THE SCHOOL FOR FIELD STUDIES

Earth Systems and Climate Science
SFS 3601

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

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, the elephants are not always where we want them to be, so be flexible!

Course Overview

Two of the most significant concerns facing our planet, not only at present but in the future, are the many aspects of climatic change and the impact of natural hazards on ecosystems and particularly on the socioeconomic stability of human populations. These general subjects are especially important to the sensitive environments of Patagonia, Chile, located close to the climatic boundary between mid-latitudes and polar regions and including the rapid changes in environmental conditions from the glaciated high-alpine regions of the Southern Andes down to the broad lowlands at sea level. In addition, Patagonia, and Chile as a whole, is very much at the mercy of its geological setting as three tectonic plates converge along the length of the country. This course will present the many individual components of the climate system and their interactions within the entire earth system including the importance of how Chile's climate has changed in the past, how to reconstruct the magnitude and timing of those past changes and the potential future changes and impacts. The Patagonia Ice Fields, largest glacier systems in the Southern Hemisphere outside of Antarctica, will provide a natural laboratory for evaluation of the role of glaciology and glacial geology in climatic studies. Reconstructing past glacier activity is a key component for understanding how climate has varied and recent changes in the extent of these glaciers is significant evidence of our present warming climate. Other key components of the earth and climate system to be evaluated in this class include the nature of vegetation and stream systems with past and recent climatic change. We will also evaluate the tectonic characteristics of the region including volcanic eruptions and their impact, not only locally but the far-reaching atmospheric impact and particularly their role in forcing climate. The strongest earthquake ever recorded was in Chile, thus we will learn about how earthquakes work and the many ways they can alter environmental conditions and especially the human component of the fragile ecosystems of Patagonia.

Learning Objectives

Upon successful completion of this course, you will learn about many components of the Earth and its systems with a notable emphasis on how our climate system works. In general, you will use class lectures and discussions; readings from the scientific literature; problem assignments; field exercises and exams to understand each of the key components of the climate system, that is, the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere. You will also identify their roles in determining the climate of a region and in forcing climate to change on various time frames ranging from millions of years to several years. Those same techniques will be used in your evaluation of volcanic activity and earthquakes and their impacts.

More specifically, you will use different types of climatic data from the region to learn how to interpret graphs of climatic and related data by looking at trends and variability in the records. An important series of techniques you will learn is how to reconstruct the history of climatic change in the Patagonia region. Paleoclimatic studies provide baseline data on the natural cycles that have forced climate change prior to and along with human influence, as well as the role natural forcing components may play in potential future changes. You will learn how to collect sediments from bogs and potentially lakes to evaluate changes in sedimentation style that is a function of process changes in the past, whether it

be climatic or a different forcing mechanism. You will learn how to identify different types of glacial sediments and landforms and what they may mean as far as former glacier extent and the climatic factors that led to those glacial conditions. Similarly, you will learn how snow pit studies can be used to evaluate water availability especially for water supply, as well as their use in avalanche studies. As glaciers can be a significant source of water for communities, you will evaluate characteristics of streams in the region both with time and in a downstream direction including suspended sediment supply, water temperature, pH, and the total number of dissolved solids being carried by the streams. We also will analyze soil profiles; thus, you will now be able to identify and characterize soil horizons and what they mean for the nature of surface material weathering and their use in the relative dating of that material including the relative age of glacial features. The evaluation of pollen diagrams as given in scientific papers and glacial features from satellite images will be the classroom assignments on these same general subjects. A frequently used method to reconstruct past climate is the use of tree rings. You will learn how to collect cores properly from trees and interpret the rings collected as far as how old the trees are and potential climatic conditions over the life span of these trees. We will not be able to do the detailed analysis of tree cores, but you will be able to determine the age of the tree, and determine years when the tree was under stress or when it was growing like crazy, that is, enjoying life!

Understanding the dynamic geology of the region will be another part of the outcomes you will obtain from this class. We will read several key papers on the impact of volcanism in Patagonia and our field work will introduce you to the nature of volcanic deposits. Exercises will be undertaken to evaluate and characterize these deposits and what they mean to the communities of Chile. Classroom assignments on the techniques used to identify the epicenter of an earthquake and its magnitude will be undertaken.

