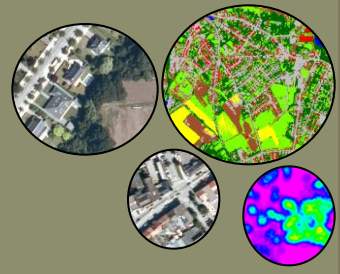
MAMUD



Measuring and modelling urban dynamics

Tim Van de Voorde (VUB), Okke Batelaan (VUB), Marc Binard (Ulg), Frank Canters (VUB), Yves Cornet (Ulg), Guy Engelen (VITO), Rudi Goossens (UGent), Carlo Lavalle (JRC), Frederik Tack (UGent), Johannes van der Kwast (VITO), Boud Verbeiren (VUB)

Belgian Earth Observation Day

Oudenburg, 25 May, 2011

BELGIAN SCIENCE POLICY

Vrije Universiteit Brussel

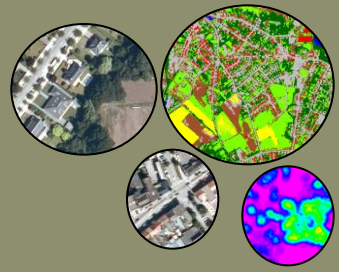
UNIVERSITEIT GENT

Université de Liège

vito vision on technology

JRC EUROPEAN COMMISSION

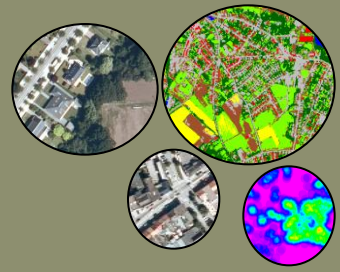
Main objectives



- Cities ⇔ Global Environmental Change
- Sustainable development of urban areas requires:
  - Knowledge about the causes, chronology and effects of urban change processes
  - Reliable and sufficiently detailed information on the urban environment and its dynamics
- Remote sensing imagery is an interesting data source for monitoring and modelling of urban change processes

Source: NASA

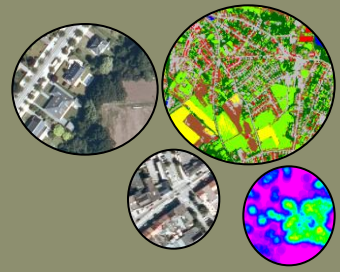
Main objectives



Investigate how remote sensing can contribute to a better monitoring, modelling and understanding of urban dynamics, and its impact on the urban and suburban environment

Study areas: Dublin, Istanbul

Main objectives



- MONITORING

  Deriving **impervious surface maps** from time-series RS images

  = surfaces where water cannot infiltrate (transportation & buildings)

  ➔ Key factor to explain & predict impact on streams and watersheds

  ➔ Represents patterns of built-up areas (urban morphology)

- MODELLING

  Improve the **calibration** of MOLAND urban growth model

  ➔ Inferring land use (additional information)

  ➔ Quantifying spatial patterns (goodness-of-fit measures)

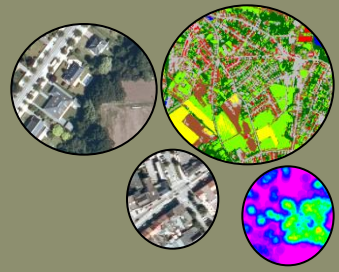
- IMPACT

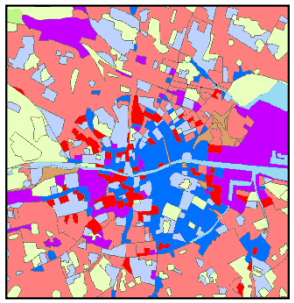
  Improving input data for hydrological run-off model

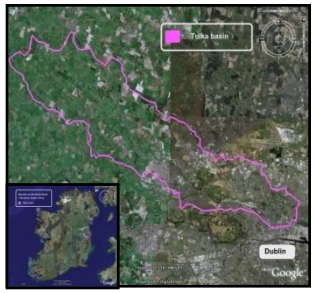
  Waste water case (with University College Dublin and Dublin City Council)

  ➔ Assessing impact of future land use on infrastructure requirements (sewers, treatment)

