Using Global Land Survey Data to Measure and Monitor Worldwide Urbanization

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LCLUC Spring Science Team Meeting,
Rockville MD, April 23, 2014

Background

- Since about 2008, the U.N. estimates more people live in cities than rural areas. Higher growth rates expected in developing world in next 30 years.

- Cities still represent relatively small 'footprint' globally (~3% of land area).

- Process of urbanization is most often irreversible, modifying carbon, water, energy cycles at various spatial scales.

- Cities as entities can be agents of land cover/use changes at local to regional scales.

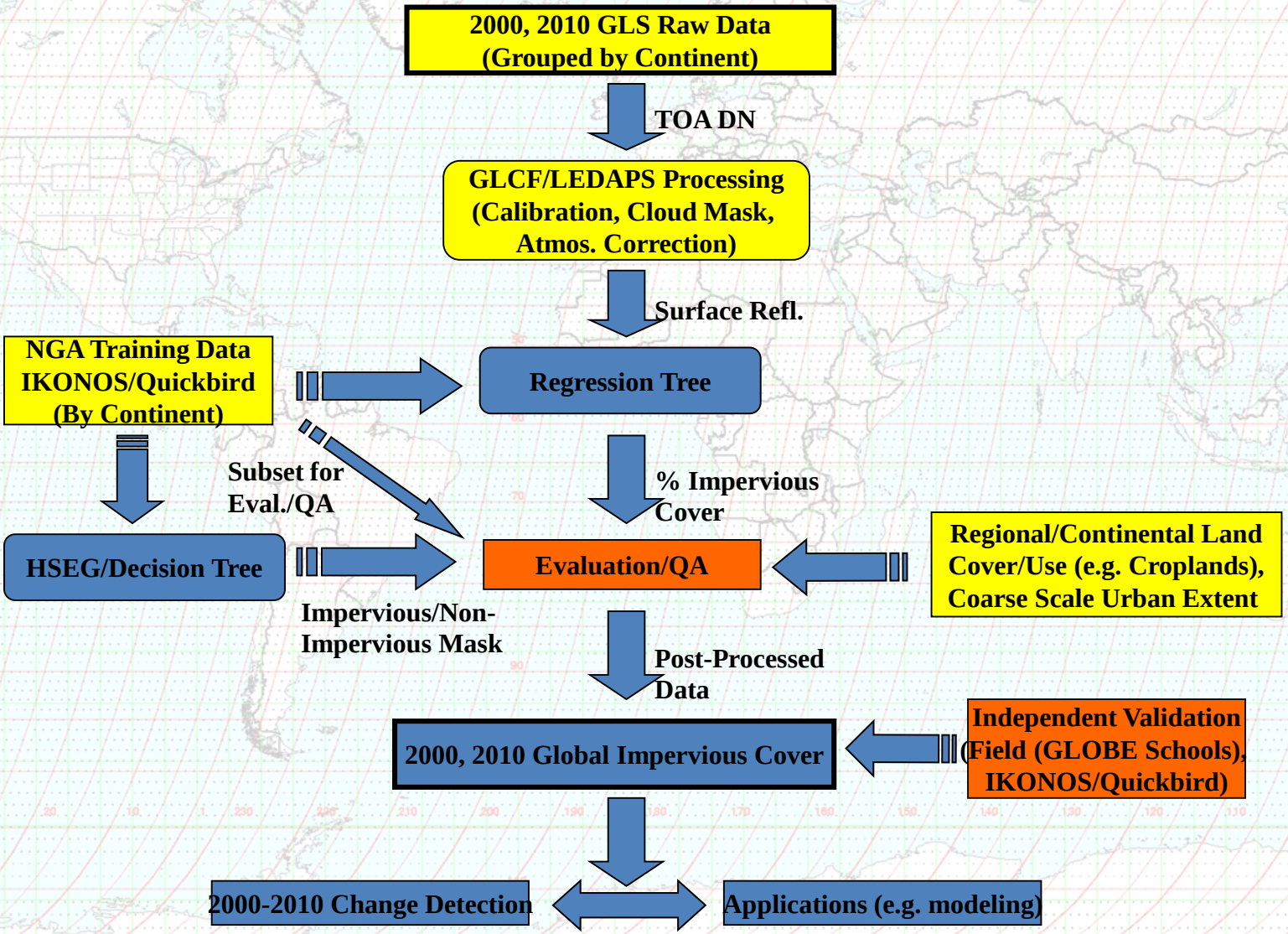
- New data sets from Landsat and NGA provide great opportunity to map and monitor urbanization at the appropriate spatial scale, and with a look to future sensors (i.e. LDCM).

Objectives

- Use the Landsat GLS data set, processed to surface reflectance, to develop high spatial resolution, baseline measurements of global % impervious cover for the 2000 and 2010 time periods.

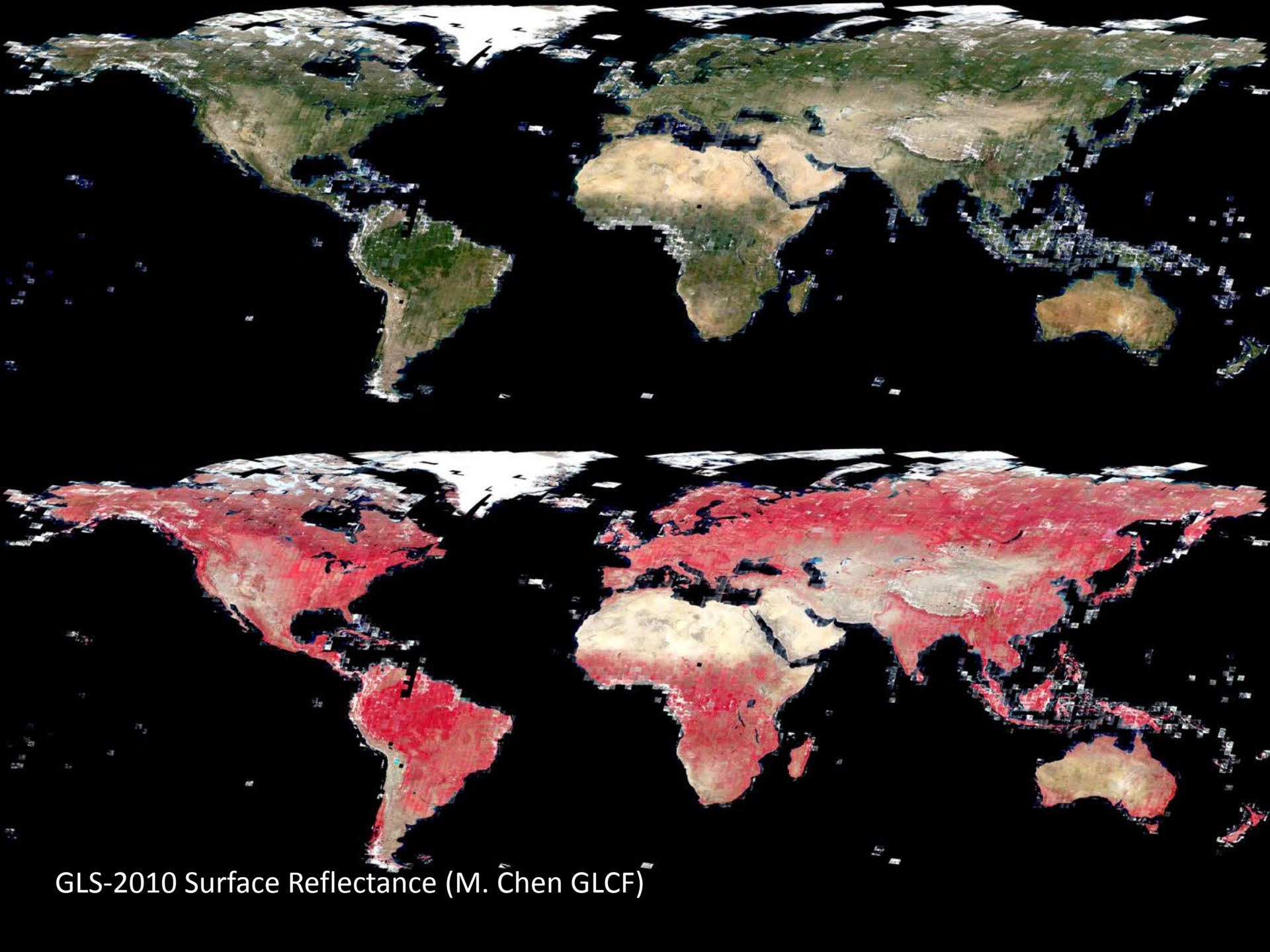
- Compare % impervious cover for 2000 and 2010 to detect and map urbanization ‘hot-spots’ at the global scale.

