Final report

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Data Synthesis and Data Assimilation at Global Change Experiments and Fluxnet Toward Improving Land Process Models

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The project was conducted during the period from 7/1/2012 to 6/30/2017 with three major tasks: (1) data synthesis and development of data assimilation (DA) techniques to constrain modeled ecosystem feedback to climate change; (2) applications of DA techniques to improve process models at different scales from ecosystem to regions and the globe; and 3) improvements of modeling soil carbon (C) dynamics by land surface models.

During this period, we have synthesized published data from soil incubation experiments (e.g., Chen et al., 2016; Xu et al., 2016; Feng et al., 2016), global change experiments (e.g., Li et al., 2013; Shi et al., 2015, 2016; Liang et al., 2016) and fluxnet (e.g., Niu et al., 2012., Xia et al., 2015; Li et al., 2016). These data have been organized into multiple data products and have been used to identify general mechanisms and estimate parameters for model improvement.

We used the data sets that we collected and the DA techniques to improve model performance of both ecosystem models and global land models. The objectives are: 1) to improve model simulations of litter and soil carbon storage (e.g., Schädel et al., 2013; Hararuk and Luo, 2014; Hararuk et al., 2014; Liang et al., 2015); 2) to explore the effects of CO_2, warming and precipitation on ecosystem processes (e.g., van Groenigen et al., 2014; Shi et al., 2015, 2016; Feng et al., 2017); and 3) to estimate parameters variability in different ecosystems (e.g., Li et al., 2016).

We developed a traceability framework, which was based on matrix approaches and decomposed the modeled steady-state terrestrial ecosystem carbon storage capacity into four can trace the difference in ecosystem carbon storage capacity among different biomes to four traceable components: net primary productivity (NPP), baseline C residence times, environmental scalars and climate forcing (Xia et al., 2013). With this framework, we can diagnose the differences in modeled carbon storage across ecosystems, biomes, and models. This framework has been successfully implemented by several global land models, such as CABLE (Xia et al., 2013), LPJ-GUESS (Ahlström *et al*., 2015), CLM (Hararuk et al., 2014; Huang et al., 2017, submitted; Shi et al., 2017, submitted), and ORCHIDEE (Huang et al., 2017, unpublished). Moreover, we have identified the theoretical foundation of the determinants of transient C storage dynamics by adding another term, C storage potential, to the steady-state traceability framework (Luo et al., 2017). The theoretical foundation of transient C storage dynamics has been applied to develop a

transient traceability framework to explore the traceable components of transient C storage dynamics responded to the rising CO_2 and climate change in the two contrasting ecosystem types Duke needleleaved forest and Harvard deciduous broadleaved forest (Jiang et al., 2017, in revision).

Overall, with the data synthesis, data assimilation techniques, and the steady-state and transient traceability frameworks, we have greatly improved land process models for predicting responses and feedback of terrestrial C dynamics to global change. The matrix approaches has the potential to be applied in theoretical research on nitrogen and phosphorus cycle, and therefore, the coupling of carbon-nitrogen-phosphorus.

Below are the highlights of key results:

Joint control of terrestrial gross primary productivity by plant phenology and physiology: Terrestrial gross primary productivity (GPP) varies greatly over time and space. A better understanding of this variability is necessary for more accurate predictions of the future climate–carbon cycle feedback. Recent studies have suggested that variability in GPP is driven by a broad range of biotic and abiotic factors operating mainly through changes in vegetation phenology and physiological processes. However, it is still unclear how plant phenology and physiology can be integrated to explain the spatiotemporal variability of terrestrial GPP. Based on analyses of eddy–covariance and satellite-derived data, we decomposed annual terrestrial GPP into the length of the CO_2 uptake period (CUP) and the seasonalmaximal capacity of CO_2 uptake (GPP_{max}). The product of CUP and GPPmax explained >90% of the temporal GPP variability in most areas of North America during 2000-2010 and the spatial GPP variation among globally distributed eddy flux tower sites. It also explained GPP response to the European heatwave in 2003 ($r^2 = 0.90$) and GPP recovery after a fire disturbance in South Dakota ($r^2 = 0.88$). Additional analysis of the eddy–covariance fluxdata shows that the interbiome variation in annual GPP is better explained by that in GPPmax than CUP. These findings indicate that terrestrial GPP is jointly controlled by ecosystem-level plant phenology and photosynthetic capacity, and greater understanding of GPP_{max} and CUP responses to environmental and biological variations will, thus, improve predictions of GPP over time and space.

Thermal optimality of net ecosystem exchange of carbon dioxide and underlying mechanisms: It is well established that individual organisms can acclimate and adapt to temperature to optimize their functioning. However, thermal optimization of ecosystems, as an assemblage of organisms, has not been examined at broad spatial and temporal scales. Here, we compiled data from 169 globally distributed sites of eddy covariance and quantified the temperature response functions of net ecosystem exchange (NEE), an ecosystem-level property, to determine whether NEE shows thermal optimality and to explore the underlying mechanisms. We found that the temperature response of NEE followed a peak curve, with the optimum temperature (corresponding to the maximum magnitude of NEE) being positively correlated with annual mean temperature over years and across sites. Shifts of the optimum temperature of NEE were mostly a result of temperature acclimation of gross primary productivity (upward shift of optimum temperature) rather than changes in the temperature sensitivity of ecosystem respiration. Ecosystem-level thermal optimality is a newly revealed ecosystem property, presumably reflecting associated evolutionary adaptation of organisms within ecosystems, and has the potential to significantly regulate ecosystem–climate change feedbacks. The thermal optimality of NEE has implications

for understanding fundamental properties of ecosystems in changing environments and benchmarking global models.

