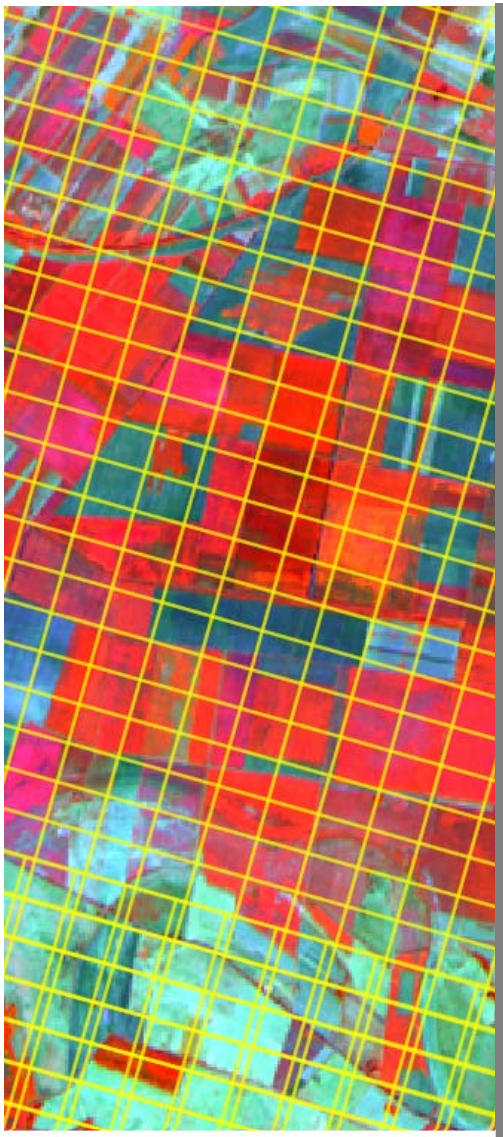

Satellite data processing and analysis:
Examples and practical considerations

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International LCLUC Regional Science Meeting in Central Europe | Sopron, Hungary 16-22nd October 2014

Institute of Geodesy, Cartography and Remote Sensing

Budapest, Hungary

Introduction

Remote Sensing can…

- Yield information over large areas simultaneously, at multiple spatial and temporal scales
- Be tailored to the objects/phenomena to be observed
- Help in the *identification* and *quantification* of changes in land surface characteristics
- Provide data over multiple decades from the archives

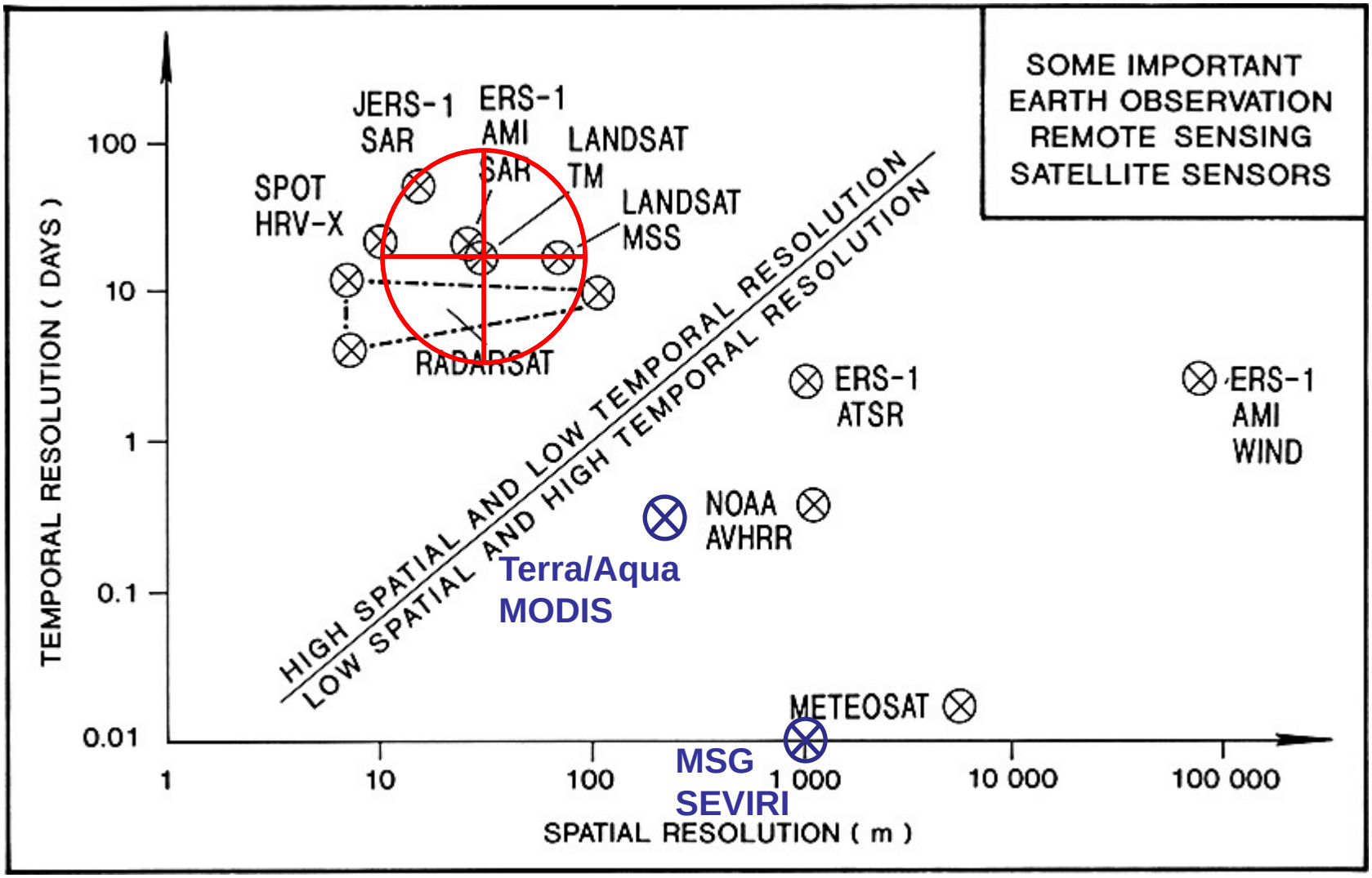
Introduction

Challenges:

- Besides real changes in land surface characteristics, multiple factors cause radiometric and geometric differences ➔"false changes"
- **"Artificial" effects**
  - Different sensors, platforms: differences due to orbit, viewing geometry, radiometric calibration, etc.
  - Change of the sensor response function in time: "sensor ageing"
- **"Natural" effects**
  - Atmospheric effects, anisotropic reflectance of targets, different Sun and sensor viewing angles, vegetation seasonal dynamics, etc.

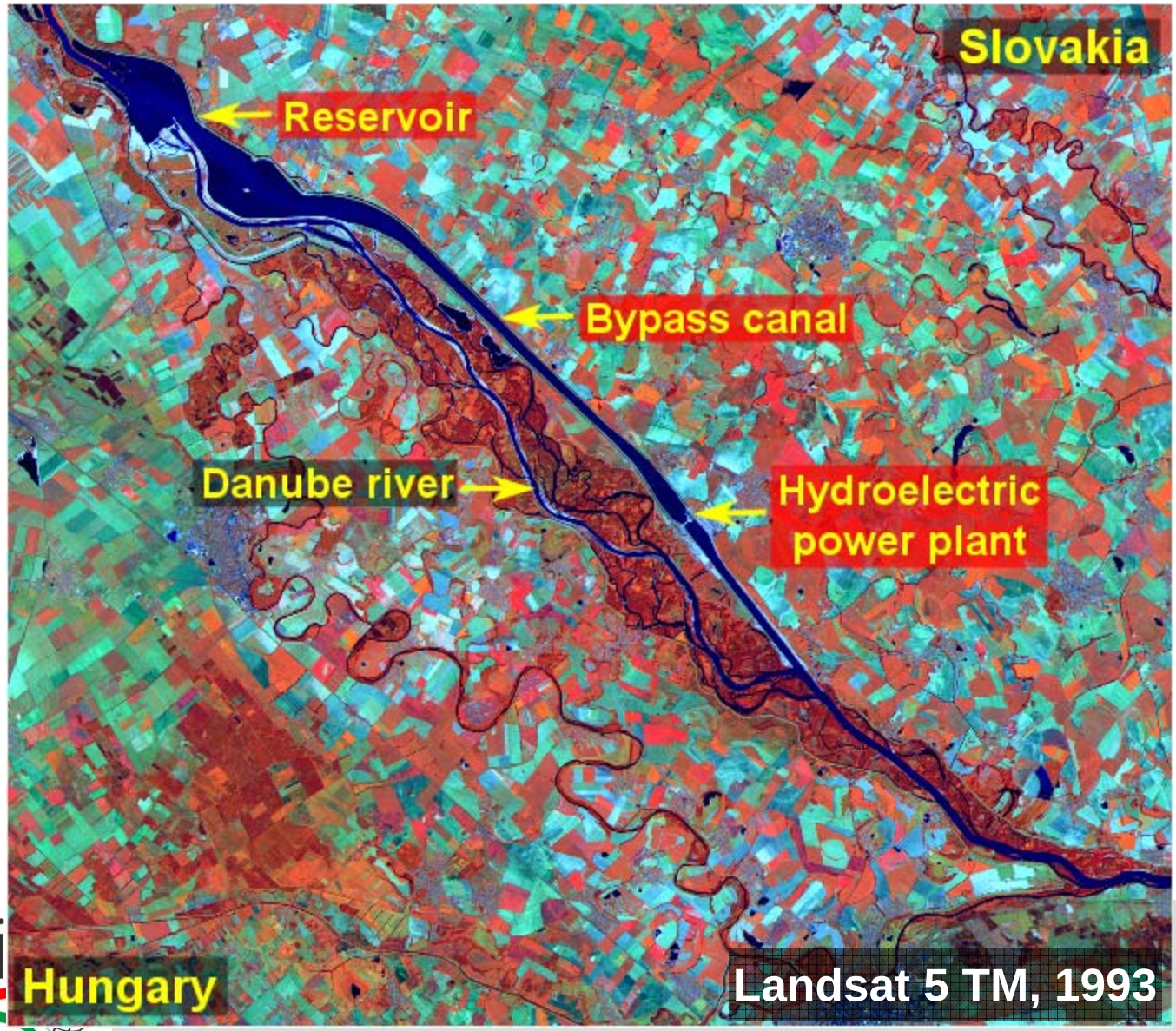
Possible solutions

- **Use preprocessed imagery: e.g. land surface reflectance**
  - Landsat CDR Land Surface Reflectance
  - MODIS daily or composite MOD09 products
- **Use preprocessing schemes tailored to your data**
  - LEDAPS for Landsat
  - Customized parameters and methods for each sensor
- **Carry out relative „radiometric rectification”**
  - Sufficient to measure changes, but not for estimating biophysical parameters, model inversion, etc.
  - May also be used for „indirect” Land Surface Reflectance calculation with appropriate reference data



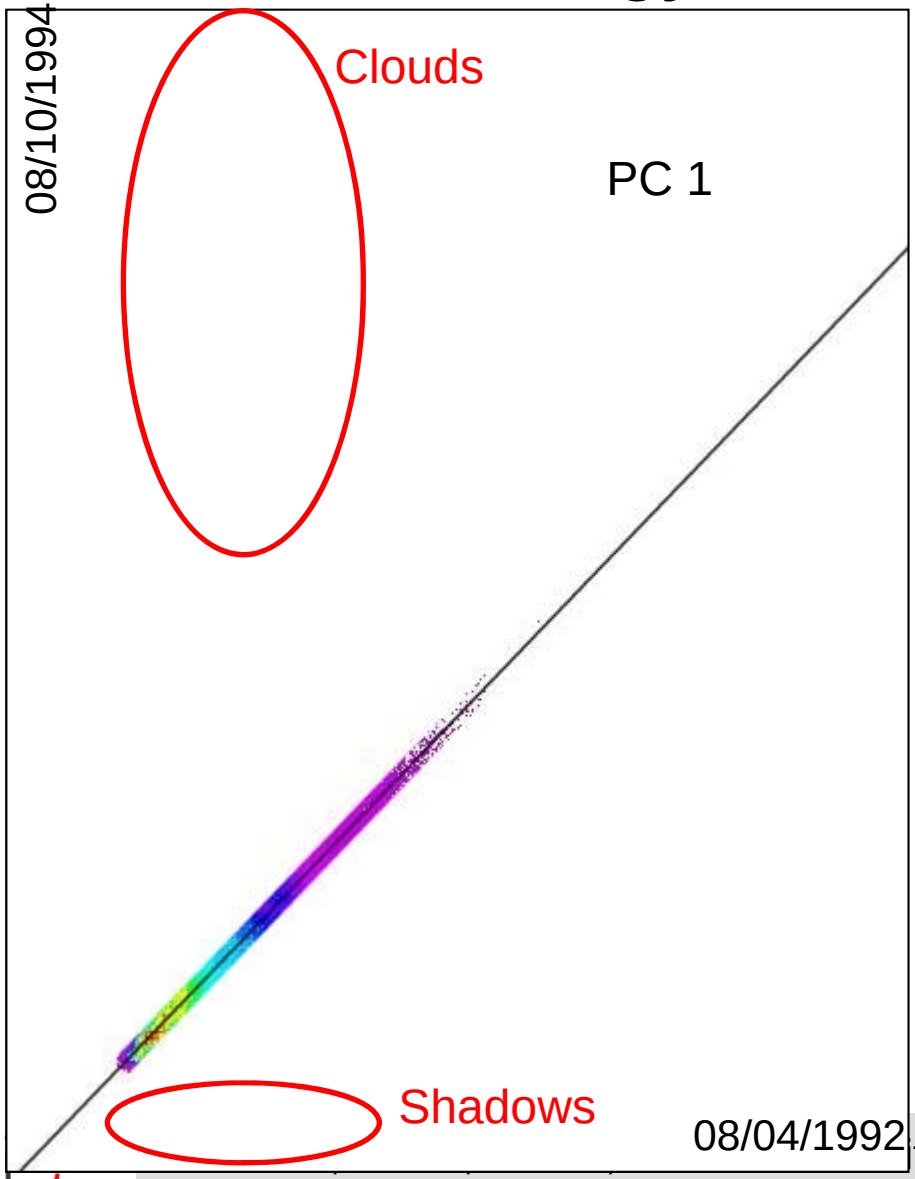
Source:
http://tidsskrift.dk/index.php/geografisktidsskrift/article/viewFile/2402/4241

Case study: Barrage system effects



Images copyright Eurimage 1987&1993

Methodology: Radiometric correction



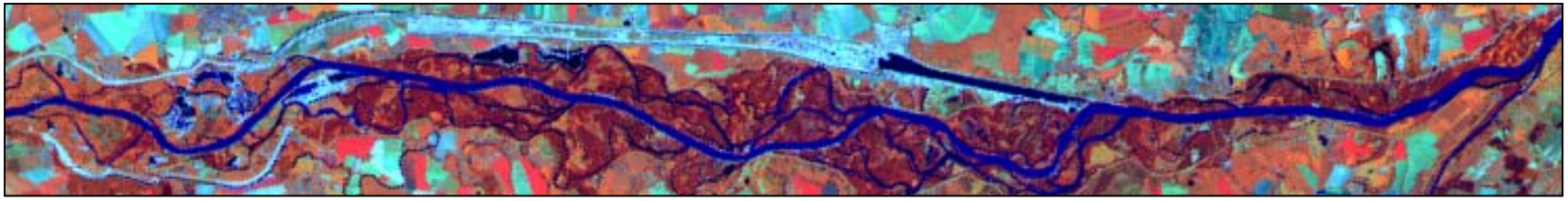
Pixels closest to the first PC axis show strong linear interdependence, thus selected as pseudo-invariant features.

