Riding the Climate Rollercoaster 2 T4 2025

2. The Atmosphere, the Oceans and Greenhouse Gases

Malte Ebach

TESEP Regional Co-ordinator

Slides by Rob Kirk and Malte Ebach

Teacher

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We wish to acknowledge the Traditional Owners of the land on which we meet today.

We also wish to pay our respects to Elders past, present and future.

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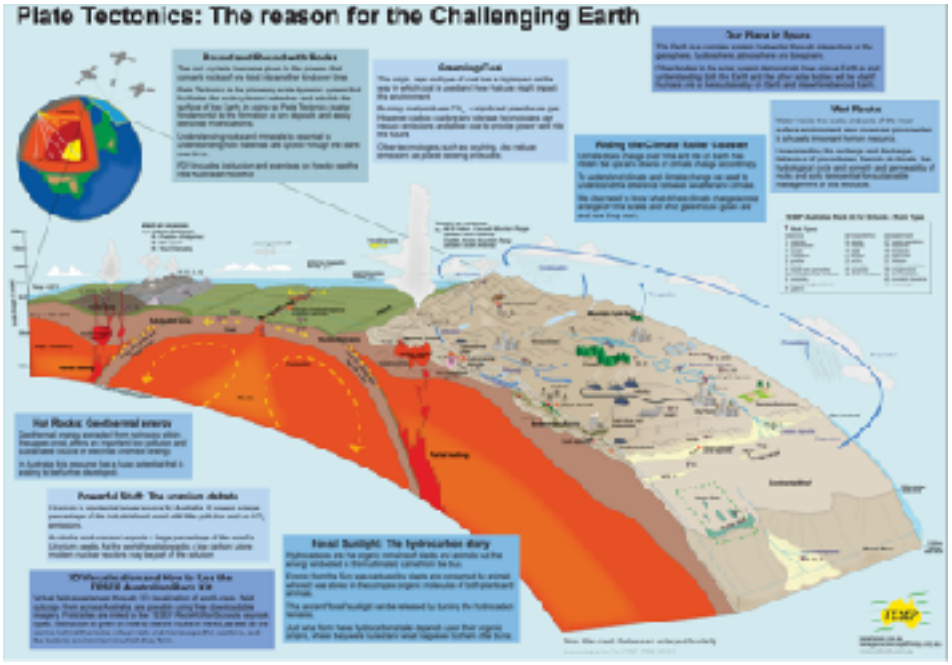

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  - Mineral Stories
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Australian Curriculum v.9 (F-10)

We will be following the Australian Curriculum v.9 (2022):

- Curriculum content for Years 7-10 only
- Focus on the Earth and Space science sub-strand
- Will follow as many other sub-strands as possible

Australian Curriculum v. 9 (2022): Examples.

Year 10 (Earth and Space Sciences)

"They appreciate how energy drives the Earth system and how climate models simulate the flow of energy and matter within and between Earth's spheres".

- Use models of energy flow between the geosphere, biosphere, hydrosphere and atmosphere to explain patterns of global climate change (AC9S10U04).
- Explain how scientific knowledge is validated and refined, including the role of publication and peer review (AC9S10H01).
- Investigate how advances in technologies enable advances in science, and how science has contributed to developments in technologies and engineering (AC9S10H02).

Australian Curriculum v. 9 (2022): Examples.

Year 10 (Geography)

“develop a range of questions for a geographical inquiry related to a phenomenon or challenge”.

- planning an investigation of a phenomenon or challenge being studied at a range of scales, using digital tools; for example, investigating the causes of human-induced climate change at the global scale and its impacts on Australia, Bangladesh and/or a Pacific Island country at the national scale (AC9HG10S01)

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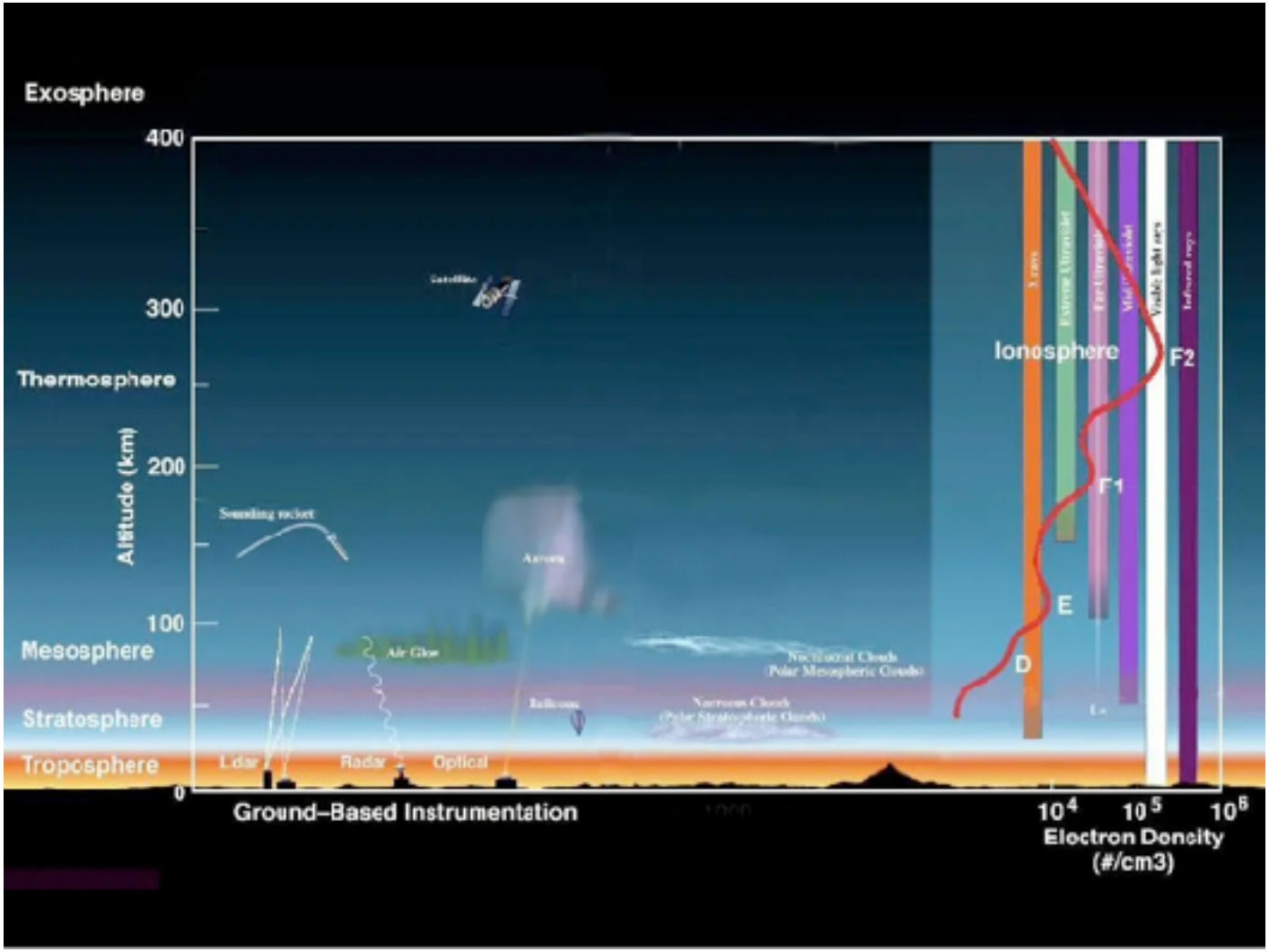
The Atmosphere and the Oceans

The Atmosphere

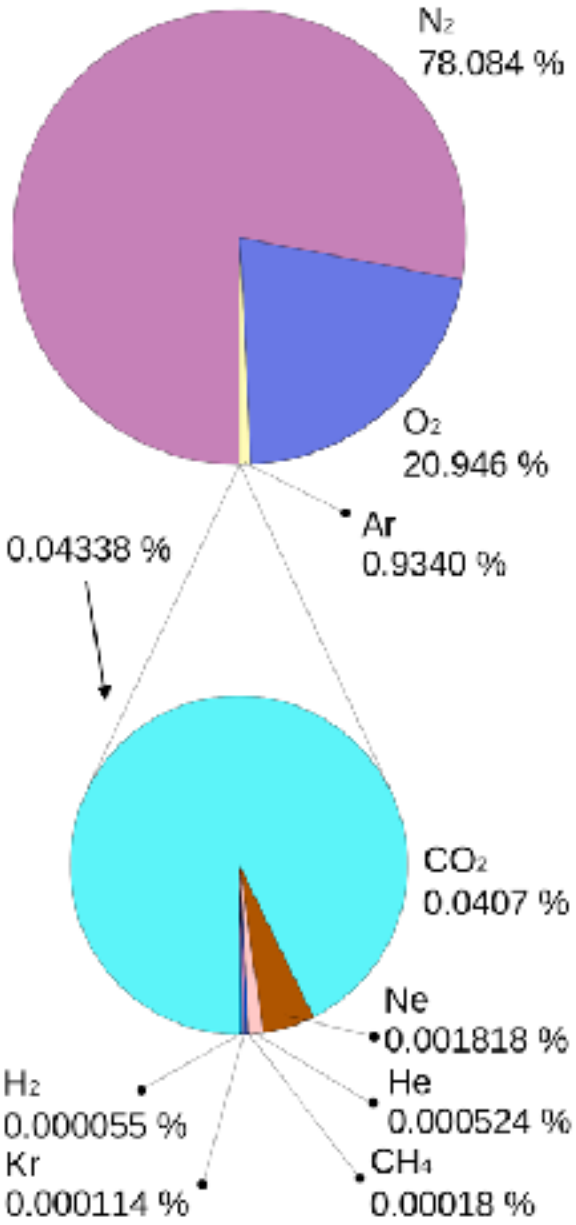
- What is the atmosphere? One layer or more?
- How do we benefit from the atmosphere?
- What does the atmosphere have to do with climate change?

The thin atmosphere is vital for life by providing air to breath, keeps us warm and wards off damaging radiation and meteorites.

