Carbon budgets and trends in China

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Content

Where China carbon study is?

1.What kinds of terrestrial carbon data we have

2.What we have done in evaluating carbon budget

3.What the situation of carbon budget is:uncertainty

4.What is essential to Chinese carbon study

1.What kinds of terrestrial carbon data we have

1.1 Ecosystem research data

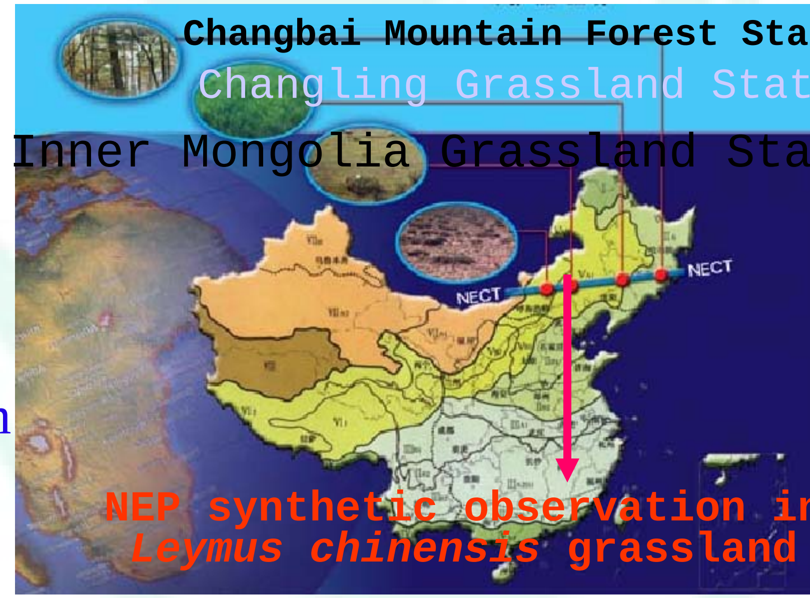
1.2 IGBP-transect research data

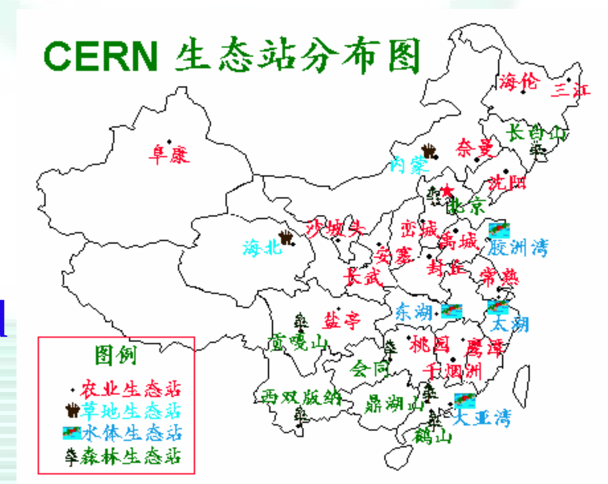
1.3 Forest inventory data

1.4 Eddy flux data

1.1 Ecosystem research data

- ♣ **Time: May, 1998 – Present**
- ♣ **Typical ecosystems**
  - •Changbai Mountain Forest Ecosystem Research Station
    - – Quercus mongolica forest ecosystem
    - – *Pinus Koraiensis* forest ecosystem
  - •Changling Grassland Station
  - •Inner Mongolia Grassland Ecosystem Research Station
    - - *meadow steppe* **&** *meadow steppe farmland*
    - - *Fenced* **&** *grazing Leymus chinensis* grassland
    - – Fenced **&** grazing *Stipa gradis* grassland
    - – Dry steppe







•Contents

－Daily and seasonal soil CO_2 fluxes

－Plant community photosynthesis

－Leaf ecophysiology

－Dynamical biomass and NPP

－C、N、P、S of dominant species

－Soil property

－Microclimate gradient observation



1.2 IGBP-transect research data

Investigation time:

- **1994**
- **1997**
- **1998**
- **2001**

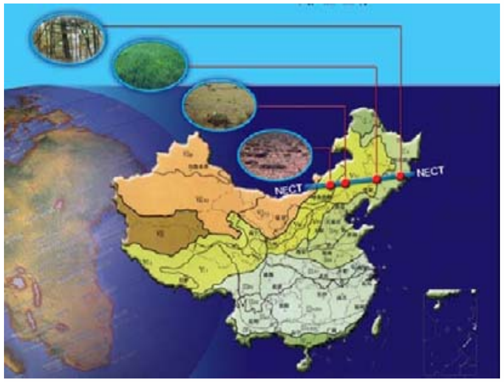
mid-latitude semi-arid areas

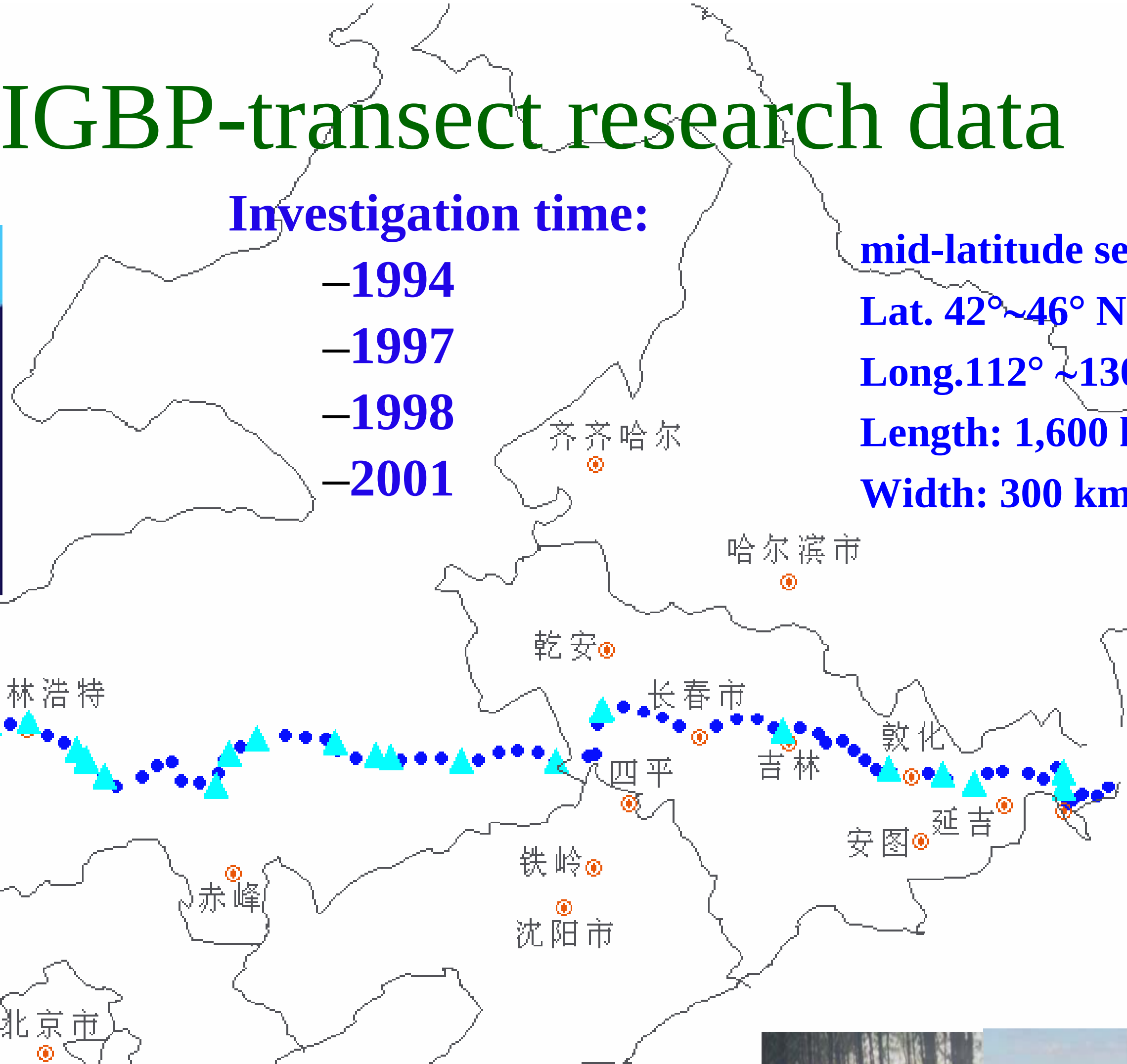
Lat. 42°~46° N

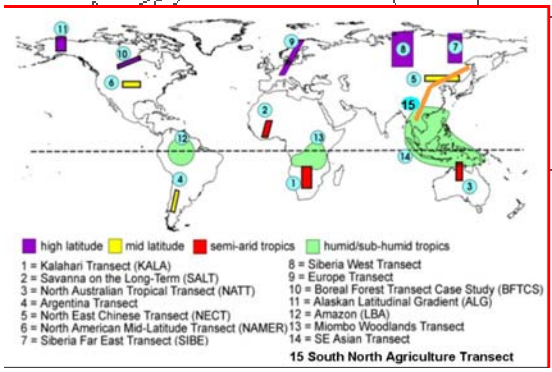
Long.112° ~130.5° E

Length: 1,600 km

Width: 300 km





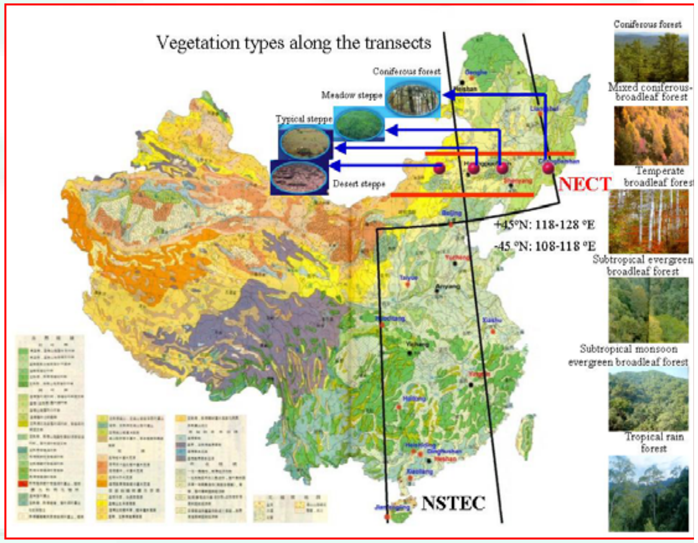


- **Land use database**
  - **Time: 1997 & 2001**
  - Sampling plots:81(every 25 kilometers one spot)
  - contents:location, land use types
- **Soil carbon database**
  - **Time: 1997 & 2001**
  - Sampling plots:30
  - contents:Bulk density,C、 N、 P、 K and effective C、N、P、S, K、Na 、Ca、Mg、Cu、Zn、Fe、Mn and effective K、Cu、Zn、Fe、Mn, Cation exchange capacity, pH, Electronic conductivity, Soil water-holding capacity, Soil texture(International system)
- **Soil CO_2 flux**
  - **Time: 2001**
  - Sampling plots:30
  - Contents:Soil CO_2 emission, Soil temperature: 0, 5, 15, 20cm

- **Plant community Photosynthesis**
  - **Time: 2001**
  - Sampling plots:30
  - contents: Photosynthesis of plant community
- **Plant leaf physiological database**
  - **Time: 1997**
  - Sampling plots:100 plots, 252 species
  - contents: location,leaf photosynthesis, leaf conductance, leaf transpiration, air temperature, air relative humidity, etc
- **Plant community investigation**
  - **Time: 1997 & 2001**
  - Sampling plots:51(1997)/30(2001)
  - Contents:
    - tree：LAI, number and DBH of every species
    - Shrub：LAI, number,coverage and height of every species
    - grass in forest sampling: number,coverage and height of each species
    - grass in grass sampling:coverage,height and frequence

1.3 Forest inventory data

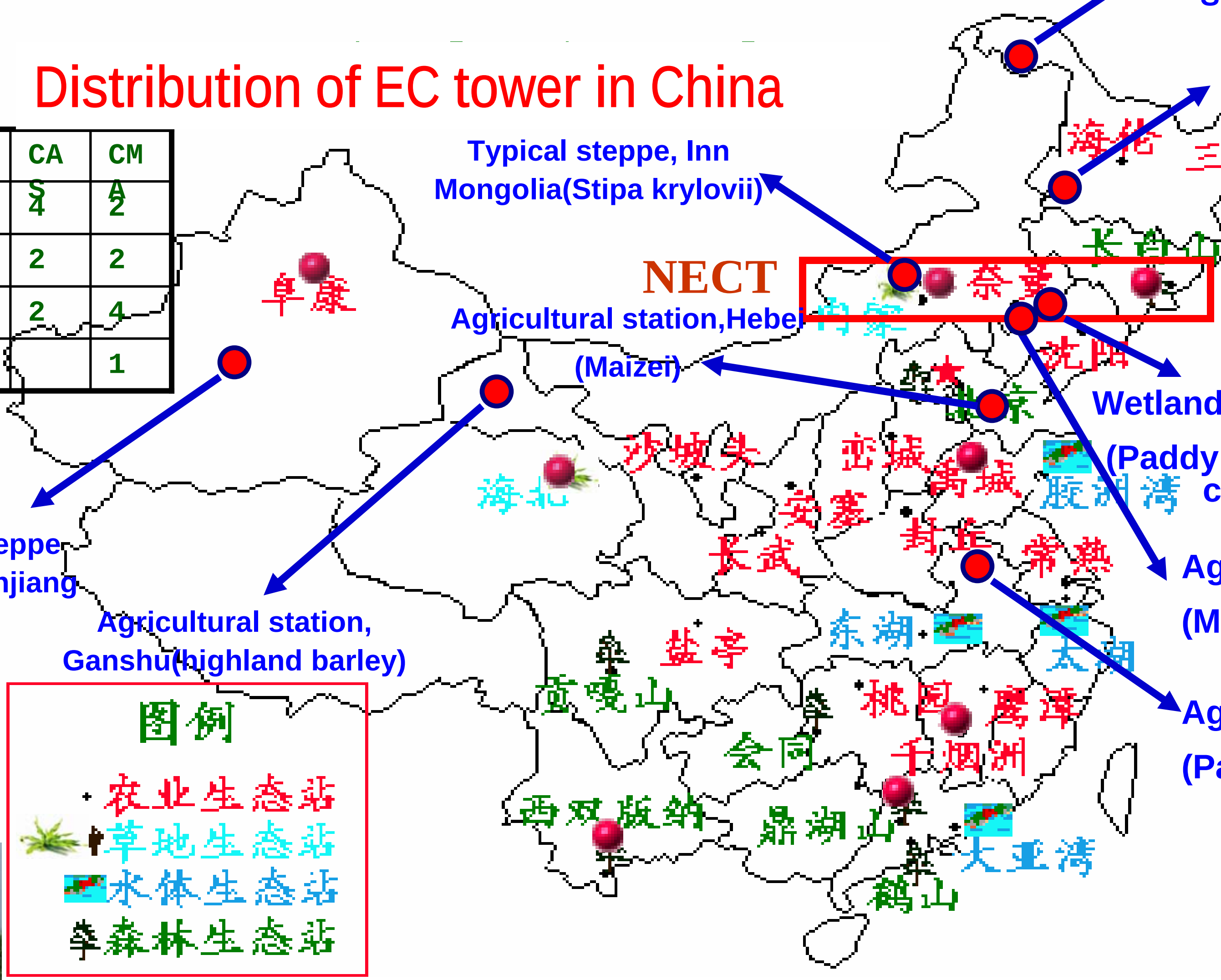
- Up to now, national level forest inventory survey in China has been executed five consecutive times from 1973 to 1998
  - 1973-1976
  - 1977-1981
  - 1984-1988
  - 1989-1993
  - 1994-1998



1.4 Eddy flux data

ChinaFlux Station(8) CMA Flux Station(9)

