Morphodynamics & Quantitative Stratigraphy
Fall 2011 (Geo 391, Unique #27930)

Instructor:
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Class Time & Location: TTH 2 – 3:30 PM EPS 1.126
Office Hours: TTH 1 – 2 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 morphodynamic model as a research tool to understand their own data from the field and/or laboratory experiments.

CLASS SCHEDULE

***1 (Aug 24 & 30)*: Introduction to Morphodynamics and Quantitative Stratigraphy**
Fossilized Dynamics: The morphology of the 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 / Types of deltas

Geometric model and 1D flume experiment

***2 (Sept 1*)*: 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. 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 even 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 (Sept 6 – 13*)*: Updated Geometric Model**
The geometric model will be updated to include sloping fluvial and foreset surfaces. The effects of these geometric changes will be evaluated by running the updated model with the set of boundary conditions previously used. 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.

***4 (Sept 15*)*: Geometric Model: Application – Experimental design**

We will modify the geometric model to design a 1D delta experiment in the University of Texas Experimental Delta (UTED) facility. The class will be separated into two groups to plan the experiments. Each group will 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 (Group Project for Experimental Design: Due on Sept 20 before class)

***5 (Sept 20 & 22)*: Geometric Model: Application – Running experiment in UTED**

Each group will conduct an experiment either on Sept 20 or Sept 22. Class will meet in building 120 on the Pickle Research Campus. Each group will input their parameters into the control computer, conduct an hour-long experiment, and collect time-lapse images and a topographic profile.

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.

***6 (Sept 27)*: 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.

2nd Project (Group Project for reporting results of the experiments: Due on Oct 6 before class)

***7 (Sept 29)*: Geometric Model: Application – Example**

We will discuss a recent result using a model that captures the response in moving boundaries of axial-channel belt and transverse fans to tectonics and sediment supply variations in a half-graben basin. The study compares the modeling results with experimental data to quantify the moving boundary migration due to lateral erosion in the transverse fans.

Kim, W., Connell, S. D., Steel, E., Smith, G. A., and Paola, C., 2011, Mass-balance control on the interaction of axial and transverse channel systems: Geology, v. 39, no. 7, p. 611-614.

***8 (Oct 4):* Modeling Carbonate-Platform Evolution**

Using a depth-dependent carbonate production curve, the class will develop a 1D model to capture carbonate platform evolution responding to various rates of sea-level rise. This simple model resolves the 30-year-long paradox of drowned reefs and platforms!

Schlager, W., 1981, The paradox of drowned reefs and carbonate platforms: Geological Society of America Bulletin, v. 92, no. 4, p. 197-211.

9 (Oct 6): Student Presentations

Each group will make a 30-min presentation based on the results of their experiments and geometric models.

GSA Week (Oct 11 & 13): No Classes

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)

***10 (Oct 18 & 20)*: Introduction to Fluid Mechanics and Depositional Mechanics**

We will review the principles of fluid mechanics and sediment transport in these lectures. The lectures include introduction of the Reynolds Equation & Navier-Stokes Equations with averaged terms. The class will also go over more details about sediment and flow properties, sediment transport modes, and bedload- & suspended-load transport

***11 (Oct 25)*: 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.

***12 (Oct 27 & Nov 1*)*: 1D Aggradation and Degradation of Rivers: Normal Flow Assumption** (Gary Parker's e-book Ch. 14)

We 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 reaches 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.

***13 (Nov 3 & 8*)*: 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 gives elevation, bankfull depth and width profiles. You can 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.

***14 (Nov 10 & 15*)*: Morphodynamics of Gravel-Sand Transition** (Gary Parker's e-book Ch. 27)

We will use two grain-sizes and a backwater formulation to model morphodynamics in subsiding basins to see how the internal grain-size boundary responds to base-level change.

Ferguson, R. I., 2003, Emergence of abrupt gravel to sand transitions along rivers through sorting processes: Geology, v. 31, no. 2, p. 159-162.

Individual meetings in office hours on Nov 15 and 17 for independent project

***15 (Nov 17 & 22*)*: 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 can also capture our experiments using this model and compare with the results using the earlier 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 (Due on Dec 1 before the class)
Thanksgiving holidays (Nov 24): No Class

***16 (Nov 29 & Dec 1*)*: 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.

4th Independent Project (Due on Dec 12)

COURSE MATERIALS

Lecture notes and extra readings will be posted electronically on *Blackboard.*
Laptop computer is required in the classes marked with *

GRADING

Your grade for this course will be based on:
20% - 1st Project
15% - 2nd Project Group Poster
15% - 2nd Project Group Presentation
20% - 3rd Project
30% - Independent Project

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

Write-ups for each class project & model must include:
1. A description of the questions addressed using the model
2. An annotated printout of your model code
3. A description of the strengths and weaknesses of the numerical model
4. Presentation and evaluation of model results.

An Independent Project will be developed by discussions with individual student **(*Individual meetings for independent project are strongly encouraged in office hours on Nov 15 and 17 or by appointment*).** This project will build on concepts and numerical methods discussed in the course. The write-up for this independent project should be similar to a journal paper that includes introduction, model description, model results and validation with data, short discussion, and conclusion.

OTHER INFORMATION

Attendance is vital for success in this course and we value your contribution to class discussion.

Use of Blackboard
This course uses Blackboard, a Web-based course management system in which a password-protected site is created for each course. Blackboard will be used to distribute course materials, and to communicate and collaborate online. Blackboard 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.