National Aeronautics and Space Administration

NASA and Exploring (Oceans)

Dr. Paula Bontempi
Ocean Biology and Biogeochemistry Program
NASA Headquarters

Exploration and NASA

Science on the Living Earth or Another Planet

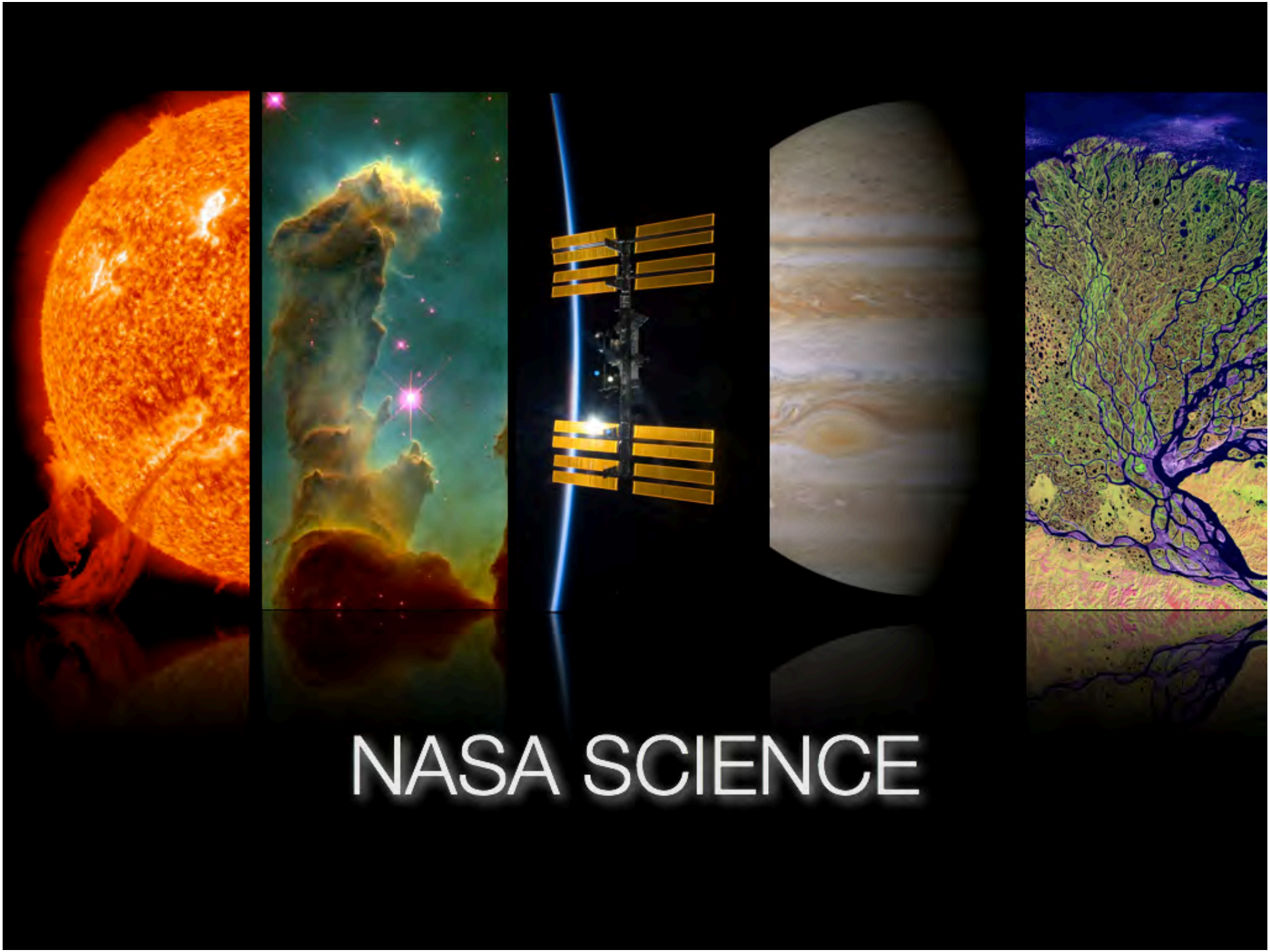
EXPLORATION

↓

DISCOVERY

↓

RESEARCH

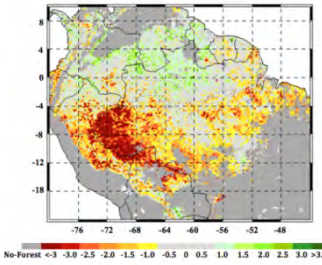

NASA SCIENCE

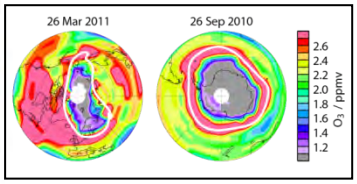
National Aeronautics and Space Administration

