Improving the fine-scale rainfall estimates of a local area weather radar:
Case of X-band radar at Leuven, Belgium

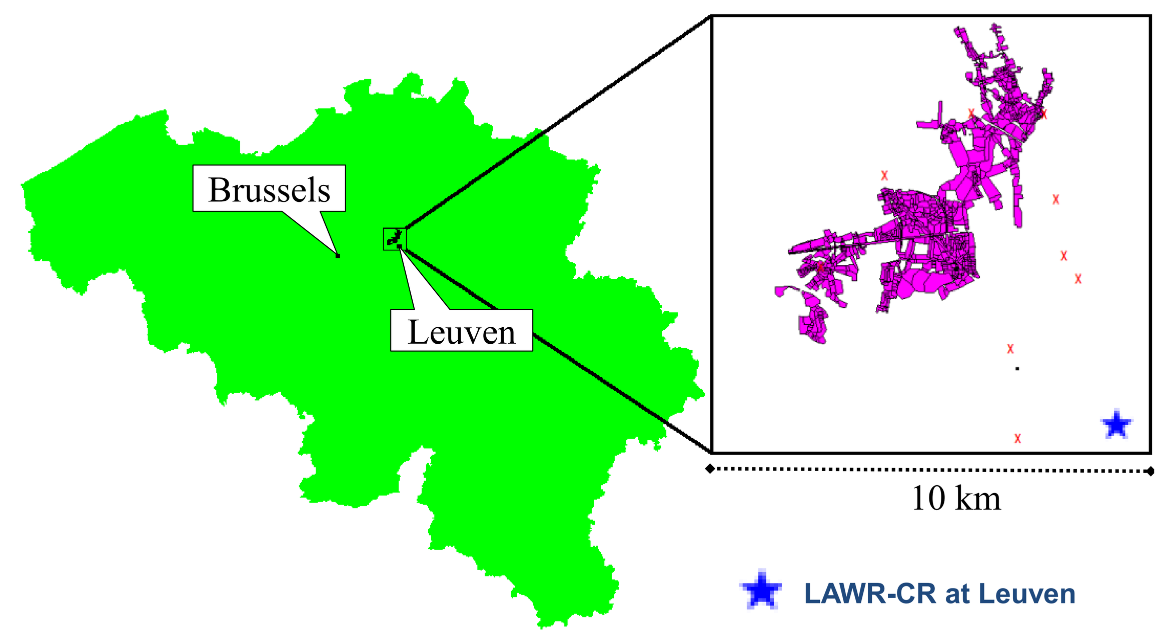
Decloedt L. C.[1] , Van Assel J.[2] and Willems P.[1]*

1 Hydraulics lab KU Leuven 2 Aquafin nv

KATHOLIEKE UNIVERSITEIT LEUVEN

Background:

RAINGAIN is a new INTERREG NWE IVB project on fine-scale rainfall estimation and forecasting in support of urban drainage flood modeling and now-casting. X-band radar technology will be integrated with the national C-band radar data, rain gauge data and numerical weather prediction. Case-studies are the cities of Leuven, Rotterdam, Paris and London. The Leuven case is studied by the Belgian partners KU Leuven – Hydraulics Division and Aquafin.



Location of Leuven and the WHW sewer network relative to the LAWR CR

Installation of LAWR-CR:

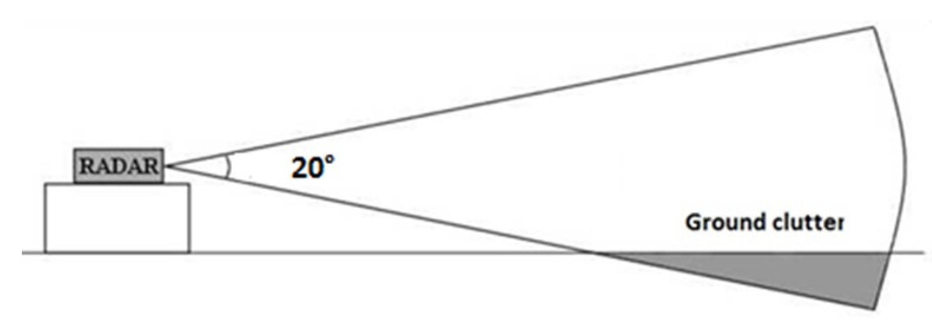
In a previous research project, funded by Aquafin, an X-band Local Area Weather Radar (LAWR-City Radar, DHI) was installed on the rooftop of the Provinciehuis building in the centre of Leuven, within range of the Winksele-Herent-Wijgmaal (WHW) sewer network. The WHW network has an area of 9.13km² and has 16.100 inhabitants. The installation height is 48m above ground level and the pit wall reduces ground clutter as it cuts off the lower half of the radar beam. For the calibration of the radar, 9 tipping bucket rain gauges were used and the runoff simulations are checked with in-sewer measurements.

