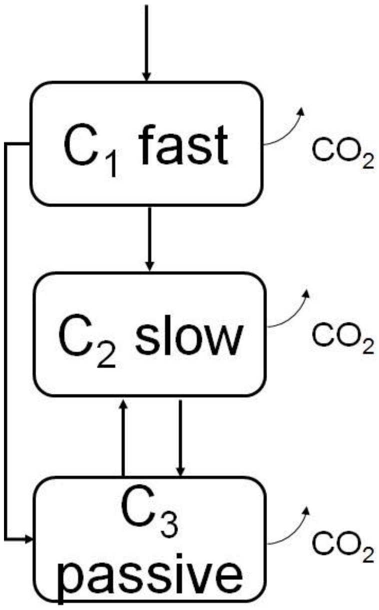
Response text to the comments 1) and 2):

Model description

In this study, a three-feedback-pool C model consisted with fast, slow, and a passive pools and carbon transfers between three pools. The dynamics of soil carbon pool follows first-order differential equation as described in the CENTURY and the Terrestrial Ecosystem models (Bolker *et al.*, 1998; Liang *et al.*, 2015). The pools and fluxes are shown in the following diagram:



The dynamics of the three C pools can be mathematically described as:

$$\begin{cases} \frac{dC_1(t)}{dt} = C_1(t\text{-}1)\text{-}Q10_1\cdot k_1\cdot C_1(t)+Q10_2\cdot k_2\cdot C_2(t)\cdot f_{12}+Q10_3\cdot k_3\cdot C_3(t)\cdot f_{13} \\ \frac{dC_2(t)}{dt} = C_2(t\text{-}1)\text{-}Q10_2\cdot k_2\cdot C_2(t)+Q10_1\cdot k_1\cdot f_{21} \\ \frac{dC_3(t)}{dt} = C_3(t\text{-}1)\text{-}Q10_3\cdot k_3\cdot C_3(t)+Q10_1\cdot k_1\cdot C_1(t)\cdot f_{31}+Q10_2\cdot k_2\cdot C_2(t)\cdot f_{32} \end{cases} \quad (1)$$

where C_1 is used to describe soil carbon pool size, f_{ij} is carbon transfer coefficient which indicating the fraction of the carbon entering i-th pool from j-th pool. k_1, k_2, k_3 is the decomposition rate in fast, slow and passive pools, respectively. carbon pool. $Q10_1$, $Q10_2$, $Q10_3$ is the temperature scalar in fast, slow and passive pools. For pool-flux approach, the in-site observation carbon dioxide in the three-pool model is the total carbon pool size and respiration. At steady state, soil respiration equals to carbon input in different biomes. Values in parenthesis indicated 99% confidence interval for predicted transit times at each site based on 50000 Monte Carlo calculations.

Bayesian inversion with Markov Chain Monte Carlo approach

The parameters in the three-pool model were estimated based on Bayes' theorem with the posterior probability density function of model parameters (θ) (Liang *et al.*, 2015; Xu *et al.*, 2016). The prior knowledge of parameter represented by a prior probability density function P(θ) and the information in the pool-flux in-situ observational data represented by a likelihood function, P(Z|θ). The posterior probability density function of model can be described as equation (2):

$$P(\theta|Z)= \frac{P(\theta|Z)\cdot P(\theta)}{P(Z)} \quad (2)$$

In this study, we adopted the prior ranges of model parameter from Liang et al. (2015) across biomes (please see Table 1).

Estimates of transit time and age from three-pool models

Based on the concepts of mean age and mean transit time published by Rasmussen et al., (2016) (Rasmussen *et al.*, 2016), the mean carbon age defined as the whole time period when a carbon atom was respired into atmosphere from the entrance at a certain time, and then the mean age of carbon $\bar{a}_i(t)$ in a certain carbon pool i could be calculated with equation (3):

$$\bar{a}_i(t)=1+ \frac{\sum_{i=1}^{3} (\bar{a}_j(t)-\bar{a}_j(t))\cdot f_{ij}(t)\cdot C_i-\bar{a}_j(t)\cdot I_i(t)}{C_i} \quad (3)$$

where the $f_{ij}(t)$ is the carbon fraction transfer from j-th to i-th pools, I_i (t) is the external input into this carbon pool.

