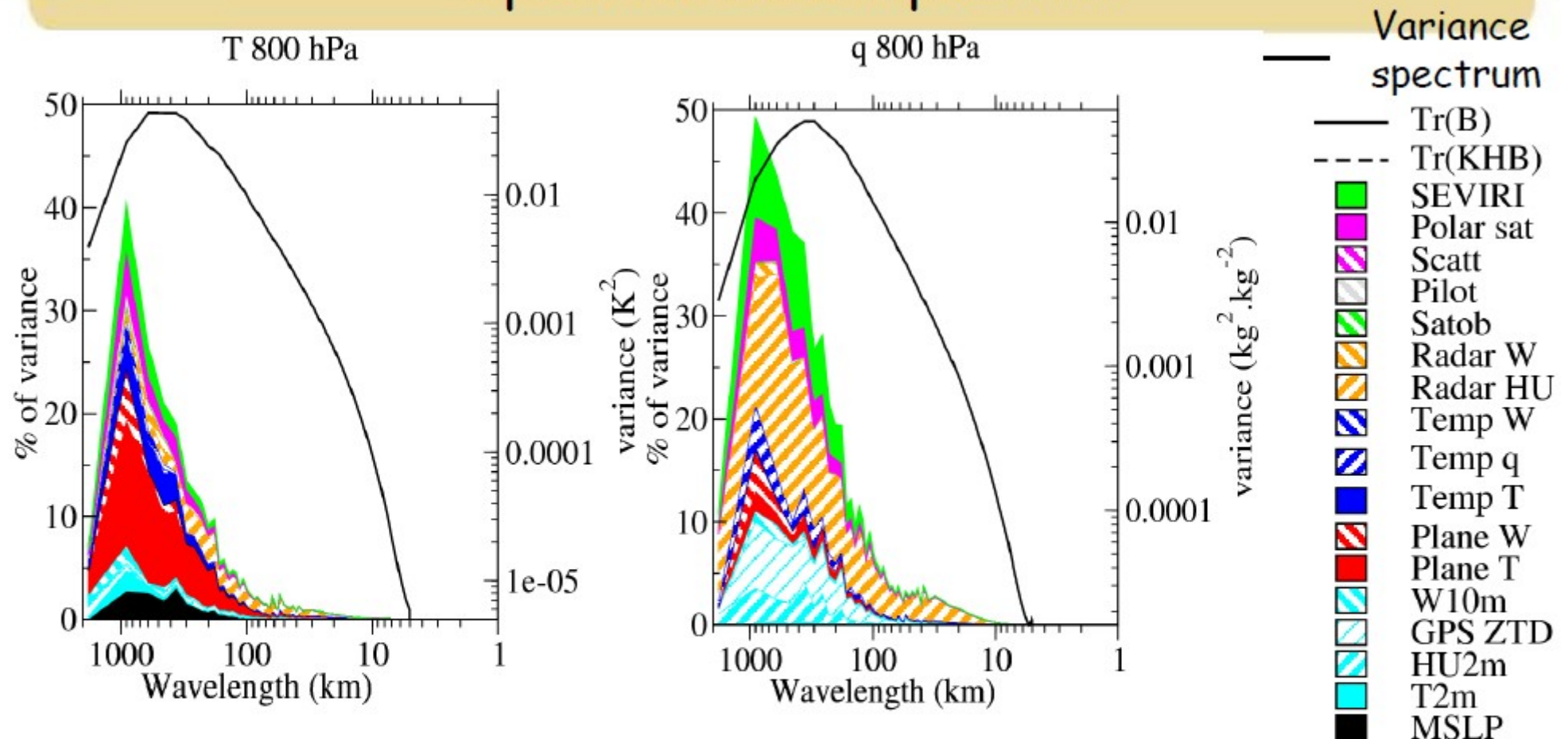


Nowcasting system at DMI

- The purpose of nowcasting is to predict weather phenomena that occur on small scales in time or space, are of great importance to society, and are difficult to impossible to predict with traditional NWP setups. Examples of importance to DMI are:
 - Heavy, local, convective precipitation.
 - Road temperatures, humidity and precip. (Slippery Road/Glatføre)
- The vital components of a NWP nowcasting system are:
 - Observations providing relevant information with **high time frequency, high timeliness, and high spatial resolution**.

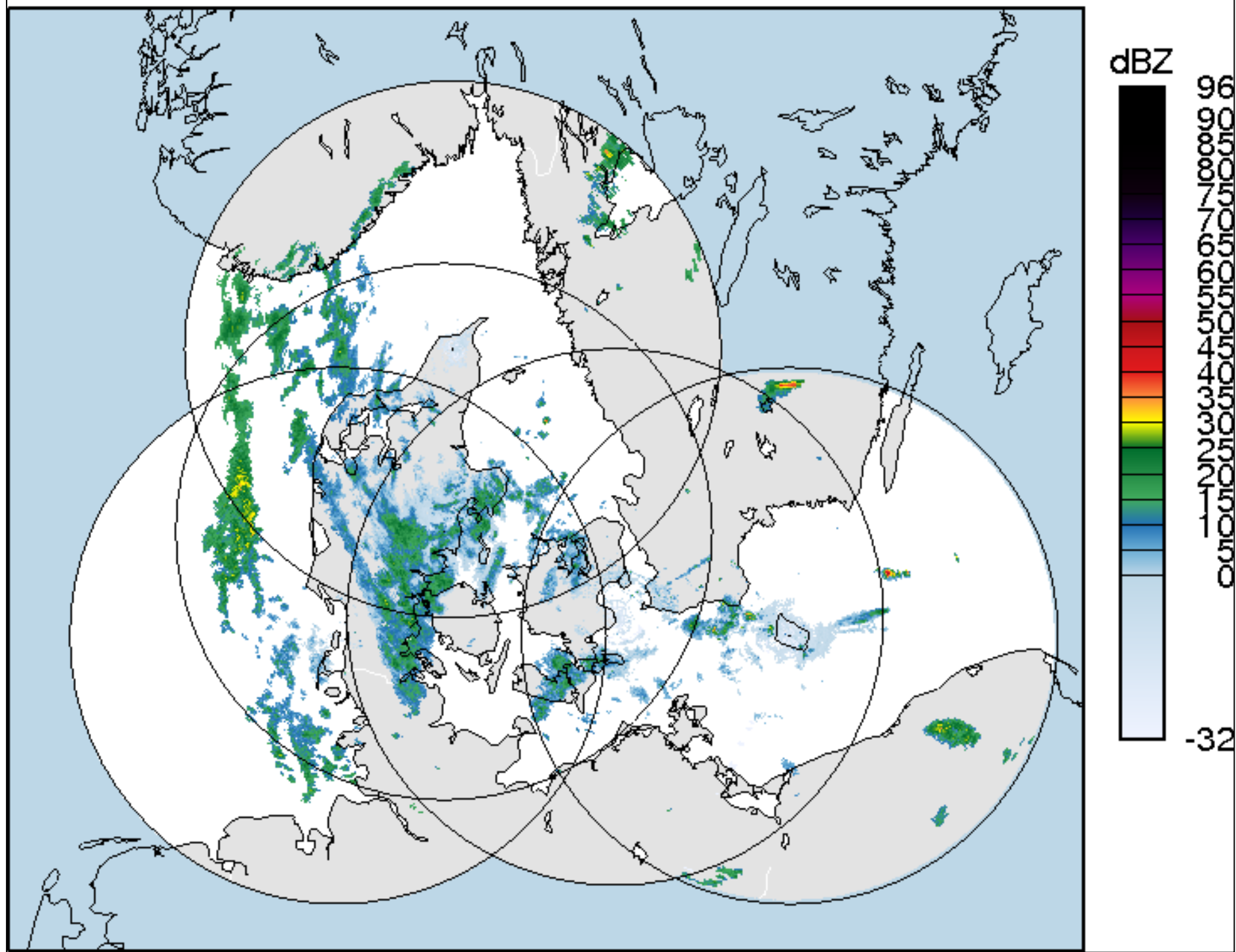
The most promising are radar data, ground-based GNSS data, ModeS data, and certain types of satellite cloud data. Exchange of more SYNOP data with some nearby countries would also help.
 - An NWP/computer system capable of doing **frequent assimilation and short range NWP forecasts, so-called "rapid update cycling" (RUC)**. E.g., assimilation every hour and 6 to 12 hour forecasts.

