FOR APPROVAL **PUBLIC** **OPEN SESSION**

TO:	UTSC Academic Affairs Committee
SPONSOR:	Prof. William A. Gough, Vice-Principal Academic and Dean
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PRESENTER:	Prof. Katherine Larson: Vice-Dean Teaching, Learning & Undergraduate Programs
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DATE:	March 16, 2022 for March 23, 2022
AGENDA ITEM:	3

ITEM IDENTIFICATION:

Major Modification: Minor in Applied Climatology, UTSC

JURISDICTIONAL INFORMATION:

University of Toronto Scarborough Academic Affairs Committee (AAC) "is concerned with matters affecting the teaching, learning and research functions of the Campus (AAC Terms of Reference, 2021, Section 4)." Under section 5.6 of its terms of reference, the Committee is responsible for approval of "Major and minor modifications to existing degree programs." The AAC has responsibility for the approval of Major and Minor modifications to existing programs as defined by the University of Toronto Quality Assurance Process (UTQAP, Section 3.1).

GOVERNANCE PATH:

1. **UTSC Academic Affairs Committee [For Approval] (March 23, 2022)**

PREVIOUS ACTION TAKEN:

No previous action in governance has been taken on this item.

HIGHLIGHTS:

The Department of Physical and Environmental Sciences (DPES) proposes to introduce a new freestanding Minor in Applied Climatology, the scientific analysis of climate data and its application. The study of climate science, which is now mainstream science, intersects with most programs offered in the Department through courses related to climate science and its associated impacts. However, there are no programs with a special focus on climate change. The proposed

Minor will provide a multidisciplinary education that combines fundamentals of climatological science, applied climatology, and environmental science, to prepare students to observe and analyze past and present weather and climate change, understand the science of atmospheric and climate processes, and evaluate the effects of human activity on the environment.

It is anticipated that the Minor will appeal to students from a broad range of science backgrounds, and will position them well for careers requiring a foundational understanding of climatic phenomenon and their immediate and long-term impacts, including work with various levels of government and non-governmental organizations (NGOs), and as consultants to the private sector. Introducing this area of study as a Minor will also meet the needs of a growing number of undergraduate students who complete their degree by combining Majors and Minors from various disciplines, allowing students to study applied climatology in complement with a range of other degree programs.

Students may enrol in the Minor following the completion of 4.0 credits. Students will complete courses in three stages, 1) introductory calculus and physics as a basis for higher year mathematics and physical science concepts, 2) foundational courses in statistics and climatology, and 3) climate change impact assessment and applied climatology. Upon completion of the Minor, students will be able to evaluate the impacts of human induced climate change on atmospheric and climate processes, and provide solutions from an applied climatological context.

The Environmental Science Specialists and Major offered by DPES meet the national standard required to earn accredited status with the Environmental Careers Organization (ECO) Canada and the Canadian Environmental Accreditation Commission (CEAC), which connects industry and academics in the environmental sector. Graduates of these programs are eligible to receive their Environmental Professional in Training (EPt) designation, which is a developmental certification for emerging environmental professionals. ECO Canada has also been working on an accreditation program for Climate Change professionals, and DPES plans to work with ECO Canada to develop accreditation for the proposed Minor.

FINANCIAL IMPLICATIONS:

There are no significant financial implications to the campus operating budget.

RECOMMENDATION:

Be It Resolved,

> THAT the Minor in Applied Climatology offered by the Department of Physical and Environmental Sciences, as described in the proposal dated March 2, 2022, be approved, effective September 1, 2022.

DOCUMENTATION PROVIDED:

1. Proposal: Major Modification, Minor in Applied Climatology, dated March 2, 2022.

University of Toronto
Major Modification Proposal:

New Freestanding Minor Where There is No Existing Specialist or Major

This template should be used to bring forward all proposals for major modifications of this type for governance approval under the University of Toronto's Quality Assurance Process.

What is being proposed: **please specify exactly what is being proposed; i.e., a new freestanding minor (where there is no existing specialist or major) in…**	**New Freestanding Minor in Applied Climatology (Science) (SCMIN1078)**
Department/unit (if applicable):	**Department of Physical and Environmental Sciences**
Faculty/academic division:	**University of Toronto Scarborough (UTSC)**
Faculty/academic division contact:	**Martha Harris, Academic Programs Officer, martha.harris@utoronto.ca**
Department/unit contact:	**Tanzina Mohsin, Assistant Professor, Teaching Stream** **George Arhonditsis, Professor and Chair**
Version date: **please change as you edit this proposal.**	**March 2, 2022**

1 Summary

- Please provide a brief summary of what is being proposed including:
  - a clear statement of the relationship of this to other programs
  - the impetus for its development in brief
  - any distinctive elements

This is a proposal to introduce a new freestanding Minor in Applied Climatology (Science), which will be housed in the Department of Physical and Environmental Sciences (DPES) at the University of Toronto Scarborough (UTSC). There are no other undergraduate programs in Applied Climatology currently offered on the UTSC campus.

The proposed Minor will complement existing undergraduate programs in Environmental Science, offered by the DPES, including:

- Specialist/Specialist (Co-operative) programs in Environmental Biology [note: a major modification proposal for these programs has been submitted in the 2022-23 curriculum cycle; upon approval the programs will be re-named as Global Environmental Change]
- Specialist/Specialist (Co-operative) programs in Environmental Geoscience
- Major/Major (Co-operative) programs in Environmental Science
- Minor program in Environmental Science (Science)
- Minor program in Natural Sciences and Environmental Management (Science)

All the Specialist and Major programs at DPES lead to the Honours Bachelor of Science (HBSc) degree, and Minor programs are Science-focused. The overarching focus of these programs is to consider human activity as a major cause of environmental change. The study of the natural and anthropogenic changes in the environment requires knowledge and understanding spanning many scientific disciplines, including biology, chemistry, geology, geography, mathematics, physics, and ecology. Recent environmental degradation such as surface and subsurface water pollution, air and soil pollution, climate change, depletion of resources, extinction of species and problems of waste disposal are all due to a limited understanding of environmental systems and processes. All programs in Environmental Science provide education and training that produces highly qualified scientists, with exceptional backgrounds in the theory and applications of environmental science, who are able to provide interdisciplinary solutions to contemporary environmental challenges. The study of climate science intersects in most of these programs offered at DPES through courses related to climate science and the associated impacts. However, currently there are no programs offered at DPES with special focus on Climate Change.

