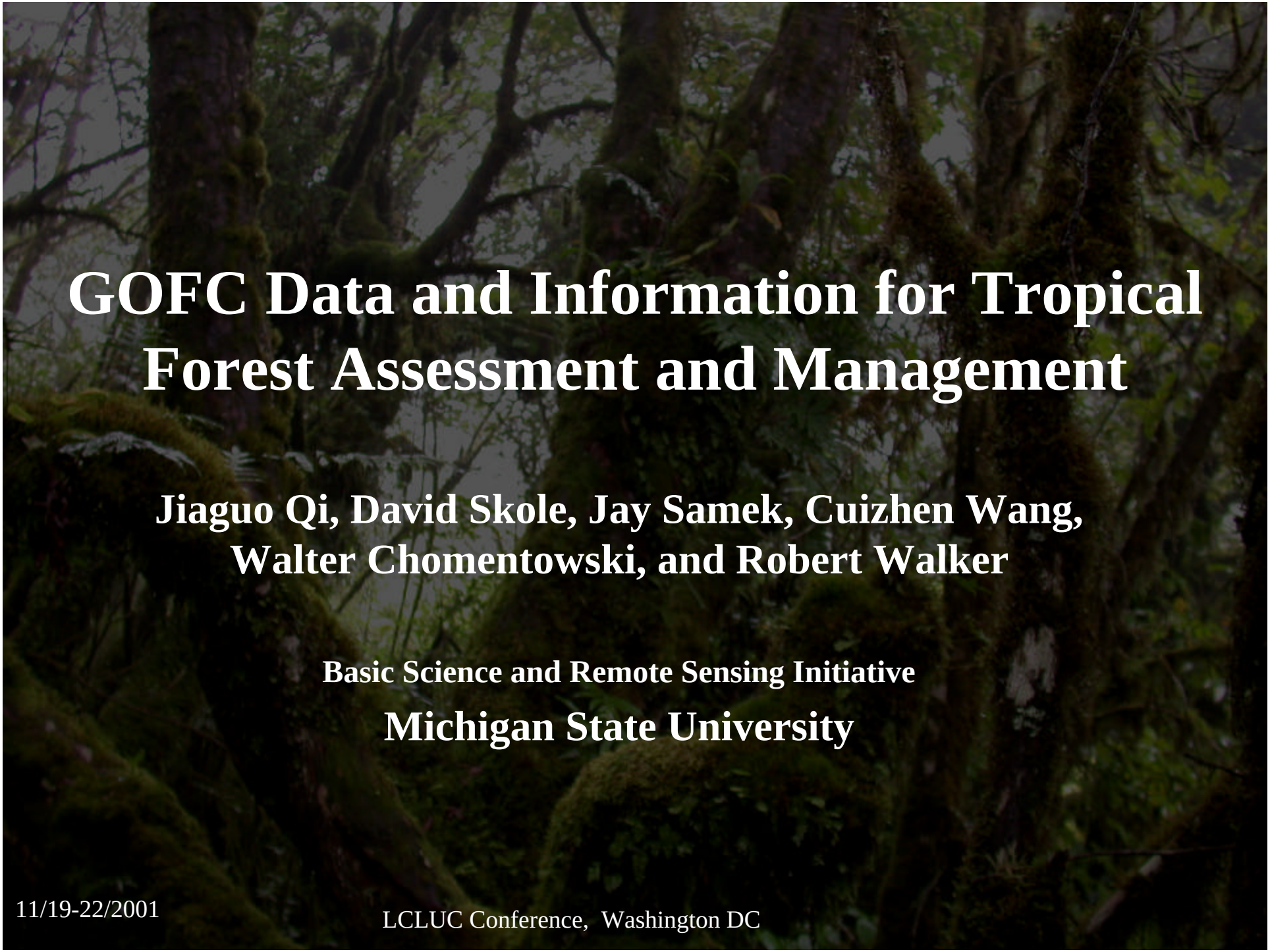

GOFC Data and Information for Tropical Forest Assessment and Management

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Basic Science and Remote Sensing Initiative

Michigan State University

11/19-22/2001

LCLUC Conference, Washington DC

Initial Project Objectives:

- **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 strengthen linkages with national resource and forest management services collaborators for better dissemination of GOFC products**

Proposed Activities and Questions to Be Addressed

- Development of New Datasets and Data Products
- Product Validation, Evaluation, and Outreach
- Information Dissemination via TRFIC

- These products would allow one to move from qualitative to quantitative assessment of carbon stocks in tropical regions

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

Where We Are

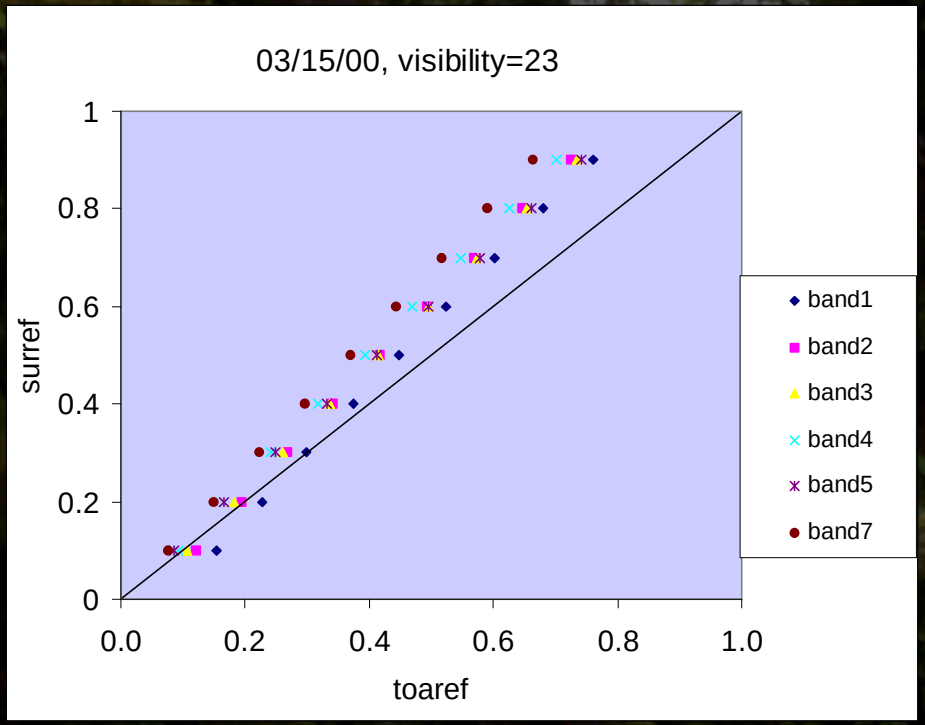
- Development of New Datasets and Products
  - Georeferenced Products – Done
  - Atmospheric Corrections
    - Algorithms proposed and being tested
  - Bidirectional Correction
    - BRDF models selected and being tested for operational applications
  - Biophysical Products
    - Fractional cover – Being validated
    - Green leaf area index – To be validated

Methods – Atmospheric Correction

- Radiative Transfer Models
  - Requires visibility data
  - Often available from nearby airports
- Simple Empirical Approach

Methods – Atmospheric Correction

- MODTRAN
  - Atmosphere model: Tropical atmosphere
  - Aerosol model: Rural extinction
  - Visibility = 23km



$$band\ 1: \quad r_{surf} = 1.3227\, r_{TOA} - 0.0978$$

$$band\ 2: \quad r_{surf} = 1.3235\, r_{TOA} - 0.0556$$

$$band\ 3: \quad r_{surf} = 1.2731\, r_{TOA} - 0.0317$$

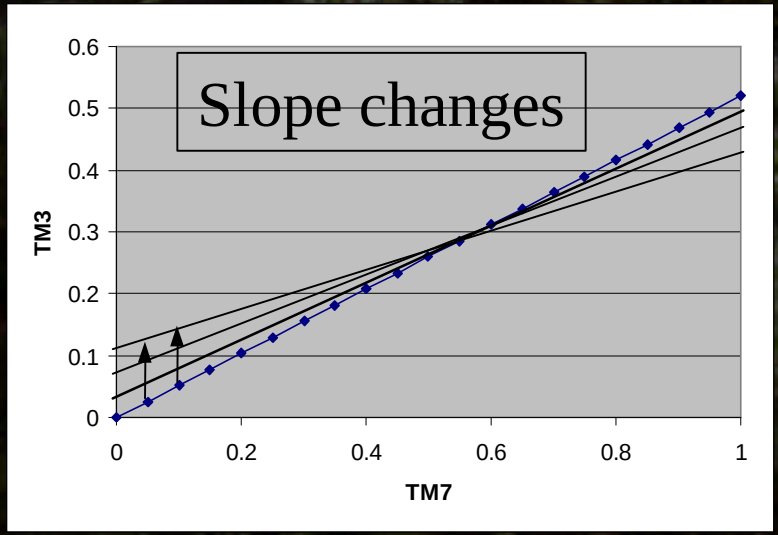
$$band\ 4: \quad r_{surf} = 1.3089\, r_{TOA} - 0.0017$$