The transit time $\tau_i(t)$ was defined as the mean age of carbon atoms leaving the carbon pool at a specific time. that is

$$\tau_i(t)= \sum_{i=1}^{d} f_i(t)\cdot a_i(t) \quad (4)$$

where the $f_i(t)$ is the fraction of carbon with mean age $a_i(t)$.

Table S1. Prior parameters of three-pool for the average of sites

Parameter	Definition	Value	Range
Q10	The temperature scalar in fast, slow and passive carbon pools	2	0-6
f12	The fraction of carbon from pool 2 to pool 1	0.1	0.1-0.6
f13	The fraction of carbon from pool 3 to pool 1	0.2	0-1
f21	The fraction of carbon from pool 1 to pool 2	0.5	0.1-0.6
f31	The fraction of carbon from pool 1 to pool 3	0.004	0-0.1
f32	The fraction of carbon from pool 2 to pool 3	0.03	0-0.03
k1	The decomposition rate of the fast soil carbon pool	0.01	0.001-0.05
k2	The decomposition rate of the slow soil carbon pool	0.006	0.001-0.0021
k3	The decomposition rate of the passive soil carbon pool	0.00002	1.910^{-6}-$2.1\ 10^{-5}$

Table S2. Estimates of and parameter of soil carbon transit time across biomes.

Parameter		Boreal forest	Temp-erate forest	Tropi-cal forest	Crop-land	Tundra	Desert/ shrubl-and	Grassland/sa-vanna
Q_{10}	C1	1.4	2.2	2.5	2.3	2.9	2.5	1.9
	C2	2.8	1.4	1.1	1.3	4.2	1.3	1.1
	C3	3.1	0.8	1.4	1.6	3.8	3.7	2.8
Transit time (yr)	Tau 1	4.7	3.2	3.0	3.2	47.1	32.7	22.6
	Tau 2	84.2	28.8	18.7	34.5	54.9	55.8	45.9
	Tau 3	131.8	36.8	18.9	71.1	105.8	114.8	88.3
	Mean	66.4	79.0	28.9	77.1	166.5	135.3	53.8
Mean age		1661.1	2761.5	366.5	1056.8	1805.7	1976.8	1127.4

Response text for comments 3): The KDE is a non-parametric approach to estimate the probability density function of a random variable. Let $(x_1, x_2, \cdots, x_n)$ denote the observed C transit time with density function f as below:

$$\hat{f}_h(x) = \frac{1}{nh} \sum_{i=1}^{n} K(\frac{x-x_i}{h})$$

where K is the non-negative function than integrates to one and has mean zero, and $h > 0$ is a smoothing parameter called the bandwidth. The density function was estimated by Gaussian Kernel Density (Sheather & Marron, 1990; Saoudi *et al.*, 1997), and the bandwidth for approaches of stable isotope ^{13}C, pool-flux and incubation are: 48.61, 35.13, 2.62, respectively. We further show the probability density distribution of transit time among 12 models which shown as figure below.

