Morphodynamics & Quantitative Stratigraphy
Spring 2014 (Geo 371T/Geo 391, Unique #26925, #27060)

Instructor:
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Class Time & Location: TTH 11:00 AM – 12:30 PM EPS 2.136
Office Hours: TTH 2 – 3 PM

The goal of this course is for students to develop their own numerical tools to quantitatively understand sediment transport and stratigraphic development in sedimentary basins. The focus of this class ranges from applications of the principles in fluid mechanics, sediment transport, and depositional mechanics to one-dimensional and quasi-two dimensional numerical modeling of sediment morphodynamics in various depositional settings such as a) river deltas, b) carbonate platforms, and c) submarine fans. Through this course, students will develop their own geometrical and morphodynamic models as research tools to understand their own data from the field and/or laboratory experiments.

CLASS SCHEDULE

1. *(Jan 19)*: Introduction to Morphodynamics and Quantitative Stratigraphy

We will go over the following concepts inducing: Fossilized Dynamics (The morphology of sediment-fluid interface dynamically responds to both depositional mechanics and environmental forcing. Landscape evolution and the affiliated deposits record the *fossilized dynamics* of this spatiotemporal moving boundary), Evolution of the earth's surface and conservation of sediment mass, and Types of deltas

Some related papers about application of morphodynamic models to modern delta formation

Kim, W., Flood-built land: *Nature Geoscience*, v. 5, no. 8, p. 521-522, DOI: 10.1038/ngeo1535
Kim, W., Mohrig, D., Twilley, R., Paola, C., and Parker, G., 2009, Is it feasible to build new land in the Mississippi River Delta?: *EOS*, v. 90, no. 42, p. 373-374.

Geometric model and 1D flume experiment

2. *(Jan 21 & 26*)*: Geometric Forward Model

We will develop our first model that uses sediment mass balance to predict shoreline migration for a delta with a flat topset and a vertical delta front, and update it with sloped topset and foreset. The model captures the effects of changes in boundary conditions (e.g., sediment supply) on the delta evolution. We will explore how much insight we can gain from using this very simple geometric model!

Kim, W., and Muto, T., 2007, Autogenic response of alluvial-bedrock transition to base-level variation: Experiment and theory: Journal of Geophysical Research-Earth Surface, v. 112, no. F3.

3. *(Jan 28 & Feb 2*)*: Updated Geometric Model

The geometric model will be updated to include changes in sediment supply, tectonic subsidence, and sea level. The stratigraphic effects of these changes will be evaluated by running the updated model with the set of boundary conditions. The concept of autostratigraphy will also be reviewed.

Muto, T., Steel, R. J., and Swenson, J. B., 2007, Autostratigraphy: A framework norm for genetic stratigraphy: Journal of Sedimentary Research, v. 77, no. 1-2, p. 2-12.
Helland-Hansen, W., and Martinsen, O. J., 1996, Shoreline trajectories and sequences; description of variable depositional-dip scenarios: Journal of Sedimentary Research, v. 66, no. 4, p. 670-688.

4. (Feb 4)*: Geometric Model: Application – Experimental design

We will modify the geometric model to design a 1D delta experiment. The class will be separated into a few groups to design group experiments. Each group will discuss their scientific questions to address through experiment and decide on their own experimental input parameters e.g., sea-level change and/or sediment supply for their group experiments.

Paola, C., Mullin, J., Ellis, C., Mohrig, D. C., Swenson, J. B., Parker, G. S., Hickson, T., Heller, P. L., Pratson, L., Syvitski, J., Sheets, B., and Strong, N., 2001, Experimental stratigraphy: GSA Today, v. 11, no. 7, p. 4-9.

1st Project (Geometric Model: Due on Feb 9 before class)

5. (Feb 9): The Use of Imagery in Laboratory Experiments

We will learn how to collect data from the digital imagery from the experiments. Some introductory instructions for using Adobe Photoshop and MATLAB will be provided.

Tal, M., Frey, P., Kim, W., Lajeunesse, E., Limare, A., and Metivier, F., in review, The use of imagery in laboratory based experiments, *in* Carbonneau, P., and Piegay, H., eds., Remote Sensing of Rivers: Management and Applications.

6. (Feb 11 – Mar 1): Geometric Model: Application – Running experiment

We will set up the experiments. Each group will conduct two hour-long experiments, and collect time-lapse images, shoreline locations and topographic profiles.

Paola, C., Straub, K., Mohrig, D., and Reinhardt, L., 2009, The "unreasonable effectiveness" of stratigraphic and geomorphic experiments: Earth-Science Reviews, v. 97, no. 1-4, p. 1-43.

Morphodynamic Model

(Gary Parker's e-book chapter: You can download the e-book at http://vtchl.uiuc.edu/people/parkerg/morphodynamics_e-book.htm)

7. (Mar 3): Bankfull Characteristics of Rivers (Gary Parker's e-book Ch. 3)

Dimensionless parameters characterizing channel bankfull geometry and their relationships

Parker, G., Paola, C., Whipple, K. X., and Mohrig, D., 1998, Alluvial fans formed by channelized fluvial and sheet flow; I, Theory: Journal of Hydraulic Engineering, v. 124, no. 10, p. 985-995.

2nd Project (4-page summary report of the experimental results: Due on Mar 8 before class)

8. (Mar 8): Student Presentations

Each group will make a 20-min presentation based on the results of their experiments and geometric models.

Spring Break Mar 14-18: No Classes

9. (Mar 10 & 22)*: 1D Aggradation and Degradation of Rivers: Normal Flow Assumption (Gary Parker's e-book Ch. 14)

We will use a diffusion sediment transport relation to model deposition in a river basin. The model shows how the river responds to sediment supply changes and tectonic activities. We can estimate how long the sedimentary system takes to respond to the external forcing and how long it takes to reach a new equilibrium condition.

