Past and Future Climate – Present Weather

Week 1

Overview -
or the whole story in one graph!

Terry Hart

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Phone: 0474 223 281

- Dates for Term 1
  - February 12 and 26
  - March 12 and 26
- Name badges (and emergency information)
- Attendance record
  - you can record an apology with an “A” on the sheet and that is sufficient.
  - you can also record an apology on-line.
- Mobile phones
- Emergency exit
- First aid – Hub staff
- U3A Nunawading newsletter
- Contact regarding classes – a few do not have an email address

Week 1 Introduction

- You don't need special scientific knowledge – hopefully I can keep the presentations comprehensible – and I know that there are many here with expert knowledge in Geology and Biology. So let me know if I step out of line.
- Please ask questions and make suggestions
- I can e-mail a copy of the presentation to save you having to copy down details such as web pages.
- (For those who do not have an email address I can print a copy if you wish).
- A new version of the U3A Member software is scheduled to start in July. It is supposed to be easier to add class notes and other resources.

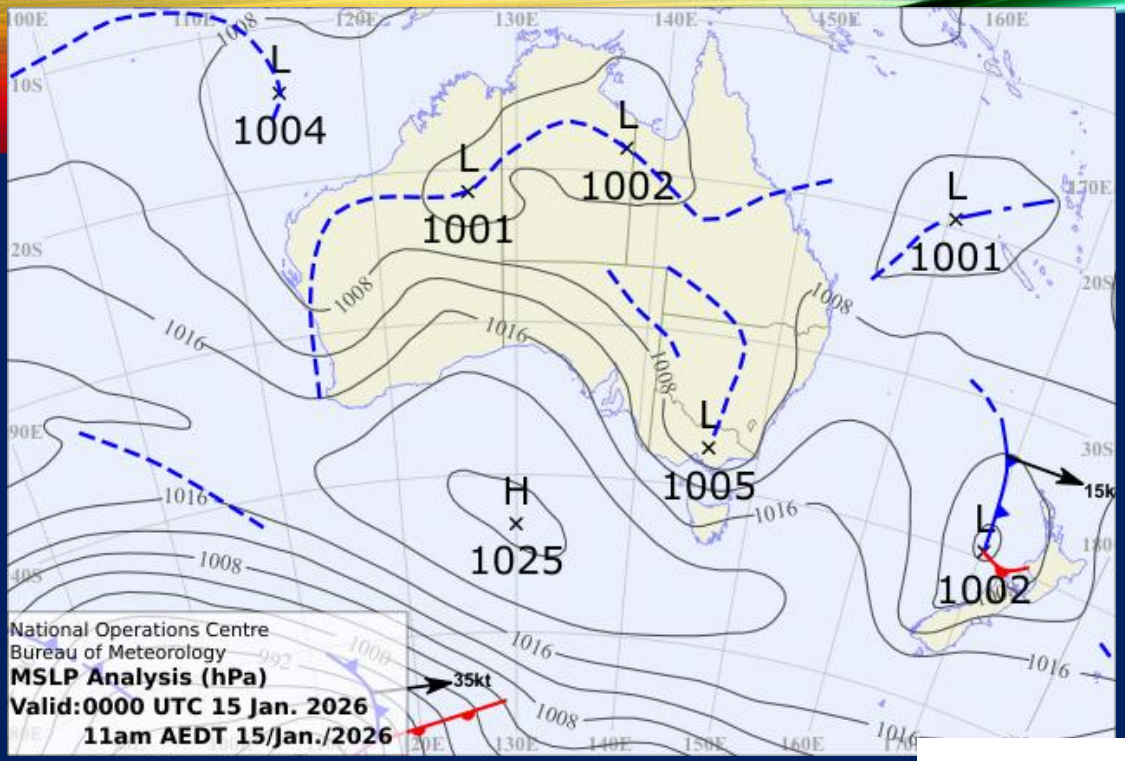
Wye River 15 January 2026

https://www.abc.net.au/news/2026-01-16/vic-what-caused-great-ocean-road-flash-flooding/106235904

Mount Cowley reported 180mm through the course of 6 hours, which is incredibly heavy rain for that part of the country," he said.

"In fact, that's the wettest day that we have on record for that particular weather station."

Mr Drayton from the SES said the previous record for that area was 123mm in a 24-hour period.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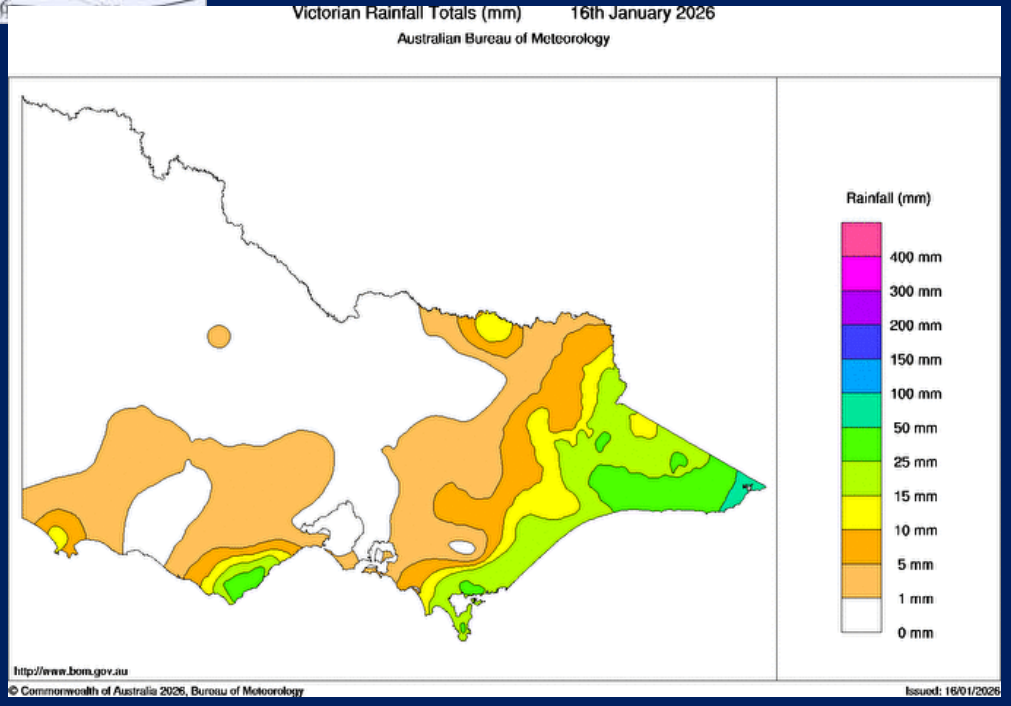
Bureau of Meteorology
MSLP Analysis (hPa)
Valid:0000 UTC 15 Jan. 2026
11am AEDT 15/Jan./2026


