The National Academies of
SCIENCES · ENGINEERING · MEDICINE


# A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research

# The Committee's Task

*[short version: the core elements that we emphasized in our work]*

Drawing upon widespread community engagement, develop a strategic vision for NSF's investments in Antarctic and Southern Ocean research for the coming decade.

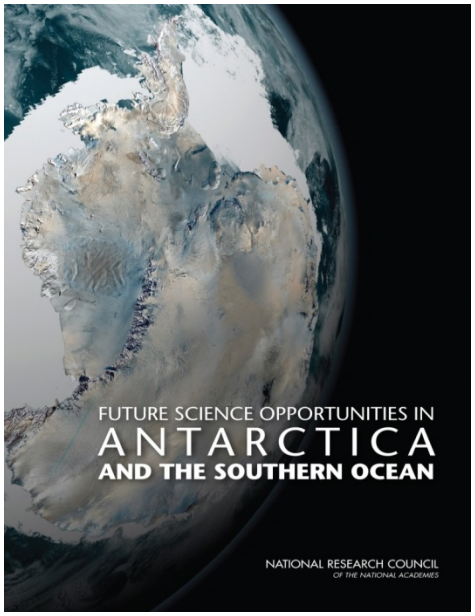
- Recommend **priorities** for investments in compelling research that may yield the highest potential scientific payoff.
- Identify key infrastructure needed to address these priority research topics.

# Committee Members

- **Robin Bell (Co-Chair)**, Lamont Doherty Earth Observatory, Columbia University
- **Robert Weller (Co-Chair),** Woods Hole Oceanographic Institution
- **David Bromwich,** The Ohio State University**,** Byrd Polar & Climate Research Center
- **John Carlstrom,** The University of Chicago
- **Chi-Hing Christina Cheng,** University of Illinois at Urbana-Champaign
- **Calvin Robert Clauer,** Virginia Polytechnic Institute and State University
- **Craig Dorman,** University of Alaska (ret.)
- **Robert Dunbar,** Stanford University
- **David Marchant,** Boston University
- **Mark Parsons,** Research Data Alliance; Rensselaer Center for the Digital Society
- **Jean Pennycook,** Penguin Science
- **A.R. Ravishankara,** Colorado State University
- **Ted Scambos,** National Snow and Ice Data Center**,** Univ. of Colorado
- **William Schlesinger,** Cary Institute of Ecosystem Studies
- **Oscar M.E. Schofield,** Rutgers University
- **Jeffrey Severinghaus,** Scripps Institution of Oceanography,
- **Cristina Takacs-Vesbach,** The University of New Mexico

# Framework for our work

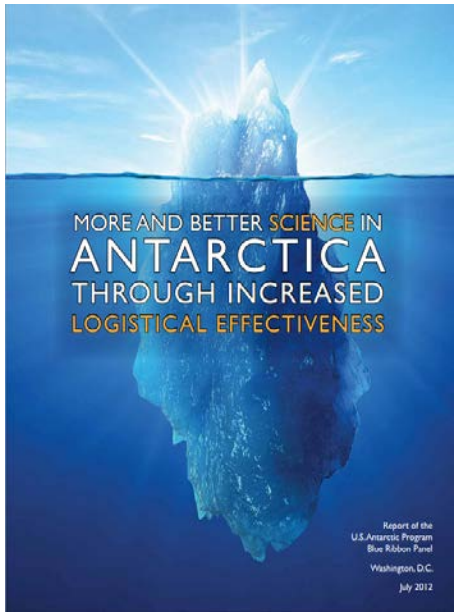
NRC, 2011:
*Future Science Opportunities in Antarctica and the Southern Ocean*
**BLUE SKY**




NSF, 2012. More and Better Science in Antarctica

Through Increased Logistical Effectiveness.