Paola, C., Heller, P. L., and Angevine, C. L., 1992, The large-scale dynamics of grain-size variation in alluvial basins; 1, Theory: Basin Research, v. 4, no. 2, p. 73-90.

10. (Mar 24 & 29)*: Long Profiles of Rivers with an Application on the Effect of Base Level Rise on Long Profiles (Gary Parker's e-book Ch. 25)

We will review a model that reproduces sedimentary basin evolution under constant subsidence or base-level rise. The model shows elevation, bankfull depth and width profiles. You will be able to see the reason for the concavity in river long profiles!

Sinha, S. K., and Parker, G., 1996, Causes of concavity in longitudinal profiles of rivers: Water Resources Research, v. 32, no. 5, p. 1417-1428.

11. (Mar 31 & Apr 5)*: Morphodynamics of Rivers ending in 1D Deltas (Gary Parker's e-book Ch. 34)

We will consider the shoreline as a moving boundary and model shoreline advance associated with relative sea-level changes. We will also capture our experiments using this model and compare with the results from the previous geometric model. Which one do you think is better?

Swenson, J. B., Voller, V. R., Paola, C., Parker, G., and Marr, J. G., 2000, Fluvio-deltaic sedimentation: a generalized Stefan problem: European J. Appl. Math., v. 11, no. 5, p. 433--452.

3rd Project (Morphodynamic Model: Long Profile with a Fault: Due on Apr 7 before class)

12. (Apr 7 & 12)*: Morphodynamics of 1D Submarine Fans (Lecture 12)

Let's taste a bit of turbidity current modeling. The lecture will overview a 3-equation formulation for the flow and the bulk Richardson number to build a turbidity current model. The model captures turbidity current fan deposition over different initial basement topography.

Kostic, S., and Parker, G., 2003, Progradational sand-mud deltas in lakes and reservoirs. Part 1. Theory and numerical modeling: Journal of Hydraulic Research, v. 41, no. 2, p. 127-140.

13. (Apr 14 – May 3): 1D Submarine Fans – Running experiment

We will set up the experiments. Each group will conduct two hour-long experiments, and collect time-lapse images and topographic profiles.

14. (May 5): Student Presentations

Each group will make a 20-min presentation based on the results of their experiments and geometric models.

4th Project (4-page summary report of the experimental results: Due on May 10)

COURSE MATERIALS

Lecture notes and extra readings will be posted electronically on *Canvas.*
Gary Parker's E-Book chapters can be also found at
http://hydrolab.illinois.edu/people/parkerg//?q=people/parkerg/
Laptop computer is required in the classes marked with *

GRADING

Your grade for this course will be based on:
20% - 1st Project
20% - 2nd Project Report
10% - 2nd Project Group Presentation
20% - 3rd Project
20% - 4th Project Report
10% - 4th Project Group Presentation

Letter grades are assigned at the end of the semester based on the total as:
A > 85
85 ≥ A- > 80
80 ≥ B+ > 75
75 ≥ B > 70
70 ≥ B- > 65

Instructions for the project report
1. Late reports will not be accepted, regardless of the reason.
2. Reports are limited to 4 pages, and must be submitted in doc (or docx) format.
3. Report file sizes are limited to 10 MB
4. Use the template available in the Canvas website.
5. All reports should be formatted and prepared in a way similar to an abstract to LPSC.
6. All reports should include introduction, model description, model results and validation with data, short discussion, conclusion, and figures and references.

OTHER INFORMATION

Attendance is vital for success in this course and I as well as others will value your contribution to class discussions.

Use of Canvas

This course uses Canvas, a Web-based course management system in which a password-protected site is created for each course. Canvas will be used to distribute course materials, and to communicate and collaborate online. Canvas is available at http://courses.utexas.edu.

IMPORTANT INFORMATION ON UNIVERSITY POLICIES

The University of Texas Honor Code

The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.

University Electronic Mail Notification Policy
(Use of E-mail for Official Correspondence to Students)

All students should become familiar with the University's official e-mail student notification policy. It is the student's responsibility to keep the University informed as to changes in his or her e-mail address. Students are expected to check e-mail on a frequent and regular basis in order to stay current with University-related communications, recognizing that certain communications may be time-critical. It is recommended that e-mail be checked daily, but at a minimum, twice per week. The complete text of this policy and instructions for updating your e-mail address are available at
http://www.utexas.edu/its/policies/emailnotify.html.

In this course e-mail will be used as a means of communication with students. You will be responsible for checking your e-mail regularly for class work and announcements. Note: if you are an employee of the University, your e-mail address in Blackboard is your employee address.

Documented Disability Statement

Students who require special accommodations need to get a letter that documents the disability from the Services for Students with Disabilities area of the Office of the Dean of Students (471-6259 – voice or 471-4641 – TTY for users who are deaf or hard of hearing). This letter should be presented to the instructor in each course at the beginning of the semester and accommodations needed should be discussed at that time. Five business days before an exam the student should remind the instructor of any testing accommodations that will be needed.
See Website below for more information: http://deanofstudents.utexas.edu/ssd/providing.php

Religious Holidays – Religious holy days sometimes conflict with class and examination schedules. If you miss an examination, work assignment, or other project due to the observance of a religious holy day you will be given an opportunity to complete the work missed within a reasonable time **after** the absence. It is the policy of The University of Texas at Austin that **you must notify each of your instructors at least fourteen days prior to the classes scheduled on dates you will be absent** to observe a religious holy day.