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Radar data quality issues in Northern Europe

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Abstract. Radar data quality issues depend on climate and other local conditions. Radar experts from seven Northern European countries discussed these issues at NORDRAD/BALTEX Workshops in November, 2003 and May, 2004. As a result, a list of problems affecting radar data quality was compiled, as well as estimates of the magnitude and frequency of each problem. Subsequent work has included describing each problem in more detail, and rating their importance in each country. Finally, two new international projects have been suggested. The first project deals with the vertical reflectivity profile, which is seen as the most important challenge in this climate. The second project is about beam propagation issues, assessing problems like sea clutter, anomalous propagation, radar siting and beam blockage corrections.

1 Introduction

A radar measures reflection and scattering of microwaves, commonly known as echoes. Our huge challenge is to identify the echo target, so that we can eliminate the unwanted echoes yet leave the weather-related echoes unharmed. Data filtering methodologies are various, from sophisticated multisource software to elementary planning of radar siting. The selection of the right weapon starts from knowing your enemy. This paper includes examples of occurance and habits of some of these enemies in Northern Europe.

The challenges and their relative importance depend on radar system, climate, topography and other local conditions. For example, flare echoes, lively discussed in the USA, are an “once in a lifetime” event in the Nordic region. Similarly, the importance of mountains and windmills is different in the Netherlands and Norway.

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2 Consortium

Radar experts from seven Northern European countries discussed these issues at two NORDRAD/BALTEX Workshops in November, 2003 and May, 2004.

Sweden, Norway and Finland form the NORDRAD community which has been exchanging and compositing radar images since 1993 (Carlsson, 1995). The NORDRAD community has completed several successful projects related to data quality and calibration (Koistinen et al., 1999; Huuskonen, 2002). Even Denmark and Estonia work closely with the NORDRAD community.

The BALTEX Radar Network (BALTRAD) comprises around 31 radars in six countries in and proximate to the Baltic Sea and its drainage basin (Koistinen and Michelson, 2002). The BALTEX Main Experiment was conducted between October 1, 1999 and February 28, 2002, during which time the non-real time datasets were generated and made available for a multitude of users and research applications. Estonia, Germany and Netherlands are members of the BALTRAD community, and thus became members of the consortium of this work.

Radar quality issues are common for BALTEX and NORDRAD communities, thus co-operation is seamless. Also, the climate and location near the sea unites these countries. For all of us, the number of snow days far exceeds the number of tornado days. A huge part of development and research around weather radars (and money) is concentrated on warmer climates and rain, whereas we are more concerned with cold climate problems, such as beam propagation in inversion situations, shallow precipitation and snowfall (Koistinen et al., 2003a).

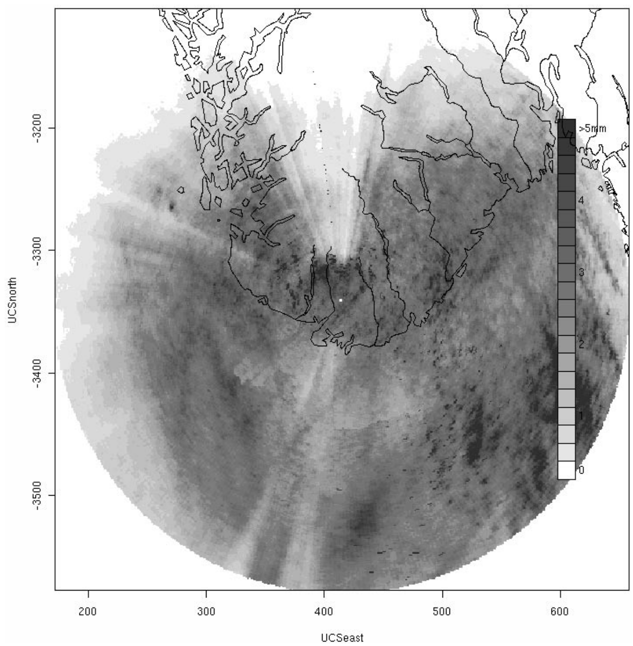

Fig. 1. Mean daily precipitation from radar Hgebostad (period 1–15 July, 2002.) Sectors north of radar are seriously affected by beam blockage.

