Earth Systems and Climate Science
SFS 3601

Syllabus
4 credits

The School for Field Studies (SFS)
Center for Climate Studies (CCS)
Puerto Natales, Chile

This syllabus may develop or change over time based on local conditions, learning opportunities, and faculty expertise. Course content may vary from semester to semester.

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COURSE CONTENT SUBJECT TO CHANGE

Please note that this is a copy of a recent syllabus. A final syllabus will be provided to students on the first day of academic programming.

SFS programs are different from other travel or study abroad programs. Each iteration of a program is unique and often cannot be implemented exactly as planned for a variety of reasons. There are factors which, although monitored closely, are beyond our control. For example:

- Changes in access to or expiration or change in terms of permits to the highly regulated and sensitive environments in which we work;
- Changes in social/political conditions or tenuous weather situations/natural disasters may require changes to sites or plans, often with little notice;
- Some aspects of programs depend on the current faculty team as well as the goodwill and generosity of individuals, communities, and institutions which lend support.

Please be advised that these or other variables may require changes before or during the program. Part of the SFS experience is adapting to changing conditions and overcoming the obstacles that they may present. In other words, this is a field program, and the field can change.

Course Overview

Many national and international reports support the statement that “climate change and global warming is the mother of all battles because it is a battle for humanity's survival”, but, it is more than this. Patagonia is a privileged location for climate change studies in the Southern Hemisphere, given its unique and continuous extent below 45 °S latitude. This region is considered a “hotspot” of paleoclimatic information that has witnessed, in different time scales, abrupt global changes, providing a natural laboratory for the study of past climate processes.

In terms of the present and future impact of climate change, Patagonia also has a lot to say. Its ecosystems are affected by drivers of global climate change, and science is becoming more able to detect these rapid changes and explain these processes. Ongoing research shows that to answer “big questions” about climate change, interdisciplinary vision and collaboration is required.

This course provides an overview of the Earth Systems – geosphere, cryosphere, hydrosphere, and atmosphere – the dynamic interactions between them, and the unique characteristics that these components display in Patagonia. The course covers Systems Theory, the overall characteristics of each system, and why we should think of the Earth as a system that is more than the sum of its parts. We will examine all systems in detail and find the relationship between them and switch the different time scale over which they operate. The course emphasizes the cryosphere and climate science and how these components interact in Patagonia and what will happen with them under climate change scenarios.

Learning Objectives

Successful completion of this course means that you will have learned about the myriad components of the Earth’s systems and their interactions, with a notable emphasis on how our climate system works in a continuous flow of matter and energy. You will use class lectures and discussions; readings from scientific literature or recognized source; you will test your ability to observe and question; field exercises; and exams, in other to understand each of the key components of Earth’s system, that is, the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere, and their interactions.

You will learn to identify the roles of each system in determining a region’s climate, and landforms and in forcing climate to change along various time frames, ranging from mere years to millions of years. Understanding the dynamic between climate and the cryosphere in Patagonia will be another part of the outcomes you will obtain from this class, and its interaction with the other components of the earth system will have a special focus on Patagonia. In addition to theoretical concepts, you will learn various field skills. You will know different techniques of the use of GPS and drone to build Digital Elevation Models (DEM) with hydroclimatic and glaciology applies.

Assessment

Assessment Item	Value (%)
Climate Project	20
Field Notebook	15
Field Exercises	15
Quizzes	15
Class Activities	15
Participation	10
Integrated Discussion	10
TOTAL	**100**

Climate Project (20%)

As the course finale, students will apply course topics and put skills into practice. During the ESCS20 class, students will be separated into groups of four, and each group will choose a question to solve from a set of questions. Each group must submit a five-page written report, along with figures. More specific instructions will be provided during the ESCS20 class. Note that we will have dedicated workshop time during the ESCS27 class to focus on answering outstanding project questions.

Field Notebooks (15%)

Each field expedition provides a context for observation and learning. As we progress through the semester, the class themes will become easier to see in the landscape, and the things we see in a new location deepen the understandings we made in prior spaces. A field notebook is a physical means of capturing the observations and insights that you gain in the field over the course of the semester.