As part of not only all of our field work, but while we are at the Center, you will learn about weather conditions and forecasting. In fact, you will be able to forecast the weather conditions based on cloud types, wind direction and temperatures, even to the point that you could forecast almost as well as those you see on mass media. You will frequently find out my thoughts on the Weather Channel. Classroom activities will include learning how to read weather maps, both surface maps and those from upper levels, the part of our atmosphere that controls what we see and feel at the surface. As day-to-day weather comprises our climate, you will learn about the big differences between the weather and climate of Patagonia, and the Southern Hemisphere as a whole, compared to what you hear about back in the States. The role the atmosphere plays in dictating the nature of ocean currents will be another subject you will become proficient in from the material covered in this class.

Another skill you will get from our field work is how to read a map especially from a geology perspective. Most people use GPS and their phones for directions and pinpointing where they are on the landscape. However, signals are not available everywhere in the world. For example, you can be without a signal in central Maine. Consequently, you will learn about topographic sheets and all the components of a map that will allow you to find your way, as well as to identify specific features. Glacial features often show up very well on such a map.

Thematic Components and Research Direction

As this is the first year of the CSC, you will be playing a vital role in helping to develop the Strategic Research Plan (SRP) of the Institution. Along those lines, the primary questions we will address in the research portion of this course are as follows.

1. How have the glacier systems of Patagonia and the Tierra Del Fuego region varied with time?

2. What has been the impact on the various ecosystems of the region with past and ongoing climatic change?

3. How has past volcanic activity modified the climate and landscape of Patagonia and altered the biogeochemical component of these sensitive ecosystems?

4. We will answer this question in collaboration with the Patagonia Ecology course. How do the physical and chemical characteristics of the glacier-fed streams of the region vary?

Assessment

The evaluation breakdown for the course is as follows:

Assessment Item	Value (%)
Participation	15
Classroom Assignments	15
Field Exercise 1	10
Field Exercise 2	10
Field Exercise 3	10
Field Exercise 4	10
Mid-term Exam	15
Final Exam	15
TOTAL	**100**

IMPORTANT NOTE: You are required to complete every assignment and exam in a reasonable manner to pass the course. Blowing-off a singe exercise results in you not passing the course, despite your overall final grade. In addition, if I feel that you did not put the effort into any of the assignments, I will take points off your class participation grade at my discretion. That means you can easily lose 1.5 letter grades should you not put effort into an assignment.

SECOND IMPORTANT NOTE: Phones and computers are not allowed in the classroom unless you will be using them for a particular assignment. I will let you know when you should bring your computer to a

lecture. Should I catch you with your phone, such as having it down on your lap, which for some reason, students think the professor does not see it, points will be taken off of your final grade with the amount. In other words, don't do it. It is that simple. Besides, re-writing lecture notes is a way of studying and it is very beneficial to your overall understanding of the material we go over.

Participation and topic discussions (15%)

The participation component of your course grade is based on several individual parts. You are expected to be prepared for class, meaning that if there are any required papers to read you should have read them before class, and to come to every class. You are expected to answer questions in class and if you need to, ask questions to help clarify any concepts. You are expected to take part and contribute to any discussions both in the class and especially in the field. I think you have to admit the landscape of Patagonia is breathtaking and there will be so many opportunities and need to discuss what you are seeing. Essentially the participation grade is a reflection of your overall effort and interest. I assume you are interested in the material we discuss or else you would not have signed up for this program, so show it. A big part of field work is observation, not running up the trail ahead of everyone. Along those lines, a big part of field work is safety, so be considerate of others. If you goof around in the field, your participation grade will suffer. As I noted above, your participation grade is my way of penalizing you for not doing work. On the other hand, the participation grade can be used to "bump" you up to the next higher grade if you are border line and have been putting in the effort. Believe me, I can tell when individuals are putting in the effort. I have been around, so to speak.

