Effects of deforestation on land surface air temperature

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Outline

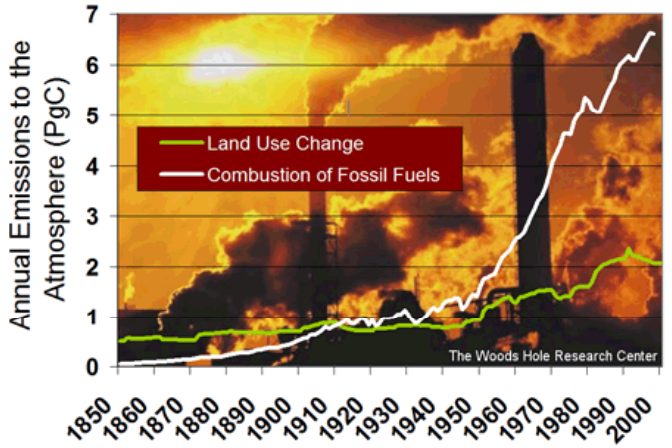
- Background
- Objectives
- Methods
- Work plan

1. Background

1.1 Characteristics of global change.

Land use / Land cover change

Atmospheric composition change → Climate change



Deforestation, afforestation, and reforestation change land use / land cover.

1.2 Roles of Forest

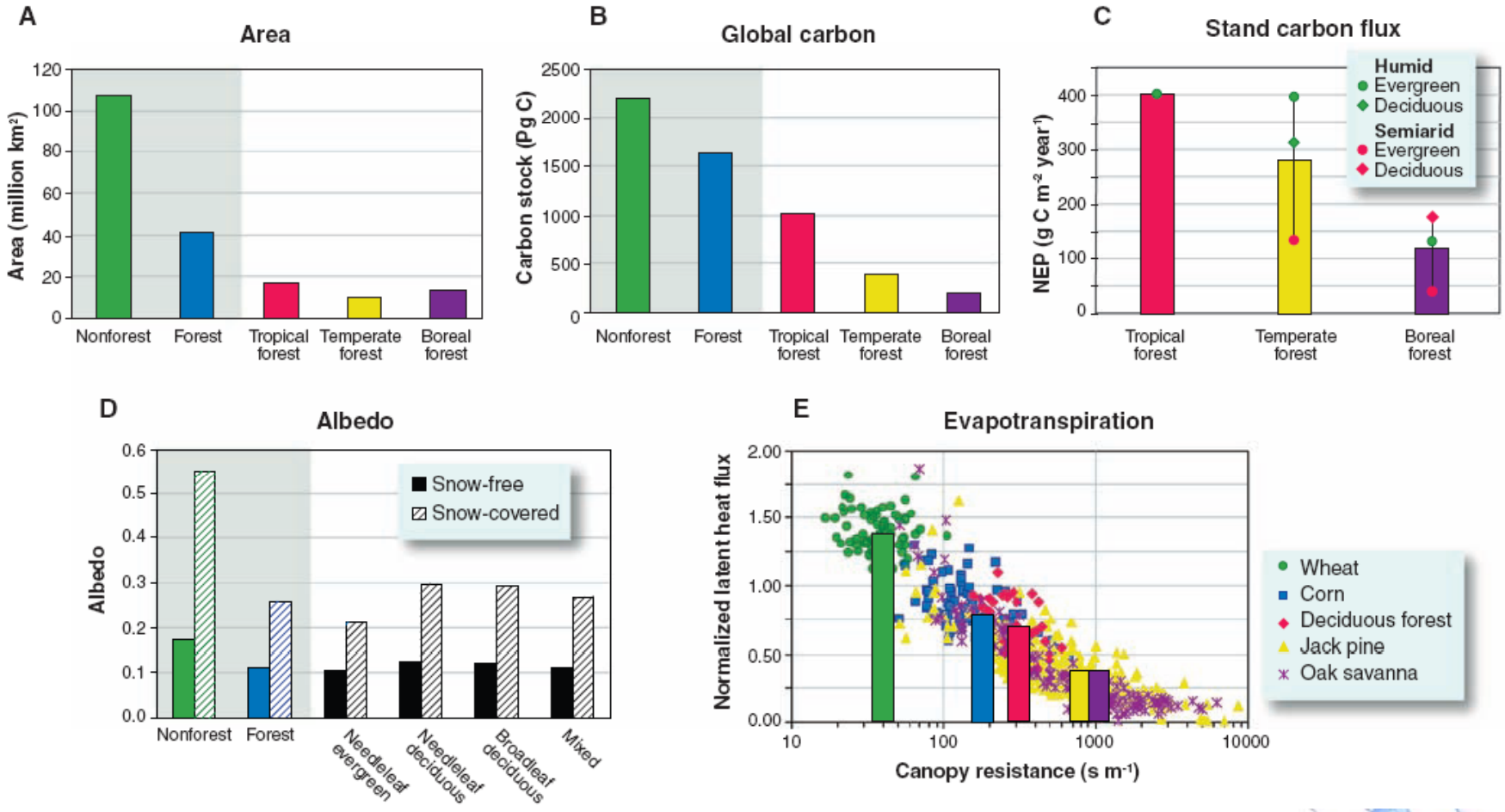


Fig. 1 Roles of forest on biogeochemical and biogeophysical processes (*Bonan, 2008*)

1.2 Roles of Forest

- The effects of different types forest on biogeochemical and biogeophysical process is not the same.
- Biogeochemical and biogeophysical positive or negative feedback can amplify or mitigate climate forcing.

1.3 Effects of deforestation on biogeochemical and biogeophysical process

Deforestation

Adding CO_2 to the atmosphere

Decreasing carbon storage in trees under future CO_2 fertilization

Biogeochemical effects

Warming !

Decreasing evapotranspiration

Increasing surface albedo

Biogeophysical effects

Cooling !

1.3 Effects of deforestation on land surface air temperature

(1) The researches based on large scale couple model.

- Third Hadley Centre Atmosphere Model (HadAM3) (*Bonan, 2000*).
- A three-dimensional coupled global carbon-cycle and climate model (Lawrence Livermore National Laboratory INCCA <Integrated Climate and Carbon> model) (*Bala et al., 2007*).

