Landsat Global Land Surveys: Status Update

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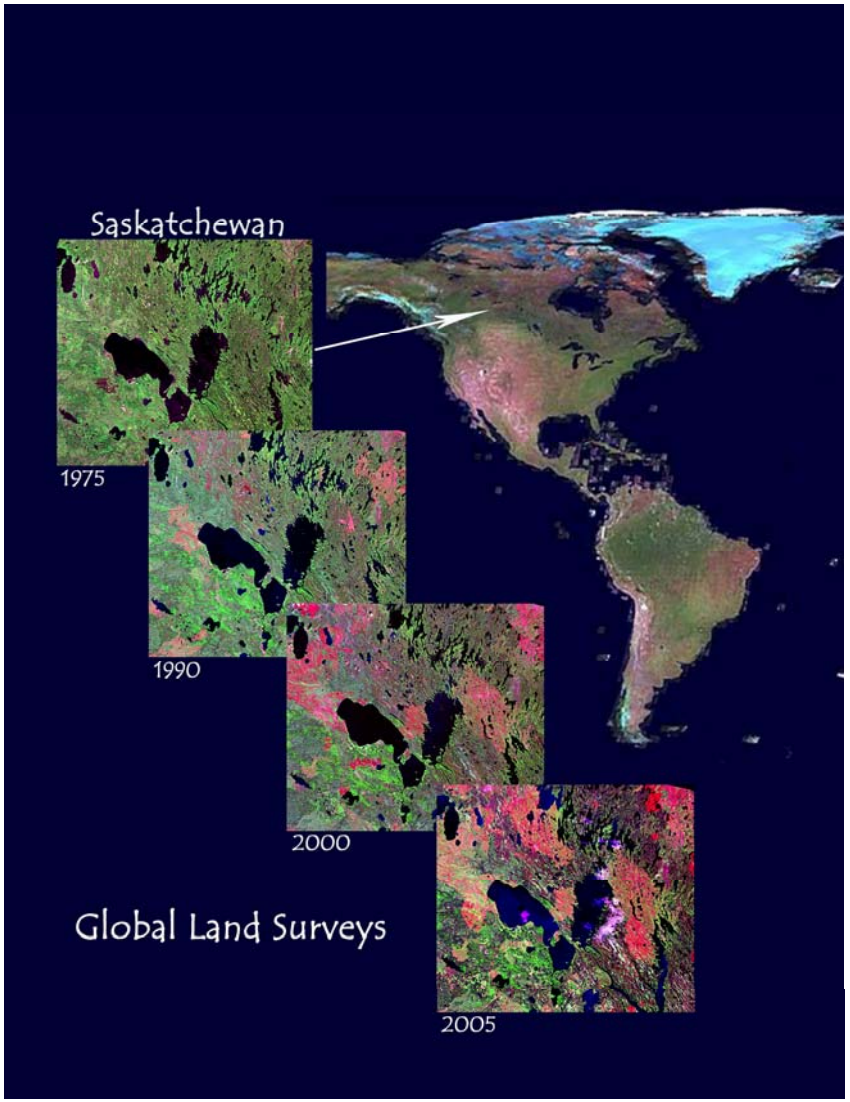
NASA Headquarters

Landsat Science Team Meeting
Rochester, NY June 22-23, 2009

Global Land Survey Data Sets

Global cloud-free, orthorectified Landsat data sets centered on 1975, 1990, 2000, 2005, and 2010

- Partnership between USGS and NASA
- Support global assessments of land-cover, land-cover change, and ecosystem dynamics (disturbance, vegetation health, etc.)
- GLS-2005: Pilot project for routine global land-cover mapping in the next decade



GLS 1975-2010❑

Previous Geocover 1975, 1990, and 2000 data sets have been reprocessed to improve geometry (“GLS” standard)

- SRTM digital topography (+ DTED, CDED, NED)
- improved density of ground control
- <25m RMSEr_error for 2000; <40m for 1990; <75m for 1975

All GLS datasets are complete and available for download via GLOVIS/EarthExplorer and bulk order

GLS-2005

•A few scenes still missing

GLS-2010 data is being collected

GLS-2010 Overview

- **Need for GLS-2010**
  - Pre-sorted “best of archive” for land-cover science
  - Inclusion of International Data
  - Gap-filled products from Landsat-7
  - Decadal consistency for change detection
- **2009-2010 acquisition window**
- **USGS/NASA MOU Signed 2008**
- **Russians are collecting L-5 under a new agreement**
- **Relying on Landsat-5 and -7, but with international contributions through CEOS Land Surface Imaging (LSI) Constellation**

GLS-2010 Schedule & Plans

2009

•Set up L-5 campaign stations, begin downlinks
•Target EO-1 ALI acquisitions for islands and reefs
•Obtain sample data sets from SPOT-5, IRS, CBERS-2b, AVNIR, THEOS

