INTERNATIONAL SCHOOL OF SPACE SCIENCE

THE POLAR UPPER ATMOSPHERE: FROM SCIENCE TO OPERATIONAL ISSUES

17-21 September 2018, L'Aquila (Italy)

Overview of the SCAR Programme

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INTRODUCTION I

The Continent of Antarctica is the coldest, driest, windiest, and iciest continent on Earth. Antarctica is the fifth largest on Earth. It covers over five million square miles; the last continent to be explored.

It is the only continent with no permanent residents. Only two percent of Antarctica is not covered by ice. The ice sheet covers almost all the continent and holds about 70 percent of the fresh water in the world.

Ice shelves, sheets of ice that connect to land on one side and float on water, line much of the coastline. Areas away from the ocean are much colder and drier than coastal areas.

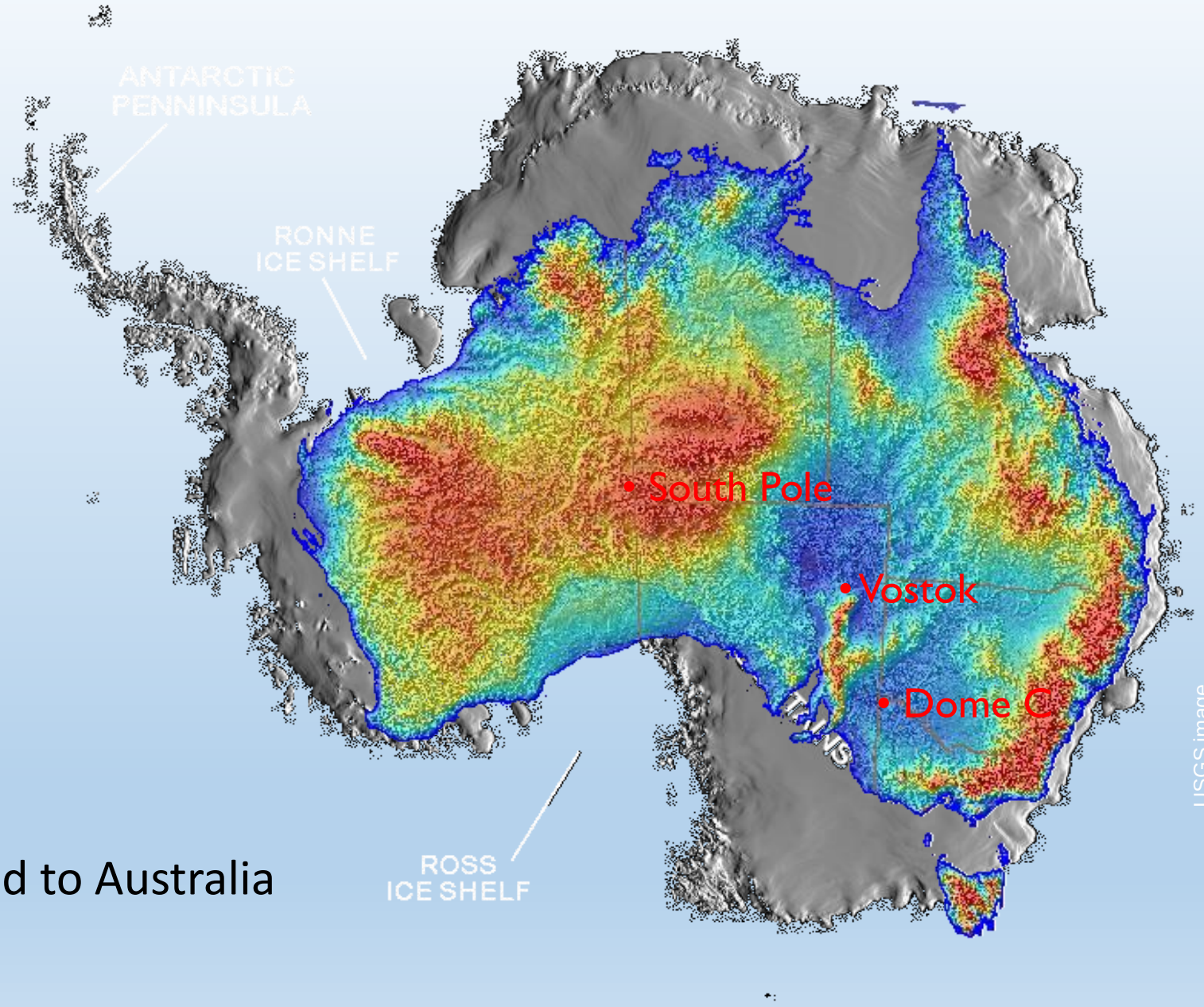
Inland winter temperatures from May to August may fall to -85 C and more below zero. The Transantarctic Mountains divide the continent into eastern and western parts.

INTRODUCTION II

The Atlantic, Indian, and Pacific oceans meet around Antarctica to form the Southern Ocean. Norwegian whalers first landed on Antarctica by the 1890s. Several explorers soon followed. Robert Falcon Scott and Ernest Shackleton led expeditions. Amundsen reached first the south pole, Scott lost his life on the harsh land. In 1929, Robert Byrd from the United States was the first person to fly a plane over the South Pole.

A few animals live around the continent and partially on it. Animals from tiny shrimp-like krill to enormous whales live there but in the Ocean. Only birds, penguins, and seals share the coast.

Also a few lichens, mosses, and insects live there, also mainly along the coast. Few living things can survive the cold, dry climate of Antarctica's interior.

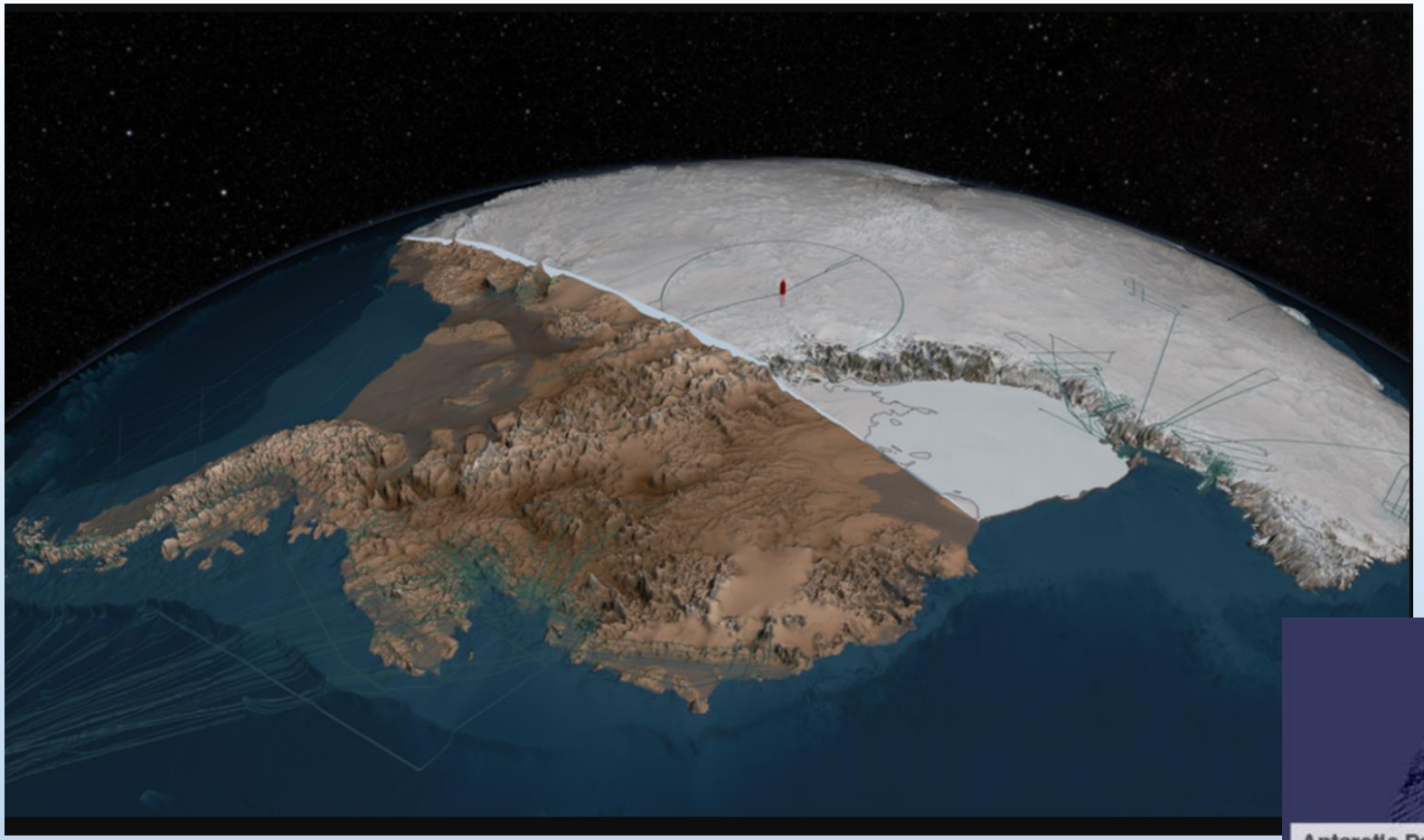


Size compared to Australia

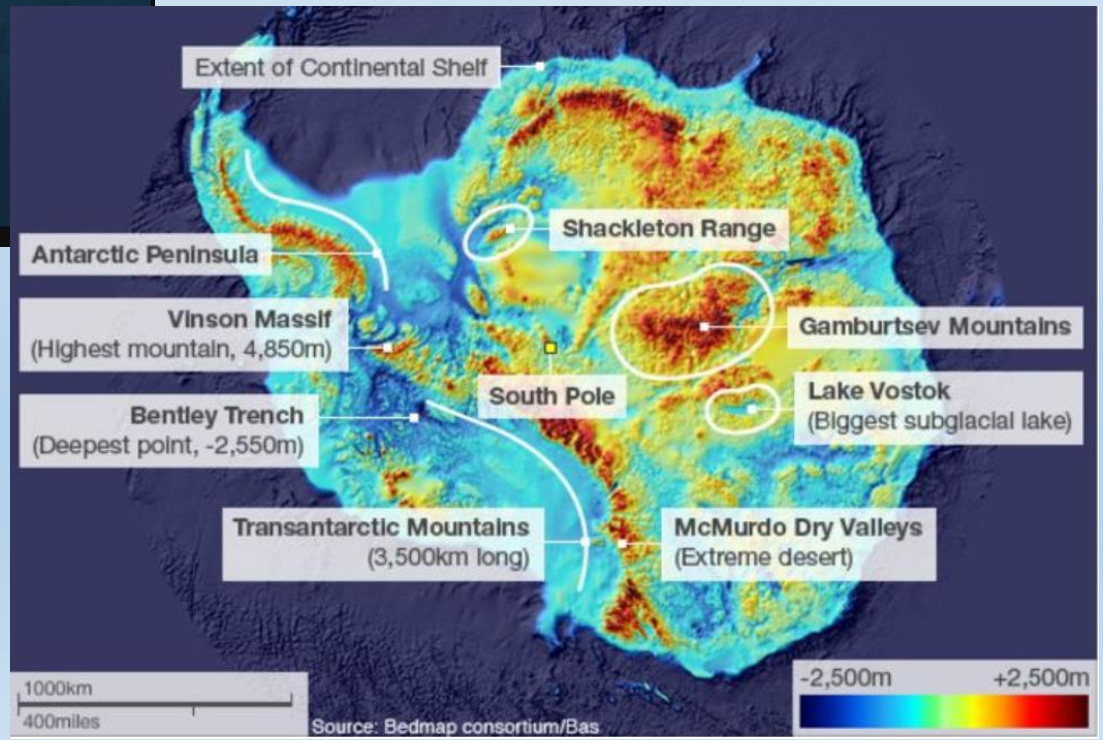
Geographic names of the Antarctic Continent and surrounding Oceans

Some Numbers on Antarctica

Total surface (including ice Shelves)		13,8 Millions km^2
Continental Area (including islands)		12,1 Millions km^2
	Europe	10,5 Millions km^2
	Usa	9,4 Milioni km^2
Ice free areas ~2,4%, along coastal areas, TAM and Peninsula		331,700 km2
Total Ice volume (including Ice Shelves)		26.600.000 km^3
Ronne-Filchner Ice shelf		507.000 km^2
Ross Ice Shelf		506.000 km^2
Amery Ice Shelf		43.000 km^2
Other Ice Shelves		671.000 km^2
Average elevation		2.500 m
Highest mountain	(Vinson Massif)	4.897 m
Maximum Ice thickness (Terra Adélie)		4.776 m
Deepest Depression (subglacial Bentley Trench)		-2.555 m



BAS new 3D map of Antarctica's ice and bedrock. The map, called Bedmap2, incorporates millions of new measurements, including data collected by NASA's ICESat satellite and airborne Operation IceBridge mission.