$$band\ 5: \quad r_{surf} = 1.2167\, r_{TOA} - 0.0028$$

$$band\ 7: \quad r_{surf} = 1.3586\, r_{TPA} - 0.0017$$

Methods – Atmospheric Correction

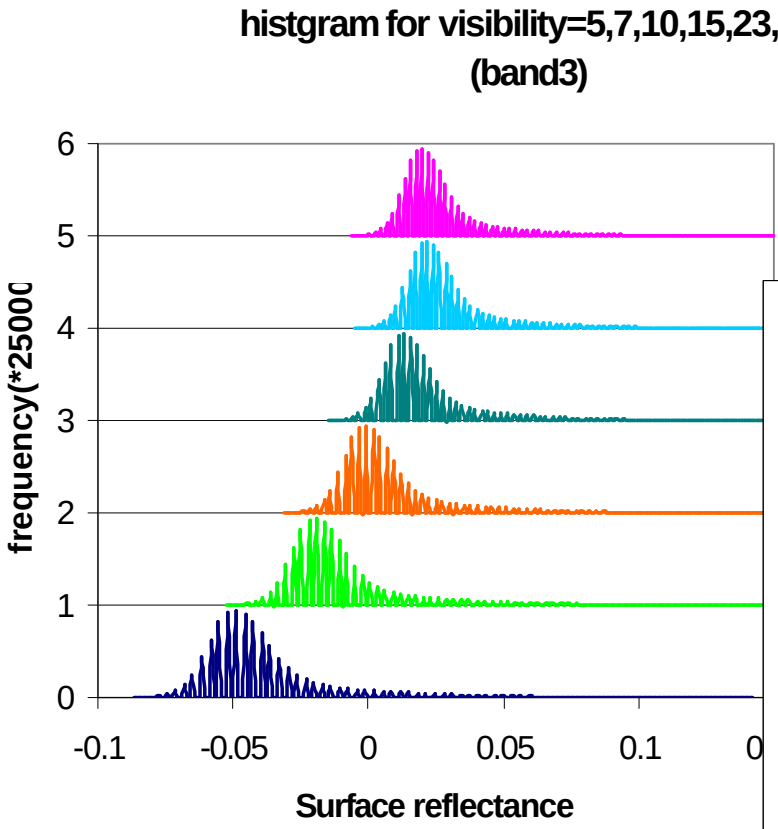
- Simple Empirical Approach

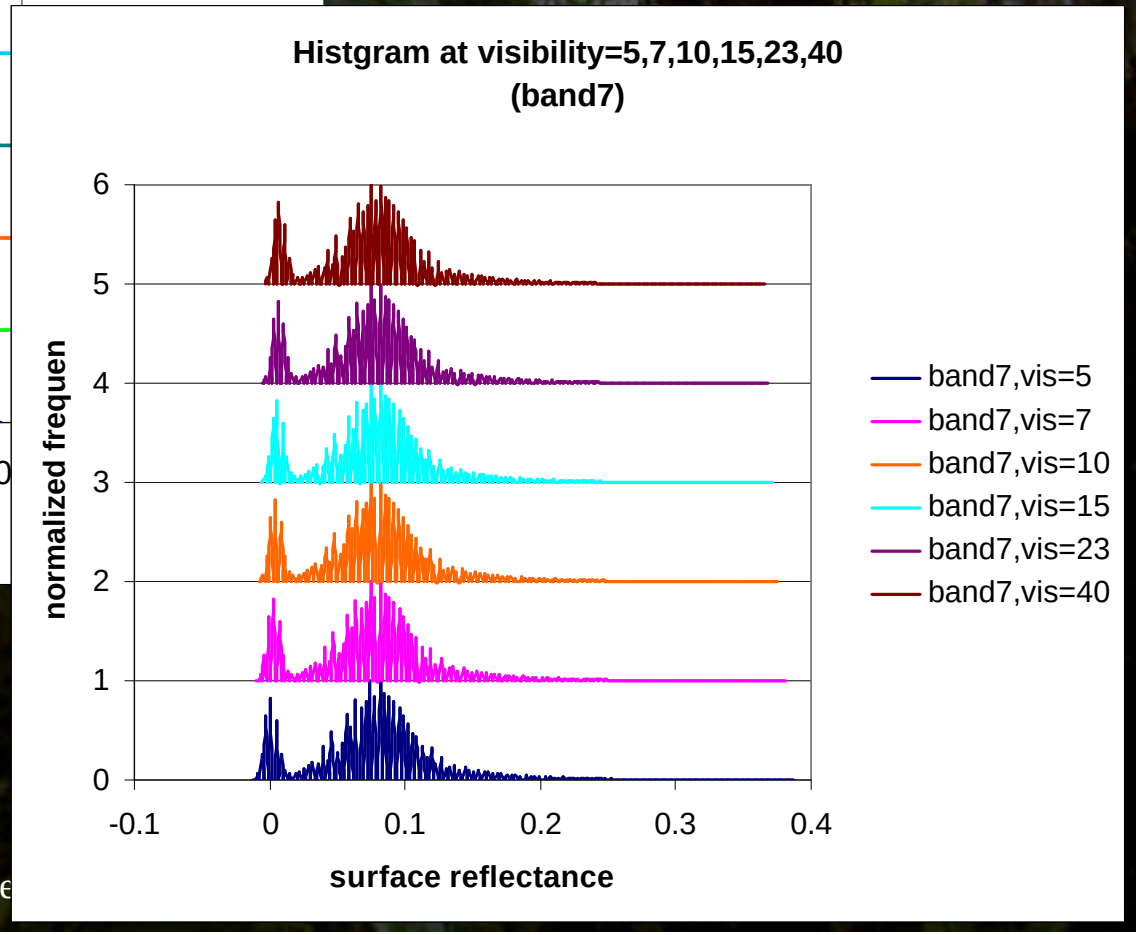


TM3 = 0.50 TM7 + a
TM3 = 0.66 TM5 + b

  - Deviation from these relationships is assumed to be a result from atmospheric effect. By using a radiative transfer model (MODTRAN), a proper atmospheric condition can be determined by comparing the scatter plots of these channels with simulated data.

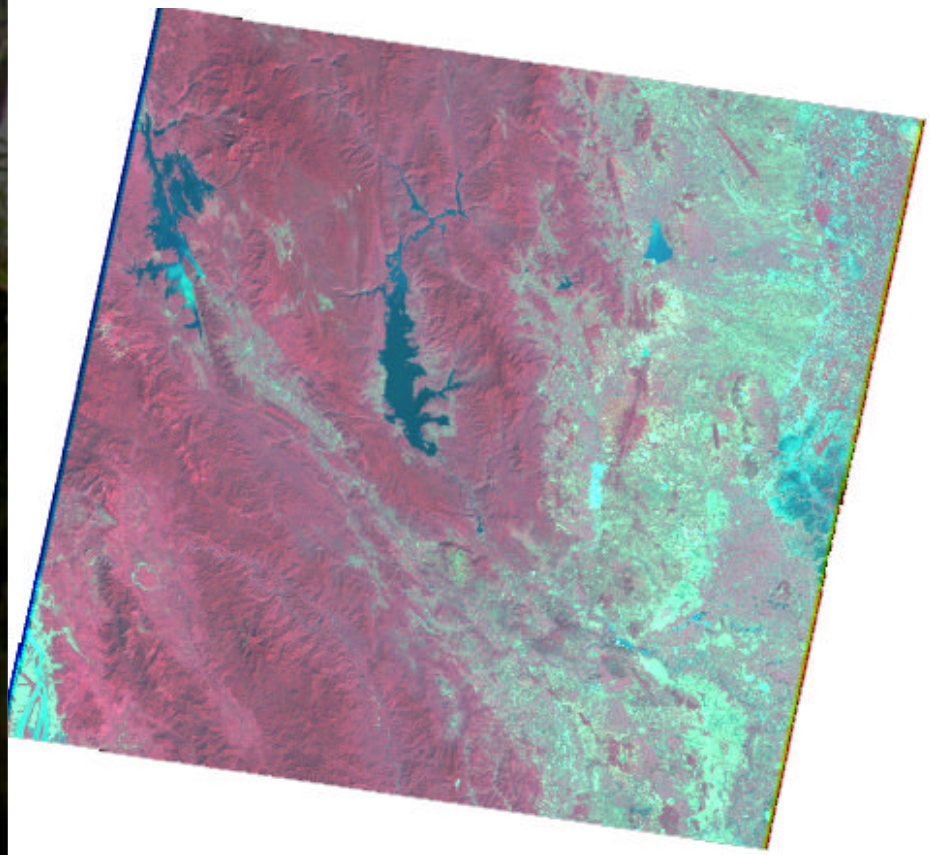
Methods – Atmosphere Correction

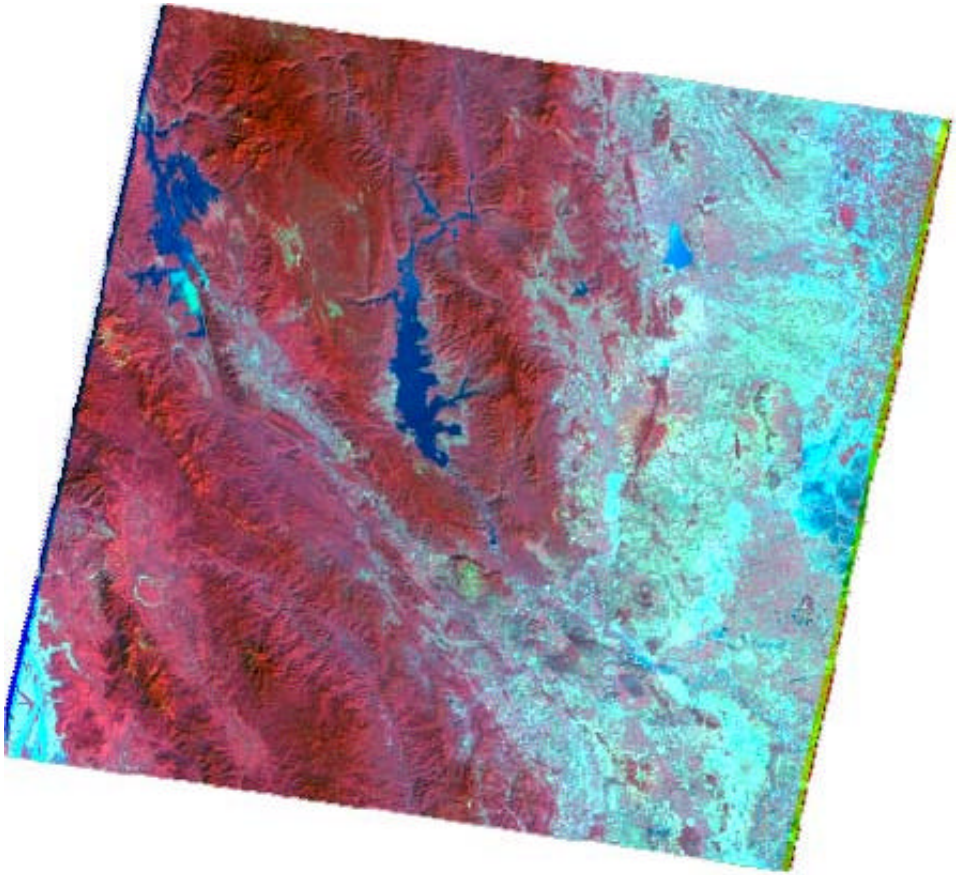




Atmospheric Correction

Northwest of Bangkok nearby Thailand-Myanmar boundary)





(before correction)

(after correction)

BRDF Correction

- Models Tested
  - Rahman et al., 1993

$$r(\theta_s,\theta_v,\phi) = r_0 \frac{(\cos\theta_s \cos\theta_v)^{k-1}}{(\cos\theta_s + \cos\theta_v)^{1-k}} \frac{1-\Theta^2}{[1+\Theta^2-2\Theta\cos(\phi-\chi)]^{3/2}} \left(1+\frac{1-r_0}{1+G}\right)$$

$$\cos\chi = \cos\theta_s \cos\theta_v + \sin\theta_s \sin\theta_v \cos\phi$$

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

Subset of DEM (source: AIRSAR, 1996)