The proposed Minor in Applied Climatology is, therefore, timely and is designed to ensure that students develop a clear understanding of the science of atmospheric and climate processes and the impacts of human induced climate change on these processes. It will also provide students with the opportunity to evaluate the effects of human activity on the environment.

In an age of expanded environmental technology, the scope of climatological applications, and their importance, are recognized by sectors such as infrastructure, forestry, tourism, agriculture, as well as by business and industry. Applied climatology is the scientific analysis of climate data and its application for both operational and impact assessment purposes. Floods causing property and infrastructure damages, droughts resulting in water shortages, and crop damage or freezing rain increasingly put human-environment systems at risk and require special consideration from an applied climatological context. In addition, weather and climate prediction and interpretation of the projections – important skills used in the agriculture, tourism, disaster management, resource management, financial, communication and renewable energy industries – are embedded in the field of applied climatology.

It is anticipated that the proposed Minor will appeal to students from a broad range of disciplines, including physical science, environmental science, health science, statistical science, chemistry, physics, computer science, economics, management, and international development studies and will position them well for careers that require a foundational understanding of climatic phenomenon and their immediate and long-term impacts. The proposed Minor will also meet the needs of a growing number of undergraduate students who prefer to diversify their education by combining majors and minors from various disciplines. The proposed Minor will compliment the existing Minor in Environmental Science (Science). While students in the Minor in Environmental Science are able to select from a range of environmental science courses, depending on their interests, students will be permitted to combine the two Minors in fulfillment of their HBA/HBSc degree requirements.

All Environmental Science Specialist programs and the Major Program in Environmental Science have earned official accreditation from Environmental Careers Organization (ECO) Canada and the Canadian Environmental Accreditation Commission (CEAC). These UTSC programs have met the national standard required to earn accredited status, which connects industry and academics in the environmental sector. Graduates of these programs are eligible to receive their Environmental Professional in Training (EPt) designation, which is a developmental certification for emerging environmental professionals. The DPES will explore the proposed Minor's potential for accreditation in the climatological field. It should be noted that ECO Canada has been working on an accreditation program for Climate Change professionals, and DPES is in communication with ECO Canada about accreditation of the proposed Minor.

2 Effective Date

September 1, 2022, for the 2022-23 academic year.

3 Academic Rationale

- Describe what is being proposed and why.
- If relevant, describe the mode of delivery (including online) and how it is appropriate to support students in achieving the learning objectives of the program.
- Context
  - Discuss how the program addresses the current state of the discipline or area of study. (Identify pedagogical and other issues giving rise to the creation of this program. Where appropriate, speak to changes in the area of study or student needs that may have given rise to this development.

  - Describe the consistency of the program with the University's mission and unit/divisional academic plan and priorities.
- Distinctiveness
  - Identify any distinctive/innovative aspects of the proposed minor.
  - As appropriate, speak to similar offerings elsewhere at the University of Toronto or at other universities.

This is a proposal to introduce a new freestanding Minor in Applied Climatology (Science), which will be housed in the Department of Physical and Environmental Sciences (DPES) at the University of Toronto Scarborough (UTSC).

Context

Climate Science is now mainstream science. Recent observations show an increase in surface air and ocean temperatures over most regions, as well as diminishing snow and ice cover at high latitudes of the Earth. The ongoing warming of climate will increase risks and stresses to humans, terrestrial and marine ecosystems, and wildlife through the 21st century and beyond, making it imperative to respond to a changing climate and plan for the future (Jones, et al, 2014).[1] The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is due to human activities, which have affected the land, oceans, and atmosphere, and these changes have altered global climatic patterns and triggered increases in extreme weather events. There is growing evidence that the stakes from these unprecedented events are massive, the risks and uncertainties are severe, and problems will continue to manifest. In order to both prevent and adapt to the consequences, society will need to learn how to better respond to the impacts. Technological and science-based strategic solutions in the near future will determine the extent of impacts of climate change and the associated challenges.

The proposed Minor in Applied Climatology is aimed at students with a variety of science or students with mixed science backgrounds, and will provide them with the foundational knowledge they need to make informed judgements about climatological problems within the broader social, political, and economic aspects of Physical and Environmental Sciences. There is a clear need, both nationally and internationally, for educated climate professionals who understand how

[1] Jones, R.N., A. Patwardhan, S.J. Cohen, S. Dessai, A. Lammel, R.J. Lempert, M.M.Q. Mirza, and H. von Storch, 2014: Foundations for decision making. In: *Climate Change 2014*: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 195-228.

climatological events occur and how to respond to the multidimensional environmental and non-environmental challenges facing humanity due to anthropogenic climate change. Students completing the proposed Minor will be able to address complex questions related to the impacts of climate change based on scientific evidence, assess the risks associated with climate change, and support decision making to find solutions. They will be able to use their knowledge of climate systems to evaluate impacts on natural and social systems. The proposed Minor will fill the knowledge gap between the climate science and its application offered to the decision makers in a more meaningful manner within an applied context.

The proposed Minor can be combined with a broad range of programs at UTSC. The following programs, in particular, will be compatible with the Minor in Applied Climatology and will strengthen students' ability to apply the science of climate change: Minor in Geographic Information Science (GIS), Minor in Applied Statistics, Major/Major Co-op and Minor in Statistics, Major in Environmental Studies, Major/Major Co-op in Environmental Science, Major/Major Co-op in Computer Science, Major/Major Co-op in Mathematics, and Specialist (BSc) Co-op in International Developmental Studies (IDS, Science).

Since the study of climate change intersects with a range of disciplines, the proposed Minor may also appeal to students with an interest in media studies or in a career as broadcast meteorologist/climatologist, and students interested to study the implications of weather and climate on people's lives, the role of weather and climate on the mental and physical health of human beings, or in incorporating impacts of climate change in decision making processes for any sector of the society.

The program will be delivered in-person, however, some first-year courses will include WebOption lecture casting during the fall/winter semesters, thereby proffering students greater flexibility in completing the program.