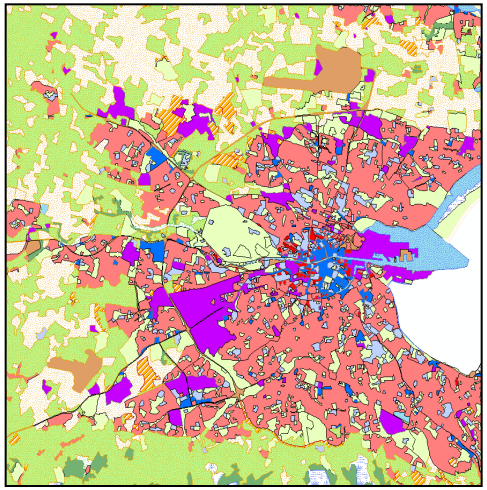
Study areas



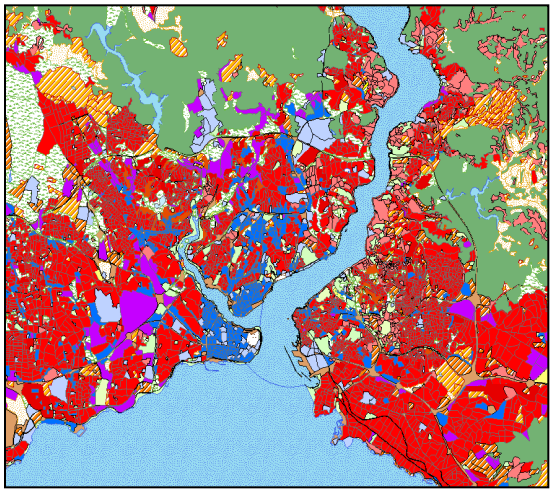


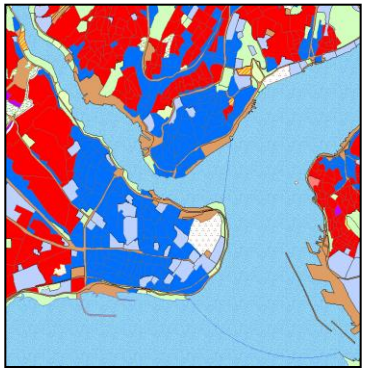


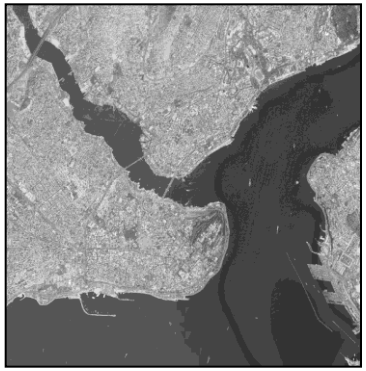
DUBLIN



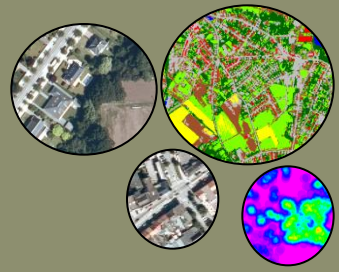
ISTANBUL

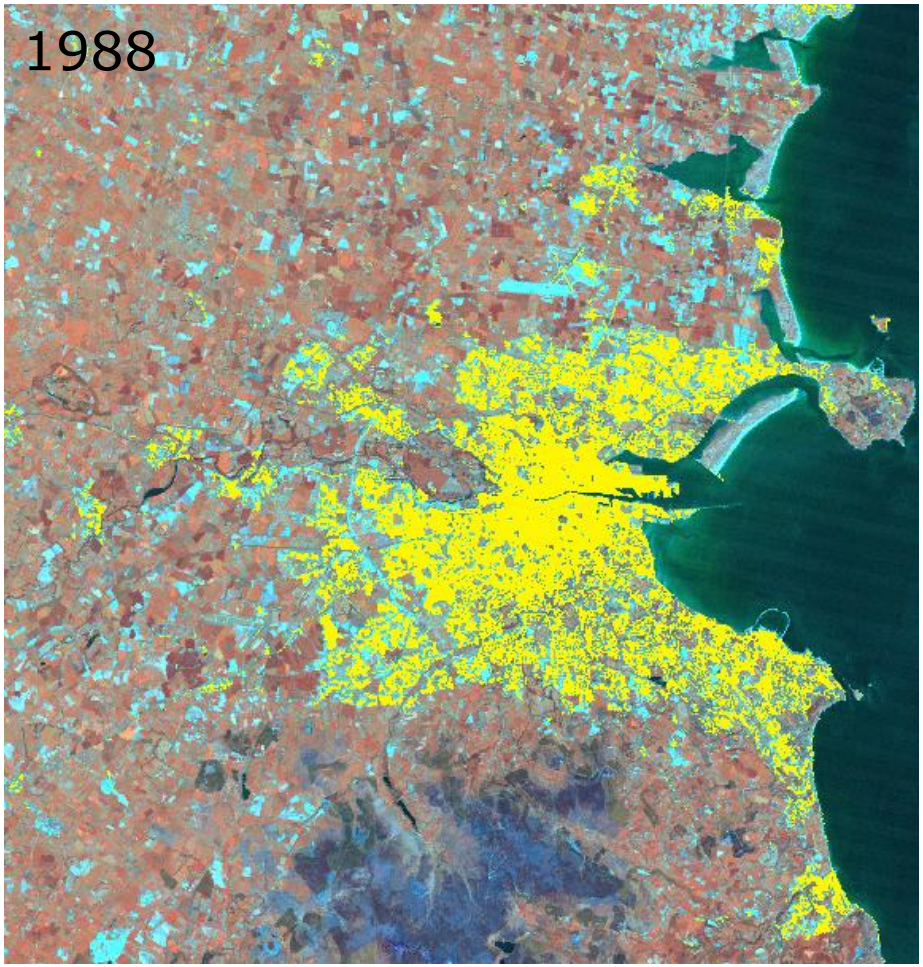


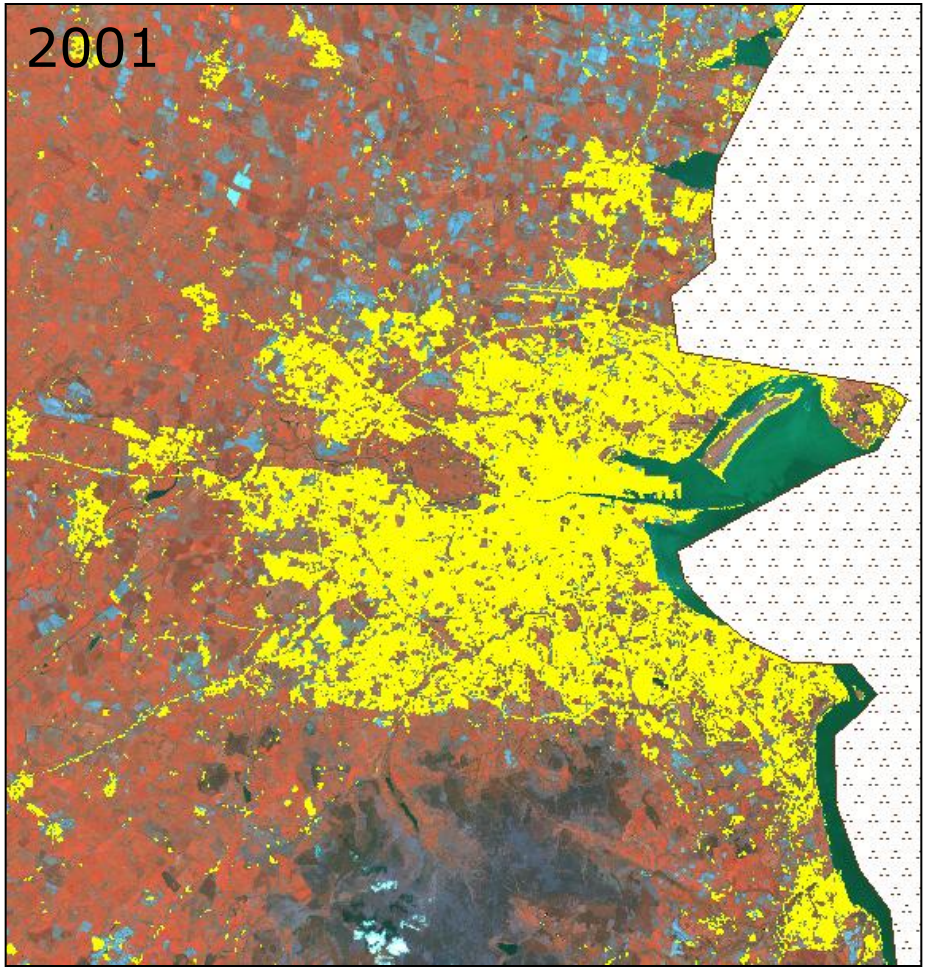




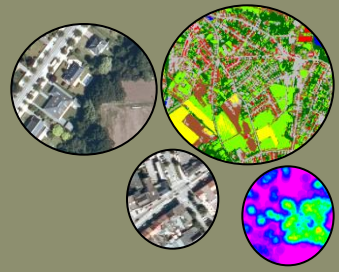
Urban masks

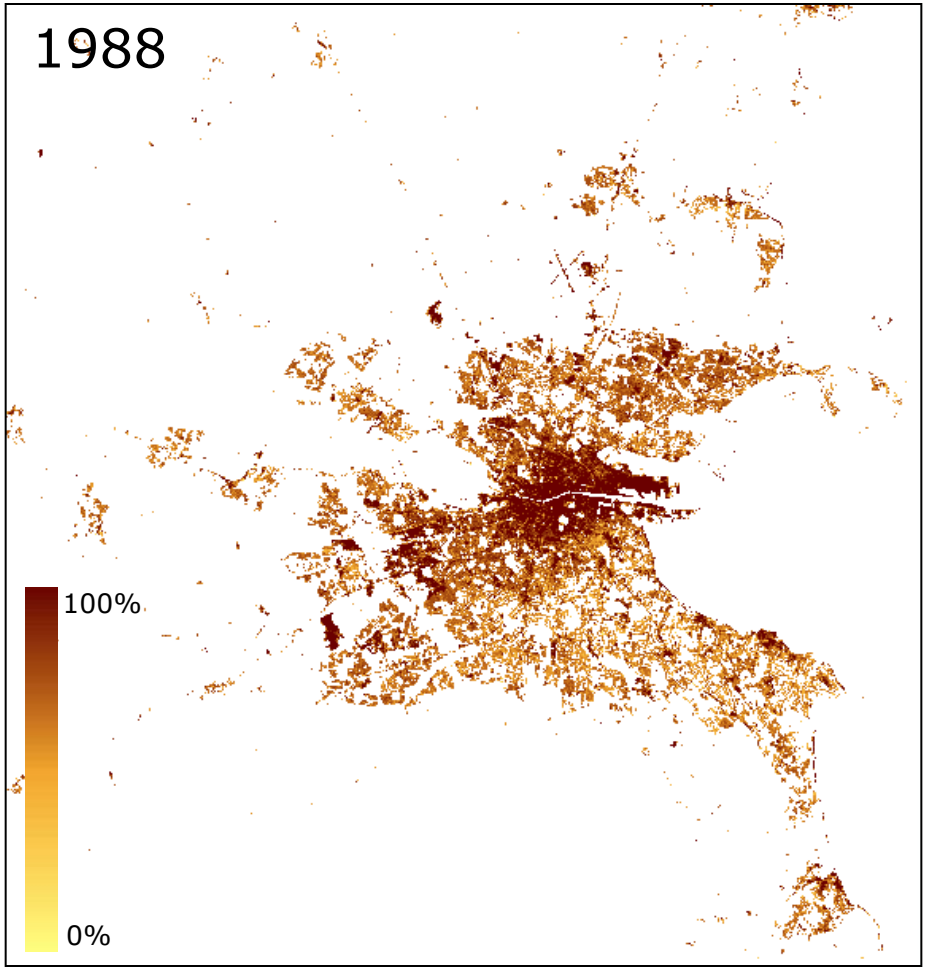


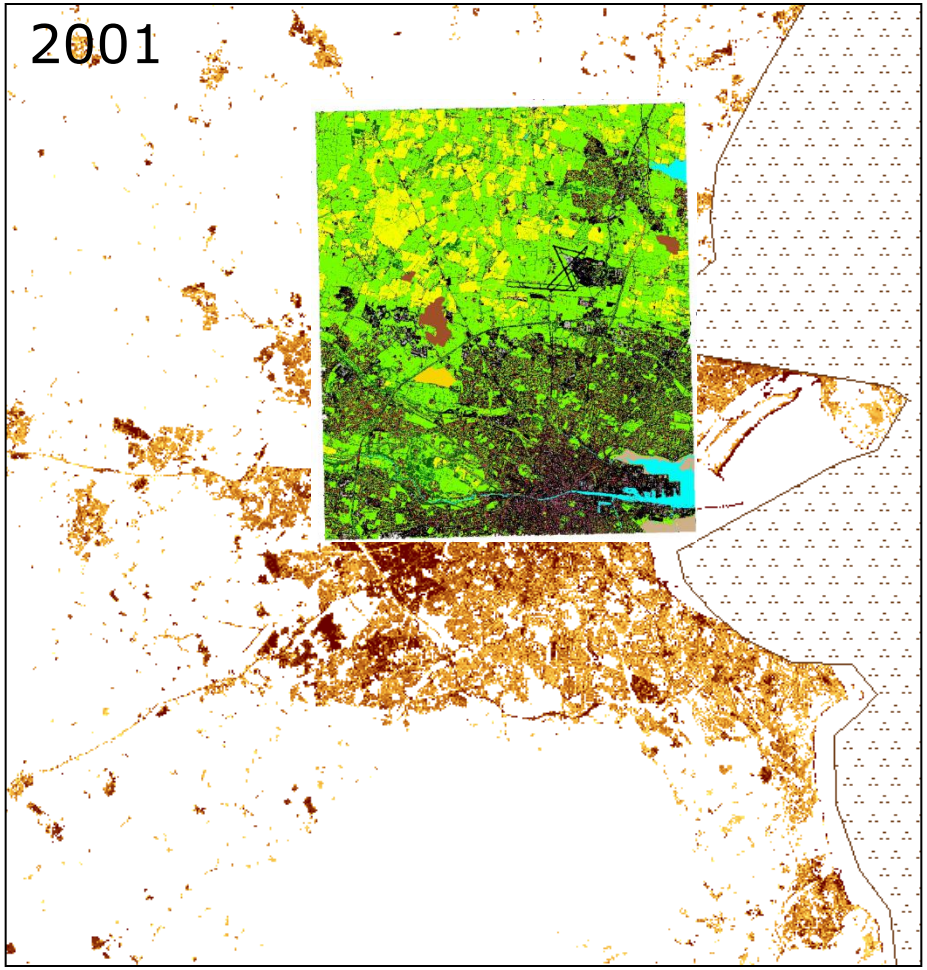




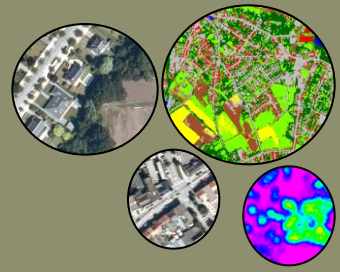
Impervious surface proportion maps

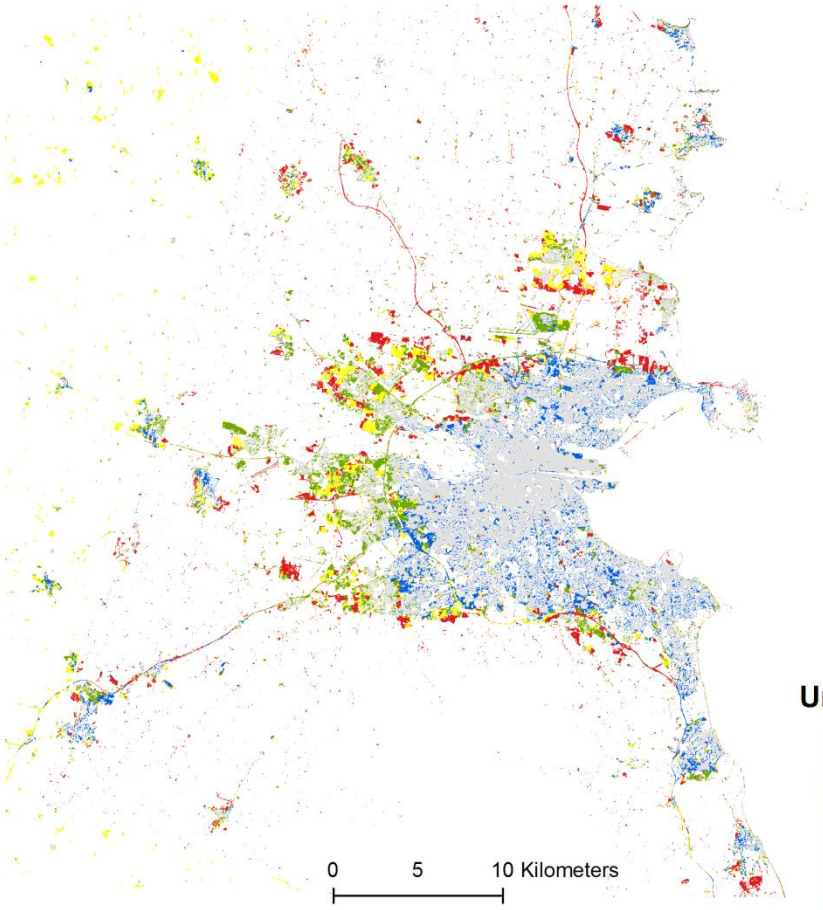






Urban growth

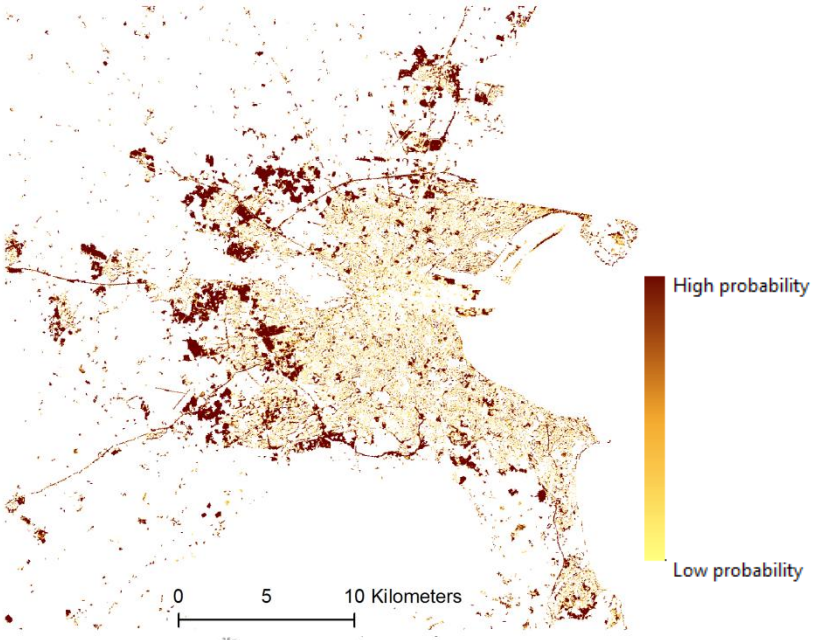


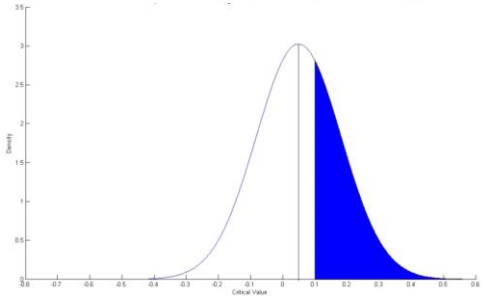


Urban growth of Dublin

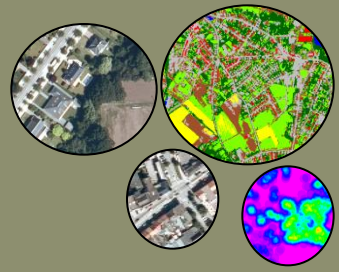
- Urban since 1988
- Urban since 1994
- Urban Since 1997
- Urban since 2001
- Urban since 2006