LAWR-CR properties:

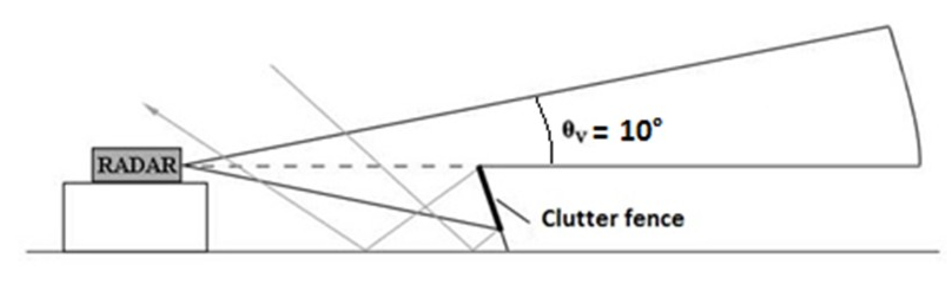
- **Marine X band technology (type Furuno) operating at 9.41GHz with a wavelength of 3.2cm, pulse length of 0.8ms and peak output of 4kW**
- **Logarithmic receiver with a 0.4m radome antenna**
- **Vertical opening angle of 20° (lower half is cut of by pit wall) horizontal opening angle of 4° (only one elevation angle)**
- **Range of 15km for qualitative precipitation estimation (QPE) and 30km for forecasting rainfall**
- **Spatial resolution of 250x250m (range: 30km from LAWR-CR) up to 50x50m (range: 7.5km from LAWR-CR)**
- **Temporal resolution of 1 or 5 minutes (1 minute is used) with 450 samples per rotation and 24 rotations per minute**

The Provinciehuis building (with LAWR-CR installed on the roof)

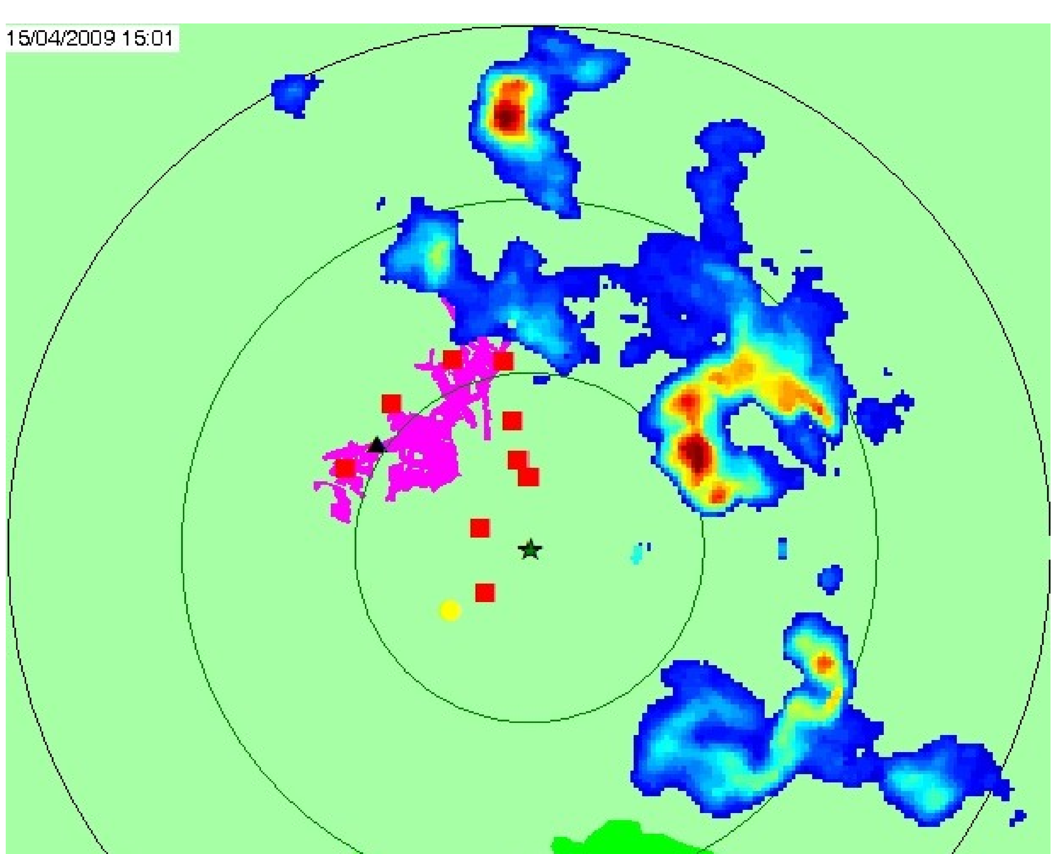
Rooftop view on the LAWR-CR (with the wall acting as clutter fence)



