Modeling Terrestrial Ecosystems at Different Spatial-Temporal Scales

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Topics Outline

I. Overview of TRIPLEX Model Development

II. Three Case Studies:

- Modelling forest growth and carbon budgets at local scale (TRIPLEX)

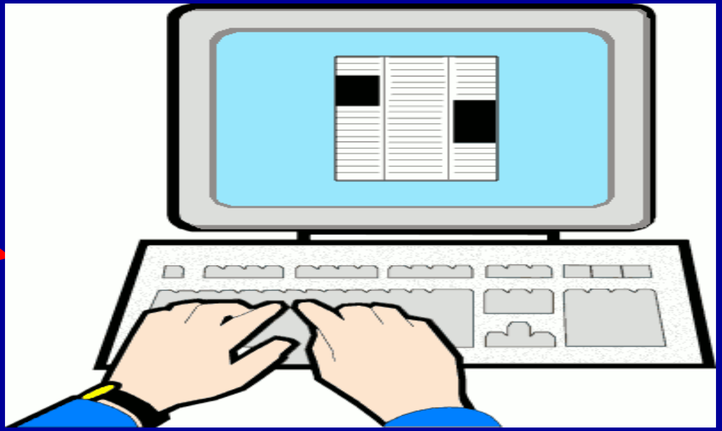
- Simulating terrestrial ecosystems at regional and global scales (TRIPLEX-GHG)

III. Ongoing Challenges and Directions

Three Main Approaches to Investigating Effect of Climate Change on Ecosystems

- **Long-term observation**

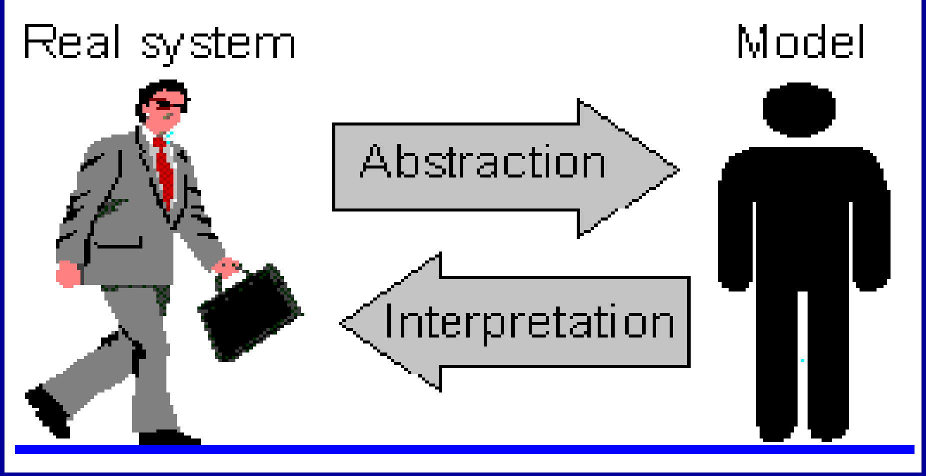
- **Experimental manipulation**
- **Model simulation**



(J.M. Melillo, 1999, Science, 283: 183)

What is a Model ?

Real system



Model

- A model is an abstraction of a real system
- We use models in two ways:
  - conceptual model
  - formal model

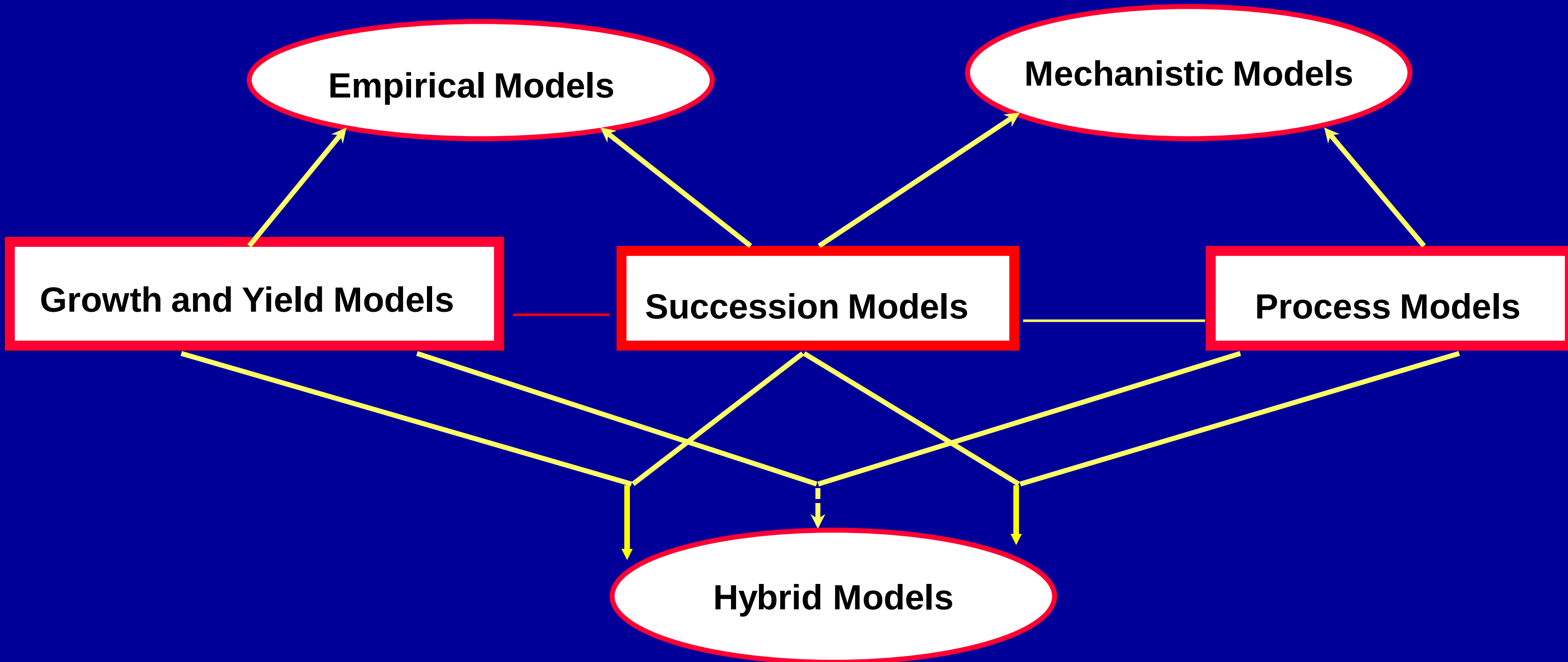
Model Catalog

- Conceptual (Word or Flowcharts) Models: used to represent our concepts or knowledge and describe the interactions between the components of a system

- Mathematical (Statistical) Models: used to present the a conceptual Model or other types by using mathematical notation.

- Computer Simulation Models: Mathematical models cab be translated Into computer languages and implemented on a computer

Forest Simulation Models



Increasing ability to predict growth under changed future conditions

Increasing model simulation options and flexibilities

Description moving towards Explanation

(Peng, 2000, FEM)

Why Do We Need Models?

- Three methods to assess the effects of a changing environment on ecosystems (Botkin 1993):

  (a) our knowledge of the past

  (b) present measurements

  (c) our ability to project into the future

- Our knowledge of the past and present measurements have been of limited use

- Long-term monitoring of the forest has proven difficult due to cost and long-term commitment

- Current experimental techniques are not directly applicable to complicated environmental change

The Roles of Models

- Models as *research tools*
  to increase our knowledge

- Models as *management tool*
  to help to make decisions

- Models as *education tools*
  to help to understand the Earth system

Current Process-Based Models

Spatial Scales

A. Organ (Leaf or Canopy) models

e.g. FOEST-BGC (Running and Coughlan, 1988); MAESTRO (Wang and Jarvis, 1990); BIOMASS (McMurtrie et al. 1990);

B. Individual tree ecophysiological models

e.g. ECOPHYS (Rauscher et al. 1990); TREGRO (Winstein and Yanai, 1994);
TREE-BGC (Korol et al., 1994)

C. Community models (gap or succession models)

e.g. JABOWA (Botkin et al. 1972); FORET (Shugart and West, 1977);
ZELIG (Smith and Urban, 1988); LINKAGE (Pastor and Post, 1985)

D. Stand or Ecosystem models

e.g. PnET (Aber and Federer, 1992); CENTURY (Parton et al. (1987), NDNC (Li, 1992), TRIPLEX (Peng et al, 2002)

E. Landscape models

e.g. FIRE-BGC (Keane et al., 1996); LANDIS (He et al. 1996) etc…

F. Global models

e.g. BIOME3 (Haxeltine and Prentice, 1996); IBIS (Foley et al., 1996); LPJ-DGVM (Sitch et al., 2003) etc

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ECO-MCS

Eco-MCS Lab. Objective

Develop state-of-the-art computer simulation models across different scales and use them to assess the impacts of past and future climate change and associated ecosystem disturbances on terrestrial and aquatic ecosystems across Canada, China and Globe

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

UQÀM
Université du Québec à Montréal

Canada Research Chairs

Chaires de recherche du Canada

TRIPLEX Model Development History (10 years)

- 2000- 2002: TRIPLEX 1.0 (OFRI, Sault Ste Marie, ON, Canada)

- 2003-2005: TRIPLEX 1.0 Testing and application at stand and landscape Levels (SD, USA; UQAM, Montreal)

2004-2010: Application of TRIPLEX1.0 in China
(Beijing U, Zhejiang U and Central-South U of Forestry & Tech.)

- 2006-2008: TRIPLEX-Flux, TRIPLEX-Fire, TRIPLEX-DOC (UQAM)

- 2008-present: TRIPLEX-Management (UQAM); TRIPLEX-Aquatic (UQAM and China); TRIPLEX-DGVM (UQAM and China)

TRIPLEX Model Development Publications (2002-2012) (www.crc.uqam.ca)

• **TRIPLEX1.0 Model**

- Peng et al, (2002), Ecol. Model ; Liu et al. (2002), CEA

•**TRIPLEX Application in Canada:**

- Zhou et al (2004), EM&S; Zhou et al (2005), CJFR; Zhou et al. (2006), MASGC

TRIPLEX Application in China

- Zhang et al. (2008), EM; Peng et al. (2009), GPC; Zhao et al. EM (2012)

• **New TRIPLEX-Flux, TRIPLEX-Fire, TRIPLEX-DOC**

- Zhou et al (2008), EM; Sun et al. (2008), EM; Two MS (in preparation)

•**TRIPLEX-Management, TRIPLEX-Aquatic, TRIPLEX-GHG**

- Wang et al (2010, 2012); Wu et al.(submitted); Zhu et al. (in preparation)

TRIPLEX: A generic hybrid model for predicting forest growth and carbon and nitrogen dynamics

(Peng et al. 2002, Ecol. Model)

- Developed based on well-established models:

  3-PG (Landsberg and Waring, 1997)

  TREEDYN3.0 (Bossel, 1996)

  CENTURY4.0 (Parton et al., 1987, 1993)

- Bridges the gap between forest growth and yield and process-based C balance models
- Can be used for:

  1) Making forest management decisions (e.g., G&Y prediction)

  2) Quantifying forest carbon budgets

  3) Assessing the effects of climate change on forest ecosystems

Key Features of TRIPLEX1.0:

- **Driving variables (main inputs):**

  Monthly climate data; tree & stand variables, LAI, soil texture, geo-location

- **Mass balances:**

  C, N, and water pools and fluxes fully balanced

- **Time step:**

  Monthly C flux and allocation calculation; annual tree growth, C , N, and water budget

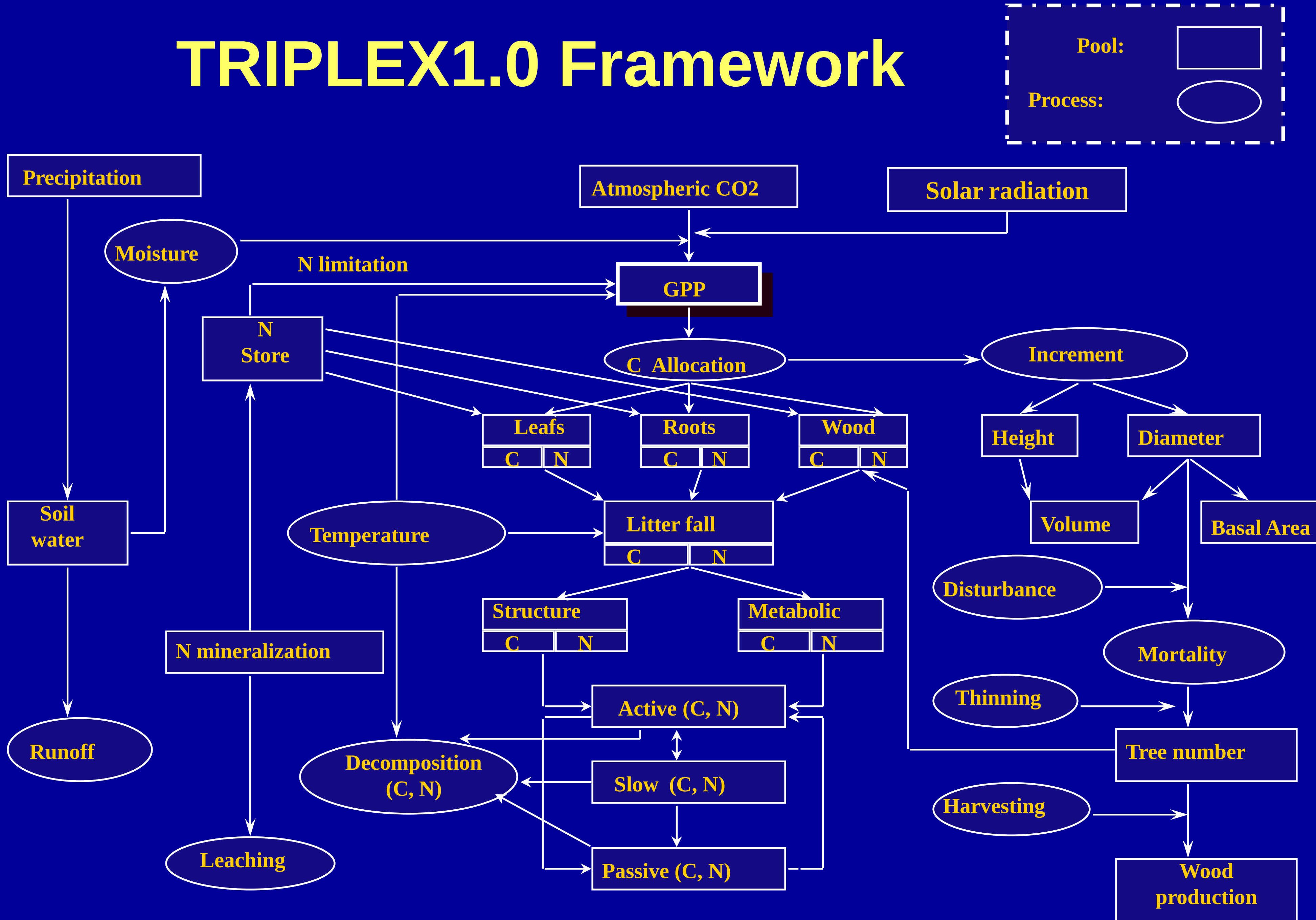
- **Outputs:**

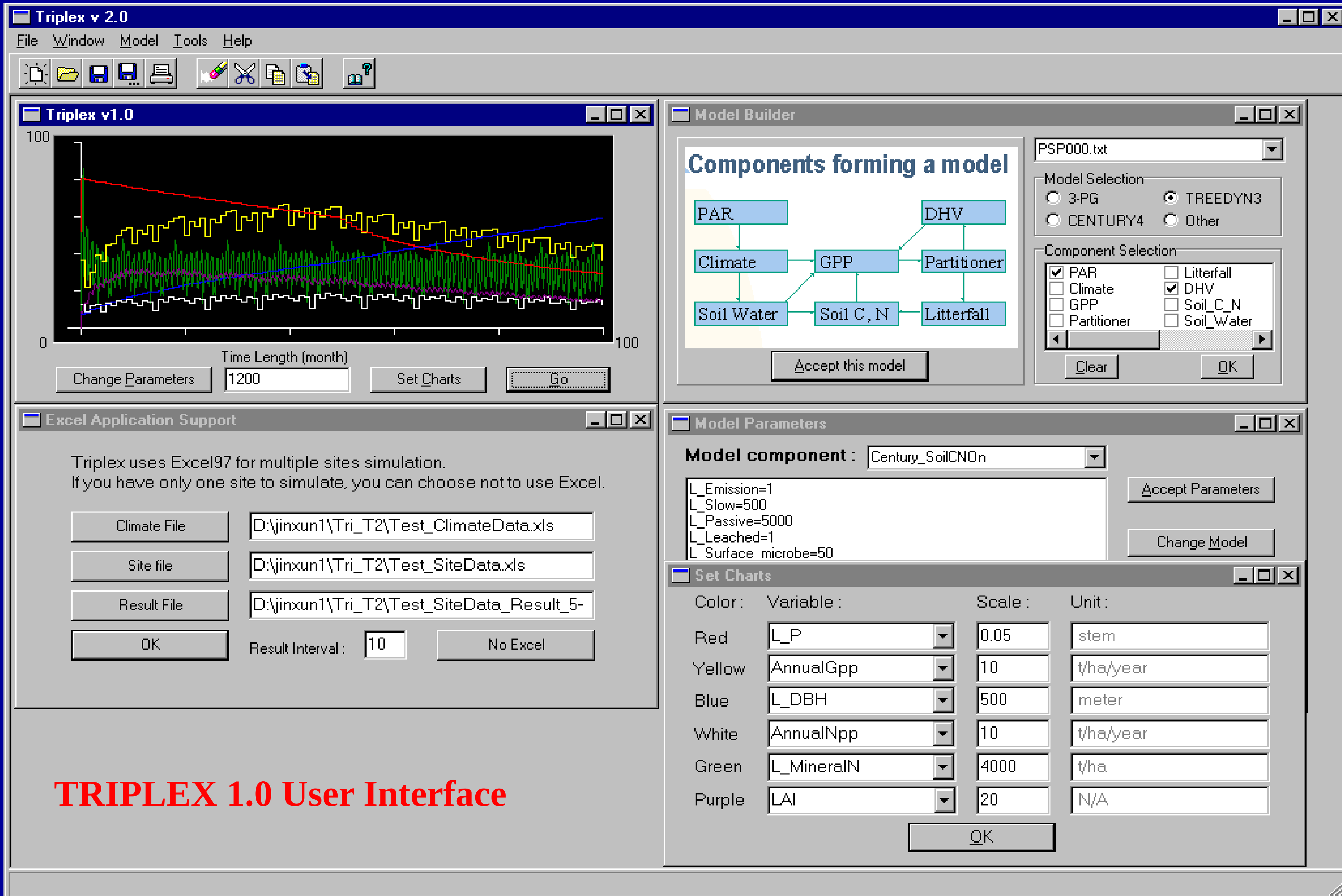
  H, DBH, BA, volume, NPP, biomass, soil C, N, and water dynamics

- **Modelling strategy:**

  OOP (objective-oriented programming - C++) and model reuse approaches

TRIPLEX1.0 Framework





TRIPLEX 1.0 User Interface

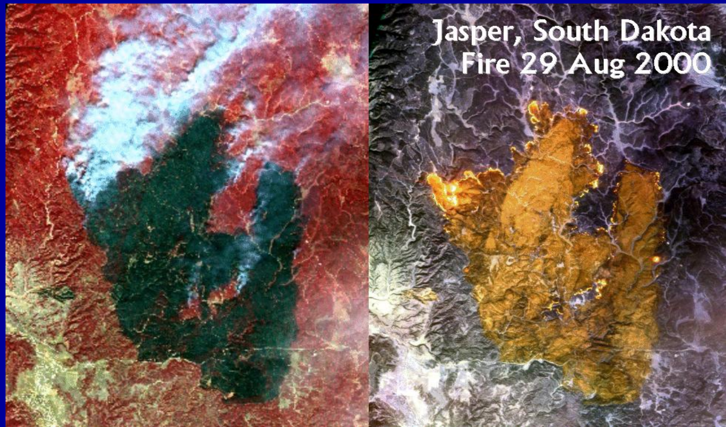
Challenge: Validation

Validation is testing a model to see how well it predicts. (How well does the model capture the structure, controls, and dynamics of a real forest ecosystem).

- **First questions is: what variable do we want to validate (test)?**
- **The second question is finding adequate data.**

Data for Validating Ecosystem Models

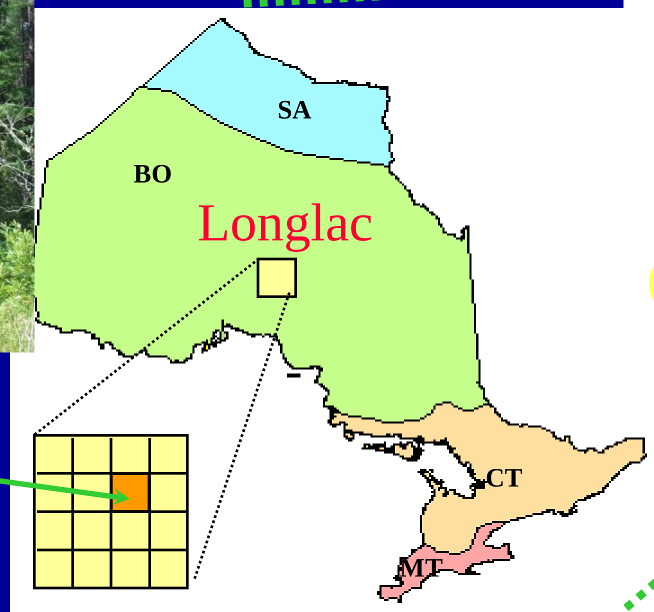
- Greenhouse or experimental data
- *Tree growth plots (PSP, TSP)*
- Forest inventory
- Flux tower (CO_2, NPP, NEP etc..)
- Remote Sensing (NDVI-NPP, MODIS etc..)
- Paleoecological data (pollen, tree-ring)

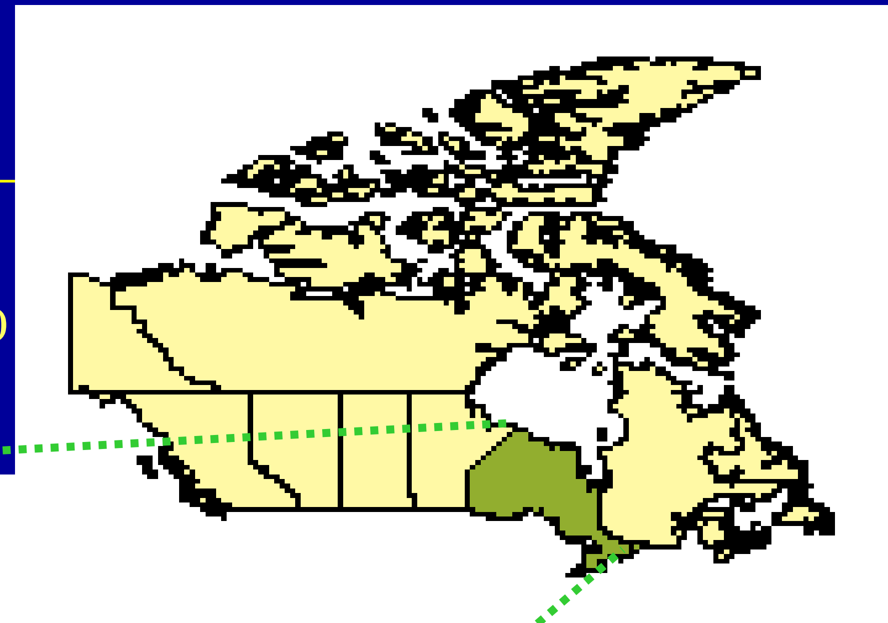


One Case Study

Location: Longlac (Kimberly Clark Ltd.)

Forest type: Jack pine (*Pinus banksiana* Lamb.)





Ontario

12 PSP
(0.08ha each)

BO: Boreal; CT: Cool Temperate; MT: Moderate Temperate; SA: Subartic

Calibration and Validation for TRIPLEX Model

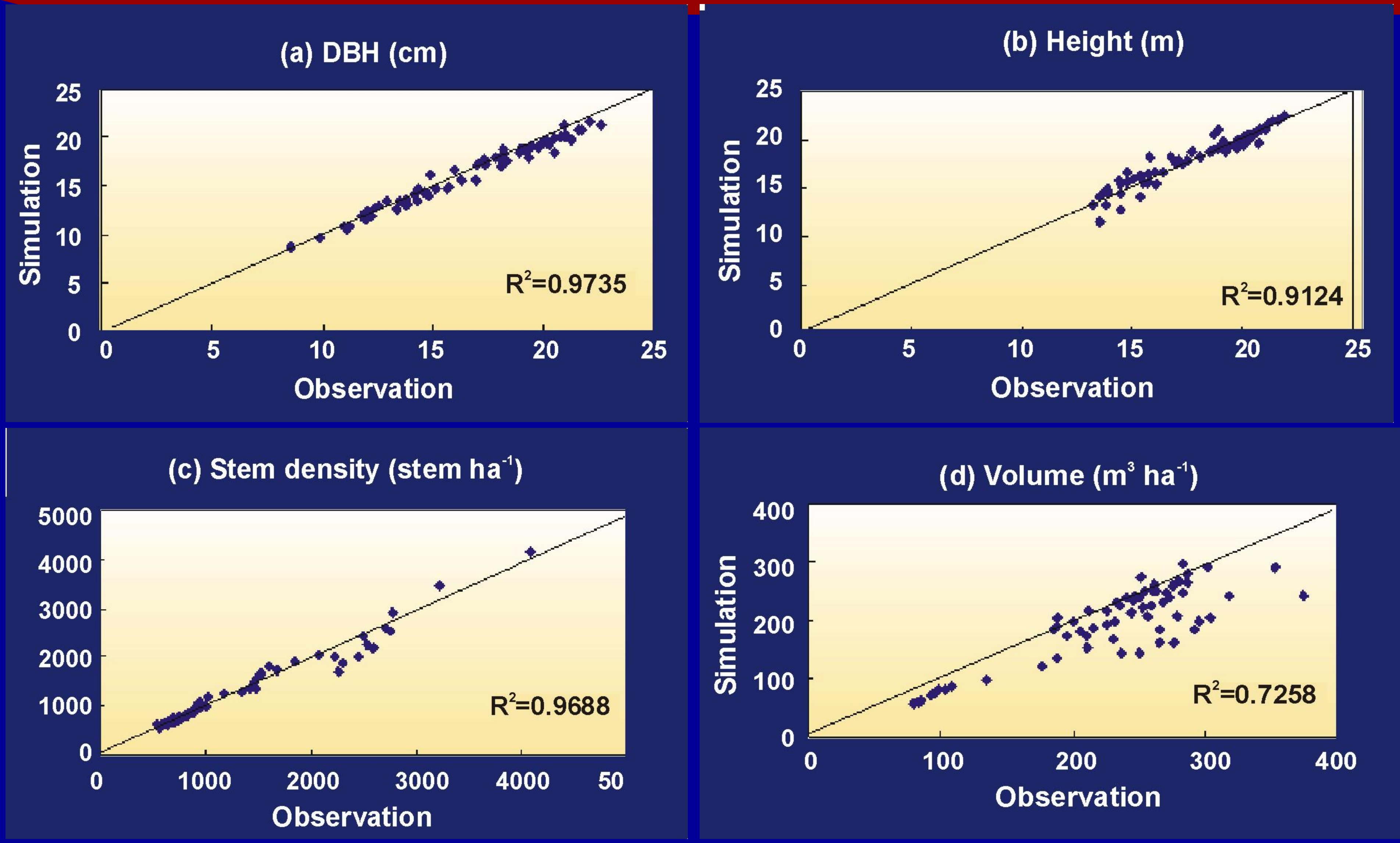
We have 6 consecutive measurements (very 5 yr) for DBH, H, tree density (1952-1982)

