# COURSE SYLLABUS

## GEO 6590/7590 Geodesy & Crustal Deformation

## Fall 2021 Lecture: MWF 8:30—9:20 GEOL 310

**Professor:** Tony Lowry (Department of Geology)
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- Email: Tony.Lowry@usu.edu
- Office Hours: MWF 9:30-11:00
- Web: http://aconcagua.geol.usu.edu/%7Earlowry/Geod_CD/index.html

**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 (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 satellite geodesy. Studies of space weather and solid-Earth natural hazards also rely heavily on ground- and space-based geodetic observations. Crustal deformation studies focus particularly 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, earthquake physics & fault dynamics, magmatism & volcanism, and global change studies all trace some of their most important advances over the past several decades to 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 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 solid-Earth physical processes that can be studied with geodesy. Emphasis here will be on processes that are relevant for hazard studies, including fault slip, magma flux/intrusion, viscoelastic rebound, and the Earth's elastic response to surface mass loading.

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!)

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|---|---|
| 17 Sep: | Luttrell et al. (2013) GRL **40**(3) 501-506 |
| 24 Sep: | Herring et al. (2016) JGR **117**(B7) |
| 1 Oct: | Hu et al. (2019) JGR **124**(B7) |
| 15 Oct: | Jacob et al. (2012) Nature **482**(7386) 514-518 |
| 29 Oct: | Chang et al. (2007) Science **318**(5852), 952-956 |
| 5 Nov: | Melgar et al. (2020) GJI 223(2), 862-874 |
| 12 Nov: | Borsa et al. (2014) Science **345**(6204), 1587-1590 |
| 19 Nov: | Lau et al. (2017) Nature **551** 321-326 |
| 3 Dec: | Ito & Simons (2011) Science, **332**(6032), 947-951 |

**(Tentative) Lecture Schedule:**

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|---|---|
| 30 Aug: | Introduction: Examples of Geodesy Applications |
| 1 Sep: | Context: Terrestrial Geodetic Measurement |
| 3 Sep: | Terrestrial Geodetic Measurement (Cont'd) |
| 8 Sep: | Space-based geodesy: Intro to GPS Measurement |
| 10 Sep: | GPS Measurement Cont'd: Signal Structure and Error Sources |
| 13 Sep: | GPS Measurement Cont'd: One Person's Noise |
| 15 Sep: | Plate Motions from GPS Velocities |
| 17 Sep: | Luttrell et al. (2013) |
| 20 Sep: | Plate Motions and GPS Reference Frames |
| 22 Sep: | Gravity: Measurement |
| 24 Sep: | Herring et al. (2016) |
| 27 Sep: | Intro to InSAR |
| 29 Sep: | Intro to InSAR |
| 1 Oct: | Hu et al. (2019) |
| 4 Oct: | Gravity & the Geoid (Introduction) |
| 6 Oct: | Gravity Measurement (Satellite & Terrestrial) |
| 8 Oct: | Satellite Geoid: Time-Variable, Ocean Altimeter |
| 11 Oct: | Gravity Anomalies |
| 13 Oct: | Strain |
| 15 Oct: | Fall Break |

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| 18 Oct: | Jacob et al. (2012) |
| 20 Oct: | Kinematic Velocity Modeling |
| 22 Oct: | Other Physical Models of Velocity (Elastic, Block, Back-Slip) |
| 25 Oct: | Modeling Dislocation Green's functions: Mogi Sources |
| 27 Oct: | Modeling Dislocation Green's Functions: Okada-type Fault Planes |
| 29 Oct: | Chang et al. (2007): Transient Deformation & Magmatic Intrusion |
| 1 Nov: | Slow Fault Slip, Back-Slip, and Seismic Hazard |
| 3 Nov: | Slow Slip: More Observations |
| 5 Nov: | Melgar et al. (2020) |
| 8 Nov: | Earth's Elastic Load Response |
| 10 Nov: | Earth's Elastic Load Response |
| 12 Nov: | Borsa et al. (2014) |
| 15 Nov: | Earth tides; Viscoelastic (Post-Glacial or Other) Rebound |
| 17 Nov: | Glacial Isostatic Adjustment |
| 19 Nov: | Lau et al. (2017) |
| 22 Nov: | Glacial Isostatic Adjustment |
| (Thanksgiving Break Nov 24-26!) | |
| 29 Nov: | Special Topics |
| 1 Dec: | Special Topics |
| 3 Dec: | Ito & Simons |
| 6 Dec: | Special Topics |
| 8 Dec: | Special Topics |

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, or your interests outside of thesis work, and will use actual data to address a problem. A write-up of the project will be turned in along with the final presentation file. **Course Project Presentations** 10 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:**

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|---|---|
| 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.