GOFC Data and Information for Tropical Forest Assessment and Management

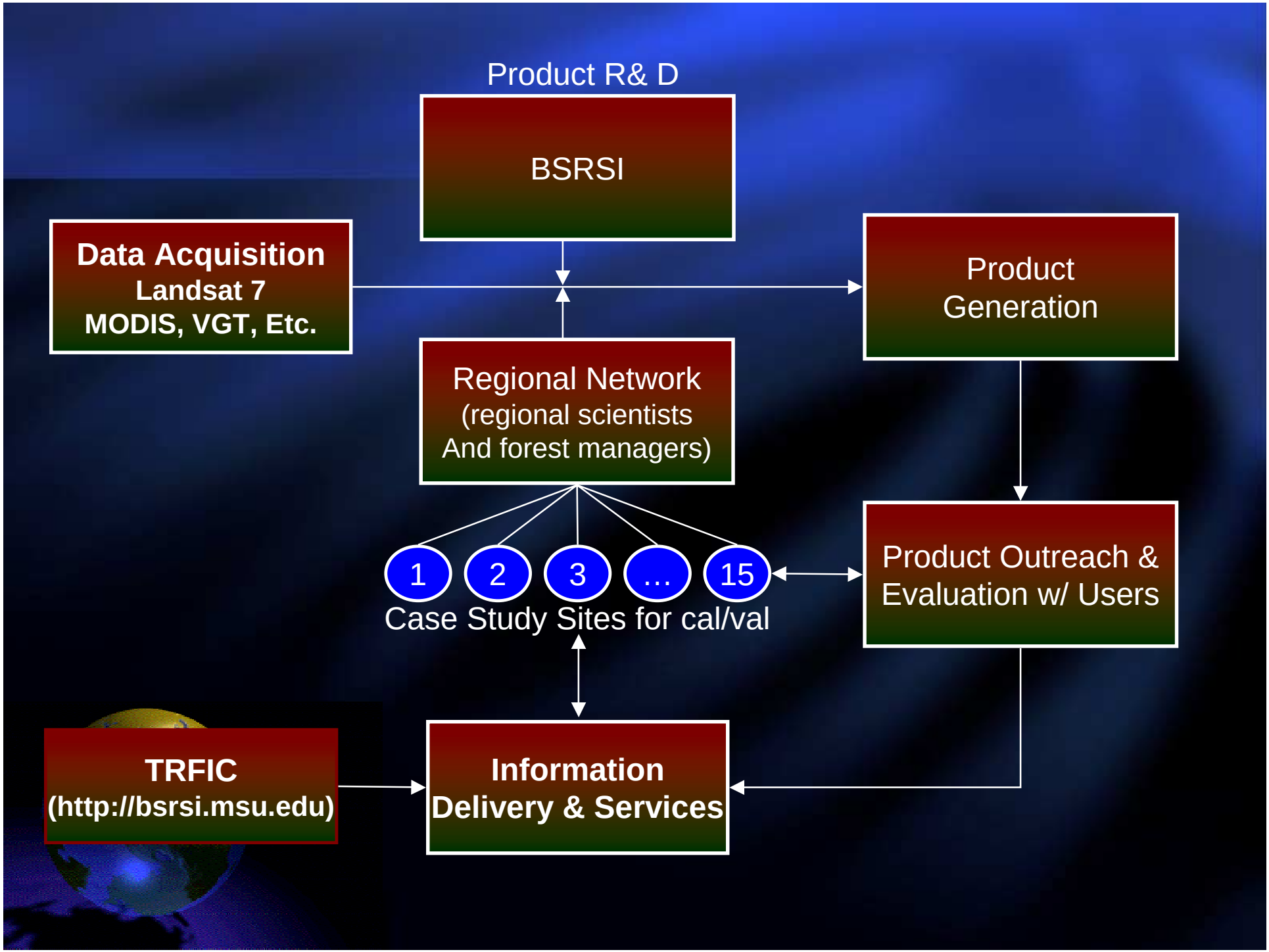
Jiaguo Qi, David Skole, Jay Samek, and Walter Chomentowski

Basic Science and Remote Sensing Initiative

Michigan State University

Objectives of the Study

- To support the GOFC project by providing new data and data products for the world's tropical forests
- To evaluate the application of data and products to tropical forest management needs through collaboration with several forestry management agencies in tropical countries, coordinated through a network of collaborating scientists
- To promote and strength linkages with national resource and forest management services collaborators for better dissemination of GOFC products


Product R& D
BSRSI
Data Acquisition
Landsat 7
MODIS, VGT, Etc.
Product
Generation
Regional Network
(regional scientists
And forest managers)
1
2
3
…
15
Case Study Sites for cal/val
Product Outreach &
Evaluation w/ Users
TRFIC
(http://bsrsi.msu.edu)
Information
Delivery & Services

Proposed Activities

- Development of New Datasets and Data Products (continuous fields)
- Product Validation, Evaluation, and Outreach (GOF SEA networks)
- Information Dissemination via TRFIC

Proposed Products

Product Level	Product Description	Spatial and temporal coverage
1a	Raw TM and ETM+ from TRFIC, no atmospheric correction, georeferenced by system correction only.	Focus area: 30m / 1yr Regional: 30m/3yr
1b	Raw VEGETATION and MODIS imagery, no atmospheric corrections, georeferenced by system correction only.	Focus area: 1km/month Regional: 1km /month
2	Georeferenced and atmospherically corrected, normalized for sun and view angles, 30m and 1km resolution imagery from Landsat, supplemented with EO-1, SPOT, and ASTER imagery. Spatial accuracy ±60m	Focus area: (30m + 1km)/1yr Regional: 30m/3yrs & 1km/month
3a	Forest Density (*FD*): Forest fractional cover computed from georeferenced ETM+ and MODIS/VEGETATION imagery	Focus areas: 30m/1yr Regional: 30m/3yr & 1km/mo
3b	Forest Density (*FD*): Estimated total green leaf area index and fPAR using MODIS LAI/fPAR algorithm, optimized for tropical forest.	Focus area: 30m/3yr Regional: 30m/3yr & 1km/mo

Science Implications

- New ways to operationalize the mapping of forest cover characteristics using direct parameterization of forest fractional cover
- Improved remote sensing data products for quantitative analysis of forest characteristics and changes including forest degradation
- New analyses will be a major contribution to carbon cycle research
- Strengthened regional networks implementation and long term application of results

Heritage for the Research

- Started early in 1990s
- Various projects at MSU
  - Landsat Pathfinder
  - TRFIC (under NASA ESIP program)
  - Southeast Asia research network (SEA)
    - Started as IGBP/START and IGBP LUCC
    - NASA LCLUC
    - APN carbon cycle
    - Currently Active as the GOFC regional network for SE Asia
  - Currently supporting NASA participation in Greening of the Globe initiative (Clinton Admin. Program proposed for FY 2001 through US AID)

Methods

- Development of New Datasets and Products
  - Georeferenced Products
  - Atmospheric Corrections
    - Must be operational and easy to implement
    - Require minimal ancillary data/inputs
    - Accuracy vs. effort levels
  - Bidirectional Correction
    - Use BRDF models
    - Be operational
  - Biophysical Products
    - Fractional cover
    - Green leaf area index

Methods

- Georeferencing (For ETM+, currently done by NASA)
- Atmospheric Corrections
  - Choice of
    - Radiative Transfer Models (require atmospheric inputs, which are difficult to obtain on an operational basis)
    - Pseudo Invariant Object Technique
    - Dark Objective Subtraction
    - MODIS algorithm Approach?
    - ***New Approach***

Methods

- Atmospheric Corrections
  - ***New Approach (based on MODIS results)***
    - *Combine models and known relationships of different spectral bands*
    - *Known relationships between TM3 and TM5/TM7*

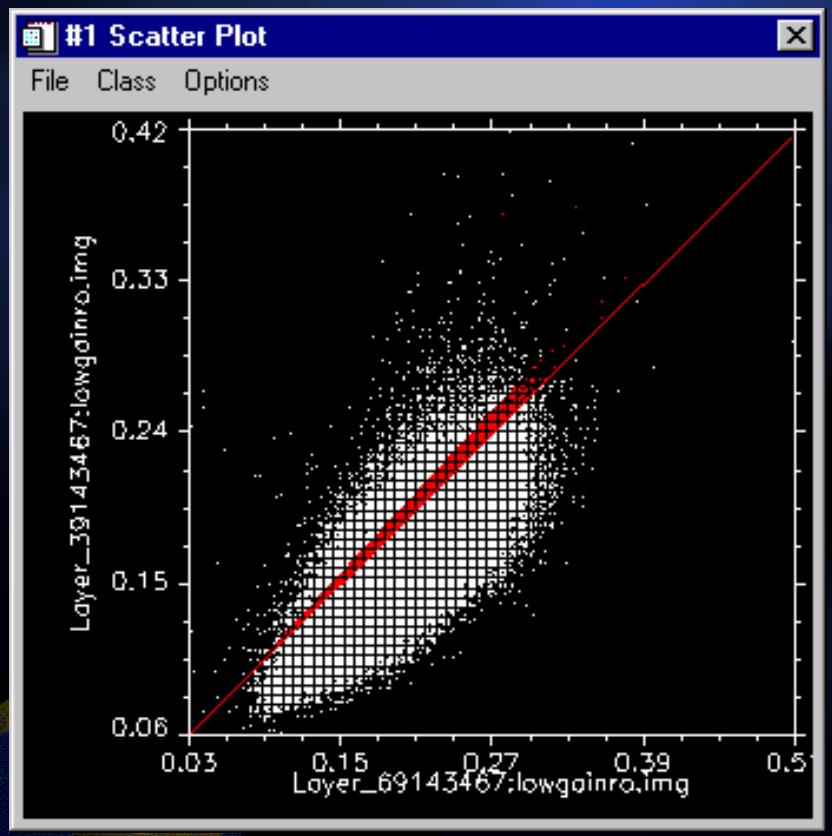
    TM3 = 0.50 TM7

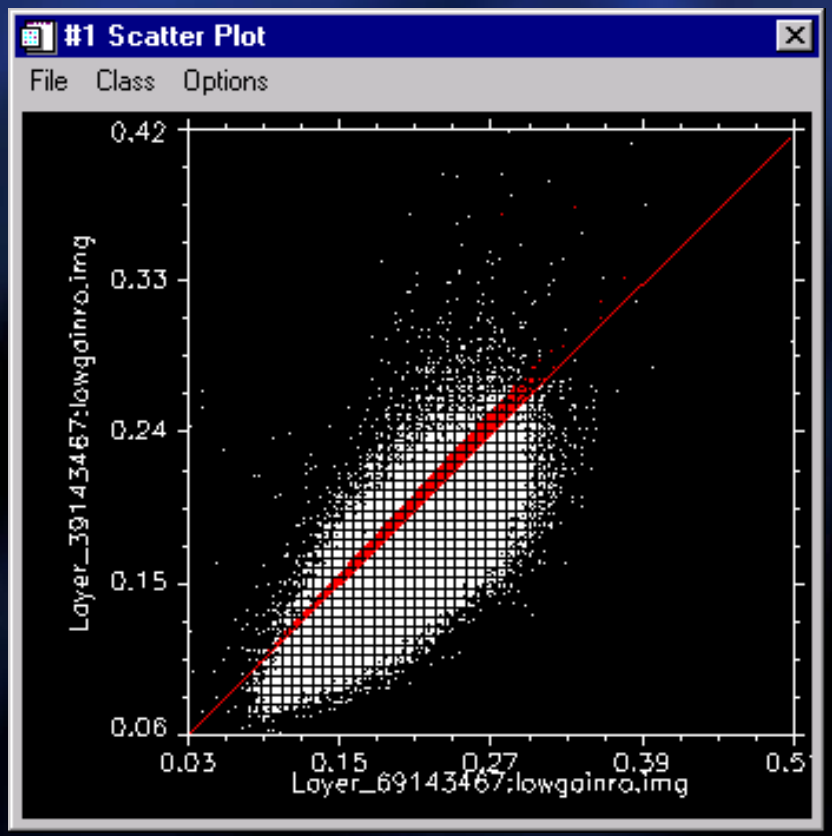
    TM3 = 0.66 TM5

    Assumption: Deviation from these relationships is assumed to be a result from atmospheric effect. By using a radiative transfer model (e.g. 6S or MODTRAN), a proper atmospheric condition can be determined by comparing the scatter plots of these channels (TOA ref.) with simulated data.

