Big Geospatial Data

GEOS F658: Fall 2023

Course information

Lectures: Tuesdays and Thursdays 9:00-10:00
Labs: Tuesdays and Thursdays: 10:00-11:30
Place: WRRB 004 or online
Instructor: Simon Zwieback, szwieback@alaska.edu
Office hours: Tuesdays and Thursdays, 11:30–12:30

Course type

Hybrid: In person and/or online synchronous

Course description

Analysis of large geospatial data sets and data-driven modeling for solving geoscientific problems. The class intertwines i) cloud-based processing of big vector and raster data sets from GPS surveys, models and remote sensing, and ii) predictive modeling using data science techniques such as Random Forests.

Pre-requisites

Graduate standing in science or engineering.

Previous experience with geospatial data analysis is helpful but not required. Complementary tutorials will be provided.

Course goals

The overarching goal is for the student to be able to answer applied or research-focused questions in Earth System Science using big geospatial data sets from such diverse sources as social media, remote sensing, ground-based GPS and geological surveys or atmospheric models.

The student will select, implement and critique data processing and data-driven modeling solutions to extract information from a wide range of data sets. The student will gain hands-on experience in cloud-based geospatial data analysis using Google Earth Engine. Data processing skills to be gained encompass visualization, geometric manipulation, filtering and spatiotemporal aggregations. Data-driven modeling skills include performance assessment, robust regression, and ensemble-based methods such as Random Forests.

Applications will be focused on the changing atmosphere, ocean and land surface in the Arctic, with emphasis on Alaska. They include trend analysis of snow conditions, the coupling between sea ice concentration and land surface temperatures, forecasting of weather and vegetation conditions, and changes in permafrost conditions.

Graduate learning outcomes

At the end of the course, the graduate student will be able to

- Load, query and visualize a diverse range of big geospatial data sets in Earth Engine
- Select data processing solutions amenable to processing of big data sets in the cloud
- Develop cloud-based workflows for filtering, combining and summarizing big geospatial data sets
- Design data-driven modeling workflows to solve geoscientific problems
- Draw independent conclusions from data-driven models, accounting for prediction skill, uncertainties, and previous findings

Instructional Methods

Lecture with demonstrations and discussions, labs combined with graded assignments, a take-home quiz and a capstone project.

The lectures will be partly interactive, including group-based data analyses and discussions. The labs will focus on and expand the concepts covered in the lectures, providing deeper exposure through hands-on analyses of actual data sets as well as self-directed scholarly inquiry. Lectures and labs will be online synchronous for distance delivery.

The capstone project for graduate students will be tackled individually or in pairs.

Evaluation

- Homework assignments 1-4: 40%
- Take-home quiz: 15%
- Capstone project (presentation, report, peer review, participation): 45%

Each of the four equally weighted homework (HW) assignments will be focused on one to two of the learning outcomes. The students will gain facility with the concepts introduced in class through hands-on data processing as well as by interpreting and critiquing data sets and workflows. The students are encouraged to work on the assignments in groups, but the write up must be done individually.

The graduate assignments differ fundamentally from the undergraduate assignments. Some tasks overlap with the undergraduate student assignments, primarily those focused on skill development and application of techniques learned in class. However, in addition, each graduate assignment will additionally contain a substantial self-directed component, requiring the students design experiments, conduct independent research-driven inquiry based on raw data, or compile critical reviews of the primary literature.

The take-home quiz is to be completed independently. Spanning all the graduate learning outcomes, the quiz will require the students to design a processing workflow for big geospatial data sets and derive quantitative answers to scientific questions about Arctic sea ice. The students have five days to complete the quiz. Extra office hours and group discussions will be offered during this time period. The graduate quiz differs from the undergraduate quiz in that the graduate students need to formulate research questions, design novel workflows and draw independent conclusions to questions that require a deep understanding of the concepts.

The capstone project is a small research project to be tackled individually or in pairs. Each project will be centered on a well-defined geoscientific problem of the student's (or students') own choosing. The students have to identify a knowledge gap, formulate a specific objective, design and implement a workflow, and appraise the results to arrive at robust conclusions. Guidance will be provided in regular meetings with the instructor. The students will present the findings in class at the end of the term and through a technical report. The students will review each other's reports.