- Use first measurements (1952) to calibrate the TRIPLEX model

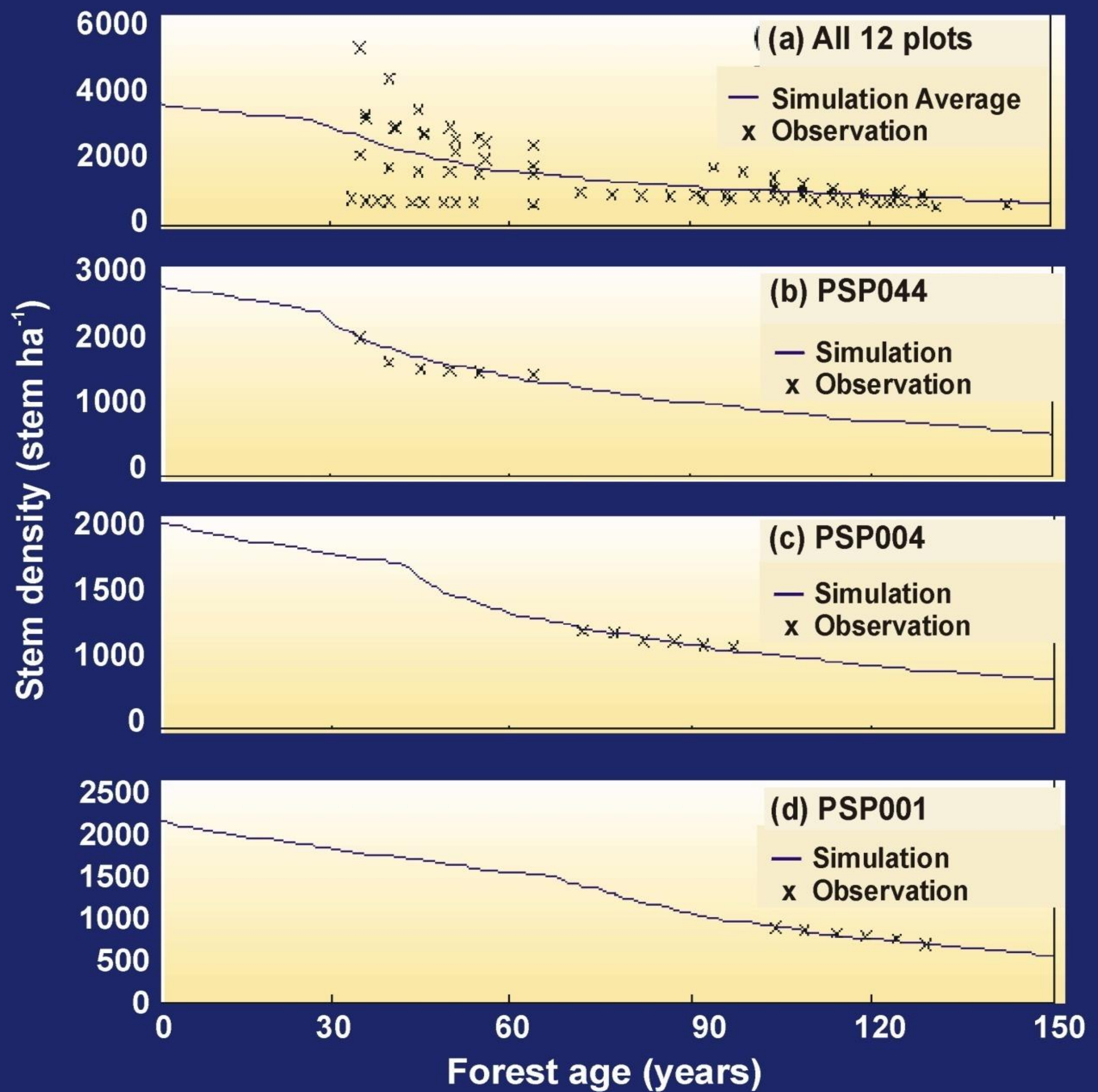
- Use the other 5 measurements to validate (1957 - 1982)

Comparison of Simulations and Observations

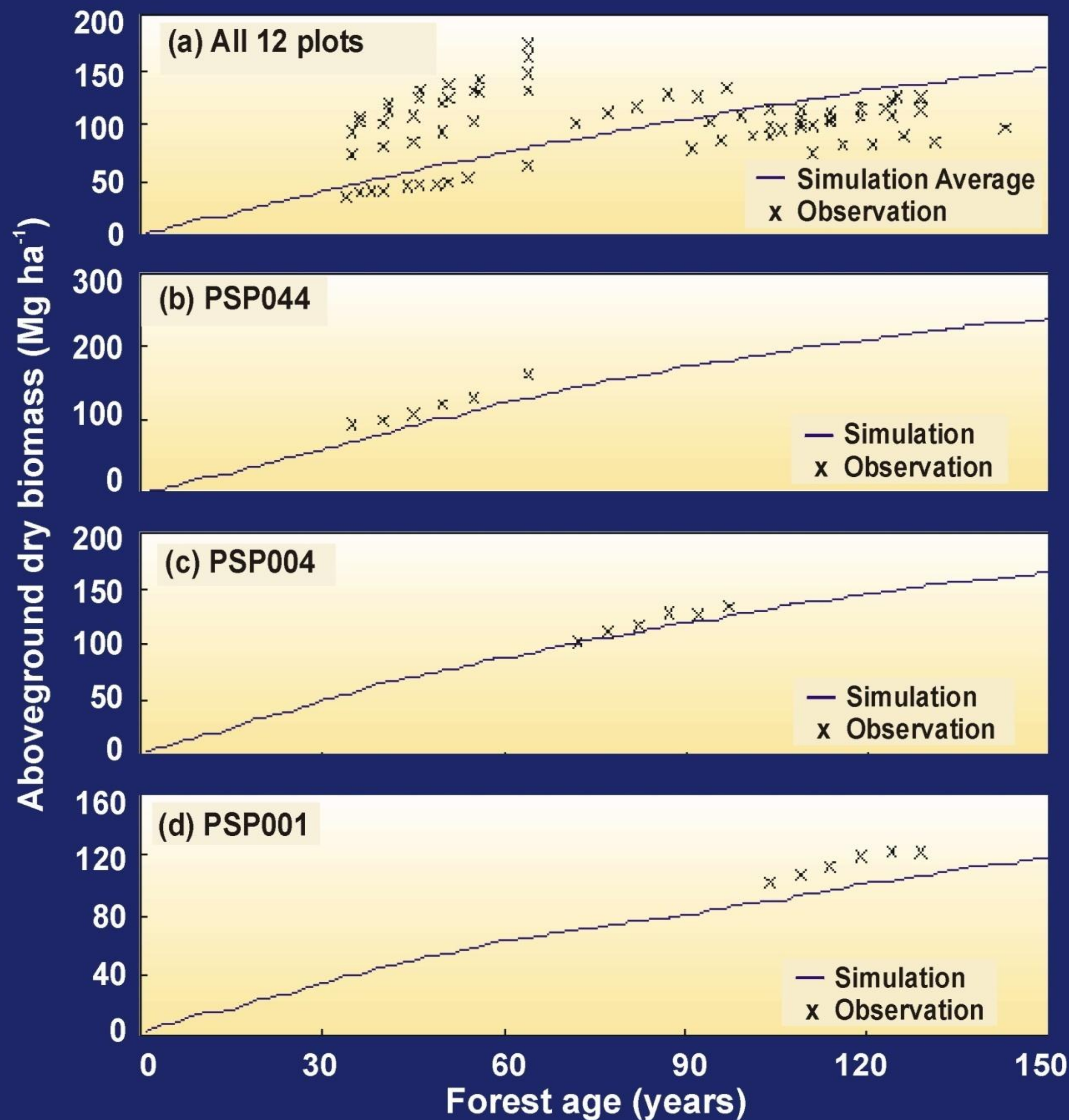
(solid diagonal is the 1:1 line; N=60)



Comparison of Averaged Simulations and Observations - *Stem Density*

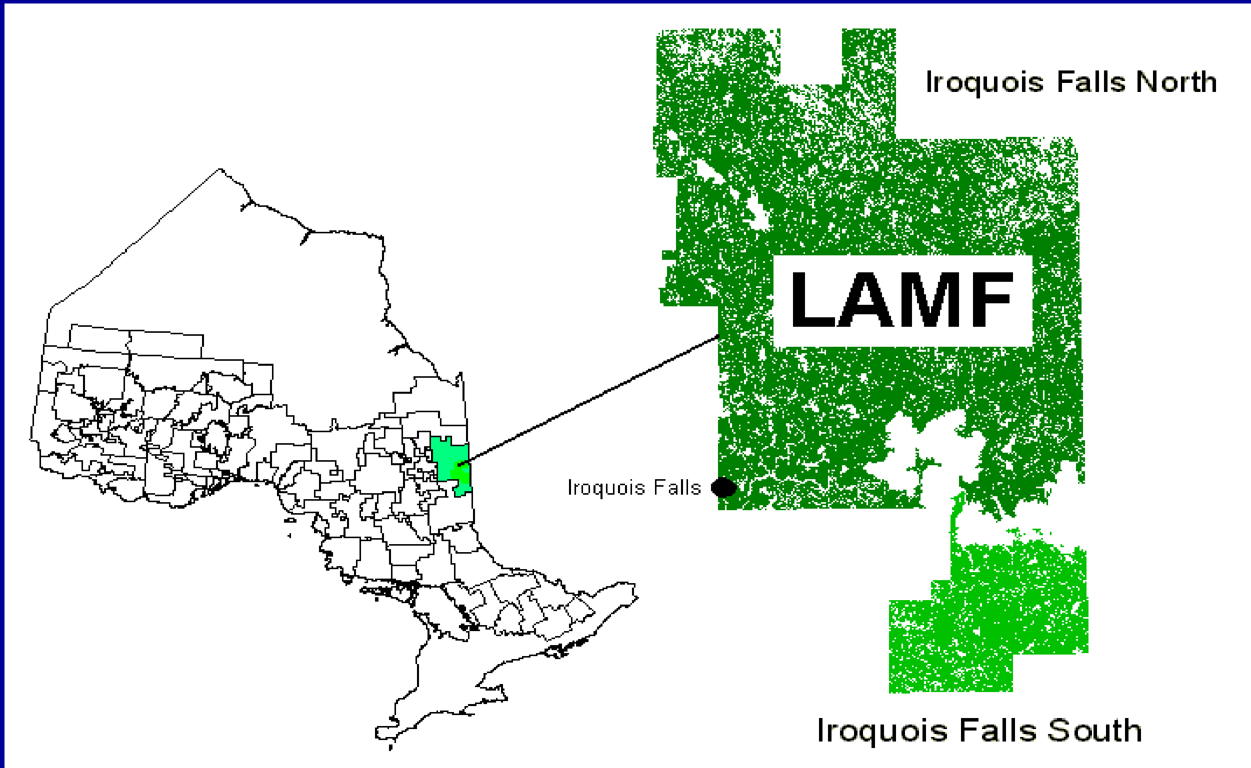


Comparison of Averaged Simulations and Observations - *Aboveground Biomass (Hegyi, 1972)*



Modeling Forest Growth and Carbon Dynamics at Landscape level in Lake Abitibi Model Forest

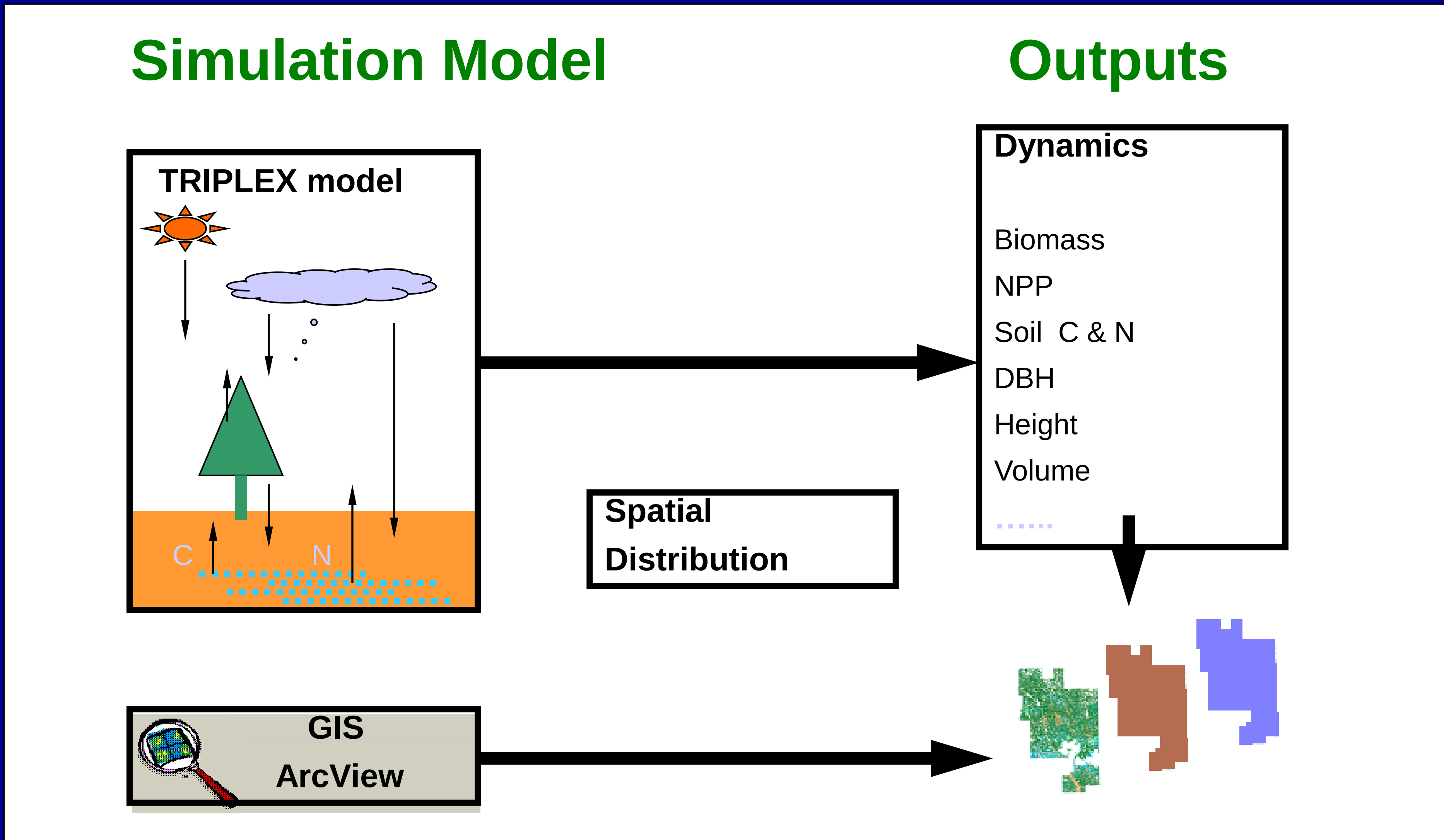
(May 12, 2002)



(Zhou et al, 2007)


• Mixedwood Forest •
Demonstration Area
• Forêt mixte •
Zone de démonstration

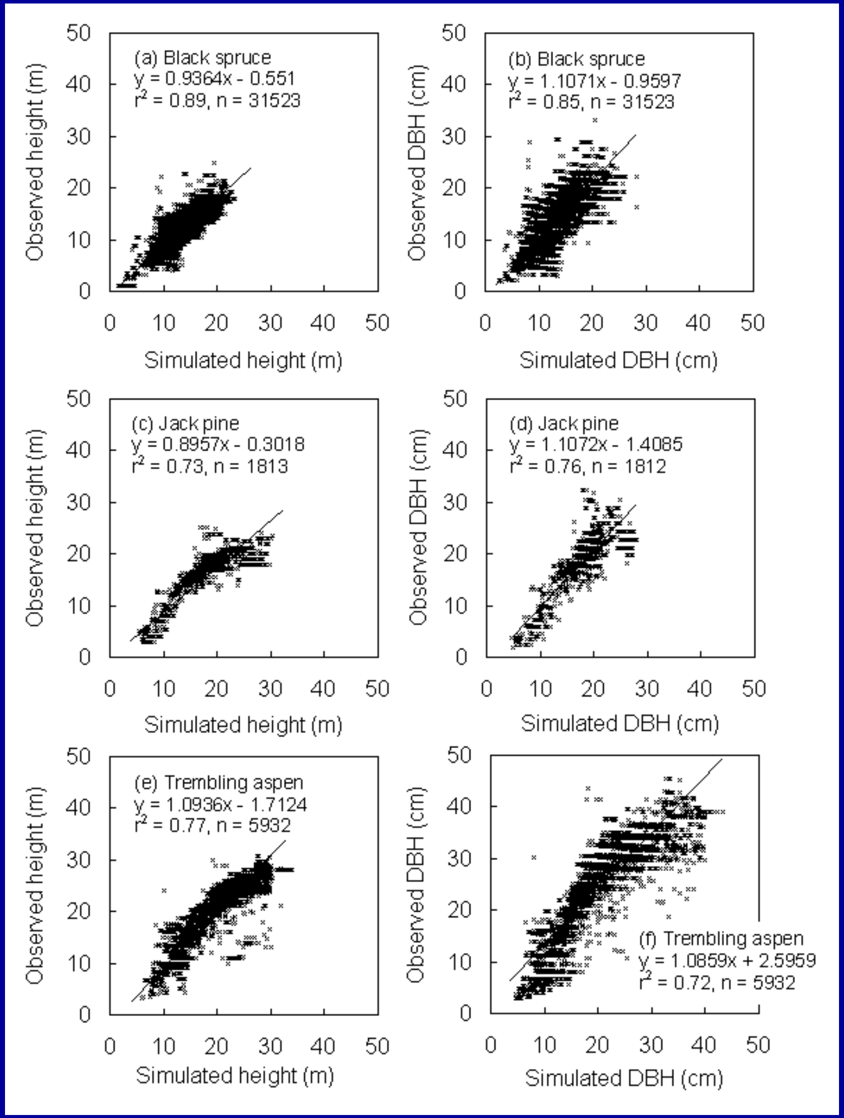
Method


Simulation Model
Outputs
TRIPLEX model
C
N
Dynamics
Biomass
NPP
Soil C & N
DBH
Height
Volume
Spatial
Distribution
GIS
ArcView

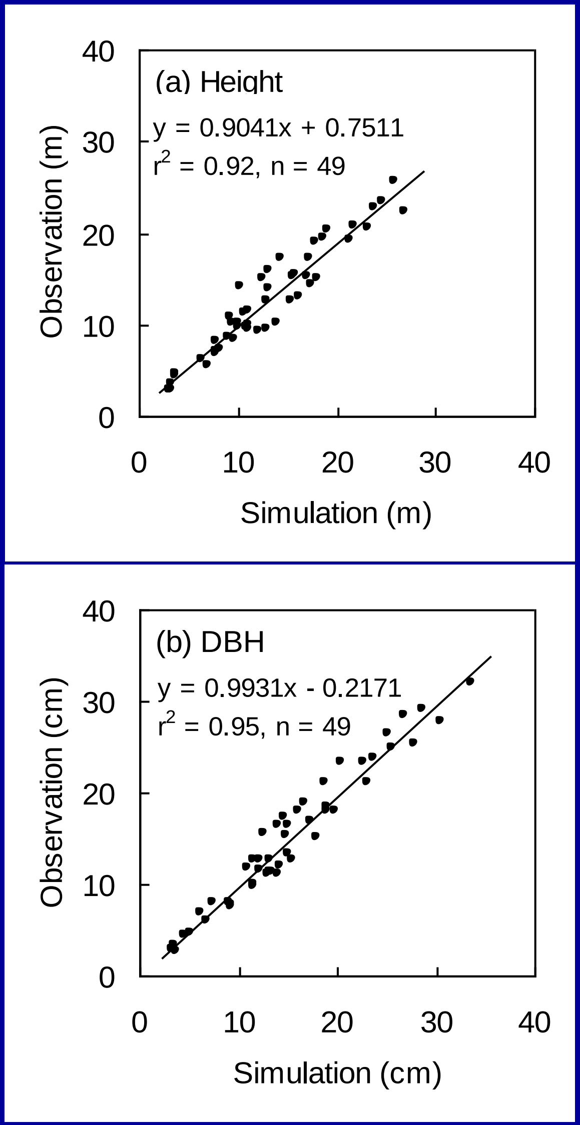
Model inputs

Forest	• LAMF Local data (stands and spatial data)
Soil	• Ontario Land Inventory Prime land Information System (OLIPIS) • A soil profile and organic carbon data base for Canadian forest
Climate	• Database from Environment Canada • Canadian Centre for Climate Modeling (CCCMa database)

Model validation



TRIPLEX vs. Forest Inventory

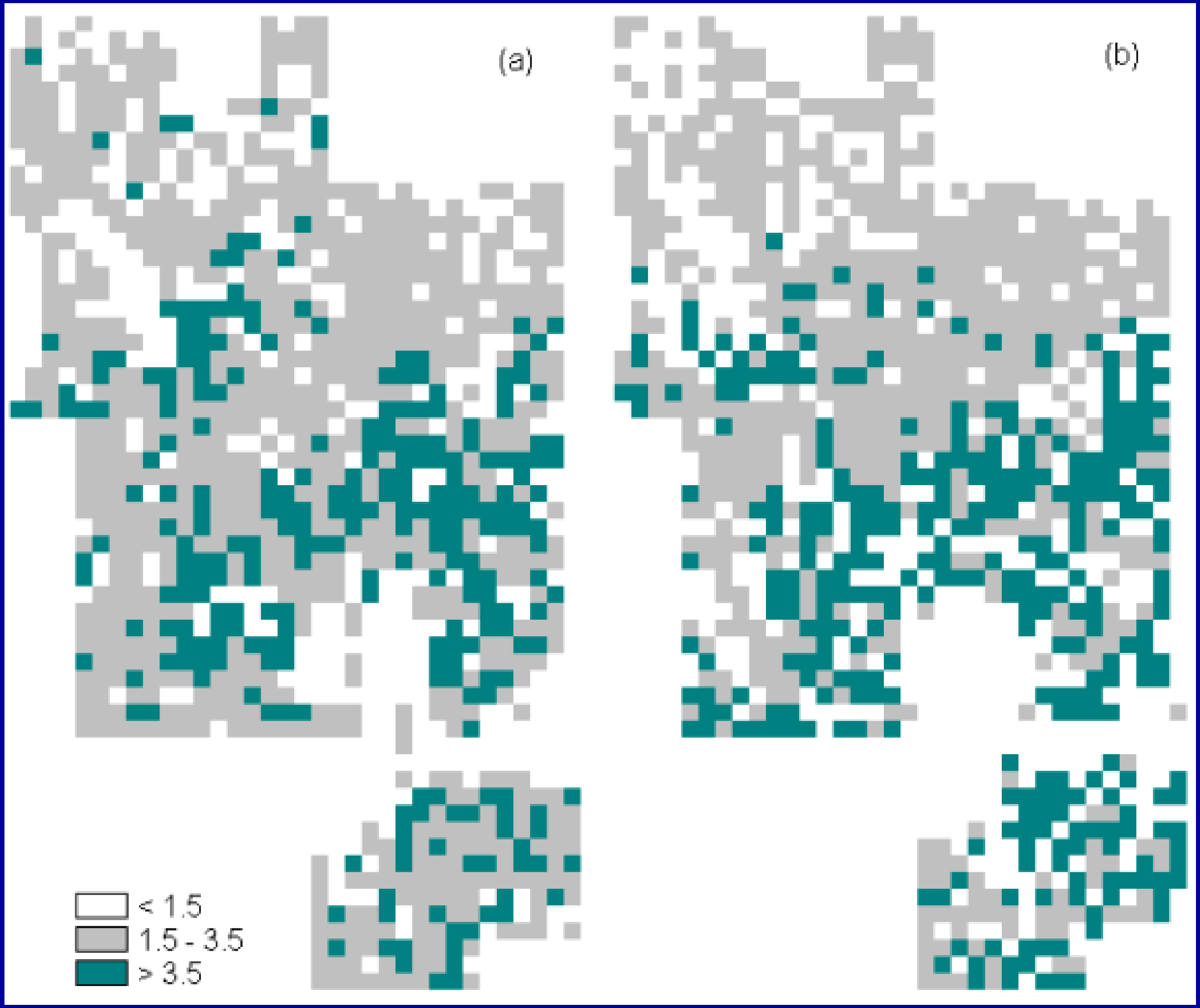


TRIPLEX vs. PSP

32 black spruce,
9 jack pine,
8 trembling aspen
plots
(measured in 1995)

(Zhou et al., 2005)

NPP Spatial Distribution at Landscape Level



(a) TRIPLEX (Zhou et al, 2005)

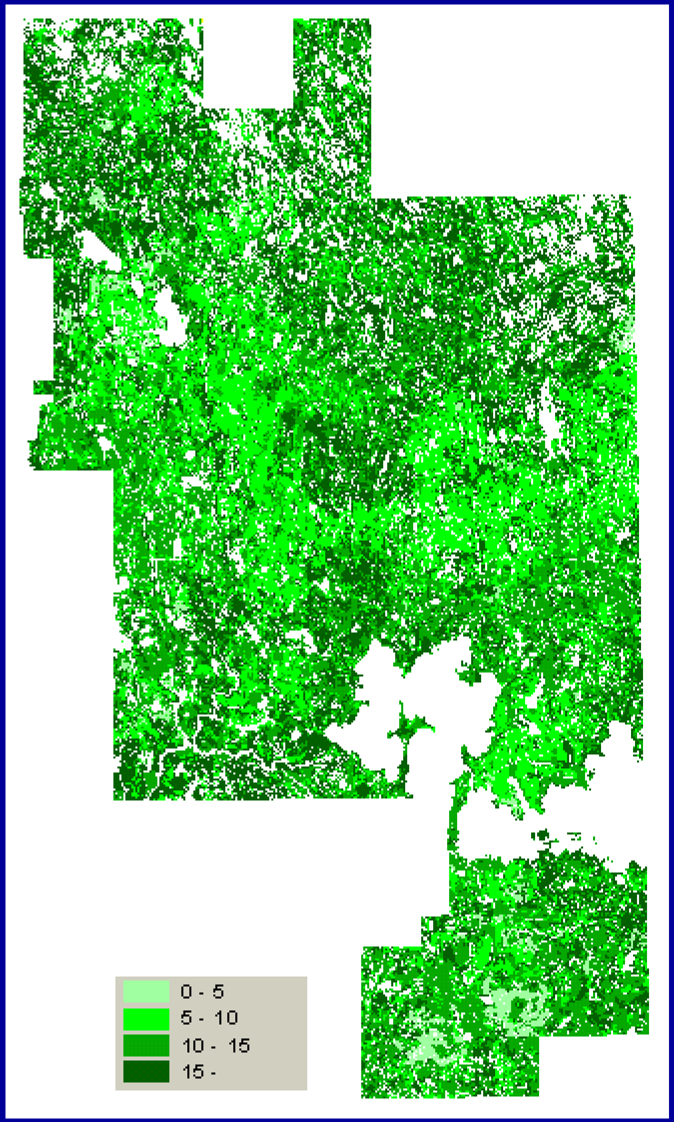
(b) Remote Sensing (Liu et al, 2002)

Fig. 4 The comparison between NPP (t C ha-1 yr-1) simulations at landscape (a) and remote sensing (b) levels for the LAMF in 1995. (a) was based on the TRIPLEX model simulation for 1995 (averaged 3.28 tC ha-1 yr-1, SD=0.79), and (b) was converted using spatial data from Liu et al. (2002) for 1994 (averaged 3.08 tC ha-1 yr-1, SD=1.15). The grid size is 3x3 km.

