GLOBAL CLIMATE OBSERVING SYSTEM
KEEPING WATCH OVER OUR CLIMATE

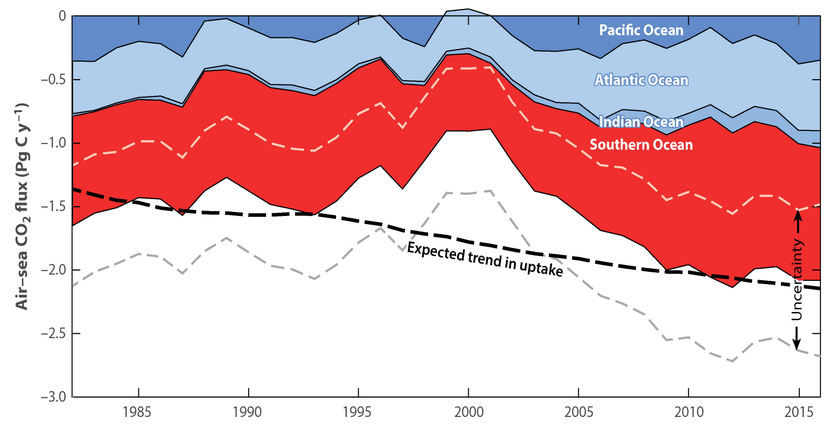
WMO | UNESCO | IOC | International Science Council | UN environment | WCRP World Climate Research Programme

Observing the role of the Oceans in the Climate System

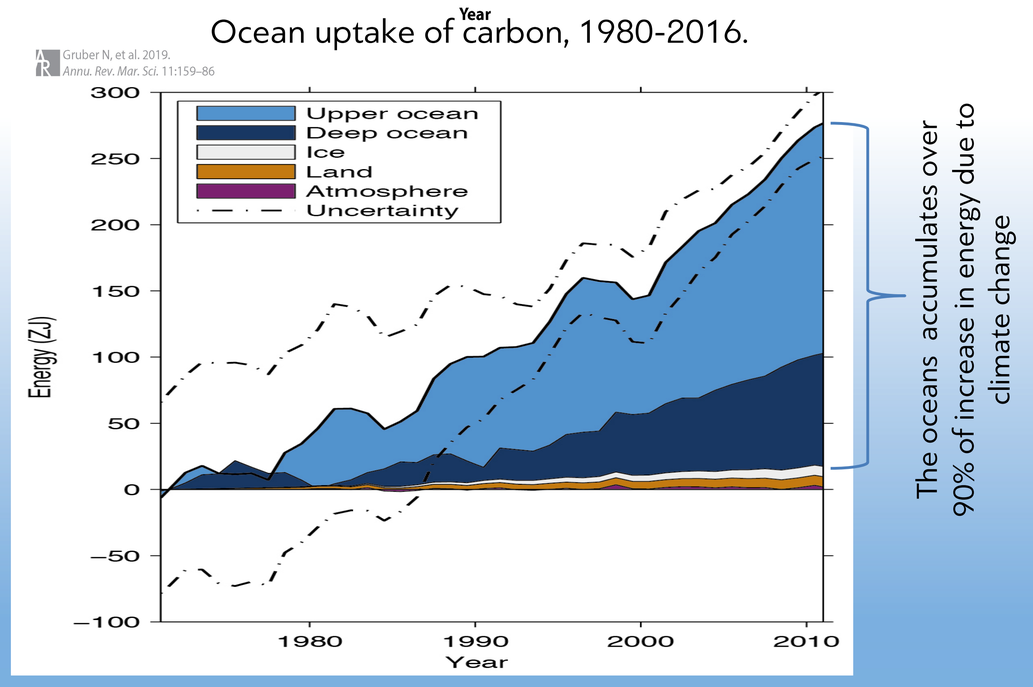
The Oceans play a major role in climate change by taking up over 90% of the additional energy and 30% of the additional CO_2.

- About half of the observed sea level rise is due to the thermal expansion of the oceans.
- Uptake of carbon by the oceans is leading to the ocean acidification.
- Increased warmer oceans, increased stratification and ice loss lead to ocean deoxygenation, changes in carbon uptake, changes in ocean circulation.
- In combination, these trends have significant impact on marine ecosystems.