3 Motivation

The inspiration of the work was the need to select the projects for common methodology development in the NORDRAD or BALTRAD countries, and to avoid overlapping use of resources. It is easy to notice that a list of most important issues is very useful in such planning. But it is also useful to know which problems are not so important in this area. Most of all, it helps non-experts avoid investing in expensive solutions to rare or insignificant problems.

4 Activities

As a result of the first workshop in November, 2003, a list of problems affecting radar data quality was compiled, as well as estimates of the magnitude and frequency of each problem, see Tables 1 and 2. The importance of these challenges was rated on a scale of one to three stars, not always reaching a consensus but more as a domination of the noisiest. The most important problems have been described in detail (one page per problem), and the medium and minor problems were explained with a chapter or two collectively. Afterwards, each country rated each problem subjectively with stars, the number of which were averaged, and the problems were sorted by this average rating. There are problems, like total beam overshooting, which all the members considered worth of at least two stars. One the other hand, there are issues like availability of polar data, which get three stars from one country and zero stars from another, reflecting the local infrastructure and environment. So any "importance rating" is more or less subjective. However, all the members agree that the vertical reflectivity profile is (at least) a three star issue in our climate.

The challenges which received 1.25 stars or less, are chaff, orographic enhancement and lee effects, dry radome attenuation, ships, aircraft in noise samples, attenuation by clouds, attenuation by gases, Bragg scattering from clear air, flare echo, forest fires, volcanic ash, insects, sidelobes and the Sun.

5 Projects

5.1 Vertical reflectivity profile project

Several projects (e.g. CARPE-DIEM, (see Alberoni et al., 2002)) have touched the theoretical parts of the problem. FMI has a running and evaluated version of vertical profile correction algorithm (Koistinen et al., 2003b), while SMHI has tested a method for handling evaporation below the cloud base applying NWP model data (Michelson et al., 2003).

In the suggested project, vertical reflectivity profiles are produced at all the radars, the FMI correction algorithm is implemented and the effect of the evaporation correction is tested.

5.2 Beam propagation project

The other suggested NORDRAD II quality project is called "Beam propagation". In the preliminary plan met.no (Norway) is the responsible member, and SMHI (Sweden), FMI (Finland) and DMI (Denmark) are participating members.

Anomalous propagation and sea clutter are common problems in the NORDRAD community since many radars are located at the coast (as seen in Fig 1). FMI identifies and removes sea clutter with an fuzzy logic-based method (Peura, 2002). In situations with AP sea clutter it is however reasonable to assume that superrefraction occurs not only where the sea clutter is visible, but also in other areas of the same data set. It might be less visible in such places, but it still affects the data quality. A realistic refraction model is also a valuable tool for optimal siting of new radar systems. Issues concerning the propagation of the radar beam are therefore identified as being of great importance for the quality of radar reflectivity and precipitation products.

The objective of the proposed project is to coordinate the work carried out in the NORDRAD member countries to define common algorithms for addressing these challenges. Methods available for this purpose are for example the Radar Simulation Model at SMHI and the Beam Propagation Model at met.no. (example of output of this is shown in Fig 2). The potential of these methods for operational use within NORDRAD is assessed.

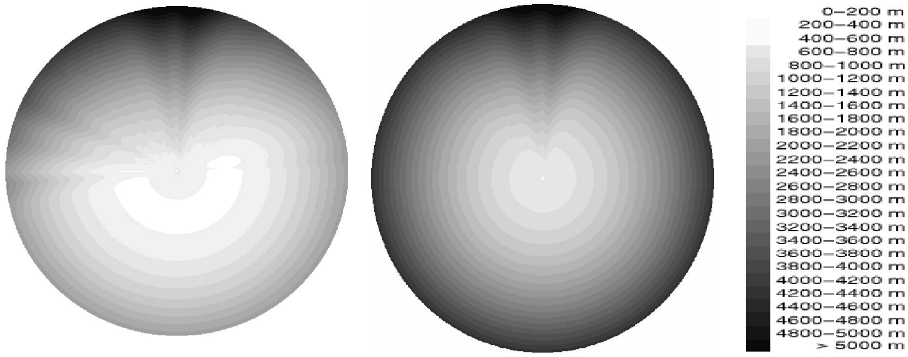

Fig. 2. Output from beam propagation model for radar Hgebostad (standard atmosphere) for elevation 0.0 degrees (left) and elevation 0.5 (right). This can be compared with the mean precipitation image.