Layers of the Atmosphere



The atmosphere is a complicated, many layered system that allows us to safely live on Earth



Gases in the Atmosphere

(excluding water vapour)

Greenhouse Gases (GHG)

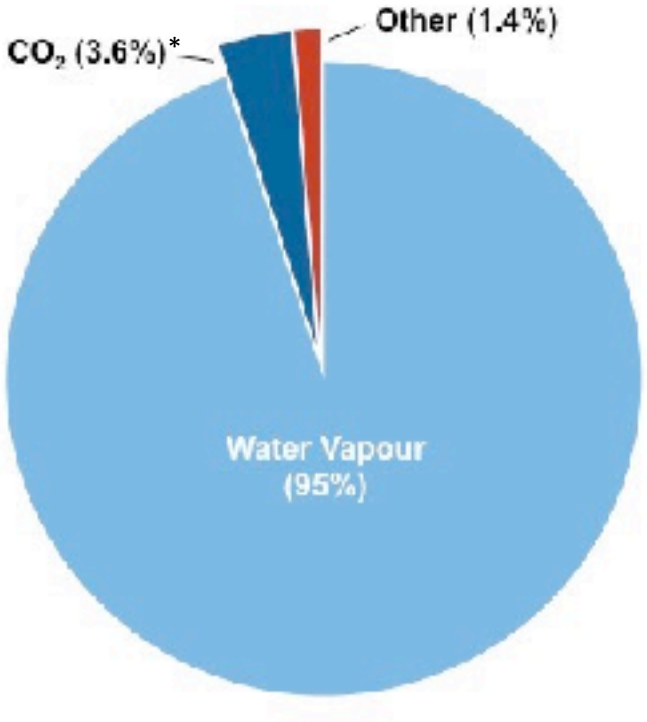
What is it?

- Gases
  - Water vapour (H_20), CO_2, O_3, N_2O, CH_4
- Natural processes
  - Solar radiation
- Together gases and solar radiation heat the surface of the Earth
  - Solar radiation heats surface materials
  - Solar radiation absorbed by gases

GHG and solar radiation keeps the surface of the Earth warm


The Greenhouse Effect
Most of the heat is absorbed by greenhouse gases
and then radiated in all directions, warming the Earth
Atmosphere
climate.nasa.gov

Greenhouse Gases (GHG)



Water vapour is the most important GHG

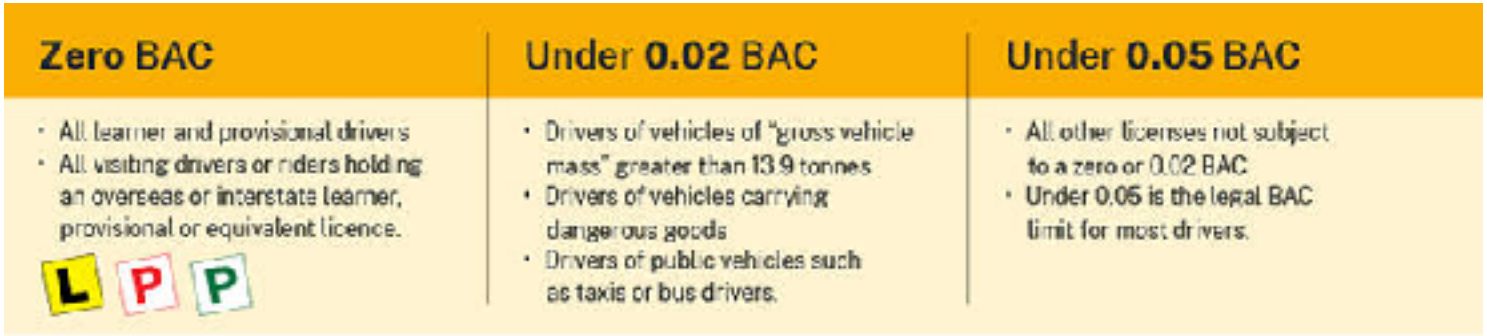
GHGs in the Atmosphere

(including water vapour)

*Remember: CO2 makes up only 0.04% of all atmospheric gases

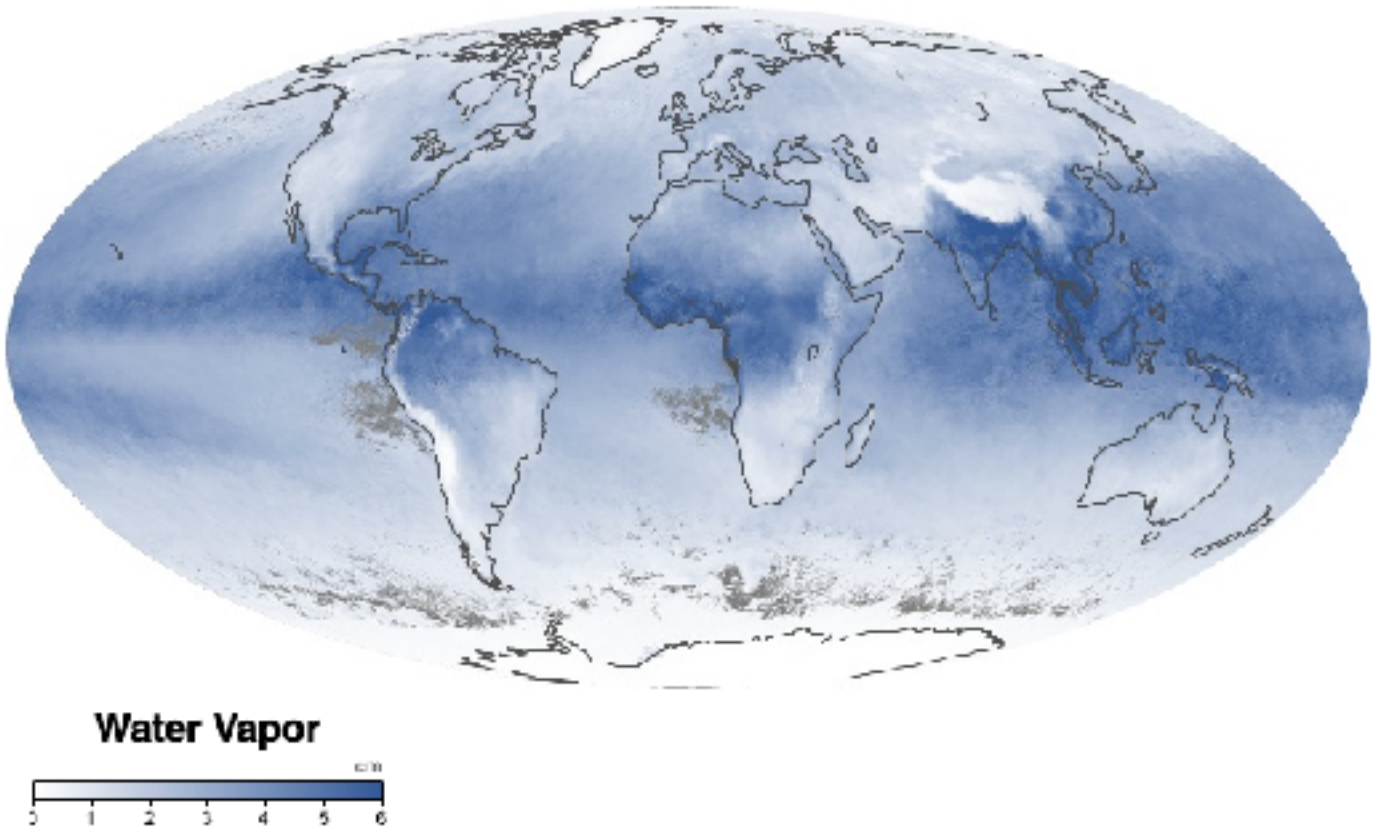
Greenhouse Gases (GHG)

A handy analogy: CO2 makes up only 0.04% of all atmospheric gases



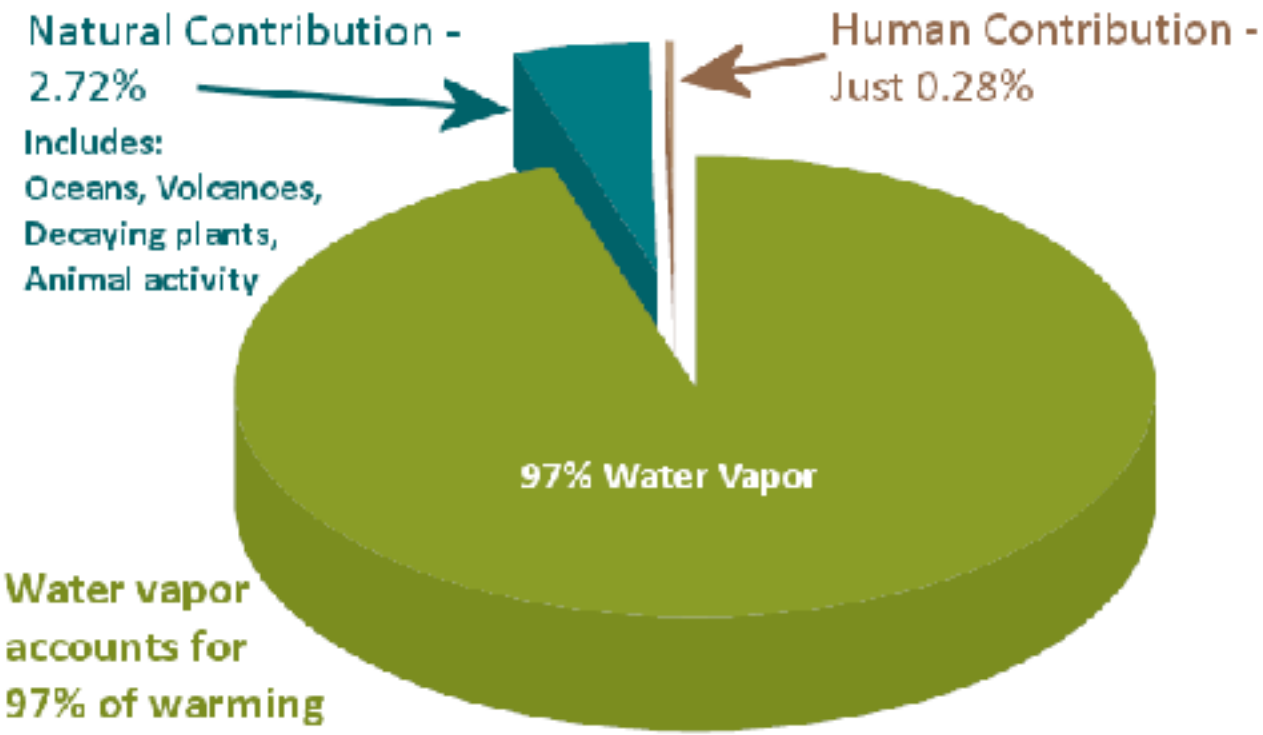
Keep BAC and CO_2 at 0.04% and you'll be fine.

