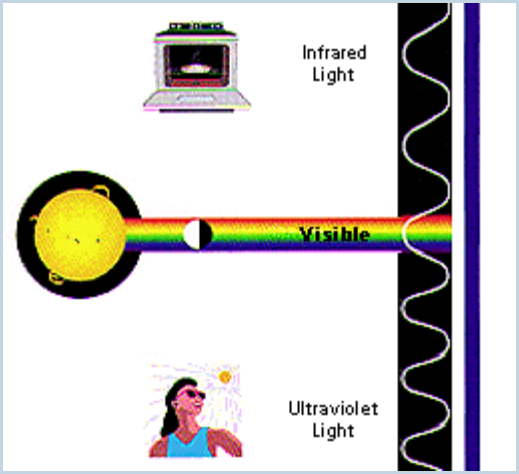
Use of image classification in urban drainage modelling



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LNH water

KRÜGER

Surface runoff – runoff coefficients

Methods traditionally used for determining impervious areas:

- Calculations based on aerial photos, technical maps etc.
- Type values based on the characteristics of the catchment

LNH water

Catchments

$$\alpha = \frac{F_1 \cdot \alpha_1 + F_2 \cdot \alpha_2 + \ldots + F_N \cdot \alpha_N}{\sum_{n=1}^{N} F_n}$$

LNH water

Model setup - drawbacks

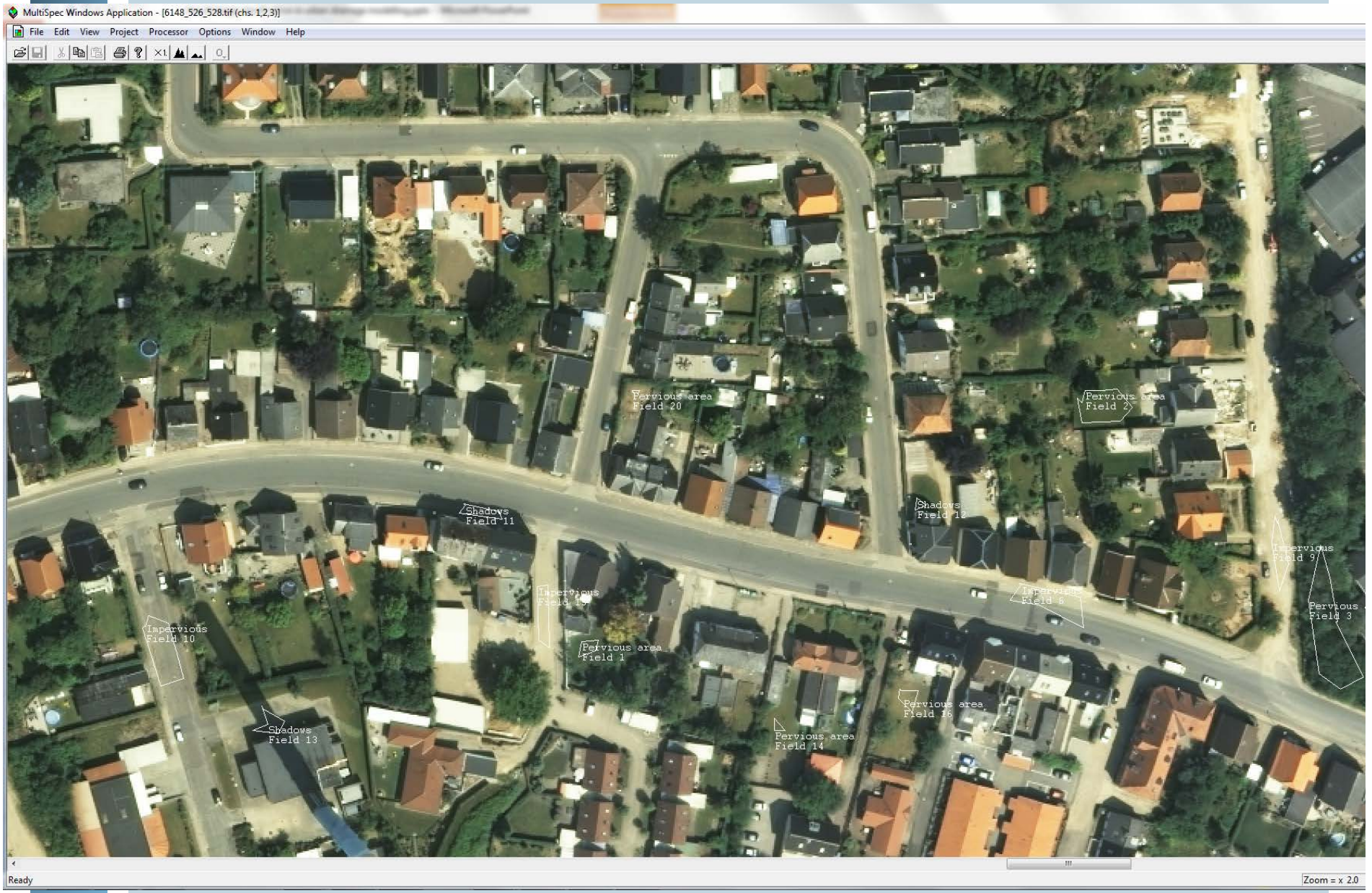
- Time consuming
- Difficult to update
- Not well documented and image interpretation is subjective
- Model parameters are static – difficult to test changes in runoff based on e.g. rain intensity or allocation of water

