



Sustained observation of the Southern Ocean

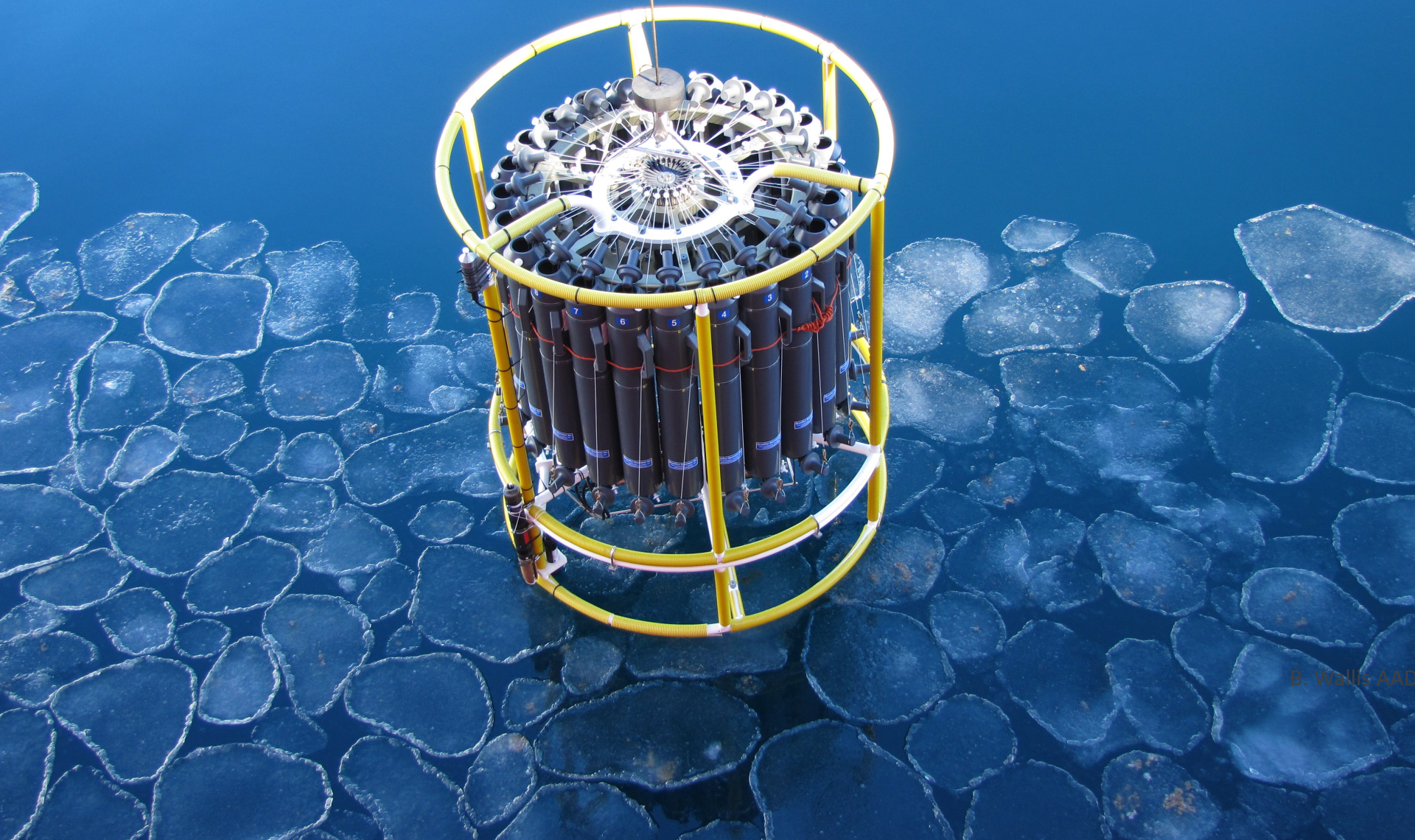
The Southern Ocean Observing System (SOOS)

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Oscar Schofield, Anna Wahlin, Andrew Constable, Sebastiaan Swart,
and the SOOS Scientific Steering Committee



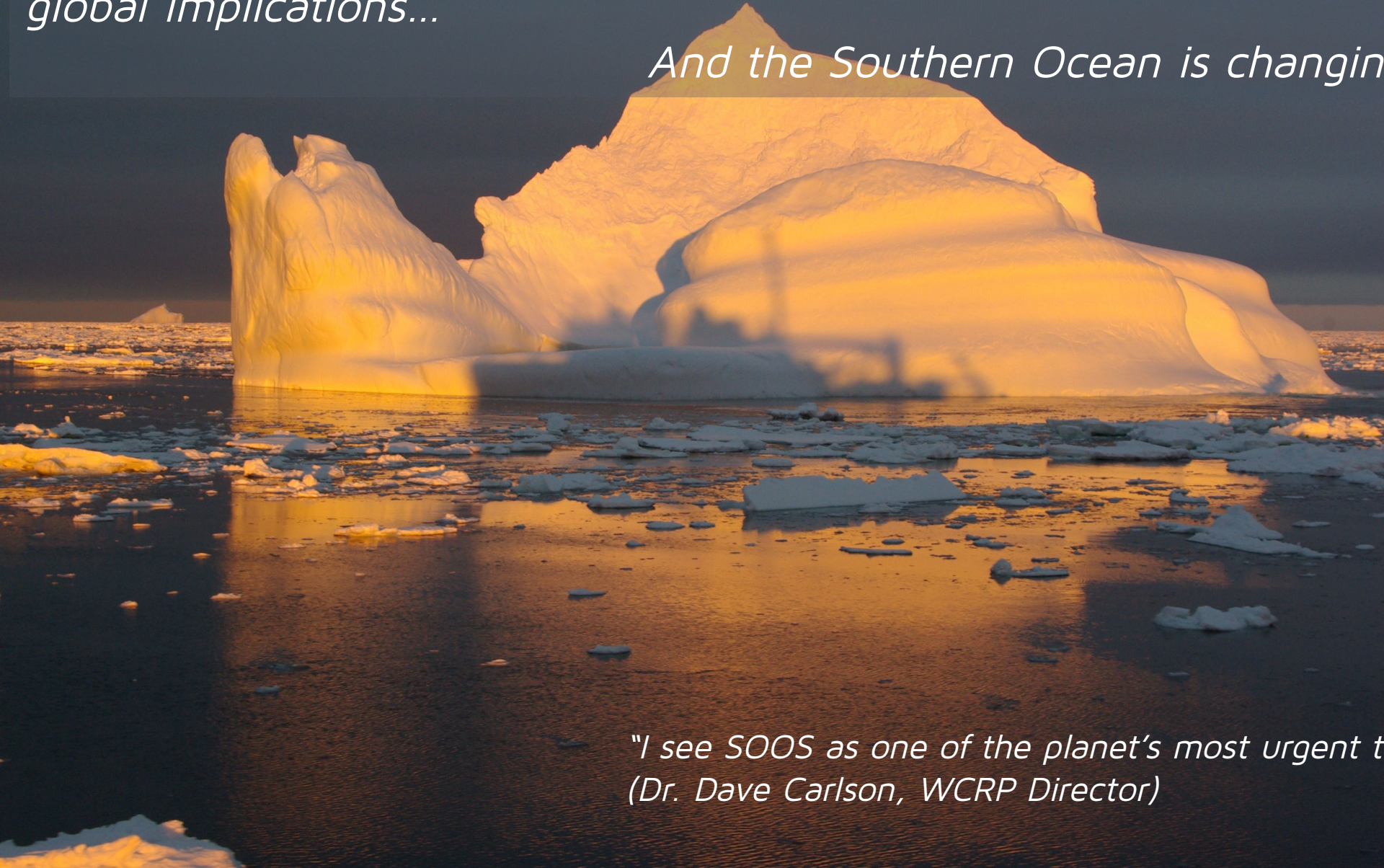
The Southern Ocean Observing System facilitates the collection and delivery of essential observations on variability and change of Southern Ocean systems to all international stakeholders, through design, advocacy, and implementation of cost-effective observing and data delivery systems.



