Ecohydrology
(Principles of Ecohydrological Modeling)
An Evolving Syllabus

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Content & Objective:
This course is an introduction to simulation modeling of ecohydrological systems. The objective of this course is to develop proficiency in fundamental modeling principles used to describe watershed hydrology and various associated ecosystem functions, primarily, plant dynamics and biogeochemical processes. The course is designed to encourage teams of students from historically disparate disciplines to collaboratively combine their unique skills and insights to develop increasingly complicated models. This course will primarily focus on scales from a few meters to a watershed, but, will address how smaller scale processes (e.g., those at stomatal or soil-pore scales) are aggregated to simulate larger scale phenomena. Emphasis will be placed on characterizing the optimally parsimonious model needed to answer specific questions.

Text:
There is no comprehensive Ecohydrology modeling text. Over this semester we, as a class, will read relevant literature, with particular emphasis on recent scientific advances. I will provide handouts as needed to reinforce or expand on models that are unfamiliar to students.

Proposed Class Meetings:
1-hour discussion twice a week – the objective of these discussions is to introduce new topics and develop new skills. Students will be expected to lead some of these.
2-hour sessions (periodic) – these sessions will provide hands-on opportunities for developing and or testing models as a group. These sessions may also be used to provide instruction in necessary computer skills, such as programming or GIS.

Activities and Assignments:
Students will program and/or run several models throughout the semester. Some modeling assignments will be simple enough to "program" in spreadsheets, but others will require more sophisticated software such as ArcGIS. We will use the R-programming language to develop model code. Students will develop a watershed, wetland, or lake model to answer the question of their choice as a final term project.

Suggested Prerequisites: computer programming and one or more of the following - ecology, hydrology, biogeochemistry, calculus

Suggested Topic Outline:

Introduction: What is Ecohydrology? What is modeling?
A review of primary hydrological fluxes in a watershed
Examples of ecological processes and systems tightly linked to hydrology
Examples of different abstractions used to model watershed ecohydrology
Modeling Session: Introduction to R

Soil Water Budget: The keystone to hydrological modeling
Soil wetting (infiltration) and soil drying (evapotranspiration and drainage)
Soil water redistribution, groundwater recharge, and some simplifications
Modeling Session: the Thornthwaite-Mather model

Evapotranspiration: Atmosphere-plant-soil connections
Energy budget – introduction to environmental biophysics
Penman, Penman-Monteith – comments on pan evaporation
Modeling Session: Energy budget and Penman

Plants: Leaves are really important
Canopies and roots
Modeling stomates
Modeling Session: Turning transpiration on and off

Terrestrial Biogeochemistry: Soil microbiology, DOC, P
Introducing Q10 and Arrhenius models
Simple and complex models
Modeling Session: TBD

Nitrogen: A modeling challenge
Review the nitrogen cycle in a modeling context (fluxes and stores)
Some general flux equations and denitrification hotspots
Modeling Session: PnET-BGC

Distributed modeling: How do we divide up a watershed?
SMR, DHSVM, TOPMODEL, VSA-Curve-Number
Modeling Session: Topographic indices

Groundwater Flow: Lateral flows in soil and deep strata
Darcy's Law, macropores, and kinematic approximations
Linear reservoir approximations
Modeling Session: Lumped watershed model with interflow

Snow: Accumulation and melt
Temperature index models
Energy budget models
Modeling Session: Energy budget and snowmelt

Storm runoff: a.k.a., quickflow
Empirical models
Hortonian vs. saturation excess processes
Modeling Session: Lumped storm runoff model

Example Applications as Time Allows:
Ecological competition
Weather reanalysis tools
Impact of human drainage systems on stream flow and quality
Running our models backwards?

New Insights: Students present term projects