COURSE SYLLABUS

GEO 6590/7590 Geodesy & Crustal Deformation

Fall 2019 Lecture: MWF 8:30—9:20 GEOL 310

Professor: Tony Lowry (Department of Geology)
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COURSE DESCRIPTION

Geodesy is the study of the Earth's shape and gravity field, including how they change over time.

Many of the observations that inform our understanding of the Earth's climate, space weather and solid-Earth natural hazards (including sea-level rise, mass change in alpine glaciers and the Greenland/Antarctica ice sheets, and unsustainable groundwater usage) are rooted in modern methods for ground-based and satellite geodesy. Crustal deformation studies focus on changes in shape of the Earth's surface and geoid, thus emphasizing active processes of strain, mass transfer, and mass loading by Earth's fluid envelopes.

Geodynamics, plate tectonics, earthquakes & fault slip, magmatism & volcanism, and global change studies all trace some of their most important advances over the past several decades to mundane (or even arcane) geodetic observations. Hence, anyone studying active Earth (& planetary) processes will benefit from an understanding of both the nuts-and-bolts of geodetic measurement and the geodetic signatures of these many different processes.

Geodesy is a highly quantitative observational metric. Not surprisingly, many of the tools we will discuss in this course are mathematical. Don't worry though: we'll be sticking to basic concepts of calculus, linear algebra and probability & statistics that should be familiar by now (and when they're not, we'll take it slow). Ultimately, this course is meant to provide you (the student) with an understanding of geodesy and crustal strain and mass transfer processes that will be helpful in both your current thesis research and your later career.

About the professor:
I am a geophysicist ("Physics of the Earth") who focuses on measuring and understanding how and why planets deform. On Earth, this relates directly to processes of fault slip, earthquakes and volcanoes, but also has implications for mass transfer in the atmosphere, hydrosphere and cryosphere.

Course Text
(Required): **Geodesy and Gravity Course Notes**, John Wahr. I have placed a pdf copy on the course website at:
http://aconcagua.geol.usu.edu/%7Earlowry/Geod_CD/index.html.

TOPICS

This course will cover two rather disparate topics. In covering both topics, the intent is to emphasize those particular tools and applications that are most relevant to the interests and research topics of students taking the course.

- **Physical Geodesy**, including the observational tools (both satellite and ground-based measurements), gravity and potential theory, and some of the "non-solid Earth" applications (e.g., atmospheric remote sensing, time transfer, surface height and mass changes in the oceans, ice sheets and groundwater).
- **Crustal Deformation**, in which we will examine several of the physical processes that can be studied with geodesy. Emphasis here will be on solid Earth processes that are relevant for hazard studies, including various processes and timescales of fault slip, magma flux/intrusion processes, viscoelastic rebound, and flexural isostasy.

Both portions of the course content will be explored partly in a reading seminar format, in which I will assign papers to be read by all and one class member will "volunteer" to present each paper to the rest of the class.

(Tentative) Reading Schedule: (Subject to change based on student interests!)

11 Sep:	Luttrell et al. (2013) GRL **40**(3) 501-506
20 Sep:	Herring et al. (2016) JGR **117**(B7)
27 Sep:	Jacob et al. (2012) Nature **482**(7386) 514-518
4 Oct:	Ghosh & Holt (2012) Science **335**(6070) 838-843
11 Oct:	Furst et al. (2018) Tectonophysics **746**, 364-383
25 Oct:	Chang et al. (2007) Science **318**(5852), 952-956
1 Nov:	McCaffrey et al. (2008) Nat. Geosci. **1**(5), 316-320
8 Nov:	Borsa et al. (2014) Science **345**(6204), 1587-1590
15 Nov:	Lau et al. (2017) Nature **551** 321-326
04 Dec:	Ito & Simons (2011) Science, **332**(6032), 947-951

(Tentative) Lecture Schedule:

26 Aug: Introduction: Examples of Geodesy Applications
28 Aug: Context: Terrestrial Geodetic Measurement
30 Aug: Space-based geodesy: Intro to GPS Measurement
4 Sep: GPS Measurement Cont'd: Signal Structure and Error Sources
6 Sep: GPS Measurement Cont'd; Plate Motions
9 Sep: Plate Motions from GPS Velocities Cont'd
11 Sep: Luttrell et al. (2013)
(No lecture Sep 13: Prof in Boulder)
16 Sep: Modeling Horizontal Velocities as Flow Strain
18 Sep: Gravity: Measurement
20 Sep: Herring et al. (2016)
23 Sep: Gravity & the Geoid
25 Sep: Gravity & the Geoid
27 Sep: Jacob et al. (2012)
30 Sep: Modeling of GPS velocities
2 Oct: More on Modeling Velocities: Blocks with Back-Slip
4 Oct: Modeling Stress Equilibrium from Velocities: Ghosh & Holt (2012)
(No lecture Oct 7: Prof in Portland)

9 Oct: Velocity Modeling Continued
11 Oct: Furst et al. (2017): Velocity-Modeling Elastic Plate Deformation
14 Oct: Deformation Measurement: InSAR (the Synoptic Viewpoint)
16 Oct: Modeling Dislocation Green's functions: Mogi Sources
(Fall Break Oct 18!)
21 Oct: Modeling Dislocation Green's Functions: Okada-type Fault Planes
23 Oct: Modeling Dislocations: Sumatra-Andaman Co- and Postseismic
25 Oct: Chang et al. (2007): Transient Deformation & Magmatic Intrusion
28 Oct: Promise/Limitations of Slip Inversion for Modeling Slow Fault Slip
30 Oct: Slow Slip: More Observations
1 Nov: McCaffrey et al. (slow slip in New Zealand)
4 Nov: Slow Slip: Obs and Models
6 Nov: Earth's Elastic Load Response
8 Nov: Borsa et al. (2014)
11 Nov: Elastic Load Response (Cont'd)
13 Nov: Earth tides; Viscoelastic (Post-Glacial or Other) Rebound
15 Nov: Lau et al. (2017)
18 Nov: Glacial Isostatic Adjustment
20 Nov: Glacial Isostatic Adjustment
22 Nov: Ito & Simons
25 Nov: Glacial Isostatic Adjustment
(Thanksgiving Break Nov 27-29!)
2 Dec: Modeling Isostatic Adjustment on a Sphere
4 Dec on: TBA

Each of you is expected to come up with a course project, which you will present on the last day of class. Ideally this project will use geodesy to examine active processes that are related to your thesis or dissertation topic, and will use actual data to address a problem. A write-up of the project will be turned in along with the ppt of the final presentation. **Course Project Presentations** 6 Dec (8:30-9:20)

Course materials (incl. ppt's) and announcements will be available on the web at
http://aconcagua.geol.usu.edu/%7Earlowry/Geod_CD/index.html

Grading:

Reading Presentations & Exercises	30 pts
Semester Project	70 pts
Total	100 pts

Late Assignment Policy:
All assignments are due at the date & time specified; no late assignments will be accepted. If you are not finished, just hand in what you have. Note that, because all assignments are to be submitted to me by email, I will not accept illness as an excuse for late assignments (unless the illness induces a coma).

Differences between the 6000 and 7000 level course:
Requirements for 7690 differ from those of 6690 in that a higher level of mathematical (i.e., theory) development will be expected of projects from 7000 level students. We will discuss specifically what that means as the project develops.

Key university policies that govern classroom behaviors, risk, etc., are found at http://catalog.usu.edu/portfolio_nopop.php?catoid=2&add=1&navoid=96#nav_links and http://catalog.usu.edu/content.php?catoid=4&navoid=546.

USU Academic Policies

- Academic Honesty
- Assumption of Risk
- E-mail Communication Policy
- Equal Opportunity Affirmative Action
- Notification of Rights Under Family Educational Rights and Privacy Act FERPA
- Student Right-to-Know and Campus Security Act
- Additional Policies