1st SCAR
Antarctic and Southern Ocean Science

Word Cloud

"A roadmap for Antarctic and Southern Ocean Science for the next two decades and beyond"

Horizon Scan Supporters

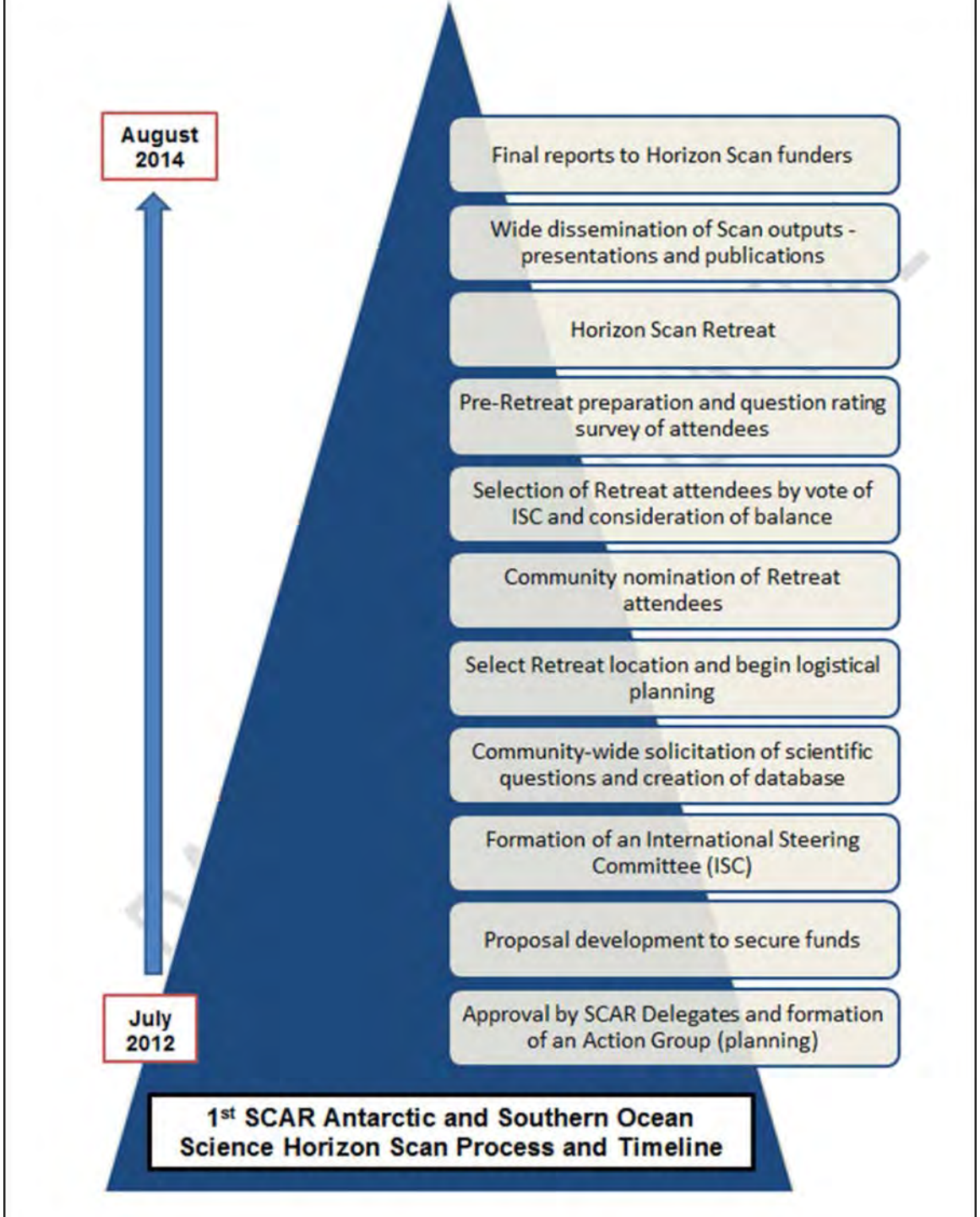
What is a Horizon Scan?

A Horizon Scan is the systematic search for opportunities, which are then articulated as a vision for future directions.

The 1st SCAR Antarctic and Southern Ocean Science Horizon Scan

The international Antarctic community came together to "scan the horizon" to identify the highest priority scientific questions that researchers should aspire to answer **in the next two decades and beyond**.

Intensive planning over a two-year period



An inclusive process

- Community-wide question solicitations
  - Round 1 – 751 questions
  - Round 2 – 115 questions
- Retreat invitation nominations
  - 789 nominations of 510 individuals
- Scientists, Program Directors/Managers, policy makers, decision makers and early career scientists.

- 75 Retreat attendees from 22 countries
- 6-8 Observers (Nature, MFAT, Tinker Foundation, Media)

Question criteria

- Answerable by an achievable research design.
- Have a factual answer independent of value judgments.
- Address important gaps in knowledge.
- Of a spatial and temporal scale that could be addressed by a research team.
- Specifically formulated - not a general topical area.
- If related to impact and interventions, contain a subject, an intervention and a measurable outcome.
- Clearly-worded, simple and concise.
- **Addressable in the next two decades and beyond.**

Questions best addressed by research in the southern polar regions or where studies in the Antarctic provide insights unobtainable elsewhere.

The Horizon Scan Retreat

Millbrook Resort, Queenstown, NZ
April 20-23, 2014

The Horizon Scan Retreat

Lots of thinking!

The Horizon Scan Retreat

Lots of discussion and debate!







The Horizon Scan Retreat

Coming to collective agreement on the top questions

Horizon Scan Outcomes

From nearly 1000 ideas, the 80 most important scientific questions were identified through structured debate, discussion, revision and voting.

Word Cloud
of all 80 Question

DAY 1

1- Southern Ocean Physics, Geology, and Chemistry

2- Southern Ocean Life and Ecology

3- The Solid Earth

4 -The Atmosphere, Near Earth Space and Beyond

5- Land Ice

6 - Biotic Responses to Change

7 -The Marine Biosphere and the Physical Environment

8 - Humankind in Antarctica

9 -The Past - A Window on the Future

10 - Terrestrial Life and Ecology

DAY 2

The Southern Ocean (1,2,7)

Land Ice and Terrestrial Life (5,10)

Earth, Atmosphere and Space (3,4)

Predicting Future Change (6,8,9)

DAY 3

Antarctic Atmosphere and Global Connections

Southern Ocean and Sea Ice in a Warming World

Antarctic Ice Sheet and Sea Level

The Dynamic Earth Beneath the Antarctic Ice

Antarctic Life on the Precipice

Human Presence in Antarctica

Near Earth Space and Beyond - Eyes on the Sky

Question Clusters

The 1st SCAR Antarctic and Southern Ocean Science Horizon Scan

Antarctic Atmosphere and Global Connections

1. How is climatic change and variability in the high southern latitudes connected to lower latitudes including the Tropical Ocean and monsoon systems?
2. How do Antarctic processes affect mid-latitude weather and extreme events?
3. How have teleconnections, feedbacks, and thresholds in decadal and longer term climatic variability affected ice sheet response since the Last Glacial Maximum, and how can this inform future climate projections?
4. What drives change in the strength and position of Westerly winds, and what are their effects on ocean circulation, carbon uptake and global teleconnections?
5. How did the climatic and atmospheric composition vary prior to the oldest ice records?
6. What controls regional patterns of atmospheric and oceanic warming and cooling in the Antarctic and Southern Ocean? *(Cross-cuts "Southern Ocean")*
7. How can coupling and feedbacks between the atmosphere and the surface (land ice, sea ice and ocean) be better represented in weather and climate models? *(Cross-cuts "Southern Ocean" and "Antarctic Ice Sheet")*
8. Does past amplified warming of Antarctica provide insight into the effects of future warming on climate and ice sheets? *(Cross-cuts "Antarctica Ice Sheet")*
9. Are there CO_2 equivalent thresholds that foretell collapse of all or part of the Antarctic Ice Sheet? *(Cross-cuts "Antarctic Ice Sheet")*
10. Will there be release of greenhouse gases stored in Antarctic and Southern Ocean clathrates, sediments, soils, and permafrost as climate changes? *(Cross-cuts "Dynamic Earth")*
11. Is the recovery of the ozone hole proceeding as expected and how will its recovery affect regional and global atmospheric circulation, climate and ecosystems? *(Cross-cuts "Antarctic Life" and*

Southern Ocean and Sea Ice in a Warming World

12. Will changes in the Southern Ocean result in feedbacks that accelerate or slow the pace of climate change?
13. Why are the properties and volume of Antarctic Bottom Water changing, and what are the consequences for global ocean circulation and climate?
14. How does Southern Ocean circulation, including its change with lower latitudes, respond to climate forcing?
15. What processes and feedbacks drive changes in the mass, properties and distribution of Antarctic sea ice?
16. How do changes in iceberg numbers and size distribution affect Antarctica and the Southern Ocean?
17. How has Antarctic sea ice extent and volume varied over decadal to millennial time scales?
18. How will changes in ocean surface waves influence Antarctic sea ice and floating glacial ice?
19. How do changes in sea ice extent, seasonality and properties affect Antarctic atmospheric and oceanic circulation? (Cross-cuts "Antarctic Atmosphere")
20. How do extreme events affect the Antarctic cryosphere and Southern Ocean? *(Cross-cuts "Antarctic Ice Sheet")*
21. How did the Antarctic cryosphere and the Southern Ocean contribute to glacial-interglacial cycles? *(Cross-cuts "Antarctic Ice Sheet")*
22. How will climate change affect the physical and biological uptake of CO_2 by the Southern Ocean? *(Cross-cuts "Antarctic Life")*
23. How will changes in freshwater inputs affect ocean circulation and ecosystem processes? *(Cross-cuts "Antarctic Life")*

Antarctic Ice Sheet and Sea Level

24. How does small-scale morphology in subglacial and continental shelf bathymetry affect Antarctic Ice Sheet response to changing environmental conditions? *(Cross-cuts "Dynamic Earth")*
25. What are the processes and properties that control the form and flow of the Antarctic Ice Sheet?
26. How does subglacial hydrology affect ice sheet dynamics, and how important is it? *(Cross-cuts "Dynamic Earth")*
27. How do the characteristics of the ice sheet bed, such as geothermal heat flux and sediment distribution, affect ice flow and ice sheet stability? *(Cross-cuts Dynamic Earth")*
28. What are the thresholds that lead to irreversible loss of all or part of the Antarctic ice sheet?
29. How will changes in surface melt over the ice shelves and ice sheet evolve, and what will be the impact of these changes?
30. How do oceanic processes beneath ice shelves vary in space and time, how are they modified by sea ice, and do they affect ice loss and ice sheet mass balance? *(Cross-cuts "Southern Ocean")*
31. How will large-scale processes in the Southern Ocean and atmosphere affect the Antarctic Ice Sheet, particularly the rapid disintegration of ice shelves and ice sheet margins? *(Cross-cuts "Antarctic Atmosphere" and "Southern Ocean")*
32. How fast has the Antarctic Ice Sheet changed in the past and what does that tell us about the future?
33. How did marine-based Antarctic ice sheets change during previous interglacial periods?
34. How will the sedimentary record beneath the ice sheet inform our knowledge of the presence or

Dynamic Earth - Probing beneath Antarctic Ice

35. How does the bedrock geology under the Antarctic Ice Sheet inform our understanding of supercontinent assembly and break-up through Earth history?
36. Do variations in geothermal heat flux in Antarctica provide a diagnostic signature of sub-ice geology?
37. What is the crust and mantle structure of Antarctica and the Southern Ocean, and how do they affect surface motions due to glacial isostatic adjustment?
38. How does volcanism affect the evolution of the Antarctic lithosphere, ice sheet dynamics, and global climate? *(Cross-cuts "Antarctic Atmosphere" and "Antarctic Ice Sheet")*
39. What are and have been the rates of geomorphic change in different Antarctic regions, and what are the ages of preserved landscapes?
40. How do tectonics, dynamic topography, ice loading and isostatic adjustment affect the spatial pattern of sea level change on all time scales? *(Cross-cuts "Antarctic Ice Sheet")*
41. Will increased sedimentation and volcanism characterize Antarctica when ice mass is reduced in a warmer world, and if so, how will glacial- and ecosystems be affected? *(Cross-cuts "Antarctic Life")*
42. How will permafrost, the active layer and water availability in Antarctic soils and marine sediments change in a warming climate, and what are the effects on ecosystems and biogeochemical cycles? *(Cross-cuts "Antarctic Life")*

Antarctic Life on the Precipice

43. What is the genomic basis of adaptation in Antarctic and Southern Ocean organisms and communities?
44. How fast are mutation rates and how extensive is gene flow in the Antarctic and the Southern Ocean?
45. How have ecosystems in the Antarctic and the Southern Ocean responded to warmer climate conditions in the past? *(Cross-cuts "Antarctic Atmosphere" and "Oceans")*
46. How has life evolved in the Antarctic in response to dramatic events in the Earth's history? *(Cross-cuts "Dynamic Earth")*
47. How do subglacial systems inform models for the development of life on Earth and elsewhere? *(Cross-cuts "Eyes on the Sky")*
48. Which ecosystems and food webs are most vulnerable in the Antarctic and Southern Ocean, and which organisms are most likely to go extinct?
49. How will threshold transitions vary over different spatial and temporal scales, and how will they impact ecosystem functioning under future environmental conditions?
50. What are the synergistic effects of multiple stressors and environmental change drivers on Antarctic and Southern Ocean biota?
51. How will organisms and ecosystems respond to a changing soundscape in the Southern Ocean?" *(Cross-cuts "Human")*
52. How will non-indigenous contaminants affect Antarctic and Southern Ocean biota and ecosystems?
53. What is the exposure and response of Antarctic organisms and ecosystems to atmospheric contaminants (e.g. black carbon, mercury, sulphur, etc.), and are the sources and distributions of these contaminants changing? *(Cross-cuts "Antarctic Atmosphere" and "Human")*
54. How will the sources and mechanisms of dispersal of propagules into and around the Antarctic and Southern Ocean change in the future?
55. How will invasive species and range shifts of indigenous species change Antarctic and Southern Ocean ecosystems? *(Cross-cuts "Human")*
56. How will climate change affect the risk of spreading emerging infectious diseases in Antarctica? *(Cross-cuts "Human")*
57. How will increases in the ice-free Antarctic interfilial zone impact biodiversity and the likelihood of biological invasions?
58. How will climate change affect existing and future Southern Ocean fisheries, especially krill stocks? *(Cross-cuts "Human")*
59. How will linkages between marine and terrestrial systems change in the future?
60. What are the impacts of changing seasonality and transitional events on Antarctic and Southern Ocean marine ecology, biogeochemistry, and energy flow?
61. How will increased marine resource harvesting impact Southern Ocean biogeochemical cycles? *(Cross-cuts "Human")*
62. How will deep sea ecosystems respond to modifications of deep water formation, and how will deep sea species interact with shallow water ecosystems as the environment changes?
63. How can changes in the form and frequency of extreme events be used to improve biological understanding and forecasting? *(Cross-cuts "Antarctic Atmosphere")*
64. How can temporal and spatial "omic-level" analyses of Antarctic and Southern Ocean biodiversity inform ecological forecasting?
65. What will key marine species tell us about trophic interactions and their oceanographic drivers such as future shifts in frontal dynamics and stratification?
66. How successful will Southern Ocean Marine Protected Areas be in meeting their protection objectives, and how will they affect ecosystem processes and resource extraction? *(Cross-cuts "Human")*
67. What ex situ conservation measures, such as genetic repositories, are required for the Antarctic and Southern Ocean? *(Cross-cuts "Human")*
68. How effective are Antarctic and Southern Ocean conservation measures for preserving evolutionary potential? *(Cross-cuts "Human")*

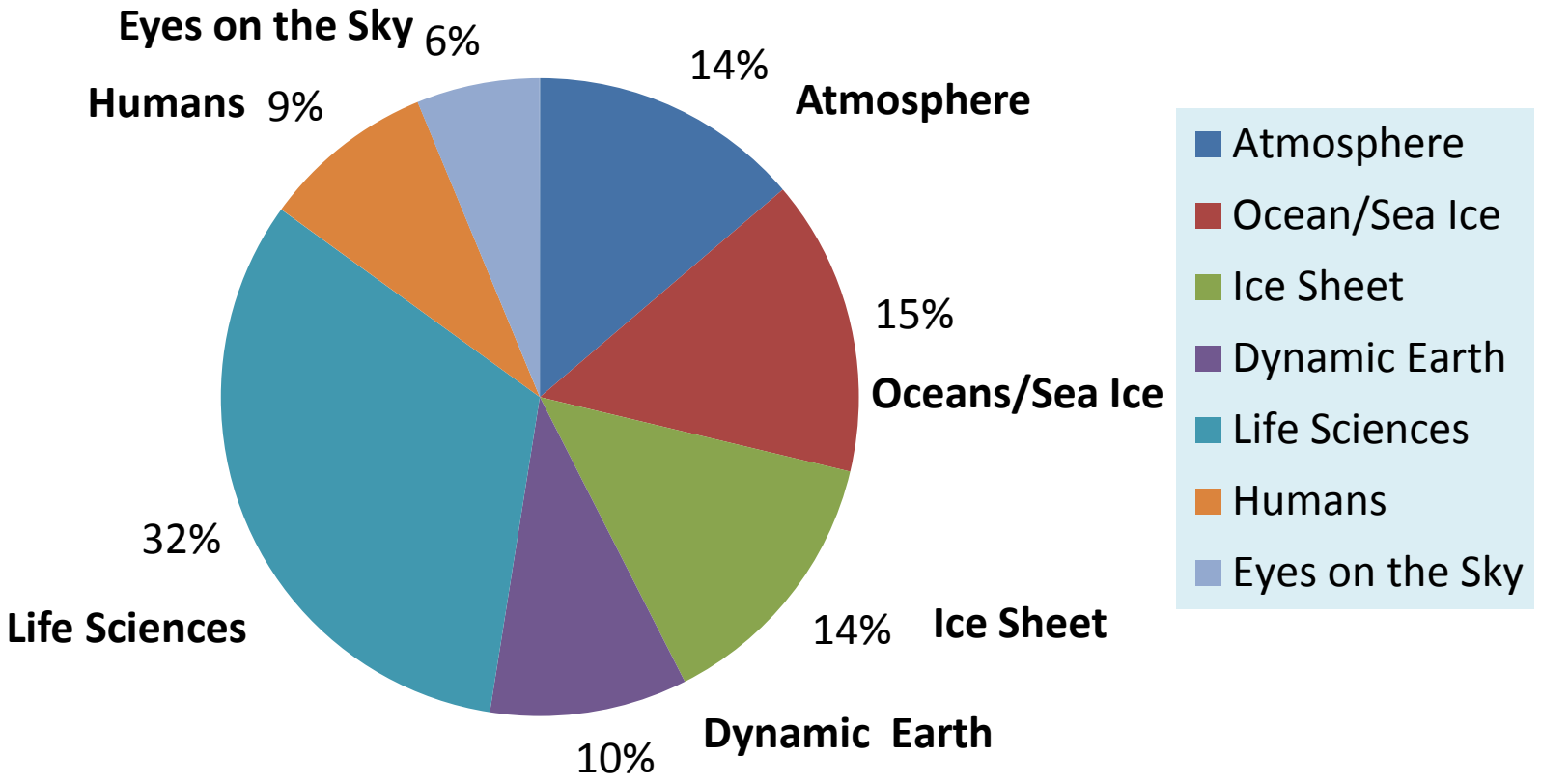
Near-Earth Space and Beyond - Eyes on the Sky

70. What is the nature of the dark universe and how is it affecting us?
71. What are the differences in the inter-hemispheric conjugacy between the ionosphere and that in the lower, middle and upper atmosphere, and what causes these differences?
72. How does space weather influence the polar ionosphere and what are the wider implications for the global atmosphere? *(Cross-cuts "Antarctic Atmosphere")*
73. How do the generation, propagation, variability and climatology of atmospheric waves affect atmospheric processes over Antarctica and the Southern Ocean? *(Cross-cuts "Antarctic Aim*

Human Presence in Antarctica

74. How can natural and human-induced environmental changes be distinguished, and how will this knowledge affect Antarctic governance? *(Cross-cuts all other Clusters)*
75. What will be the impacts of long-acting, direct human modification of the Antarctic environment? *(Cross-cuts "Antarctic Life")*
76. How will external pressures and changes in the geopolitical configurations of power affect Antarctic governance and science?
77. How will the use of Antarctica for peaceful purposes and science be maintained as tourism in access changes?
78. How will regulatory mechanisms evolve to keep pace with Antarctic tourism?
79. What is the current and potential value of Antarctic ecosystem services?
80. How will humans, diseases and pathogens change, impact and adapt to the extreme Antarctic environment? *(Cross-cuts "Antarctic Life")*

