April 15, 2008
The 2nd GEOSS-Asia Pacific Symposium

Parallel session: Monitoring and Predicting Climate Change
“Needs from Carbon Cycle Modeling”

Data Utilization by Terrestrial Carbon Cycle Modeling

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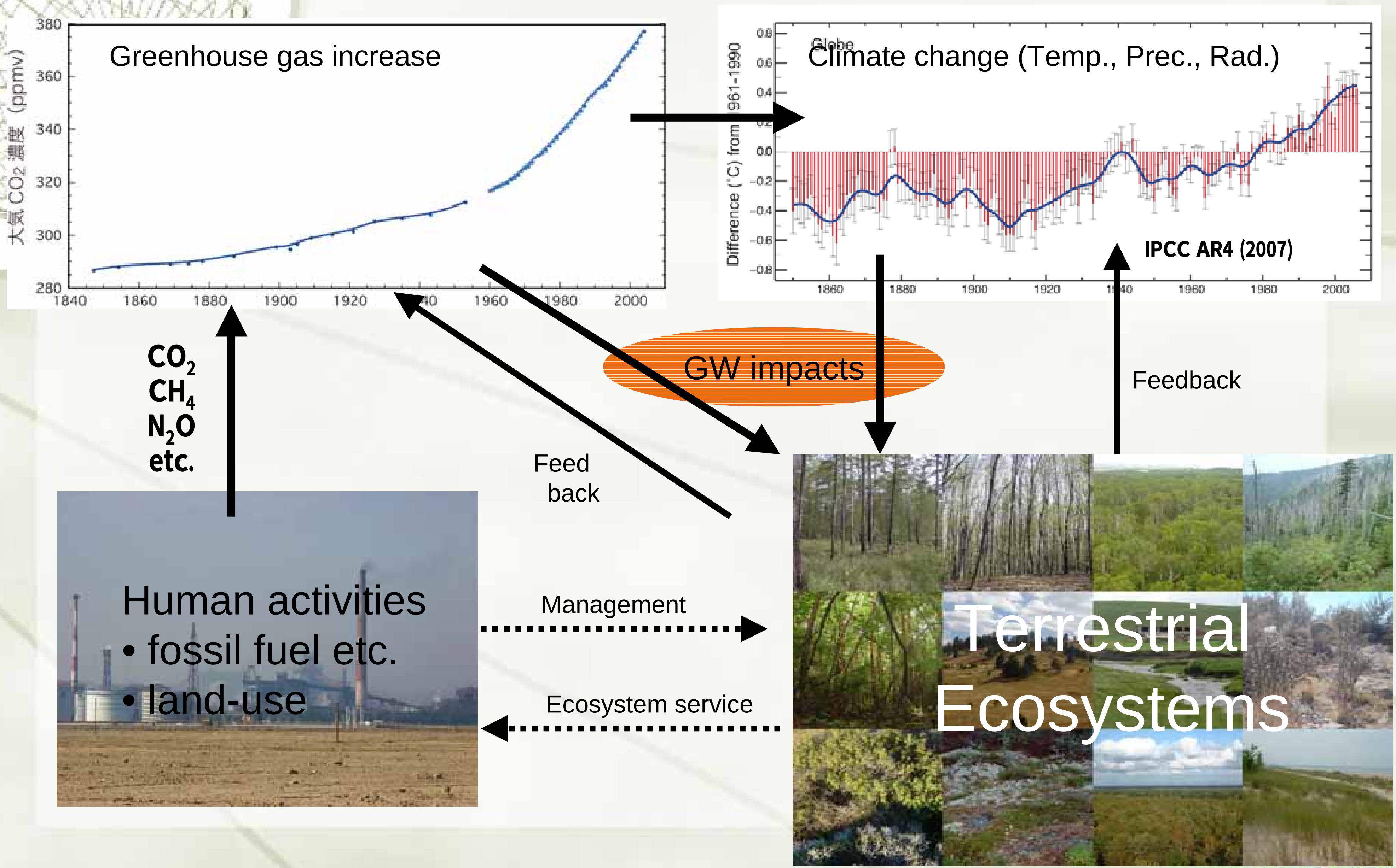
Global Change and Carbon Cycle Modeling



Carbon Cycle Feedback

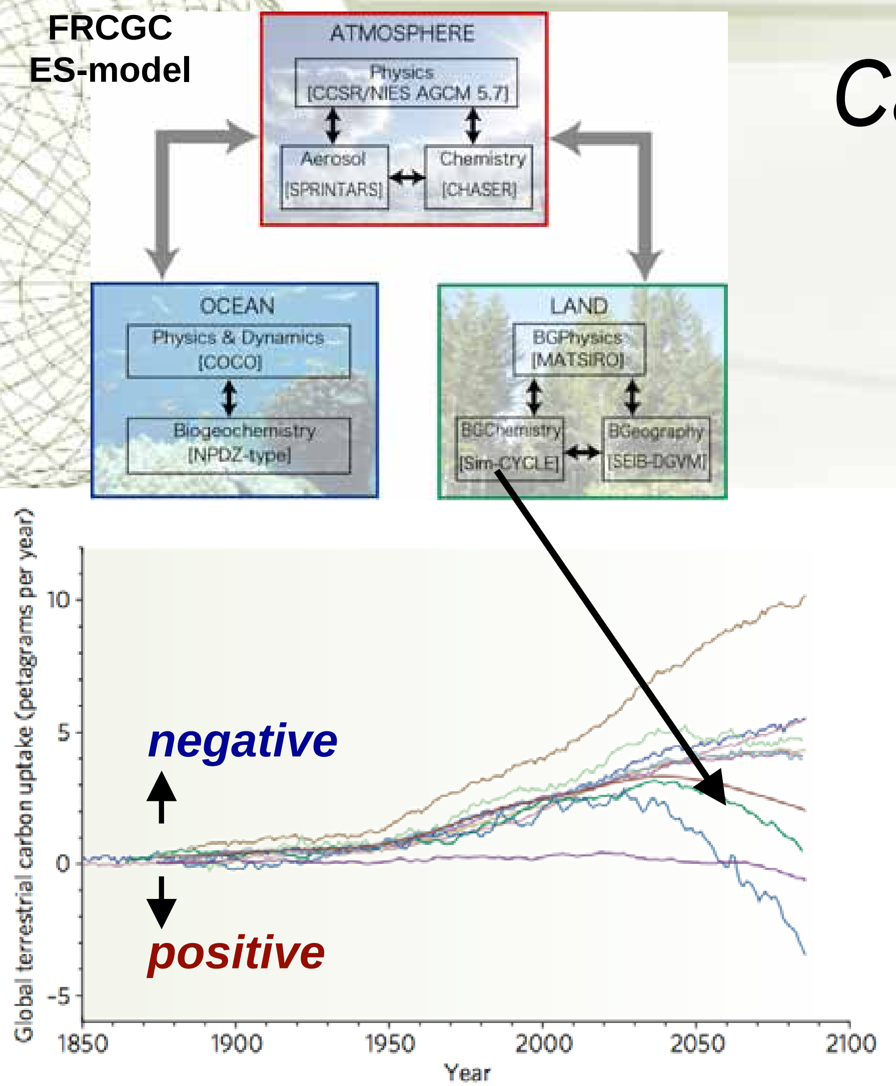


Figure 2 | Comparison of estimated global terrestrial carbon uptake in different models of the carbon-cycle–climate system. Global terrestrial carbon uptake was simulated by 11 coupled carbon-cycle–climate models driven with carbon emissions from the SRES-A2 emissions profile. Data are taken from the Coupled Carbon Cycle Climate Model Intercomparison Project[2], with uptake rates smoothed with a 30-year moving average.

