Urban Impervious Surface Change in Central and Eastern Europe Mapped Using Global Land Survey Data

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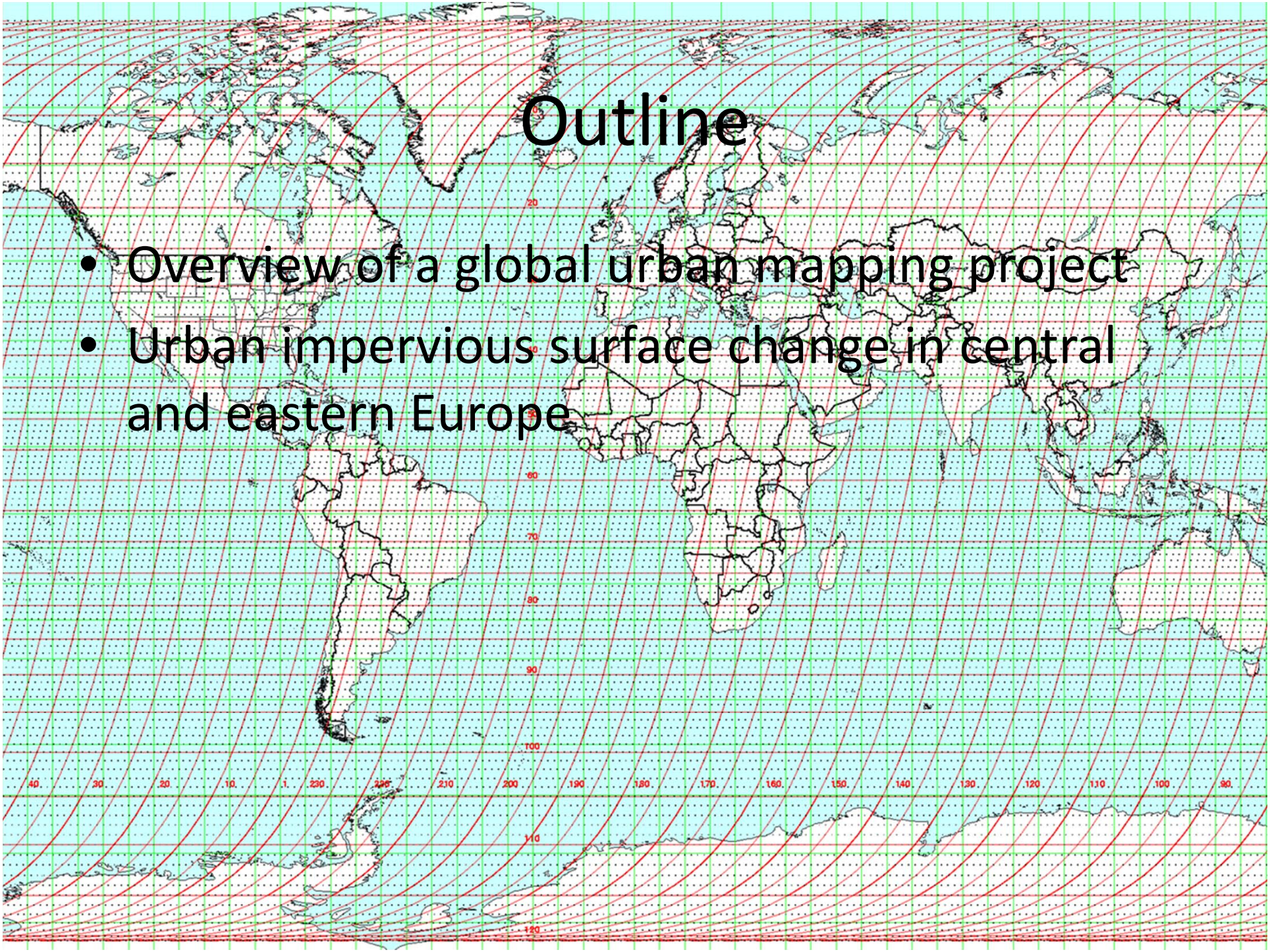
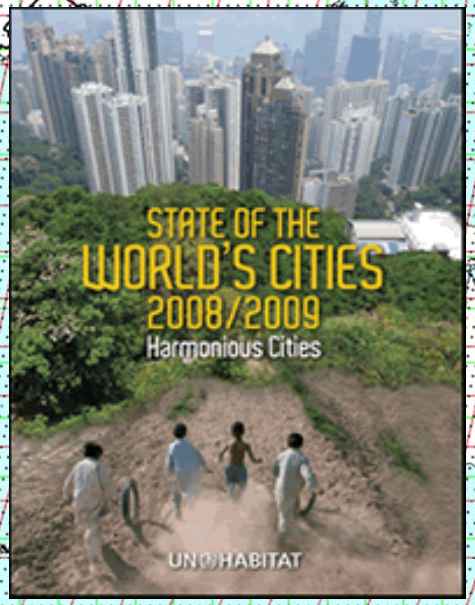


Outline

- Overview of a global urban mapping project
- Urban impervious surface change in central and eastern Europe

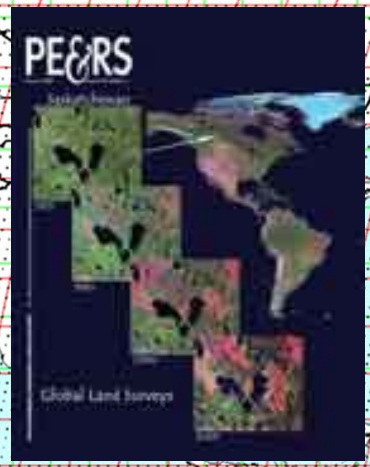
Need for Global Urban Monitoring

- Though small "footprint", urban more relevant to human society than other LULC types
  - Home to > 50% of population since 2008
  - Where most economic activities occur
  - Urbanization is a dramatic, mostly irreversible change
  - Urban consumption drives LCLUC globally
- Continental to global studies are lacking
  - Most urban studies are local
  - Existing global datasets too coarse



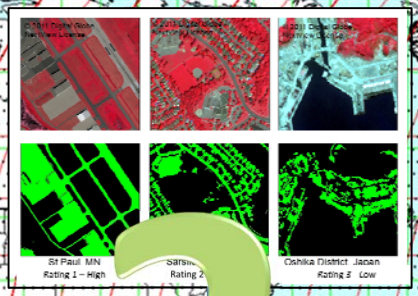
Using Landsat Global Land Survey Data to Measure and Monitor Worldwide Urbanization – a LCLUC Project

- Possible with newly available global data sets
  - Global Land Survey (GLS) Landsat datasets
    - Circa 1975, 1990, 2000, 2005, 2010
  - Meter resolution datasets from NGA



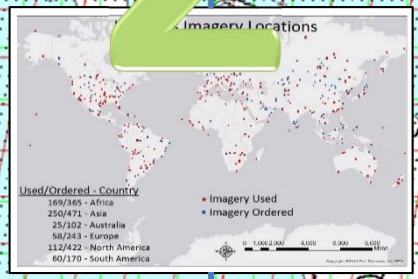
- Goals are to
  - Use the GLS Landsat data set to develop global, fine resolution % impervious cover maps for circa 2000 and 2010.
  - Detect and map global urbanization 'hot-spots' for the 2000-2010 period.

