Course Syllabus

SIT Study Abroad
School for International Training

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The Arctic: Changing Ecosystems and Resilience

ENVI 3000 (3 credits / 45 class hours)

SIT Study Abroad Program:

Iceland and Greenland: Climate Change and The Arctic

PLEASE NOTE: This syllabus represents a recent semester. Because courses develop and change over time to take advantage of unique learning opportunities, actual course content varies from semester to semester.

Description

The Arctic, a region of major importance to the world, is changing rapidly. This seminar makes the effects of climate change in this unique part of the world a subject of discussion. It addresses the conditions of change in the Arctic, spanning ecological, social, and political-economic contexts. The seminar also considers community adaptation to the changing environment around them. Sessions will take place in different parts of Iceland in cooperation with program partners and working groups of the Arctic Council, as well as in Nuuk, Greenland, at the Greenland Institute of Natural Science. Students will learn from experienced scientists, competent instructors, and experts of the Arctic Council.

Learning Outcomes

By the end of the seminar, students will be able to:

- Demonstrate understanding of the landscape, geography, and biological and physical systems of the Arctic, how these interact with and affect climate, and observed changes in Arctic climate;
- Recognize observed patterns of recent climate variability as well as projected changes;
- Understand key environmental impacts of climate variability and characterize the uncertainties associated with predictions of future changes;
- Analyze both scientific perspectives and traditional knowledge of climate change in the Arctic and produce analytical essays on these perspectives.

Language of Instruction

This course is taught in English, but students will be exposed to vocabulary related to course content through in-country expert lectures and field visits in a wide range of venues and regional locales.

Course Schedule

*Please be aware that topics and excursions may vary to take advantage of any emerging events, to accommodate changes in our lecturers' availability, and to respect any changes that would affect student safety. Students will be notified if this occurs.

Module 1: The Arctic and the Arctic Climate System

This module introduces students to the landscape and recent issues of the Circumpolar World. The course broadly examines Arctic geography and the region's biological and physical systems, as well as observed changes. The course content is an interdisciplinary mix of topics designed to introduce students to the Arctic.

Session 1: The Role of the Arctic in the Global Climate System

Changes that take place in the Arctic climate system exert influence throughout the global climate system and vice versa. Students are introduced to the global climate system and Arctic climate feedbacks.

Required Reading:

Callaghan, T. et al. (2011) Feedbacks and Interactions: From the Arctic Cryosphere to the Climate System. In *AMBIO*, 40:75-86.

Session 2: Physical Characteristics and Climate Features

This session provides an introduction to characteristics of the Arctic climate system and climate features. The session addresses the diverse characteristics of the Arctic which encompass a range of land- and seascapes, from mountains and glaciers to flat plains, from coastal shallows to deep ocean basins, from polar deserts to sodden wetlands, from large rivers to isolated ponds.

Required Reading:

Serreze, M. and Barry, R. (2014) *The Arctic Climate System. Second Edition.* Cambridge Atmospheric and Space Science Series (Chapter 2: Physical Characteristics and Basic Climate Features).

Session 3: Trends and Projected Changes in the Arctic

Students will analyze trends and projected changes regarding the changing climate. The focus is on climate variability and scientific projections regarding climate change in the Arctic. The session also provides a preliminary discussion of climate modelling.

Required Reading:

Serreze, M. and Barry, R. (2014) *The Arctic Climate System. Second Edition.* Cambridge Atmospheric and Space Science Series. (Chapter 11: Recent Climate Variability, Trends and the Future).

Module 2: Arctic Climate Change

This module addresses causes and consequences of climate variability in the Arctic. Topics will include structure of the climate system, observed changes and emerging impacts, climate variability, an overview of trends, and associated uncertainties. Emphasis is placed on the science of climate change. Students will learn to recognize observed patterns of recent climate

variability, understand key environmental impacts, and characterize the uncertainties associated with predictions of future changes.

