CLUE

Z GIS

... experts for the spatial view

Discovering the Dutch mountains

An experiment with automated landform classification for purposes of archaeological predictive mapping

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geomorphological maps and predictive modelling

- geomorphological maps are important data sources for predictive modelling
  - settlement is often concentrated on specific landform units, like ridges
- disadvantages
  - low resolution (1:50.000)
  - expert judgement classification of landform, based on both morphometric and genetic criteria
- difficult to produce at higher resolution
  - visual interpretation of LIDAR-based DEMs is time-consuming

an example

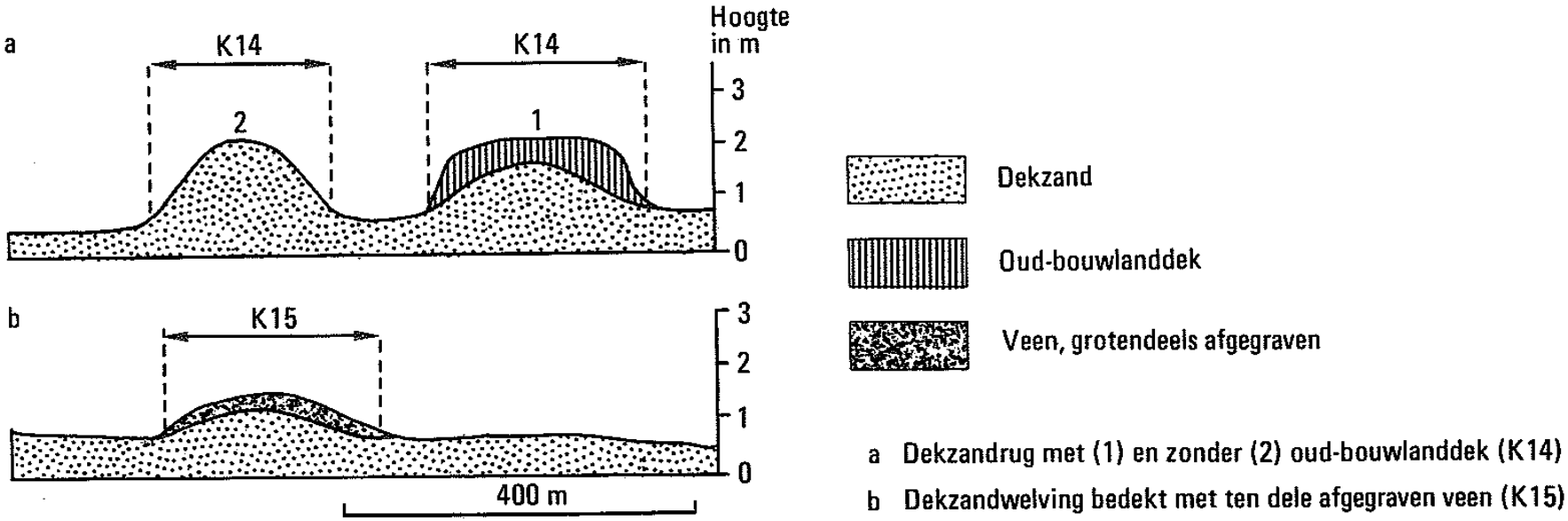
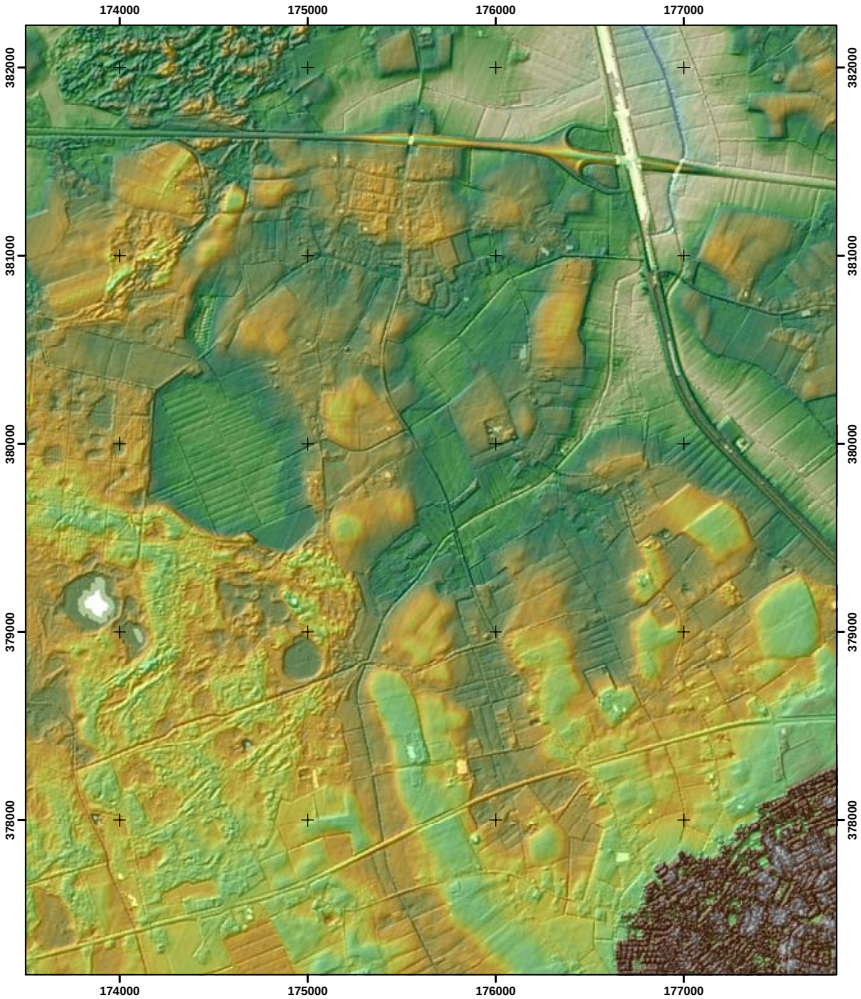