LNH water

Objective

- Find a new method that would improve the flexibility of surface runoff modelling
- Use methods from remote sensing to describe surface types based on aerial photos and image classification
- Adapt to the level of detail that is required in urban drainage modelling
- Make the method as automated as possible

LNH water


MultiSpec Windows Application - [6148_526_528.tif (chs. 1,2,3)]
File Edit View Project Processor Options Window Help
Pervious area Field 20
Pervious area Field 2
Shadows Field 11
Shadows Field 12
Impervious Field 9
Impervious Field 10
Impervious Field 1
Impervious Field 6
Pervious area Field 1
Pervious area Field 3
Shadows Field 13
Pervious area Field 16
Pervious area Field 14
Ready
Zoom = x 2.0

Text Output

```
   Classification of Training Fields

   TRAINING CLASS PERFORMANCE (Resubstitution Method)

   Project                    Reference          Number of Samples in Class
    Class              Class  Accuracy+ Number              1          2       3
    Name               Number    (%)    Samples  Pervious are Impervious Shadows

   Pervious area           1     93.7     27762         26015         55    1692
   Impervious              2     99.6     24852            94      24758       0
   Shadows                 3     97.6      2778            65          2    2711

                      TOTAL              55392         26174      24815    4403

                  Reliability Accuracy (%)*            99.4       99.8    61.6

      OVERALL CLASS PERFORMANCE (53484 / 55392 ) =  96.6%
      Kappa Statistic (X100) =  93.8%. Kappa Variance = 0.000002.

      + (100 - percent omission error); also called producer's accuracy.
      * (100 - percent commission error); also called user's accuracy.

   Area classification not saved to disk.
   Classification of Selected Area
        Lines 1 to 16000 by 1.  Columns 1 to 32000 by 1

   CLASS DISTRIBUTION FOR SELECTED AREA

                       Number
