

Interdisciplinary research for carbon cycling in a forest ecosystem and scaling to a mountainous landscape in Takayama, central Japan.

- Scaling from plot to landscape by “Satellite Ecology” -

Hiroyuki MURAOKA

Director of 21st Century COE Program “Satellite Ecology”,
Institute for Basin Ecosystem Studies, Gifu University, Japan

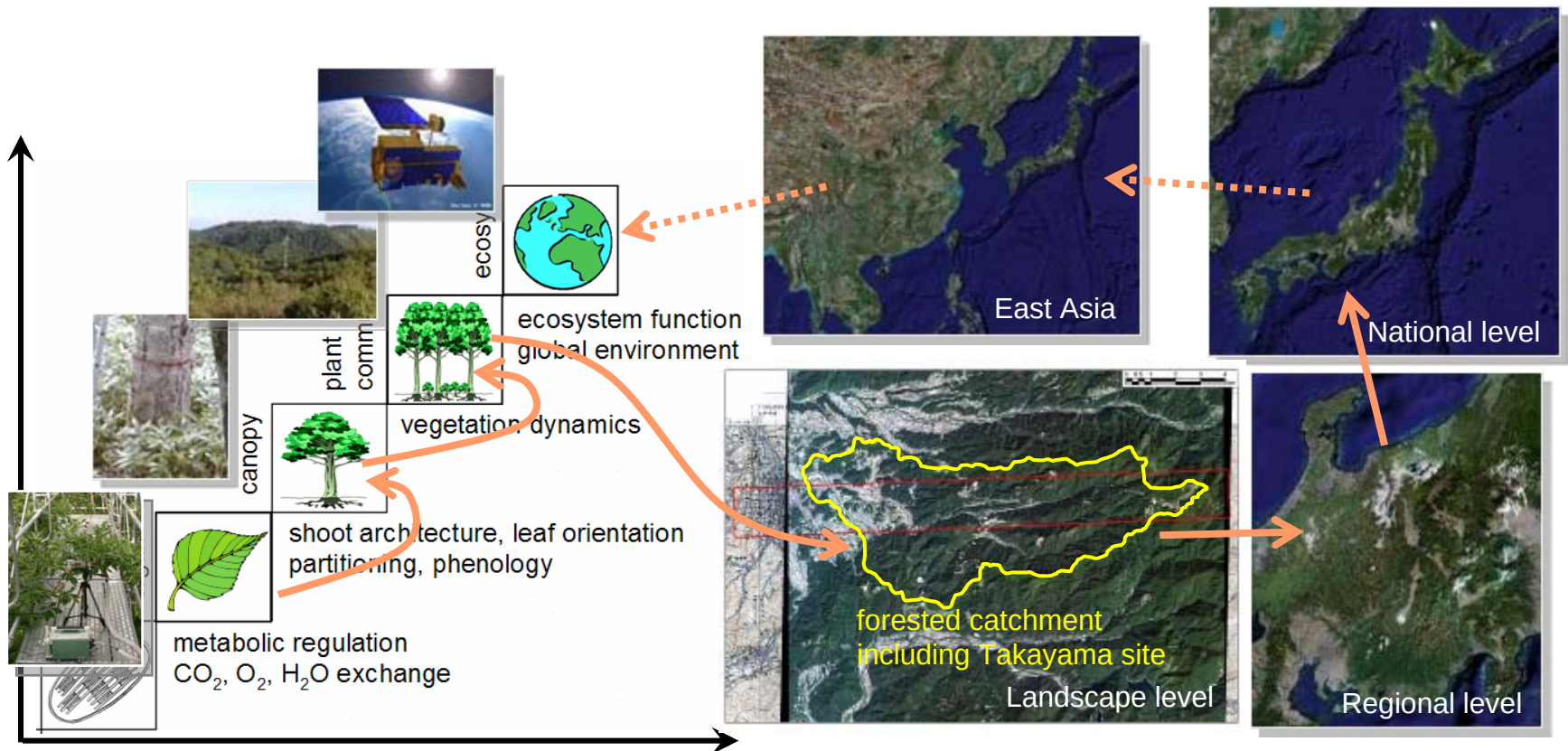
ALOS イメージ提供：JAXA

Revealing carbon cycle processes and scaling

Carbon cycling in plot, landscape, regional, continental and global.....

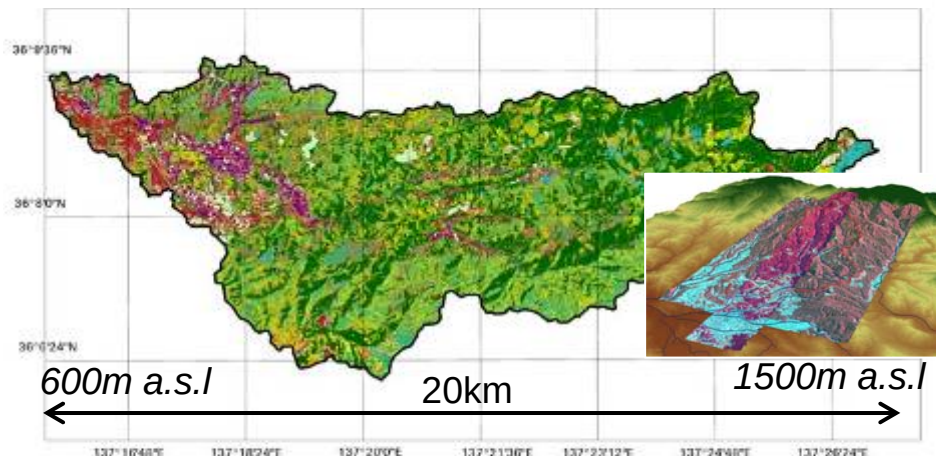
In mountainous landscapes, scaling should be done carefully
from a canopy to ecosystems, landscape, regional....,

... If we don't want to miss the consequences of the processes ...



Spatial resolution must be tested carefully

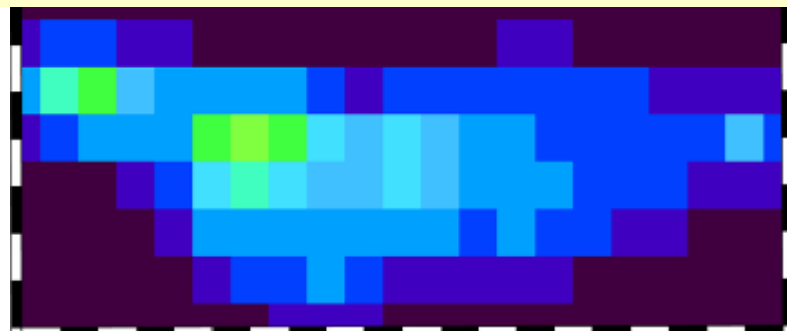
Vegetation and land-use type distribution in a forested catchment of Takayama site (2-10m resolution by CASI-III, ALOS, QuickBird)



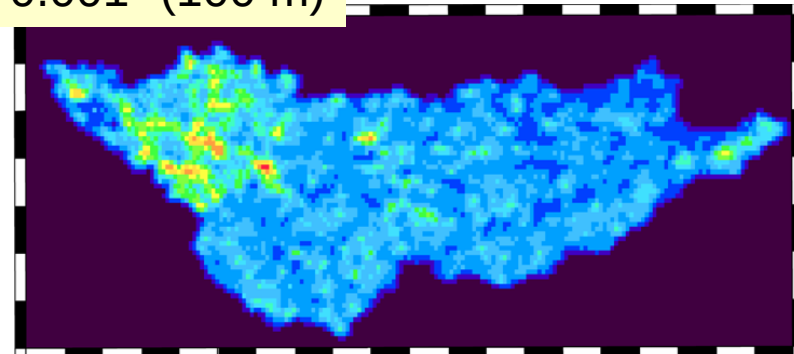
High spatial resolution provides:

- (1) consequences of ecosystem structure/function – meteorology – topography interactions
- (2) accurate estimate of spatial patterns of ecosystem functions
- (3) application to ecosystem management policy

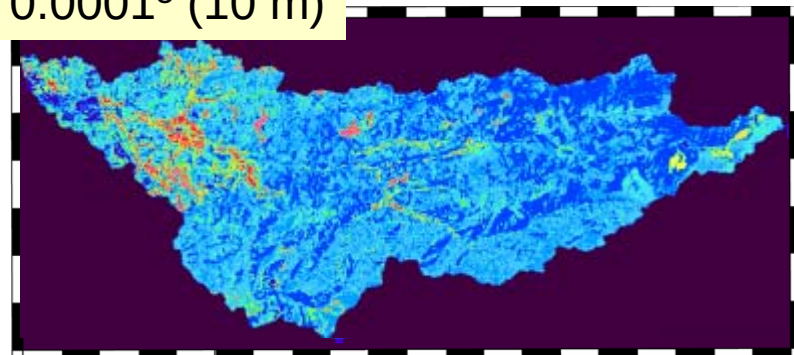
0.01° (1 km) MOD15, MOD17



0.001° (100 m)

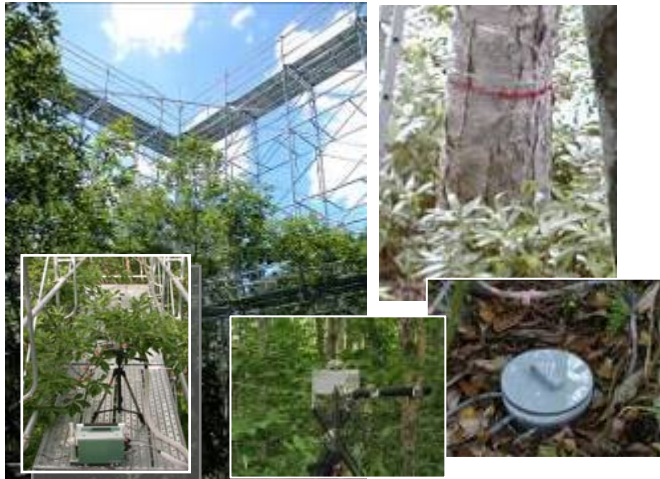


0.0001° (10 m)



CO₂ cycling research: scale and methods

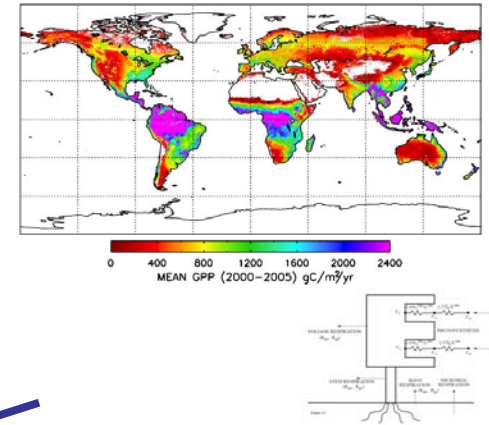
Ecological process research



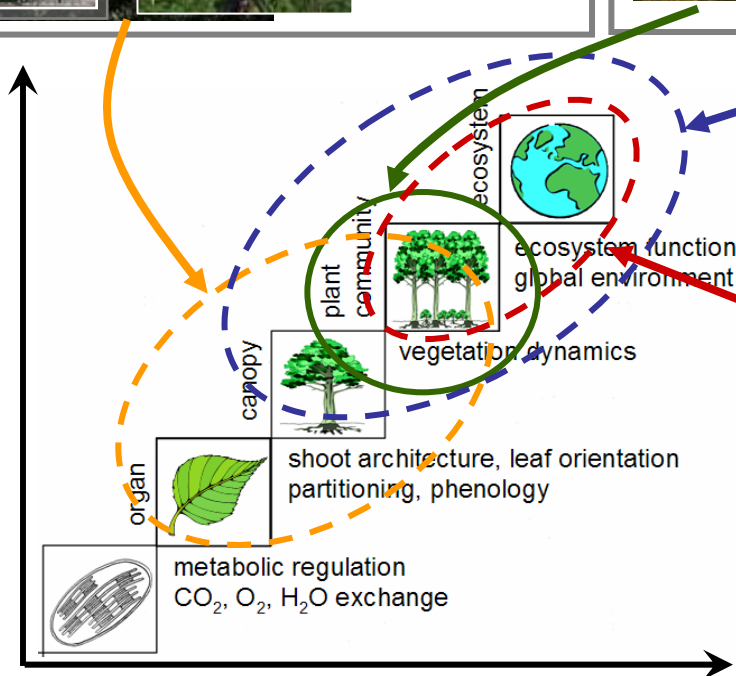
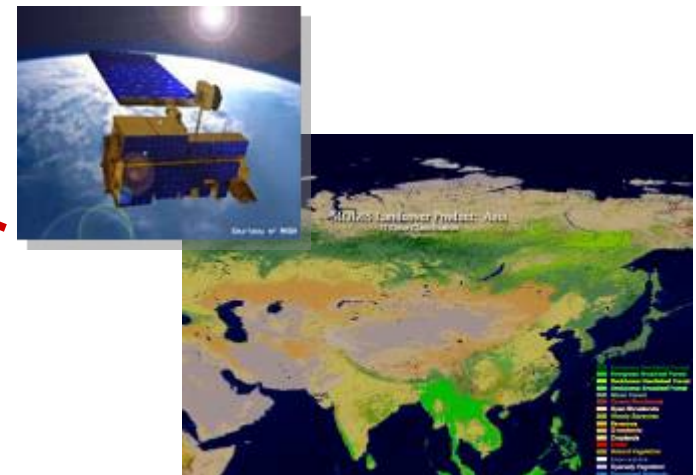
CO₂ flux / meteorological observation



Simulation models



Satellite remote sensing



Topics

Introduction

Carbon cycling study in a cool-temperate forest.