Greenhouse Gases (GHG)

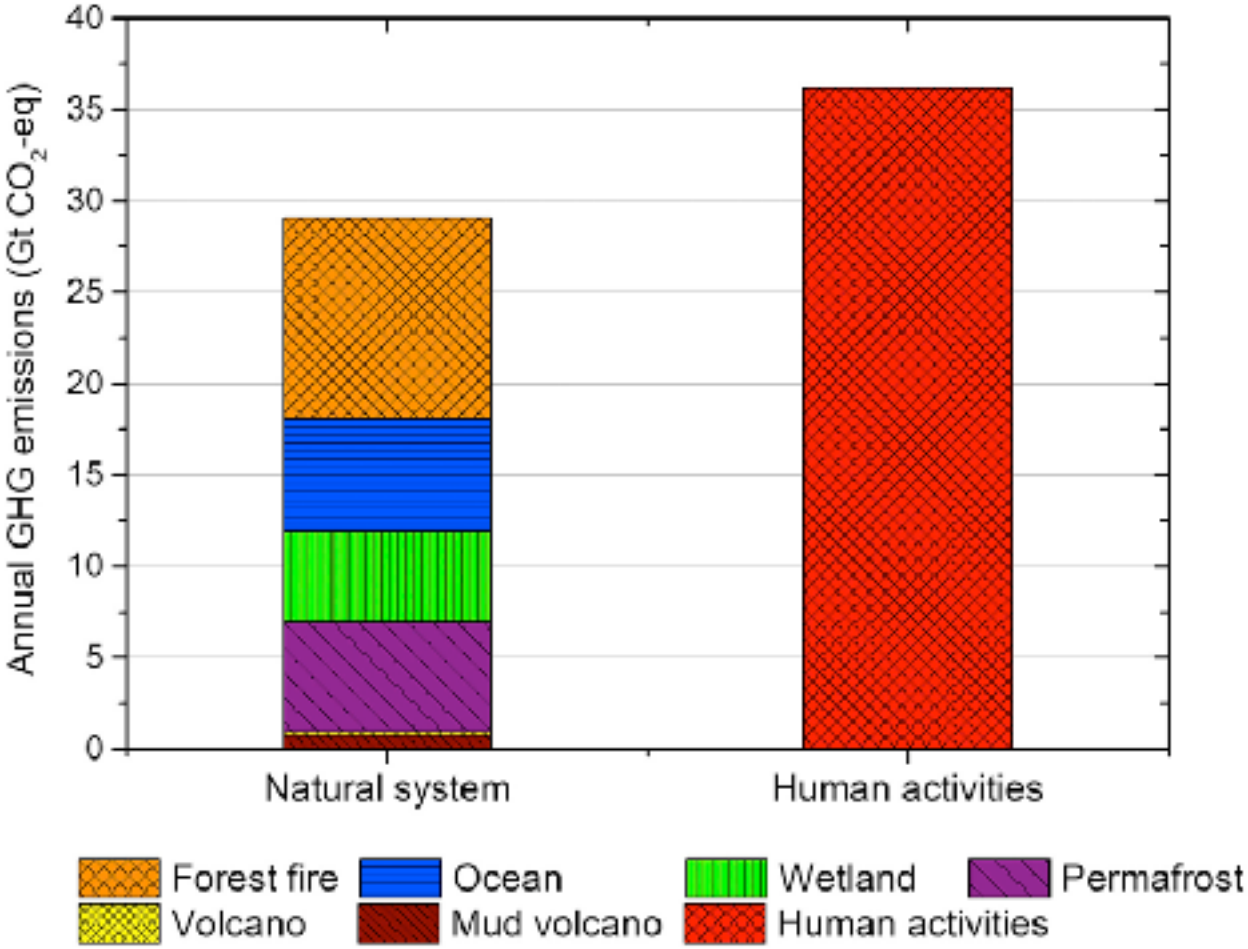


Water vapour for September 2024

Natural versus Man made sources of GHGs

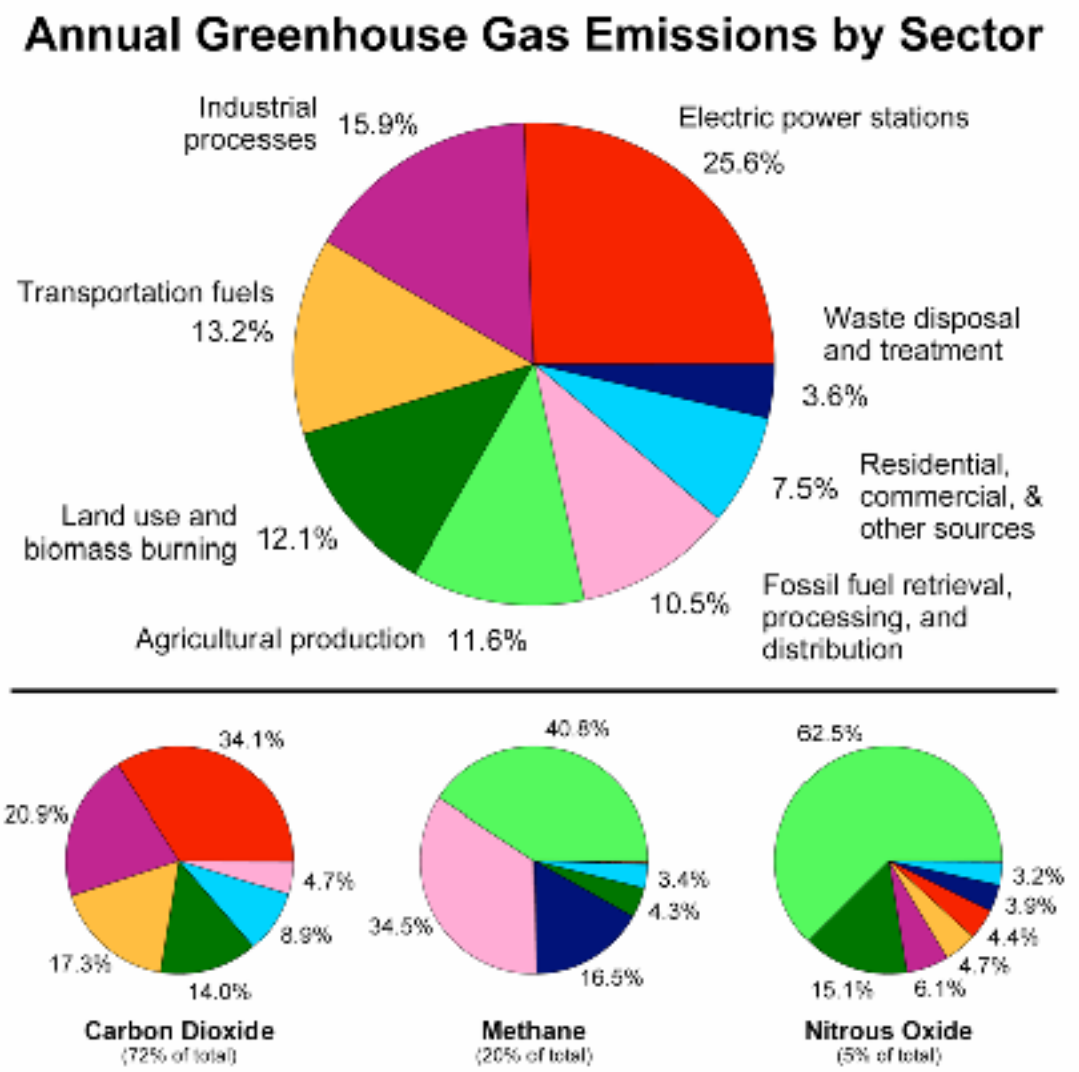


Natural Sources of GHGs



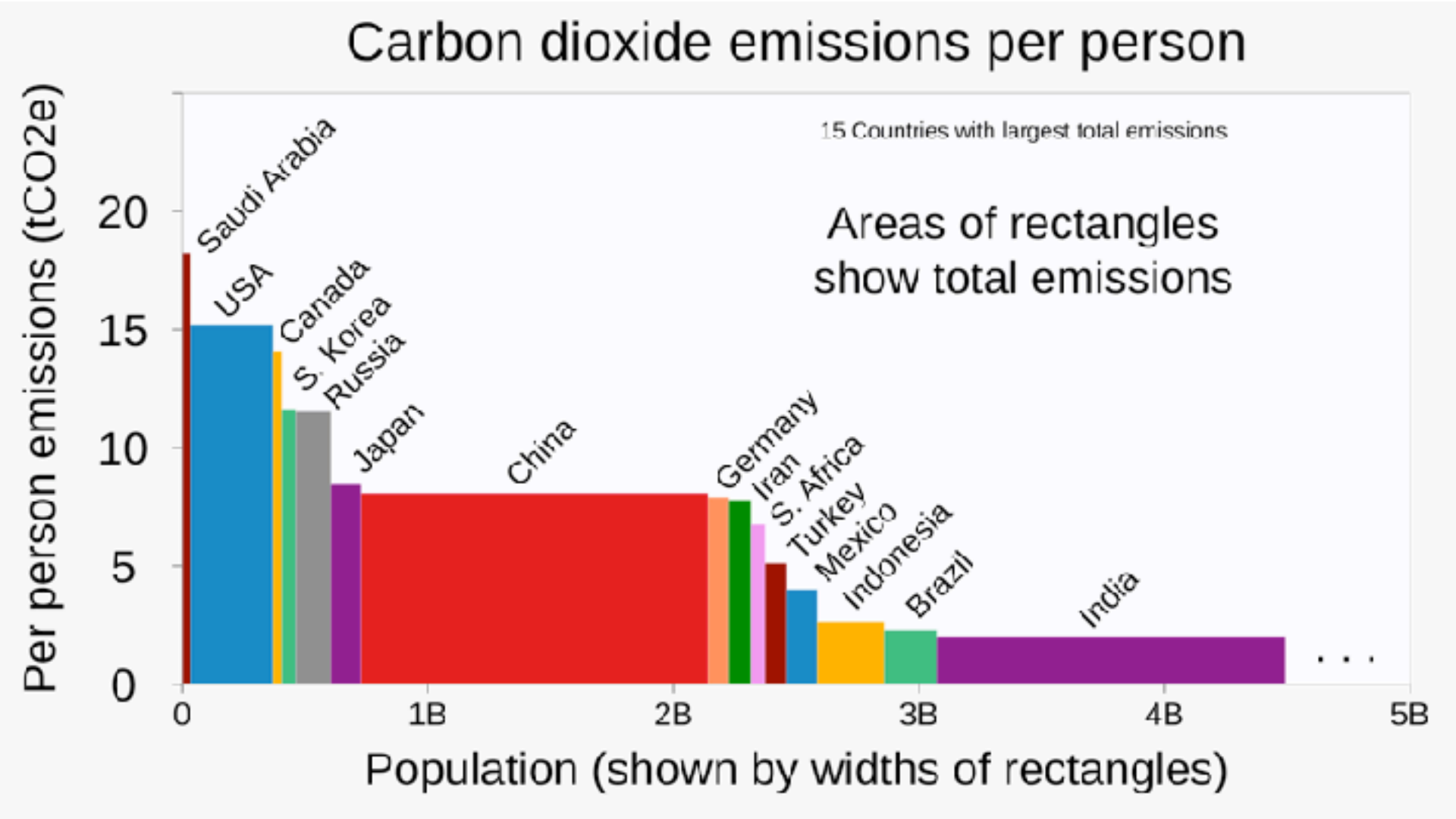
Forest fires and the melting of permafrost could be linked to human GHGs

