SEA LEVEL CHANGE

Jieun Park
Weronika Aftarczuk
Sepideh Motamedpooya
Joanna Maraszek

Contents

Global mean sea level in 2018 was about 20 cm higher than at the beginning of the 20th century.

3,3 mm per year since 1993

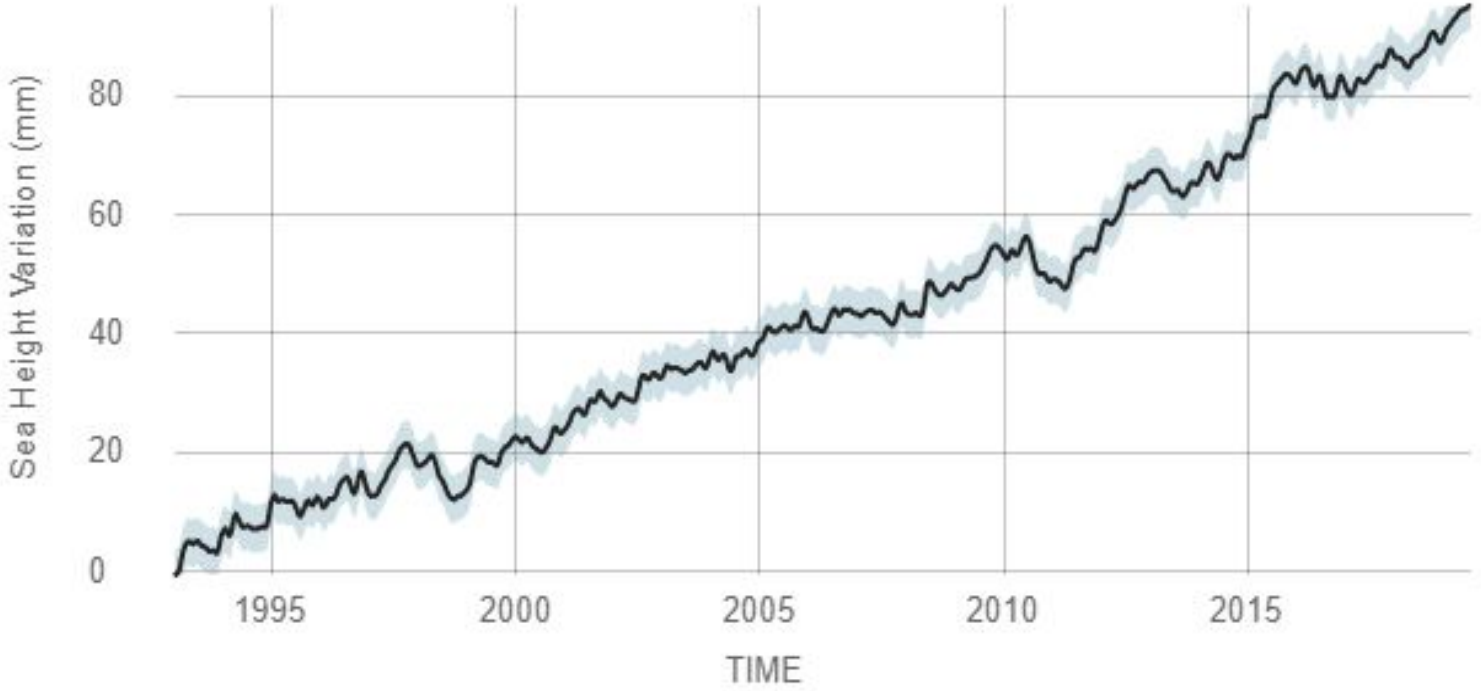
SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.
Credit: NASA Goddard Space Flight Center