- Combining ecological process research and CO₂ flux obs. in “Takayama site”, central Japan.

Scaling carbon budget processes from plot to landscape.

- “Satellite Ecology”: an interdisciplinary approach for fine- spatial and temporal resolution estimates.

Networking for future research and education.

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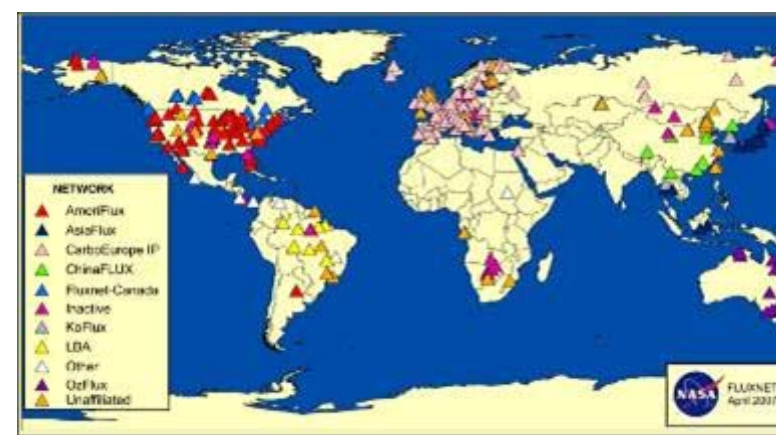
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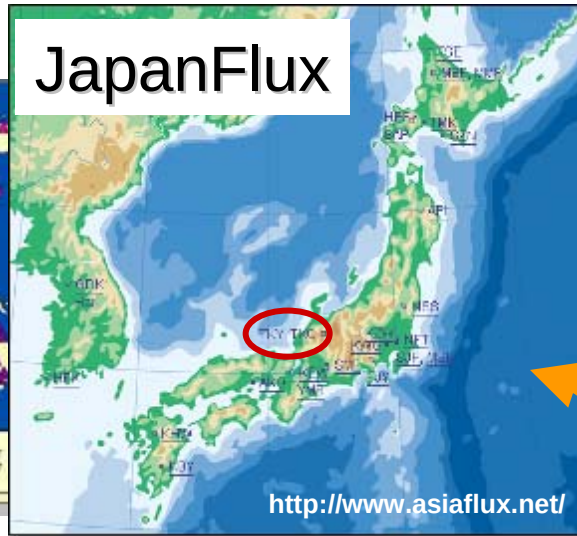
Networking for future research and education.

Takayama super-site to bridge research communities

FLUXNET



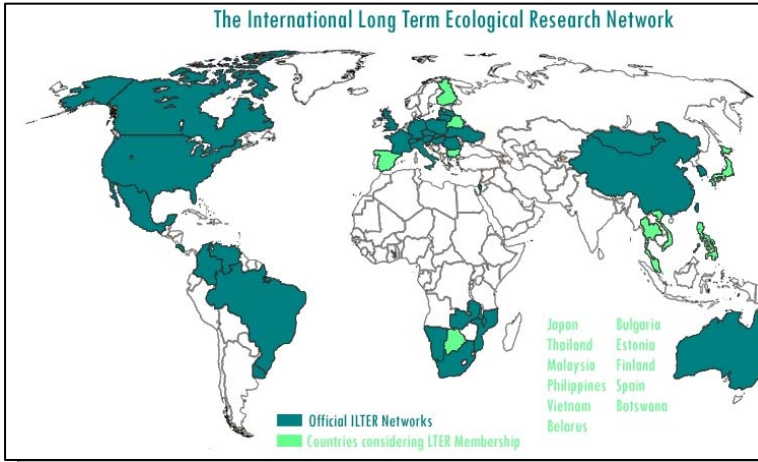
JapanFlux



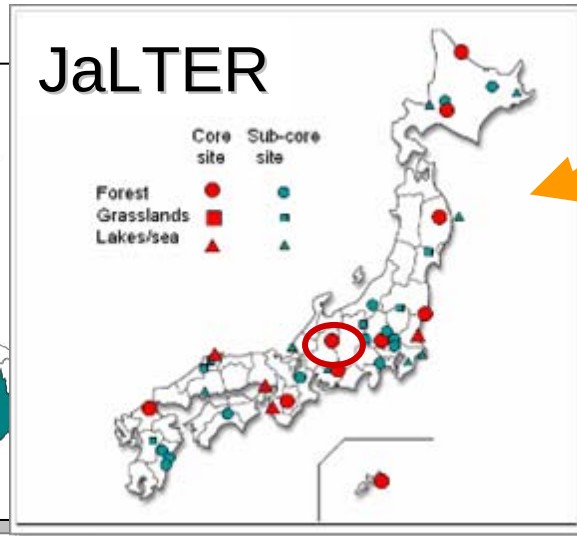
LTER

(Long Term Ecological Research network)

The International Long Term Ecological Research Network



JaLTER

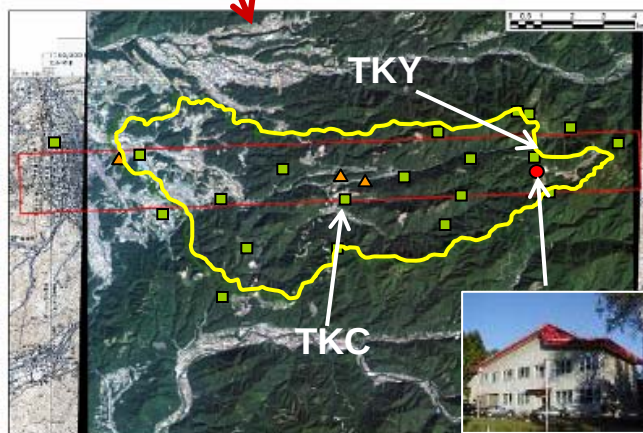
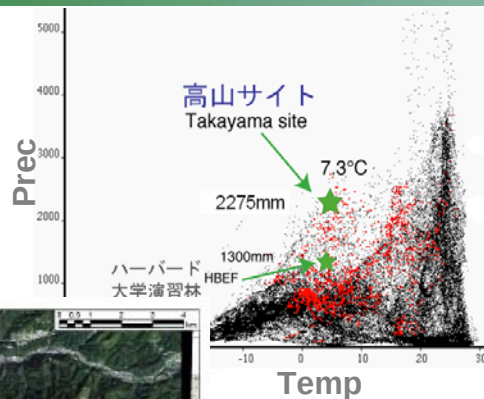
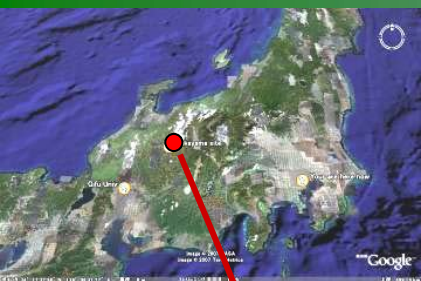


Why don't you solve a mystery in ecosystem ?



AsiaFlux network
JaLTER (Japan Long-Term Ecological Research Network)
TAKAYAMA in Japan
River Basin Research Center, Gifu University
National Institute of Advanced Industrial Science and Technology

Takayama super-site



Evergreen coniferous
forest (TKC)



Deciduous broadleaf
Forest (TKY)



Atmospheric measurements

① Meteorological observation



② Isotope



③ CO₂ flux



④ PAR
(Photosynthetic Active Radiation)



Ecological measurements

⑤ Photosynthesis



⑥ Soil respiration



⑦ Litter trap



⑧ Biomass



Remote-sensing measurements

⑨ Phenology image



⑩ Shoot-phenology
(Measurement of leaf number,
size, angle, and SPAD)



