# SIO 210: Observational methods

Observing systems

Remote sensing
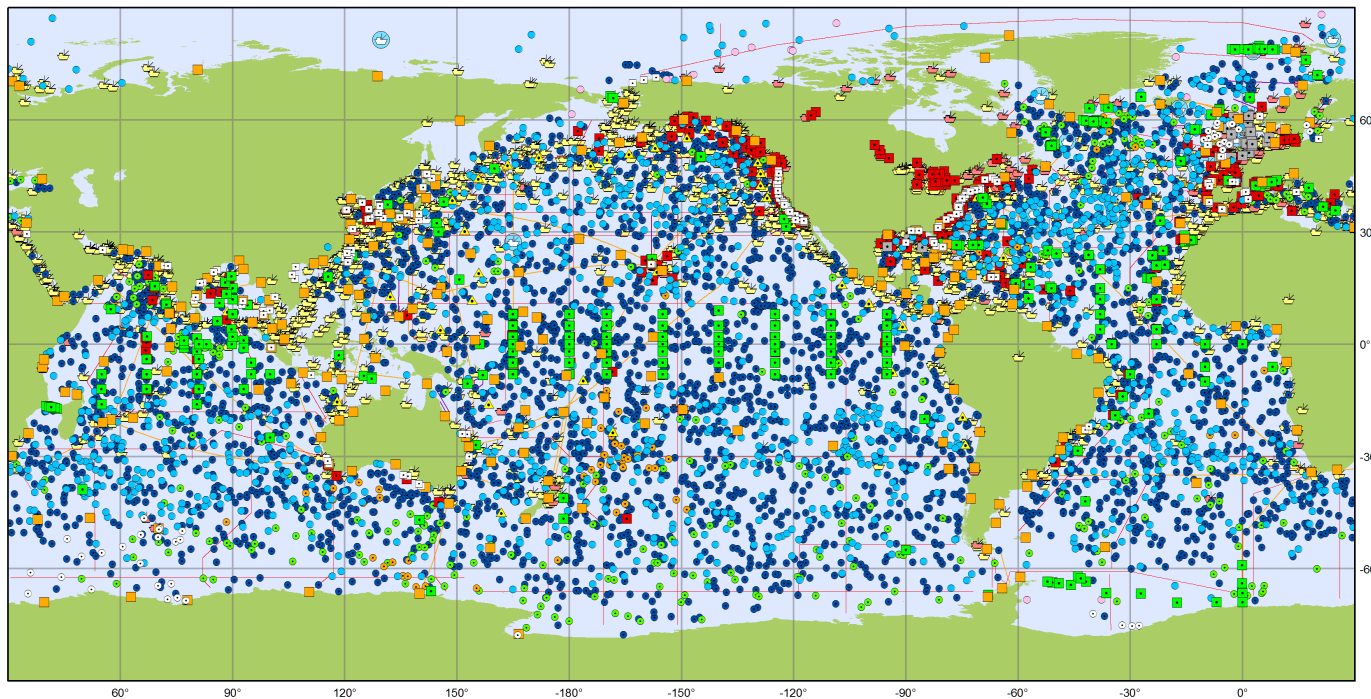
In situ T, S and tracers

Velocity

Reading: DPO 6.1, S16.1, S16.4, S16.5, S16.9

# Definitions

- Lagrangian - measurements following the flow. Examples: drifters, floats


- Eulerian – measurements at a fixed location. Examples: single profiles, moored instruments, satellites, spatial averages of Lagrangian measurements

# 'In situ' (in the ocean) observing system
## https://www.jcommops.org/



Main in situ Elements of the Global Ocean Observing System                    August 2018

| Profiling Floats (Argo) | Data Buoys (DBCP) | Timeseries (OceanSITES) | Ship based Measurements (SOT) | Other Networks |
|---|---|---|---|---|
| Core (3944) | Surface Drifters (1383) | Interdisciplinary Moorings (451) | Automated Weather Stations (254) | HF Radars (270) |
| Deep (70) | Offshore Platforms (97) | **Repeated Hydrography (GO-SHIP)** | Manned Weather Stations (1738) | Animal Borne Sensors (53) |
| BioGeoChemical (329) | Ice Buoys (16) | Research Vessel Lines (61) | Radiosondes (16) | Ocean Gliders (31) |
|  | Moored Buoys (392) | **Sea Level (GLOSS)** | eXpendable BathyThermographs (37) |  |
|  | Tsunameters (36) | Tide Gauges (252) |  |  |

*Generated by www.jcommops.org, 17/09/2018*

Click to enter integrated system.

Click on small gray globe at top and select 'static maps'

Otherwise select interactive and have a look.

# Research ship hydrographic sections
## https://www.jcommops.org/
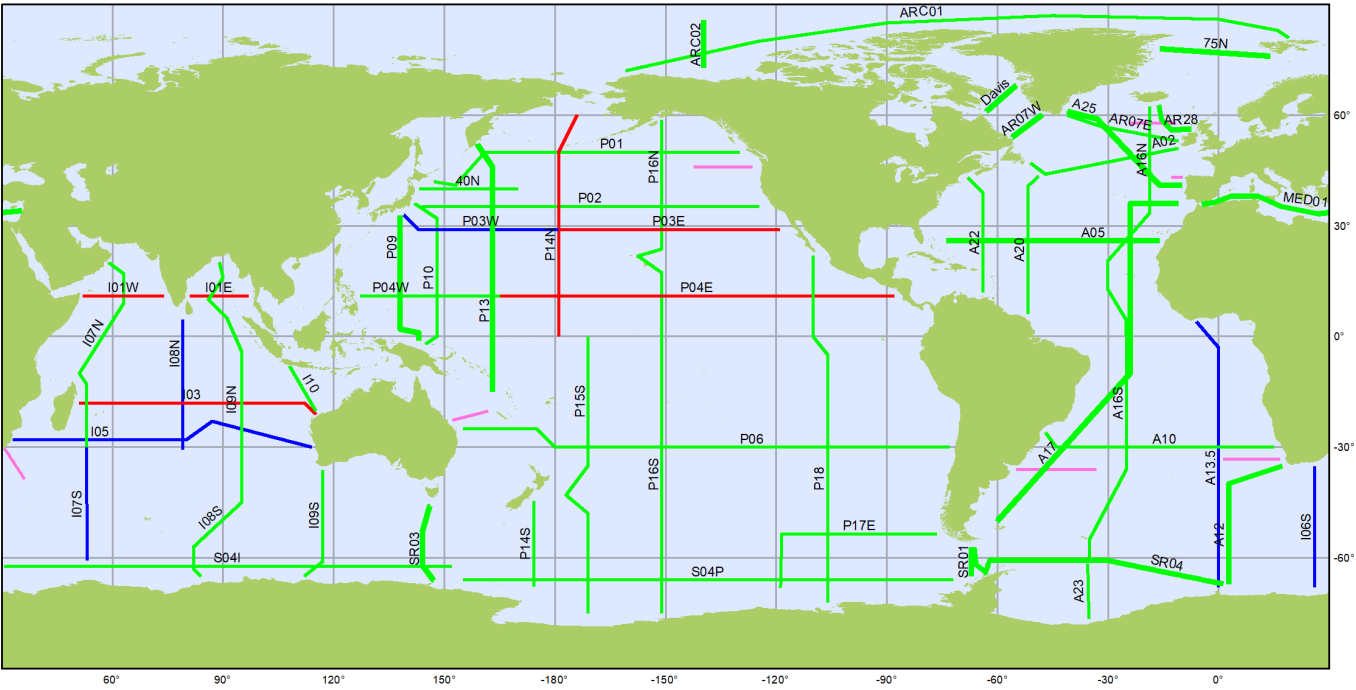


GO-SHIP

**Status of 2012-2023 Survey (62 Lines)**

October 2018

Bold lines: High Frequency (reduced requirements)     Thin lines: Decadal GO-SHIP (full requirements)

