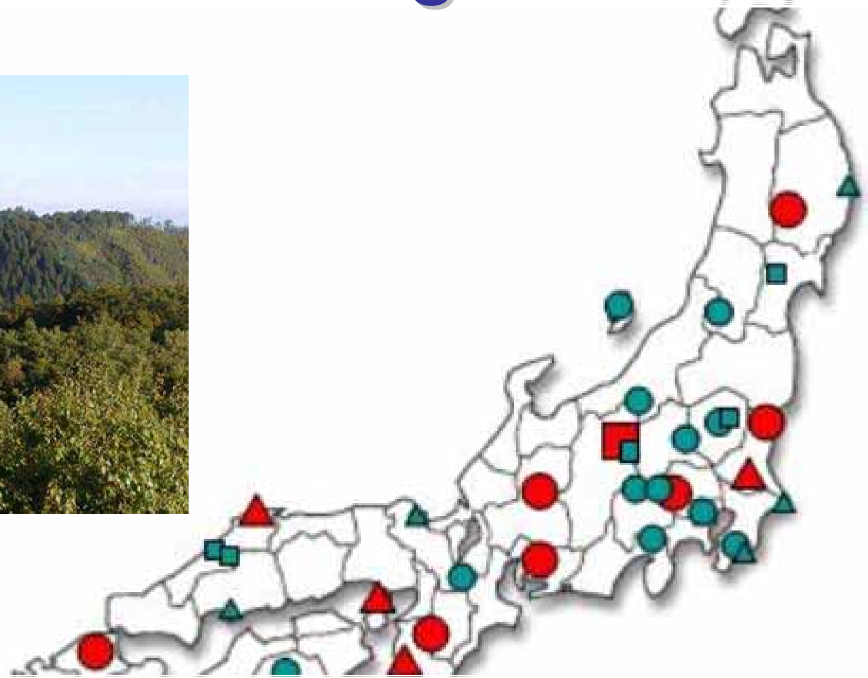
Challenges of JaLTER toward interdisciplinary study on ecosystem adaptation under global changes



Hideaki Shibata (Hokkaido University)
Tohru Nakashizuka (Tohoku University)

Contents

- Need of interdisciplinary ecosystem study
- What's JaLTER?
- Challenge of JaLTER
  - Long-term study of ecosystem process
  - Cross-site analysis
  - Data archiving and sharing

Human system needs strategy for adaptation and mitigation under predicted global change.

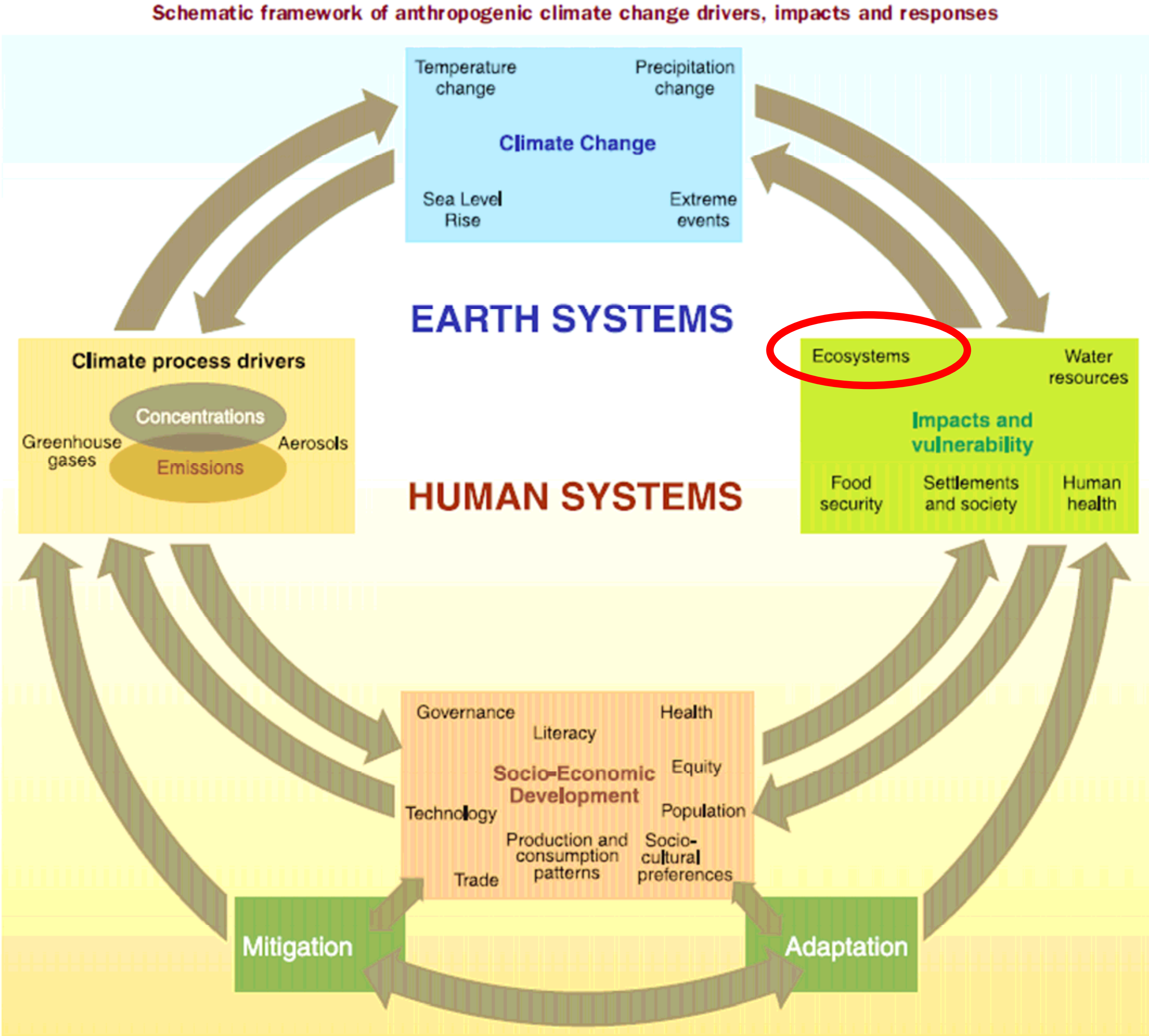


Figure I.1. Schematic framework representing anthropogenic drivers, impacts of and responses to climate change, and their linkages.

(IPCC AR4)

Importance of Ecosystem in GEOSS

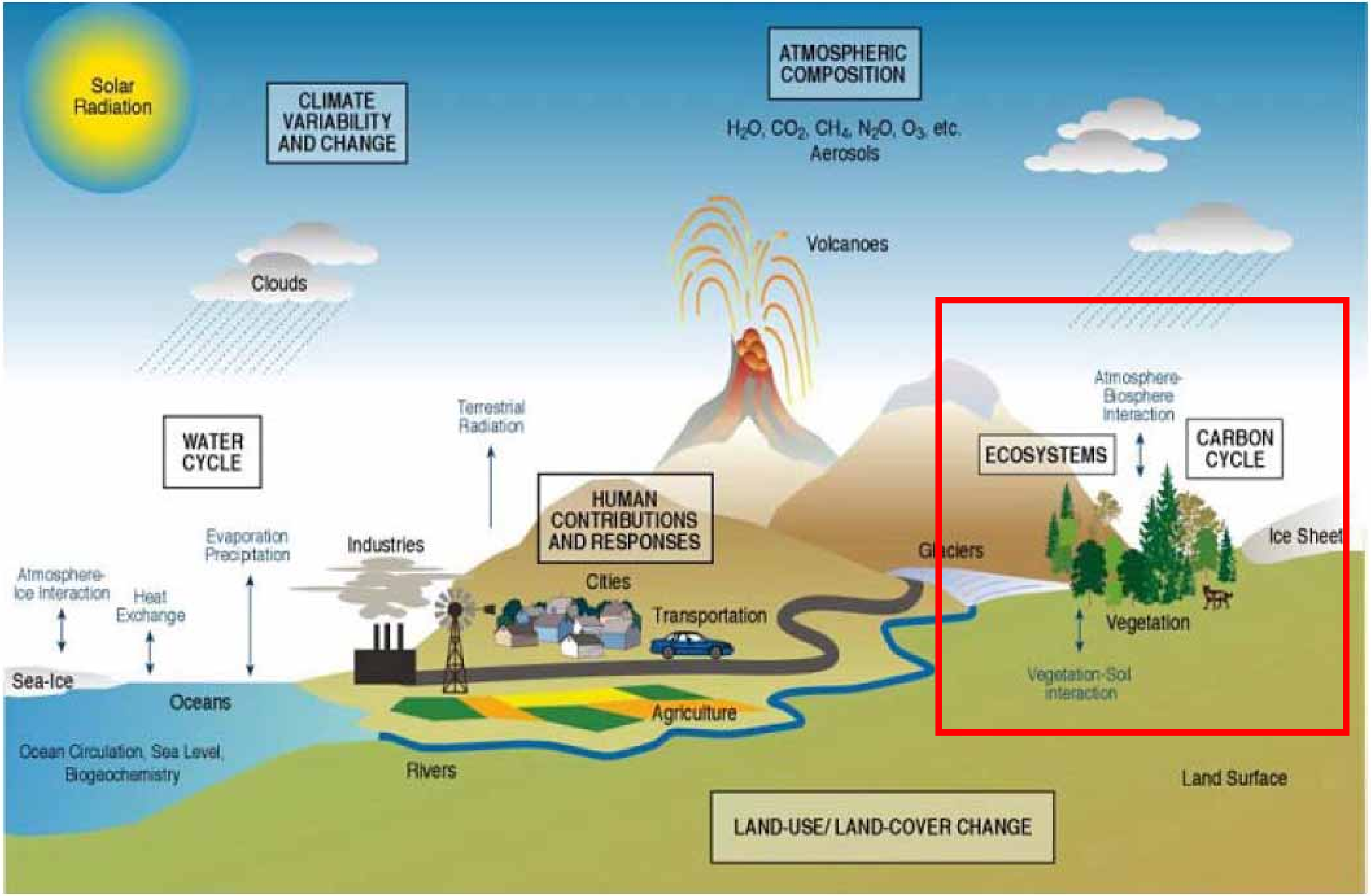
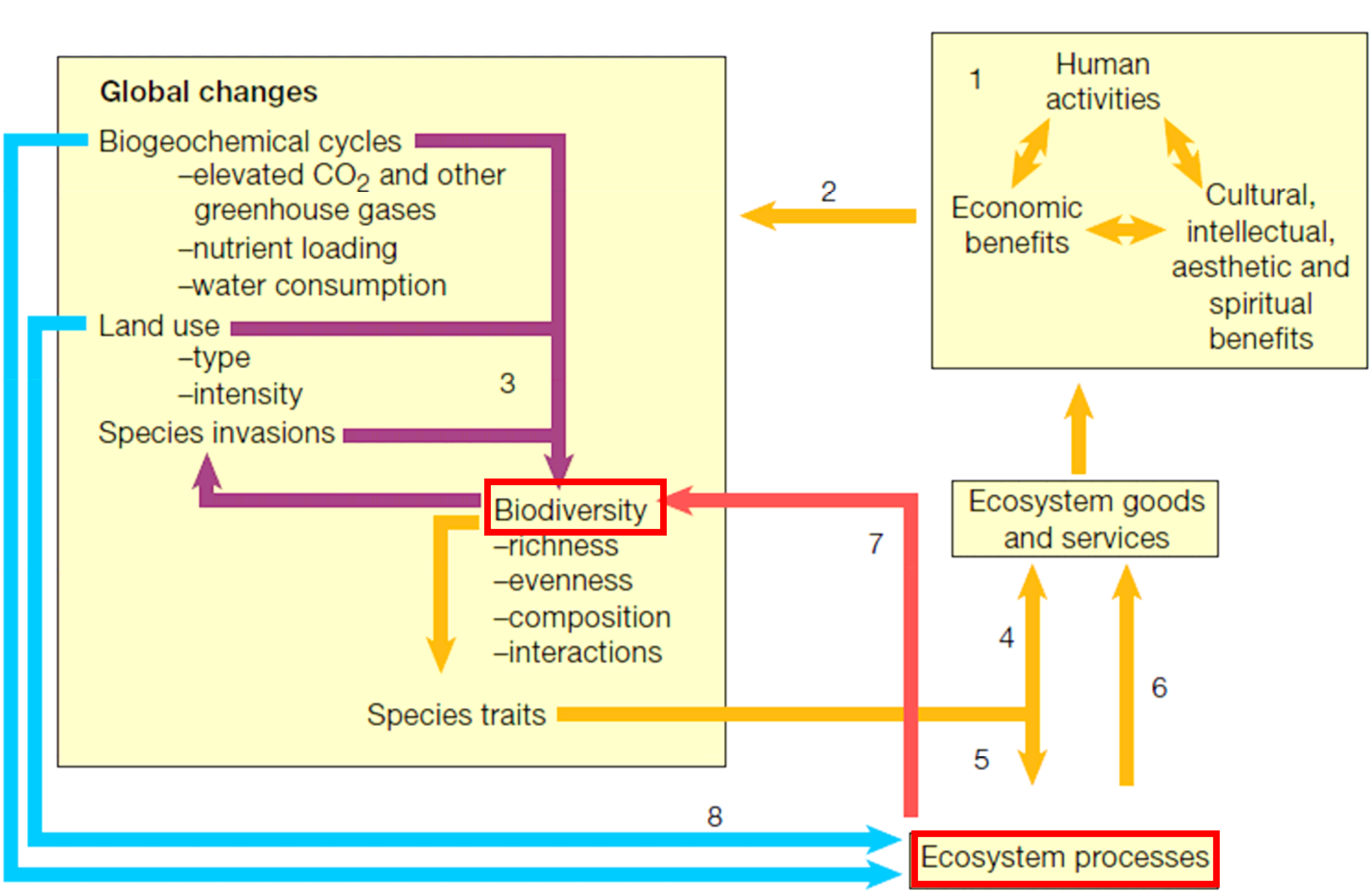


