Term Information

Effective Term	Autumn 2022

General Information

Course Bulletin Listing/Subject Area	Earth Sciences
Fiscal Unit/Academic Org	School of Earth Sciences - D0656
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	4911
Course Title	Earth’s climate: Past and Future
Transcript Abbreviation	Paleoclimate
Course Description	This class will examine Earth’s climate and its natural development as understood from the geologic record spanning the full history of the planet, as well as how the future climate is likely to evolve under ongoing human modifications.Team-taught with a faculty member in Geography.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster

Prerequisites and Exclusions

Prerequisites/Corequisites	EARTHSC/HIST/EEOB 2911 or GEOG 3900/3901H
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings	GEOG 4911

Subject/CIP Code

Subject/CIP Code	40.0601
Subsidy Level	Baccalaureate Course
Intended Rank	Sophomore, Junior, Senior

Requirement/Elective Designation

Sustainability

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Providing a context to distinguish the natural Earth climate system as an integrated system of energy and biogeochemistry that humans can and do alter on different scales. At the end of this course, students should successfully be able to:
- Draw upon fundamental Earth system science concepts to describe how the evolution of earth's climate system relates to the evolution of planet/solar system.
- Draw upon fundamental Earth system science concepts to describe how the evolution of earth's climate system relates to the evolution of planet/solar system.
- Recall the fundamental radiation laws and apply them to the history of Earth's atmosphere to explain relative intensity of the greenhouse effect.
- Quantitatively describe the interactions of the short-term carbon cycle and anthropogenic sources of greenhouse gases.
- Critically evaluate the methods and limitations of using proxies to understand past climates over different spans of time.
- Students will be able to recognize spatial and temporal variations in climate patterns.
- Students will develop practical experience analyzing paleoclimate data time series.

Content Topic List

- Framework of Climate Science: Earth's Climate System Today, Climate Archives, Data, and Models
- Tectonic-Scale Climate Change: CO2 and Long-Term Climate, Plate Tectonics and Long-Term Climate, From Greenhouse to Icehouse: The Last 50 Million Years
- Orbital-Scale Climate Change: Astronomical Control of Solar Radiation, Insolation Control of Monsoons
- Glacial/Deglacial Climate Change
- Historical and Future Climate Change

Sought Concurrence

No

Attachments

- New EARTHSC-GEOG 4911 course rationale.docx: Rationale

  (Cover Letter. Owner: Griffith,Elizabeth M)
- EARTHSC-GEOG 4911 new course syllabus.pdf: Syllabus

  (Syllabus. Owner: Griffith,Elizabeth M)
- GE Sustainability Theme - EARTHSC-GEOG 4911.pdf: Theme application Sustainability

  (Other Supporting Documentation. Owner: Griffith,Elizabeth M)
- CURRICULAR MAP OF COURSES AVAILABLE IN EARTH SCIENCES BS - 4911.docx: Curricular Map of Earth Science BS

  (Other Supporting Documentation. Owner: Griffith,Elizabeth M)

Comments

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Griffith,Elizabeth M	04/01/2022 01:11 PM	Submitted for Approval
Approved	Griffith,Elizabeth M	04/01/2022 01:33 PM	Unit Approval
Pending Approval	Vankeerbergen,Bernadette Chantal	04/01/2022 01:33 PM	College Approval

SYLLABUS
GEOG/EARTHSC 4911

Earth's climate: Past and Future
Spring 2023 –Course # 4 911

COURSE OVERVIEW

Course information

- Class lecture periods: Tuesday, Thursday, [time].
- Credit hours: 3
- Prerequisites: either EARTHSC/HIST/EEOB 2911 or GEOG 3900/3901H
- Mode of delivery: in person

Instructors

Instructors:

Dr. Bryan G. Mark (address as Professor Mark)

- Email address: mark.9@osu.edu
- Phone number: 614-247-6180
- Office hours: T/R 11 a.m. -12 p.m. on zoom or by appointment

Dr. Matthew R. Saltzman

- Email address: saltzman.11@osu.edu
- Phone number: 614-292-0481
- Office hours: T/R 10 a.m. -11 a.m. on zoom or by appointment

GE Category Description & Goals

This class will examine Earth's climate and its natural development as understood from the geologic record spanning the full history of the planet, as well as how the future climate is likely to evolve under ongoing human modifications.

New **GE Theme Goals & ELOs**

This course may fulfill the following GE Theme:

Sustainability: GE Goal and Expected Learning Outcomes for Sustainability Theme courses:

GOALS: Successful Students will (1) analyze sustainability at a more advanced and in-depth level than in the foundations; (2) integrate approaches to sustainability by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or work they have done in previous classes and that they anticipate doing in the future; and (3) (specific to *Sustainability Theme*) analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.

EXPECTED LEARNING OUTCOMES: Successful students are able to: (1.1) engage in critical and logical thinking about sustainability; (1.2) engage in advanced, in-depth, scholarly exploration of sustainability; (2.1) Identify, describe and synthesize approaches or experiences as they apply to sustainability; (2.2) Demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts; (3.1) (specific to *Sustainability Theme*) describe elements of the fundamental dependence of humans on Earth and environmental systems and on the resilience of these systems; (3.2) describe, analyze and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, currently, and in the future, and (3.3) devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values.

This course fulfills the learning outcomes for the Sustainability Theme by:

Providing a context to distinguish the natural Earth climate system as an integrated system of energy and biogeochemistry that humans can and do alter on different scales. At the end of this course, students should successfully be able to:

- Draw upon fundamental Earth system science concepts to describe how the evolution of earth's climate system relates to the evolution of planet/solar system. *To address ELO 3.1 students will develop an advanced understanding of how chemical elements*

like carbon originate and are distributed throughout our planetary system, giving perspective on how they are essential for sustaining life, and are impacted by human activity.