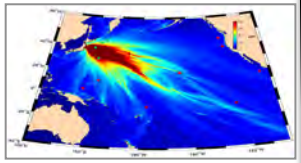
Earth Science

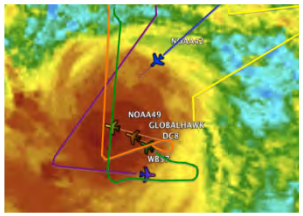
NASA's Earth Science Division

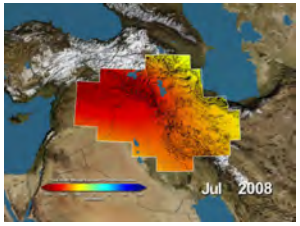
Research

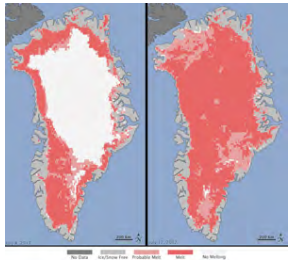




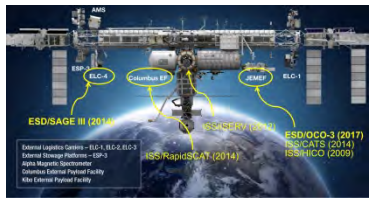




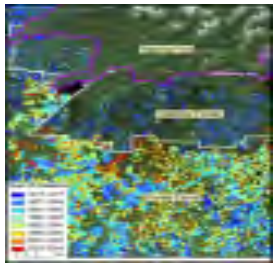


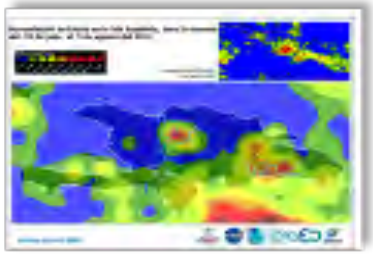


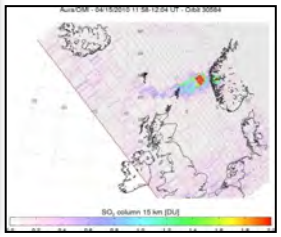
Flight

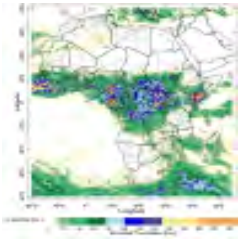


Applied Sciences

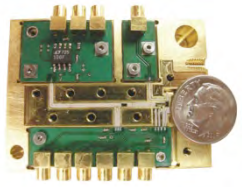


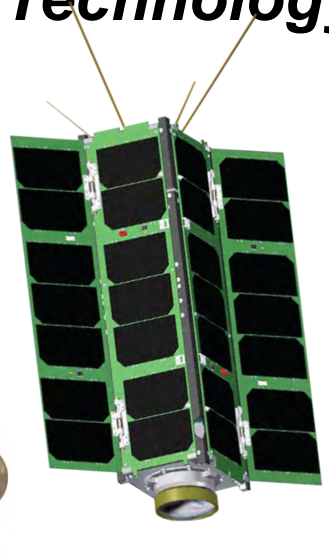


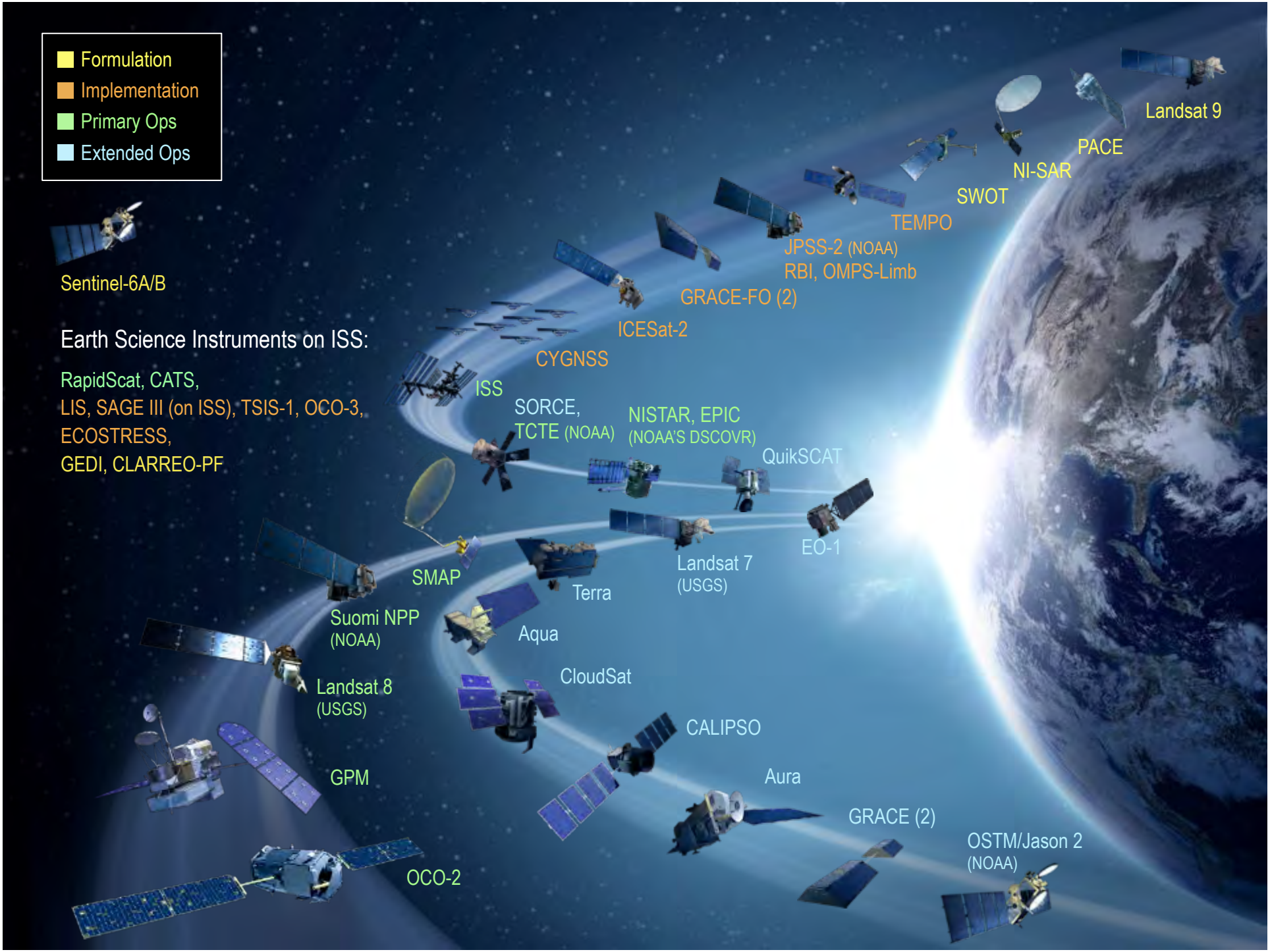


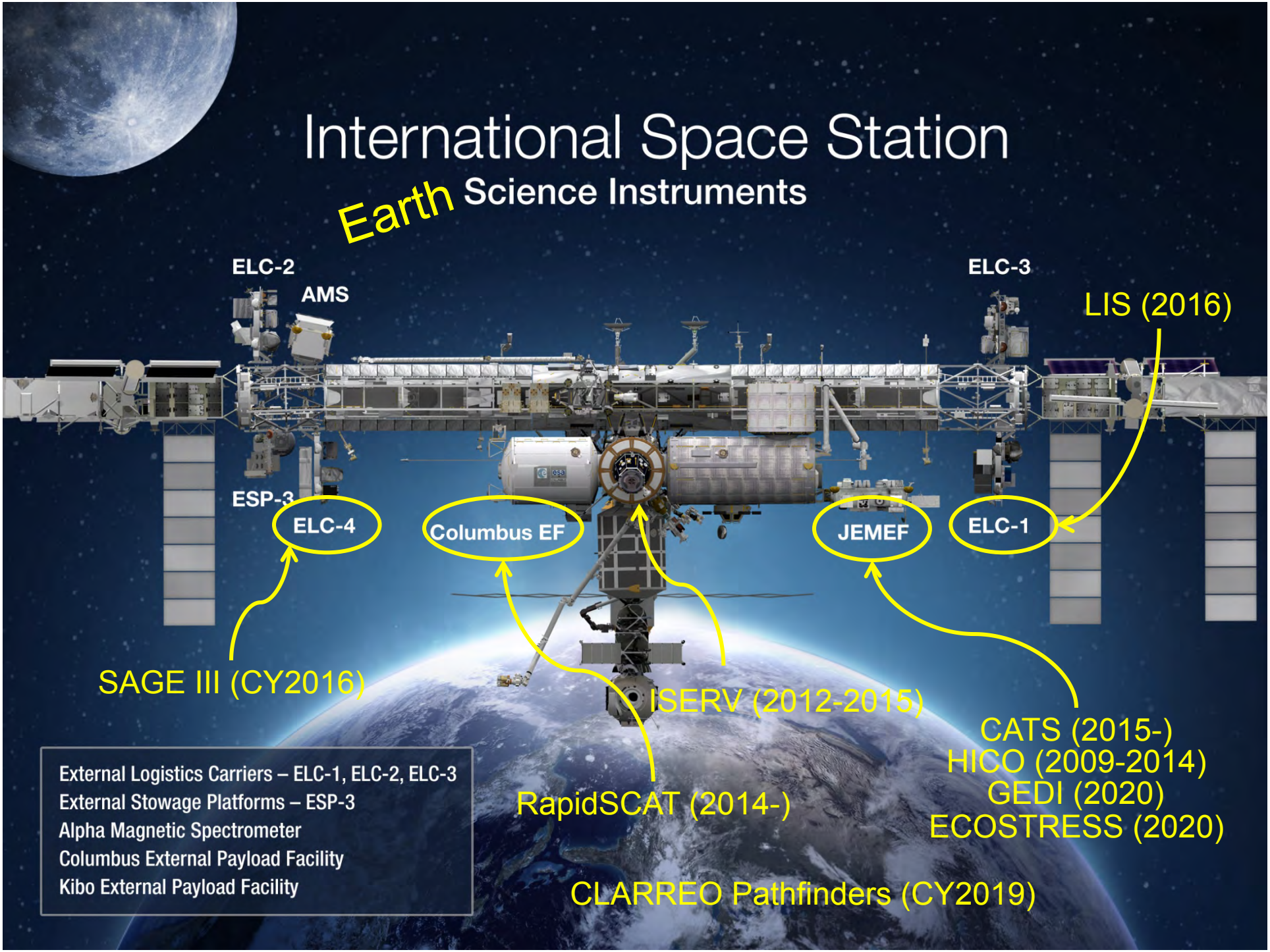


Technology






Formulation
Implementation
Primary Ops
Extended Ops
Sentinel-6A/B
Earth Science Instruments on ISS:
RapidScat, CATS,
LIS, SAGE III (on ISS), TSIS-1, OCO-3,
ECOSTRESS,
GEDI, CLARREO-PF
Landsat 9
PACE
NI-SAR
SWOT
TEMPO
JPSS-2 (NOAA)
RBI, OMPS-Limb
GRACE-FO (2)
ICESat-2
CYGNSS
ISS
SORCE,
TCTE (NOAA)
NISTAR, EPIC
(NOAA'S DSCOVR)
QuikSCAT
EO-1
Landsat 7
(USGS)
SMAP
Terra
Suomi NPP
(NOAA)
Aqua
Landsat 8
(USGS)
CloudSat
CALIPSO
GPM
Aura
GRACE (2)
OSTM/Jason 2
(NOAA)
OCO-2


International Space Station
Earth Science Instruments
ELC-2
AMS
ELC-3
LIS (2016)
ESP-3
ELC-4
Columbus EF
JEMEF
ELC-1
SAGE III (CY2016)
ISERV (2012-2015)
CATS (2015-)
HICO (2009-2014)
GEDI (2020)
ECOSTRESS (2020)
RapidSCAT (2014-)
CLARREO Pathfinders (CY2019)
External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

