Prepared
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Demonstration of real-time integrated monitoring system supporting improved rainfall monitoring (D 1.3.8) in Aarhus

Demonstration Report

SEVENTH FRAMEWORK PROGRAMME

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Contents

1 INTRODUCTION

As a part of the “Climate Change Adaptation Initiative” in Aarhus the “Integrated Control and Early Warning” project has installed a LAWR radar [DHI, 2010 to 2012] on the roof of the Harlev WWTP. The objective of the radar is to provide high spatial and temporal information on rainfall over the city. This radar is named “AROS”.

Due to the antenna design, this radar type is sensitive to ground clutter from buildings in its vicinity. The radar has been in operation since 2008, originally at another site. Due to organizational reasons, the radar was relocated to Harlev WWTP in December 2009.

In order to reduce the clutter impact the installation is equipped with a physical clutter fence to reduce echoes from the surrounding buildings.

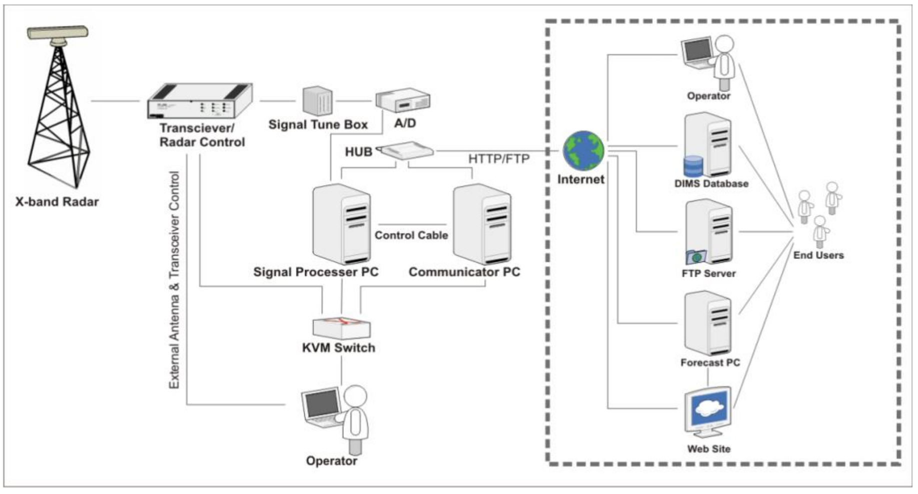

Figure 1-1 Model layout of Local Area Weather Radar system. The elements contained by the dashed frame are optional add-ons and all require an internet connection to the LAWR installation.

1.1 Bias adjustment

The conventional rain gauges have been used for more than 100 years, and it is a common understanding that rain gauge measurements yield a trustworthy estimate of the actual rainfall. For a number of reasons, the rainfall estimates from radars do not give the exact same result as the gauges. To compensate for this the “Dynamic Weight Field Bias Adjustment of radar-based N-hours precipitation accumulations” method by Niels Einar Jensen, DHI has been adapted.

The Bias adjustment method aims at adjusting the radar results in such a way that the result from radar estimates will be the same as the gauge measurements at the "gauge pixels". The method does not address the question of which estimate is the best.

2 FINDINGS

The radar images produced from 15.04.2012 to 09.01.2013 and measurements from four rain gauges from 01.01.2012 to 09.01.2013 have been used in this study. The data coverage is high with a few images missing; however, some issues have affected the radar images and their fidelity during the period.

In order to quantify the difference between the rain gauge and the radar, accumulations for both 24-hour and 3-hour have been calculated. Visual inspection of accumulated rainfall measured with radar against accumulated rainfall measured with rain gauges reveals a fairly strong linear relation with a bias. In the selected period the radar has a tendency to find lower accumulated values than the rain gauges.

To quantify the bias the data have been exported to Excel where linear regression has been applied. Using the formula:

$$RadarAccDepth = a*RainGaugeAccDepth$$

The relation given in Table 2-1 was found.