Man made sources of GHGs*

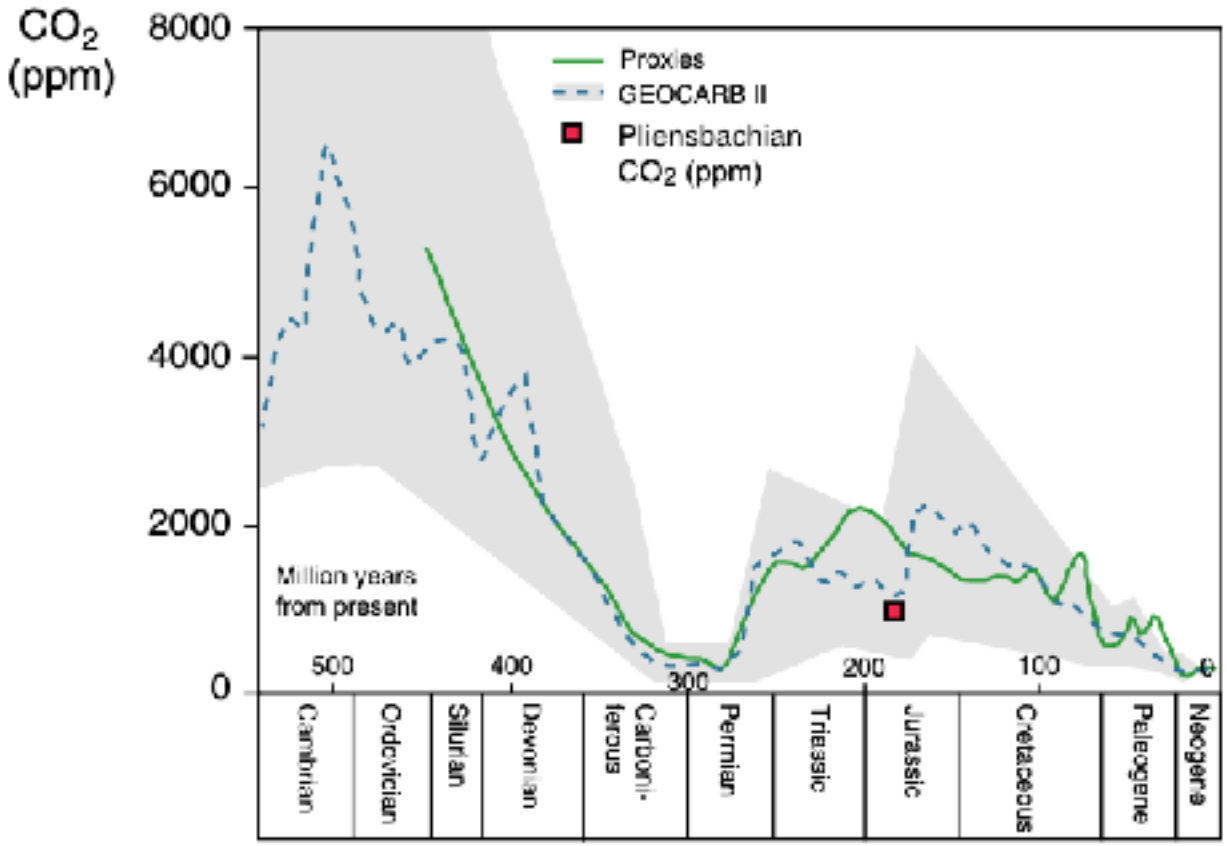


* Excluding water vapour

Man made sources of GHGs

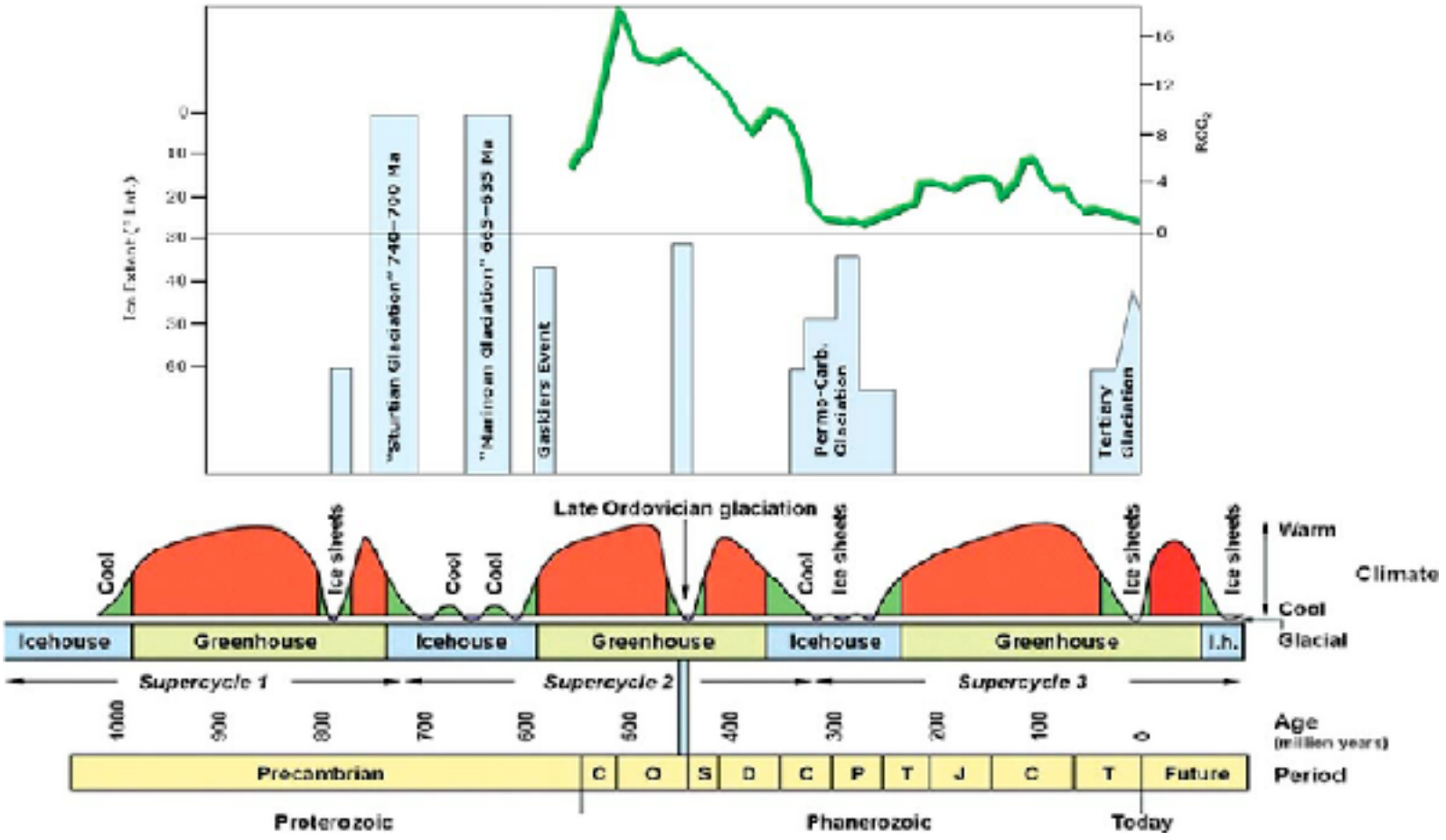


Past CO_2 levels



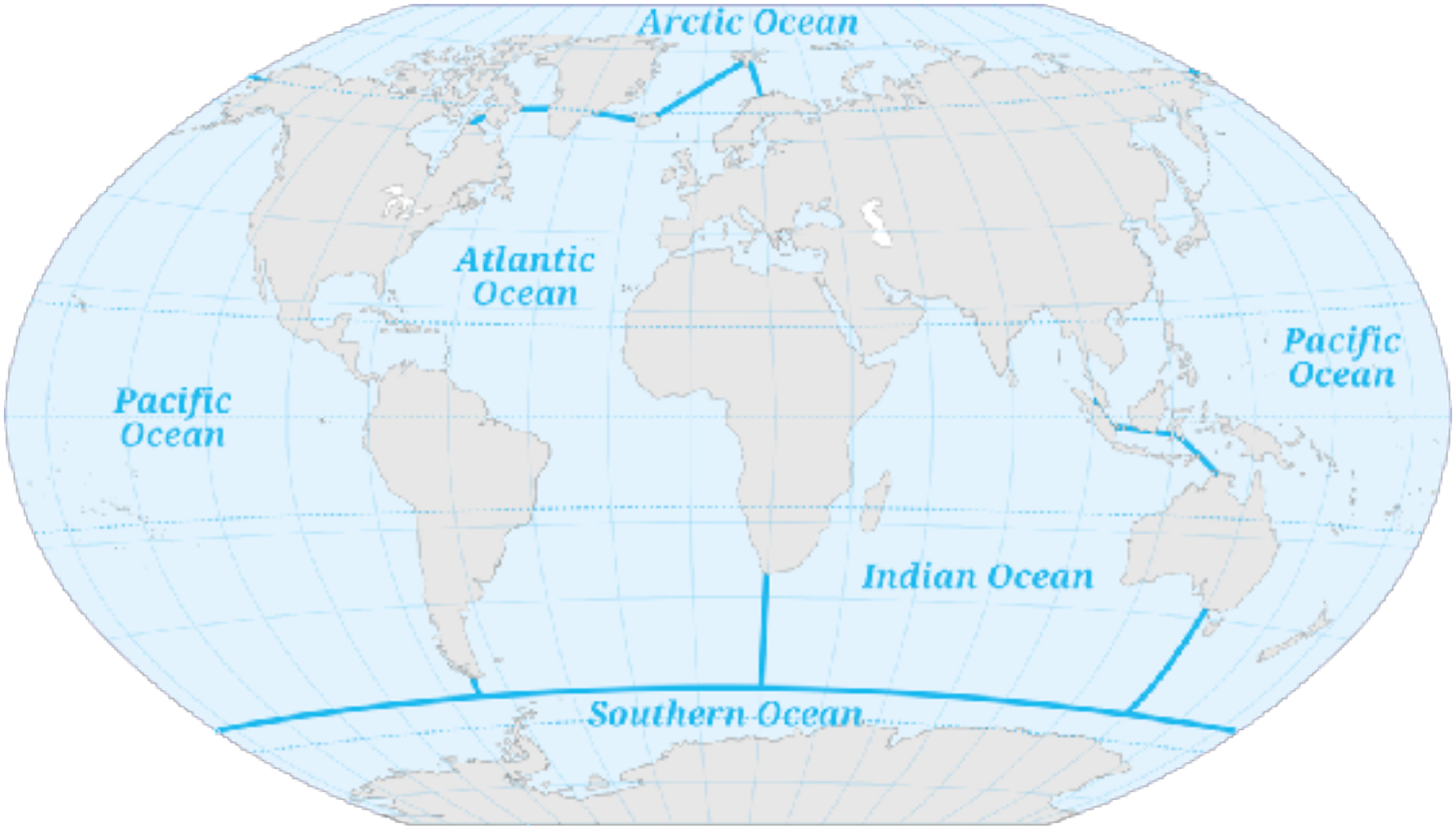
Stomatal proxy-based CO2 estimate of ~900ppm, using Australian fossil conifer leaves, is shown (red box) relative to the Phanerozoic pCO2 obtained by the GEOCARB models (GEOCARB II of Berner (1994) as adjusted in GEOCARB III of Berner and Kothavala (2001) (blue line with gray error envelope) and various additional proxies (green line) (Steinthorsdottir and Vajda 2015, fig. 4).

