Modeling the effects of changes in diffuse radiation on light use efficiency in broad leaved Korean pine forest of Changbai Mountain

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Outline

1. **Background**
2. **Objective**
3. **Material and methods**
4. **Results & Discussion**
5. **Next work**

1. Background

Diffuse radiation ⬆

Light use efficiency (LUE) ⬆

(Gu et al., 2002; Law et al., 2002).

Quantitative analysis of the effect of diffuse radiation on LUE needs to be further studied.

(He et al., 2011).

Soil-Plant-Atmosphere Continuum (SPAC) multiple layers, separated into sunlit and shaded components

(WILLIAMS M et al., 1996).

Broad leaved Korean pine forest of Changbai Mountain (CBS) is a typical representative of north temperate forest ecosystem.

(Zhang et al., 2006).

2. Objective

① **Validation of SPAC model in CBS.**

② **Quantitative analysis of the effect of diffuse radiation on light use efficiency in different canopy layers by SPAC model.**

3. Material and methods

3.1 Experimental Site

Table 1. Broad leaved Korean pine forest of Changbai Mountain

Location	42.40°N，128.09°E
Mean annual temperature, ℃	3.6℃
Annual precipitation, mm	713
Mean annual total solar radiation, $MJ \cdot m^{-2}a^{-1}$	4349
Altitude, m	736
Canopy height, m	26
Dominant species	*Pinus koraiensis*、*Tilia amurensis*、*Quercus mongolica*、*Fraxinus mandshurica*、*Acer mono*

3.2 Material:

- **30-min flux data**
- **Routine meteorological data (T, VPD, Wspd, PAR, Rain et al.)**
- **Parameters (Vegetation properties, Soil parameters)**

3.3 Methods:

1. Light Use Efficiency（LUE）

$$LUE = \frac{GPP}{PAR} \qquad (1)$$

where GPP is ecosystem gross primary productivity, $mgCO_2 \cdot m^{-2} \cdot s^{-1}$; PAR is photosynthetic active radiation, $\mu mol \cdot m^{-2} \cdot s^{-1}$.

$$GPP = -NEE + R_{\mathrm{e}} \qquad (2)$$

$$R_{\mathrm{e}} = R_{\mathrm{ref}} \mathrm{e}^{E_0 (1/(T_{\mathrm{ref}} - T_0) - 1/(T_{\mathrm{s}} - T_0))} \qquad (3)$$

