Forest Changes and Biomass Estimation

Project Title: Comparative Studies on Carbon Dynamics in Disturbed Forest Ecosystems: Eastern Russia and Northeastern China

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Guoqing Sun, University of Maryland, College Park, MD 20742
Jeffrey G. Masek, Biospheric Sciences Branch, Code 614.4, GSFC, Greenbelt, MD 20771

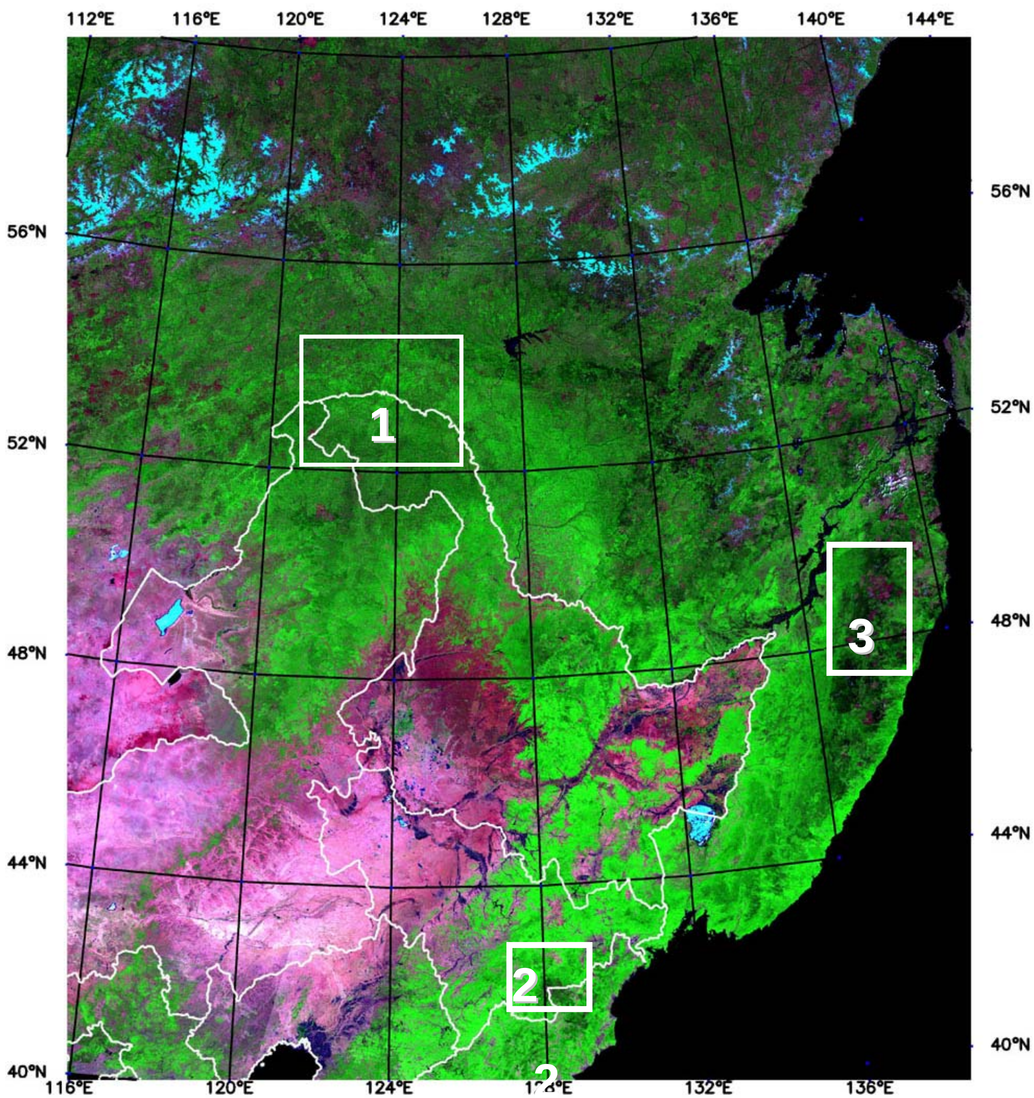
Co-Is:
Dr. Olga Krankina, Oregon State University
Dr. Vyacheslav Kharuk, Sukachev Institute of Forest, Krasnoyarsk, Russia
Dr. V. I. Trush, Far Eastern Forest Inventory Enterprise, Khabarovsk, Russia
Dr. Zengyuan Li and Dr. Yong Pang, IFRIT, Chinese Academy of Forestry

OBJECTIVES

Identify the major disturbances and disturbance patterns in Russian Far East and Northeastern China;

Understand the impact of forest fire and human activities on forest structure, carbon stocks and uptakes.

the Northeast Asia



Study Region

False color image is from averaged MODIS 16-day composite of summer 2004:
R – MIR, G – NIR and B - RED

Intensive Study Sites:

1. Daxing'anling

Where more than 1 million ha of forests were burnt in 1987. For study of forest recovery from fire.

2.Changbaishan nature reserve was set up in 1970's for protecting the forest ecological system in this area

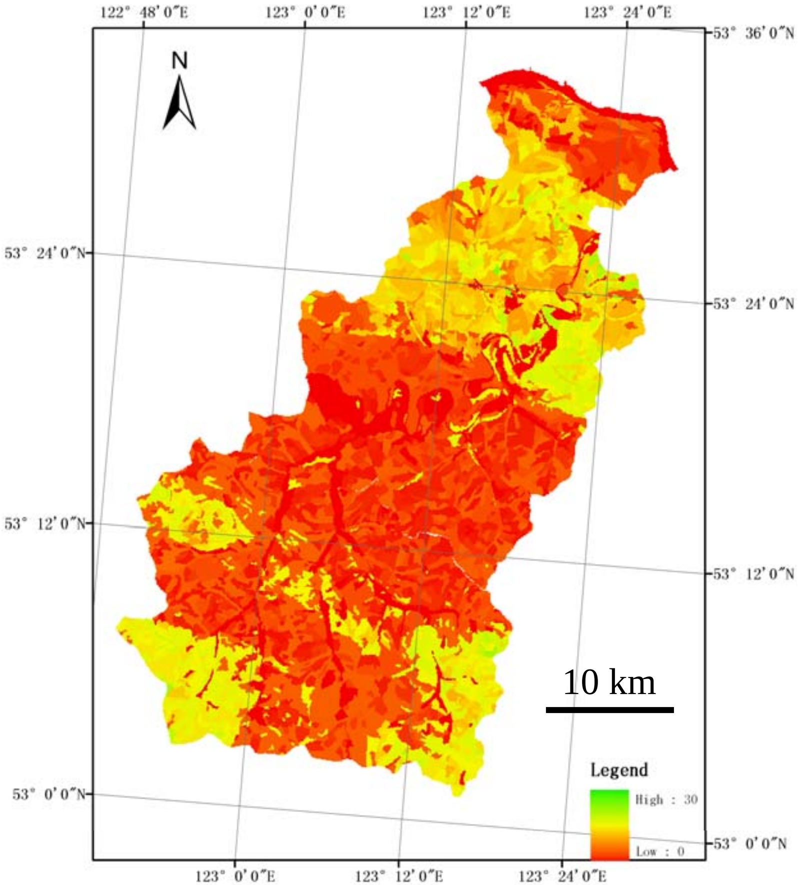
3. Siberia East coast where forest fires and logging are active since 1998

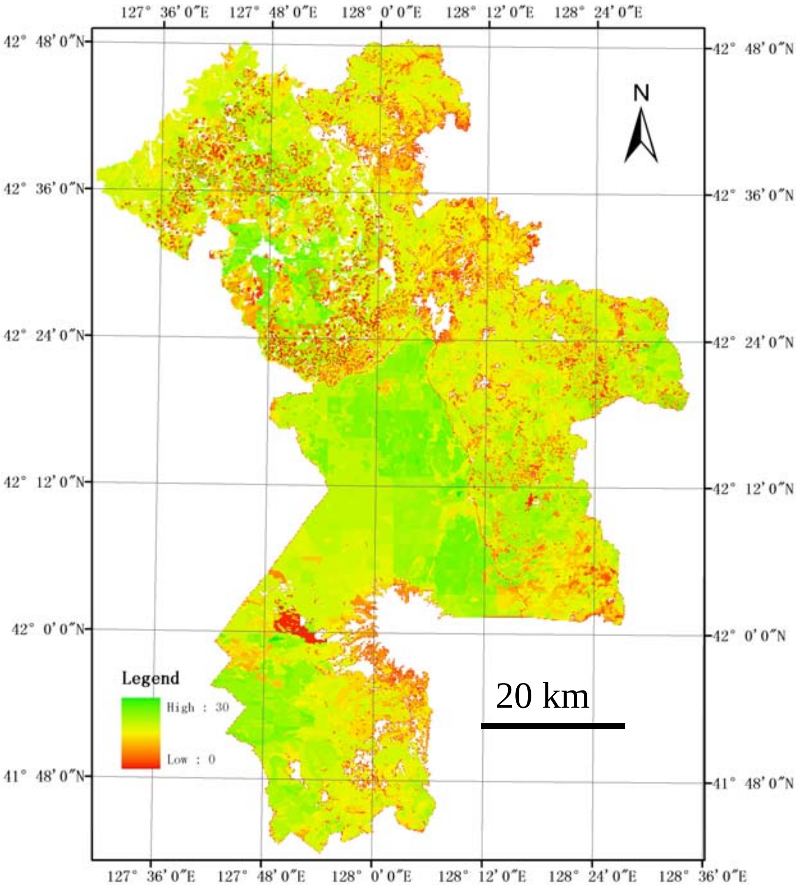
DATA

MODIS 16-day composite, Tree Coverage, Fire Products
Lidar (GLAS), Radar (ENVISAT ASAR and ALOS PALSAR)
LANDSAT, ASTER, CBERS

Forest inventory data and Field measurements

Examples of forest inventory data (mean tree height):





