



The Ocean: A key component of the Global Climate System

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Ice

THE EARTH CLIMATE SYSTEM

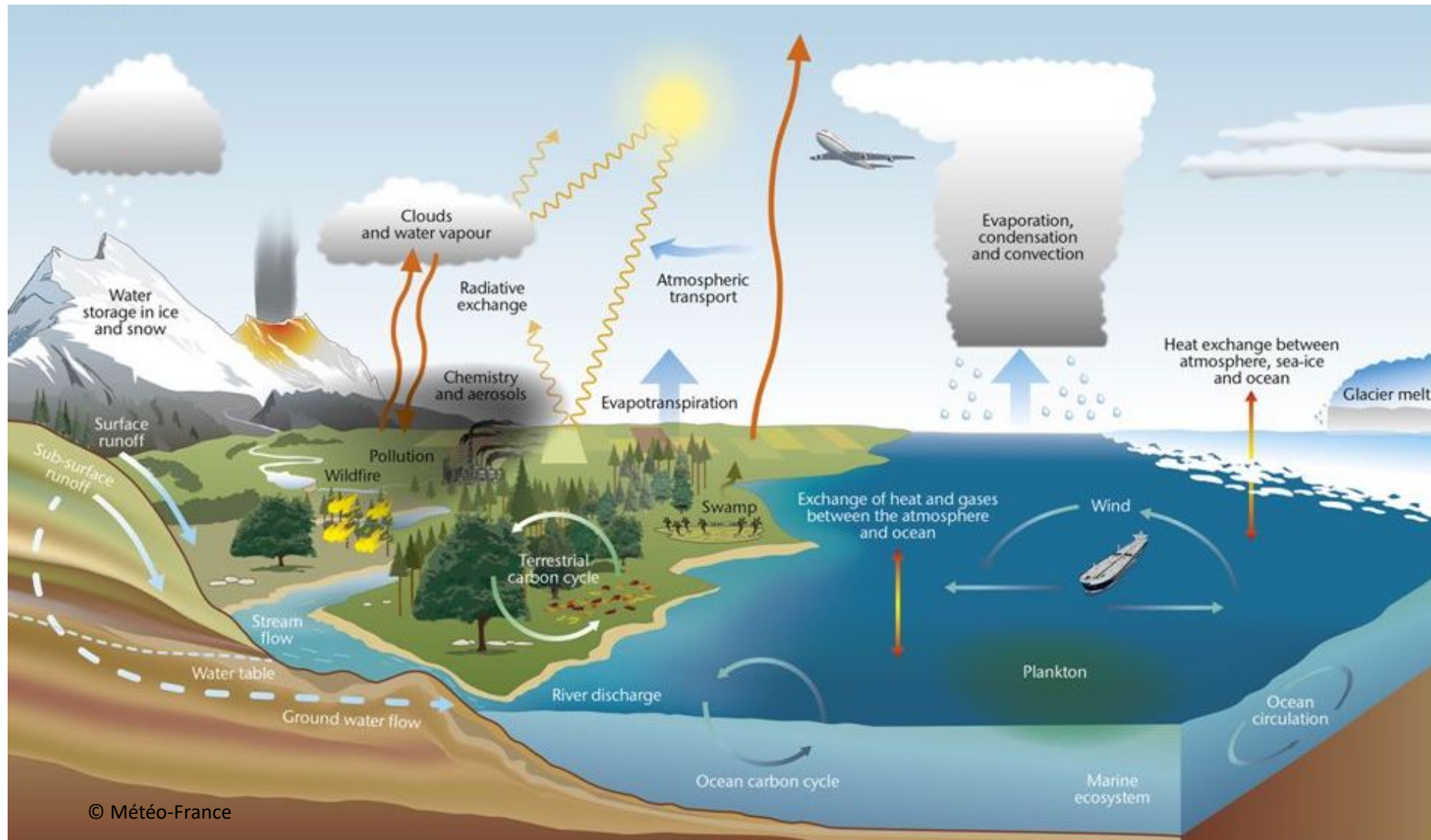
Land

Biosphere

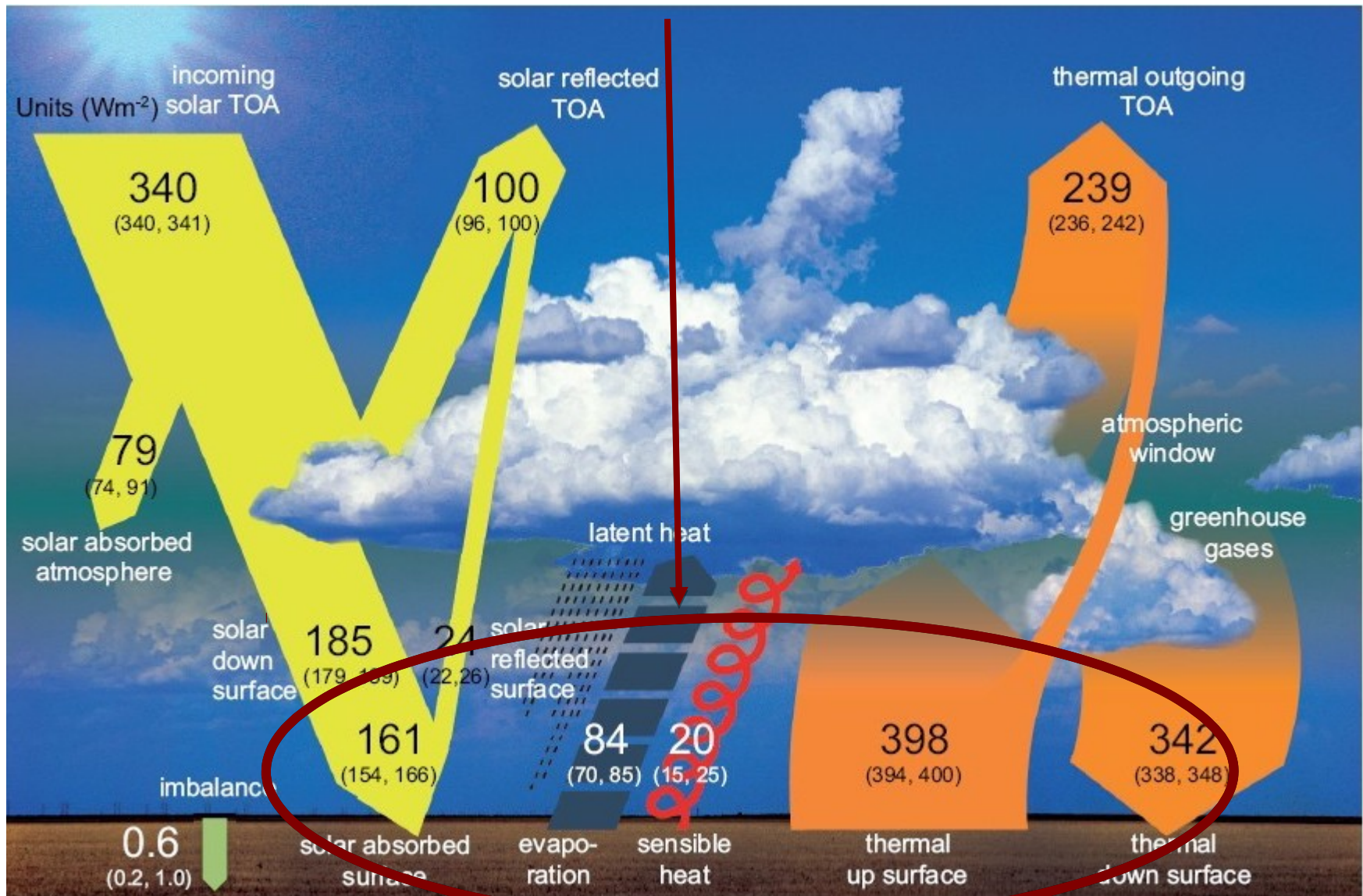
Atmosphere

Ocean

The Earth Climate System is an extremely complex system with energy exchanges implying physical, chemical, and biological processes evolving continuously over a very wide spatio-temporal spectrum



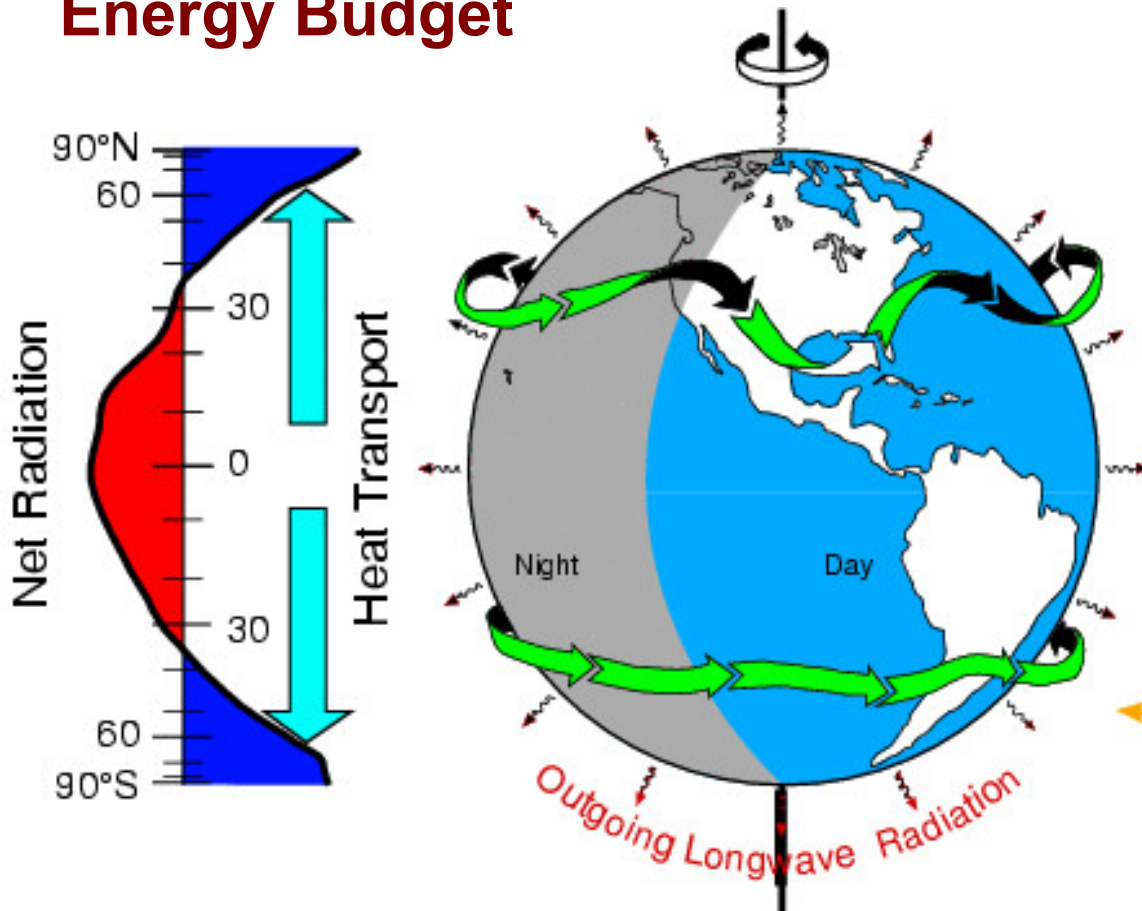
FOCUS ON THE ENERGY BUDGET & THE OCEAN: 70.8% OF THE EARTH SURFACE