Based on HadAM3 Model

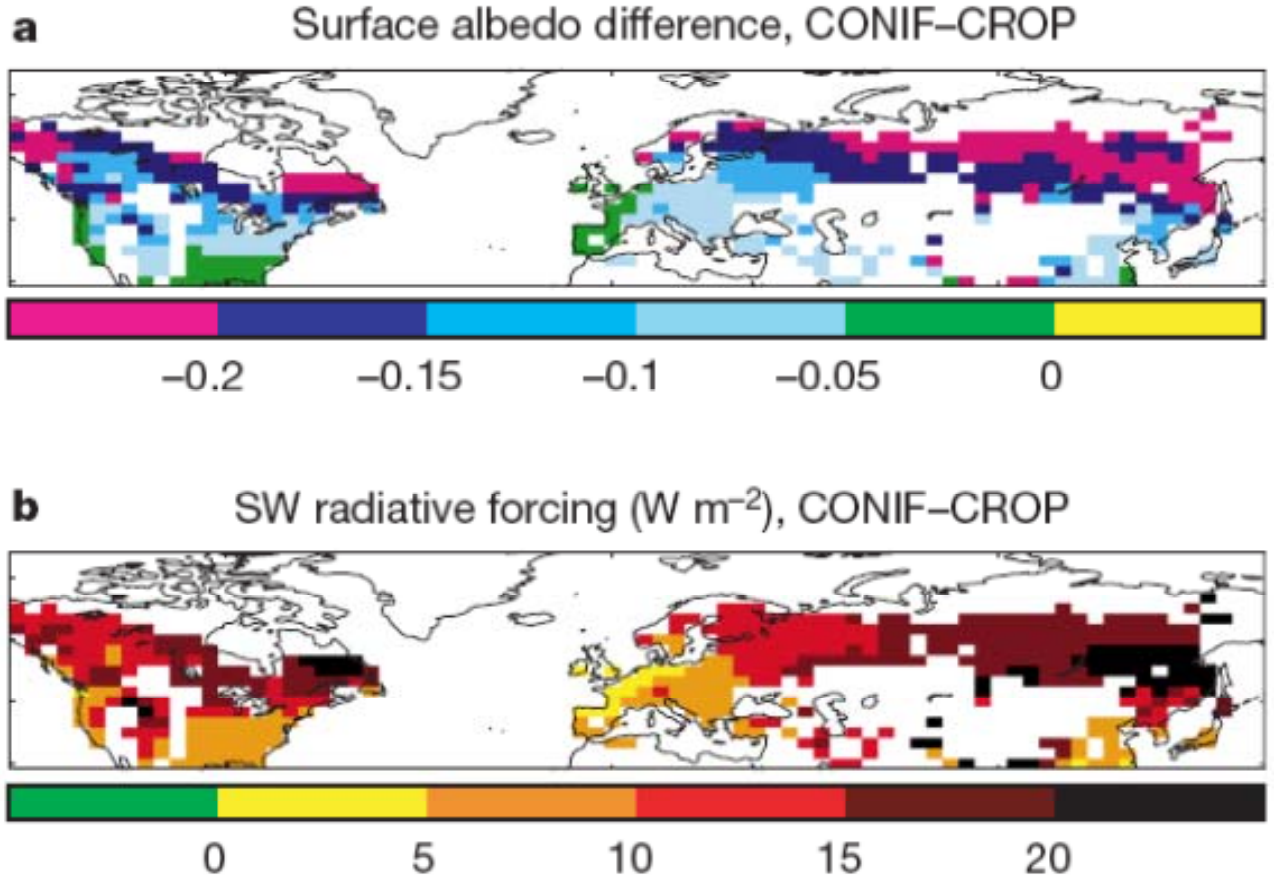


Fig.2 Effects of forestation on the solar radiation budget. **a**, Difference in annual-mean surface albedo α simulated by CONIF and CROP. **b**, Local instantaneous shortwave (SW) radiative forcing at the tropopause due to surface albedo change. At uncoloured gridpoints, vegetation was identical in CONIF and CROP. (*Bonan, 2000*)

Based on HadAM3 Model

Table 1 Sequestration and albedo forcings in terms of carbon stock change (*Bonan, 2000*).

Region	Sequestration potential, SP (t C ha^{-1})	Emissions-equivalent of shortwave forcing, EESF (t C ha^{-1})	Net equivalent stock change, NESC (t C ha^{-1})	NESC/SP (%)
Boreal				
Former Soviet Union	80–120	100	–20–20	–30–20
British Columbia	190	80	110	60
Rest of Canada	60	90	–30	–50
Nordic Europe	120	60	60	50
Temperate				
Western Europe	140–280	30	110–250	80–90
Eastern Europe	150	40	110	70
Southern Europe	90	40	50	60
Temperate USA	200–420	70	130–350	70–80
Southern USA	210	40	170	80
China	80	60	20	30
Rest of temperate Asia	200	60	140	70