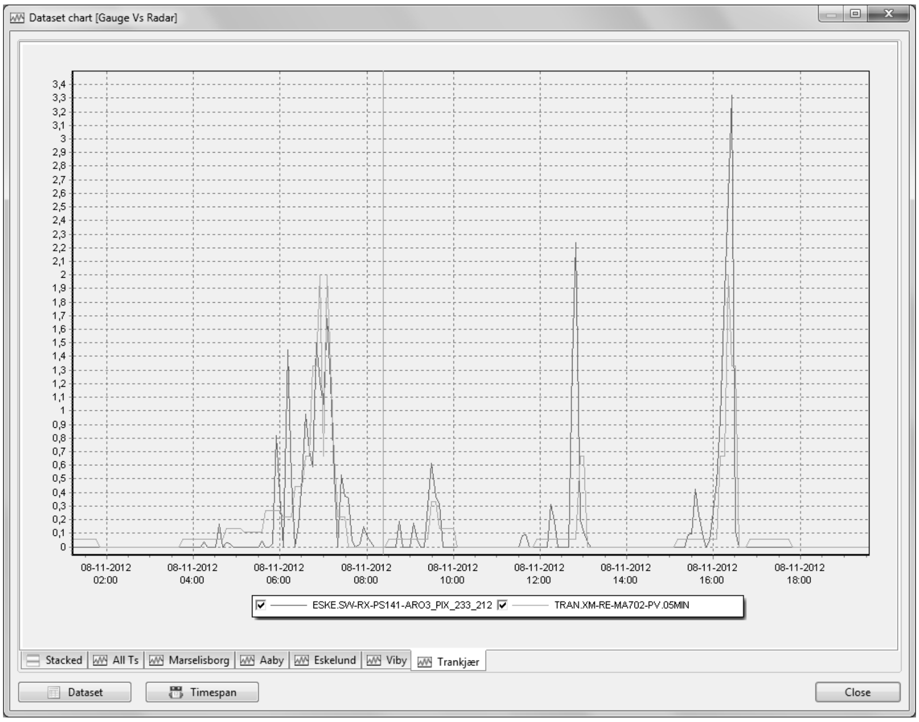

Figure 2-1 Comparison of rain gauge data (light grey) with radar data for pixel over rain gauge (dark grey)

Note that in principle the radar bias is the reciprocal value of a. This means that the average radar bias for the time span is 1.38 based on the a-factor of 0.7229 found using data for all four rain gauge sites.

Table 2-1 Bias adjustment factors

Rain gauge site	a [mm/mm]	R^2
Eskelund	0,6874	0,7474
Tranjær	0,7281	0,7110
Viby	0,8156	0,5459
Aaby	0,6549	0,6489
All data	0,7229	0,6559

2.1 Partial beam blockage

In direction NNW from the radar the terrain reaches 52 MASM in the distance of 1 km from the radar. The antenna is installed in 28 MASM. The result is that beam in this direction is reduced with 1.4 degree. Assuming the energy in the radar beam is Gauss distributed [Skolnik, 1990] symmetrically around a horizontal line where 1.4 degrees are lost; the loss in energy in this direction will be more than 15 %. In the following no attempts have been done to correct for the variation.

2.2 Changes in the LAWR radar

Since end February 2012 the radar has been upgraded with the latest signal processing that provides output directly in dBZ values.

2.3 Processing

Preparation of rain gauge data means creating a time series that is comparable with the values read from the radar images. As radar images contain average values of the last five minutes, the rain gauge data were aggregated to five minute values.

2.4 Comparing rain gauge data with radar estimates

Within the coverage area of the AROS LAWR radar the municipality maintains a number of rain gauges, typically installed at WWTP facilities. In the following rain gauge data is compared to radar rainfall. The radar rainfall is estimated using the Marshall-Palmer equation applying A and B as 200 and 1.6.