Earth Science

CYGNSS
10/16 – 5/17

TEMPO
FY17/21

ICESat-2
FY18

GRACE-FO
FY18

CLARREO PF FY19
ECOSTRESS FY19
GEDI FY18/20
TSIS-1 FY17
TSIS-2 FY20/22
OCO-3 FY17/18

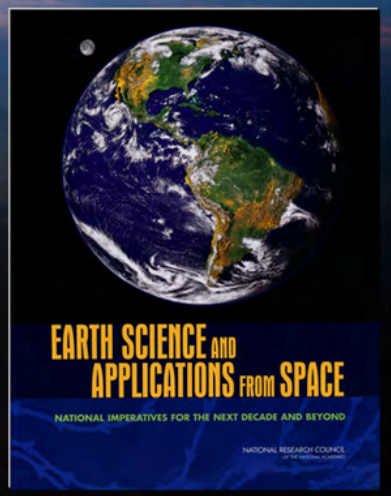
OMPS-L FY18/21
RBI FY19/21

SWOT FY20

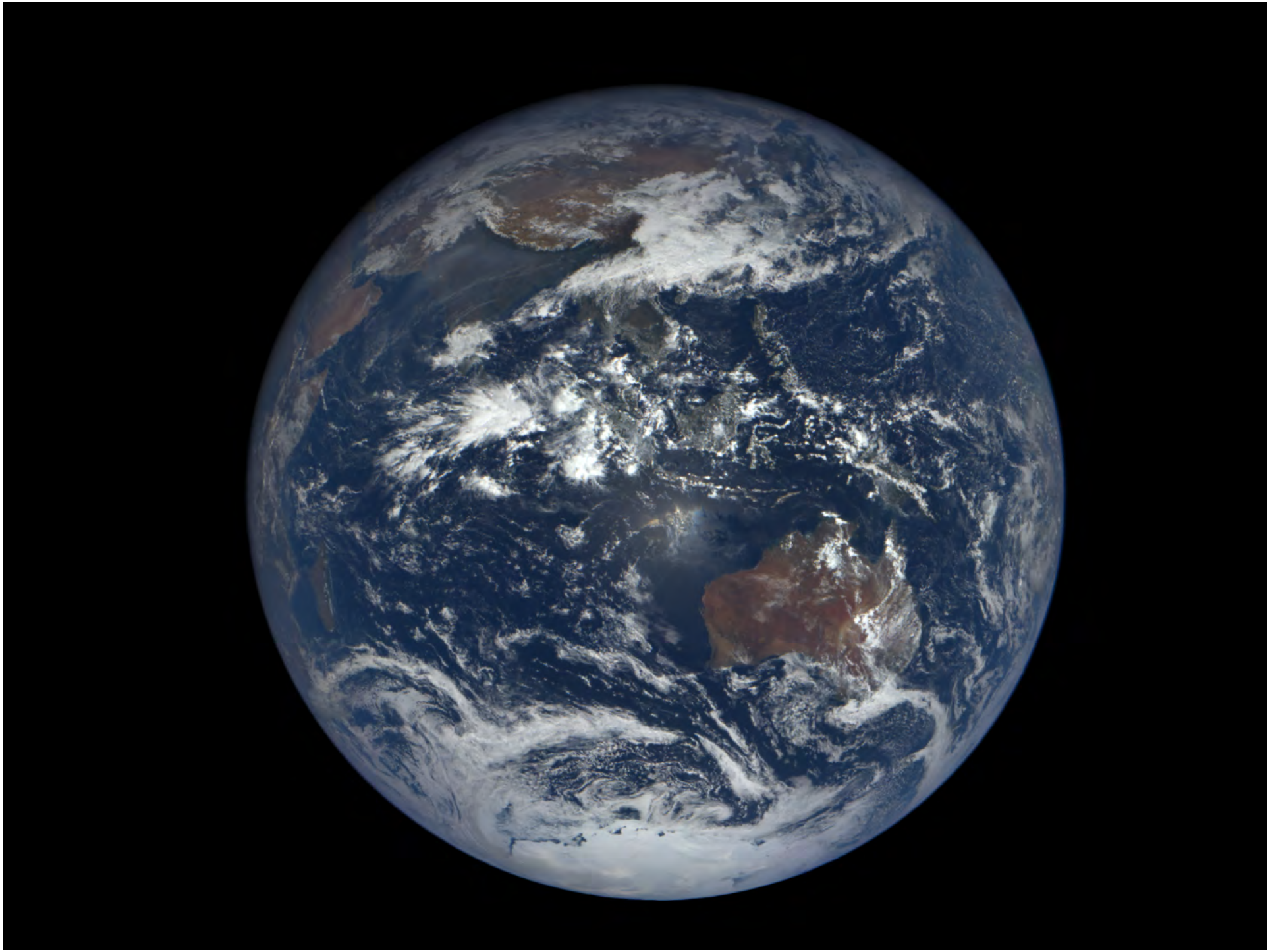
NI-SAR
FY22

PACE
FY22

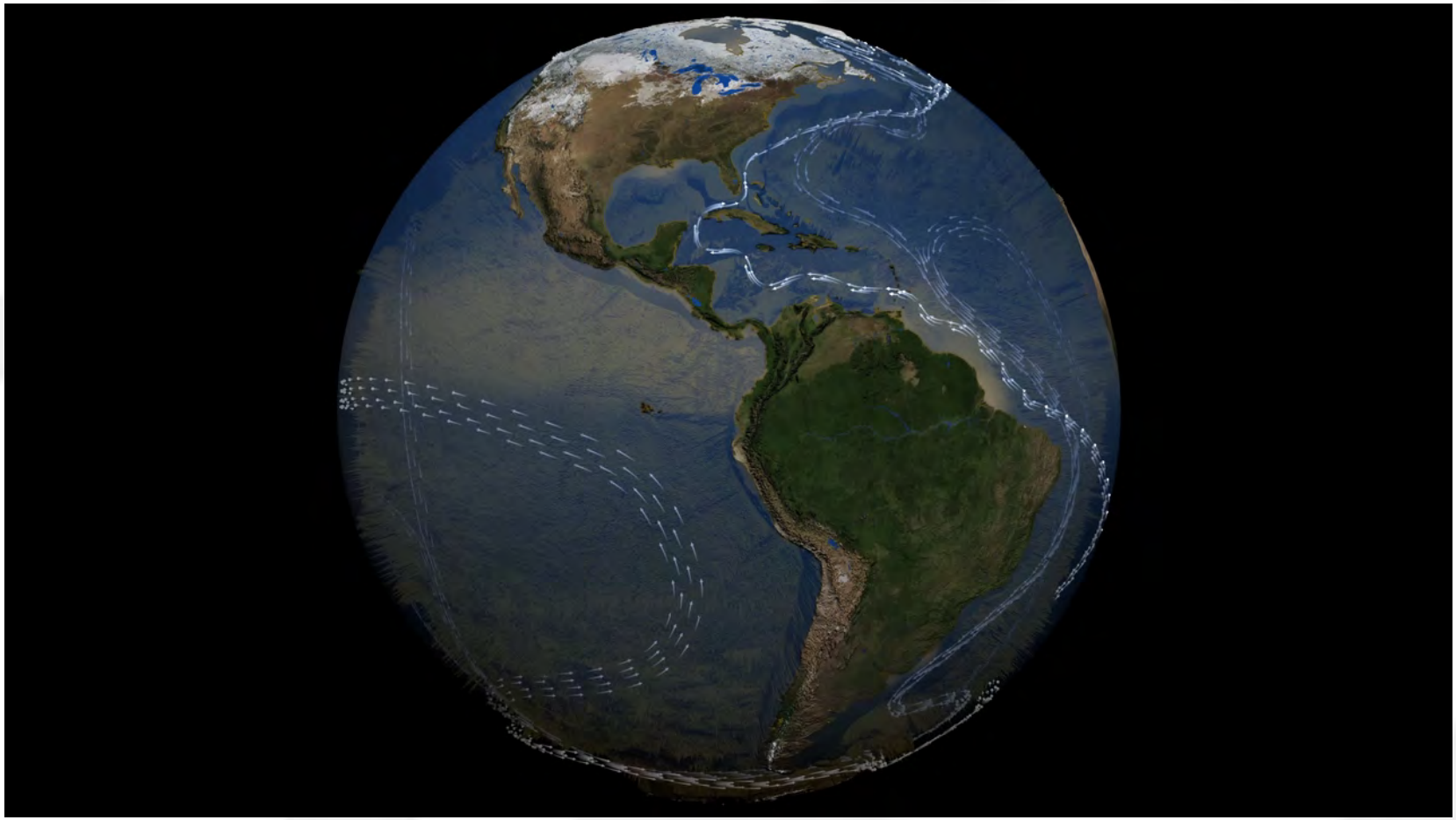
Sentinal-6A/B
FY20/24



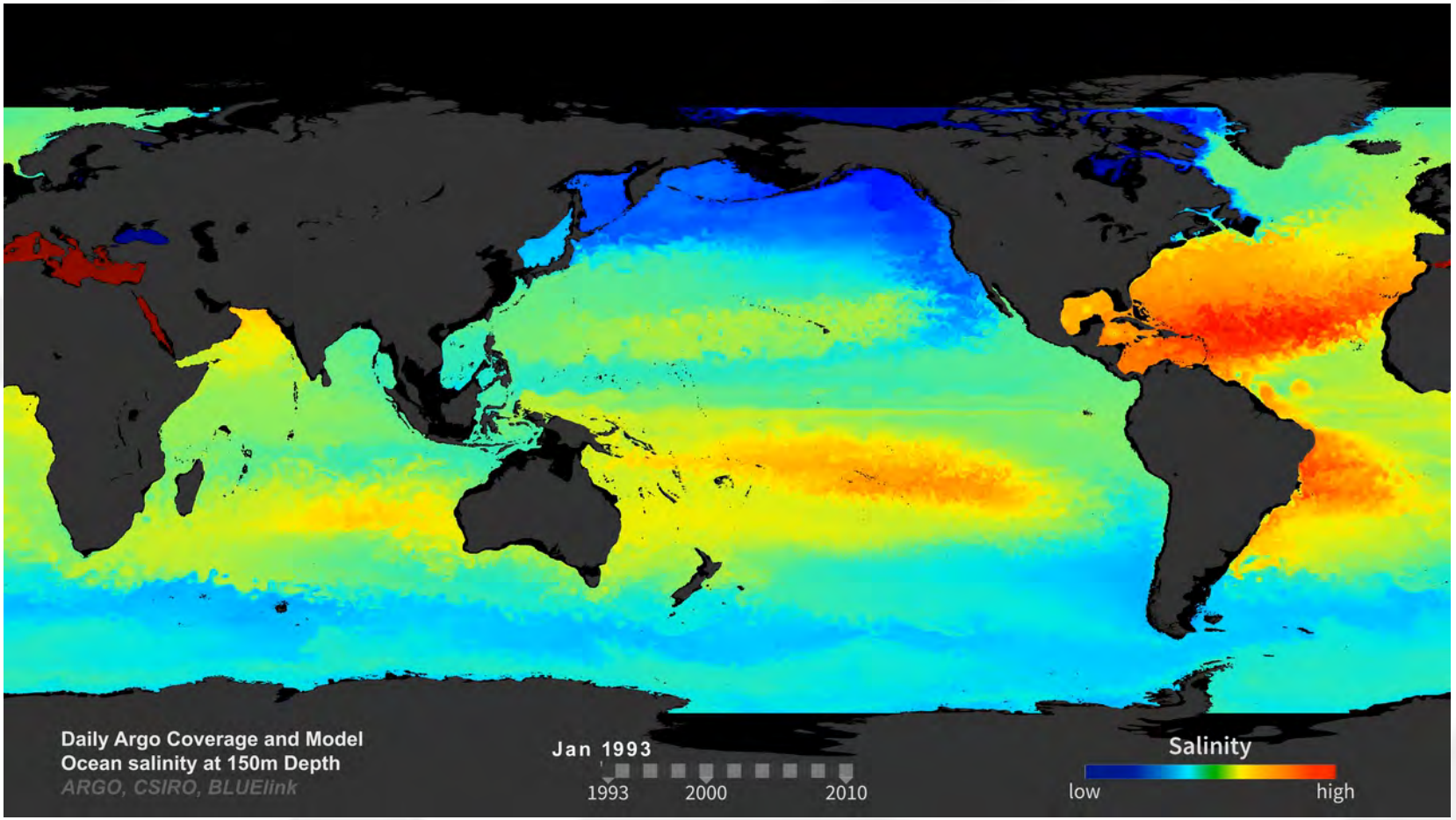
2007
Decadal Survey



Earth's Circulatory System



Ocean Salinity and Daily Argo Coverage

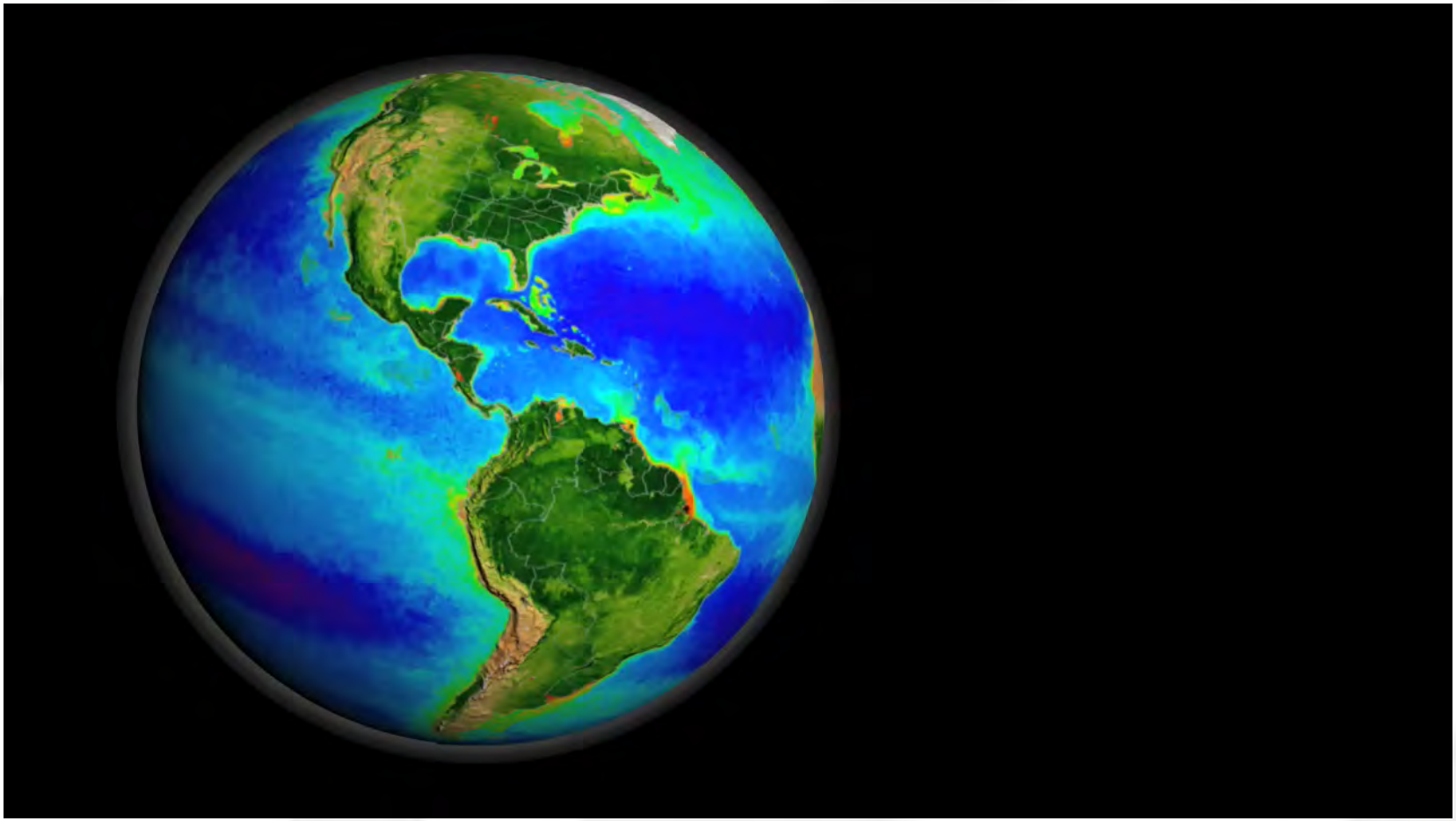


SUSTAINABLE FISHERIES

Fisheries depend on a healthy, balanced ocean. Earth-observations from NASA and its partners allow scientists to monitor and predict change in the ocean that influence ocean productivity (e.g., El Niño and La Niña) as well as the overall health of our planet. From the tiniest of organisms

(e.g., phytoplankton) to global ocean temperatures, NASA keeps many “eyes” on our living planet.

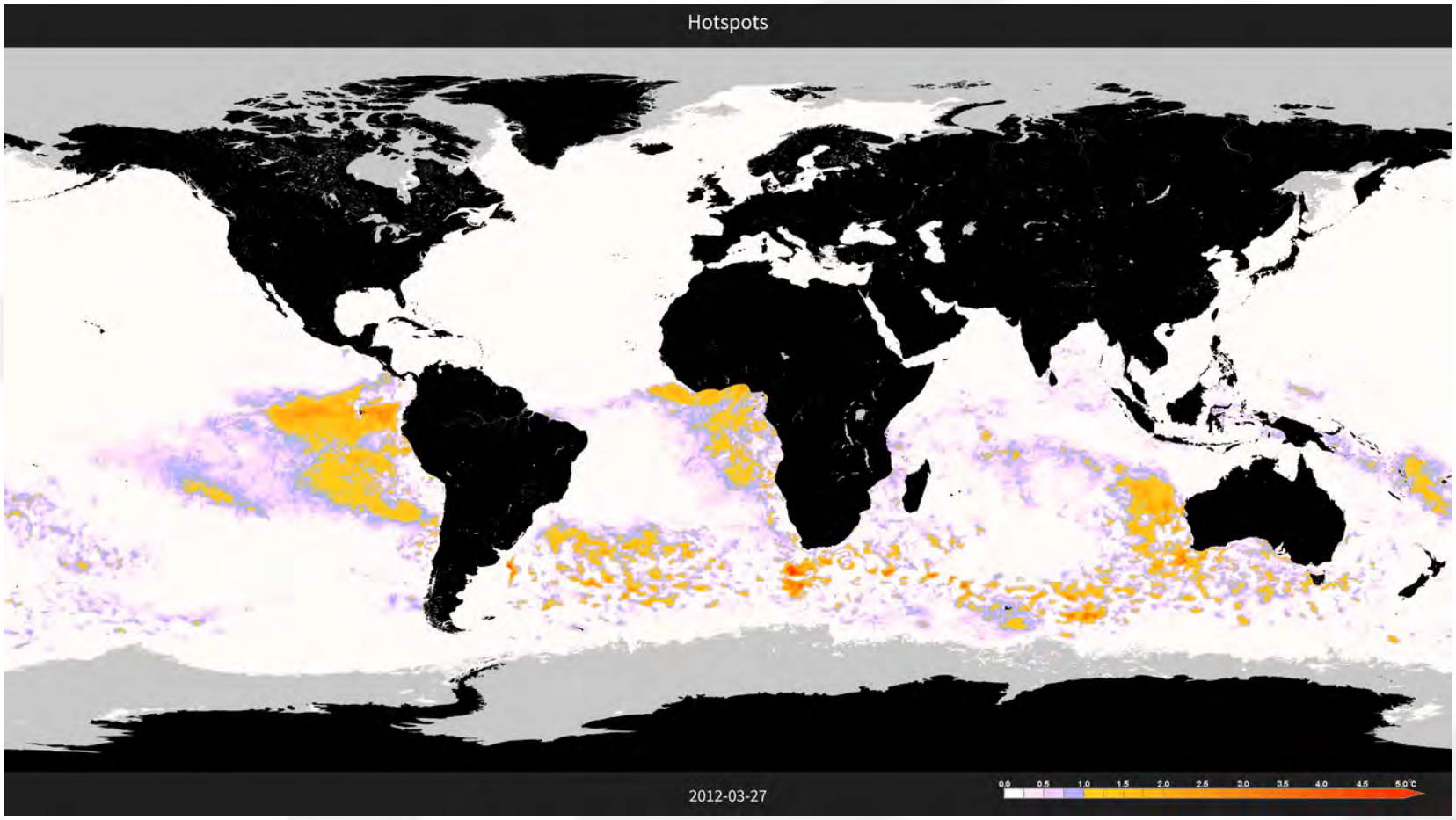
SeaWiFS Biosphere Data Over the North Atlantic



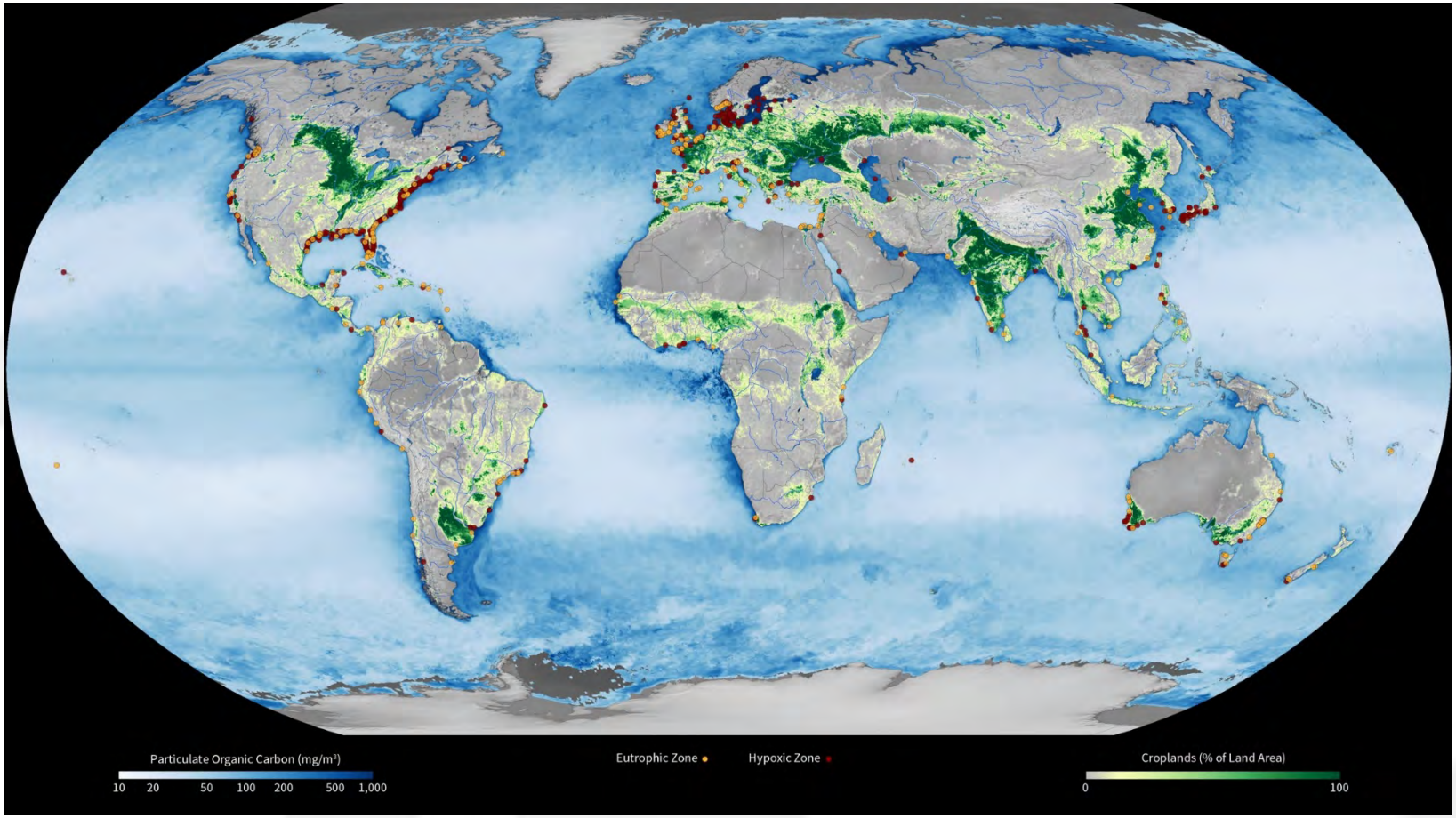
MARINE PROTECTED AREAS

A marine protected area is an area of sea especially dedicated to the protection and maintenance of biodiversity, and of natural and associated cultural resources, and managed through legal or other effective means. Marine parks, nature reserves and other marine protected areas can include: reefs, seagrass beds, shipwrecks, archaeological sites, tidal lagoons, mudflats, saltmarshes, mangroves, rock platforms, underwater areas on the coast and seabed in deep water. NASA satellite data can be used to understand and model ocean ecosystem health.

