SIO 210: Observational methods

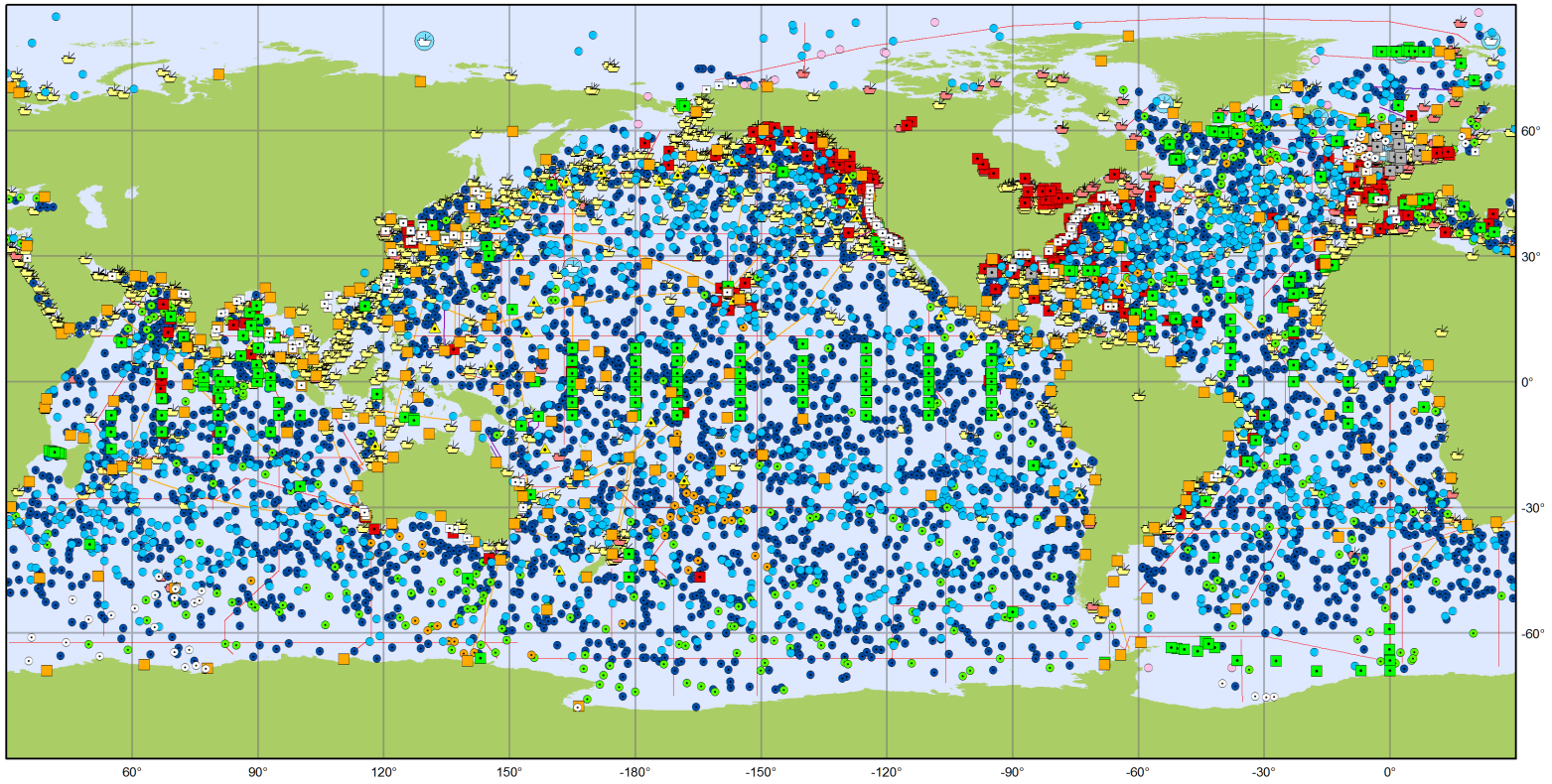
Remote sensing

In situ T, S and tracers

Velocity

Observing systems

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



Main in situ Elements of the Global Ocean Observing System

August 2018

Profiling Floats (Argo)
- Core (3944)
- Deep (70)
- BioGeoChemical (329)

Data Buoys (DBCP)
- Surface Drifters (1383)
- Offshore Platforms (97)
- Ice Buoys (16)
- Moored Buoys (392)
- Tsunameters (36)

Timeseries (OceanSITES)
- Interdisciplinary Moorings (451)

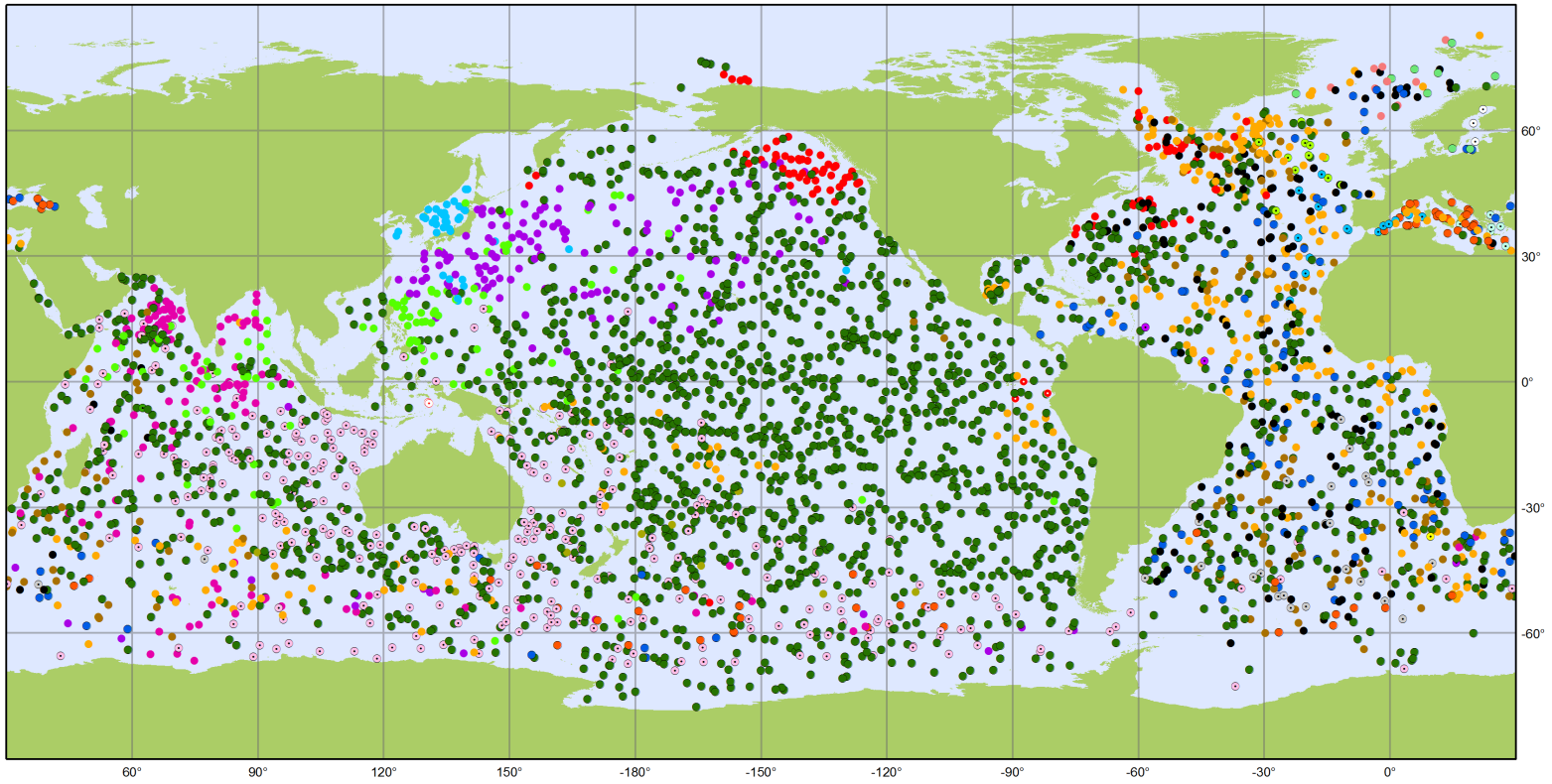
Repeated Hydrography (GO-SHIP)
- Research Vessel Lines (61)

Sea Level (GLOSS)
- Tide Gauges (252)

Ship based Measurements (SOT)
- Automated Weather Stations (254)
- Manned Weather Stations (1738)
- Radiosondes (16)
- eXpendable BathyThermographs (37)

Other Networks
- HF Radars (270)
- Animal Borne Sensors (53)
- Ocean Gliders (31)