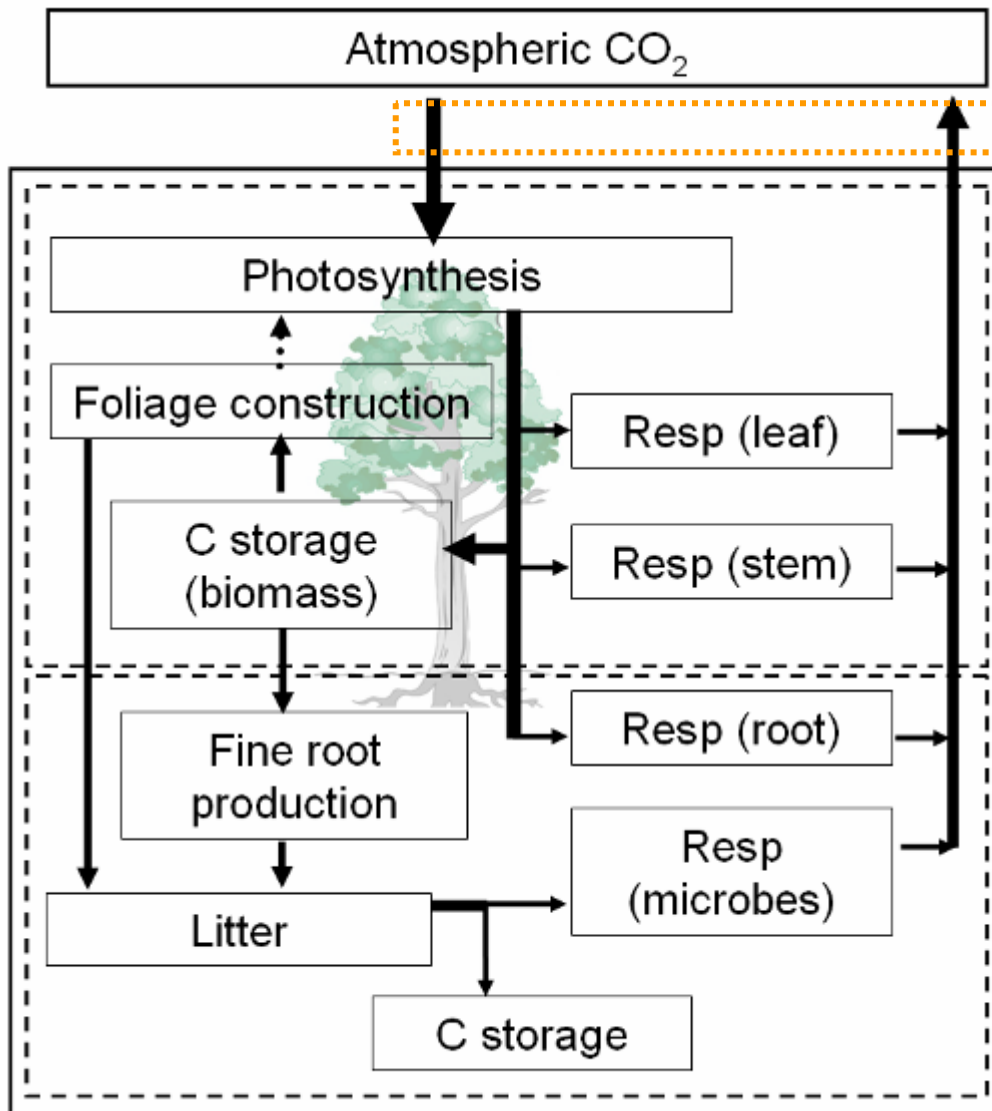
⑪ Radiometric
measurement



⑫ Sky image



Interdisciplinary approach for carbon cycling study



Interdisciplinary approach

< Tower observation >

Continuous measurements in high temporal resolution

- *ecosystem scale response to climatic conditions* -

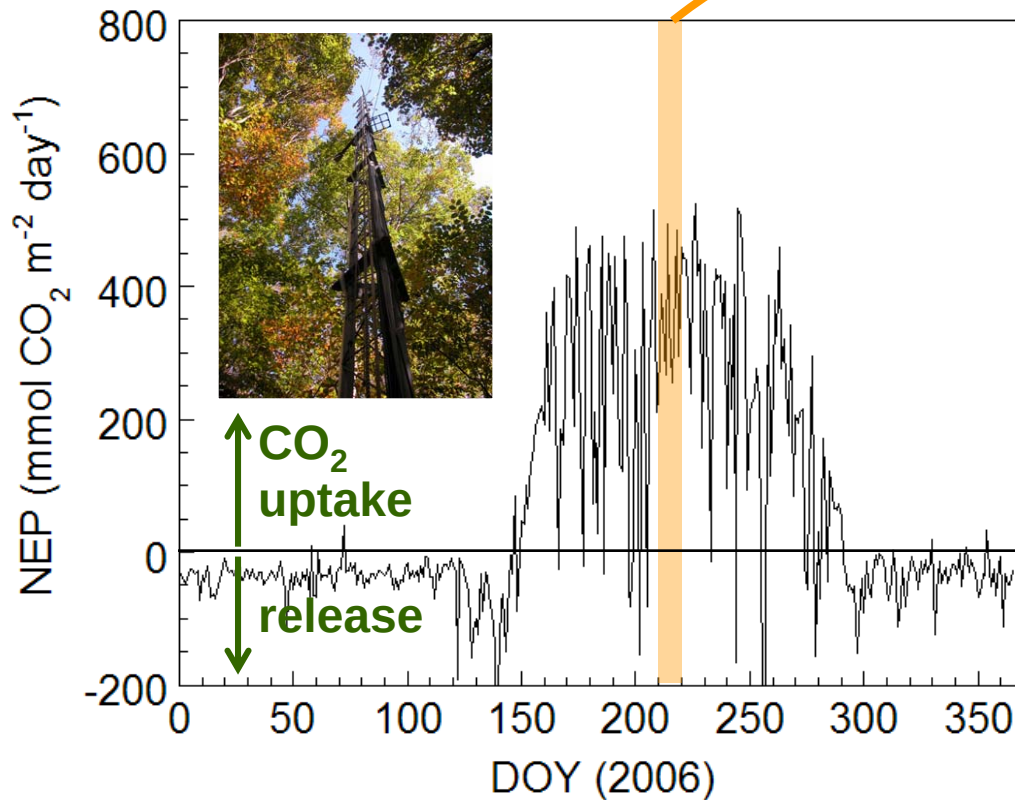
< Ecological process study >

Revealing the processes of carbon flow and pools

- *ecological mechanisms of the ecosystem response* -

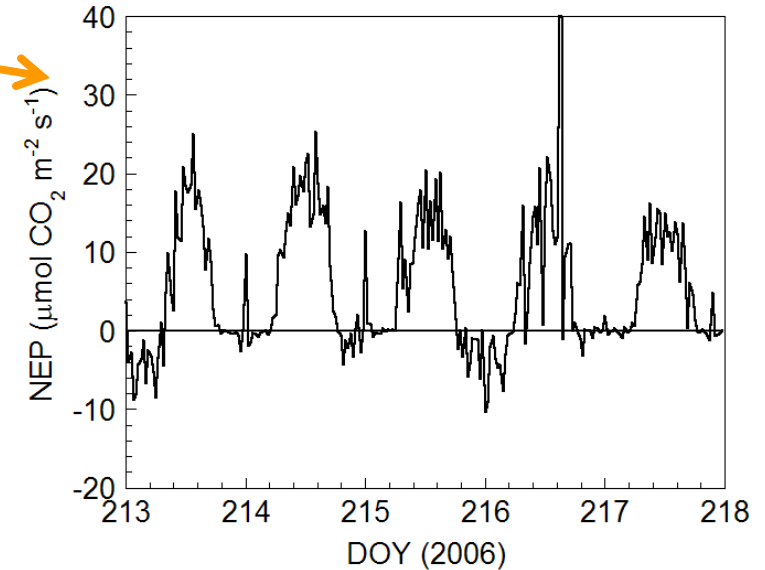
CO₂ flux by tower measurements

CO₂ flux: seasonal change

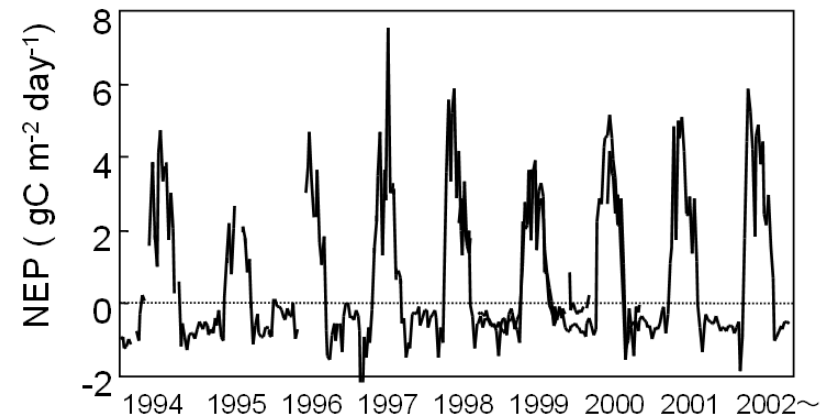


NEP: Net Ecosystem Production

CO₂ flux: diurnal change

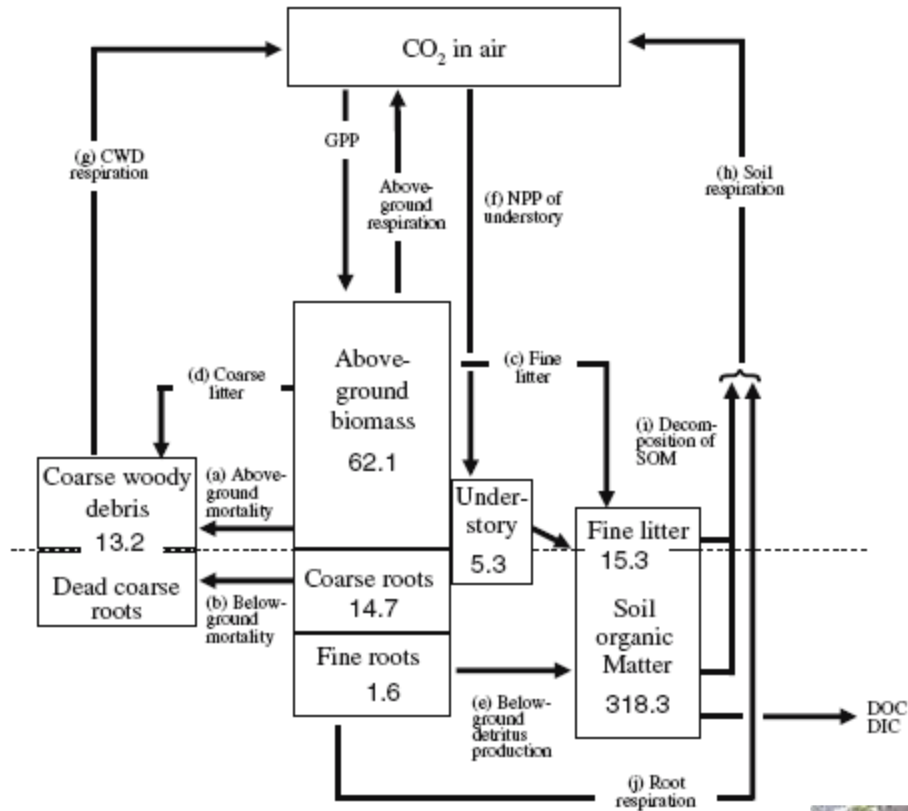


CO₂ flux: yearly change

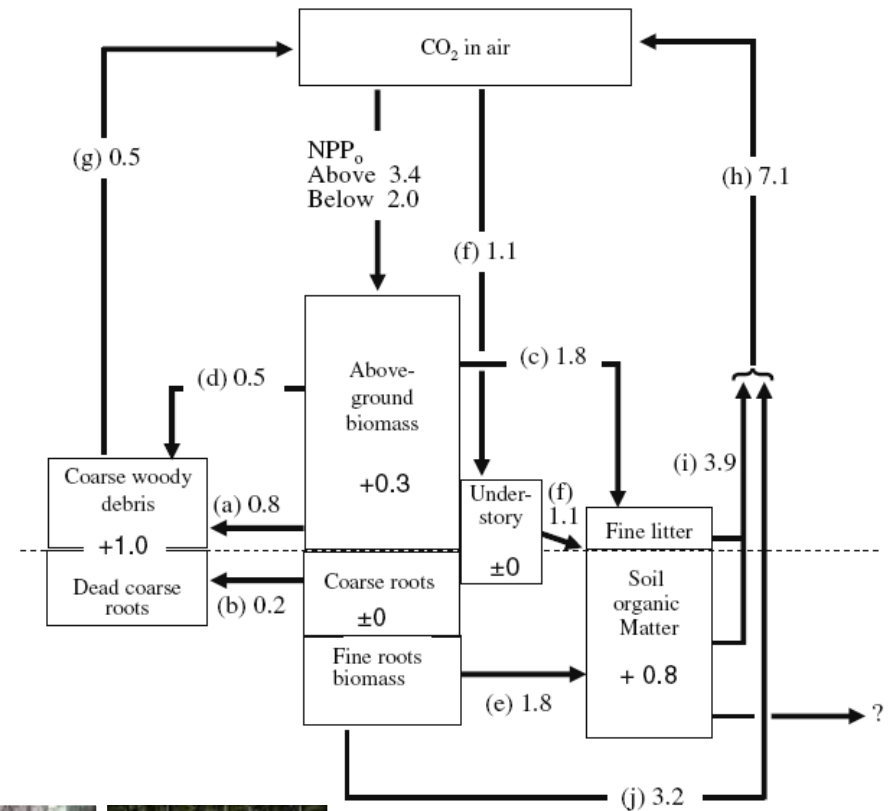


Carbon pools and flows by ecological research

Carbon pools



Carbon flows

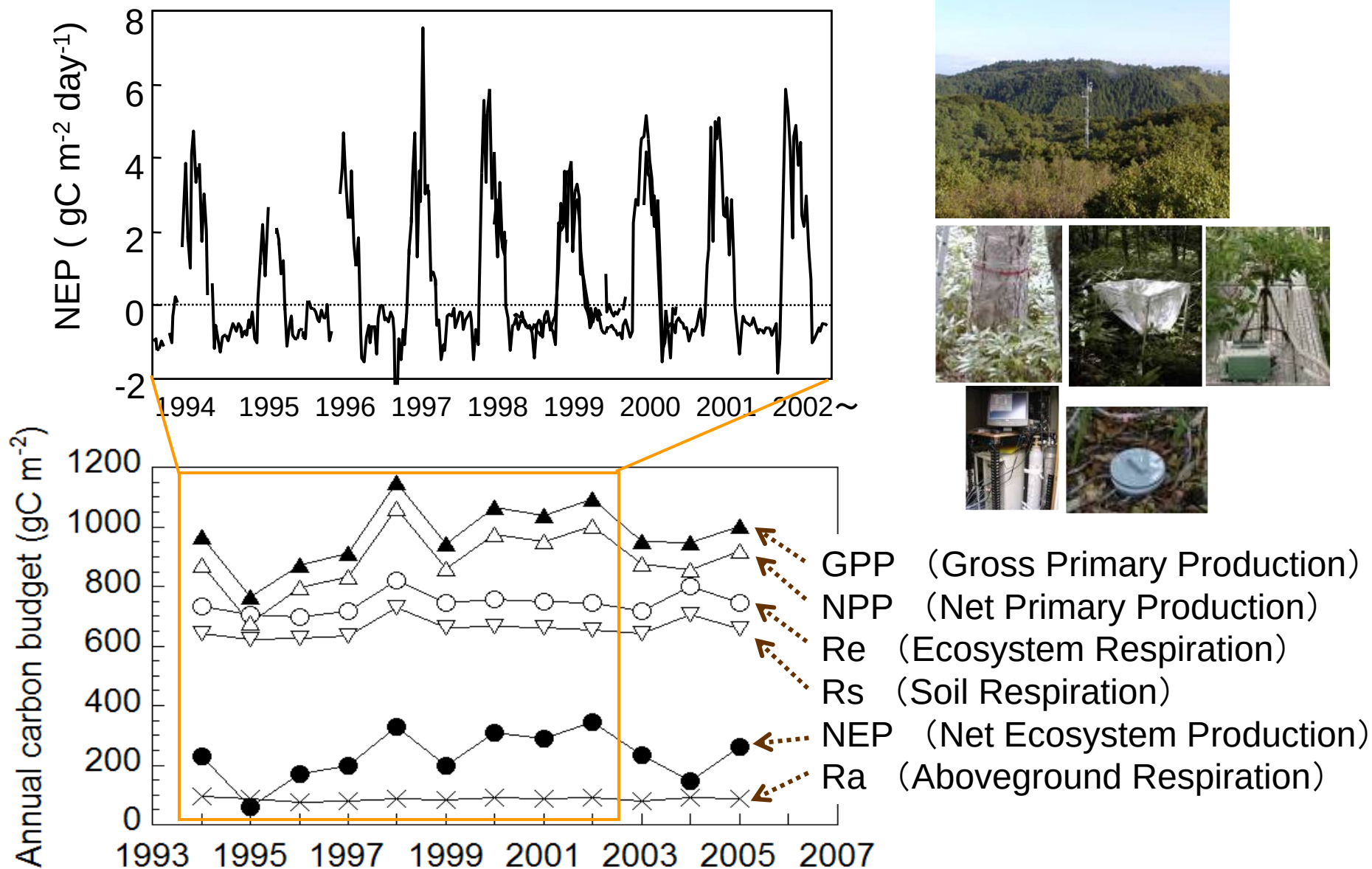


Ecosystems (2007) 10: 324–334
DOI: 10.1007/s10021-007-9017-z

Biometric Based Carbon Flux Measurements and Net Ecosystem Production (NEP) in a Temperate Deciduous Broad-Leaved Forest Beneath a Flux Tower