- Apply the scientific method to evaluate how plate tectonics influences the long-term carbon cycle. *To address ELO 3.2 students will learn that volcanic activity emits carbon dioxide at a rate that is more than a factor of 10 less than humans, and therefore only human activity can explain the growth of carbon dioxide in Earth's atmosphere in the past century.*
- Recall the fundamental radiation laws and apply them to the history of Earth's atmosphere to explain relative intensity of the greenhouse effect. *By connecting the composition of Earth's atmosphere to radiative balance, students will conceptually link fundamental physics to the resilience of the Earth system, as moderated by humans. Emissions of greenhouse gases generated through human activity cause more energy to be retained, impacting sustainability now and into the future; technology could be applied to cool by radiation modification or carbon dioxide sequestration (ELOs 3.1, 3.2)*.
- Quantitatively describe the interactions of the short-term carbon cycle and anthropogenic sources of greenhouse gases.
- Critically evaluate the methods and limitations of using proxies to understand past climates over different spans of time.
- Students will be able to recognize spatial and temporal variations in climate patterns
- Students will develop practical experience analyzing paleoclimate data time series. *To address ELO 3.3 students will devise informed and meaningful responses to problems and arguments in the area of sustainability by visually examining the carbon dioxide levels on Earth that occurred naturally in the past 800,000 years, which clearly delineates a period of perturbed and unabated increase in CO2 that can be contrasted with the natural variability which was far less than current levels.*

HOW THIS COURSE WORKS

Class Format: This course will be delivered ***in-person***, with all course materials accessible from OSU's **Carmen Canvas** interface.

Credit hours and work expectations: This is a **3-credit-hour course**. According to Ohio State policy, students should expect around 3 hours per week of time spent on direct instruction (instructor content and Carmen activities, for example) in addition to 6 hours of homework (reading and assignment preparation, for example) to receive a passing grade.

Attendance and participation requirements: Student attendance and participation will be tracked by use of TopHat, as well as completion of feedback and entrance/exit surveys. Students are expected therefore to be attentive regularly to the class Carmen page.

- **TopHat: RANDOM DURING LECTURES.** Regular assessment of understanding and participation will be evaluated and recorded via TopHat during lectures. We will count full credit for participating, but award additional extra credit for correct responses.
- **Group activities: PERIODIC.** There will be in-class activities that will require active participation and a single group grade. The final project grade will be modified to reflect individual participation effort, but active involvement is expected from all students.

COURSE MATERIALS

Textbook

We will use a **primary textbook** for the class. Required weekly readings will help organize our inquiry into global climate change AND provide good reference to basic principles. Because students can access used copies in different editions, it is listed as recommended with OSU Bookstore.

1. **Ruddiman, W.F., *Earth's Climate: Past and Future.*** MacMillan.

Other readings, media:

We will introduce other readings from news and scientific journals, as well as mixed media (video, podcasts). These will all be provided as pdfs or URL links via Assignments in Carmen, and linked to the weekly modules. One of the valuable resources in the class will be a repository of articles, web media, and more that will be archived in Carmen.

All other required articles, book sections, web paged, videos or podcasts are directly embedded in modules on Carmen (topics see course schedule).

CARMEN ACCESS

You will need to use BuckeyePass multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you take the following steps:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter a Passcode** and then click the **Text me new codes** button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Download the Duo Mobile application to all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357 (HELP) and IT support staff will work out a solution with you.

GRADING AND FACULTY RESPONSE

How your grade is calculated (% breakdown)

ASSIGNMENT CATEGORY	% POINTS
TopHat (quizzes and participation)	15
Climate connections (2 during semester)	10
Team Projects (abstract and presentation)	25
Midterm exam	25
Final exam	25
Total	**100**

Assignment descriptions:

Top Hat and Quizzes: At least one quiz will be given per lecture, based on material presented in lectures, readings, videos and other online material from the respective module. Note that some material from previous modules may also be on quizzes.

Climate connections (2): Students will be required to find relevant articles published in main-stream news media, and write a 1-page synthesis describing how the story relates to any topic discussed in class, and how paleoclimate approaches, data and/or methods are used. These short essays will include properly cited references to scholarly literature. For example, daily news articles are readily accessible through the New York Times climate portal and serves as a reputable source of news and information https://www.nytimes.com/section/climate. Two submissions are required and can be submitted any time before the last week of lectures. Submission is electronic and uploaded via Carmen.

Team project: The final project will include a group presentation. The groups will be assigned early in the class, and students will be interacting throughout the semester to select a topic and complete a multi-media presentation.

Description of Team Project Assignment

During 4th week, we will split up into groups of 3-4 students. Each group will need to decide on a class-related topic that interests them, on which they will give a 20 minute presentation during the last 2 classes of the semester. Once you decide on something (I would recommend choosing about ½ way through the semester), let us know what it is. The assignment will be to follow the development of thinking on the topic through the literature, describing the evolution of the idea. This will involve making liberal use of ISI or GEOREF searches: each pointade in the presentation needs to be backed up by a peer-reviewed citation. The project includes the following deliverables:

• Topic and science question: 8th week. Science questions need to address a single, specific question related to the course material. Calculations are not required, but literature must be consulted in formulating the question.

• Abstract: 11th week. A paragraph elaborating the science question, and describing the main conclusions needs to be emailed to both instructors. Thus, the conclusions of the project should be mostly finalized by this time.