TASKS, PROBLEMS and STRATEGIES

- No direct measurements of biomass from remote sensors
- Need to infer biomass from secondary parameters such as:
  - Forest type, LAI, Coverage (from Optical data)
  - Volumetric scattering related to water contents or fresh biomass (Long-wavelength polarimetric SAR); de-coherence due to vegetation and height of scattering centers (InSAR)
  - Canopy vertical structure (Lidar)
- Optical data (eg MODIS) provide the best global coverage, but need additional information on forest age for biomass estimates
- Polarimetric SAR provides direct measurements of canopy water content, but is very sensitive to geometry (forest spatial structure and terrain slopes)
- Lidar has the potential to provide a 3D measurements of forest canopy, but the regional or global coverage will not be available in near future.
- Estimates of regional or global forest biomass :

  -- Stratification and statistical sampling

  -- Remote sensing measurements and forest growth modeling

Ongoing Work

1. Use of multi-temporal optical data to detect forest changes and stratify the forested area

Use the MODIS data quality flag to chose the data with quality above ‘fair’ level and calculate mean values for each season

Find the best bands for detection of forest disturbances, and for forest classification

Objective: Forest change maps and a map of current growth stage

2. Evaluation of GLAS data

Tree height from GLAS data

Timber volume (biomass) from GLAS height indices

Objective: Tree height and biomass from all ‘good’ GLAS footprints

3. Simulation of forest growth

Parameterize forest growth model (ZELIG) and simulate forest growth trajectories

Verify simulation results using forest inventory data

Objective: verified forest growth trajectories for three major forest regions

4. Inversion of 3D radiative transfer models

Simulate tree architecture using L-system and build 3D forest landscape

Build signature database for spectral radiometry, radar and lidar

Develop inversion algorithms

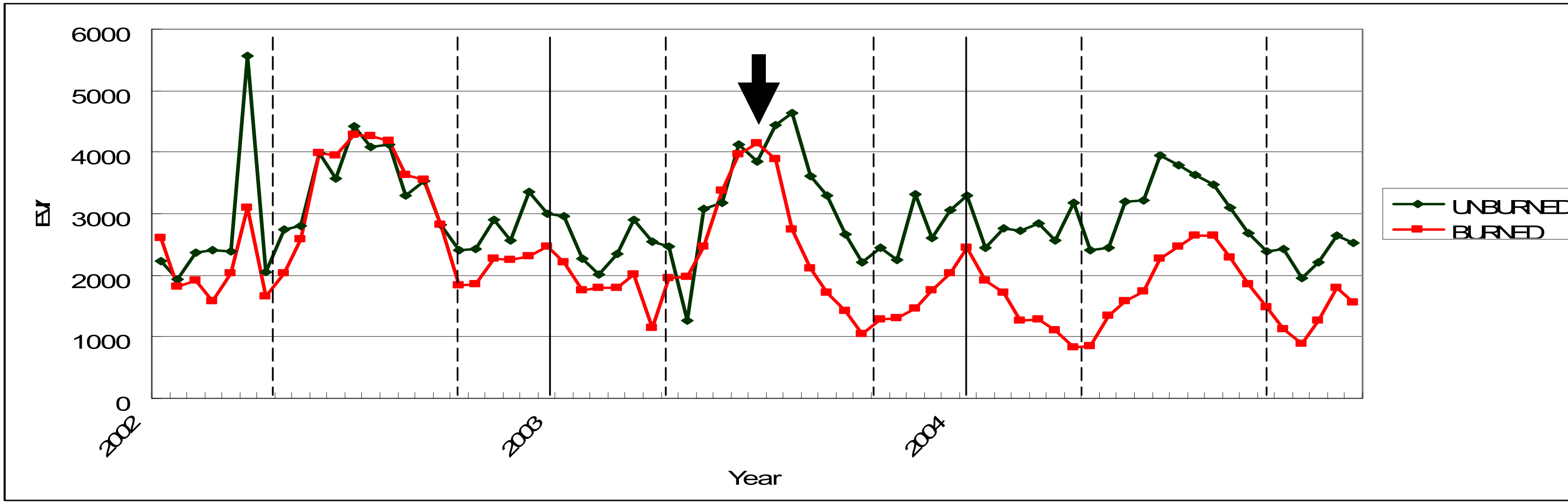
Objective: Forest attributes at intensive test sites

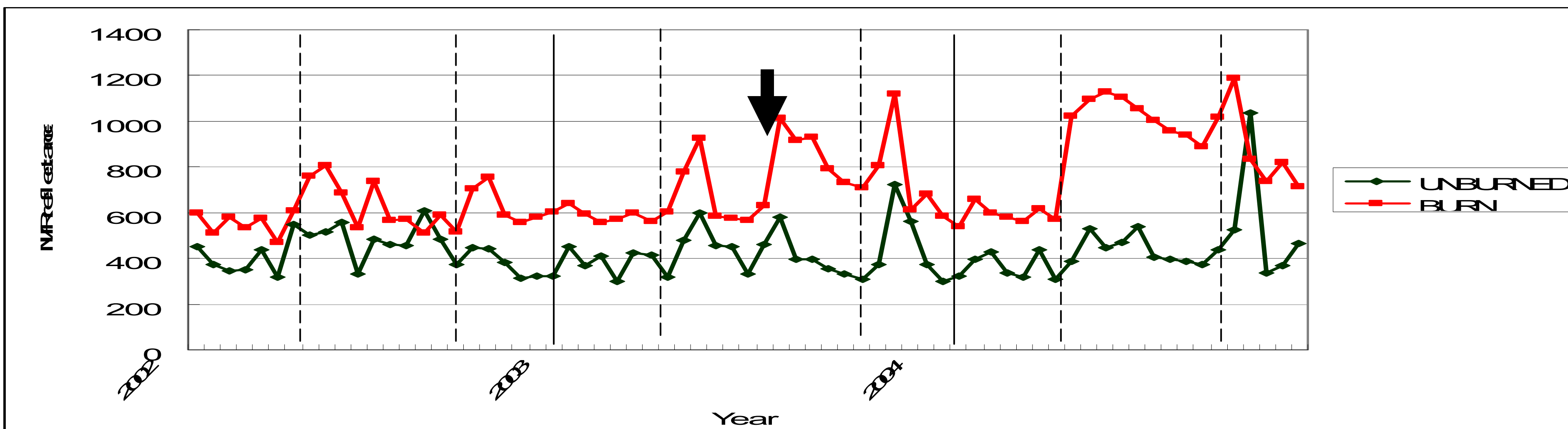
Changes of EVI and MIR reflectance due to forest fire in 2003