2. Soil Plant Atmosphere Continuum Model :

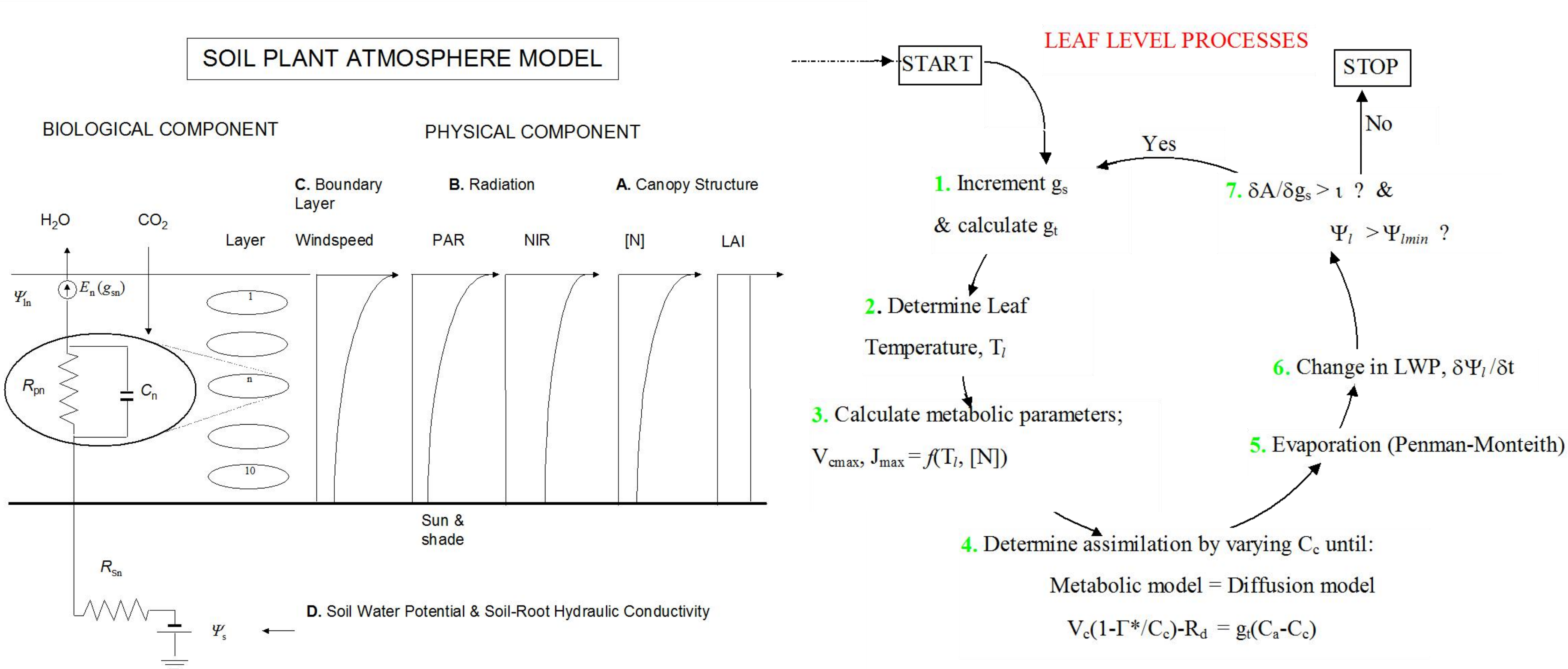


Figure 1. Basic principles of SPAC model（ WILLIAMS M et al., 1996）

Parameter sensitivity analysis of SPAC model in CBS in July in 2003

Table 2. List of key parameters and their effect on GPP when ±10％ bias is applied on these key parameters

	Parameter	GPP变化率
Driving variable	T(℃)	7.105%
	CO_2 (ppm)	9.665%
	WSPD (m/s)	0.575%
	DPAR	6.934%
	VPD (kpa)	2.205%
	PAR	17.296%
	rain (mm)	0.059%
Stable parameters in the model	Gplant (μmol m^{-1} s^{-1} MPa^{-1})	0.228%
	Minlwp (MPa)	6.372%
	Iota (N/a)	47.739%
	Capac (μmol m^{-2} MPa^{-1})	0.625%
	Rootresist (MPa s g μmol^{-1} (biomass based))	4.931%
	V_{cmax} (μmol m^{-2} s^{-1})	1.047%
	J_{max} (μmol m^{-2} s^{-1})	3.066%

4. Results & Discussion

4.1 Relationship between LUE and S_f/S_0 in CBS

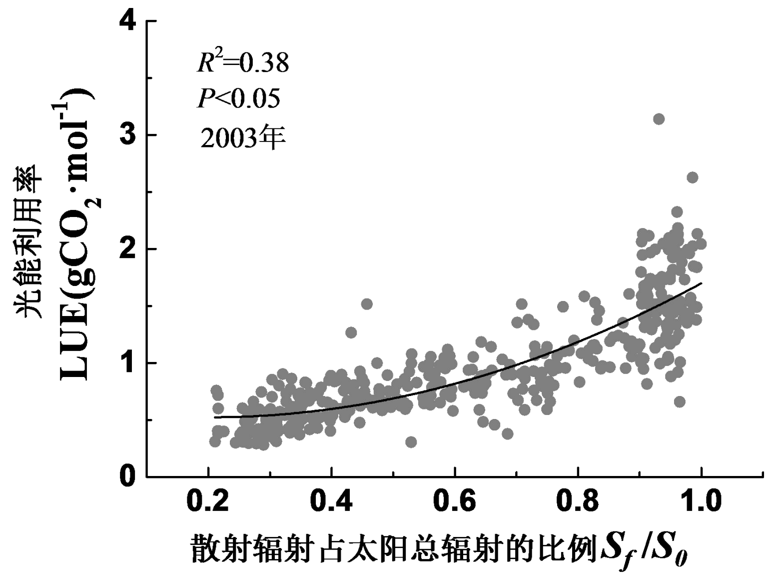


Figure 1. Relationship between LUE and S_f/S_0 (solar elevation 61.4°-71.4°) in CBS from June to August in 2003

4.2 Parameter setting in SPAC model in CBS from June to August in 2003

Table 3a. Vegetation properties

Canopy layers	1	2	3	4	5	6	7	8	9	10
la_frac	0.023	0.027	0.027	0.134	0.134	0.145	0.145	0.122	0.122	0.122
nit_frac	0.023	0.027	0.027	0.134	0.134	0.145	0.145	0.122	0.122	0.122
ht	26.5	24.5	22.5	20.5	18.5	16.5	14.5	12.5	10.5	8.5

Table 3b. Vegetation properties

Parameter	Explanation	Typical values	values
totla (m^2 m^{-2})	Total LAI	0.1-10.0	5.52
totn (gN m^{-2})	Total foliar N	0.1-20.0	7.72
gplant (μmol m^{-1} s^{-1} MPa^{-1})	Stem conductivity or stem conductance	1-20	10
Minlwp (MPa)	Minimum leaf water potential	-2- -4	-3
Iota (N/a)	Stomatal efficiency	1.01-1.0007	1.01
Capac (μmol m^{-2} MPa^{-1})	Leaf capacitance	1000-10000	5000
Dimen (m)	Leaf characteristic dimension	0.01-0.2	0.08
Rootresist (MPa s g $μmol^{-1}$ (biomass based))	Root resistivity	10-500	250
Kappac (μmol g^{-1} s^{-1})	Rate constant for V_{cmax}	10–50	46
Kappaj (μmol g^{-1} s^{-1})	Rate constant for J_{max}	20–100	77