Session 1: Observed Changes and Emerging Impacts

Observations from satellites, sensors, data, and from people who live in the Arctic reveal that the Arctic climate is changing. This session familiarizes students with recent observations and provides a summary of the effects of Arctic climate change and regional implications.

Required Reading:

ACIA - Arctic Climate Impact Assessment (2004) *Impacts of a warming arctic.* Cambridge University Press, Cambridge, UK, p 139.

ACIA - Arctic Climate Impact Assessment (2005) *Arctic Climate Impact Assessment.* Cambridge, Cambridge University Press.

Anisimov, O.A., D.G. Vaughan, T.V. Callaghan, C. Furgal, H. Marchant, T.D. Prowse, H. Vilhjálmsson and J.E. Walsh, 2007 Polar regions (Arctic and Antarctic). Climate Change 2007: Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, 653-685.

ACIA - Arctic Climate Impact Assessment (2005) *Arctic Climate Impact Assessment.* Cambridge, Cambridge University Press.

Session 2: Adaptation to Climate Change in the Arctic

Adaptation to climate change is a main challenge for Arctic indigenous communities and the world. This session appraises the importance of indigenous knowledge in adapting to climate change and explores the implications of projected changes to the climate on human resilience.

Required Reading:

Huntington, H., Fox, S. (2005). The Changing Arctic: Indigenous Perspectives. In *Arctic Climate Impact Assessment* – ACIA, (Chapter 3), pp. 61-98.

Session 3: Field Excursion

This field-based session will provide students with the opportunity to observe the impact of climate change on Arctic vegetation, soils, and permafrost.

Module 3: Sea Ice and the Ocean

The most visible and informative indicator of climate change in the Arctic is the change in sea ice cover. Arctic sea ice extent has declined over the past decades with far-reaching consequences for ecosystems and humans. Knowledge of the elements of the cryosphere, environmental changes, and associated impacts is an essential component in the study of climate change and the Arctic. Students are introduced to both traditional knowledge and scientific perspectives.

Session 1: Overview of Changes in Sea Ice Cover

The first session introduces students to the history of Arctic sea ice conditions and the state of research, trends, and prognosis. The session also provides an overview of changes in sea ice cover and the thinning of the ice sheet.

Required Reading:

Stroeve, J. et.al (2012) The Arctic's rapidly shrinking sea ice cover: a research synthesis. *Climatic Change,* 110:3-4, pp 1005-1027.

Stroeve J. (2009) Overview of Changes in the Arctic Sea Ice Cover. *Climate Change and Arctic Sustainable Development.* Paris, UNESCO publishing.
UNEP (2007) *Global Outlook for Ice and Snow.* United Nations Environment Programme, UNEP/GRIDArendal, Norway. Retrieved from: http://www.unep.org/publications.

Session 2: Sea Ice Formation and Morphology

This session focuses on the characteristics, properties, and processes related to sea ice. Students learn about the growth, structure, and properties of sea ice and the impact of climate change on ice sheet melting.

Required Reading:

Petrich, C. and Eicken, H. (2010) Growth, structure and properties of sea ice. In Thomas, D. and Dieckmann, G (Eds.) *Sea Ice. (Second Edition).* Blackwell Publishing.

Session 3: Sea Ice Motion and Sea Ice Thickness

This session introduces students to sea ice dynamics and drift systems. Students learn about further characteristics and features of sea ice, including thickness and age, as well as their relevance for recent research. This session will take place in the field.

Required Reading:

Haas, C. (2010) Dynamics vs Thermodynamics: The Sea Ice Thickness Distribution. In Thomas, D. and Dieckmann, G (Eds.) *Sea Ice. (Second Edition)* Blackwell Publishing.

Session 4: Cryosphere and Climate System

This session addresses the changing Arctic cryosphere and its interactions with the global climate system. The focus is on changes in retreating ice sheets and permafrost and ocean-sea ice climate interaction.