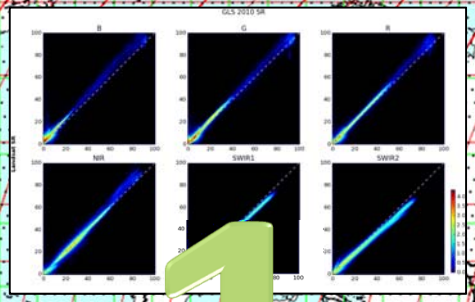
Overall Approach



2

Meter r ution
trai data





1

MODIS-I surface
refle nce

Global t data

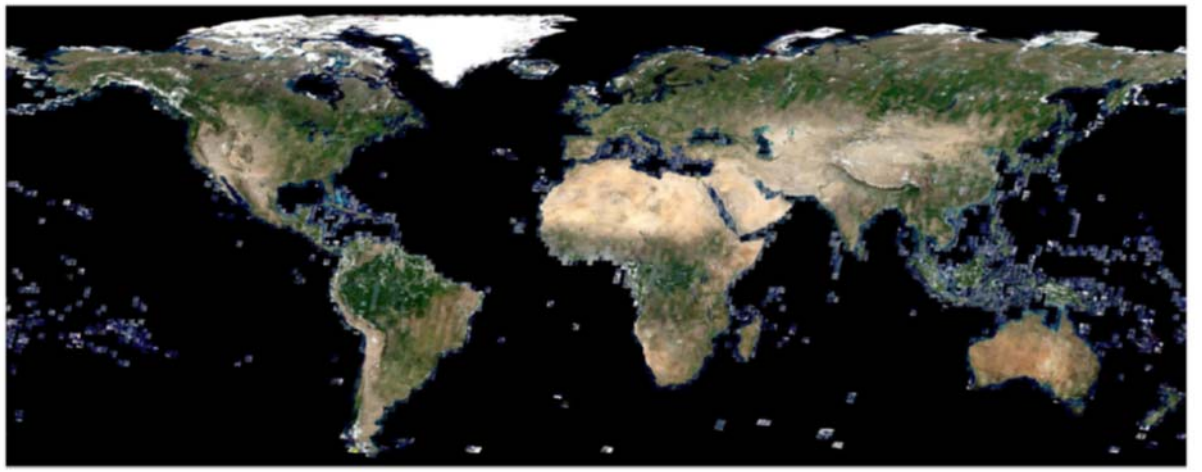
4

Regression Tree Model

3

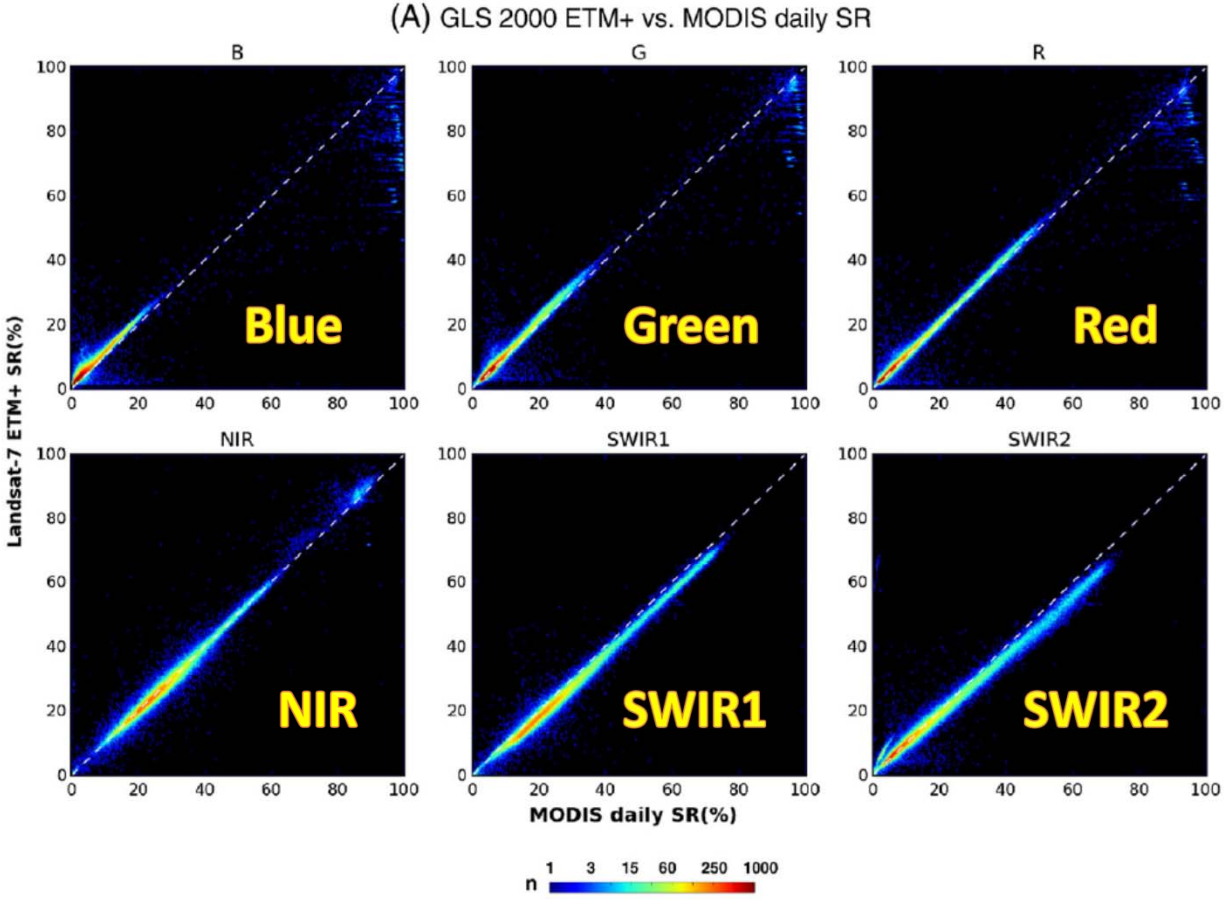
Percent Im ousness

1. Global Landsat Surface Reflectance (2000)

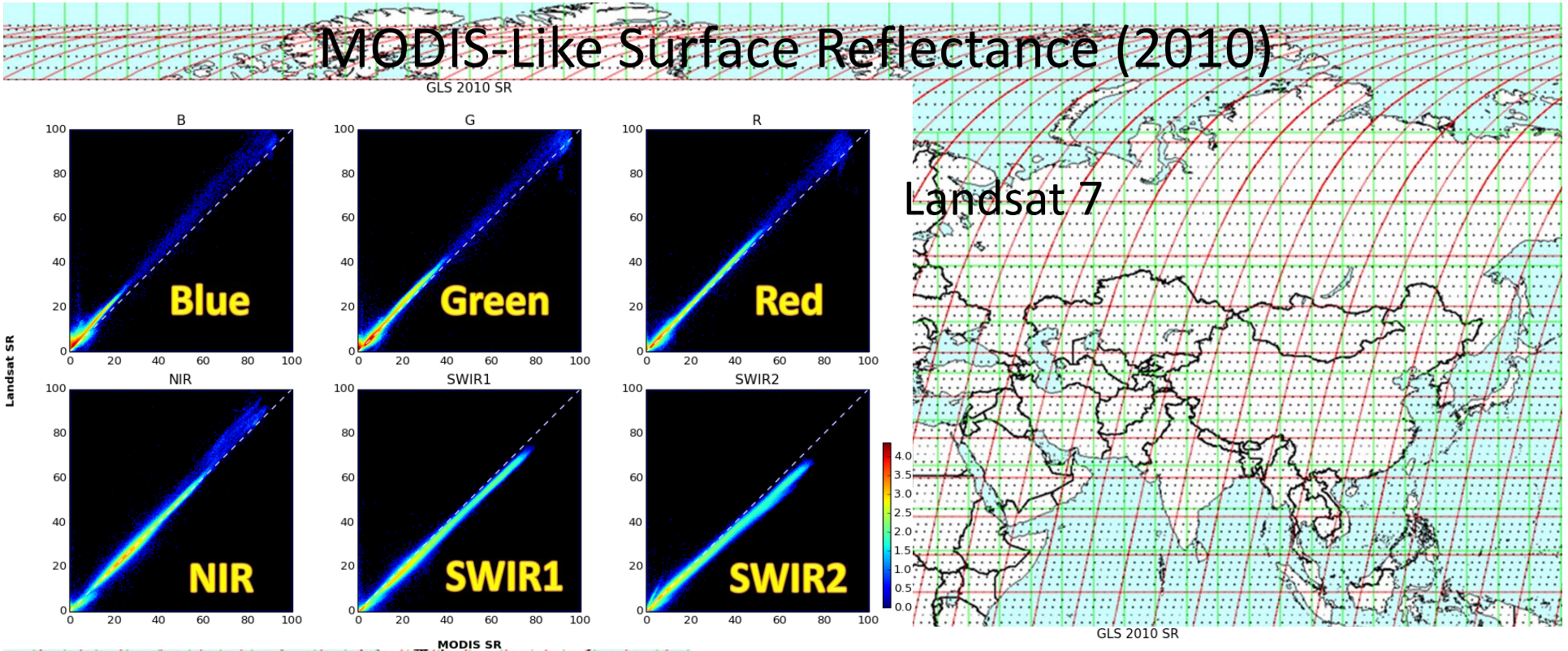


