SIO115 Ice and the Climate System
Syllabus & Timetable 2023

Monday/Wednesday/Friday 9am in Revelle Conference Room (4301)

Course texts:
- IPCC: Special Report on the Ocean and Cryosphere in a Changing Climate (SROCCC)
- UNEP Report: Global Outlook for Snow and Ice
- CLiC Integrated Global Observing Strategy Report
- IPCC AR5 Chapter 4; AR6 Chapter 6 in 2023

Week 1. Introduction to the Cryosphere in the Earth System
- 1) Elements of the cryosphere; importance of the cryosphere
- 2) Role of the cryosphere in the climate system; NASA Tour of Cryosphere video
- 3) Role of the cryosphere in the climate system; sea-level change; paper & book discussion

Discussion papers:
- Scambos et al. 2011 Earth’s ice: Sea level, climate, and our future commitment
- What is the cryosphere? Hint: It's vital to farming, fishing and skiing (Mark Serreze, The Conversation)

Additional reading:
- Chapter 1 of "The Cryosphere" by Shawn Marshall.
- Chapters 1, 2 and 3 of the UNEP Report

Week 2. Past climate change and past climate records
- 1) Transition of snow to ice; ice divides; ice cores
- 2) Ice ages; ocean isotopes
- 3) Paper discussion for ice cores and ice ages (Lorius and Petit)

Discussion papers:
- Shackleton et al., 2020 Abegail
- Lorius et al. 1985; Michael
- (Extra) Petit et al. 1999

Additional reading:
- Ice cores and climate change fact sheet: British Antarctic Survey
- Van Ommen, The Conversation, 2016
- Wolff, The Conversation, 2014
- BBC Article 14 Nov 2016

Week 3. Snow cover, river ice and lake ice
- 1) MARTIN LUTHER KING HOLIDAY -- NO CLASS
- 2) Snow cover
- 3) River Ice and lake Ice

Discussion papers:
- Climate change is shrinking winter snowpack, which harms Northeast forests year-round (to be presented by Roger Chou) (Reimann and Templer, The Conversation, 2018)

Additional reading:
- Lake Baikal: how climate change is threatening the world’s oldest, deepest lake (Mackay and Swann, The Conversation, 2019)
- Breaking the ice: river ice as a marker of climate change (EGU Blog post by Wayana Dolan).
- Chapters 2, 3 and 4 of The Cryosphere" by Shawn Marshall.

Week 4. Lake ice & permafrost
- 1) Permafrost; active layer; importance of permafrost to climate
- 2) Permafrost; thermokast; undersea permafrost; effects of thawing permafrost; monitoring permafrost
- 3) Permafrost wrap up and paper discussion (see below)

**Discussion papers:**
- Airborne electromagnetic imaging of discontinuous permafrost [Minsley et al., 2012](#)
- The impact of the permafrost carbon feedback on global climate [Schaefer et al., 2014](#)
- Economic impacts of carbon dioxide and methane released from permafrost [Hope & Schaefer, 2015](#)
- Will the Arctic shift from a carbon sink to a carbon source [Rawlins, The Conversation, 2015](#)
- Methane and the risk of runaway global warming [Glikson, The Conversation, 2013](#)
- How Thawing Permafrost Is Beginning to Transform the Arctic [21 January 2020](#)
- POLAR VORTEX EXPLAINER FROM NOAA
- Another explainer from Climate Signals

**Suggested additional reading:**
- Chapter 7 of "The Cryosphere" (~14 easy pages)
- Chapter 7 of UNEP report [NEW UNEP REPORT ON PERMAFROST](#)
- Facts about Permafrost (CenPerm in Denmark)
- Duguay 2005 AGU book chapter

**Watch:**
- AWI video on Permafrost (shown in class)
- AGU 2015 Fall meeting press conference on Permafrost

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**Week 5. Sea ice**
- 1) Sea ice; ice-albedo feedback; sea-ice types
- 2) Sea ice growth; monitoring sea-ice extent and thickness
- 3) Age of sea ice; future projections.

