



The Global Ocean Observing System  
*goosocean.org*

# Ocean Observing: Latest Developments in Support of the Paris Agreement

**Toste Tanhua**

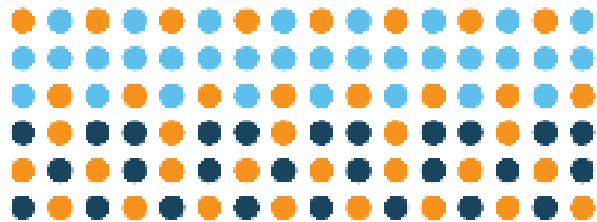
*Co-chair, GOOS Steering Committee, ttanhua@geomar.de*

*Earth Information Day*

*COP25 Dec 3 2019*



# OCEAN OBS'19



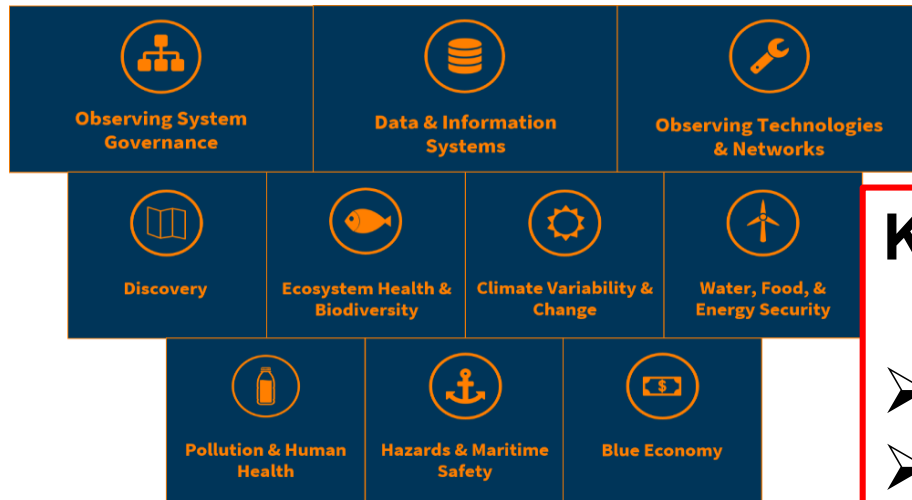
## An Ocean of Opportunity

1500 attendees

128 Community White Papers

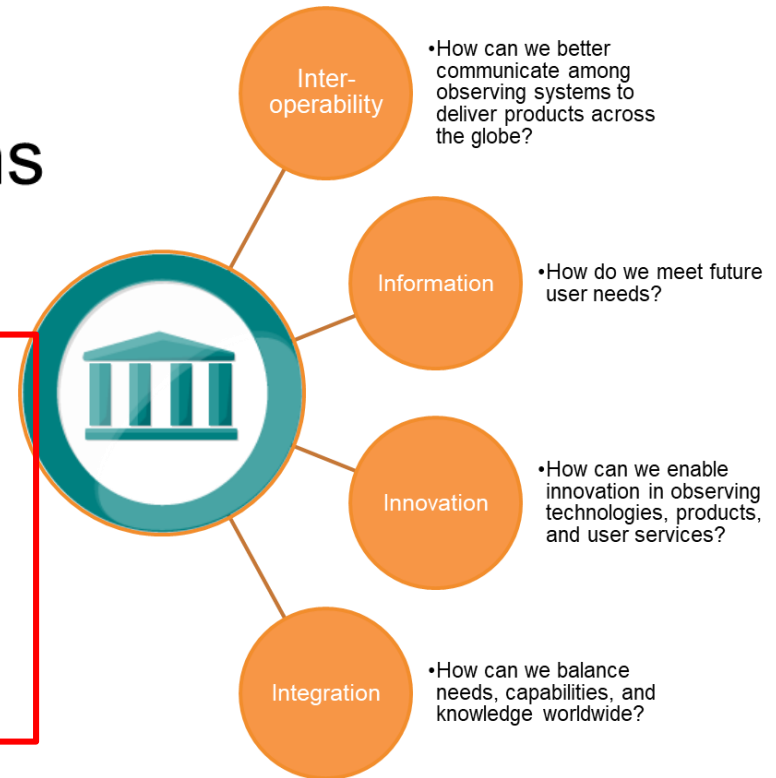
2480 contributing authors

### Ocean solutions



### Key themes emerged:

- Planning for Impact
- Core System Integration
- Embracing Innovation



# Monitoring the Status and Impact of the Ocean Observing System

## IN SITU AND SATELLITE OBSERVING SYSTEM STATUS



In 2018, extreme weather and climate events affected about 62 million people with many parts of the globe impacted by climate change. The current increase of carbon dioxide levels in the atmosphere is having a significant impact on temperatures, with 2015-2018 having been confirmed as the four warmest years on record and with an unprecedented increase in ocean acidity which is impacting a number of commercial fisheries.

With the current and increasingly urgent need for nations to take decisions related to the impact of climate change, the **Ocean Observing System Report Card 2019** provides insight into the status of the global ocean observing system and highlights the need for sustained ocean monitoring.

The global ocean observing system networks are also fundamental in providing critical data to nations for delivering marine weather and ocean services, to ensure safe and efficient maritime operations, and improving

emergency response efficiency for extreme events. They are also crucial for providing scientific assessments to enable environmental prediction and adaptation to climate change, as well as leading to more effective protection of ecosystems. To better meet expanding societal needs, the global ocean observing system is introducing new technologies and improved capabilities. These advancements will provide more observational information in real-time and long duration high-quality data needed for detection of ocean change, as well as help to address the lack of data in poorly sampled regions.

The sustained ocean observing networks are internationally coordinated by the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), under the Observation Coordination Group. JCOMM works across oceanographic and marine meteorological communities for observations, data management and services, in order to maximize value and impact for local, regional and global societal issues.

### 2018: ocean observations by the numbers

**86** countries involved in ocean observations

**18** Ocean and **9** Atmosphere Essential Climate Variables (ECVs)<sup>(1)</sup> observed

**2** million Temperature and Salinity profiles acquired in 20 years by the Argo program - a historical record!

**THOUSANDS OF SCIENTIFIC PAPERS** based on ocean observations are published every year - adding to our knowledge and supporting societal decisions

**US\$1,5** trillion/year the estimated ocean economy - this will double, to 3 trillion, by 2030<sup>(2)</sup>. Ocean observations help understand the ocean and why it is changing

**8,933** *in situ* ocean observing platforms and...

**170** satellites continuously monitor the global ocean and atmosphere

**HUNDREDS OF THOUSANDS OF WEATHER FORECASTS** issued annually by meteorological agencies that have assimilated *in situ* ocean observations to initialize and improve numerical model forecasts



# Monitoring Ocean

## IN SITU AND SATELLITE OBSERVING SYSTEM

In 2018, extreme weather and climate events affected about 62 million people. The current increase of carbon dioxide levels in the atmosphere is having 2015-2018 having been confirmed as the four warmest years on record and which is impacting a number of commercial fisheries.

With the current and increasingly urgent need for nations to take decisions regarding the **Observing System Report Card 2019** provides insight into the status of the global ocean observing system for sustained ocean monitoring.

The global ocean observing system networks are also fundamental in providing weather and ocean services, to ensure safe and efficient maritime operations.

### 2018: ocean observations by the

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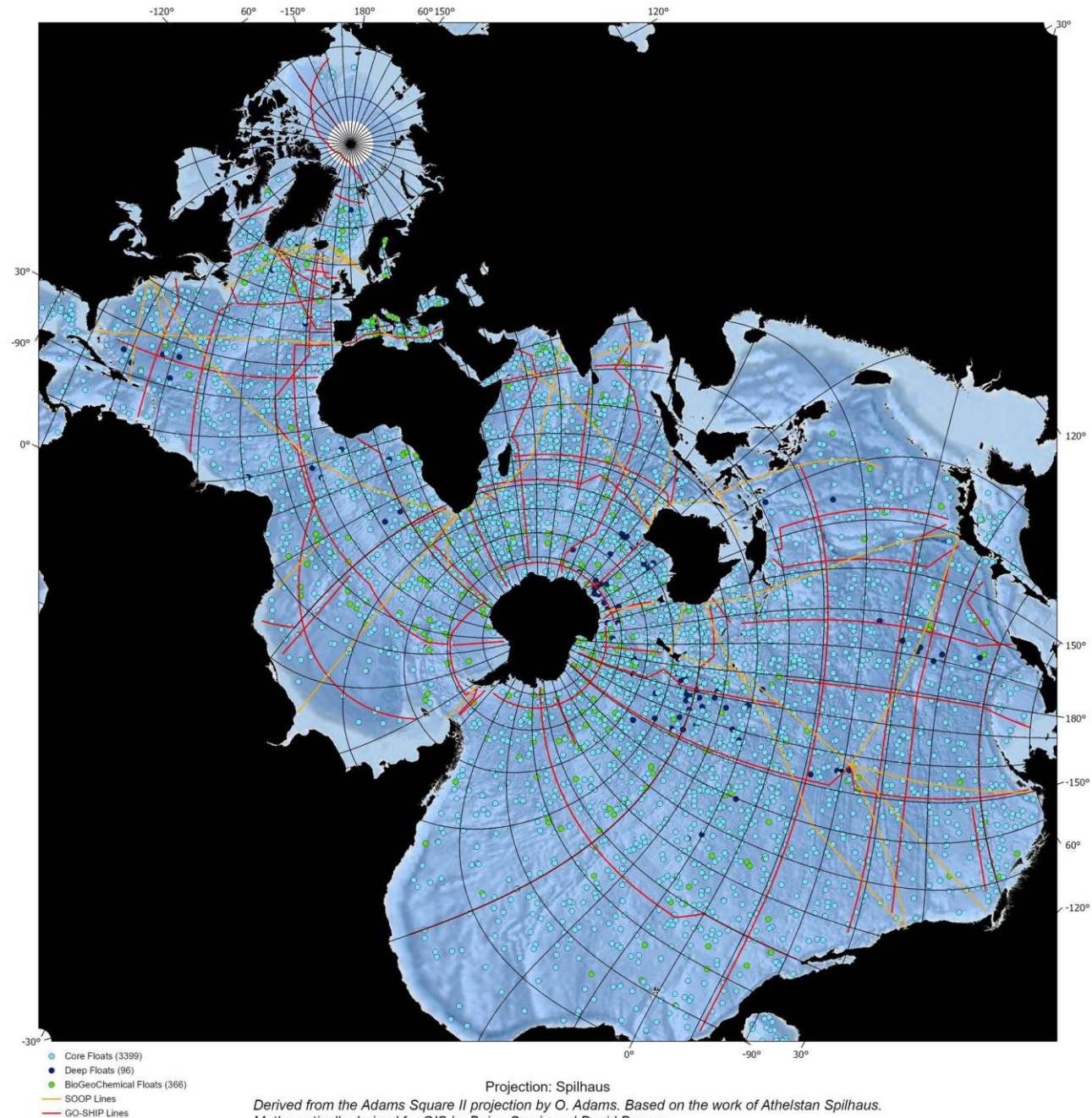
THOUSANDS OF SCIENTIFIC PAPERS based on ocean observations are published every year - adding to our knowledge and supporting societal decisions

HUNDREDS OF issued annual reports assimilated in improve numerical

US\$1,5 trillion/year the estimated ocean economy - this will double by 2030 if we don't understand the ocean and why it is changing

One Planet, One Ocean...

