SYLLABUS
HONR 292A – Science as a Way of Knowing: Ocean Dynamics and Carbon Dioxide

INSTRUCTOR: Ursula Quillmann

COURSE DESCRIPTION

Why has climate change become the focal point of an increasingly polarized political conversation, whereas the vast majorities of other countries have long accepted climate change as a scientific fact and have accepted that human activities are the foremost cause of it? Climate science has become a pawn in the US political arena, with numerous politicians ignoring, rejecting, or misrepresenting scientific conclusions that conflict with their political views. People who lack authority on climate science are discussing the causes and solutions for climate change. The heated debate over climate science begs the question, what is science? In our seminar we will explore “science as a way of knowing.” Ocean dynamics and carbon dioxide (CO₂) will provide the framework for our seminar. Ocean dynamics and CO₂ are the crucial players in climate change, regardless of whether climate change is natural or caused by human activities. We live on an ocean planet with >70% of the Earth’s surface covered by ocean and >97% of the Earth’s surface water being stored in the ocean. The ocean plays an enormous role in absorbing CO₂ from the atmosphere, thus mitigating the effects of global warming by absorbing approximately one half of the CO₂ added to the atmosphere from fossil fuel burning. Scientists fear the ocean reaching a tipping point when it can no longer uptake any additional CO₂ from the atmosphere. We will examine the oceanic processes that make it possible for the ocean to take up excess atmospheric CO₂. We will examine scientific tools that are being used to determine past CO₂ levels in the atmosphere and in the ocean. We will scrutinize climate models that are being used to predict future climate change. We will also look at the effects a warming ocean has on sea level, ice sheets and glaciers, sea ice, hurricanes, monsoons, and El Niño events. The role of CO₂ in warming was recognized long before the “other” CO₂ problem was recognized. The “other” CO₂ problem is ocean acidification, often referred to as the “evil twin” of climate change.

COURSE LEARNING OBJECTIVES

After completing this course, a successful student will be able to:
1. Present and assess the major approaches to distinguishing science from other intellectual pursuits.
2. Apply and integrate ways of knowing in the sciences to contemporary issues and topics in a scientific discipline.
3. Creatively engage and integrate the science with expression of one’s own understanding and experience.
4. Explore and appreciate how scientific knowledge is produced, constructed, expressed, and contested in a scientific discipline.
5. Explain the potential sources of a distinctive rationality or objectivity that scientific knowledge might be thought to possess.
6. Articulate the value and purpose of ways of knowing in and through the sciences.
7. Describe crucial differences among the kinds of evidence adduced in favor of scientific claims, and explain the significance of these differences.
8. Critically assess interdisciplinary connections and interdependent overlaps between ways of knowing in the arts and humanities and the natural sciences.

REQUIRED TEXTS

COURSE SCHEDULE: TOPICS, READINGS, AND OTHER MATERIALS

Weeks 1 through 5 – The Nature and Values of Knowing in the Sciences

The readings will be posted on Canvas.

Week 1: Science and Pseudoscience (01/22 & 01/24)

Carl Sagan (1943-1996)

- Readings:
  - Karl Popper, “Science: Conjectures and Refutations”
  - Thomas Kuhn, “Logic of Discovery or Psychology of Research?”

- Discussion questions assignment #1

Week 2: Science and Objectivity (01/29 & 01/31)

“Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world.”
Louis Pasteur (1822-1895)

- Readings:
  - Helen Longino, “Values and Objectivity”
  - Lorraine Daston, “Objectivity and the Escape from Perspective”

- Discussion questions assignment #2

Week 3: Scientific Ignorance, Scientific Knowledge, and Their Applications (02/05 & 02/07)

“Thoroughly conscious ignorance is the prelude to every real advance in science.”
James Clark Maxwell (1831-1979)

- Readings:
  - Stuart Firestein, “The Quality of Ignorance”
  - Stuart Firestein, “Case Histories”
  - Laurence M. Krauss, “What Is Science Good For?”

