9-2013

GEO 560.01: Fluvial Geomorphology

Andrew C. Wilcox
University of Montana - Missoula, andrew.wilcox@umontana.edu

Geosciences 560: Fluvial Geomorphology
Fall 2013
University of Montana
3 credits
Tuesday, Thursday 10:10-11:30; Clapp 333

Instructor: Andrew Wilcox
email: andrew.wilcox@umontana.edu
Office: CHCB 357
Phone: 243-4761

Office Hours: M 2:30-4 PM, or by appointment

Fluvial Geomorphology will provide an in-depth investigation of the processes that determine the form and evolution of rivers and streams. The course will combine lectures, discussions, field data collection, and modeling activities. This is not a straight lecture class! Active learning and student participation will be an essential component.

Our inquiries this semester will be guided by several related questions / themes:

- What processes determine the form and evolution of rivers and streams?
- How can we infer process from form and vice versa?
- How do river form and process vary spatially and temporally?
- How can we apply knowledge about fluvial geomorphic processes to river restoration and management?

Goals

As a result of your experiences in G560, you will have the opportunity to:

- gain a strong understanding of river channel processes and of the linkages between river channel form and process
- acquire fundamental knowledge about fluvial geomorphic processes needed to manage and restore rivers
- communicate an understanding of the interrelationships among fluvial geomorphic concepts and theories to peers and others
- use models, data, and logical reasoning to critically evaluate and connect information about river processes
- interpret and analyze literature about fluvial geomorphology from both secondary and primary sources
- improve your capacity to work as a member of a productive, collaborative team
- gain experience collecting and analyzing field data
- improve writing skills.

Course Website: This course will use Moodle (https://umonline.mrooms3.net/login/index.php). Please check the course website regularly, especially before class, for announcements, notes, readings, assignments, and schedule updates. Some of the class lecture notes will be posted. For instructions on using Moodle and on obtaining your NetID, which is required to access Moodle, go to: http://umonline.umt.edu/Moodle%20Tip%20Sheets/tipsheetandvideosstudents.aspx

Prerequisites
Graduate standing or the consent of the instructor are prerequisites. Some background in calculus, physics, and river processes is expected. In lectures, the textbook, and journal papers, you will see derivatives, integrals, and physics concepts such as force, stress, and Newton's Second Law. However, what I would consider extensive manipulation of equations will not be required. A degree of computer literacy is also required. Assignments will be given involving the use of spreadsheets, retrieval of data over the internet, and basic computer tools. If you are not proficient in these types of tasks, assignments will take longer to complete.

Topics covered (updates will be announced in class and posted on Moodle)

1. Introduction: Overview of river processes, dichotomies in approaches (Week 1; 8/27, 8/29)
2. River hydraulics / Flow mechanics (Weeks 1-4; 8/29-9/19)
    a. Overview of open-channel flow
    b. Conservation equations (mass, momentum, energy)
    c. Types of flow (Steady uniform flow, super vs subcritical, turbulent vs laminar)
    d. Flow resistance and shear stress partitioning
    e. Velocity profiles
3. Sediment transport (Weeks 5-8; 9/24-10/17)
    a. Forces on particles
    b. Incipient motion & critical shear stress
    c. Estimating transport rates
    d. Armoring, supply effects
    e. Sediment transport and channel change
    f. Conservation of mass
4. Channel morphology (alluvial rivers) (Weeks 9-12; 10/22-11/14)
    a. The bankfull channel
        i. Hydraulic geometry
        ii. Flow regimes and dominant discharge
    b. Bars and meandering
    c. Multi-thread channels, avulsions
    d. Floodplains
    e. River long profiles: Graded streams, base level, downstream fining
    f. Channel classification
    g. Interpreting channel conditions
5. Bedrock rivers (Week 13; 11/19, 11/21)
    a. Morphology
    b. Erosion processes
    c. Role in landscape evolution
6. Ecogeomorphology; River management and restoration (Weeks 14-15; 11/26, 12/3, 12/5)
    a. Riparian vegetation
    b. Large woody debris
    c. Dams and dam removal
    d. Linking process knowledge to restoration

Other topics that may be covered as time permits:

- The channel width problem
- River basin morphology (drainage networks, runoff processes)
- Climate change and river processes
- Modeling tools (computational, physical, remote sensing)

Labs

We will spend portions of several class session doing labs to gain experience with various forms of hands-on, mostly computational, fluvial geomorphic inquiry. These will include:

- HEC-RAS 1-D modeling
- HEC-GeoRAS
- BAGS sediment transport
- IRIC 2-D modeling
- Other tools as time permits

Readings:

Readings will be announced in class and posted on Moodle with sufficient advance notice for you to complete readings in advance of the relevant classes.

We will largely rely on journal literature and/or open-source material, including:

Wilcock, P., J. Pitlick, and Y. Cui (2009), *Sediment transport primer: Estimating bed-material transport in gravel-bed rivers*, Gen. Tech. Rep. RMRS-GTR-223, 78 pp, U.S. Department of Agriculture, Forest Service, Fort Collins, CO. (free download: http://www.treesearch.fs.fed.us/pubs/32966)

There is no required textbook. Having a textbook for reference is certainly useful; one that I highly recommend is:

Dingman, S.L. (2009) *Fluvial Hydraulics*, Oxford UP. (on 24-hour reserve at Mansfield Library)

Other useful references:

Parker, G. *1D Sediment Transport Morphodynamics with Application to Rivers and Turbidity Currents* (free download: http://vtchl.uiuc.edu/people/parkerg/morphodynamics_e-book.htm)

Wohl, E. (2010), *Mountain Rivers Revisited*, 573 pp., American Geophysical Union Water Resources Monograph Vol.19, Washington DC, doi:10.1029/WM019.