Special thanks to ESRI Team and A. Spilhaus



- Core Floats (3399)
- Deep Floats (96)
- BioGeoChemical Floats (366)
- SOOP Lines
- GO-SHIP Lines

Projection: Spilhaus

Derived from the Adams Square II projection by O. Adams. Based on the work of Athelstan Spilhaus. Mathematically derived for GIS by Bojan Savric and David Burrows

# The Ocean Essential Climate Variables (ECVs)

## Ocean

### Physical

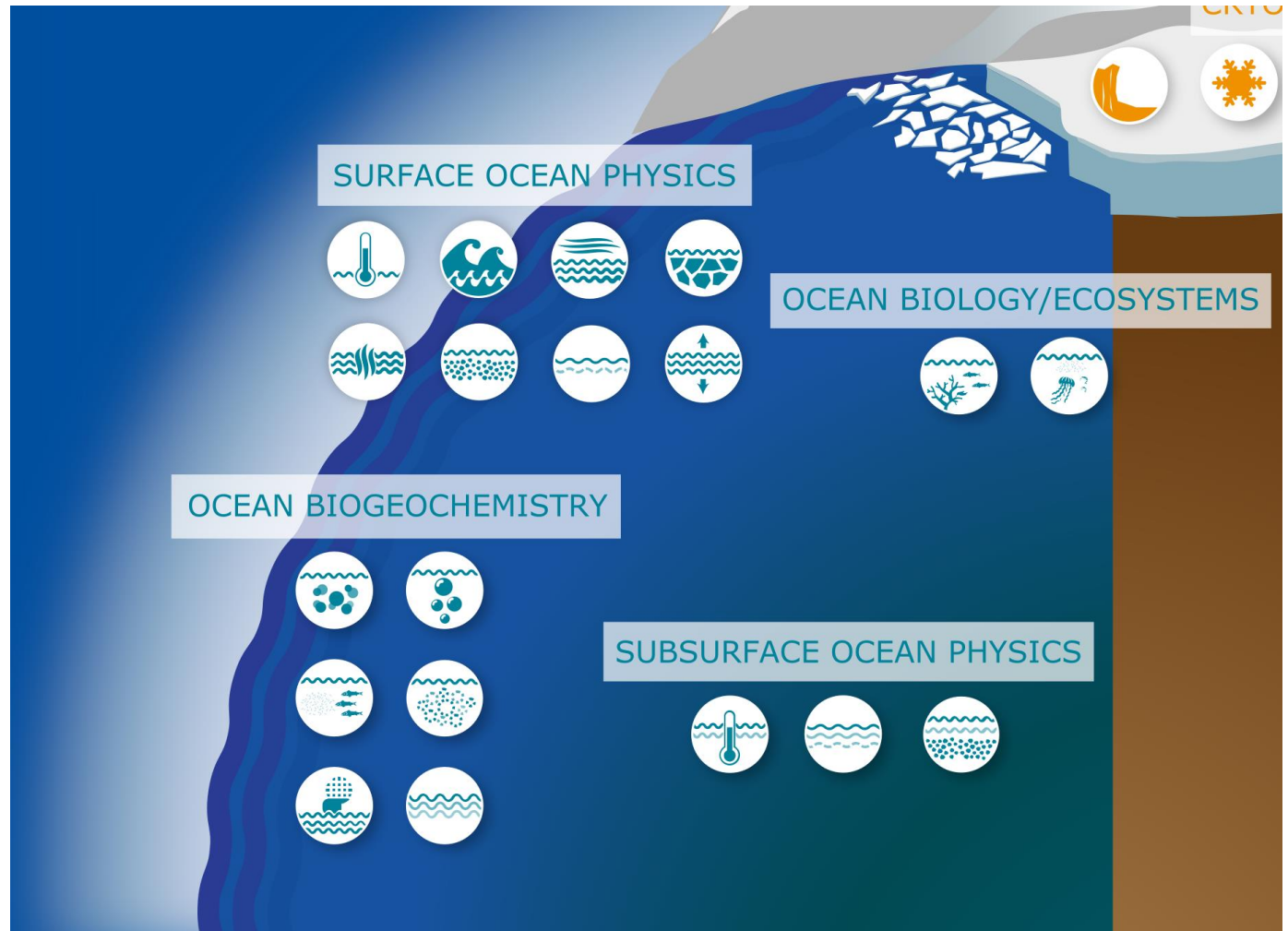
- [Ocean surface heat flux](#)
- [Sea ice](#)
- [Sea level](#)
- [Sea state](#)
- [Sea surface currents](#)
- [Sea surface salinity](#)
- [Sea surface stress](#)
- [Sea surface temperature](#)
- [Subsurface currents](#)
- [Subsurface salinity](#)
- [Subsurface temperature](#)

### Biogeochemical

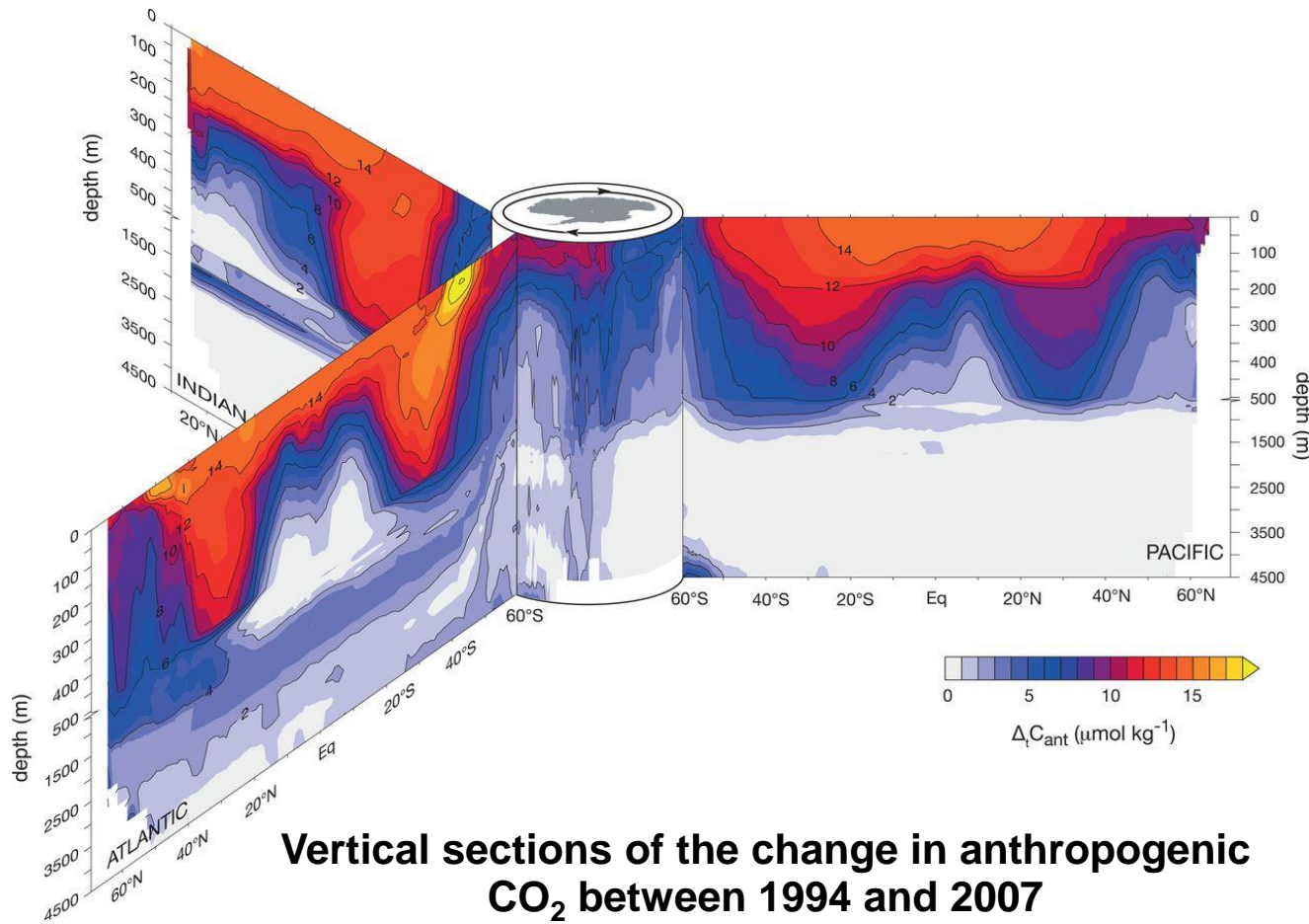
- [Inorganic carbon](#)
- [Nitrous oxide](#)
- [Nutrients](#)
- [Ocean colour](#)
- [Oxygen](#)
- [Transient tracers](#)

### Biological/ecosystems

- [Marine habitats](#)
- [Plankton](#)