Probability of increase IS > 20% between 1988 and 2001

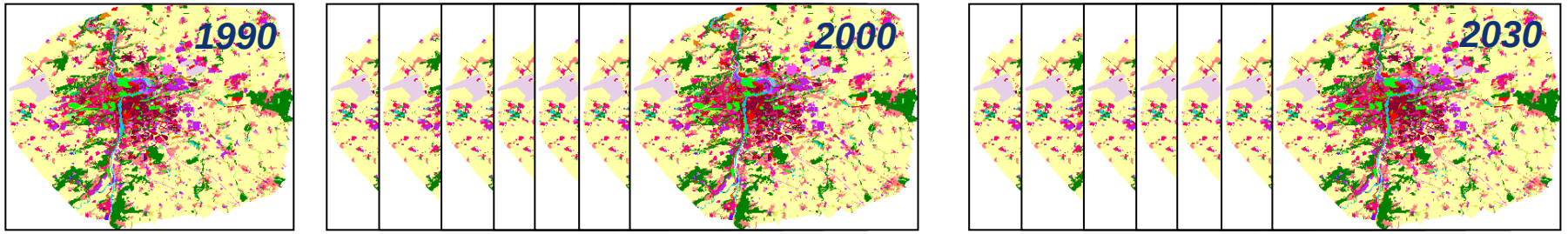




Historic calibration procedure

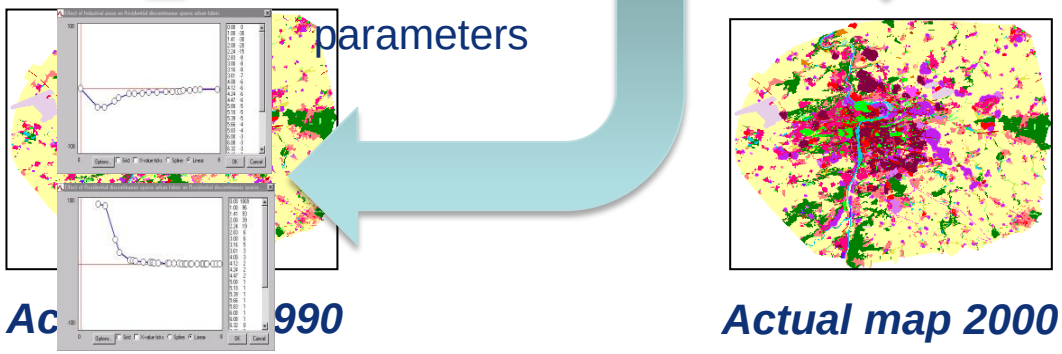


Model initialisation ***Hindcast*** ***Forecast***



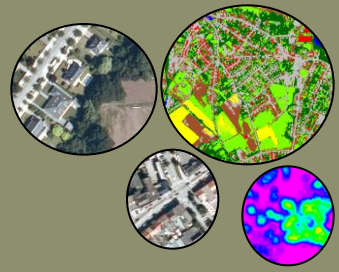
not Ok **Ok**

parameters

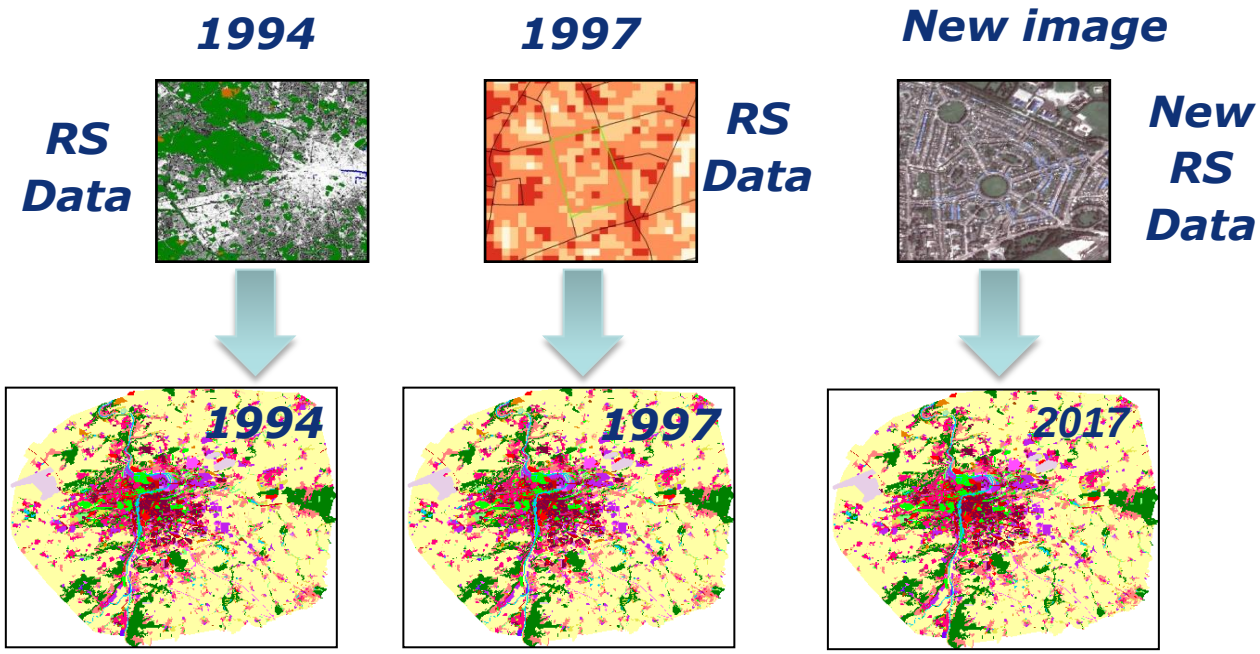


Ac 990 ***Actual map 2000***

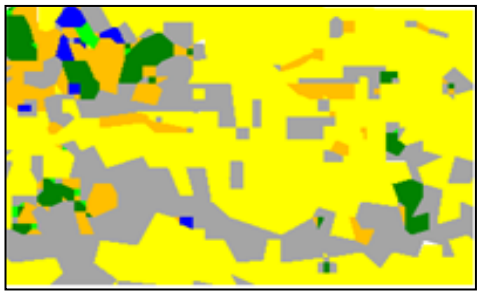
Inferring land use



- Inferring land use from RS data



Inferring land use



≠

Land-use map

Functional

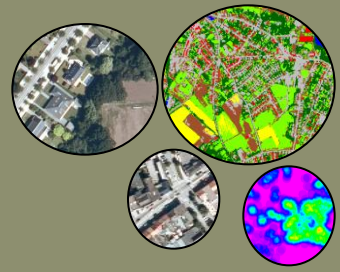
Remote sensing image

Physical

- Relationship between land use and land cover patterns

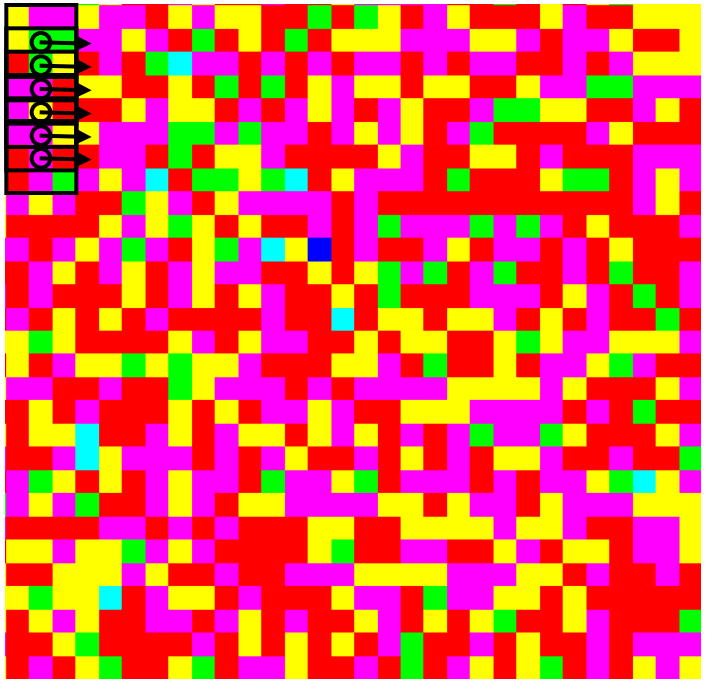
➔Inferring land use from RS requires **spatial context**
➔Different ways of defining context
➔**Moving window** (kernel) and **building blocks** (region)

Inferring land use
Kernel based approach



SPARK
Barnsley and Barr (1996)

OSPARK
Optimised SPAtial Reclassification Kernel



Characteristic template matrices:

Commercial area

B	B	G
B	B	T
G	T	G

Residential area

B	T	B
T	B	G
B	G	G

Frequency table:

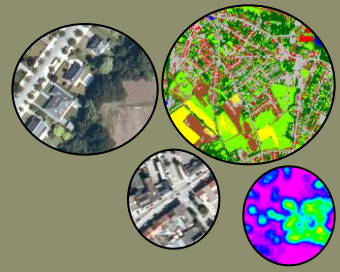
B	G	T
4	3	2

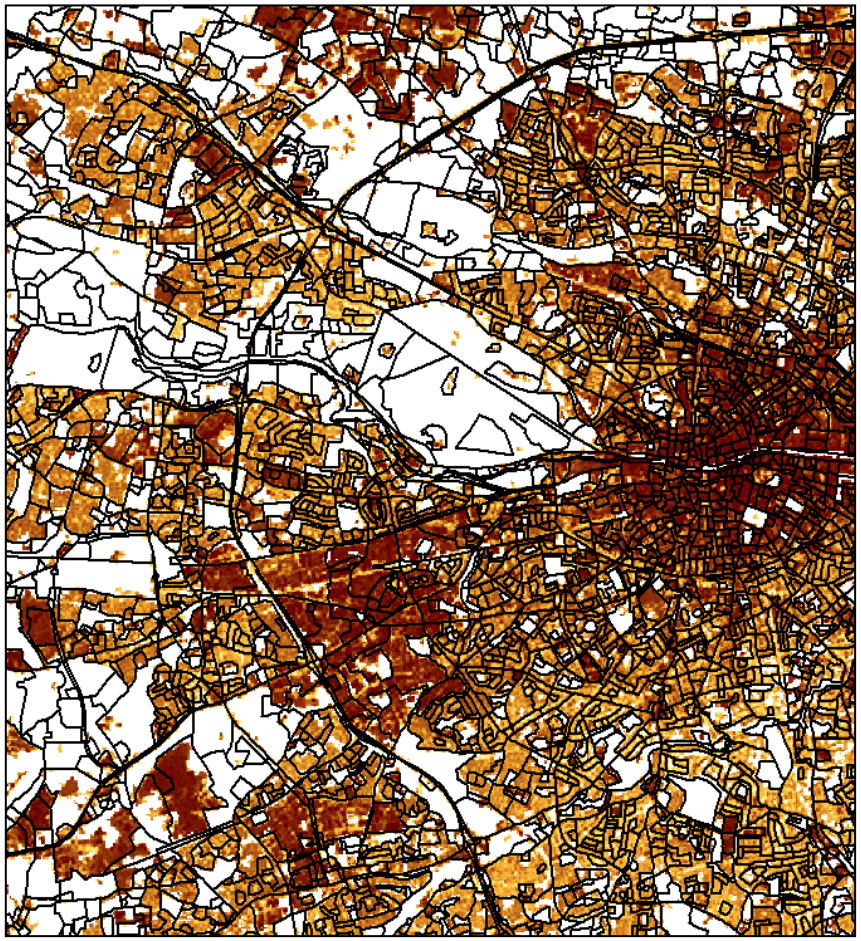
Adjacency event matrices:

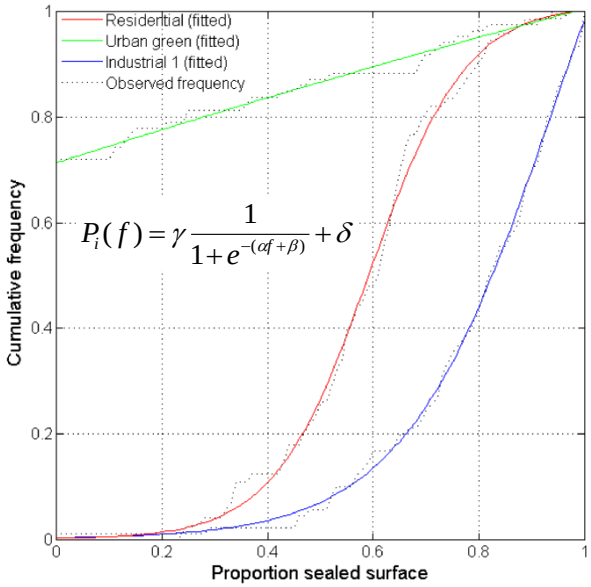
	B	G	T
B	6	5	4
G	-	0	4
T	-	-	1

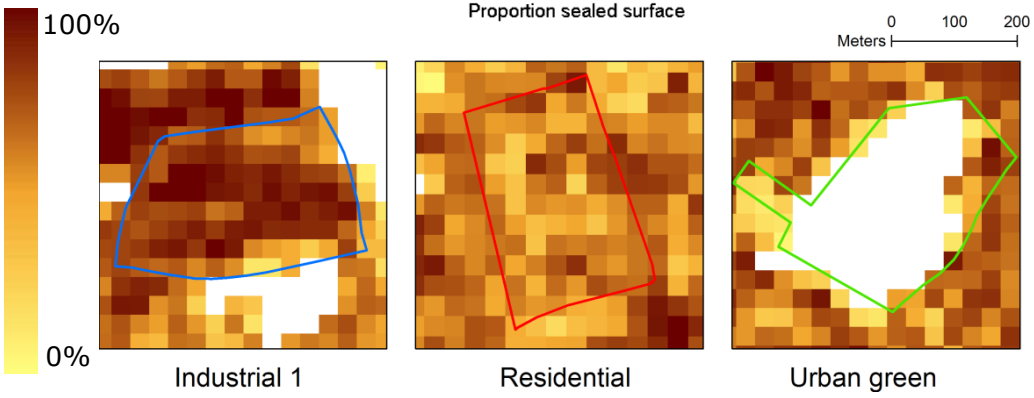
	B	G	T
B	3	5	6
G	-	3	2
T	-	-	1

Inferring land use
Building blocks

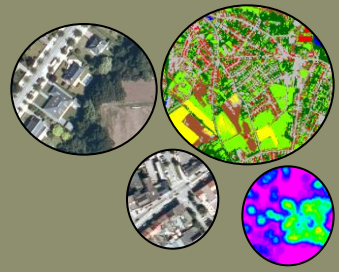


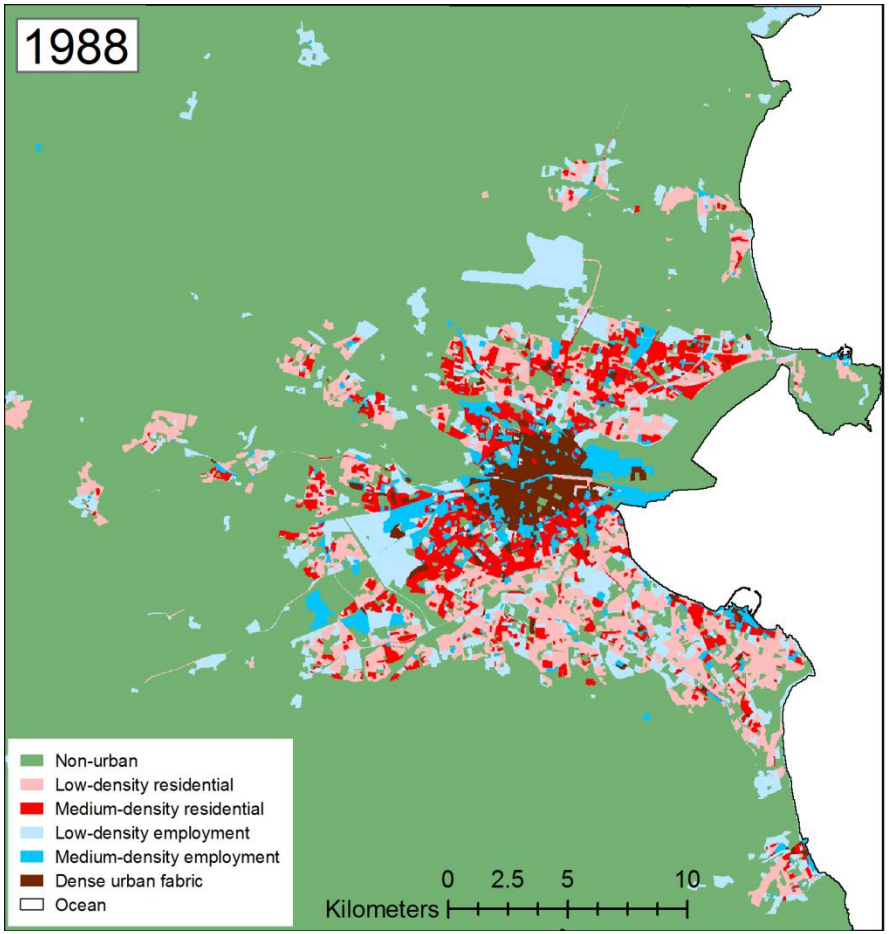






Inferring land use
Land use maps



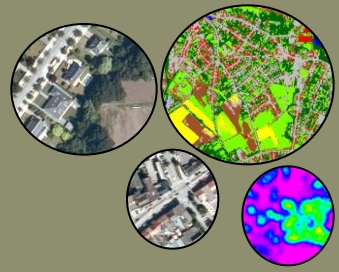


PCC: 86%

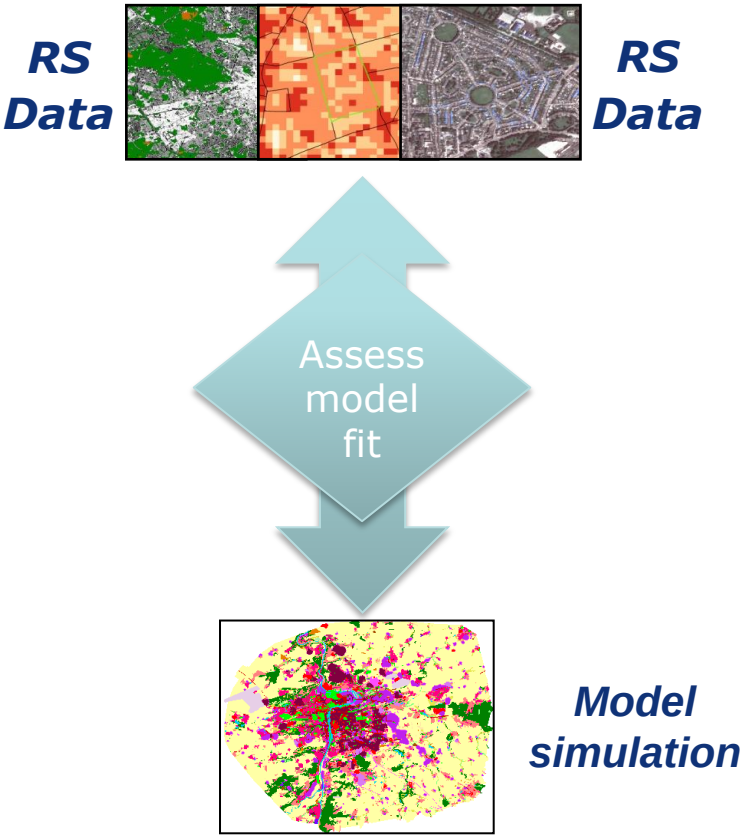
User's accuracies:

Residential: 80%
Employment: 95%

MAMUD calibration framework



- Developing goodness-of-fit measures

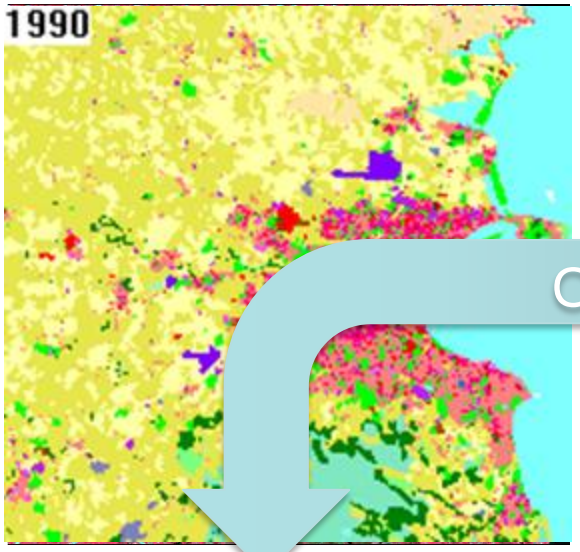


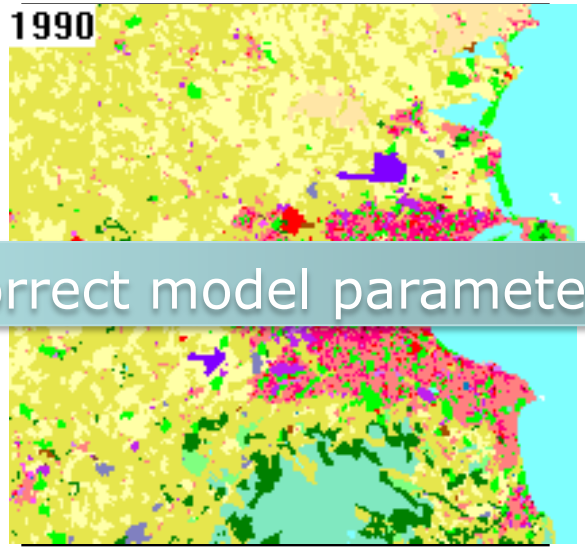
MAMUD calibration framework

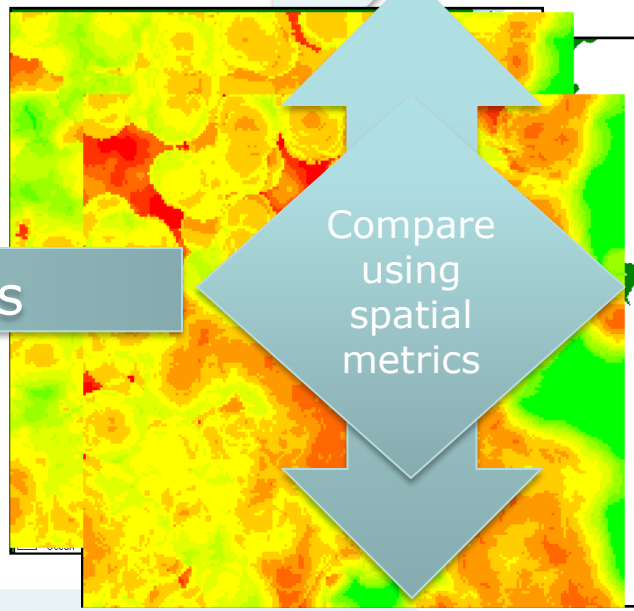
Remote sensing image

Image interpretation

Inferred land use







Correct model parameters

Compare using spatial metrics

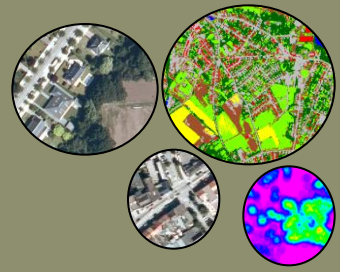
Model initiation

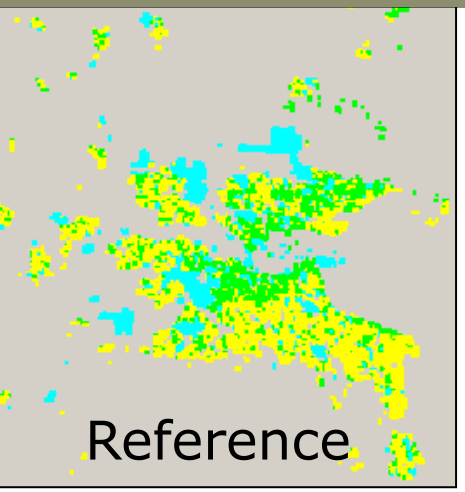
Simulation

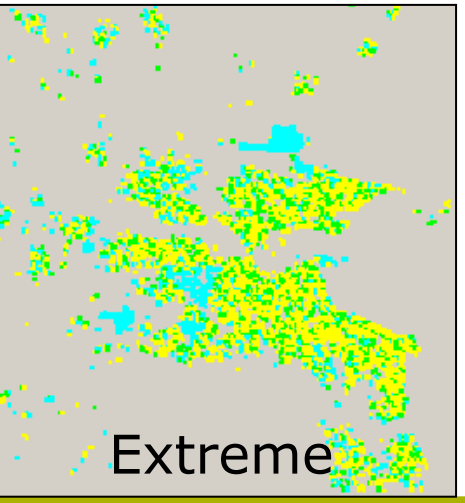
Simulated land use

MAMUD calibration framework

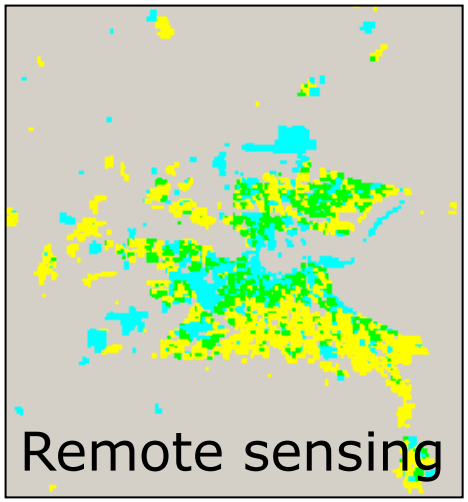
Spatial metrics as goodness-of-fit measures

