**EAS-A 476 Climate Change Science Indiana University, Spring 2019**

## Course Goal

The **enduring understandings** of our course will enable students to:

* Summarize how climate proxy data explains Earth’s past climate variations
* Describe how Earth’s climate system functions in present day
* Assess the current state of climate change science literature

## Essential Questions in our Course

1. How do we know that Earth’s climate has changed in the past?
2. What is happening in the climate system now, and what is our best scientific evidence that explains why?
3. What is the proper way to invoke past evidence as we try predict future outcomes?

## Catalog Description

Evidence for and theories of climate change over a range of time scales. Sources of natural climate forcing are presented, historical evolution of climate change is quantified, and model tools and climate projections are presented along with analyses of climate change impacts.

## Instructor & Meeting Details

Class meetings: MWF, 10:10 – 11:05, Geology 210 Instructor: Dr. Cody Kirkpatrick (codykirk@indiana.edu)

Office Hours: Thursday, 10 – 12, Geology 405. Appointments most any time on Friday. If my office door is open (Geology 405), you are always welcome to come in.

## Textbook

*Climate Change Science, A Modern Synthesis* by Farmer and Cook is available for FREE electronically through the IU library. Please download a copy.

## Assessment

40% Homework/reading summaries/in class activities & “pop” quizzes/etc. 15% Midterm exam – Monday, 4 March ← corrected date

15% Comprehensive final exam

The final exam may be taken at any of these times. However, **these are your only options**. I cannot accommodate other test times during finals week.

- Tuesday, 30 April, 2:45 - 4:45 p.m.

- Wednesday, 1 May, 12:30 - 2:30 p.m.

- Friday, 3 May, 5:00 - 7:00 p.m. (The originally scheduled time.) 15% Impact Poster

Due: Thursday, 7 March, 11:59 p.m. Eastern Time ← corrected date

Task: Explain what climate change means to, and how it will be important to, a selected group of end users. Each team of students will appeal to a different group (emergency managers, politicians, doctors, hoteliers, etc.). More details will be provided as the semester begins.

You’ll work: in teams of two, which will be randomly assigned.

You’ll produce: (a) a “mini-poster” (11 inches by 17 inches) suitable for hallway display, and (b) a one page, single spaced, executive summary of your argument.

15% Annotated bibliography and presentation

Due: Monday, 22 April, with the presentation during that week (the final week of classes)

Task: More details coming before spring break. You’ll work: individually.

Guaranteed grades: A+/A/A- for 90% or higher; B+/B/B- for 80% or higher; and so on.

## Further Course Details

**Cancellations:** If any class is canceled by the University (bad weather, etc.), all deadlines, due dates, and assignments for that day are moved to the next class period.

**Technology in the Classroom:** I have no problem with you bringing laptops, iPads, or whatever to class, as long as you are using them for a classroom purpose. Texting the girlfriend or checking Facebook or ESPN usually won’t qualify. If I find students abusing this policy, I reserve the right to ban individuals from using these devices, to ban certain devices, or to ban them entirely. “Please use responsibly.”

**Accommodation:** It is the policy of Indiana University to provide reasonable accommodations or academic adjustments as needed. These accommodations and adjustments will be made in a timely manner and on an individualized and flexible basis. Our campus policy is here: [http://www.iu.edu/~ada/policy/.](http://www.iu.edu/%7Eada/policy/) Please come speak to me privately so we can make the necessary arrangements.

**Academic Misconduct:** As members of the University community, we are all obligated to the “Indiana University Code of Student Rights, Responsibilities, and Conduct”. The code is accessible on the internet at [http://www.iu.edu/~code/.](http://www.iu.edu/%7Ecode/)

**Complaints:** If you have difficulties or complaints related to this course, your first action usually should be to discuss them with me. If such a discussion would be uncomfortable for you or fails to resolve your difficulties, you should contact Professor Brophy, Chair of the Department of Earth and Atmospheric Sciences. Professor Brophy’s office is in the Geology Building, Room 123. If you are still unsatisfied, you should discuss the matter with Professor Friel, Associate Dean of the College of Arts and Sciences. Professor Friel’s office is in Kirkwood Hall, Room 104.