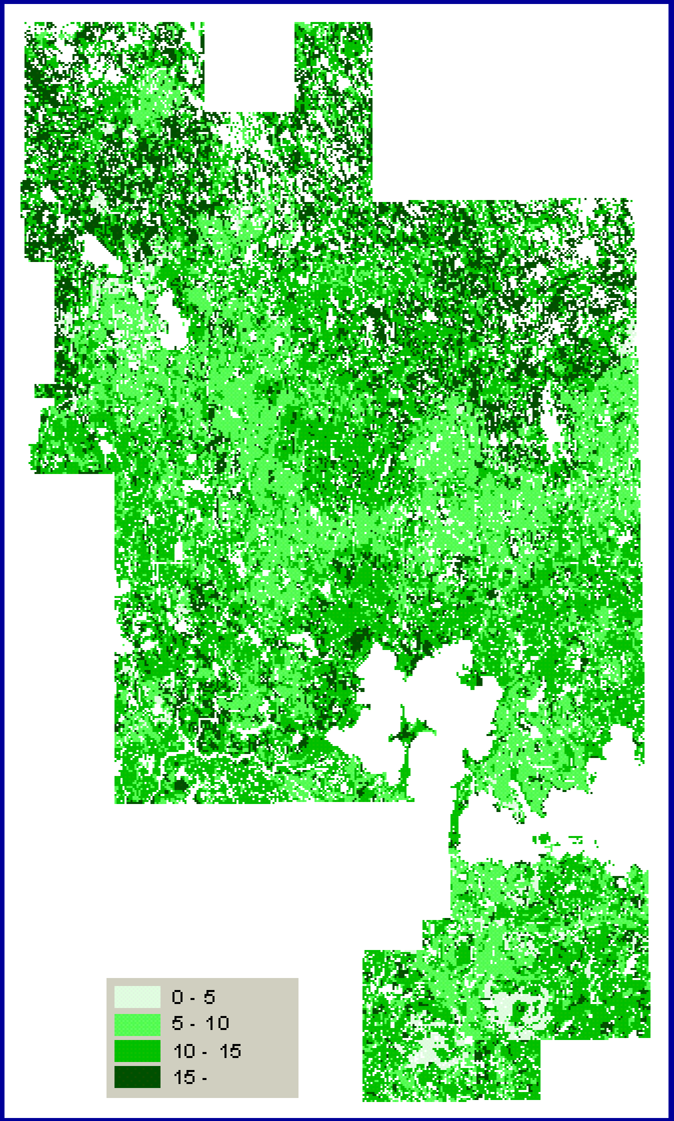
Kappa Statistic (k) = 0.55

Good agreement if 0.55<K<0.7

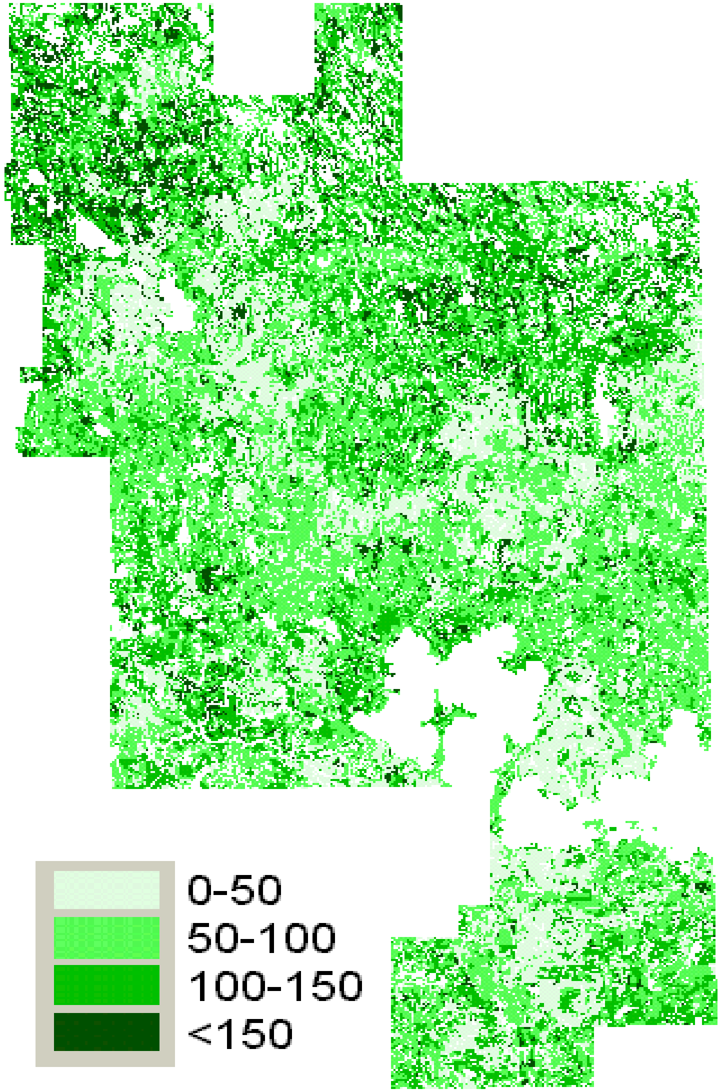
Total Height (m)



DBH (cm)

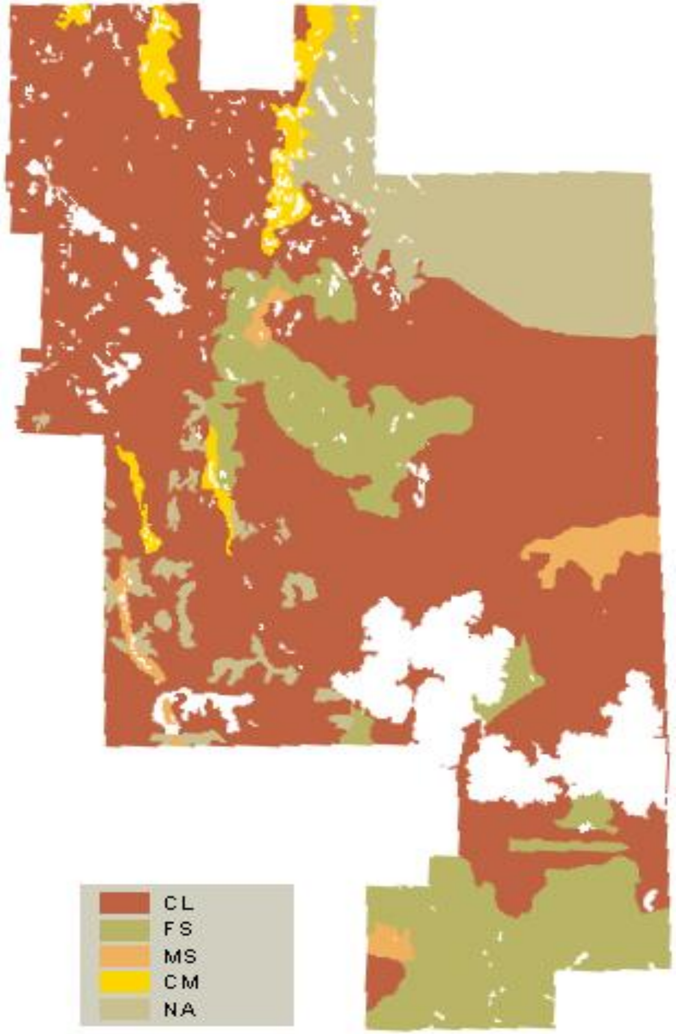


2000



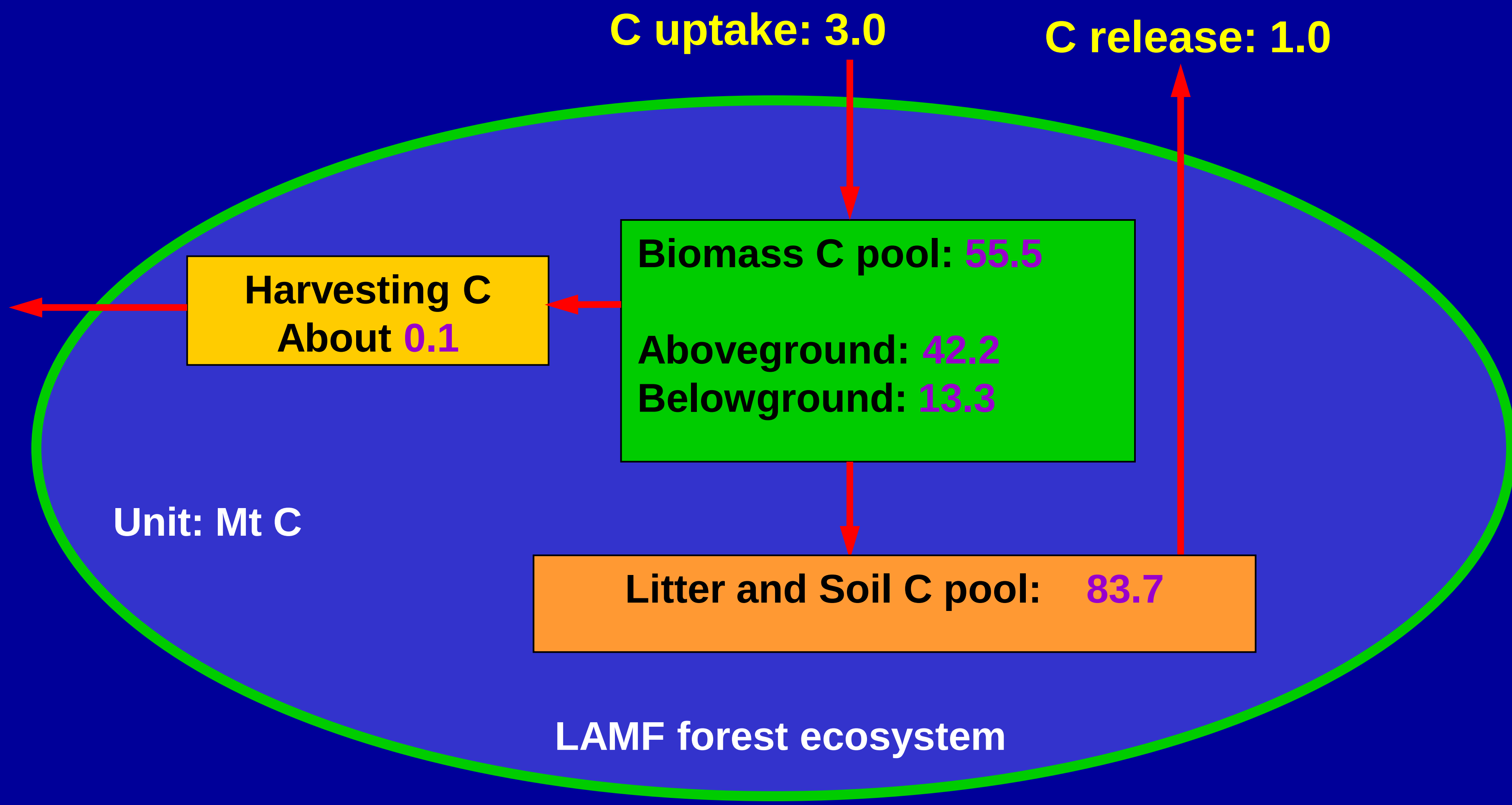
Simulated Biomass (t ha^{-1}) in 2000

Simulated NPP (tC $ha^{-1}yr^{-1}$) in 2000



Simulated Soil carbon (tC ha^{-1}) in 2000

Soil texture



C budget of LAMF forest ecosystem in 2000:

Net carbon balance (NCB) = 2.0 Mt C

(Zhou et al., 2007)

Case Study 3

Global and Planetary Change 66 (2009) 179–194

Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Quantifying the response of forest carbon balance to future climate change in Northeastern China: Model validation and prediction

Changhui Peng[a,c,*], Xiaolu Zhou[a], Shuqing Zhao[a,b], Xiangping Wang[b], Biao Zhu[b], Shilong Piao[b], Jingyun Fang[b]

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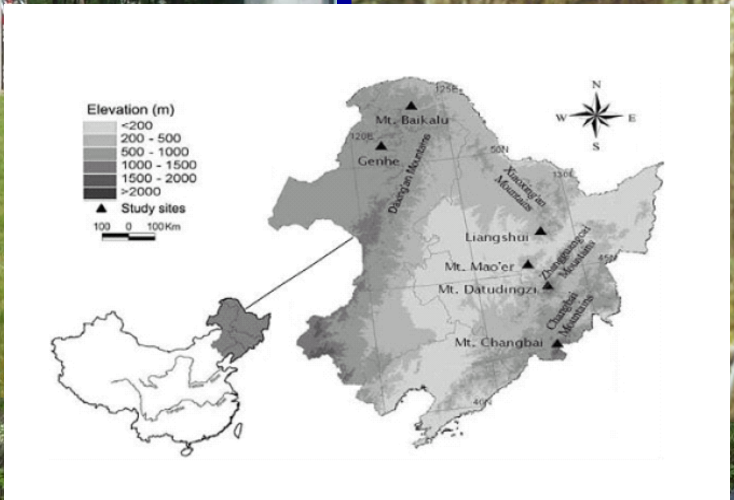
[b] *Department of Ecology, College of Environmental Sciences, and Key Laboratory for Earth Surface Processes of the Ministry of Education, Peking University, Beijing 100871, China*
[c] *Ecology Research Section, Central-South University of Forestry & Technology, Changsha, Hunan 410004, China*


June, 2004
中国科学院长白山森林生态系统定位站


Elevation (m)
<200
200 - 500
500 - 1000
1000 - 1500
1500 - 2000
>2000
Study sites
100 0 100Km
N
W
E
S
Mt. Baikalu
Genhe
Daxing'an Mountains
Xiaoxing'an Mountains
Liangshui
Mt. Mao'er
Zhangguangcai Mountains
Mt. Datudingzi
Changbai Mountains
Mt. Changbai
125E
120E
50N
130E
45N
40N

Chinese Forest Carbon

Science Reprint

Carbon storage increased significantly after the late 1970s from 4.38 to 4.75 pg of carbon by 1998, for a mean accumulation rate of 0.021 pg of carbon per year.

Changes in Forest Biomass Carbon Storage in China Between 1949 and 1998

Jingyun Fang,[1*] Anping Chen,[1] Changhui Peng,[2] Shuqing Zhao,[1] and Longjun Ci[3]

22 June 2001, Volume 292, pp. 2320–2322

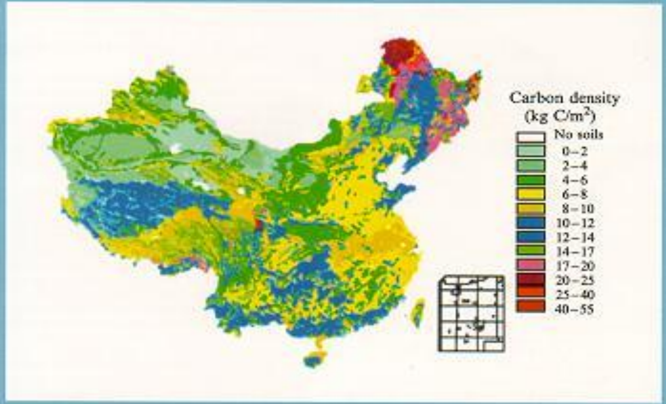
Chinese Soil Carbon

ISSN 1354–1013
http://www.blackwellpublishing.com/journals/gcb

VOLUME 9
NUMBER 3
MARCH 2003

Global Change Biology

A loss of 7.1 pg soil C due to increasing human activities (land use)



(Wu et al., 2003)

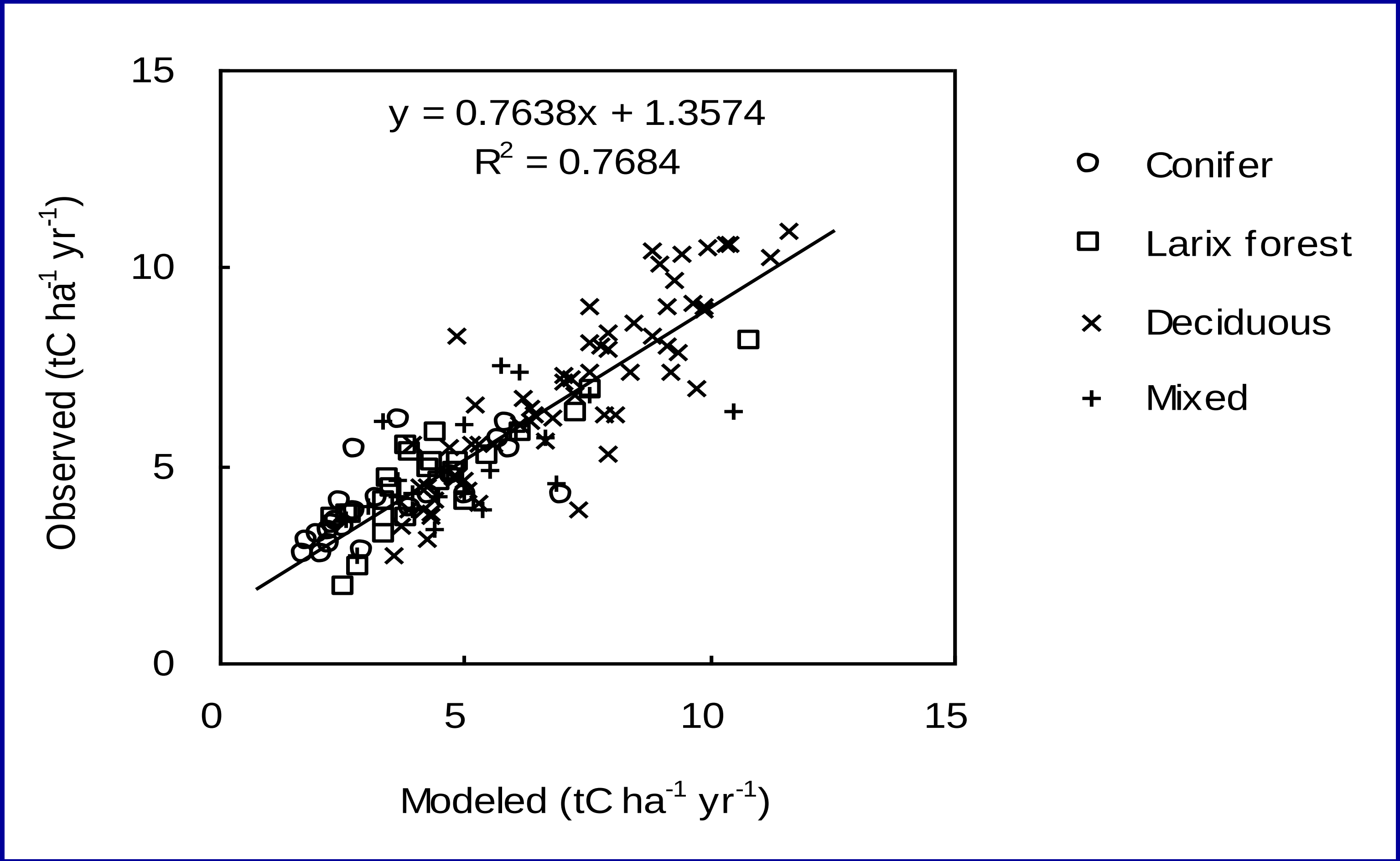
Blackwell Publishing

- Land-use change and soil organic carbon storage in China
- Cross-biome comparison of light-use efficiency for GPP
- Elevated CO_2, nitrogen and fungal endophyte infection
- Climate change and fitness of migratory birds

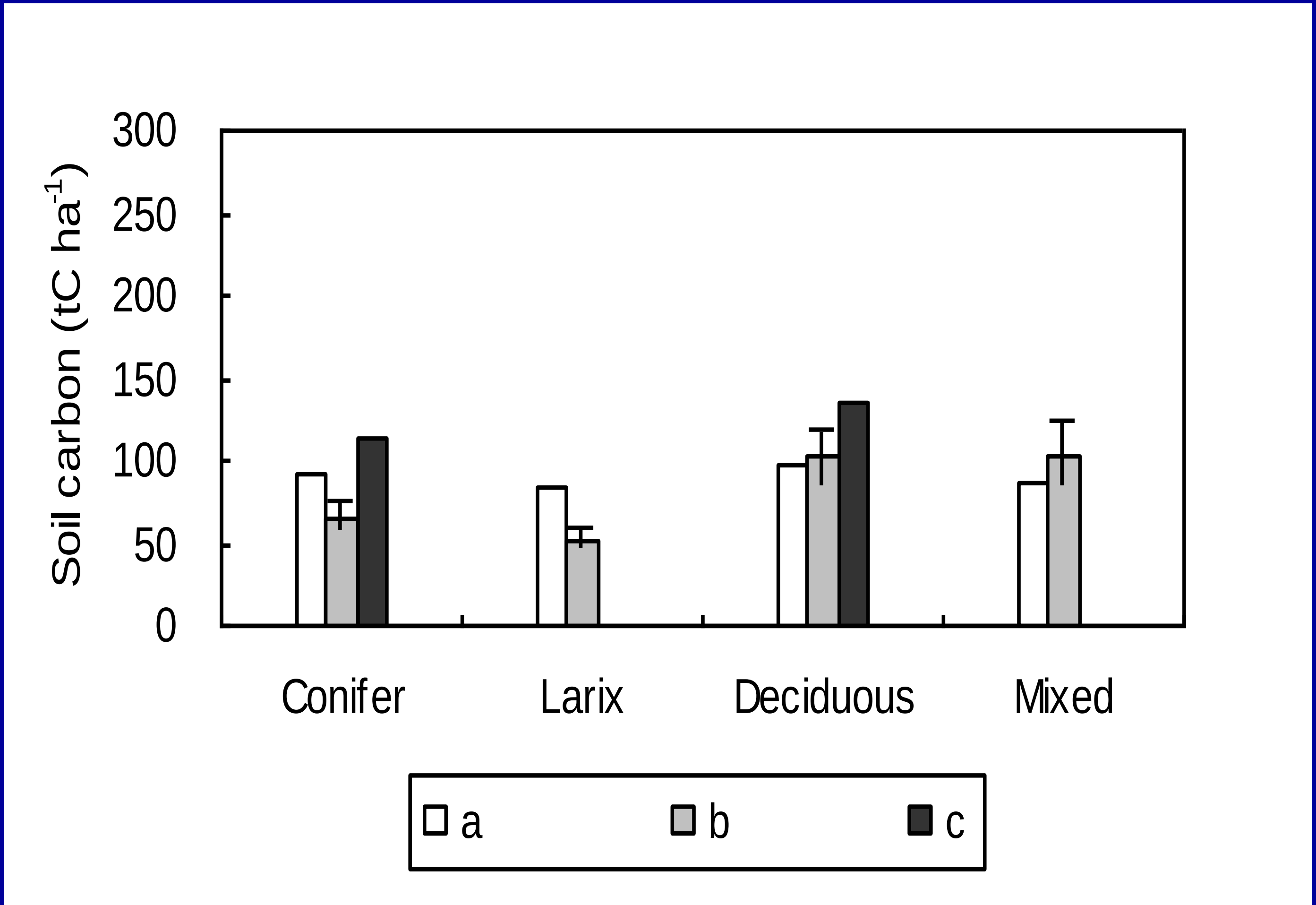
Objectives

1) Validate the TRIPLEX1.0 model using a comprehensive ground observations and measurements;

2) Simulate the temporal and spatial response of NPP and carbon balance under projected future climate change and increasing CO2 scenarios



Comparison of simulated forest NPP against 133 observed forest NPP in northeastern China. The observed forest NPP data sets are obtained from the most comprehensive database complied by the PhD dissertation of Luo (1999) and Ni et al. (2001).



Comparison between simulated and observed soil carbon for four major forest types. (a) refers to averaged values of model simulations in this study. (b) and (c) represent average values measured by Zhu et al. (2005) and Yang and Li (2003), respectively. The vertical line represents standard error *(SE)* for b.

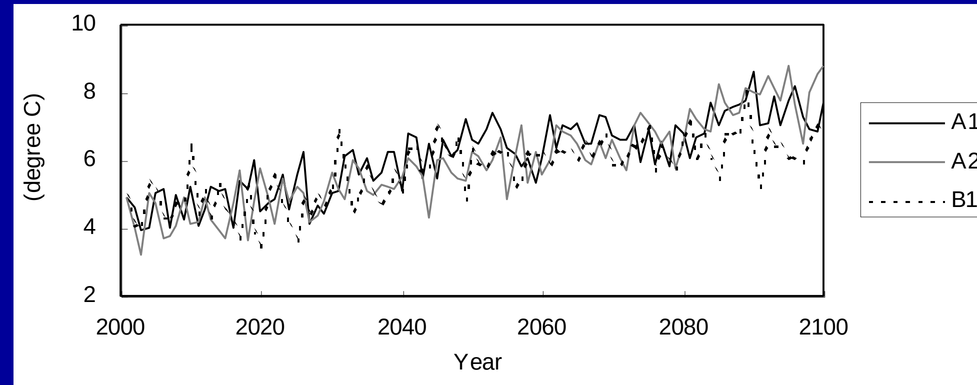
Climate Change Scenarios

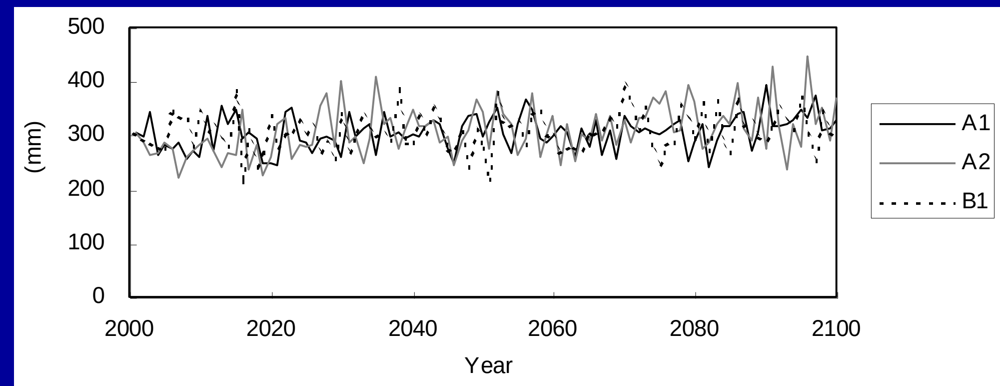
CGCM3.1 outputs for the period from 2001 to 2100, under three scenarios (IPCC, 2005):

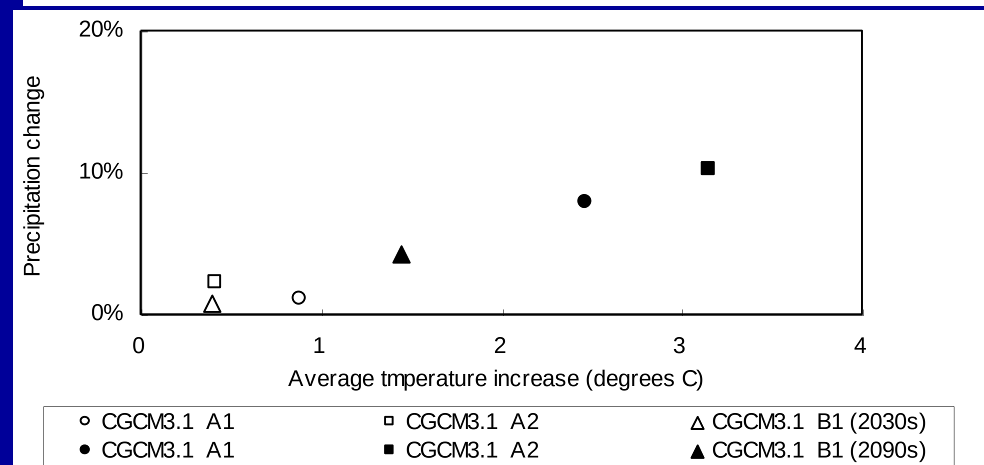
(a) A2, Temperature and CO2 increase 4 ºC and 350-850 ppm;

(b) A1, Temperature and CO2 increase 3 ºC and 350-700 ppm;

(c) B1, Temperature and CO2 increase 2 ºC and 350-550 ppm;