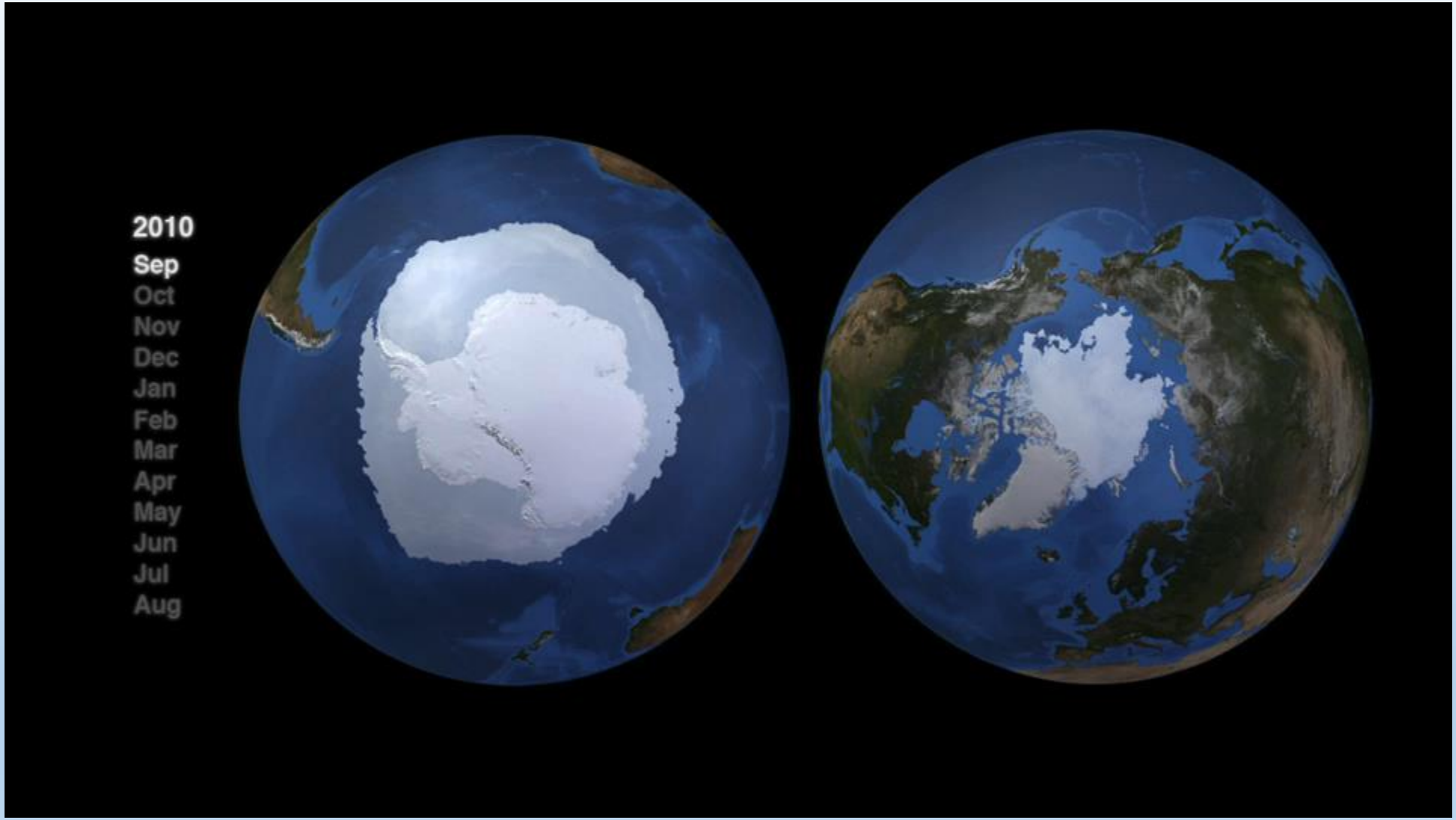


Total Ice volume (including Ice Shelves)
26.600.000 km³

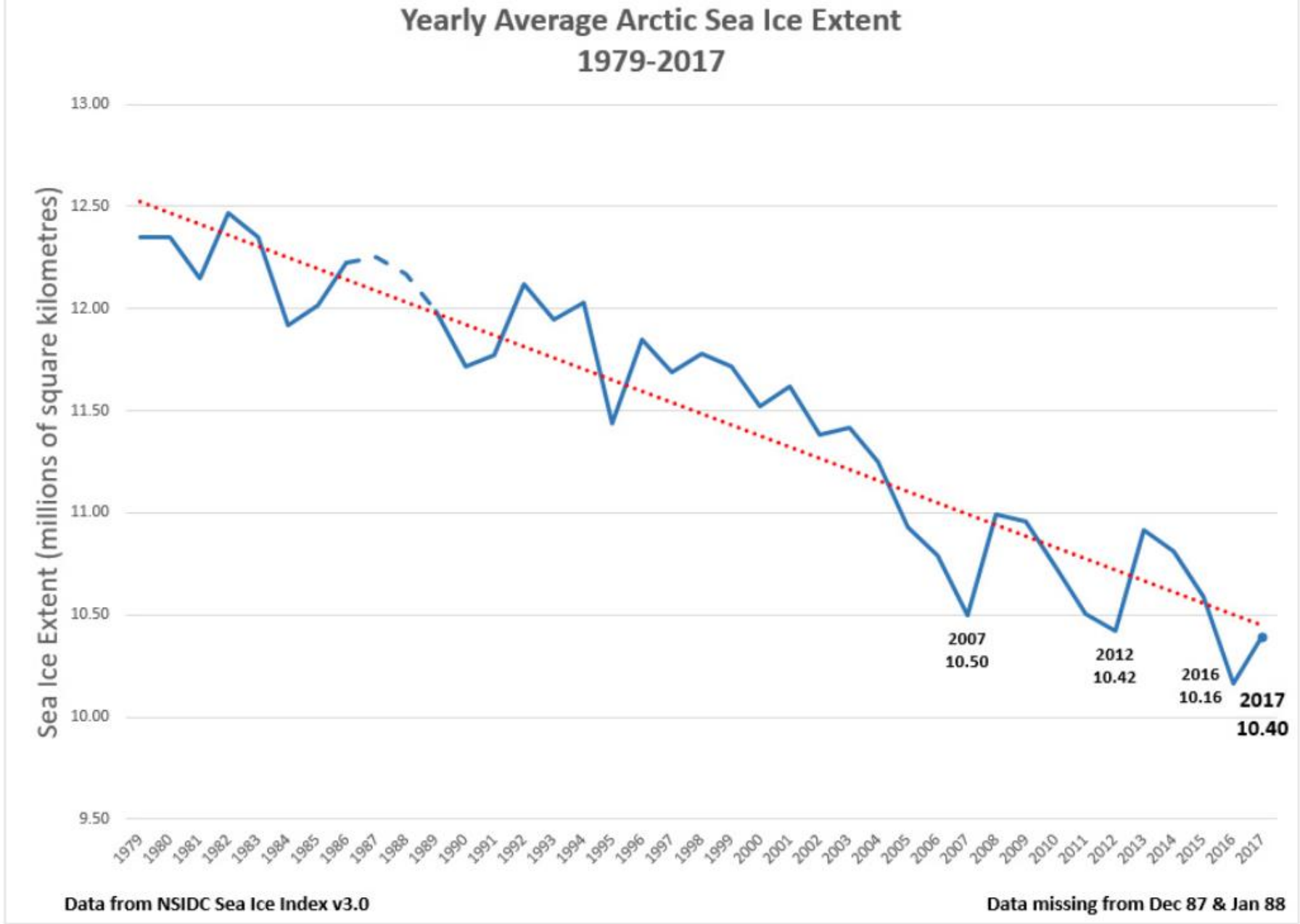
South Pole

Antarctic and Artic OCEAN ICE seasonal variation

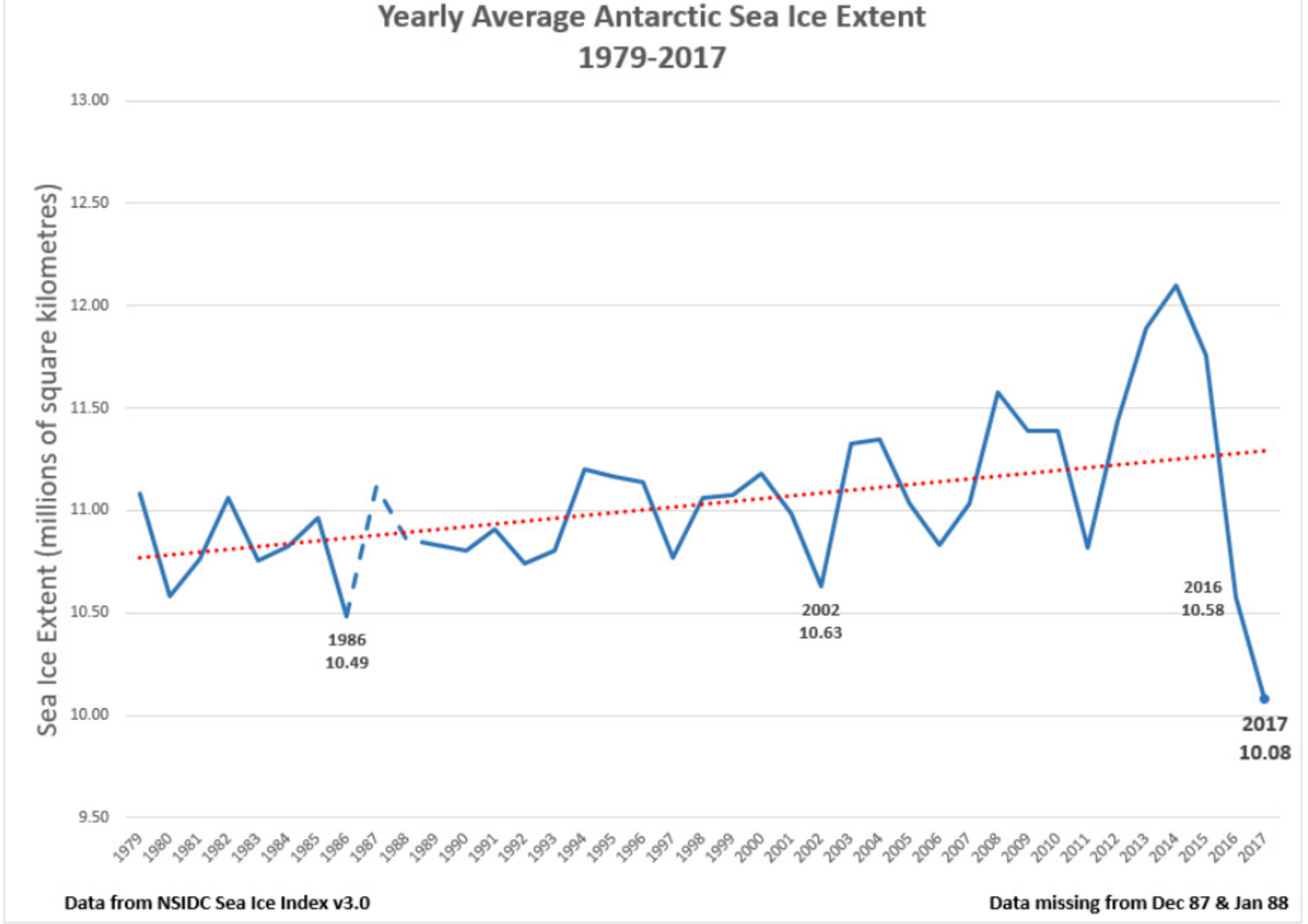
North Pole



September



Annual average Arctic sea ice extent, from 1979 to 2017. Although the long-term trend remains negative, 2017 actually finished the year at 10.4 million sq. km, roughly 260,000 sq. km larger than 2016's record low. Missing data from Dec '87 and Jan '88 prevent an accurate annual average for those two years. Credit: NSIDC/Scott Sutherland



Annual average Antarctic sea ice extent, from 1979 to 2017. The long-term trend is positive for sea ice around the Antarctic continent, but 2016 and 2017 are showing an alarming drop away from that trend. Missing data from Dec '87 and Jan '88 prevent an accurate annual average for those two years. Credit: NSIDC/Scott Sutherland

The declining of Arctic sea ice is one of Earth's greatest seasonal habitat changes. In Antarctica the extent of the sea ice has increased modestly since the 1970s, with high inter-annual variability, and there is now evidence of longer-term decline in its extent.

In austral winter, Antarctica and the surrounding ocean are covered in a 31.6 million km2 cap of ice. Of this, approximately 18.5 million km2 is formed as sea ice when the ocean freezes, 11.9 million km2 is a near-permanent ice sheet resting on land or the sea floor and 1.6 million km2 is contained within longlived ice shelves that are floating extensions of the continental ice.

Each element plays its role in the climate system; the grounded ice is Earth's primary freshwater reservoir, the ice shelves are a major source of ocean fresh water, and the sea ice is an important factor in the planetary albedo.

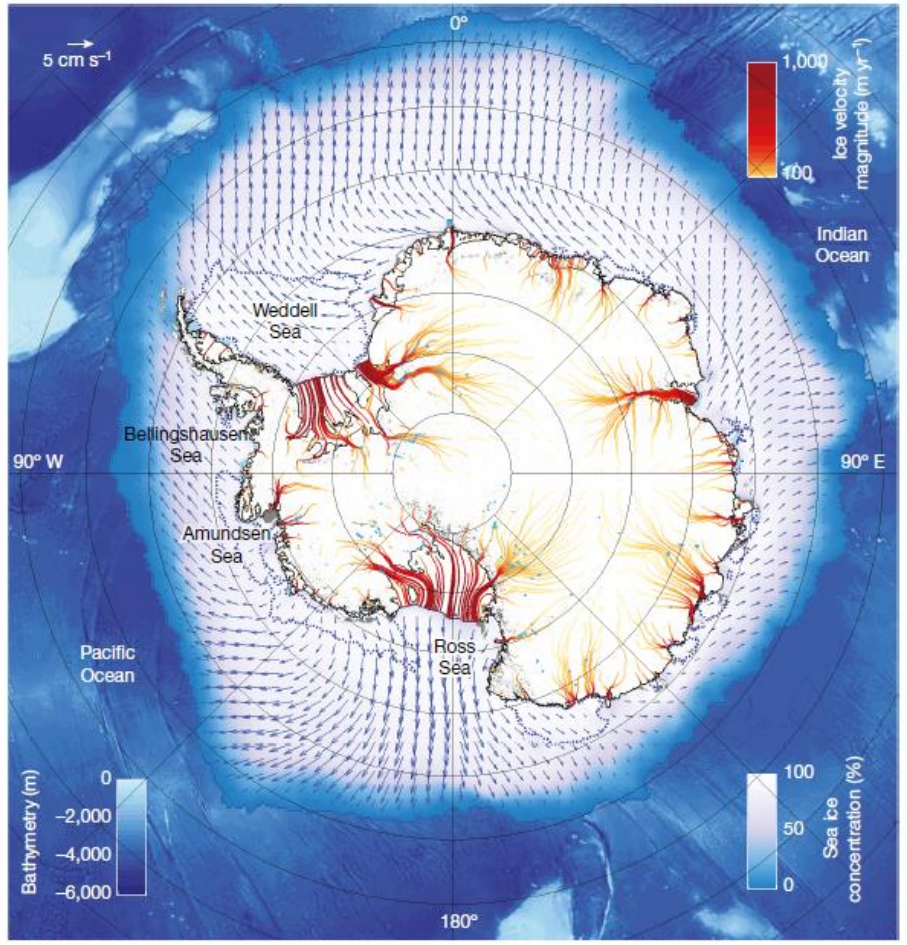
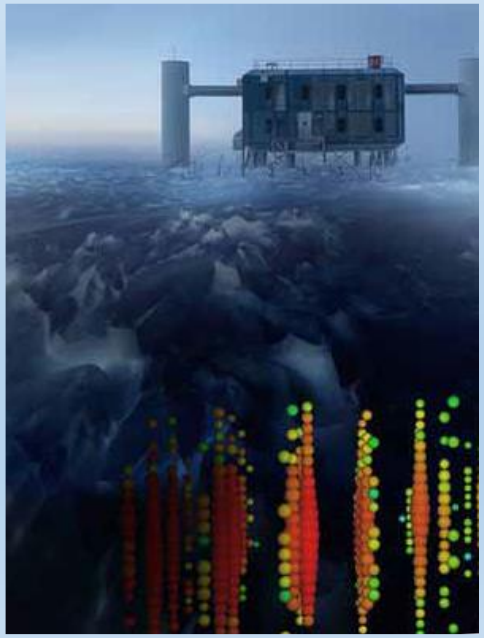


Fig. 1 | Average annual motion of the Antarctic ice sheet and ice shelves, and of the surrounding sea ice in winter. The ice sheet is drained by around 30 principal flow units and the sea ice transport is generally northwards, with gyres in the Ross and Weddell seas. Grounded-ice and ice-shelf motion are derived from multiple satellite interferometric synthetic aperture radar data acquired[20] between 2007 and 2009. Ice sheet motion flowlines are superimposed on the MODIS mosaic of Antarctica[142]. Imagery from the NASA MODIS instrument, courtesy NASA NSIDC DAAC. Sea ice motion is the mean of daily gridded Polar Pathfinder radiometry obtained during peak winter (September) of each year in the period[143] 1990 to 2016. Sea ice motion vectors are superimposed on a map of mean sea ice concentration derived from passive microwave brightness temperatures[144] in September 1990 to 2016. Also shown are the average minimum extent of sea ice recorded[144] between 1990 to 2016 (blue dashed boundaries), the grounded ice sheet and the floating ice shelves (black boundaries), and the bathymetry of the surrounding ocean[145]. Active subglacial lakes (light blue) were mapped using satellite radar and laser altimetry[51].

