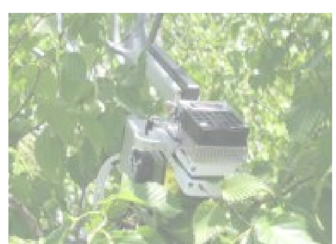
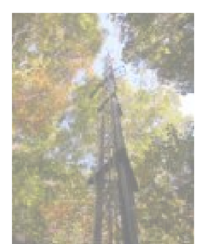
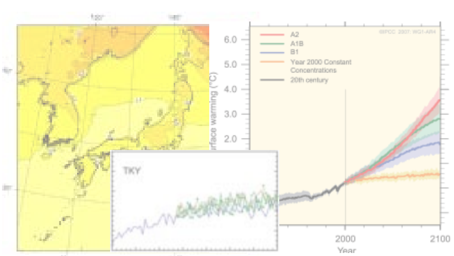
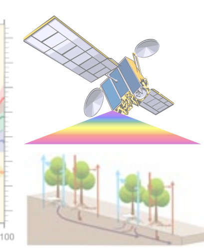
# “Satellite Ecology” initiative for ecosystem function and biodiversity analyses

*Key topics:*
*“Satellite Ecology” concept, networking networks,*
*super-site, canopy phenology, mapping ecosystem functions*


Hiroyuki Muraoka
(Gifu University, Japan)

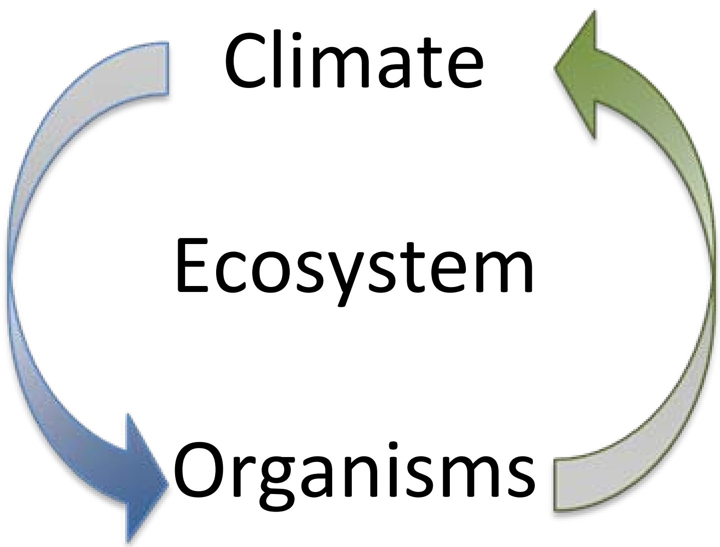
Shin Nagai, Rei-ichiro Ishii, Rikie Suzuki
(JAMSTEC, Japan)

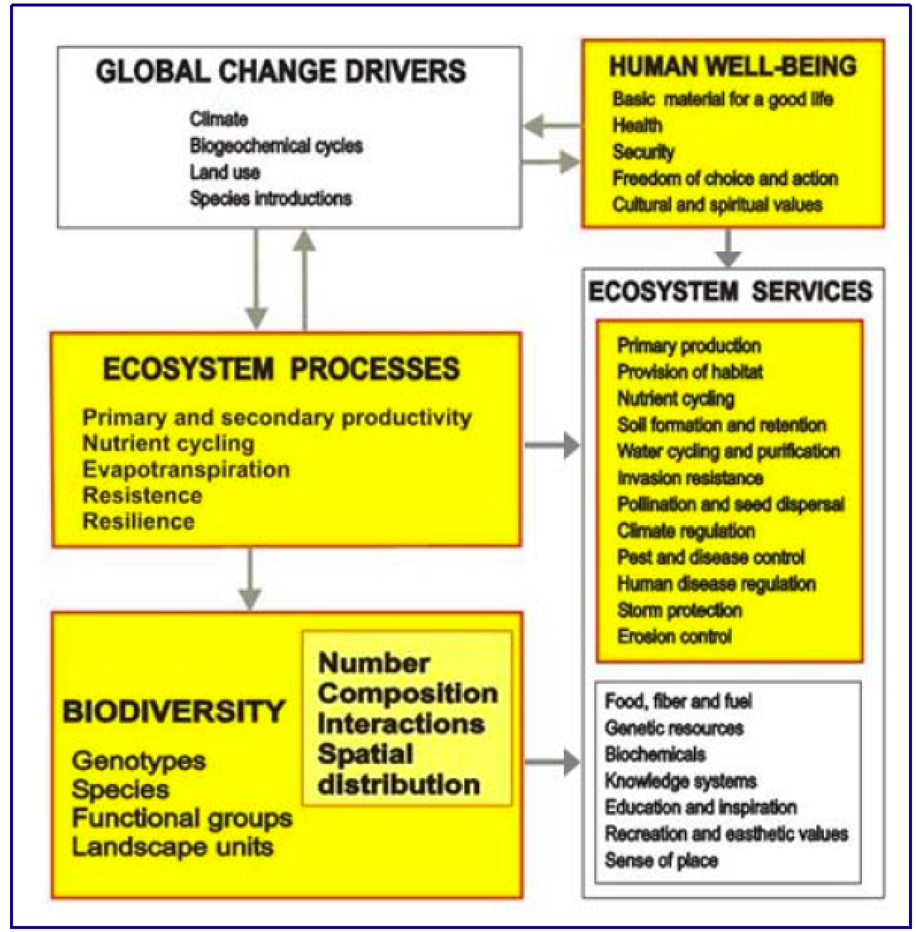

SATECO
Linking Satellite-Ecophysiology-Micrometeorology

# Background: Ecosystem, Biodiversity and Climate change

GEO
**B**iodiversity
**O**bservation
**N**etwork (BON)



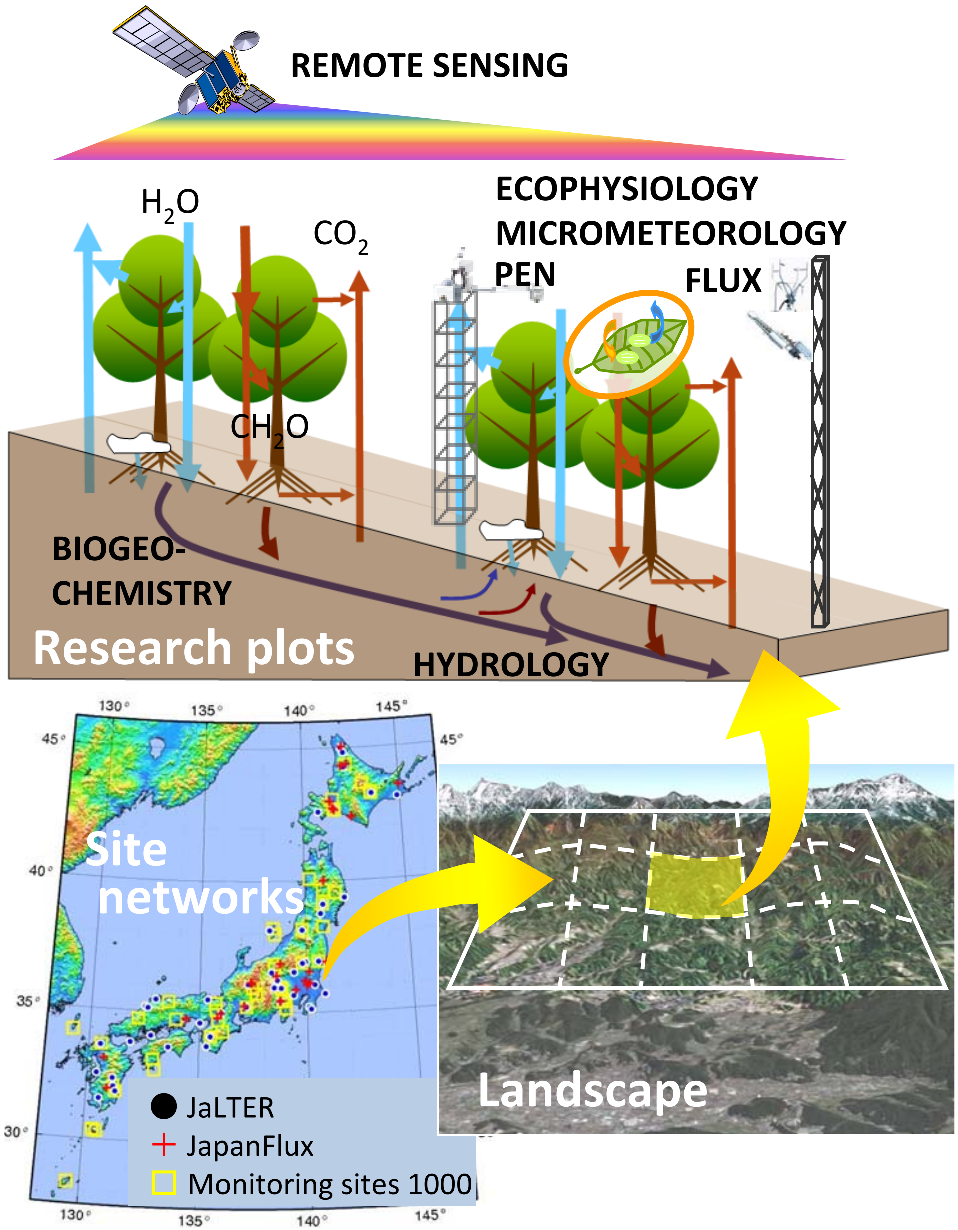



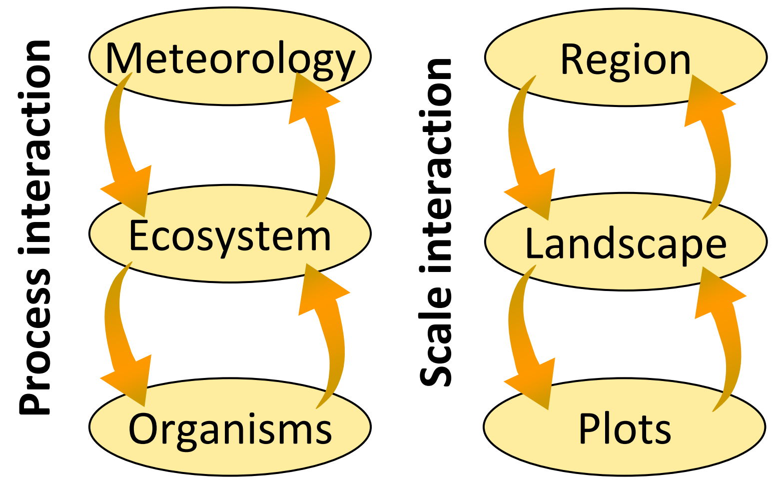

GEO (2008)

