Master of Science in Sustainability Science

SUSC PS5030 Observing and Understanding Sea Level Change
3 credits

Instructor: James L. Davis, Lamont Research Professor in the Lamont-Doherty Earth Observatory of Columbia University, jdavis@ldeo.columbia.edu, (845) 365-8425

Office Hours: Zoom by appointment.

Response Policy: Instructor is available for discussions on e-mail or Zoom, with response within 24 weekday hours.

Prerequisites: SUCS 5060 (Statistics, Data Analysis, and Coding for Sustainability Science) or equivalent experience in Python coding is required.

Course Overview

This course provides an overview of the science related to observing and understanding sea-level change, which has an important place in the Sustainability Science Masters curriculum through its profound impact on the sustainability of coastal cities and ecosystems. In modern research, sea-level rise is viewed as a complex response of the Earth “system of systems” to climate change. Measuring ongoing sea-level change is challenging due to the great natural variability of sea level on short time scales caused by tides, weather, and ocean currents. Interpreting measurements so that one can assess (and mitigate against) potential economic and societal impacts of sea-level rise is crucial but can be complicated, since so many Earth-system processes play a role. Some of these processes are related and others are unrelated to climate change; some of the latter are natural and others are of anthropogenic origin. Students enrolled in this course will through lectures and class discussions address the following topics related to the underlying observational basis for sea-level rise:

1. Definitions and scientific language describing sea-level change.
2. Survey of satellite, airborne, ground-based, and in situ observations relevant to sea-level change.
3. Interpretation of observations in terms of processes within and interactions among Earth systems (cryosphere, ocean, atmosphere, and solid Earth).
4. Sea-level change budgets.
5. Using observations of sea-level change to distinguish between anthropogenic and natural contributions.
6. Contrast between global mean sea-level change and local sea-level change.
7. Major community-wide efforts to synthesize a wide range of observations to make conclusions regarding the impact of climate change on sea level.
8. Introduction to the problem of predicting sea-level change.

An undergraduate background in any field of science or engineering and mathematics through statistical and time-series analysis is required. Basic computer coding skills will be useful.

Learning Objectives

By the end of this course, students will be able to:

L1: Describe the major observational systems on which our understanding of sea-level change is based.

L2: Identify the primary Earth-system processes that contribute to present-day sea-level change and explain how they are used to interpret the observations.

L3: Distinguish between global mean sea-level change and local/regional sea-level change.

L4: Assess scenarios for future sea-level rise at a location based on a sea-level change budget.

L5: Critically evaluate synthesis reports on sea-level rise such as those from the Intergovernmental Panel on Climate Change.
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Readings

There is no required textbook. Some papers will be assigned for readings for individual classes.

Resources

*Columbia University Library*
Columbia’s extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online: http://library.columbia.edu/.

*SPS Academic Resources*
The Office of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: http://sps.columbia.edu/student-life-and-alumni-relations/academic-resources.

*Programming/Data analysis*
Students should have familiarity with and access to software capable of simple trend-fitting and plotting, such as Excel or Matlab. In addition, students should be familiar with standard office software to support their completion of course assignments.

Course Requirements (Assignments)

**Class Participation (10%) (L1, L2, L3, L4, L5)**
Class participation, including oral and written communication, exercises important job and life skills. Assigned readings must be completed before class. Classes will consist of an interactive lecture with time for class discussion and questions. Students will be expected to participate in this discussion by preparing brief summaries of the main points of the readings prior to class.

**Problem Sets (40%) (L1, L2, L3)**
Students will be assigned two problem sets during the term, each of a single problem. Each problem will consist of specific questions that must be addressed by analysis and interpretation of sea-level data sets obtained from public web sites or provided by the instructor, use of on-line tools described in class, and of trend-fitting software.

**Class Presentations (20%) (L1, L2, L3, L4, L5)**
Students will be assigned two problem sets during the term, each of a single problem. Each problem will consist of specific questions that must be addressed by analysis and interpretation of sea-level data sets obtained from public web sites or provided by the instructor, use of on-line tools described in class, and of trend-fitting software.

**Final Paper (30%) (L1, L2, L3, L4, L5)**
Students will write a report (approximately 5 pages in length) focusing on analysis of the sea-level problem for a specific location, selected from a list of locations provided by the instructor. The report will be aimed at an audience consisting of the general public and/or policy makers and other stakeholders who are assumed not to have a technical background. The focus of the paper will be on interpreting the sea-level change budget (provided by the instructor) for this location, providing a summary of data on which the sea-level budget is based, and describing implications of the sea-level budget for future sea-level rise.
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Evaluation/Grading

Participation (10%)

Participation will be graded on a scale of 0–100. Participation includes class attendance, preparation of reading summaries, and active discussion in class. The students are expected to show critical thinking, respectful interactions with classmates and a positive attitude towards learning and freely discussing the topics proposed. The student will be expected to interact during the student class presentations.

Problem Sets (40%)

Two problem sets, each having 20% weight, will be judged on a scale of 0–100. Students will have approximately three weeks to complete each problem set, which consists of analysis and interpretation of sea-level data to address specific questions. Some of the analysis may involve Python coding. Each problem set will be evaluated based on data analysis, interpretation, and clarity and accuracy of the written answers, which must reflect the concepts presented in the course and include plots/figures that back up the answer.

