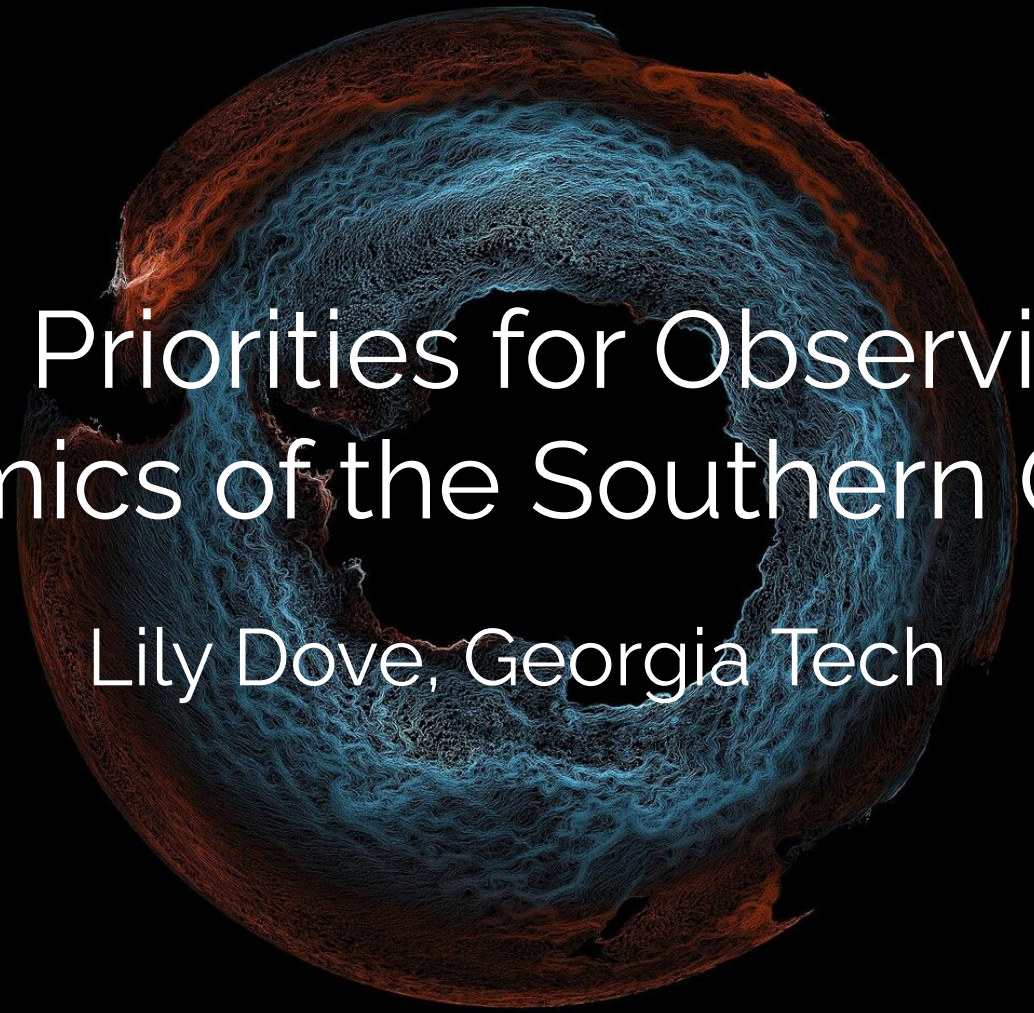
Future Priorities for Observing the Dynamics of the Southern Ocean

Lily Dove, Georgia Tech

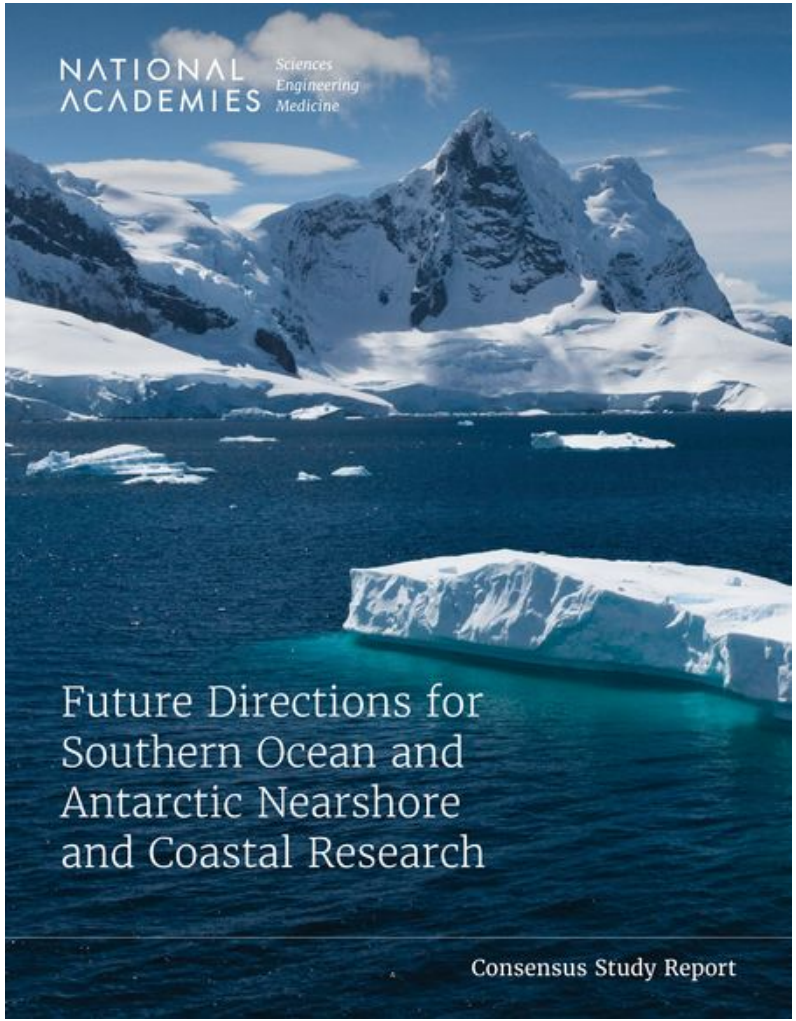


Visualization by R. Brady

Presentation based off the 2024 workshop **Observing the Dynamics of the Southern Ocean: Present Challenges and Future Strategies**