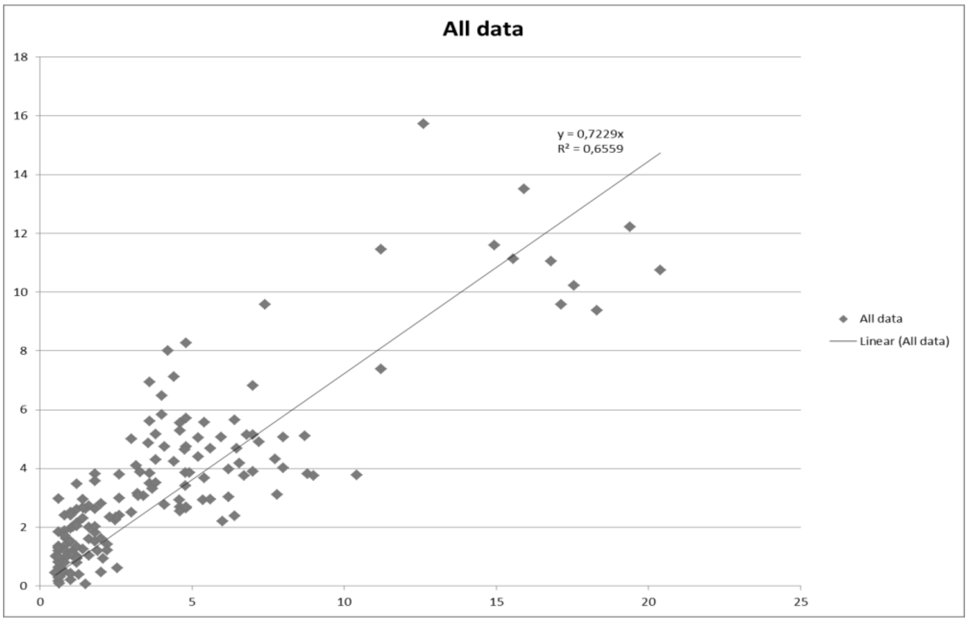

Figure 2-2 24 hours accumulations from Aarhus rain gauges. Radar accumulations on the vertical axis, rain gauge accumulations on the horizontal axis.

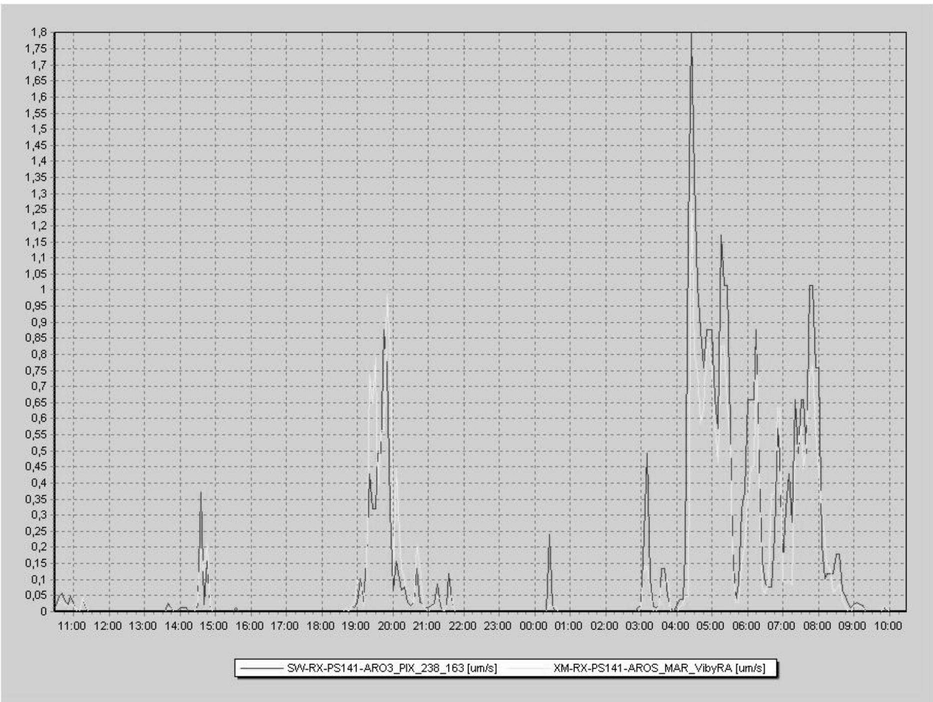

Figure 2-3 Mean areal rainfall estimate from AROS radar compared with SVK (the Danish Wastewater Committee) operated rain gauge at Viby WWTP.

3 CONCLUSIONS AND RECOMMENDATIONS

Based on comparison of 24 h accumulations the radar has been found to underestimate the accumulated rainfall by approximately 20 %. This should be seen in relation to studies on variability and point vs. area rainfall measurements that show intra event variability of 1 – 26 % for 9 gauges within a 500 x 500 m pixel [Pedersen, 2009] and to the uncertainties of rain gauge measurements: A conventional rain gauge of good quality may display an uncertainty of 20 % (WMO, 2005).

As the radar system was delivered and configured by DHI, the end-user (Aarhus) has not been active in this part of the project. The results of this activity are feed directly to the control system for the sewer system. See Report of demo in Aarhus D 1.3.4.

4 REFERENCES

Skolnik, M, 1990, Radar Handbook, Second edition.

DHI, 2010,2011,2012 LAWR documentation

Pedersen, Lisbeth 2009, Identification and Quantification of Uncertainties Related to Using Distributed X-band Radar Estimated Precipitation as input in Urban Drainage Models, Technical University of Denmark, IMM-PHD-2009-215

WMO, 2005, Laboratory Intercomparison of Rainfall Intensity Gauges, Annex VII