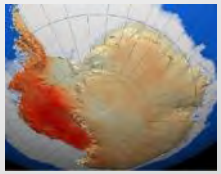
Cluster Topical Distribution



50% of the questions
cross-cut other topical clusters

SCIENCE PRIORITIES FOR…

DEFINE
the global reach of the Antarctic atmosphere and Southern Ocean



Stieg et al 2009

UNDERSTAND
how, where and why ice sheets lose mass

RECOGNIZE AND MITIGATE
human influences

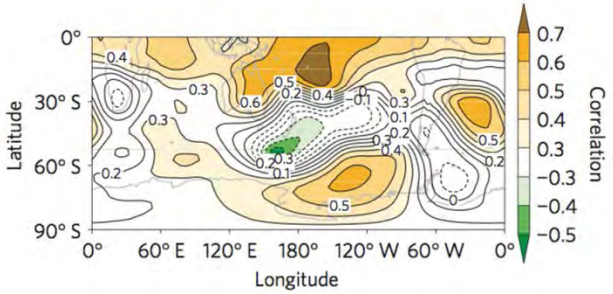
Antarctic and Southern Ocean science

REVEAL
Antarctica's history

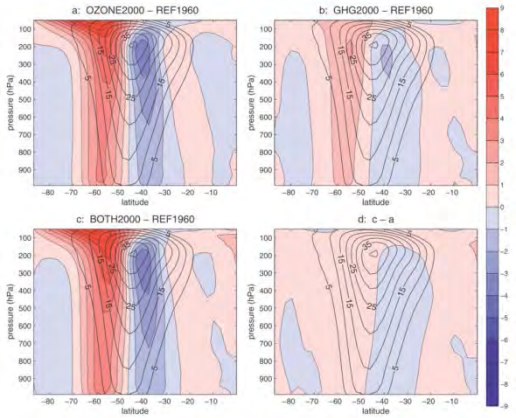
OBSERVE
space and the Universe

LEARN
how Antarctic life evolved and survived

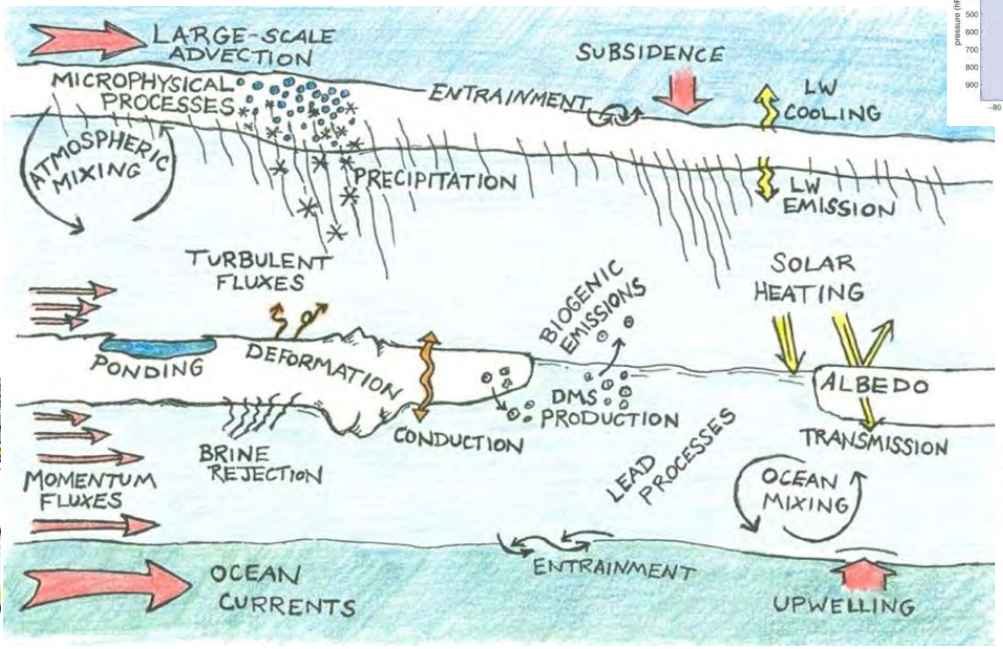
Antarctic Atmosphere and Global Connections



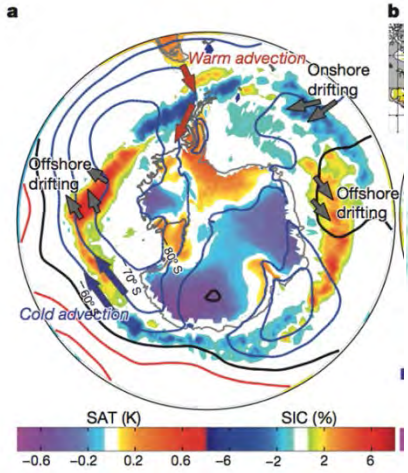
Tele-connections



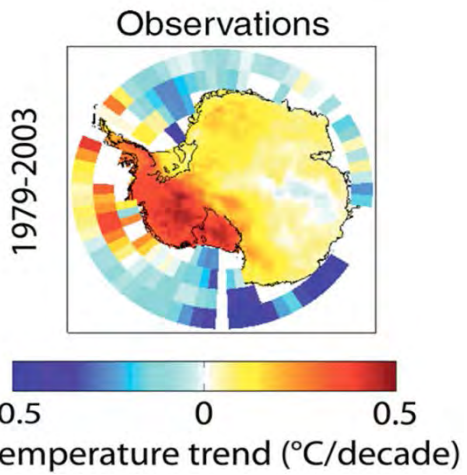
Processes and interfaces



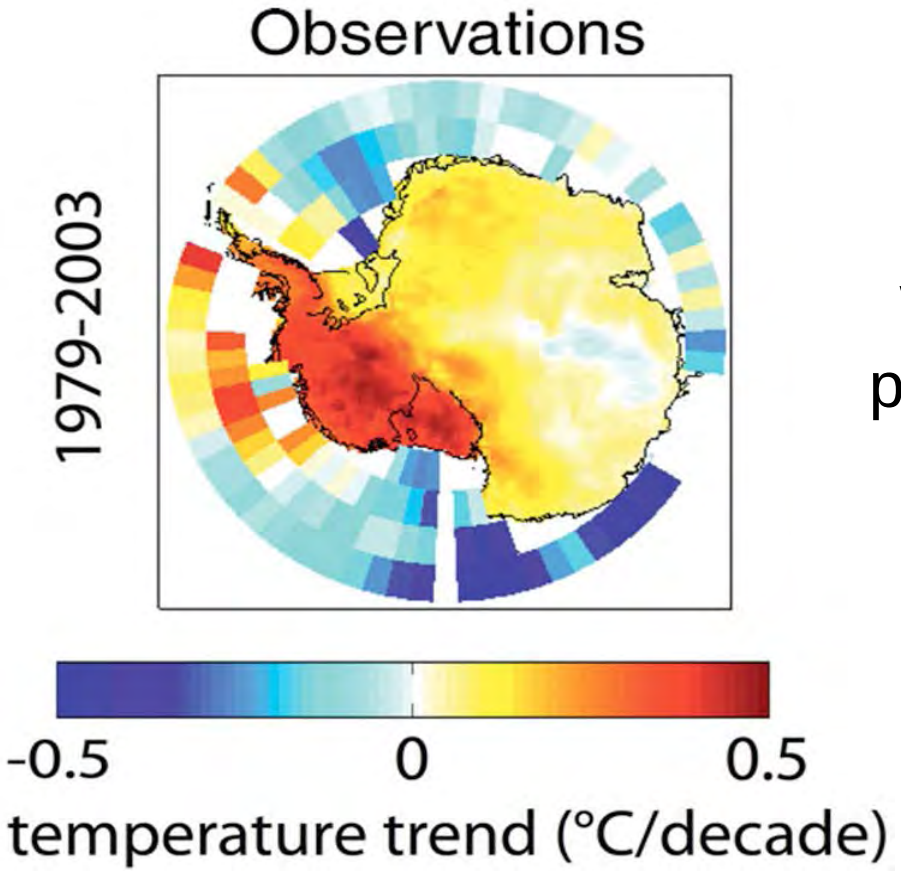
Greenhouse gases



Regional variations



Antarctic climate change has a pronounced regional signature

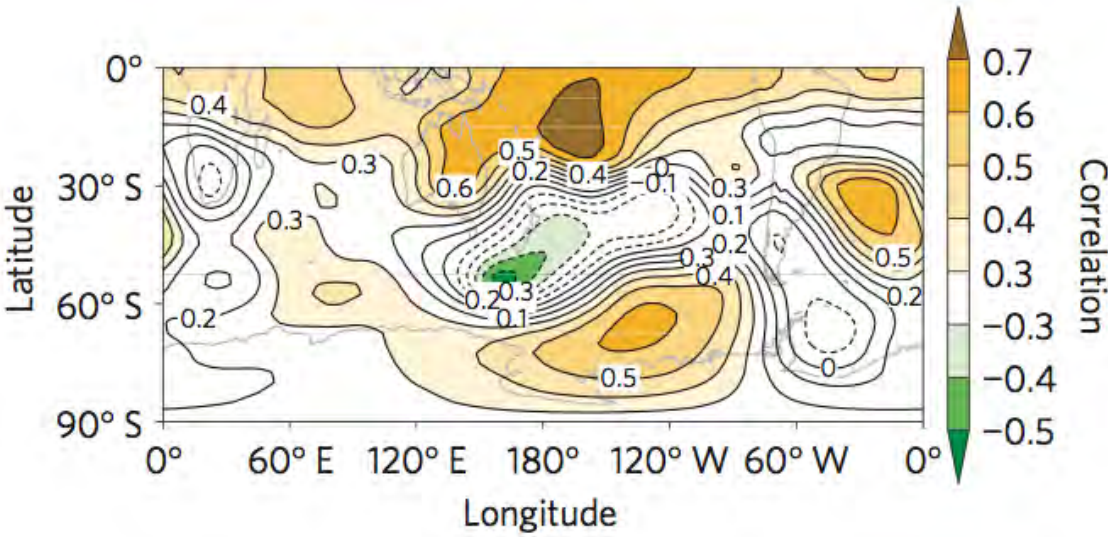


Steig et al. 2009 (Nature)

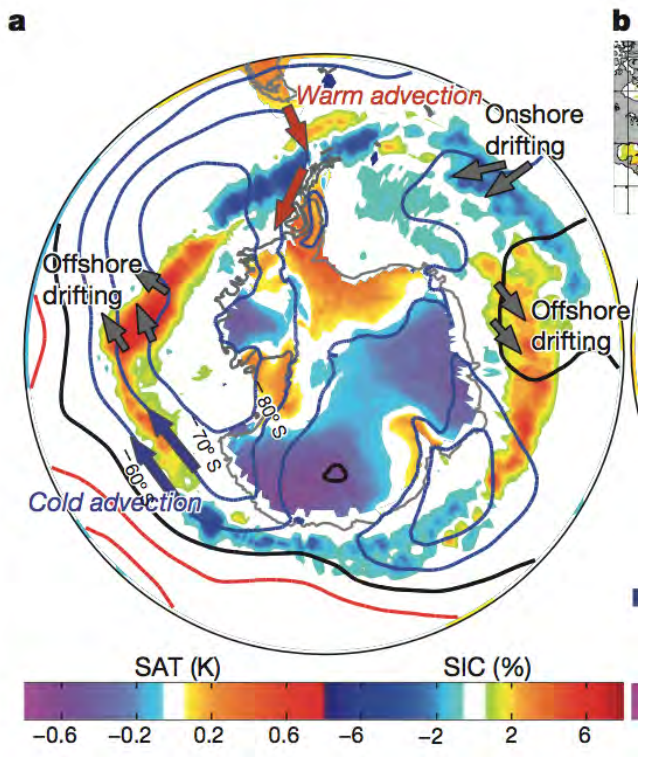
What drives the regional patterns of climate change in Antarctica?

Lower latitudes force Antarctic climate

The impact of Antarctic climate change on lower latitudes is unknown.

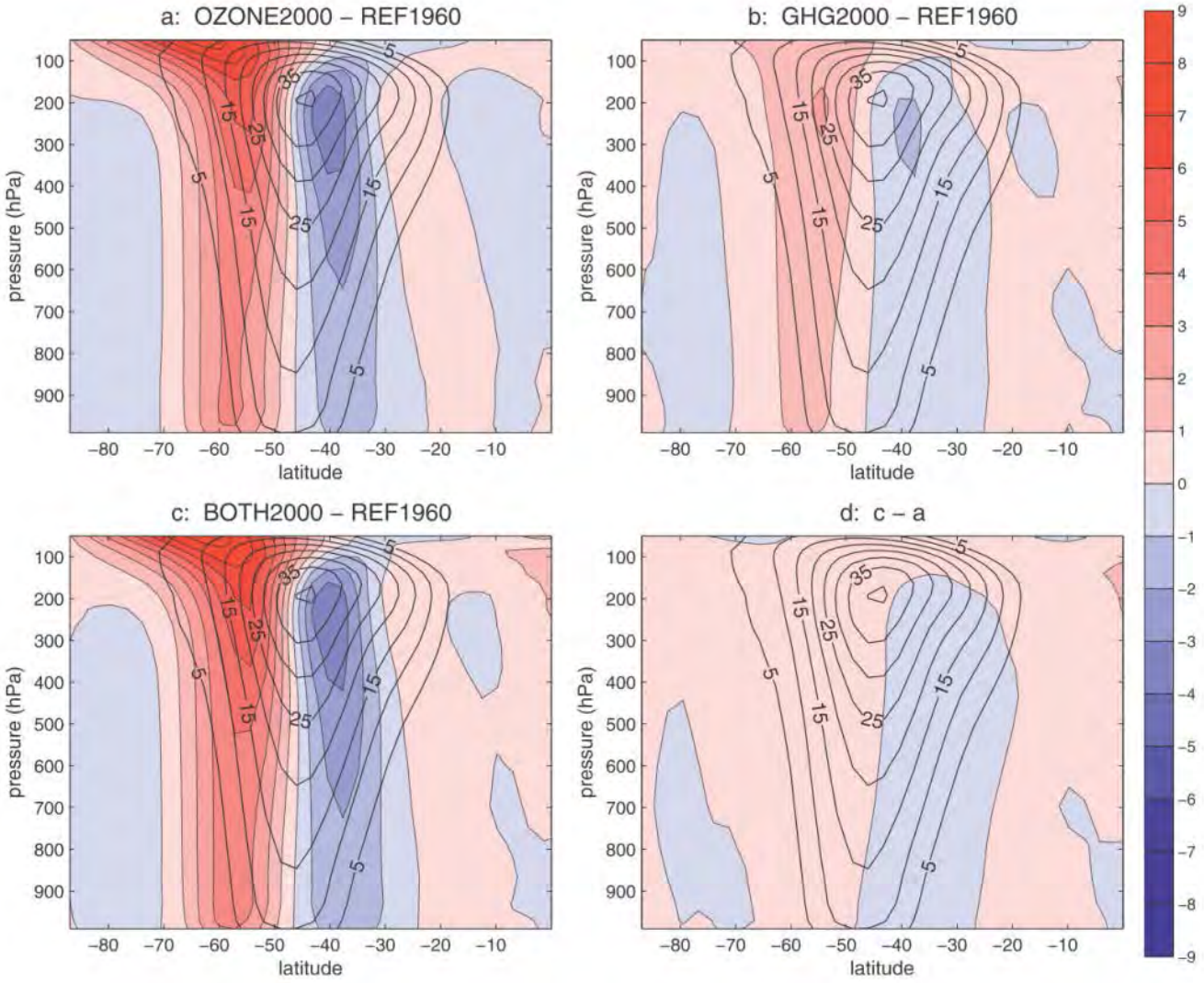


Ding et al. 2011 (Nature Climate Change)



Li et al. 2014 (Nature)

Role of ozone and GHG on Antarctic climate

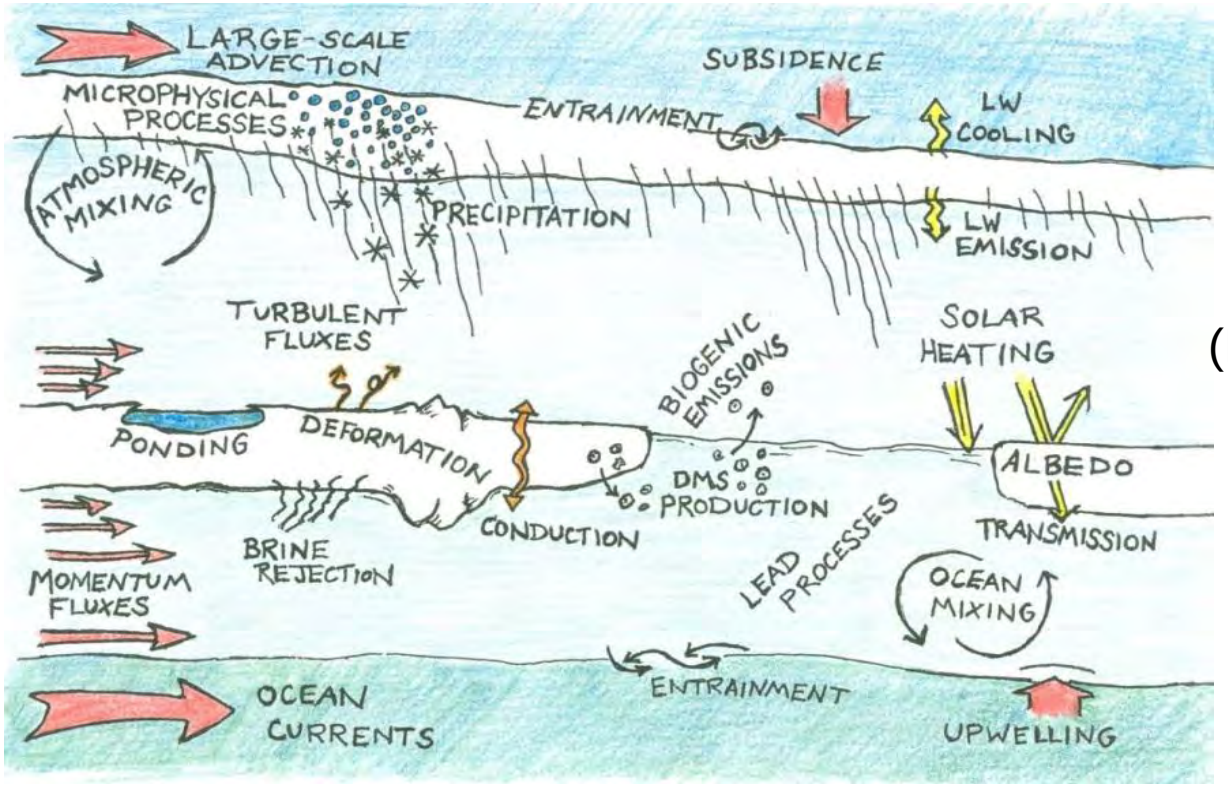


How will future changes in ozone and GHGs impact Antarctic climate?

What impact will changes in atmospheric circulation have on the ocean and sea ice?

Polvani et al. 2011 (Journal of Climate)

Understand the processes that drive Antarctic climate



Courtesy Matt Shupe, MOSAIC science plan

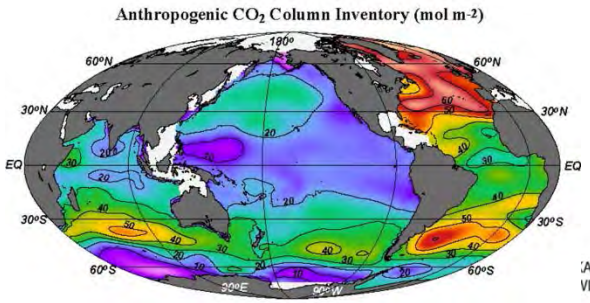
Atmosphere
(Clouds, precipitation, radiation, turbulence)

Sea and land ice
(Ice extent, thickness, snow cover, melting)

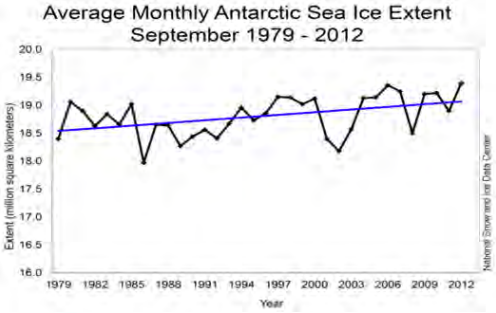
Ocean
(Currents, SST, trace gas fluxes, biology)

Process level understanding is critical for climate projections.

