

# Climate Change in an Historical Perspective

DIS Syllabus, Spring 2012

Class Meeting Times: Tuesdays and Fridays at 08:30-9:50

Location: Vestergade 10-A11

## Course description

This course seeks to lay down the fundamental scientific principles behind climate change through an exploration of how climate has changed in the past and to describe how we have made these discoveries. The contextual framework and motivation is that recent trends of climate and other environmental changes, whether due to human activity or natural variability, have focused societal attention on their potential negative impacts on human and environmental health. An understanding of past climate variability and its underlying causes is the basis for separating natural and anthropogenic climate change and for making useful projections of future climate and assessing its impacts.

The course takes a journey through deep time describing periods of Earth's past when the climate was at times markedly different than it is today and which are particularly instructive in revealing the mechanisms and feedbacks with which the climate system operates. Many climate epochs and events of the past (and transitions between them) give hints or serve as analogues to what we might expect in the future. What can we learn from Snowball and Greenhouse Earth conditions in the very distant past, Past Ice Ages and Interglacial Periods in the more recent past, or the suite of dramatic abrupt climate changes discovered by scientists only in the last few decades? A particular emphasis is placed on the last 20,000 years, which includes the transition from the last Ice Age through the current Holocene period up to the present day. This period spans all recorded human history and the development of sedentary cultures and agriculture.

A particularly Danish dimension shines through in this course via Denmark's leading role historically and internationally in the study of polar ice cores. Ice core analysis is a key and powerful tool for investigating the past, where long cores of glacial ice from the Greenland and Antarctic ice sheets provide some of the most detailed and comprehensive archives of environmental change available to scientists. A visit to the ice core facility at University of Copenhagen and special lectures from our local experts on ice cores will supplement the course activities.

While understanding of the climate system is the main objective, the role of mankind in the dual role of both adapting to and causing climate change will be emphasized. The historical development of the science of climate change and the scientists that played key roles in our present understanding of the dynamics of climate and the challenges they faced in the dogma of their time will add flavour to the class.

## Learning objectives

At the end of this course students should be able to:

- explore past climate change in order to contextualize current and projected climate change
- understand a selection of climate change causes
- be able to separate weather and climate phenomena
- understand similarities and differences between "natural" and "anthropogenic" climate change
- gain an understanding of the methods applied in palaeoclimatology, including different indirect measurements (proxies) and dating methods
- understand climate conditions as a key factor in the evolution of modern civilization.
- understand the basis for climate projections and the source of some of the main uncertainties

## Instructors

The teachers work at Centre for Ice and Climate at the Niels Bohr Institute of University of Copenhagen, which is a world leading research group in ice core science.

**Trevor Popp**, postdoc at Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen. BS in Chemistry and MS in Oceanography (Florida State University); PhD in Geology (University of Colorado, Boulder).

Works with isotope analysis of ice cores for understanding abrupt and catastrophic climate changes. Chief driller of the NEEM deep ice core drilling project in Greenland.

**Sune Olander Rasmussen**, postdoc and coordinator at Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen.

BS in Physics, MS and PhD in geophysics (University of Copenhagen).

Works with dating and stratigraphic analysis of ice cores and studies of how Greenland climate records compare with other records of past climate.

Chairman of the EU-funded project INTIMATE (INTegrating Ice core, MARine and TERrestrial records).

The teachers do not have fixed office hours for students consultations. You are always welcome to talk after class or to contact us for a meeting at our work place, Juliane Maries Vej 30, Østerbro.

### **DIS Contacts:**

Anette Birck, SIE Program Director: [abi@dis.dk](mailto:abi@dis.dk)

Madeleine Brown, SIE Program Assistant: [mbr@dis.dk](mailto:mbr@dis.dk)

## Course Structure

The plan of topics, reading etc. is updated on the Forum course pages. Assigned reading and other details on the meetings is subject to change but will be updated online no later than 6 days before each meeting.