	CAS	CMA
Forest	4	2
Grassland	2	2
Agriculture	2	4
Wetland		1



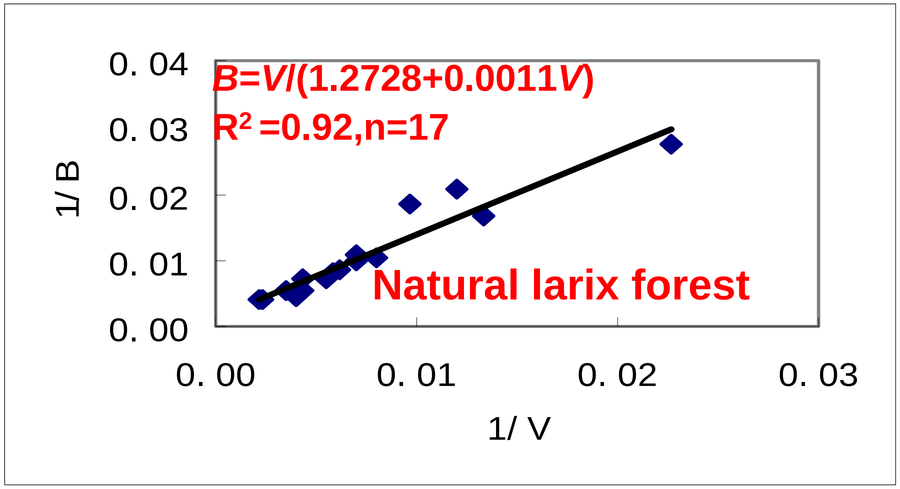
2.What we have done in evaluating carbon budget

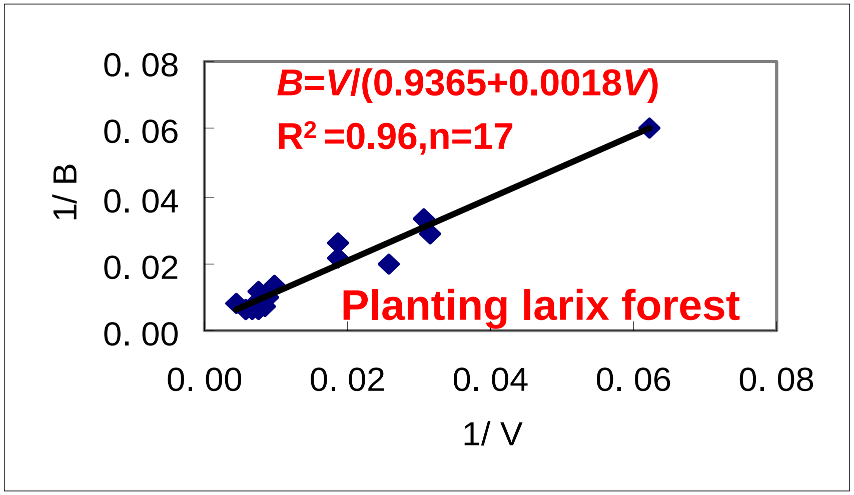
2.1 FID-based NPP model

2.2 Terrestrial ecosystem dynamic model

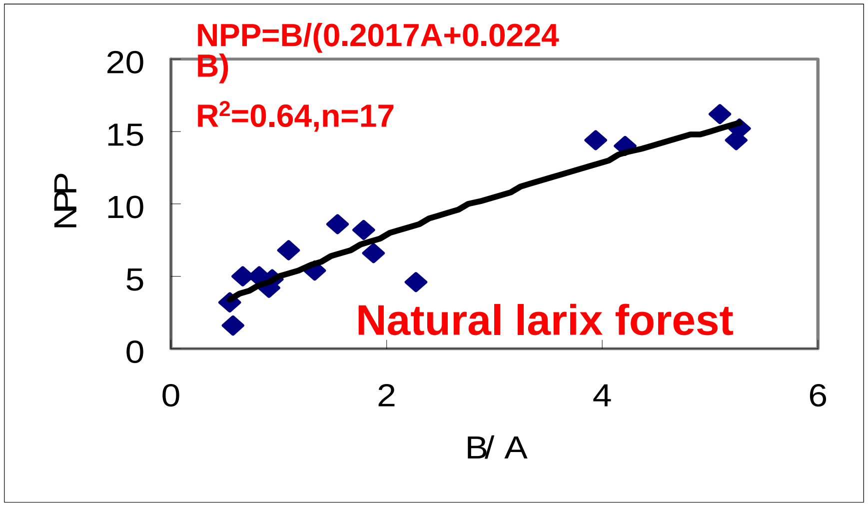
2.1 FID-based NPP model

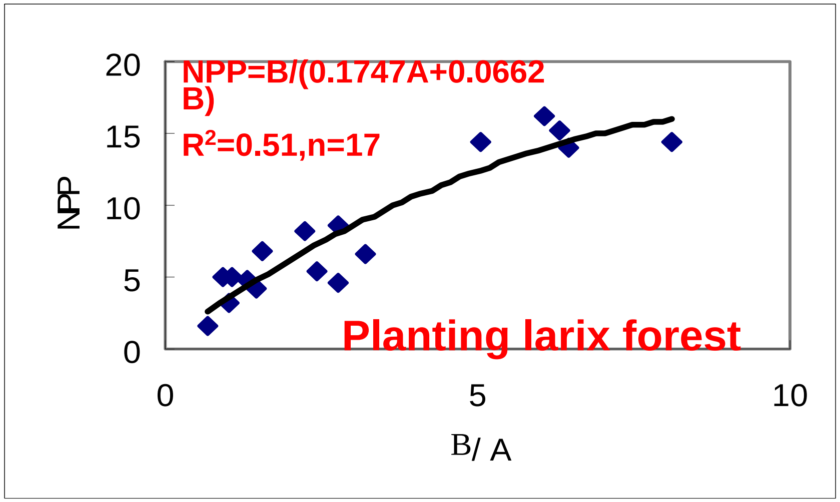
B＝aV （Brown & Lugo，1984）or B=aV+b(Fang et al., 1996)