Methods

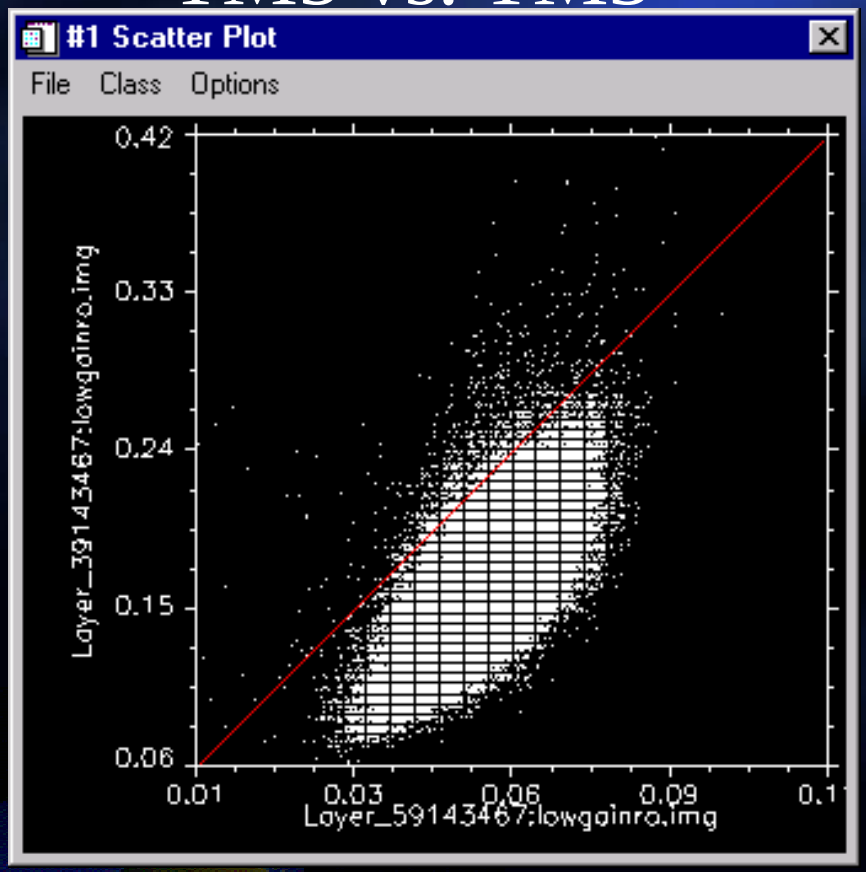
- TM7 vs. TM3

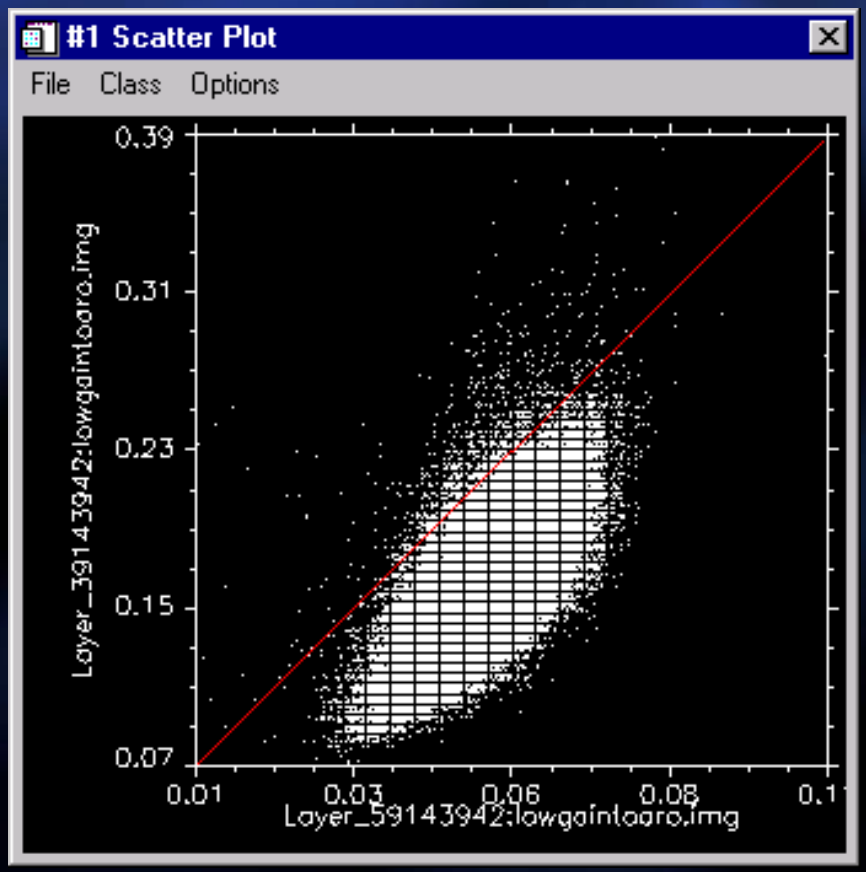




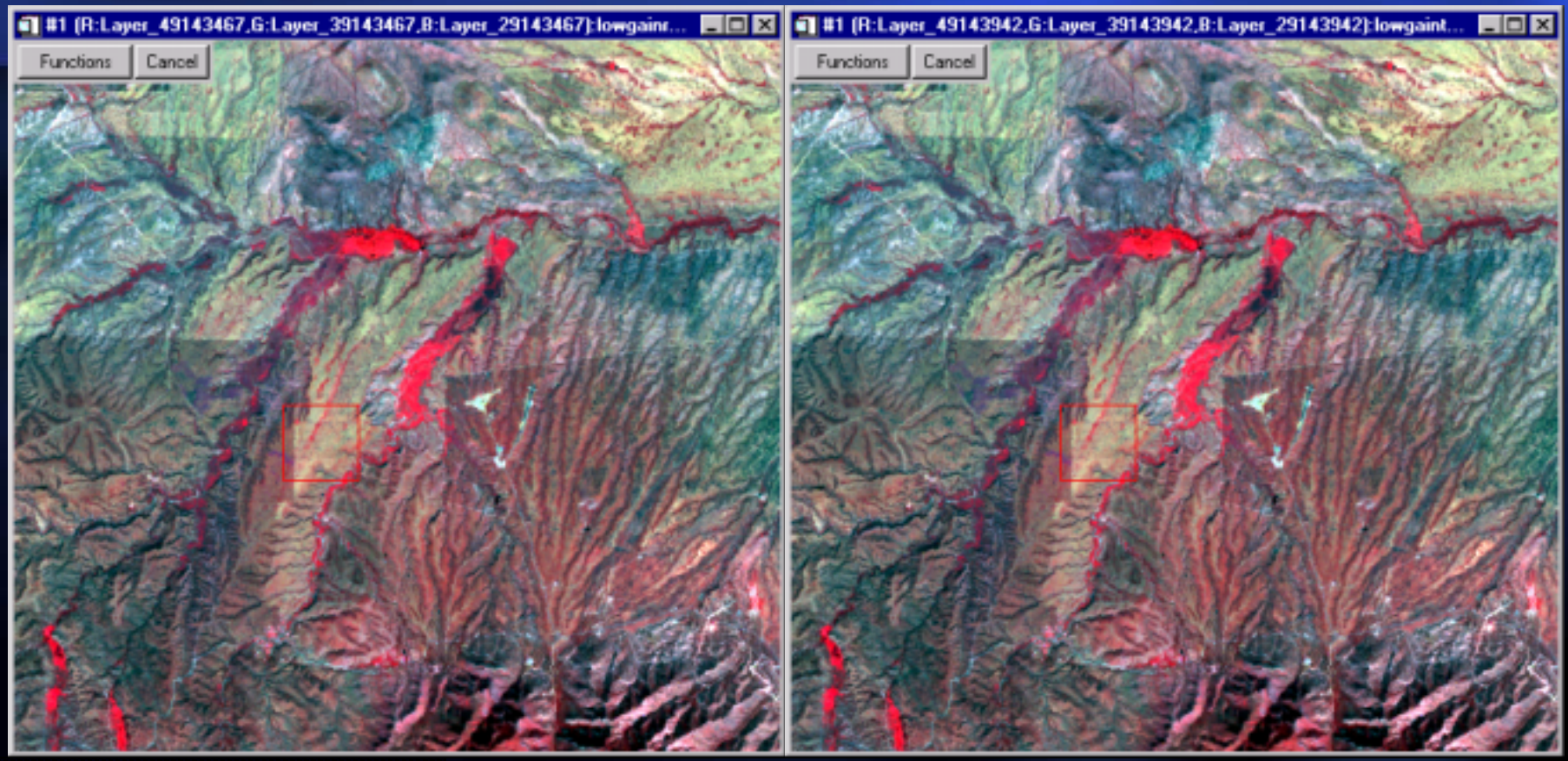
Methods

- TM5 vs. TM3

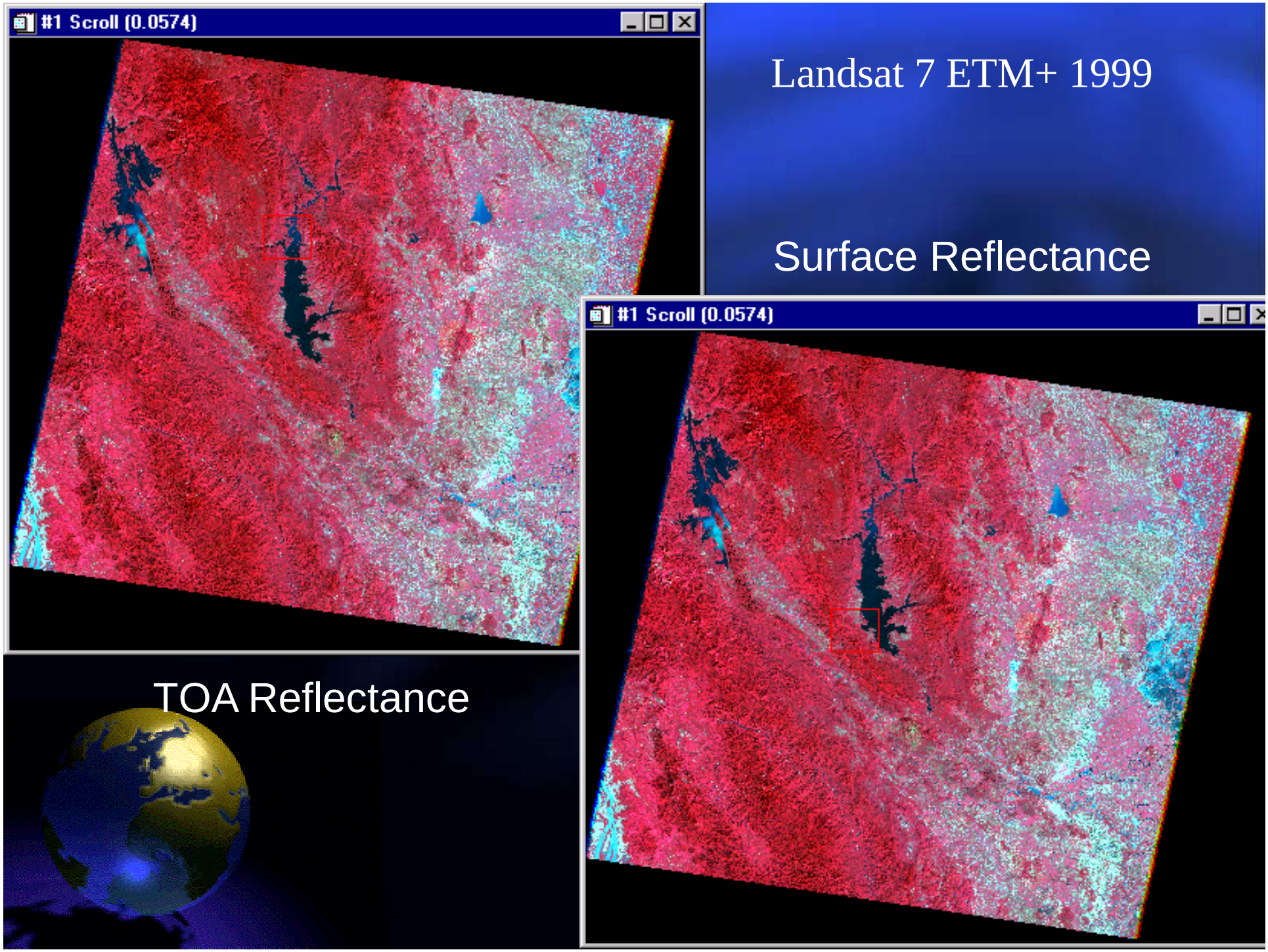




Before and after ATM correction



Landsat 7 ETM+ 