        Class          Samples Percent   Area (Hectares)
   1 Pervious area 389,280,644    76.0  608.251
   2 Impervious    102,169,421    20.0  159.640
   3 Shadows        20,549,935     4.0   32.109

     Total         512,000,000   100.0  800.000

End maximum likelihood classification

38 CPU seconds for classification.  09-03-2012  12:41:15
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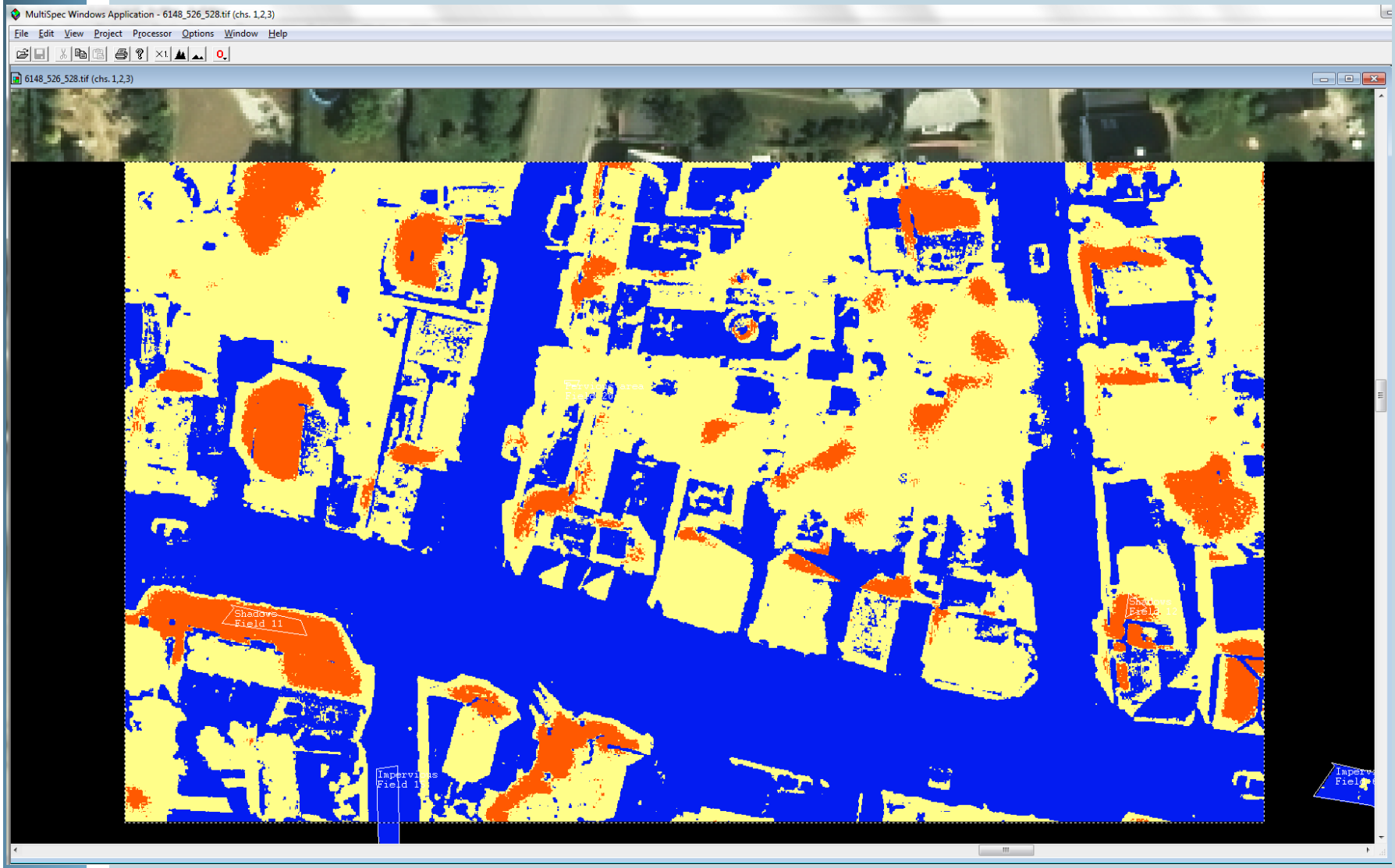

MultiSpec Windows Application - 6148_526_528.tif (chs. 1,2,3)
File Edit View Project Processor Options Window Help
6148_526_528.tif (chs. 1,2,3)
Shadows
Field 11
Impervious
Field 1

NDVI – normal differential vegetation index