Required Reading:

AMAP (Arctic Monitoring and Assessment Programme) (2011) *Arctic Climate Issues 2011. Changes in Arctic Snow, Water, Ice and Permafrost.*
Callaghan, T. et al. (2011) Feedbacks and Interactions: From the Arctic Cryosphere to the Climate System. In *AMBIO, 40:75-86.*
Noty, D. (2000) The future of ice sheets and sea ice: Between reversible retreat and unstoppable loss. In *PNAS,* 106:49.
Serreze, M. and Barry, R. (2014) *The Arctic Climate System. (Second Edition)* Cambridge Atmospheric and Space Science Series *(*Chapter 7: Arctic Ocean-Sea Ice-Climate Interactions).

Session 5: Sea Ice Monitoring and Prediction

This session provides an introduction to sea ice monitoring techniques and research methods. The session also tools and methods for monitoring ice thickness changes.

Required Reading:

National Snow and Ice Data Center: http://nsidc.org/arcticseaicenews/
Duerr, RE, J McCusker, MA Parsons, SS Khalsa, PL Pulsifer, C Thompson, R Yan, DL McGuinness and P Fox (2015) Formalizing the semantics of sea ice. *Earth Science Information 8* (1) 51-62. (Accessed through: http://cires1.colorado.edu/websites/nsidc/publications/index.php)

Module 4: Glaciers and Climate Change
This module analyzes the role of glaciers in the equilibrium of Arctic ecology and ecosystems. Students learn about the morphology of glaciers and glacial mechanics, glacial erosion, permafrost, and modeling.

Session 1: Glaciers and Geomorphology
This session provides an overview of glacial geomorphology and impacts of glaciers and ice sheets on landform and landscape development. The session also addresses process models and form evolution on the basis of indicators such as ice flow, basal sliding, erosion and deposition processes.

Required Reading:
Alan R. Gillespie**,** Alan R. (2014) Glacial Geomorphology and Landforms Evolution. *Encyclopedia of Snow, Ice and Glaciers*, pp. 341-358.
Harbor, Jonathan M. (1993) Glacial geomorphology: modeling processes and landforms. *Geomorphology* (7): 1–3**,** July, pp. 129–140.

Session 2: Glaciers and Permafrost
This session analyzes the complex relationship between glaciers and permafrost. Permafrost can be thousands of years old, newly formed, and often close to its melting point. Model projections and observations indicate permafrost degradation. The session also addresses the impact of retreating and decaying glaciers on climate change.

Required Reading:
Harris, C. and Murton, J. B. (Eds.) (2005) Interactions between glaciers and permafrost: an introduction. *Cryospheric Systems: Glaciers and Permafrost.* London: Geological Society, Special Publications, 242, 1-9. Retrieved from: http://sp.lyellcollection.org/content/242/1/1.full.pdf+html
Schuur, EAG, AD McGuire, C Schadel, G Grosse, JW Harden, DJ Hayes, G Hugelius, CD Koven, P Kuhry, DM Lawrence, SM Natali, D Olefeldt, VE Romanovsky, K Schaefer, MR Turetsky, CC Treat and JE Vonk (2015) Climate change and the permafrost carbon feedback. *Nature 520* (7546) 171-179. Accessed through: http://cires1.colorado.edu/websites/nsidc/publications/index.php

Session 3: Field Excursion (Drangajökull – Icelandic Met office)
Through this field excursion to Drangajökull in the Westfjords, students study glaciers where, unlike in south Iceland, enough snow has accumulated for the past couple of years to add to the mass of the glaciers. The excursion is co-led by a glaciologist from the Icelandic Met office.

Required Reading:
Brynjólfsson, Skafti et al. (2015) A 300-year surge history of the Drangajökull ice cap, northwest Iceland, and its maximum during the 'Little Ice Age.' *The Holocene*, March 24.