(Friedlingstein et al. 2006; Heimann & Reichstein 2008)

Large uncertainty in the terrestrial 'carbon-cycle' feedback (e.g., C4MIP)

TCCFB = GPP – AR – HR – LUC

GPP: photosynthetic uptake
AR: plant respiration
HR: microbial respiration
LUC: land-use change emission

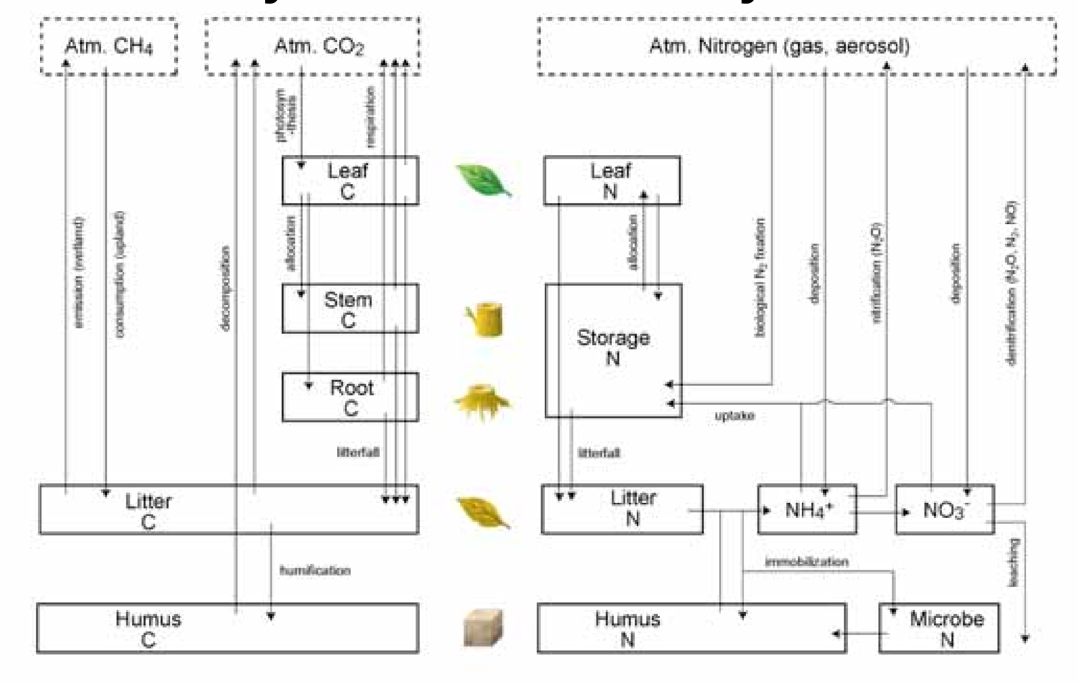
If TCCFB > 0, negative FB
If TCCFB < 0, positive FB
i.e., warming feeds warming
=> climate risk

Model Development

Vegetation Integrative SImulator for Trace gases

Terrestrial carbon cycle model (Sim-CYCLE) coupled with nitrogen cycle and gas schemes

C cycle **N cycle**



<u>Greenhouse gases</u>

- CO_2 (GPP, AR, HR)
- CH_4(Produc., Oxid.)
- N_2O (Nitrif., Denitrif.)

<u>Land use change</u>

<u>N gases</u>

- N_2 (Biol. Fix., Denitif.)
- NO (Denitif.) 、NH_3volat.

<u>Biomass burning</u>

- CO_2, CO, CH_4, NMHC, NO_x , SO_2, OC, BC, PM2.5, TPM, TEC

<u>BVOC</u>

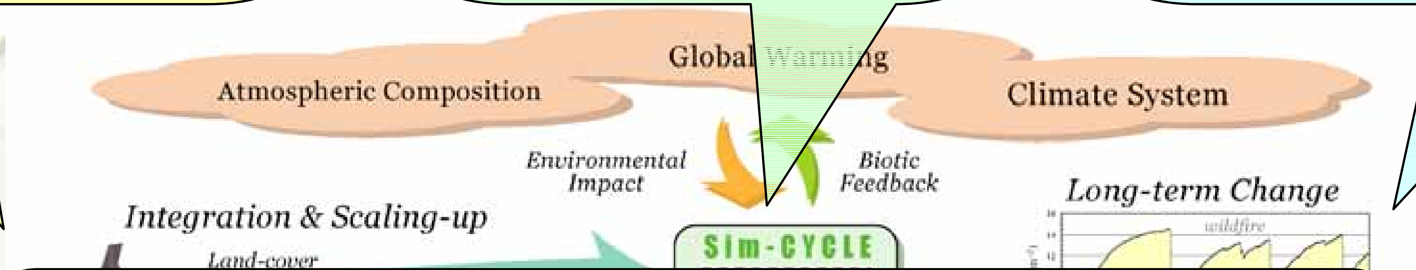
- Isoprene, monoterpene, Methanole, acetone, Formardehyde, acetoardehyde, acetic acid, formic acid、CO

How do models use data?