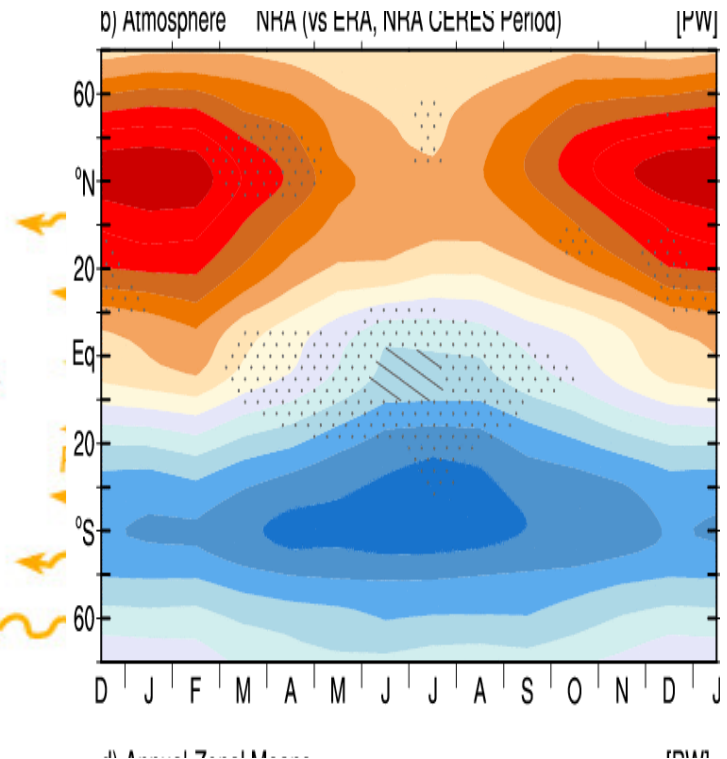
ENERGY ON EARTH

At equilibrium: Balance between the incoming and outgoing radiation

Energy Budget



Energy Transport

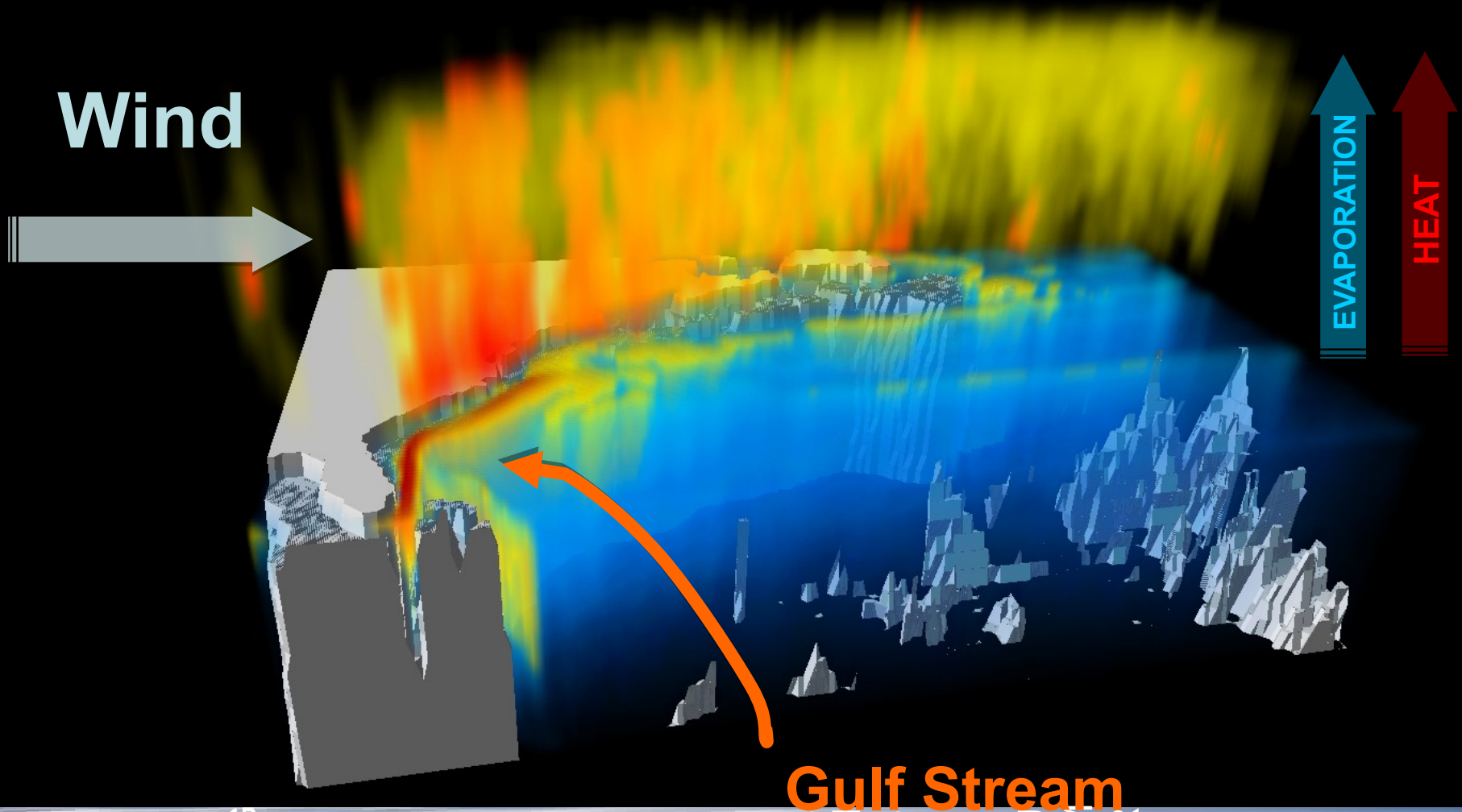


Ocean observing

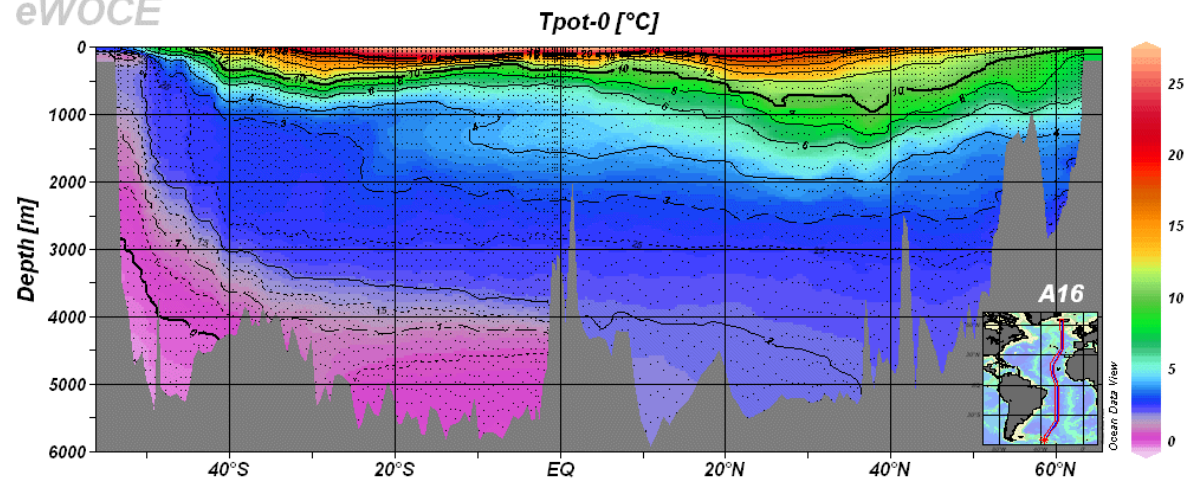
Satellite surface Temperature & geostrophic velocities