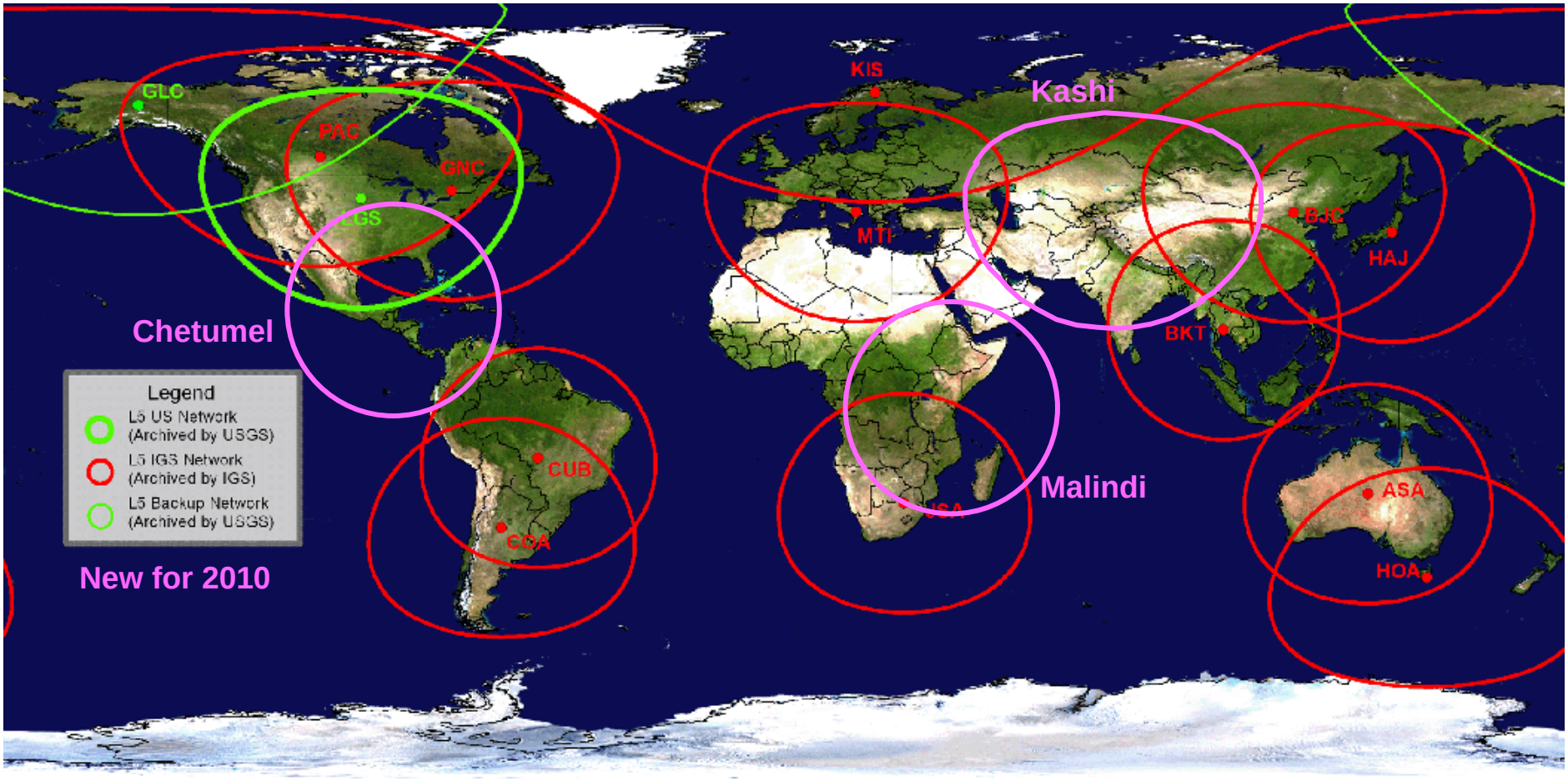
2010

•Continue ground station operations
•Additional international data acquisition/contribution?
•Begin scene selection process via LASSI
•Deploy gap-filling code at GSFC

2011

•Obtain collects from IC's
•Process L-5/L-7 data to L1T at EROS
•Gap-filling of L-7 imagery at GSFC
•Release final product by end of 2011

Landsat-5 Ground Stations



International Participation

- **Letter sent to space agencies in October 2008 soliciting data contributions through CEOS LSI Constellation activities**
  - Regional Data Set Initiatives (Townshend)
  - GLS-2010 (Masek)
- **Positive responses from JAXA, CNES, INPE, CONAE, GISTDA**
- **Initially focused on three "target" areas for data intercomparison (Central South America, southern Africa, SE Asia).**
- **Spring 2009: Work with agencies to acquire data and host through CEOS Land Portal.**

GLS Science Products

The GLS effort is focusing on both *data products* and long-term *land-cover analysis*

NASA LCLUC (ROSES2007) and Earth Science Information Systems programs are funding analyses of GLS (1975-2005) record:

- **Chander, G. (USGS EROS) - Sensor cross-calibration**
- **Davis, B. (NASA SSC) - Sensor intercomparison for land cover**
- **Giri, C. (USGS EROS) – Monitoring Tropical Mangrove Forests**
- **Hansen, M. (SDSU) – Forest Cover in Humid Tropics**
- **Skole, D. (MSU) – Tropical Forest Cover Change**
- **Townshend, J. (UMD) –Global Forest Cover Change Data Record**
- **Xiao, X. (UNH) – Land Cover Products for Monsoon Asia**

Producing composite imagery and forest cover and change characterizations for the humid tropics

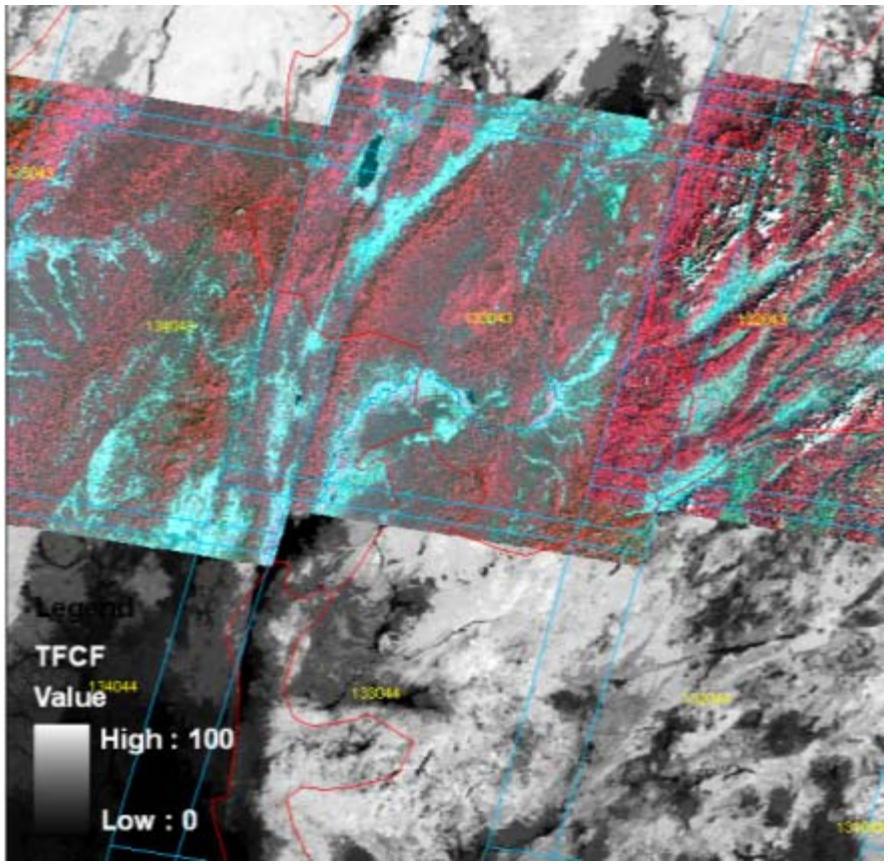
PI: Matthew C. Hansen (South Dakota State U.)