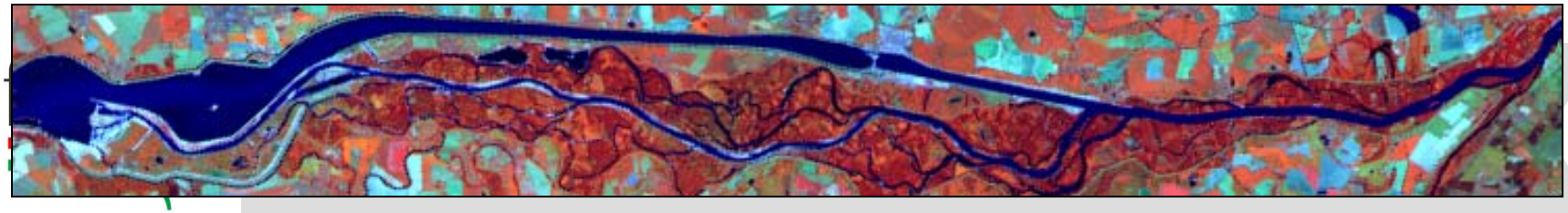
PIFs are used for radiometric normalization.

Data used

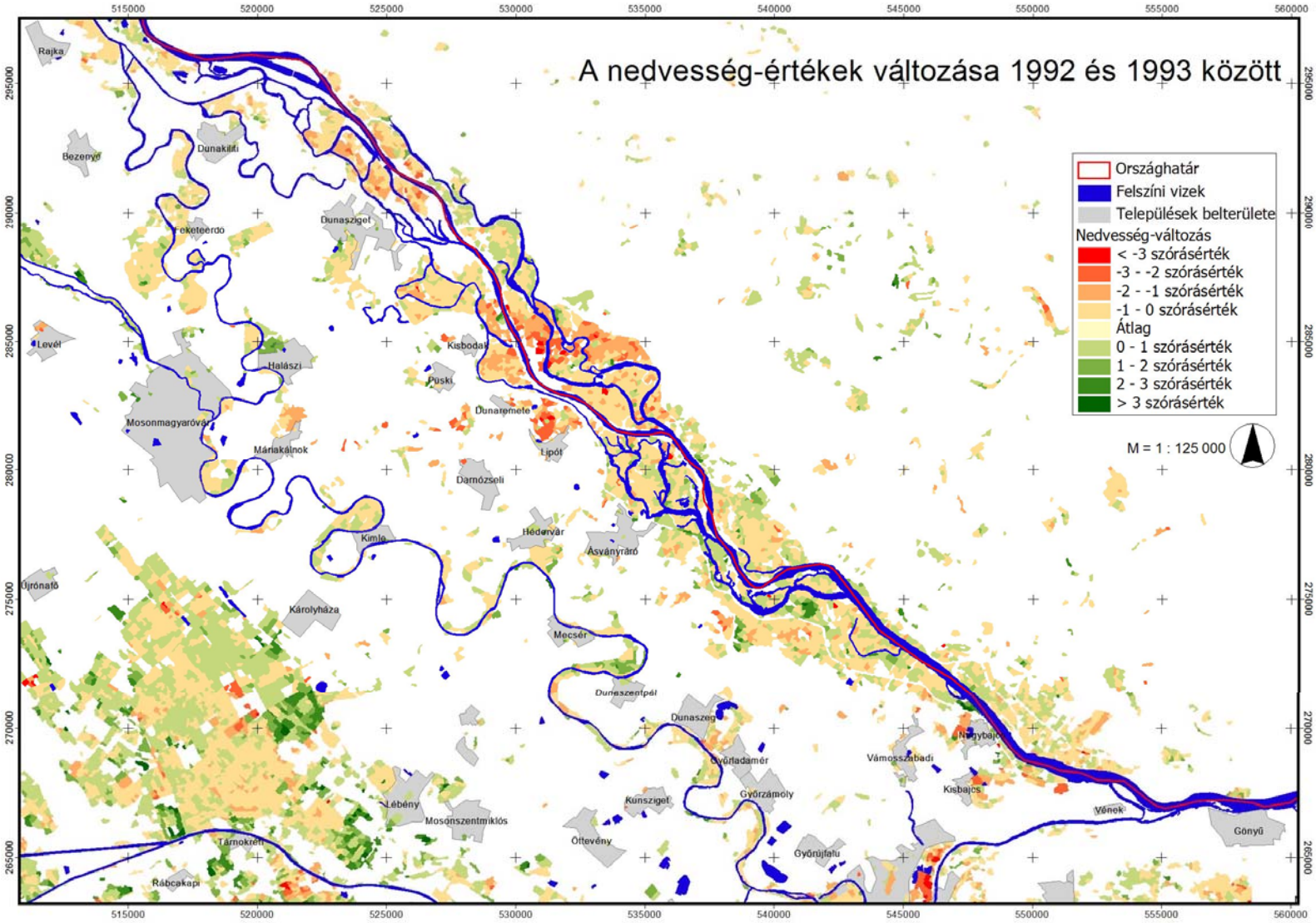
Satellite imagery

- 23 images dating from 1981 to 2001
- **Landsat MSS** (4 bands from visible to NIR, 80 x 80 m pixel size),
- **Landsat TM, ETM+** (7 bands from visible to TIR, 30 x 30 m pixel size)
- **SPOT HRVIR** (4 bands from visible to MIR, 20 x 20 m pixel size)

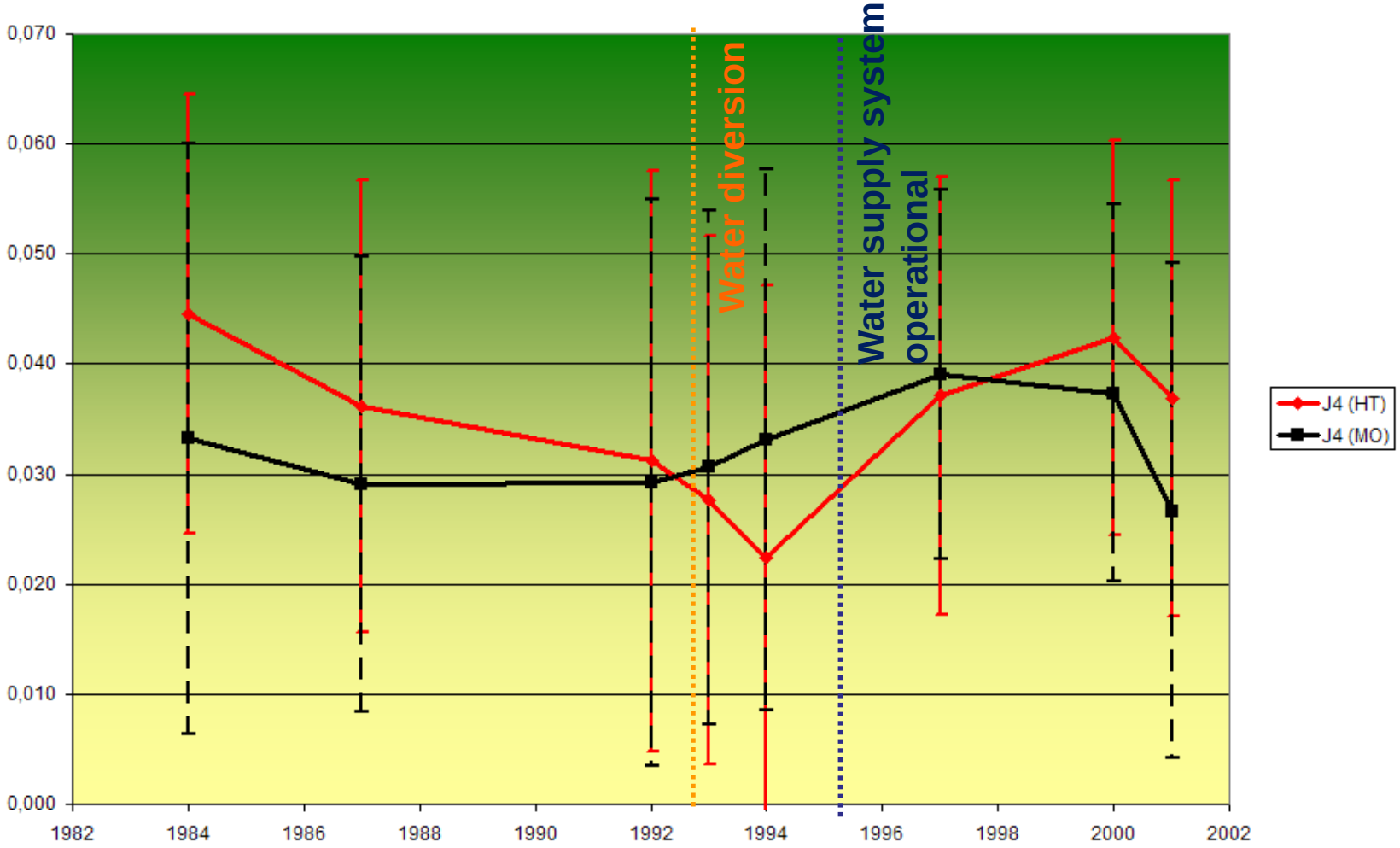




Results: Change maps

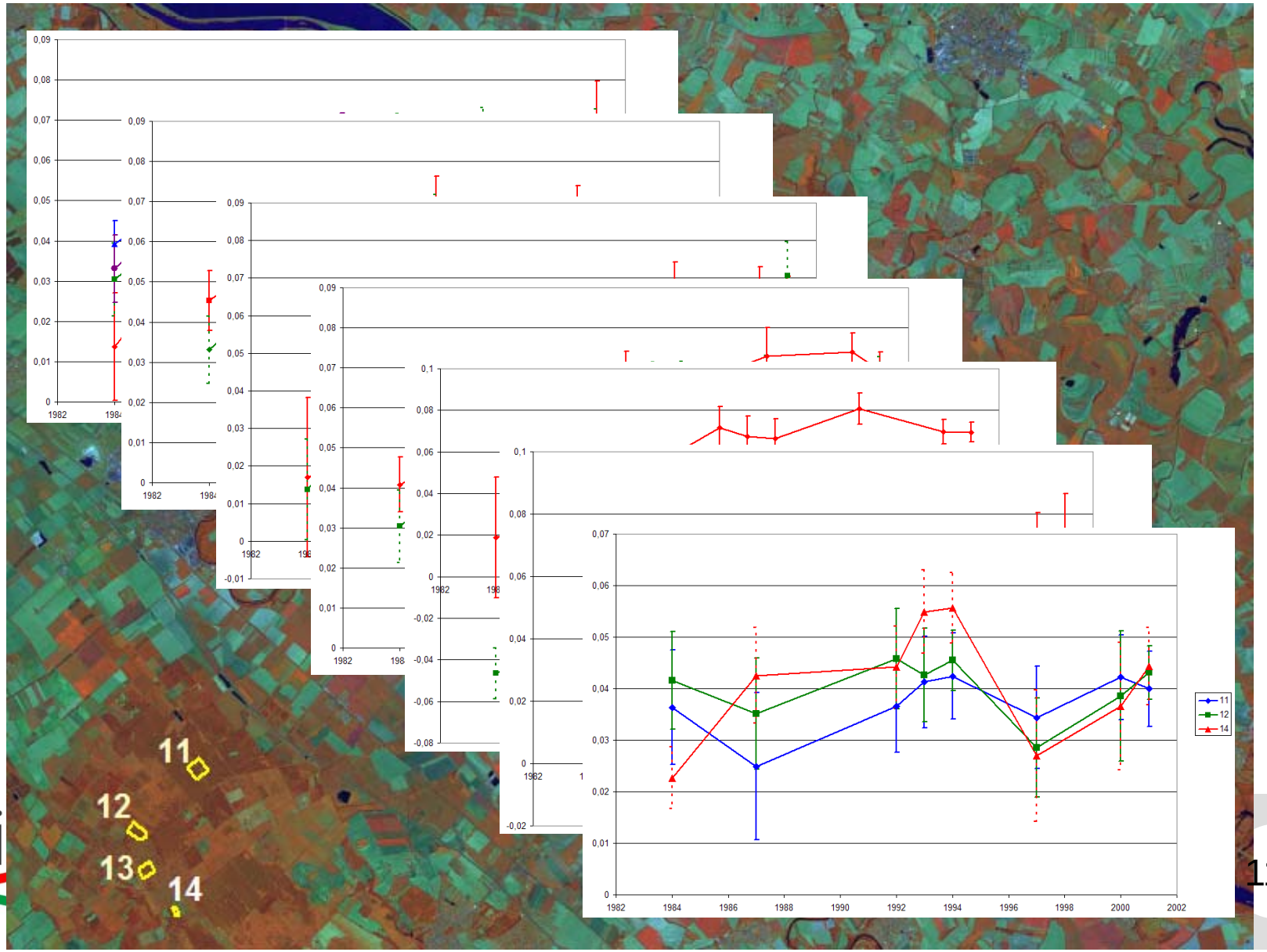


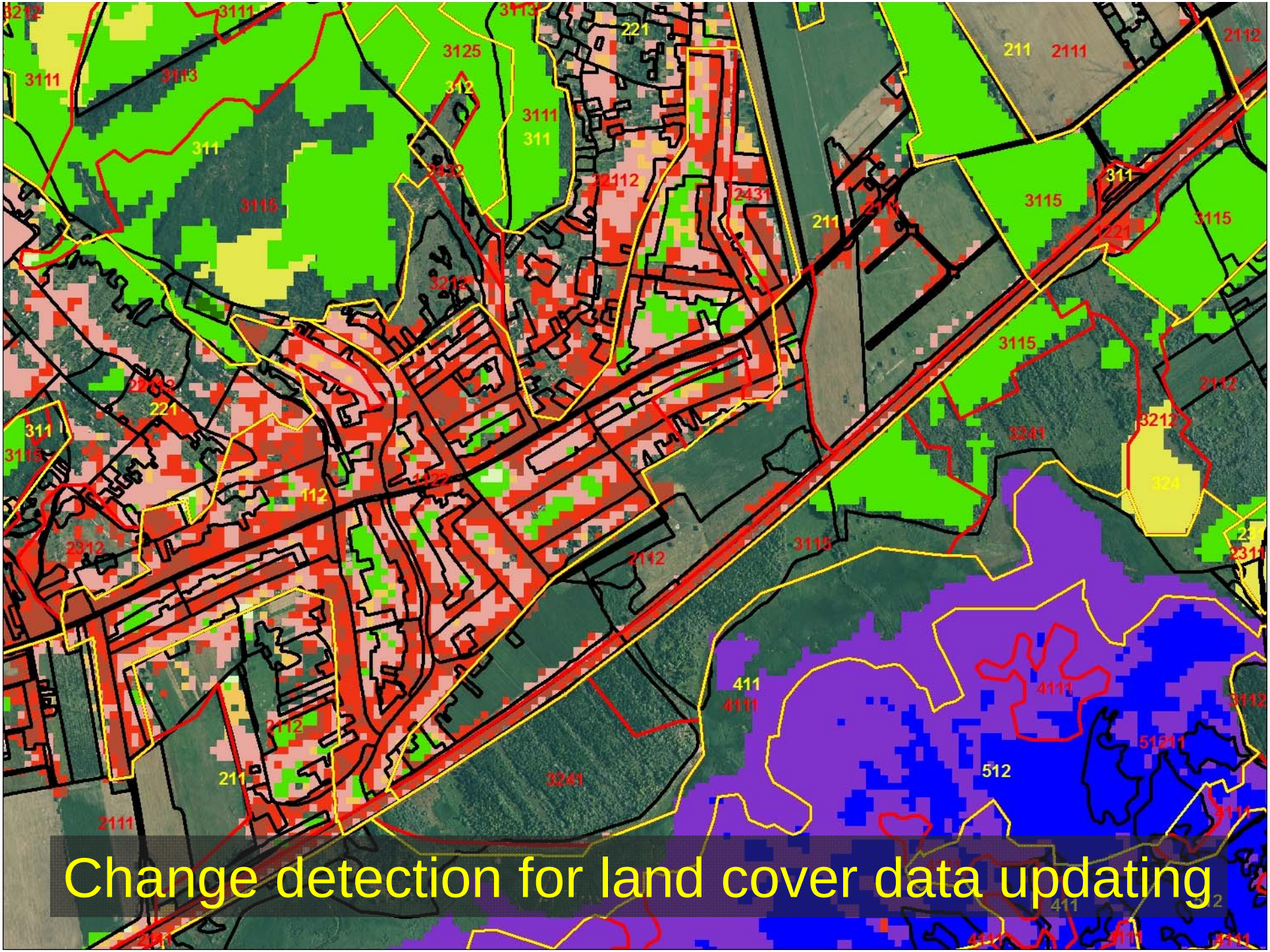
Results: Trends



Comparison of wetness values for floodplain (HT) and non-floodplain (MO) willow forests