Grading criteria

A (A+: > 97%, A: 93–96%, A-: 90–92%)
B (B+: 87–89%, B: 83–86%, B-: 80–82%)
C (C+: 77–79%, C: 73–76%, C-: 70–72%)
D (C+: 67–79%, C: 63–66%, C-: > 60–62%)
F (< 60%)

Reading

Required textbook: James, Witten, Hastie and Tibshirani, An Introduction to Statistical Learning, Second Edition. The textbook is available for download from the official website. It covers the data-driven modeling modules.

Additional tutorials and lecture notes will be provided by the instructor.

Software and technology requirements

Google Earth Engine can be run from any browser.

Course policy

Students are expected to attend and participate in the lectures.

Late assignments will be accepted with a 5% penalty per day late.

Course calendar

The course comprises six modules:

Module	Geoscientific applications
M1 Earth Engine • Application Programming Interface (API) • Data set types • Visualization • Server-based processing (Map/Reduce)	Glacier extent in Alaska Glacier dynamics in Southeastern Alaska
M2 Data processing • Filtering • Mathematical operations • Geospatial joining • Spatiotemporal aggregation	Interannual changes in snow cover Seasonal snow depth dynamics
M3 Basic predictive modeling • Linear and robust regression • Prediction performance • Interpreting results	Air temperature trends in Alaska Localized weather forecasts (model output statistics)
M4 Take-home quiz	Changes in Arctic sea ice concentration and extent
M5 Advanced predictive modeling • Model complexity trade-offs • Ensemble methods • Predictor importance	Land cover classification Modeling tundra vegetation phenology
M6 Project	Student's choice

Tentative schedule:

Week	Content	Evaluation	Additional information
1	M1: API		
2	M1: visualization		HW1 assigned
3	M2: filtering and math. operations		
4	M2: aggregation	HW1 due	HW2 assigned
5	M3: regression		
6	M3: prediction performance	HW2 due	HW3 assigned
7	M3: interpretation		
8	M4	Take-home quiz	
9	M5: ensemble methods	HW3 due	HW4 assigned
10	M5: predictor importance		
11	M6: project	HW4 due	
12	M6: project		
13	Thanksgiving		
14	M6: project wrap-up		
15	M6: presentations	Presentation, report, peer review	

COVID-19 statement

Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website: https://sites.google.com/alaska.edu/coronavirus/uaf?authuser=0

Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

Student protections statement

UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/.

Disability services statement

I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

ASUAF advocacy statement

The Associated Students of the University of Alaska Fairbanks, the student government of UAF, offers advocacy services to students who feel they are facing issues with staff, faculty, and/or other students specifically if these issues are hindering the ability of the student to succeed in their academics or go about their lives at the university. Students who wish to utilize these services can contact the Student Advocacy Director by visiting the ASUAF office or emailing asuaf.office@alaska.edu.

Student Academic Support

- Speaking Center (907-474-5470, uaf-speakingcenter@alaska.edu, Gruening 507)
- Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor)
- UAF Math Services, uaf-traccloud@alaska.edu, Chapman Building (for math fee paying students only)
- Developmental Math Lab, Gruening 406
- The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, https://www.ctc.uaf.edu/student-services/student-success-center/)

For more information and resources, please see the Academic Advising Resource List (https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf)

Student Resources

- Disability Services (907-474-5655, uaf-disability-services@alaska.edu, Whitaker 208)
- Student Health & Counseling **[6 free counseling sessions]** (907-474-7043, https://www.uaf.edu/chc/appointments.php, Gruening 215)
- Center for Student Rights and Responsibilities (907-474-7317, uaf-studentrights@alaska.edu, Eielson 110)
- Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)

Nondiscrimination statement

The University of Alaska is an affirmative action/equal opportunity employer and educational institution. The University of Alaska does not discriminate on the basis of race, religion, color, national origin, citizenship, age, sex, physical or mental disability, status as a protected veteran, marital status, changes in marital status, pregnancy, childbirth or related medical conditions, parenthood, sexual orientation, gender identity, political affiliation or belief, genetic information, or other legally protected status. The University's commitment to nondiscrimination, including against sex discrimination, applies to students, employees, and applicants for

admission and employment. Contact information, applicable laws, and complaint procedures are included on UA's statement of nondiscrimination available at www.alaska.edu/nondiscrimination. For more information, contact:

UAF Department of Equity and Compliance

1692 Tok Lane, 3rd floor, Constitution Hall, Fairbanks, AK 99775
907-474-7300
uaf-deo@alaska.edu