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



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)	

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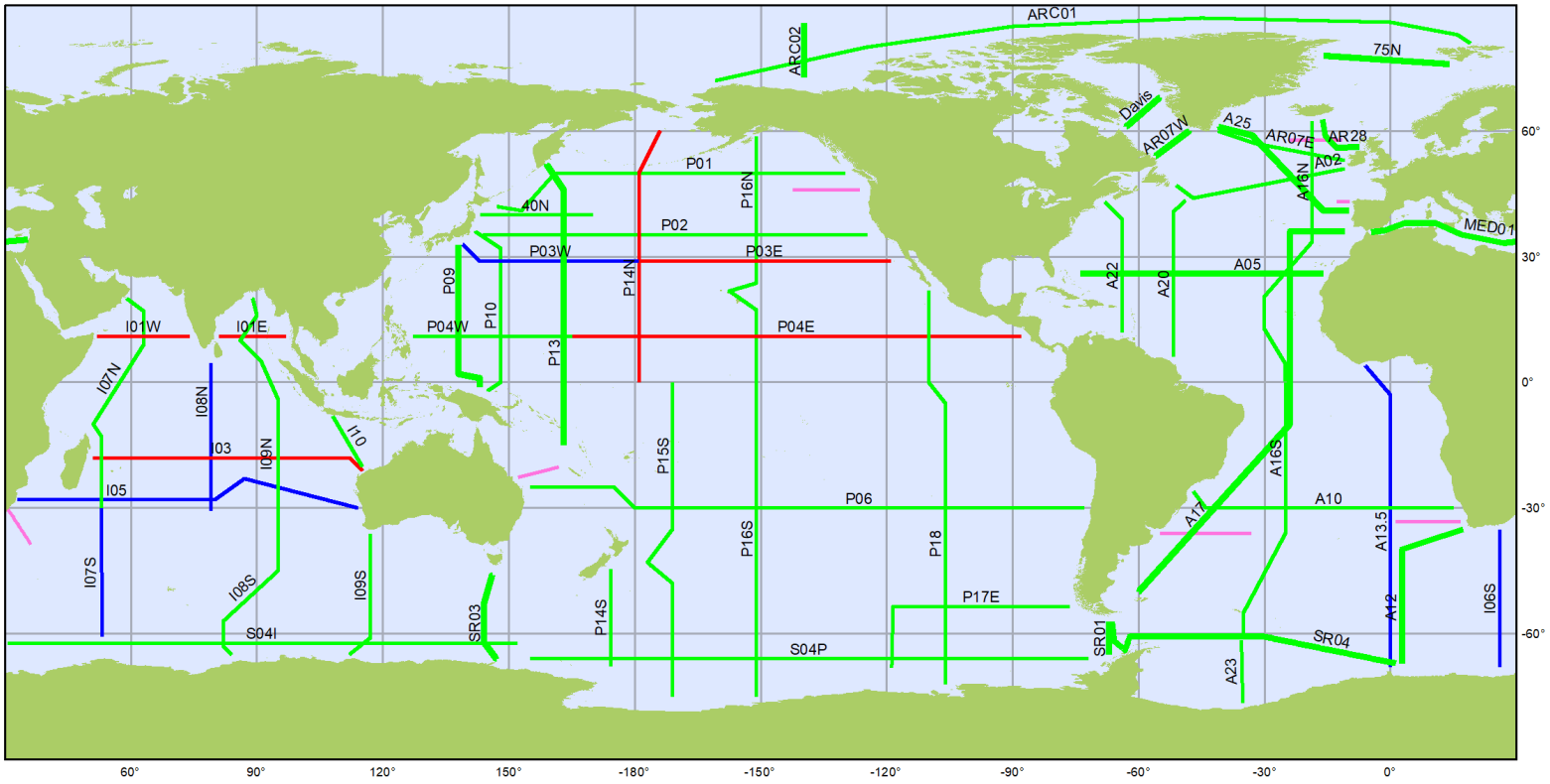

GO-SHIP **Status of 2012-2023 Survey (62 Lines)** **October 2018**

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

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

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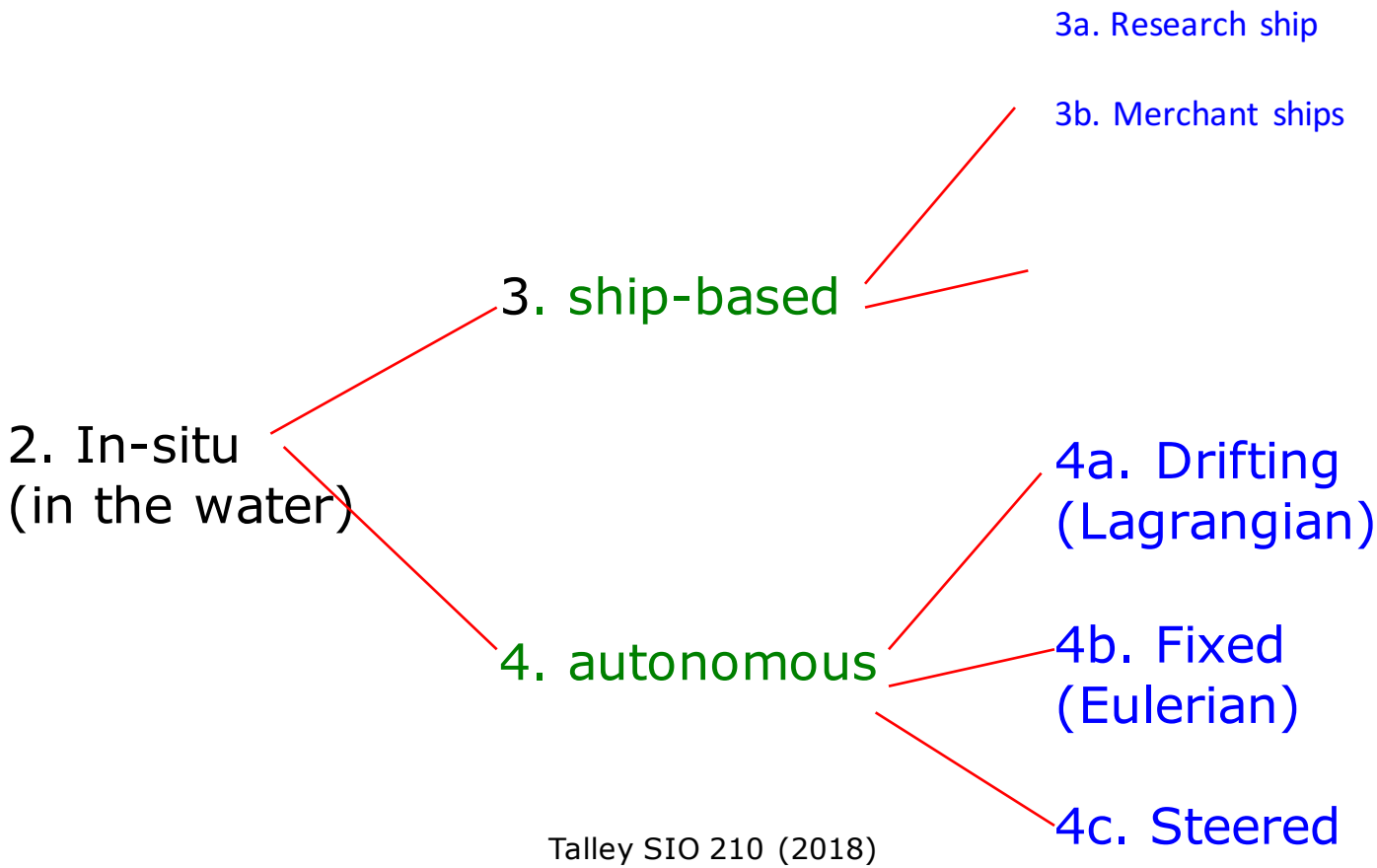
Definitions