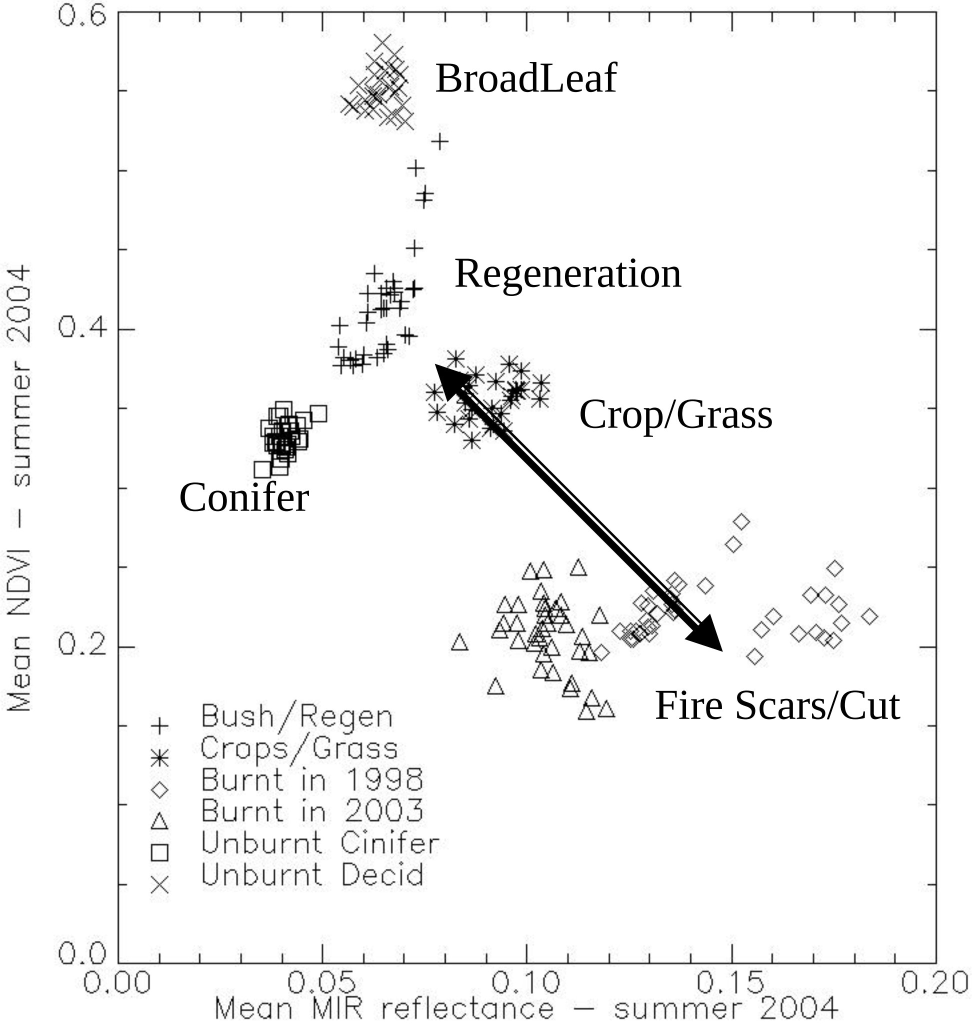
Previous Summer

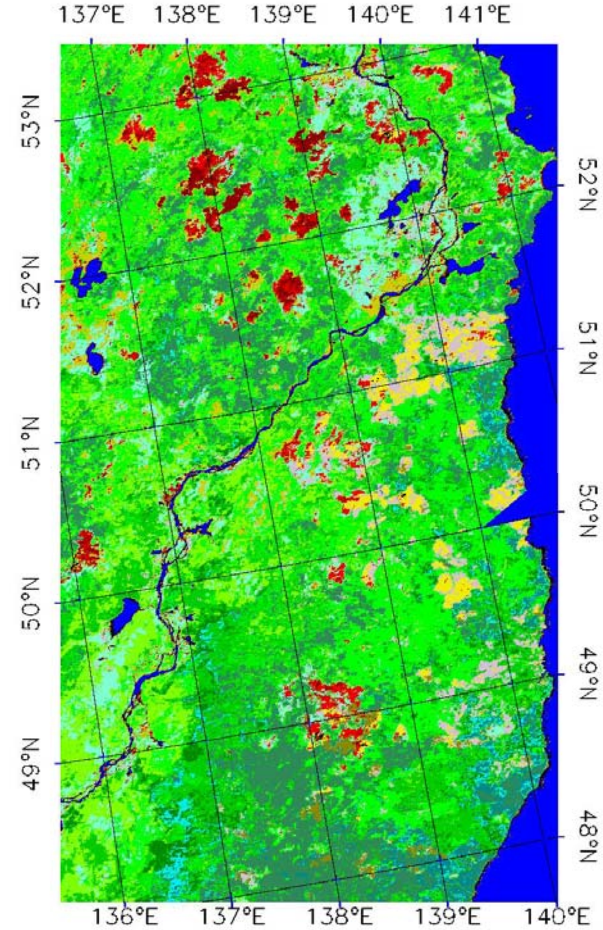
Burnt in Summer

Following Summer

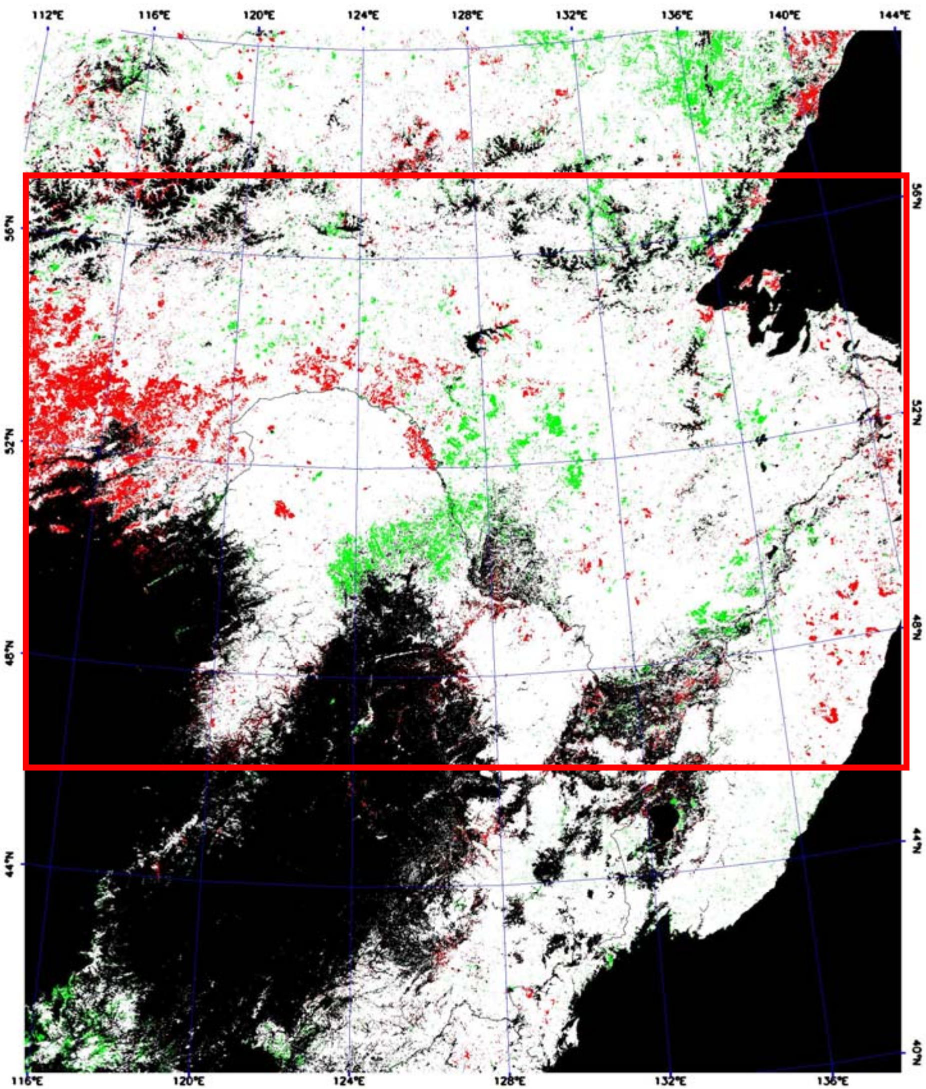






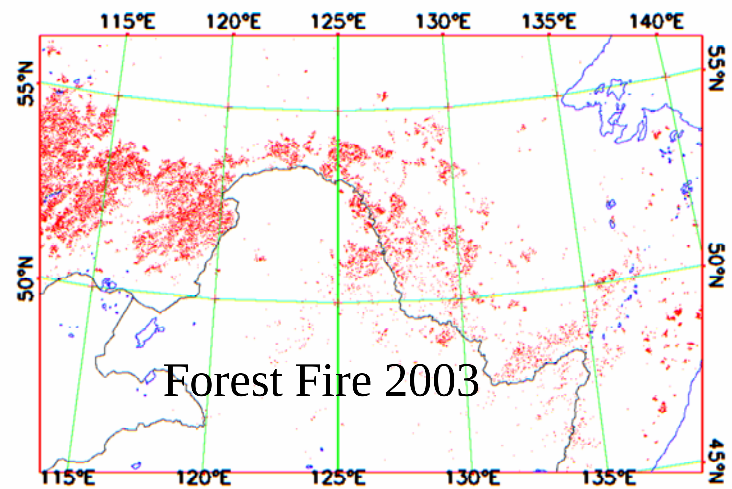


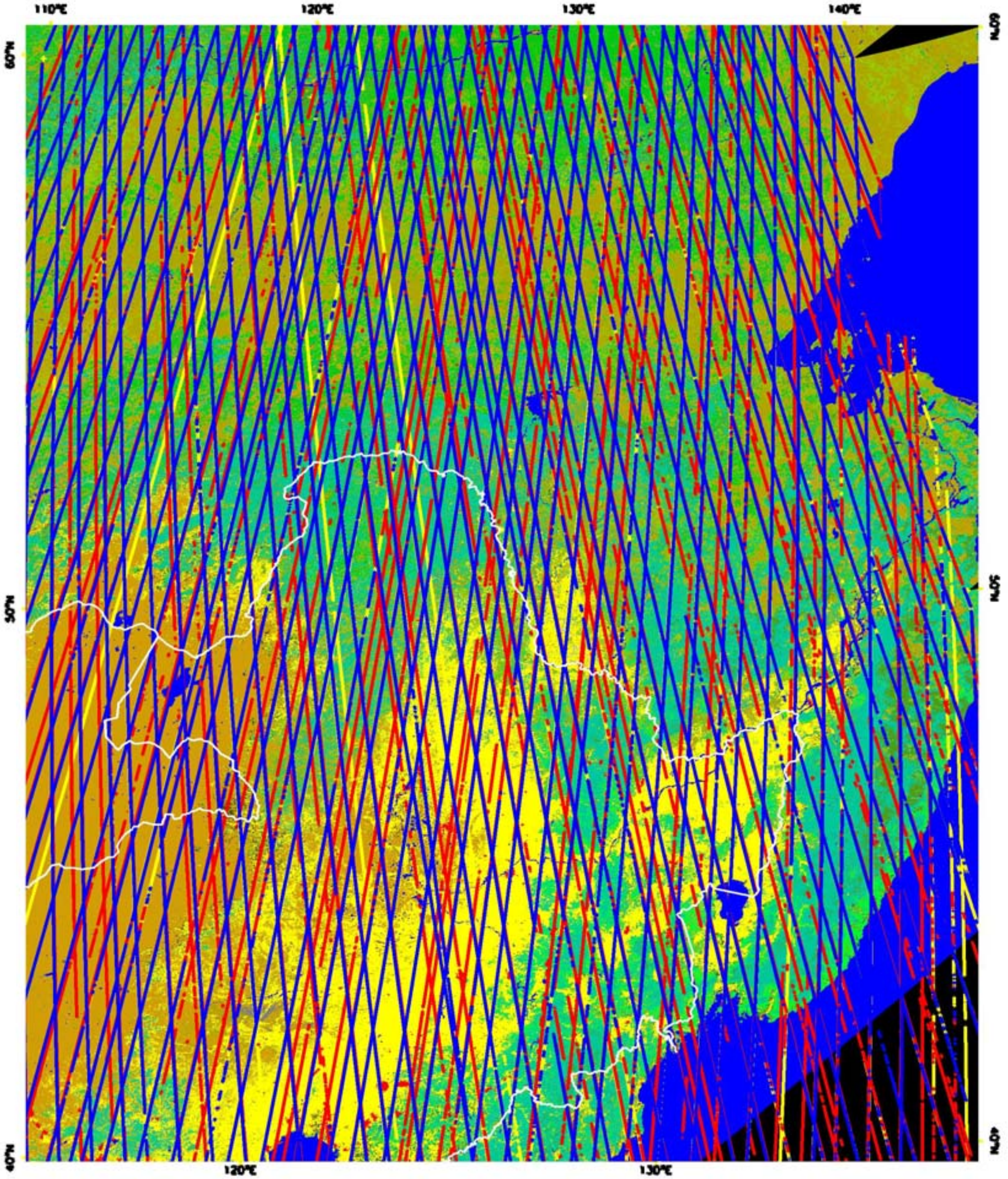
Classification using information shown in left plot: Green – undisturbed area, Dark red – old burn (before 1998)
Yellow – burned in 1998
Cyan – burned in 2003



Detection of changes of forests using MODIS Data . MODIS 500m 16-day composite data with above-fair quality were averaged over growing season and fall-winter for each year from 2000 to 2005. The figure on the left shows the changes derived from the differences between 2002 and 2004. The red shows areas where the vegetation indices reduced and MIR reflectance increased, indicating the reduction of vegetation. The pattern is consistent with the MODIS 2003 fire product (below).