From **Trends and connections across the Antarctic cryosphere**
Andrew Shepherd1*, Helen Amanda Fricker2 & Sinead Louise Farrell, 2018



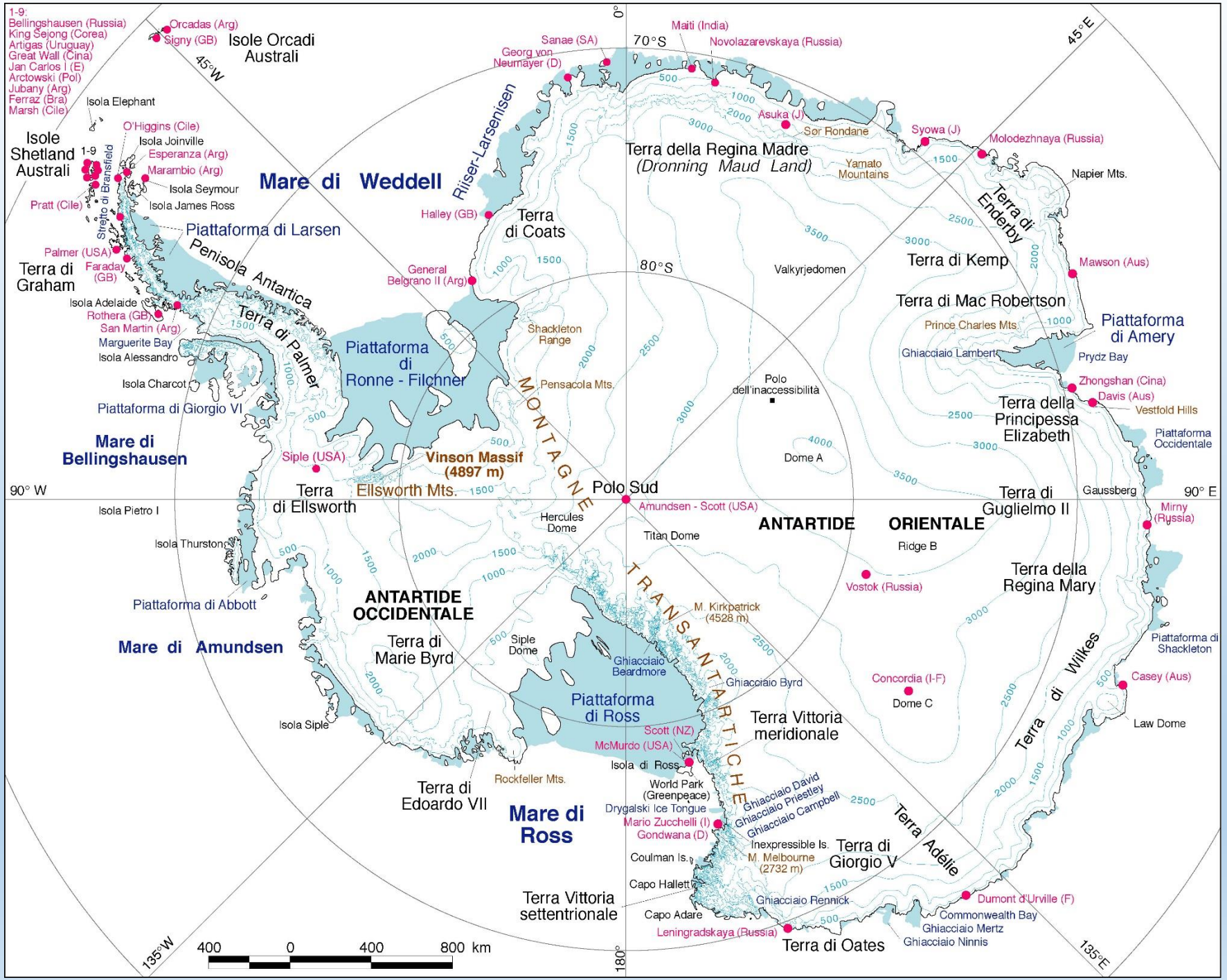
INTRODUCTION III

Today, scientists from more than 25 countries are the main inhabitants of Antarctica.

Since 1959, more than 30 nations have signed the Antarctic Treaty. This treaty stated that the continent would be used for Science (research) and Peace (no sovereignty or military activity). Scientists from around the world gather in Antarctica only to conduct research. Countries would share the research results.

Planetary global warming could affect severely the icecap and melt the ice there. This polar melt would go to the seas increasing the world sea level. If all Antarctic ice would be melted, this would mean a 65-70 m global sea level increase.

Human Settlements



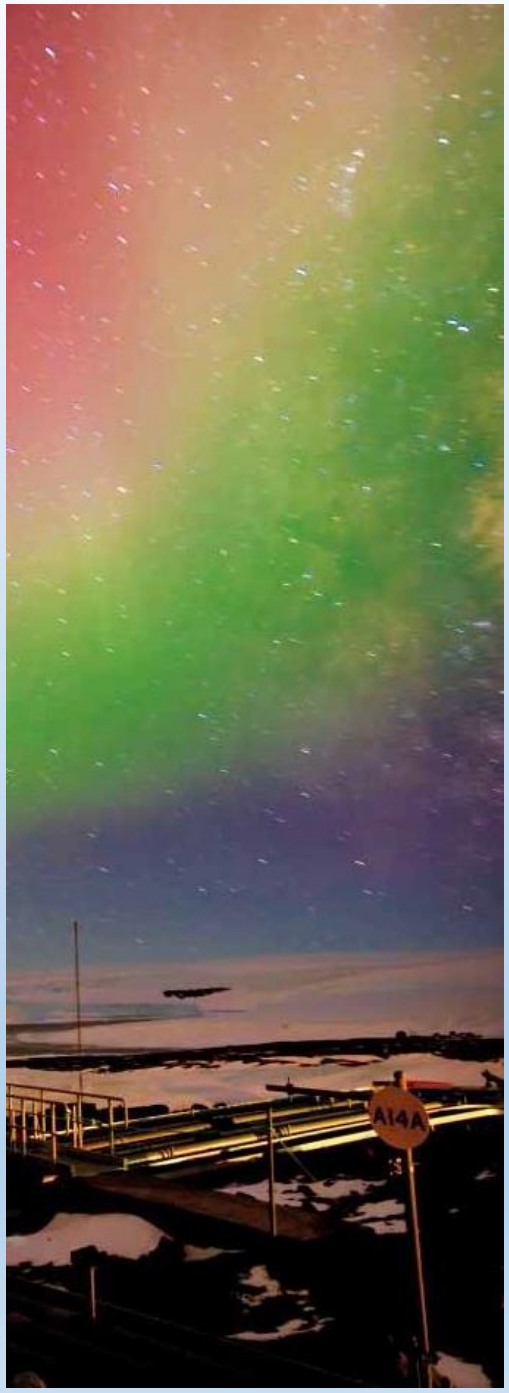
SCIENTIFIC VALUE OF RESEARCH IN AND ON ANTARCTICA I

Antarctica is the continent that much less than the others has been explored.

Because of its geographical position and physical characteristics it is home to a unique flora and fauna, whose study enlightens the complex relationship between living organisms and the environment.

Due to the distance from the main sources of pollution and the almost total absence of anthropic disturbance, Antarctica provides us with the opportunity to obtain some global knowledge of the planet from a remote observation point.

The ice of Antarctica contains the record of snow precipitation over several past hundreds of thousands of years, thus providing an insight on past climate.



SCIENTIFIC VALUE OF RESEARCH IN AND ON ANTARCTICA II

Because of its location with respect to the geomagnetic field, Antarctica (as well as the Arctic region) enables us to study phenomena ensuing the interactions between the Sun and the Earth.

The transparency of the atmosphere makes it ideal for astronomic observation, consequently for cosmological research.

The harsh conditions and isolation of some Stations may also turn an Antarctic expedition into an efficient training field for space missions.

The Antarctic values have also driven scientists to get acquainted with specific problems and most advanced technologies; last but not least, to interface with the large spectrum of international research in progress in Antarctica now and for the years to come.

SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH, SCAR I

Antarctic scientists have been providing information about the state of the continent and its surrounding seas since polar exploration began going back to the 19th century and more effectively in the last century.

That work was galvanized especially by the International Geophysical Year of 1957-58 (IGY) that represented the first really coordinated study action in Antarctica

Realizing the importance of continuing international Antarctic collaboration at the end of the IGY, the Scientific Committee on Antarctic Research (SCAR) was established to facilitate and coordinate it.

So SCAR as an inter-disciplinary committee of the International Council for Science (ICSU) was born.

SCAR held its first meeting in The Hague on 3-5 February 1958, and February 5 th, 2018 represented SCAR's formal 60th birthday.

SCAR II

•SCAR initiates, develops and coordinates high quality international scientific research in the Antarctic region.

•The scientific business is conducted by SCAR Science Groups which represent the scientific disciplines active in Antarctic research.

•SCAR provides objective, independent scientific advice to the Antarctic Treaty Consultative Meetings and other organizations such as the UNFCCC& IPCC

A modern view of ‘Antarctic Science’ is not only the knowledge of the continent life, structure and history but also the understanding of the wide-ranging regional and global effects of change taking in Antarctica and the Southern Ocean.

SCAR III

SCAR's scientific work is achieved through the engagement and support of thousands of researchers from around the world who together comprise the SCAR community, supported by SCAR's 43 national committees reporting to their national academies of science or equivalent bodies.

SCAR adds value to national scientific activities by addressing topics covering the whole of Antarctica or the surrounding Southern Ocean in ways impossible for any one nation to achieve alone.

A key part of its mission is also to provide independent and objective scientific advice to the policy makers of the Antarctic Treaty and other intergovernmental bodies.

SCAR's governing body, the International Council for Science, recently merged with the International Social Science Council to form the International Science Council… Amendments to the SCAR website are in progress and the SCAR logo has been updated to reflect the change of name…

SCAR MISSION

To be engaged, active, forward-looking organisation that promotes, facilitates and delivers scientific excellence and evidence-based policy advice on globally significant issues in and about Antarctica.

Map of SCAR member countries in 2017

Full Members
Associate Members
Union Members:
International Astronomical Union - IAU
International Geographical Union - IGU
International Union for Quaternary Research - INQUA
International Union of Biological Sciences - IUBS
International Union of Geodesy and Geophysics - IUGG
International Union of Geological Sciences - IUGS
International Union of Physiological Sciences - IUPS
International Union of Pure and Applied Chemistry - IUPAC
Union Radio Scientifique International - URSI

30 Full Members: Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, Chile, China, Ecuador, Finland, France, Germany, India, Italy, Japan, Korea (Rep. of), Malaysia, Netherlands, New Zealand, Norway, Peru, Poland, Russia, South Africa, Spain, Sweden, Switzerland, United Kingdom, Uruguay, USA,

13 Associate Members: Austria, Colombia, Czech Republic, Denmark, Iran, Monaco, Pakistan, Portugal, Romania, Thailand, Turkey, Ukraine, Venezuela.

9 ICSU Scientific Union Members: International Astronomical Union (IAU); International Geographical; Union (IGU); International Union for Quaternary Research (INQUA); International Union of Biological Sciences (IBU); International Union of Geodesy and Geophysics (IUGG); International Union of Geological Sciences (IUGS); International Union of Physiological Sciences (IUPS); International Union of Pure and Applied Chemistry (IUPAC); and Union Radio Scientifique International (URSI).

SCAR is governed by its Memorandum of Association (the legal statement agreed when the organisation became a registered company) and its Articles of Association (the legal rules about how the organisation is run). These two documents form SCAR's Constitution. More detailed rules about the duties and responsibilities of SCAR's members are laid out in the Rules of Procedure. The Rules of Procedure for Subsidiary Bodies describe how SCAR's working groups are established and governed.

The Antarctic Treaty System I

The Antarctic Treaty System is the whole complex of arrangements made for the purpose of regulating relations among states in the Antarctic. At its heart is the Antarctic Treaty itself. The original Parties to the Treaty were the 12 nations active in the Antarctic during the International Geophysical Year of 1957-58. The Treaty was signed in Washington on 1 December 1959 and entered into force on 23 June 1961.

The Consultative Parties comprise the original Parties and other States that have become Consultative Parties by acceding to the Treaty and demonstrating their interest in Antarctica by carrying out substantial scientific activity there.