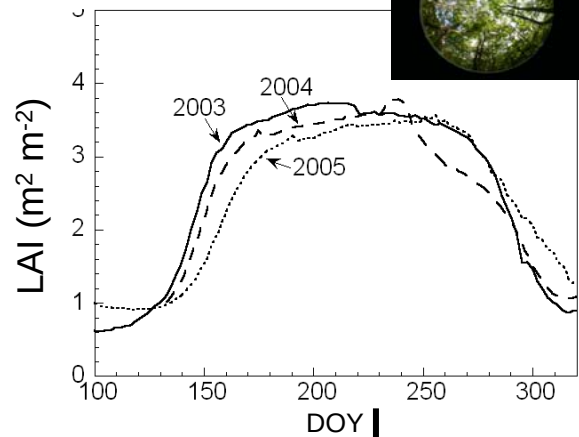


Yearly NEP and its ecological determinants in TKY

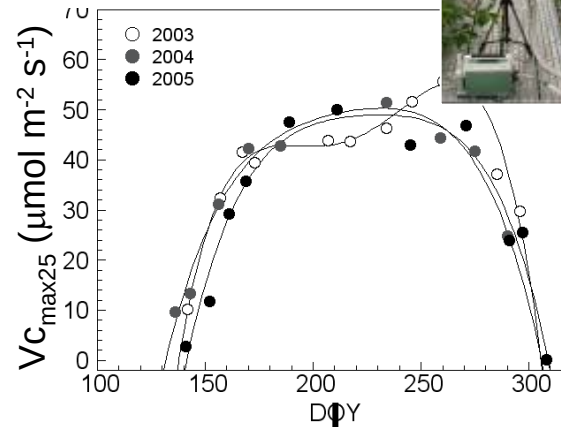


Yearly GPP depends on LAI and leaf photosynthesis

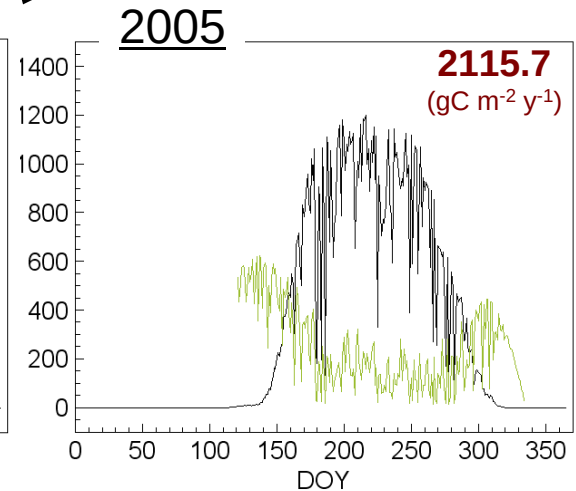
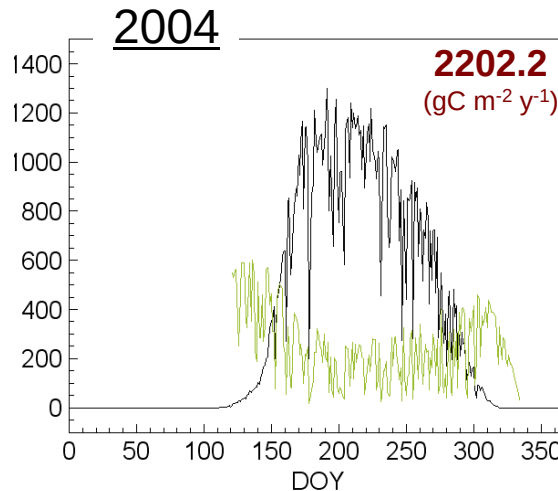
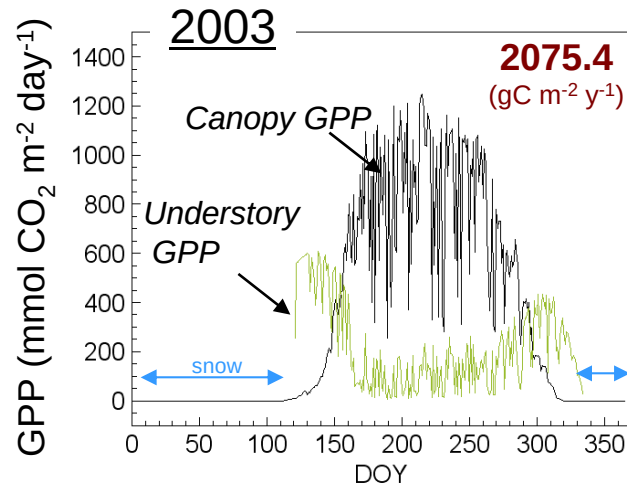
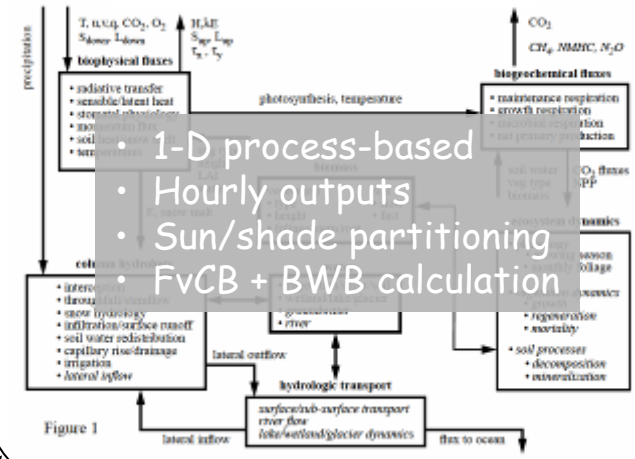
Leaf Area Index



Leaf photosynthesis



Process-based model



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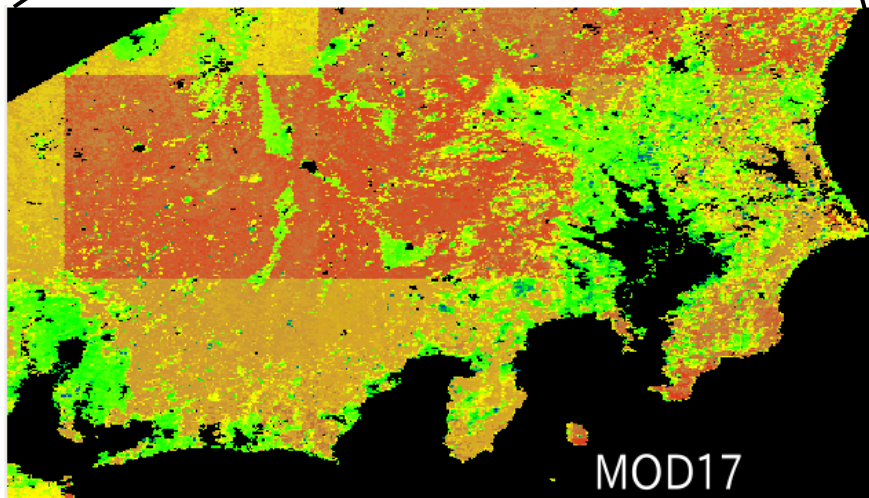
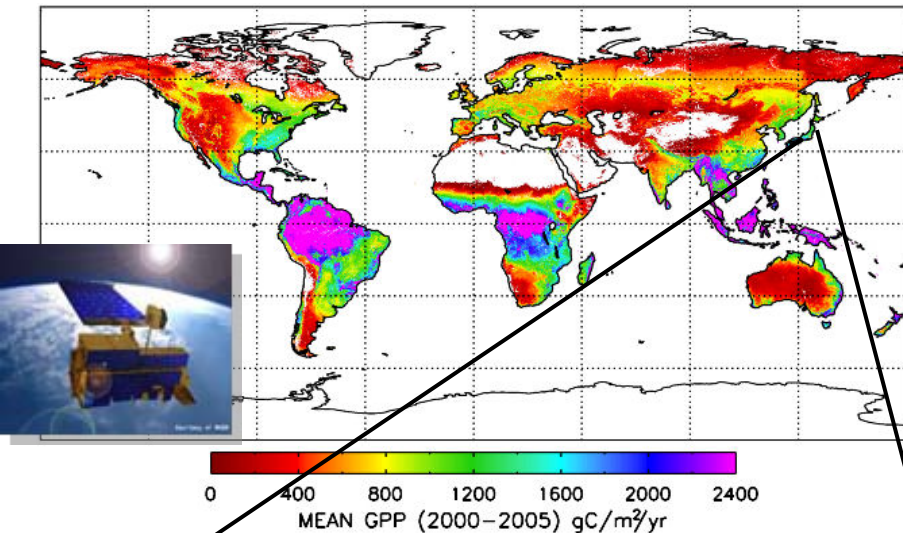
Scaling carbon budget processes from plot to landscape.

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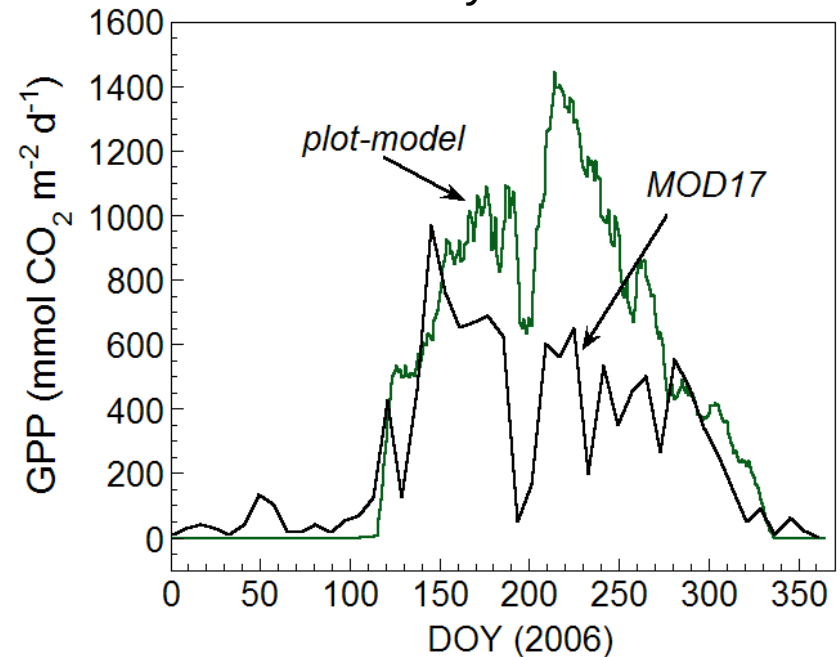
Networking for future research and education.

CO₂ flux estimates by remote sensing

MODIS GPP estimation (MOD17)



at Takayama site



Satellite remote sensing is useful, but still needs careful tests considering the spatial heterogeneity in ecosystem structure and complexity in topography and micro-climatic conditions.

21st Century COE Program “Satellite Ecology” in Gifu Univ.

Linking ecosystem ecology, remote sensing, micrometeorology and modeling for studying ecosystem structure and function in complex landscape.

Ecological Process Research

Vegetation structure, plant growth, plant ecophysiology, soil respiration, etc...