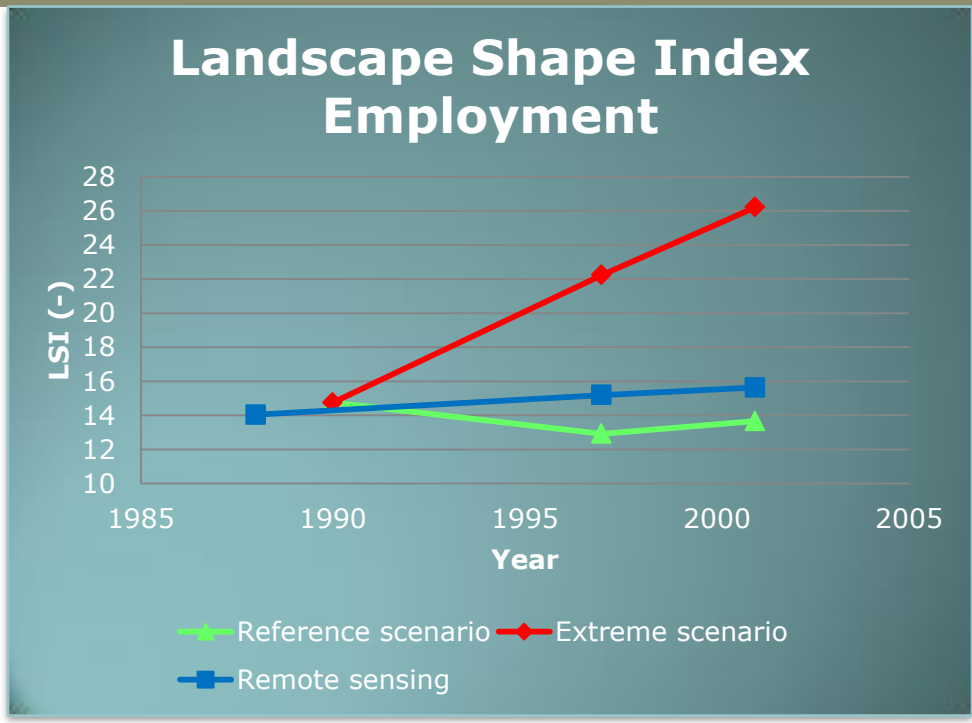


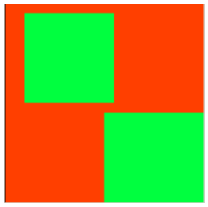




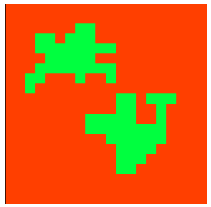
Population/ employment 1997





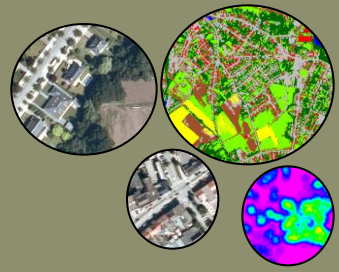


LSI = 1.4

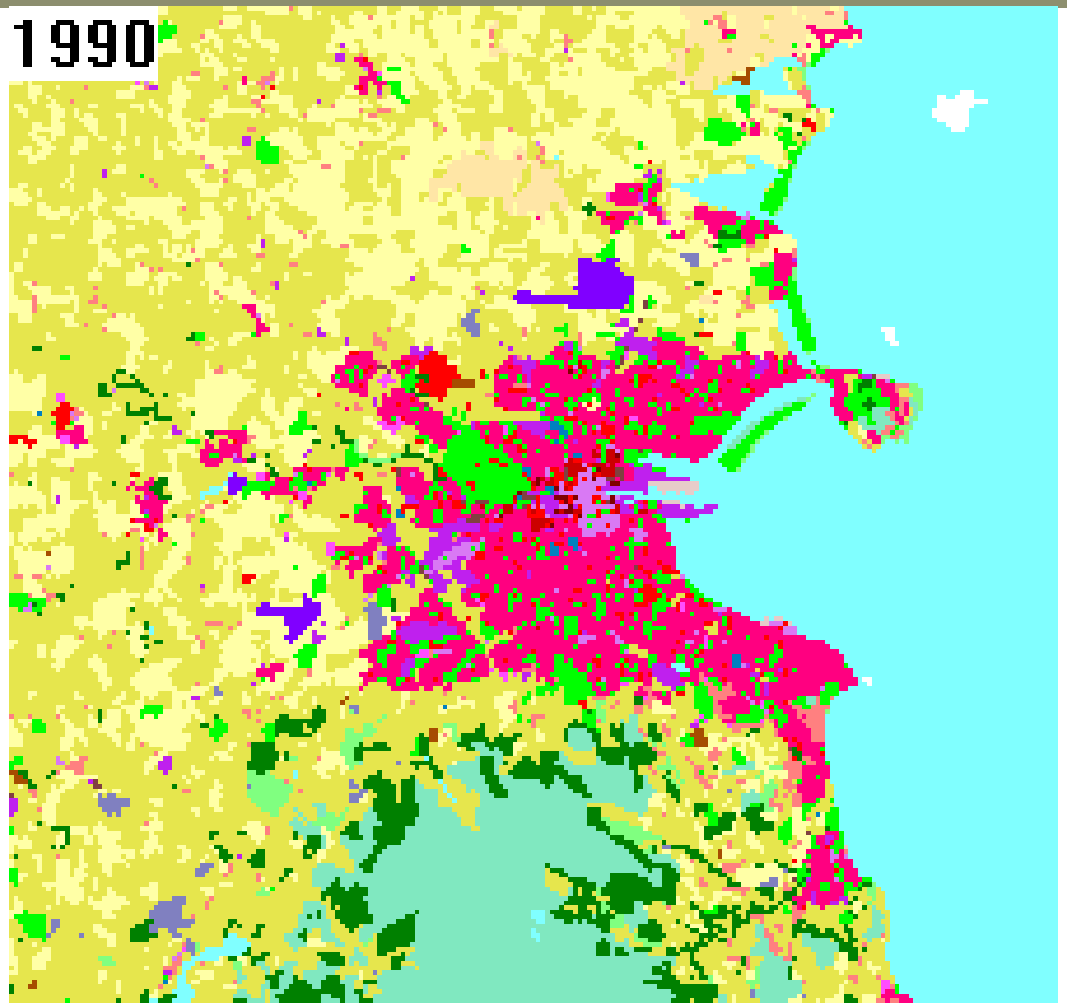


LSI = 2.5

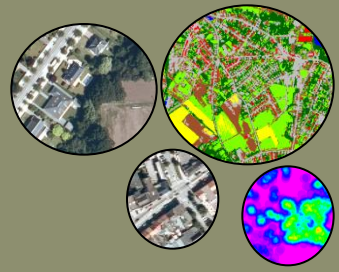
Calibrated MOLAND model Dublin

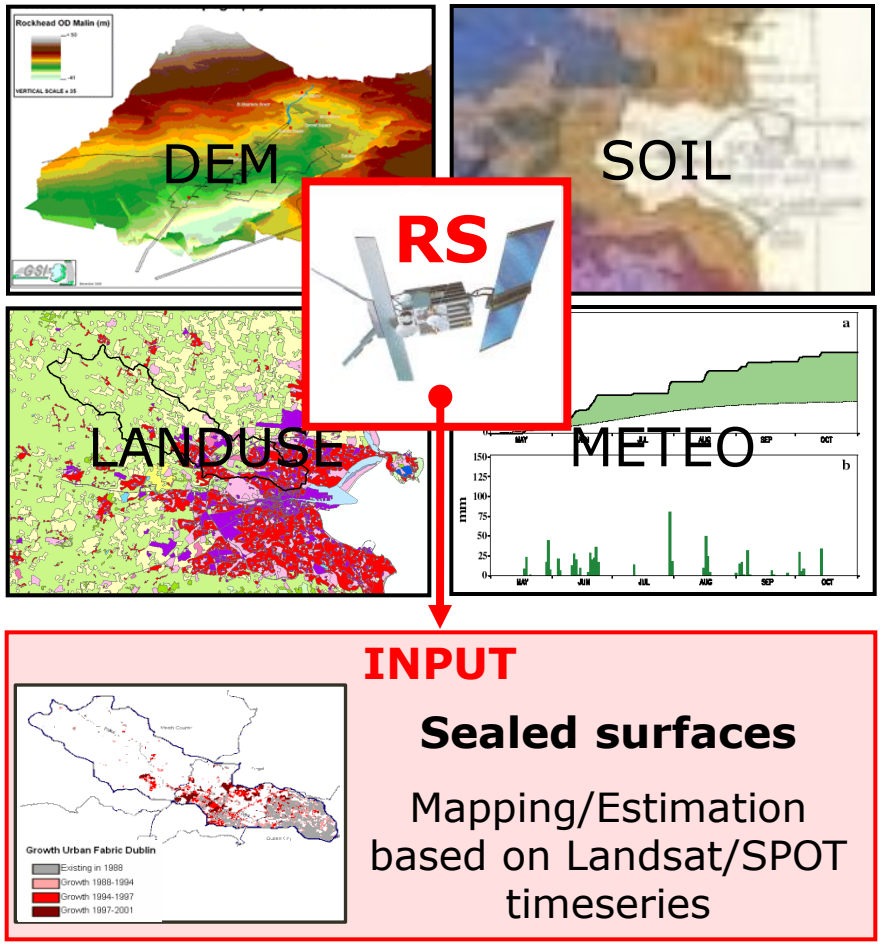


- Arable land
- Pastures
- Heterogeneous agricultural areas
- Forests
- Semi-natural areas
- Wetlands
- Abandoned
- Residential continuous dense urban fabric
- Residential continuous medium dense urban fabric
- Residential discontinuous urban fabric
- Residential discontinuous sparse urban fabric
- Industrial areas
- Commercial areas
- Public and private services
- Port areas
- Construction sites
- Road and rail networks and associated land
- Airport
- Mineral extraction sites
- Dump sites
- Artificial non-agricultural vegetated areas
- Restricted access areas
- Water bodies
- Outside area

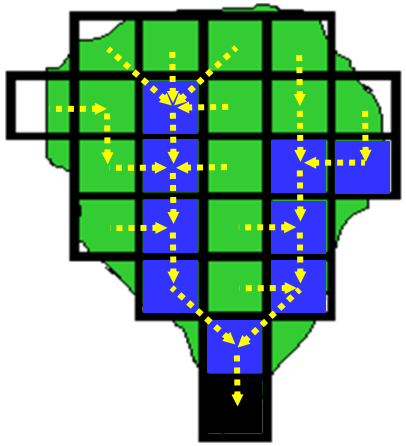


Impact urban growth on hydrology



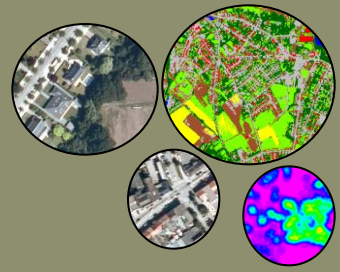


WetSpa model (Rainfall-Runoff)