**BLUE RIBBON**




**This REPORT**

**A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research**

**PRIORITIZE**

# The 'Big 8' Science Questions from NRC (2011)

*Global Change*

***1] How will Antarctica contribute to changes in global sea level?***

***2] What is the role of Antarctica and the Southern Ocean in the global climate system?***

***3] What is the response of Antarctic biota and ecosystems to change?***

***4] What role has Antarctica played in changing the planet in the past?***

*Discovery*

***5] What can records preserved in Antarctica and the Southern Ocean reveal about past and future climates?***

***6] How has life adapted to the Antarctic and Southern Ocean environments?***

***7] What can the Antarctic platform reveal about the interactions between the Earth and the space environment?***

***8] How did the Universe begin, what is it made of, and what determines its evolution?***

# Significant Community Engagement in the Report – online & In Person

| | |
|---|---|
| **May 7** | Columbus OH |
| **May 22** | Washington DC (for DC, MD, VA, DE area) |
| **June 9** | Antarctic Meteorology conference [Charleston] |
| **June 16** | Geospace Environment Modeling workshop [VA] |
| **July 30** | Woods Hole MA (for Boston area) |
| **Aug 25** | SCAR Open Science Conference [Auckland] |
| **Sept 18** | POLENET workshop [DC] |
| **Sept 25, 26** | WAIS ice core workshop [LaJolla CA]<br>WAIS ice sheet meeting [Camp Julien CA] |
| **Sept 25** | Southern Ocean Carbon Cycle workshop [LaJolla] |
| **Oct 8** | Boulder CO (for Colorado area, TX reps. invited) |
| **Oct 15** | Palisades NY (for NY/NJ area) |
| **Oct 21** | Madison WI (for upper Midwest area) |
| **Nov 12** | Stanford CA (for middle CA) |
| **Nov 13** | virtual (webex) session |
| **Nov 14** | Seattle WA (for Pacific NW area) |
| **Dec 15** | AGU: informal outreach to individuals |

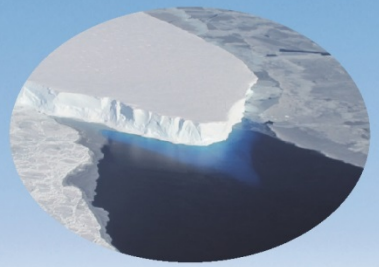
# The Committee's proposed "Strategic Framework"

*How fast and by how much will sea level rise?*

**The Changing Ice Initiative**

A multidisciplinary initiative to study the changing Antarctic ice sheets and key sections of the ocean

Using the past as a guide to our common future



*How do Antarctic biota evolve and adapt to the changing environment?*

Decoding the genomic and transcriptomic bases of biological adaptation across Antarctic organisms and ecosystems

*How did our universe begin and what are the underlying physical laws that govern its evolution and ultimate fate?*

A next generation of Cosmic Microwave Background studies

**LARGE-SCALE STRATEGIC INITIATIVES**

Opportunities for basic research across all the core programs

**INVESTIGATOR-DRIVEN RESEARCH**

| Logistical support | Critical observing systems | Data management | Public engagement, education, training | Partnerships—intra-agency, inter-agency, international |
|---|---|---|---|---|

**FOUNDATIONAL ELEMENTS**

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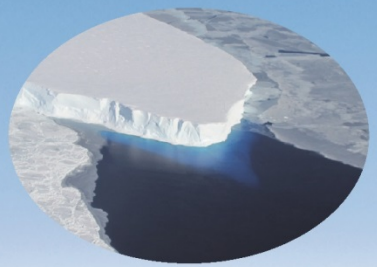

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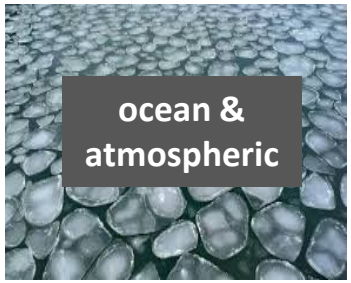
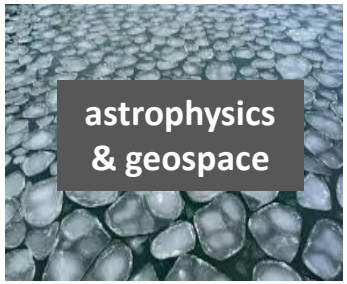
## *Recommendation:*

**Continue to support a diverse array of PI-driven research across the existing core programs.**








**Actively look for opportunities to gain efficiencies and improve coordination and data sharing among independent studies -- for instance, with a Ross Sea 'Research Coordination Network'.**

# evaluation criteria for identifying priorities for the large-scale strategic initiatives

Primary filter

- **Compelling science**

Secondary filters:

- **Time-sensitive in nature**
- **Potential for societal impact**
- **Readiness, feasibility**
- **Key area for U.S. and NSF/PLR leadership**

Tertiary filters:

- **Partnership potential**
- **Impacts on program balance**
- **Potential to help bridge disciplinary divides**

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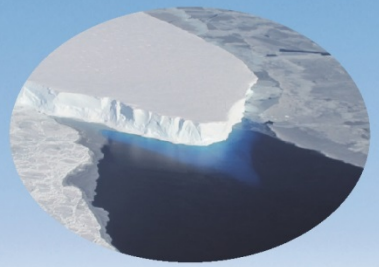