Diagram of the Earth System

(GEO Information Sheet 2008)

Ecosystem and biodiversity under global change



(Chapin *et al*. 2000: *Nature* **405**: 234-242)

Global and continental temperature change

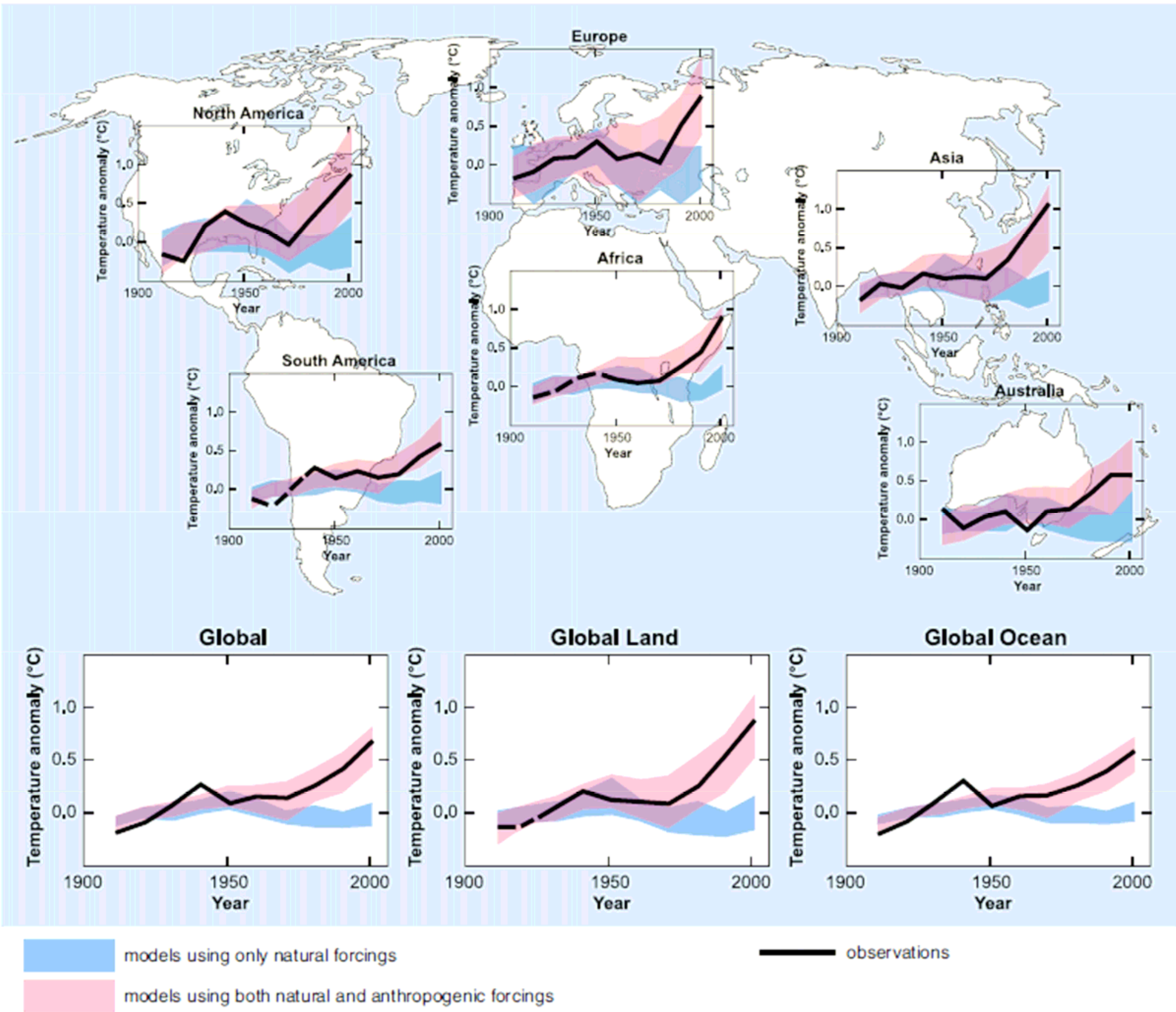
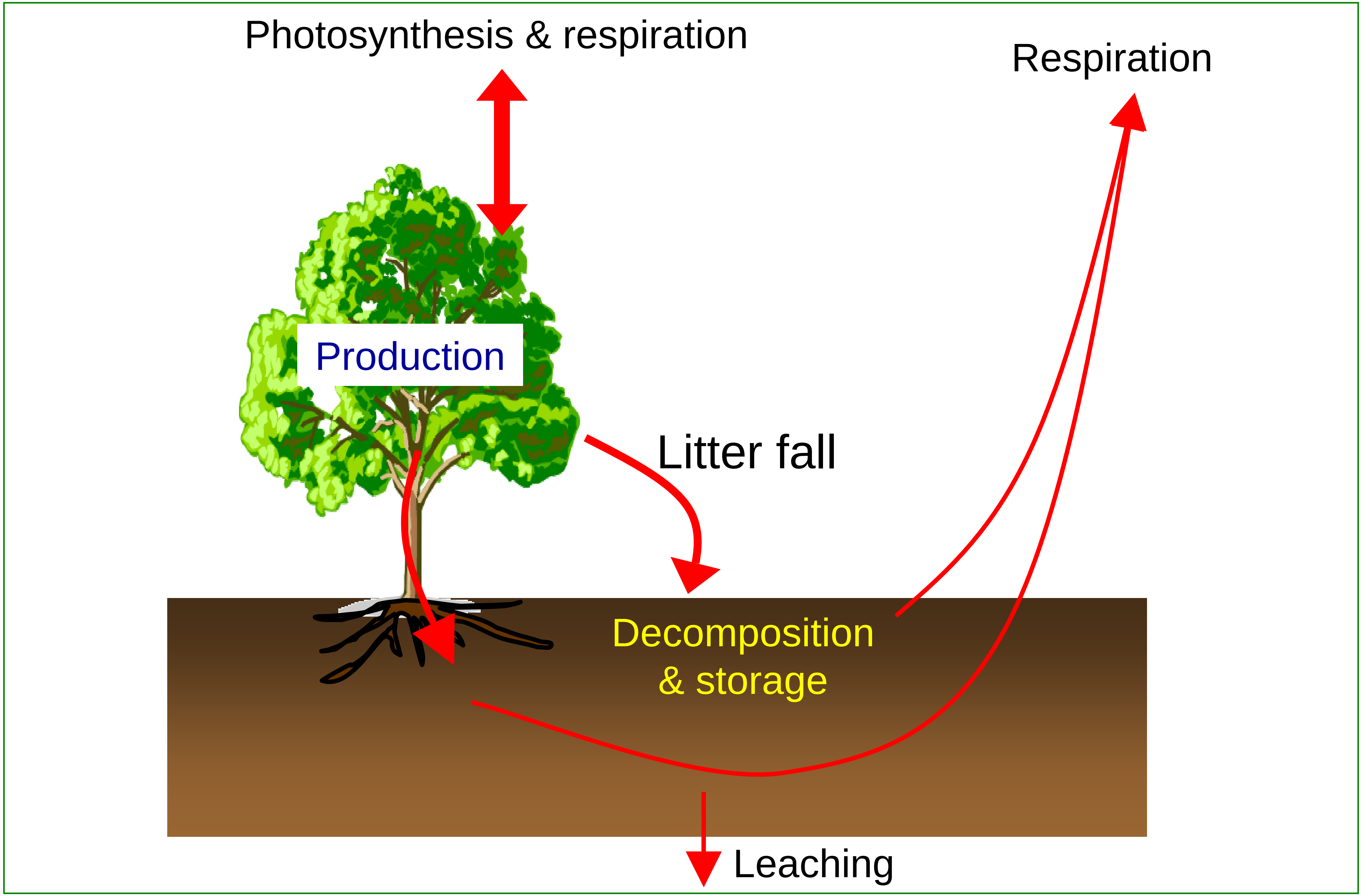


Figure 2.5. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the centre of the decade and relative to the corresponding average for the 1901-1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5 to 95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5 to 95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {WGI Figure SPM.4}

(IPCC AR4)

Ecosystem function under the global climate change

--- Inter-related processes of carbon cycle in terrestrial ecosystem ---



Carbon uptake by terrestrial ecosystem

(FLUXNET: Baldocchi et al. 2001)

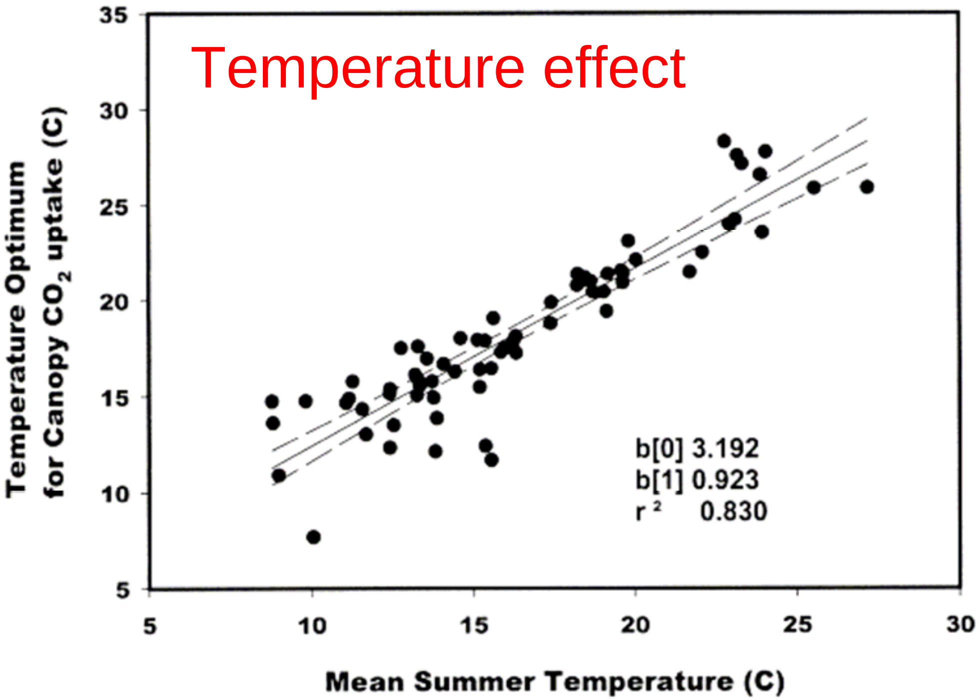


FIG. 9. The relation between the optimum temperature for canopy-scale gross primary productivity vs maximum mean monthly air temperature during the summer growing season. These data show how photosynthesis adapts to climate. Here $b(0)$ is the zero intercept and $b(1)$ is the slope of the regression curve, and r^2 is the coefficient of determination. Dashed lines are the standard error of the regression at the 95% level.