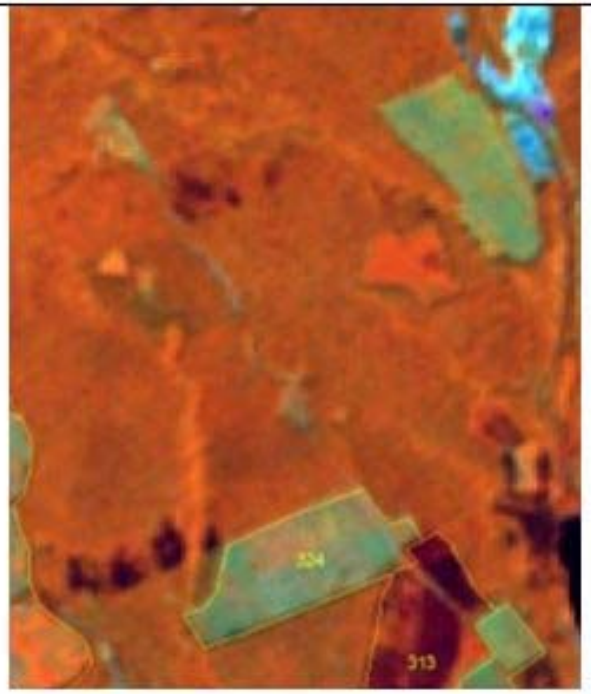
Results: Trends



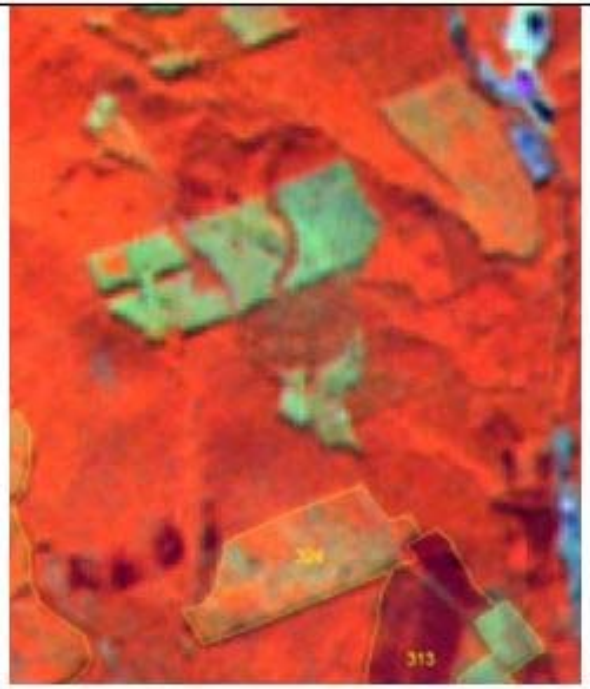

Change detection for land cover data updating

Deforestation, reforestation, afforestration

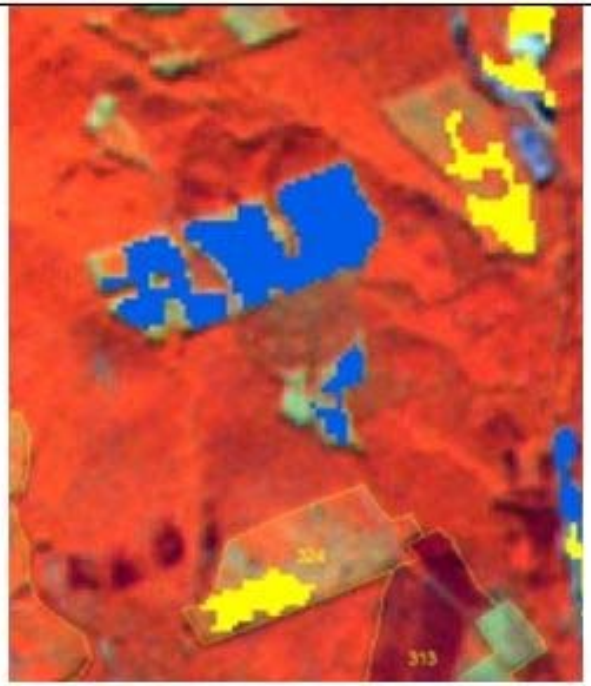
Detection based on multi-temporal NDVI differences



(a) 2006 évi űrfelvétel-kivágat



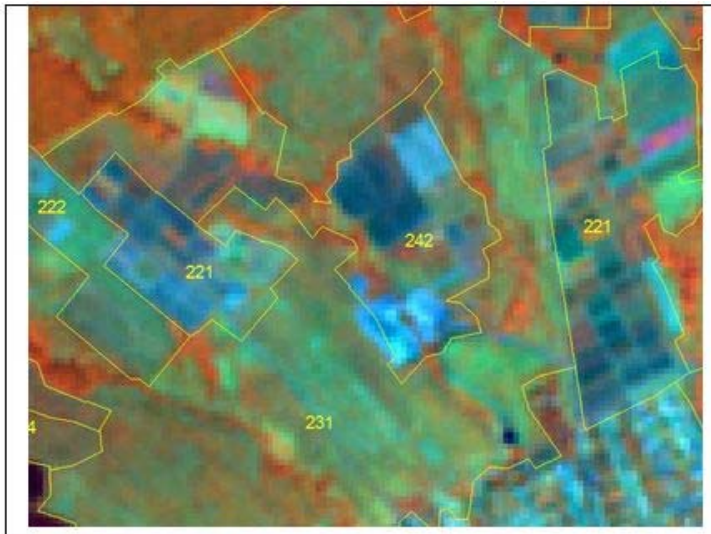
(b) 2011 évi űrfelvétel-kivágat



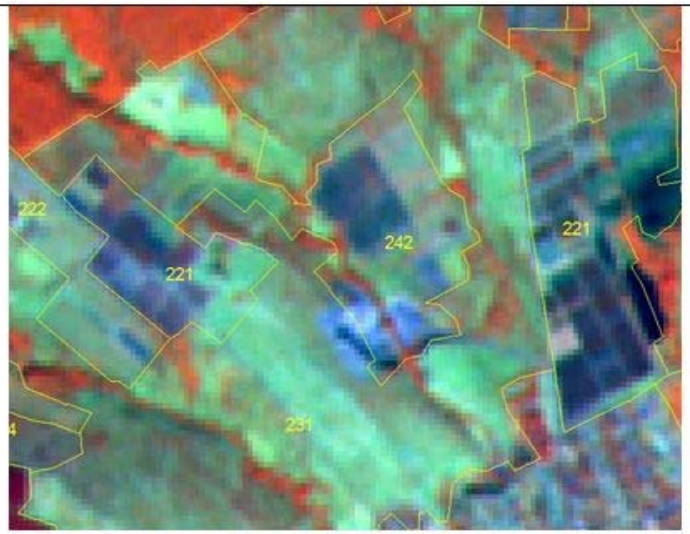
(c) Erdő-változás adatbázis (kék:kivágás; sárga: felnövekedés)

New built-up areas and mines

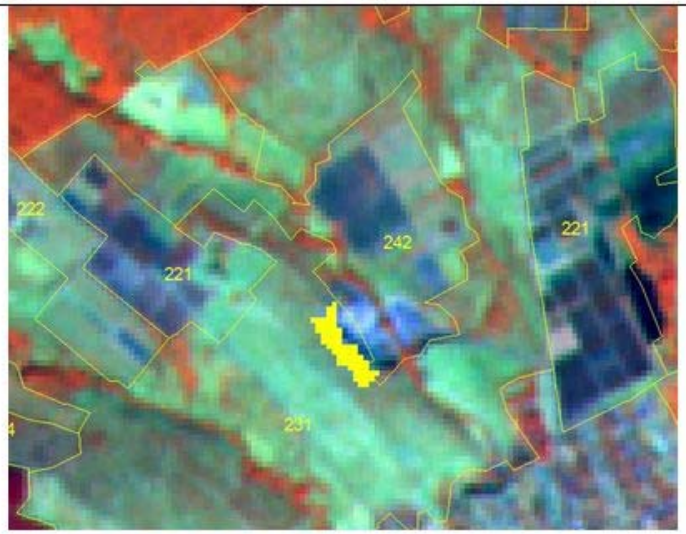
Detection based on ancillary data and multi-temporal NDBI (Norm. Diff. Built-up Index)



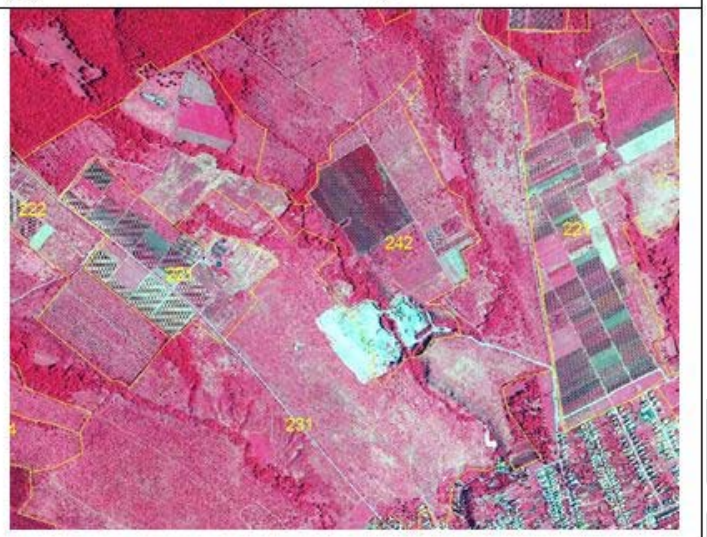
(a) 2006 évi űrfelvétel-kivágat



(b) 2011 évi űrfelvétel-kivágat



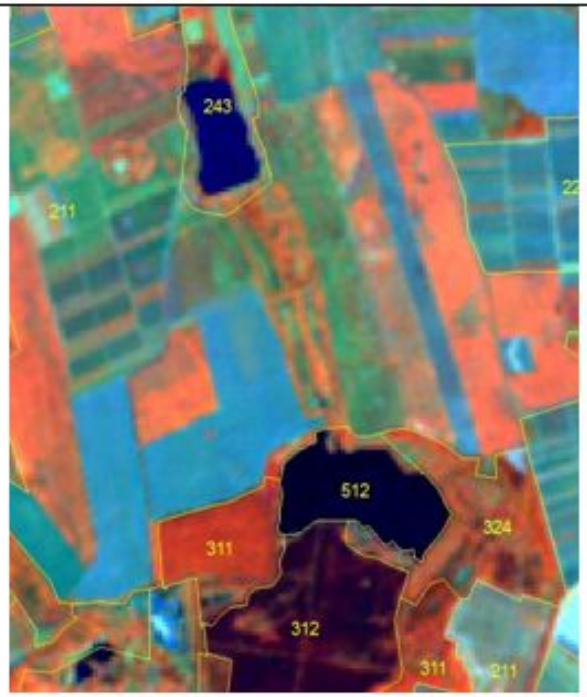
(c) Szántó/legelő beépítés



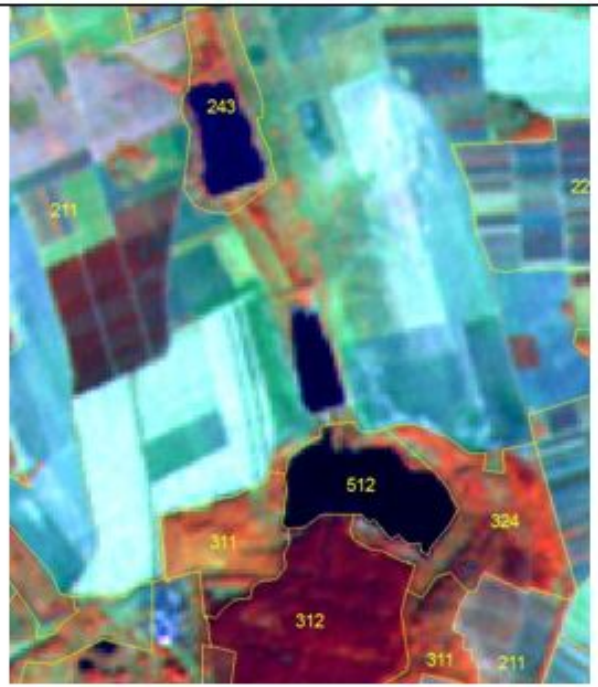
(d) a terület ortofotó kivágata (2010)

New water bodies in agricultural land

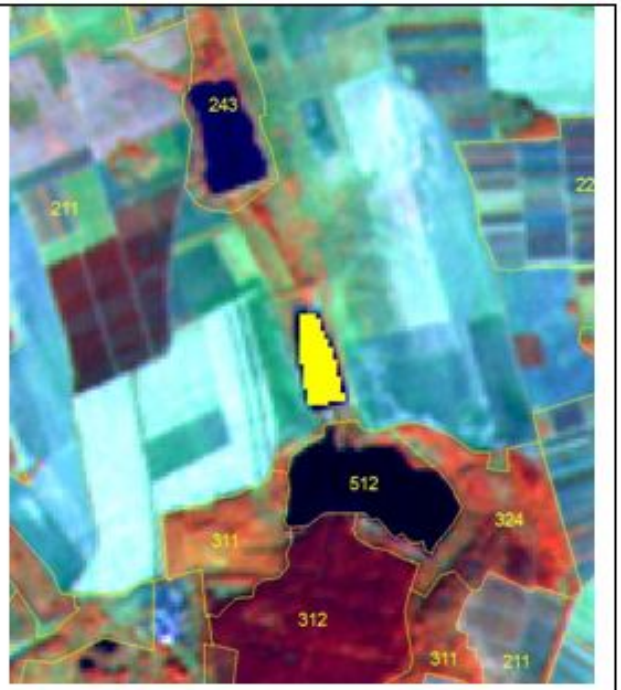
Detection based on ancillary data and multi-temporal NDWI (Norm. Diff. Water Index)



