CORE 103
The Process of Change in Science
The Discovery of Global Warming
Fall 2023

Course Description

Synopsis Today there is a quasi-absolute scientific consensus that human activities are warming the planet. How did we go from the idea that Earth was too vast and powerful for humans to possibly change, even comprehend, to the recognition that Earth's surface is a collection of fragile systems that humanity must manage and preserve for its own survival? This class will survey the discovery of global warming, whose 200-year history mirrors the fundamental progress of science: quantum physics, electromagnetism, fluid dynamics, biogeochemistry, radioisotope chemistry, chaos theory, ecology, supercomputing, state estimation, and the theory of complex adaptive systems. The journey will teach us much about the nature of scientific inquiry, the culture of "organized skepticism" at the root of scientific progress, and the emergence of scientific consensus based on a consilience of evidence involving theory, direct and indirect observations, as well as experiments *in silico*.

Requirements An open mind

General Information

Instructors

Professor:	Julien Emile-Geay	ZHS 275	julieneg@usc.edu
Teaching Assistant:	Alexander James	ZHS 275	akjames@usc.edu

Where/When

Class meets Tues/Thurs, 12:30–1:50 in DMC101

Discussions meet Fri at 9:00 or 10:00 in THH209 (register separately).

Office Hours Th 10-12:00 or by appointment. Zoom option possible when I am not on campus.

Connectivity All contact hours are designed to be interactive, and involve writing.

A recorded Keynote presentation will be posted no more than 24h after each class period. The latter will be used to clarify aspects that need to be, or delve deeper into topics of interest to you. Friday's discussion sections are highly interactive group discussions, based on assigned readings. A short written assignment pertaining to this reading will be due each Friday at class time, and group writing will be expected in each discussion section.

Blackboard: announcements, assignments, course materials, link to lectures.
Access at `https://blackboard.usc.edu`.

Zoom: recorded lectures

Slack: optional Slack channel in the USC Dornsife workspace. May be used for asynchronous discussions with everyone in the class, at your discretion. Standard rules of respectful online behavior apply. Enrolled students will receive an invitation the first week of class.

Field trips Field trips are scheduled on Fridays, 10am – 5pm. Three amazing trips:

1. Mount Wilson Observatory in the scenic San Gabriel mountains. This is where galaxies, and the expansion of the Universe, were first observed.
2. the urban swamp of the La Brea Tar Pits, for a look behind the scenes at their unique collections, informing of megafaunal responses to fire and humans.
3. NASA's Jet Propulsion Laboratory, sending robots to Mars and Starshades to the edge of the solar system. And keeping eyes on Earth, too.

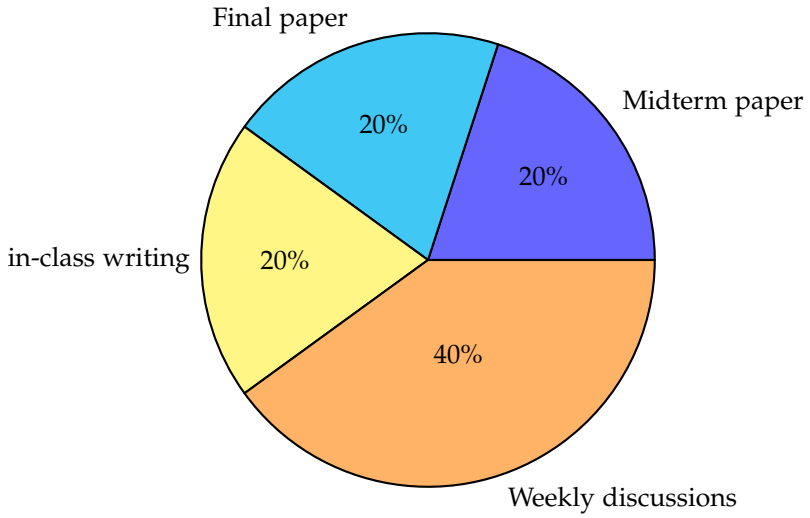
Books

Required Books

- Weart, Spencer R., *The Discovery of Global Warming*, 2nd edition, ISBN:978-0674031890. URL
- Archer, D. and Pierrehumbert, R., *The Warming Papers: The Scientific Foundation for the Climate Change Forecast*. ISBN: 978-1405196161. URL (hereafter, "WP")

Supplemental Reading

- Oreskes, N. & Conway, E., *The Collapse of Western Civilization: A View from the Future*, URL
- Edwards, P.N., *A vast machine: Computer Models, Climate Data, and the Politics of Global Warming*, ISBN: 978-0262013925 URL.



Grade

The class is worth 4 units, which means that it requires assiduous and substantial work. Attendance to discussion sections is mandatory (register separately, please). You will write two papers: a midterm and a final. At each week's discussion (12 total), short written assignments will be given and graded. The remaining 20% of the grade will be based on in-class writing. You will get full marks for completing at least 90% of those. If circumstances beyond your control compel you to miss more than 10% of assignments, please reach out the instructors as early as you can to figure out a solution. We're all the same side, but we can't help those who don't help themselves.