— completed  — at sea  — funded  — planned  — not planned yet  — associated & completed
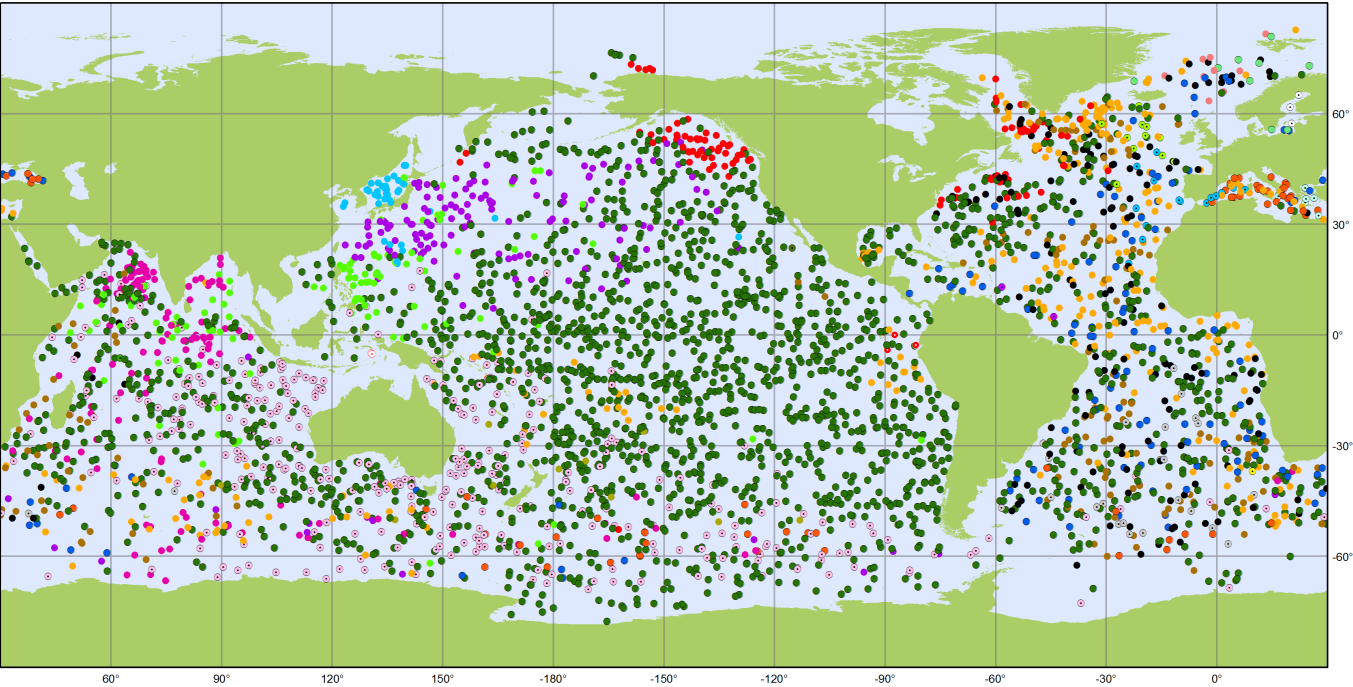
Click on GO-SHIP icon.

Click on small gray globe at top and select 'static maps', check out dropdown menus.

Otherwise select interactive and have a look.

# Profiling float network 'Argo'
## https://www.jcommops.org/



**Argo**

**National contributions - 3983 Operational Floats**
Latest location of operational floats (data distributed within the last 30 days)

**September 2018**

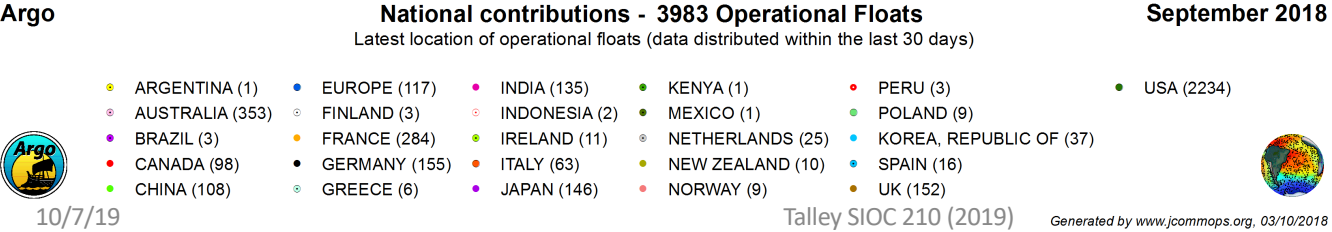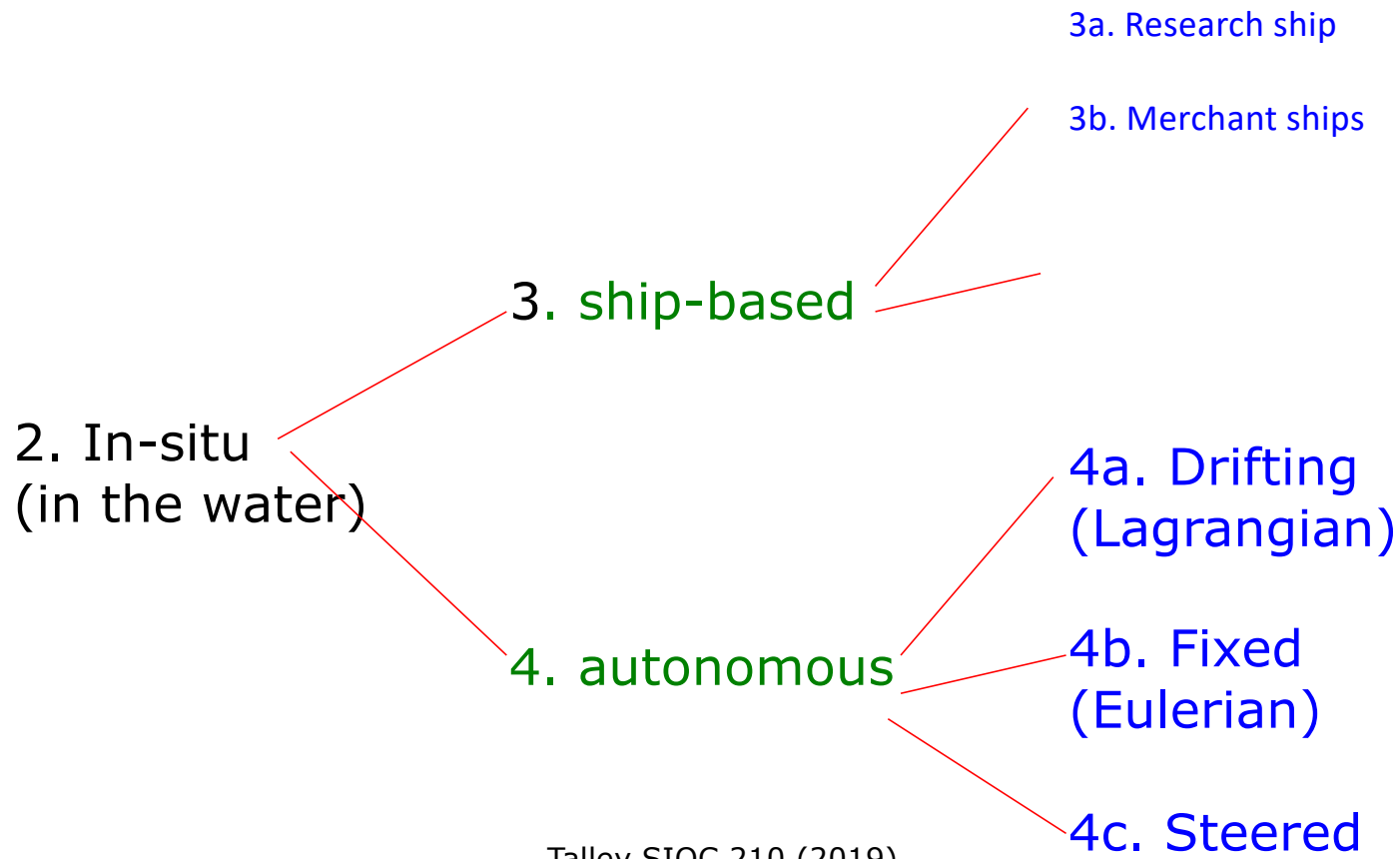| | | | | | |
|---|---|---|---|---|---|
| ARGENTINA (1) | EUROPE (117) | INDIA (135) | KENYA (1) | PERU (3) | USA (2234) |
| AUSTRALIA (353) | FINLAND (3) | INDONESIA (2) | MEXICO (1) | POLAND (9) | |
| BRAZIL (3) | FRANCE (284) | IRELAND (11) | NETHERLANDS (25) | KOREA, REPUBLIC OF (37) | |
| CANADA (98) | GERMANY (155) | ITALY (63) | NEW ZEALAND (10) | SPAIN (16) | |
| CHINA (108) | GREECE (6) | JAPAN (146) | NORWAY (9) | UK (152) | |