RATE OF CHANGE

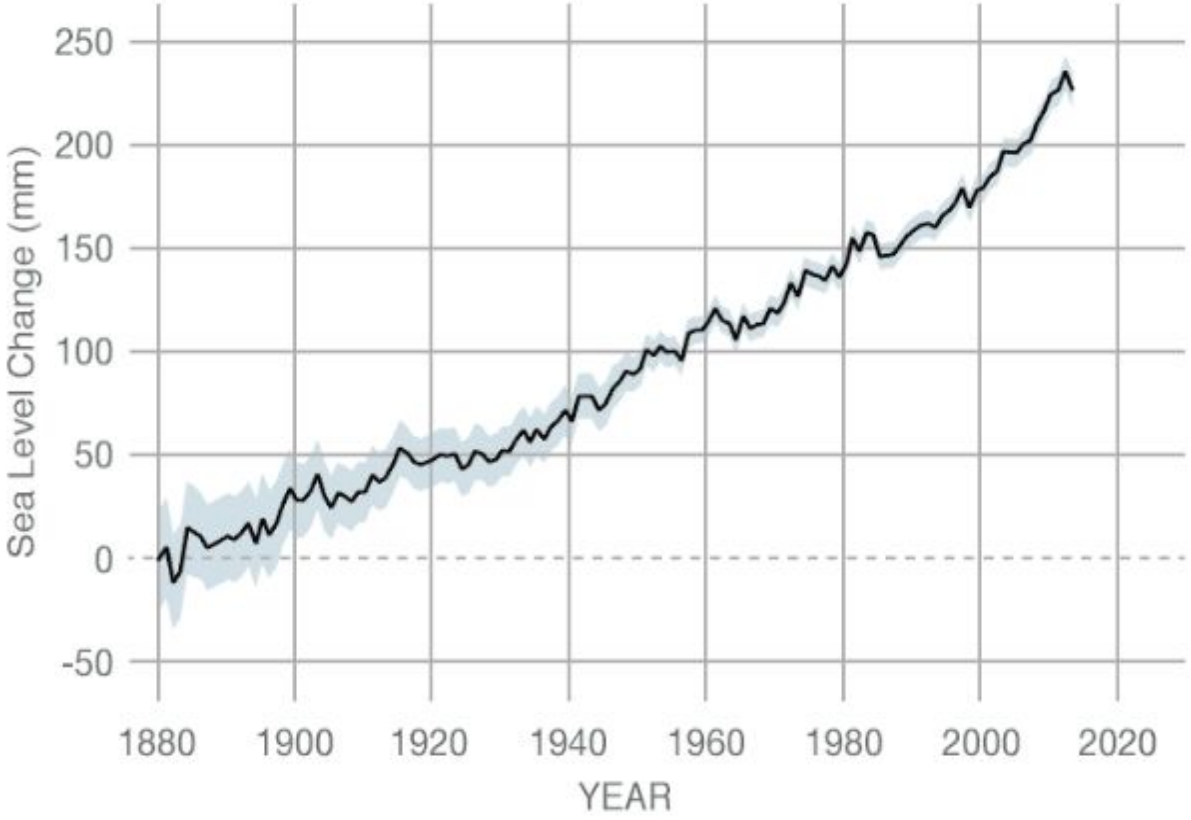
↑ 3.3

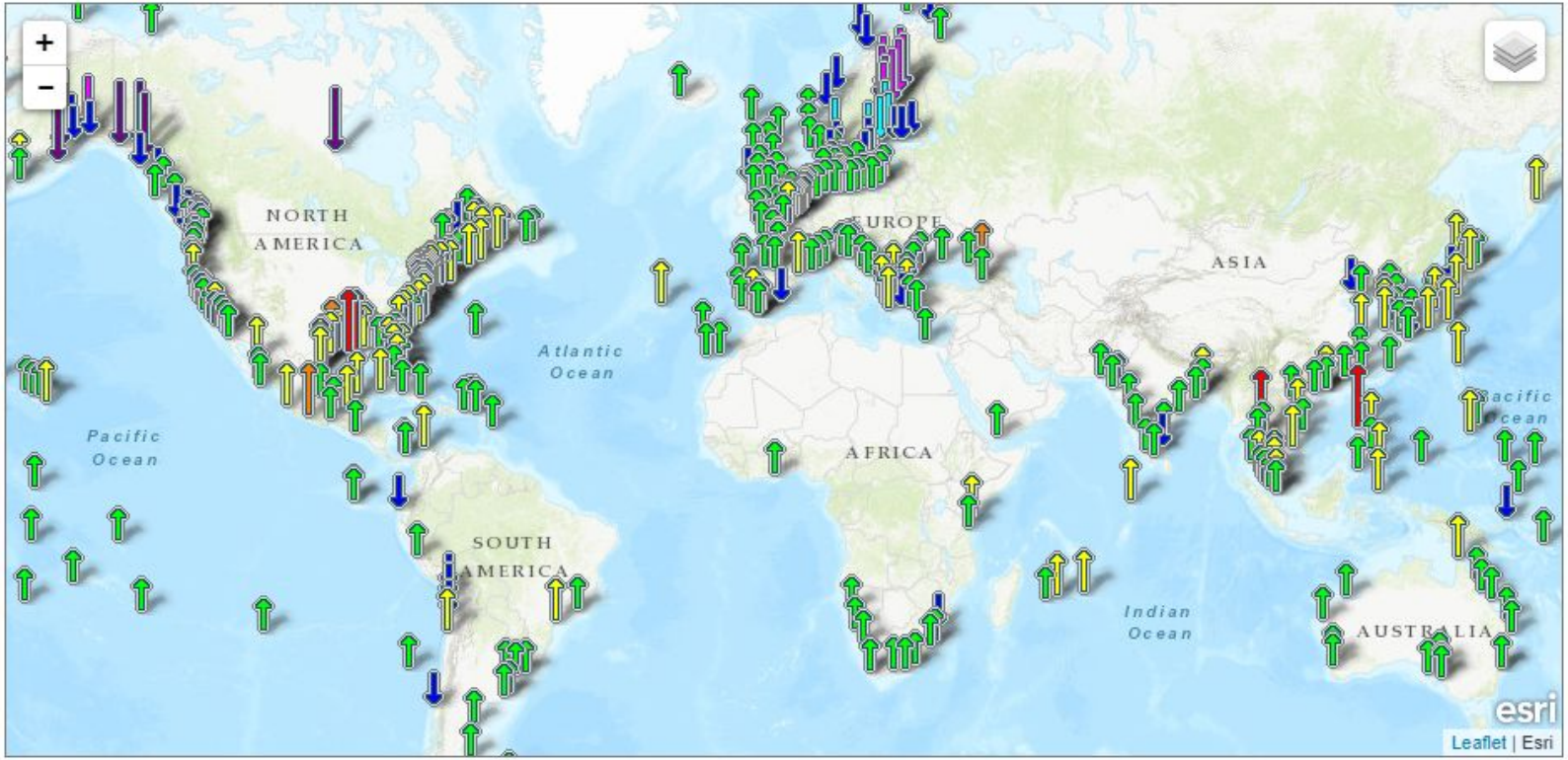
millimeters per year



GROUND DATA: 1870-2013

Data source: Coastal tide gauge records.
Credit: CSIRO



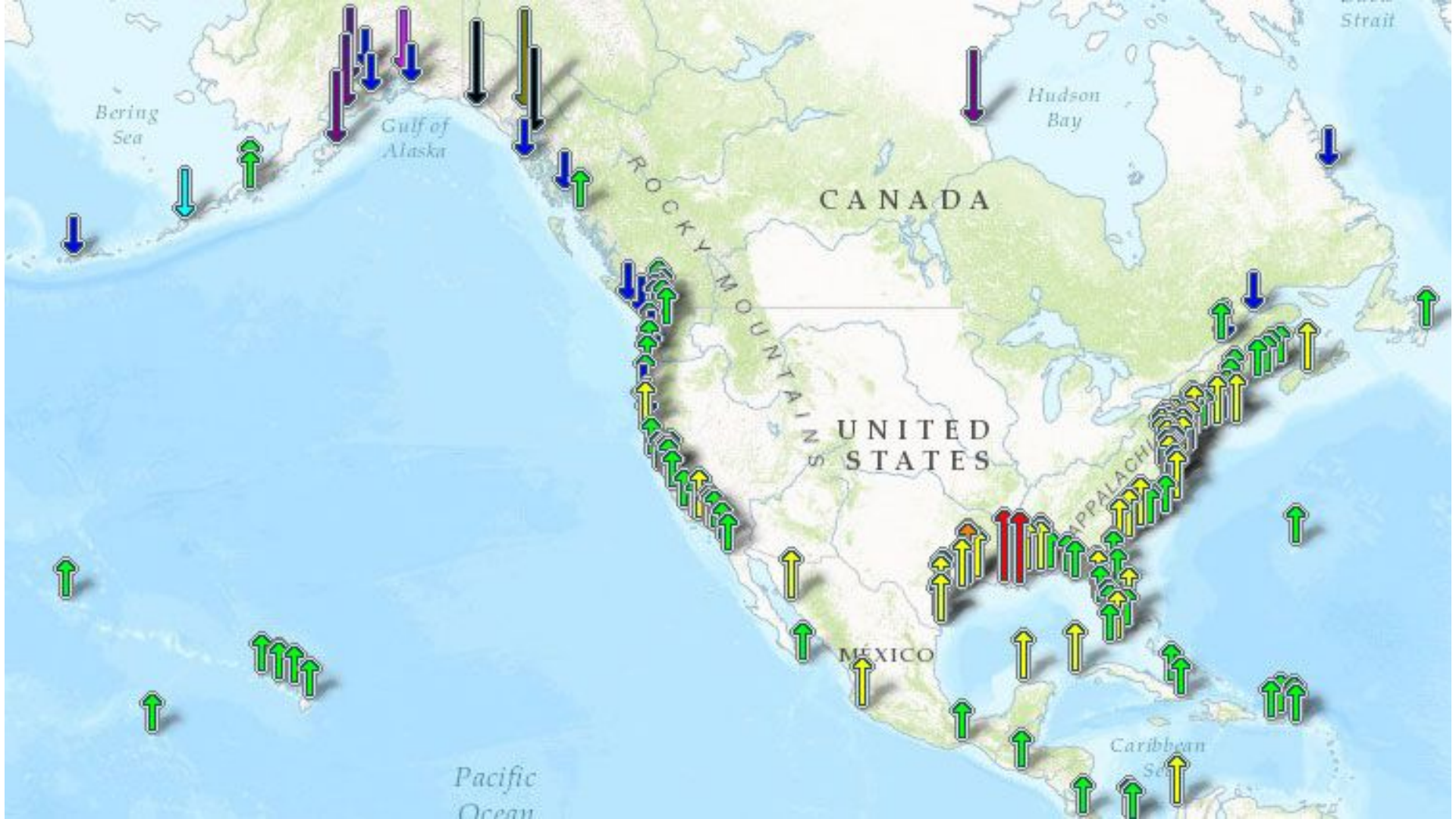


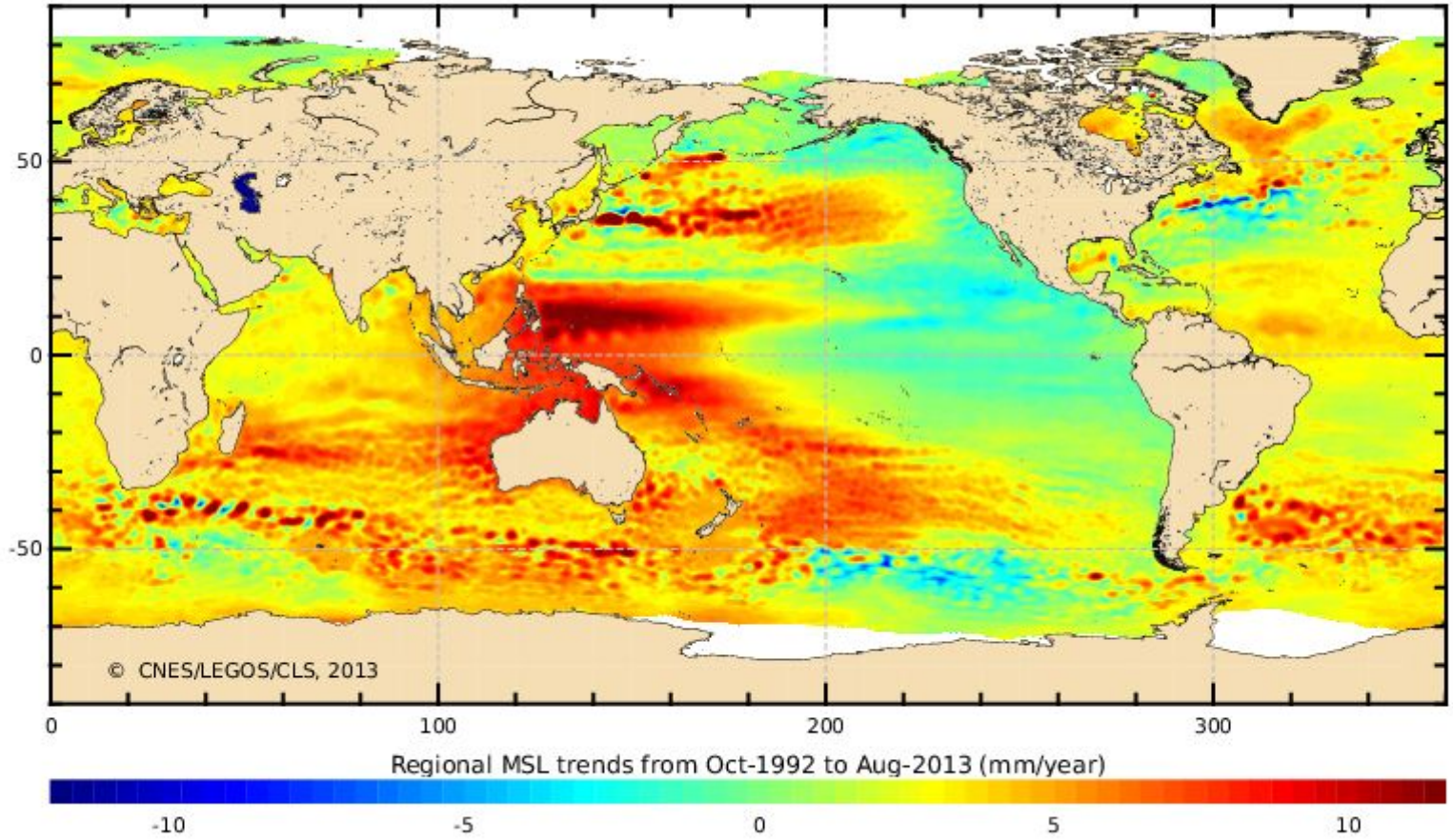
The map above illustrates relative sea level trends , with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

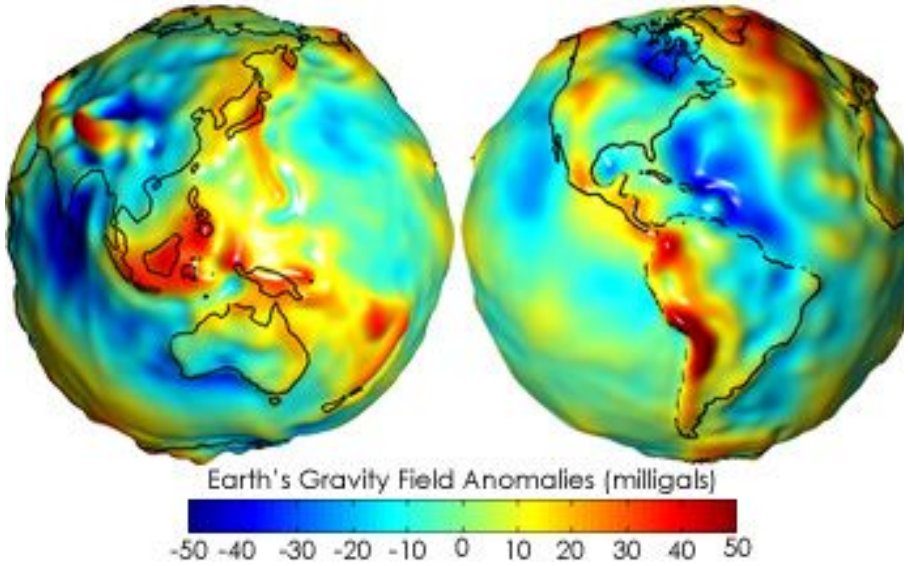
Relative Sea Level Trends

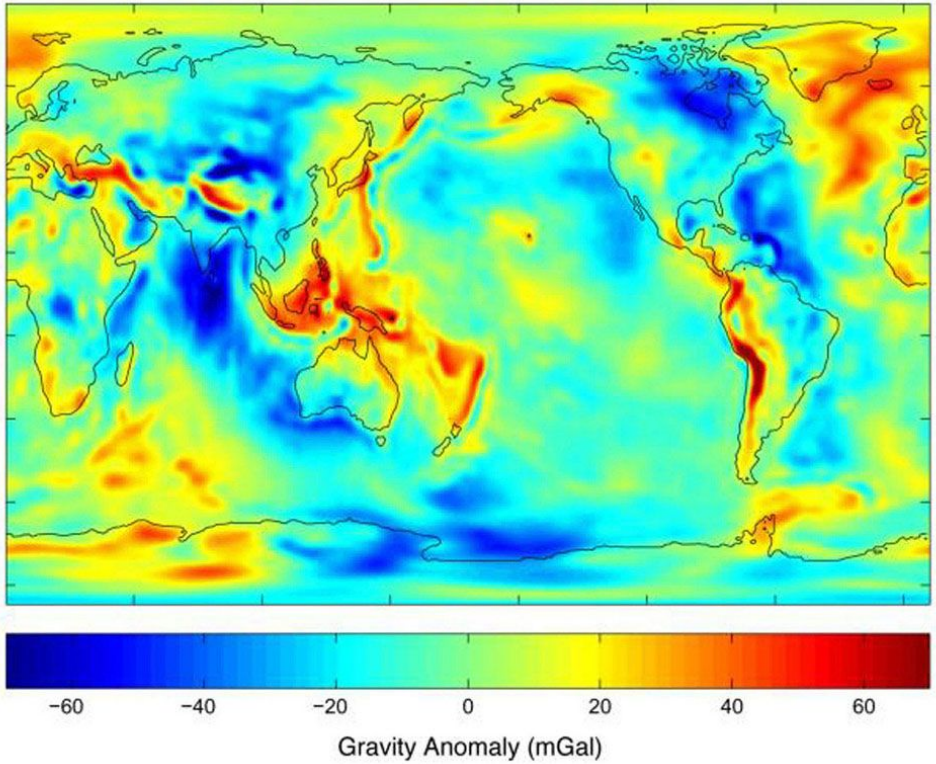
mm/yr (feet/century)

Above 9 (Above 3)	6 to 9 (2 to 3)	3 to 6 (1 to 2)	>0 to 3 (0 to 1)	-3 to 0 (-1 to 0)	-6 to -3 (-2 to -1)	-9 to -6 (-3 to -2)	Below -9 (Below -3)


Bering Sea
Gulf of Alaska
Hudson Bay
CANADA
ROCKY MOUNTAINS
UNITED STATES
MÉXICO
Caribbean Sea
Pacific Ocean


50
0
-50
0
100
200
300
© CNES/LEGOS/CLS, 2013
Regional MSL trends from Oct-1992 to Aug-2013 (mm/year)
-10
-5
0
5
10


Earth's Gravity Field Anomalies (milligals)
-50 -40 -30 -20 -10 0 10 20 30 40 50


−60 −40 −20 0 20 40 60
Gravity Anomaly (mGal)

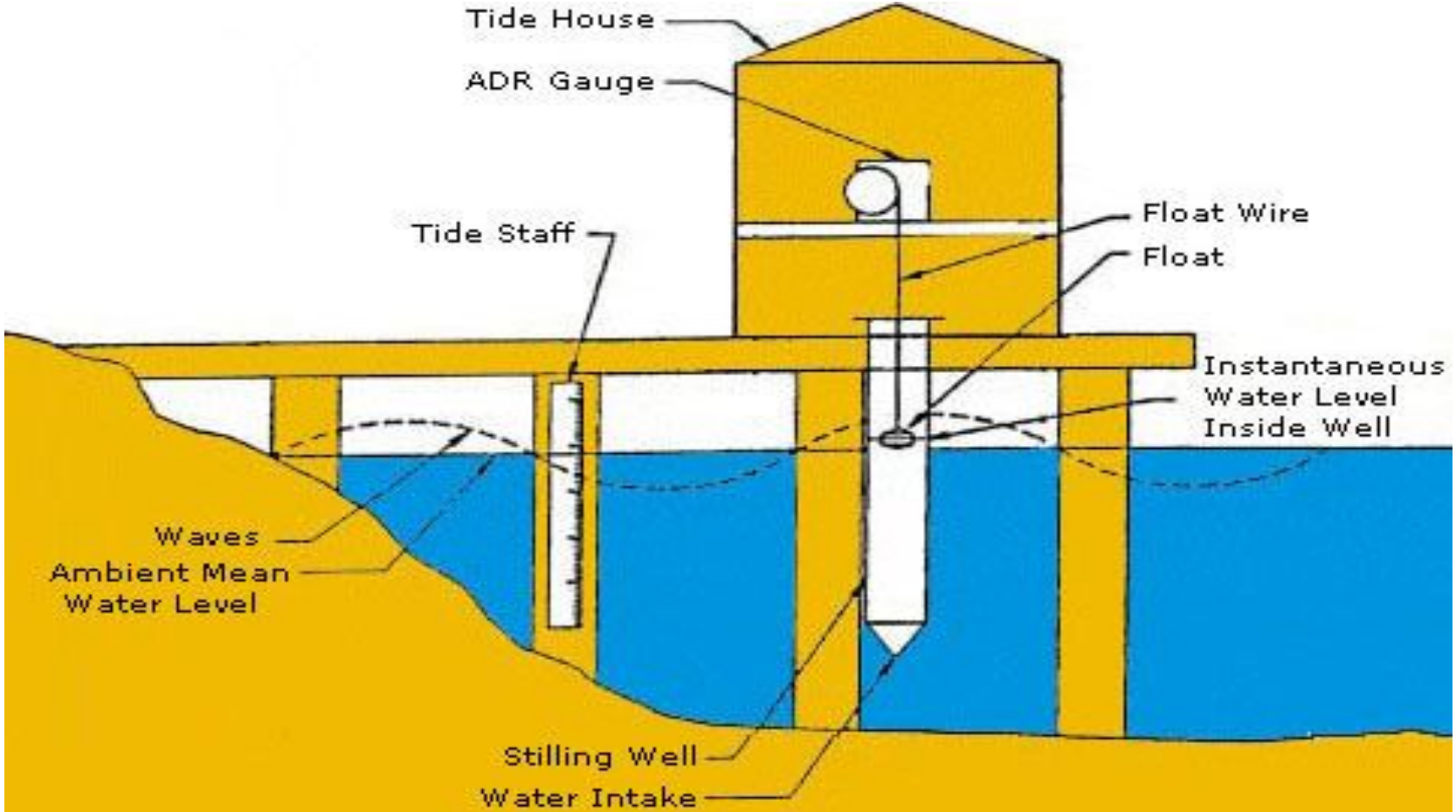
Measurement of sea level

- Tide gauge
- Argo floats
- Satellite altimetry

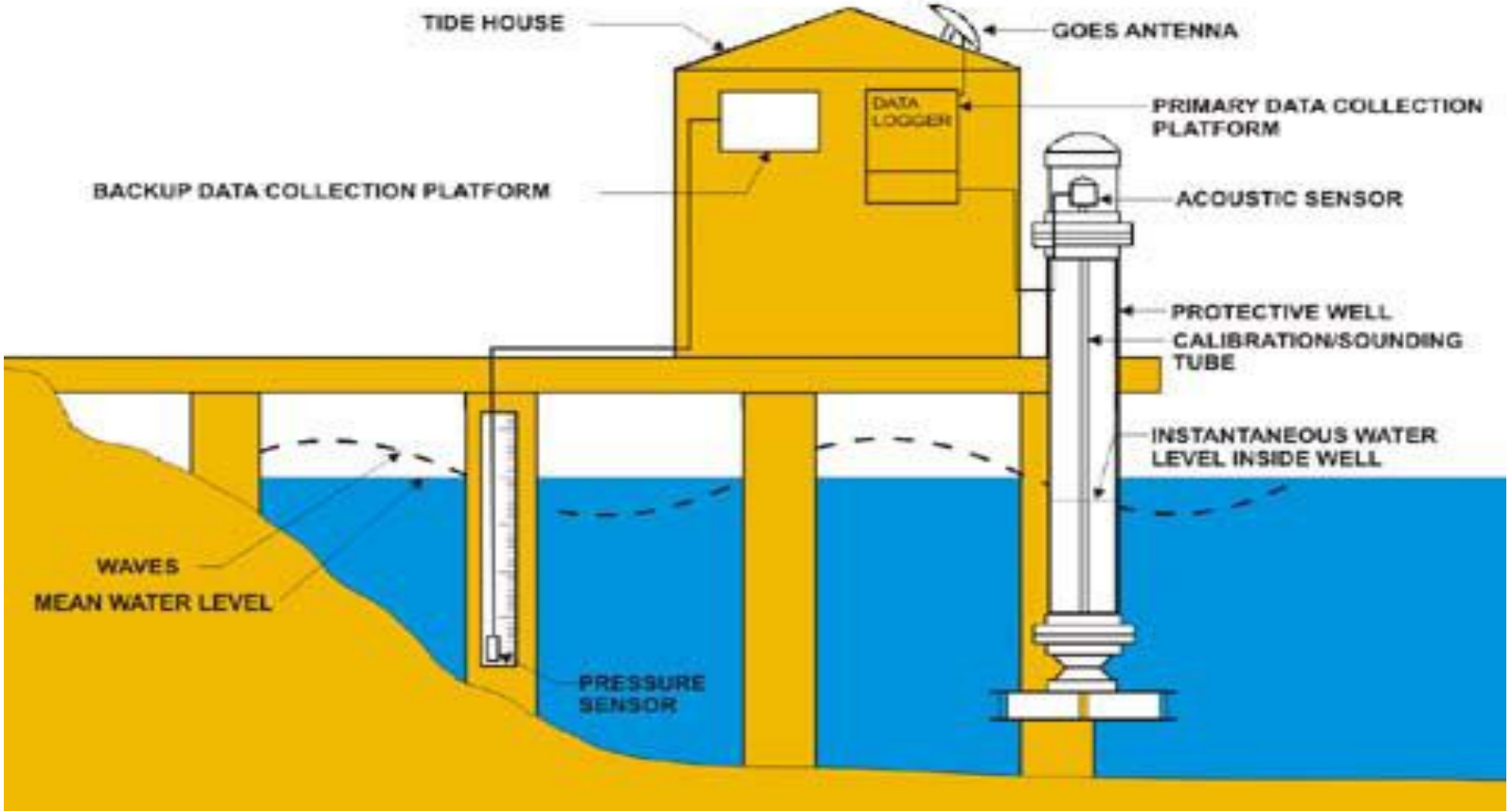
By combining these methods, scientists can put together a picture of average global sea level changes.