Processes regulating progressive nitrogen limitation under elevated carbon dioxide: The nitrogen (N) cycle has the potential to regulate climate change through its influence on C sequestration. Although extensive research has explored whether or not progressive N limitation (PNL) occurs under CO_2 enrichment, a comprehensive assessment of the processes that regulate PNL is still lacking. Here, we quantitatively synthesized the responses of all major processes and pools in the terrestrial N cycle with meta-analysis of CO_2 experimental data available in the literature. The results showed that CO_2 enrichment significantly increased N sequestration in the plant and litter pools but not in the soil pool, partially supporting one of the basic assumptions in the PNL hypothesis that elevated CO_2 results in more N sequestered in organic pools. However, CO_2 enrichment significantly increased the N influx via biological N fixation and the loss via N_2O emission, but decreased the N efflux via leaching. In addition, no general diminished CO_2 fertilization effect on plant growth was observed over time up to the longest experiment of 13 years. Overall, our analyses suggest that the extra N supply by the increased biological N fixation and decreased leaching may potentially alleviate PNL under elevated CO_2 conditions in spite of the increases in plant N sequestration and N_2O emission. Moreover, our syntheses indicate that CO_2 enrichment increases soil ammonium (NH_4^+) to nitrate (NO_3^-) ratio. The changed NH_4^+/NO_3^- ratio and subsequent biological processes may result in changes in soil microenvironments, above-belowground community structures and associated interactions, which could potentially affect the terrestrial biogeochemical cycles. In addition, our data synthesis suggests that more long-term studies, especially in regions other than temperate ones, are needed for comprehensive assessments of the PNL hypothesis.

Evaluation and improvement of a global land model against soil carbon data: Long-term land C cycle feedback to climate change is largely determined by dynamics of soil organic carbon (SOC). However, most evaluation studies conducted so far indicate that global land models predict SOC poorly. This study was conducted to evaluate predictions of SOC by the Community Land Model with Carnegie-Ames-Stanford Approach biogeochemistry submodel (CLM-CASA'), investigate underlying causes of mismatches between model predictions and observations, and calibrate model parameters to improve the prediction of SOC. We compared modeled SOC to the SOC pools from a globally gridded observation data product and found that CLM-CASA' on average underestimated SOC pools by 65% ($r^2 = 0.28$). We applied data assimilation to CLM-CASA' to estimate SOC residence times, C partitioning coefficients among the pools, and temperature sensitivity of C decomposition. The model with calibrated parameters explained 41% of the global variability in the observed SOC, which was substantial improvement from the initial 27%. The SOC and litter C feedback to changing climate differed between models with original and calibrated parameters: after 95 years of climate change (2006–2100), soils released 48 Pg C less in the calibrated than in the noncalibrated model and litter released 6.5 Pg C less in the calibrated than the noncalibrated model. Thus, assimilating estimated soil carbon data into the model improved model performance and reduced the amount of C released under changing climate. To further reduce the uncertainty in the soil carbon prediction, we need to explore alternative model structures, improve representation of ecosystems, and develop additional global datasets for constraining model parameters.

Improvement of global litter turnover rate predictions using a Bayesian MCMC approach: Global terrestrial C cycle has a strong influence on atmospheric CO_2 concentrations and temperatures. Litter mass is relatively small in comparison to soil and plant pools but its turnover rate is fast. Litter dynamics is important part of the global terrestrial carbon cycle as it is a critical stage in the soil organic matter formation and nutrient mineralization. Litter turnover rates have been observed on site, regional, and global levels, however little effort has been put into validating and calibrating litter decay models against the observations. In this study, we used a Bayesian Markov Chain Monte Carlo data assimilation technique and globally observed leaf litter turnover rates to calibrate a first order litter decay model with different assumptions about litter quality limitations of decomposition. The first order decay model with original parameters and a commonly-used litter quality limitation function explained 15% of the spatial variation in the observed leaf litter turnover rates, and parameter calibration increased the explained variation in the observations to 44%. When litter quality limitation of decomposition was determined by litter lignin-to-nitrogen ratio rather than structural lignin content the performance of the calibrated first order decay model was further improved, explaining 62% of variation in the observations. Litter feedbacks to changing climate differed between the original and best-fitting models: original model predicted a 16% decrease in leaf litter pool after 95 years of climate change (2006-2100), whereas the bestfitting model predicted a 2% increase. Furthermore, assuming that litter quality decreased with increasing CO_2 concentrations resulted in a 28% decrease in leaf litter pool predicted by the original model, and a 15% increase predicted by the best-fitting model. Thus, assimilating observed leaf litter turnover rates into a first-order decay model improved model fit and reversed leaf litter feedbacks to changing climate.

Methods for estimating temperature sensitivity of soil organic matter based on incubation data: Although the temperature sensitivity (Q_{10}) of soil organic matter (SOM) decomposition has been widely studied, the estimate substantially depends on the methods used with specific assumptions. Here we compared several commonly used methods (i.e., one-pool (1P) model, two-discrete-pool (2P) model, three-discrete-pool (3P) model, and time-for-substrate (T4S) Q_{10} method) plus a new and more process-oriented approach for estimating Q_{10} of SOM decomposition from laboratory incubation data to evaluate the influences of the different methods and assumptions on Q_{10} estimation. The process-oriented approach is a three-transfer-pool (3PX) model that resembles the decomposition sub-model commonly used in Earth system models. The temperature sensitivity and other parameters in the models were estimated from the cumulative CO_2 emission using the Bayesian Markov Chain Monte Carlo (MCMC) technique. The estimated Q_{10}s generally increased with the soil recalcitrance, but decreased with the incubation temperature increase. Our results indicated that the 1P model did not adequately simulate the dynamics of SOM decomposition and thus was not adequate for the Q_{10} estimation. All the multi-pool models fitted the soil incubation data well. The Akaike information criterion (*AIC*) analysis suggested that the 2P model is the most parsimonious. As the incubation progressed, Q_{10} estimated by the 3PX model was smaller than those by the 2P and 3P models because the continuous C transfers from the slow and passive pools to the active pool were included in the 3PX model. Although the T4S method could estimate the Q_{10} of labile carbon appropriately, our analyses showed that it overestimated that of recalcitrant SOM. The similar structure of 3PX model with the decomposition sub-model of Earth system models provides a possible approach, via the data assimilation techniques, to incorporate results from numerous incubation experiments into Earth system models.