**Disclaimer:** In cases of *force majeure,* I reserve the right to deviate from this syllabus. I will notify you as soon as I realize this is necessary, and I will document all changes with the department and if required the Dean’s office.

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Slides, Handouts, and Readings

# On this page we'll keep track of all the handouts and readings, plus any slides from class. Week 1 (7-11 January)

From Homework 1: **Problem Climates or Problem Societies.pdf (https://iu.instructure.com/courses/1771812/files/86797982/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/86797982/download?wrap=1)**

# Week 2 (14-18 January)

Wednesday's slides on the **Homework 1 discussion.pdf (https://iu.instructure.com/courses/1771812/files/87192108/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87192108/download?wrap=1)** Friday's slides on **A476 Radiation and Wavelengths.pdf (https://iu.instructure.com/courses/1771812/files/87192110/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87192110/download?wrap=1)**

# Week 3 (21-25 January)

Wednesday's slides on **A476 Global Circulation and Jet Stream.pdf (https://iu.instructure.com/courses/1771812/files/87363092/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87363092/download?wrap=1)**

# Week 4 (28 January-1 February)

Monday's slides on **A476 Ice Cores Etc.ppt (https://iu.instructure.com/courses/1771812/files/87605251/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87605251/download?wrap=1)** Friday's slides on **A476 Milankovitch Cycles.pdf (https://iu.instructure.com/courses/1771812/files/87605231/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87605231/download?wrap=1)** Friday's handout, the current **A476 Insolation Graph.pptx (https://iu.instructure.com/courses/1771812/files/87605262/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87605262/download?wrap=1)**

# Week 5 (4-8 February)

Monday's slides on **A476 The Hockey Stick.pdf (https://iu.instructure.com/courses/1771812/files/87836389/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87836389/download?wrap=1)** Monday's handout on the Mann Hockey Stick: **A476 Mann 1998 Handout.pdf (https://iu.instructure.com/courses/1771812/files/87836400/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87836400/download?wrap=1)**

Monday: links about stalactites and stalagmites as climate proxies: **Link 1 (https://**[**www.futurity.org/stalagmites-weather-climate-927622/)**](http://www.futurity.org/stalagmites-weather-climate-927622/)) , **Link 2 (**[**http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.897.6671&rep=rep1&type=pdf)**](http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.897.6671&amp;rep=rep1&amp;type=pdf)) , and **Link 3 (https://**[**www.sciencedaily.com/releases/2017/04/170411085953.htm)**](http://www.sciencedaily.com/releases/2017/04/170411085953.htm)) (all are provided by Matthew S.) Wednesday's **Radiation Check Responses (https://docs.google.com/document/d/1ocH2i96fjlz3VCeA7VxyRkytUsqb8yFHilEyS6gd4O8/edit? usp=sharing)**

Friday's handout of four **Temperature Sets for Class Activity.xls (https://iu.instructure.com/courses/1771812/files/87819553/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87819553/download?wrap=1)** (we used these to explore some things in today's slides)

Friday's slides on **A476 Temperature Distributions.pdf (https://iu.instructure.com/courses/1771812/files/87819448/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87819448/download?wrap=1)**

# Week 6 (11-15 February)

Monday's slides on **A476 El Nino.pdf (https://iu.instructure.com/courses/1771812/files/87970697/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87970697/download?wrap=1)** Wednesday's slides on **A476 Sunspots.pdf (https://iu.instructure.com/courses/1771812/files/87970682/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/87970682/download?wrap=1)** Wednesday's handout with **examples of correlation coefficients (https://iu.instructure.com/courses/1771812/files/88486310/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88486310/download?wrap=1)** Friday's slides on **A476 Aerosols.pdf (https://iu.instructure.com/courses/1771812/files/88040368/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88040368/download?wrap=1)**