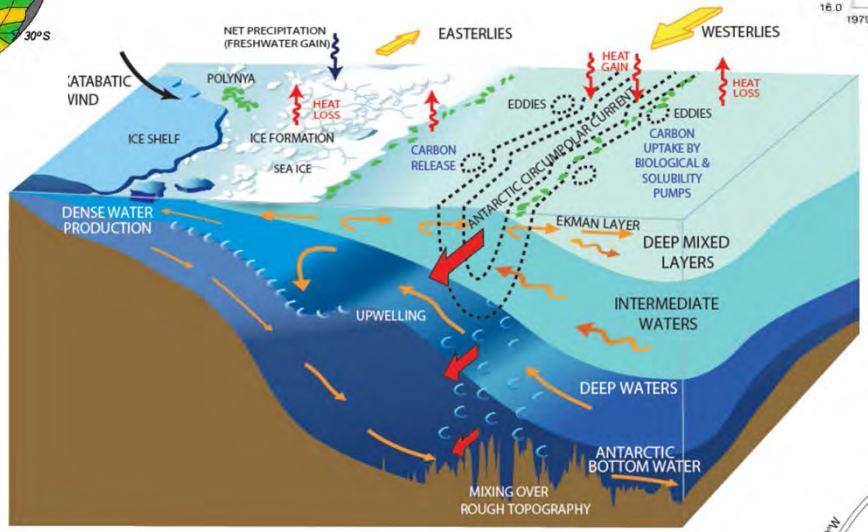
The Southern Ocean and Sea Ice in a Warming World



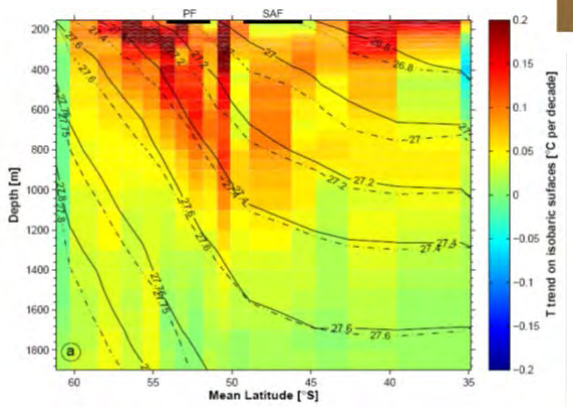
Human role in ocean change



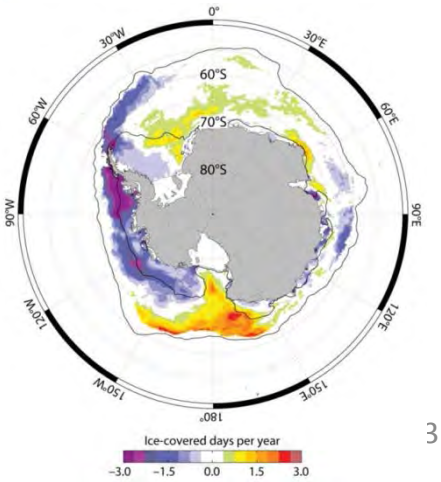
Heat, energy, carbon dioxide, carbon, oxygen and nutrient cycles and budgets



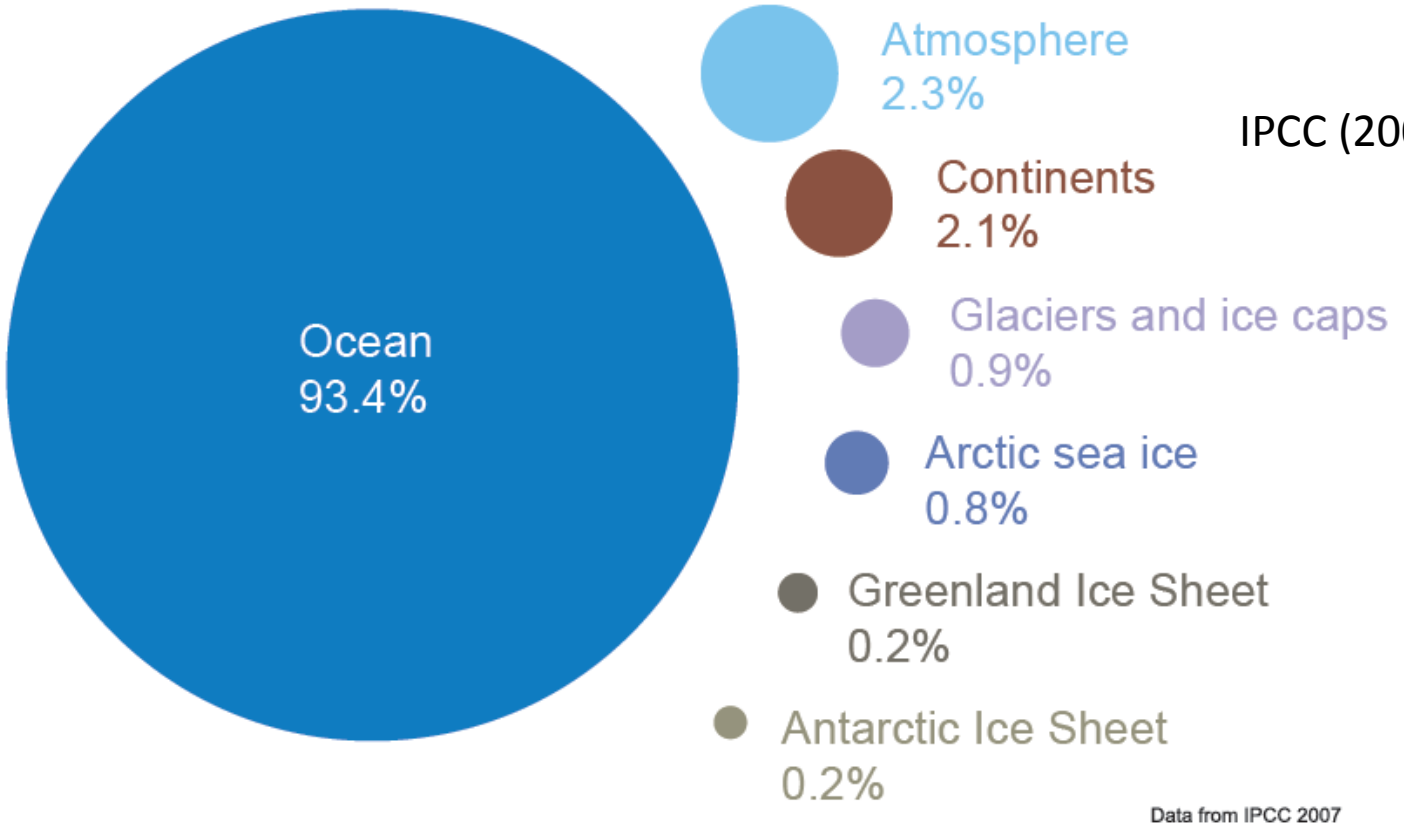
Sea ice variability



Improved climate forecasts



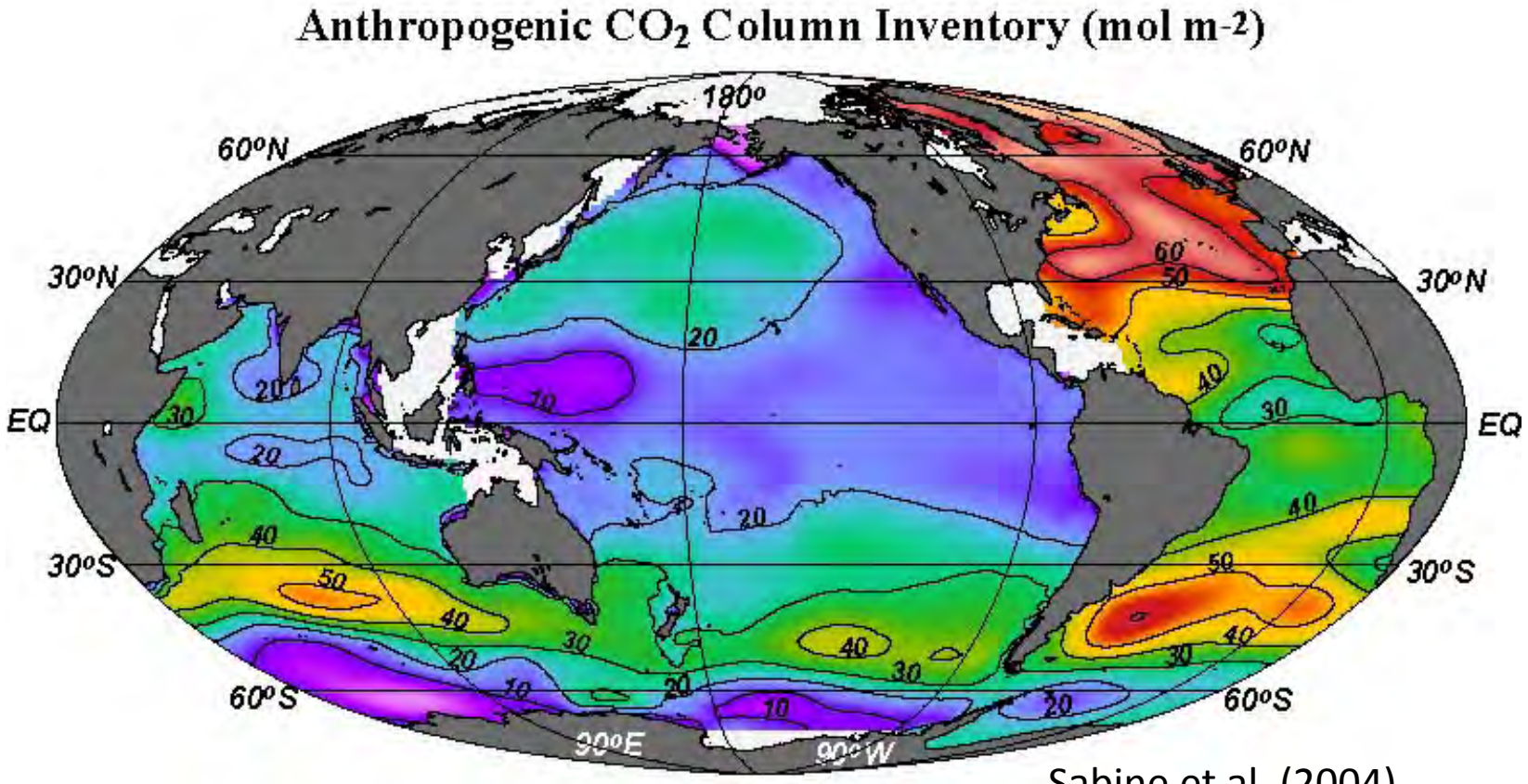
The Southern Ocean and Sea Ice in a Warming World



IPCC (2007; 2013)

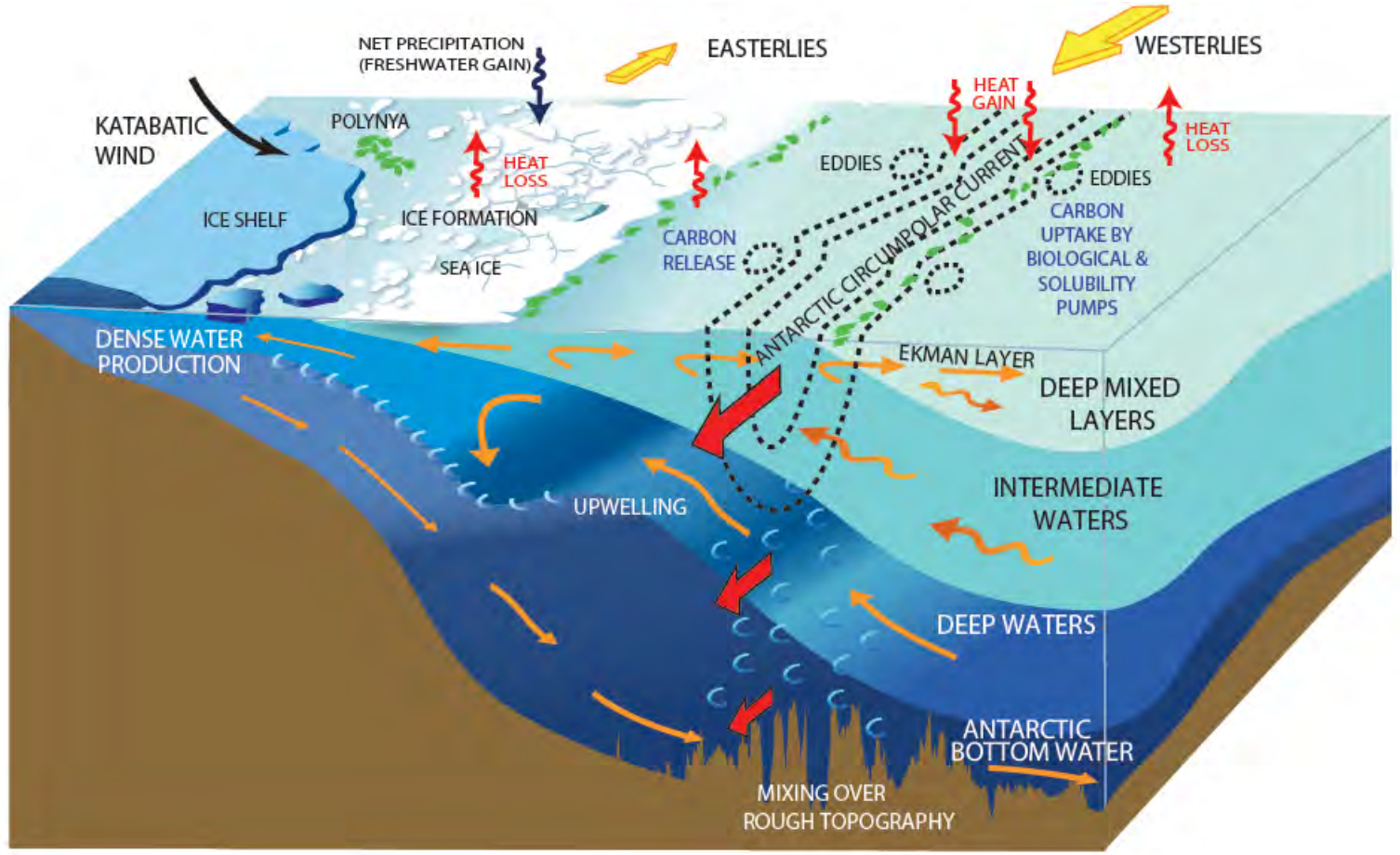
Global warming is ocean warming … and the Southern Ocean takes up more heat than other ocean regions

Southern Ocean stores more anthropogenic carbon dioxide than other ocean latitudes



Sabine et al. (2004)

Pace of climate change and sea level rise is strongly influenced by Southern Ocean processes



US National Research Council (2011)

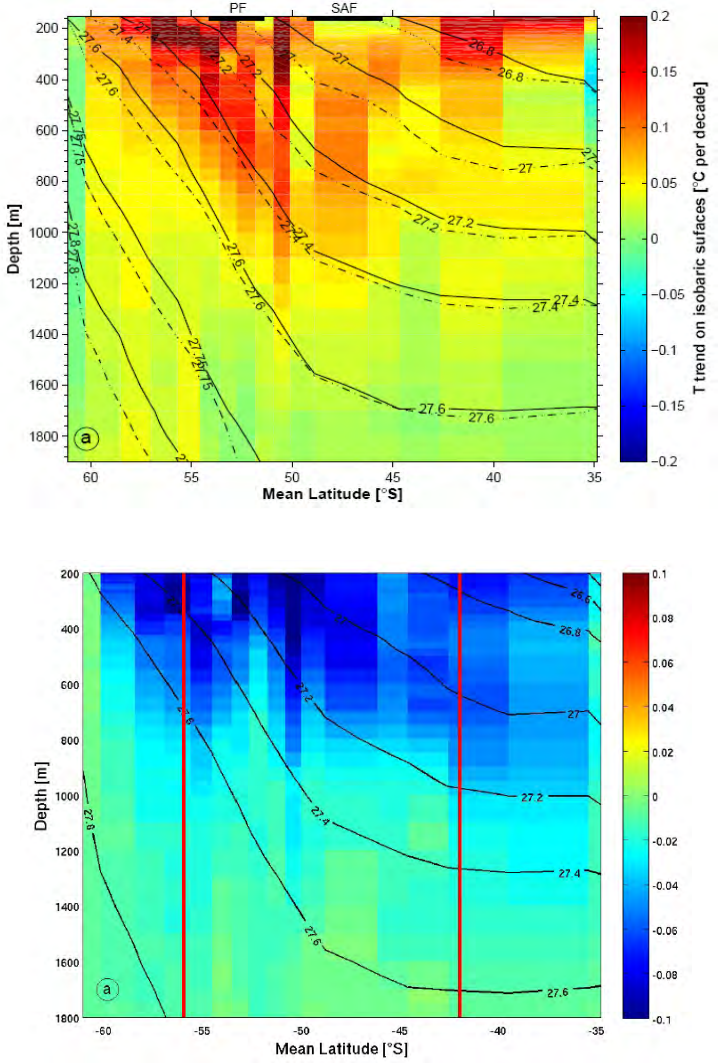
Human activities are driving change in the Southern Ocean

Southern Ocean is:

- warming
- freshening
- melting ice shelves
- acidifying

Both the ozone hole and greenhouse gases have contributed to observed changes.

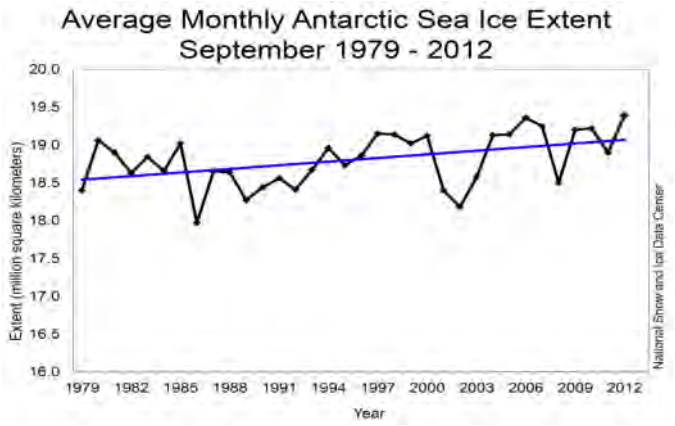
Will the Southern Ocean continue to slow the rate of climate change by taking up heat and carbon dioxide?

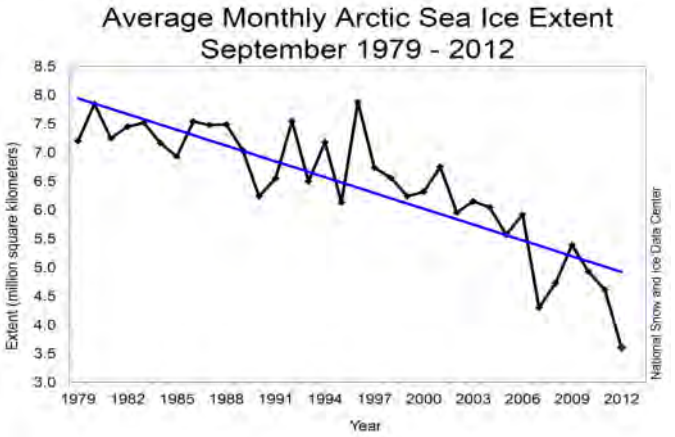


Böning et al. (2008)

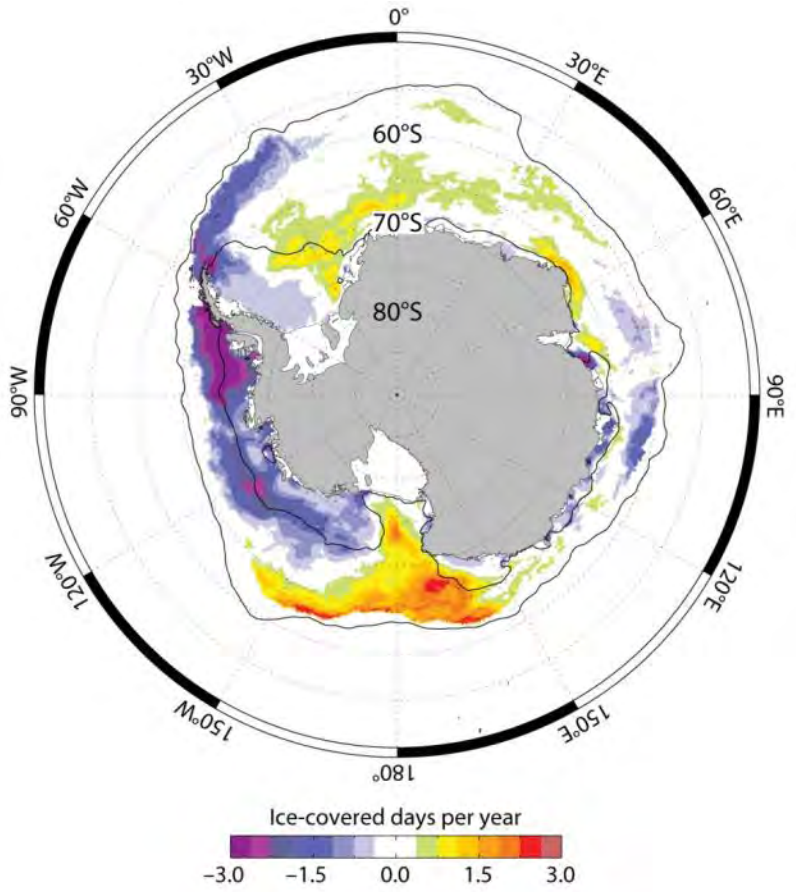
Antarctic sea ice is expanding

… regional changes rival those seen in the Arctic



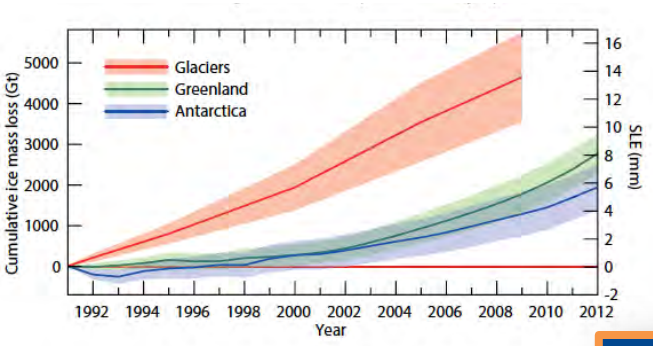


National Snow and Ice Data Center

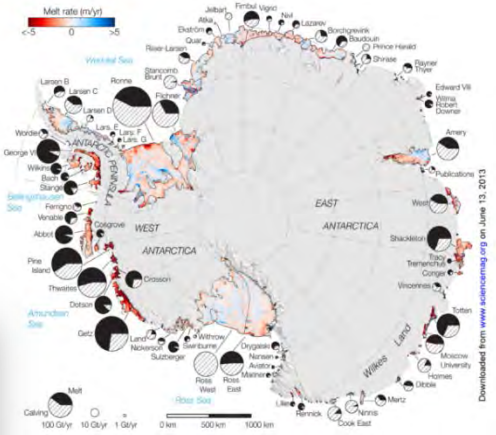


Maksym et al. (2012)