You should become in the habit of making observations of your surroundings and contextualizing them to the processes that surround them. Especially when we go out of town, every day on a field excursion is an opportunity to develop your field observation skills. During a field outing, these personal observations will form the basis of entries you write up in your field notebook. You can develop your field notebook observations in many forms, including a written description, a drawing with its short description, a conceptual diagram, etc. However, your field observations should **not** be a simple recapitulation of the academic field activities (i.e., lectures, FEXs, professor-guided activities). Rather, they should be based on **your own** observations, insights, and musings.

During every field expedition, you will have assigned time to develop your field notebook. This programming promotes efficient time use and considers that faculty members will be present to clarify any observation you make on that day. Your field notebook must have at least one (1) entry per field day, and it must include at least two (2) entries for each class at each hand-in, namely following the Clim14 and Clim27 classes.

Keep in mind the following grading rubric:

- **Completeness (1%):** Each individual entry must include the *location*, the *date*, the *course* to which the entry is directed, and the *observation* you made.
- **Coherence (4%):** Each entry should be **coherent** in the way it presents information. This includes legibility, connection of ideas, and concept development. If figures and drawings are included, coherence would mean placing them in their observed context and indicating how they connect with the short writing description of it.
- **Correctness (6%):** Each entry should contain factually **correct information**. If you need clarifications, faculty members are geared to help you.
- **Connection (4%):** Each entry should try to connect the field observation with something beyond the location. This can be to other observations you made within your field notebook, course content, and even familiar landscapes back home. The key is to use the field notebook as a tool to connect with understandings that are being developed in the classes, knowledge that you bring with you, and observations and insights you have made in various locations.

FEX 1: Climate and its relationship with water pathways (8%)

Objective: This assignment is to apply both data analysis and connect a theoretical understanding of the relationship between the atmosphere and ecosystems.
Skills to develop: Data analysis, Climate Trends, Scientific writing

Methods: We will use scientific equipment that measures different climate variables. Students will produce a 2-page report with a description of the main processes involved. More detailed instructions are forthcoming.

FEX 2: The Ice Path (7%)

Objective: This assignment is to practice observational field skills and connect a theoretical understanding of the glacial processes and landscape formation and use different technics to show these processes on the locations visited.
Skills to develop: GPS survey, GIS, Remote Sensing
Methods: We will use observation to find clues to the glacial process in the landscape and digital techniques. Students will produce a schematic and analysis drawing also including a digital map in a 1-page report. More detailed instructions are forthcoming.

Quizzes (15%)

This course contains short quizzes, each one to evaluate the contents of lectures and field activities.

Class Activities (15%)

Students will be assessed based on their ability to develop field observations and linking with the class topics, making a small report for the indicated field activities.

Participation (10%)

Grading of the participation component will be based on the following individual parts. All students should be prepared for each class by reading the required literature on each topic and asking or answering relevant questions to clarify concepts. It is also expected that all students actively participate and contribute to discussions that may arise during classroom and field lectures. Additionally, during the semester, all students will be required to briefly introduce a specific topic by presenting the main ideas of a paper and leading the discussion on the specific topics.

Integrated Discussion (10%)

To review and develop our understandings of the topics explored in the field, we will have **two** integrated discussions (ESCS12 and ESCS28). Since all field locations provide context for observation and learning, this activity will take advantage of your Field Notebook entries and class notes to integrate knowledge. For each integrated discussion, the class will be broken into four (4) groups, with each group in charge of connecting specific themes with specific field locations. Each group will use an online platform to make a presentation and guide a discussion of their peers.

Keep in mind the following grading rubric:

- **Digital platform use (3%):** Each group must select an online platform to create their presentation and discussion guide. Your use of this platform should best display the knowledge gained in field locations. This platform should display content in an interactive way and must be capable of offline sharing.
- **Connecting field locations to course contents (3%):** Each group will be evaluated on how they connect their assigned field locations with course content on the platform. This includes coherency of the written content.
- **Presentation and discussion (4%):** Each group member will be evaluated on the presentation of their materials to their peers, their ability to lead and moderate a discussion that covers the topics they were assigned, and also their level of engagement with the discussions of other groups.