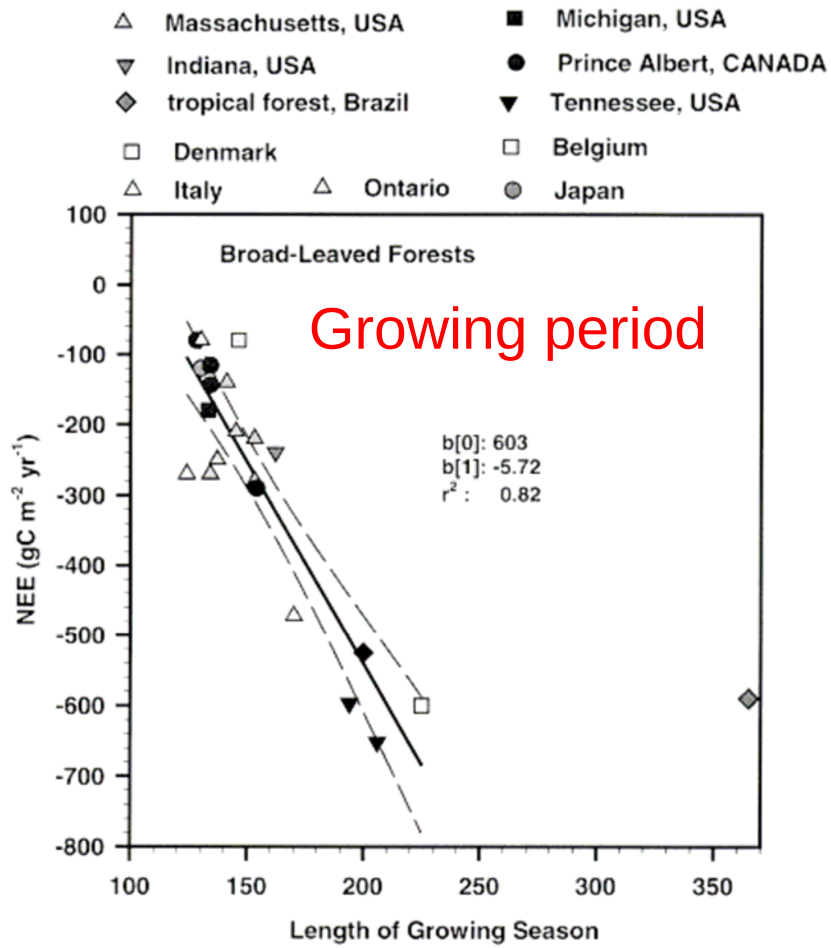


FIG. 4. Annual net ecosystem CO_2 exchange: Impact of length of growing season (in days) on temperate broadleaved forests and one tropical forest (Brazil). Here, b_0 is the zero intercept and b_1 is the slope of the regression curve, and r^2 is the coefficient of determination. Dashed lines are the standard error of the regression at the 95% level.

Control of temperature and nitrogen on C uptake

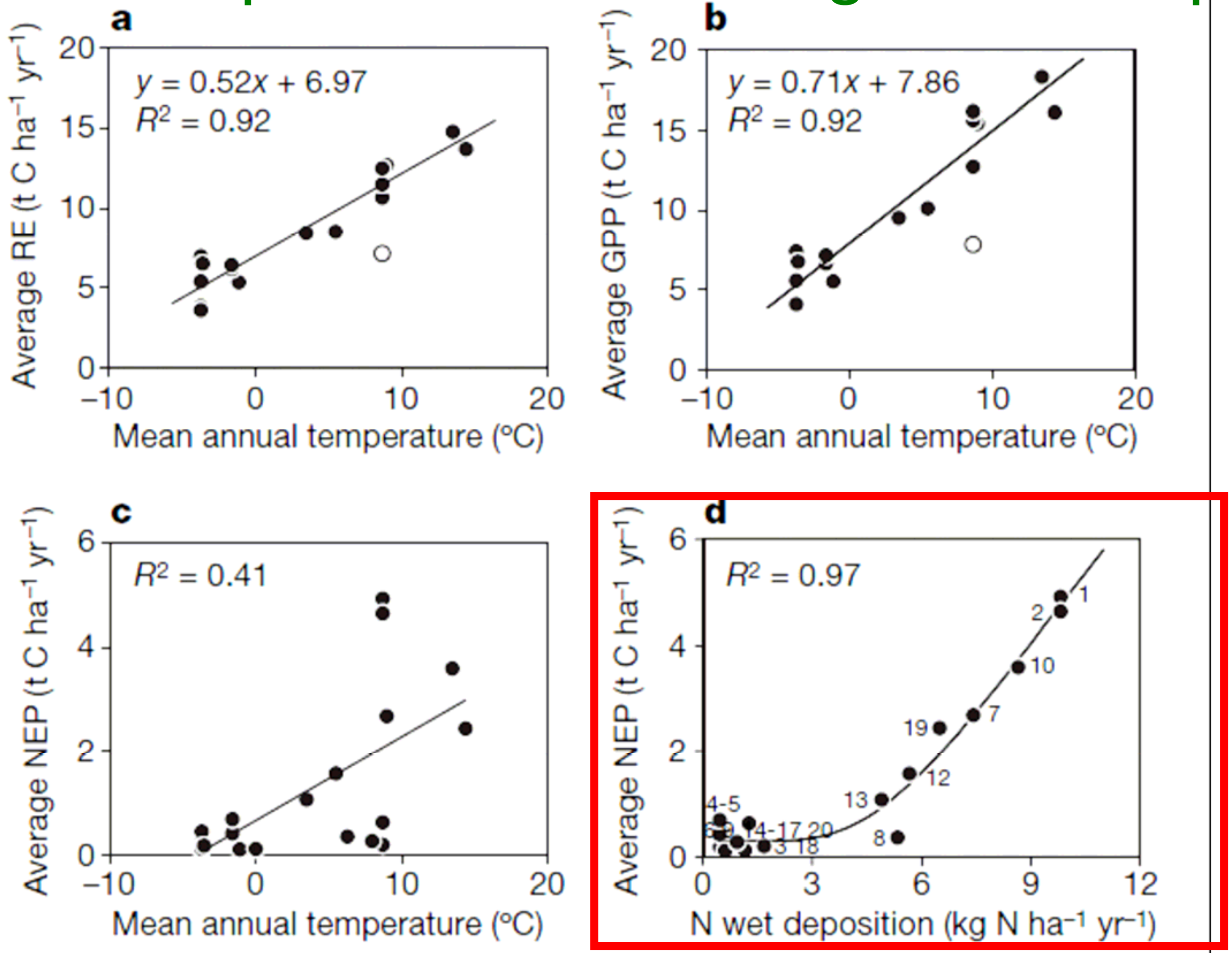
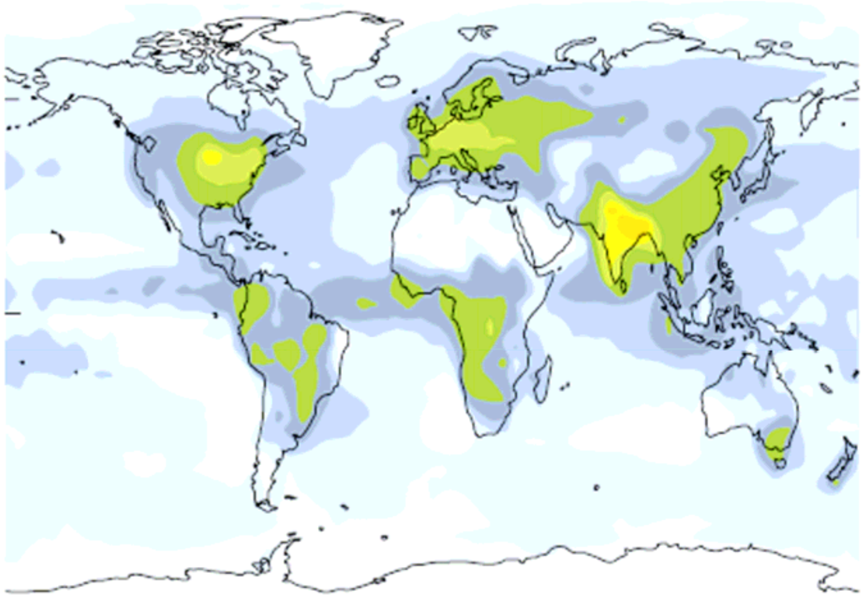
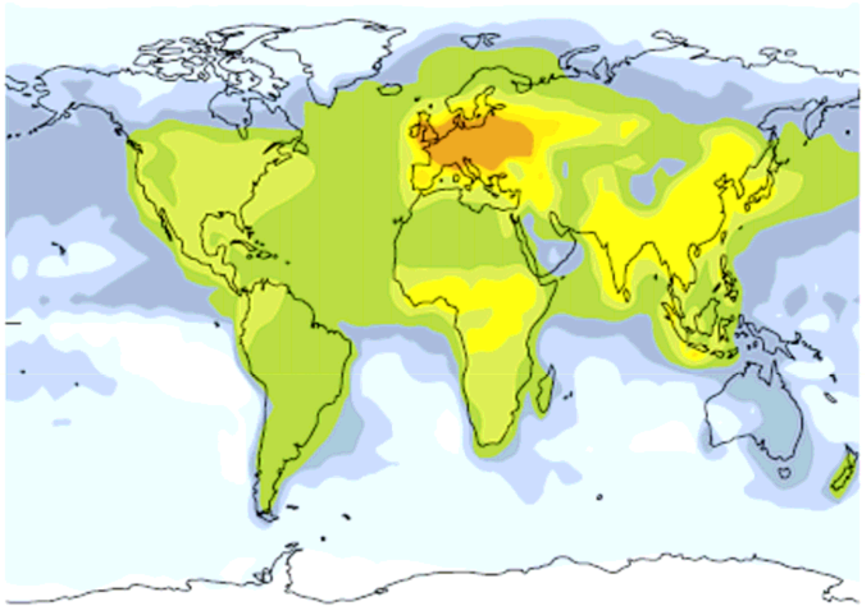


Figure 3 | Environmental control of average C exchange over an entire rotation. Linear relationships between average RE (**a**) and average ecosystem GPP (**b**) and mean annual temperature at the study sites. In both **a** and **b**, the only drought-prone site[9] (white circle) has been excluded from the analysis. **c**, Average NEP is only poorly correlated to temperature. **d**, Average NEP is strongly related to N deposition. Numbers refer to site codes in Table 1. An Arrhenius function has been empirically fitted onto the entire data set ($n = 20$).