Green shows the increase of vegetation. One of the area was disturbed in early 90, and forest is recovering.





GLAS footprint on MODIS 1-km Classification map: (three near-repeat paths)

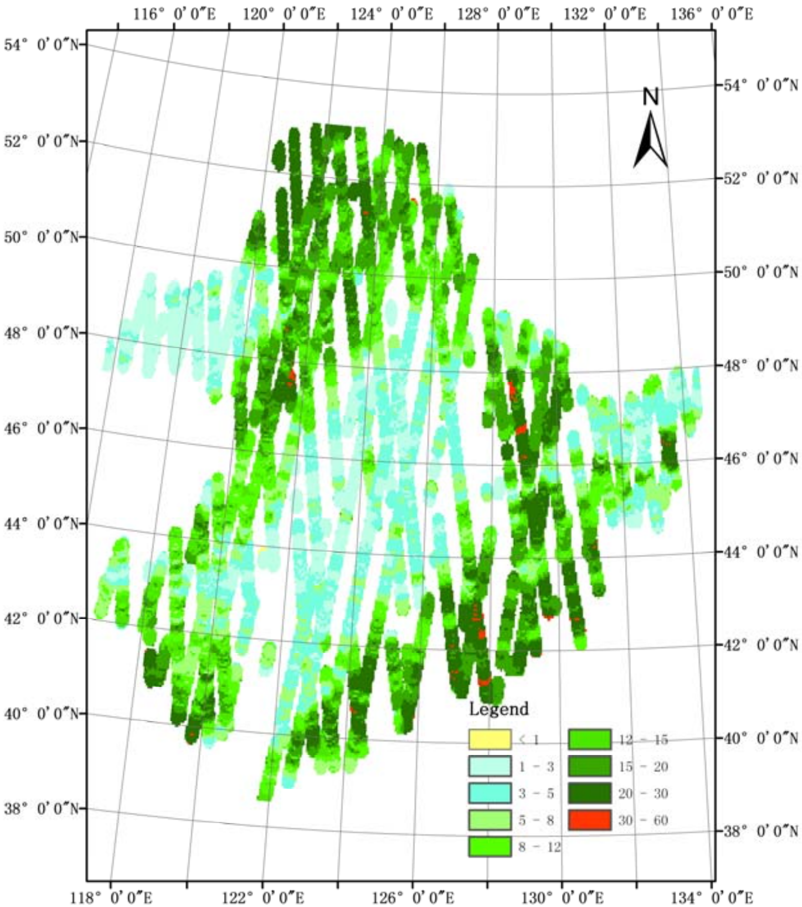
L2A: 9/26-11/19/2003

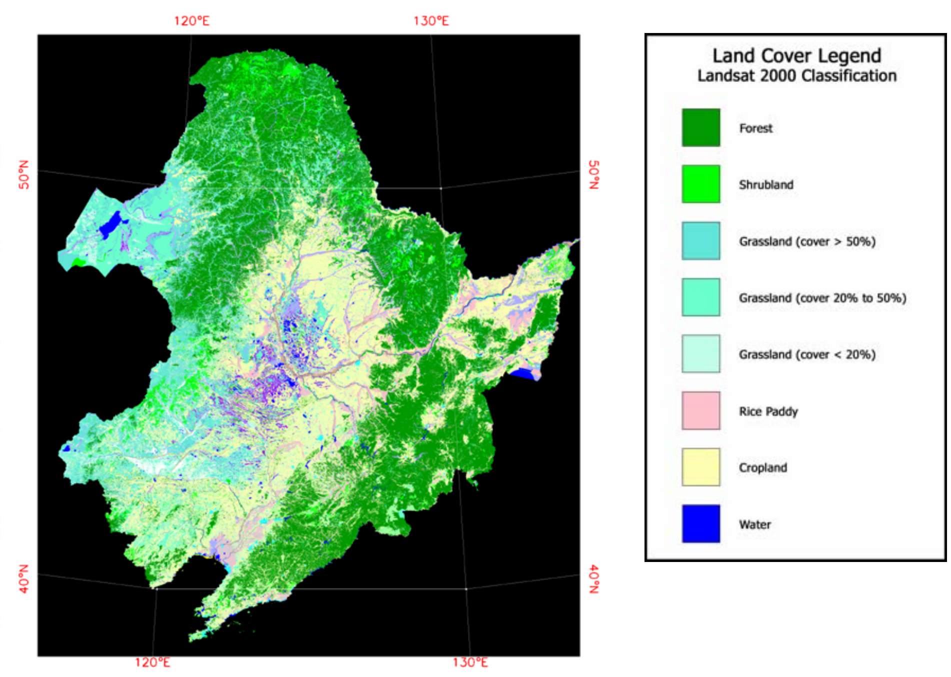
L3A: 10/6-11/9/2004

L3B: 2/19-3/24/2005

L3C: May-June, 2005

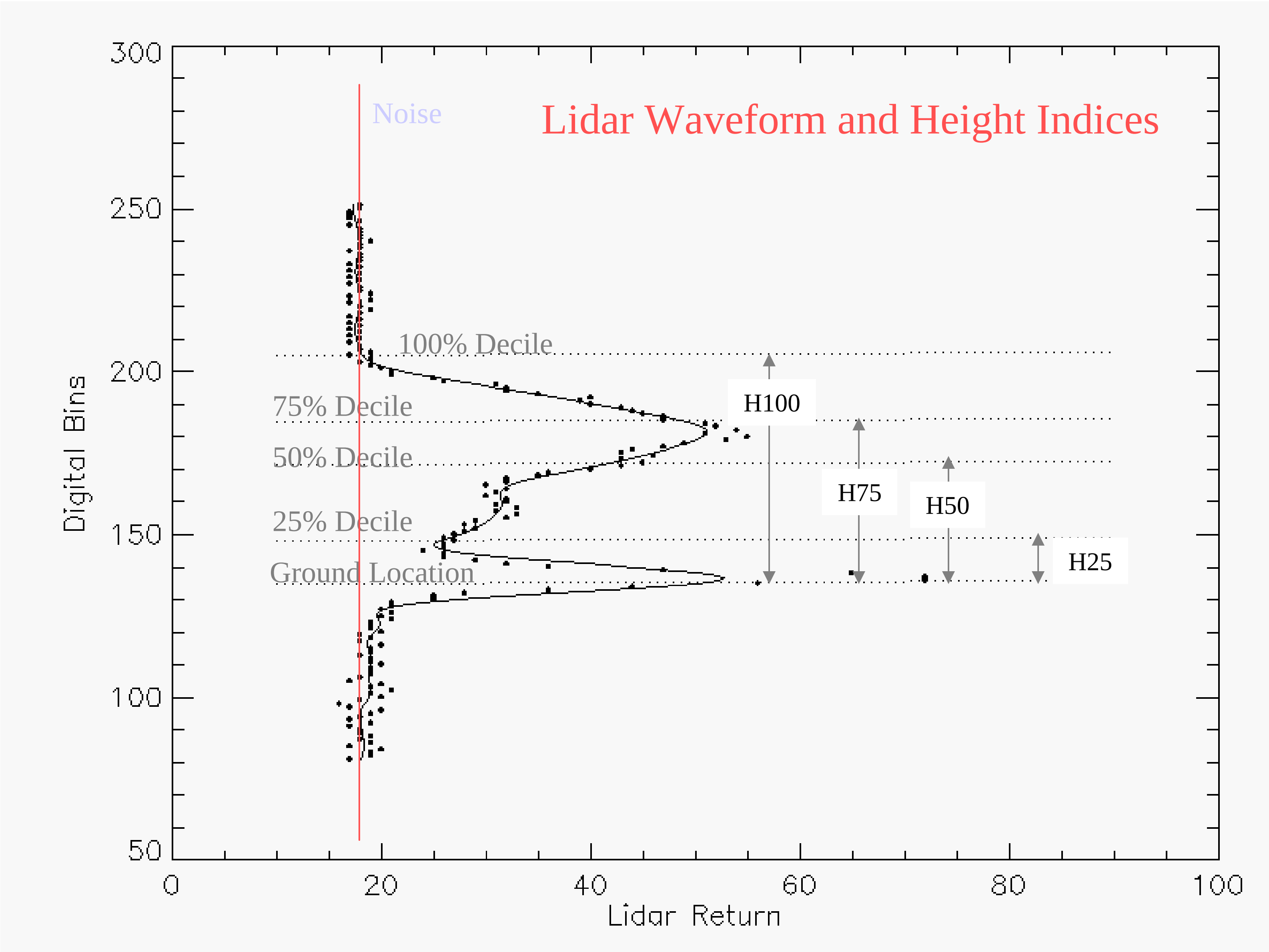
L3D: Oct-Nov, 2005



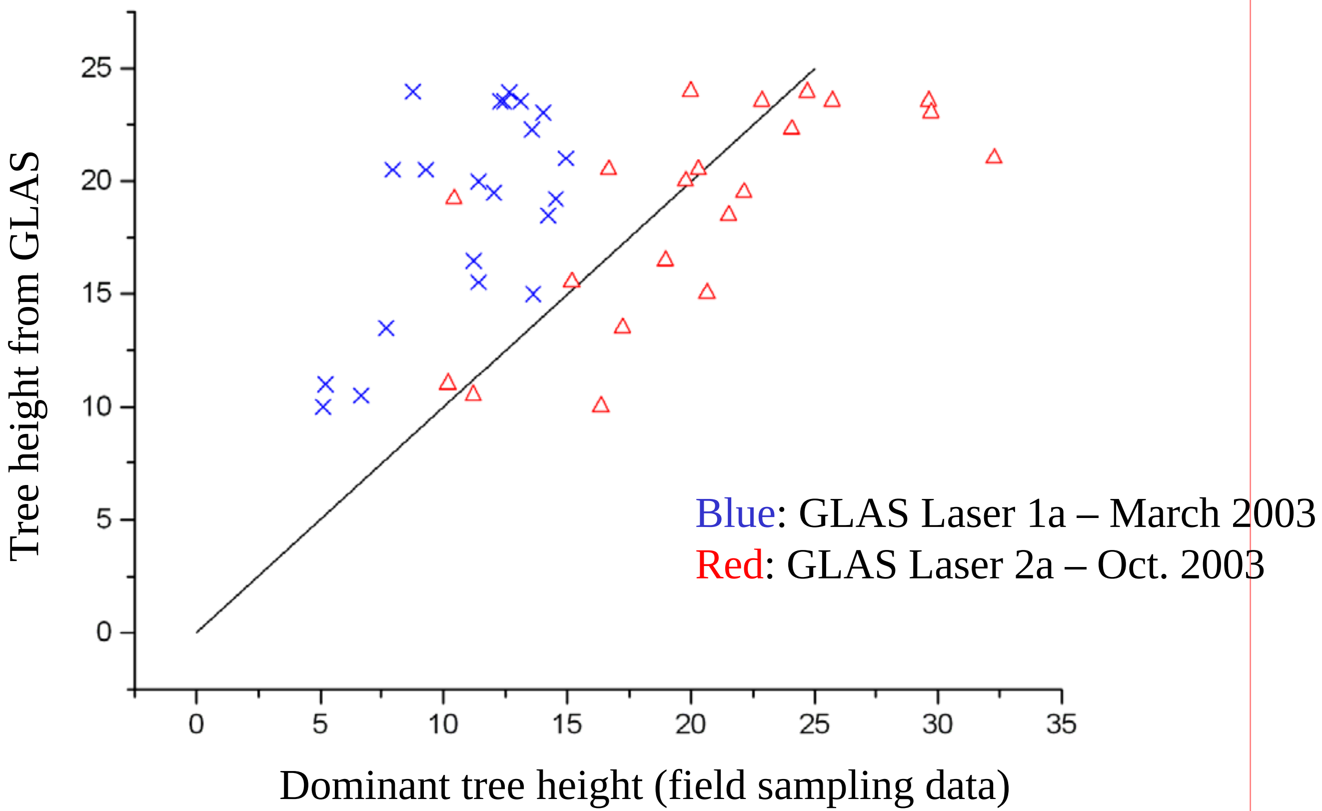


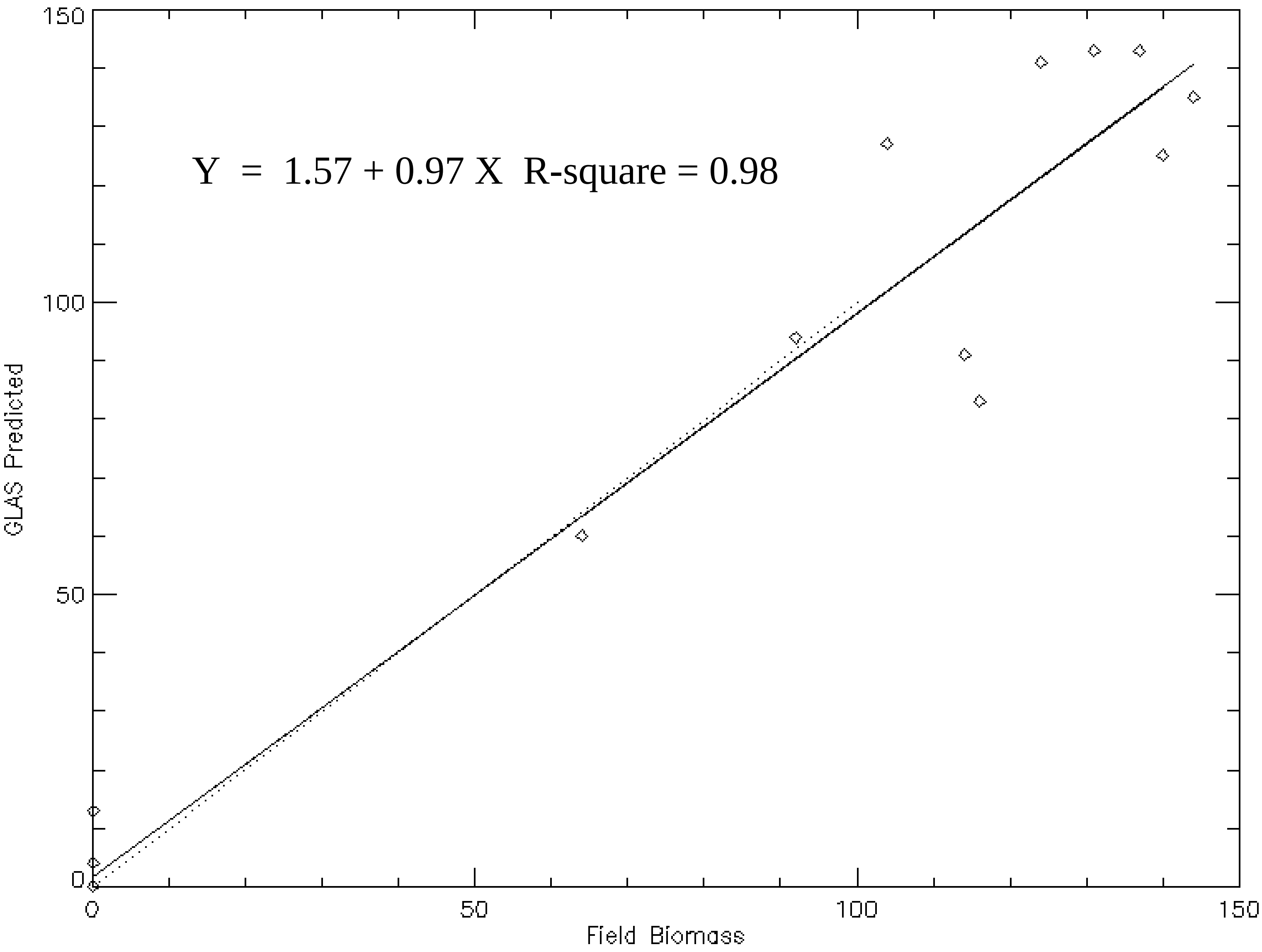
Land use map from L-7 ETM+ imagery in 2000