1999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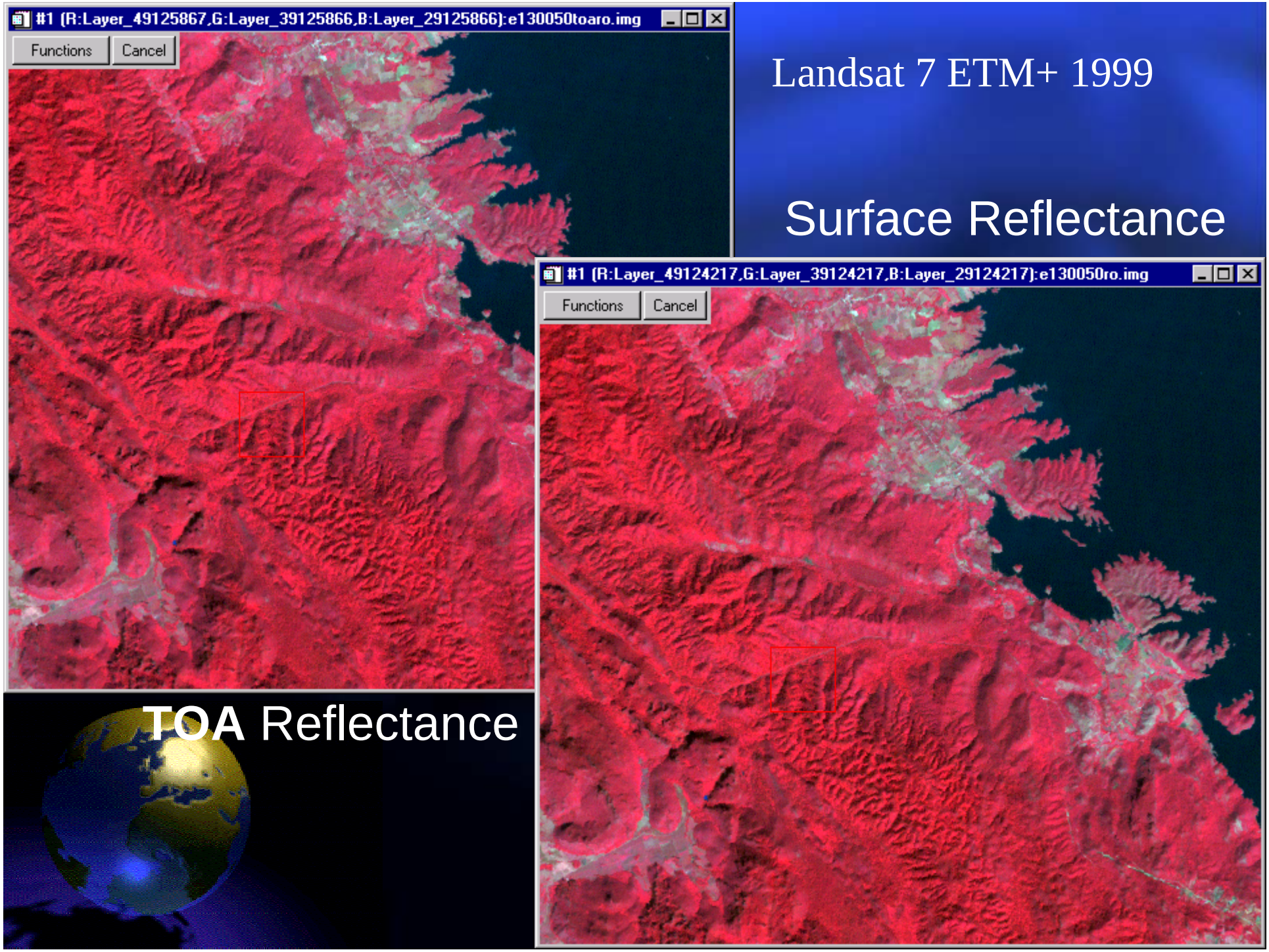
Landsat 7 ETM+ 1999
Surface Reflectance
#1 Scroll (0.0574)
TOA Reflectance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Surface Reflectance
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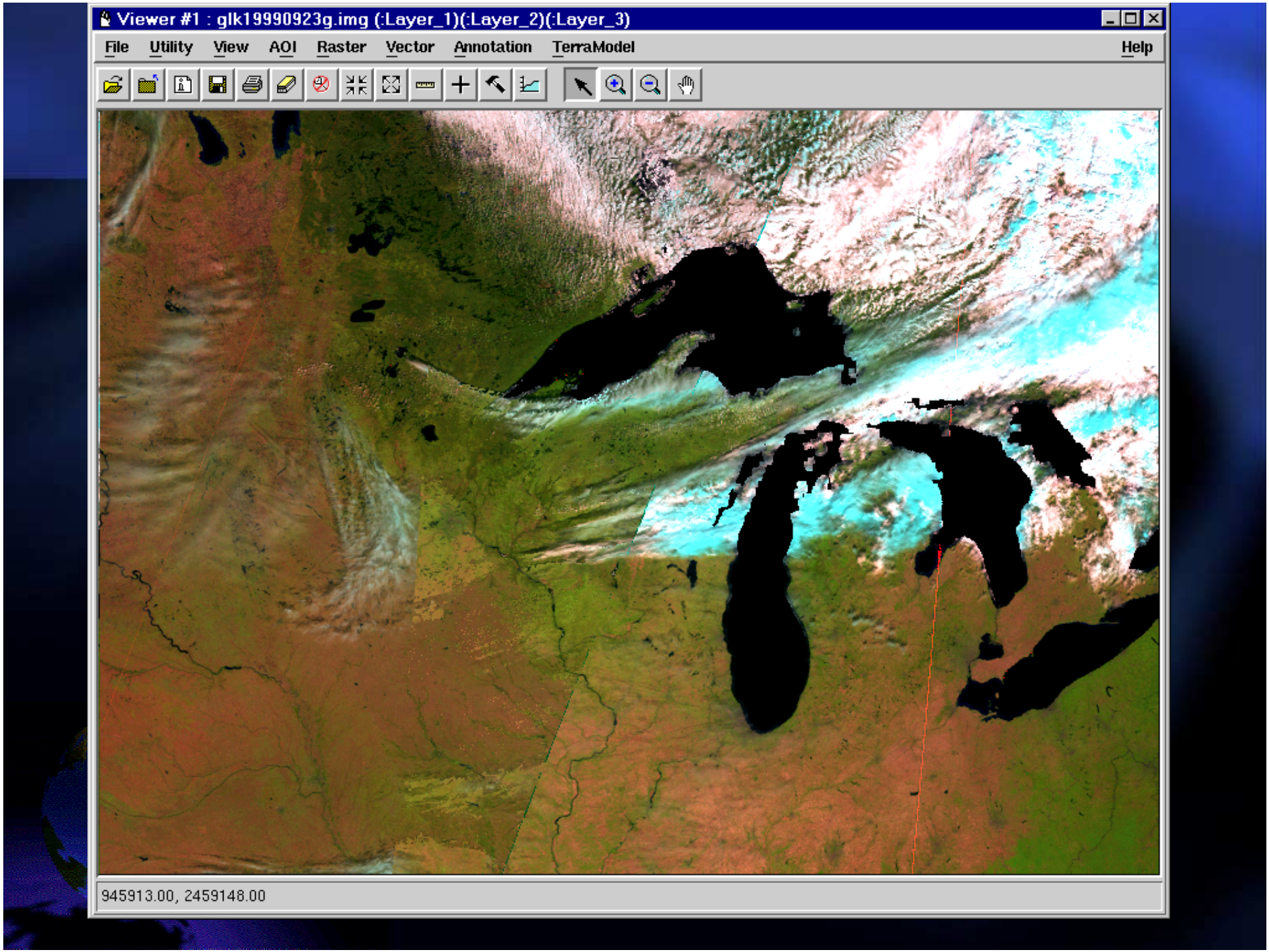
TOA Reflectance

