Earth Science Data Records (ESDR) of Global Forest Cover Change

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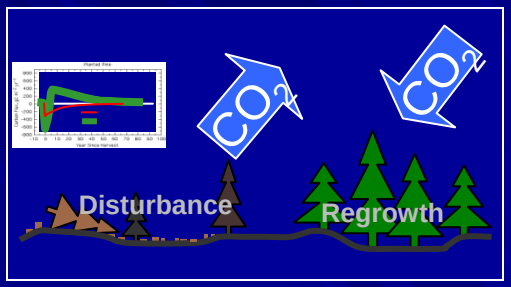
Project Background

- Funded primarily through NASA's MEASURES program
  - Significant LCLUC funding
- Multi-institute collaboration
  - University of Maryland
    - John Townshend (PI)
    - Chengquan Huang, Saurabh Channan, Joe Sexton, Raghuram Narasimhan, Min Feng, Kuan Song, Xiaopeng Song, DoHyung Kim, Danxia Song, Paul Davis, Sam Goward, et al.
  - NASA/GSFC and contractors
    - Jeff Masek, Robert Wolfe, Eric Vermote,
    - Feng Gao, Bin Tan, Greg Ederer, Jim Tucker, et al.
  - South Dakota State University
    - Matt Hansen, Peter Potapov

Primary Goals

- Develop global FCC products to support
  - Modeling
    - Climate
    - Carbon: REDD
    - Hydrology
  - Biodiversity and conservation
- Demonstrate routine global FCC monitoring capability



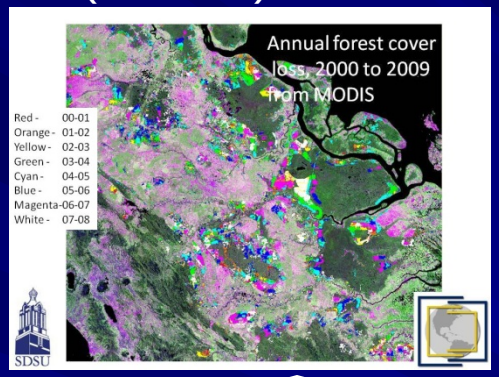
GOFC-GOLD GLOBAL OBSERVATION OF FOREST AND LAND COVER DYNAMICS

US Global Change Research Program
www.usgcrp.gov

GCOS Global Climate Observing System
Ensuring the Availability of Global Observations for Climate

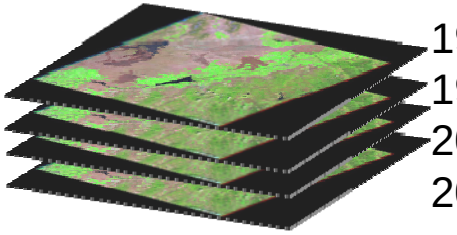
Deliverables

Forest cover change (MODIS) ESDR

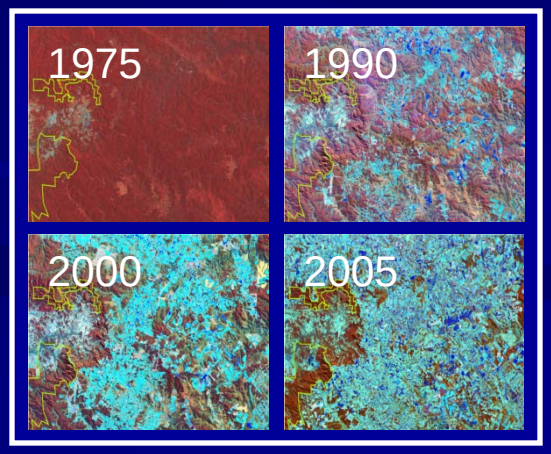


MODIS VCF (2000-2005)

"Global" Land Survey (GLS)

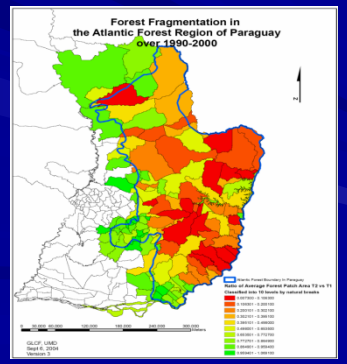


Landsat-MODIS consistency



Surface reflectance ESDR

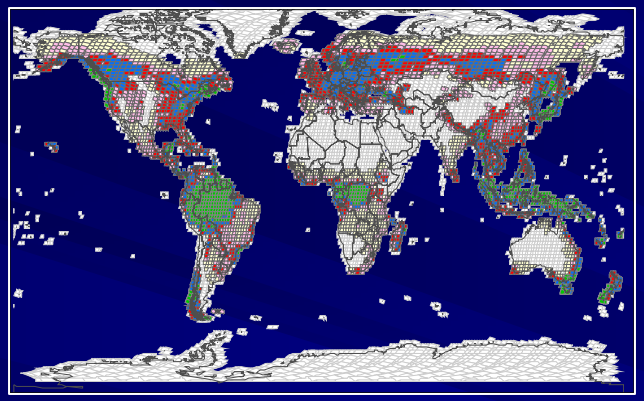
Forest cover change (Landsat) ESDR

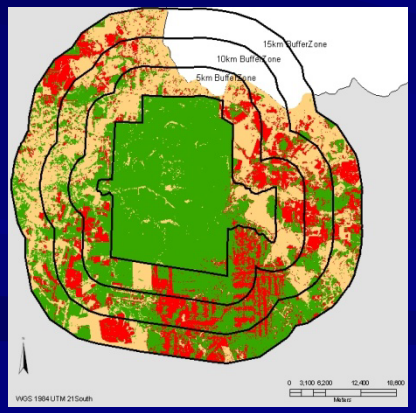


Fragmentation & change ESDR

Subsets and Aggregation

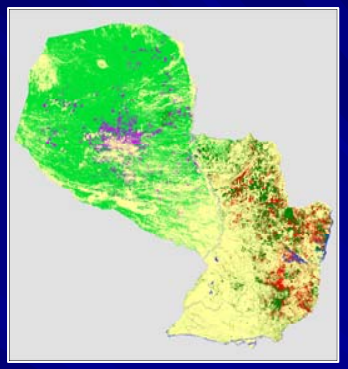
Global Products





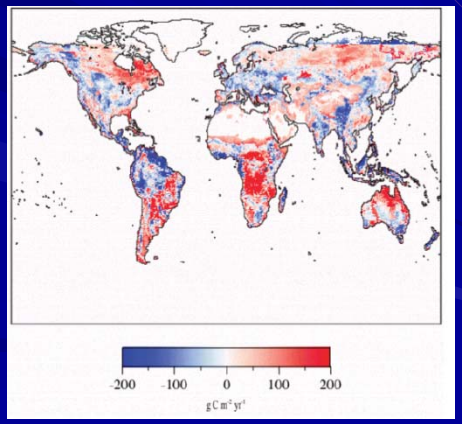
Complete subset for all WDPA protected areas

