School for International Training | 1 Kipling Road, PO Box 676 | Brattleboro, VT 05302-0676 USA
Tel 888 272-7881 | Fax 802 258-3296 | studyabroad.sit.edu

Climate Modeling and Carbon Management

ENGR 3000 (3 credits / 45 hours)

Iceland: Climate Change and the Arctic

This syllabus is representative of a typical semester. Because courses develop and change over time to take advantage of unique learning opportunities, actual course content varies from semester to semester.

Description

This seminar focuses on the analysis and use of climate models in understanding and projecting climate change in the future. Though climate models are based on quantitative data and physical principles and have been shown to reproduce climate projections, they are constantly subjected to more systematic evaluation for higher fidelity. Estimates based on climate variables such as temperature and cloud or cryospheric feedbacks provide high credibility for scientific climate change projections. Though a reliable model of metrics for climate projections is yet to be developed, interactive aerosols are now included in most climate models and substantial progress has been made in the areas of computational methods and the simulation of modes of climate variability. The seminar also addresses issues of gas emission, carbon containment, and management. The focus is on Iceland's innovative experiments with carbon storage and the development of renewable energies. The seminar relies on resources available through program partners including University Centre of the Westfjords, University of Akureyri, University of Iceland, and the University Lapland's Arctic Centre in Rovaniemi, Finland.

Learning Outcomes

The *Climate Modeling and Carbon Management* course comprises 45 hours of instruction (3 credits). Upon completion of the course, students will be able to:

- Judge the feasibility of existing carbon management strategies/goals and design new targets or strategies to meet goals;
- Use software to generate climate models;
- Analyze climate literature, with the aim of contextualizing literature within its proper field and theoretical background and identifying uncertainties in climate research.

Language of Instruction

This seminar 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
Students will be provided a detailed course schedule during orientation on the program. 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: Modeling Arctic Climate Change
This module facilitates students' work with climate data and simulations of the earth's changing climate. It uses insights from physics, chemistry, biology, and earth and atmospheric sciences. The module discusses models of climate systems and analyzes the role of climate simulation and uncertainty in modeling Arctic climate change.

Session 1: Types and Sensitivity of Climate Models
This session provides a general introduction to types of climate models and techniques for assessing model performance. The session also addresses methods used to assess climate sensitivity.

Recommended Reading:
Drake, J. B. (2014). *Climate modeling for scientists and engineers* (Vol. 19). SIAM.
Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W. J., ... & Forest, C. (2013). Evaluation of climate models. In: climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. *Climate Change 2013*, *5*, 741-755 (Chapters 9.1 Climate Models and Their Characteristics and 9.2 Techniques for Assessing Model Performance). Retrieved from: https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter09_FINAL.pdf
Randall, D. A., Wood, R. A., Bony, S., Colman, R., Fichefet, T., Fyfe, J., ... & Stouffer, R. J. (2007). Climate models and their evaluation. In *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC (FAR)*. Cambridge University Press, 629-639 (Chapter 8.6 Climate Sensitivity and Feedbacks). Retrieved from: https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter8.pdf

Session 2: Working with Climate Models: Integrated Assessment Modeling
This session focuses on ways in which climate models work and the reliability model predictions for future climate change. The session also addresses climate modeling in the atmosphere and surface warming.

Recommended Reading:
Rasch, P. J. (Ed.) (2015). *Climate Change Modeling Methodology*. Larkspur, CA: Springer.
Skeptical Science. (2012). How do climate models work? Retrieved from: http://www.skepticalscience.com/how-do-climate-models-work.html

Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W. J., ... & Forest, C. (2013). Evaluation of climate models. In: climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. *Climate Change 2013*, *5*, 760-794 (Chapter 9.4 Simulation of Recent and Longer-Term Records in

Global Models). Retrieved from: https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter09_FINAL.pdf

Session 3: Uncertainty and Climate Modeling
This session addresses climate model inadequacy and uncertainty and the importance of understanding the uncertainty in climate predictions. The session focuses on key uncertainties such as greenhouse gas forcing and model inadequacy. The session also analyzes examples of model uncertainty and methods to reduce uncertainty and increase resilience.

Session 4: Integrated Assessment Modeling and Climate Simulation and Analysis
The session addresses the strengths and limitations of integrated assessment modeling and its impact on sustainability. The session also focuses on reliability and efficiency of integrated assessment models in simulating climate change.

Module 2: Geoengineering and Carbon Economics
This module analyzes the greenhouse effect, the carbon cycle, and how fossil fuels affect that cycle. Students survey innovative strategies for a low-carbon built environment. The focus is on Iceland's innovative approach to carbon dioxide management, renewable energy, and the impact of climate change.