Past CO_2 levels and Climate



Earth goes through cool and warm periods

The Oceans

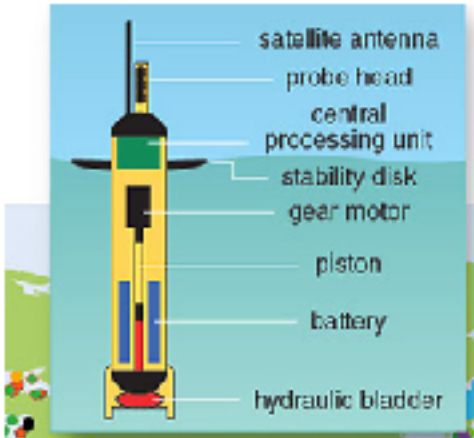


The ocean is a significant influence on Earth's weather and climate. This great reservoir continuously exchanges heat, moisture, and carbon with the atmosphere, driving our weather patterns and influencing the slow, subtle changes in our climate.

The Oceans

- When sunlight reaches the Earth's surface, the oceans absorb some of this energy and store it as heat.
- This heat is initially absorbed at the surface, but some of it eventually spreads to deeper waters.
- Water has a much higher heat capacity than air, meaning the oceans can absorb larger amounts of heat energy with only a slight increase in temperature.
- Ocean temperature plays an important role in the Earth's climate system—particularly sea surface temperature- because heat from ocean surface waters provides energy for storms and thereby influences weather patterns.
- Increasing GHGs are trapping more energy from the sun, but because changes in ocean systems occur over centuries, the oceans have not yet warmed as much as the atmosphere, even though they have absorbed more than 90 percent of the Earth's extra heat since 1955.
- If not for the large heat-storage capacity provided by the oceans, the atmosphere would warm more rapidly.
- We need to better understand the oceans and the role they play in the climate

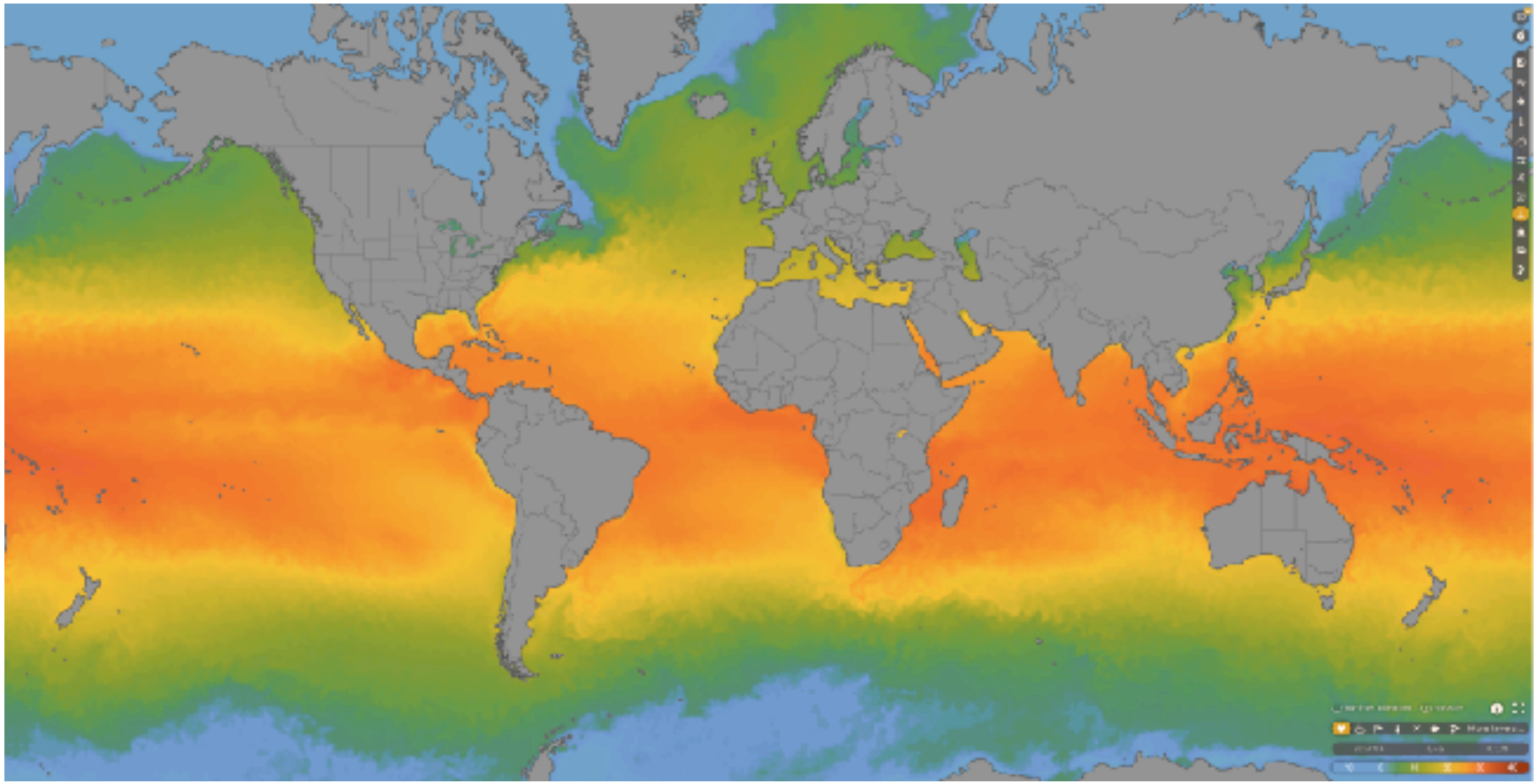
Measuring the Oceans



The Robot Ocean Network | American Scientist

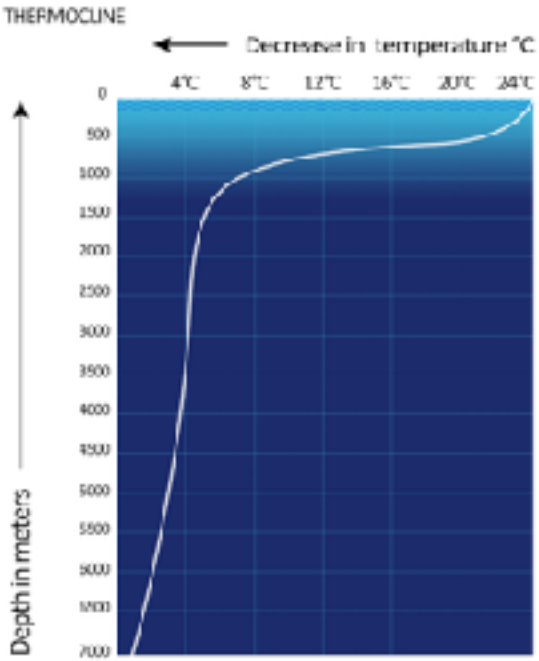
There are 3500 automated underwater vehicles (AUV) studying the oceans at all depths and sending data back via satellites.

