

Fluxcourse syllabus: teaching and learning strategy

www.fluxcourse.org

The Fluxcourse – Annual summer course in flux measurement and advanced modeling.

Course coordinator: Dave Moore (University of Arizona)

Instruction team (2015): Pat Morgan, Aaron Saathoff, and James Kathilankal (LI-COR Biosciences), Andrew Leakey (University of Illinois), Ed Swiatek, Ryan Campbell, Ben Conrad, Ivan Bogoev (Campbell Scientific, Inc.), Russell Monson (University of Arizona), Tristan Quaife (Reading University), Sean Burns (University of Colorado), Kim Novick (Indiana University), Marcy Litvak (Univ New Mexico), Abigail Swann (University of Washington), Dennis Baldocchi (University of California), Dario Papale (University of Tuscia), Dave Schimel (NASA JPL), John Zobitz (Augsburg College), Mike Dietze (Boston University), Deborah Huntzinger (Northern Arizona University), Andrew Fox (NEON Inc)(cast in order of appearance – kinda)

The fluxcourse could not be accomplished without the kind support and voluntary efforts by the instructors personally and our hosts at University of Colorado Mountain Research Station. We also gratefully acknowledge support from Campbell Scientific, Inc., the Department of Energy, National Science Foundation, the National Ecological Observatory Network and LI-COR Biosciences.

Overall Course Objectives:

The Fluxcourse seeks to cross train attendees in measurement techniques and advanced modeling approaches for quantifying carbon and water fluxes between the atmosphere and the biosphere. Week one we cover Leaf Level Gas Exchange Measurements , Leaf Level Biochemistry (Farquhar Model), From Leaf to Canopy (Penman-Monteith), Theory and Measurement of Canopy Fluxes, Eddy Flux Measurement, Sonics and Sensors, Applications of Flux Tower Networks, Using Eddy Covariance Instrumentation, Soil Efflux measurements. Week two we cover The Challenge of Data and Models, Principles of Modeling Ecosystem Fluxes, Satellite Observations and Surface Fluxes, Theory and Practice of Data Assimilation, Extracting Information from Data, Combining Multiple Data Streams, Regional and Global Model Flux Estimates, Informing Land Surface Models with Data, The Global Carbon Cycle.

Locations and Times

Last two weeks in July, Niwot Ridge Mountain Research Station, Colorado

Contact information:

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Please use #fluxcourse in the subject line

Office Location: Suite 205, Office of Arid Lands Studies, 1955 East 6th Street, Tucson, AZ 85719

Web information including course homepage and instructor homepage: www.fluxcourse.org

Specific learning goals

To understand the fundamentals of measuring fluxes of carbon (and other gases) using a mass balance approach, including instrumentation, 'best practice' for sensor and tower placement

Sensors: Principles of gas exchange, infra-red gas analysis, sonic anemometers, open path and closed path sensors, meteorological sensors

Sampling and placement: eddy covariance theory, eddy covariance tower construction and placement, sampling ecological systems

To understand the complexities and assumptions implicit in gas exchange and eddy covariance methods

Data processing: linking data from sensors, using data loggers, gap filling techniques, corrections for physical and biological biases (WPL, advection, ecological sampling), uncertainty analysis

To understand the uses and limitations of data products derived from flux measurements

Separation of NEE into component fluxes – assumptions and techniques, standardized data products, known biases and uncertainty

To expose students to complementary and alternative approaches and new applications of existing techniques

*Basics of isotope biogeochemistry, Basics of satellite or airborne remote sensing, methane measurement, network analysis *these topics vary year to year*

To understand the key fluxes of the global carbon cycle

Atmospheric measurements, Earth as a system of components, ecosystem fluxes

To understand the key components of land surface models

Empirical and process based models, simple and complex models, parameters and state variables, boundary conditions, diagnostic and prognostic models

To understand how data and models can be combined to provide understanding of key carbon cycle components

Principles of data assimilation and parameter estimation, MCMC, ensemble Kalman filter

Learning methods: We hope attendees will gain both theoretical and practical understanding of the methods used to measure fluxes and the approaches used to combine these measurements with process based mathematical models. Often we have lectures in the morning followed by hands on activities in the afternoon. Hands-on activities include field measurements, instrument set-up, analysis of field observations, data handling, running ecosystem models and analysis of model output. Some lessons are paired with online exercises with embedded video content. Students are expected to participate in group project work and present their findings to the larger group. This is an opportunity to learn from each other and to think through issues brought up during lessons.