Monitoring Coral Reefs
Hot Spots

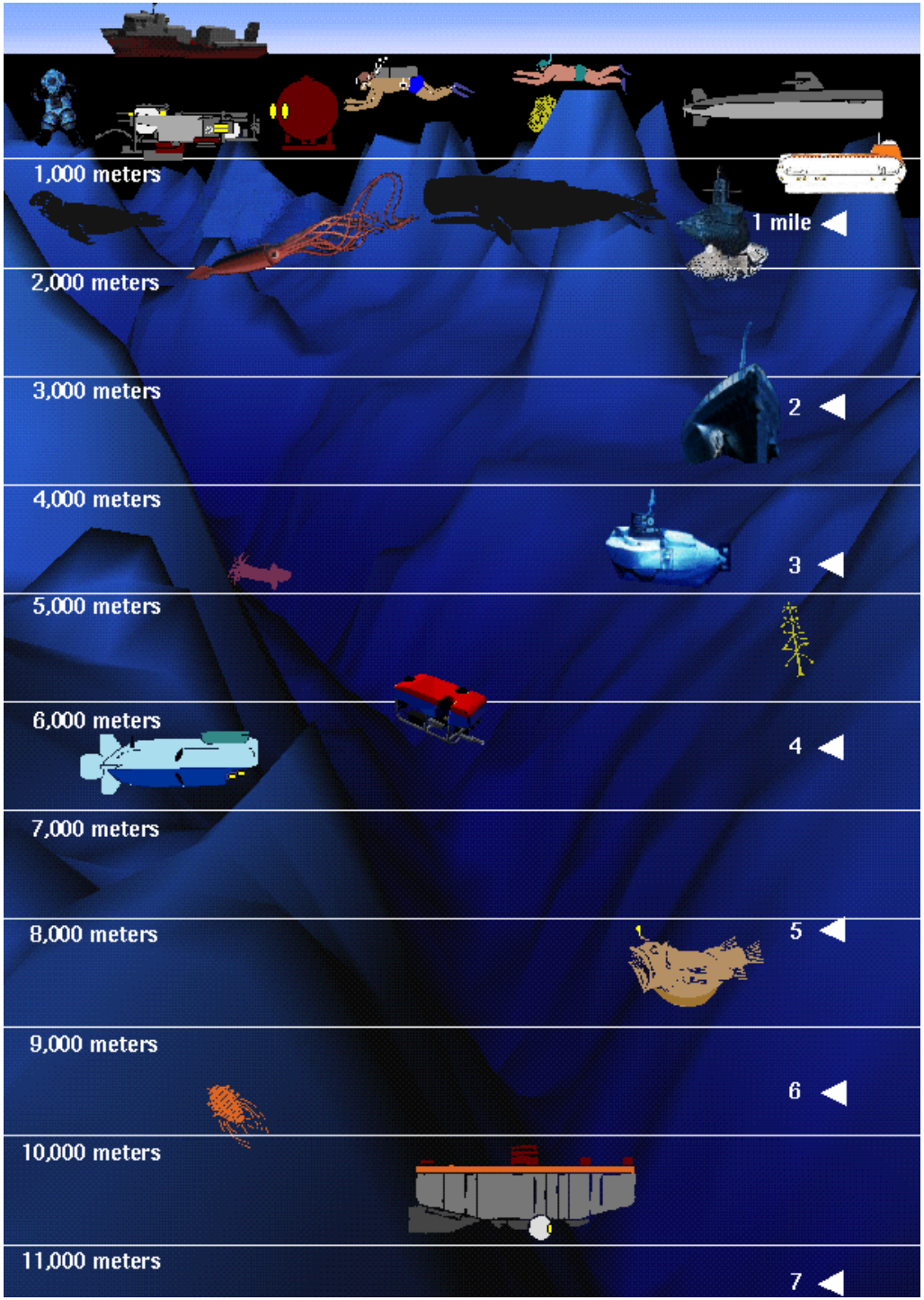


Coastal Dead Zones



Phytoplankton in the World's Oceans

Pre-Aerosol, Cloud, ocean Ecosystem (PACE) Mission

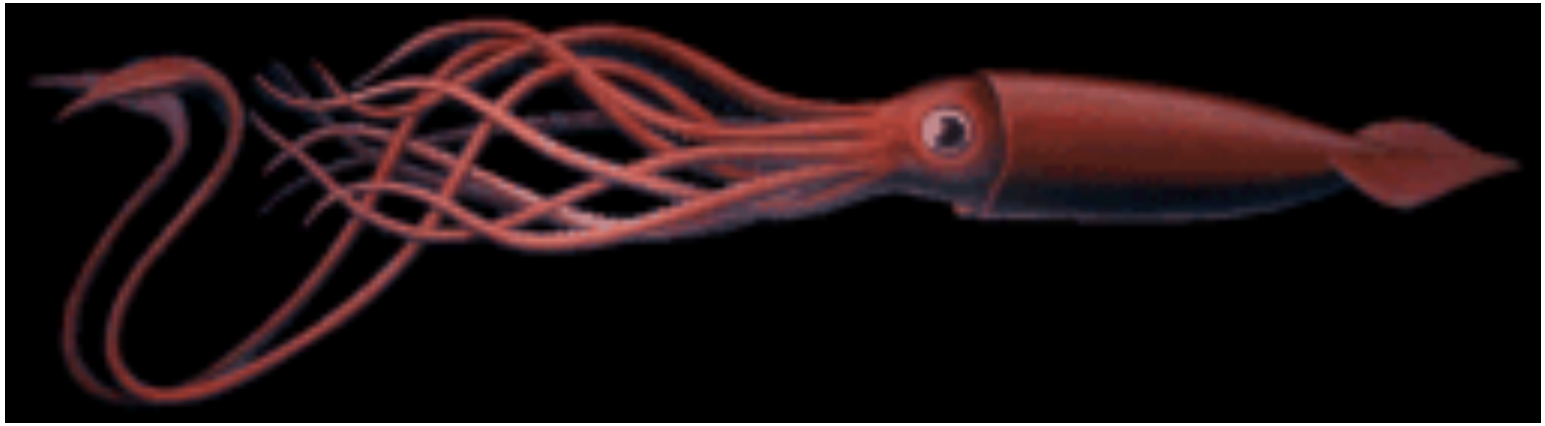


The oceans are different.

Back in 1960 when people descended to the deepest part of the ocean for the very first (and last) time, they turned on the outside lights and there, in front of the viewport at a depth of over seven miles (35,802 ft (10,912 m)), was a strange looking little fish looking back at them.

This "flatfish at the very nadir of the earth" was living at a place where the water pressure was more than 8 tons per square inch, or the equivalent of one person trying to support 50 jumbo jets.

You could cut Mount Everest off at sea level and put in on the ocean floor at the bottom of the Marianas Trench, where that little fish was swimming, and there would still be over a mile of water over the top of it.



While we may think that the only mysteries left to discover await us on distant planets, there are still plenty of wondrous creatures to study and incredible places waiting to be explored right here in our own backyard....especially in the ocean.

The blue whale, *Balaenoptera musculus*, is the largest known animal ever to have lived on sea or land and can reach more than 110 feet and weigh nearly 200 tons - more than the weight of 50 adult elephants?

One recent study of a deep-sea community revealed 898 species from more than 100 families and a dozen phyla in an area about half the size of a tennis court. More than half of these were new to science.

Consider the fact that there exists a creature in the oceans that we know to be the world's largest invertebrate, that can grow to at least 60 feet in length, has eyes as large as volleyballs but which has never been seen alive in its' natural habitat. Although the Giant Squid may be the stuff of legend, it is very real indeed and is just one of the as yet unsolved mysteries of the ocean.

NASA Oceanography Program Overview

Drs. Eric Lindstrom (Physical Oceanography) & Paula Bontempi (Ocean Biology and Biogeochemistry)

NASA Headquarters, Washington, DC

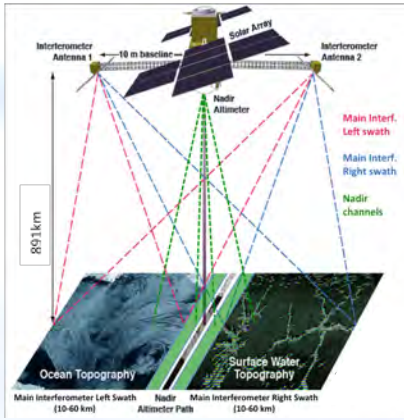
Where does NASA Oceanography fit into the overall NASA mission?

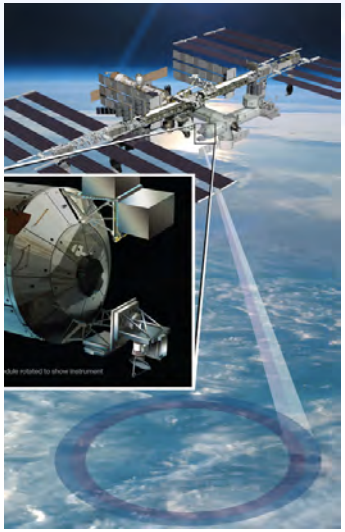
- **Earth Science Division (ESD) Strategic Goal:**
  - Advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet.
- **ESD Science Questions:**
  - How is the global Earth system changing?
  - What causes these changes in the Earth system?
  - How will the Earth system change in the future?
  - How can Earth system science provide societal benefit?

Physical Oceanography

Program Manager: Eric Lindstrom

- **Support Physical Oceanography Missions on Orbit**
  - Jason-2 (Altimetry), QuikSCAT (Winds), Aquarius (Salinity), GRACE (Gravity), RapidSCAT (Winds)
- **Support Physical Oceanography Missions in Development**
  - Surface Water and Ocean Topography (SWOT), Jason-3 (Altimetry),
- **Support Research Teams**
  - Ocean Surface Topography (OSTST), Ocean Vector Winds (OVWST), Ocean Salinity (OSST), Next Generation SST (GHRSST), Atlantic Meridional Overturning Circulation (AMOC), Sea Level Change
- **Support Climate Focus Area/Ocean Observing**
  - US CLIVAR, USGCRP, GOOS, GCOS, OOPC, GODAE OceanView, NOAA COSC, IOOC, CEOS, ….
- **Process Studies Related to NASA Physical Oceanography Missions**
  - **S**alinity **P**rocesses in the **U**pper ocean **R**egional **S**tudy: SPURS-1 (2012-2015)
  - **S**alinity **P**rocesses in the **U**pper ocean **R**egional **S**tudy: SPURS-2 (2015-2018)





Salinity Processes in the Upper ocean Regional Study (SPURS)