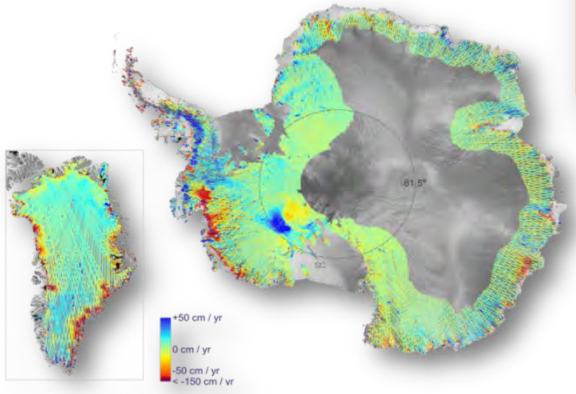
Antarctic ice sheet and sea level



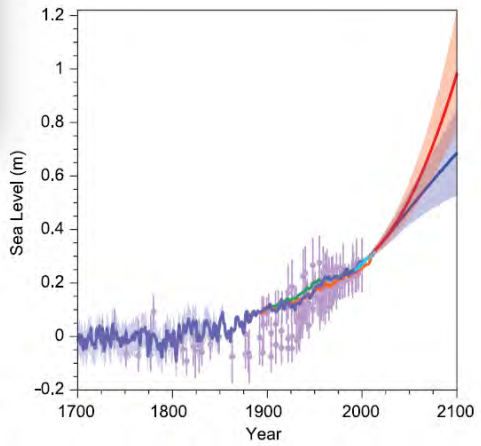
Controls and processes



Ice sheet thinning, retreat, and melt



Sea level

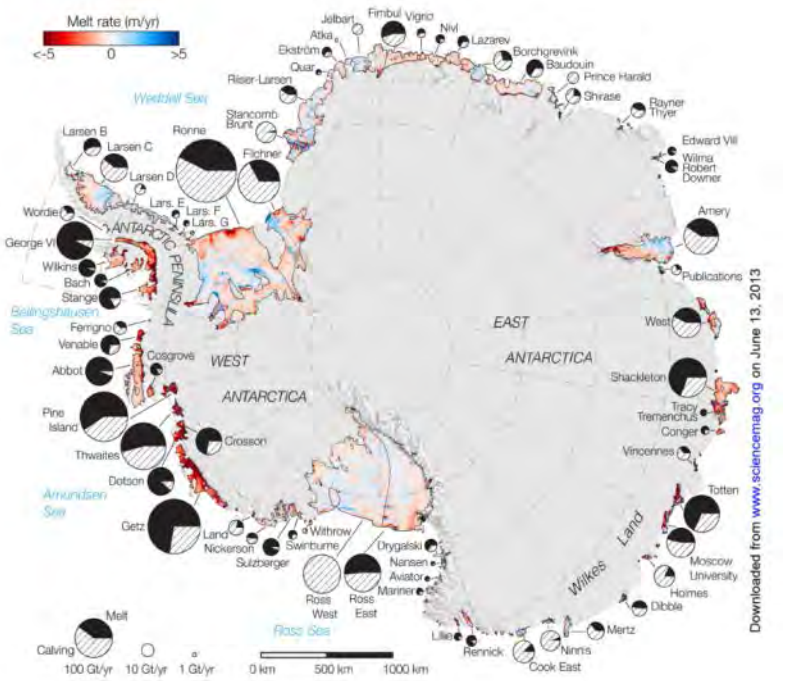


Improved climate and sea level forecasts

Understand how, where and why the ice sheets lose mass

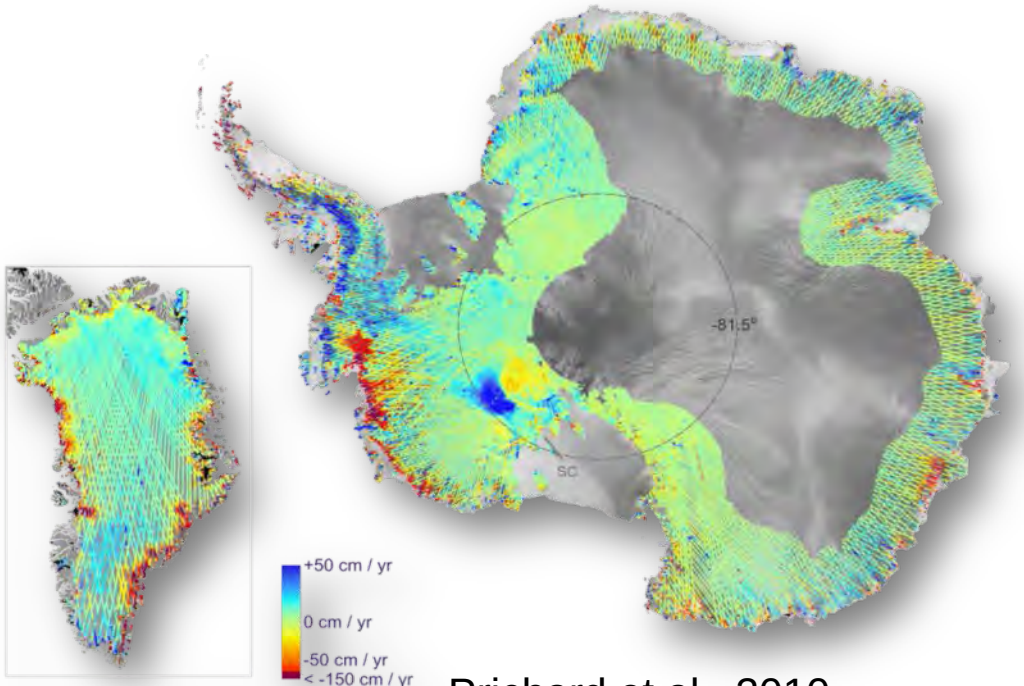
- The ice sheet is thinning
- The ice sheet margin is retreating
- The ice shelves are melting

Rate of Ice Sheet melt and mass-loss



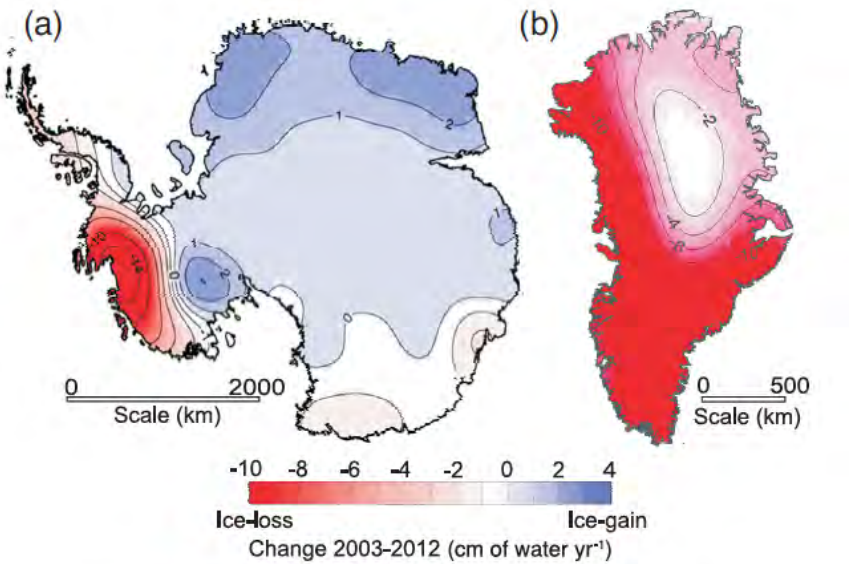
Rignot et al. 2013

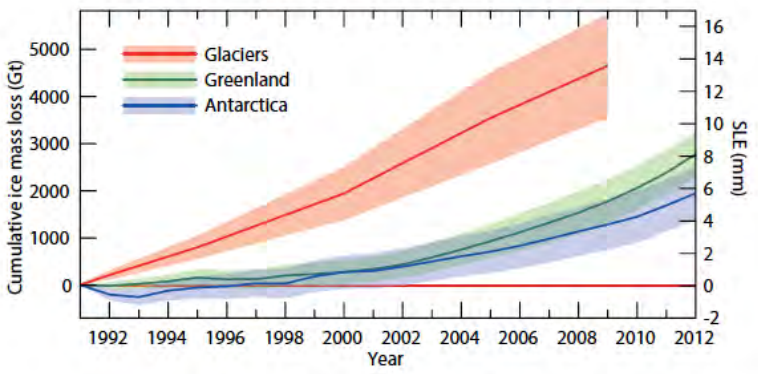
Ice Sheet thickness change 2002 - 2006



Prichard et al., 2010

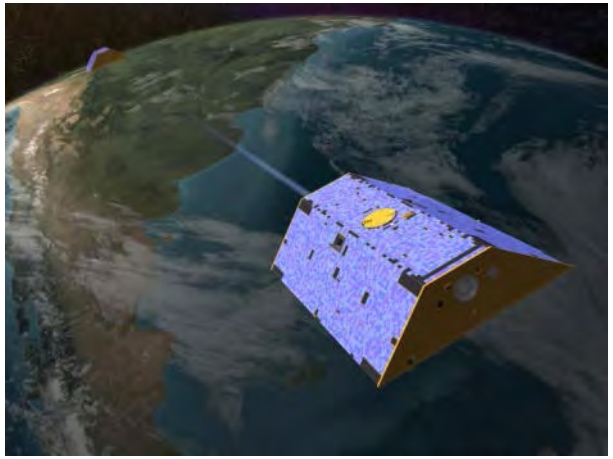
Ice sheets are losing mass at an accelerating rate



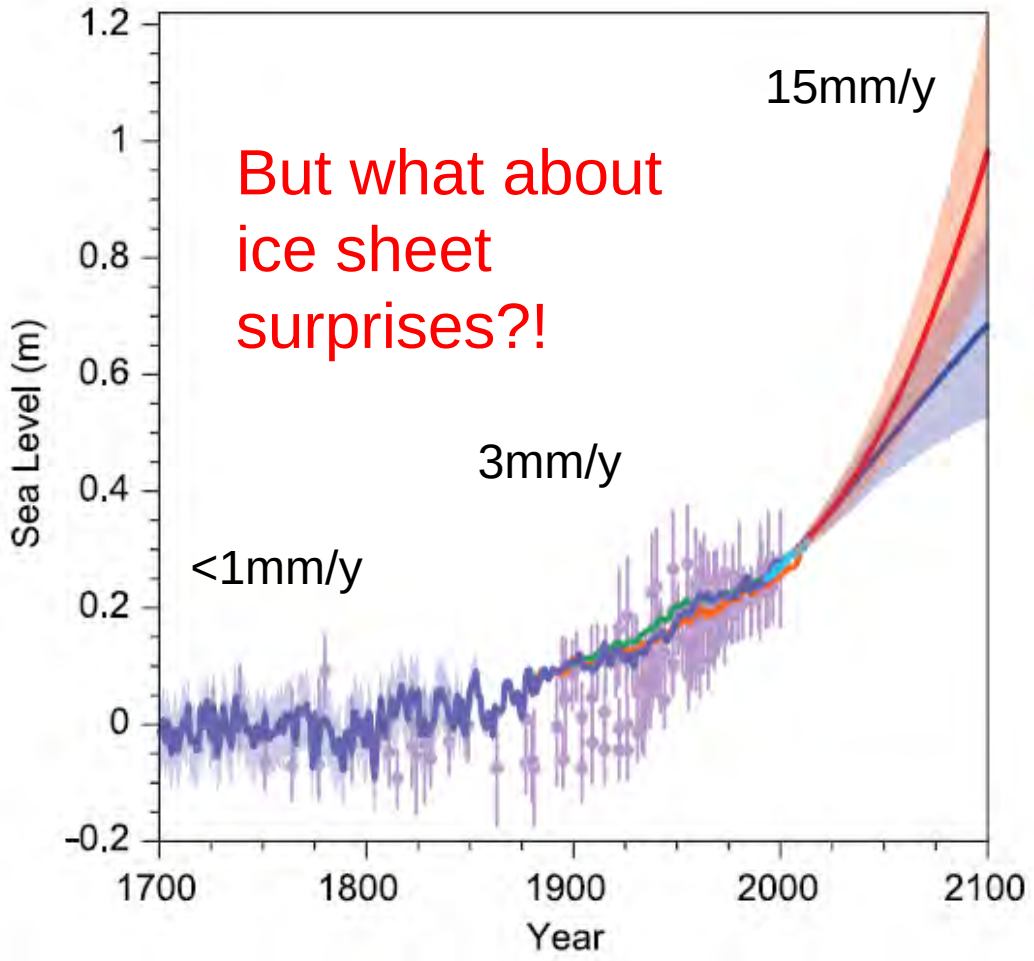


Sources listed in Vaughan et al. IPCC (2013)

- Progressive increase in mass loss over the last years
- Approaching 6mm per year
- Mass loss doubled in the last 10 years
- Acceleration: yes, but the time series is short
- Implications for predictions?



What are the implications for global sea-level rise?



RCP 8.5 (business as usual)

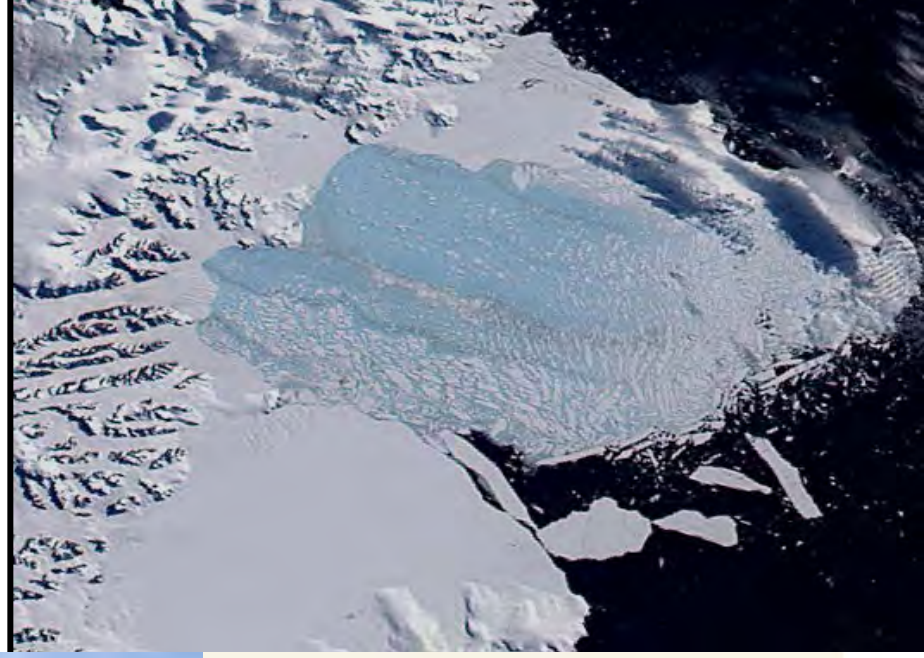
RCP 4.5

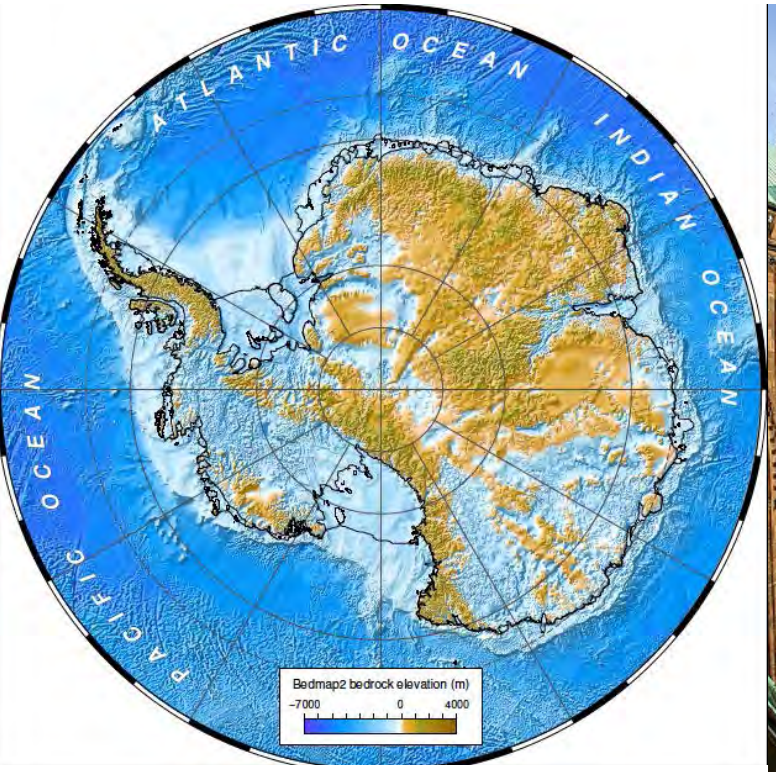
Sources listed in Church et al. IPCC (2013)

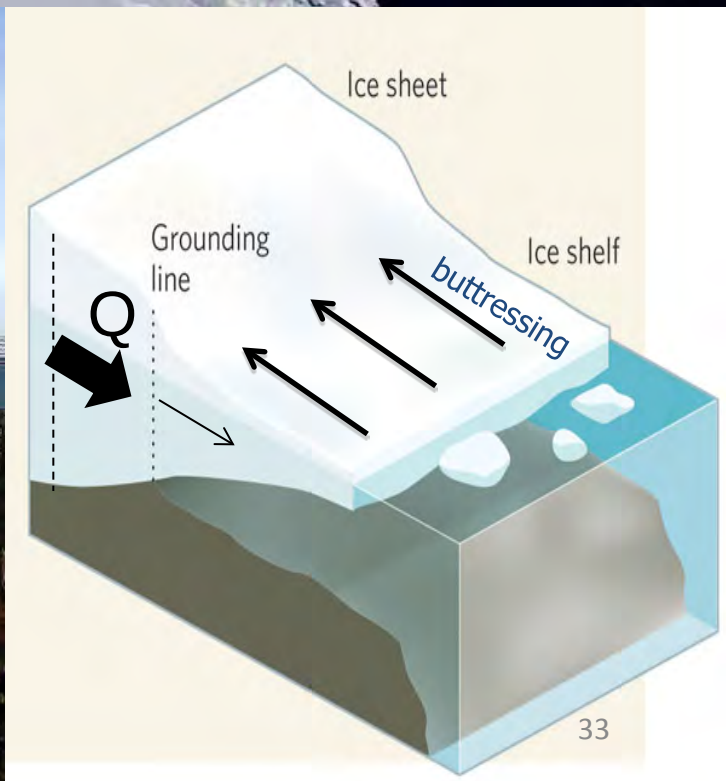
Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the likely range during the 21st century….IPCC AR5, 2013

What controls the rate of melt and their effect on sea-level rise?

- Ocean heat and circulation?
- The bedrock topography?
- Ice shelf buttressing?
- Marine ice sheet instability?
- Water at the bed?







Is the West Antarctic Ice Sheet on the brink of irreversible collapse?