Journal papers and discussion:

We will read 1-2 journal papers each week and spend a portion of the Thursday class section discussing them. Discussion leadership will rotate among students; please read the "Guidelines for discussion leadership" posted on Moodle. These discussions will be designed to encourage critical thinking about primary literature and broad participation. A partial list of discussion papers, listed in order of when they may be discussed, rather than alphabetically, is below.

Walter, R.C. and D.J. Merritts. 2008. Natural streams and the legacy of water-powered mills. *Science* 319:299-304. Comments by Bain et al, Wilcock, and Response by authors, *Science* 2008

Montgomery, D. R. 2008. Dreams of natural streams, *Science*, *319*(5861), 291-292.

Montgomery, D.R. and J.M. Buffington. 1997. Channel reach morphology in mountain drainage basins. *GSA Bulletin* 109.
Schumm, S.A., 1973. Geomorphic thresholds and complex response of drainage systems. In: Morisawa, M. (Ed.), Fluvial Geomorphology. New York St. Univ. Pub. Geomorph, Binghamton: 299– 310.
Nittrouer, J. A., J. L. Best, C. Brantley, R. W. Cash, M. Czapiga, P. Kumar, and G. Parker (2012), Mitigating land loss in coastal Louisiana by controlled diversion of Mississippi River sand, *Nature Geosci*, *5*(8), 534-537, doi: http://www.nature.com/ngeo/journal/v5/n8/abs/ngeo1525.html#supplementary-information.
Kim, W. (2012), Geomorphology: Flood-built land, *Nature Geosci*, *5*(8), 521-522.
Wilcock, P.R. 1998. Two-fraction model of initial sediment motion in gravel-bed rivers. *Science*. 280: 410-412.
Dietrich, W.E., J.W. Kirchner, H. Ikeda, and F. Iseya. 1989. Sediment supply and the development of the coarse surface layer in gravel-bedded rivers. *Nature* 340: 215-217.
Buffington, J. M., and D. R. Montgomery. 1999. Effects of hydraulic roughness on surface textures of gravel-bed rivers. *Water Resources Research* 35:3507-3521.
Comments by Wilcock, Millar and Rennie, and Reply to comments by authors
Wolman, M.G. and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology* 68: 54-74.
Andrews, E.D. 1983. Entrainment of gravel from naturally sorted riverbed material. *Geological Society of America Bulletin* 94:1225-1231.
Braudrick, C.A., W.E. Dietrich, G.T. Leverich, and L.S. Sklar. 2009. Experimental evidence for the conditions necessary to sustain meandering in coarse-bedded rivers. *Proceedings of the National Academy of Sciences* 106(40): 16936-16941.
Schmidt, J.C. and P.R. Wilcock. 2008. Metrics for assessing the downstream impacts of dams. *Water Resources Research* 44,W04404, doi:10.1029/2006WR005092.
Beechie, T.J., Sear, D.A., Olden, J.D., Pess, G.R., Buffington, J.M., Moir, H., Roni, P., and Pollock, M.M., 2010, Process-based principles for restoring river ecosystems: BioScience, v. 60, p. 209-222, 10.1525/bio.2010.60.3.7.
Lauer, J. W., and G. Parker. 2008, Modeling framework for sediment deposition, storage, and evacuation in the floodplain of a meandering river: Application to the Clark Fork River, Montana, *Water Resour. Res.*, 44, W08404, doi:10.1029/2006WR005529.

Grading

40% Homework assignments and labs
20% Field Project
10% Midterms
10% Final exam
20% Class participation: 1) in-class activities testing and applying material from readings and lectures; 2) leadership of a paper discussion; 3) active participation in paper discussions, 4) questions and other participation during class activities

Consistent productivity is essential to your grade. Don't miss any assignments; keep up with the lectures, the labs, and the reading; complete all in-class work; and ask questions.

Other notes

1. *Exams:* There will be one or two short midterms, as well as a final. All exams will be open book / note.
2. *Field trip*: Saturday, October 5. Data collected on this trip will be used in the main class field project. Our field data will be used for various geomorphic calculations, modeling, and analyses.
3. *Guest lectures:* I will be traveling on 9/10 and 10/29. My postdocs, Rebecca Manners and Phairot Chatanantevet, will guide class on those days.
4. *Email.* Feel free to communicate with me by email. Please rely on office hours or questions in class for homework questions. Please rely on Moodle and classmates to find

out what you missed if you miss class. If you hand in assignments electronically, they must be well organized and consolidated into at most two files.

5. *Late policy*: No credit allowed for assignments handed in > 1 week after due date or after answer key posted, whichever comes first.
6. *Academic Integrity:* All students need to be familiar with and abide by the Student Conduct Code and its definitions of academic misconduct. The Code is available for review online at http://life.umt.edu/vpsa/student_conduct.php
7. *Equal Access*: The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students (DSS). If you think you may have a disability adversely affecting your academic performance, and you have not already registered with DSS, please contact DSS in Lommasson 154. I will work with you and DSS to provide an appropriate accommodation