Tree height from GLAS data (kridging)

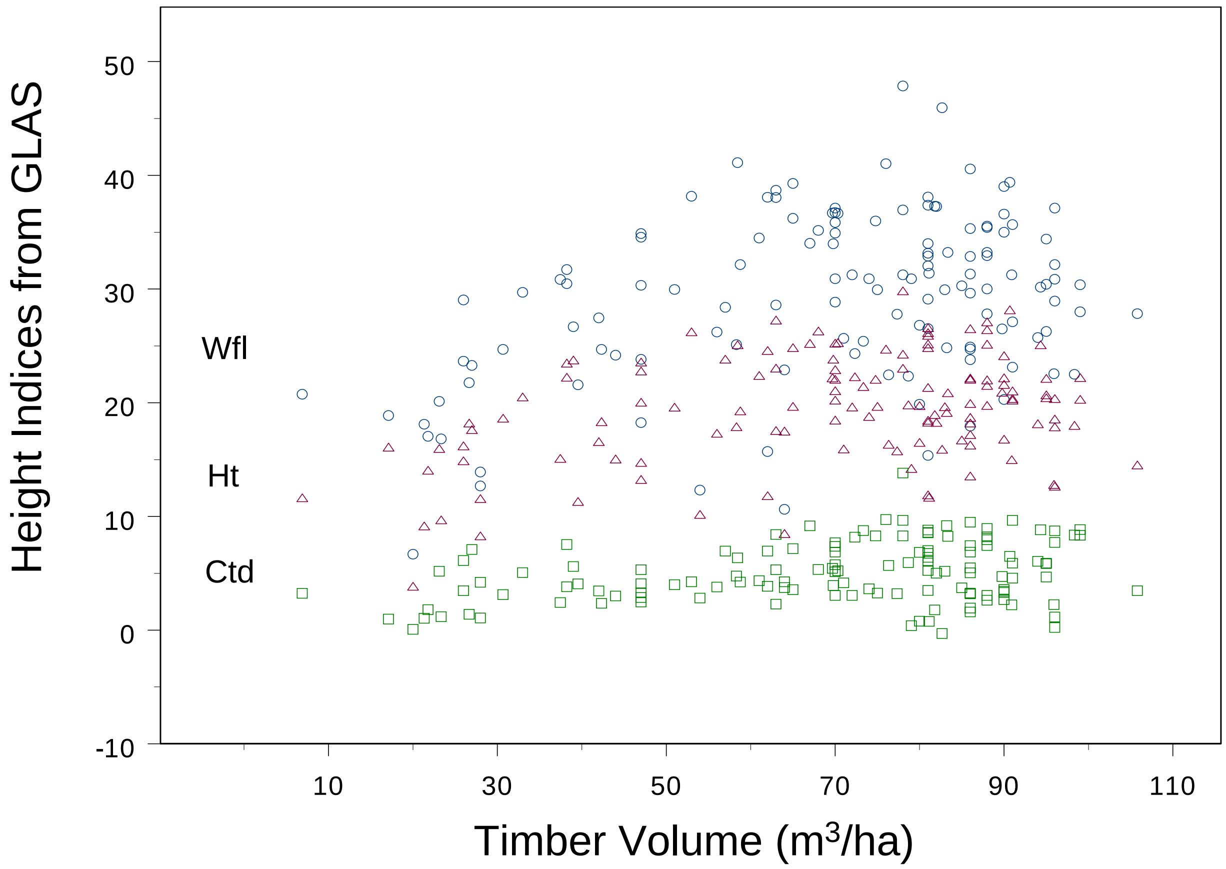

Lidar Waveform and Height Indices
Noise
100% Decile
75% Decile
50% Decile
25% Decile
Ground Location
H100
H75
H50
H25
Digital Bins
Lidar Return
300
250
200
150
100
50
0
20
40
60
80
100

Top tree height from GLAS versus height of dominant trees Measured in field in Summer 2004 by Chinese Academy of Forestry (GLAS data was in very early version. The blue points are doubtable. Much more GLAS footprints will be measured in coming summer)