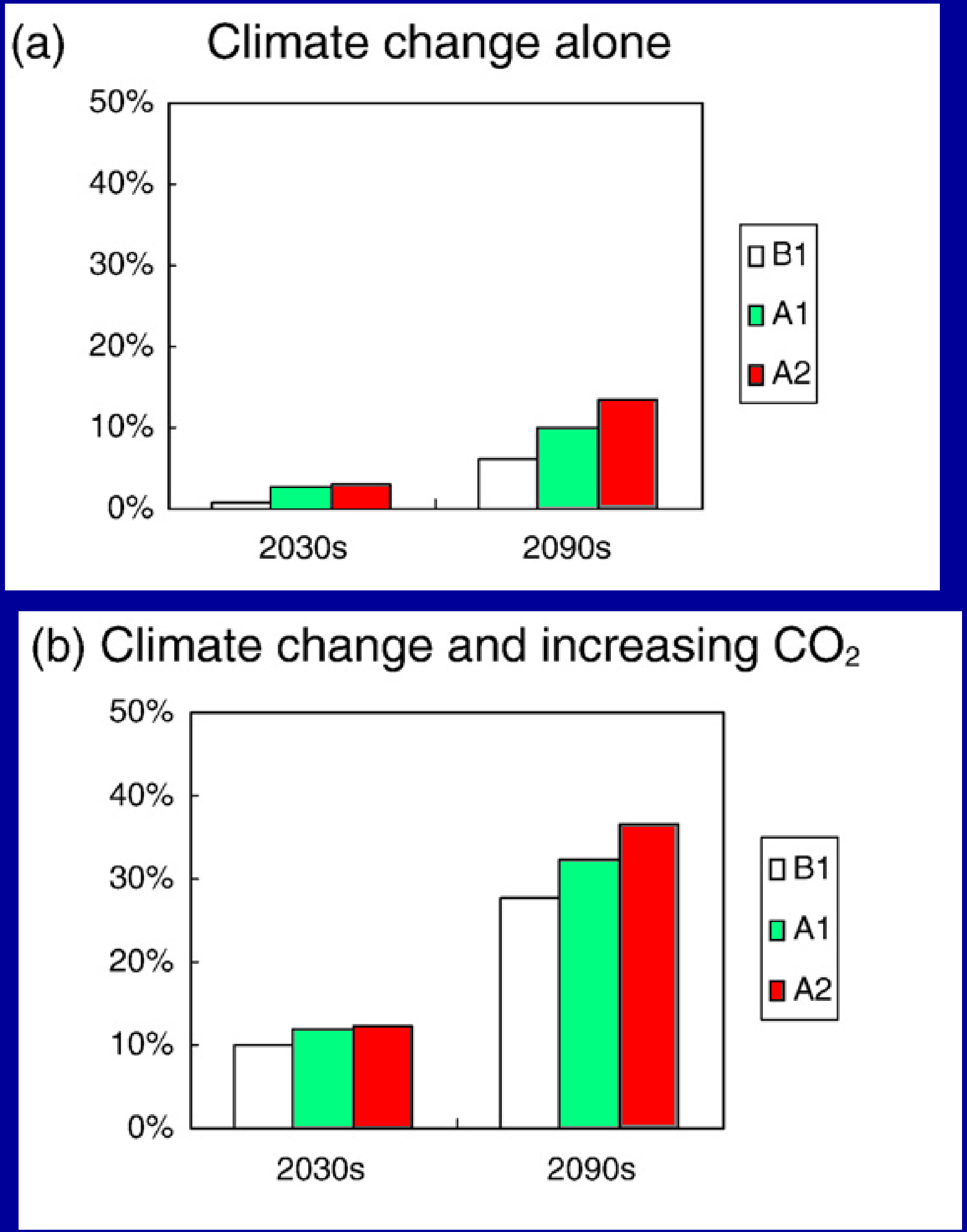




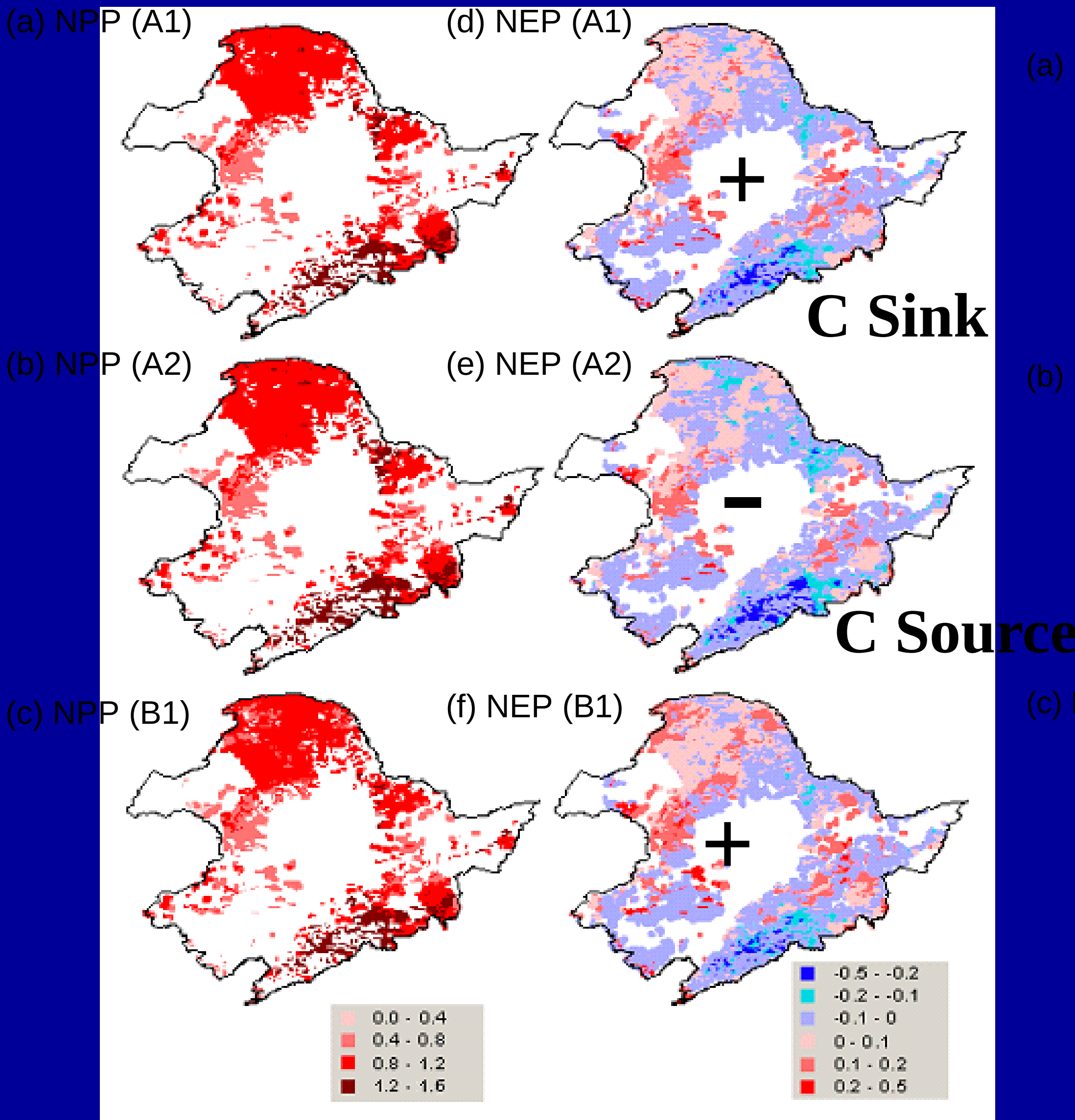


Relative changes of NPP ($t\ C\ ha^{-1}yr^{-1}$) in 2030s (averaged over 2030-2040) and 2090s (averaged over 2090-2100) under different three scenarios (A1, A2, B1) compared with baseline (1999).

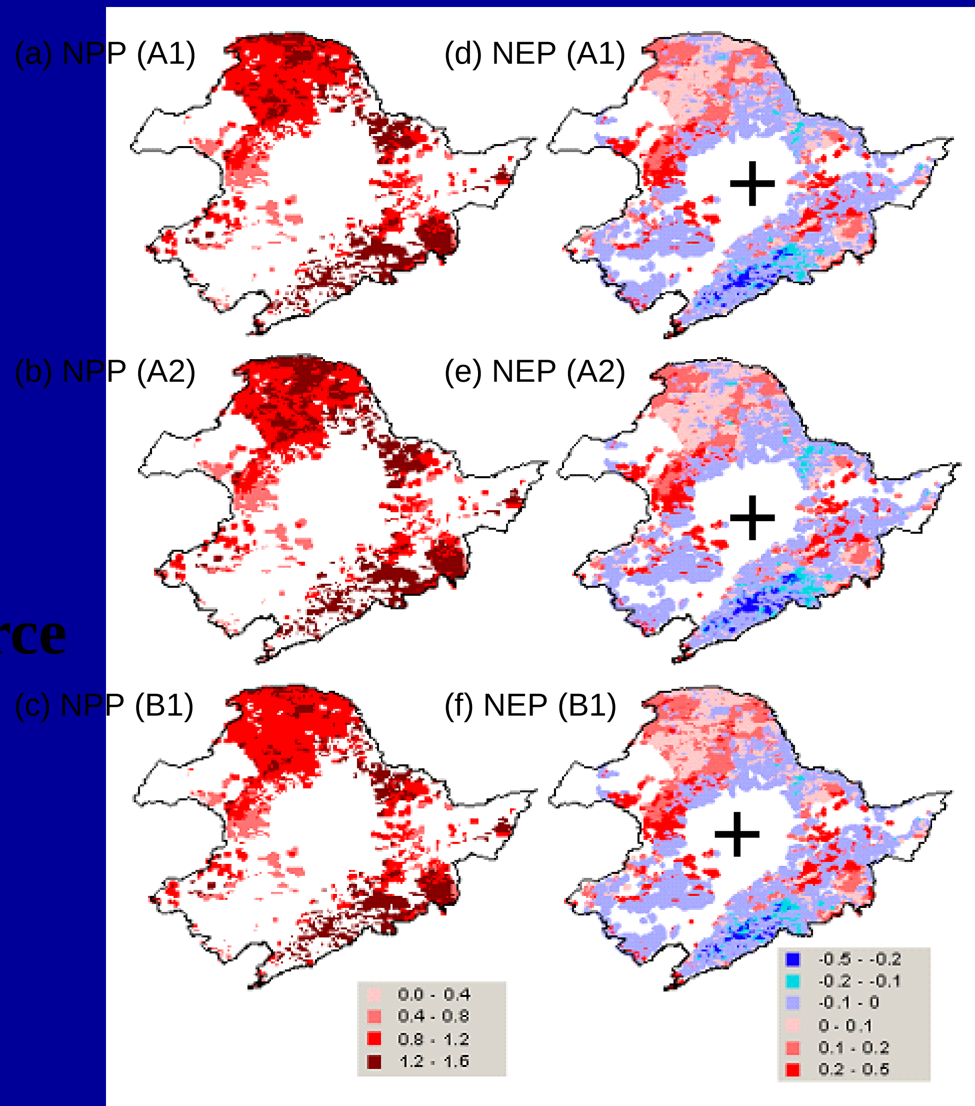
(Peng et al, GPC, 2009)

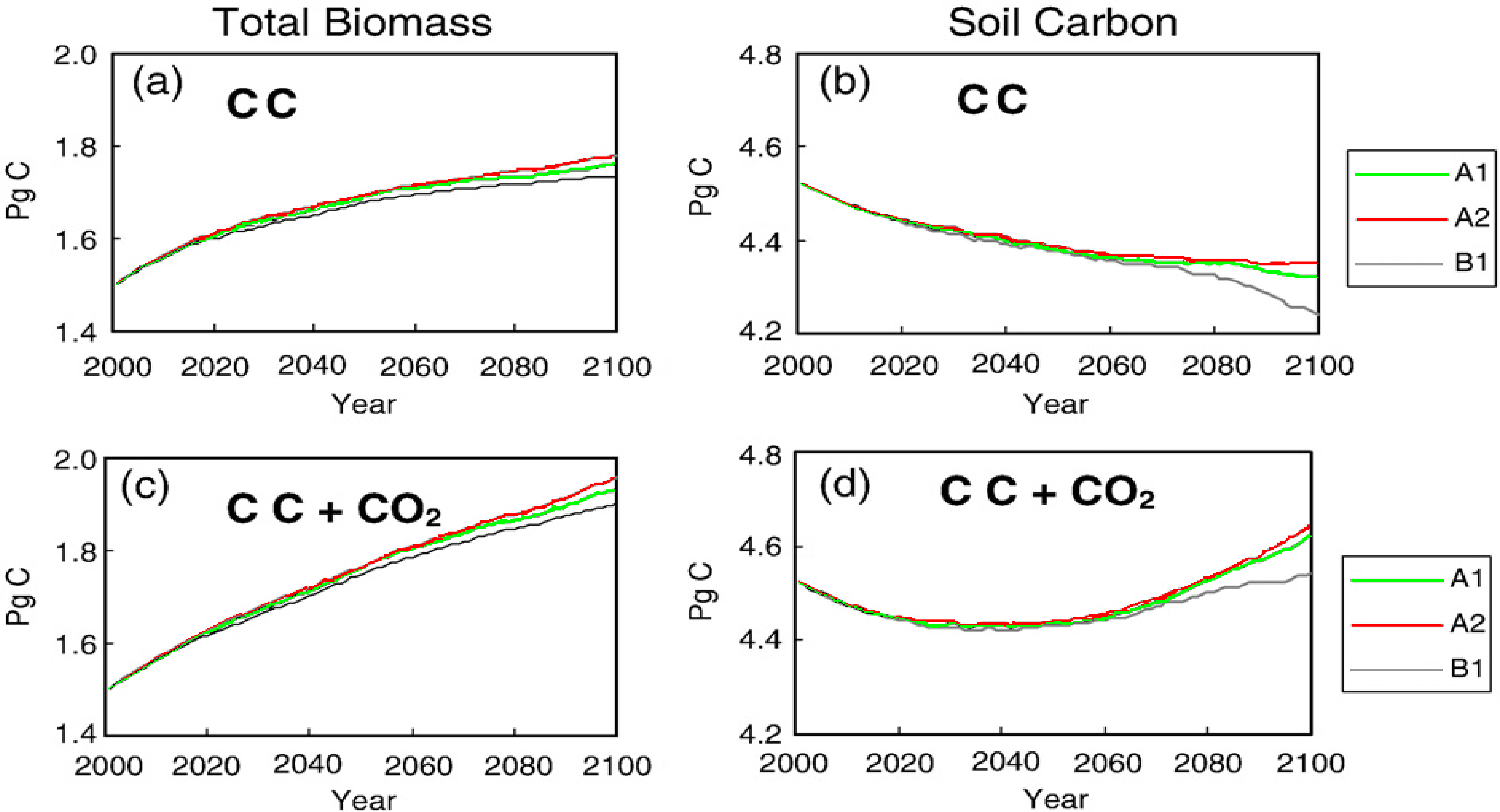


(a) Climate change along (CC)



(b) CC + CO_2 fertilization effect





Simulated temporal dynamics of total biomass (left) (Pg C= 10^{15} g C) and soil carbon stock (right) (Pg C) under 3 different climate change scenarios with two experiments

Summary

The results show that the simulated forest yield, NPP, total biomass and soil carbon are consistent with observed data across northeastern China, suggesting that the TRIPLEX1.0 model is able to simulate forest growth and carbon dynamics for boreal and temperate forest ecosystems at regional scales.

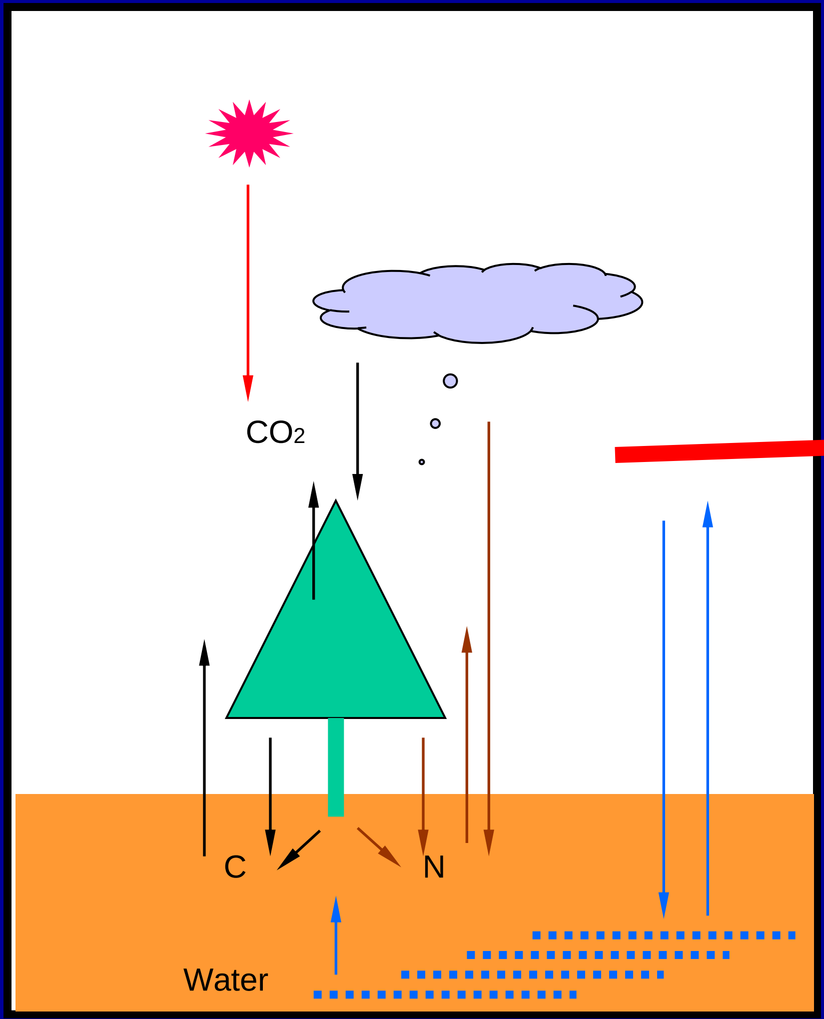
Climate change would increase forest NPP and biomass carbon, but decrease overall soil carbon under all three climate change scenarios. Combined effects of climate change and increased atmospheric CO_2 would result in increased NPP and carbon within vegetation and soil for both the short-term (30 to 40 years) and long-term (90 to 100 years).

The simulated effect of CO_2 fertilization significantly offset the soil carbon loss due to climate change alone.

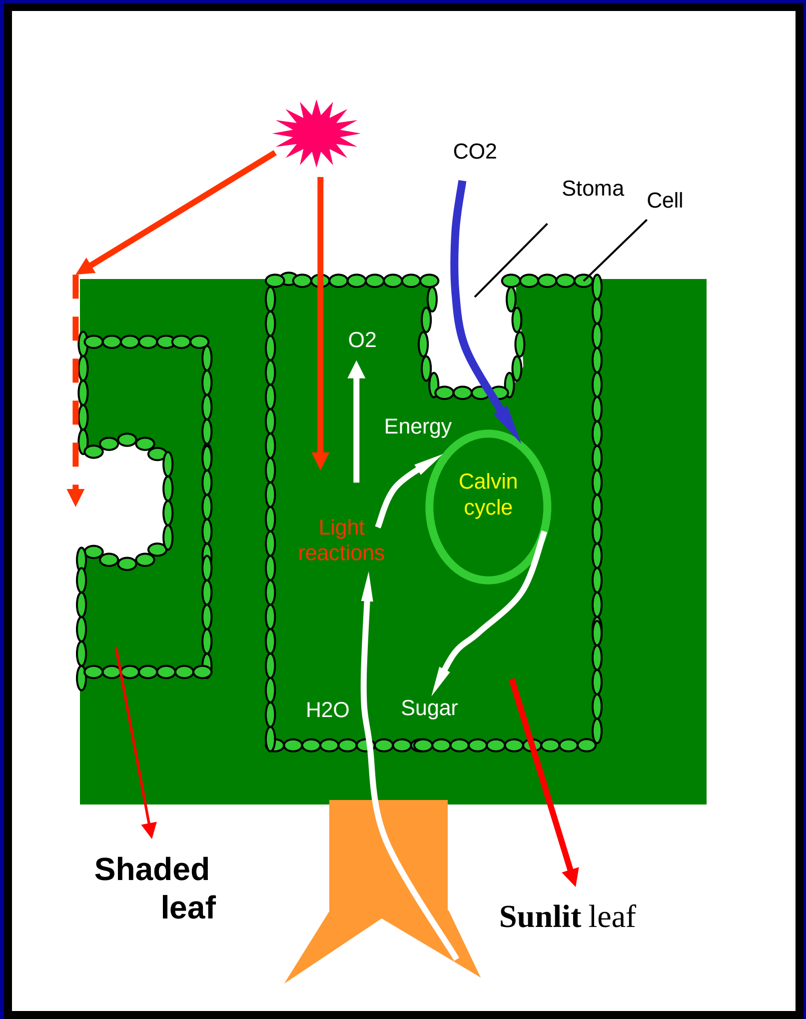
Overall, the forest ecosystems of northeastern China are very sensitive to changes in future climate change and increasing CO_2 in the atmosphere.

New TRIPLEX-Flux Model Development

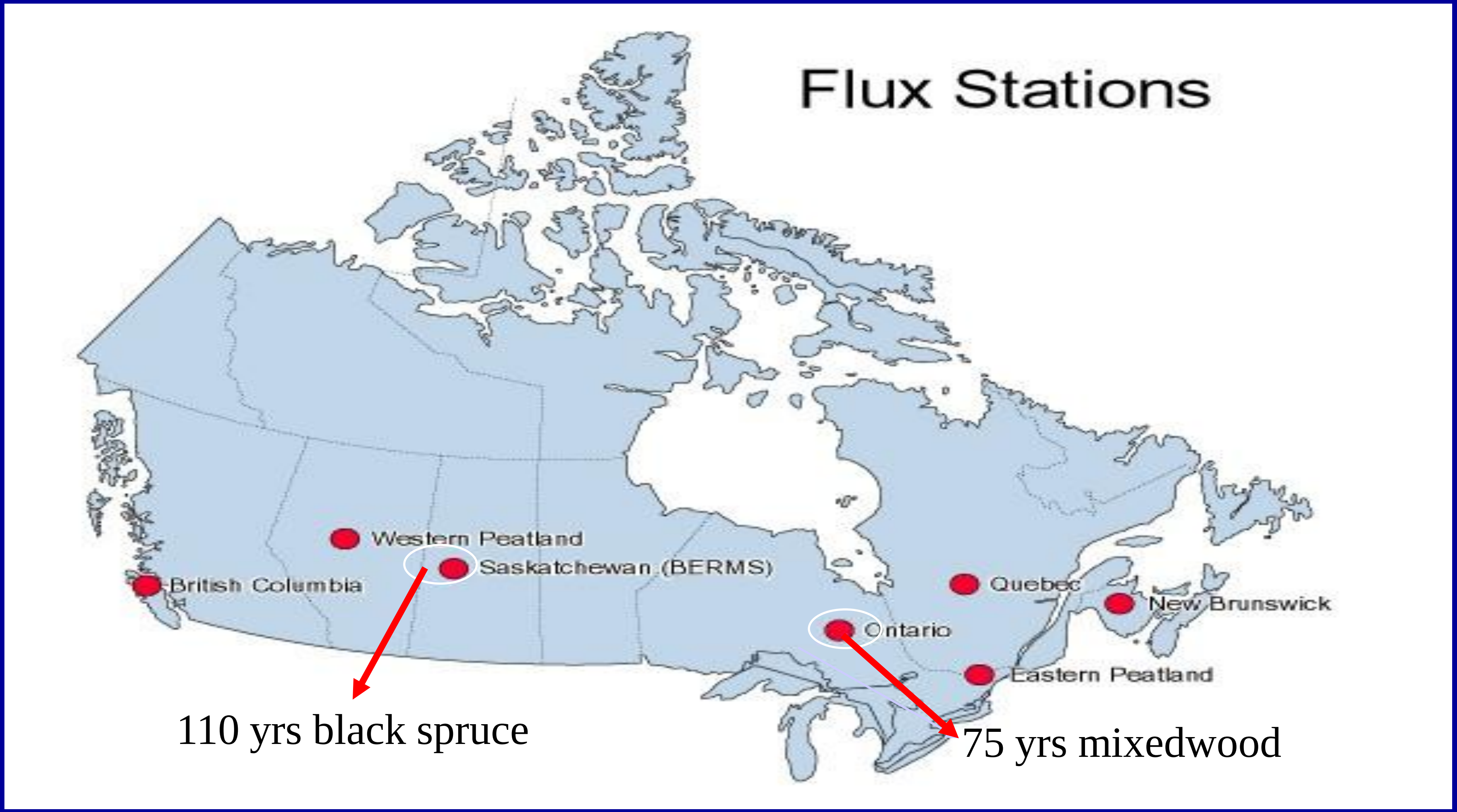
TRIPLEX1.0 (big leaf, monthly)



TRIPLEX-Flux (two leaves, daily)

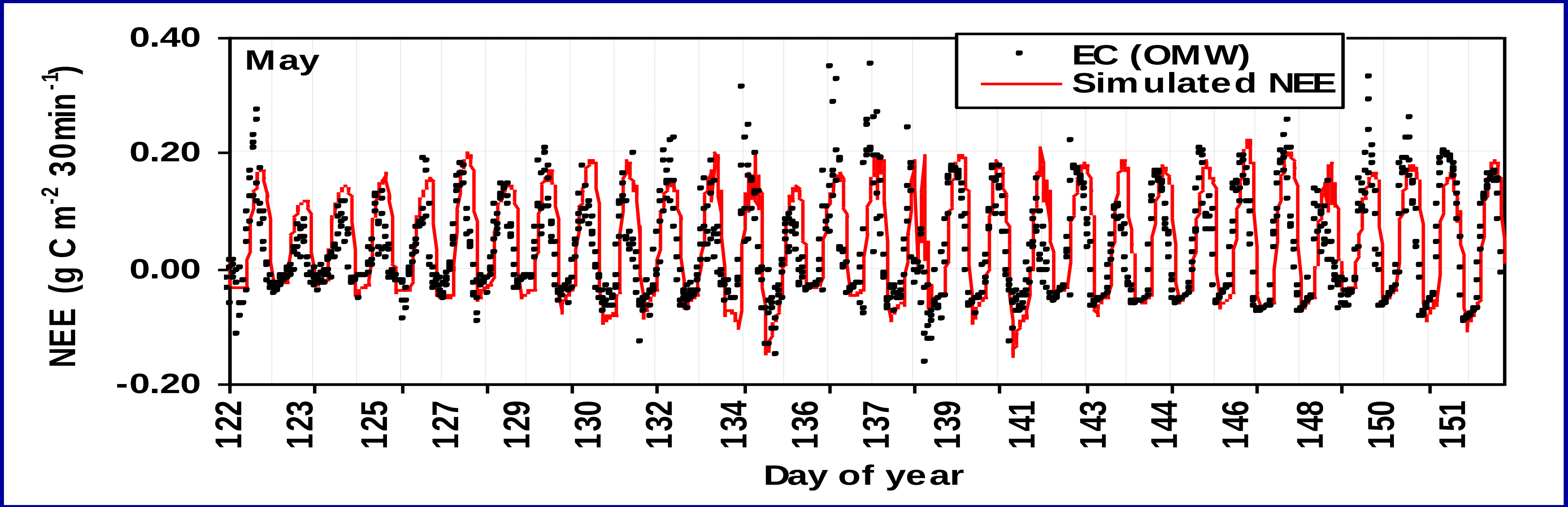


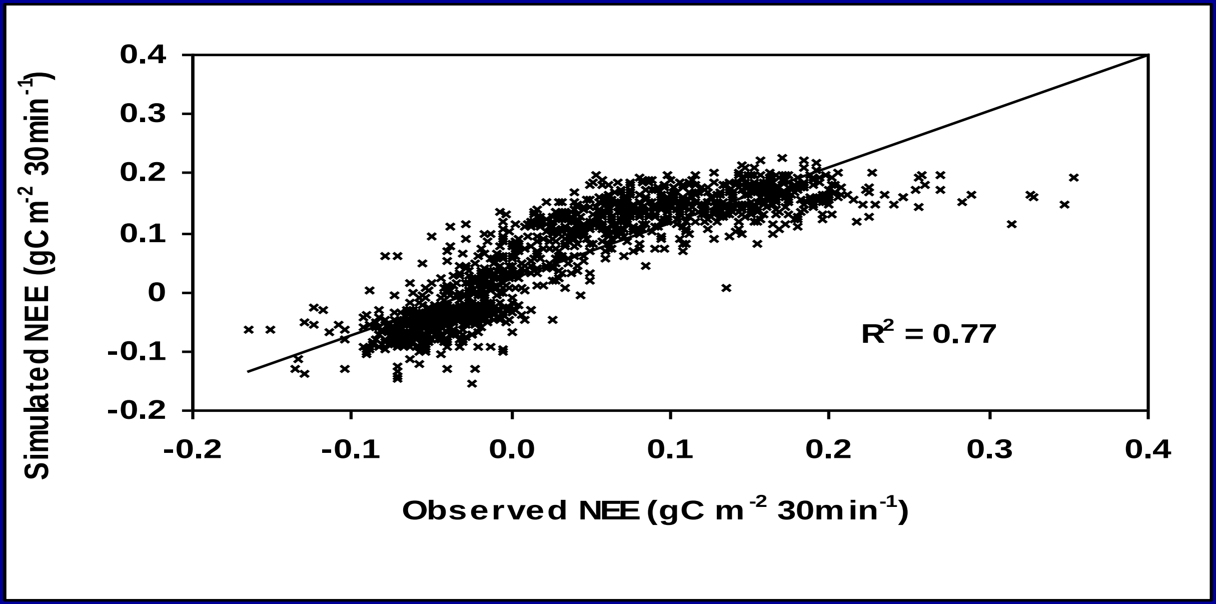
Model Testing for 2 Flux tower sites



(Fluxnet-Canada)