Landsat/MODIS resolution



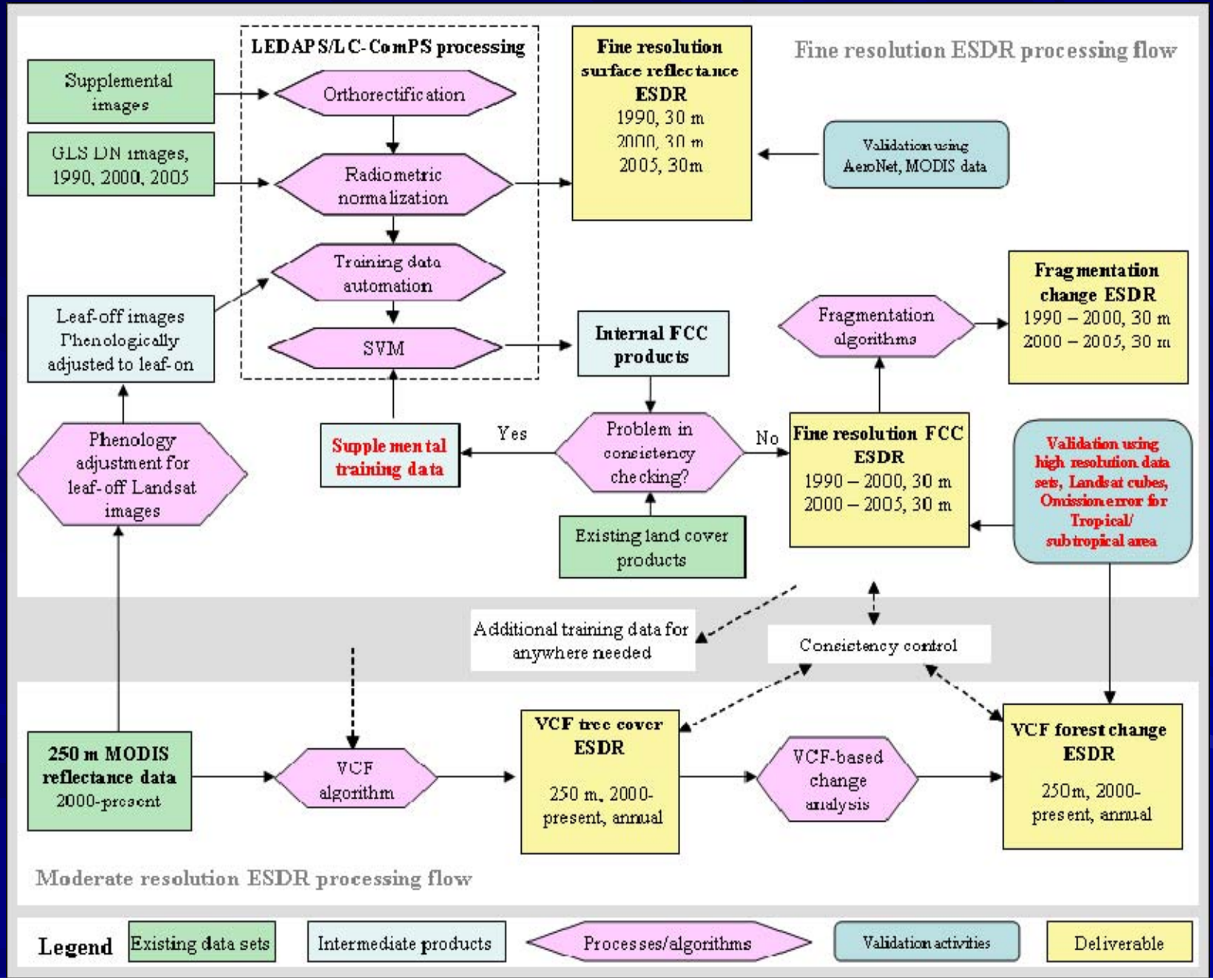
Aggregation

250 m – 5 km (MODIS-AVHRR)



5 km – 1 degree (model grids)

GFCC-ESDR Processing Flow

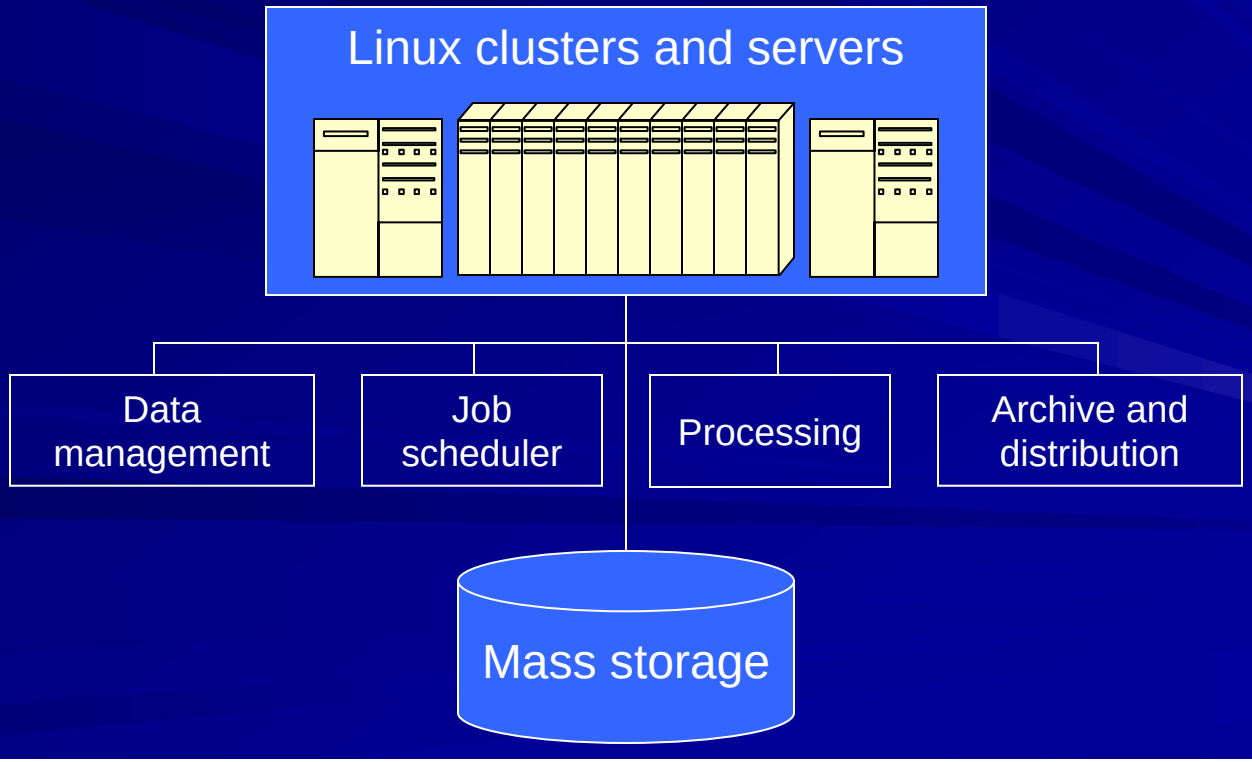


Key Requirements of the Approach

- Mass processing capability
  - ~9000 images x 4 epochs
- Radiometric adjustment/atmospheric correction
  - Geometry mostly satisfactory
- Automated change mapping
- Consistency and quality checking

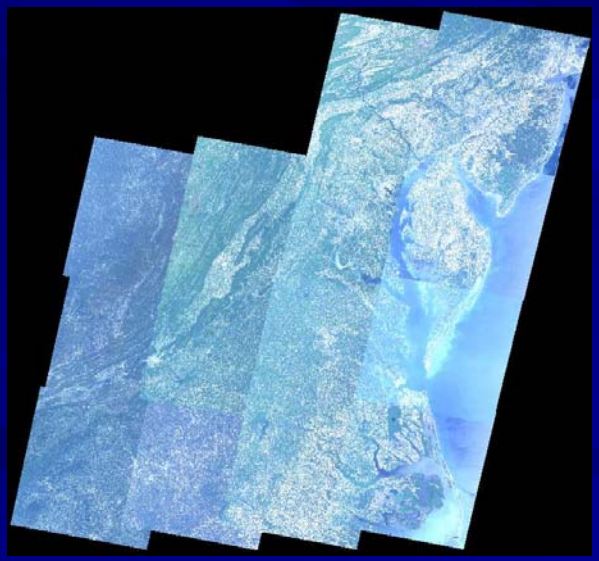
Mass Processing Capability

- LEDAPS (Landsat Ecosystem Disturbance Adaptive Processing System)
  - An adaption of MODAPS by NASA/GSFC (Masek)
  - Have been used to process a few thousands Landsat images
  - UMD enhancement
    - **~9,000 Landsat images x 4 epochs (10 times more than can be handled by current LEDAPS)**



Atmospheric Adjustment

- Based on the MODIS 6S approach (Masek et al. 2006)
  - Fully automated
  - Validated at many locations