Click on Argo icon.

Click on small gray globe at top and select 'static maps', check out dropdown menus.
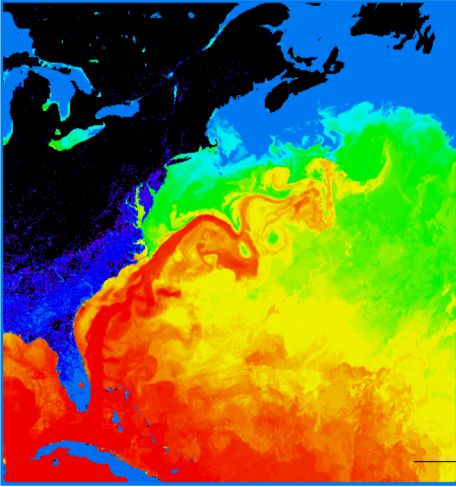
Otherwise select interactive and have a look.

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# Options for ocean observations

1. Remote sensing (satellite)

3a. Research ship

3b. Merchant ships

3. ship-based

2. In-situ
(in the water)

4. autonomous

4a. Drifting
(Lagrangian)

4b. Fixed
(Eulerian)

4c. Steered
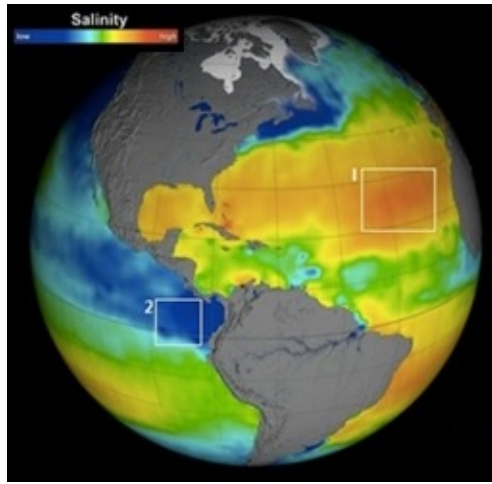
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# 1. Remote sensing (satellites)

Sea surface temperature    Sea surface salinity    Sea surface height    Ocean color



https://podaac.jpl.nasa.gov/CoreMeasurements    https://oceancolor.gsfc.nasa.gov/
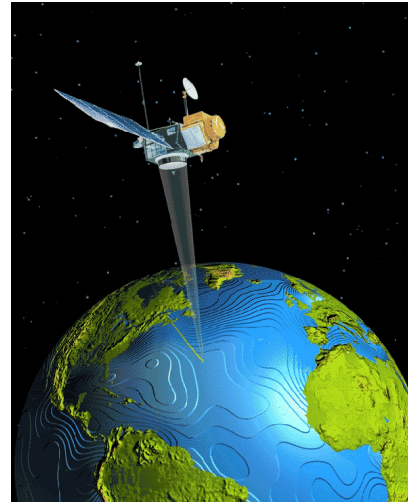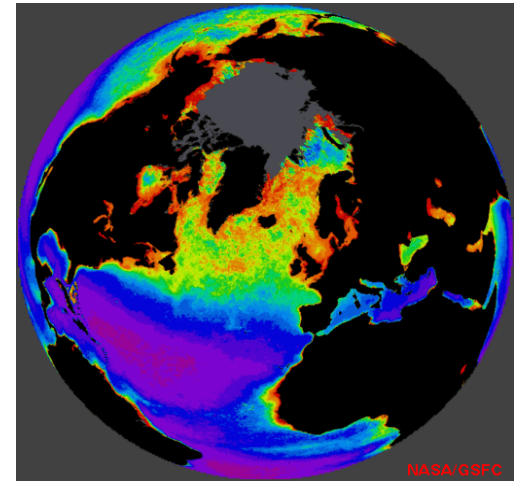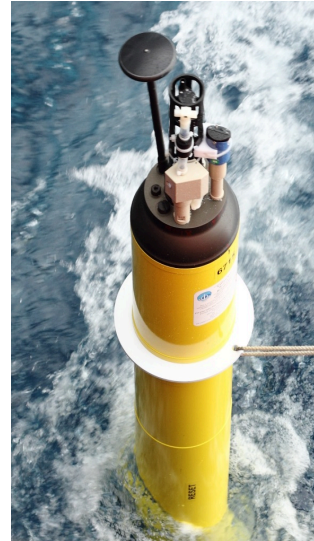
and other quantities (wind, ice, waves,.)

# 2. In situ sampling: platforms

- Research ships
- Merchant ships (VOS = Volunteer Observing Ships)
- Surface drifters
- Subsurface floats
- Fixed moorings
- Coastal stations (radar)
- Gliders (steered)

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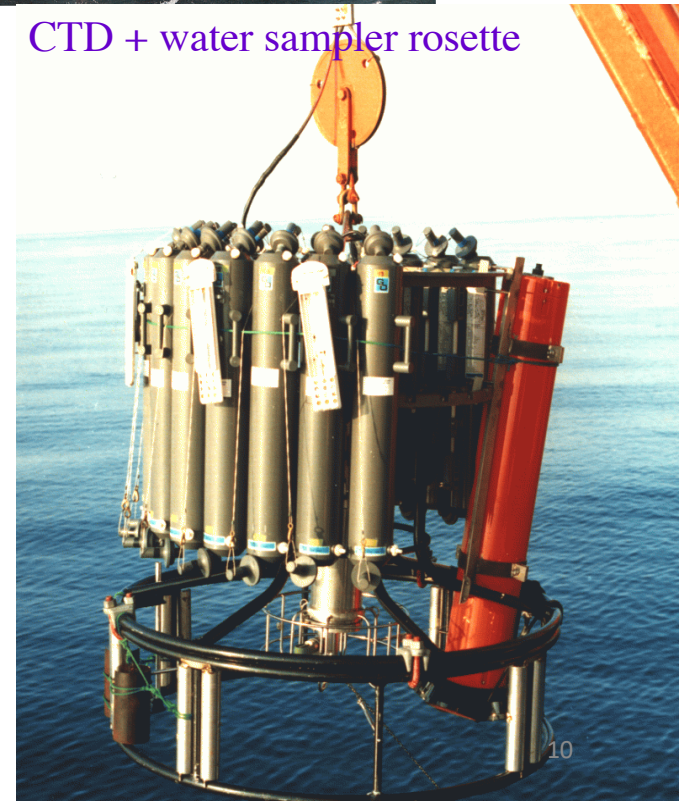# 2. In situ sampling: sensors carried on many different platforms