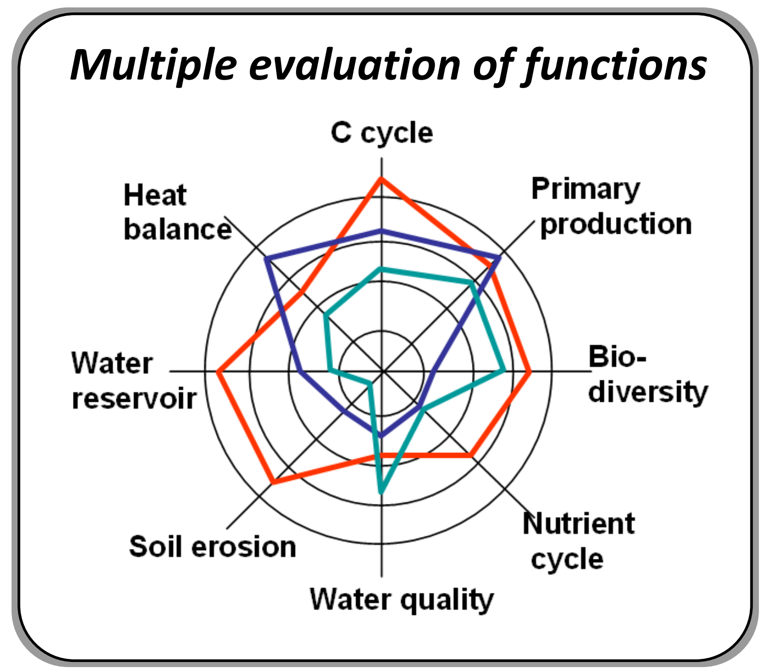
Primary production (NPP) and biodiversity

Vulnerability assessment of ecosystem functions

# “Satellite Ecology” concept for multiple-observations

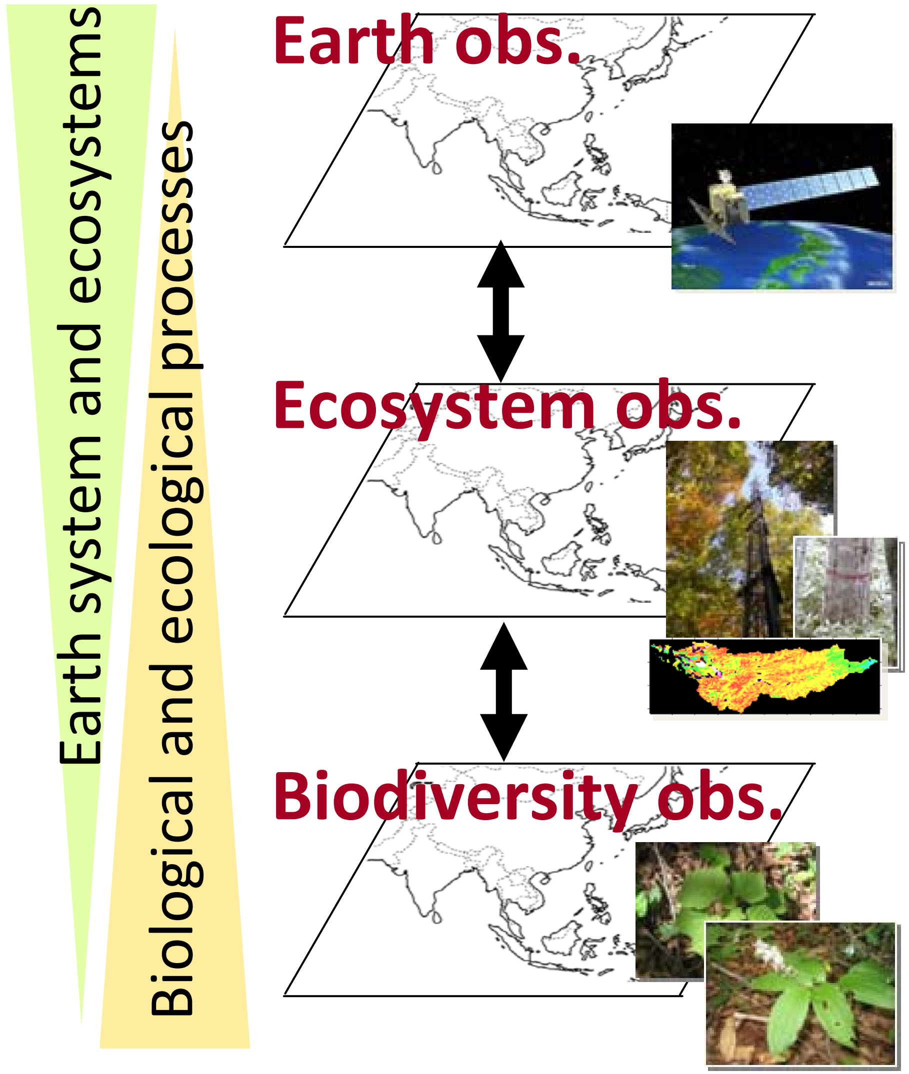



(Muraoka et al. 2012)

# SATECO initiative to link Earth, Ecosystem & Biodiversity obs.




**Satellite remote sensing**

- Ecosystem and landuse types
- Vegetation structure
- Temporal change in ecosystems

**Ecological process research, tower flux obs. and modeling**

- Primary production (carbon cycling)
- Eco-hydrology
- Carbon & Nutrient cycling

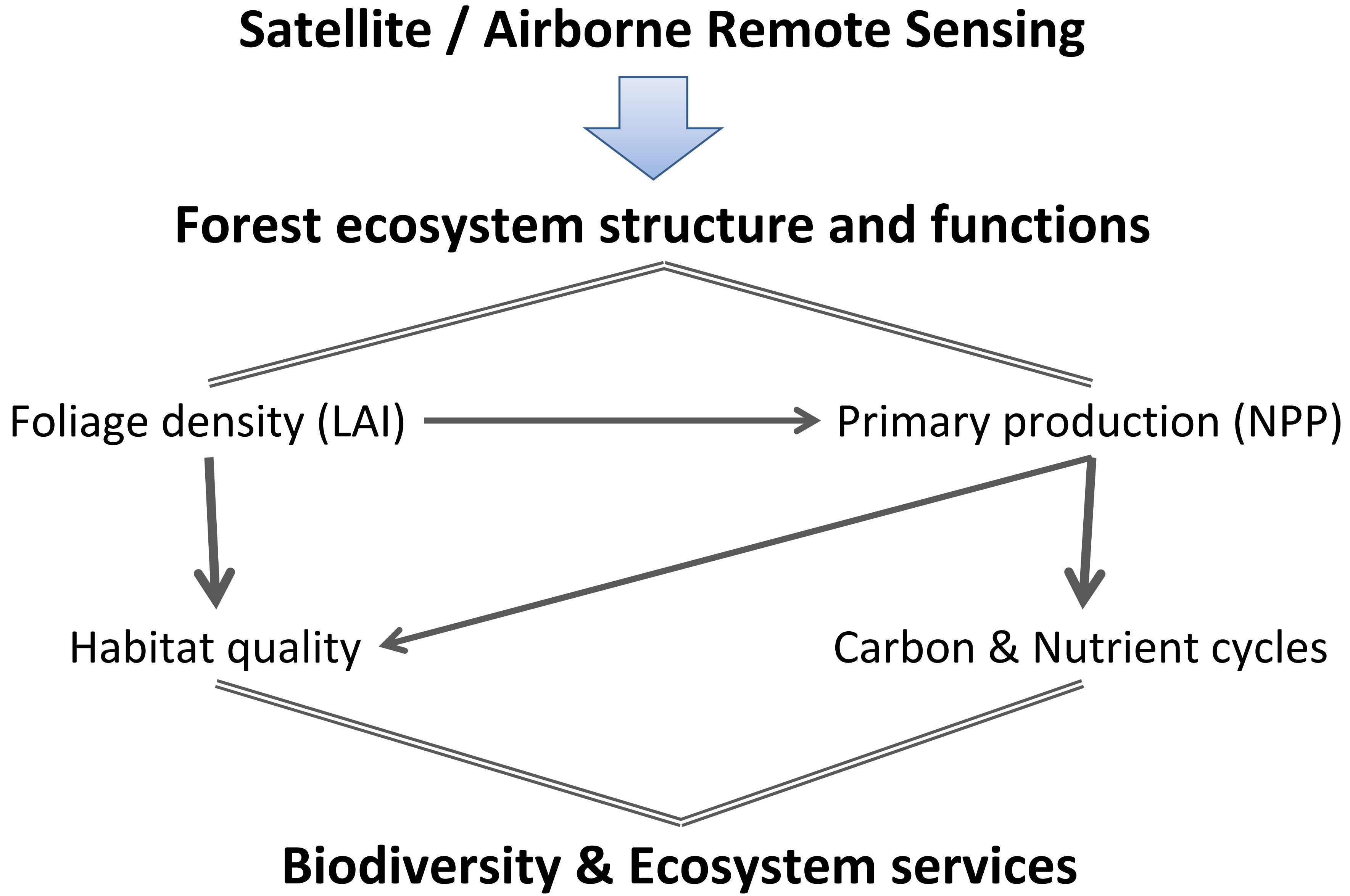
**Species and genetic level research**

- Plant species distribution
- Wildlife habitat assessment
- Biological interactions