Classroom Assignments (15%)

You will do five (5) in-class assignments (3% per assignment) that utilize various types of climatic data to train you in the process of interpreting those data, evaluate weather maps, introduce you to the methods of determining the location and magnitude of an earthquake and write an op-ed piece. Remember that you still must put a significant effort into each assignment to get a passing grade for the course. In other words, don't blow off the assignment because it is only worth 3% of your total grade. One other important point: LATE ASSIGNMENTS ARE NOT ACCEPTED, unless you have a valid reason like being very sick.

Assignment 1 (3%): The first assignment will introduce you to the interpretation of instrumental data, both temperature and precipitation, and what has been happening to the climate of Patagonia. You will compare these data with similar records from your hometown or school area. This assignment will help you in deciding trends in data, nature of variability in the record and the significance of outliers/extreme events. This methodology can be applied to any time-series data set.

Assignment 2 (3%): The second assignment will be the evaluation of paleoclimatic data sets and how climate has changed in the Patagonia regions including the nature of vegetation changes and fire history. You will also evaluate some of the past glacial records.

Assignment 3 (3%): This assignment will allow you to look at a weather map and forecast what may happen in the future. The emphasis will be on looking at weather conditions during extreme weather events or during events that are anomalous for the area, such as, for the Patagonia region.

Assignment 4 (3%): In the fourth assignment, you will use records from seismographs to determine the epicenter of a past quake and the magnitude of that quake. You will also use an additional method of evaluating the impact of a quake, that is, the amount of damage associated with the event and the reason for that extent of damage.

Assignment 5 (3%): Op-Ed Piece. You are going to write and op-ed (open editorial) piece on some aspect of climatic change in Chile and particularly here in Patagonia. If you are not familiar with the terminology, op-ed pieces are those open editorials submitted by anybody to newspapers expressing your opinion about a particular subject. An excellent example would be submitting an editorial to the New York Times or LA Times or Chicago Tribune on how SFS is paving the way for new scientists/environmentalists to address important issues facing humans on how our planet is changing, has changed and could change in the future. Your concluding statement would be all students should sign-up for SFS programs, especially the one in Patagonia.

Field Exercises (FEX) (40%)
Four field exercises will be conducted. With these FEXs students you will gain experience for the Directed Research component at the end of the semester. In addition, the FEXs will require field observation, data collection and report writing, the type of technical writing done in professional papers and in reports produced by environmental companies, non-profit organization and similar institutions.
Context: Science is based on intuition, logic and reason. The scientific method begins with an *observation*; we seek for *patterns* and then formulate *hypotheses* that could explain those patterns. We can also use experiments to test hypotheses. Finally, we conclude on the results thus contributing to a broad theory.
Objective: Our overall objective is to develop observation skills in the field and to learn the process of the scientific method as well as learn how to present the outcomes of your studies to your peers and to the general public.

FEX 1 (10%)
Subject: Observational skills and hypothesis testing
Methods: I have two options for this first assignment. If there are still some snow banks in protected areas of Torres del Paine (TdP), we will dig a snowpit so you can see how such studies are done to evaluate both water supply and avalanche danger. If there are no snow banks or they are too small, you will do a geological study on the rock types there and how individual rock types weather and the significance of rock weathering in both the climate system and the overall environment of the particular drainage basin.
Assessment: You will be assessed based on their ability to develop a sound hypothesis, data collection effort, and the written report. I will provide a detailed summary of the components included in such a report.

FEX 2 (10%)

Subject: Glacial History Studies
Methods: . You will develop a map of the glacial features found in a specific area of TdP and an overall interpretation of how they formed and their implications as to past climatic change.
Assessment: You will be assessed based on their ability to develop a sound hypothesis, data collection effort, and the written report. I will provide a detailed summary of the components included in such a report.

FEX 3 (10%)
Subject: Volcanic Products
Methods: . You will characterize the different types of volcanic materials we see in the Lakes Region, as far as grain size, shape of particles and composition. You will then determine the nature of the eruption that produced those deposits or features.
Assessment: You will be assessed based on their ability to develop a sound hypothesis, data collection effort, and the written report. I will provide a detailed summary of the components included in such a report.