- **Work plan includes producing wall-to-wall maps for the Congo Basin and Boreal regions**
- **Data are being assembled and methods prototyped for these activities**
- **Processing includes MODIS inputs for normalizing Landsat imagery and developing Landsat-specific forest cover and change models**
- **Initial results are expected at the end of year one and will include 2000 to 2005 maps of forest cover and change for the entire Congo Basin (completed) and test areas for European Russia**

TROPICAL FOREST CHANGE USING LANDSAT GLOBAL DATA

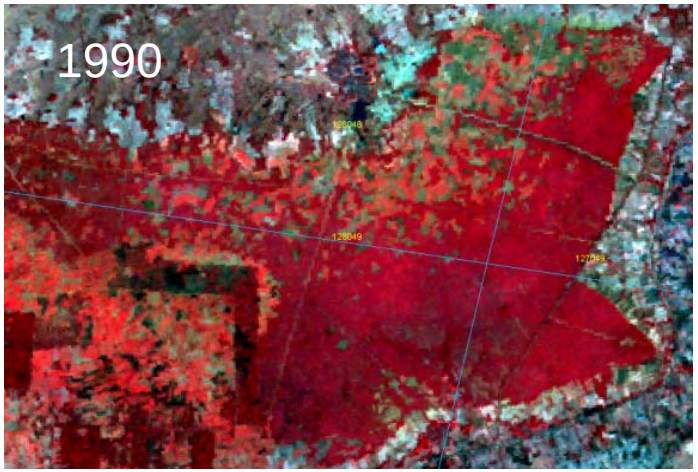
PI: Dave Skole (Michigan State U.)

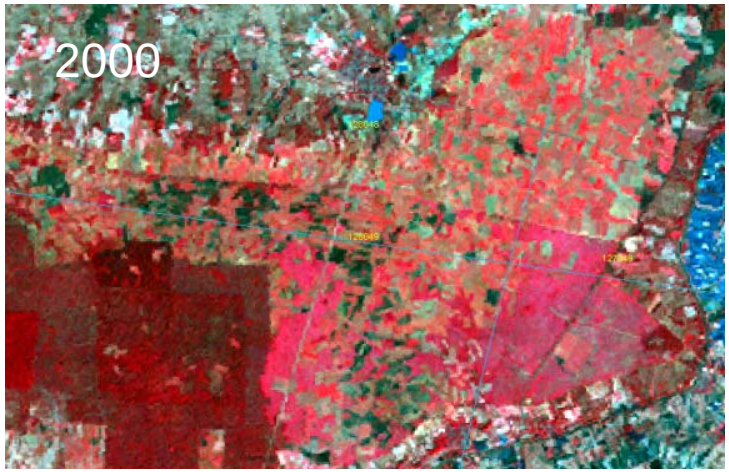
- **Central Task is to develop four products:**
  - A Landsat-MODIS fusion Tropical Forest Continuous Fields product (TFCF)
  - A Landsat Tropical Forest Disturbance Index (TFDI) and Disturbance Index Change product (ΔTFDI)
  - A Tropical Forest Fractional Cover Product (fC)
  - An inter-annual Tropical Forest Annual Dynamics product (TFAD) using dense samples of Landsat multi-temporal data



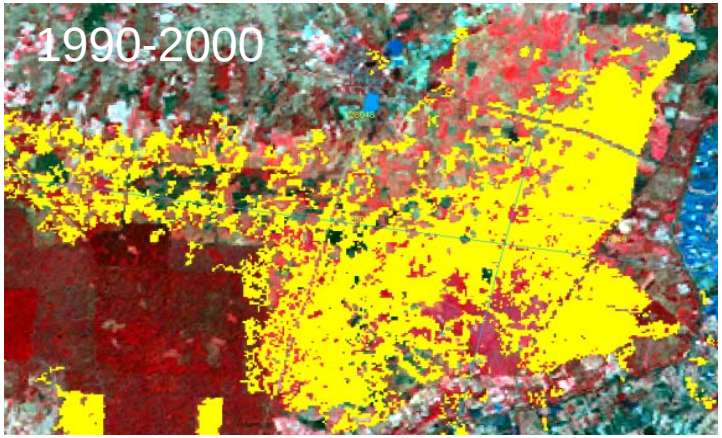
. Landsat GeoCover 2000 false color bands 4, 3, 2 overlaid on the TFCF product over Thailand: Forest – red; bluish-gray areas are not forested

Skole: Continue





Change is detected using the TFCF product to determine areas of forest and non forest. The data is level sliced using the FAO definition of closed forest at 40% cover or more. A forest mask is created by taking all pixels that have percent cover value less than the threshold of 40% cover from the 30-m TFCF 2000 dataset. This forest mask is then overlaid on the 1990 Tasseled Cap Transformation (TCT) product. All 1990 pixels within the non forest mask are then compared for changes in brightness, greenness and wetness. Pixels that have significant changes in all three TCT bands are considered areas of change



Thailand: 1990 to 2000 forest cover change (yellow) detected by the TFCF and Tasseled cap method