Input
- Boundary condition
- Driving force

Development
- parameter values
- parameterization

Validation
- observation
- literature

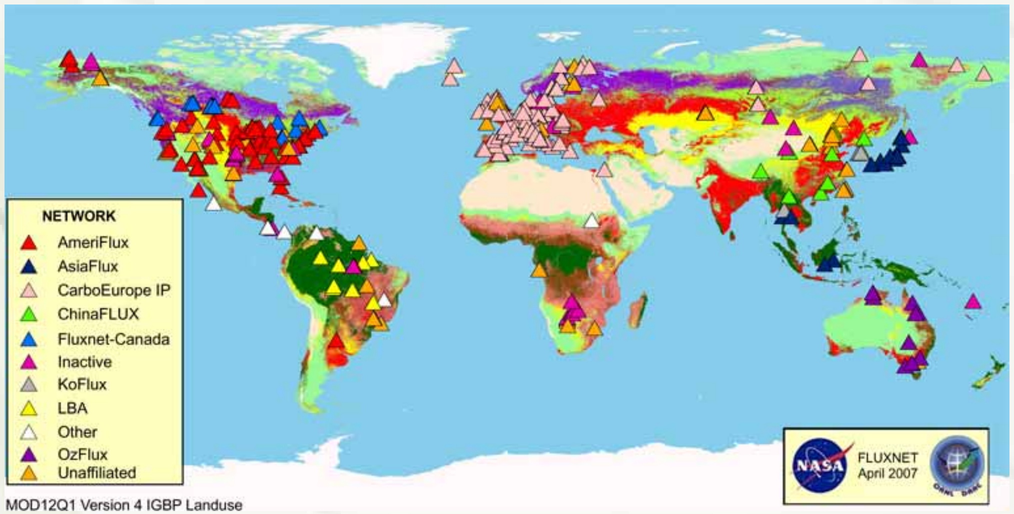


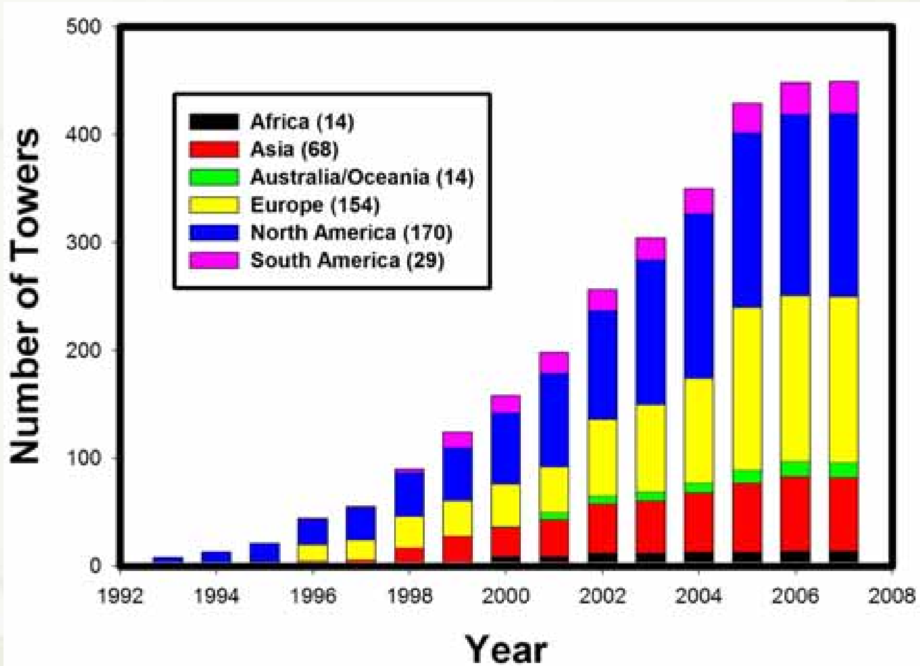
Related international activities
- GEOSS
- ESSP - Global Carbon Project (GCP)
- IGBP - iLEAPS, GLP, AIMES
- FLUXNET (CarboEurope, AmeriFlxu, AsiaFlux, etc.)
- Long-Term Ecological Research (LTER)

In situ Measurements

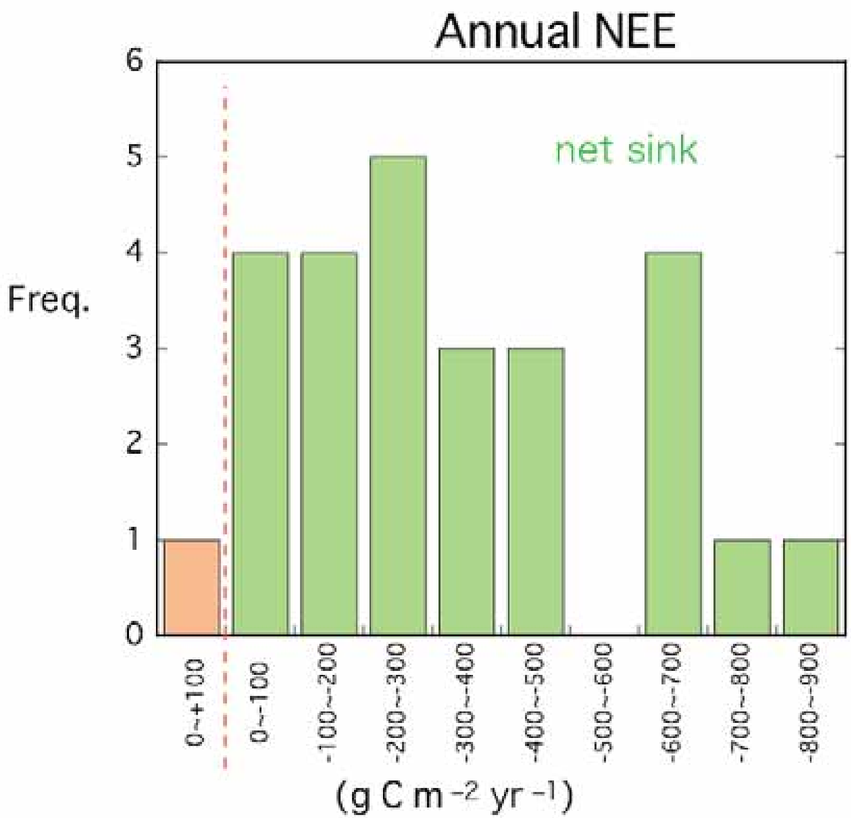
- FLUXNET - AsiaFlux - JapanFlux

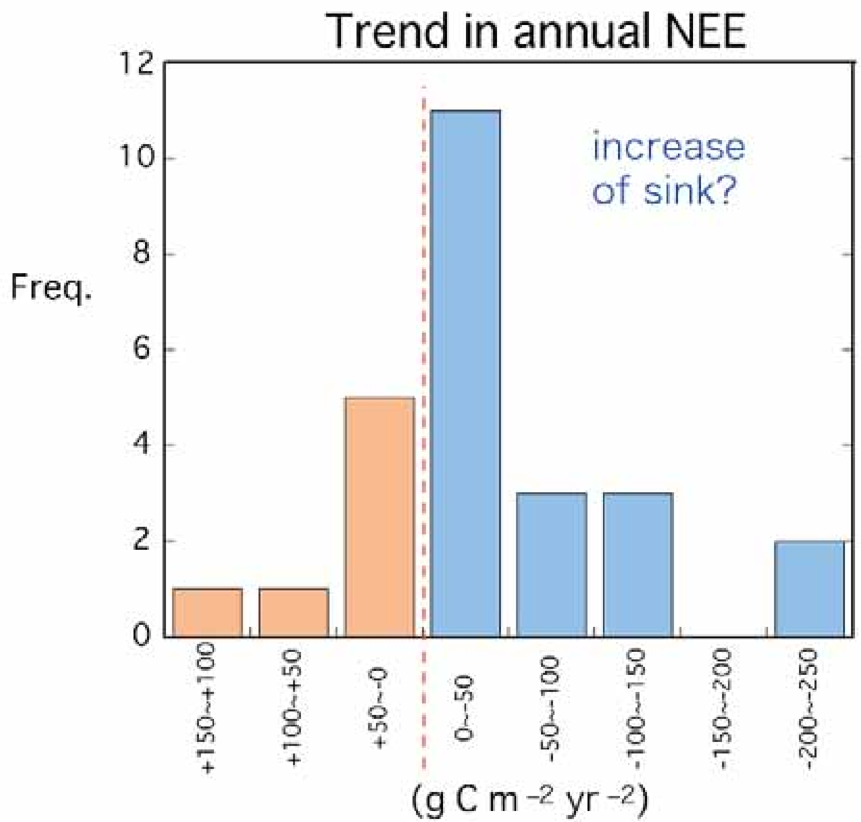
  => database development
- Global coverage (ca. 500 sites)
- Long-term continuous
- Net CO_2 budget, NEE (+ other gases)

