



Haus der Astronomie

SPACE

awareness

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Our fragile planet

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01

OUR FRAGILE PLANET

Overview

OUR PALE BLUE DOT



<http://www.hq.nasa.gov/office/pao/History/alsj/a410/AS8-14-2383HR.jpg>

Apollo 8, NASA/Bill Anders

OUR PALE BLUE DOT



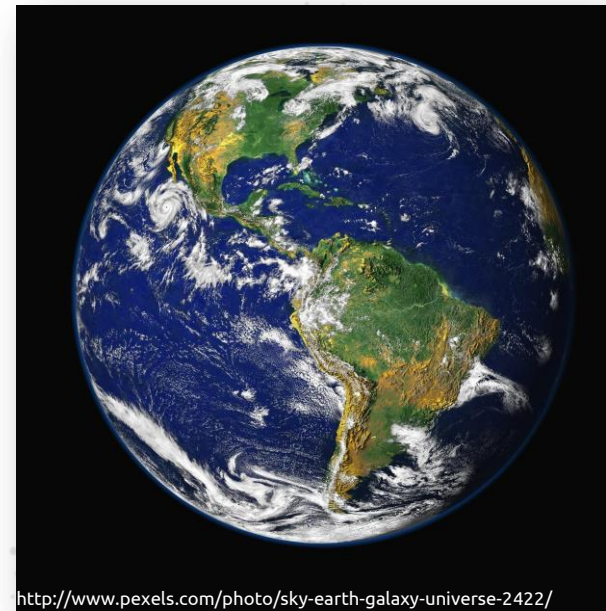
<http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA17171>

Cassini Orbiter, NASA/JPL

OUR FRAGILE PLANET

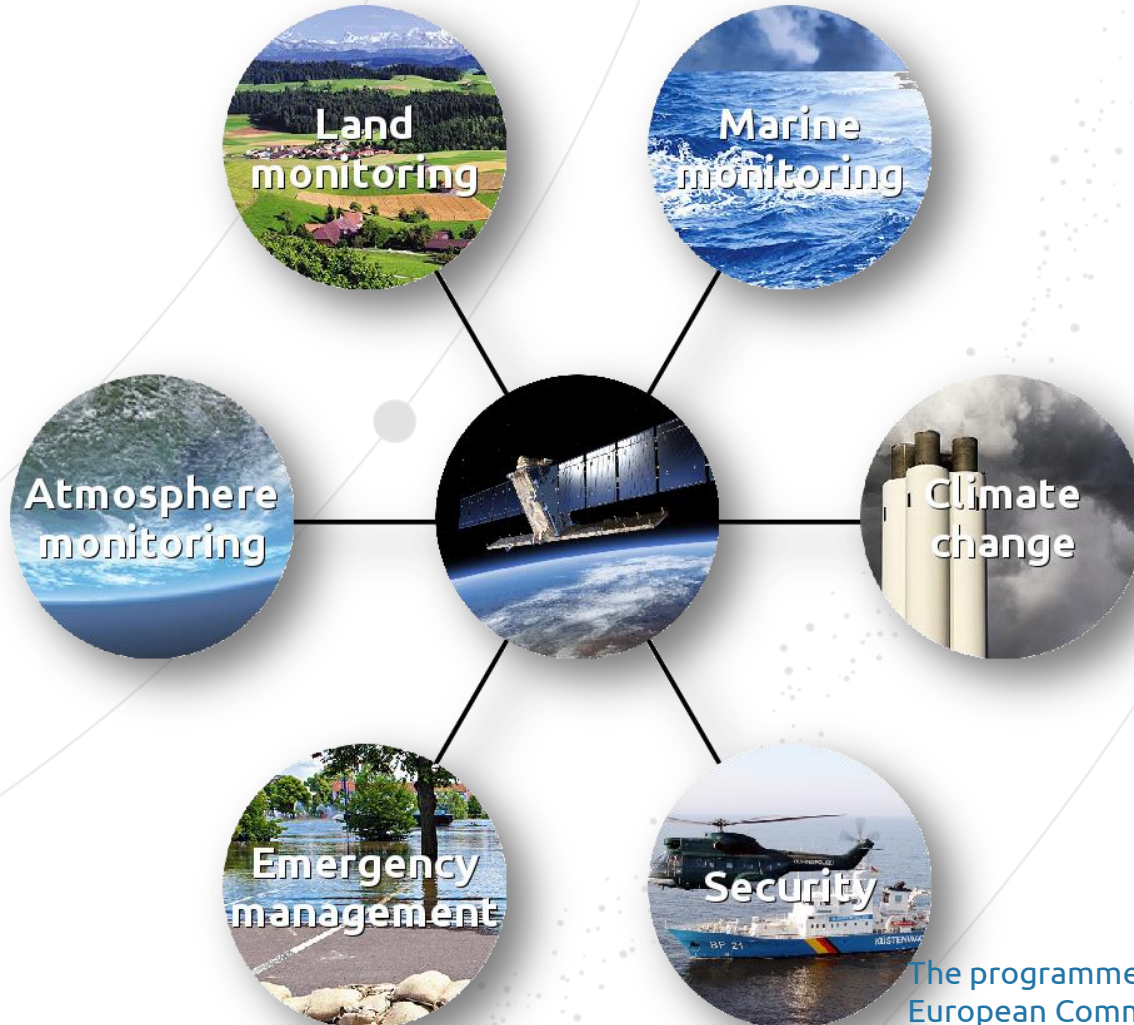
With many challenges ...

- Climate change
- Management of resources
- Weather monitoring
- Natural disasters
- Pollution
- Overpopulation



We are living in the epoch of the Anthropocene.

MONITORING THE EARTH FROM SPACE



The programme is headed by the European Commission (EC) in partnership with the European Space Agency (ESA).

COPERNICUS SCIENCE LINKED TO CURRICULA

- Climate change
- Atmosphere
- Oceans
- Seasons
- Orbit/Rotation
- Satellites
- Habitability of the Earth
- Biodiversity