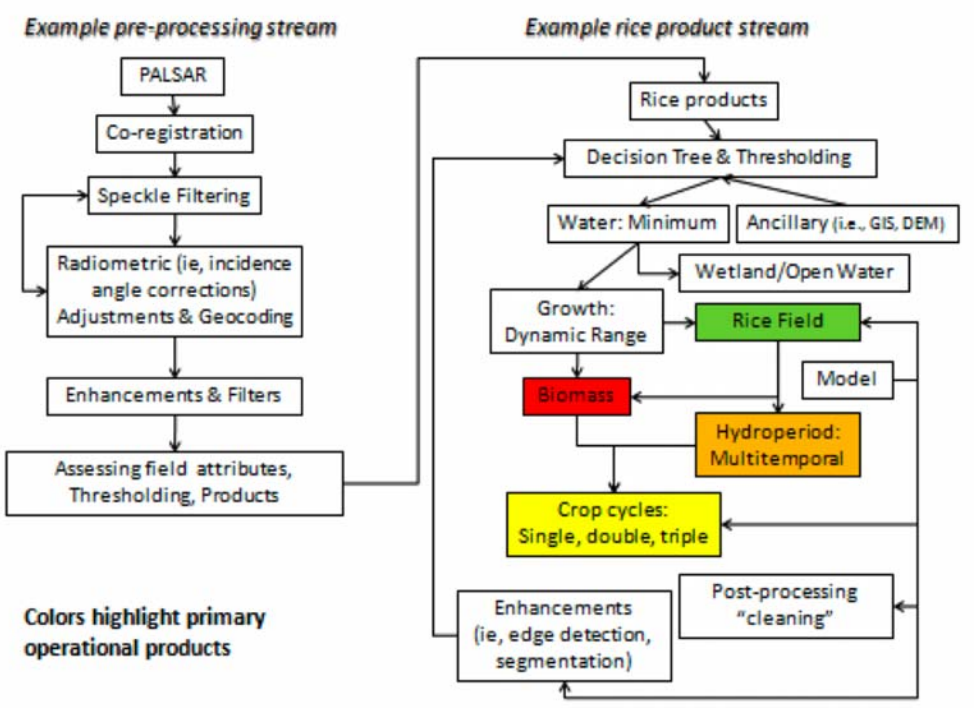
Land Cover Products for Monsoon Asia

PI: Xiao, X. (U. New Hampshire)

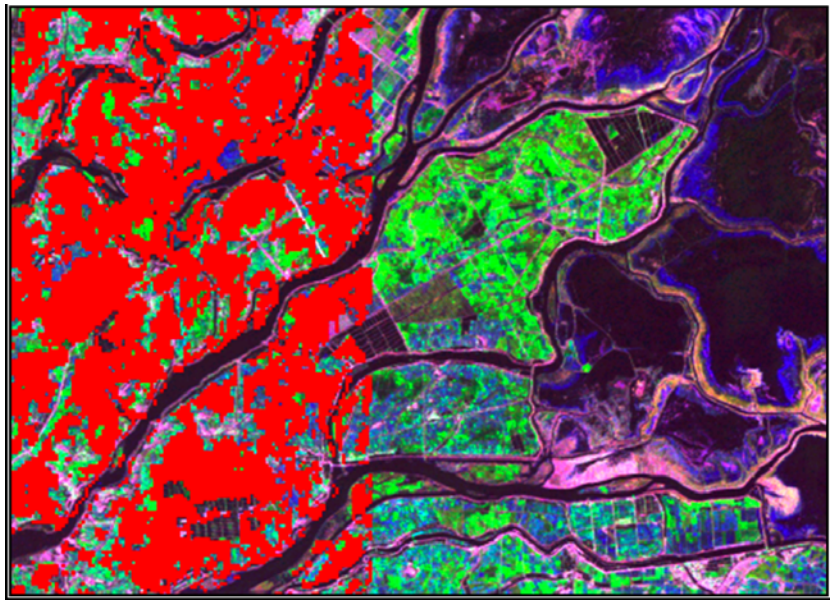
- **PALSAR-data acquisition, preprocessing and algorithm development**
  - PALSAR efforts on data acquisition, data preprocessing and algorithm development for:
  - mapping the extent of rice paddies
  - mapping rice cropping systems
  - mapping inundation period of rice
  - mapping and monitoring rice biophysical characteristics (biomass, LAI, age, height)
- **Cropping intensity and evergreen forest mask from analysis of multi-temporal MODIS data**
- **Landsat image data acquisition, pre-processing and algorithm development**

Xiao: Continue

A schematic flowchart for PALSAR processing . Output products are highlighted in color

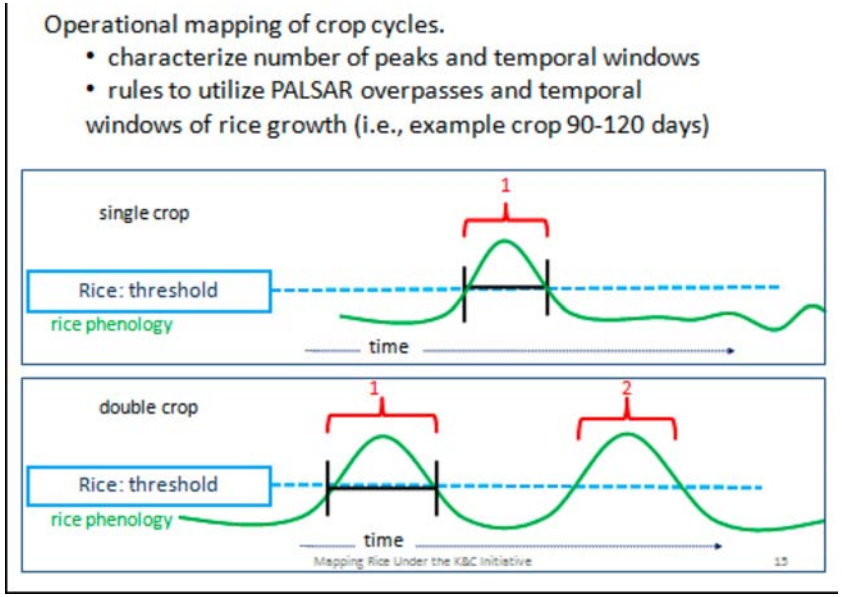


A case study in Poyang Lake region, China. It shows a rice map (red area) partially (left half of image frame) overlaid on multi-temporal PALSAR imagery