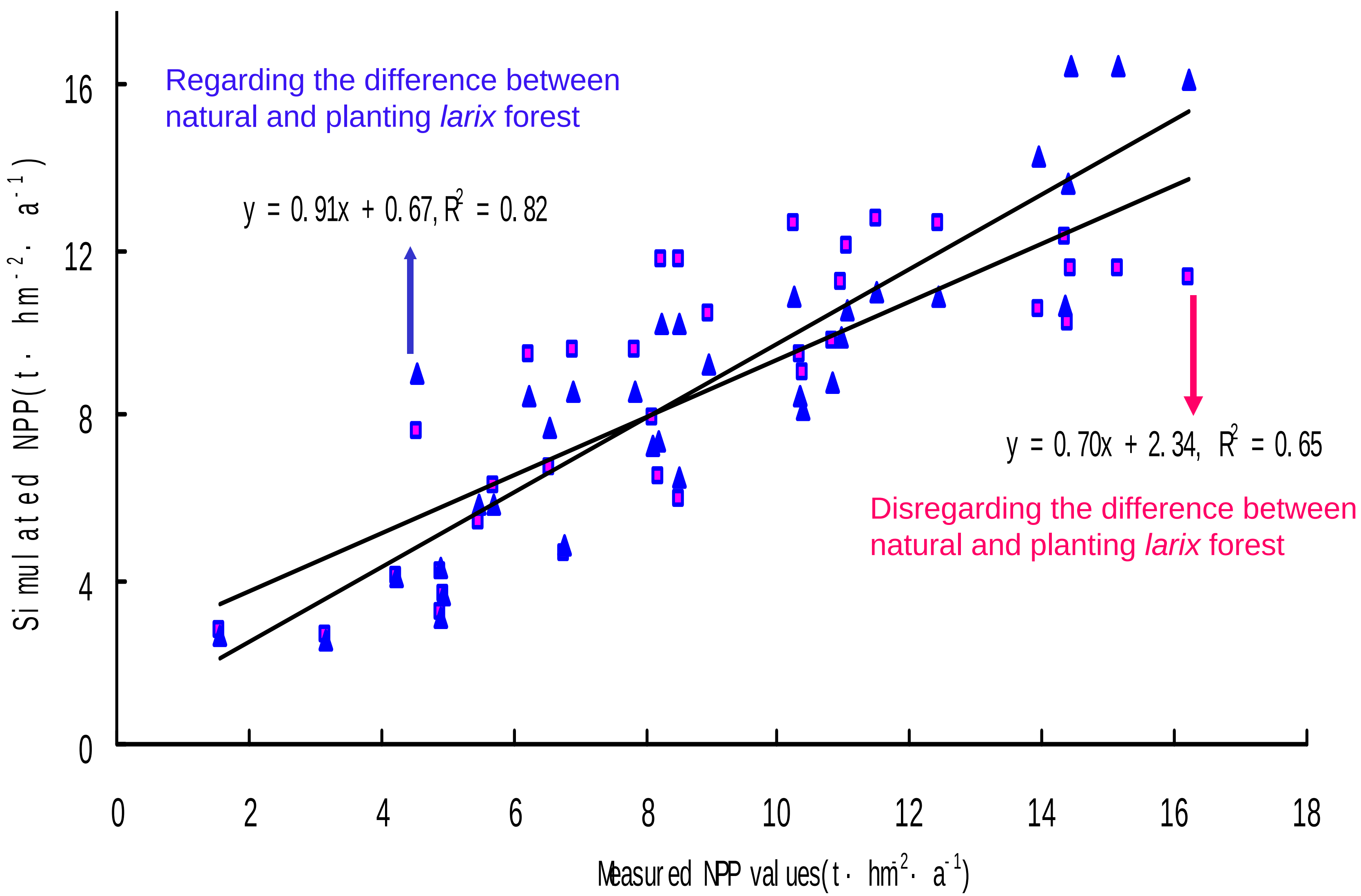




NPP＝f(B),Linear,Exponential and Power functions(Fang et al.,1996）







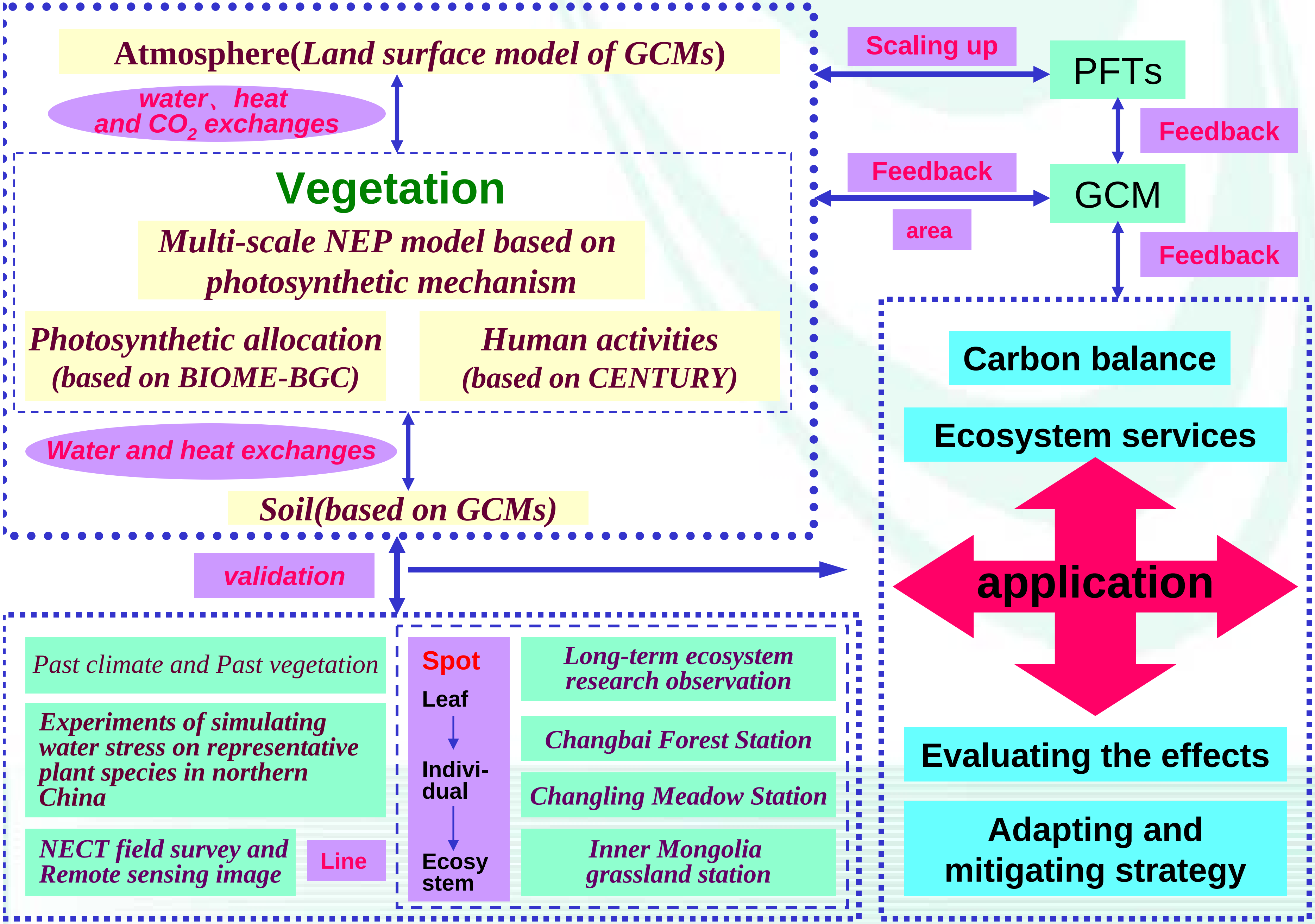
Regarding the difference between natural and planting *larix* forest
y = 0.91x + 0.67, R2 = 0.82
y = 0.70x + 2.34, R2 = 0.65
Disregarding the difference between natural and planting *larix* forest
Simulated NPP(t · hm-2 · a-1)
Measured NPP values(t · hm-2 · a-1)
0
4
8
12
16
0
2
4
6
8
10
12
14
16
18

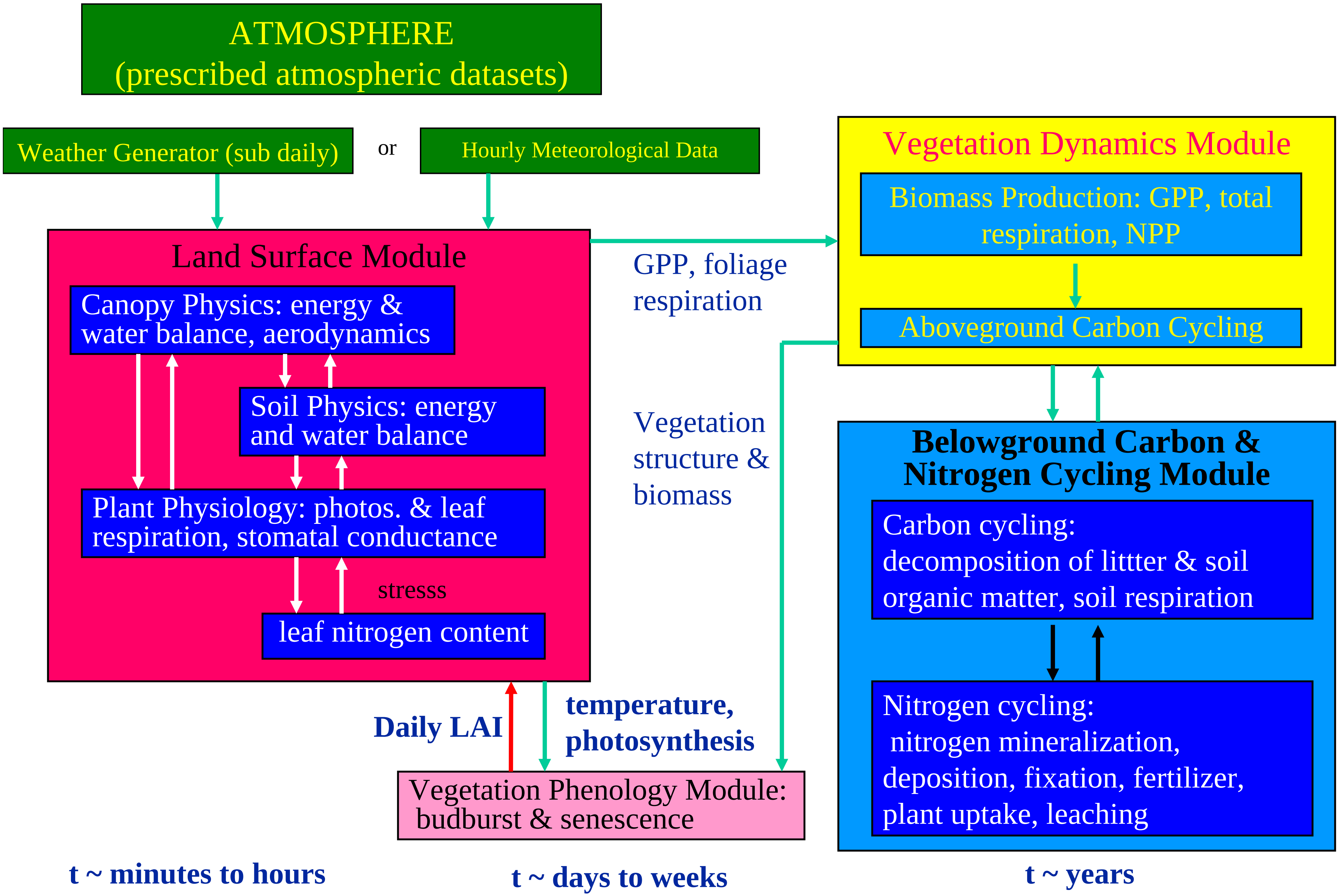
Application of FID-based model in forest of China