*Concept by In-Situ/RS integration WG, J-BON*

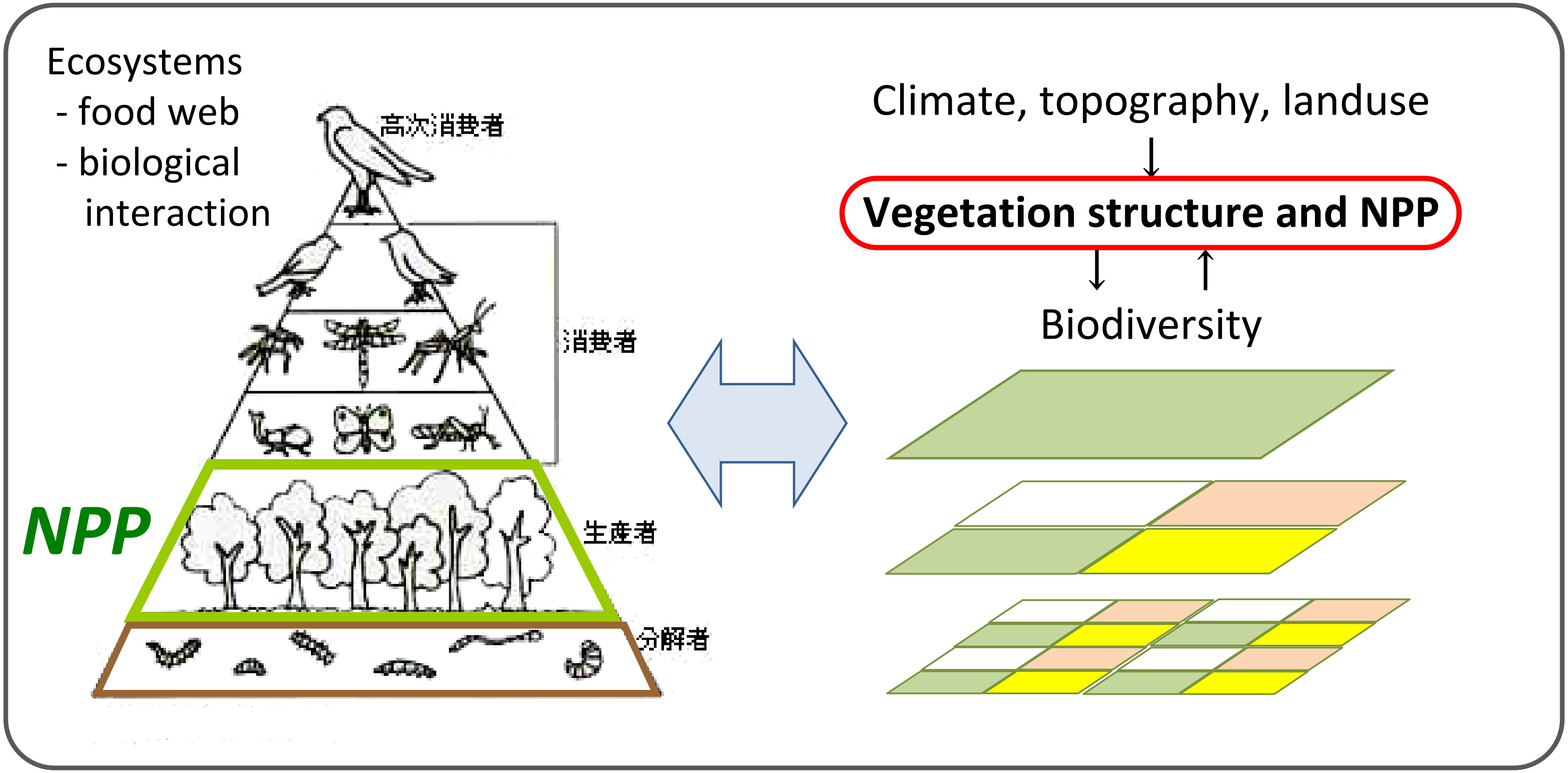
(Muraoka et al. 2012)

# Linking ecosystem functions and biodiversity by RS+model



# Vegetation structure and NPP as the indicator of biodiversity

- Ecosystem structure as the habitat for biodiversity
- Ecosystem function (primary production) as the resource for biodiversity
- Primary production as the indicator of climate change impacts on ecosystems



# GPP and bird species richness

IS THE EFFECT OF FOREST STRUCTURE ON BIRD DIVERSITY MODIFIED BY FOREST PRODUCTIVITY?

Jacob P. Verschuyl,[1,4] Andrew J. Hansen,[1] David B. McWethy,[1] Rex Sallabanks,[2] and Richard L. Hutto[3]

*Ecological Applications*, 18(5), 2008, pp. 1155–1170

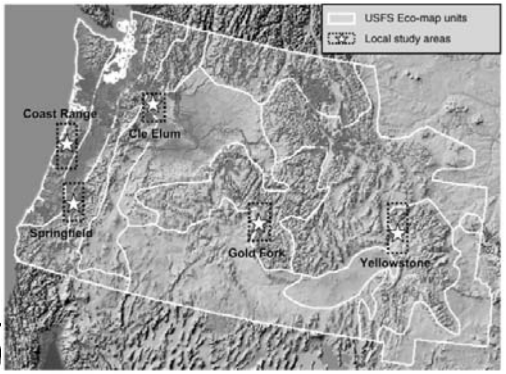




Fig. 1. Locations of study landscapes in the northwest United States.

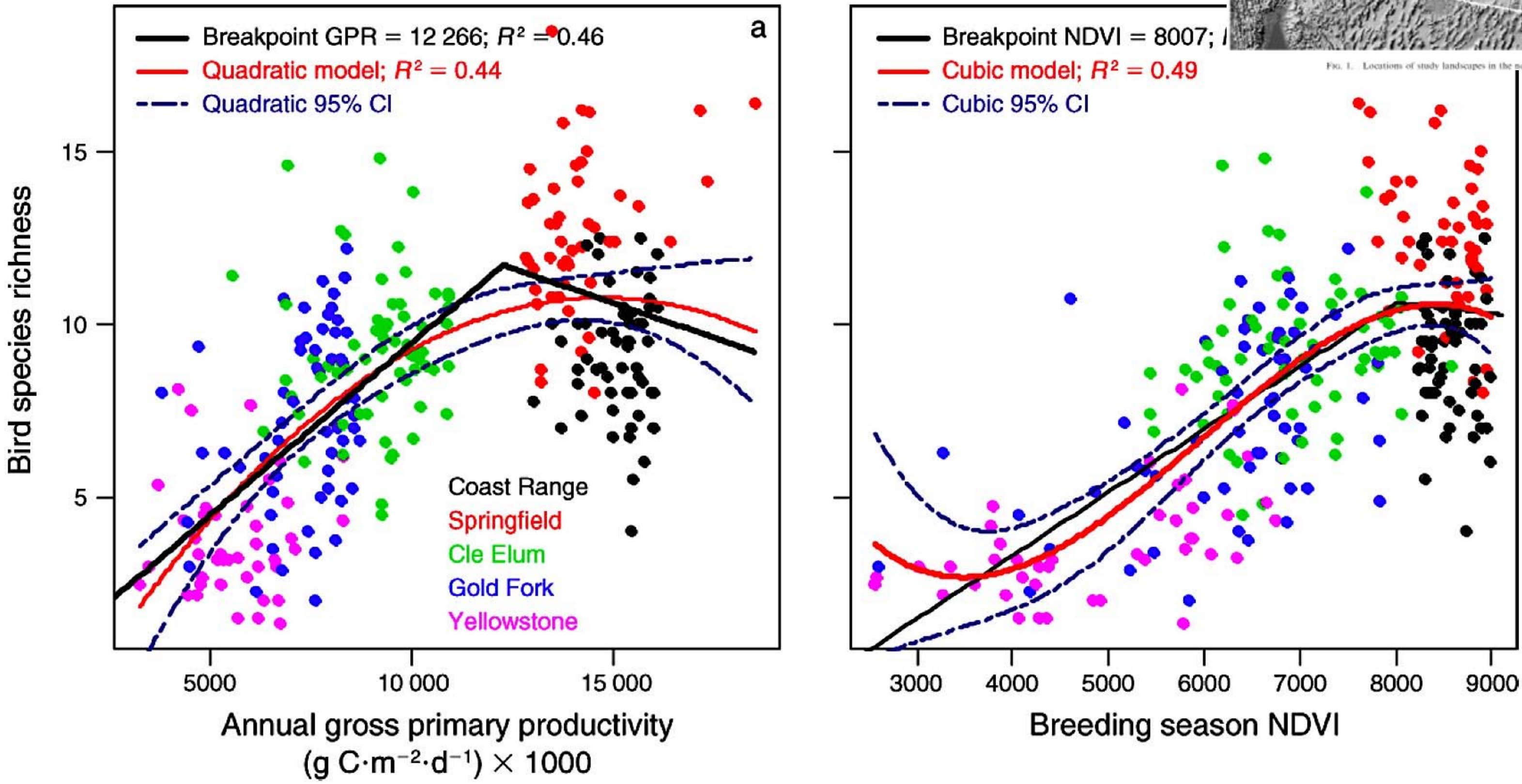
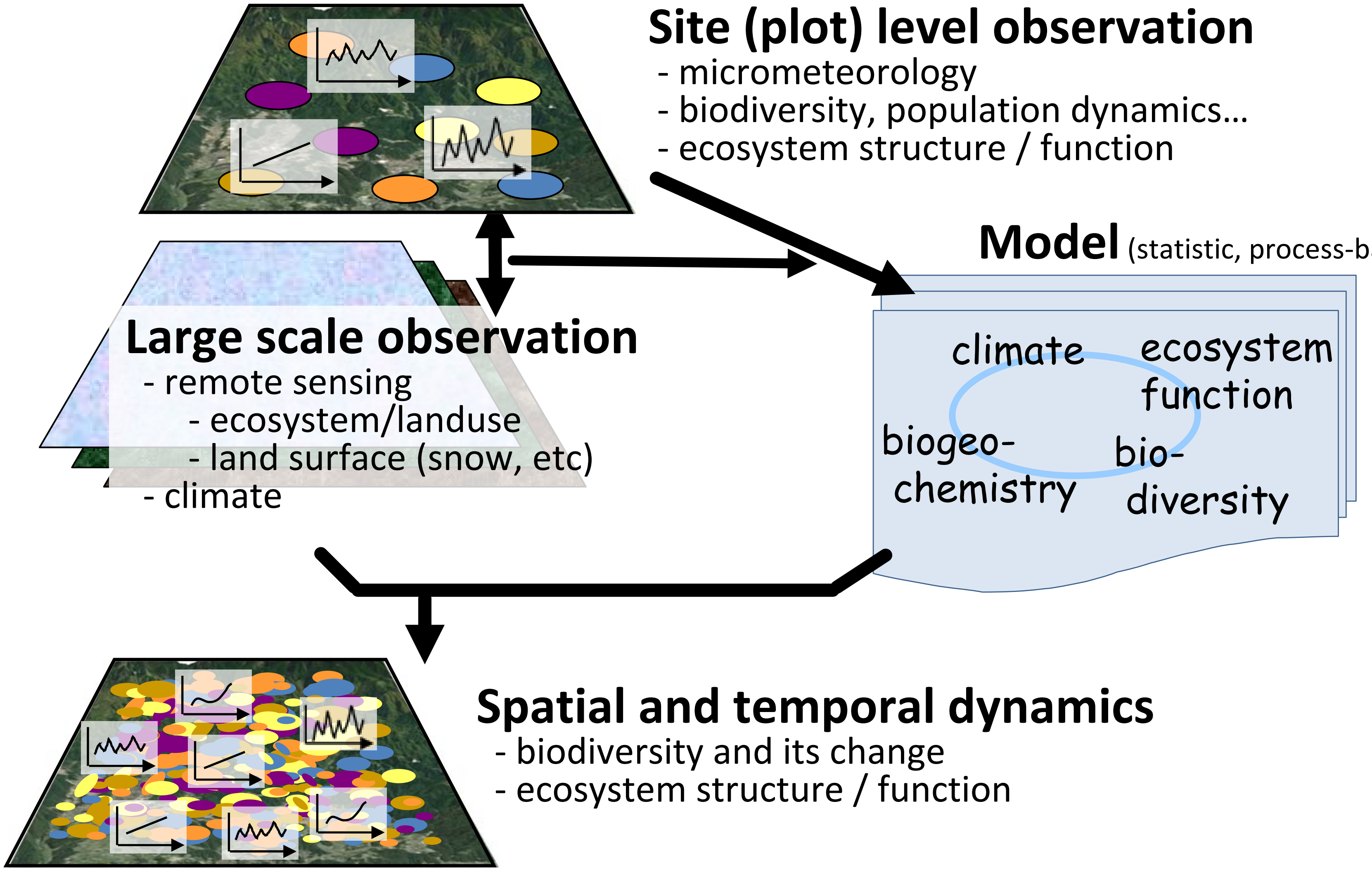