$$NDVI = \frac{\rho_{IR} - \rho_R}{\rho_{IR} + \rho_R}$$

Where:

ρ_{IR} = pixel reflectance values in the near infrared spectrum

ρ_R = pixel reflectance values in the red spectrum

NDVI – normal differential vegetation index

NVEI – non vegetation elimination index

$$NVEI = \frac{\rho_B - \rho_R}{\rho_{IR} - \rho_R}$$

Where:

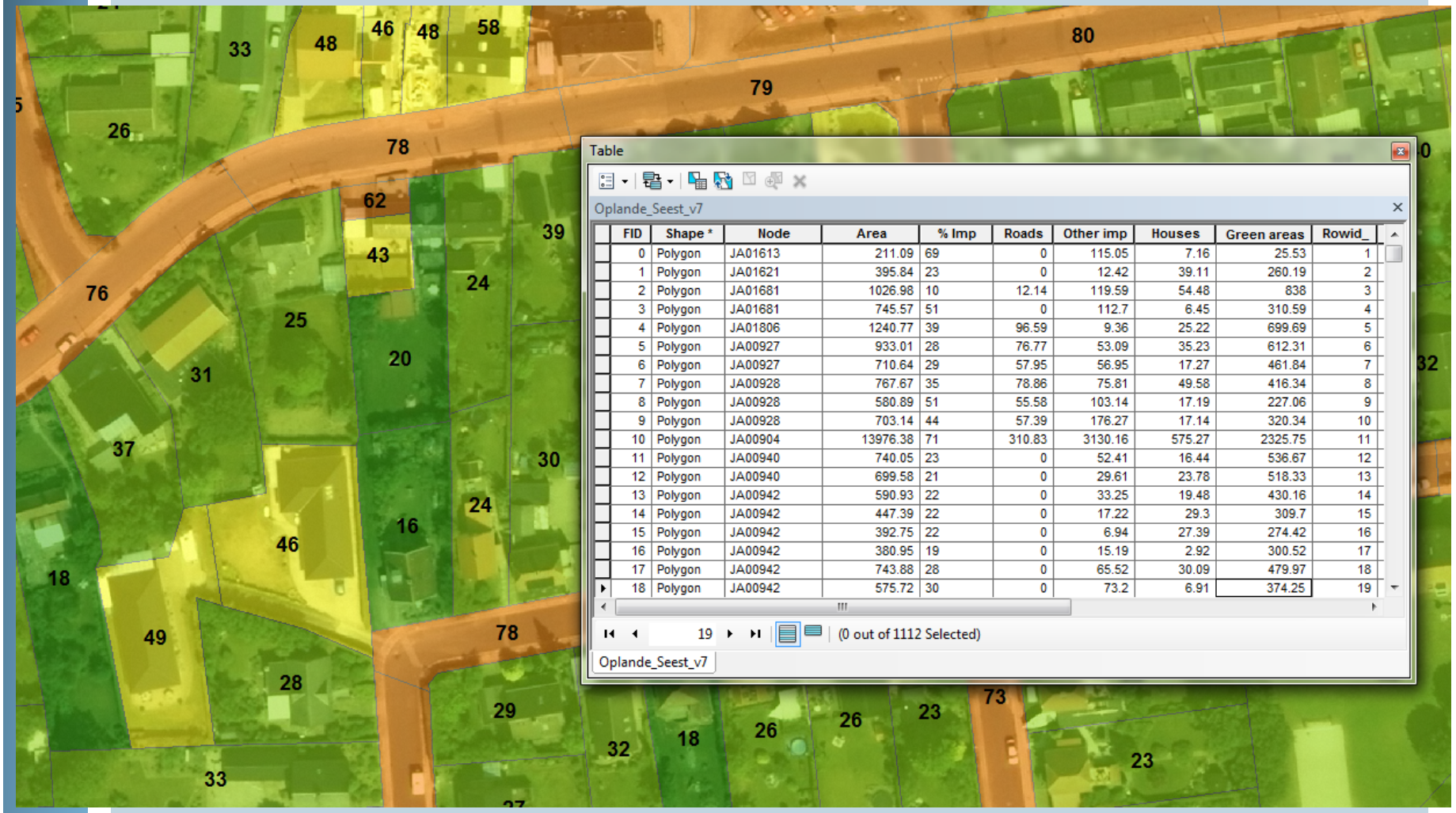
ρ_{IR} = pixel reflectance values in the near infrared spectrum

ρ_R = pixel reflectance values in the red spectrum

ρ_B = pixel reflectance values in the blue spectrum

Spectral analysis, vegetation/non vegetation index, tech. maps and manual inspection

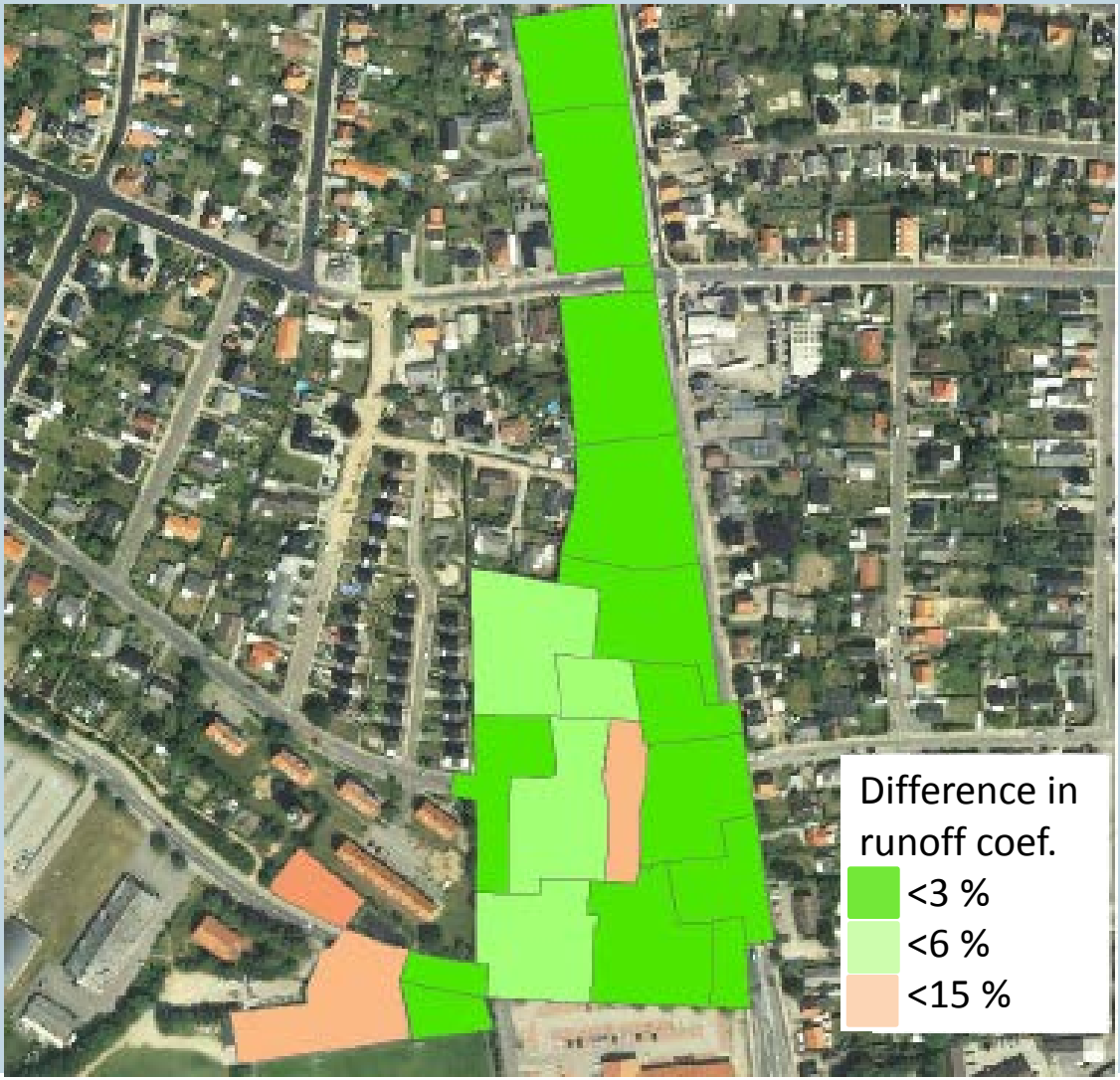