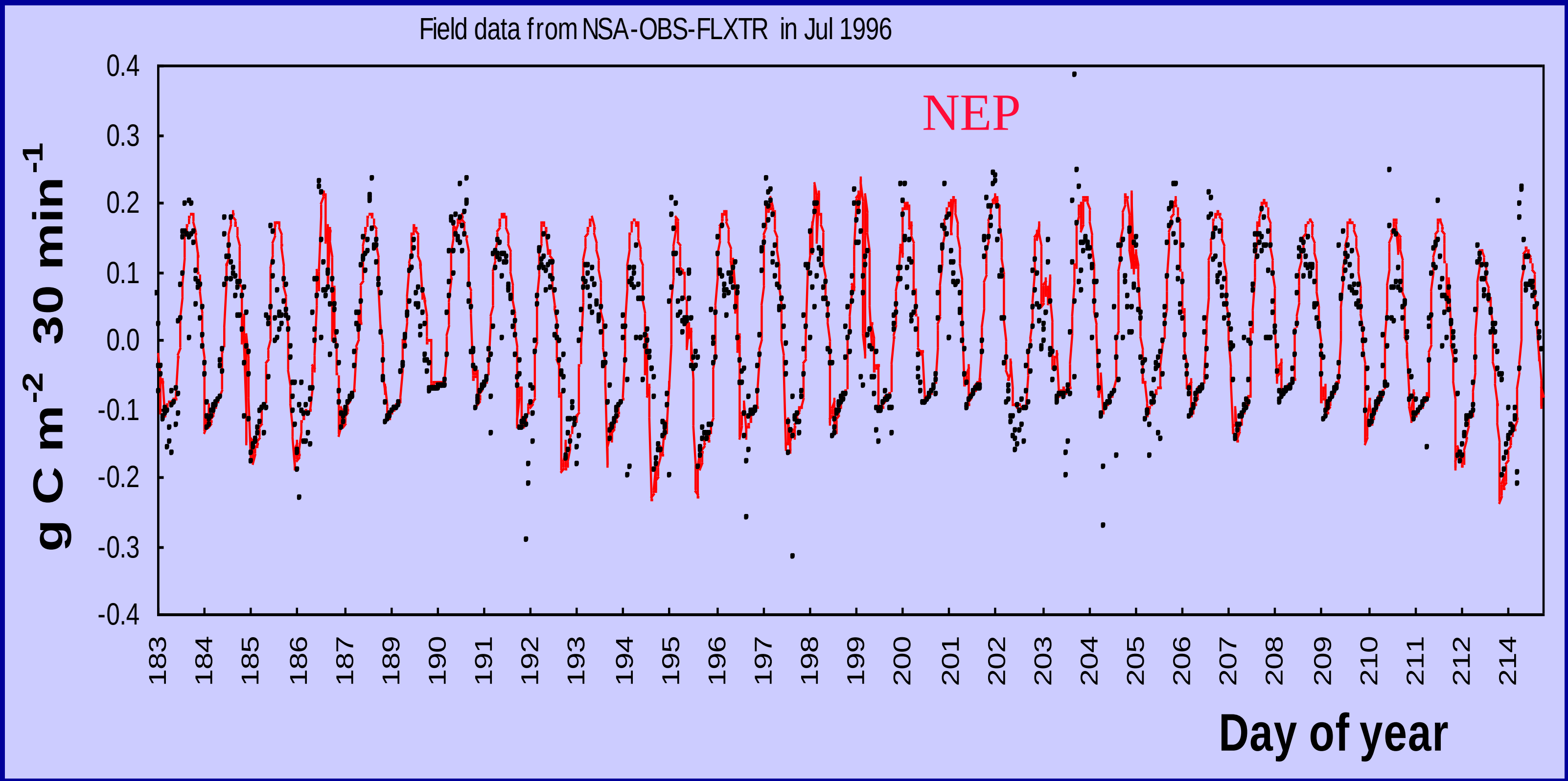
Boreal Mixedwood Site (Ontario)

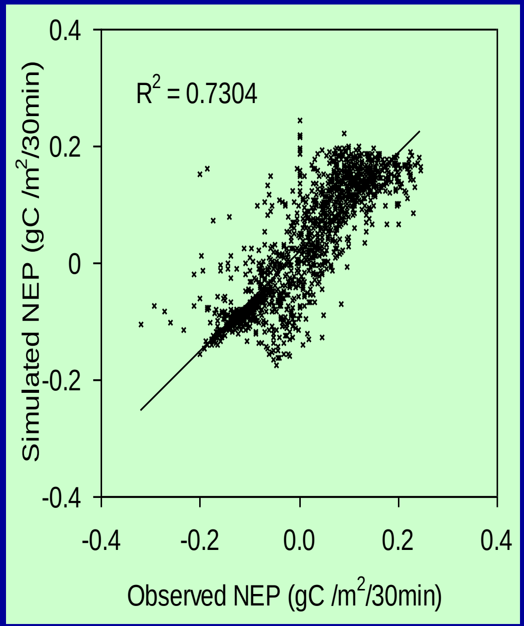




(Sun et al., 2008)

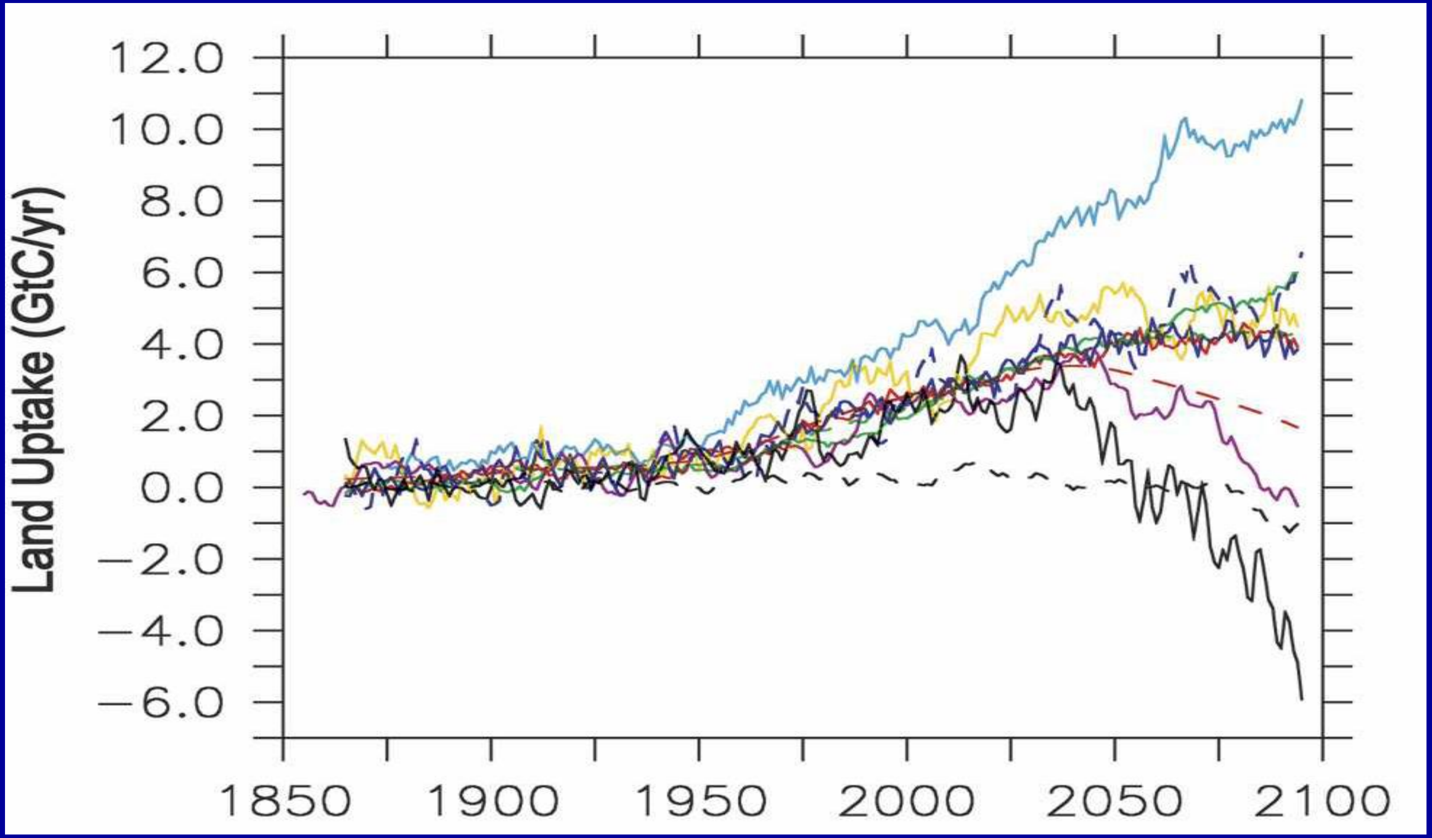
Model Validation – OBS Flux Tower





Daily Simulation using TRIPLEX-flux (Zhou et al, 2008)

Simulation Uncertainty



11 Models:

HadCM3LC
IPSL-CM2C
IPSL-CM4-LOOP
CSM-1
MPI
LLNL
FRCGC
UMD
UVic-2.7
CLIMBER
BERN-CC

Source: Friedlingstein et al., 2006

Parameters estimation and net ecosystem productivity prediction through model-data fusion approach for seven forest flux sites in North America (Zhou et al., submitted)

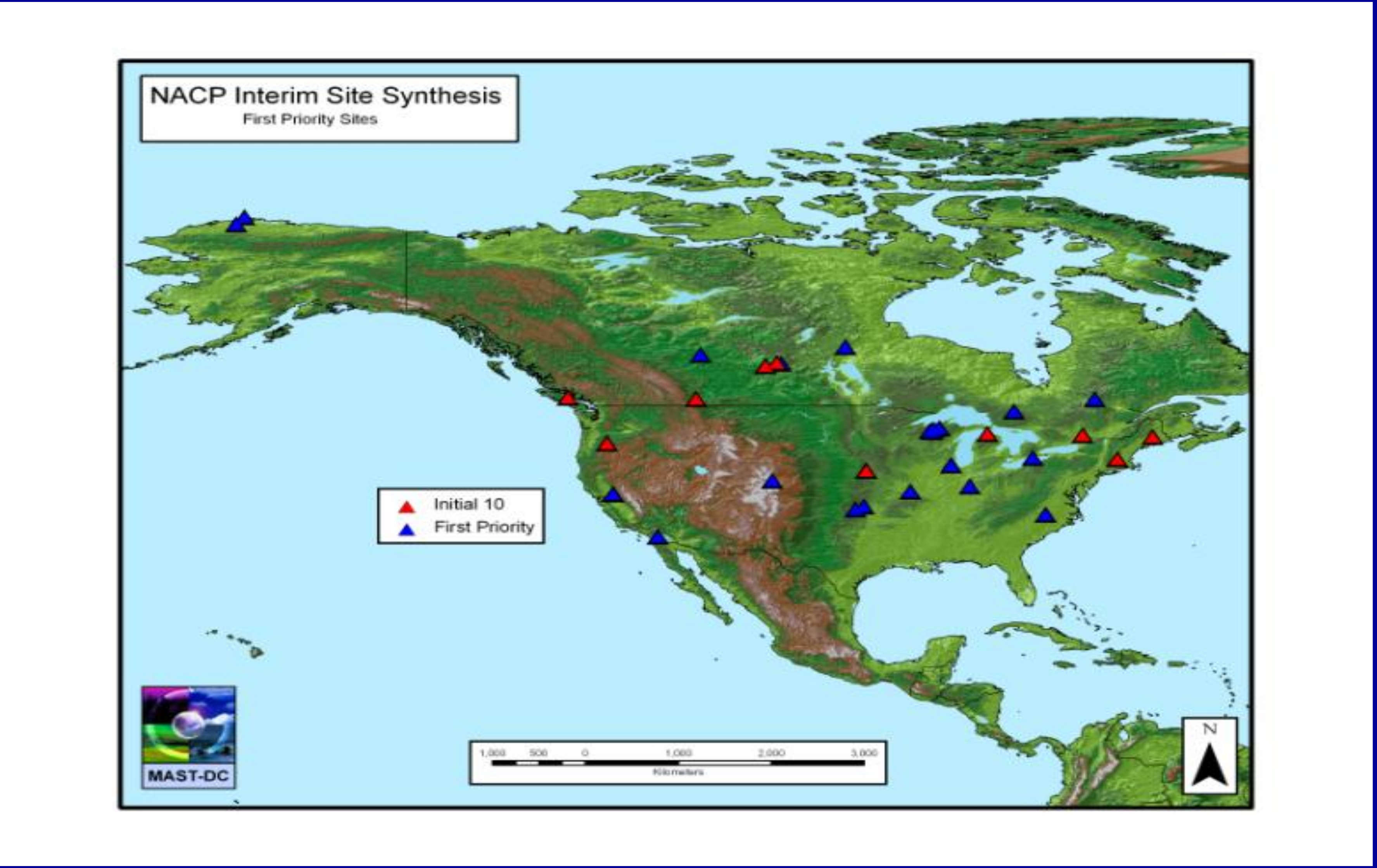
Objectives

- to estimate some key parameters using data assimilation approach;
- to test TRIPLEX-Flux model simulations against flux tower measurements;
- to understand the uncertainty of estimating carbon sequestration due to model parameters variation for different forests

Sources of Uncertainty

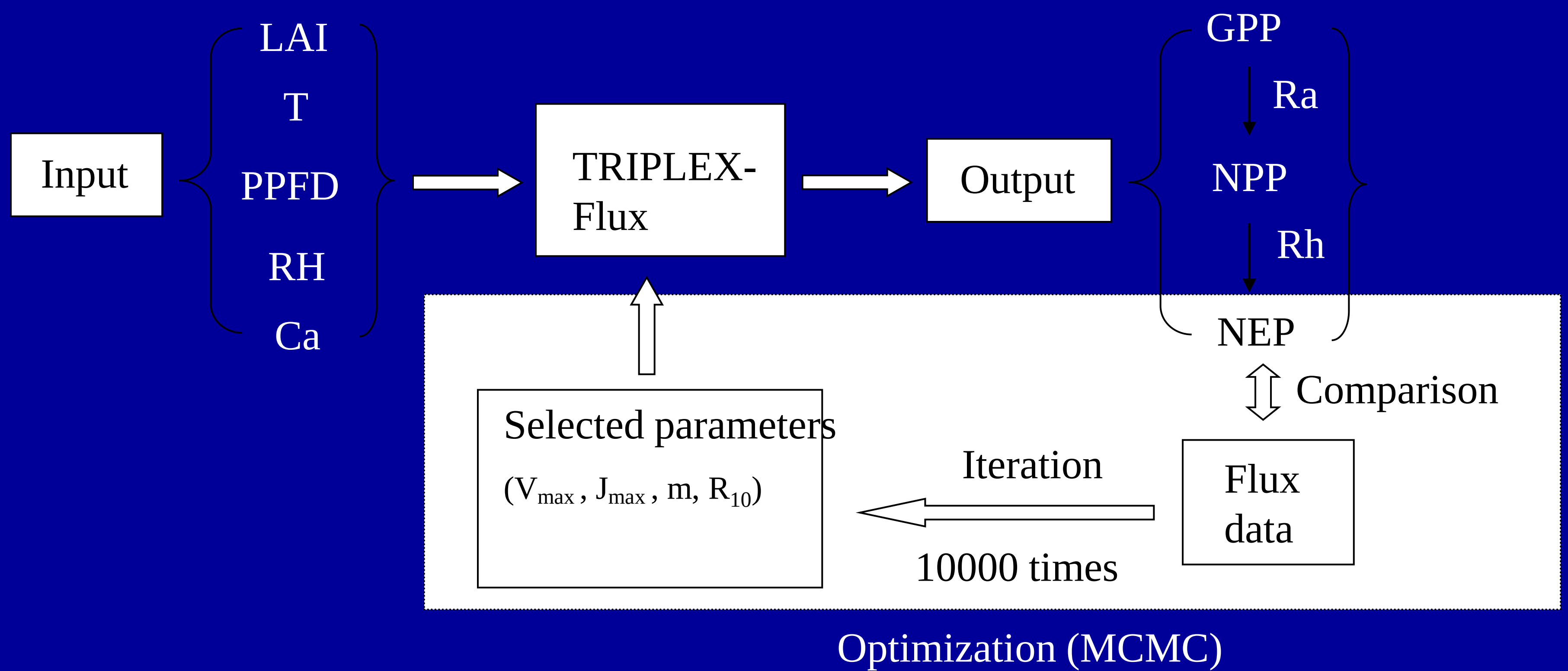
- basic model structure
- initial conditions (e.g.vegetation types, especially mixed)
- model parameters
- data input
- representation of natural and anthropogenic disturbance
  (e.g. regeneration after fire and cutting)
- scaling exercises
- knowledge limitation for ecosystem process

Flux Tower Sites



Davis et al, 2008, AGU

model-data assimilation

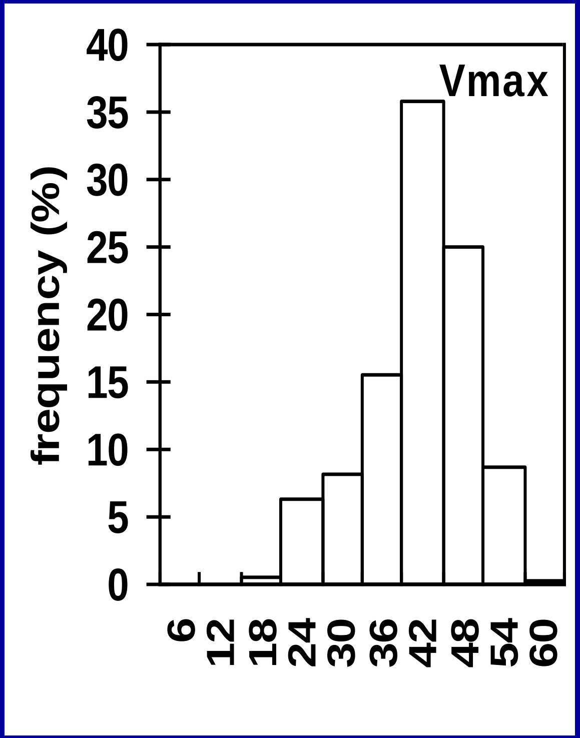


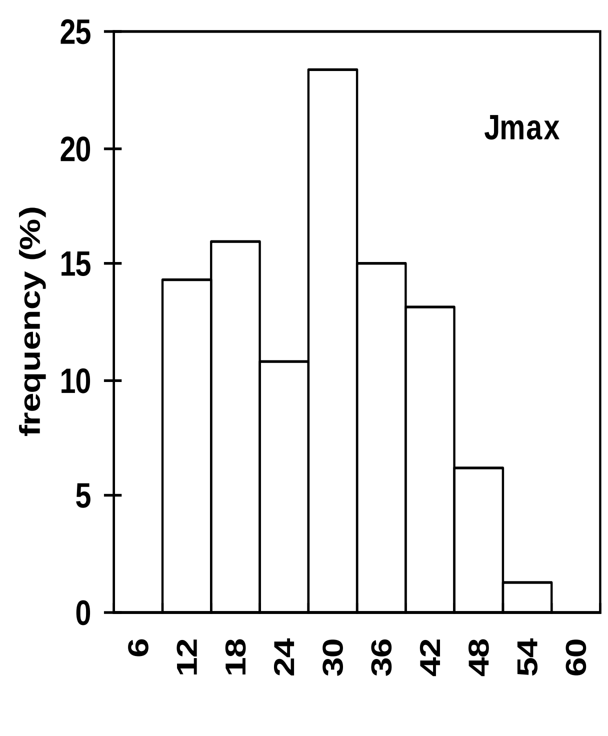
MCMC: Markov chain Monte Carlo

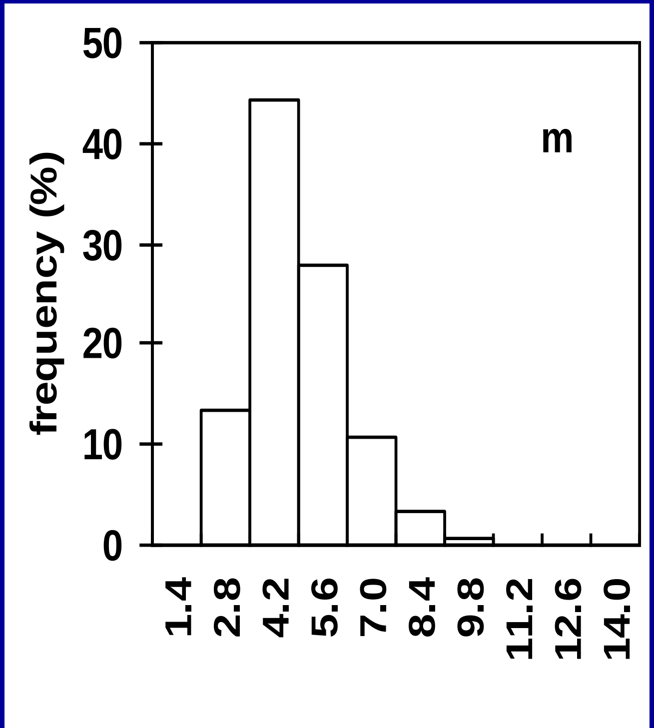
Selected Parameters

- V_{max} : maximum carboxylation rate at 25° C in the photosynthetic carbon cycle in leaf
- J_{max} : light-saturated rate of electron transport in the photosynthetic carbon cycle in leaf
- m : coefficient of stomatal conductance
- R_{10} : the reference respiration rate at 10 ºC

Maximum likelihood estimation

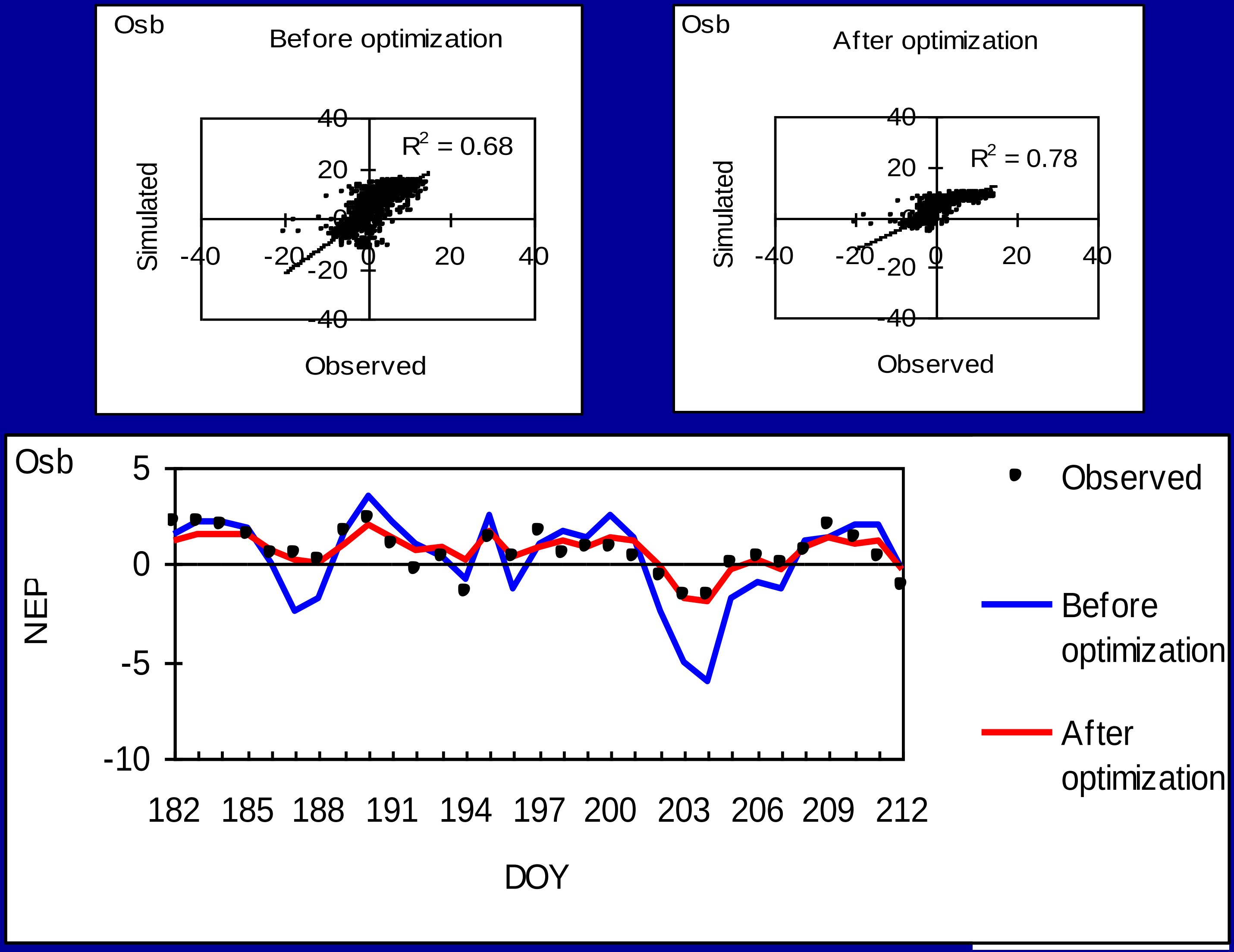






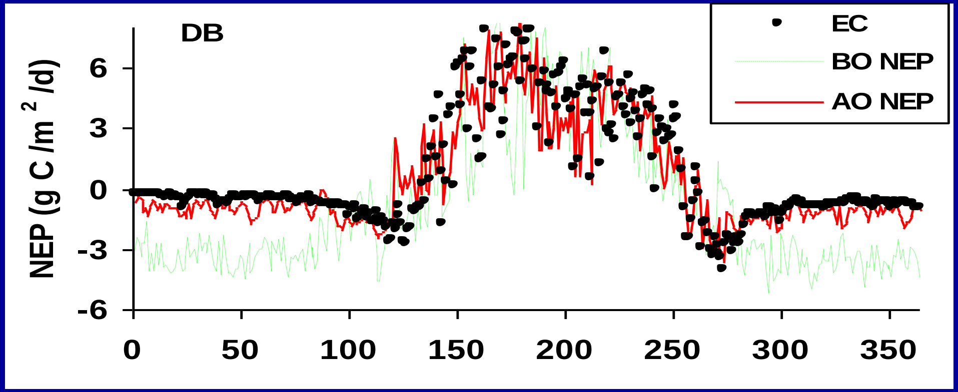
CA-OBS in July of 2006

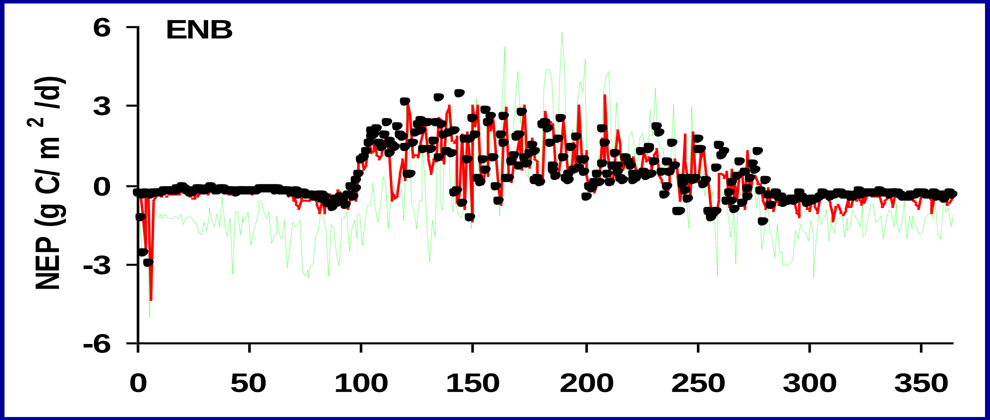
Model Parameter Optimization (MCMC)

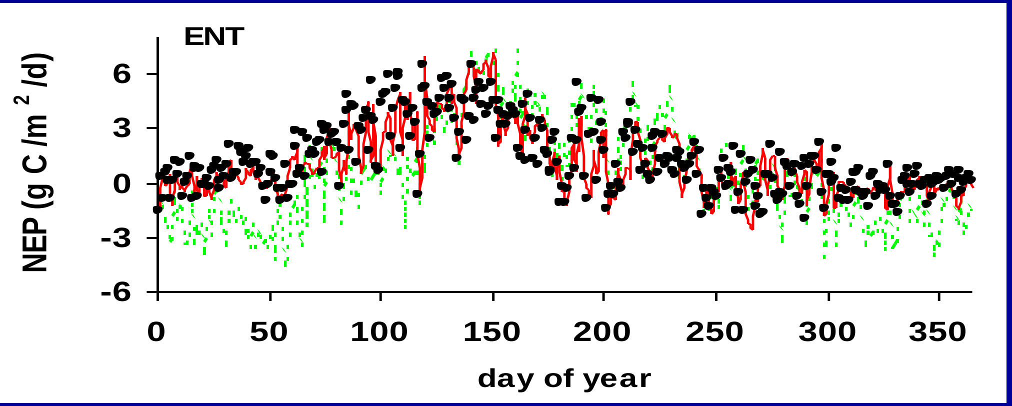


(Sun et al, in preparation)

