OPTIMIZING WEATHER RADAR OBSERVATIONS USING AN ADAPTIVE MULTIQUADRIC SURFACE FITTING ALGORITHM

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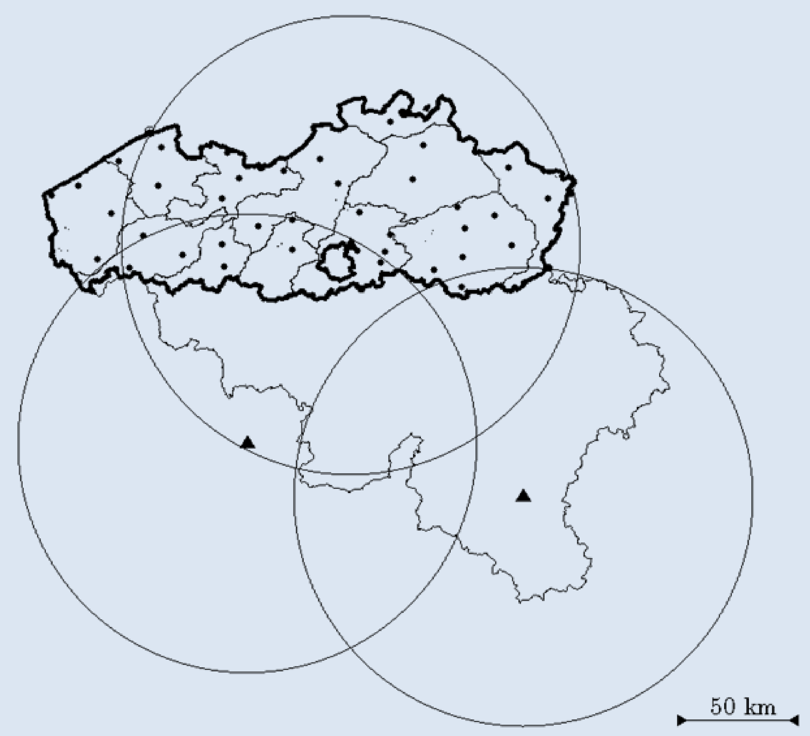
1. INTRODUCTION

A system for real time forecasting of river flow is an essential tool in operational water management. Such modelling systems require well calibrated hydrological and river flow models which can make use of spatially distributed and real time rainfall observations. Weather radar products provide spatial data on rainfall. However, weather radars are subject to a large range of error sources. Therefore, these observations often do not correspond to the measurements at the ground. Through merging ground-based rain gauge observations with the radar rainfall product, often referred to as recalibration (or rescaling) of the radar image, one may force the radar observations to better correspond to the ground-based measurements, without losing the spatial information.

The aim of this study is to investigate possible improvements for a data merging algorithm, currently used by the Flemish Environment Agency as a processing tool for radar images, developed by Moore et al. (1994).

2. DATA AND STUDY AREA



Observations from 43 rain gauges (bullets) located in Flanders (bold contour) and 3 C-band weather radars (triangles) located in Belgium and France are available.

3. DATA MERGING ALGORITHM

Merging both data sources encompasses three steps (Moore et al. (1994)):

1. Calculation of scaling factors: $C(\mathbf{x}_\alpha) = \frac{I_g(\mathbf{x}_\alpha) + \varepsilon_g}{I_r(\mathbf{x}_\alpha) + \varepsilon_r}$ with $\varepsilon_g = \varepsilon_r = \varepsilon = 17.22$ mm/h