Why SOOS?

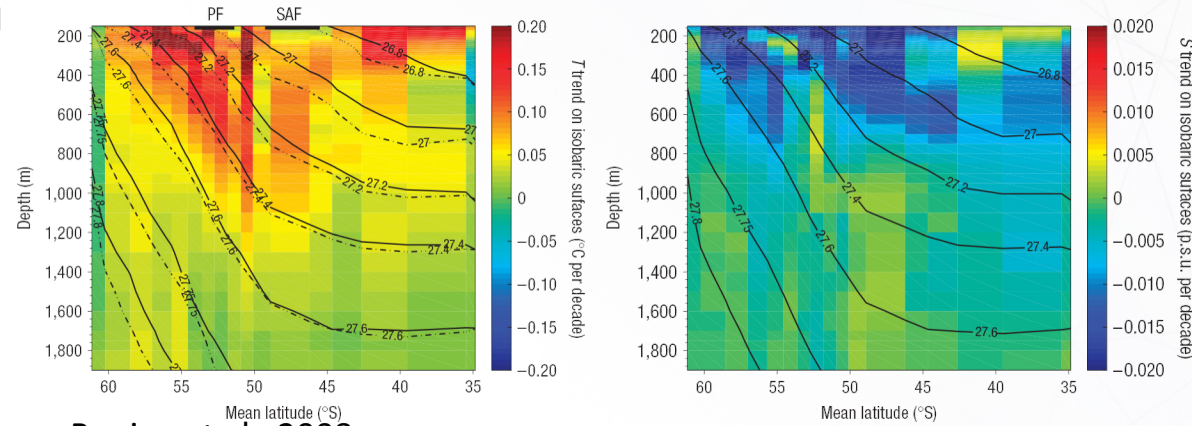
The Southern Ocean is globally important, any changes will have global implications...

And the Southern Ocean is changing



*"I see SOOS as one of the planet's most urgent threats"
(Dr. Dave Carlson, WCRP Director)*

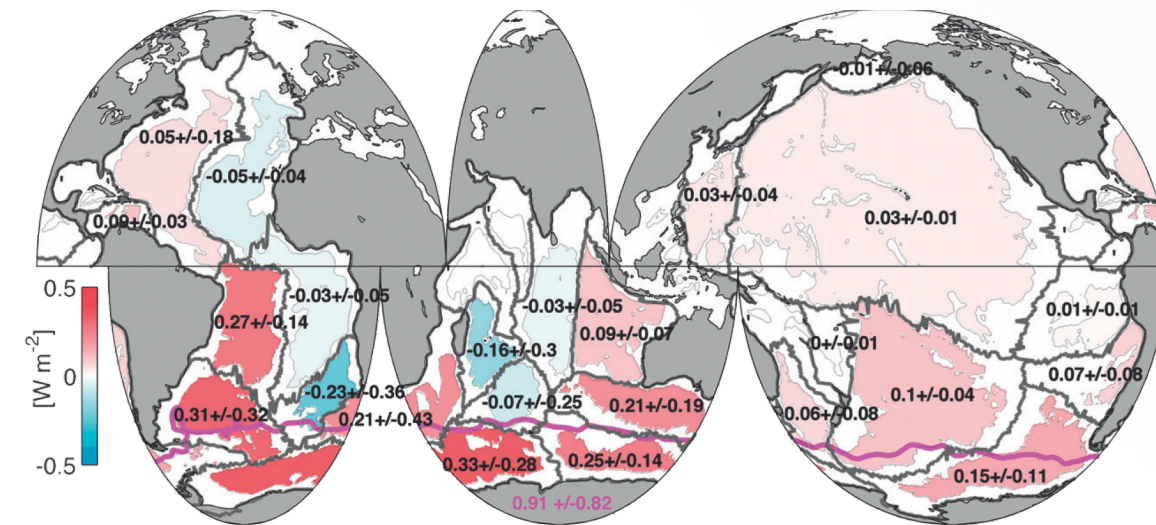
Some aspects are changing rapidly...



Boning et al., 2008

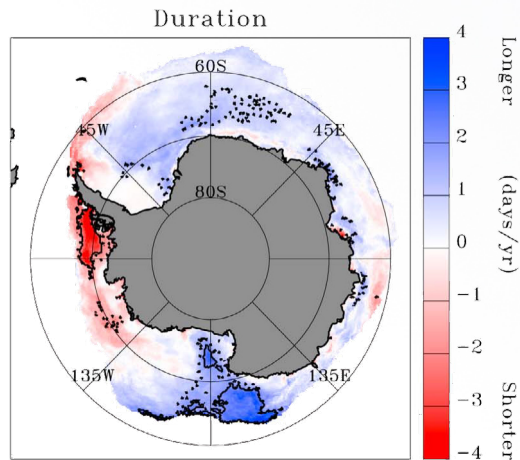
Rate of warming exceeds that of the global ocean as a whole. Not just in surface but abyssal warming as well

Freshening is consistent(ish) with an accelerating hydrological cycle.