Session 1: Low-Carbon Energy Technologies
This session focuses on the development of local-carbon energy technologies and greenhouse gas emissions cuts. The focus is on Iceland's innovative approach and EU and global climate objectives. The session also addresses low-carbon energy development in the particular area of built environment.

Recommended Reading:
Emmanuel, R., & Baker, K. (2012). *Carbon management in the built environment*. Routledge.

Session 2: Development of Non-fossil Energy Systems
This session is focused on the discussion of the non-fossil energy systems as they relate to a limited fossil energy, increasing energy demand, and global warming. The session also addresses the development of non-fossil energy technologies and policy.

Recommended Reading:
Narbel, P. A., Hansen, J. P., & Lien, J. R. (2014). *Energy technologies and economics*. Springer. (Chapter 1: Basic Physical Processes and Economics and Chapter 2: Fossil Energy Systems).

Session 3: Innovation and Carbon Dioxide Management
This session is led by Sandra Snaebjornsdottir (depending on availability), an Icelandic scientist engaged in an innovative experimental project that aims to make gas turn into stone for better storage of carbon dioxide emitted in the air.

Recommended Reading:
Fountain, H. (2015).Turning Carbon Dioxide into Rock, and Burying It. In *The New York Times.* Retrieved from: http://www.nytimes.com/2015/02/10/science/burying-a-mountain-of-co2.html?_r=0

Session 5: Marine Renewable Energy

This session explores the benefits of offshore wind, wave, and tidal energy development as renewable energy options. Students assess the promise and challenges of these energy options through field visits and interactions with the community of local experts.

Recommended Reading:

International Energy Authority Renewable Energy Technology Deployment (IEA-RETD). (2012). *Offshore Renewable Energy: Accelerating the Deployment of Offshore Wind, Tidal, and Wave Technologies*. Oxford: Routledge. (Chapter 3: Offshore Renewable Energy Technologies).

Module 3: Arctic Energy

This module introduces students to energy topics in the Arctic with a particular focus on tangible case studies and projects in Iceland and Finland. Topics include global energy markets, Arctic resources, relevant technological developments, associated environmental risks, and impacts on Arctic coastal communities.

Session 1: Arctic Energy Resources

This session addresses energy potential of the Arctic, including projected quantity and location of oil and gas reserves. The session engages with the question of how the Arctic's energy resources will contribute to the global energy mix in the decades to come.

Recommended Reading:

Schaeffer, R., Szklo, A. S., de Lucena, A. F. P., Borba, B. S. M. C., Nogueira, L. P. P., Fleming, F. P., ... & Boulahya, M. S. (2012). Energy sector vulnerability to climate change: a review. *Energy*, *38*(1), 1-12.

Session 2: Arctic Oil and Gas Exploration

This session focuses on the recent and projected development of oil and gas exploitation in the Arctic.

Required Reading:

Arctic Council (2009): Arctic Council Offshore Oil and Gas Guidelines. Retrieved from: http://www.govmin.gl/images/stories/petroleum/Arctic_Offshore_Oil_and_Gas_Guidelines_2009.pdf

Session 3: Renewable Energy Potential in the Arctic

This session provides a comprehensive overview of the future potential of renewable energy sources and the role of alternative energy systems and the new Arctic portal. The session is led by Bjorn Gunnarsson, from the School for Renewable Energy Science in Akureyri, Iceland.

Required Reading:

Aslani, A., Naaranoja, M., & Wong, K. F. V. (2013). Strategic analysis of diffusion of renewable energy in the Nordic countries. *Renewable and sustainable energy reviews*, *22*, 497-505.

Session 4: Renewable Energy Potential in Finland
This session takes place in Finland, where students are introduced to sample renewable energy projects and research from Finland.

Required Reading:
Aslani, A., Naaranoja, M., & Wong, K. F. V. (2013). Strategic analysis of diffusion of renewable energy in the Nordic countries. *Renewable and sustainable energy reviews*, *22*, 497-505.

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

Carbon footprint assignment (45%): Students will analyze carbon footprints at three scales, create carbon scenarios for all scales, and determine the most efficient level of implementation.

Climate modeling assignment (45%): Students will find an example of a climate paper in the literature and run the same climate scenario. Student results will be compared to published results and efficacy and discrepancies will be evaluated.

Participation (10%):
Participation will be graded by timely arrival, active involvement in class discussions, and culturally appropriate behavior on excursions.

Assessment:

Carbon Footprint assignment	45%
Climate modeling assignment	45%
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 to discuss. Be on time, have your readings completed and points in mind for discussion or clarification. Complying with these elements raises the level of class engagement for everyone.

- Have assignments completed on schedule 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. There is no tolerance for plagiarism or cheating.
- 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.