SOOS
SOUTHERN OCEAN OBSERVING SYSTEM

Sustained, Coordinated, & Integrated Southern Ocean Observations to support climate change mitigation & adaptation

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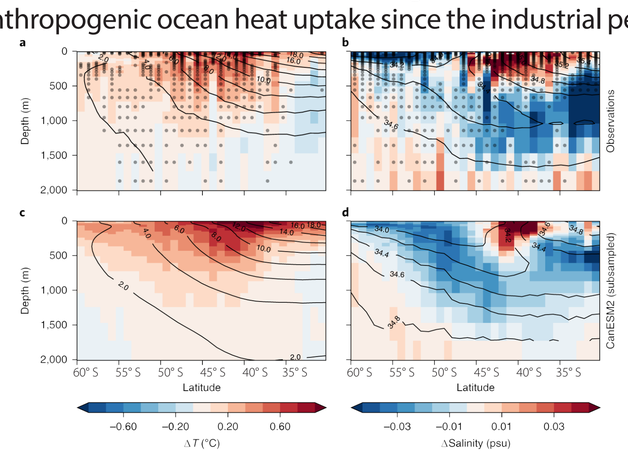
Global Impact of the Southern Ocean

The Southern Ocean is **taking up more heat** than any other sector of the global ocean, accounting for 60-90% of the total anthropogenic ocean heat uptake since the industrial period.



Temperature (a, c) and salinity changes (b, d) from observations (a, b) and models (c, d), indicating significant warming (red) in the last decade (2006-2015) in comparison to 30 years previous (1950-1980). From Swart et al., 2018.

Southern Ocean warming directly **impacts the stability of the Antarctic Ice Sheet**, which is the greatest source of uncertainty in projections of future sea-level rise.

The Southern Ocean represents a major 'blind spot' in our climate understanding

The Southern Ocean is Earth's **largest sink of anthropogenic carbon**, yet recent research suggests that this sink is weakening - with global consequences.

The Southern Ocean is home to one of **Earth's largest seasonal changes** - with the annual growth and retreat of sea ice - influencing surface albedo, driving the movement of heat, freshwater and nutrients around the globe, and supporting diverse and unique ecosystems.

The Southern Ocean **modulates nearly all ecosystems and life in Antarctica** and the rest of the world's oceans, impacting not only ecosystems of incalculable intrinsic value for conservation and management, but also significant economic value for fisheries and tourist activities.

Small sensors on seals provide vital data on water column properties around the Antarctic coast & continental shelf.

These measurements are an important tool for examining ice-ocean interactions & many other climate relevant processes.

Photo from D. Costa.

A Coordinated Approach to Addressing the Gaps in our Understanding

Significant investment in data collection over the last decade has enhanced our knowledge of the Southern Ocean and its impact on the Earth system. Yet, the Southern Ocean remains one of the **most poorly observed regions on Earth,** leading to uncertainty in estimates of future states and consequences for the Earth system.

The critical need to observe and understand the Southern Ocean to better determine its role in global environmental change, increase our resilience to such change, and ensure sustainable resource (i.e. fisheries) exploitation provided the basis for establishing the Southern Ocean Observing System (SOOS).

To prioritise data collection efforts, the Southern Ocean community identified key short (≤5 years) and long (5-10 years) term science challenges within the five SOOS Science Themes that encompass the **scientific drivers of a Southern Ocean observing system** (as shown below).

1. Cryosphere

1.1 Understand ocean properties, processes and circulation beneath ice shelves and Antarctic sea ice

1.2 Understand influences of changes in freshwater fluxes from iceberg melting, sub-ice shelf melting, subglacial discharge and sea ice

1.3 Quantify sea ice-ocean-atmosphere characteristics and processes including wave-ice interaction and deformation processes

1.4 Understand changes in the Antarctic Ice Sheet and its impact on global sea level to improve projections and predictions of future states

1.5 Improve subglacial and continental shelf bathymetry

2. Circulation

2.1 Understand the impacts of SO heat, freshwater and carbon exchange and storage on the global ocean

2.2 Understand dynamical processes in the SO and their likely changes in the future

2.3 Understand how climate change will alter surface fluxes and freshwater input from the cryosphere, and the impact of these changes on water mass properties, formation and circulation, and implications for heat and carbon

3. Carbon & biogeochemistry

3.1 Constrain variability in the SO CO_2 sink over different temporal scales and across regions

3.2 Evaluate the contribution of seasonally ice-covered areas to carbon uptake and export

3.3 Assess the extent and impact of ocean acidification across the SO

3.4 Assess the spatial, seasonal and inter-annual distribution of climate-active gases and halogens in ice-covered & ice-free waters