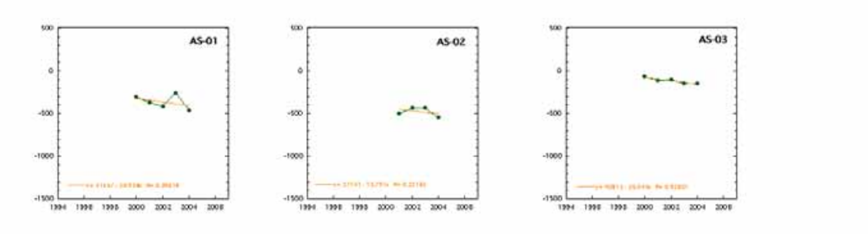


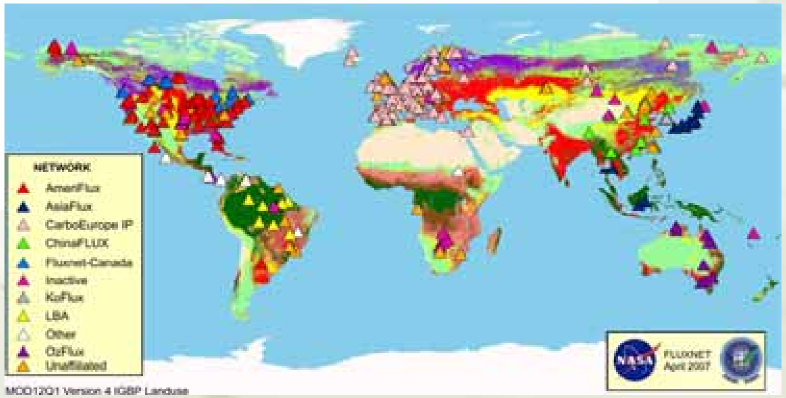


Detection of Global Warming Impacts



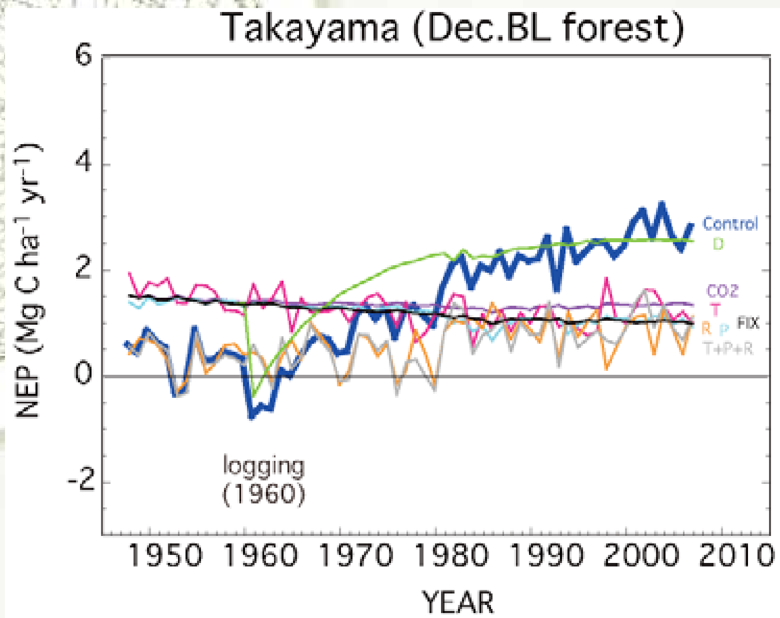






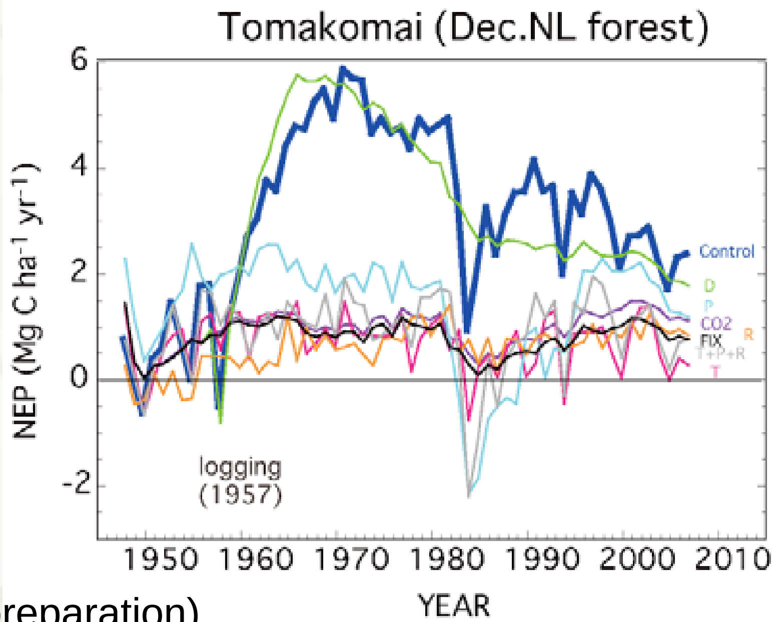
Ito (in preparation)

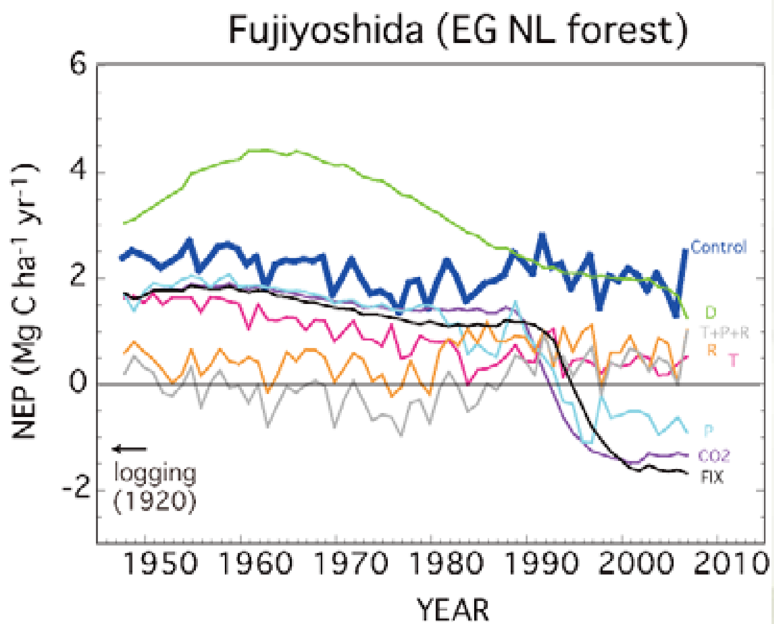
Factoring with Model



What mechanism is causing net CO_2 sink?

- Elevated CO_2 level ?
- Temperature ?
- Precipitation ?
- Radiation ?
- Disturbance ?