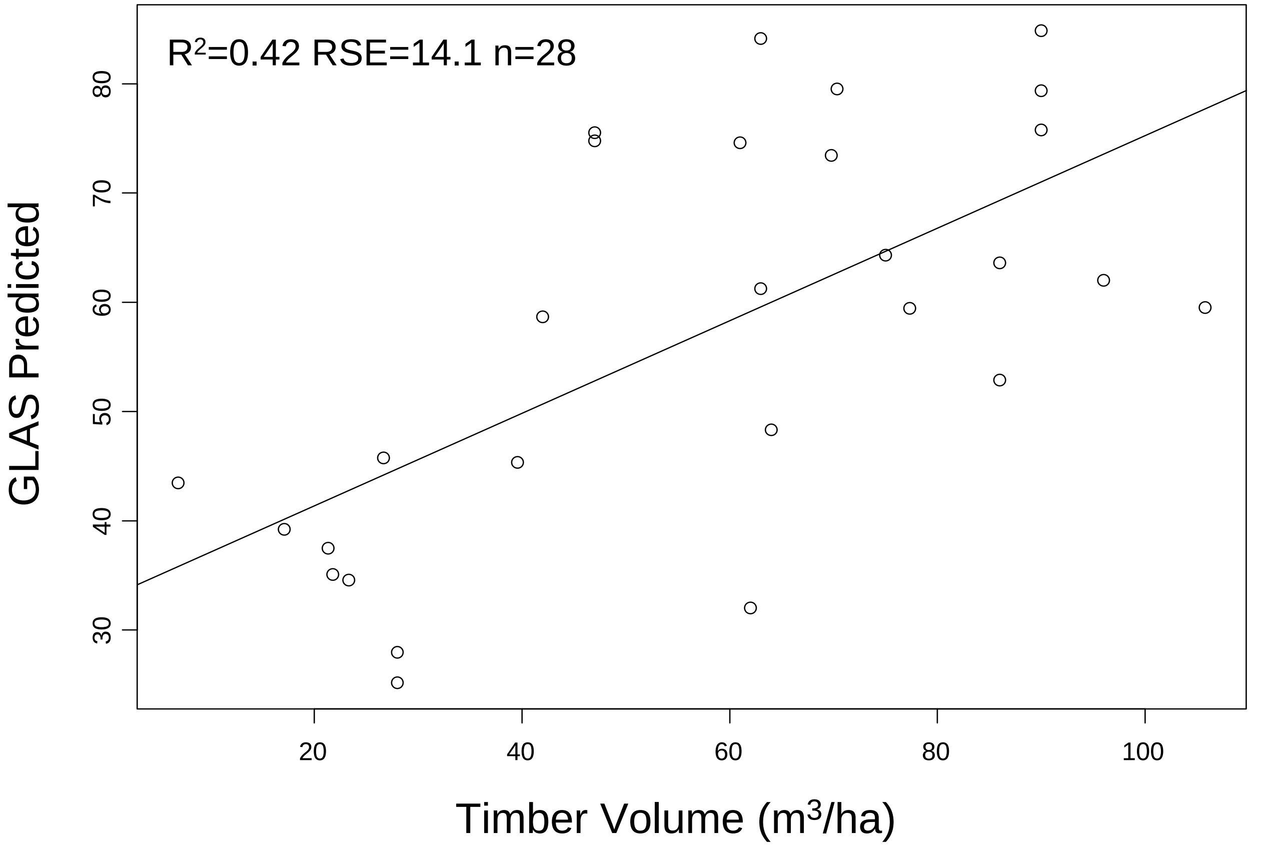


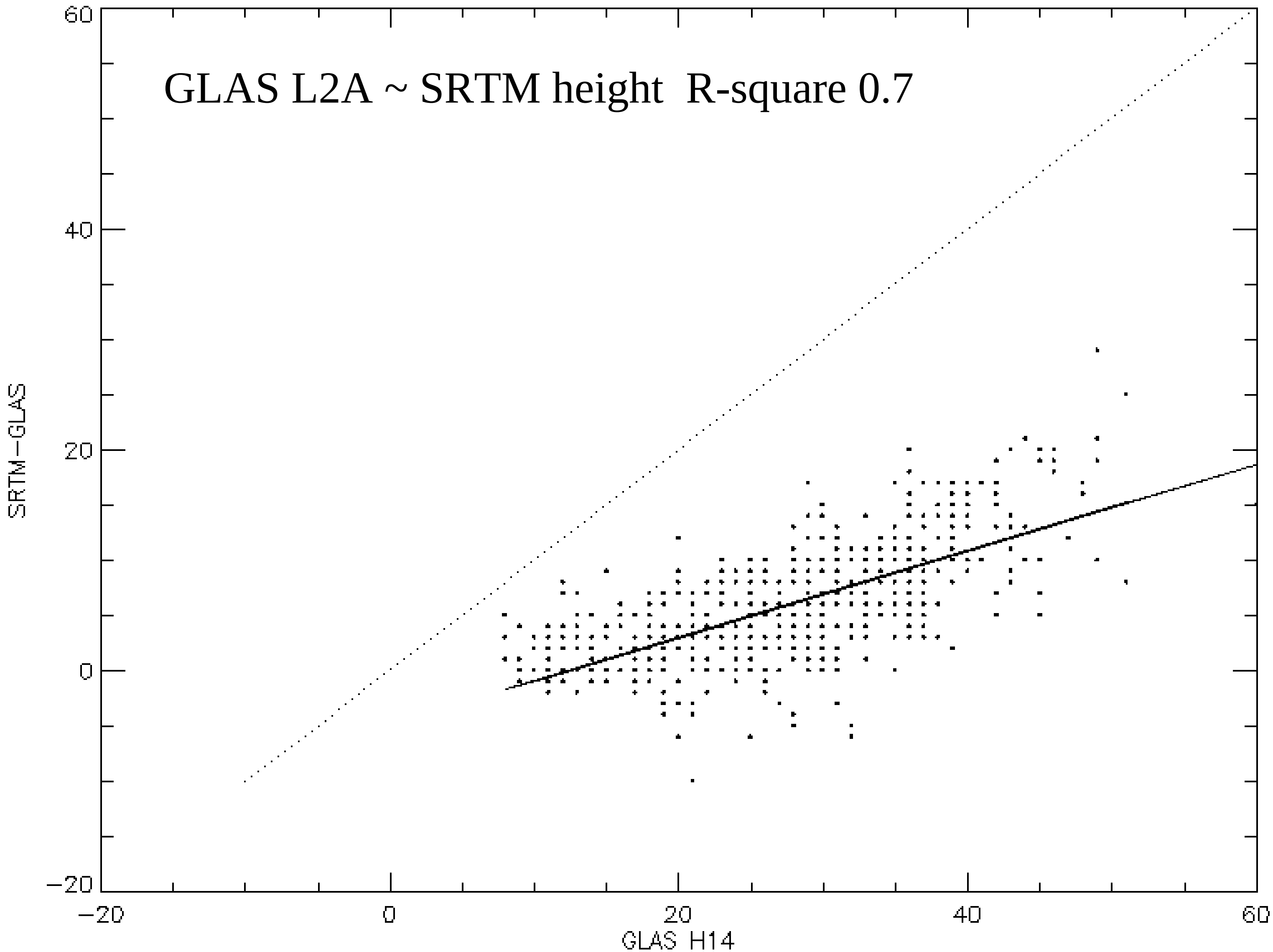

150
100
50
0
GLAS Predicted
Y = 1.57 + 0.97 X R-square = 0.98
0
50
100
150
Field Biomass

Height indices from GLAS (wfl – length of waveform, Ht – top Tree height, and Ctd – centroid of waveform) and timber volume From forest inventory



Timber volume from inventory data of Changqing Forest Bureau versus the prediction from GLAS height indices. Inventory data was compiled in 1999-2000, and GLAS data was acquired in 2003. Inventory data is man-made polygons, and GLAS footprint is an ellipse (~120mx50m). Need to have a better way to match the data.

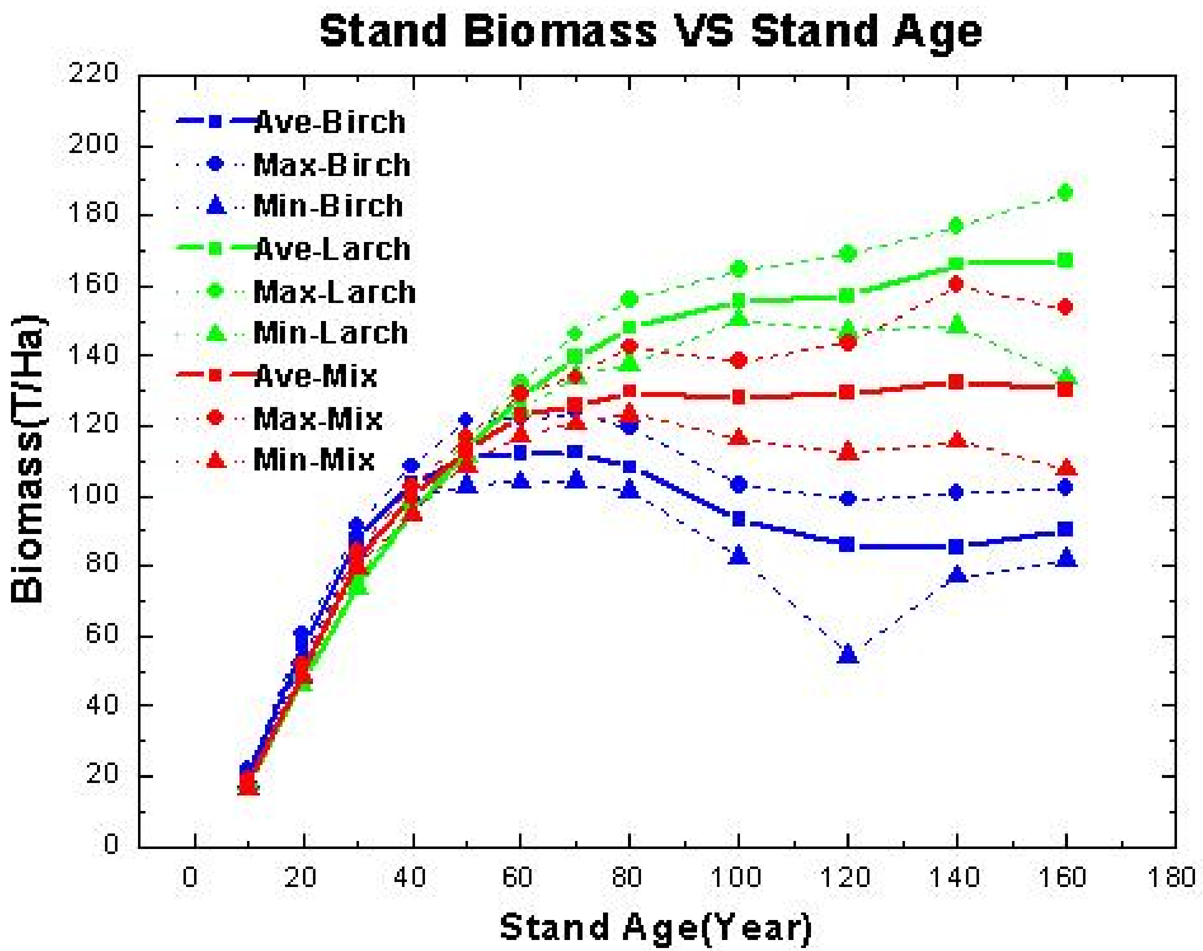




GLAS L2A ~ SRTM height R-square 0.7
SRTM−GLAS
GLAS H14
60
40
20
0
−20
−20
0
20
40
60