Approach


2000, 2010 GLS Raw Data (Grouped by Continent)
TOA DN
GLCF/LEDAPS Processing (Calibration, Cloud Mask, Atmos. Correction)
Surface Refl.
NGA Training Data IKONOS/Quickbird (By Continent)
Regression Tree
Subset for Eval./QA
% Impervious Cover
HSEG/Decision Tree
Evaluation/QA
Regional/Continental Land Cover/Use (e.g. Croplands), Coarse Scale Urban Extent
Impervious/Non-Impervious Mask
Post-Processed Data
2000, 2010 Global Impervious Cover
Independent Validation Field (GLOBE Schools), IKONOS/Quickbird)
2000-2010 Change Detection
Applications (e.g. modeling)

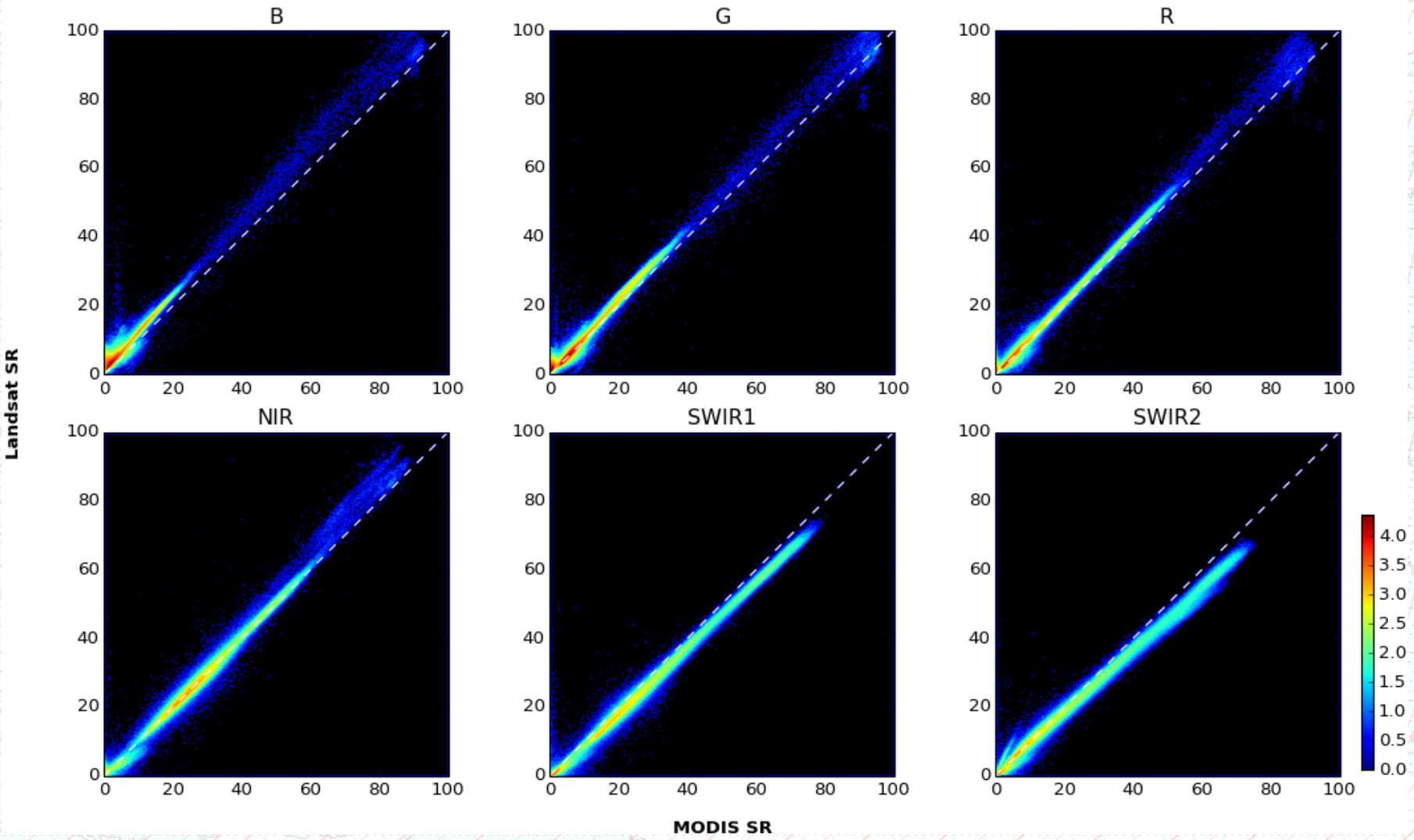
GLS-2010 Surface Reflectance

- GLS 2010 consists of 4734 L5 and 3821 gap-filled L7 images
  - Converted to surface reflectance (SR) products by GLCF
  - L7 SR compared with same day MODIS SR
  - L5 SR compared with MODIS NBAR for the same 16-day period
    - Same day L5 and MODIS images have very different view angles



GLS-2010 Surface Reflectance (M. Chen GLCF)