Fig. 90 Schematische doorsnede van dekzandruggen en van een dekzandwelving. Zie fig. 93 voor de reliëfsubklassen van K14 en K15.



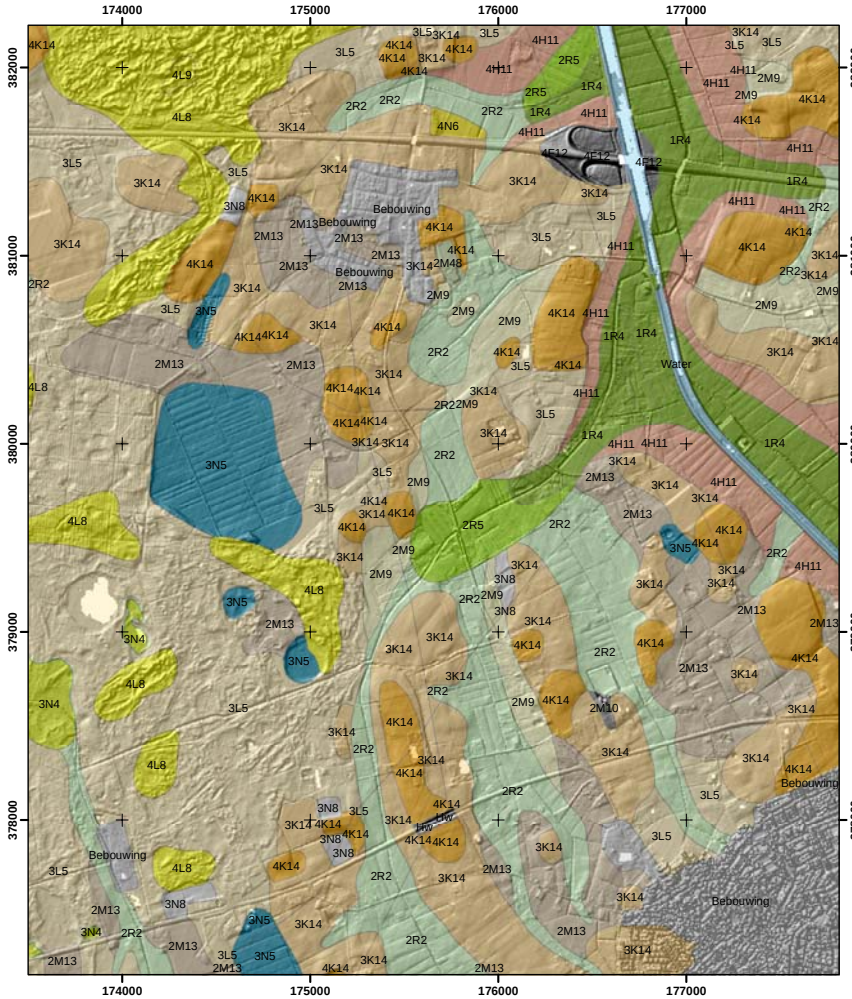
Hillshaded DEM (5x5 m resolution)

High : 43,803

Low : 14,895

250125 0 250 500 750 Meters

N



Geomorphological map 1:50.000

1R4	2R1	3K14	3N8	4L9	Dijk	
2M13	2R2	3L5	4H11	4N6	Water	
2M48	2R4	3N4	4K14	4N8		
2M9	2R5	3N5	4L8	Bebouwing		