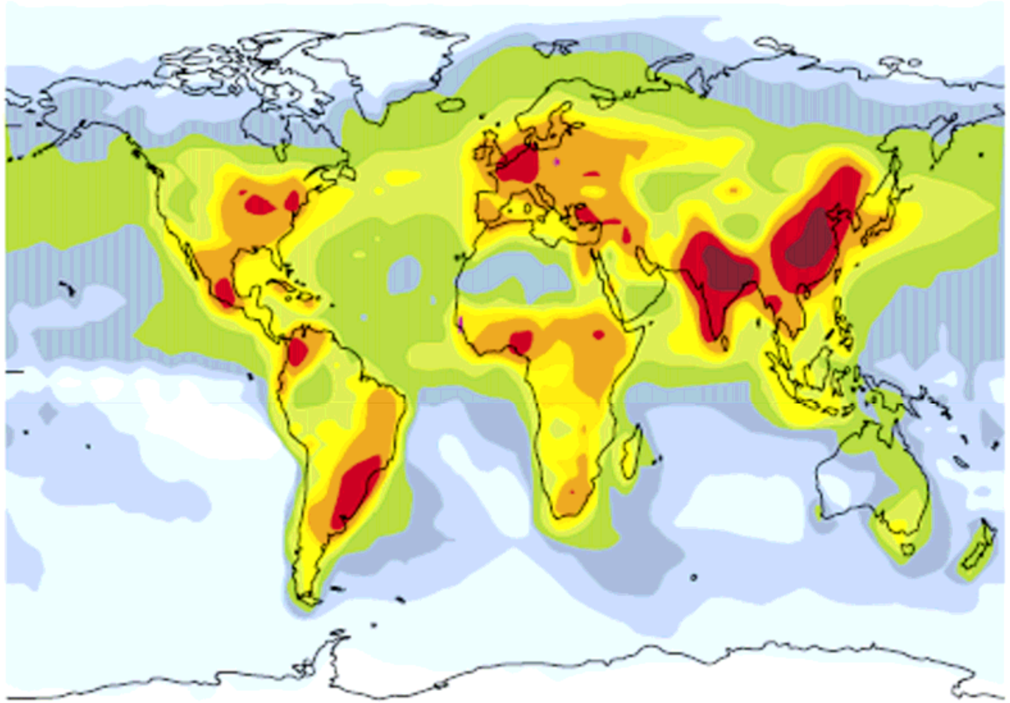
(Magnani et al. 2007, *Nature* **447**: 848-850)



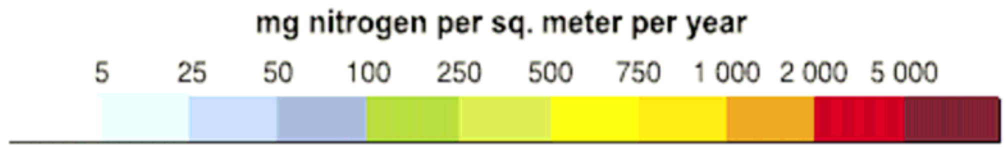
1860



Early 1990s



2050



Source: Galloway et al. 2004

Future increase of nitrogen pollution

(Galloway et al; MA Synthesis 2005)

Change of litter decomposition associated with nitrogen nutrition would control nutrient supply for plant and carbon storage in soil.

Progressive nitrogen limitation under climate change

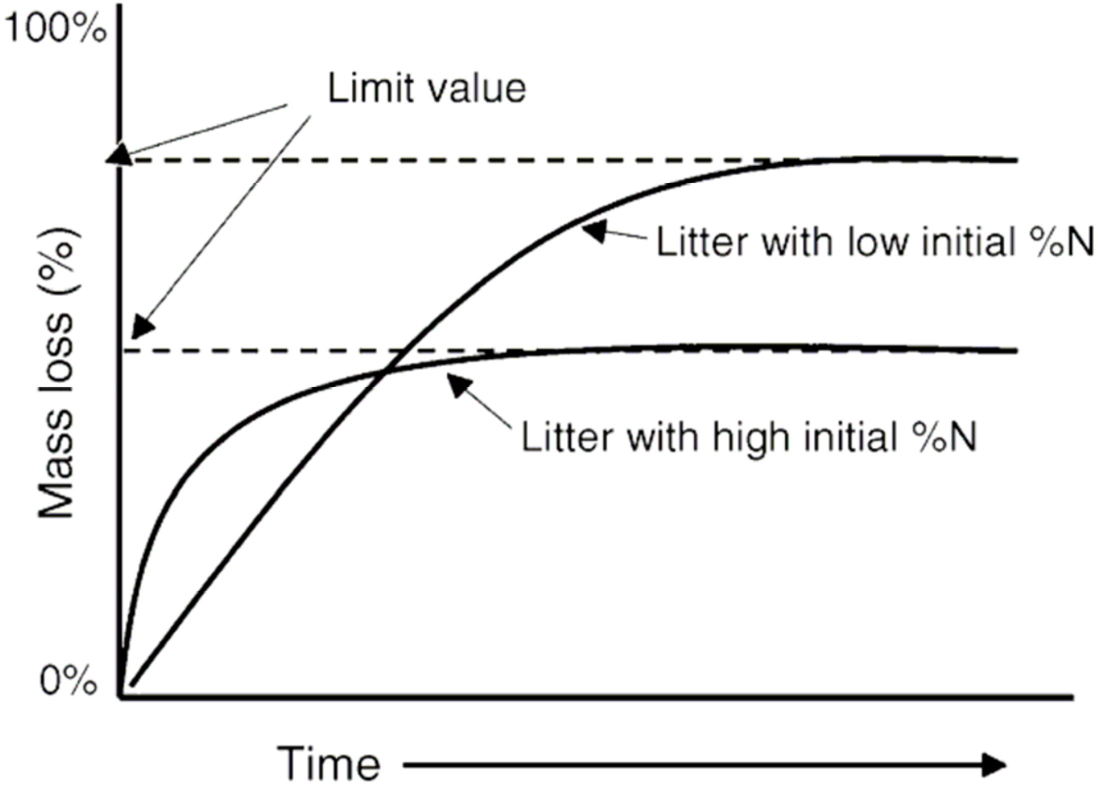


FIG. 4. Schematic representation of the theoretical changes in loss of litter mass over time with high and low initial N concentrations. The figure is adapted from Berg and McClaugherty (2003).

(Johnson et al. 2006, *Ecology* **87**: 64-75)

Biodiversity also affect ecosystem productivity affected by elevated CO_2 and nitrogen.

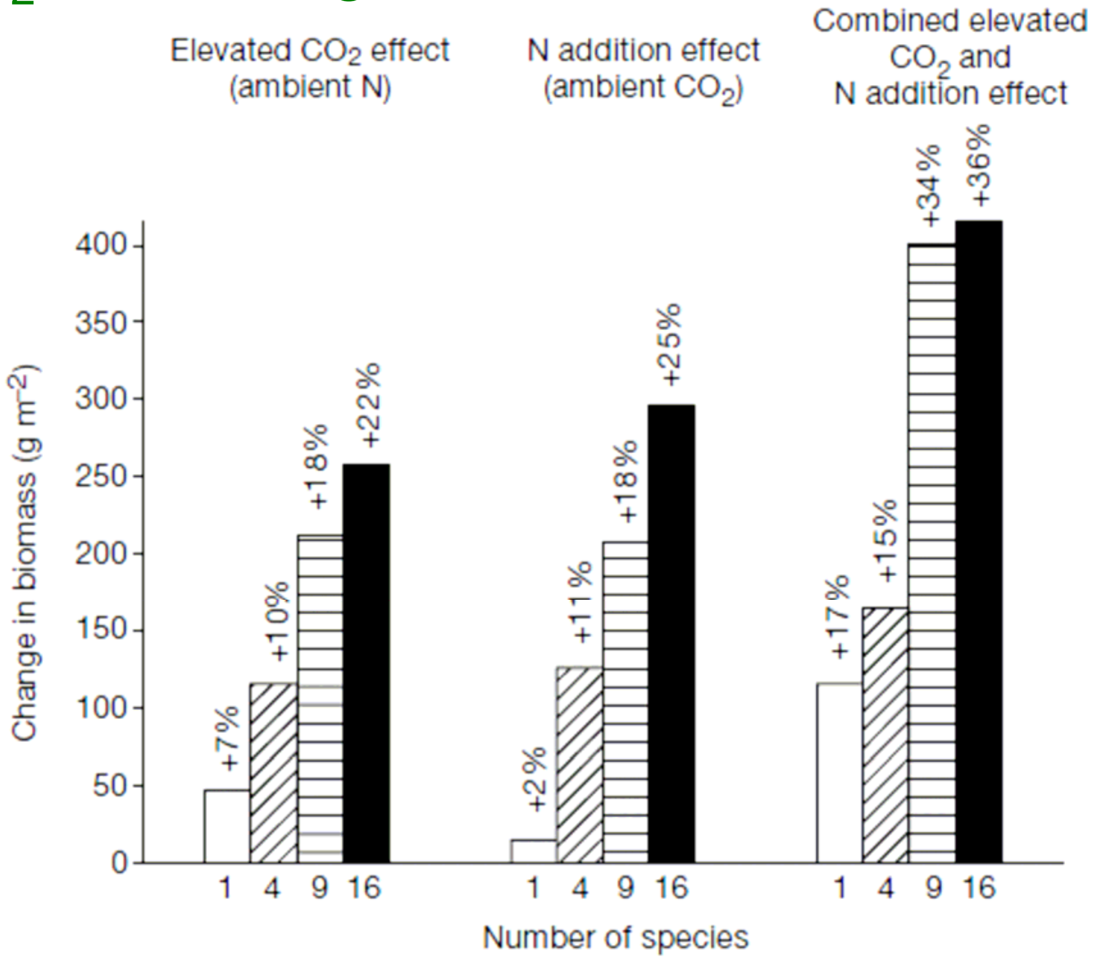


Figure 2 Change in total (above-ground plus 0–20 cm below-ground) biomass (compared with ambient levels of both CO_2 and N) in response to elevated CO_2 alone (at ambient soil N), to enriched N alone (at ambient CO_2), and to the combination of elevated CO_2 and enriched soil N, for plots containing 1, 4, 9 or 16 species. Data were averaged for 4 harvests over 2 yr. Per cent change is shown above each histogram for each diversity treatment.

(Reich *et al*. 2001, *Nature* **410**: 809-812)

From carbon fertilization to saturation and loss

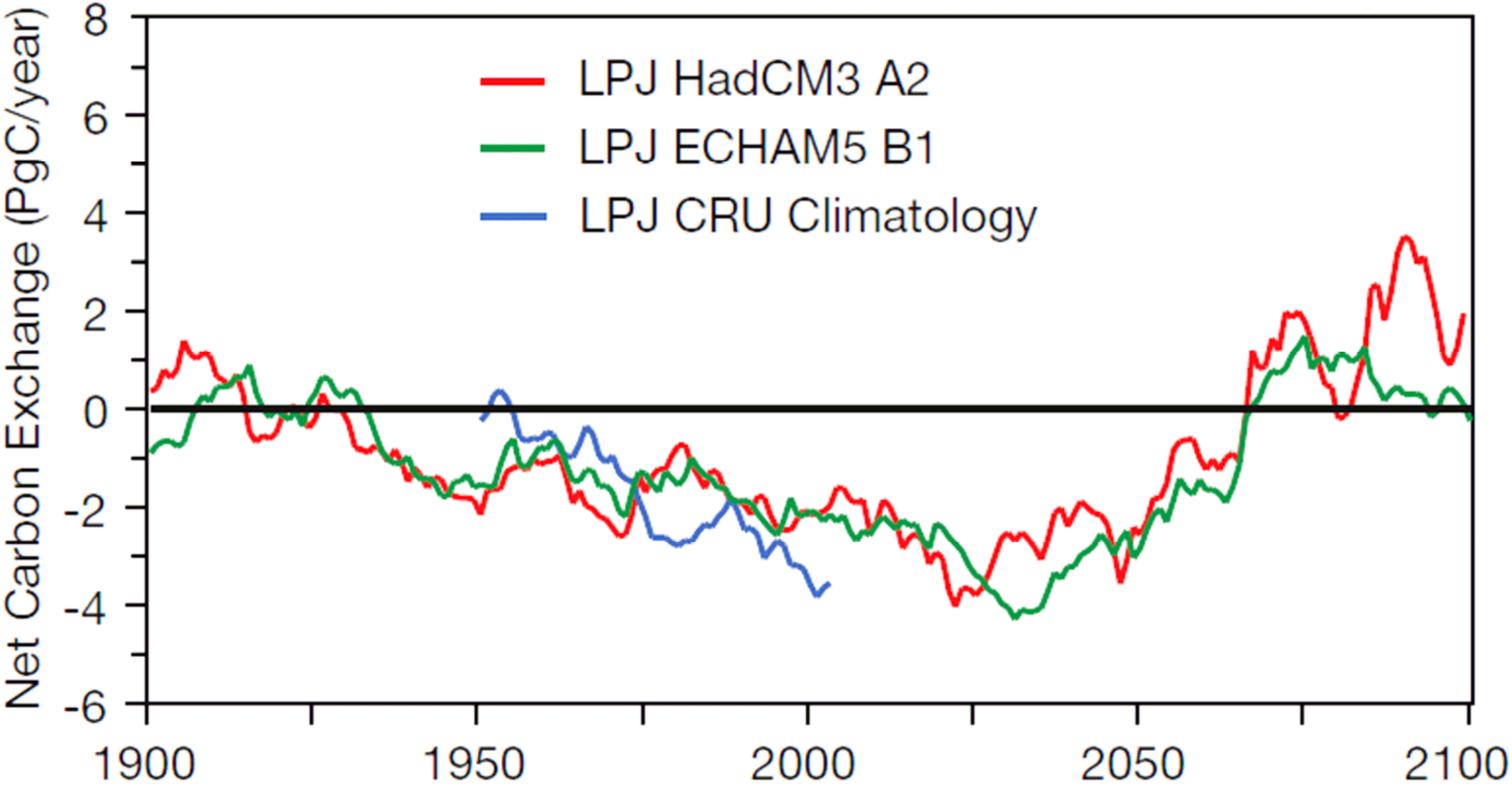


Figure 4.2. *Net carbon exchange of all terrestrial ecosystems as simulated by the DGVM LPJ (Sitch et al., 2003; Gerten et al., 2004 – negative values mean a carbon sink, positive values carbon losses to the atmosphere). Past century data are based on observations and climate model data were normalised to be in accord with these observations for the 1961-1990 data (CRU-PIK). Transient future projections are for the SRES A2 and B1 emissions scenarios (Nakićenović et al., 2000), forcing the climate models HadCM3 and ECHAM5, respectively (cf. Lucht et al., 2006; Schaphoff et al., 2006).*