FEX 4 (10%)
Subject: Volcanic History
Methods: . Given the volcanic deposits in this region, you will determine what needs to be done to determine the eruptive history of the source volcano. In the process, you will address the importance of knowing the history of the particular volcano.
Assessment: You will be assessed based on their ability to develop a sound hypothesis, data collection effort, and the written report. I will provide a detailed summary of the components included in such a report.

Midterm Exam and Final Exam (15%)
Two exams will be given with each exam worth 15% of your total grade. Exams will be based on classroom and field lectures; readings and any videos you are required to watch. They will not be extensive and you should be able to finish them in 45 mins to an hour.

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.

Grading Scheme

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

This is the section to list policies on attendance, deadlines, and penalties for academic dishonesty. The policies stated in this section should be consistent across courses – there should never be multiple standards when dealing with things such as plagiarism or cheating. The General Reminders section

should include the following statements (can be modified slightly by Center if needed but will need to be approved by the Deans):

Plagiarism – using the ideas or material of others without giving due credit – is cheating and will not be tolerated. A grade of zero will be assigned for anyone caught cheating or aiding another person to cheat either actively or passively.

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 not be accepted anymore. Assignments will be handed back to students after a one-week grading period.

Participation – In addition to the specific aspects of class participation elaborated on above, here are some general thoughts on the subject as a reminder. 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.

Accommodations – Please let me know if you have any concerns or anything in particular that could impact your ability to undertake the requirements for the course and your overall performance. I'm here to help and make your learning experience a pleasure as opposed to a chore. After all, you are basically paying me to help you so take advantage of that aspect. Most importantly, if you have any specific or even general concerns, talk to me as soon as possible as opposed to waiting to later in the semester.

Lectures, Exercises, and Exams

EAR- Earth Systems and Climate Science

Type: D: Discussion, **FL:** Field Lecture, **GL:** Guest Lecture, **L**: Lecture, **O**: Orientation

Code	*Title and outline*	*Required Readings*	*Type*	*Hours*
EAR1	**Introduction to Systems:** Terminology, Types of Climatic Data: Instrumental records vs Proxy data. Systems and data presentation in climatic studies		O	1.25
EAR2	**World and Patagonia Climate:** Koppen-Geiger System, Southern Hemisphere and Patagonia's climate and controlling factors. Difference from Northern Hemisphere. Instrumental records. Assignment 1: Climatic Data Interpretation	Sarricolea et al. (2017), Garreaud et al. (2013) Lenearts, et al. (2014) Schneider et al. (2003)	L	1.25

Code	Title and outline	Required Readings	Type	Hours
EAR3	**Climate System-Atmosphere:** various components of the Earth's climate system, the sun. Our atmosphere (jet streams, pressure systems, wind) and global circulation patterns, how they work.	Lutgens et al. (2016)	L	1.75
EAR4	**Hydrosphere and Cryosphere:** Role of the ocean, ocean currents and the frozen part of the hydrosphere. Importance of snow and ice in our climate system. Lecture on top of hill outside of town. A first hike for the class.	Emery (1977) Hsu et al. (2018) Lamy et al. (2004) Ruddiman (2014) Aguirre et al. (2018)	L	1.75
EAR5	**Glacier Systems:** Why do glaciers exist, how do they flow and what do they produce on the landscape?	Bennett and Glasser (2009) Sagredo and Lowell (2012)	FL	1.75
EAR6	**Geosphere:** The solid component of the climate system and overall earth systems. General geologic principles.	Montgomery (2014) Ruddiman (2014) Ramos and Ghiglione (2008)	L	1.5
EAR7	**Biogeochemical Cycles:** How important are chemical reactions within our climate system? What are greenhouse gases and how they work. The individual components of the carbon cycle (inorganic vs organic, terrestrial vs marine) and their role, importance and implications for future climatic conditions.	Rudddiman (2014) IPCC (2013)	L	1.5
EAR8	**Bus to Boat/Sea Level Change:** How should you talk about sea level change?	See TdF GLACIERS References	FL	0.75
EAR9	**Reconstructing glacial history**: Evidence used to develop the chronology of glacier systems in the Ainsworth Bay region, including Marinelli Glacier, and Brookes Bay region.	See TdF GLACIERS References	FL	1.0
EAR10	**Reconstructing climatic history:** Beagle Channel area and Pia Glacier System. Evidence used to develop the glacial chronology. Comparisons in the Cordillera Darwin region.	See TdF GLACIERS References	FL	1.0
EAR11	**Evidence of Sea Level Change:** What type of evidence is used to reconstruct changes I sea level, pre-historical and historical**.**	Rojas et al. (2018)	FL	1.0