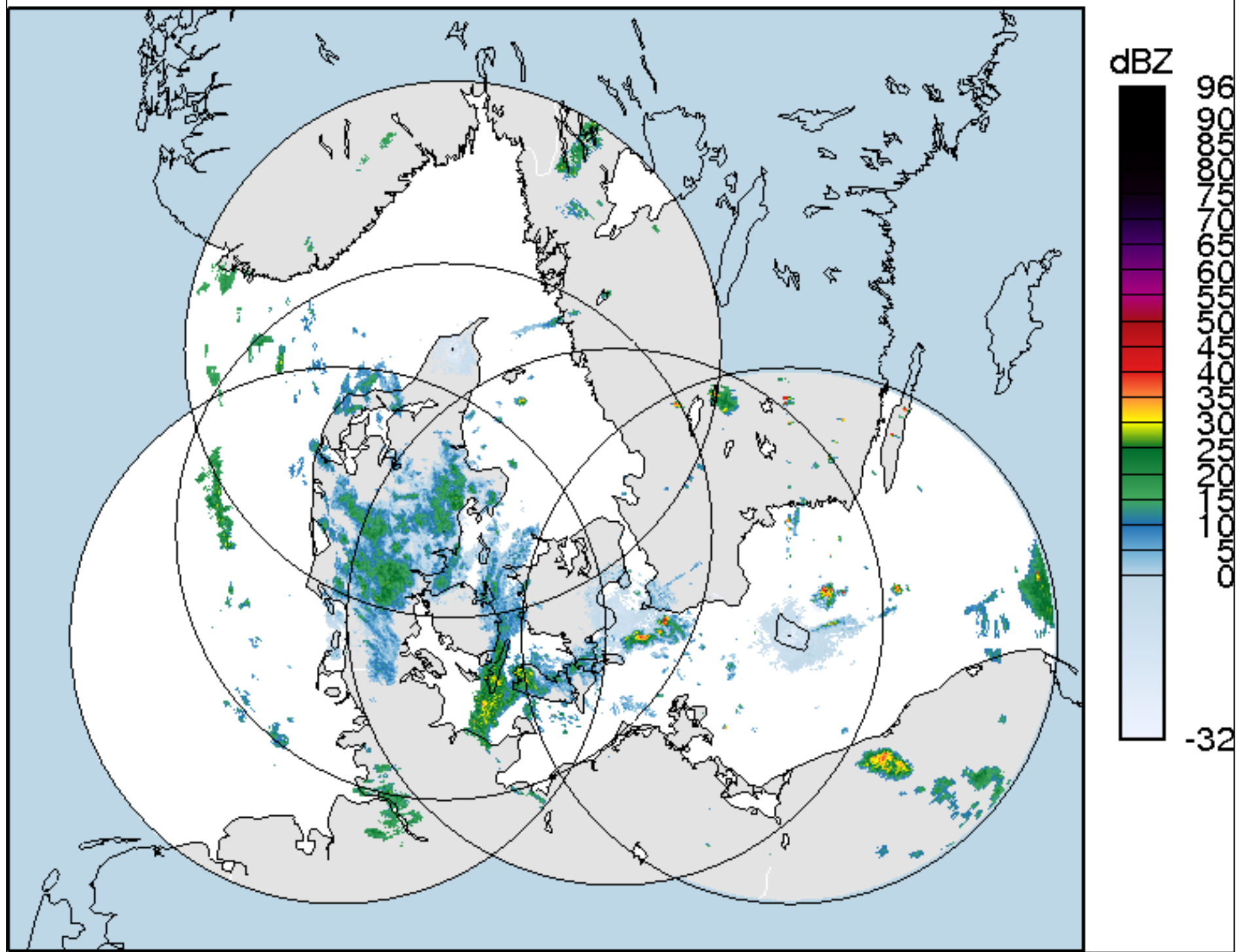
Spectral decomposition



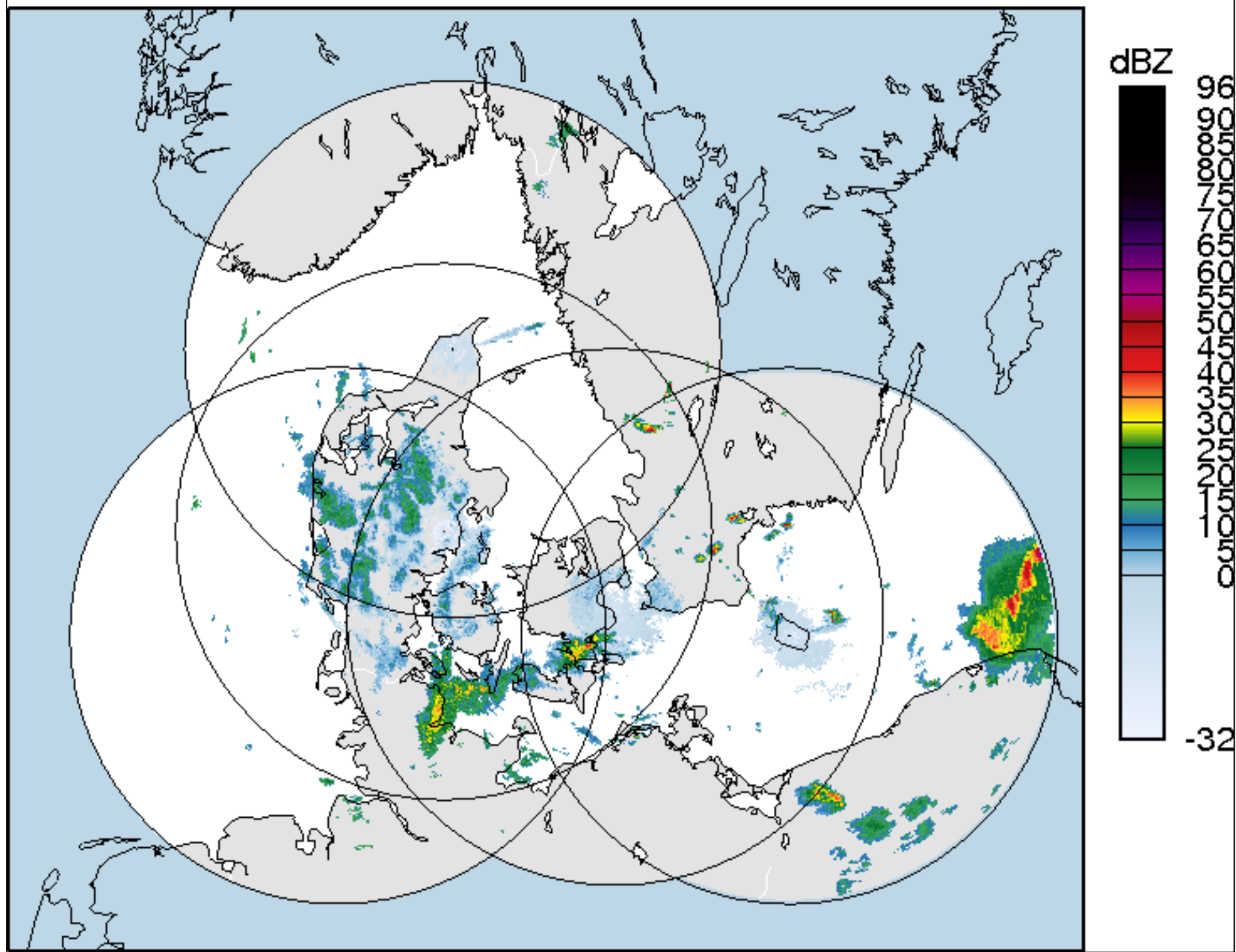
- Higher reduction of variance error for wavelengths corresponding to the higher values of variance spectra
- For wavelengths shorter than :
 - 200 km, only radar and plane measurements for temperature (GPS for specific humidity) contribute to the variance reduction
 - 100 km, the variance reduction reach only 5% of the error variance and it is only provided by radar observations

Composite reflectivity 201107021200

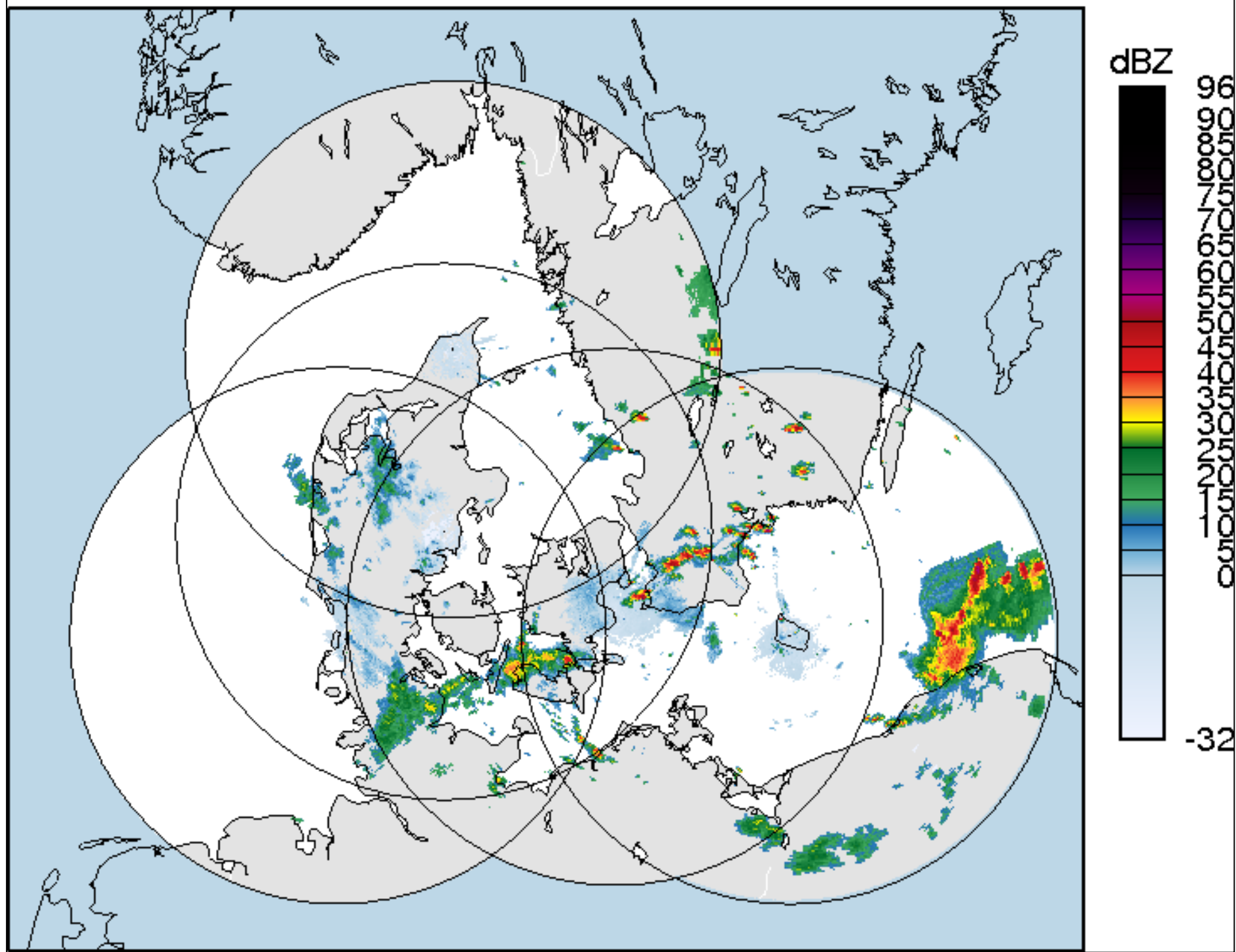




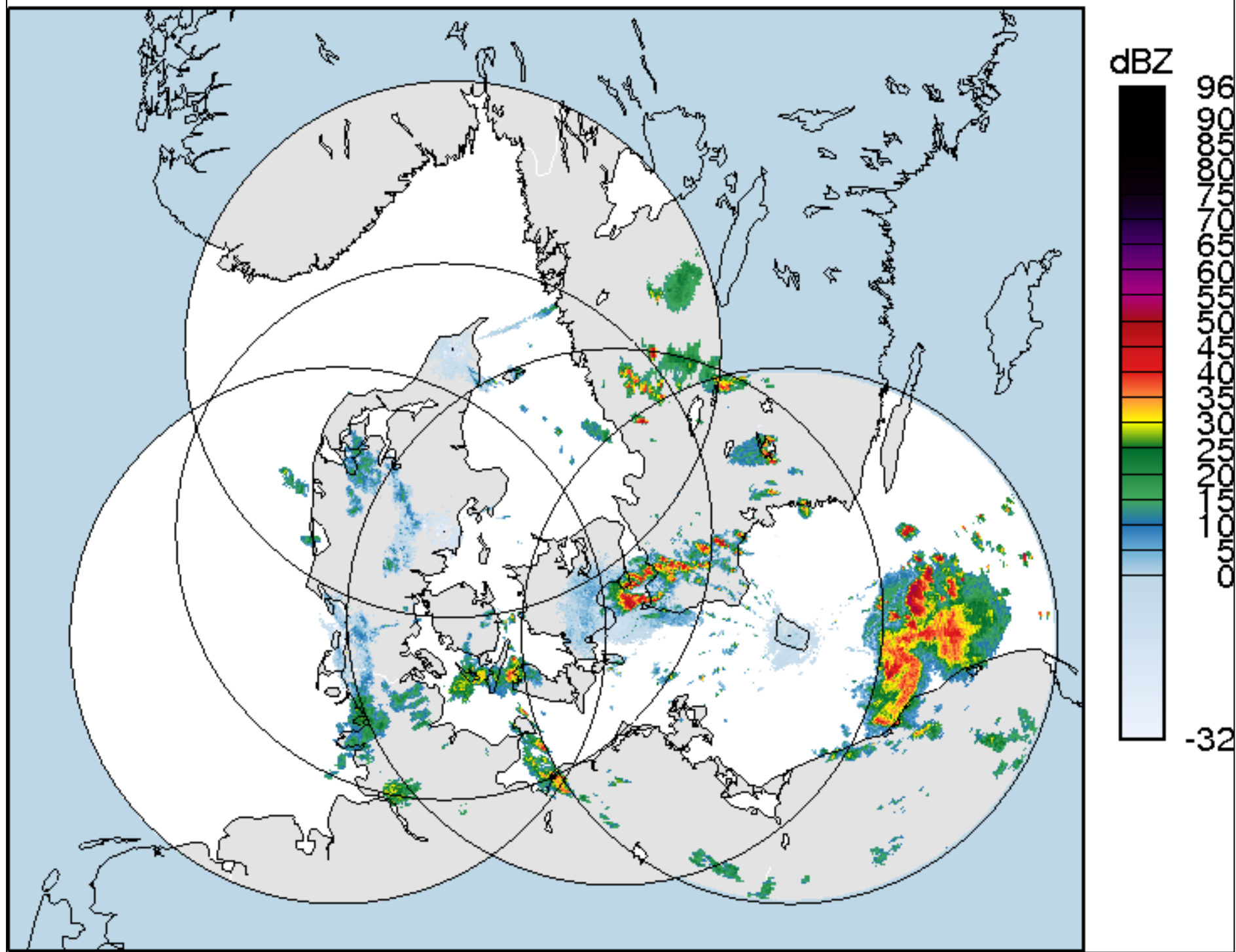
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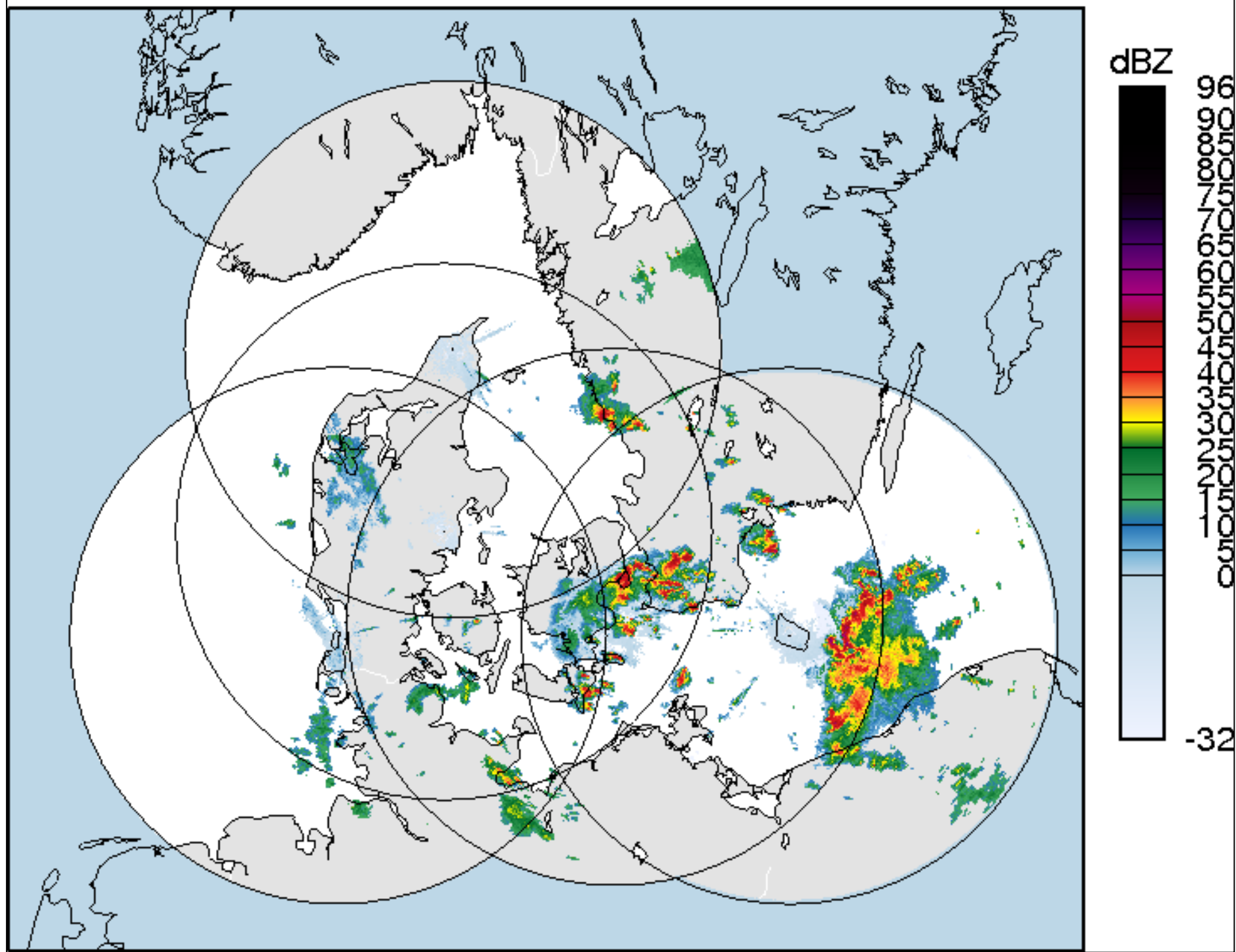
Composite reflectivity 201107021500