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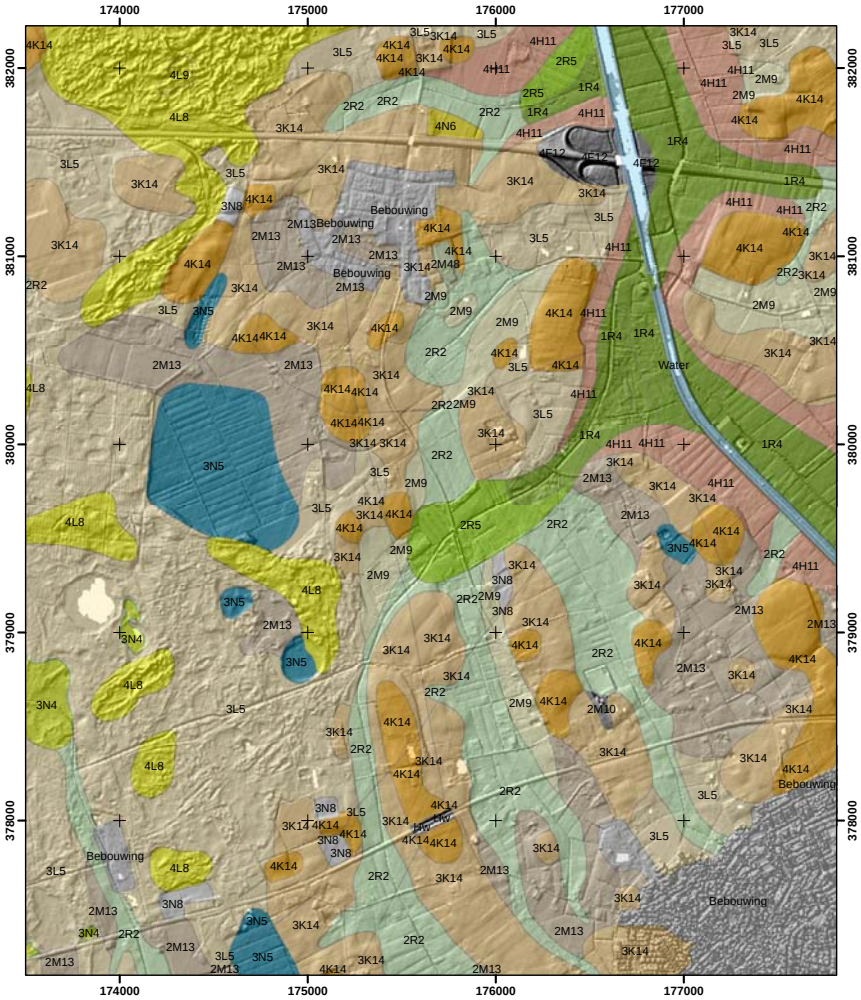

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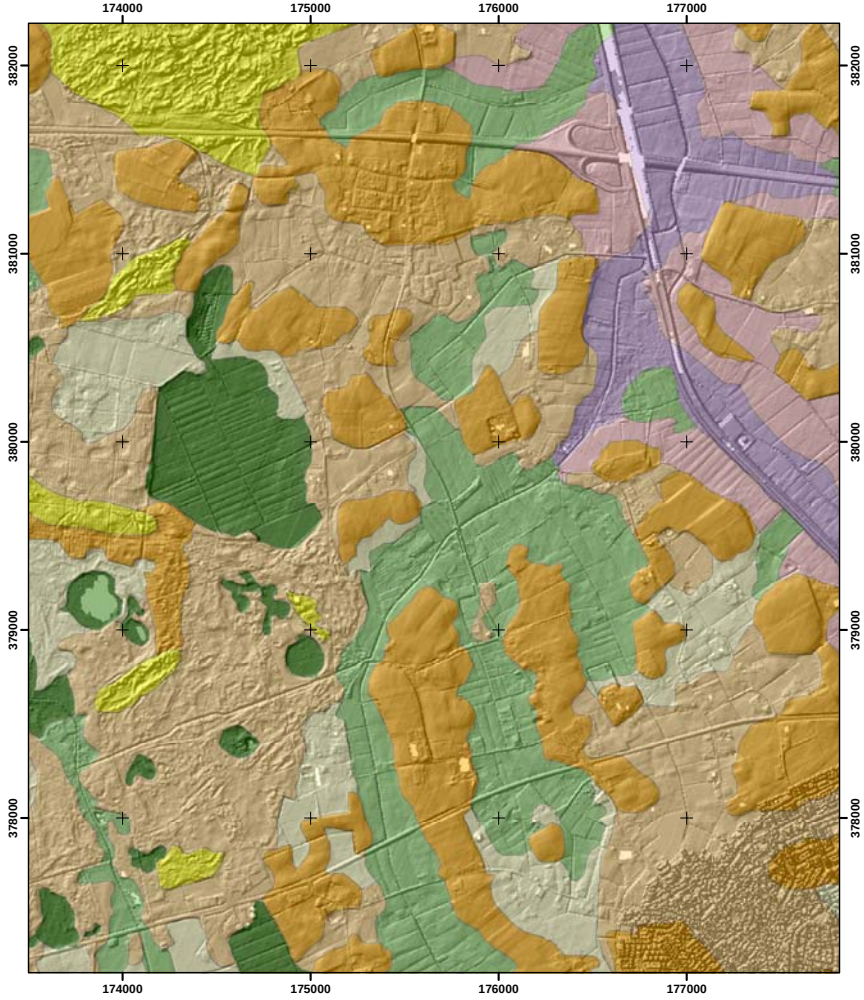