Based on INCCA model

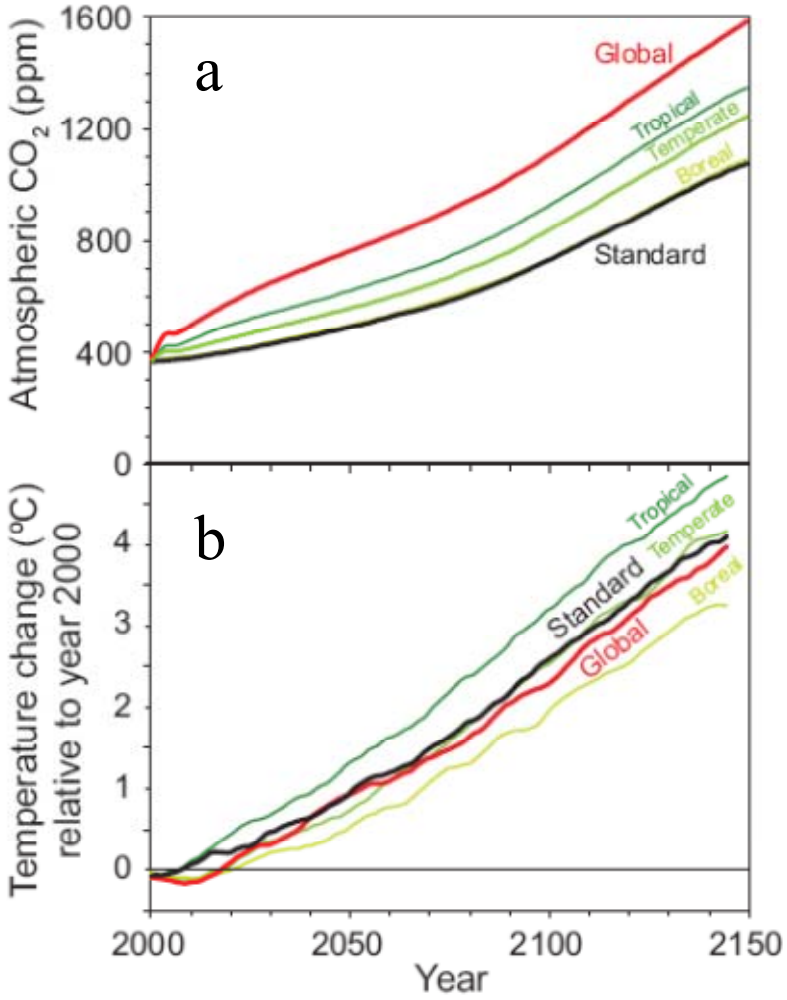
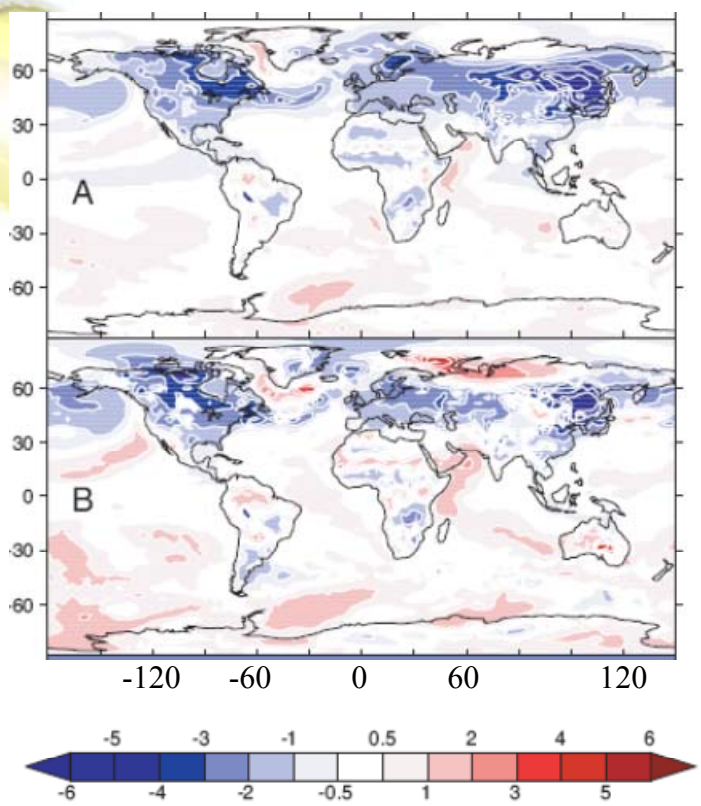


Fig.3 Simulated temporal evolution of atmospheric CO_2 (a) and 10-year running mean of surface temperature change (b) for the period 2000-2150 in the standard and deforestation experiment. (Bala et al., 2007)



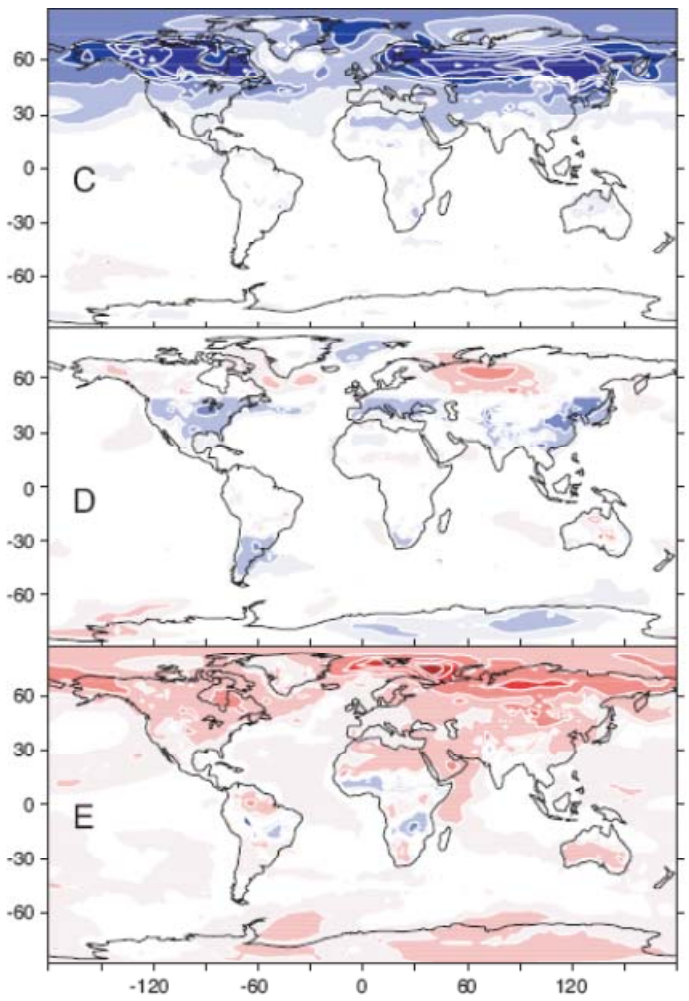


Fig. 4 Simulated spatial surface temperature differences relative to the standard experiment in the decade centered on year 2100 for global (A) and linear sum (B) of Boreal (C), Temperate (D), and Tropcial (E) deforestation experiments. (Bala et al., 2007)

Table 2. Climate variable differences between Global and Standard experiments for the decade centered on year 2100 (*Bala et al., 2007*).