Fit with Departmental and Campus Academic Mission

The proposed Minor is consistent with DPES academic priorities. The program is designed to:

- Achieve interdisciplinary learning by combining foundational courses in physics, mathematics, and core courses in climate sciences, environmental sciences and modelling through structured methodology that is inherently integrative in various fields of environmental sciences.
- Attract national and international students from a variety of science backgrounds.
- Fill the knowledge gap in climate sciences and career expectations of other science graduates.
- Enrich student experience through life-long learning and career development.

It also supports the following strategic directions and initiatives from the UTSC Strategic Plan, *Inspiring Inclusive Excellence* (2020-25):

- Develop new programs and review existing programs/curricula with consideration for their responsiveness to developments in relevant fields, transformations in society more broadly, and the realization of learning outcomes that give our graduates the competencies needed to be successful in their careers and to adapt to a dynamic world (1.2.i).
- Create select programs to enhance education required to facilitate career transitions in the new economy (1.4.iii).
- Enhance and grow current and emerging areas of research strength that will establish University of Toronto Scarborough as a global research leader in those fields (2.1).

Distinctiveness

The proposed Minor is distinct from programs in Atmospheric Science, which include core courses in climatology, climate physics, air quality, and meteorology to develop an understanding of the mechanisms driving severe weather and climate events. It is also distinct from programs in Meteorology which focus on specific meteorological fields including air quality, weather monitoring and instrumentation, and forecasting. The Minor in Applied Climatology, instead, focuses on the relationships between changing climate conditions and the countless climate/weather-sensitive industries and considers them through the lens of applied science to find solutions to the ongoing and future challenges faced by various sectors.

There are no other programs that are similar to the proposed Minor, offered at the wider University of Toronto. However, there are some climate-focused programs at other Canadian universities:

- University of Prince Edward Island (UPEI) offers a Bachelor of Science (4 years) in Applied Climate Change and Adaptation that differs from the proposed Minor in its emphasis on physical science and applied courses in climate science and modelling to assess the impacts of climate change.
- Trent University offers an option in Climate Change Science and Policy under their School of Environment that is entirely different from the proposed Minor. It requires students to take some courses as part of a degree in Geography, Environmental Science/Studies, or Environmental and Resource Science/Studies.
- The University of Waterloo offers a specialization in Climate Change and Environment as part of an honours program in Geography and Environmental Management that does not require students to take any climate science and modelling focused courses. Neither program integrates core courses that are focused on in-depth climate science or applied skill-based content. The proposed Minor makes a greater attempt to integrate both theoretical and

applied knowledge and uses it for problem solving and decision-making purposes at various sectors through the lens of Applied climate science.

DPES has also begun developing a proposal to introduce a brand-new Major program in Climate Change, leading to the Honours Bachelor of Arts, which will focus on the human dimension of climate change. This Major is designed to provide students with a strong foundation in the human dimensions of climate change, including policy responses, social justice concerns, and cultural change, as well as the physical science basis of climate change. The proposed Minor in Applied Climatology will be distinguished from the proposed Major in Climate Change by its focus on climate science and modelling. The proposed Minor and proposed Major will be complimentary programs that students will be able to combine to gain a comprehensive understanding of climate science and human dimension of climate change.

4 Need and Demand

- Provide a brief description of the need and demand for the proposed minor focusing, as appropriate, on student interest, societal need, employment opportunities for prospective graduates, accreditation requirements.

Societal Need

The essential sectors of society, which meet the basic needs of the population, such as agriculture, industries including retail, urban health, insurance, forestry, infrastructure, and many more are all sensitive to the changes in climate. There is a growing need for climate science literacy among students with science, social science or even business and economics backgrounds, whose careers in any of these sectors may demand an understanding of weather and climate phenomenon and the associated impacts. For example, an economist asked to estimate the current impacts and project the future impacts of climate change must be able to base this estimate on a fundamental understanding of the physical and dynamical processes associated with many climatic events. Or a business graduate working with an insurance company who needs to develop weather derivatives will benefit from an applied climatological background. The proposed Minor will provide a multidisciplinary education that combines fundamentals of climatological science and applied climatology, and environmental science, that will provide students with the skills set they need to observe and analyze past and present weather and climate change and make informed decisions. It will put emphasis on the relationship between changing climate conditions and countless climate/weather-sensitive industries through the

lens of applied science to find solutions to the ongoing and future challenges faced by various sectors of the society.

Student Demand

Enrolments in the Major and the Minor programs in Environmental Science have grown steadily over the last five years; in particular, enrolment in the Minor in Environmental Science has grown from 125 students in 2015-2016 to 241 students in 2019-2020, suggesting that there is a strong student demand for programs focused on the Environment. The proposed Minor will capitalize on this interest at UTSC.

As an area of study, climate change intersects with wide ranges of disciplines, including computer science, mathematics, statistics, international development studies (science), geography, environmental science, biology, and health studies. There is also evidence that a growing number of undergraduates seek to diversify their education by combining majors and minors from various disciplines. Students will be able to combine the proposed Minor with a broad range of programs at UTSC, including the following: Minor in Geographic Information Science (GIS), Minor in Applied Statistics, Major/Major Co-op and Minor in Statistics, Major in Environmental Studies, Major/Major Co-op in Environmental Science, Major/Major Co-op in Computer Science, Major/Major Co-op in Mathematics, and Specialist (BSc) Co-op in International Developmental Studies (IDS).

Table 1, below, provides projected enrolments.

Table 1: Undergraduate Enrolment Projections

Level of study	**Academic year** 2022-23	**Academic year** 2023-24	**Academic year** 2025-26	**Academic year** 2027-28	**Academic year** 2028-29*
1st year	**10**	**15**	**25**	**35**	**45**
2nd year	**0**	**8**	**12**	**20**	**30**
3rd year	**0**	**0**	**8**	**12**	**20**
4th year	**--**	**----**	**---**	**---**	**---**
Total enrolment	**10**	**23**	**45**	**67**	**90**

**Offering reaches steady-state.*

Students graduating from the proposed Minor will be able to pursue careers at various levels of government including in Ministries, in non-government organizations, and as consultants in private sector organizations that require knowledge of climate science and assessment of impacts, including financial institutions. Students in the proposed program will also be motivated to pursue

graduate study in climatological education, including in programs like the Master of Environmental Science (MEnvSc) that is housed in the Graduate Department of Physical and Environmental Sciences.