- Discussion questions assignment #3

Week 4: Experimental, Observational, and Statistical Evidence (02/12 & 02/14)

“Facts are stubborn, but statistics are more pliable.”
Mark Twain (1835-1910)

Readings:
- Samuel Scheiner, “Experiments, Observations, and other Kinds of Evidence”
- Nate Silver, “Less and Less and Less Wrong”
Discussion questions assignment #4

Week 5: Crucial Historical and Methodological Episodes (02/19 & 02/21)

“I know not how I seem to others, but to myself I am but a small child wandering upon the vast shores of knowledge, every now and then finding a small bright pebble to content myself with while the vast ocean of undiscovered truth lay before me.”

Isaac Newton (1643-1727)

- **Readings:**
  - Barry Gower, “Isaac Newton: Rules for Reasoning Scientifically”

- **Writing Project #1 due**

Weeks 6 through 12 – Science as a Way of Knowing: Ocean Dynamics and Carbon Dioxide (CO₂) (02/26 & 02/28)

NOTE: The readings may be subject to change. Any changes will be discussed in class and updated on Canvas. The PDFs or the links to the readings will be posted on Canvas.

Week 6: CO₂ and Global Climate Change: From Science to Political Agenda

“To be of true service to humanity, science must be an exquisite blend of data, theory, and narrative.”

Michael Schermer (2007)

“At COP21 (Convention on Climate Change) in Paris, on 12 December 2015, Parties to the UNFCCC (United Nations Framework Convention on Climate Change) reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris Agreement builds upon the Convention and – for the first time – brings all nations into a common cause to undertake take ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.” On June 1, 2017, President Trump announced that he has decided to pull the U.S. out of the Paris Agreement. Photograph: Daron Taylor/The Washington Post

Readings and materials:

Day 1

- Communicating the science of climate change (Somerville and Hassol, 2011, Physics Today)
- Global priorities bigger than climate change (Lomborg, 2005; Ted talk, 16:41 min)
- Listen to two of the following interviews:
    https://www.reuters.com/article/us-usa-epa-pruitt-idUSKBN19W2D0
  - Fox News Interview - EPA Administration Scott Pruitt – April 2017
    https://youtu.be/DRHKB7Vmxzk
  - EPA Administration Scott Pruitt ”Meet the Press” host Chuck Todd – June 4, 2017
    https://youtu.be/L5nkMBF3qM
Day 2

- How the Republican Party turned against climate science (VOX Aug, 2016, 10:58 min) [https://youtu.be/O4Q8Nm4ksVU](https://youtu.be/O4Q8Nm4ksVU)
- What Americans really think about Climate Change? (The Atlantic, Meyer April 22, 2017)
- The science behind a climate headline (Pike, Ted Global July, 2009, 4:13 minutes)

Discussion questions assignment #5

Week 7: CO₂ and its effect on temperature in the atmosphere and in the ocean (03/05 & 03/07)

“The paleoclimate record shouts to us that, far from being self-stabilizing, the Earth’s climate system is an ornery beast which overreacts even to small nudges.”

Wallace Broecker (1931- age 85)

Changes in global surface temperature relative to 1951-1980 average temperatures (NASA). Different areas of Earth heat up at different rates. The ocean heats up less than landmasses because water resists to changes in temperature (inertia). Some areas are cooling, namely in the Southern Hemisphere around Antarctica. The Northern Hemisphere takes the brunt of the warming. One of the concerns is global sea level rise. Warmer water expands, thus contributing to sea level rise. Warmer ocean water and atmospheric warming lead to increased melting of ice sheets. Once melting, the freshwater from the ice sheets, enters the ocean, thus contributing as well to sea level rise.