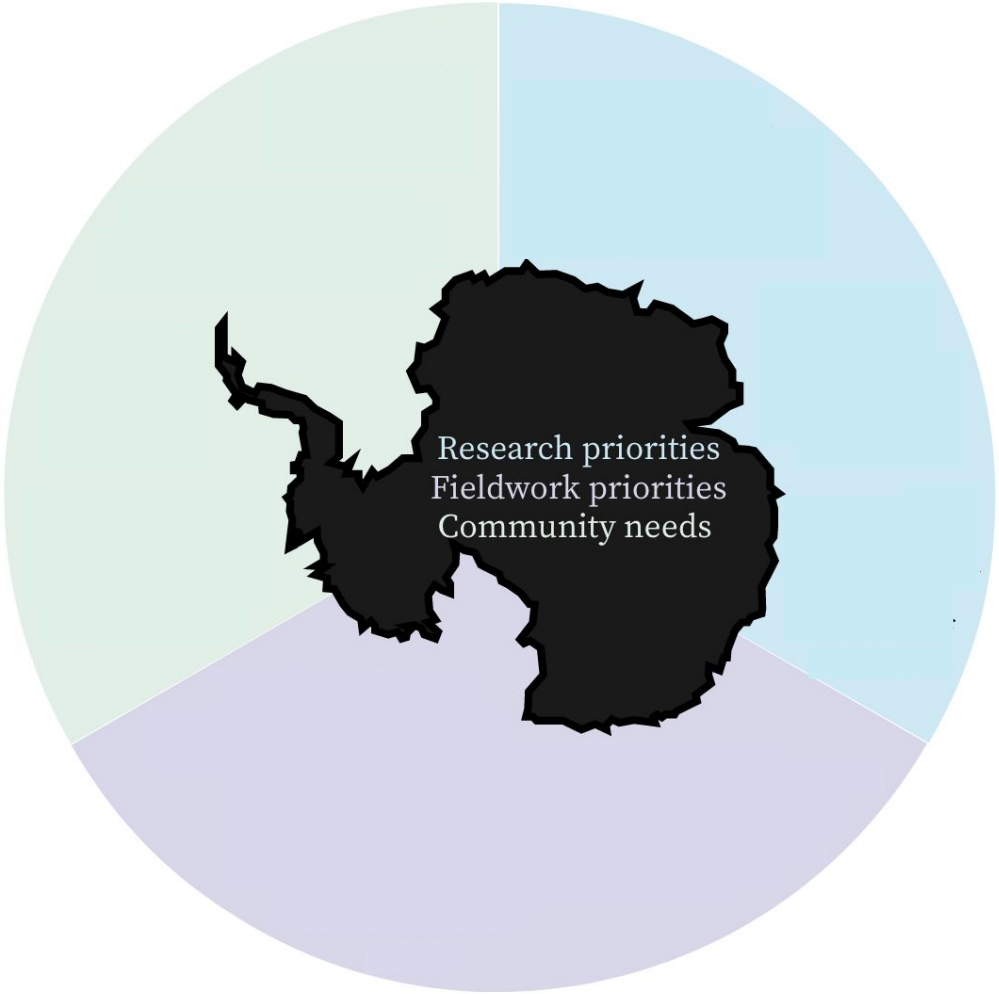
Goal: to **identify key knowledge gaps** and **outline a set of research and observational priorities** for the next 5-10 years

Written up in Wilson et al. (2025, BAMS)



Recent (2024) National Academies Consensus Report

PAULA BONTEMPI (*Co-chair*), University of Rhode Island
ALAN MIX (*Co-chair*), Oregon State University
KIM S. BERNARD, Oregon State University
EDWARD A. BOYLE, Massachusetts Institute of Technology
DANIEL P. COSTA, University of California, Santa Cruz
JAMIN S. GREENBAUM, Scripps Institution of Oceanography
YING-TSONG LIN, Woods Hole Oceanographic Institution
HEATHER JOAN LYNCH, Stony Brook University
W. BERRY LYONS, The Ohio State University
EDWARD (TED) MAKSYM, Woods Hole Oceanographic Institution
JILL MIKUCKI, University of Tennessee, Knoxville
WEISEN SHEN, Stony Brook University
ANDREW F. THOMPSON, California Institute of Technology



Recent advances

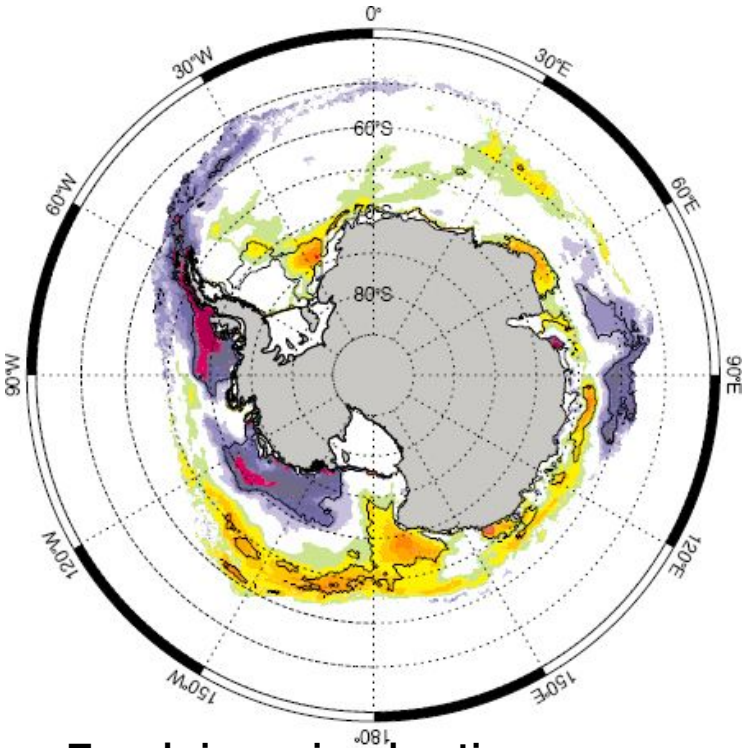
Current gaps

Places to build

Research priorities

Recent advances:

- Growing appreciation for the **asymmetry** of the dynamics of the Southern Ocean
- Increased observations of the Antarctic sea ice zone with **remote sensing**
- Recognition of the importance of the **freshwater budget** for large-scale dynamics



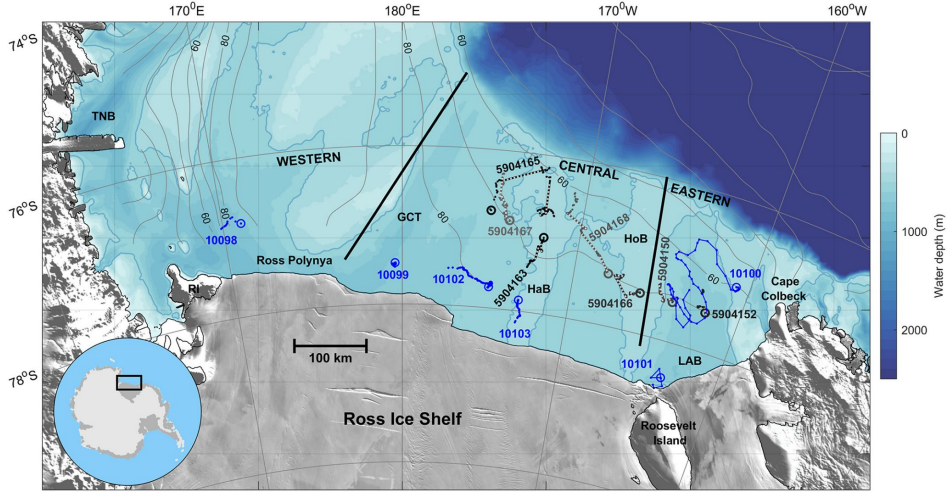
Trends in sea ice duration, 1979–2023

DiGirolamo et al., 2022; Meier et al., 2023

Research priorities

Current gaps:

- Observations of the **seasonal variations** in ocean heat content and transport as well as inter-shelf-sea exchange
- Extensive **under-ice** observational networks
- Understanding of how regional circulation and small-scale mixing impact **coupled climate dynamics**

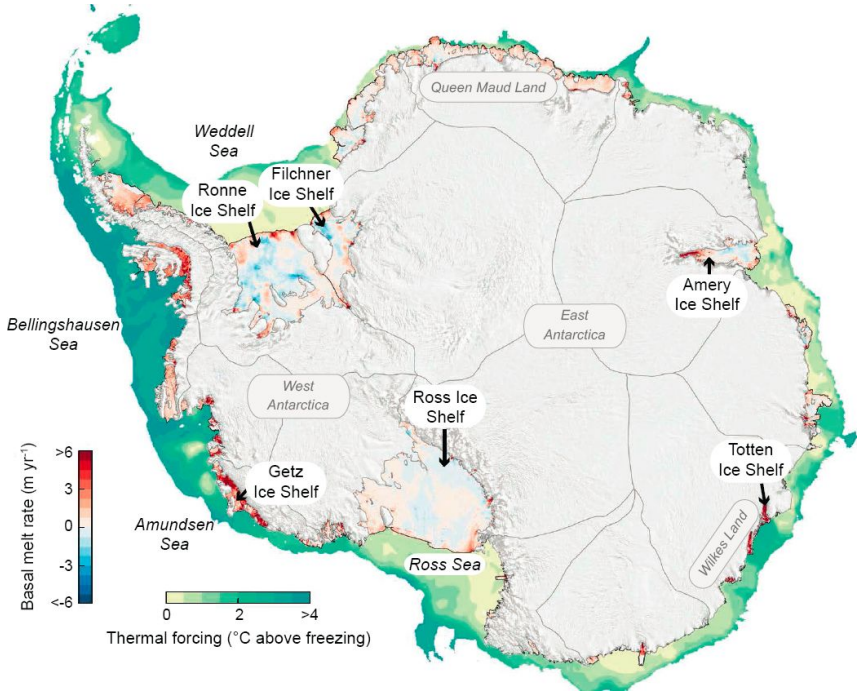


Porter et al. (2019)

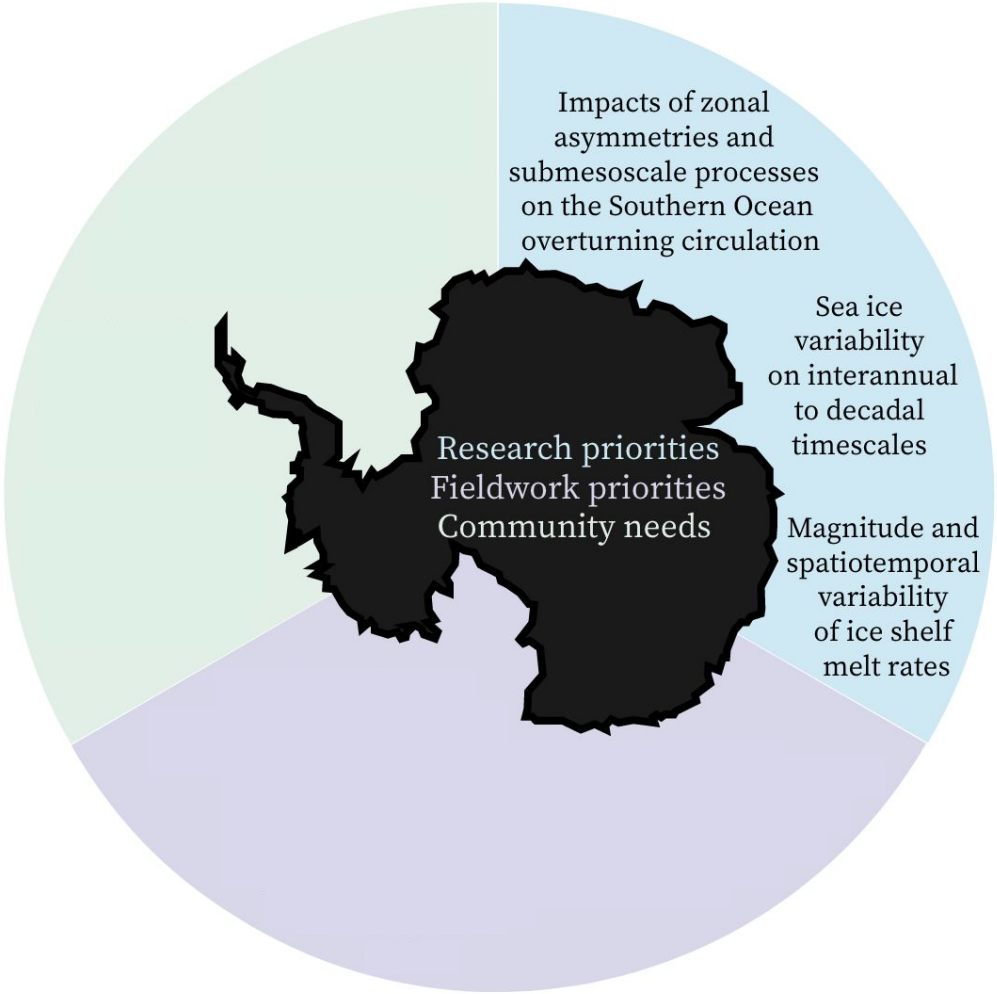
Research priorities

Places to build:

- Observations of the dynamics resulting in ice variability on **interannual to decadal timescales**
- Quantification of the magnitude and spatiotemporal variability of **ice shelf melt rates**
- Clarification of how zonal asymmetries and multi-scale processes impact the **overturning circulation**