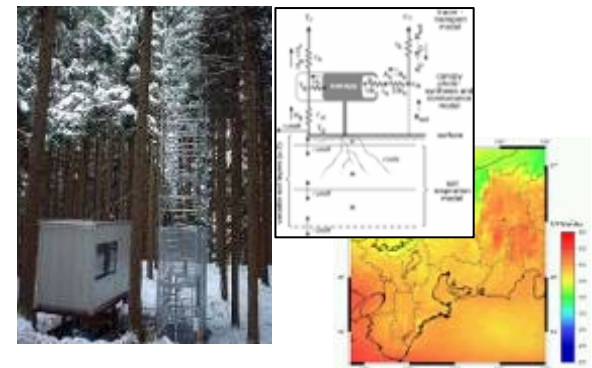
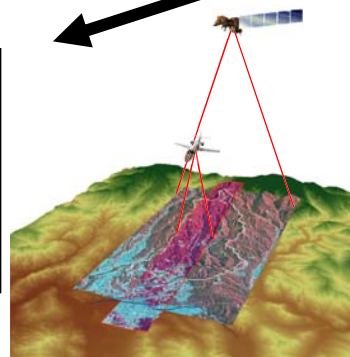
Satellite Ecology (SATECO)

Meteorological Obs. and Modelling

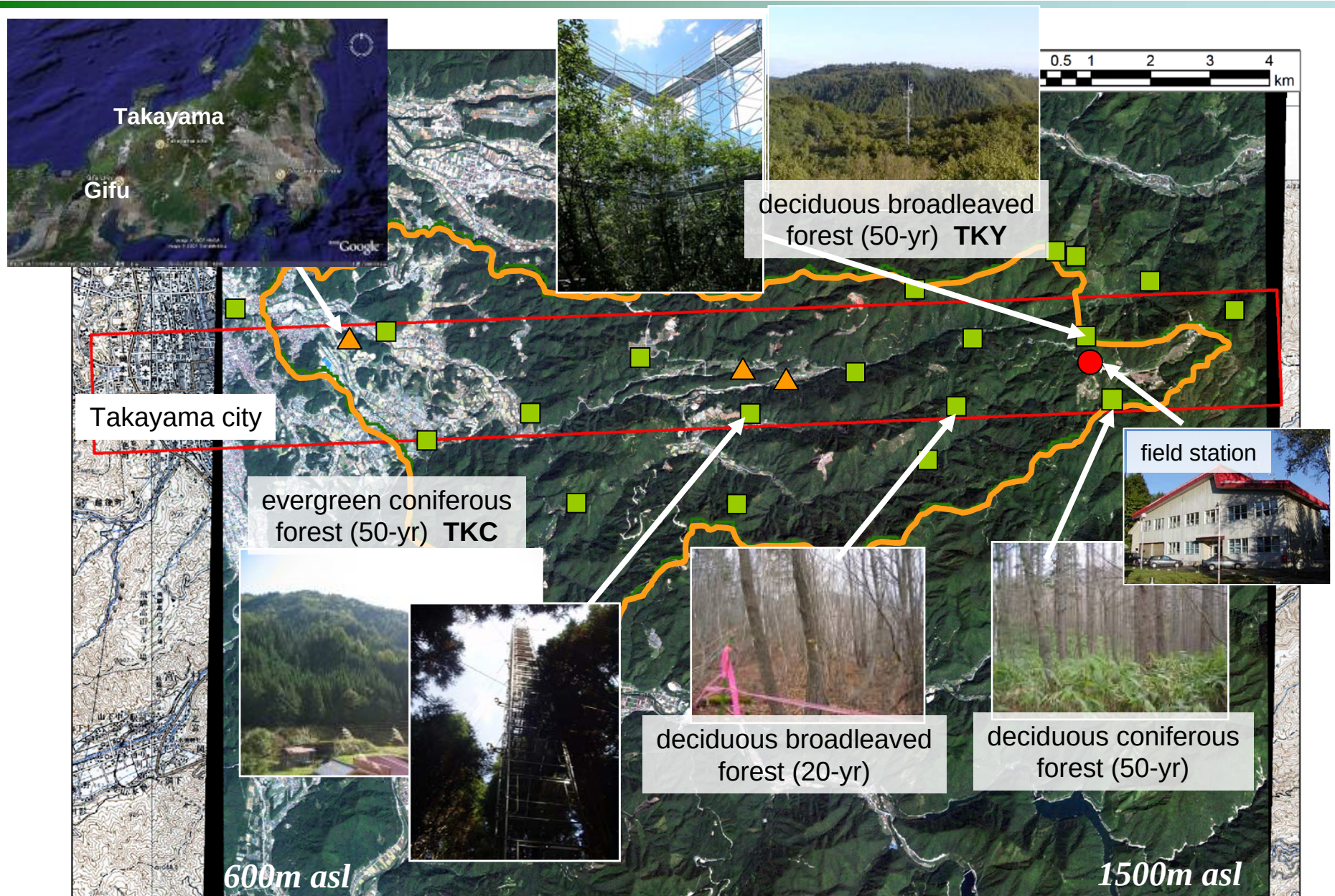
Measurements of CO₂ and heat fluxes, simulation models

Remote Sensing Analysis

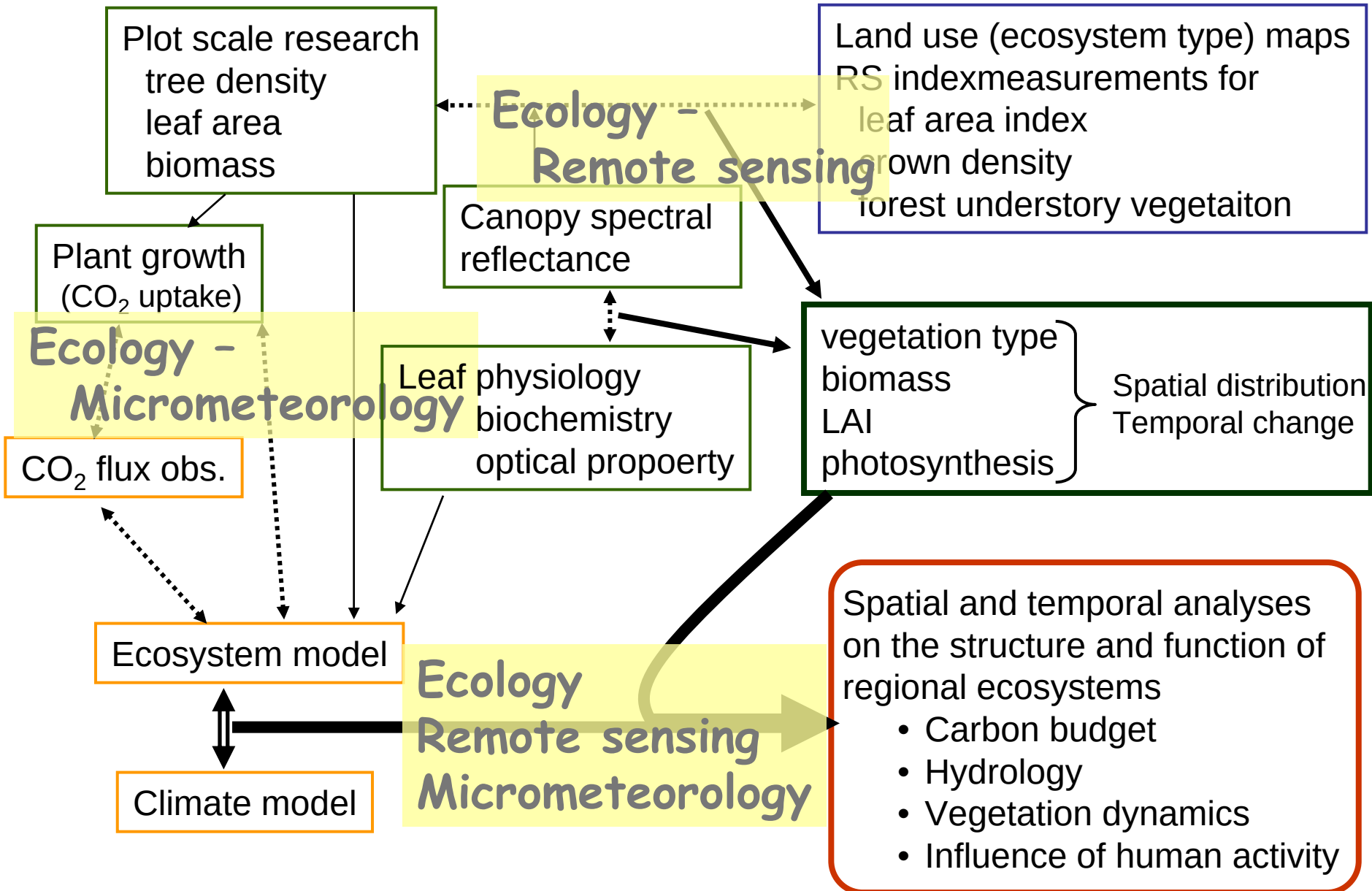
Distribution of various ecosystems and their components (leaf area, biomass), etc...



Study plots around Takayama site

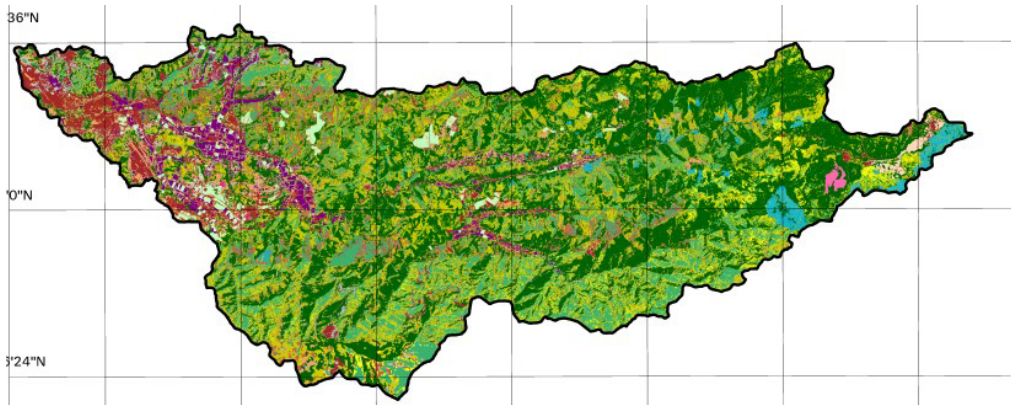


Linking processes and integration



Re-classify vegetation types to 'functional types'

detailed vegetation/land-use type map



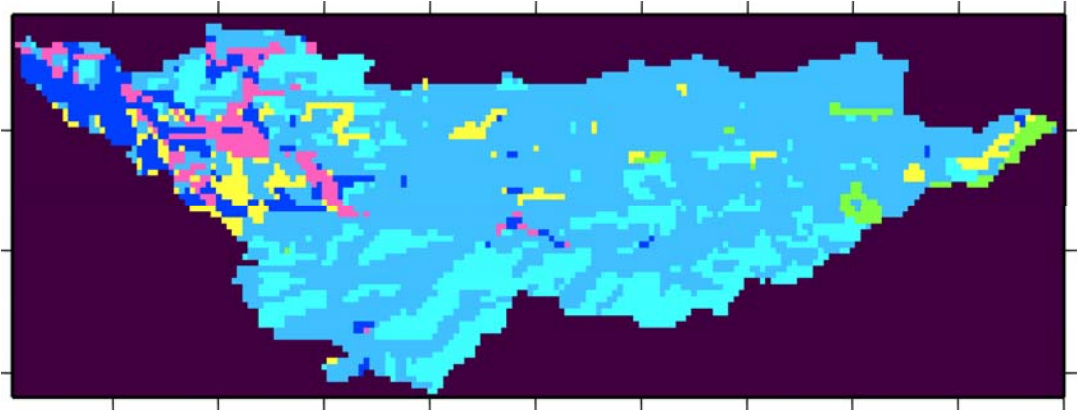
Class Name



- 0 No classify
- 1 Bare ($b=1.0$)
- 2 Broadleaf Deciduous Tree ($bdt=1.0$)
- 3 Needleleaf Evergreen Tree ($net=1.0$)
- 4 Needleleaf Deciduous Tree ($ndt=1.0$)
- 5 Cool C3 Grass ($cg=1.0$)
- 6 Deciduous Shurbl ($ds=1.0$)
- 7 Crop ($c=1.0$)