Same-Day L7-MODIS Comparison



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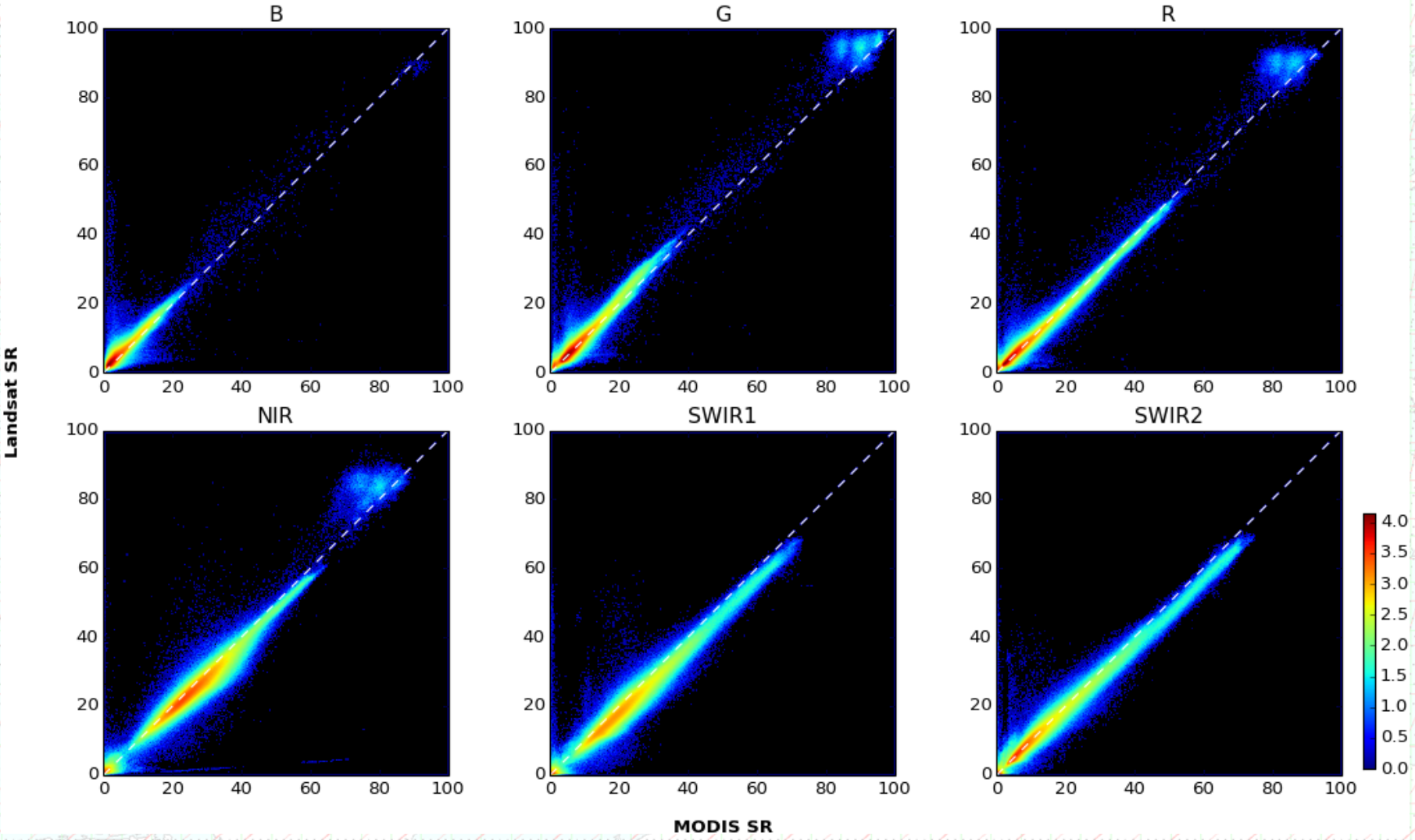
(M Feng, GLCF)

L5-MODIS NBAR Comparison



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(M Feng, GLCF)

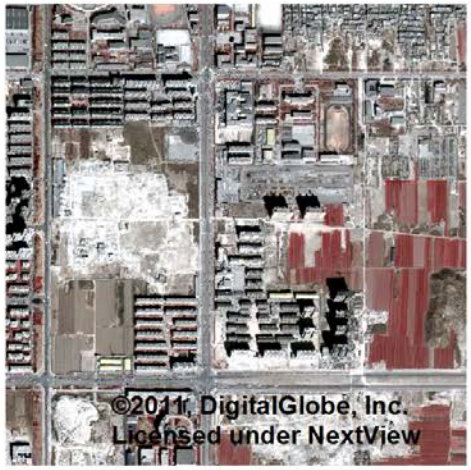
Summary of Landsat-MODIS SR Comparison

- SR products from Landsat and MODIS highly consistent.
- Differences are due to
  - Saturation in Landsat (8bit) but not in MODIS
  - Clouds moving between L7 and MODIS overpass
  - Quality problems in Landsat or MODIS data (rare but exist)

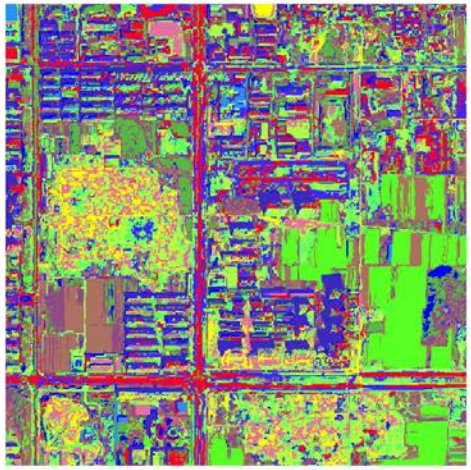
Data Available at ftp://ftp.glcf.umd.edu/glcf/Landsat/stow/GLCF.TSM.AZ-003.00.GLS2010/