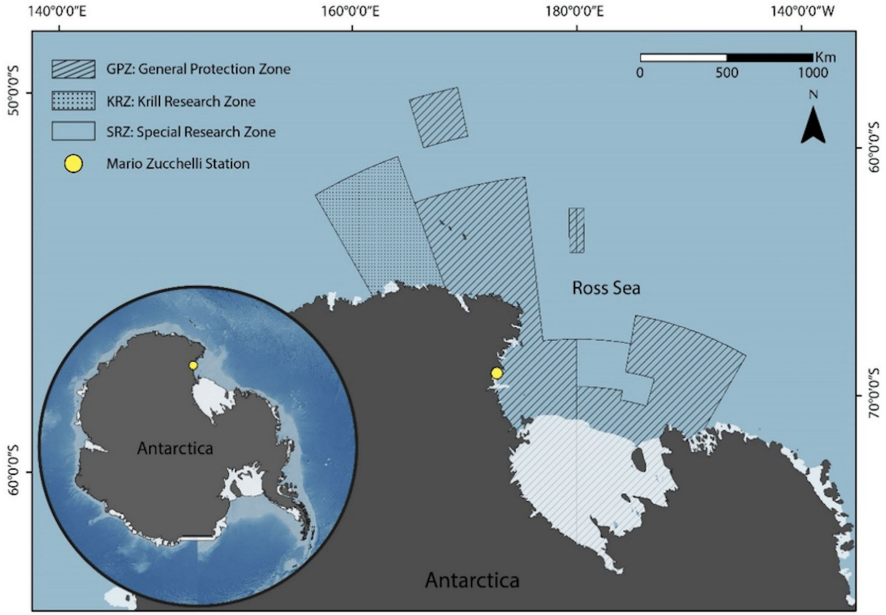
Adusumilli et al., 2020


Impacts of zonal asymmetries and submesoscale processes on the Southern Ocean overturning circulation
Sea ice variability on interannual to decadal timescales
Magnitude and spatiotemporal variability of ice shelf melt rates
Research priorities
Fieldwork priorities
Community needs

Observing priorities

Recent successes:

- Growth of **OneArgo**: includes core (T/S), biogeochemical, and deep Argo floats
- International investment in the **Ross Sea Marine Protected Area**
- Observations at the **submesoscale** in both the open Southern Ocean and the seasonal ice zone

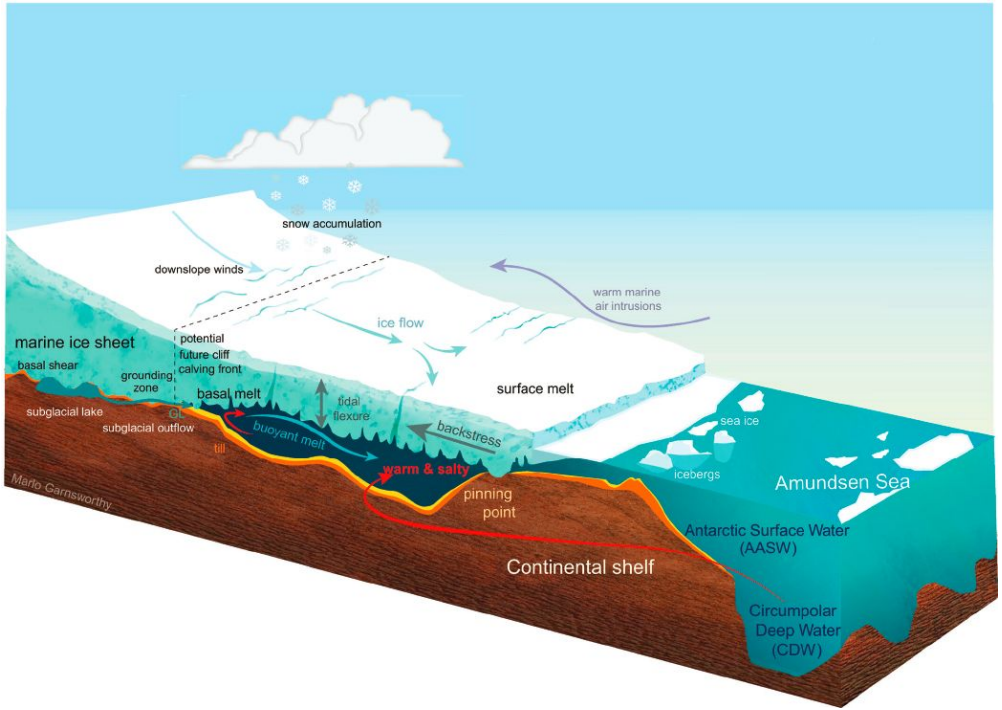


Castellan et al. (2021)

Observing priorities

Current gaps:

- **Under-ice measurements** in ice shelf cavities and in the sea ice zone
- **Bathymetric data** on the Antarctic shelf
- Mechanistic understanding of small-scale processes (*e.g.* storms, wave-ice interactions) on large-scale sea ice and oceanic properties

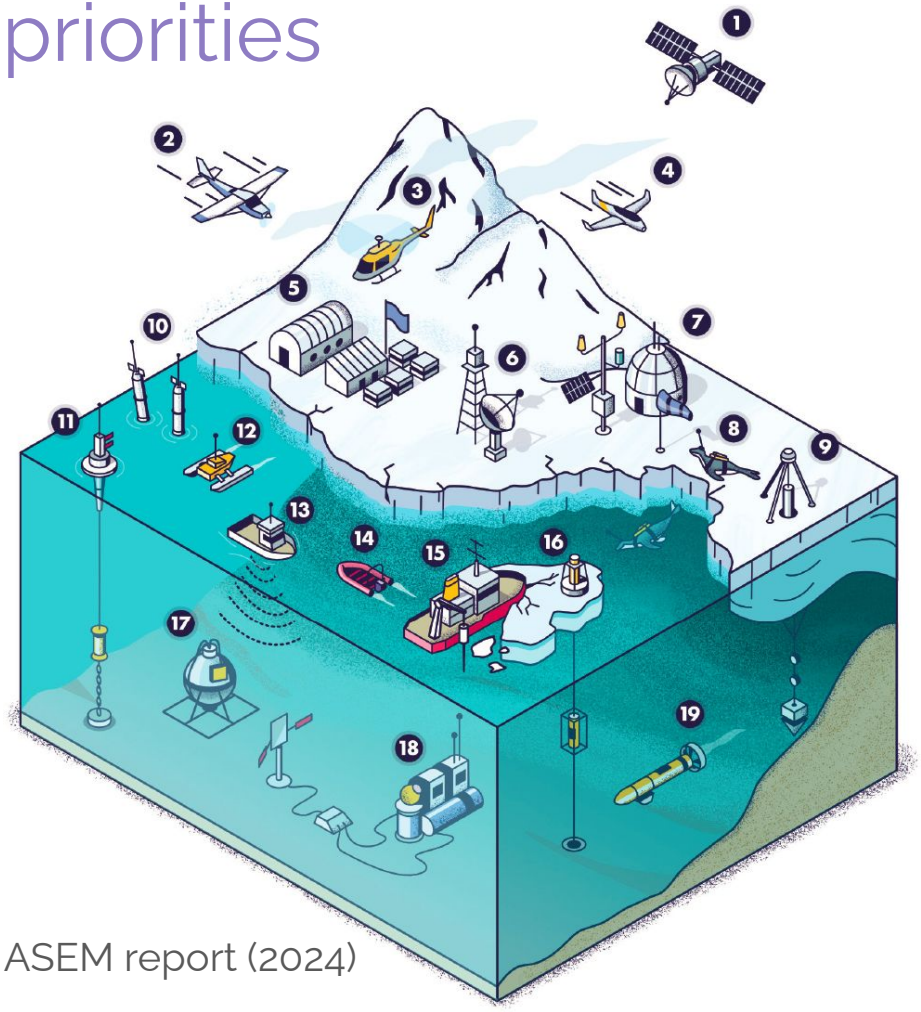


Larter et al. 2022

Observing priorities

Places to build:

- Large-scale deployment of profiling floats along the **Antarctic continental shelf**
- NASA/NSF **joint projects** combining *in situ* observations with remote sensing
- **Multi-year process studies** to connect atmospheric conditions to upper ocean turbulence and the overturning circulation

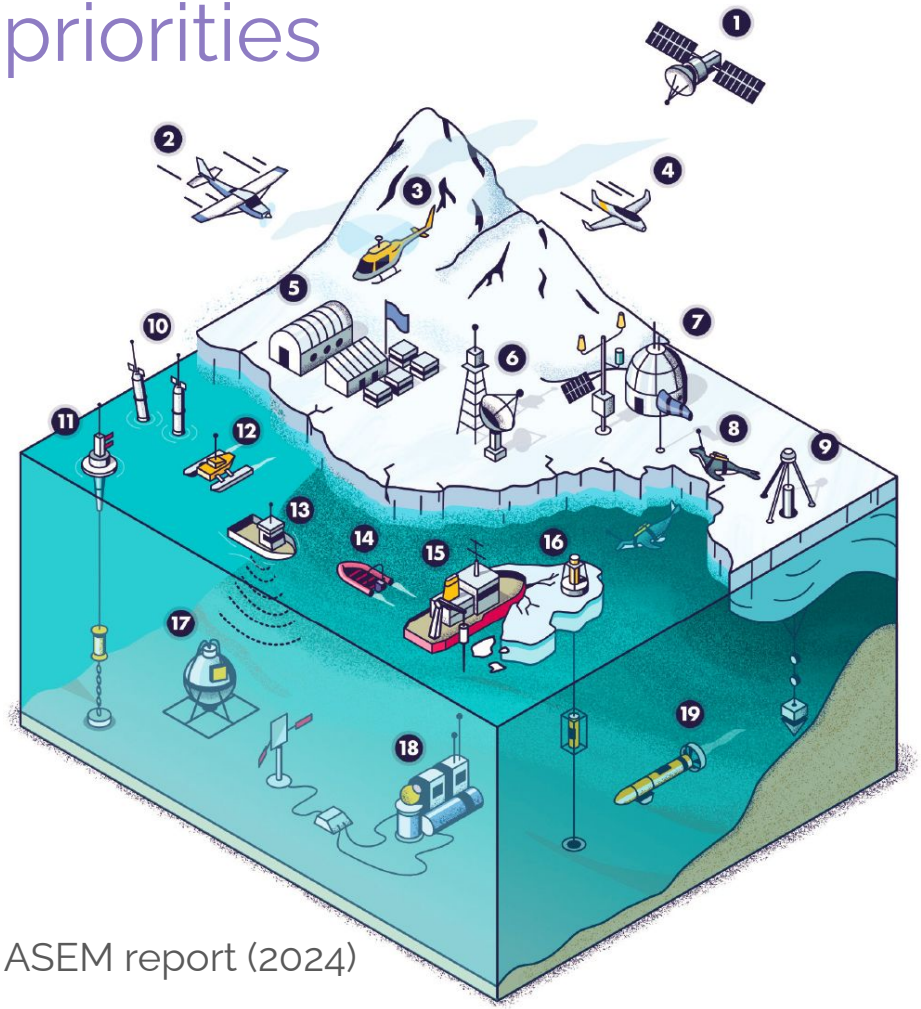


NASEM report (2024)

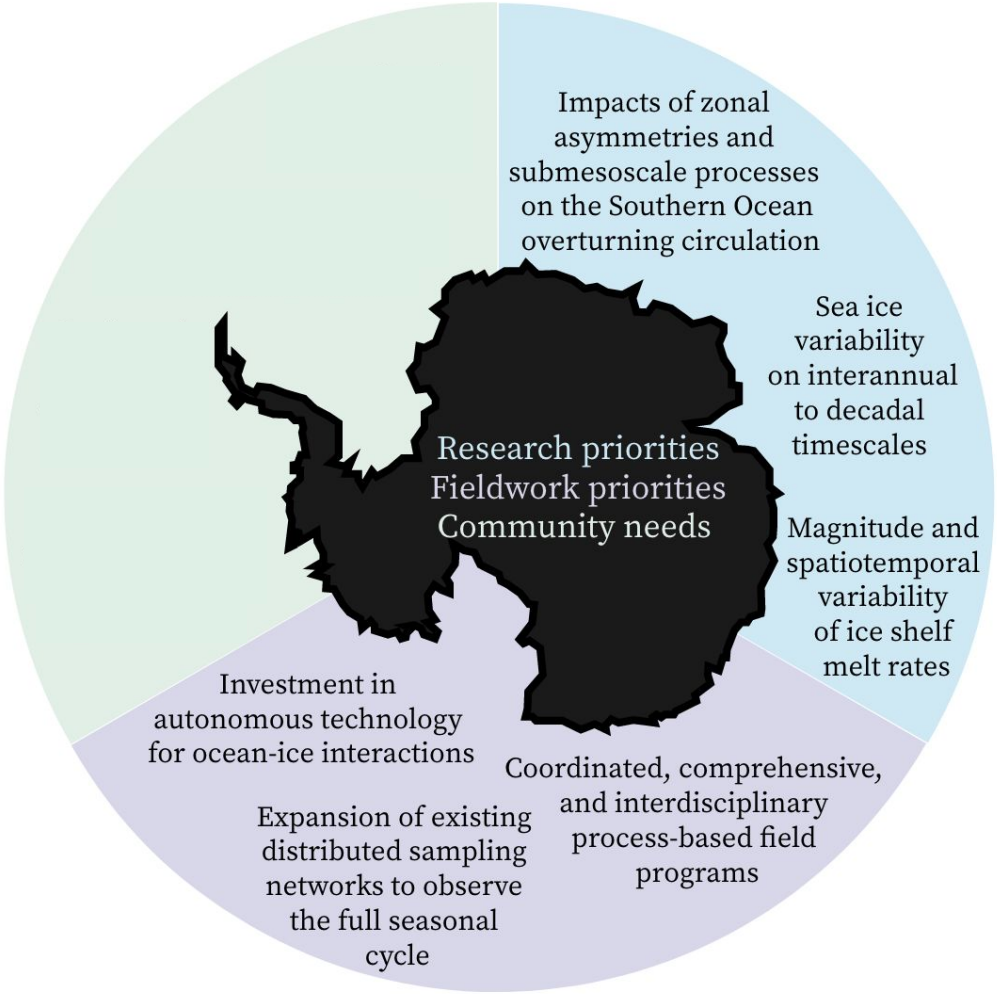
Observing priorities

Infrastructure to maintain:

- OneArgo: continuing to grow biogeochemical, deep, and core measurements
- Decadal hydrographic transects
- Long-term surveys of key locations for physical and biological interactions (*e.g.* Palmer LTER)
- Access to U.S. vessels in the Southern Ocean/Antarctic marginal seas



NASEM report (2024)


Impacts of zonal asymmetries and submesoscale processes on the Southern Ocean overturning circulation
Sea ice variability on interannual to decadal timescales
Magnitude and spatiotemporal variability of ice shelf melt rates
Coordinated, comprehensive, and interdisciplinary process-based field programs
Expansion of existing distributed sampling networks to observe the full seasonal cycle
Investment in autonomous technology for ocean-ice interactions
Research priorities
Fieldwork priorities
Community needs

Community needs

Recent advances:

- Increased influence of the Polar Science Early Career Community Office (PSECCO) and **grassroots community groups**
- Recognition of the importance and potential opportunities for **data reuse**
- Increased interest in **international collaborations** for research around the Antarctic continent

PSECCO
Polar Science Early Career Community Office

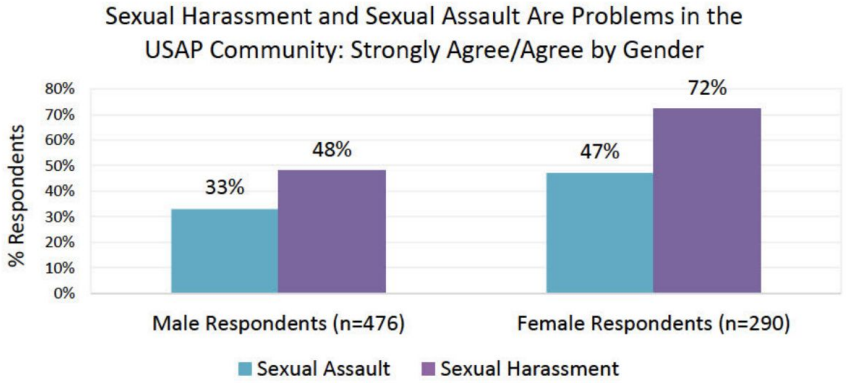
USAPECS
Association of Polar Early Career Scientists

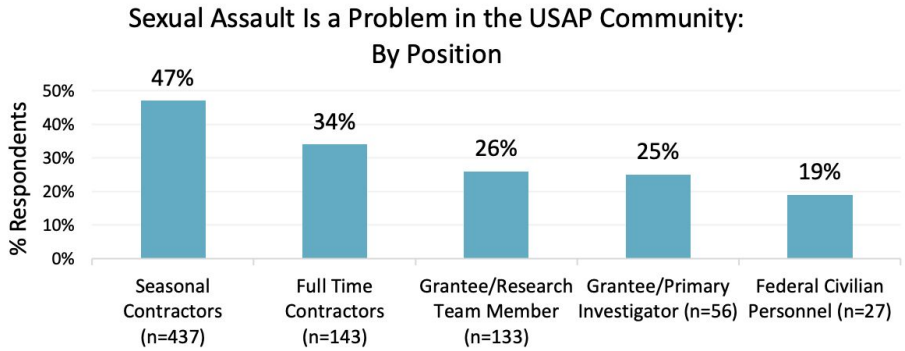
POLAR IMPACT
FOUNDED 2019

Community needs

Current gaps:

- Potential **exclusion of participants** in fieldwork due to a non-transparent Physical Qualification process
- **Barriers to participation** for early career researchers (*e.g.* extensive gear needs, harassment)
- Lack of maintained, searchable, and interoperable **repositories for data**



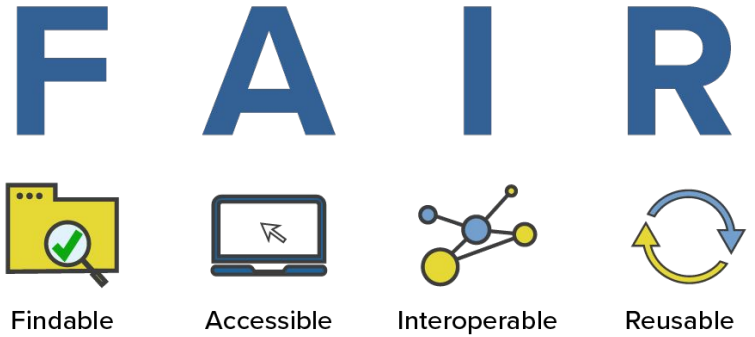


NSF/OPP Sexual Assault/Harassment Prevention and Response Final Report (2022)