Indicative course schedule

Monday, week 1 (July 20)

8:30 AM – 9:00 AM	Dave Moore: Welcome and Introduction to the Course
9:00 AM – 10:30 AM	Pat Morgan & James Kathilankal: Introduction to leaf level flux measurements
10:30 AM – 10:45 AM	Break
10:45 AM – 12:00 PM	Pat Morgan, Aaron Saathoff & Dave Moore: Making leaf flux measurements
12:00 PM – 1:30 PM	Lunch
1:30 PM – 4:30 PM	Hands-on Work with Infra-red gas analyzer (Measurements of A:CI curves and A:PPFD curves on aspen leaves) Pat Morgan, Aaron Saathoff & Dave Moore
4:30 PM – 6:00 PM	Free Time
6:00 PM	Dinner
7:00 PM	<i>Crash test talks</i> - Introductions to each other (3 slides / 3 minutes)

Tuesday, week 1 (July 21)

9:00 AM – 10:15 AM	Andrew Leakey: Chloroplast- and Leaf-Level Flux Modeling (Lecture)
10:15 AM – 10:30 AM	Break
10:30 AM – 12:30 PM	Andrew Leakey: Modeling the Biochemistry of Photosynthesis (Hands-on computer)
12:30 PM – 1:30 PM	Lunch
1:30 PM – 3:00 PM	Russ Monson: Theory and Measurement of Canopy Fluxes
3:00 PM – 3:15 PM	Break
3:15 PM – 4:45 PM	Ed Swiatek: Calculation of the Eddy Flux using pen and paper
4:45 PM – 6:00 PM	Free Time
6:00 PM - 7:00 PM	To Be Determined <i>Monson's Musings/ The discovery of C4 photosynthesis</i>

Wednesday, week 1 (July 22)

9:00 AM – 10:30 AM	Edward Swiatek: Eddy Flux Instrumentation – Sonics
10:30 AM – 11:45 AM	James Kathilankal: Cross Site Calibration
12:00noon – 1:00 PM	Lunch
1:00 PM – 2:30 PM	Ankur Desai: Flux data partition – guidelines, uncertainty and caveats
2:30 PM – 2:45 PM	Break
2:45 PM – 4:00 PM	Kim Novick: Energy flux and evapotranspiration
4:00 PM – 6:00 PM	Free Time *set up groups for Thursday projects*
6:00 PM – 7:00 PM	Dinner
7:00 PM – 9:00 PM	To Be Determined <i>Monson's Musings/ The discovery of C4 photosynthesis</i>

Thursday, week 1 (July 23)

8:30 AM – 11:30 PM	9 Students set up Eddy Covariance & biometeorology systems with Ed and Larry Students Prepare Projects (groups of 4-6): Kim Novick (Energy & Water), Ankur Desai (Flux processing)
11:30 – 12pm	quick lunch
12:00 PM – 4:00 PM	Tour of Campbell Scientific Instrumentation, current and past experiments at the Niwot Ridge AmeriFlux Site (field trip)
	Ed Swiatek, Ryan Campbell, Ben Conrad, Ivan Bogoev Peter Blanken, Sean Burns, Dave Moore, Russ Monson

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4:00 PM – 6:00 PM Free Time / finish presentations

6:00 PM – 7:00 PM Dinner

7:00 PM Student Presentations: Megaron

Friday, week 1 (July 24)

9:00 AM – 10:30 AM Marcy Litvak: Asking Ecological Questions with Flux Towers

10:30 – 10:45 AM Break

10:45 AM – 12:15 PM Tristan Quaife: Remote sensing measurements and models of carbon flux

12:15 PM – 1:15 PM Lunch

1:15 PM – 2:30 PM Tristan Quaife: Hands on: Satellite observations and estimates of fluxes.

2:30 PM – 2:45 PM Break

2:45 PM – 5:30 PM Tristan Quaife: Hands on: Satellite observations and estimates of fluxes.