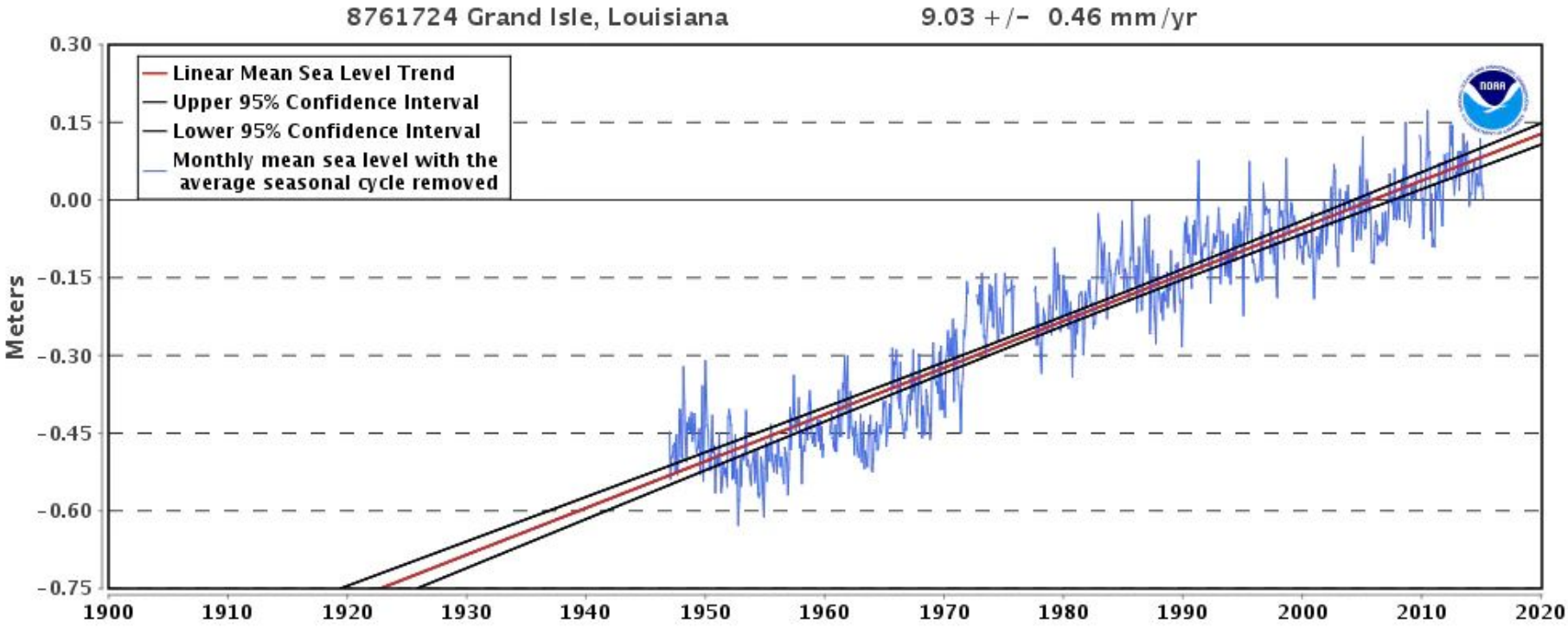
Tide Gauge

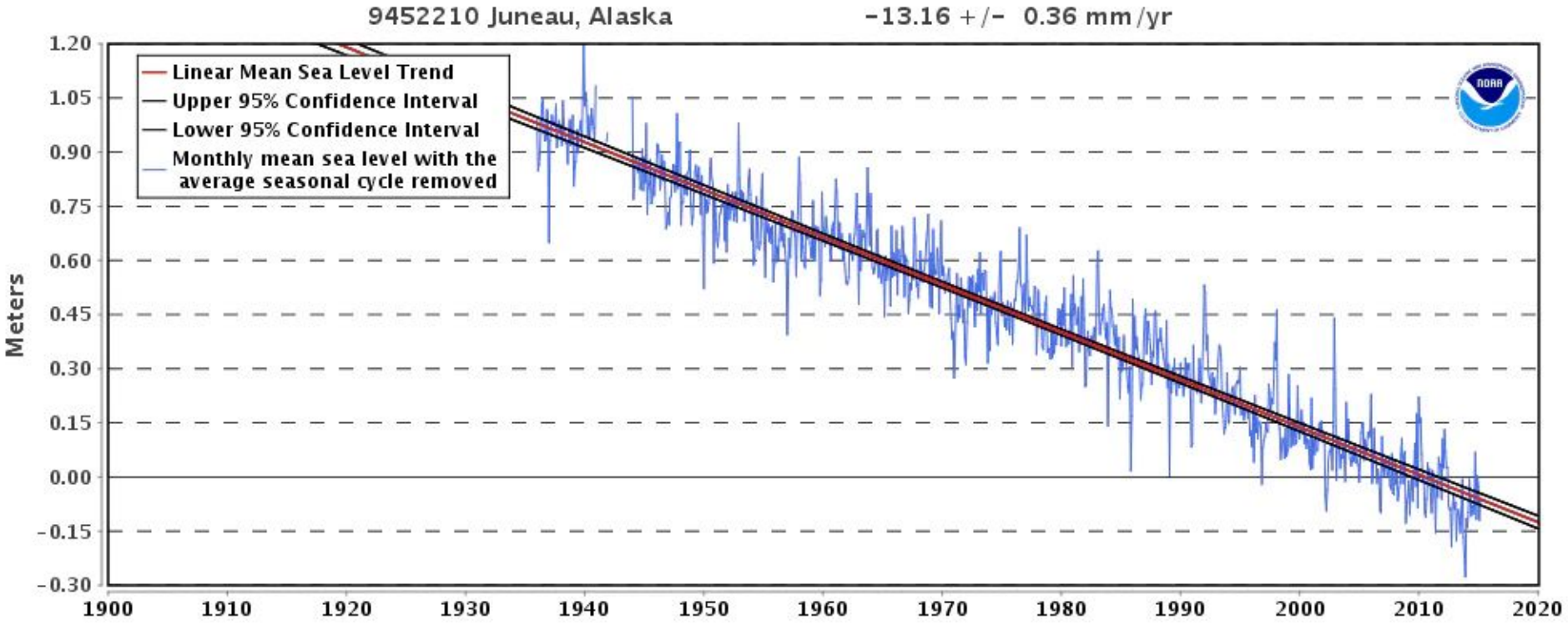
The old


Tide House
ADR Gauge
Tide Staff
Float Wire
Float
Instantaneous
Water Level
Inside Well
Waves
Ambient Mean
Water Level
Stilling Well
Water Intake

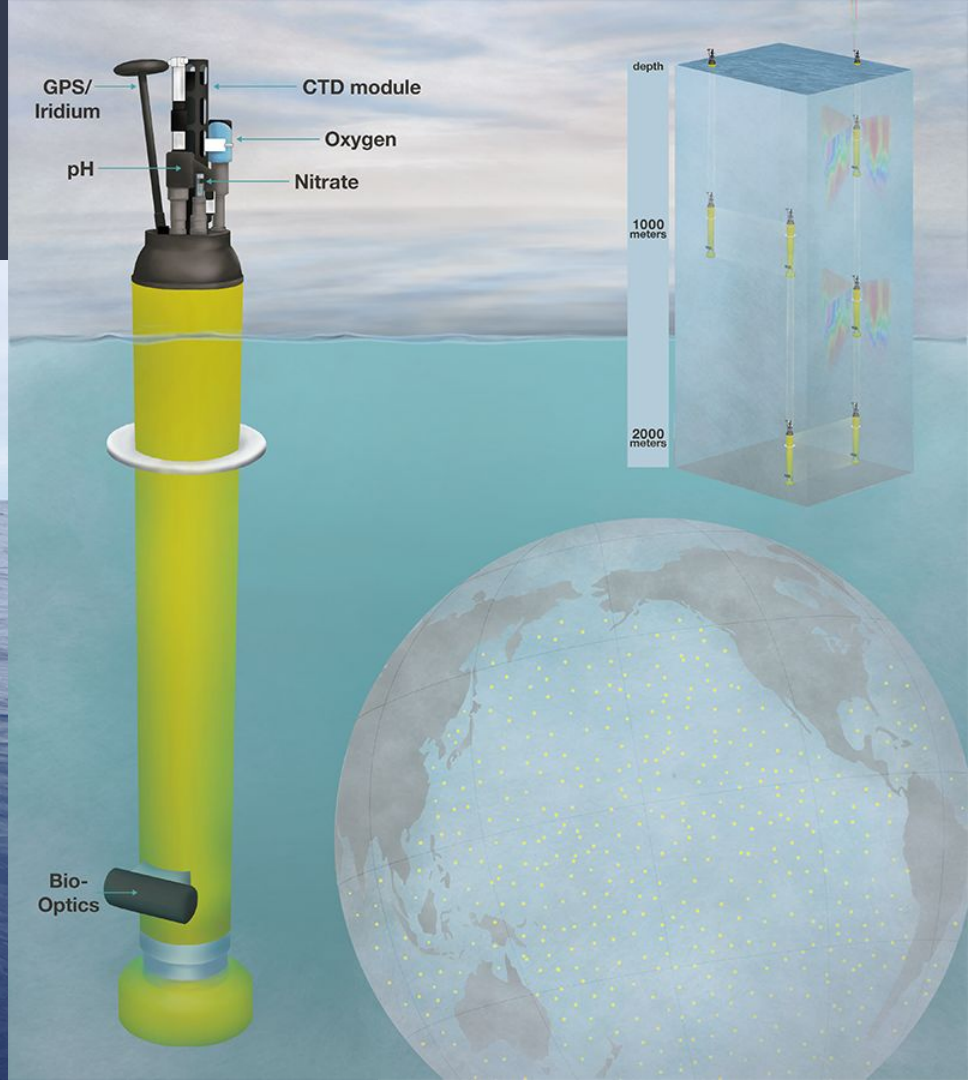
The new

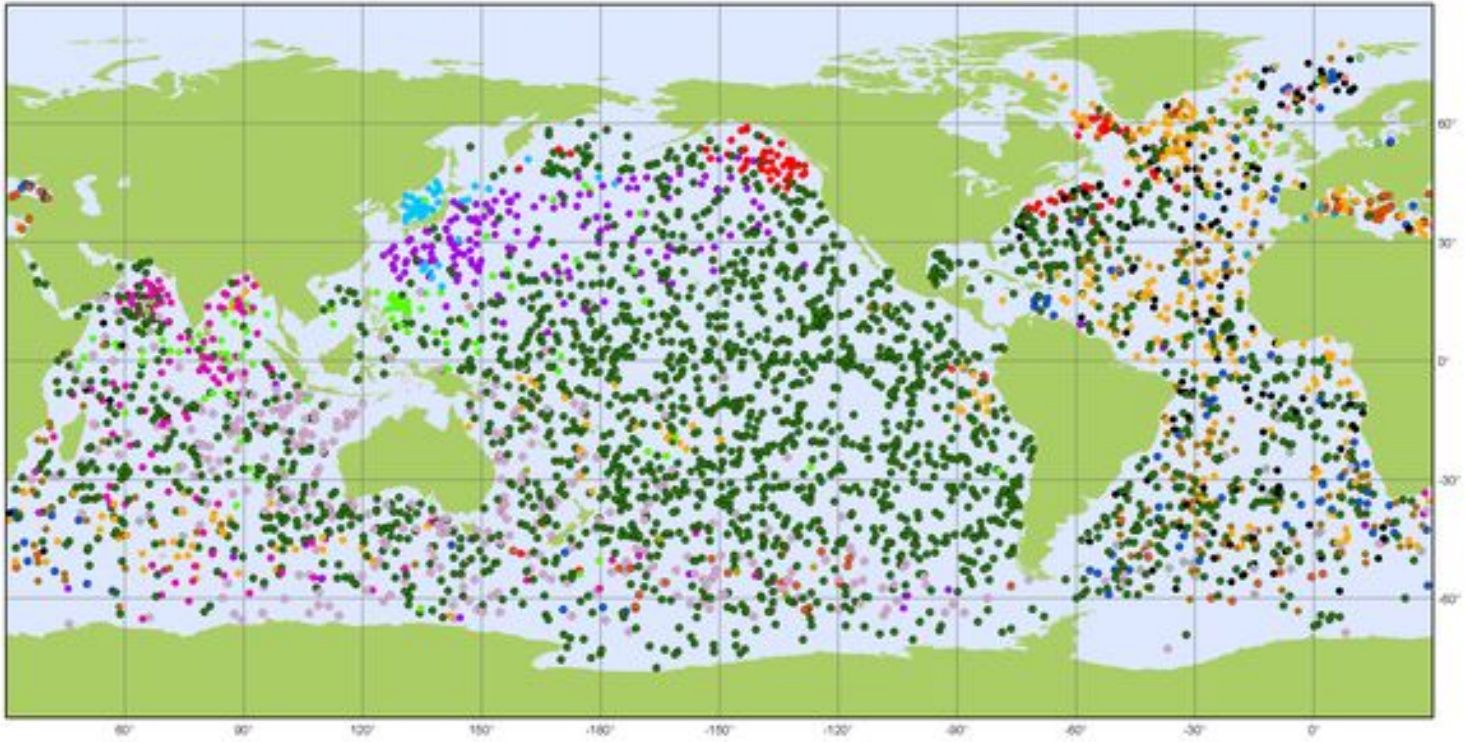

TIDE HOUSE
GOES ANTENNA
DATA LOGGER
PRIMARY DATA COLLECTION PLATFORM
BACKUP DATA COLLECTION PLATFORM
ACOUSTIC SENSOR
PROTECTIVE WELL
CALIBRATION/SOUNDING TUBE
INSTANTANEOUS WATER LEVEL INSIDE WELL
WAVES
MEAN WATER LEVEL
PRESSURE SENSOR


8761724 Grand Isle, Louisiana
9.03 +/- 0.46 mm/yr
Linear Mean Sea Level Trend
Upper 95% Confidence Interval
Lower 95% Confidence Interval
Monthly mean sea level with the average seasonal cycle removed
Meters
0.30
0.15
0.00
-0.15
-0.30
-0.45
-0.60
-0.75
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020


9452210 Juneau, Alaska
-13.16 +/- 0.36 mm/yr
Linear Mean Sea Level Trend
Upper 95% Confidence Interval
Lower 95% Confidence Interval
Monthly mean sea level with the average seasonal cycle removed
Meters
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
-0.15
-0.30
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

Argo


GPS/
Iridium
CTD module
Oxygen
pH
Nitrate
depth
1000
meters
2000
meters
Bio-
Optics



Argo

National contributions - 3881 Operational Floats

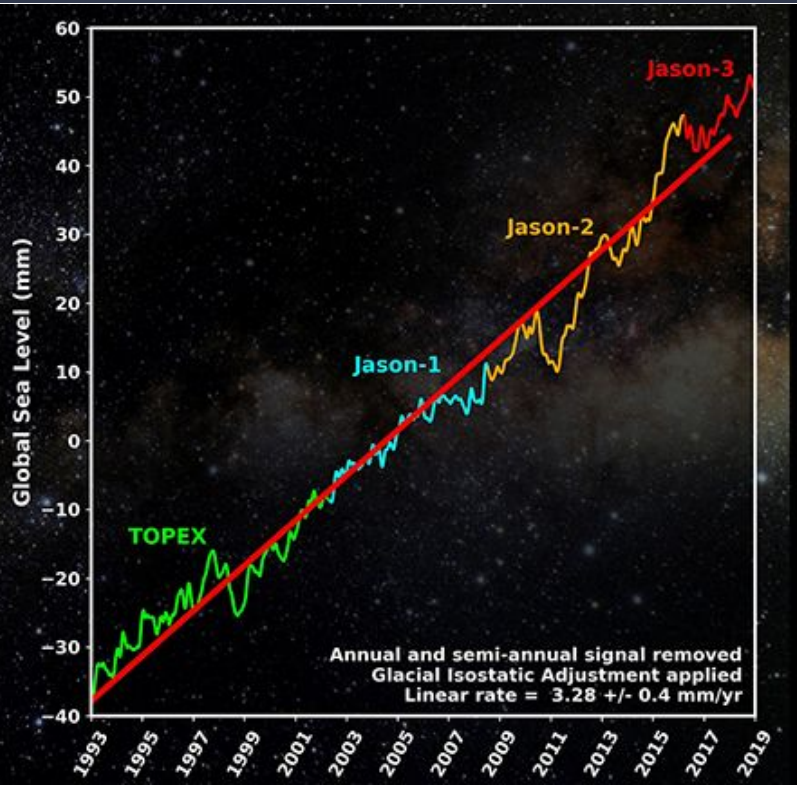
Latest location of operational floats (data distributed within the last 30 days)