($B = \frac{V}{a + bV}$, **B and V are biomass(Mg/ha) and volume(m^3/ha), a、b are constants)**

	2	Parameters in Eq.2		
Type of forest stands	a	b	n	r^2
Cuninghamia Lanceolata	0.808	0. 0067	29	0. 64
Pinus Massoniana, P.yunanensis	1. 428	0. 0014	27	0. 79
Larix spp.	0. 94	0. 0026	34	0. 94
Picea, Abies	0. 56	0. 0035	26	0. 85
P.tabulaeformis	0. 32	0. 0085	32	0. 86
P.armandii	0. 542	0. 0077	17	0. 73
Other pines and conifer forests	1. 393	0. 0008	15	0. 72
Cypress	1. 125	0. 0002	21	0. 97
Mixed conifer and deciduous forests	2. 558	- 0. 0038	11	0. 95
Populus	0. 587	0. 0071	21	0. 92
Betula	0. 975	0. 001	14	0. 91
Quercus	0. 824	0. 0007	48	0. 92
Cinnamomum, Phoebe	0. 76	0. 0012	10	0. 87
Casuarina	0. 807	- 0. 0001	14	0.88
Sassafras *Eucalyptus* and mixed broad-leaf forests	0. 727	- 0. 0012	21	0. 75
Nonmerchantable woods	0. 98	- 0. 0007	14	0. 95

2.2 Terrestrial Ecosystem Dynamic Model(TEDM)





ATMOSPHERE
(prescribed atmospheric datasets)
Weather Generator (sub daily)
or
Hourly Meteorological Data
Land Surface Module
Canopy Physics: energy & water balance, aerodynamics
Soil Physics: energy and water balance
Plant Physiology: photos. & leaf respiration, stomatal conductance
stresss
leaf nitrogen content
GPP, foliage respiration
Vegetation structure & biomass
Vegetation Dynamics Module
Biomass Production: GPP, total respiration, NPP
Aboveground Carbon Cycling
Belowground Carbon & Nitrogen Cycling Module
Carbon cycling:
decomposition of littter & soil organic matter, soil respiration
Nitrogen cycling:
nitrogen mineralization, deposition, fixation, fertilizer, plant uptake, leaching
Daily LAI
temperature, photosynthesis
Vegetation Phenology Module: budburst & senescence
t ~ minutes to hours
t ~ days to weeks
t ~ years

Effects of soil nutrient(Sc, Sn,g/m²) on An

Biochemical model： **An=min{ Wc,Wj,Wp}-Rd= f (C_i ,T_l,PPFD)**

$$W_c = \frac{V_{c\max}(C_i - \Gamma)}{C_i + K_c(1 + O/K_o)}; \quad W_j = \frac{J(C_i - \Gamma)}{4.5(C_i + 2.33\Gamma)}; \quad W_p = \frac{V_{c\max}}{2}$$

$$V_{cmax} = V_{cmax15} \bullet \exp\{3000 \bullet [\frac{1}{288.16} - \frac{1}{T_l + 273.16}]\}$$

$$V_{cmax15} = \frac{(Amax + Rd)[Ci + Kc \bullet (1 + O/Ko)]}{Ci - \Gamma}$$

$$A_{max} = \frac{190 \bullet N}{360 + N}$$

$$N = N_T \bullet \frac{I}{I_0}$$

$$N_T = \frac{\exp[u_1 - u_3/(0.00831T_r)]}{1 + \exp[(u_2 \bullet Tr - 205.9)/(0.00831T_r)]} \bullet K_T(T_r)$$