Relevant ECVs include
Ocean Surface Heat Flux
Sea Surface Temperature
Subsurface Temperature
Inorganic Carbon
Carbon Dioxide, Methane and other Greenhouse Gases
Anthropogenic Greenhouse Gas Fluxes
Marine Habitat Properties.



Ocean uptake of carbon, 1980-2016.



Energy accumulation by distinct components of the Earth's climate system from 1971 to 2010 (SOURCE: IPCC AR5, WG1, Box 3.1, Figure 1)

Role of Systematic Observations

Sustained observations are needed to monitor the role of the oceans in the climate system, how it is changing and the impacts.

GCOS works with the World Climate Research Programme and the global climate research community to ensure the Essential Climate Variables (ECVs) in combination are able to track the Climate System including the major climate cycles, feedbacks and tipping points.

The IPCC Special Report on 1.5C Report identifies 4 global tipping points of concern – all are related to the Oceans.

There is a medium risk of at least one of these occurring at temperature increase of 1C and a high risk at 2C

The cryosphere: West Antarctic ice sheet, Greenland ice sheet

A global temperature increase of between 1.5°C and 2°C

- May initiate irreversible loss of the West-Antarctic and Greenland ice sheet though total Ice sheet loss could take millennia.
- Global sea level rise is estimated between several tenths of a meter to 1–2 m.

(SOURCE IPCC Special Report on Global, Warming of 1.5 °C 2019).

Relevant ECVs include
Ice Sheets and Shelves, Glaciers, Sea Ice, Albedo, Sea Level, Surface/Subsurface Temperature, Surface/Subsurface Salinity, Surface/Subsurface Currents, Sea State.

The thermohaline circulation: slowdown of the Atlantic Meridional Overturning Circulation (AMOC)

It is more likely than not that the AMOC has been weakening in recent decades, and there is limited evidence linking the recent weakening of the AMOC to anthropogenic warming.

- **Very likely** that the AMOC will weaken over the 21st century.
- **No evidence** of significantly different amplitudes of AMOC weakening for 1.5°C vs 2°C of global warming, or of a shutdown of the AMOC at these thresholds.

(SOURCE IPCC Special Report on Global, Warming of 1.5 °C 2019)

Relevant ECVs include
Surface/Subsurface Currents, Surface/Subsurface Salinity, Surface/Subsurface Temperature, Ice sheets and Ice shelves, Glaciers, Sea Ice.

El Niño-Southern Oscillation (ENSO)

ENSO is the biggest Climate Signal outside of the annual cycle; while centred on the Tropical Pacific, impacts climate globally, particularly rainfall patterns.

- Extreme El Niño event frequency increases linearly with the global mean temperature, and may double (one every ten years) with 1.5°C of global warming. This challenges the limits of adaptation. No change projected in La Niña event frequencies.

(SOURCE IPCC Special Report on Global, Warming of 1.5 °C 2019)

Relevant ECVs include
Sea Level, Ocean Surface Stress, Heat Fluxes, Surface/Subsurface Temperature, Surface/Subsurface Salinity, Ocean Currents, Precipitation.

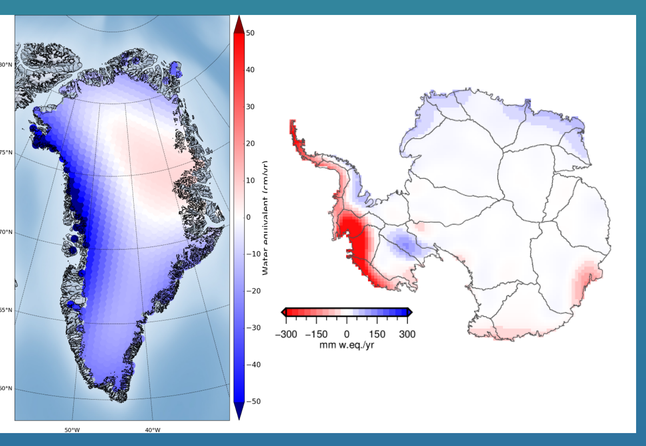
The role of the Southern Ocean in the global carbon cycle

The critical role of the Southern Ocean as a net sink of carbon might decline under global warming,