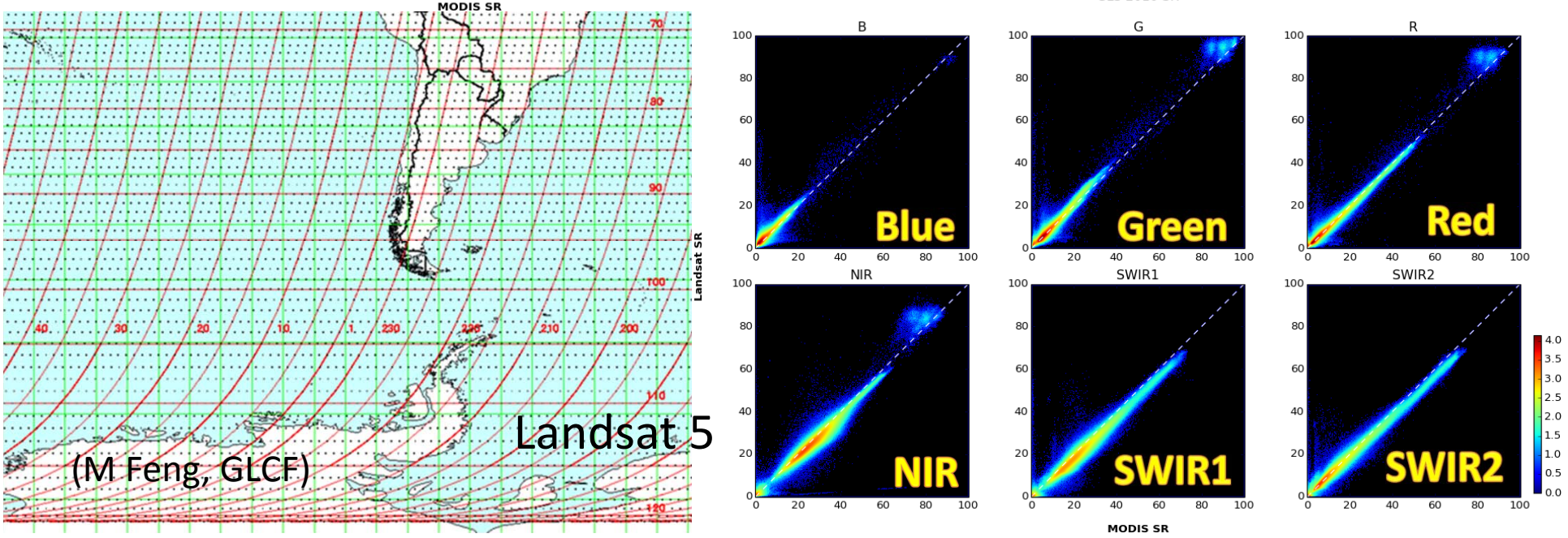
- Derived using LEDAPS
- Comparable with MODIS data

(Feng et al, 2013)

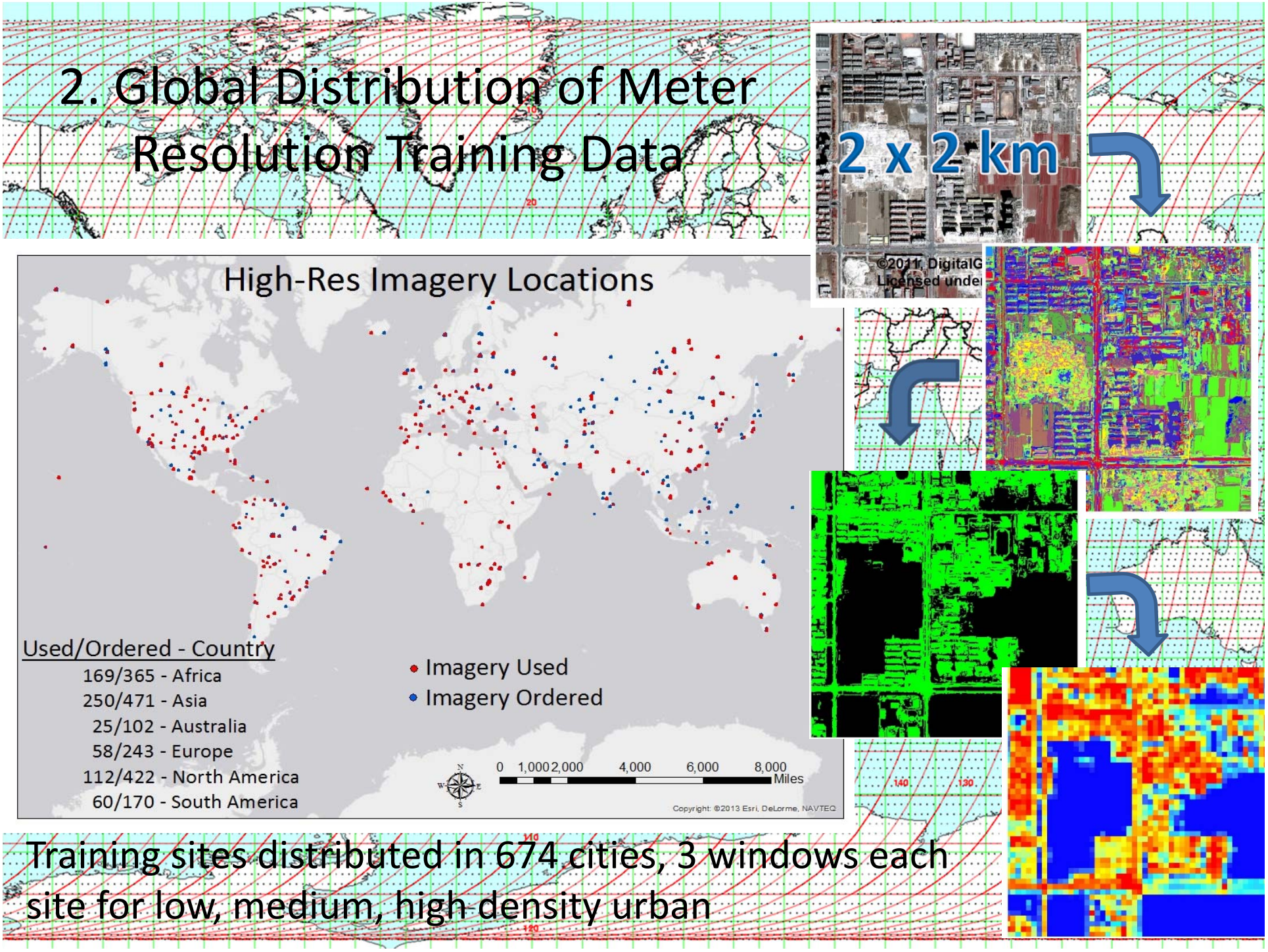


MODIS-Like Surface Reflectance (2010)



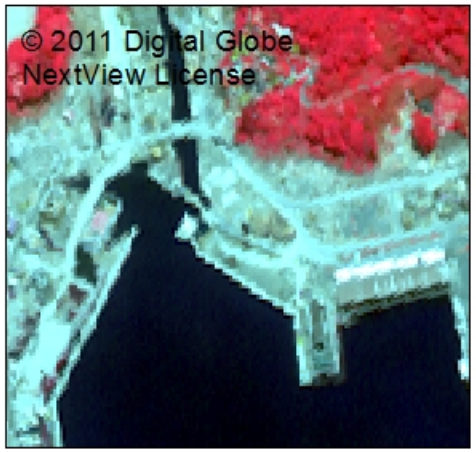


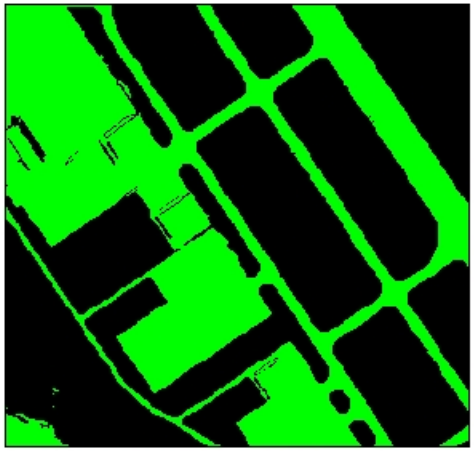
2. Global Distribution of Meter Resolution Training Data