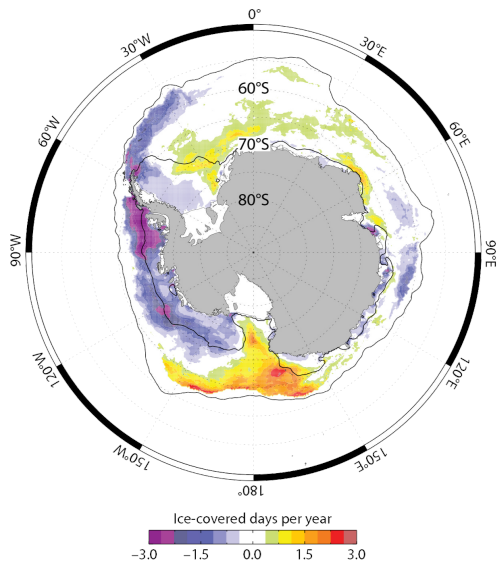


Purkey & Johnson, 2010

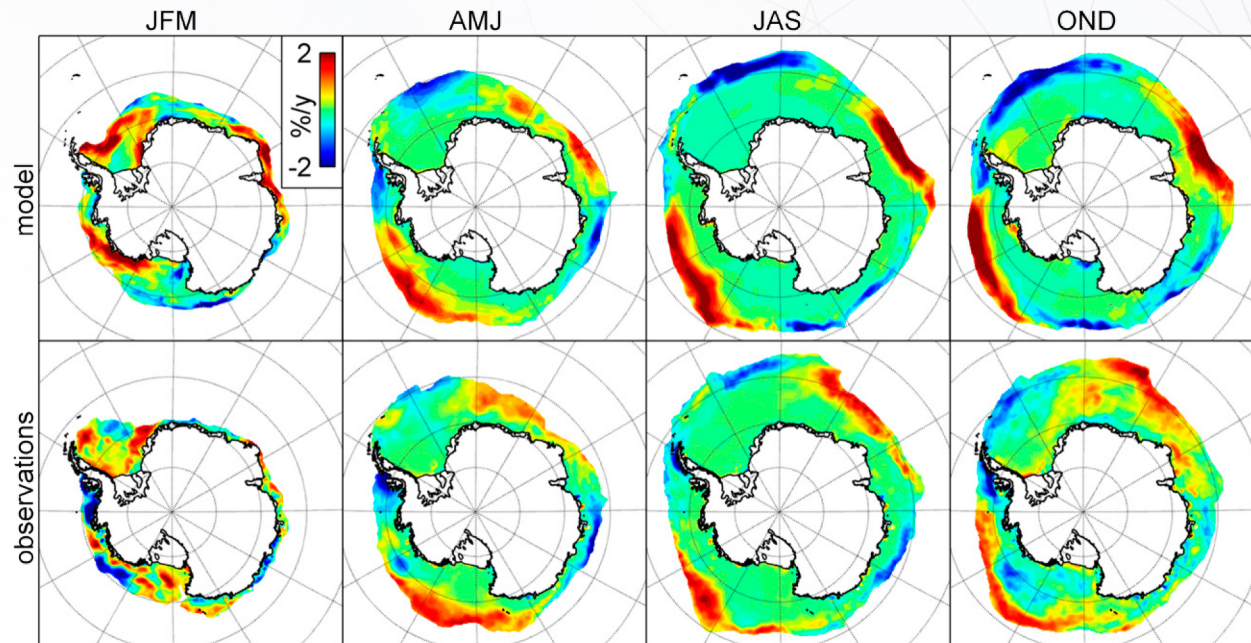
Significant changes in sea-ice (extent, concentration)



Stammerjohn et al. (2012)



Makysm et al. (2012)



Holland et al. (2014)

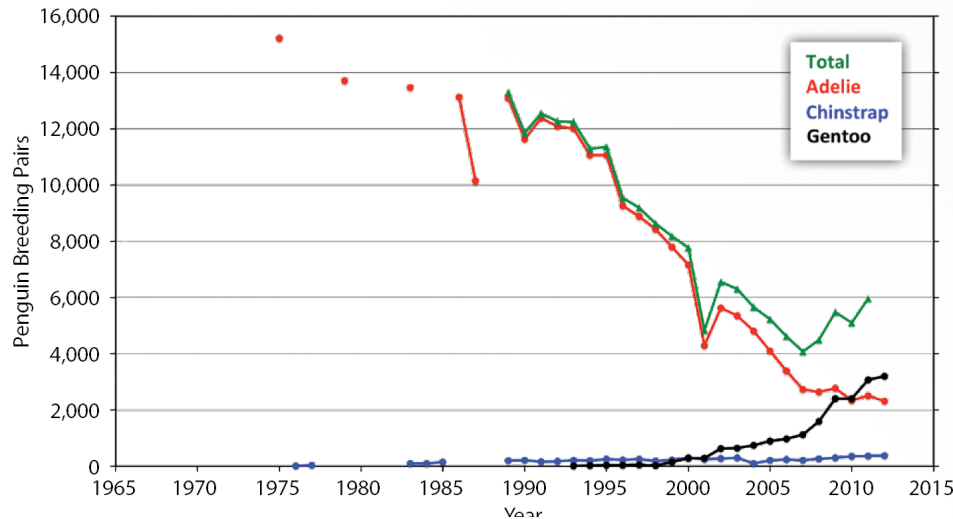
Impacts on marine ecosystems...

Many recorded impacts on the Southern Ocean ecosystem...some winners, some losers