5 Admission/Eligibility Requirements

- Describe any specific requirements that students must meet to be eligible for the proposed minor and how these will be administered.

Students interested in the minor need to complete high School Physics and Mathematics, to be able to take the first year core courses.

The proposed Minor will be unlimited enrolment, and students will be able to enrol after completing 4.0 credits.

6 Requirements for the Minor

- Describe in your own words the requirements and structure of the minor.

The proposed Minor requires students to complete a total of 4.5 credits, including 1.5 credits at the C- and D-levels. As such it meets the UTSC Degree Criteria for a Minor offering (i.e., there is a minimum of 4.0 credits and no more than 5.0 credits in total, including at least 1.0 credit at the C- and/or D-level). This Minor required 4.5 credits, since the program has core courses both in the 1st and in the 3rd/4th years. In general, most minors do not include core courses in more than one year of the undergraduate programs. However, since this is a specialized minor, the learning outcomes cannot be met without the additional core courses. Importantly, the ECO Canada accreditation program for climate professionals requires certain learning outcomes to be fulfilled related to climate change science and impact analysis, which necessitates for the Minor to have 4.5 credits instead of 4.0.

The overarching goal of the first two years in the Minor is to provide students with an appropriate background in physical science and mathematics. Then, in the third and fourth years, students take specific core courses and can choose elective courses in specific areas of interest within the broader field of climate science, applied climatology, and environmental science. The applied science approach of the Minor involves coursework in climatology as well as experiential learning opportunities offered in courses such as EESD31H3 (Applied Climatology), and two new courses, EESC25H3 (Urban Climatology) and EESD28H3 (Fundamentals of Environmental Modelling), to find real-world evidence-based solutions based on the student's area

of interest. The Minor also prepares students with project-based training, applied research skills and climate education so that they are motivated to pursue graduate studies in any field of climatology, including the Climate Change Impacts and Adaptation concentration in the Master of Science in Environmental Science (MEnvSc) offered by the Graduate Department of Physical and Environmental Sciences.

More specifically, the Minor is structured such that students are required to complete the following components:

- In Year 1, students will complete 1.5 credits in introductory courses in calculus and physics (MATA30H3 and PHYA10H3), as well as EESA03H3 (Wind). Through these courses, students will gain a basic understanding of the required math and physical science, which are the requirements for the upper year courses.
- In Years 2 and 3, students will complete 1.5 credits in foundational courses in statistics (STAB22H3) and climatology (EESB03H3), as well as selecting either EESB15H3 (Earth History) or EESB18H3 (Natural Hazards). Through these courses, students gain a fundamental understanding of climate change and the associated physical processes, and will be prepared to take the advanced climate courses.
- In Years 3 and 4, students will complete 1.5 credits in upper-level courses focused on climate change impact assessment (EESD06H3) and applied climatology (EESD31H3), as well as selecting one further course, according to their interests, from a bin. Through these courses, students will achieve comprehensive understanding of the science of atmospheric and climate processes and the impacts of human induced climate change on these processes. They will be able to evaluate the impact of such processes and provide solutions from an applied climatological context to the challenges that the society face today.

- Provide, as an appendix:
  - An exact program description as it will appear in the undergraduate calendar, including all required courses and recommended electives and their prerequisites.
  - A detailed copy of the program requirements as they will appear in the undergraduate calendar, including all required courses and recommended electives and their prerequisites.
- Provide, as an appendix:
  - A full list of the course numbers and titles, indicating clearly whether they are new or existing. (Please note that new courses need to be proposed and approved separately following established Faculty/divisional procedures.)

Please see Appendix A for proposed calendar copy. Please see Appendix B for a full list of the course numbers and titles, indicating clearly whether they are new or existing.

7 Program Structure, Learning Outcomes and Degree-Level Expectations (DLEs)

- Address how the design, structure, requirements, and delivery of the program support the program learning outcomes and DLEs.
- Identify DLEs, how each is addressed in this particular program and specify how the program design and requirements support the attainment of student learning outcomes. Proponents may find the language in the table useful or should feel free to use their own.

The proposed Minor is designed to ensure students achieve a broad understanding of the fundamental physical and dynamical processes governing the motions and behaviours of weather and climatic phenomenon. It focuses on developing skills to observe and analyze climate data, understand climate change modelling, assess the impacts of climate change, and interpret the climate forecasts applied to various sectors such as industry, business, and government.

Degree Level Expectations	**Program Learning Outcomes – e.g. what students will know or be able to do at the completion of the Minor program**	**How the program design / structure supports the degree level expectations**
1. Depth and Breadth of Knowledge **Depth of Knowledge: is attained through a progression of introductory, core and specialized courses. Specialized courses will normally be at the C and D levels.** Breadth of Knowledge: students will gain an	Depth and breadth of knowledge in the Minor in **Applied Climatology** is reflected in students who will be able to: - PLO1 Understand the physical and atmospheric concepts as a mastery of the underlying scientific basis of the earth's climate system - PLO2 Apply knowledge of climate science to understand the impacts of climate on the applied sectors of the society	Depth and Breadth of knowledge are achieved through the various stages of the program. The program consists of three stages **1) Introductory core as requirement to move forward with the advance courses:** MATA30; PHYA10; EESA09H3, **2) Fundamental and Advanced:** STAB22; EESB03; EESB18, and **3) Applied Climatological Science** including compulsory