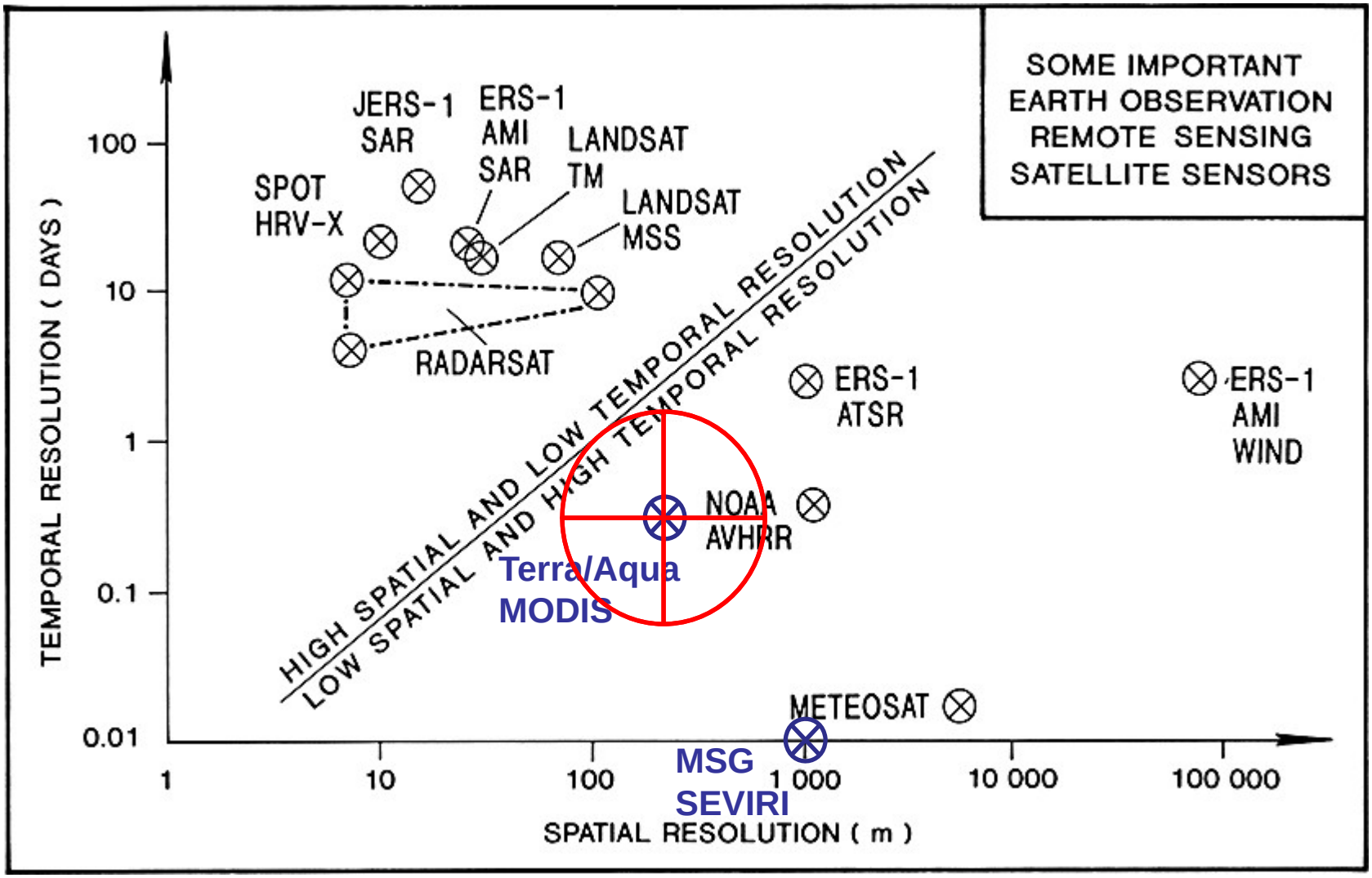
(a) 2006 évi űrfelvétel-kivágat



(b) 2011 évi űrfelvétel-kivágat

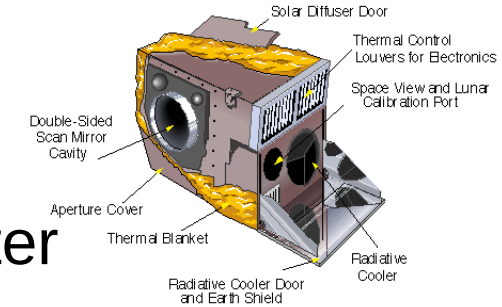


(c) Új tó (sárga)



Source:
http://tidsskrift.dk/index.php/geografisktidsskrift/article/viewFile/2402/4241

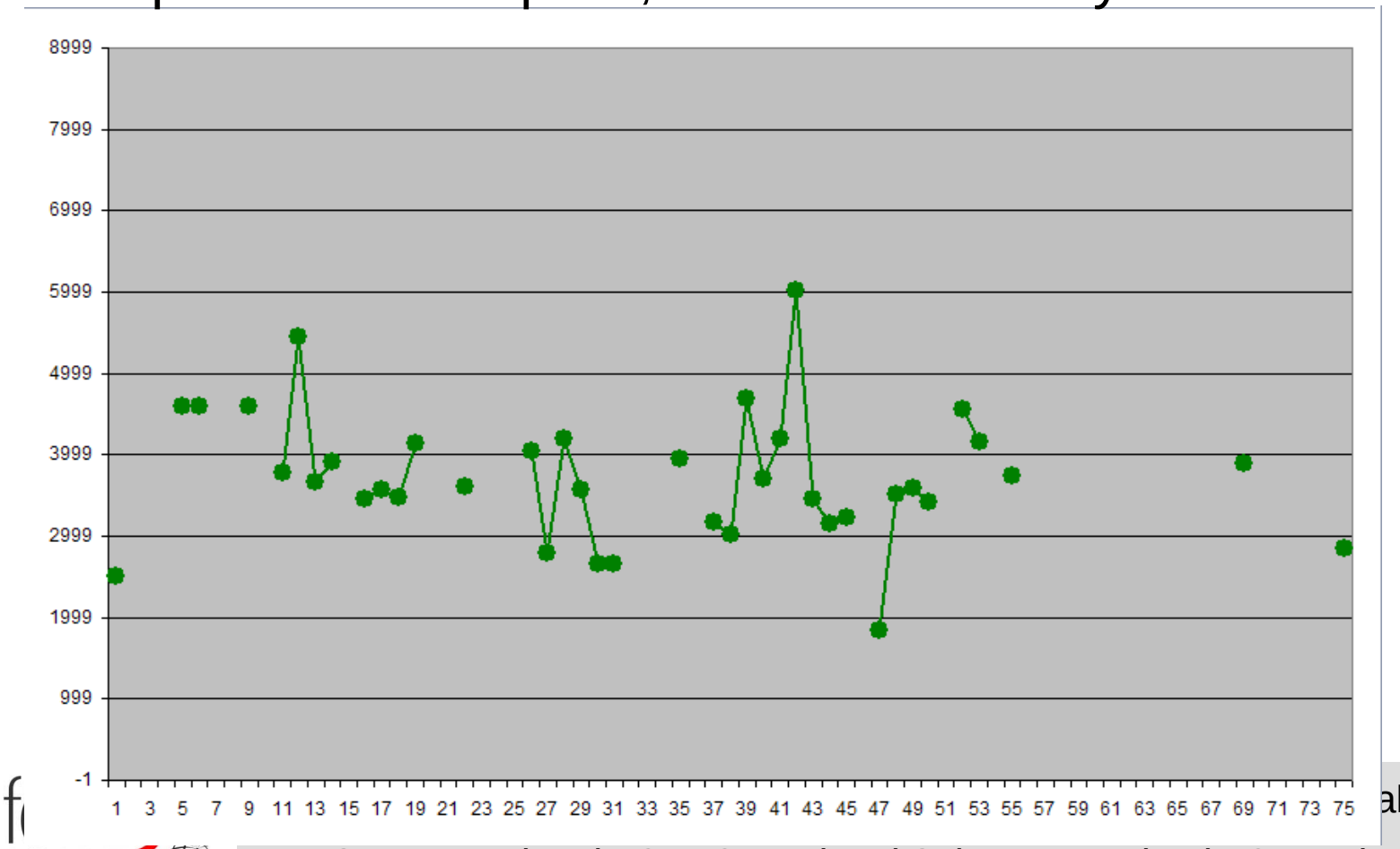
MODIS



- Moderate Resolution Imaging Spectroradiometer
- Onboard NASA's Terra&Aqua satellites
- 36 spectral bands between 0.405 and 14.385 micrometers
- Wide field of view, daily (or even more frequent) coverage with nominal nadir resolutions of 250, 500 and 1000 meters
- Sophisticated operational data processing (MODAPS)
- A large number of preprocessed data & scientific products available (for free…), timeliness
- Well-published algorithms, systematic revision and reprocessing (also backwards processing; Currently: „Collection 5")
- An archive continuous in time: (almost) gapless data since 1999!

Beginning: initial motivation…

- A user wants to detect the date of interventions on agricultural fields
- Spatial scale: ~ pixel, Time scale: ~ day



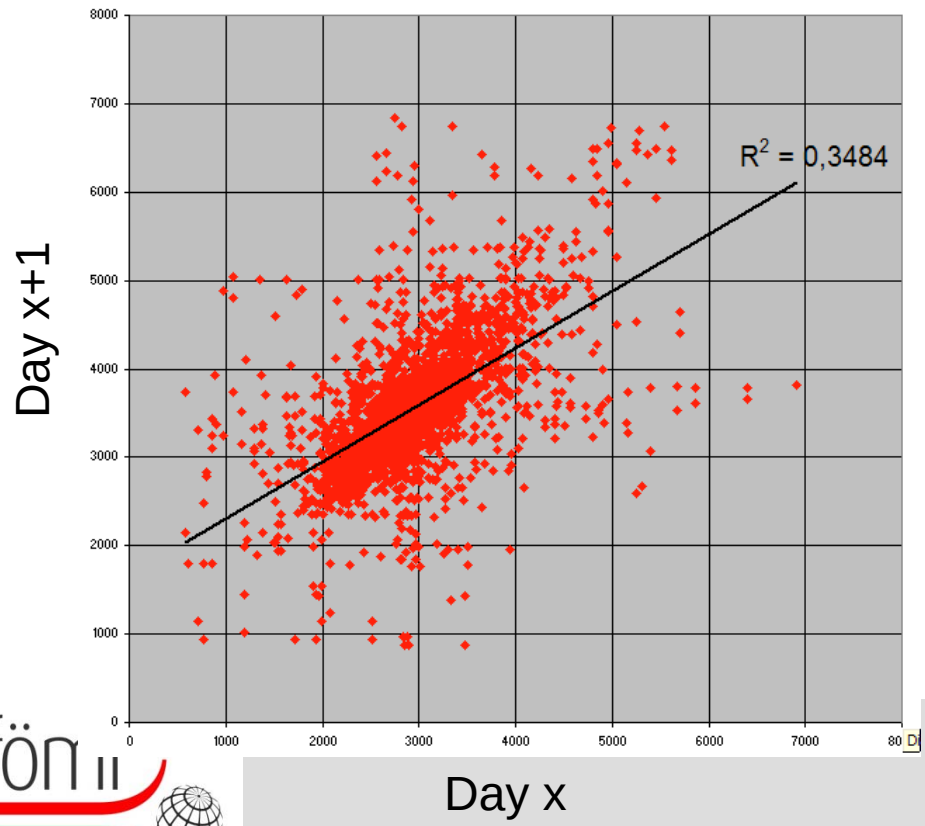
Band 2

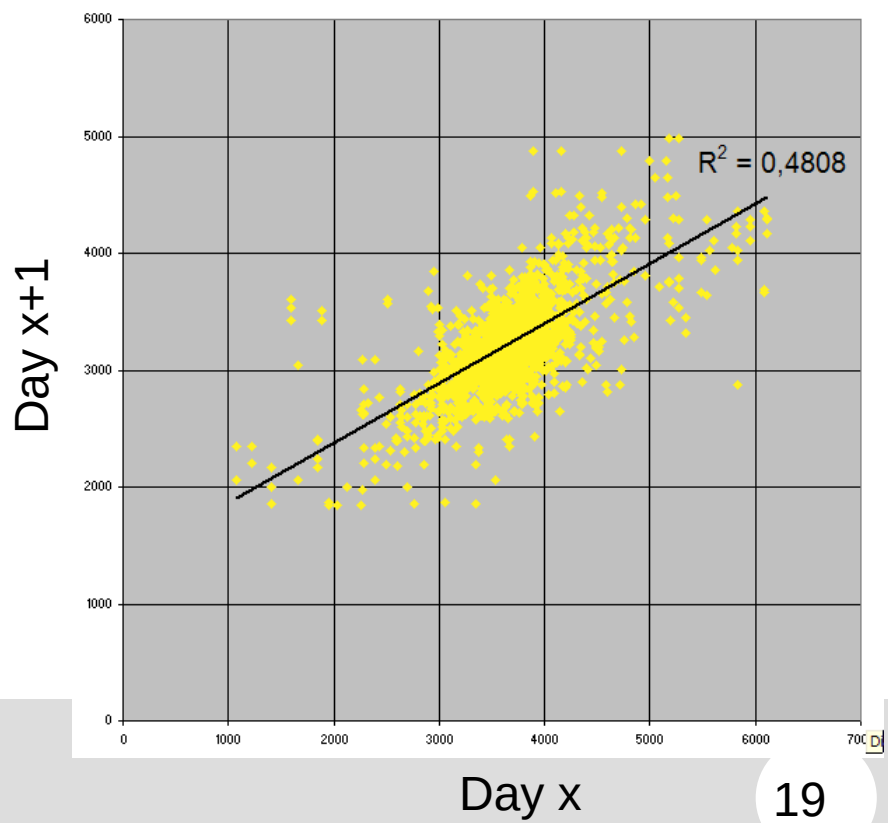
Band 2, QC 4096 (OK)

alysis

Beginning: initial motivation…

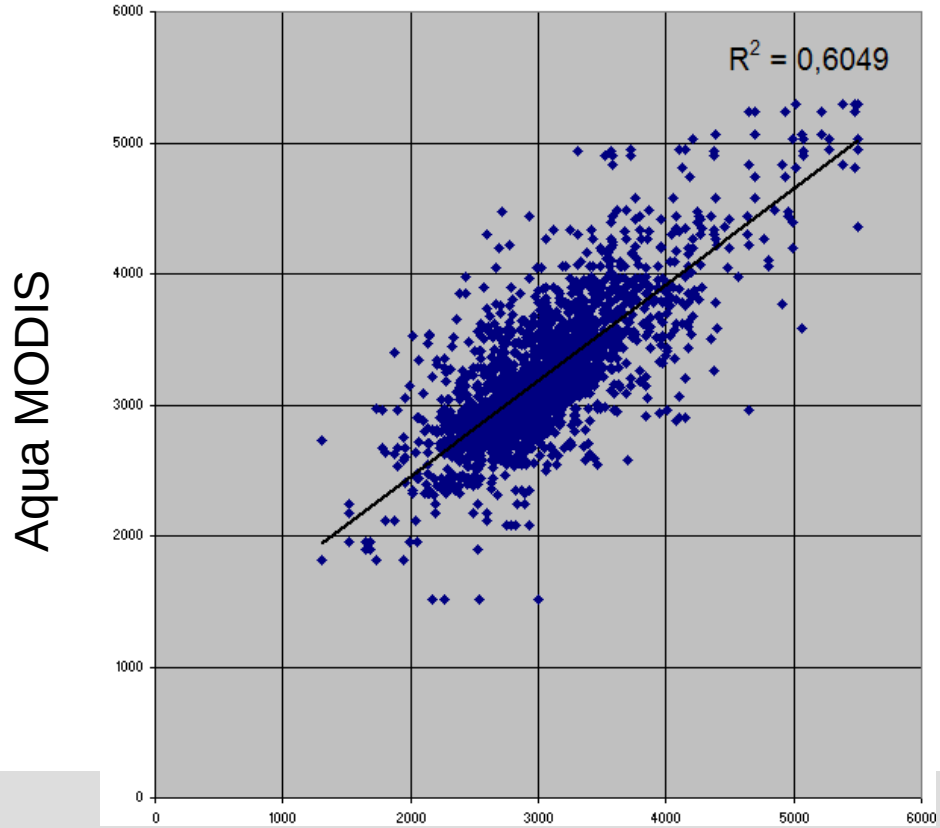
- Aqua MODIS land surface reflectance
- Terra MODIS land surface reflectance