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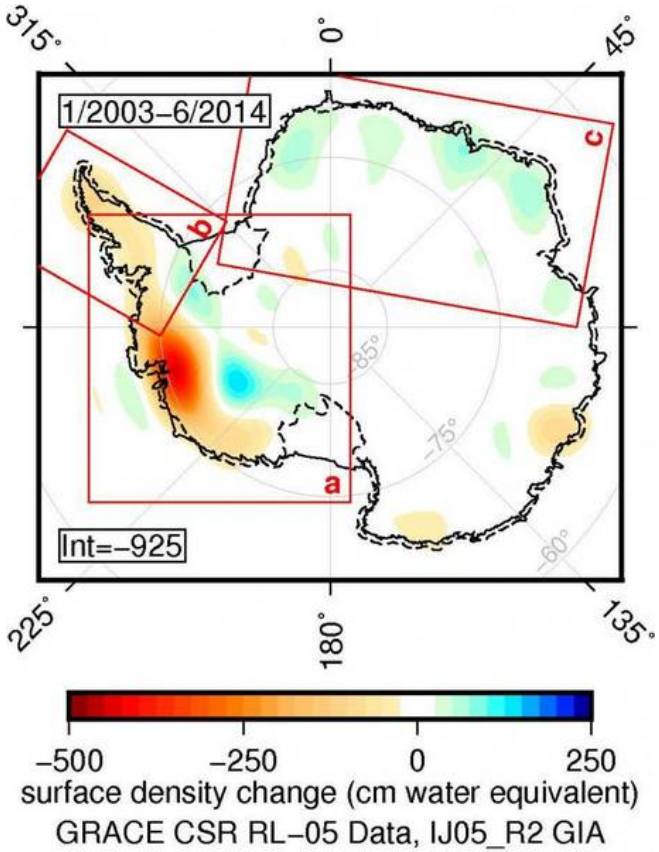
**FOUNDATIONAL ELEMENTS**

## ***Strategic Priority I.*** How fast and by how much will sea level rise? The Changing Antarctic Ice Sheets Initiative

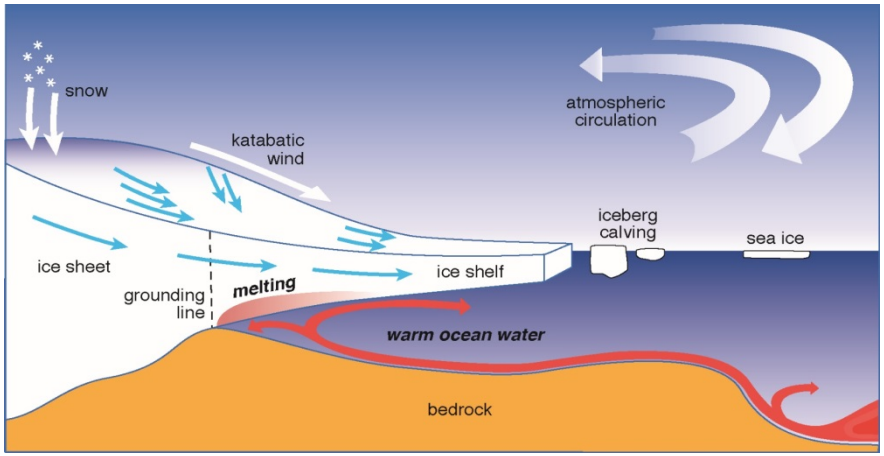
- Growing concerns about Marine Ice Sheet Instability leading to rapid, large changes.
- Potentially vulnerable areas exist around the continent, but greatest concern centers on key areas of the West Antarctic Ice Sheet.
- Better understanding the detailed dynamics of past and current changes is critical for improving projections of future sea level rise.
- NSF/PLR's successful history of WAIS research provides a strong foundation for a next-generation initiative.



# ***Strategic Priority I.*** The Changing Antarctic Ice Sheets Initiative

## *Component i. Studies to understand why the Antarctic ice sheets are changing now and how they will change in the future.*