Adelie's on the Peninsula

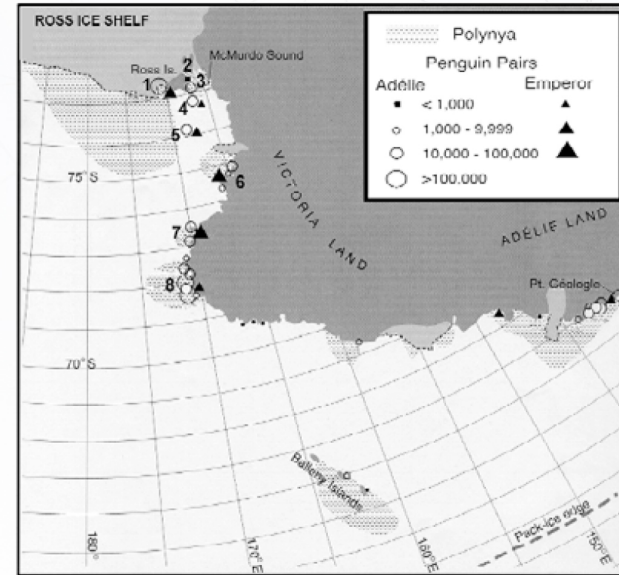
v's

Adelie's in the Ross Sea



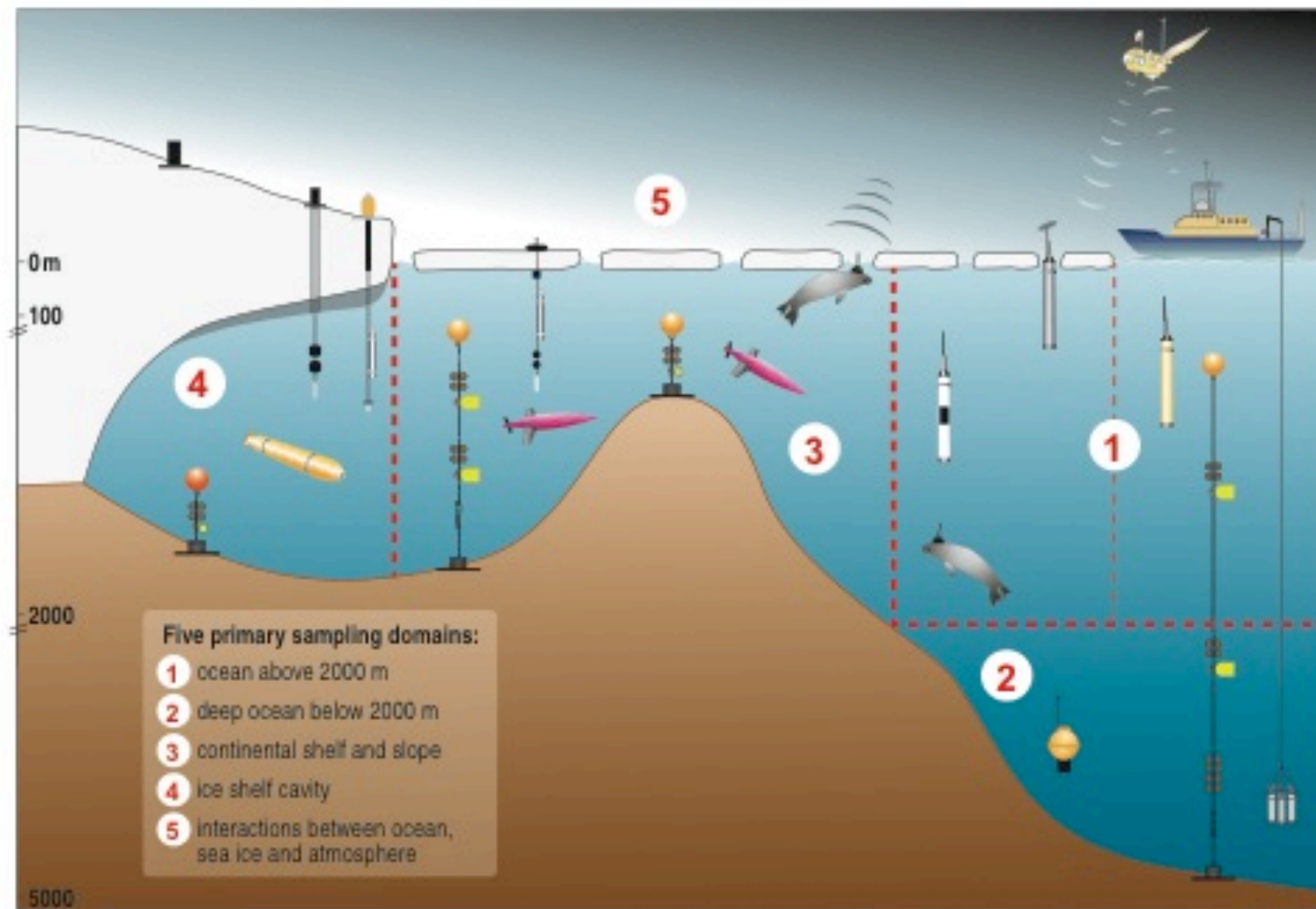
Since at least the 1970s, rapid warming, sea-ice loss, and other related climate changes (e.g., krill harvesting) have resulted in an 80% decline in the Adelie penguin population on the Peninsula

Ducklow et al. (2013)



By comparison, Adelie populations are increasing in the Ross Sea, likely due to changes in Polynya and sea-ice dynamics