Training Data Generation

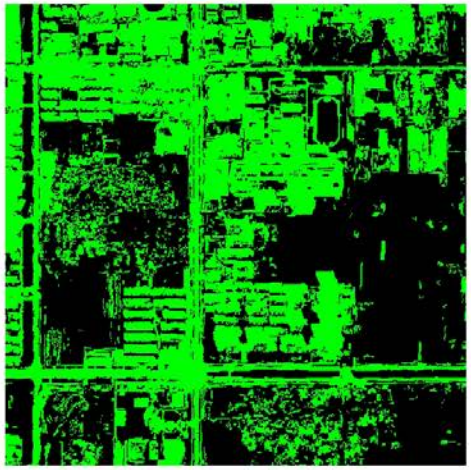
Shijiazhuang, China



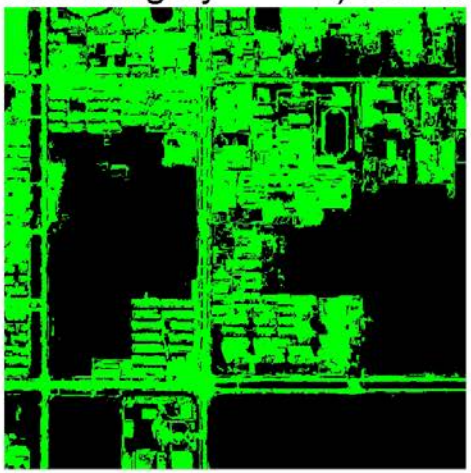
1) Obtain High-Res Imagery



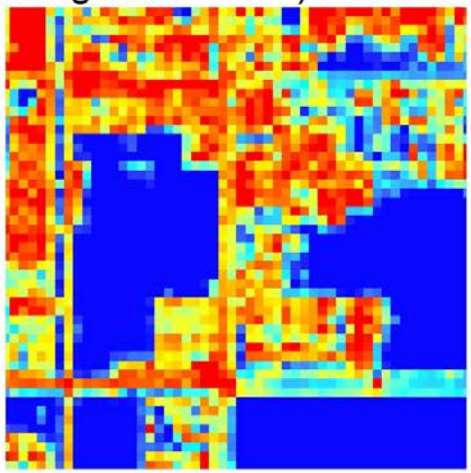
2) Generate HSeg Files



3) Label in HSegLearn



4) Refine in HSegViewer



5) Aggregate to 30m

Labels

- Non-Impervious
- Impervious

Percent Impervious

High : 100

Low : 0

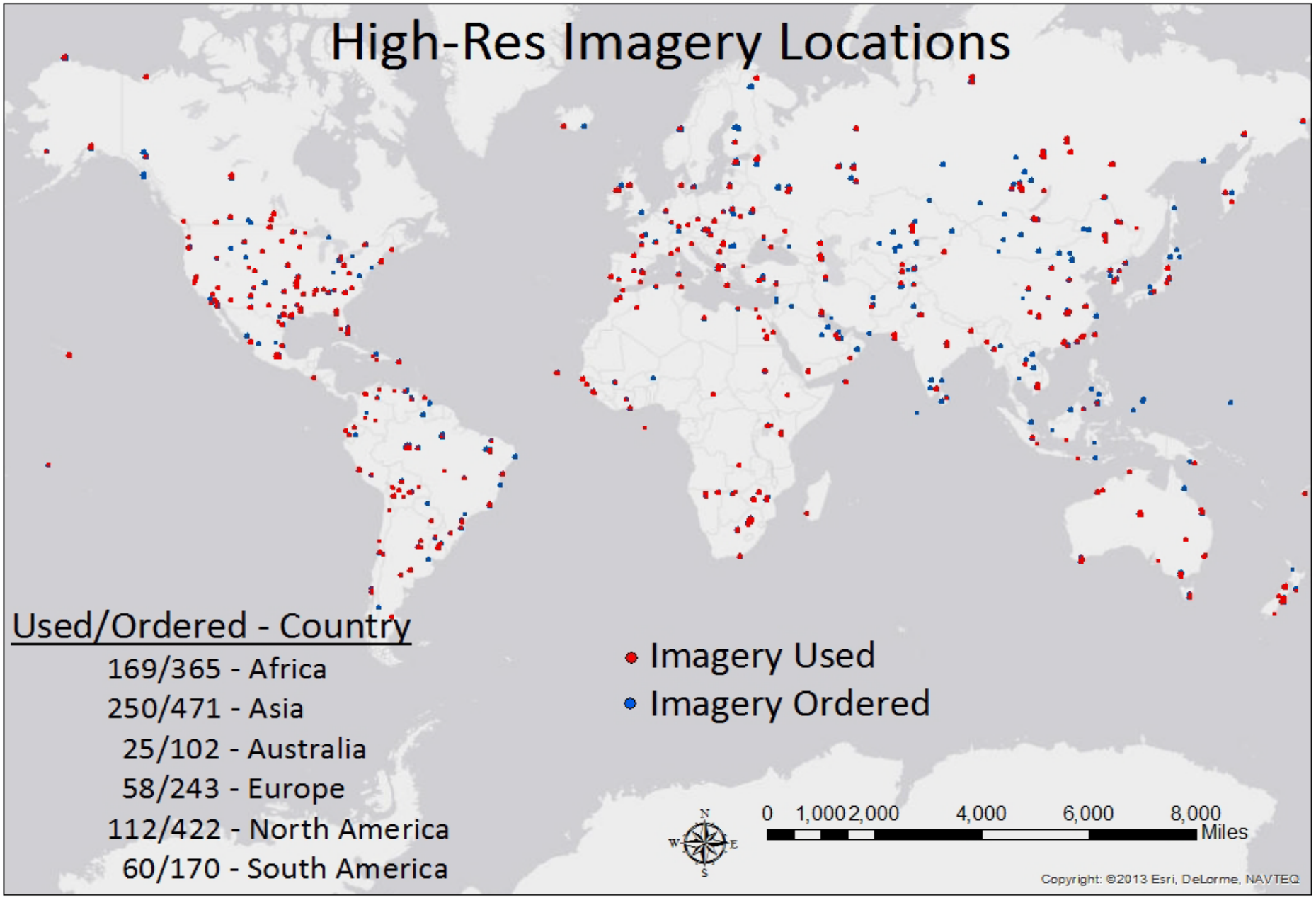
0 0.25 0.5 0.75 1 Miles

For each training pixel:

-Reflectance (Landsat 1-7)

-NDVI

-Tasseled Cap (B, G, W)


High-Res Imagery Locations
Used/Ordered - Country
169/365 - Africa
250/471 - Asia
25/102 - Australia
58/243 - Europe
112/422 - North America
60/170 - South America
Imagery Used
Imagery Ordered
N
W
E
S
0 1,000 2,000 4,000 6,000 8,000
Miles
Copyright: ©2013 Esri, DeLorme, NAVTEQ

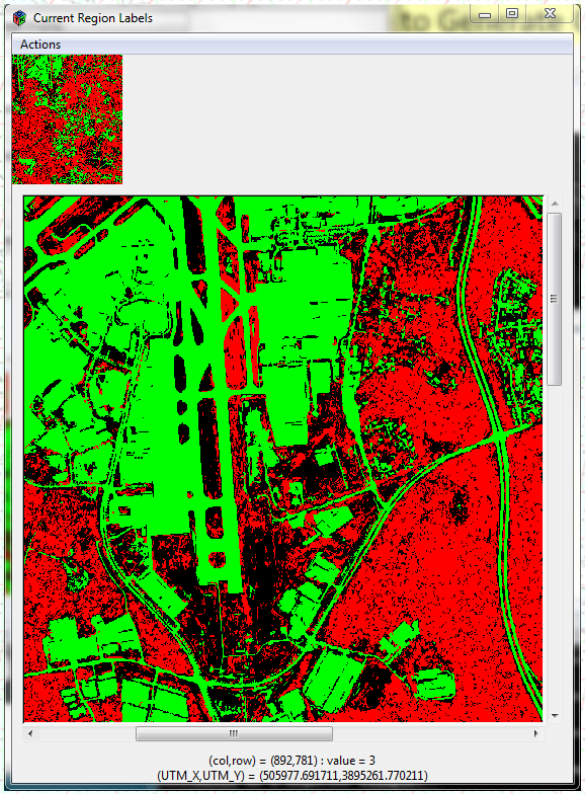
HSegLearn – A Tool for Computer-Assisted Ground Reference Data Development

- We've developed an interactive software tool – HSegLearn – to speed and facilitate the photo-interpretation of high spatial resolution imagery.
- HSegLearn takes as input a hierarchical set of image segmentations such as produced by the HSeg best-merge region growing segmentation program.
- Through HSegLearn, an analyst specifies a selected set of positive and negative examples of impervious land cover.
- HSegLearn searches the hierarchical set of segmentations for the coarsest level of segmentation at which the selected positive examples do not conflict with negative example locations and labels the image accordingly.

HSegLearn Example

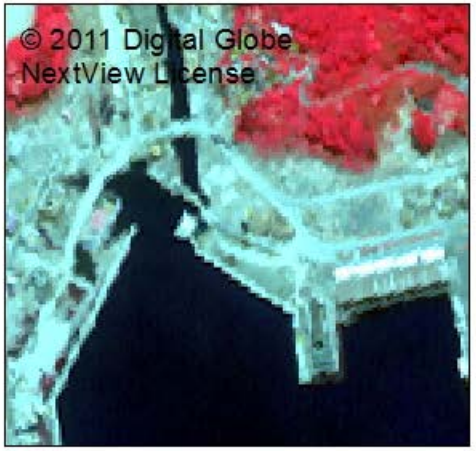
The HSegLearn RGB Image Panel displaying a subsection of a WorldView2 image in the vicinity of the Charlotte, NC International Airport.

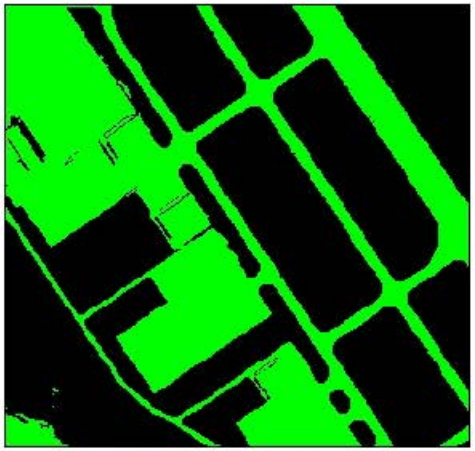
The HSegLearn Current Region Labels Panel after the analyst selected some positive example region objects (yellow) and some negative example objects (white).