Separating soil CO_2 efflux into C-pool-specific decay rates via inverse analysis of soil incubation data: Soil organic matter (SOM) is heterogeneous in structure and has been considered to consist of various pools with different intrinsic turnover rates. Although those pools have been conceptually expressed in models and analyzed according to soil physical and chemical properties, separation of SOM into component pools is still challenging. In this study, we conducted inverse analyses with data from a long-term (385 days) incubation experiment with two types of soil (from plant interspace and from underneath plants) to deconvolute soil C efflux into different source pools. We analyzed the two datasets with one-, two- and three-pool models and used probability density functions as a criterion to judge the best model to fit the datasets. Our results indicated that soil C release trajectories over the 385 days of the incubation study were best modeled with a two-pool C model. For both soil types, released C within the first 10 days of the incubation study originated from the labile pool. Decomposition of C in the recalcitrant pool was modeled to contribute to the total CO_2 efflux by 9–11 % at the beginning of the incubation. At the end of the experiment, 75–85 % of the initial soil organic carbon (SOC) was modeled to be released over the incubation period. Our modeling analysis also indicated that the labile C-pool in the soil underneath plants was larger than that in soil from interspace. This deconvolution analysis was based on information contained in incubation data to separate carbon pools and can facilitate integration of results from incubation experiments into ecosystem models with improved parameterization.

Soil properties control decomposition of soil organic carbon: Results from data assimilation analysis: Soil properties, such as clay content, are hypothesized to control decomposition of soil organic carbon (SOC). However, these hypotheses of soil property-C decomposition relationships have not been explicitly tested at large spatial scales. Here, we used a data-assimilation approach to evaluate the roles of soil properties and environmental factors in regulating decomposition of SOC. A three-pool (active, slow, and passive) C-cycling model was optimally fitted with 376 published laboratory incubation data from soils acquired from 73 sites with mean annual temperature ranging from − 15 to 26 °C. Our results showed that soil physical and chemical properties regulated decomposition rates of the active and the slow C pools. Decomposition rates were lower for soils with high clay content, high field water holding capacity (WHC), and high C:N ratio. Multifactor regression and structural equation modeling (SEM) analyses showed that clay content was the most important variable in regulating decomposition of SOC. In contrast to the active and slow C pools, soil properties or environmental factors had little effect on the decomposition of the passive C pool. Our results show inverse soil property-C decomposition relationships and quantitatively evaluate the essential roles of soil texture (clay content) in controlling decomposition of SOC at a large spatial scale. The results may help model development and projection of changes in terrestrial C sequestration in the future.

Faster decomposition under increased atmospheric CO_2 limits soil carbon storage: Soils contain the largest pool of terrestrial organic C and are a major source of atmospheric carbon dioxide (CO_2). Thus, they may play a key role in modulating climate change. Rising atmospheric CO_2 is expected to stimulate plant growth and soil C input but may also alter microbial decomposition. The combined effect of these responses on long-term C storage is unclear. Combining meta-analysis with data assimilation, we show that atmospheric CO_2 enrichment stimulates both the input (+19.8%) and the turnover of C in soil (+16.5%). The increase in soil C turnover with

rising CO_2 leads to lower equilibrium soil C stocks than expected from the rise in soil C input alone, indicating that it is a general mechanism limiting C accumulation in soil.

Enhanced decomposition of stable soil organic carbon and microbial catabolic potentials by long-term field warming: Quantifying soil organic carbon (SOC) decomposition under warming is critical to predict carbon–climate feedbacks. According to the substrate regulating principle, SOC decomposition would decrease as labile SOC declines under field warming, but observations of SOC decomposition under warming do not always support this prediction. This discrepancy could result from varying changes in SOC components and soil microbial communities under warming. This study aimed to determine the decomposition of SOC components with different turnover times after subjected to long-term field warming and/or root exclusion to limit C input, and to test whether SOC decomposition is driven by substrate lability under warming. Taking advantage of a 12-year field warming experiment in a prairie, we assessed the decomposition of SOC components by incubating soils from control and warmed plots, with and without root exclusion for 3 years. We assayed SOC decomposition from these incubations by combining inverse modeling and microbial functional genes during decomposition with a metagenomic technique (GeoChip). The decomposition of SOC components with turnover times of years and decades, which contributed to 95% of total cumulative CO_2 respiration, was greater in soils from warmed plots. But the decomposition of labile SOC was similar in warmed plots compared to the control. The diversity of C-degradation microbial genes generally declined with time during the incubation in all treatments, suggesting shifts of microbial functional groups as substrate composition was changing. Compared to the control, soils from warmed plots showed significant increase in the signal intensities of microbial genes involved in degrading complex organic compounds, implying enhanced potential abilities of microbial catabolism. These are likely responsible for accelerated decomposition of SOC components with slow turnover rates. Overall, the shifted microbial community induced by long-term warming accelerates the decomposition of SOC components with slow turnover rates and thus amplify the positive feedback to climate change.

Traceable components of terrestrial carbon storage capacity in biogeochemical models: Biogeochemical models have been developed to account for more and more processes, making their complex structures difficult to be understood and evaluated. Here, we introduce a framework to decompose a complex land model into traceable components based on mutually independent properties of modeled biogeochemical processes. The framework traces modeled ecosystem carbon storage capacity (Xss) to (i) a product of NPP and ecosystem residence time (τ_E). The latter τ_E can be further traced to (ii) baseline carbon residence times (τ'_E), which are usually preset in a model according to vegetation characteristics and soil types, (iii) environmental scalars (ξ), including temperature and water scalars, and (iv) environmental forcings. We applied the framework to the Australian Community Atmosphere Biosphere Land Exchange (CABLE) model to help understand differences in modeled carbon processes among biomes and as influenced by nitrogen processes. With the climate forcings of 1990, modeled evergreen broadleaf forest had the highest NPP among the nine biomes and moderate residence times, leading to a relatively high carbon storage capacity (31.5 kg cm^{-2}). Deciduous needle leaf forest had the longest residence time (163.3 years) and low NPP, leading to moderate carbon storage (18.3 kg cm^{-2}). The longest τ_E in deciduous needle leaf forest was ascribed to its longest τ'_E (43.6 years) and small ξ (0.14 on litter/soil carbon decay rates). Incorporation of nitrogen processes into the CABLE model decreased Xss in all biomes via reduced NPP (e.g., -12.1% in

shrub land) or decreased τ_E or both. The decreases in τ_E resulted from nitrogen-induced changes in τ'_E (e.g., -26.7% in C_3 grassland) through carbon allocation among plant pools and transfers from plant to litter and soil pools. Our framework can be used to facilitate data model comparisons and model intercomparisons via tracking a few traceable components for all terrestrial carbon cycle models. Nevertheless, more research is needed to develop tools to decompose NPP and transient dynamics of the modeled carbon cycle into traceable components for structural analysis of land models.