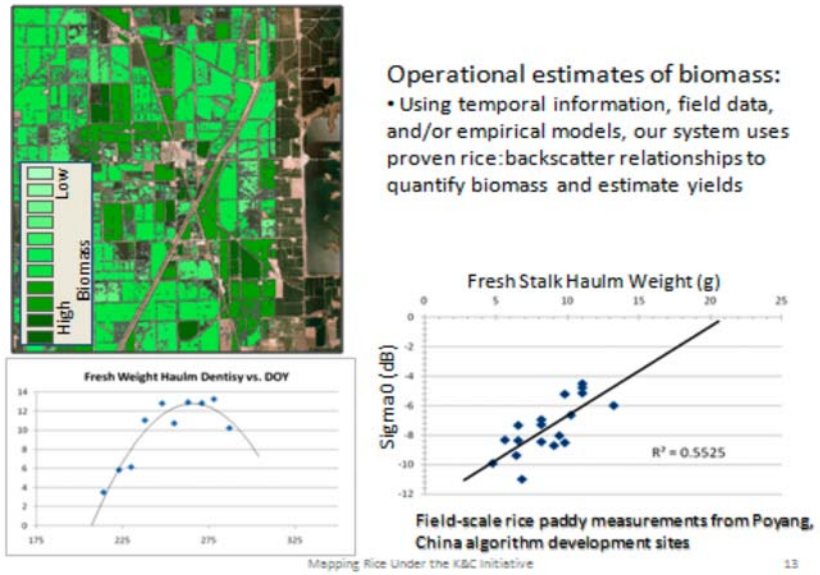


Xiao: Continue

Logic for mapping cropping intensity from PALSAR data

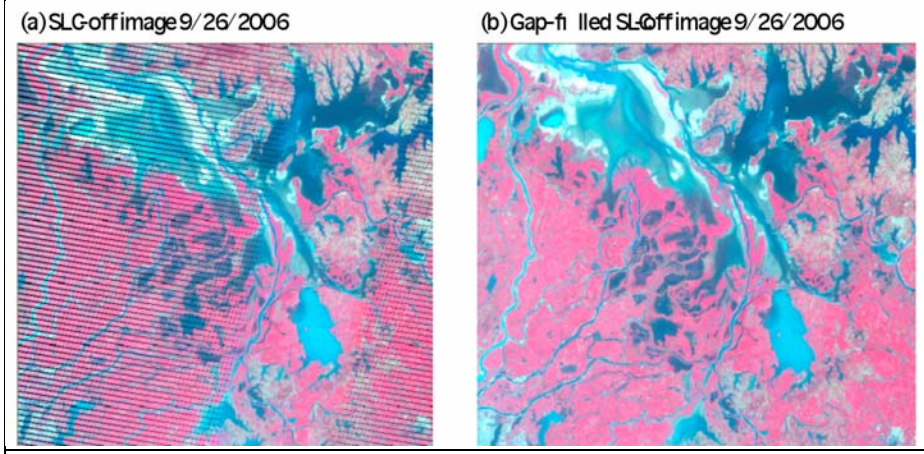


Estimating aboveground biomass of rice with PALSAR data. Lower left panel shows field measured changes in rice biomass (fresh weight) with age. Lower right panel shows relationship between PALSAR HH backscatter and field measured biomass. Upper right panel shows PALSAR derived biomass.

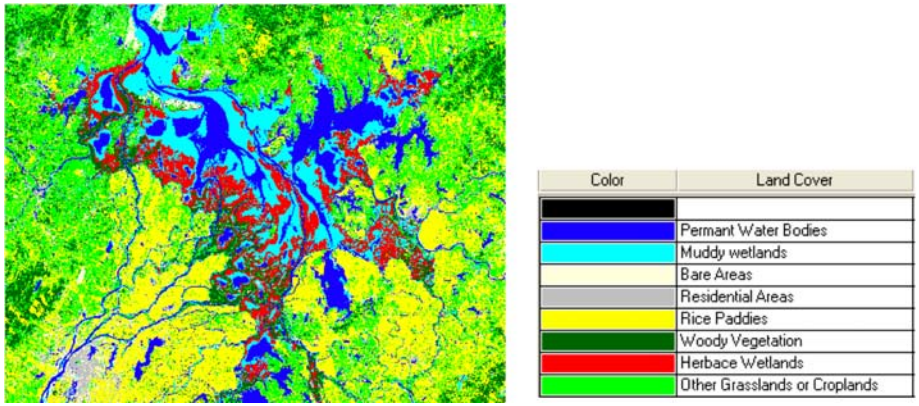


Xiao: Continue

A comparison between SLC-off image and gap-filled SLC-off image in Poyang lake, Jiangxi province, China. The local linear histogram algorithm is used for gap-filling



A draft map of land cover in Poyang lake region, Jiangxi Province, China. It uses Landsat ETM+ images from 12/10/1999 to 7/8/2001



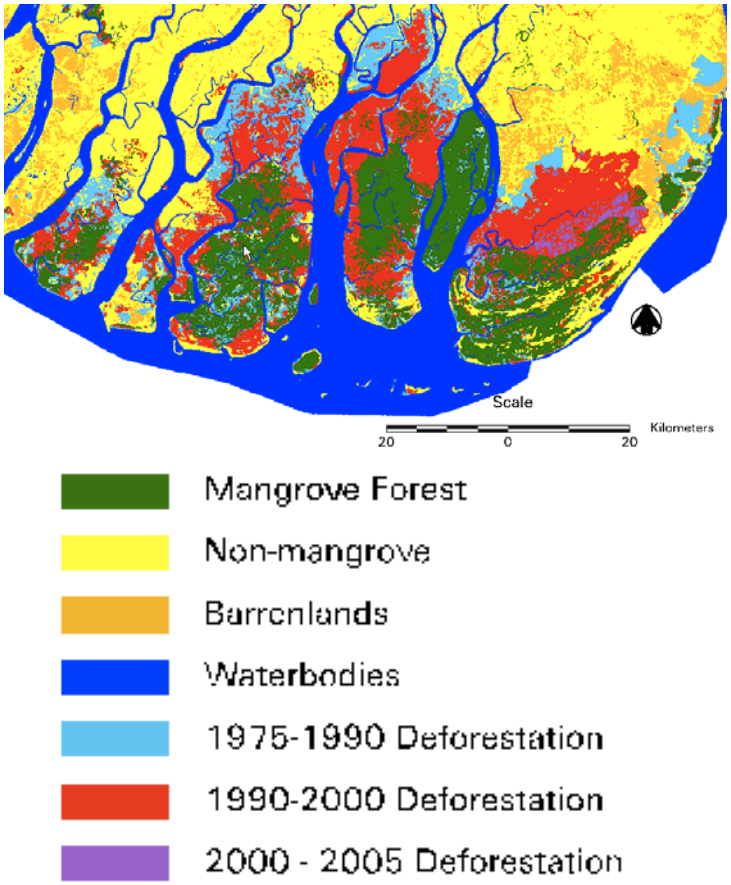
- **Field data collection**
  - Over 150 GPS-based field data (land-cover type, vegetation species) were collected in the Poyang Lake region for 2005-2009
  - Will be used to label land-cover classes and evaluate the classification result.
- **Decision rules**
  - three index layers (brightness, greenness and wetness) of tasseled cap transform and NDVI
- **Difficult to select seasonal imagery to generate land-cover map because of local complicated hydrological condition and various crop calendar**
- **Development of decision tree is highly dependent on timely selection of the satellite data**
- **Other indices and GIS data will be further added to investigate classification algorithm**

Tropical Mangrove Forests: Global Distributions and Dynamics (1990-2005)

