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The Danish weather radar network

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1 Introduction

The Danish Meteorological Institute (DMI) operates four c-band radars for weather monitoring. Three of these radars are doppler and were purchased from Electronic Enterprise Corporation (EEC) in the last 2 – 4 years. The fourth radar is an older non-doppler radar manufactured by Ericsson of Sweden and is situated on the island of Bornholm in the Baltic Sea. Geographical location of the radar sites is illustrated in fig. 1 below.

Fig. 1. The Danish weather radar network showing the location of the four radars together with the 240 km maximum range.

The operational radar parameters settings are summarised in table 1. In the current operational set up the volume scans are undertaken every 10 minutes. CAPPI products generated using the manufactures software package, together with the volume data are transferred to DMI via a 512 kb/sec internet connection.

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Table 1. Operational parameters settings for Rømø, Sindal and Stevns radars.

Radar parameter	Parameter value
Radar frequency	5.625 GHz
Radar peak power	250 kW
Pulse length used	2 µs
Radar range	240 km
Gate size settings	500 m
Radar rotational rate	20 deg./s
Pulse repletion frequency (prf)	250 Hz
Volume scanning angles (in degrees)	0.5, 0.7, 1.0, 1.5, 2.4, 4.5, 8.5, 13.0, 15.0

To improve the qualities of the data and to make an optimal use of radar resources a number of studies have been undertaken within the last 4 -5 years. Brief descriptions of these studies together with the results are summarized below.

2 Difference between EEC and Ericsson pseudo CAPPI products

In 2002 when the first of the radar from EEC was installed at Stevns the Weather Services Department of DMI, which is the main end user of these data, expressed some concerns about its data quality, especially in comparison to the data from Ericsson radars at that time. In particular, the users complained about the artificial ring structures and radial streaks, such as shown in figs. 2, which occasionally plagued the data. Further concern was the unusual number of false echoes in the data.

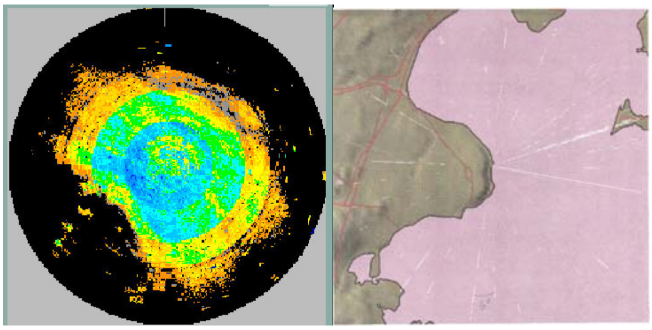


Fig. 2. Display of artificial ring structure (left) and the radial streaks (right) caused by external interference at Stevns from 26th February 2002.

Investigation showed that some of these concerns were due to the geographical location of the radar at Stevns rather than any fundamental differences in the sensitivity between the radars from the two manufactures. In particular during mainly early spring and late autumn the radar at Stevns suffers from sea clutter as the radar is unfortunately situated only ~ 100 m from coast on a ~ 40 m cliff. Further this radar also suffers from signal interference from radar situated at Sturup airport in southern Sweden. However, there were few differences which were due to the different parameters settings in the two radar systems, such as rain and atmospheric attenuation constants, and the numerical algorithms used to compute the individual CAPPI layers by the two manufactures. In the Ericsson software nearest neighbour method was used to compute the CAPPI reflectivities while in the EEC EDGE s/w these values are computed using weighted average. Other differences were contributed to the performance of the noise removal filters in the two radar systems. Full details of the comparison between EEC and Ericsson radars are given in Gill and Overgaard, (2002).

3 Monitoring the calibration and elevation differences of the radars using NORDRAD radar pair comparison method

Between 1999 - 2002 NORDRAD member countries developed numerical data analysis tools to monitor the performance of the radars in their network, Huuskonen et. al., (2002). Their aim was to ensure that the calibration difference between the 20 odd radars in their network remained within ± 2 dB on a monthly basis. Today these software tools play a very important part in achieving this goal.