3.5 Determine the key drivers of primary productivity and the biological carbon pump, and assess ongoing changes in these parameters

3.6 Quantify impact of recycling and remineralization on nutrients & carbon cycling

4. Ecosystem & biodiversity

4.1 Assess the key drivers of change and their impacts on SO ecosystems at circumpolar and regional scales, with emphasis on the effects of changing sea-ice conditions on key species that are central to SO food webs

4.2 Understand biodiversity of SO benthic and pelagic ecosystems at regional and circumpolar by investigating the potential changes accruing from influences of climate change and human activities

4.3 Evaluate the distribution of species in relation to CCAMLR, MPAs and climate change, considering historical changes and future projections

4.4 Assess the extent to which the "greening" of the SO is changing phytoplankton biodiversity, distribution and abundance, investigating the impact of these changes on CO_2 uptake, and zooplankton grazers

5. Ocean-sea ice-atmosphere fluxes

5.1 Increase air-sea flux observations

5.2 Improve satellite flux measurement capabilities

5.3 Decrease uncertainty in atmosphere and ocean dynamics and boundary-layer thermodynamic processes, aiding improvements in weather and climate models

5.4 Constrain variability in SO carbonate system and ocea-atmosphere CO2 fluxes over seasonal and annual temporal scales

5.5 Assess the spatial, seasonal and inter-annual distribution of essential climate variables in the sea ice impacted SO to decrease uncertainty on ocean-sea ice-atmosphere fluxes of biogeochemical and physical properties

5.6 Evaluate the contribution that seasonal variability of sea ice makes to heat budgets considering turbulent fluxes at the ocean-sea ice-atmosphere interface

5.7 Increase spatial and temporal coverage of measurements of the ocean-sea ice-atmosphere fluxes of other climate relevant gases

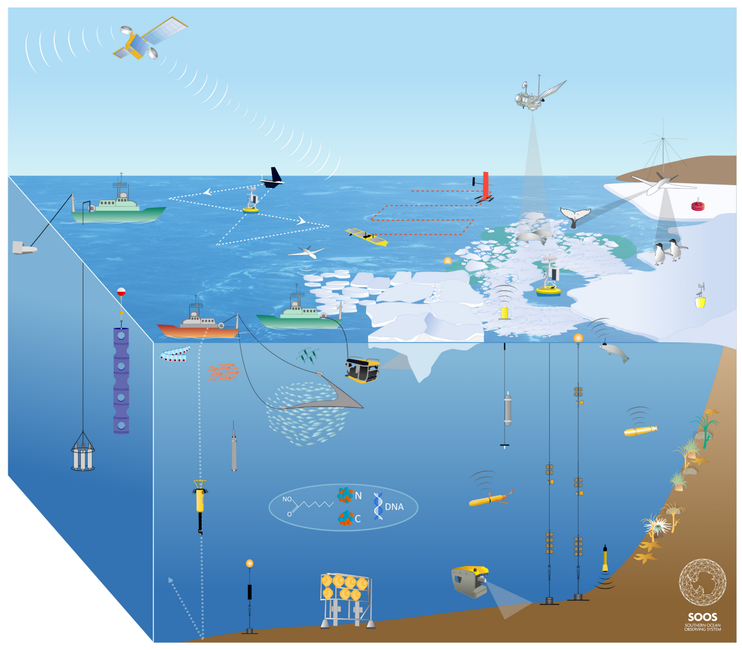
Observing System of the Future Southern Ocean

The SOOS vision identifies required networks and infrastructure to deliver a backbone of sustained, fundamental observations for use by a breadth of stakeholders across scientific, policy, and educational communities.

The observational coverage will provide a **foundation to advance understanding of the Southern Ocean and to address critical societal challenges**.

This will be achieved by:
- Aligned and supported scientific observational priorities
- Enhanced collaboration and observational capabilities
- Enhanced management and delivery of observational data
- Shared knowledge and values

The long-term vision for SOOS (figure below) is to have **a coordinated multidisciplinary program** integrating cutting-edge autonomous platforms and novel approaches with traditional observing techniques to readily **deliver "essential" data to stakeholders, including real-time information**.



The data, networks and integrated science generated by this developing system is already a major resource for the Southern Ocean community. As the system grows, it will improve our ability to **obtain the most reliable projections of future changes and states**.

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Literature: Newman *et al.* (2022): "2021-2025 Science and Implementation Plan", DOI: 10.5281/zenodo.6324359
Newman *et al.* (2019): "Delivering sustained, coordinated, and integrated observations of the Southern Ocean for global impact". DOI: 10.3389/fmars.2019.00433