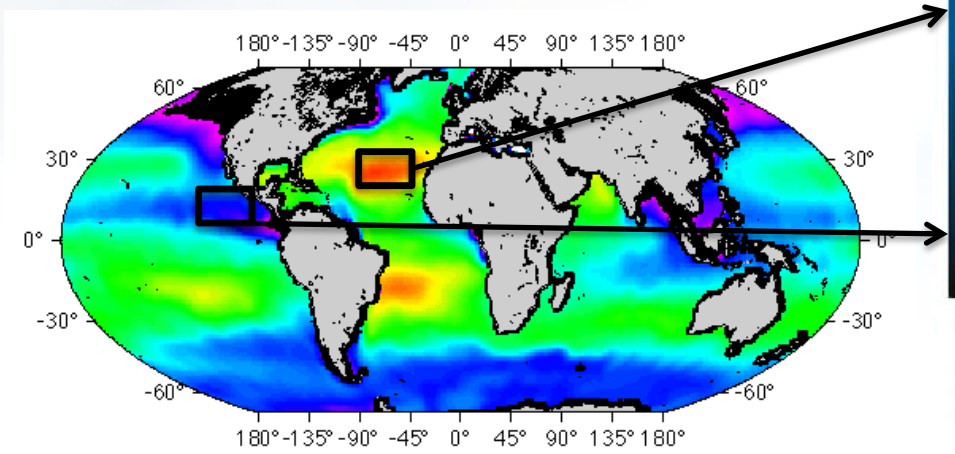
http://spurs.jpl.nasa.gov

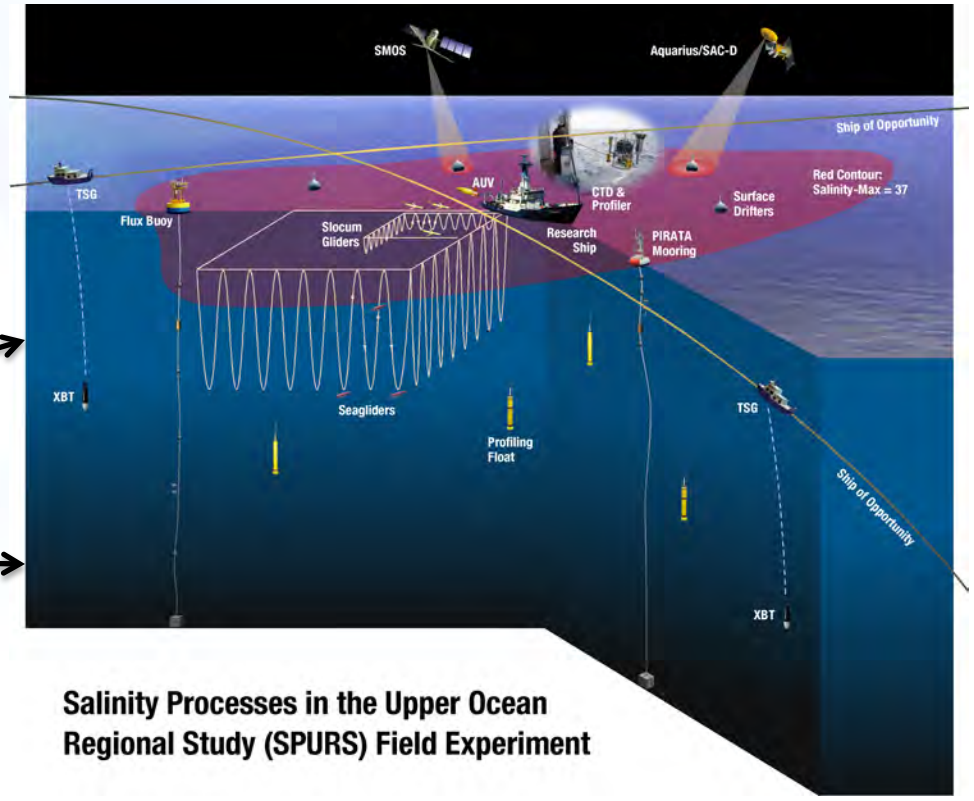
What is controlling the upper ocean salinity?

This question is addressed with interagency/international collaboration of measurements from satellites, ships, drifting surface buoys & profiling floats, gliders, AUVs and theoretical & numerical model simulations.

Motivation

Launch of the Aquarius/SAC-D satellite motivates plans for field campaigns in the salinity maximum and minimum region of the North Atlantic and Eastern Tropical Pacific.

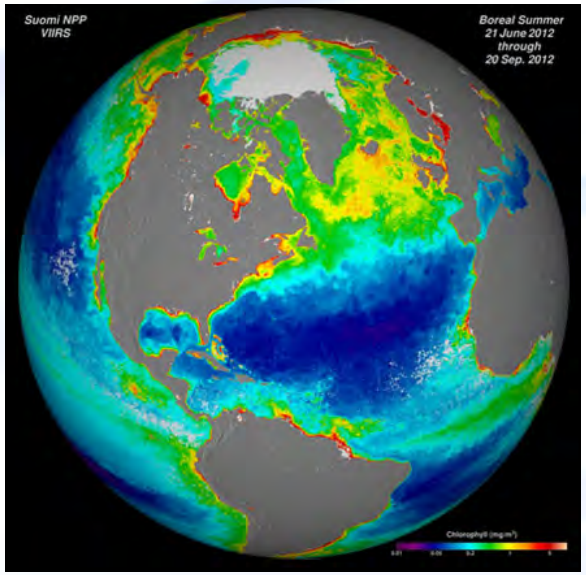




Salinity Processes in the Upper Ocean Regional Study (SPURS) Field Experiment

Ocean Biology and Biogeochemistry

Program Manager: Paula Bontempi



- **Support Ocean Color Missions on Orbit**
  - Aqua (MODIS), Suomi NPP (VIIRS)
- **Support Ocean Color Missions in Development**
  - PACE, GEO-CAPE, ACE, HyspIRI
- **Support Research Teams**
  - Ocean Color, MODIS, Suomi NPP, PACE ST
- **Support Carbon Focus Area/Ocean Observing**
- **Process Studies Related to NASA Ocean Color Missions**
  - **I**mpacts of **C**limate on the **E**co-**S**ystems and **C**hemistry of the **A**rctic **P**acific **E**nvironment (ICESCAPE) (2010-2011)
  - **S**hip **A**ircraft **B**io-**O**ptical **R**esearch (SABOR) campaign (summer 2014)
  - **EX**port **P**rocesses in the **O**cean from **R**emo**T**e **S**ensing (EXPORTS: 2017-2022)
  - Field Campaign Scoping Study: **Arctic CO**astal **L**and **O**cean inte**R**actions **S**coping study (Arctic-COLORS) (A. Mannino, NASA GSFC)
  - Field Campaign Scoping Study: **I**nterdisciplinary **C**oordinated **E**xperiment of the **S**outhern **O**cean **C**arbon **C**ycle (ICESOCC) (G. Mitchell, Scripps/UCSD)

EXport Processes in the Ocean from RemoTe Sensing (EXPORTS)

http://cce.nasa.gov/obb/exports/index.html

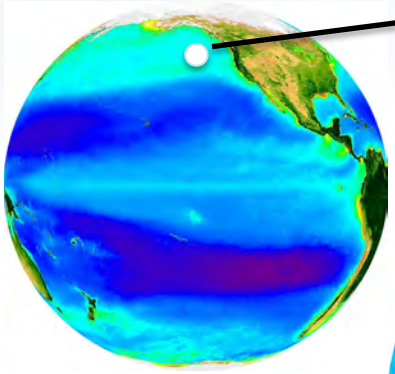
What is the role and interaction between planktonic ecosystem characteristics and the functioning of the ocean's biological pump?

Develop a predictive understanding of the export and fate of global ocean PP and its implications for the Earth's Carbon Cycle in present and future climates - satellites, ships, profiling floats, gliders, and model simulations.

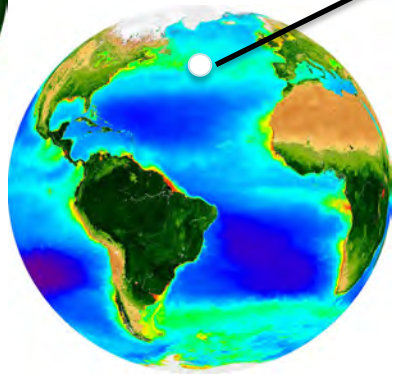
Motivation

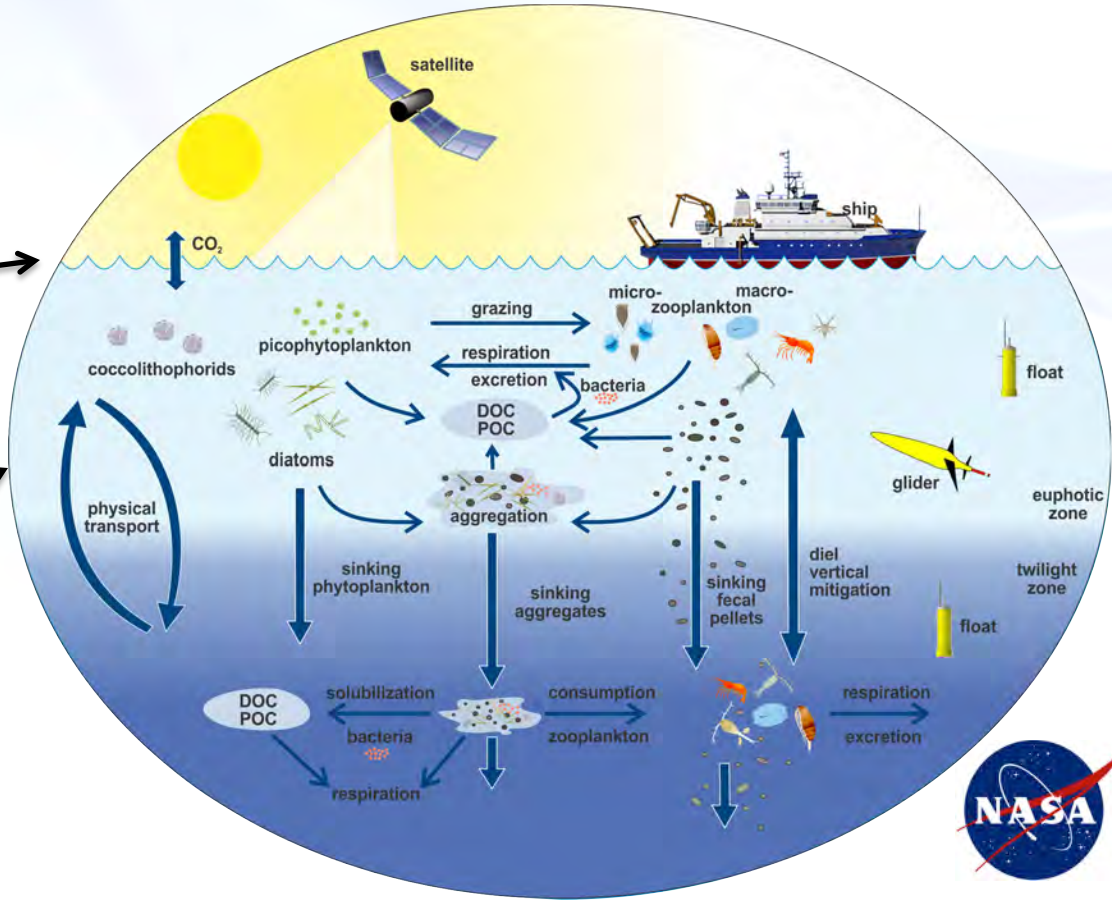
Advances in remote sensing (e.g., PACE) and autonomous tools.