Database with runoff coefficients



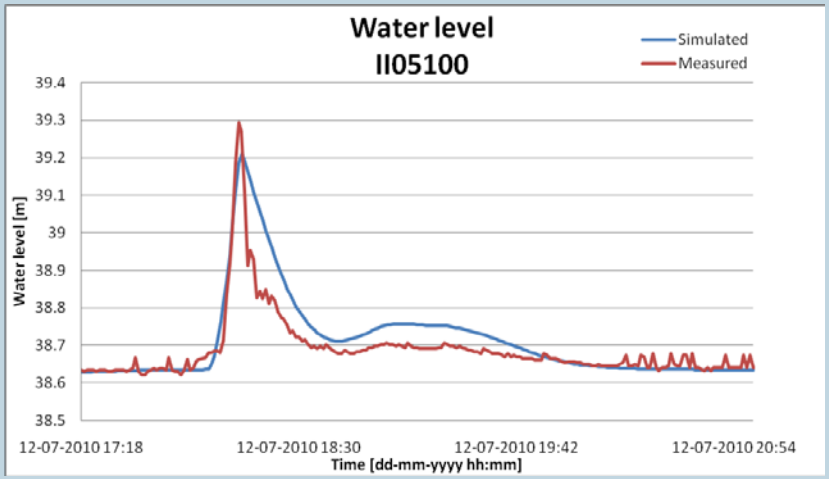
Testing the method

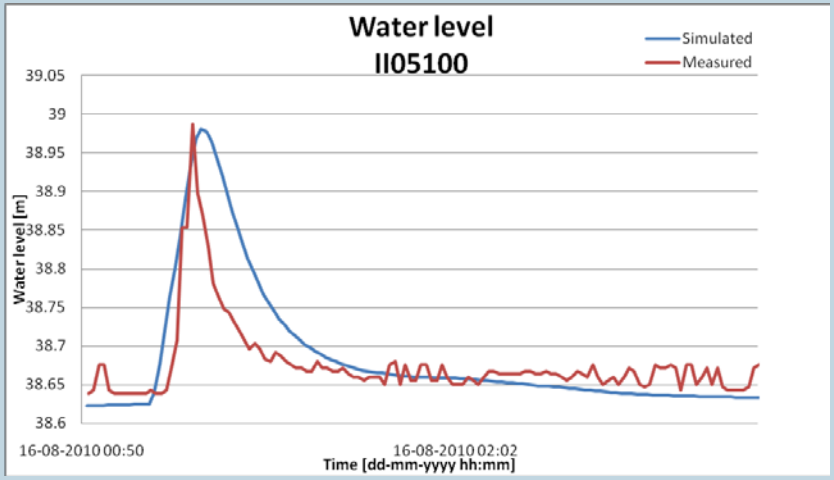
- Tested the fully automated method against best manual fit
- Validated surface runoff against measured water levels/flow compared to calculated
- Mouse was used as the sewage model
- Used rain gauges operated by the Danish Water Pollution Control Committee (T<2 yrs.)

Manual versus automated

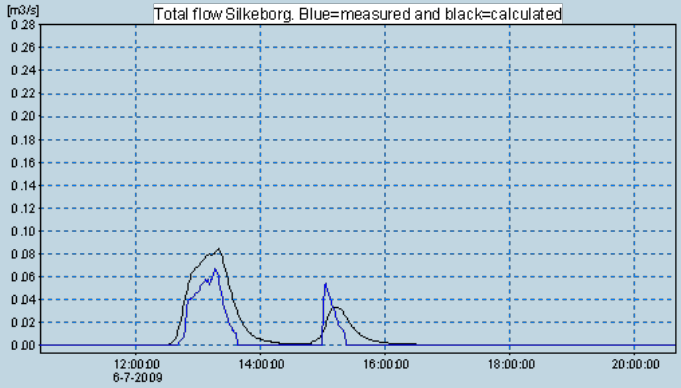


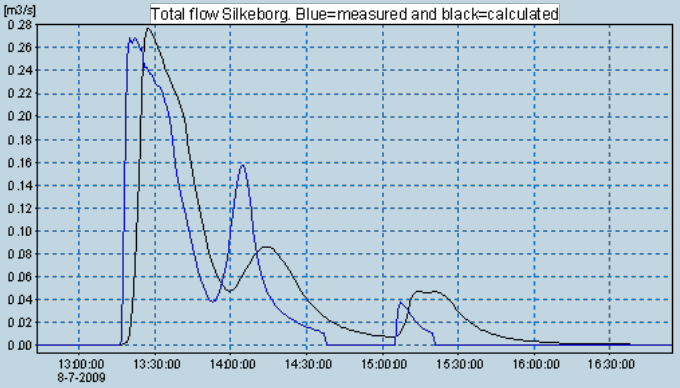
Measured and calculated water levels

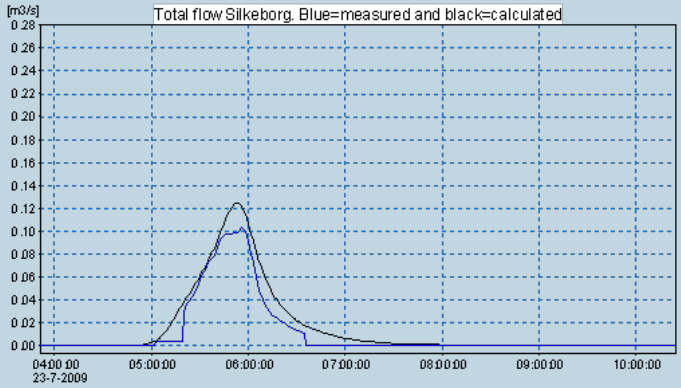


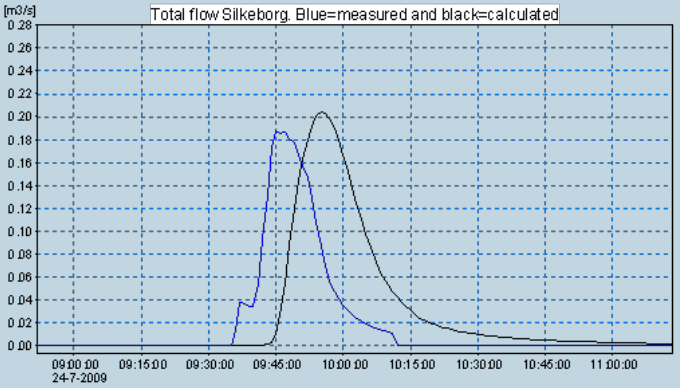