Methods

- Bidirectional Correction
  - Models to be tested
    - Roujean et al., 1992
    - Rahman et al., 1993
    - Kuusk and Nilson, 2000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Utility
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Vector
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Roujean Model (1992)

$$\rho(\theta_s,\theta_v,\varphi) = k_0 + k_1 f_1(\theta_s,\theta_v,\varphi) + k_2 f_2(\theta_s,\theta_v,\varphi)$$

$$f_1(\theta_s,\theta_v,\varphi) = \frac{1}{2\pi}\left((\pi-\varphi)\cos\varphi + \sin\varphi\right)\tan\theta_s \tan\theta_v - \frac{\tan\theta_s + \tan\theta_v + G}{\pi}$$

$$f_2(\theta_s,\theta_v,\varphi) = \frac{4}{3\pi}\frac{1}{\cos\theta_s + \cos\theta_v}\left(\left(\frac{\pi}{2}-\xi\right)\cos\xi + \sin\xi\right) - \frac{1}{3}$$

$$\cos\xi = \cos\theta_s \cos\theta_v + \sin\theta_s \sin\theta_v \cos\varphi$$

$$G = \sqrt{\tan^2\theta_s + \tan^2\theta_v - 2\tan\theta_s \tan\theta_v \cos\varphi}$$

Rahman et al. Model(1993)

$$\rho(\theta_s,\theta_v,\varphi)=\rho_0\frac{\left(\cos\theta_s\cos\theta_v\right)^{k-1}}{\left(\cos\theta_s+\cos\theta_v\right)^{1-k}}\frac{1-\Theta^2}{\left[1+\Theta^2-2\Theta\cos(\pi-\xi)\right]^{3/2}}\left(1+\frac{1-\rho_0}{1+G}\right)$$

$$\cos\xi=\cos\theta_s\cos\theta_v+\sin\theta_s\sin\theta_v\cos\varphi$$

$$G=\sqrt{\tan^2\theta_s+\tan^2\theta_v-2\tan\theta_s\tan\theta_v\cos\varphi}$$

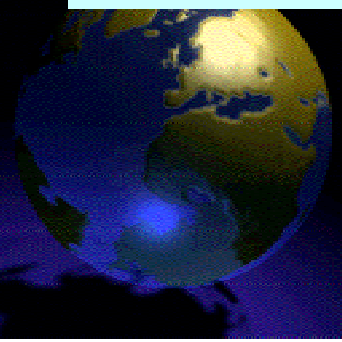
Kuusk and Nilson (2000)

$$\rho(r_1, r_2) = \frac{I}{Q}\rho_1(r_1, r_2) + \frac{D}{Q}\rho_D(r_2)$$

$$\rho_D(r_2) = \frac{\int_{2\pi} d(r_1)\rho_I(r_1, r_2)\mu_1 dr_1}{D} \approx$$

$$\frac{\int_0^{2\pi} d(\theta_1, \phi - \frac{\pi}{2})\rho_I(\theta_1, \theta_2, \phi - \frac{\pi}{2})\mu_1 d\theta_1}{D}$$

$$I(r_1, r_2) = \frac{I_0(r_1)\mu_L\Gamma(r_1, r_2)}{\pi}\int_V p(x, y, z, s_1, s_2, \alpha)dxdydz$$



Methods

- Fractional Cover
  - Unmixing Approach

$$[D] = [R][C]$$

Here, [D] is data matrix, [R] is response matrix, and [C] is the eigenvector matrix consisting of the relative contributions of the reflecting features.

Methods

- Two Components Example

$[D] = [R][C]$ becomes

$$\rho = fc \times \rho_{forest} + (1 - fc)\rho_{soil}$$

$$R(\lambda) = f_v R_v(\lambda) + f_{is} R_{is}(\lambda) + f_{ss} R_{ss}(\lambda)$$

$$R_v(\lambda) = R_\infty(\lambda) + [\rho_s(\lambda) - R_\infty(\lambda)]e^{-C \times LAI}$$

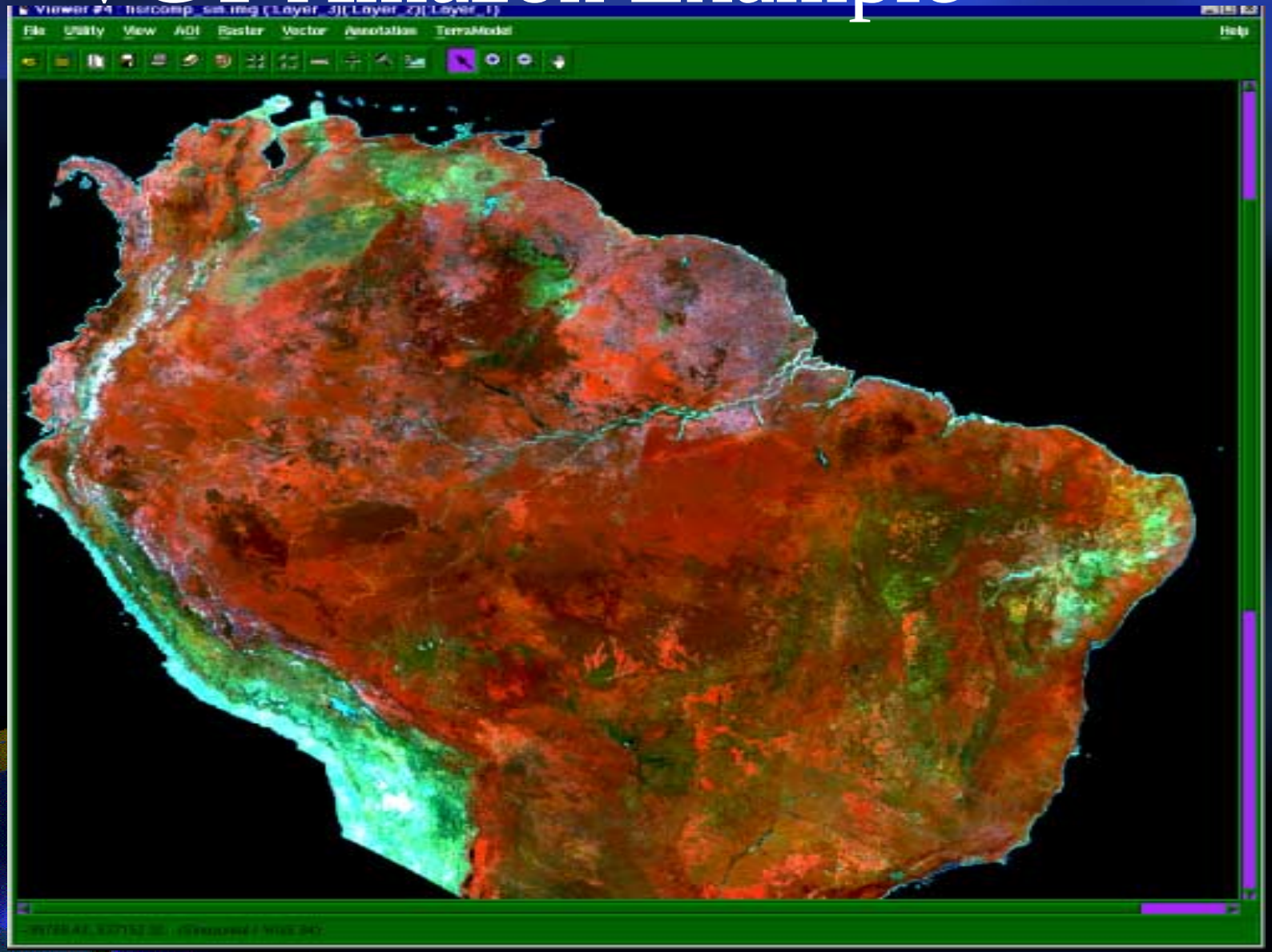
Methods

- When only two components are considered, fractional cover can be estimated with

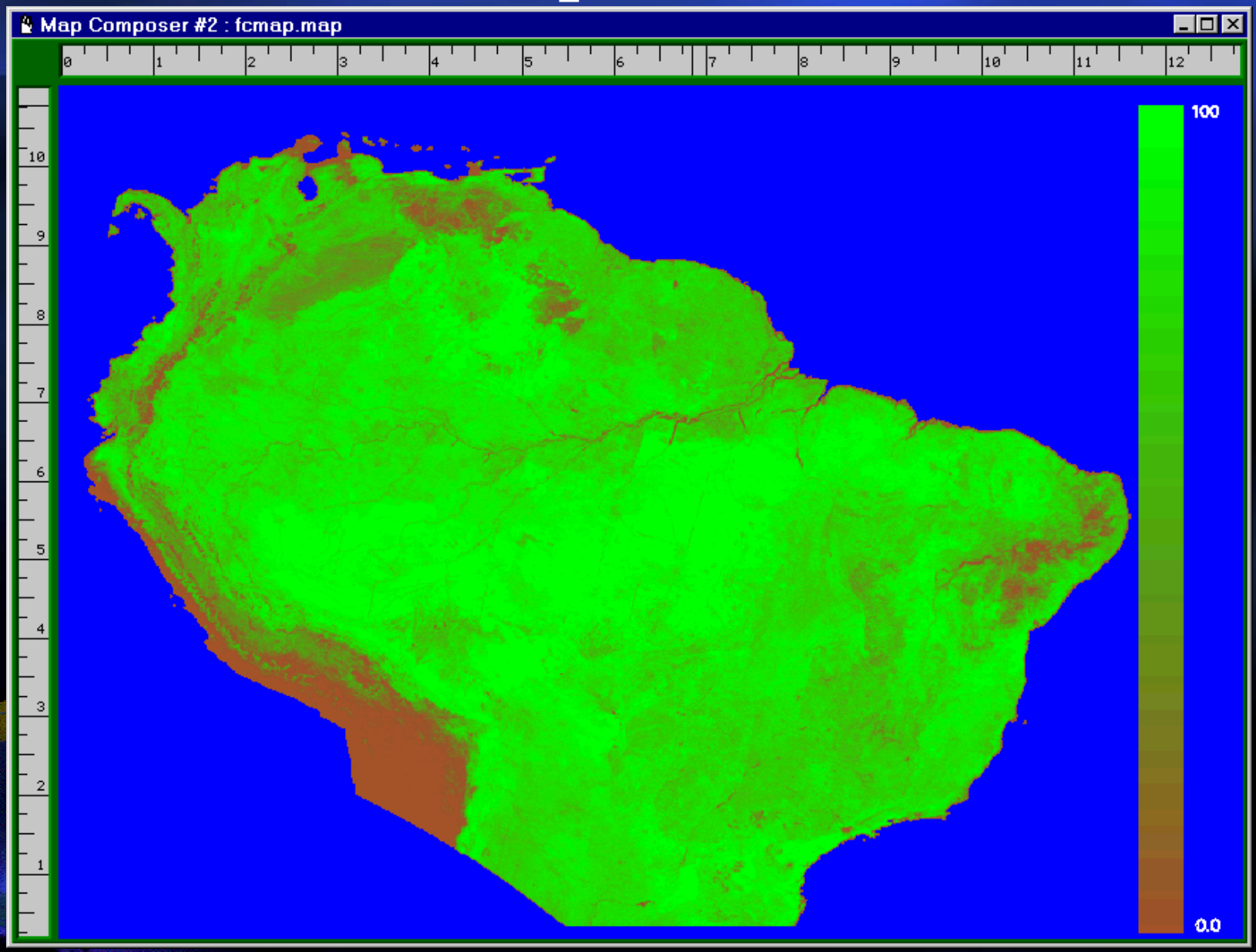
$$fc = \frac{vi - vi_s}{vi_v - vi_s} \times 100\%$$