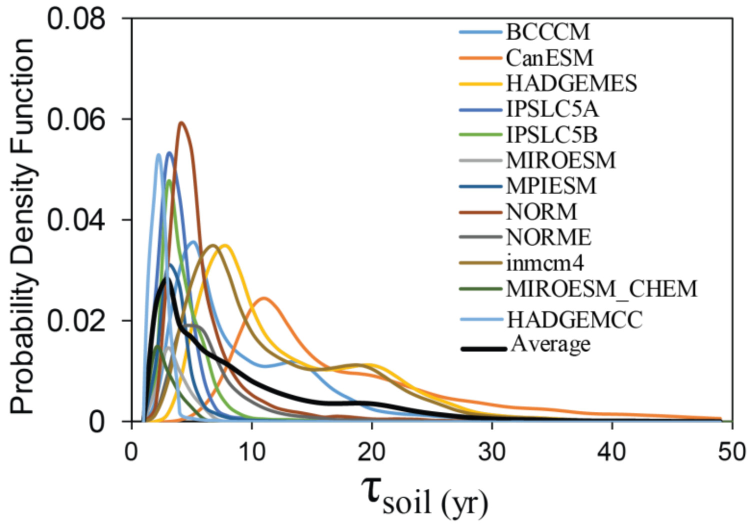
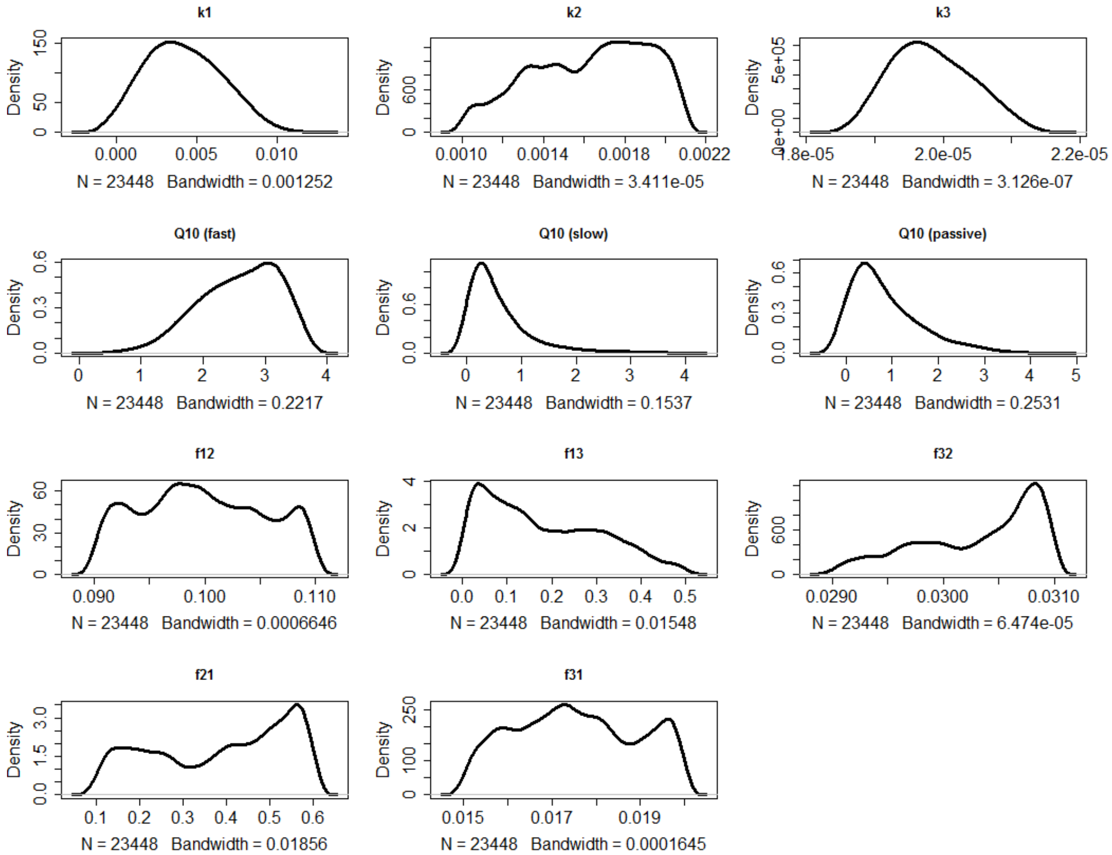
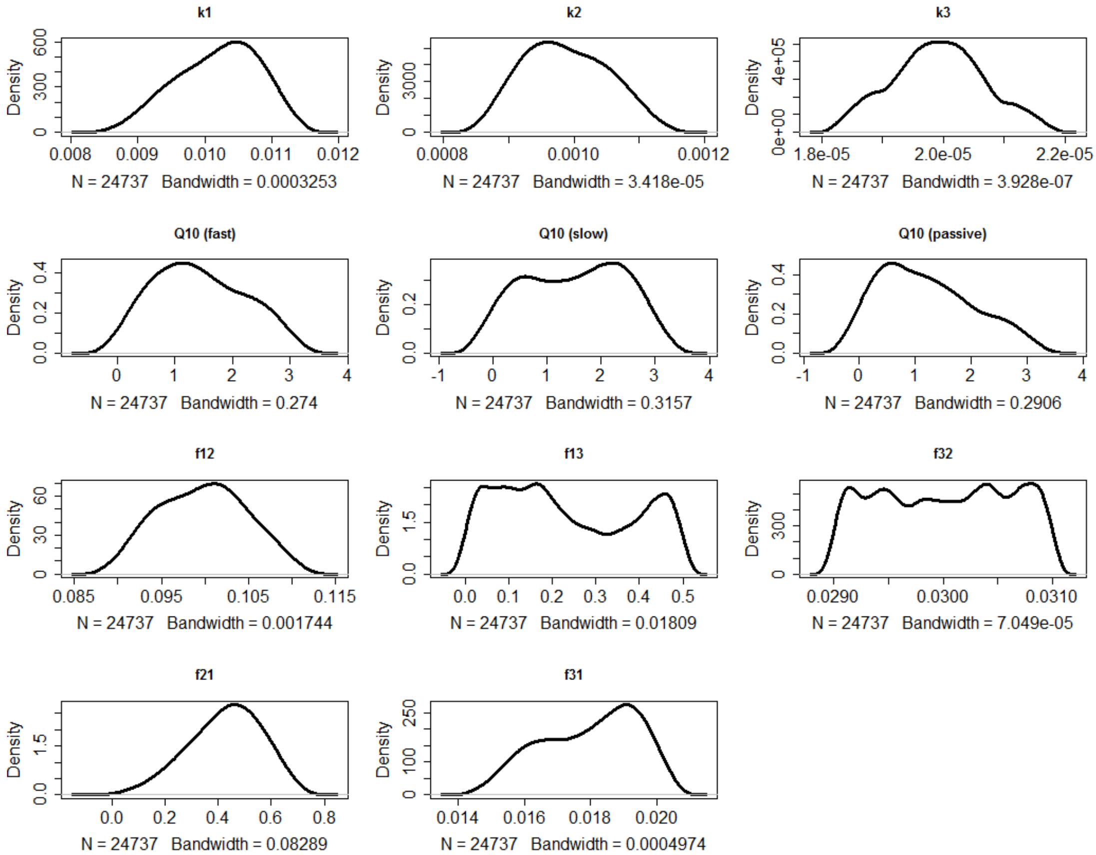