Class Presentation (20%)

Each student will make a class presentation reporting on how the topic of sea-level change was reported in some form of media (print, broadcast, social media, or web site). The student will present the media report, discuss and critically evaluate the content of the report in the context of concepts presented in the course, and answer questions about the report.

Final Paper (30%)

The written final paper will be graded on a scale of 0–100. The final paper will be expected to be ~5 pages, and will be graded based on completeness and following the structure of a scientific paper (i.e., introduction, methods, results, conclusions and citations), interpretation of the sea-level budget, and clarity of the report, which must describe scientific concepts presented in class for a more general (assumed educated) audience.

The final grade will be calculated as described below:

FINAL GRADING SCALE

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
<th>Assignment</th>
<th>% Weight</th>
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</thead>
<tbody>
<tr>
<td>A+</td>
<td>98–100 %</td>
<td>Problem set #1</td>
<td>20</td>
</tr>
<tr>
<td>A</td>
<td>93–97.9 %</td>
<td>Problem set #2</td>
<td>20</td>
</tr>
<tr>
<td>A-</td>
<td>90–92.9 %</td>
<td>Class presentation</td>
<td>20</td>
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<tr>
<td>B+</td>
<td>87–89.9 %</td>
<td>Final paper</td>
<td>30</td>
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<tr>
<td>B</td>
<td>83–86.9 %</td>
<td>Class participation</td>
<td>10</td>
</tr>
<tr>
<td>B-</td>
<td>80–82.9 %</td>
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<tr>
<td>C+</td>
<td>77–79.9 %</td>
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<tr>
<td>C</td>
<td>73–76.9 %</td>
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<tr>
<td>C-</td>
<td>70–72.9 %</td>
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<tr>
<td>D</td>
<td>60–69.9 %</td>
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<tr>
<td>F</td>
<td>59.9% and below</td>
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Course Policies

Participation and Attendance
You will be expected to come to class on time and prepared. It is understandable that new concepts to which you are introduced in the readings may not be fully absorbed; you will not be judged by having an imperfect understanding of the concepts in the readings but you will be expected to ask questions during class discussion. Attendance is thus very important, and more than one absence will affect your grade. Lecture notes will be made available on the day after class.

Late work
Work that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor will be graded down 1/3 of a grade for every day it is late (e.g., from a B+ to a B).

Citation & Submission
All written assignments must cite sources using a consistent citation format and be submitted to the course website (not via email).

Homework
Problem sets and the final paper must be worked on outside of class. Collaboration on homework is encouraged, but students must turn in their own assignments.

School Policies

Copyright Policy
Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or reproduction. One of these specified conditions is that the photocopy or reproduction is not to be “used for any purpose other than private study, scholarship, or research.” If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of “fair use,” that user may be liable for copyright infringement.

Academic Integrity
Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility
Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information...
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gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: [http://health.columbia.edu/services/ods/support](http://health.columbia.edu/services/ods/support).

### Course Schedule/Course Calendar

<table>
<thead>
<tr>
<th>Date/Lecture</th>
<th>Topics and Activities</th>
<th>Readings (to be completed before class)</th>
<th>Assignments</th>
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</thead>
<tbody>
<tr>
<td>1/19 Class 1</td>
<td>Introduction to sea level; Overview of observational evidence for sea-level change</td>
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<tr>
<td>1/26 Class 2</td>
<td>Background: Physics relevant to sea-level change</td>
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<tr>
<td>2/2 Class 3</td>
<td>Measuring relative sea level at one location: tide gauges</td>
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<tr>
<td>2/9 Class 4</td>
<td>Overview of processes impacting sea level change</td>
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<tr>
<td>2/16 Class 5</td>
<td>Satellite radar altimetry</td>
<td>Problem Set #1 (due 2/26)</td>
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<tr>
<td>2/23 Class 6</td>
<td>Ocean density and circulation; in situ measurements of ocean temperature and salinity; atmospheric pressure</td>
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<tr>
<td>3/2 Class 7</td>
<td>Observation of vertical land motion: Postglacial rebound, crustal loading, earthquakes, plate tectonics, and local subsidence</td>
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<tr>
<td>3/9 Class 8</td>
<td>Satellite measurement of ice sheet and ocean mass</td>
<td>Problem Set #2 (due 3/26)</td>
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<tr>
<td>3/16 Spring Break</td>
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<tr>
<td>3/23 Class 9</td>
<td>Sea-level fingerprints; discussion of final paper</td>
<td>Love et al. (2016)</td>
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<tr>
<td>3/30 Class 10</td>
<td>Sea-level change budgets</td>
<td>Final Paper (due 5/1)</td>
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<tr>
<td>4/6 Class 11</td>
<td>Communicating sea-level change</td>
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<tr>
<td>4/13 Class 12</td>
<td>Communicating sea-level change</td>
<td>Class presentations</td>
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<tr>
<td>4/20 Class 13</td>
<td>Sixth IPCC Assessment Report</td>
<td>Selections from IPCC (2022)</td>
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<tr>
<td>5/1</td>
<td></td>
<td>Final paper due</td>
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