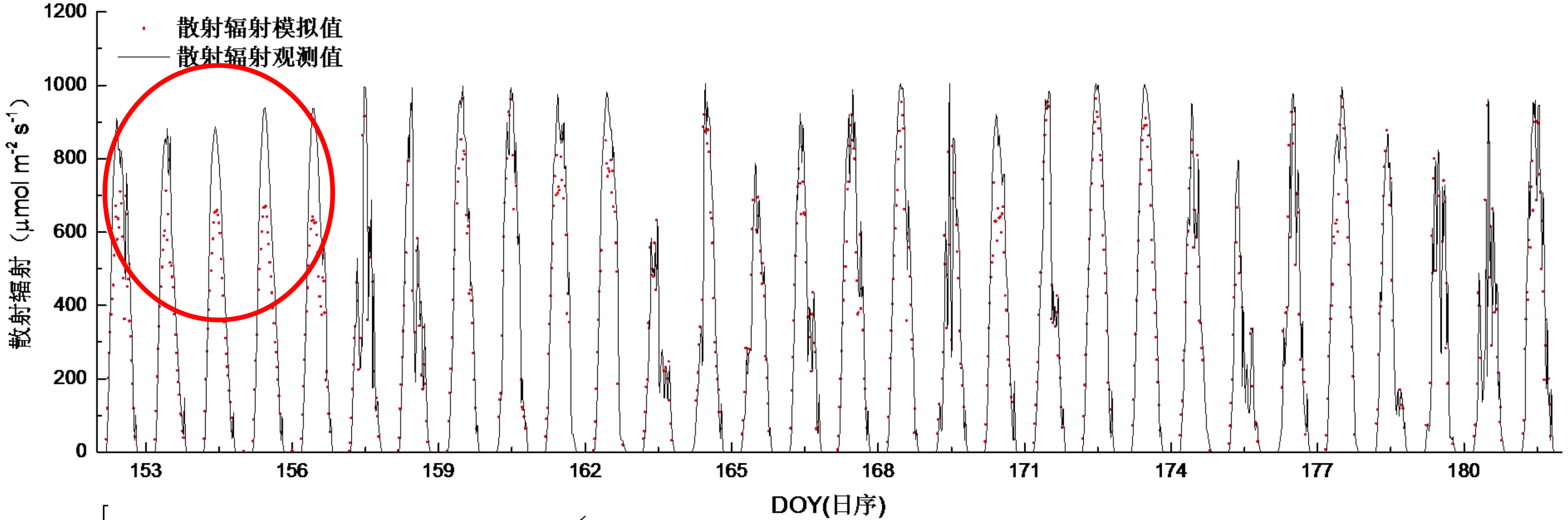
Table 4a. Soil parameters

Soil layers	1	2	3	4	5	6	core
Layer_thickness	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Organic_fraction	0.34	0.12	0.12	0.08	0.08	0.08	0.08
Mineral_fraction	0.1	0.2	0.2	0.3	0.4	0.45	1
Initial_water_fraction	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Initial_soil_temp	289	288	287	286	285	284	283
Initial_ice_proportion	0	0	0	0	0	0	0
rootfrac	0.412	0.277	0.186	0.125	0	0	0

Table 4b. Soil parameters

Parameter	Explanation	Typical values	values
rootbiomass(g biomass m^{-2} ground)	Total root biomass	100-2000	541
Sandpc(%)	% sand in soil layers	10-50	35
claypc(%)	% sclay in soil layers	10-50	25
rootrad(m)	Fine root radius	0.0005	0.0005
draincheck(Fraction)	Fraction of porosity above which gravitational drainage occurs	0.5-0.7	0.6
snowweight(Kg m^{-2})	Initial total snow weight	0+	0
snowheight(m)	Initial snow height	0+	0