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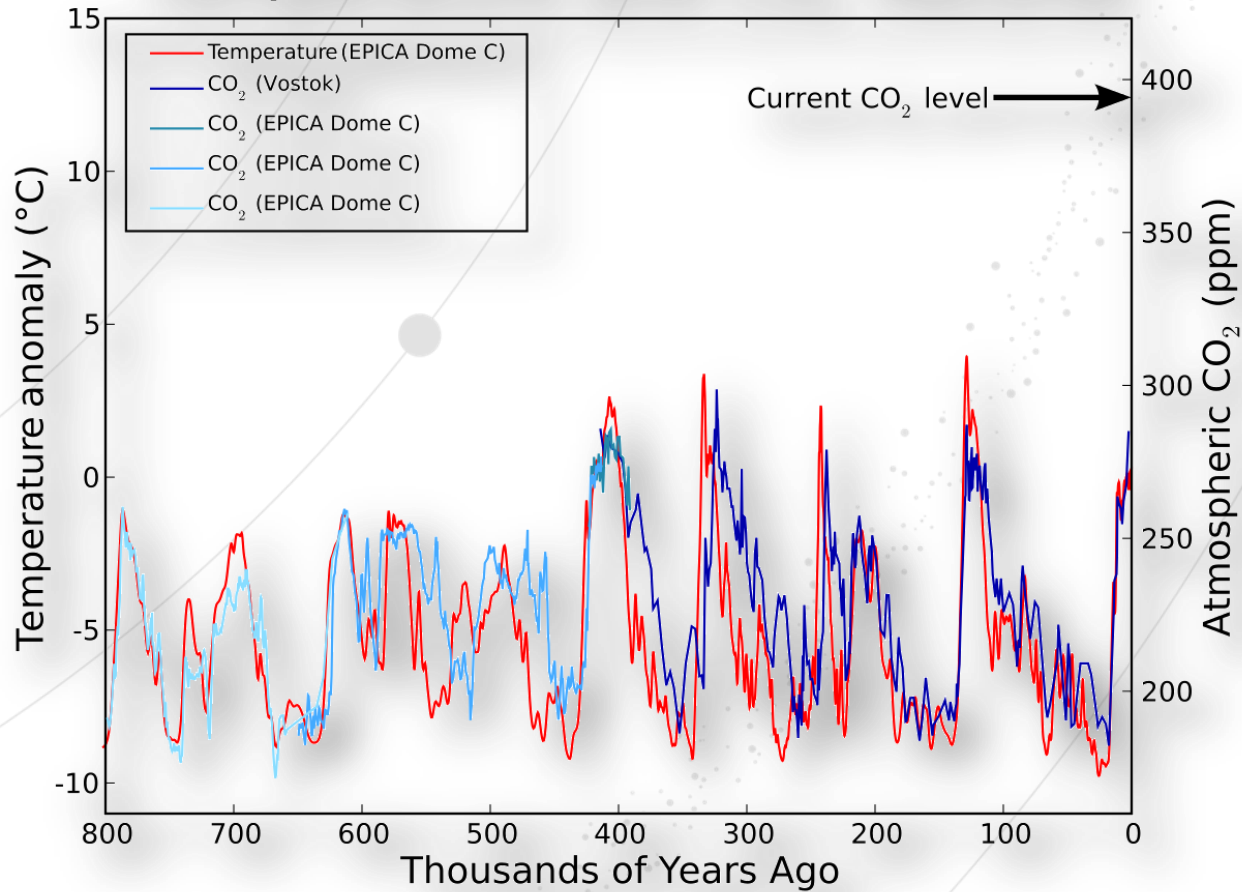
02