Composite reflectivity 201107021600

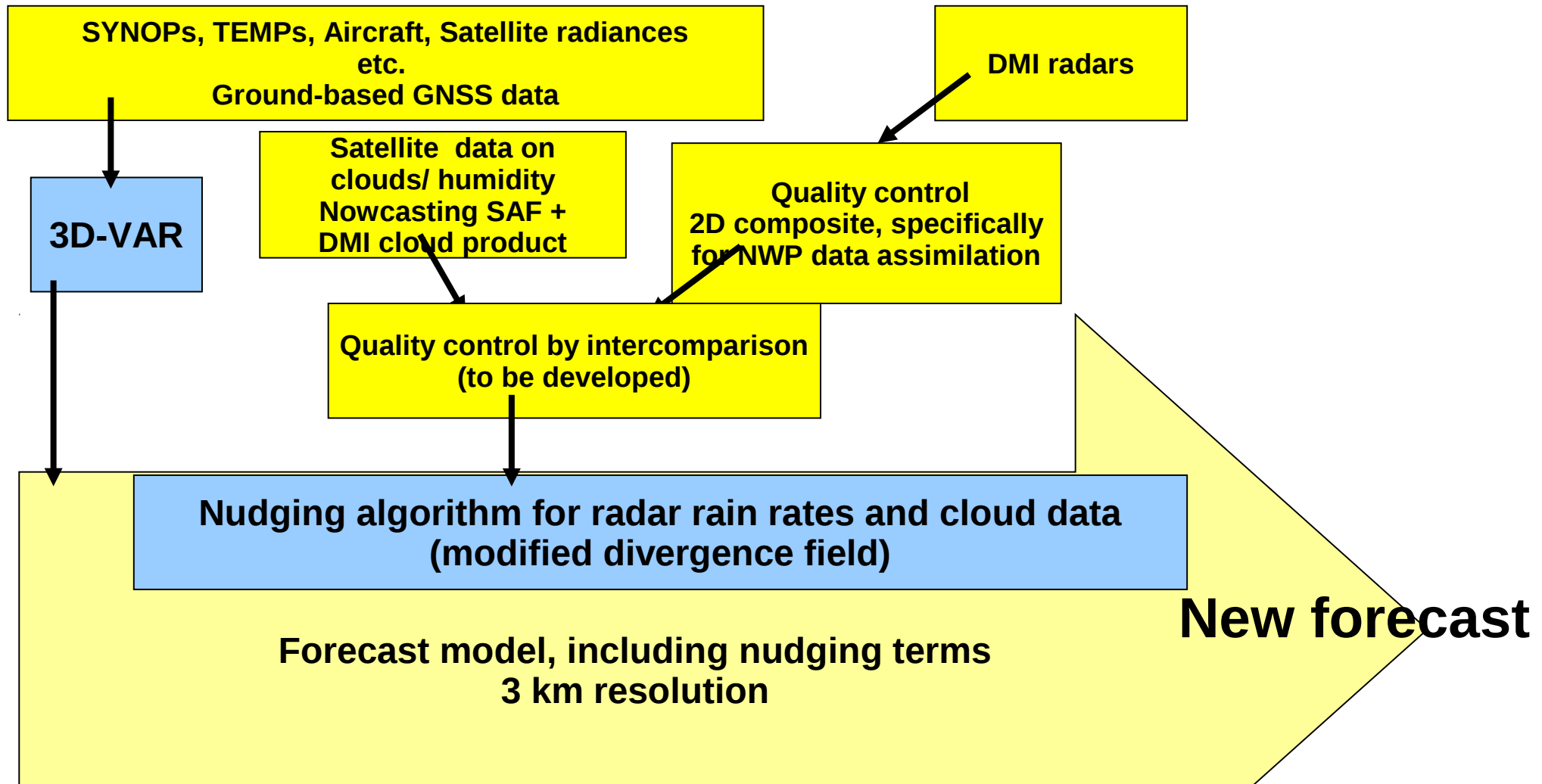


Composite reflectivity 201107021700



The GF system data assimilation is a two step procedure

- 1: Traditional 3DVAR, done hourly, with cut-off time of approx. 1.5 h.
- 2: Nudging, done hourly with very small cut-off time.

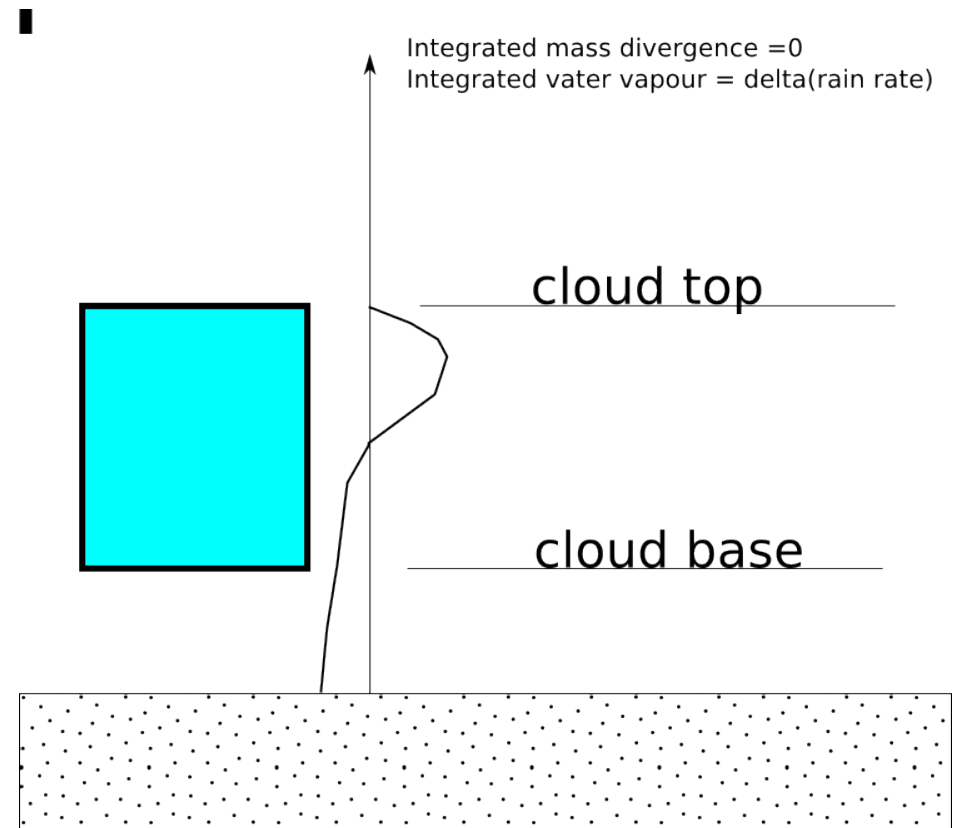
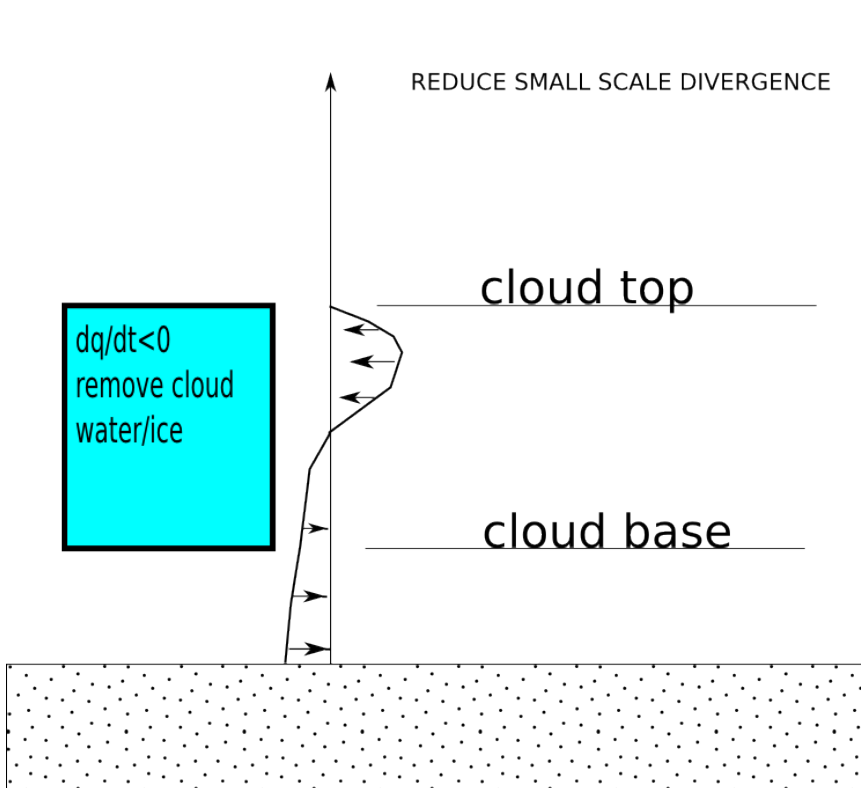


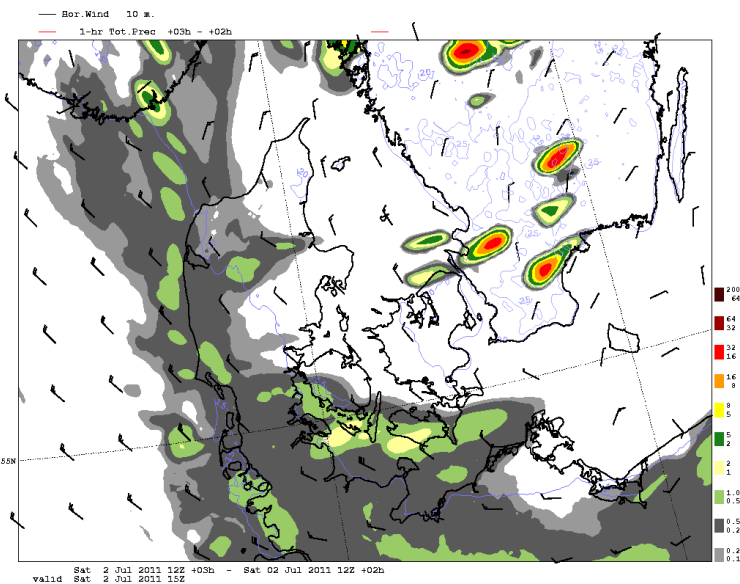
New forecasts minimum once an hour, possible several times per hour, each time including new observations in the nudging, and made available shortly after the valid time of the observations. The forecast takes about 5 min.