Code	Title and outline	Required Readings	Type	Hours
EAR12	**Return on Bus/Ocean Temperatures and Acidity:** . What has been happening and what could happen in the future? What does it mean for the climate system and its impact on marine organisms, fishing industries among others. Impact on storms.		FL	1.0
EAR13	**Soils:** Controls on soil profile development, soil types in Chile. Emphasis on climatic controls on soil development and use in paleoclimate studies.	Birman and Montgomery (2014)	L	1.25
EAR14	**Identifying climatic change via vegetation changes:** Especially extreme changes, wet/dry season variability. Record of changes in forests over last 20+k years	Borromei et al. (2010) Srur et al. (2018)	L	1.25
EAR15	**Vegetation changes in Patagonia with time:** How has climate and vegetation changed in Patagonia.	Heusser (1995) Moreno et al. (2018) Fletcher and Moreno (2012) Mansilla et al. (2016)	L	1.25
EAR16	**Wildfires and climate:** Types and climatic controls with changing temperature regime. Fires in Chile. Evidence of past fire histories through pollen (vegetation records), macrofossils and charcoal in lake and bog sediments. Assignment 2: Interpretation of Records	Whitlock et al. (2007) Markgraf and Huber (2010) Markgraf et al. (2007)	L	1.25
EAR17	**Climatic Change and Air Quality**: Impact of changing climate on air quality, causes of concern with increased pollution and ozone levels. Impact of ozone on vegetation.	IPCC (2013)	L	1.0
EAR18	**Climatic Change and Human Health:** Related changes in disease distributions. Evaluate migration of tropical/sub-tropical diseases into mid-latitudes	IPCC (2013)	L	1.0
EAR19	**Other Impacts/Review: Any additional impacts. Review for exam if you have questions for review!!**		L	0.75
EXAM	**EXAM 1**		EX	0.75
EAR20	**Torres del Paine:** Applied nature of snow OR Plate Tectonics and Rock Types. See explanation in grading summary.	Altenberger et al. (2003)	FEX1	2.0
EAR21	**Alpine geomorphology:** Evolution of an alpine landscape from original uplift to weathering types and glaciation impact.	Birman and Montgomery (2014)	FL	2.0

Code	Title and outline	Required Readings	Type	Hours
EAR22	**Glacial History:** Determine the glacial history of the area through evaluation and sampling of glacial features.	See GLACIAL references.	FEX2	2.0
EAR23	**Reconstructing Past Climatic Conditions:** Methods used to develop a chronology of past climatic conditions**.**		L	1.25
EAR24	**El Calafate - Controls on glacial cycles:** Importance of orbital cycles. Use of isotopes in identifying glacial cycles. Northern vs Southern Hemisphere glaciations.	See GLACIAL references	FL	1.5
EAR25	**El Calafate – Rapid Climatic Change Events:** How fast can our climate change? The timing and the evidence.		FL	1.5
EAR26	**Glaciology and Climatic Change:** The role of glacial flow. The significance of Perito Merino Glacier as an analog.	See GLACIAL references	FL	2.0
EAR27	**Weather Systems:** What are the major components that produce the weather around you?	Lutgens et al. (2016)	L	1.25
EAR28	**Weather Maps:** How to read a weather map, especially for severe weather events. Assignment 3: Weather Map Interpretation	Lutgens et al. (2016)	L	1.0
EAR29	**Coastal Systems/Fjords:** What processes dominate along a coastline and particularly within a fjord system?	Bujalesky (2007)	FL	1.25
EAR30	**Lacustrine Systems:** What are the physical and chemical characteristics of lake systems?	Waldmann et al. (2014) Lamy et al. (2010)	L	1.0
EAR31	**Stream Systems:** How do stream systems operate including channel types?	Birman and Montgomery (2014) Montgomery (2014)	L	1.0
EAR32	**Changes in the Stream System:** How do they adjust to changes in the landscape either through climatic change or tectonic activity? What would these changes mean to the riparian ecosystems?	Birman and Montgomery (2014) Montgomery (2014)	FL	1.0
EAR33	**Seismicity and Earthquakes:** The earthquakes of Chile, evidence and historical record. How they work and the potential impacts.	Montgomery (2014) Jennings et al. (1995) Various web site readings.	L	1.25