Ainley et al., 2005

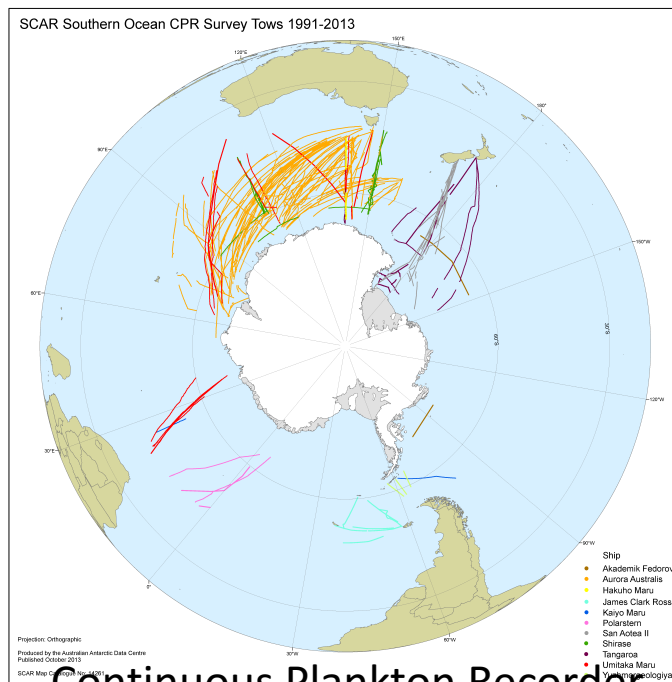
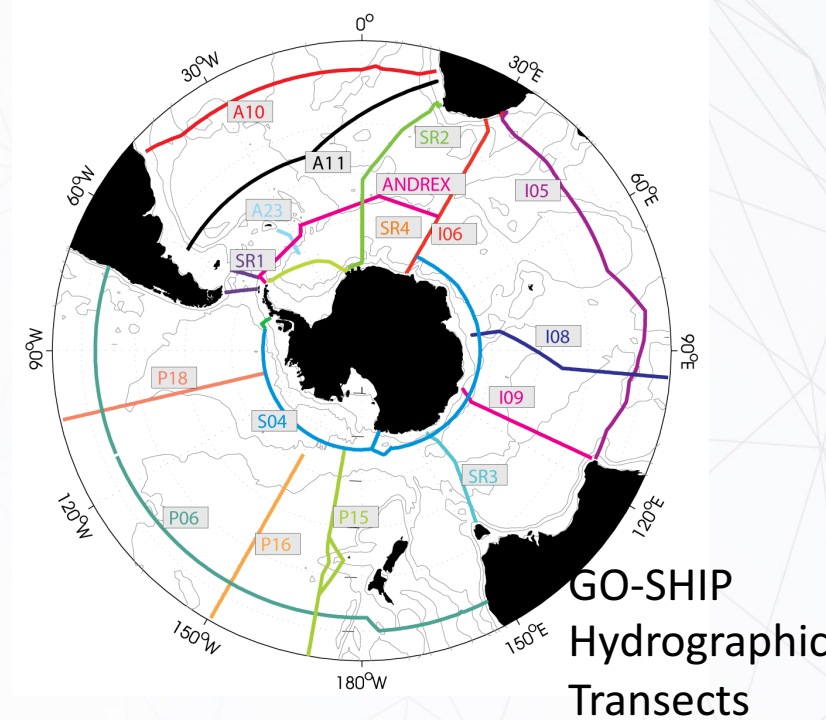
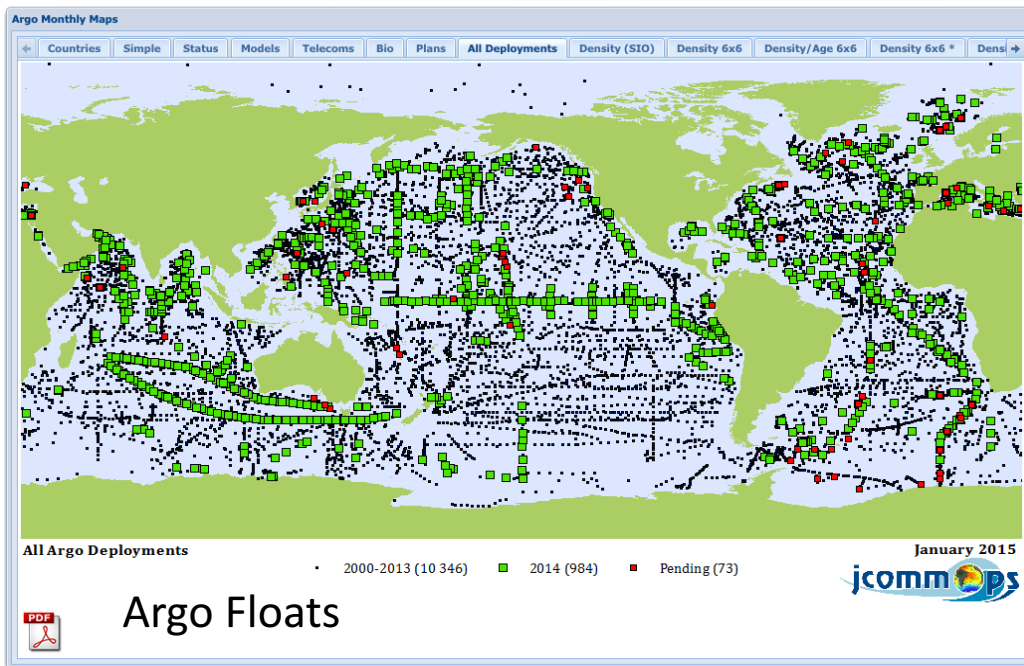


In order to detect and attribute changes in the Southern Ocean to their causes, and understand the impacts of these changes we need sustained, and internationally coordinated observations of the Southern Ocean

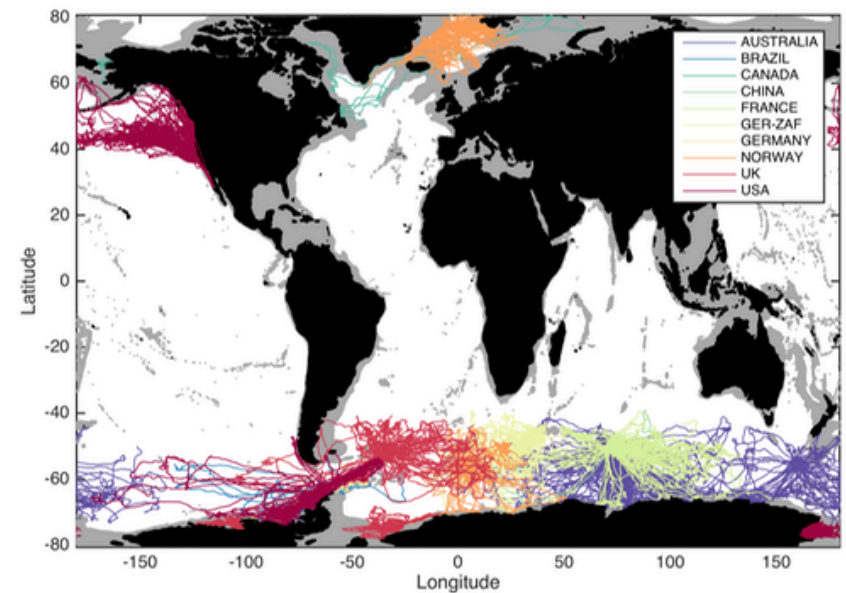
Its beyond the capability of one nation alone to address.

SOOS Objectives

- 1) Facilitate the design of a comprehensive and multi-disciplinary observing system for the Southern Ocean
- 2) Advocate and guide the development of new observation technologies
- 3) Compile and encourage use of existing international standards and methodologies, and facilitate the development of new standards where required
- 4) Unify and enhance current observation efforts and leverage further resources across disciplines, and between nations and programmes
- 5) Facilitate linking of sustained long-term observations to provide a system of enhanced data discovery and delivery, utilising data centres and programmatic efforts combined with, as needed, purpose-built data management and storage systems
- 6) Provide services to communicate, coordinate, advocate and facilitate SOOS objectives and activities