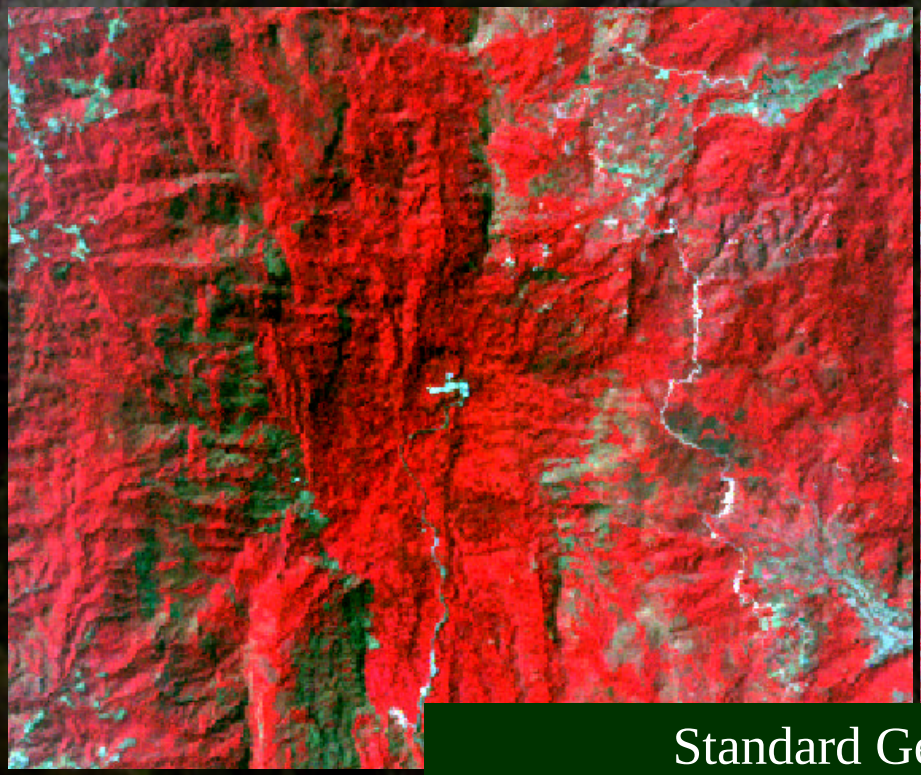
BRDF Correction Factors

Visible bands

NIR band

BRDF Correction Factors

(before correction)



(after correction)

Standard Geometry:

Solar Zenith: 37.66; Solar Azimuth: 128.32
View Zenith: 0; View Azimuth: 0

Fractional Cover

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

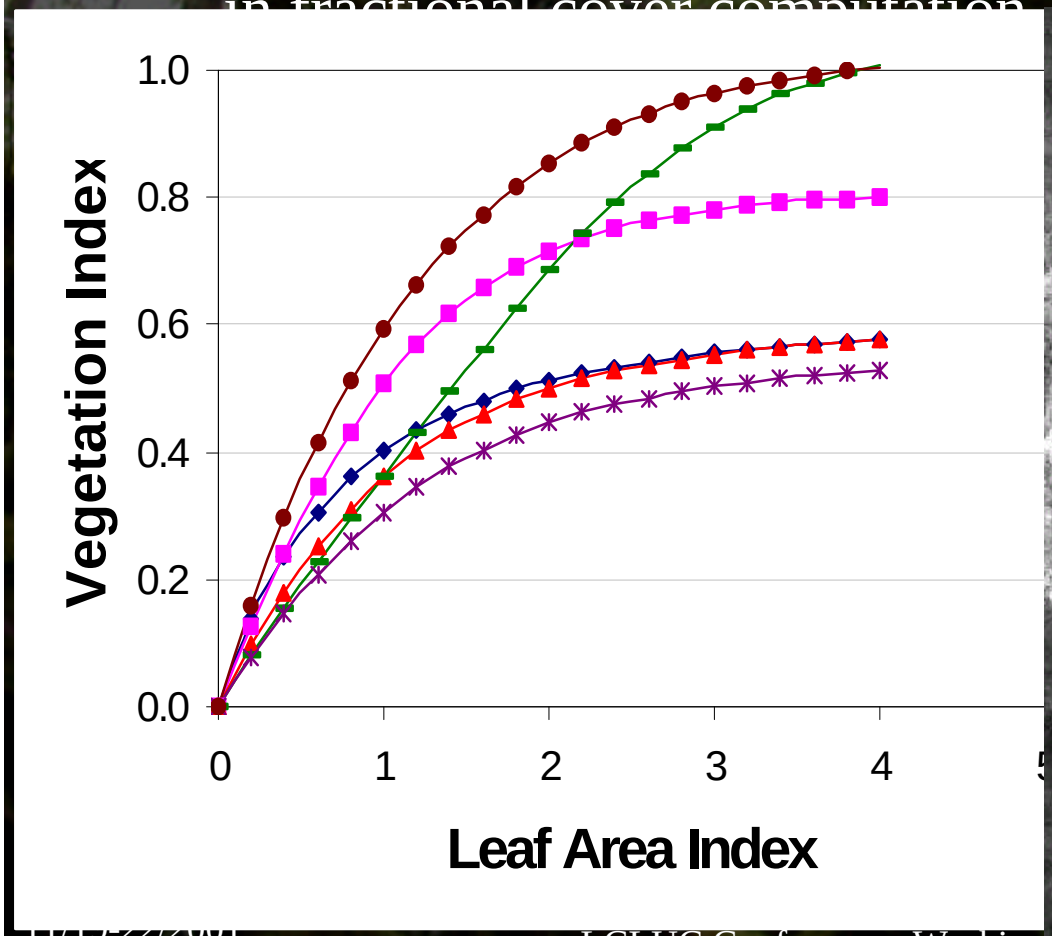
$$fc = \frac{vi - vi_s}{vi_v - vi_s} \times 100\%$$

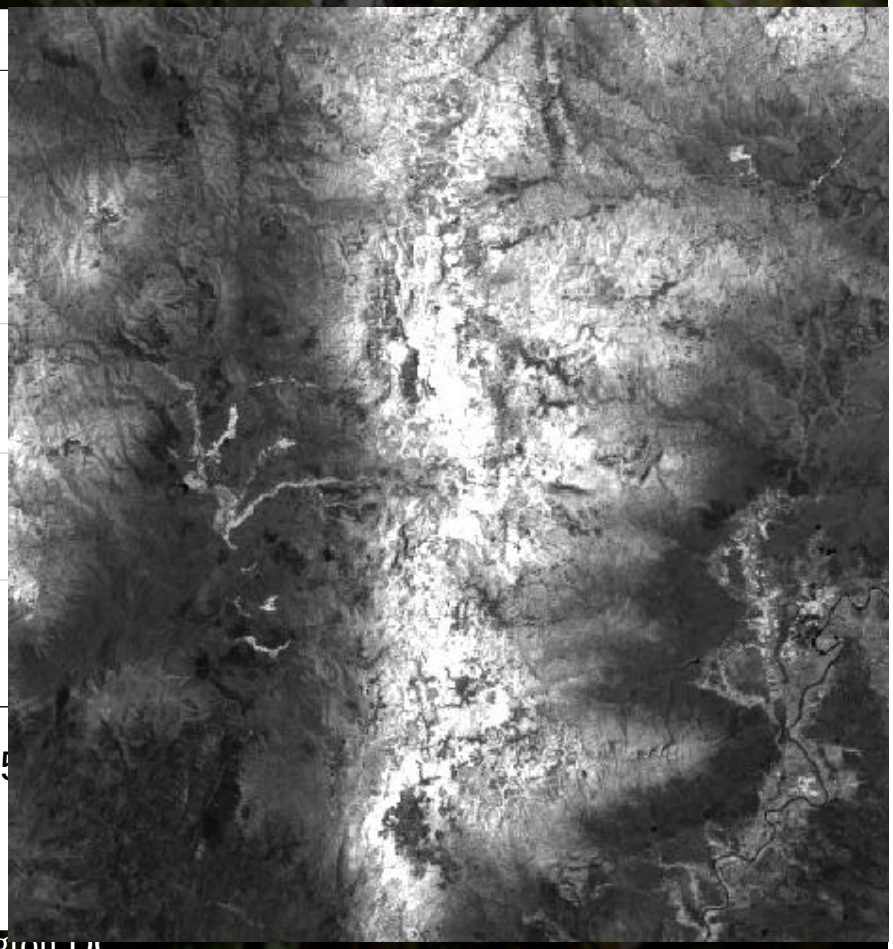
- References: Foody, Gutman, Zeng, Maas, and Qi