The Ocean: The Earth heater through small-scale air-sea interactions

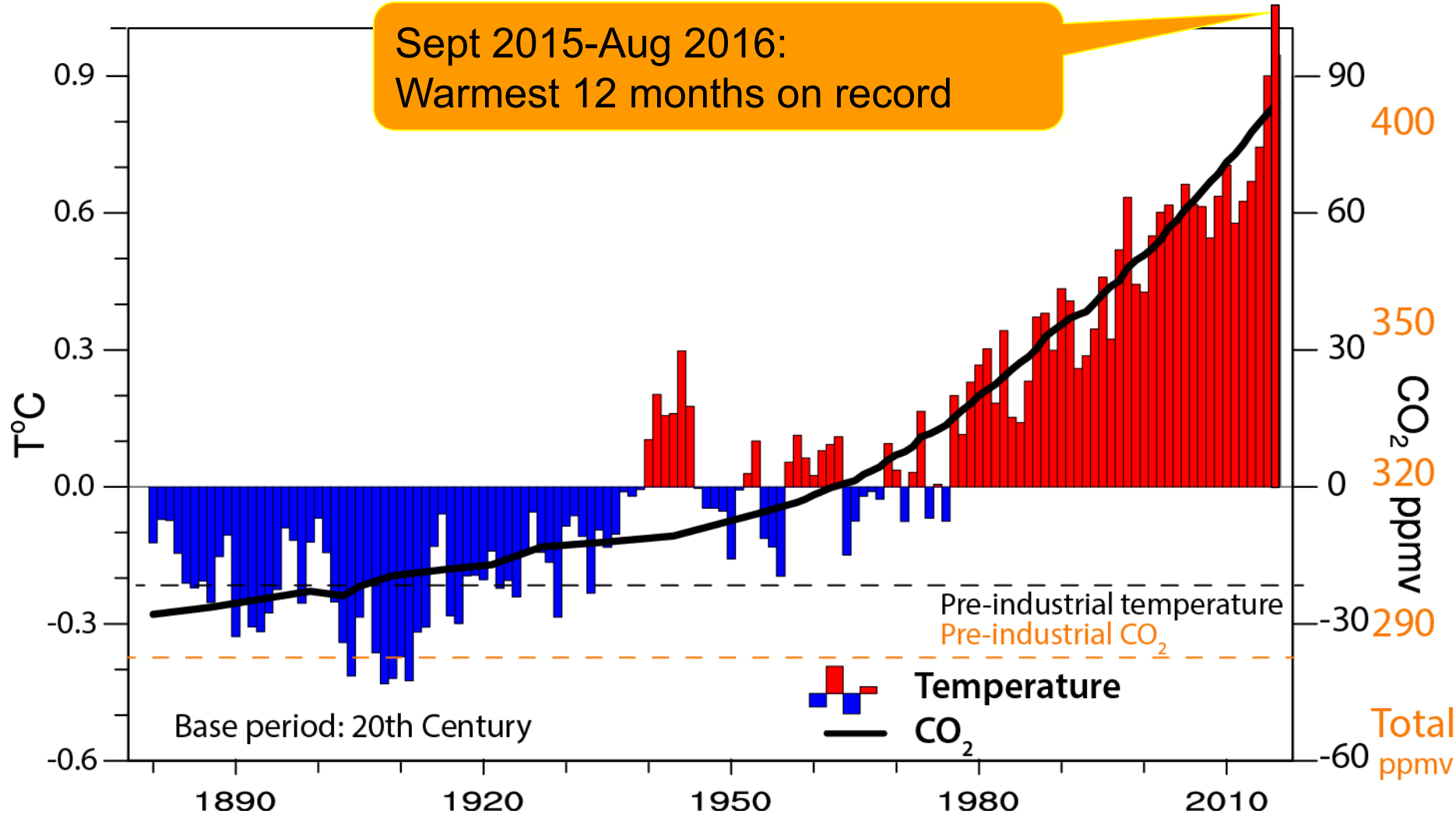


Océan

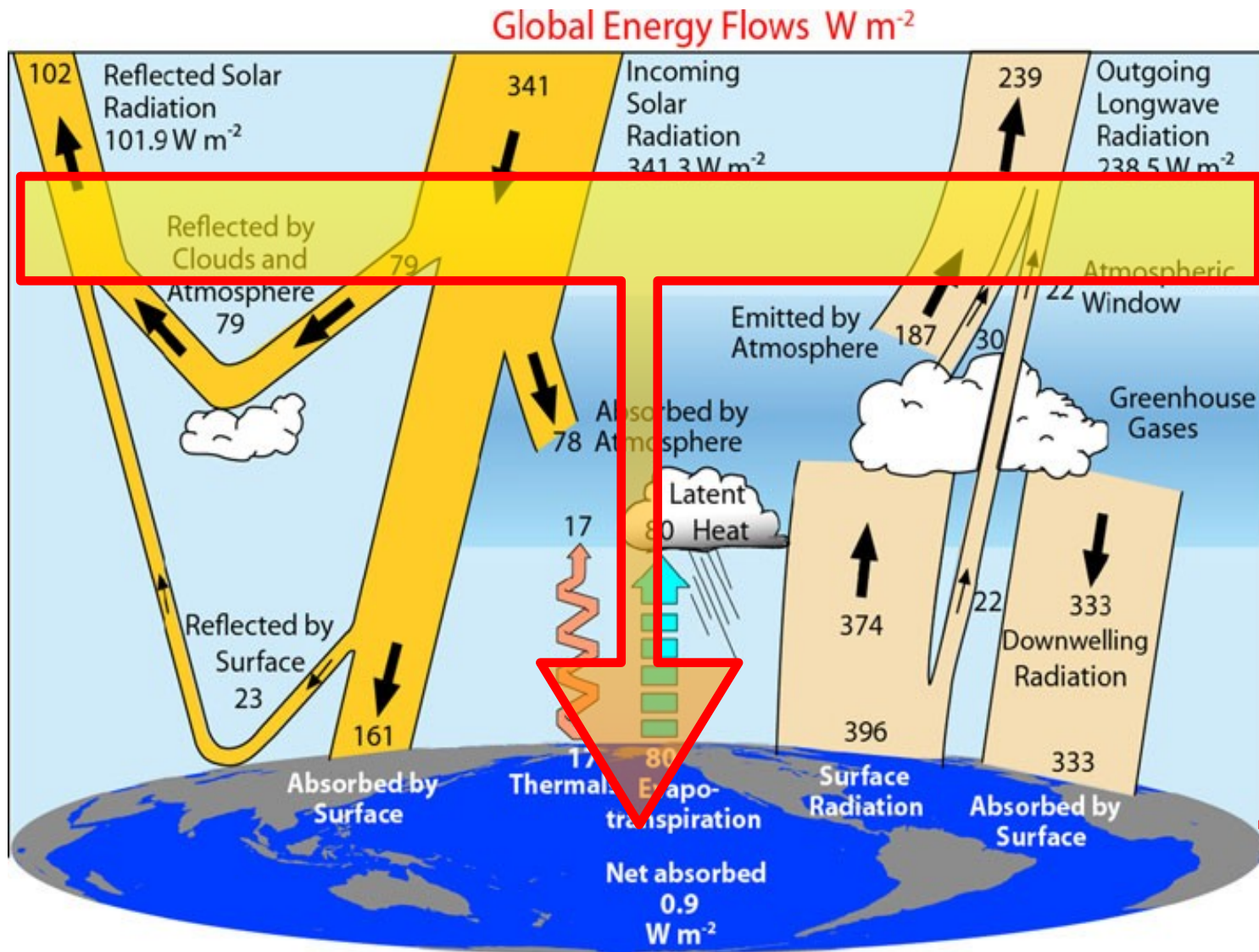


Global temperature and CO₂: Anomalies through 2016

Sept 2015-Aug 2016:
Warmest 12 months on record



FOCUS ON THE ENERGY BUDGET & THE LOST HEAT

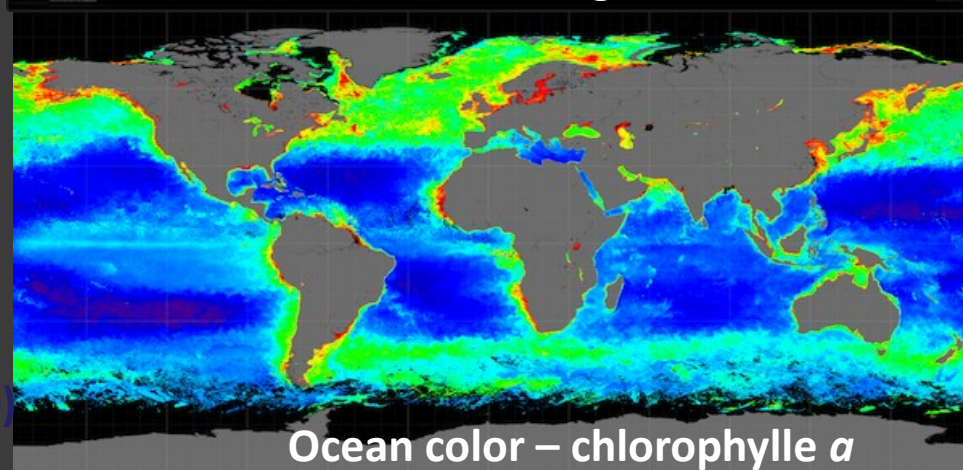
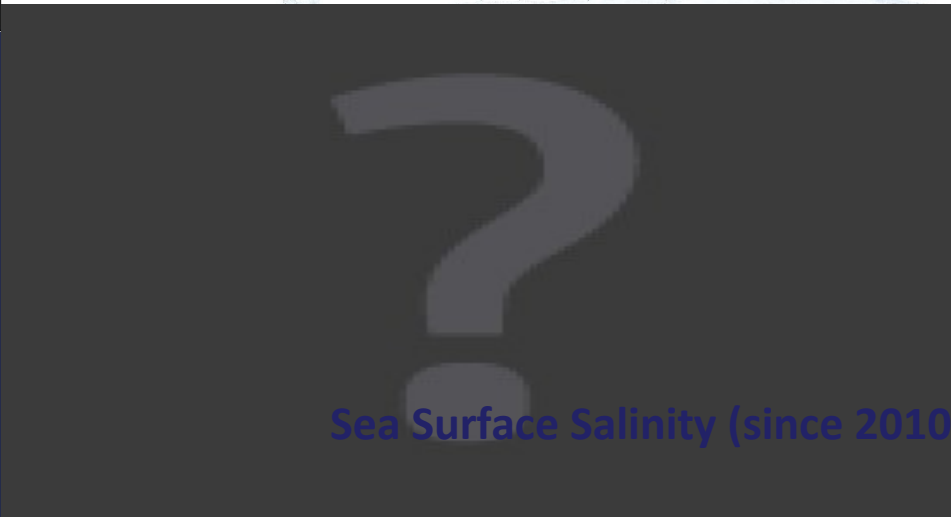
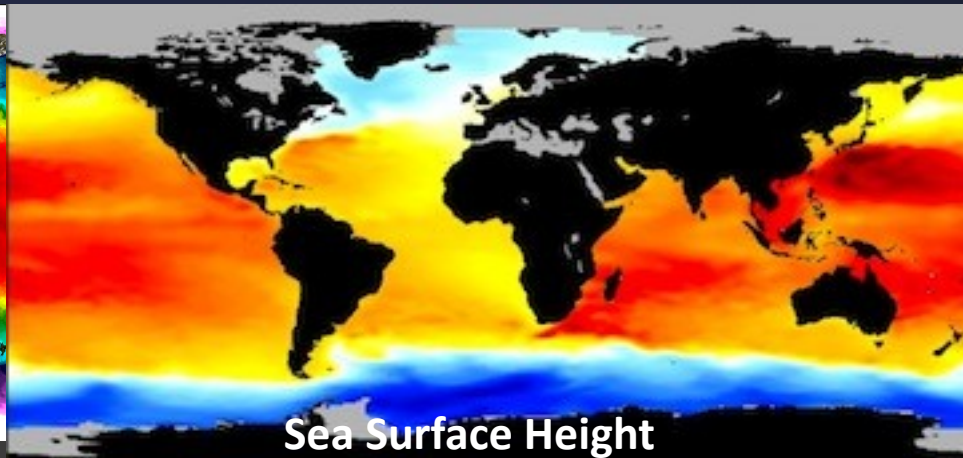
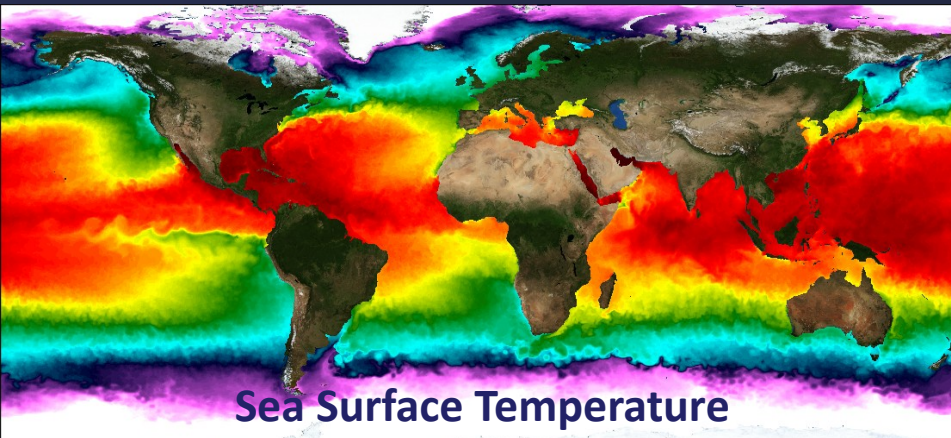


Ocean observing

... by remote sensing (satellites)



Ocean observing ... by remote sensing (satellites)