Beginning: initial motivation…

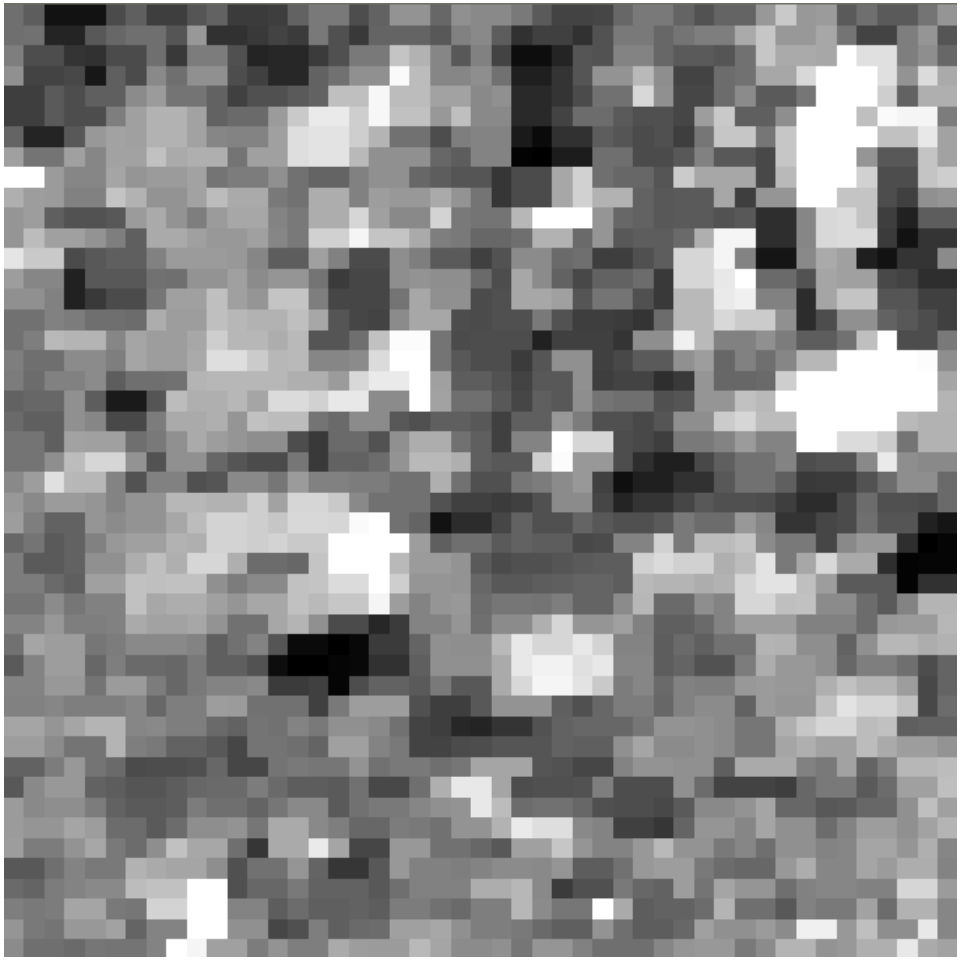
- Terra & Aqua MODIS, the same day

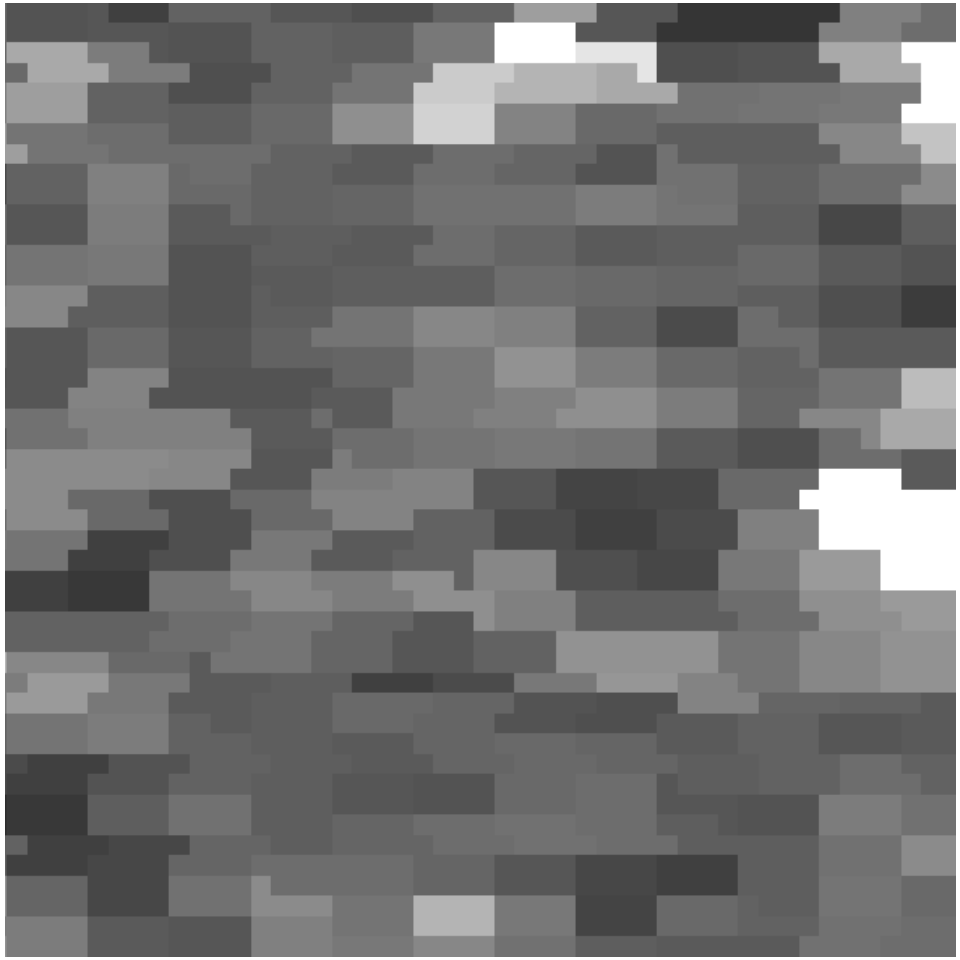


Why…? MODIS particularities:

- Gridding artifacts:
  - Data stored in a predefined grid, resampled
  - Average overlap between observations and their respective grid cells less than 30% *[Tan et al., RSE 105(2006):98-114]*
- Problems with the raster data model itself:
  - Fixed size and orientation of the cells although the observation dimensions vary across the scene due to the wide field of view (+/- 55 degrees), orientation definitely not N-S
  - The grid cells / pixels do not represent the area where the signal is originated from

MODIS particularities





Close to nadir

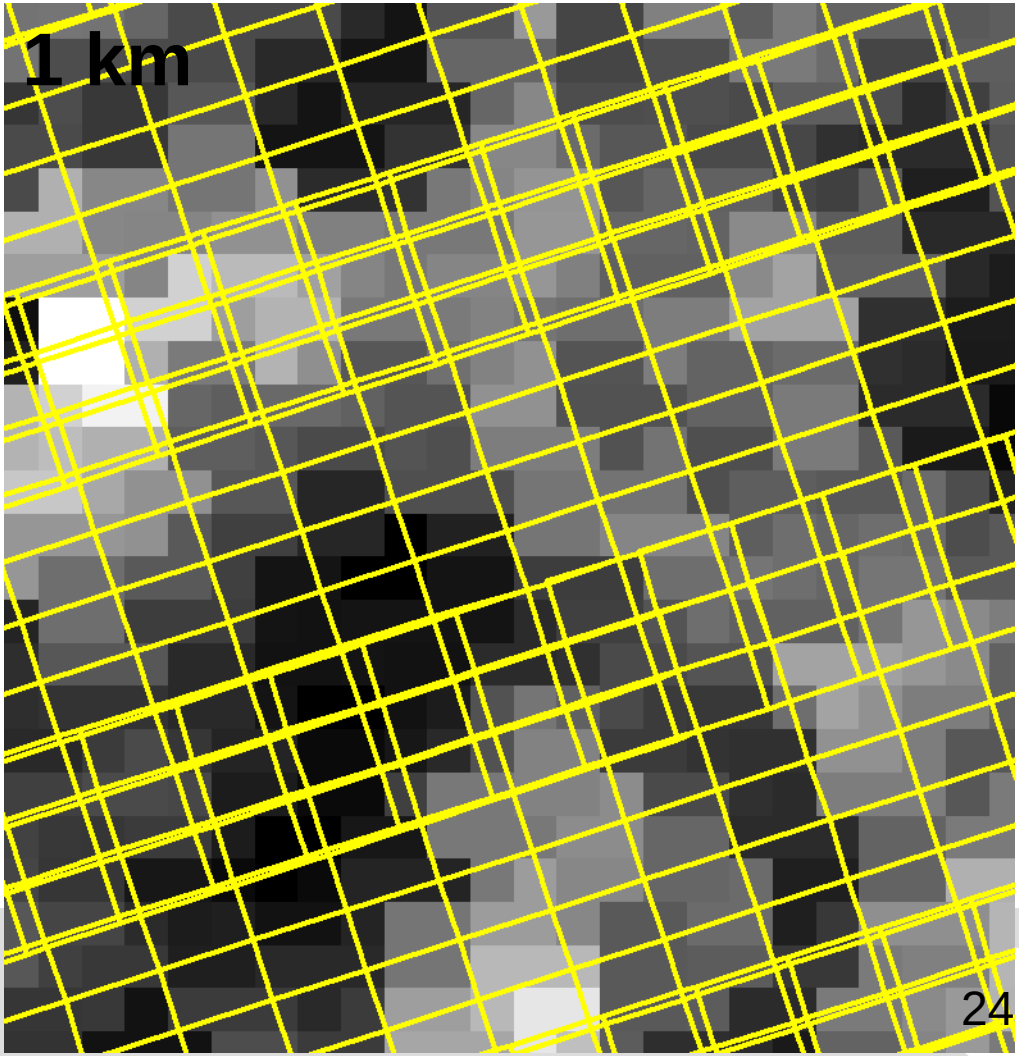
Close to swath edge

Proposed solution

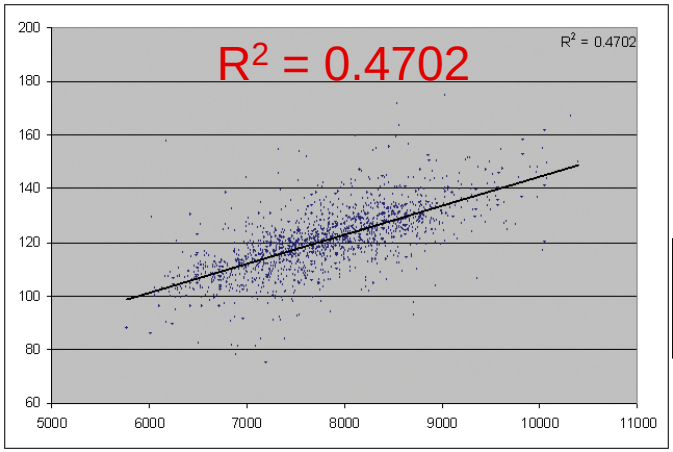
- A possible solution would be the spatial and/or temporal compositing and/or filtering, but: loss of resolution and information…
- Our approach: Change data representation
  - Calculate and store observation footprints in polygon format
  - Each polygon represents the respective observation footprint (“real pixel”) sensed during image acquisition
- Geolocation datasets (MOD/MYD03) contain all necessary info to do this
  - Ground location, dimensions and orientation of each MODIS pixel footprint can be determined from: Latitude, Longitude, Height, Sensor Zenith Angle, Sensor Azimuth Angle, Slant Range
  - Geolocation accuracy: 50 m at 1 sigma at nadir
  - Swath images (MOD/MYD02) or „backsampled” Surface Reflectance

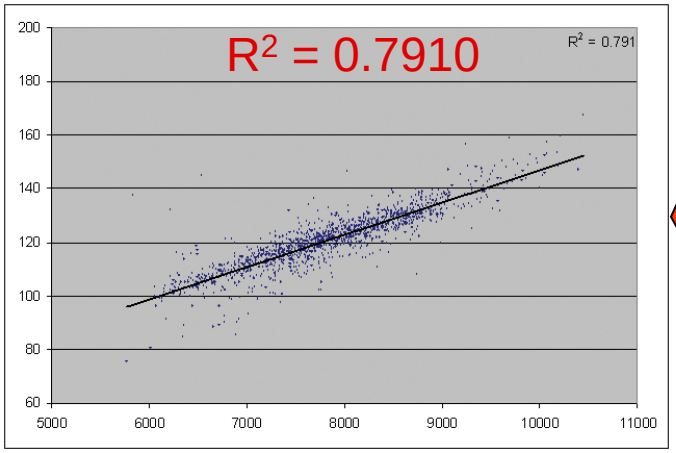
Proposed solution

What does it look like?

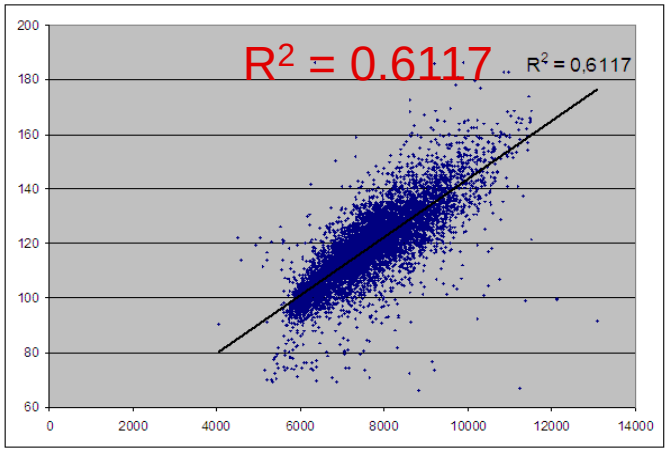


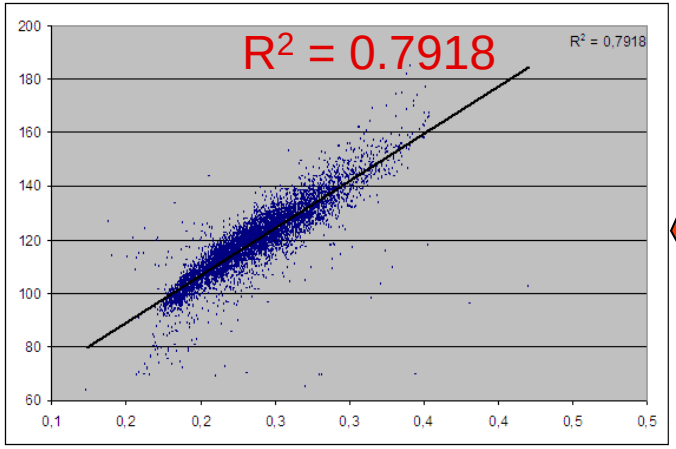
First results: correlation with SPOT data (NIR band)