As the NORDRAD's radar monitoring tools is equally relevant to the DMI's radars, it was decided to implement them and see what can be learnt about the quality and performance of the radars in the DMI network. The results of the analysis showed the possible quantitative differences between the three EEC radars in the DMI network and are reported in Gill and Overgaard, (2005a). In particular, using the data for 2004 gave the following results:

1. Calibration difference between:
   (Rømø – Stevns) ≈ + (3.23 ± 1.39) dB
   (Rømø – Sindal) ≈ + (3.8 4± 1.19) dB
   (Sindal – Stevns) ≈ -(0.05 ± 1.54) dB

2. Elevation difference between :
   (Rømø – Stevns) ≈ 0.16º ± 0.10º
   (Rømø – Sindal) ≈ -0.51º ± 0.13º
   (Sindal – Stevns) ≈ 0.50º ± 0.10º

The above results imply that in comparison to Sindal and Stevns radars Rømø radar has a possible bias of ≈ +3 dB. Recalling that as a general rule of thumb, a difference of 5 dBZ translates to ≈ 50 % difference in the deduced precipitation rate (mm/hour). Further, it appears that, in comparison to Rømø and Stevns radars, Sindal radar is pointing ≈ 0.5º upwards in elevation.

As a result of these findings investigations have been initiated to under-ping the reasons for these differences.

4 Difference between the pseudo CAPPI and the EEC BASE products

Ad-hoc manual interpretation of the pseudo CAPPI product used at DMI to display the weather data from its radars and the EEC BASE product generated by the manufacture of these radars have shown that there is significant difference between them. In particular, it has been noticed that the latter does not contain the false echoes that occasionally plague the pseudo CAPPI product from Stevns radar nor artificial ring structure that are observed during heavy participation. These are illustrated in figs. 3a and 3b.

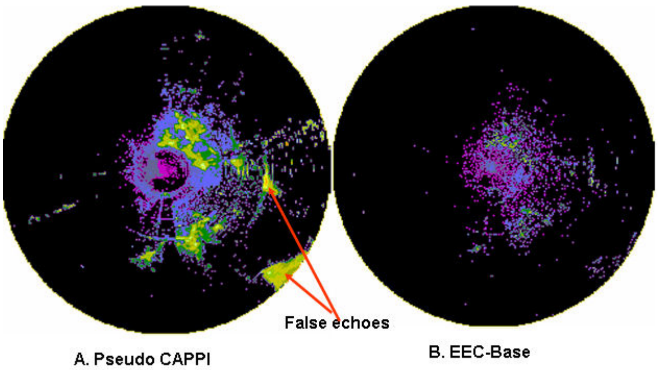
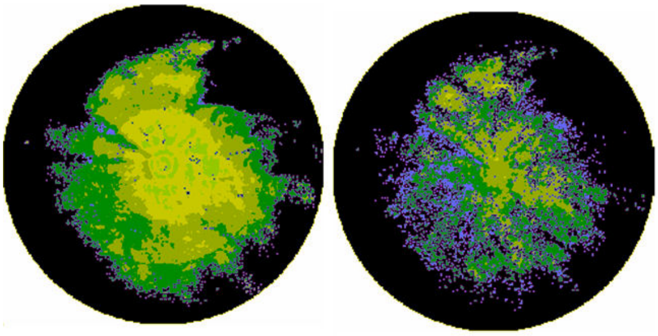


Fig. 3a. Display of false echoes (sea clutter) in the pseudo CAPPI and the EEC BASE products by the radar at Stevns 4th September, 2004.



A. Pseudo CAPPI B. EEC-Base.

Fig. 3b. Pseudo CAPPI and EEC BASE product displays by the Sindal radar, 17th October 2004 during heavy precipitation.

The study has shown that the observed difference between the pseudo CAPPI and BASE products is due to the fact that the two products represent different ‘cross-sections’ of the three dimensional precipitation volumes measured by the radars. The EEC BASE product represent the bottom of the precipitation front i.e., its lowest altitude above the surface of the Earth, and hence the term base. It is created by projecting each of the PPI scans in a three dimensional cube and then examining each column separately and allocating to it the lowest, clutter free, reflectivity. The pseudo CAPPI product, on the other hand, is created in the usual way by first creating the CAPPIs at specified altitudes and then simply stacking them on top of each other, with the lowest altitude on top of the stack. At DMI the 11 CAPPIs are created at altitudes of 1 km, 2 km , …, 11 km.