- 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

Options for ocean observations

1. Remote sensing (satellite)



1. Remote sensing (satellites)
Sea surface height: Altimetry

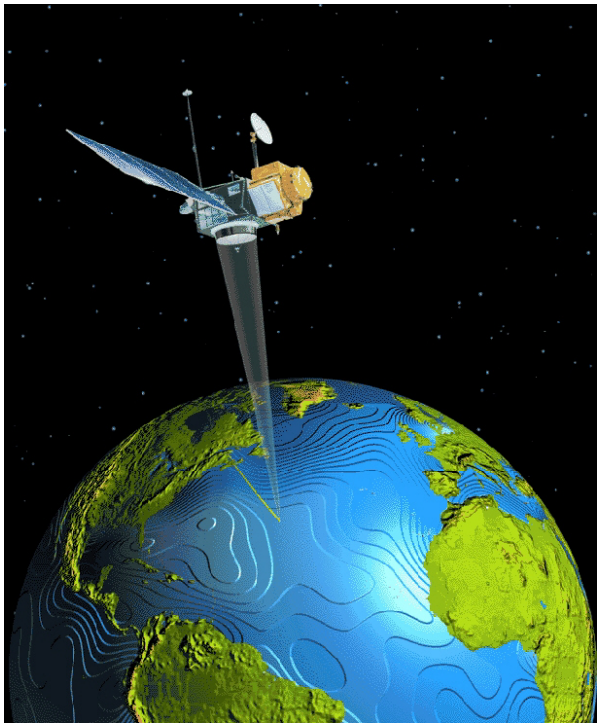
Rationale:

cm-accuracy sea-surface height

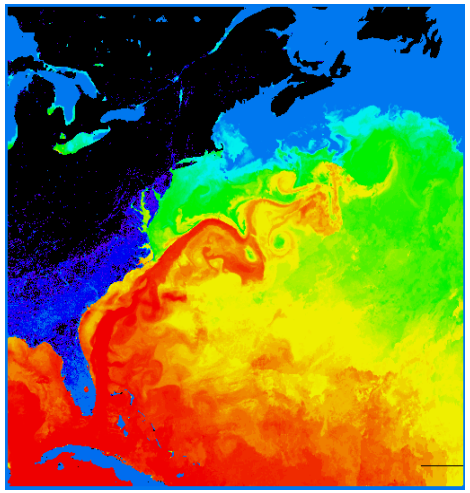
variability from 20-10000km, 20days-10years

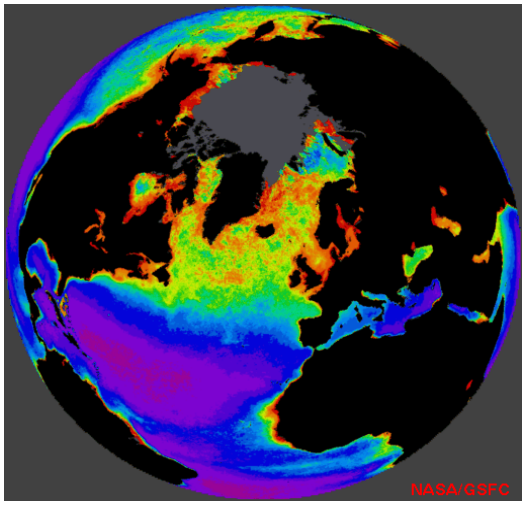
heat storage from large-scale steric effect

geostrophic surface flow relative to geoid



SST and ocean color

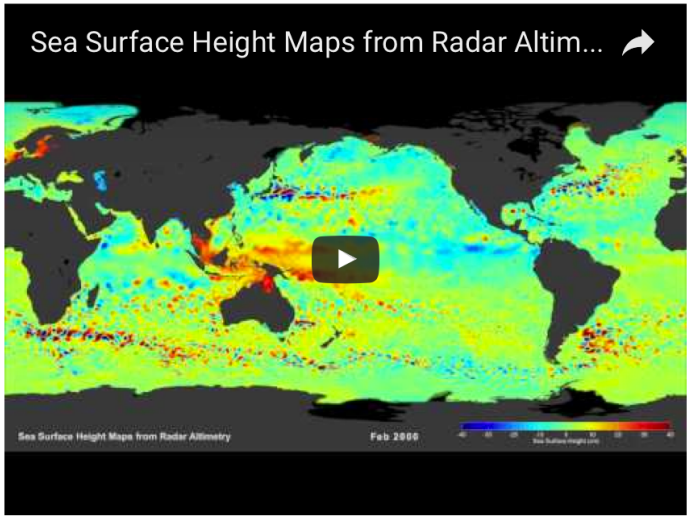




and other quantities (wind, ice, waves, salinity,….)

NASA animations: sea surface height

http://podaac.jpl.nasa.gov/AnimationsImages/Animations?page=2
https://www.youtube.com/watch?v=F8zYKb2GoR4

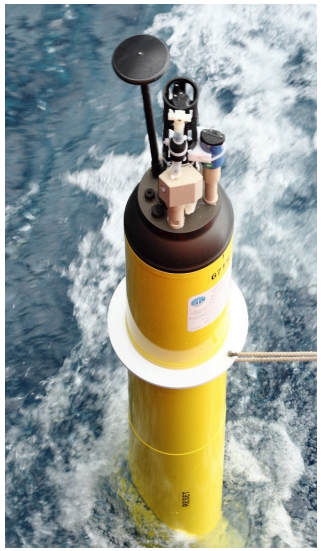


Sea Surface Height Maps from Radar Altimetry

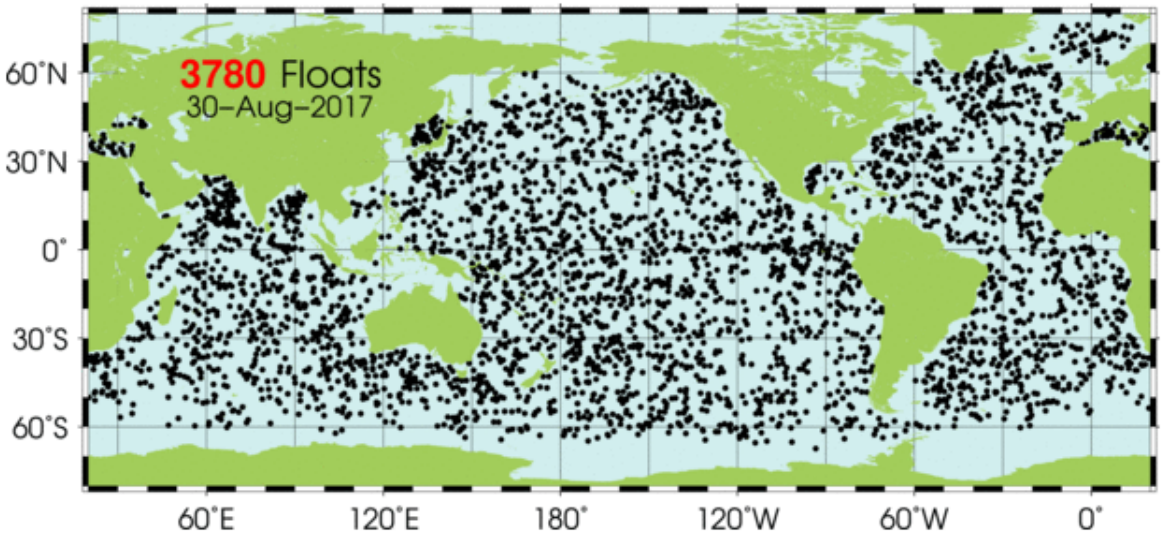
October 22, 2012

Using data from several satellite altimeters, a finer picture of the ever-changing height of the oceans is revealed. Swirling currents called eddies pepper the global ocean. Like small pock-marks in sea surface height, these eddies are found in every major ocean basin. Near the Equator, the eddies give way to fast moving features called Kelvin Waves. When they build up in the Pacific, these waves can usher in a phenomenon known as El Nino, which happens when warm water and high sea levels move into the Eastern Pacific along the Equator.

Argo autonomous profiling floats

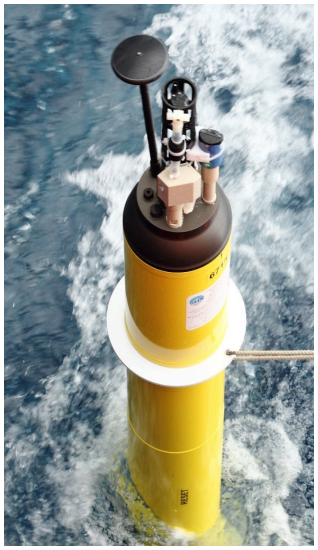


- 3500 to 4000 floats
- Temperature and salinity profiles
- Every 10 days to 2000 m



2. In situ sampling: platforms

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



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)