Code	Title and outline	Required Readings	Type	Hours
	Assignment 4: Determining the Epicenter and Magnitude of an Earthquake.			
EAR34	**Tsunamis:** How they work and the significance of the great 1960 Chilean quake and loss of coastlines.	Montgomery (2014) These two videos deal with volcanism but I want you to watch them prior to our trip to the Lakes Region. These are two NOVA episode available on youtube. One of them starts you know who!!! https://www.youtube.com/watch?v=oC9Q-iEGoqA https://www.youtube.com/watch?v=kPFgfmwDUKg	L	1.25
EAR35	**Lakes Region – Volcanic Systems:** Causes and types of volcanic eruptions.	Global Volcanism Program Garcia (2012)	FL	1.0
EAR36	**Lakes Region – Volcanic Products**: What is produced by an eruption and the characteristics of resulting deposits.		FL	2.0
EAR37	**Lakes Region – Volcanic Products**: Characterization of different types of volcanic materials , such as, grain size, shape of particles and composition. You will then determine the nature of the eruption that produced those products.	Stern (2008), Stern et al. (2011)	FEX3	2.0
EAR38	**Lakes Region – Volcanic History:** The records and impacts of volcanism in both northern Chile and Patagonia region.	Global Volcanism Network Kilian et al. (2006)	FL	1.25
EAR39	**Lakes Region – Volcanic History:** Given the volcanic deposits in this region, what would you do to determine the eruptive history of the source volcano. Why is determining this history important?	Kilian et al. (2003)	FEX4	2.0
EAR40	**Lakes Region – Volcanism and Climate: .** How and why do some volcanic eruptions impact climate, while others do not. When does an eruption affect global climate?		FL	1.0
EAR41	**Mega-Eruptions:** What are they and how	NOVA episode, You Tube	FL	1.0

Code	Title and outline	Required Readings	Type	Hours
	often do they occur? Famous mega-eruptions such as Toba and Yellowstone, and potential impacts.	video. https://www.youtube.com/watch?v=oC9Q-iEGoqA		
EAR42	**Global Climate Change with Time:** Summary of what has been happening throughout Earth's History: Ice box vs Hot box climates. Further use of field techniques in TdF Assignment 5: Op-ed Piece	Ruddiman (2014)	FL	1.0
EAR43	**Climate over the last 2000 years:** How has climate changed over the last 2000 years, controls and magnitude of changes? The "hockey stick" of climate. Further use of field techniques in TdF.	Rosenbluth et al. (1997) Bosier et al., (2018) Moy et al., (2009)	FL	1.25
EAR44	**Future Climate:** What are the predictions? How bad is it going to get?	National Environmental Commission-Chile,2008-2012 Muck (2012) IPCC (2013)	L	1.0
EAR45	**Summary and Review**		L	0.50
EXAM	**EXAM2**		EX	0.75
.	. . .	. . .	. . .	. . .
		Total contact hours		**60**

A note about the reading list as I will or have explained in lecture. Many of the articles are written for specialists, thus the material may not be easy to understand. However, the abstracts will give you the dominant conclusions drawn. I will let you know which are required and which are optional. However, the abstracts of the optional readings are required. I also have included some articles that may come in handy as you decide about the type of directed research you would like to undertake or might be relevant to what you ending up doing.