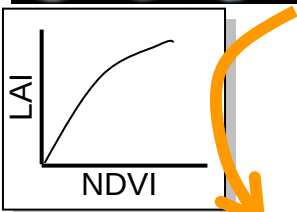
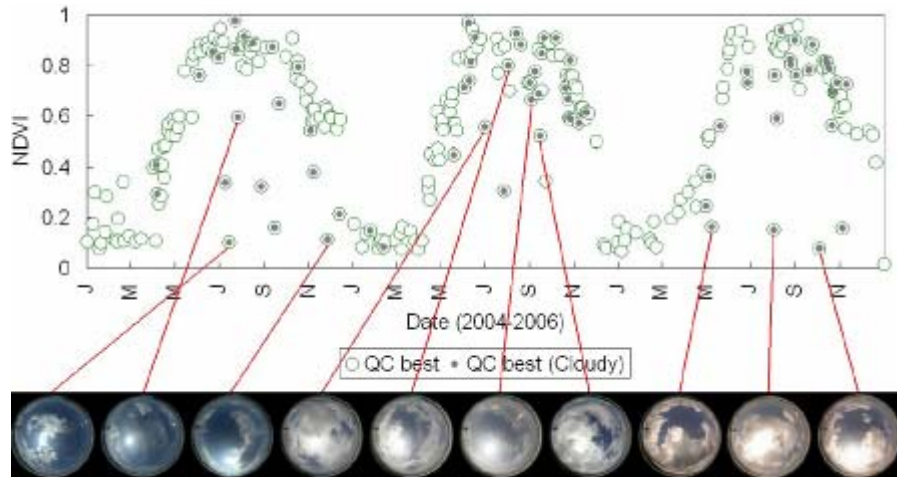


ecosystem 'functional type' map

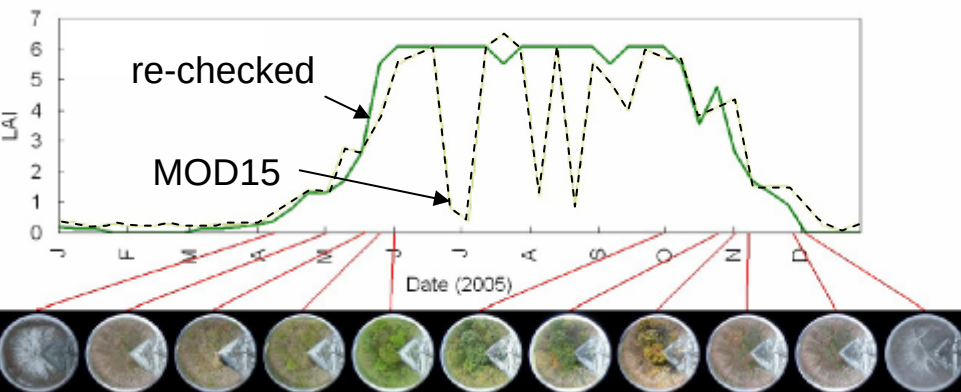


Spatial and seasonal distribution of LAI

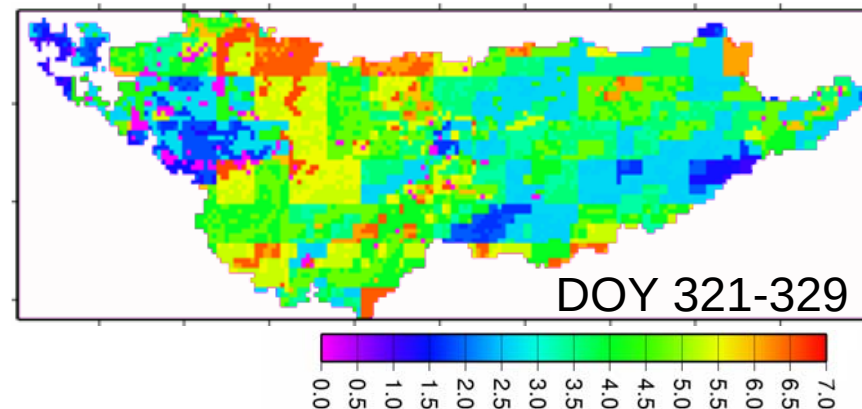
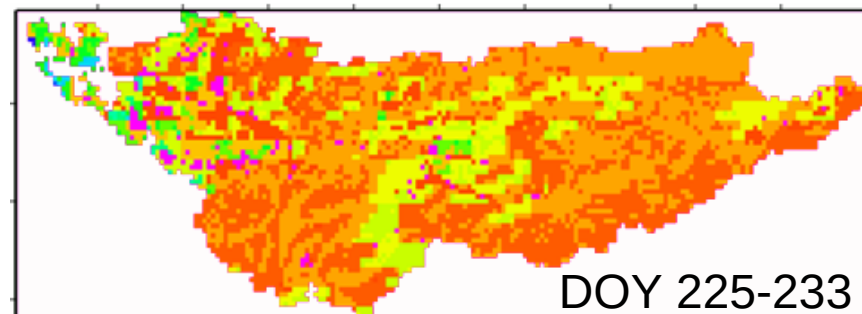
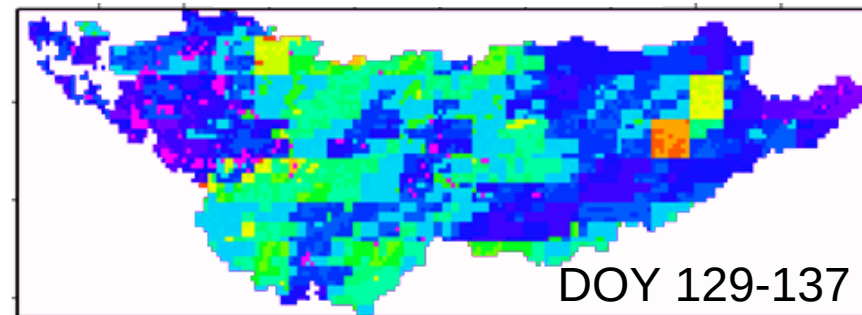
Re-check of quality-controlled MODIS data



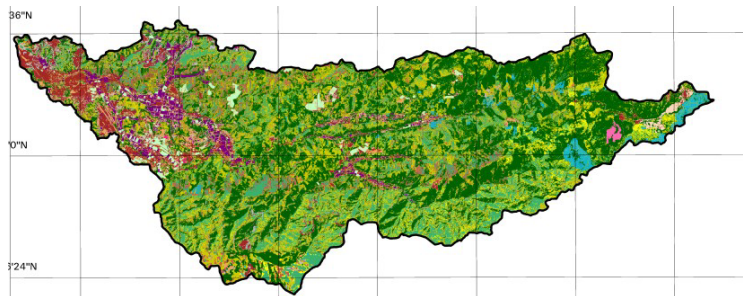
LAI at Takayama site



Original map of LAI (100m resolution)



SATECOModel outputs (early Aug, 2002)

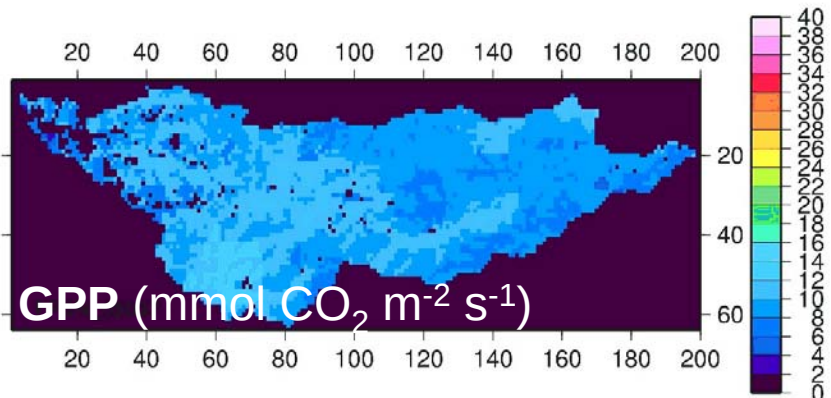
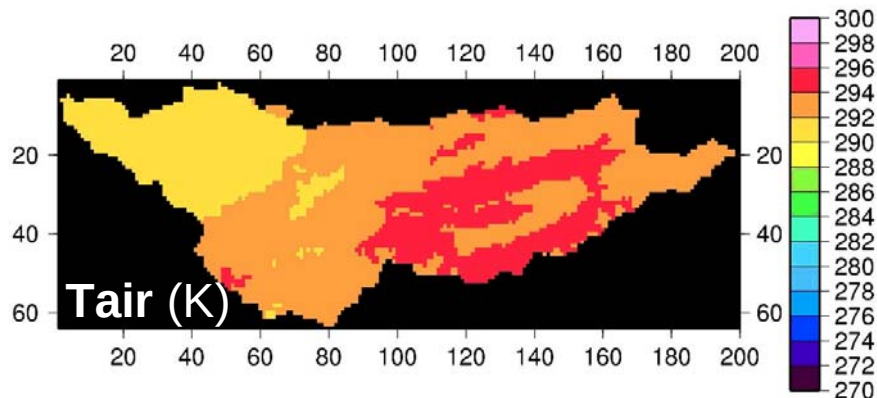
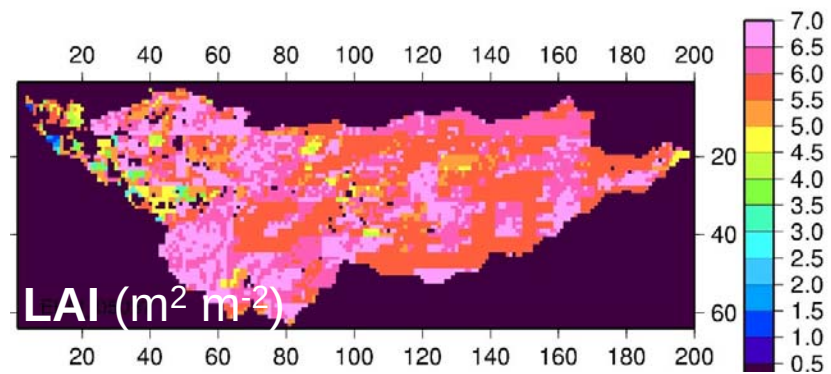
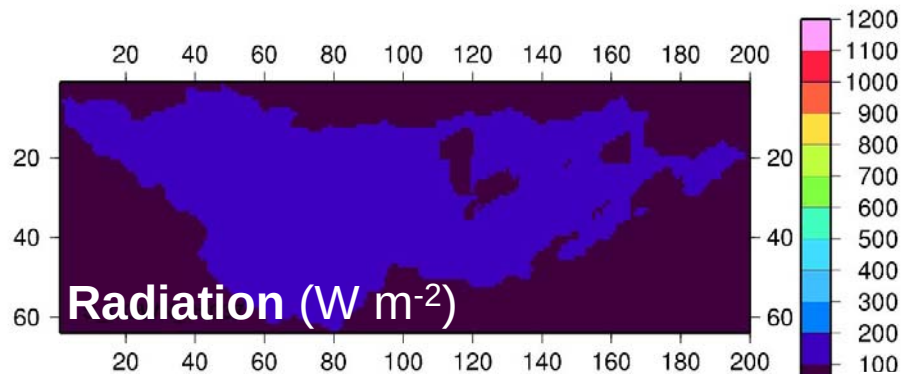


Class Name

- Broadleaf Forest
- Cedar Forest
- Mixed Forest
- Cypress Forest
- Red Pine Forest
- Larch Forest

- Grass
- Pasture
- Ski Resort Area
- Orchard
- Paddy

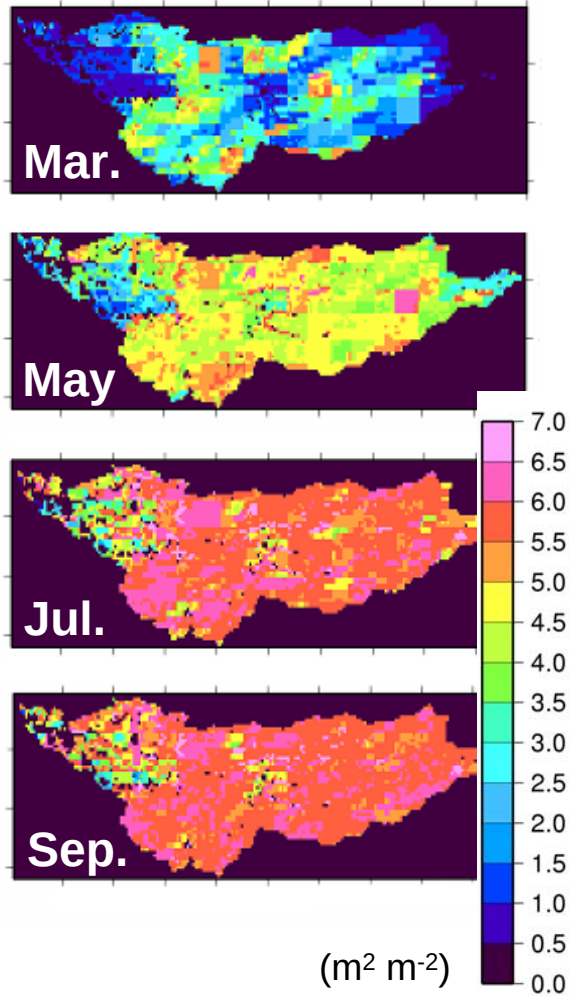
(100m resolution, every 1-hr)