• Presentations: last week. The science question, analysis of the literature, and conclusions should be clearly presented. Examples related to the question and your answers need to be presented. For the presentation, Powerpoints are encouraged, but only to show figures – no written words are allowed on slides (besides references or figure labels). This helps you learn what you are talking about; otherwise, it's easy to just recite words pulled from a paper. Each group member will need to contribute to equally to the presentation.

Exams: There will be a midterm and a final consisting of multiple choice and short answer essay questions.

Late assignments

Please refer to Carmen for due dates. Generally, modules will be completed by midnight on Monday night before new modules begin on Tuesdays (first class session of each week). Late assignments will be penalized by 10% per day late, and only accepted up to a maximum of 4 days late. If students anticipate having conflicts they are expected to discuss with instructors ahead of time.

Grading scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+

73–76.9: C
70 –72.9: C-
67 –69.9: D+
60 –66.9: D
Below 60: E

Instructor feedback and response time

We provide the following list to give you an idea of our intended availability throughout the course. (Remember that you can call **614-688-HELP** at any time if you have a technical problem.)

- **Grading and feedback:** For regular assignments, you can generally expect feedback within 10 days. Some exercises and papers will take longer to grade.
- **Email:** We will generally reply to emails and Carmen messages within **24 hours on days when class is in session at the university**. Please add "G3900" to the subject in your email to identify yourself; we teach multiple classes.
- **Discussion board:** We will check and reply to messages in the Carmen discussion boards regularly.

OTHER COURSE POLICIES

Academic integrity policy

POLICIES FOR THIS COURSE

- **Quizzes and exams**: You must complete the TopHat quizzes and the exams by yourself, without external help or communication from the internet or other people.
- **Written assignments**: Your written assignments should be your own original work. In formal assignments, you should follow a consistent citation style (e.g. MLA, APA, or AGU) to cite the ideas and words of your research sources. You are encouraged to ask a trusted person to proofread your assignments before you turn them in—but no one else should revise or rewrite your work.
- **Reusing past work**: In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you've explored in previous courses, please discuss the situation with us.
- **Falsifying research or results**: All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.
- **Collaboration and informal peer-review**: The course includes opportunities for formal collaboration with your classmates. While study groups and peer-review of major written

projects is encouraged, remember that comparing answers on a quiz or assignment is not permitted. If you're unsure about a particular situation, please feel free just to ask ahead of time.

- **Group projects**: This course includes group projects, which can be stressful for students when it comes to dividing work, taking credit, and receiving grades and feedback. We have attempted to make the guidelines for group work as clear as possible for each activity and assignment, but please let us know if you have any questions.

OHIO STATE'S ACADEMIC INTEGRITY POLICY

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university's *Code of Student Conduct*, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the university's *Code of Student Conduct* and this syllabus may constitute "Academic Misconduct."

The Ohio State University's *Code of Student Conduct* (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the university or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the university's *Code of Student Conduct* is never considered an excuse for academic misconduct, so I recommend that you review the *Code of Student Conduct* and, specifically, the sections dealing with academic misconduct.

If we suspect that a student has committed academic misconduct in this course, we are obligated by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university's *Code of Student Conduct* (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact us.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- The Committee on Academic Misconduct web pages (COAM Home)
- *Ten Suggestions for Preserving Academic Integrity (Ten Suggestions)*

- *Eight Cardinal Rules of Academic Integrity* (www.northwestern.edu/uacc/8cards.htm)

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on Title IX

All students and employees at Ohio State have the right to work and learn in an environment free from harassment and discrimination based on sex or gender, and the university can arrange interim measures, provide support resources, and explain investigation options, including referral to confidential resources.

If you or someone you know has been harassed or discriminated against based on your sex or gender, including sexual harassment, sexual assault, relationship violence, stalking, or sexual exploitation, you may find information about your rights and options at titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu. Title IX is part of the Office of Institutional Equity (OIE) at Ohio State, which responds to all bias-motivated incidents of harassment and discrimination, such as race, religion, national origin and disability. For more information on OIE, visit equity.osu.edu or email equity@osu.edu.

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you find yourself feeling isolated, anxious or overwhelmed, please know that there are resources to help: ccs.osu.edu. You can reach an on-call counselor when CCS is closed at (614) 292-5766 and 24 hour emergency help is also available through the 24/7 National Prevention Hotline at 1-(800)-273-TALK or at suicidepreventionlifeline.org. The Ohio State Wellness app is also a great resource available at go.osu.edu/wellnessapp.

COURSE SCHEDULE

See separate document that will be updated regularly on Carmen and labeled with current version date. Class content is subject to change, so students should download most current version. Changes will also be communicated using Announcements on Carmen.

ACCESSIBILITY ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Requesting accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let us know immediately so that we can privately discuss options. To establish reasonable accommodations, we may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. **SLDS contact information:** slds@osu.edu; 614-292-3307; 098 Baker Hall, 113 W. 12th Avenue.

WEEKLY SCHEDULE

Class Topics, Required Readings, and Exercises

*Note: These topics and readings are *subject to change*! Students will be advised of updates to the schedule on Carmen, and should follow the version with most current date.