Transient dynamics of terrestrial carbon storage: mathematical foundation and its applications: Terrestrial ecosystems have absorbed roughly 30% of anthropogenic CO_2 emissions over the past decades, but it is unclear whether this C sink will endure into the future. Despite extensive modeling and experimental and observational studies, what fundamentally determines transient dynamics of terrestrial C storage under global change is still not very clear. Here we develop a new framework for understanding transient dynamics of terrestrial C storage through mathematical analysis and numerical experiments. Our analysis indicates that the ultimate force driving ecosystem C storage change is the C storage capacity, which is jointly determined by ecosystem C input (e.g., NPP) and residence time. Since both C input and residence time vary with time, the C storage capacity is time dependent and acts as a moving attractor that actual C storage chases. The rate of change in C storage is proportional to the C storage potential, which is the difference between the current storage and the storage capacity. The C storage capacity represents instantaneous responses of the land C cycle to external forcing, whereas the C storage potential represents the internal capability of the land C cycle to influence the C change trajectory in the next time step. The influence happens through redistribution of net C pool changes in a network of pools with different residence times. Moreover, this and our other studies have demonstrated that one matrix equation can replicate simulations of most land C cycle models (i.e., physical emulators). As a result, simulation outputs of those models can be placed into a three dimensional (3-D) parameter space to measure their differences. The latter can be decomposed into traceable components to track the origins of model uncertainty. In addition, the physical emulators make data assimilation computationally feasible so that both C flux- and pool-related datasets can be used to better constrain model predictions of land C sequestration. Overall, this new mathematical framework offers new approaches to understanding, evaluating, diagnosing, and improving land C cycle models.

We published 141 papers during the period from 2012 to 2017 as listed below

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CD Jones, C Koven, D Lawrence, DJ Li, M Mahecha, SL Niu, R Norby, SL Piao, X Qi, P Peylin, IC Prentice, W Riley, M Reichstein, C Schwalm, YP Wang, JY Xia, S Zaehle, XH Zhou. 2012. A framework for benchmarking land models. *Biogeosciences*, 9: 3857-3874.

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134. Zhou XH, SF Fei, R Sherry, YQ Luo. 2012. Root Biomass dynamics under experimental warming and doubled precipitation in a tallgrass prairie. *Ecosystems*, 15: 542-554.
135. Li DJ, SL Niu, YQ Luo. 2012. Global patterns of soil carbon and nitrogen dynamics following afforestation: a meta-analysis. *New Phytologist,* 195: 172-181.
136. Xu X. Y. Luo, J. Zhou. 2012. Carbon quality and the temperature sensitivity of soil organic carbon decomposition in a tallgrass prairie. *Soil Biology and Biochemistry*, 50: 142-148.
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Carry-over from previous-year environmental conditions alters dominance hierarchy in a prairie plant community. *Journal of Plant Ecology*, 5: 134-146.

We published 6 book chapters/encyclopedia assays

1. Hui DF, Q Deng, HQ Tian, YQ Luo. 2017. Climate Change and Carbon Sequestration in Forest Ecosystems. Pp. 555-594. In: *Handbook of Climate Change Mitigation and Adaptation*. WY Chen et al. (eds.), Springer Science+Business Media New York 2015 1 DOI 10.1007/978-1-4614-6431-0_13-2.
2. Jiang LF, J Jiang, JY Liang, KR Wilcox, SL Collins, AK Knapp, WT Pockman, MD Smith, YQ Luo. 2016. Frontiers of Ecosystem Modeling and Large Scale Experiments. In: *Terrestrial Ecosystem Research Infrastructures Challenges, New developments and Perspectives*. A Chabbi and H Loescher (eds.), CPR, Talor and Francis.
3. Niu SL, YL Fu, LH Gu, YQ Luo. 2013. Temperature Sensitivity of Canopy Photosynthesis Phenology in Northern Ecosystems. In: *Phenology: An Integrative Environmental Science*. MD Schwartz (eds.), DOI 10.1007/978-94-007-6925-0_27, Springer Science+Business Media B.V.
4. Grimm NB, FS Chapin III, B Bierwagen, P Gonzalez, PM Groffman, YQ Luo, F Melton, K Nadelhoffer, A Pairis, P Raymond, J Schimel, CE Williamson, MJ Bernstein. 2012. Chapter 3. Impacts of Climate Change on Ecosystem Structure and Functioning. In: *Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment*. MD Staudinger, NB Grimm, A Staudt, SL Carter, FS Chapin III, P Kareiva, M Ruckelshaus, BA Stein (eds.), Cooperative Report to the 2013 National Climate Assessment. 296pp. Available at: http://assessment.globalchange.gov.
5. Luo YQ, ES Weng, YH Yang. 2012. Ecosystem Ecology. In: *Sourcebook in Theoretical Ecology*. A Hastings and L Gross (eds.), Pp. 219-229. The University of California Press.
6. Hui DH, HQ Tian, YQ Luo. 2012. Impacts of Climatic Changes on Biogeochemical Cycling in Terrestrial Ecosystems. In: *Handbook of Climate Change Mitigation*. WY Chen, JM Seiner, T Suzuki, M Lackner (eds.), SPRINGER, New York and Science Press, Beijing.