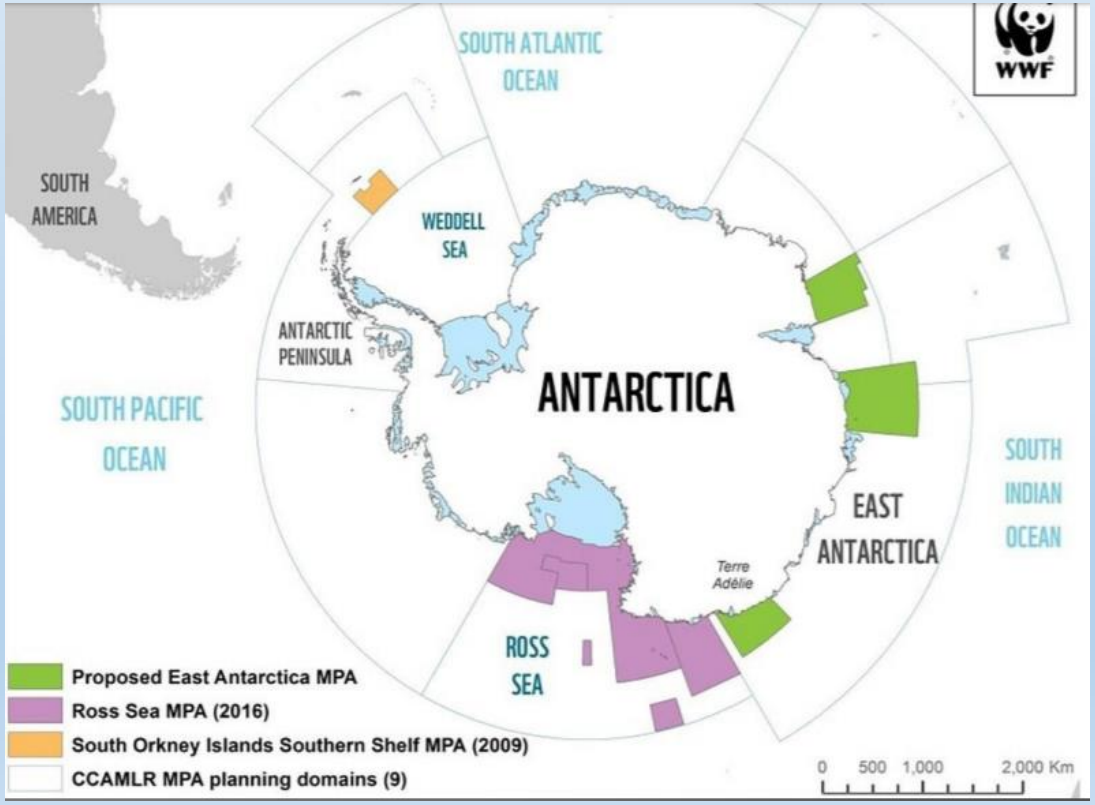
The primary purpose of the Antarctic Treaty is to ensure: **in the interests of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord.**

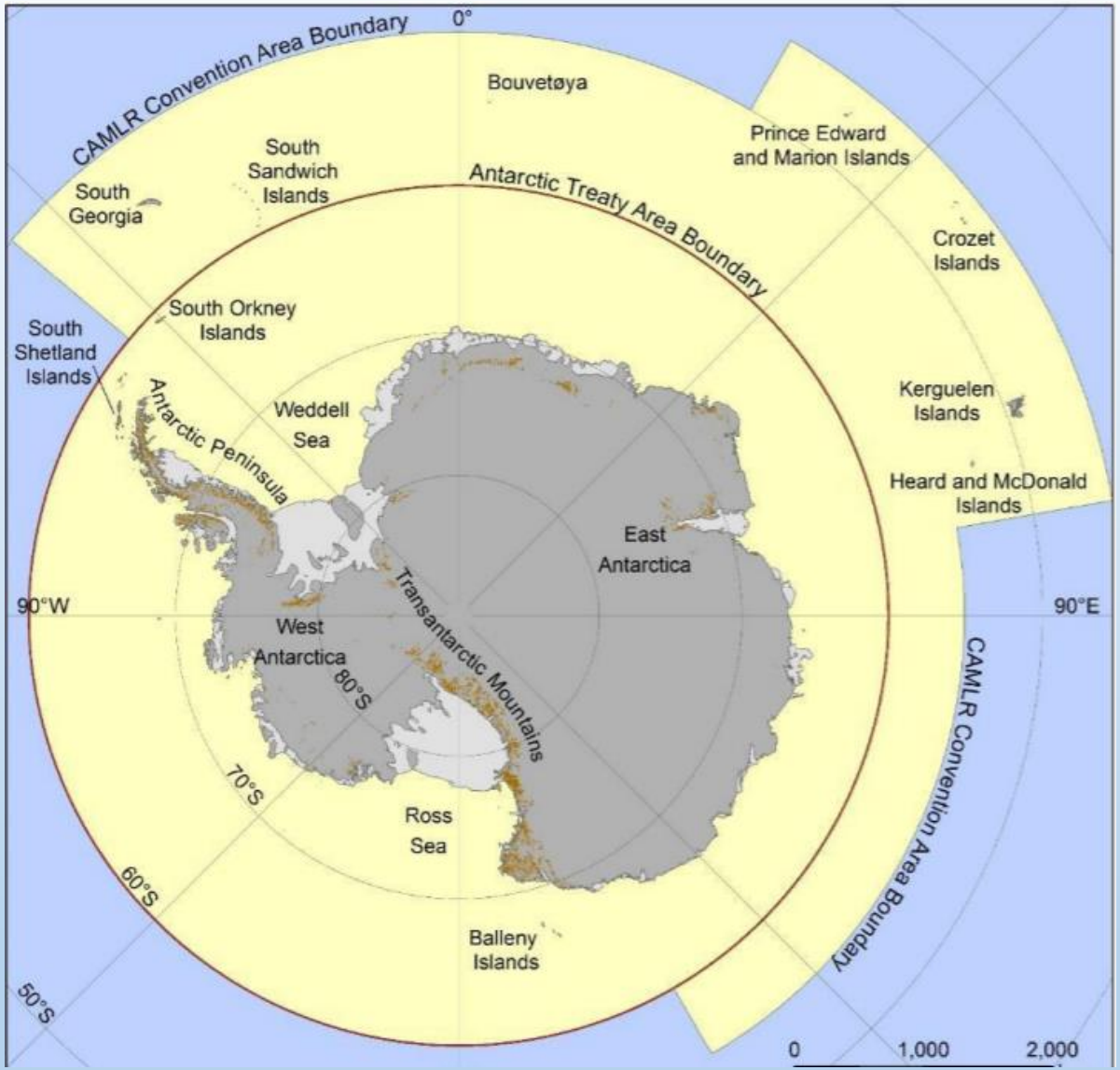
The Antarctic Treaty System II

To this end the ATS prohibits military activity, except in support of science; prohibits nuclear explosions and the disposal of nuclear waste; promotes scientific research and the exchange of data; and holds all territorial claims in abeyance. The Treaty applies to the area south of 60° South Latitude, including all ice shelves and islands.

The Treaty is augmented by Recommendations adopted at Consultative Meetings, by the Protocol on Environmental Protection to the Antarctic Treaty (Madrid, 1991), and by two separate conventions dealing with the Conservation of Antarctic Seals (London 1972), and the Conservation of Antarctic Marine Living Resources (Canberra 1980). The Convention on the Regulation of Antarctic Mineral Resource Activities (Wellington 1988), negotiated between 1982 and 1988, will not enter into force.

The provisions of the Antarctic Treaty apply to the area south of 60° S The CCAMLR area is wider, the Northern limit being close to the Polar Front





Created by a unanimous decision of the CCAMLR, 24 countries, including USA and the EU. **World's Largest Marine Reserve Created Off Antarctica. A 598,000 square-mile protected area (more than twice Texas) will protect everything from penguins to whales.**

Its nutrient-rich waters are the most productive in the Antarctic, leading to huge plankton and krill blooms that support vast numbers of fish, seals, penguins, and whales.

More exactly Ross Sea is “the least altered marine ecosystem on Earth,” citing intact communities of emperor and Adelie penguins, crabeater seals, orcas, and minke whales.

The Antarctic Treaty System III

The Antarctic Treaty Consultative Meeting (ATCM) is now held annually. During each ATCM, there is also a meeting of the Committee for Environmental Protection (CEP). The Scientific Committee on Antarctic Research (SCAR) is an Observer at ATCMs and CEPs, and provides independent and objective scientific advice in a variety of fields, particularly on environmental and conservation matters. For more information on the Antarctic Treaty, please visit the Antarctic Treaty Secretariat website.

SCAR's Standing Committee on the Antarctic Treaty System is responsible for coordinating the advice presented to the Antarctic Treaty Consultative Meetings. This is mainly done through the presentation of papers at the meetings. These papers are coordinated by SCATS and involve many scientists from around the world helping to convey the most recent and up-to-date status of research in any particular area.

> ***Activities shall be planned and conducted…….so as to accord priority to scientific research and to preserve the value of Antarctica as an area for the conduct of such research, including research essential to understanding the global environment" - Article 3(3) of the Protocol***

60 Years of Significant Antarctic Science Discoveries

Antarctic scientists working with SCAR have been involved in many leading scientific discoveries, for example of:

_The Ozone Hole, and elucidation of its chemistry;
_The history of the ice sheet and its implications for changing sea level;
_The circulation of the Southern Ocean and its role in the storage and emission of CO2 and heat;
_The fossil flora of Antarctica, which was covered by flourishing vegetation 100 million years ago, and of Antarctic dinosaurs;
_The 600 million year journey of Antarctica from North Pole to South Pole, under the influence of plate tectonics;
_The sub-ice topography, including the existence of subglacial rivers and lakes;
_The amazing circum-Antarctic land-free travel of albatrosses;
_The extraordinary diversity of marine life;
_The detection of neutrinos originating in outer space;
_Antarctica as an analogue for life and other aspects of planetary development elsewhere.

SCAR ORGANIZATION

Much of SCAR's work is carried out through its subsidiary groups:

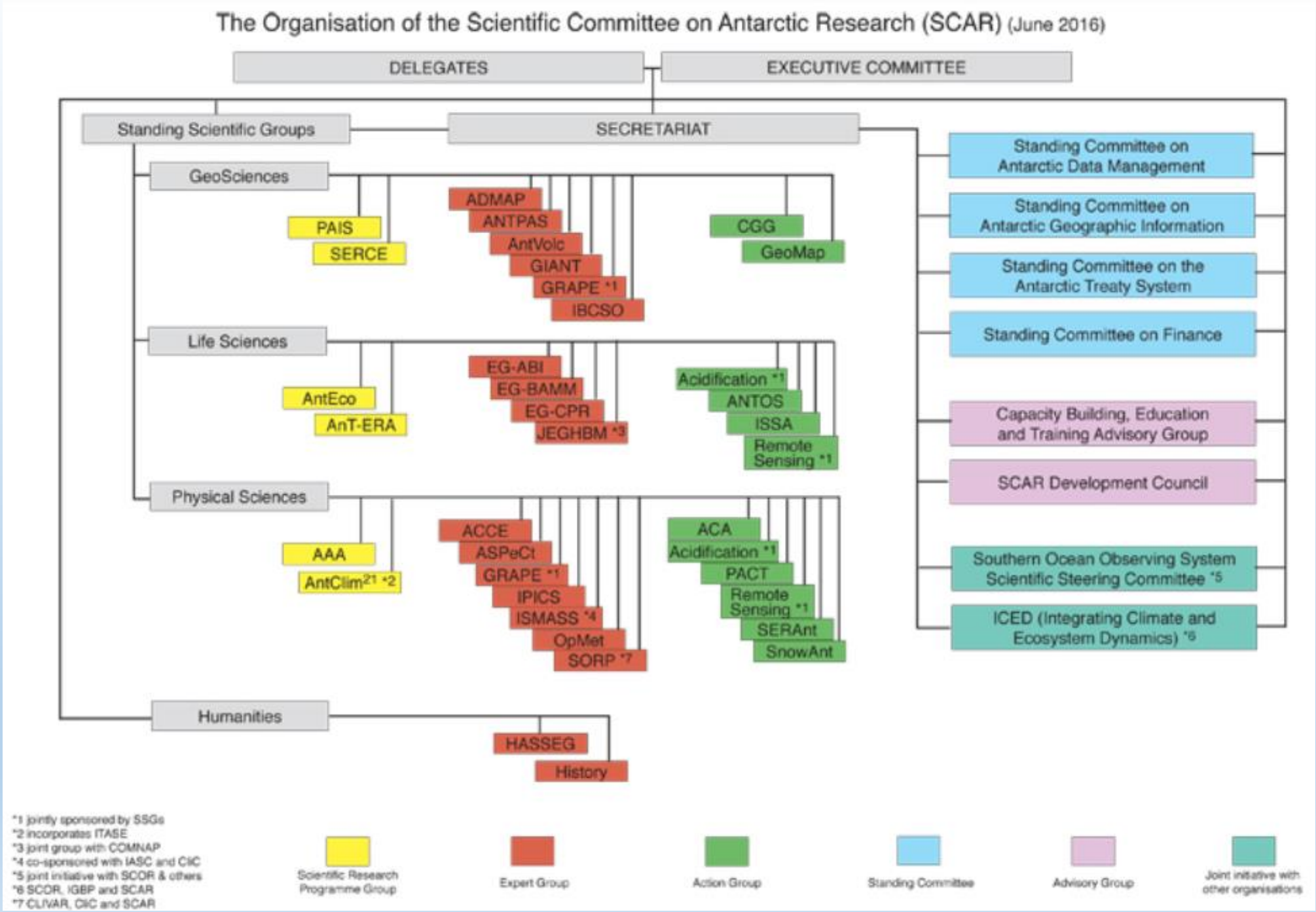
- Science Groups (SGs)
- Scientific Research Programmes (SRPs)
- Expert Groups
- Action Groups
- Advisory Groups
- Groups co-sponsored with other organisations

SCAR’s three Science Groups are:

- GeoSciences
- Life Sciences
- Physical Sciences

In brief, they are responsible for:

- Sharing information on disciplinary scientific research,
- Identifying research areas or fields where current research is lacking,
- Coordinating proposals for future research,
- Establishing Scientific Programme Planning Groups to develop formal proposals to the Delegates, and Action and Expert Groups to address specific research topics within the discipline.