Victorian Rainfall Totals (mm) 16th January 2026
Australian Bureau of Meteorology
Rainfall (mm)
400 mm
300 mm
200 mm
150 mm
100 mm
50 mm
25 mm
15 mm
10 mm
5 mm
1 mm
0 mm
http://www.bom.gov.au
© Commonwealth of Australia 2026, Bureau of Meteorology
Issued: 16/01/2026

Heatwave live: Records tumble as Victorian firefighters battle out-of-control blazes

These include **Walpeup** and **Hopetoun** in north-west Victoria, which broke an all-time Victorian record when they each reached **48.9 degrees Celsius**.

Just across the border in South Australia, **Renmark** reached **49.6C**.

These are all-time highs since 1910, when standardised records began.

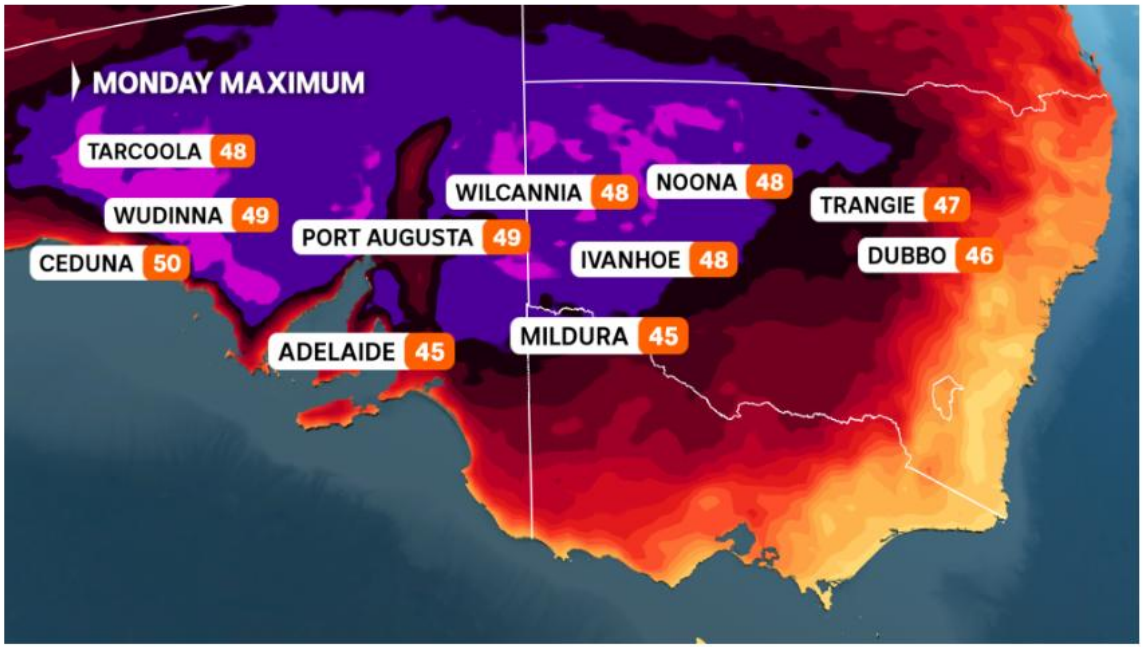
Suburbs across Melbourne are still recording temperatures above 40C at 7pm.

Worst heatwave in decades sending temperatures close to 50C over south-east Australia

By ABC meteorologist **Tom Saunders**

https://www.abc.net.au/news/2026-01-26/south-east-australia-weather-hit-close-to-50c-worst-heatwave/106270302

- 49.5C at Ceduna, its hottest day on record.
- 48.6C at Wudinna, its hottest day on record.
- 47.3C at Trangie, its hottest day since 1932.
- 46.1C at Dubbo, equal hottest day on record.



Temperature climbed to the high 40s across much of southern Australia on Monday as the heatwave reached day three. *(ABC News)*

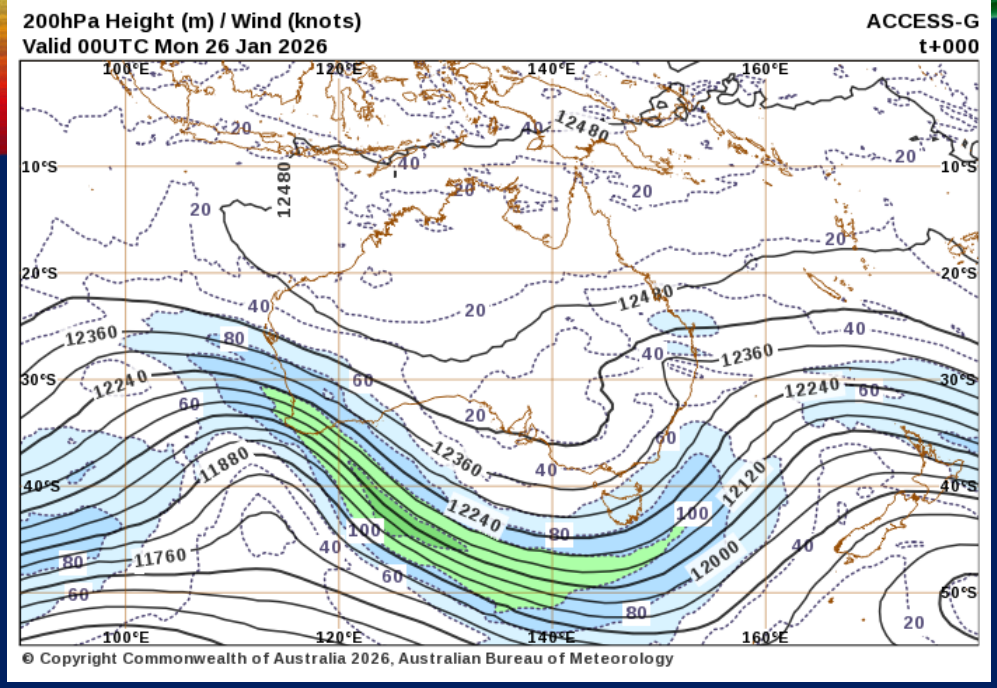
“So what is behind the unprecedented heat this week?

