

Course  Information

1.  Course  Name:  Introduction to Climate

2.  Department:  SMAST

3.  Number:  MAR 115

4.  Cluster  Requirements:  2B

Faculty  Information

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Required  Components

8.  Master  Syllabus:  See  following  document

9.  Course  Overview  Statement:

This is a University Studies (2B) course on introduction to climate. The course is designed by meteorologists and climatologists nationally recognized in atmospheric science education. In this course, students are introduced to the many elements of Earth's climate system in a dynamic and highly motivational environment where they investigate Earth's climate system using real-world environmental data. Students will be exposed to scientific literature regarding climate change and compare this material to what is widely available to the public. Students will ultimately build upon the knowledge gained in this course to conduct and write up a research project following the scientific method.

In particular, Students are introduced to the following elements of Earth's climate system: Earth's climate as a dynamic system; observation and analysis tools; radiation, heat and water budget; atmospheric circulation; atmosphere-ocean relationships; natural and anthropogenic drivers of climate change; future climate projection; human and ecosystem vulnerabilities; climate change mitigation and energy; human needs, actions and public policy; climate studies as a scientific endeavor in a changing society.

In terms  of  US  2B,  the  course  fulfills  the  associated  learning  outcomes. First, the students will be able to explain the basic elements of the Climate System and how they impact the different components of the society in different ways. They will be able to describe how science (particularly climate science) works, how scientific theories are advanced, and how scientific understanding can impact the world around us. Students will be able to discuss (among groups and peers) the science underpinning of climate data, analysis and future projections and its interaction with the human ecosystem. And finally, the students will be able to give examples of the role of the climate in the Earth System in the context of climate related environmental issues and current events.

10.  Signed  Faculty  and  Chair  Sponsor  Sheet:  Sent  Separately

11.  Official  Course  Catalog  Description  of  the  Course:

Earth's climate system: Earth's climate as a dynamic system; observation and analysis tools; radiation, heat and water budget; atmospheric circulation; atmosphere-ocean relationships; natural and anthropogenic drivers of climate change; future climate projection; human and ecosystem vulnerabilities; climate change mitigation and energy; human needs, actions and public policy; climate studies as a scientific endeavor in a changing society.

12.  Course  Approval  Form:  Not  Entered

**Master Syllabus**

**Course: MAR 115: Introduction to Climate**

**Cluster Requirements: 2B Science in the Engaged Community**

This  University  Studies  Master  Syllabus  serves  as a  guide  and  standard  for  all   instructors  teaching  an  approved  course  in  the  University  Studies  program.  Individual   instructors  have  full  academic  freedom  in  teaching  their  courses,  but  as  a  condition  of   course  approval,  agree  to  focus  on  the  outcomes  listed  below,  to  cover  the  identified   material,  to  use  these  or  comparable  assignments  as  part  of  the  course  work,  and  to   make  available  the  agreed-­‐upon  artifacts  for  assessment  of  learning  outcomes.

**Course Overview:**

This course provides a general introduction to the essential principles of climate sciences.

Upon successful completion of the course, the student will be able to:

* Explain the basic elements of the Climate System and how they impact the different components of the society in different ways.
* Describe how science (particularly climate science) works, how scientific theories are advanced, and how scientific understanding can impact the world around us.
* Discuss the science underpinning of climate data, analysis and future projections and its interaction with the human ecosystem.
* Give examples of the role of the climate in the Earth System in the context of climate related environmental issues and current events.

The course material consists of three major components: (i) 10-12 Lectures; (ii) 7 Lab Assignments; and (iii) 1 Research Project/paper development and presentation. The lectures will focus on several topics (see later) on climate science and will follow the textbook (Dire Predictions: Understanding Climate Change: The visual Guide to the Findings of the IPCC).

The labs will be based on the AMS Climate Studies course recommendation on Current Climate Studies (See list of labs and two sets of excerpts from lab #2 and #5 later). The foundation of these assignments is the highlights of the National Climate Assessment (NCA3) Findings available at <http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf>*.* These lab exercises will heavily refer to the 2015 Paris Agreement (<http://unfccc.int/resources/docs/2015/cop21/eng/109r01.pdf>) in the context of social, environmental or political issues of climate change.

Finally, the research project/paper will be developed in a group mode (4-5 students) who will be tasked to write their own version of the regional impact in the US from the latest findings from the US Climate Change site (<http://nca2014.globalchange.gov>) and present the key findings in class.