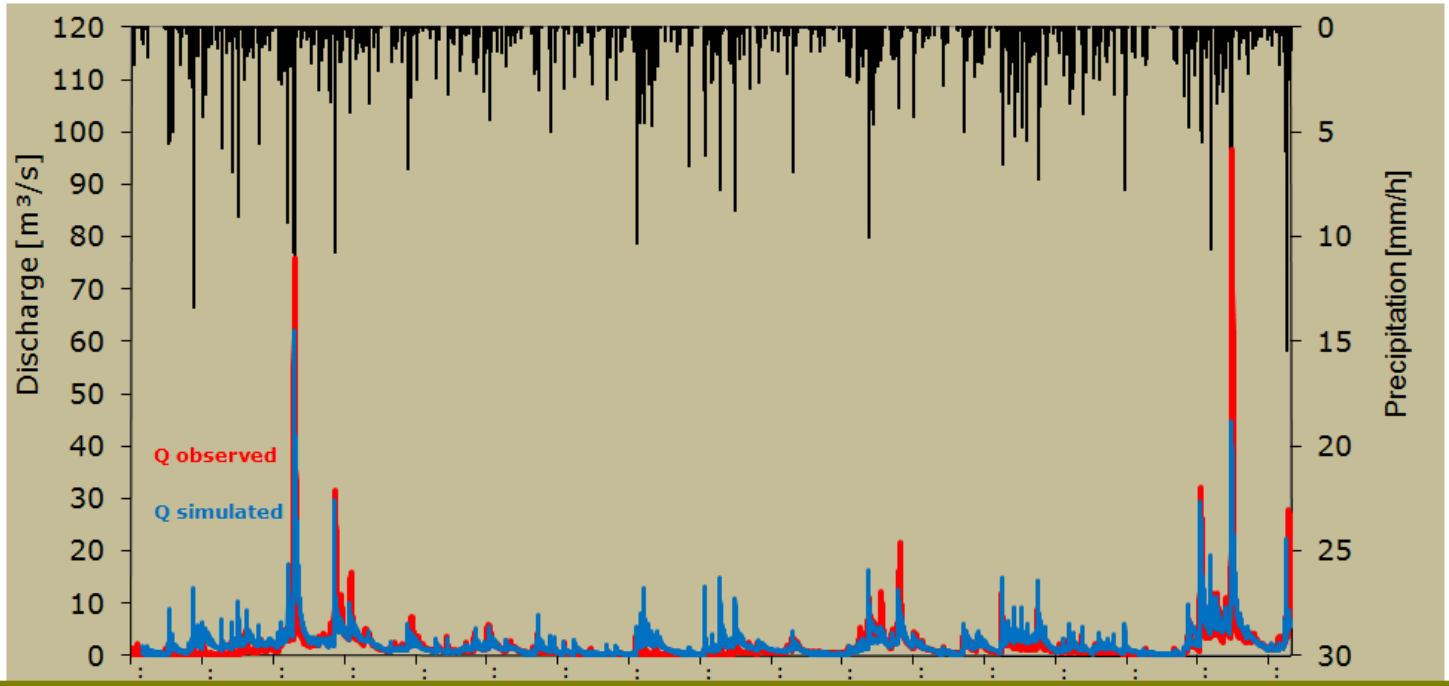


Case Study: Tolka, Dublin

Case study: Tolka – Dublin



- Calibration 2.5 years: **Hydrograph - Sub-pixel**

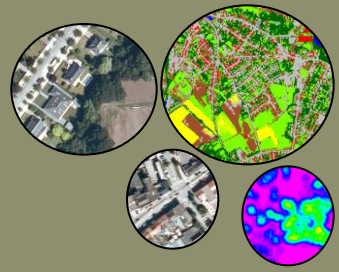


RESULTS

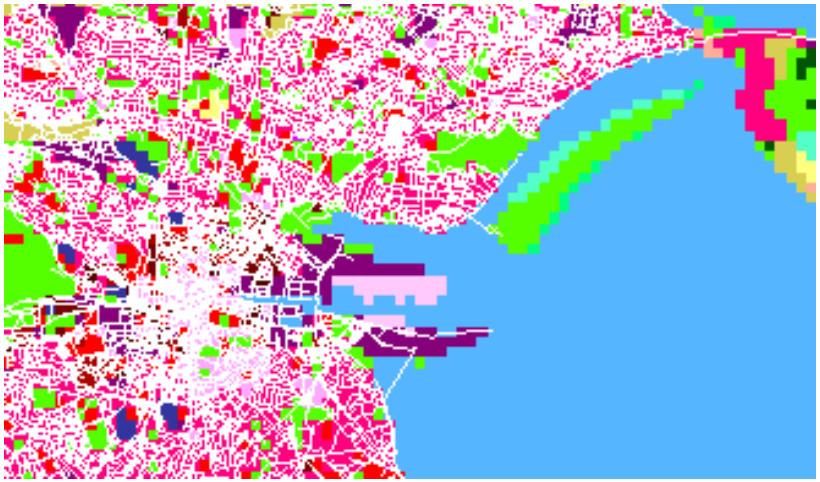
Calibration: NSE = 0.63 (Event: 0.74)

Underestimation extreme peaks, overestimation smaller events

User case



- Case focuses on **Urban Sprawl** and its effects on **Urban Waste Water**
- Predict urban waste water loads due to increasing population
- Collaboration with local stakeholders (UCD, Dublin City Council)



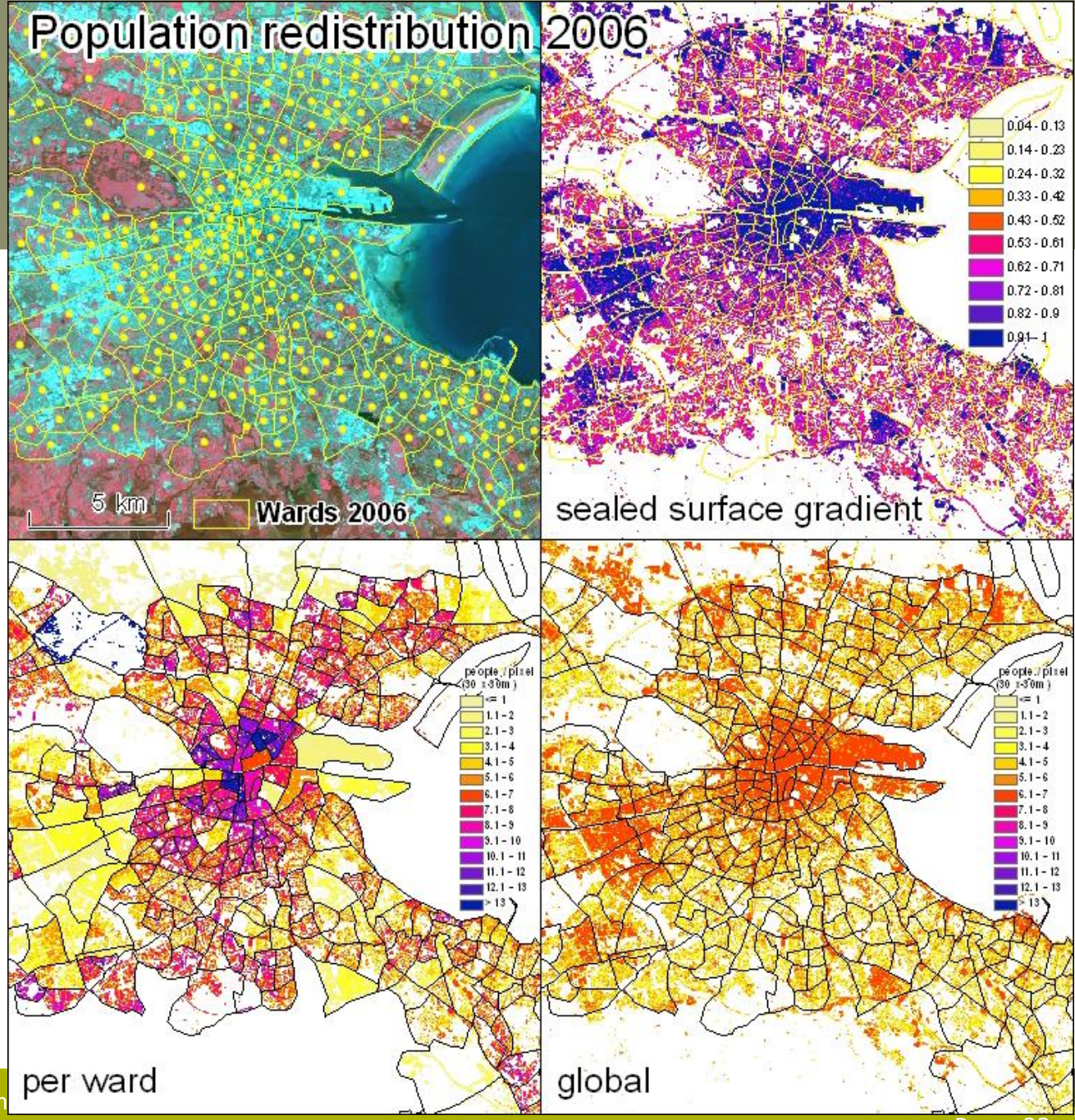
Forecast expansion of residential activity
- 4 scenarios will be simulated with MOLAND model of Dublin

Estimate spatial distribution of impervious surfaces for given LU class
- based on variables describing spatial context