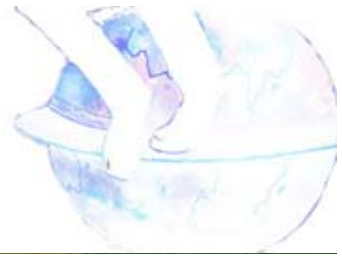
	Global	Global land	SH mid-latitude land (50°S to 20°S)	Tropical land (20°S to 20°N)	NH mid-latitude land (20°S to 50°N)	NH high-latitude land (50°S to 90°N)
Surface temperature, K	−0.3	−1.0	0.1	−0.4	−1.6	−2.1
Evapotranspiration, %	−2.6	−7.8	−16.7	−5.8	−5.8	−14.6
Surface albedo, %	1.9	5.2	5.0	4.1	4.7	10.7
TOA albedo, %	0.6	1.6	0.5	−0.3	1.7	5.5
Total cloudiness, %	−0.7	−1.7	−4.7	−4.6	−1.2	2.5
Surface SW absorbed, Wm^{-2}	−1.4	−4.3	−1.7	1.2	−5.2	−13.8
Surface downward SW, Wm^{-2}	2.2	5.1	11.3	12.9	3.0	−3.2

Evapotranspiration percentage differences are relative to Standard mean climate for this period. Cloudiness and albedo changes are absolute changes. SH, Southern Hemisphere; NH, Northern Hemisphere; TOA, Top of Atmosphere; SW, shortwave.

Table 3. Surface temperature changes (K), relative to Standard, in Global, Tropical, Temperate, and Boreal deforestation experiments (*Bala et al., 2007*).

Deforestation experiments	Global-mean	Global land mean	SH mid-latitude land (50°S to 20°S)	Tropical land (20°S to 20°N)	NH mid-latitude land (20°S to 50°N)	NH high-latitude land (50°S to 90°N)
Global	−0.3	−1.0	0.1	−0.4	−1.6	−2.1
Tropical	0.7	0.9	0.8	0.2	1.1	1.7
Temperate	−0.04	−0.2	−0.3	0.07	−0.7	0.4
Boreal	−0.8	−1.4	−0.3	−0.3	−1.6	−3.8

SH, Southern Hemisphere; NH, Northern Hemisphere.



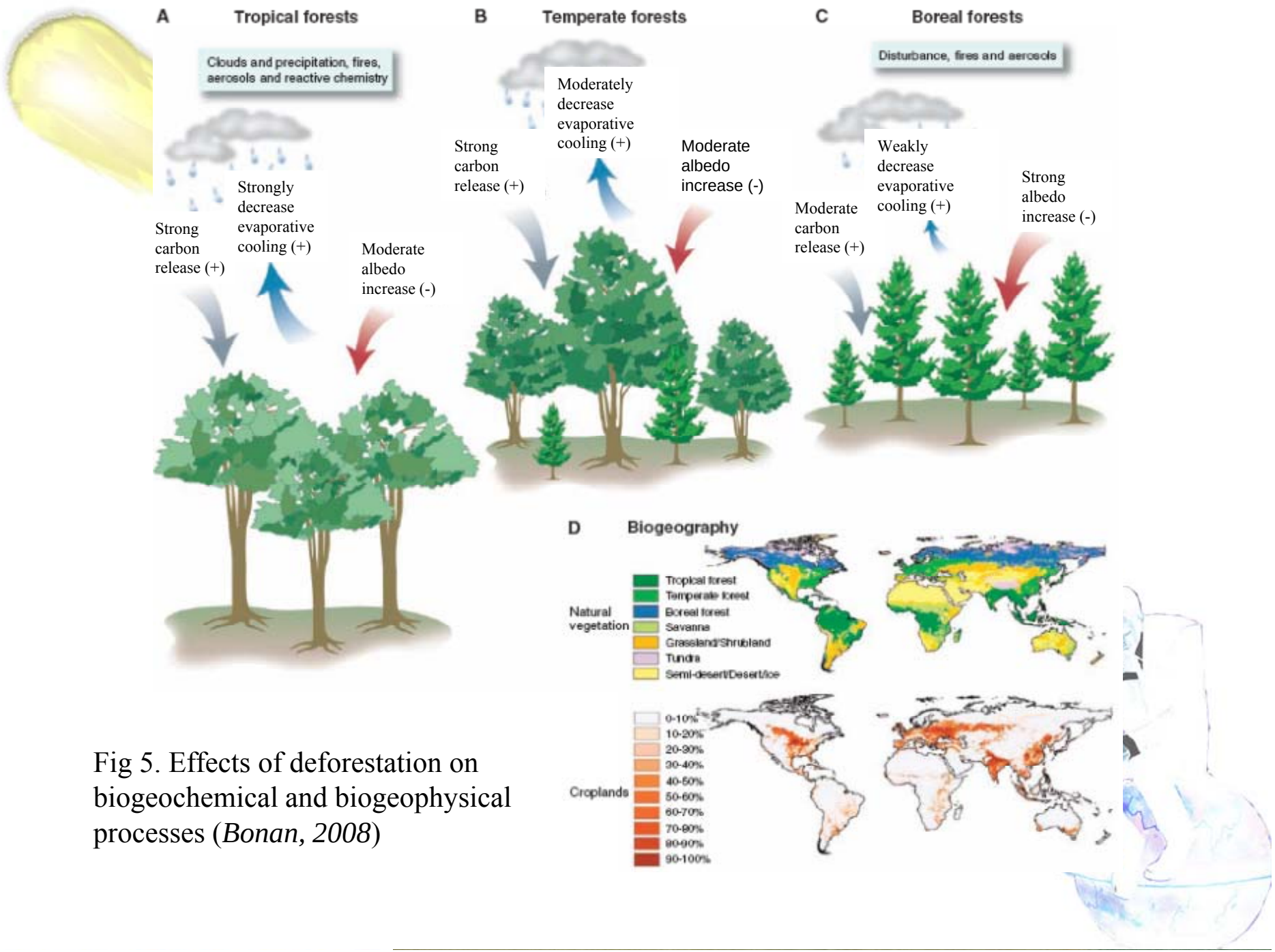


Fig 5. Effects of deforestation on biogeochemical and biogeophysical processes (*Bonan, 2008*)

Conclusion in these researches

- Largest surface albedo changes in boreal regions because of snow lying in winter, when deforestation takes place.
- The evapotranspiration changes are larger in deforested tropical and temperate regions, especially in summer.
- Tropiacl deforestation warms the planet everywhere.
- Temperate deforestation warms the planet is not visible.
- Boreal deforestation cools the planet.