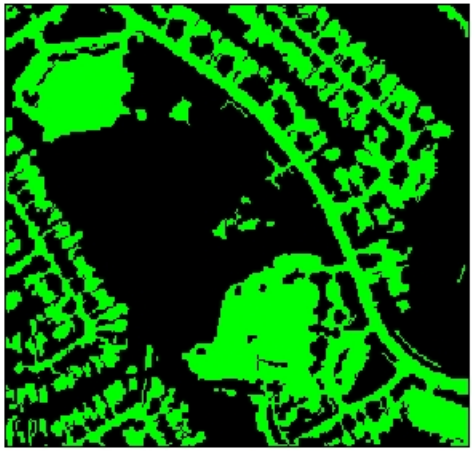


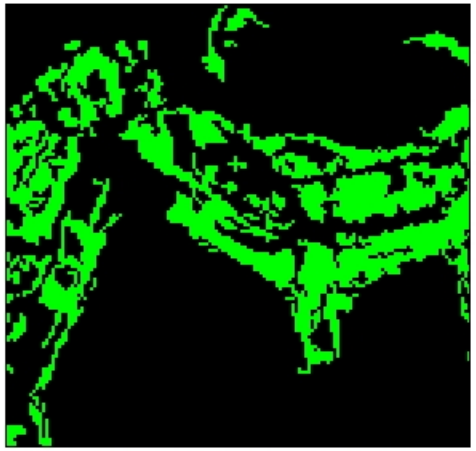
Training sites distributed in 674 cities, 3 windows each site for low, medium, high density urban

Quality Checking of Training Data









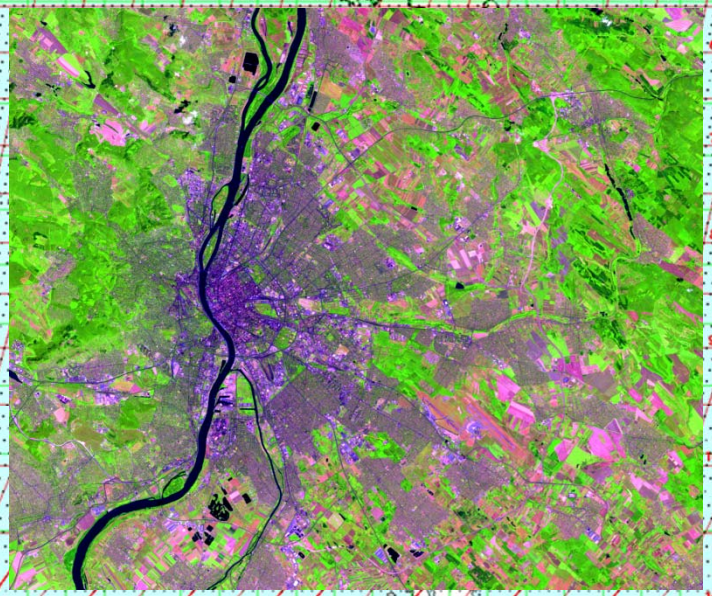
St Paul. MN
Rating 1 – High

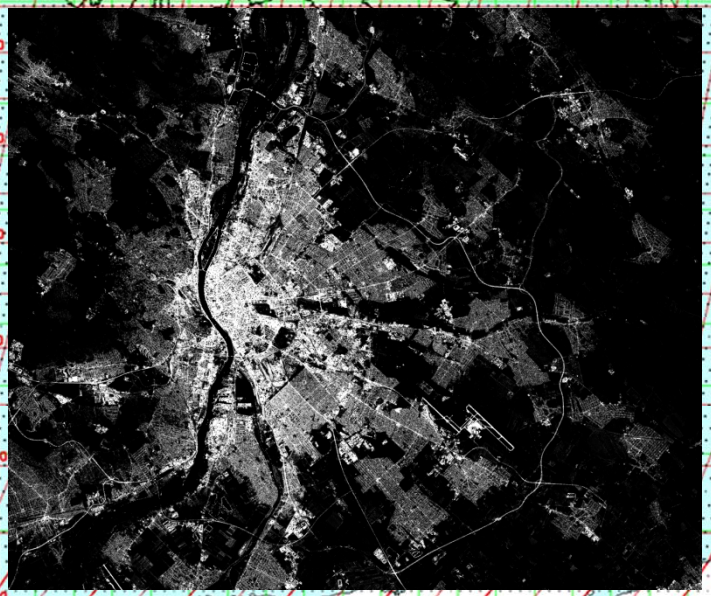
Sarsfield. Canada
Rating 2 – Moderate

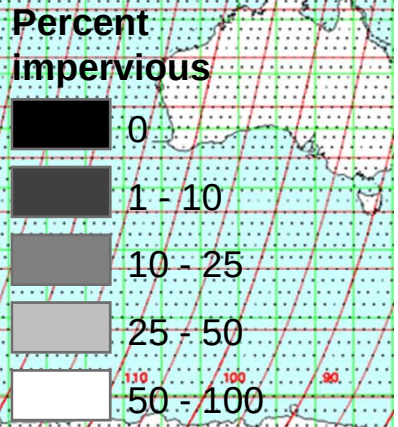
Oshika District. Japan
Rating 3 - Low

3. Percent Impervious Surface Modeling

- Using regression tree
  - Can model complex, nonlinear relationships
  - Cubist, Random Forest