NEP simulation



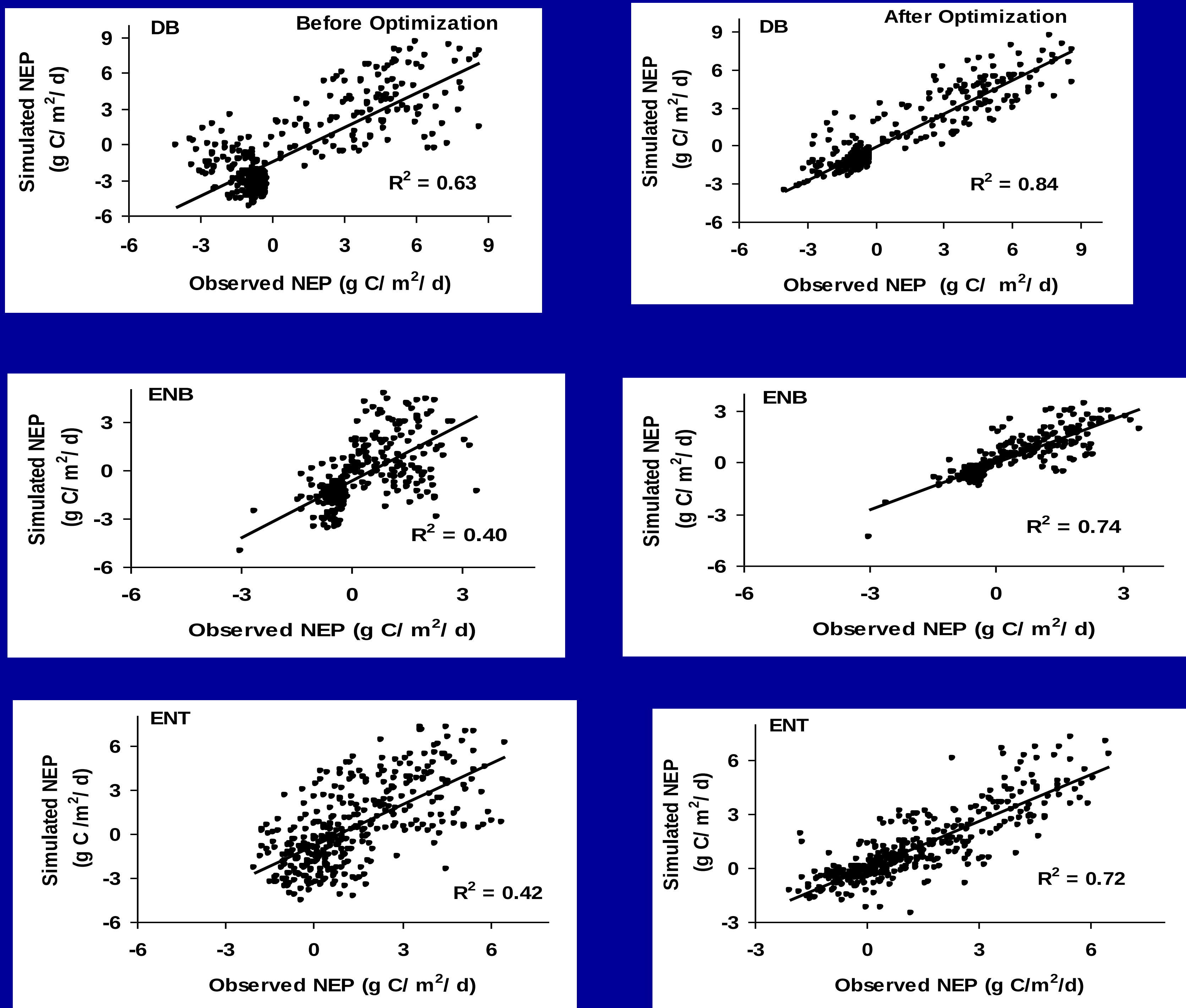




EC: eddy covariance, BO: before optimization, AO: after optimization

ENB = Evergreen needle-leaf boreal forest, ENT = evergreen needle-leaf temperate forest, DB = deciduous broad-leaf forest

for 2006

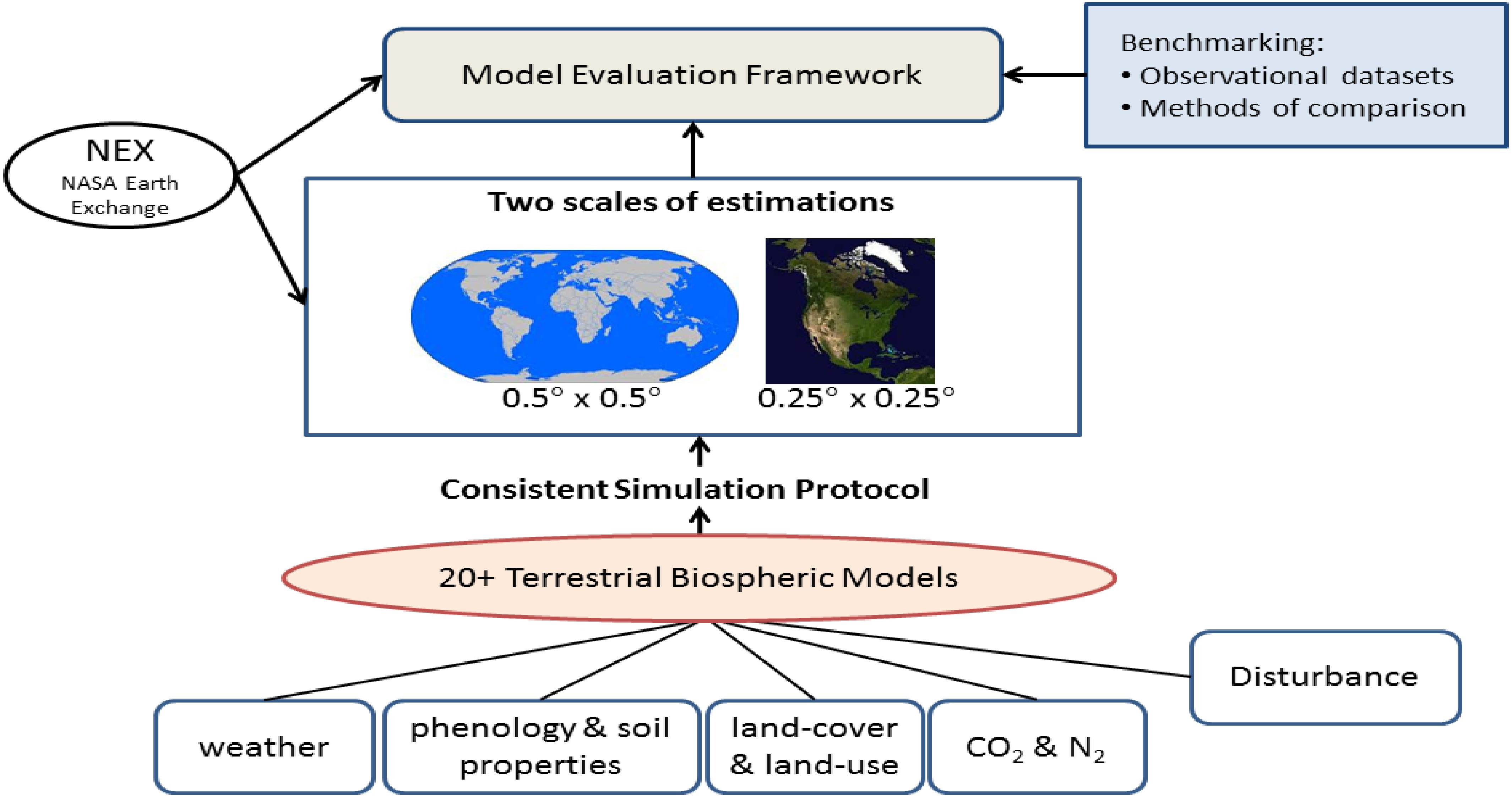

DB
Before Optimization
Simulated NEP (g C/ m2/ d)
Observed NEP (g C/ m2/ d)
R2 = 0.63
DB
After Optimization
Simulated NEP (g C/ m2/ d)
Observed NEP (g C/ m2/ d)
R2 = 0.84
ENB
Simulated NEP (g C/ m2/ d)
Observed NEP (g C/ m2/ d)
R2 = 0.40
ENB
Simulated NEP (g C/ m2/ d)
Observed NEP (g C/ m2/ d)
R2 = 0.74
ENT
Simulated NEP (g C /m2/ d)
Observed NEP (g C/ m2/ d)
R2 = 0.42
ENT
Simulated NEP (g C/ m2/ d)
Observed NEP (g C/m2/d)
R2 = 0.72

for 2006

The North American Carbon Program (NACP) Multi-Scale Synthesis and Terrestrial Model Intercomparison (MsTMIP) Project (http://nacp.ornl.gov/MsTMIP.shtml)

The overall goal of the MsTMIP is to

provide feedback to the terrestrial biospheric modeling community to improve the diagnosis and attribution of carbon sources and sinks across regional and global scales.



Model Evaluation Framework
Benchmarking:
• Observational datasets
• Methods of comparison
NEX
NASA Earth Exchange
Two scales of estimations
0.5° x 0.5°
0.25° x 0.25°
Consistent Simulation Protocol
20+ Terrestrial Biospheric Models
weather
phenology & soil properties
land-cover & land-use
CO_2 & N_2
Disturbance

MsTMIP Participants

- Over 19 different institutions
- Over 20 different models
  - ~6 dynamic vegetation models
  - ~9 models have prognostic fire
  - ~2 data assimilation models
- Most models participated in NACP site and/or regional interim synthesis activities

VEGAS	DLEM	CLM-VIC	ISAM
SIPNET	PRIPLEX-GHG	LPJ-wsl	Ecosys
MC1	CLASS-CTEM-N+	GEMS	ORCHIDEE
SiB	SiB-CASA	TEM	CLM-CN
Biome-BGC	IRC	ED	GTEC

+ multiple models out of JPL

MsTMIP **workshop 1** was held at NASA Ames Research Center on October 13th and 14th, 2011.

Next MsTMIP **workshop** will be held the beginning of March, 2012 (location TBD).

Terrestrial biospheric models participating in the MsTMIP activity

Model Name	**Affiliation (Team Contact)**	**Model Name**	**Affiliation (Team Contact)**
BIOMAP	Pacific NW Research Station (John Kim)	JULES	NASA Jet Propulsion Lab (Joshua Fisher)
Biome-BGC	NASA Ames (Weile Wang)	LPJ	Laboratoire des Sciences du Climat et l'Environnement (LSCE), France (Ben Poulter)
CABLE	NASA Jet Propulsion Lab (Joshua Fisher)	MC1	Oregon State University (Dominique Bachelet)
CLASS-CTEM-N+	McMaster University (Altaf Arain)	ORCHIDEE	NASA Jet Propulsion Lab (Joshua Fisher)
CLM	Oak Ridge National Lab (Dan Hayes)	ORCHIDEE	Laboratoire des Sciences du Climat et l'Environnement (LSCE), France (Shushi Peng)
CLM4-VIC	Pacific Northwest National Lab (Maoyi Huang)	SiB3.1	Colorado State University (Ian Baker)
DLEM	Auburn University (Hanqin Tian)	SiB3	NASA Jet Propulsion Lab (Joshua Fisher)
ED	University of Maryland (George Hurtt)	SiBCASA	National Snow and Ice Data Center (Kevin Schaefer)
GEMS	USGS (Shuguang liu)	SIPNET	Applied GeoSolutions, LLC (Rob Braswell)
GTEC	Oak Ridge National Lab (Dan Riccuito)	TEM	Oak Ridge National Lab (Dan Hayes)
Hyland	NASA Jet Propulsion Lab (Joshua Fisher)	TRIPLEX-GHG	University of Quebec at Montreal (Chanqhui Peng)
IRC/DayCent5	Colorado State University (Tom Hilinski)	VEGAS	University of Maryland (Ning Zeng)
	[illegible]		[illegible]

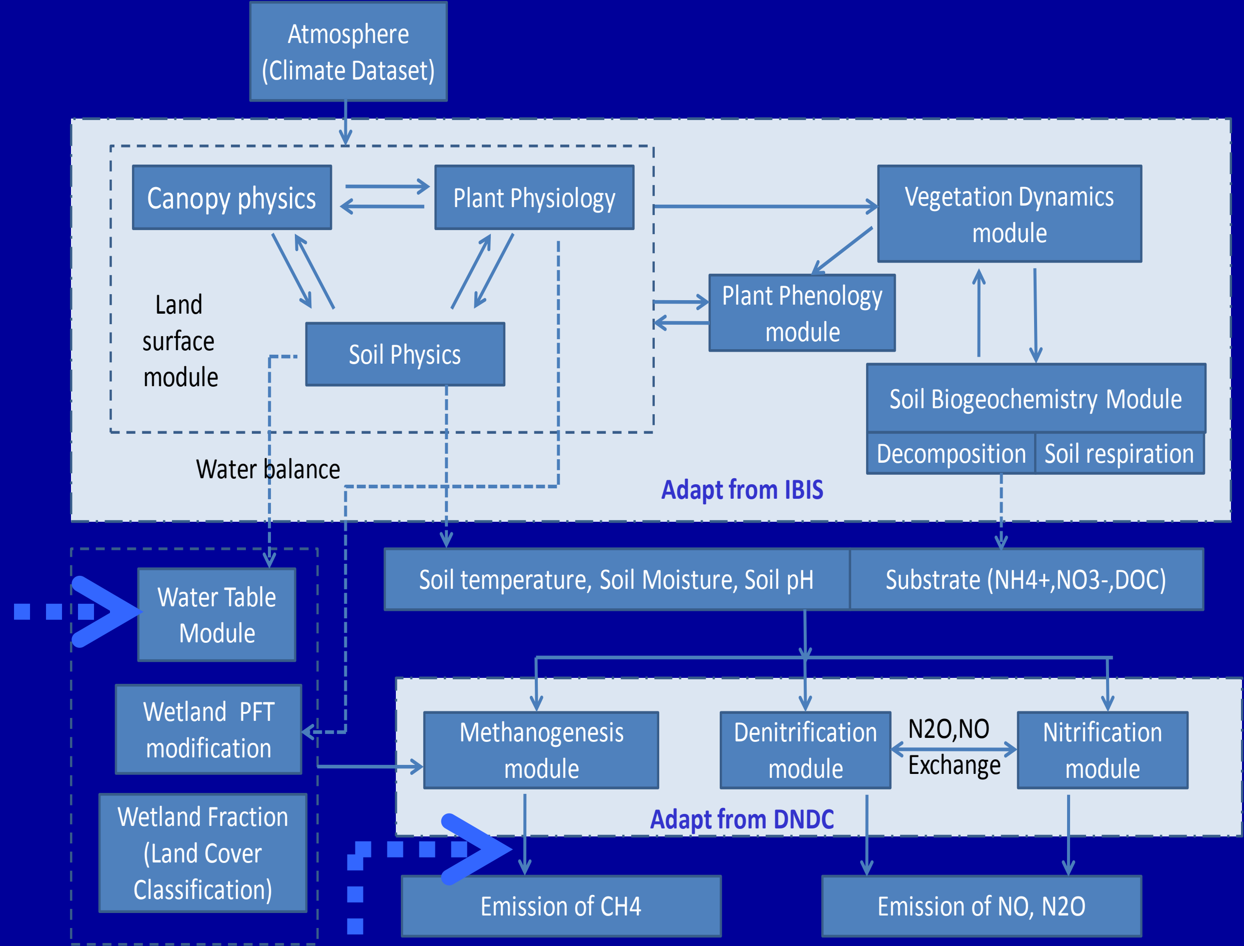
Ten Simulations (1801-2010)

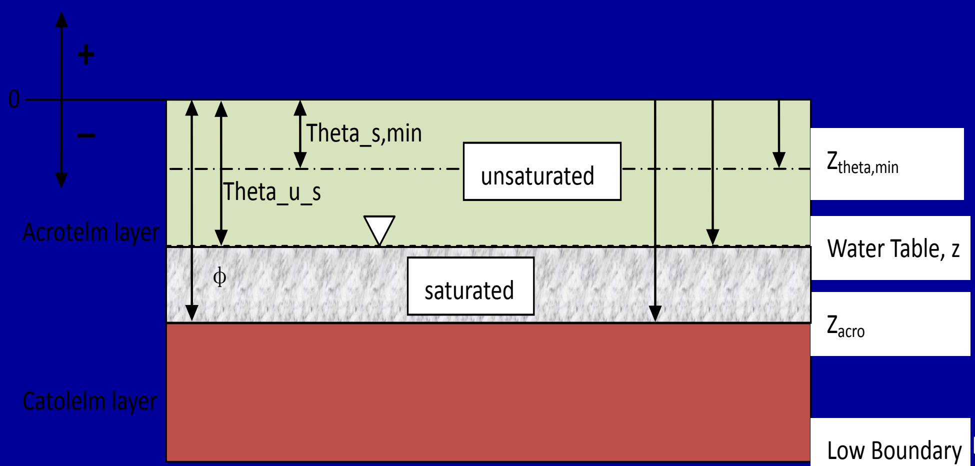
Order	Domain	Code	Climate	LULUC	Atm. CO_2	Nitrogen
1	Global 	RG1	Constant	Constant	Constant	Constant
2		SG1	CRU+NCEP			
3		SG2		Hurtt et al.		
4		SG3			Observed	
5		BG1				Observed
6	North Amer. 	RR1	Constant	Constant	Constant	Constant
7		SR1	NARR			
8		SR2		Hurtt et al.	Observed	
9		SR3				
10		BR1				Observed

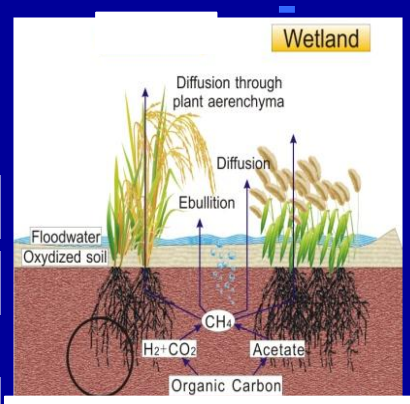
Framework of integrating trace greenhouse gas emission processes into

TRIPLEX- GHG (DGVM)

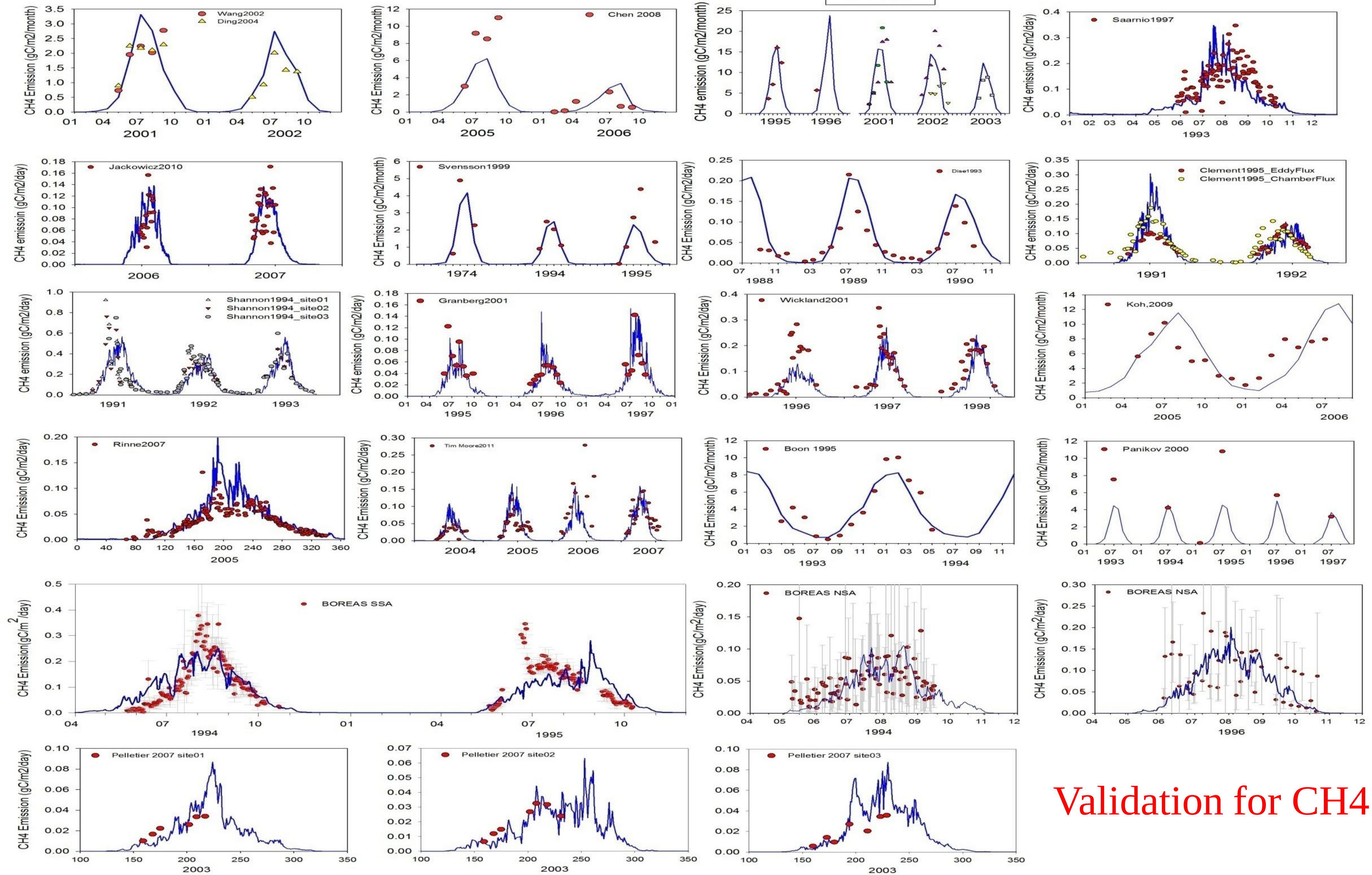
(under development)





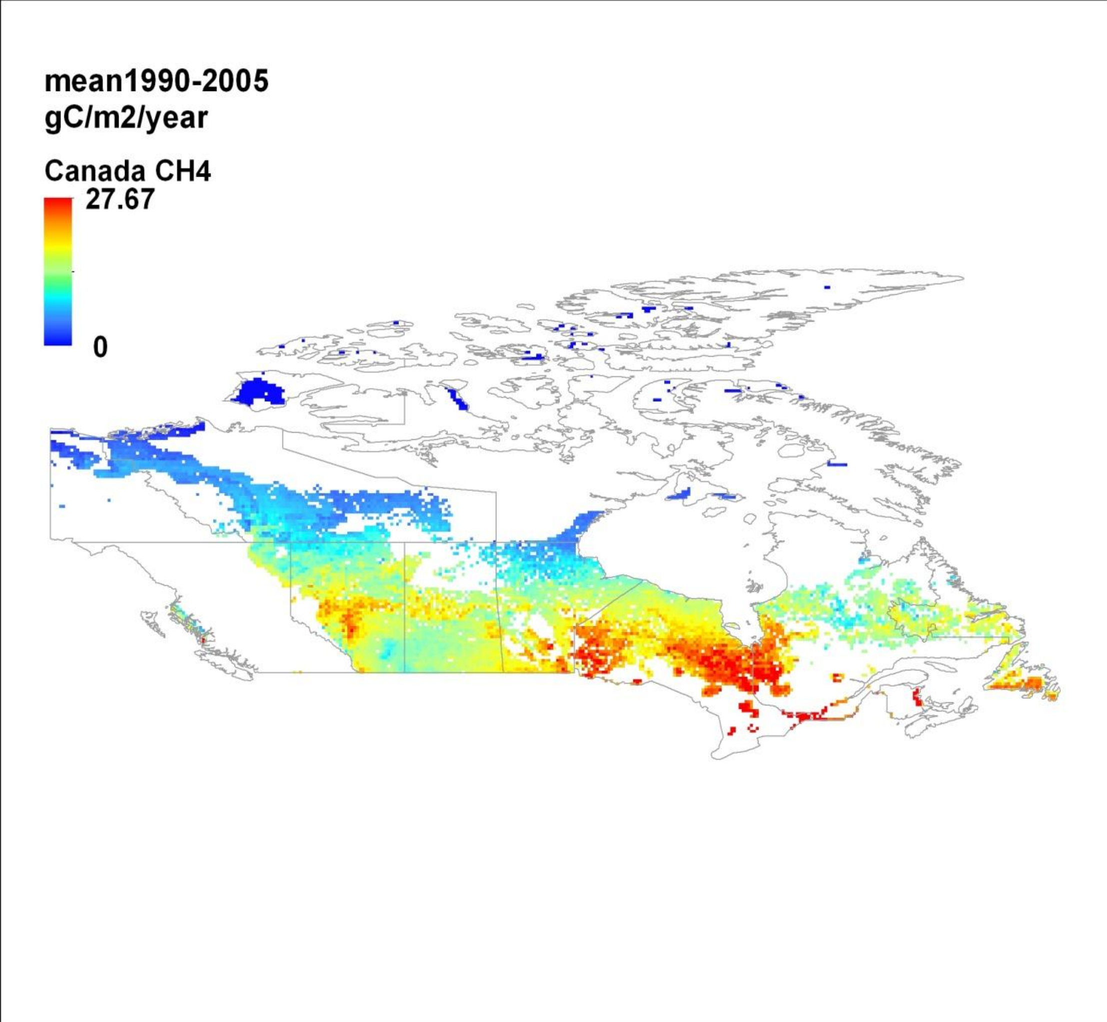


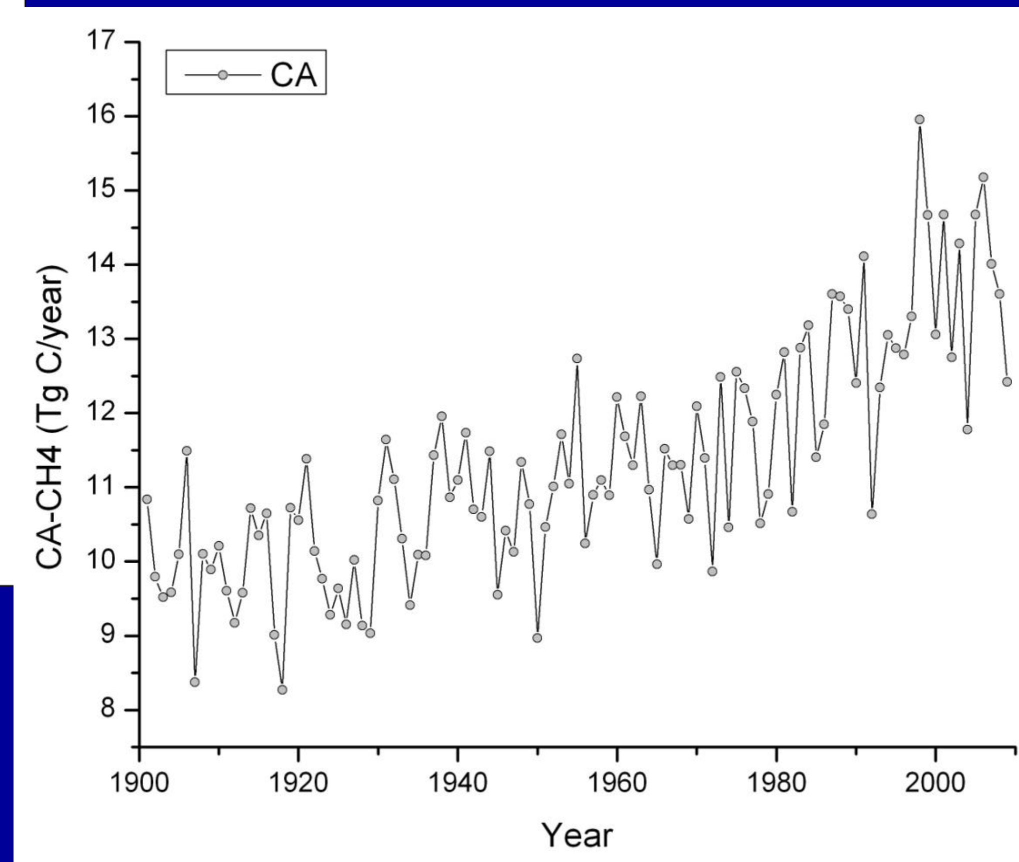
(Zhu et al., in prepa.)