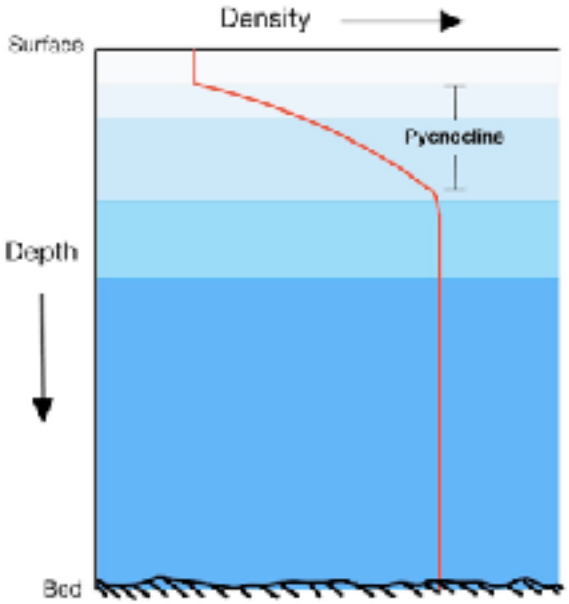
Ocean Surface Temperature



Warmer and cooler colours represent temperature

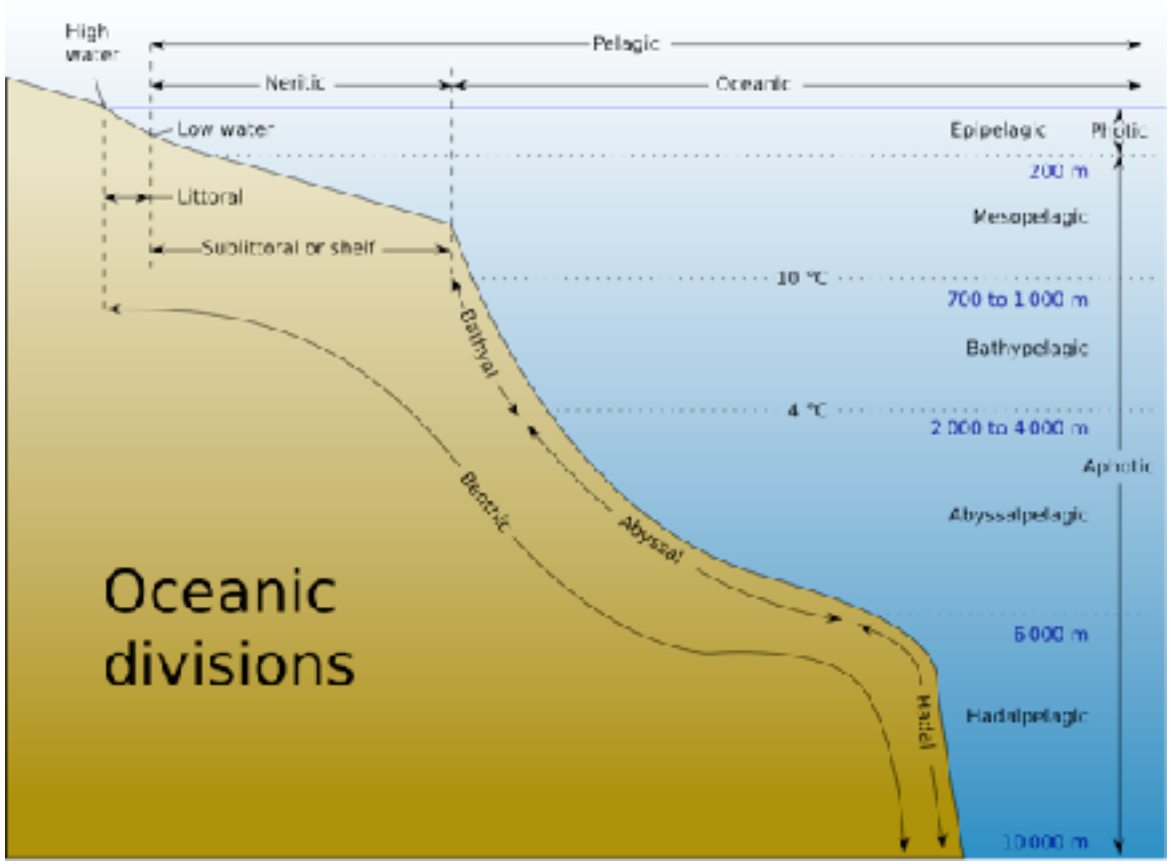
Ocean Surface Temperature





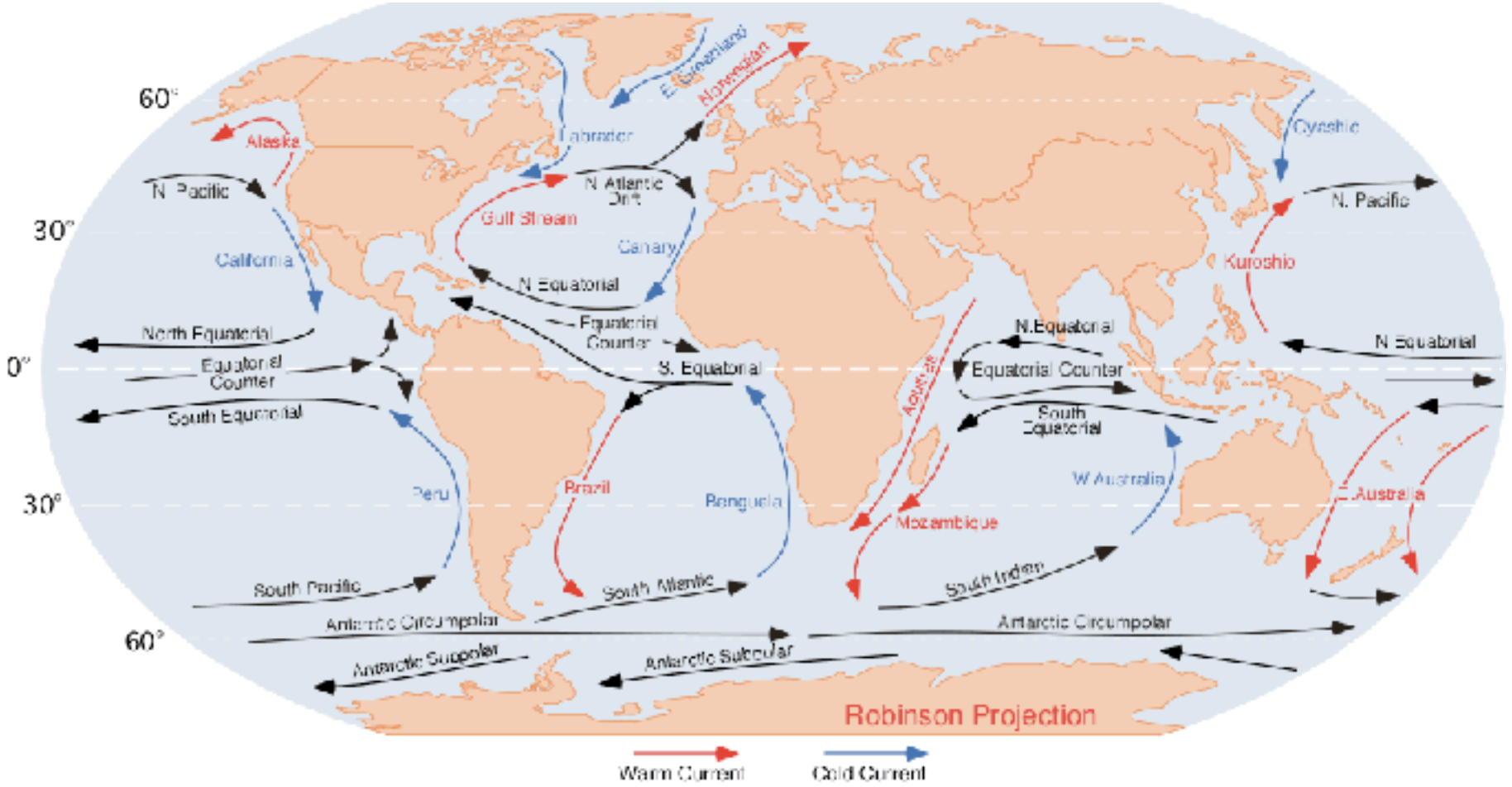
Salinity can affect the density of water. Density mixing occurs at the pycnocline. The pycnocline and the permanent thermocline act as a barriers to vertical mixing of chemicals