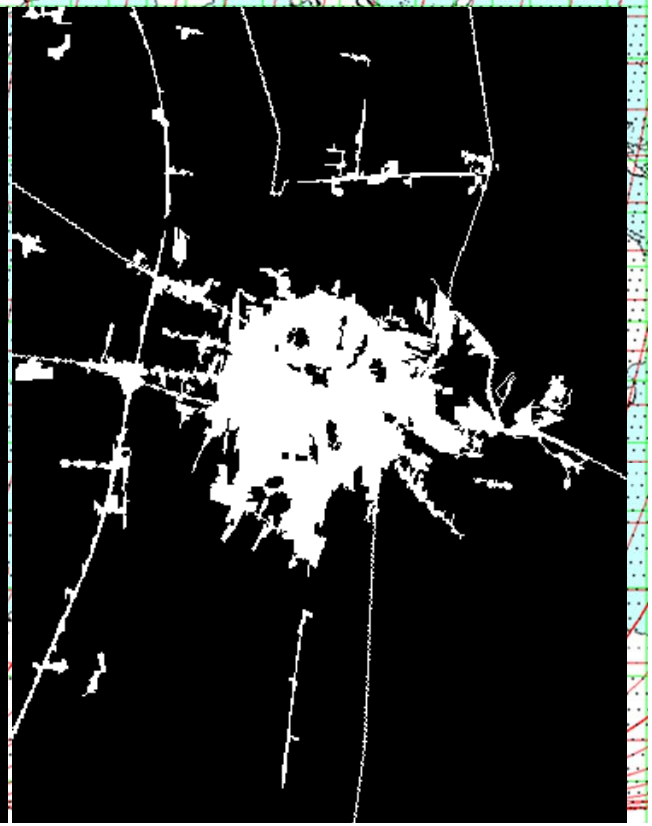






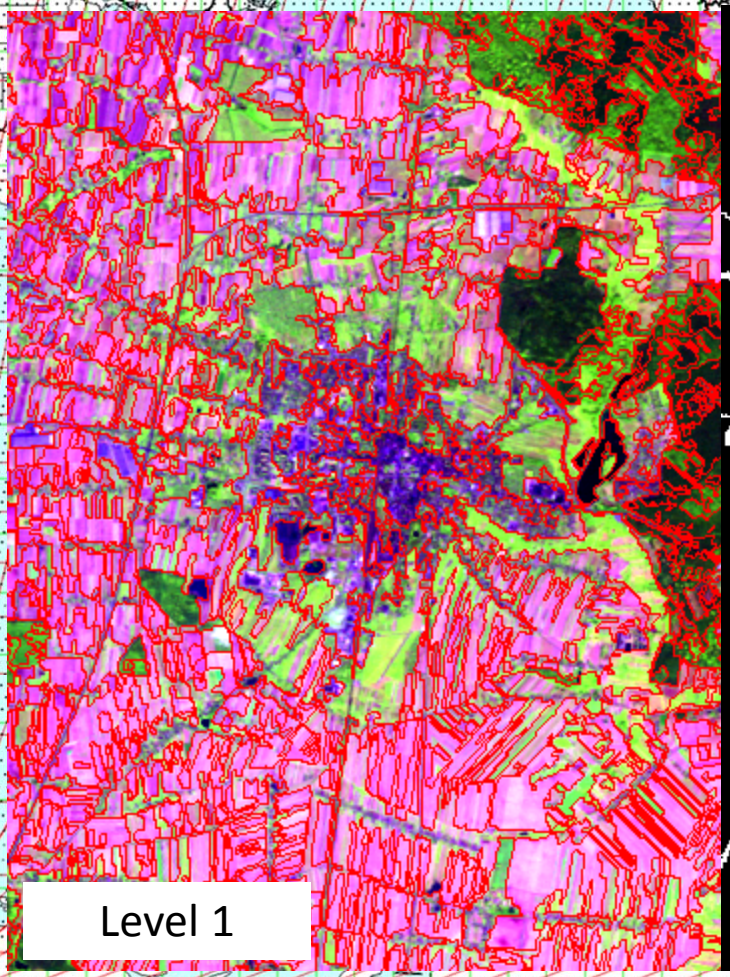
4. Urban Area Mask

- Many nonurban surfaces spectrally similar to urban
- Need to mask out, only model within urban mask
- Created using multiple sources
  - Segmentation-texture based classification
  - Open street map to get roads
  - Nightlight (too coarse)



Hierarchical Segmentation (Hseg)

- Developed by Jim Tilton of NASA/GSFC
- Lots of improvements during this project



Use of Cloud Computing Critical

- Large data volume
  - ~20000 Landsat images -> ~20 TB inputs
- Hseg CPU intensive
  - Segmentating 1 image takes ~1 hour on a 64-CPU cluster
- Use NASA DISCOVER supercomputer system
  - 439,600 CPU hours used so far

Impervious Surface Map for Central and Eastern Europe (CEE)

2000

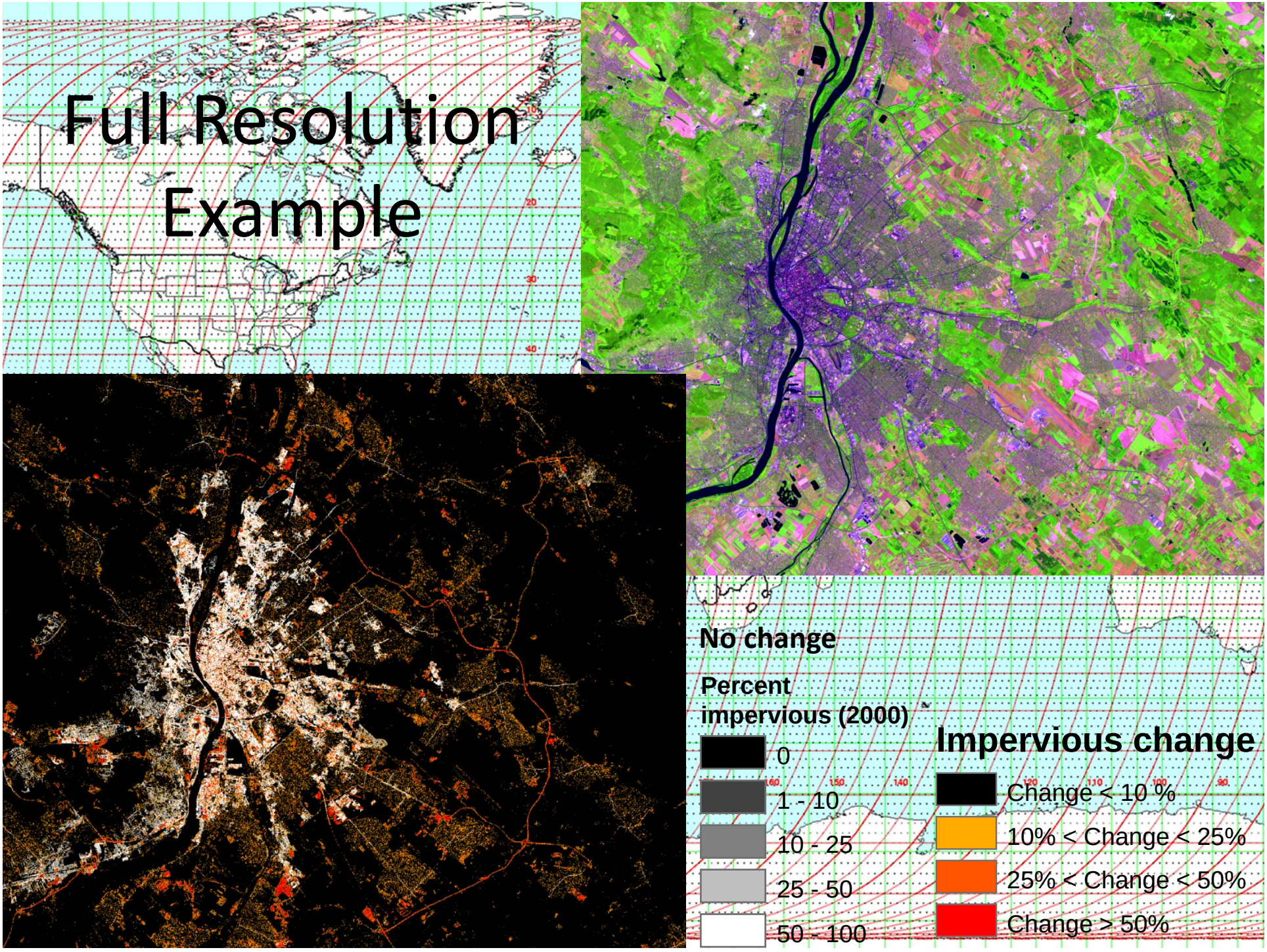
Impervious Surface Map for Central and Eastern Europe (CEE)

