Exploring Key Research Topics for the Fifth International Polar Year

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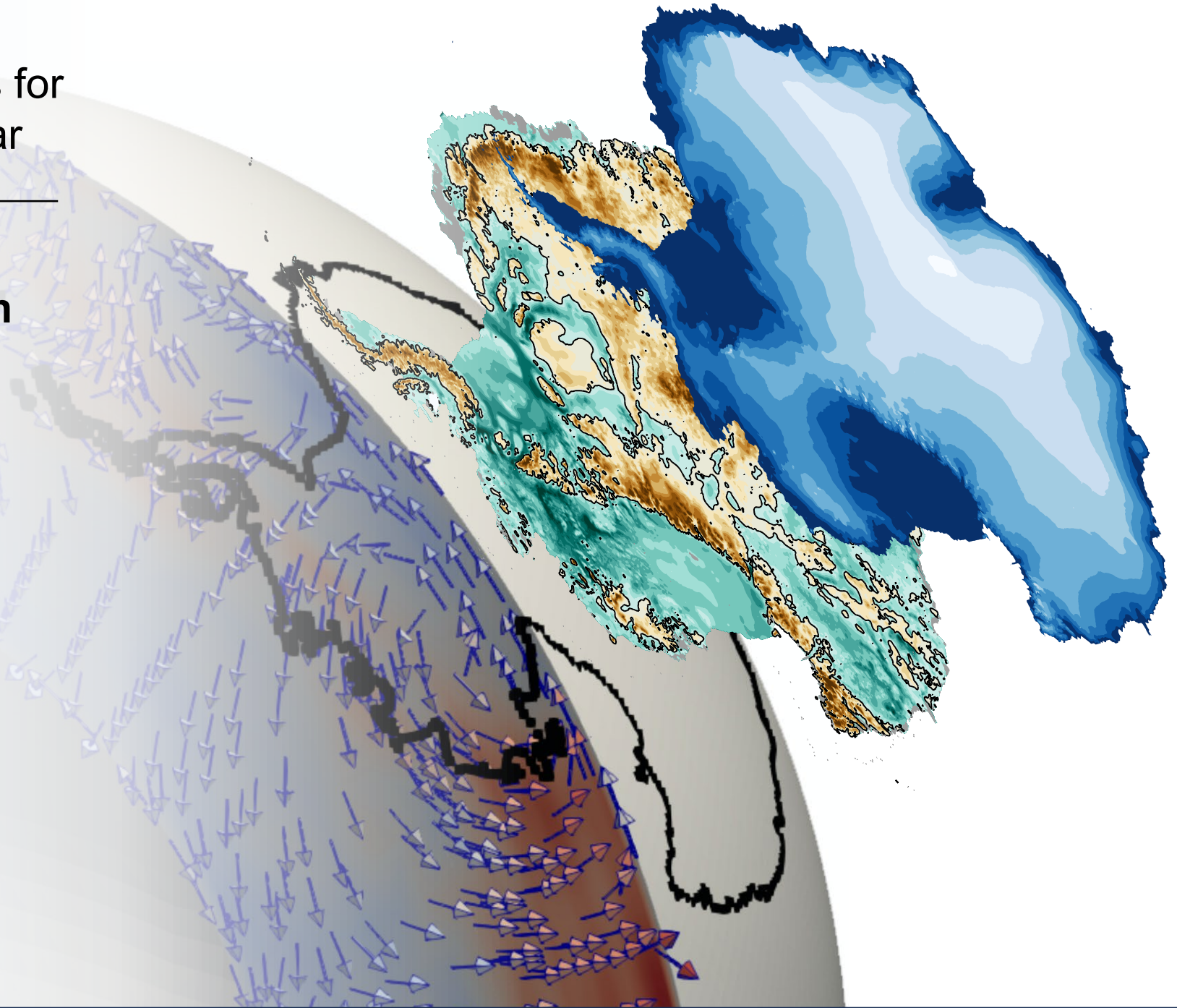
Key Scientific Questions & Science to Meet Multi-domain Operations Needs

Jacky Austermann
Columbia University



NATIONAL ACADEMIES Sciences Engineering Medicine

How fast will ice sheets melt?

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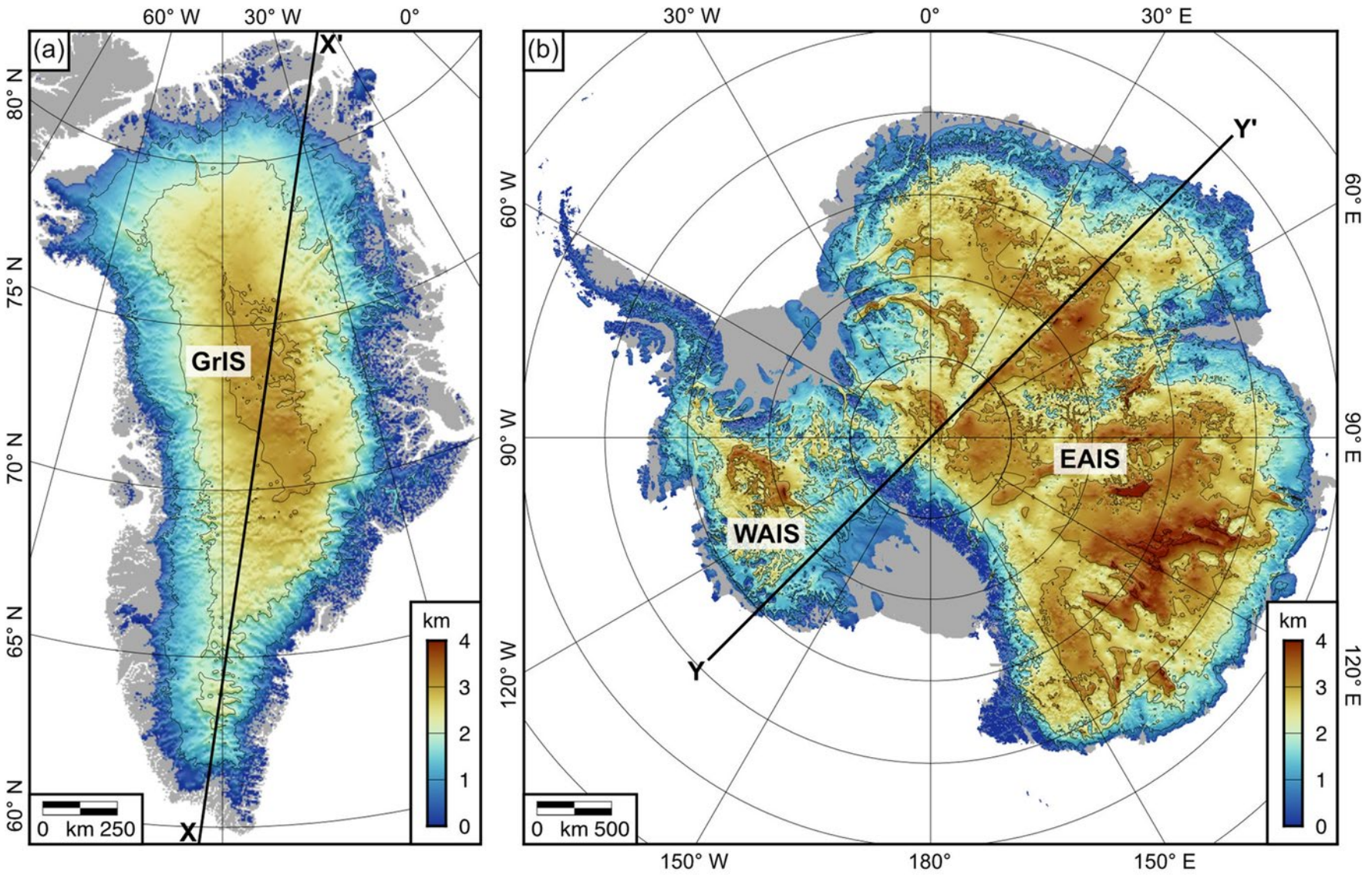


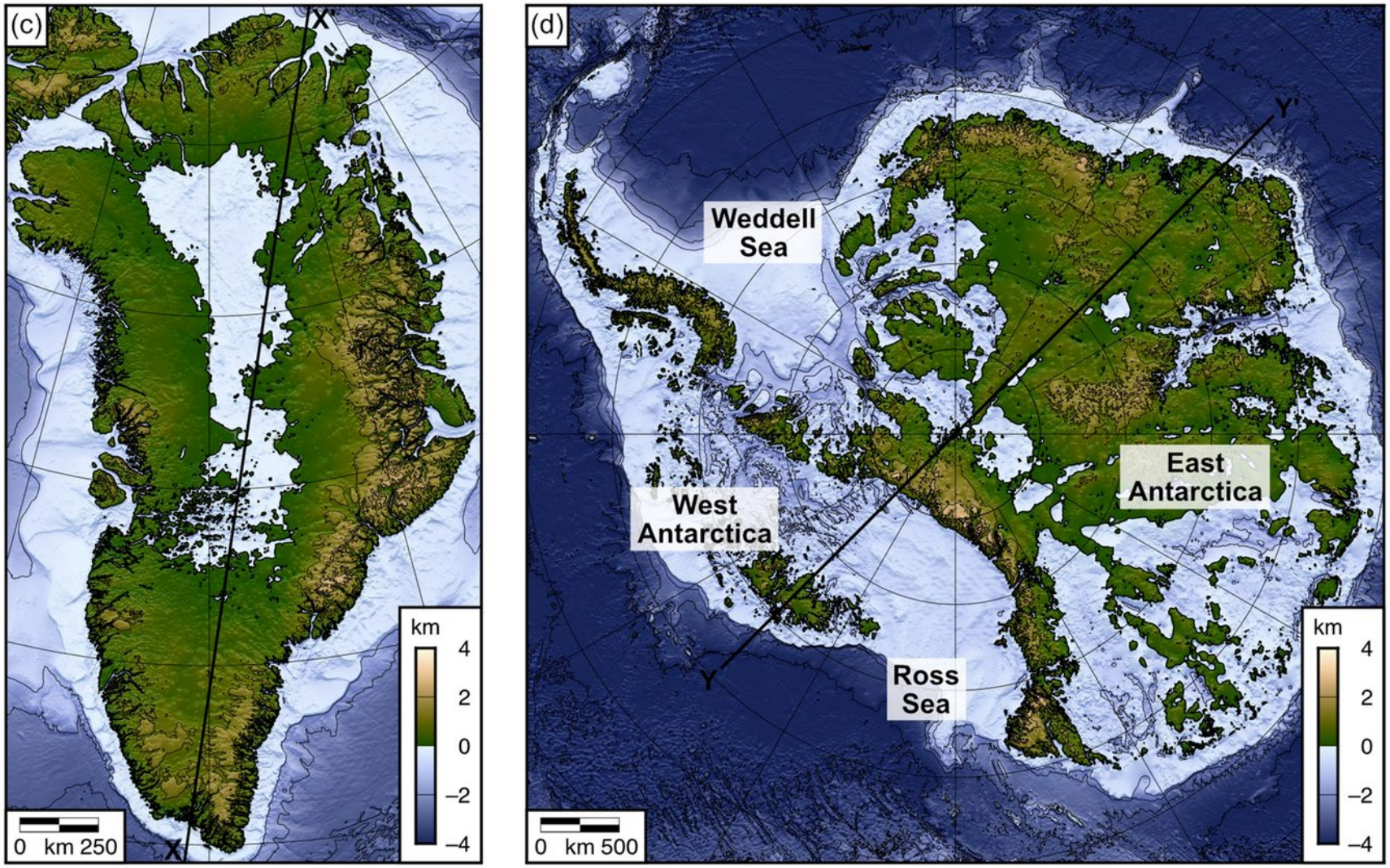
Greenland Ice Sheet (GrIS) 7m

West Antarctic Ice Sheet (WAIS) 5m

East Antarctic Ice Sheet (EAIS) 55m

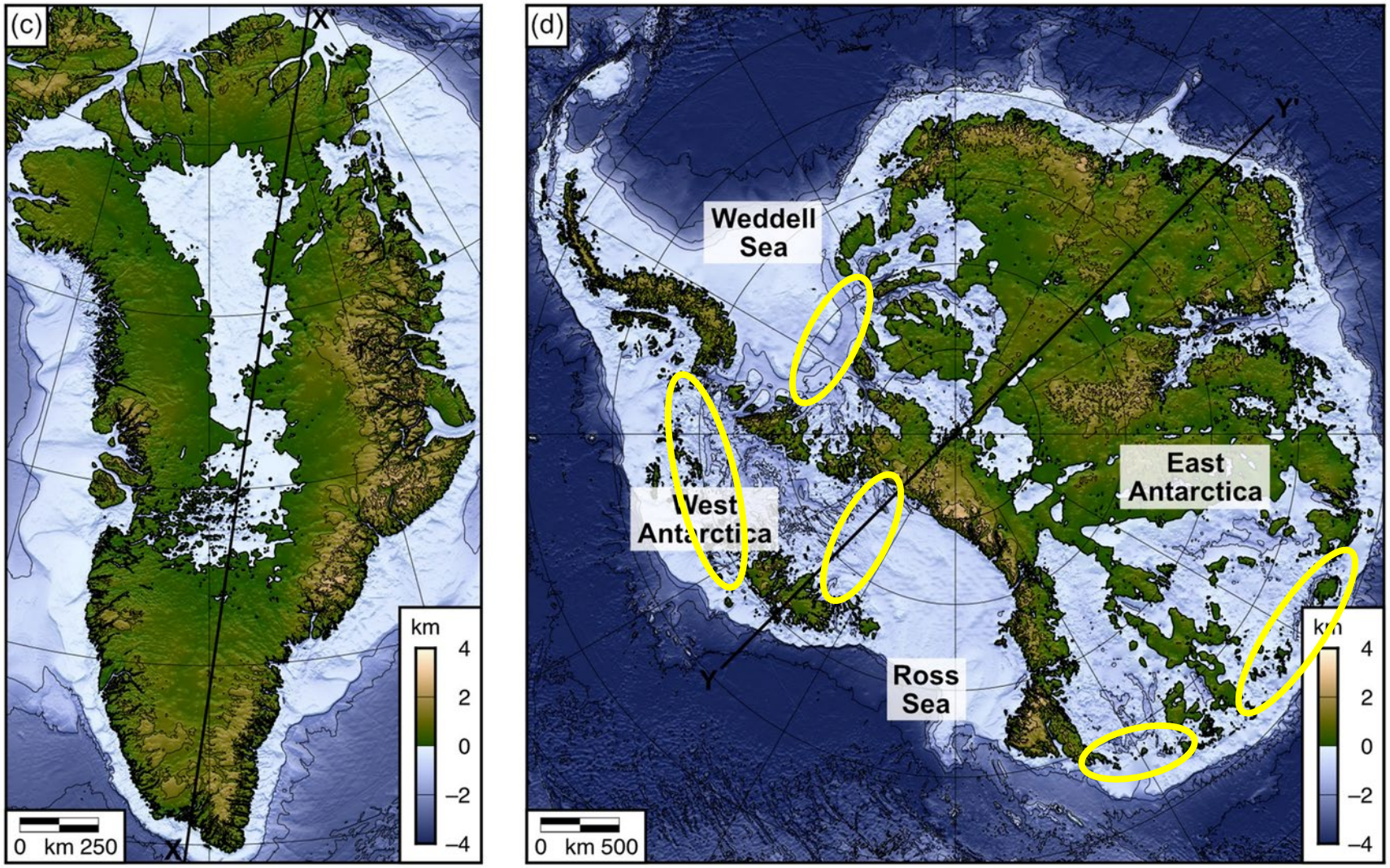
Paxman et al., 2021

How fast will ice sheets melt?



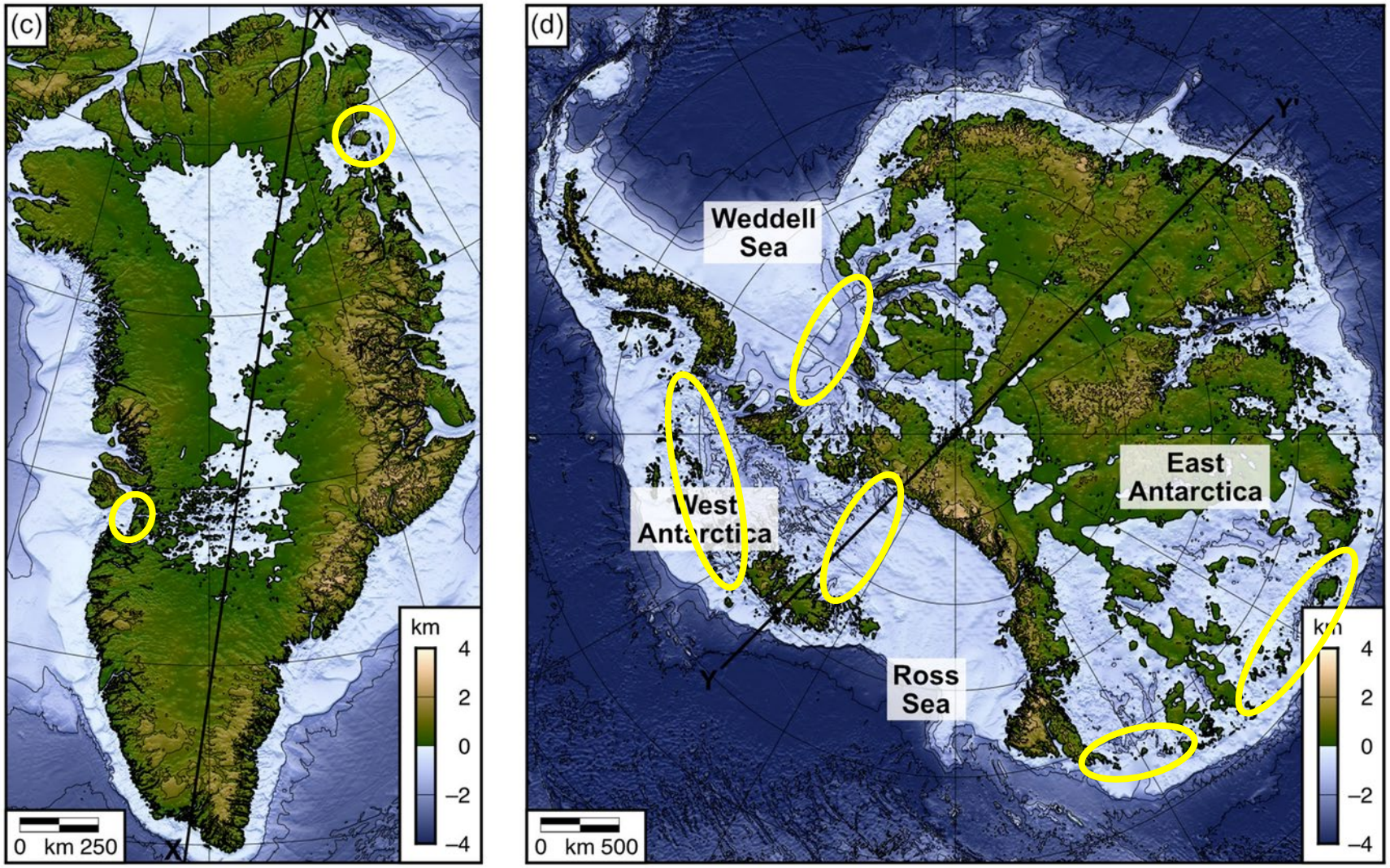
Paxman et al., 2021

How fast will ice sheets melt?