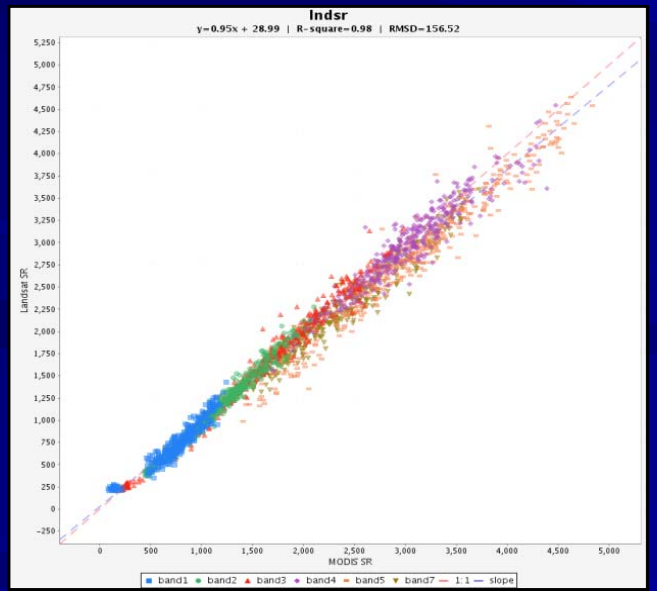
Before adjustment

After adjustment

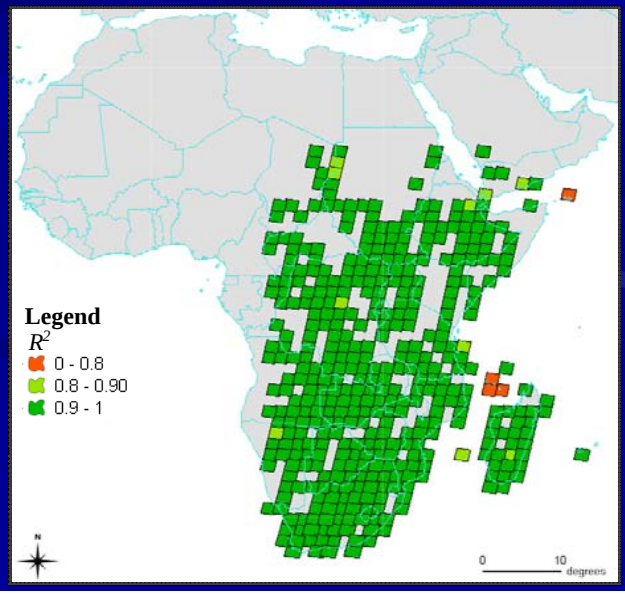
Landsat SR Mosaic for North America

Landsat-MODIS SR Comparison

- Every Landsat SR checked against MODIS SR
  - MODIS SR validated extensively
  - Landsat 7 SR ≈ MODIS SR (daily)
    - Same acquisition date, ~30 minutes apart (Landsat 7 images)
    - Aggregate Landsat to MODIS resolution
    - Use samples from homogeneous areas
  - Fully automated, will be applied to all Landsat 7 images
- Landsat 5 SR ≈ MODIS SR (NBAR)

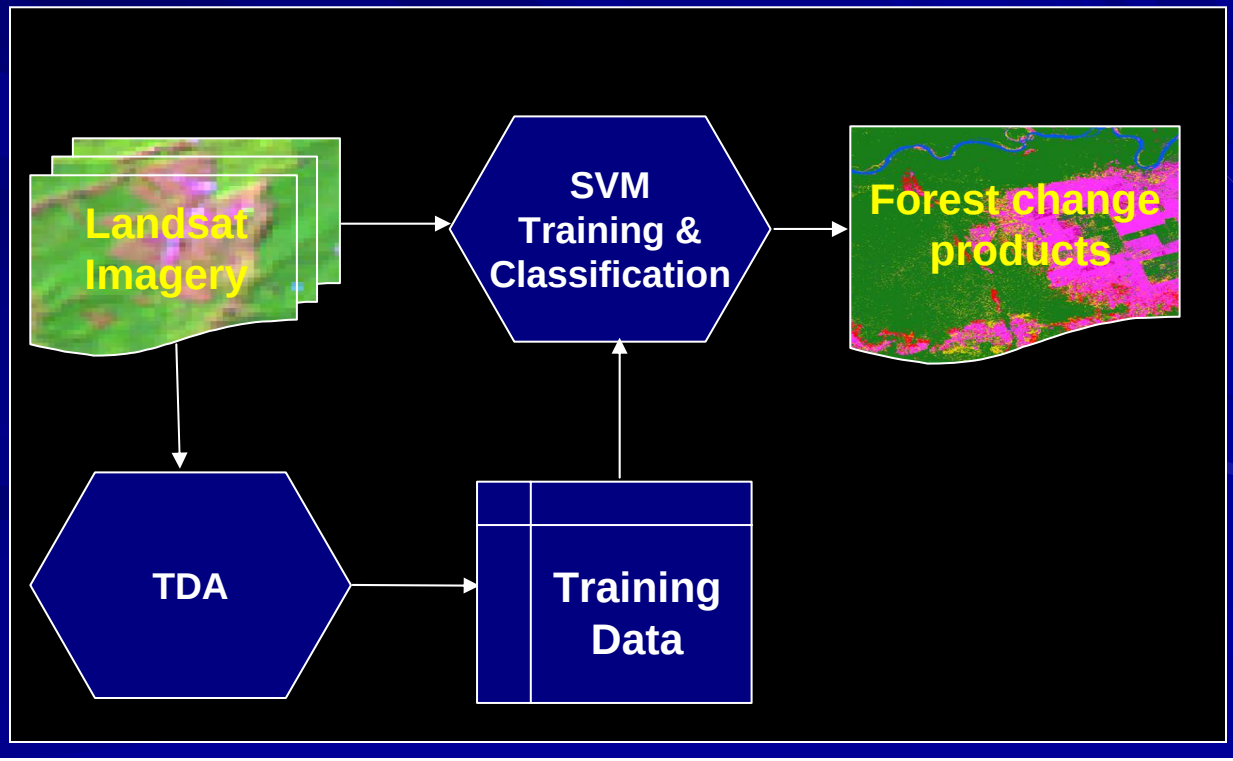


R square
RMSD



Automated Forest Change Mapping Method

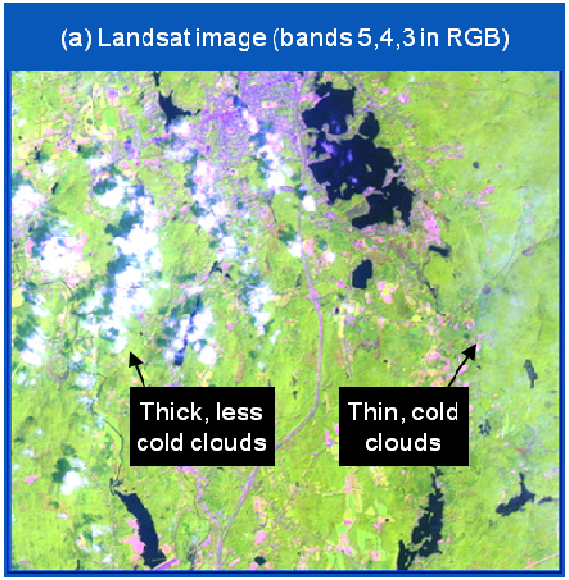
- SVM (support vector machines) more accurate than other classifiers (Huang et al., 2002; Pal & Mather, 2005, and others)
- Automation possible by TDA (training data automation) (Huang et al., 2008)