Ground clutter giving a false signal



Clutter fence cutting off the lower half of the beam



A radar image from the LAWR-CR on 15/04/2009 15:01, with a convective rainfront active over the Leuven area (concentric circles are at 5km interval)

Calibration of the LAWR-City Radar:

Since the LAWR-CR generates digitized values of the electrical signal produced by the received electromagnetic waves, the system required calibration first. For this, tipping bucket rain gauge (TBR) measurements were used, and various calibration methods were investigated. It was found that the calibration factor (CF) strongly depends on the location relative to the radar. From the evaluation based on non-recording gauges operated by the Royal Meteorological Institute (RMI) of Belgium, a nonlinear (power) regression equation taking range to the radar into account was found to best describe this location dependency for the case study. Rainfall estimation accuracy could be slightly improved by making CF dependent on radar output.

For the rain gauges (TBR) in the context of urban drainage applications, in which high rainfall rates are of specific interest, the underestimation due to the tipping motion of the bucket on the one hand, and the long-term bias due to local wind effects on the other hand, are the most important issues to tackle to obtain qualitatively accurate results of the rain intensities for the calibration of the LAWR-City Radar.

As a part of the RainGain project, attempts will be made to enhance the fine scale rainfall estimation of the LAWR-CR. This involves investigating the effect of some parameters possibly influencing the radar-rain gauge relationship. For this, a convective stratiform separation algorithm (Steiner et al. 1995) was adapted and implemented as well as a cloud movement speed and direction determination algorithm. Other parameters investigated are, amongst others, the relative filling of the radar image, the mean rainfall intensity during the storm event, the mean air temperature during the event etcetera.

Correlations of the radar-rain gauge relation have been found with several of these parameters and these relations will be used to improve the LAWR-CR's fine scale rainfall estimates.