Ocean observing

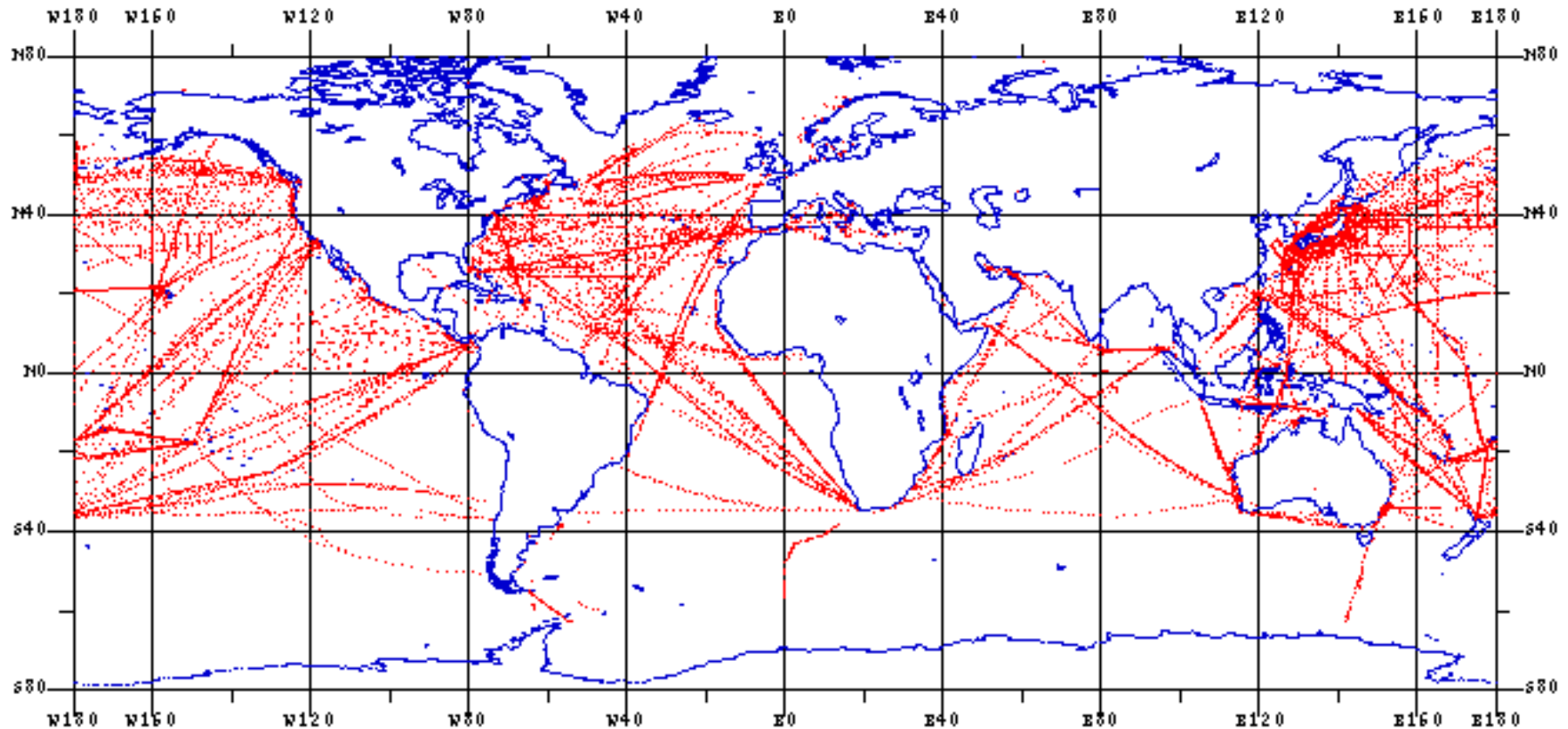
... therefore, we need to acquire *in situ* measurements



In Situ Ocean Observing: Vertical Profiles Of Temperatures (0 – 700 M)

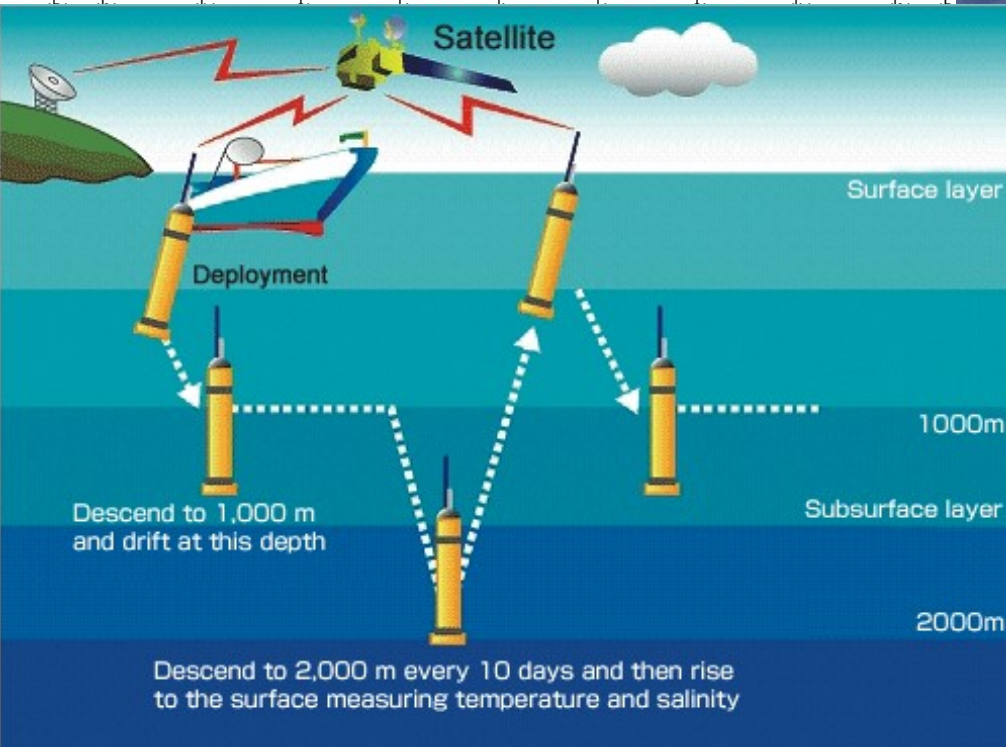
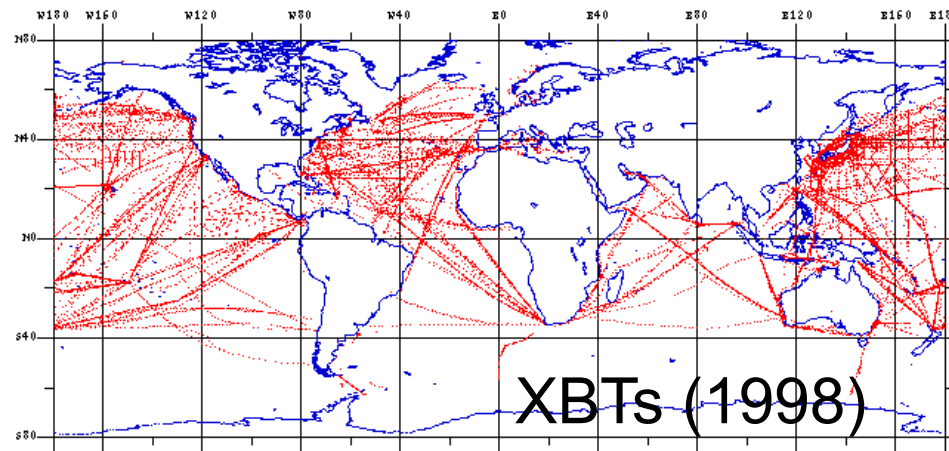
Expandable Bathymograph
Temperature – XBTs (1998)

Real Time and Delayed XBTs collected in 1998

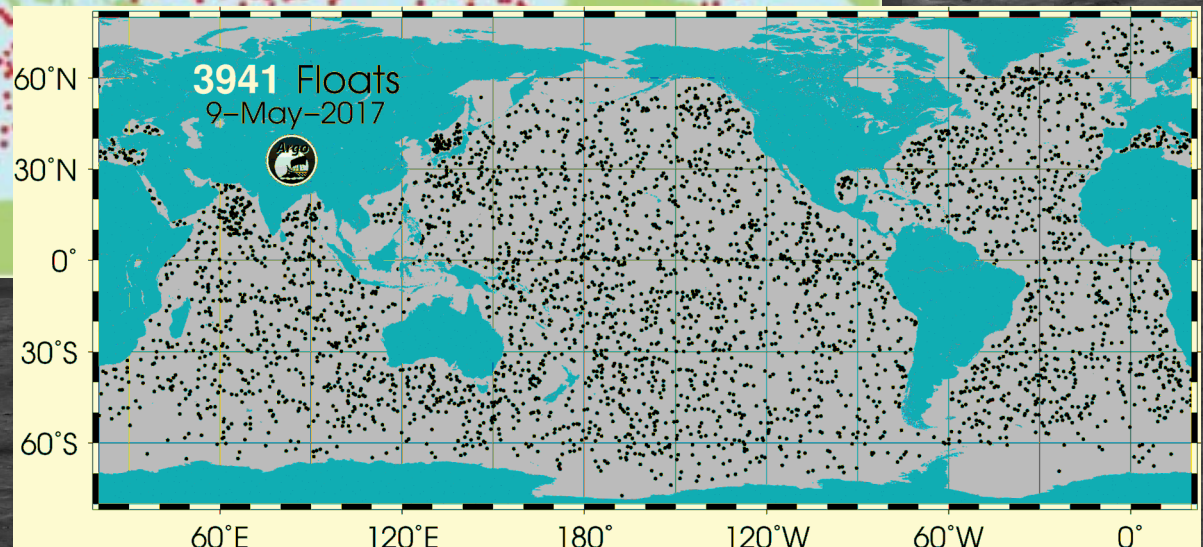
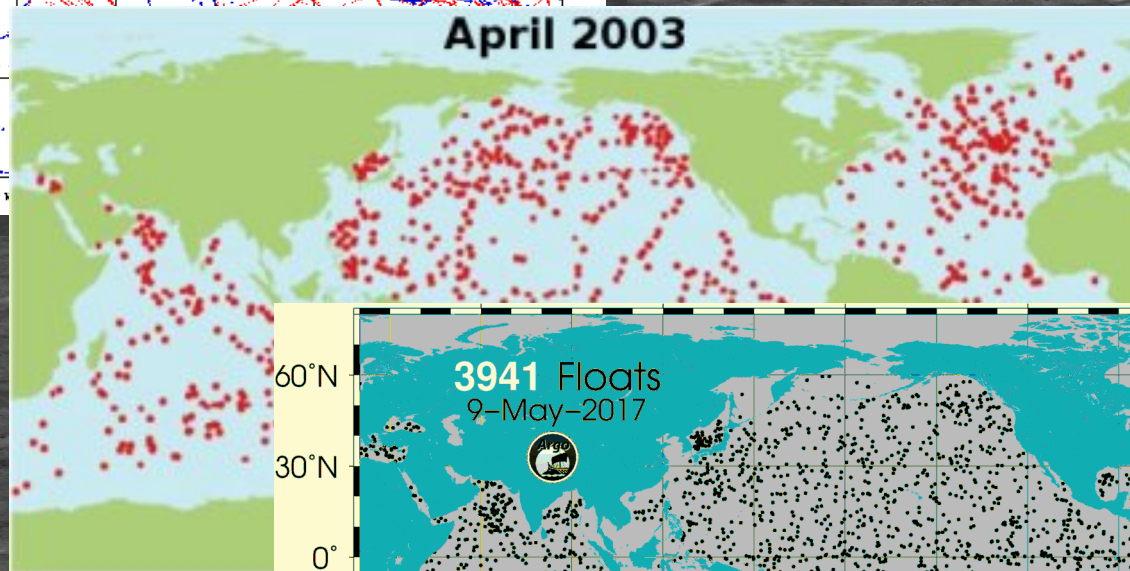
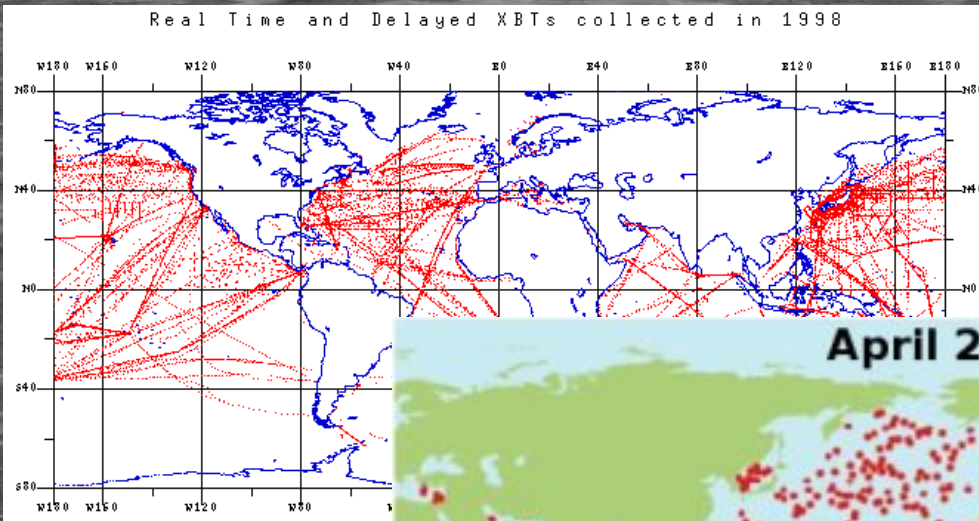