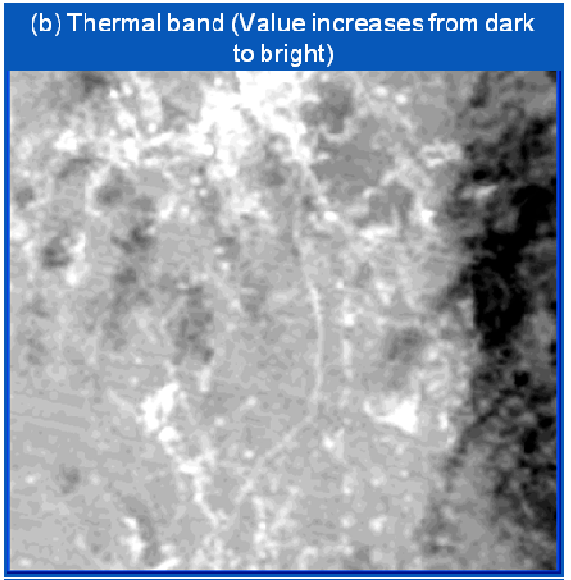


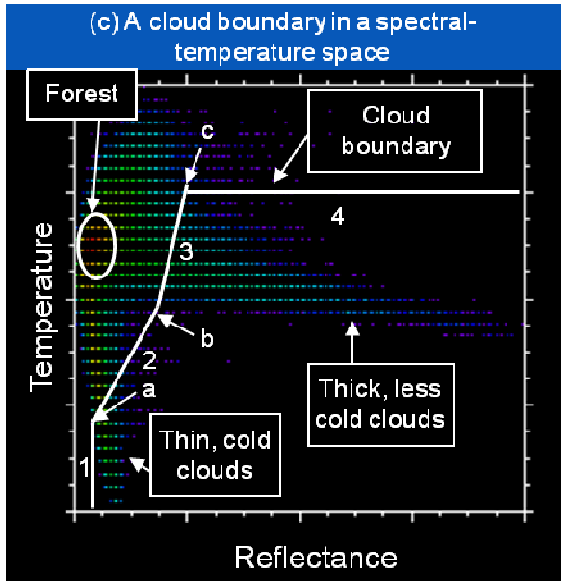
Cloud and Shadow Masking

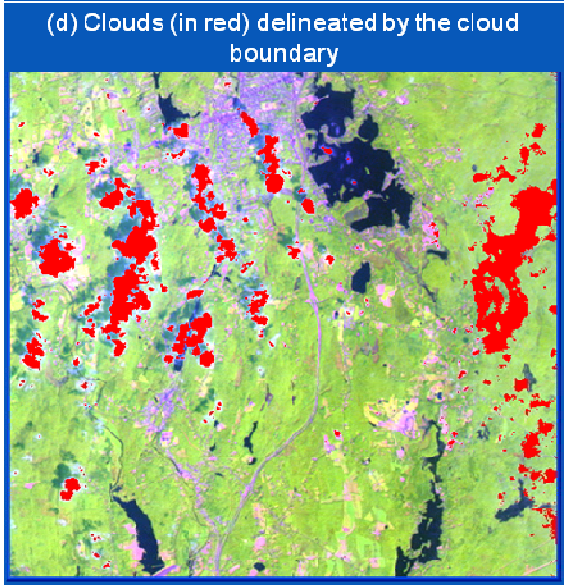
Fig. 1. Use of a cloud boundary in a spectral-temperature space to delineate cloud pixels. In the spectral-temperature space shown in (c), the color of each dot indicates the number of pixels plotted at that point, which increases from purple to blue, green, yellow, and red. The cloud boundary consists three segments, which are labeled from 1 to 3, and are defined and joined by points a, and b. See section 2.4 on discussions of the cloud boundary.

(Huang et al., in press)

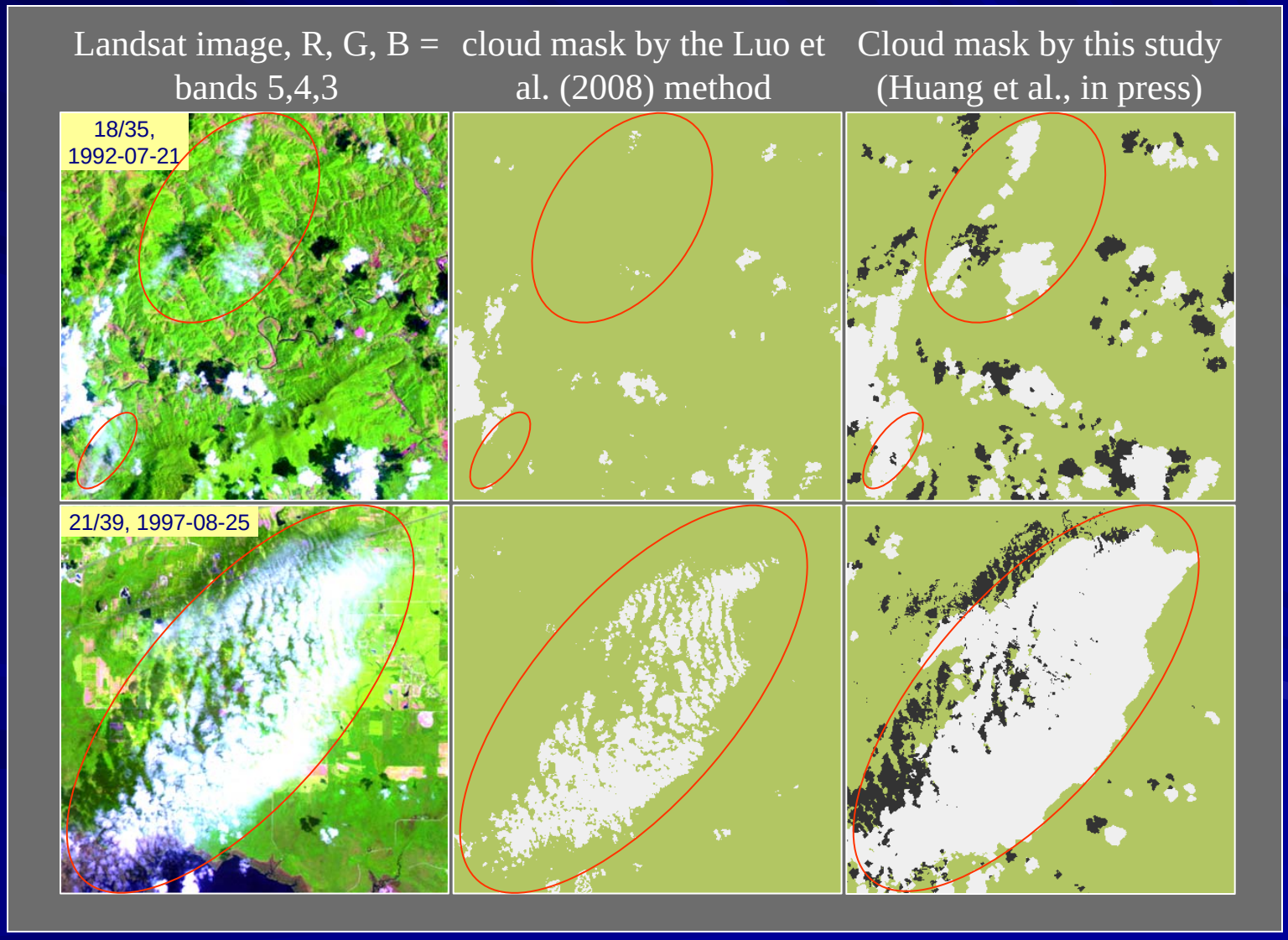








Cloud and Shadow Masking



FCC Products Assessment

- Comparison with existing land cover products
  - Global & regional products
    - Rule out gross errors
  - NAFD dense time series change products
    - Highly reliable
    - Accuracy estimates
- Design-based accuracy assessment