Paxman et al., 2021

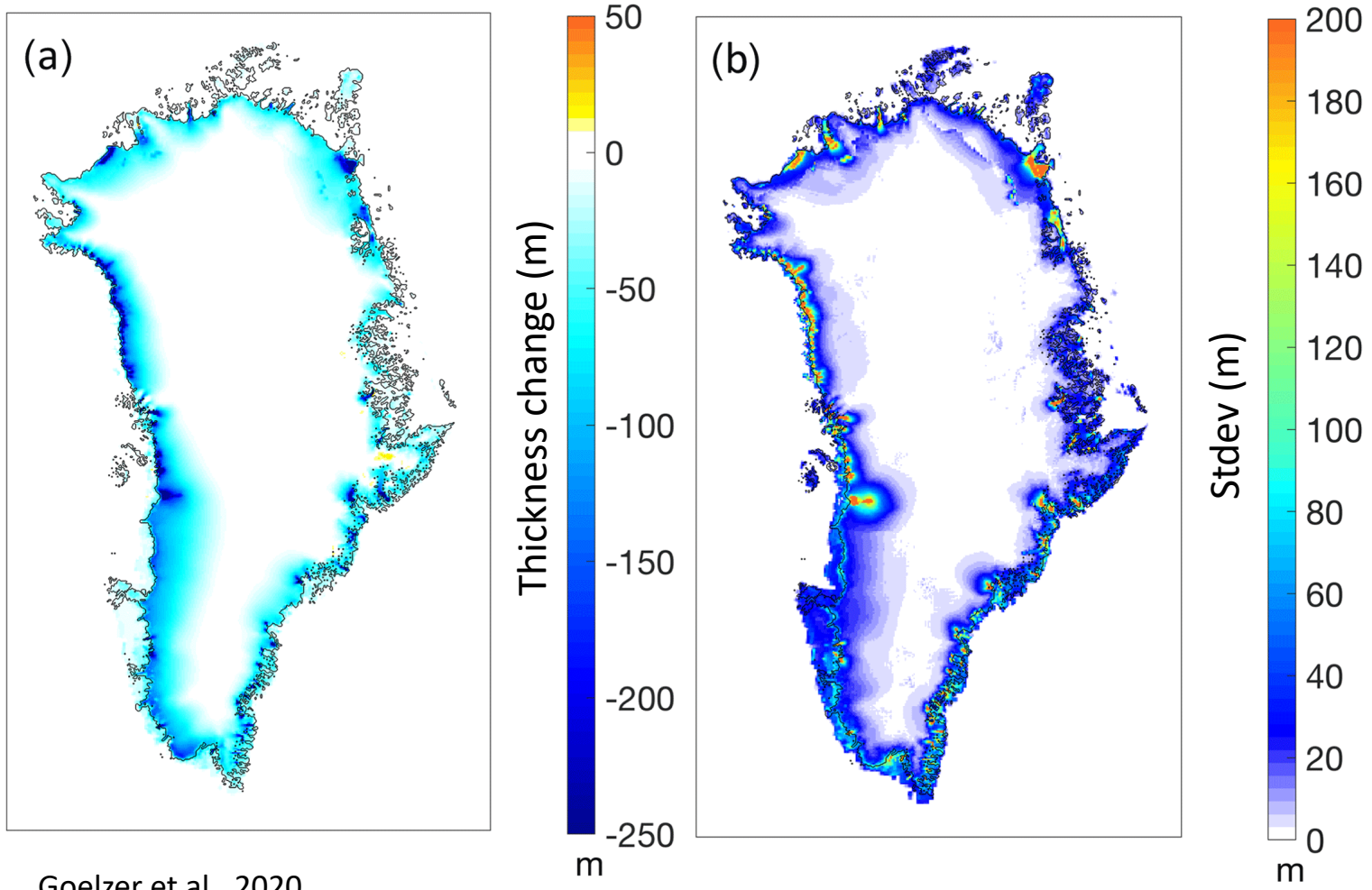
How fast will ice sheets melt?



Paxman et al., 2021

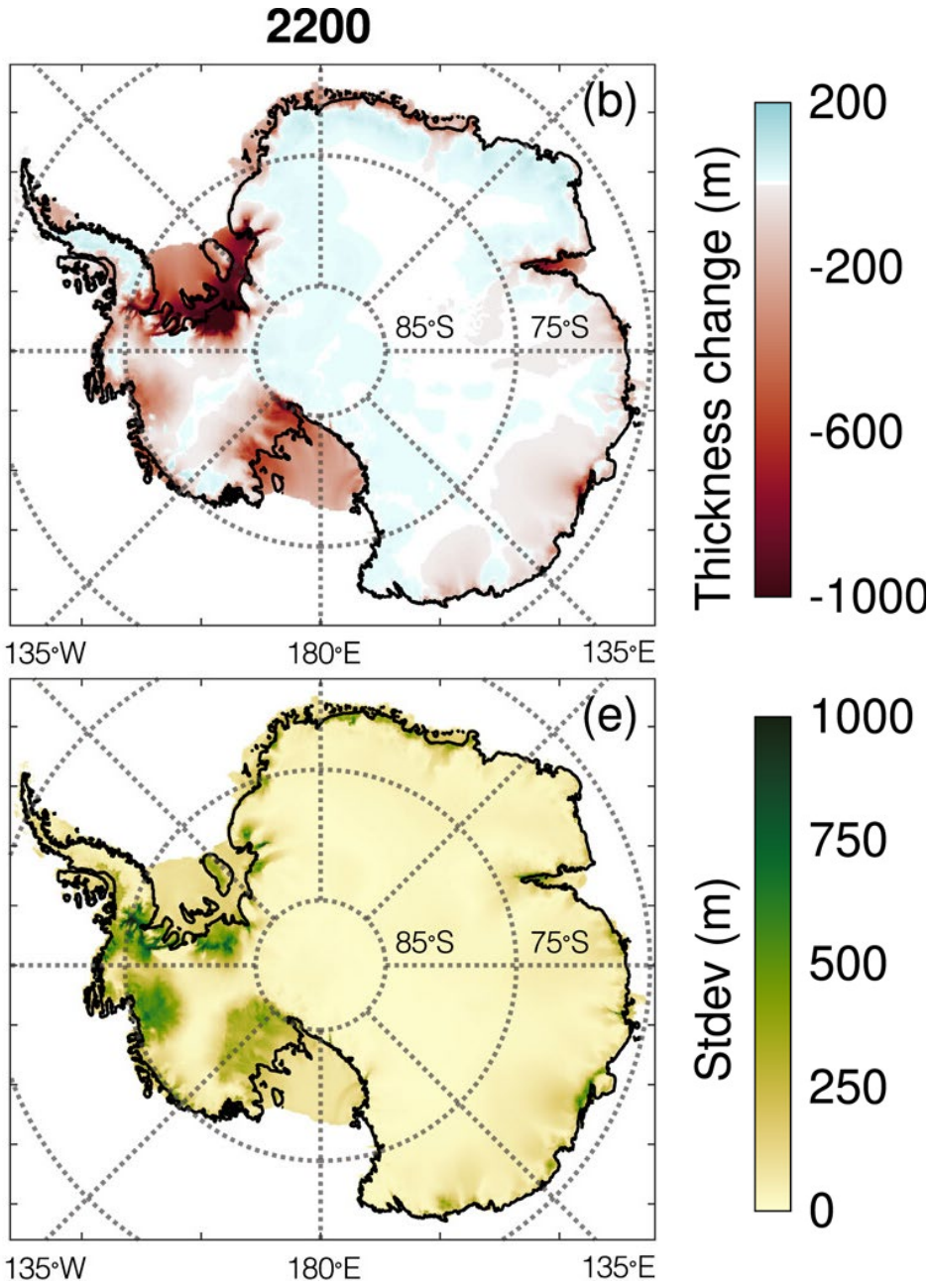
Predictions of future ice melt

2100



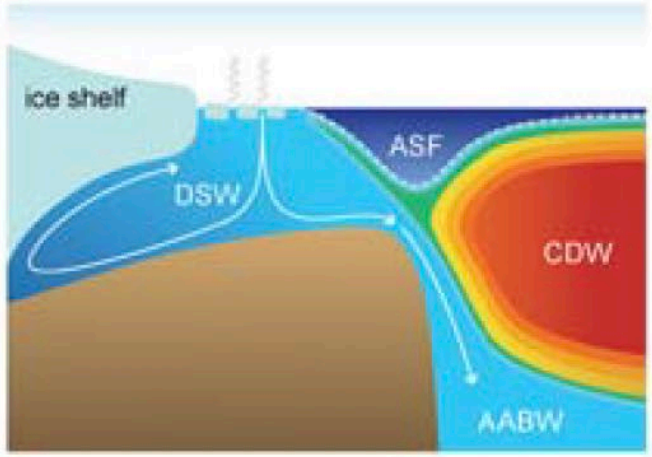
Goelzer et al., 2020

2200

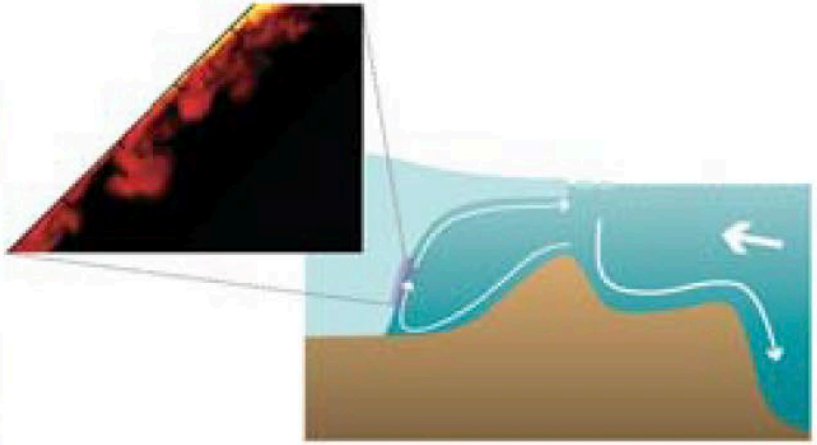


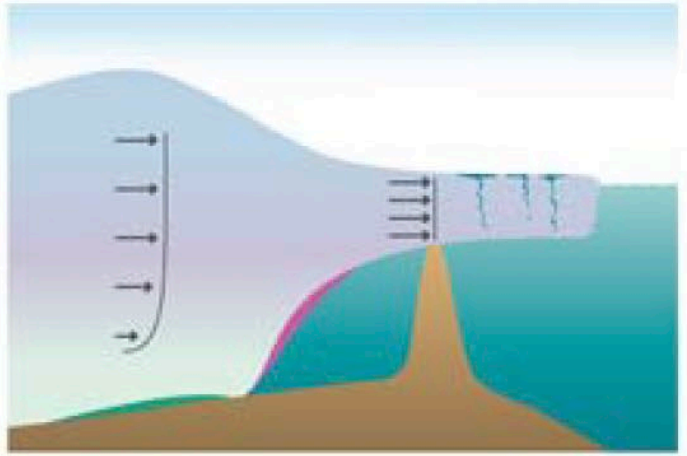
Seroussi et al., 2024

The grounding zone

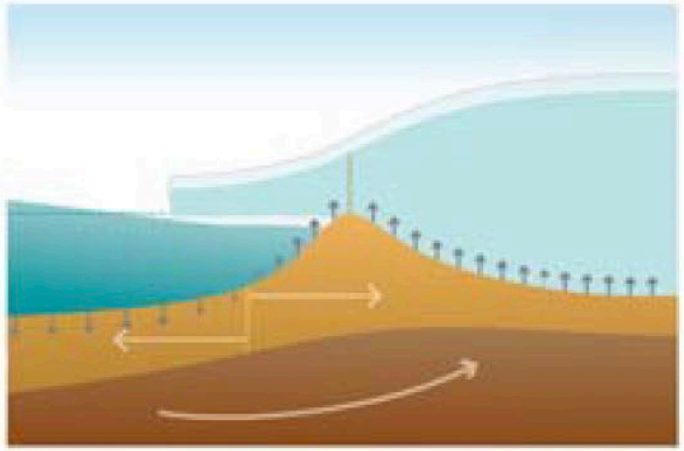


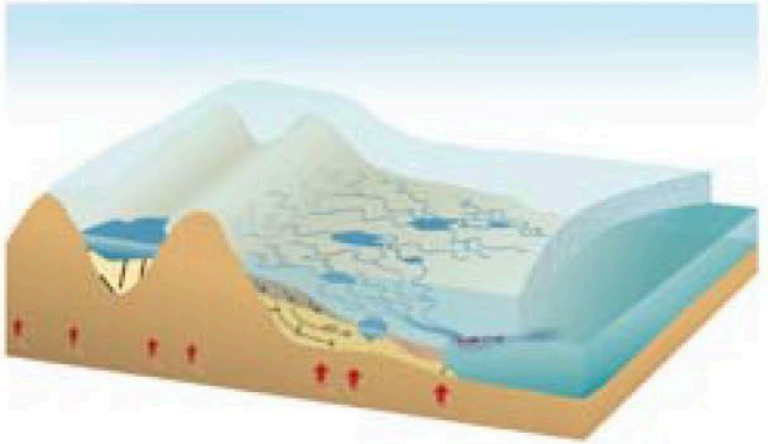
1. Atmosphere and ocean


2. Sub-ice shelf processes


3. Ice dynamic processes


4. Erosion and sedimentation processes


5. Glacial isostatic adjustment


6. Subglacial hydrology

Noble et al., 2020

How fast will ice sheets melt?

(1) Instrument & model the grounding zone
study the known unknowns

(1) Instrument & model the grounding zone

Rignot et al., 2023

(1) Instrument & model the grounding zone

Radar
GPS
Seismometer

Rignot et al., 2023

How fast will ice sheets melt?

(1) Instrument & model the grounding zone
study the known unknowns

(2) Understand conditions of collapse by looking at the past
study the unknown unknowns