OUR FRAGILE PLANET

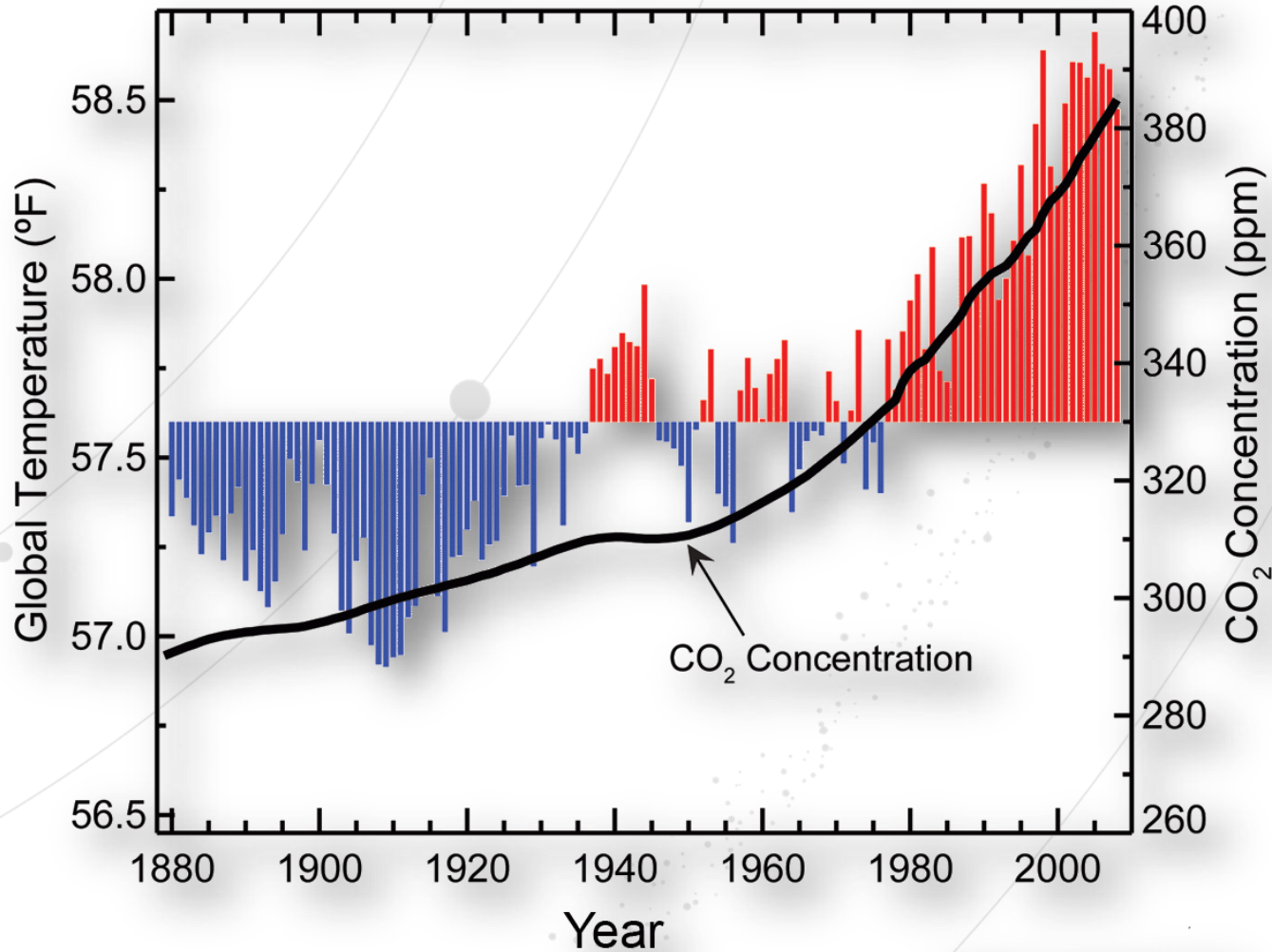
Climate Box – Rising Sea Levels

OCEANS ON THE RISE

Temperature and CO₂ Records



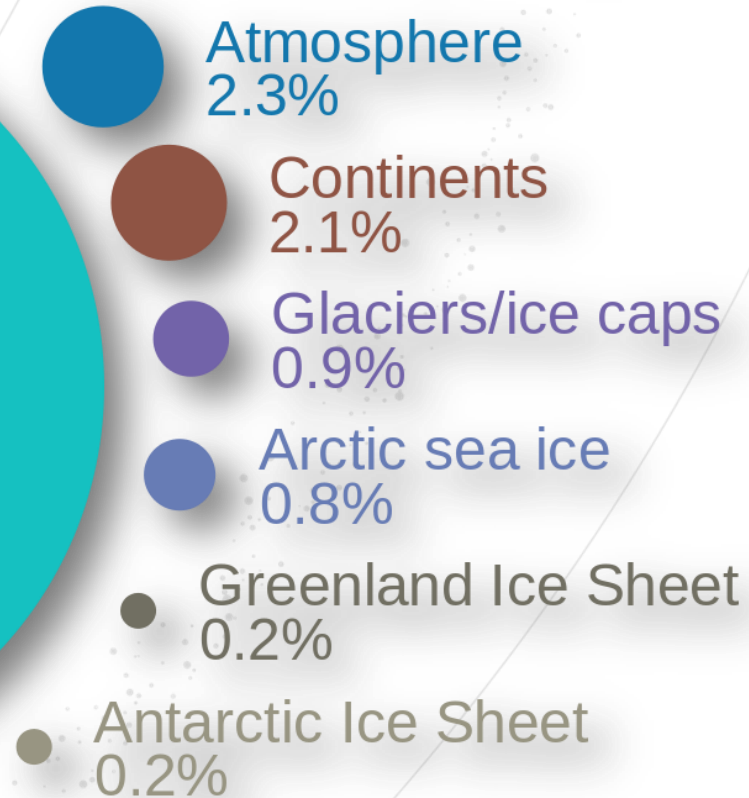
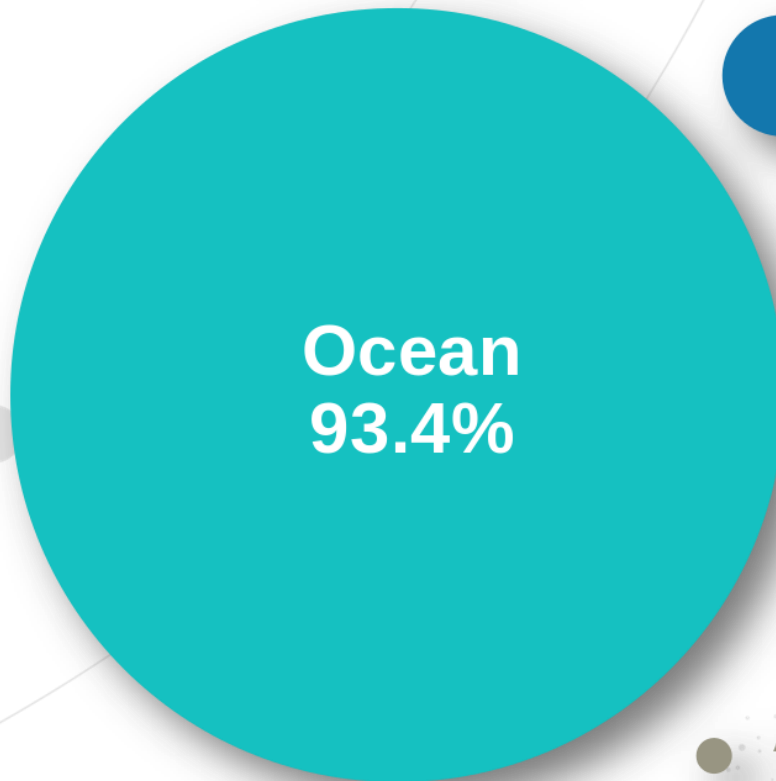
OCEANS ON THE RISE



$$\Delta T(^{\circ}F) = 1.8 \cdot \Delta T(^{\circ}C)$$

OCEANS ON THE RISE

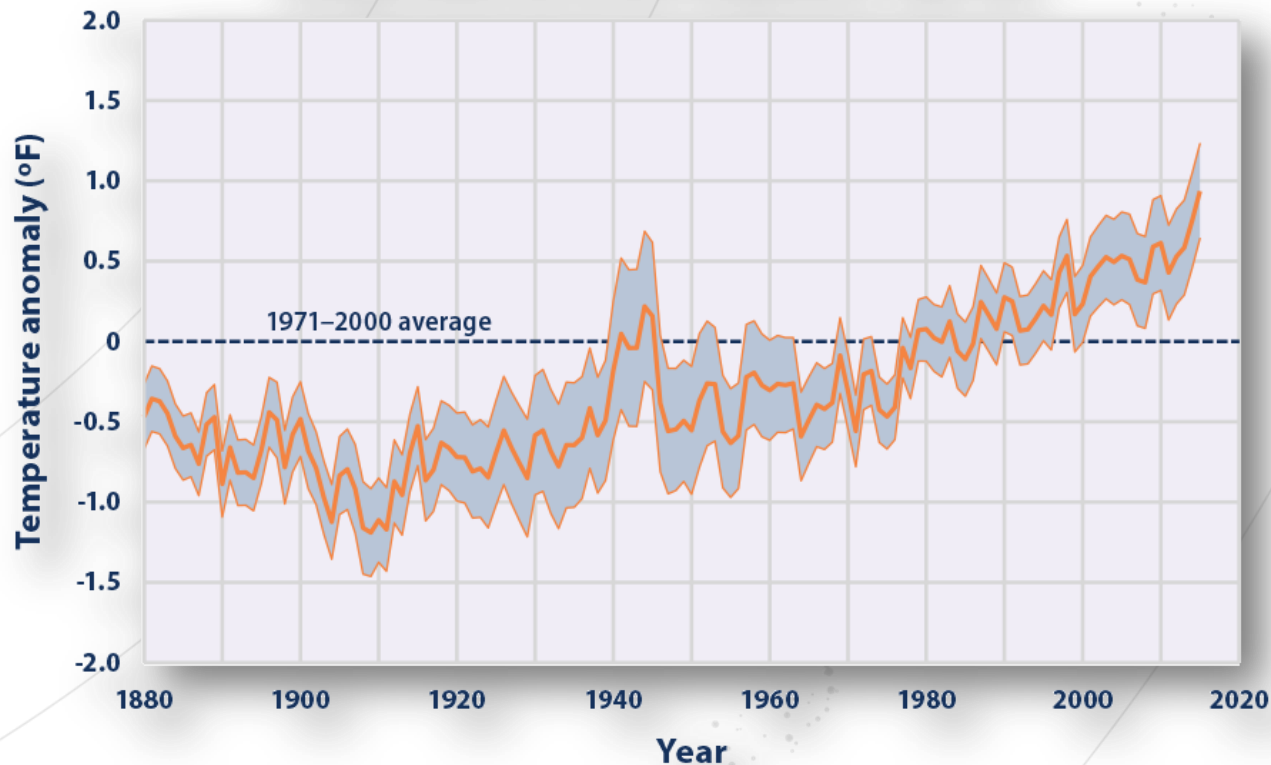
Where is global warming going?



OCEANS ON THE RISE

$$\Delta Q = c \cdot m \cdot \Delta T$$

Average Global Sea Surface Temperature, 1880–2015



Data source: NOAA (National Oceanic and Atmospheric Administration). 2016. Extended reconstructed sea surface temperature (ERSST.v4). National Centers for Environmental Information. Accessed March 2016.
www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst.

