UofT MEnvSc: Climate Change Impacts & Adaptation

There is an urgent societal need for science-based, policy relevant expertise in assessing the impacts of climate change. The Climate Change Impacts and Adaptation (CCIA) stream is designed for a new generation of climate change scientists, providing a well-defined curriculum ensuring quality training of graduates in this field and, explore and plan for climate change over the next few decades.

Core Courses:

EES1100H Advanced Seminar in Environmental Science

This course is designed to introduce MEnvSc students in the research, internship and part-time enrollment options to the key topics of relevance in their chosen fields of study in environmental science. In the first (fall) term, seminar speakers are drawn from faculty, visiting researchers and environmental science professionals. In the second (winter) term, students are required to participate in an experiential learning opportunity that focuses on solutions to a current environmental problem. This class is co-facilitated by MEnvSc Program Directors and the Internship Team.

To support students' career development and job search preparation, instruction and events/activities related to the following topics will also be included:

- Professional development instruction on the environmental labour market, job search skills, resume and cover letter writing, interview preparation and networking
- Employer guest speakers from various sectors of the environmental field including government, non-profit and private industry
- Alumni-to-peer mentoring events; and
- Participation in exclusive student-employer networking events and/or information sessions

EES1117H Climate Change Impact Assessment

The study and consideration of climate change is of increasing significance to society. This course will review the evidence for climate change over the past 150 years using both direct measurements and proxy data. Projection of future climate change will also be considered by modeling. Students will complete a major case study and research paper.

EES1132H Climate Data Analysis

This course will offer an advanced introduction to climate data analysis. It is intended for graduate students studying climate science and is mainly laboratory (computer) based. For the first part of the course, the goal is to provide an understanding of the theory underlying the statistical analysis of climate data, in the space, time and spectral domain. In the second part of the course, the basic concepts of time series analysis will be introduced in terms of identifying stationarity or trends in the data. Some of the important statistical estimation techniques such as regression, correlation and spectral analysis will be used for the time series analysis by giving a detailed account on the interpretation of the data and the associated climatological questions. Although some previous knowledge of probability and statistics will be helpful, a review will be provided at the beginning of the course. Concepts and notation will be reintroduced, as needed. If time permits, the statistical modelling approach will also be covered.

EES1133H Climate Change Science and Modelling

The course is designed to introduce the fundamental concepts underlying our current understanding of the climate system. The science of climate includes basic radiation physics and dynamics, which are the basis of modern climate modelling. The changes in the radiation energy budget will be examined in terms of natural variability and anthropogenic activities, in particular, greenhouse gases and their sources and sinks. Underlying physical processes that shape our climate will be explored e.g. solar variability, orbital mechanics, atmospheric and oceanic circulation, and volcanic and atmospheric aerosols. In addition, the types of climate modelling experiments performed with modern climate models and scenarios will be reviewed by focusing on the evidence for past and present climate change. The latest projections of future climate on a variety of temporal and spatial scales will also be presented and evaluated. This course is aimed at connecting the essentials of climate science and modelling, and training students to interpret the results of modelling experiments.

EES1134H Climate Change Policy

All policy is climate change policy. The challenges and solutions for climate change span across society and the economy, which means that addressing the climate crisis requires transformative change to both eliminate greenhouse gas emissions and adapt to the impacts of climate change. Global greenhouse gas emissions need to reduce rapidly in the next ten years and reach net zero around mid-century in order to have a chance of avoiding dangerous climate change. At the same time, climate change is exacerbating existing societal vulnerabilities and is having deep impacts across natural and social systems. This course focuses on the governance of the transformation necessary to address this crisis and covers theories behind and practical approaches to the multilevel governance of climate change. The course covers a range of public policy areas related to climate change mitigation and adaptation, including energy supply, energy use and demand, carbon markets and economic tools, food and agriculture, and transportation. In this course, students will learn about dealing with complexity in climate policy-making and the range of actors involved in climate change policy spanning multiple levels of government as well as non-state actors. The primary focus is on policy-making in Canada, but the course also incorporates international policy and global North case studies.