The main reason for the ring structure, which is sometimes observed in the DMI’s pseudo CAPPI products during heavy precipitation, is the large altitude step size of 1 km between the successive CAPPIs. A much improved pseudo CAPPI product is expected if more CAPPIs are created at intermediate heights so that the altitude differences between successive CAPPIs is reduced. It is planned to generate a new pseudo CAPPI product which is based on CAPPIs created at ¼ km - ½ km height interval starting at 1 km.

As regard to removing false echoes in the EEC BASE and the pseudo CAPPI products, it was found that heavy clutter filter is used in the EDGE software. Detailed analysis has shown that the clutter filter is very effective at removing unwanted false echoes in severe anomalous wave propagation events from e.g., the Stevns radar, while other times it has the unfortunate affect in removing real precipitation pixels of even up to moderate intensity (range ≈ 15 dBZ to 30 dBZ corresponding to 0.34 mm/hour to 5.6 mm/hour of precipitation). One of the unfortunate consequences of the latter is that the BASE product shows much reduced precipitation, especially towards the outer boundary of the radar coverage. As a result of the above findings it was decided not to use the BASE product. For more detailes the reader is referred to Gill and Overgaard, (2005b).

Based on the BASE and the more traditional pseudo CAPPI product a new in–house developed algorithm for the representation of the 3[D] volume scans in 2 [D] space is undergoing evaluation. In the new algorithm the raw volume data is used in the computations and it is based on the BASE product indicating the lowest altitude of the precipitation and further some of the none precipitation echoes such as signal from external emitters are removed. Fig. 4 shows an example of the output from the new product.

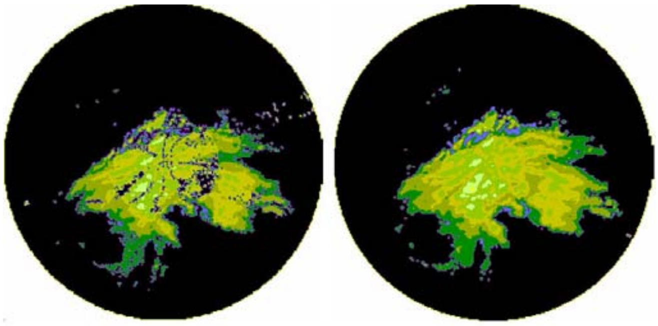


Fig. 4. Current DMI pseudo CAPPI (left) and the new DMI BASE (right) products, from Stevns radar 5th December 2005.

5 Current and planned activties

To further improve the quality of the data and to make an optimal use of radar resources a number of studies are underway or are planned in the near future. For example, the current scanning strategies are under review so as to generate additional high resolution precipitation product within a radius of ˜ 100 km and doppler winds product. New products aimed at commercial customers are planned, e.g., improved areal precipitation product using combined weather radar and ground measurements and short term precipitation forecast by a combined use of the above two data sources with model forecasts from numerical prediction models and satellite products from the Satellite Application Facility (SAF) on Nowcasting.

Since 2005 a PhD project, in collaboration with the Institute of Informatics and Mathematical Modelling, Technical University of Denmark, is underway concerning the elimination of false echoes such as sea clutter signals in radar data.

The current geographical location of the four radars gives Denmark already one of the best spatial coverage in Europe. DMI’s goal is to improve this network further by operating 5 radars so that a maximum distance of anyone point to the nearest radar is at the most ˜120 km. This will enable the monitoring of low lying precipitation fronts at maximum altitude of ~ 2 km. A study is underway in identifying a new radar site in central Denmark.

References

Gill, R. S. and S. Overgaard , 2002: Report on the DMI weather radars, an analysis of the differences between the Ericsson and EEC radars, DMI internal report, 02-17.

Gill, R. S. and S. Overgaard , 2005a: Monitoring the calibration and elevation differences of the DMI weather radars, DMI internal report, 05-02.

Gill, R. S. and S. Overgaard , 2005b: Weather radar DMI pseudo CAPPI product versus the EEC BASE product, DMI internal report, 05-10.

Huuskonen, A., I. Carlsson, Å. Granstroem, D. Michelson and O. Thorersen, 2002, Final report on the NORDRAD QA project', http://nordrad.fmi.fi/qa/QA_final_repoirt.pdf.