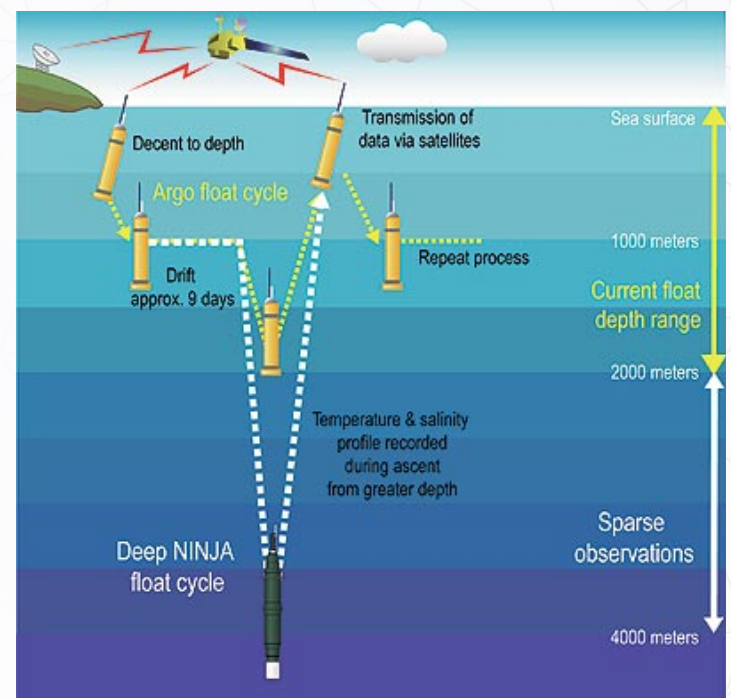
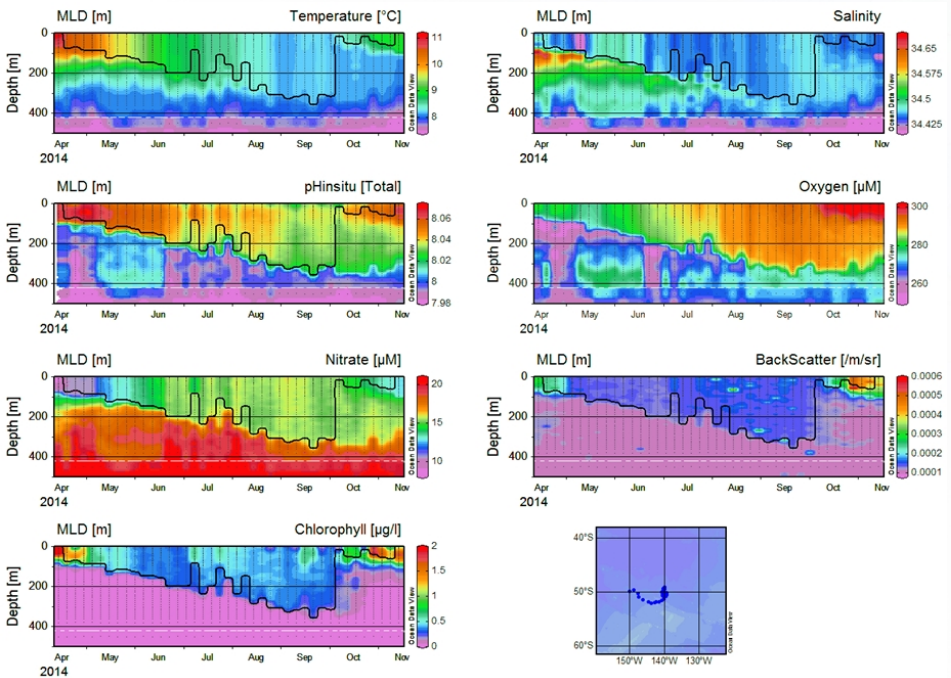


MEOP-CTD dataset : 329565 profiles, 104 deployments, 772 tags



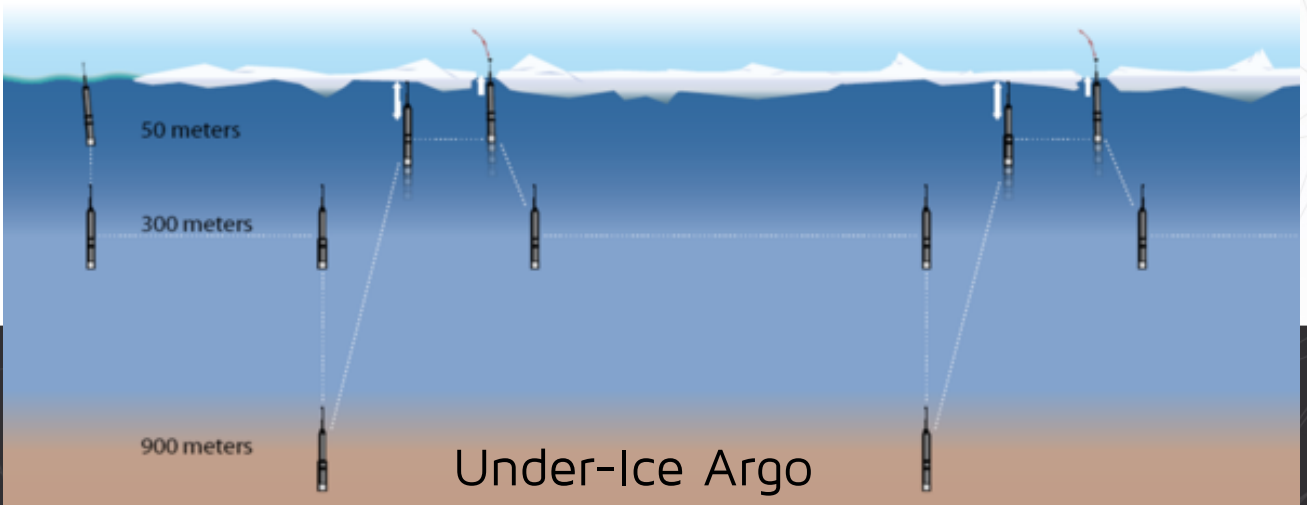
Seal CTD data (MEOP)