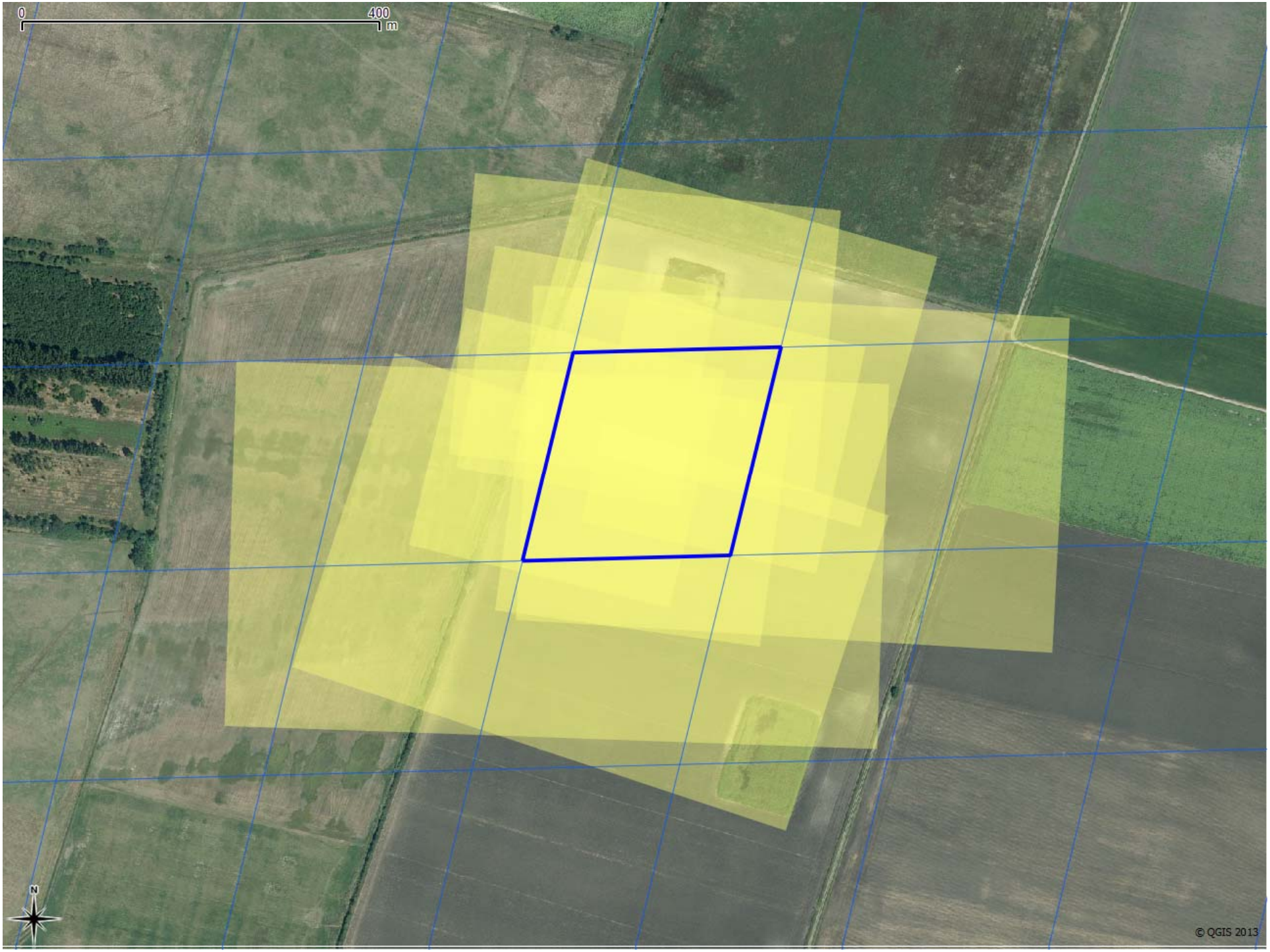


MODIS at 1 km resolution





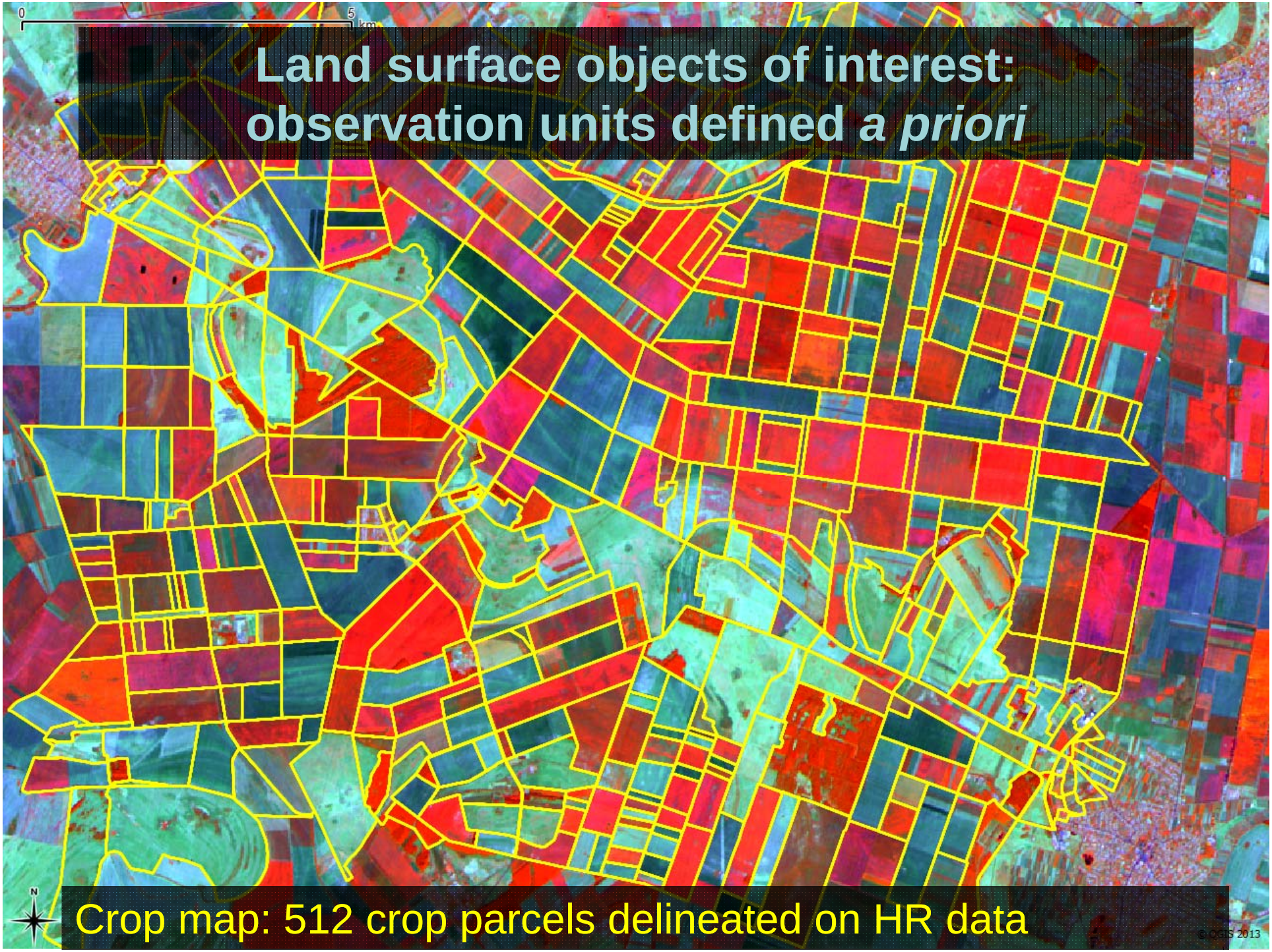
MODIS at 250 m resolution


0
400
m
N
© QGIS 2013

First results

- Possible application: one-step radiometric normalization of high-resolution imagery by using same-day MODIS surface reflectance.

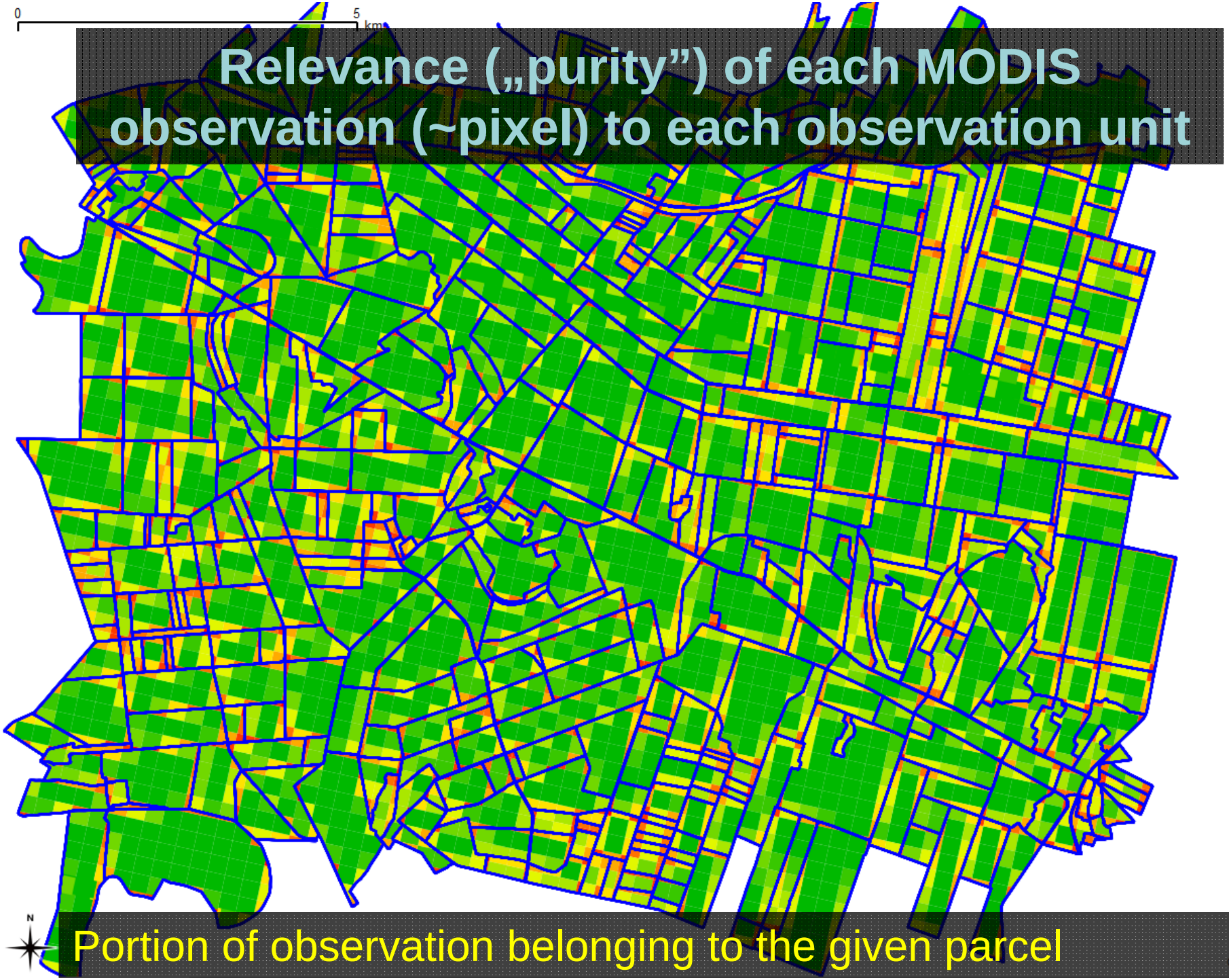
- What next? How to handle ever-changing observation geometries as a time series?



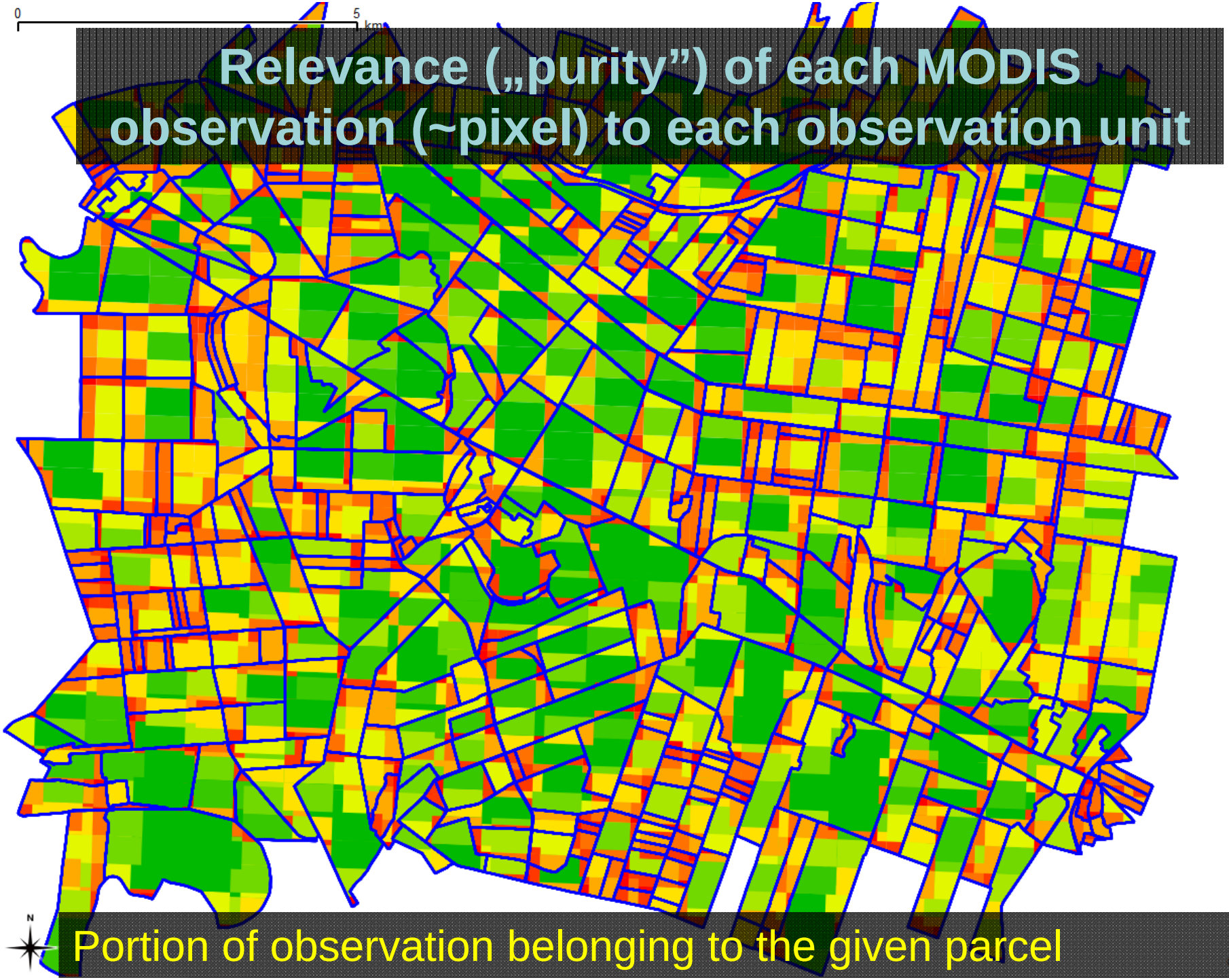
Land surface objects of interest: observation units defined *a priori*

Crop map: 512 crop parcels delineated on HR data

Relevance („purity”) of each MODIS observation (~pixel) to each observation unit



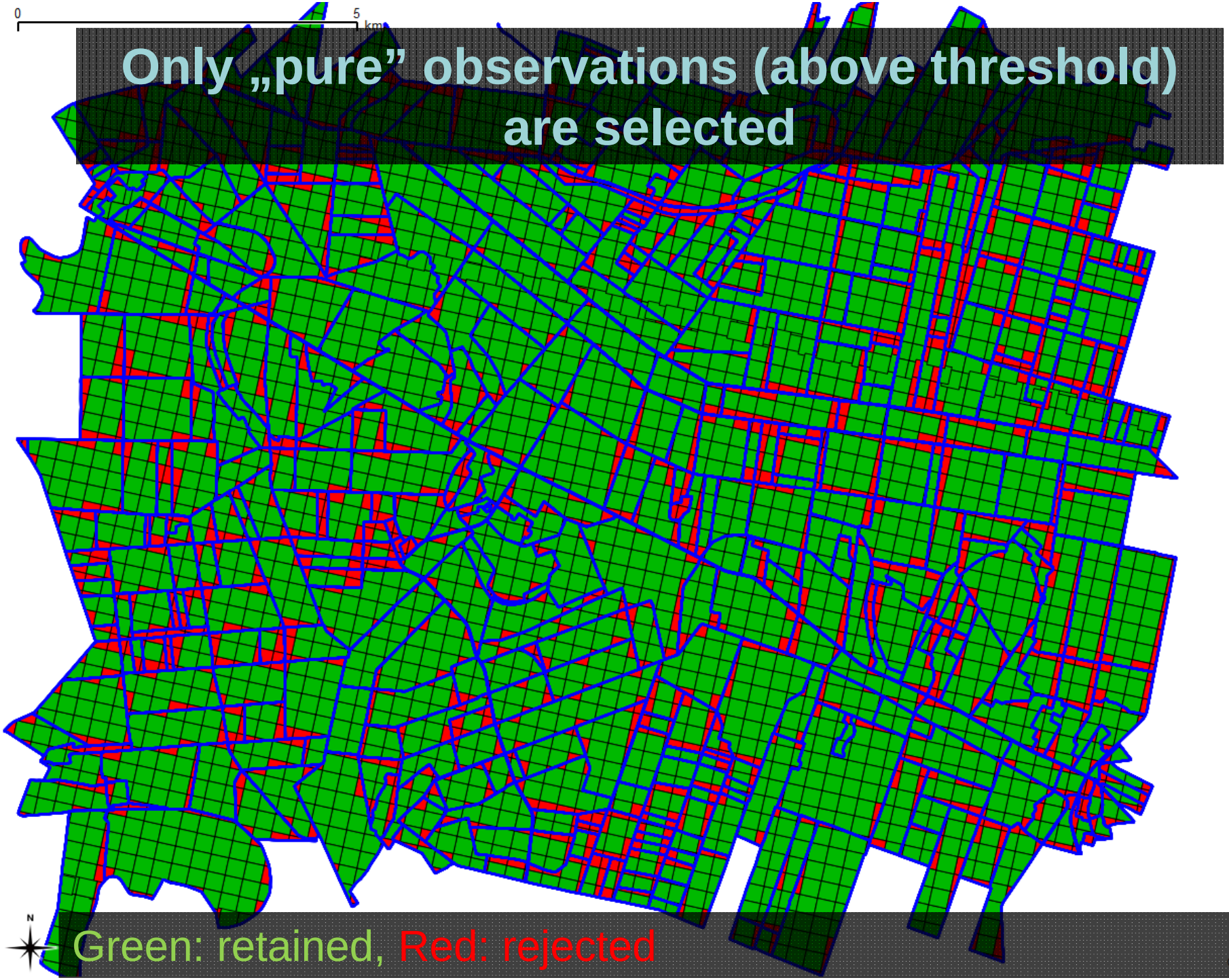
Portion of observation belonging to the given parcel