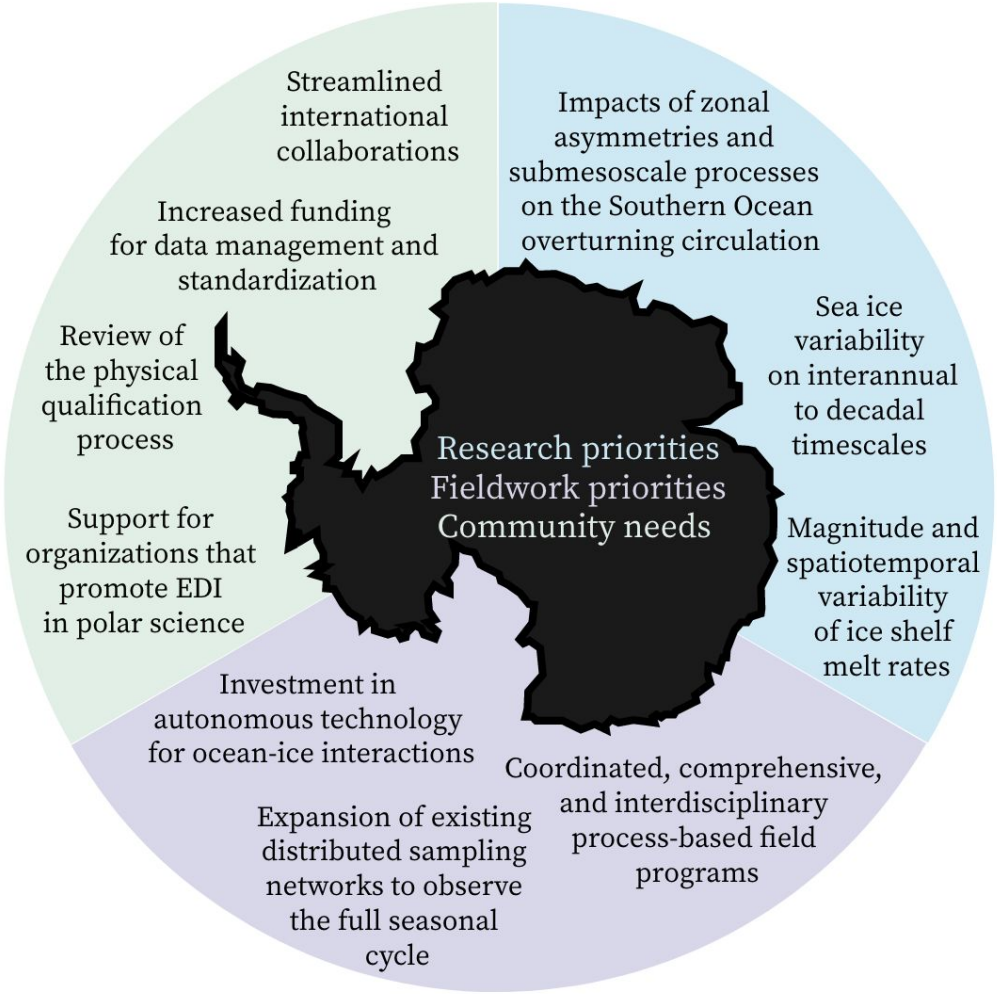
Community needs

Places to build:

- **Increased transparency** on factors that lead to medical exclusions through the Physical Qualification process
- Funding for FAIR **data management personnel and infrastructure** to enable data reuse
- **Streamlined international collaboration** through expansion of NSF's Lead Agency Opportunity program



National Library of Medicine


Streamlined international collaborations
Increased funding for data management and standardization
Review of the physical qualification process
Support for organizations that promote EDI in polar science
Investment in autonomous technology for ocean-ice interactions
Expansion of existing distributed sampling networks to observe the full seasonal cycle
Coordinated, comprehensive, and interdisciplinary process-based field programs
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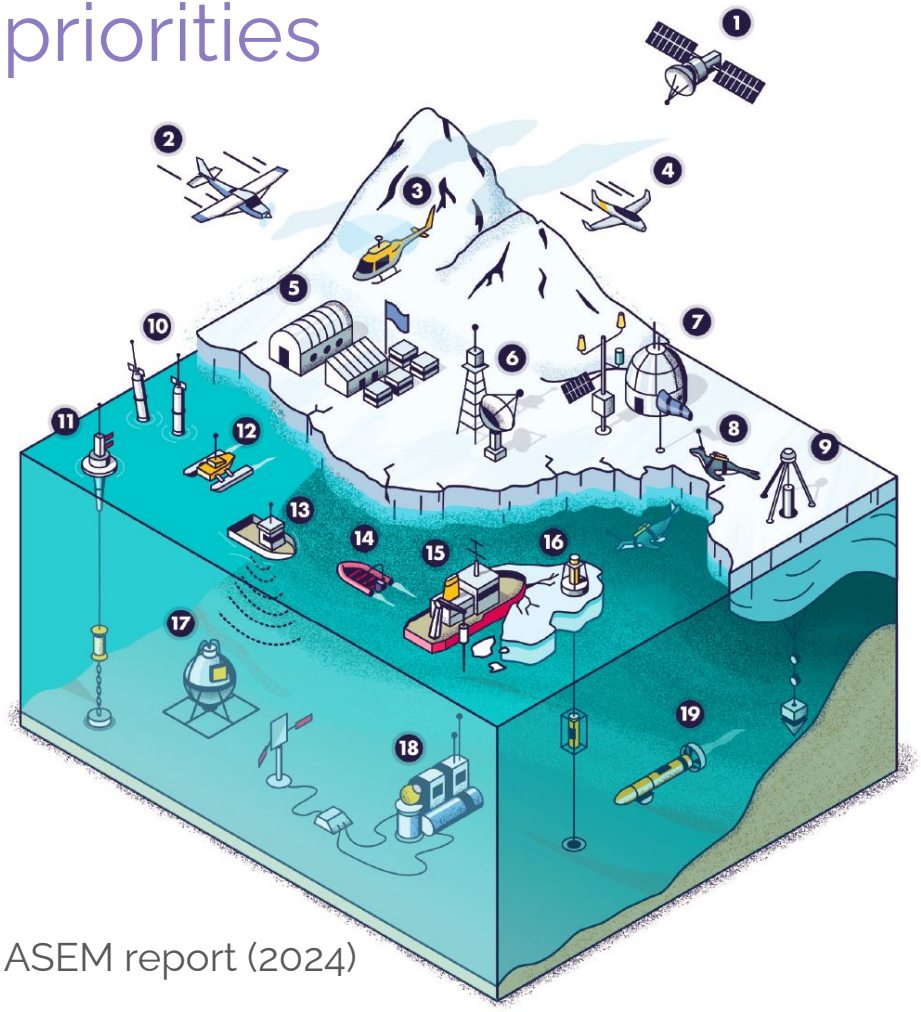
Community needs

Extra slides

Observing priorities

(1) satellite
(2) fixed-wing aircraft
(3) helicopters
(4) uncrewed aerial systems
(5) research station
(6–7) autonomous land-based stations
(8) instrumented animals
(9) drilling and coring
(10) buoys
(11) ocean moorings
(12) autonomous surface vehicle
13) small coastal vessel (with hull-mounted sensors)
(14) rigid inflatable boat
(15) icebreaker (with seafloor sampler)
(16) sea ice–tethered mooring and profiler
(17) autonomous ocean-based stations
(18) cabled observations
(19) autonomous underwater vehicle.