4.3 Validation of SPAC model in CBS from June to August in 2003



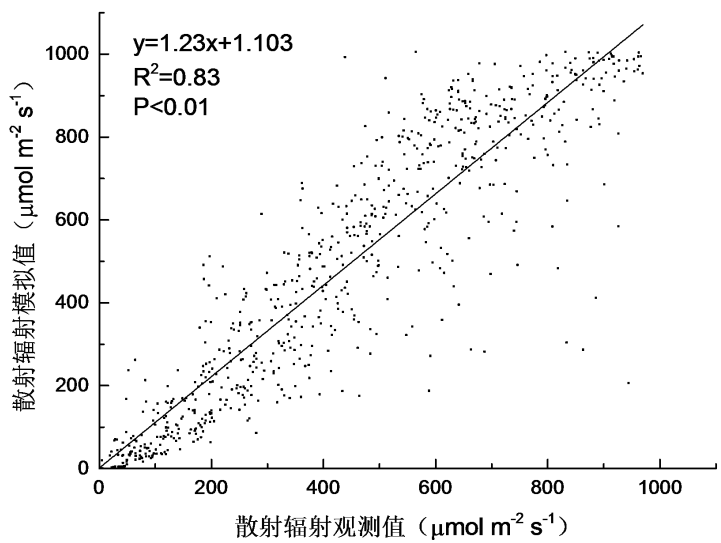
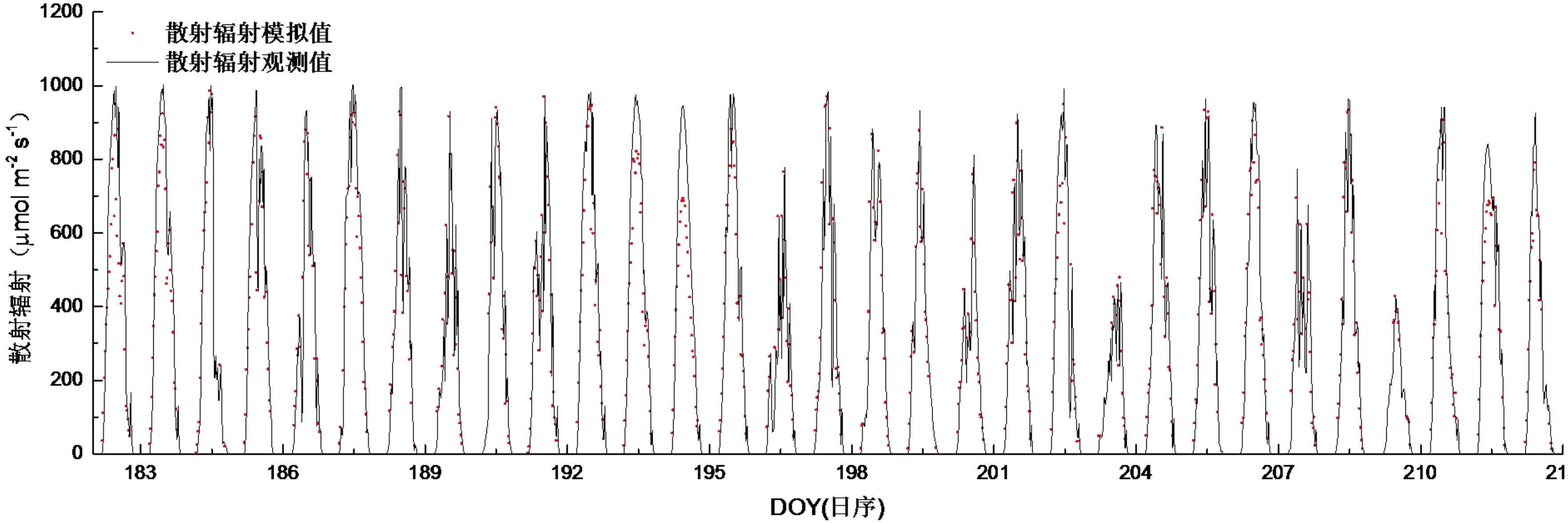


Figure 3. The comparison between the simulated and measured diurnal variation of diffuse radiation of canopy of broad-leaved and Korean pine forest in Changbai mountain in June 2003.



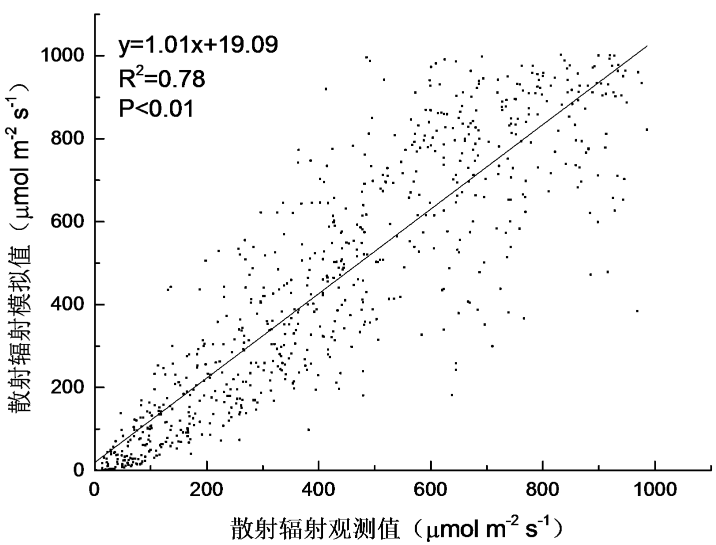
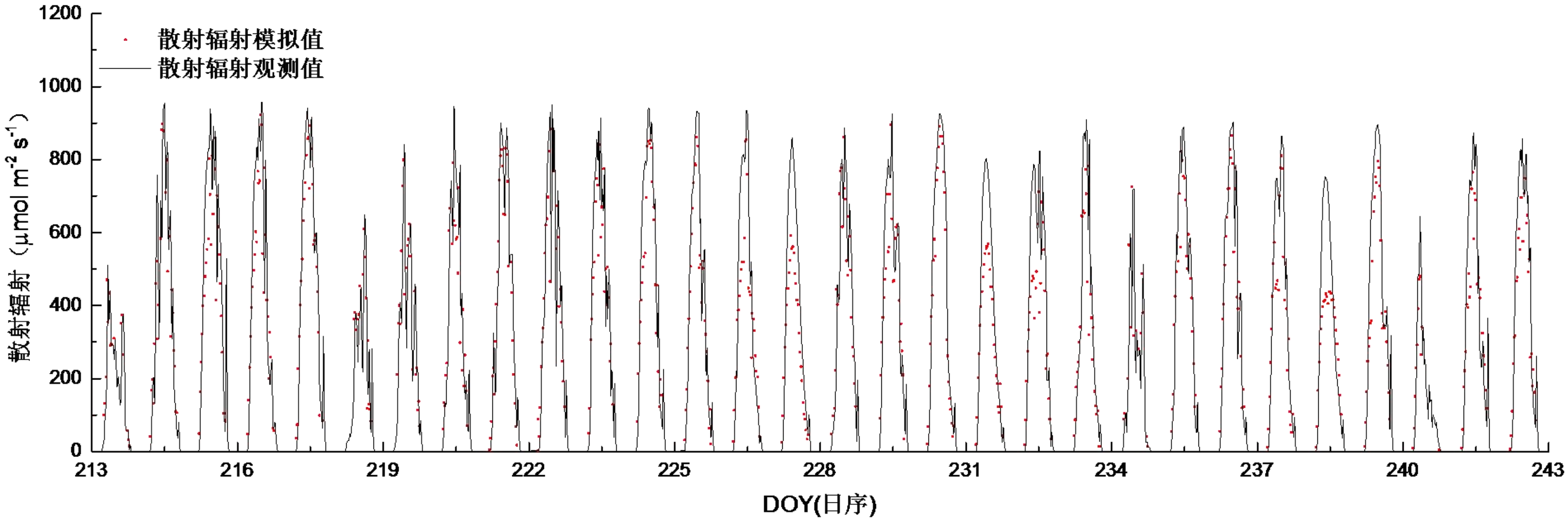