A Modified Index for Tropics

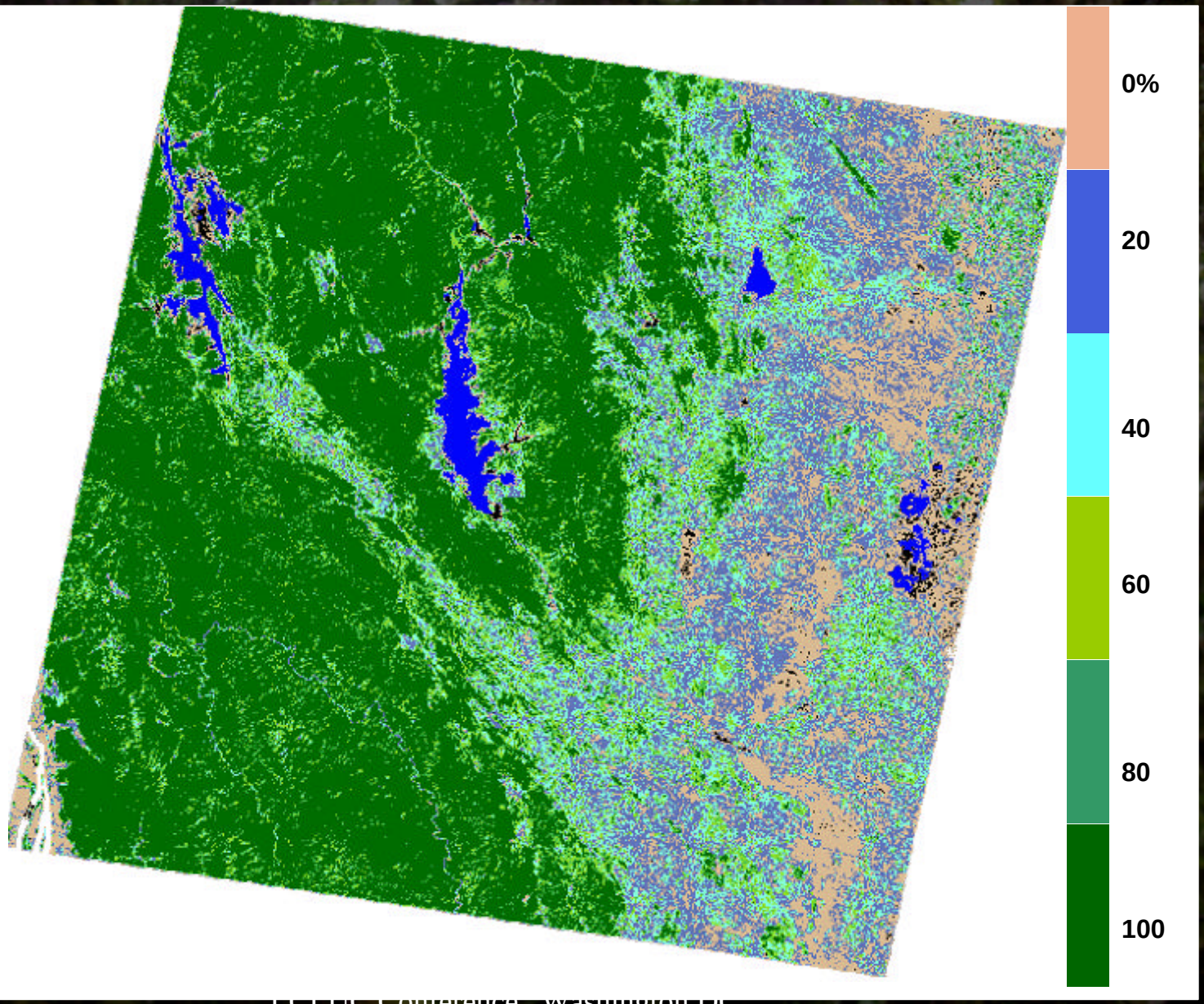
MSAVI

Most vegetation indices become insensitive at high forest densities,which presents a problem in using them in fractional cover computation

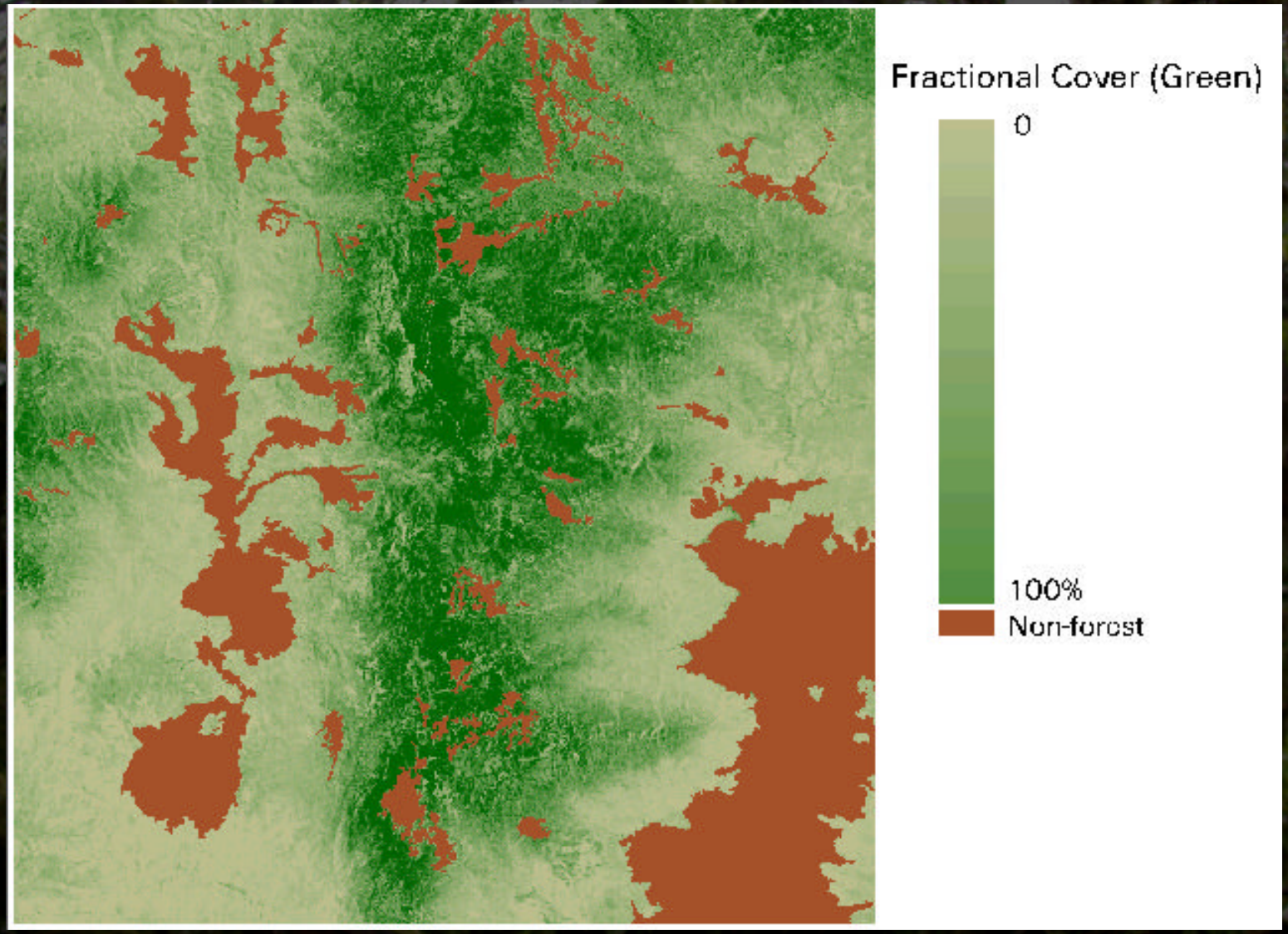




Example of *fc* (1)



Example of *fc* (2)