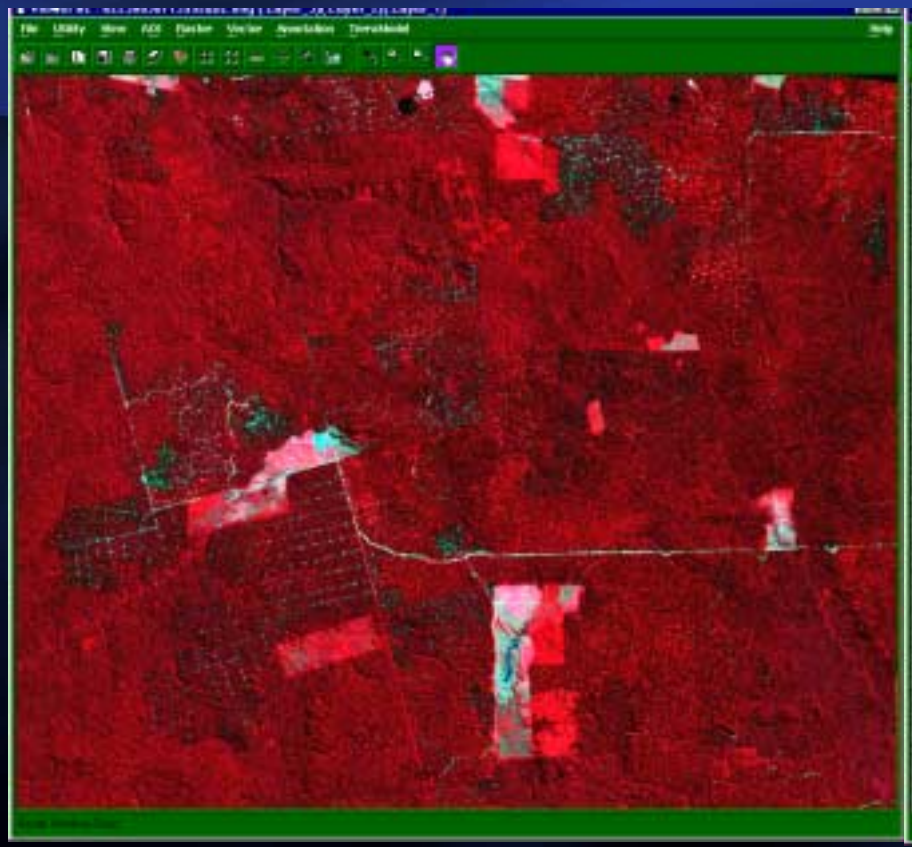
- This equation can be used in vegetation index domain as well, which corresponds to geometric modeling

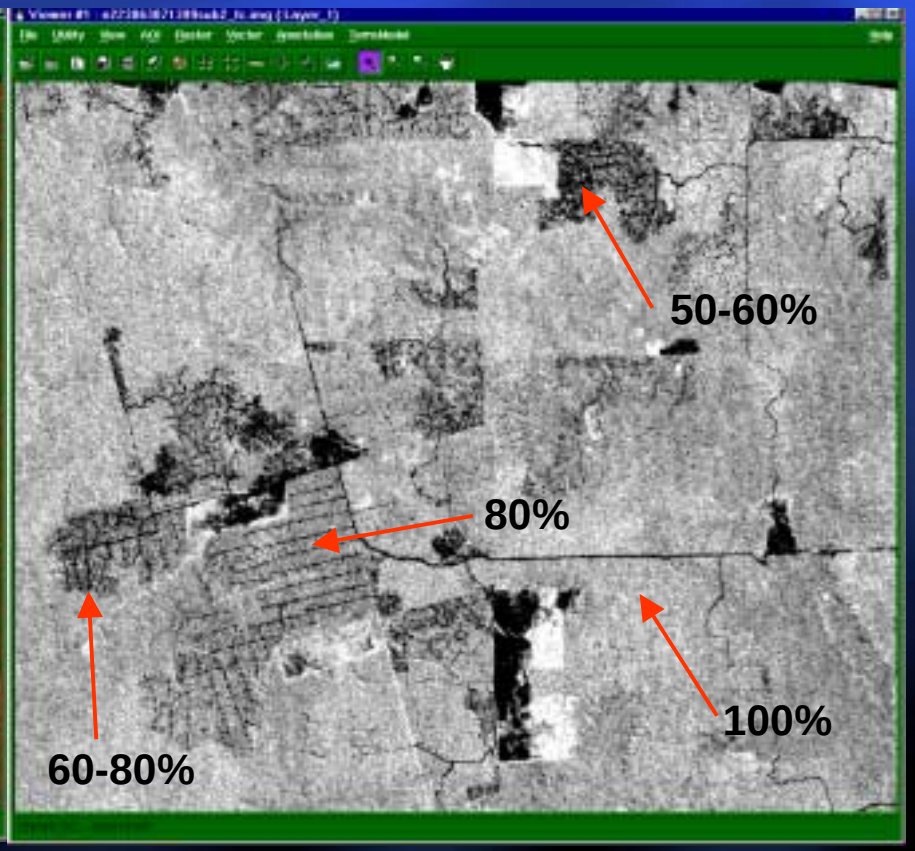
VGT Amazon Example



VGT-FC Example

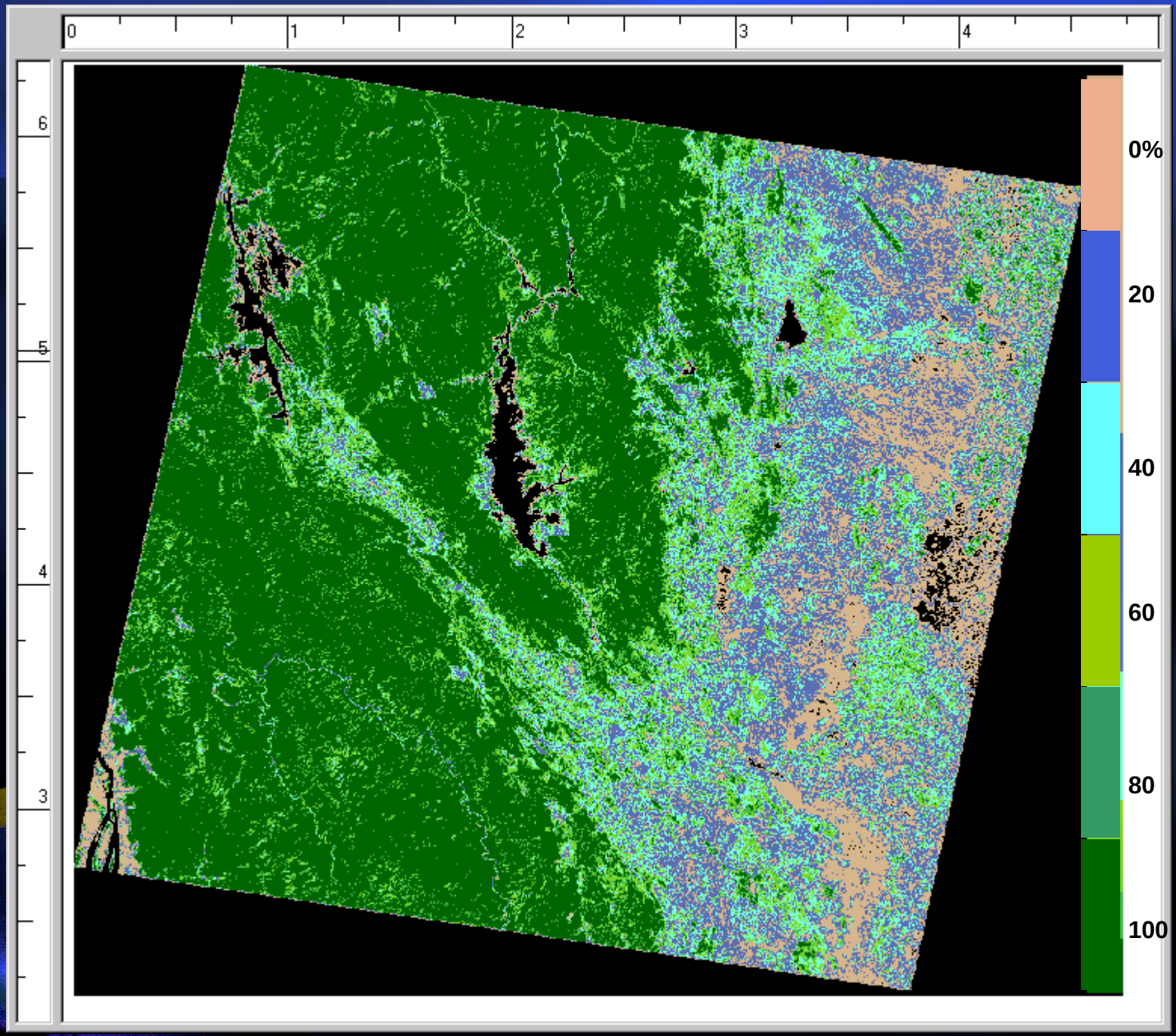






Color composite

Fractional Cover


0
1
2
3
4
6
5
4
3
0%
20
40
60
80
100

Methods

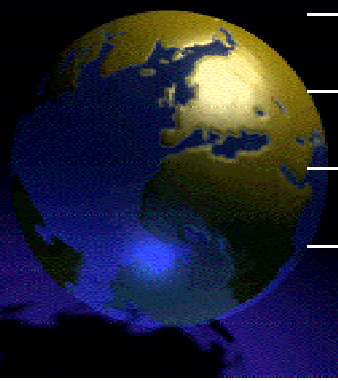
- Green Leaf Area Index/fPAR
  - MODIS approach
    - Inversion of a radiative transfer model
    - Specifically tuned for forest
    - At a broader category
    - To be implemented
  - Empirical Approach
    - Vegetation Indices
    - MODIS VI is one of the candidates
    - New index
  - Synergistic use of SAR and Optical
    - Some success, but need R&D

Product Calibration & Validation

- Calibration and Validation of Products will be made in three ways:
  - Top Down Approach
    - Validate large scales with fine IKONOS and airphotos
  - Use existing data at our case study sites via SEA Network
    - LCLUC data exist at Case Study sites with coincident TM and ETM+ images. Products developed will be calibrated and verified with existing data sets
  - Collect supporting data at intensive sites
    - Field works via SEA Network

Southeast Asia Science Network

- Thailand
  - National Resource Council of Thailand
  - Land Development Department
  - Royal Forestry Department of Thailand
  - Kesetsart University
  - Mahidol University
  - Chiang Mai University
- Malaysia
  - University Kebangsaan Malaysia
  - Department of Agriculture Malaysia
  - Forestry Department Malaysia
  - Malaysian Center for Remote Sensing (MACRES)