Figure 4. The comparison between the simulated and measured diurnal variation of diffuse radiation of canopy of broad-leaved and Korean pine forest in Changbai mountain in July 2003.



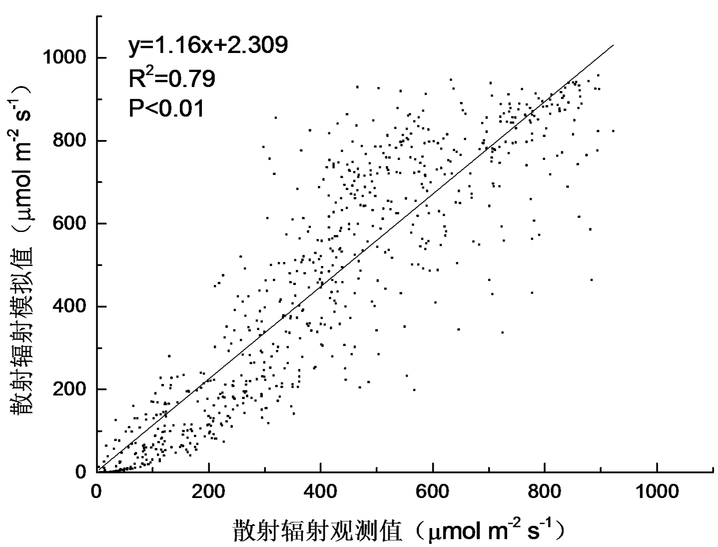
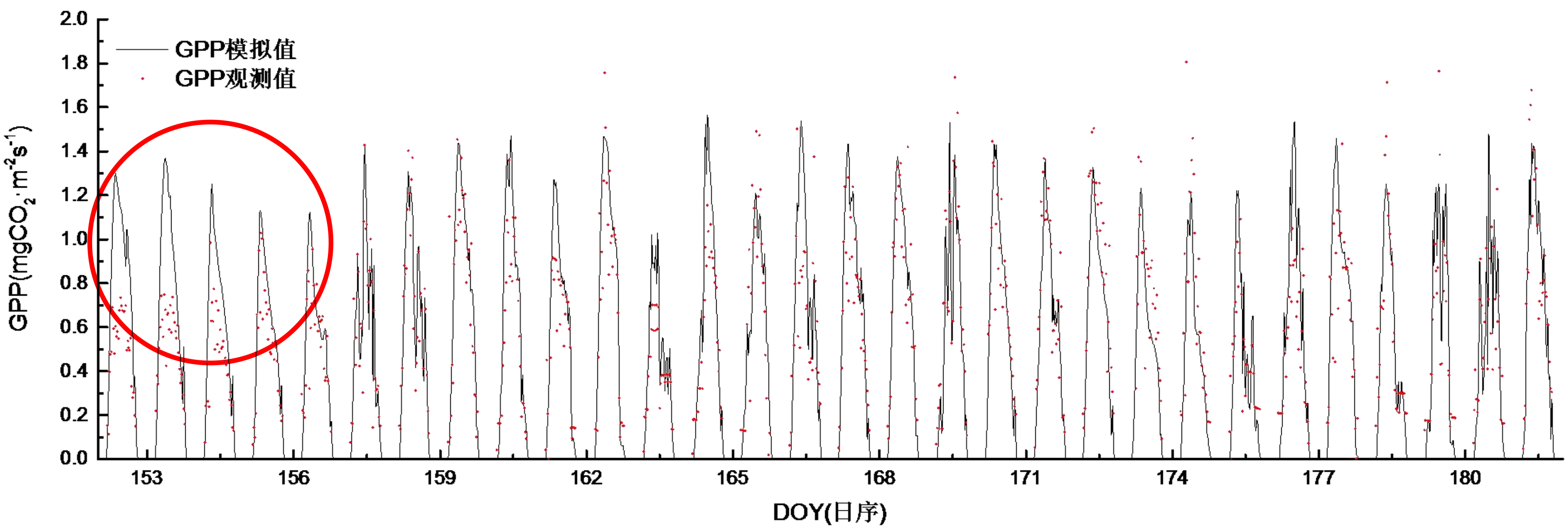


Figure 5. The comparison between the simulated and measured diurnal variation of diffuse radiation of canopy of broad-leaved and Korean pine forest in Changbai mountain in August 2003.