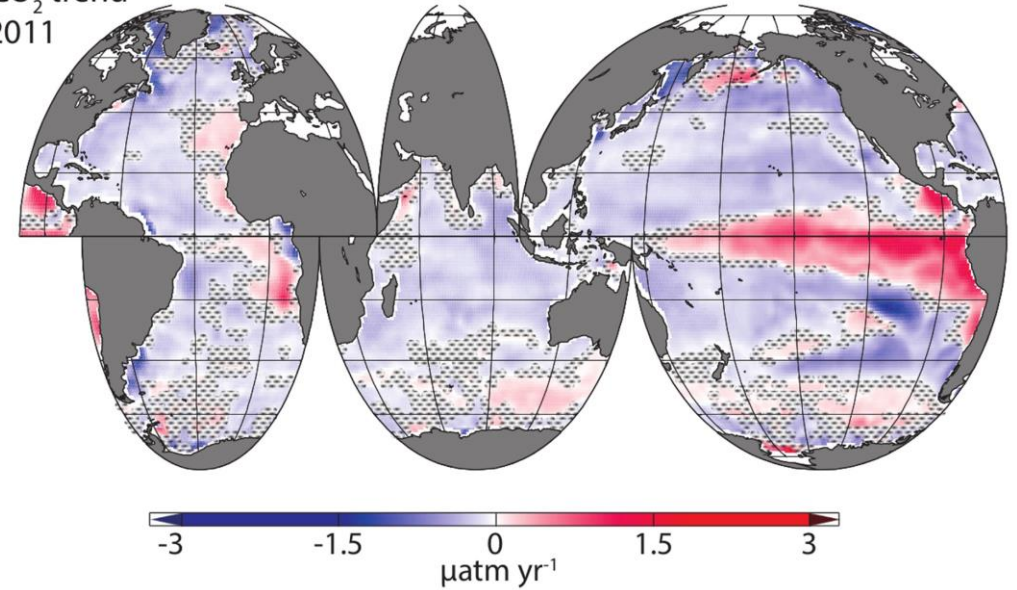


# The Ocean stores ~30% of Anthropogenic CO<sub>2</sub>

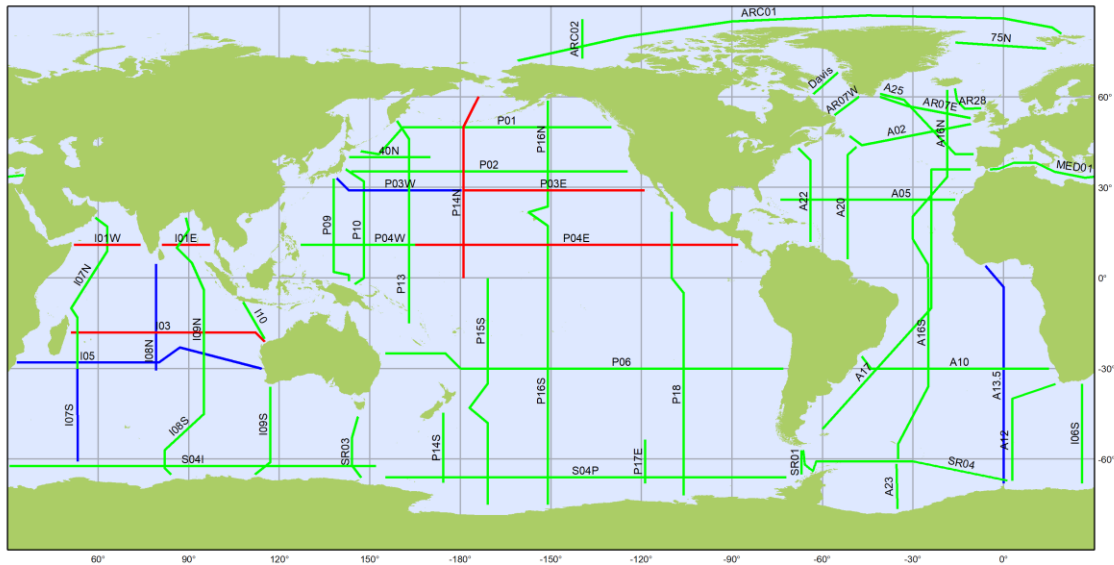


**Vertical sections of the change in anthropogenic CO<sub>2</sub> between 1994 and 2007**  
Gruber et al. Science 2019

(a) ΔpCO<sub>2</sub> trend  
1982-2011



**Long-term linear trend of ΔpCO<sub>2</sub> over the 1982 through 2011 period.**  
Landschützer et al. 2016



GO-SHIP

Status of 2012-2023 Survey (55 Core Lines)

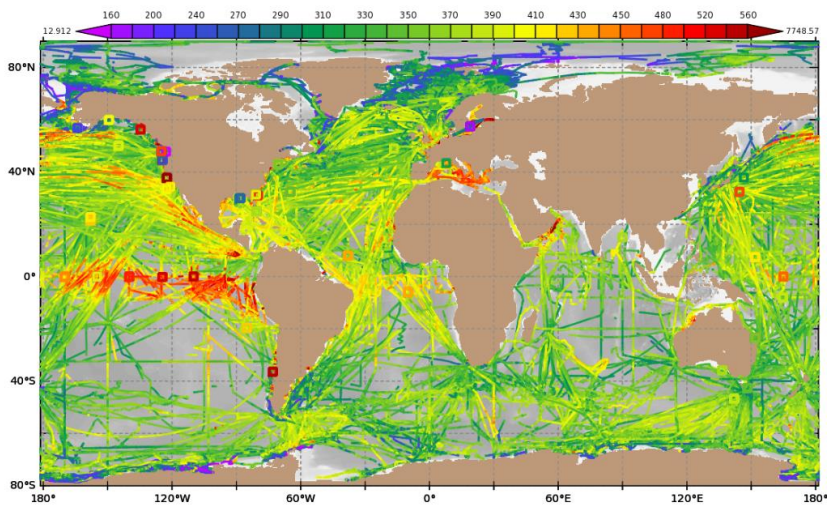
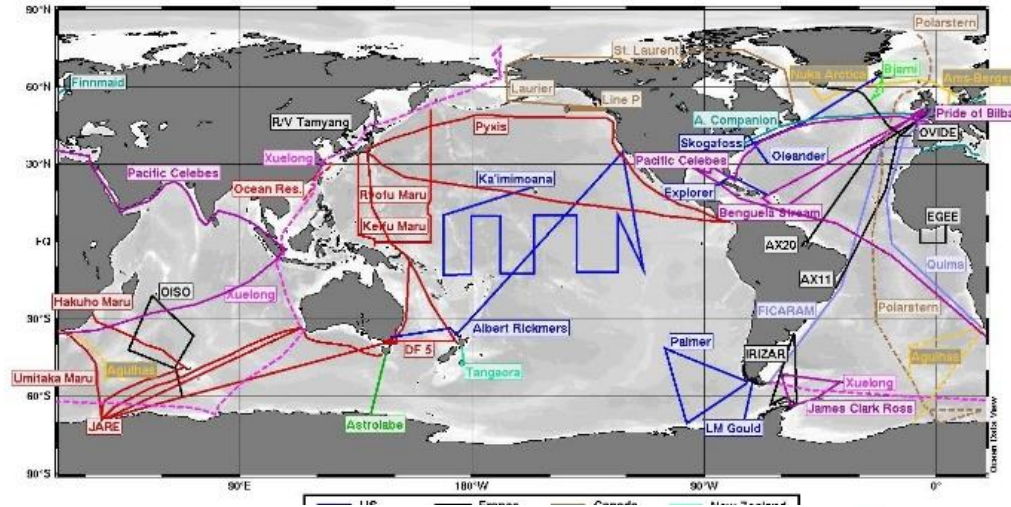
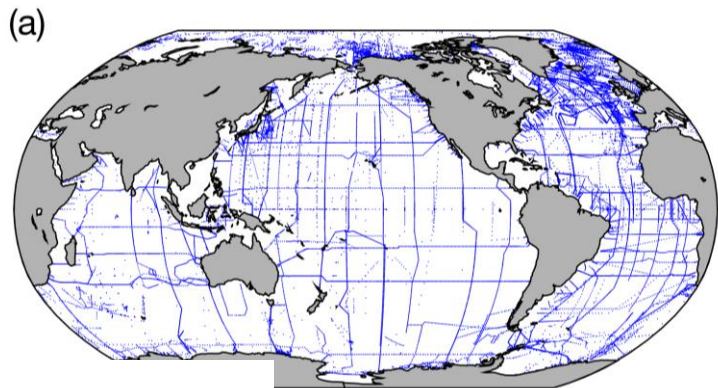
August 2019

Completed (80% of all core lines)  
 Funded (9% of all core lines)  
 Not planned yet (11% of all core lines)

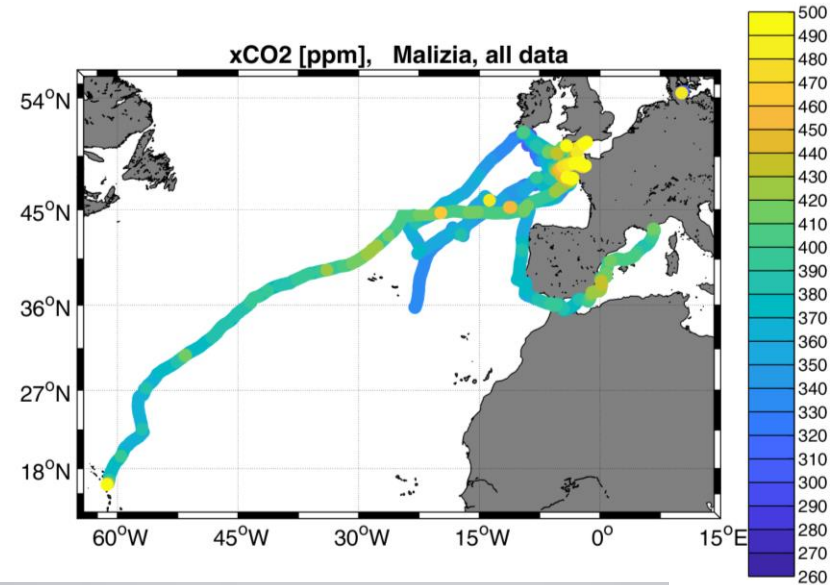
Lines completed or funded: 89% (49 core lines)  
 Countries providing ship-time: 10  
 Elapsed survey time: 64% (floating 12-year survey)



