Syllabus and Course Description
Geophysical Geodesy Fall 2013
GPH 411/611

Course Location: LME 422
Course Time: Tuesday & Thursday 12:00 - 1:15
Units: 3

Instructor Name: Bill Hammond
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Course Description:
This course develops the basic concepts and practice of geophysical geodesy, with an emphasis on the measurement and modeling of deformations of the solid Earth using precise space-based methods such as GPS and InSAR. Topics include the earthquake cycle, tectonic plate boundary deformation, volcanoes, subsidence, etc. The curriculum will emphasize the relationships between data and models, recent seismic events, and provide an overview of new geodetic facilities such as the EarthScope Plate Boundary Observatory. The course is appropriate for graduate students and upper division undergraduates, and has in recent years been a catalyst for incorporating geodesy into Masters and Ph.D. theses.

Course Prerequisites: GPH 333 and PHS 301 (or permission from instructor)

Required texts, course materials:
No required text or materials

Course Objectives and/or learning outcomes:
Students will acquire knowledge of modern space geodetic technologies (e.g. GPS and InSAR), their precision, capabilities and limitations. They will develop skills in building quantitative computer models that explain geodetic data in terms of solid Earth processes.

Description of Assignments: (exams, quizzes, projects, papers)
Readings with group discussions
Problems sets
1 Mid-term
Project involving computer programming/data analysis
Graduate students do more sophisticated project and give an oral presentation.

Grading Criteria:
Participation - Includes attendance, contribution to class discussions (15%/15%)
Problem sets - Graded according to completeness, neatness, correctness (35%/20%)
Mid-term - Graded (25%/15%)
Projects - Graded on completeness, neatness and quality (25%/30%)
Presentations - Graded on preparation, clarity, structure diction, content (0%/20%)
(undergrad/grad %)

Assignments handed in late will be accepted at reduced value towards grade.
Additional Requirements for 611 credit:
Students who take this course at the graduate level will be required to do a more sophisticated numerical analysis or modeling project and present the outcome of this project orally to the class at the end of the term.

Academic Dishonesty Policy:
Students are expected to adhere to the ethical code as described in the UNR Student Handbook. This code specifies that with enrollment, an individual commits to the principles embodied in the code. Academic dishonesty in any form is unacceptable. In the event of an academic dishonesty issue, the procedures for addressing the issue are outlined in the University’s “Academic Dishonesty Procedures”, which can be obtained from the Director of Student Judicial Affairs in the Jones Visitor Center.

Students With Disabilities:
Students with disabilities or who require special accommodations should notify the instructor at the beginning of the course so that suitable arrangements may be made.

Statement on Audio and Video Recording:
Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may be given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Academic Success Services:
Your student fees cover usage of the Math Center (784-4433 or www.unr.edu/mathcenter/), Tutoring Center (784-6801 or www.unr.edu/tutoring/), and University Writing Center (784-6030 or http://www.unr.edu/writing_center/). These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.

Course Calendar/Topics Outline:

I. THEORETICAL BASICS & TOOLKITS

week 1. Introduction to the Class and Geodetic Lexicon
   Class Goals and Logistics
   Pillars of geodesy - what we will and won't cover in this class
   History of geodesy
   Modern geodetic technologies
   Earth’s gravity field and geoid
   Datums
   latitude, longitude
   What is height?

   Problem set #1 - getting started with MatLab
week 2. Reference Systems, Frames and Transformations
- Reference frame basics (Earth Centered, Earth Fixed, CM, CE, CF, etc.)
- The International Terrestrial Reference Frame vs. North America Reference Frames
- The Western US Velocity field, basic properties.
- Helmert 7-parameter transformations: Rotation, Translation, Scale
- Euler Rotations: A plate moving on a sphere
- Coordinate Transformations: X,Y,Z to N,E,U
- Uncertainty and Covariance
- Models and Data
- Solving for the slope of a line using linear inverse theory

Problem set #2 - Solve for rates from GPS time series

week 3. Fundamentals of Deformation: Strain and Strain Rate
- Velocity gradients
- Strain tensors, 2 and 3 dimensions
- Rotation versus strain
- Invariants
- Estimating strain or strain rate
- Continuum models: Strain Rate Maps
- Plane strain vs. non-plane strain

Problem sets #3 - solve for strain rates from velocity fields

week 4. Fundamentals of Rheology, Stress, Elasticity, Viscosity
- Shear and bulk moduli
- Stress vs. Strain
- Other rheologies, e.g. viscoelasticity
- Power law rheology
- Laboratory experiments
- Simple analog models
- World Stress Map

Problem set #4 - Project proposal due to Bill

week 5. Interferometric Synthetic Aperture Radar (InSAR)
- What is InSAR?
- How does InSAR work?
- Strengths, Weaknesses
- Earthquakes (e.g. Wells, NV), Subsidence (e.g. Las Vegas, LA Basin)
- InSAR Time series analysis, SBAS
- GPS and InSAR
- Sierra Nevada uplift

II. CURRENT TOPICS, TECTONICS AND THE EARTHQUAKE CYCLE

week 6. Plate Motions
Plate tectonics, rigidity of plates  
Description of motion, Euler poles  
Comparison of geodetic data to geologic data: NUVEL-1

*Problem set #5: Solve for rotation parameters*

week 7. Plate Boundary Zones  
Distributed continental deformation  
Continuum vs. block representations  
Stress in the lithosphere, boundary vs. gravitational stress  
Basal tractions  
Mantle flow  
Vertical motions

*Problem set #6: Solve for rotation and strain rate parameters*

week 8. The EarthScope Plate Boundary Observatory and the Nevada Geodetic Laboratory  
Online tour of the Facilities  
Instrumentation  
Data products, Access  
The Mobile Array of GPS for Nevada Transtension: MAGNET  
Western US and Basin and Range tectonic deformation

*Problem set #7: Solve for strain rate parameters from GPS velocities*

week 9. The Earthquake Cycle – Interseismic Deformation  
Observations, Western U.S. perspective  
Fault models  
Savage equation  
The San Andreas fault  
Fault Creep

*Problem set #8: Solve for slip rate on a fault*

week 10. The Earthquake Cycle – Coseismic Deformation  
What happens during an Earthquake?  
The Earthquake as seen by Seismology vs. Geodesy  
Using data to infer the properties of an earthquake model  
Okada functions  
Geodetic case studies:  
    The 1906 San Francisco Earthquake  
    The February 2008 Wells NV earthquake  
    2008 Mogul Swarm  
The coming big ones (Cascadia, Southern California, etc.)  
Periodic, Time predictable and slip predictable models.  
Episodic Tremor and Slip in Cascadia and elsewhere

*Problem set #9: Earthquake deformation forward models*

week 11. The Earthquake Cycle - Post-seismic deformation  
Observations and case studies
Transient vs. secular deformation
Afterslip
Viscoelastic postseismic relaxation
Models
Time series viewpoint

week 12. Volcanic and Magmatic Geodesy
Case studies from InSAR and GPS
Three Sisters, OR
Long Valley, CA
Slide Mountain, NV
Afar Rift

week 13. Vertical motions
Signals observed
Subsidence
Mountain Uplift
Hydrological response
Poroelastic deformation
Glacial Isostatic Adjustment
Fennoscandia and North America

week 14.
Guest Lectures
What's the Professor been up to?

week 15. available for catchup

week 16. Fall AGU

Finals week: Class Presentations