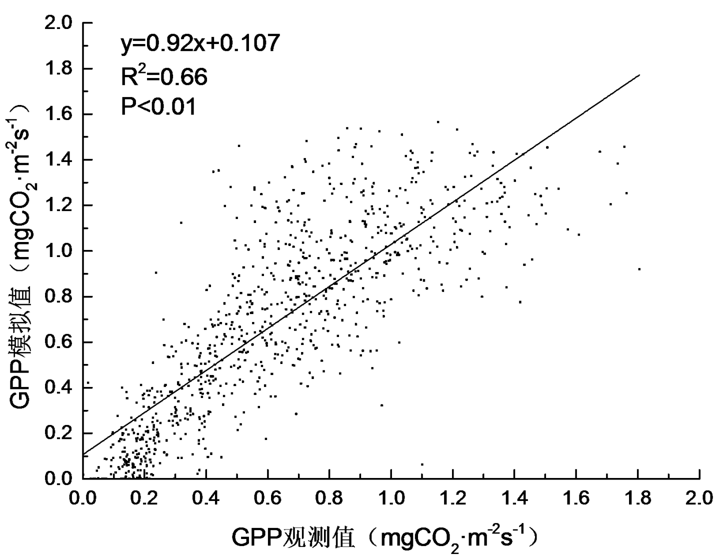


Figure 6. The comparison between the simulated and measured through eddy covariance diurnal variation of GPP of canopy of broad-leaved and Korean pine forest in Changbai mountain in June 2003.

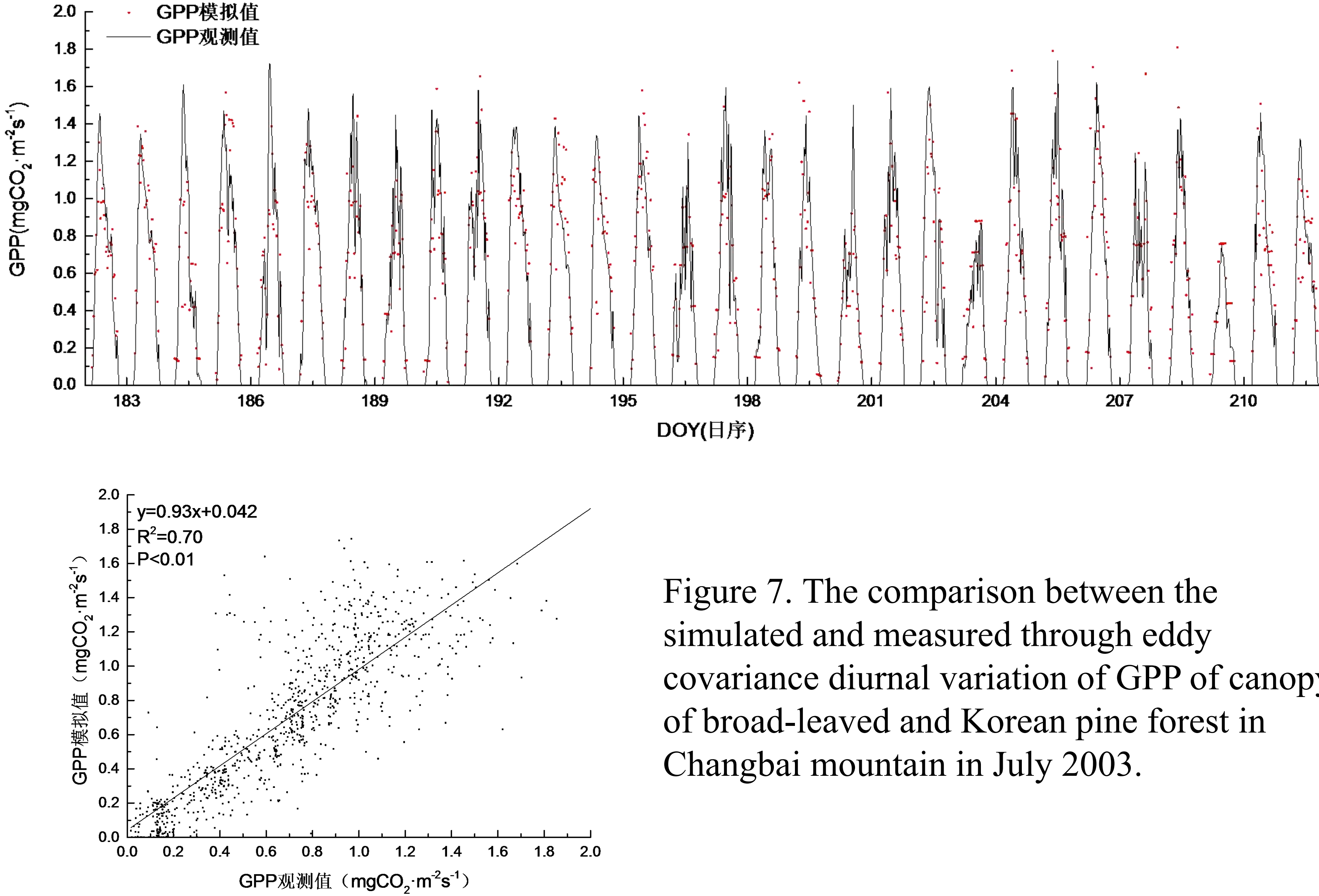
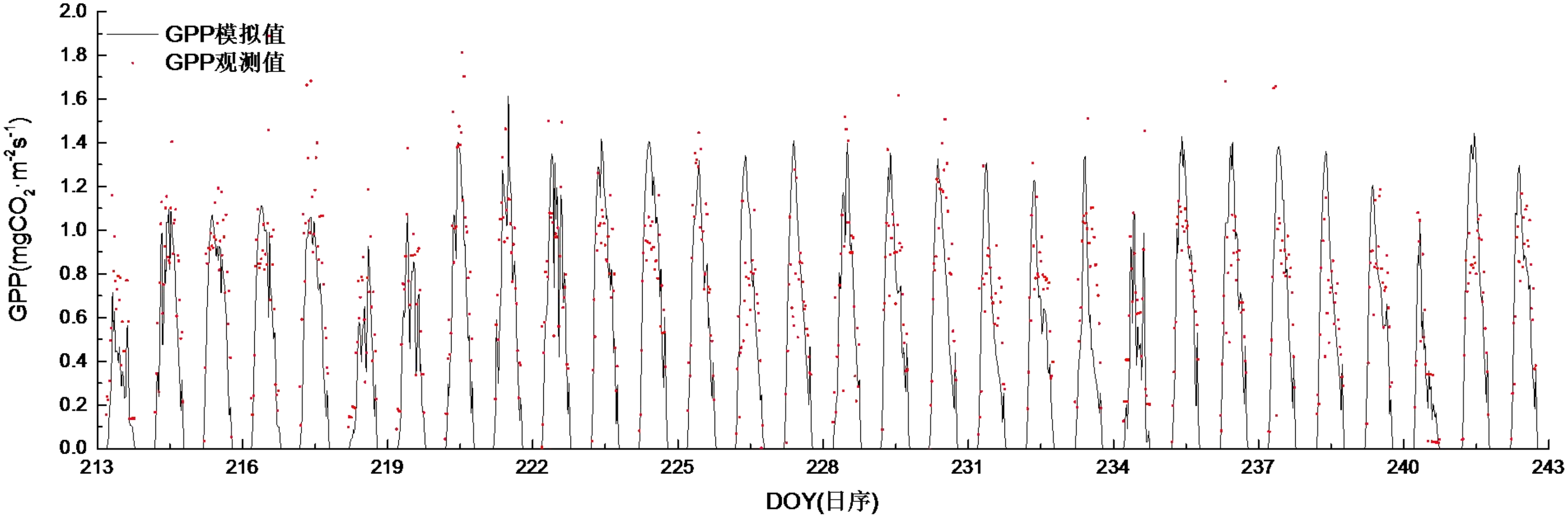


