Inverse Methods in Geophysics
CERI 7260/8260
CIVL 7128/8128
Spring 2018
MW 12:40 – 2:05 PM
Instructor: C.A. Langston
3 Credits

Overview: Quantification is one of the hardest problems in the Earth Sciences but is the corner stone for developing and examining scientific hypotheses. This course will provide an advanced undergraduate student or first year graduate student the mathematical foundations of linear algebra, vector spaces, and generalized linear inverse theory, with an introduction to statistics. Example problems in the Earth Sciences will be incorporated in class projects showing how to set up a parameter-estimation problem and appropriate ways of solving them. The Matlab programming language will be used for solving homework problems and project development. Class grades will be based on homework assignments and the final project with class presentation.

Text: Strongly suggested but not required: Aster, R., B. Brochers, C. Thurber (2005). *Parameter estimation and inverse problems*, Elsevier Academic Press. (There is a new edition as well.)

Another book that is quite good and I will be using off and on: Gershenfeld, N. (1999). *The nature of mathematical modeling*, Cambridge University Press.

I will be providing notes and papers in the class as we go along, so book purchase is not required.

Grading:	Homework:	40%
	Written Report:	40%
	Oral Presentation:	15%
	Class Participation:	5%

Written Report: Last day of class Wednesday, April 25th (15% report grade bonus if submitted by April 18th)

The written report will be typed, 15 pages maximum, in 12 point font, 1 and ½ line spacing. Outlines will not be accepted. The report format will follow standard scientific publication format:

Title Page (1 page)
Abstract (1 page, 250 words maximum)
Introduction
Main Body (e.g., "Data", "Theory", "Data Analysis", etc.)
Discussion
Conclusions
Acknowledgements
References
Tables
Figure Captions
Figures

Oral Presentations: The class will meet Wednesday, April 25th for presentations of their term projects. The presentations will be in AGU-style with 12 minutes for the presentation and 3 minutes for questions.

In addition, each student will be assigned 3 topics over the course of the semester to be given to the class as a 10-minute mini-lecture. Preparation, clarity, and impact will be the important attributes of each mini-lecture. Class participation will also be gauged during these events.

Syllabus

Quantification of Problems in the Earth Sciences
Introduction to Inverse Methods
Introduction to Matlab: Interactive computer demonstration
Forward Problems and Inverse Problems

***Review of Linear Algebra**
Matrices, Matrix Operations, Determinants and solution to linear equations, Eigenvalues and Eigenvectors (Book Appendix A)

***Review of Probability and Statistics**
Probability and random variables, distribution functions, expectation, variance, statistical tests (Book Appendix B)

Linear Regression
Linear regression, least-squares, error ellipses, confidence intervals, errors

Discretizing Continuous Inverse Problems
Numerical approximations of integrals, Backus and Gilbert method

Rank Deficiency and Ill-Conditioning
Singular value decomposition, null and data spaces, rank, conditioning

Regularization
Methods for stabilizing inversion problems.

Nonlinear Inverse Problems
Regularizing nonlinear least squares problems.

Setting Up Practical Inversion Problems
Student contributions for defining inversion problems of interest and setting them up.

- Examples of practical inversion problems will be given as we go along.

*Depends on the background of class participants