Fig. 3. Bird species richness across the northwest United States (color coded by landscape name) by (a) annual energy (gross primary productivity [GPP]), and (b) breeding season energy (normalized difference vegetation index [NDVI]). Best curvilinear (red lines with blue dashed confidence bands) and breakpoint regression (black lines) relationships are shown.

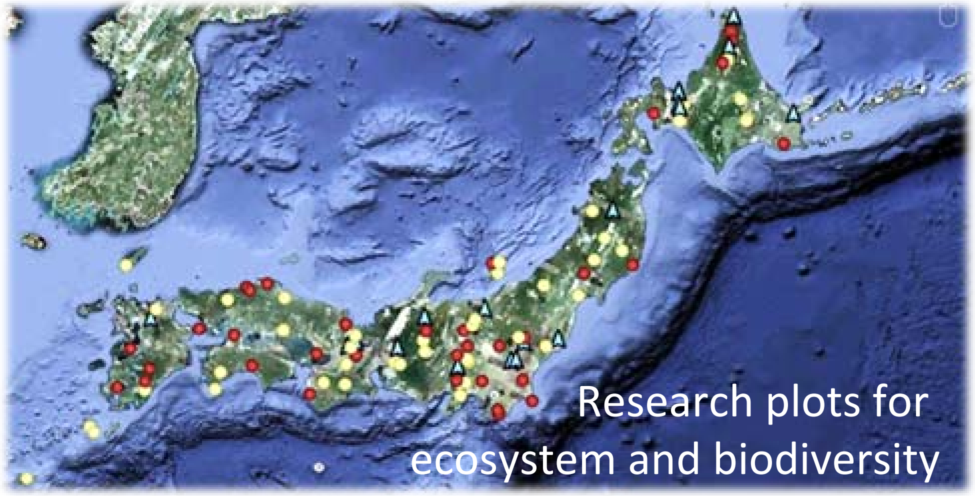
# Spatial scaling by RS+models based on plot-studies

“LENS” concept by GEO BON (2008)




(Muraoka et al. 2012)

# Challenge in Japan: cross-scale evaluation by multi-networks




JaLTER

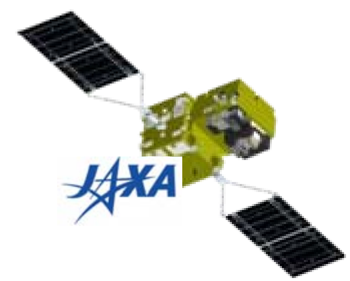
モニタリングサイト1000
Since 2003

JapanFlux

JAMSTEC 独立行政法人 海洋研究開発機構
JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY

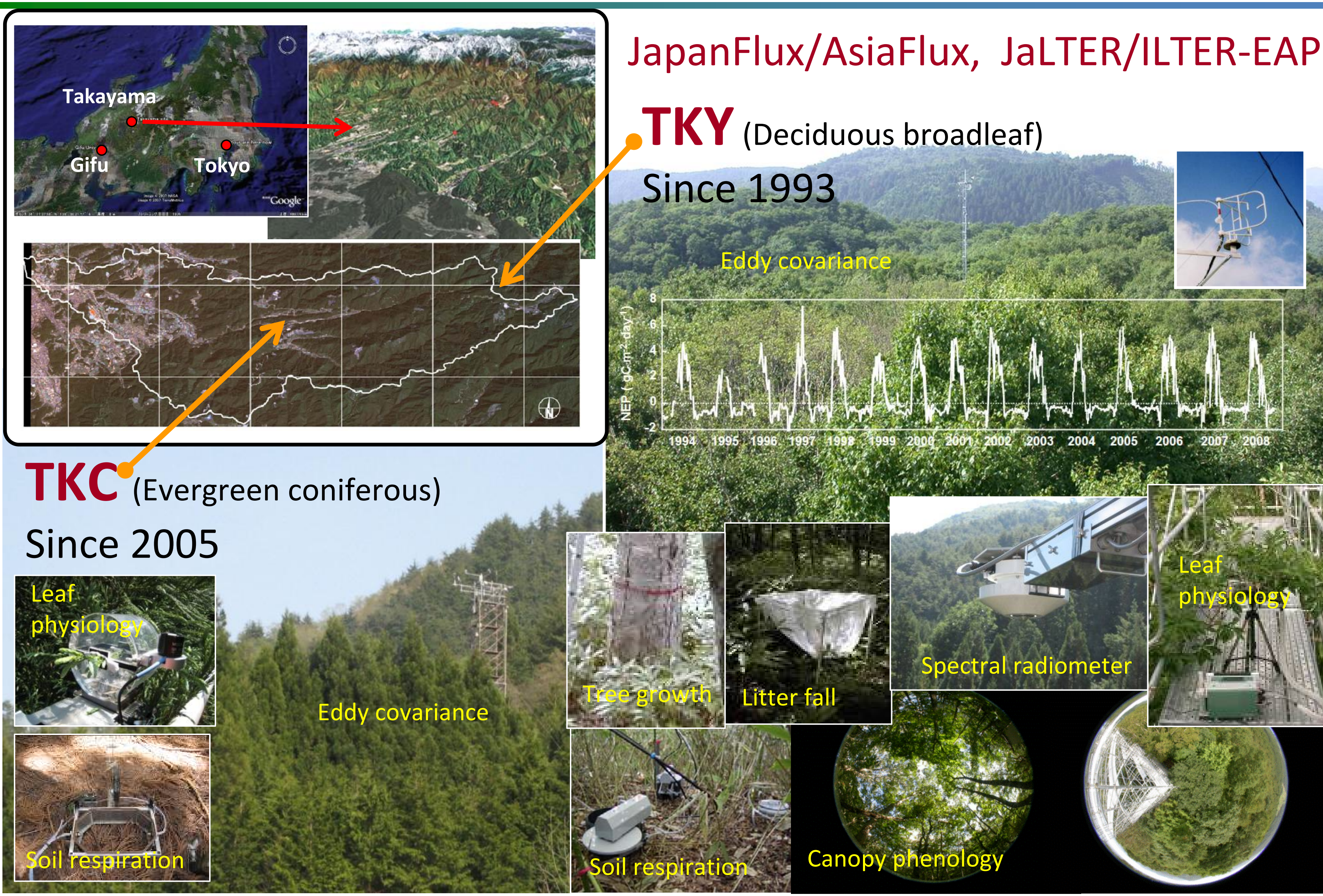
Ecosystem – biodiversity relationships at plots

Satellite RS & models
(canopy phenology, NPP, etc.)