# Week 7 (18-22 February)

Monday's slides on **A476 Albedo and Land Use.pdf (https://iu.instructure.com/courses/1771812/files/88198999/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88198999/download?wrap=1)** Wednesday's slides on **A476 Chemistry Day.pdf (https://iu.instructure.com/courses/1771812/files/88199012/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88199012/download?wrap=1)**

Friday: **What's Really Warming the World? (https://**[**www.bloomberg.com/graphics/2015-whats-**](http://www.bloomberg.com/graphics/2015-whats-) **warming-the-world/)** from Bloomberg

# Week 8 (25 February-1 March)

Reading: **Hartmann - The Hydrologic Cycle.pdf**

**(https://iu.instructure.com/courses/1771812/files/88254250/download?wrap=1)**

**(https://iu.instructure.com/courses/1771812/files/88254250/download?wrap=1)** Monday's slides on **A476 Precipitation I.pdf (https://iu.instructure.com/courses/1771812/files/88473002/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88473002/download?wrap=1)** Wednesday's slides on **A476 Precipitation II.pdf (https://iu.instructure.com/courses/1771812/files/88473004/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88473004/download?wrap=1)**

# Week 9 (4-8 March)

Monday: **Midterm Exam (https://iu.instructure.com/courses/1771812/assignments/9000488)**

# Wednesday: review the exam

Friday: **Impact Poster (https://iu.instructure.com/courses/1771812/assignments/9153653)** presentations Week 10 (18-22 March)

**Monday: Reading prior to Monday's class (https://iu.instructure.com/courses/1771812/files/88634933/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88634933/download?wrap=1) Monday: Worksheet due at the start of class on Monday (https://iu.instructure.com/courses/1771812/files/88634988/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88634988/download?wrap=1)** Monday: Stakeholder Analysis report (**what you'll do in class on Monday (https://iu.instructure.com/courses/1771812/files/88634982/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88634982/download?wrap=1)** )

Monday: Stakeholder Analysis Powerpoint (**stakeholder\_analysis\_coastal\_impact\_v3.pptx) (https://iu.instructure.com/courses/1771812/files/88811960/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88811960/download?wrap=1)**

Monday: Word versions of the **Pre-reading (https://iu.instructure.com/courses/1771812/files/89109557/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89109557/download?wrap=1)** and the **Stakeholder Analysis (https://iu.instructure.com/courses/1771812/files/89109570/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89109570/download?wrap=1)**

Wednesday: Unit 2 Global sea level response to temperature changes (**unit\_2\_student\_exercise.v9.docx) (https://iu.instructure.com/courses/1771812/files/88812027/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88812027/download?wrap=1)** Wednesday: Unit 2 Data File (**unit\_2\_student\_exercise\_data\_file.xlsx) (https://iu.instructure.com/courses/1771812/files/88812126/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88812126/download?wrap=1)** Wednesday: Thermal Expansion Calculation (**unit\_2\_thermal\_expansion.v3.pptx) (https://iu.instructure.com/courses/1771812/files/88812076/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88812076/download?wrap=1)**

Friday: Unit 3 Student handout (**unit\_3\_student\_exercise.v6 (1).docx) (https://iu.instructure.com/courses/1771812/files/88903371/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88903371/download?wrap=1)** Friday: Unit 3 Student data files (**unit\_3\_ice\_mass.v3 (1).xlsx (https://iu.instructure.com/courses/1771812/files/88903404/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88903404/download?wrap=1)** )

Friday: Unit 3 Background PowerPoint materials A (**overview\_how\_grace\_satellites\_measu (1).pptx) (https://iu.instructure.com/courses/1771812/files/88903470/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88903470/download?wrap=1) (https://iu.instructure.com/courses/1771812/files/88903470/download?wrap=1)** Friday: Unit 3 Background PowerPoint materials B (**unit3insar\_icevelocityoverv\_15495208291403145401.v4 (1).pptx) (https://iu.instructure.com/courses/1771812/files/88903563/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88903563/download?wrap=1)**