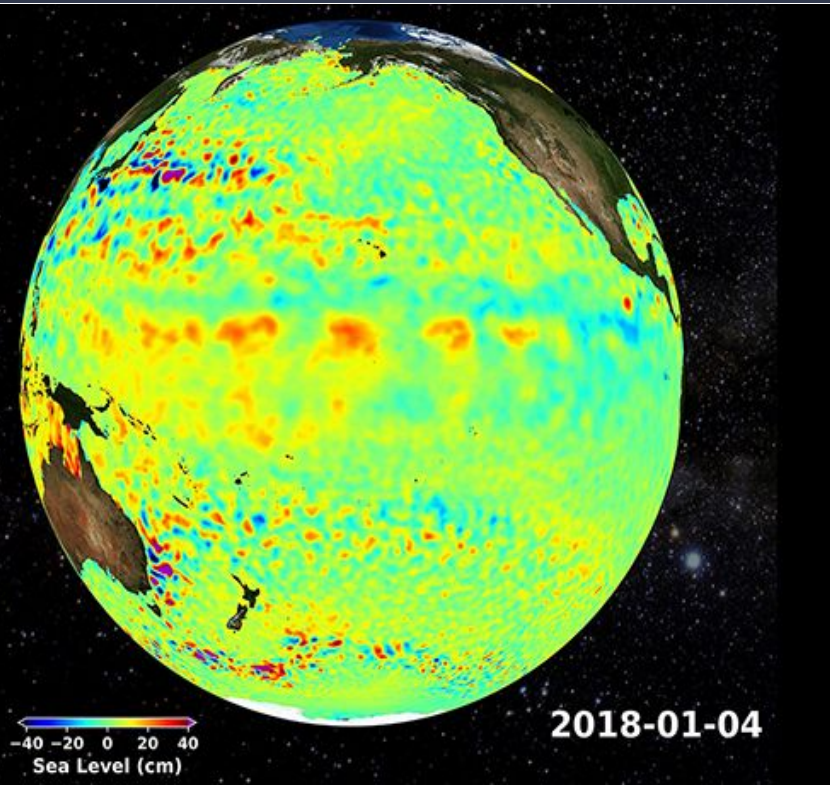
February 2018

- ARGENTINA (1)
- AUSTRALIA (361)
- BRAZIL (3)
- CANADA (87)
- CHINA (105)
- EUROPE (94)
- FINLAND (3)
- FRANCE (277)
- GERMANY (142)
- GREECE (2)
- INDIA (124)
- INDONESIA (1)
- IRELAND (12)
- ITALY (65)
- JAPAN (156)
- KENYA (1)
- MEXICO (2)
- NETHERLANDS (24)
- NEW ZEALAND (6)
- NORWAY (7)
- PERU (3)
- POLAND (5)
- KOREA, REPUBLIC OF (53)
- SPAIN (5)
- UK (163)
- USA (2179)

Generated by www.jcommops.org, 02/03/2018

Satellite Altimetry





NASA Missions Studying Water


Aqua


CloudSat


GPM


GRACE-FO


ICESat-2


ISS-RapidScat


Jason-3


Jason-CS/Sentinel-6


OSTM (Jason-2)