Southeast Asia Science Network

- Philippines
  - National Mapping and Resource Information Authority (NAMRIA)
  - National Research Council of the Philippines
  - National Economic Development Authority (NEDA)
  - Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)
- Indonesia
  - Agency for Assessment and Application of Technology (BPPT)
  - National Institute of Aeronautics and Space (LAPAN)
  - National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL)
  - Center for Development Studies, Bogor Agricultural University (BSP-IBP)

NASA LCLUC Southeast Asia Science Team

USA

Dr. David L. Skole, Director, Basic Science and Remote Sensing Initiative, Dept. of Geography, Michigan State University (Principal Investigator)
Dr. Maureen Cropper, UMD and The World Bank
Mr. Walter Chometowski, BSRSI, Dept. of Geography, Michigan State University
Mr. Jay Samek, BSRSI, Dept. of Geography, Michigan State University
Mr. William Salas, University of New Hampshire

Indonesia

Dr. Ir. Indroyono Soesilo, BPPT
Dr. Ir. Mahdi Kartasasmita, LAPAN
Dr. Iwan Gunumwan, BPPT
Mr. Asep Karsidi, BPPT
Ir. Muchamad Muchlis JI., LAPAN
Dr. Arco Nurlambang, University of Indonesia
Mr. Hartanto Sanjaya, BPPT
Mr. Andi Rahmadi, BPPT
Dr. Siti Adiprigandari Adiwoso Suprato, University of Indonesia

Philippines

Dr. Flaviana D. Hilario, PAGASA
Dr. Virgilio S. Santos, NAMRIA
Ms. Alma Arquero, NAMRIA
Mr. Romeo Tejada, NAMRIA,
Mr. Bobby Crisostomo, NAMRIA
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Mr. Sunday Langad, NAMRIA
Mr. Jojo Bernardo, NEDA
Ms. Cresencia Cadiente, NAMRIA
Ms. Evangeline Saracanlao, NAMRIA

China -Taipei

Dr. Chin-Hong Sun, National Taiwan University
Dr. David Chang, National Taiwan University

Malaysia

Dr. Sharifah Mastura Syed Abdullah, Dept. of Geography,Universiti Kebangsaan Malaysia
Dr. Othman Bin A. Karim, Dept. of Civil & Structural Engineering Faculty of Engineering, Universiti Kebangsaan Malaysia
Dr. Abdul Rahim Md. Nor, Dept. of Geography, Universiti Kebangsaan Malaysia
Dr. Abd. Rahim Md. Nor, Dept. of Geography, Universiti Kebangsaan Malaysia
Dr. Asmah Ahmad, Dept. of Geography, Universiti Kebangsaan Malaysia
Dr. Rahimah Adb. Aziz, Dept of Anthopology and Sociology, Universiti Kebangsaan Malaysia
Dr. Maimon Abdullah, Dept. of Zoology, Universiti Kebangsaan Malaysia
Dr. Zuriata Zakaria, Dept. of Chemestry, Universiti Kebangsaan Malaysia
Dr. Juhari Mat Akhir, Dept. of Geology, University of Kebangsaan Malaysia
Dr. Mahamud Ismail, Dept. of Civil Engineering, Universiti Kebangsan Malaysia
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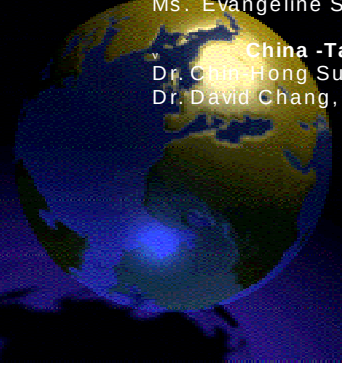
Mr. Lam Kuok, Dept. of Geography, Universiti Kebangsaan Malaysia
Mr. Alias Sood, Malasia Forestry Department
Mr. Laili Nordin, MACRES

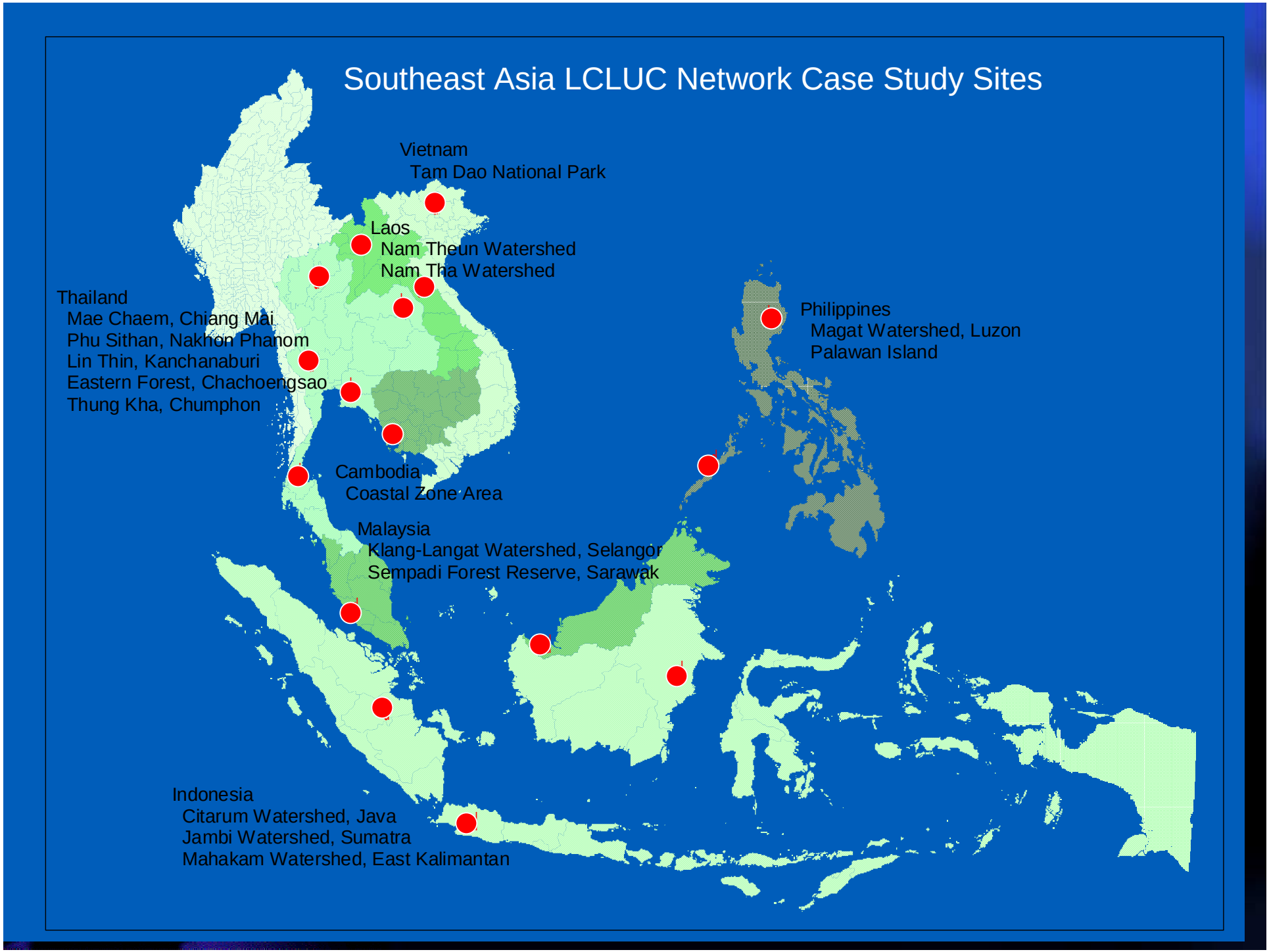
Thailand

Dr. Yothin Sawangdee, Institute for Population and Social Research Mahidol University at Salaya
Dr. Charlie Navanugraha, Faculty of Environment and Resource Studies Mahidol University
Dr. Suwit Ongsomwang, Forest Research Office Royal Forest Department
Dr. Chumpol Wantanasarn, Director, Land Use Planing Division Department of Land Development
Mr. Kamron Saifuk, Department of Land Development Landuse Planning Division
Ms. Dararat Disbunchong , Remote Sensing Division National Research Council of Thailand
Dr. Pong-In Rakariyatham, Faculty of Social Sciences Chiang Mai University
Prof. Kasem Chunkao, Faculty of Forestry, Kasetsart University
Dr. Wasant Pongsapich, The Environmental Research Institute, Chulalongkorn University
Mr. Chetphong Butthep, National Research Council of Thailand
Dr. Jariya Boonjawat, SEA START RC, The Environmental Research Institute, Chulalongkorn University

Vietnam

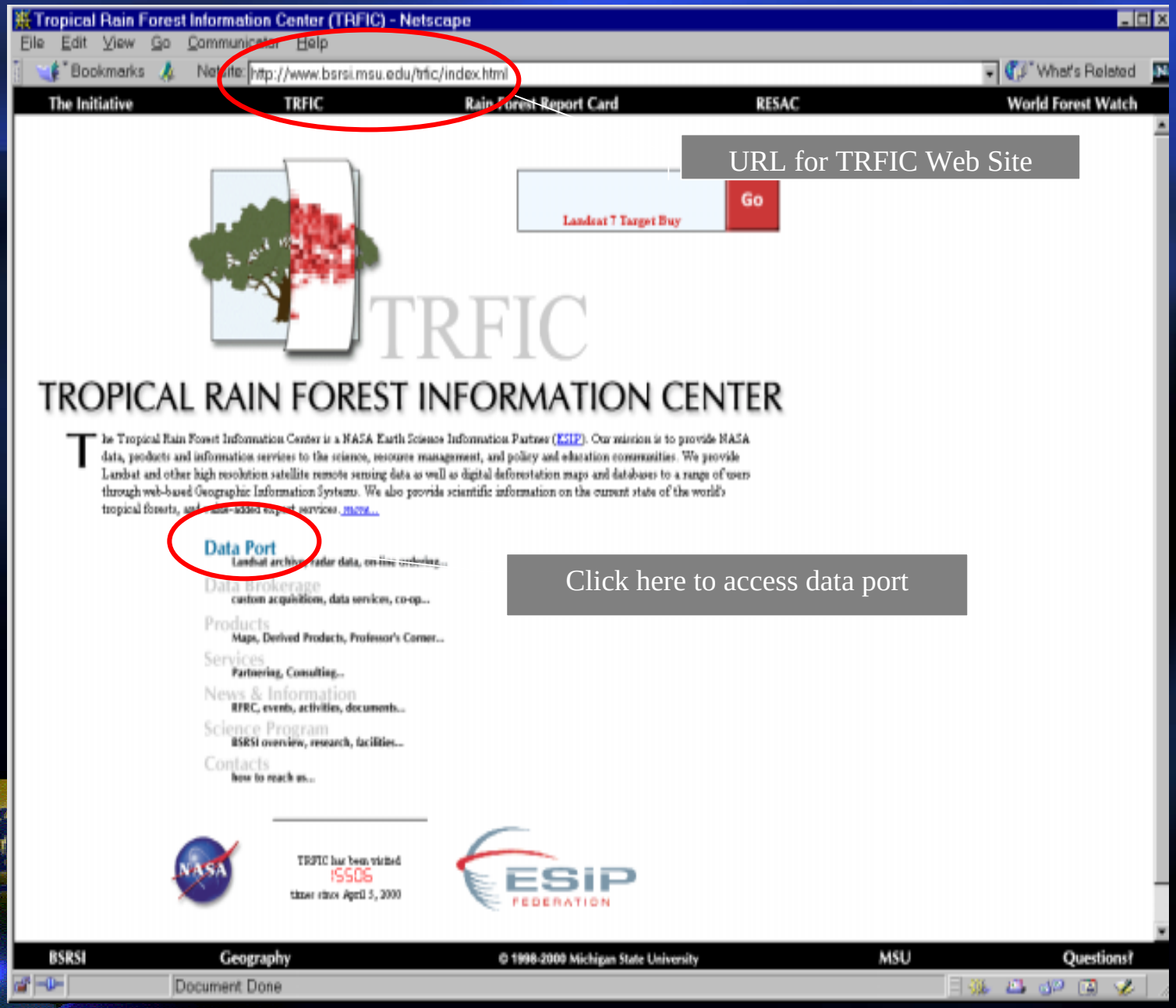
Dr. Hoang Minh Hien, Hydro-Meteorological Service of Vietnam
Ms. Tran Thi Bang Tam, Hanoi Agricultural University