Some problems

- The net climate forcing of temperate forest deforestation is uncertain (*Bonan, 2008*).
- These research based on large scale (e.g continental scale land clearing) would lose some intrinsic biophysical mechanism about effects of deforestation on local scale (*Lee et al., 2011*).
- Currently, land use activities or deforestation or reforestation occurs at local scales (hectares) (*Lee et al., 2011*).
- Effects of seasonal change.

(2) The researches based on local scale measured data.

- Ensure the effects of deforestation on land surface air temperature.
- Based on observation at FLUXNET forest tower and surface weather stations in North America and using the latter as proxies for small land clear land, the surface air temperature was compared (*Lee et al., 2011*).

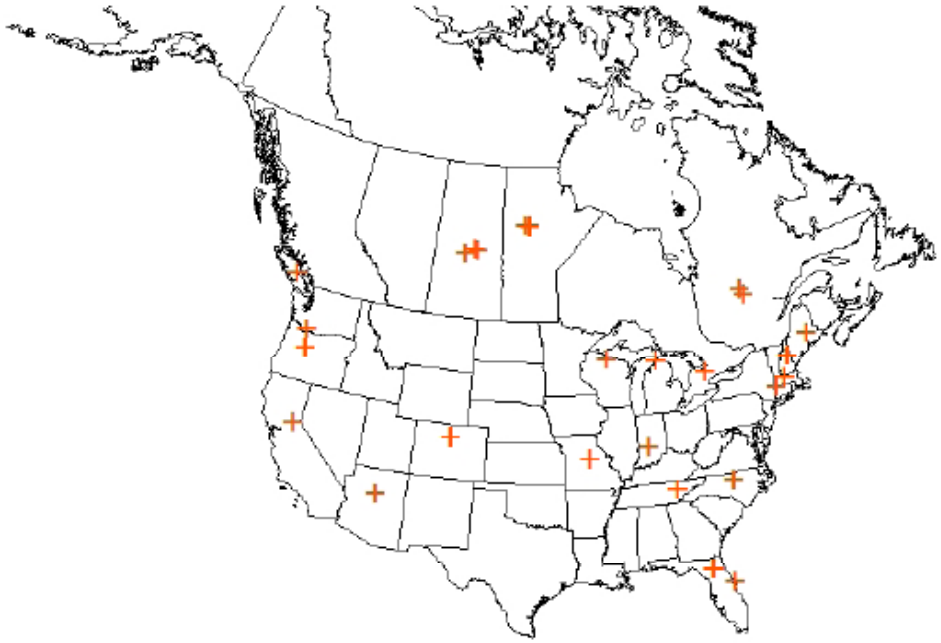


Fig.6 Map of the FLUXNET forest sites used for the paired analysis weather station
versus forest (*Lee et al., 2011*).

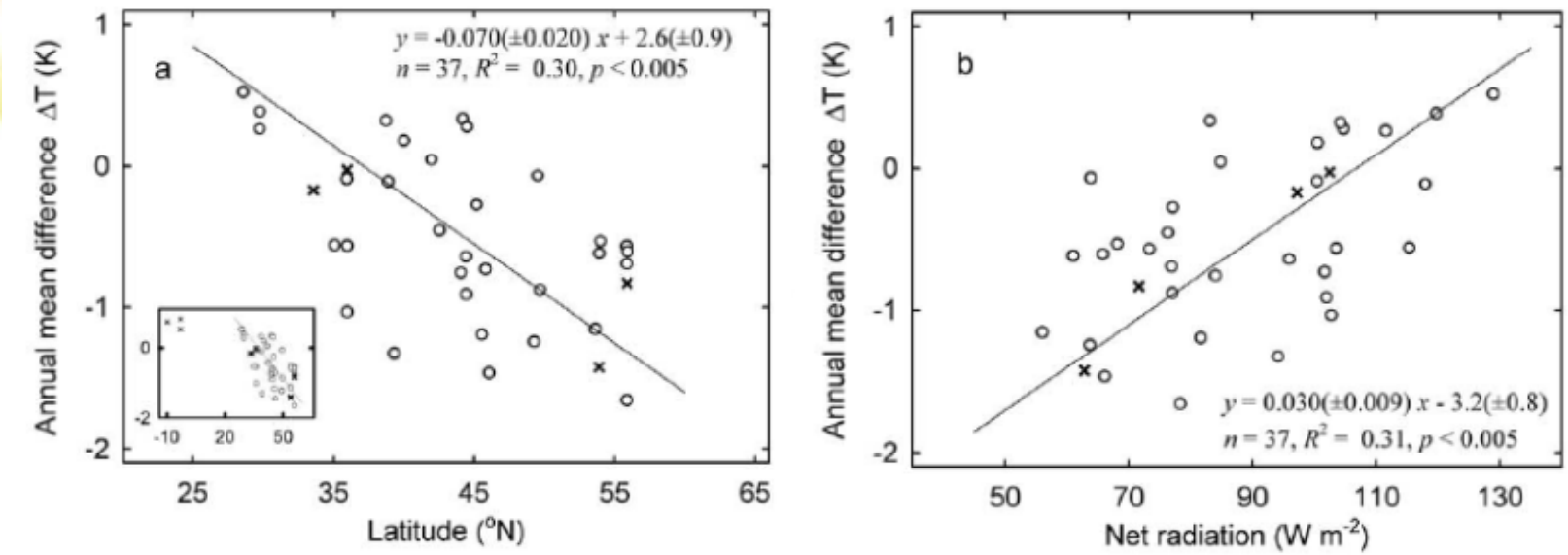


Fig.6 Annual mean difference (open land - forest) in surface air temperature. a) Correlation with latitude; b) Correlation with surface net radiation; Inset: as in panel a but with tropical FLUXNET site data included. (circles: weather station/forest site pairs; crosses: FLUXNET site clusters) (*Lee et al., 2011*).

- For the site pairs north of 45° N, The mean annual ΔT is -0.85±0.44K.
- For the site pairs south of 45° N, the mean annual ΔT is -0.21 ± 0.53 K.