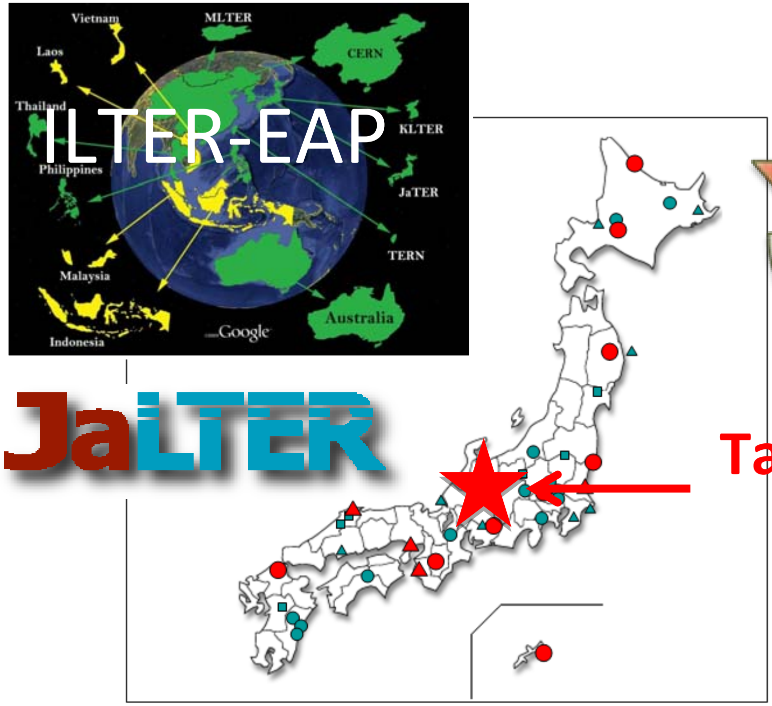

Broad-scale ecosystem-biodiversity monitoring and understandings
(human impacts, disturbance and climate change, etc.)

# “**Takayama**” super-site (long-term, multidisciplinary obs.)

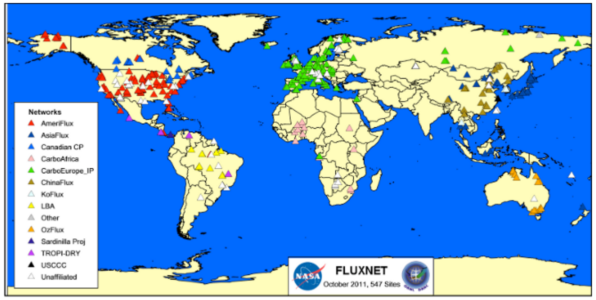


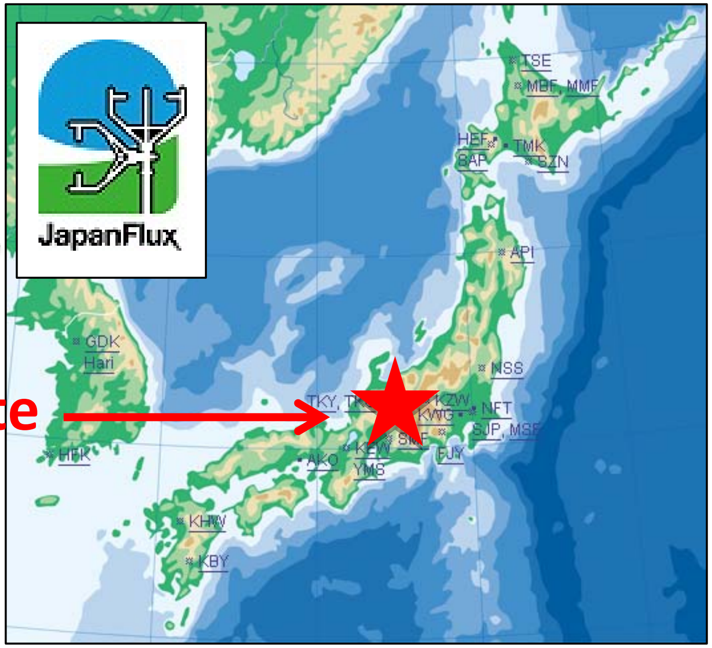
# Networking networks at super-sites

## International Long-Term Ecological Research Network (ILTER)


## $CO_2$/water/heat flux measurements Network (FLUXNET)




Takayama site (TKY)

# SATECO-2 (FY2011 – 2014)

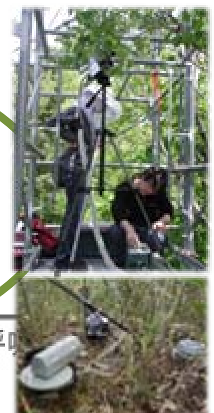
## “Climate change impact assessment of forest ecosystem functions by satellite-ecophysiology-modeling integrated study”

### Satellite remote sensing

Observation and analysis of; phenology and productivity over years (sign of changes?)

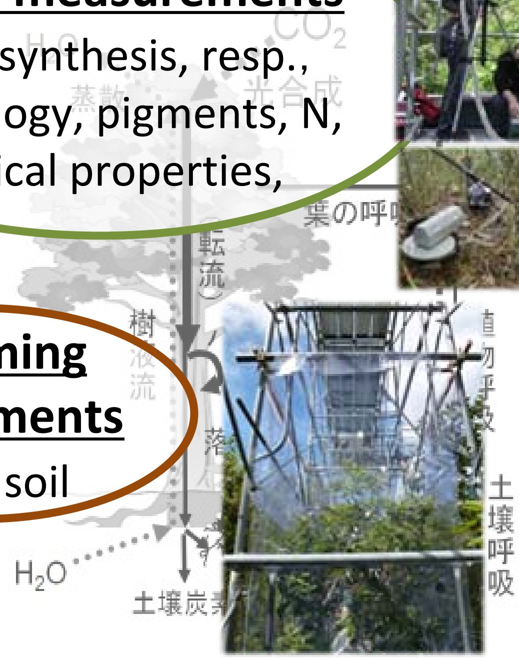
### *In situ* measurements

photosynthesis, resp., phenology, pigments, N, optical properties,



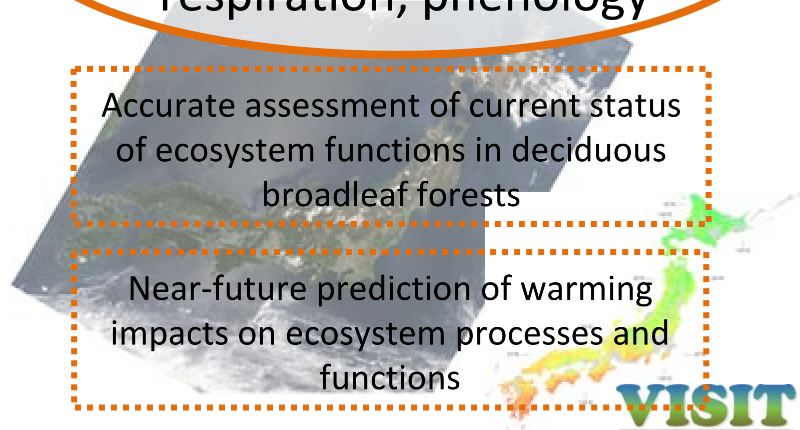
### Warming experiments

tree, soil




### Model analysis

Tree and forest photosynthesis, respiration, phenology

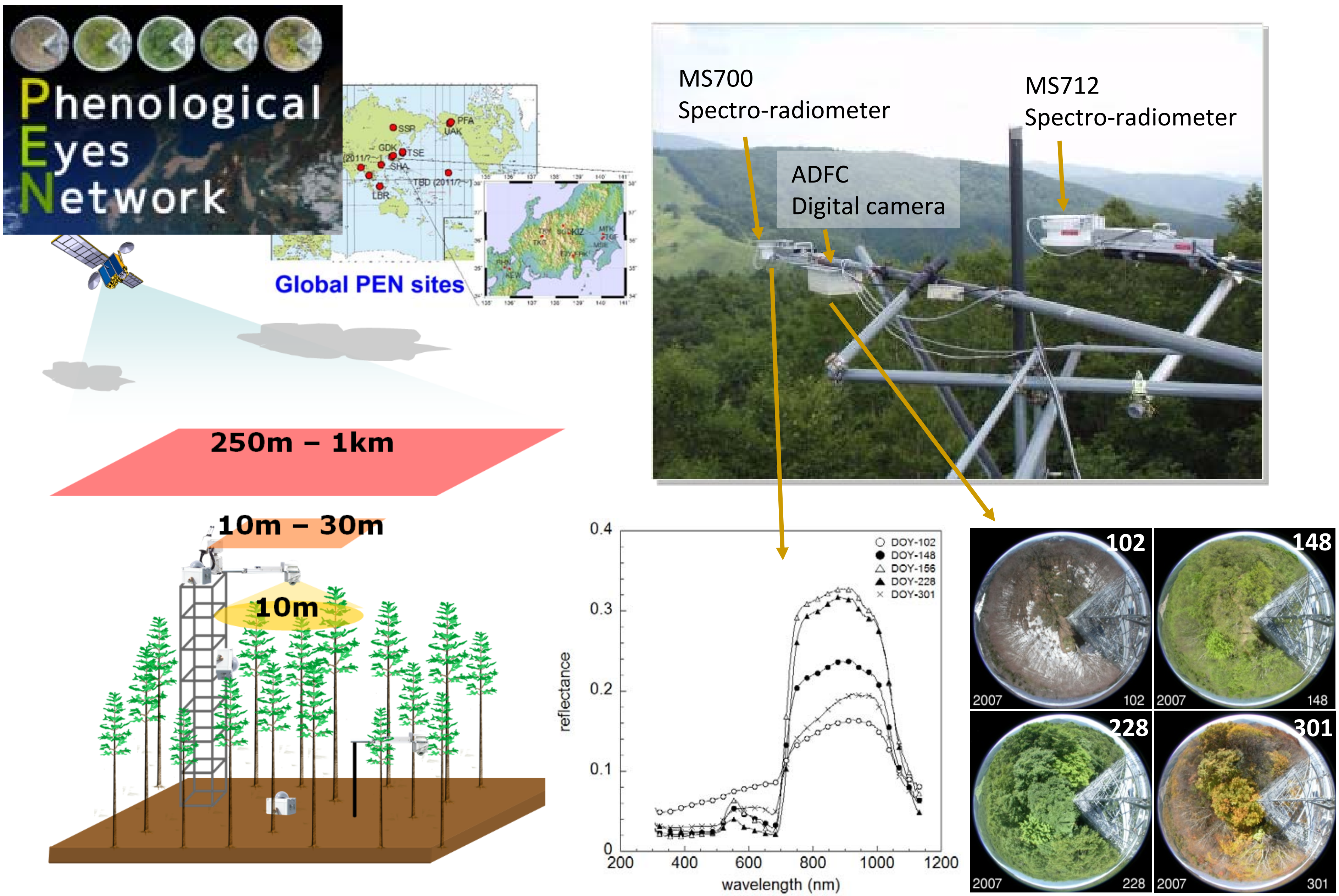



Accurate assessment of current status of ecosystem functions in deciduous broadleaf forests