Southeast Asia LCLUC Network Case Study Sites
Vietnam
Tam Dao National Park
Laos
Nam Theun Watershed
Nam Tha Watershed
Thailand
Mae Chaem, Chiang Mai
Phu Sithan, Nakhon Phanom
Lin Thin, Kanchanaburi
Eastern Forest, Chachoengsao
Thung Kha, Chumphon
Philippines
Magat Watershed, Luzon
Palawan Island
Cambodia
Coastal Zone Area
Malaysia
Klang-Langat Watershed, Selangor
Sempadi Forest Reserve, Sarawak
Indonesia
Citarum Watershed, Java
Jambi Watershed, Sumatra
Mahakam Watershed, East Kalimantan

Information Dissemination

- TRFIC (**Tropical Rain Forest Information Center**)
  - An operational site has been established and functioning well
  - Online to disseminate data and information
  - Major protocol for this project
  - A few examples of the TRFIC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TROPICAL RAIN FOREST INFORMATION CENTER
The Tropical Rain Forest Information Center is a NASA Earth Science Information Partner (ESIP). Our mission is to provide NASA data, products and information services to the science, resource management, and policy and education communities. We provide Landsat and other high resolution satellite remote sensing data as well as digital deforestation maps and databases to a range of users through web-based Geographic Information Systems. We also provide scientific information on the current state of the world's tropical forests, and value-added support services. more...
Data Port
Landsat archive, radar data, on-line ordering...
Data Brokerage
custom acquisitions, data services, co-op...
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Maps, Derived Products, Professor's Corner...
Services
Partnering, Consulting...
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15506
times since April 5, 2000
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Landsat 7 Target Buy for Southeast Asia.
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Data Archive

TRFIC Landsat Data Holdings

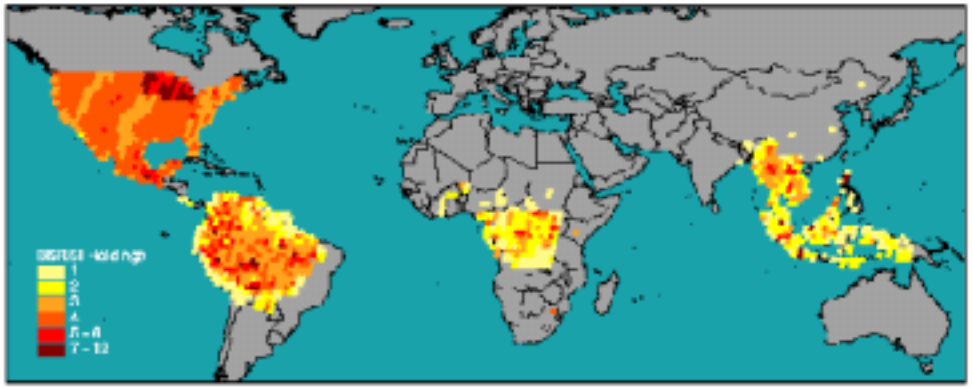


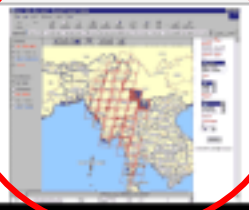
Table of Holdings by Region and Sensor

Landsat 7 ETM+ data are now available for the Brazilian Amazon.

Preview map of ETM+ acquisitions

Browsing and

Click here to access TRFIC Core System

Option 1	Option 2
	

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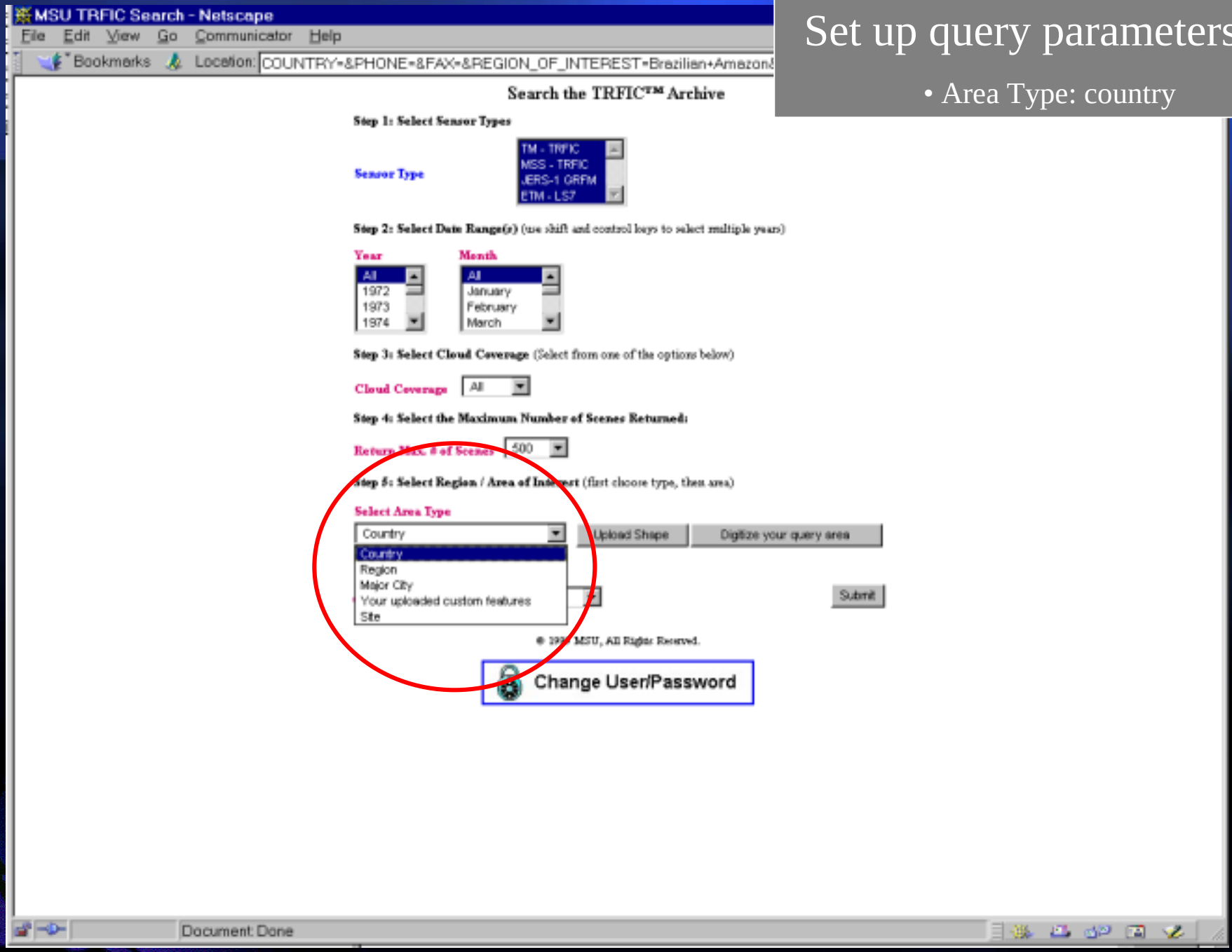
samekjay
Password: *
Log in
*(The above information is mandatory for access to the TRFIC Web GIS.
First-time users can create their own new passwords.)
These fields are optional. Please complete them if you have time. Your feedback will assist TRFIC in meeting the needs of our user community more efficiently and more effectively.
• Name (First, MI, Last)
• Organization
• Title
• Mailing Address
Document: Done