**US Learning Outcomes: 2B**

|  |  |
| --- | --- |
| **2B:** **Science in**  **Engaged Community** | **Assignment/Activity/Evaluation** **Tool** |
| 1. Analyze and evaluate the use of scientific  information in the context of social, economic, environmental or political issues. | **Lab Assignments** *Students experience these basic issues in responses to questions on the laboratory topics in Current Climate Studies. The foundation of these assignments is the highlights of the National Climate Assessment (NCA3) Findings available at* [*http://www.globalchange.gov/sites/globalchange/files/NCA3\_Highlights\_LowRes-small-FINAL\_posting.pdf*](http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf)*. Included in this report is the 2015 Paris Agreement* (<http://unfccc.int/resources/docs/2015/cop21/eng/109r01.pdf>). As an example, excerpts from sample Assignment #1 is shown later where questions 9,10,11 and 12 address the specific Learning Outcome # 1 of US 2B requirement. This assignment alone constitutes about 4% of total points. |
| 2.  Apply scientific theories and knowledge to real-world problems | **Lectures (1-12) supported by Labs**  Different theoretical models are explored for the different components of the Climate System – Ocean circulation, Atmospheric Circulation, Extreme events, Greenhouse Effects, Impact of Climate Change affecting these different systems. These will allow the students to become familiarize with the important theories relevant to Climate Change. Many Lab Assignments will then cover questions which apply the scientific theories and knowledge to real-world problems. An example of such application is shown in the Sample Assignment #2, Questions 1 through 13. Questions 1-12 are based on NCA3 findings ([*http://www.globalchange.gov/sites/globalchange/files/NCA3\_Highlights\_LowRes-small-FINAL\_posting.pdf*](http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf) *and derived from the first 5 lectures.* Questions 13 and 14 are specifically on Greenhouse Gas increase in 2014. (Weight is about 5% of the total points) |

|  |  |
| --- | --- |
| 3.  Effectively communicate scientific information in writing. | **Research Paper and presentation**  *For this requirement, each student will be part of a group of 4-5 students. Each group*  *Will choose a region of their interest during the 3rd week of the semester from the site* ([*http://nca2014.globalchange.gov*](http://nca2014.globalchange.gov)*). This site describes 4-5 key findings on the impact of climate change on 10 regions (Alaska, Northeast, Southeast, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawaii, Rural Communities and the Coasts). The students will prepare a 3-page paper on a key finding in a particular region as illustrated in sample Assignment # 3. Each student will give his/her presentation as part of the group presentation. The written communication paper and the presentation together weigh for 25% of the total points.* |

**Learning** **Resources:**

1. Textbook: Dire Predictions Understanding Climate Change The Visual Guide to the Findings of the IPCC, 2nd edition, MichaelE. Mann and Lee Kump, Pearson.
2. *Highlights of the National Climate Assessment (NCA3) Findings available at* [*http://www.globalchange.gov/sites/globalchange/files/NCA3\_Highlights\_LowRes-small-FINAL\_posting.pdf*](http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf)*.*
3. *Report is the 2015 Paris Agreement* (<http://unfccc.int/resources/docs/2015/cop21/eng/109r01.pdf>).
4. The US Climate Resilience Toolkit (<https://toolkit.climate.gov/>).
5. <http://nca2014.globalchange.gov>

**Evaluation and Grading Breakdown:**

* Laboratory Assignments and Homework: 25%
* Mid-Term: 25%
* Final Exam: 25%
* Communication paper and presentation (15 + 10) : 25%

**Lecture Topic** **Outline:**

Topic 1: Climate and Climate Change

Topic 2: Atmospheric Currents

Topic 3: Ocean Currents

Topic 4: Humans and Climate Change

Topic 5: Climate Variability

Topic 7: Extreme Climate

Topic 8: Numerical Modeling

Topic 9: Aerosol Feedback

Topic 10: Sea Level Rise

**Laboratory** **Assignments** **(from AMS):**

Lab 1: Physical Basis for Earth’s Climate System

Lab 2: Visiting Global Climate Change and Impact Study Resources

Lab 3: Highlights and Key Findings about Climate and Climate Change

Lab 4: Climate Change: Planetary and National Perspectives

Lab 5: National Climate Assessment (NCA3): Overview of Report Findings

Lab 6: National Climate Assessment (NCA3): Climate Trends

Lab 7: Climate Change Impacts: Scientific Assessments Across Sectors and Region

**Sample Assignment #1 (Excerpt for Q 9-12) to illustrate US 2B # 1)**

**The United Nations Framework Convention on Climate Change**

**(UNFCCC) 2015 *Paris Agreement*:**

The **2015 United Nations Climate Change Conference** was held in Paris, France, from

30 November to 12 December 2015. Recognizing “that climate change is a common concern of humankind”, a total of 195 countries negotiated and signed an historically significant agreement to address climate change.