(IPCC AR4-WGII report Chapter 4)

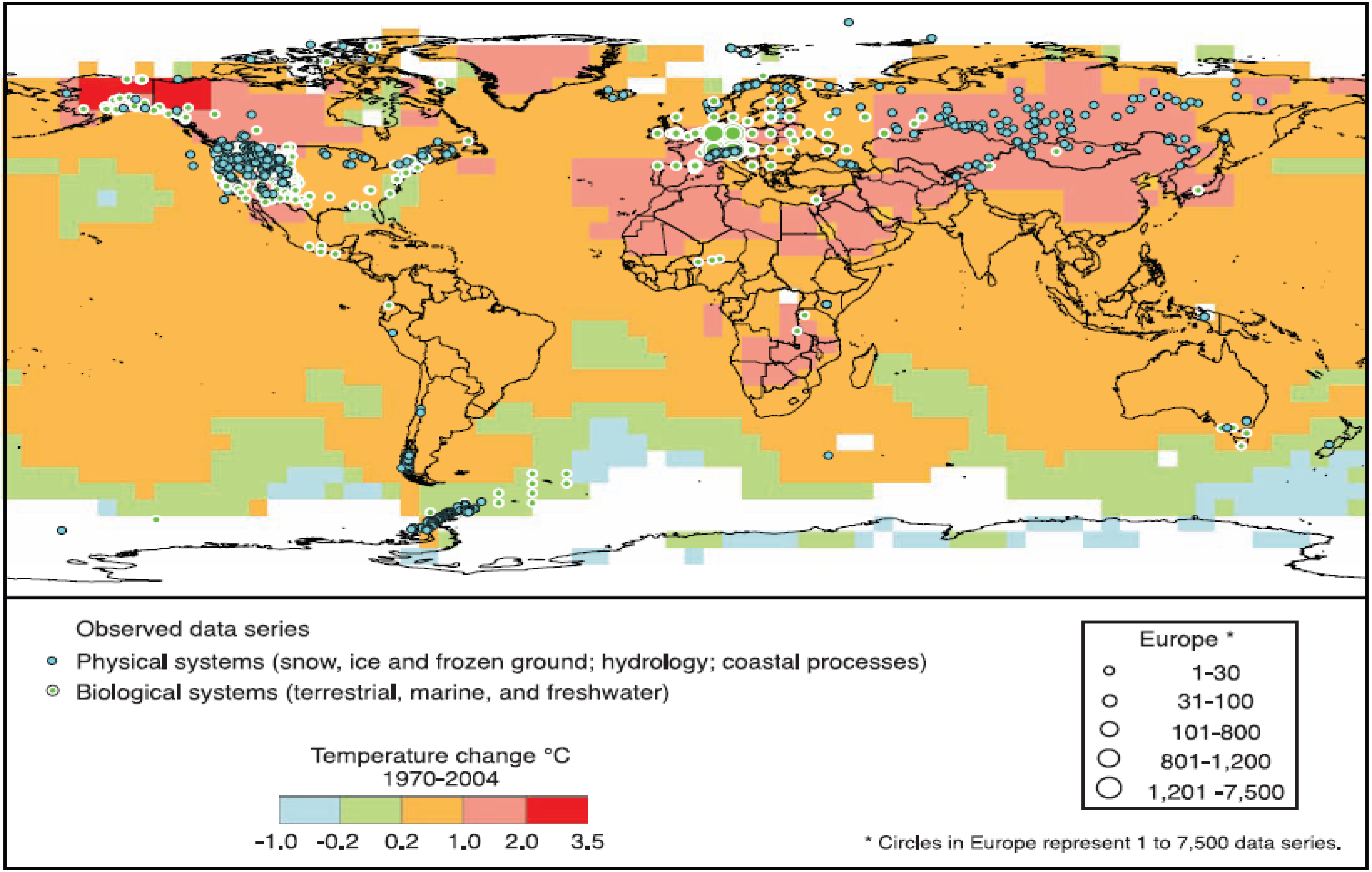
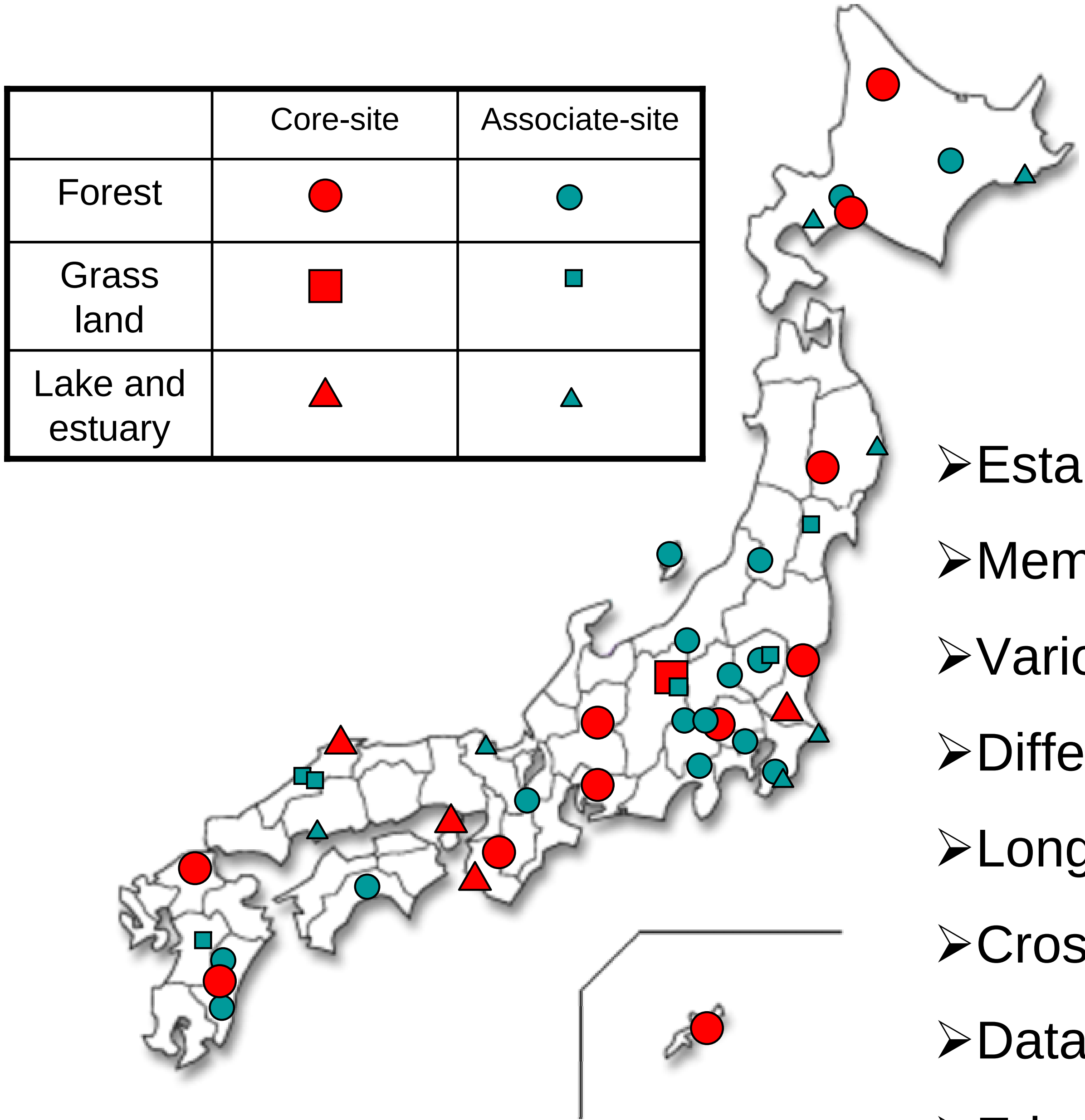


Figure 1.8. *Locations of significant changes in observations of physical systems (snow, ice and frozen ground; hydrology; coastal processes) and biological systems (terrestrial, marine and freshwater biological systems), are shown together with surface air temperature changes over the period 1970 to 2004 (from the GHCN-ERSST datatset). The data series met the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; (3) showing a significant change in either direction, as assessed by individual studies. White areas do not contain sufficient observational climate data to estimate a temperature trend.*

IPCC Fourth Assessment Report

Working Group II Report "Impacts, Adaptation and Vulnerability"

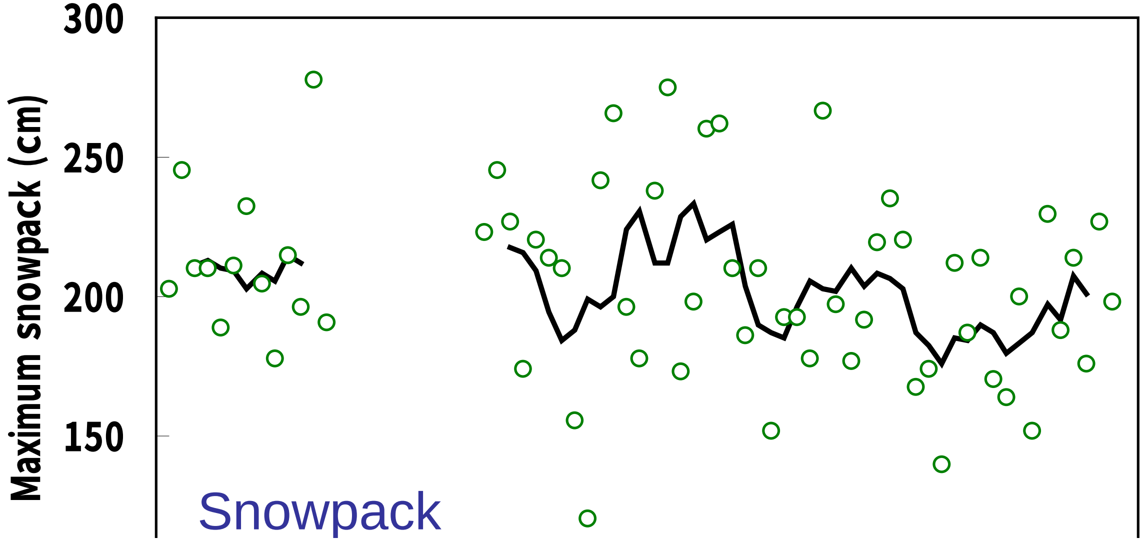
Japan Long-Term Ecological Research Network (JaLTER)