Enhancements to conventional Argo



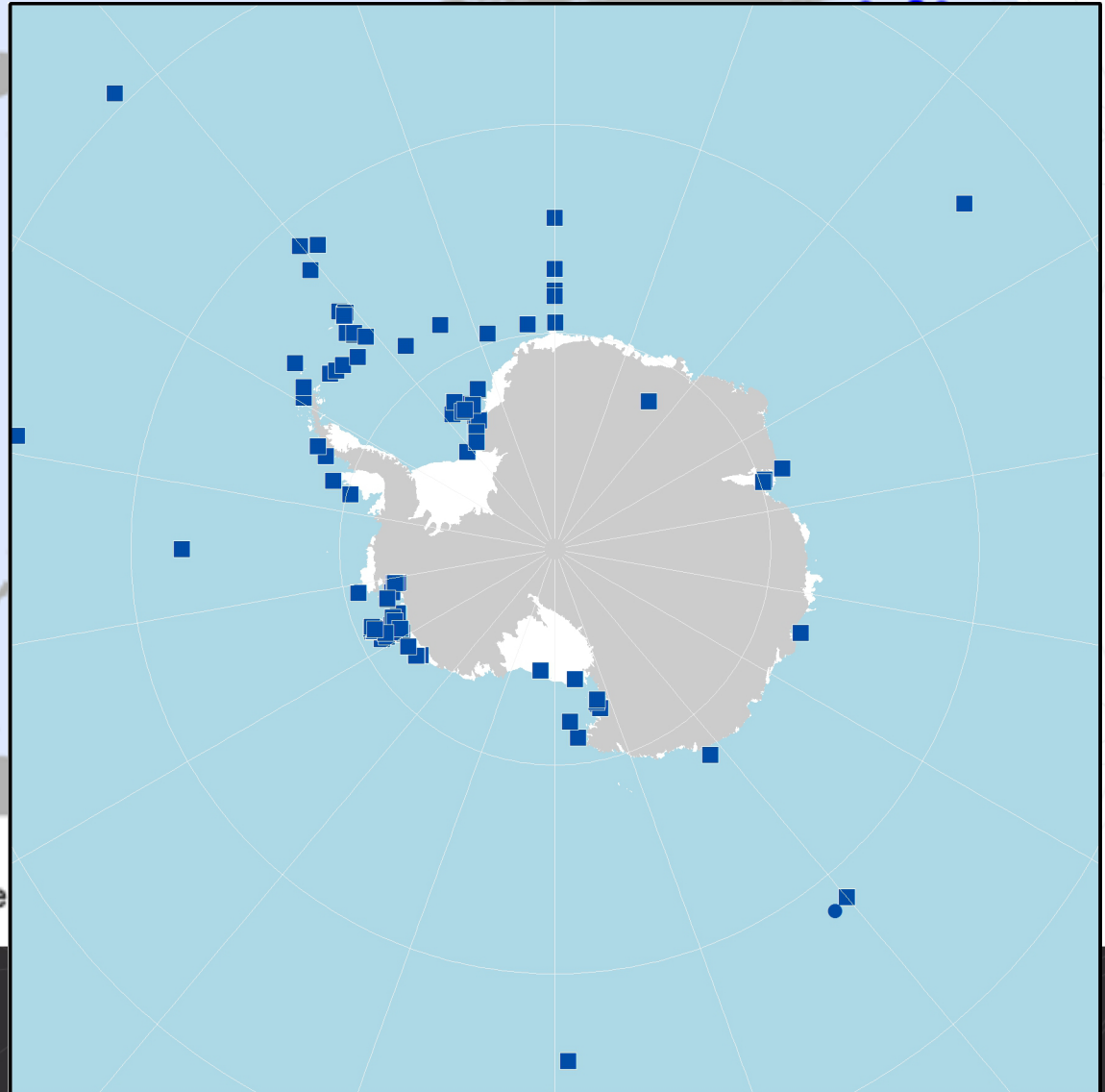
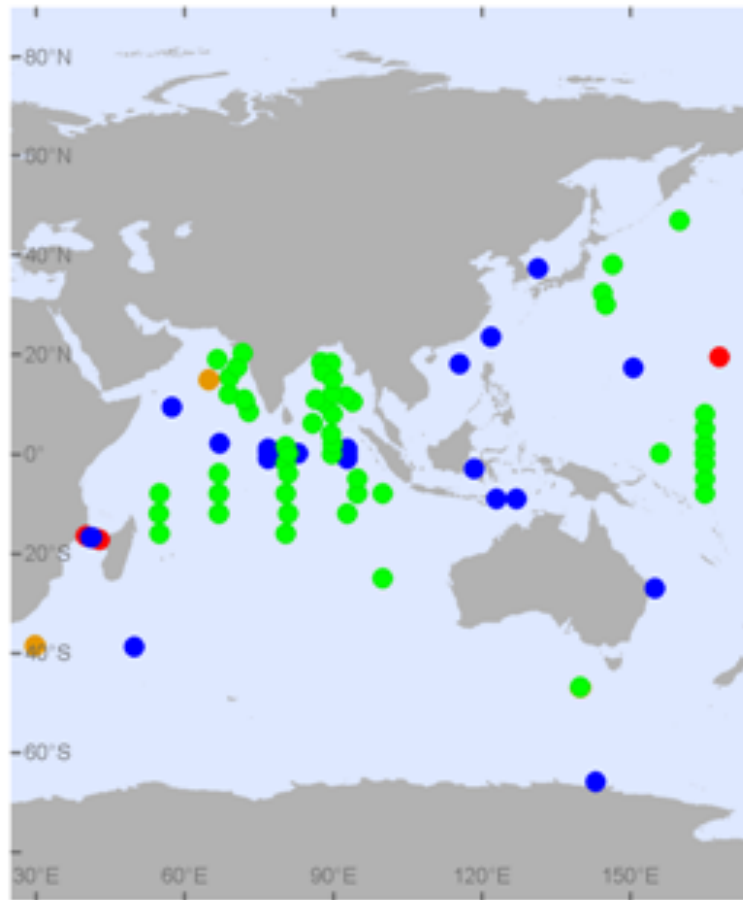
Deep Argo

Biogeochemical sensors on large float arrays
(courtesy Ken Johnson)



OceanSITES

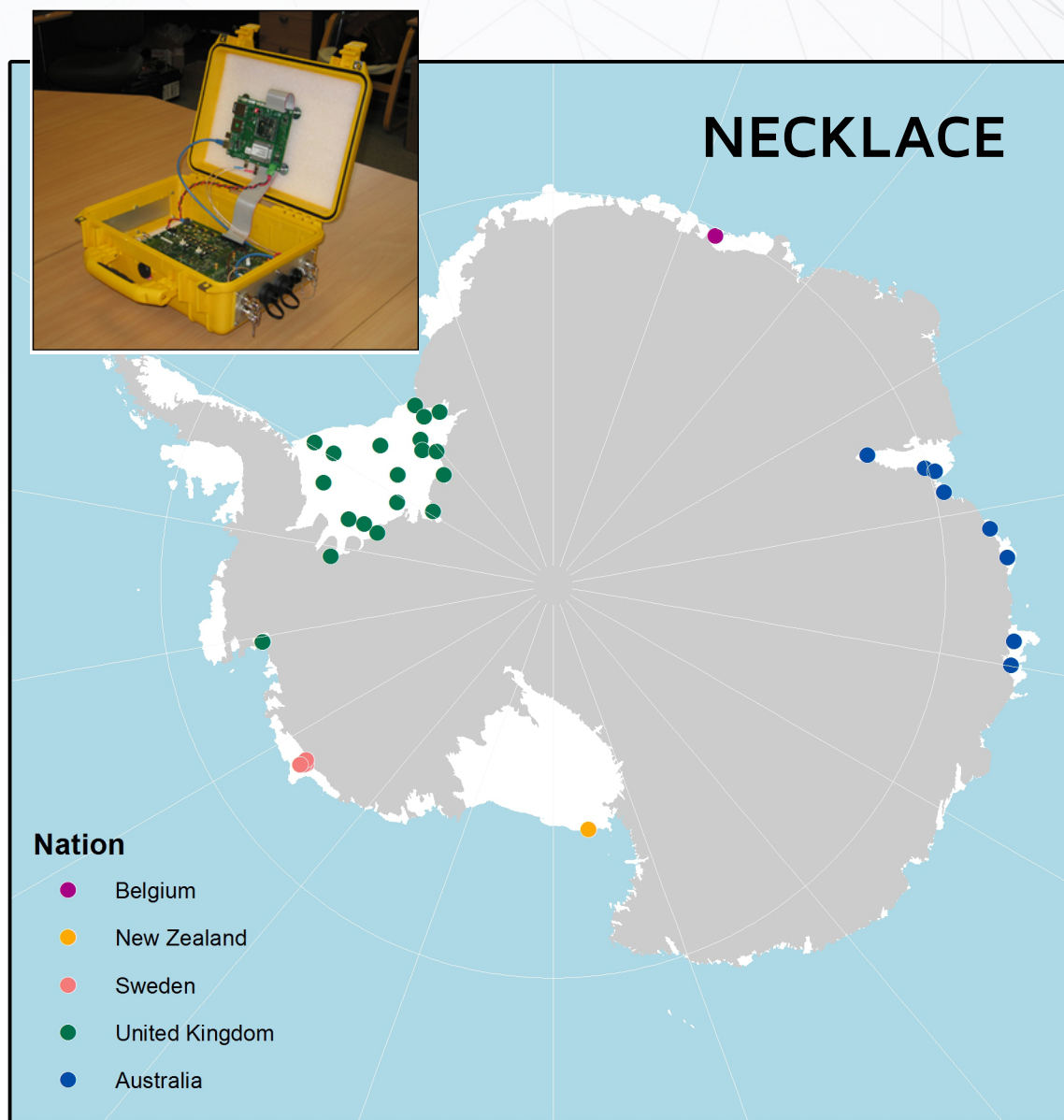
Sustained moorings coverage is poor (except Weddell Sea)