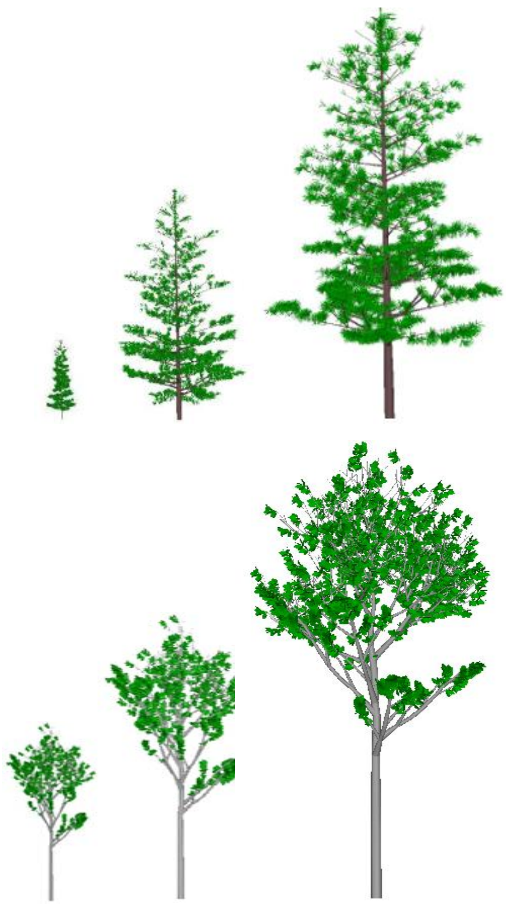
Simulation of Forest Growth

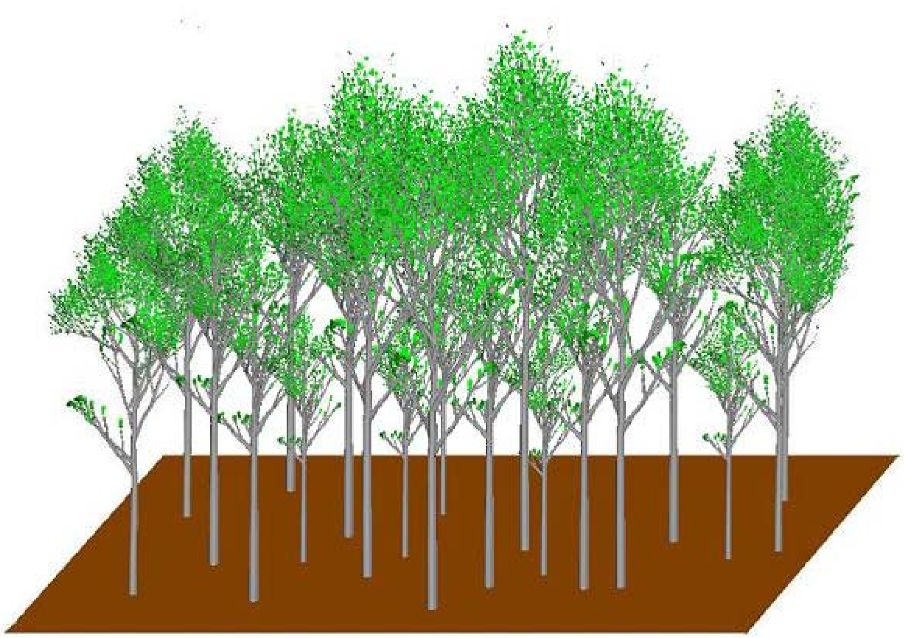
Forest growth model (ZELIG) was parameterized using local environmental and vegetation information and forest growth trajectories were simulated. This dataset will be used to link forest physical parameters currently measured from Remote Sensing technology, and other parameters (e.g. biomass) required.



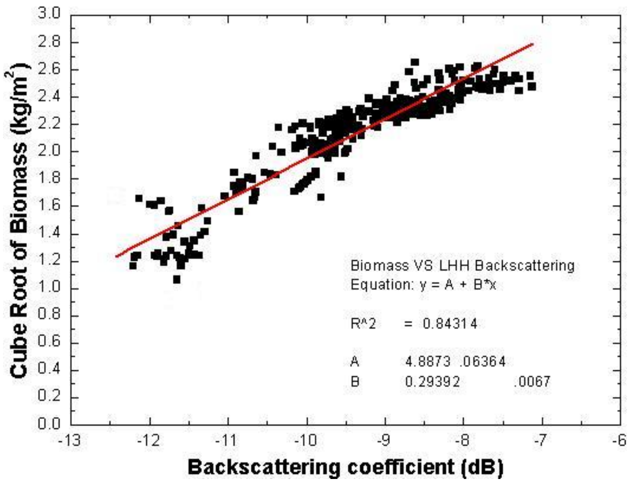
Simulation of Tree 3D Structure and Forest Stand

Tree architecture was simulated using L-systems. These simulated stands serve as input to 3D radiative transfer models (optical, radar backscatter and lidar waveform) to build a database for inversion algorithm development.

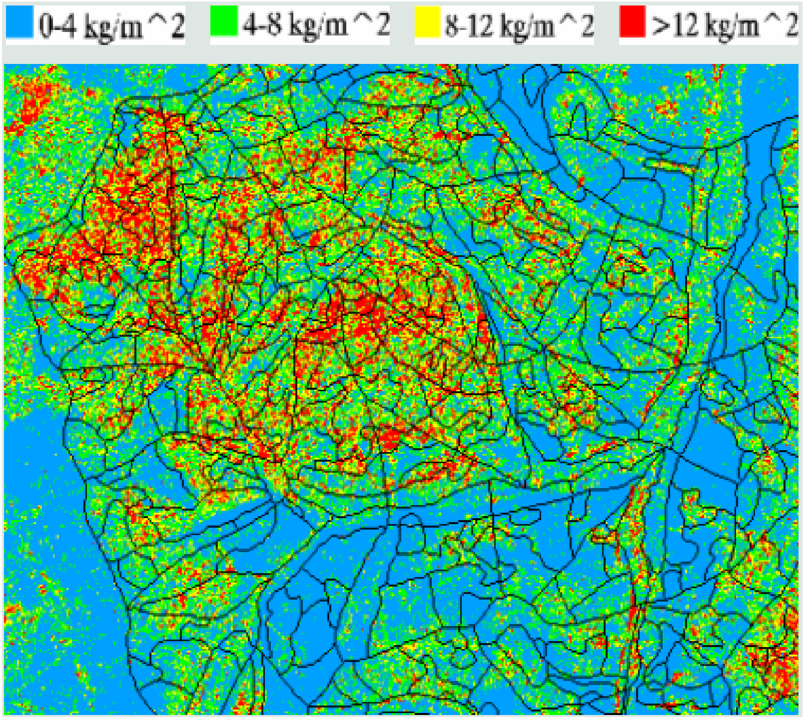


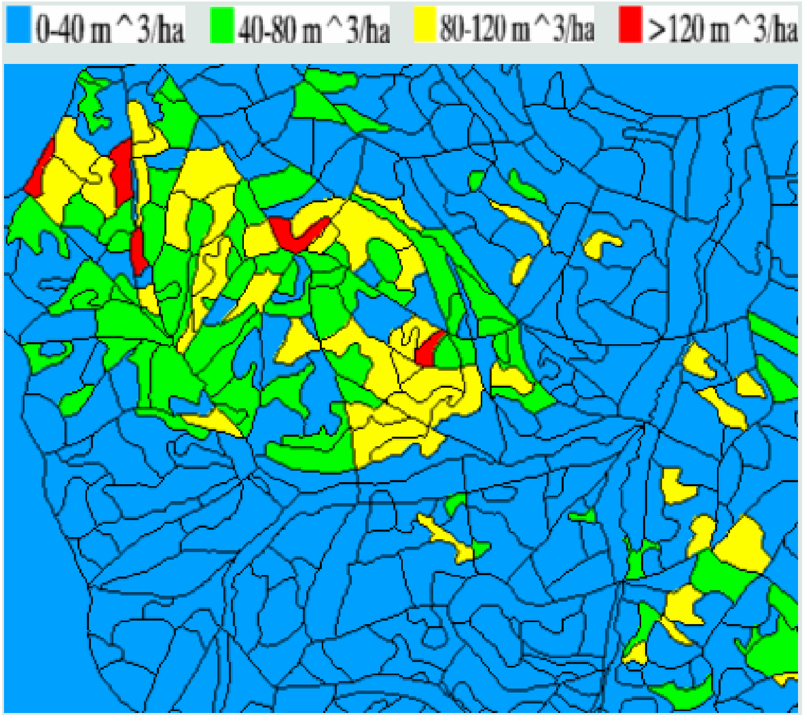


Biomass estimation algorithm developed
Using simulated database and
Biomass estimation from JERS-1 LHH



