CERI 8211 Introduction to Global Geophysics

SPRING 2024

Instructor: Eunseo Choi

Time and Location: MWF, 9:10 - 10:05 am, CERI House 3

Contact: echoi2@memphis.edu, MS Teams: CERI8211001.2024S

Course website: `https://echoi.github.io/course/introgeophysics/` for lecture notes distribution; Canvas for grades and homework submission.

Grades

Quiz (30 %), homework (40 %), mini-lectures and class participation (15 %) and term project (15 %).

Office Hours

After class or by appointment.

Course Objectives

After taking this course, students will have acquired knowledge on

- important physical characteristics of the planet Earth and how they were discovered and
- the physical state of the Earth's interior that can be inferred from the observed physical properties.

A term project will provide students with training in

- scientific paper writing and
- oral scientific communication.

Textbooks and References

- No required textbook.
- Reference books
  - Fowler, C. M. R. (2005). *The Solid Earth: An Introduction to Global Geophysics*. Cambridge University Press, New York, 2nd edition
  - Lowrie, W. and Fichtner, A. (2020). *Fundamentals of geophysics*. Cambridge University Press, Cambridge, United Kingdom; New York, 3rd edition.
  - Lowrie, W. (2007). *Fundamentals of Geophysics*. Cambridge University Press, New York, New York, 2nd edition
- Links to many other online resources will be added to the course web page or given in lecture notes.

Quiz

- 3 quizzes in total
- taken after two topics are finished
- non-accumulative
- closed-book and in-class

Homework

- posted after each topic
- can require using a computer
- submitted in person in the beginning of a class; or electronically to a designated dropbox on Canvas (e.g., scripts for plotting or computation).

Do not copy and paste anyone else's entire code! If codes are copied from a public resource, it should be clearly marked and should not take up a substantial portion of an assignment.

Mini-lectures

- Intention: Learn selected topics through peer-teaching.
- Preparation: A student
  1. studies an assigned topic thoroughly by reading main reference books.
  2. designs an in-class lecture to help classmates understand the topic.
- Format
  - 15-20 min. per person
  - Students choose teaching style and materials that best serve their lecture topics: e.g., a combination of Powerpoint slides, handouts, chalkboard, physical demo, YouTube video, etc.
- Evaluation: Both presenter and audience will be evaluated.
  - Presenter: How well they help the audience understand a topic.
    - This rubric will be used.
    - Each presenter is responsible for getting a lecture plan approved by the instructor.
  - Audience: How actively they participate in the lecture by asking questions or making comments.
- Quiz
  - Presenters must include one or two review questions in the presentation materials.
  - After all the lectures on a theme are given, those review questions will be asked in the next quiz.
  - A presenter can review questions or re-emphasize relevant parts of the lecture. However, the answers themselves are not to be distributed with the lecture materials.

Term Projects

Students carry out a small research project, write up results, and present them Through this project, students will get familiar with

- resources available for finding references on a subject
- a common structure of scientific papers
- modern word processing and reference management tools
- presentation skills

Types of a project

- *Literature survey*. Students read up to 10 original references, usually research or review papers, on a selected topic. One can refer to encyclopedia, wikipedia, on- and offline lecture materials etc to build background knowledge on the topic. However, they are not counted as original references. Examples topics include
  - When and how did the Earth's plate tectonics emerge?
  - How does subduction initiate?
  - How did plate tectonics influence the Earth's climate and the appearance of life?
  - Geology and geophysics of other rocky planets like Venus or Mars
  - Why do natural intraplate earthquakes occur?
  - What do mantle plumes really look like?
  - How do surface processes interact with tectonics?
- *In-depth study*. Students study an advanced physical or mathematical theory that is not covered in the course and demonstrate thorough understanding; or learn a computer code and present applications that are non-trivial and relevant to global geophysics. Example topics include
  - Overview of spherical harmonics and geophysical applications
  - Mechanics of rigid body and non-trivial examples
  - Mantle convection code with theoretical background and demo models
  - Seismic wave propagation code with theoretical background and demo models
  - Global relative sea level change calculations due to glacial isostatic adjustment

Timeline

1. By Friday, February 2nd, a student writes a 1-page project proposal and get it approved by the instructor. The proposal should include why the selected topic is interesting or important. It will become the introduction of your written summary.
2. By Friday, February 16th, finish necessary preparations: e.g., getting a reference list approved and collecting references; installing software, etc. Note that once a work plan including a reading list is approved, it should not be arbitrarily modified. Please always consult the instructor.
3. By Friday, March 1st, finish Introduction by expanding the proposal and get it approved.

4. Work on the project for the following 5 or 6 weeks. Reading one or two papers per week is a suggested workload.
5. On April 24th, deliver final products (see below for more details).

Research "products"

- An oral presentation on the last day of class, April 24th, 2024, in the format of 20-minute conference talk.
- A written summary not exceeding 15 pages. The page limit includes only figures and tables, not a reference list: A summary can have 15 pages of main texts plus a 10 page-long reference list.
  - Presentation materials themselves are not considered as a written summary. The summary should be submitted on the day of in-class presentations.

Evaluation will be based on the final products but feedback will be provided at each of the 4 steps laid out in Timeline.