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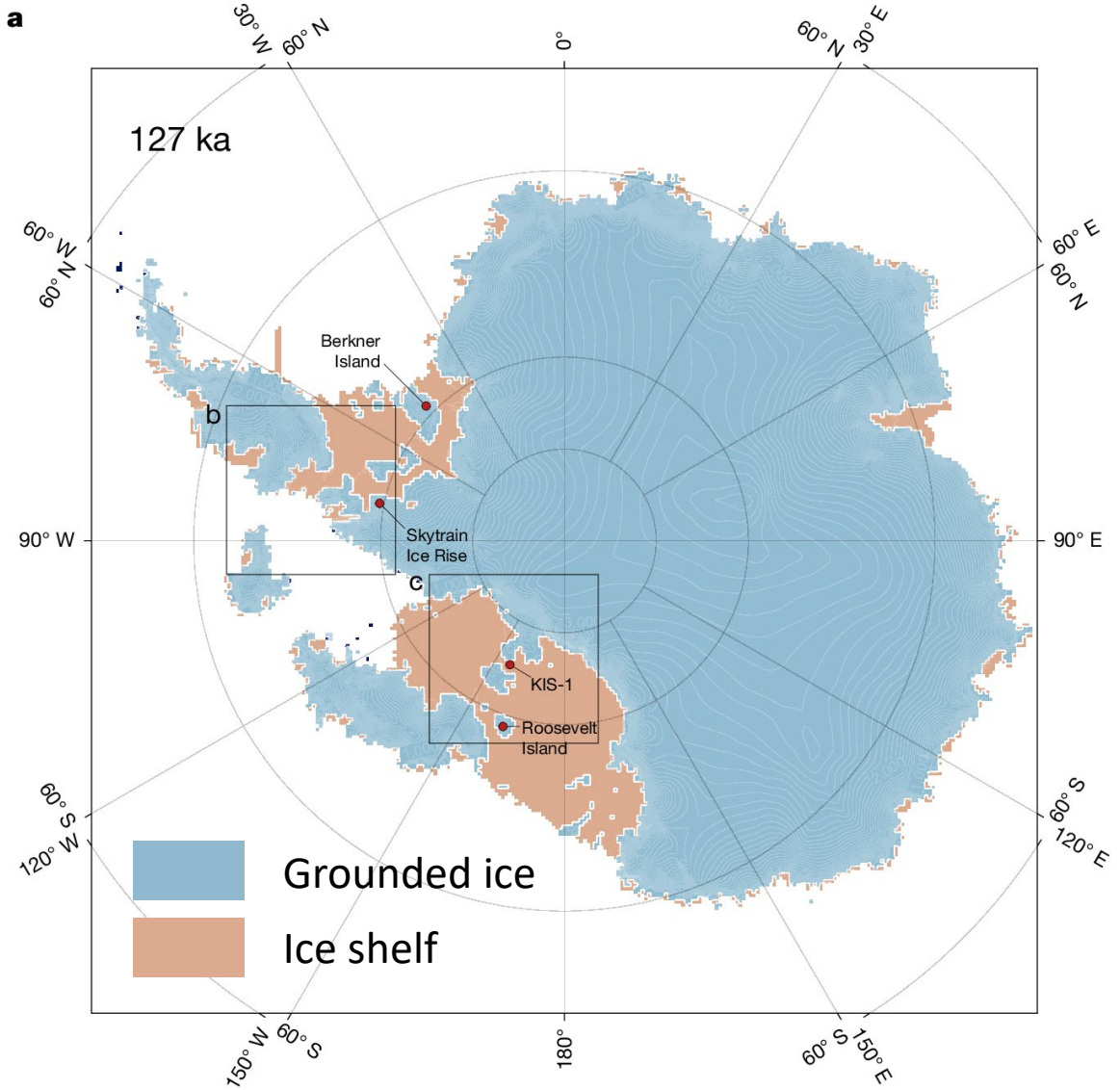
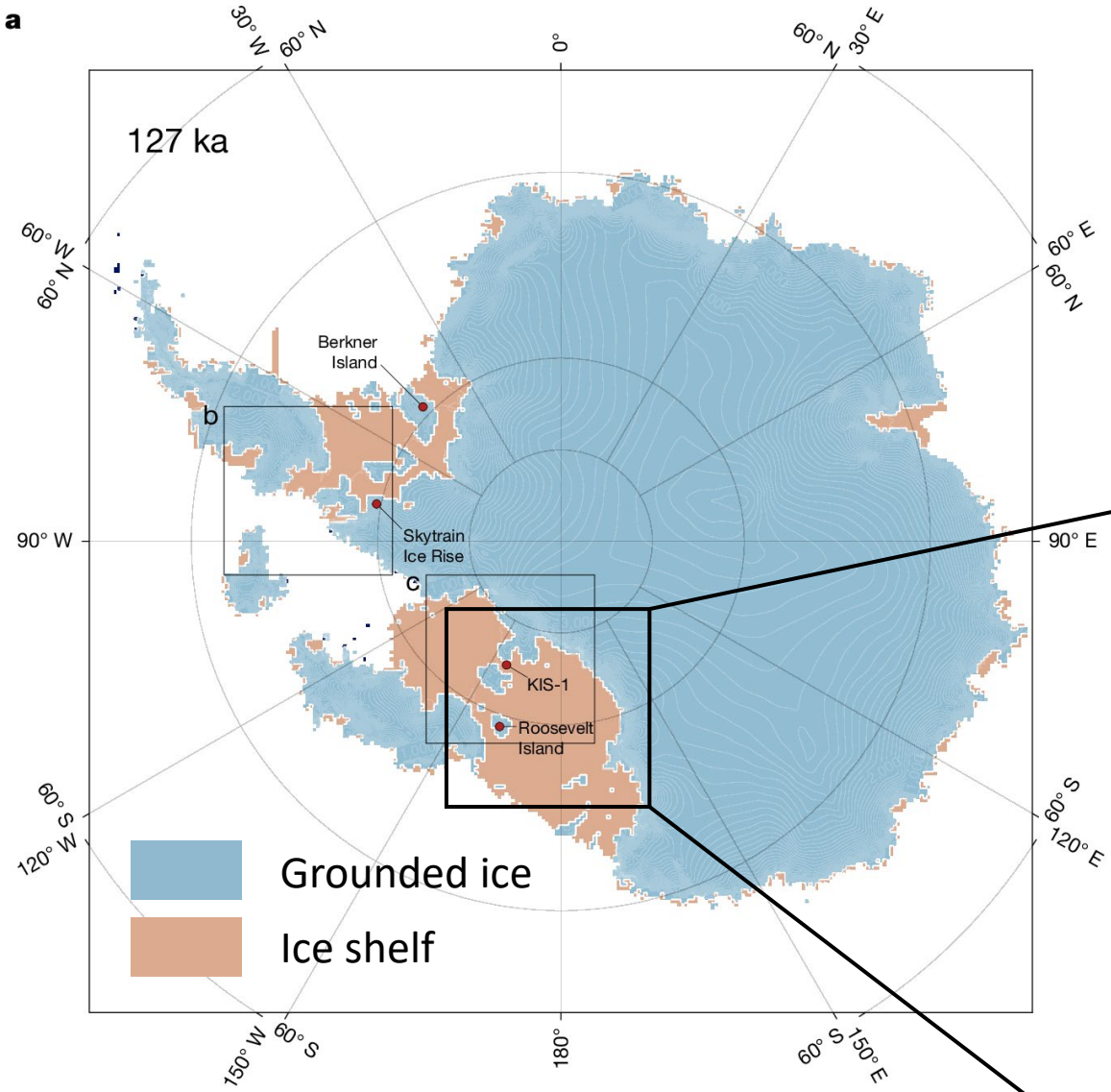
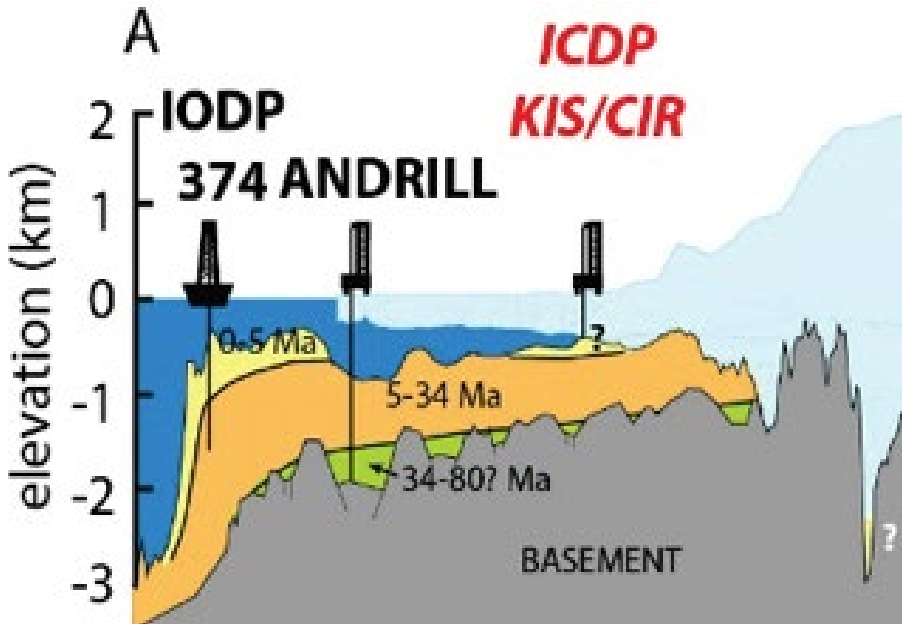
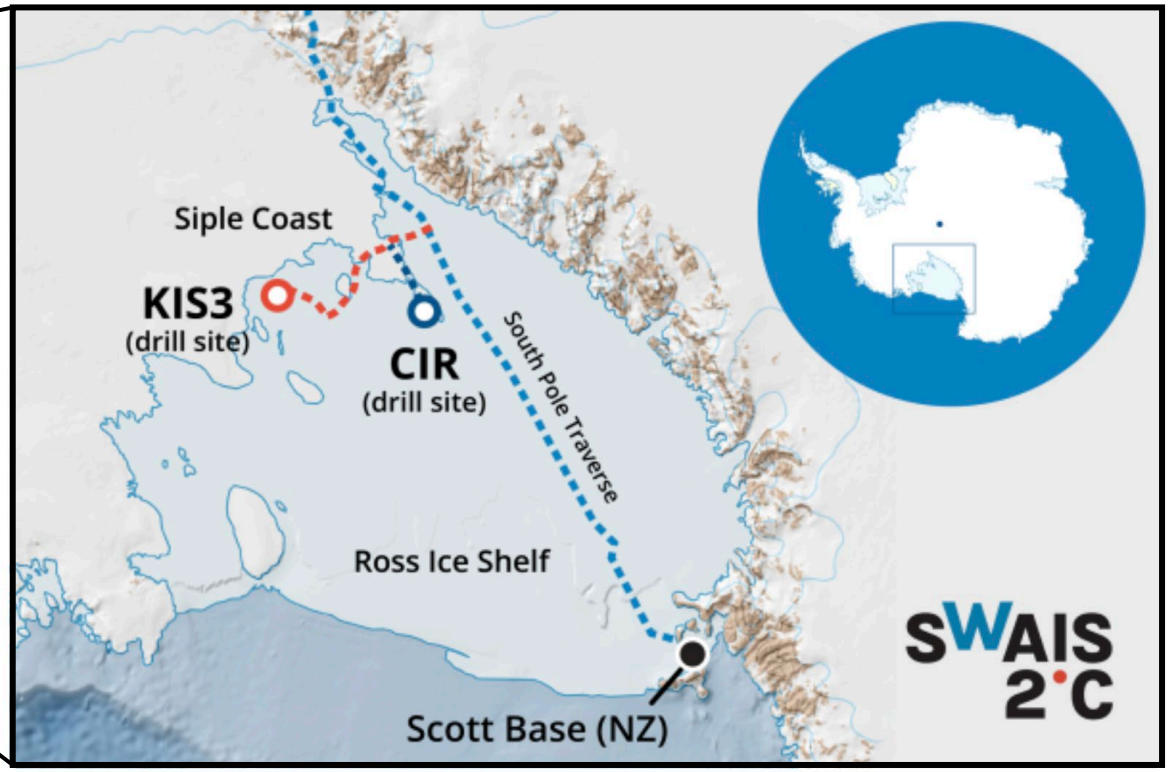


Wolff et al., 2024







Wolff et al., 2024

How fast will ice sheets melt?

(1) Instrument & model the grounding zone
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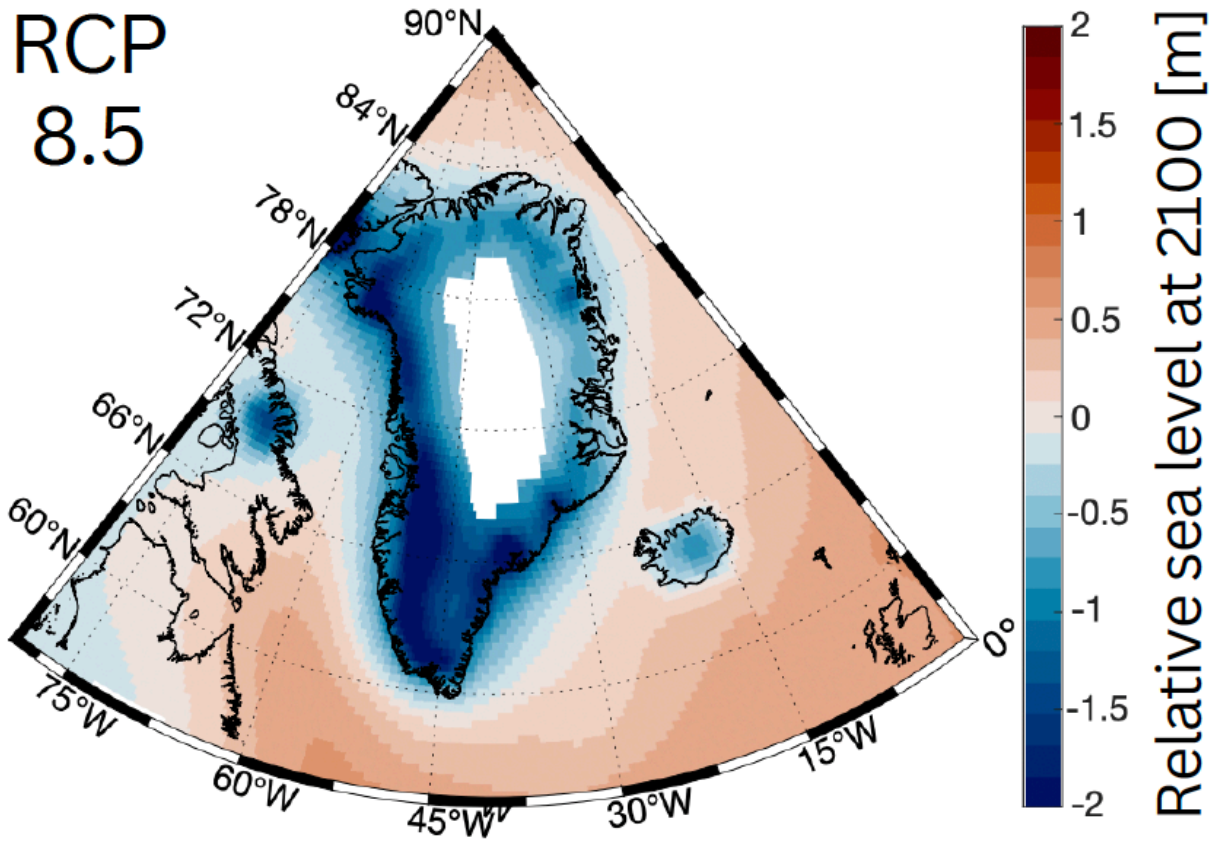
(3) Instrument & model coastlines
study the impact

(3) Instrument & model coastal change

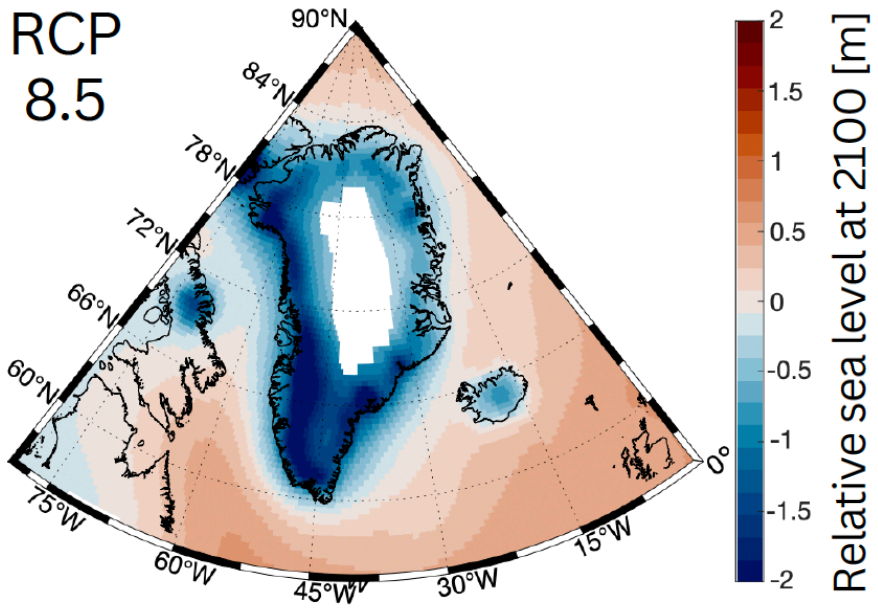


Lewright et al., in rev.

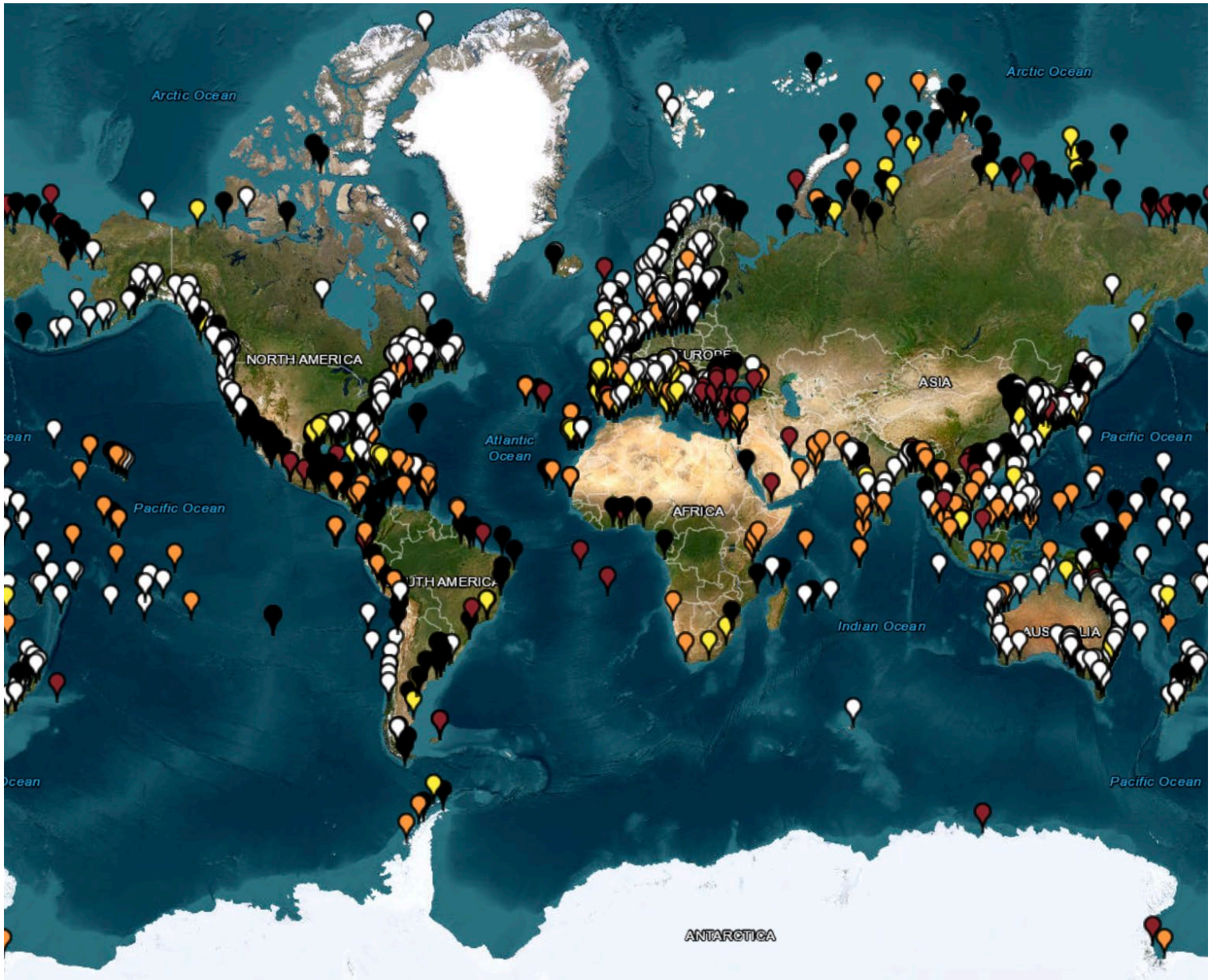
Datum controlled global tide gauges

Latest Data From:

- 2023 or later
- 2022 - 2020
- 2019 - 2015
- 2014 - 2005
- Before 2005



Lewright et al., in rev.



psmsl.org

How fast will ice sheets melt?