µ± $S_C > 13000\ g/m^2$ ÇÒ $T_r < 288.16\ K$ Ê±£¬

$$K_T(T_r) = \{1 + [15 - (T_r - 273.16)]/30\} \bullet (1 + S_C - 13000/10000)$$

µ± $S_C <= 13000\ g/m^2$ »ò $T_r >= 288.16\ K$ Ê±£¬

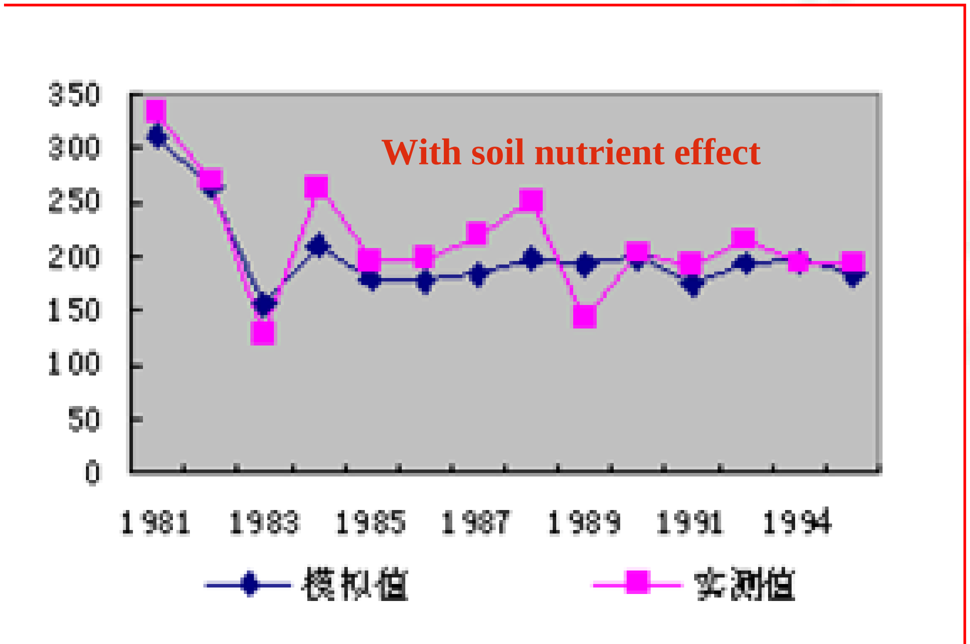
$$K_T(T_r) = 1$$

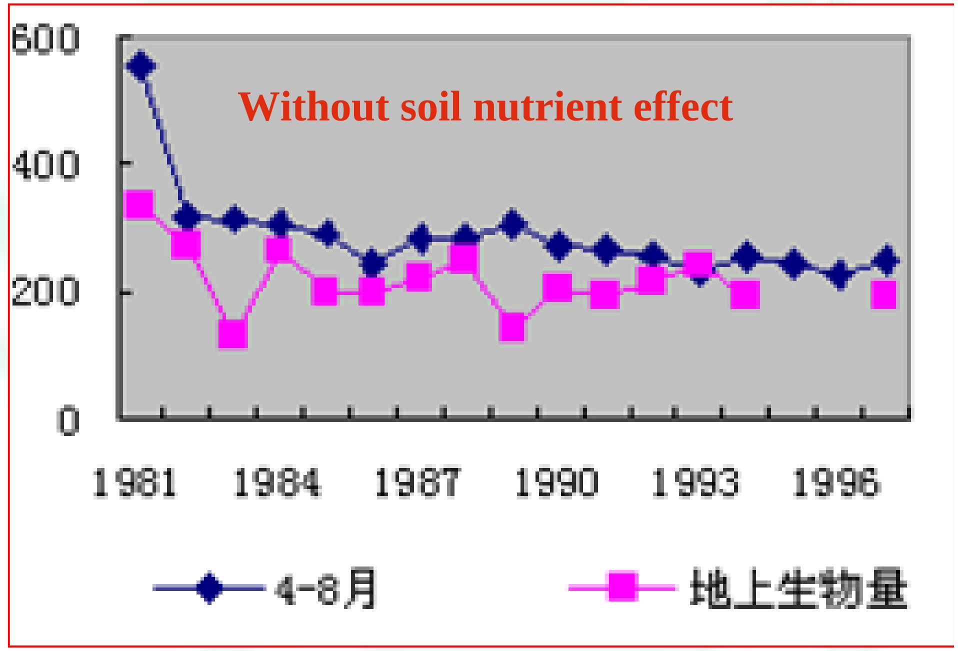
$$u_1 = 40.8 + 0.01 \bullet (T_r - 273.16) - 0.002(T_r - 273.16)^2$$

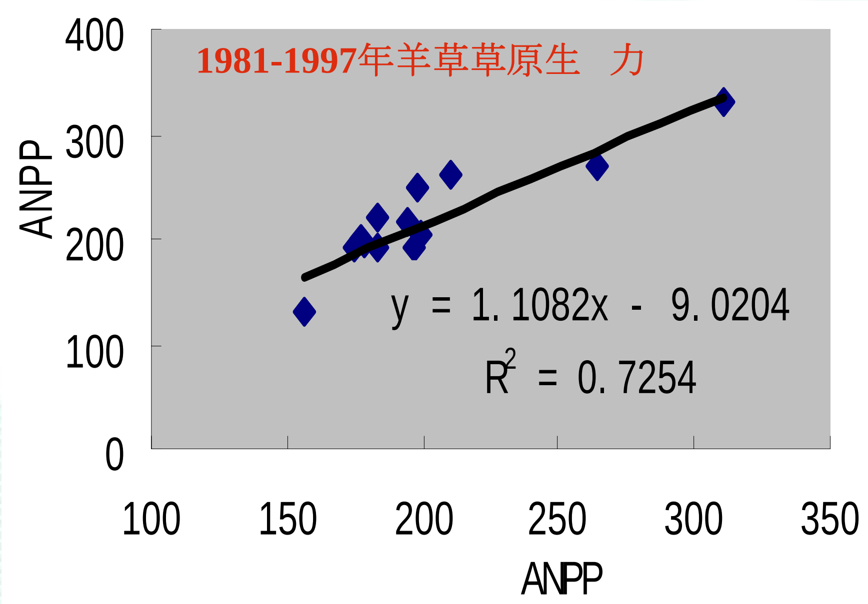
$$u_2 = 0.738 - 0.002(T_r - 273.16)$$

$$u_3 = 97.412 - 2.504 \ln(N_p)$$

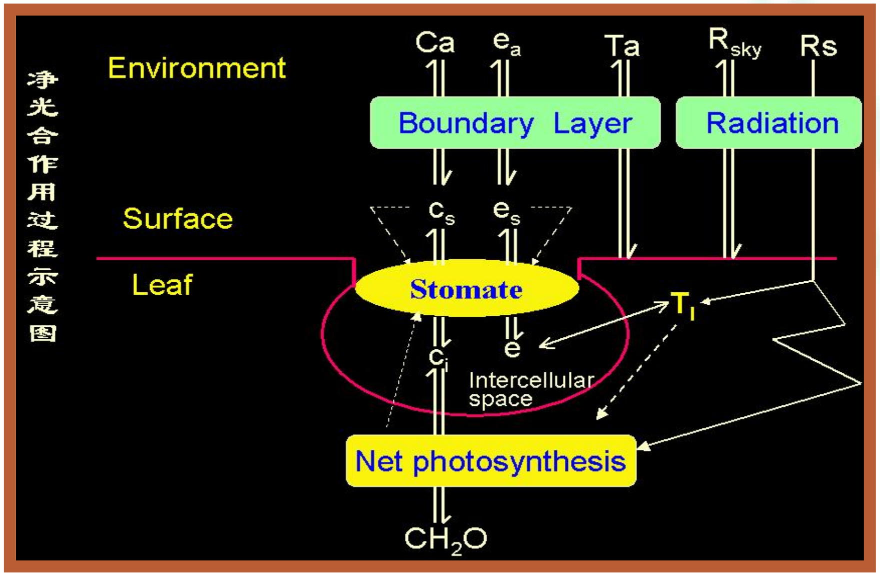
$$N_p = 120 \bullet Min\{Sn/600, 1\} \bullet \exp(-8 * 10^{-5} \bullet Sc)$$

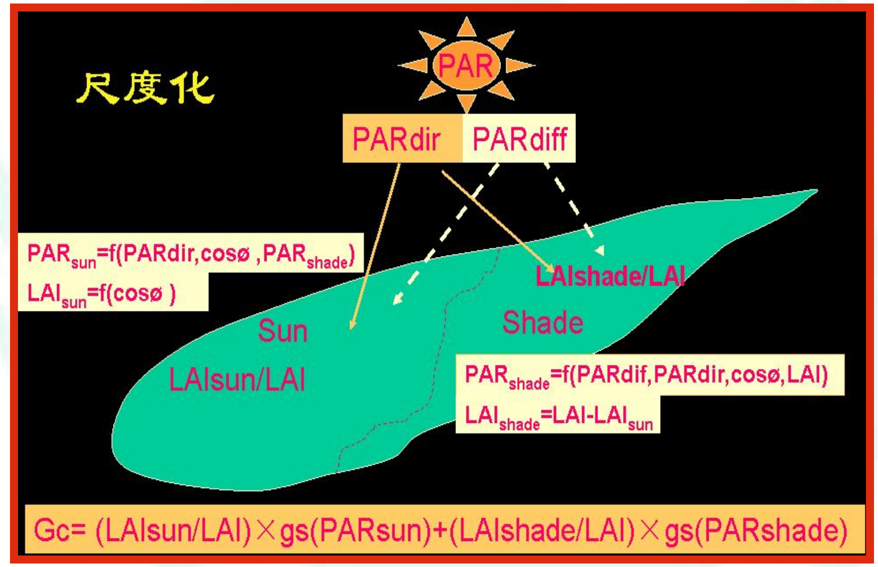

With soil nutrient effect
350
300
250
200
150
100
50
0
1981
1983
1985
1987
1989
1991
1994
模拟值
实测值

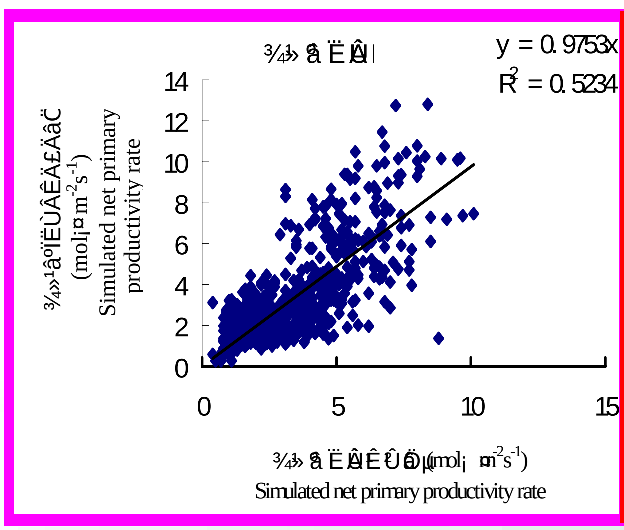

Without soil nutrient effect
600
400
200
0
1981
1984
1987
1990
1993
1996
4-8月
地上生物量