Map population based on IS distribution
- with dasymetric mapping

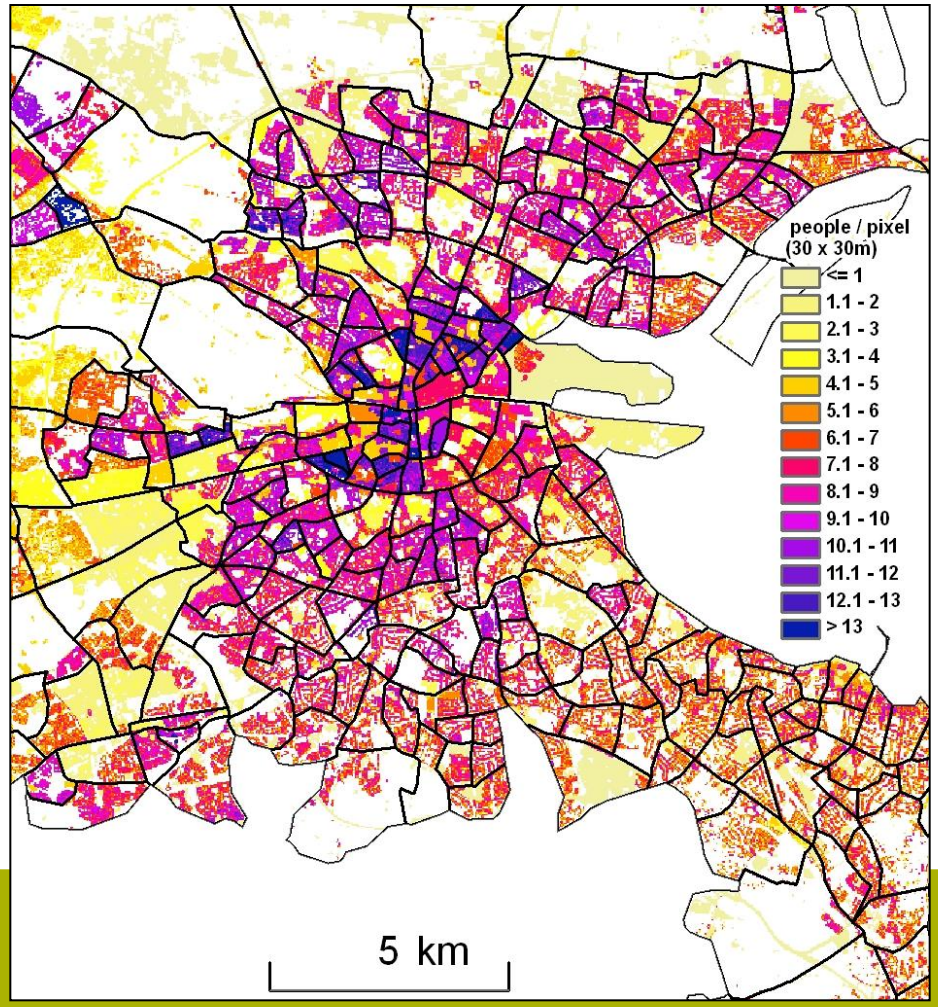
Population redistribution

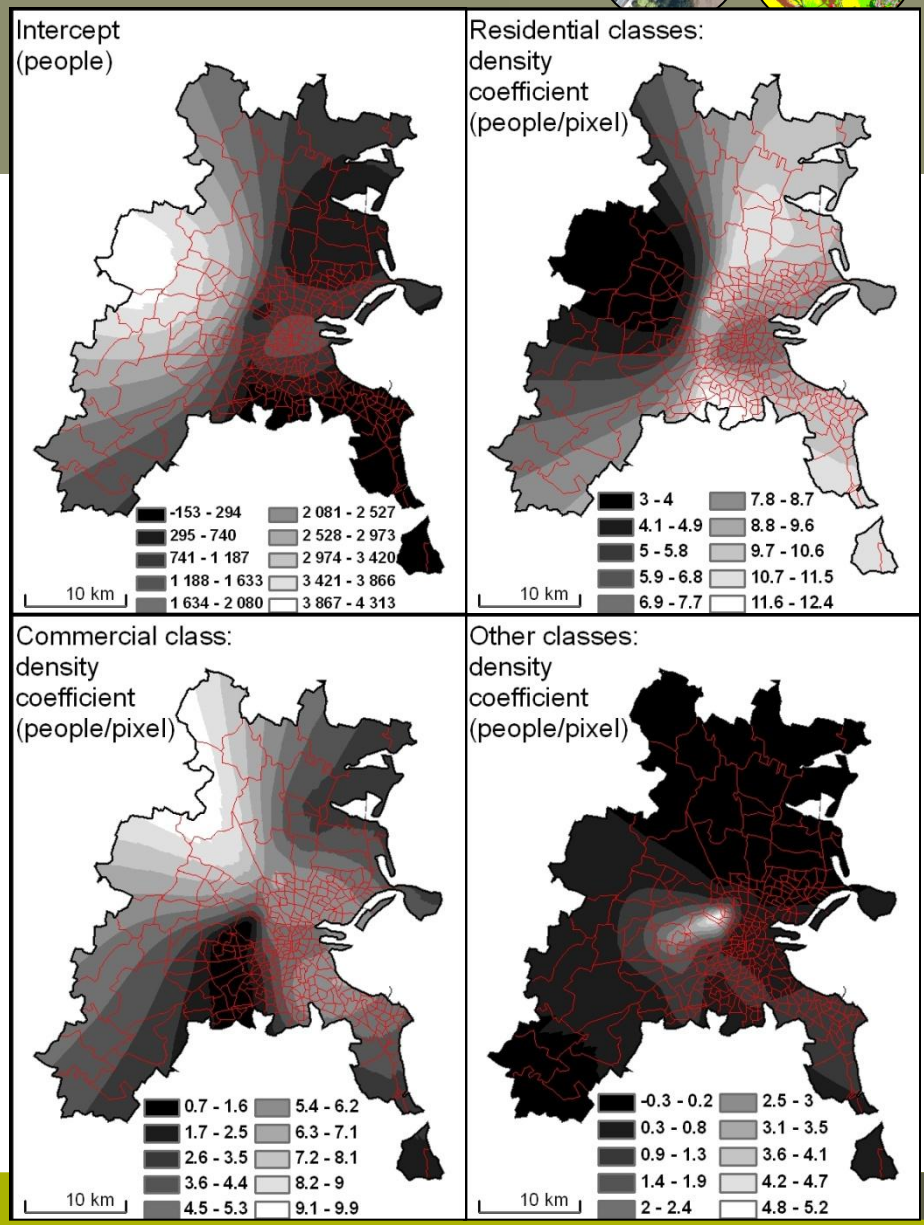
Binary methods:
census +
sealed surface
gradient



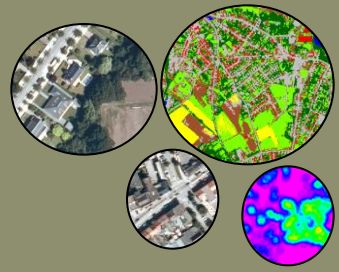
Population redistribution

GWR method: census + MOLAND + sealed surface gradient





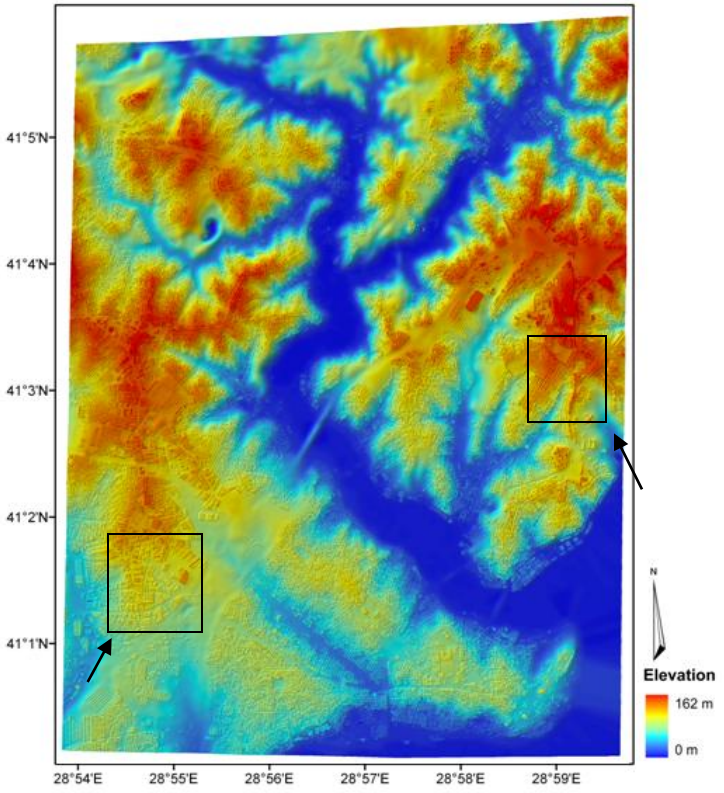
DSM extraction improvement



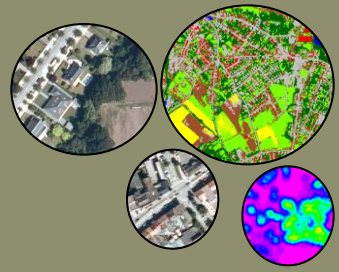
Different approaches to improve surface model extraction and especially 3D building reconstruction

- Advanced matching algorithms
- Trinocular stereo mapping
- Fusion with cadastre data

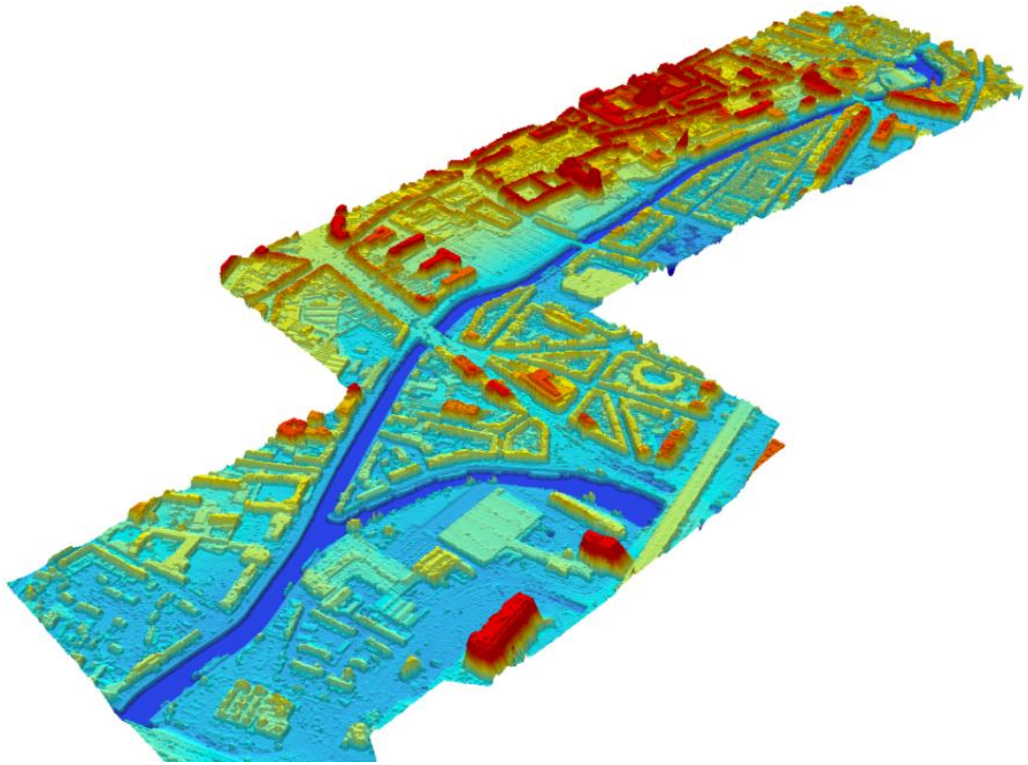
	Stereoscopic approach		Trinocular approach		Fusion with 2D data	
	Zone UA1	*Zone UA2*	*Zone UA1*	*Zone UA2*	*Zone UA1*	*Zone UA2*
# Compared buildings	11999	41757	11999	41757	11999	41757
Min dZ (m)	-11.51	-12.89	-6.22	-8.37	-7.72	-7.03
Max dZ (m)	5.81	11.16	7.57	7.08	5.35	7.12
Mean dZ (m)	-3.05	-1.56	0.59	-0.83	-0.97	0.05
St.dev. (m)	3.39	4.56	2.54	3.04	2.41	2.89
MAE (m)	3.75	3.89	2.06	2.44	2.00	2.30
RMSE (m)	4.56	4.82	2.60	3.15	2.60	2.89