- **A new scheme (modifying the divergence field) for nudging of 2D radar composite data ("rain rates") have been developed.**
- **Tests have been done on assimilation of radar data, so far for July 2, 2011.**
- **The forecasts including radar observations clearly outperforms the control runs regarding both level, timing, and location of precipitation in the heavy precipitation case July 2, 2012.**

The principle in the "DMI nudging of precipitation"

- If observed rainrate is above NWP model rainrate, the divergence is reduced near ground, the opposite at top to conserve mass.
- If observed rain rate is below NWP model rainrate, the divergence is increased, and humidity reduced.





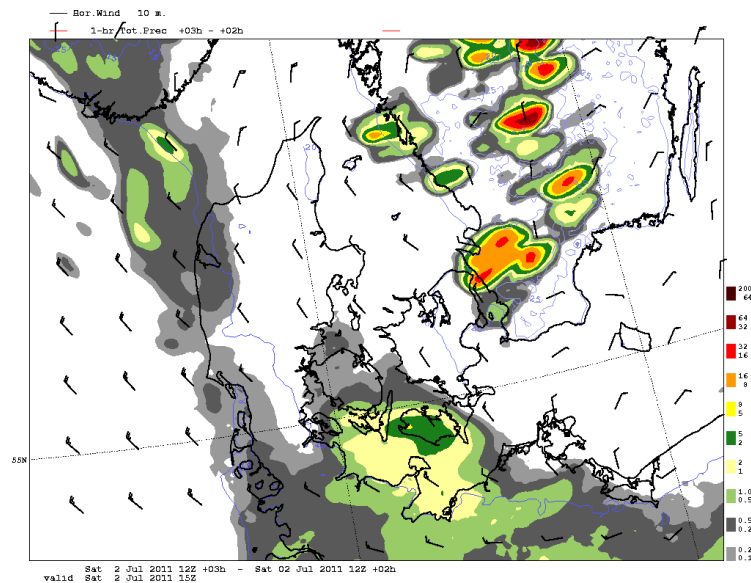
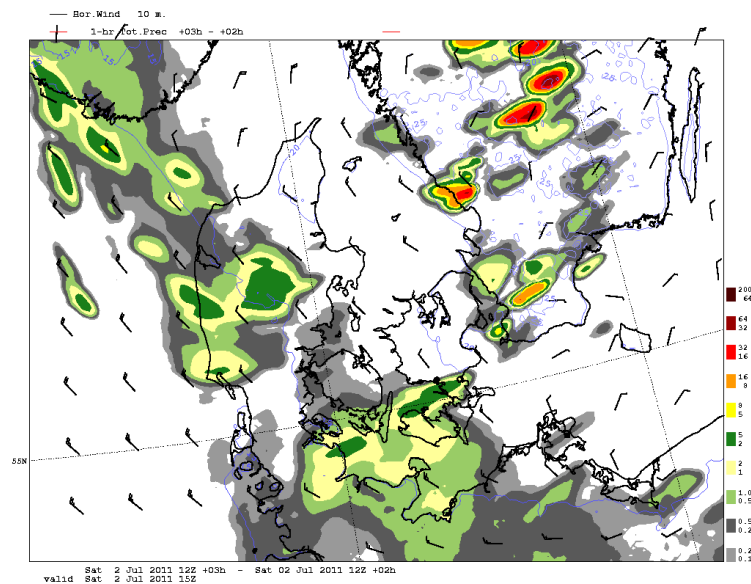
Operational

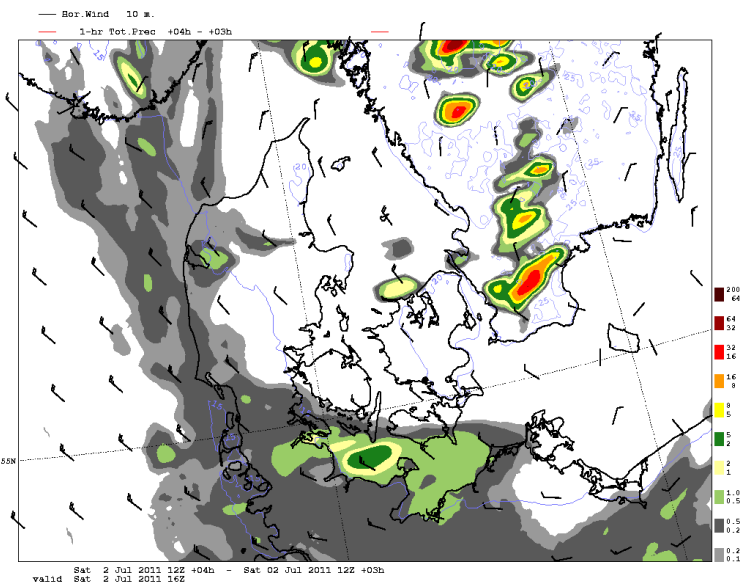
GF incl radar,
clouds, GNSS

Sequence of hourly precipitation
maps.

Precipitation 14-15 UTC

GF incl
clouds, GNSS



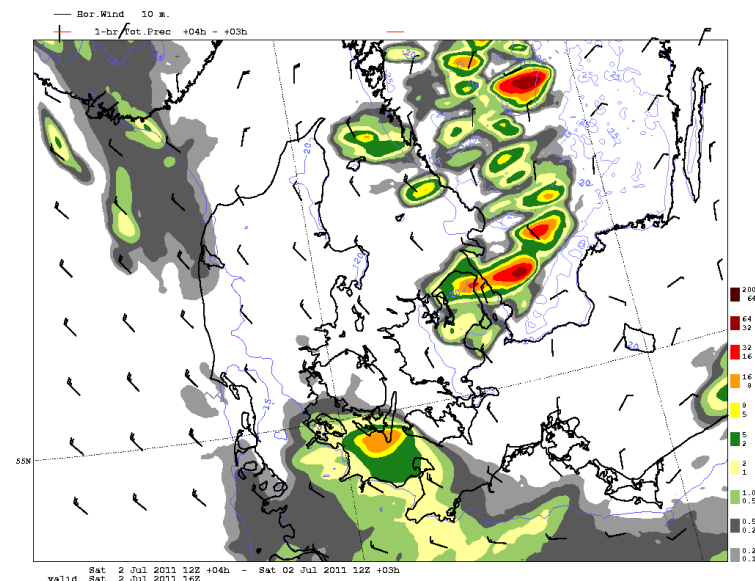
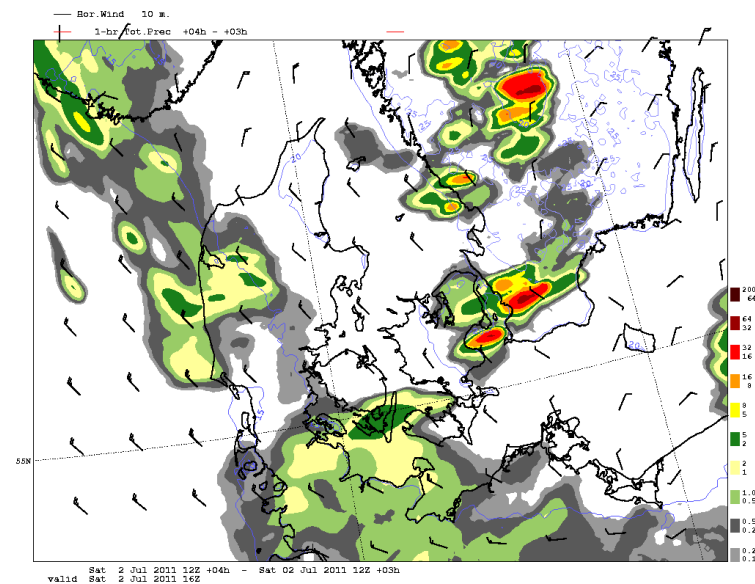


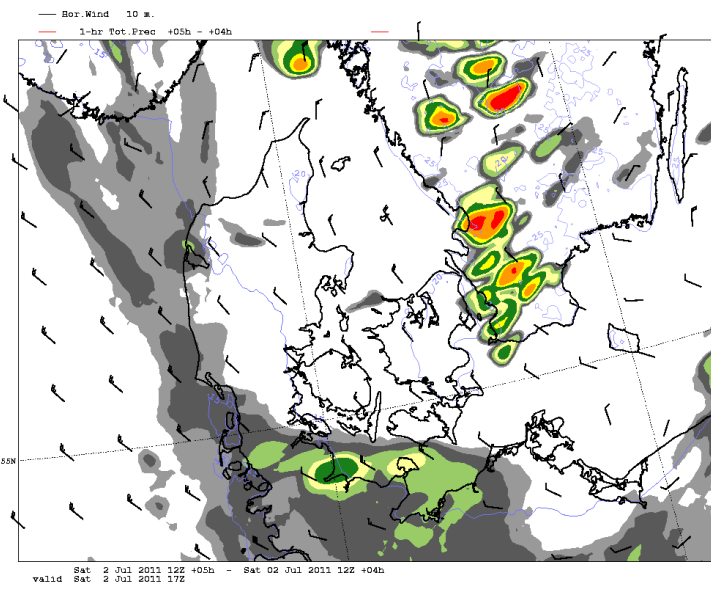
Operational

GF incl radar,
clouds, GNSS

Precipitation 15-16 UTC

GF incl
clouds, GNSS



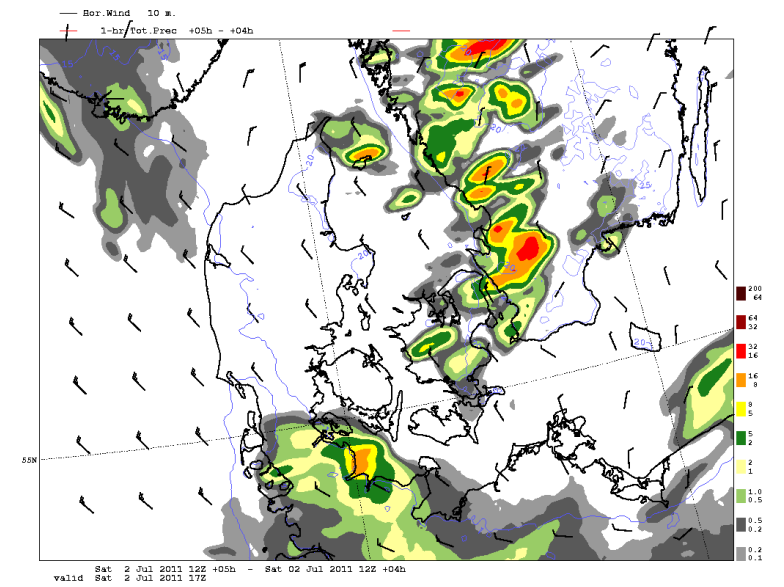
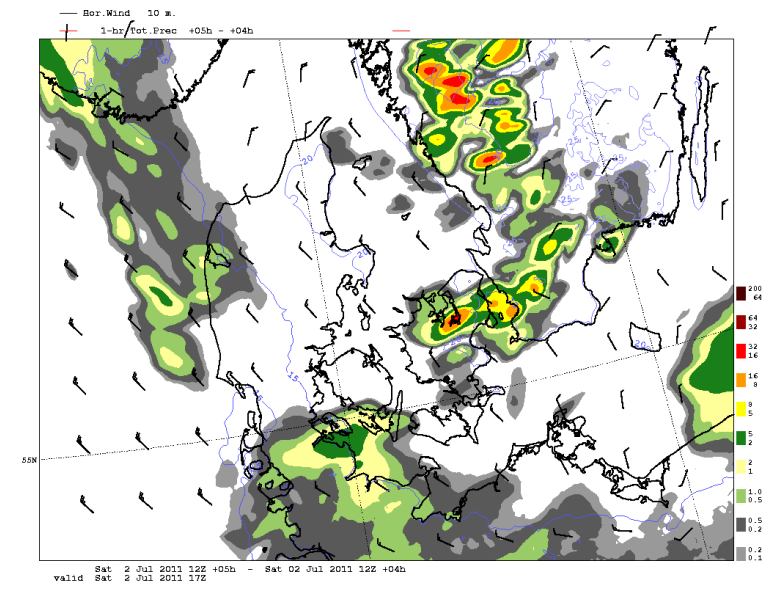