Figure 7. The comparison between the simulated and measured through eddy covariance diurnal variation of GPP of canopy of broad-leaved and Korean pine forest in Changbai mountain in July 2003.



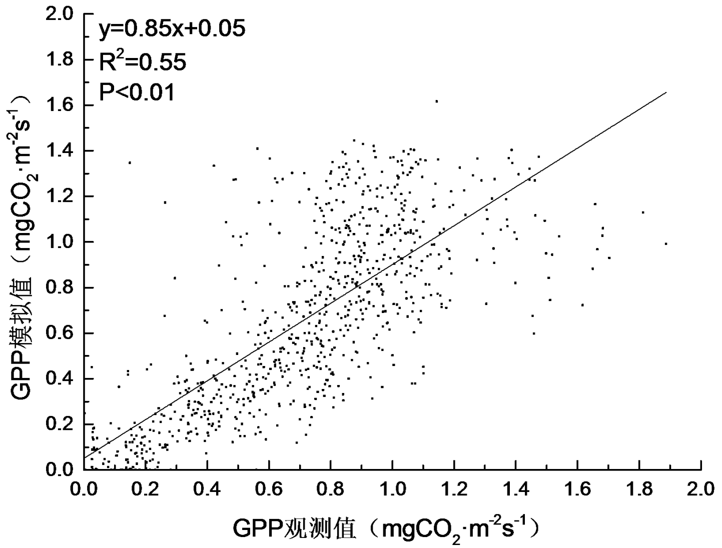


Figure 8. The comparison between the simulated and measured through eddy covariance diurnal variation of GPP of canopy of broad-leaved and Korean pine forest in Changbai mountain in August 2003.

Table 5. Assessment index between simulated and observed values for GPP and diffuse photosynthetic active radiation at CBS

Month		r	RMSE	MBE
6	GPP	0.891	0.249	0.058
	DPAR	0.939	142.217	46.014
7	GPP	0.908	0.241	0.003
	DPAR	0.932	146.523	27.148
8	GPP	0.850	0.276	0.057
	DPAR	0.92	148.14	49.228