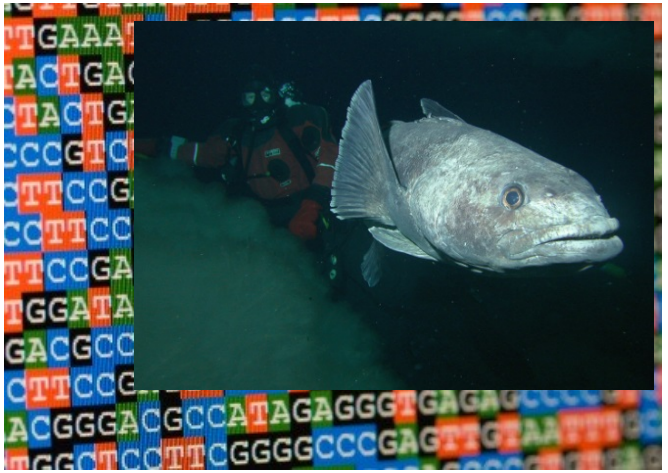
In situ observations of atmospheric and oceanic circulation, ice sheet flow, sub-ice shelf and grounding line environment; mapping unknown terrains beneath ice shelves and ice sheet; developing coupled atmosphere/ocean/ice models.
Focus on Thwaites Glacier, Pine Island.




## *Component ii: Using multiple records of past ice sheet change to understand the speed and extent of past WAIS collapse*

- Ice core studies targeting the last interglacial that can provide annually-resolved layers
- marine sediment cores that can yield high-resolution records
- Mapping the areal extent of past ice sheet collapse using cosmogenic isotope exposure dating of bedrock cores and glacial deposits, geological studies that document changes in ice thickness relative to grounding line retreat

***Strategic Priority II.*** How do Antarctic biota evolve and adapt to the changing environment? *Decoding the genomic and transcriptomic bases of biological adaptation and response across Antarctic organisms and ecosystems.*



A unique natural laboratory to study evolution and functional specializations driven by the extreme environment.

Rapidly advancing capacity to decode genomes and transcriptomes of key species– and meta-genomes and meta-transcriptomes of species assemblages.
New opportunities to advance understanding of Antarctica's biodiversity, and potential for species to adapt to new environmental challenges.

Coordinated efforts among:

- lab-based genomic analyses (based in part on existing biological samples)
- collection of targeted new biological samples
- field-based investigations to study hypothesis developed through lab studies

Potential for new collaborations across universities, research institutes, and federal agencies (e.g. , with DOE, NIH).

***Strategic Priority III.*** How did our universe begin and what are the underlying physical laws that govern its evolution and ultimate fate? A *next-generation Cosmic Microwave Background program*

The CMB is light from the early universe of nearly 14 billion years ago– carries unique information on the origin and evolution of the universe.

A next generation CMB experimental program could provide definitive measurements of the early universe and its evolution. Could also elucidate the quantum nature of gravity, the properties of "dark energy", the number and type of neutrino species.

Project involves a global-scale array of telescopes, located at South Pole, Chile and new Northern Hemisphere site.

- Next step for the CMB observational program; continued return on current investment.
- The U.S. research community is ready to move ahead; the technology exists.
- Recommended by the Particle Physics Project Prioritization Panel (P5).
- Collaborative interest from three NSF divisions (PLR, PHY, AST), the DOE Office of Science, NASA, and possible international partners

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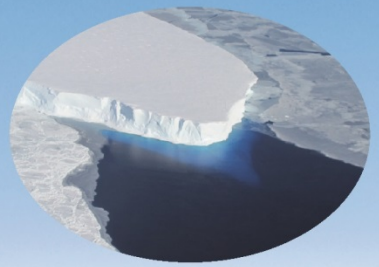

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**FOUNDATIONAL ELEMENTS**

# Foundations: logistical support


**Develop plans to <u>expand deep-field access</u> in key regions in and around the West Antarctic, e.g: deep field camp, over-snow science traverse capabilities, ship support, all-weather aircraft access to McMurdo, improved aircraft access to remote field locations.**

**Support the efforts of the Coast Guard to design and acquire <u>a new polar-class icebreaker</u>. Design and acquire <u>a next-generation polar research vessel.</u>**
**In the near term, work with international partners to provide ocean-based research and sampling opportunities through other countries' research ships.**

# Foundations: critical observing systems

**Actively pursue opportunities to <u>coordinate and strategically augment</u> existing <u>observational networks</u>; better coordinate national vessels to increase sampling of the Southern Ocean.**

## Foundations: data transmission / data management

- Continue advancing efforts to improve USAP communication and data transmission capacity, (including for autonomous underwater instrumentation).
- Identify specific archives to manage and preserve data collected in all the core programs.
- Support all projects to include personnel specifically tasked to address data management needs throughout a project's planning and execution.

## Foundations: public engagement, education, training

- Antarctic science is an under-utilized element in educational curricula. NSF/PLR can help develop more Antarctic-themed educational resources that use real datasets and personal stories from scientists in the field.
- Critical to provide opportunities in teaching and research for graduate students, post-docs, and early-career scholars--with targeted funding opportunities, international collaborations, institutional exchanges.