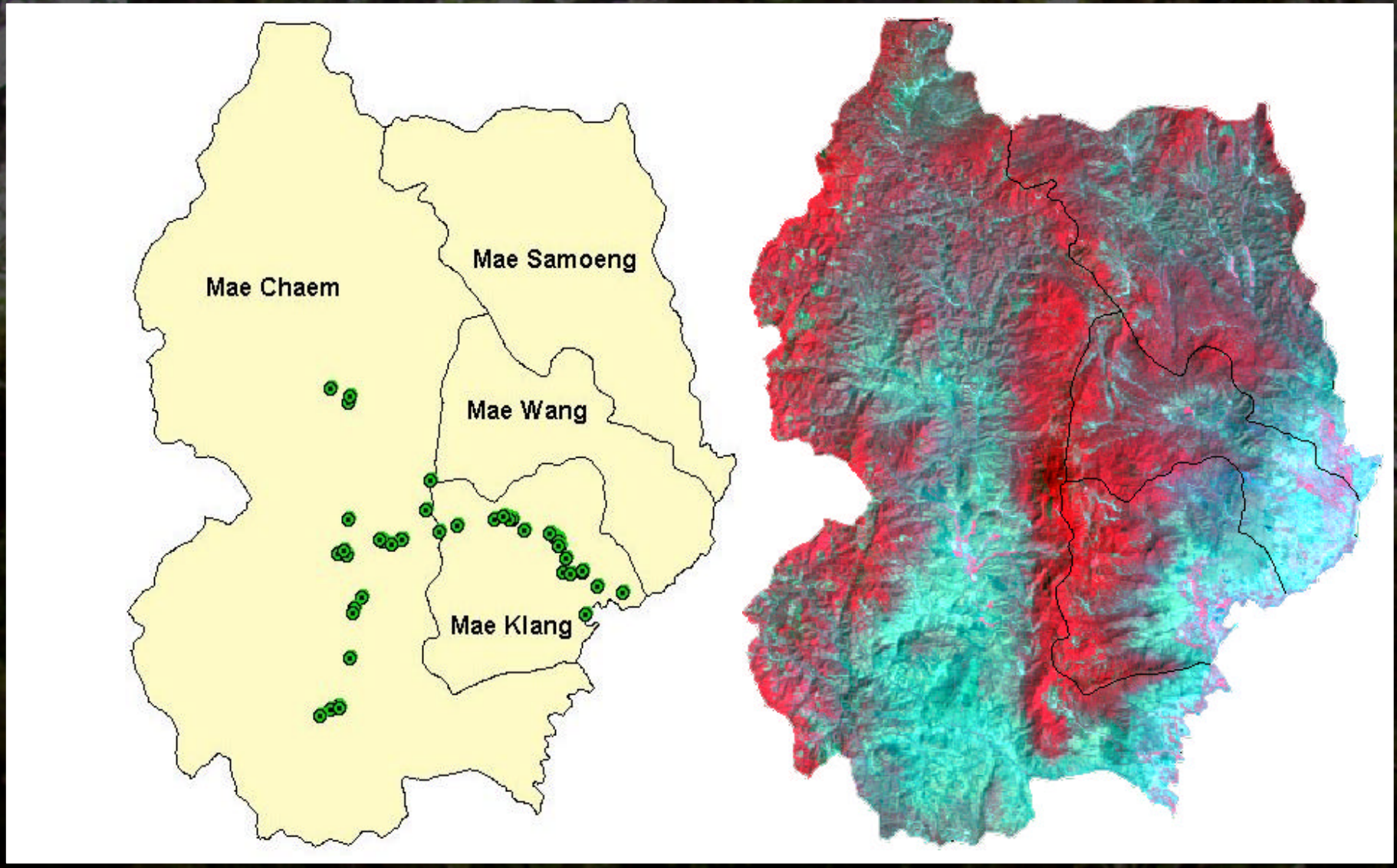


Product Calibration & Validation

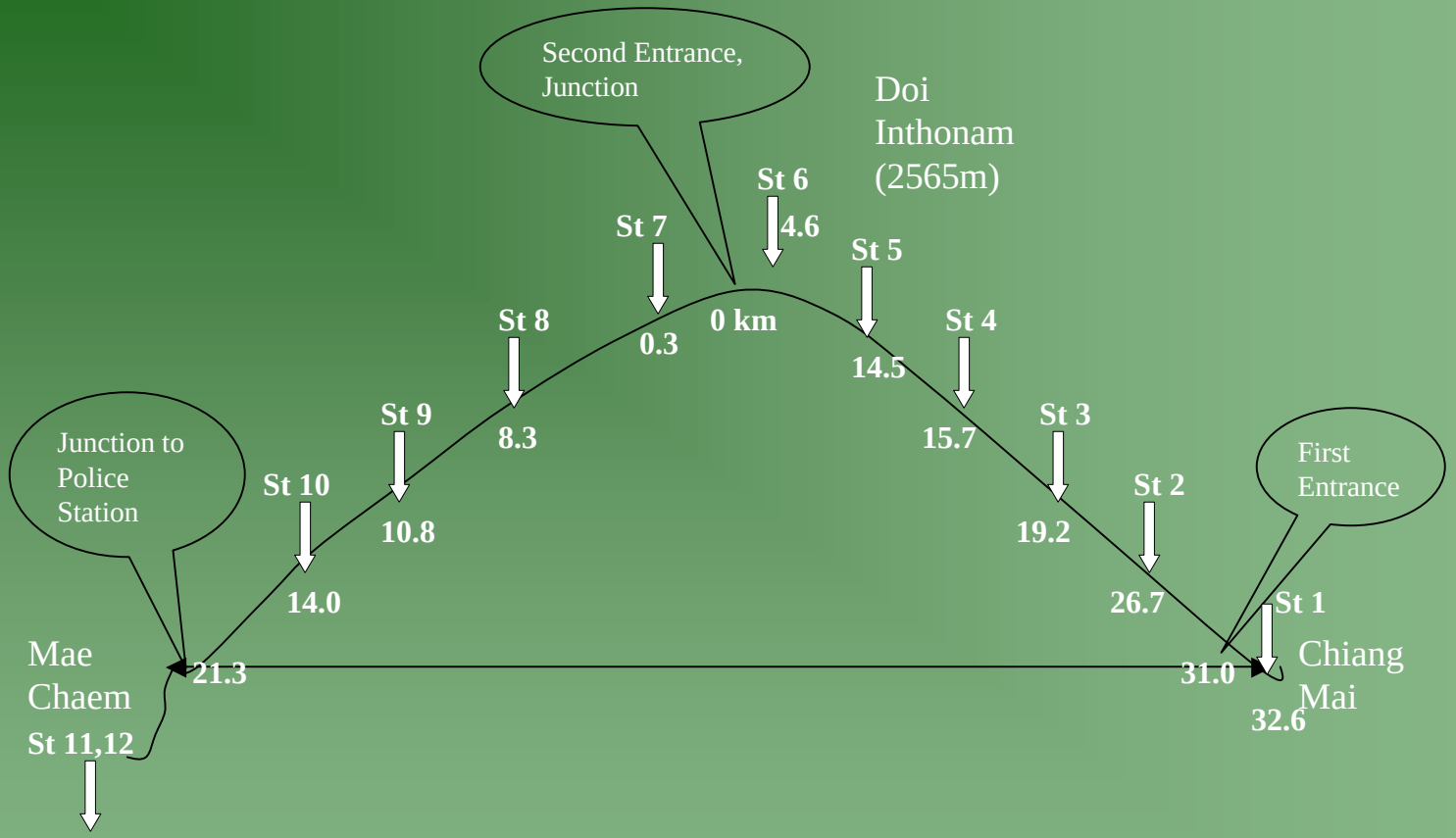
- Conducted an intensive field campaign in this past summer in Thailand, Vietnam, and Laos
- More challenging than expected
- Good ground truth data collected
- Validation in progress

SEA GOFC Network study sites

Field Study Sites



Field Sites:


Second Entrance, Junction
Doi Inthonam (2565m)
St 6
4.6
St 7
St 5
St 8
0.3
0 km
St 4
14.5
St 9
8.3
St 3
15.7
Junction to Police Station
St 10
10.8
St 2
19.2
First Entrance
14.0
26.7
St 1
Mae Chaem
21.3
31.0
Chiang Mai
St 11,12
32.6


MASON
FUSA


ทรงพระเจริญ
หน่วยพิทักษ์ยอดดอย


TA
4WD

Field Sites Description

Site	Description	Site	Description
1	Secondary Dry Dipterocarps	**7**	Lower (dry) Tropical Evergreen
2	Degraded Dry Dipterocarps	**8**	Pine Transition to Evergreen
3	Mixed Deciduous	**9**	Mixed Deciduous
4	Tropical Rain Evergreen (along rivers)	**10**	Secondary Dry Dipterocarps
5	Pine Transition to Evergreen	**11**	Degraded Dry Dipterocarps
6	Upper (moist) Tropical Evergreen	**12**	Teak Plantation

Forest Types:

Dry Dipterocarps

Mixed Deciduous (bamboo)

Mixed Deciduous (pine)

Hill Evergreen

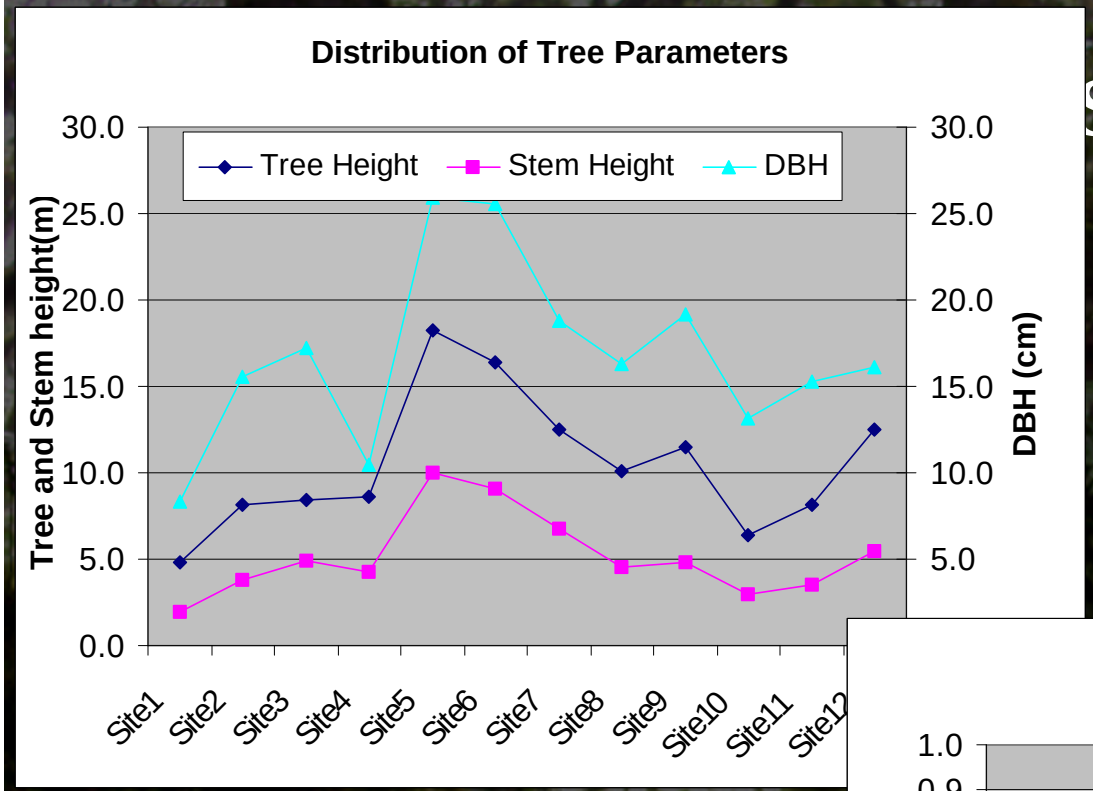
Field Measurements

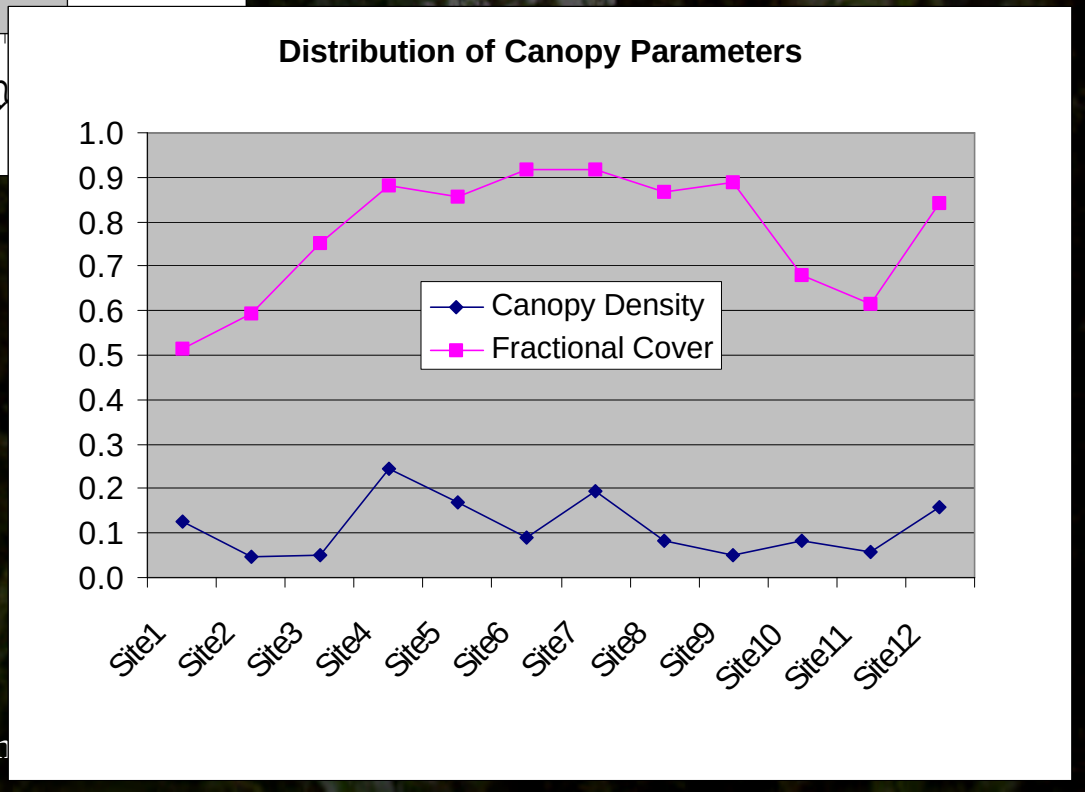
500m transect, 5 sampling points for each site:

- Forest Type
- Tree Height
- Stem Height
- DBH
- Fisheye Photo (*fc*)
- Slope/Aspect