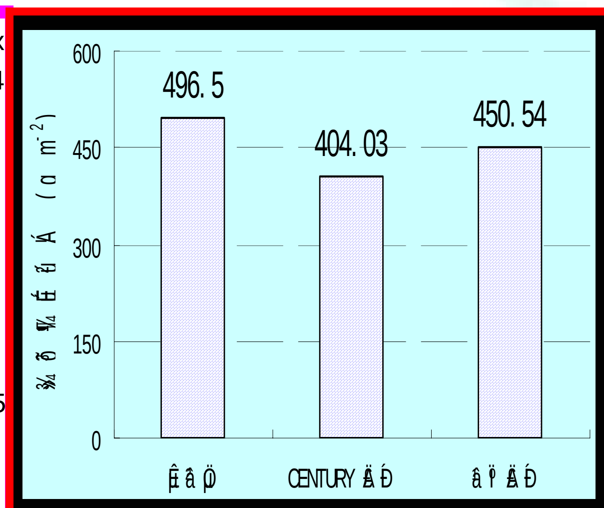

1981-1997年羊草草原生 力
ANPP
400
300
200
100
0
y = 1.1082x - 9.0204
R^2 = 0.7254
100
150
200
250
300
350
ANPP

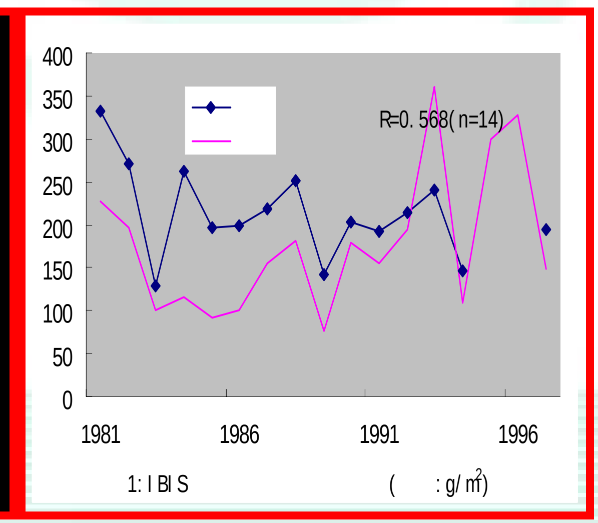
Scaling from leaf to canopy



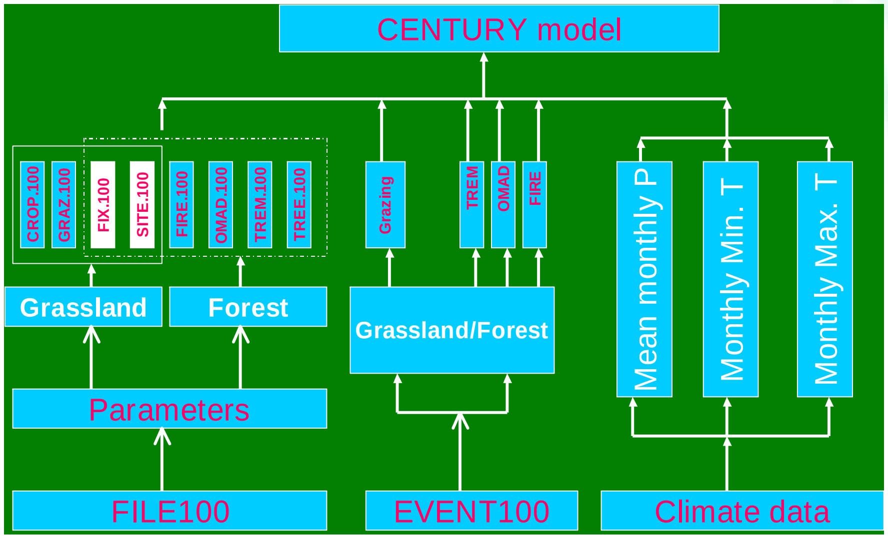


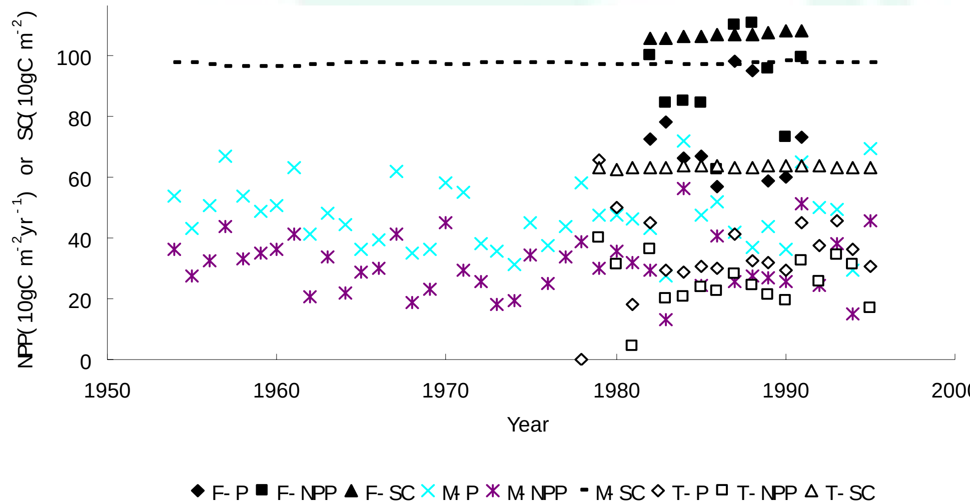




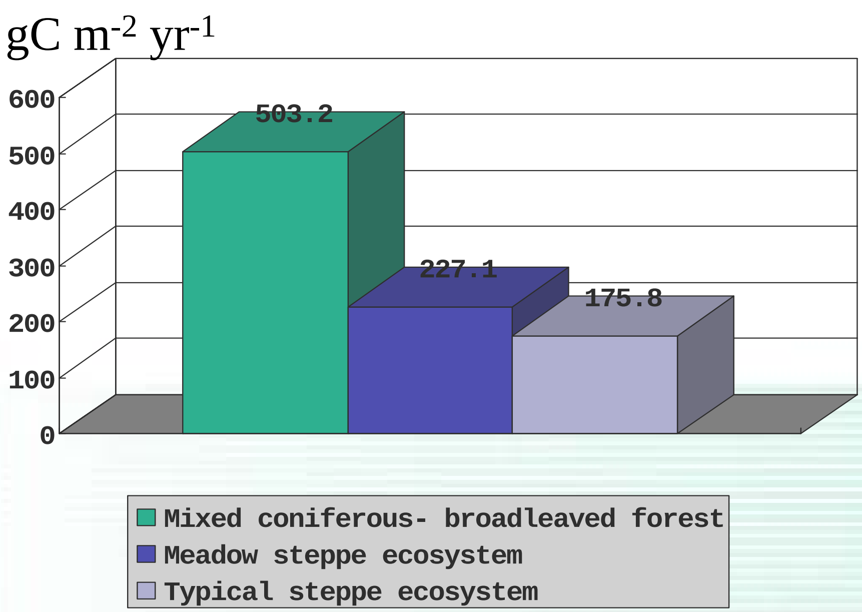


3.What the situation of carbon budget is:uncertainty





F: Changbai Forest Ecosystem Research Station
M: Changling Grassland Station
T: Inner Mongolia Grassland Ecosystem Research Station
P: precipitation (cm)
NPP: 10gC•m^{-2}•a^{-1}
SC: total soil carbon(10gC•m^{-2})