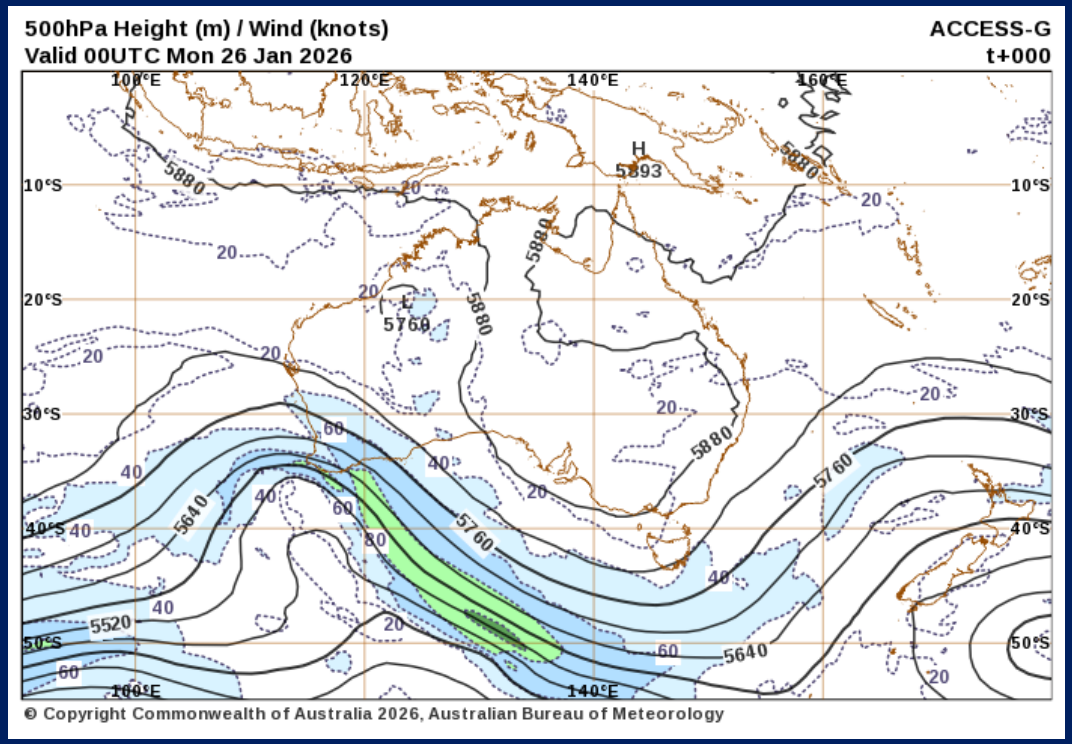
A glance at a basic weather map offers no explanation

The actual cause .. is what is happening higher in the atmosphere — a stationary high-pressure system has anchored itself a few kilometres above NSW, …, its elevated position is forcing air down towards the surface.

This compression process leads to a rapid warming of an air mass by about 10^{o}C per kilometre of descent, leading to a dome of hot air over the surface.

Upper-level high pressure systems are common in summer. However, the current high is further south relative to normal, and critically, its slow movement has allowed the heat dome to intensify over several days.”


200hPa Height (m) / Wind (knots)
Valid 00UTC Mon 26 Jan 2026
ACCESS-G
t+000
© Copyright Commonwealth of Australia 2026, Australian Bureau of Meteorology