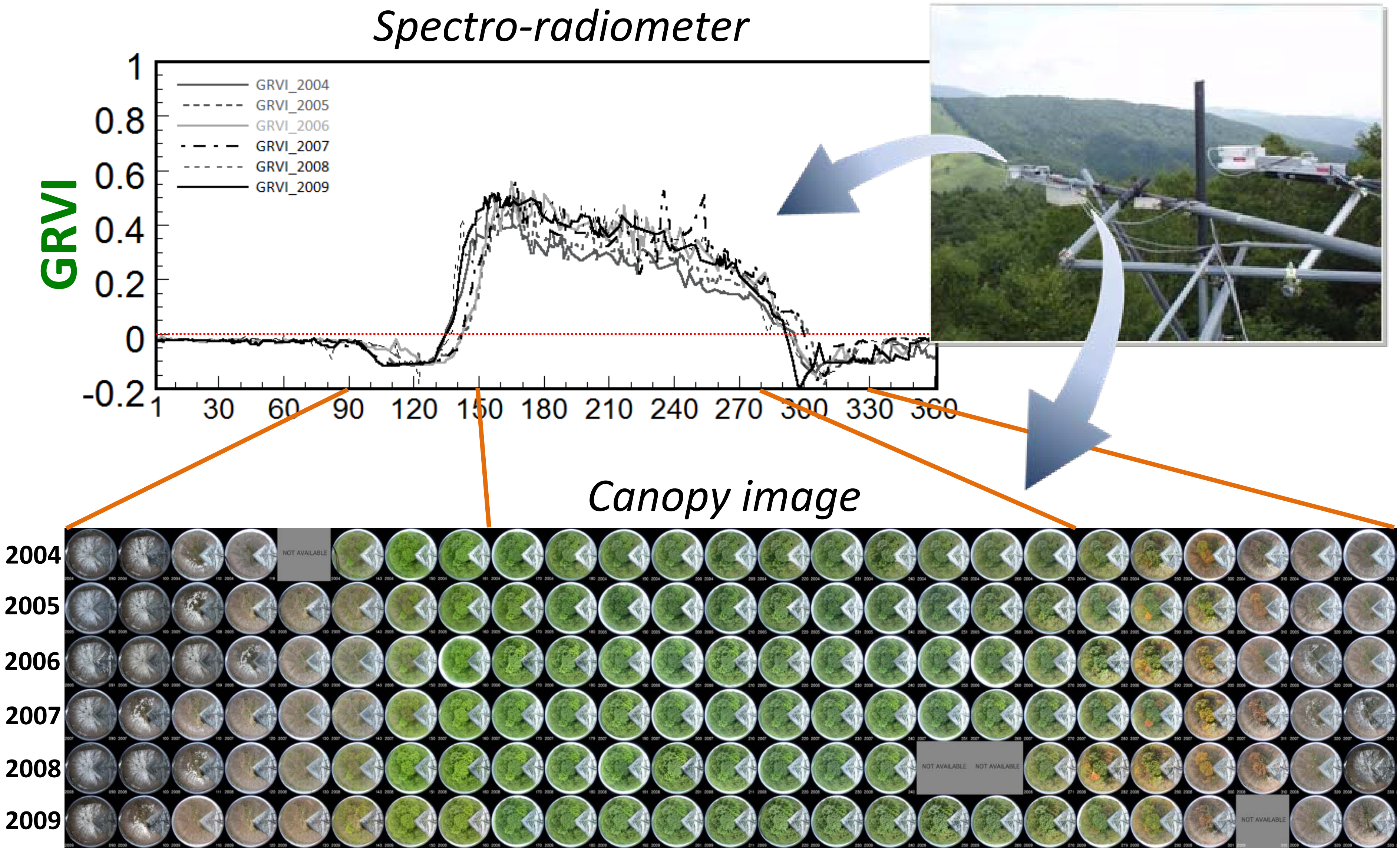
Near-future prediction of warming impacts on ecosystem processes and functions

**Vulnerability assessment** of forest ecosystem functions to climate change

# Multi-scale remote sensing of canopy processes

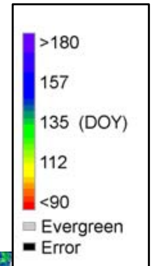


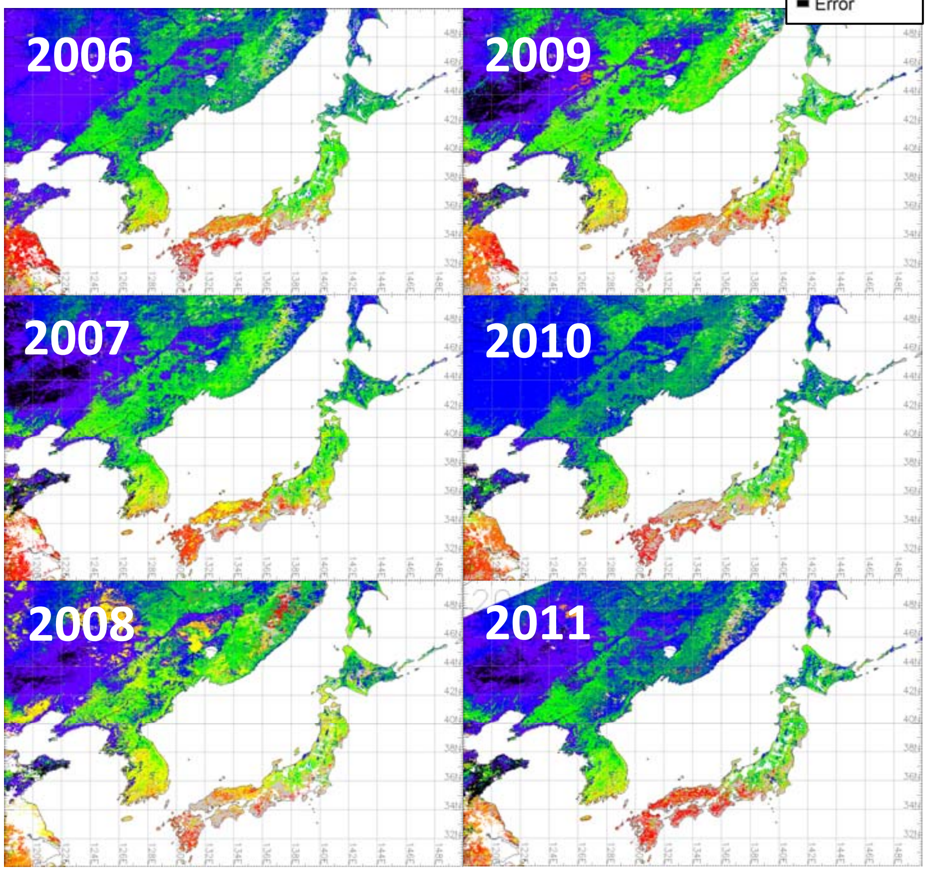
# *In-situ* leaf phenology and spectral vegetation index (VI)



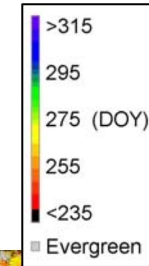
# Mapping leaf phenology by MODIS (Terra, Aqua)

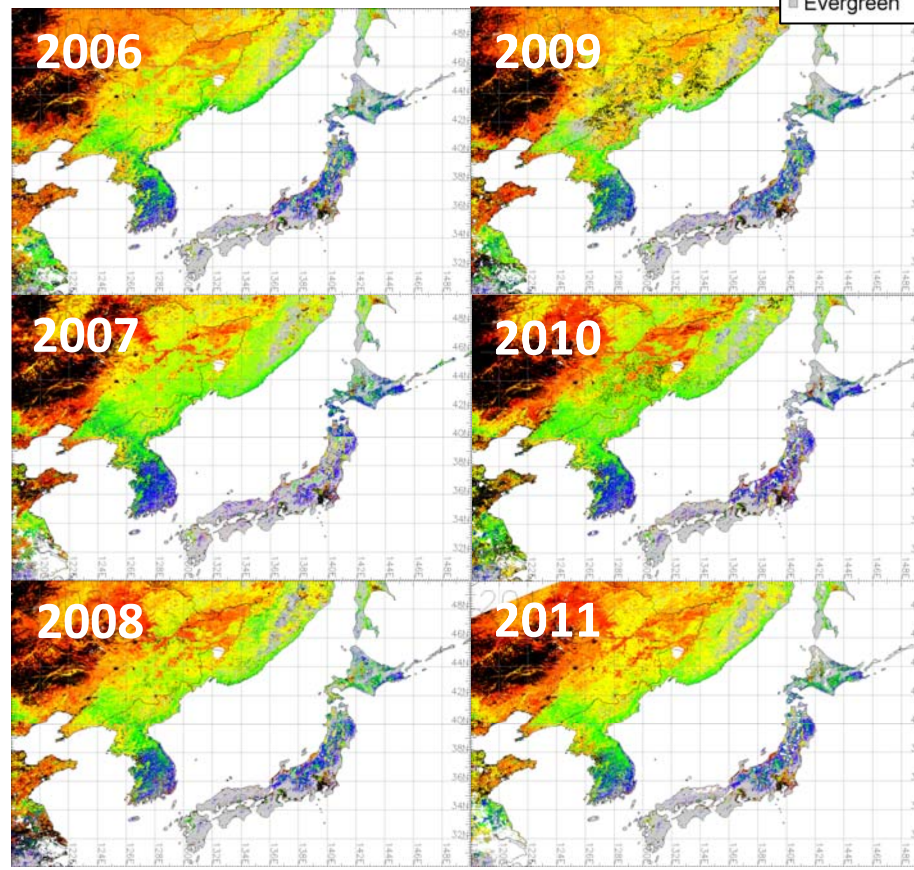
## Leaf expansion date (GRVI > 0)