Ocean observing

Real Time and Delayed XBTs collected in 1998



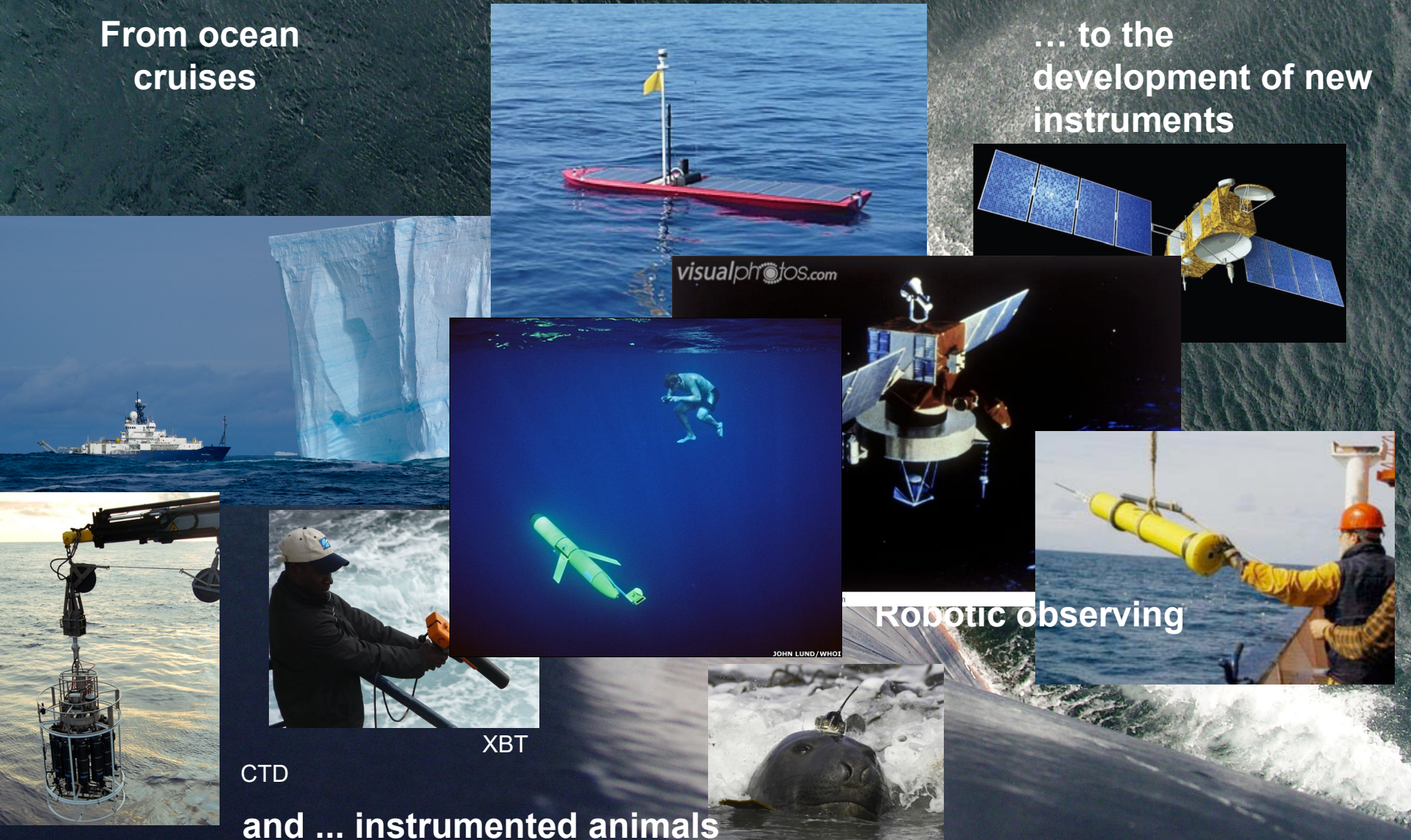
Ocean observing evolution: Argo floats



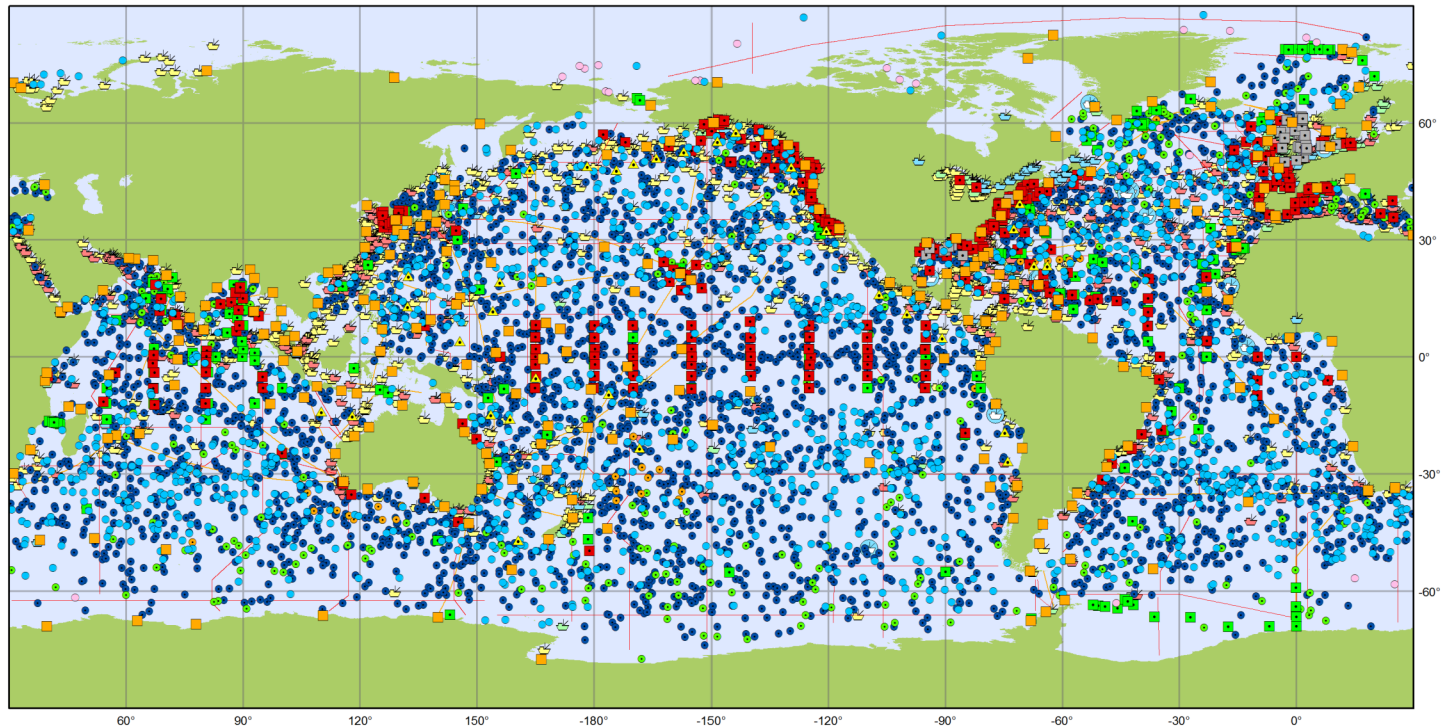
Ocean observing evolution: all together

From ocean
cruises

... to the
development of new
instruments



Ocean observing evolution: all together



Main in-situ Elements of the Global Ocean Observing System

March 2017

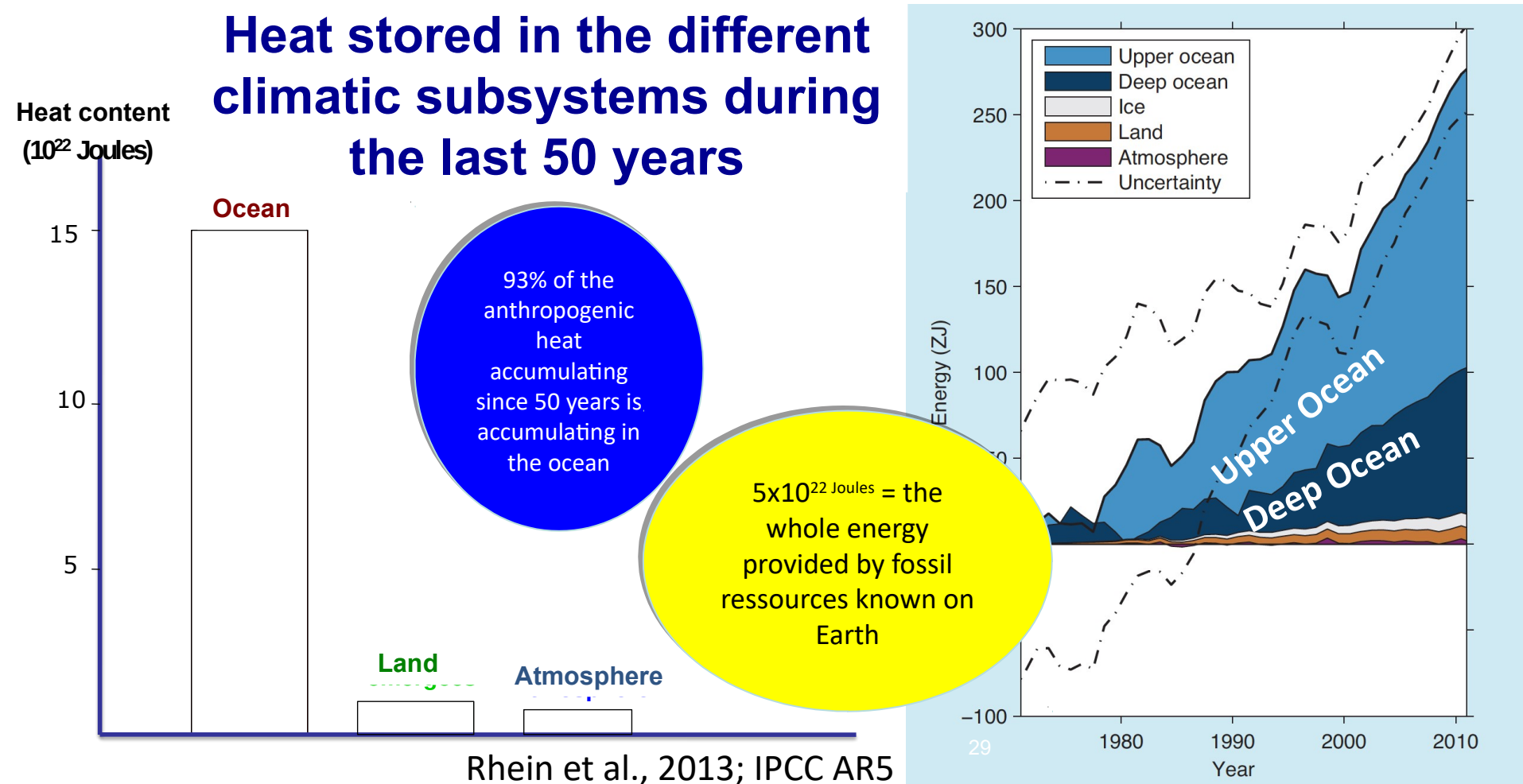
| Argo | DBCP | OceanSITES | SOT |
|------------------|---------------------------|---------------------|---------------------------|
| • Argo (3937) | • Surface Drifters (1407) | ■ Platforms (332) | • VOSclim-Automated (102) |
| • Deep-Argo (32) | ■ Fixed Platforms (103) | GO-SHIP | • VOSclim-Manned (371) |
| • BGC-Argo (282) | • Ice Buoys (22) | — GO-SHIP (61) | • VOS-Automated (149) |
| | ■ Moored Buoys (394) | GLOSS | • VOS-Manned (1188) |
| | ▲ Tsunameter (34) | ■ Tide Gauges (252) | |
| | | | • ASAP Radiosondes (20) |
| | | | — SOOP XBTs (37) |