500hPa Height (m) / Wind (knots)
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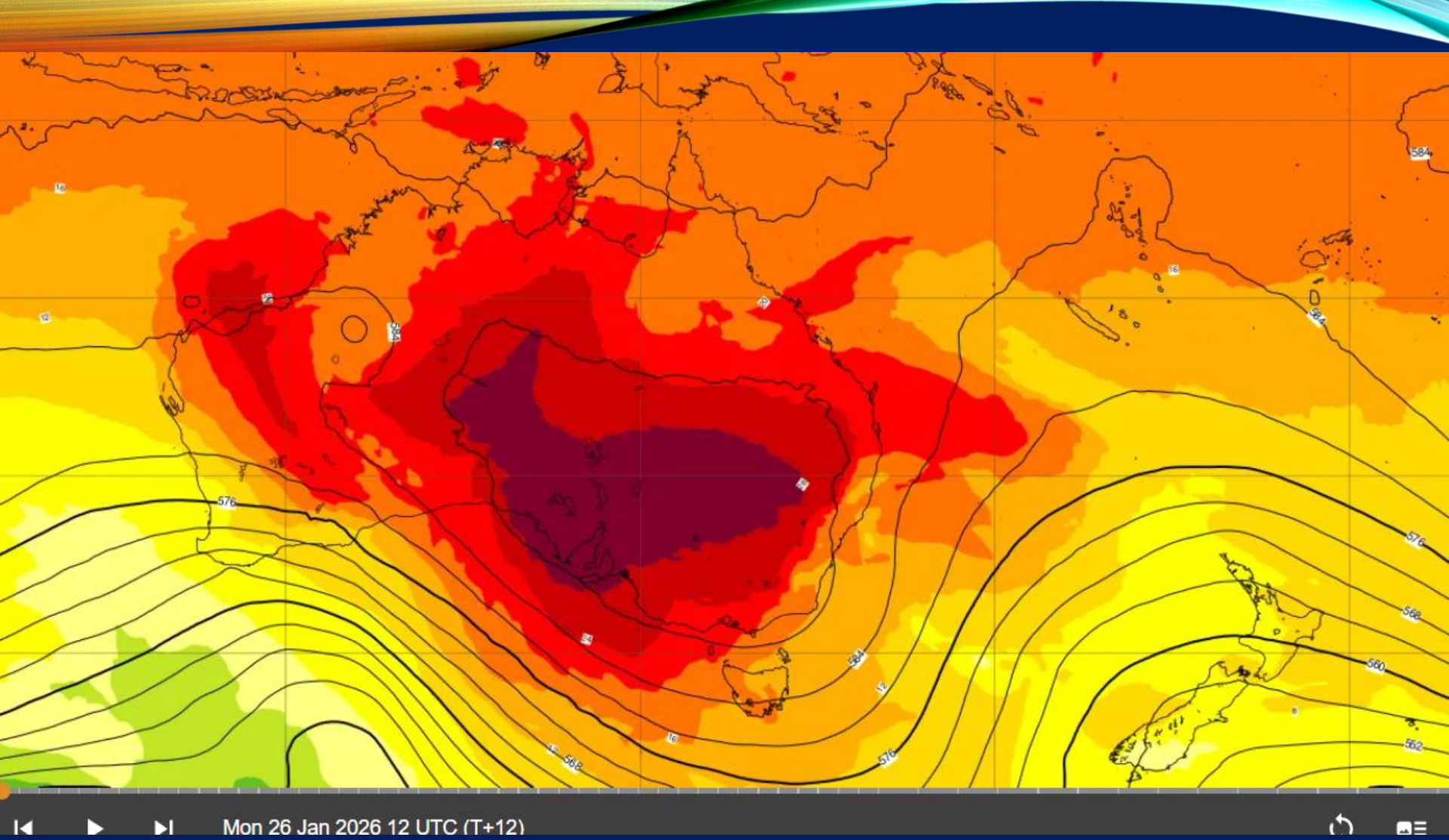
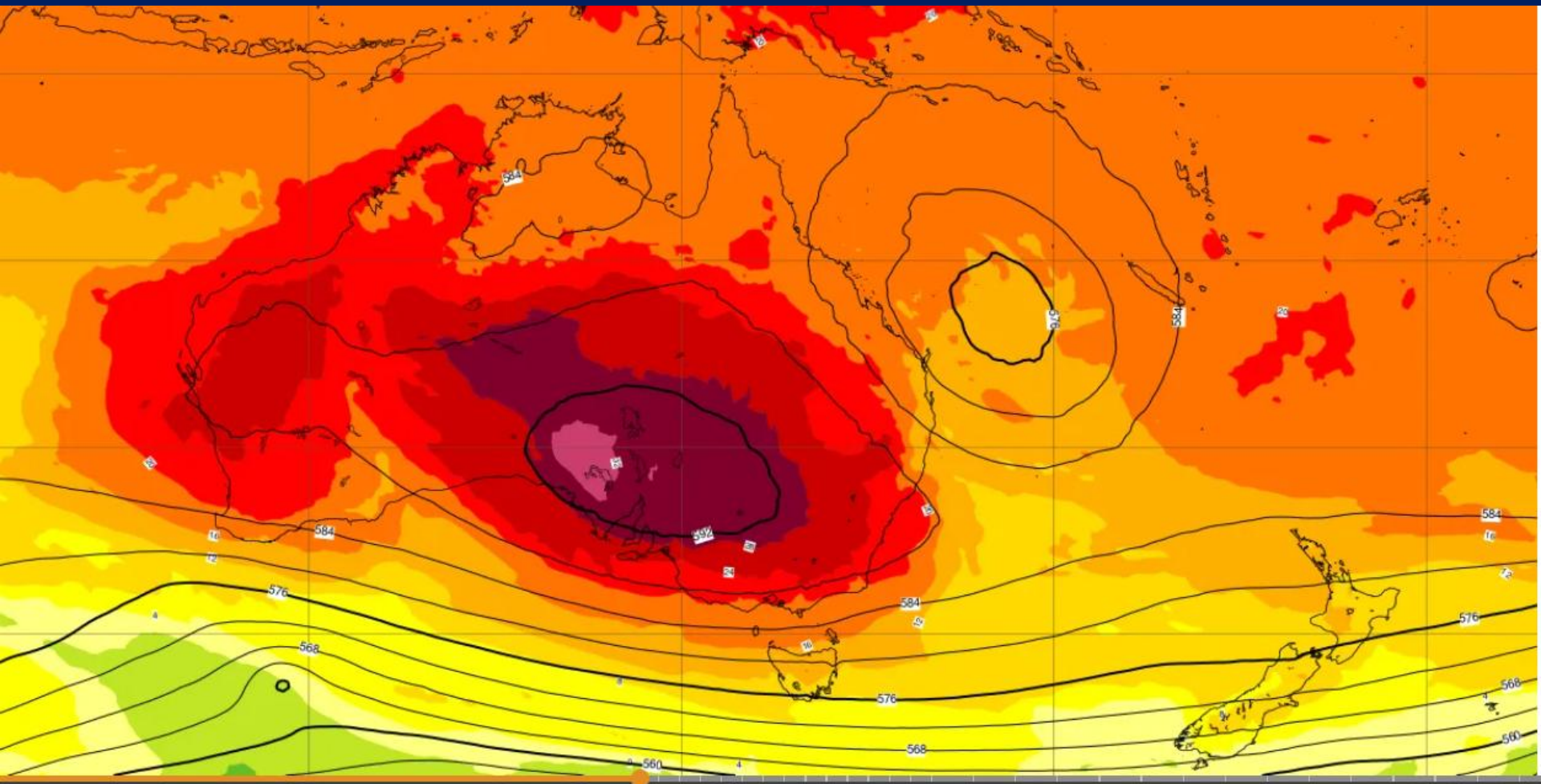


500 hPa geopotential height and 850 hPa temperature

10 pm Monday 26 January 2026

500 hPa is about 5.5 km above the surface
850 hPa is about 1.5 km above the surface.