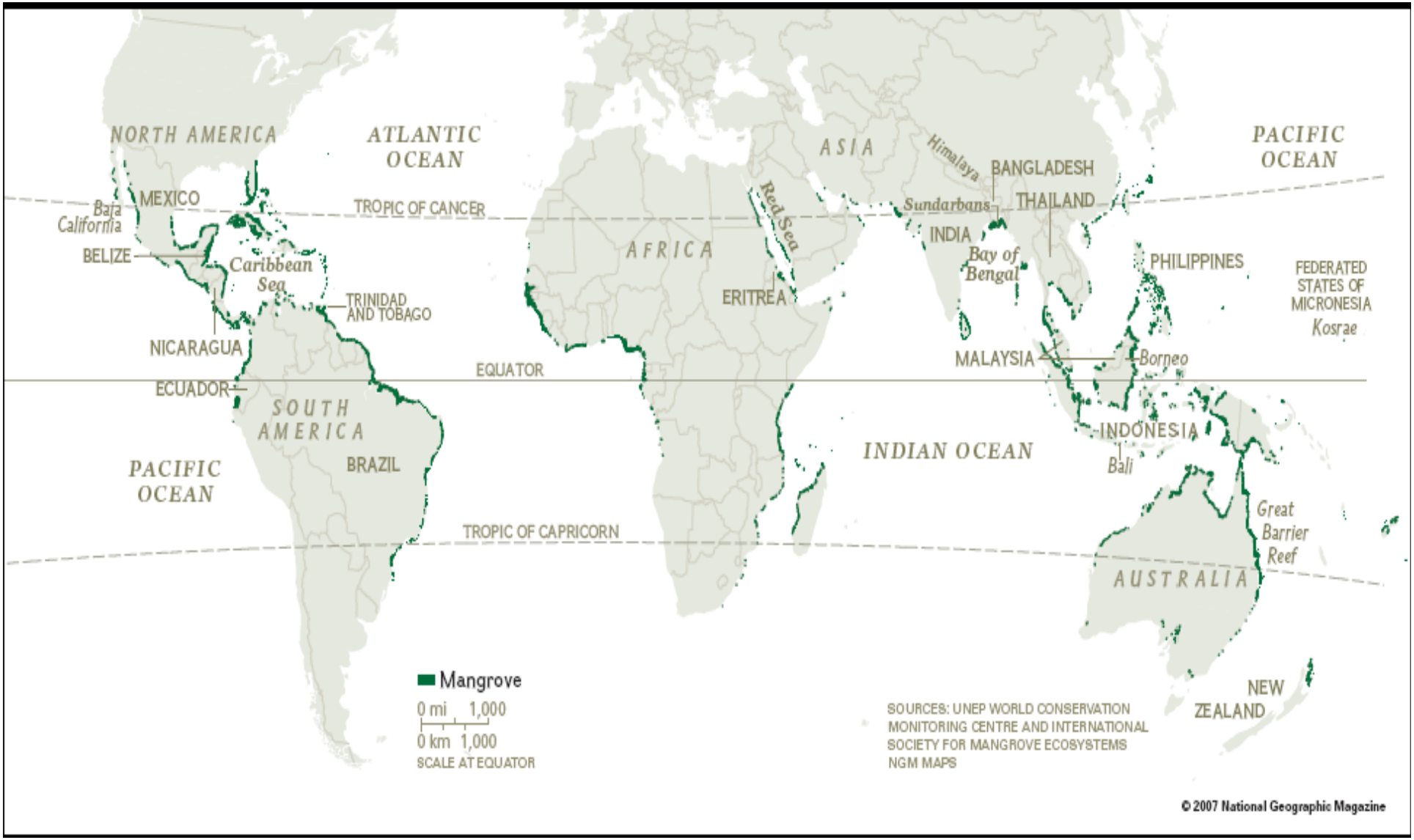
PI: Chandra P. Giri

- **Compiled crucial datasets derived from remotely sensed imagery, GIS, and field work**
  - Acquired the GLS data for 1990 and 2000 for the whole study area, and pre-processed the data for their geometric accuracies
  - collected existing mangrove data in GIS format that can be used for training data collection and results validation
  - The secondary data collected were converted to an appropriate format (e.g. GRID) that can be used for training data collection and results validation
- **Developed, tested, and refined methodologies for both mangrove classification/change analysis in selected areas**
  - Ffor the year 1990 and 2000 in Madagasca, Sunderbans, and tsunami-impacted regions of Asia
  - Completed wall-to-wall mapping of the tsunami-impacted region of Asia, North America, South America, and Africa.
- **Progress in producing the first wall-to-wall map of the mangrove forests of the world (Completed for the year 2000)**
- **Satellite image prepared by the project published in an article “Forests of the Tide” in the National Geographic**
- **Research results were highlighted on a ‘big screen” by the American Museum of Natural History and 22 affiliate museums around the country**