# Foundations: partnership

***Some examples of collaborative opportunities in the Changing Ice Initiative***

## Interagency

**NASA**

- ice sheet monitoring and mapping efforts

**NOAA**

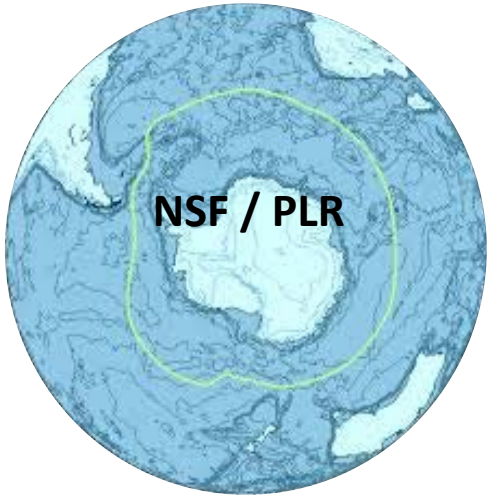
- meteorological and atmospheric observations

**DOE**

- earth system model development (role of polar processes)

## International

Many possibilities. Collaboration with the British Antarctic Survey on WAIS research looks like a particularly good opportunity




## Intra-NSF

**GEO/AGS**

- Earth system and climate model development
- S. Ocean studies of aerosols, clouds & radiative balance
- Roles of Antarctica and S. Ocean in the global climate system

**GEO/EAR**

- Mapping/dating of far-field sea level rise indicators
- Developing new geo-chronological tools for dating glacial landforms

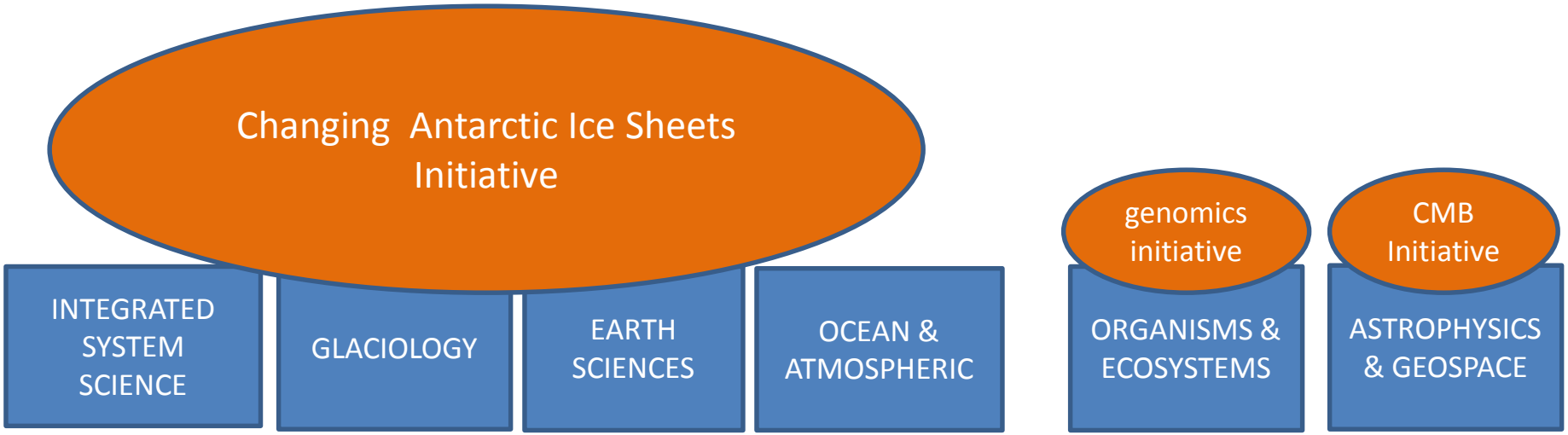
**GEO/OCE**

- integrated planning for use of research ships

# Supporting the Priority Initiatives

The Committee did not estimate specific costs for the three recommended initiatives, but they did suggest that the *Changing Ice Initiative* may require resources (sustained over several years) equivalent to much of the total ANT research budget.

**Because of the urgency and magnitude of the threats that sea level rise poses for human society, there is strong rationale for NSF to seek to significantly augment the funding available to support this research.**




# Discussion

# Community Engagement Efforts

small regional gatherings

sessions at community-wide conferences

outreach to early-career scientists

"virtual townhall" website

Overall, received input from ~ 450 people.