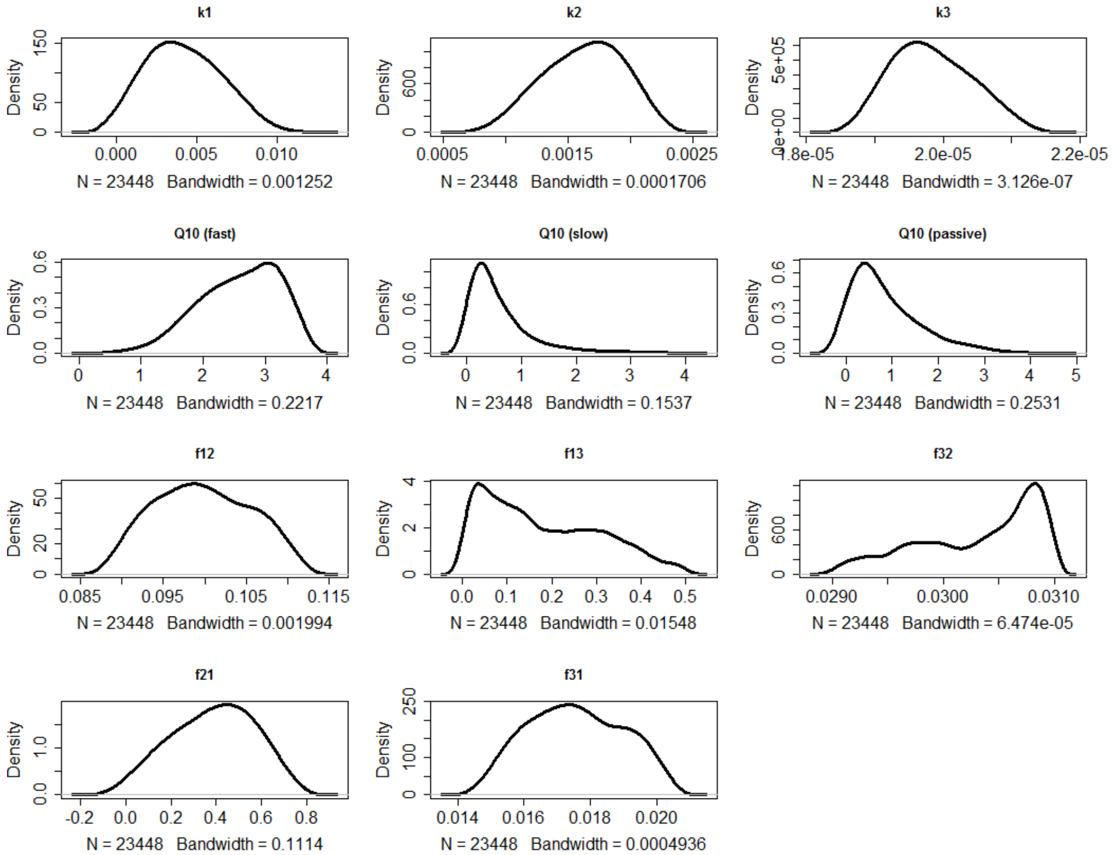
Figure S1. The probability density function of CMIP5 output, the black line is the ensemble-model mean transit time.