Generated by www.jcommops.org, 11/09/2019

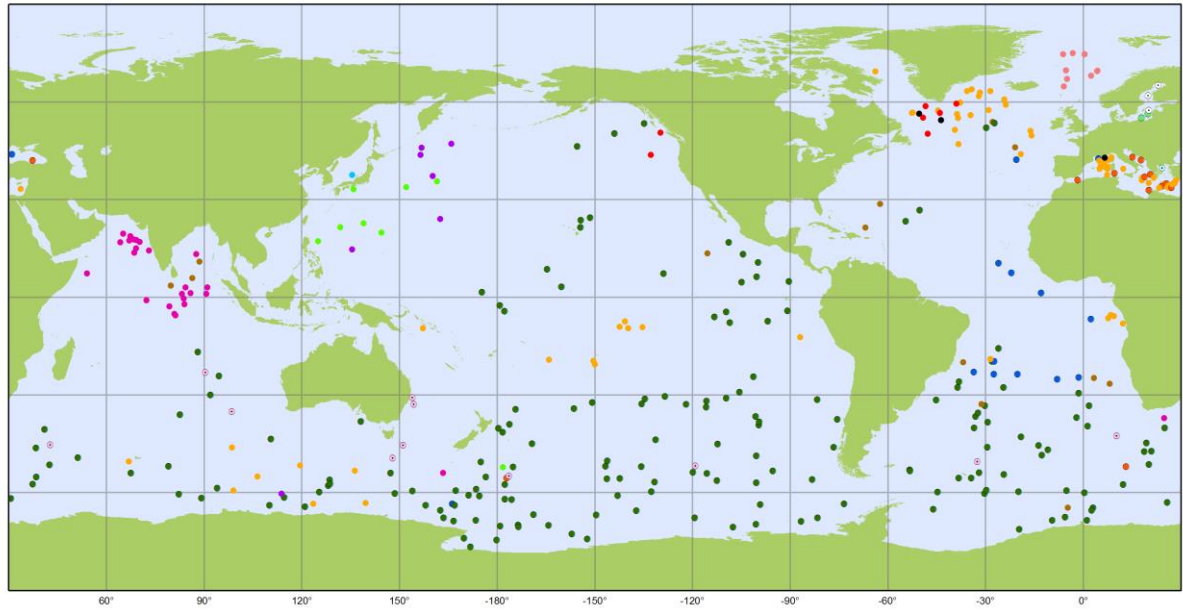


# Engagement with race yachts as ocean observers





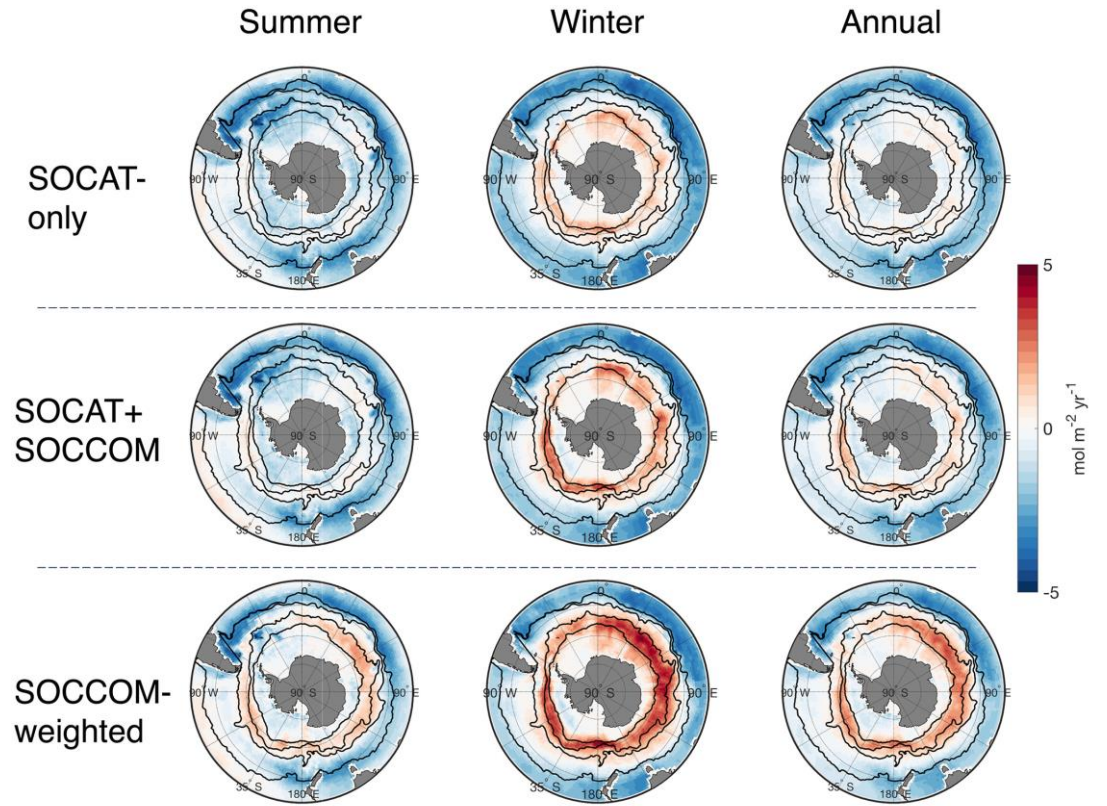
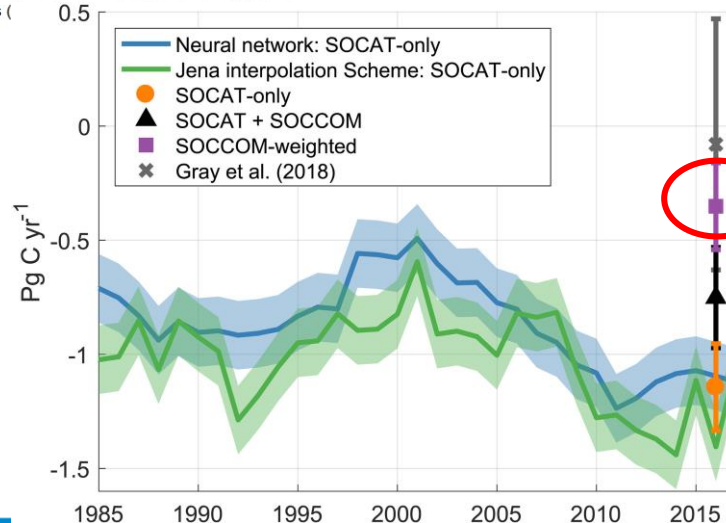
# Biogeochemical Argo



Argo BioGeoChemical

National contributions - 362  
Latest location of operational floats (

October 2019



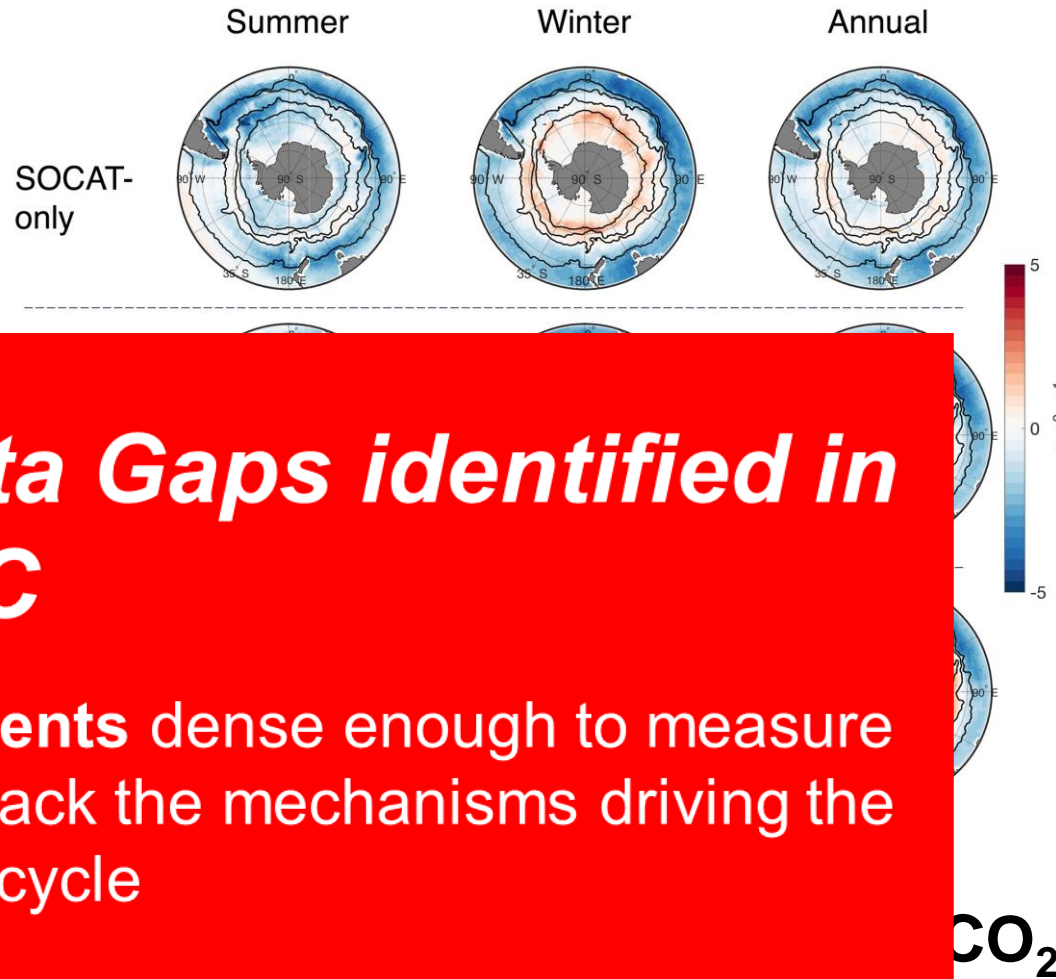
**Reassessing Southern Ocean CO<sub>2</sub> flux with BGC argo winter data**  
**Reduces SO carbon flux by 1/3**  
 Bushinsky et al., 2019