Table 1: Numeric to letter grade conversion (cutoffs)

< 60	60	63	67	70	73	77	80	83	87	90	≥ 94
F	D-	D	D+	C-	C	C+	B-	B	B+	A-	A

Schedule

I Light & Matter

Week 1 — 08/21/23— Foundations

Reading: Weart, Chapter 1.

Tuesday A brief history of global warming. Climate's Three Big Questions.

Thursday Earth's temperature: Fourier's Footing and Forays

Friday No discussion (starts in week 2).

Week 2 — 08/28/23— Thermodynamics

Reading: WP, Chapter 1 + Pierrehumbert, [2004].

Tuesday Energy and the First Law. Statistical mechanics and atomism.

Thursday The kind of motion we call heat. Entropy and the Second Law.

Friday Discussion: The temperature of the celestial sphere.

Week 3 — 09/04/23— Radiant Energy

Reading WP, Chapters 2 & 3. Simple Climate, Arrhenius.

Tuesday The Nature of light. Maxwell's equations. Planck's law

Thursday Light & Matter. The Quantum Revolution.

Friday trip to Field Mount Wilson (no discussion section, but assignments still due)

Week 4 — 09/11/23— Planetary Energy Balance

Reading: Pierrehumbert [2011]. WP, Chap 4; The CO_2 theory of Gilbert Plass.

Tuesday The Greenhouse Effect

Thursday Climate Feedbacks

Friday Discussion: "By the Light of the Silvery Moon".

Week 5 — 09/18/23— Monitoring Earth

Reading WP, Chapter 12. A vast Machine, Chap 1. The modern temperature record

Tuesday Taking Earth's temperature

Thursday Eyes on Earth

Friday Discussion: "The Callendar Effect"

II From Atoms to Planets

Week 6 — 09/25/23— The Carbon Cycle

Reading WP, Chapter 13. Simple Climate: Suess; Broecker; Keeling.

Tuesday Short-term carbon: The Keeling Curve

Thursday Long-term carbon: plate tectonics

Friday Discussion: The Carbon Cycle.

Week 7 — 10/02/23— Atomic Science, Cold War Science

Reading: Atoms in trees; World's loneliest tree records the Anthropocene; The age of the Earth; Simple Climate, Dansgaard

Tuesday Nuclear Physics: isotopes and atomic bombs

Thursday Cold War Science (guest lecture by Andy Lakoff)

Friday Discussion: Atoms for Earth.

Week 8 — 10/09/23— Space and Time

Reading Weart: Venus & Mars; The Sixth Extinction

Tuesday A journey in space: Mars, Earth, Venus and the solar system.

Assignment Midterm Paper due.

FALL BREAK : Oct 12 – 15

Week 9 — 10/16/23— Paleoclimatology

Reading: Weart: Ice Age Cycles; Simple Climate: Milankovitch; Broecker, part II.

Tuesday Quaternary Ice Ages

Thursday Abrupt climate change

Friday Discussion: paleoclimates

III Science in silico

Week 10 — 10/23/23— Climate modeling

Reading WP, Chapter 5 (Manabe & Wetherald 1967). Schmidt: the physics that we know; Simple Climate: Manabe; Weart: GCMs. Edwards: History of Climate Modeling.

Tuesday General Circulation Models.

Thursday The Attribution of Climate Change.

Friday Field Trip to the Jet Propulsion Laboratory (TBC)

Week 11 — 10/30/23— Chaos and Order

Reading WP, pp 241–254. (Charney Report). What is Chaos Theory?. Weart, "Chaos". The Science Behind the Butterfly Effect

Tuesday Laplace and Lorenz: living on a butterfly's wings

Thursday Weather vs Climate Prediction

Friday Discussion: Predicting Climate

Week 12 — 11/06/23— Experiments *in silico*

Reading Oreskes & Conway: The Collapse of Western Civilization; Weart: Impacts

Tuesday Climate Impacts

Thursday Climate Solutions

Friday Field Trip to La Brea Tar Pits (departing USC at 12, return by 4pm)

IV Science: from war winner to culture war

Week 13 — 11/13/23— On the shoulder of giants

Reading How do you know a paper is legit?; Schermer: Why Climate Skeptics Are Wrong. ExxonMobil's climate communications

Tuesday Scientific progress & consensus

Wednesday? Movie night: Merchants of Doubt

Thursday Good Science, Bad Science, and Ugly Science

Friday Discussion: Consensus & Denial

Week 14 — 11/20/23— Decoding the Mind

Assignments **Podcast:** tribal psychology; Hoffmann: Climate Science as Culture War;

Tuesday motivated reasoning, confirmation bias, identify-protective cognition

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Thanksgiving Break Nov 22–26

Week 15 — 11/27/23— Climate Narratives

Assignments Oreskes & Conway, The Fall of Western Civilization.

Tuesday Dueling narratives: Climate vs Capitalism, Power vs Freedom; Planet vs Profit.