Expert judgment geomorphological map based on DEM

afgegraven	dekzandrug/-kop	stuifzandgebied
beekdalflank	dekzandvlakte	veen
dalvormige laagte	dekzandwelvingen	veenontginningsvlakte
dalvormige laagte met veen	laagte	

250125 0 250 500 750 Meters

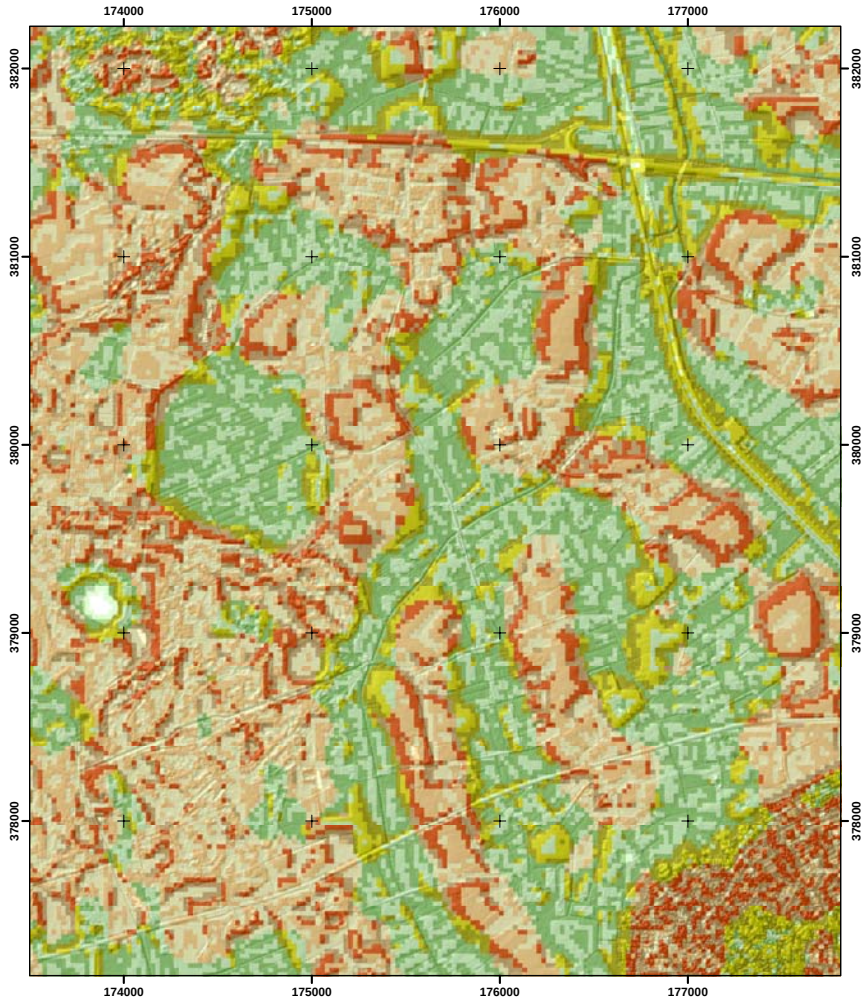
automated landform classification

- GIS offers tools to derive landforms from DEMs, like delineating watersheds, channels and ridges
  - however, standard GIS methods are not very good at classifying more complex landforms
  - more sophisticated methods that classify DEMs into forms and relative position have been developed
  - these are mostly used in mountainous areas
  - primary application in geomorphology and soil science

- two methods tried
  - unsupervised nested means (Iwahashi & Pike 2007)
  - multiresolution ('dynamic') segmentation (Drăguț & Blaschke 2006)
- would these perform well in a flat area?

unsupervised nested means

- takes 3 factors into account
  - slope
  - local convexity (3x3 neighbourhood)
  - ‘texture’ (median of elevation in 3x3 neighbourhood)
- DEM smoothed and resampled to 25x25 m
- texture did not give clear results
  - replaced by the mean of elevation within a 10 cell circular neighbourhood
- the three factors are each sliced in two categories
  - below and above the mean value in the study region
- the final map shows the combination of the sliced factor maps in 8 classes



Landform classification based on Iwahashi and Pike (2007)

- flat, concave, low
- flat, concave, high
- flat, convex, low
- flat, convex, high
- steep, concave, low
- steep, concave, high
- steep, convex, low
- steep, convex, high