# Biogeochemical Argo

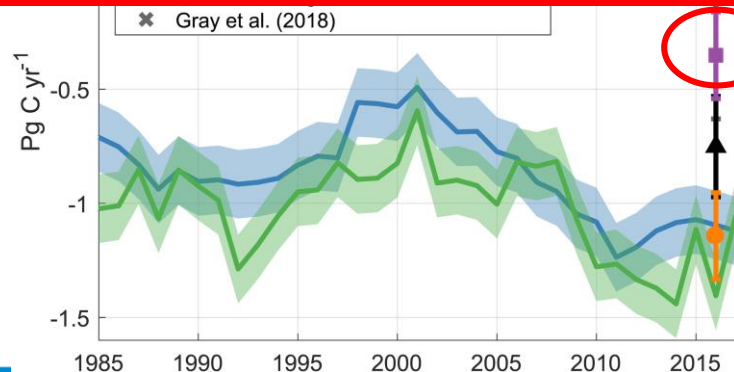


Argo BioGeo



## *Some Knowledge and Data Gaps identified in SROCC*

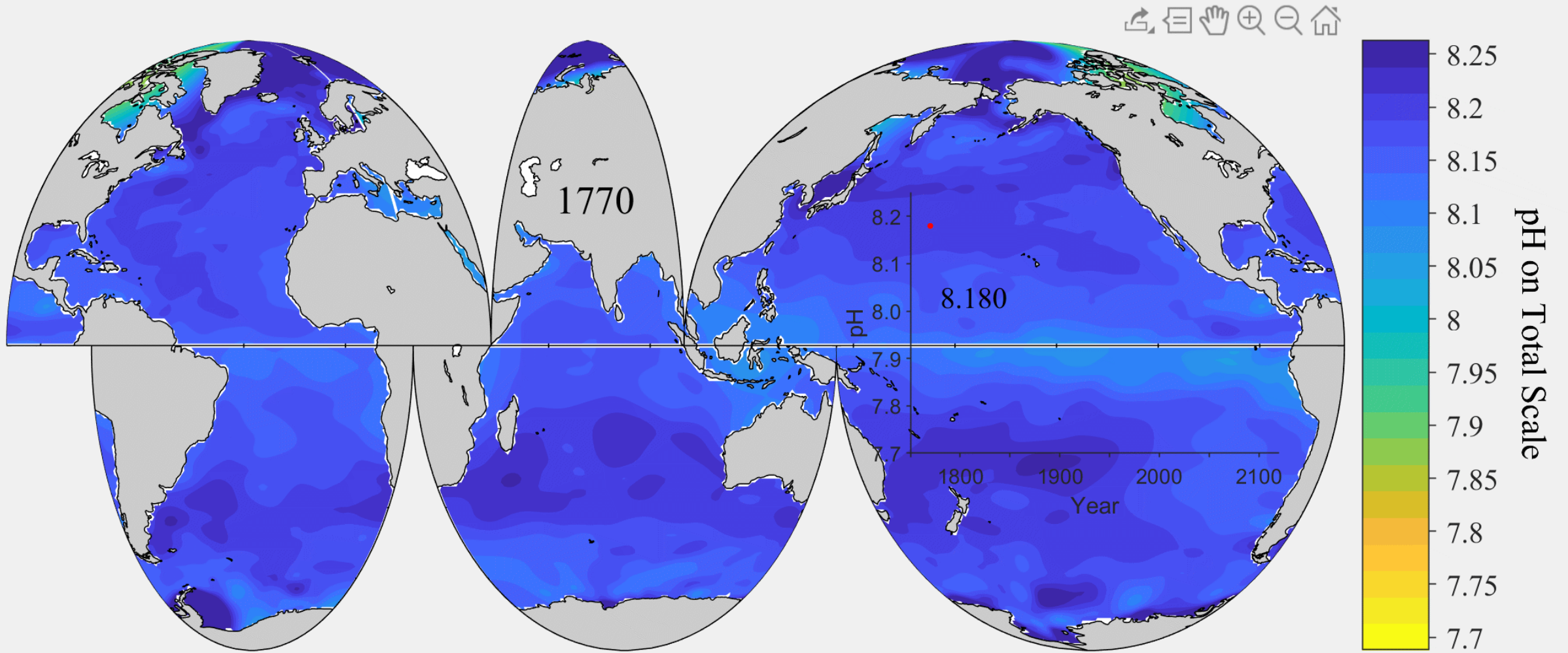
Gaps in oxygen and carbon measurements dense enough to measure de-oxygenation of the world ocean and track the mechanisms driving the ocean carbon cycle



**flux with BGC argo winter data**  
Reduces SO carbon flux by 1/3  
Bushinsky et al., 2019

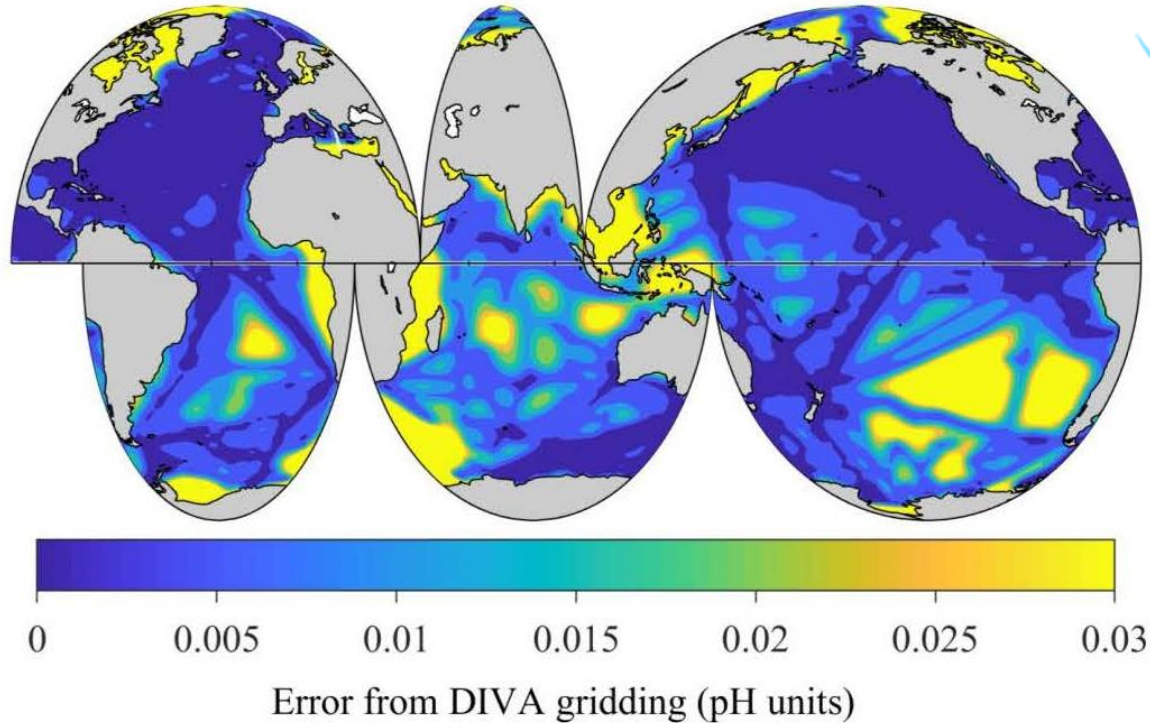


# Surface ph from 1770 to 2100 under rcp8.5



(Jiang et al. 2020)

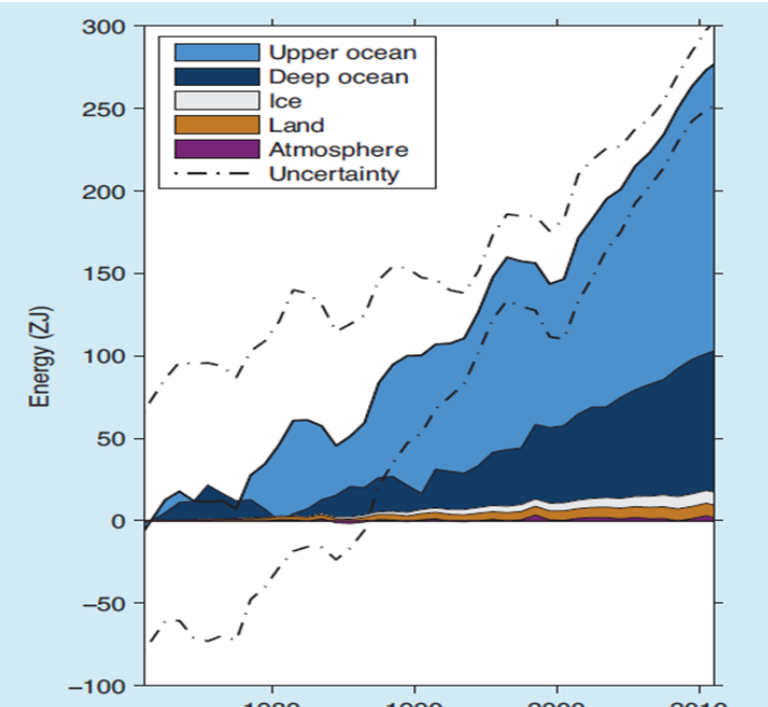
# Global Ocean Acidification – Observing Network



- Large gaps in the observational record leads to significant uncertainties in the estimation of Ocean Acidification
- Significant progress on regional hubs, capacity building, observing sites etc.