The Organisation of the Scientific Committee on Antarctic Research (SCAR) (June 2016)
DELEGATES
EXECUTIVE COMMITTEE
Standing Scientific Groups
SECRETARIAT
GeoSciences
PAIS
SERCE
ADMAP
ANTPAS
AntVolc
GIANT
GRAPE *1
IBCSO
CGG
GeoMap
Life Sciences
AntEco
AnT-ERA
EG-ABI
EG-BAMM
EG-CPR
JEGHBM *3
Acidification *1
ANTOS
ISSA
Remote Sensing *1
Physical Sciences
AAA
AntClim21 *2
ACCE
ASPeCt
GRAPE *1
IPICS
ISMASS *4
OpMet
SORP *7
ACA
Acidification *1
PACT
Remote Sensing *1
SERAnt
SnowAnt
Humanities
HASSEG
History
Standing Committee on Antarctic Data Management
Standing Committee on Antarctic Geographic Information
Standing Committee on the Antarctic Treaty System
Standing Committee on Finance
Capacity Building, Education and Training Advisory Group
SCAR Development Council
Southern Ocean Observing System Scientific Steering Committee *5
ICED (Integrating Climate and Ecosystem Dynamics) *6
*1 jointly sponsored by SSGs
*2 incorporates ITASE
*3 joint group with COMNAP
*4 co-sponsored with IASC and CliC
*5 joint initiative with SCOR & others
*6 SCOR, IGBP and SCAR
*7 CLIVAR, CliC and SCAR
Scientific Research Programme Group
Expert Group
Action Group
Standing Committee
Advisory Group
Joint initiative with other organisations

SCAR Scientific Research Programmes

- Major cutting-edge research questions
- International in participation and interdisciplinary in scope
- Expected duration: 6 to 8 years
- Strategic and implementation plans required
- 2-year internal and 4-year external review
- Data management policy and outreach plan

The current generation of SCAR SRPs

- **State of the Antarctic Ecosystem (AntEco)**
- **Antarctic Ecosystems: Adaptations, Thresholds and Resilience (Ant-ERA)**
- **Past Antarctic Ice Sheet Dynamics (PAIS)**
- **Solid Earth Responses and Influences on Cryospheric Evolution (SERCE)**
- **Antarctic Climate 2100 (AntClim21)**
- **Astronomy and Astrophysics from Antarctica AAA**

LIFE SCIENCES -SCIENTIFIC RESEARCH PROGRAMMES

State of the Antarctic Ecosystem –AntEco

This Scientific Research Programme aims to increase the scientific knowledge of biodiversity, from genes to ecosystems that, coupled with increased knowledge of species biology, can be used for the conservation and management of Antarctic ecosystems.

Antarctic Thresholds -Ecosystem Resilience and Adaptation -AnT-ERA

This Scientific Research Programme aims to provide a platform for the exchange of knowledge and for the support of research on biological processes at ecological time scales especially related to environmental change.

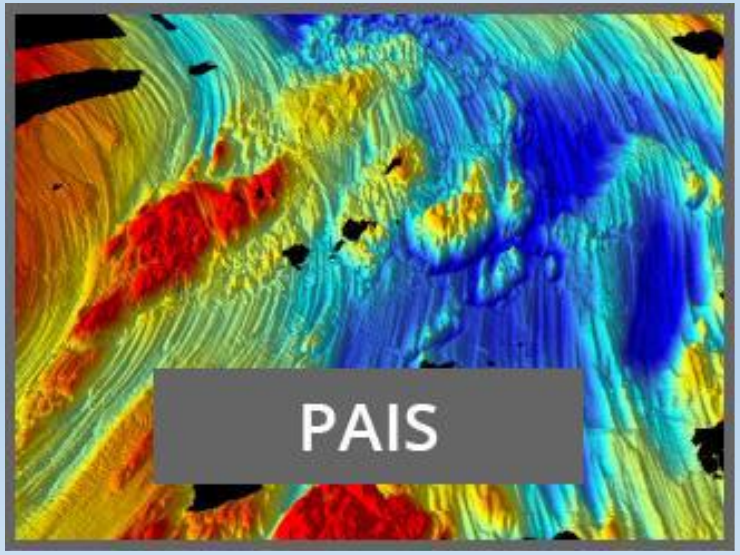
GEOSCIENCES -SCIENTIFIC RESEARCH PROGRAMMES

Past Antarctic Ice Sheet Dynamics –PAIS

This Scientific Research Programme aims to improve understanding of the sensitivity of East, West, and Antarctic Peninsula Ice Sheets to a broad range of climatic and oceanic conditions and to improve confidence in predictions of ice sheet and sea level response to future climate change and ocean warming.

Solid Earth Responses and influences on Cryospheric Evolution –SERCE

This Scientific Research Programme aims to advance understanding of the interactions between the solid earth and the cryosphere to better constrain ice mass balance, ice dynamics and sea level change in a warming world.



PHYSICAL SCIENCES -SCIENTIFIC RESEARCH PROGRAMMES

Astronomy and Astrophysics from Antarctica –AAA

Aims to coordinate astronomical activities in Antarctica in a way that ensures the best possible outcomes from international investment in Antarctic astronomy, and maximizes the opportunities for productive interaction with other disciplines.

Antarctic Climate Change in the 21st Century -AntClim21

Aims to deliver improved regional projections of key elements of the Antarctic atmosphere, ocean and cryosphere for the next 20 to 200 years and to understand the responses of the physical and biological systems (through multi-disciplinary collaboration) to natural and anthropogenic climate drivers.

POLAR 2018
XXXV SCAR Biennial Meetings
Arctic Science Summit Week ASSW
SCAR/IASC Open Science Conference

POLAR2018 was a joint event from the Scientific Committee on Antarctic Research SCAR and the International Arctic Science Committee IASC. The SCAR meetings, the ASSW and the Open Science Conference were hosted by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL under the patronage of the Swiss Committee on Polar and High Altitude Research. The WSL Institute for Snow and Avalanche Research SLF organized POLAR2018, which took place in Davos, Switzerland from 15 - 27 June 2018.

Over 2500 attendees who presented 1600 posters and 1000 oral papers as well as plenary sessions, panel discussions, side meetings and social events, were welcome

POLAR 2018 XXXV SCAR Biennial Meeting **Principal Outcomes**

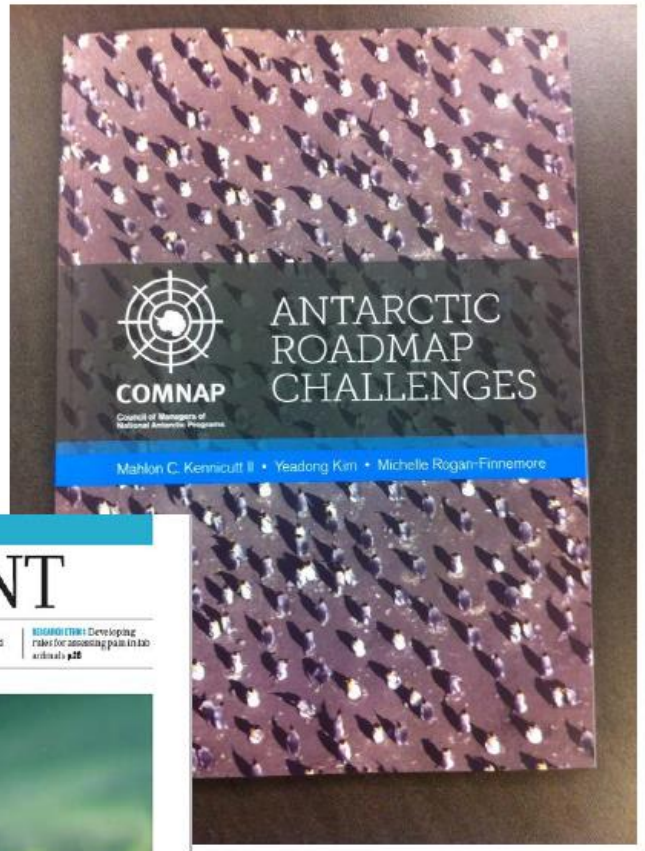
New action groups have been established: Earth Observation (Physical Sciences), ANGWIN - ANtarctic Gravity Wave Instrument Network (Physical Sciences), AntArchitecture (Geosciences and Physical Sciences), IMPACT - Input Pathways of Persistent Organic Pollutants to Antarctica (Life Sciences), SKAG – Krill action group (Life Sciences) and Plastics in Polar Environment (Life Sciences).

SCAR's current Scientific Research Programmes (SRPs) will come to an end in 2020 and discussions are underway on what will follow. The Programme Planning Groups (PPGs) are developing proposals for future SRPs.

At the Delegates Meeting, three new PPGs were proposed: Integrated science to support Antarctic and Southern Ocean conservation (ANT-ICON); Near-term Variability and Prediction of the Antarctic Climate System (AntClimnow) and Antarctic Ice Sheet Dynamics and Global Sea Level (AISSL).

Three new Executive Committee members, appointed at this meeting – Dr Catherine Ritz (Vice President for Science), Dr M Ravichandran (Vice President for Capacity Building) and Professor Gary Wilson (Vice President for Administration).

Future research focus: Climate change on Antarctica a high priority



Understanding the impacts and avoided impacts on Antarctica of Paris Climate Agreement, is a key *Future Science Challenge* identified by SCAR. See ACTM XL Working Group 2 agenda item 15a (see Background Paper 20).


COMMENT

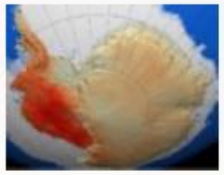
Six priorities for Antarctic science

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.

Science Priorities for…

DEFINE

the global reach of the Antarctic atmosphere and Southern Ocean

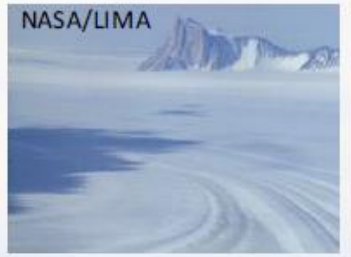


RECOGNIZE AND MITIGATE

human influences

UNDERSTAND

how, where and why ice sheets lose mass



Antarctic and Southern Ocean Science

OBSERVE

space and the Universe

REVEAL

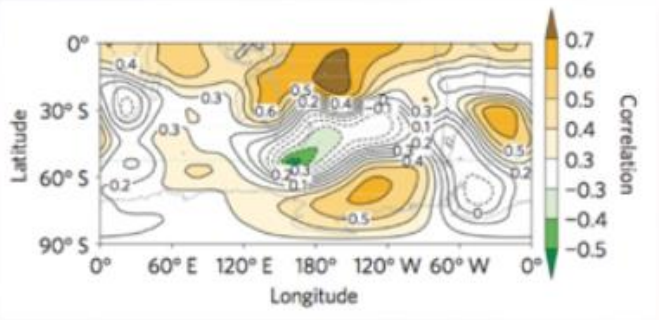
Antarctica's history

LEARN

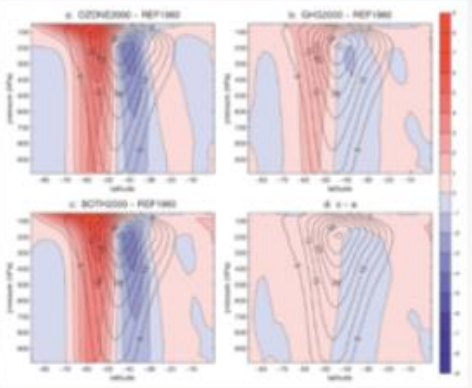
how Antarctic life evolved and survived

From now on we will follow the Physical Sciences …

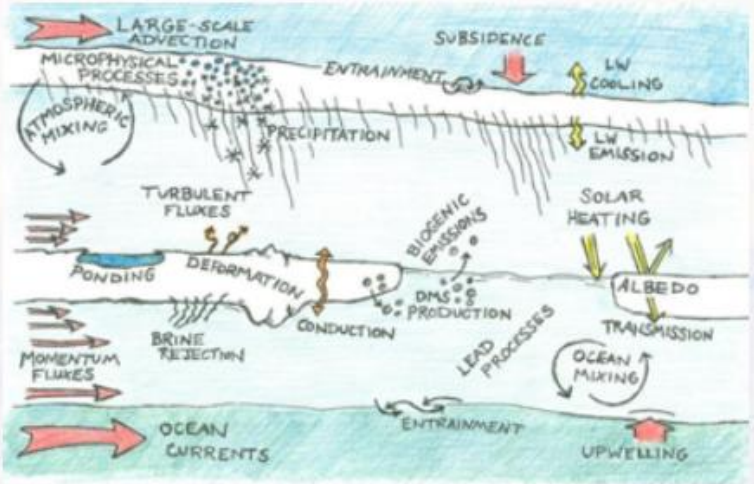
Antarctic Atmosphere and Global Connections