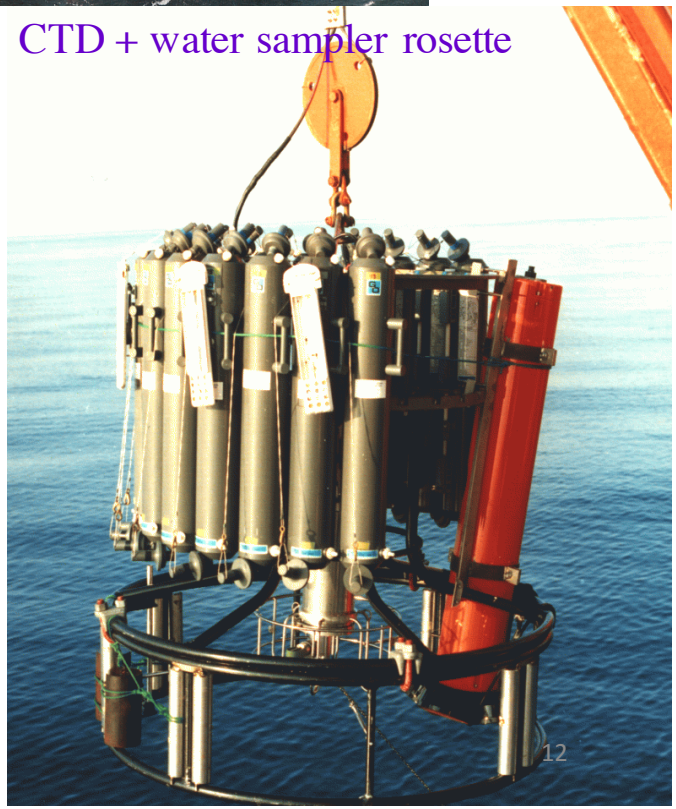
- Velocity:
  - current meters (mechanical with compass)
  - acoustic doppler current meters (sound waves reflecting off particles suspended in the water)
  - floats and drifters (moving with the water)

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

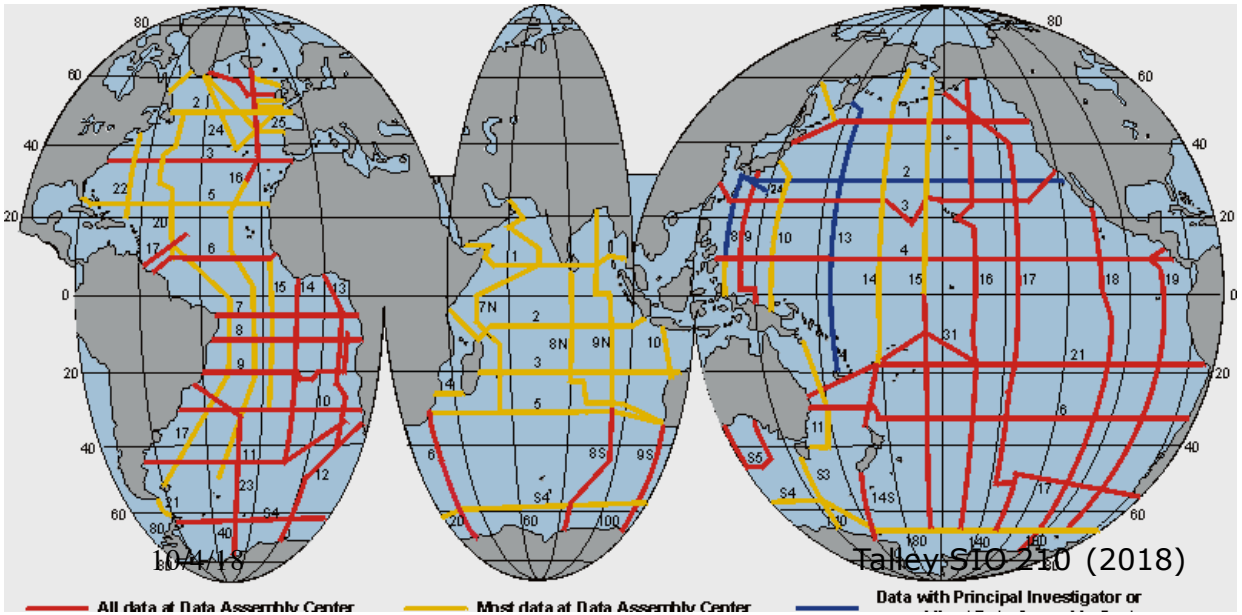
3a. Ship-based: research ships

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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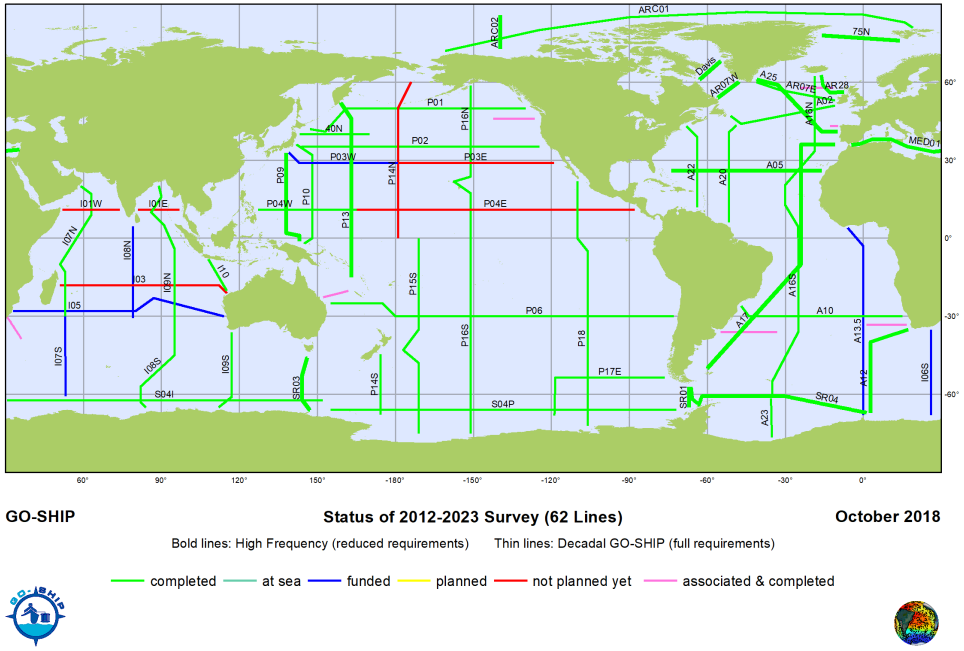
Present: „GO-SHIP“ http://go-ship.org

GO-SHIP decadal hydrography



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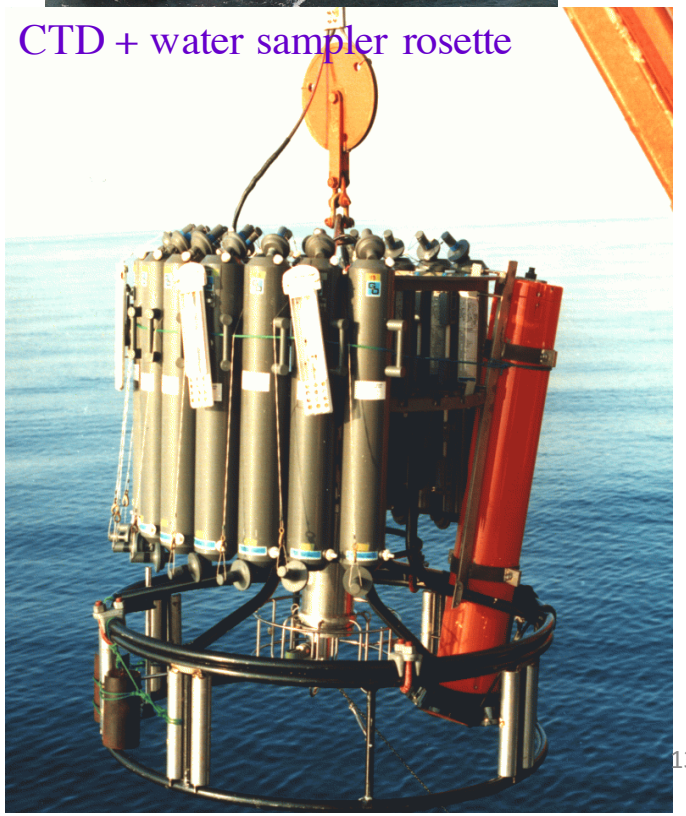
018)