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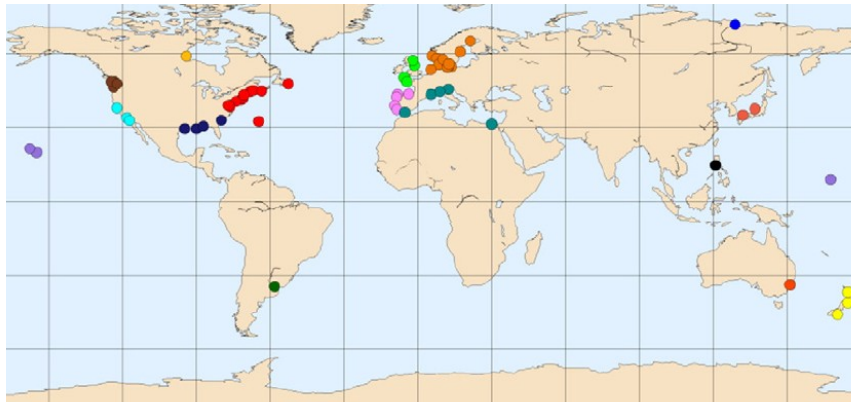
The Ocean : The anthropogenic heat repository

Heat stored in the different climatic subsystems during the last 50 years

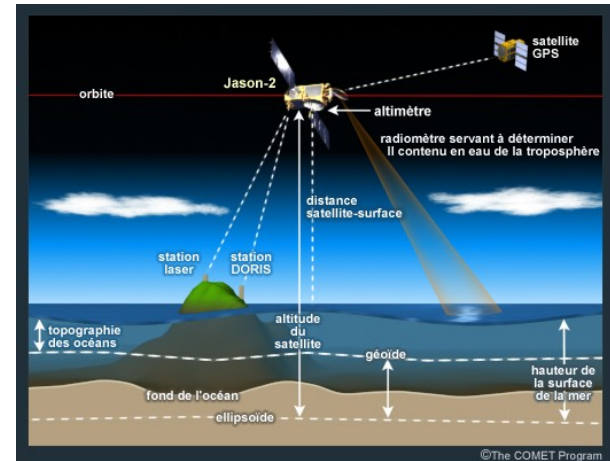


Sea level rise

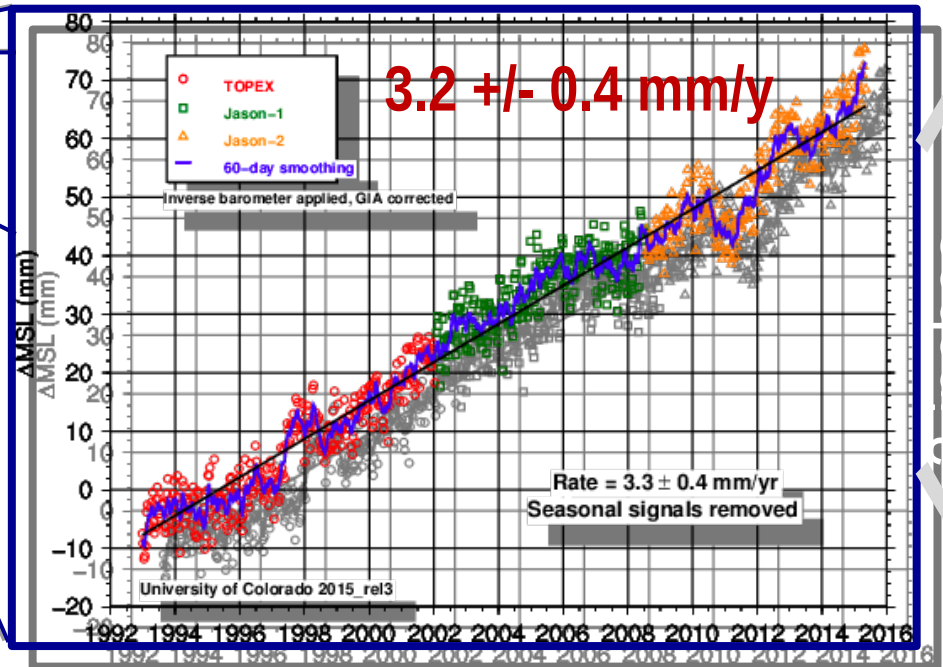
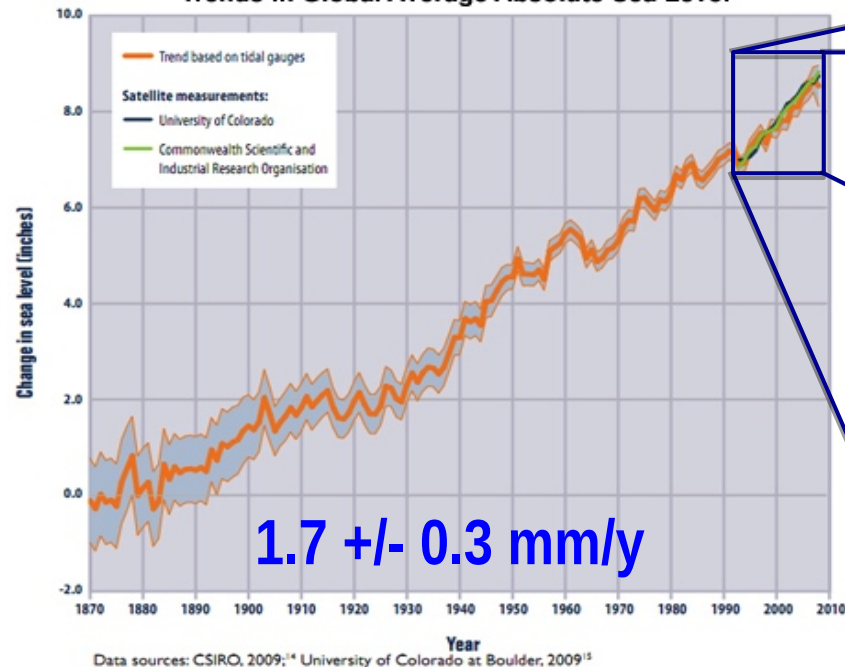
20th century: tide gauges



Last 20 years: satellite altimetry



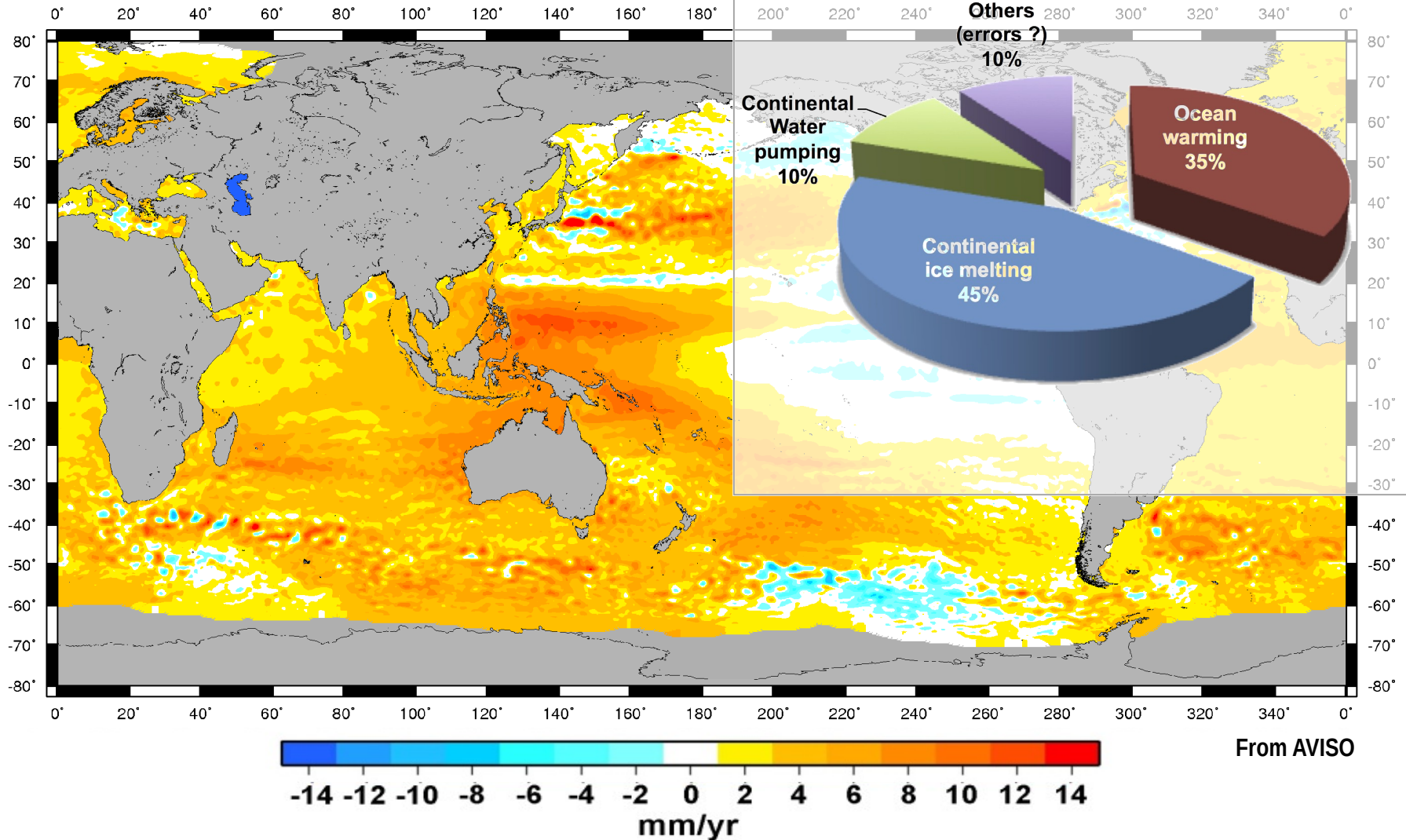
Trends in Global Average Absolute Sea Level