appreciation of the variety of modes of thinking, methods of inquiry and analysis, and ways of understanding the world that underpin different intellectual fields.	- PLO3 Gain an understanding of various perspectives on the climate change related environmental problems and solutions.	and interdisciplinary courses: EESC25; EESC13; EESD06; EESD31; ESTD19, EESD28
2. Knowledge of Methodologies Students have a working knowledge of different methodologies and approaches relevant to their area of study. They are able to evaluate the efficacy of different methodologies in addressing questions that arise in their area of study.	Knowledge of methodologies in the Minor in Applied Climatology is understood as the ability to apply different methodologies and approaches relevant to the impact of climate change analysis. For example, students use numerical problem-solving skills, statistical methods, experiential learning approaches, and a climate change impact assessment framework (IPCC derived) for data analysis and to understand climate modelling process in addressing questions that arise in their areas of study. This is reflected in students who: -PLO4 will understand a variety of methodologies and approaches (classroom, and lab) through the application of current climate model outputs and methods of study of the climate system and analysis of climate data. - PLO5 will be able to apply experiential learning approaches to better understand and construct the connection between the climate and human system in managing the climate related problems and solutions.	-Students gain working knowledge of scientific methodology through B, C, some D-level courses in climate and environmental sciences (STAB22; EESB03; EESC25; EESD06; ESTD19).
3. Application of Knowledge Students are able to frame relevant questions for further inquiry. They are familiar with or will be able to seek the tools with which, they can address such questions effectively.	Application of knowledge in the Minor in Applied Climatology is understood as the ability to frame relevant questions to inquiry about the past, present and future impacts of climate change in the applied sectors of the society (e.g. agriculture, forestry, infrastructure, natural resources, urban environments, transportation, etc.) This is reflected in students who will be able to: -PLO6 apply their knowledge of climate systems and the feedback	Application of knowledge in the specialized climate and environmental science courses at the C and D levels in third and fourth years of the program (EESC25; EESC13; EESD06; EESD31; ESTD19) will equip students in providing solutions for challenges that intersects multiple sectors across the physical, the climate and the human systems.

	processes to evaluate impacts on natural and social systems and address critical questions with regards to impacts of climate change, -PLO7 use a climate change impact assessment framework in assessing the impact of climate change on a range of sectors and how to support decision making to find solutions -PLO8 examine problems that intersect environment, climate and the society.	
4. Awareness of Limits of Knowledge Students gain an understanding of the limits of their own knowledge and an appreciation of the uncertainty, ambiguity, and limits to our collective knowledge and how these might influence analyses and interpretations.	Awareness of the limits of knowledge in the Minor in Applied Climatology reflects in an appreciation of the uncertainty of climate change forecasts, and the limits to our collective knowledge and how these might influence analyses and interpretations, as well as decision making. This is reflected in students who will be able to: -PLO9 question their understanding of the subject matter as well as the established understanding of the climate science and modelling. For example, address the issues in choosing scenarios derived from physical scientific basis and how use of different models and forecasting techniques can affect in choosing options for mitigation and adaptation at various levels. -PLO10 develop an appreciation for the limits of science and will be motivated to develop a new theory or modify an existing one.	The fundamental understanding of the climate and atmospheric processes will be accomplished in the 1st and 2nd year of the program (PHYA10, EESA09H3, EESB03; EESB18) and will provide the basis for the 3rd and 4th year courses (EESC25; EESC13; EESD06; EESD31; EESD28), which establish the role of contemporary climate science within the context of Applied Climatology. Through the sequence of courses that develop depth within each of the core areas of study, students will develop an appreciation for the limits of science.
5. Communication Skills Students are able to communicate information, arguments, and analyses accurately and reliably, both orally and in writing. They learn to read and to listen critically.	Communication skills in the Minor in Applied Climatology are understood as communicating the consequences (impacts, risks, etc.) of climate change to a variety of audiences, such as the stakeholders of the various sectors of the society, to the decision makers at the various level of governments etc. This is reflected in students who will be able to:	The program supports communication skills expectations in the upper year courses, particularly in the core courses. Students will practice and hone their communication skills in the C and D-level courses (EESC13; EESC25; EESD06; EESD31; ESTD19).

	- PLO11 communicate their findings in the form of proposals, research and technical papers, and oral presentations and working with community and industry partners in an applied climatological context	
6. Autonomy and Professional capacity as a climatologist The education students receive achieves the following broad goals: • **It gives students the skills and knowledge they need to become informed, independent and creative thinkers** • **It instils the awareness that knowledge and its applications are influenced by, and contribute to, society** • It lays the foundation for learning as a life-long endeavour	Autonomy and professional capacity in the Minor in Applied Climatology is understood as the ability to integrate applied knowledge with broader issues including impacts of extreme climate and weather events, and other environmental phenomenon that influence the natural and human system. Students completing the minor program will develop knowledge and skills such that they will be able to: - PLO12 understand the world around them and will be able to evaluate and tackle the climate related environmental issues and challenges that are faced by the society. - PLO13 defend/establish arguments to make conversation with climate skeptics.	The program is designed to cultivate an interest in climate science and provide skills and knowledge that students with diverse academic background can apply to understand the climate change and the associated physical process through the A and B-level courses (PHYA10; EESA09H3, EESB03; EESB18), which will offer a journey into climate sciences and how they're intimately linked with all the major societal sectors that intersect with our day to day lives. The program will offer an understanding of climate change through physical mechanisms and their impacts and how they are linked with all the major challenges in our day to day lives. The courses in the upper year of the program (EESC25; EESC13; EESD06; EESD31; ESTD19, EESD28) will prepare students to integrate and work with other disciplines to help make informed decisions and to understand and manage climate change related issues, which will motivate them to become a climate professional. The future goal of this program is to receive a professional certification as a climate change professional.

8 Assessment of Teaching and Learning

- Describe how the methods for assessing student achievement are appropriate and effective relative to established program learning outcomes and degree-level expectations.

The methods of assessment in the proposed Minor in Applied Climatology include: midterm tests, final exams; lab and project-based research work; and written assignments/papers, oral presentations, and debates on current climate change issues. Experiential learning elements are embedded within these methods of assessments, for both foundational and core courses of the program.

Learning outcomes in depth and breadth of knowledge and awareness of limits of knowledge will be developed throughout the minor with assessments in core subjects, beginning in the A and B-level required courses and continuing into the C and D level options. Debates on current climate change issues, and written assignments will motivate students to engage in critical thinking and questioning of their understanding of the subject matter, and analyze current theories of climate change.

Learning outcomes in knowledge of methodologies will be developed throughout the program in B, C and D-level courses, through tests, exams, and lab work consisting of numerical problem-solving and data analysis techniques. These will prepare students to apply climate modelling methods and assess impacts of climate change in different sectors of society. Introductory courses in Mathematics, Physics, and Statistics at the A and B-level provide students with foundational quantitative skills to support the progression of the learning outcomes.