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

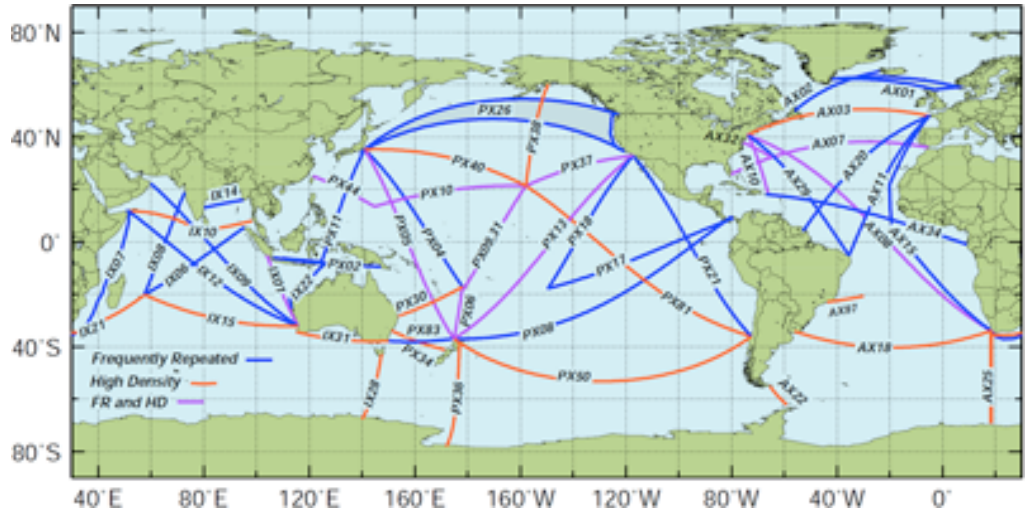
Commercial ships (ferries, container vessels, etc) which carry out various observations on the way, or deploy probes/instruments

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

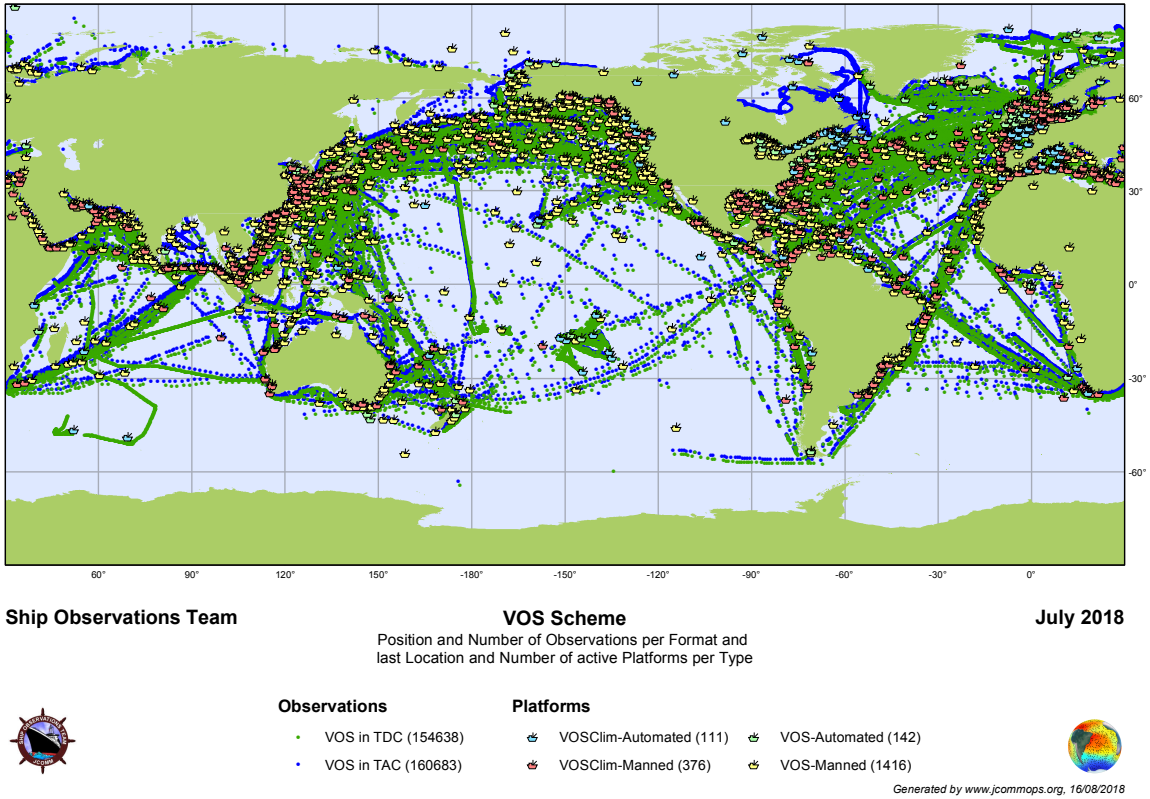
Disadvantages:
- startup effort is large
- limited sensors
- speed
- ships may be moved

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



XBT network

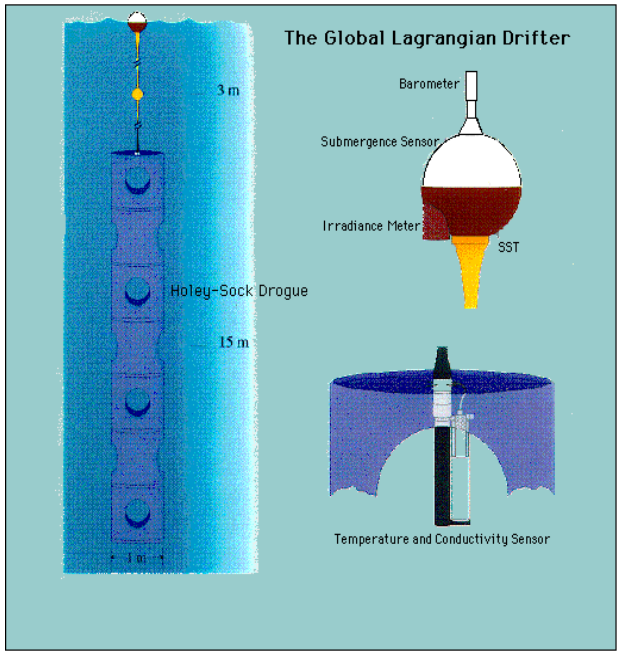
3b. VOS: XBT (eXpendable BathyThermograph) temperature probes

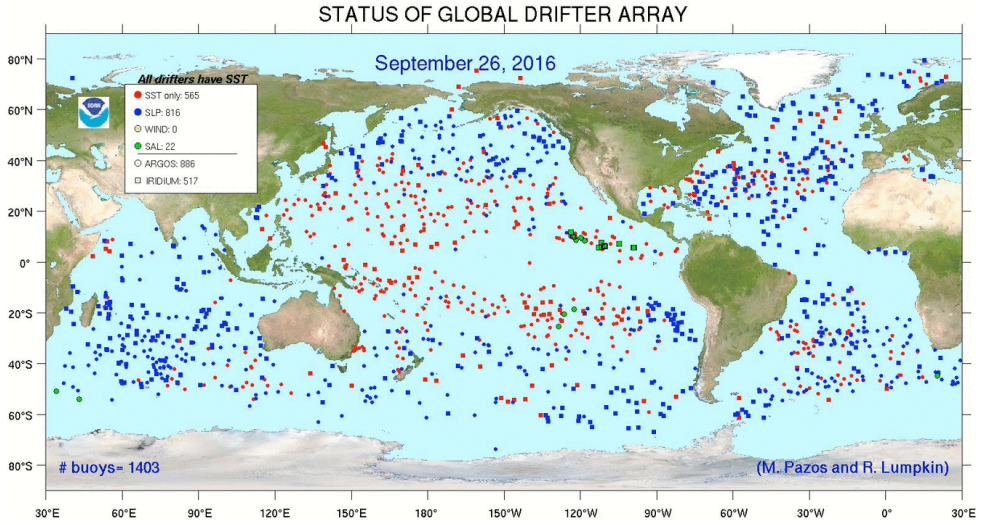


XBT network

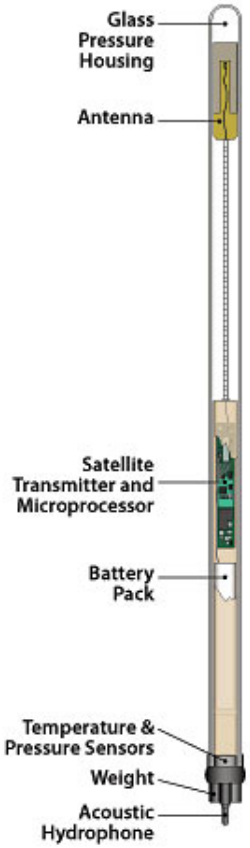
4a. Autonomous (Lagrangian)

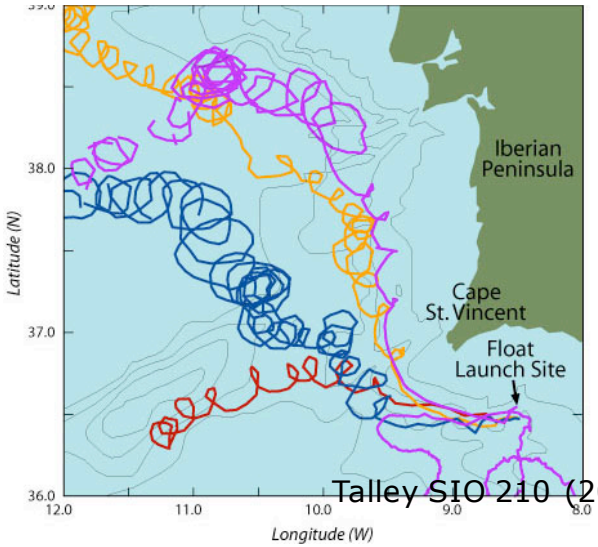
Surface drifters: velocity and a few sensors (SST, SSS, air pressure are common)





4a. Autonomous (Lagrangian)
Subsurface floats: acoustically-tracked





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

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

Floats record the signals and are later located by triangulation.