2010

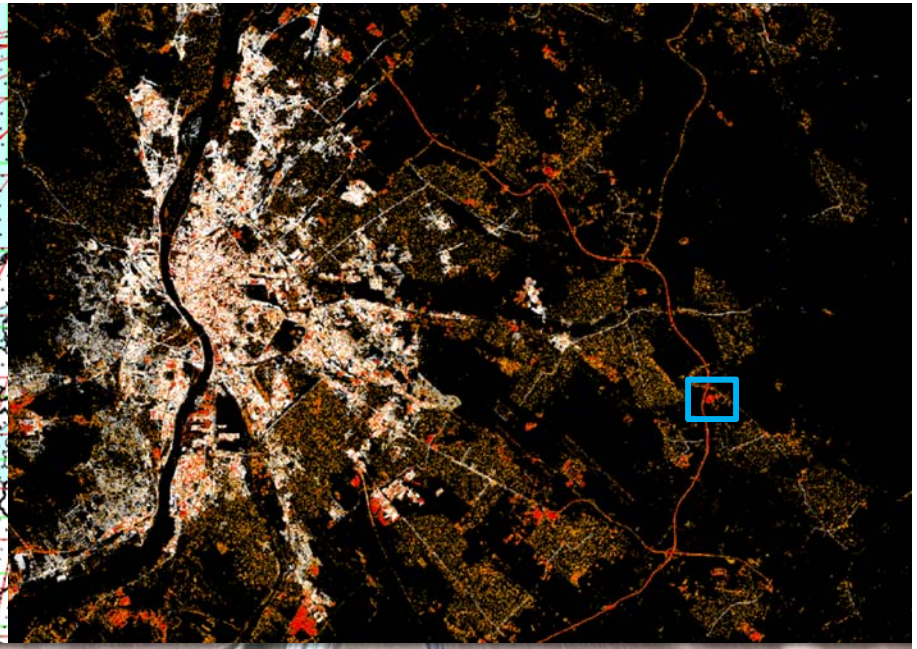
Impervious Surface Map Change

2000-2010

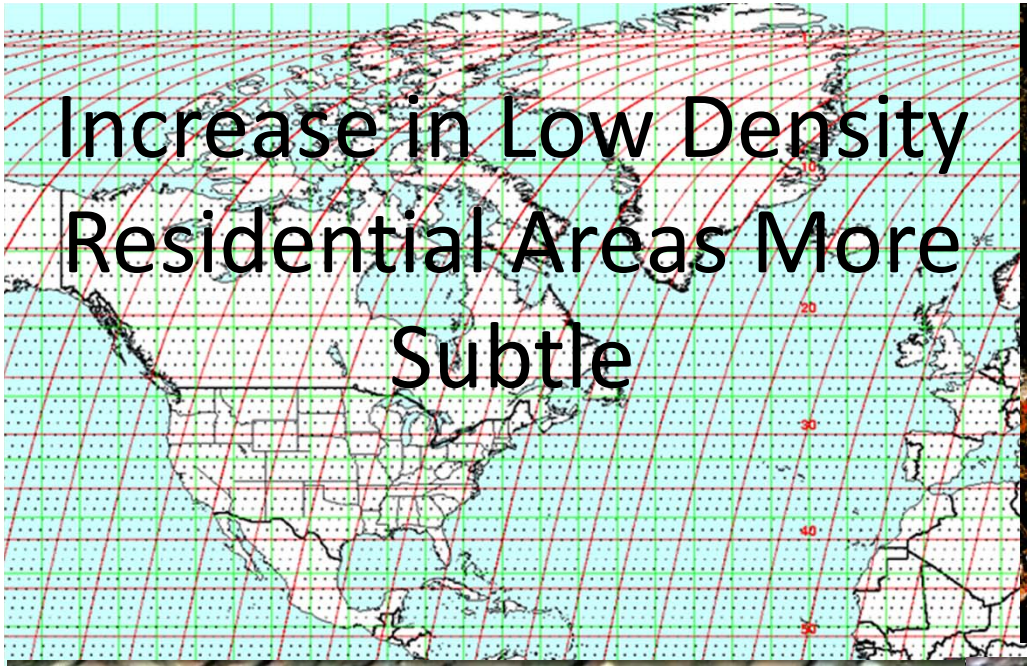
Full Resolution Example

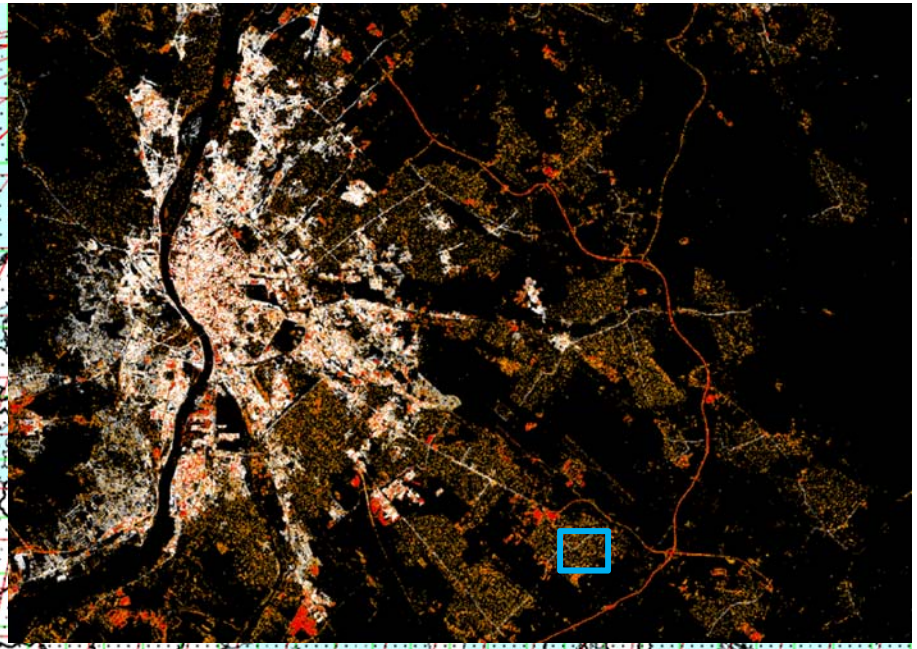


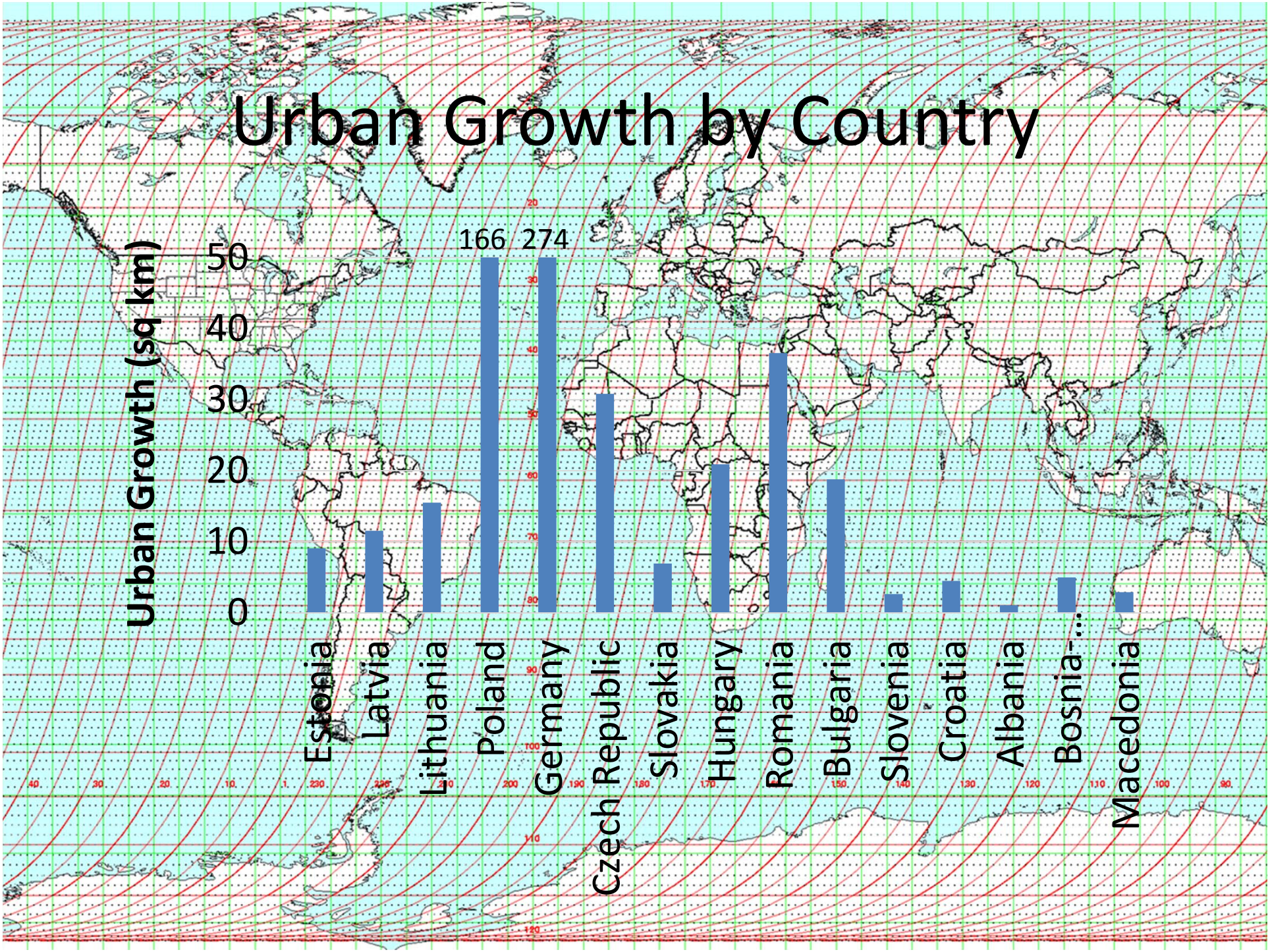
New Development Easy to Validate using Google Earth



