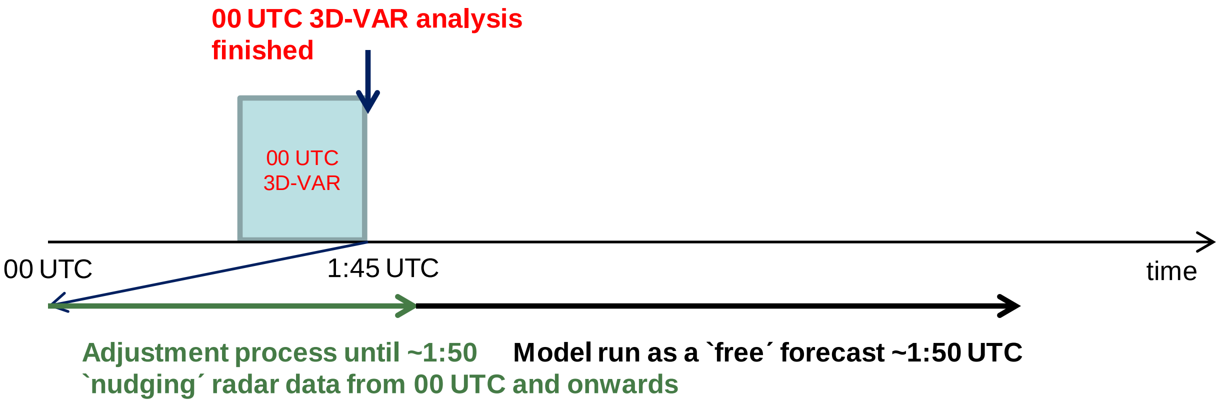
Pm is the model precipitation rate

Pa is the analysed precipitation rate

$q(z)$ is current model specific humidity

$\delta D(z)$ is imposed change of divergence as a prescribed function of height

Current DMI data assimilation with radar data



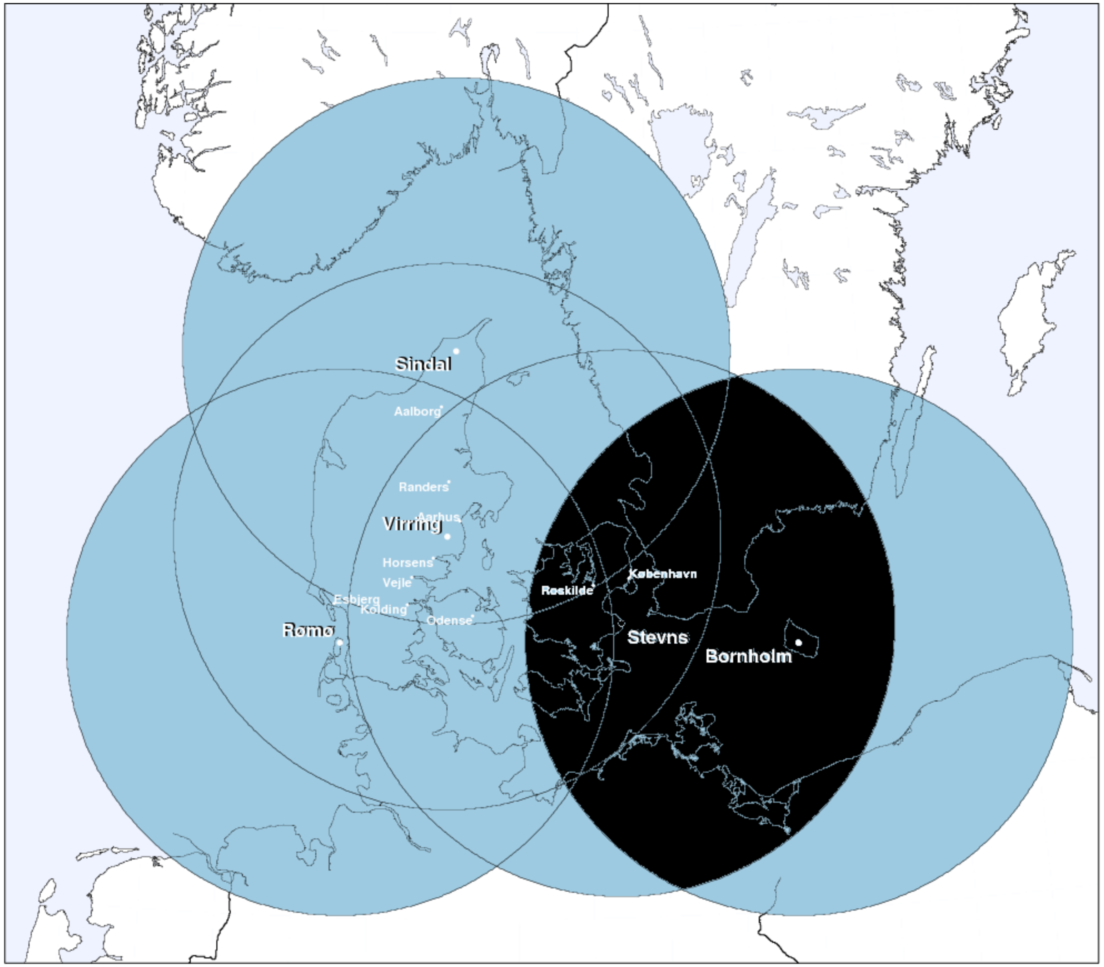
DMI Radar network

`old radars´:
Sindal
Rømø
Stevns

`New radars´:
Virring
Bornholm

New radars are socalled `dual – pol´

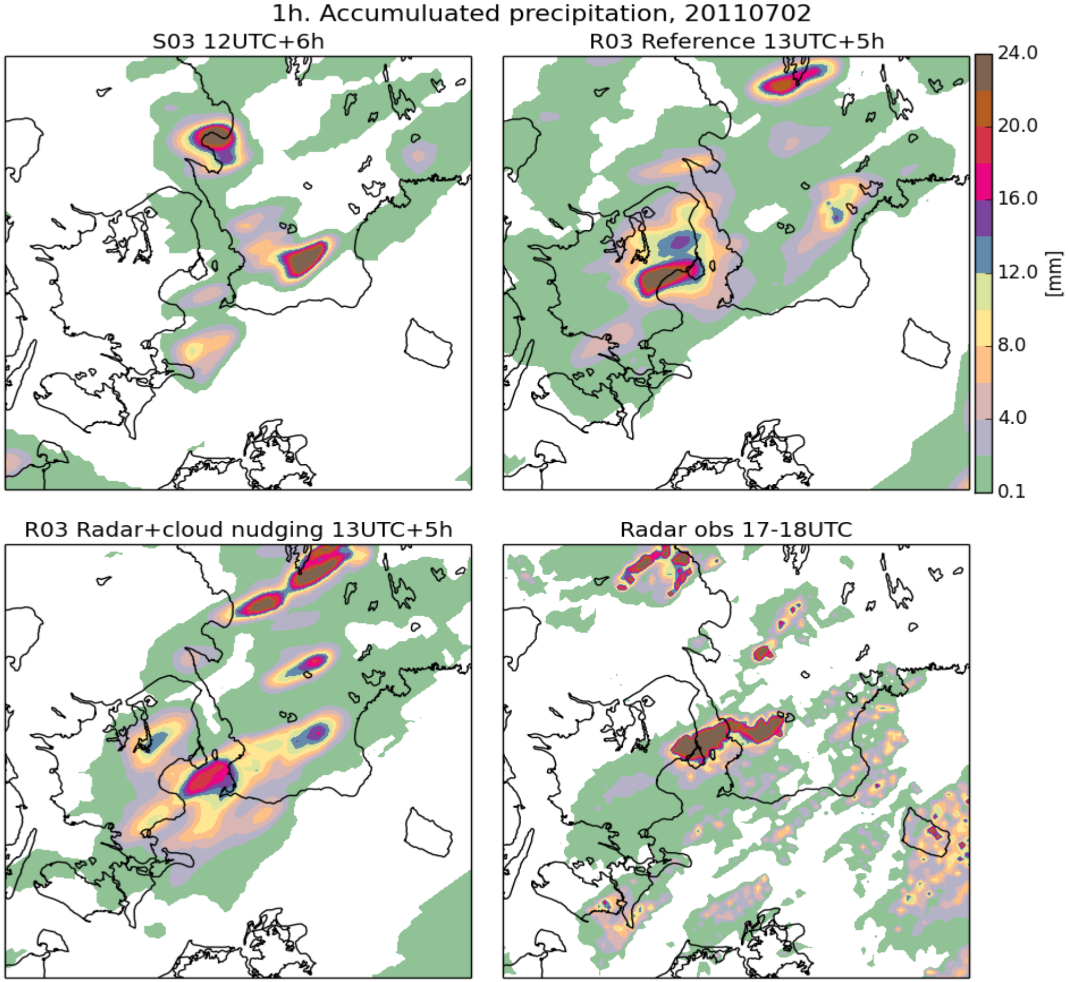
Notice that the radars are overlapping which can be used for calibration purposes



DMI

Flash flood in Copenhagen 2 July 2011 (1)

An example showing useful forecast for the flooding event when 1h-cycling is used -
The original operational forecast S03 did not produce good forecast skill for Copenhagen.



conclusions and outlook (1)

Conclusions

- The new assimilation of data from radar deduced precipitation is fast and numerically very stable for a period of almost a year
- The scheme adjusts quite well the model precipitation to radar-deduced precipitation during assimilation period
- Operational screening and correction of radar data not representing precipitation properly is essential
- Good experiences with rapid update compared to e.g. 6 hourly cycles (e.g. the severe Copenhagen flash flood was forecast hours before it occurred with rapid updates, but not with 6-hourly cycling)

DMI

conclusions and outlook (2)

Outlook

- Radar derived precipitation for verification purposes will be made operational by the end of 2013. New verification scores , e.g. fractions skill score will be used.
- Potential shortcomings of the current method for assimilating radar data will be cured as far as possible
- Is it wise to combine NWP with radar extrapolation methods in the short term, e.g nudging towards extrapolation for the first hour ?
- Investigate possibility to transfer new ideas to Harmonie system
- What is the potential of an ensemble of model runs for Nowcasting ?