- Temperature: thermistors
- Salinity: conductivity sensors
- Pressure: quartz transducers
-         (CTD: instrument carrying T, S, P plus ancillary sensors)
-         (XBT: expendable temperature probe)
- Depth: altimeters (sound or EM wave reflection)

- Velocity:
-         current meters (mechanical with compass)
-         acoustic doppler current meters (sound waves reflecting off particles suspended in the water)
-         floats and drifters (moving with the water)

- Other sensors:
-         Oxygen, chlorophyll fluorometer, optical properties and radiation sensors

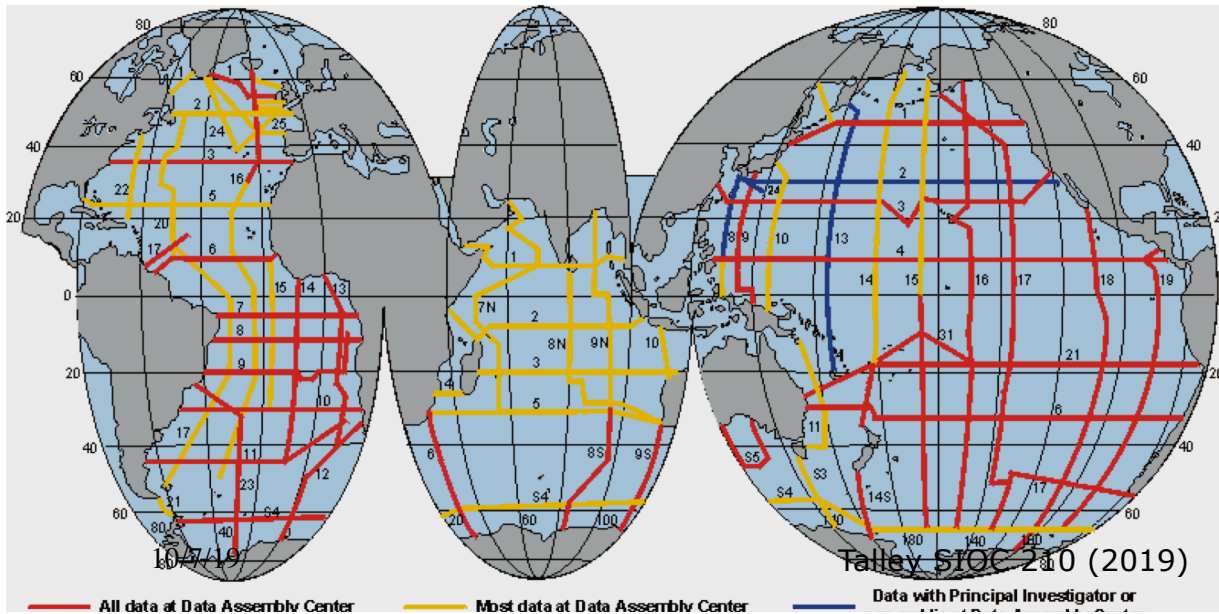# 3a. Ship-based: research ships



Can reach remote areas, full depth measurements, highest accuracy, handle heavy equipment, but are expensive and slow
(the WOCE survey below took 10 years ....).

CTD + water sampler rosette



WOCE Experiment



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All data at Data Assembly Center    Most data at Data Assembly Center    Data with Principal Investigator or

# 3a. Ship-based: research ships

can reach remote areas, full depth measurements, highest accuracy, handle heavy equipment, but are expensive and slow

Present: „GO-SHIP" http://go-ship.org



CTD + water sampler rosette
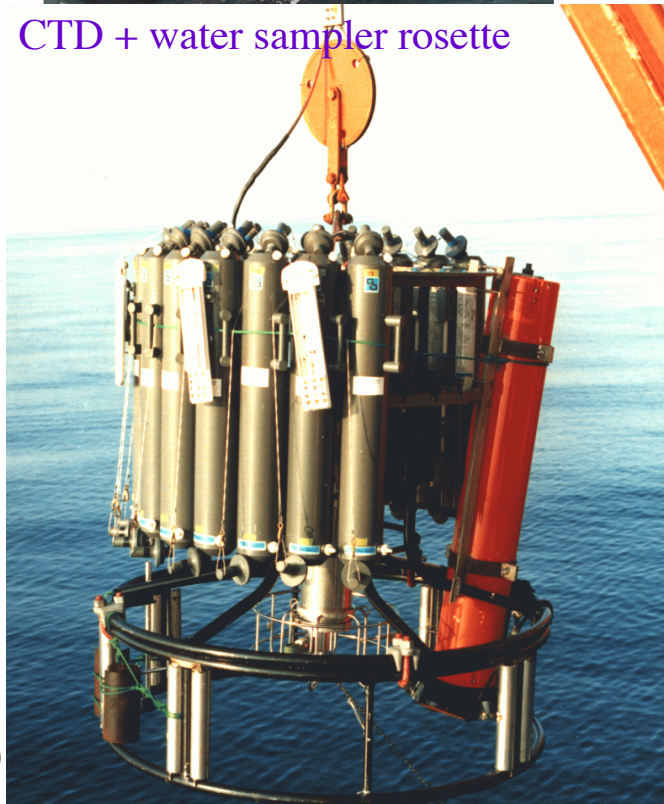
GO-SHIP decadal hydrography
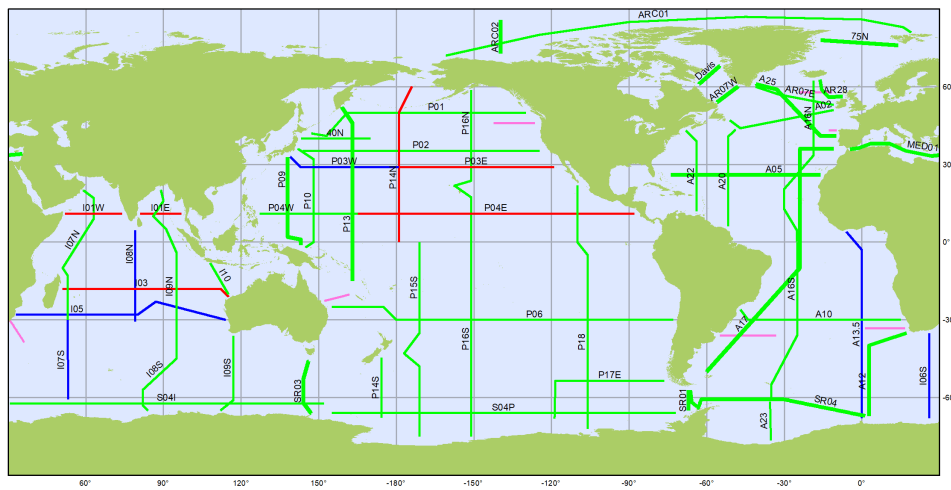


GO-SHIP                    Status of 2012-2023 Survey (62 Lines)                    October 2018

Bold lines: High Frequency (reduced requirements)    Thin lines: Decadal GO-SHIP (full requirements)

— completed    — at sea    — funded    — planned    — not planned yet    — associated & completed

:019)

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# 3b. Ship-based: Volunteer Observing Ships (VOS)

Commercial ships (ferries, container vessels, etc) which carry out various observations on the way, or deploy probes/instruments

Main requirement:
- must be able to do this at full speed
- should take minimum effort/attendance by crew
- modifications to ship should be small