N

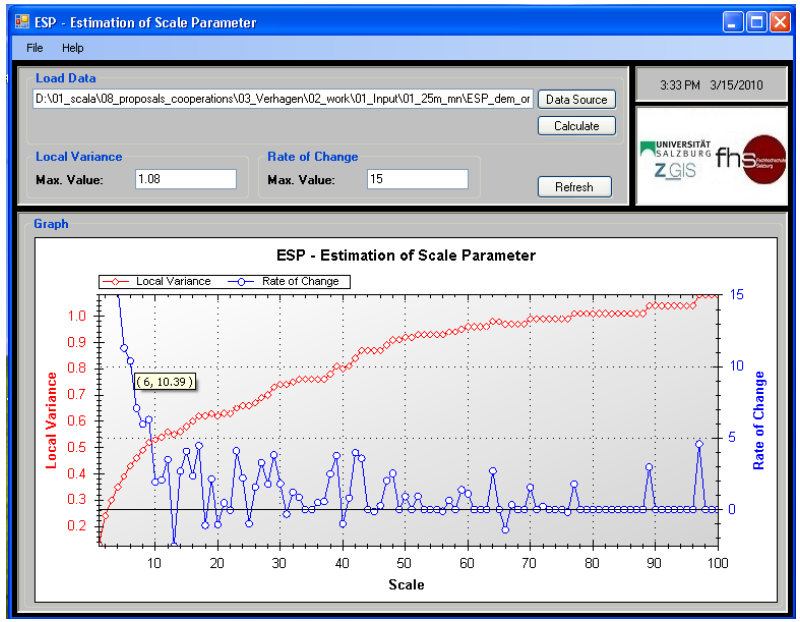
250125 0 250 500 750
Meters

results

- satisfactory classification for ridges, less so for valleys and depressions
- sensitive to scale
  - when using larger neighbourhoods, larger landform units are created
- thresholds of mean elevation do not conform to original geomorphological classification
- no possibility to automatically combine classified zones into larger units
  - on geomorphological maps, a ridge includes the top and the sides

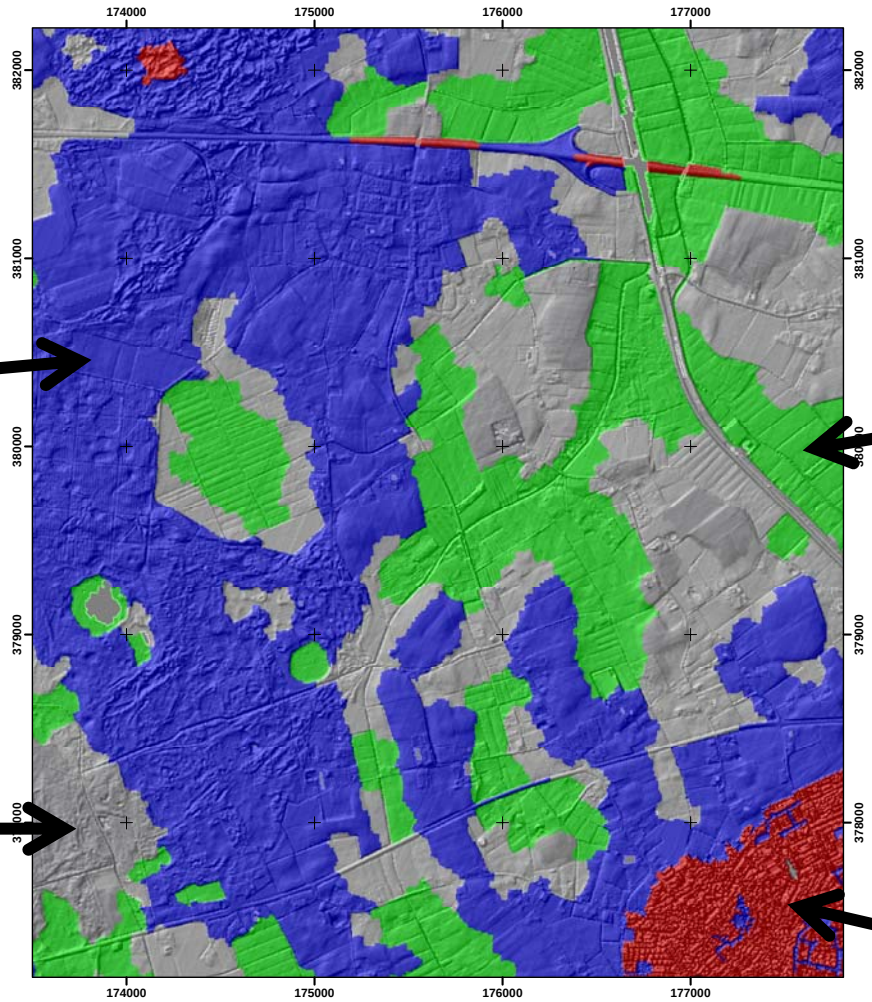
object-based image analysis (OBIA)