Reading List

Altenberger, U., Oberhansli, R., Putlitz, B. and Wemmer, K., 2003, Tectonic controls and Cenozoic magmatism at the Torres del Paine, Southern Andes (Chile, 51°10'S). Reviews in Geology of Chile, 30, 65-81.

Aguirre, F., Carrasco, J. Sauter, Schneider, C., Gaete K. Garin, E., Adaros, R., Butorovic, N. Jana, R. and Casasse G. Snow cover change as a climate indicator in Brunswick Peninsula, Patagonia. Frontiers in Earth Science, 6,130. Doi: 10.3389/feart.2018.00130.

Aniya, M., 2013, Holocene glaciations of Hielo Patagonico (Patagonia Icefield), South America: A brief review. Geochemical Journal, 47, 97-105. GLACIAL

Bennett, M. and Glasser, N.,2009, Glacial Geology: *Ice Sheets and Landforms, 2nd Ed.*. Wiley-Blackwell, Chichester, p. 385.

Bertrand, S., Lange, C.B., Pantoja, S., Hughen, K., Van Tornhout, E., and Wellner, J.S., 2017, Postglacial fluctuation of Cordillera Darwin glaciers (southernmost Patagonia) reconstructed from Almirantazgo fjord sediments. 177, 265-275. DOI.org/10.1016/j.quascirev.2017.10.029. TdF GLACIERS

Bierman, P. R. and Montgomery, D.R., 2014, *Key Concepts in Geomorphology*. W.H. Freeman, p. 544.

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Your Instructor – Gregory A. Zielinski

Greg was born in Reading PA and received his BS from Pennsylvania State University, MS from Idaho State University and PhD from University of Massachusetts-Amherst. He has held research professorships at several universities, most recently attaining full research professor at the University of

Maine. He is an internationally renowned scientist and was one of the leading researchers in the world in the study of the climatic impact of volcanic eruptions through the use of ice cores, as well as the overall evaluation of the environmental significance of past volcanic eruptions. His teaching and research experience is in the broad discipline of Earth System Science with specific interests in the fields of Paleoclimatology, Meteorology, Geology and Climatology. He has always been active in research that includes field work with programs that have taken him to remote polar sites including the Antarctica and Greenland Ice Sheets, and the Penny Ice Cap in the Canadian Arctic. In addition, he has done field work in several high alpine regions of the world including research on the Ngozumpa Glacier in the Khumbu Himal (Nepal), Wind River Range, Wyoming, and the Ten Mile Range, Colorado. Grants he received in support of this research have totaled over $4M.

This research led to the publication of over 60 professional articles in scientific journals, including papers in *Nature* and *Science*, and a similar number of professional presentations. The overall multidisciplinary nature of his background is further highlighted by publications in both the *Bulletin of the American Meteorological Soci*ety (January 2002, cover story) and the *Geological Society of America Bulletin* along with research programs evaluating the impact of changing climate on glacier, stream and lake systems. In addition, he led or co-led several international commissions on various aspects of climate. He was a featured scientist on several television documentaries related to the impact volcanic eruptions have on climate including shows on PBS (NOVA), History Channel, National Geographic Channel, Discovery Channel and Animal Planet among others. Many international, national and local television and radio stations and newspapers have interviewed him about his research and on general weather and climatic questions. His interest in helping the general public be aware of our changing climate and its impact was exemplified further through his work as the Maine State Climatologist and as an extension climatologist with Sea Grant. He also published two scientific books for the general public on the weather and climate of New England.

Greg has always enjoyed outdoor activities such as bicycling, snowshoeing, hiking and backpacking, and he is a certified Wilderness First Responder. In fact, he has always incorporated students in his research programs and has taught earth and environmental field courses. He has an extensive yoga practice and has done many other types of workout regimes. He has taught yoga classes and has been a certified personal trainer.