Teak plantation

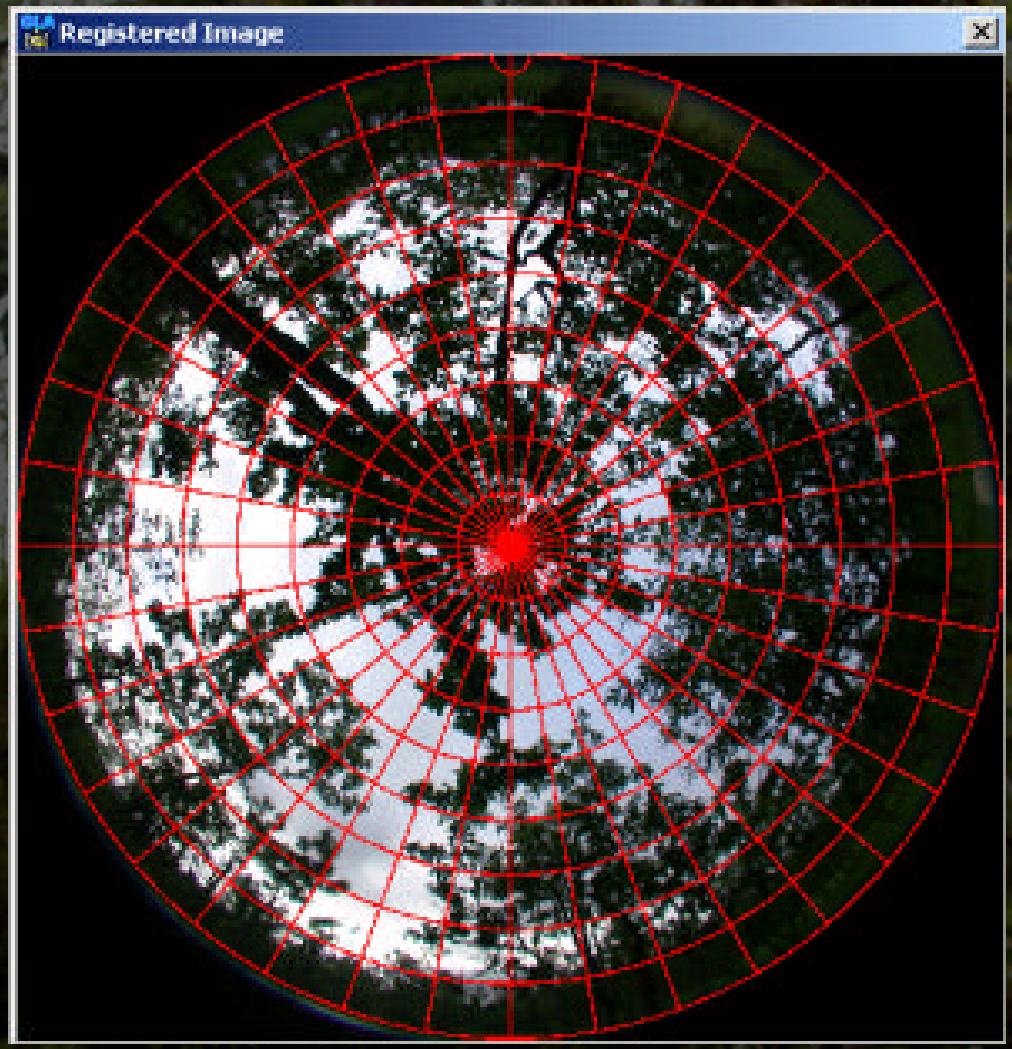
S


Distribution of Tree Parameters
Tree and Stem height(m)
DBH (cm)
Tree Height
Stem Height
DBH
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Site1
Site2
Site3
Site4
Site5
Site6
Site7
Site8
Site9
Site10
Site11
Site12


Distribution of Canopy Parameters
Canopy Density
Fractional Cover
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Site1
Site2
Site3
Site4
Site5
Site6
Site7
Site8
Site9
Site10
Site11
Site12

Fractional Cover Measurements

- Fisheye Photo
- Gap Light Analyzer (GLA_v2.0)