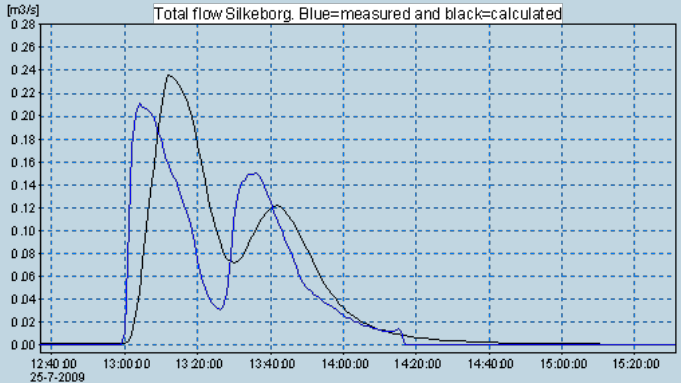
Measured and calculated flows

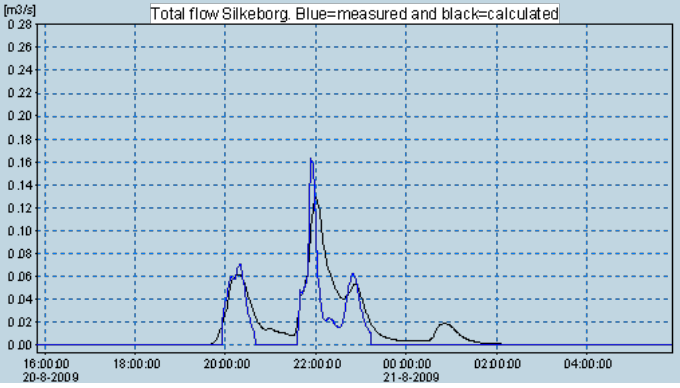




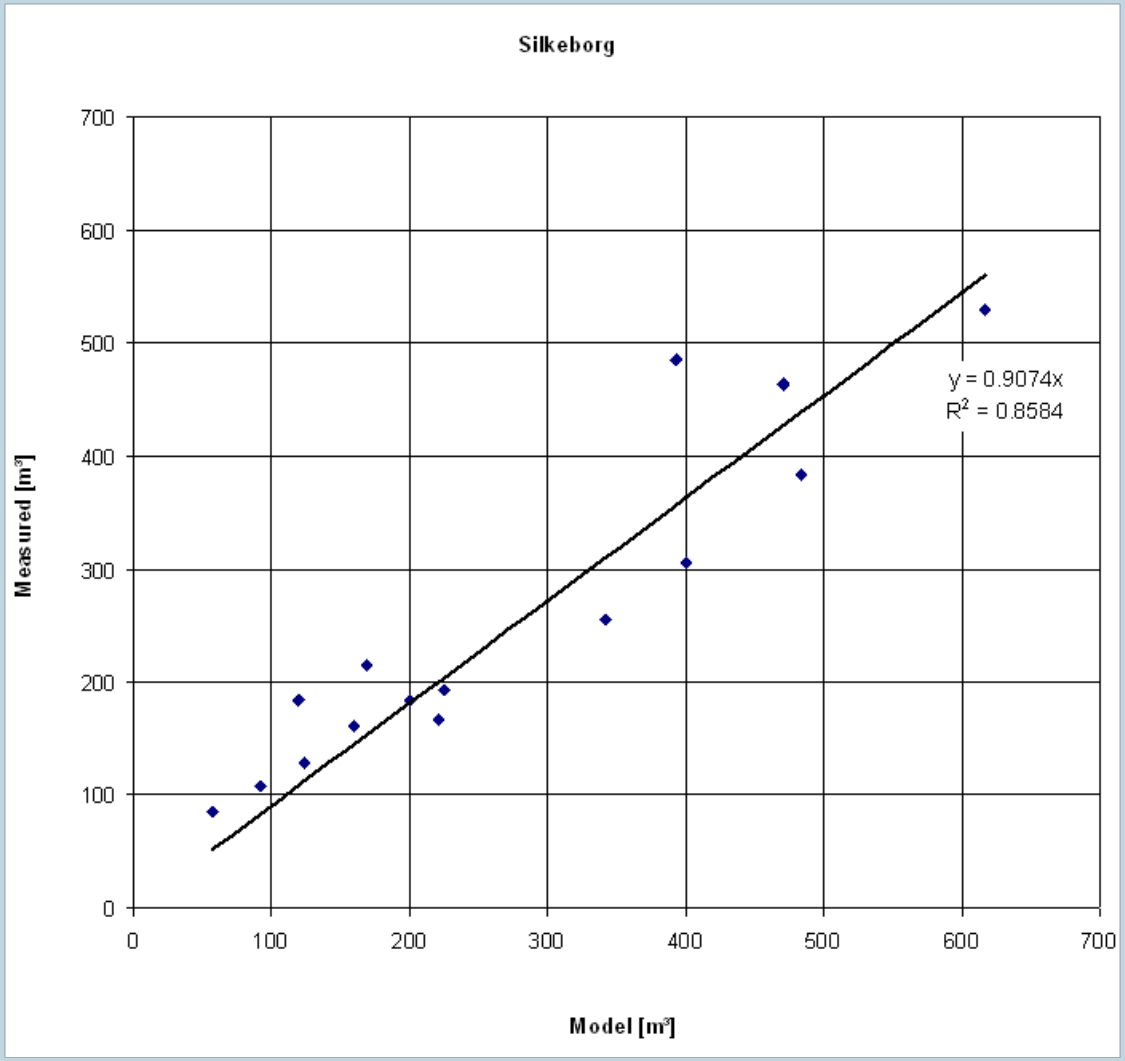








Measured and calculated flows



Discussion

- Screwed images will introduce errors
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Conclusions

- It is possible to use image classification as a tool for describing surface types for use in urban drainage modelling
- Surface types are stored in a database and give full flexibility and documentation in relation to modelling surface runoff
- Reliable result can be achieved by a fully automated method
- Implement satellite images in the future