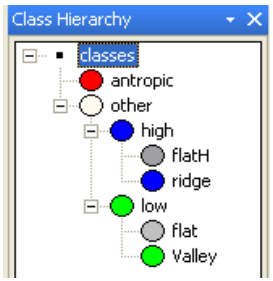
- generates discrete objects from images (segmentation)
  - computes local variance (LV) at different scale levels
  - LV is plotted against scale to detect thresholds of change
  - indicates the scale levels at which the image can be best segmented



method applied

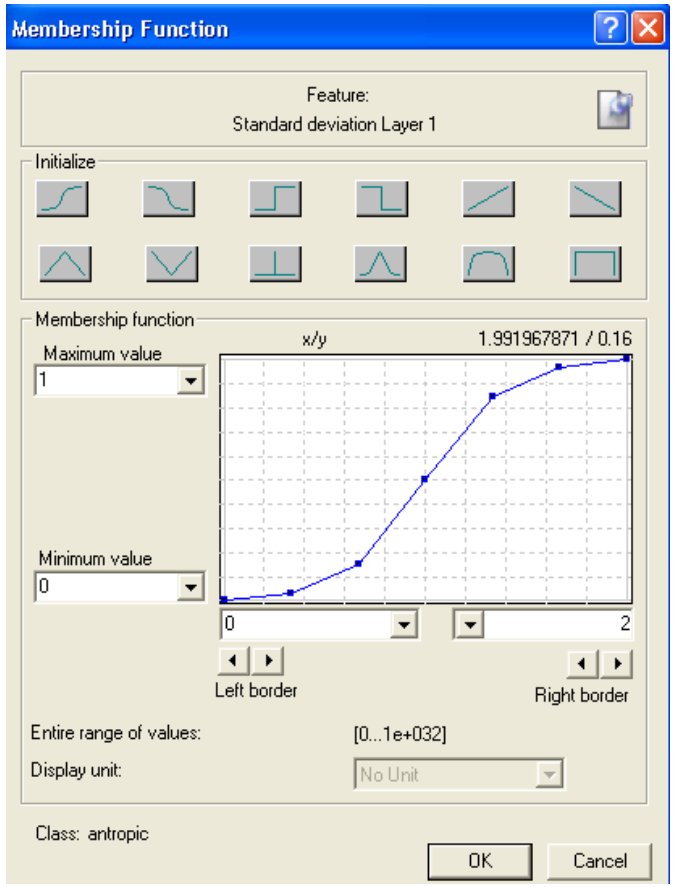
- based on 5x5 m elevation
  - slope and curvature not included
- resulted in clear distinction between built-up and natural areas
- the natural areas were further subdivided in high and low
  - compared to the mean elevation values within a 5 km radius
- these were further subdivided in flat and sloping areas

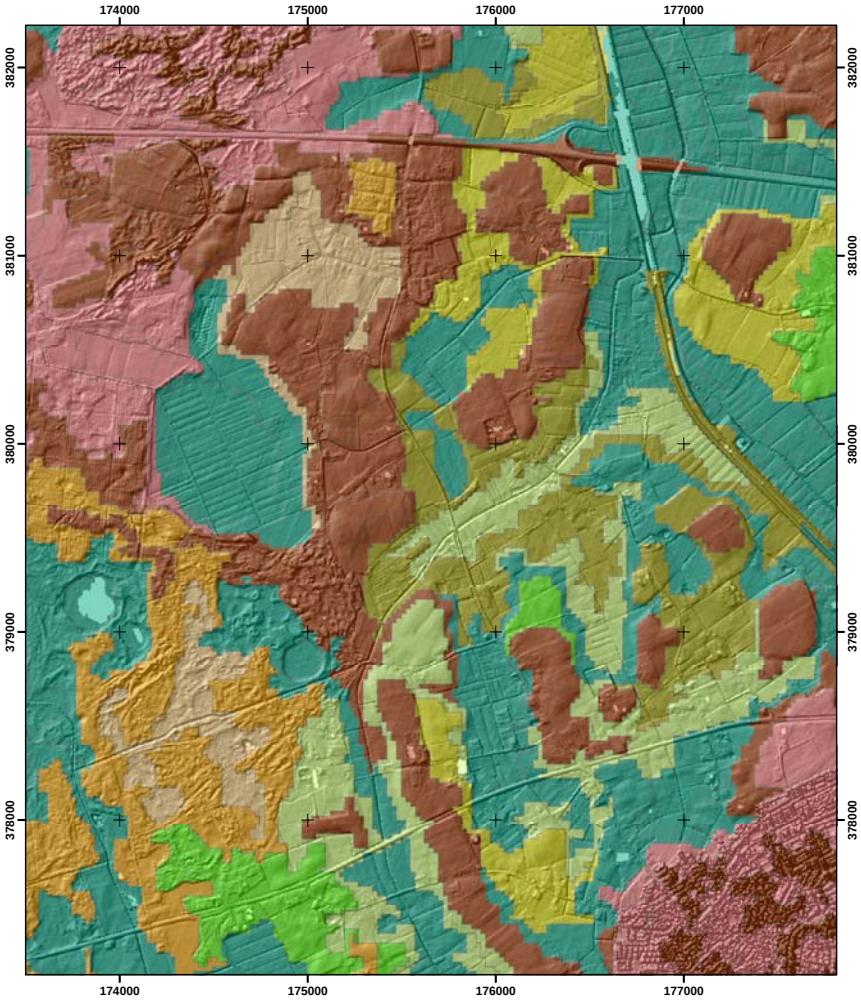

174000
175000
176000
177000
382000
381000
380000
379000
378000
ridges
valleys
flat
built-up
Landform classification using dynamic segmentation
Red: Band_1
Green: Band_2
Blue: Band_3
250125 0 250 500 750
Meters
N


