Syllabus

MO7019: Data-based modeling and understanding climate-carbon feedbacks, Spring 2015.
Class Hours: 10:15-12:00 PM; **Class Room:** C645
3 hp, no written exam, but a term paper of a research project (50%) and a presentation (50%), available to everyone in MISU.

Instructor: Prof. Chuixiang (Tree) Yi; Office: C670, **Office Hours** by appointment; **Email:** cyi@qc.cuny.edu; **Work Phone:** +46-08-16-4338

Course description:

This is a short research-related course based on FLUXNET database. First, students learn what eddy-covariance (EC) technique is and understand the EC measurements and datasets (FLUXNET data). The main goal of this course is to use the FLUXNET data to understand climate-carbon dynamics.

Date	Topic	Reading, project timing
Monday 02/03/15	turbulence, eddy covariance technique, and CO2 flux measurements, Advection problems in CO2 flux measurements, friction velocity, super-stable layer,	Download fluxnet data and select research topics, read the fluxnet readme and reference paper #1
Wednesday 04/03/15	Canopy flow, K-theory, Mixing-length theory, canopy turbulent transport theory, stability analysis, numerical simulation of canopy flows	Tell the instructor your research topic at the beginning of the class and read the listed references in your research topic after class
Thursday 05/03/15	Photosynthesis - Light reaction, Calvin reaction, stomatal opening dynamics, Michaelis-Menten equation, enzyme kinetics, competitive inhibition, Farquhar model, Rubisco-limited, light-limited	Conduct your data analysis and discuss with the instructor if you have questions
Friday 06/03/15	Water budget: evaporation, transpiration, stomatal control, vapor pressure deficit, bucket overflow model, Budyko curve, Penman-Monteith evapotranspiration equation	Discuss your initial results with the instructor
Monday 09/03/15	Climate controls of NEE, synthetic fluxnet data analysis, temperature control, dryness control	Discuss your initial results with the instructor and write your research paper
Wednesday 11/03/15	Global warming, Extreme climates, ecosystem performance, CO2 fertilization control, climate-carbon feedbacks	Prepare your presentation
Thursday 12/03/15	Presentations: each student has10 minutes for presentation and 5 minutes for discussion	Write your term-paper
Friday 20/03/15	Turn in your term-paper	

Reference Textbooks:

Terrestrial Biosphere-Atmosphere Fluxes, by R. Monson & D. Baldocchi, 2014
Terrestrial Hydrometeorology, by W. James Shuttleworth. 2012.

Reference papers:

1. Lovett GM, Cole JJ, Pace ML (2006) Is net ecosystem production equal to ecosystemcarbon accumulation? Ecosystem, 9, 152–155.

2. Baldocchi DD (2003) Assessing the eddy covariance technique for evaluating carbon dioxide exchange rates of ecosystems:Past, present and future. Global Change Biology 9, 479-492.
3. Yi, C., K. J. Davis, P. S. Bakwin, B. W. Berger, and L. Marr, The influence of advection on measurements of the net ecosystem-atmosphere exchange of CO2 from a very tall tower, Journal of Geophysical Research , 105, 9991-9999, 2000

This is a research-related course to everyone in MISU, Bolin Centre, and Uppsala etc. There is no written exam. The grading is based on a term paper (50%) and a presentation (50%). Students can focus on any one of following potential research topics or your own research topic that is related to course lectures.

Research topics:

(1) **Effects of climate change on terrestrial ecosystems' water use efficiency (WUE)**

References:

CN13 →Claesson J and Nycander J 2013 Combined effect of global warming and increased CO2-concentration on vegetation growth in water-limited conditions *Ecological Modelling* **256** 23-30, DOI: 10.1016/j.ecolmodel.2013.02.007.

BWB86 → Ball, J. T., I. E. Woodrow, and J. A. Berry, 1986: A model predicting stomatal conductance and its contribution to the control of photosynthesis under different environmental conditions. Progress in Photosynthesis Research, J. Biggins, Ed., Vol. 4, Martin Nijhoff, 221–224.

Ideas → using fluxnet hourly and monthly data to study the predictions of equation (4) in CN13 with different climate condition or vegetation type, or derive new formulae by combining formulations of BWB86 and CN13, or ideas from yourselves

(2) **Inter-annual variability of net ecosystem-atmosphere exchanges (NEE) of CO2 across biomes and continents**

References:

Y2010 → Yi, C. et al. (2010) climate control of terrestrial carbon exchange across biomes and continents, Environmental Research Letters, 5, doi: 10.1088/1748-9326/5/3/034007.

K2013 →Keenan, T. F. et al. Increase in forest water-use efficiency as atmospheric carbon dioxide concentrations rise, Nature, 499, 324–327, 2013.

R2013 →von Randow et al.(2013) Inter-annual variability of carbon and water fluxes in Amazonian forest, Cerrado and pasture sites, as simulated by terrestrial biosphere models, *Agricultural And Forest Meteorology*. 182–183.

Ideas → using similar methods as K2013/R2013 used to study interannual variability of NEE of CO2 from fluxnet data, especially using fluxnet data to produce a figure like Figure 3 in K2013.

(3) **Climate extremes and NEE deficits**
References:
Y2012 →Yi, C., G. Rustic, X. Xu, J. Wang, A. Dookies, S. Wei, G. Hendrey, D. M. Ricciuto, T. Meyers, Z. Nagy, K. Pinter, Climate extremes and grassland potential productivity, Environmental Research Letters, 7, 035703 (6pp) doi:10.1088/1748-9326/7/3/035703, 2012.
W2014 →Wei, S., C. Yi, G. Hendrey, T. Eaton, G. Rustic, S. Wang, H. Liu, N. Y. Krakauer, W. Wang, A. R. Desai, L. Montagnani, K. T. Paw U, M. Falk, A. Black, C. Bernhofer, T. Grünwald, T. Laurila, A. Cescatti, E. Moors, R. Bracho, and R. Valentini, Data-based perfect-deficit approach to understanding climate extremes and forest carbon assimilation capacity, Environ. Res. Lett. 9 065002 (9pp), (2014).

Ideas → using perfect-deficit approach as described in Y2012 to study climate control NEE of CO2 from fluxnet data, or ideas from yourselves

(4) **Study NEE differences between the warm part and cold part of the land that is divided by 16oC latitudinal belt**
References:
Y2014 →Yi, C., S. Wei & G. Hendrey, Warming climate extends dryness-controlled areas of terrestrial carbon sequestration. Sci. Rep. 4, 5472; DOI:10.1038/srep05472 (2014).

Ideas → You can learn where the warm/cold part of the land is from Y2014 and then study NEE differences from fluxnet data, or ideas from yourselves

(5) Instability analysis of canopy flow over complex terrain
References:
Y2009 →Yi, C., Instability analysis of terrain-induced canopy flows, Journal of the Atmospheric Sciences, 66, 2134-2142, doi:10.1175/2009JAS3005.1, 2009.
C2012 →Chen, H., and C. Yi, Optimal control of katabatic flows within canopies, Quarterly Journal of the Royal Meteorological Society, DOI:10.1002/qj.1904, 2012
Y2008 →Yi, C., Momentum transfer within canopies, Journal of Applied Meteorology and Climatology, 47, 262-275, doi:10.1175/2007JAMC1667.1, 2008.

Ideas → Using instability analysis approach described in Y2009 conduct instability analysis for the governing equations (1a) and (1b) in C2012. This is a theoretical study (no data are required to use).

Essential parts of your term-paper: (i) title; (ii) introduction (research question); (iii) data and research method; (iv) results and discussion; (v) conclusion; and (vii) references.