

Training course on  
**New Advances in Land Carbon Cycle Modeling**

May 13-24, 2019 at Northern Arizona University, Flagstaff, Arizona, USA  
(Science and Health Building (#36), Room 502)

**Tentative schedule**

**Note 1:** The course usually starts at 8:30, breaks for lunch around 12:00 noon, resumes at 1:30pm, and dismiss around 6pm. Coffee/tea breaks at 10:00am in the morning and 3:30pm in the afternoon.

**Note 2:** Lectures are usually in the morning and trainees learn modeling by hand-on practice in the afternoon. Each lecture in the morning lasts 45 mins, including Q&A.

**Day 1** (May 13, Monday): Basic concepts and structures of carbon cycle models, including carbon flow diagrams and balance equations

Morning

Yiqi Luo: Overview and objectives of the training course

Yiqi Luo: Theoretical foundation of carbon cycle in terrestrial ecosystems

Danica Lombardozzi: Overview of CLM5.0

Yuanyuan Huang: Carbon flow diagrams and balance equations of TECO, CLM, and ORCHIDEE

Afternoon (by working groups, each having 5 trainees plus 1 instructor, up to 6 groups):  
Developing carbon flow diagrams and balance equations of TECO, CLM, and possibly other models (led by Yuanyuan Huang)

End-of-day Quiz

6:00pm, Mixing at the Annex

**Day 2** (May 14, Tuesday): Matrix representation of carbon balance equations and coding

Morning

Yuanyuan Huang: Development of matrix models for TECO, CLM and/or ORCHIDEE

Ying Wang: Basic operation of matrix equation

Carlos Sierra: Compartmental systems and general properties of matrix equations

Danica Lombardozzi: Crop modeling and photosynthetic acclimation modeling

Afternoon

Creating and Coding matrix equations of TECO, CLM and/or possibly other models (Led by Yuanyuan Huang)

Brief introduction on programming (Led by Xin Huang)

End-of-day Quiz

**Day 3** (May 15, Wednesday): Diagnostics of carbon cycle with matrix models for uncertainty analysis

### Morning

Yiqi Luo: Unified diagnostic system for uncertainty analysis

Yuanyuan Huang: Uncertainty analysis with matrix equations of CLM and ORCHIDEE

Xingjie Lu: Ecosystem carbon turnover vs. transit times in response to climate changes

Enqing Hou: Matrix phosphorus model and data assimilation

### Afternoon

Adding diagnostic variables in matrix models for uncertainty analysis (led by Chris Lu)

End-of-day Quiz

**Day 4** (May 16, Thursday): Semi-analytic spin-up

### Morning

Ying Wang: Ordinary differential equation solver

Chris Lu: Semi-Analytic Spin-Up (SASU) of coupled carbon-nitrogen CLM matrix model

Carlos Sierra: Time characteristics of land carbon cycle

Michelle Mack: Increasing wildfire disturbance and the carbon balance of boreal forests

### Afternoon

Adding a module to enable SASU in CLM5.0 (led by Chris Lu)

End-of-day Quiz

**Day 5** (May 17, Friday): Data assimilation: Basic concepts and general procedure

### Morning

Yiqi Luo, General concept, procedure, and applications of data assimilation.

Kiona Ogle, Bayesian inference

Shuang Ma: Methane modeling at SPRUCE

Ted Schuur, Carbon cycle in permafrost regions

### Afternoon

General procedure as described by Xu et al. (2006) (Led by Yiqi Luo)

Practicing data assimilation with code in Xu et al. paper (2006) to reproduce its results (led by Xin Huang)

End-of-day Quiz

5:00pm Happy hour to mix with ECOSSians

**Days 6 and 7** (May 18-19, Saturday and Sunday): Off for fun, e.g., hiking in Grant Canyon and/or Sedona or sightseeing in Antelope Canyon, Horseshoe Bend, or Petrified Forest

**Day 8** (May 20, Monday): Data assimilation: Information content of data sets

### Morning

Enqing Hou: Drought impacts on ecosystems in drylands

Chris Doughty, Tropical forest leaves may darken in response to climate change

Feng Tao, Data assimilation with CLM4.5

The rest of general procedure as described by Xu et al. (2006)

Afternoon

Practicing data assimilation with Xu's Code to evaluate estimated parameter values with different combinations of the six data sets (led by Xin Huang)

Yiqi Luo: Data assimilation with eddy-flux data and soil incubation data

End-of-day Quiz

**Day 9** (May 21, Tuesday): Phenocam, its data streams, data assimilation and phenology forecasting

Morning

Andrew Richardson, PhenoCam overview

Bijan Seyednasrollah, PhenoCam image processing

Katharyn Duffy, PhenoCam real-time data stream

Christina Schädel: Phenocam at SPRUCE

Afternoon

Data assimilation and forecasting phenology at SPRUCE with multiple model ensemble (led by Dafeng Hui)

End-of-day Quiz

**Day 10** (May 22, Wednesday): Data assimilation and ecological Forecasting at SPRUCE

Morning

Daniel Ricciuto, Modeling at SPRUCE

Mariah Carbone, 14C data to constrain models

Anthony Bloom: Data assimilation with satellite observations in general  
His own research using data assimilation approaches

Afternoon

Running forward modeling, data assimilation and forecasting with TECO-SPRUCE (led by Shuang Ma)

End-of-day Quiz

**Day 11** (May 23, Thursday): Data assimilation and ecological Forecasting at other sites

Morning

Daniel Ricciuto, Surrogate modeling

Dafeng Hui: Measurement and modeling of greenhouse gases in croplands

Yiqi Luo: Predictability of land carbon cycle

George Koch: Plant water relation, drought legacies, and model representation.

Afternoon

Data assimilation with TECO at trainee's own study sites or at Sevilleta site (i.e., replacing forcing files, input data files, and files of data sets for assimilation) (led by Shuang Ma)

End-of-day Quiz

**Day 12** (May 24, Friday): Ecological forecasting: Hindcast and forecast

Morning

Yiqi Luo, General concepts and procedure of ecological forecasting

Shuang Ma: General architecture of EcoPAD for ecological forecasting

Lifen Jiang: Traceability analysis with matrix equations of TECO

Bruce Hungate: From Microbes to Ecosystems to Earth: A Culture Transition

Afternoon

Practice with EcoPAD for simulation, data assimilation, and forecasting (Led by Chang Gyo Jung)

End-of-day Quiz

6:30, Party at Yiqi Luo's house

**Instructors**

Matrix approach in days 1-4:

1. Yuanyuan Huang
2. Cuijuan Liao
3. Chris Lu
4. Shaung Ma
5. Carlos Sierra
6. Feng Tao

Data assimilation and ecological forecasting

1. Enqing Hou/Xuehe Lu
2. Xin Huang
3. Dafeng Hui
4. Chang Gyo Jung
5. Shuang Ma
6. Feng Tao