(1) Instrument & model the grounding zone
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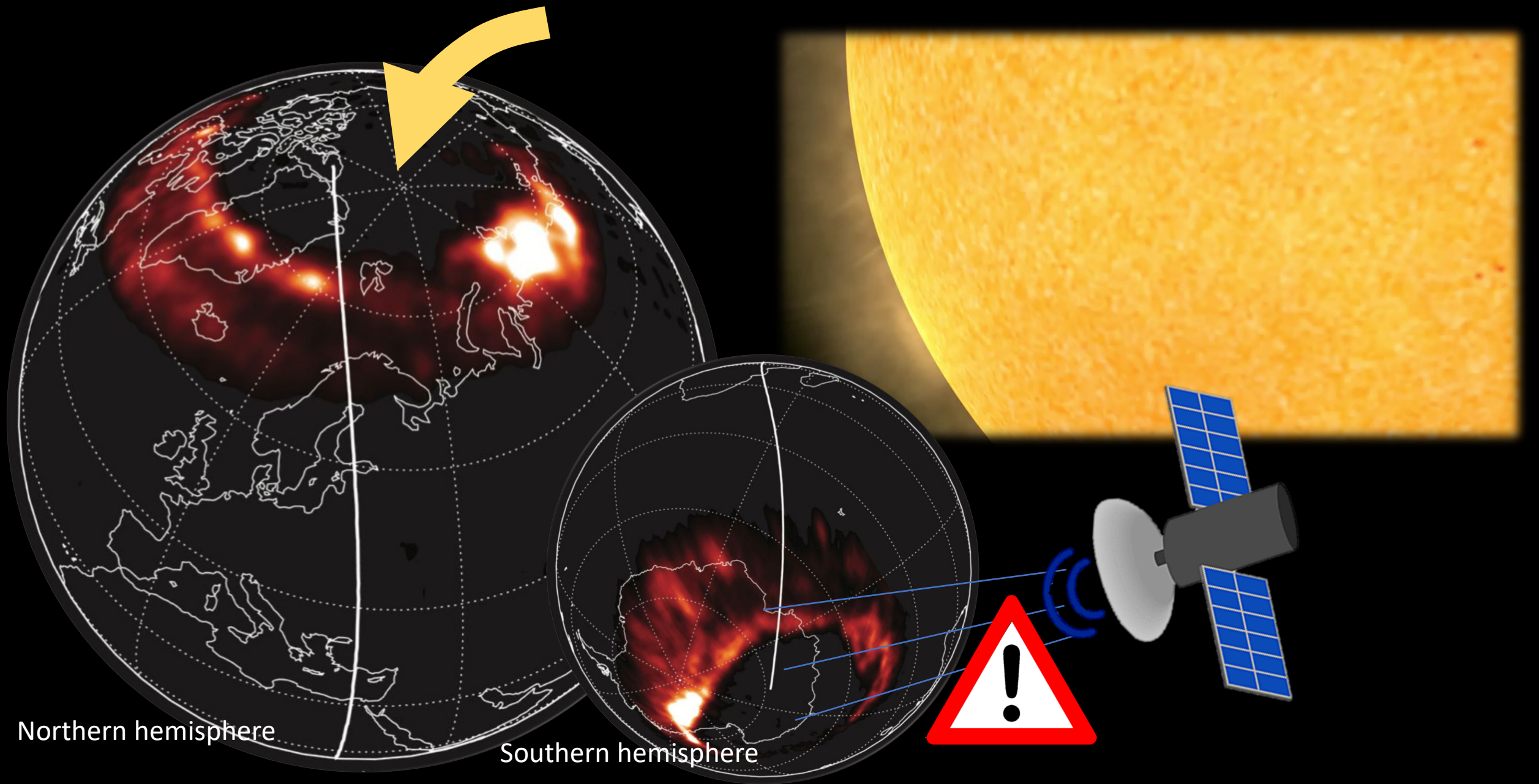
Geospace Perspective

Big picture problems and multi-domain operational needs

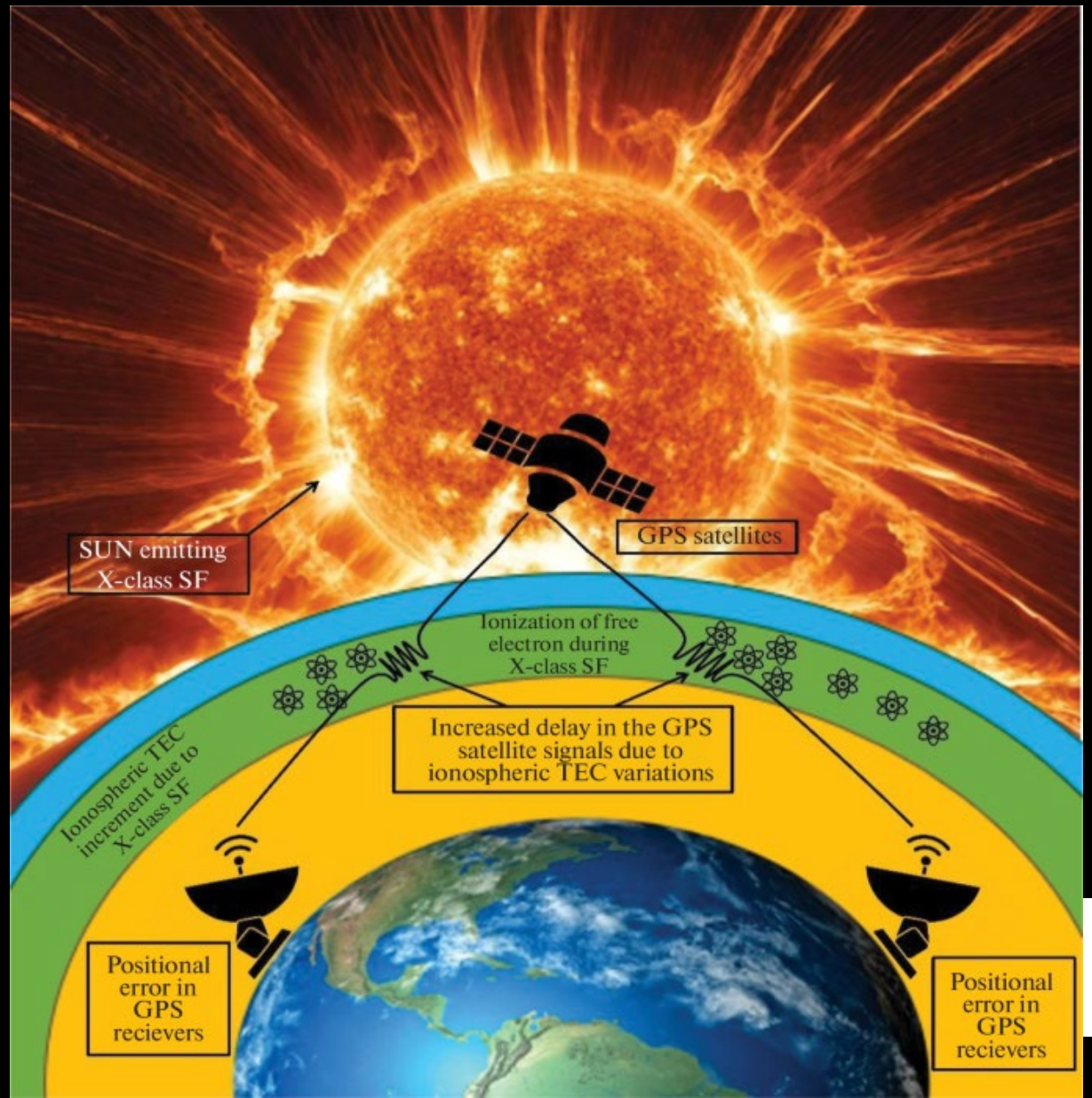
Prof. Allison N. Jaynes, University of Iowa

May 2025

Energy from space comes into Earth at the poles



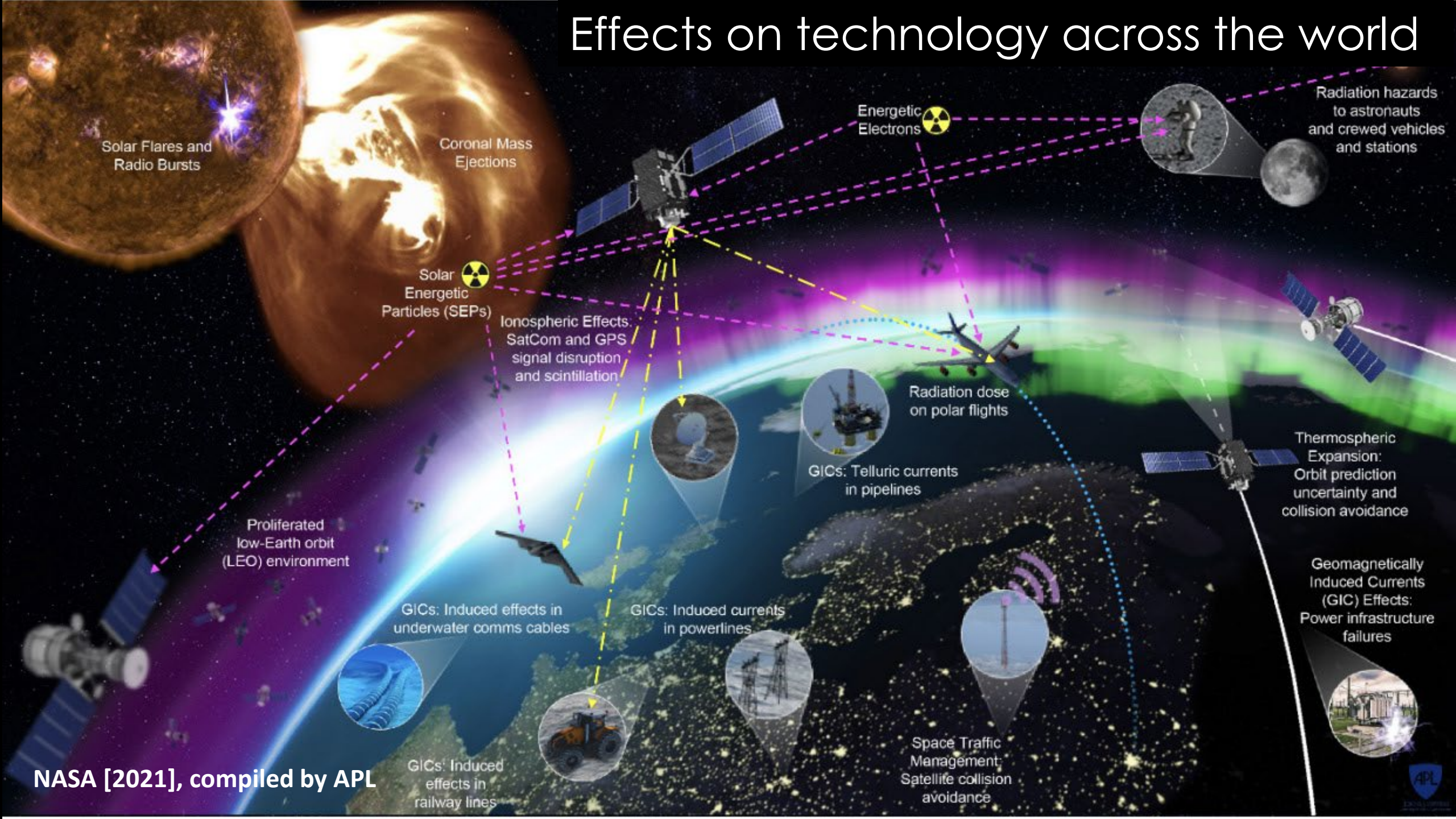
Disruption of GPS and communication



- Loss of GPS lock
- GPS errors
- Loss of communication signals
  - Cellular signal
  - Satellite internet link
  - Military communications
- Temporary or permanent loss of satellite functionality

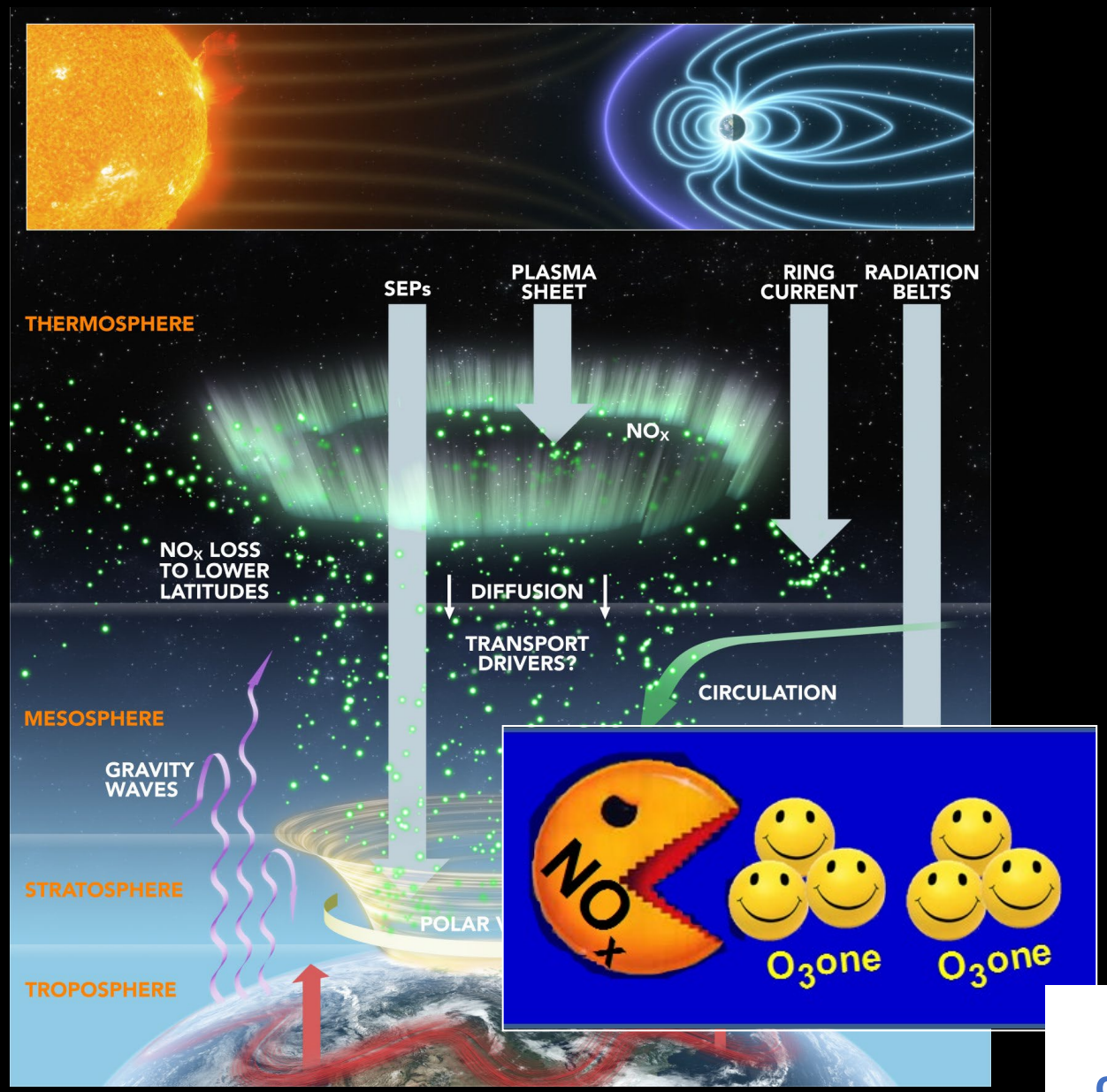
Need to understand near-Earth space to improve space weather forecasting and prediction

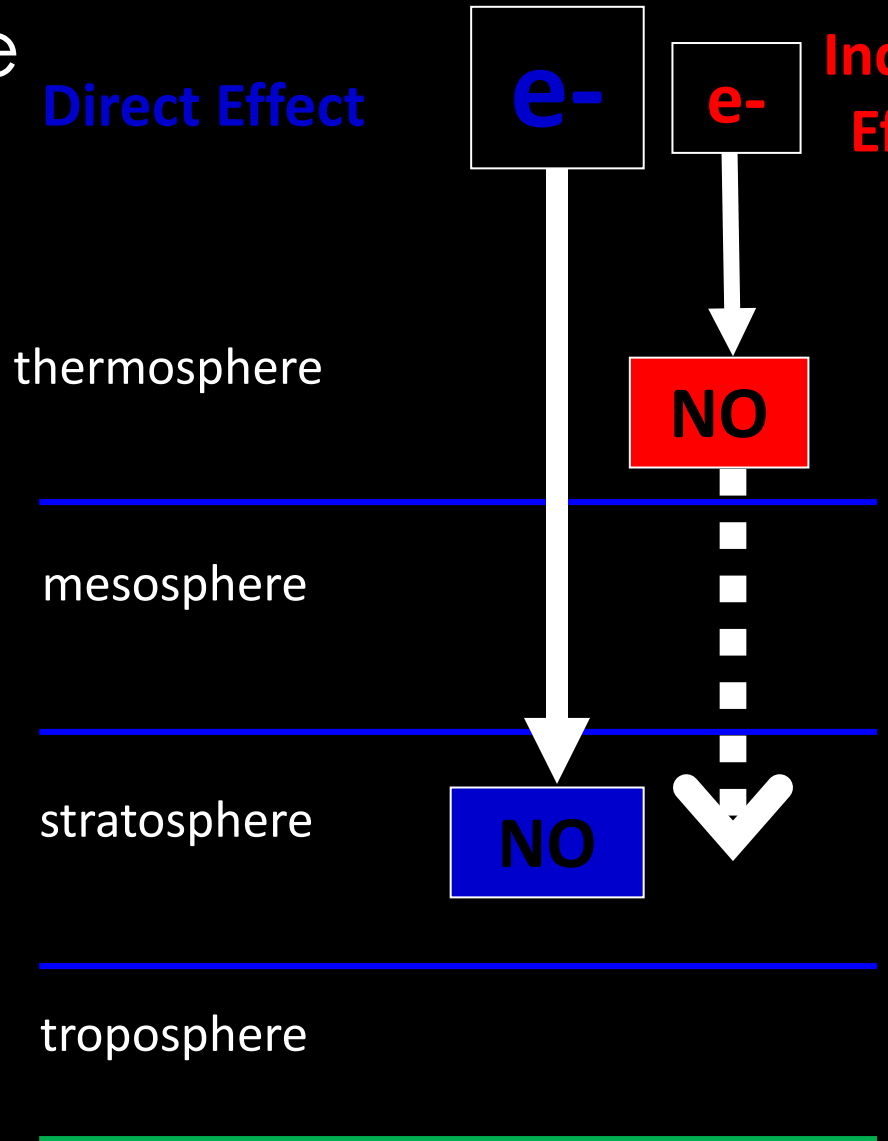
Effects on technology across the world



NASA [2021], compiled by APL

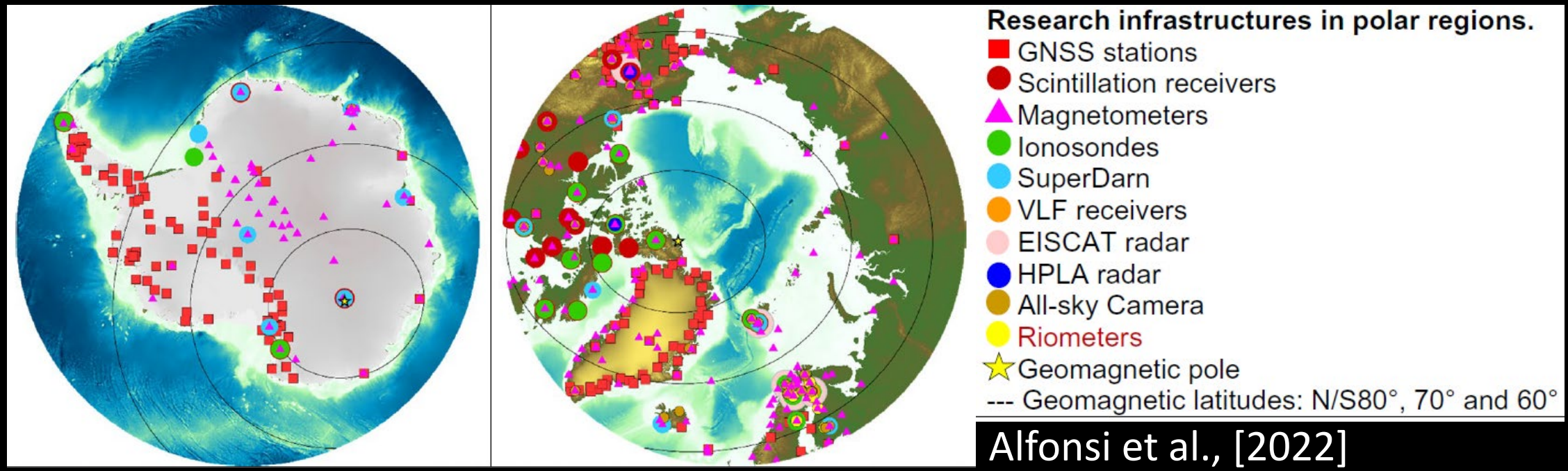
Relevance to atmospheric science





Need to understand atmospheric effects to contribute to whole atmosphere climate modeling