Among unanimously accepted fundamental understandings stated in the *Paris Agreement*

was recognition that

• “climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions,” and,

• “deep reductions in global emissions will be required in order to achieve the ultimate objective of the Convention and emphasizing the need for urgency in addressing climate change”.

Built on the assessments of the IPCC and the findings of other science-based investigations of Earth’s climate system, the *Paris Agreement* is intended to steer all countries away from employing fossil fuels as the primary energy sources for economic sustainability and growth, and to show that governments around the world take climate change seriously. The *Paris Agreement* will be a major reference our course when treating climate change public policy. [<http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>]

**U.S. Global Change Research Program:**

The **U.S. Global Change Research Program** (**USGCRP**), the combined effort of 13

Federal departments and agencies, is a comprehensive and integrated United States research program that assists the nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change*.* The USGCRP released its third *National Climate Assessment* (NCA3) in May 2014. This state of knowledge report summarizes the science of climate change and impacts of climate change on the United States, now and in the future. The report presents climate-related impacts for various societal and environmental sectors and regions across the country.

Go to the highlights of the third *U. S. National Climate Assessment* (NCA3) at: [http://www.globalchange.gov/sites/globalchange/files/NCA3\_Highlights\_LowRes-small- FINAL\_posting.pdf](http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf). This *Highlights* component of NCA3 will be the primary reference used in the *Current Climate Studies* component of the **AMS Climate Studies** course.

9. NCA3 was produced by more than 300 experts drawing from a large body of scientific peer-reviewed research, technical input reports, and other publically

available sources. According to the first paragraph on page iii of the Highlights report, the overall goal of the publication is to better inform .

[ ] climate science researchers

[ ] public and private decision making at all levels

10. In the section on *Climate Change and the American People*, at the top of page 3, it is indicated the NCA3 report includes .

[ ] analyses of impacts on seven sectors

[ ] the interactions among sectors at the national level

[ ] assessments of key impacts on all U.S. regions

[ ] all of these

11. In the *Response Options* section, on page 10, it is pointed out that as the impacts of climate change become more prevalent, Americans face choices. In particular, choices have to be made about emissions of heat-trapping gases into the atmosphere. The choices are actions society should be taking to respond to the climate change challenge. These actions fall into the category(ies) of .

[ ] mitigation

[ ] adaptation

[ ] both mitigation and adaptation

**The *U.S. Climate Resilience Toolkit***:

*Current Climate Studies* segments will frequently refer to the ***U.S. Climate Resilience Toolkit***. The Toolkit is a website developed by NOAA and other Federal agencies to provide access to scientific and technical information to ensure that communities have actionable information they need to better understand climate-related risks and opportunities in order to take steps to improve their resilience to extreme events.

The *Toolkit* builds on the findings of NCA3 and related climate change scientific publications. The *Toolkit* provides guidance through the process of planning and implementing resilience-building projects.

12. Go to <https://toolkit.climate.gov/>. Click on “Steps to Resilience” at the top of the web page. Then click on “Overview” and scroll down to the Getting started section and click on “Steps to Resilience glossary.” *Resilience* is defined as the capacity of a

community, business, or natural environment to a disruption.

[ ] prevent

[ ] withstand

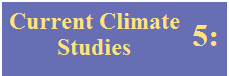
[ ] respond to

[ ] recover from

[ ] all of these

**Sample Assignment # 2 (US 2B # 2)**

***THIRD NATIONAL CLIMATE ASSESSMENT* (*NCA3*): OVERVIEW OF REPORT FINDINGS**



**The *Third National Climate Assessment* (*NCA3*) Findings**

As part of its overview, the *Third National Climate Assessment* (*NCA3*) *Highlights* document lists and briefly describes its major climate-change findings. To access *NCA3 Highlights*, go to your bookmarked *Highlights* address (if you have it bookmarked), go to the course website and click on “National Climate Assessment Highlights”, or go directly to the *Highlights*

report at [http://www.globalchange.gov/sites/globalchange/files/NCA3\_Highlights\_LowRes- small-FINAL\_posting.pdf](http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf). Then, go to page 12 where a list of a dozen particularly noteworthy findings begins.