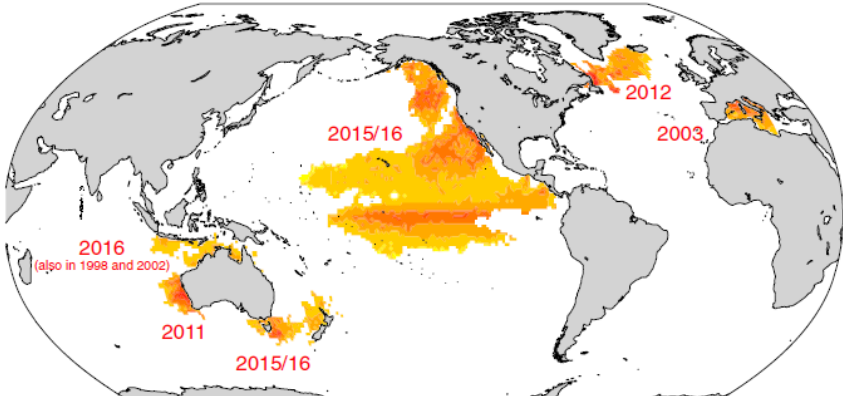
This product is based on the surface ocean  $p\text{CO}_2$  observation network, poor observational coverage = high uncertainty

# Ocean Heat Content and Marine Heatwaves

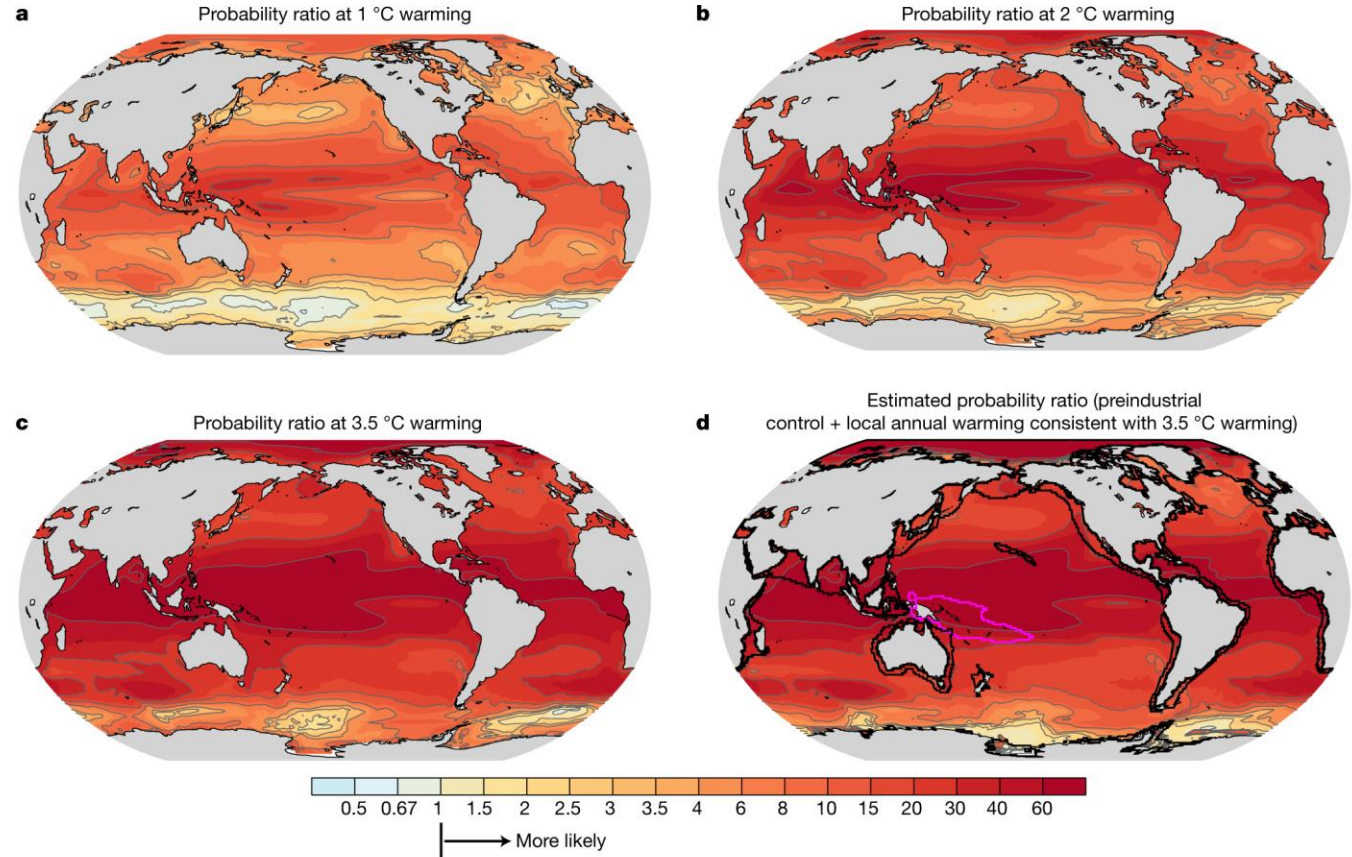


~ 5 Hiroshima-class nuclear explosions....  
 ..every second for the last 25 years.

IPCC AR5

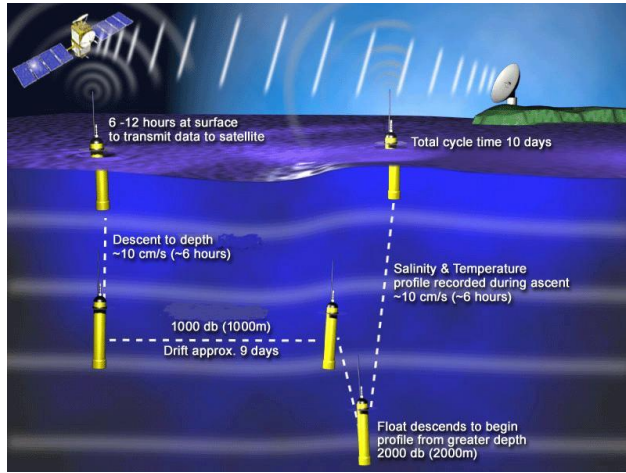


Recent marine heatwaves  
 Frölicher and Laufkötter et al., 2018

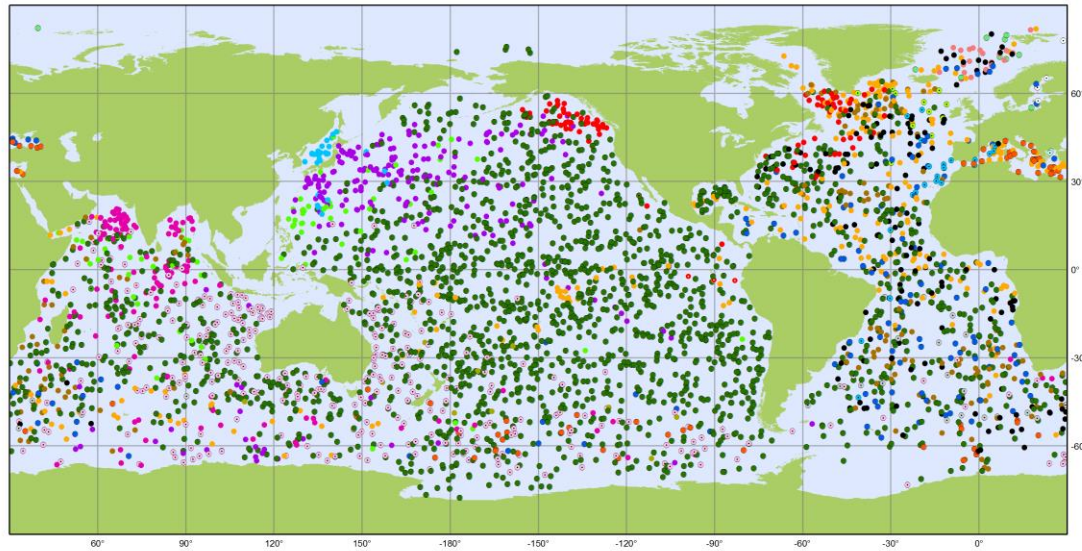


**In climate warming, the likelihood of marine heatwaves are increasing significantly.**

Frölicher et al., 2018



# Argo is one core network, with Deep Argo in pilot mode.



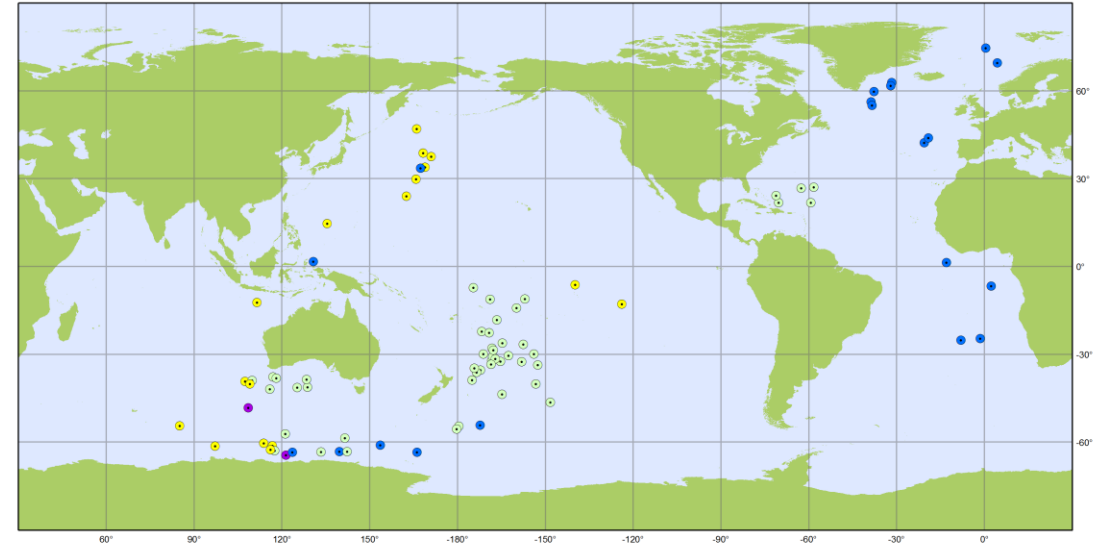
Argo National contributions - 3850 Operational Floats October 2019  
Latest location of operational floats (data distributed within the last 30 days)