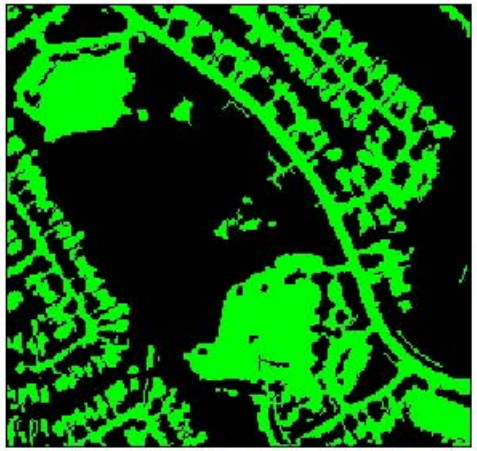


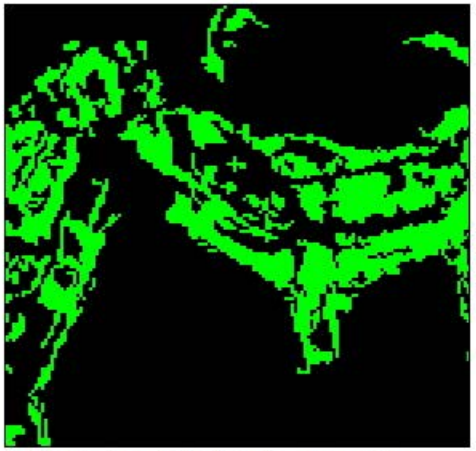
The HSegLearn Current Region Labels Panel after the analyst submitted the positive and negative example region objects for processing. The positive example regions are colored green and negative example regions are colored red. Note the generalization of the positive example regions.