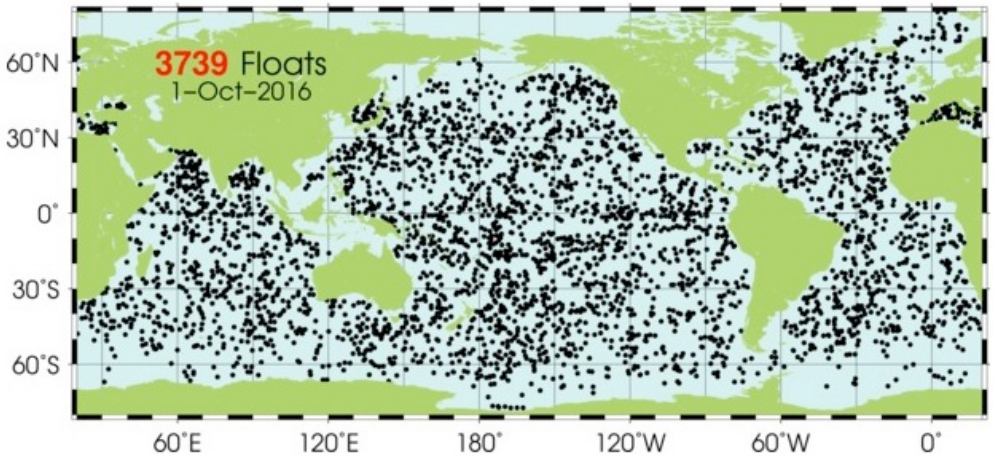
Stay submerged for entire mission, and surface after 1-3 years, telemetering all data home. Expendable.

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

Profile to 2000 m and tracked every 5 to 10 days, so not eddy resolving.

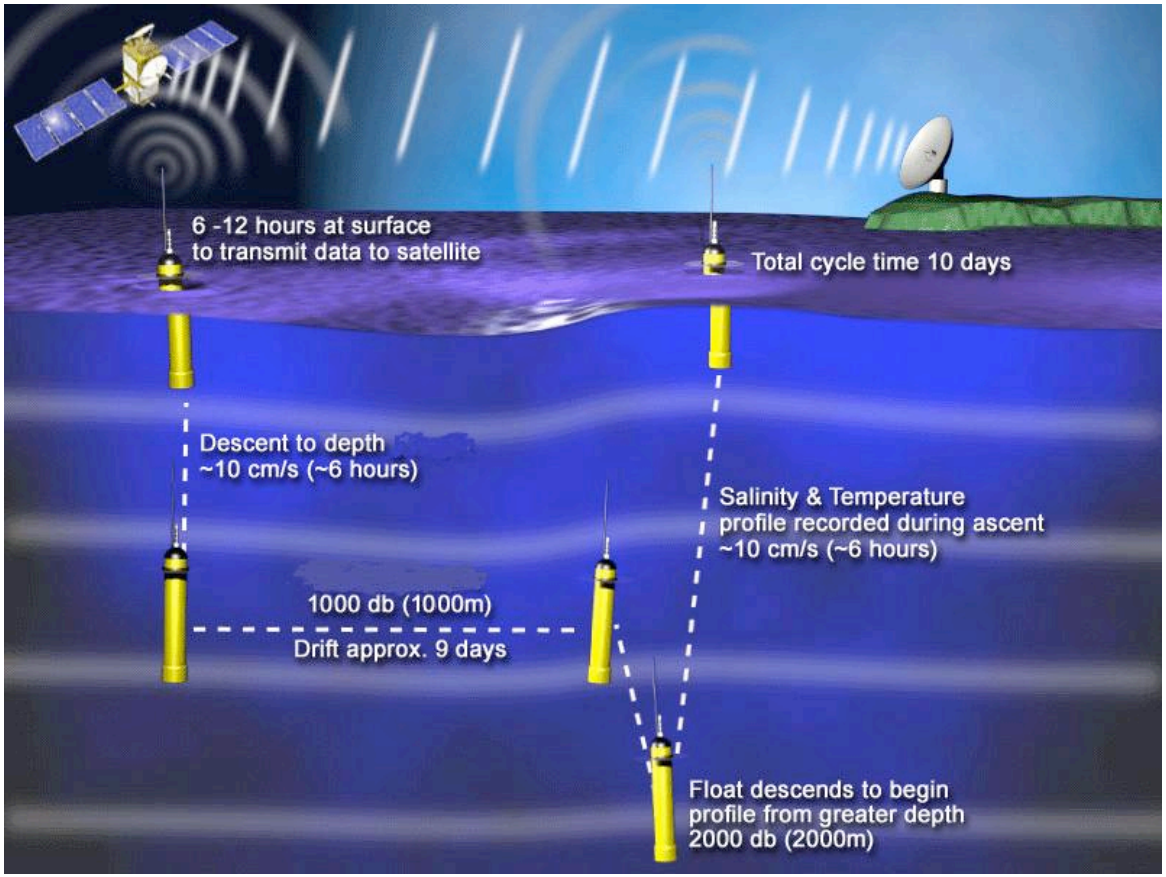
Best for repeat profiling of water column (T,S,other properties)

Up to 200 profiles



Positions of the floats that have delivered data within the last 30 days

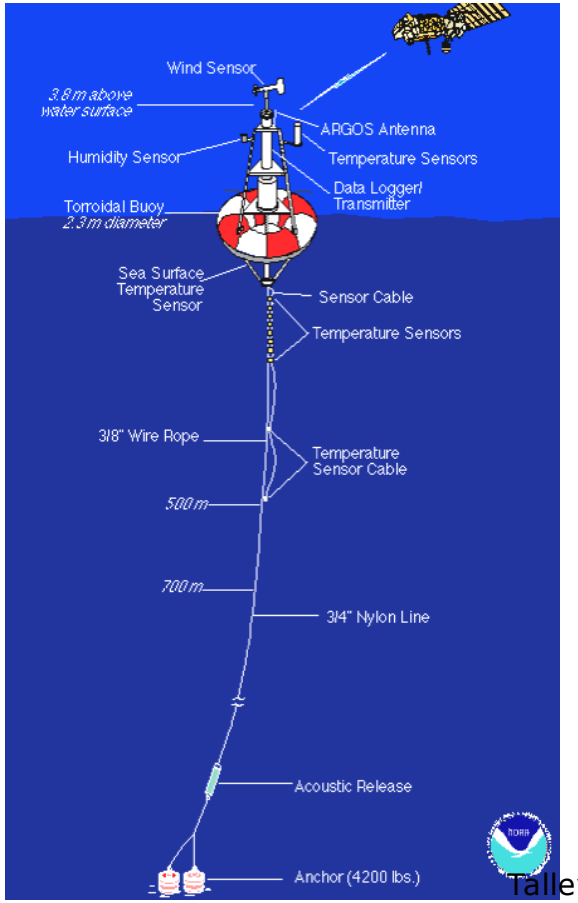
4a. Autonomous (Lagrangian) Subsurface floats: “pop-up” (Argo)