- AUSTRALIA (336)
- CANADA (93)
- CHINA (75)
- EUROPE (124)
- FINLAND (5)
- FRANCE (279)
- GERMANY (155)
- GREECE (2)
- INDIA (139)
- IRELAND (12)
- ITALY (69)
- JAPAN (214)
- KENYA (1)
- MEXICO (1)
- NETHERLANDS (24)
- NEW ZEALAND (10)
- NORWAY (22)
- PERU (3)
- POLAND (11)
- KOREA, REPUBLIC OF (31)
- SPAIN (24)
- UK (159)
- USA (2061)



Generated by www.jcommops.org, 12/11/2019



Argo Deep Float Models October 2019  
Latest location of operational floats (data distributed within the last 30 days),

- APEX\_D (17)
- ARVOR\_D (20)
- NINJA\_D (2)
- SOLO\_D (47)

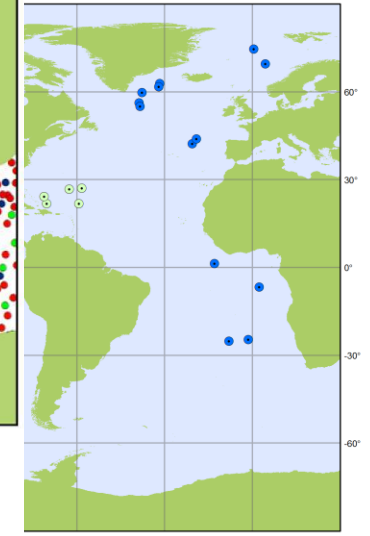
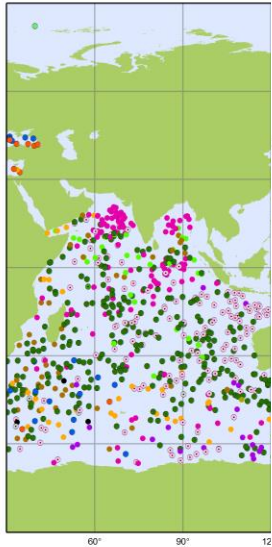
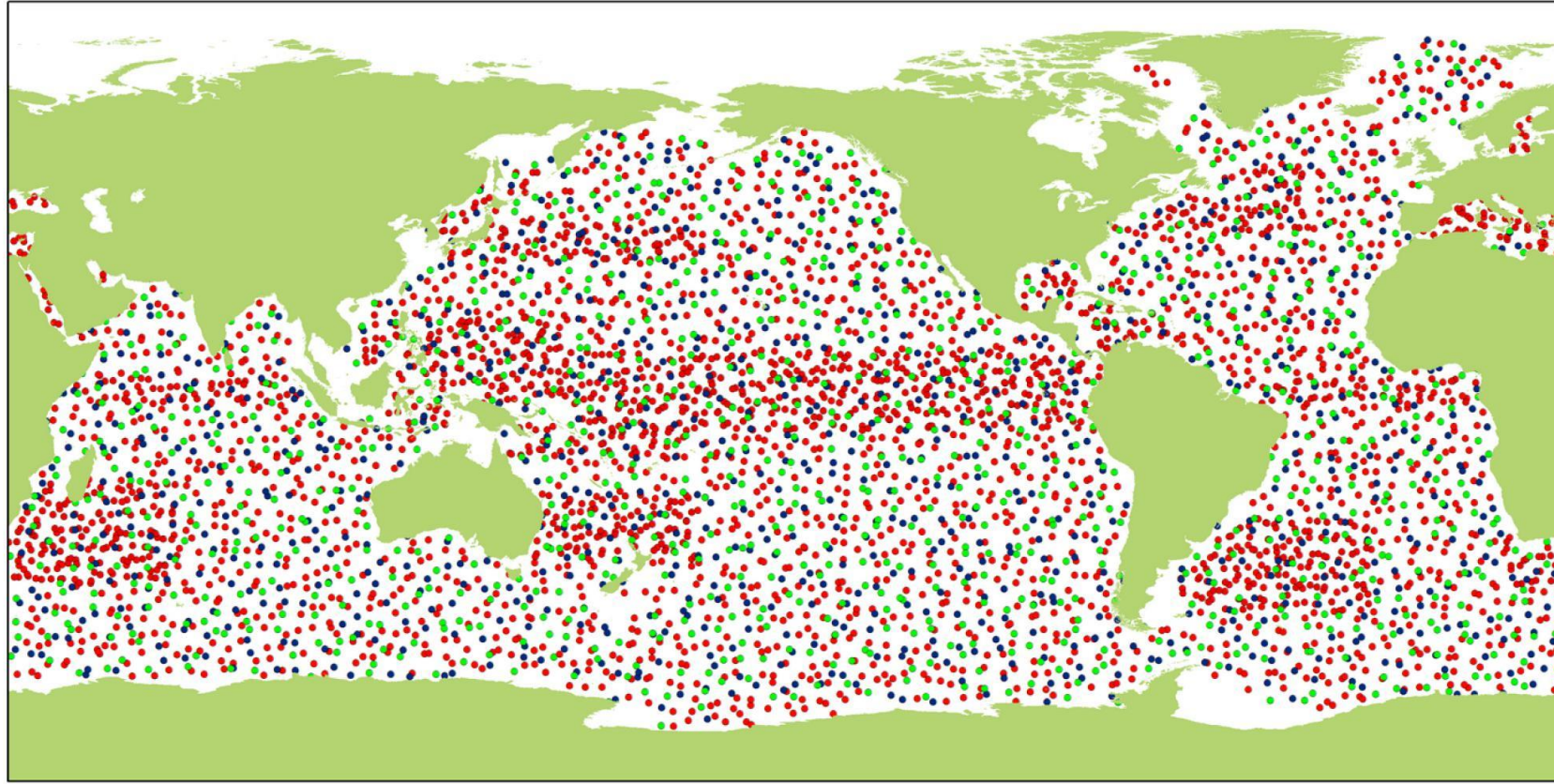
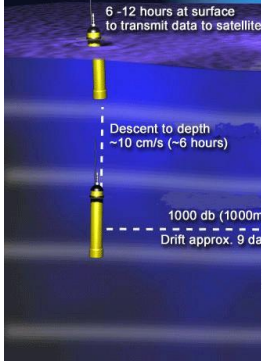


Generated by www.jcommops.org, 12/11/2019



# Argo is one core

# Deep node.



60°E 120°E 180° 120°W 60°W 0°

## Argo 2020 Design: 4600 Floats

- Core Floats, 2350
- Deep Floats, 1250
- BGC Floats, 1000

- APEX\_D (17)
- ARVOR\_D (20)
- JCOMMOPS NINJA\_D (2)
- SOLO\_D (47)

Argo



- |                   |                 |                |                    |                           |              |
|-------------------|-----------------|----------------|--------------------|---------------------------|--------------|
| ● AUSTRALIA (336) | ● FINLAND (5)   | ● INDIA (139)  | ● KENYA (1)        | ● NORWAY (22)             | ● SPAIN (24) |
| ● CANADA (93)     | ● FRANCE (279)  | ● IRELAND (12) | ● MEXICO (1)       | ● PERU (3)                | ● UK (159)   |
| ● CHINA (75)      | ● GERMANY (155) | ● ITALY (69)   | ● NETHERLANDS (24) | ● POLAND (11)             | ● USA (2061) |
| ● EUROPE (124)    | ● GREECE (2)    | ● JAPAN (214)  | ● NEW ZEALAND (10) | ● KOREA, REPUBLIC OF (31) |              |



October 2019





# Arco is one core

## Some Knowledge and Data Gaps Identified in SROCC

**Need of full-depth, high-quality and unbiased ocean temperature profile data**

required to estimate thermal expansion

required to understand drivers of variability and long-term change

**Deep ocean below 2000 meters is still rarely observed**

limiting (for example) the accurate estimate of deep ocean heat uptake and, consequently the full magnitude of Earth's energy imbalance



Argo



2019



- AUSTRALIA (336)
- CANADA (93)
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- USA (2061)

● BGC Floats, 1000



- APEX\_D (17)
- ARVOR\_D (20)
- JCOMMOPS<sup>days</sup> NINJA\_D (2)
- SOLO\_D (47)



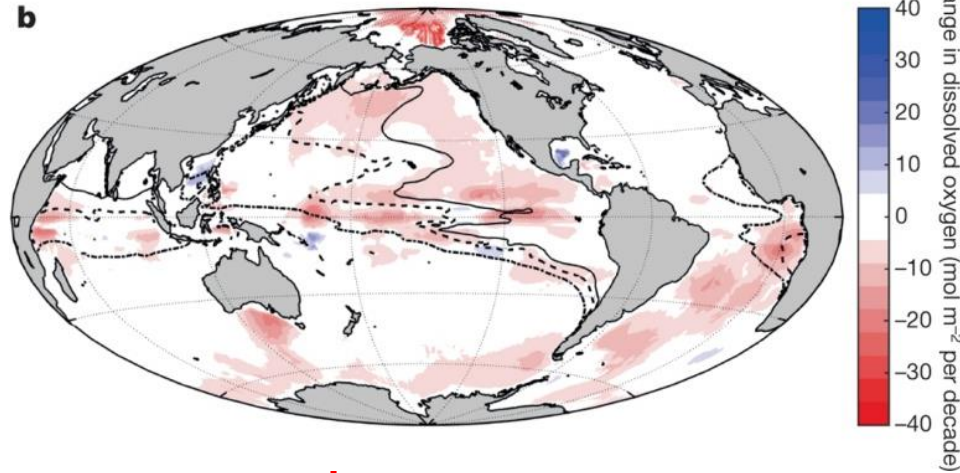
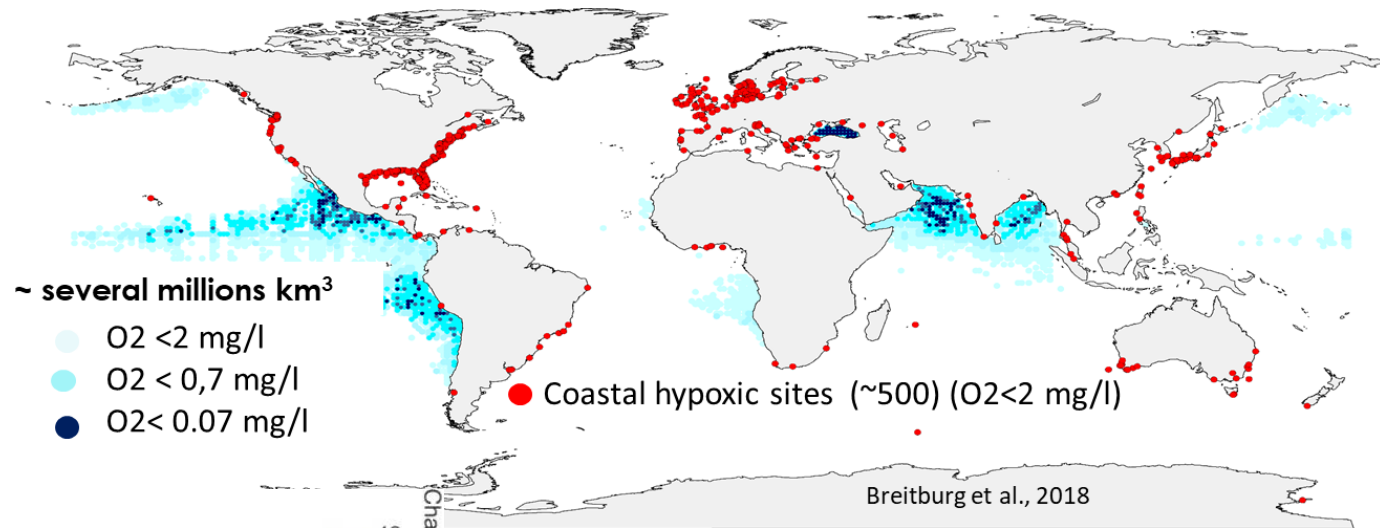