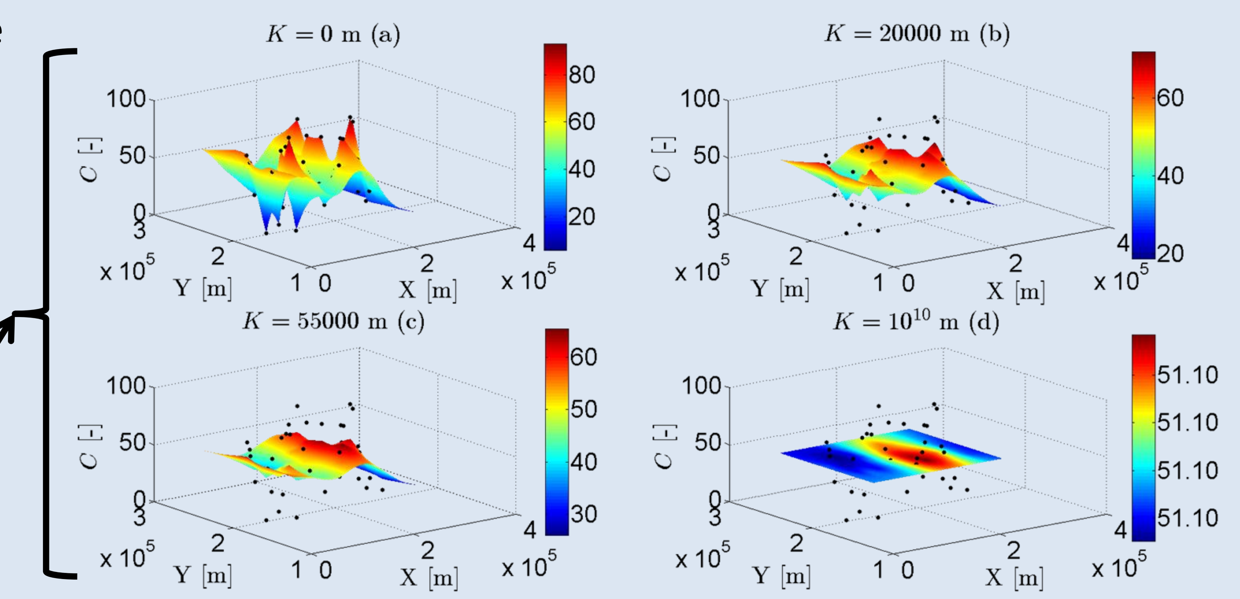
   → Location of rain gauge

2. Interpolation of scaling factors using multiquadric surface fitting (Hardy, 1971):

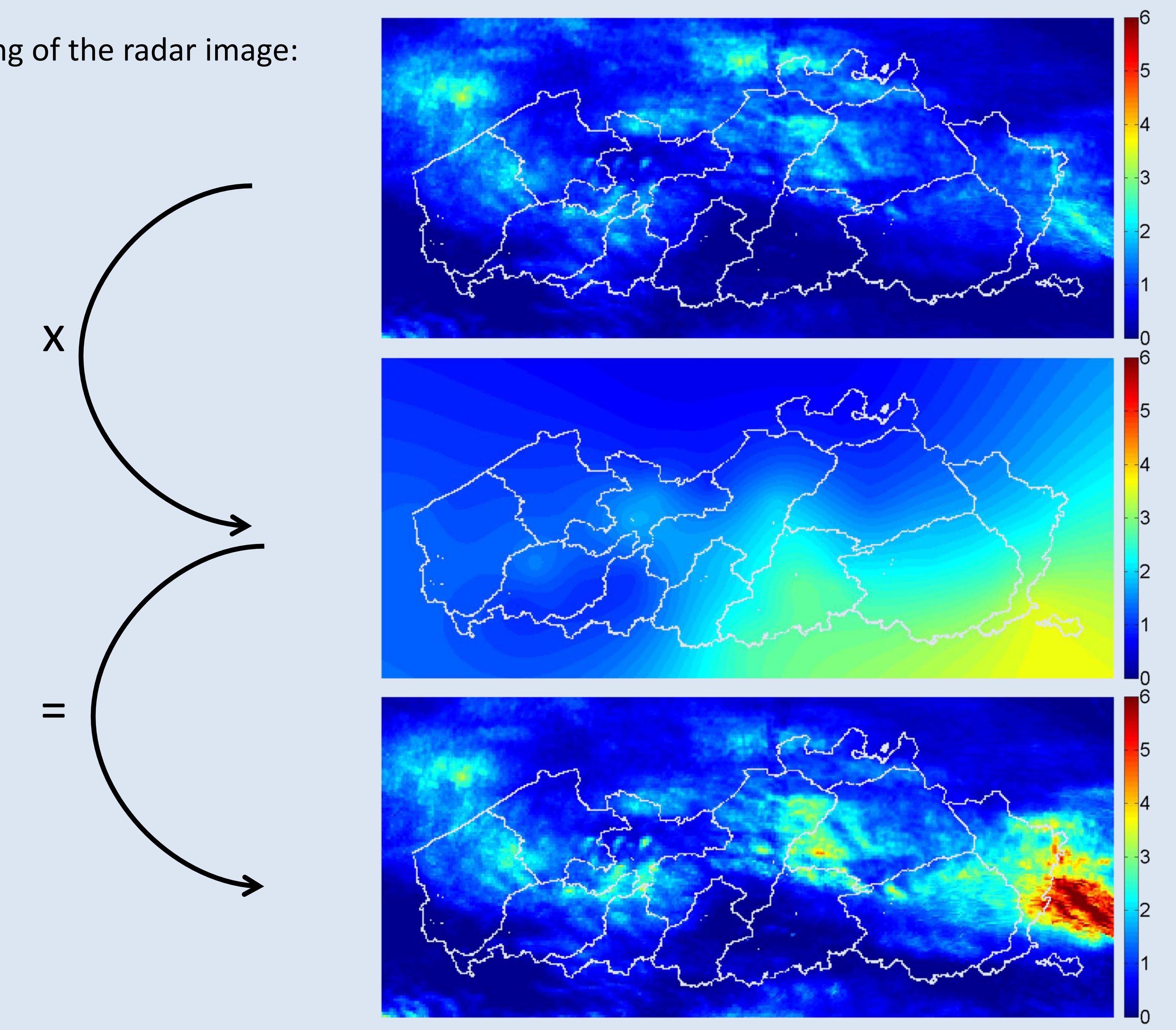
   $C^*(\mathbf{x_0}) = \mathbf{a}^T\mathbf{v} + a_0$