Use Existing LC Products to Rule Out Gross Errors

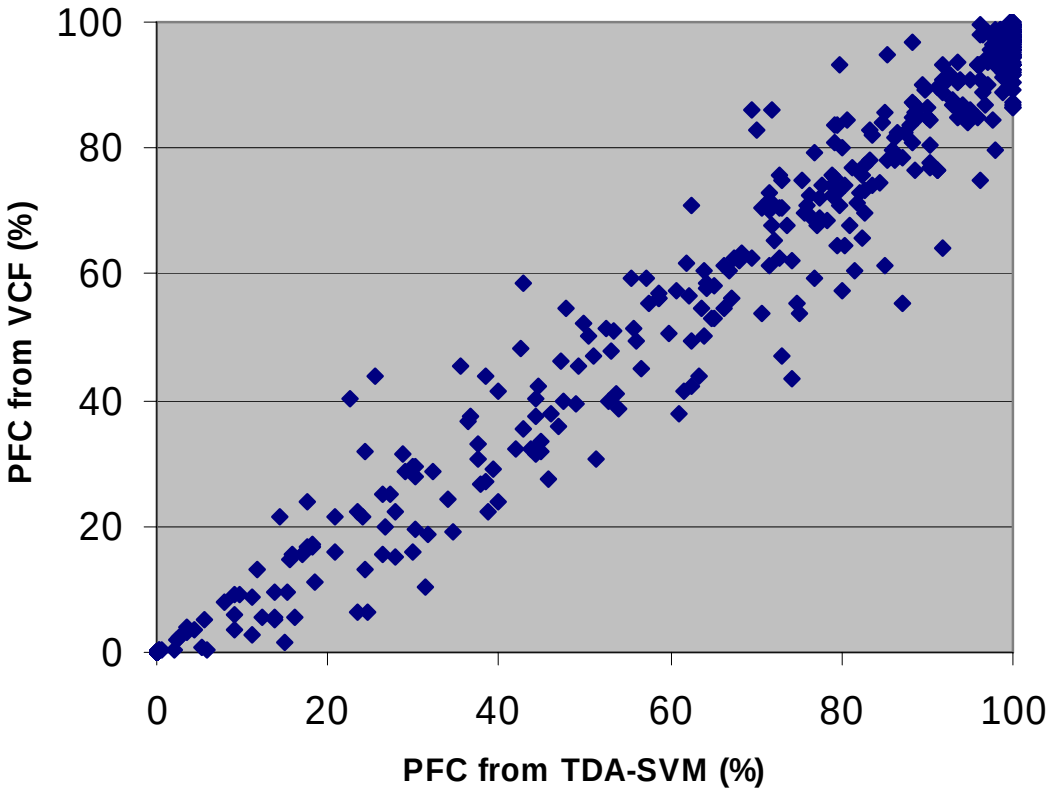
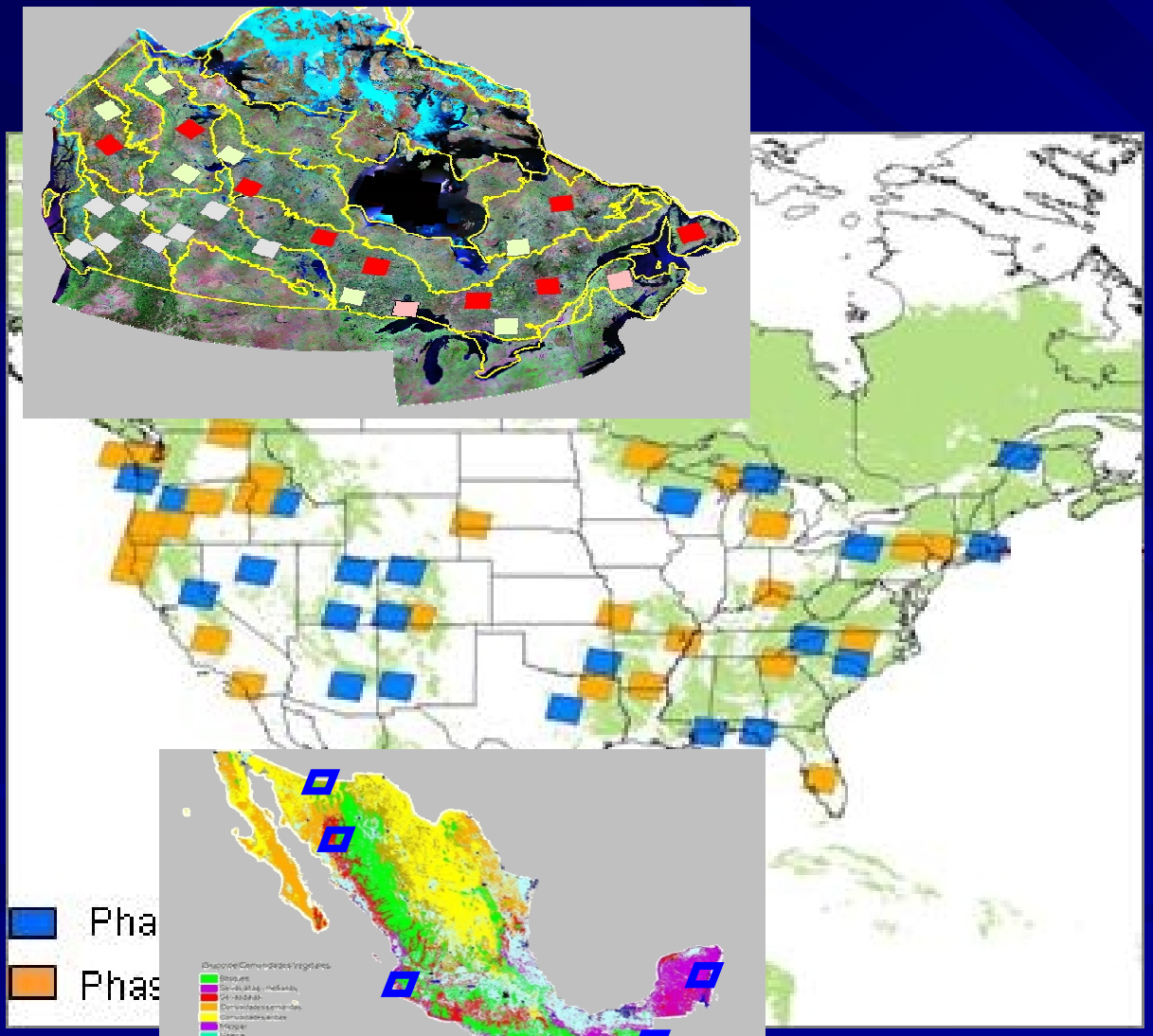


Figure 5. Percent forest cover (PFC) within 10 km grid cells for the 2000 epoch calculated using a TDA-SVM derived FCC product and the MODIS VCF tree cover product. The near 1:1 relationship between the two sets of PCF values is an indicator of the high quality of the TDA-SVM derived FCC product.

Dense Time Series FCC Products



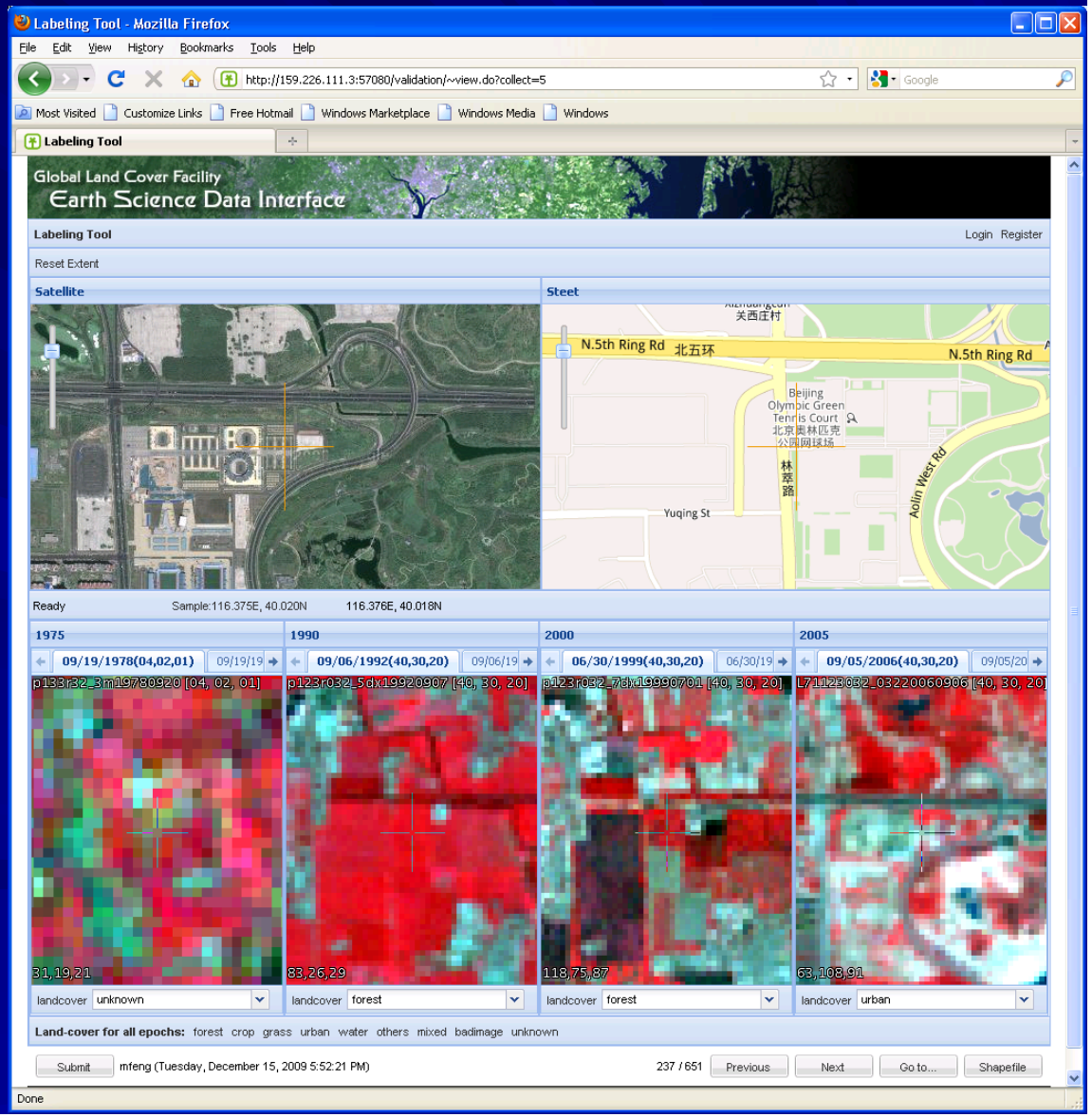
State level:

Utah, Mississippi, Alabama, Maryland, North Carolina

LVIS acquisition sites

Accuracy Assessment

Random Sample (known inclusion probability)