Advantages:
- Cheap
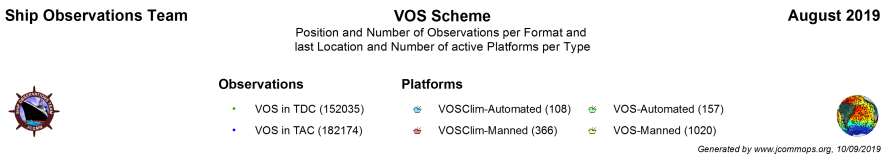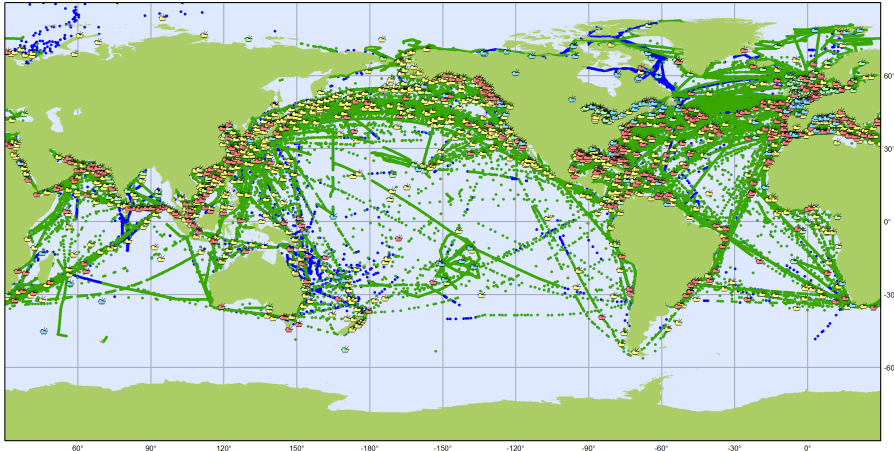- frequent trans-basin coverages

Disadvantages:
- startup effort is large
- limited sensors
- speed
- ships may be moved

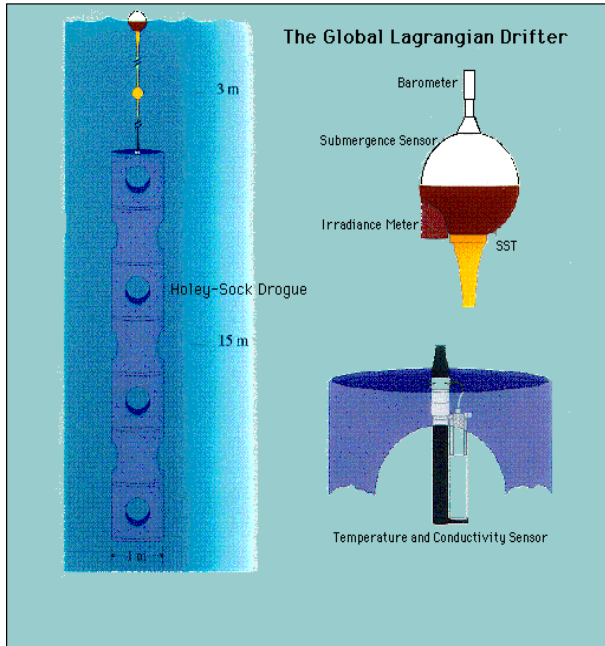# 3b. VOS: XBT (eXpendable BathyThermograph) temperature probes







Ship Observations Team          VOS Scheme          August 2019
Position and Number of Observations per Format and
last Location and Number of active Platforms per Type

XBT network
„Ship Observations Team"
https://www.jcommops.org/board?t=sot

**Observations**                    **Platforms**
- VOS in TDC (152035)        · VOSClim-Automated (108)    · VOS-Automated (157)
- VOS in TAC (182174)        · VOSClim-Manned (366)       · VOS-Manned (1020)
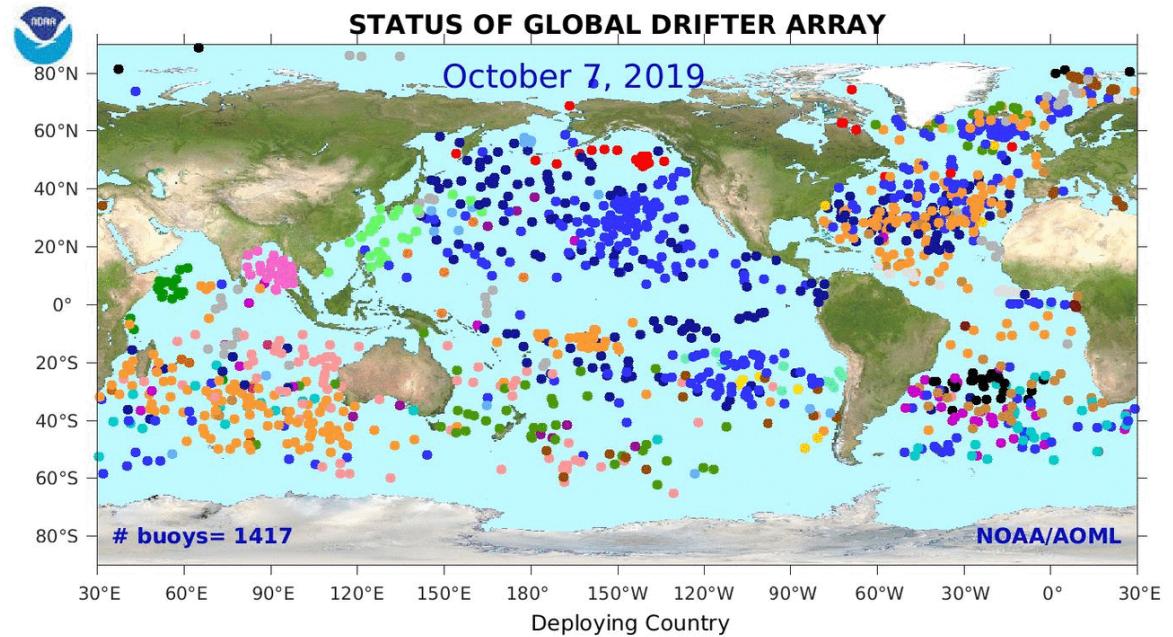
*Generated by www.jcommops.org, 10/09/2019*

# 4a. Autonomous (Lagrangian)

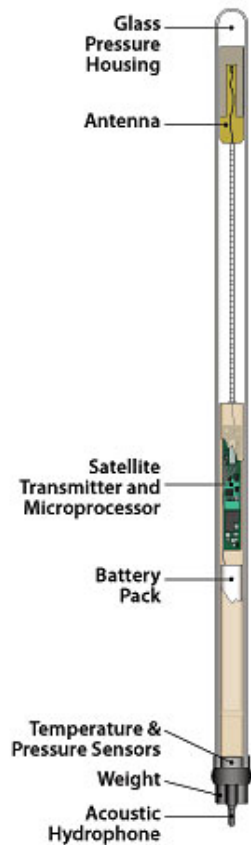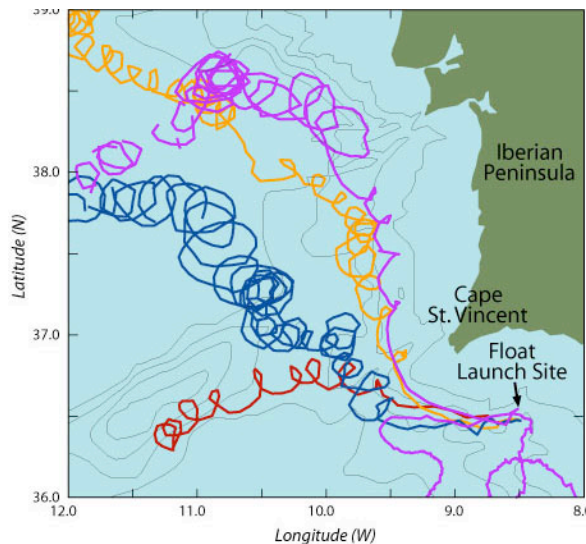Surface drifters: velocity and a few sensors (SST, SSS, air pressure are common)







STATUS OF GLOBAL DRIFTER ARRAY
October 7, 2019

https://www.aoml.noaa.gov/phod/gdp/
10/7/19

# 4a. Autonomous (Lagrangian)
## Velocity measurements using subsurface floats



Glass Pressure Housing

Antenna

Satellite Transmitter and Microprocessor

Battery Pack

Temperature & Pressure Sensors

Weight

Acoustic Hydrophone





Iberian Peninsula

Cape St. Vincent

Float Launch Site

**Acoustically-tracked floats**: best for continuous tracking (eddy timescales) RAFOS floats ("SOFAR" reversed)

Small and cheap, requires at least 2 sound sources within reach, usually 3-4. Range several 1000km.