EES1136H Climate Change Adaptation

This graduate course will focus on adaptation science and practice at local, provincial, national and international scales. Students will learn about how climate change adaptation is perceived, studied and performed by civil society groups and governments through various theoretical perspectives: resilience theory, neo-liberal theory and critical theory. Students will also learn about different governance approaches that support adaptation: multi-level, poly-centric, experimental and anticipatory governance arrangements. Using case studies ranging from local adaptation planning in Canada to the IPCC's contributions to knowledge synthesis, students will gain a better understanding of the social, economic, political and ethical dilemmas at the core of adaptation science and practice. Combined lecture-seminar format.

Common Elective Courses (CCIA students select 1 additional course from the 25+ available):

EES1104H Microorganisms and the Environment

This applied microbiology course introduces students to microbial activities with environmental implications in diverse areas such as public health, bioremediation, agriculture and green technologies. A key focus of the course is to introduce classical and advanced molecular methods used to detect and quantify microbes, and microbial activities, in environmental samples. Students are given the opportunity to perform microbial enumeration and characterization techniques in the lab to supplement the lectures.

EES1106H Geological Evolution and Environmental History of North America
This course reviews the geological and environmental evolution of the North American continent over the past 4 billion years by exploring the range of plate tectonic processes involved in continental growth and how those processes are expressed today as geologic hazards. The course will also review the origins of Canada's natural resources and review changes in terrestrial and marine environments including climate, and the associated ecosystem changes up to the present day. Students will become familiar with recent anthropogenic influences on the environment in regard to waste management, resource extraction and the impacts of urbanization on watersheds on a weekend field trip. This course will provide students with knowledge of naturally occurring long- and short-term environmental changes as context to modern day environmental concerns. The course meets the requirements of the Association of Professional Geoscientists of Ontario.

EES1109H Advanced Techniques in Geographic Information Systems
This course covers an advanced set of techniques and applications of GIS, including a substantial practical component. Technical issues (including data format and conversion, geo-referencing, spatial indexing and terrain analysis), application/spatial modeling (including watershed analysis, land use classification, soil erosion modeling, etc) as well as visualization and incorporation of spatial data and analysis into decision support systems will be examined. Underlying programming techniques will be reviewed and extended on a student-project basis.

EES1111H Freshwater Ecology and Biomonitoring
Freshwater environments support diverse communities of plants and animals that are controlled by both biotic and abiotic factors. Organisms respond to changes in the habitat through detectable shifts in population abundances and the loss/gain of species. Monitoring such biological changes in freshwater communities is an established protocol for assessing the condition of rivers, lakes and ponds subject to human influence. This course will have a large practical component in which students will have the opportunity to learn the skills necessary to evaluate the condition of aquatic environments variously affected by urbanization.

EES1118H Fundamentals of Ecological Modelling
This course provides an introduction to the rapidly growing field of ecological and environmental modelling. Students will become familiar with most of the basic equations used to represent ecological processes. The course will also provide a comprehensive overview of the population and dynamic biogeochemical models; prey-predator, resource competition and eutrophication models will be used as illustrations. Emphasis will be placed on the rational model development, objective model evaluation and validation, extraction of the optimal complexity from complicated/intertwined ecological processes, explicit acknowledgment of the uncertainty in ecological forecasting and its implications for environmental management.

EES1119H Quantitative Environmental Analysis
This course provides an introduction to the field of ecological statistics. Students will become familiar with several methods of statistical analysis of categorical and multivariate environmental data. The course will provide a comprehensive presentation of the methods: analysis of variance, regression analysis, structural equation modeling, ordination (principal component & factor analysis) and classification (cluster & discriminant analysis) methods, and basic concepts of Bayesian analysis. Emphasis will be placed on how these methods can be used to identify significant cause-effect relationships, detect spatiotemporal trends, and assist environment management by elucidating ecological patterns (e.g., classification of aquatic

ecosystems based on their trophic status, assessment of climate variability signature on ecological time series, landscape analysis). The course will consist of 2 hr-lectures/tutorials where the students will be introduced to the basic concepts of the statistical methods and 2-hr lab exercises where the students will have the opportunity to get hands-on experience in statistical analysis of environmental data.