Assessment in courses in the C- and D-level will emphasise learning outcomes in depth and breadth of knowledge, communications skills, and application of knowledge. Communication skills will be developed through the preparation of oral presentations, research and academic scientific papers, and media-oriented writing pieces. These will ensure students are prepared to communicate consequences of climate change to a variety of audiences and sectors of society.

9 Consultation

- Describe any consultation with programs and units that may be affected.

Within the Department of Physical and Environmental Sciences:
There has been extensive consultation with the DPES including:

- The Environmental Science and Environmental Studies (EES) groups - June 11, 2021
- Department Chair: August 09, 2021
- Environmental Science and Environmental Studies (EES) Groups - August 2021
- Teaching and curriculum Committee at DPES - Sept. 9, 2021

At UTSC:
There was consultation with the Department of Computer and Mathematical Sciences (Associate Chair, Michael Evans) – (May 18, 2021)

10 Resources

- Describe any resource implications of the change(s) including, but not limited to, faculty complement, space, libraries and enrolment/admissions.
- Please be specific where this may impact significant enrolment agreements with the Faculty/Provost's office.
- Indicate if the major modification will affect any existing agreements with other institutions or will require the creation of a new agreement to facilitate the major modification (e.g., Memorandum of Understanding, Memorandum of Agreement, etc.). Please consult with the Provost's office (vp.academicprograms@utoronto.ca) regarding any implications to existing or new agreements.

There are no resources implications for faculty complement, administrative staff, library resources, space or equipment. Existing faculty and administrative staff that support programs in Environmental Science and Environmental Studies will also support the proposed Minor. Library resources, space, and equipment that support other DPES programs will support the proposed Minor.

There are two new courses associated with the proposed Minor:

1. EESD28H3 Fundamentals of Environmental Modelling- taught by George Arhonditsis
2. EESC25H3 Urban Climatology – taught by Tanzina Mohsin

EESD28H3 will provide students with an advanced understanding of the complex interplay among physical, chemical, and biological processes that shape ecosystem phenology in the context of climate change. This course will discuss how these processes are mathematically depicted in the most commonly used numerical models. Emphasis will also be placed on methods to rigorously evaluate and validate models, extract the optimal complexity from complicated/intertwined ecosystem

processes and quantify the uncertainty in ecological forecasting and its implication to environmental management under changing climate condition.

EESC25H3 will give students the opportunity to explore the factors and the processes associated with the development of urban climate and will choose their own areas of interest to apply the knowledge they learn throughout the course by working on a project led by community/industry partners.

These new courses in the program will be taught by existing DPES faculty, and no additional faculty resources are required. In the short term, we do not anticipate a need for additional TA support. DPES is committed to provided with TA support in case any additional TA hours are required. Other experiential learning opportunities will be provided through the C and D level courses included in the program.

10.1 Faculty Requirements

- Brief statement to provide evidence of the participation of a sufficient number and quality of faculty who will actively participate in the delivery of the program,
  - Discuss the role of any adjunct or contractual faculty,
  - Comment on the provision of supervision of experiential learning opportunities, as appropriate.
  - If relevant, describe the plan to provide additional faculty resources to support the program.

The proposed Minor in Applied Climatology will be supported by the multidisciplinary strength of the existing DPES faculty, including two full Professors (Arhonditsis, Gough), one Associate Professor (Wells), one Associate Professor, Teaching Stream (Meriano), and three Assistant Professors, Teaching Stream (Daxberger, MacLellan, Mohsin). These faculty members have expertise in the two overarching areas of study: Earth and Environmental Sciences, and Physical and Climate Science

Earth and Environmental Sciences
The faculty under these areas have diverse expertise. Prof. Arhonditsis's research involves novel modelling techniques for elucidating ecological processes and he developed several mechanistic and statistical (both Bayesian and frequentist methods) models to address eutrophication problems, quantify land-lake interactions, identify climate change effects on aquatic ecosystem phenology. Prof. Meriano has expertise in water and geoscience research. She designed and integrated innovative approaches to experiential learnings in her courses and has received numerous teaching enhancement grants. Prof. Daxberger has expertise in sedimentology and

geomorphology and her research focus is on Remote Sensing techniques in combination with tectono-morphologic analysis and interpretations. Prof. MacLellan is a decision analyst who specializes in environmental issues. He has an extensive background in ecology, sociology and economics, as well as experience with an array of analytical techniques, which he uses to support his research\application in environmental decision-making, climate change adaptation planning and institutional capacity building.

Physical and Climate Science
This group of faculty has vibrant background in climate science. Prof. Gough is the director of the Climate Lab at UTSC, and his research group investigates various phenomena related to climate change, including climate change in the eastern Arctic, numerical ocean and climate modelling, air quality in southwestern Ontario, urban climate, hurricanes, climate change impact assessment, and climate change policy. Prof. Wells is a Physical Limnologist who studies environmental flows in lakes and coastal zones and his research aims to study the fundamental processes to quantify water body flows and mixing, particularly in large lakes, the dynamics of internal seiches in the Great lakes related to contaminant fate and fish habitat issues. Prof. Mohsin has been teaching the environmental science and climatology courses for the past ten years at DPES, and her research includes detection and attribution of climate change using time series analysis of climate data from diverse sources, statistical downscaling of climate variables, climate change and climate extremes in cities and the climate change impact assessment within the framework of Applied Climatology.

Table 2: Detailed list of faculty involvement in the program

Faculty name and rank	Home unit	Area(s) of Specialization
George Arhonditsis (Professor)	**DPES (100%)**	**Earth and Environmental Sciences**
William A. Gough (Professor)	**DPES (100%)**	**Physical and Climate Science**
Mathew Wells (Associate Professor)	**DPES (100%)**	**Physical and Environmental Sciences**
Mandy Meriano (Associate Professor, Teaching Stream)	**DPES (80%)**	**Earth and Environmental Science**
Heidi Daxberger (Assistant professor, Teaching Stream)	**DPES (100%)**	**Environmental Sciences**
Jim MacLellan (Assistant Professor, Teaching Stream)	**DPES (100%)**	**Environmental Studies/Science**
Tanzina Mohsin (Assistant Professor, Teaching Stream)	**DPES (75%)**	**Physical and Climate Science**
Karen Smith (Assistant Professor, Teaching Stream)	**DPES (100%)**	**Environmental Sciences**

10.2 Space/Infrastructure

- Address any unique space/infrastructure requirements including information technology, laboratory space and equipment, etc.