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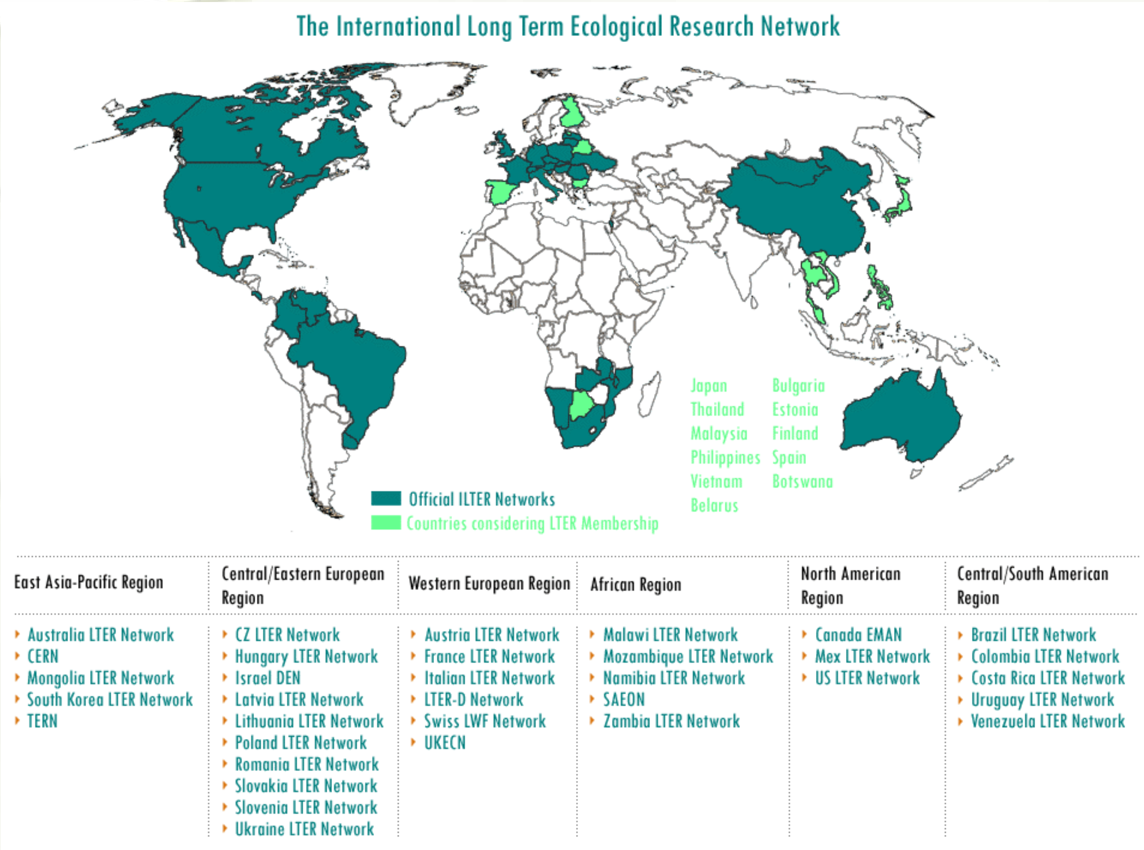
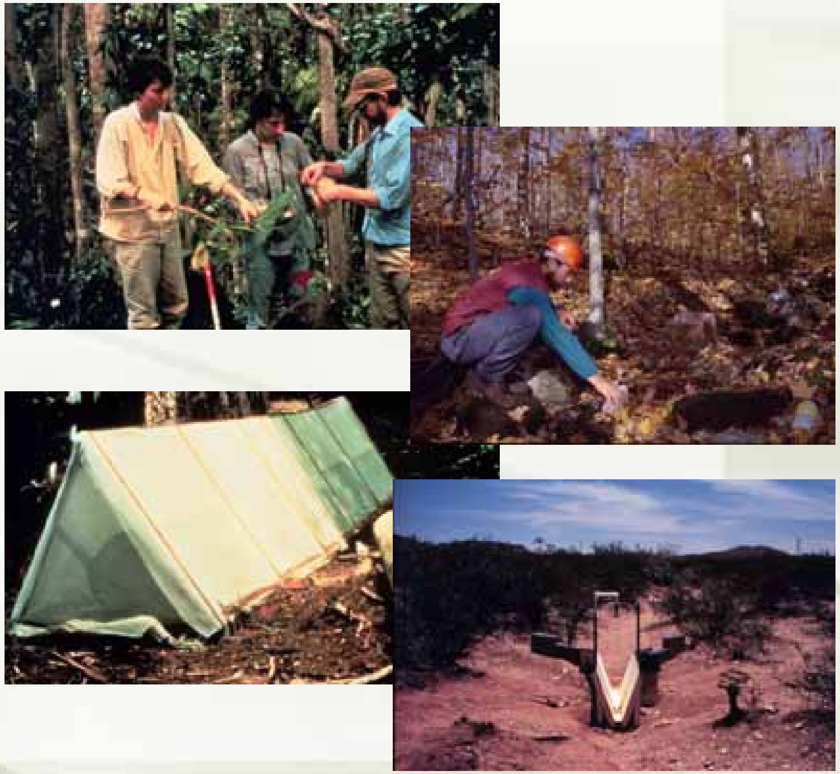
Long-Term Monitoring

Long-term observation is essential for understanding dynamics of terrestrial ecosystems, including carbon budget.

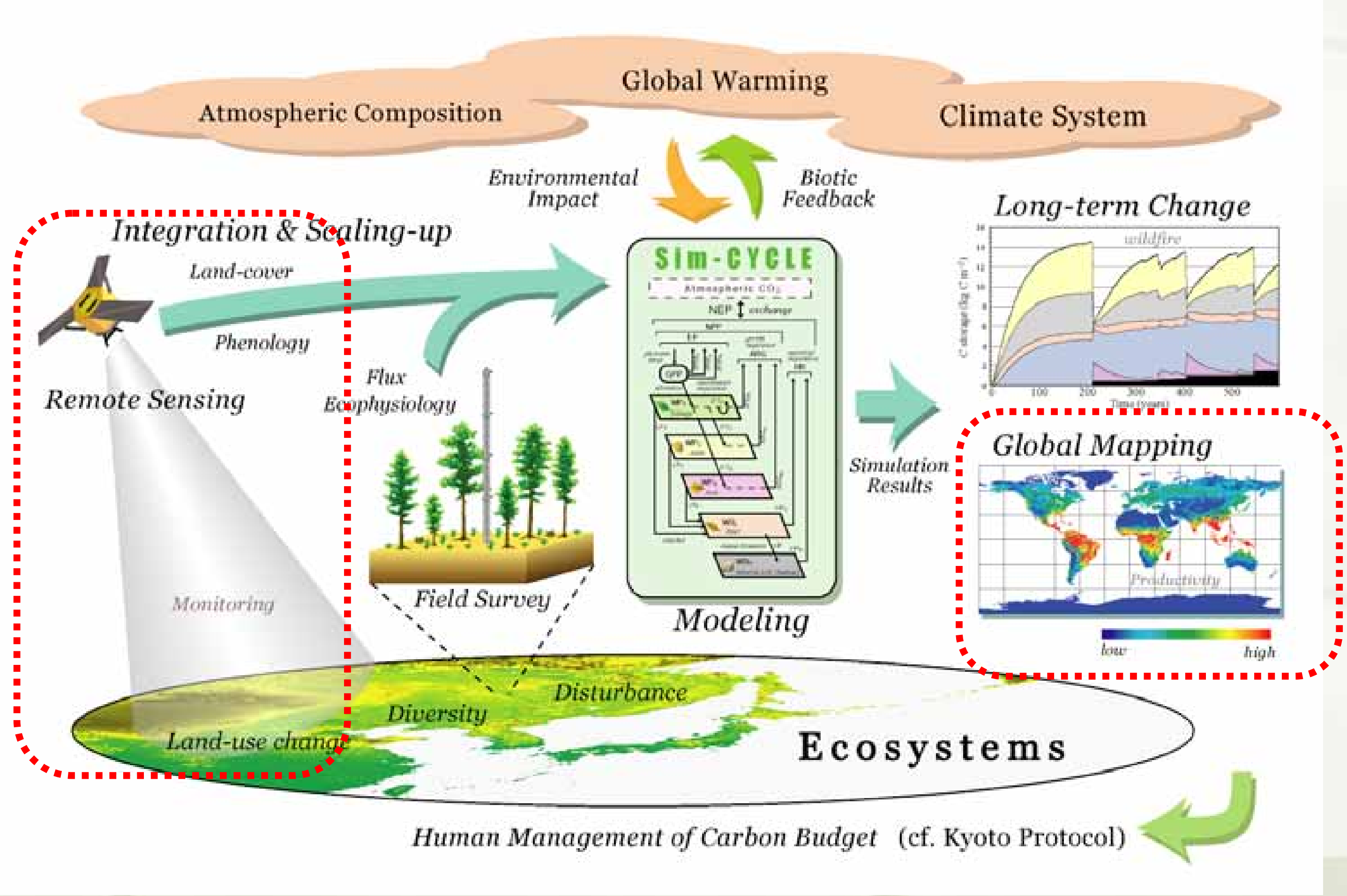
=> LTER, Long-Term Ecological Research





Remote Sensing will Play the Key Role

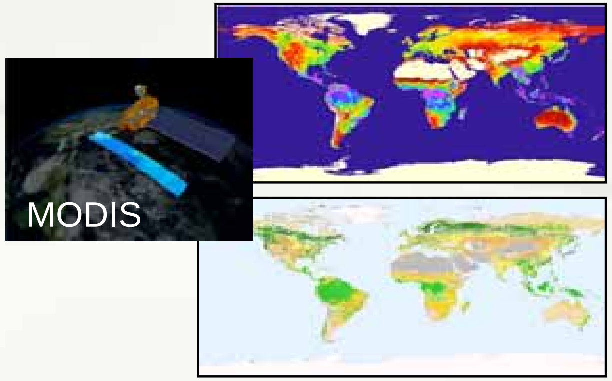
Satellite remote sensing provides invaluable data for model development, simulation, and validation.