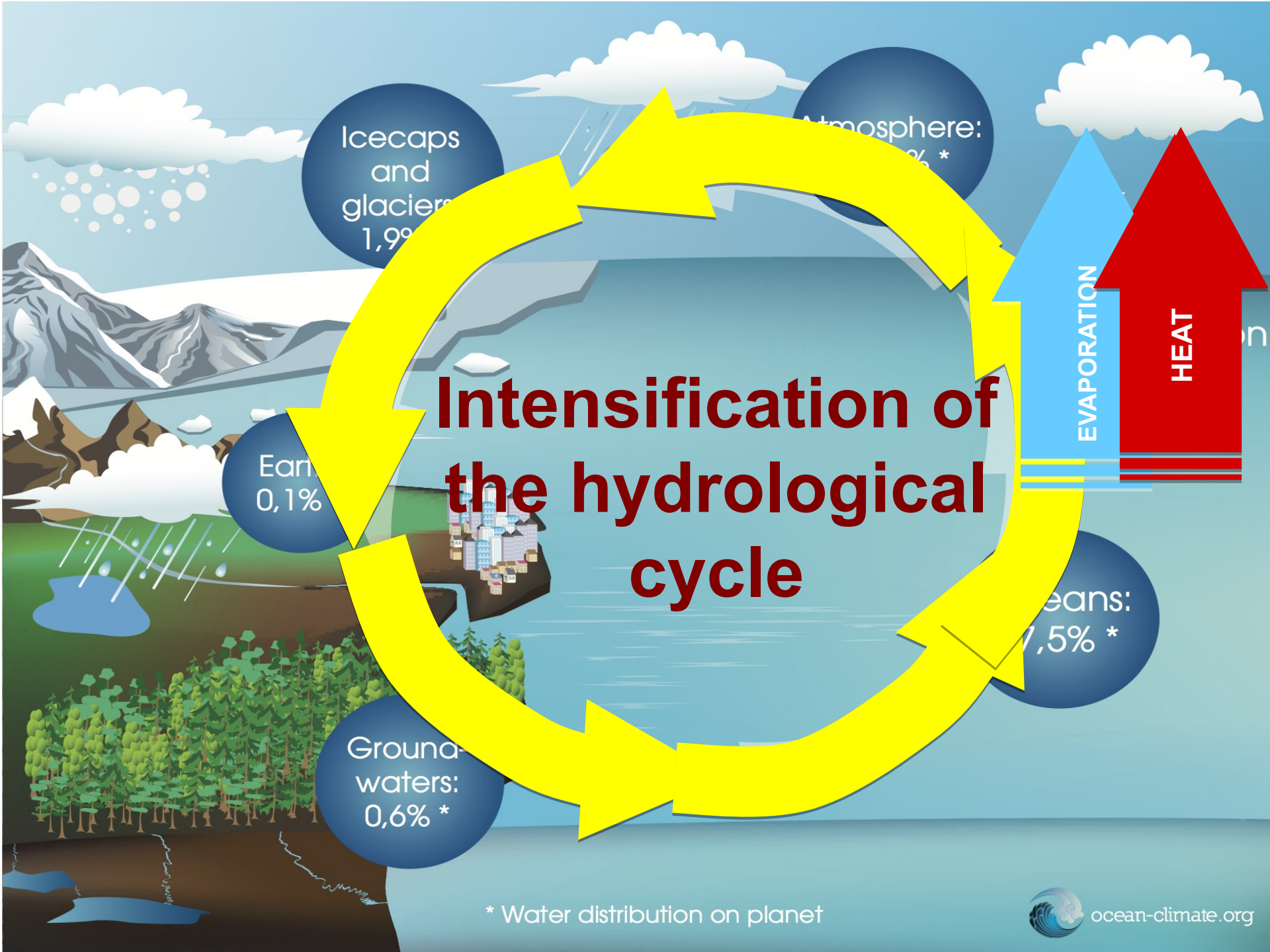


Sea level rise

Sea level does not rise uniformly!

Sea level trend from altimetry over 1993-2013



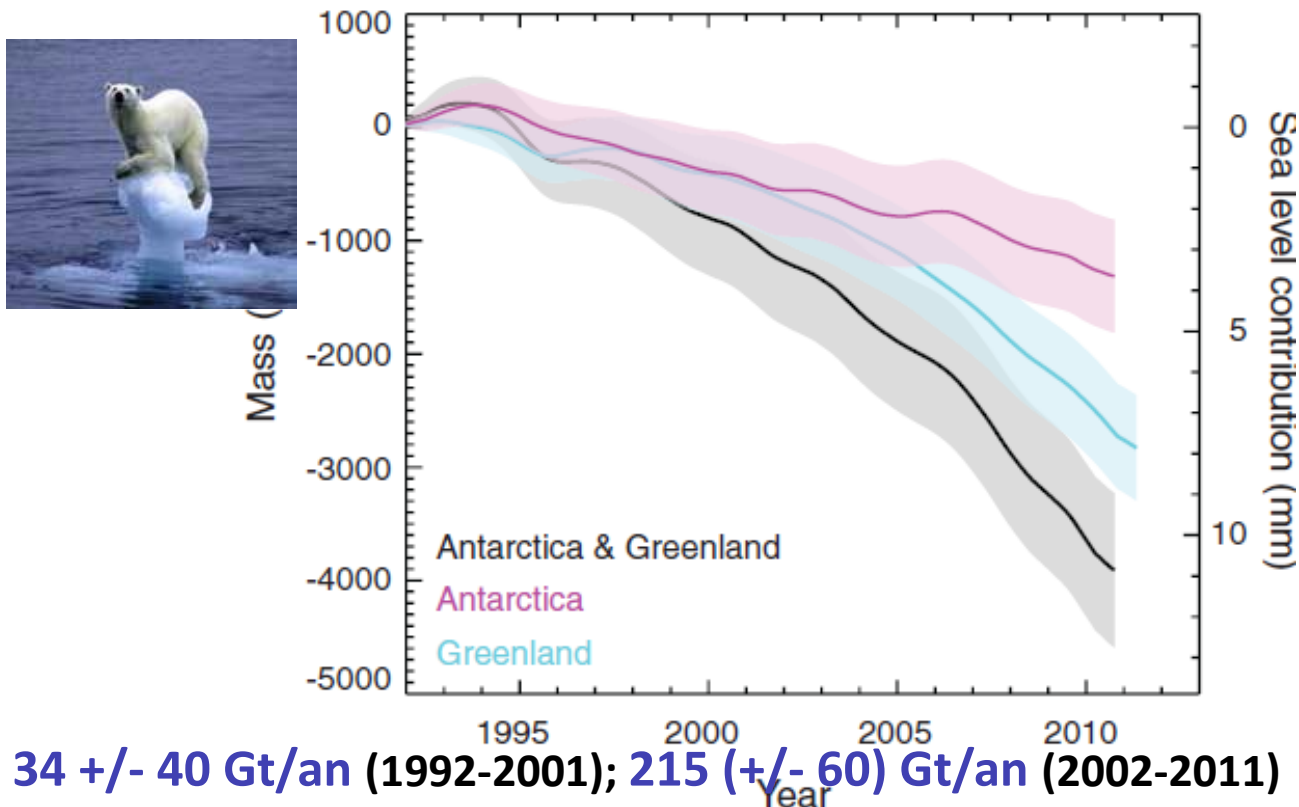


* Water distribution on planet

Mass variation of polar ice caps

Observed from space since 1990 (in billions of tons)

→ acceleration since 15 years

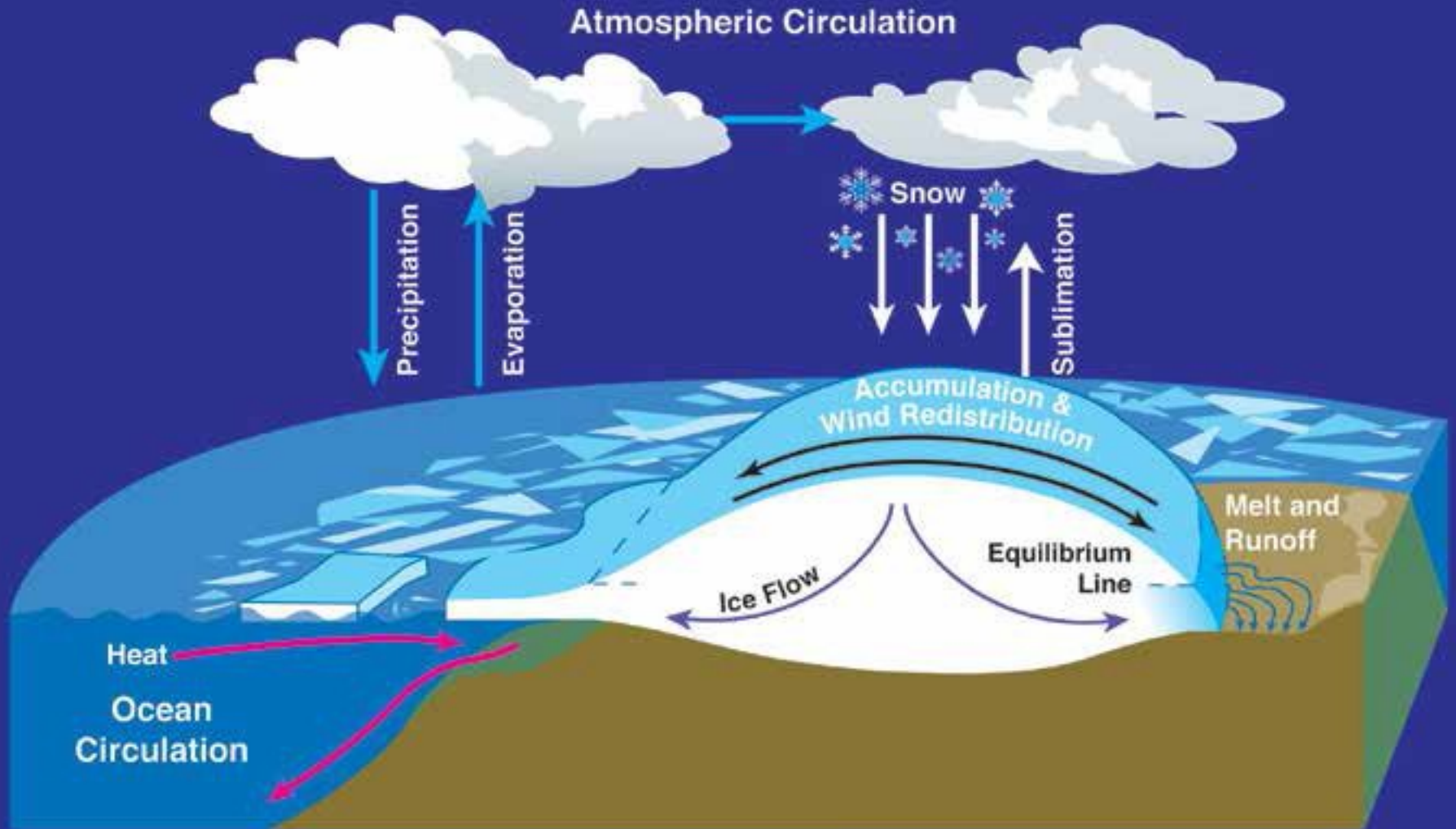


Greenland: 34 +/- 40 Gt/an (1992-2001); 215 (+/- 60) Gt/an (2002-2011)

Antarctica: 30 +/- 67 Gt/an (1992-2001); 147 (+/- 74) Gt/an (2002-2011)