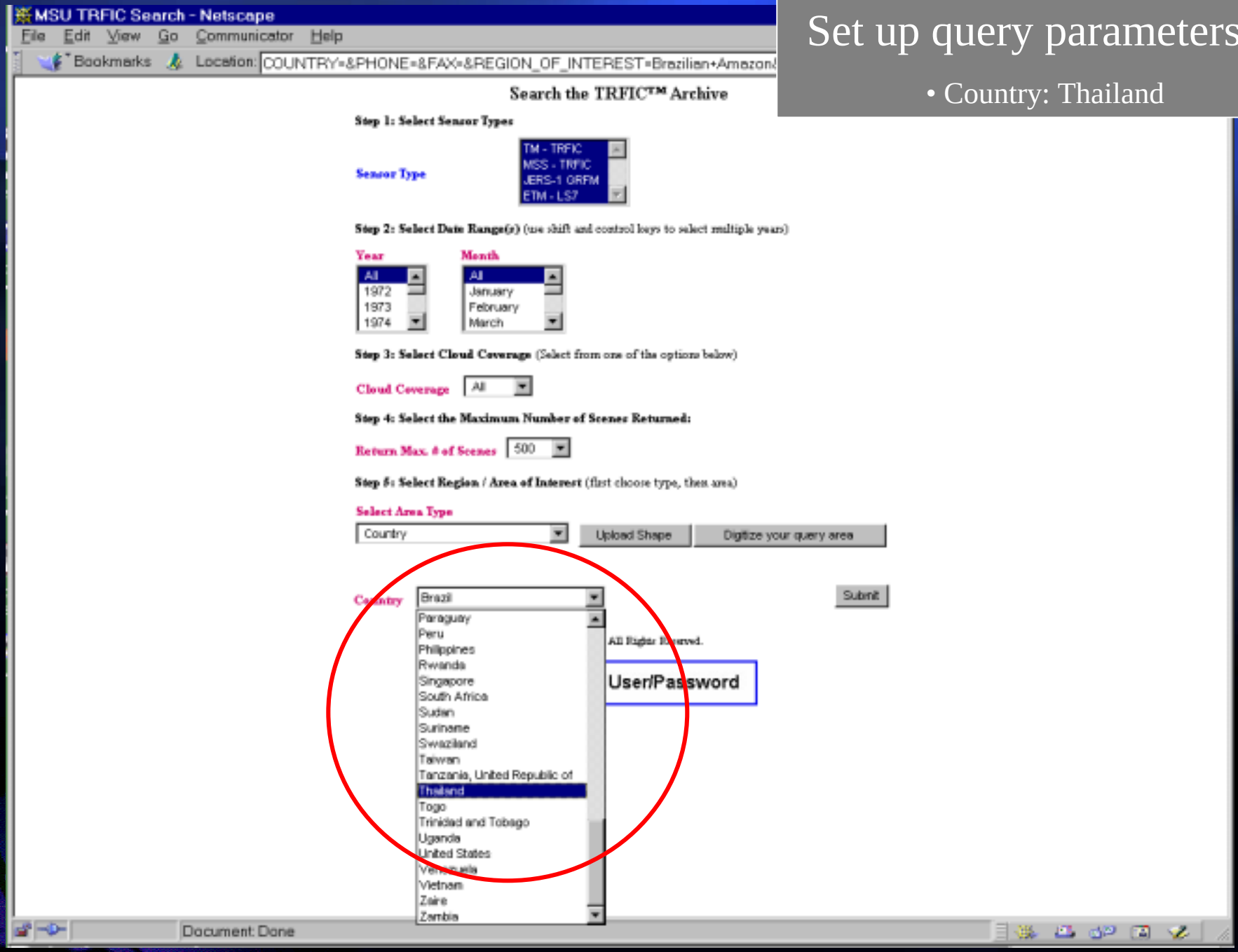
Set up query parameters

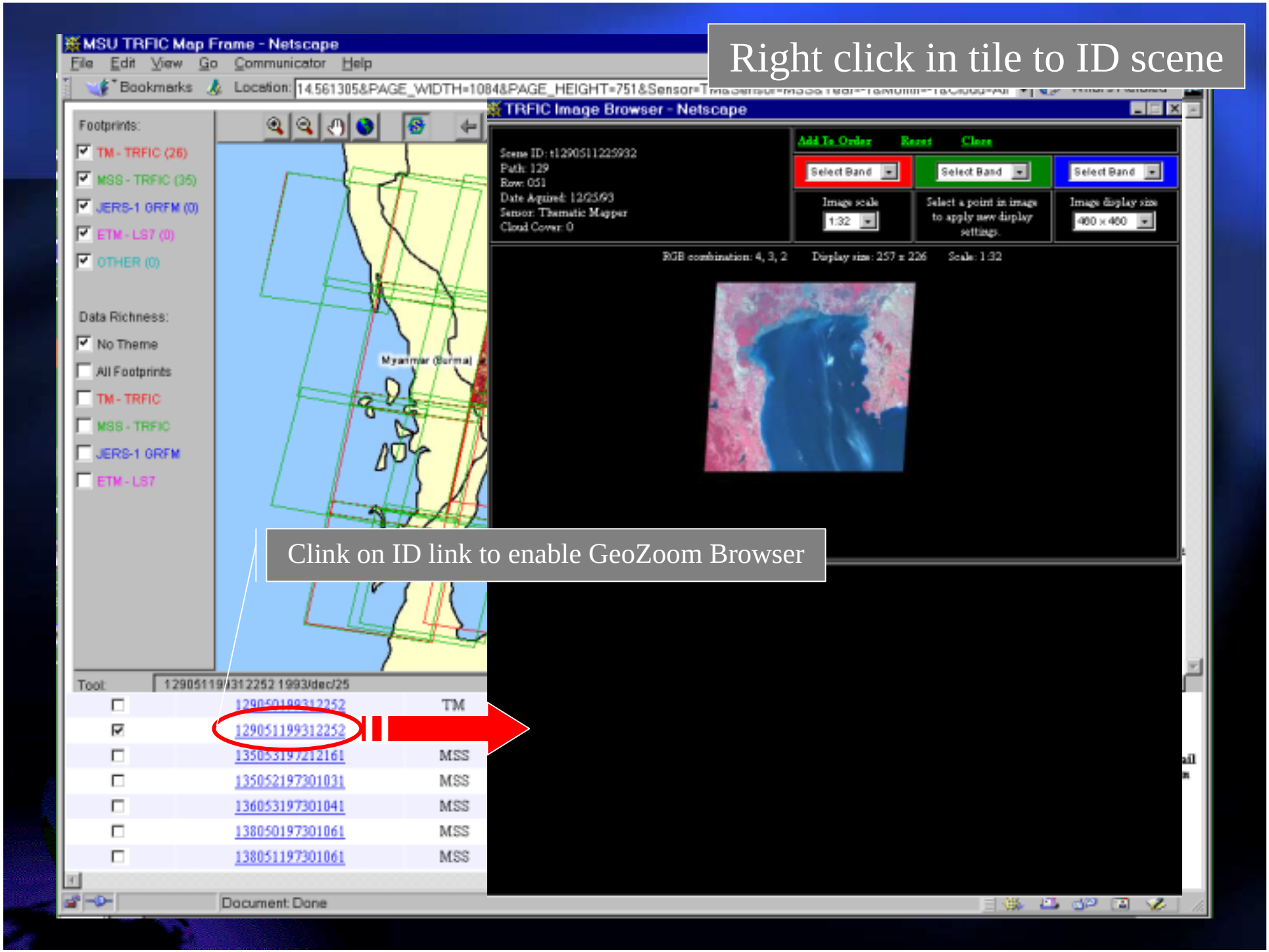
- Area Type: country



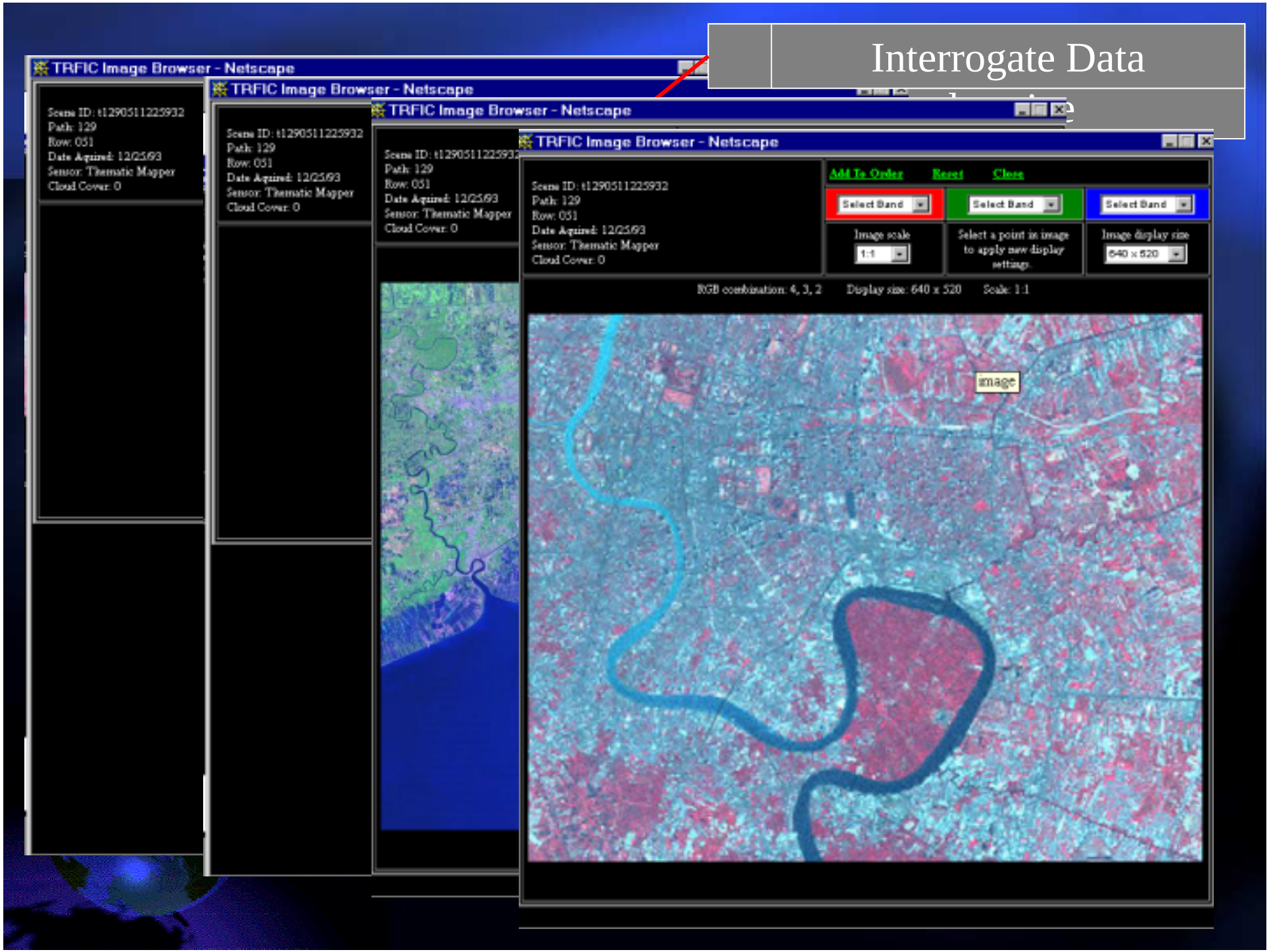
Set up query parameters

- Country: Thailand




Right click in tile to ID scene
MSU TRFIC Map Frame - Netscape
File Edit View Go Communicator Help
Bookmarks Location:
TRFIC Image Browser - Netscape
Add To Order
Reset
Close
Select Band
Select Band
Select Band
Image scale
1:32
Select a point in image to apply new display settings.
Image display size
400 x 400
RGB combination: 4, 3, 2
Display size: 257 x 226
Scale: 1:32
Footprints:
TM - TRFIC (26)
MSS - TRFIC (35)
JERS-1 GRFM (0)
ETM - LS7 (0)
OTHER (0)
Data Richness:
No Theme
All Footprints
TM - TRFIC
MSS - TRFIC
JERS-1 GRFM
ETM - LS7
Myanmar (Burma)
Clink on ID link to enable GeoZoom Browser
Tool:
129051199312252 1993/dec/25
129051199312252 TM
135053197212161 MSS
135052197301031 MSS
136053197301041 MSS
138050197301061 MSS
138051197301061 MSS
Document: Done

Interrogate Data



Data Plan: *what the project will provide*

- Historical Landsat from TRFIC
- Year 2000 Landsat 7 acquisition
- Spot 4 VGT from VEGA 2000 campaign is likely
- MODIS from standard MODLand products
- Calibration data from test sites provided by SE Asia GOFC research network teams
- Validation supported with ancillary data at test sites
- Data access and distribution using TRFIC services; will provide also to GOFC scientists (TRFIC can support the Science Team needs as well as a distribution/hosting service)

Data Plan: *what the project needs*

- Updated Landsat 7 acquisition for 2001/2002, approximately 300 scenes
- IKONOS acquisition for validation, from NASA data buy program, approx. 30 scenes
- Selected ASTER data, approx 80 scenes
- Selected MISR data, approx 20 scenes

Work Schedule

- ETM+ acquisition is continuing
- Requested VEGETATION images for 11/99 – 12/00 period
- Product Development
  - Started and will continue into 2nd year
  - Validation will start next summer
- Calibration and Validation
  - Ongoing till 2002