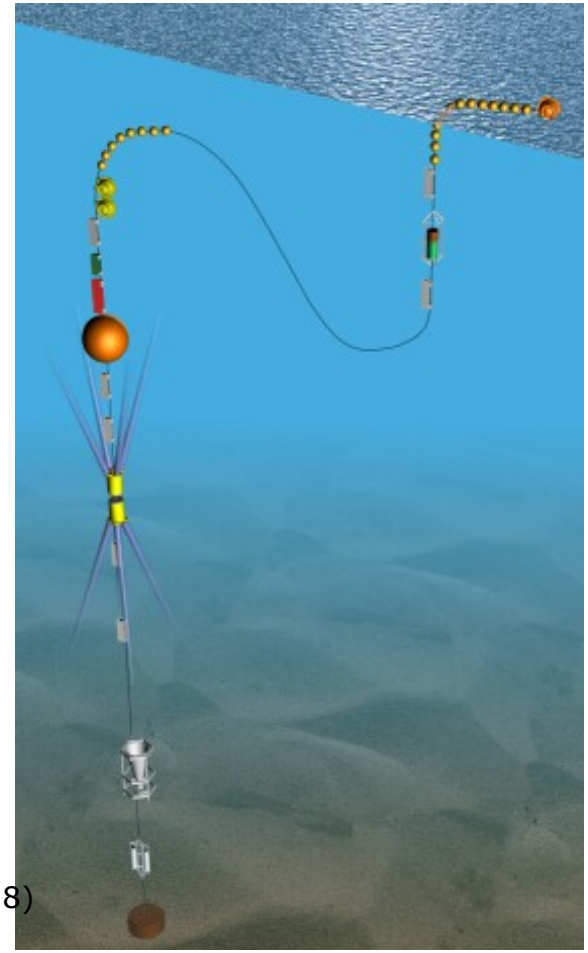


Argo float mission

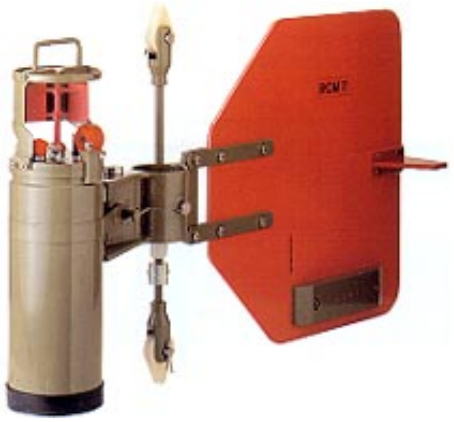
4b. Autonomous (Eulerian – fixed sensors)

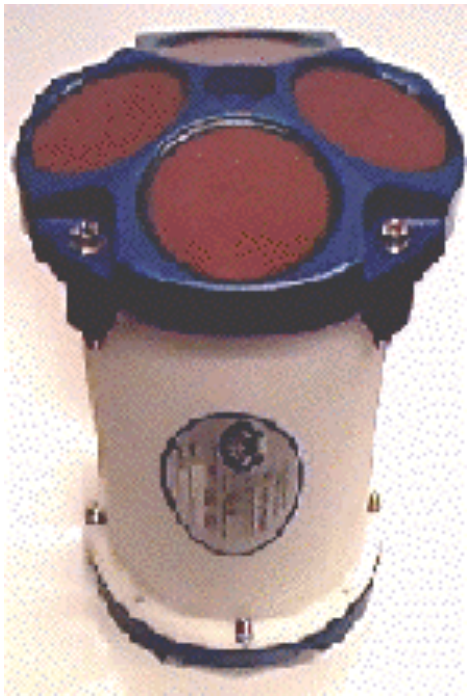
Moorings can sample with high rate, from surface to bottom, many simultaneous sensors, and can carry heavy instruments





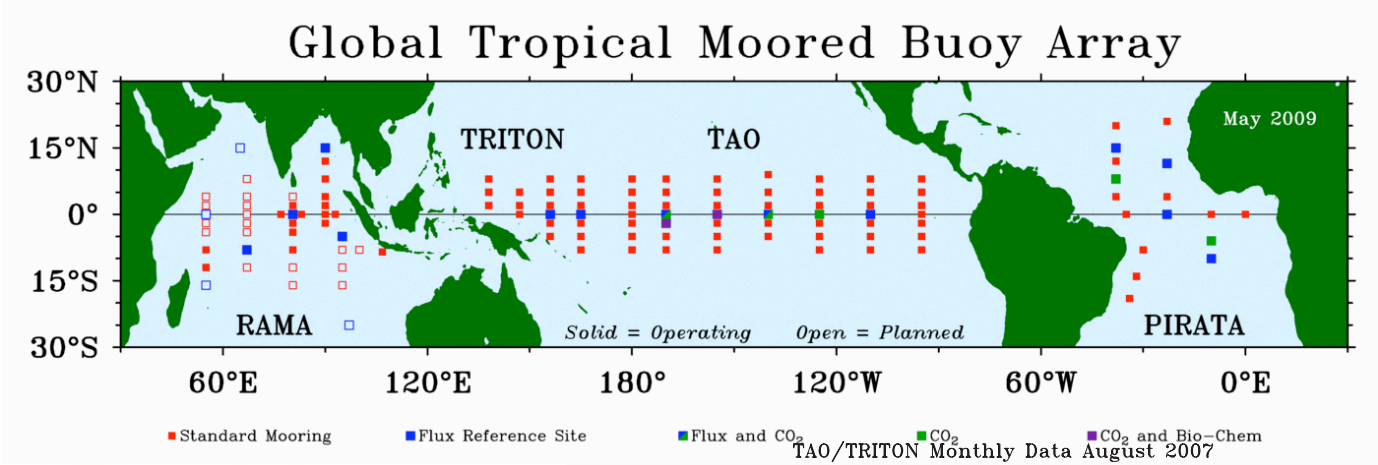
4b. Autonomous (Eulerian)
Moored current meters (velocity etc)

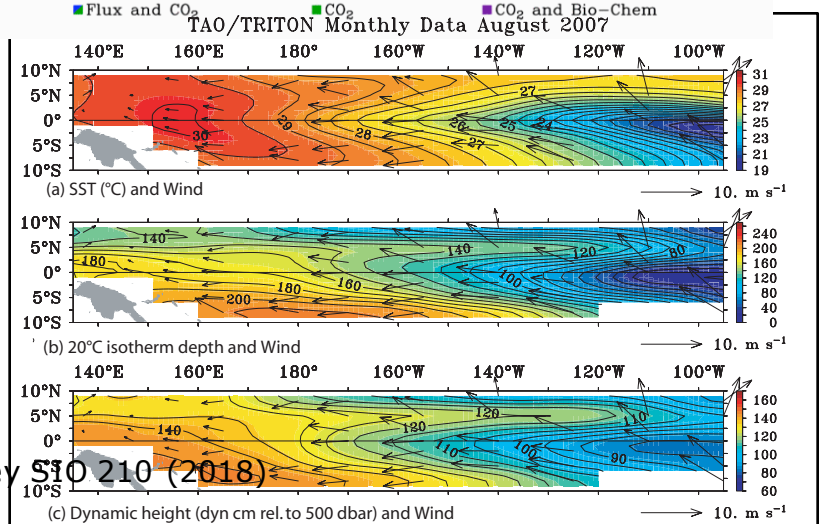




Acoustic Doppler Current Profiler (ADCP)

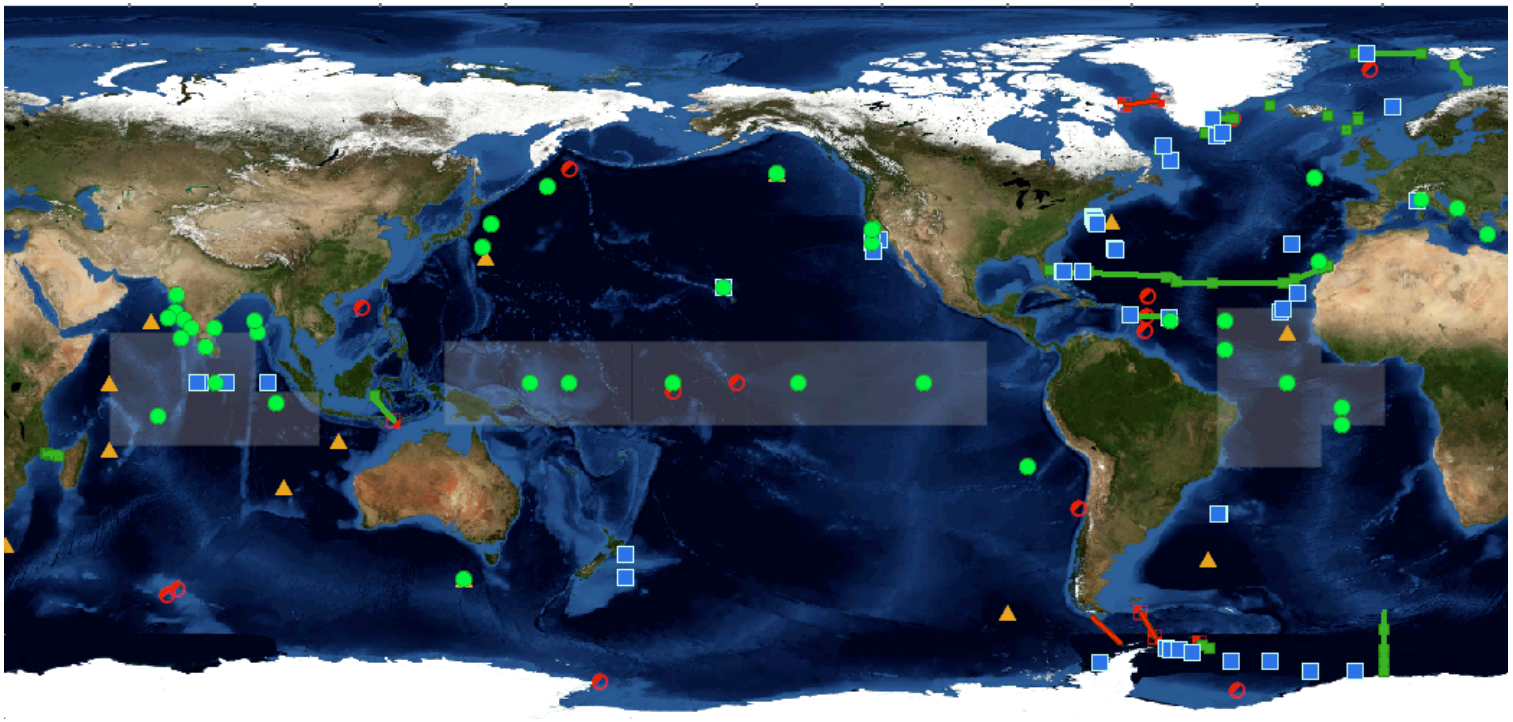
4b. Observing system: TAO/Pirata array: tropical ocean - atmosphere