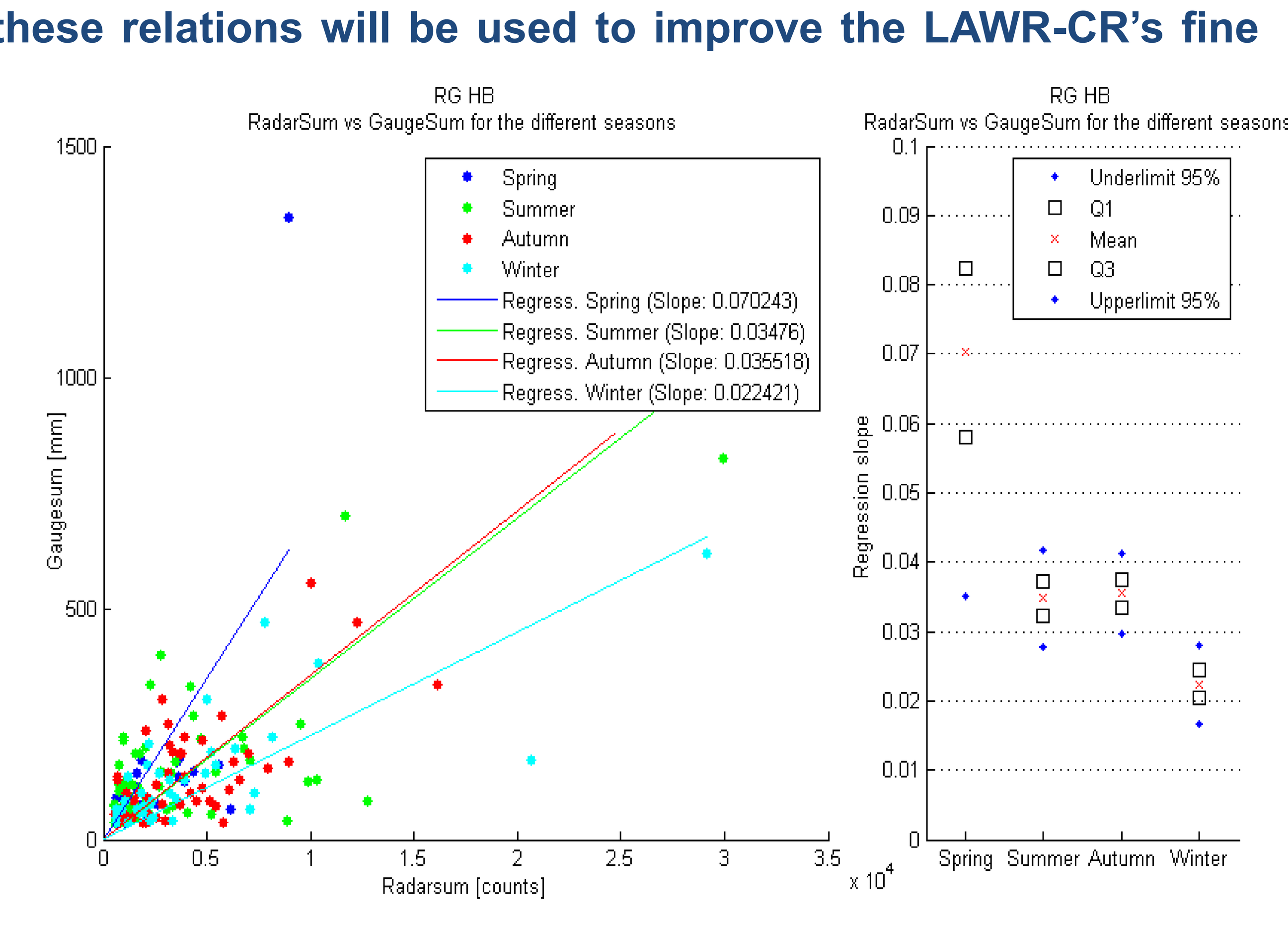
Conclusions:

Large quantitative deviations exist in the city LAWR driven simulations of the WHW sewer network response. However, the qualitative course of water depth and flow in the monitored conduits is reproduced fairly well.

Although certain events show a higher correspondence between measured and simulated water depth and flow time series when using LAWR-CR based rainfall input, on average, the gauge based rainfall input outperforms the radar based input, at least for this case study and accompanying model. Further radar adjustments are required to improve the radar-based rainfall estimates.

In the research new calibration methods are developed and tested, departing from the traditional linear approach. Some of the new methods yield a more accurate calibration compared to the traditional methods. More research is, however, required to further improve the calibration.

In future applications, the found correlations will be used to improve the fine scale rainfall estimates.



Example of a correlation study – seasonal effects on the radar-rain gauge relation

Acknowledgements:

The RAINGAIN project has received INTERREG NWE IVB funding. The authors also would like to thank the provincial government of Flemish Brabant for allowing the installation of the LAWR-CR on its property.

Contact: cas.decloedt@bwk.kuleuven.be or patrick.willems@bwk.kuleuven.be