Wk	Module-Part	Lecture topic	Date	Instructor	Text chapter
1	**Part I** Framework of Climate Science	1. Overview of climate science	T 1/12	Both	R1 (3-18)
		2. Earth's Climate System Today	R 1/14	Bryan	R2 (19-54)
2		3. Climate Archives, Data, and Models (1)	T 1/19	Bryan	R3 (55-68)
		4. Climate Archives, Data, and Models (2)	R 1/21	Matt	R3 (68-80)
3	**Part II** Tectonic-Scale Climate Change	5. CO2 and Long-Term Climate	T 1/26	Matt	R4 (81-96)
		6. Plate Tectonics and Long-Term Climate (1)	R 1/28	Matt	R5 (97-107)
4		7. Plate Tectonics and Long-Term Climate	T 2/02	Matt	R5 (108-120)
		8. Greenhouse climate	R 2/04	Matt	R6 (121-136)
5		9. From Greenhouse to Icehouse: The Last 50 Million Years (1)	T 2/09	Matt	R7 (137-142)
		10. From Greenhouse to Icehouse: The Last 50 Million Years (2)	R 2/11	Matt	R7 (143-155)
6	**Part III** Orbital-Scale Climate Change	11. Astronomical Control of Solar Radiation (1)	T 2/16	Matt	R8 (156-164)
		12. Astronomical Control of Solar Radiation (2)	R 2/18	Matt	R8 (165-176)
7		13. Insolation Control of Monsoons	T 2/23	Bryan	R9 (177-194)
		14. Insolation Control of Ice Sheets	R 2/25	Bryan	R10 (195-214)
8		15. Orbital-Scale Changes in Carbon Dioxide and Methane (1)	T 3/02	Matt	R11 (215-220)
		16. Orbital-Scale Changes in Carbon Dioxide and Methane (2)	R 3/04	Matt	R11 (221-232)
9		17. Orbital-Scale Interactions, Feedbacks, and Unsolved Mysteries	T 3/09	Bryan	R12 (233-250)
		MIDTERM EXAM	R 3/11		
10	**SPRING BREAK**		T 3/16		
			R 3/18		
11	**Part IV** Glacial/Deglacial Climate Change	19. The Last Glacial Maximum	T 3/23	Bryan	R13 (251-272)
		20. Climate During and Since the Last Deglaciation	R 3/25	Bryan	R14 (273-294)
12		21. Millennial Oscillations of Climate	T 3/30	Bryan	R15 (295-314)
	Part V Historical and Future Climate Change	22. Humans and Preindustrial Climate	R 4/01	Bryan	R16 (315-334)
13		23. Climate Changes During the Last 1,000 Years	T 4/06	Bryan	R17 (335-356)
		24. Climatic Changes Since 1850	R 4/08	Matt	R18 (357-374)
14		25. Causes of Warming over the Last 125 Years	T 4/13	Matt	R19 (375-392)
		26. Future Climatic Change	R 4/15	Bryan	R20 (393-409)
15		Group presentations	T 4/20		
			R 4/22		

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New Course Proposal: EARTHSC/GEOG 4911 Earth's Climate: Past and Future

Matthew Saltzman (SES) and **Bryan Mark** (GEOG)

Rationale for a new course

There are currently two GE courses at Ohio State focused entirely on the subject of climate change, EARTHSC/EEOB/HIST 2911 (Climate Change: Mechanisms, Impacts, and Mitigation) and GEOG 3900/3901 (Global Climate Change: Causes and Consequences). These courses teach the subject matter at an introductory level and emphasize breadth in the material. The rationale for a new advanced, team-taught interdisciplinary course in Climate Change is to allow students to pursue in depth the area of climate science, including a more detailed knowledge and understanding of past and future climates. The proposed 4000-level course in 'Earth's Climate: Past and Future' will have a prerequisite of either EARTHSC/EEOB/HIST 2911 or GEOG 3900/3901. This new course will be team-taught by Earth Sciences and Geography, bringing together two departments with a history of collaboration in the areas of climate change and climate science, in part through interactions at the Byrd Polar and Climate Research Center (i.e. the ice core paleoclimatology team comprises Distinguished Geography Professor Ellen Mosley-Thompson in partnership with Distinguished SES Professor Lonnie Thompson). New skills and training will include project-based learning focused on the global effort to keep climate warming to below 2 degrees Celsius.

Course Description

Building on fundamentals of global climate change (covered in course prerequisites, either GEOG 3900 or ES/HIST/EEOB 2911), this class will examine Earth's climate and its natural development as understood from the geologic record spanning the full history of the planet. This requires a deeper and more comprehensive knowledge of the Earth system and the mechanisms that force climate change – its tectonic cycles, the evolution of the sun, ocean and atmosphere, the planetary energy balance and biogeochemical cycles. Only by appreciating the full range of natural variability of Earth's climate can we fully grasp the ways in which human activity now dominates the changes to climate and will continue to do so in response to societal choices in the future. Grappling with the consequences of climate change invokes broader political and economic dimensions related to development and energy conversion technology.
This new course is aimed at advanced undergraduates and will be team taught in Earth Sciences and Geography. The class is open to all majors having completed a prerequisite class in climate change. We will examine the key evidence of climate change and learn directly from climate researchers how they conduct their science. In addition, we will study links between climate and society's energy demands, sources and usage. By the end of the class, students will be more energy literate, and able to critically evaluate divergent facts about climate presented in media sources.

Similar courses to the proposed new course at the 4000- or 5000- level include Soils and Climate Change (ENR 5268), Measurement and Modeling of Climate Change, the Atmospheric Boundary Layer and Ecosystem Fluxes (ENVENG 5218), Weather, Climate and Global warming (GEOG 5900), Climate Change and Human Health (PUBHEHS 5320). We will address a critical gap in paleoclimatology accessible to undergraduates that will allow students to explore in depth the divers and processes of Earth's natural climate history that are the basis for assessing

the relative magnitude of future climates, their relationship to human activity, and their full ecological implications.