Mangrove forest cover change in Ayeyarwady Delta, Myanmar



Mangrove forest cover change 1990-2005



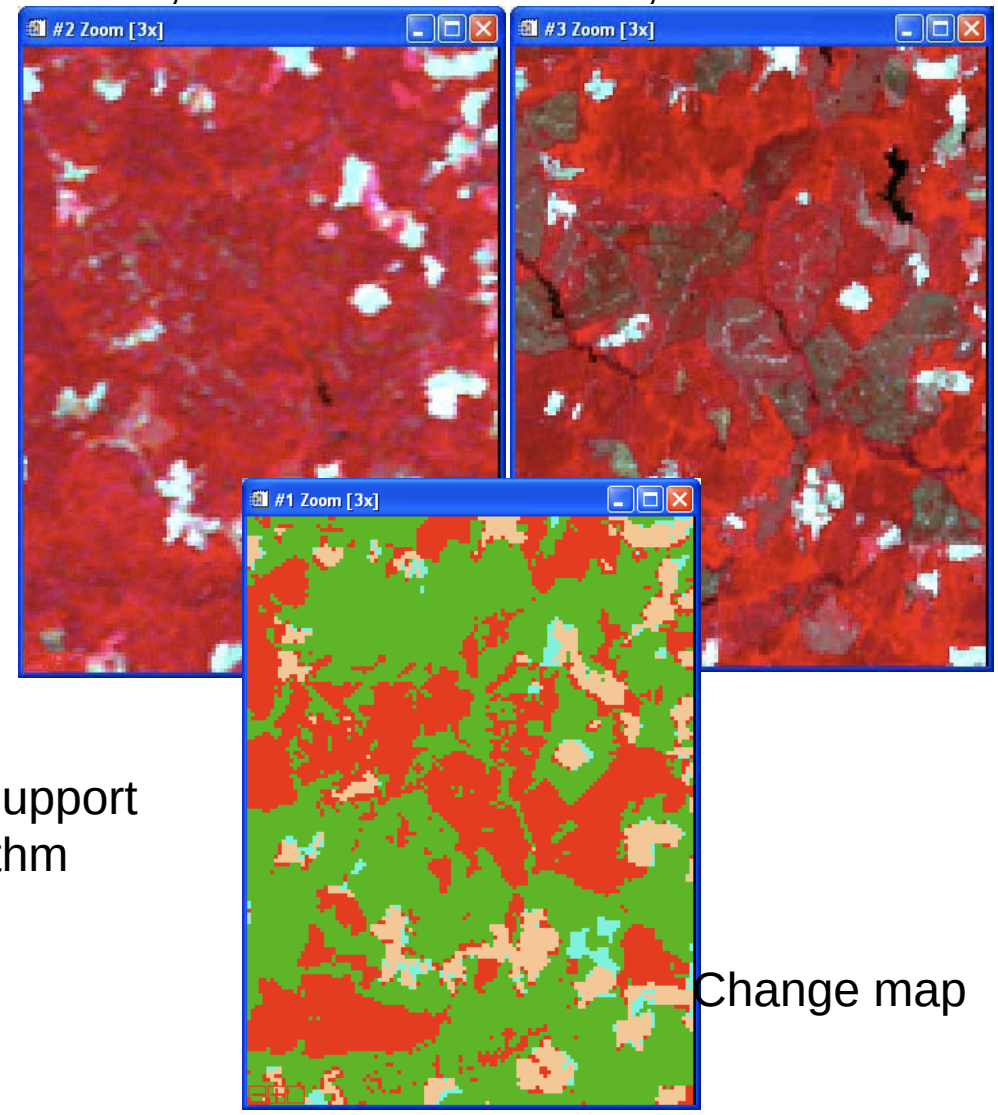
Three Decades of Forest Cover Change in the Americas Evaluated Using the GLS Data Sets

PI: John R. Townshend

- **GLS-1975, -1990, -2000, and -2005**
- **Focus on non-tropical South America**
- **Science modules have been developed or refined and configured from the previously developed**
  - orthorectification module
  - calibration and TOA reflectance calculation module
  - atmospheric correction module (for TM and ETM+ images)
  - cloud and shadowing module
  - forest cover change module