Module 5: Arctic Resilience and Adaptation
This module is delivered in Greenland. The Arctic has always undergone change, and indigenous peoples in the Arctic have depended on and adapted to their environment. Their knowledge of their surroundings is a vital resource for their well-being. Adaptation to climate change is a key challenge for Arctic peoples and the world. The module is also based on knowledge and information derived from field visits and interaction with local communities in Greenland.

Session 1: Community-Based Adaptation – A Case Study from Greenland

This session explores community-based reactive and anticipatory interventions to climate change. Climate change and policy and regulations have compelled households and individuals to adapt to the new environment. Discussions about the efficiency of adaptation to climate change continue throughout the excursion.

Required Reading:

Ford, James D. and Goldhar, Christina (2012) Climate change vulnerability and adaptation in resource dependent communities: a case study from West Greenland. Climate Research, 54, pp. 181-196. Retrieved from: http://www.int-res.com/articles/cr_oa/c054p181.pdf

Session 2: Traditional Knowledge for Adaptation

This session is focused on the importance of indigenous knowledge in the design of adaptation strategies to climate change. The session looks at cases from the areas of fishing, construction, and energy use.

Required Reading:

Huntington, H., Fox, S. (2005): The Changing Arctic: Indigenous Perspectives. In: Arctic Climate Impact Assessment – ACIA. Chapter 3. Pp. 61-98.

Johnson, N, L Alessa, C Behe, F Danielsen, S Gearheard, V Gofman-Wallingford, A Kliskey, EM Krummel, A Lynch, T Mustonen, P Pulsifer and M Svoboda (2015) The Contributions of Community-Based Monitoring and Traditional Knowledge to Arctic Observing Networks: Reflections on the State of the Field**.** *Arctic 68* (5). (Accessed through: http://cires1.colorado.edu/websites/nsidc/publications/index.php)

Evaluation and Grading Criteria

Papers will be graded on style and structure, depth of analysis, and synthesis of secondary and primary sources.

Description of Assignments:

- Review (4 pages): the review should cover at least two of the references of the required predeparture readings.
- Research Paper (6-8 pages): the paper should demonstrate the student's ability to apply scientific methods and critical thinking in engaging with Arctic climate change, changing ecosystems, and resilience.
- Quizzes: Two in-class quizzes will be used to assess students' knowledge of the theoretical and field-based materials covered in class lectures and during site visits.
- Participation: Participation will be graded by timely arrival, active involvement in class discussions, and culturally appropriate behavior on excursions.

Assessment:

Review	20%
Thematic paper	40%
Two quizzes	30%
Participation	10%

Grading Scale:

94-100% A

90-93%	A-
87-89%	B+
84-86%	B
80-83%	B-
77-79%	C+
74-76%	C
70-73%	C-
67-69%	D+
64-66%	D
below 64%	F

Expectations and Policies

- Show up prepared. Be on time, have your readings completed and points in mind for discussion or clarification. Complying with these elements raises the level of class discussion for everyone.
- Have assignments completed on schedule, printed, and done according to the specified requirements. This will help ensure that your assignments are returned in a timely manner.
- Ask questions in class. Engage the lecturer. These are often very busy professionals who are doing us an honor by coming to speak.
- Comply with academic integrity policies (no plagiarism or cheating, nothing unethical).
- Respect differences of opinion (classmates, lecturers, local constituents we engage with on site visits). You are not expected to agree with everything you hear, but you are expected to listen across difference and consider other perspectives with respect.

Academic Policies: SIT prides itself on providing students with an experientially based program; we hold ourselves, and our students, to the highest of academic standards. Students are asked to refer to the **SIT Study Abroad Handbook** for policies on academic integrity, ethics, academic warning and probation, diversity and disability, sexual harassment and the academic appeals process.

Disability Services: Students with disabilities are encouraged to contact Disability Services at disabilityservices@sit.edu for information and support in facilitating an accessible educational experience. Additional information regarding SIT Disability Services, including a link to the online request form, can be found on the Disability Services website at http://studyabroad.sit.edu/disabilityservices.