Station P

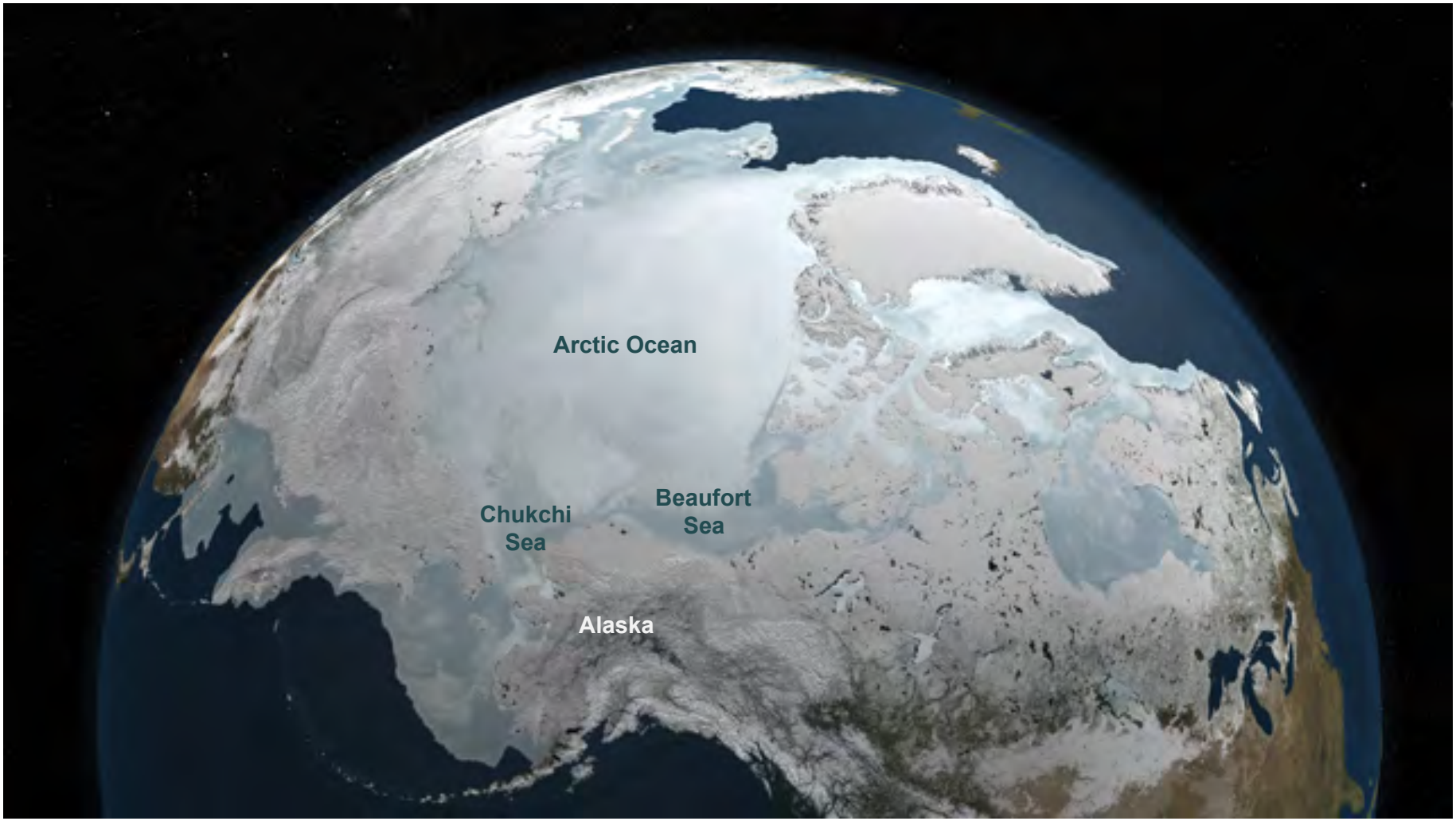


North Atlantic

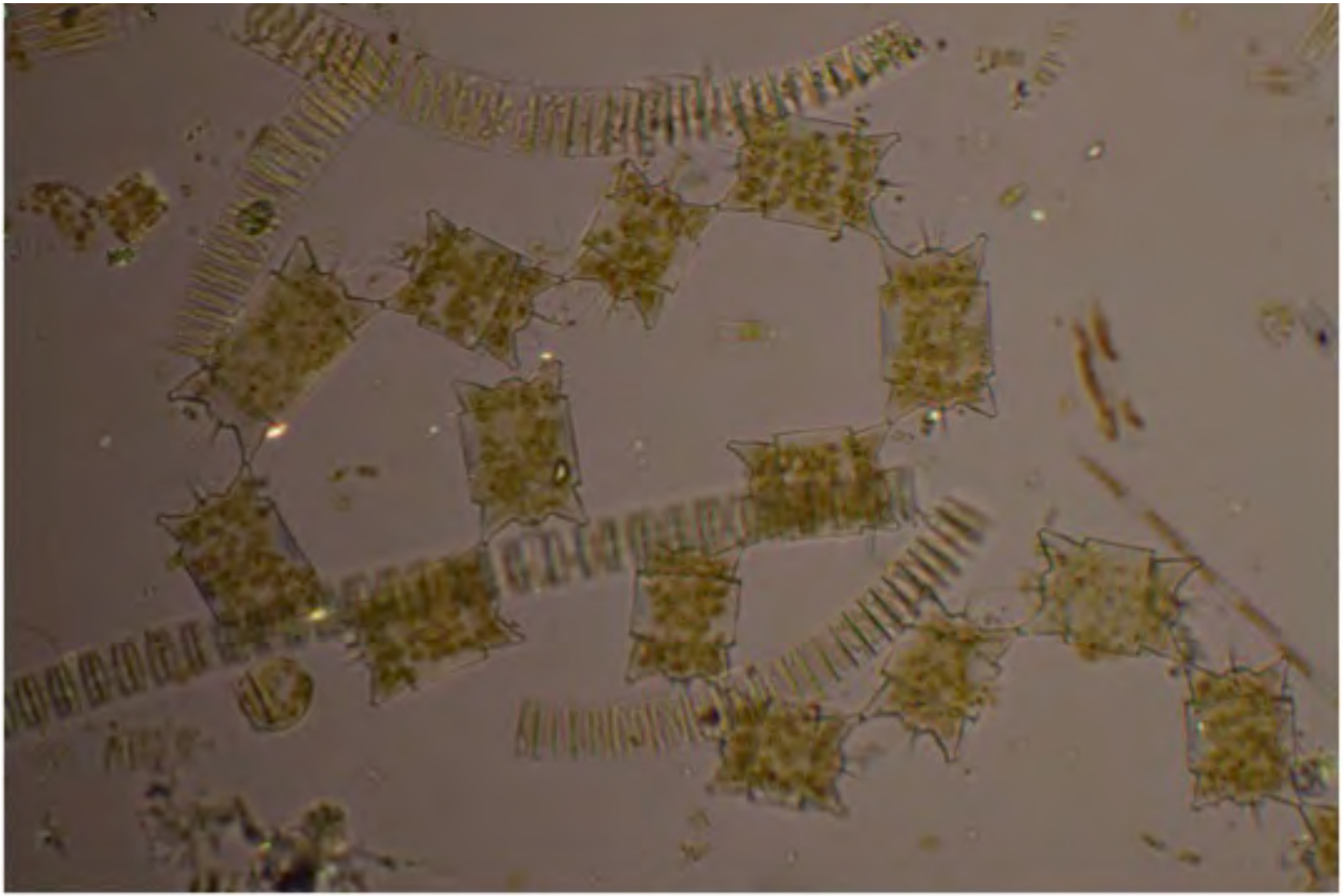


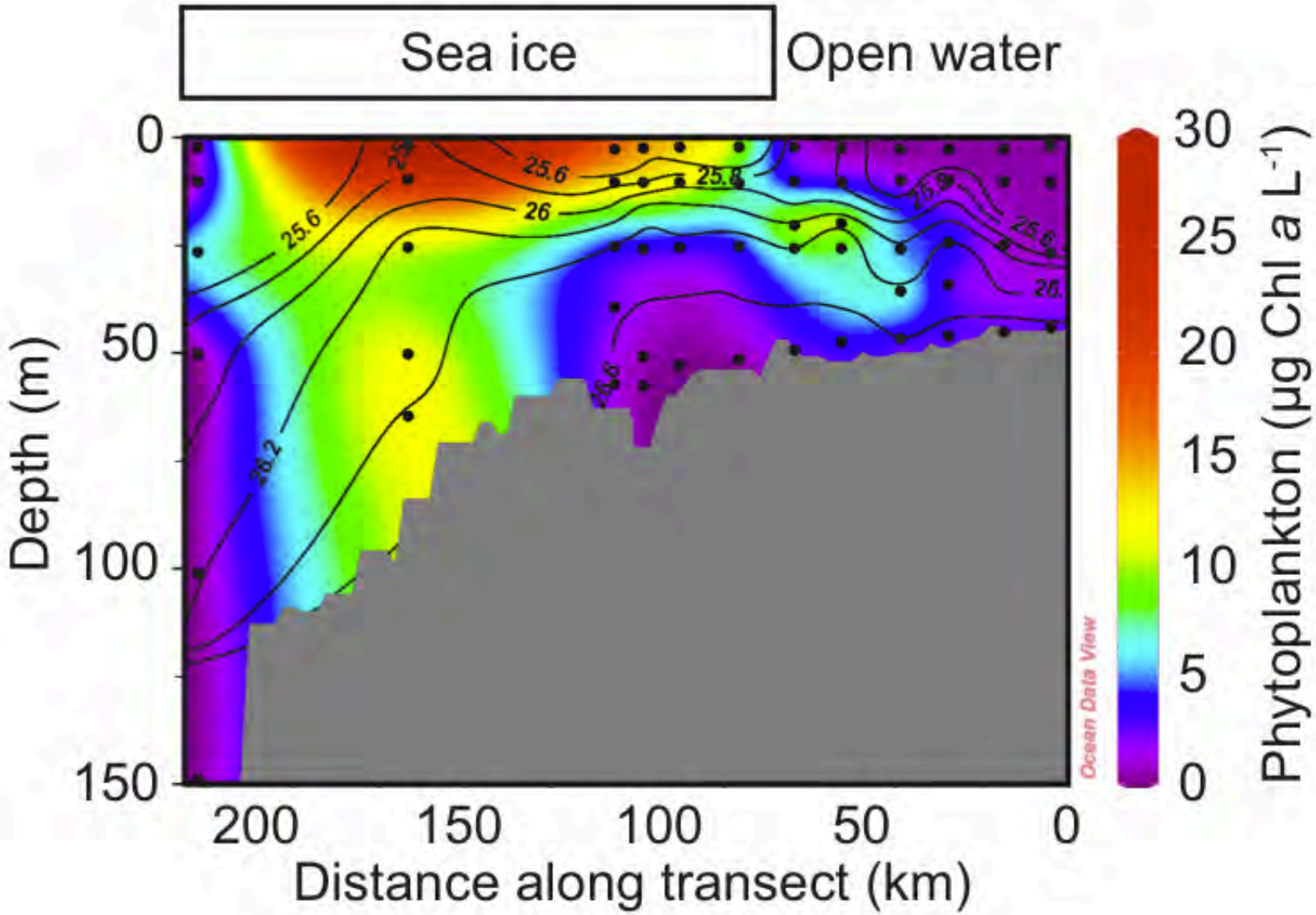


First ICESCAPE results
14 June 2012

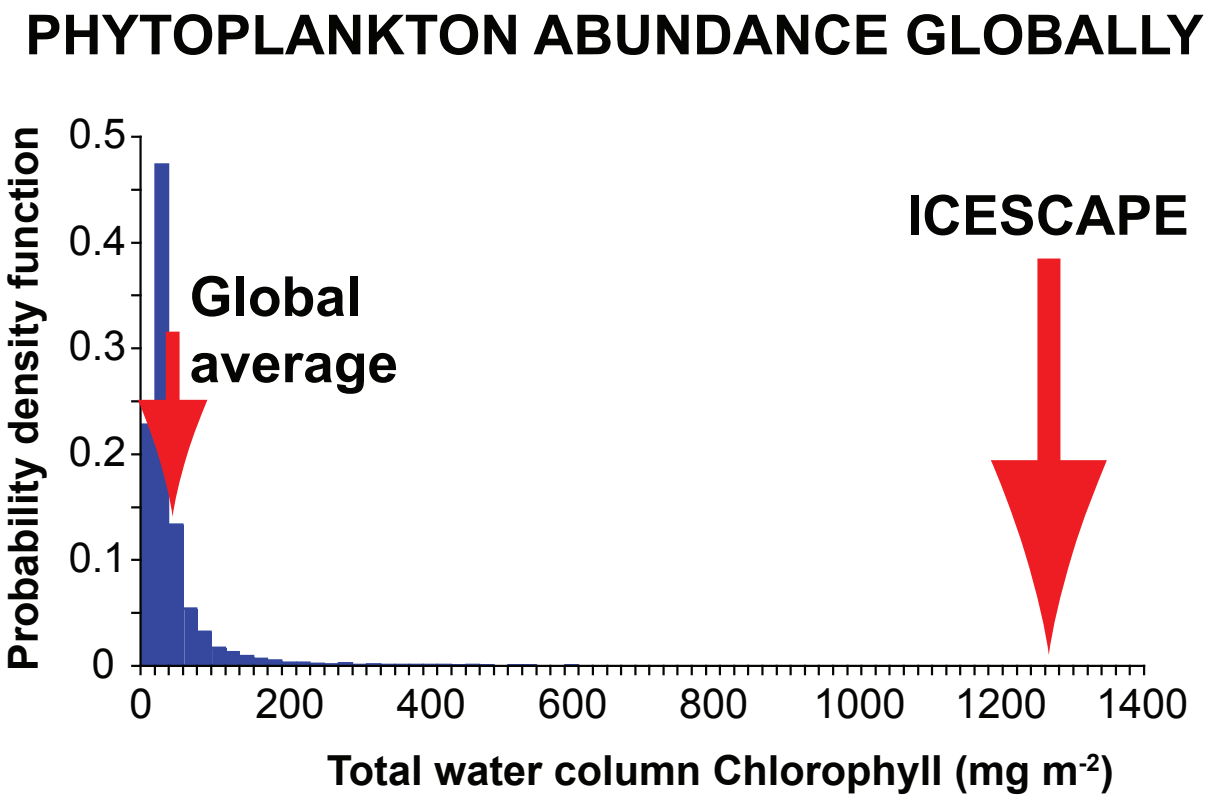

Arctic Ocean
Chukchi Sea
Beaufort Sea
Alaska


20
U. S. CO




Sea ice
Open water
0
50
100
150
Depth (m)
200
150
100
50
0
Distance along transect (km)
25.6
26
26.2
Ocean Data View
30
25
20
15
10
5
0
Phytoplankton (µg Chl a L-1)

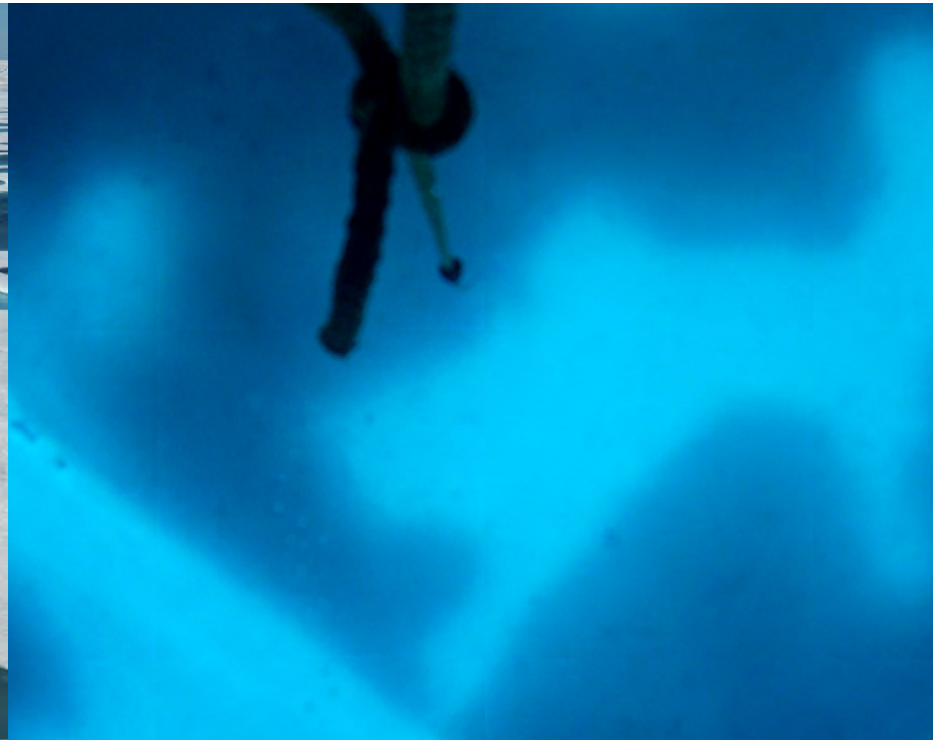
Most Phytoplankton Anywhere?