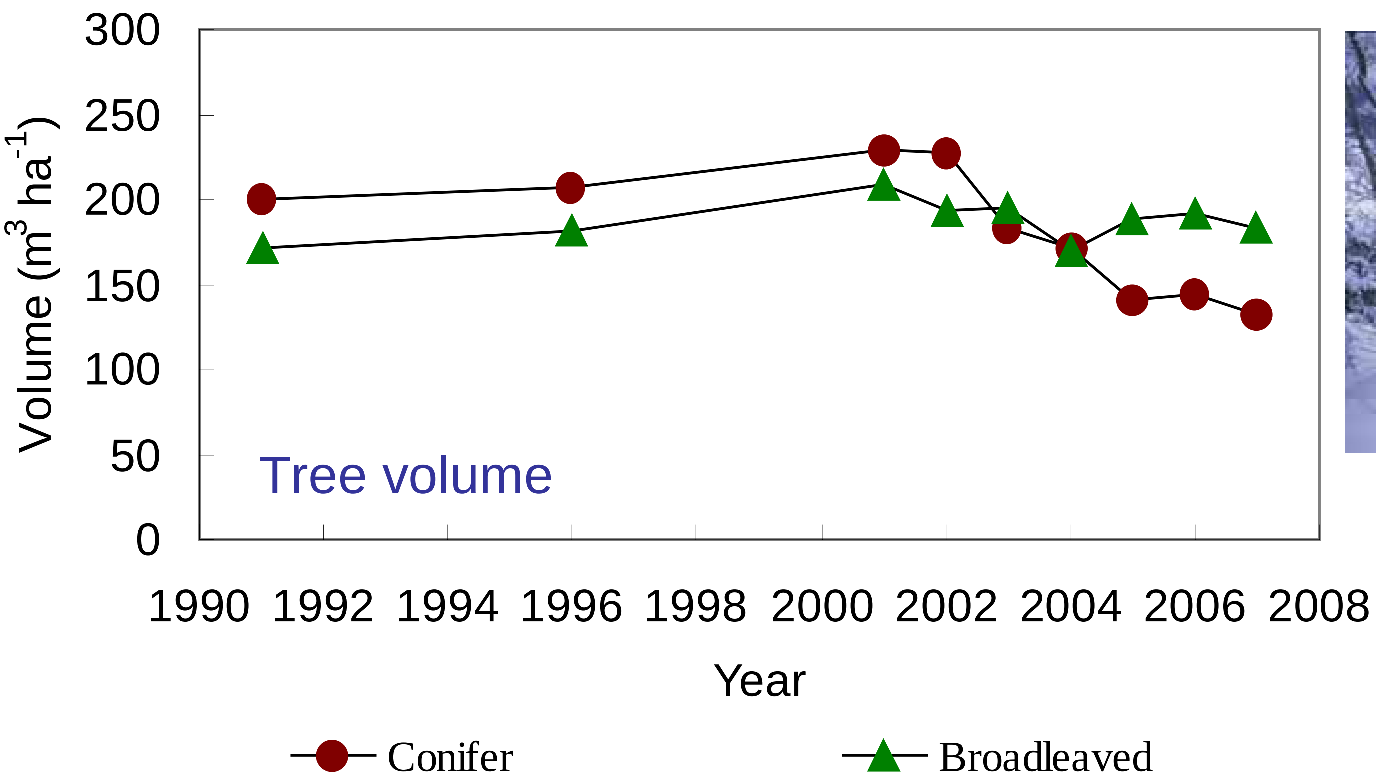


JaLTER site network (April 2008)

- Established in 2006
- Membership of ILTER in 2007
- Various ecosystems and institutes
- Different environmental conditions
- Long-term and Large-scale study
- Cross-site analysis
- Data archive and sharing
- Education program

Challenge of JaLTER; Long-term monitoring of environment and ecosystem





Natural mixed forest

Challenge of JaLTER: Large-scale infrastructures

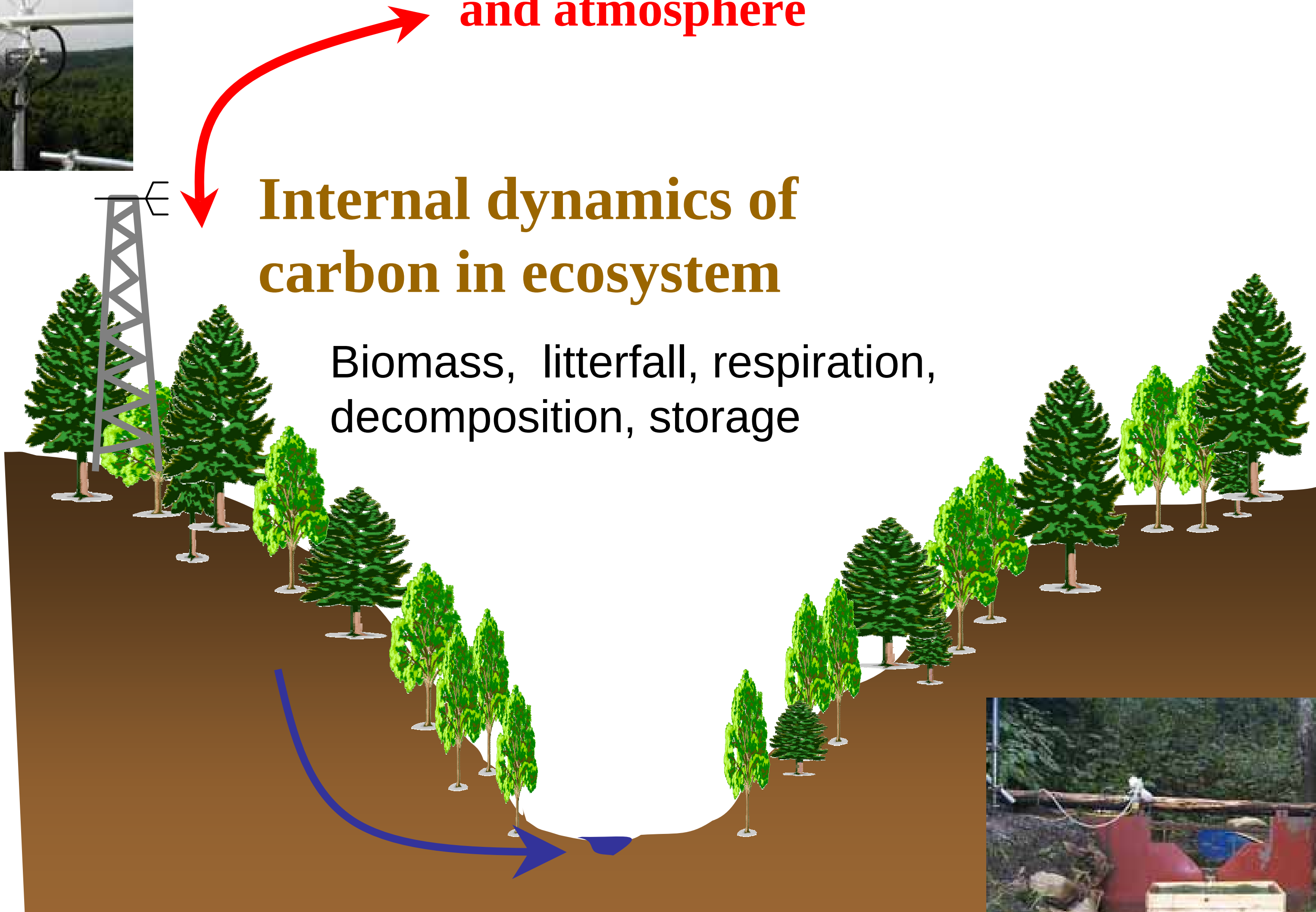
Challenge of JaLTER: Integrated study of ecosystem processes

-- carbon cycling in watershed ecosystem --

Carbon exchange between ecosystem and atmosphere

Internal dynamics of carbon in ecosystem

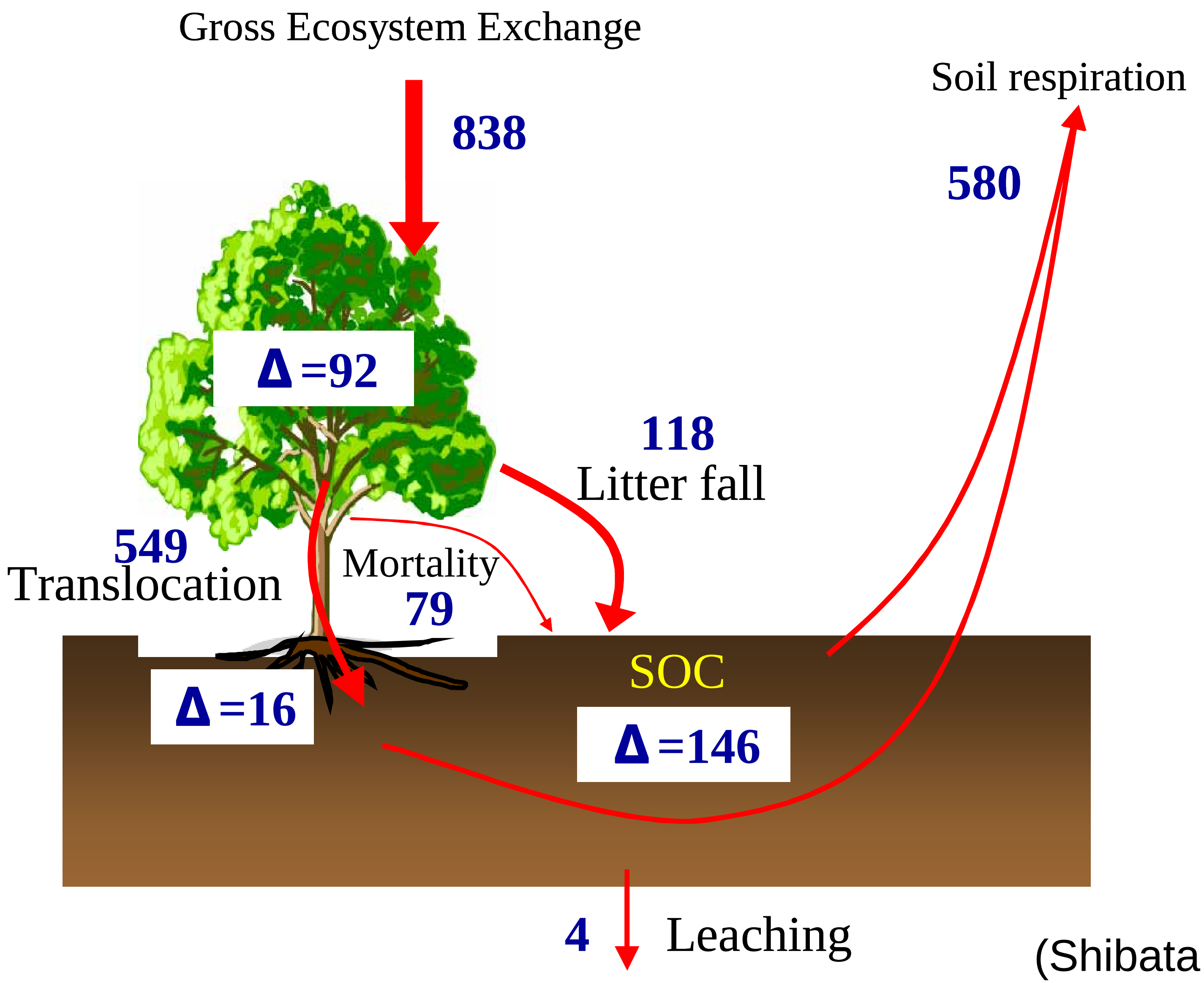
Biomass, litterfall, respiration, decomposition, storage