Class Hierarchy
classes
antropic
other
high
flatH
ridge
low
flat
Valley

second attempt

- DEM was smoothed and resampled to 25x25 m
- segments represent areas with homogeneous elevation
- classification then followed the logic of the Iwahashi and Pike method
  - e.g. a valley is classified as a segment with mean elevation more than 0.5 standard deviations below the mean of its neighbouring segments



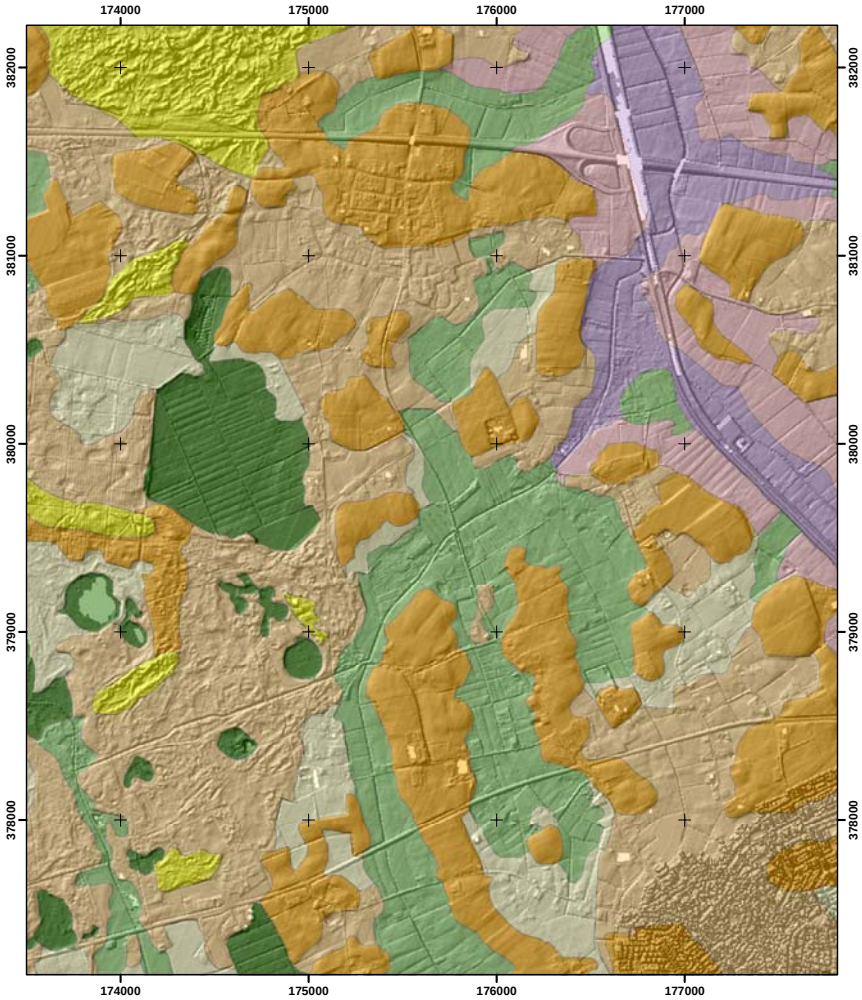


New landform classification using dynamic segmentation

- Flat, concave, high
- Flat, concave, low
- Flat, convex, high
- Flat, convex, low
- Sloping, concave, high
- Sloping, concave, low
- Sloping, convex, high
- Sloping, convex, low
- Valley or depression

N

250125 0 250 500 750 Meters



Expert judgment geomorphological map based on DEM

- afgegraven
- beekdalflank
- dalvormige laagte
- dalvormige laagte met veen
- dekzandrug/-kop
- dekzandvlakte
- dekzandwelvingen
- laagte
- stuifzandgebied
- veen
- veenontginningsvlakte