5:30 PM – 6:00 PM Free Time

Saturday, week 1

Morning: Transportation to Boulder (if desired) – Possibility of overnight stay in Boulder at your expense

Late afternoon: Return to Mountain Research Station

Sunday, week 1

Evening: Return to Mountain Research Station from Boulder (for those staying overnight)

Otherwise, free Day (enjoy hiking, fishing, or whatever...)

Monday, week 2 (July 27)

9:00 AM – 9:30 AM Dave Moore: Introduction to Week Two – the challenge of data and models

9:30 AM – 10:30 AM Abby Swan: Quantitative Description of Ecosystem Energy and Land Surface Modeling (Lecture)

10:30 AM – 10:45 AM Break move to Computer room

11:45 AM – 12:30 PM Data Assimilation using simple models (ecosystem scale)

12:30 PM – 1:30 PM Lunch

1:30 PM – 2:30 PM John Zobitz: Theory and practice of data assimilation

2:30 PM – 2:45 PM BREAK

4:30 PM – 6:00 PM Debbie Huntzinger (land surface scale)

6:00 PM – 7:00 PM Dinner

7:00 PM Evening panel with Dennis Baldocchi (outgoing Editor of JGR – Biogeosciences), Henry Gholz (Program Officer, NSF Bio/Ecosystems), Dario Papale – writing better papers, career strategies and the FLUXNET community

Tuesday, week 2 (July 28)

9:00 AM – 10:15 AM Dennis Baldocchi – FLUXNET syntheses

10:15 AM – 10:30 AM Break

10:30 AM – 12:00 PM Dario Papale - “Eddy Flux data post-processing, uncertainty and organization”

12:00 PM – 1:30 PM Lunch

1:30 PM – 2:20 PM Ankur Desai /Mike Dietze: Combining Flux Observations with other data in a hierarchical Bayesian Framework

2:30 PM – 3:20 PM Ankur Desai /Mike Dietze/Betsy Cowdery: using the PEACAN framework to combine models and data

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3:45 PM – 6:00 PM Ankur Desai /Mike Dietze/Betsy Cowdery: “Hands on” comparing data and models (with PECaN) | Breaks as needed

6:00 PM BBQ

7:00 PM – 9:00 PM

Dave Schimel The Global Carbon Cycle – ‘*The Chalk Talk*’

Wednesday, week 2 (July 29)

9:00 AM – 10:30 AM Drive to NEON

10:30 AM – 1:00 PM Tour of NEON / NEON Talks

NEON Subsystems tour, flux measurements, airborne remote sensing, biological measurements

1:00 PM – 2:00 PM Lunch with NEON Scientists (poster session)

2:00 PM – 5:00 PM Free time – downtown Boulder

5:00 PM – 6:00 PM Return to MRS

Thursday, week 2 (July 30)

9:00 AM – 9:15 AM Dave Moore: Introduction to class projects (SIPNET/PEACAN/MIP data)

9:15 AM – 10:05 AM Debbie Huntzinger: Regional and Global Biospheric Model Flux Estimates

10:10 AM – 11:05 AM Andy Fox: Informing Land Surface Models with Data – challenges with getting from sites to continental and global scales (with break)

11:05 AM – 11:15 AM Break (move to lodge)

11:15 AM – 11:30 AM Introduction to projects and set up (Dave Moore with all instructors)

11:30 AM – 12:00 PM Hands on: Modeling and Data assimilation group projects (Part 1)

12:00 PM – 1:30 PM Lunch

1:30 PM – 3:30 PM Hands on: Modeling and Data assimilation group projects (Part 2)

3:30 PM - 4:00 PM Break

4:00 PM – 4:30 PM Small group discussions: project progress / questions

4:30 PM - 6:00 PM Free Time / project work

6:00 PM Dinner

Friday, week 2 (July 31)

9:00 AM – 10:30 AM Student Presentations

10:30 AM Break

10:45 AM – 12:00 PM Student Presentations

12:00 PM – 1:30 PM Lunch

1:30 PM – 2:45 PM All instructors: Course Wrap up lessons learned

2:45 PM – 3:00 PM Dave Moore: Course Evaluations

3:00 PM Course Adjourns**

6:00 PM Dinner for those who remain

**transportation to Boulder