   → Unsampled location

   Use of a smoothing parameter: $K = 7.93 \cdot 10^{-8}$ m



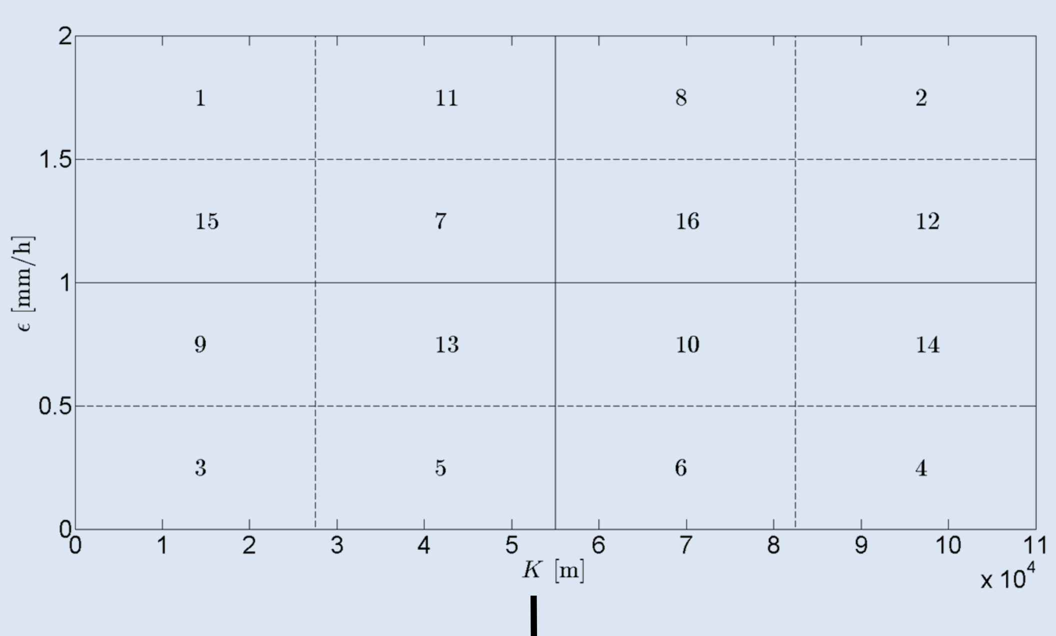
3. Rescaling of the radar image:



4. ADAPTIVE MULTIQUADRIC SURFACE FITTING

Optimizing the key parameters (K and ε (RRA_2P), or K only (RRA_1P)) in function of the available data, instead of keeping them fixed across time frames (RRC_2P). Adapting the parameters is performed by making use of an efficient real time multi-start calibration scheme:

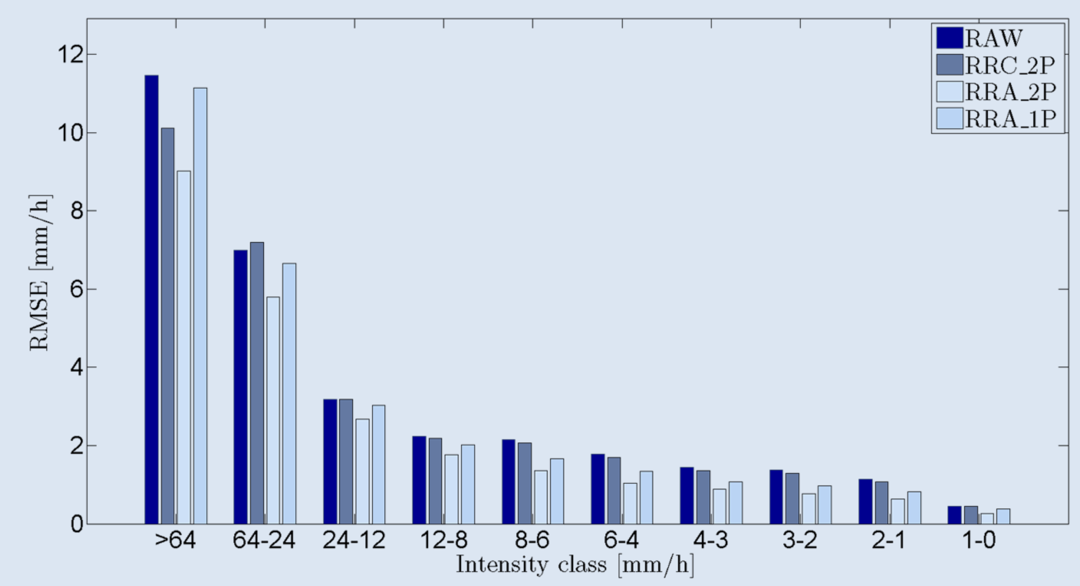
- Limited amount of ground-based observations → Cross validation
- Objective function → RMSE
- Calibration technique → Nelder Mead simplex algorithm (Nelder and Mead, 1965)
- Rain gauge observations → Ground truth
- Avoiding local optima → Multi-start algorithm (see Figure below)