Before melt

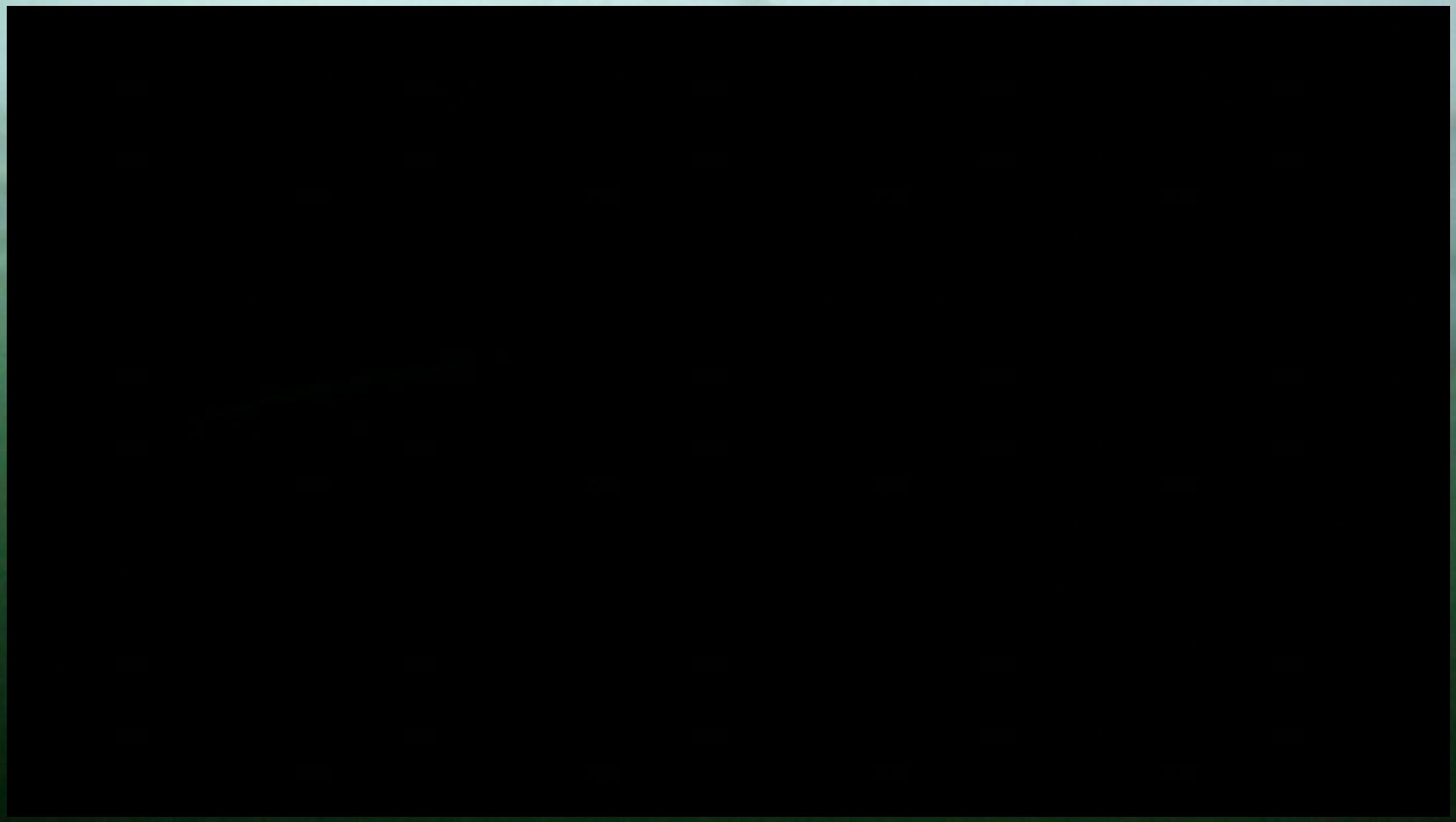
The ice above the ocean is bright – it is dark under the ice