Floats record the signals and are later located by triangulation.

Stay submerged for entire mission, and surface after 1-3 years, telemetering all data home. Expendable.

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# 4a. Autonomous (Lagrangian)
## Subsurface floats: "pop-up" (Argo) for velocity and profiles of properties

Positions of the floats that have delivered data within the last 30 days before date listed on map
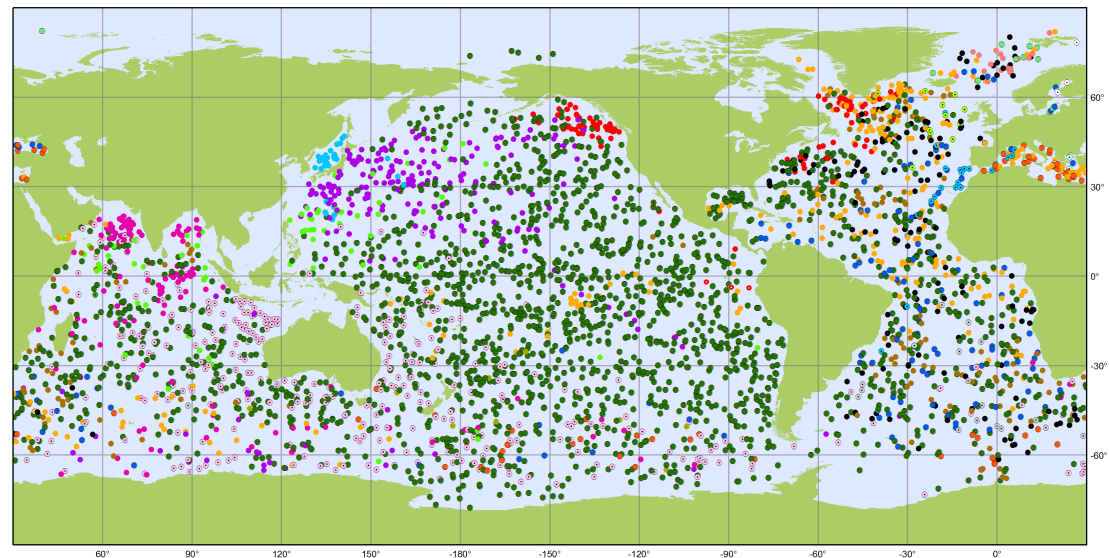


Profile to 2000 m, park at 1000 m, and tracked every 10 days, so not eddy-resolving for velocity.

Excellent for repeated profiling of water column (T,S,other properties)
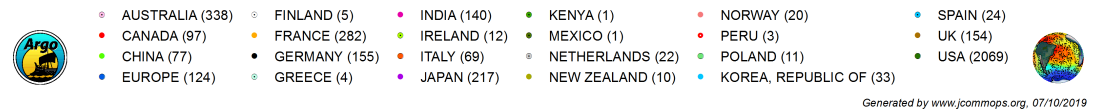
Up to 200-300 profiles

**Argo**
**National contributions - 3867 Operational Floats**
Latest location of operational floats (data distributed within the last 30 days)
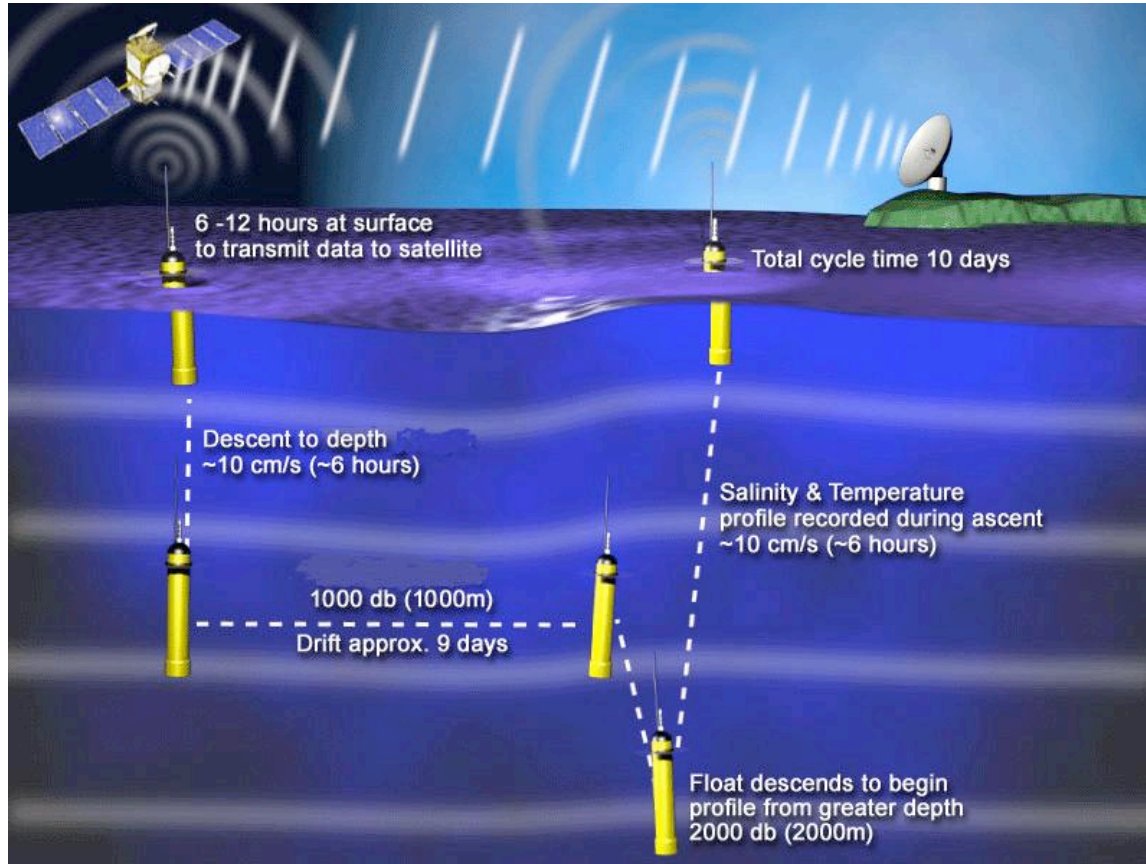**September 2019**

| | | | | | |
|---|---|---|---|---|---|
| AUSTRALIA (338) | FINLAND (5) | INDIA (140) | KENYA (1) | NORWAY (20) | SPAIN (24) |
| CANADA (97) | FRANCE (282) | IRELAND (12) | MEXICO (1) | PERU (3) | UK (154) |
| CHINA (77) | GERMANY (155) | ITALY (69) | NETHERLANDS (22) | POLAND (11) | USA (2069) |
| EUROPE (124) | GREECE (4) | JAPAN (217) | NEW ZEALAND (10) | KOREA, REPUBLIC OF (33) | |

*Generated by www.jcommops.org, 07/10/2019*

10/7/19

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# 4a. Autonomous (Lagrangian)
## Subsurface floats: "pop-up" (Argo)

Start here

6 -12 hours at surface
to transmit data to satellite

Total cycle time 10 days

Descent to depth
~10 cm/s (~6 hours)