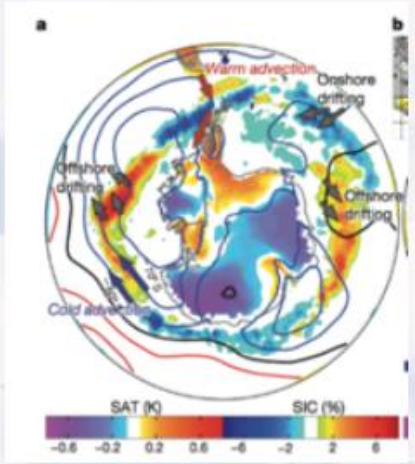
Tele-connections



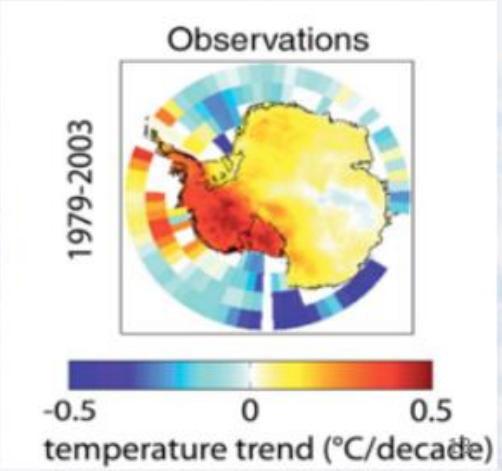
Processes and interfaces



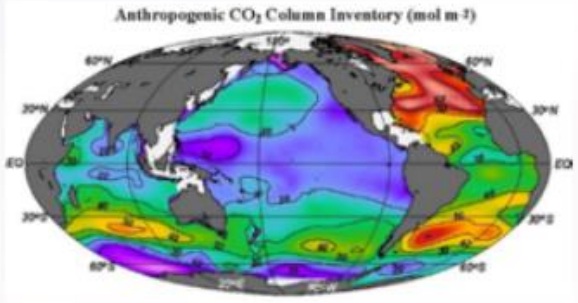
Greenhouse gases/Ozone recovery



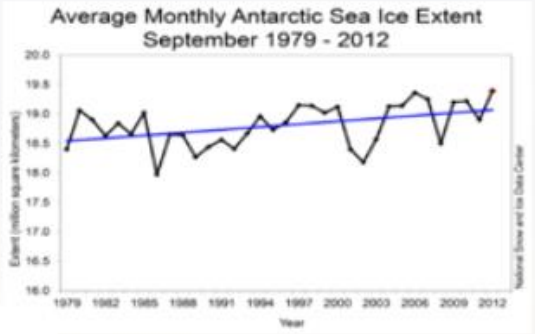
Regional variations



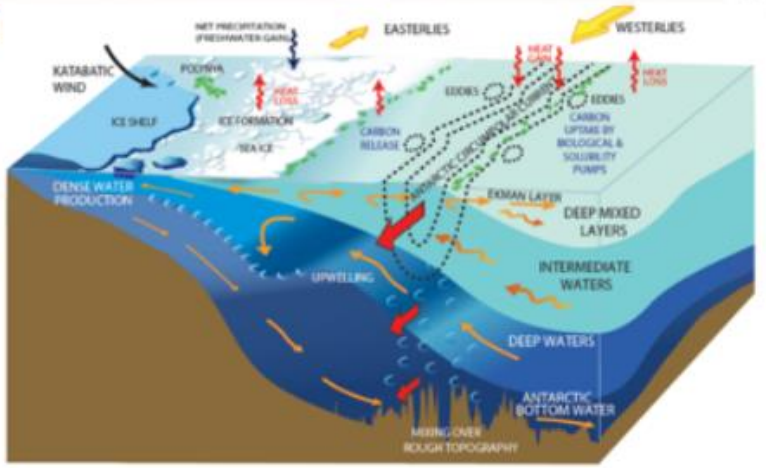
The Southern Ocean and Sea Ice in a Warming World



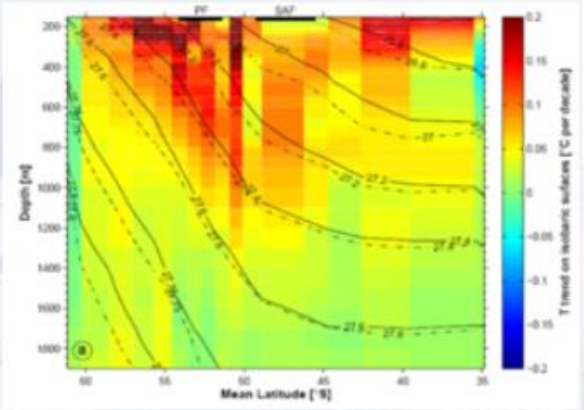
Human role in ocean change



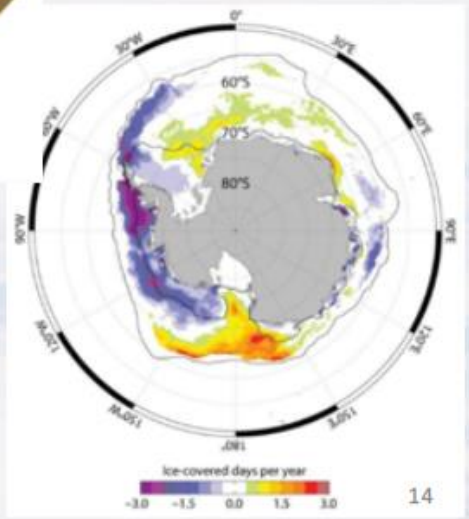
Heat, energy, carbon dioxide, carbon, oxygen and nutrient cycles and budgets



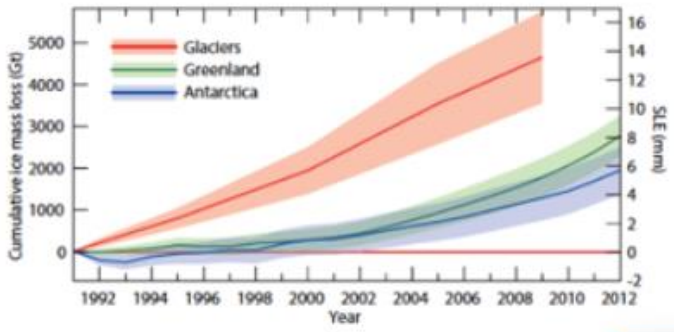
Sea ice variability



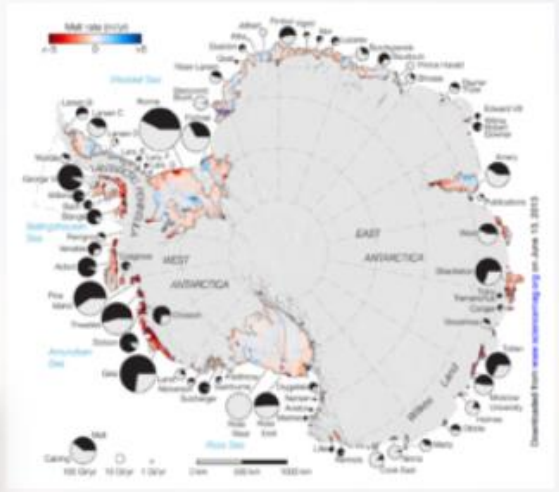
Improved climate forecasts



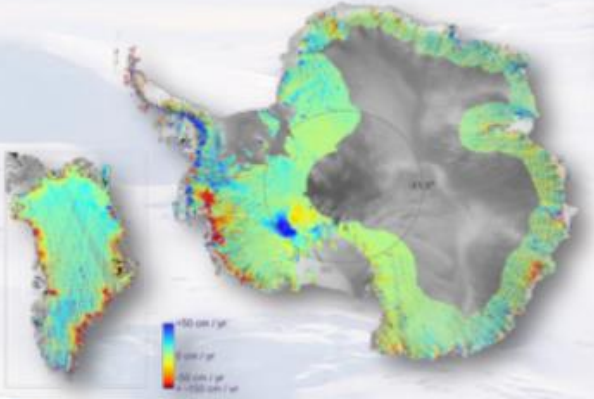
Antarctic ice sheet and sea level



Controls and processes

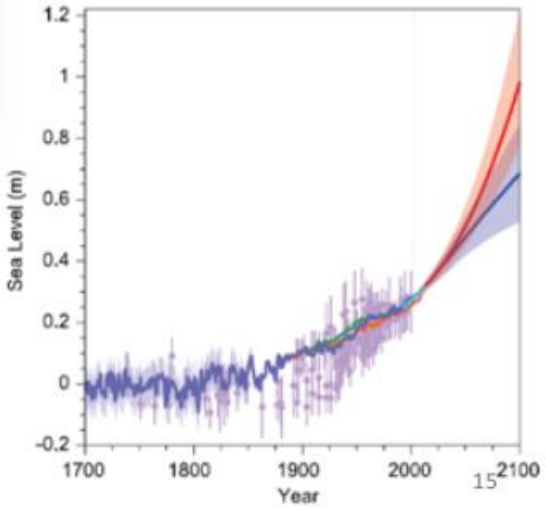


Ice sheet thinning, retreat, and melt



Improved climate and sea level forecasts

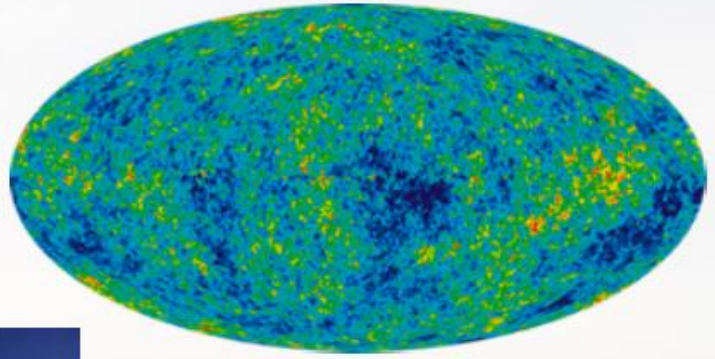
Sea level

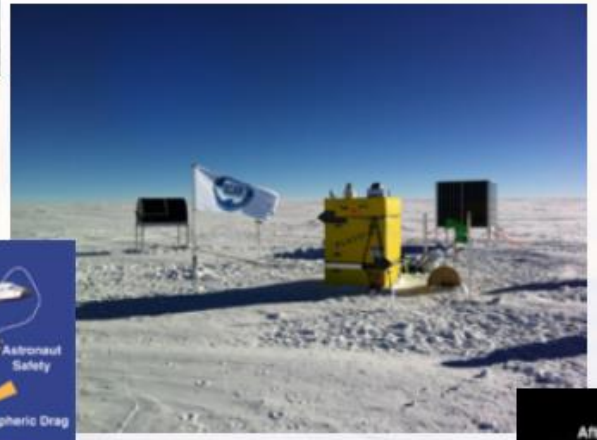


Near-Earth space and beyond – eyes on the sky

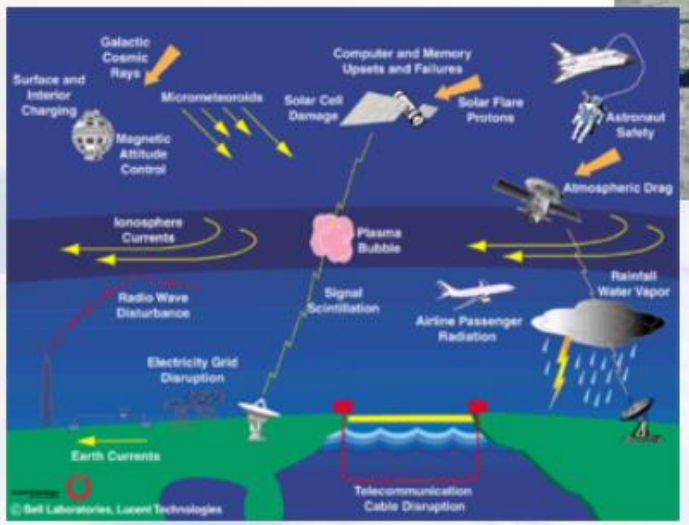
Life beyond Earth

The origins of the Universe

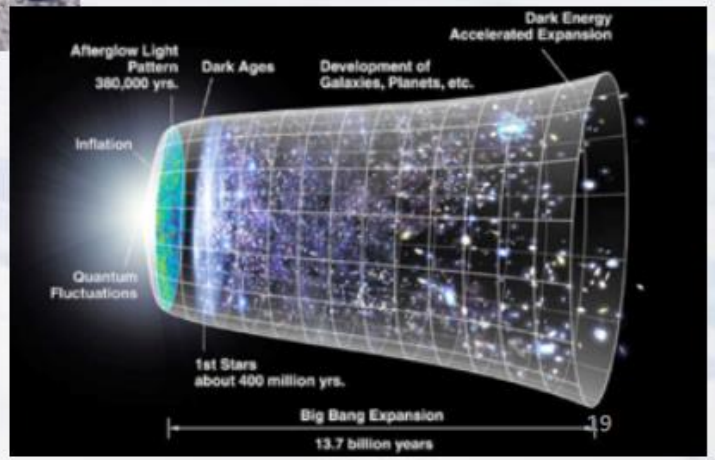




The nature of the dark Universe



Space weather



Six priorities for Antarctic science for the next two decades and beyond.

Define the global reach of the Antarctic atmosphere and Southern Ocean.

Understand how, where and why ice sheets lose mass.

Reveal Antarctica's history.

Learn how Antarctic life evolved and survived.

Observe space and the Universe.

Recognize and mitigate human influences

New SCAR Strategic Plan 2017-2022

- SCAR will use the key questions arising from the **1st Antarctic and Southern Ocean Science Horizon Scan to guide research priorities and research direction** over the next five years and beyond.

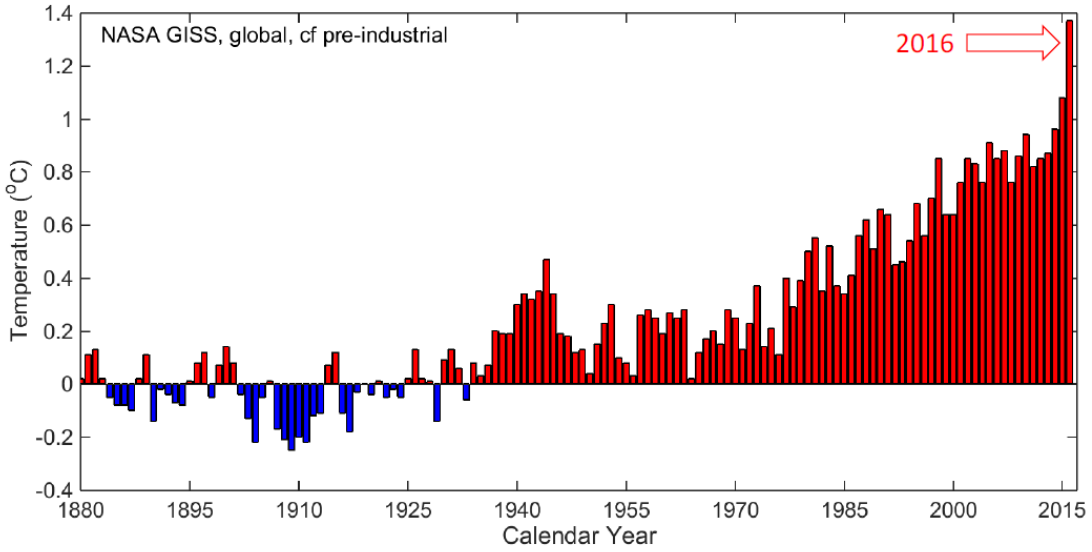
- SCAR's vision is **to be an engaged, active, forward-looking organization that promotes, facilities, and delivers scientific excellence and evidence-based policy advice on globally significant issues that are relevant to Antarctica.**

SCAR's vision is to create a legacy of Antarctic research as a foundation for a better future. SCAR will
establish a thorough understanding of the nature of Antarctica, the role of Antarctica in the global system, and the character and effects of environmental change and human activities on Antarctica.
SCAR's work in the next five years will focus on five key objectives:
a) To amplify its leadership in Antarctic research by further strengthening and expanding high-quality collaborative and visionary Antarctic research, including observations from Antarctica;
b) To offer independent scientific advice to Antarctic Treaty Consultative Meetings and other bodies dealing with Antarctic and Southern Ocean matters;
c) To enhance and grow research capacity in SCAR member countries;
d) To enhance public awareness and understanding of Antarctic issues through communication of Antarctic research results in a timely and accessible manner; and
e) To facilitate unrestricted and free access to Antarctic research data.