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2014GL060140

Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011

E. Rignot[1,2], J. Mouginot[1], M. Morlighem[1], H. Seroussi[2], and B. Scheuchl[1]

[1]Department of Earth System Science, University of California, Irvine, California, USA, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

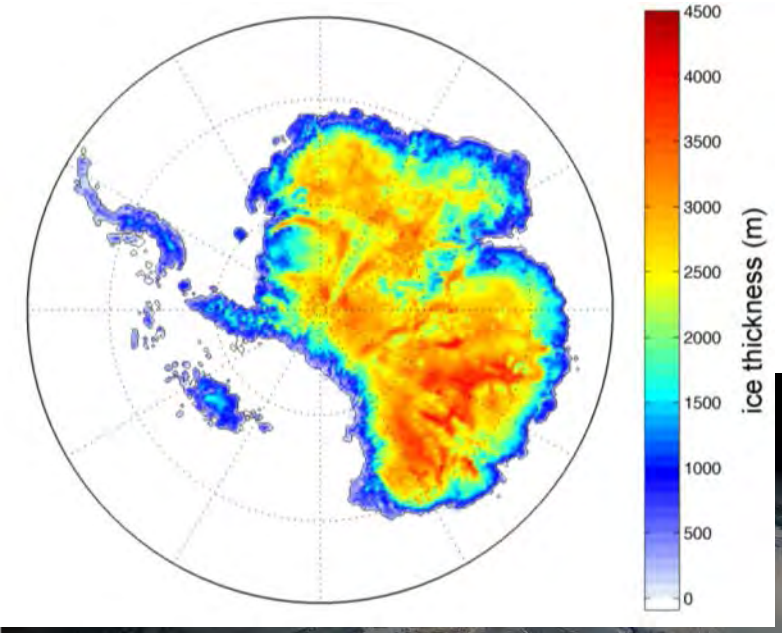
Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica

Ian Joughin, Benjamin E. Smith, Brooke Medley

www.sciencemag.org SCIENCE VOL 344 16 MAY 2014

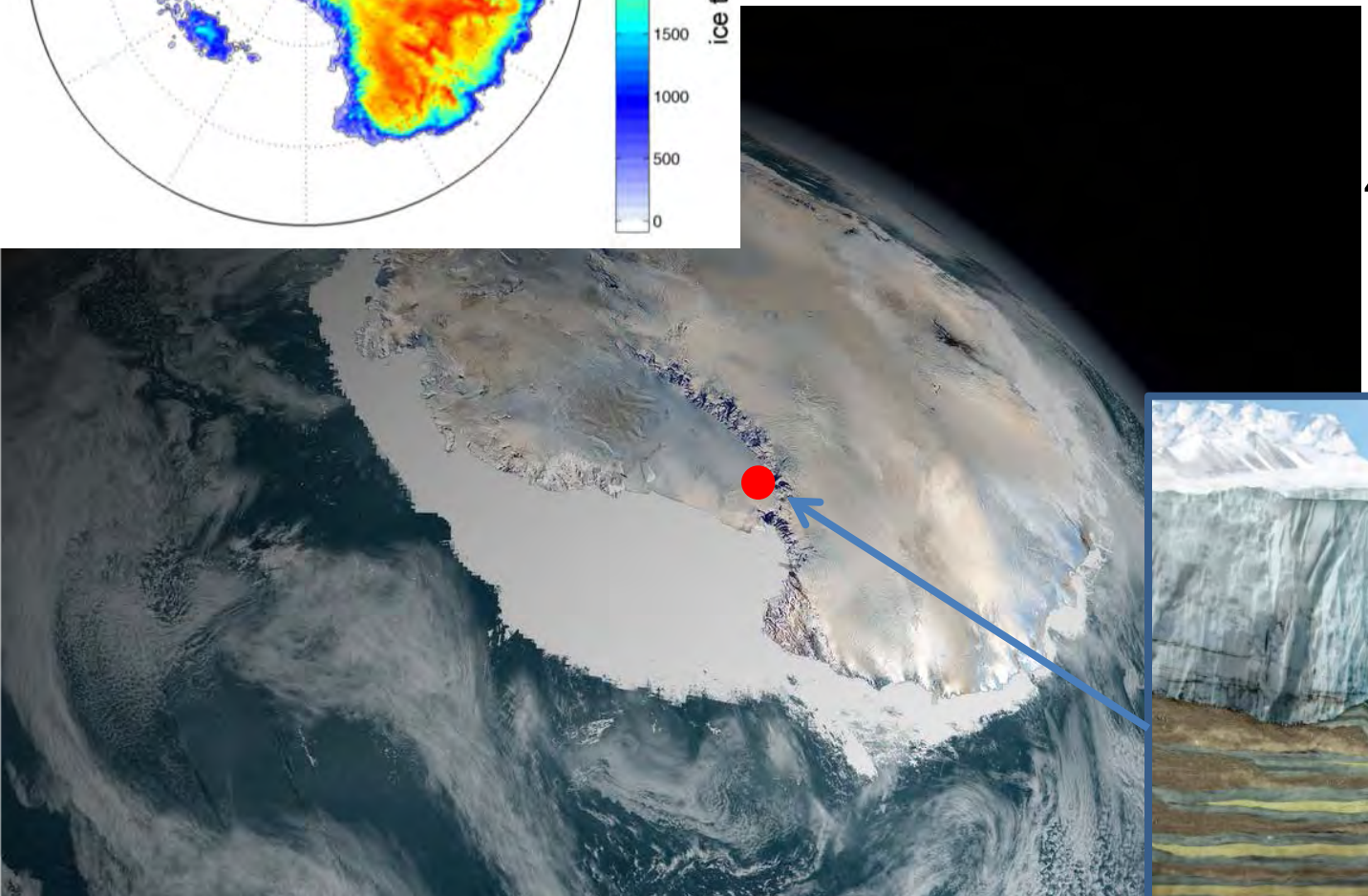
+7m GMSL

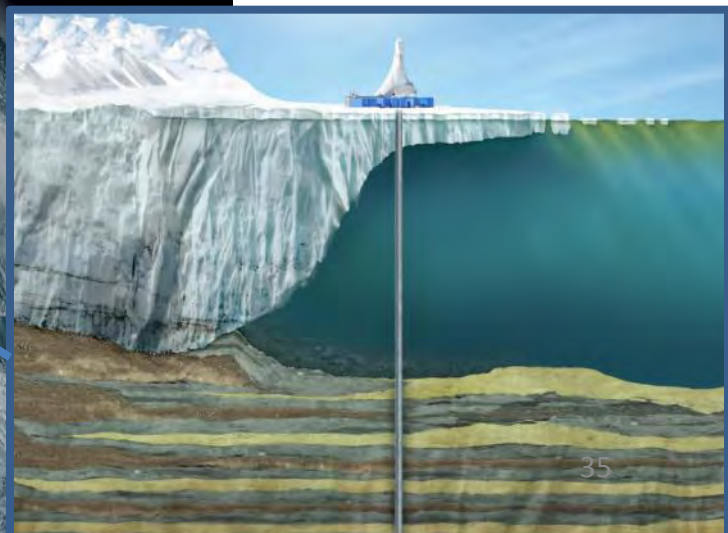
(Pollard and DeConto, 2009, Nature)



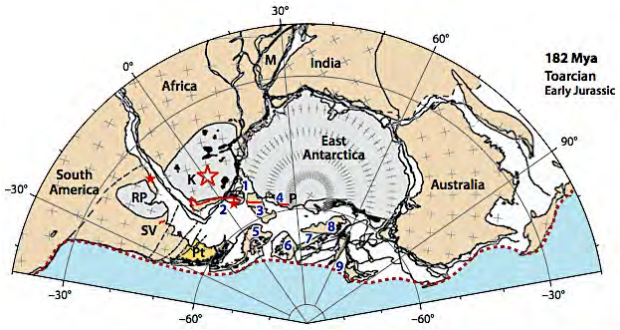
Is there an atmospheric CO_2 threshold beyond which ice sheets collapse and sea-level rises dramatically?

The last time the world saw 400 ppm CO_2 levels was 3 million years ago

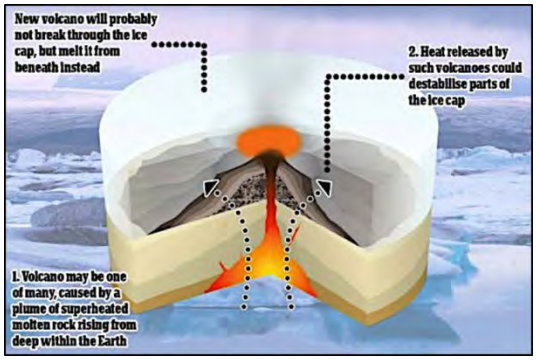




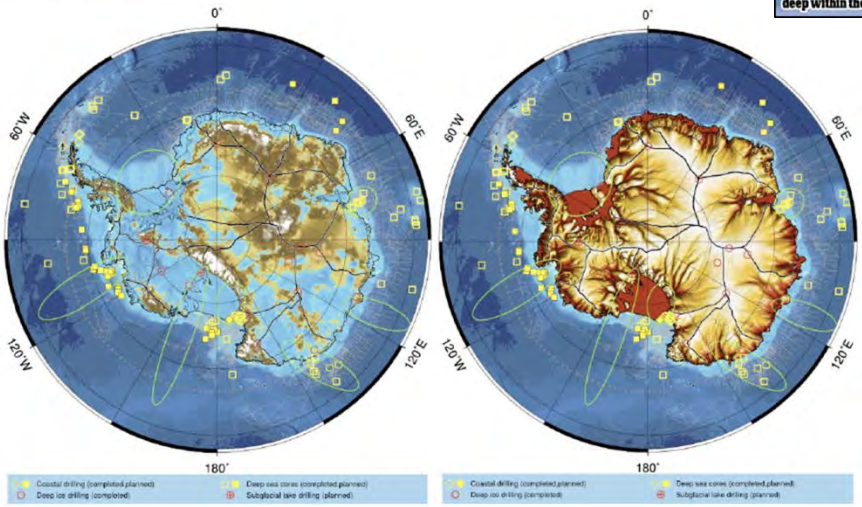
Dynamic earth – probing beneath Antarctic ice



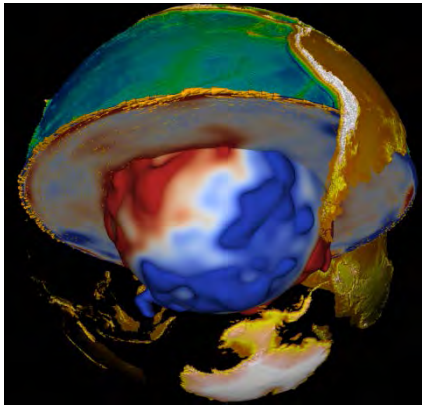
Heat flux and volcanism

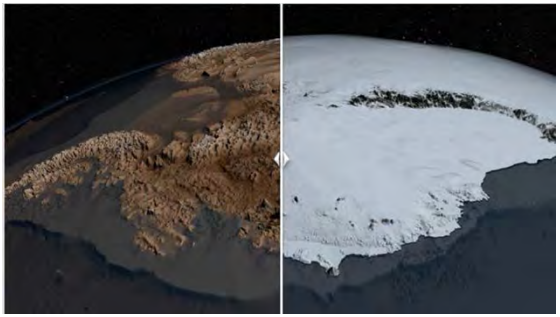


Super continent assembly



Deep Earth structure

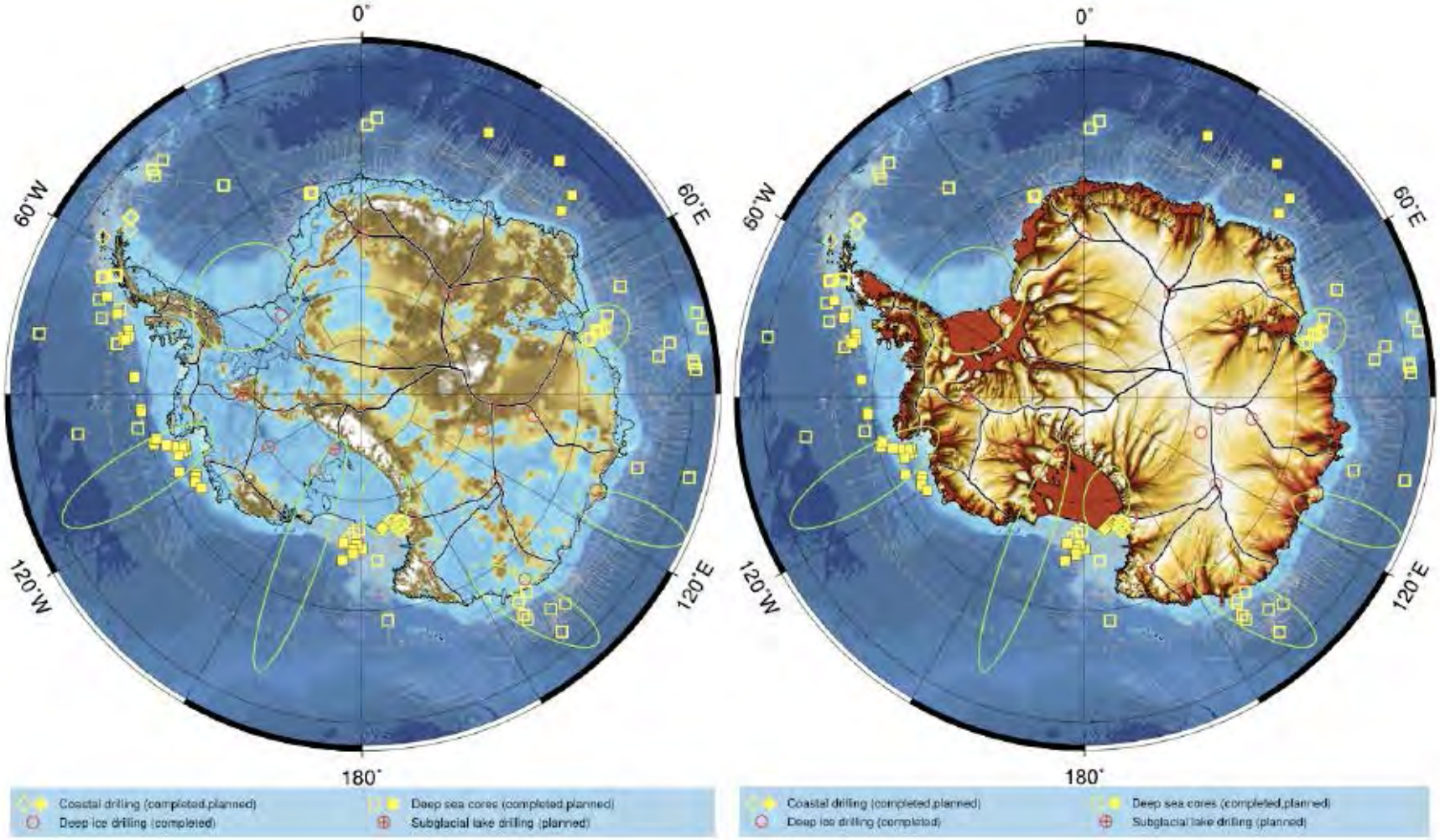




Cryospheric feedback

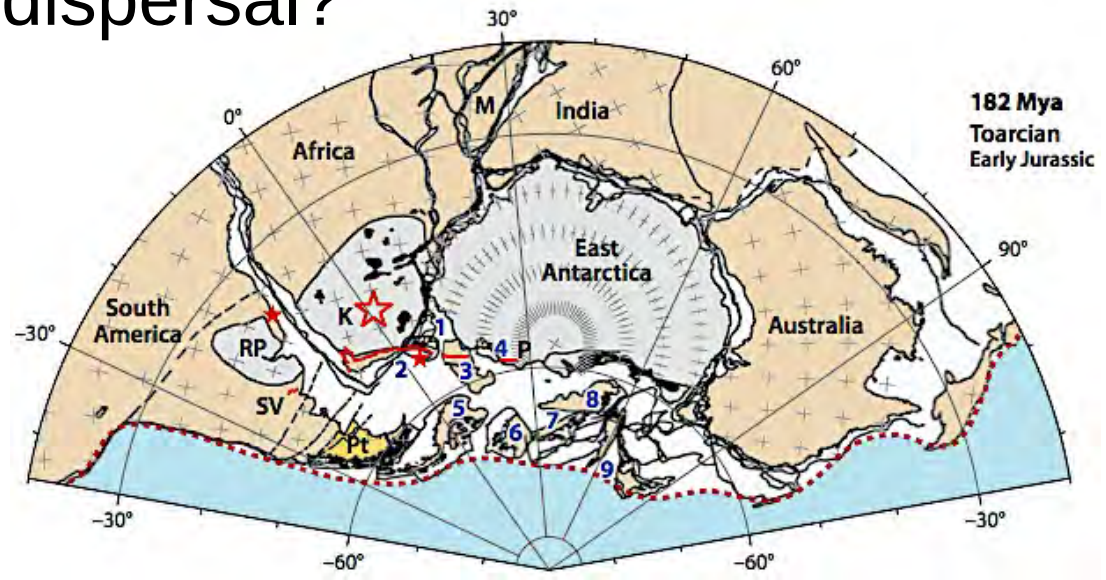
Reveal Antarctica's history

What lies beneath?

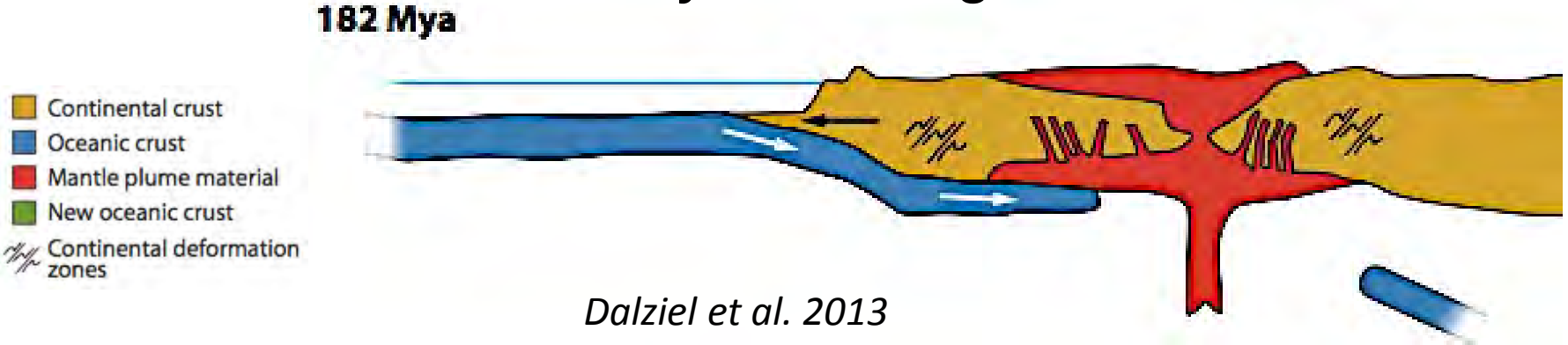


Dynamic Earth - Deep Time

Antarctic record of supercontinent assembly and dispersal?



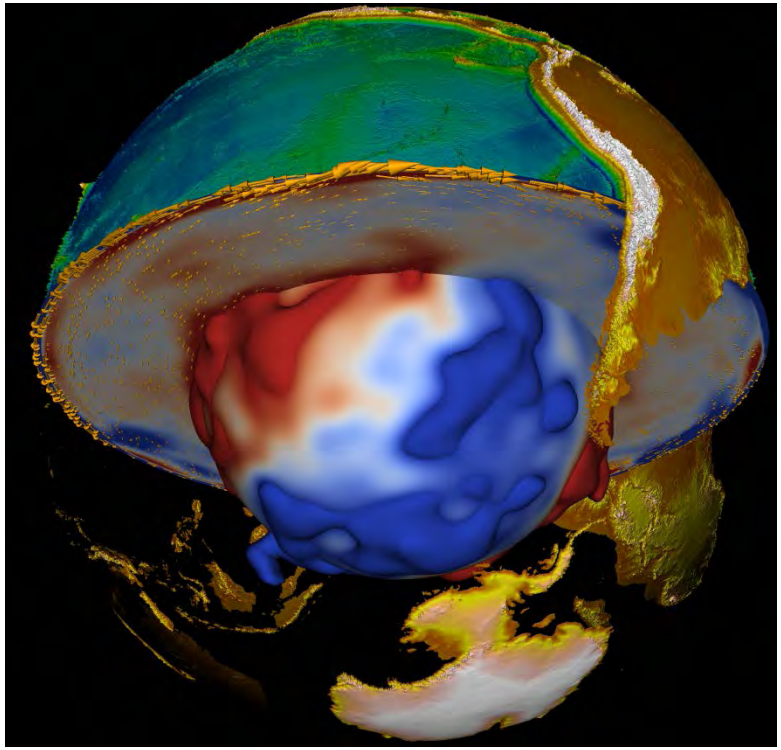
Magmatism – influence on Antarctic lithosphere, ice sheet dynamics, global climate?