Carbon leaching to stream

Challenge of JaLTER: Integrated study of ecosystem processes

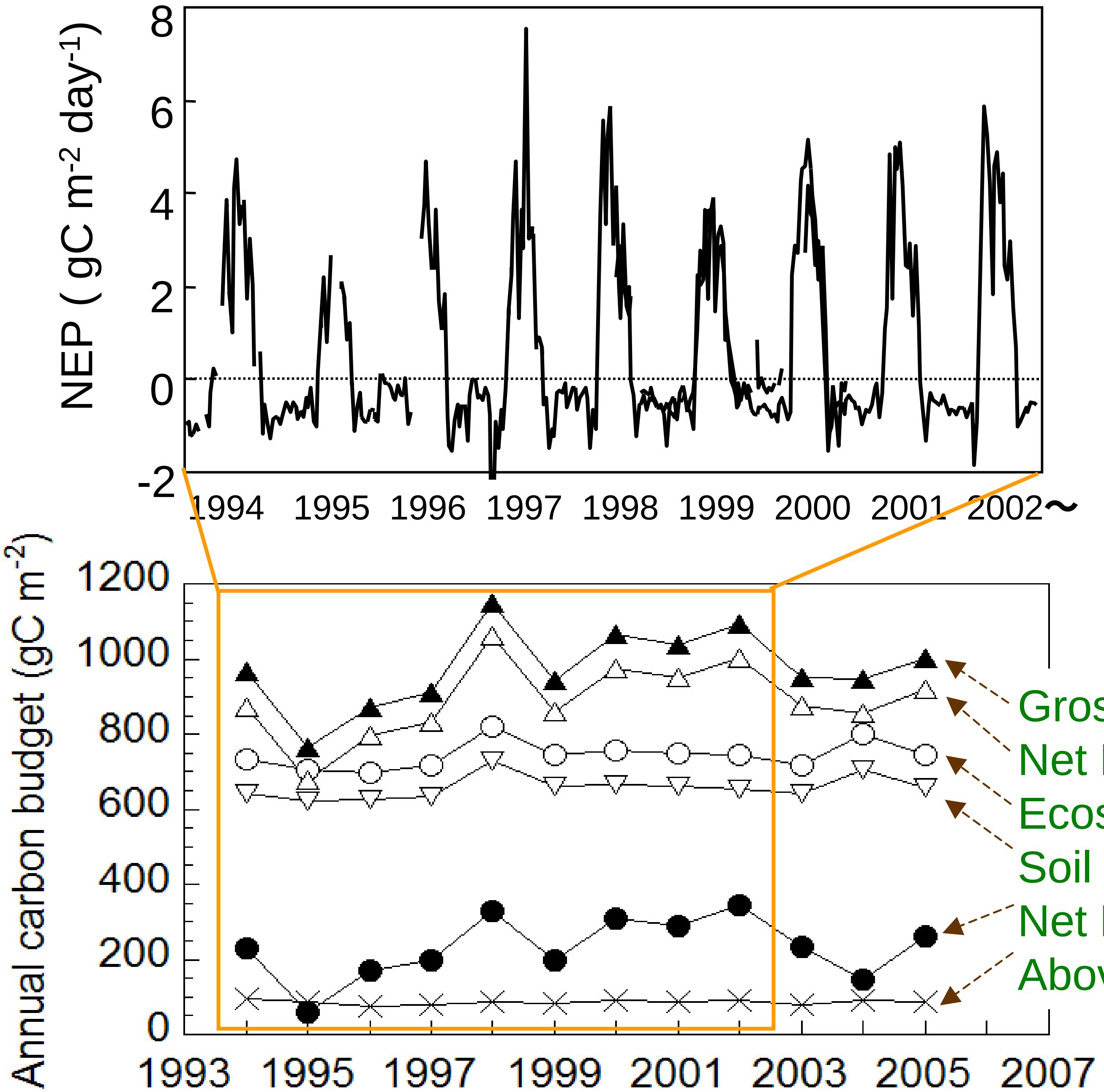
IGBP/MEXT・GCTE project (JaLTER core-site; Tomakomai)



(Shibata et al. 2005)

Carbon cycling and budget in forest ecosystem (gC m^{-2} y^{-1})

Challenge of JaLTER: Long-term study of ecosystem processes



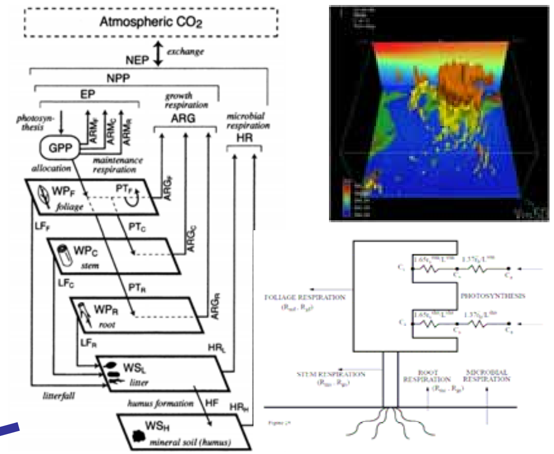
JaLTER core-site; Takayama (provided by Dr. Muraoka (Gifu Univ.))

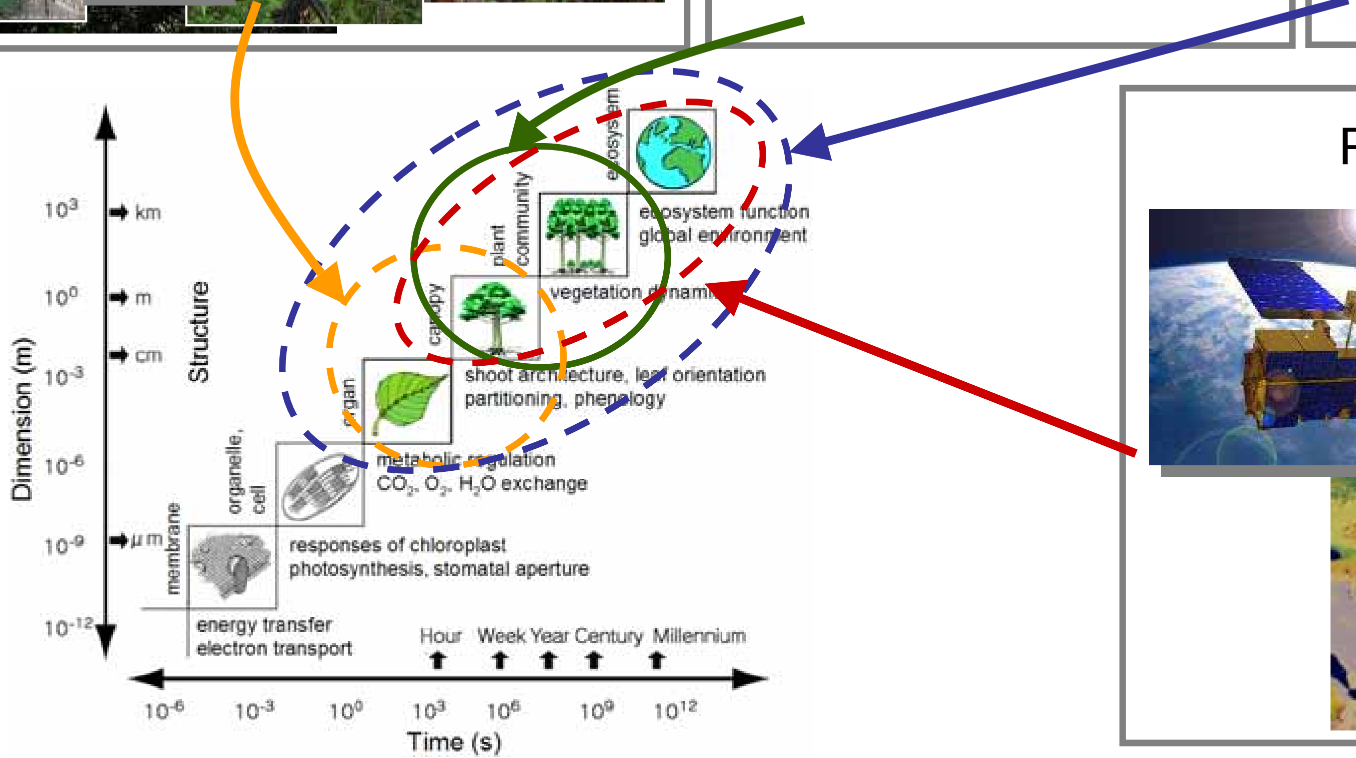
Challenge of JaLTER: Interdisciplinary approach

Ecosystem process

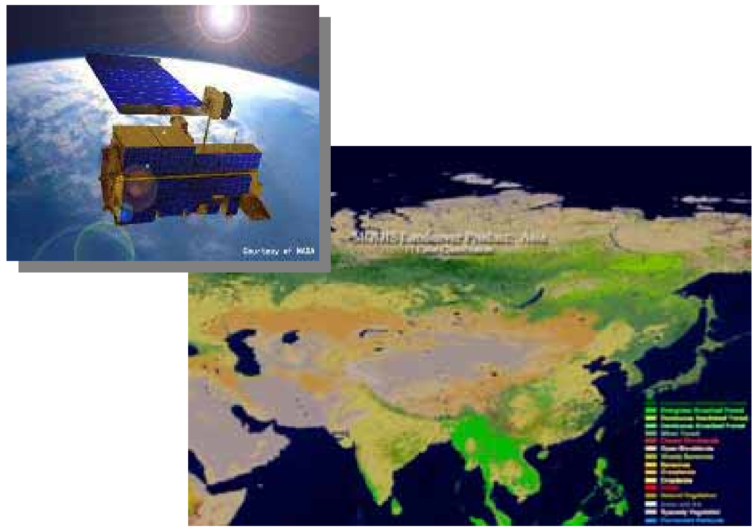
Flux measurement

Process model





Remote sensing



JaLTER core-site; Takayama (provided by Dr. Muraoka (Gifu Univ.))

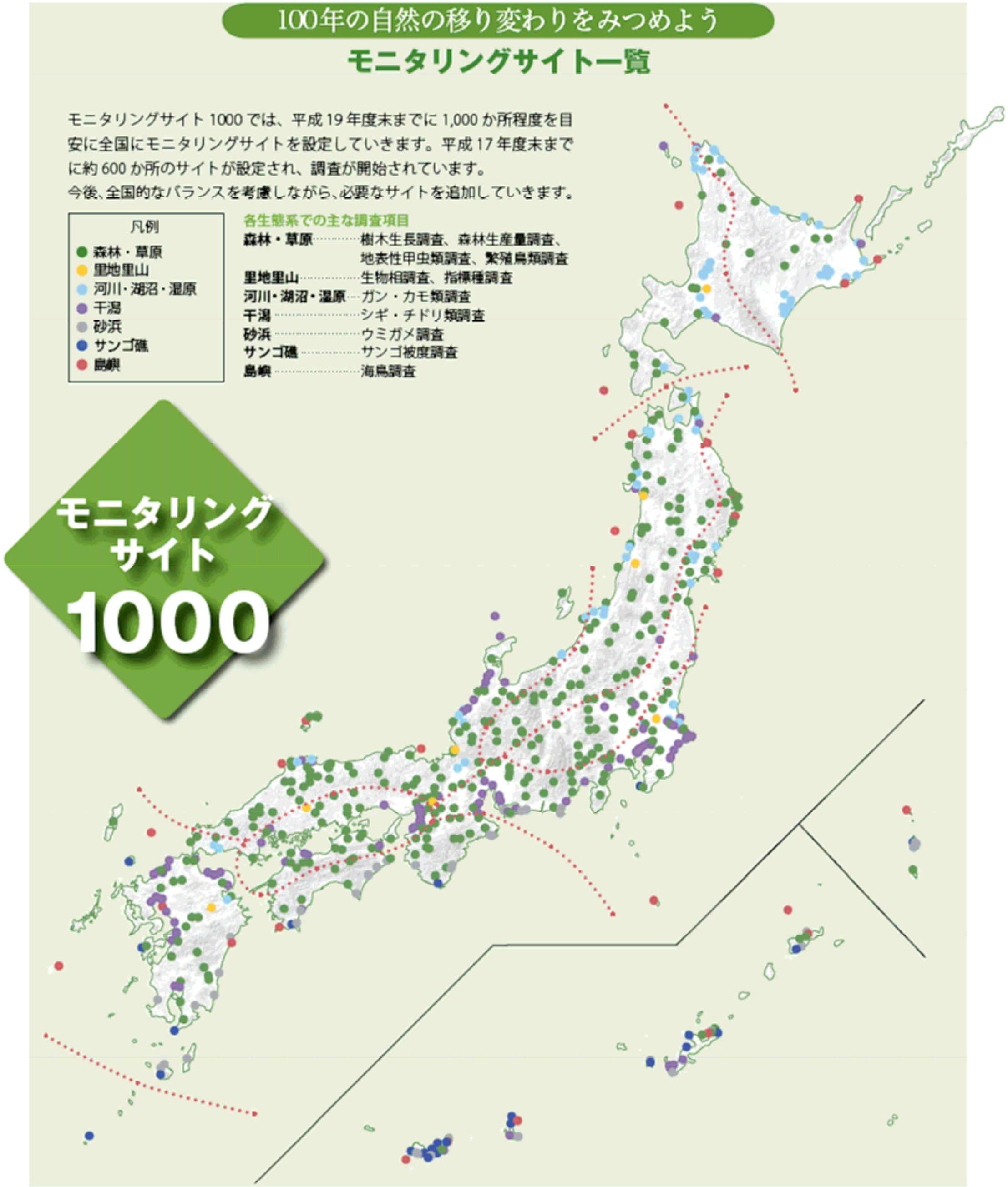
Challenge of JaLTER: Application of experimental manipulation