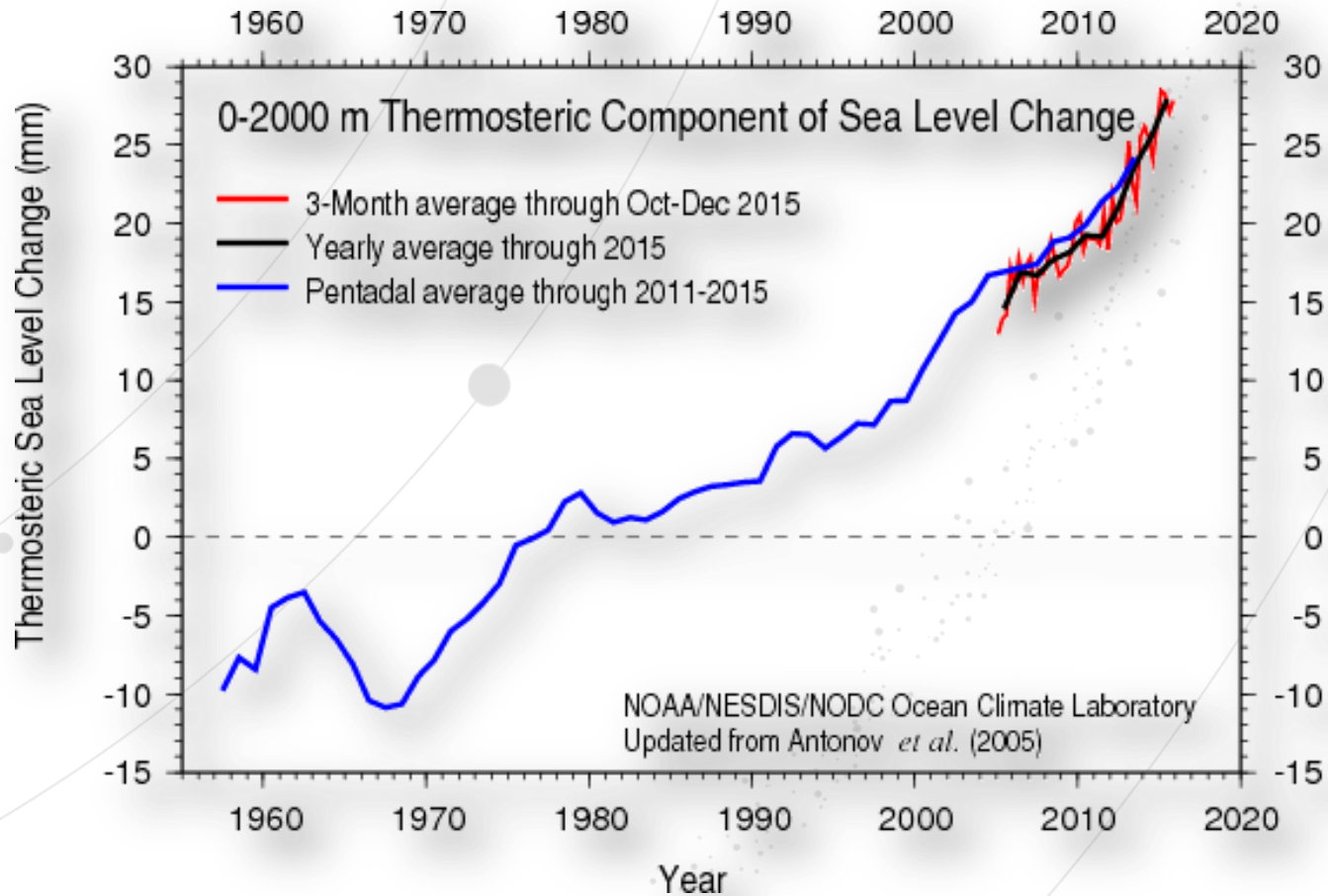
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

<https://www.epa.gov/sites/production/files/styles/large/public/2016-07/sea-surface-temp-download1-2016.png>

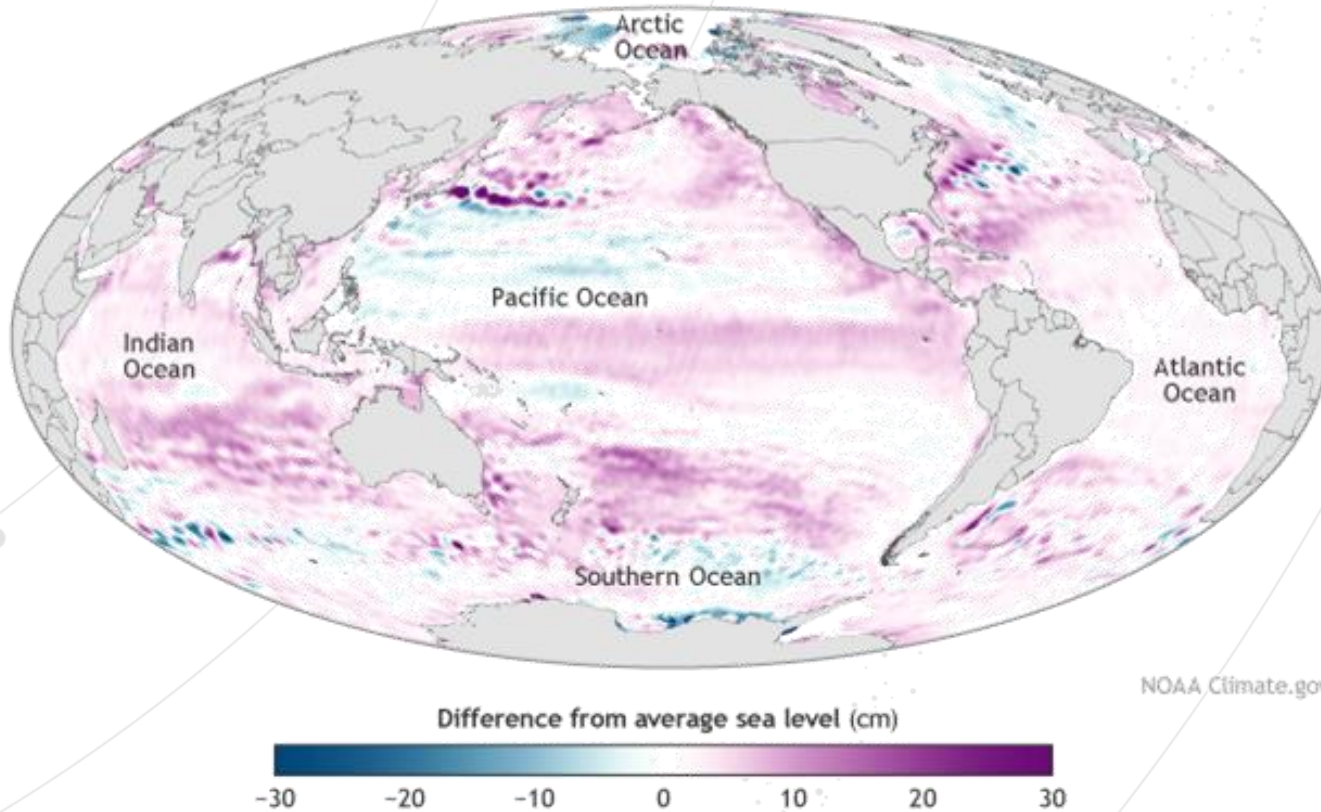
$$\Delta T(^{\circ}F) = 1.8 \cdot \Delta T(^{\circ}C)$$