Dalziel et al. 2013

Dynamic Earth
Deep Earth structure

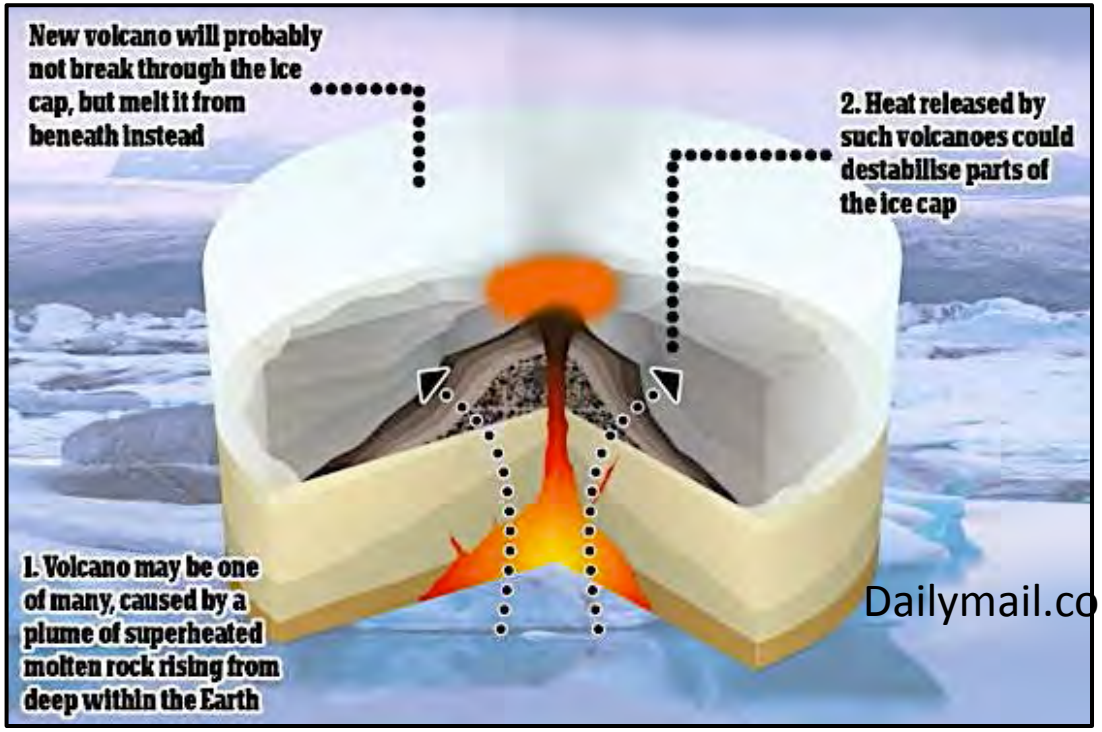
- **Subglacial geology?**
- **Heat flux?**
- **Impacts on ice sheet dynamics & isostatic rebound?**



Becker, 2010, Science

Antarctica as the ice sheets shrink….

- Increasing volcanism & deformation?
- Greenhouse gas release?



Dailymail.co.uk

Active Volcano Found Under Antarctic Ice: Eruption Could Raise Sea Levels

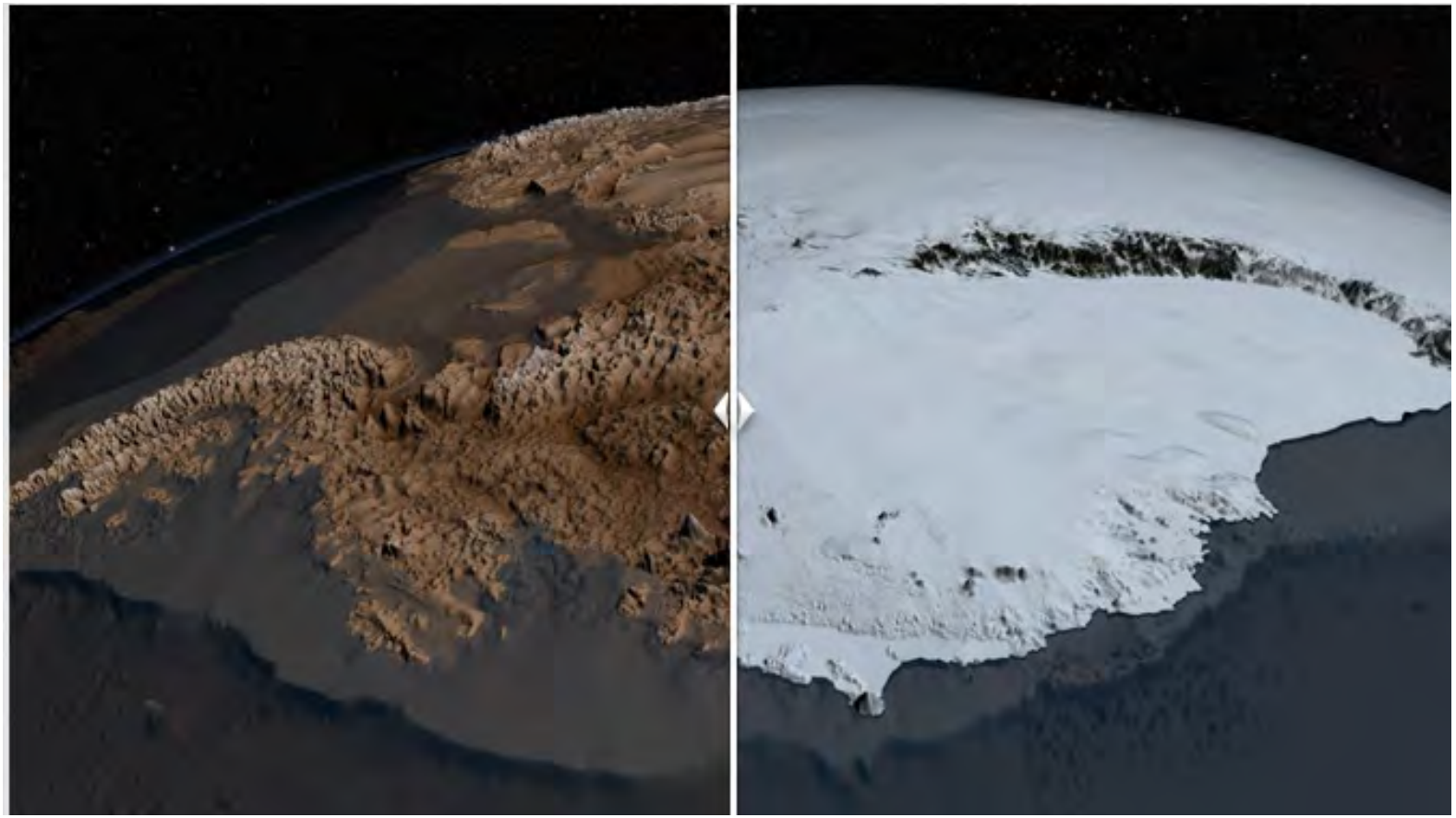
Inevitable eruption will speed up ice loss on frozen continent, study says.

Antarctic Methane Could Escape, Worsen Warming

As glaciers melt, gas could belch into atmosphere, study suggests.

Dynamic Earth
Feedbacks with Cryosphere

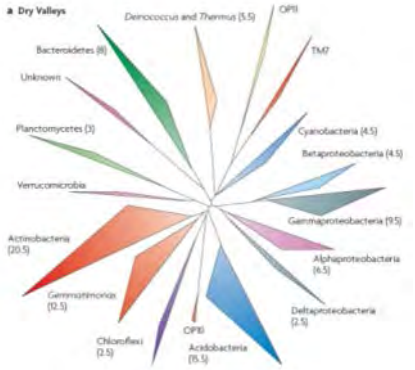
Ice sheet dynamics: influences of bed morphology, subglacial hydrology, geothermal heat flux?

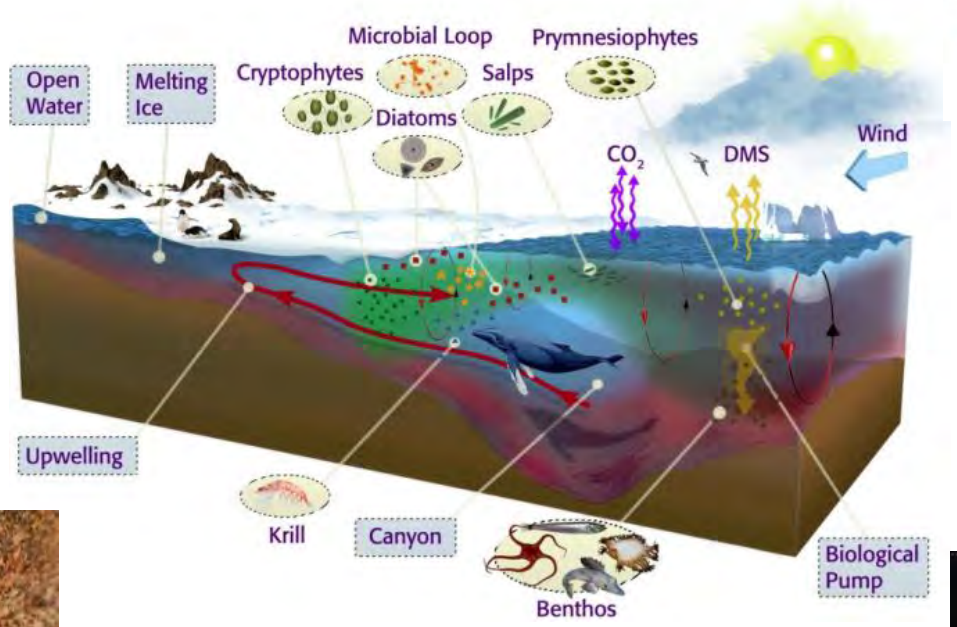


NASA Goddard Space Flight Center

Antarctic life on the precipice

Ecosystem structure and function





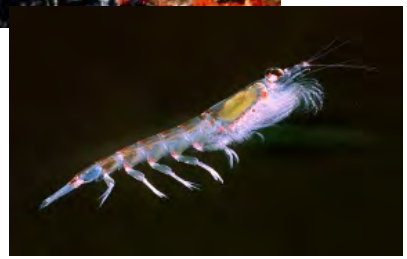
Adaptation and biodiversity

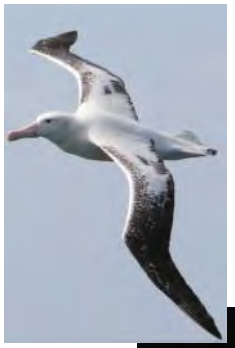
Environmental drivers

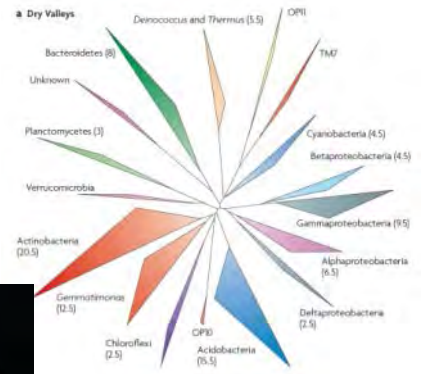
Conservation science

Antarctic Life on the Precipice

Low diversity, isolated, recent, protected	Diverse, more connected, refugia, unprotected





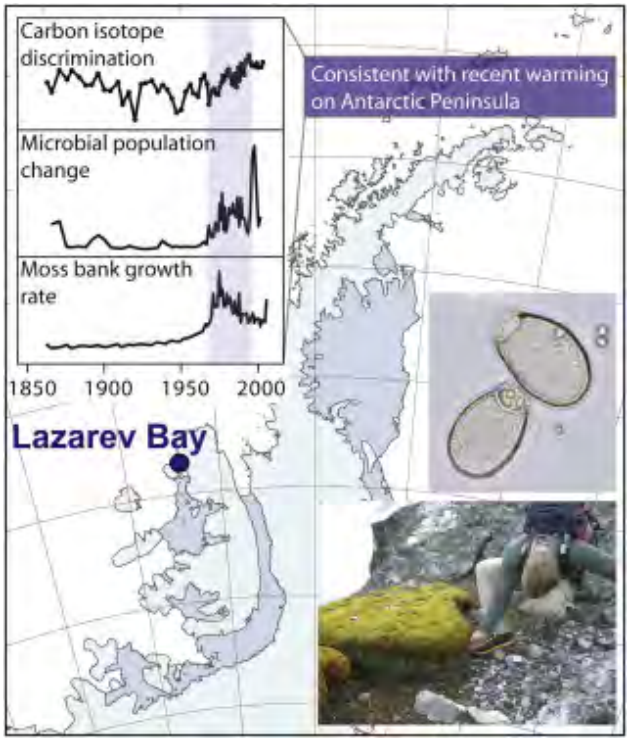


Exploring biological constraints on the glacial history of Antarctica

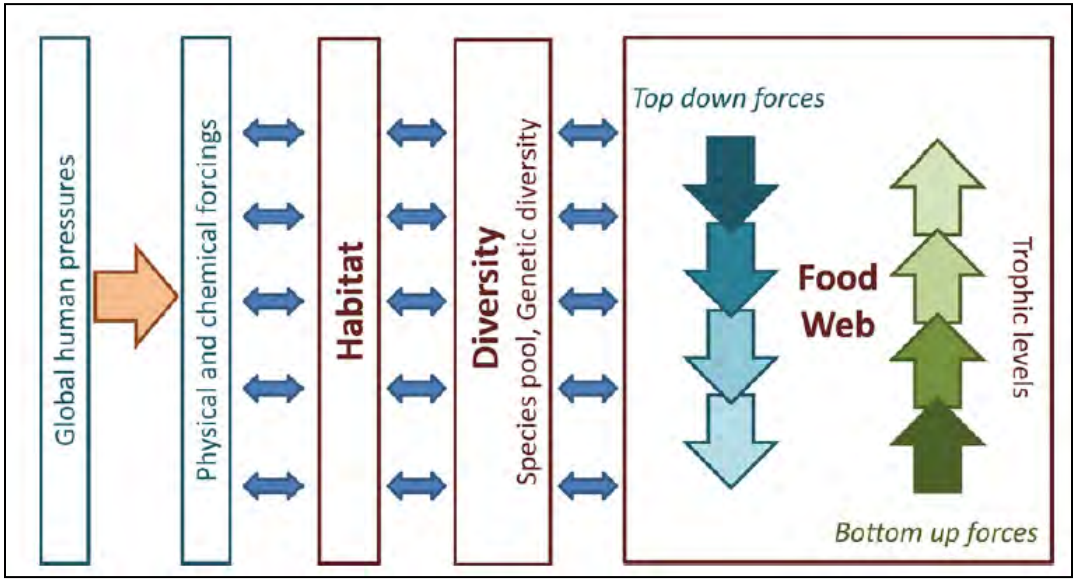
Antarctica's Protected Areas Are Inadequate, Unrepresentative, and at Risk

Time and understanding

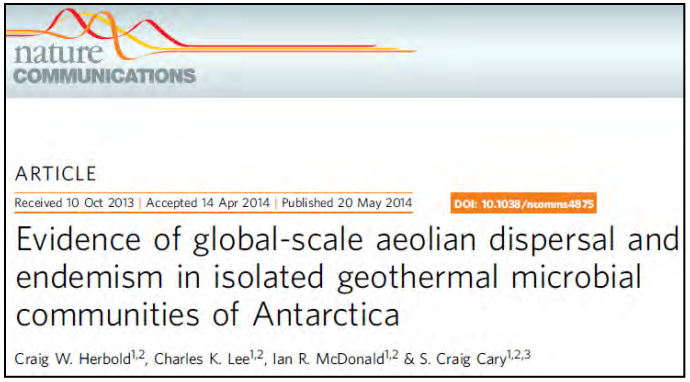
Antarctic Life on the Precipice

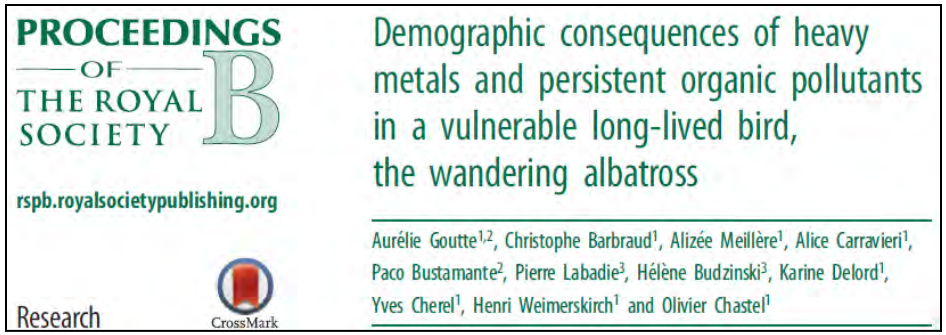


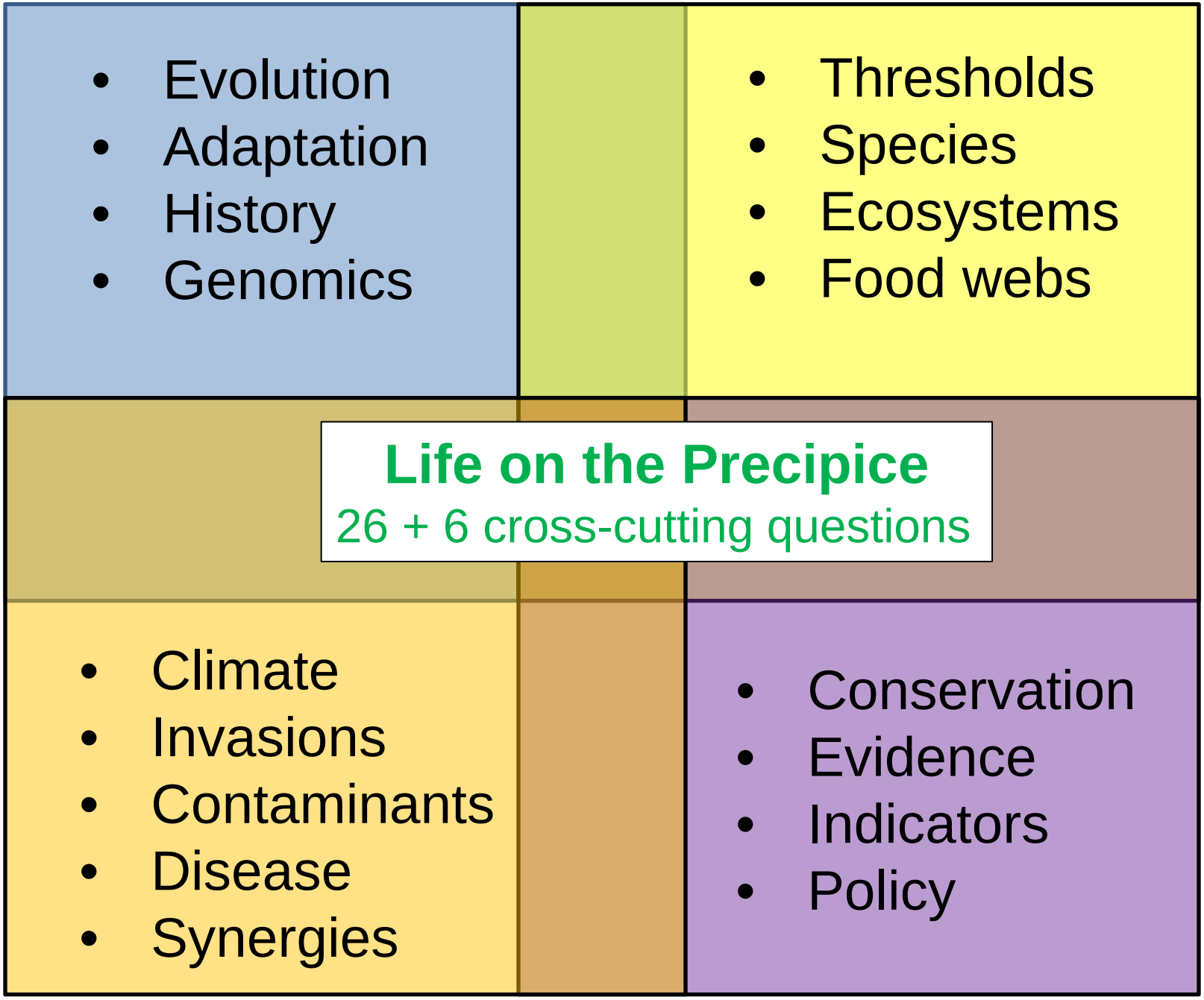
Royles et al. 2013, Curr. Biol.