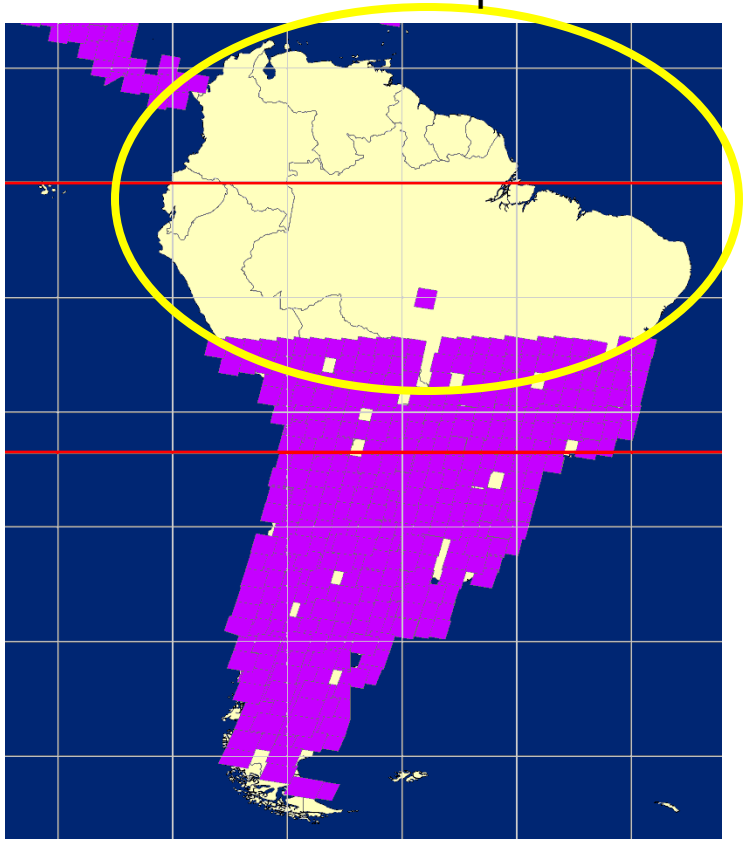


Summary

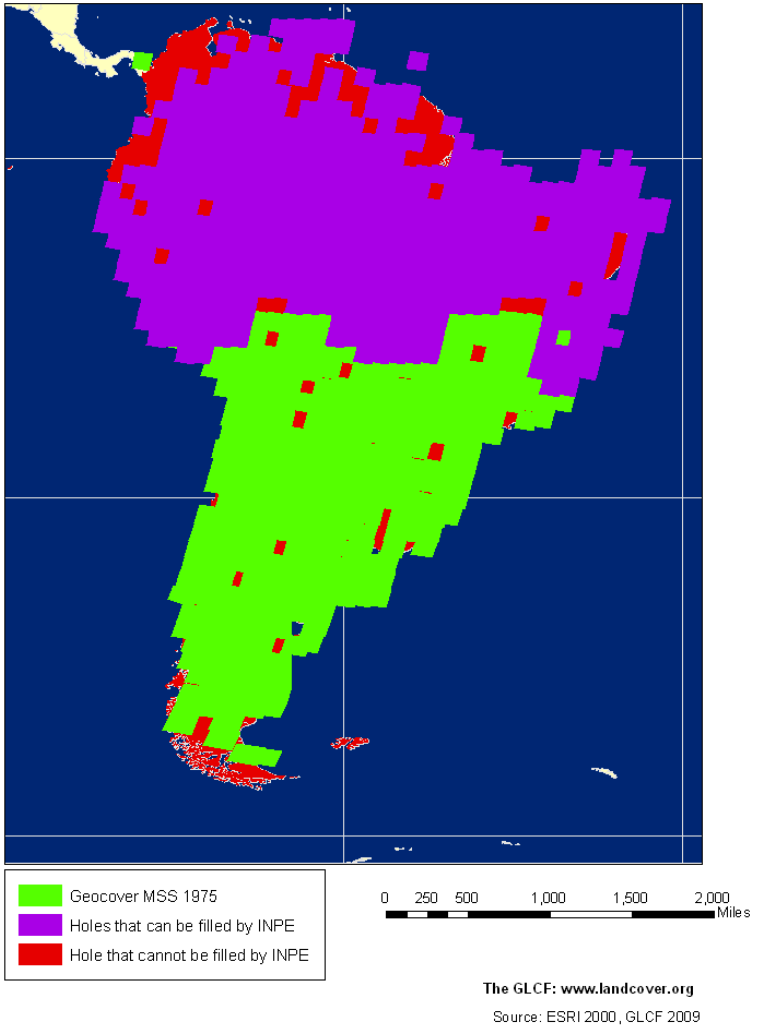
- Producing global forest cover change products will be achieved through
  - Fully automated algorithms
  - Systematic quality checking/verification
  - Mass processing capability
- Issues with the GLS Data Sets
  - Major data holes
  - Difficulty to calibrate the 1990 data set