Remote Sensing and Modeling

Legacy satellites
- NOAA/AVHRR
- Landsat, SPOT
- TRMM etc.

Vegetation Information



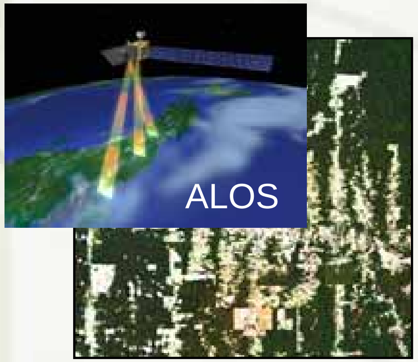
LAI, fire, etc.

Topography

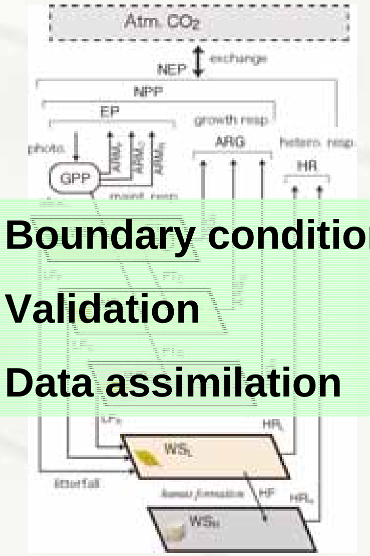
cf. ASTER

topography

Deforestation

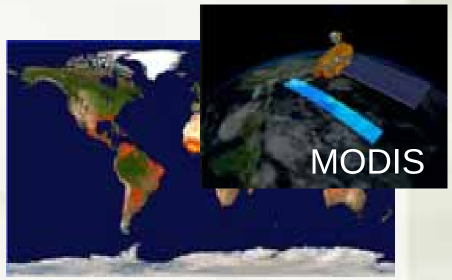


Deforestation



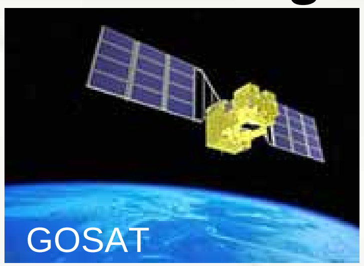
- **Boundary condition**
- **Validation**
- **Data assimilation**

Disaster



Fire

GHG Budget

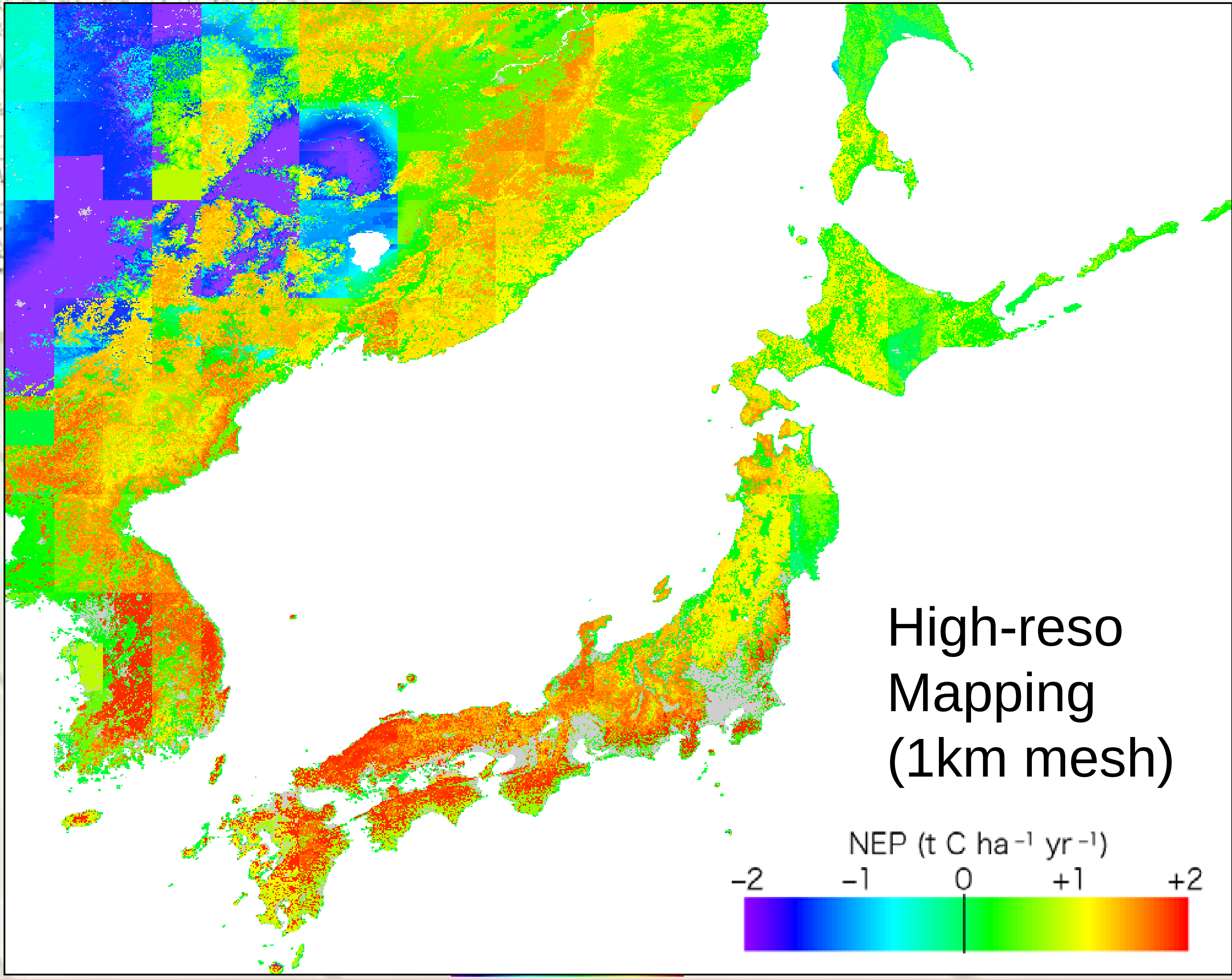


cf. SCIAMACHY, OCO

CO_2 exchange
CH_4 exchange

Future satellites
- GCOM etc.