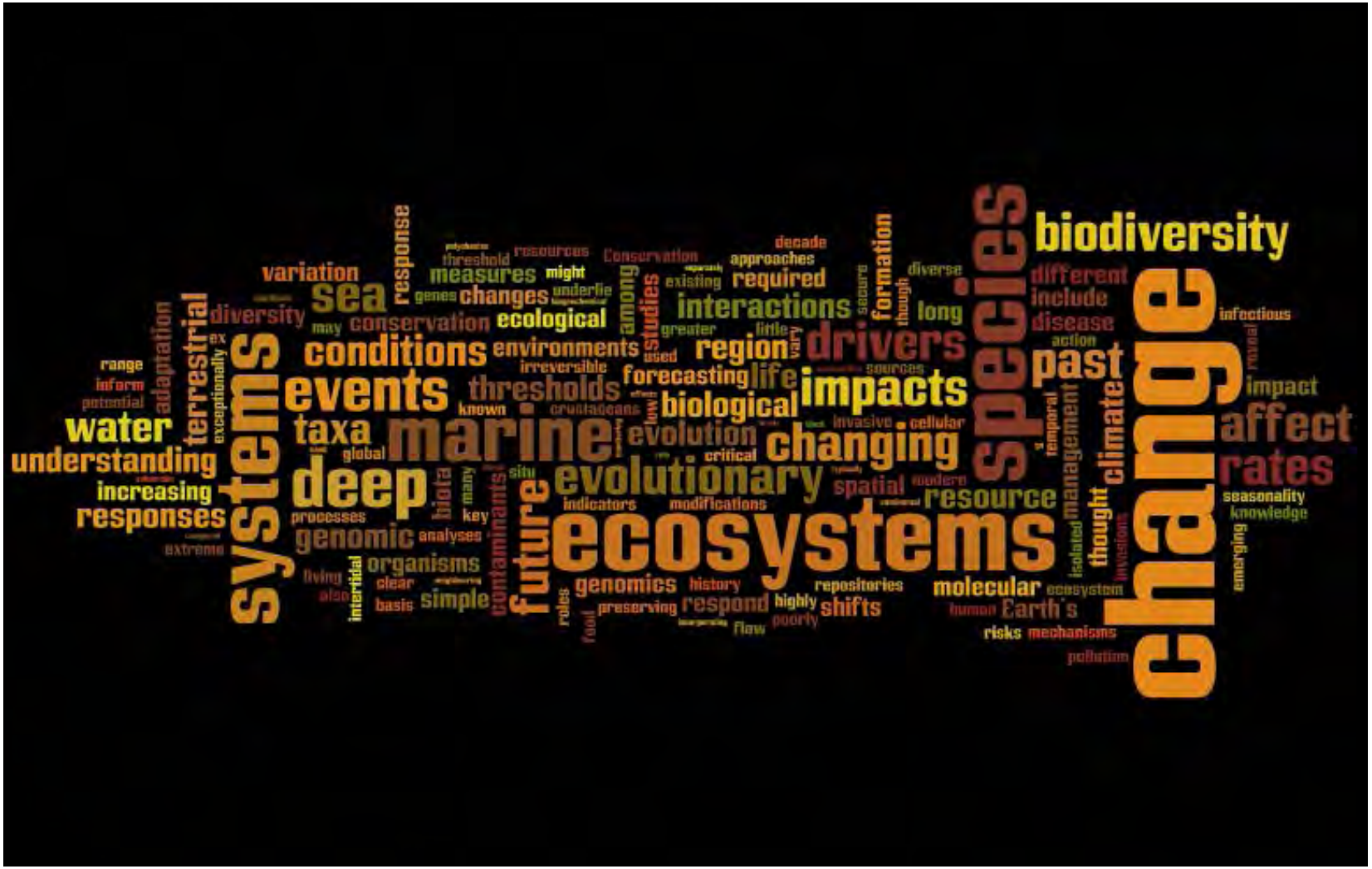
Constable et al. 2014, Global Change Biol.






Evolution
Adaptation
History
Genomics
Thresholds
Species
Ecosystems
Food webs
Life on the Precipice
26 + 6 cross-cutting questions
Climate
Invasions
Contaminants
Disease
Synergies
Conservation
Evidence
Indicators
Policy

Antarctic Life on the Precipice

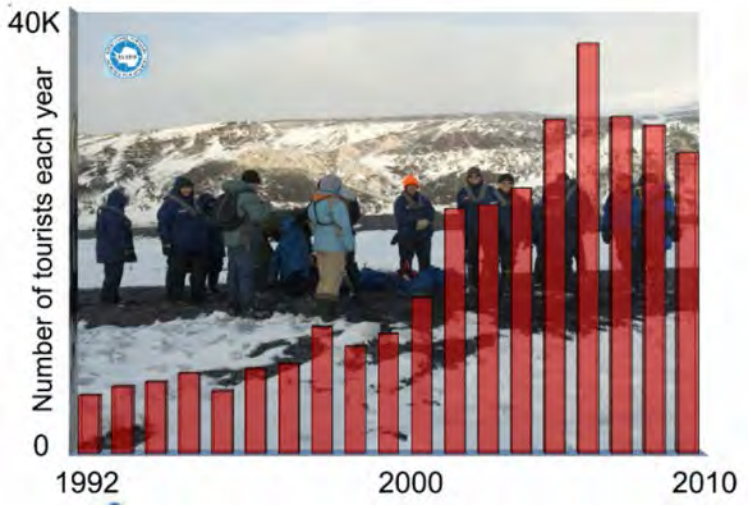


Antarctic Life on the Precipice
General Themes

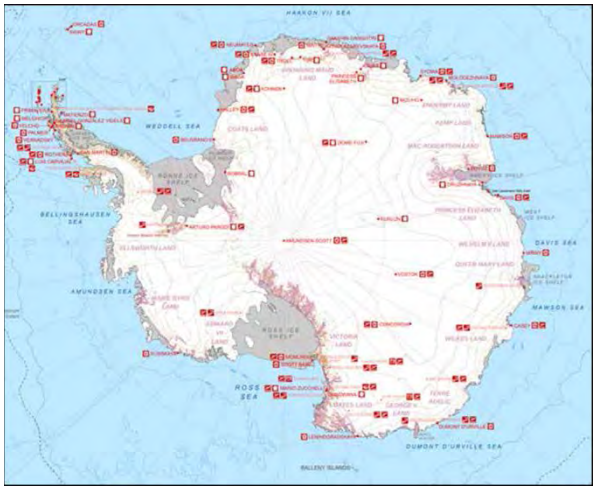
- Genomics, evolutionary rates, adaptation
- Responses to change, extreme events and thresholds
- Dispersal characteristics of diseases, invasive species, indigenous groups
- Deep sea responses to changing environments
- Trophic interactions, resource harvesting, biological indicator efficacy
- Conservation both *in situ* and *ex situ*
- Evidence-based advice to conservation policy
- Sensing and data handling systems

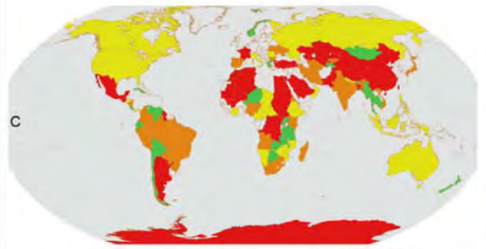
Human presence in Antarctica

Tourism



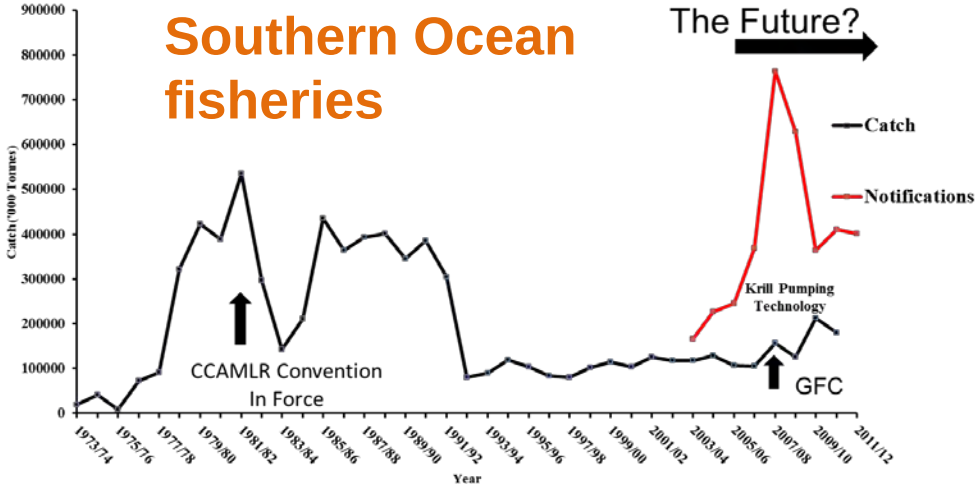
Scientific footprint





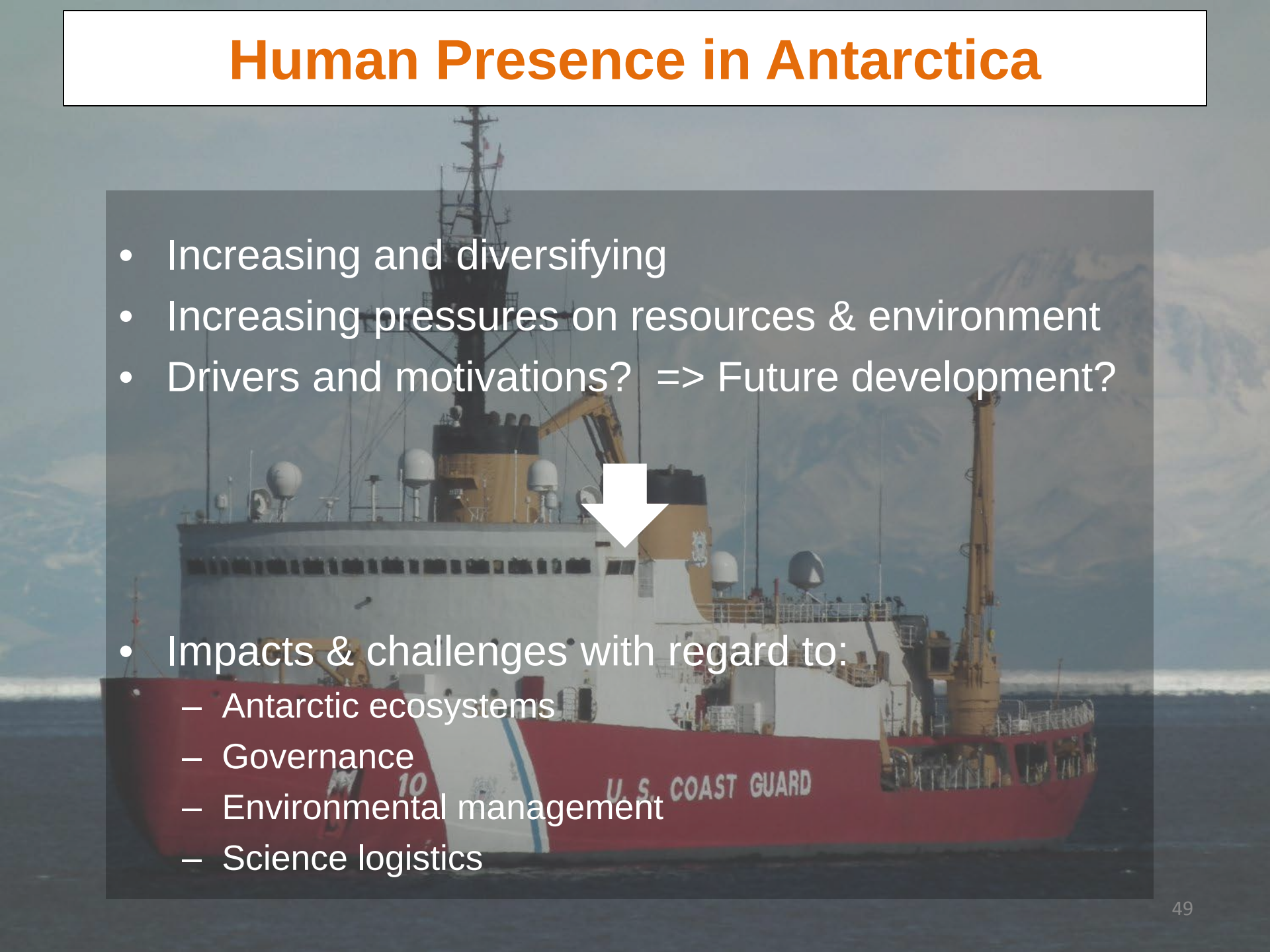
Antarctica: 69th out of 84, between Mali and Kazakhstan

Southern Ocean fisheries



Conservation, protection ecosystem services, and governance

Human Presence in Antarctica



- Increasing and diversifying
- Increasing pressures on resources & environment
- Drivers and motivations? => Future development?

- Impacts & challenges with regard to:
  - Antarctic ecosystems
  - Governance
  - Environmental management
  - Science logistics

Antarctic tourism

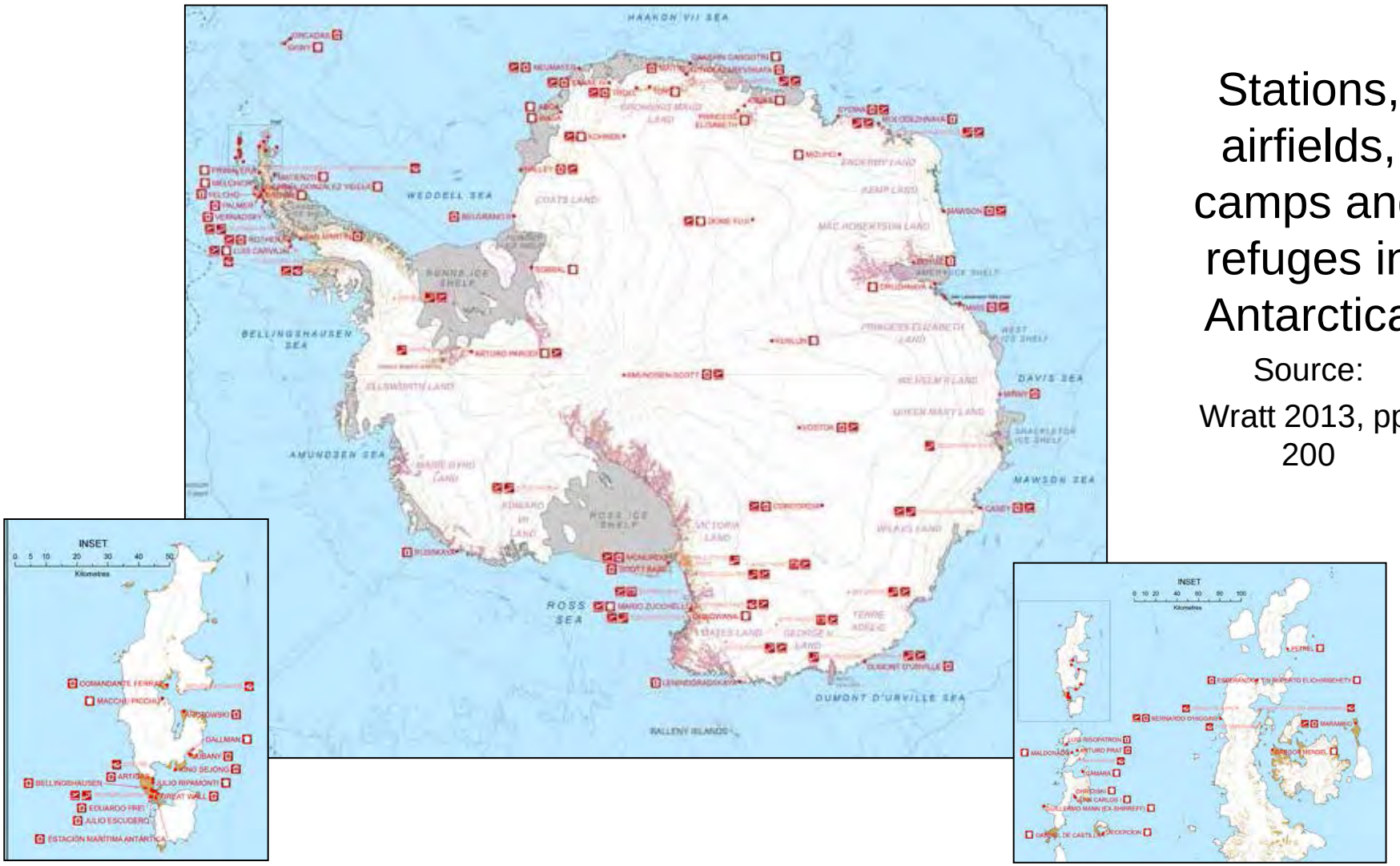
Photo: AFP

National Geographic

Number of tourists visiting Antarctica per season

(based on IAATO data)

Scientific footprint

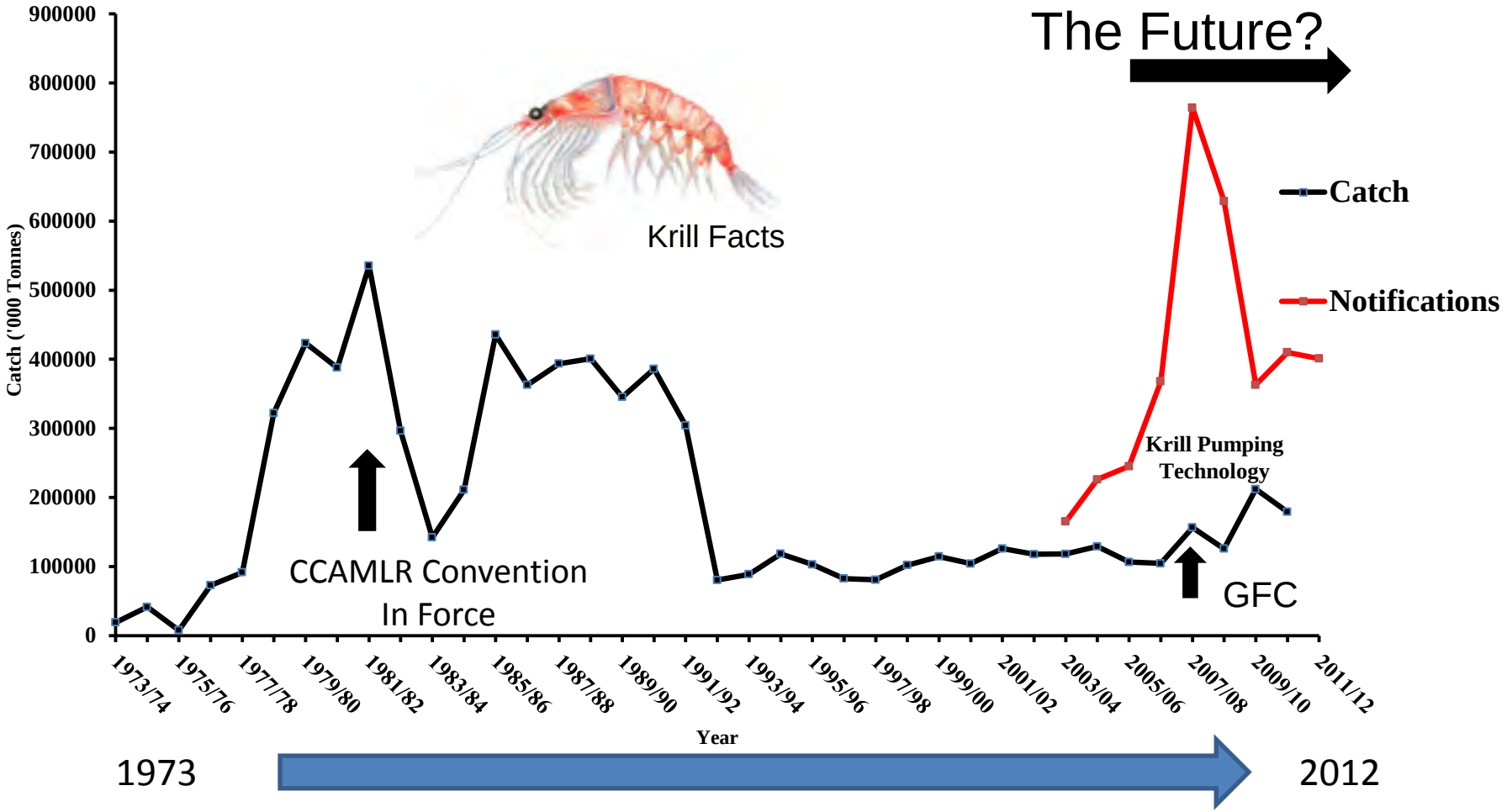


Stations, airfields, camps and refuges in Antarctica

Source:

Wratt 2013, pp. 200

Southern Ocean fisheries



Total krill catches reported to CCAMLR

Source: Miller 2014, p.69

Antarctic Protected Areas

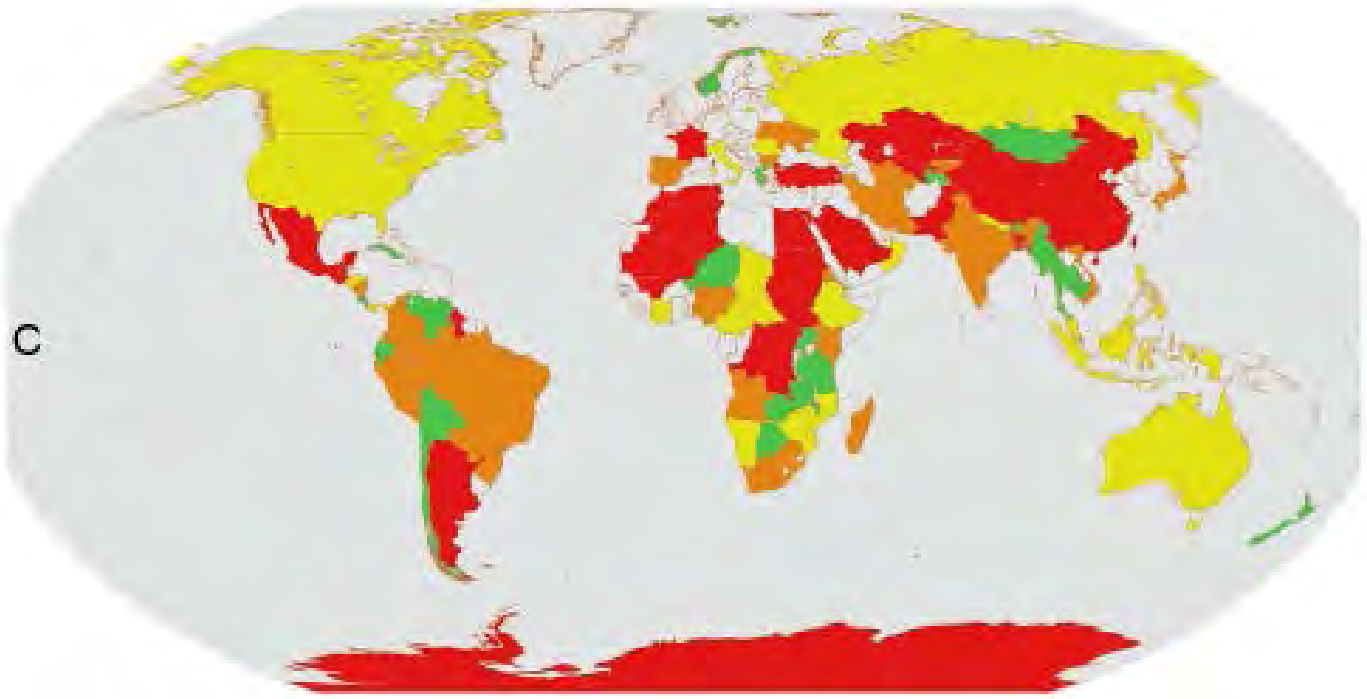
OPEN ACCESS Freely available online

PLOS | BIOLOGY

Perspective

Antarctica's Protected Areas Are Inadequate, Unrepresentative, and at Risk

Justine D. Shaw[1,2*], Aleks Terauds[2], Martin J. Riddle[2], Hugh P. Possingham[1], Steven L. Chown[3]