Grading Scheme

Grade corrections in any of the above items should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

A	95.00 - 100.00%	B+	86.00 - 89.99%	C+	76.00 - 79.99%	D	60.00 - 69.99%
A-	90.00 - 94.99%	B	83.00 - 85.99%	C	73.00 - 75.99%	F	0.00 - 59.99%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

General Reminders

Honor Code/Plagiarism – SFS places high expectations on their students and we hold students accountable for their behaviors. SFS students are held to the honor code below. SFS has a zero-tolerance policy towards student cheating, plagiarism, data falsification, and any other form of dishonest academic and/or research practice or behavior. Using the ideas or material of others without giving due credit is cheating and will not be tolerated. Any SFS student found to have engaged in or facilitated academic and/or research dishonesty will receive no credit (0%) for that activity.

> *"SFS does not tolerate cheating or plagiarism in any form. While participating in an SFS program, students are expected to refrain from cheating, plagiarism and any other behavior which would result in a student receiving credit for work which they did not accomplish on their own. Students are expected to report any instance of cheating or plagiarism by others."*

Deadlines – Deadlines for written and oral assignments are instated to promote equity among students and to allow faculty ample time to review and return assignments before others are due. As such, deadlines are firm; extensions will only be considered under extreme circumstances. Late assignments will incur a penalty of 10% of your grade for each day you are late. After two days past the deadline, assignments will no longer be accepted. Assignments will be handed back to students after a one-week grading period. Grade corrections for any assessment item should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

Content Statement – Every student comes to SFS with unique life experiences, which contribute to the way various information is processed. Some of the content in this course may be intellectually or emotionally challenging but has been intentionally selected to achieve certain learning goals and/or showcase the complexity of many modern issues. If you anticipate a challenge engaging with a certain topic or find that you are struggling with certain discussions, we encourage you to talk about it with faculty, friends, family, the HWM, or access available mental health resources.

Participation – Since we offer a program that is likely more intensive than you might be used to at your home institution, missing even one lecture can have a proportionally greater effect on your final grade simply because there is little room to make up for lost time. Participation in all components of the course is mandatory, it is important that you are prompt for all activities, bring the necessary equipment for field exercises and class activities, and simply get involved.

Course Content

Type: CA: Class Activity, **FEX:** Field exercise, **FL:** Field Lecture, **L:** Lecture, **O:** Orientation

*Readings in **Bold** are required. "Sess": Class session, where 1 class session ≈ 50 minutes

Code	Title and outline	Type	Sess.	Required Readings
ESCS01	**Course Introduction** General description of the course, syllabi review, principal themes, and methodology	O	0.5	Syllabus Review
One-day Field expedition: EXPLORA Torres del Paine				
ESCS02	**Earth Systems and Climate Sciences** Introduction of the main course topics and their links with the field elements.	O	1	
Topic 1: The Earth Systems				
ESCS03	**A) Introduction to Earth Systems and Climate Sciences:** General description of Earth Systems and Climate Sciences with emphasis on Patagonia and define different time scales to study these systems.	L	1	**Steffen et al., 2016**
	B) Read papers by groups: Strategy and methods to read papers, and discussion activity	CA	2	**Steffen et al., 2020; Colling & Open University Oceanography Course Team., 2001; Chronostratigraphic chart**
	C) Introduction to glacier systems: Description of cryosphere, introduction to glacier systems and their process, description of the interaction between glaciers and the landscape	L	1	**Vaughan et al., 2013**
One-day Field expedition: Monumento Natural Cueva del Milodón				
ESCS04	**Fluctuations and landscape evidence of glaciations**: Identify and interpret the processes on the landscape	FL	1.5	**Sagredo et al., 2011**
ESCS05	**Skills workshop:** improving skills for Field Exercises and class activities.	CA	4	
Multiday Field expedition: Punta Arenas				
ESCS06	**Long-term climate monitoring, Punta Arenas** Exploring one of the more important long-term sites in Patagonia (Instituto de la Patagonia). [FEX 1 Introduction]	FL	1.5	
ESCS07	Glacier and sea interactions, and Strait of Magellan 100 years ago. [FEX 1]	FEX	1.5	
ESCS08	**Soils, water supply and climate** Description of the process of soil profile development with an emphasis on coal formation, environmental risk, and las minas watershed	FL	2	**Otero et al., 2012**