# Ocean Deoxygenation

Oxygen is measured on a few different platforms, including

- Ship-based CTD and bottle measurements (GO-SHIP)
- BGC Argo
- Gliders
- Moorings
- Surface vehicles

We still need a quality controlled data product integrating oxygen data from all platforms.



**IUCN**

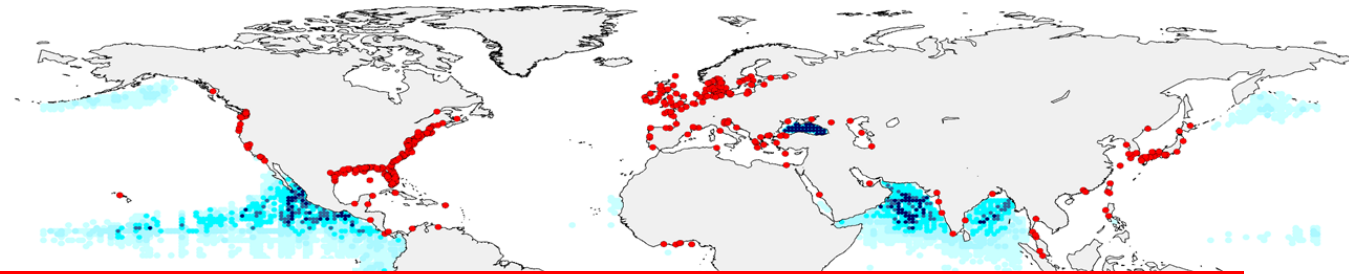
**OCEAN DEOXYGENATION**

**Everyone's problem**

IUCN report on Ocean Deoxygenation  
Launch December 8, 2019  
The wake up call for the world to unite around ambitious targets to cut emissions

This is the cover of the IUCN report on Ocean Deoxygenation. The cover features a blue background with white circles and a white shark. The IUCN logo is in the top right corner. The title 'OCEAN DEOXYGENATION' is in large, bold, white letters. Below the title, the subtitle 'Everyone's problem' is in white. At the bottom, the text reads 'IUCN report on Ocean Deoxygenation', 'Launch December 8, 2019', and 'The wake up call for the world to unite around ambitious targets to cut emissions'.

# Ocean Deoxygenation



Oxygen is measured on a few different platforms, including

- Ship-borne measurements
- BGC Argo
- Gliders
- Moorings
- Surface buoys

## Some Knowledge and Data Gaps Identified in SROCC

Observations for many key ocean variables do not yet have global coverage or have not reached the required density or accuracy for detection of change

E.g. ocean currents, surface heat fluxes, oxygen, inorganic carbon, subsurface salinity, phytoplankton biomass and diversity

We still need a quality controlled data product integrating oxygen data from all platforms.

Schmidt et al. Nature 2018

Deoxygenation  
Launch December 8, 2019  
The wake up call for the world to unite around ambitious targets to cut emissions

## Vision

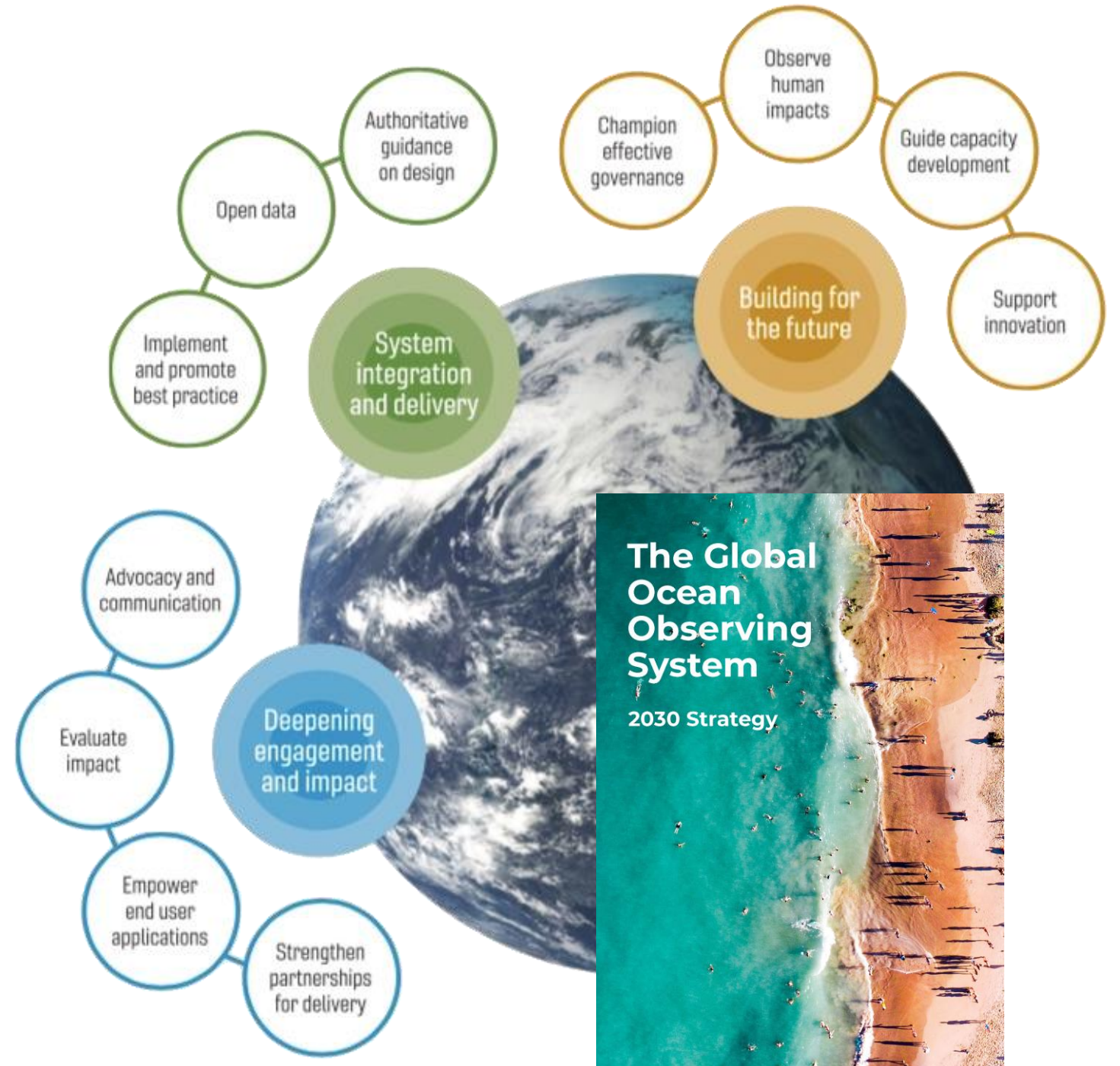
A truly global ocean observing system that delivers the essential information needed for our sustainable development, safety, wellbeing and prosperity

## Mission

To lead the ocean observing community and create the partnerships to grow an integrated, responsive and sustained observing system



goosocean.org



# UN Decade of Ocean Science for Sustainable Development 2021-2030

## GOOS and the Ocean Decade

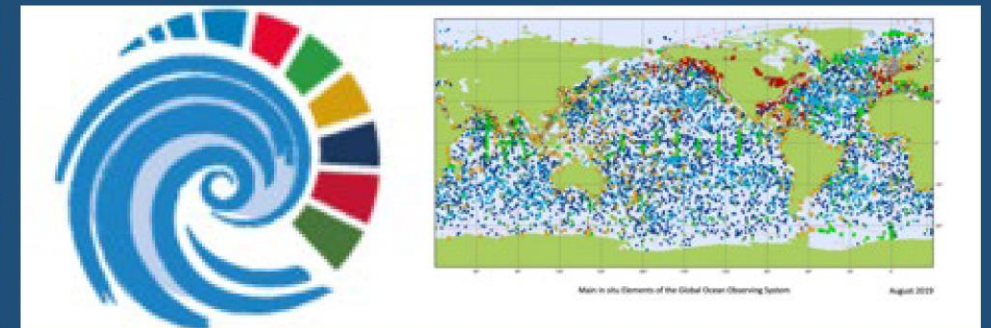


Implementing objectives of the GOOS 2030 Strategy will advance the Ocean Decade. Transformative partnerships will deliver the right information. Technology and capacity innovation will support climate solutions.



## The Science We Need for the Ocean We Want

The United Nations  
Decade of Ocean Science  
for Sustainable Development  
(2021-2030)



# 2021 2030 United Nations Decade of Ocean Science for Sustainable Development