There are no new or additional space or infrastructure needs associated with the proposed Minor.

11 UTSC Administrative Steps

Administrative Steps Required	Date
Departmental Curriculum Committee	• Environmental Science and Environmental Studies (EES) Groups - August 2021 • Teaching and Curriculum Committee - Sept. 9, 2021
Dean's Office Green Light	**September 30, 2021**

12 UTQAP Process

Levels of Approval Required	Date
1. Decanal Sign-Off 2. **Provost Office Sign-Off**	**February 2, 2022** **February 24, 2022**
UTSC Academic Affairs Committee	**March 23, 2022**
Submission to Provost's Office	
AP&P – reported annually	
Ontario Quality Council – reported annually	

Appendix A: Calendar Copy

MINOR PROGRAM IN APPLIED CLIMATOLOGY (SCIENCE)

The Minor in Applied Climatology is designed to provide students with a unique educational experience that combines the fundamental understanding of climate change science, associated atmospheric processes and their impacts. The program will prepare students to observe and analyze past and present weather and climate change in the context of Applied Climatology. It will consider the relationship between changing climate conditions and countless climate/weather-sensitive industries through the lens of applied science to find solutions to the ongoing and future challenges faced by various sectors.

As an area of study, climate change intersects with wide ranges of disciplines, including computer science, mathematics, statistics, international development studies (science), geography, environmental science, biology, and health studies. This Minor is intended for students with an interest in climate change and preparing for a career that will demand a basic understanding of the physical and dynamical processes associated with climatic events and their impacts.

Program Requirements

Students must complete a total of 4.5 credits as follows:

1. First Year (1.5 Credits)
MATA30H3 Calculus I for Physical Sciences
PHYA10H3 Physics I for the Physical Sciences
EESA09H3 Wind

2. Second/Third Year (1.5 Credits)
EESB03H3 Principles of Climatology
STAB22H3 Statistics I or equivalent
and
0.5 credit from the following:
EESB15H3 Earth History
EESB18H3 Natural Hazards

3. Third/Fourth Year (1.5 Credits)
EESD06H3 Climate Change Impact Assessment
EESD31H3 Applied Climatology
and
0.5 credit from the following:
EESC03H3 Geographic Information Systems and Remote Sensing
EESC13H3 Environmental Impact Assessment and Auditing
EESC19H3 Oceanography
EESC25H3 Urban Climatology
ESTD19H3 Risk
EESD28H3 Fundamentals of Environmental Modelling

Appendix B: List of Courses

Complete List of Courses Associated with the Program, Including Full Calendar Copy:

MATA30H3: Calculus I for Physical Sciences

An introduction to the basic techniques of Calculus. Elementary functions: rational, trigonometric, root, exponential and logarithmic functions and their graphs. Basic calculus: limits, continuity, derivatives, derivatives of higher order, analysis of graphs, use of derivatives; integrals and their applications.
Prerequisite: Grade 12 Calculus and Vectors
Exclusion: (MATA20H3), (MATA27H3), MATA29H3, MATA31H3, MATA32H3, MAT123H, MAT124H, MAT125H, MAT126H, MAT133Y, MAT135Y, MAT137Y, MAT157Y, JMB170Y
Breadth Requirements: Quantitative Reasoning

PHYA10H3: Physics I for the Physical Sciences

The course is intended for students in physical, environmental and mathematical sciences. The course introduces the basic concepts used to describe the physical world with mechanics as the working example. This includes mechanical systems (kinematics and dynamics), energy, momentum, conservation laws, waves, and oscillatory motion.
Prerequisite: Physics 12U - SPH4U (Grade 12 Physics) and Calculus and Vectors (MCV4U) and Advanced Functions (MHF4U)
Corequisite: MATA30H3 or MATA31H3
Exclusion: PHYA11H3, PHY131H, PHY135Y, PHY151H, (PHY110Y), (PHY138Y)
Breadth Requirements: Natural Sciences

EESA09H3 Wind

A survey of the science, history, and applications of wind. Topics include storms including hurricanes, tornadoes and mid-latitude cyclones, global circulation, local circulations, measurement of winds, impact of winds on land surfaces, wind power, winds and pollution, historical and literary winds, and contemporary wind research. No prior knowledge of environmental science is required.
Breadth Requirement: Natural Sciences

EESB03H3 Principles of Climatology

This is an overview of the physical and dynamic nature of meteorology, climatology, and related aspects of oceanography. Major topics include atmospheric composition, nature of atmospheric radiation, atmospheric moisture and cloud development, atmospheric motion including air masses, front formation and upper air circulation, weather forecasting, ocean circulation, climate classification, climate change theory and global warming.
Prerequisite: [EESA06H3 or EESA09H3] and [MATA29H3 or MATA30H3]
Exclusion: GGR203H, GGR312H

Breadth Requirements: Natural Sciences

EESB15H3 Earth History

Planet Earth is at least 4,400 million years old, and a geological record exists for at least the last 3,900 million years in the form of igneous, metamorphic and sedimentary rocks. The changing dynamics of convection deep within the Earth's mantle and associated super-continent assembly and breakup along with meteorite impacts, are now recognized as the major controls on development of the planet's atmosphere, oceans, biology, climate, and geo-chemical cycles. This course reviews this long history and the methods and techniques used by geologists to identify ancient environments.
Prerequisite: EESA06H3
Breadth Requirement: Natural Sciences
NOTE: Note: Priority will be given to students in Specialist programs in Environmental Geoscience and Environmental Chemistry.