N

250125 0 250 500 750 Meters

results

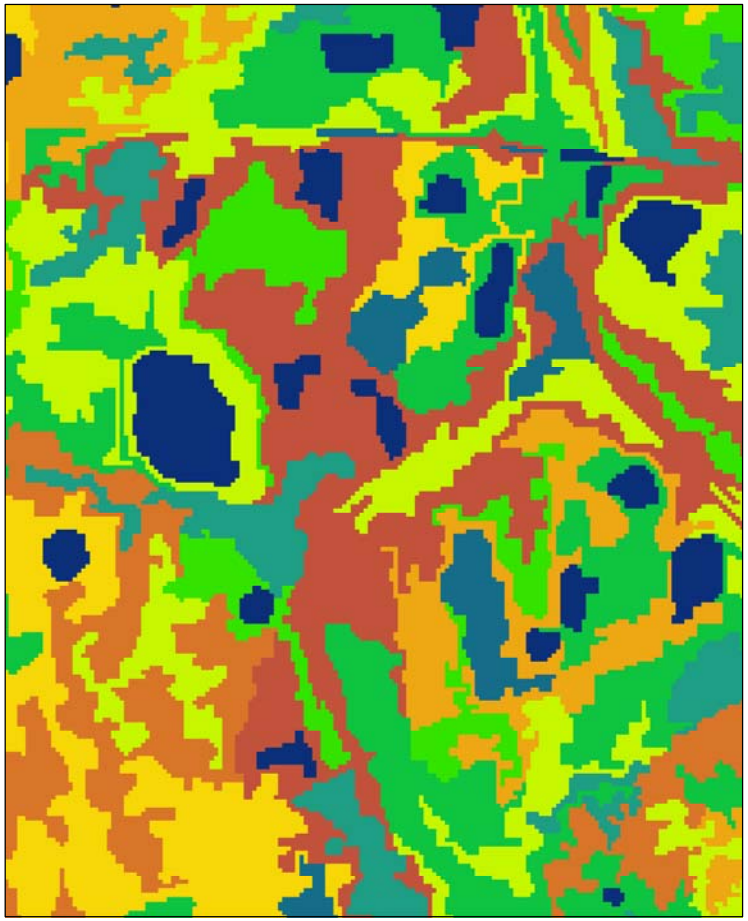
- some clear advantages
  - segmentation results are region-specific
  - segmentation rules are objective
  - method is transferable to other regions

- issues to be solved
  - classification rules are subjective
    - especially the neighbourhood threshold chosen is important in this respect
  - software used (Definiens/eCognition) is proprietary (and expensive)

conclusions

- dynamic segmentation is a powerful method to extract landform, but
  - segmentation does not always give a good match with the geomorphological map
  - the genetic component used in the standard classification scheme cannot be extracted with automated rules
  - automatic combination of landform classes into larger units needs additional formal rules
- the role of scale in defining landform should be more closely investigated
- classification rules should be re-assessed
  - how can we merge the standard geomorphogical classification system with automated classification rules?
  - do archaeologists perhaps need different classification schemes?

TO BE CONTINUED ….

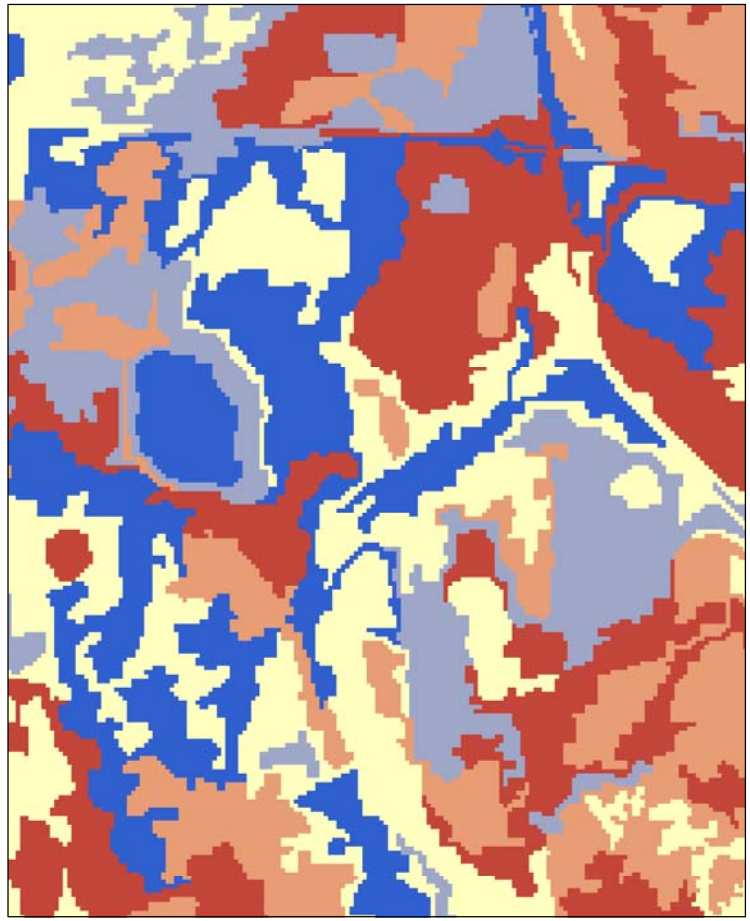


Legend

Segmented image

Shape metric (FragStats)

- 1 - 1,5625
- 1,562500001 - 2,0256
- 2,025600001 - 2,4762
- 2,476200001 - 2,9216
- 2,921600001 - 3,3514
- 3,351400001 - 3,7885
- 3,788500001 - 4,2838
- 4,283800001 - 4,8293
- 4,829300001 - 5,6237
- 5,623700001 - 7,2105



Legend

Segmented image

proportion of lower neighbouring segments

- 0 - 0,15
- 0,15 - 0,35
- 0,35 - 0,6
- 0,6 - 0,85
- 0,85 - 1