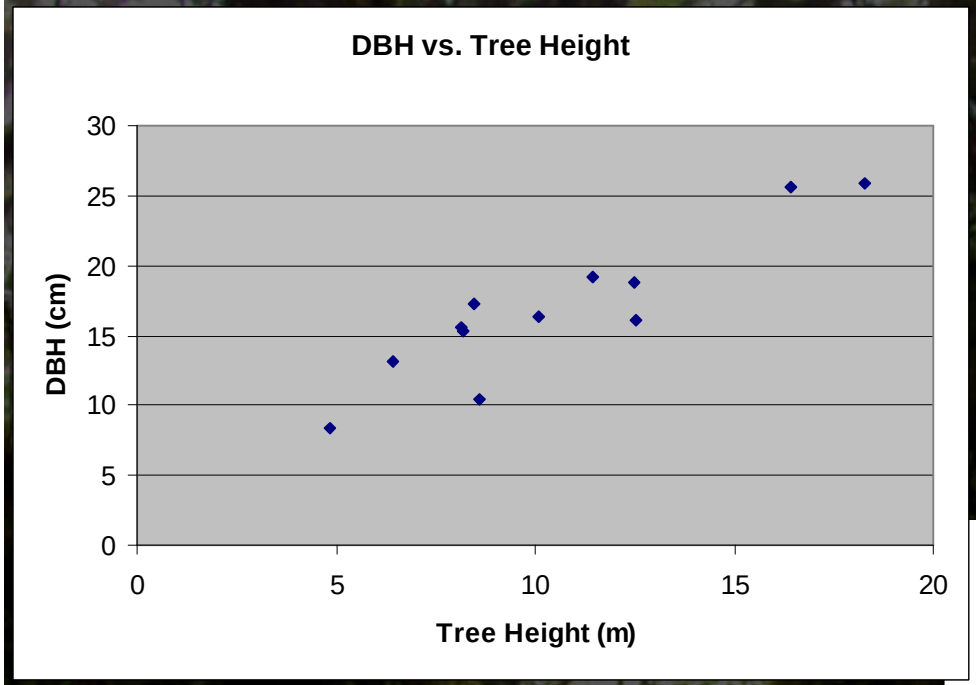


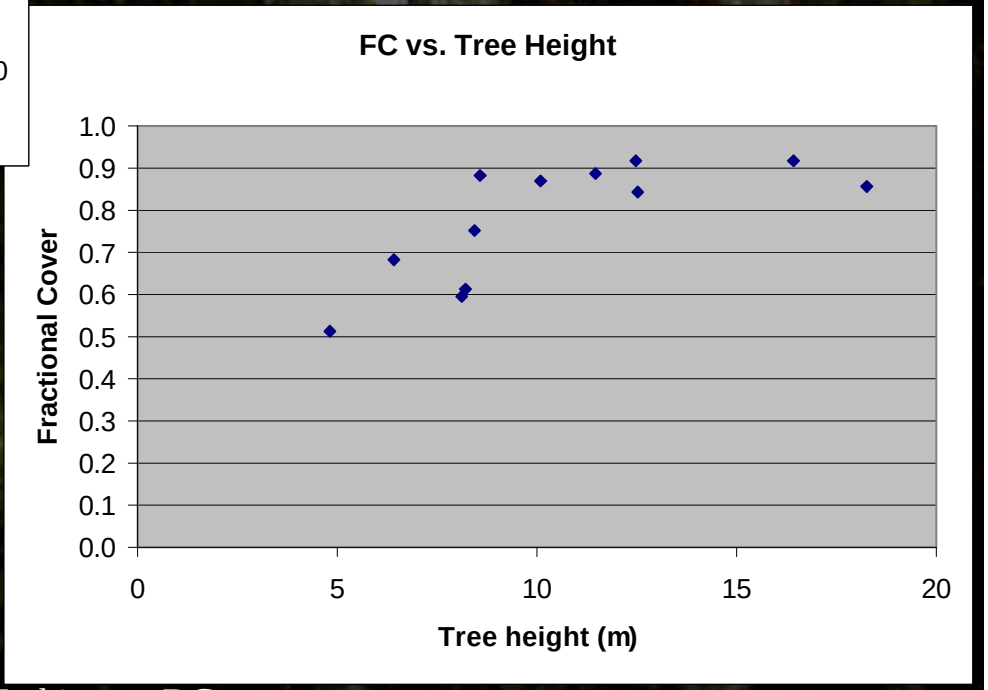
Fisheye Technique Issues

Effects of understory

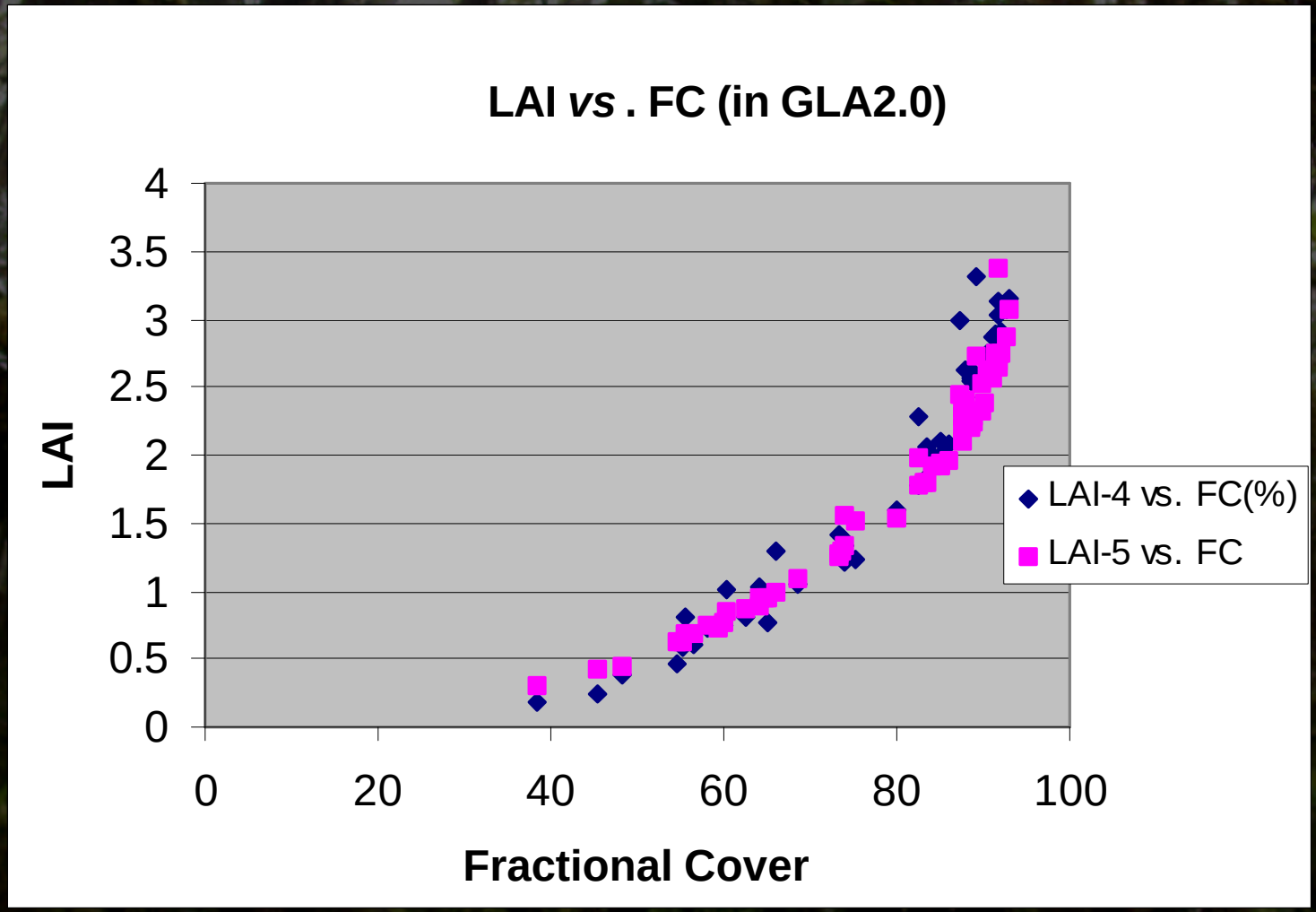
Effects of topography

Relationship between Forest Attributes

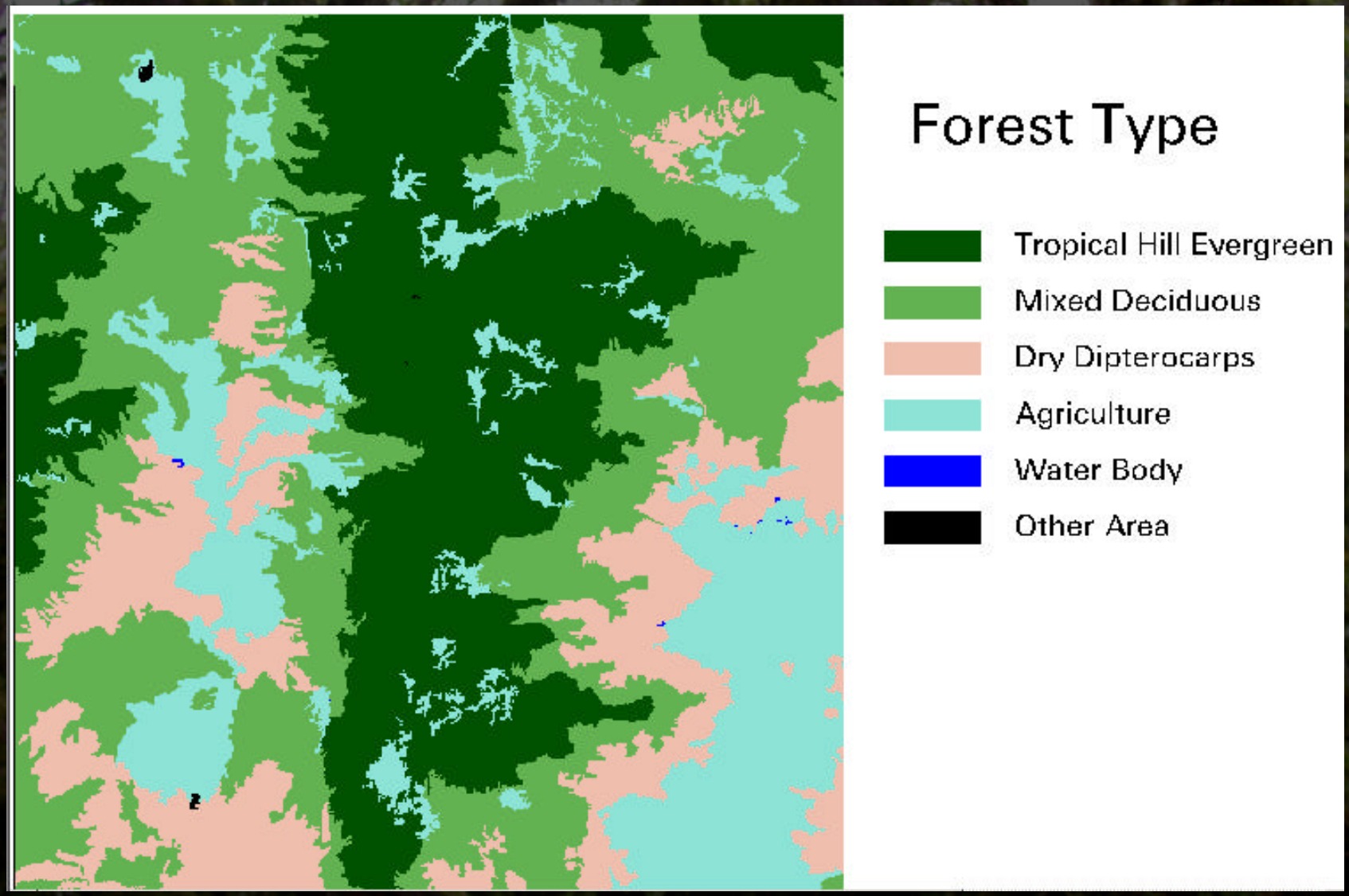




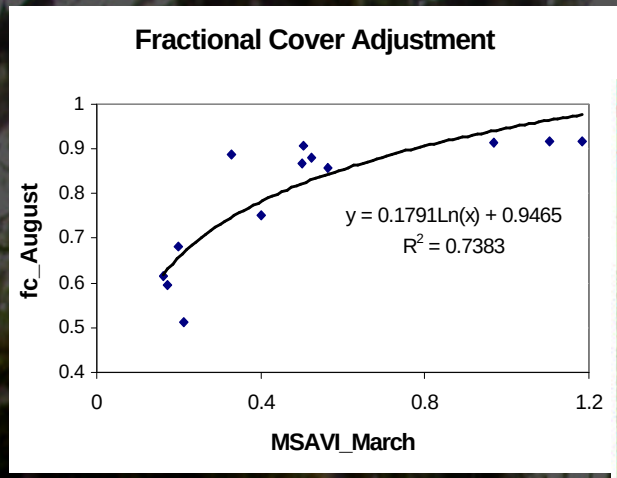
Relationship between Forest Attributes

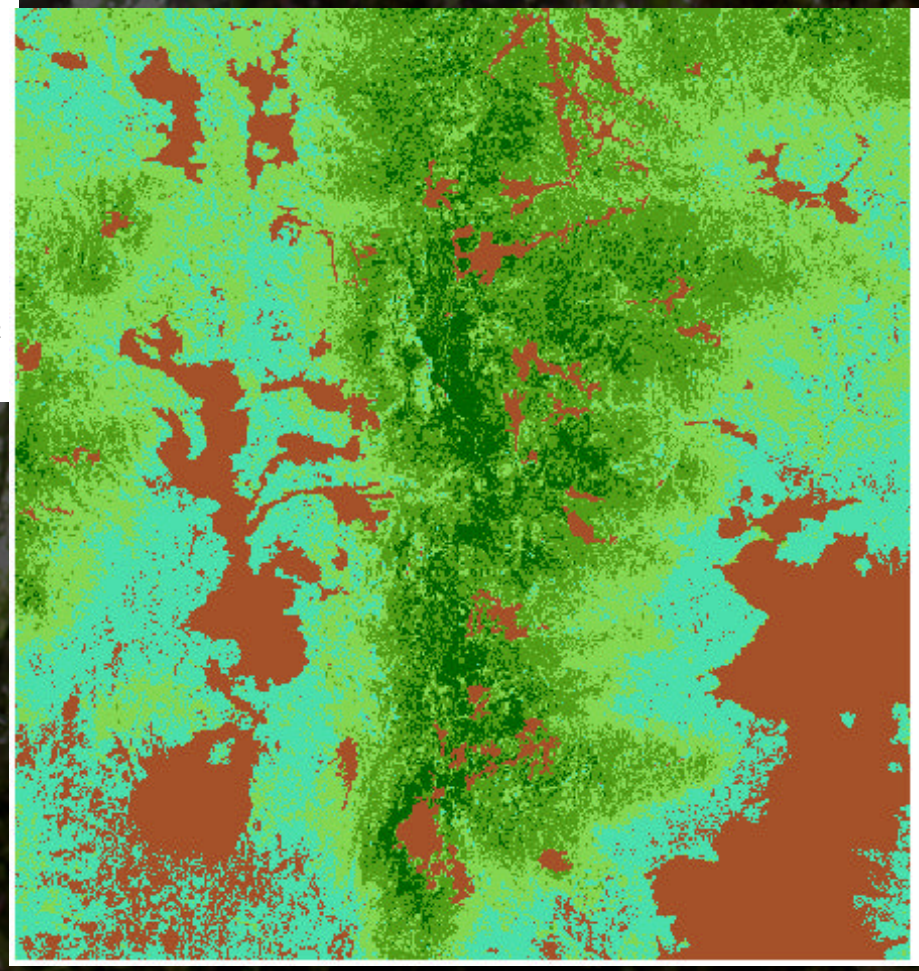


Forest Type Map



Fractional Cover (Adjusted)





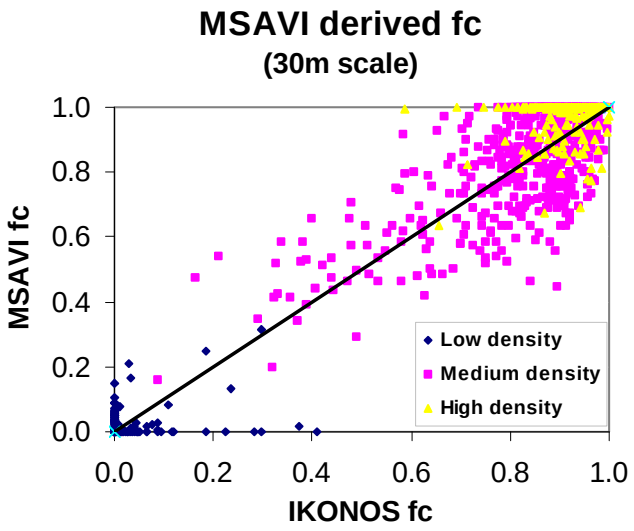
Fractional Cover (Adjusted)