EES1122H Global Environmental Security and Sustainable Development

The major objectives of EES1122H are to:

1. discuss major environmental challenges the planet earth is now facing
2. examine how human interventions are deteriorating global environment and that affecting sustainable development;
3. analyse major environmental initiatives which include: the Stockholm Conference on Human Development, The Brundtland Commission Report, the Rio Earth Summit, the Johannesburg World Summit on Sustainable development, Montreal Protocol on Ozone Depletion, Kyoto Protocol and other global conventions, protocols and processes and their usefulness:
4. discuss extensive north-south cooperation in facilitating global environmental security and sustainable development.

EES1123H Environmental Regulations

This course will cover selected federal and provincial environmental regulations. Students will discuss key regulations with experienced practitioners and be taught the values, assumptions and guiding principles which underlie regulations as they relate to the environment. Federal and provincial regulations that will be discussed include: environmental assessment, air quality and air emissions, contaminated lands and brownfields, water resources, fisheries, waste management, and other areas.

EES1124H Environmental Project Management

Environmental projects must be completed in a timely manner, for a preset cost and must satisfy many levels of regulation. This course will cover the best practices in project planning, cost estimation, contracting and coordination of the numerous individuals and companies engaged to accomplish the project.

EES1125H Contaminated Site Remediation

This course elaborates on the practical implementation of the common remediation processes including Soil Vapour Extraction, Groundwater Pump and Treat (including treatment train design), Monitored Natural Attenuation, Bioremediation and novel innovative methods. Each method considered will be evaluated in the context of the applicability & treatment analyses, and pilot studies that must be completed before project implementation; full scale design & construction; startup & optimization; reporting requirements; off-gas/residue treatment methods; decommissioning & closure.

EES1126H Hydrology and Watershed Management

This course focuses on advanced processes in watershed hydrology for furthering our understanding of complex environmental problems, ranging from the characterization of freshwater resources to contaminant transport in aquatic systems. Course topics will include a quantitative understanding of how water moves on, and below, the earth's surface, how tracer studies can be coupled with physical measurements to understand complex problems in hydrology and water quality, land use change impacts, and approaches to watershed management. Students will participate in discussions on current and benchmark scientific literature.

EES1127H Applied Biogeochemistry and Geomicrobiology
The course will aim to provide an introduction to geomicrobiology and to describe how microbial communities have influenced biogeochemical and mineralogical processes through geologic time. Topics will include microbial properties and diversity; microbial metabolism, cell surface reactivity and metal sorption; biomineralization; microbial weathering; microbial zonation and early microbial life. This course will also include a practical laboratory part; students will perform experiments on microbial zonation and biomineralization.

EES1128H Biophysical Interactions in Managed Environments
This course will focus on biophysical interactions at the advanced level, incorporating specialized concepts on plant-soil relationships, biogeochemical cycles, and ecosystem functioning in managed forests and agriculture. Students will be provided the opportunity to engage with course topics in seminar, field and laboratory format. Sampling and analytical techniques covered are in-situ soil and leaf-level gas exchange analysis, soil sampling, preparation and elemental analysis, and quantification of plant metrics. By the end of this course, students will have an understanding of the complexities and dynamics in managed environments, specifically ecosystem structure and function, soil fluxes including decomposition and mineralization processes, plant growth and nutrition, and production-diversity relationships.

EES1129H Brownfields Redevelopment
This course introduces students to the regulatory framework for brownfields redevelopment in Ontario. The focus of the course will be building competency in Phase One and Phase Two Environmental Site Assessments (ESAs), determining the requirement for remediation or environmental risk assessments, and in the filing of a record of site condition (RSC) according to Ontario Regulation 153/04. Students will be guided in the use of real data from actual GTA locations as case studies.

EES1137H Quantitative Applications for Data Analysis
In this course data analysis techniques utilizing Python and R statistical language will be discussed and introduced, as well as the basics of programming and scientific computing. The goal of this course is to prepare graduate students to perform scientific data analysis. Students will learn how to use statistical inference tools to gain insight into large and small data sets, as well as be exposed to cutting-edge techniques and best practices to store, manage and analyze (large) data. Topics include: Python and R programming, version control, automation, modular programming and scientific visualization.

EES1701H Environmental Legislation and Policy
This course will cover environmental legislation at all levels of government that determines the way in which the Canadian Environment is managed. Students will be taught the values, assumptions and guiding principles which underlie environmental legislation and will cover the basic regulatory policies governing the environment, particularly as they relate to contaminants in the environment.