Salinity & Temperature
profile recorded during ascent
~10 cm/s (~6 hours)

1000 db (1000m)

Drift approx. 9 days

Float descends to begin
profile from greater depth
2000 db (2000m)

Get approximate 1000m velocity during the 9 days of parking, using displacement of float

Get temperature and salinity profile (and other properties) during ascent from 2000 m to surface
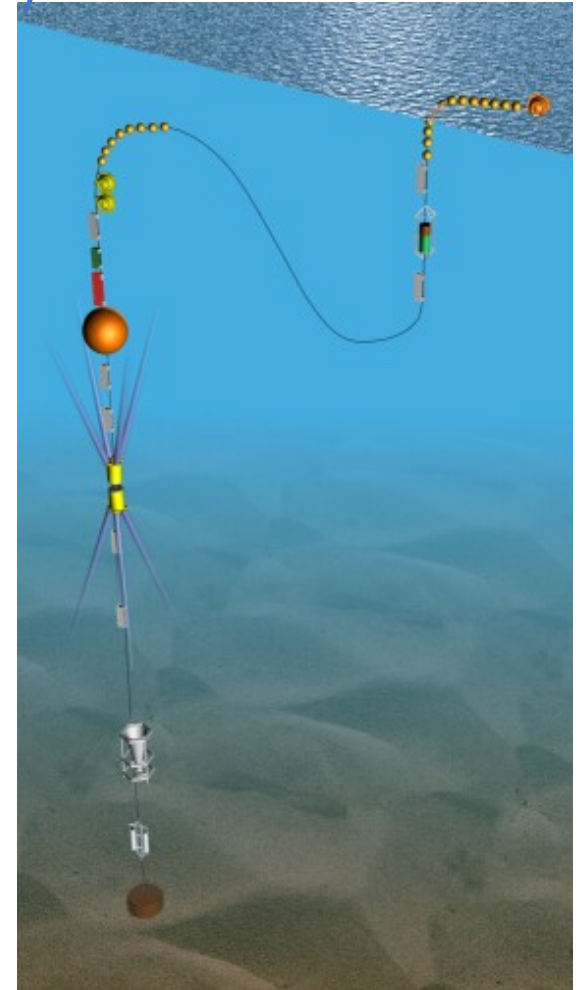
Argo float mission

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# 4b. Autonomous (Eulerian – fixed sensors)

Moorings can sample with high rate, from surface to bottom, many simultaneous sensors, and can carry heavy instruments.
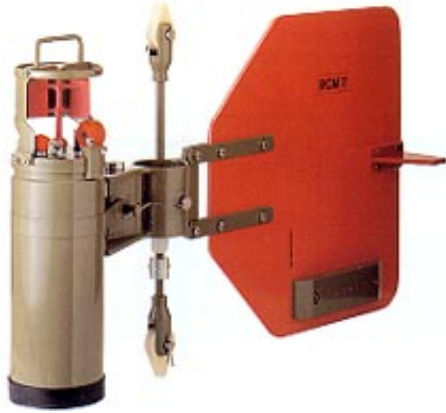
Can include meteorological measurements on surface buoy, etc.
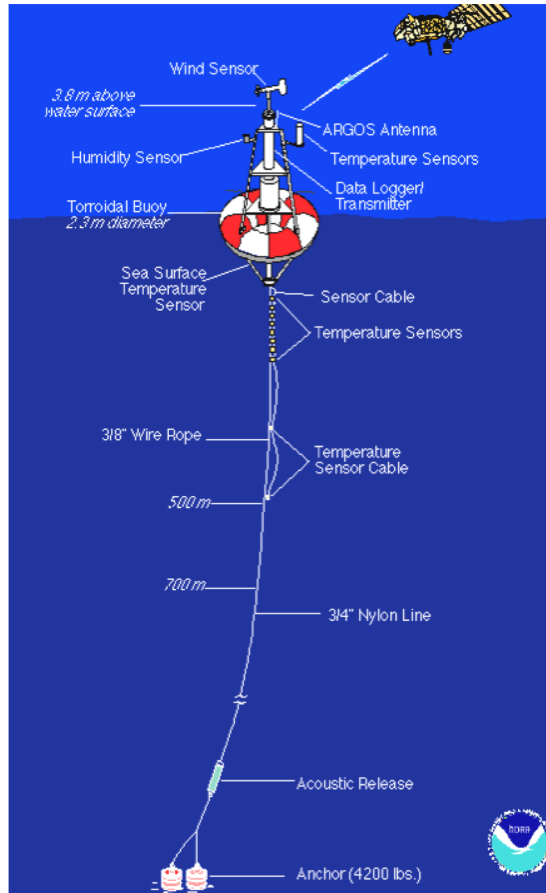
Talley SIOC 210 (2019)

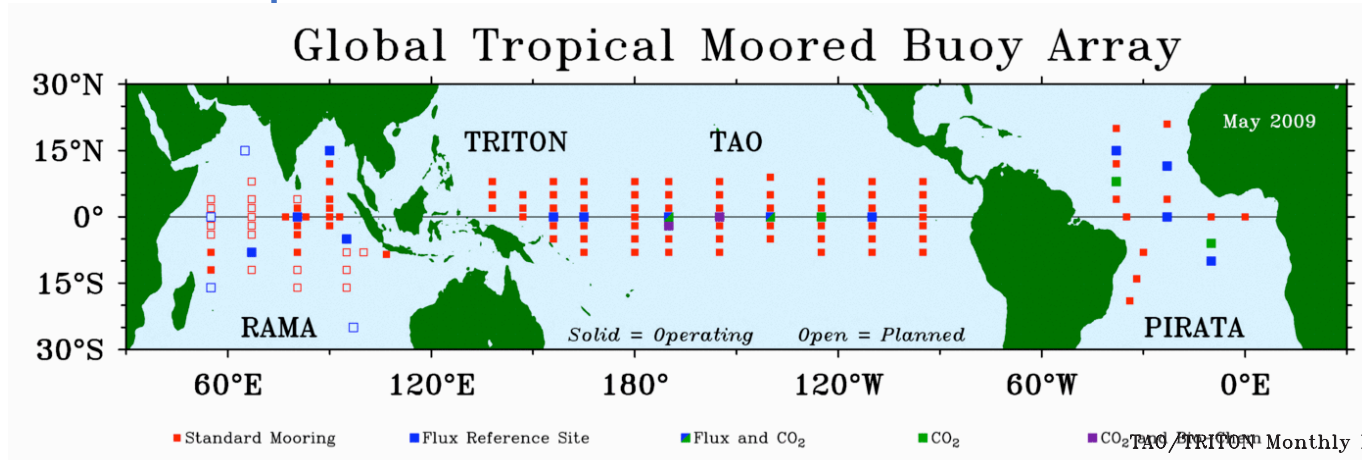# 4b. Autonomous (Eulerian)
# Moored current meters (velocity etc)



Acoustic Doppler Current Profiler (ADCP)