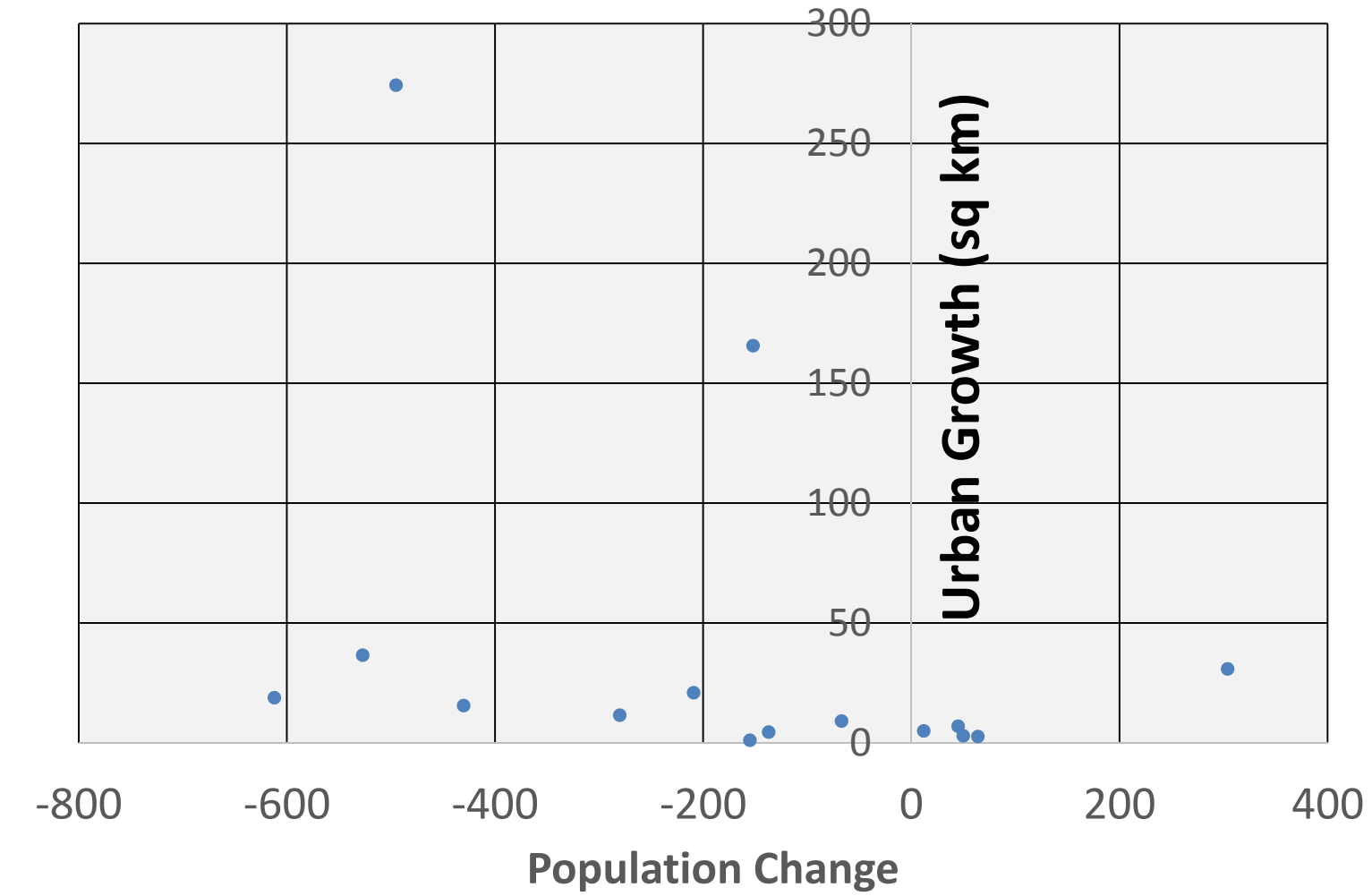
Increase in Low Density Residential Areas More Subtle



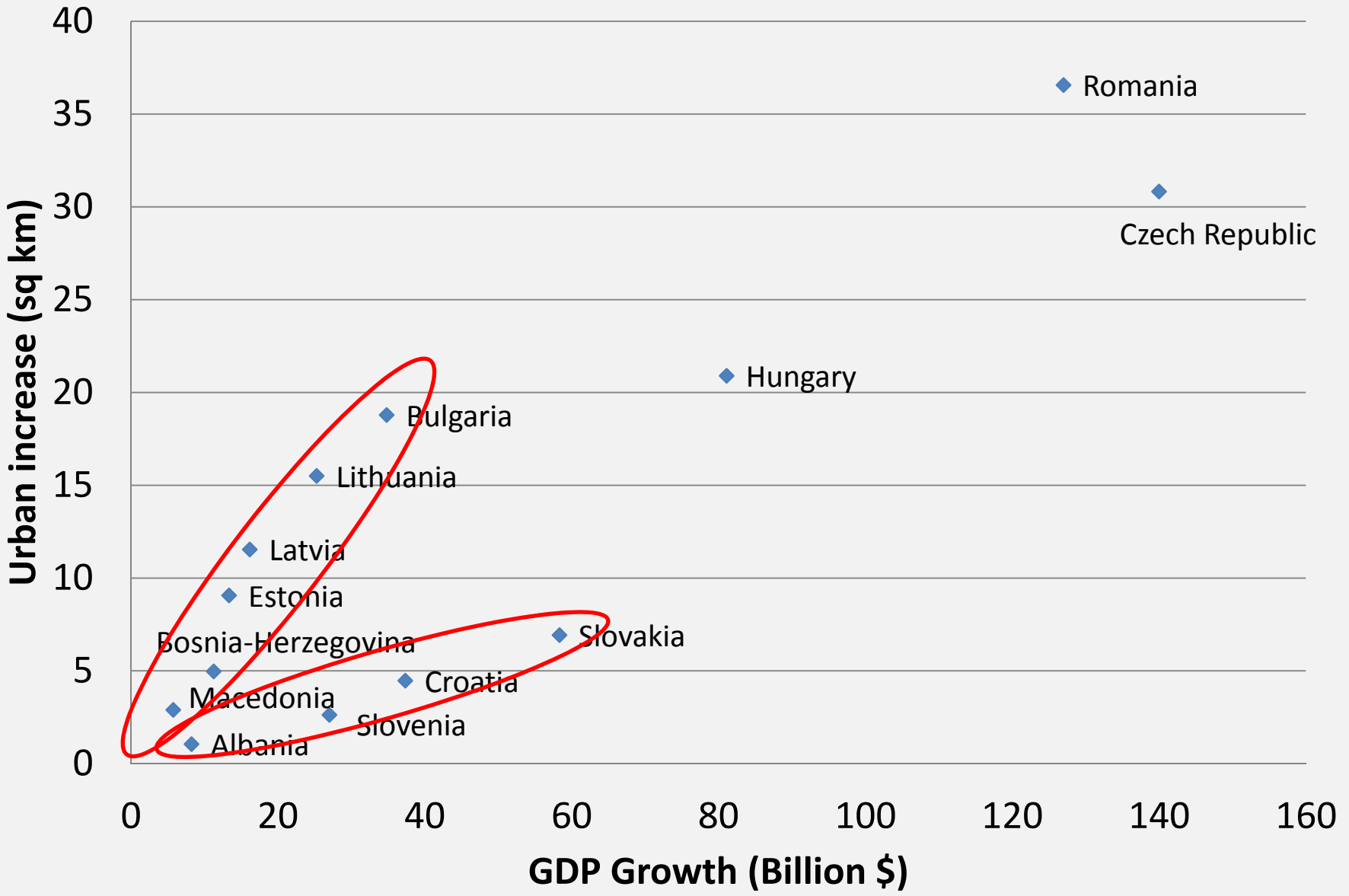



Urban Growth by Country
Urban Growth (sq km)
50
40
30
20
10
0
166
274
Estonia
Latvia
Lithuania
Poland
Germany
Czech Republic
Slovakia
Hungary
Romania
Bulgaria
Slovenia
Croatia
Albania
Bosnia-...
Macedonia