OCEANS ON THE RISE

$$\Delta V = V_0 \cdot \gamma \cdot \Delta T$$



OCEANS ON THE RISE



Sea level in 2014 compared to the global average at the mid-point of the 1993-2013 time series

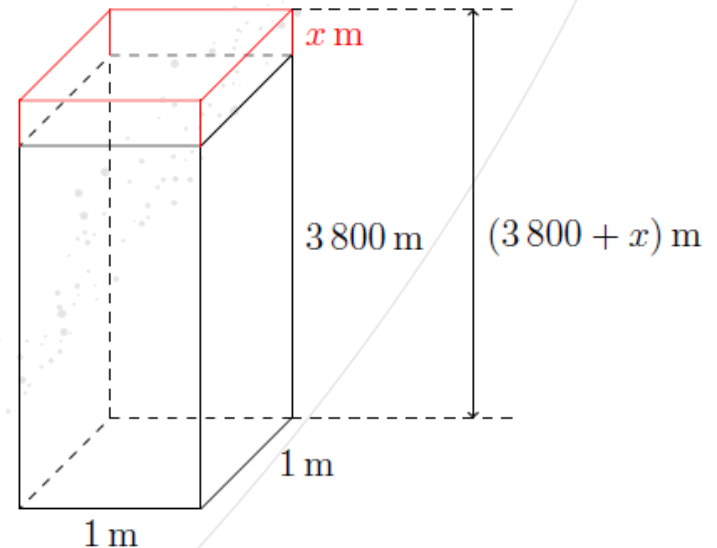
OCEANS ON THE RISE

Exercise 1: volume increase of water

- 1 litre (dm^3) of water
- heating from 10°C to 20°C

Exercise 2: idealised sea level rise

- ocean depth: 3800 m
- heating from 4°C to 5°C





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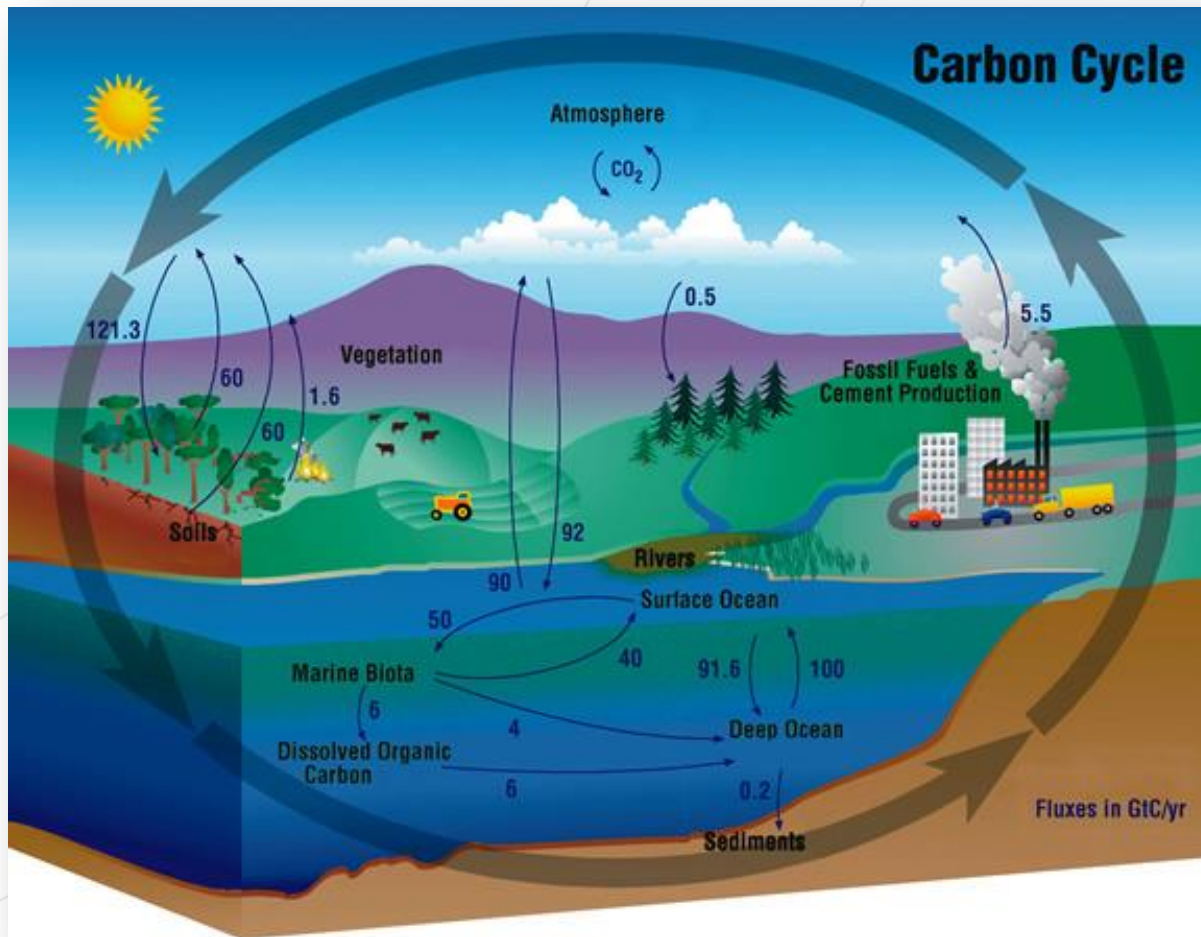
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03