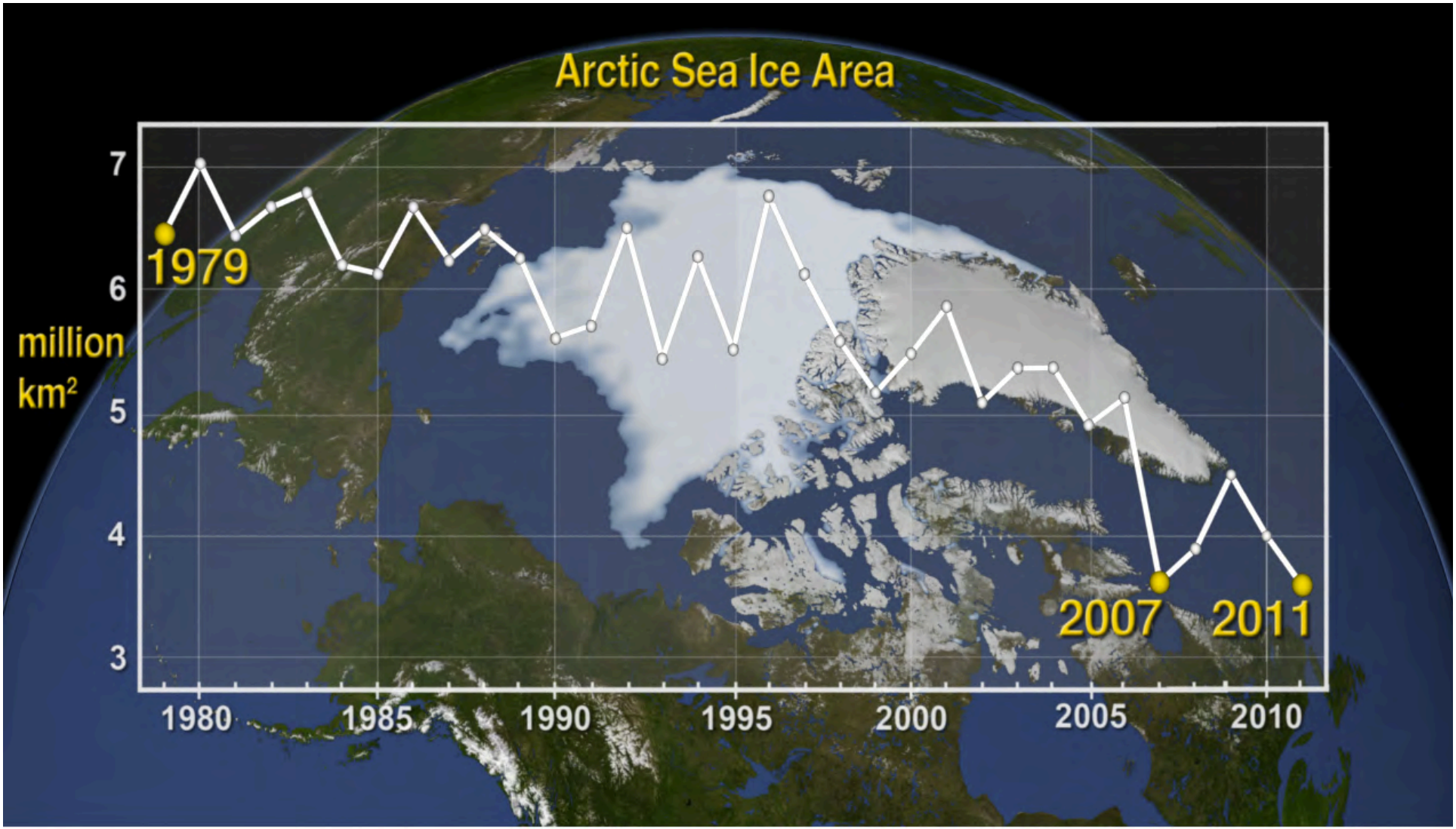
After melt

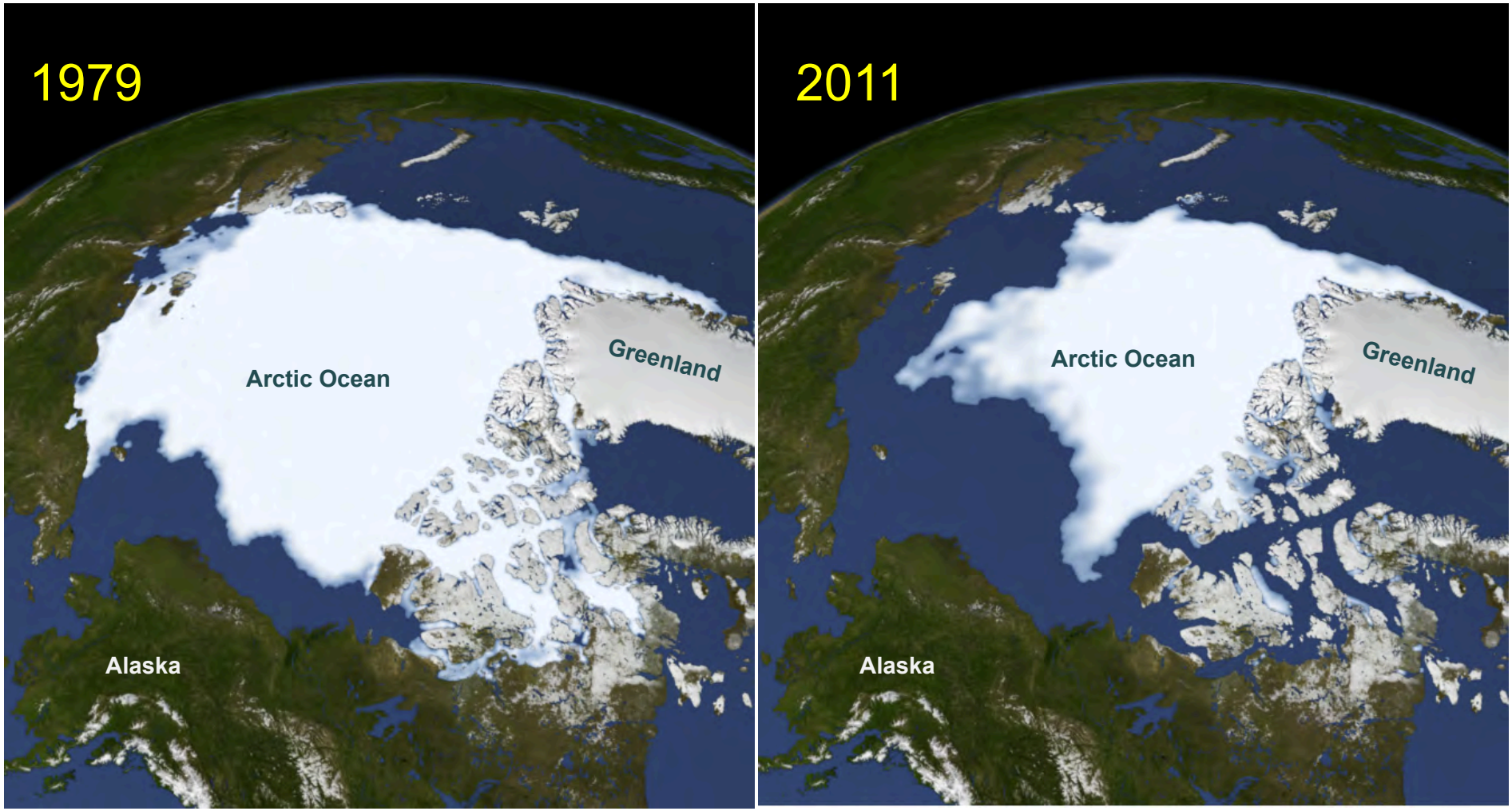


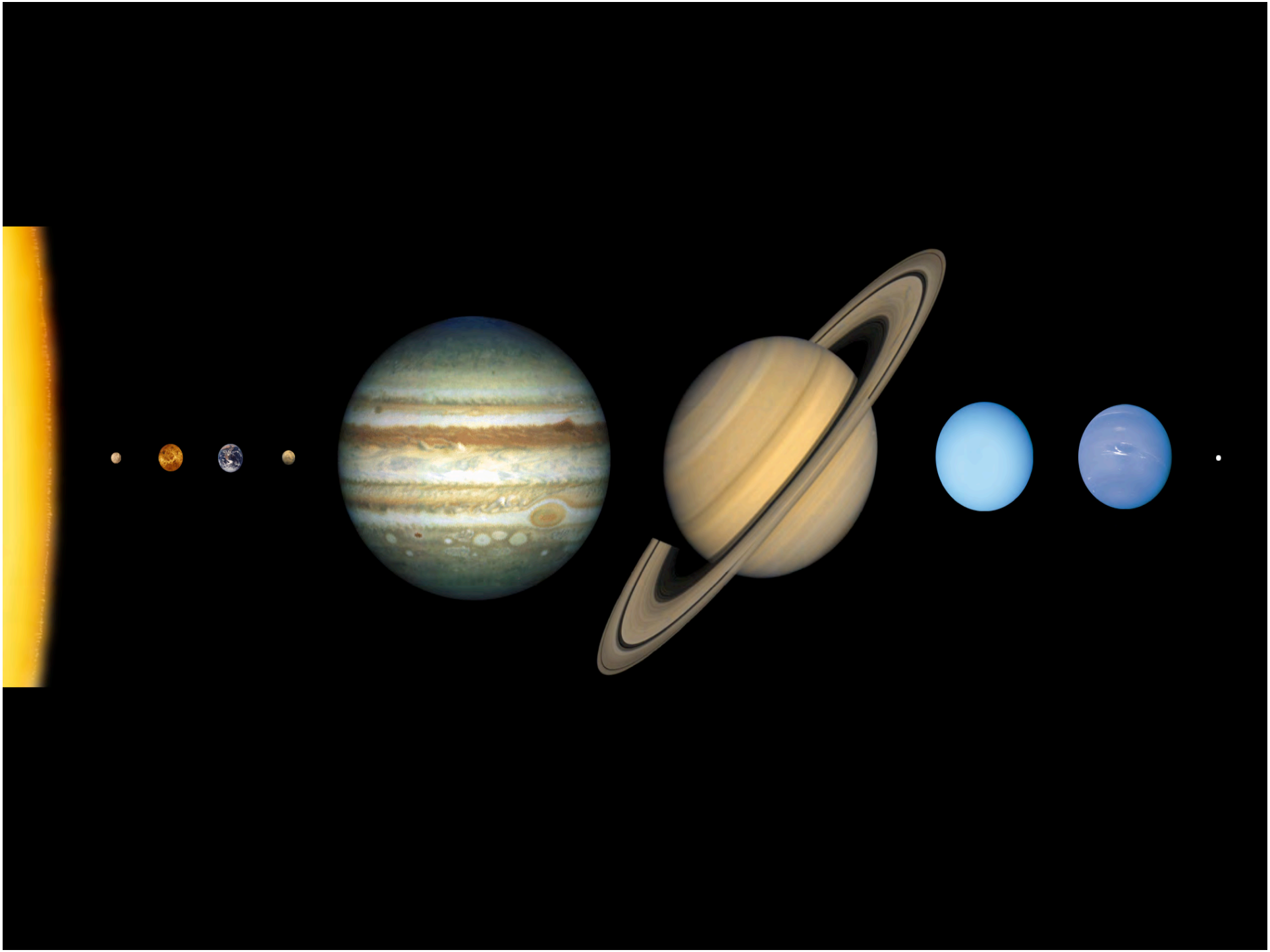
The above ice is darker – much more light is transmitted under the ice

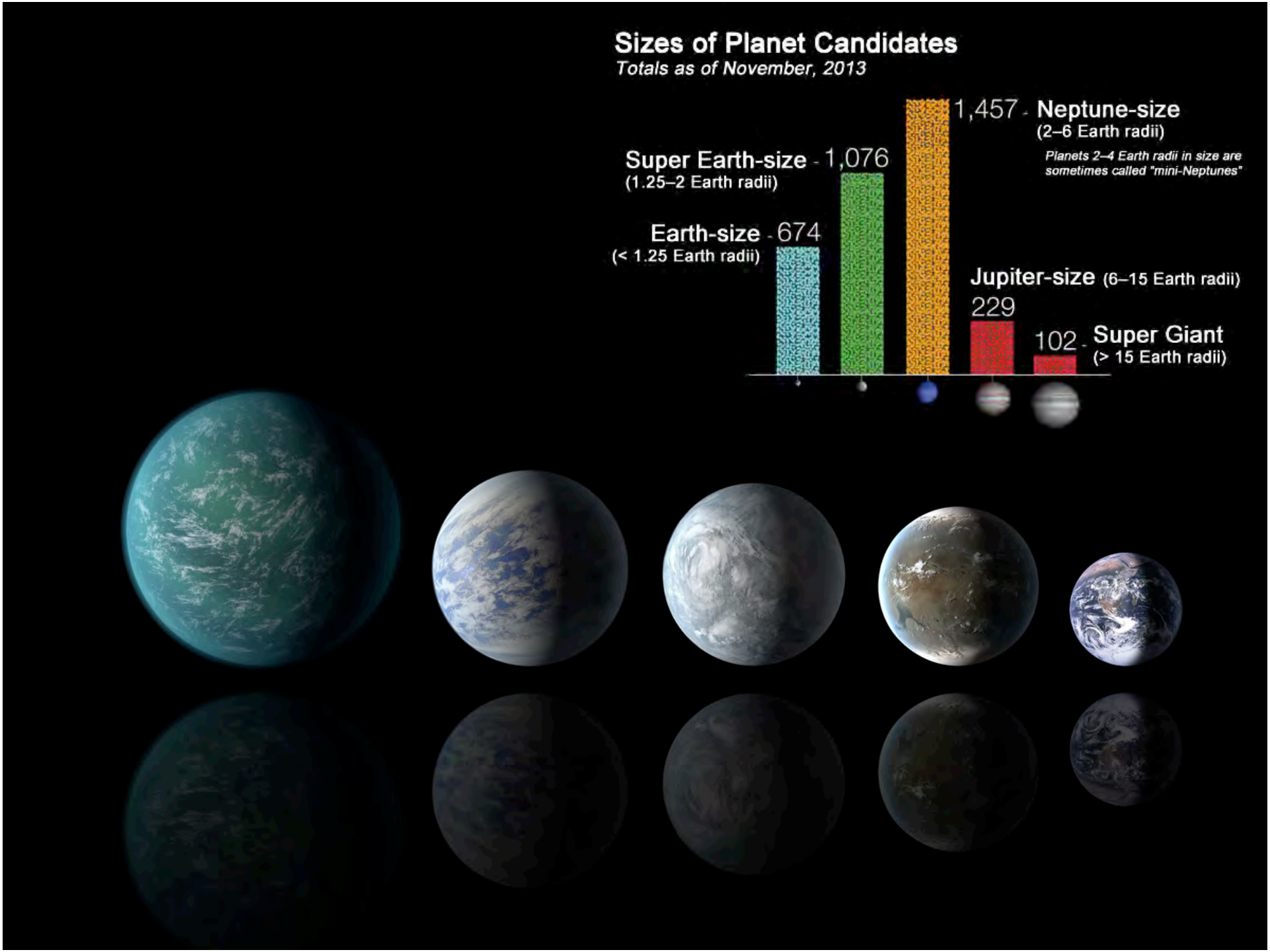
Light and nutrients = phytoplankton bloom



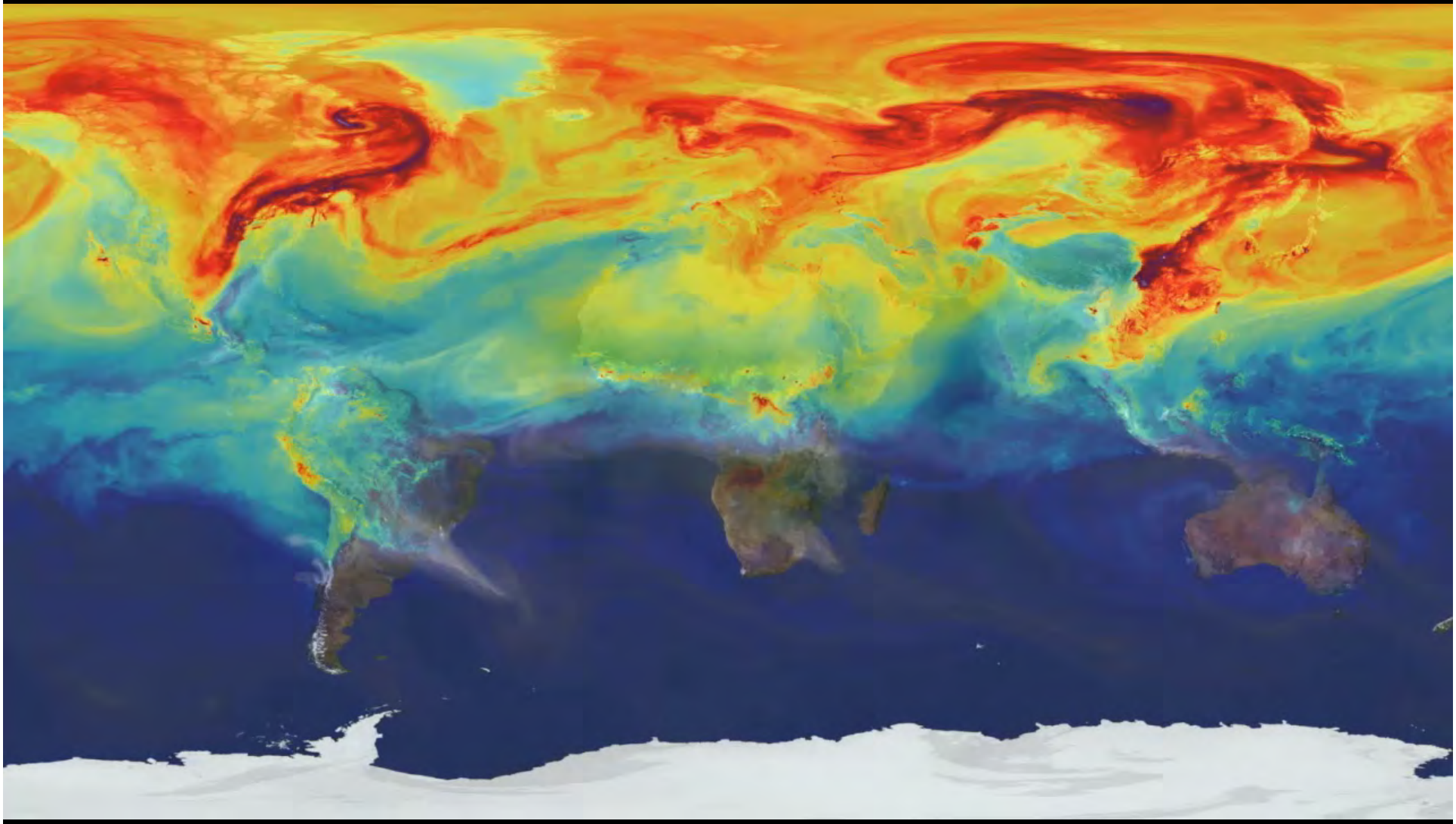

Arctic Sea Ice Area
7
6
5
4
3
million
km²
1979
2007
2011
1980
1985
1990
1995
2000
2005
2010


1979
Arctic Ocean
Greenland
Alaska
2011
Arctic Ocean
Greenland
Alaska



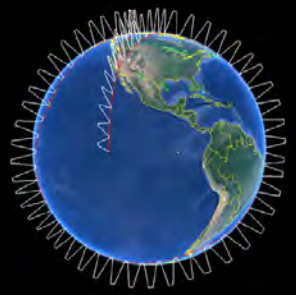

Sizes of Planet Candidates
Totals as of November, 2013
Earth-size
(< 1.25 Earth radii)
674
Super Earth-size
(1.25–2 Earth radii)
1,076
1,457
Neptune-size
(2–6 Earth radii)
Planets 2–4 Earth radii in size are sometimes called "mini-Neptunes"
Jupiter-size (6–15 Earth radii)
229
102
Super Giant
(> 15 Earth radii)

Back up

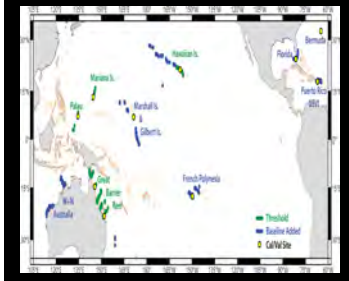


Earth Venture Suborbital – 2: Investigations

ACT-America (Atmospheric Carbon and Transport – America): Quantify the sources of regional carbon dioxide, methane, and other gases, and document how weather systems transport these gases; Ken Davis, Penn State Univ

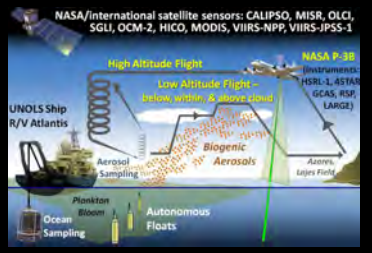


ATom (Atmospheric Tomography Experiment): Study the impact of human-produced air pollution on certain greenhouse gases; Steven Wofsy, Harvard Univ

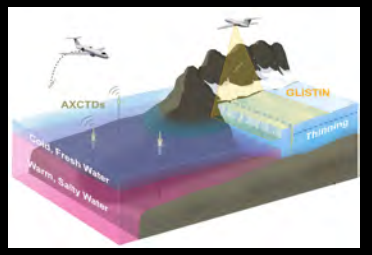


CORAL (Coral Reef Airborne Laboratory): Develop critical data and new models needed to analyze the status of coaral reefs and predict their future; Eric Hochberg, Bermuda Institute of Ocean Science

NAAMES (North Atlantic Aerosols and Marine Ecosystems Study): Improve predictions of how ocean ecosystems would change with ocean warming; Michael Behrenfeld, Oregon State Univ



OMG (Oceans Melting Greenland): Investigate the role of warmer, saltier Atlantic subsurface waters in Greenland glacier melting; Josh Willis, JPL



ORACLES (ObseRvations of Aerosols Above CLouds and Their IntEractionS): Probe how smoke particles from massive biomass burning in Africa influences cloud cover over the Atlantic; Jens Redemann, ARC