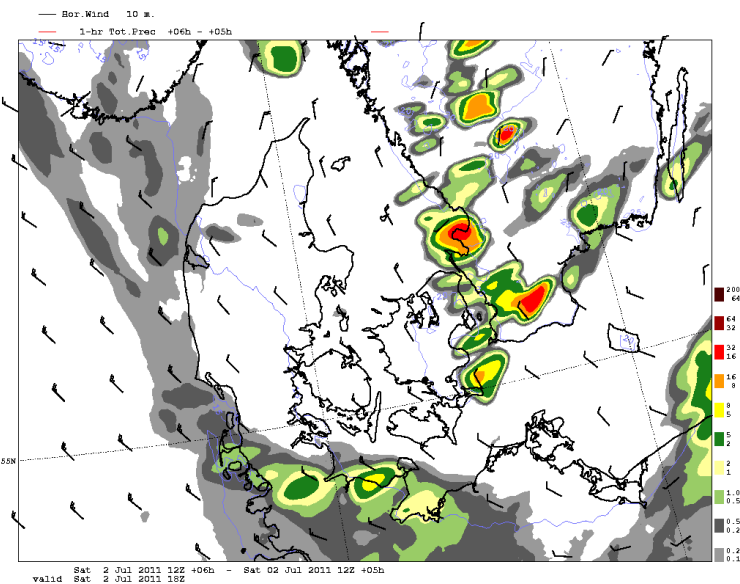
Operational

GF incl radar,
clouds, GNSS

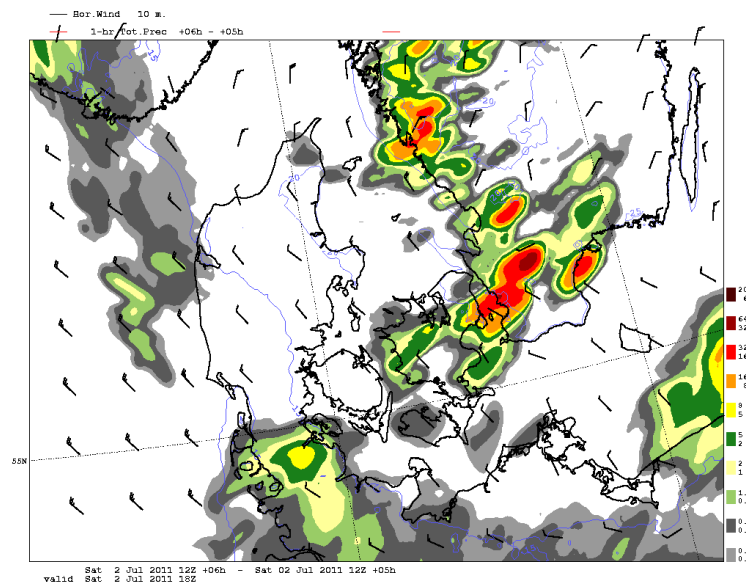
Precipitation 16-17 UTC

GF incl
clouds, GNSS

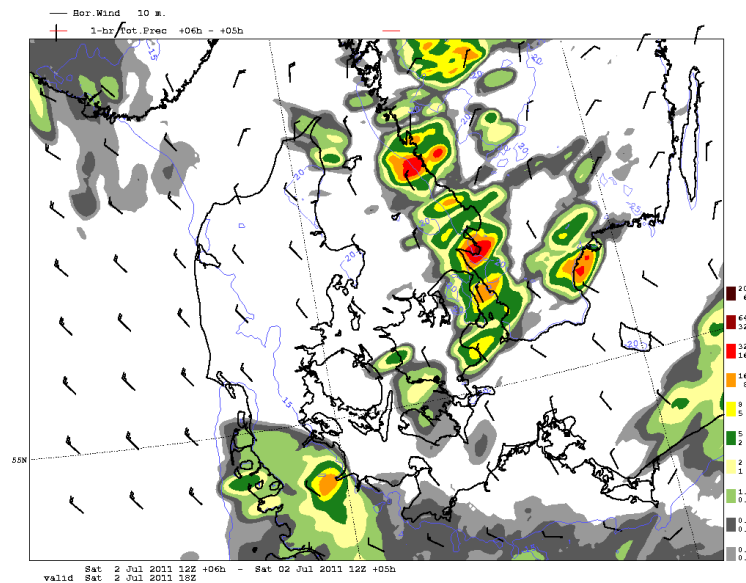


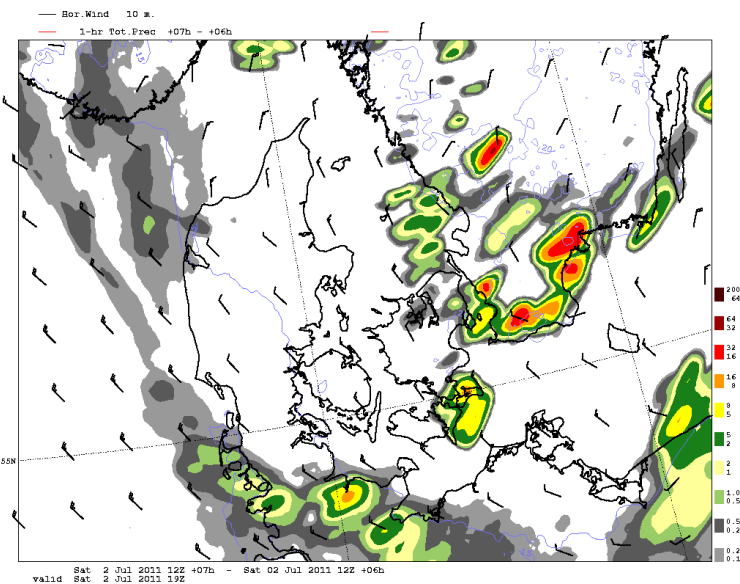


GF incl radar,
clouds, GNSS



GF incl
clouds, GNSS



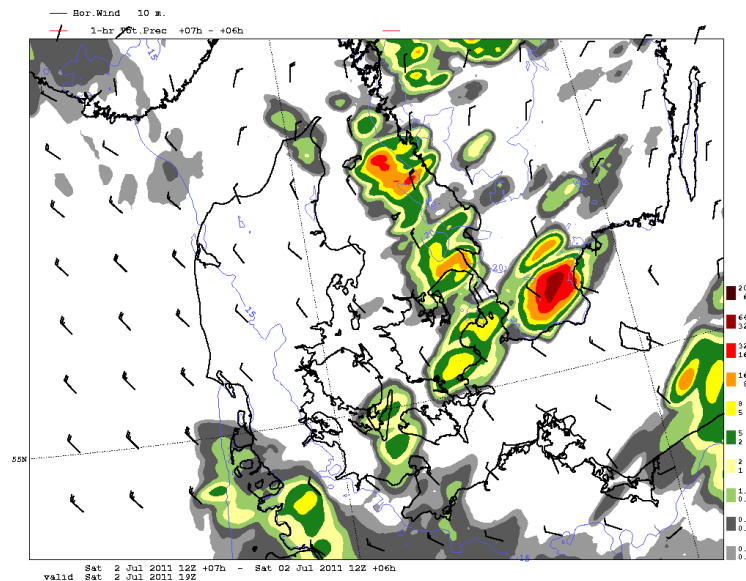
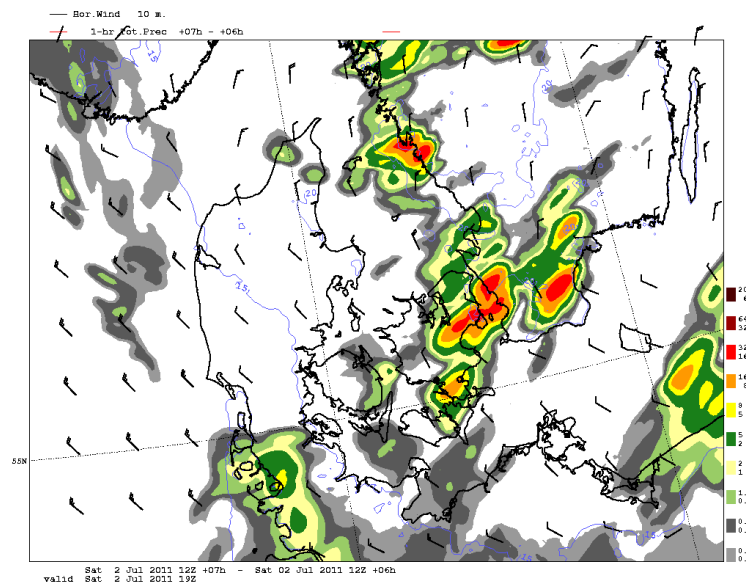