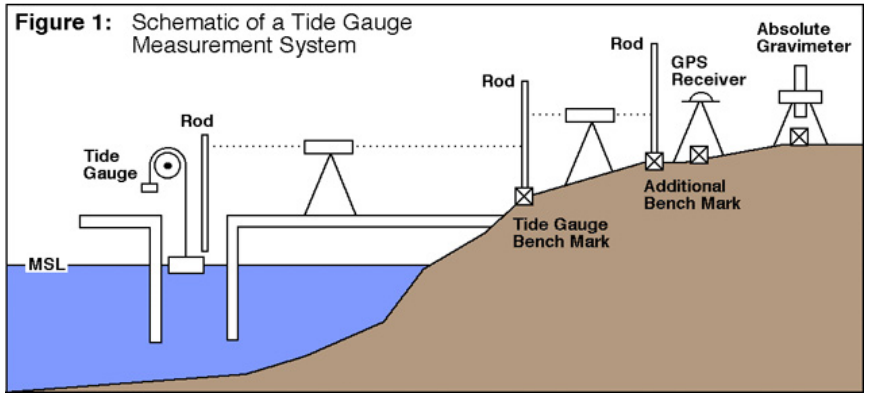
4b. Autonomous (Eulerian)

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



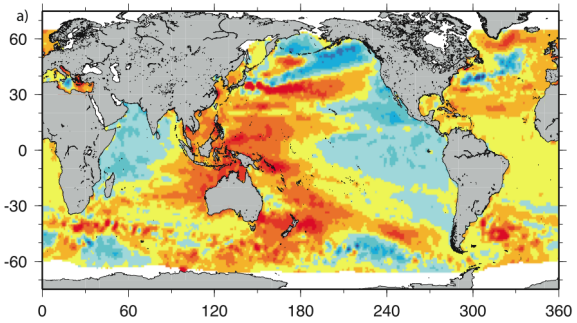
http://www.whoi.edu/virtual/oceansites/index.html

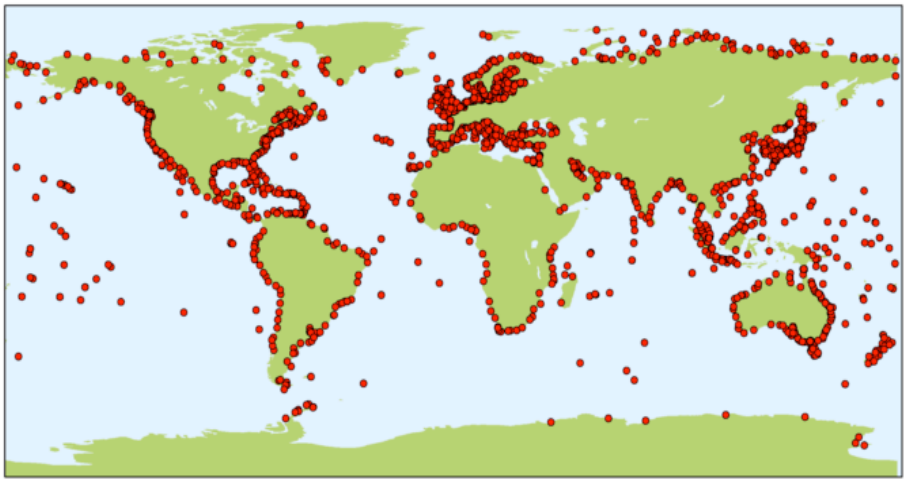
4b. Sea level: tide gauges (Eulerian)



"GLOSS"

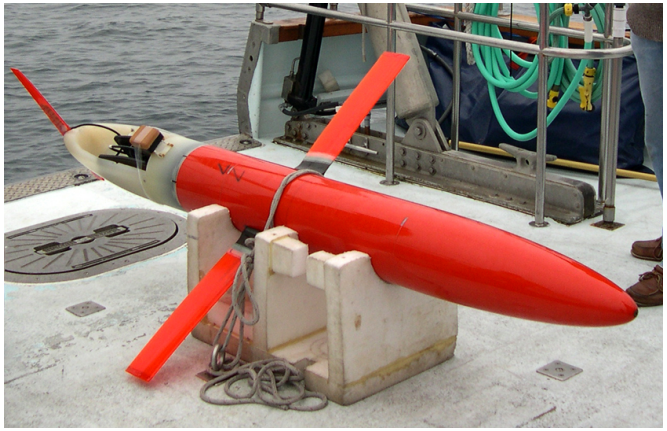
Linear trends in sea level 19
2003 (mostly altimetry)

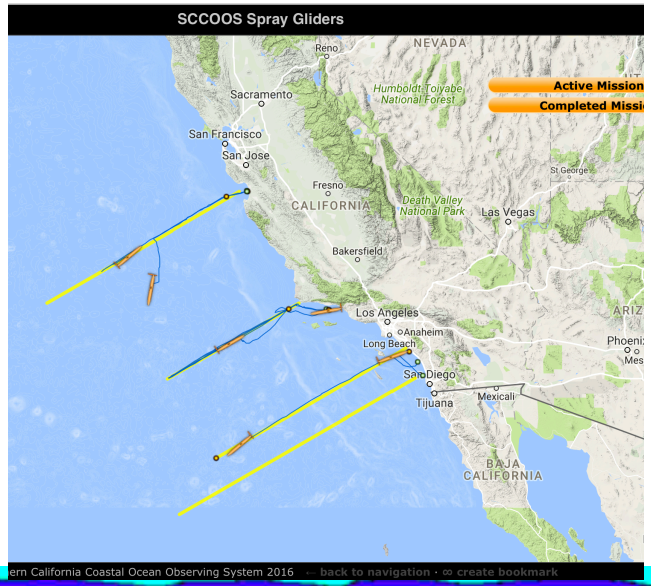


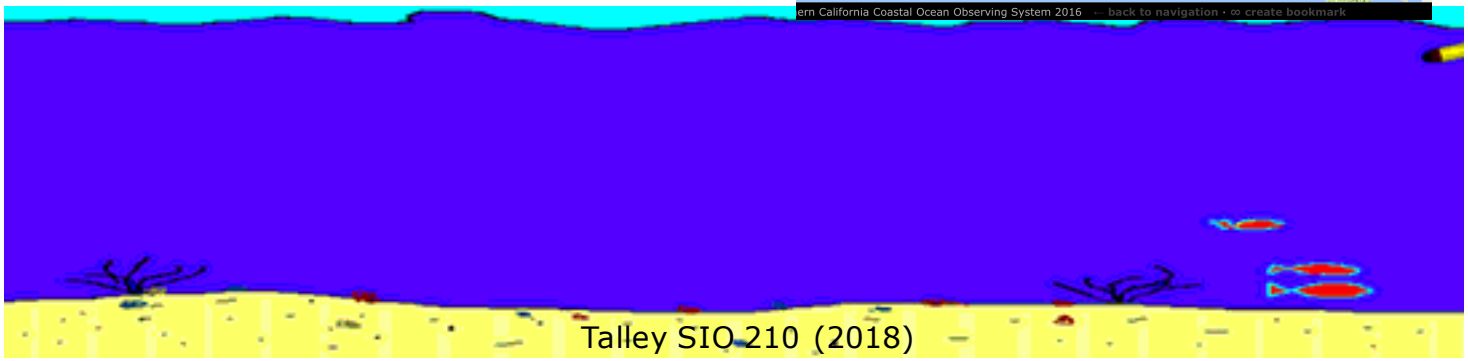


4c. Steered platforms/sensors: Underwater gliders

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







Talley SIO 210 (2018)