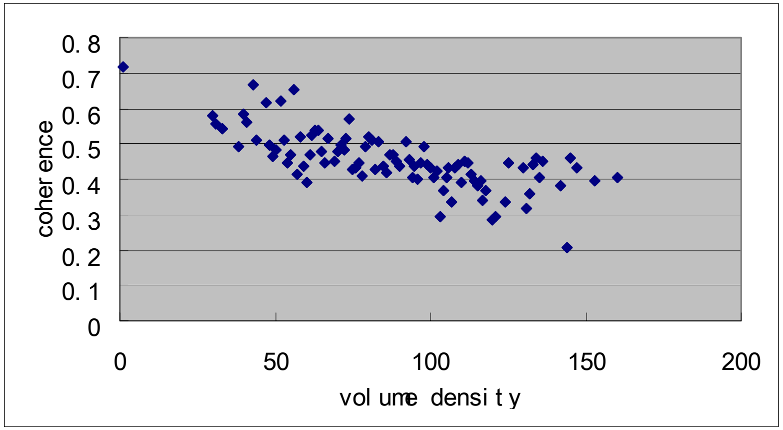
(Changqing Forest Bureau)



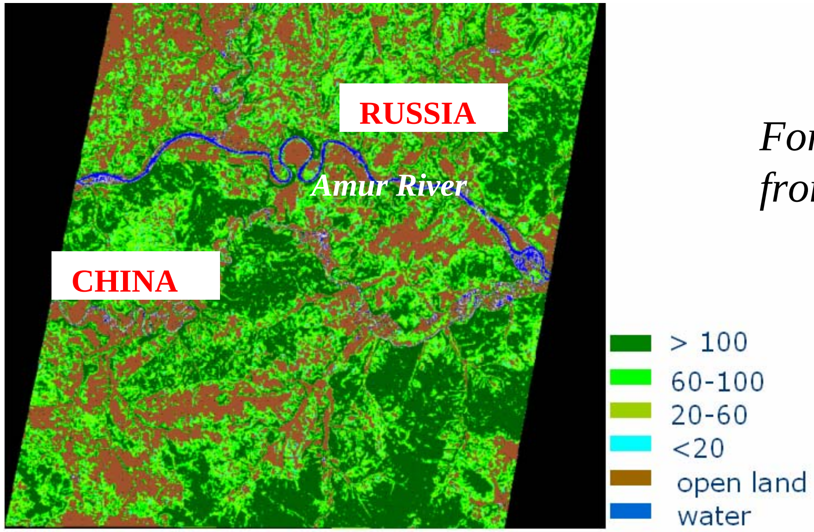


Biomass from radar data

Timber volume from inventory

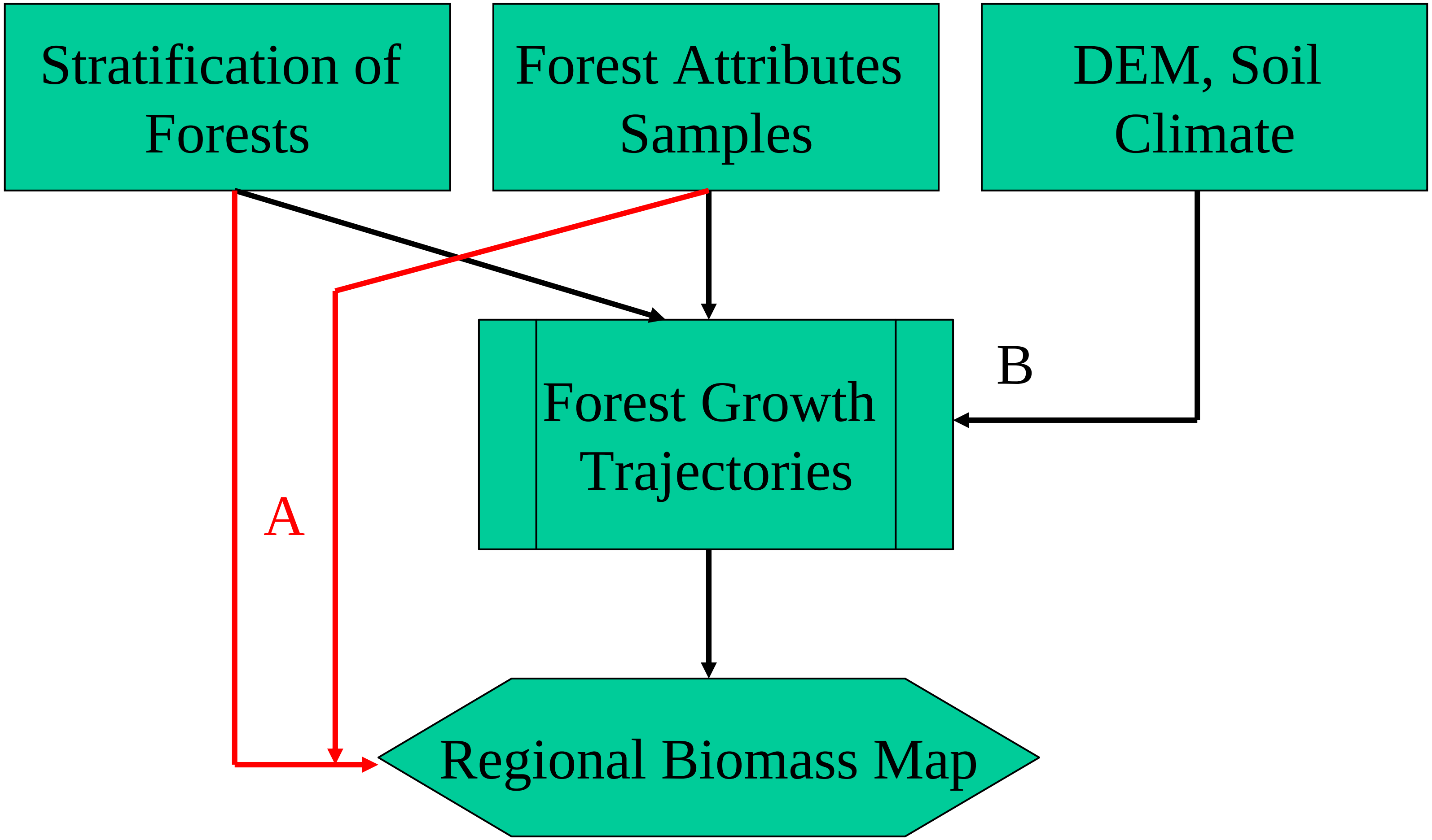


Relations between ERS-1/2 tandem data coherence and forest timber volume



Forest timber volume map (m^3/ha) from ERS-1/2 coherence data

"Road Map" to regional biomass estimation



A. Forest units * biomass/unit => Total biomass

B. (Forest type, crown cover, height, etc. soil, DEM) > find match in forest Growth trajectories => Biomass

THANK YOU!

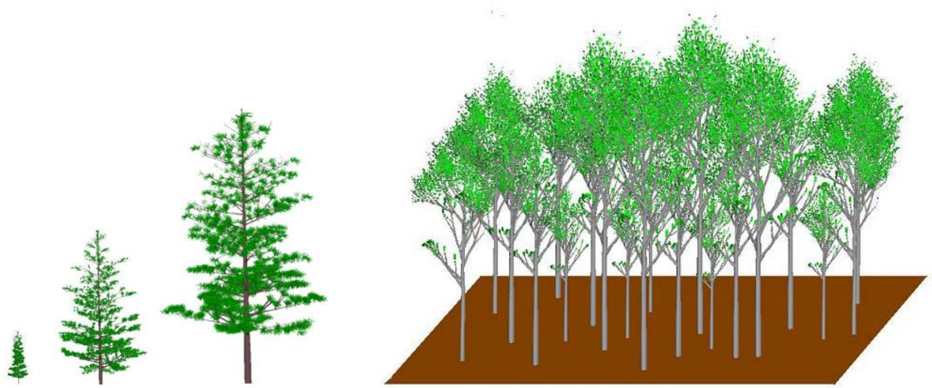
Additional collaborators working in the project:

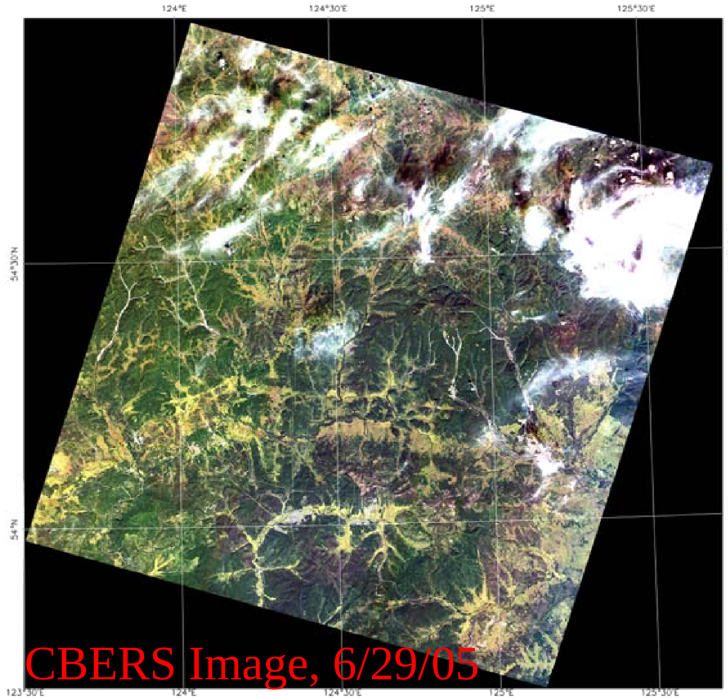
Ph. D. Students in Institute of Remote Sensing Applications, CAS, and Institute of Forest Resources Information Technology, CAF:

Fu Anmin – Forest disturbances from optical RS data

Wang Diajung – Forest growth and C, N cycle modeling

Liu Dawei – Tree architecture from L-system and InSAR modeling





CBERS Image, 6/29/05