Underlining all objectives is SCAR's aim to enhance the information flow to all interested researchers and policy makers, and stimulate cross- and trans-disciplinary exchange.

Thank you for your attention…

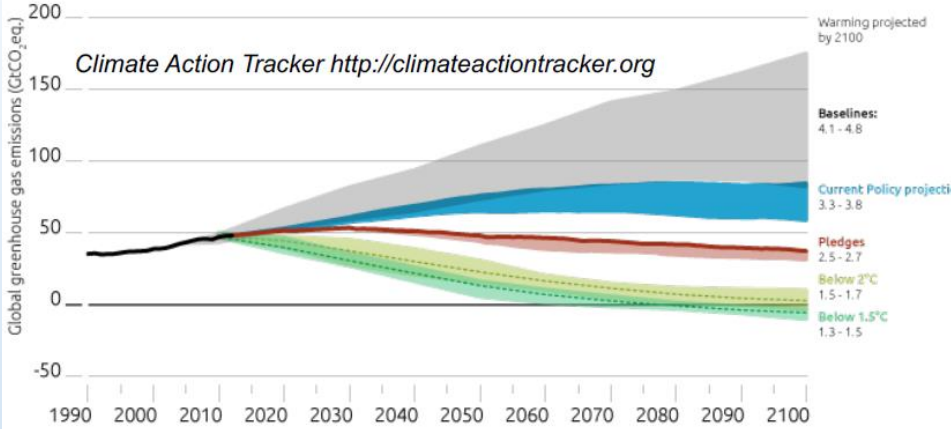
The challenge of the Paris Agreement

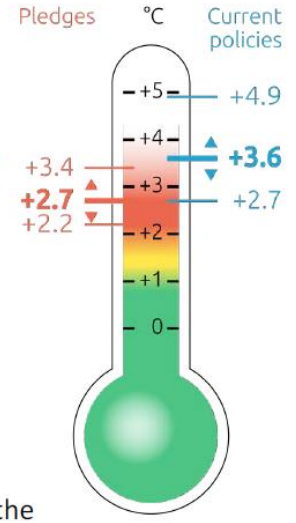


Paris Climate Change Agreement

- The Paris climate Agreement was signed by 196 member nations of the United Nations Framework Convention on Climate Change (UNFCCC) at the 21st meeting of the Conference of Parties (COP 21) in December 2015.
- The UNFCCC is an international environmental treaty negotiated at the Earth Summit in Rio de Janeiro in 1992, with the objective to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".
- The Paris Agreement aims to keep global warming below 2°C - “the safe guardrail for dangerous climate change” identified by the Intergovernmental Panel on Climate Change (IPCC)
- This will be achieved through nationally determined commitments (NDCs) aimed to reduce all anthropogenic greenhouse gas emissions to zero before the end of this century.

How is the world tracking?





- The NDCs tabled in Paris, if implemented, will restrict global warming to ~2.7°C.
- This is still above the UNFCCC safe guardrail, and well-above the more ambitious goal of 1.5°C.
- Current policy settings sees global temperatures stabilizing closer to 3.5°C.
- In five years-time nations will be asked to increase their ambition for emissions reduction.
- We need to be 40% below 1990 levels by 2030 to be on track

Mass balance of the Antarctic Ice Sheet from 1992 to 2017

The IMBIE team*

The ice sheets of Antarctica hold enough water to raise global sea level by 58 m. They channel ice to the oceans through a network of glaciers and ice streams, each with a substantial inland catchment…

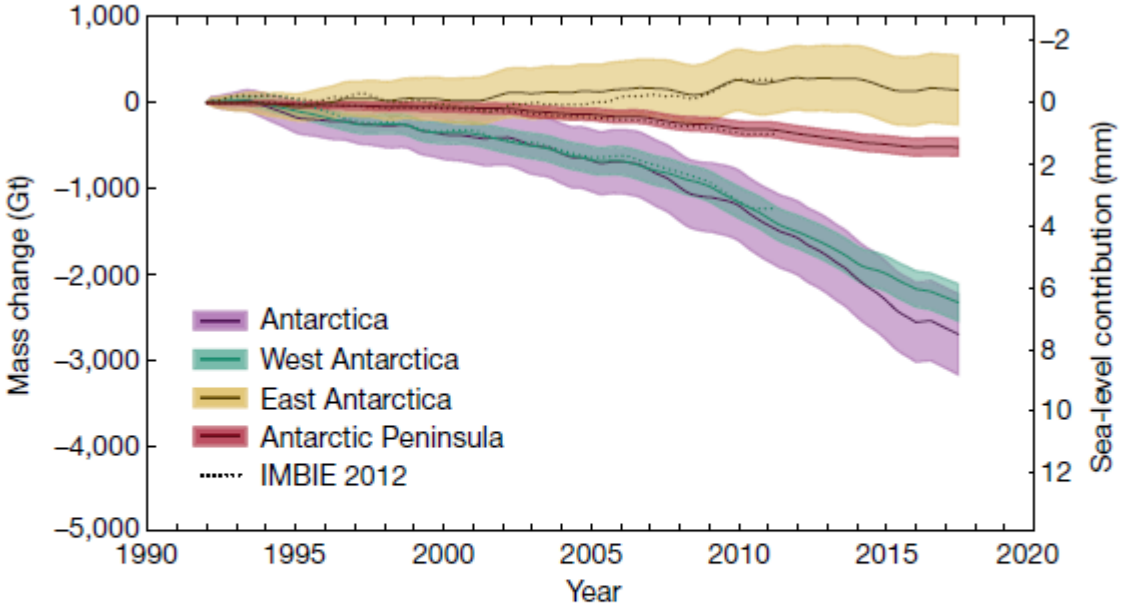
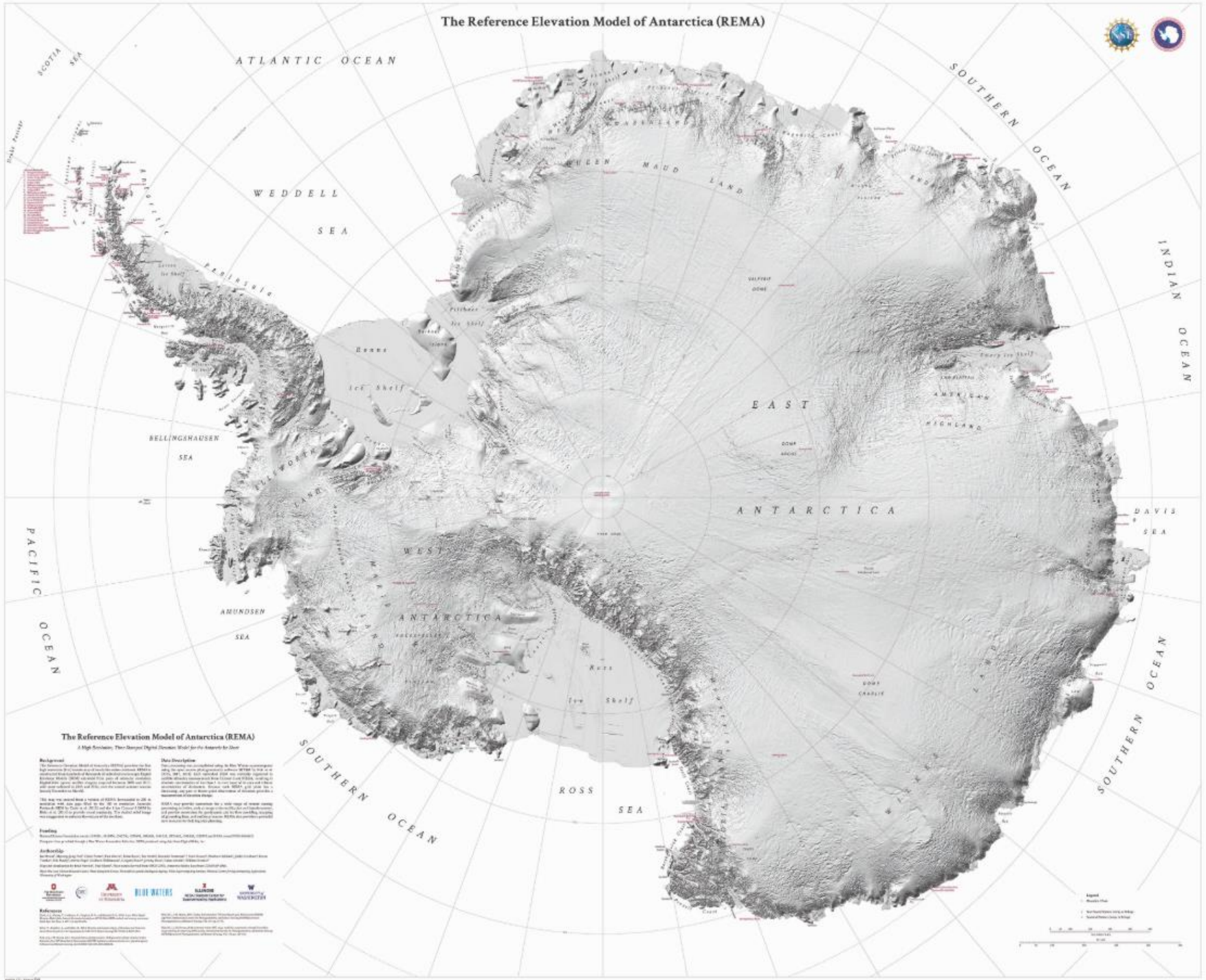
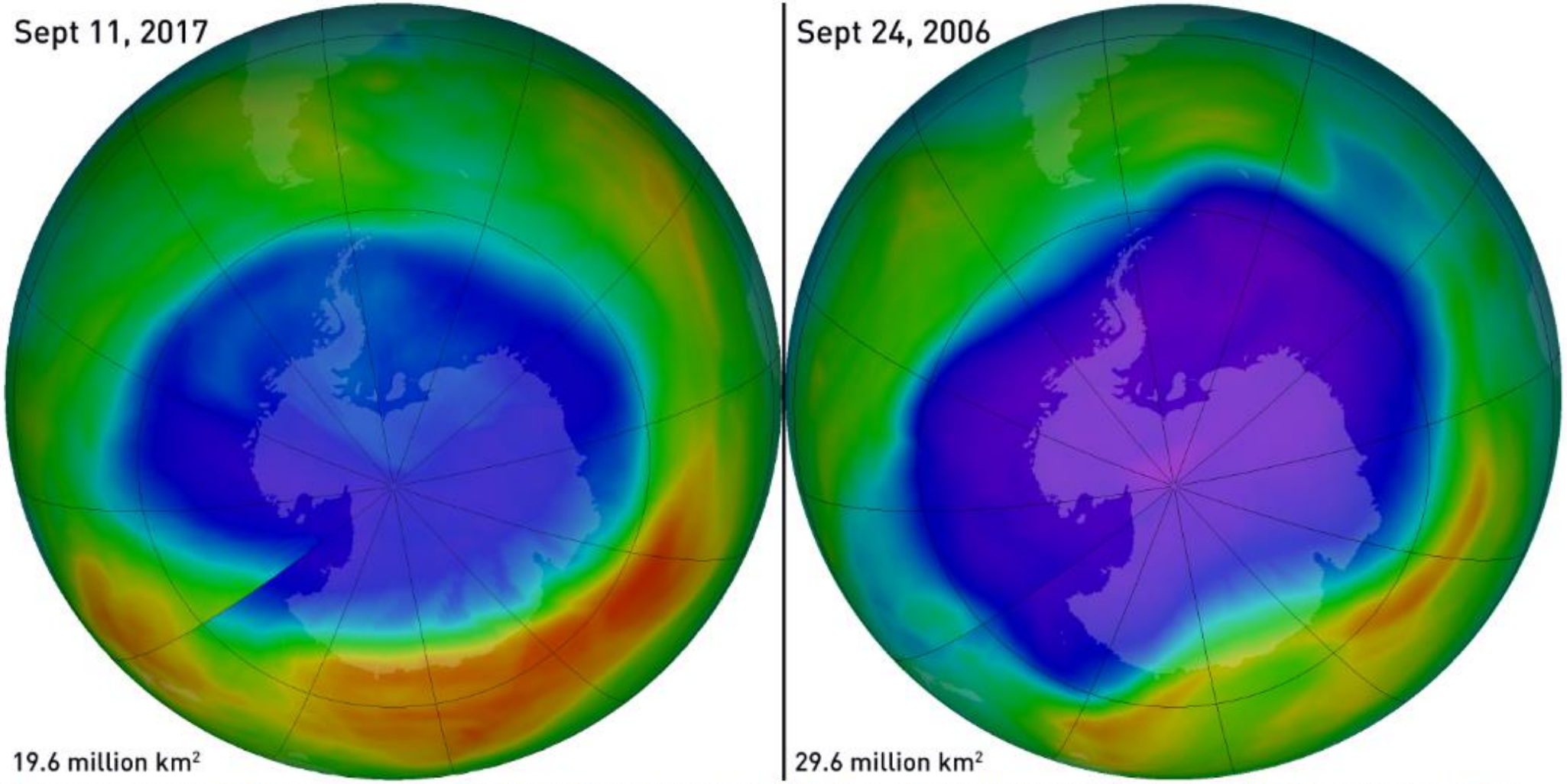


Fig. 2 | Cumulative Antarctic Ice Sheet mass change. The cumulative ice-sheet mass changes (solid lines) are determined from the integral of monthly measurement-class averages (for example, the black lines in Fig. 1) for each ice sheet. The estimated 1σ uncertainty of the cumulative change is shaded. The dashed lines show the results of a previous assessment[18].