Layers of the Oceans

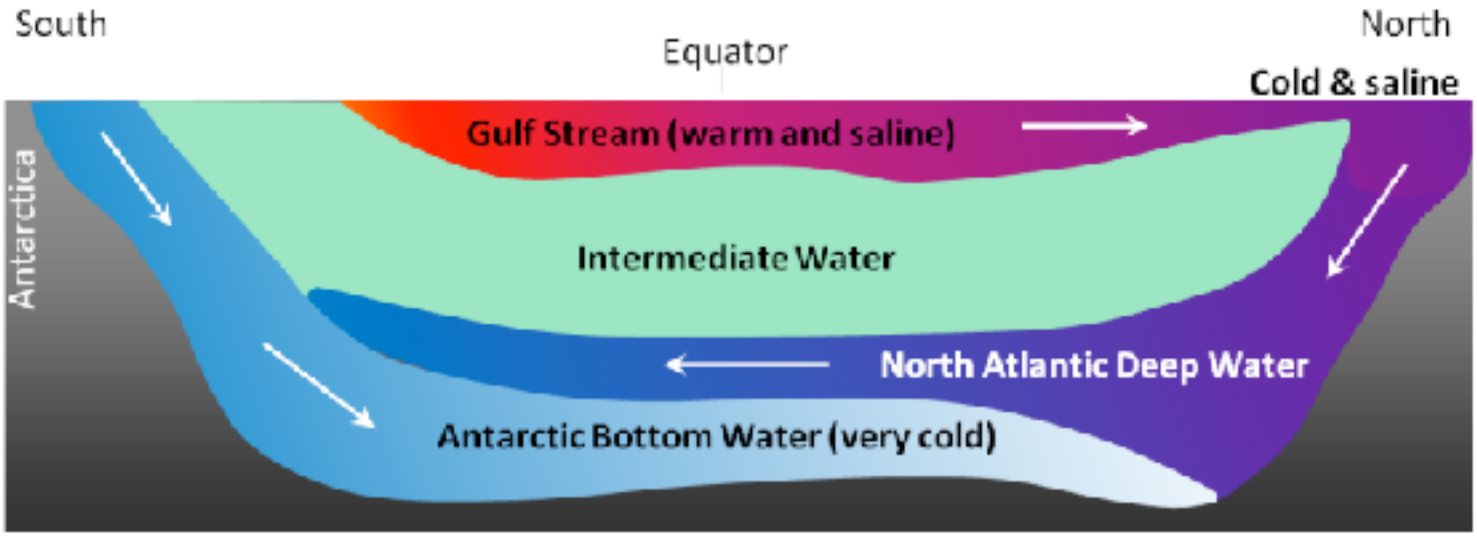


Plankton in the Photic Zone make 50% of the world's oxygen by photosynthesis

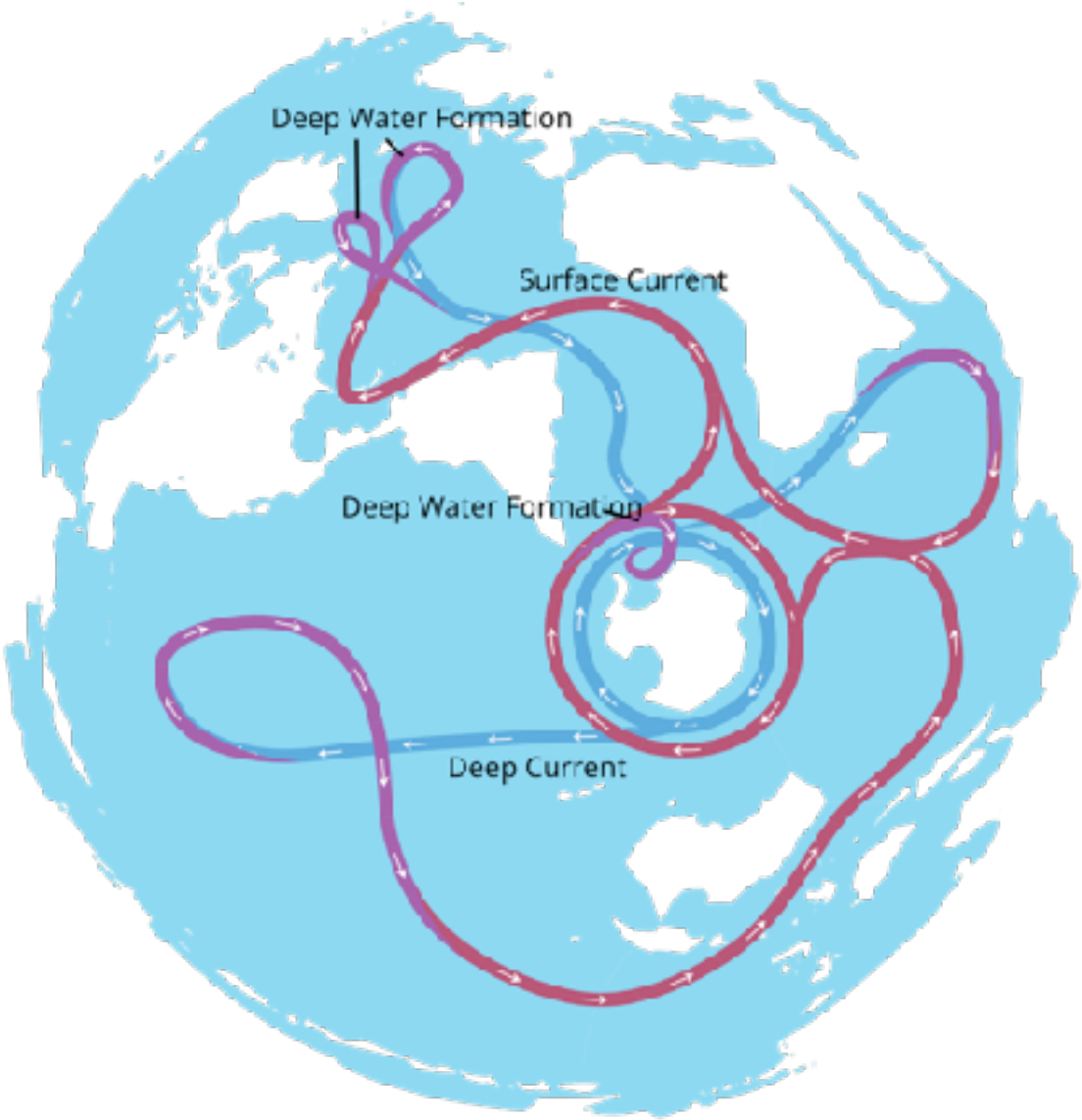
Surface Currents

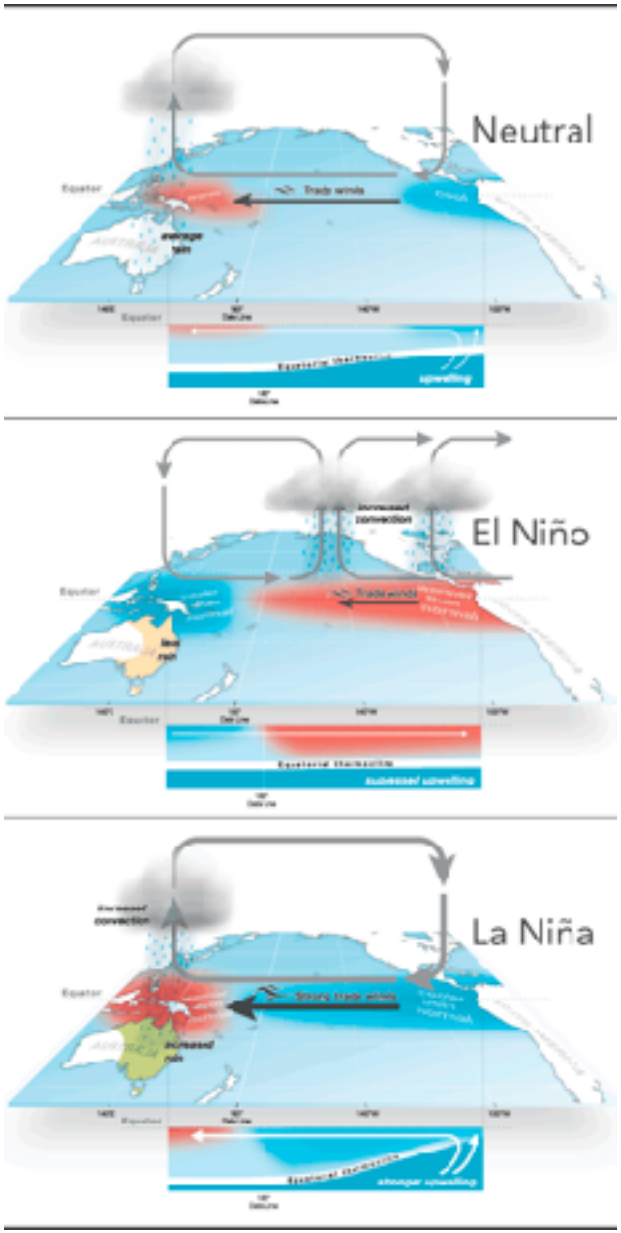


Ocean Currents



There is a worldwide conveyor belt of deep, cold saline currents and warm saline, surface currents

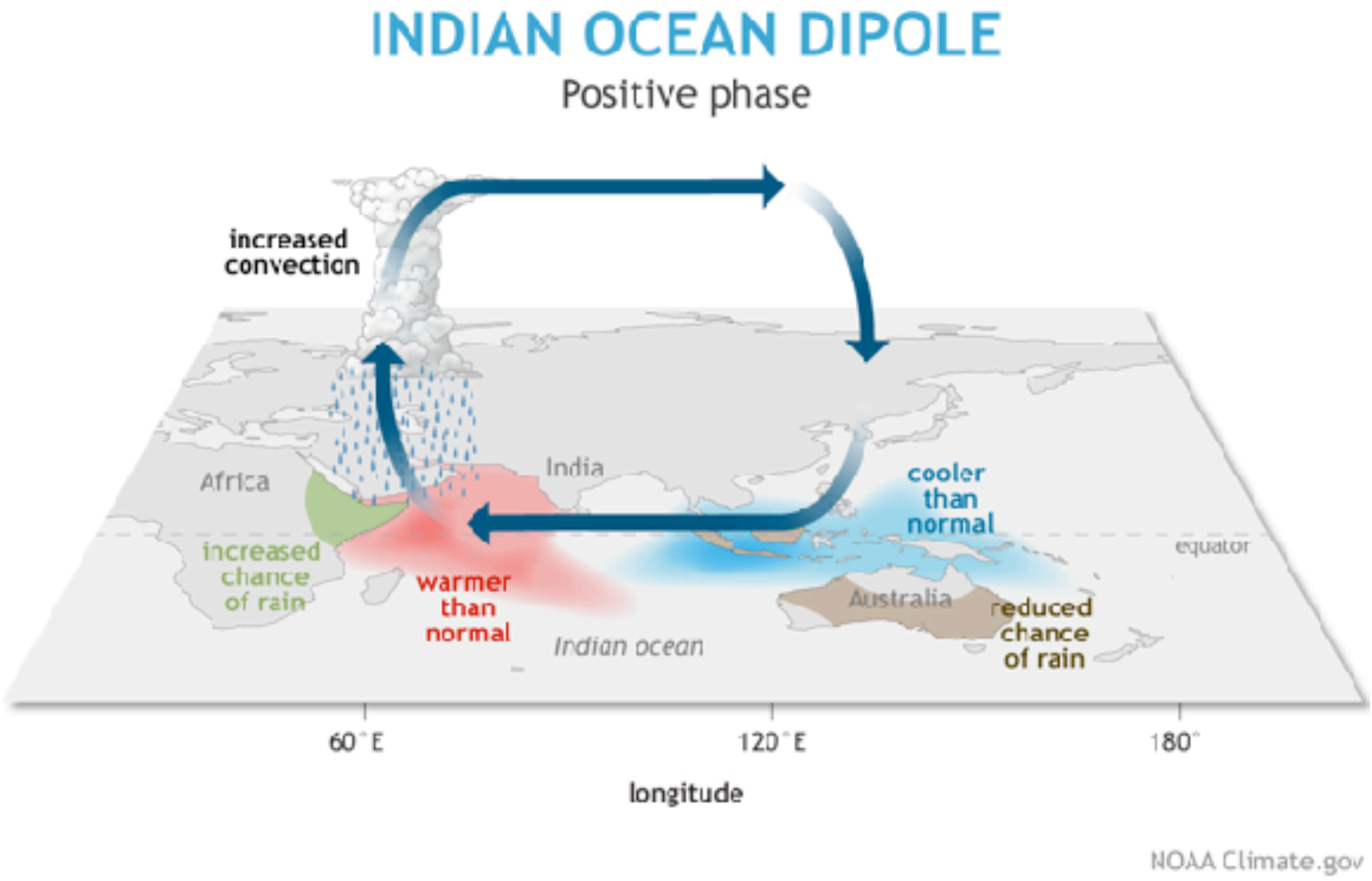

Deep Water Formation
Surface Current
Deep Water Formation
Deep Current



- The El Niño–Southern Oscillation or ENSO is a single climate phenomenon that periodically fluctuates between three phases: Neutral, La Niña or El Niño.
- The neutral phase does not affect the rainfall in Australia

- El Niño (or negative phase) occurs when air pressure over the west Pacific is unusually high and low over the east Pacific
- El Niño causes lower than average rainfall in Australia

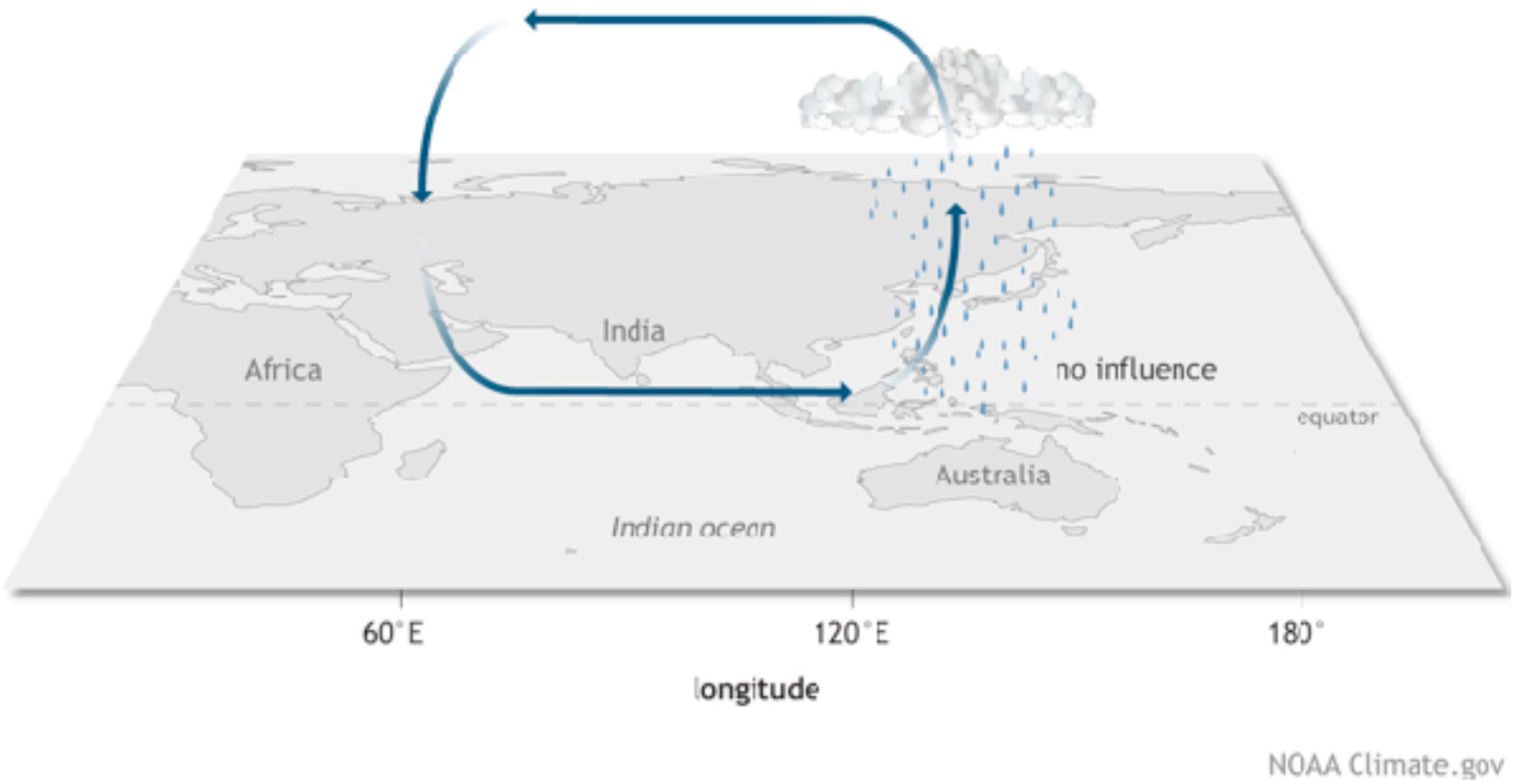
- La Niña (or positive phase) occurs when air pressure over the east Pacific is unusually high and low over the west Pacific
- La Niña causes higher than average rainfall in Australia