## Leaf senescence date (GRVI < 0)



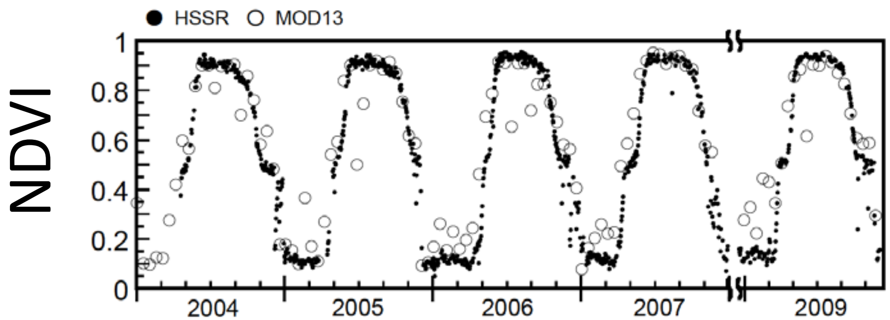



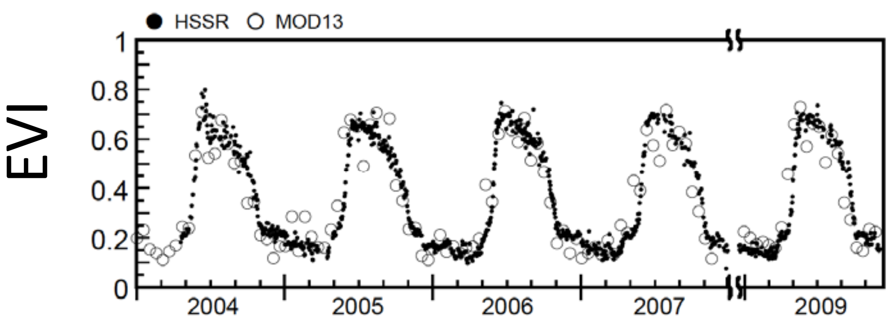

Careful *in-situ* examination of satellite RS data enables us to map ecosystem functions.
Further validation of satellite RS data at ecological research sites is required.