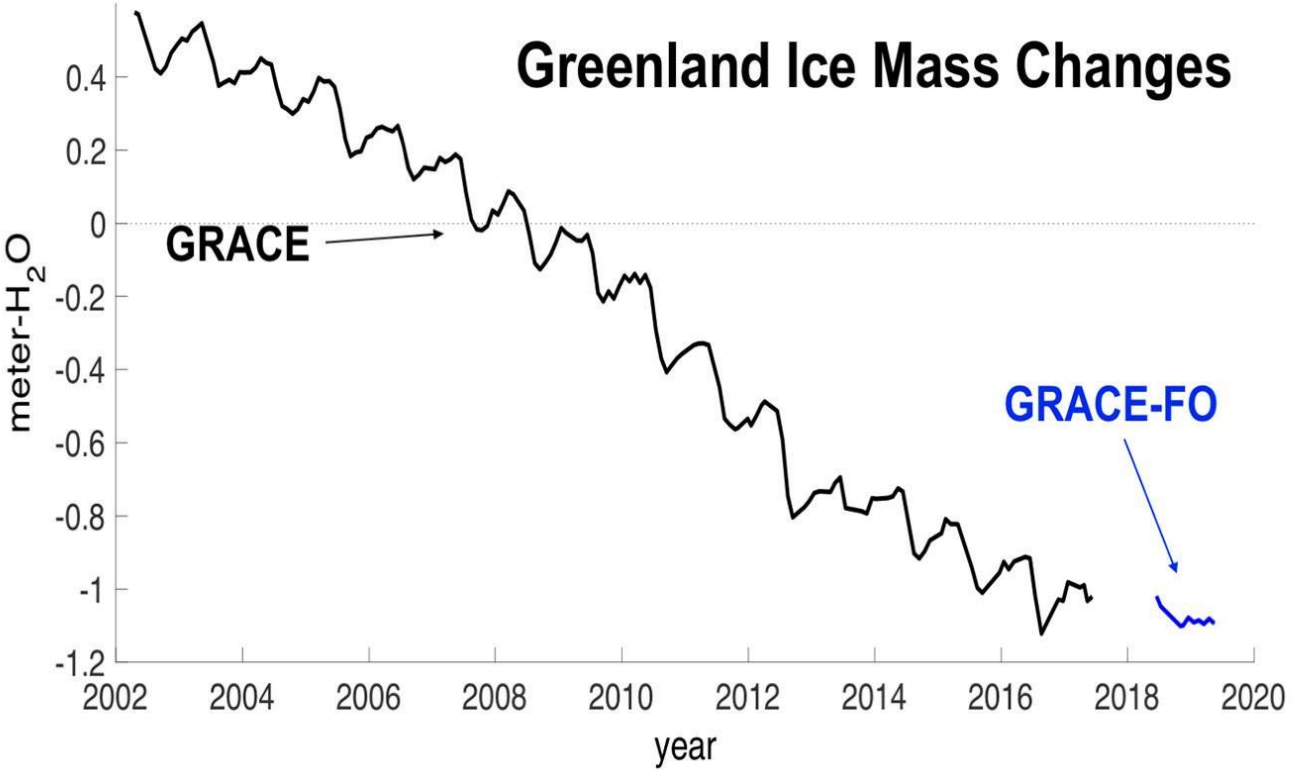

Raincube


SMAP

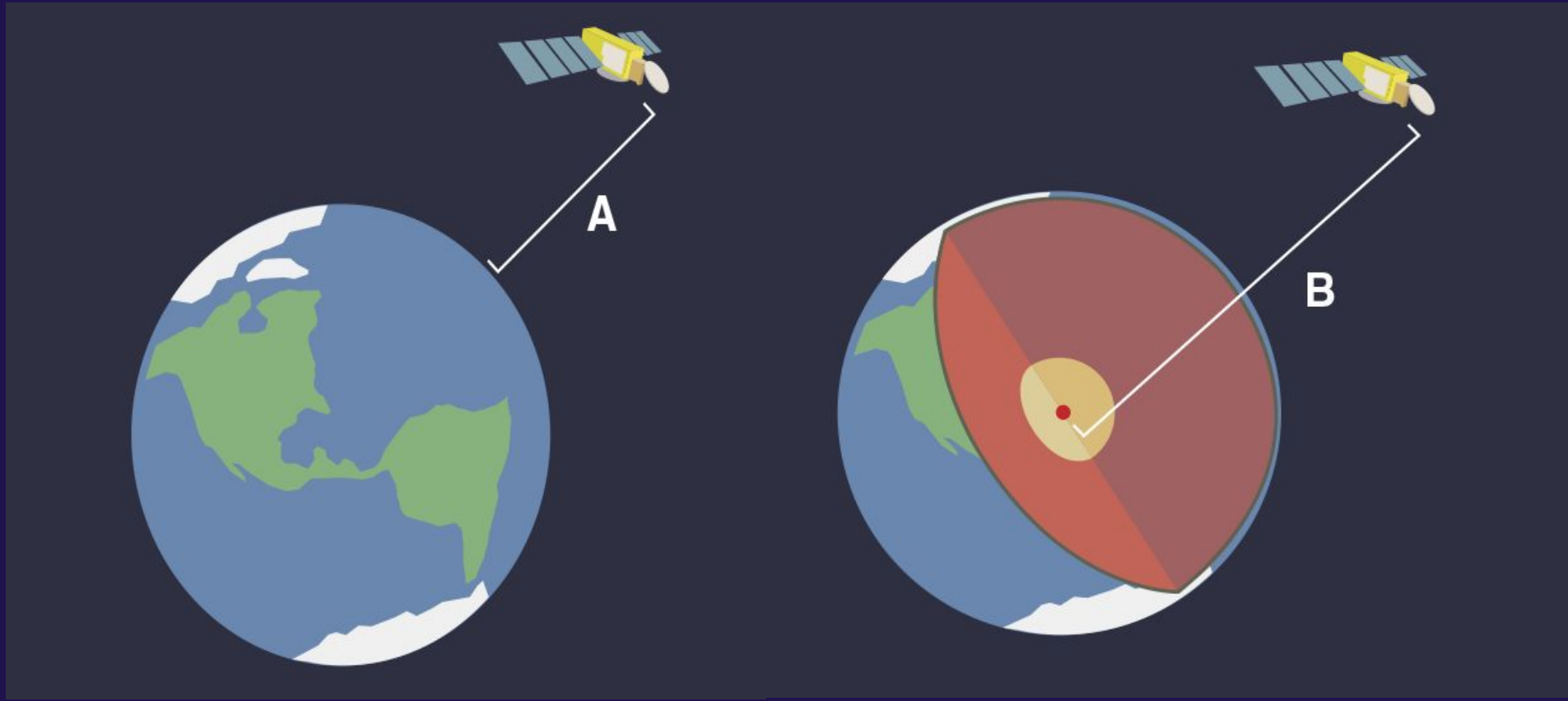

Suomi NPP

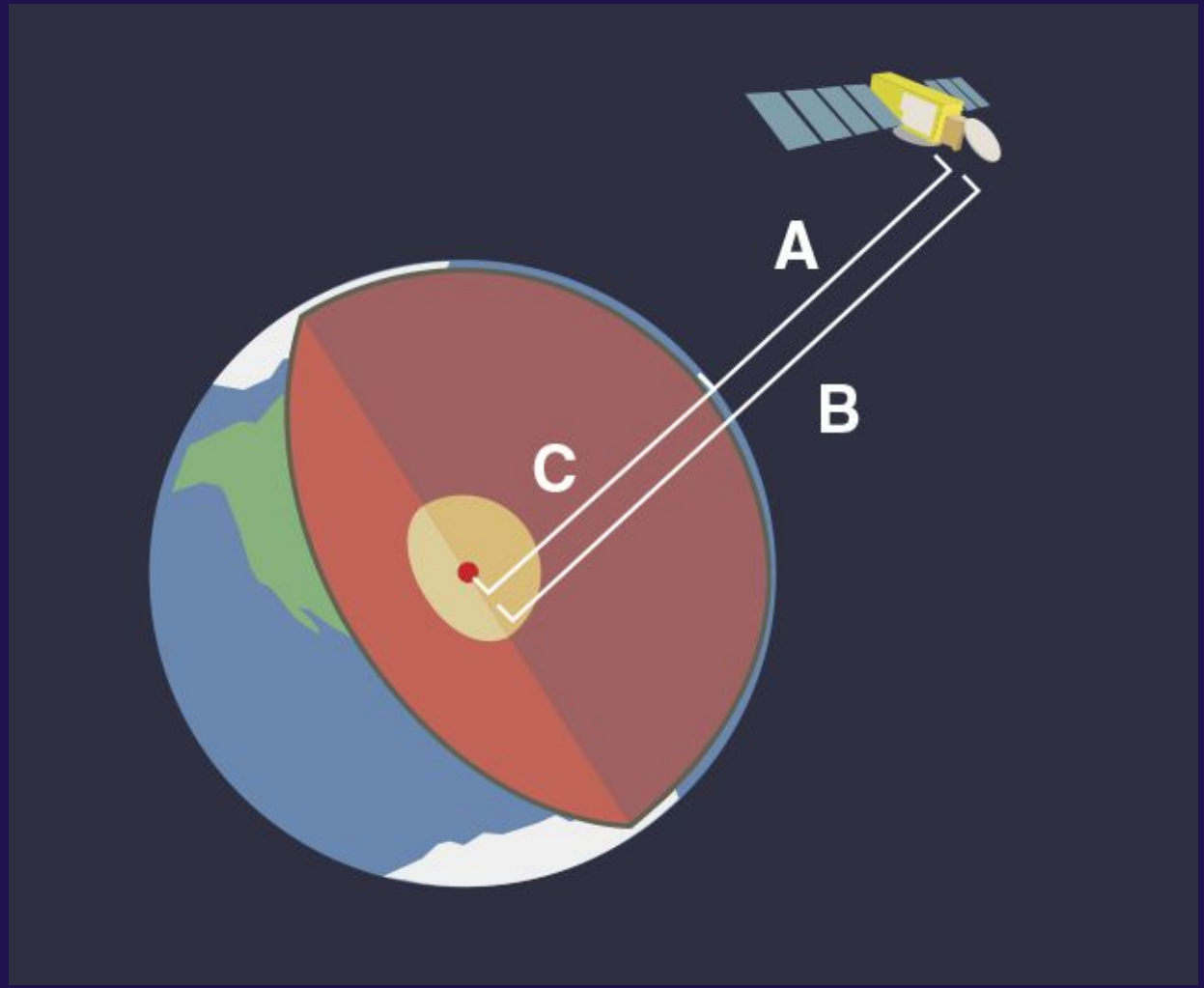

Terra

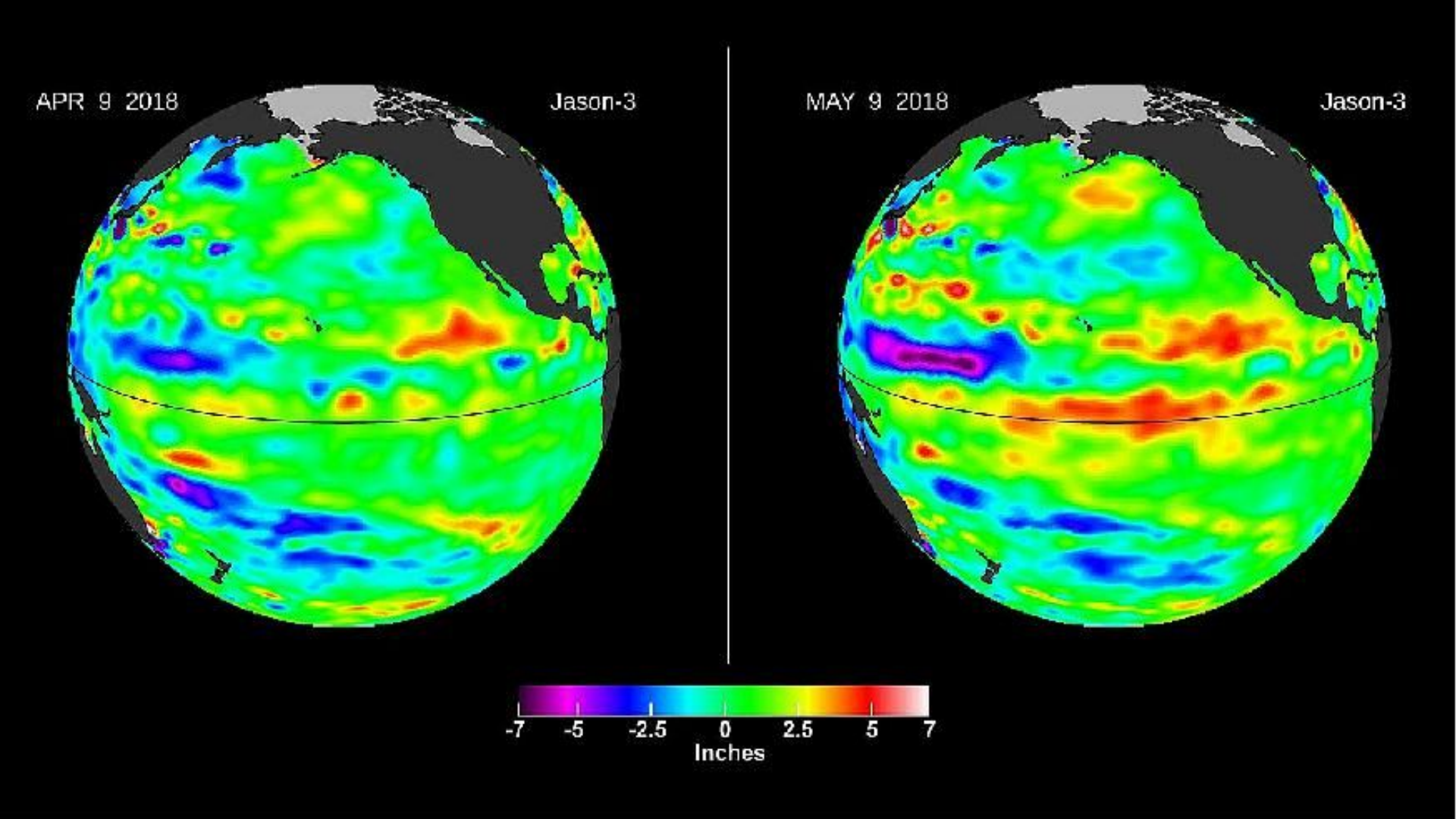
Grace-FO


Greenland Ice Mass Changes
GRACE
GRACE-FO
meter-H2O
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
year

Jason 3




A
B
C


APR 9 2018
Jason-3
MAY 9 2018
Jason-3
-7
-5
-2.5
0
2.5
5
7
Inches

Causes

Jieun Park

Thermal expansion
Ice melt
Land water storage

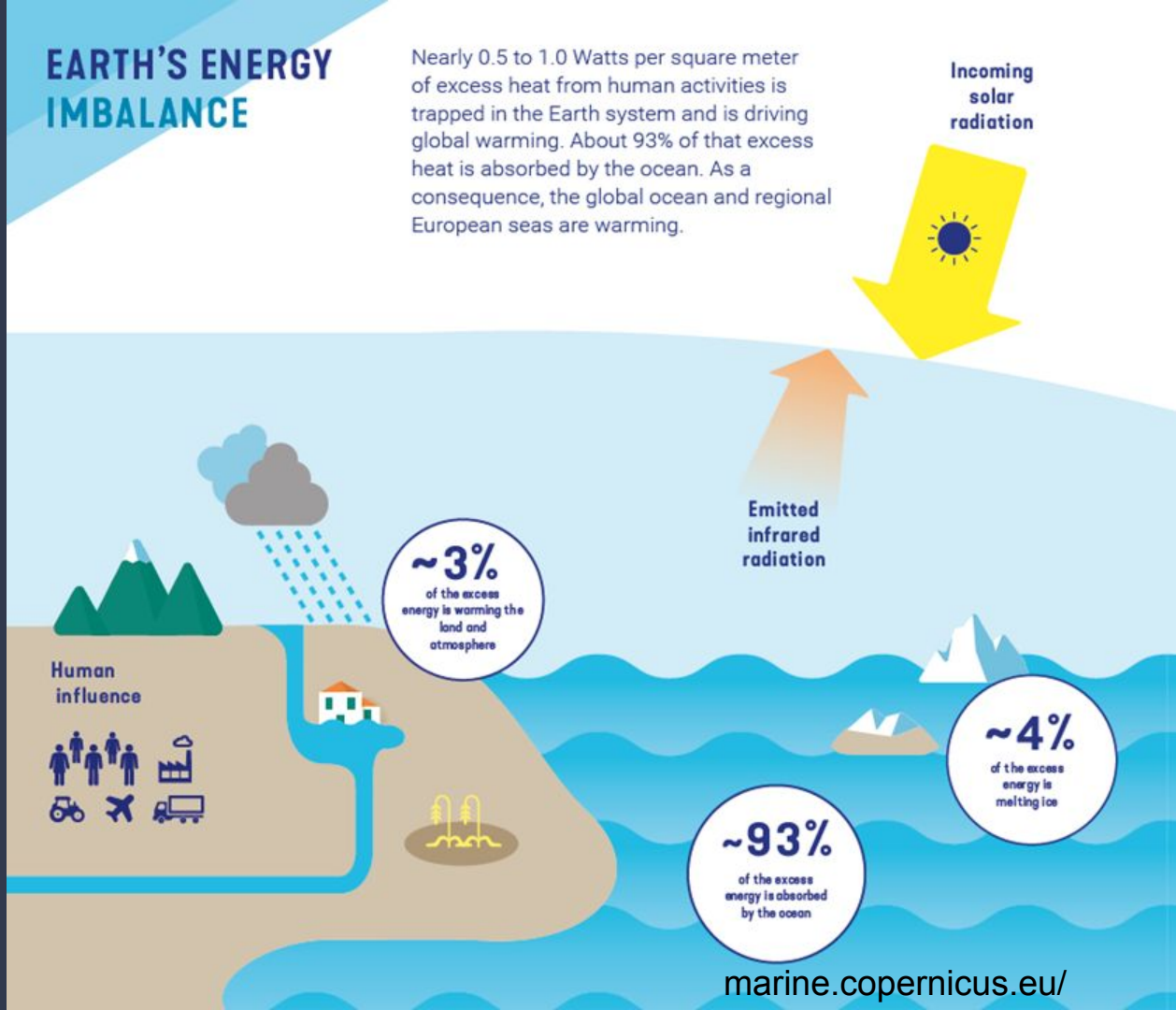
Causes

Thermal expansion

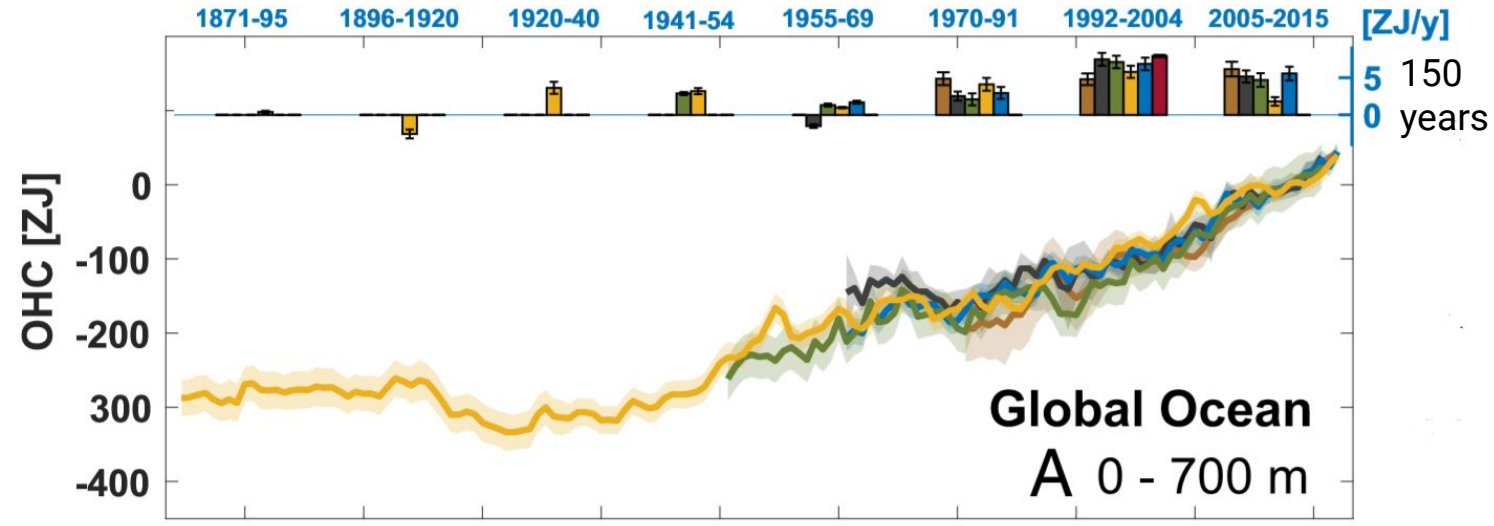
Ice melt

Land water storage

Do you know how much of heat has absorbed by the ocean?



93%



Ocean Heat Content (OHC)

NAS

Global reconstruction of historical ocean heat storage and transport

Laure Zanna[a,1], Samar Khatiwala[b], Jonathan M. Gregory[c,d], Jonathan Ison[a], and Patrick Heimbach[e,f]

[a]Department of Physics, University of Oxford, Oxford OX1 3PU, United Kingdom; [b]Department of Earth Sciences, University of Oxford, Oxford OX1 3AN, United Kingdom; [c]Met Office Hadley Centre, Exeter EX1 3PB, United Kingdom; [d]National Centre for Atmospheric Science–Climate, University of Reading, Reading RG6 6BB, United Kingdom; [e]Institute for Computational Engineering and Sciences, The University of Texas at Austin, Austin, TX 78712; and

2018 (received for review June

$436 \times 10^{21} J$

=1000 times of world annual Energy usage

(150 years)