Antarctica: 69th out of 84, between Mali and Kazakhstan

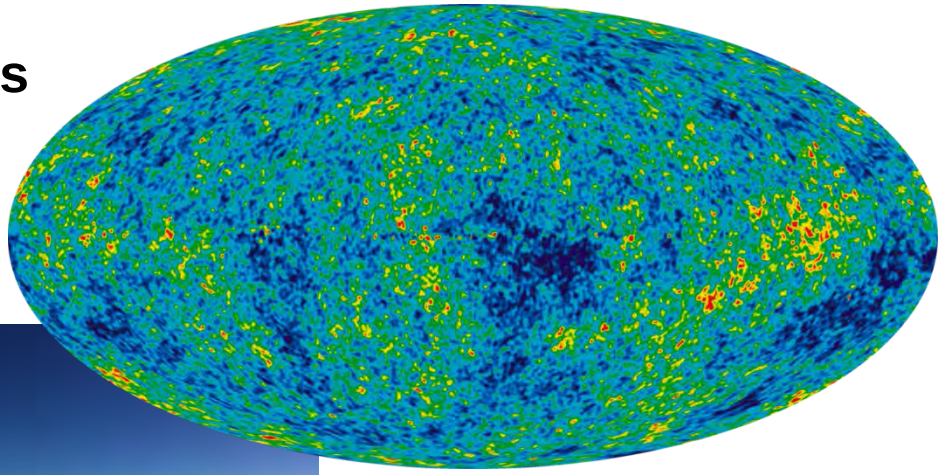
Human Presence in Antarctica

Research Requirements

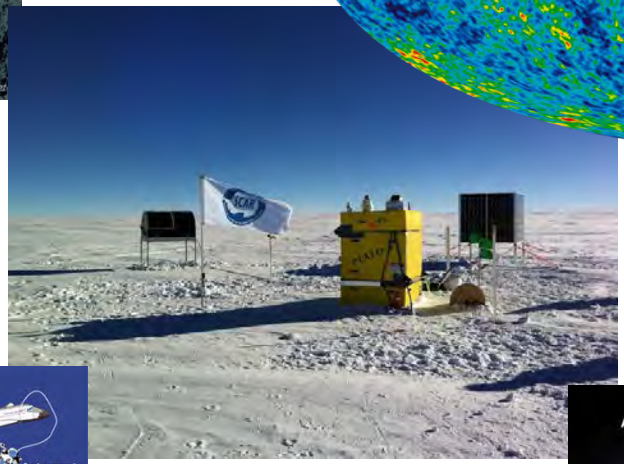
- Understanding, evaluating and forecasting …
  - future human activities in the Antarctic
  - the impacts of large-scale human modifications
  - the effectiveness of Antarctic tourism regulation
  - the effect of state and non-state actors on Antarctic governance and the free conduct of science
  - the value of economic and non-economic Antarctic ecosystem services
  - the adaptation of humans, diseases and pathogens
  - the difference between anthropogenic & natural change

Near-Earth space and beyond – eyes on the sky

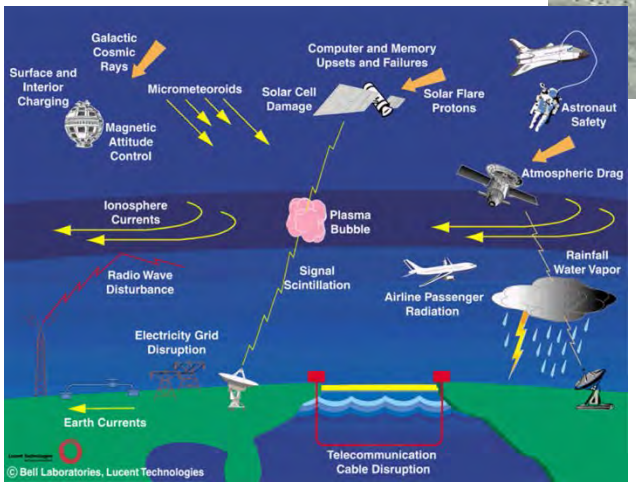
The origins of the Universe



Life beyond Earth



The nature of the dark Universe



Space weather

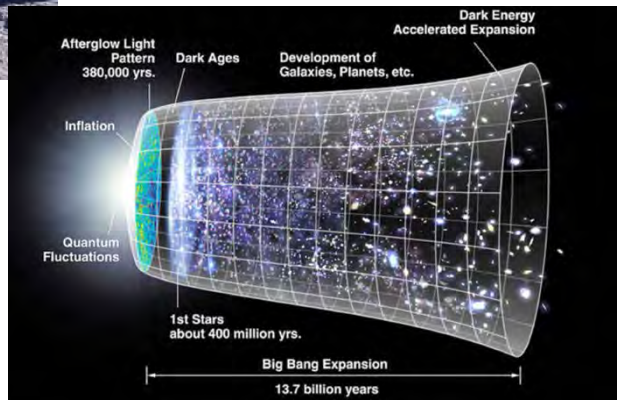



Image: Daniel Luong-Van

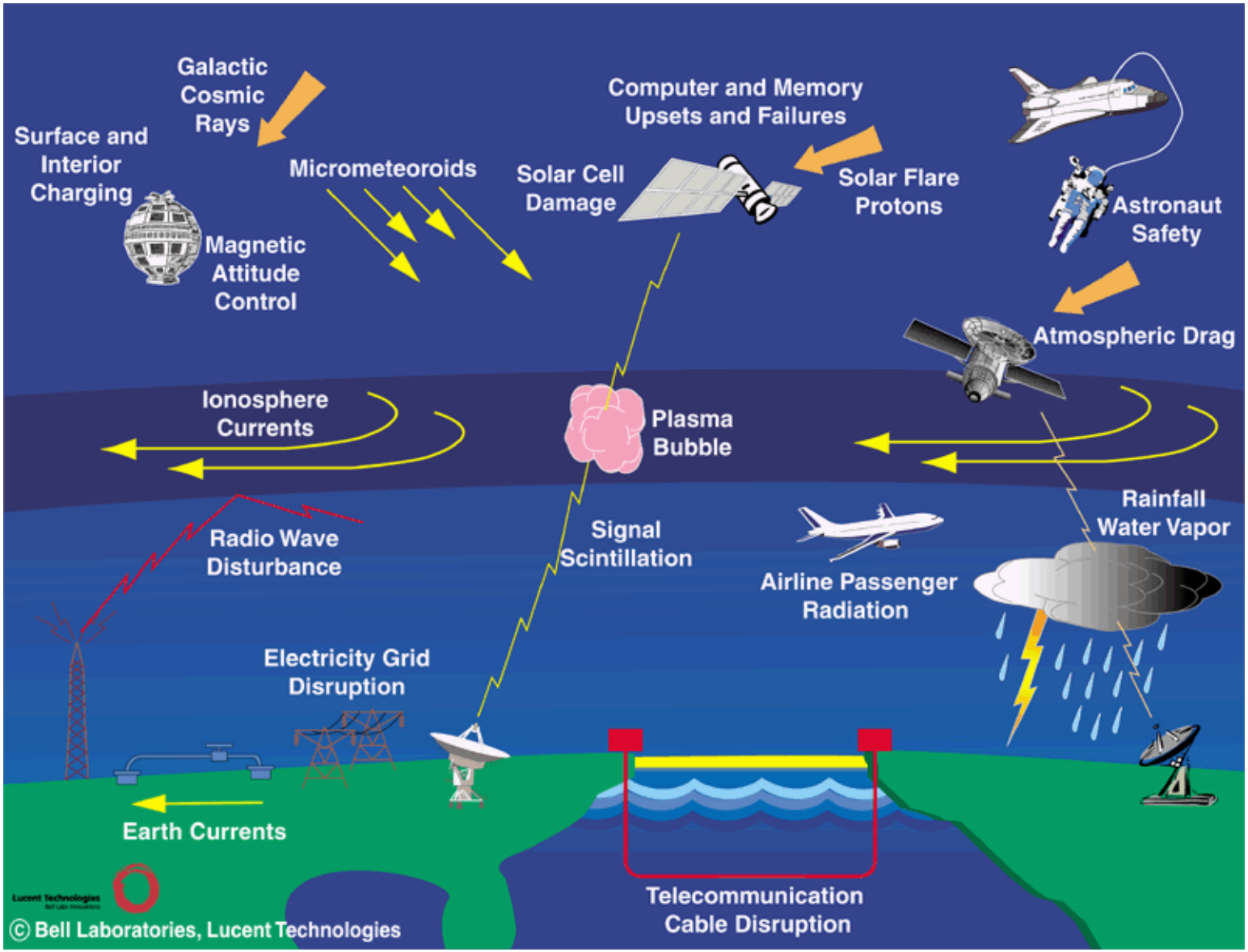
Antarctica—a special place for space scientists…

- The Earth's magnetic field lines funnel high-energy charged particles to the poles.
- The poles represent unique points in the Earth's atmospheric circulation system.

…and astronomers

- Antarctica has the clearest, most transparent and stable skies on the planet.
- Vast quantities of pure ice act as natural detectors for high energy particles.

Question #72. How does space weather influence the polar ionosphere and what are the wider implications for the global atmosphere?



Question #70: What is the nature of the dark Universe and how is it affecting us?

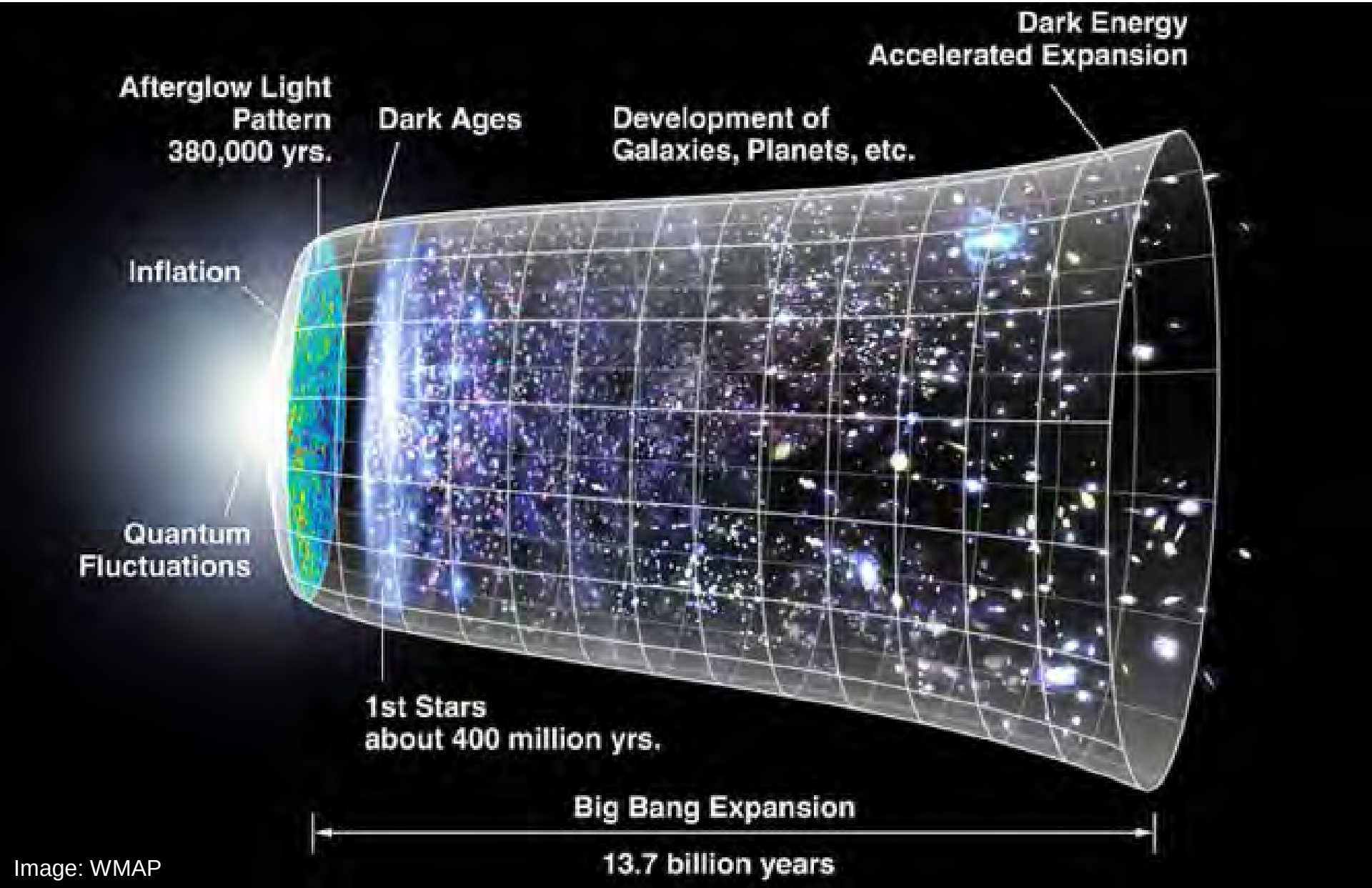
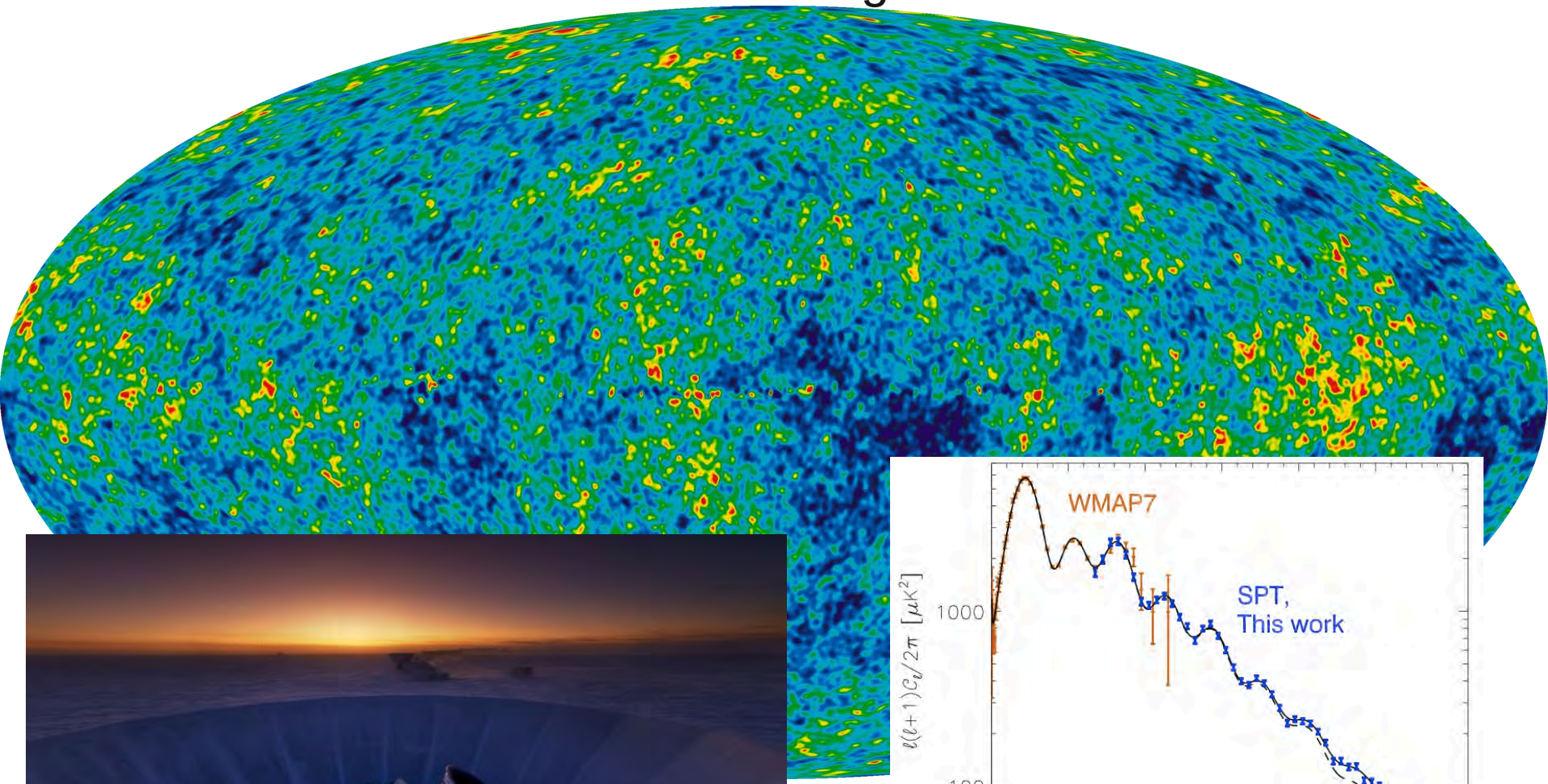


Image: WMAP

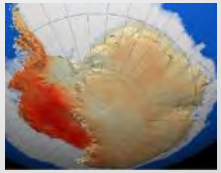
Question 69: What happened in the first second after the Universe began?



Keisler et al., 2011

THE CHALLENGE…

SUSTAIN STABLE FUNDING



Stieg et al 2009

PROVIDE ACCESS

Region-wide

Year-round

COMMUNICATE

with all stakeholders

Realizing the promise of Antarctic science

APPLY EMERGING TECHNOLOGIES

ENHANCE INTERNATIONAL COOPERATION

STRENGTHEN ENVIRONMENTAL PROTECTION

Publications

7 August 2014 Issue

COMMENT

Six priorities for Antarctic science

Mahlon C. Kennicutt II, Steven L. Chown and colleagues outline the most pressing questions in southern polar research, and call for greater collaboration and environmental protection in the region.

Online
August 2014

Process
and Outcomes

Presentations

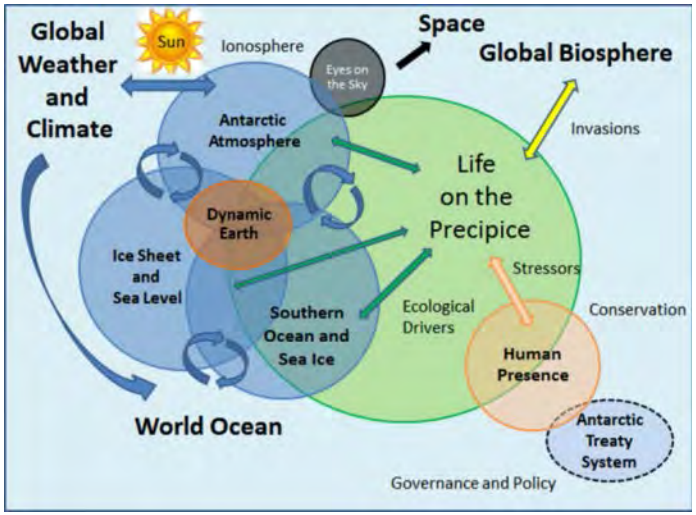
- *U.S. National Academies: May 2014, Washington, DC*
- *NZARI/Antarctica New Zealand: June 2014, Christchurch, NZ*
- **SCAR Biennial Meetings: Open Science Conference, Special Event; Aug.-Sept. 2014, Auckland NZ**
- Polar Research Institute of China: October 14-16, 2014 (Shanghai and Beijing, China)
- UK SCAR National Committee: October 27, 2014, London, UK
- IASC ICARP III Executive Committee – November 2014, Potsdam, Germany
- (National Polar Research Institute: TBA 2015, Tokyo, Japan
- World-wide Regional Meetings: South America, Pacific Rim, Europe; TBA

To Reach the Horizon:

“A coordinated, portfolio of interdisciplinary science, based on enhanced international collaboration as no one scientist, program or nation can realize these aspirations alone.”

"The best way to predict the future is to invent it.”

A. Kay



"Tomorrow belongs to those who prepare for it today.”

paraphrase of an African proverb

QUESTIONS?