Validation for CH4

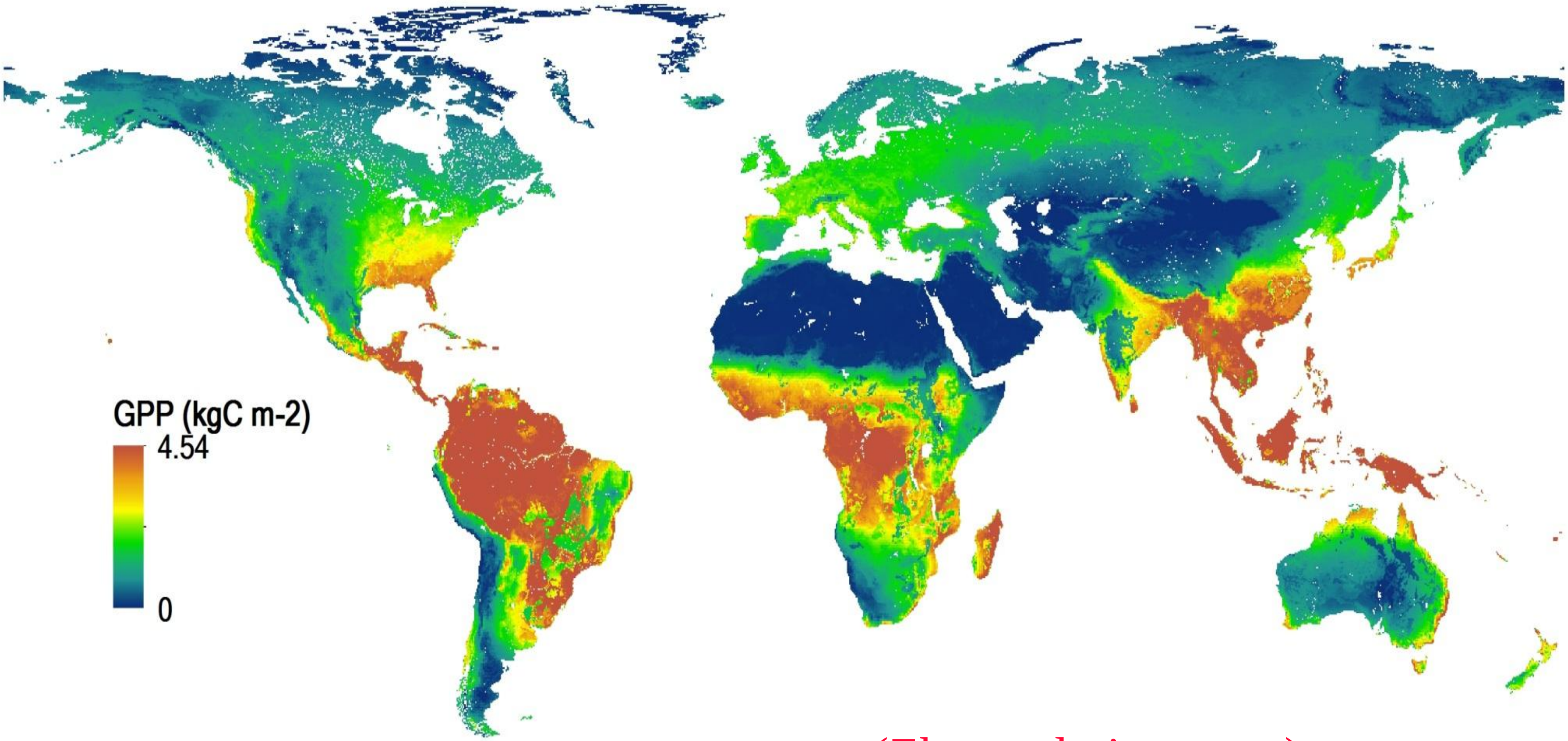
(Zhu et al., in prepa.)





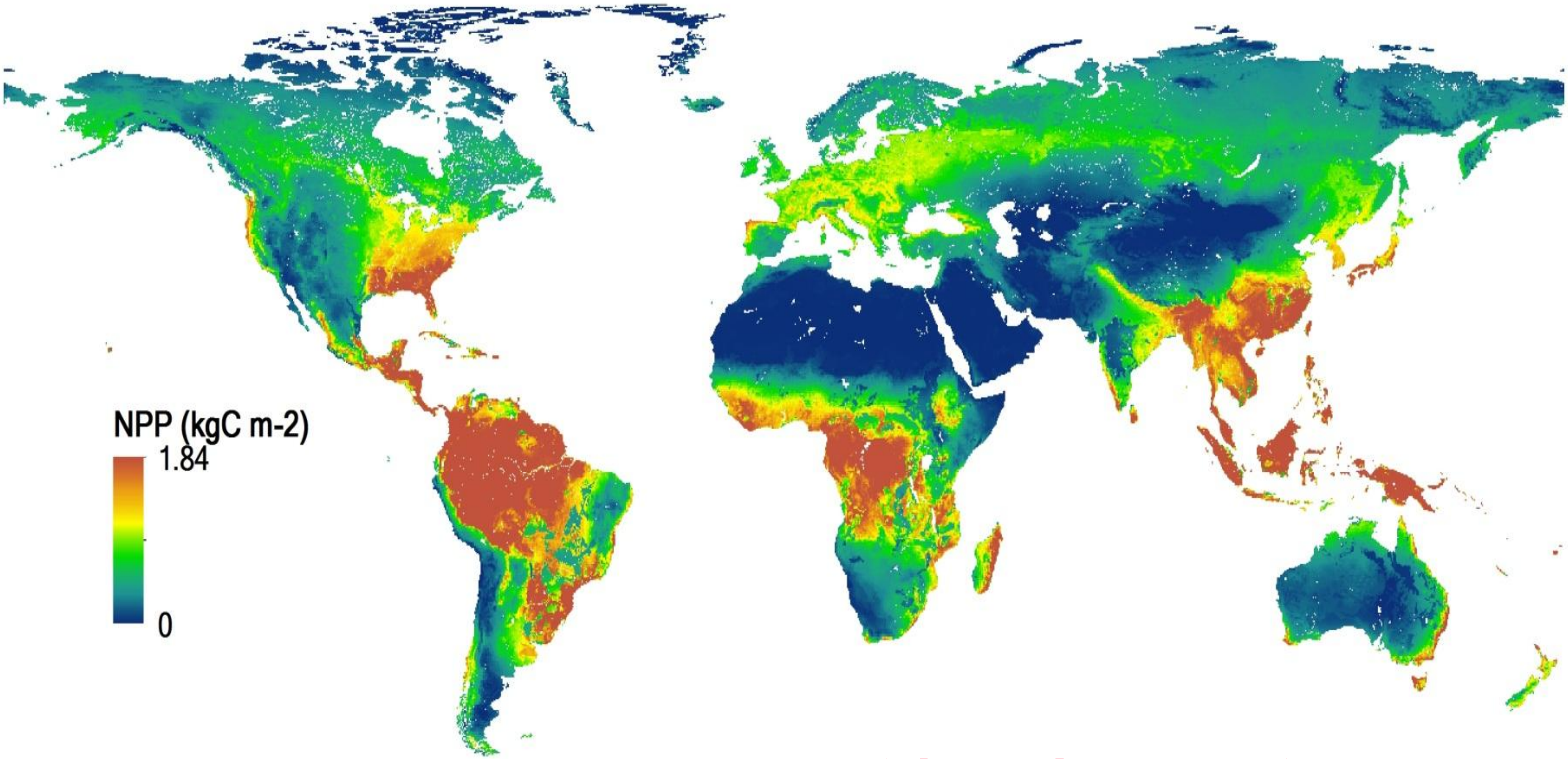
(Peng et al., in prepa.)

Mean Annual GPP (1980-2010)



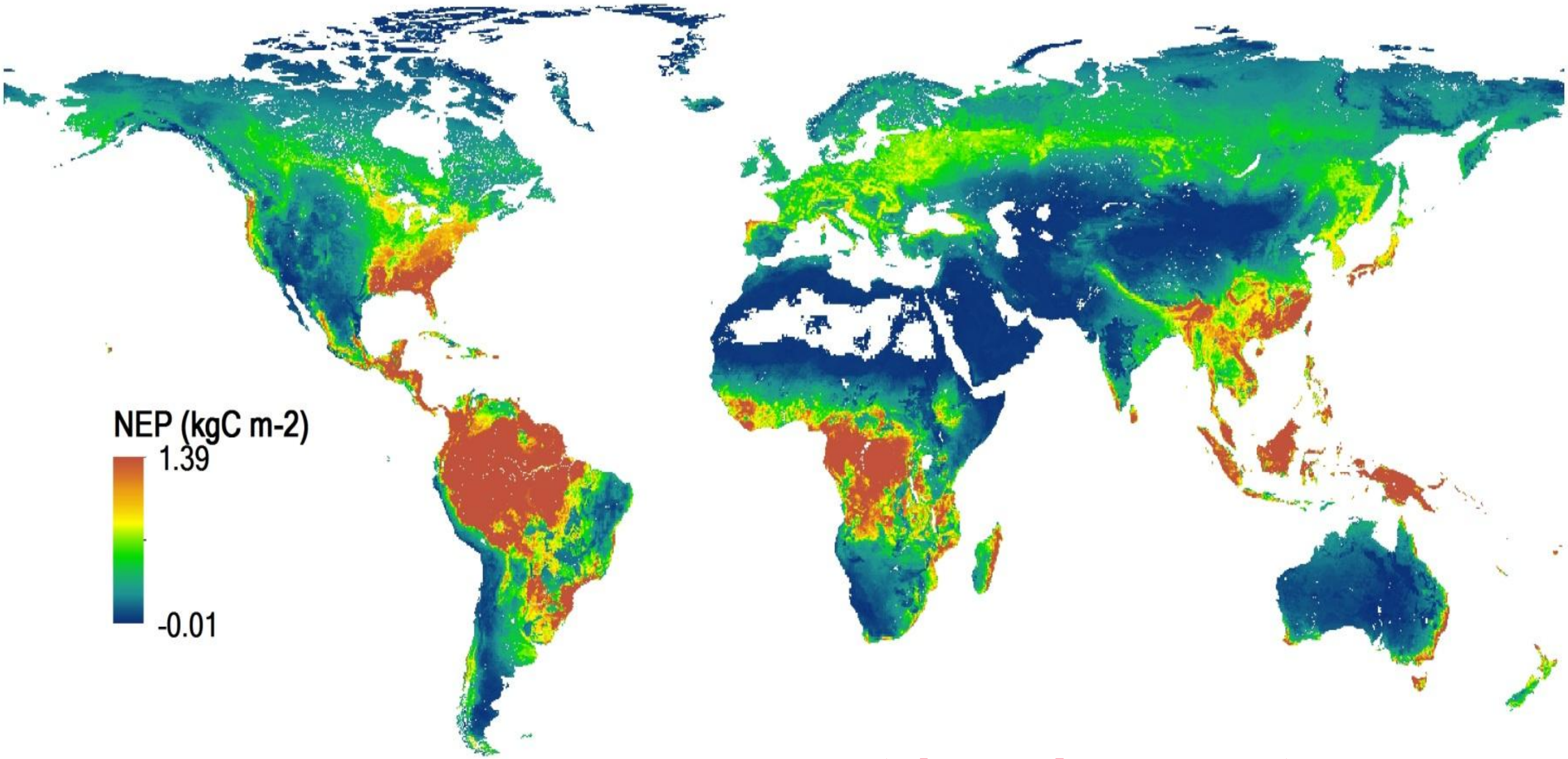
(Zhu et al., in prepa.)

Mean Annaul NPP (1980-2010)



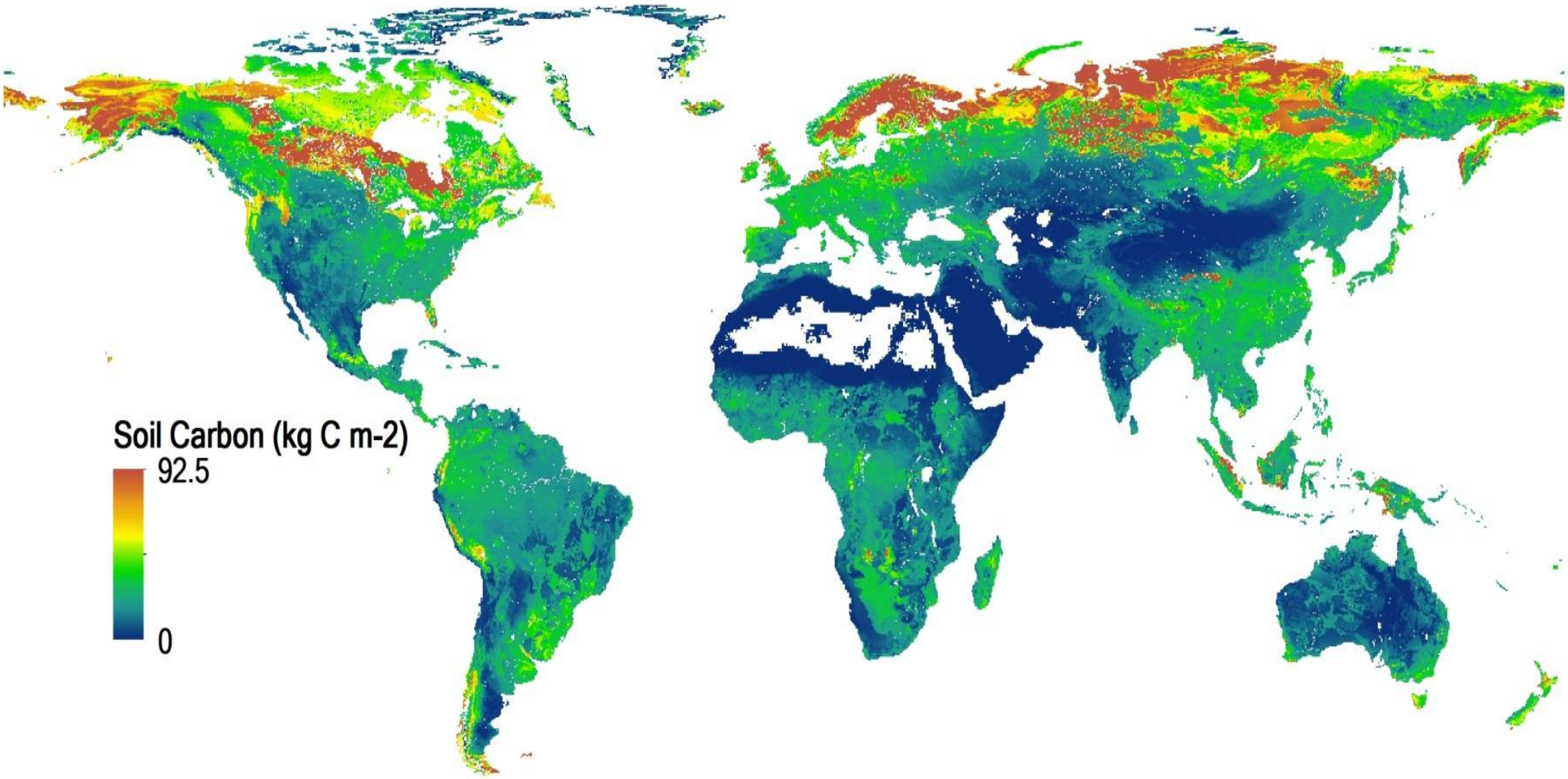
(Zhu et al., in prepa.)

Mean Annual NEP (1980-2010)



(Zhu et al., in prepa.)

Soil Carbon



(Zhu et al., in prepa.)

Challenges for TRIPLEX Development

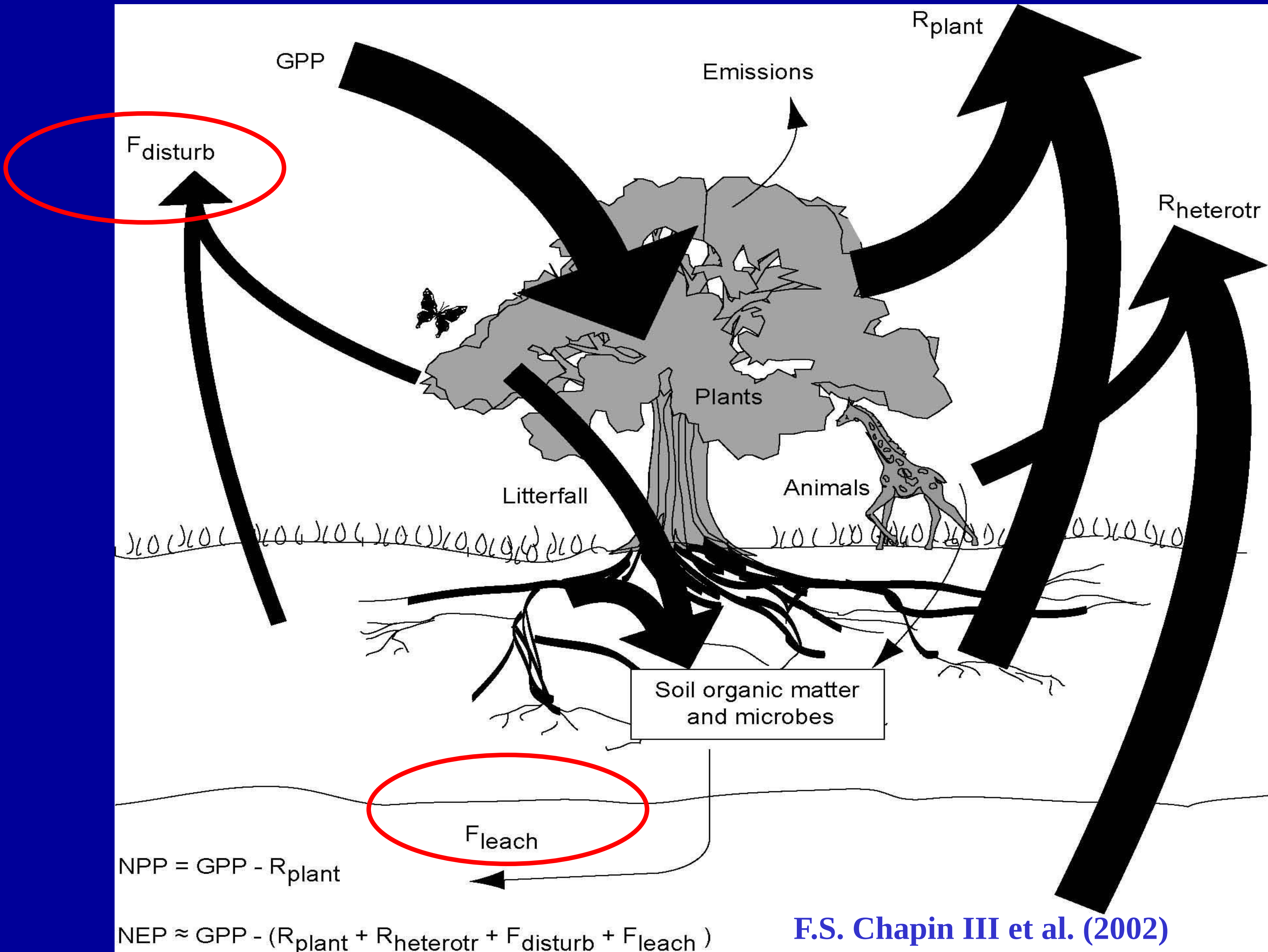
- Continued testing of the model's ability to belowground biomass, soil C, N and water (BOREAS sites as well as Canada-Fluxnet)

- Developing new submodels (TRIPLEX-Fire, TRIPLEX-DOC, TRIPLEX-management) to include the effects of ecosystem disturbances (fire, harvesting, insects, disease), land use, and forest management planning

- Linking terrestrial ecosystem with aquatic ecosystem : TRIPLEX-Aquatic

- Integrating trace greenhouse gas emission processes into TRIPLEX model (TRIPLEX-GHG, TRIPLEX-DGVM)

Uncertainty in Ecosystem Carbon Budget

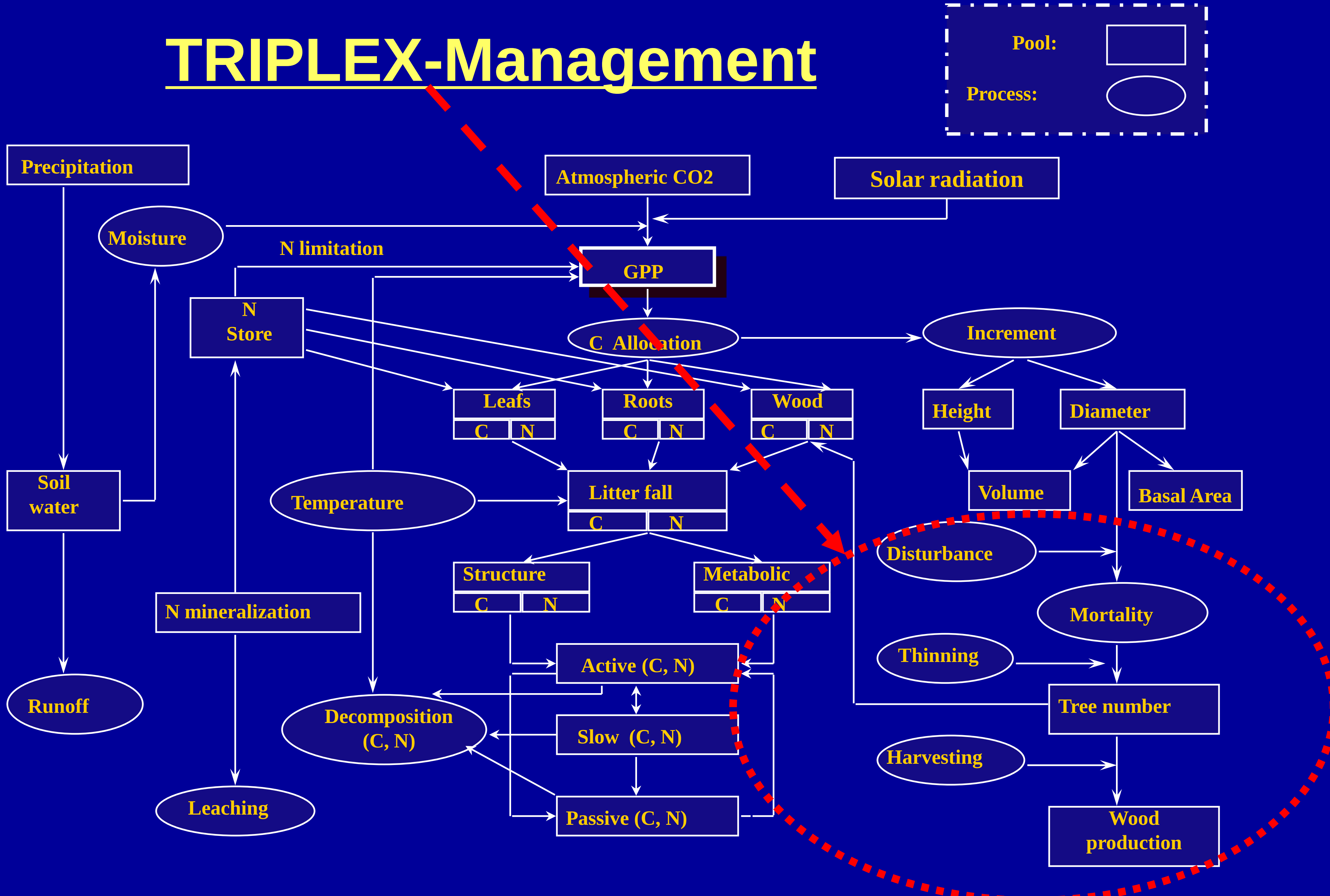


F.S. Chapin III et al. (2002)

Accidental mortality after disturbances

Des infestations et des maladies
fréquentes après perturbation

TRIPLEX-Management



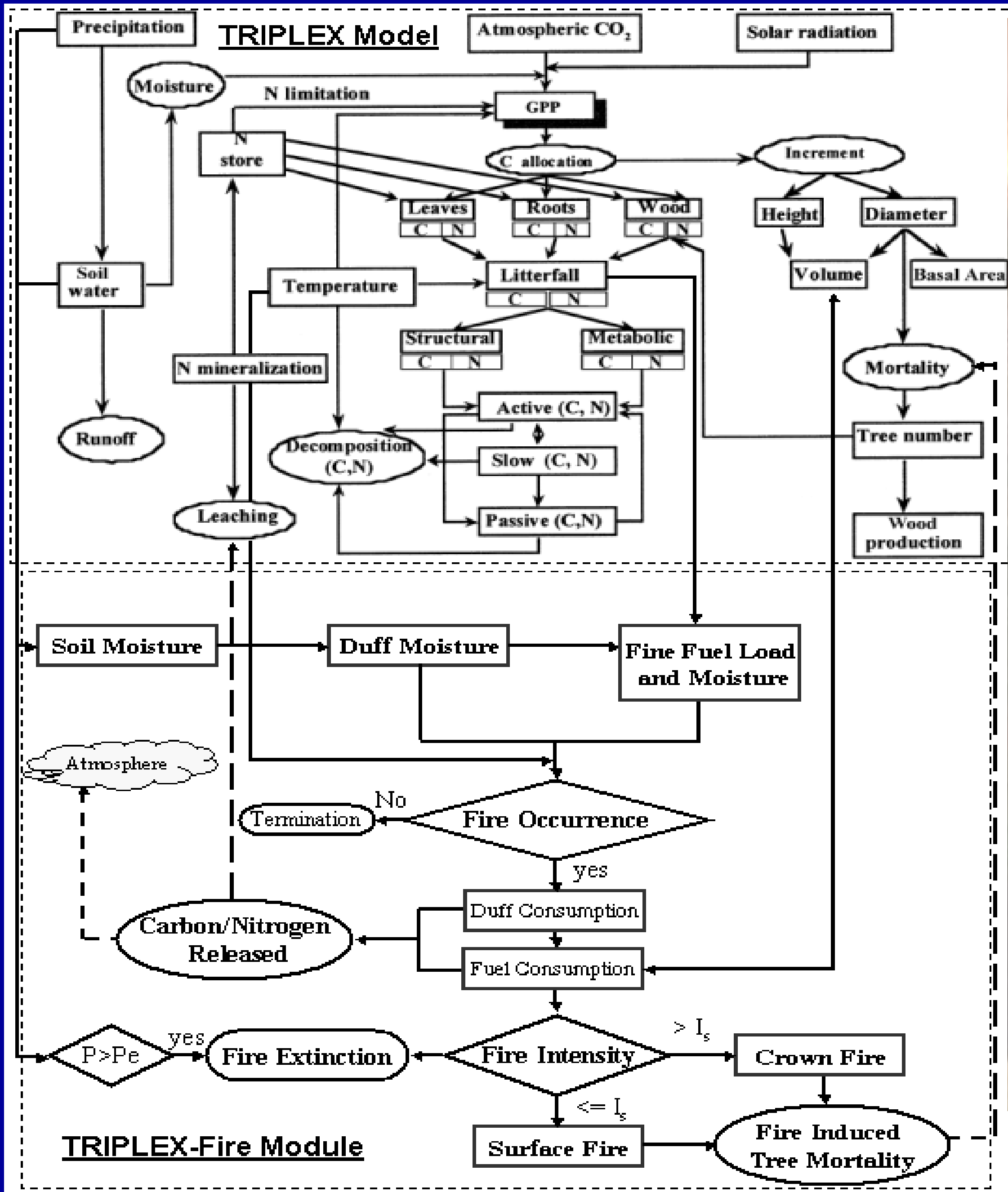
Disturbance

Disturbance is a cause of carbon loss from many ecosystems

Fire and harvest of plants or peat can be the dominant Avenues of carbon losses from ecosystems:

Carbon losses during fires in the Canadian boreal forests

= 10 to 30% of average NPP
(Harden et al., 2000, GCB)