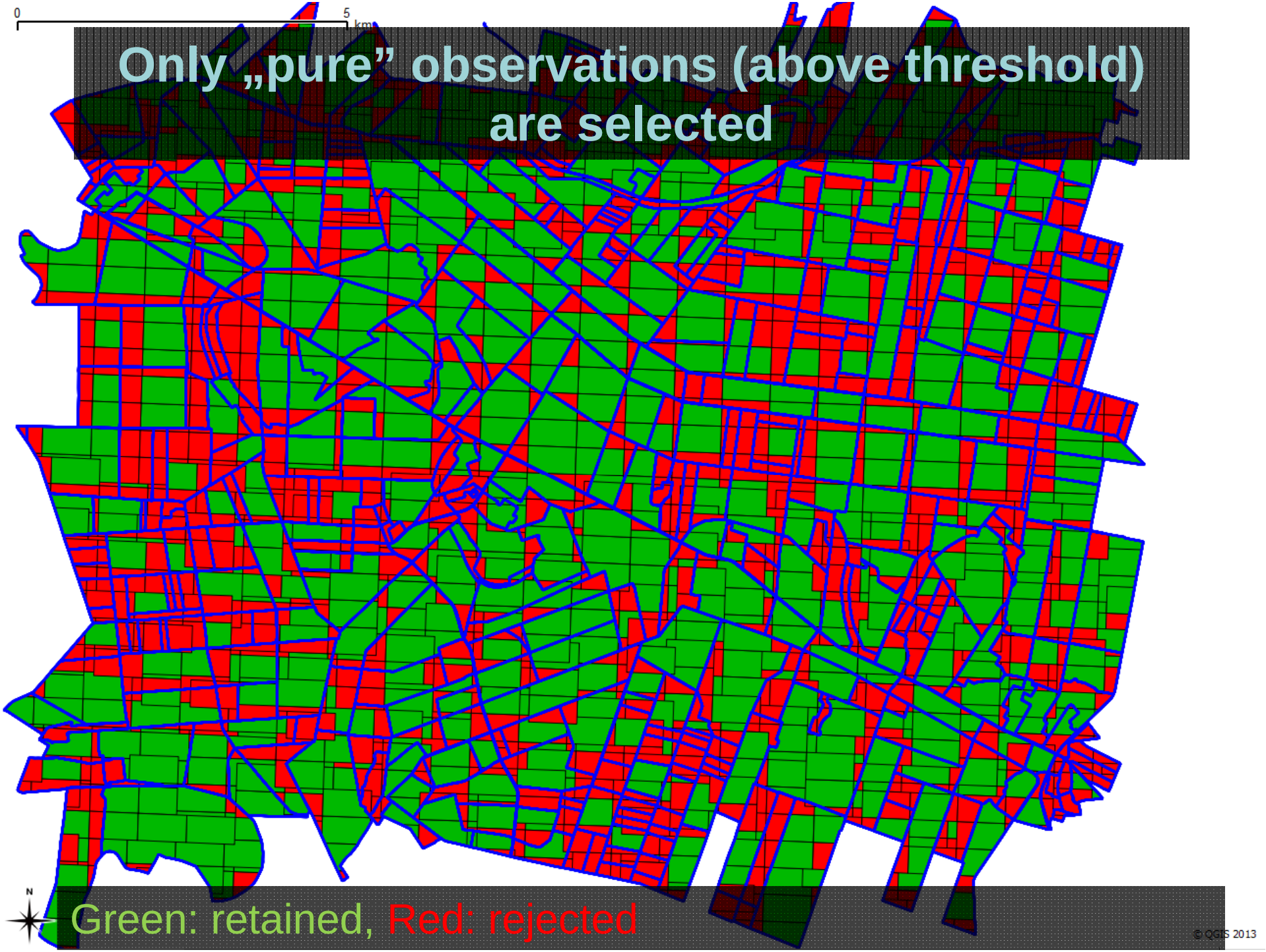
Relevance („purity”) of each MODIS observation (~pixel) to each observation unit

Portion of observation belonging to the given parcel

Only „pure” observations (above threshold) are selected



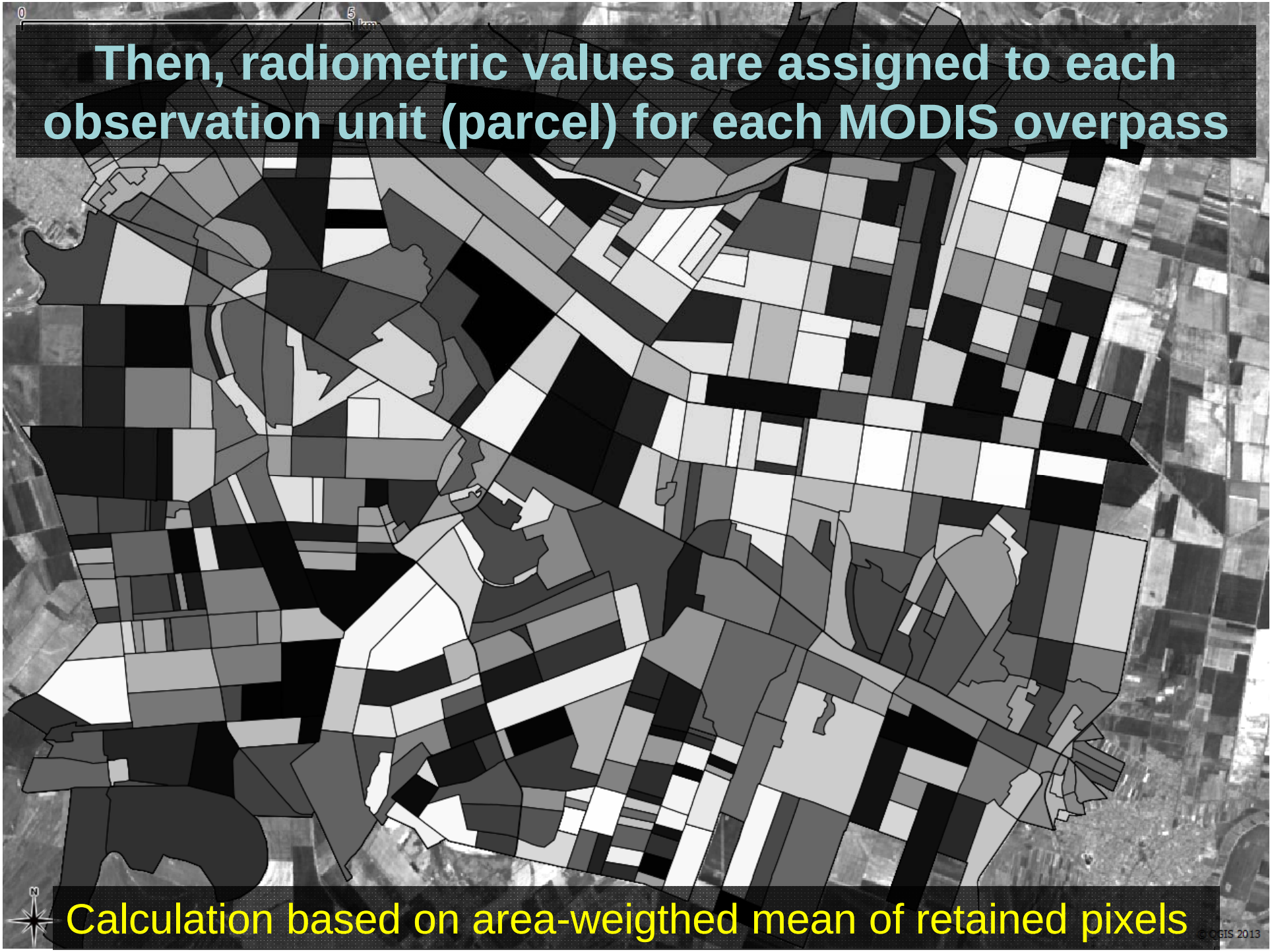
Green: retained, Red: rejected



Only „pure” observations (above threshold) are selected

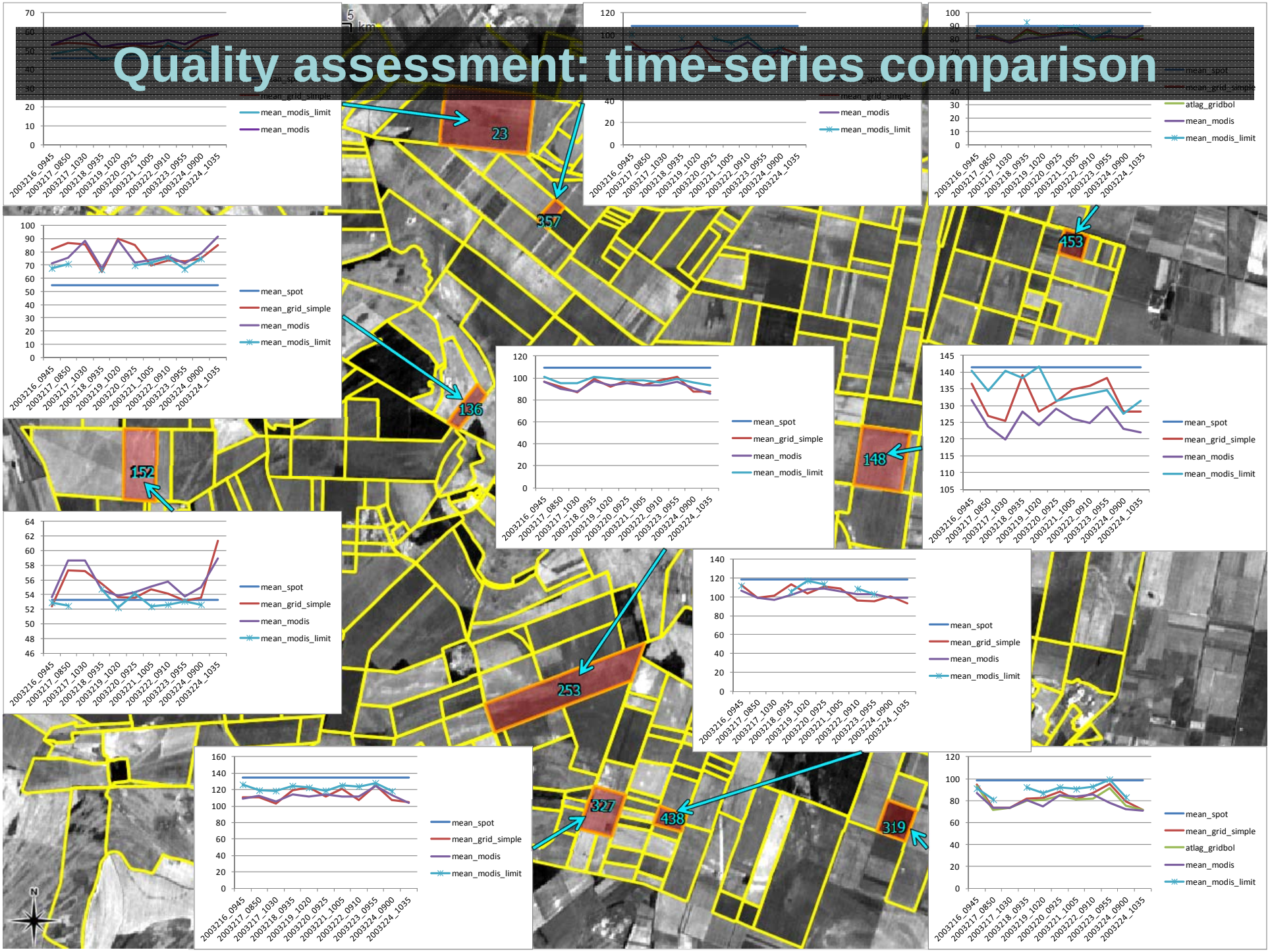
Green: retained, Red: rejected

Then, radiometric values are assigned to each observation unit (parcel) for each MODIS overpass