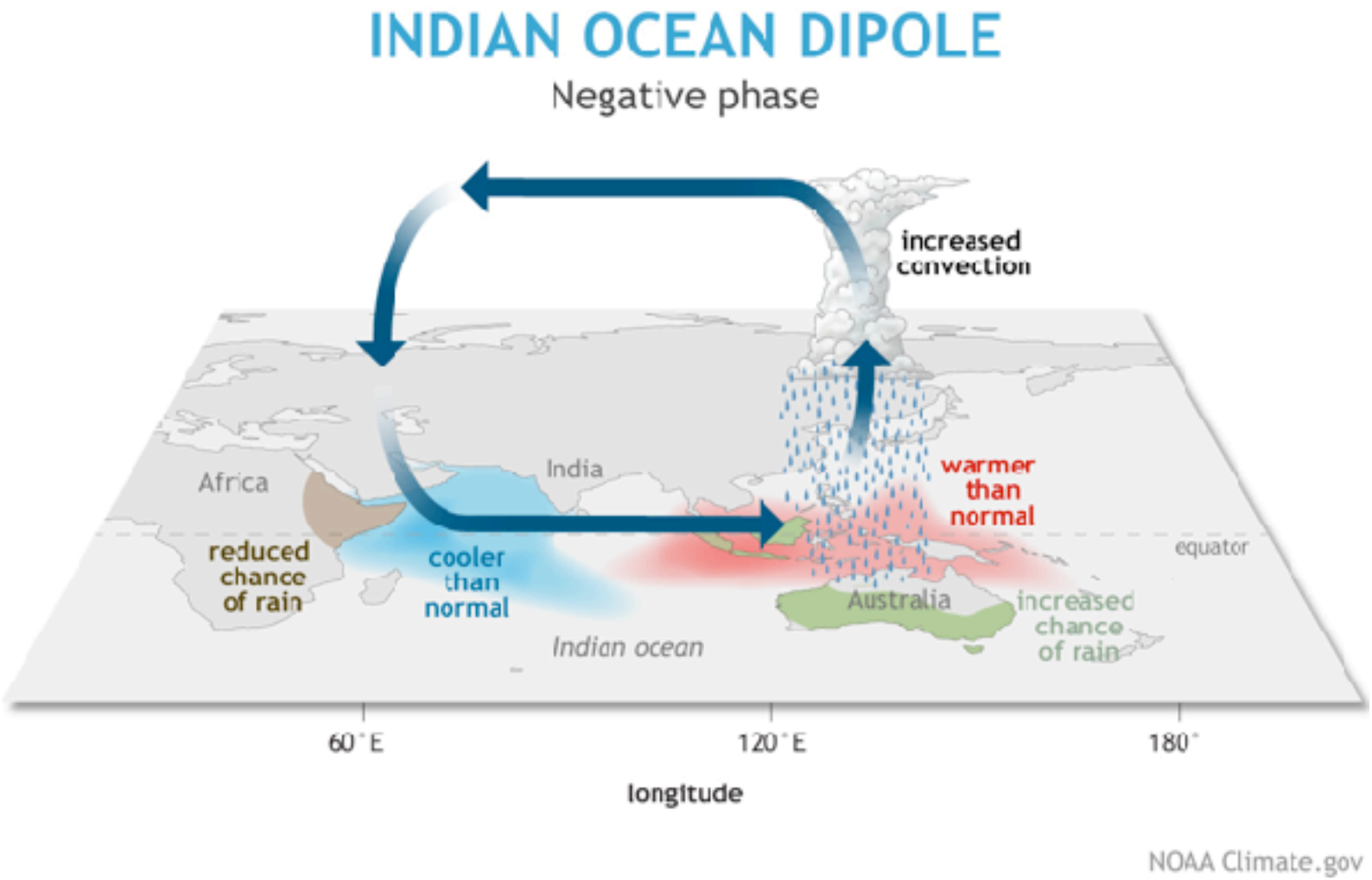
Positive phase peaks in September to November, leads to a drier Australia (e.g., bushfires)

INDIAN OCEAN DIPOLE

Neutral phase



Neutral phase shows no effects in Australia's climate

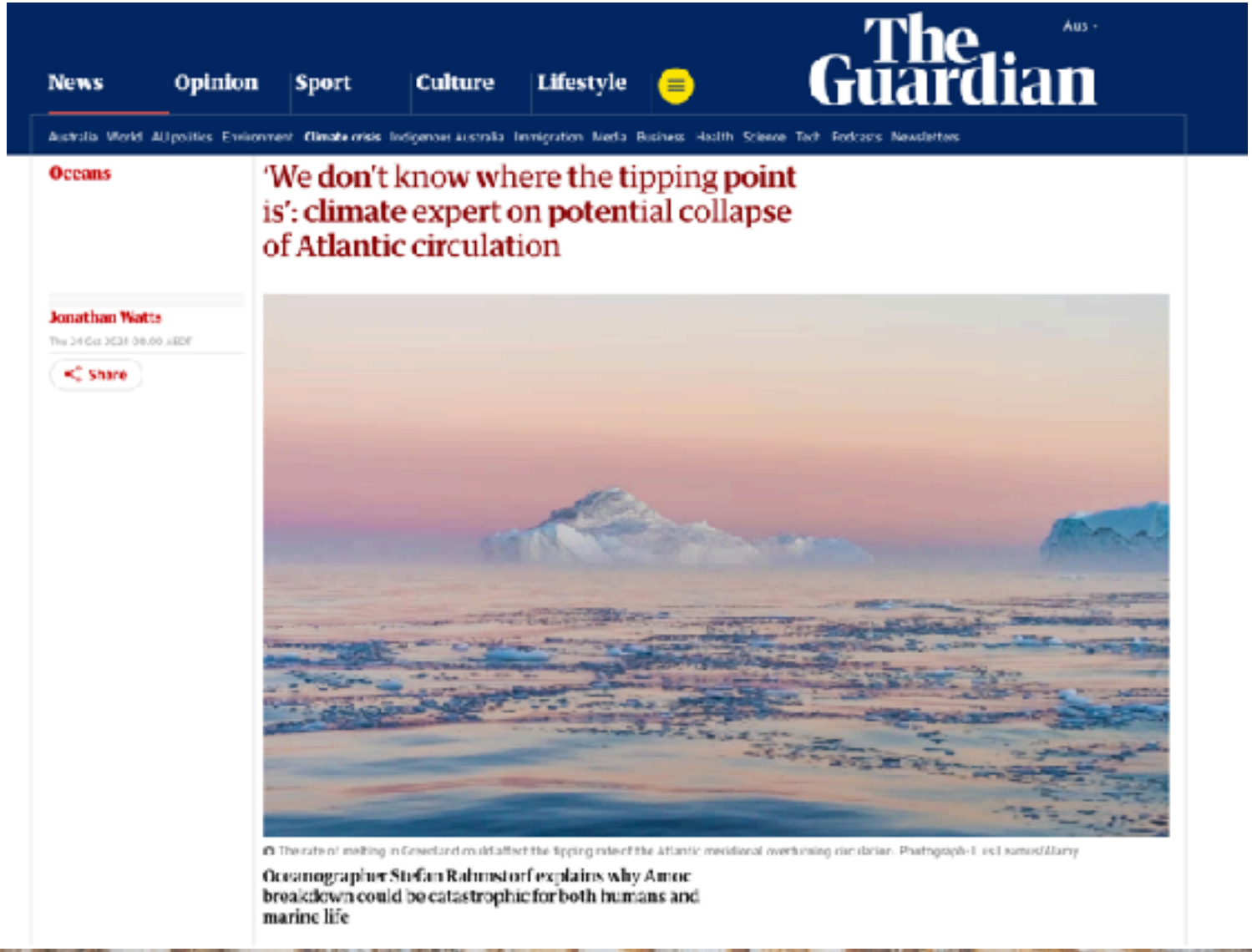


Negative phase shows a wetter phase in Australia

The Gulf Stream

(part of the AMOC or Atlantic meridional overturning circulation)

Ocean Currents in the News



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The Guardian

Oceans

'We don't know where the tipping point is': climate expert on potential collapse of Atlantic circulation

Jonathan Watts

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Oceanographer Stefan Rahmstorf explains why Amoc breakdown could be catastrophic for both humans and marine life

nature communications

Article

https://doi.org/10.1038/s41467-023-39810-w

Warning of a forthcoming collapse of the Atlantic meridional overturning circulation

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Accepted: 29 June 2023

Published online: 25 July 2023

Check for updates

Peter Ditlevsen [1,2] & Susanne Ditlevsen [2,3]

The Atlantic meridional overturning circulation (AMOC) is a major tipping element in the climate system and a future collapse would have severe impacts on the climate in the North Atlantic region. In recent years weakening in circulation has been reported, but assessments by the Intergovernmental Panel on Climate Change (IPCC), based on the Climate Model Intercomparison Project (CMIP) model simulations suggest that a full collapse is unlikely within the 21st century. Tipping to an undesired state in the climate is, however, a growing concern with increasing greenhouse gas concentrations. Predictions based on observations rely on detecting early-warning signals, primarily an increase in variance (loss of resilience) and increased autocorrelation (critical slowing down), which have recently been reported for the AMOC. Here we provide statistical significance and data-driven estimators for the time of tipping. We estimate a collapse of the AMOC to occur around mid-century under the current scenario of future emissions.