1. *Finding 1* in the list states that global climate is changing and it is apparent across the

United States. The finding also indicates that the global warming of the past

years has been primarily due to human activity, predominantly from the burning of fossil fuels.

|  |  |
| --- | --- |
| [ ] | 50 |
| [ ] | 75 |
| [ ] | 100 |

2. *Finding 2* indicates that some extreme weather events (prolonged periods of excessively high temperatures, more heavy downpours, and in some regions, more severe drought)

have increased in recent decades. New and stronger evidence confirms that of these increases are related to human activities.

[ ] none [ ] some [ ] all

3. *Finding 3* states that human-induced climate change is projected to continue and will accelerate if global emissions of heat–trapping gases continue to increase.

Concentrations of heat-trapping gases already in the atmosphere commit us to

a hotter future over the next few decades.

[ ] does

[ ] does not

4. *Finding 4* informs us that impacts to climate change are already evident and are expected to become increasingly disruptive across the nation over the next century and beyond. There is growing evidence that harm to our country will grow over time unless global emissions of heat-trapping gases are .

[ ] totally eliminated

[ ] greatly reduced

[ ] brought to a steady rate

[ ] allowed to increase at a modest rate proportional to economic growth

5. According to *Finding 5*, climate change threatens human health in many ways, including

.

[ ] more extreme weather events

[ ] more wildfires

[ ] decreased air quality

[ ] more diseases transmitted by insects, food, and water

[ ] all of these

6. *Finding 6* indicates the damaging impacts of climate change on infrastructure is already evident and is projected to increase. Sea level rise, storm surge, heavy downpours, flooding, prolonged rains, rapid melting of snowpack, and extreme heat are listed as major causes of damage. Specifically, extreme heat is listed as damaging \_ infrastructure.

[ ] buildings

[ ] ports

[ ] industrial facilities

[ ] transportation

7. *Finding 7* states that water quality and water supply reliability are being jeopardized by climate change. Surface and groundwater supplies are already stressed in some locations due to increasing demand and declining runoff and groundwater recharge. The

part of the contiguous U.S. is projected to be most impacted by climate change in terms of water shortages and competition for water among its many users.

[ ] northern

[ ] western

[ ] eastern

[ ] southern

8. *Finding 8* describes climate disruptions to agriculture and the projection that such disruptions will become more severe during this century. Some U.S. regions and some

types of agricultural production are more resilient to climate change than others, at least for the next 25 years or so. From about 2050 onward, climate change is projected to have more negative impacts on crops and livestock in the part(s) of the country.

[ ] northern

[ ] western

[ ] eastern

[ ] southern

[ ] all of these

9. *Finding 9* reveals that Indigenous Peoples’ health, well-being and ways of life are especially susceptible to climate change. The effects of chronic stresses, including extreme poverty, are worsened by climate-change impacts. Indigenous Peoples in

are highlighted as having their critical infrastructures and traditional livelihoods negatively impacted by climate change.

[ ] Oklahoma

[ ] Washington

[ ] Florida

[ ] Alaska

10. The impact of climate change on ecosystems and the benefits they provide to society,

such as the buffering of extreme events, is treated in *Finding 10*. Climate-change impacts on biodiversity include \_ .

[ ] range shifts

[ ] species extinctions

[ ] droughts

[ ] pest outbreaks

[ ] floods

[ ] wildfires

[ ] all of these

11. Finding 11 informs that ocean waters are warming and becoming chemically

more marine life.

[ ] basic

[ ] acidic

, bringing about changes in ocean circulation, chemistry, ecosystem, and

12. *Finding 12* confirms that planning for climate-change adaptation and mitigation is becoming more widespread, but current implementation efforts are insufficient. Actions reducing heat-trapping gas emissions, increasing carbon uptake, taking adaptive measures, and increasing resilience to unavoidable impacts are steps that can improve

.

[ ] public health

[ ] economic development

[ ] ecosystem protection

[ ] quality of life

[ ] all of these

**Evidence of Climate Change Continues to Grow**

Subsequent to the publication of the *Third National Climate Assessment* (*NCA3*), a number of updated climate publications have been published. For example, the World Meteorological Organization (WMO) released its latest annual *Greenhouse Gas Bulletin* (*GGB*) as of this writing in November 2015 ([http://library.wmo.int/pmb\_ged/ghg- bulletin\_11\_en.pdf](http://library.wmo.int/pmb_ged/ghg-bulletin_11_en.pdf) ). The report confirmed that atmospheric concentrations of greenhouse

gases had reached a record high in 2014 with the average global abundance of carbon dioxide

(CO2) measured at 397.7 ppm. This value was 143% of the atmospheric concentration of CO2 in preindustrial time (1750). [The Carbon Dioxide Information Analysis Center (CDIAC) of the U.S. Department of Energy reports that in July 2016 the monthly mean CO2 measurement at Mauna Loa, HI was 404.39 ppm. (<http://cdiac.ornl.gov/>).]