EESB18H3 Natural Hazards

This course is an investigation of the geological background and possible solutions to major hazards in the environment. Environmental hazards to be studied include landslides, erosion, earthquakes, volcanic eruptions, asteroid impacts, flooding, glaciation, future climate change, subsidence, and the disposal of toxic wastes. This may be of interest to a wide range of students in the life, social, and physical sciences; an opportunity for the non-specialist to understand headline-making geological events of topical interest. No prior knowledge of the Earth Sciences is required.
Exclusion: (EESA05H3), GLG103H
Breadth Requirement: Natural Sciences

STAB22H3: Statistics I

This course is a basic introduction to statistical reasoning and methodology, with a minimal amount of mathematics and calculation. The course covers descriptive statistics, populations, sampling, confidence intervals, tests of significance, correlation, regression and experimental design. A computer package is used for calculations.
Exclusion: ANTC35H3, MGEB11H3/(ECMB11H3), (POLB11H3), PSYB07H3, (SOCB06H3), STAB23H3, STAB52H3, STAB57H3, STA220H, STA250H
Breadth Requirements: Quantitative Reasoning

EESC03H3 Geographic Information Systems and Remote Sensing

This course focuses on the use of Geographic Information Systems (GIS) and Remote Sensing (RS) for solving a range of scientific problems in the environmental sciences and describing their relationship with - and applicability to - other fields of study (e.g. geography, computer science, engineering, geology, ecology and biology). Topics include (but are not limited to): spatial data types, formats and organization; geo-referencing and coordinate systems; remotely sensed image manipulation and analysis; map production.
Prerequisite: EESA06H3 and 0.5 credit at the B-level in EES courses

Corequisite: 0.5 credit at the B-level in EES courses
Recommended Preparation: GGRB30H3
Breadth Requirements: Quantitative Reasoning

EESC13H3 Environmental Impact Assessment and Auditing
To familiarize students with the relevant legislation, qualitative and quantitative approaches and applications for environmental impact assessments and environmental auditing. The focus will be on the assessment of impacts to the natural environment; however, socio-economic impacts will also be discussed. Environmental auditing and environmental certification systems will be discussed in detail. Examples and case studies from forestry, wildlife biology and land use will be used to illustrate the principles and techniques presented in the course. Students will acquire "hands-on" experience in impact assessment and environmental auditing through case studies.
Prerequisite: 1.0 credit in EES courses
Corequisite: 0.5 credit in EES courses
Exclusion: GGR393H
Breadth Requirement: Natural Sciences

EESC19H3 Oceanography
The world's oceans constitute more than 70% of the earth's surface environments. This course will introduce students to the dynamics of ocean environments, ranging from the deep ocean basins to marginal seas to the coastal ocean. The large-scale water circulation is examined from an observationally based water mass analysis and from a theoretical hydro-dynamical framework. The circulation of marginal seas, the role of tides, waves and other currents are studied in terms of their effects upon the coastal boundary.
Prerequisite: EESB03H3
Recommended Preparation: EESB02H3
Breadth Requirements: Natural Sciences

EESC25H3 Urban Climatology (NEW)
This course will focus on how urban areas modify the local environment, particularly the climates of the cities. The physical basis of the distinct urban climatology will be examined with energy balance of urban surfaces by focusing on the factors and the processes involved in the development of urban climate. Urban heat island phenomenon and its modelling will be studied based on the conceptual and applied urban-climate research. The impact of climate change on urban sectors such as urban energy system, water and wastewater system, and urban transportation and health system will be examined through case studies. Students will have the opportunity to choose their own areas of interest to apply the knowledge they learn throughout the course and demonstrate their understanding in tutorial-based discussions. The students will be required to work with community or industry partners to work on a project to assess the impacts or unban climate change.
Prerequisites: A minimum of 6.0 credits, including at least 2.0 credits in EES courses
Breadth: Requirement: Natural Sciences

EESD06H3 Climate Change Impact Assessment
Climate change over the last 150 years is reviewed by examining the climate record using both direct measurements and proxy data. Projection of future climate is reviewed using the results of sophisticated climate modeling. The climate change impact assessment formalism is introduced and applied to several examples. Students will acquire practical experience in climate change impact assessment through case studies.
Prerequisite: EESB03H3
Breadth Requirements: Natural Sciences

EESD28H3 Fundamentals of Environmental Modelling (NEW)
This course introduces the rapidly growing field of Environmental modelling. Emphasis will be placed on the rational of model development, objective of model evaluation and validation, extraction of the optimal complexity from complicated/intertwined environmental processes. By focusing on the intersections between climate change and ecological systems, students will develop the ability to integrate information from a variety of disciplines, including geosciences, biology, ecology, chemistry, and other areas of interest. The course will also involve practical training in the computer lab. Students will have to develop an intermediate complexity mathematical model, calibrate the model, and assess the goodness-of-fit against observed data, identify the most influential model parameters (sensitivity analysis), and present their results.
Prerequisites: MATA30H3 and STAB22H3 (or equivalent) and [an additional 6.0 credits at the C-level in EES courses]
Exclusion: EES1118H
Breadth Requirements: Natural Sciences

EESD31H3 Applied Climatology
This course will introduce and discuss the basic topics and tools of applied climatology, and how its concepts can be used in everyday planning and operations (e.g. in transportation, agriculture, resource management, health and energy). The course involves the study of the application of climatic processes and the reciprocal interaction between climate and human activities. Students will also learn the methods of analyzing and interpreting meteorological and climatological data in a variety of applied contexts. Topics include: Solar Energy; Synoptic Climatology and Meteorology; Climate and Agriculture; Climate and Energy; Climate and Human Comfort; Urban Effects on Climate and Air Pollution.
Jointly offered with EES1131H
Prerequisite: STAB22H3 and EESB03H3 and [an additional 1.0 credit in EES courses, of which 0.5 credit must be at the C-level]
Exclusion: EES1131H
Enrolment Limits: 38
Breadth Requirements: Natural Sciences

ESTD19H3 Risk

A practical introduction to the concept of 'risk' as utilized in environmental decision-making. Students are introduced to risk analysis and assessment procedures as applied in business, government, and civil society. Three modules take students from relatively simple determinations of risk (e.g., infrastructure flooding) towards more complex, real-world, inclusive considerations (e.g., ecosystem impacts of climate change).
Prerequisite: 14.5 credits and STAB22H3 (or equivalent)
Breadth Requirements: Natural Sciences