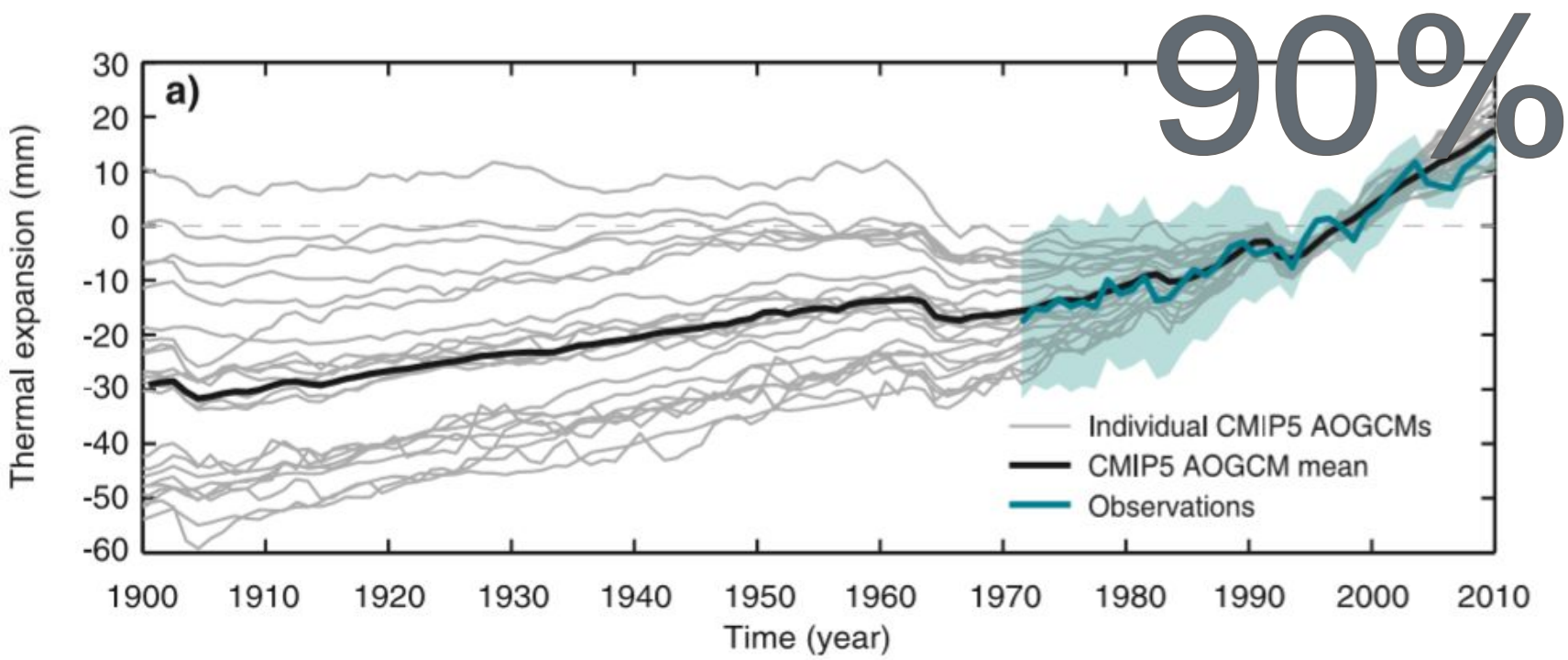
Thermal Expansion _ Experiment

The change of movement of Water molecule

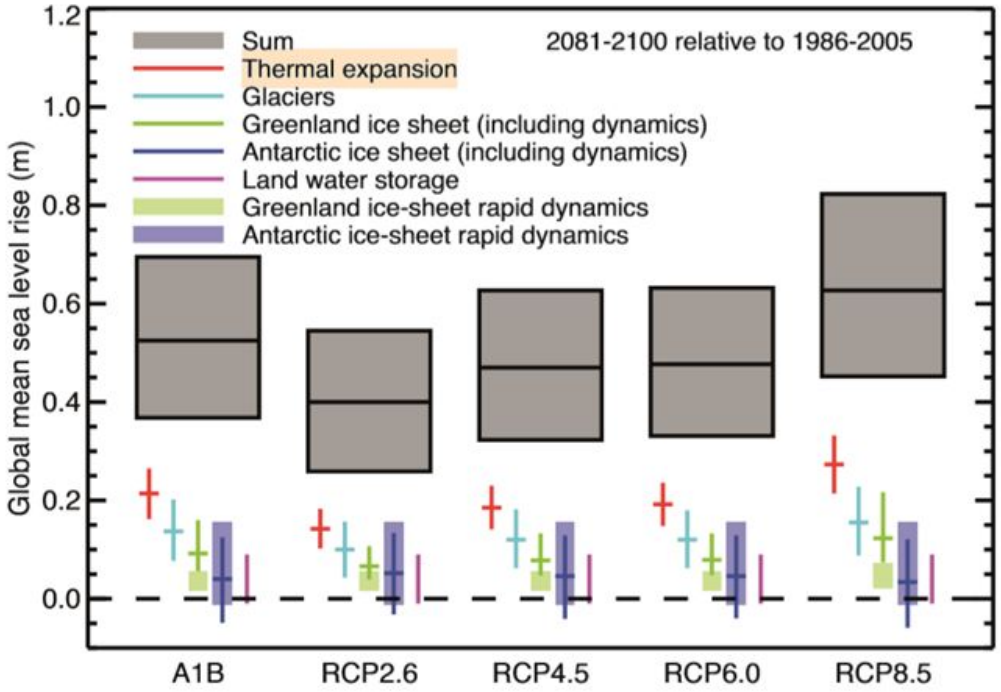
Thermal Expansion _ Experiment

The change of the water level

Contributions to Global Mean Sea Level Rise During the Instrumental Period



Projected Contributions to Global Mean Sea Level



1/3

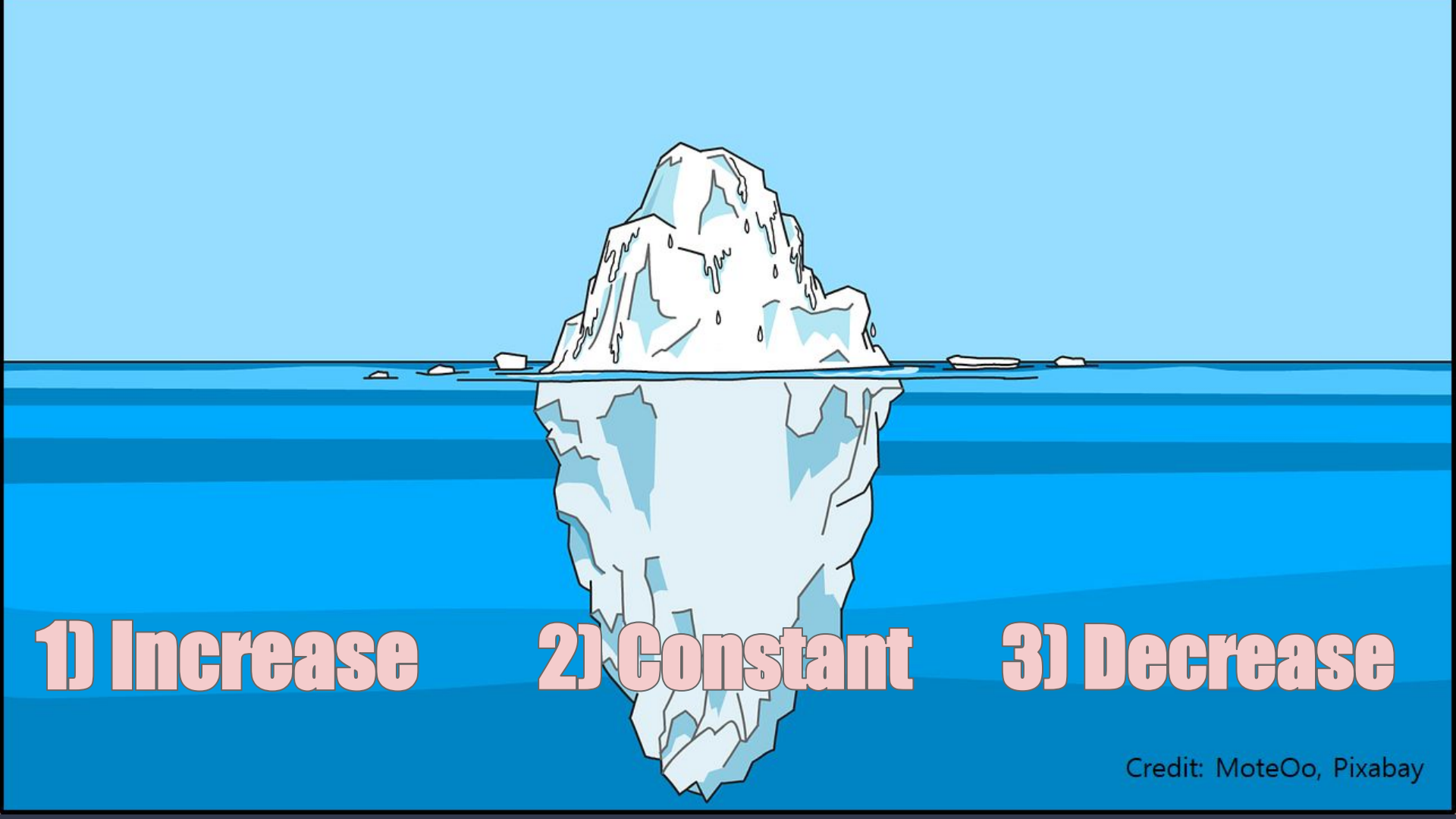
For the highest scenario (RCP8.5), GMSL rise due to thermal expansion can exceed 2 m above the pre-industrial level by the year 2500

Causes

Thermal expansion

Ice melt

Land water storage


1) Increase
2) Constant
3) Decrease
Credit: MoteOo, Pixabay

Ice Melt _Experiment

sealevelrise.org

Glacier

Ice Sheet

Ice Shelf

Iceberg

Different Kinds of Ice

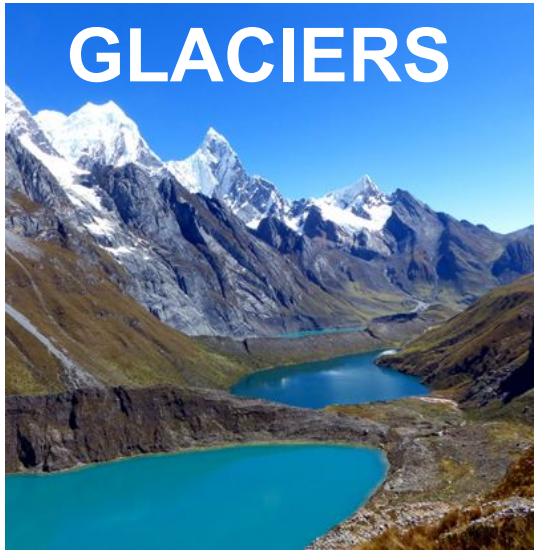
Glacier

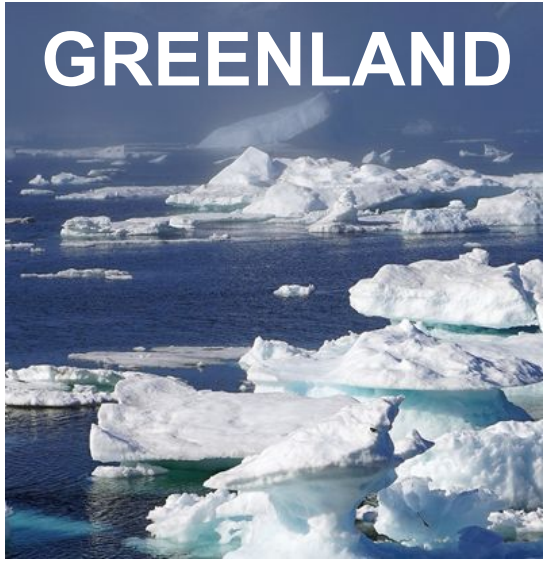
Ice Sheet

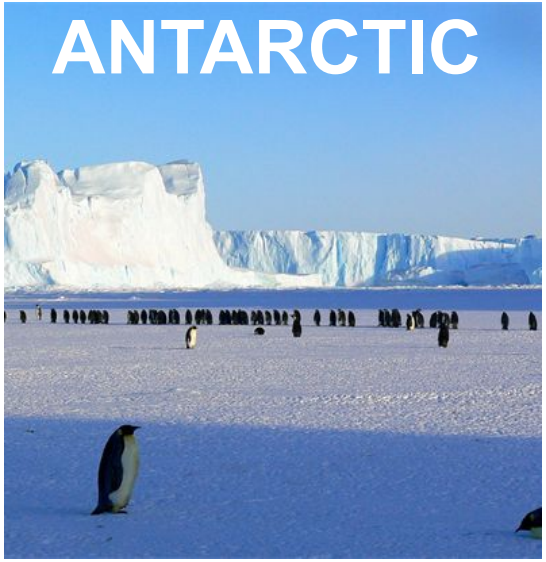
Ice Shelf

Iceberg

Most Significant Contributions of Ice Melt





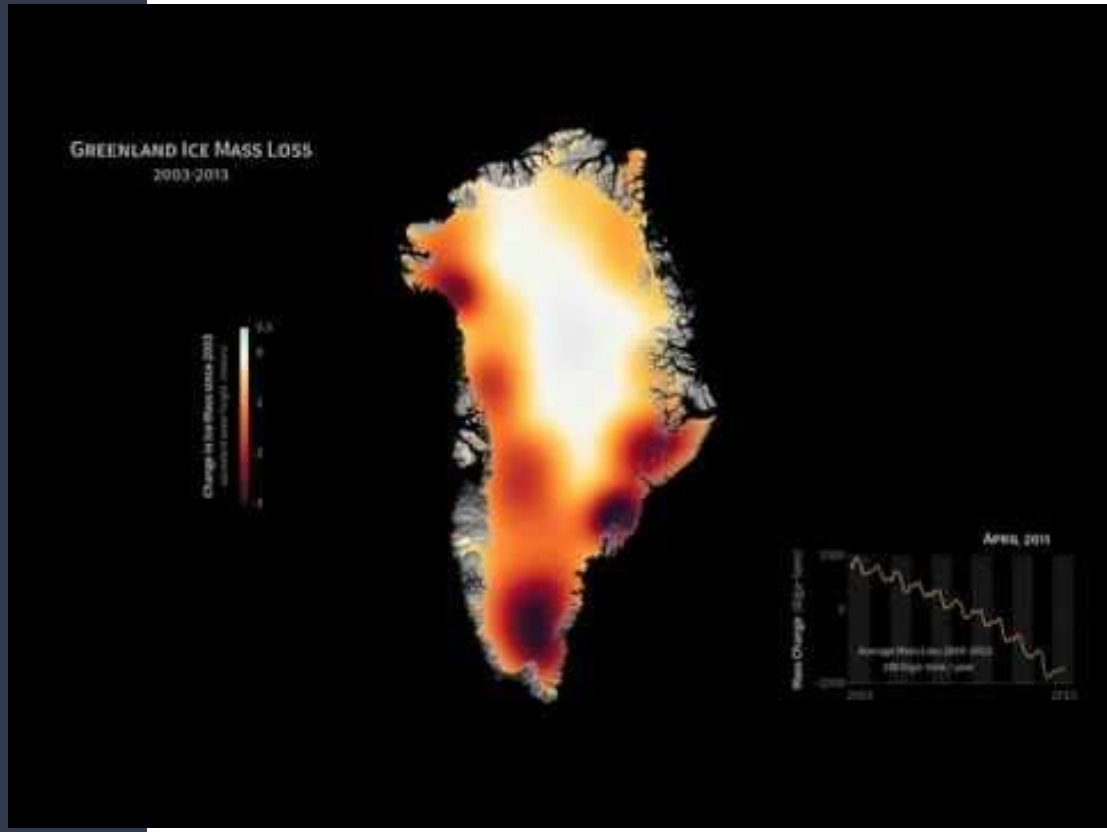


Greenland Ice Mass Loss

August 1, 2019

The loss of 12.5 billion tons of ice in 24 hours was the largest since advance measurements began in 1950.

Forbes

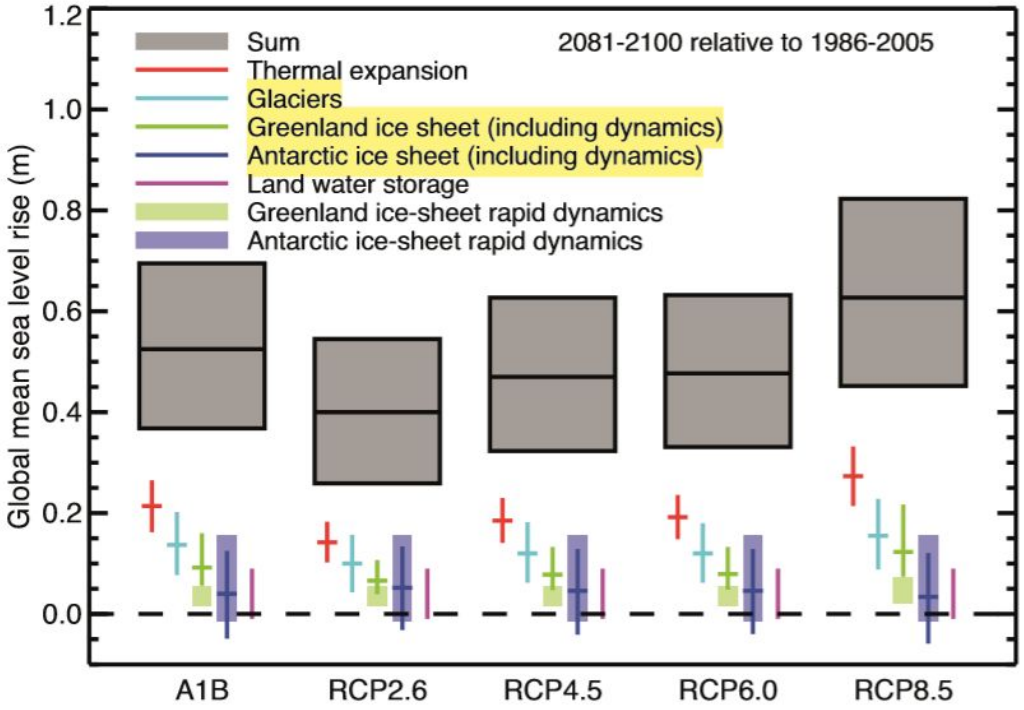


Greenland Ice Mass Loss

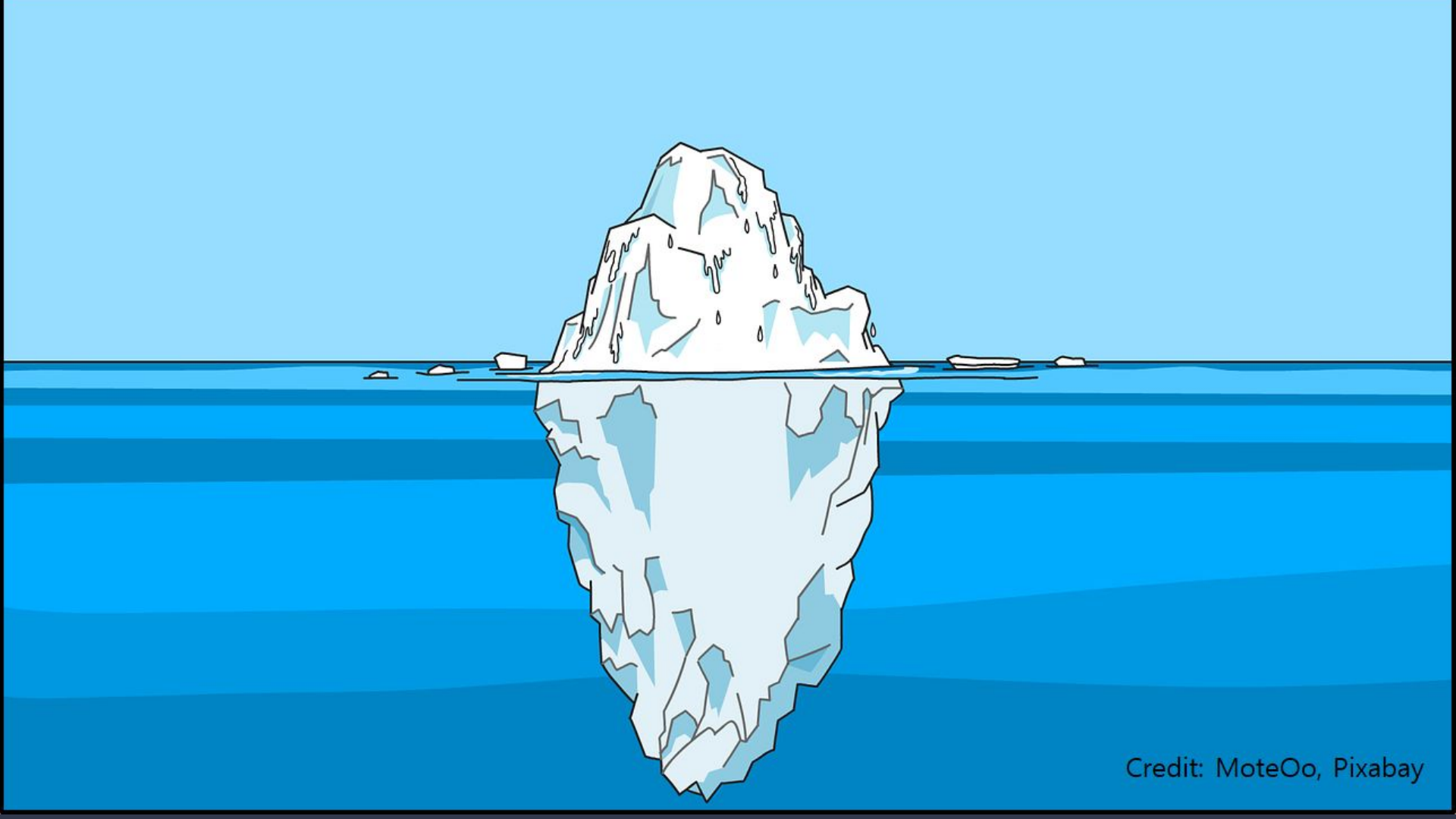
Ice melt of greenland
= 12.5 billion tons/day
Empire building = 365,000 tons