## Excursions

### **February 22: Excursion to the Ice Core Laboratory at Centre for Ice and Climate, University of Copenhagen**

Please reserve the afternoon of February 22, 1 – 5 PM.

### **April 25: Exam preparation, 8.30-12.30 in Vestergade 10-A11**

### **April 28: Weekend excursion to Møns Klint and Stevns Klint: Looking into the ancient past**

Møns Klint is a spectacular natural attraction with visible evidence of active geological processes, and includes a high-class geology museum. Stevns Klint contains a world-renowned visible record of past climate change known as the K-T boundary, between the Cretaceous and the Paleogene approximately 65 million years ago.

Depending on time and weather, some of the following sites of cultural significance in the area will be added: Højerup's old church, Elmelunde, Keldby or Fanefjord churches (the Elmelunde Master, 15<sup>th</sup> century), King Asgars Mound (one of Denmark's biggest passage graves, 3-1.5 BC).

The excursion starts in the morning and continues into the evening; do not make other plans for the entire day.

## Course evaluation:

To be eligible for a passing grade in this class you must complete all of the assigned work. The overall grade will come from the following:

25%: *5 short quizzes* based on assigned reading and class discussions, one for each topic block as defined in the syllabus. These will be announced and completed during 10-15 minutes of class time.

30%: *Mid term written exam* with ½-page answers of a number of essay questions based on the first three topic blocks of the course. This will take place in class before the long study tour. Please note the notice on notes below.

30%: *Final oral exam*: With both instructors each student will have 20 minutes to present and discuss of one out of four questions, all known in advance. The questions are based on the entire course content. Each student will schedule a time to take the exam on either May 10 and 11. A special session will be held April 25th to aid in your preparation and clarify expectations for the exam.

15%: *Participation and Forum Reading Feedback*. We expect and encourage active participation in class discussions and require written feedback via DIS Forum of each lessons assigned reading. Here you will summarize the main points of the reading and pose questions that can be covered as part of the class discussion (see below).

## Reading and notes:

### Required texts:

*Ice, Mud and Blood: Lessons from Climates Past.* Chris Turney, 2008

*Earth's Climate Past and Future*, 2<sup>nd</sup> edition, William F. Ruddiman, 2008

We expect students to read the assigned reading prior to each class. We expect the students to spend at least 2 hours for reading and preparation per meeting. In the classroom, we will not cover all the material in the assigned text, but will focus on key concepts and the understanding of the underlying processes and the similarities and differences between climate change on different time scales.

In order to get the most out of the time in class, we ask you to post the following on the course page on the DIS Forum course page no later than 1pm the day before each class:

- What would you define as the key 1-3 messages of today's text?
- Mention any specific sections or concepts in today's text that you find particularly difficult.
- Pose questions that you would like to include as part of the class discussion

Students are encouraged to write notes to summarize the assigned reading. Self-made notes (one standard paper page per textbook chapter) are the only allowed aids during the mid-term written exam.

Specific additional reading can be assigned among the following based on the direction of class discussions and interest of the students:

-*Rocks, Bones and Stars*, Chris Turney, 2006

-*Quaternary Dating Methods*, Mike Walker, Wiley 2005

-*Reconstructing Quaternary Environments*, John Lowe and Mike Walker, 1997

-IPCC AR4: Summary for policymakers, Technical Summary, and chapters from WG1

-*Abrupt Climate Change: Inevitable Surprises*, National Research Council, 2002

-Sources in primary and secondary scientific literature may also be employed if class discussion warrant.



## Policies and expectations

Attendance is expected. Please let us know by e-mail if you are unable to attend a meeting. You are welcome in class also if late, but note that we often give vital clues about test questions etc. during the first 10 seconds of class.

Focused and constructive contribution in class discussions is encouraged and expected. If you feel tired, feel free to get up and walk around in the back of the classroom.

Laptops, phones and other portable electronic devices can be used for taking notes if in silent mode, but please refrain from writing or checking e-mail and text messages, browsing, or using social networks during class hours. As an exception, snappy tweets about climate-related subjects are accepted.