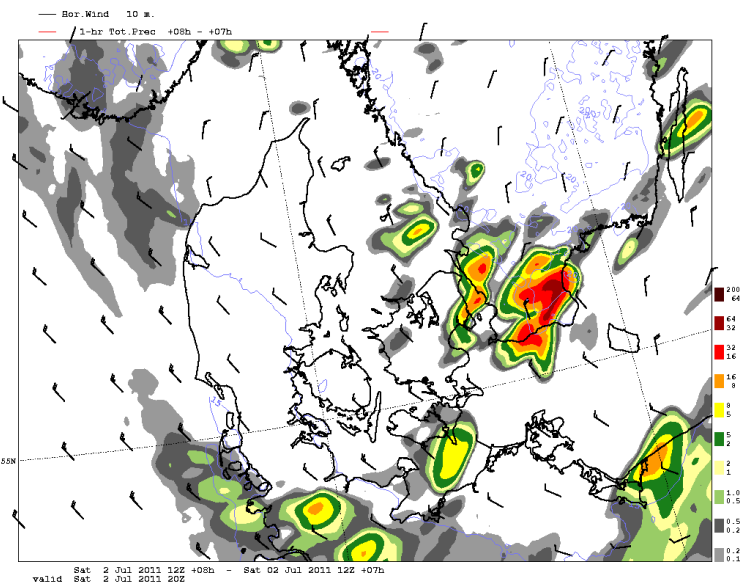
Operational

GF incl radar,
clouds, GNSS

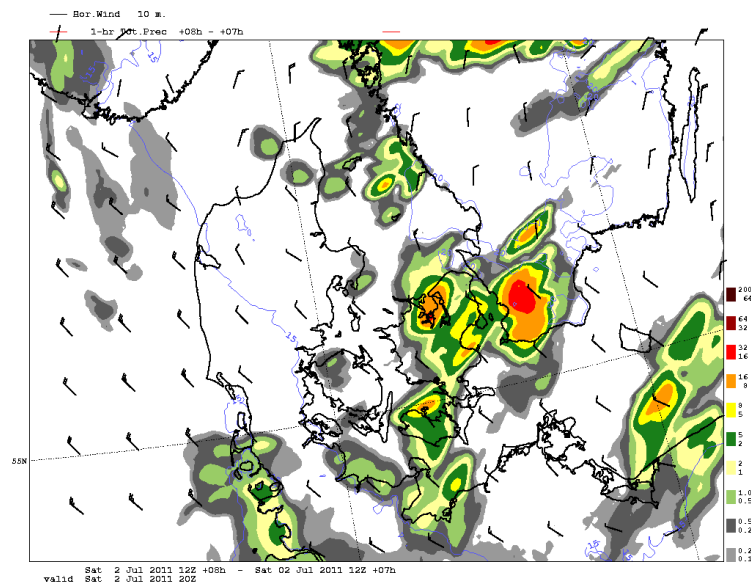
Precipitation 18-19 UTC

GF incl
clouds, GNSS

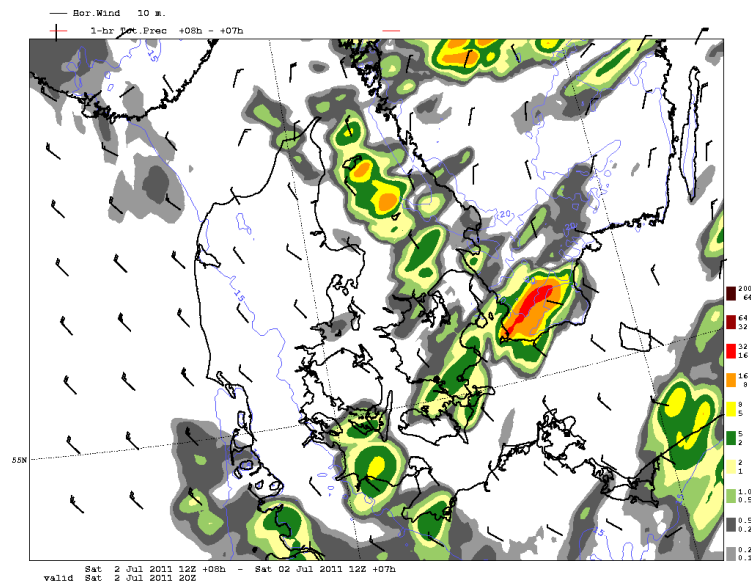


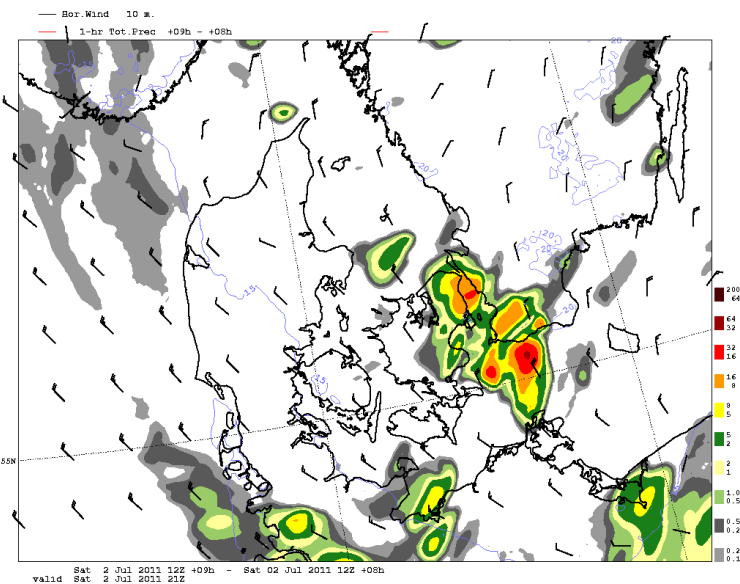


GF incl radar,
clouds, GNSS



GF incl
clouds, GNSS



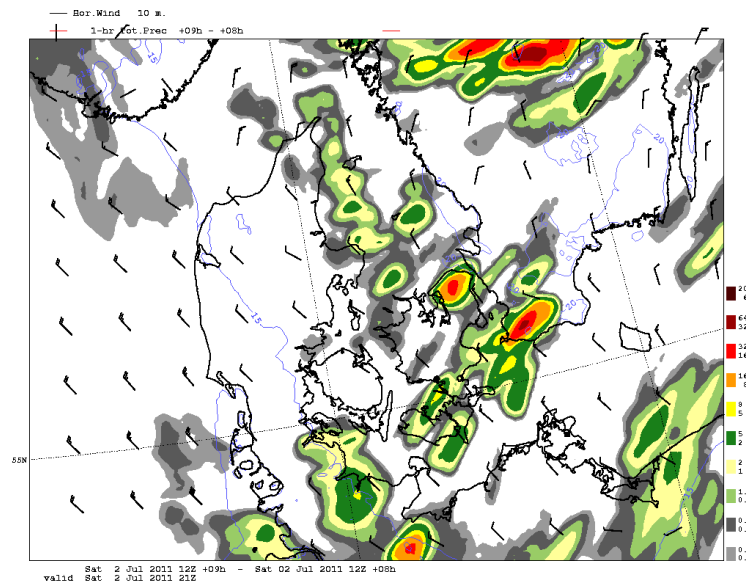
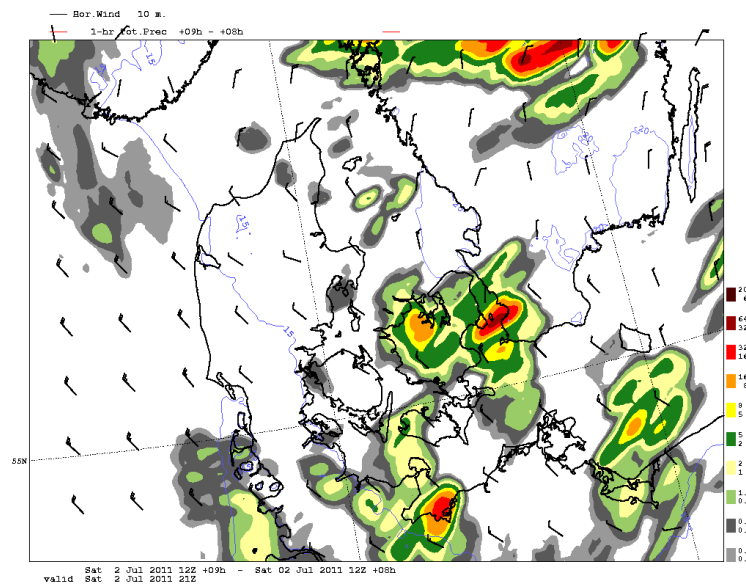


Operational

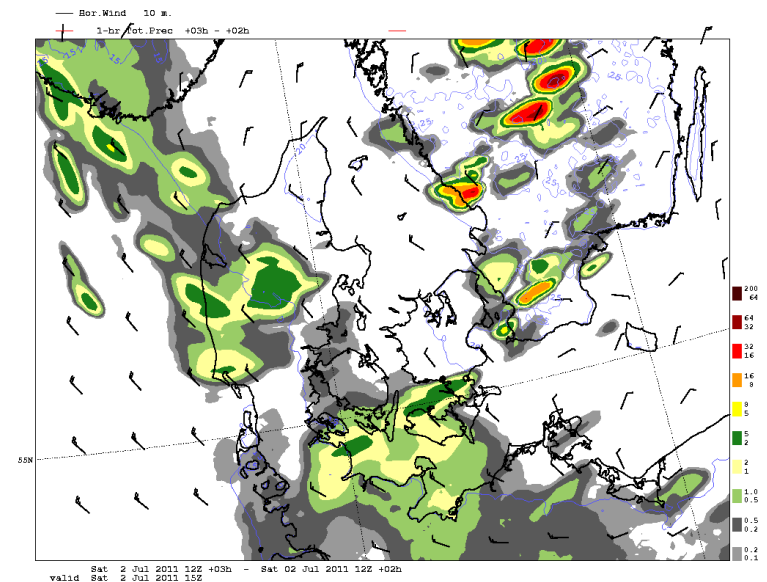
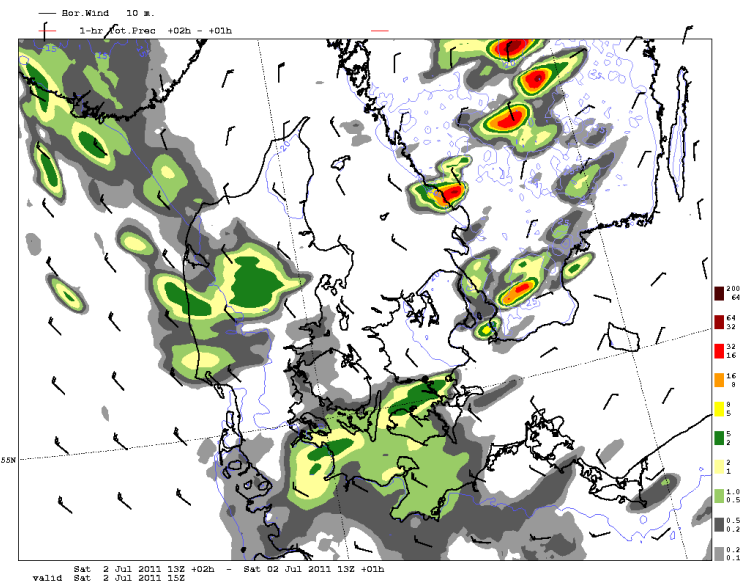
GF incl radar,
clouds, GNSS

Precipitation 20-21 UTC

GF incl
clouds, GNSS



Effect of hourly updates on GF with radar forecasts

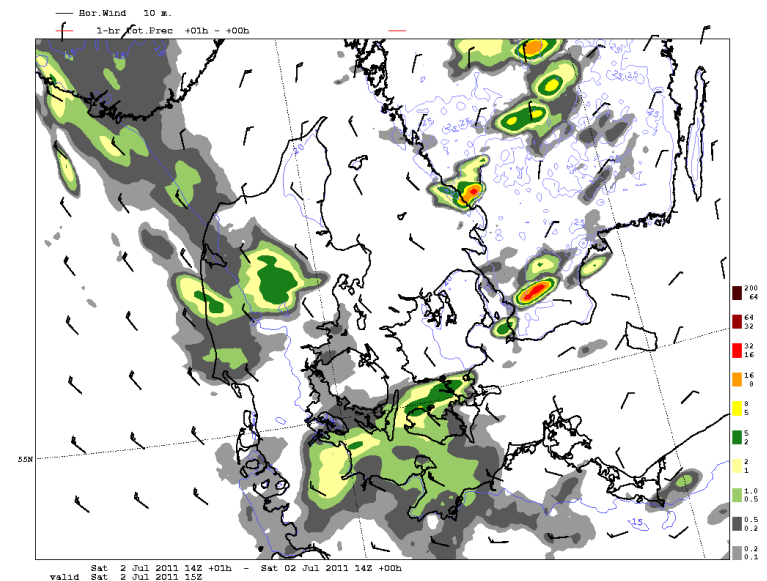


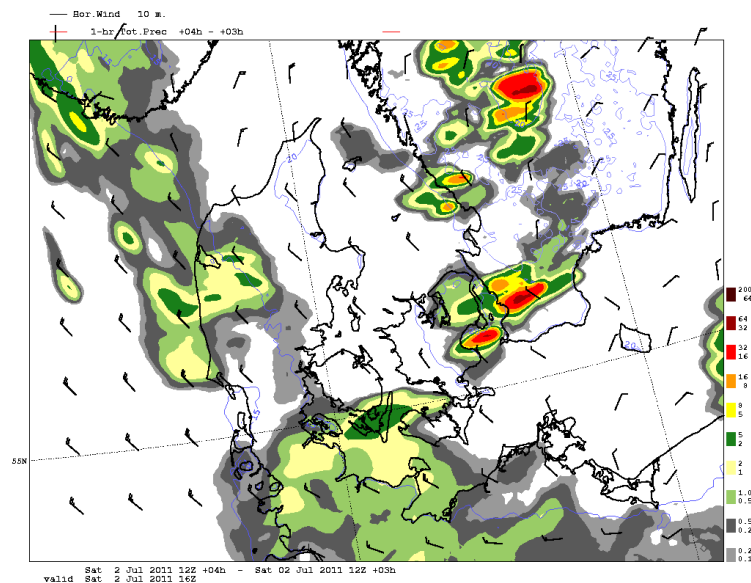
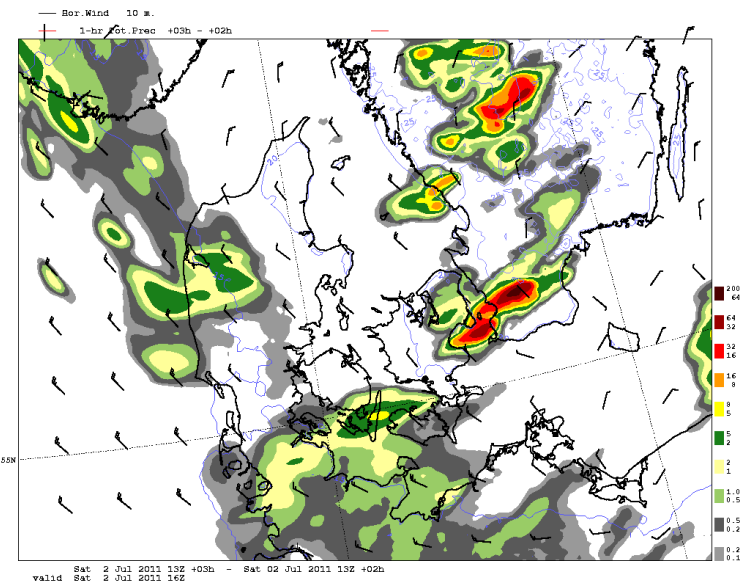
GF Radar 13 UTC GF Radar 12
All incl radar, cloud, GNSS

Sequence of hourly precipitation
maps.