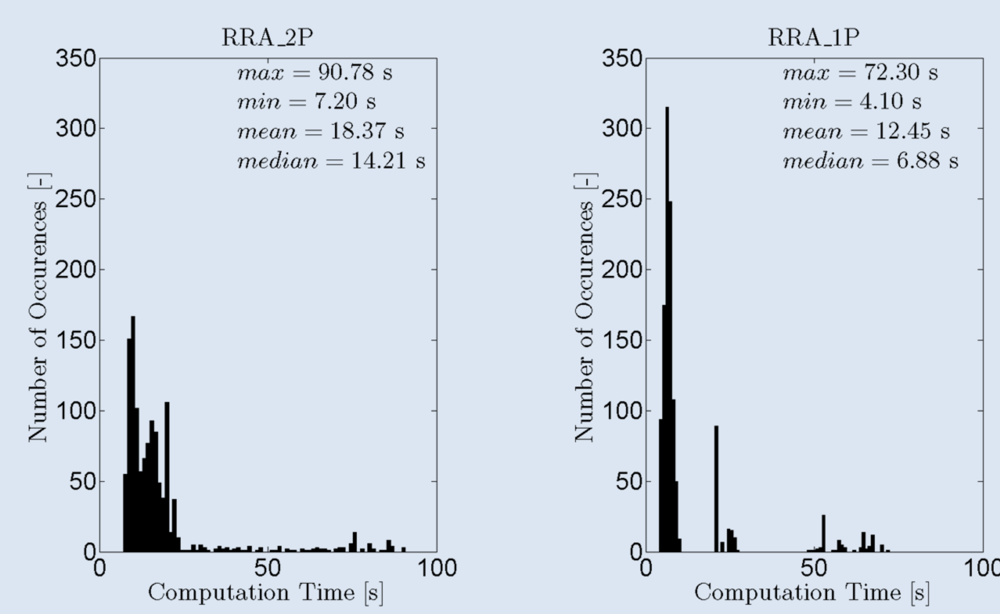


The parameters are initiated in different zones of a predefined parameter space

5. RESULTS

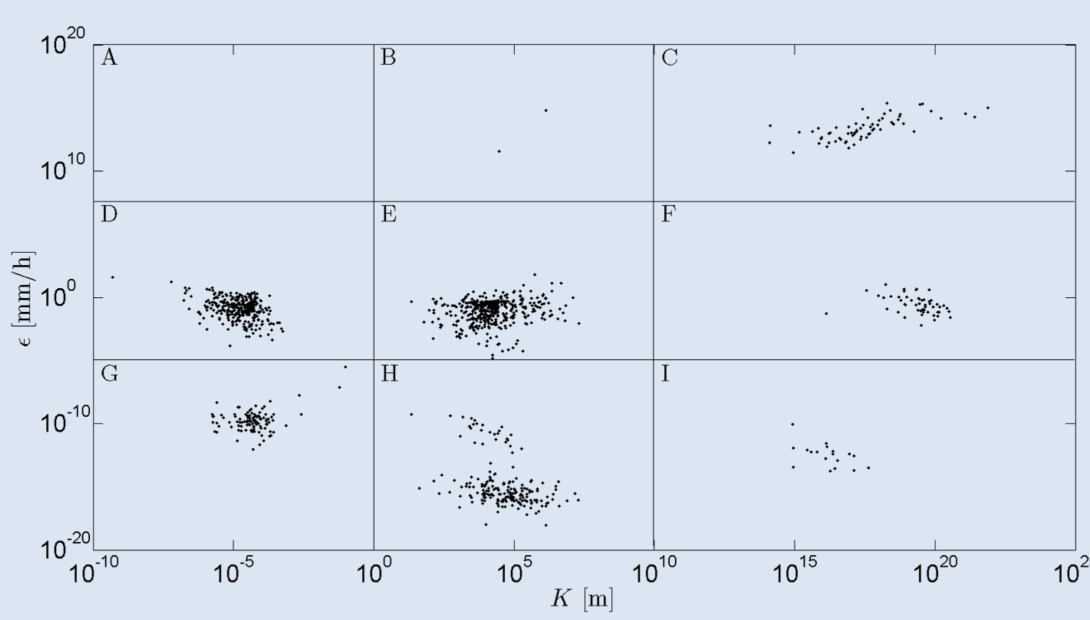
- Both adaptive algorithms (RRA_2P and RRA_1P) perform significantly better then the raw radar (RAW) and the constant parameter merging algorithm (RRC_2P) (see Figure at the right)
- RRA_2P performs significantly better then RRA_1P
- RRC_2P performs only slightly better then RAW





- Computation times are limited (see Figure at the left)
- The adaptive algorithms can be applied in near-real time
- Optimizing K only (RRA_1P) results in a significant lowering of the processing times

- Wide variety of optimized parameters
- Parameter sets can be classified into 9 groups, giving rise to particular properties of the fitted surface (see Figure at the right)
- Parameters can vary strongly between subsequent time steps



6. CONCLUSIONS

- Both adaptive data merging algorithms result in a significant lowering of the RMSE compared to the RMSE obtained with constant parameters
- Using an adaptive one parameter data merging algorithm (RRA_1P) can significantly lower the processing times, while the RMSE can still be significantly reduced
- Applying the adaptive algorithm is possible in near-real time

7. REFERENCES

Hardy, R.L., (1971) Multiquadric equations of topography and other irregular surfaces, *Journal of Geophysical Research*, 76(8): 1905-1915.

Nelder, J.A. and R. Mead, (1965) A simplex-method for function minimization, *Computer Journal*, 7(4): 308-313.

Moore, R.J., B.C. May, D.A. Jones and K.B. Black, (1994) Local calibration of weather radar over London, in: *Advances in radar technology*, Almeida-Teixeira, M., R. Fantechi, R. Moore and V. Silva.