Readings and materials:

Day 1:
- The carbon dioxide greenhouse effect (Weart, 2017)
- Roger Revelle’s discovery (Weart, 2017)
- Other greenhouse gases (Weart, 2017)
- Global Warming (Riebeek, 2010)

Day 2:
- Climate and Earth’s energy budget (Lindsey, 2009)
- The carbon cycle (Riebeek, 2011)
- The public and global warming (Weart, 2017)

Discussion questions assignment #6
Week 8: CO$_2$ in the Atmosphere and Ocean: How do we know what is “normal”? (02/12 & 02/14)

“We're running the most dangerous experiment in history right now, which is to see how much carbon dioxide the atmosphere can handle before there is an environmental catastrophe.”

Elon Musk (1971 – age 46)

This graph shows CO$_2$ levels over the last 400,000 years. Past CO$_2$ levels were reconstructed based on trapped air bubble in ice cores. CO$_2$ concentrations have been measured directly on Mauna Loa since 1956. CO$_2$ has fluctuated naturally between 180 ppm (parts per million) during ice ages and 280 ppm during warm periods. Current CO$_2$ concentrations exceed 400 ppm, which is outside the range of natural variations of CO$_2$ concentrations. (Credit: Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO$_2$ record.)

Readings and materials:
Day 1:
- World Ocean Review (2010; The oceans – the largest CO$_2$ reservoir, pp 28-35)
- Modern temperature trend (Weart, 2017)
- Rapid climate change (Weart, 2017)
- General circulation models of climate (Weart, 2017)

Day 2:
- Past climate cycles: ice age speculations
- Inside an Antarctic time machine (Hotz, Ted talk 2010, 9:45 min)

Discussion questions assignment #7

SPRING RECESS
Week 9: Rising Atmospheric CO₂ Levels, Rising Ocean Temperature, and Rising Sea Level (03/26 & 03/28)

“…we humans are programmed to think that big changes on the Earth happened a long time ago, or will happen a long time in the future. What we don't realize is that they actually can happen right now. Right here, right now, while we're alive, in our own hours and days and months and years.”

James Balog (1952 – age 65)

National Geographic dedicated its September 2013 issue to the impacts of sea level rise. Rising seas are inevitable, according to National Geographic. The cover features the hypothetical scenario of all ice on Earth melted. The Statue of Liberty would be submerged up to her midsection in the ocean. The image in the background features Seaside Heights in New Jersey in the aftermath of Superstorm Sandy. Protecting our coastlines will be costly and we will be faced with the decision of what to save and what to abandon. Photograph: Stephen Wilkes.

Readings and materials:

Day 1:
- IPCC Assessment Report, Chapter 3.7 (Observation Ocean) Sea level change, pp 285-291
- IPCC Assessment Report, Chapter 13 Sea level change, pp 1139-1159

Day 2:
- Chasing Ice (Documentary)
- Scientists keep increasing projections of sea-level increase by 2100 (Mooney, 2017; Boston Globe)
- Sea-level rise due to polar ice-sheet mass loss during past warm periods (Dutton et al., 2015; Science)

Discussion questions assignment #8

Week 10: Effects of Atmospheric CO₂ Levels, Ocean Temperature, and Ice Sheets on Ocean Circulation (04/02 & 04/04)

“The sea is the source of water and the source of wind; for neither would blasts of wind arise in the clouds and blow out from within them, except for the great sea, nor would the streams of rivers nor the rain-water in the sky exist but for the sea; but the great sea is the begetter of clouds and winds and rivers.”

Xenophanes (c. 570 B.C. - c. 480 B.C)
Satellite measurements of the Greenland ice sheet began in 2002. The graph shows the overall steady monthly decline in the ice sheet mass from 2002 through 2016. Melting ice sheets contribute to global sea level rise and to the freshening of ocean water, which can impact ocean circulation. Ice sheets have high reflectivity (albedo), and most of the energy from incoming solar energy is radiated back into space. As the ice sheets melt, melt ponds form on the surface of the ice sheet, which have a lower albedo. More of the incoming energy of sun will be absorbed, contributing even more to warming atmospheric temperature and accelerated ice loss. (Climate.gov; data provided by Marco Tedesco/Lamont-Doherty)

Readings and materials:

Day 1:
- Thermohaline Circulation, the Achilles Heel of Our Climate System: Will Man-Made CO$_2$ Upset the Current Balance? (Broecker 1997, SCIENCE VOL. 278)
- Ocean circulation and climate during the past 120,000 years (Rahmstorf, 2002; Nature 419, 207-214)
- The great ocean currents – the climate engine in World Ocean Review, 2010, pp 16-25

Day 2:
- The Recent Global Surface Warming Hiatus (2015, NOAA National Centers for Environmental Information)
- Global warming ‘hiatus’ debate flares up again (Tollefson, 2016; Nature News & Comment)
- The Atlantic Ocean and an Actual Debate in Climate Science (Meyer, 2017, The Atlantic)
- Warm ocean currents are slowing down (Gonzaga, 2016; EarthSky)

Discussion questions assignment #9:

Week 11: Rising CO$_2$ Levels and Wind Patterns and Storm Tracks (04/09 & 04/11)

“Rain clouds come floating in, not to muddy my days ahead, but to make me calm, happy and hopeful.”

Rabindranath Tagore (1861-1941)

Monsoons are tropical and subtropical seasonally reversed winds. During the wet phase of the monsoon, countries like India receive intense precipitation, upon which India’s agriculture and economy depends. The image depicts laborers planting saplings in a paddy field on the outskirts of the eastern Indian city of Bhubaneswar July 19, 2014, during the wet monsoon season. (Image: Reuters)
Readings and materials:

Day 1:
- Early monsoon rains flood northern India (Taylor, 2013, 23 pictures; The Atlantic)
- Monsoon, or later (2012, The Economist)
- Why India’s monsoon is difficult to forecast (2016, The Economist)
- The mothers of all disasters: The maximums of maximums (Graham, 2015; The Atlantic)
- Weather and War (Fisman, 2011, Slate)

Day 2:
- Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2°C global warming could be dangerous (Hansen et al., 2016; Atmos. Chem. Phys., 16, 3761–3812)

Discussion questions assignment #10

Week 12: The “Evil Twin” of Climate Change: Ocean Acidification (04/16 & 04/18)

“An acid ocean spells the end of life on Earth.”
Tim Winton (1960 – age 57)

Pteropods, small sea snails less than 1cm (~0.4 in) in length, are an important part of the marine food web. Pteropods have delicate, translucent shells made of calcium carbonate that reacts with acid water. The pteropod on the left is healthy. The middle image shows a pteropod grown in a laboratory in seawater with elevated CO₂ concentrations as found in the ocean off the Pacific Northwest. The right image shows a damaged pteropod. This pteropod was grown in a laboratory in seawater with extreme CO₂ concentration that could become reality in the worst-case scenario. Photographs by Steve Ringman, Seattle Times

Readings and materials:
Day 1:
- Ocean Acidification (Bennet, Smithsonian Ocean Portal)
- The Other CO₂ Problem (Doney et al., 2009, Annual Review of Marine Science)

Day 2:
- Ocean Acidification: The evil twin of climate warming (Alfred-Wegener-Institut)
- Why the EPA Doesn't Regulate Ocean Acidification (Meyer, 2016, The Atlantic)
- How pollution is changing the ocean's chemistry (McGrath, 2017, Ted Talk, 9:45 min)
- Scientists Find That Polluted Oceans Could Make Fish Anxious (Narula, 2013, The Atlantic)

Writing Project #2 due
Weeks 13 through 14 – Formal Speeches (04/23, 04/25, 04/30, & 05/02)

Week 15: Conclusion and wrap up (05/07 & 05/09)

Week 16: Final Critical Analysis and Research Writing Projects

EVALUATION SYSTEM

The requirements that will be used to evaluate student learning are:
1. Discussion question assignments (10% of grade). Weekly one-page writing assignment on readings (10 total).
2. Two writing projects (30% of grade). Writing assignments (5-10 pages each) can be in the form of a traditional academic essay, personal essay, creative nonfiction, fiction, poetry, or art/design project with narrative.
3. Formal speech (20% of grade). A 7-minute extemporaneous speech to the class related to content.
4. Analytical research writing project (10-20 pages; 20% of grade).
5. Reflection Journal (5% of grade)
6. Student-led discussions (10% of grade)
7. Participation (5% of grade).