Anticipated demand and enrollment: We anticipate initial enrollment to be modest, about 15-20 students per year. Growth will be facilitated with outreach to the relevant populations in both Earth Sciences and Geography, as well as students in related disciplines, including Environmental Engineering, Environmental Science, and EEDS. The Undergraduate Studies Committees in both Earth Sciences and Geography will advertise the course during student visit days and communicate the opportunity to advisors. As the course is aimed at the Sustainability Theme and is also part of a new Certificate we are proposing, we anticipate that this course can be quite popular. Specifically, in our new Certificate this course we are proposing on Earth's Climate will fill an important need for students seeking and advanced course in Climate System Science, which includes a component of understanding the natural Earth system in order to appreciate the human influence on the natural system.

GE THEME COURSES

Overview

Courses that are accepted into the General Education (GE) Themes must meet two sets of Expected Learning Outcomes (ELOs): those common for all GE Themes and one set specific to the content of the Theme. This form begins with the criteria common to all themes and has expandable sections relating to each specific theme.

A course may be accepted into more than one Theme if the ELOs for each theme are met. Courses seeing approval for multiple Themes will complete a submission document for each theme. Courses seeking approval as a 4-credit, Integrative Practices course need to complete a similar submission form for the chosen practice. It may be helpful to consult your Director of Undergraduate Studies or appropriate support staff person as you develop and submit your course.

Please enter text in the boxes to describe how your class will meet the ELOs of the Theme to which it applies. Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

EARTHSC/GEOG 4911

Course subject & number

General Expectations of All Themes

GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations.

Please briefly identify the ways in which this course represents an advanced study of the focal theme. In this context, "advanced" refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities. *(50-500 words)*

Building on fundamentals of global climate change (covered in course prerequisites, either GEOG 3900 or EARTHSC/HIST/EEOB 2911), this class will examine Earth's climate and its natural development as understood from the geologic record spanning the full history of the planet. This requires a deeper and more comprehensive knowledge of the Earth system and the mechanisms that force climate change – its tectonic cycles, the evolution of the sun, ocean and atmosphere, the planetary energy balance and biogeochemical cycles. For example, in module 2 of our syllabus (weeks 3-5) students will learn about the tectonic drivers of natural climate variability going back over 3.5 billion years of Earth history. In a subsequent module 3 (weeks 6-9), students will learn about orbital scale changes in solar radiation and greenhouse gases that drive a higher frequency of climate variability and feedbacks. Only by appreciating the full range of natural variability of Earth's climate can we fully grasp the ways in which human activity now dominates the changes to climate and will continue to do so in response to societal choices in the future. Students will synthesize their understanding of these fundamentals and engage in grappling with the consequences of human induced climate change that invokes broader political and economic dimensions related to development and energy conversion technology.

Requiring students to have completed a prior climate change class as a prerequisite, this course will challenge students to develop advanced understanding of the processes and patterns of climate change throughout Earth's history. Lectures and exercises will draw upon cutting-edge research findings from evolving peer-reviewed literature, as well as the most recent IPCC and National Climate Assessment reports. Students will be required to critically evaluate and synthesize findings from specific studies in the scientific literature beyond the text to substantiate their responses, using proper citation. Students work with real climate data sets and advanced concepts during in-class activities and discussions with break out groups, and exams will involve synthesis to produce essays.

Course subject & number EARTHSC/GEOG 4911

ELO 1.1 Engage in critical and logical thinking about the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. (50-700 words)

In this course, students apply critical thinking by quantifying natural fluxes of carbon through the Earth System and comparing this to human induced fluxes. Human activity, specifically by societal choices for energy conversion, is altering the rates of biogeochemical exchange between natural reservoirs. For example, the largest source of carbon on earth is in the lithosphere, and the extraction and combustion of fossil fuel extracts more carbon at a much faster rate than natural volcanic activity. In this course, students apply critical thinking by quantifying natural fluxes of carbon through the Earth System and comparing this to human induced fluxes. Humans are emitting CO2 at a greater rate than natural fluxes can absorb, resulting in more carbon dioxide in the atmosphere that is not sequestered by natural processes and thus causes the planet to retain more thermal energy, altering climate and having myriad impacts to societal well-being. However, students need to appreciate the magnitude of past carbon fluxes and the evolution of the atmosphere to appreciate the relative impact of human alterations.

Students will be challenged to think critically about climate data in various forms. They will evaluate and intercompare time series of paleoclimate proxy data with measurements to provide quantitative evidence distinguishing human altered climate change from natural. For example, in weeks 11-12 of the syllabus students will do an in class group assignment in which they will compute and intercompare rates of temperature change based on stable isotopes preserved in ice cores spanning the past million years with the historical record of atmospheric temperature measurements over the past century. Students will be asked to calculate the amount of carbon dioxide that could be emitted over the past century by both natural volcanic activity and anthropogenic activity. As these rates differ by an order of magnitude, students can draw conclusions about the impacts of human activity. Students will make use of the Keeling curve of atmospheric carbon dioxide levels from the Mauna Loa Observatory in Hawaii to compare emissions rates (natural and anthropogenic) with the buildup of carbon dioxide in the atmosphere.

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

The class lectures will cover broad themes and concepts related to sustainability, and students will have opportunities to engage at greater depth with scholarly explorations published in peer-review literature. Students will examine the key evidence of climate change and learn directly from climate researchers how they conduct their science. Students will research topics by accessing and reading scientific literature, and properly citing these materials in writing assignments. Also, in an exercise in week 6 of the syllabus, students will quantify changes in solar radiation on Earth's climate over longer periods of time. Specifically, they will calculate the magnitude of variability relating to Earth's orbit around the sun, and compare it to alterations in solar output due to sun spot cycles. The final group project assigned in the 4th week will involve an advanced, in-depth, scholarly exploration of a topic of their choice.