Code	Title and outline	Type	Sess.	Required Readings
Multiday Field expedition: Pingo Salvage				
ESCS09	**Study and evidence different changes and time scales:** Explore and interpret the evidence of different time scale change on the landscape.	FL	2	
ESCS10	**Watershed in a warming world:** Exploring the different component of the water cycles and its changes in a warming world.	FL	2	
Topic 2: Freshwater				
ESCS11	**A) Hydrosphere and Cryosphere:** Introduction to the hydrosphere, the water cycle in Patagonia, ice and water interactions in a changing world. Reading papers. **B) Student Activities:** Hydrosphere and Cryosphere interactions, Data repositories **C) Changes in the Stream and Lacustrine Systems:** Recent changes in the stream-lacustrine systems in Patagonia. **D) FEX 1 workshop**	L CA L CA	1 1 1 1	**Allan et al., 2020; Hock et al., 2019**
ESCS12	**Integrated discussion:** A student-led exploration combining themes and locations visited during the first half of the course.	CA	2	
Multiday Field expedition: El Calafate				
ESCS 13	**Wetland:** Explore and understand the geomorphological processes on Argentino Lake and its relationship with climate change	FL	1	
ESCS14	**Perito Moreno Glacier:** Glacier dynamic and recent behaviors	FL	1	
Topic 3: Ice				
ESCS15	**A) Physical Glaciology:** Physical processes of glacier formation, and its sensitivity and feedback on climate variability. **B) GIS and Remote Sensing activity** **C) Control on glacier cycles:** Glacial cycles, great past climatic events and global drivers **D) FEX 2 introduction**	L CA L CA	1 1 1 1	**Cuffey & Paterson, 2010** **Broecker & Denton, 2015; Oerlemans, 2001; Oerlemans, 2005**
Multiday Field expedition: Torres del Paine				
ESCS16	**Ice Path:** [FEX 2 Site 1]	FEX	1.5	
ESCS17	**Rapid Climatic Change Event:** Review and discussion about the recent and rapid changes on Grey Glacier. [FEX 2 Site 2]	FL, FEX	1.5	**Weidemann et al., 2018**
ESCS18	**Torres del Paine:** Geological and glaciological processes in Torres del Paine Massif	FL	1.5	**Leuthold et al., 2012**

Code	Title and outline	Type	Sess.	Required Readings
One-day Field expedition: Vega Castillo				
ESCS19	**Lake monitoring and drone survey:** Use of drones for lake monitoring. Explore and interpret the evidence of climate change on the landscape.	FL	1.5	
Topic 4: Fire				
ESCS20	**A) Climatic Change and Air Quality:** Description of air quality management **B) Data management and climate trends** **C) Climatic Change and Air Quality, Part 2:** How these processes are affected in a warming world and the different feedback between the Earth systems components. Papers discussions **D) FEX 2:** Workshop to final details to FEX 2	L CA CA CA	1 1 1 1	**Cordero et al., 2022; Jacob & Winner, 2009; Kinney, 2008**
Multiday Field expedition: Tierra del Fuego				
ESCS21	**Volcanism and Climate (Pali Aike):** Description of volcanism and climate interactions, and explain Pali Aike volcanism process	FL	2	**Ross et al., 2011**
ESCS22	**Glacier and peatland:** Biogeochemical cycle as part of Earth systems and climate science.	FL	1.5	**Baldocchi, 2014**
ESCS23	**Geosphere and Volcanism:** Description of the geosphere systems and their principal processes, with a focus on the context of volcanic and layering process	FL	1.5	**McCulloch et al., 2005**
ESCS24	**Cyanobacteria and its relevance on Patagonia**	FL	1.5	**Zaytseva et al., 2021**
ESCS25	**Skills workshop:** improving skills for Field Exercises and class activities.	CA	4	
Topic 5: Climate Change				
ESCS26	**A) Global and Patagonian Climate:** Characterization of the climate in Patagonia **B) Climate over the last 2000 years:** Review of climate change over the last 2000 years and its impact on the Earth Systems **C) Future Climate:** Predictions, models, and their implication for Earth Systems in Patagonia D) **Paper reading and discussion:** Students will distill topics from climate change papers and apply them to the Patagonian context.	L CA L CA	0.5 0.5 1 2	**Aguirre et al., 2021; Garreaud et al., 2013** **Moreno et al., 2014** **Meehl et al., 2020**
ESCS27	**Day to finish up end-of-semester assignments**	CA	1.0	

Code	Title and outline	Type	Sess.	Required Readings
ESCS28	**Integrated discussion** Semester review and discussion of the many ways in which the lecture themes tie together**.**	CA	2	
	Total session hours		59.5	

Reading List

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