GF radar 14

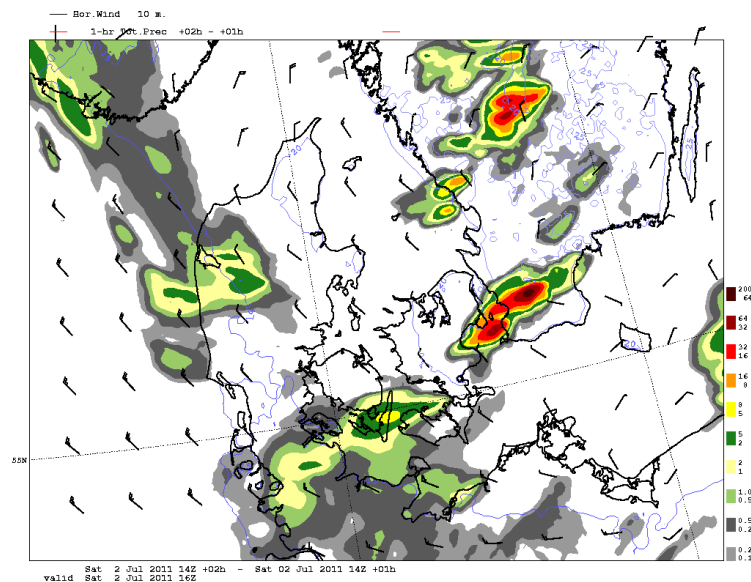
UTC
Precipitation 14-15 UTC

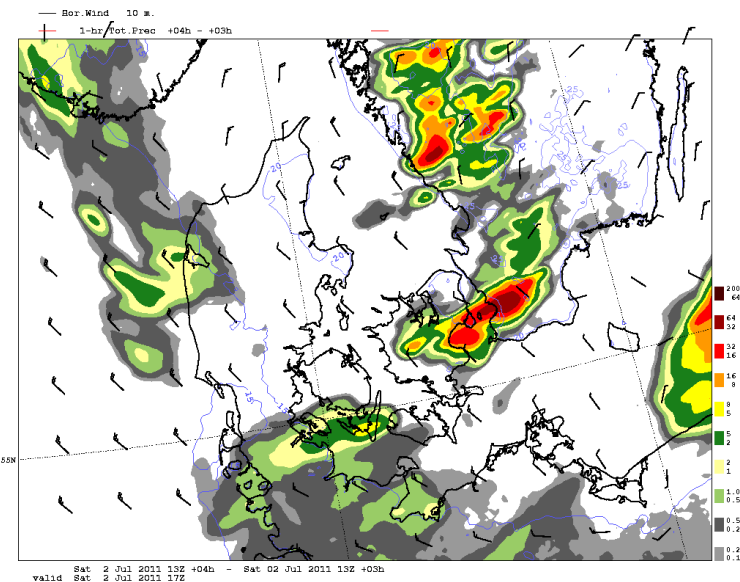




GF radar 14

UTC
Precipitation 15-16 UTC

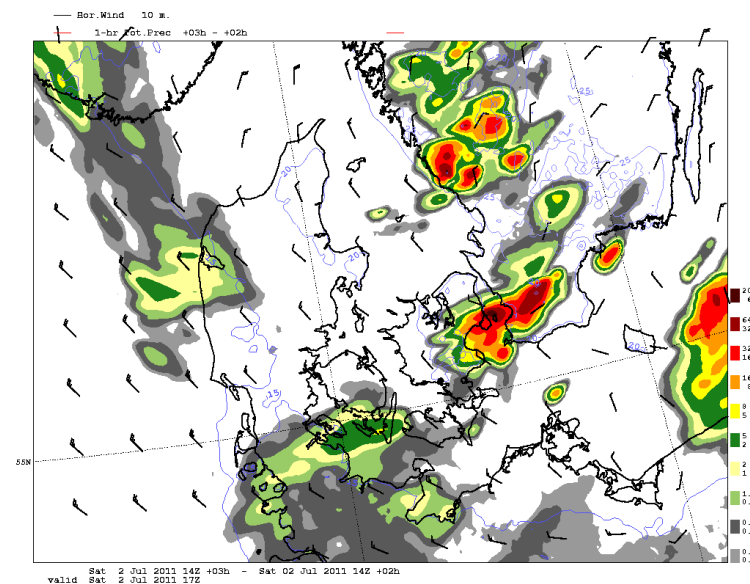
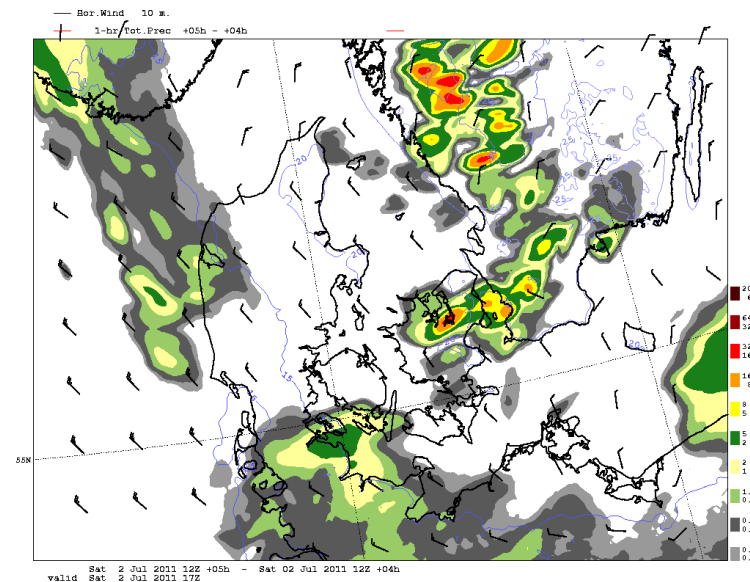


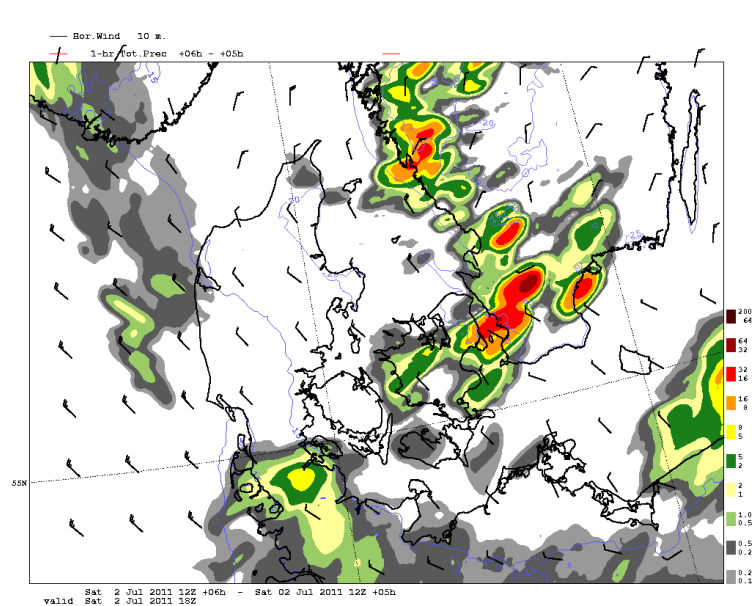
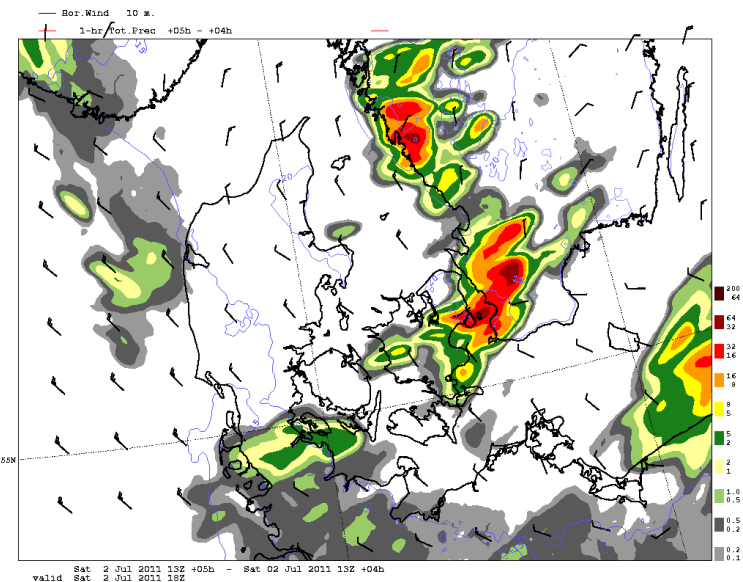