Soil warming experiment

Nitrogen addition

Clear-cut experiment

Challenge of JaLTER: Interdisciplinary cross-site study



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TEL 0555-72-6033 FAX 0555-72-6035

--- Monitoring sites 1000 ---

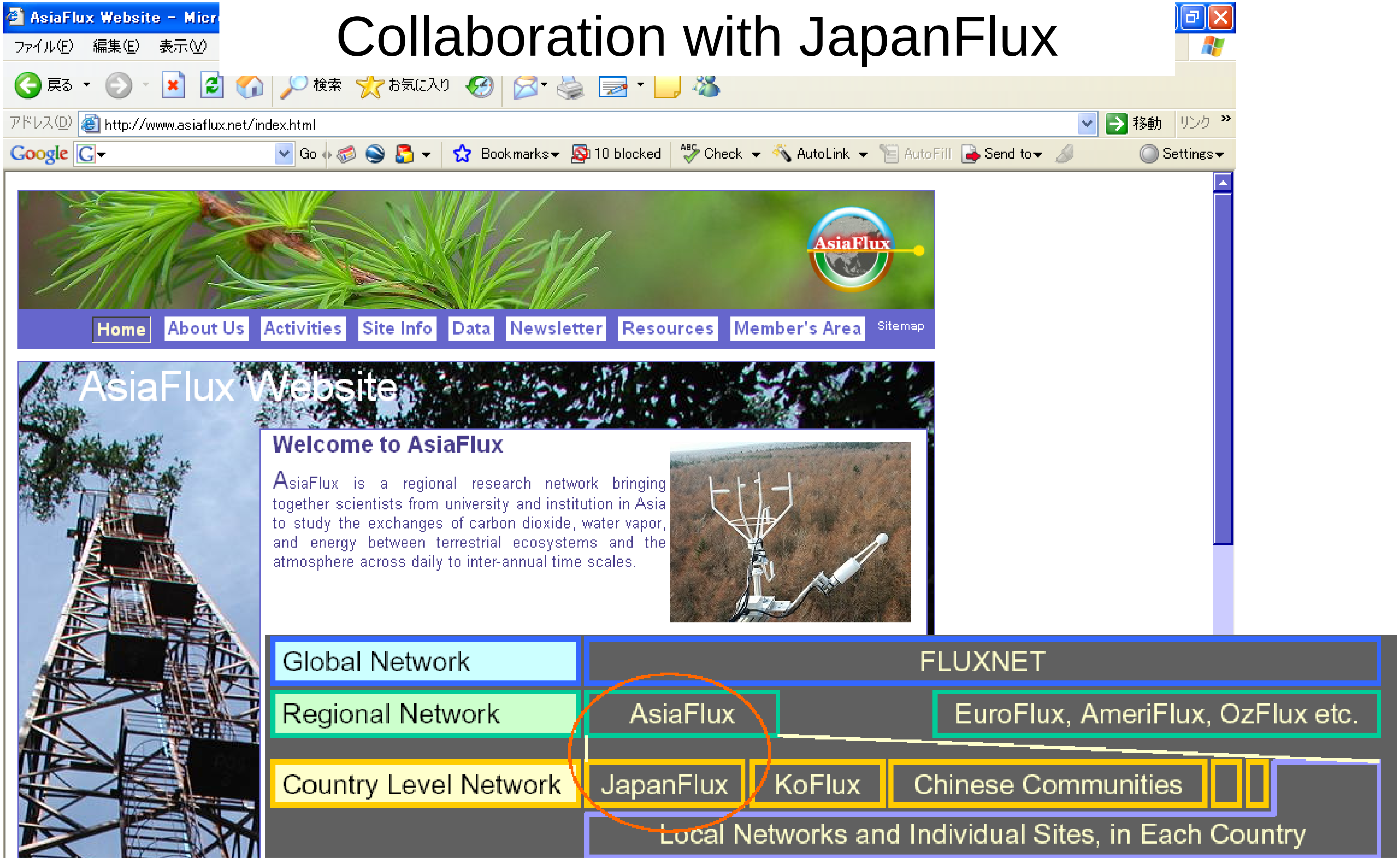
Ministry of Environment, Japan

- ✓Biodiversity & Ecosystem
- ✓Tree growth
- ✓Litter-fall
- ✓Seed production
- ✓Forest-floor insects
- ✓Bird community

Forest and estuary sites are strongly over-lapped by JaLTER-site.

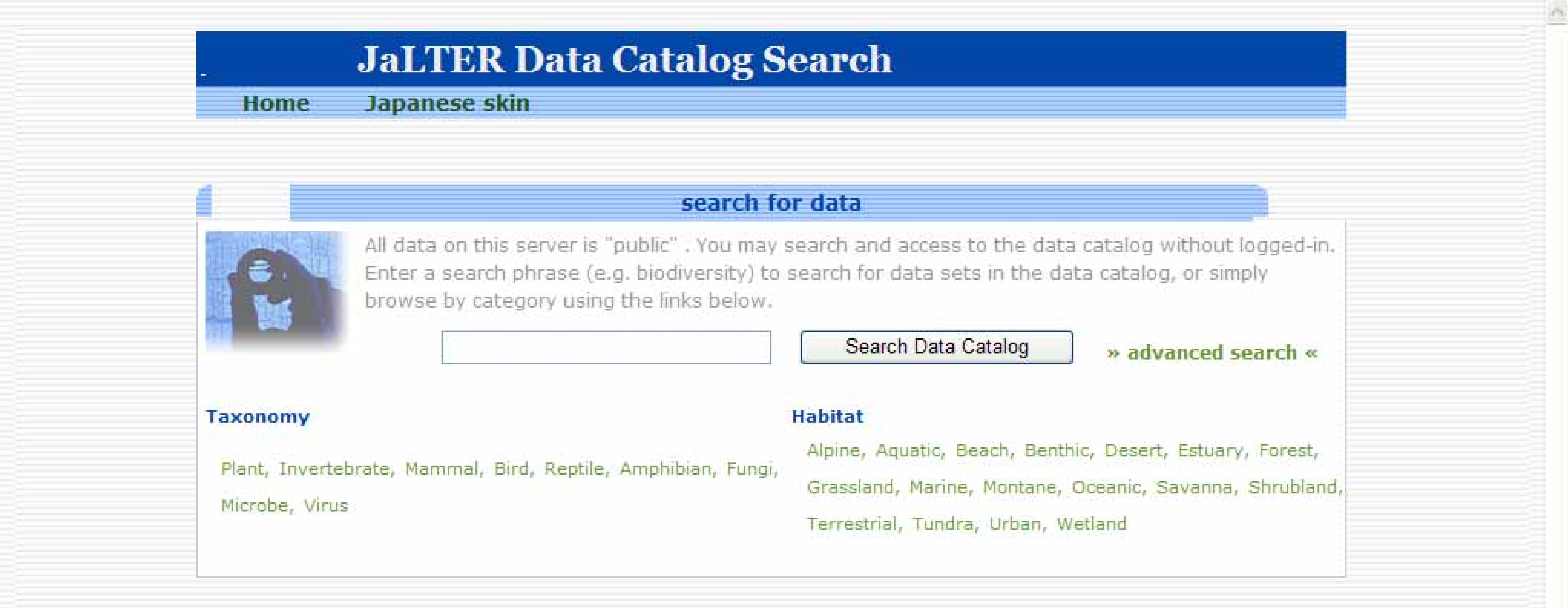
Mr. Sakamoto will explain details in the afternoon session.

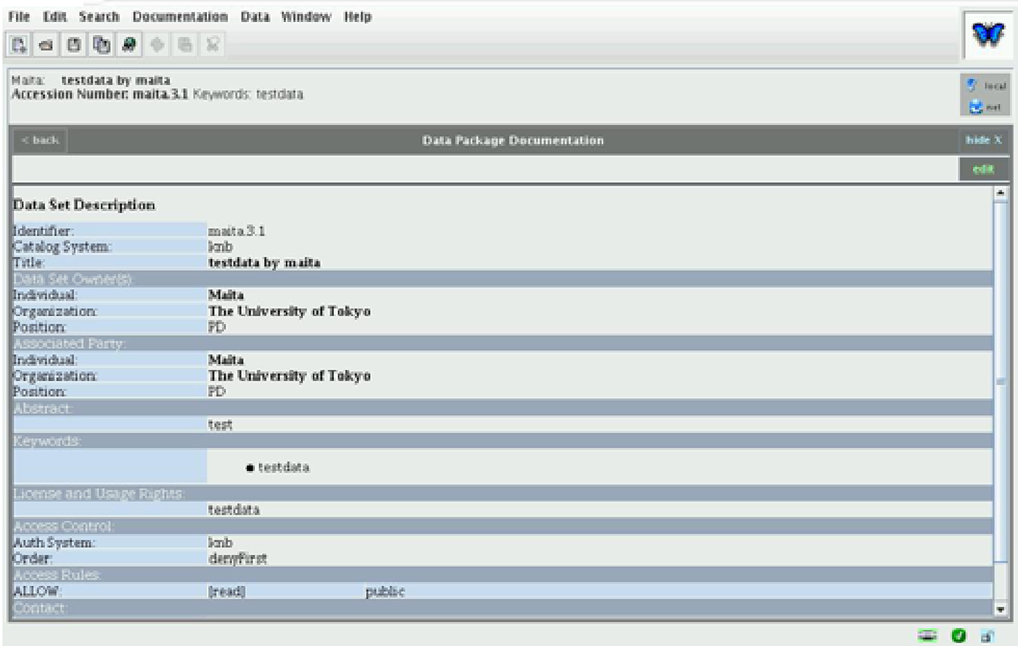
Challenge of JaLTER: Interdisciplinary cross-site study II

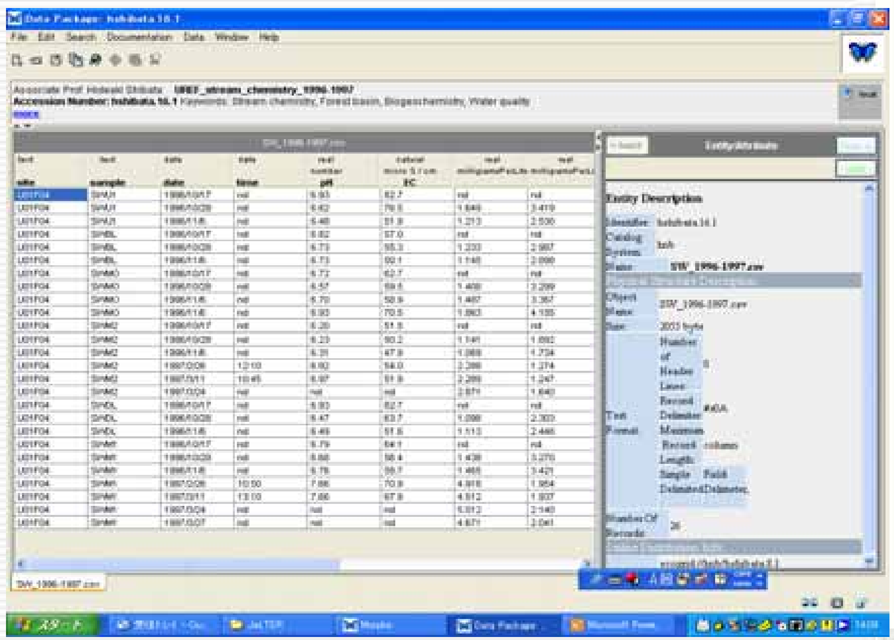


Some JapanFlux sites are registered as JaLTER site.

Challenge of JaLTER: Data archiving and sharing – EML database







Education program for next generation

Conclusive remark

- Linkage between GEOSS and on-site ecosystem research network with interdisciplinary approach would be quite important for ecosystem management toward the adaptation under global changes.
- Understandings of the interrelationship between carbon, water, nutrition and biodiversity in ecosystem with different environmental conditions and different spatial and temporal scale would be one of the key research themes for GEOSS-Ecosystem and Biodiversity.

We thank JaLTER and ILTER colleagues.

Kick-off meeting of JaLTER in Tomakomai Experimental Forest (November 2006)