⇒ 34,000 empire buildings/day

Projected Contributions to Global Mean Sea Level



2/3


Credit: MoteOo, Pixabay


Kurzgesagt – In a Nutshell

Causes

Thermal expansion

Ice melt

Land water storage

Land Subsidence

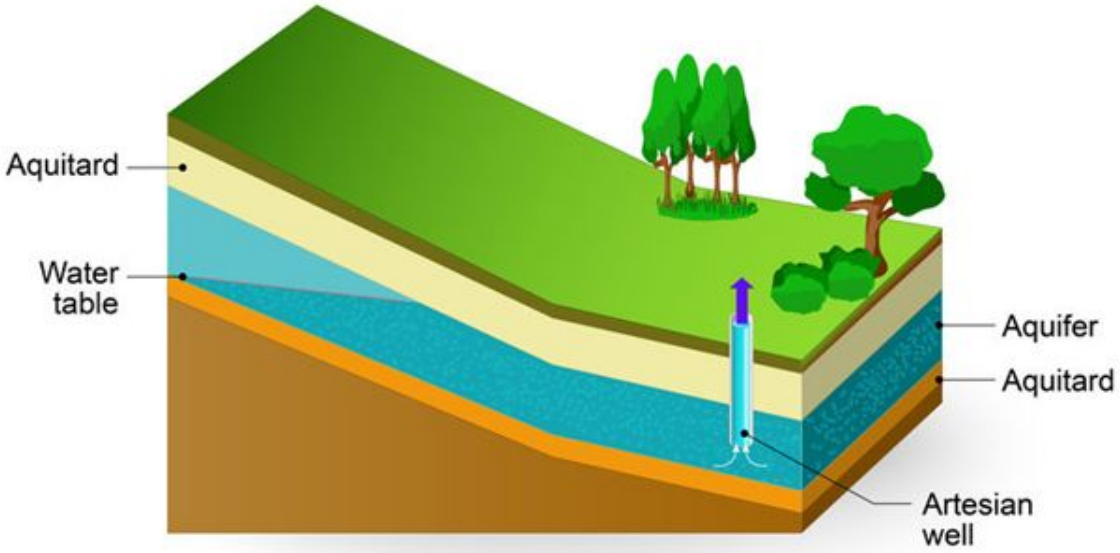
Land subsidence in California - Approximate location of maximum subsidence in the United States.

Signs on pole show approximate altitude of land surface in 1925, 1955, and 1977. The site is in the San Joaquin Valley southwest of Mendota, California.

Dr. Joseph F. Poland (pictured)

Czuber, Dreamstime.com

Groundwater depletion



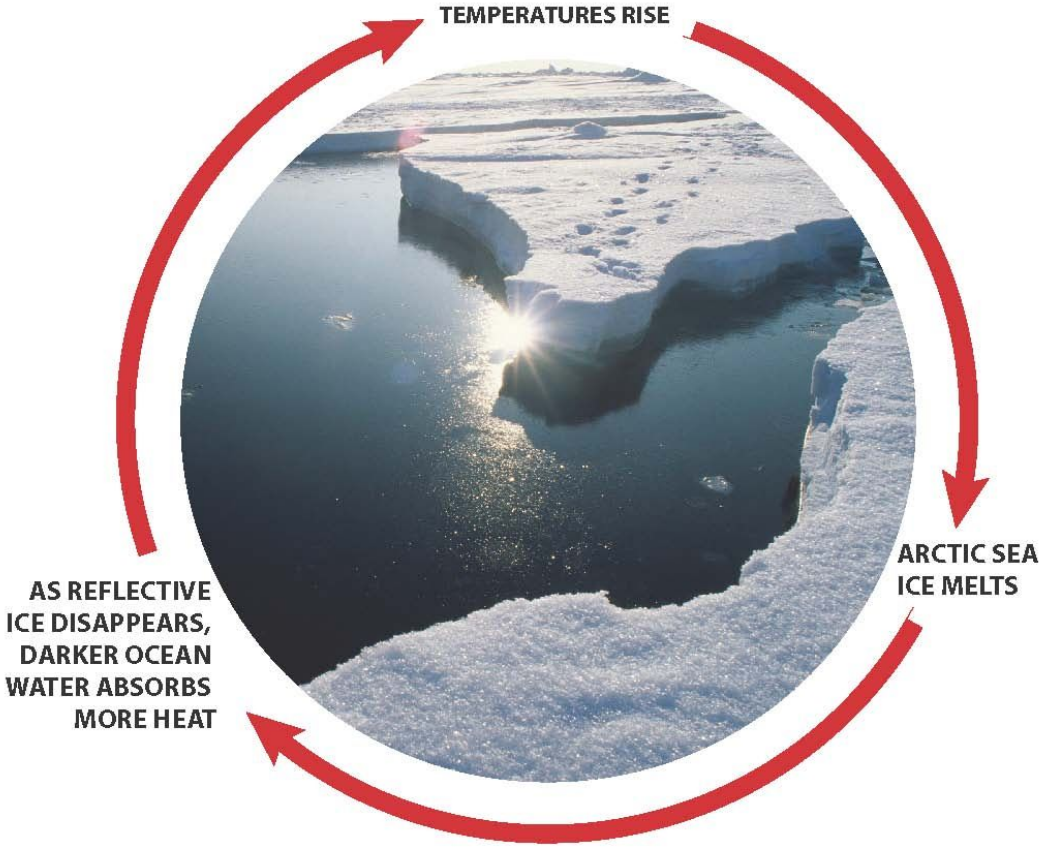
Ground Water Consultants, LLC – Katy

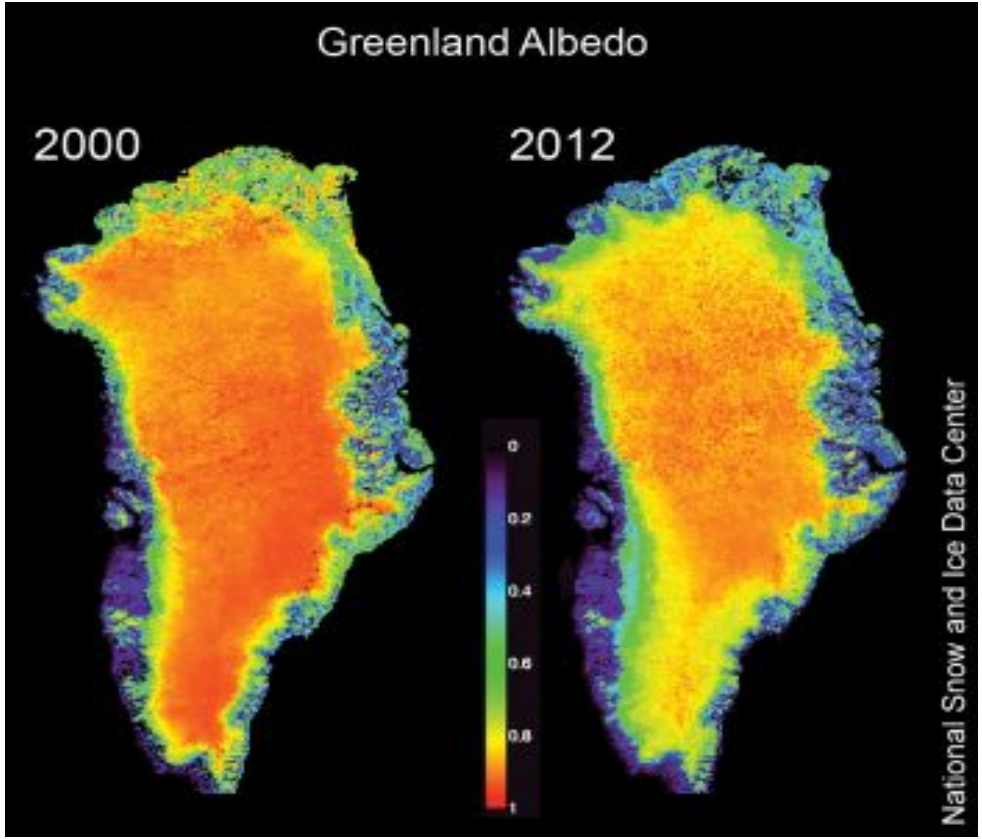
Causes

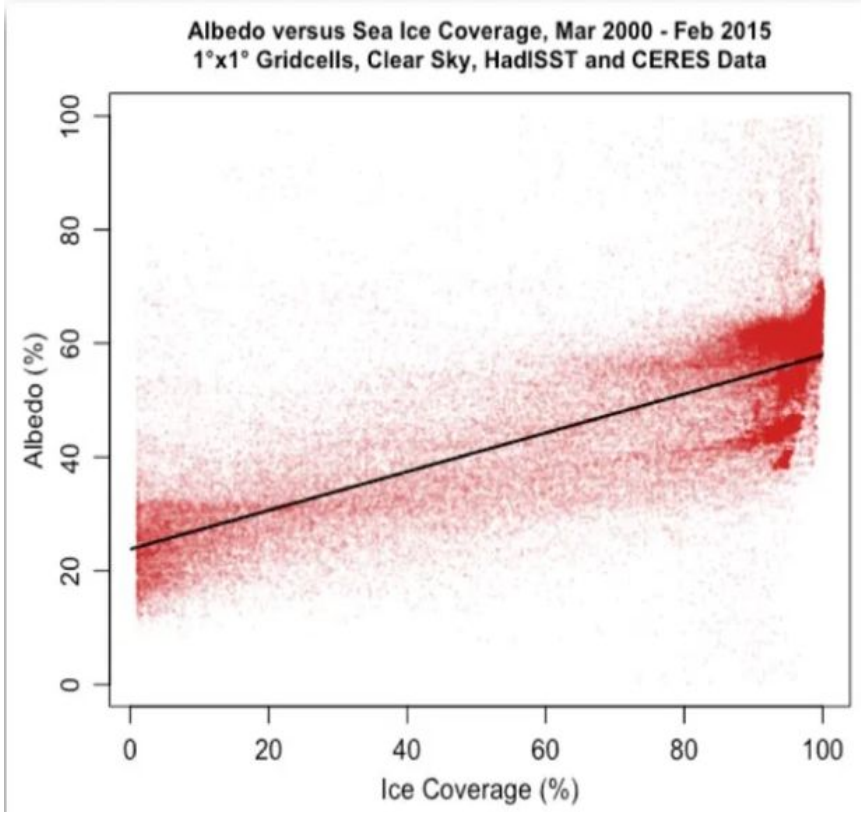
Jieun Park

Thermal expansion
Ice melt
Land water storage

Ice-albedo feedback




Greenland Albedo
2000
2012
0
0.2
0.4
0.6
0.8
1
National Snow and Ice Data Center


Albedo versus Sea Ice Coverage, Mar 2000 - Feb 2015
1°x1° Gridcells, Clear Sky, HadISST and CERES Data
Albedo (%)
0
20
40
60
80
100
Ice Coverage (%)
0
20
40
60
80
100

consequences

coastal area

human

wildlife

threaten wildlife population

change coastal plant life

Causing soil erosion and threatening farmland

Heavy rains

strong winds

Disappearance of some countries

1. New york
2. Bambei
3. Londan
4. Shanghai
5. Mexico city
6. Amsterdam
7. Hinson
8. Rio de janeiro
9. Venice
10. Bangkok

Hurt the economy

Mitigation & Adaptation

200 000 000

PEOPLE THREATENED BY COASTAL FLOODS TODAY

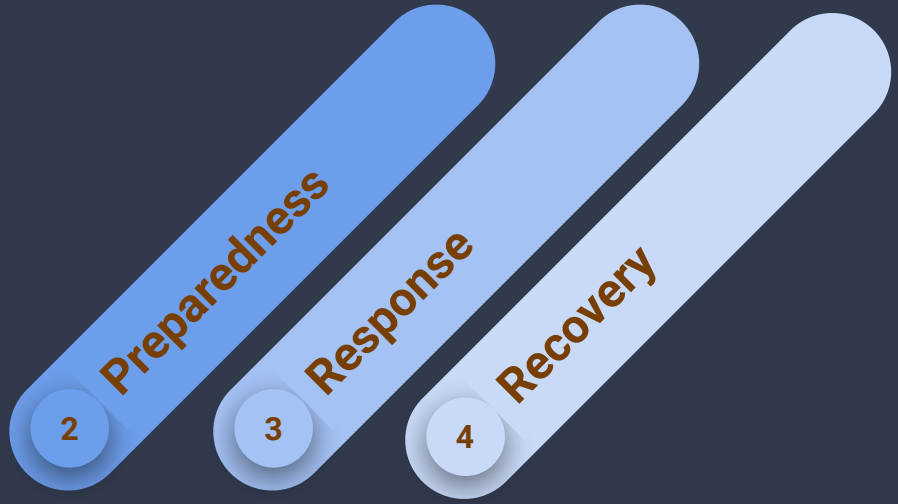

THREATED INFRASTRUCTURE ESTIMATED TO COST
1 TRILLION USD

Mitigatoin

the action of reducing the severity, seriousness, or painfulness of something

The Four Phases of Emergency Management

- prevent an emergency
- reduce the damaging effects of unavoidable emergencies.
- insurance