GF Radar 13 UTC GF Radar 12
All incl radar, cloud, GNSS

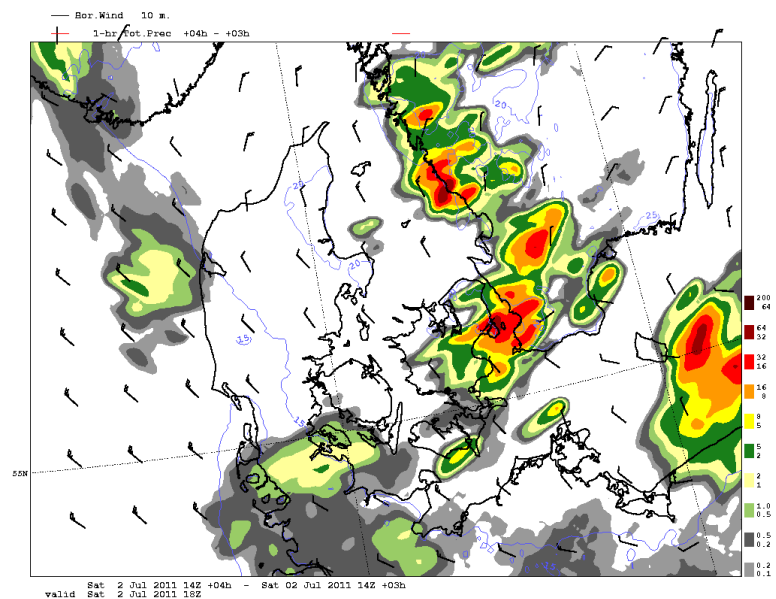
UTC
Precipitation 16-17 UTC

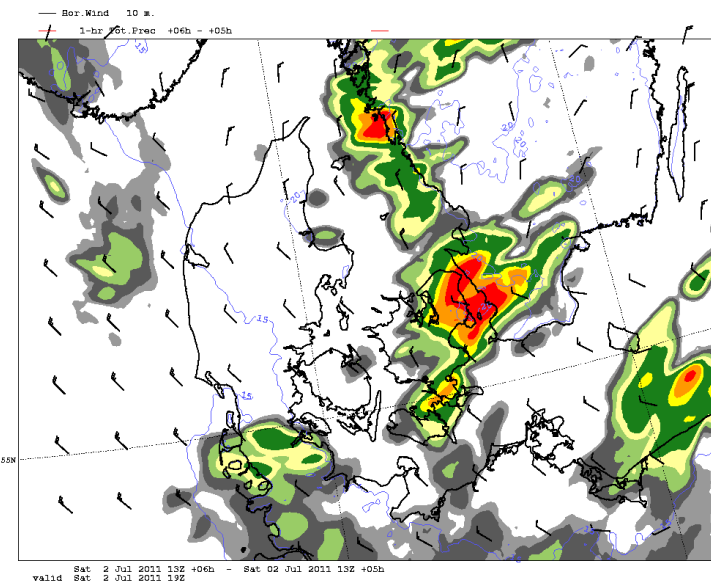
GF radar 14





Precipitation 17-18 UTC

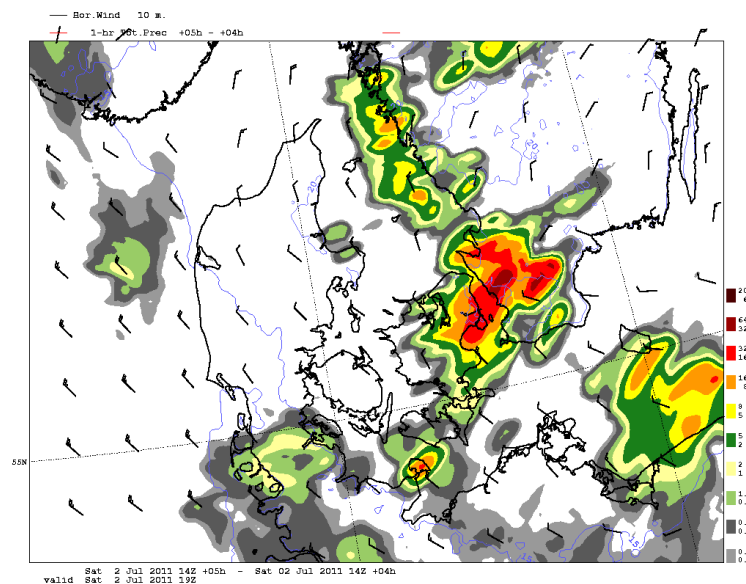
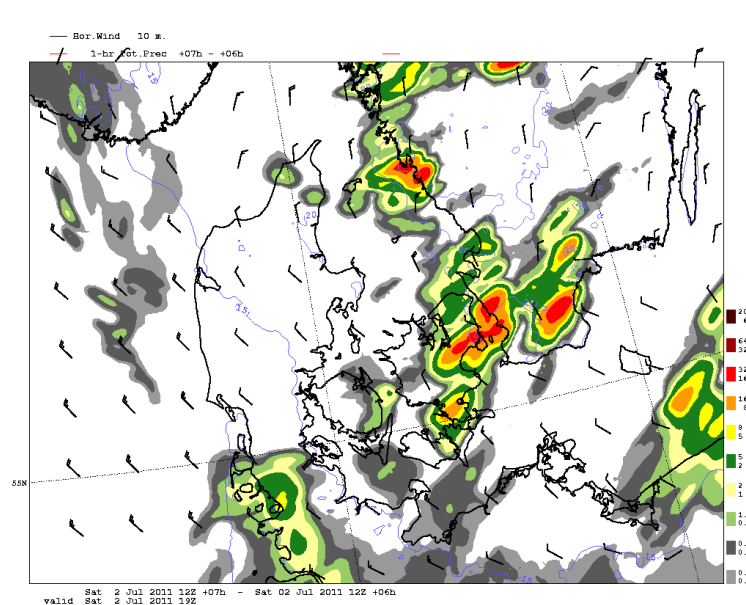


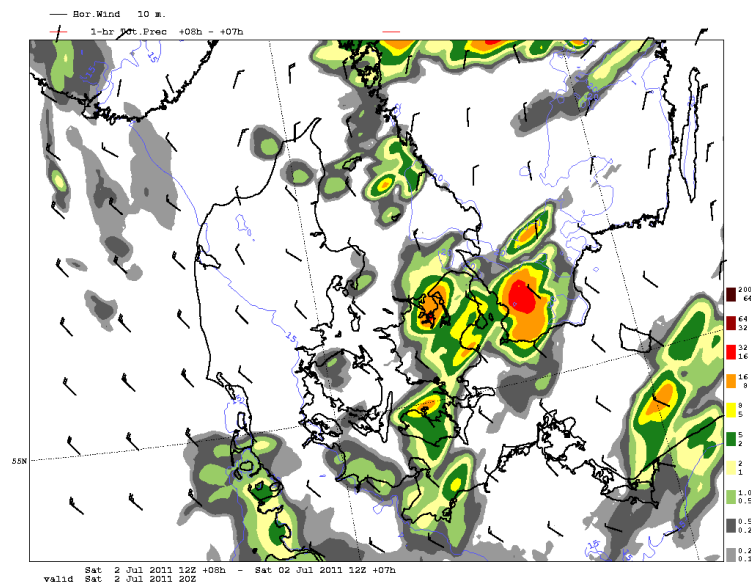
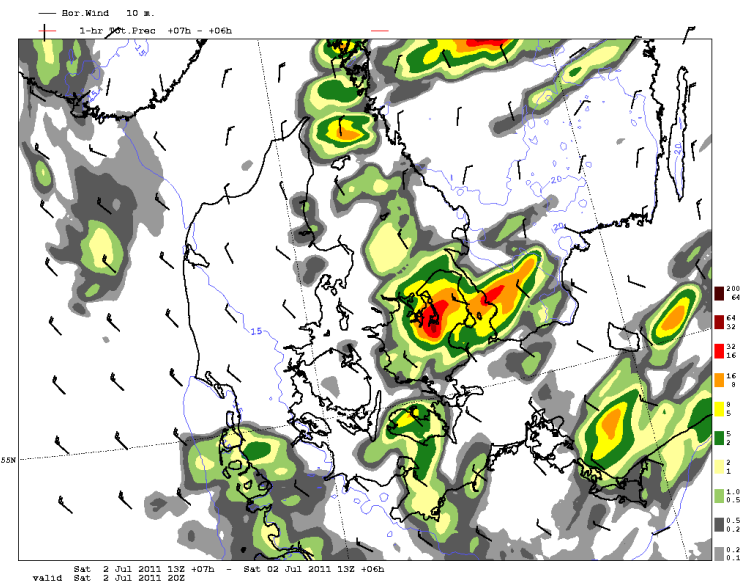


GF Radar 13 UTC GF Radar 12
All incl radar, cloud, GNSS

UTC
Precipitation 18-19 UTC

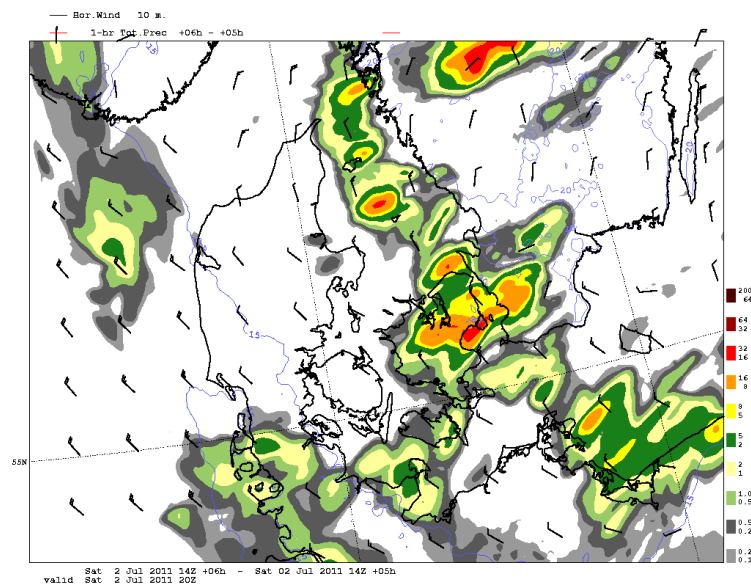
GF radar 14

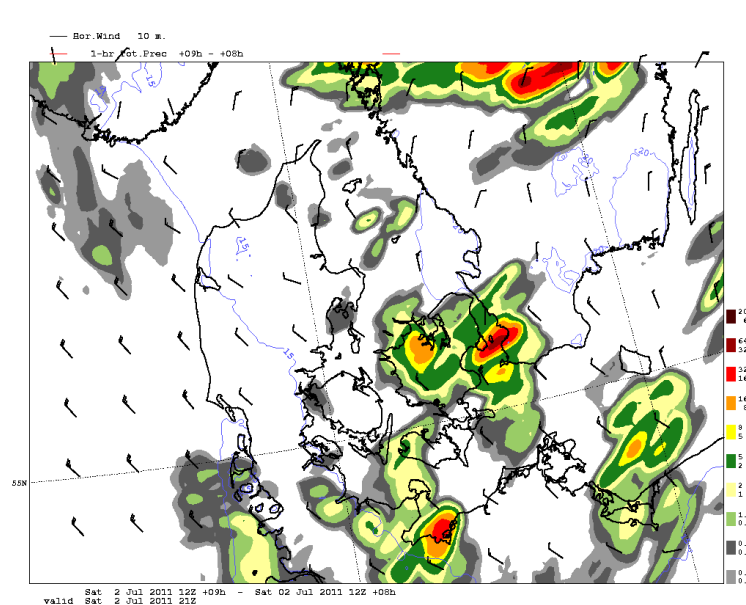
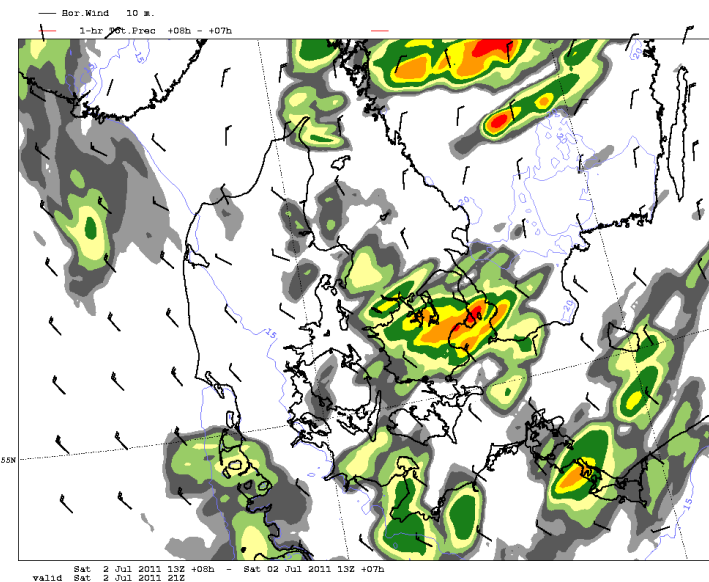




GF radar 14

UTC
Precipitation 19-20 UTC





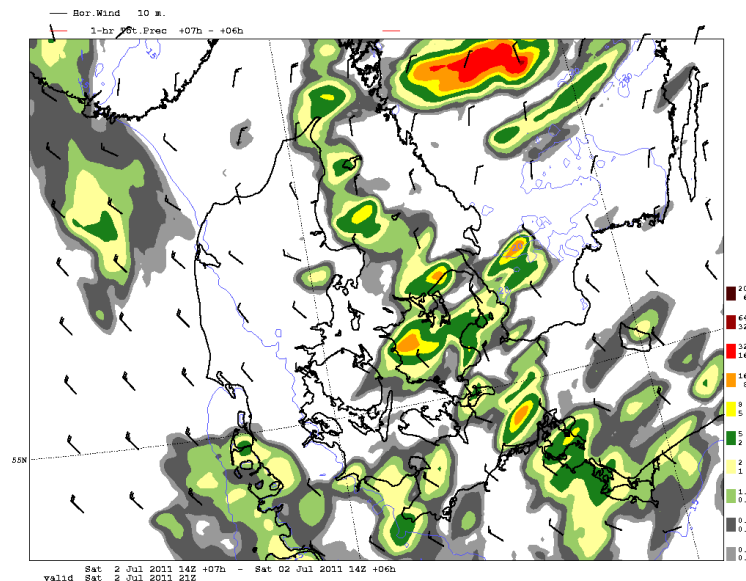
GF Radar 13 UTC GF Radar 12

All incl radar, cloud, GNSS

GF radar 14

UTC

Precipitation 20-21 UTC



- Tests are now being done for Nov-Dec 2011, the results are still under investigation.
- Next the model DMI-HIRLAM GF system with radar assimilation will be set up to run in parallel with the operational Slippery Road Model runs.
- This testing is vital, in order to develop and fine tune
 - the preparation of the 2D radar composite data,
 - the intercomparison quality control of the radar data and satellite cloud data.
 - the nudging scheme
 - the weight given to radar versus cloud information
- Cloud data: Assimilated into GF via nudging. New product made at DMI for assimilation and for verification of radar data.
- Rain verification dataset with hourly precip from Danish radars being developed and made available (in DMI "radarprojekt"). Crucial for verification – rain gauge data are not well suited for verification of high res. NWP. Again access to high quality radar data prior to rain estimation is vital.
- More ground-based GNSS data to be included (via 3DVar) and higher weight given to them.
- It is expected that by next summer these forecasts can be made operational. Pending the verification is good of course.