GRADING

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<tr>
<th>Assignment</th>
<th>Percentage</th>
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<tr>
<td>Participation</td>
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<tr>
<td>Discussion question assignments (10)</td>
<td>10%</td>
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<tr>
<td>Writing projects (2)</td>
<td>30%</td>
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<tr>
<td>Student-led discussions</td>
<td>10%</td>
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<tr>
<td>Reflection Journal</td>
<td>5%</td>
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<td>Final research paper (1)</td>
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<td>Formal speech (1)</td>
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<td>Total</td>
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Grade (Official CSU grading scale):
A+ (97-100); A (93-96); A- (90-92); B+ (87-89); B (83-860; B- (80-82); C+ (77-79); C (70-76); D (60-69); F (<60)

Incomplete
The grade of “I” is a temporary grade awarded to indicate that for reasons beyond the student’s control or that the student could not have reasonably have anticipated, he/she could not complete the requirements for the course. When an instructor assigns an “I,” he/she shall specify in writing the requirements the student shall fulfill to complete the course. After one year, or at the end of the semester in which the student graduates (whichever comes first), an “incomplete” grade will automatically changed to an “F” grade unless the course has been completed and the grade change submitted. Student must be in good academic standing in the class in order to receive an incomplete. (CSU Faculty Council policy)

Honors Competencies and Skills for Honors Students (“PICC” feedback)
The CSU University Honors Program has prioritized four general competencies skills that should be addressed in each honors course. These skills include (1) Professionalism, interpersonal skills, and emotional intelligence; (2) Interdisciplinary learning integrated with global and/or cultural viewpoints; (3) Critical thinking; and (4) Creativity and problem solving. This is a two-stage process. First students complete a self-evaluation of these skills at the beginning of the semester. At the end of the semester instructors will provide feedback for each student, based on assignments and activities. The feedback is part of the University Honors Program; it is for advising purposes only and is confidential. It is not part of a student’s grades or academic record. A standardized rubric is used to provide feedback for growth in these areas and to measure the Honors Programs progress in helping students to develop these skills through their academic career. The feedback categories and activities/assignments used to measure progress in HONR 292 are listed below and noted in the assignment descriptions.
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<tr>
<th>Skill Category (PICC)</th>
<th>Relevant Course Activities &amp; Assignments</th>
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| **1. Professionalism, interpersonal skills, & emotional intelligence:** Acts ethically & positively to foster a supportive instructional or work environment. Has the emotional intelligence (ability to perceive, evaluate, & manage emotions) & interpersonal skills to work effectively with others. | - Class participation & conduct  
- Discussion question assignments  
- Formal speech                                                                 |
| **2. Interdisciplinary learning integrated with global &/or cultural viewpoints:** Integrates diverse knowledge, perspectives, &/or skills into arguments &/or strategies; is aware of and can clearly incorporate global &/or cultural perspectives to an argument or issue. | - Class discussions  
- Discussion question assignments  
- Writing projects  
- Final research paper  
- Formal speech                                                                 |
| **3. Critical thinking:** Student advances a position with specific theses or hypotheses & can conceptualize ideas or lines of thought. Conclusions and related outcomes acknowledge complexities of an issue (implications and consequences) and recognize differing points of view. Formulates & develops claims with sufficient support, including reasoning, evidence, & persuasive appeals, & proper attribution where necessary. Uses written and oral communication effectively in persuasive arguments. | - Class discussions  
- Discussion question assignments  
- Writing projects  
- Final research paper  
- Formal speech                                                                 |
| **4. Creativity & problem solving:** Creatively applies discipline-based and/or cross-discipline-based knowledge to discover and design a variety of forms often using a problem-solving strategy | - Class discussions  
- Discussion question assignments  
- Writing projects  
- Final research paper  
- Formal speech                                                                 |