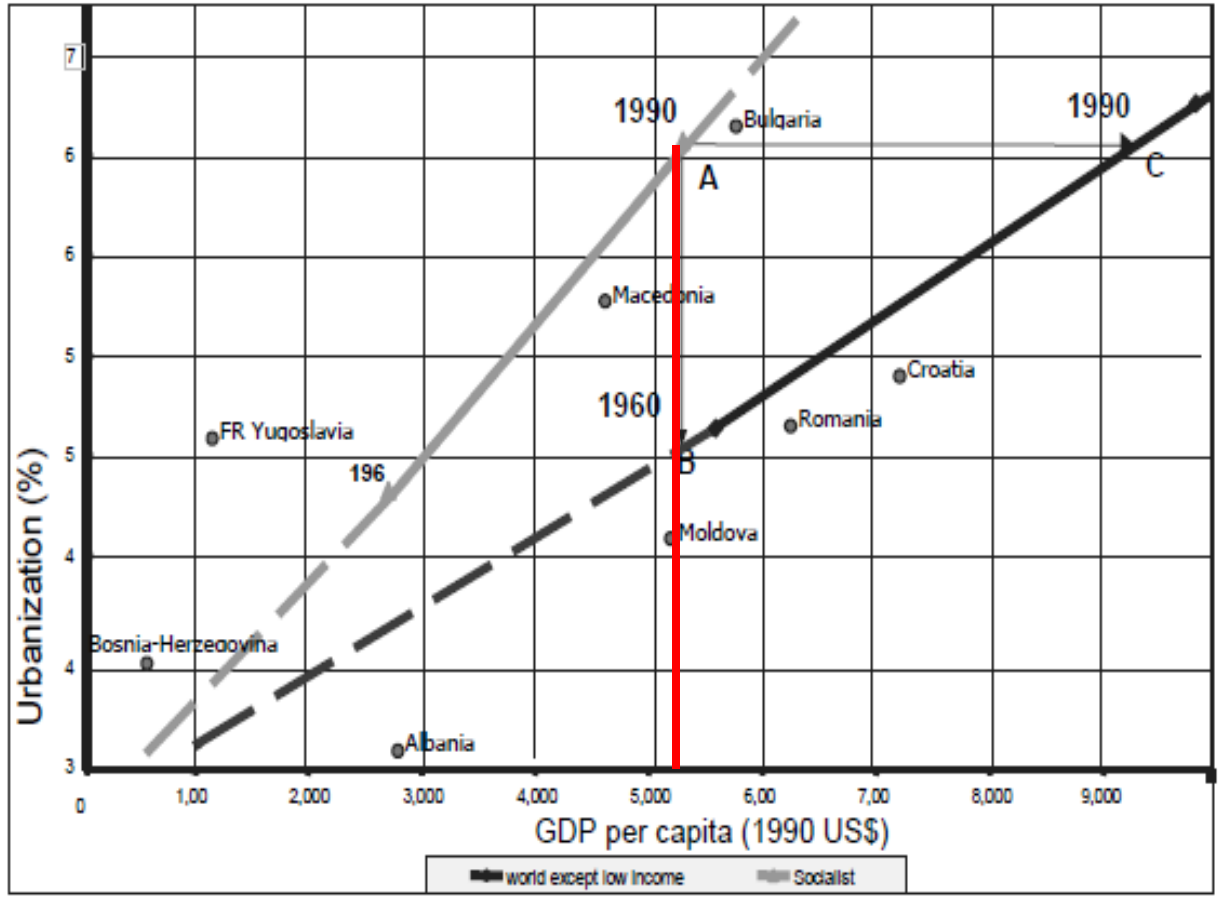
Is Urban Growth Related to Population Growth?



Is Urban Growth Related to Economic Development?

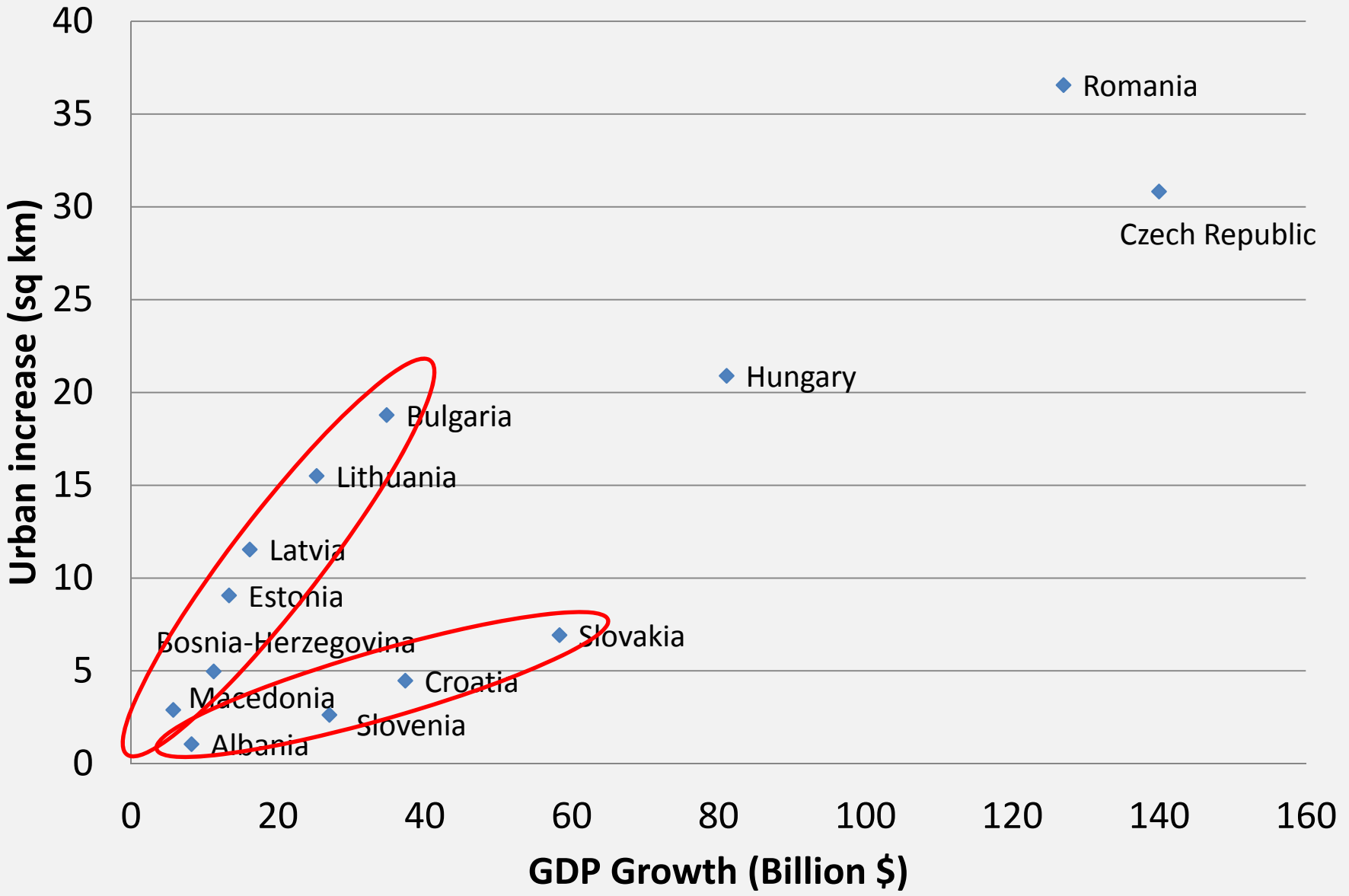


Urbanization-GDP Relationships Affected by Pre-1990 Urbanization History



"The emphasis on industrialization and urbanization during socialism has caused the dual imbalance of 'overindustrialization' and 'over-urbanization' that affects much of the region today." (Tzenkova, 2006)

Is Urban Growth Related to Economic Development?



Summary

- Global urban change mapping
  - Subpixel impervious estimation at 30m necessary
  - Need to address many challenges in global assessment
    - Globally distributed, meter-resolution training data
    - Complex, nonlinear relationships modeled using regression tree
    - Hierarchical segmentation and texture for nonurban masking
    - Supercomputing/cloud computing essential
- CEE urban change
  - Highly variable among CEE countries
  - Correlated with GDP increase, but not population change
    - Relationships affected by pre-2000 urbanization/development