4.4 Simulation of diffuse radiation and GPP in different canopy layers in CBS in July 2003

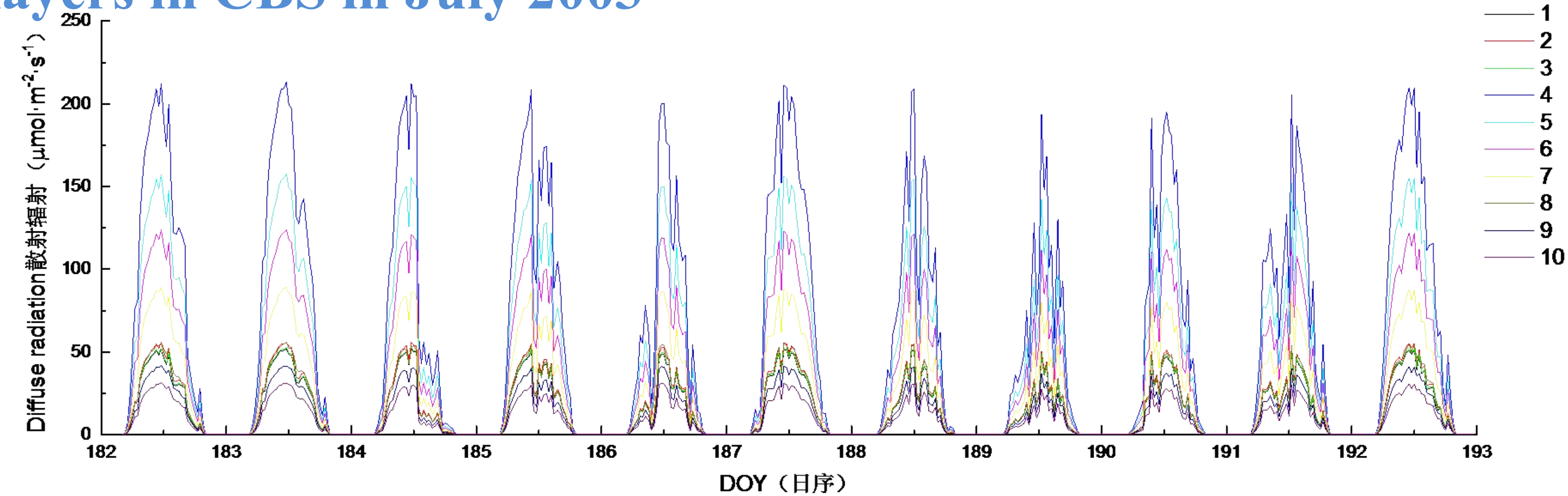


Figure 9. The simulated diurnal variation of diffuse radiation in different canopy layers of broad-leaved and Korean pine forest in Changbai mountain in July 2003.

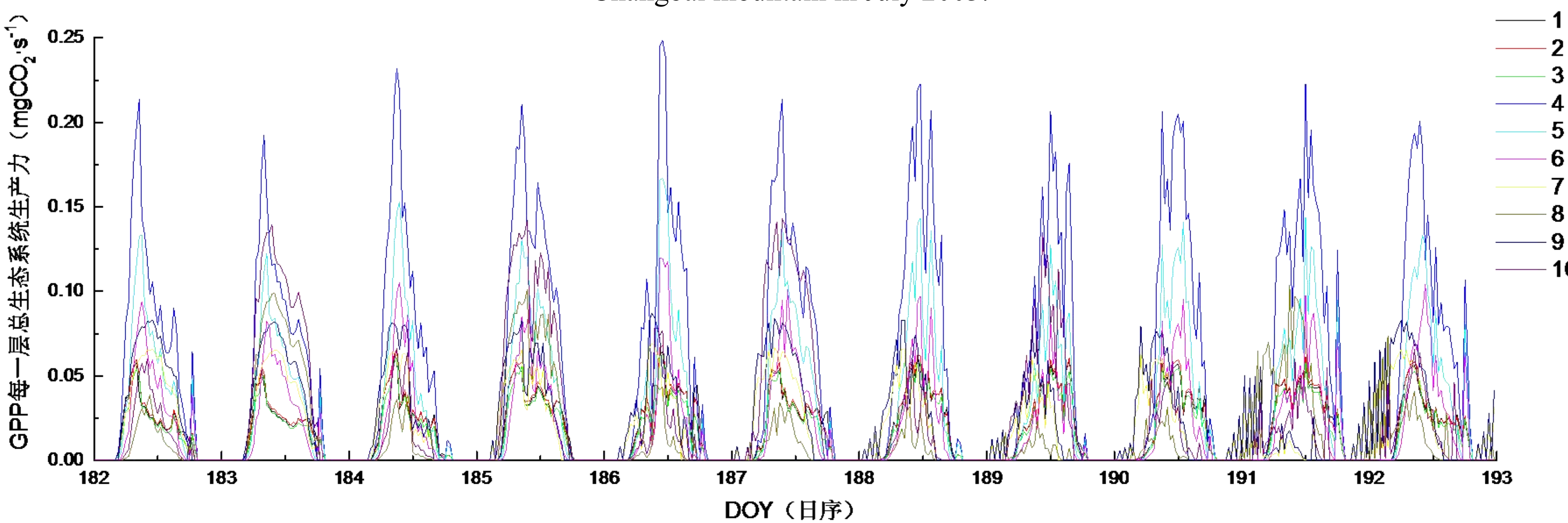


Figure 10. The simulated diurnal variation of GPP in different canopy layers of broad-leaved and Korean pine forest in Changbai mountain in July 2003.

5. Next work

- Simulation of GPP in 2004~2009.
- The effect of diffuse radiation for LUE on each layer.
- Research paper writing.

Thank you！