Course subject & number EARTHSC/GEOG 4911

GOAL 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 2.1 Identify, describe, and synthesize approaches or experiences as they apply to the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Students will have to synthesize and apply their knowledge from fundamentals in biology, geography, chemistry, and Earth Science to appreciate how all these elements comprise the Earth's Climate System, and how humans are altering it. For example, balancing basic chemical equations will allow students to appreciate how tectonic uplift and silicate weathering impacts carbon dioxide levels over time. Similarly, the biological functions of photosynthesis and respiration impact seasonal to interannual levels of carbon dioxide, and students will draw upon this understanding to interpret ongoing measurements by monitoring stations.

Climate connections: as indicated in the syllabus students will find current news articles and identify concepts covered in class, and provide a synthesis of how paleoclimate approaches, data and/or methods are relevant. These short essays will include properly cited references to scholarly literature. For example, daily news articles are readily accessible through the New York Times climate portal, and serves as a reputable source of news and information https://www.nytimes.com/section/climate.

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Through the course, students will engage in reflection of what they know and the source of their understanding. First, students will conduct a pre and post surveys. Students will fill in entrance/exit questionnaires based on national standards of climate literacy as vetted by AAAS (https://www.climate.gov/teaching/essential-principles-climate-literacy/essential-principles-climate-literacy). Students will be able to appreciate the scope of expected standards of knowledge at the beginning of class, and reflect how their knowledge level changed after class. Second, we will use Top Hat to ask occasional opinion-based questions throughout the semester, and in some cases, we will track responses to similar questions towards the beginning and end of the course. For example, we will ask how effective a tax on carbon is likely to be, and what social aspects of communities may portend the successes and failures of implementing climate-based policies. Finally, students will be encouraged make specific connections of course content to their lives. They will relate news media of interest to class content in the 'climate connections' assignment.

Course subject & number EARTHSC/GEOG 4911

Specific Expectations of Courses in Sustainability

GOAL 1: Students analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.

1.1 Describe elements of the fundamental dependence of humans on Earth and environmental systems and on the resilience of these systems. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Climate relies fundamentally on biogeochemical cycles that alter the levels of greenhouse gases in the atmosphere. Human activities strongly moderate these biogeochemical processes largely through energy conversion and thus impact the climate by altering the radiative properties of the atmosphere. Students will be expected to demonstrate understanding of how the natural climate system operates, including fundamental drivers and feedbacks, based on critical appreciation of paleoclimate data that document these processes throughout Earth's planetary history. For example, in week 2 the lectures will focus on Earth's radiation budget and how human activity alters greenhouse gas concentrations. We will Top Hat questions to assess mastery of the concepts and understanding of how all life relies on the moderation of Earth's climate through the natural greenhouse effect. With no greenhouse effect the Earth would be frozen. Then, the student's will be challenged with understanding the many ways humans alter these processes, and the implications for both climate and society. This will involve coming to grips with thresholds within these biogeochemical and socio-ecological systems.

Course subject & number EARTHSC/GEOG 4911

1.2 Describe, analyze and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, currently, and in the future. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course activities will enable students to examine the range of time scales over which natural variations in climate occur in order to understand the role of human activity in the context of past changes in climate. For example, in lectures in weeks 11-12 we will focus on how the ice ages occur naturally with a rhythm that is driven ultimately by solar radiation changes but also involves feedbacks with carbon dioxide levels in the ocean-atmosphere system that occur naturally as a function of changing temperature. Human emissions of carbon dioxide have altered the rhythms of the ice ages, and this has implications for how the impacts of climate change will be felt by different communities including those here in Ohio and the Midwest. A student assignment in week 13 will ask for a critique of whether delaying an ice age has been a positive or negative outcome for themselves and the planet depending on the perspective of communities with locations on Earth that may be impacted by ice ages such as Ohio.

1.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Through project-based learning, students will understand the values of various communities affected differently by climate change, as well as those implicated by modern socio-economic systems, and practice developing informed responses to the problems of ongoing and future climate change.
IPCC scenarios describe potential climate futures based on integrated social and physical science tied to levels of greenhouse gas emissions. Students will be challenged to appreciate the implicit societal values associated with these, and them make connections to specific past states of Earth's climate exemplified by the paleoclimate record to interpret and justify proposals to limit future emissions. In articulating arguments, they will be required to use comparative rates of change, constrained by both paleoclimate archives and future climate models output. Specific activities will include a group project requiring creating compelling visualizations connecting values and energy choices with likely future environments and rates of change.

CURRICULAR MAP OF COURSES AVAILABLE IN EARTH SCIENCES B.S.