Polar observing networks: dual uses



Alfonsi et al., [2022]

- Global Navigation Satellite System (GNSS) Stations and radiosondes
  - Geospace: Total electron content, electron density profiles, and ionospheric scintillation (radio signal propagation)
  - Atmosphere: Precipitable water (PW) estimates in high latitude regions for weather / climate models
- Relative Ionospheric Opacity Meter (Riometer)
  - Geospace: Cosmic ray monitoring, D-region ionization events
  - Atmosphere: Atmospheric heating, cloud formation
- Auroral optical imagers with radio observations
  - Geospace: Auroral activity and energy deposition in ionosphere
  - Atmosphere: Polar stratospheric clouds, meteors
- Ionosondes (low power HF transmitter)
  - Geospace: Ionospheric density and scintillation, signal propagation
  - Atmosphere: Mesospheric cooling and anomalies, thermospheric gravity waves, historical database for long term greenhouse effects in ionosphere

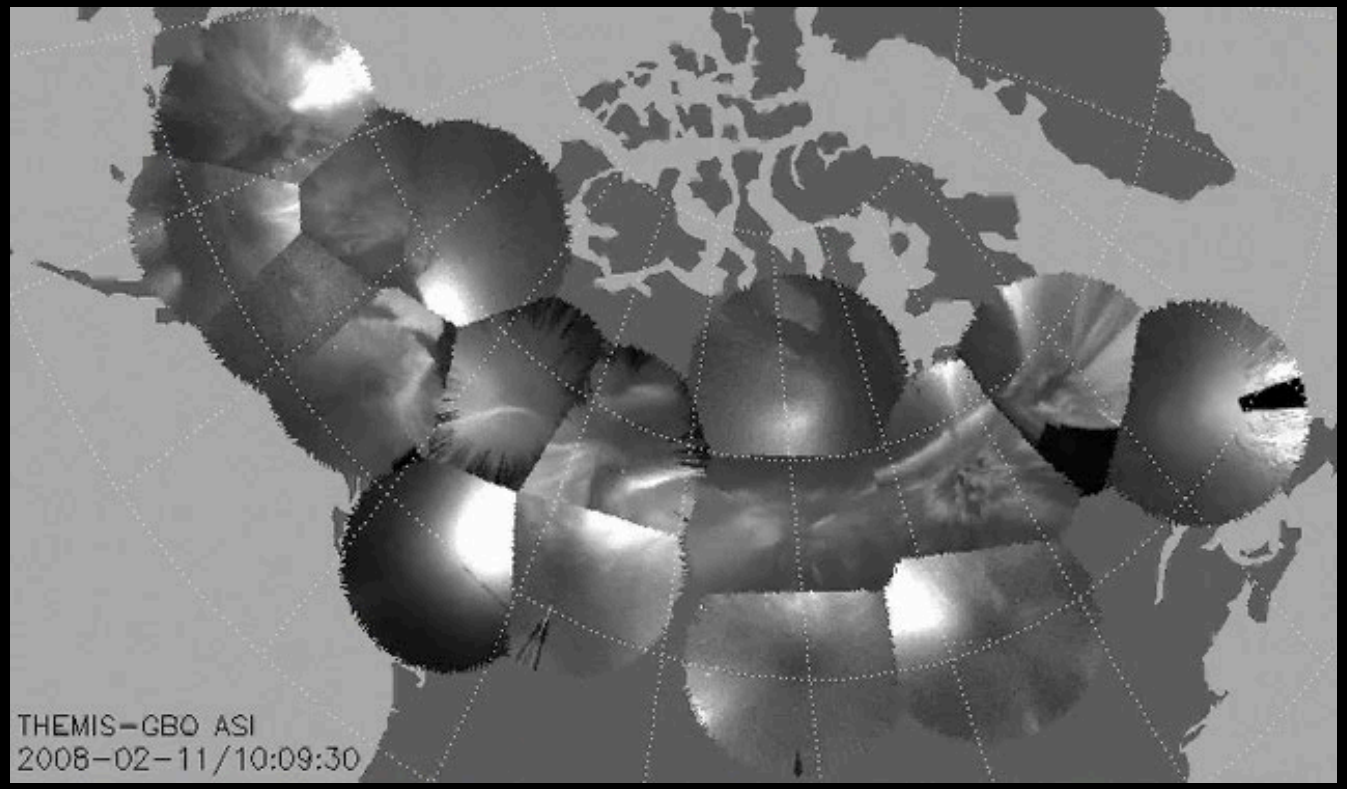
Shared logistical support to maximize science impact

Credit: Zhonghua Xu

- Multiple research communities need access to similar regions
- Coordinate flights/scientific traverses/field camps
- More communities involved → stronger case for scientific traverses, more flights, etc
- Widen the number of possible international collaborations by including different research areas

Backup slides

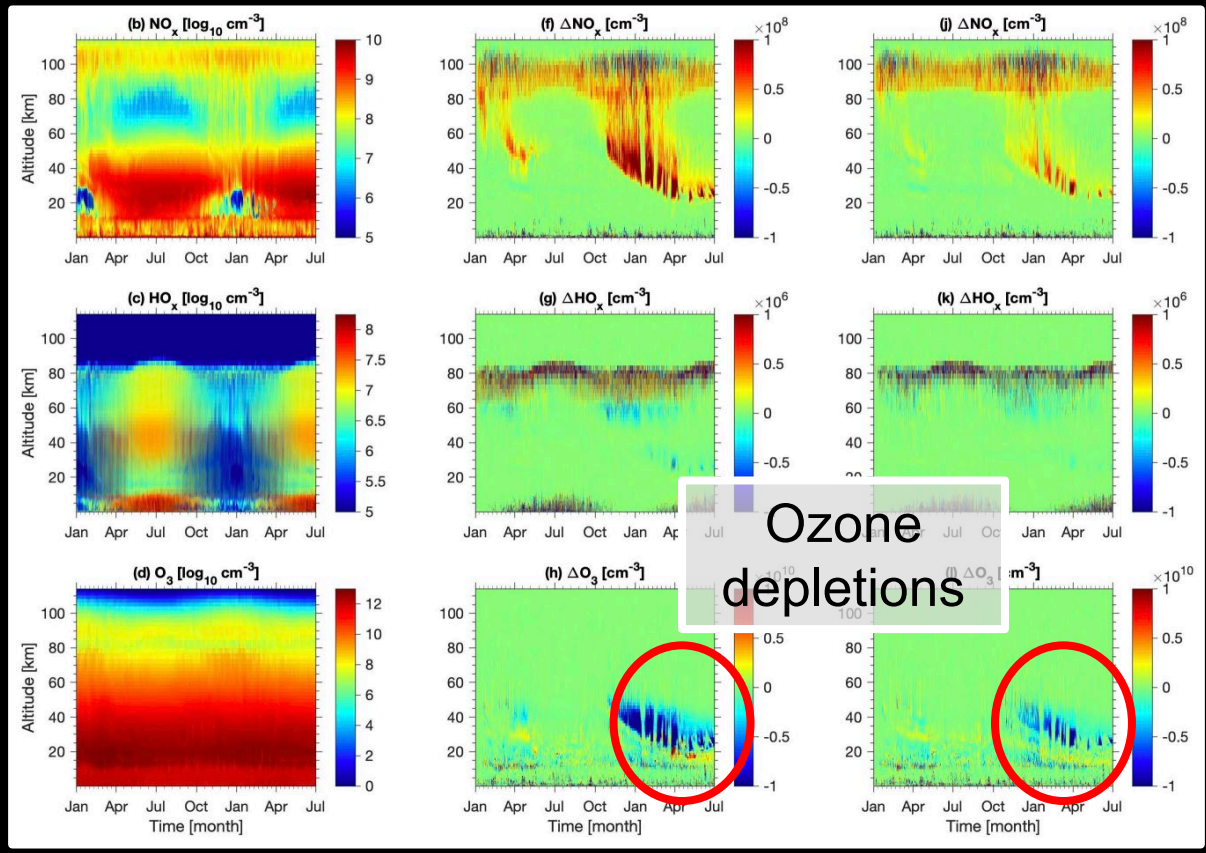
Why do we care?



Jones+ 2013

Pulsating aurora likely constitutes a significant amount of the total energy dumped from the magnetosphere to our ionosphere/atmosphere

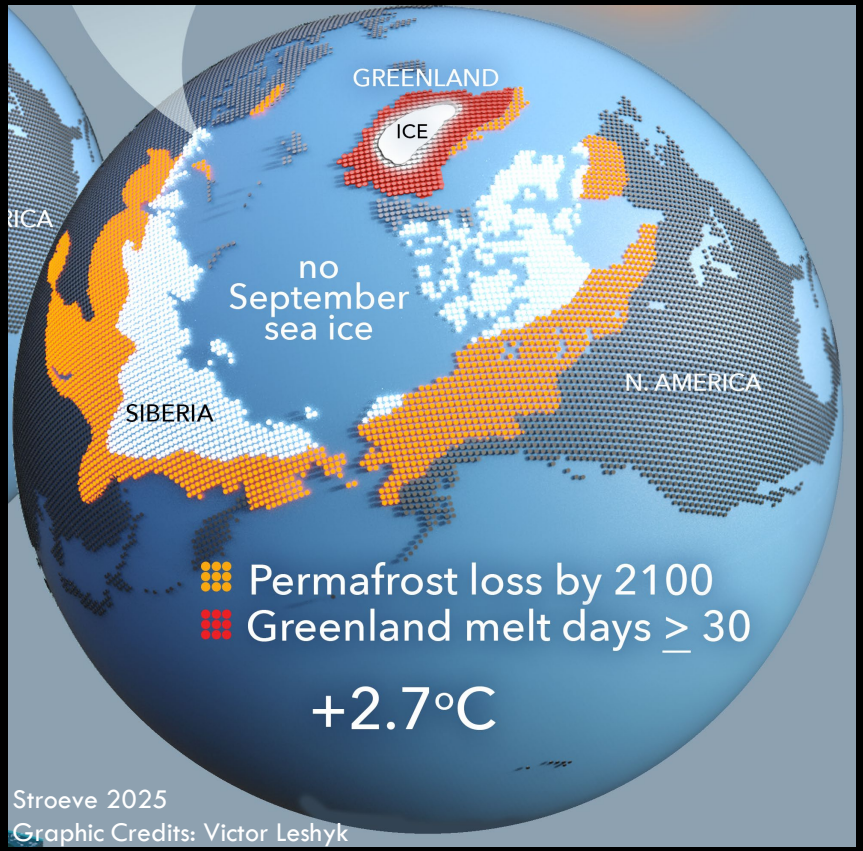
Pulsating aurora initiates compositional changes in the atmosphere that result in localized ozone losses



Verronen+ 2021

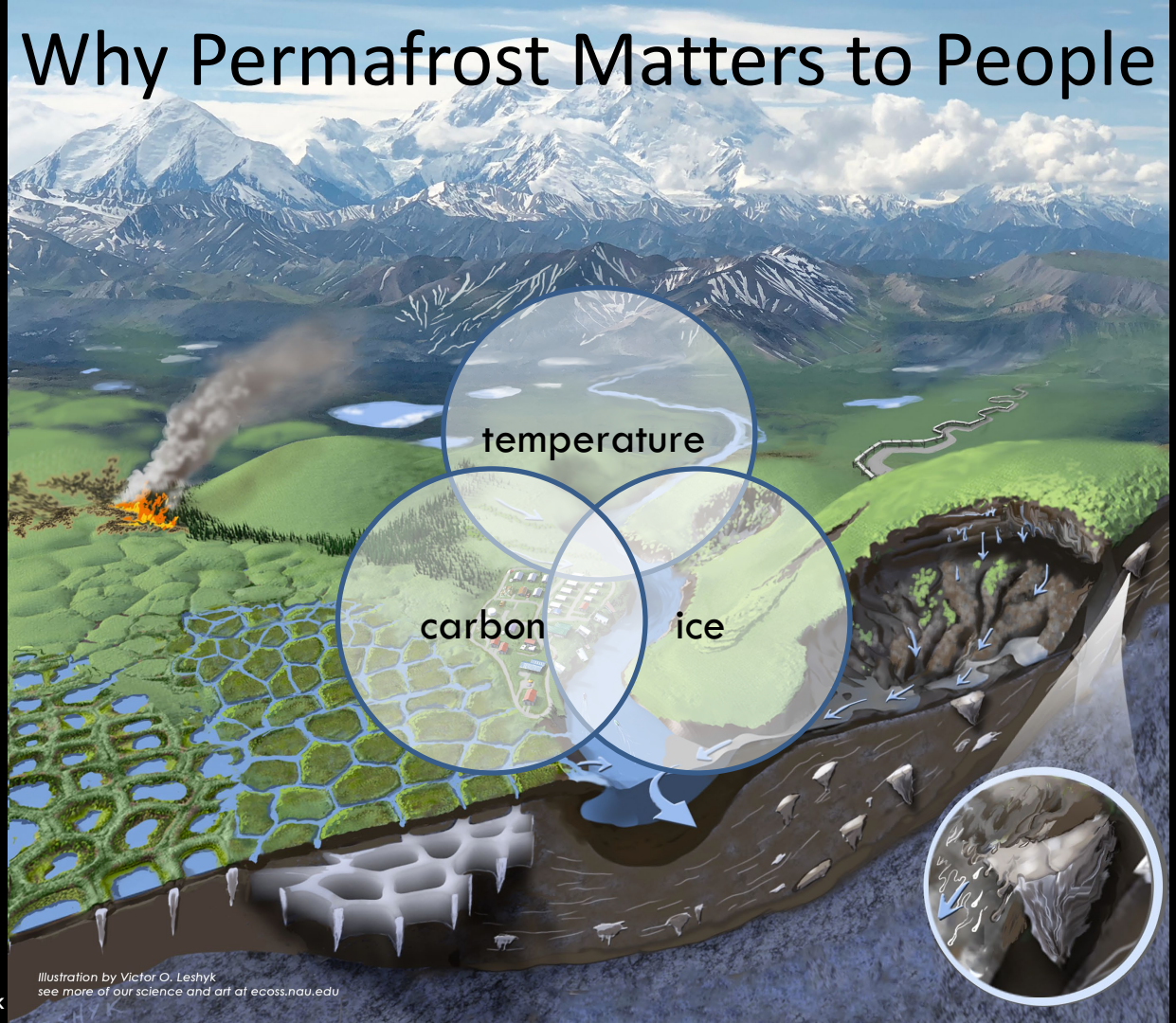
2032-33 IPY

2087-88 IPY



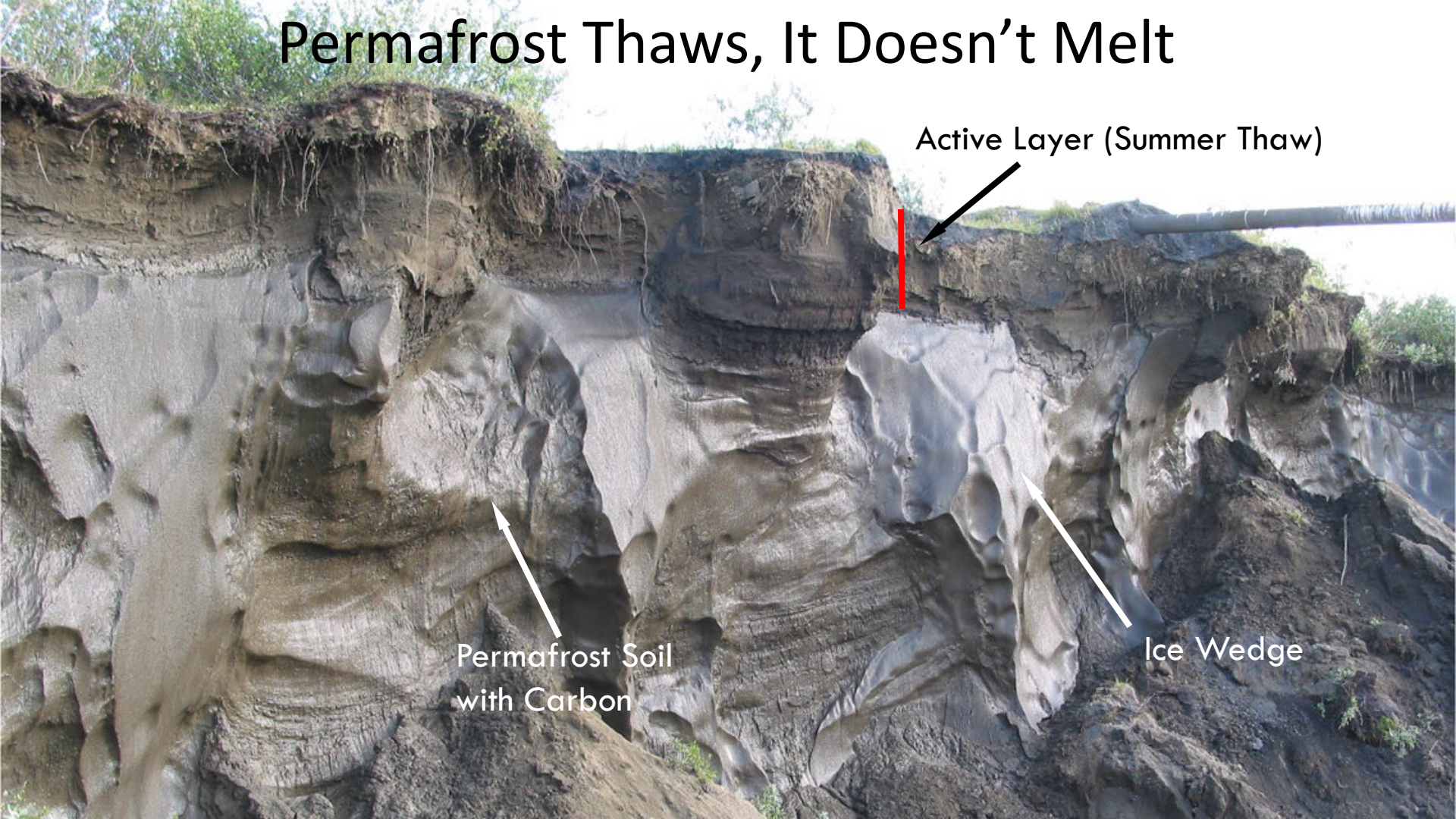
Dr. Ted Schuur; Center for Ecosystem Science & Society; Northern Arizona University