SATECOModel outputs

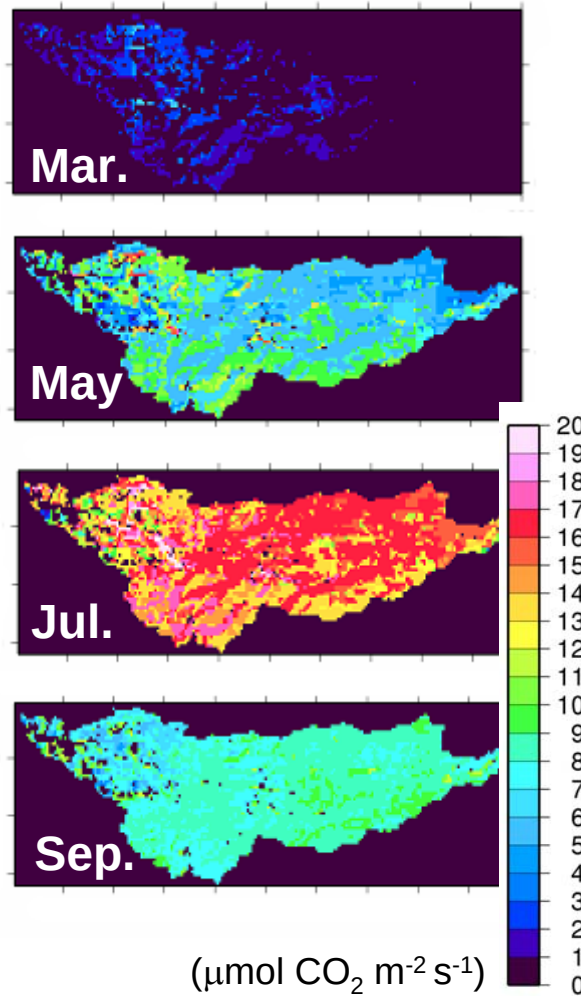
LAI

(leaf area index)



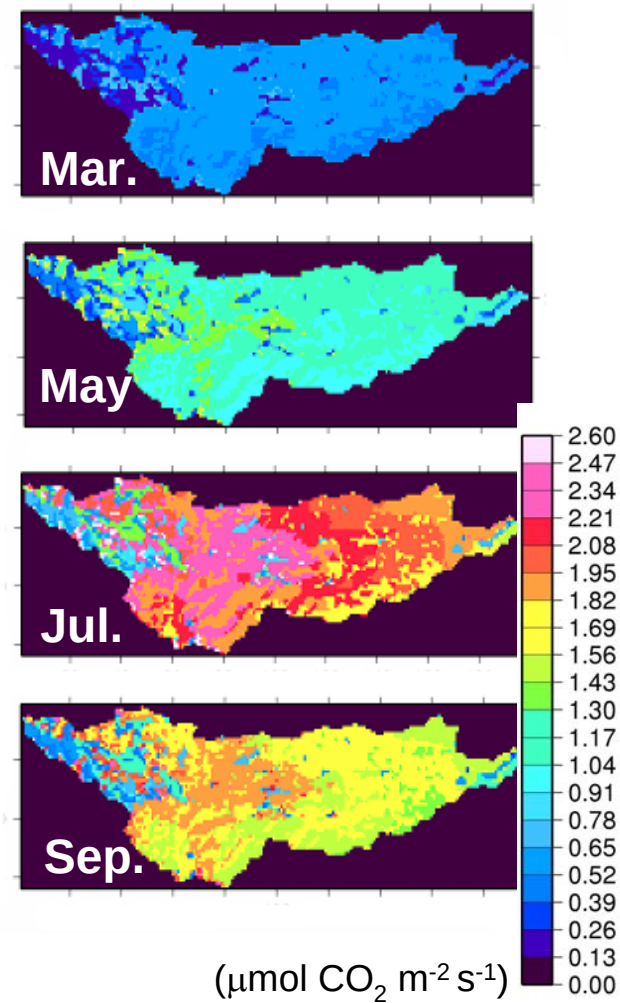
GPP

(gross photosynthesis)



Rsoil

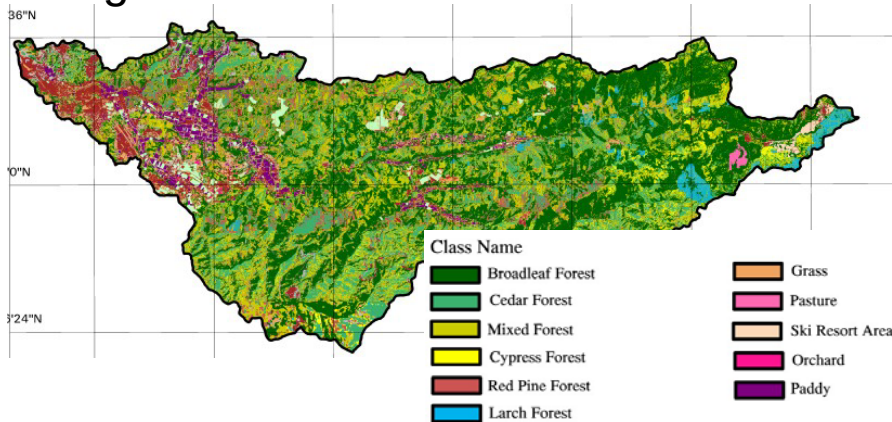
(soil respiration)



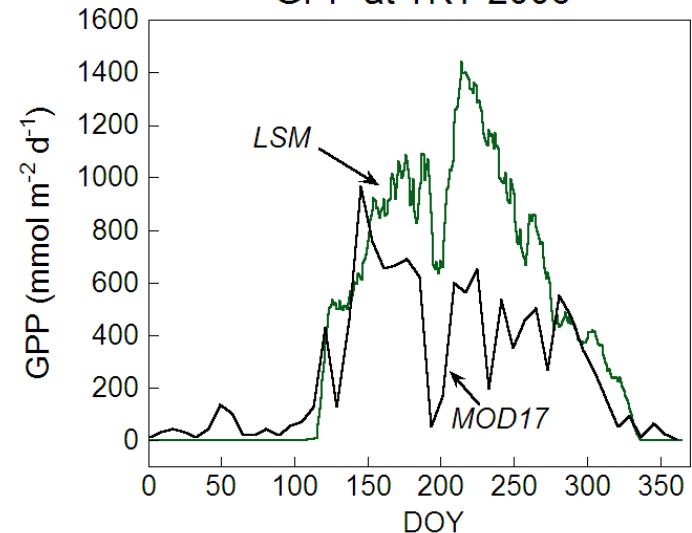
SATECOmodel vs. MOD17

Ecosystem, landscape and regional scale photosynthesis should be estimated carefully, considering the spatinal and temporal variations in the processes.

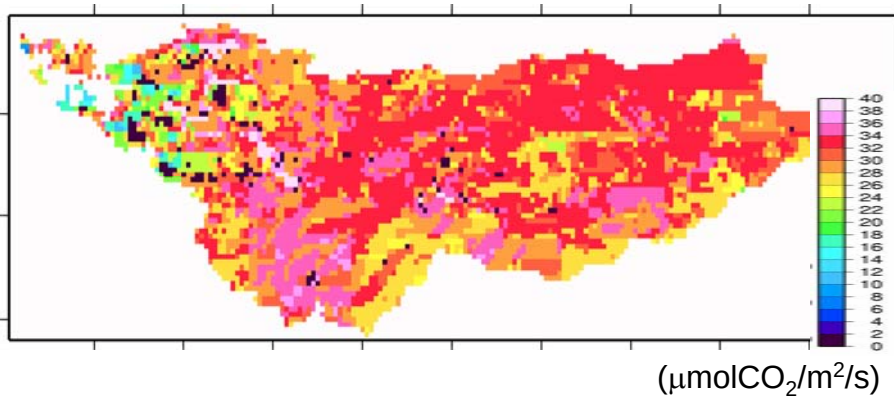
Vegetation / land-use distribution



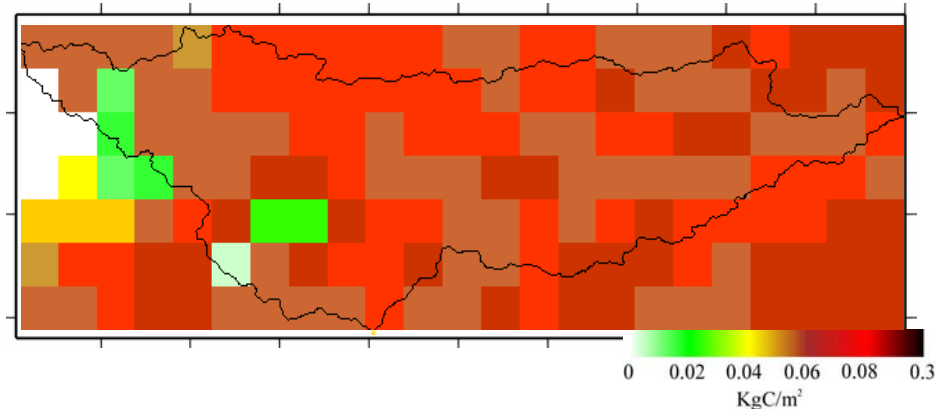
GPP at TKY 2006



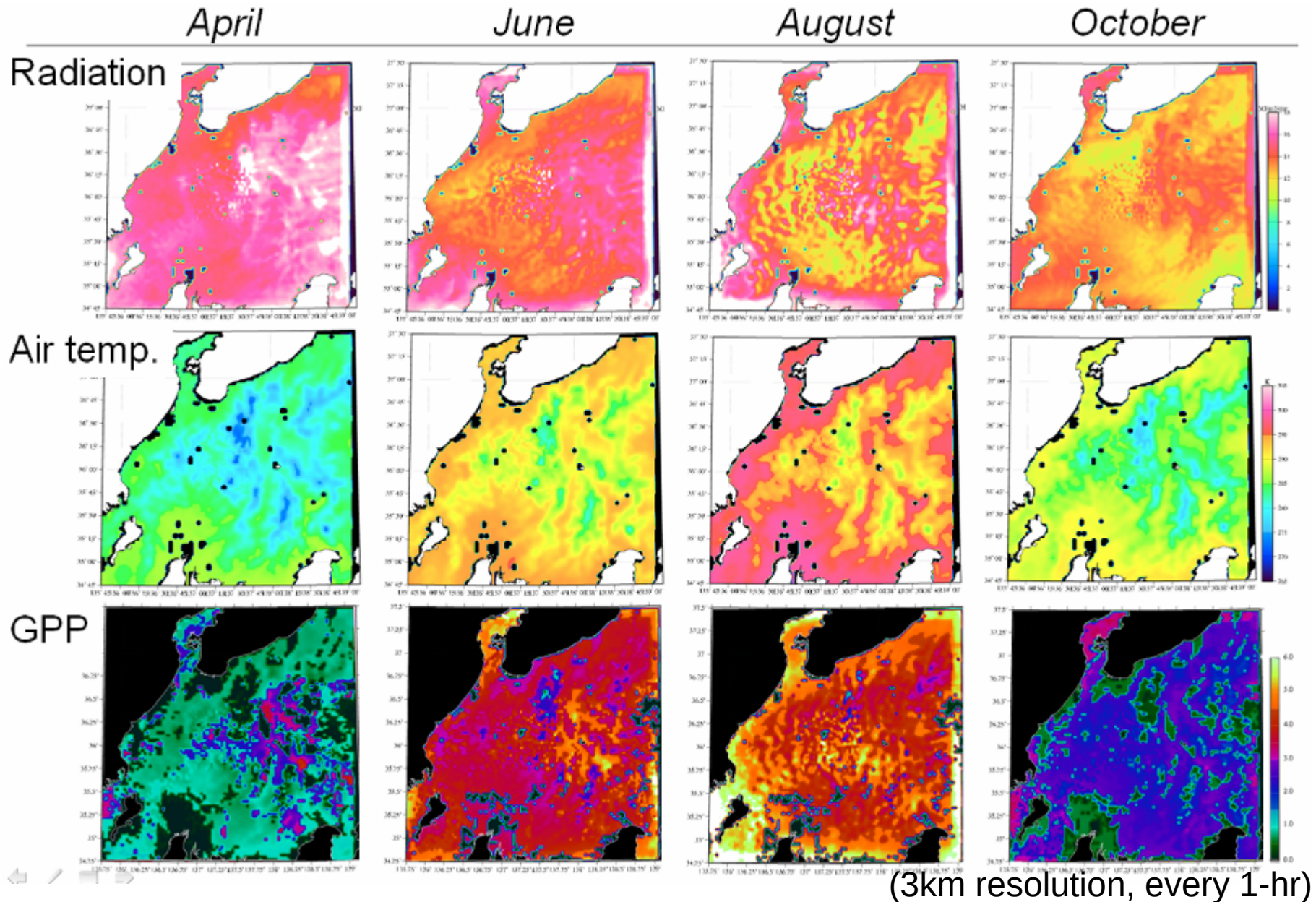
SATECO (2002 DOY184) 100m resolution



MOD17 (2006 DOY177) 1 km resolution



SATECOModel for central Japan



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Networking for future research and education.