Course Number	Course Title	PLO A: Read/ evaluate Earth Sci literature	PLO B: Present Earth Sci info	PLO C: Apply Earth Sci data	PLO D: Apply appropriate techniques/ methods	PLO E: Identify Earth Sci problems, develop solutions	PLO F: Apply other sciences	BS program required /elective
Earth Sciences 1100	Planet Earth: How it works	B	B	B	B	B	B	O-prep
Earth Sciences 1105	Geology of the National Parks	B	B	B		B	B	O-prep
Earth Sciences 1108	Gemstones	B	B	B		B	B	O-prep
Earth Sciences 1121	The Dynamic Earth	B	B	B	B	B	B	O-prep
Earth Sciences 1151	Natural Hazards	B	B	B	B	B	B	O-prep
Earth Sciences 2203	Environmental Geoscience	B	B	B		B	B	O-prep
Earth Sciences 2205	The Planets	B	B	B		B	B	O-prep O-PS
Earth Sciences 2206(&S)	Principles of Oceanography	B	B	B		B	B	O-prep O-SS
Earth Sciences 1200	Introductory Earth Science Lab		B	B	B	B	B	O-prep
Earth Sciences 2000	Preparation for Thesis and Careers in the Earth Sciences	B-I	B-I	B-I		B-I		R-GS R-GP R-CWE
Earth Sciences 2122	Climate and Life over Billions of years on Earth	B-I	B-I	B-I	B-I	B-I		O-SS R-GS
Earth Sciences 2155	Energy and Environment	B-I	B-I	B-I	B-I	B-I		O-SS
Earth Sciences 2203	Environmental Geoscience	B-I	B-I	B-I	B-I	B-I		O-SS
Earth Sciences 2204	Exploring Water Issues	B-I	B-I	B-I	B-I	B-I		O-SS
Earth Sciences 2210	Energy, Mineral Resources, and Society	B-I	B-I	B-I	B-I	B-I		O-SS
Earth Sciences 2212	Intro to Earth Materials	B-I	B-I	B-I	B-I	B-I		O-CWE
Earth Sciences 3411	Water Security for the 21st Century	I	I	I	I	I		O-SS

Earth Sciences 2245	Introductory Data Analysis for Earth and Environmental Sciences	B-I	B-I	B-I	B-I	B-I		R-GS R-CWE R-GP
Earth Sciences 4194	Group Studies	I	I	I	I	I	I	
Earth Sciences 4194H	Honors Group Studies	I	I	I	I	I	I	
Earth Sciences 5310	Remote Sensing in the Earth Sciences	A	A	A	A		A	O-GP O-PS O-MS
Earth Sciences 4421	Earth Materials	I	I	I	I	I	I	R-GS O-CWE O-CWE O-MC
Earth Sciences 4423	Introductory Petrology	I	I	I	I	I	I	R-GS O-MC
Earth Sciences 4425	Energy Resources and Sustainability	I	I	I	I	I	I	O-SS
Earth Sciences 4450	Water, Ice, and Energy in the Earth System	I	I	I	I	I	I	R-CWE O-MS O-HG
Earth Sciences 4501	Paleontology	I	I	I	I	I	I	O-MC
Earth Sciences 4502	Stratigraphy and Sedimentation	I	I	I	I	I	I	R-GS O-CWE O-MC
Earth Sciences 4530	Structural Geology	I	I	I	I	I	I	R-GS R-GP
Earth Sciences 4560	Applied Geophysics	I	I	I	I	I	I	R-GP O-PS O-PG
Earth Sciences 4880	Seminar in Geophysics	I	I	I	I	I	I	
Earth Sciences 4911 (This course)	Earth's Climate: Past and Future	I - A	I - A	I - A	I - A	I - A	I - A	O-SS O-CWE
Earth Sciences 4998	Undergraduate Research in Earth Sciences	I - A	I - A	I - A	I - A	I - A	I - A	
Earth Sciences 4998H	Honors Undergraduate Research in Earth Sciences	A	A	A	A	A	A	
Earth Sciences 4999.01	Undergraduate Thesis in Earth Sciences	I - A	I - A	I - A	I - A	I - A	I - A	R-GS R-CWE R-GP
Earth Sciences 4999.01H	Honors Undergraduate Thesis in Earth Sciences	A	A	A	A	A	A	

Earth Sciences 5189.01	Field Geology I	I - A	I - A	I - A	I - A	I - A	I - A	R-GS R-PG O-MC
Earth Sciences 5189.02	Field Geology II	A	A	A	A	A	A	R-GS O-PG
Earth Sciences 5191	Internship in the Earth Sciences	I - A	I - A	I - A	I - A	I - A	I - A	
Earth Sciences 5191.01	Museum Internship	A	A	A	A	A	A	
Earth Sciences 5193.xx	Individual Studies	I - A	I - A	I - A	I - A	I - A	I - A	
Earth Sciences 5194	Group Studies	I - A	I - A	I - A	I - A	I - A	I - A	
Earth Sciences 5203	Geo-environment and Human Health	A	A	A	A	A	A	O-CWE O-HG
Earth Sciences 5205	Planetary Science	A	A	A	A	A	A	R-PS
Earth Sciences 5206	Advanced Oceanography	A	A	A	A	A	A	R-MS O-CWE
Earth Sciences 5242	Natural History of The Bahamas	I-A	I-A	I-A	I-A	I-A	I-A	O-MS O-CWE
Earth Sciences 5268	Soils and Climate Change	A	A	A	A	A	A	O-CWE O-HG
Earth Sciences 5501	Museum Databases	A	A	A	A	A	A	O-MC
Earth Sciences 5550	Geomorphology	I-A	I-A	I-A	I-A	I-A	I-A	O-PS O-HG
Earth Sciences 5600	Siliciclastic Depositional Systems	A	A	A	A	A	A	
Earth Sciences 5601.01	Sedimentary Petrology: Sandstones	A	A	A	A	A	A	
Earth Sciences 5601.02	Sedimentary Petrology: Carbonate Rocks and Shales	A	A	A	A	A	A	
Earth Sciences 5602.01	Carbonate Depositional Systems I	A	A	A	A	A	A	
Earth Sciences 5602.02	Carbonate Depositional Systems II	A	A	A	A	A	A	O-MS
Earth Sciences 5603	Stratigraphy	A	A	A	A	A	A	
Earth Sciences 5604	Sequence Stratigraphy	A	A	A	A	A	A	
Earth Sciences 5605	Paleoceano graphy	A	A	A	A	A	A	