Why Permafrost Matters to People



Schuur & Mack 2018
Graphic Credits: Victor Leshyk

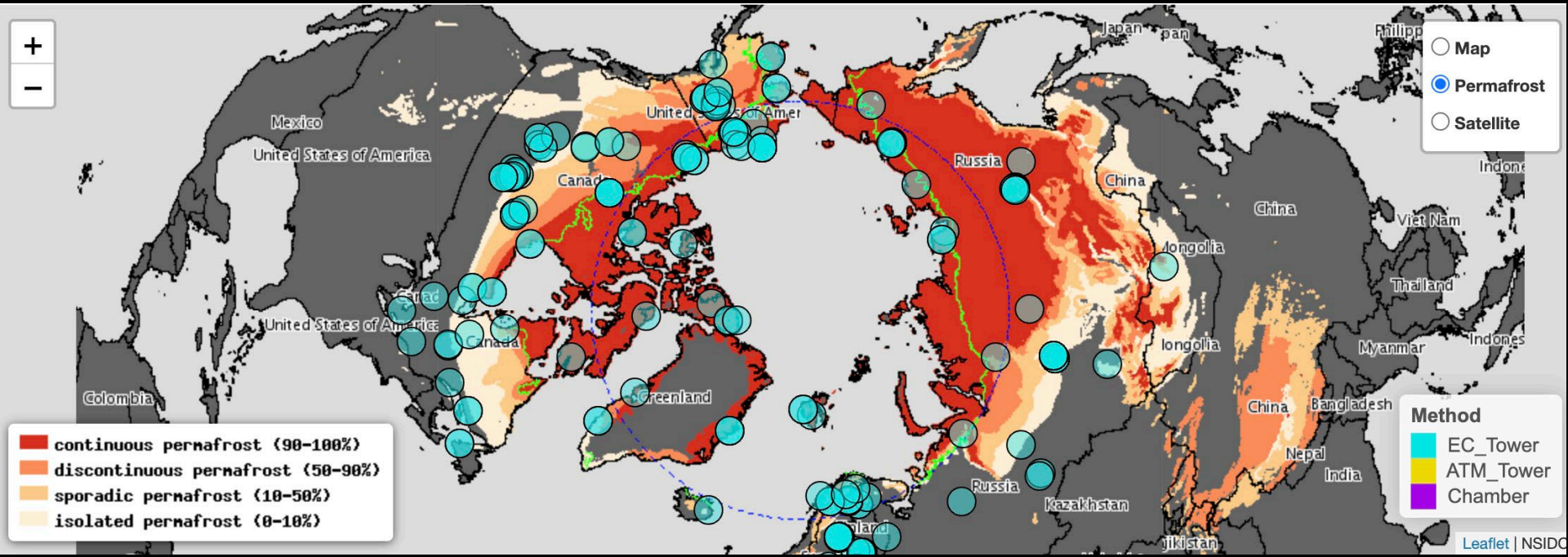
Permafrost Thaws, It Doesn't Melt



Local and Global Impacts of Changing Permafrost

Study for Environmental Arctic Change
Graphic Credits: Christina Schaedel

Arctic Carbon Dioxide and Methane Network



Virkkala et al. NCC 2025
See et al. NCC 2024
Vogt et al. ESSD 2025
Falvo et al. 2025

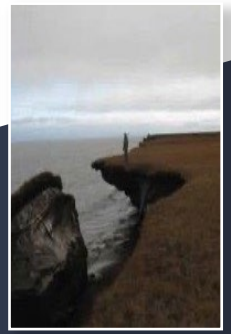
cosima.nceas.ucsb.edu/carbon-flux-sites/

Discussion Points

- Arctic emissions could add carbon to the atmosphere similar in scale to a large industrialized country; these must be considered to meet temperature targets.
- A network of ground-based measurements is critical for permafrost and carbon
- Upscaling using remote sensing and science synthesis both needed for regional and global impacts
- Some permafrost metrics become unreliable in future warmer world
- Geopolitics put monitoring network at risk for information loss

Alaska Ocean Observing System (AOOS)
Overview

Sheyna Wisdom, Executive Director
wisdom@aoos.org
907-748-5864

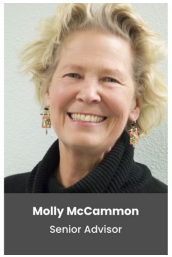



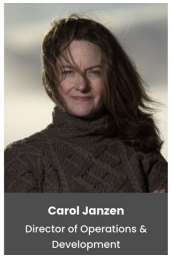
AOOS
Alaska Ocean Observing System

Who is AOOS?

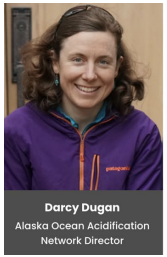
- **Integrated Ocean Observing System (IOOS)**
  - NOAA funded program under National Ocean Service (NOS)
  - 1 of 11 Regional Associations across U.S.
  - Operating since 2003
- **AOOS organizational setup**
  - Mission to increase observing & forecasting in all regions of Alaska
  - Board of federal and state agencies, academic institutions, research facilities, industry, non-profits, tribal
  - Operates as a non-profit organization with Alaska SeaLife Center (ASLC) acting as fiscal sponsor
  - 10 staff members
- **AOOS observing activities are highly leveraged**
  - Partners are **essential** for successful ocean observing in our region

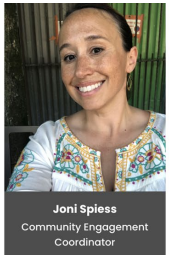

Sheyna Wisdom
Executive Director


Molly McCammon
Senior Advisor

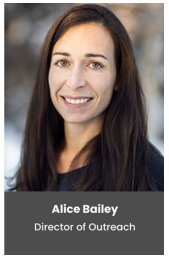

Carol Janzen
Director of Operations & Development

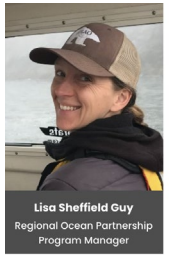

Holly Kent
Director of Administration

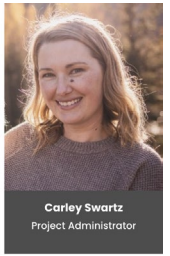

Darcy Dugan
Alaska Ocean Acidification Network Director


Joni Spiess
Community Engagement Coordinator


Thomas Farrugia
Alaska Harmful Algal Bloom Coordinator


Alice Bailey
Director of Outreach


Lisa Sheffield Guy
Regional Ocean Partnership Program Manager


Carley Swartz
Project Administrator

AOOS Board

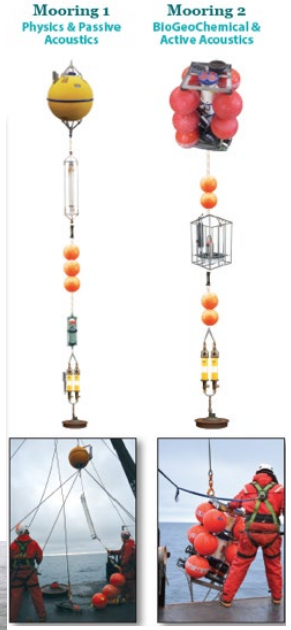
Organizations with designated representatives

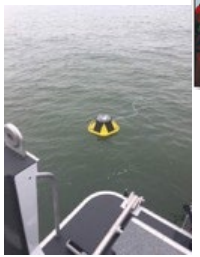
- **State Agencies**
  - Department of Environmental Conservation: Megan Kohler
  - Department of Fish & Game: Hamachan Hamazaki
  - Department of Natural Resources: John Crowther
- **Federal Agencies**
  - NOAA: TBD
  - US Coast Guard: Jennifer Whitcomb
  - US Geological Survey: Ann Gibbs
  - BOEM: Sharon Randall
- **State/Federal**
  - Alaska Sea Grant: Ginny Eckert
- **Industry**
  - Marine Exchange of Alaska: Steve White (Chair)
  - North Pacific Fishery Management Council: Rudy Tsukada
  - Hilcorp Alaska: Chuck Wheat
- **Research**
  - University of Alaska Fairbanks: Brad Moran
  - North Pacific Research Board: Lynn Palensky (Treasurer)
  - Prince William Sound Science Center: Katrina Hoffman
  - NOAA Alaska Fisheries Science Center: Bob Foy
  - Alaska SeaLife Center: Wei Ying Wong
- **Environmental NGO**
  - Wildlife Conservation Society: Martin Robards (Vice Chair)
- **Indigenous**
  - Co-Management: Mike Miller, Indigenous Peoples Council on Marine Mammals
  - For-Profit Alaska Native Organization: Larry Jackson, Port Graham Native Corporation
  - Non-Profit Alaska Native Corporation: Karen Pletnikoff, Aleutian Pribilof Islands Association
  - Tribal Authorized Government: Estelle Thompson, Native Village of Paiumiut (Secretary)

Overview of AOOS Approach

AOOS
Alaska Ocean Observing System

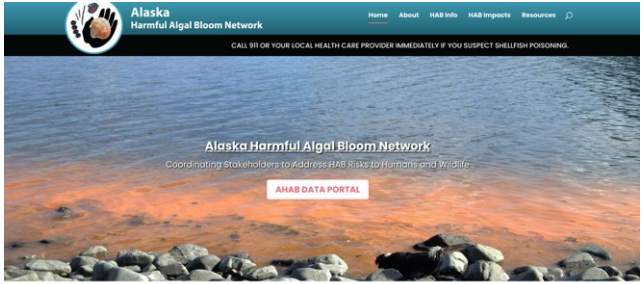
- **Sustained observations and assets**
  - Moorings
  - Gliders
  - High frequency radars (HFRs)
  - Ship surveys
- **Fund/test new and innovative technologies**
  - Coastal hazard assets (water level sensors, Hydroball bathymetry
  - Imaging Flow Cytobot (IFCBs) for HABs
  - Sofar Ocean Spotter wave buoys (Backyard Buoys)
- **Collaborations and partnerships to find solutions**
  - Collaborative networks
  - Community sampling programs
  - Leverage funding
- **Work with ocean users to collect, use, and how information in meaningful way**
  - Data portal
  - Incident Response Tools
  - Mariner's dashboards
  - Other products/services





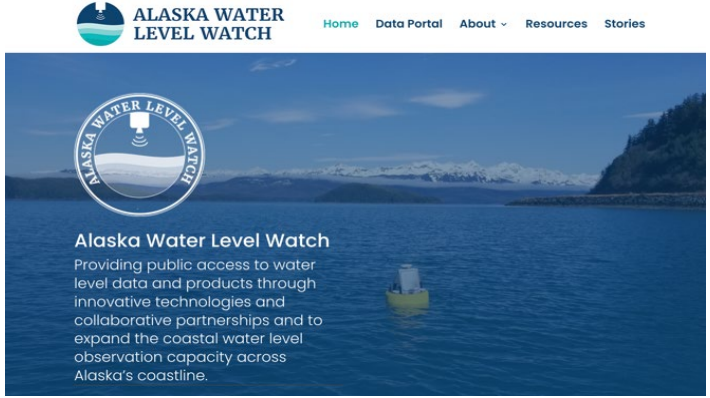
Collaboration Networks

Alaska Harmful Algal Bloom Network (AHAB)
https://ahab.aoos.org/



Alaska Ocean Acidification Network (AOAN)
https://aoan.aoos.org/

Alaska Water Level Watch (AWLW)
https://awlw.aoos.org/



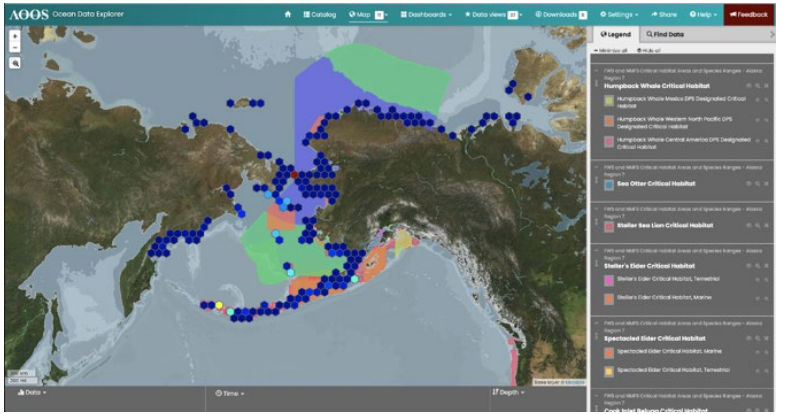
Alaska Marine Policy Forum
https://aoos.org/alaska-issues/alaska-marine-policy-forum/

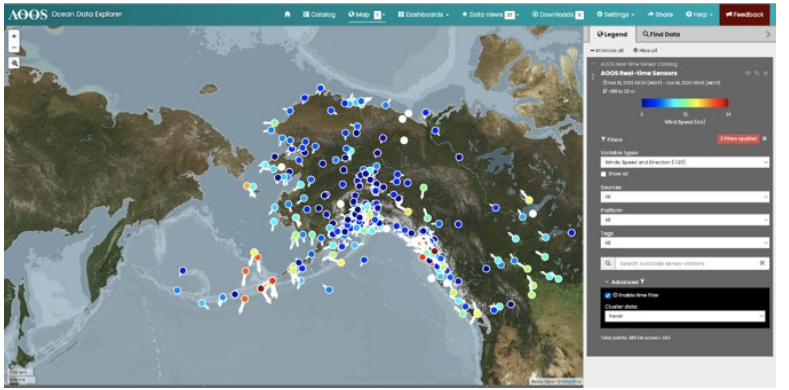
https://alaskaseagrant.org/events/alaska-marine-policy-forum/

Making Data Accessible

AOOS
Alaska Ocean Observing System

- **Ocean Data Explorer** (https://portal.aoos.org/)
- **Map View: Integrates & visualizes data**
  - AOOS funded projects
  - Real-time sensors
  - Moving platforms
  - Data rescue projects
- **Catalog View: Search & data download**
  - 3000 + data layers
  - Search with keywords
  - Download data
- **Data View: Compare different data streams**
- **REACH OUT if you need something you can't find!**





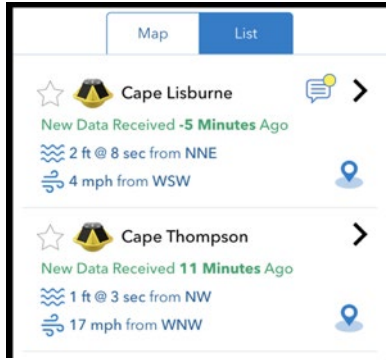
Other Data Resources

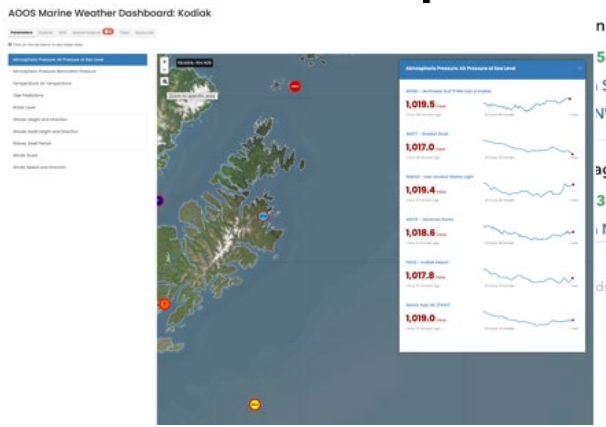
- **Backyard Buoys Wave Buoy App**
  - Designed by University of Washington
  - https://backyardbuoys.org
- **Mariner's Dashboard**
  - Portal (desktop version): https://aoos.org/portal_-highlights-2/real-time-information-for-current-maritime-conditions
  - Dashboard (mobile version): https://aoos_-demo.thedigteam.tech/
- **Working on more products outside of data portal**
- **Would love feedback!!!**

Download the Backyard Buoys app

Iphone:

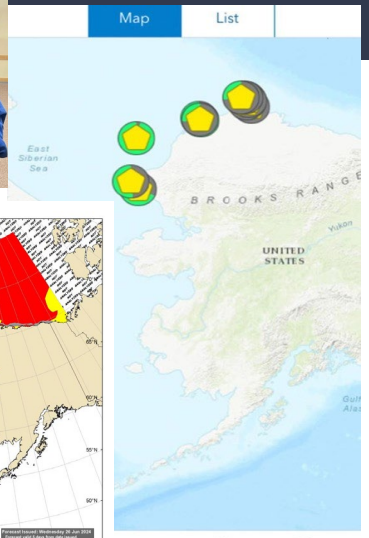
Google Play:

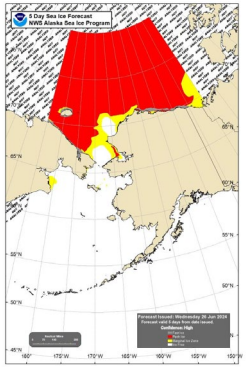


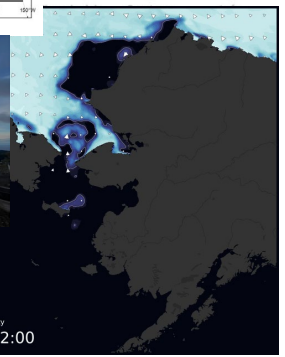


Examples of Key Arctic Programs

AOOS
Alaska Ocean Observing System



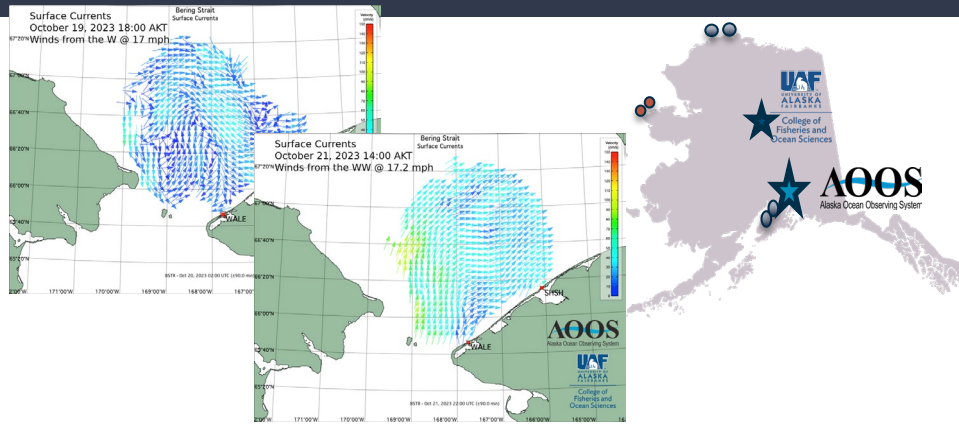


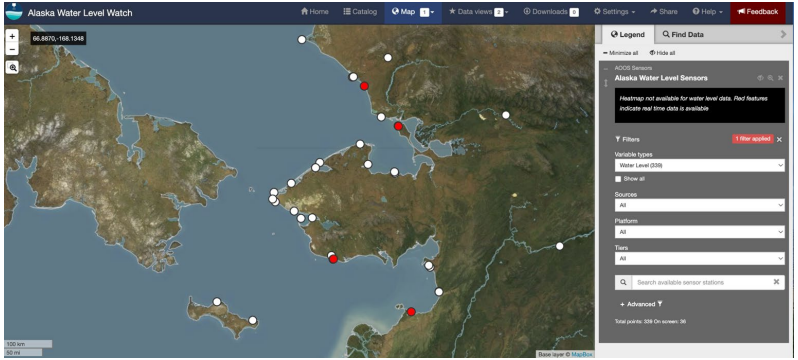


- **Backyard Buoys** (https://backyardbuoys.org)
  - partner with Alaska Eskimo Whaling Commission (AEWC) for hunters to steward wave buoys in villages
- **Sea Ice for Walrus Outlook** (https://www.arcus.org/siwo)
  - partner with Eskimo Walrus Commission (EWC) and Arctic Consortium of the US (ARCUS) for sea ice prediction movements and observer support
- **Arctic Watch Program** (https://arcticwatch.org/)
  - partner with Marine Exchange of Alaska and Kawarek for real-time vessel management system in Bering Strait
- **Skipper Science** (https://www.skipperscience.org/)
  - partner with Aleut Community of St. Paul Island and Alaska Conservation Foundation for collecting oceanographic information by fisherman & observers
- **Alaskan Arctic Observatory & Knowledge Hub** (https://arctic -aok.org/)
  - Partner with UAF and Alaskan Arctic coastal community residents
- **Nalaquq LLC**
  - Salmon counts using drones: https://nalaquq.com/portfolio/salmon -fish-count/
  - Buoys/drifters: https://nalaquq.com/portfolio/sofar -buoy-project/

Assets in Region

- **High Frequency Radars (HFRs)**
  - https://cordc.ucsd.edu/projects/hfrnet/
  - Located at Utqiaġvik, Wainwright, Shishmaref, Wales
  - Surface currents
  - *only during open water*
- **Alaska Water Level Watch (AWLW)**
  - https://awlw.aoos.org/
  - https://water -level-watch.portal.aoos.org/#map
  - Tide gauges, GNSS-R, NWLON stations for real time water levels, tide levels, etc.
- **Weather Stations on AIS Receivers**
  - https://www.mxak.org/services/mda/weather/map-of-sites/





Summary of AOOS Role in IPY5

AOOS
Alaska Ocean Observing System

- **Connector/convener role**
  - AOOS is VERY connected within Alaska
  - Use of existing collaborative networks (OA, HABs, AWLW)
  - AOOS connected within NOAA and other regions (NERACOOS/MARACOOS)
- **Data Portal with 3000+ layers**
  - Work to share information, does not have to be ingested on our portal
- **Reduce redundancy for Alaskan communities**
- **Leverage funding to fill gaps in ocean observing**
  - Find creative ways to be impactful with funds

Sheyna Wisdom, Executive Director, wisdom@aoos.org

Key Ecosystem Research Topics for the Fifth International Polar Year

Jackie M. Grebmeier
University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory, Solomons, Maryland, USA

"Exploring Key Research Topics for the Fifth International Polar Year 2032-2033 - A Workshop"

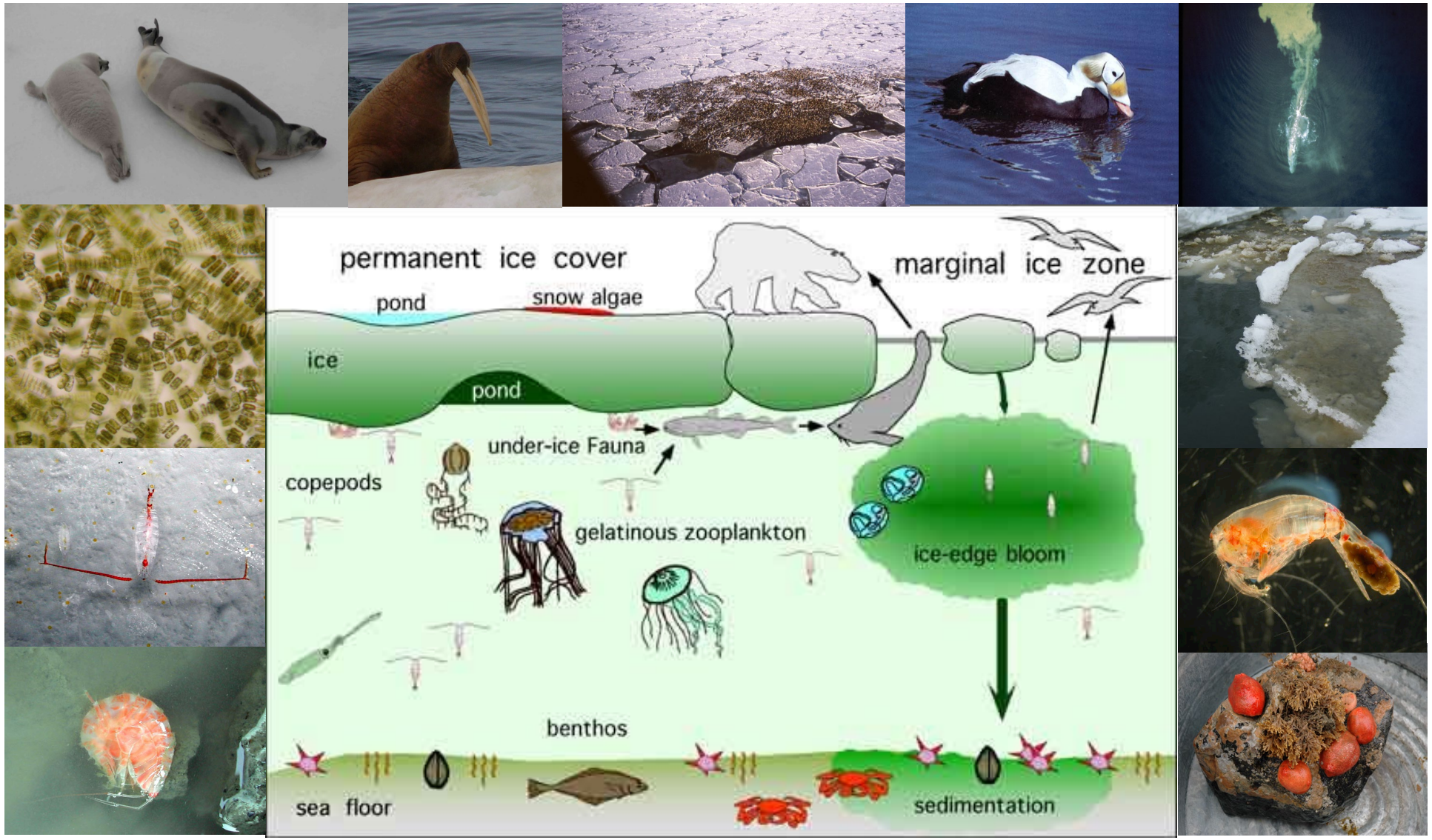
National Academy of Sciences
Polar Research Board
Washington DC
May 20, 2025

- Arctic ecosystem status and change: importance of biology in ecosystem studies
- Time series ecosystem studies through national and international collaborations
- Shelf-to-basin Pan-Arctic collaborative studies during ongoing ecosystem change

Arctic Marine Food Web

Why ecosystem studies?

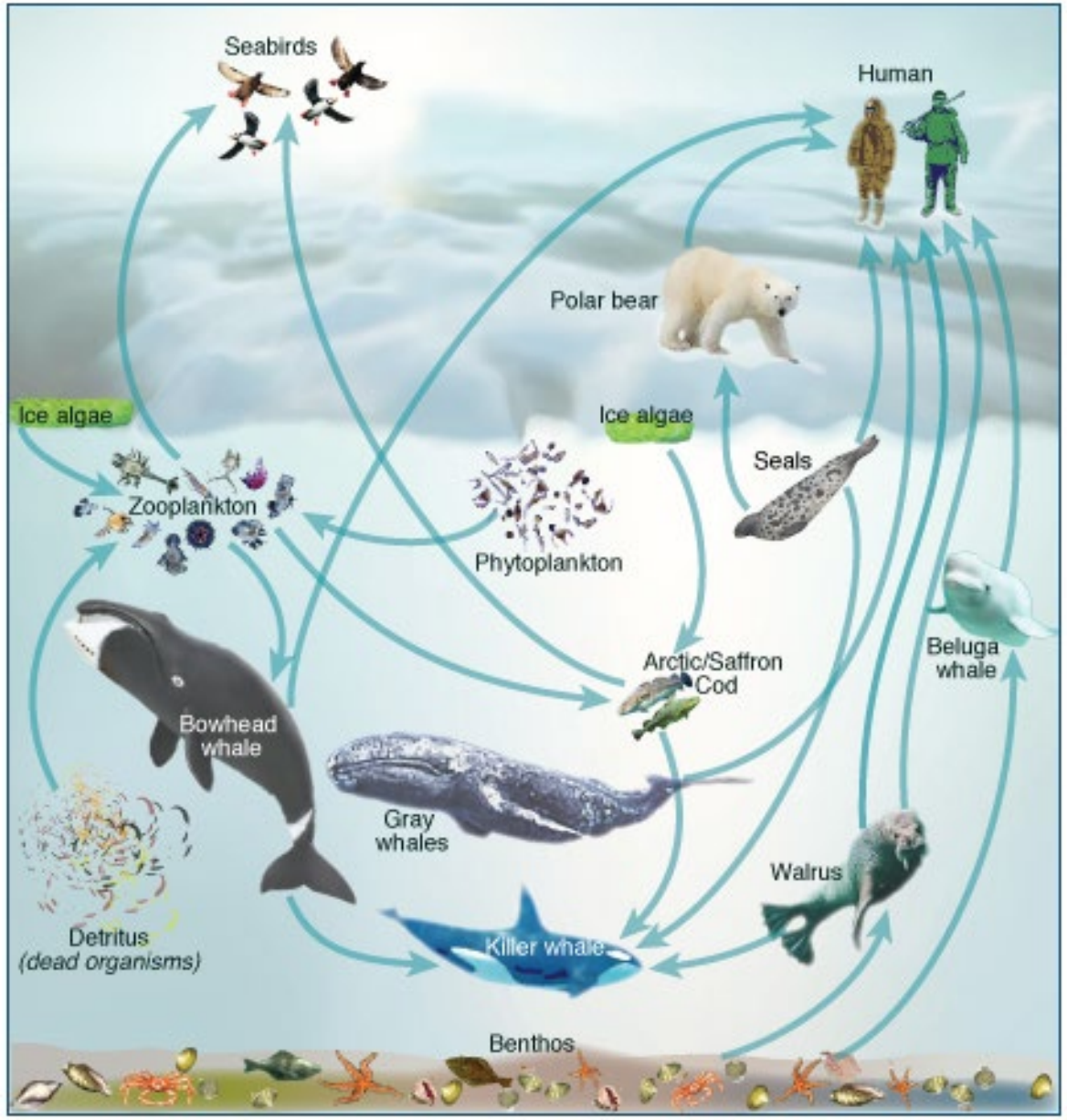
Sea ice extent and seawater temperature, coastal erosion and other changes are obviously important, but how ecosystems respond requires complex and sustained efforts well suited to new approaches in the 2030's.



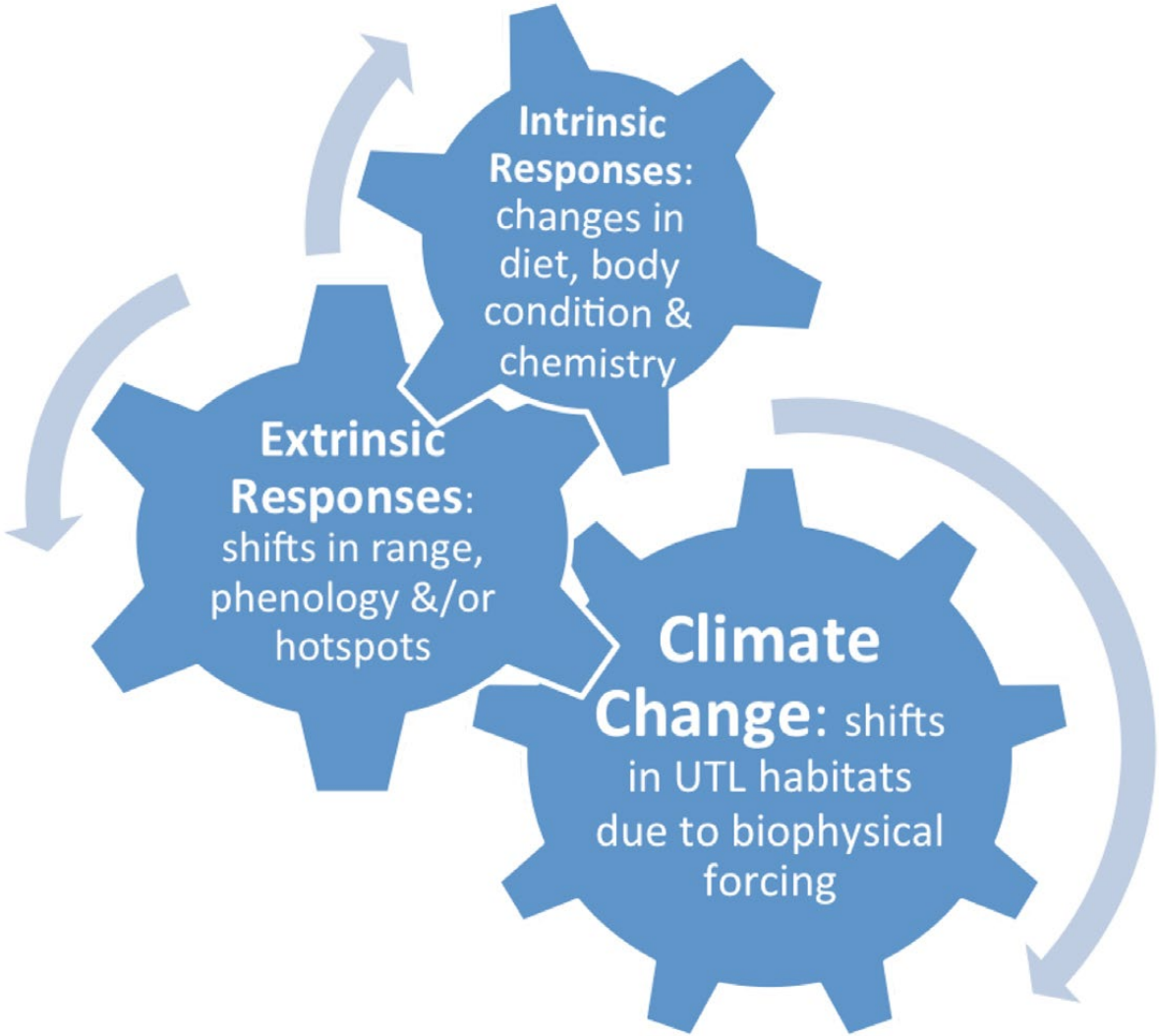
[inside figure from http://www.arcodiv.org/]

- Topics: biodiversity changes, northward lower and upper trophic species shifts, food security concerns, change in carbon cycling components leading to ecosystem shifts

Pacific Arctic

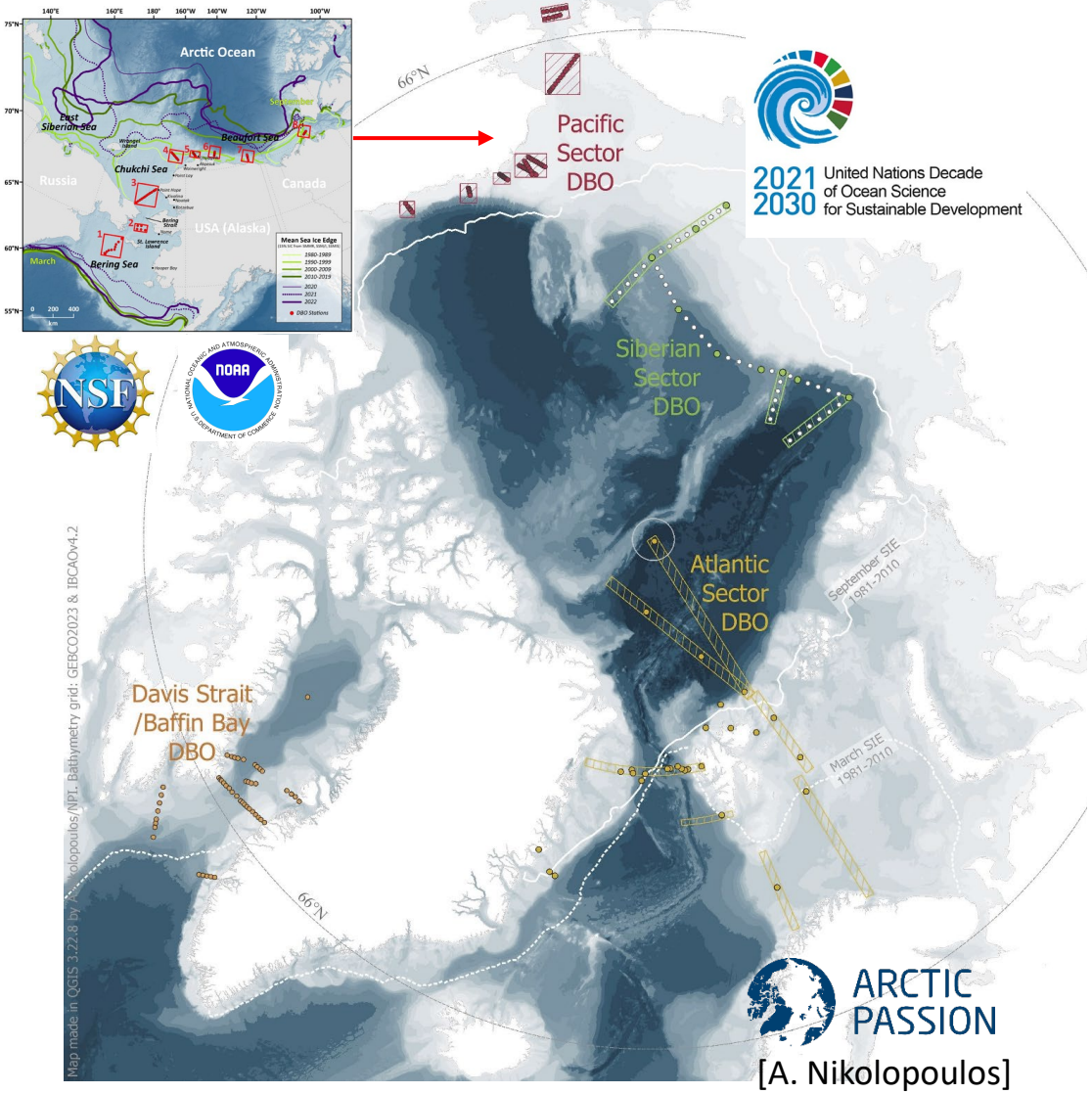


Marine birds and mammals reflect ecosystem alterations by changes in habitat use (extrinsic) and body condition (intrinsic)