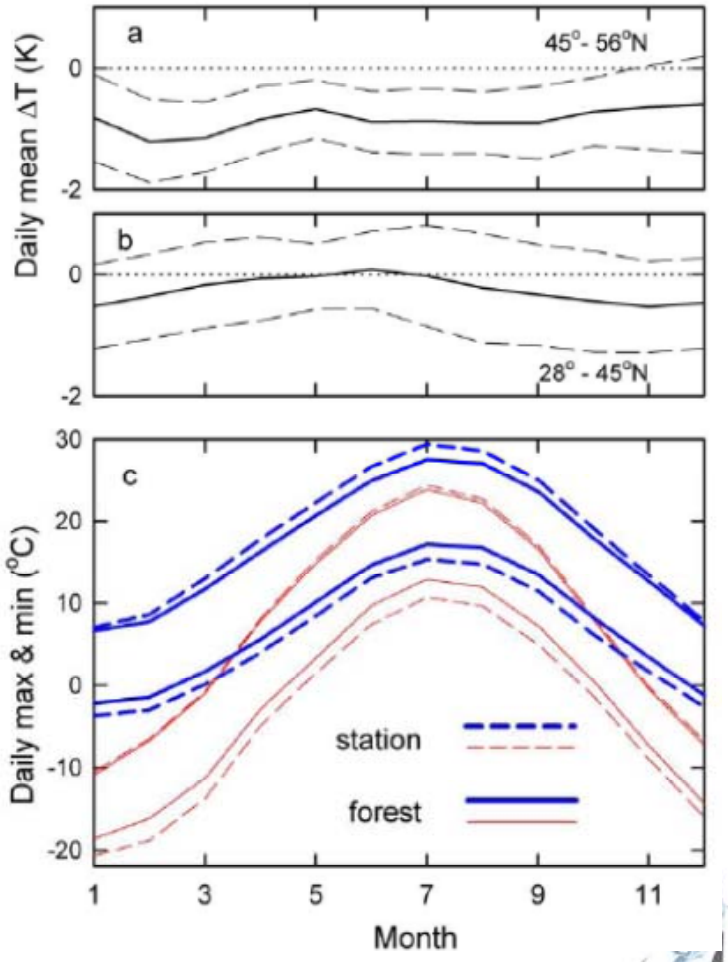


Fig.7 Seasonal and diurnal patterns of surface air temperature. a) and b): mean temperature difference ± one standard deviation for the site pairs north and south of 45° N; c) mean daily maximum and minimum temperatures for the forests and the surface stations (thick blue lines: 28-45° N; thin red lines: 45-56° N) (*Lee et al., 2011*).

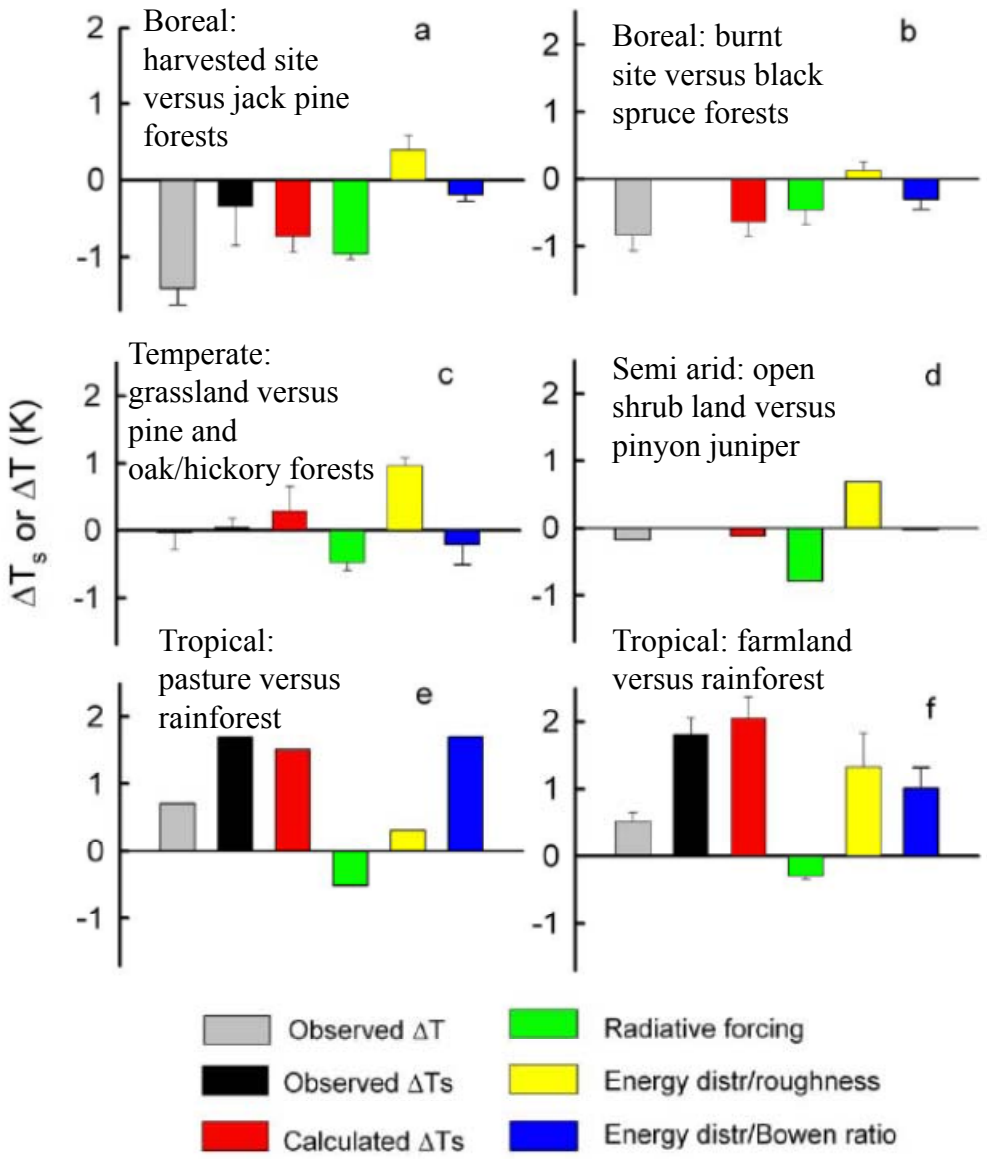


Fig.8 Partition of the biophysical effect at six FLUXNET site clusters in four different climate zones. Temperatures are 24 h means (*Lee et al., 2011*)..