We made the following meeting presentation during 2012-2017

1. Jianyang Xia, Yiqi Luo, Anthony Walker, Martin G. De Kauwe, Kristina Luus, Anna B. Harper, Bertrand Guenet, Christiane Werner, Xinjie Lu, Junyi Liang, Lifen Jiang, Ensheng Weng, Belinda E. Medlyn, Sönke Zaehle, Philippe Ciais, Yingping Wang, Richard Norby. Diagnosing model uncertainty on terrestrial carbon cycle with field manipulative experiments. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
2. Shuang Ma, Jiang Jiang, Yiqi Luo. Impacts of seasonal changes in precipitation on carbon sequestration in a tallgrass prairie. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
3. Rosvel Bracho, Edward A. G. Schuur, E. F. Pegoraro, Cesar Plaza, Lauren Hale, Konstantinos Konstantinidis, Liyou Wu, Jizhong Zhou, Yiqi Luo, James Tiedje, Temperature sensitivity of organic matter decomposition of permafrost-region soils

during laboratory incubations. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL

4. Zhao Li, Jianyang Xia, Geli Zhang, Junyi Liang, Zheng Shi, Jinwei Dong, Lifen Jiang, Xiangming Xiao, Yiqi Luo, Liming Yan. Shifted warming seasons led to slow down of plant growth increase over northern lands. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
5. Yiqi Luo. At the interface of microbial genomics and biogeochemistry. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
6. Sebastian Leuzinger, Claus Beier, Christian Körner, Yiqi Luo, Sara Vicca, J. Adam Langley, Mark Hovenden. You can add up the parts, but you won't have the sum: Can many global change experiments tell us more than the individual ones? 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
7. Chang Gyo Jung, Junyi Liang, Yiqi Luo. Response of carbon fluxes under long-term warming, and its relationship with plant biomass. 101th ESA Annual Meeting (August 7-12, 2016), Ft Lauderdale, FL
8. Jiang Jiang, Mark Stacy, Yiqi Luo, Daniel Ricciuto, Paul Hanson, Interactive ModEx, SPRUCE All Hands Meeting (May 10-11, 2016), St Paul, MN
9. Yiqi Luo. A theory of terrestrial carbon storage dynamics and its applications. DOE PI meeting: the 2016 Environmental System Science (ESS) PI Meeting (April 26-27, 2016), Potmac, MD
10. Yiqi Luo. The third dimension of carbon cycle dynamics. OU EcoMunch (Feburary 24, 2016), Norman, OK
11. Jiang L, J Liang, Y Luo. Carbon residence time explains changes in predicted 21st century vegetation carbon across CMIP5 Earth system models. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
12. Xia J, R Norby, A Walker, M D Kauwe, K. Luus, A Harper, X Lu, B Guenet, B Medlyn, S. Zaehle, C Werner, Z Shi, L Jiang, J Liang, L Lei, S Wan, Y Wang, E Weng, P Ciais, Y Luo. Diagnosing model uncertainty on terrestrial carbon cycle with field manipulative experiments. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
13. Deng Q, D Hui, Y Luo, J Elser, Y Wang, I Loladze, Q Zhang, S Dennis. Down-regulation of tissue N:P ratios in terrestrial plants by elevated CO_2. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
14. Ahlstrom A, J Xia, A Arneth, Y Luo, B Smith. Importance of vegetation distribution for future carbon balance. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
15. Luo Y, Z Shi, L Jiang, J Xia, Y Wang, M KC, J Liang, X Lu, S Niu, A Ahlstrom, O Hararuk, A Hastings, F Hoffman, B Medlyn, M Rasmussen, M Smith, K Todd-Brown, Y Wang. Terrestrial carbon storage dynamics: Chasing a moving target. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
16. Shi Z, S Crowell, Y Luo, P Rayner, B Moore. Column carbon dioxide and biometric data jointly constrain parameterization and projection of a global land model. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
17. Luo Y. The big data-big model (BDBM) challenges in ecological research. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
18. Xiao X, Y Zhang, S Zhou, H McCarthy, P Ciais, Y Luo. Vegetation canopy and physiological control of GPP decline during drought and heat wave. AGU Fall Meeting (December 14-18, 2015), San Francisco, CA
19. Luo Y. Dynamic equilibrium and disequilibrium components of the terrestrial carbon

cycle. 20th Annual Community Earth System Model (CESM) Workshop (June 15-18, 2015), Breckenridge, CO

20. Yiqi Luo, Trevor F. Keenan, Matthew Smith. Predictability of the terrestrial carbon cycle, DOE PI meeting: Environmental System Science PI meeting (April 28-29, 2015), Potomac, MD
21. Xue Guo, Xishu Zhou, Mengting Yuan, Zhou Shi, Liyou Wu, Zhili He, Joy D. Van Nostrand, Lauren Hale, Qichao Tu, Jie Deng, Jianjun Wang, Zhenxing Li, Tong Yuan, Yiqi Luo, Jizhong Zhou. Successional dynamics of grassland microbial communities in response to warming, precipitation alternation and clipping. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
22. Yingping Wang, Jiang Jiang, Benito Chen-Charpentier, Fola B. Agusto, Alan Hastings, Forrest M. Hoffman, Martin Rasmussen, Katherine Todd-Brown, Matthew Smith, Ying Wang, Xia Xu, Yiqi Luo. What determines the sensitivities of the simulated soil carbon to warming and substrate priming in three different soil carbon models? 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
23. Jizhong Zhou, Mengting Yuan, Cong Wang, Xue Guo, Katherine Todd-Brown, Liyou Wu, Zhili He, Kostas Konstantinidis, Yiqi Luo, Edward A. G. Schuur, James R. Cole, James M Tiedje. Feedback responses of soil microbial communities to climate warming. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
24. Eric Johnston, Chengwei Luo, Luis Rodriguez-R, Liyou Wu, Yiqi Luo, Edward Schuur, James Tiedje, Jizhong Zhou, Kostas Konstantinidis. Soil microbial community responses to warming as revealed by comparative metagenomics. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
25. Wenting Feng, Jizhong Zhou, James M Tiedje, Konstantinos Konstantinidis, Edward A. G. Schuur, Yiqi Luo. Does microbial community affect soil organic carbon decomposition directly across ecosystems? 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
26. Ying Wang, Yiqi Luo, Alan Hastings, Martin Rasmussen, Yingping Wang. Nonautonomous systems: Mathematical properties and ecological applications. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
27. Forrest M. Hoffman, Matthew Smith, Katherine Todd-Brown, Yiqi Luo, Yingping Wang. Explaining the sources of variation in CMIP5 models by fitting reduced complexity models to their simulation outputs. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
28. Junyi Liang, Lifen Jiang, Jianyang Xia, Ying Wang, Yiqi Luo. Diagnosing the uncertainty of Earth system models using a traceability framework. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
29. Yiqi Luo. Terrestrial carbon cycle: Ecological and mathematical properties. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
30. Jiang Jiang, Yiqi Luo, Alan Hastings. General applications of nonautonomous system theory to ecological research. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
31. Alan Hastings, Martin Rasmussen, Ying Wang, Yiqi Luo. Residence time and turnover times in a changing environment. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
32. Katie Stuble, Kaitlin Bacon, Marie-Anne de Graaff, Yiqi Luo, Aimee Classen, Lara Souza. Above and belowground impacts of climatic warming drive rates of

decomposition in a grassland ecosystem. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD

33. Ji Chen, Yiqi Luo, Jianyang Xia, Zheng Shi, Lifen Jiang, Shuli Niu, Xuhui Zhou, Junji Cao. Differential responses of ecosystem respiration components to experimental warming in a meadow grassland on the Tibetan Plateau. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
34. Oleksandra Hararuk, Matthew Smith, Yiqi Luo. Effect of explicit microbial dynamics on the performance of soil carbon cycle models. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
35. Jianwei Li, Siyang Jian, Dafeng Hui, Yiqi Luo. Effects of nitrogen additions on soil extracellular enzyme activity: A meta-analysis. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
36. Lifen Jiang and Yiqi Luo. Uncertainties in predicted 21st century vegetation carbon storage by CMIP5 Earth system models. 100th ESA Annual Meeting (August 9-14, 2015), Baltimore, MD
37. Oleksandra Hararuk and Yiqi Luo. 2015. Evaluation and improvement of global carbon cycle models against soil carbon and microbial data sets using a Bayesian MCMC method. European Geosciences Union General Assembly (April 12-17, 2015), Vienna.
38. Yiqi Luo, Jianyang Xia, Junyi Liang, Lifen Jiang, Zheng Shi, Manoj KC, Oleksandra Hararuk, Rashid Rafique, Ying-Ping Wang. A traceability framework for diagnostics of global land models. European Geosciences Union General Assembly (April 12-17, 2015), Vienna.
39. Alan Knapp, Scott Collins, Yiqi Luo, Melinda Smith. Differential sensitivity to drought in central U.S. grasslands arrayed along an aridity gradient. European Geosciences Union General Assembly (April 12-17, 2015), Vienna.
40. Luo YQ, X Xu, K Todd-Brown, JY Liang. . What does data tell us about decomposition model of soil organic matter? AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
41. Luo, YQ, Z. Shi, S. Collins, A. Knapp, W. Pockman, M. Smith. Stability of grassland communities to altered precipitation: A meta-analysis. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
42. Zhou JZ, LY Wu, ZL He, K. Konstantinidis, YQ Luo, T. Schuur, J Cole, J Tiedje. Metagenomics-enabled understanding of soil microbial feedbacks to climate warming. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
43. Todd-Brown K, YQ Luo, J Randerson, S Allison, M Smith. Understanding the Dynamics of Soil Carbon in CMIP5 Models. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
44. Todd-Brown K, HQ Yin, JZ Zhou, LY Wu, J Tiedje, EAG Schuur, K Konstantinidis, YQ Luo. Incorporating functional gene quantification into traditional decomposition models. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
45. Jiang LF and YQ Luo. Uncertainties in predicted 21st century vegetation carbon storage by CMIP5 Earth system models. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
46. Liang JY, CF Hao, Z. Shi, JY Xia, YQ Luo. Increase in recalcitrant carbon: a positive balance between stabilization and priming effect. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
47. Allison S, JW Li, YQ Luo, M Mayes, GS Wang. Insights from intercomparison of

microbial and conventional soil models. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA

48. Xia JY, AD McGuire, D Lawrence, E Burke, XD Chen, C Delire, C Koven, A MacDougall, SS Peng, A Rinke, K Saito, WX Zhang, R Alkama, T Bohn, P Ciais, B Decharme, I Gouttevin, T Hajima, D Ji, G Krinner, D Lettenmaier, P Miller, J Moore, B Smith, T Sueyoshi, Z Shi, L Yan, J Liang, L Jiang, YQ Luo. Terrestrial ecosystem model performance for net primary productivity and its vulnerability to climate change in permafrost regions. AGU Fall Meeting (December 11-19, 2014), San Francisco, CA
49. Shi Z, ML Thomey, ME. Litvak, N Brunsell, SL Collins, WT Pockman, MD Smith, AK Knapp, YQ Luo. Differential effects of extreme drought on production and respiration: Synthesis and modeling analysis. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
50. Knapp AK, DL Hoover, ML Avolio, SE Koerner, KJ La Pierre, ME Loik, YQ Luo, OE Sala, MD Smith. Characterizing precipitation regimes of extreme wet and dry years: Implications for regional to global scale experiments. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
51. Jiang LF, YN Yan, O Hararuk, N Mikle, JY Xia, Z Shi, J Tjiputra, TW Wu, YQ Luo. Scale-dependent performance of earth system models in simulating terrestrial vegetation carbon. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
52. Luo YQ. What does data tell us about model structure of microbial decomposition of soil organic carbon. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
53. Luo YQ. Model data assimilation in climate change research. 99th ESA Annual Meeting (August 10 - 15, 2014), Sacramento, CA
54. Rafique R, YQ Luo, JY Xia, O Hararuk, Parameter differences cause diverse predictions of carbon sequestration between two global land models. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
55. Li M, YH He, XH Zhou, B Li, YQ Luo. Patterns of nitrogen processes across soil mineral nitrogen gradient in terrestrial ecosystems: A global synthesis. 99th ESA Annual Meeting (August 10-15, 2014), Sacramento, CA
56. Luo Y, JY Xia, O Hararuk, YP Wang, Traceability analysis of global land models. 19th Annual CESM Workshop (June 16-19, 2014), Breckenridge, CO
57. Xu X, Y Luo et al. Soil properties control decomposition of soil Organic carbon: a global data assimilation. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
58. Liang JY, D Li, Z Shi, J Tiedje, J Zhou, E Schuur, K Konstantinidis, Y Luo, Estimating soil decomposition parameters for Earth system models from soil incubation data, International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
59. Xia J, Y Luo et al. Traceability of global land models. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
60. Hararuk O, Y Luo et al. Data assimilation to improve parameterization of carbon models. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
61. Zhou T, Y Luo et al. Nonsteady state data assimilation. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC

assessments" (June 12-14, 2014), Breckenridge, CO
62. Jiang L, Y Luo et al. Global distributions of plant biomass and turnover. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
63. Wang YP, Y Luo et al. Nonlinear dynamics of microbial models. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
64. Luo YQ. Welcome and overview. International workshop: "Representing soil carbon dynamics in global land models to improve future IPCC assessments" (June 12-14, 2014), Breckenridge, CO
65. Luo YQ, X Xu, N Mikle, J Xia, L Jiang, J Liang, O Hararuk, R Rafique. Evaluation and improvement of ierrestrial carbon cycle models with observations. Joint TES/SBR Principal Investigator (PI) Meeting (May 5-7, 2014), Potomac, MD
66. Luo YQ, JY Xia, O Hararuk, YP Wang. Traceability of land carbon cycle models, Webinar (April 1, 2014)
67. Rashad Rafique, Jianyang Xia, Oleksandra Hararuk, Yiqi Luo, Yongjiu Dai, Craig Macaulay. Carbon-structural analysis of global land models (C-SALM). AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
68. Anthony P Walker, Soenke Zaehle, Martin G De Kauwe, Belinda E Medlyn, Michael Dietze, Thomas Hickler, Colleen M Iversen, Atul K Jain, Yiqi Luo, Heather R McCarthy, William J Parton, Colin Prentice, Peter E Thornton, Shusen Wang, Yingping Wang, David Warlind, Jeff Warren, Ensheng Weng, Paul J Hanson, Ram Oren, Richard J Norby. Model-experiment synthesis at two FACE sites in the southeastern US. Forest ecosystem responses to elevated CO_2. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
69. Bracho R, EAG Schuur, E Pegoraro, KG Crummer, S Natali, J Zhou, Y Luo, JL Wu, J Tiedje, K Konstantinidis. Temperature sensitivity (Q_{10}), and dynamics of soil organic matter (SOM) decomposition in permafrost soils with different carbon quality and under experimental warming. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
70. Lifen Jiang, Yiqi Luo, Yaner Yan, Oleksandra Hararuk. Scale-dependent performances of CMIP5 earth system models in simulating terrestrial vegetation carbon. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
71. Xuecheng Chen, Yiqi Luo, Xia Xu, Dejun Li, Shuli Niu, Warming and altered precipitation affect litter decomposition and nitrogen dynamics in a mixed-grass prairie. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
72. Oleksandra Hararuk, Matthew J Smith, Yiqi Luo. Improving global soil carbon predictions with data-constrained microbial based models. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
73. Yingping Wang, Matthew J Smith, Yiqi Luo, Maria Leite, Folashade Agusto, Benito Chen, Forrest M Hoffman, Belinda E Medlyn, Martin Rasmussen. Theoretical analysis of the global land carbon cycle: what determines the trajectory of future carbon uptake? AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
74. Nathaniel Mikle and Yiqi Luo. Toward identification of a threshold to ecosystem collapse using rain- use efficiency as an indicator. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
75. Yiqi Luo, Zheng Shi, Nathaniel Mikle, Jianyang Xia, Shuli Niu, Liming Yan. Search for generalizable mechanisms and patterns from variable ecosystem responses to climate

extremes (invited). AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
76. Jianyang Xia, Yiqi Luo, Shuli Niu, Dafeng Hui, Jinwei Dong, Jiquan Chen, Ensheng Weng, Jianwei Li. Convergence of phenological and physiological control on annual terrestrial carbon dioxide uptake. AGU Fall Meeting (December 9-13, 2013), San Francisco, CA
77. Kai Xue, Mengting Yuan, Lei Cheng, Jason Shi, Ye Deng, Liyou Wu Zhili He, Joy D. Van Nostrand, Edward AG Schuur, Yiqi Luo, Konstantinos Konstantinidis, James Tiedje, Jizhong Zhou. Soil microbial community determines vulnerability of soil carbon exposed to warming in northern permafrost. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
78. Mengting Yuan, Jin Zhang, Liyou Wu, Kai Xue, Lei Cheng, Ye Deng, Tong Yuan, Joy Van Nostrand, Zhili He, Edward AG Schuur, Yiqi Luo, James Tiedje, Jizhong Zhou. Climate warming induced permafrost thaw changes soil microbial communities. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
79. Zheng Shi, Yiqi Luo, Alan K Knapp, Melinda D Smith, Scott L Collins, Will Pockman. More reduction in plant productivity than respiration under extreme drought across grassland types along a rainfall gradient: A modeling analysis Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
80. Yiqi Luo, Trevor Keeman, Matthew Smith. Predictability of the terrestrial carbon cycle. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
81. Junyi Liang and Yiqi Luo. Less increase in apparent than intrinsic Q_{10} of soil carbon release. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
82. Meng Lu, Xuhui Zhou, Yiqi Luo, Bo Li. Responses of ecosystem carbon cycle to experimental warming: A meta-analysis. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
83. Jianwei Li, Yiqi Luo, Susan M. Natali, Edward AG Schuur, Jianyang Xia, Bernard Pak, Eva Kowalczyk, Yingping Wang. Permafrost thaw and ecosystem carbon cycle under multifactor global change at a tundra site: A modeling approach. Annual ESA meeting (August 4-9, 2013), Minneapolis, MN
84. Luo Y, T Keenan, M Smith. Predictability of the terrestrial carbon cycle. The 9th International Carbon Dioxide Conference (June 3-7, 2013), Beijing, China.
85. Luo Y, J Xia, YP Wang, O Hararuk O. Theoretical Analysis of the terrestrial carbon cycle. 4th NACP All-Investigators Meeting (February 6, 2013), Albuquerque, NW
86. Luo Y, J Xia, YP Wang, O Hararuk, S Niu, et al. A traceability framework to facilitate model evaluation. CESM Land Model and Biogeochemistry Working Group Meetings (February 20-22, 2013), Boulder, CO
87. Xia J, Y Luo, YP Wang, S Niu, O Hararuk. Traceable components of modeled carbon storage capacity in terrestrial ecosystem. 4th NACP All-Investigators Meeting (February 6, 2013), Albuquerque, NW
88. Xia J, Y Luo, YP Wang, S Niu, O Hararuk. A traceability framework for model intercomparisons. Multi-Scale Synthesis and Terrestrial Biospheric Model Intercomparison Project (MsTMIP) Workshop (February 8, 2013), Albuquerque, NM
89. Luo Y, J Xia, Ecolab members. Evaluating and improving performances of global land-surface models through data synthesis and data assimilation. TES/SBR Joint Investigators Meeting (May 14-15, 2013), Potomac, MD
90. Luo Y. Nonautonomous linear system of the terrestrial carbon cycle. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA

91. Schaedel C, EA Schuur, R Bracho, B Elberling, C Knoblauch, A Kotowska, H Lee, Y Luo, M Lupascu, S Natali, GR Shaver, MR Turetsky. Pan-arctic permafrost C quality and vulnerability over time: A synthesis of long-term incubation studies (Invited). AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
92. Li J, S Natali, C Schaedel, EA Schuur, Y Luo. Permafrost carbon cycles under multifactor global change: A modeling analysis. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
93. Li D, R Kelly, F Hu, Y Luo. Impacts of shifting fire regime on ecosystem carbon storage capacity in the interior Alaskan forests. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
94. De Kauwe MG, BE Medlyn, MC Dietze, PJ Hanson, T Hickler, AK Jain, Y Luo, RJ Norby, R Oren, WJ Parton, IC Prentice, PE Thornton, A Walker, Y Wang, S Wang, J Warren, D Warlind, E Weng, S Zaehle. Water use and water use efficiency at elevated CO_2: a model-data intercomparison at two contrasting temperate forest FACE sites AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
95. Hararuk O. J Xia. Y Luo Evaluation and improvement of two global land models against soil carbon data using a data assimilation approach. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
96. Wieder W, GB Bonan, O Hararuk, Y Luo, Integrating observations to inform soil biogeochemistry in CLM4. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
97. Weng E, Y Luo, W Wang, H Wang, DJ Hayes, AD McGuire, A Hastings, D Schimel. Ecosystem carbon storage capacity as affected by disturbance regimes: a general theoretical model. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
98. Walker AP, S Zaehle, MG De Kauwe, MC Dietze, PJ Hanson, T Hickler, AK Jain, Y Luo, HR McCarthy, BE Medlyn, WJ Parton, PE Thornton, S Wang, Y Wang, D Warlind, E Weng, R Oren, RJ Norby. Climatic drivers of variability in the response of NPP to elevated CO_2: A model-data comparison at two FACE sites in the south eastern US. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
99. Niu S and Y Luo. State changes in terrestrial ecosystem carbon cycling after recovering from disturbance. AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
100. Luo Y, J Yuan, S Niu. Climate and biological controls of carbon fluxes along latitudinal gradients (Invited). AGU Fall Meeting (December 3-7, 2012), San Francisco, CA
101. Qi X and Y Luo. Effect of elevated CO_2 on ecosystem nitrogen fluxes and pools: Meta-analysis. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
102. Zhou J, L Wu, K Xue, L Cheng, M Yuan, J Zhang, Y Deng, JD Van Nostrand, Z He, R Penton, J Cole, J Tiedje, R Bracho-Garrillo, EAG Schuur, C Luo, K Konstantinidis, X Xu, D Li, Y Luo. From community structure to function: Metagenomics-enabled predictive understanding of microbial communities to climate warming at the temperate grassland ecosystems in Oklahoma. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
103. Cheng L, Y Luo, L Wu, Y Deng, Y Qin, J Van Nostrand, Z He, M Beth Leigh, EAG Schuur, J Tiedje, J Zhou. Experimental warming increases old carbon decomposition through shifting functional microbial communities in a tallgrass prairie. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
104. Luo Y, X Xu, RA Sherry, S Niu, D Li, J Xia. State transition of US Great Plains

prairie under experimental warming. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR

105. Xue K, J Xie, Y Deng, L Wu, Z He, JD Van Nostrand, Y Luo, J Zhou. Interactive effects of clipping practice and experimental warming on soil microbial communities involved in nitrogen cycling in a tallgrass prairie. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
106. Xia J, Y Luo, Y Wang. Traceable components of modeled carbon storage capacity in terrestrial ecosystem. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
107. Li D, C Schädel, J Zhou, Y Luo. A data-model fusion technique to evaluate the temperature sensitivity of SOC decomposition. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
108. Hararuk O, D Obrist, Y Luo. Modeling the sensitivity of soil mercury storage to climate-induced changes in soil carbon pools. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR
109. Luo R, D Li, Y Luo. Global patterns of fire regime analysis based on fire frequency. 97th ESA Annual Meeting (August 5-10, 2012), Portland OR

Student training

2016-pres. Volodymyr Saruta (Ph.D.)
2016-pres. Guopeng Liang (Ph.D.)
2015-pres. Ling Du (Ph.D.)
2015-pres. Shuang Ma (Ph.D.)
2015-pres. Chang Gyo, Jung (Ph.D.)
2014-pres. Qiangyue Li (Ph.D.) at Center for Earth System Science, Tsinghua University.
2013-2014. Nate Mikle (MS), Extreme climate effects on global productivity.
2013-2016. Junyi Liang (Ph.D.), Data assimilation.
2011-2014. Xuecheng Cheng (MS), Litter decomposition.
2011-2015. Zheng Shi (Ph.D.), Data assimilation and ecological forecasting.
2010-2012. Esther Ali (MS), Soil carbon dynamics of tropical forest ecosystems after fire.
2010-2013. Xuan Qi (MS), Soil nitrogen dynamics in response to global change.
2008-2014. Junjiong Shao (Ph.D.), Interannual variability of net ecosystem exchange (located at Fudan Univ. Shanghai, China).
2008-2014. Oleksandra Hararuk (Ph.D.), Modeling study of soil carbon in terrestrial ecosystems.
2008-2012. Xia Xu (Ph.D.), Temperature sensitivity of soil organic matter.