A Major Data Hole in the GLS 1975

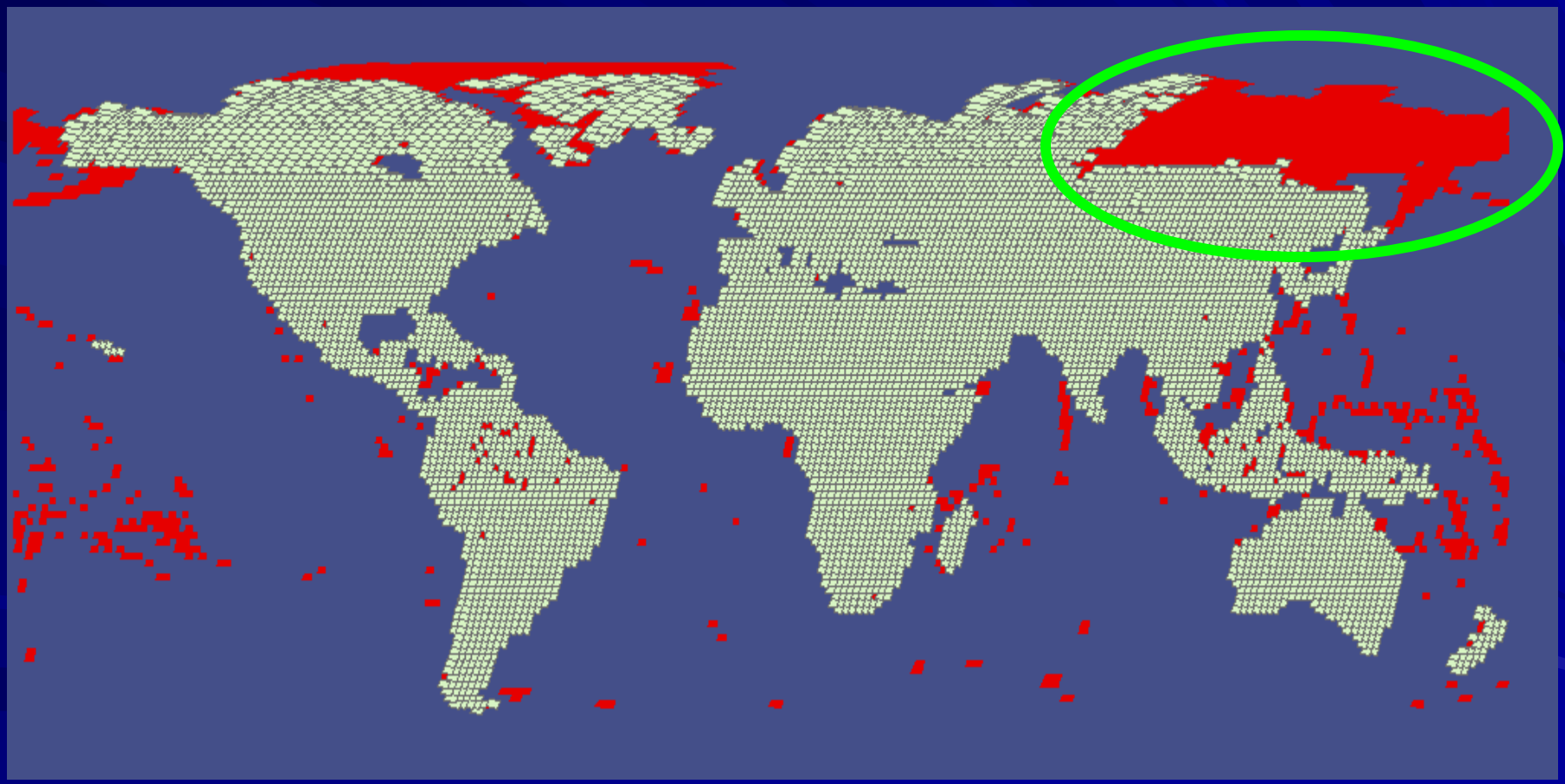
No data for the north part of SA



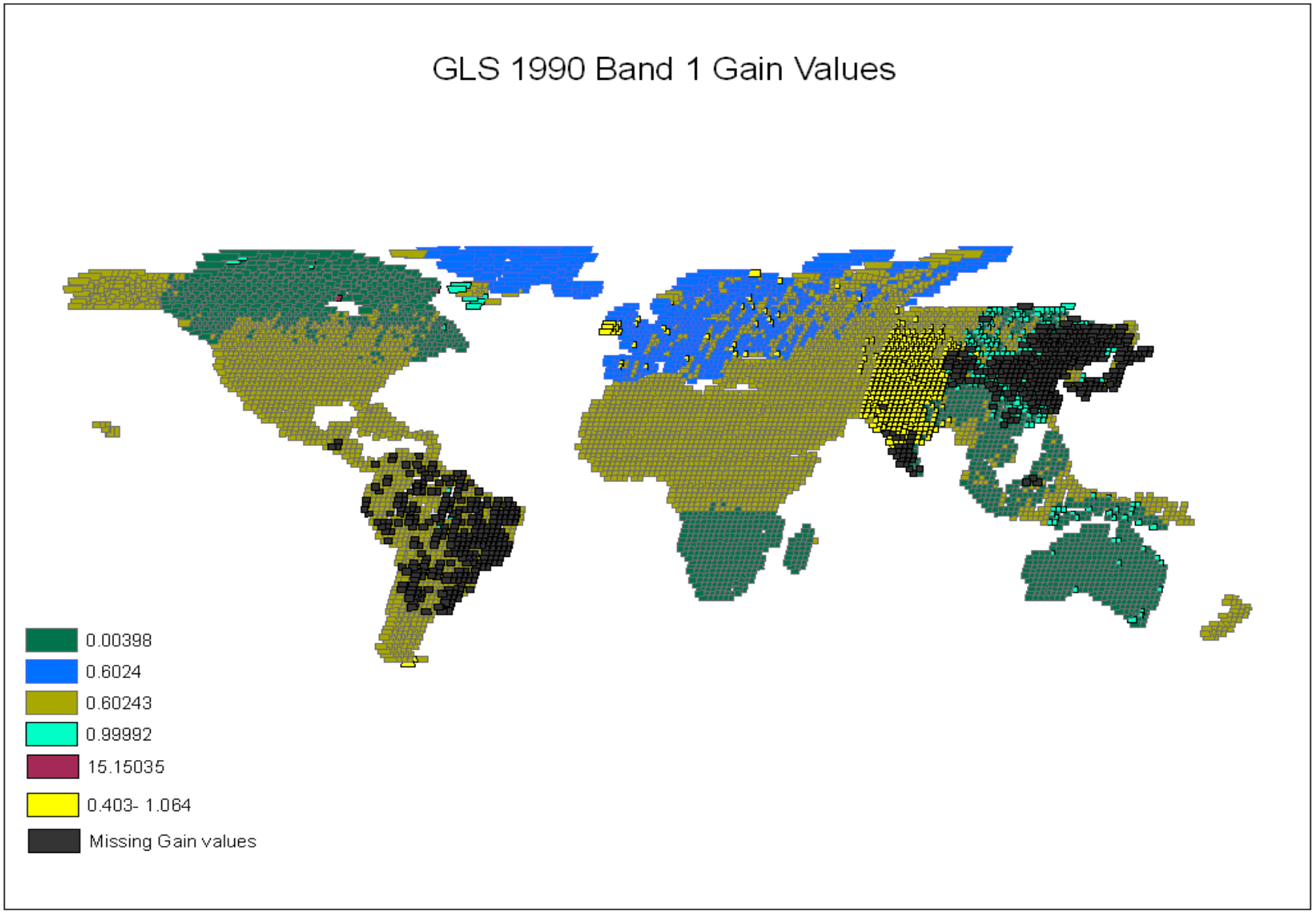
INPE has the data to fill the gap



Eastern Siberia Not Covered in 1990

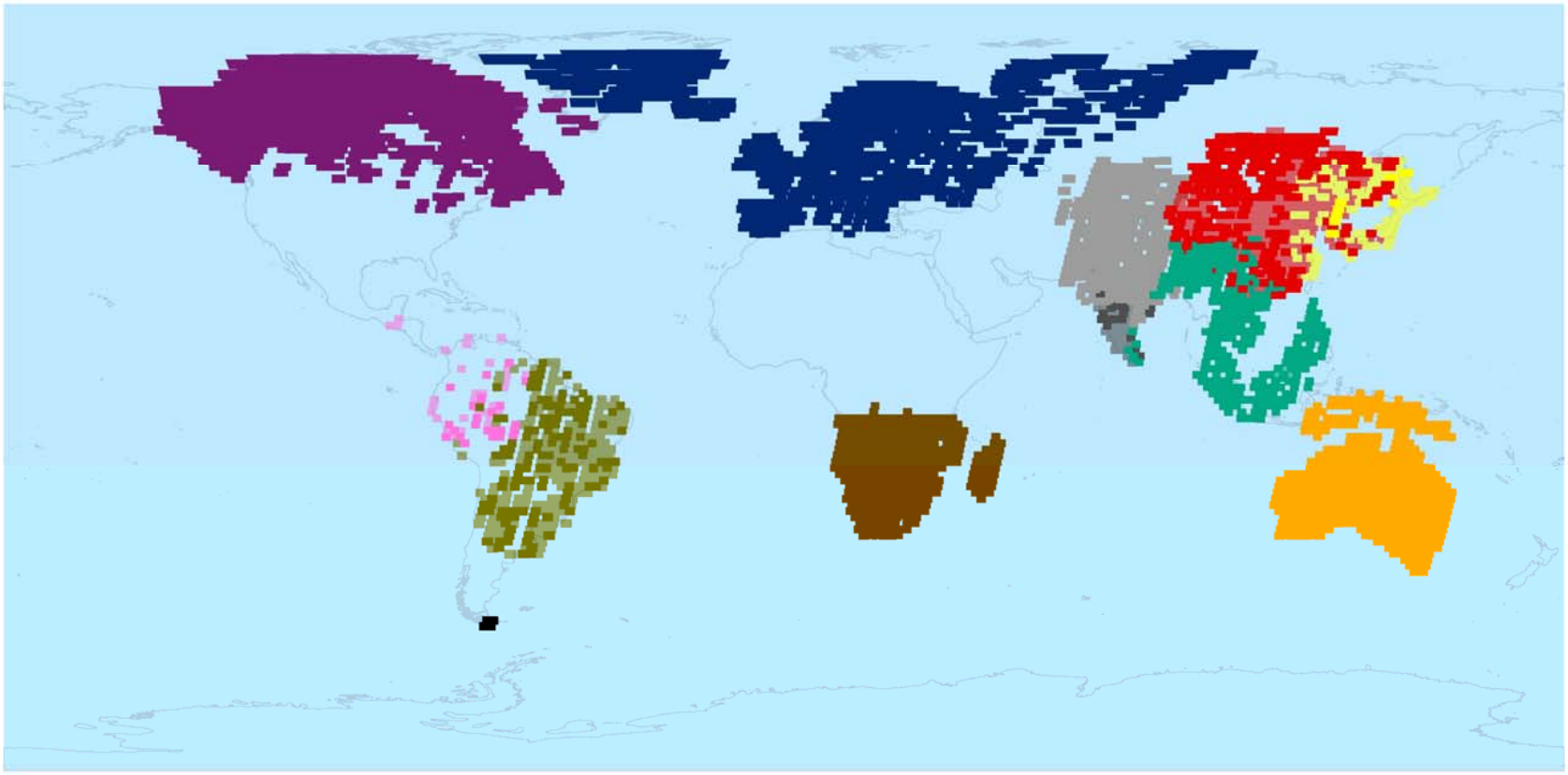


GLS 1990 Calibration Challenge



GeoCover 1990 International GRS & GLS1990 Band1 Gain Values

Similar spatial pattern for Bands 2,3,4,5 and 7



Australia (ACRES): 0.00398, 0.60243, 0.99992

Brazil (INPE): -9999, 0.60243, 0.99992

Canada: 0.00398, 0.60243, 0.99992, 15.15035

China: -9999, 0.00398, 0.60243, 0.99992, 1.06365

Ecuador (CLIRSEN): -9999, 0.60243

EOSAT: 1.05473, 1.05509

Europe (ESA): 0.6024, 0.60243, 0.7314

India (NRSA): -9999, 0.00398, 0.48733 -1.06365

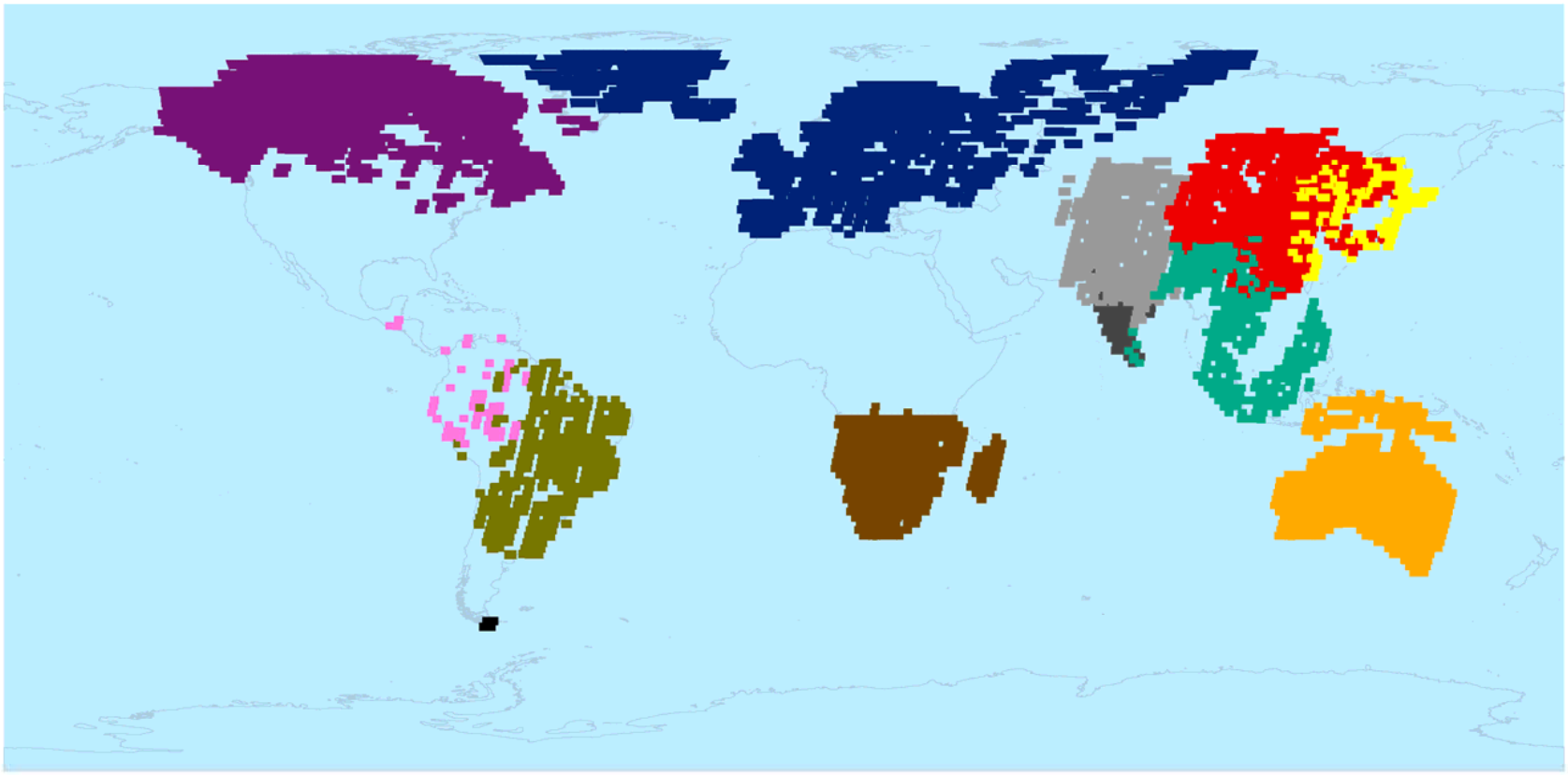
Japan (RESTEC): -9999, 0.60243

Pakistan: 0.00398, 0.40258-1.06365

South Africa (SAC): 0.00398, 0.60243

Thailand: -9999, 0.00398, 0.60243, 1.06365

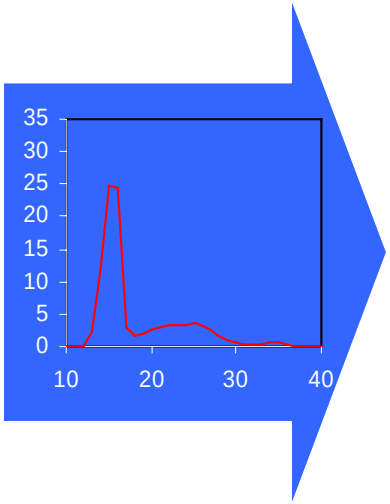
GeoCover 1990 International GRS & GLS1990 Band6 Gain Values

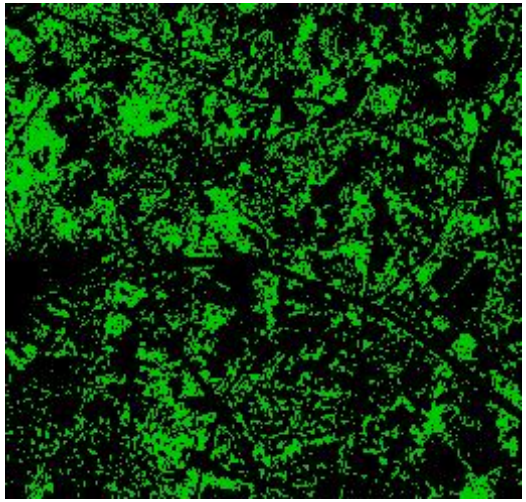


Australia (ACRES) -9999, 0.05515, 3.20107
Brazil (INPE): -9999 0.05515, 3.20107
Canada: -9999, 0.05515, 1.52432, 3.20107
China: -9999, 0.05515, 0.89048 - 1.35381, 3.20107
Ecuador (CLIRSEN): -9999, 0.05515
EOSAT: 1.52431
Europe (ESA): -9999, 0.05515, 0.0552
India (NRSA): -9999 0.89048, 0.92357- 1.10559
Japan (RESTEC): -9999 0.05515
Pakistan: -9999, 0.05515, 0.66433 - 1.53031
South Africa (SAC): -9999 0.05515
Thailand: -9999, 0.05515, 1.03389

Backup Slides

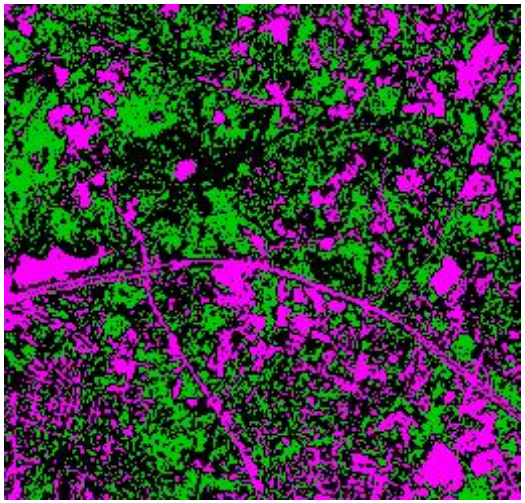
Training Data Automation





Forest Index

Threshold FI



(Huang et al. 2008)

SVM More Accurate

- Classify using optimal class boundary

Method	single-scene test	multiple-scene test
MLC	85%	60%-70%
Bayesian	86%	60%-70%