Earth Sciences 5613	Micropaleon tology	A	A	A	A	A	A	
Earth Sciences 5614	Paleobiology	A	A	A	A	A	A	
Earth Sciences 5615	Paleoecology	A	A	A	A	A	A	
Earth Sciences 5617	Petrology of Earth and Planets	A	A	A	A	A	A	
Earth Sciences 5618	Advanced Historical Geology	A	A	A	A	A	A	
Earth Sciences 5621	Introduction to Geochemistry	A	A	A	A	A	A	O-CWE O-HG
Earth Sciences 5622	Stable Isotope Biogeo chemistry	A	A	A	A	A	A	O-MS
Earth Sciences 5625	Igneous Petrology	A	A	A	A	A	A	
Earth Sciences 5627	Global Biogeochemical Cycles	A	A	A	A	A	A	
Earth Sciences 5628	Environmental Isotope Geochemistry	A	A	A	A	A	A	
Earth Sciences 5629	Principles of Petrology	A	A	A	A	A	A	
Earth Sciences 5636	Advanced Topics in Mineralogy and Crystallography	A	A	A	A	A	A	
Earth Sciences 5641	Geostatistics	A	A	A	A	A	A	O-GP
Earth Sciences 5642	Geomathe matical Analysis	A	A	A	A	A	A	
Earth Sciences 5644	Tectonic Evolution of Continents	A	A	A	A	A	A	
Earth Sciences 5645	Advanced Structural Geology	A	A	A	A	A	A	
Earth Sciences 5646	Geodynamics	A	A	A	A	A	A	O-GP O-PS
Earth Sciences 5650	Glaciology	A	A	A	A	A	A	O-CWE
Earth Sciences 5651	Hydrogeology	A	A	A	A	A	A	O-CWE O-GP R-HG
Earth Sciences 5655	Land Surface Hydrology	A	A	A	A	A	A	O-CWE O-HG
Earth Sciences 5660	Geology of Metallic Deposits	A	A	A	A	A	A	
Earth Sciences 5661	Petroleum Geology	A	A	A	A	A	A	O-PG

Earth Sciences 5663	Global Change and Sustainability in the Earth System	A	A	A	A	A	A	O-SS
Earth Sciences 5670	General and Economic Geology of Selected Areas	A	A	A	A	A	A	
Earth Sciences 5676	Elemental Chemical Analysis using Inductively Coupled Plasma Optical Emission and Mass Spectrometry	A	A	A	A	A	A	
Earth Sciences 5680	Deep Earth Geophysics	A	A	A	A	A	A	O-GP O-PS
Earth Sciences 5687	Borehole Geophysics	A	A	A	A	A	A	O-GP O-PG
Earth Sciences 5703	Principles of Biostratigraphy	A	A	A	A	A	A	
Earth Sciences 5713	Taxonomy and Phylogeny in the Fossil Record	A	A	A	A	A	A	
Earth Sciences 5714	Biometry	A	A	A	A	A	A	
Earth Sciences 5717	Critical Issues in World Freshwater Resources	A	A	A	A	A	A	
Earth Sciences 5718	Aquatic Geochemistry	A	A	A	A	A	A	
Earth Sciences 5719	Environmental Organic Geochemistry	A	A	A	A	A	A	
Earth Sciences 5746	Seminar in Rheological Properties of Solids	A	A	A	A	A	A	
Earth Sciences 5751	Quantitative Ground-Water Flow Modeling	A	A	A	A	A	A	O-PG O-HG
Earth Sciences 5752	Contaminants in Aqueous Systems	A	A	A	A	A	A	
Earth Sciences 5754	Risk Assessment and Management in Earth Systems	A	A	A	A	A	A	
Earth Sciences 5779	Seminar in Physical Properties of Minerals and Rocks	A	A	A	A	A	A	
Earth Sciences 5780	Reflection Seismology	A	A	A	A	A	A	O-MS O-PG
Earth Sciences 5781	Gravity Exploration	A	A	A	A	A	A	

Earth Sciences 5782	Magnetic Exploration	A	A	A	A	A	A	
Geod Sci 5781	Geodesy and Geodynamics	A	A	A	A	A	A	O-GP O-PS
Electives from other departments (Geog, AtmosSC, EEOB, ENR, Chem, Math, etc.)							I-A	

Program Learning Goals:
A) Students critically read and evaluate Earth Science literature

B) Students present Earth Science information in a clear and logical manner, both orally and in writing.

C) Students apply knowledge of Earth Science data to understand the dynamic physical, chemical, and biological processes of the Earth and its history.

D) Students apply knowledge of appropriate techniques, field methods, field mapping, and numerical methods to measure, portray, analyze, and interpret Earth Science data in specific subdisciplines.

E) Students identify Earth Science problems and develop solutions.

F) Students apply knowledge of modern applications from chemistry, physics, biology, mathematics, statistics, and computing to the solution of Earth Science problems.

Key: B = Beginning level; I = Intermediate level; A = Advanced level

Program Course Listing:
R- Required
O - one of multiple option
prep - preparation (all BS programs)
SS – science of sustainability (all BS programs)
GS – Geological Sciences subprogram
CWE- Climate Water Environment subprogram
GP- Geophysics subprogram
MS – Marine Science certificate
PS- Planetary Science certificate
HG- Hydrogeology certificate
MC – Museum Curation certificate
PG- Petroleum Geology certificate