584
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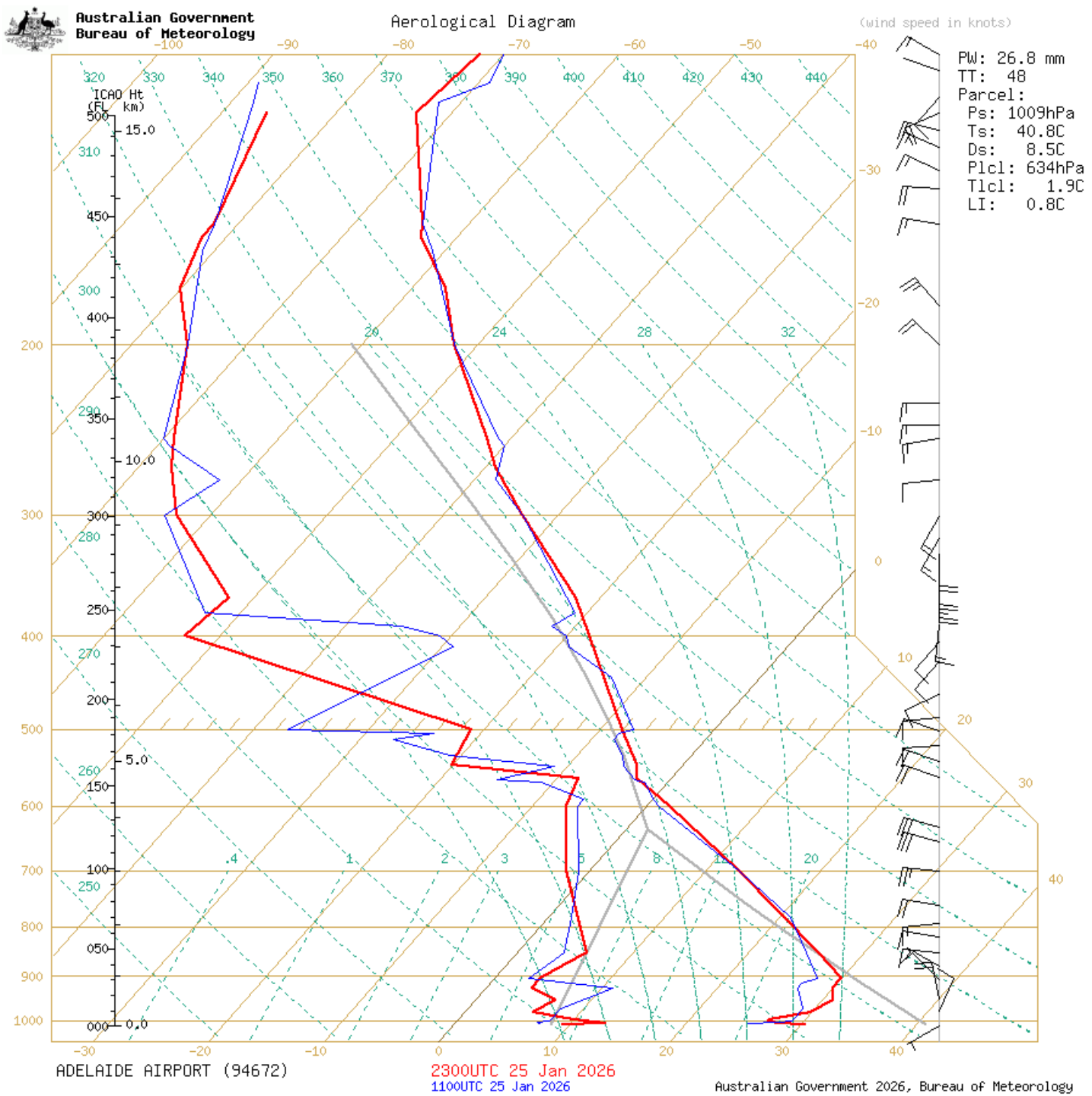
592
Fri 30 Jan 2026 06 UTC (T+102)