Thursday Rewriting the Climate Story

Dec 10 – Final Paper due

V Participation

Class participation is a critical aspect of this course. The first way to participate in class is to show up to class and discussions. However, *active participation* is what we're after: ask questions, offer comments. You are not required to know much science to take this class, so there is no such thing as a stupid question; also, we will encounter many controversial topics, in which your opinion matters – it would be too bad to keep it for yourself. Please contact the instructor if you are not able to attend sessions for any reason.

VI Papers

Midterm Paper

In this paper you will write a 6-10 page paper following the process of change in a branch of (any)science. It can be related to what we have seen in class, but that is not an absolute requirement.

Term Paper

This paper will allow you to develop your own topic based on class material, or choose from one of the following: *From Stasis to Crisis; From Biosphere to Noosphere; Science & Agnotology; Civilization as a geosystem; Natural Laws vs Human Nature; Anthropocentrism & Anthropocene; Revolutions in Earth Science;*

VII Technology

USC technology rental program

Attending classes online and completing coursework remotely requires access to technology that not all students possess. If you need resources to successfully participate in your classes, such as a laptop or internet hotspot, you may be eligible for the university's equipment rental program. To apply, please submit an application. The Student Basic Needs team will contact all applicants in early August and distribute equipment to eligible applicants prior to the start of the fall semester.

Blackboard

BlackBoard is our primary medium of communication outside the classroom. It is where I post class notes, announcements, and assignments. Is is where you access that content, participate in discussions, and check your grades. **It is your responsibility to ensure that you receive BlackBoard announcements**. Make sure you enable email notifications, and importantly, make sure your inbox is not full; every year I get emails bounced from students too neglectful to clean up their inbox. If you have a doubt about when an assignment is due, go check it on BlackBoard. Also note that BlackBoard messages are richer than the email notifications they generate. Frequently, the announcements contain links to content archived on BlackBoard – those links will not appear in the emails. If the email digest you read does not make sense, please check it on BlackBoard; it might have the answer you need. If it still doesn't, please email me.

USC Technology Support Links

Zoom information for students: https://keepteaching.usc.edu/start-learning/

Blackboard help for students : https://studentblackboardhelp.usc.edu

Software available to USC Campus: https://software.usc.edu

VIII Academic Conduct

Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Plagiarism

Presenting someone else's ideas as your own, either verbatim or recast in your own words, is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct. These comments apply as well to text generated by artificial intelligence.

Generative Artificial Intelligence

In a few short months, generative A.I. tools like ChatGPT have taken academia by storm and rocked the very foundations of the college experience. Mindfully used, large language models (LLMs) can be incredible tools to boost productivity and get your creative juices flowing; mindlessly used, they will stifle your creativity, dull your critical thinking, and stunt your intellectual growth. In an age where AI's capabilities are rapidly catching up with humankind's, your only competitive edge going forward is to use your limitless creativity to do what machines can never do: imagine, dream, intuit, critically evaluate and create. If you surrender to them now, there is no future for you.

In this class, instructors will assume that, if you are using LLMs, you are doing so mindfully and ethically. That means:

- critically evaluating their output
- keeping a record of the conversation you had with the chat bot, and documenting your prompts (e.g. in an appendix)
- appropriately crediting the LLM in your written assignments
- providing adequate citations for every statement made by the algorithm. That's right: even if ChatGPT ad libs without citations, you, the writer, are not exempt from basic intellectual honesty, and must substantiate argumentative points with actual references. ChatGPT is currently bad at this, though it may no longer be so by semester's end.

Some writing assignments will explicit leverage ChatGPT, and ask you to critique its output based on what you know. However, you are under no obligation to use them for other assignments ; in fact, we strongly advise you to think without the crutch of an AI, lest you want to be replaced by one.

Discrimination

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity or to the Department of Public Safety . This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men provides 24/7 confidential support, and the Relationship and Sexual Violence Prevention and Services webpage describes reporting options and other resources.

IX Support Systems

Trojans Care For Trojans (TC4T)
An initiative within the Office of Campus Wellbeing and Crisis Intervention that empowers USC students, faculty and staff to take action when they are concerned about a fellow Trojan challenged with personal difficulties.

A private and anonymous request form provides an opportunity for Trojans to help a member of our Trojan Family.

Office of the Ombuds The UPC Ombuds Office is located at the University Park Campus in room 203A of the URC (University Religious Center)* located at 835 W. 34th Street. To schedule an appointment with the UPC Ombuds, please call (213) 821-9556. https://ombuds.usc.edu

Student Counseling Services (SCS) (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.
https://sites.usc.edu/counselingandmentalhealth/

National Suicide Prevention Lifeline –1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.
http://www.suicidepreventionlifeline.org

Sexual Assault Resource Center For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: https://sites.usc.edu/clientservices/

Office of Equity and Diversity (OED) (Title IX compliance) – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. https://equity.usc.edu/

Diversity at USC Tabs for Events, Programs and Training, Task Force (including representatives for each school), Chronology, Participate, Resources for Students.
https://diversity.usc.edu/