OUR FRAGILE PLANET

Climate Box – Ocean Acidification

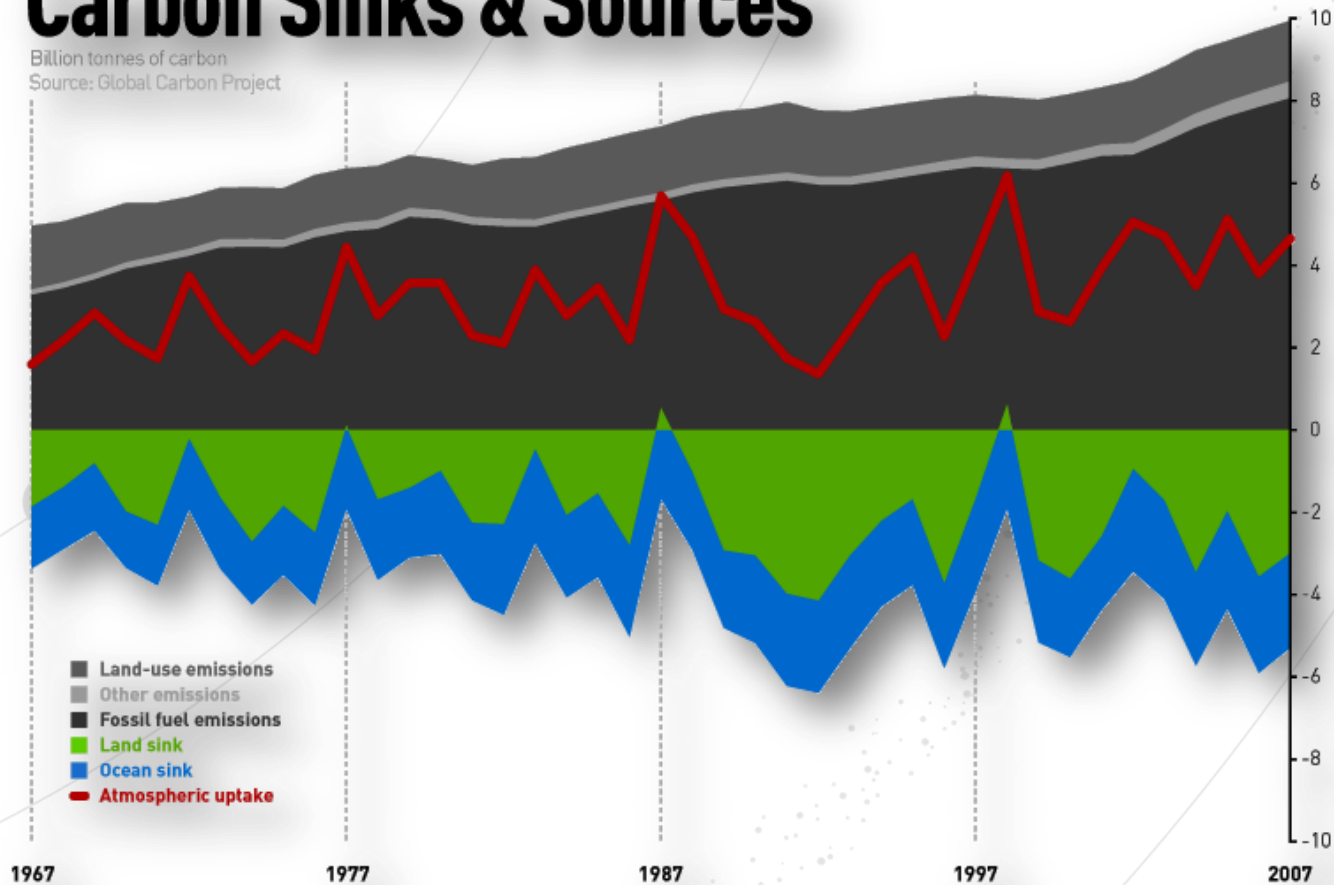
TRANSFORMING WATER INTO ACID ... AND BACK