The Reference Elevation Model of Antarctica (REMA)
ATLANTIC OCEAN
SCOTIA SEA
WEDDELL SEA
QUEEN MAUD LAND
SOUTHERN OCEAN
INDIAN OCEAN
EAST ANTARCTICA
WEST ANTARCTICA
ANTARCTICA
PACIFIC OCEAN
BELLINGSHAUSEN SEA
AMUNDSEN SEA
ROSS SEA
DAVIS SEA
Ronne Ice Shelf
Ross Ice Shelf
Filchner Ice Shelf
Larsen Ice Shelf
Amery Ice Shelf
ANTARCTIC PENINSULA
ELLSWORTH LAND
TRANSANTARCTIC MOUNTAINS
VALKYRIE DOME
DOME ARGUS
DOME CHARLIE
AMERY HIGHLAND
The Reference Elevation Model of Antarctica (REMA)
A High-Resolution, Time-Stamped, Digital Elevation Model for the Antarctic Ice Sheet
Background
Data Description
Funding
Authorship
References
BLUE WATERS
Legend

Reaching a maximum area of 19.6 million km^2, on September 11, 2017,
the Antarctic ozone hole was 10 million km^2 smaller than the largest ozone hole ever seen, on September 24, 2006.

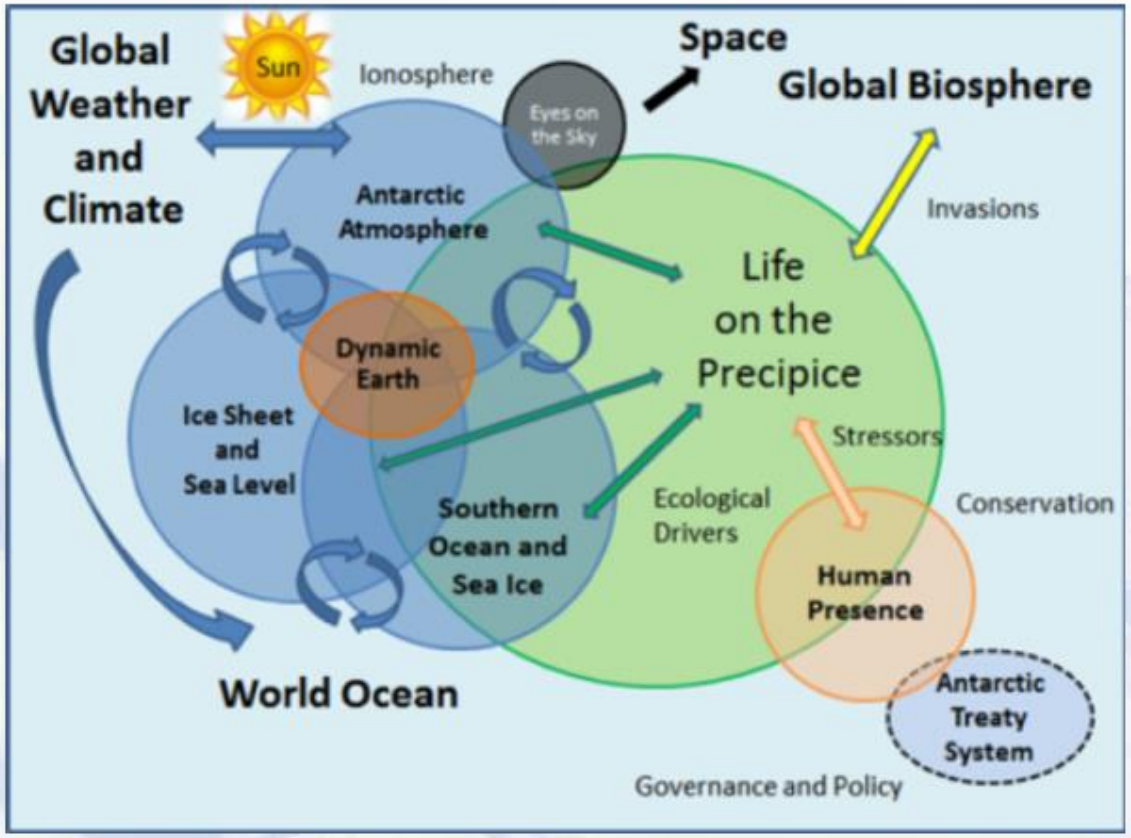


Antarctic ozone hole maxima, from 2017 (left) and 2006 (right). The abrupt discontinuity in the 2017 plot is due to the orientation of the ozone hole rotating as the satellite gathered its data over the full 24 hour period. Credit: NASA Ozone Watch/Scott Sutherland

To reach for the horizon:

A coordinated, portfolio of interdisciplinary science, based on enhanced international cooperation is essential

Future Antarctic science will continue to address multi-disciplinary issues, will be complex and will require international collaborative efforts…



No one scientist, program or nation can realize these aspirations alone

WHO OWNS **ANTARCTICA?**

IT STRETCHES 5.4 MILLION SQUARE MILES, IT'S FREEZING, INHOSPITABLE, AND DEVOID OF ANY NATIVE RESIDENTS. WHY, THEN, IS THE SOUTHERNMOST CONTINENT AT THE CENTER OF SUCH CONTENTIOUS WRANGLING? WE TAKE A LOOK AT WHO OWNS WHAT IN ANTARCTICA AND WHY THE BATTLES HAVE RECENTLY GROWN MORE TUMULTUOUS.

PROFILE OF THE FROST-BOUND CONTINENT

ROUGHLY **1.5 TIMES** THE SIZE OF THE UNITED STATES

ALTHOUGH HOME TO ANIMALS INCLUDING PENGUINS AND WHALES, THERE ARE **NO NATIVE** LAND MAMMALS

98% COVERED BY A THICK SHEET **OF ICE** ATLEAST A MILE DEEP

70% OF WORLD'S SUPPLY OF **FRESH WATER**

RECEIVES **LESS THAN 2 INCHES** OF RAIN PER YEAR THE DRIEST CONTINENT ON EARTH

WINTER TEMPERATURES CAN DROP TO AS LOW AS **-20°F**

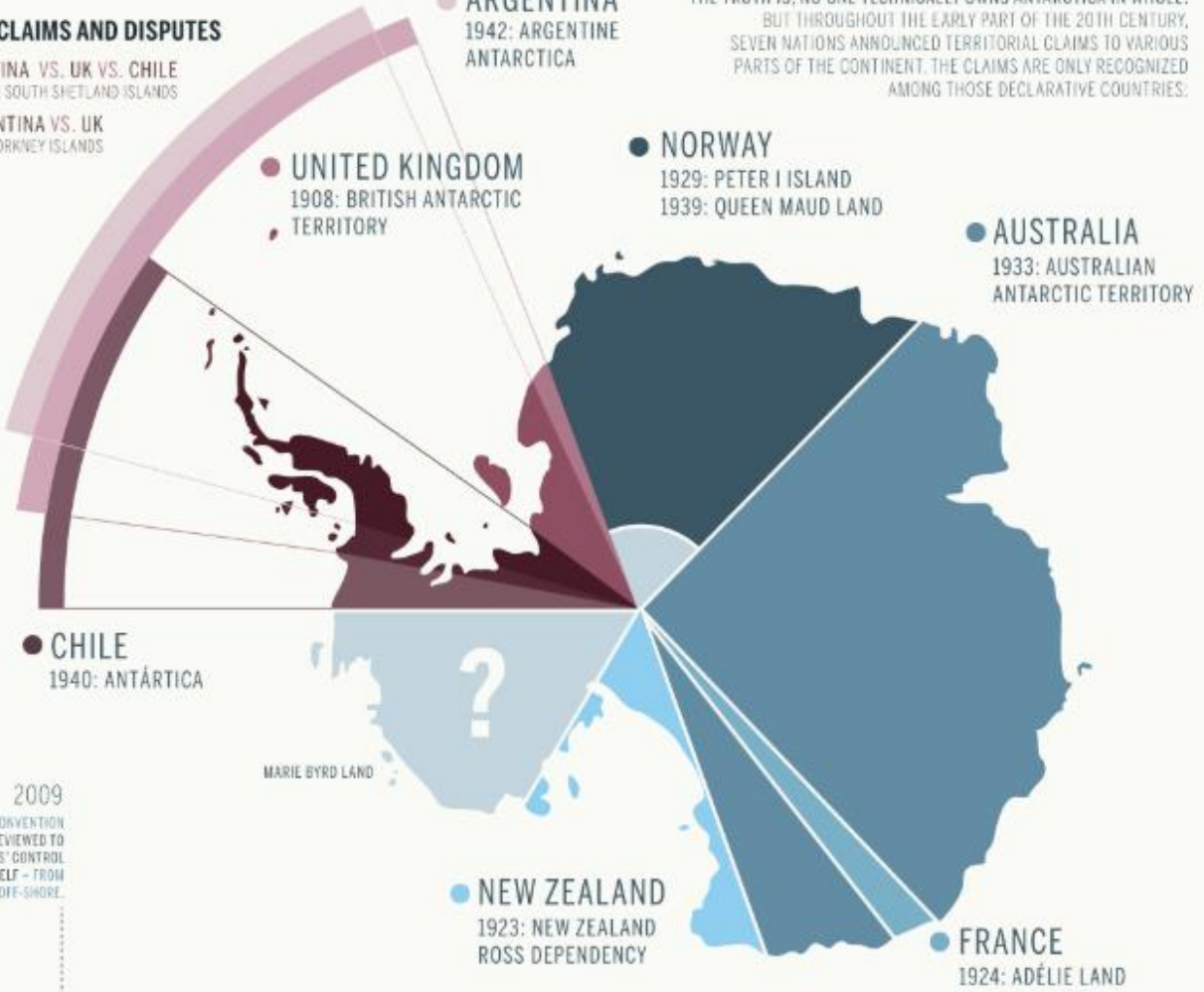
SUMMER HAS ONLY REACHED A MAXIMUM OF **58°F**

SEA LEVELS COULD RISE **200 FEET WORLDWIDE**

OVERLAPPING CLAIMS AND DISPUTES

ARGENTINA VS. UK VS. CHILE
OVER SOUTH SHETLAND ISLANDS

ARGENTINA VS. UK
OVER SOUTH ORKNEY ISLANDS



THE TRUTH IS, NO ONE TECHNICALLY OWNS ANTARCTICA IN WHOLE. BUT THROUGHOUT THE EARLY PART OF THE 20TH CENTURY, SEVEN NATIONS ANNOUNCED TERRITORIAL CLAIMS TO VARIOUS PARTS OF THE CONTINENT. THE CLAIMS ARE ONLY RECOGNIZED AMONG THOSE DECLARATIVE COUNTRIES.

THE FINAL FRONTIER: A TIMELINE

1908-1942
OVER THE COURSE OF 35 YEARS, A TOTAL OF SEVEN NATIONS RUSHED TO CLAIM VARIOUS TERRITORIES BELOW THE 60° PARALLEL IN ANTARCTICA.

12 PARTICIPATING COUNTRIES

JULY, 1957, TO DECEMBER, 1958
SCIENTIFIC EXPLORATION BEGAN IN THE AREA AND BECAME KNOWN AS THE INTERNATIONAL GEOPHYSICAL YEAR. VARIOUS SCIENCE STATIONS WERE SET-UP ON THE CONTINENT BY 12 DIFFERENT PARTICIPATING COUNTRIES, INCLUDING THE SEVEN THAT PREVIOUSLY ASSERTED SOVEREIGNTY OVER THE LAND.

1961
THE ANTARCTIC TREATY, EVENTUALLY SIGNED BY 47 COUNTRIES, AGREED TO SET ASIDE THE EXPANSIVE LAND STRICTLY AS A SCIENTIFIC PRESERVE, AND SUSPENDED ALL FURTHER TERRITORIAL CLAIMS IN ORDER TO JOINTLY FOCUS ON RESEARCH.

1991
TWENTY FOUR OF THE NATIONS ADDED A PROTOCOL TO THE TREATY THAT WOULD PROHIBIT OIL AND OTHER MINERAL EXPLORATION FOR AT LEAST 50 YEARS.

50 YEARS

2007
THE UNITED KINGDOM, CITING A CENTURY-OLD TERRITORIAL RIGHT, CLAIMED 385,000 SQUARE MILES OF ANTARCTICA, INCLUDING THE PENINSULA AND COASTAL SHELF ALONG IT.

385,000 SQUARE MILES

2009
THE UNITED NATIONS'S CONVENTION OF THE LAW OF THE SEA REVIEWED TO EXPAND COASTAL NATIONS' CONTROL OVER THE CONTINENTAL SHELF – FROM 200 MILES TO 380 MILES OFF-SHORE.

WHAT'S NEXT?

DUE TO ITS PRISTINE MAJESTY, THERE IS AN INCREASING TOURIST INTEREST IN THE AREA. CURRENTLY, TOURISM IS CONFINED TO RARE CRUISE SHIP TRIPS TO THE COASTAL SHELVES. IN THE NEAR FUTURE, IT MAY EXPAND TO HOTEL AND EVEN CASINO DEVELOPMENTS.

IF AND WHEN ANTARCTICA IS OPEN FOR MINERAL AND OIL EXPLORATION, THE TREATY'S CONSULTATIVE PARTIES HAVE ALREADY BEEN WORKING ON HOW PLANS SHOULD PROCEED.

WHAT LIES BENEATH AND THE PROBLEMS IT CAUSES

AS THE ICE MELTS, SO DO THE FRIENDLY TIES. DESPITE THE MILE-THICK SHEET OF ICE BLANKETING THE CONTINENT, DEMAND FOR MORE PETROLEUM SUPPLIES HAS SPURRED CURIOSITY IN WHAT'S BENEATH THE SURFACE. OIL? GAS RESERVES?

THE POTENTIAL LOOMS LARGE FOR PROSPECTING NATIONS, CAUSING SOME TO FIGHT OVER LAND, INCLUDING THE CONTINENTAL SHELF – AREAS NOT EXPLICITLY BANNED BY THE TREATY IN 1961.

sources: theatlantic.com, globalclassroom.org, jonbowermaster.com, wikimedia.org

A COLLABORATION BETWEEN GOOD AND COLUMN FIVE

Expeditions in Antarctica before the Heroic Age of Antarctic Exploration, 1897