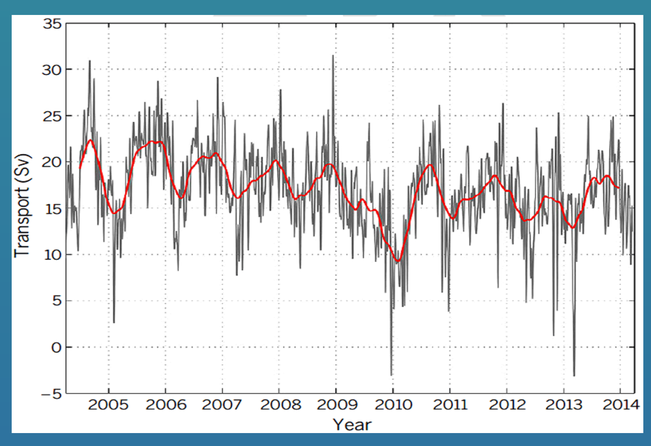
- Research Priority: assessing the sink effect under 1.5°C compared to 2°C scenarios.
- Changes in ocean chemistry (e.g., declining oxygen content, ocean acidification), especially those associated with the deep sea, are associated concerns.

(SOURCE IPCC Special Report on Global, Warming of 1.5 °C 2019)

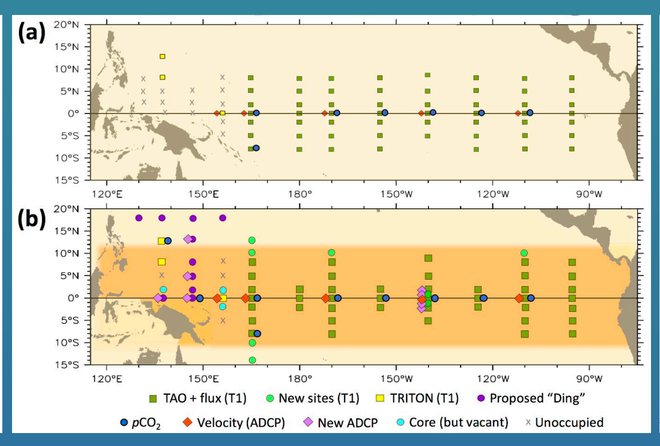
Relevant ECVs include
Inorganic Carbon, Surface/Subsurface Temperature, Surface/Subsurface Salinity, Surface/Subsurface Currents; Carbon Dioxide, Methane and other Greenhouse Gases, Anthropogenic Greenhouse Gas, Fluxes.



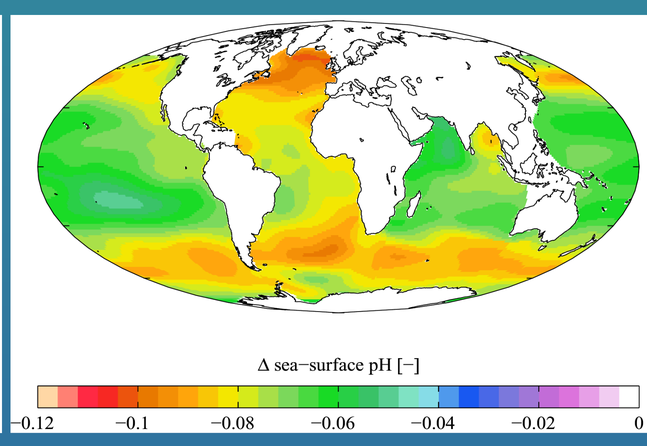
Greenland and Antarctic Gravimetric Mass balance, Satellite-based observations. Warmer polar ocean waters and circulation under ice shelves are a contributor to ice sheet loss. Measuring the oceans under ice shelves is an observational challenge.
SOURCE: ESA Greenland Ice Sheet CCI, Antarctic Ice Sheet CCI



10-year time series of the AMOC measured at 26.5°N from April 2004 to March 2014. The gray line represents the 10-day filtered measurements, and the red line is the 180-day filtered time series. (1 Sv = 1 million m^3/sec). (SOURCE - RAPID Rapid Programme https://www.rapid.ac.uk/)



Proposed redesign (a: current, b: future) of the Tropical Pacific Observing System, to meet future needs monitoring the El Niño – Southern Oscillation. "Core and vacant" - sites are high-priority but not maintained.
SOURCE TPOS http://www.tpos2020.org/



Estimated change in sea water pH between the 1700s and the 1990s, from the Global Ocean Data Analysis Project. (GLODAP)