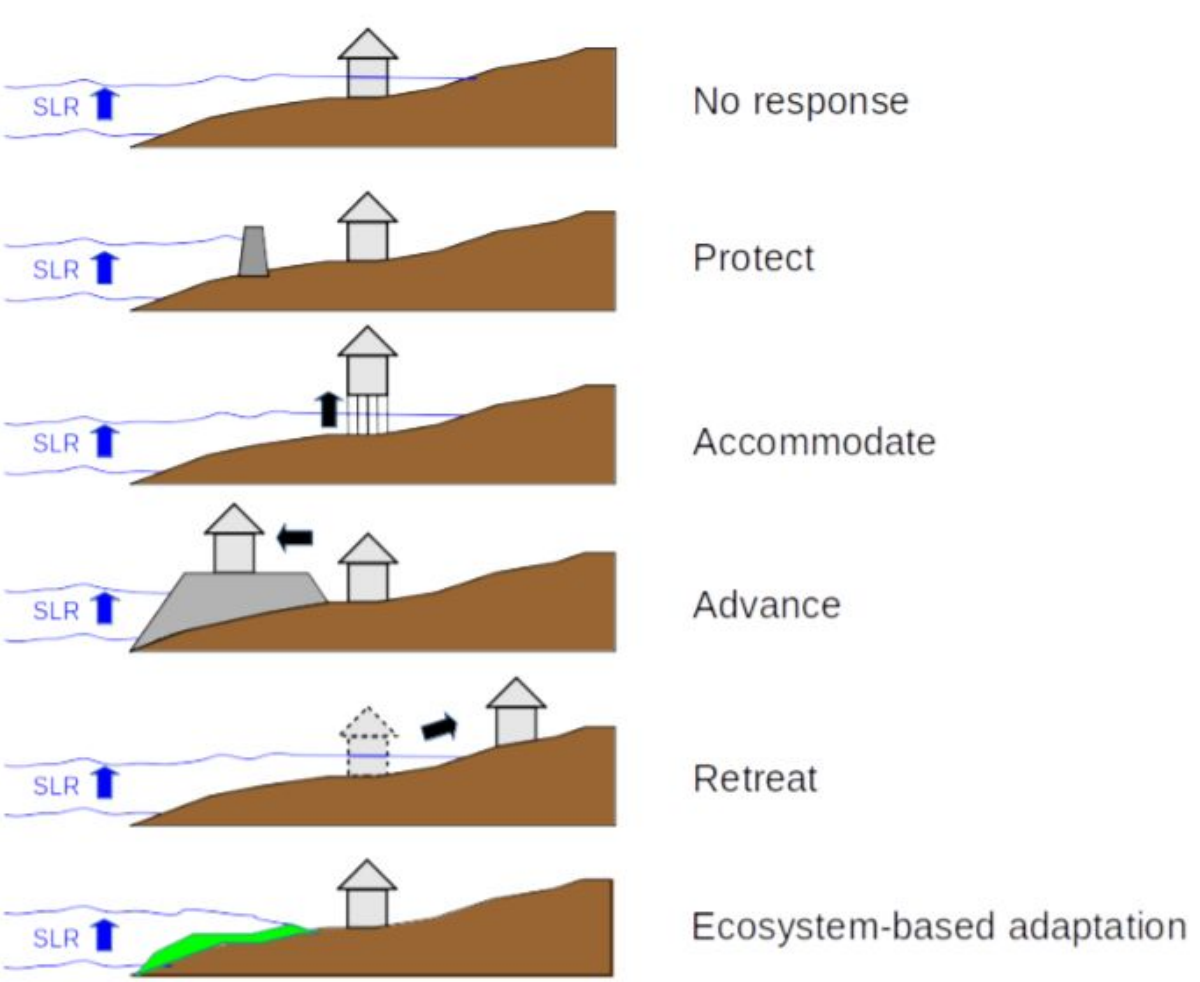
Mitigation activities take place **before** and **after** emergencies.

Sea level rise mitigation
=
Climate change mitigation

the policy

Responses to Sea-Level Rise

by IPCC



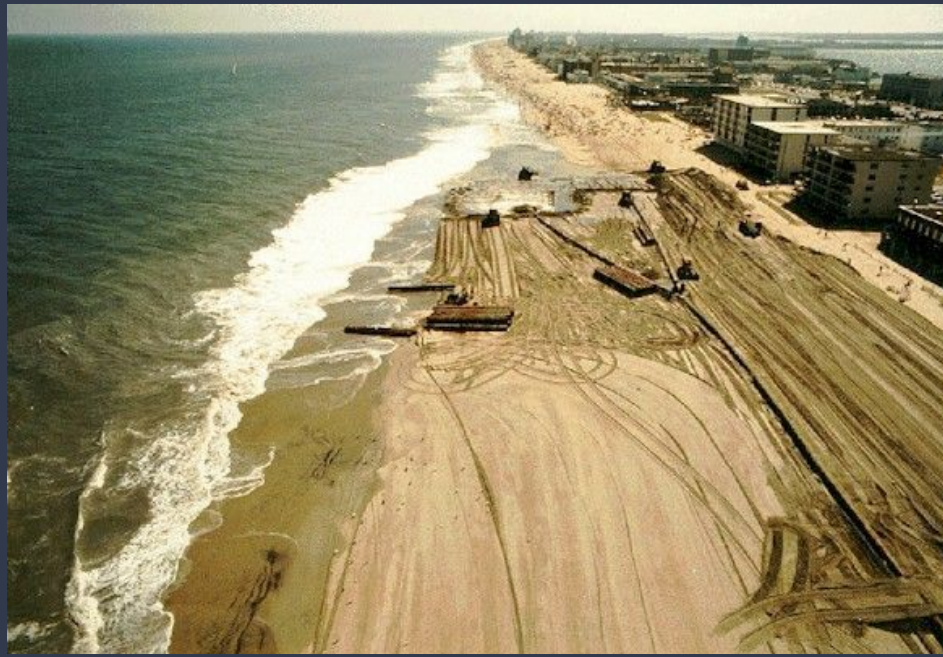
Box 4.3, Figure 1: Different types of responses to coastal risk and SLR

Protection

Hard protection

dikes, seawalls, breakwaters, barriers and barrages

Sediment based protection



beach and shore nourishment, dunes

Accommodation

raising house elevation | lifting valuables to higher floors | and floating houses and gardens
rice to brackish/salt shrimp aquaculture or changes to salt tolerant crop varieties.
Institutional accommodation responses include early warning systems, emergency planning, insurance schemes, and setback zones

Advance

creates new land

Policy lever	Information provision	Regulatory/economic instruments	Dedicated national funding	Monitoring and evaluation
Description	e.g. climate modelling, impact, vulnerability, and/or risk assessments, guidance and tools for other levels of government, business and citizens	e.g. land-use planning, building regulations, coastal protection infrastructure standards, economic incentives for risk reduction	e.g. funding of investment in risk reduction; funding for household-level protection measures	e.g. stakeholder surveys, quantitative and qualitative indicators measuring climate effects, policy process and policy outcome
Australia	•	–	–	•
Belgium	•	–	–	•
Canada	•	•	•	•
Chile	•	–	–	•
Denmark	•	•	–	–
Estonia	•	•	–	•
Finland	•	•	–	•
France	•	•	•	•
Germany	•	•	•	•
Greece	•	–	–	–
Iceland*	–	–	–	–
Ireland	•	•	–	•
Israel	•	–	–	–
Italy	•	–	–	–
Japan	•	•	–	•
Korea	•	•	–	•
Latvia	•	–	–	–
Mexico	•	•	–	•
Netherlands	•	•	•	•
New Zealand**	•	–	–	–
Norway	•	–	–	•
Poland	•	•	–	•
Portugal	•	–	–	•
Slovenia	–	–	–	•
Spain	•	•	–	•
Sweden	•	•	•	•
Turkey	•	–	–	–
United Kingdom	•	•	•	•
United States*	•	–	–	–

Approaches to sea-level rise management mentioned in adaptation plans

OECD Countries

Retreat

Migration

voluntary

Displacement

involuntary

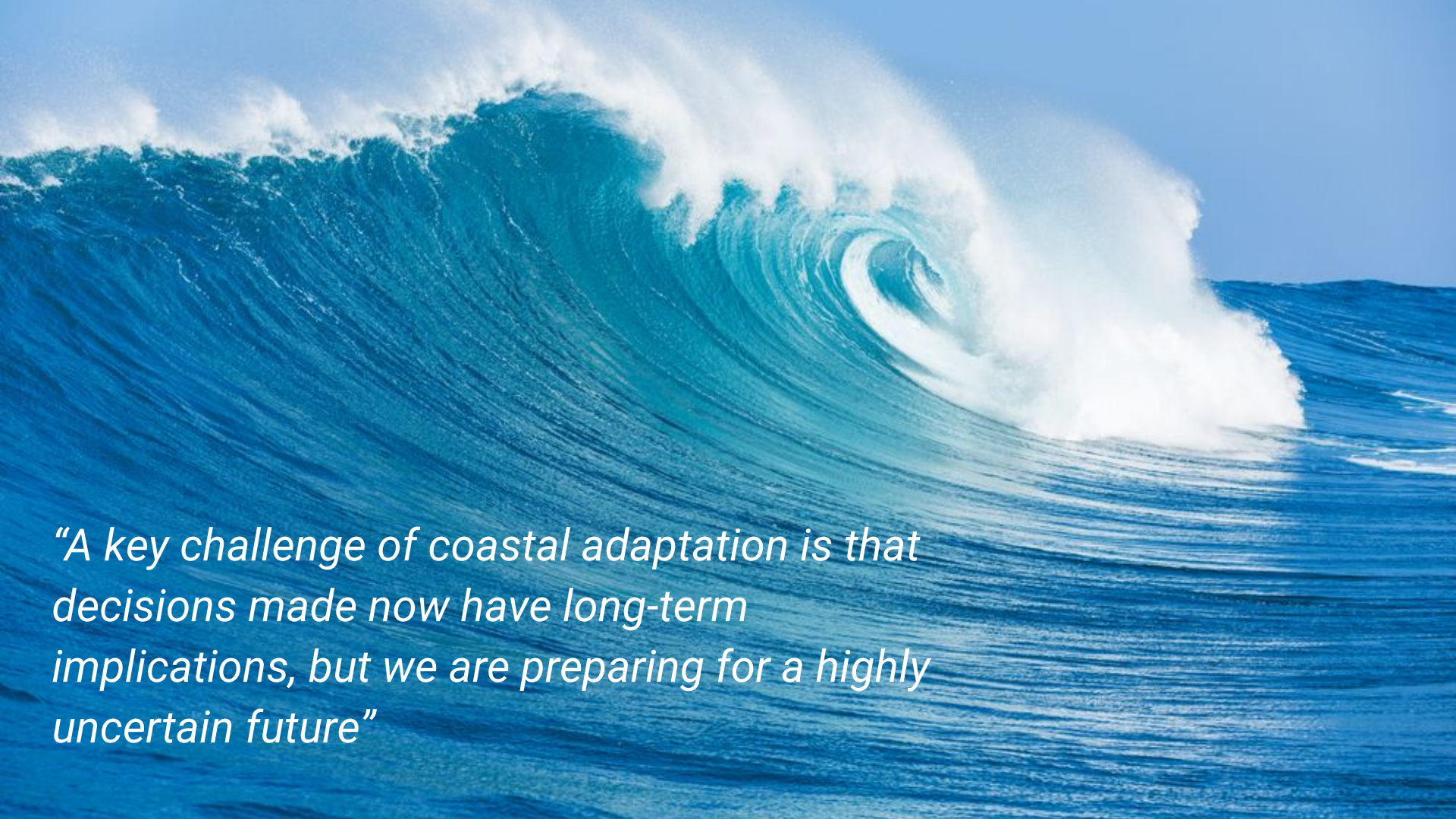
Relocation

supervised resettelment

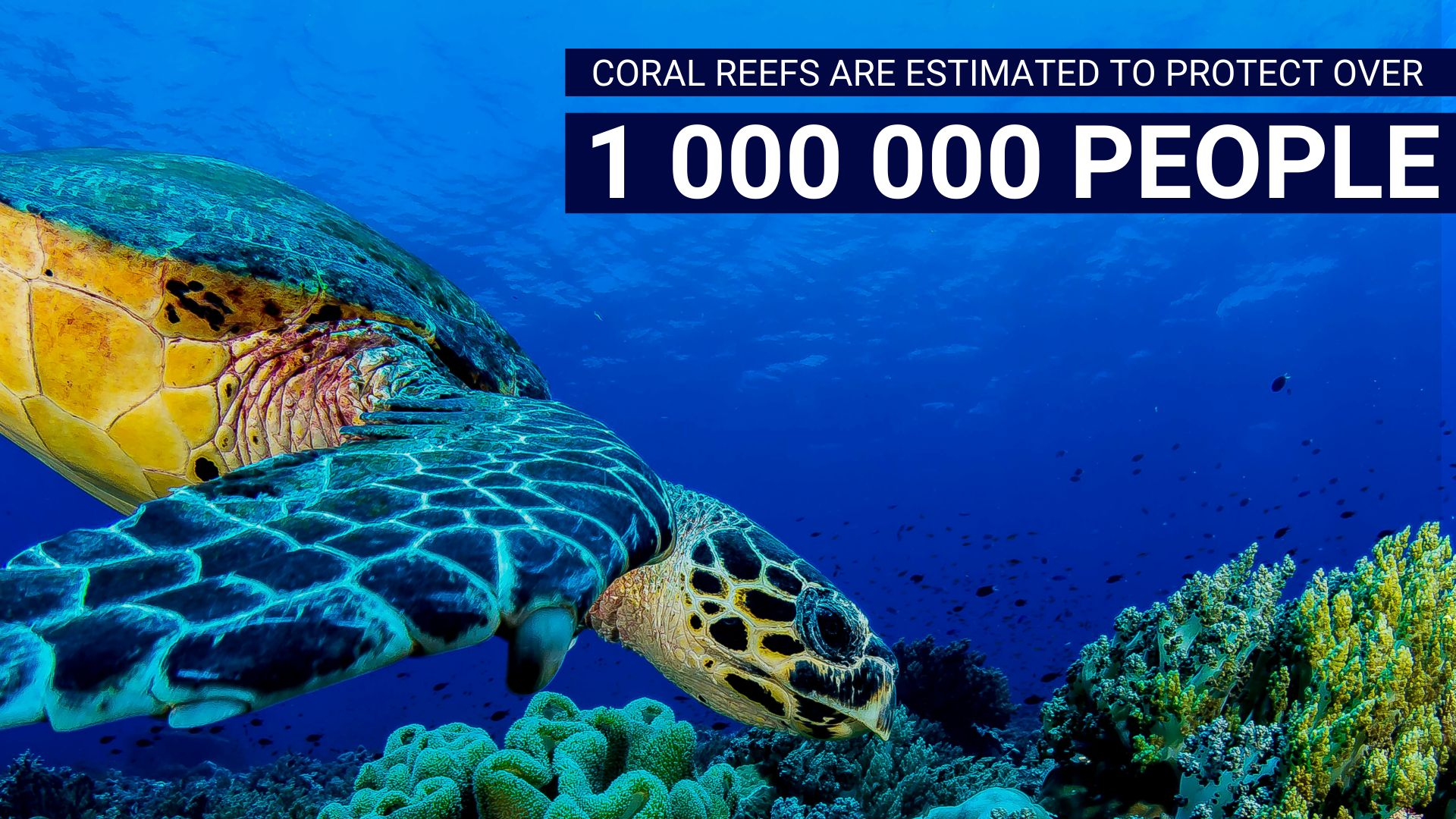
Ecosystem-based adaptation

Sustainable management, conservation, and restoration of ecosystems

Without adaptation, flood damage under higher-end sea-level rise of 1.3 metres would be equivalent to 4% of world GDP annually (USD 50 trillion)


“A key challenge of coastal adaptation is that decisions made now have long-term implications, but we are preparing for a highly uncertain future”


Coral Reefs
are awesome!


CORAL REEFS ARE ESTIMATED TO PROTECT OVER
1 000 000 PEOPLE


ANNUAL EXPECTED FLOOD DAMAGEREDUCTION
USD 400 MILLION

FOOD SECURITY THREATENED BY SEA-LEVEL RISE

Mitigatoin - examples

Switzerland

Every Year, the Swiss Cover Their Melting Glaciers in White Blankets

China

Sponge cities

The Netherlands

Maeslant Barrier

Florida

Upgrading Sewage Systems

Agriculture adaptation

Research on adaptation crops to more salty water

Dredging?

Related Sustainable Development Goals

Goal 1

No Poverty

Goal 2

Zero Hunger

Goal 3

Good Health and Well-Being

Goal 6

Clean Water and Sanitation

Goal 7

Affordable and Clean Energy

Goal 11

Sustainable Cities and Communities

Goal 12

Sustainable Consumption and Production

Goal 13

Climate Action

Goal 14

Life Below Water

Goal 15

Life on Land

Goal 16

Peace, Justice and Strong Institutions

Goal 17

Partnerships for the Goals

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