Friday: Unit 3 Graphs for answering questions 9 and 10 (**unit\_3\_question\_9\_student\_handout.v2 (1).docx) (https://iu.instructure.com/courses/1771812/files/88927858/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88927858/download?wrap=1)** , (**unit\_3\_question\_10\_student\_handout.v2 (1).docx) (https://iu.instructure.com/courses/1771812/files/88927876/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88927876/download?wrap=1)**

# Week 11 (25-29 March)

Monday: Unit 4 GETSI Student Handout (**unit\_4\_student\_handout.v7.docx) (https://iu.instructure.com/courses/1771812/files/88930133/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88930133/download?wrap=1)** Monday: Unit 4 GETSI Student Data Set (**student\_file\_containing\_vertical.v4.xlsx (https://iu.instructure.com/courses/1771812/files/88930152/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/88930152/download?wrap=1)** )

Monday: Unit 4 Background **(https://iu.instructure.com/courses/1771812/files/88930171/download? wrap=1)** information on GPS response to ice mass loss (**cc\_unit\_4\_background\_no\_scans\_v2.pptx (https://iu.instructure.com/courses/1771812/files/89046879/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89046879/download?wrap=1)** )

Monday: Unit 4 Grading Rubric (**CC\_unit4\_assessment\_rubric\_v3.docx (https://iu.instructure.com/courses/1771812/files/89061275/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89061275/download?wrap=1)** )

# Wednesday: Continue to work on Units 3 and 4 remembering that you do not need to complete the de-trending calculations nor answer any questions related to these plots. You should compare the vertical GPS vectors you plot on the Greenland Map with the NASA animation of Greenland ice flow based on the InSAR data

**Greenland Ice Flow (https://**[**www.youtube.com/watch?v=GDXq8Oa5d5Q)**](http://www.youtube.com/watch?v=GDXq8Oa5d5Q))



**(https://**[**www.youtube.com/watch?v=GDXq8Oa5d5Q)**](http://www.youtube.com/watch?v=GDXq8Oa5d5Q))Friday: Unit 5 Stakeholder Executive Summary overview (**student\_unit\_5\_instructions\_v8bdck.docx**

**(https://iu.instructure.com/courses/1771812/files/89060977/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89060977/download?wrap=1)** )

Friday: Unit 5 Stakeholder Executive Summary rubric (**unit\_5\_executive\_summary\_rubric-1.docx) (https://iu.instructure.com/courses/1771812/files/89047520/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89047520/download?wrap=1)**

Friday: Unit 5 Metacognition Essay (**unit\_5\_metacognition\_statement.v2.docx) (https://iu.instructure.com/courses/1771812/files/89047540/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89047540/download?wrap=1)**

Friday: Unit 5 Metacognition Essay Rubric (**climate\_change\_metacognition\_rubric\_v3.docx (https://iu.instructure.com/courses/1771812/files/89061107/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89061107/download?wrap=1)** )

Friday: Here is an updated version of the Unit 4 background PowerPoint that includes a map with all of the Greenland GPS stations plotted (**cc\_unit\_4\_background\_no\_scans\_v4.pptx (https://iu.instructure.com/courses/1771812/files/89112728/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89112728/download?wrap=1)** )

# Weeks 12-14: IPCC Reports

**Climate Velocity paper (https://iu.instructure.com/courses/1771812/files/89172141/download?wrap=1) (https://iu.instructure.com/courses/1771812/files/89172141/download?wrap=1)**



**What will climate change feel like in my location? (https://fitzlab.shinyapps.io/cityapp/)** Comparison of the different **RCP Scenarios.doc (https://iu.instructure.com/courses/1771812/files/89979914/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89979914/download?wrap=1)**

**The 5th Assessment Synthesis Report "Summary for Policymakers" (https://iu.instructure.com/courses/1771812/files/89171921/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89171921/download?wrap=1) The 5th Assessment Synthesis Report (https://iu.instructure.com/courses/1771812/files/89171928/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89171928/download?wrap=1) The 5th Assessment Working Group II "Summary for Policymakers" (https://iu.instructure.com/courses/1771812/files/89171939/download?wrap=1) ** **(https://iu.instructure.com/courses/1771812/files/89171939/download?wrap=1)**