NASEM report (2024)

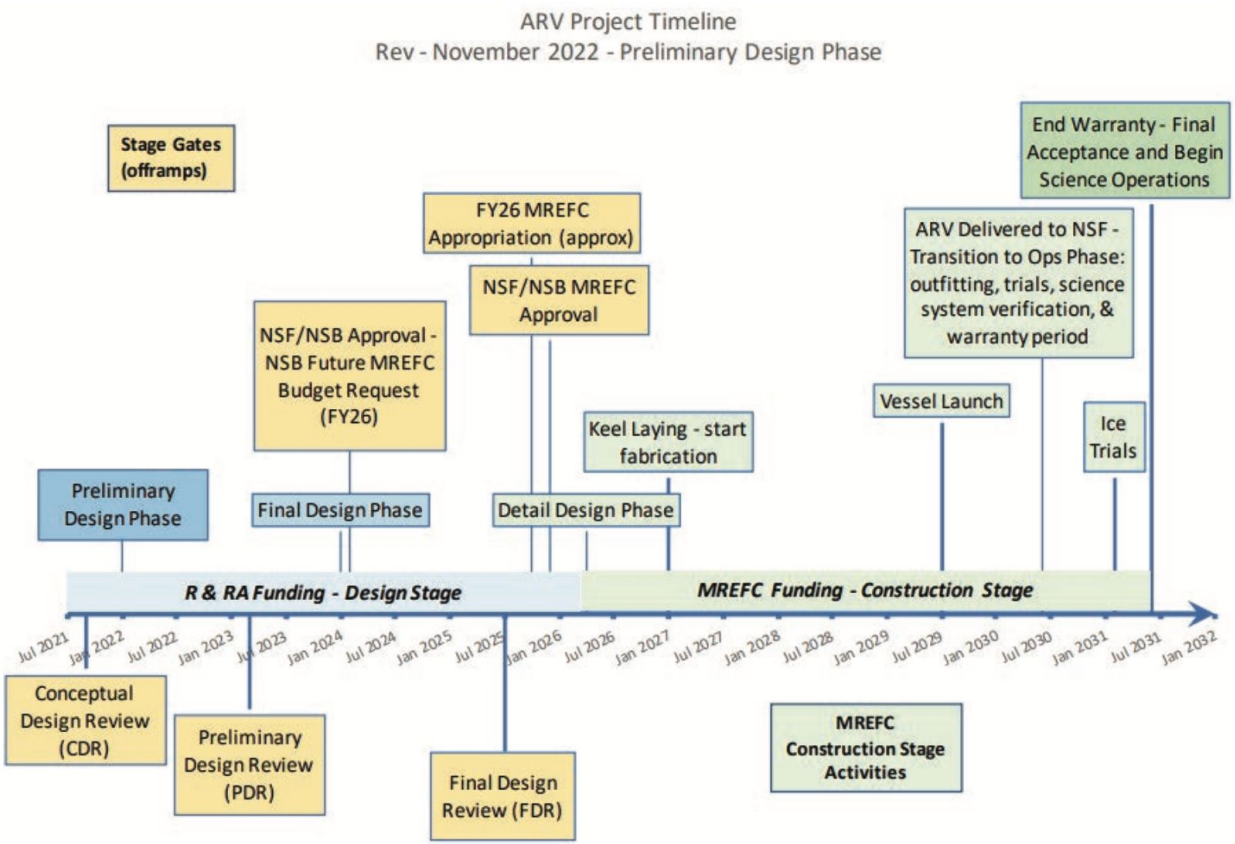
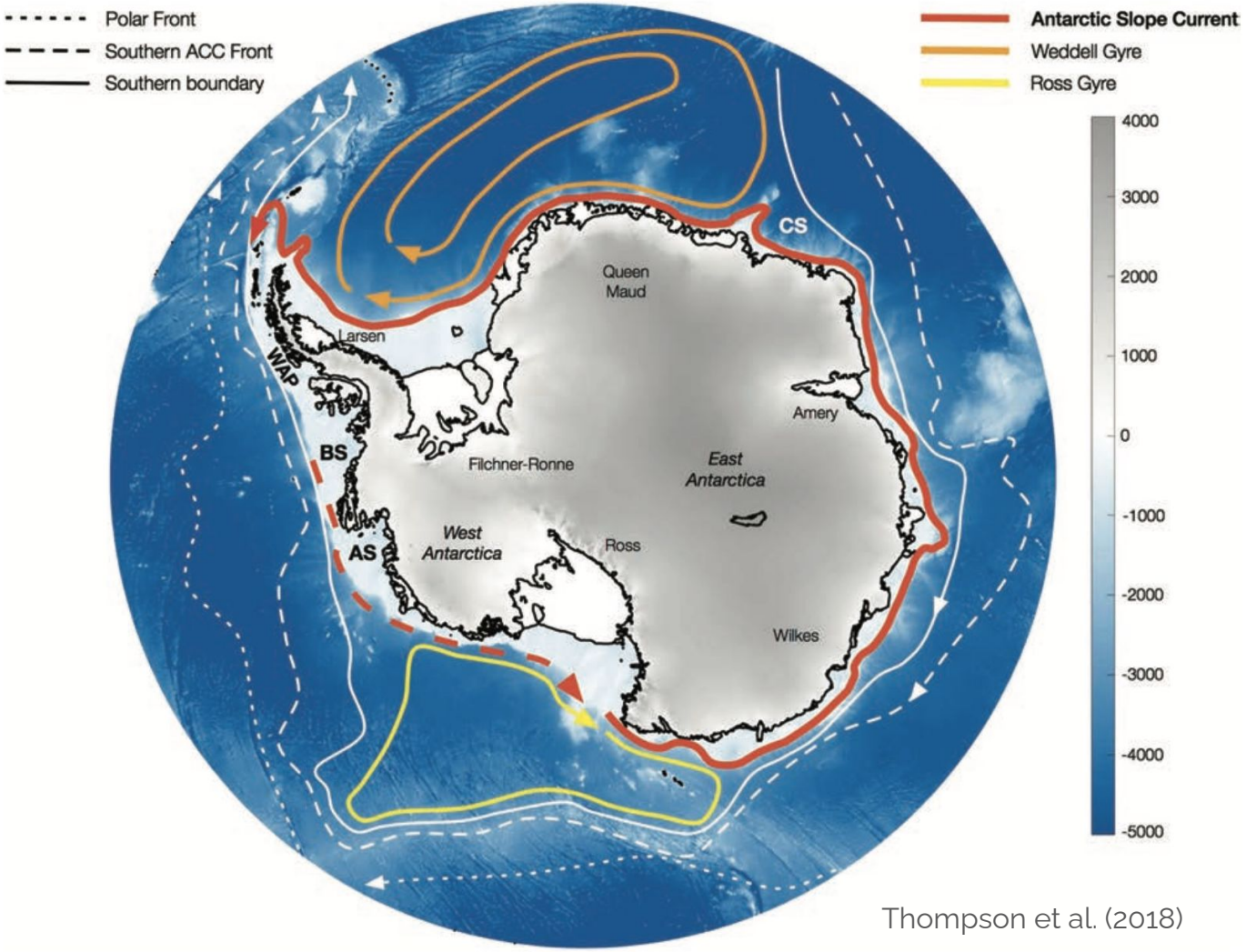


FIGURE 2-5 Timeline of the ARV and the MREFC process.
NOTES: ARV = Antarctic Research Vessel; MREFC = Major Research Equipment and Facilities Construction; NSB = National Science Board; NSF = National Science Foundation; R&RA = Research and Related Activities.
SOURCE: Future USAP (2023c).



Thompson et al. (2018)