During student presentations and group work, we kindly ask you to turn off or put electronic devices away.

Any student who has a need for disability accommodations should contact Sean Green ([sgr@dis.dk](mailto:sgr@dis.dk)) to coordinate this. Upon DIS approval, students should inform the instructor of accommodations within the first 2 weeks of class.

## Class Schedule:

Meeting	Instructor	Date	Lecture Title	*Reading
1	Both	January 27	Course Orientation, Defining the Climate Change Problem	<i>IMB</i> pp. 1-11; <i>EC</i> pp. 4-16
2	Sune	January 31	The physics of the Greenhouse	<i>EC</i> pp. 44-53; <i>IMB</i> Chapt 1
3	Sune	February 3	Climate Models	<i>EC</i> pp. 31-39; plus supplementary
4	Trevor	February 7	Time Scales; Earth's climate and the atmospheric composition over deep geological time	<i>IMB</i> Chapter 2
5	Trevor	February 14	Paleoclimate archives and dating methods (1)	<i>EC</i> pp. 18-31
6	Trevor	February 17	Paleoclimate archives and dating methods (2)	<i>B.R.S.</i> Chapter 3; <i>EC</i> 359-364
7	Trevor	February 21	Earth's orbit and climate change (1): The discovery of Ice Ages	<i>IMB</i> Chapter 3
<i>FS</i>	<i>Both</i>	<i>February 22</i>	<i>Field study to CIC</i>	
8	Trevor	February 24	Earth's orbit and climate change (2): Orbital geometry and Milankovitch	<i>EC</i> pp. 116-133
9	Trevor	February 28	Past interglacials and the Eemian	<i>IMB</i> Chapter 4
10	Sune	March 2	The ice age in Denmark ( <i>Guest Lecture: Kurt Kjær, Geological Museum</i> )	No assigned reading
			<i>long study tour</i>	
11	Sune	March 13	The Last Glacial Period: Millennial Oscillations, DO events, and THC	
12	Sune	March 16	Bølling-Allerød and Younger Dryas climate events and the Bi-Polar Seesaw	
13	Sune	March 20	Sea level history and glacial melt water pulses	
14	Sune	March 23	A third lecture on the above topics with time for group work / cause-and-effect game etc.	
15	Trevor	March 27	Abrupt Climate Change and Thresholds	
16	Trevor	March 30	<b>Mid Term Exam</b>	
			<i>travel break</i>	
17	Sune	April 17	Early Holocene climate and impacts for migration and agriculture	
18	Trevor	April 20	Vikings in Greenland, the Little Ice Age and Medieval warm period	
19	Sune	April 24	Tying instrumental records to archives of paleoclimate	
<i>FS</i>	<i>Both</i>	<i>April 25</i>	<i>Oral exam preparations</i>	
20	Sune	April 27	Causes of warming since the industrial revolution	
<i>Excursion</i>	<i>Both</i>	<i>April 28</i>	<i>Møns Klint etc.</i>	
21	Sune	May 1	Forecasting the future	
22	Trevor	May 8	Adaptation and mitigation of climate change/Greenhouse gases: budgets, sources and sinks	
23	Both	May 11	Oral Exam (To include May 10th)	
			<b>Field Studies:</b>	
		February 22	1 - 5 PM, Center for Ice and Climate ice core facility	
		April 25	8.30-12.30 in 10-A11, Exam Preparation	
		April 28	Field Trip (Whole Day): Møns Klint and Stevn's Klint: geological and cultural histories of Denmark	
			<b>*Reading:</b> EC = Earth's Climate Past and Future, 2nd edition, William F. Ruddiman, 2008	
			IMB = Ice, Mud and Blood: Lessons from Climates Past. Chris Turney, 2008	
			BRS = Rocks, Bones and Stars, Chris Turney, 2006 (posted on Forum)	
			<i>Additional readings will be posted as pdf files on Forum</i>	