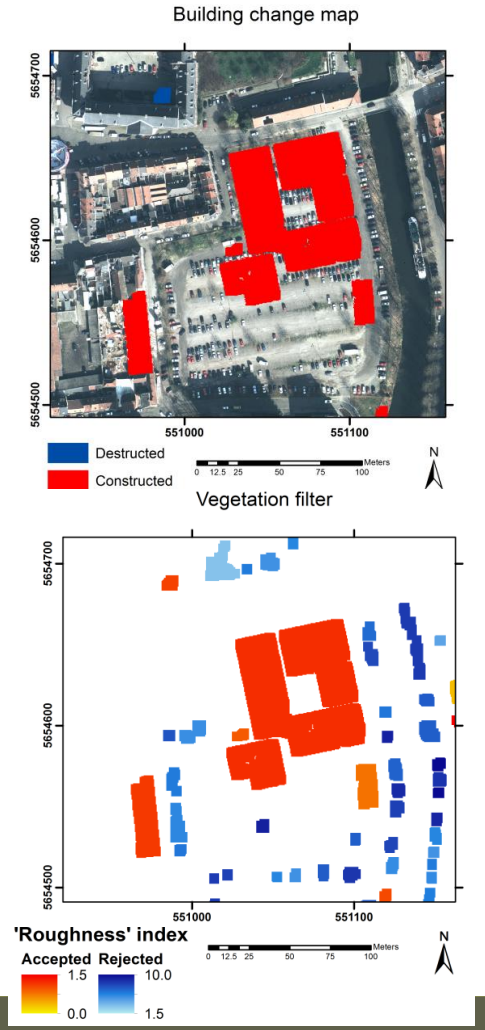


3D change detection

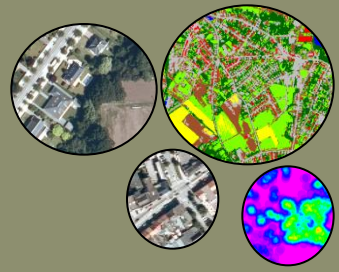


3D building change detection between high quality multi-temporal surface models





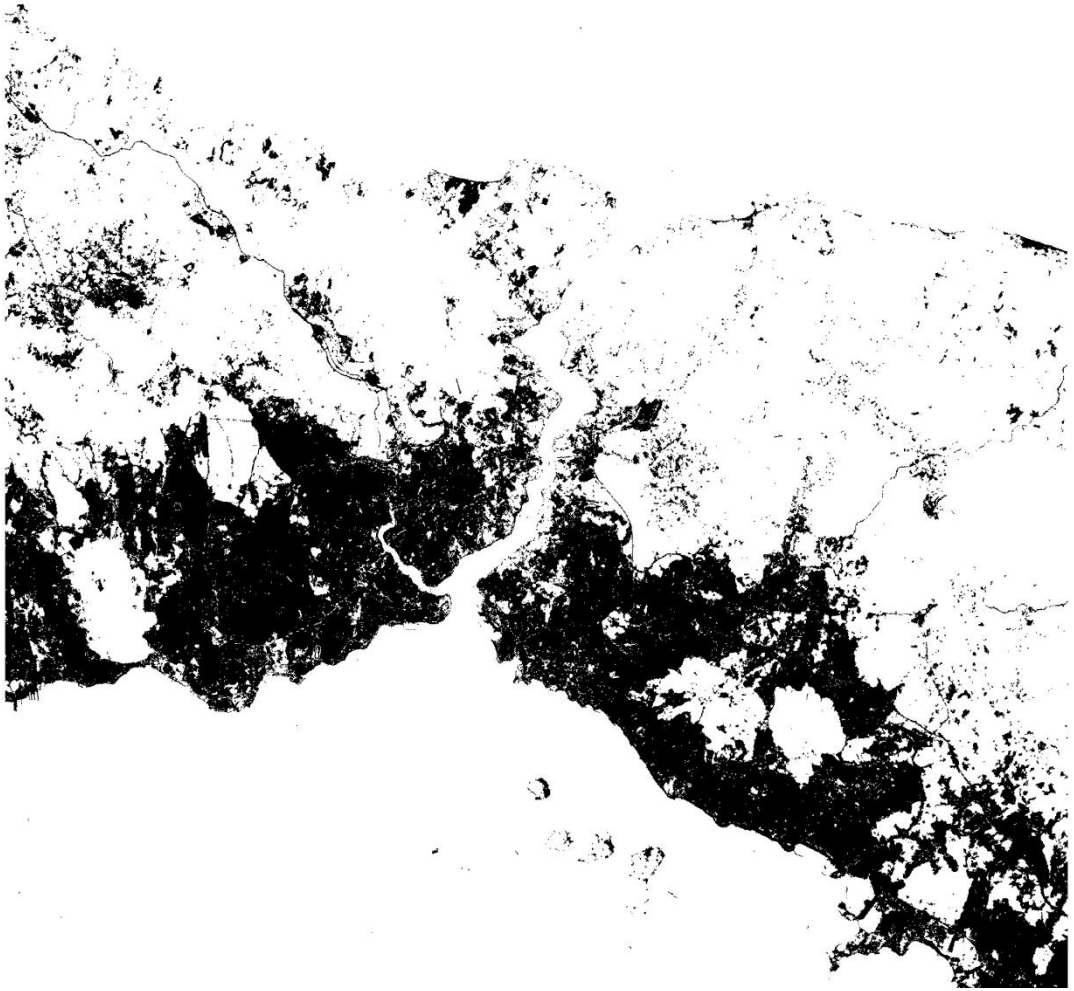
Deriving urban masks

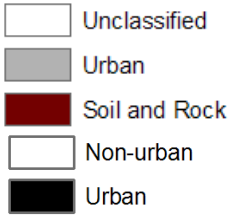


- Landsat 07/2000

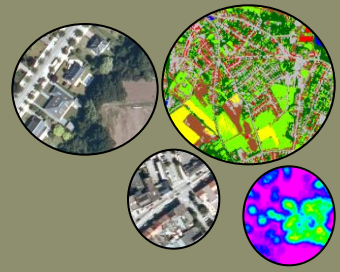
Urban mask

Classification

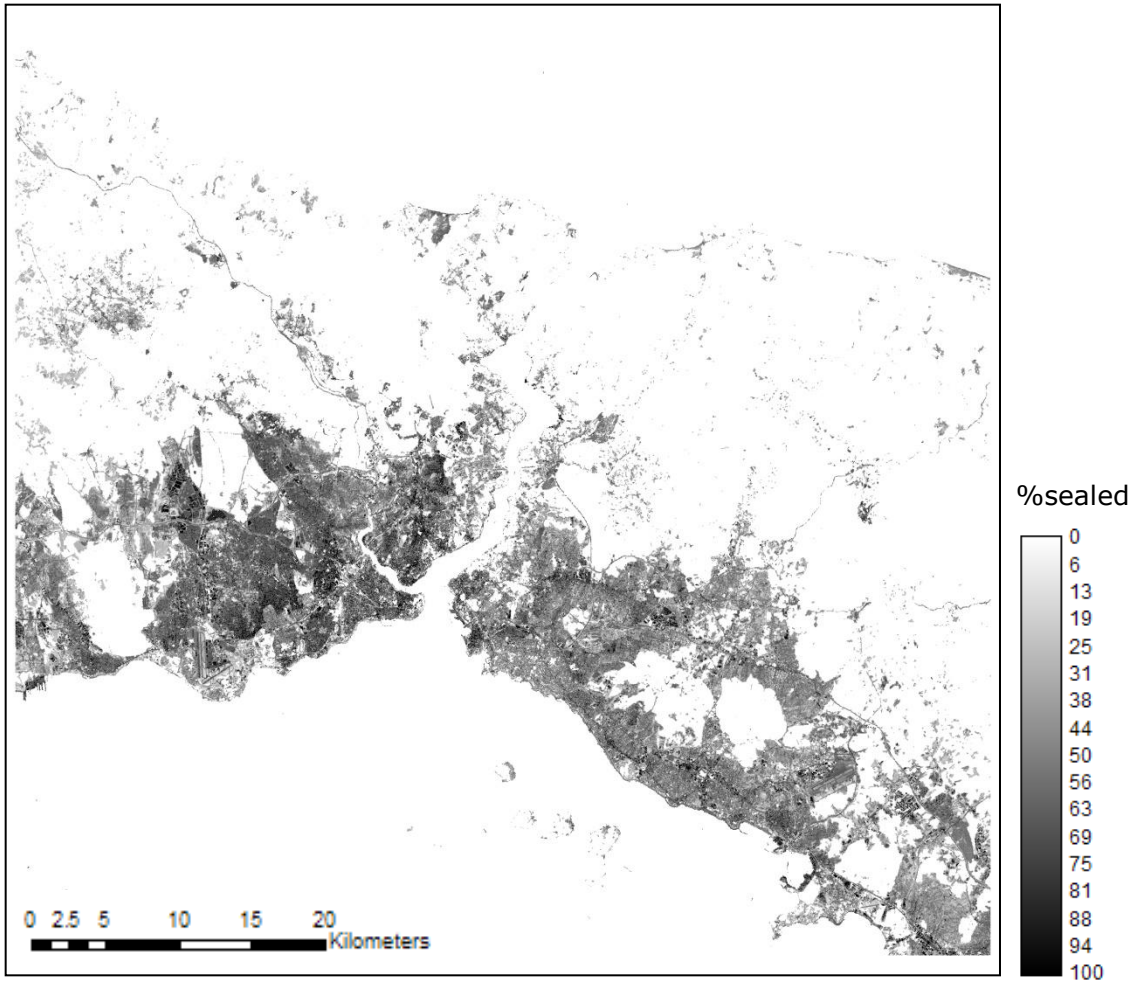




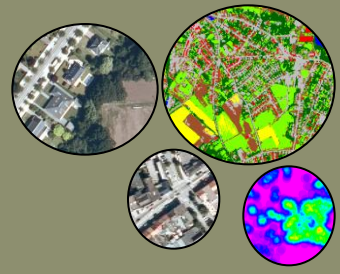
Time-series Istanbul: sealed surface proportions

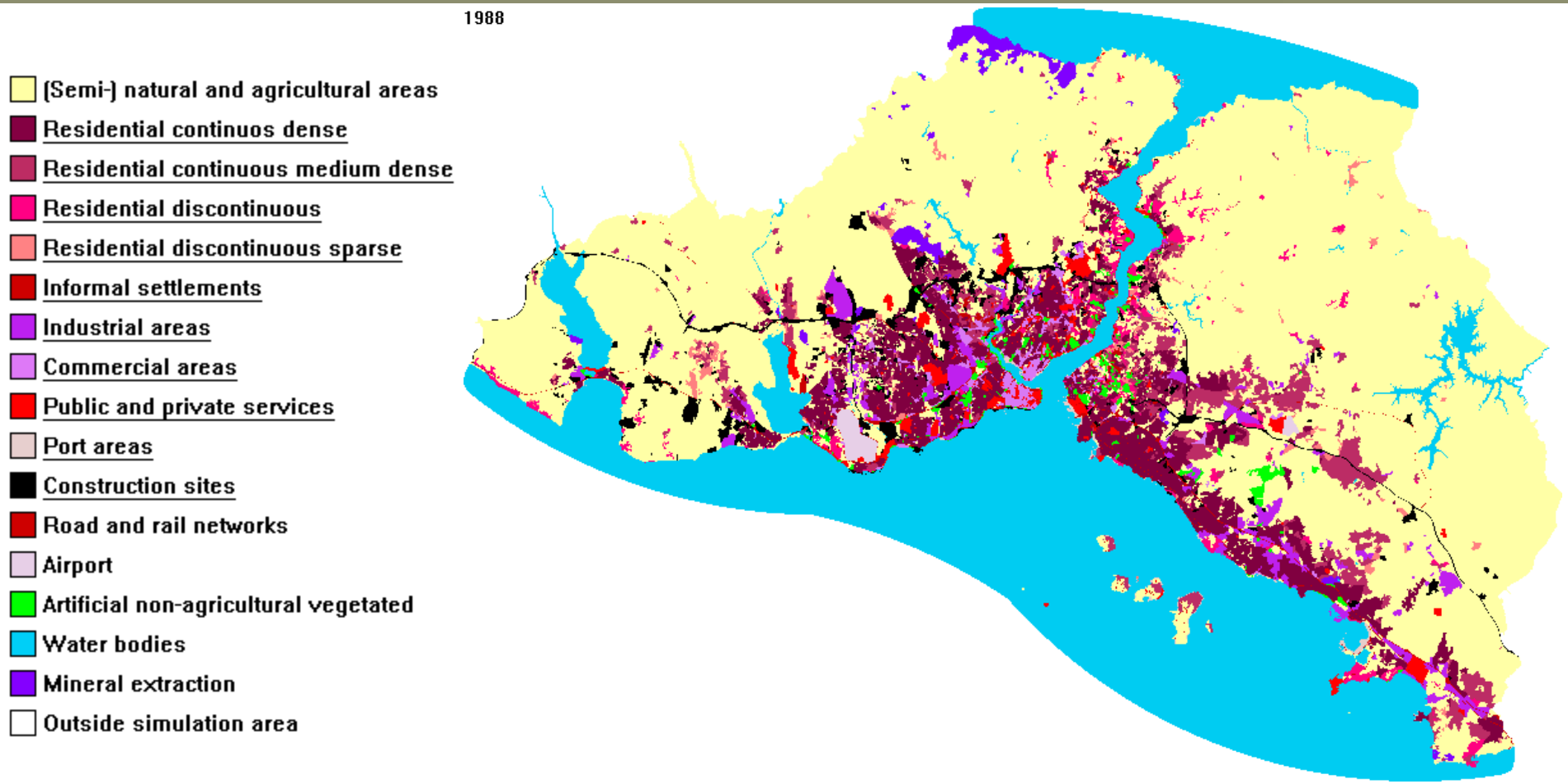


Landsat 07/2000



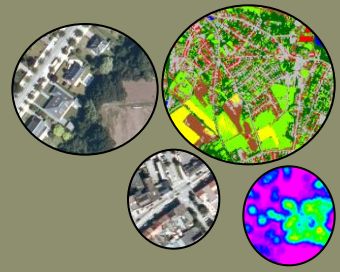
Calibrated MOLAND model Istanbul





Kappa = 0.95, Fraction correct = 0.965

Conclusions



- Several methods have been developed that use RS data for
  - Monitoring
    - Urban masks and IS maps
    - Elementary land-use classes
    - 3D information and 3D change detection
  - Modelling
    - RS based calibration framework
      - Spatial metrics for quantifying structure and patterns
  - Impact assessment
    - Input for hydrologic model
    - For mapping population distribution based on model scenarios

- SPIN-off project : ASIMUD

  ➔ further automation of RS-based calibration framework with data assimilation