TRANSFORMING WATER INTO ACID ... AND BACK

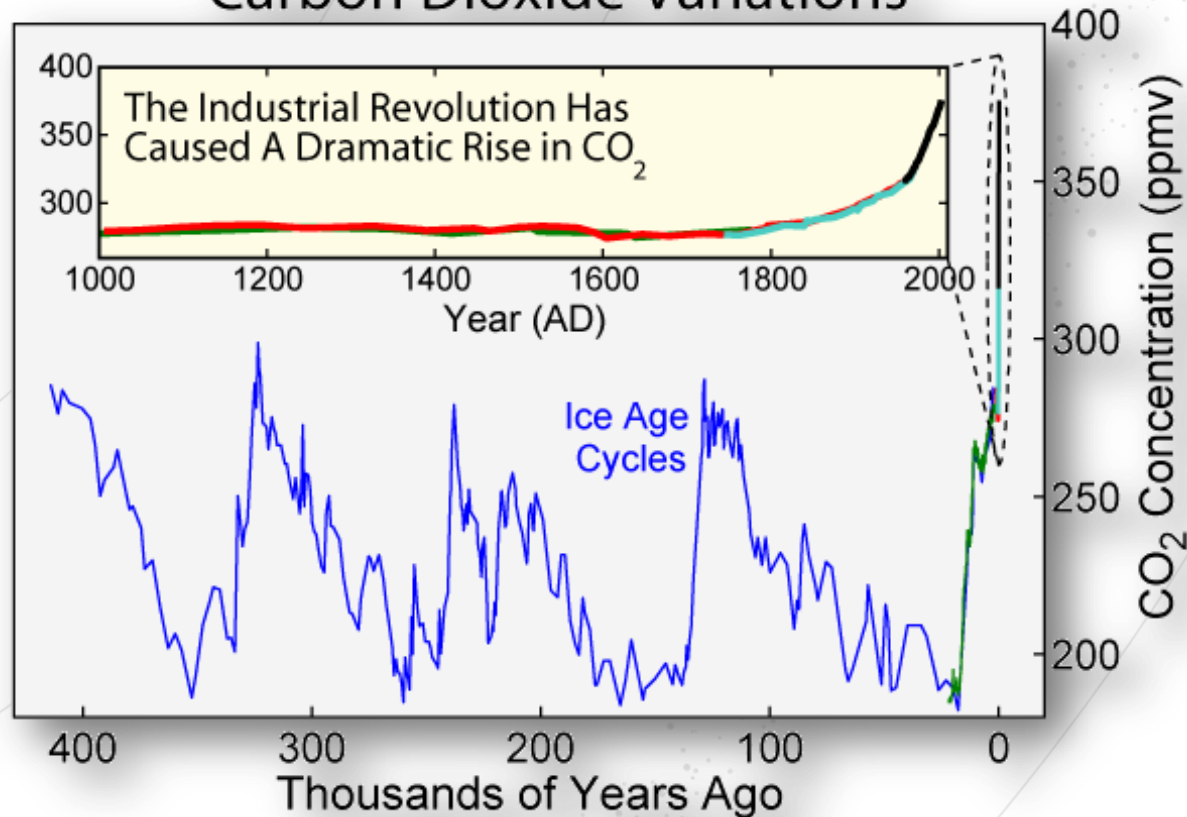
Carbon Sinks & Sources

Billion tonnes of carbon
Source: Global Carbon Project



TRANSFORMING WATER INTO ACID ... AND BACK

Carbon Dioxide Variations



TRANSFORMING WATER INTO ACID ... AND BACK

OCEAN ACIDIFICATION

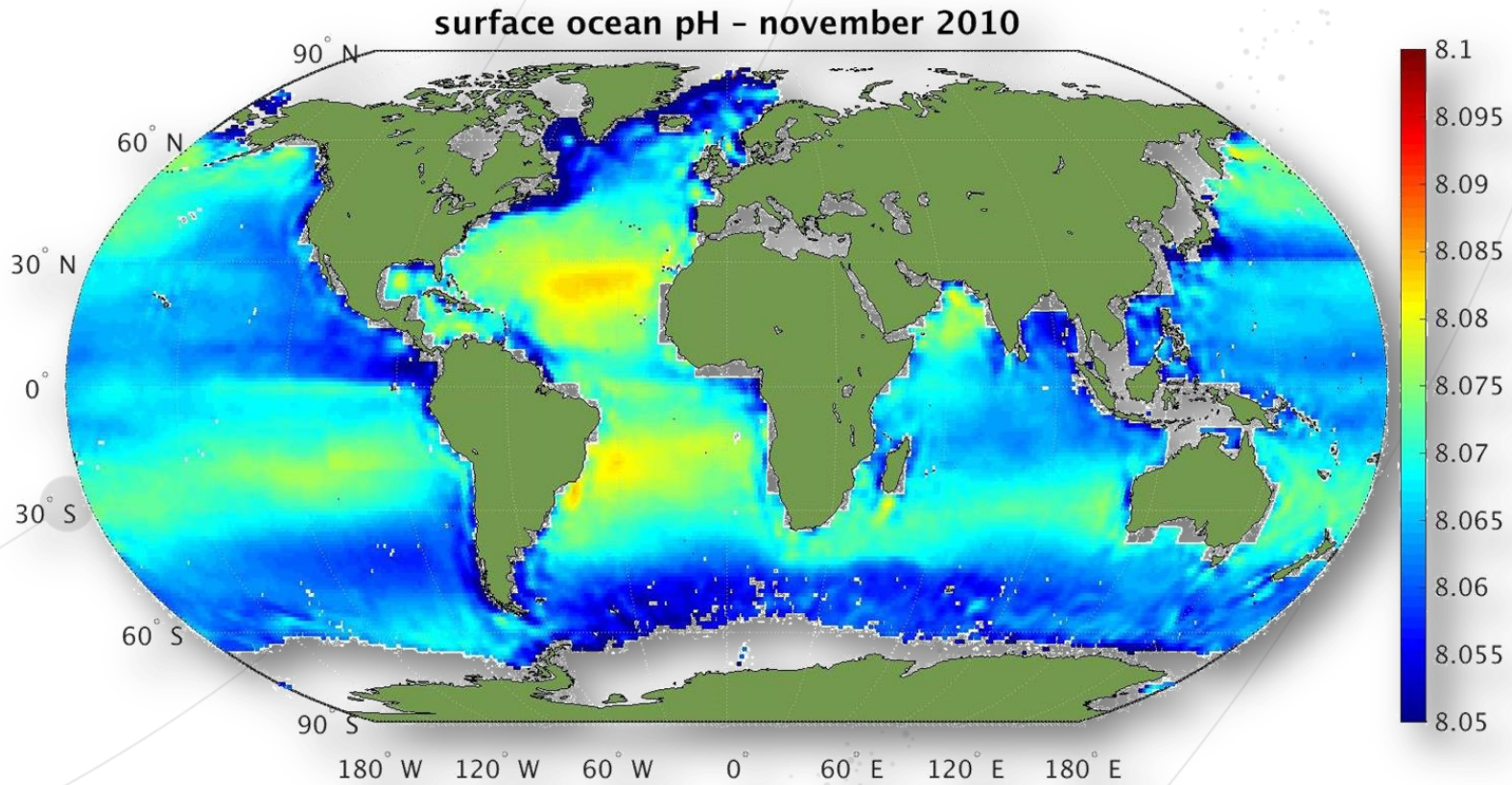
HOW WILL CHANGES IN OCEAN CHEMISTRY AFFECT MARINE LIFE?

CO₂ absorbed from the atmosphere

The diagram illustrates the process of ocean acidification. At the top, four red arrows point downwards from the atmosphere, labeled 'CO₂ absorbed from the atmosphere'. Below this, a horizontal line separates the atmosphere from the ocean. In the ocean, a chemical reaction is shown: $\text{CO}_2 + \text{H}_2\text{O} + \text{CO}_3^{2-} \rightarrow 2 \text{HCO}_3^-$. Below the equation are ball-and-stick molecular models for each species: carbon dioxide (a black carbon atom with two red oxygen atoms), water (one black carbon atom with two red oxygen atoms and two white hydrogen atoms), carbonate ion (one black carbon atom with three red oxygen atoms), and two bicarbonate ions (one black carbon atom with three red oxygen atoms and one white hydrogen atom). To the left of the reaction, a green, healthy-looking shell is shown in a circular inset. A yellow arrow points from this shell to a yellow, partially eroded shell in a circular inset. A red arrow points from this shell to a broken, orange-red shell in a circular inset. The background of the ocean shows a gradient from blue to red, with small fish and a larger fish visible on the left.

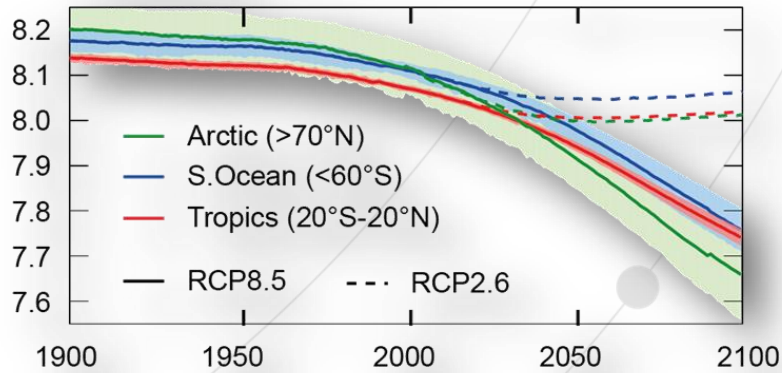
consumption of carbonate ions impedes calcification