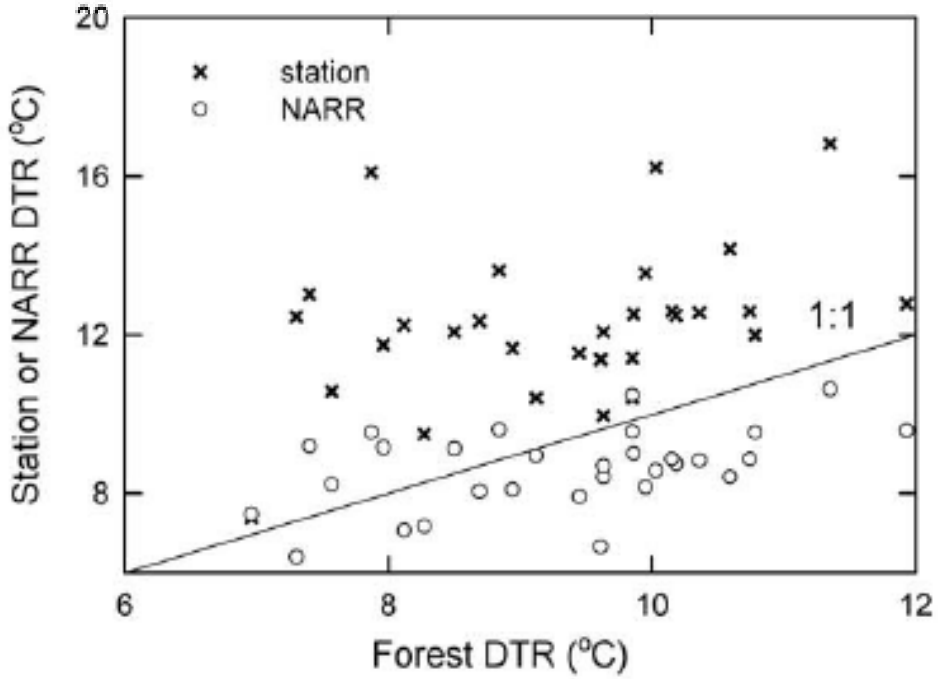


Fig.9 Comparison of the diurnal temperature range (DTR) between the forests, the surface stations and the NARR (North American Regional Reanalysis) model product (*Lee et al., 2011*).

Some problems

- The results need to be test at local-scale in different climate region.

2. Objectives

- Test the effects of deforestation on land surface air temperature at local-scale in Asia area, especially in tropical area.
- Uncover the temperature difference between forest site and surface station in different climate region of Asia.
- Uncover diurnal temperature range (DTR) seasonal and annual changes at different forest sites and surface station in Asia area.

3. Method

3.1 Site, Measurement, and data

- Forest Sites belong to ChinaFLUX, CERN, CFERN, AsiaFLUX.
- Based on the air temperature data measured at forest towers and surface station.

ChinaFLUX & CERN

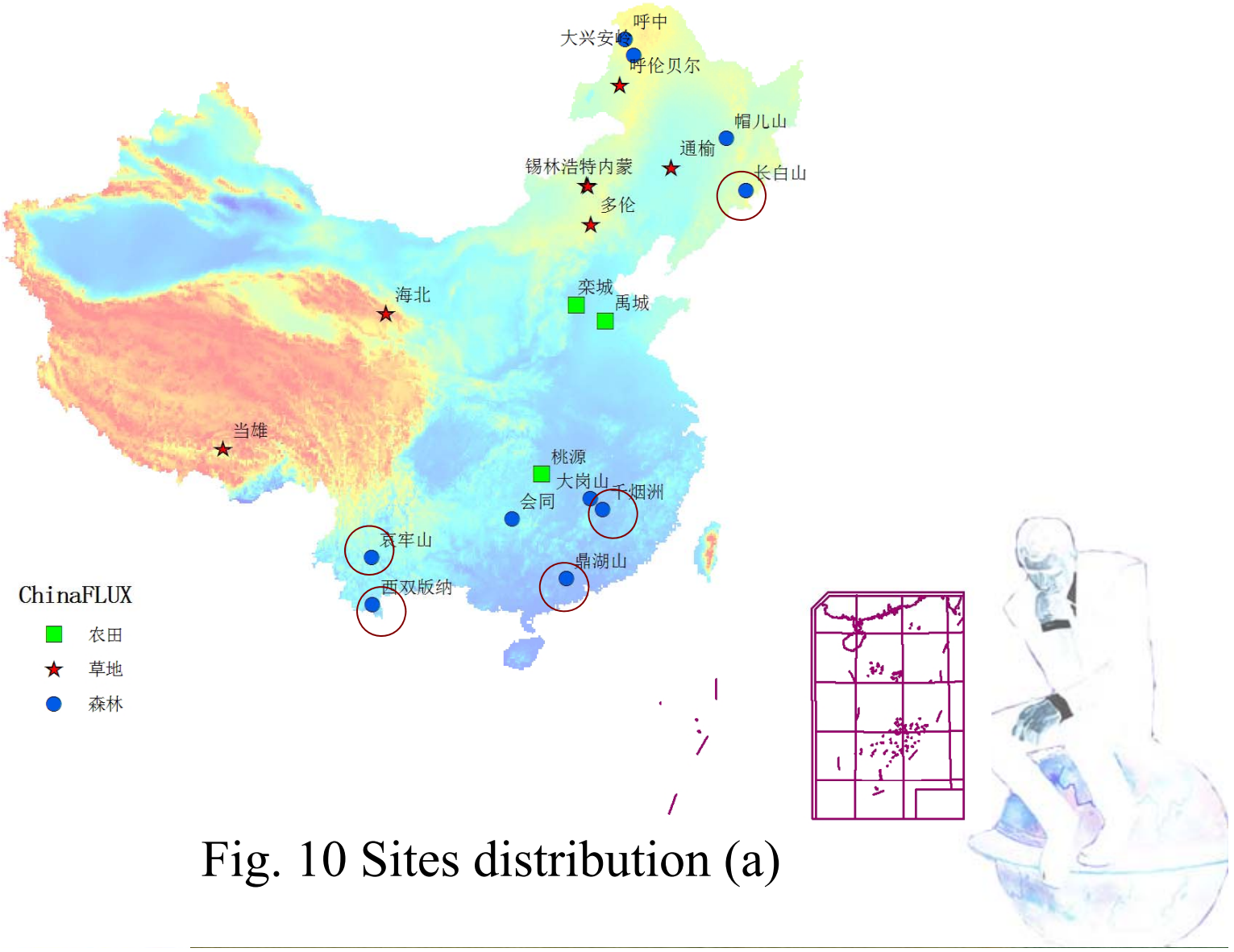


Fig. 10 Sites distribution (a)