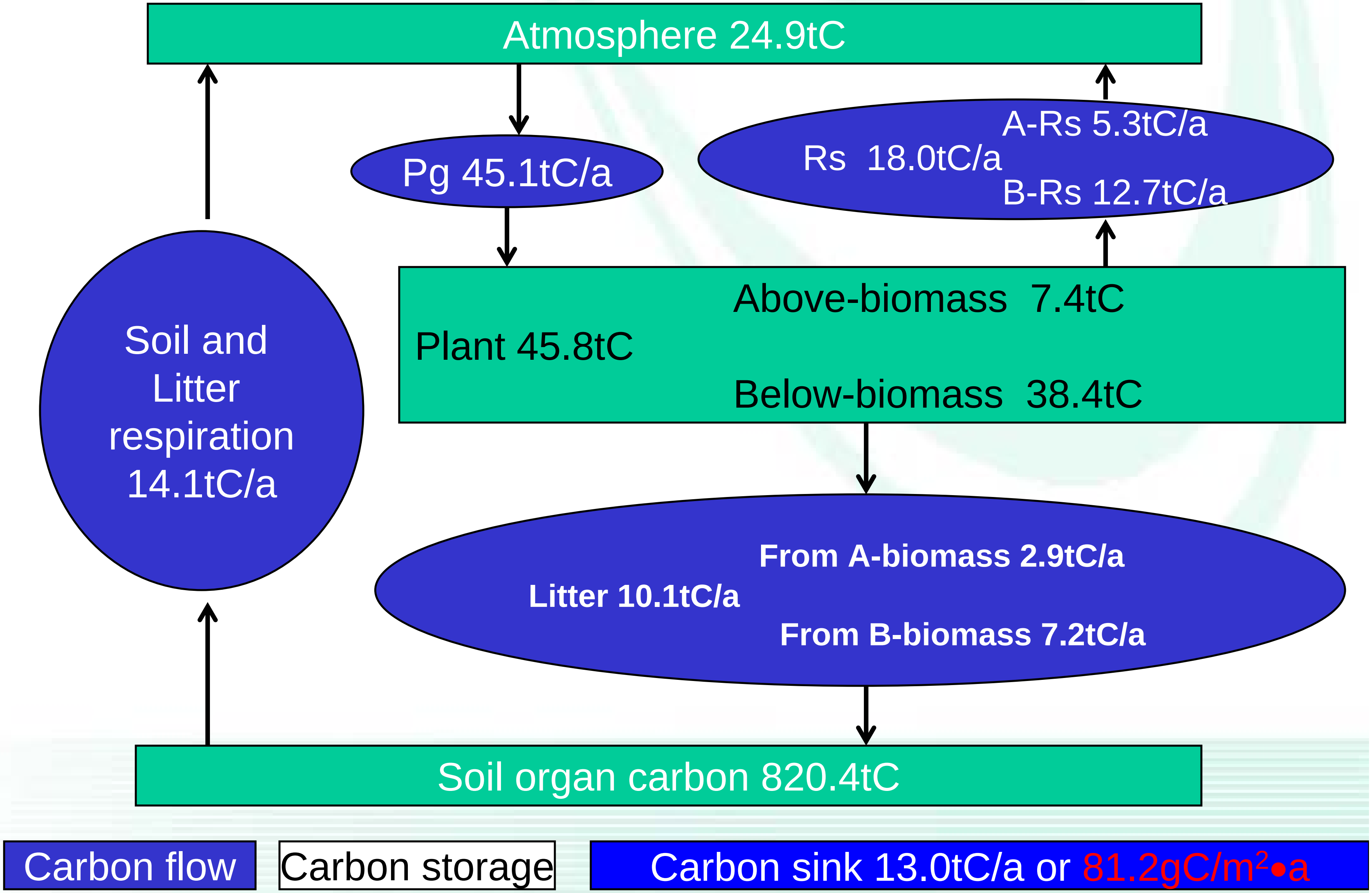
Annual NEP: 4.03tC/hm^2•a

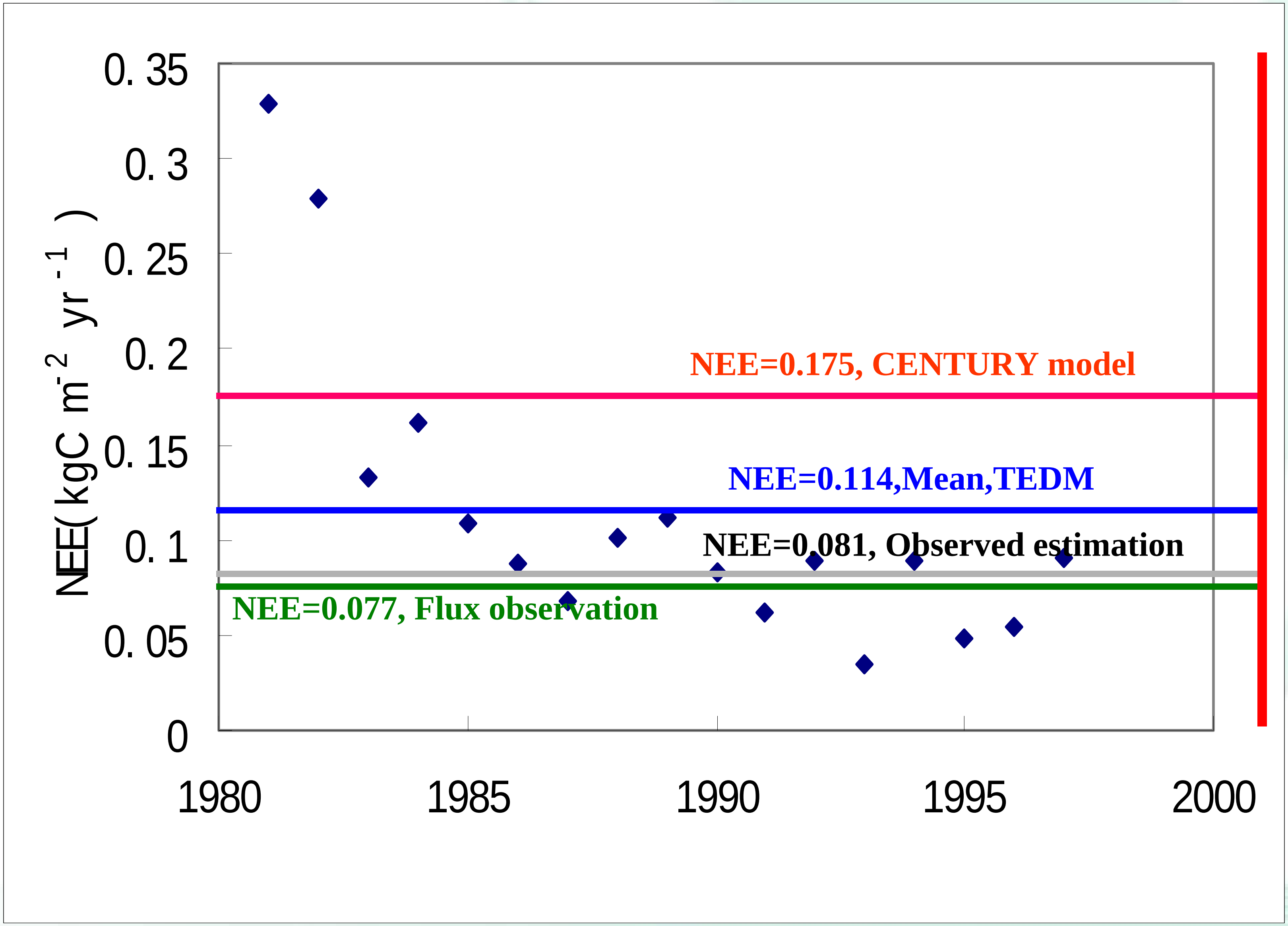
Annual soil emission: 1.91tC/hm^2•a

Carbon budget:2.12tC/hm^2•a

Boreal Forest is a carbon sink

Case study —— Carbon budget of the *Stipa Grandis* steppe(estimating area:400m×400m) in Inner Mongolia





NEE of Typical steppe ecosystem in Inner Mongolia by TEDM model

4.What is essential to Chinese carbon study

- How to obtain properly carbon flux? E.g. sampling time, data calibration, and EC in mountain region
- How to evaluate regional carbon flux by EC? IGBP-transects, remote sensing method
- Data fusion: how to integrate different carbon data?
- How to mitigate carbon emission and enhance carbon sequestration? Wind energy, bio-fuel

Thanks!