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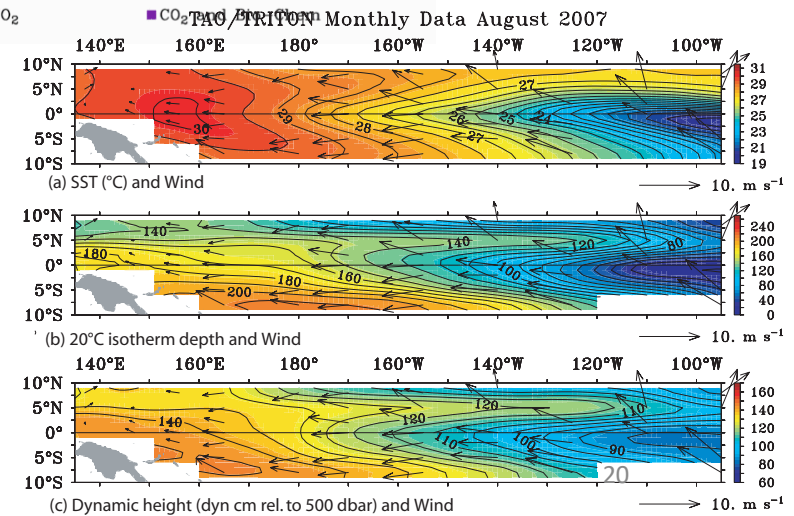# 4b. Observing system: TAO/Pirata array: tropical ocean - atmosphere
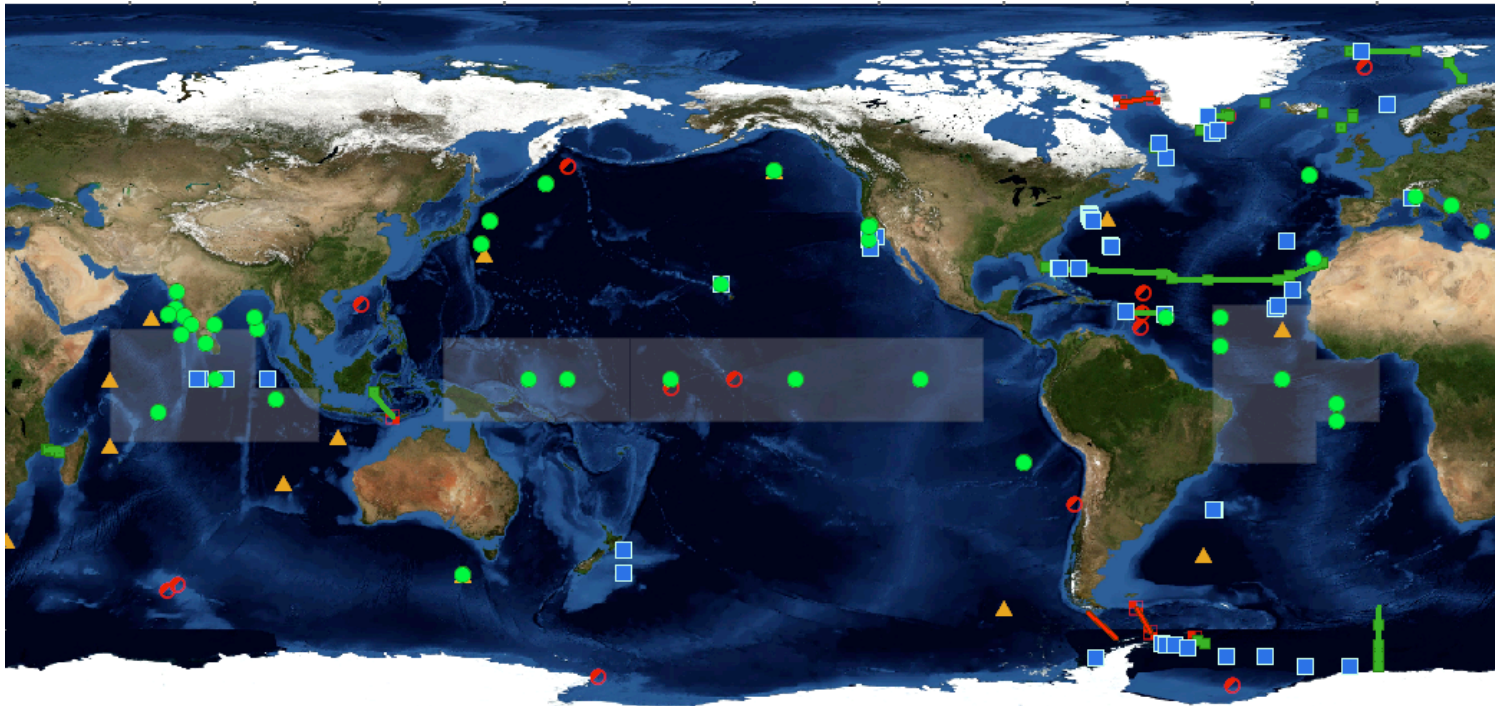
https://www.pmel.noaa.gov/gtmba/



10/7/19

Talley SIOC 210 (2019)

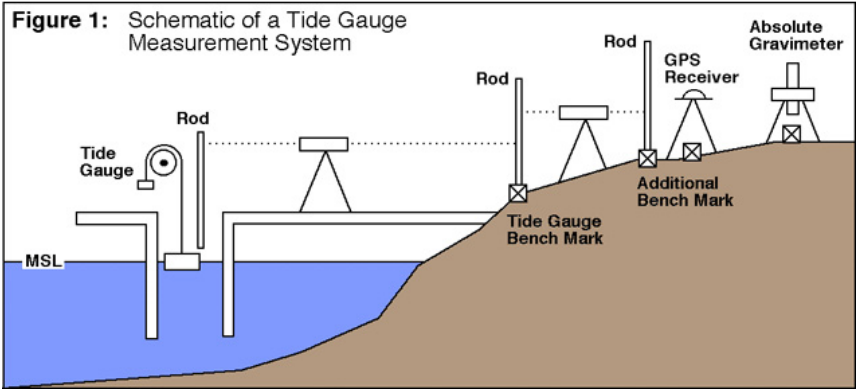# 4b. Autonomous (Eulerian)

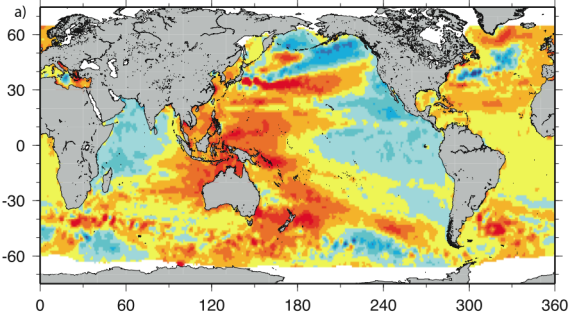OceanSITES program – network of moored ocean observatories (bottom and surface moorings)



http://www.whoi.edu/virtual/oceansites/index.html

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# 4b. Sea level: tide gauges (Eulerian)
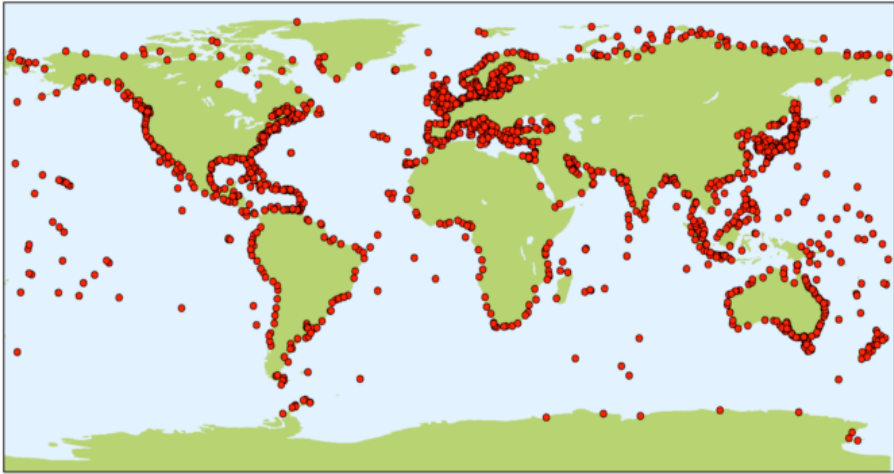

Figure 1: Schematic of a Tide Gauge Measurement System

"GLOSS"

Linear trends in sea level 1993-2003 (mostly altimetry)

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# 4c. Steered platforms/sensors:  Underwater gliders

For long repeat sections or profiling in fixed location – new observatories now based on this technology (e.g. California Current)

https://spraydata.ucsd.edu/projects/CUGN/

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