**Discussion papers:**
- Observed Arctic sea-ice loss directly follows anthropogenic CO2 emission, Notz & Stroeve, Science, 2016 (to be presented by Xinyue Zhao)
- Why Antarctica's sea ice cover is so low, Arblaster et al., The Conversation

**Extra discussion papers:**
- The Arctic Ocean has lost 95 percent of its oldest ice — a startling sign of what’s to come, Washington Post
- Snow in the changing sea-ice systems, Webster et al., Nature Climate Change
- Arctic Sea-ice 101 (Program Manager Tom Wagner)
- Interactive sea-ice map from NSIDC
- Arctic Report Card 2018 video
- Arctic Report Card 2018 website

**Suggested additional reading:**
- Chapter 5 of "The Cryosphere" (~20 easy pages)
- Chapter 5 of UNEP report [Arctic Report Card 2014](#)

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**Week 6. Land ice: Glaciers and ice caps (GIC)**
- 1) Introduction to GIC; types of glaciers; contribution of GIC to sea-level
- 2) Transformation of snow to ice; glacier mass balance
- 3) Glacier mass balance & measurement

**Discussion papers:**
- Glaciers are retreating. Millions rely on their water Jeremy Engle, New York Times

**Extra reading:**
- Warm ice in Mount Everest’s glaciers makes them more sensitive to climate change — new research Katie Miles, The Conversation
- **A bird’s eye view of New Zealand’s changing glaciers**, Andrew Lorrey et al., *The Conversation*
- **We’ve been studying a glacier in Peru for 14 years – and it may reach the point of no return in the next 30 years**, Matthias Vuille, *The Conversation*

*Suggested additional reading:*
- Relevant section of Chapter 6 of UNEP report
- [World Glacier Monitoring Service](http://www.wgms.ch)

*Watch:*
- [Glacier animation shown in class](#)
- [Greenland Ice Sheet Ice Age video](#)

**Week 7. Land ice: Ice sheets (Greenland & Antarctica)**
- 1) PRESIDENTS’ DAY HOLIDAY - NO CLASS
- 2) Mass balance of ice sheets; ice streams
- 3) Ice-ocean interaction; basal melting; surface melting; iceberg calving -- Greenland and Antarctica

*Discussion papers:*
- [Nonlinear rise in Greenland runoff in response to post-industrial Arctic warming](#), Nature, December 2018 (to be presented by Rence Balitaan)

*Extra reading:*
- [The big melt: Earth’s ice sheets are under attack](#), Science News for Students, Jan 2019
- [Antarctic surface hydrology and impacts on ice-sheet mass balance](#), *Nature Climate Change*, November 2018

**Week 8. Land ice: Glacier Dynamics**
- 1) Surface melting in Greenland and Antarctica
- 2) Glacier dynamics: creep; flow-law; force balance
- 3) Ice dynamics; glacier surges; subglacial systems

*Discussion papers:*
- [The paradigm shift in Antarctic ice sheet modelling](#), Frank Pattyn

*Extra reading:*
- [Ocean waves and lack of sea ice can trigger Antarctic ice shelves to disintegrate](#), Bennetts, *The Conversation*, 2018
- [Why Antarctica and the Arctic are polar opposites](#), Science News for Students, January 201
- [Deformation and sliding](#) Antarctic Glaciers

**Week 9. Changes in land ice**
- 1) Subglacial water; subglacial processes; subglacial lakes
- 2) Marine ice sheet instability; ice shelf changes; buttressing
- 3) Wrap up and paper discussion (see below -- two papers)

*Read [2014 media page](#) about the West Antarctic Ice Sheet instability*
*Link to VICE program on Antarctic mass loss*

*Discussion papers:*
- [Ice shelf buttressing](#), The International Encyclopedia of Geography, Dan Goldberg 2017
- [Marine ice sheet instability](#), AntarcticGlaciers, Bethan Davies, 2014

*Extra reading:*
- [Ocean-Ice Shelf Interaction in East Antarctica](#), Oceanography, Silvano et al. 2016
- [The Greenland and Antarctic ice sheets under 1.5 °C global warming](#), Nature, Pattyn 2018

**Week 10. Presentations of term papers**