TRANSFORMING WATER INTO ACID ... AND BACK

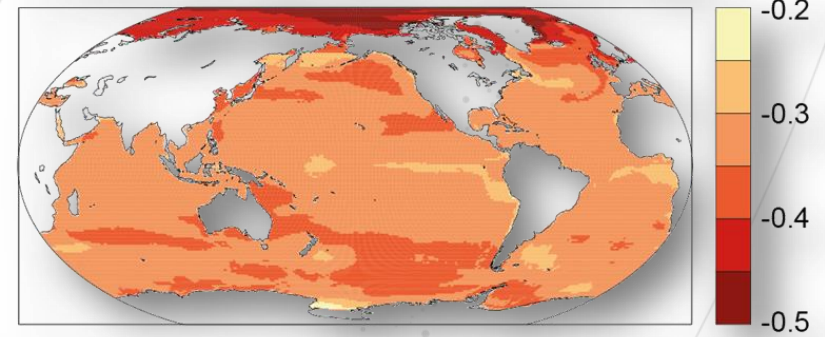


TRANSFORMING WATER INTO ACID ... AND BACK

a. Surface pH

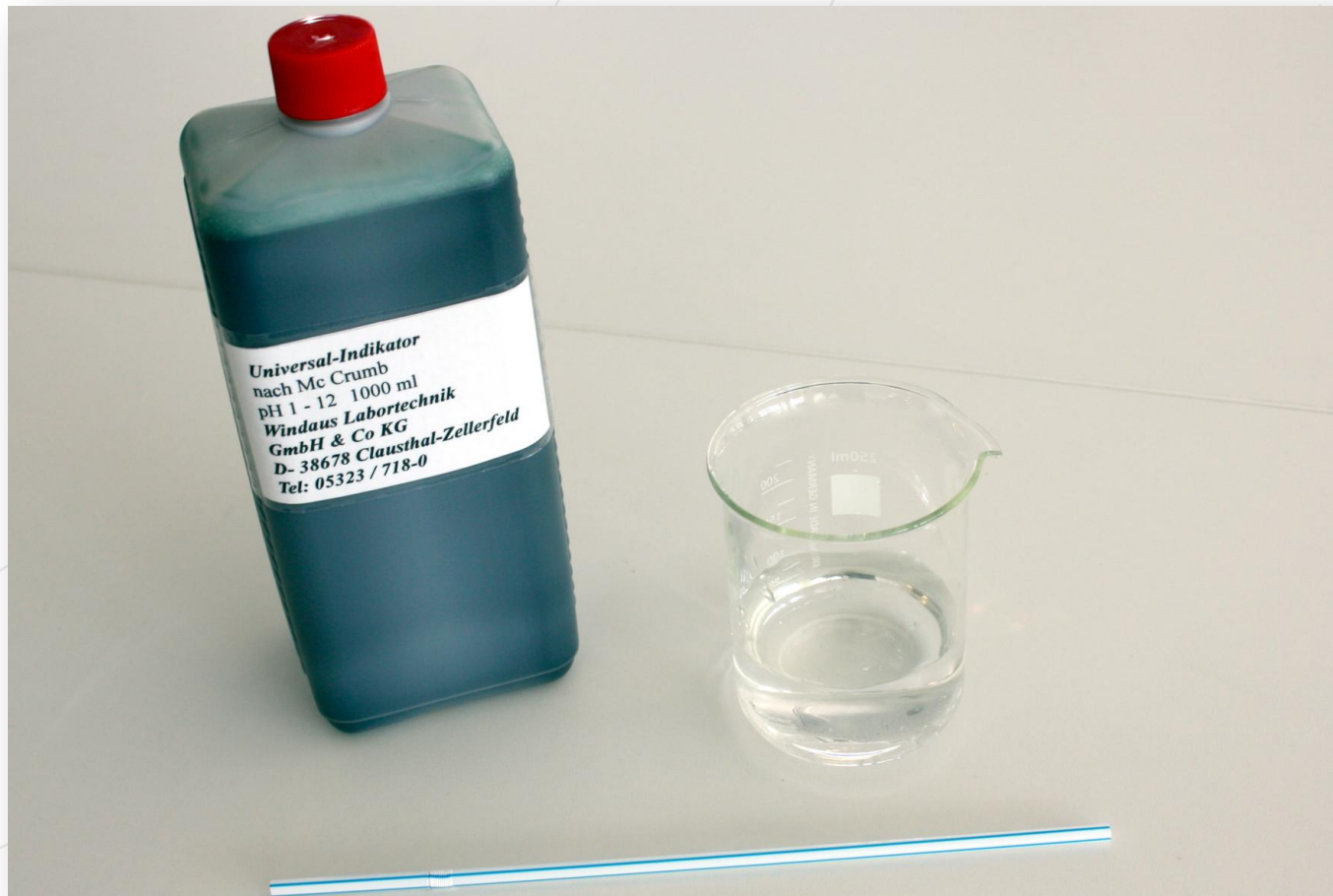


b. Surface pH in 2090s (RCP8.5, changes from 1990s)

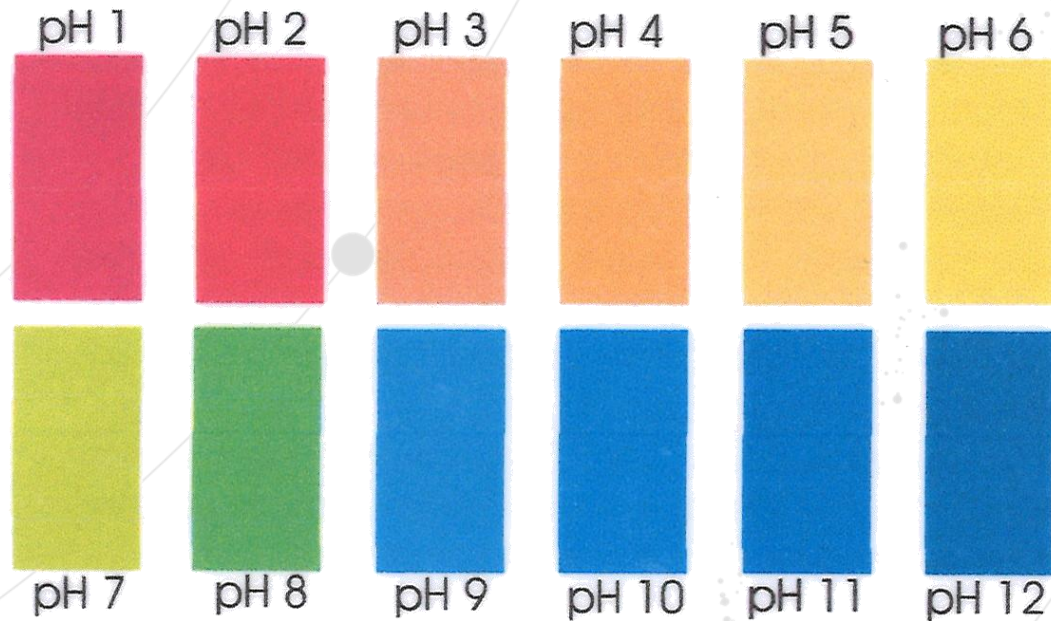


[IPCC Report, 2013, Working Group I, Chp. 6, p. 532](#)

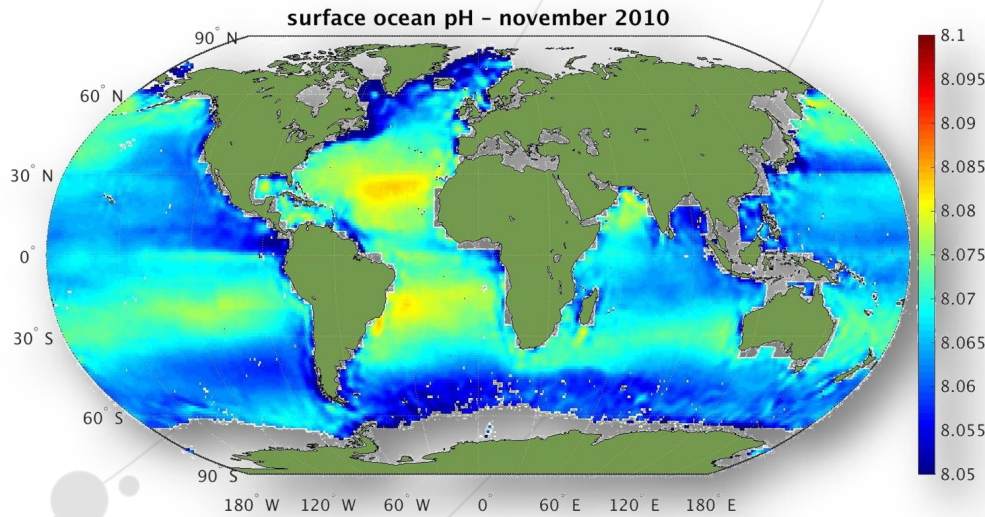
TRANSFORMING WATER INTO ACID ... AND BACK



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TRANSFORMING WATER INTO ACID ... AND BACK



INVITATION TO CHECK OUT RESOURCES YOURSELF

<http://www.space-awareness.org/en/activities/>

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CAREERS

READ

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SPACE
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EDUCATE

DEVELOP

KNOW US

EDUCATE & INSPIRE
PEER-REVIEWED EDUCATIONAL ACTIVITIES



VALLEYS DEEP AND MOUNTAINS HIGH

Understand how maps are made from satellite measurements





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This presentation was developed based on resources and data from ESA and the Space Awareness project.