Training Data Examples and QA







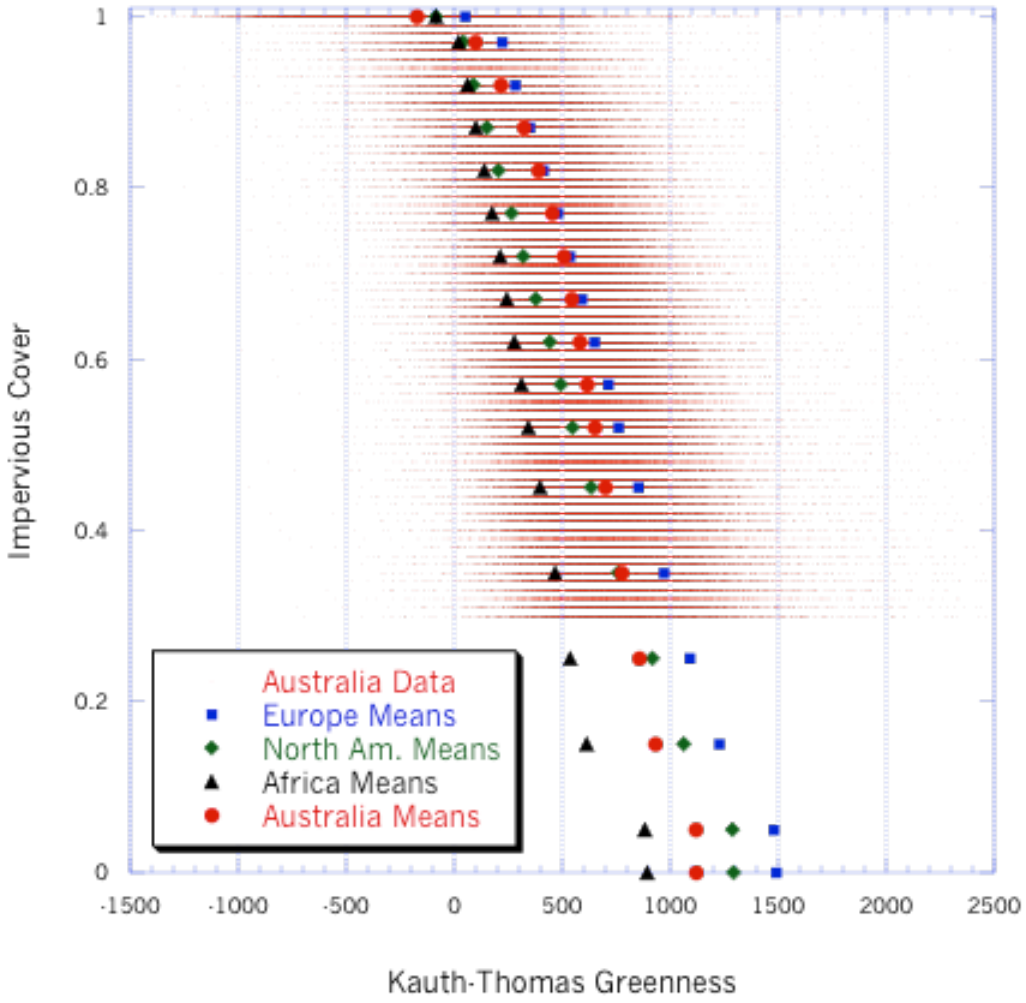


St Paul, MN
Rating 1 – High

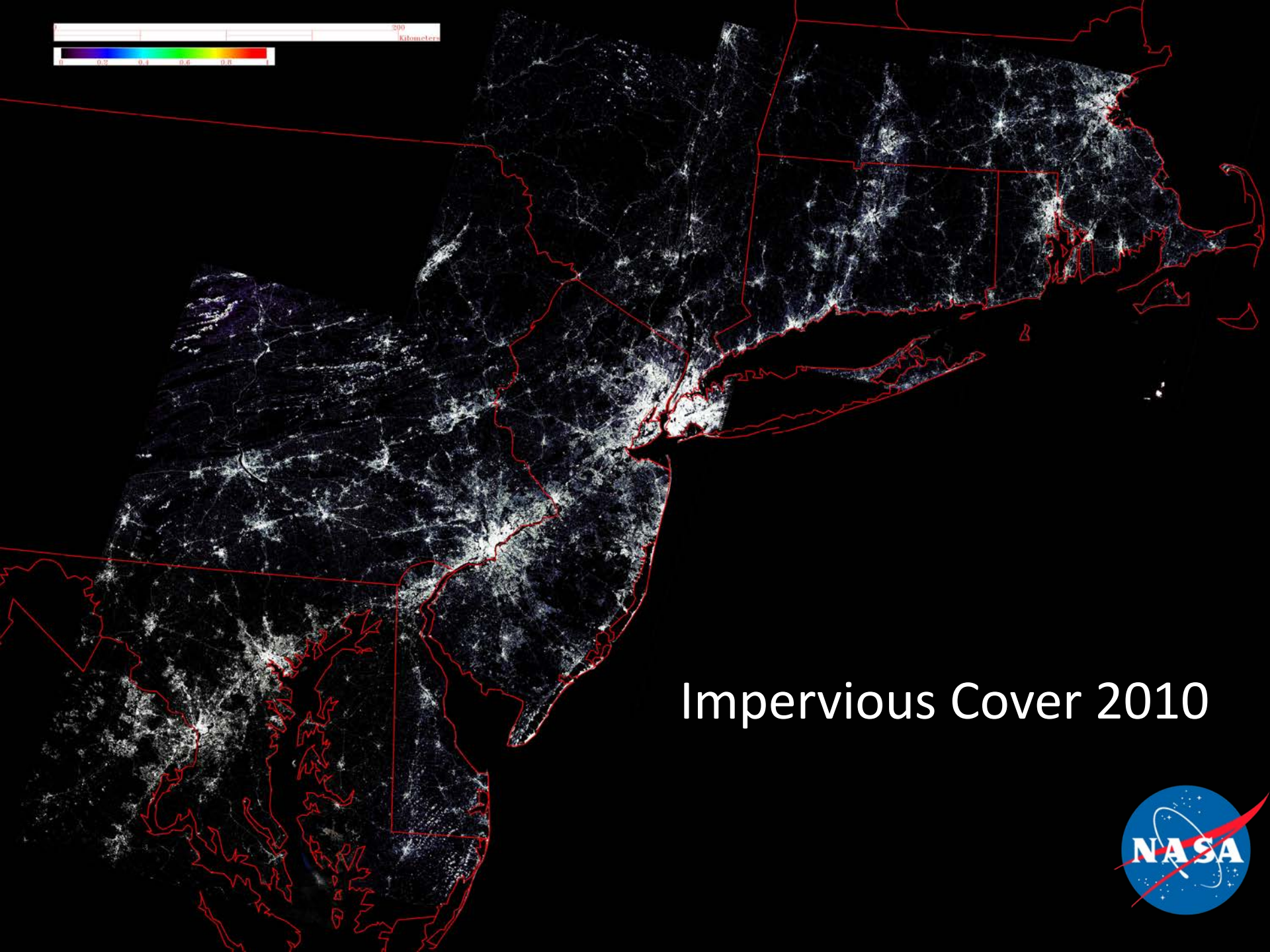
Sarsfield, Canada
Rating 2 – Moderate

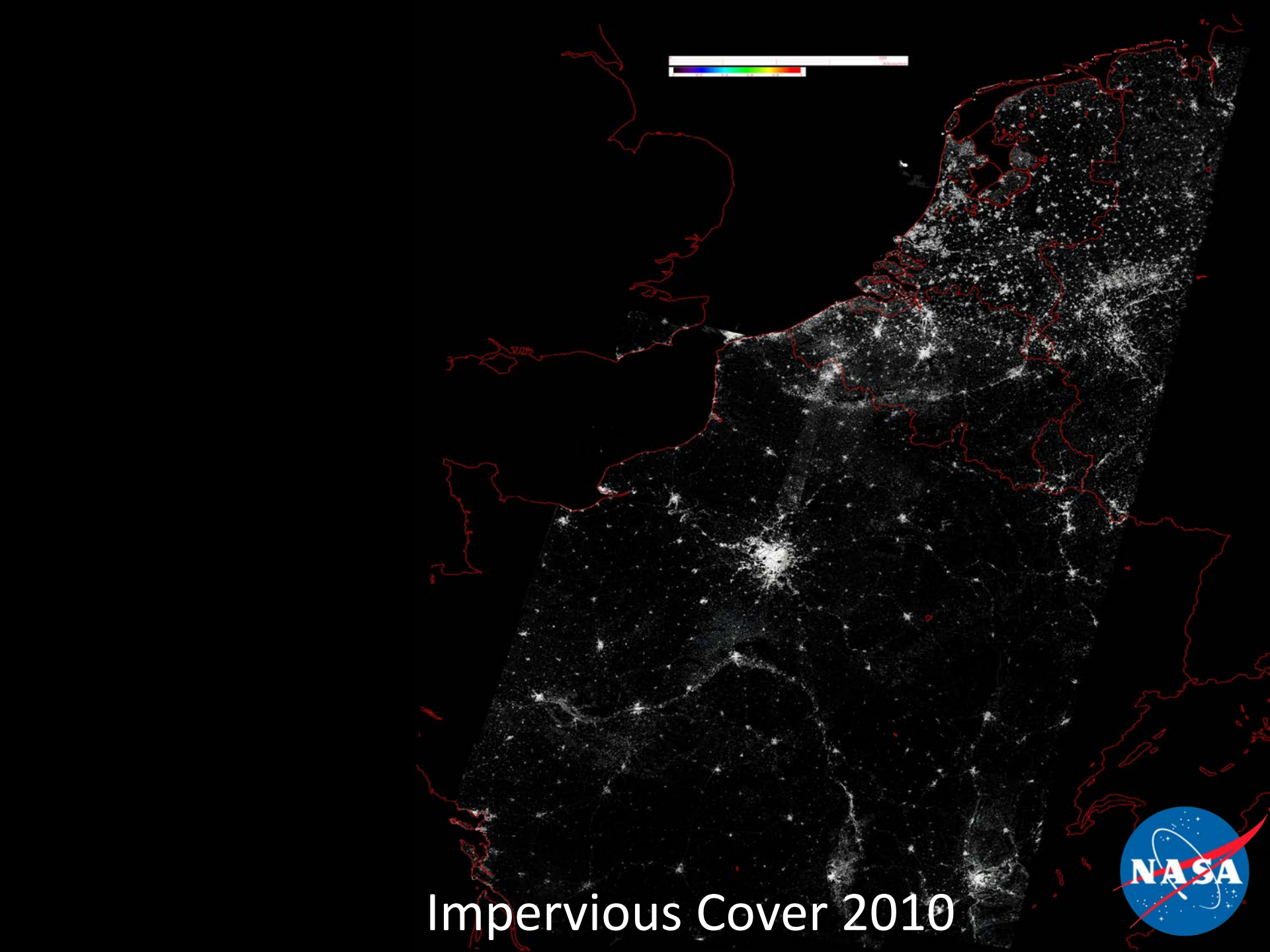
Oshika District, Japan
Rating 3 - Low

Continental Training Data

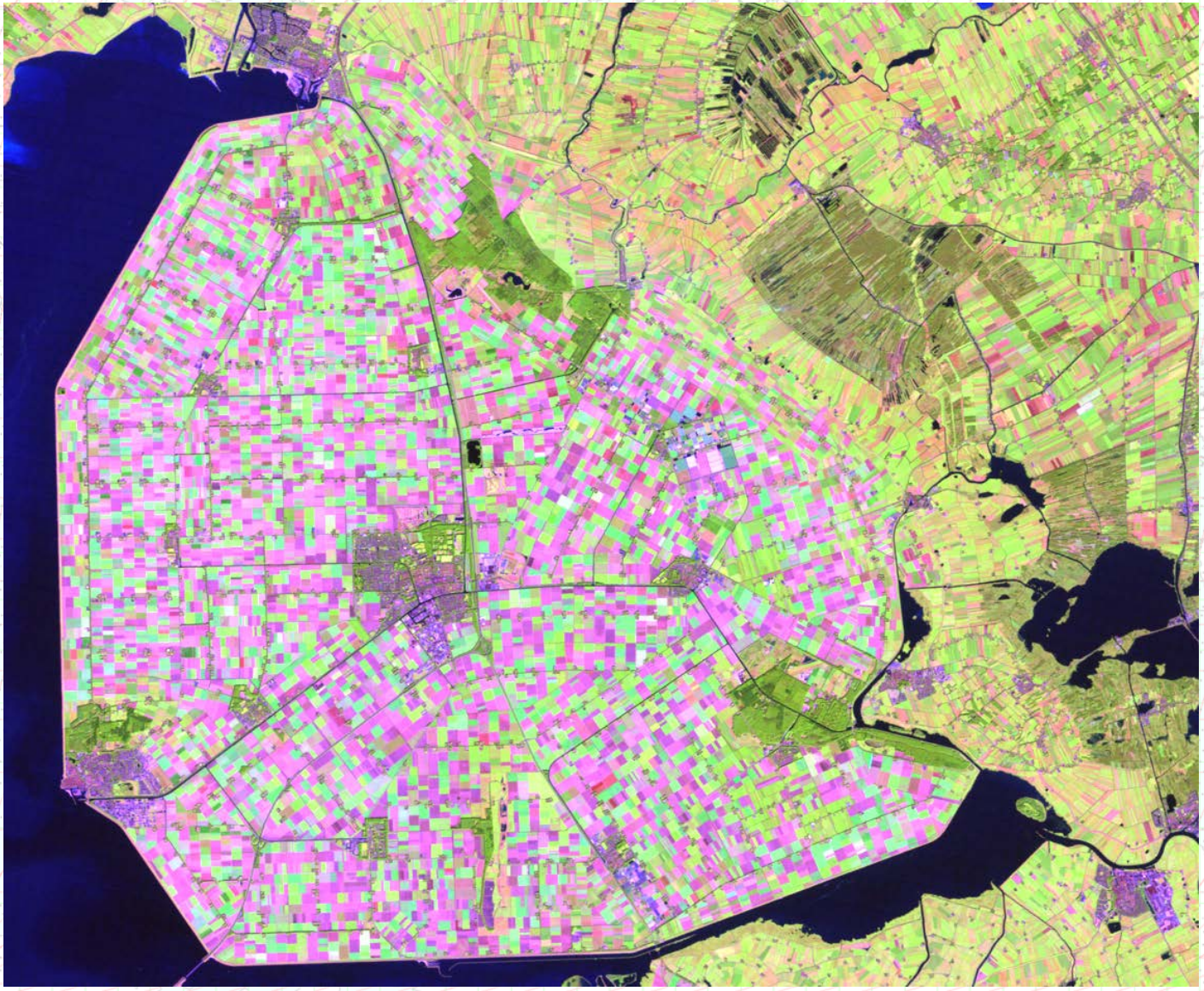