Australian Government
Bureau of Meteorology
Aerological Diagram
(wind speed in knots)
PW: 26.8 mm
TT: 48
Parcel:
Ps: 1009hPa
Ts: 40.8C
Ds: 8.5C
Plcl: 634hPa
Tlcl: 1.9C
LI: 0.8C
ICAO Ht
(FL km)
ADELAIDE AIRPORT (94672)
2300UTC 25 Jan 2026
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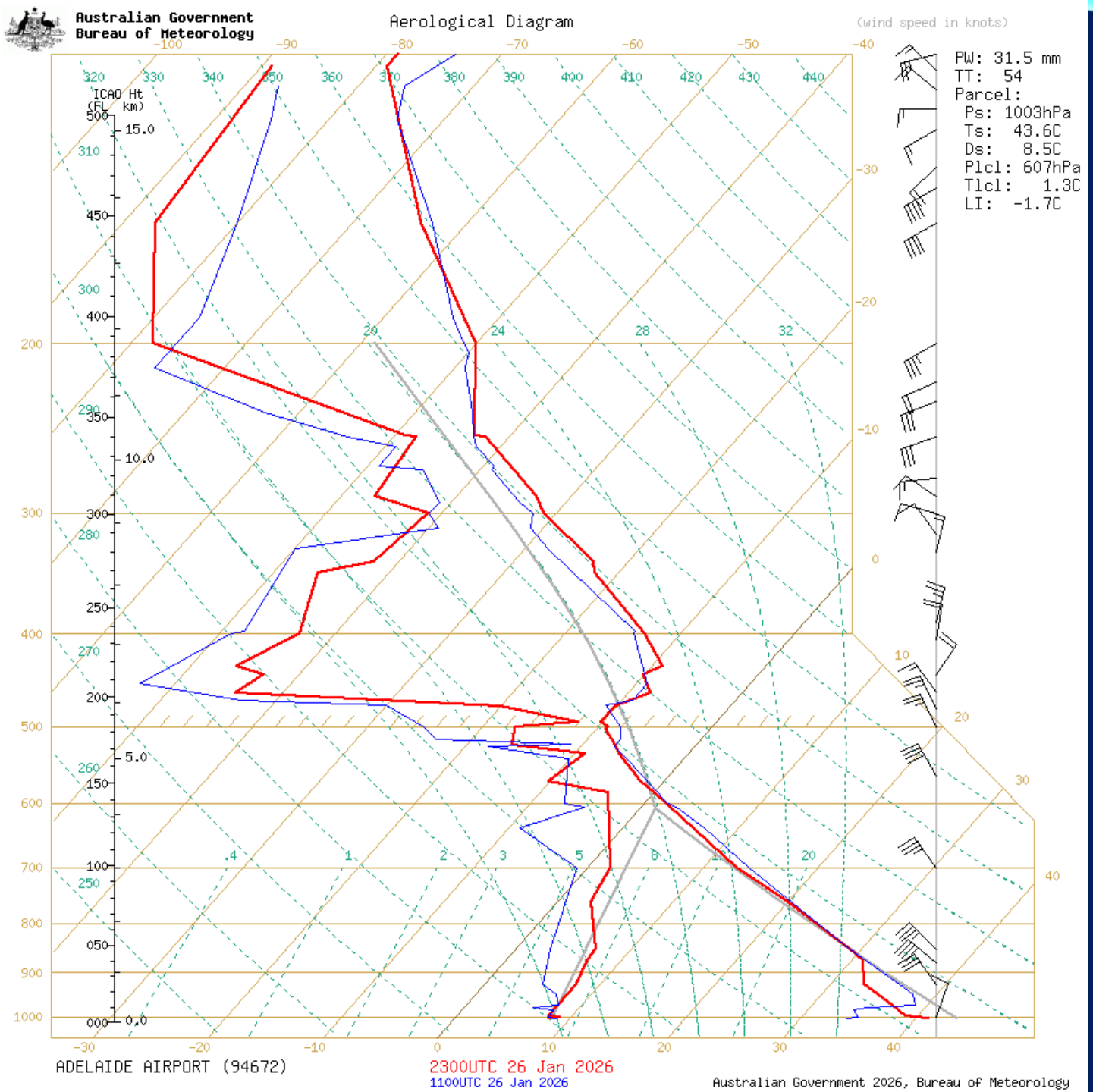
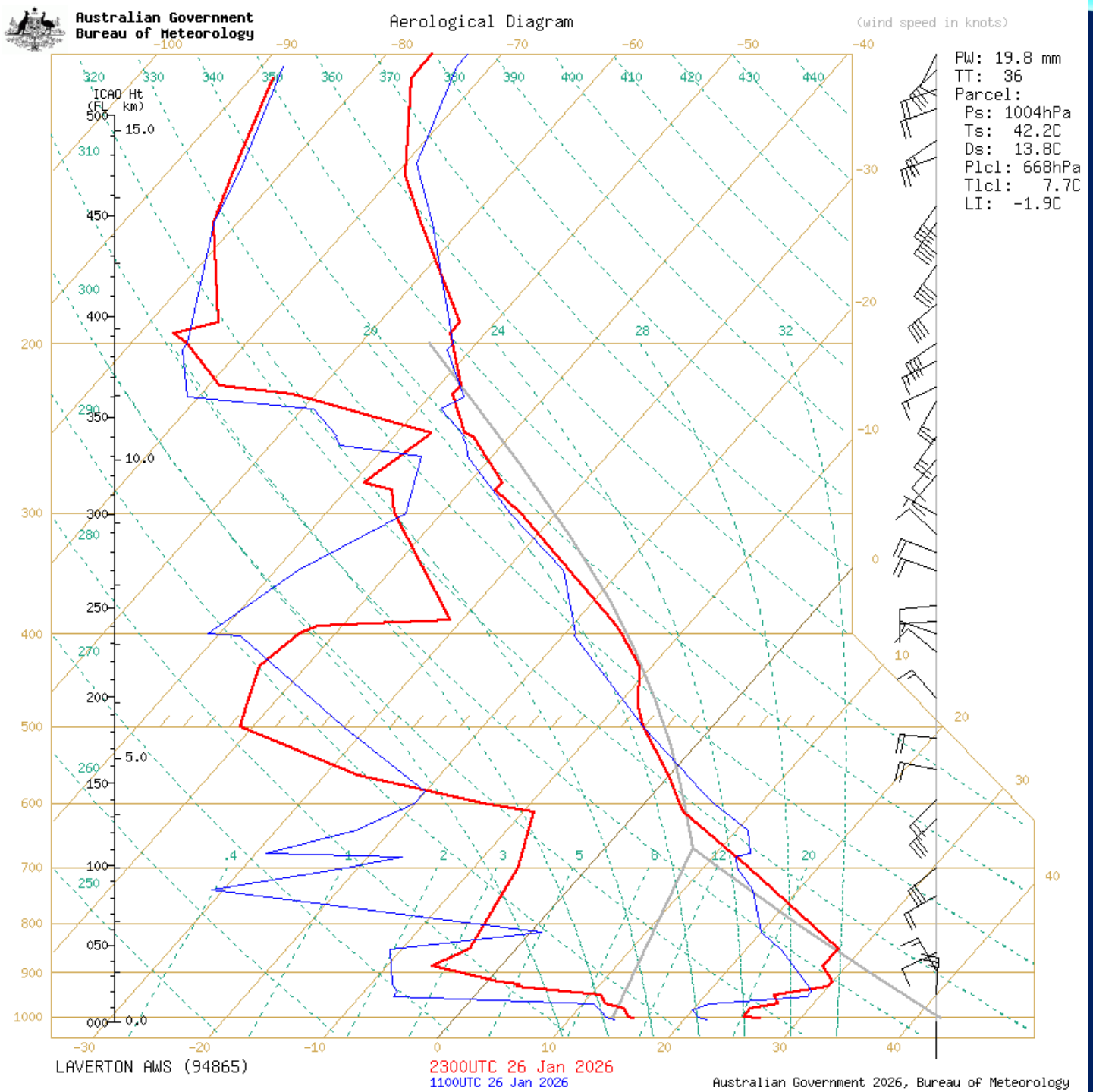
Australian Government 2026, Bureau of Meteorology


Australian Government
Bureau of Meteorology
Aerological Diagram
(wind speed in knots)
PW: 31.5 mm
TT: 54
Parcel:
Ps: 1003hPa
Ts: 43.6C
Ds: 8.5C
Plcl: 607hPa
Tlcl: 1.3C
LI: -1.7C
ICAO Ht
(FL km)
ADELAIDE AIRPORT (94672)
2300UTC 26 Jan 2026
1100UTC 26 Jan 2026
Australian Government 2026, Bureau of Meteorology