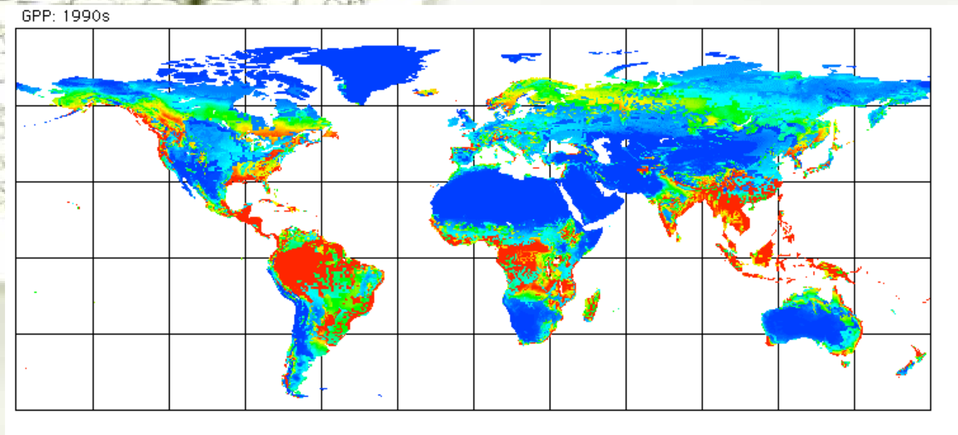
Global Modeling of Carbon Budget

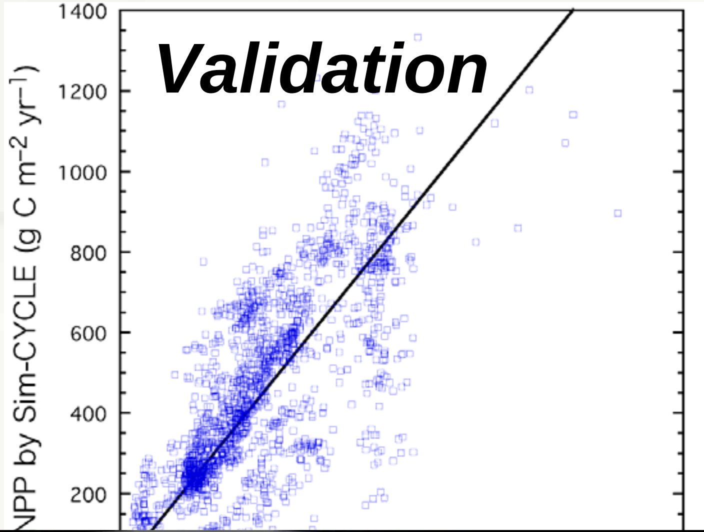


esses
P)
)
T, NPP
HR)
/

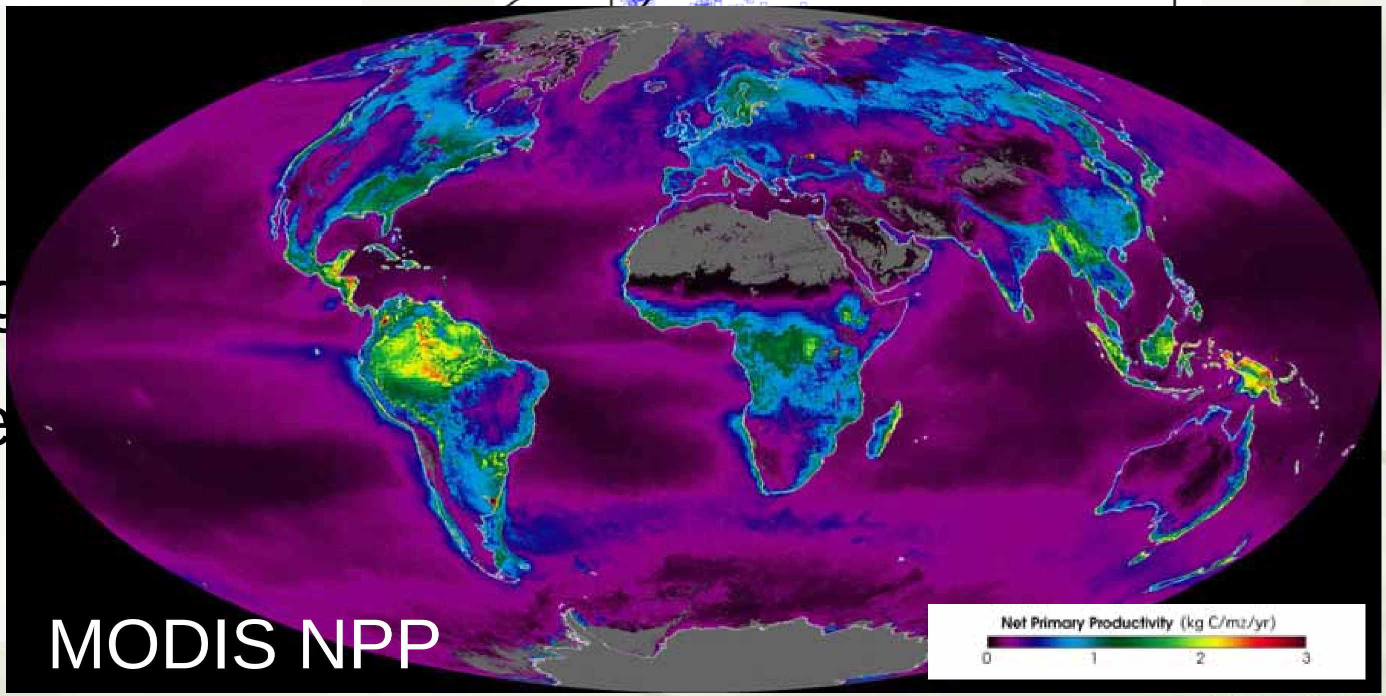
Validation Data are Insufficient

Model simulation



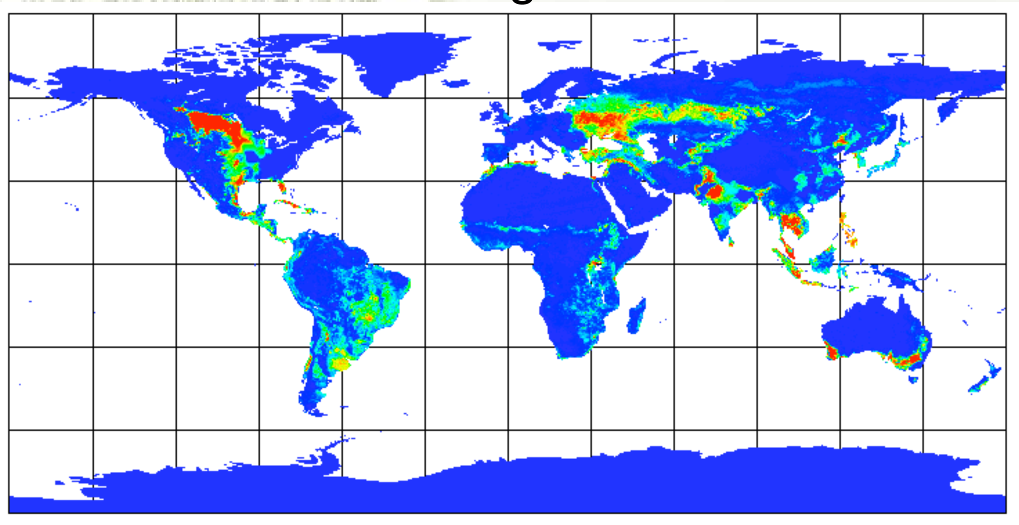


- Spatial coverag
- Spatial represe
- Technical prob

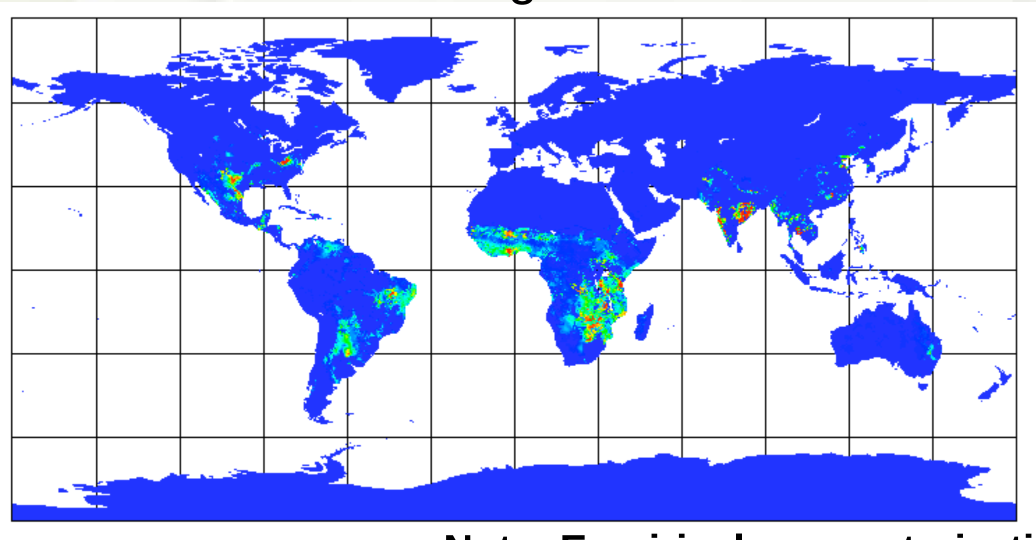


Land-use Change (deforestation)