Table Sites information and data (a)

Site Name	position	Climate region	Mean Annual Air Temperature	Annual Precipitation	Vegetation type	Data type	Data year
Changbaishan (CBS)	127.09°E 42.40°N	Temperate	3.6℃	713mm	Temperate mixed forest	F/S	2003~Now
Qianyanzhou (QYZ)	115.07°E 26.74°N	subtropical	18.6℃	1488mm	Subtropical planted coniferous forest	F/S	2003~Now
Dinghushan (DHS)	112.53°E 23.17°N	subtropical	21℃	1956 mm	South subtropical evergreen broadleaved forest	F/S	2003~Now
Xishuangbanna (XSBN)	101.02°E 21.95°N	Tropical	21.5℃	1493 mm	Tropic seasonal rainforest	F/S	2003~Now
Ailaoshan (ALS)	101.02°E 24.54°N	Subtropical	11.3℃	1840mm	Subtropical evergreen broadleaved forest	F/S	2009~Now

F: measurement in forest tower; S: measurement in surface station

CFERN

Fig. 10 Sites distribution (b)

Table Sites information and data (b)

Site Name	position	Climate region	Mean Annual Air Temperature	Annual Precipitation	Vegetation type	Data type	Data year
Dagangshan (DGS)	114.57°E 27.58°N	Subtropical	15.8℃	1590mm	Subtropical evergreen broadleaved forest	S	2001~2005
Huitong (HT)	109.75°E 26.83°N	Subtropical	16.8℃	1250mm	Subtropical evergreen broadleaved forest	S	2002
Wuyishan (WYS)	117.45°E 27.55°N	Subtropical	15℃	2000mm	Subtropical evergreen broadleaved forest	S	2001~2005
Jianfengling (JFL)	108.80°E 18.38°N	tropical	19.8℃	2449mm	Tropical rain forest	S	2001-2005

AsiaFLUX

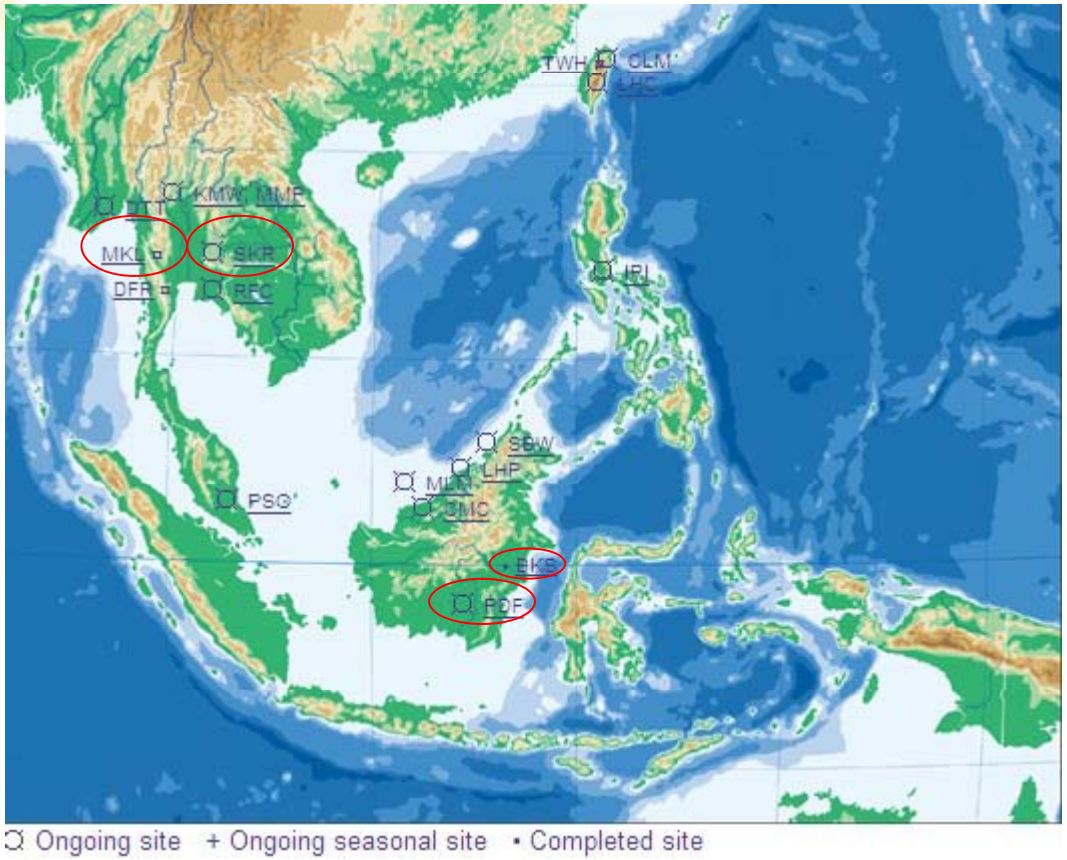


Fig. 10 Sites distribution (c)

Table Sites information and data (c)

Site Name	position	Climate region	Mean Annual Air Temperature	Annual Precipitation	Vegetation type	Data type	Data year
Sakaerat (SKR)	101.90°E 18.48°N	Tropical desert	24℃	1200-1300mm	Tropical seasonal evergreen forest	F	2001-2003
Mae Klong (MKL)	98.84°E 14.58°N	Tropical-monsoon	25℃	1500mm	Tropical seasonal deciduous forest	F	2003-2004
Palangkaraya drained forest (PDF)	114.04°E 2.75°S	Tropics	26.3℃	2231mm	Tropical peat swamp forest	F	2002-2005
Bukit Soeharto (BKS)	117.04ºE 0.86ºS	Tropical-fully humid	27℃	3300mm	Tropical secondary forest	F	2001-2002

3.2 Data process

- Obtain daily average air temperature of forest and surface station.
- Obtain daily maximum and minimum air temperature of forest and surface station.
- Calculate Diurnal temperature range of forest and surface station.

4. Work plan

- Collect data
- Data process
- Analysis primary results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