SOOS Endorsed, UK-led development of cheap, downward looking radar to measure ice-shelf thickness

SOOS is helping to coordinate the uptake of this technology by nations working on or near ice shelves to encourage circumpolar network of ice shelf melt observations over the next 5 years.

Workshop alongside FRISP meeting in October 2016, Sweden



The figure is a map of the Weddell Sea region, showing bathymetry and various research tracks. The main map is a fan-shaped projection with latitude from 70°S to 76°S and longitude from 100°W to 135°W. Bathymetry is shown with color contours: dark blue for depths greater than 500m, light blue for 500-1000m, yellow for 1000-2000m, and orange for 2000-3000m. A depth scale in meters is provided on the right, ranging from 0 to -6000m. The map shows the Getz Ice Shelf, Dotson Ice Shelf, Thwaites Glacier, and PIG (Pine Island Glacier). Research tracks are shown as lines with markers: 2012 Ship track & CTD (black line with circles), 2014 Ship track & CTD (magenta line with circles), Glider track (US Rutgers) (green line with circles), Mooring (KOPRI) (red triangle), Mooring (Sweden UGor) (yellow triangle), Mooring (UK BAS) (green triangle), and Mooring (US ASPIRE) (cyan triangle). An inset map in the top right corner shows the location of the study area within the Weddell Sea, with labels for Weddell Sea, Ross Sea, and Amundsen Sea. The inset map is a polar projection with latitude from 60°S to 90°S and longitude from 180°W to 90°E.



Objective - Facilitate the design of a comprehensive and multi-disciplinary observing system for the Southern Ocean

We must articulate and prioritise our requirements in a quantifiable way

Following the process defined in the Framework for Ocean Observing

- Identify *candidate* Essential Ocean Variables (EOVS)
- Prioritise based on *feasibility* and *impact* = EOVs
- Quantify sampling requirements

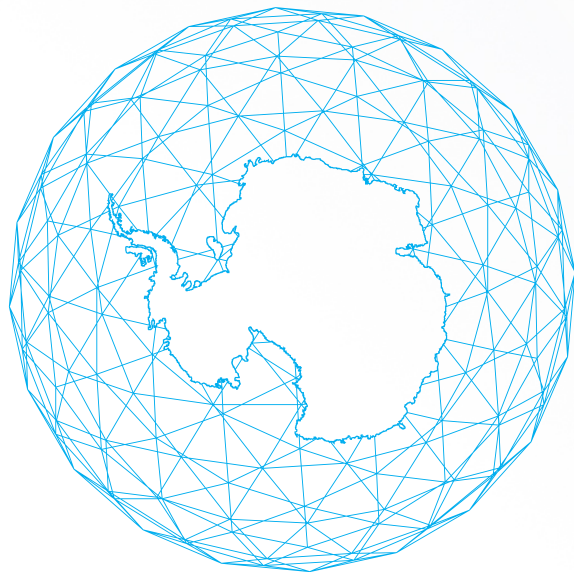
SOOS Science Theme

- | | |
|---------------------------------|---------------------------|
| 1) Heat and Freshwater movement | (Based on OOPC-GOOS-GCOS) |
| 2) Overturning circulation | (Based on OOPC-GOOS-GCOS) |
| 3) Ice Shelves and sea level | (SOOS-led, FRISP input) |
| 4) Carbon | (Taken from IOCCP-GOOS) |
| 5) Sea ice | (Provided by ASPeCt) |
| 6) Ecosystems | (SOOS-led) |



Candidate EOV	Specifics
Temperature	Water column, sea surface
Salinity	Water column, sea surface
Oxygen	Dissolved O ₂
Velocity	
Microstructure	
Tracers	Non-transient, transient
Bottom Topography	Below ice shelves, seafloor bathymetry general and under floating ice, bedrock under grounded ice
Sea surface height	
Seabed pressure	
Wind, accumulation	
Nutrients	Macro
Ice shelf topography	
Ice shelf thickness	
Ice shelf flow speed	
Glacier topography	
Glacier flow speed	
Ice shelf basal melt/freeze rates	
Ice shelf englacial temperatures	Ocean-ice heat transfer flux
Sea-ice cover/concentration	

Candidate EOV	Specifics
Sea-ice thickness	
Sea-ice drift	
Snow depth on sea ice	
Sea-ice types	
Carbonate system	
Suspended particulates	
Particulate matter export	
Nitrous oxide	
Carbon isotope ¹³ C	
Dissolved organic matter	
Hyperspectral reflectance	
Multispectral backscatter	
Photosynthetically active radiation	
Fluorescence	
Multispectral irradiance	
Benthic Species	Species diversity, size spectrum, habitat extent/relative abundances
Protists, zooplankton, mesopelagic fish	Biomass, relative abundance, size spectrum
Krill	Abundance, size spectrum
Marine mammals and birds (select species)	Abundances, Foraging Range, Diet, Reproductive Success



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