Table 1. The most important challenges in Northern Europe. These sixteen challenges received average ratings of two stars or more, on scale of zero to three.

Challenge	Magnitude	Frequency	Tool
Vertical dBZ profile	−55.. 40 dB	Always	Vertical dBZ profile correction, multisource, gauge
Beam blockage	0..100 dB	Local	Software: precipitation accumulation, beam propagation, complaining
Radar siting	N/A	Ongoing	Design and experience
Attenuation by precipitation	0..30 dB	Daily	Commercial software, sophisticated software
Overhanging precipitation (including ice clouds)	−10..30 dBZ	Daily	Network density, VPRC, multisource
Sea clutter	−10..60 dBZ	Local, in weather	Dual polarization, pattern recognition, dBZ profile, Scan strategy
Data assimilation to models	N/A	Daily	Co-operation, dialog, multisource
Nowcasting tools, automatic detection of phenomena	N/A	Growing	Co-operation, education, multisource
AP clutter	−10..95 dBZ	Local, in weather	Doppler, statistical, multisource, profile, dual pol,
Gauge adjustment	−10..20 dB	Continuous	Intelligent methods
Scan strategy	N/A	N/A	User negotiations, Metadata, documentation, Upgrades
Total beam overshooting	Total	Seasonal	Network density, scan strategy, multisource
R,S(Ze)	0..5 dB	Continuous	Prec. type recognition, dual pol, multisource
Suboptimal compositing algorithms	N/A	Continuous	Unique solutions, 3D compositing, quality flagging
Ground clutter	−10..95 dBZ	Local, always	Doppler, Clutter map, Statistical, Multisource, Dual pol
Water phase	7 dB	Constant	Software, multisource, dual pol

6 Conclusions

The radar community is a small world. At least for meteorological institutes in small countries, co-operation with other countries in similar climate is not only fruitful, it also provides a critical mass needed to address common problems properly. Even though local conditions such as infrastructure and software are different, the relative importance of various challenges and the best algorithms to tackle them are often identical. The solution is not always a complicated piece of software, but some challenges can be dealt with logistically, e.g. through changes to infrastructure or the radar scan strategy.

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Table 2. Moderately important challenges. These fifteen challenges received average ratings of 1.3 to 1.8 stars, on scale of zero to three.

Challenge	Magnitude	Frequency	Tool
Hail	0..30 dB	Seasonal, local	Dual pol, multisource
Wet radome attenuation	0..6 dB	7% or less	HW experiment, AWS + Time series analysis
Availability of polar data	Nationally critical	System dependant	Negotiations, communication, maintenance
Infrastucture: electricity, tower structure	Hours	Siting dependent	UPS, tower structure
Attenuation by icy, sleety, salty or dirty radome	Medium to severe	Locally varying	Washing, coating, training, heating
Hardware	N/A	Age-dependent	Maintenance, upgrades
Pointing error (elevation)	0.1.. 0.5 deg	Age, design dep.	Monitoring, sun, maintenance
Propagation changes	In beam blocking	Locally, in weather	Refractivity analysis
Second trips Cb+AP	−20..+30 dBZ	Seasonal	SQI, low PRF, whitening, phase control
Miscalibration	2 dB	Continuous	Monitoring
Absence of metadata	Tragical	Continuous	(Self) discipline, file format, product design, OPERA database
Birds	−10..+20 dBZ, false winds	Seasonal	Pattern recognition, dBZ threshold, Special interest group, User training
Water clouds	−10..−15 dBZ	Always	Neglected
Interfering emitters,jamming	−10.. 95 dBZ	Local, occasional	Interference filter in DSP, pattern rec., SQI
Specular reflections	−10.. 50 dBZ	Local	Politics (preventive action) , sector blinding, motion vector analysis, siting
Windmills	−10..40 dBZ	Local	Building permissions, Clutter mapping

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