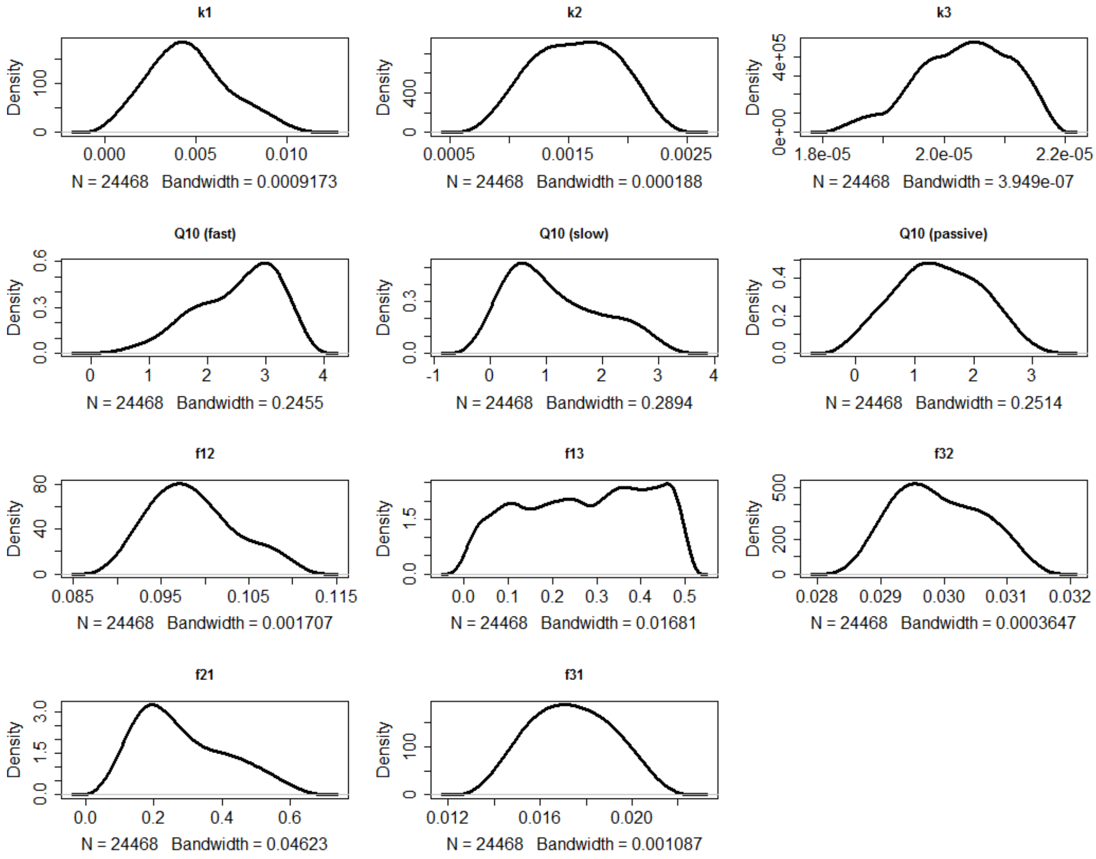
FigureS2. Probability distributions of the parameters in the three -pool-feedback model for tundra ecosystem (See Equation (1) for abbreviations).