MSS, 1973-10-06

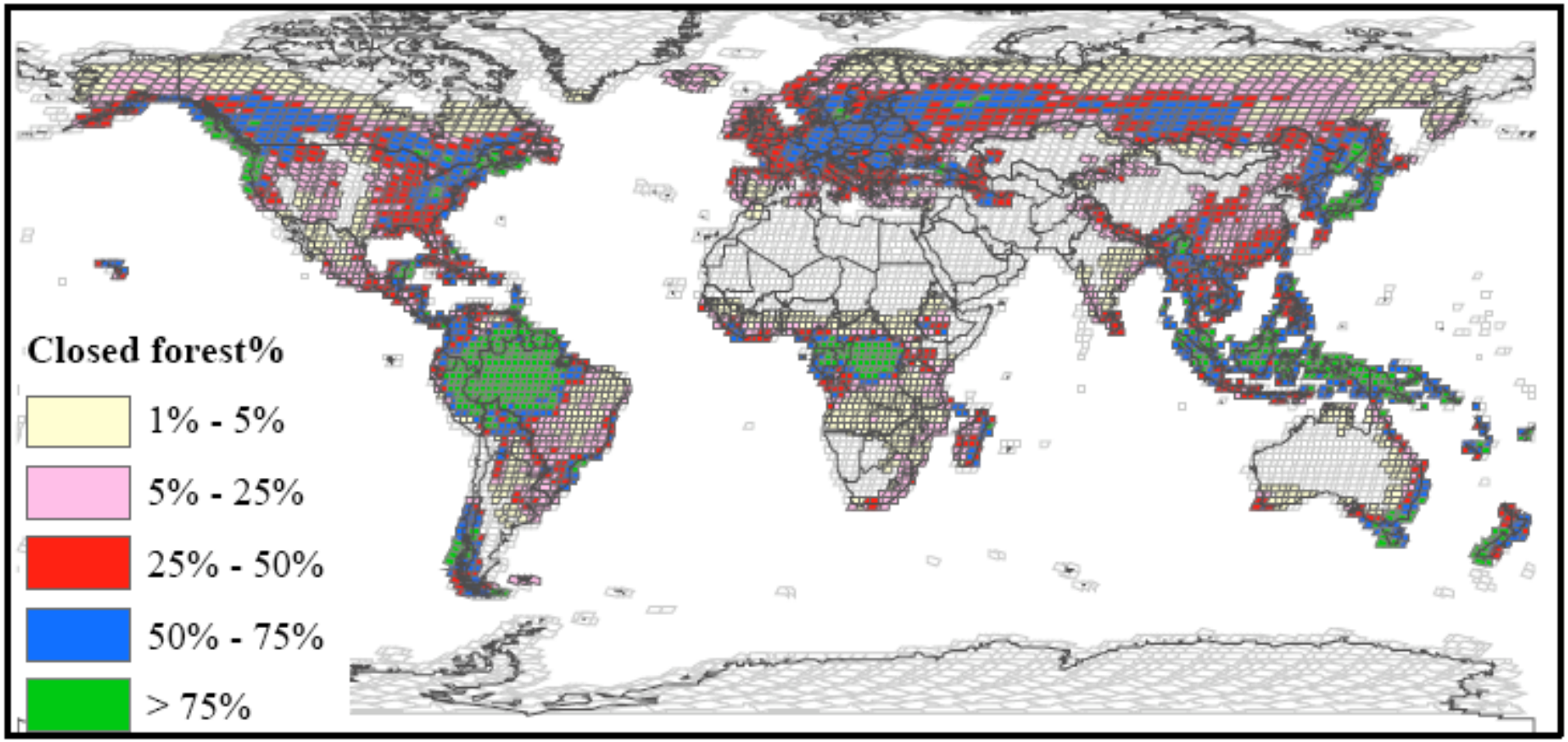
TM, 1990-05-08

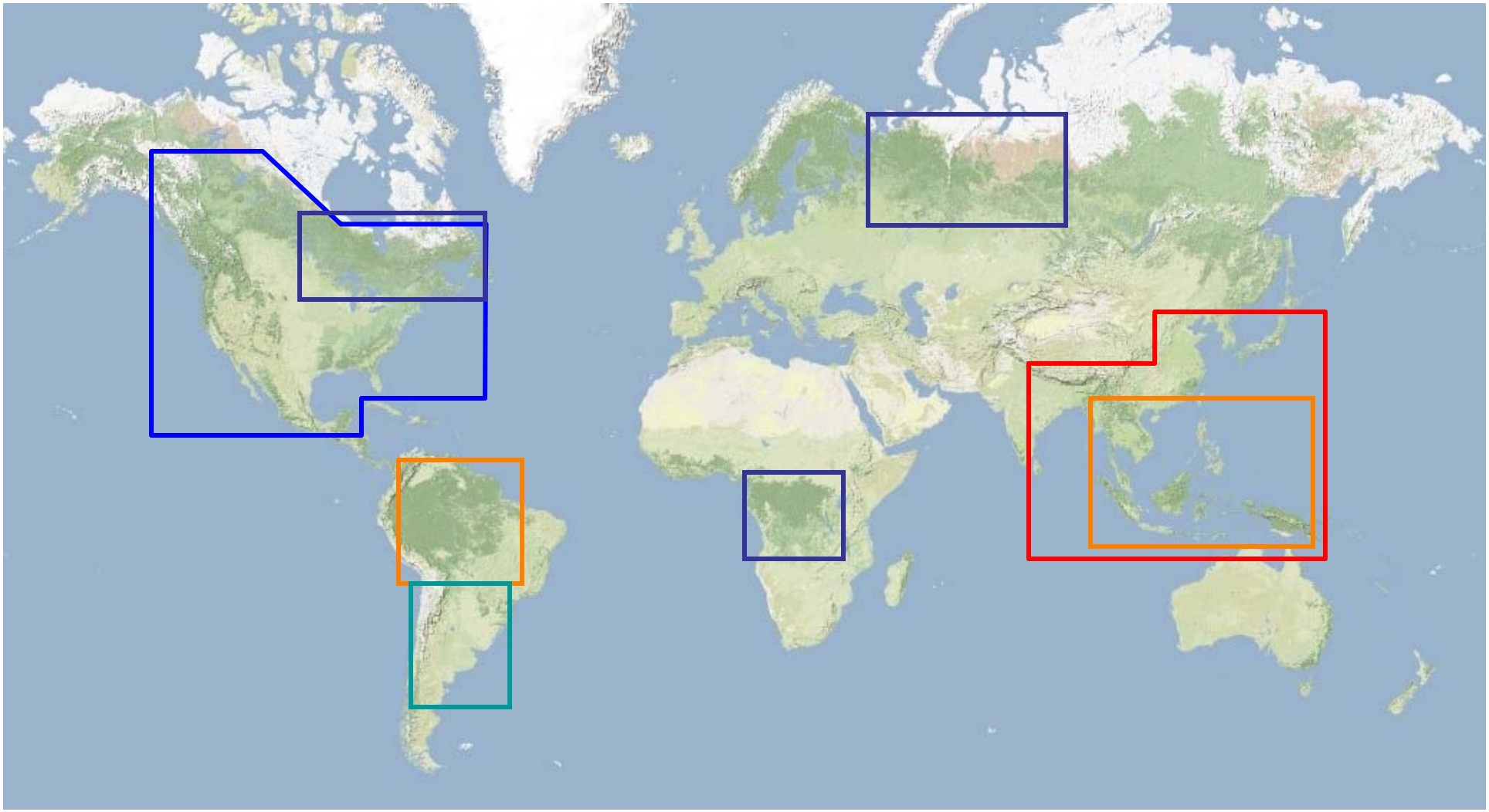


Training data automation (TDA)-support vector machines (SVM) algorithm

Change map

Townshend MEASURES - all GLS frames w/ > 1% closed canopy forest
forest Change, 1990-2005; fragmentation




Hansen 1990-2005
(forest conversion)
Townshend 1975-2005
(forest conversion)
Goward/Masek 1990-2005
(forest disturbance)
Skole 1990-2005
(forest conversion + logging)
Xiao 2005 (land cover)

Conclusions

- **Global Land Surveys offer decadal views of the Landsat archive for monitoring land-cover trends**
- **GLS-1975, -1990, -2000 are reprocessed**
- **GLS-2005 is complete and released**
- **GLS large scale products for specific regions (land cover and land-cover change) to become available during the coming year**
- **All projects include validation as an important component of developing products**
- **Two GLS projects explore IRS and CBERS data for their use as a backup in GLS-2010**
- **GLS-2010 is in its collection phase; pushing international involvement and a back-up for Landsats**

General Outstanding Issues

- **A number of systems exist or are planned but there is NO coordination in building systems, launching and using them**
- **There is no agreement upon global acquisition strategy by the space agencies**
- **Data availability from some international satellites for large areas is either a big challenge or non-existent**
- **Data policies are inequitable**
- **LDCM launch is not firm due to TIRS issue**
- **The LSI constellation is only virtual**
- **The international aspects of GLS-2010 are moving very slowly**

WHAT IF...

Post Scriptum:
Garik's Dreaming

- **Imagine all the CEOS getting its act together**
- **All Landsat-like systems are developed in coordination**
- **All future launches are scheduled in concert**
- **There are a dozen satellites in space so that each target on earth is revisited daily**
- **What would it take?**

Sentinel-2: Planning for operational land surface imaging

•Full and systematic coverage of land surfaces (including major islands) from 56ºS to +83ºN, providing cloud-free products every 15–30 days

•A constellation of two operational satellites is required, yielding **5 days** between revisits

•At the beginning, with only one satellite, the gap will be **10 days**

•To support operational services for at least 15 years from the launch of the first satellites, a series of four satellites is planned, with two operating in orbit and a **third in ground storage as backup**

The Dream:

How to Achieve Almost Daily Coverage Globally With 10-30m Spatial Resolution by 2020?

- **2 Sentinels as planned**
- **Build 2 Landsats with a wider swath (about double of the present)**
- **Additionally**
  - Any non-EU/non-US satellite build (e.g. CBERS or THEOS)
- **All sensors intercalibrated**
- **Launched in a staggered fashion**
- **Common protocols developed**
- **Uniform readout capability**
- **Data policy resolved**
- **Free data for “public good”**


You may say I am a dreamer
But I am not the only one,
I hope some day you'll join us
And the world will be as one.
Aqua
Terra
Aura