Continent	Training Pixels
Europe	2,816,916
North America	5,099,105
South America	3,571,483
Africa	3,603,191
Asia	9,505,845
Australia/Oceana	1,694,548
Total	26,291,088

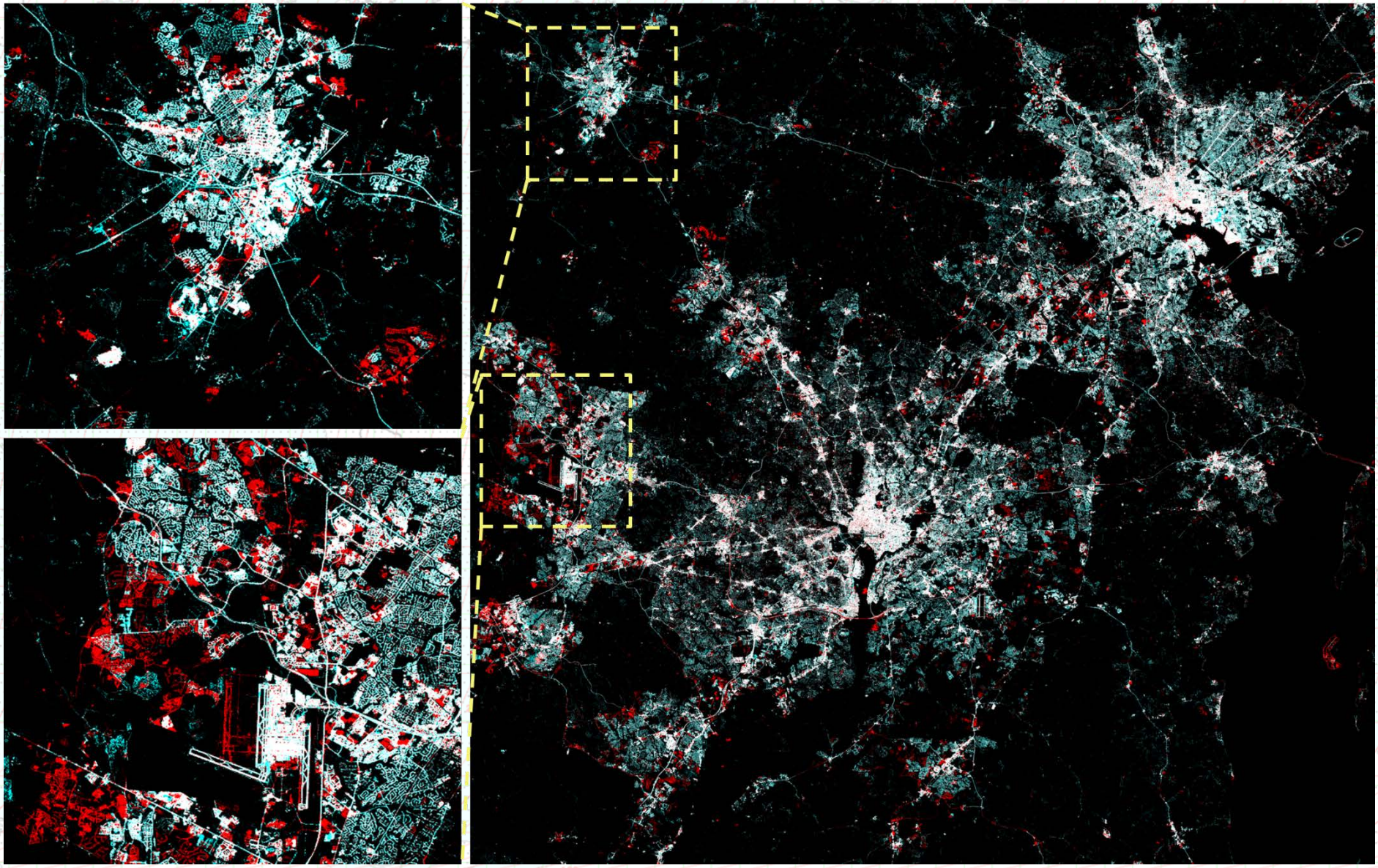

200
Kilometers
0
0.2
0.4
0.6
0.8
1
Impervious Cover 2010


Impervious Cover 2010

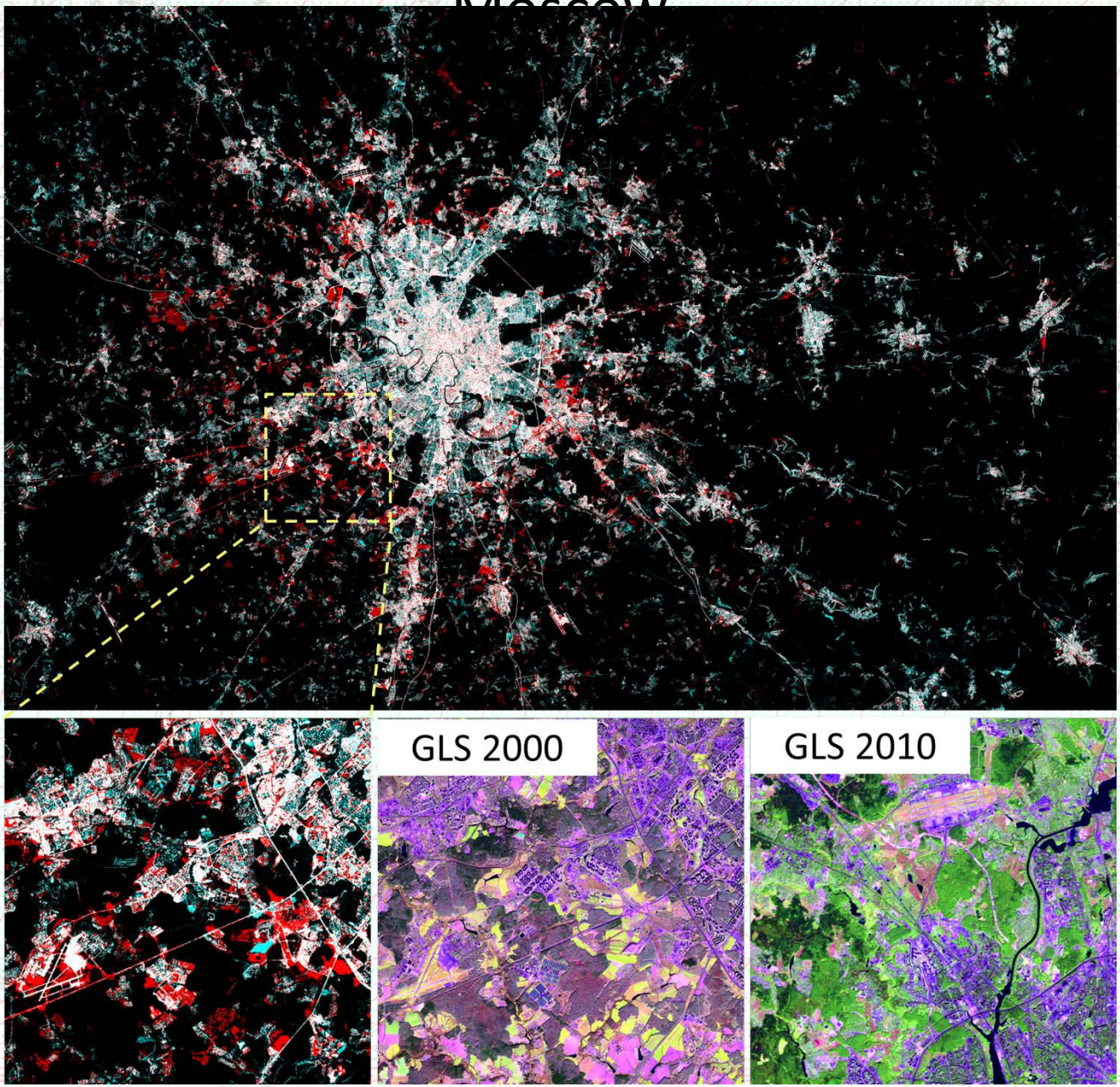
The Devil is in the Details!