Australian Government
Bureau of Meteorology
Aerological Diagram
(wind speed in knots)
PW: 19.8 mm
TT: 36
Parcel:
Ps: 1004hPa
Ts: 42.2C
Ds: 13.8C
Plcl: 668hPa
Tlcl: 7.7C
LI: -1.9C
ICAO Ht
(FL km)
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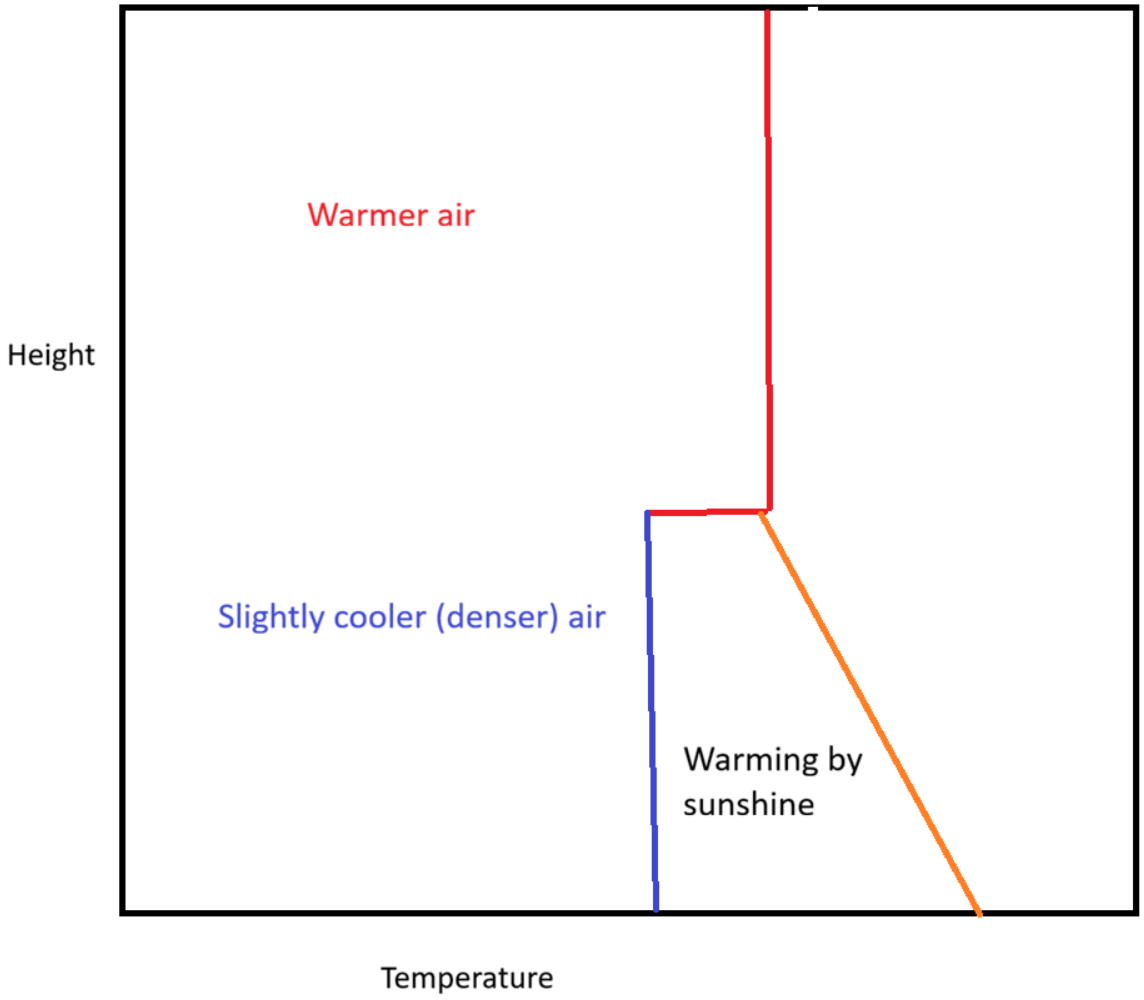
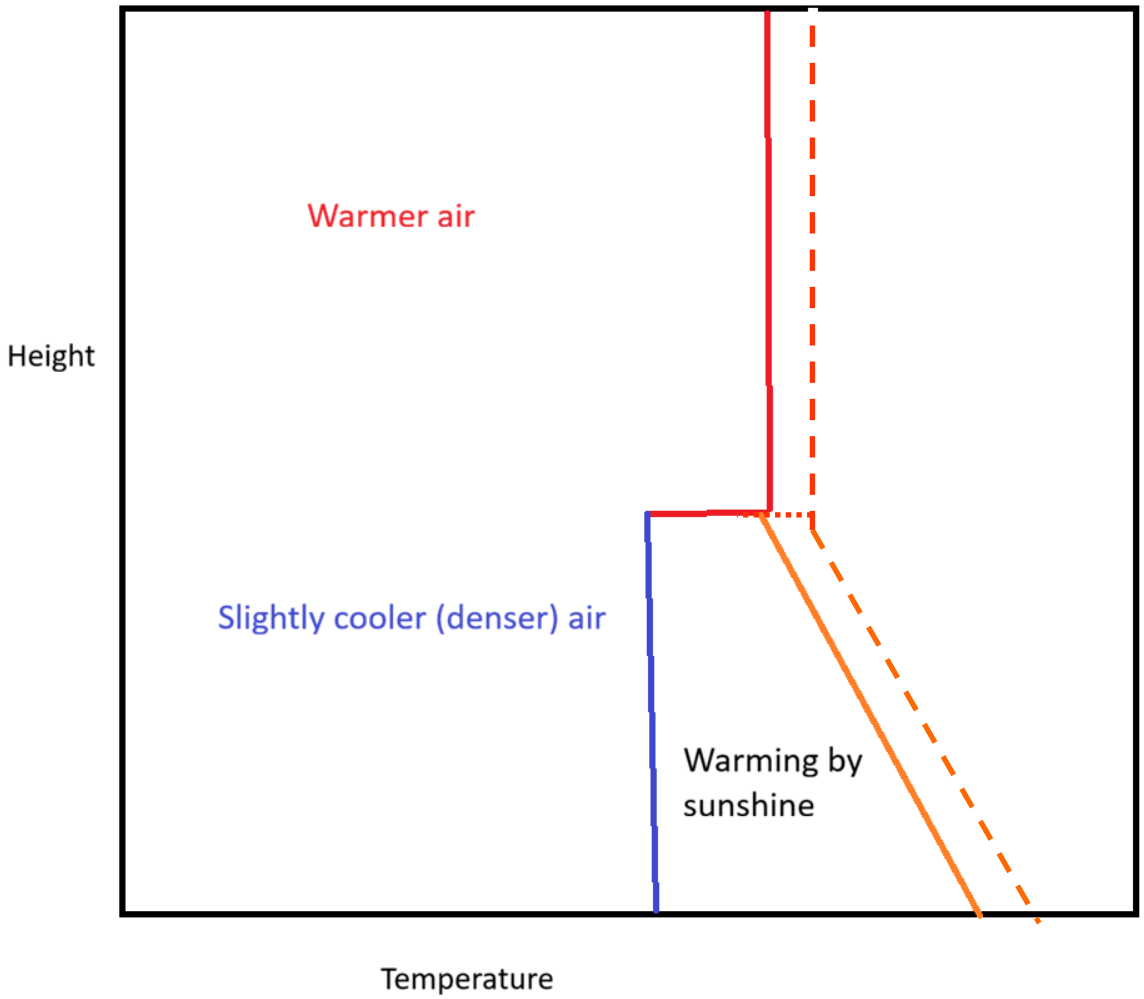
Australian Government 2026, Bureau of Meteorology



Why maximum temperature records can be broken.