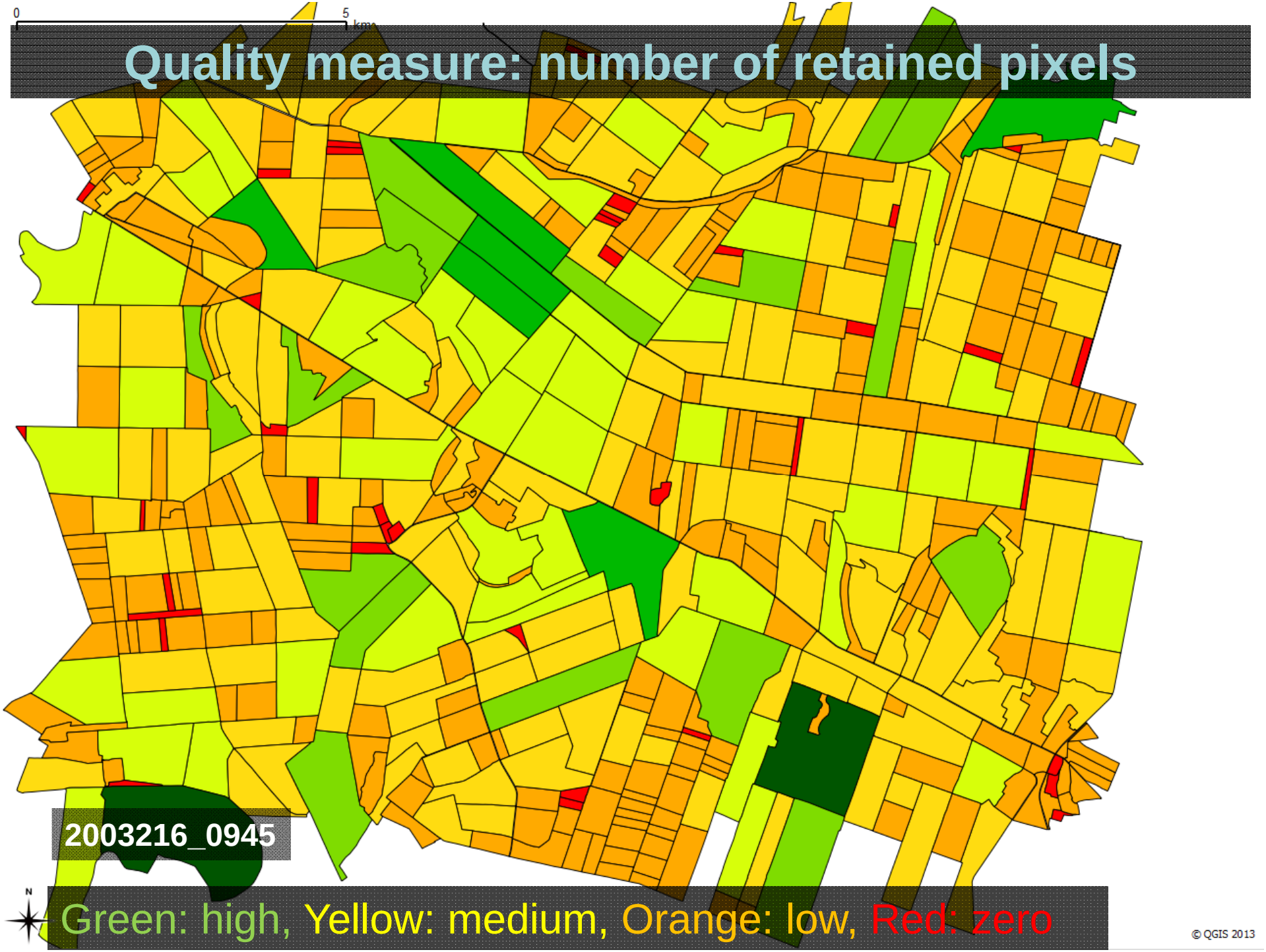


Calculation based on area-weigthed mean of retained pixels

Quality assessment: time-series comparison

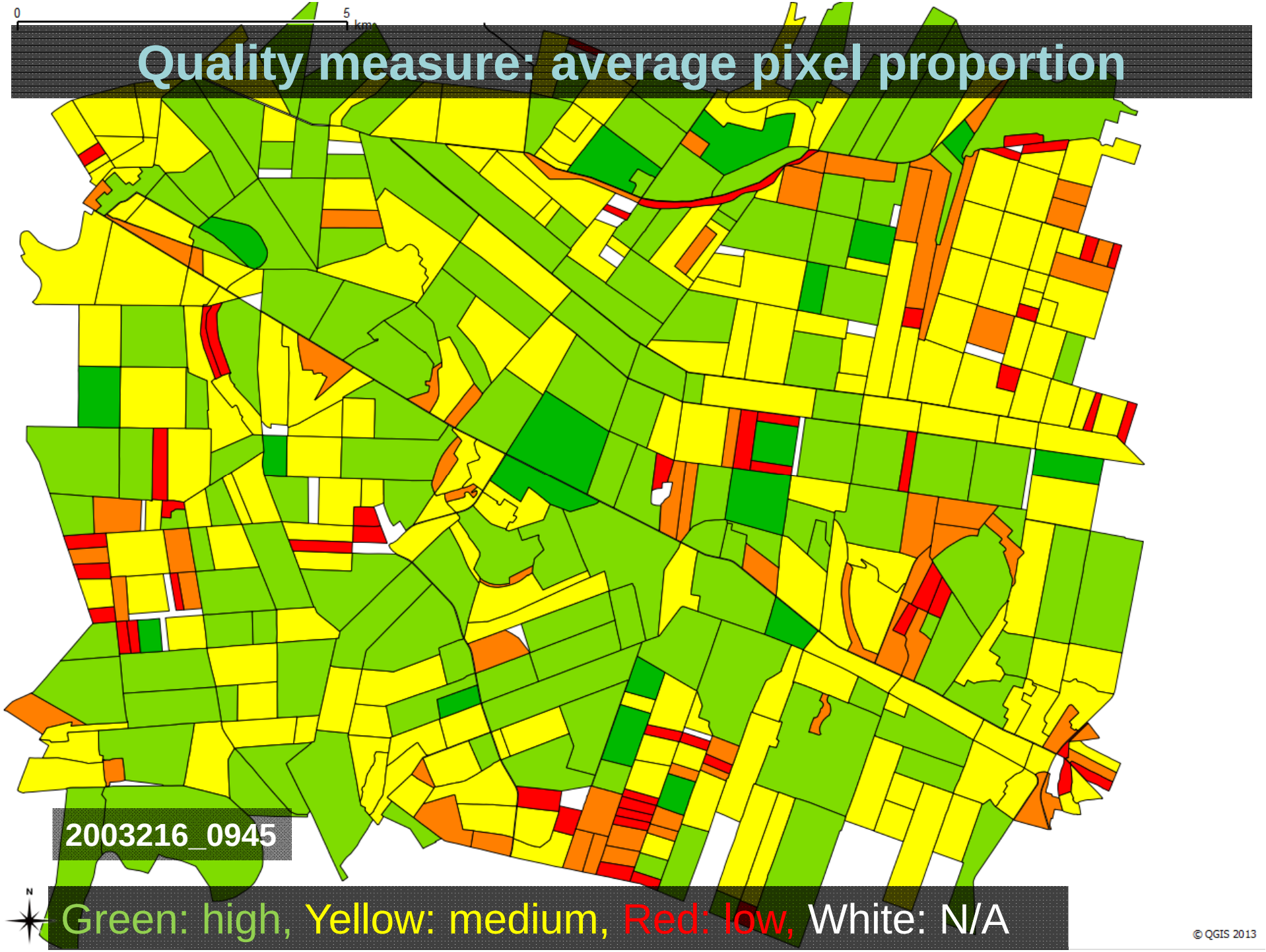


Quality measure: number of retained pixels



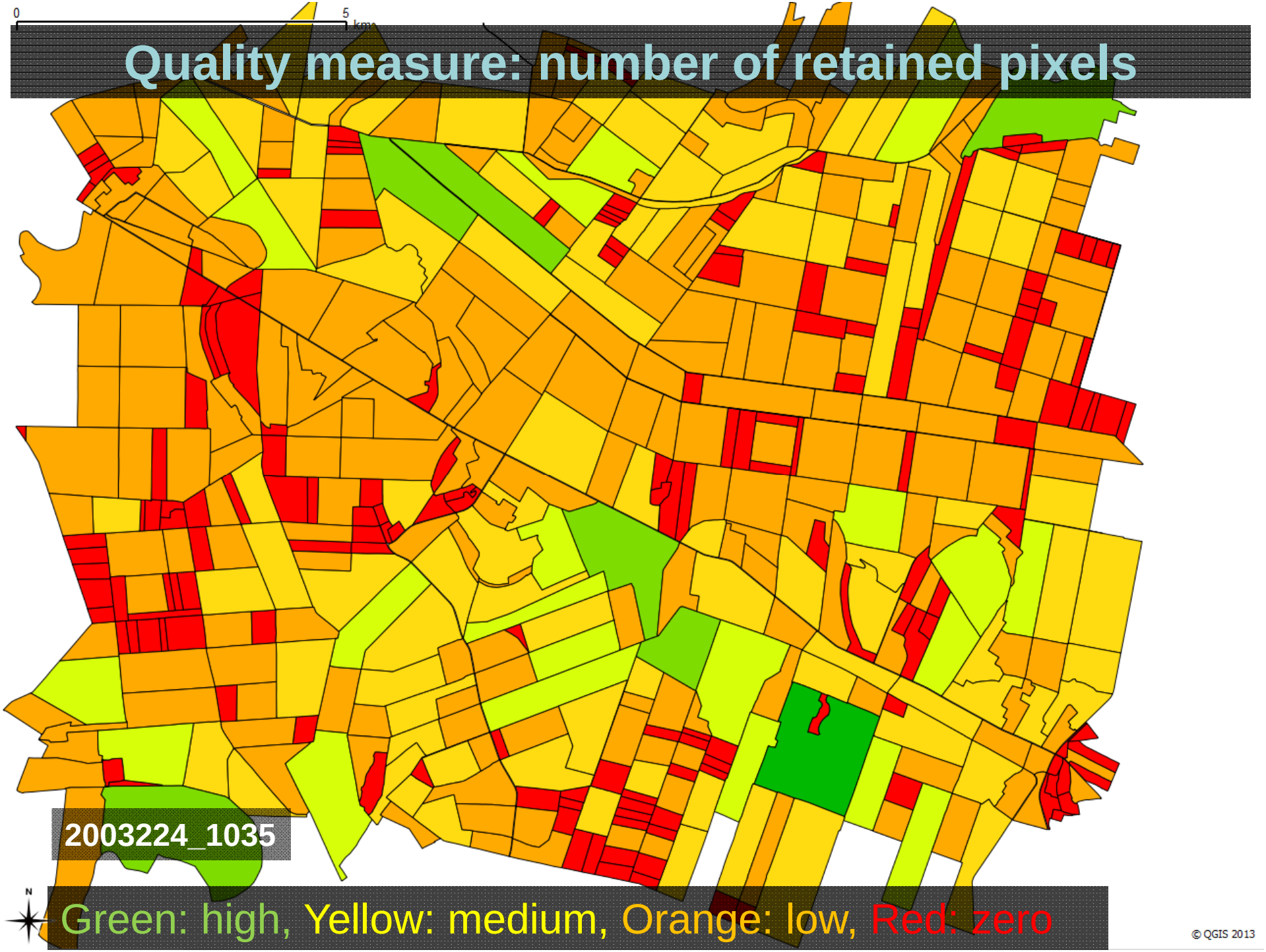
Green: high, Yellow: medium, Orange: low, Red: zero

Quality measure: average pixel proportion



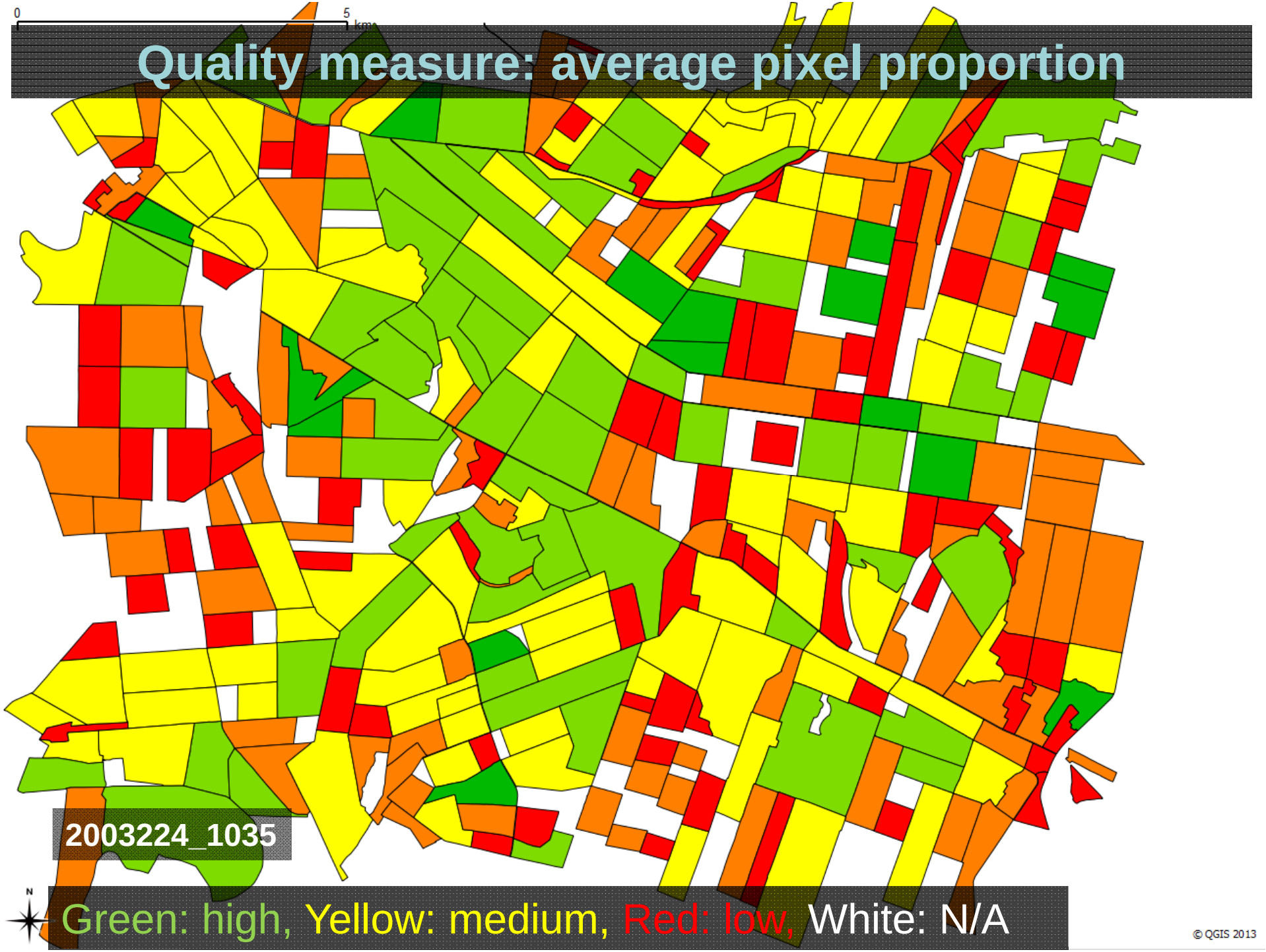
Green: high, Yellow: medium, Red: low, White: N/A

Quality measure: number of retained pixels



Green: high, Yellow: medium, Orange: low, Red: zero

Quality measure: average pixel proportion



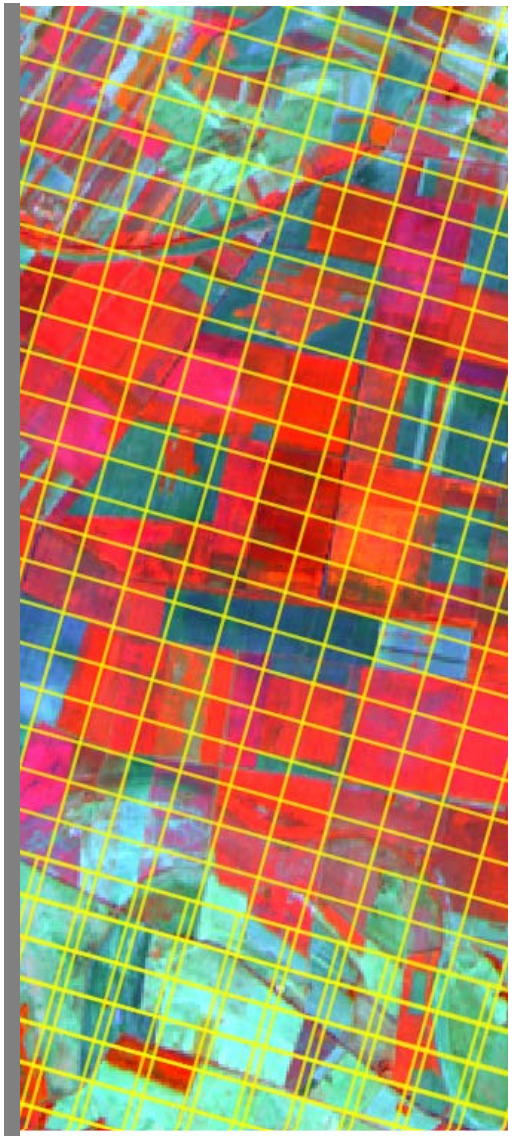
Green: high, Yellow: medium, Red: low, White: N/A

Conclusions

- Gridding is a major source of inaccuracy and noise
- New polygon representation of MODIS observations has significantly increased correlation with same-day high-resolution data: better representation of observation geometry
- Landscape objects delineated *a priori* can be efficiently used to construct time series
- Data processing requires more computing power, but the user has full control over the process (thresholds, quality measures, etc.) and can obtain more accurate data with maximal spatial and temporal coverage

Thank you!

Dániel Kristóf
head

Geoinformation Department
Institute of Geodesy, Cartography and Remote Sensing

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web: www.fomi.hu