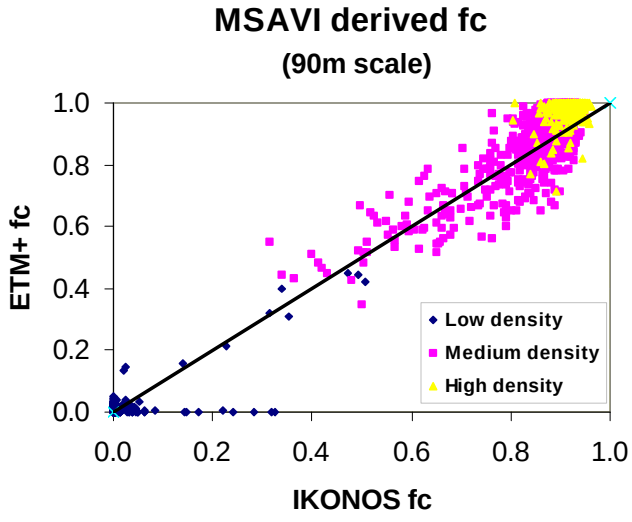
- 60 - 70%
- 71 - 80%
- 81 - 90%
- 91 - 100%
- Non-forest

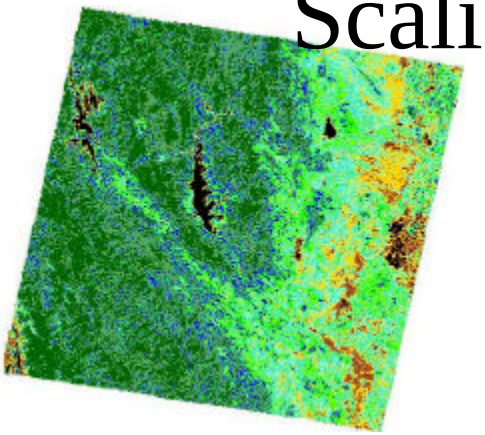
Future Steps

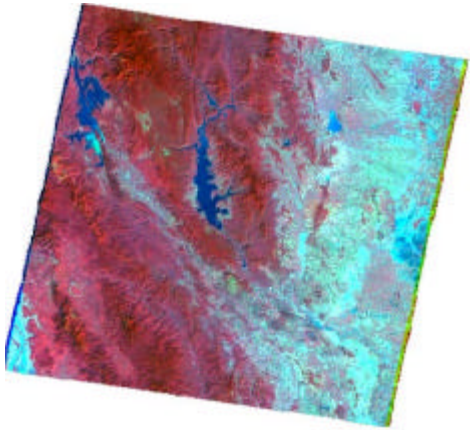
- Rigorous Validation with field data and IKONOS high resolution images (earlier next year)
  - Validation in Vietnam, Laos, Indonesia, Malaysia, and China
- Areal expansion to include entire SEA (next summer)
- Radiosonde data in Philippines (next summer)
- Topographic correction (earlier next year)
- Scale from local to region with Ikonos, ETM+, and VEGETATION images (next summer)

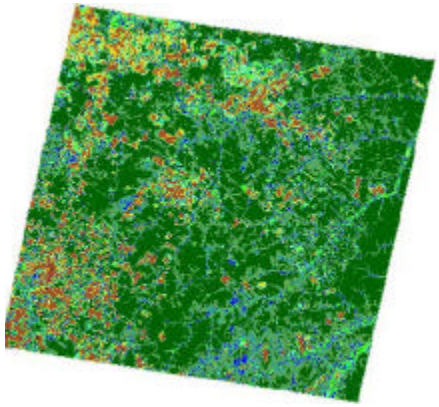
Scaling Effect

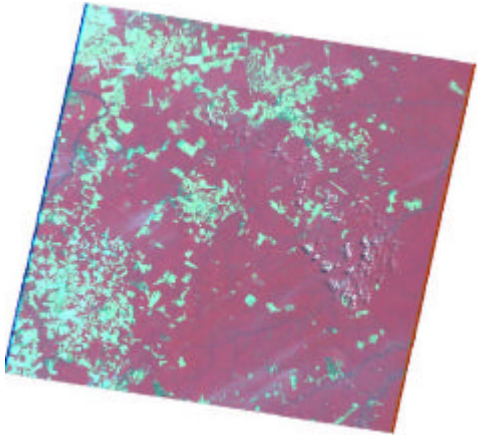


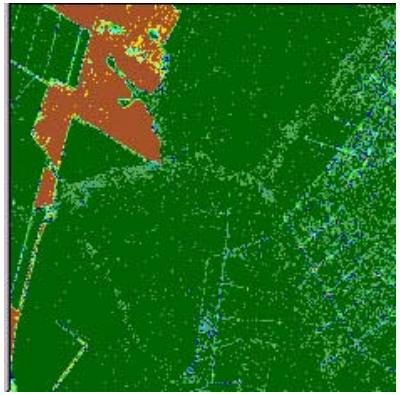


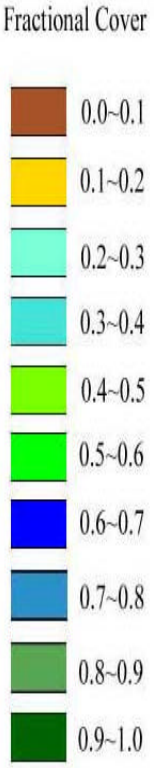


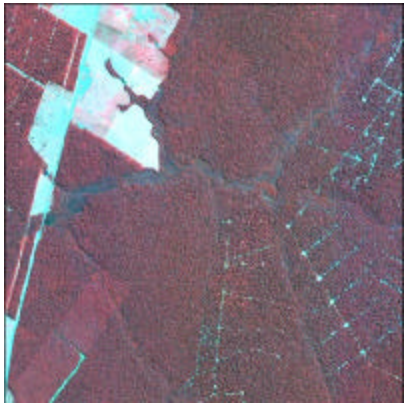






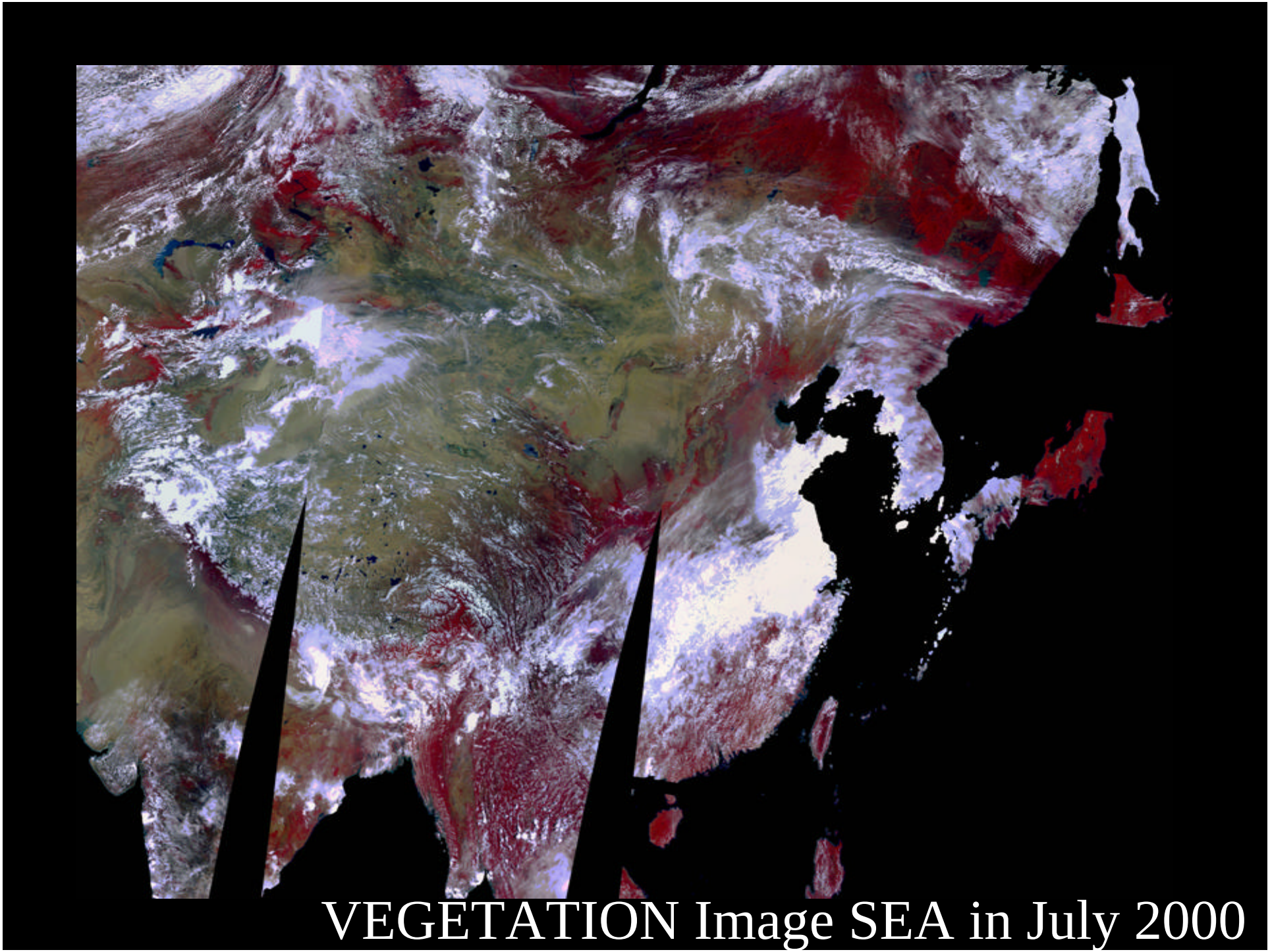






VEGETATION Images Acquired

- 850 CDs of SPOT 4 VEGETATION images acquired and being processed
- Fc maps will be produced and cross calibration with ETM+ images
- A scaling scheme will be developed


VEGETATION Image SEA in July 2000

Programmatic Summary

- Significant results: Developed improved GOFC data and information products
- Relevance: Improved measure of forest changes in terms of not only fragmentation but also changes in biophysical attributes
- Social science proportion: ~25%
- Carbon (25%) and GOFC (75%)
- New Findings
- New potentials (towards a quantitative measure of carbon stocks)
- New products (improved maps of forest cover and attributes)

Project Timeline

	2000				2001				2002			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Data Acquisition												
ETM+												
VGT												
IKONOS												
Data Products Development												
Georeferencing												
Atm. Correction												
BRDF Normalization												
Forest Fractional Cover												
GLAI and fPAR												
Product Cal/Validation												
Calibration												
Validation												
Outreach												