Toward more integration and progress in ecosystem science

Synthesis of ecosystem observation concepts, systems, etc.

- why and how do we try and proceed? (*Concepts*)
- how can we achieve? (*Methodology*)
- how do we continue? (*Education and Fund*)
- where do we proceed? (*Super-site concept*)

Collaborations with international networks

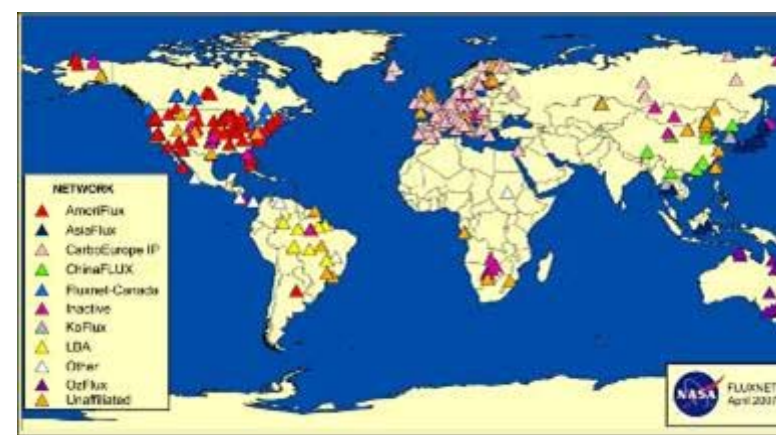
- FLUXNET
- LTER (Long Term Ecological Research Network)
- and other plans

Sharing knowledge with other research communities

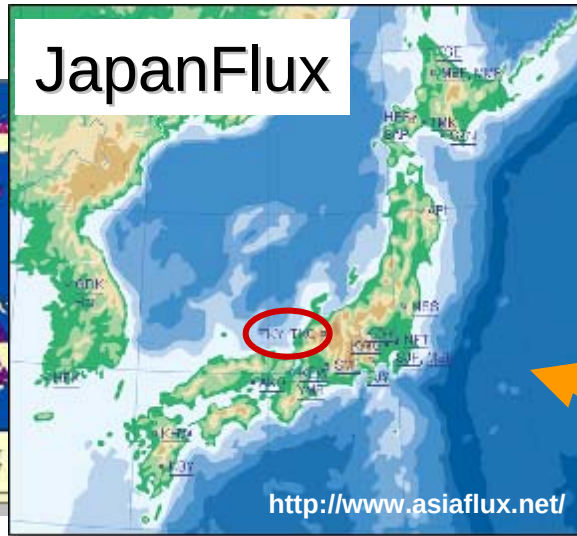
- Manipulating experiments (FACE, etc.)
- Plant and soil microbial physiology
- Environmental engineering
- Environmental economy

Takayama super-site to bridge research communities

FLUXNET



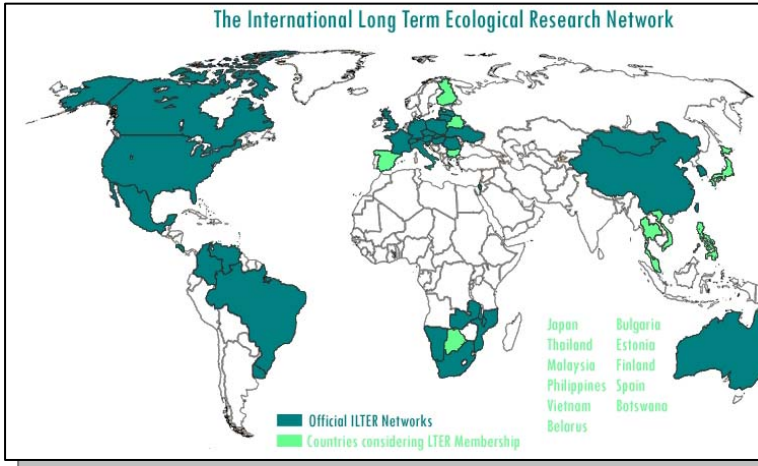
JapanFlux



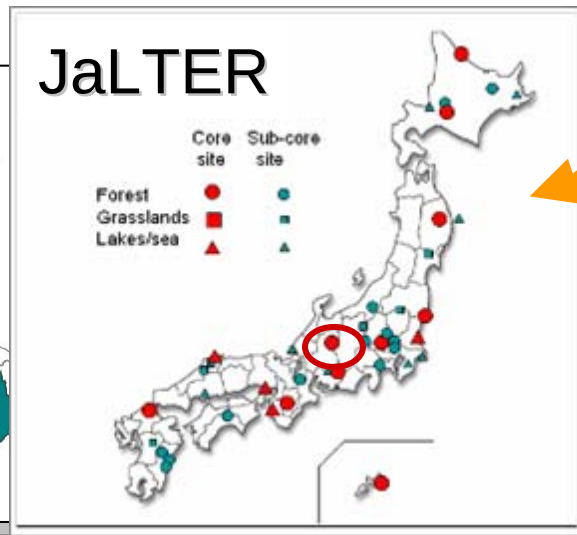
LTER

(Long Term Ecological Research network)

The International Long Term Ecological Research Network



JaLTER



Why don't you solve a mystery in ecosystem ?

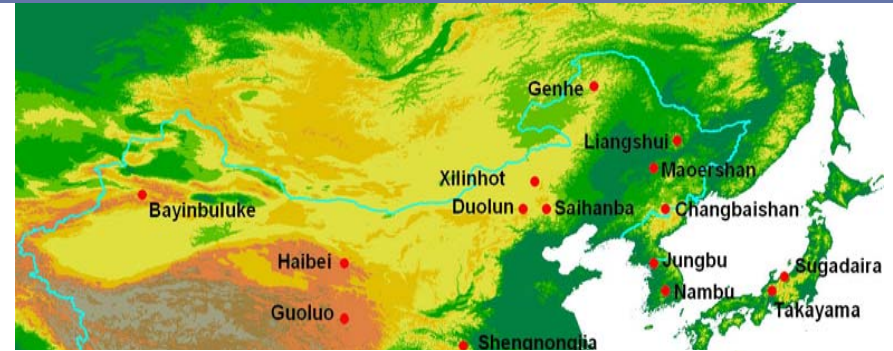
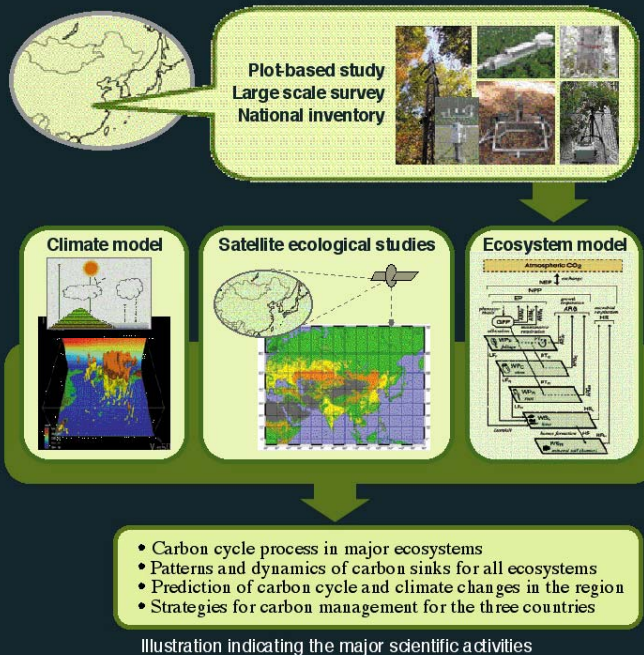


AsiaFlux network
JaLTER (Japan Long-Term Ecological Research Network)
TAKAYAMA in Japan
River Basin Research Center, Gifu University
National Institute of Advanced Industrial Science and Technology

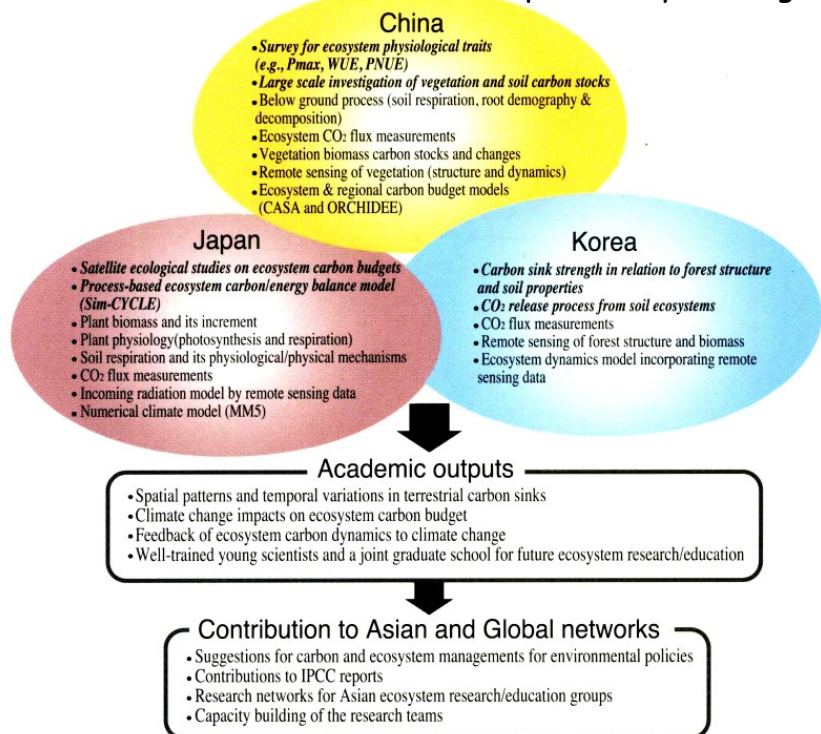
“Quantifying and predicting terrestrial carbon sinks in East Asia: toward a network of climate change research”

A3 Foresight Program

Quantifying and Predicting Terrestrial Carbon Sinks in East Asia
- Toward a Network of Climate Change Research -



【Common research theme and responsibility sharing】



Objectives

This project is to assess the size and spatial patterns of terrestrial carbon sinks under changing climate, and to provide evidence for current and future studies in ecological and environmental science.

Importance and necessity

Recent IPCC report and the Stern Review (<http://www.hm.gov.uk/sternreview/>) evidence is now overwhelming: climate change is a serious global response. Terrestrial ecosystems store about three times as much carbon as the atmosphere. If they can be either an important carbon sink or source under climate change, it is urgent to understand the potential of



Acknowledgements

T.M. Saitoh¹, J. Yoshino², S. Nagai¹, M. Ishihara¹, K.N. Nasahara^{1,3},
T. Ohtsuka¹, A.M. Kishimoto⁴, M-S. Lee¹, N. Saigusa⁵, S. Murayama⁵, H. Kondo⁵,
H. Noda¹, T. Kojima¹, I. Tamagawa¹, T. Akiyama¹, T. Yasuda², S. Yamamoto⁶,
H. Koizumi⁷ and other students in Gifu Univ. and Univ. Tsukuba

1 River Basin Research Center, Gifu University

2 Graduate School of Engineering, Gifu University

3 Institute of Agricultural and Forest Engineering, University of Tsukuba

4 National Institute of Agro-Environmental Sciences

5 National Institute of Advanced Industrial Sciences and Technology (AIST)

6 Okayama University

7 Department of Biology, Waseda University



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Global Environmental Research Fund S-1 (Ministry of the Environment)

21st Century COE Program “Satellite Ecology” (JSPS, Gifu University)

A3 Foresight Program (JSPS, NSFC and KOSEF)