Contextual MLC	88%	60%-70%
DT	90%	80%
SVM	92%	85%

- TDA-SVM tested in many places
  - Huang, C., Song, K., Kim, S., Townshend, J., Davis, P., Masek, J. & Goward, S.N. (2008). Use of a Dark Object Concept and Support Vector Machines to Automate Forest Cover Change Analysis. *Remote Sensing of Environment*, *112*, 970-985.

Coordination with Related Projects

- **NASA LCLUC**
  - **Chandra Giri, USGS EROS**
    - **Tropical Mangrove Forests: Global Distributions And Dynamics (1990-2005)**
  - **Matthew Hansen, South Dakota State University**
    - **Producing Composite Imagery And Forest Cover And Change Characterizations For The Humid Tropics - A Contribution To The MDGLS Activity**
  - **Mutlu Ozdogan, University of Wisconsin**
    - **Land-Use And Land-Cover Changes In Temperate Forests Of European Russia: The Past, The Current, And The Future**
  - **David Skole, Michigan State University**
    - **Enhancing Global Observations And Information On Tropical Forest Change Using Landsat Global Data**
  - **John Townshend, University of Maryland**
    - **Three Decades Of Forest Cover Change In The Americas Evaluated Using The Geocover And MDGLS Data Sets**
  - **Xiangming Xiao, University of New Hampshire**
    - **Developing Land Cover Classification Products In Monsoon Asia Over The Period Of 2004-2007 Through Integration Of Landsat And ALOS/PALSAR Images**

Coordination with Related Projects

- **Other NASA Projects**
  - **Jeff Masek, NASA/GSFC**
    - **Recent North American Forest Dynamics via Integration of ASTER, MODIS, and Landsat Reflectance Data**
  - **Jeff Masek, NASA/GSFC**
    - **Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS)**

Stay tuned …

- Five-year project started this summer
- Current progress
  - System setup
  - Data ingestion
  - Prototype studies