EES1704H Environmental Risk Assessment

This course is a broad introduction to applied risk assessment for environmental professionals. Course material will cover Human Health Risk Assessment and Ecological Risk Assessment including conceptual models, risk characterization, uncertainty analysis, and risk perception and communication. Through specific examples, students will understand how to apply the theoretical concepts to conduct "quantitative" and "semi-quantitative" risk assessments as required under provincial regulations, and to communicate the results to a variety of stakeholders, including managers, regulators and the general public.

EES3000H Applied Conservation Biology

Canada has a complex conservation landscape. Through lectures and interactive discussions with leading Canadian conservation practitioners, this course will examine how conservation theory is put into practice in Canada from our international obligations to federal and provincial legislation and policies, and the role of environmental non-government organizations. The course will emphasize how conservation theory is put into practice in Canada, from its international obligation (Convention on Biological Diversity) to its federal legislation (Species at Risk Act) and policies (Canadian Biodiversity Strategy) to provincial legislation and policies, and the role of environmental non-government organizations (ENGOs). The course will link conservation science theory to policy in Canada through lectures and interactive panel discussions with leading Canadian conservation practitioners. The course will provide the students with an in-depth understanding of the role of science in Canadian conservation policy and the roles of conservation practitioners in government agencies and ENGOs and will better prepare students to engage in the Canadian conservation landscape.

EES3001H Professional Scientific Literacy

For decades, environmental scientists have been documenting anthropogenic impacts on the planet's ecosystems. Currently, the weight of scientific evidence showing the severity of the biodiversity and climate crises is immense, and many scientists are advocating for increased governmental engagement with environmental issues. As such, environmental science is closely tied to human valuation of the environment; a linkage that requires one to be able to identify sound science and also understand how science is communicated and used in public policy. This is scientific literacy. It is increasingly recognized that environmental considerations need to be integrated into all aspects of our economies, a trend that is evidenced by the steady growth of the environmental sector as well as increasing public concern for environmental sustainability. In order to prepare for a career in environmental management or conservation science, it is vital that students develop science literacy skills. Environmental professionals employ a range of tools that fall under the umbrella of scientific literacy. It is the goal of this course that students develop 1) a clear understanding of the scientific process & scientific analysis, 2) the ability to communicate environmental science to different audiences, 3) the ability to think critically about environmental issues, how they are studied, and how they are discussed in public discourse, and 4) the ability to place individual environmental studies and issues in the larger context of environmental and conservation science.

EES3002H Conservation Policy

Through lectures, this course will examine the legislation, regulations, and policies that form the foundation for the conservation of biodiversity in Canada including our international obligations and federal and provincial legislation and policies. To become professional conservation practitioners, students must understand the legislation, regulations, and policies that form the foundation for the conservation of biodiversity in Canada. The course will provide an in-depth examination of conservation policy in Canada from its international obligation (Convention on Biological Diversity) to its federal legislation (Species at Risk Act) and policies (Canadian Biodiversity Strategy) to provincial legislation and policies.

EES3003H Topics in Applied Biodiversity

Taxonomic skills are in increasing demand among the Canadian conservation community. This course will provide students with in-depth taxonomic training. The course will include lecture, lab, and field components taught by taxonomic experts and will be held over 37.5h during the second last week of April. Students will be required to choose training for one taxonomic group.

EES3113H Topics in Population and Community Ecology

The field of ecology is rapidly changing and this course will cover recent advances, concepts or controversies in ecology. This course will focus on specific scientific issues using current literature and the learning experience will be augmented by student presentations and discussions. The course will help ensure that students become familiar with current basic ecological concepts. Students who did not take advanced ecology courses during their undergraduate studies will find this course especially attractive. This 'Topics' course is meant to be a flexible offering that focuses on recent advances, concepts and/or controversies in ecology.

Climate Change and Impacts & Adaptation Program Director

Professor Karen Smith
Assistant Professor, Teaching Stream
Program Director, Climate Change Impacts & Adaptation, Master of Environmental Science
karen.smith@utoronto.ca | Website

Research interests:

- Atmosphere-cryosphere interactions
- Stratosphere-troposphere coupling
- Polar climate change
- Atmospheric general circulation