- Oral presentations must
  - follow the style guides in Unit 4: Giving Oral Presentations, *English Communication for Scientists* on Scitable by Nature Education (see Online Resources below).
  - must be shared with everyone in class including the instructor.
  - include one or two review questions at the end. The final quiz will include those questions.
- Written summaries must
  - be prepared on an online collaborative platform: e.g., MS Office365 Word, Google Docs, overleaf.com, latex source files on github.com
  - follow the suggestions given in English Communication for Scientists on Scitable by Nature Education, Unit 2: Writing Scientific Papers as closely as possible.
  - **NOT commit plagiarism**. Sentences from cited references must be either quoted or rephrased. Copying materials word-for-word into your summary constitutes plagiarism even if you cite the source properly. Refer to Graduate Student Handbook for more information.

Preparing a written summary

- Use available resources for finding references
  - The University library
  - Inter-library loan
  - Web-based databases by academic societies/organizations and publishers
- Your summary must be shared on one of the following online collaborative platforms that can track changes:
  - MS Office Word Online
  - Google Docs
  - overleaf.com for LaTeX

- Citations and reference list must be managed by a reference manager:
  - Zotero (a tip to use Zotero with another research tool)
  - Mendeley
  - EndNote
- A written summary must have abstract, introduction, multiple sections constituting the main body and summary
- The main body should be organized by topics across multiple references. It is NOT acceptable to have as many sections as references you read, each being a summary of a single reference.
- An important criterion for grading is the percentage of paragraphs with an easily identifiable topic sentence.
- Plagiarism must be avoided.
  - Take it seriously. It recently cost a Harvard's president her job! Excuses will be accepted very rarely.
  - Accidental plagiarism: There is no such thing.
  - Forms of plagiarism that might have been permitted in other cultures will not be tolerated in the US academia.
  - Sentences from cited references must be either quoted or significantly rephrased.
  - You should enclose materials copied word-for-word into your summary in quotation marks AND cite a reference.
  - The same principle is applied to assignments involving coding: Do not copy and paste anyone else's entire code.
  - If codes are copied from a public or open resource, it should be clearly marked and should not take up a substantial portion of an assignment.

Preparing an oral presentation

- graded based on this rubric.
- An oral presentation of a literature survey must follow the style guides in *Unit 4: Giving Oral Presentations, English Communication for Scientists by Nature Education*. See "Online Resources" below.
- If the style is not followed without prior approval from the instructor, you will be asked to stop presenting immediately and leave the classroom.
- Presentation materials must be shared with the whole class.
- As in a mini-lecture, two review questions should be included. The final quiz will include those questions
- Answers to review questions must not be distributed with the presentation materials.

Online Resources

Guides to good oral presentations

- Giving scientific talks
- Unit 4 in English Communication for Scientists by Nature Education
- Science Communication: Communicating Trustworthy Information in the Digital World on Coursera

Online references for writing skills

- Nature Education English Communication for Scientists
- Writing a Journal Manuscript
- Ten simple rules for better figures: `https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1003833`
- Why Most People's Charts & Graphs Look Like Crap: `https://blog.hubspot.com/marketing/data-visualization-mistakes`
- Using narratives and storytelling to communicate science with non-expert audiences: `http://www.pnas.org/content/111/Supplement_4/13614.full`
- 11 steps to structuring a science paper editors will take seriously

Jupyter notebooks

Jupyter notebook is a web interface to the Python programming language and an open-source alternative to Matlab. It has become a highly popular research and educational tool in science and engineering. A student in science should still learn Matlab; but it is becoming equally important to get familiar with Jupyter and Python.

- Google Colaboratory: Preconfigured and up-to-date. Provides tutorials. Needs internet access and a Google account.
- Introduction to python for computational science and engineering
- Tips, tricks and useful extensions
- A gallery of interesting Jupyter Notebooks.
- Beginner's guide to matplotlib: A Python plotting package with Matlab-like interfaces.

Course Outline and Tentative Schedule

- Course introduction
- Gravity and the figure of the Earth. Lecture Sec. 2.1, 2.2 of Lowrie (2007).
- Normal Gravity and Geoid. Sec. 2.4 of Lowrie (2007).
- Gravity anomaly. Sec. 2.5.1-2.5.4 and 2.6.4 of Lowrie (2007).

- Gravity anomaly over major tectonic structures.
- Earth's age and various age-dating techniques. Sec. 4.1.2 of Lowrie (2007).
- Basics of radioactive isotope age dating, mass spectrometer.
- Age dating methods: U-Pb/Pb-Pb, Rb/St, Sm/Nd, K/Ar, fission-track
- Mini-lectures
- Review of key points in age dating methods. The oldest rocks on the Earth.
- Quiz 1/3.
- Physics of magnetism. Sec. 5.2.1-5.2.6 of Lowrie.
- Rock magnetism. Sec. 5.3.1-5.3.4 and 5.3.6 of Lowrie (2007).
- Geomagnetism. Sec. 5.4.1-5.4.6 of Lowrie.
- Plate tectonics. Sec. 3.2 of Fowler (2005).
- Plate boundary kinematics on the flat and spherical Earth. Sec. 2.1-2.3 of Fowler (2005).
- Quiz 2/3.
- Thermodynamic principles and Heat conduction.
- Internal heat sources and global heat flow: Geotherm and radioactive heat sources. Sec. 4.2.3 and 4.2.5 of Lowrie
- Internal heat sources and global heat flow: Global heat flow
- Internal heat sources and global heat flow: Convection.
- Rheology
- Basic rheology, brittle strength, strength envelope
- Isostasy.
- Estimating mantle viscosity using glacial isostatic adjustment.
- Term project presentations
- Quiz 3/3