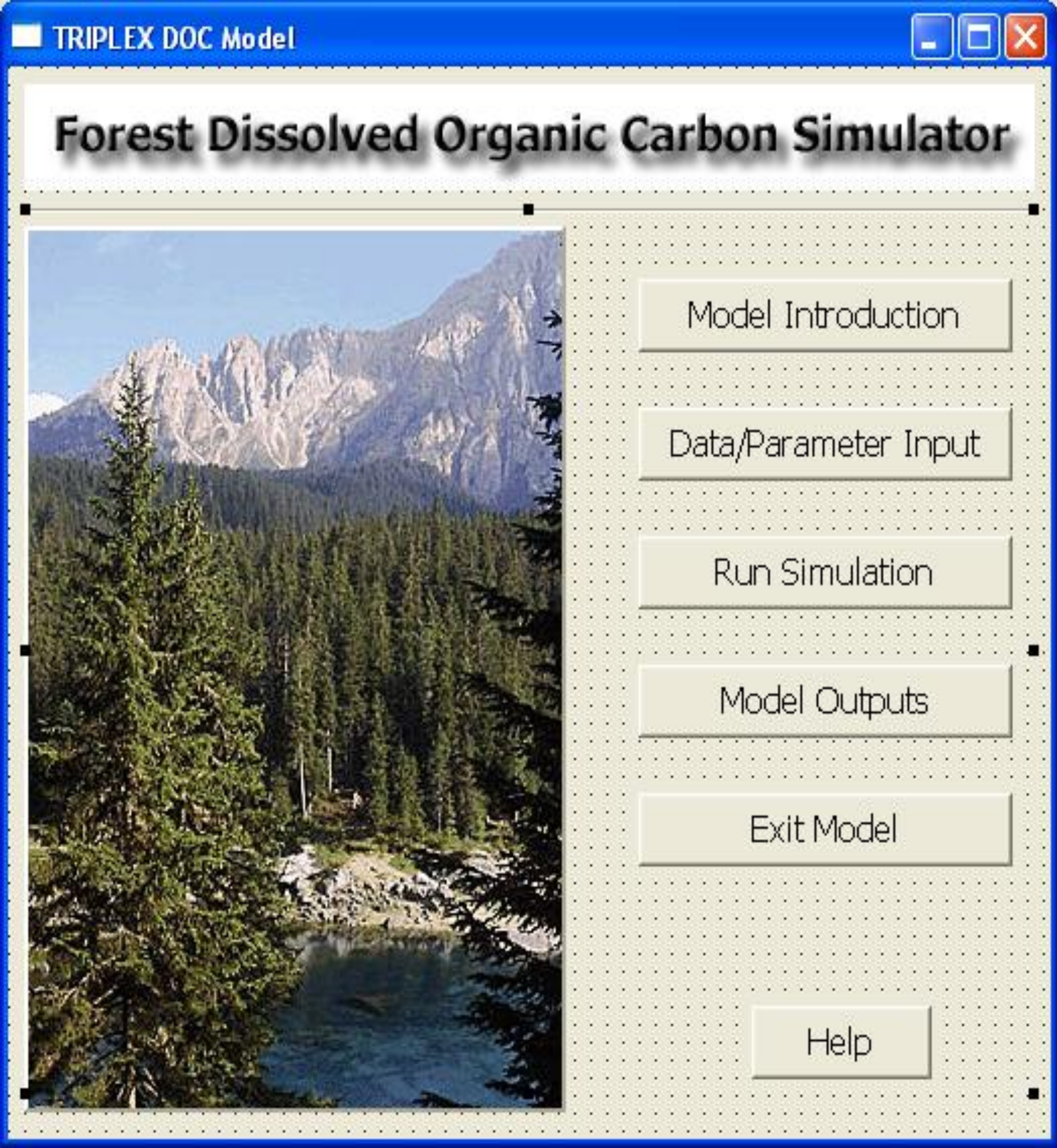


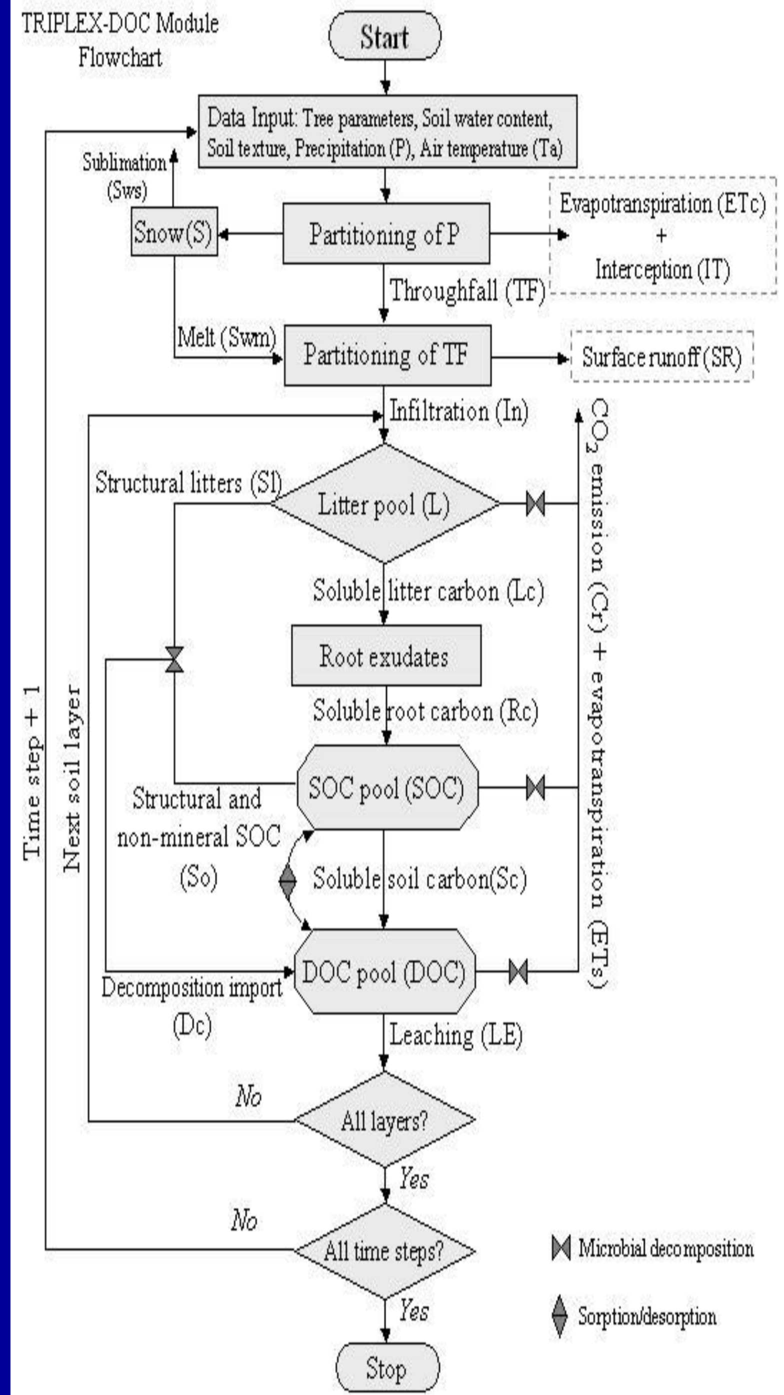
Ongoing: TRIPLEX-Fire Model

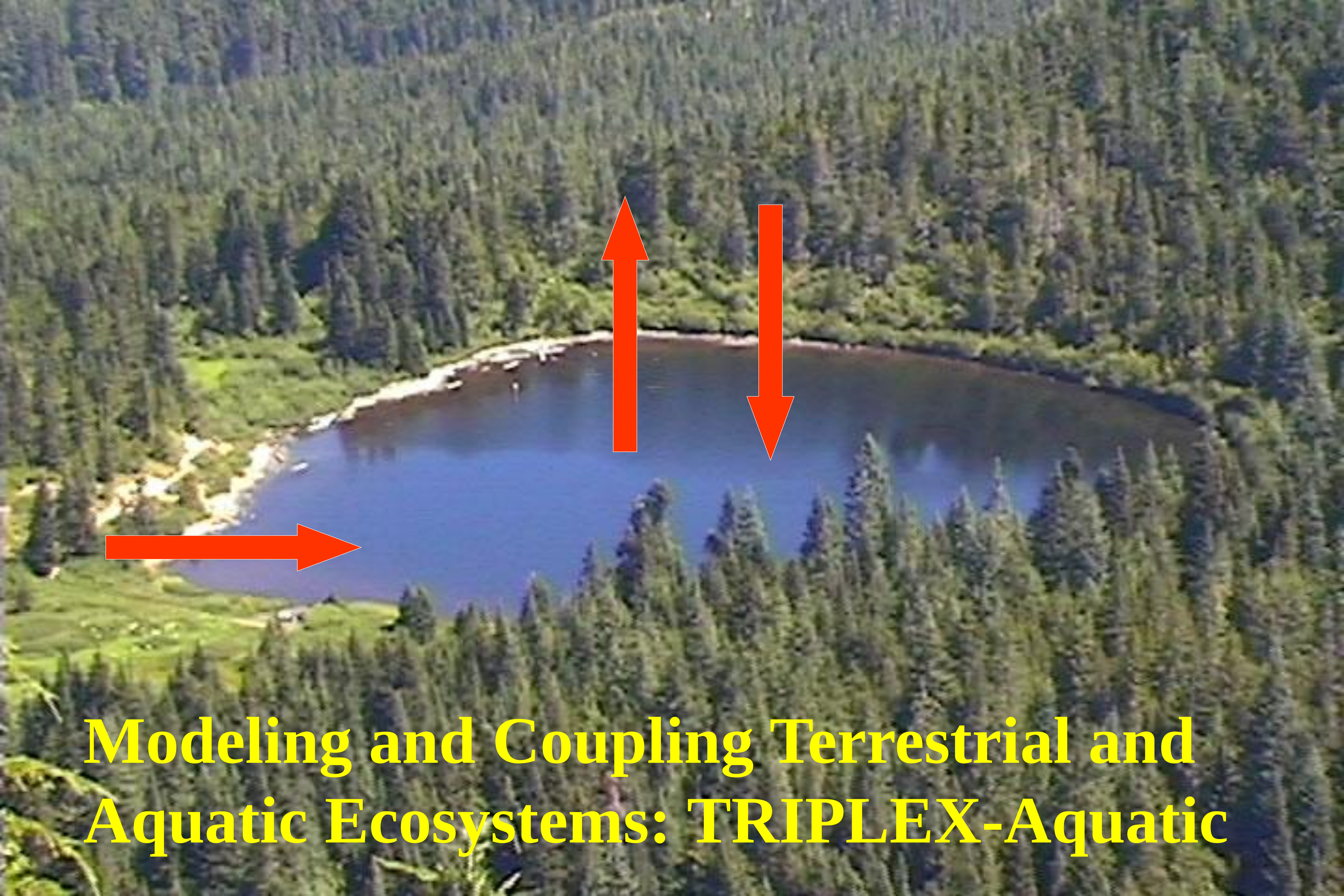
DOC is still missing in current ecosystem carbon budget

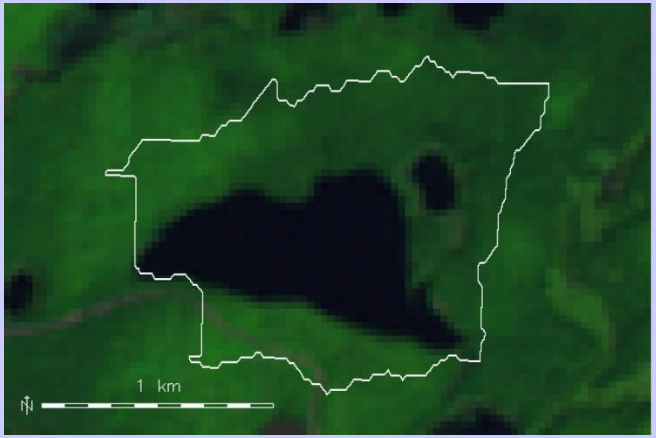
DOC is poorly represented in most terrestrial carbon models

Within forested ecosystem, DOC leaching from the forest floor and organic soil horizons ranges from **10 to 85 g m^{-2} yr^{-1}** (Neff and Asner, 2000)


TRIPLEX DOC Model
Forest Dissolved Organic Carbon Simulator
Model Introduction
Data/Parameter Input
Run Simulation
Model Outputs
Exit Model
Help


TRIPLEX-DOC Module Flowchart
Start
Data Input: Tree parameters, Soil water content, Soil texture, Precipitation (P), Air temperature (Ta)
Sublimation (Sws)
Snow (S)
Partitioning of P
Evapotranspiration (ETc) + Interception (IT)
Throughfall (TF)
Melt (Swm)
Partitioning of TF
Surface runoff (SR)
Infiltration (In)
Structural litters (Sl)
Litter pool (L)
Soluble litter carbon (Lc)
Root exudates
Soluble root carbon (Rc)
Structural and non-mineral SOC (So)
SOC pool (SOC)
Soluble soil carbon (Sc)
Decomposition import (Dc)
DOC pool (DOC)
Leaching (LE)
CO2 emission (Cr) + evapotranspiration (ETs)
Time step + 1
Next soil layer
No
All layers?
Yes
No
All time steps?
Yes
Stop
Microbial decomposition
Sorption/desorption


Modeling and Coupling Terrestrial and
Aquatic Ecosystems: TRIPLEX-Aquatic



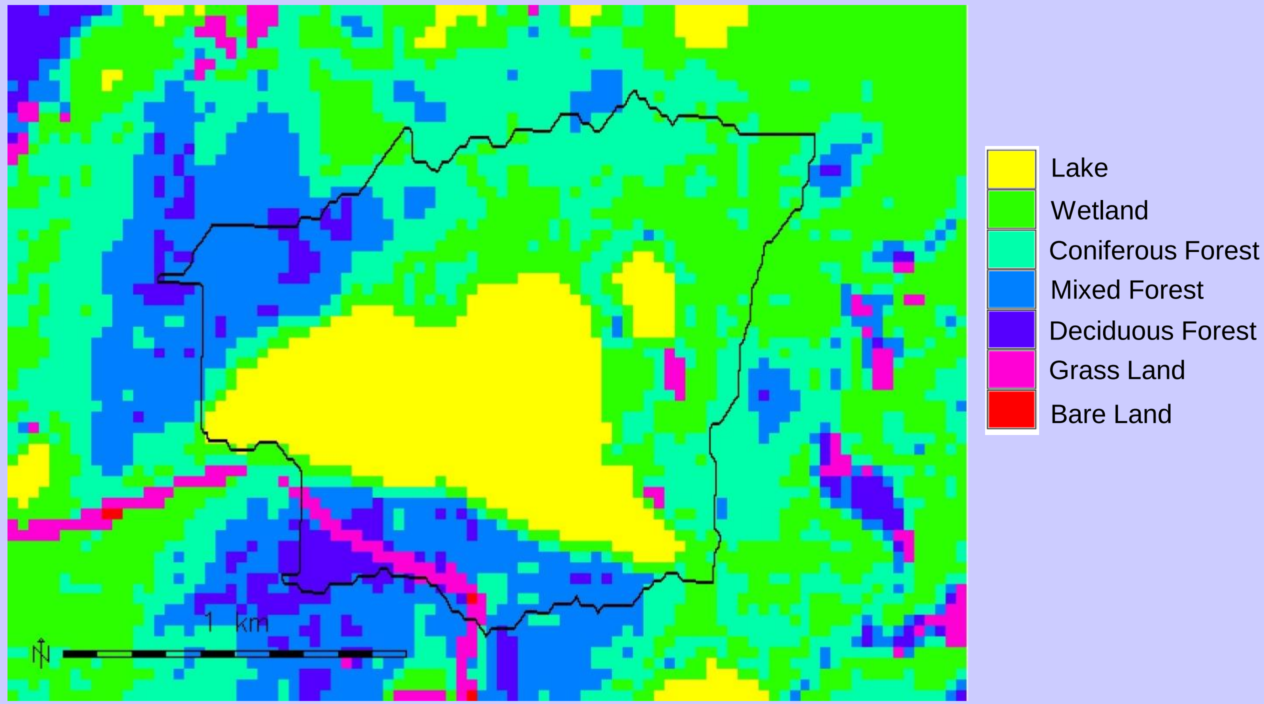
Lake Mary

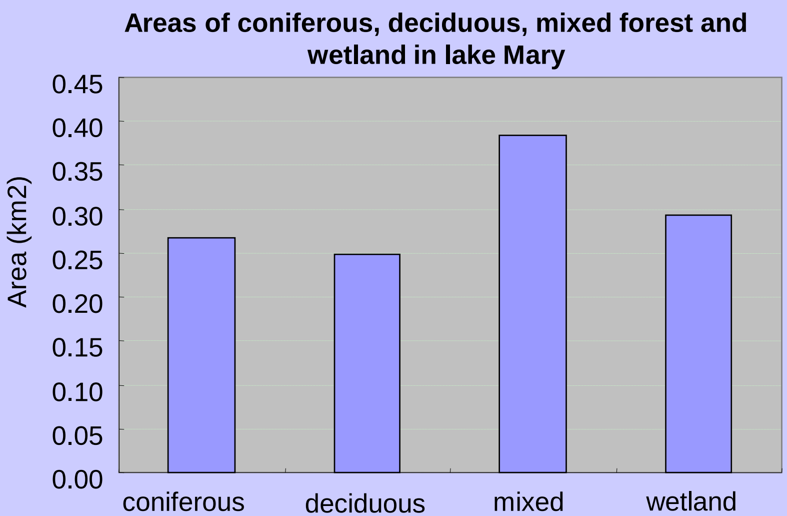
Condition:

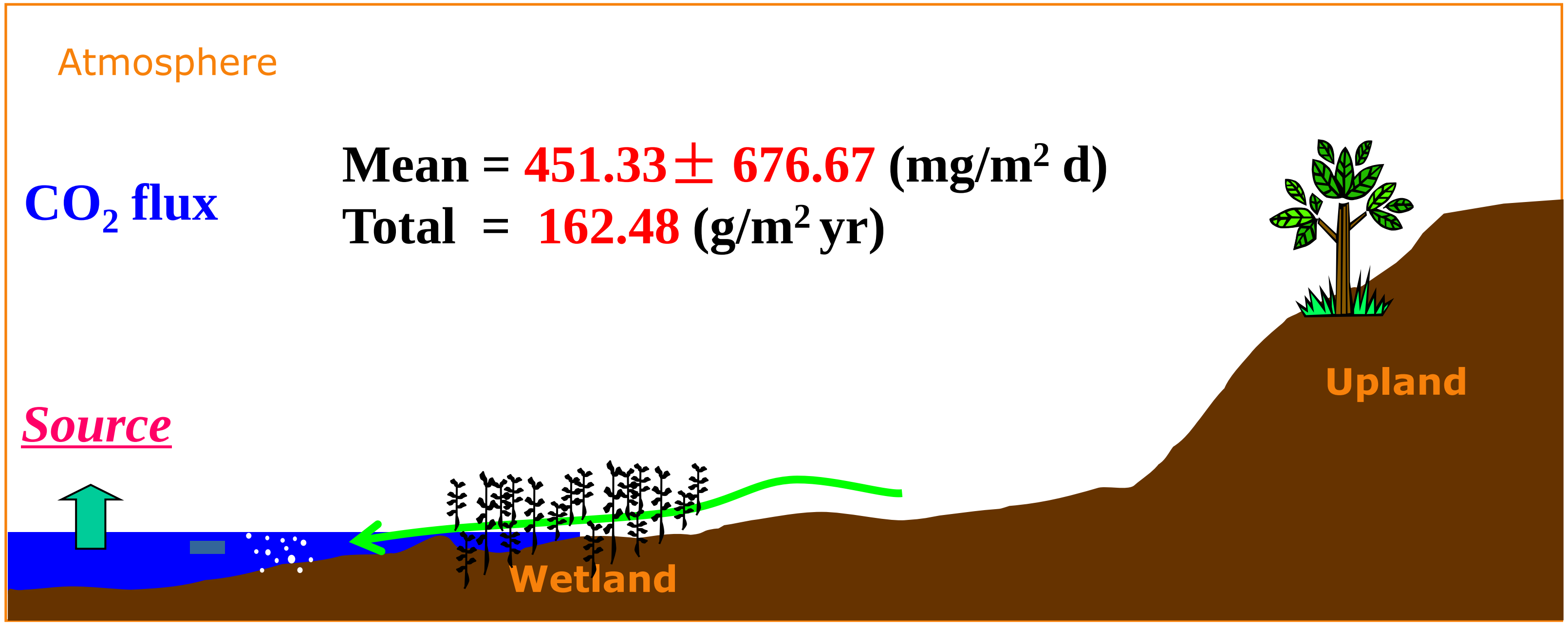
No perturbed

Lake: 0.58 km²

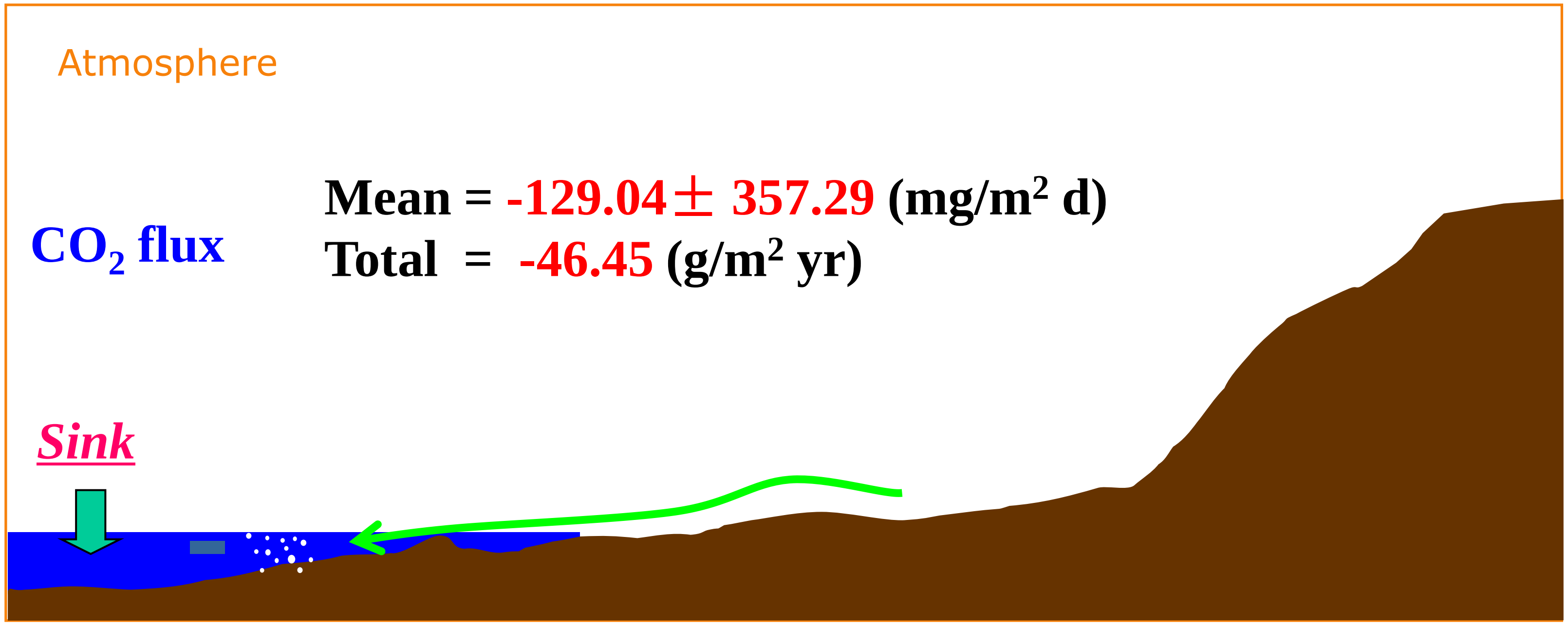
Watershed:1.22 km²







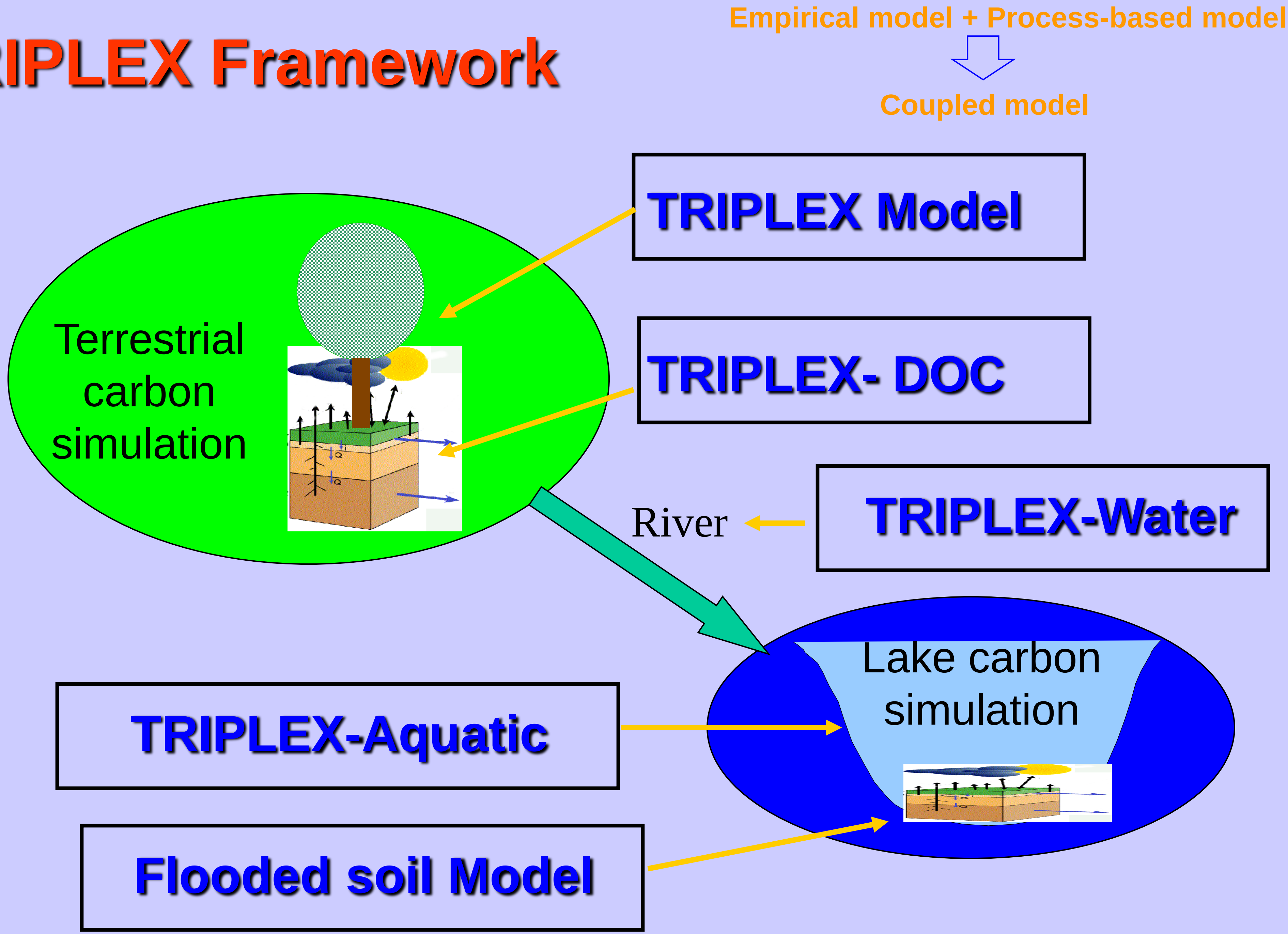
Input of DOC from watershed



No input of DOC from watershed

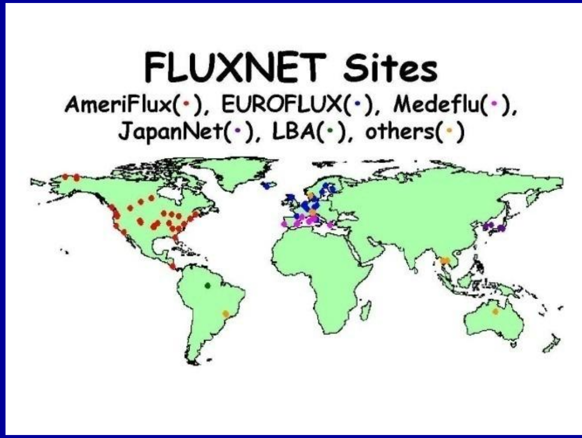
TRIPLEX-Aquatic Simulations (Wu et al., submitted)

TRIPLEX Framework



Challenges for Science

- **Weaknesses in Scientific Understanding:**
  - *Allocation of C in plant tissues*
  - *Nutrient feedback*
  - *CO_2 fertilization at ecosystem scale -* is it real? important?
  - Projecting *changes in disturbance regimes (fire, insect, harvesting, ice damage…)*
  - *Peatland and wetland carbon dynamics*
  - *Other GHG (CH4 and N2O) etc….*



Proposed Sites, Fluxnet-Canada

Take –Home Messages:

" To keep the model as simple as possible,
as complex as necessary"

" I hear and I forget;
I see and I remember;
I do and I understand ! "

Thanks!

Open for
Questions and Collaboration
(www.crc.uqam.ca)