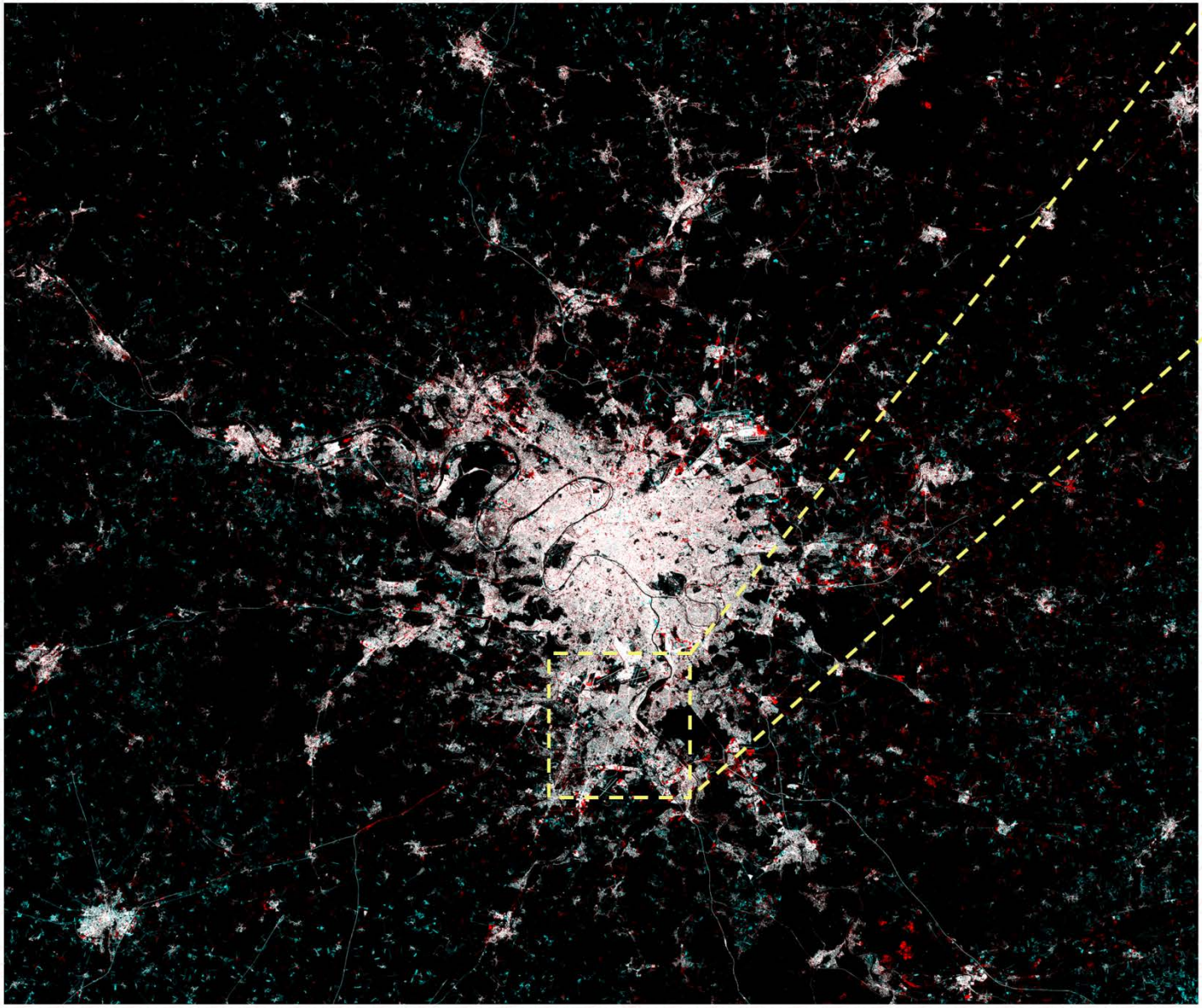
Urban Impervious Change (2000-2010) Around Baltimore-Washington Corridor

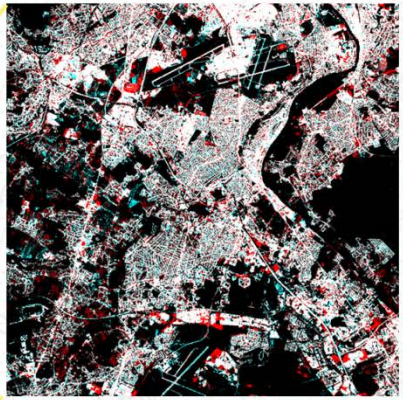


Urban Impervious Change (2000-2010) Around Moscow

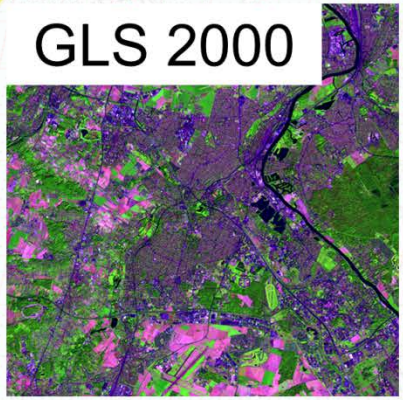


Urban Impervious Change (2000-2010) Around Paris

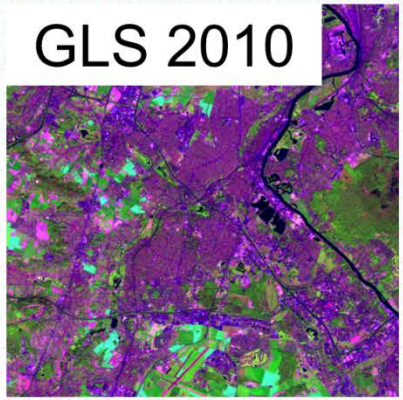




GLS 2000



GLS 2010



Next Steps

- RT has been applied on all continents except Asia.
- We are working on refining cloud/water masks.
- Using high-end NASA computing resources to apply Hseg at global scale.
- Testing methods for data training refinement, enhancement.
- Develop coarse-scale urban mask from best available sources and GIS.
- Complete 2000-2010 impervious comparison.
- Release products Fall 2014

THANK YOU!