[Moore SE 2022]

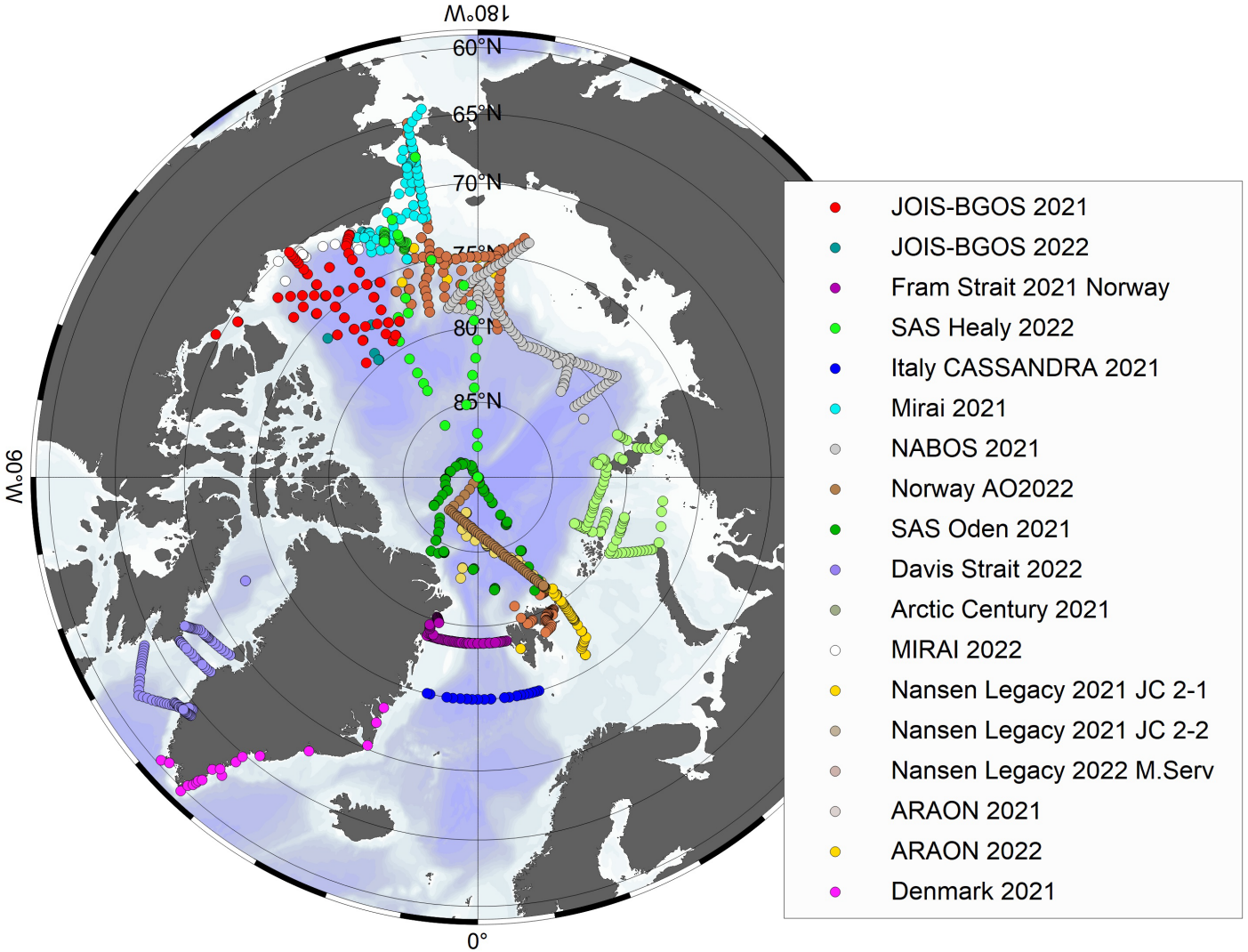
Pan-Arctic Distributed Biological Observatory Network



2021 2030 United Nations Decade of Ocean Science for Sustainable Development

[A. Nikolopoulos]

Synoptic Arctic Survey transects in the Arctic Basin



[Map by M-L. Timmermans]

Arctic Ecosystem Studies from Shelf-to-Basin and Pan-Arctic

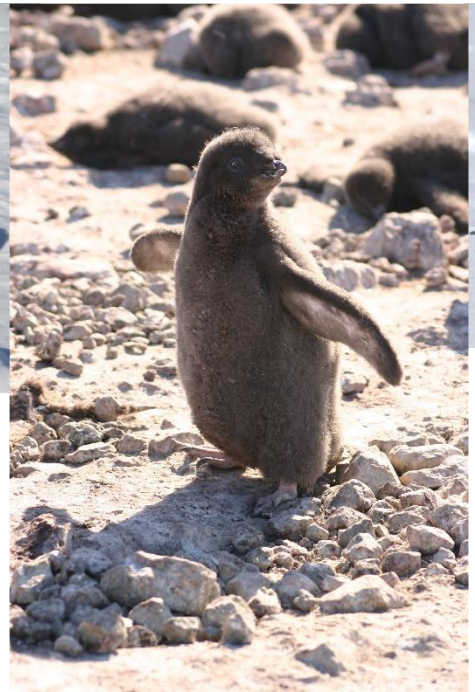
Select Topics

- Multi-disciplinary, international time series shelf and slope to basin studies to evaluate status and trends of biological components within polar ecosystems
- Emerging observations indicate physical changes (warming seawater, declining sea ice) are driving shifts in marine species composition and habitat suitability at variable trophic levels
- Environmental changes have potential to influence carbon cycling that may signal ecosystem reorganization
- Ship sampling, moorings, including water sampling and biological sensors, satellite observations, autonomous vehicles; new biological sensors to moorings; new technologies for increased real-time data streams
- Key parameters, inclusive of ship-based core water column and sediment measurements, utilize new genomic studies, include biological sensors and mammal passive acoustics on moorings, enhanced satellite observations for polar regions, imaging capabilities for plankton and benthos
- International collaboration needed for agreed set of standardized measurements in different regions of the Arctic for broader scale comparisons, including developing national-led Pan-Arctic transects into deep basins
- Expand ecosystem modeling capabilities for evaluating and forecasting polar ecosystem change
- Include all levels of scientific professionals (early career to established scientists) and members of Arctic coastal communities

Michelle LaRue

Associate Professor, University of Canterbury

The Ross Sea Marine Protected Area: *"is it working?"* is a place to start



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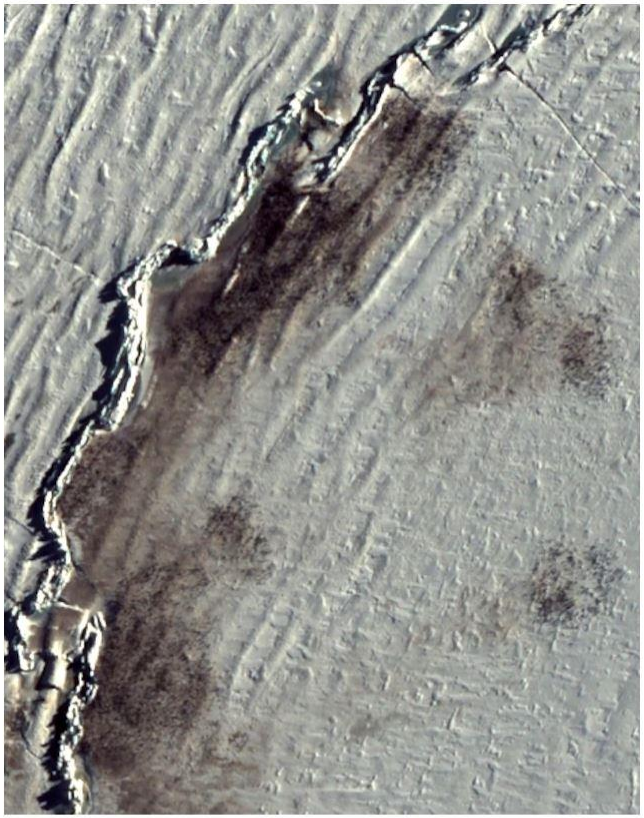
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND



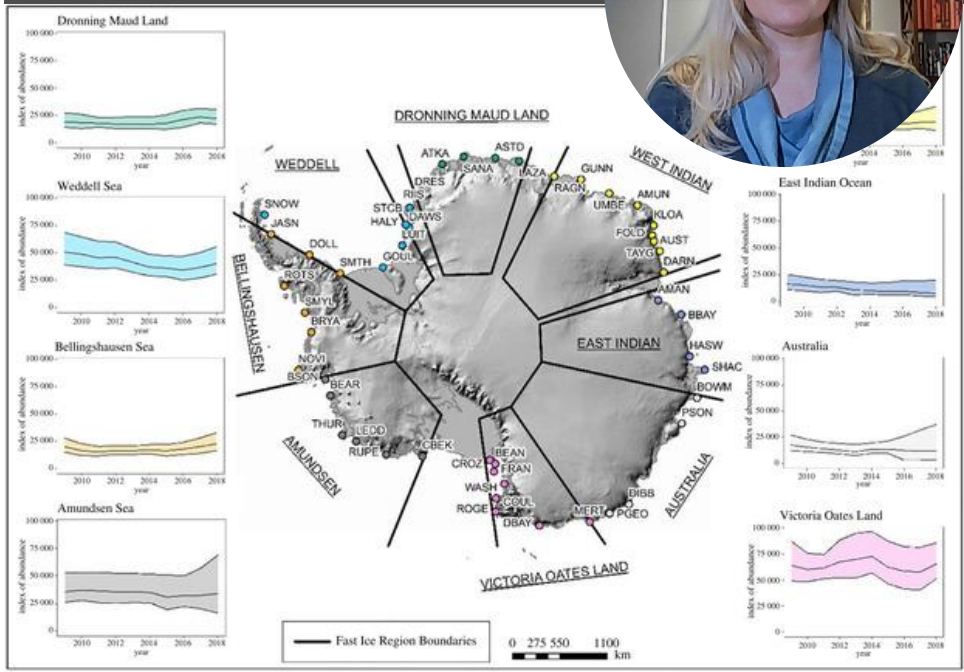
A satellite view of penguin colonies in Cape Colbeck, Antarctica.
SATELLITE IMAGE COURTESY UNIVERSITY OF MINNESOTA

Emperor Penguins Counted From Space—A First

Satellite images show species population has doubled, study says.

BY **CHRISTINE DELL'AMORE**, NATIONAL GEOGRAPHIC NEWS

PUBLISHED APRIL 14, 2012 • 4 MIN READ

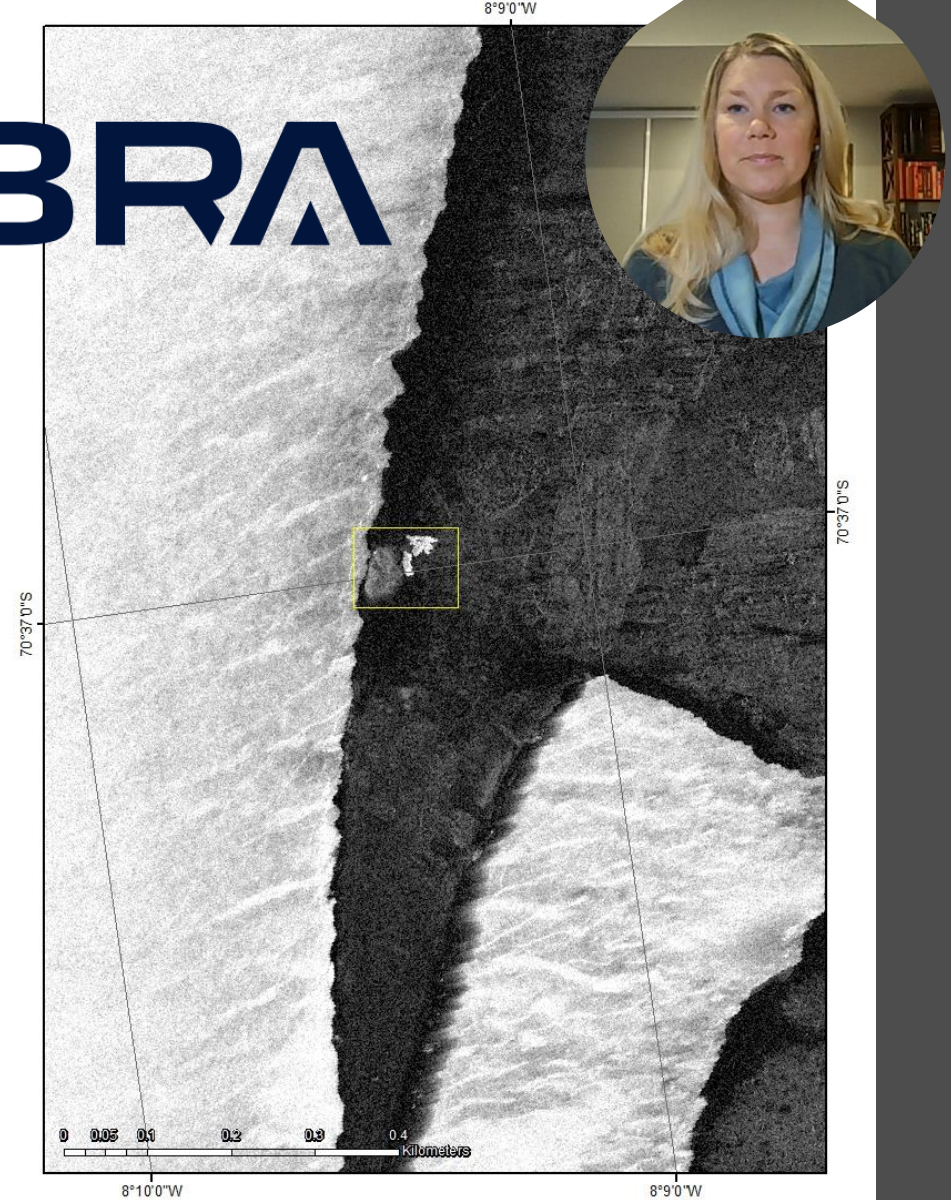


10-year global survey*

*probably fledgling abundance (Sen et al. 2025)

UMBRA

Winter surveys now possible



Molting habitat
Foraging habitat/behavior

Satellite

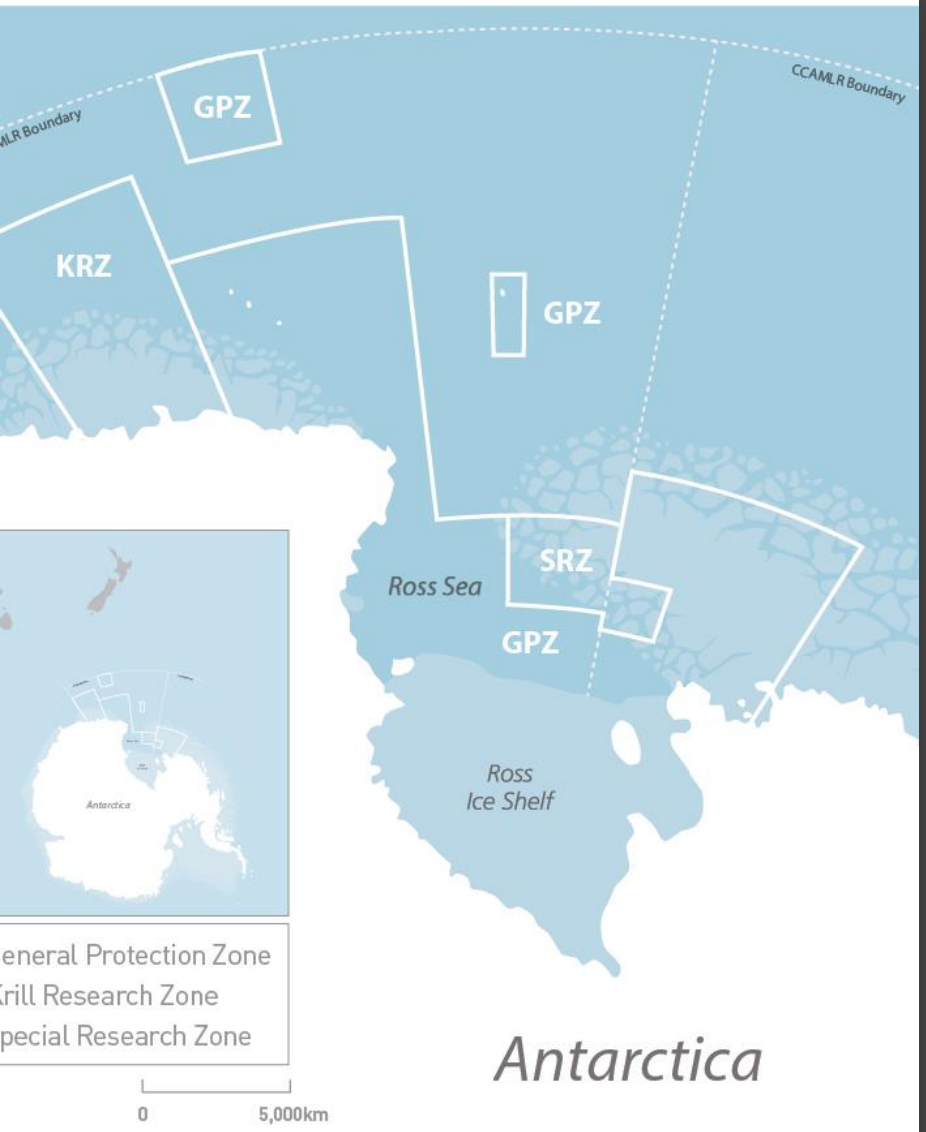
Name: Mr. Pingu
Name: Sparkles
Name: Big Mac Turbo 2000
Name: Harry

WILDLIFE COMPUTERS

Map of raw location data for display purposes only

Measure Distance

Keyboard shortcuts | Imagery ©2025 NASA, TerraMetrics | Terms



With satellite technology alone…

US observation resources

Building on international collaborations

Lessons (hopefully!) from high seas MPA evaluation

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