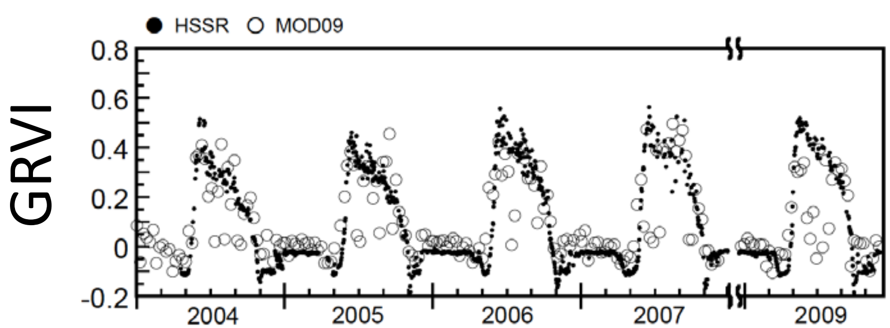
# VIs and canopy productivity

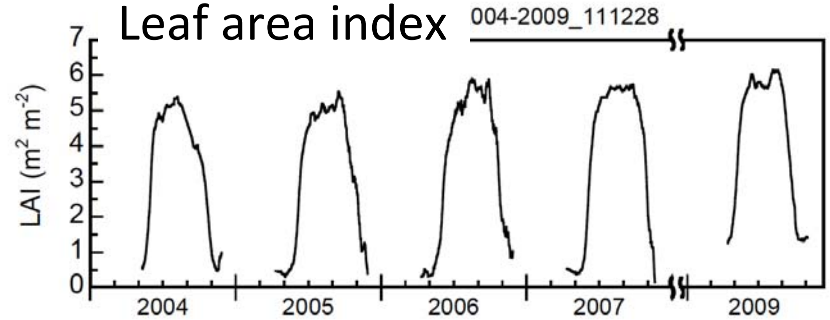
Spectral reflectance

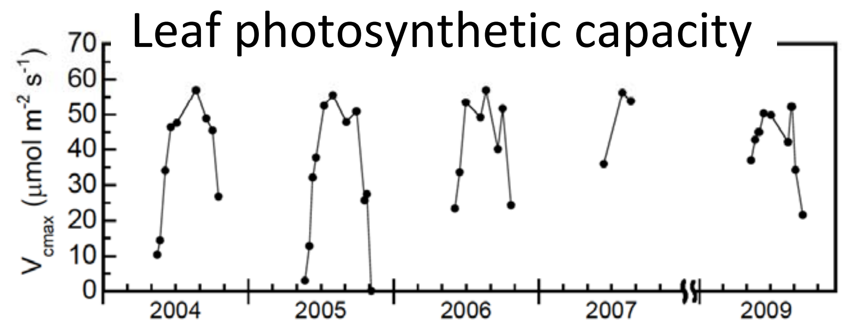
Leaf , canopy

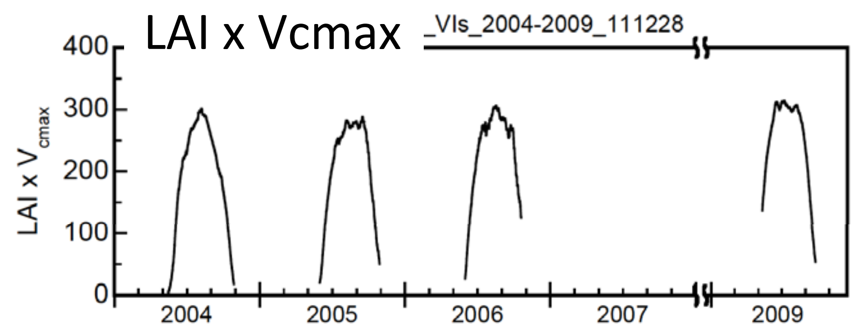


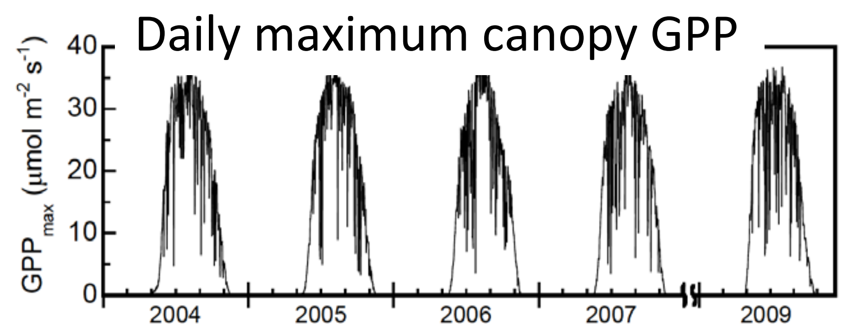



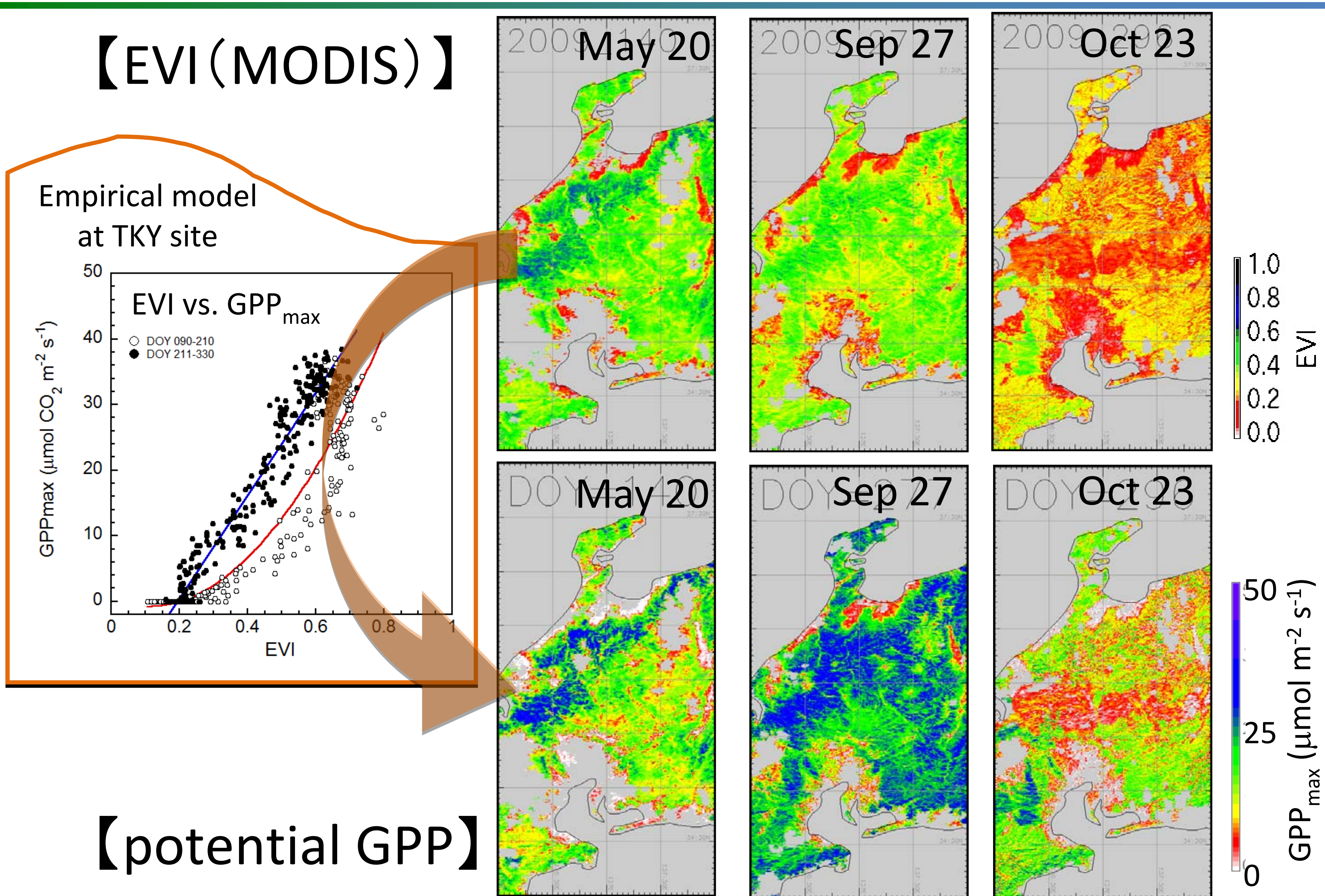



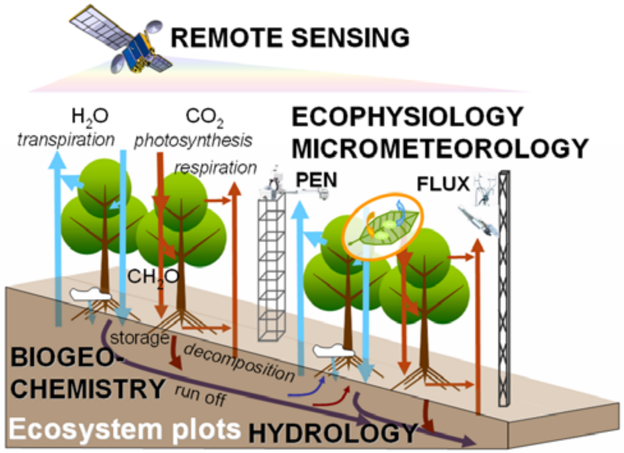
# From EVI to potential photosynthetic productivity (GPP)

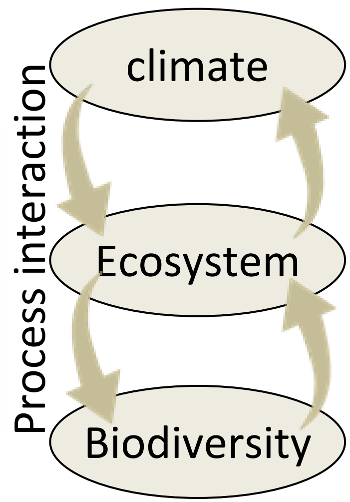


# Networking networks for climate-ecosystem-biodiversity obs.

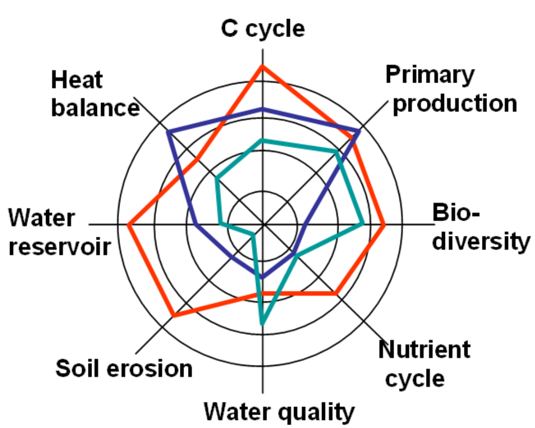
## Concepts to be shared

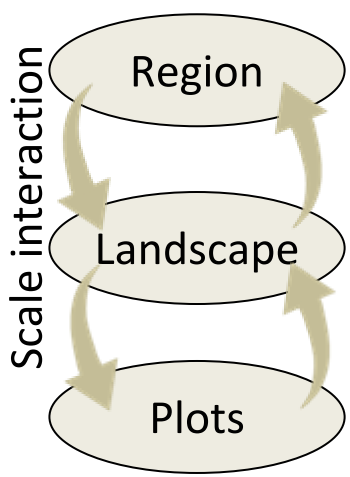
Integrations (data, viewpoints)



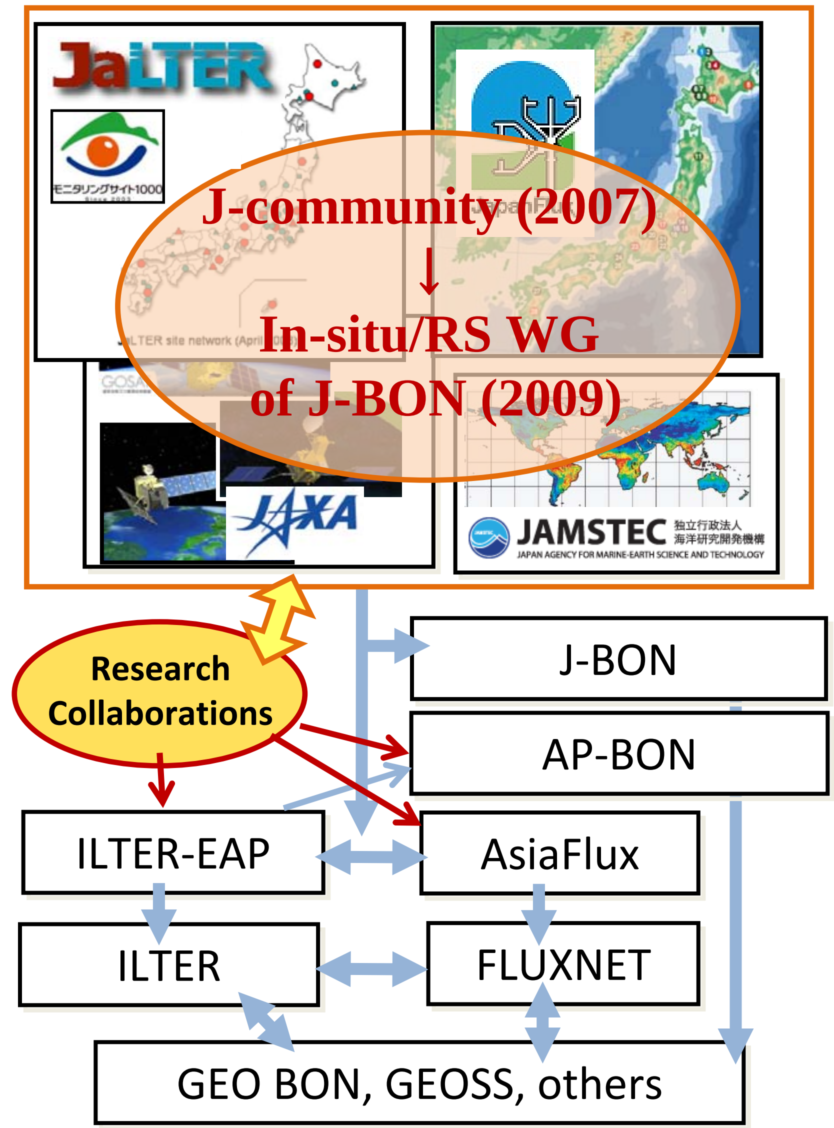




Multiple assessment




## Current efforts in Japan

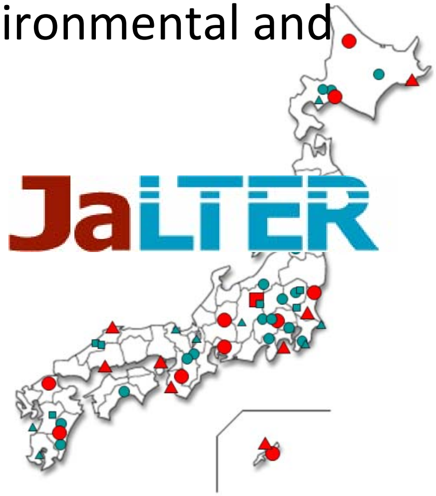


# Linking with ILTER for NPP-biodiversity issues

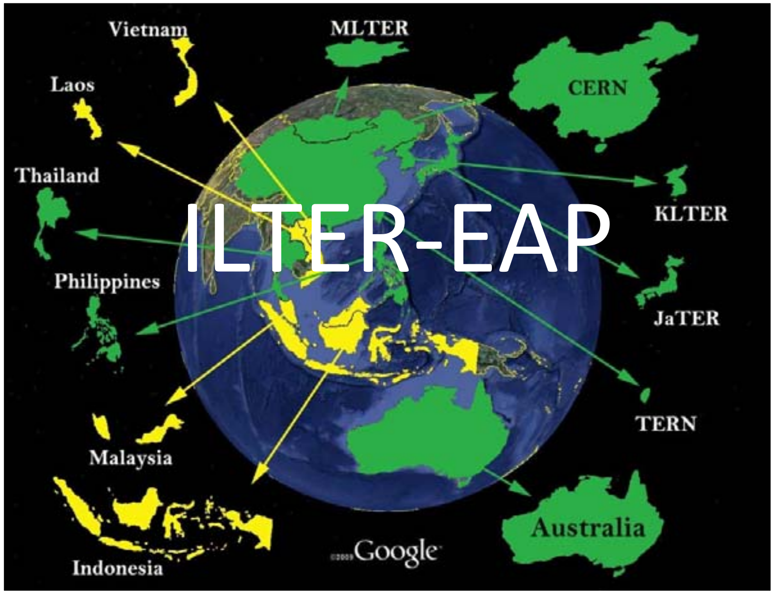
**International Long Term Ecological Research** (ILTER) is a 'network of networks', a global network of research sites located in a wide array of ecosystems worldwide that can help understand environmental change across the globe.

**ILTER's vision** is a world in which science helps prevent and solve environmental and socio-ecological problems.

***<u>Partner of GEO BON</u>***




JaLTER site network (April 2011)

# SATECO initiative for *In situ* / RS integration

## Recommendations: networkings for cross-scale collaborations

### **(I) "Vertically deep – laterally sparse network"**

to find consequences among ecosystem composition, structure and functions for various ecosystems along the environmental gradients, by networking 'super-sites' of existing research networks.

### **(II) "Vertically shallow – laterally dense network"**

to find the general relationships between the ecological aspects of plants, animals, birds and microorganisms (i.e., assessment of habitat quality and preferences, distribution patterns, etc.).

### **(III) "Integration of biological, ecological and physical data by GIS"**

to achieve a comprehensive understanding on the ecosystem composition – structure – functions, and then to predict these changes under climate and human impacts.

(Muraoka et al. 2012)