According to the *GGB*, the NOAA *Annual Greenhouse Gas Index* in 2014 reported a 36% increase in total radiative forcing – the warming effect on climate - by all long-lived greenhouse gases since 1990 and a 1.2% increase from 2013 to 2014). This acceleration in the impact of greenhouse gas emissions is basic to the increased sense of urgency for action against “potentially devastating climate change.”

For the first time, the previous *GGB* issued in November 2014 included a section on ocean acidification. It reported that about a quarter of the total greenhouse gas emissions into the atmosphere due to fossil fuel combustion are absorbed by the ocean. This slows the increase in their atmospheric concentrations while making seawater more acidic. This current rate of ocean acidification appears to be the greatest during at least the last 300 million years, and is already causing destructive impacts on calcifying marine organisms and their ecosystems.

The contents of the recent issues of the WMO *GGB* are consistent with the contents of other recent climate-related publications, including the *NCA3*, except they indicate the possibility the CO2 uptake by Earth’s biosphere has been reduced. If so, this would result in higher atmospheric CO2 concentrations, greater climate change due to accelerated warming, and even more dire consequences.

13. The 2014 WMO *GGB indicated* that between 1990 and 2013, the radiative forcing (warming effect) resulting from increases in greenhouse gas concentrations in the atmosphere increased .

|  |  |
| --- | --- |
| [ ] | 36% |
| [ ] | 121% |
| [ ] | 142% |
| [ ] | 253% |

14. About a quarter of the total greenhouse gas emissions from the burning of fossil fuels that enter the atmosphere are absorbed by the ocean. This has resulted in .

[ ] the lowering of greenhouse gas concentrations from what they would have been with no ocean absorption

[ ] an increase in the acidity of the ocean

[ ] both of these

**Summary**

Studying modern climate and climate change requires, as does all scientific research, the continuous updating and revising of the knowledge base of the discipline under study. The brief overview of findings published by the WMO in its *GGB* exemplifies this iterative process.

The *National Climate Assessment* (*NCA*) is a quadrennial report that summarizes the impacts of climate change on the United States, now and in the future. The third and most recent *National Climate Assessment* (*NCA3*) released by the U.S. Global Change Research Program (USGCRP) in May 2014 drew from a large body of scientific research to produce it findings. In this *Current Climate Studies*, the synthesis of important results of the *NCA3* is presented by briefly examining many of its major findings. These findings will be visited in detail as the course progresses.

*NCA3* serves as the scientific foundation on which a ***Climate Resilience Toolkit*** has been developed “that provides a framework for understanding and addressing the climate issues that impact people and their communities.” The *Toolkit* is a website developed by the National Oceanic and Atmospheric Administration (NOAA) and other federal agencies. You can visit the *Toolkit* by going to: [http://toolkit.climate.gov/.](http://toolkit.climate.gov/)

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**Sample Assignment # 3 (US 2B # 3)**

The National Climate Assessment summarizes the impacts of climate change on the United States, now and in the future. A team of more than 300 experts guided by a 60-member Federal Advisory Committee produced a report, which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences. This report is available at <http://nca2014.globalchange.gov>.

Following tasks are to be carried out in class:

1. Browse through the report in the site above, which describes 4-5 key findings on the impact of climate change on 10 regions (Alaska, Northeast, Southeast, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawaii, Rural Communities and the Coasts). For example, for the Northeast, the four key messages are: (i) climate risks to people (heat waves, coastal flooding, river flooding); (ii) stressed infrastructure due to coastal flooding, sea level rise and intense precipitation; (iii) agriculture, fisheries and ecosystem impacts and adaptation; and (iv) planning and adaptation of municipalities and cities for future changes.

2. In our class we need to form 8 groups of students. Each of you is part of a group of 4-5 students and your group has chosen a region. This is done by the third week of the semester.

3. You will prepare a 4-5-page paper on a key finding for the particular region following the guidelines below. Each paper should contain the following sections:

* Title of the paper
* Name of the Individual Student
* Names of Group Members
* Introduction
* Overview of the Climate Assessment Report
* Summary of all Key Messages for your region
* Choose a particular Key Message and elaborate on this message (This is your unique contribution)
* Summary of the Key Message with a perspective on the Region
* References

4. You will give your presentation as part of the group presentation.

Note: The written communication paper and the presentation together weigh for 25% of the total points.