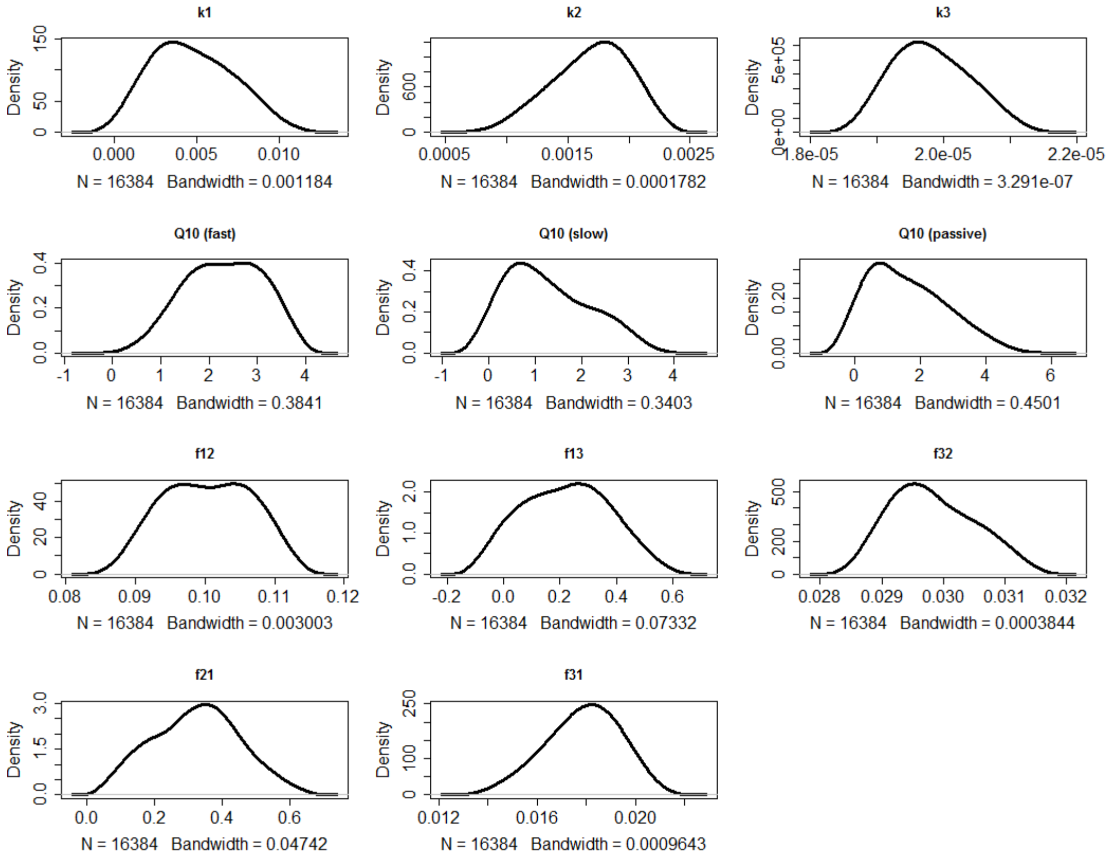
FigureS3. Probability distributions of the parameters in the three -pool-feedback model for boreal forest ecosystem (See Equation (1) for abbreviations).



FigureS4. Probability distributions of the parameters in the three -pool-feedback model for temperate forest (See Equation (1) for abbreviations).



FigureS5. Probability distributions of the parameters in the three-pool-feedback model for tropical forest (See Equation (1) for abbreviations).



FigureS6. Probability distributions of the parameters in the three -pool-feedback model for cropland (See Equation (1) for abbreviations).