Tectonic Geodesy

GEOS 655
Spring 2011
Tu-Th 11:30-1:00, AVO Record Reading Room

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The Earth's crust is constantly in motion, with every part of the surface moving due to plate tectonics, and constantly deforming. The Earth is subject to a variety of periodic, steady and transient deformations. Motion and deformation is characteristic of both the solid earth and the cryosphere, and hydrologic and cryospheric mass changes cause observable deformation of the solid earth. Modern space-based geodetic techniques like the Global Positioning System (GPS) provide the ideal tools for studying the kinematics and dynamics of the earth.

The course is intended to teach you how modern geodetic techniques work, with a focus on GPS, and how they are applied to the study of problems in tectonics and other causes of motion and deformation. It begins with a description of how the measurements are made, followed by a mathematical description of coordinates and strains, and then provides an overview of the mathematical models used to relate observed deformation to tectonic, volcanic, and loading source models. Practical examples and applications are interspersed throughout, and the last few weeks of the class will be dominated by such examples. We will conclude with a discussion of related problems in sea level change, altimetry, and gravity change, which are made using different geodetic tools and provide measurements of the dynamic changes in the cryosphere and hydrosphere.

Textbook

There is no suitable textbook for this course; book publishers have not yet caught up with this fairly new field, although there are several books that cover parts of this course in detail. Xerox copies or PDF files of reading material will be provided. When I assign reading assignments, I expect to you read the material before the next class. That will allow me to use the lecture time to summarize key points and answer your questions, rather than trying to give you the details.

Grading

Students will be assigned several homework assignments, with a mix of analytical and numerical exercises. The homework load will not be very heavy, and will be scheduled to minimize time conflicts with the projects. Numerical exercises will be done using MATLAB or a similar programming environment. In addition, there will be midterm and final projects. The midterm project will be in the form of a written report summarizing, analyzing and synthesizing results from two or more published papers on a similar topic. The final project will be in the form of a written research proposal. In both cases, the students will also make a 10-minute presentation of their report or proposal to the class.

Grades will be based on homework assignments, and a class project. We will have several numerical exercises done using MATLAB.

Homework 70%
Project 30%

Projects

The class project will involve working with some real data, preferably GPS or InSAR data, and will be chosen by each student with the approval of the instructor. Students will construct a deformation model, or estimate a best- fitting model in an inverse sense, using an actual data set, and report their results in writing.

Class Time and Location

Class will meet Tuesdays and Thursdays from 11:30 am to 1:00 pm. We will meet in the 3rd floor Elvey Record Reading Room (aka AVO meeting room).

Homework Assigned

Homework 1. 2D GPS location problem.

Homework 2. Computing plate motions.

Homework 3. Strain and index manipulation.

Homework 4. Computing strain and rotation.

Detailed Schedule

Each lecture title is a link to the powerpoint file for that lecture.

Day	Date	Lecture Topic
Tue	Jan 25	1. Introduction; What is Geodesy; History of Geodesy applied to tectonics
Thu	Jan 27	2. Measurement systems; sampler of applications; online resources

Tue	Feb 1	3. Measurement systems: Global Positioning System (GPS)
Thu	Feb 3	4. Measurement systems: Global Positioning System (GPS)
		4a. Perspectives on Least Squares
Tue	Feb 8	5. Measurement systems: Global Positioning System (GPS): time series, practical reference frames
Thu	Feb 10	6. Measurement systems: Ambiguity Resolution, Kinematic GPS and GPS "Seismology"
Tue	Feb 15	7. Measurement systems: InSAR
Thu	Feb 17	8. Plate kinematics, rigid plate motions, plate-fixed reference frames
Tue	Feb 22	Computational Exercise (HW2)
Thu	Feb 24	9. Practical applications: steady plate boundary deformation
Tue	Mar 1	10. Coordinates and transformations; vectors; Displacements and strains; tensors; Displacement gradient tensor
Thu	Mar 3	11. Strain tensor; Rotation; Line length and angle measurements 12. Strain examples
Tue	Mar 8	12. Strain examples
Thu	Mar 10	13. Large scale strain maps 14. Measurement systems: terrestrial measurements, datum defects, special solutions, Singular Value Decomposition, Model coordinate solution
Tue	Mar 15	SPRING BREAK

Thu	Mar 17	SPRING BREAK
Tue	Mar 22	15. Description of faults; Earthquake cycle
Thu	Mar 24	16. Dislocation theory; Screw and edge dislocations; *No powerpoint*
Tue	Mar 29	19. Practical applications: earthquakes; seismic vs. aseismic slip
Thu	Mar 31	20. Practical applications: slow slip and stress transfer
Tue	Apr 5	21. Practical applications: postseismic deformation
Thu	Apr 7	22. Practical applications: volcanoes I
Tue	Apr 12	23. Practical applications: volcanoes II
Thu	Apr 14	17. Glacial Isostatic Adjustment
Tue	Apr 19	18. Loading deformation 18b. Global scale loading
Thu	*Apr 21*	*No Class:* Review Tides, Altimetry
Thu	*Apr 26*	*No Class:* Review Tides, Altimetry
Thu	*Apr 28*	*No Class:* Review Tides, Altimetry
FINALS	WEEK	*Presentation of Final Projects*

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