Land use change: 1901-1990



Land use change: 1991-2100



Historical cropland

- **Ramankutty & Foley (1999)**

Future projection

- **IMAGE2 (Wang et al. 2006)**

=> Post-Kyoto Carbon Accounting

cf. REDD session

Note: Empirical parameterization

Global Forest Carbon Monitoring System (GERF B-81)

Subtopic 1

Developing Carbon Accounting Methods

- International research regarding the Forest Carbon Monitoring System
- Develop carbon accounting methods
  - IPCC compliant approach
  - Ecosystem modeling approach
  - Evaluation of environmental benefits

Expected Outcomes

- Contributing to international debate on climate change mitigation through prevention of deforestation
- Contributing to scientific knowledge towards building an international forest monitoring system

Deforestation mapping using PALSAR

Data from Asian sites
Collaboration with international research organizations

Carbon balance mapping with ecosystem models

Subtopic 3

Analysis of Forest Inventories

- Collecting ground-based measurement data
- Integrated analysis of governmental statistics, inventories, and remote sensing data

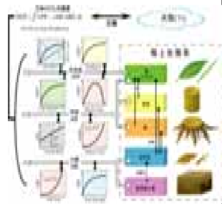
Local vegetation data

Deforestation /Degradation map

Subtopic 6

Evaluating Carbon Balance with Ecosystem Models

- Estimating temporal patterns of change in above- and below-ground carbon stocks
- Evaluating carbon emissions from Deforestation /Degradation



Field Verification Data

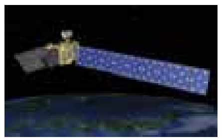
Deforestation area detection

Detailed Forest Structure data

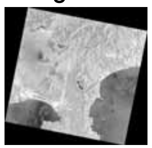
Land-cover change, Forest fire, Forest management mapping

Subtopic 2

Analysis of SAR Images



- Extracting forested and non-forested regions
- Extracting deforested regions
- Ortho-rectification of SAR images



Truth data
Results of modeling

SAR ortho-image
Forest map

Subtopic 4

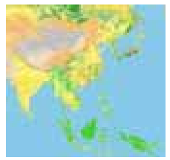
Estimating Forest Structure Parameters using Microwave

- Collecting truth data
- Backscatter modeling

Subtopic 5

Using Remote Sensing to Understand Vegetation Disturbance

- Land-cover classification
- Managed forest areas
- Forest fire areas



Terrestrial Trace-gas Exchanges

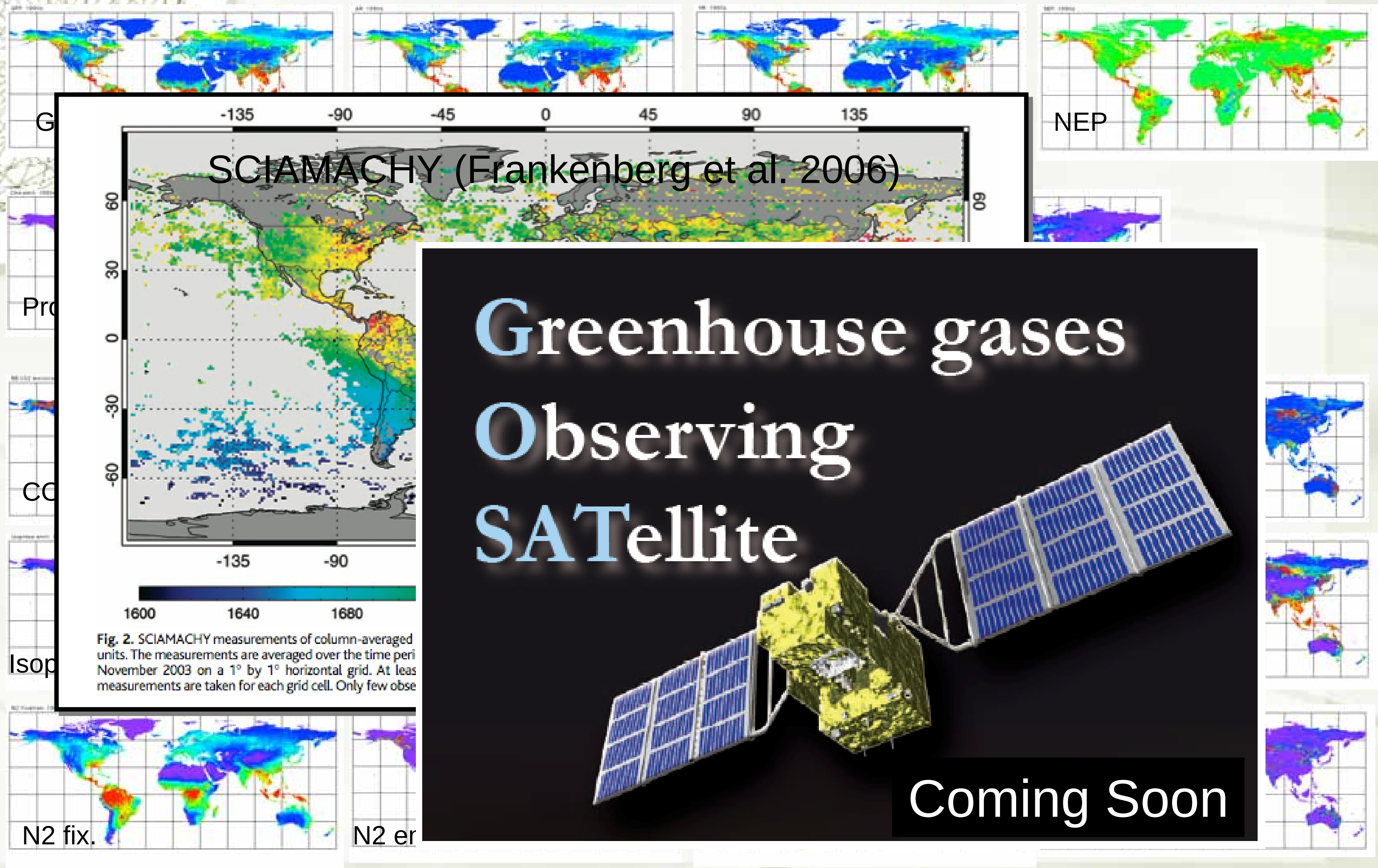
CO_2

CH_4

BB

BVOC

Others



Conclusion

- Terrestrial carbon cycle models require both plot-scale and global-scale observational data.
- Flux network and remote sensing provide increasing amount of data useful for model studies.
- Long-term monitoring is important for detection of global warming and land-use change impacts.
- GEOSS: international coordination