

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) (Reinmann 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; under sea 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)
- [Dugway 2005 AGU book chapter](#)

Watch:

- [AWI video on Permafrost](#) (shown in class)
- [AGU 2015 Fall meeting press conference on Permafrost](#)

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](#)

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](#)

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:

- [Scientist at work: Tracking melt water under the Greenland ice sheet](#), Joel Harper, The Conversation, 2016
- [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