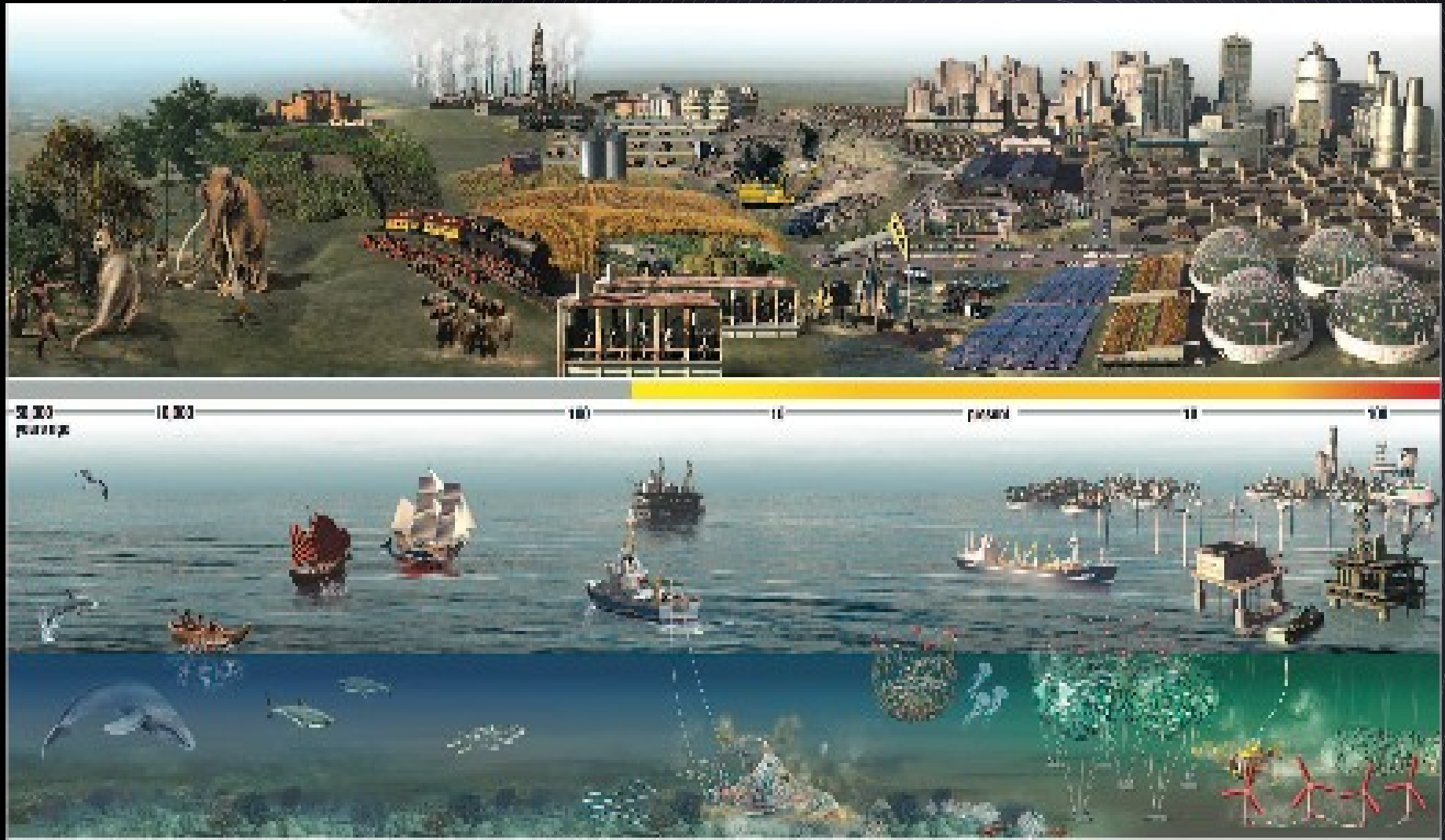


Polar Ice Caps Mass Budget =
Surface Mass Budget (accumulation/ablation)
+ coastal glacier flow into the ocean (dynamical effect)

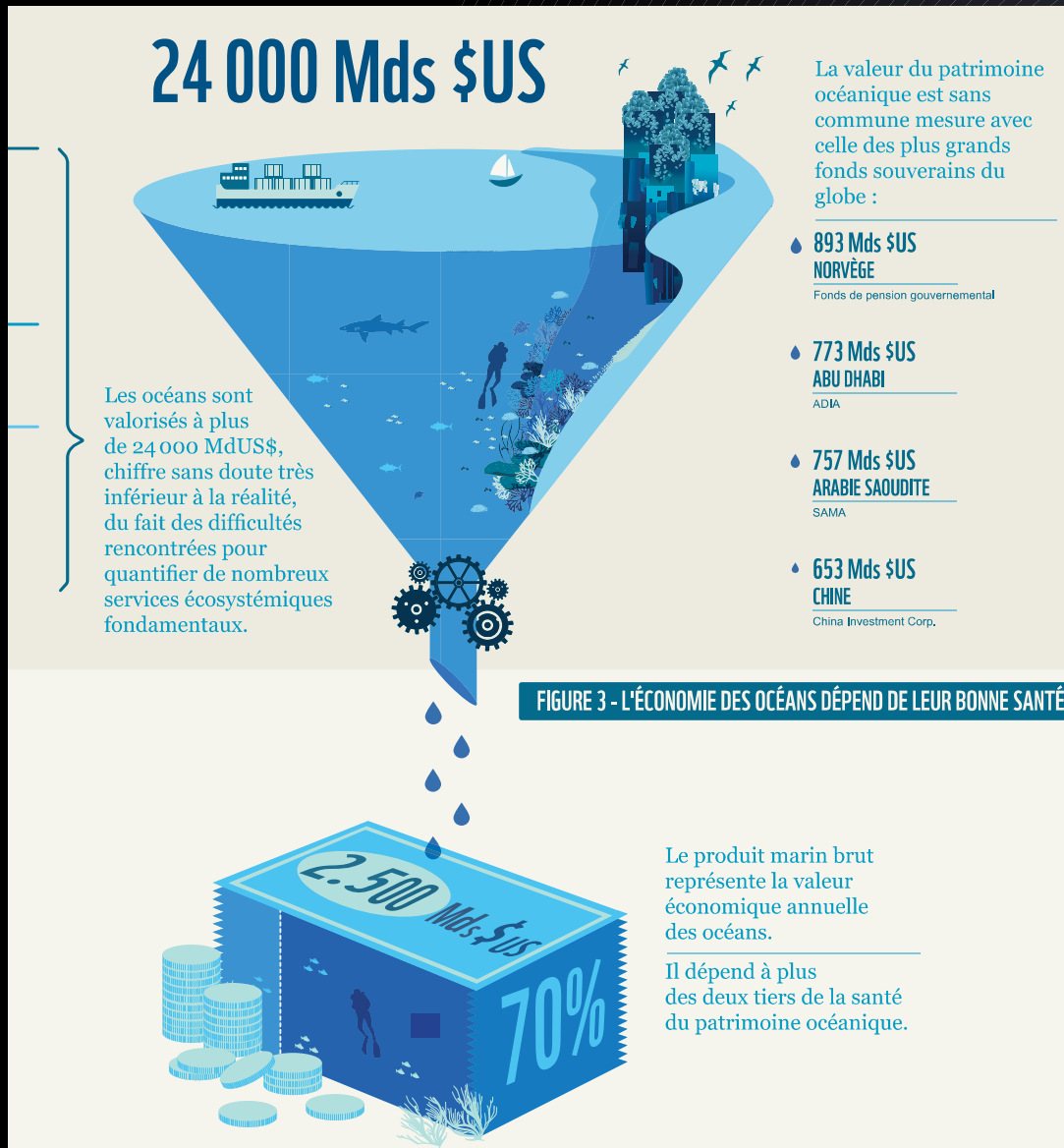


THE ENVIRONMENTAL LIMITS OF OUR PLANET

Plus many other kinds of pressures that increase with time



The ECONOMY of the OCEAN depends on its HEALTH



The oceanic regions represent:

- More than 90% of the Earth living space
- They host 25% of the most evolved species
- They provide 11% of the animal proteins consumed by humans

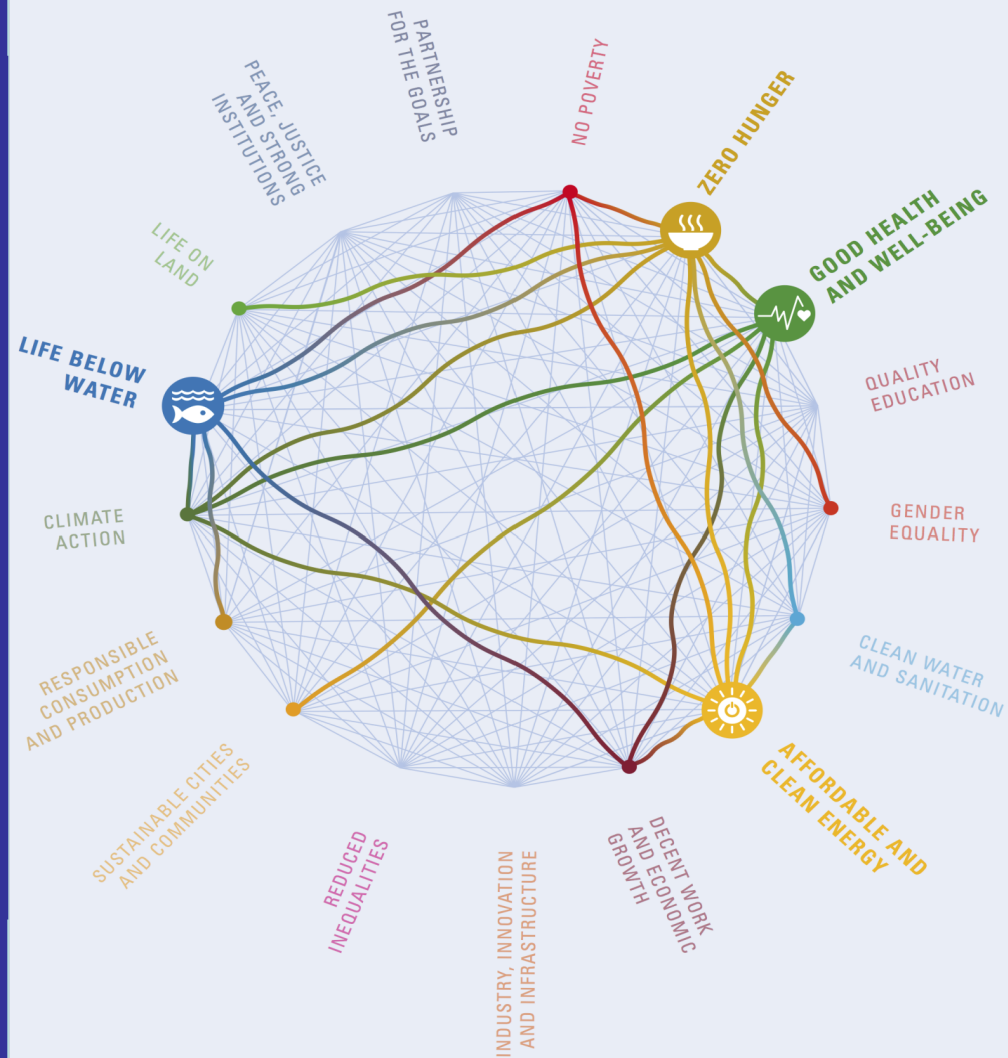
The Sustainable Development Goals (SDGs)

The UN 2030 Agenda for Sustainable Development

UN 2030 Agenda works now in frameworking SDGs and their interactions.

Last week the UN Ocean Conference took place at in New York (USA) with 8000 participants (politics, scientists, ONGs,)

as well as global civil society



Thank you for listening

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Global warming means more heat: Where does the heat go?

> 90%

1. Warms land and atmosphere
2. Heat storage in the ocean (raises sea level)
3. Melts land ice (raises sea level)
4. Melts sea ice and warms melted water
5. Evaporates moisture \Rightarrow rain storms, cloud
 \Rightarrow possibly reflection to space