How warming upper air temperatures affect the temperature at ground level.

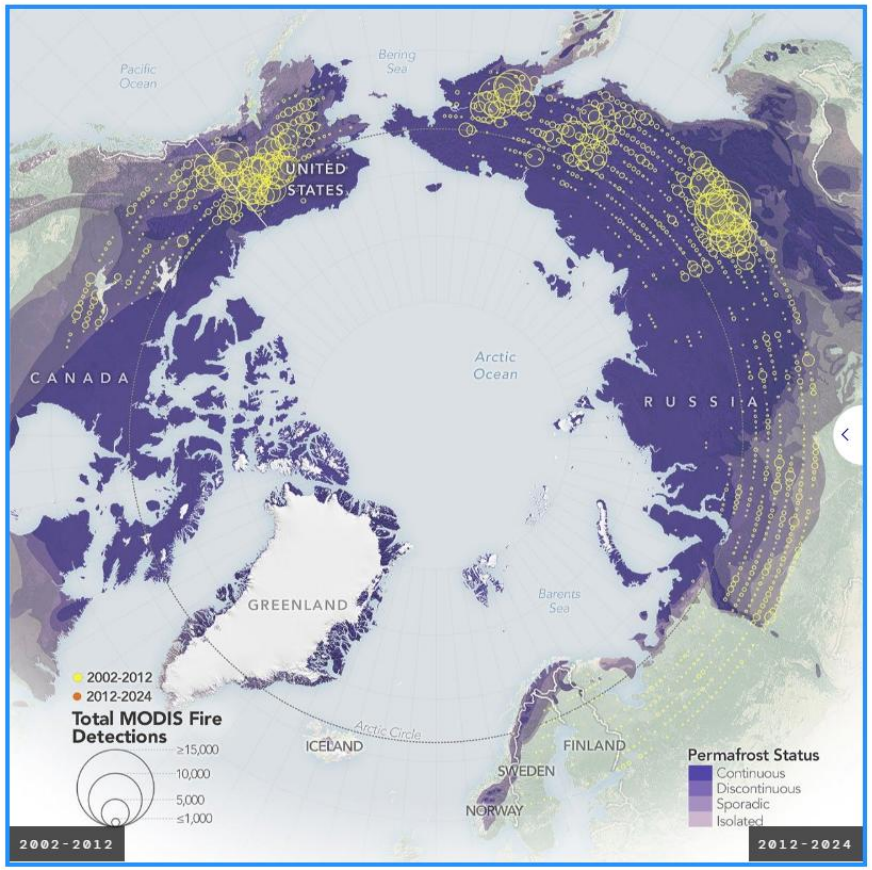


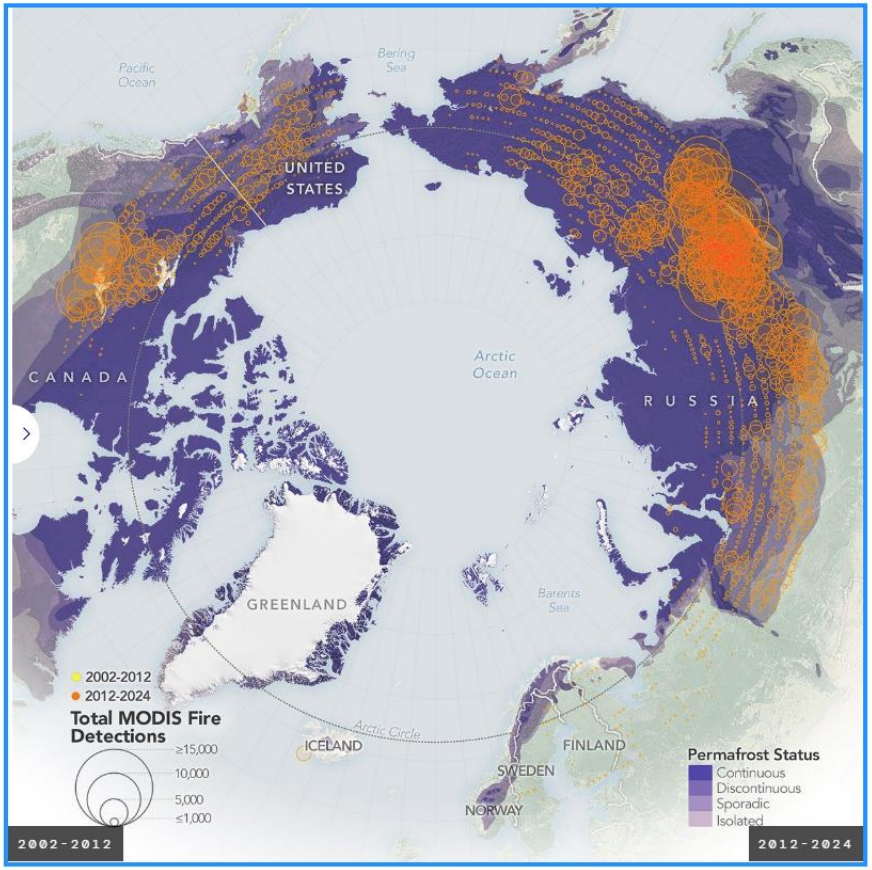
Why maximum temperature records can be broken.

Dashed line shows what can happen if the upper temperature increases.

If the upper temperatures reach record levels that can lead to record maximum temperatures at ground level.

How warming upper air temperatures affect the temperature at ground level.





https://science.nasa.gov/earth/earth-observatory/fires-on-the-rise-in-the-far-north/

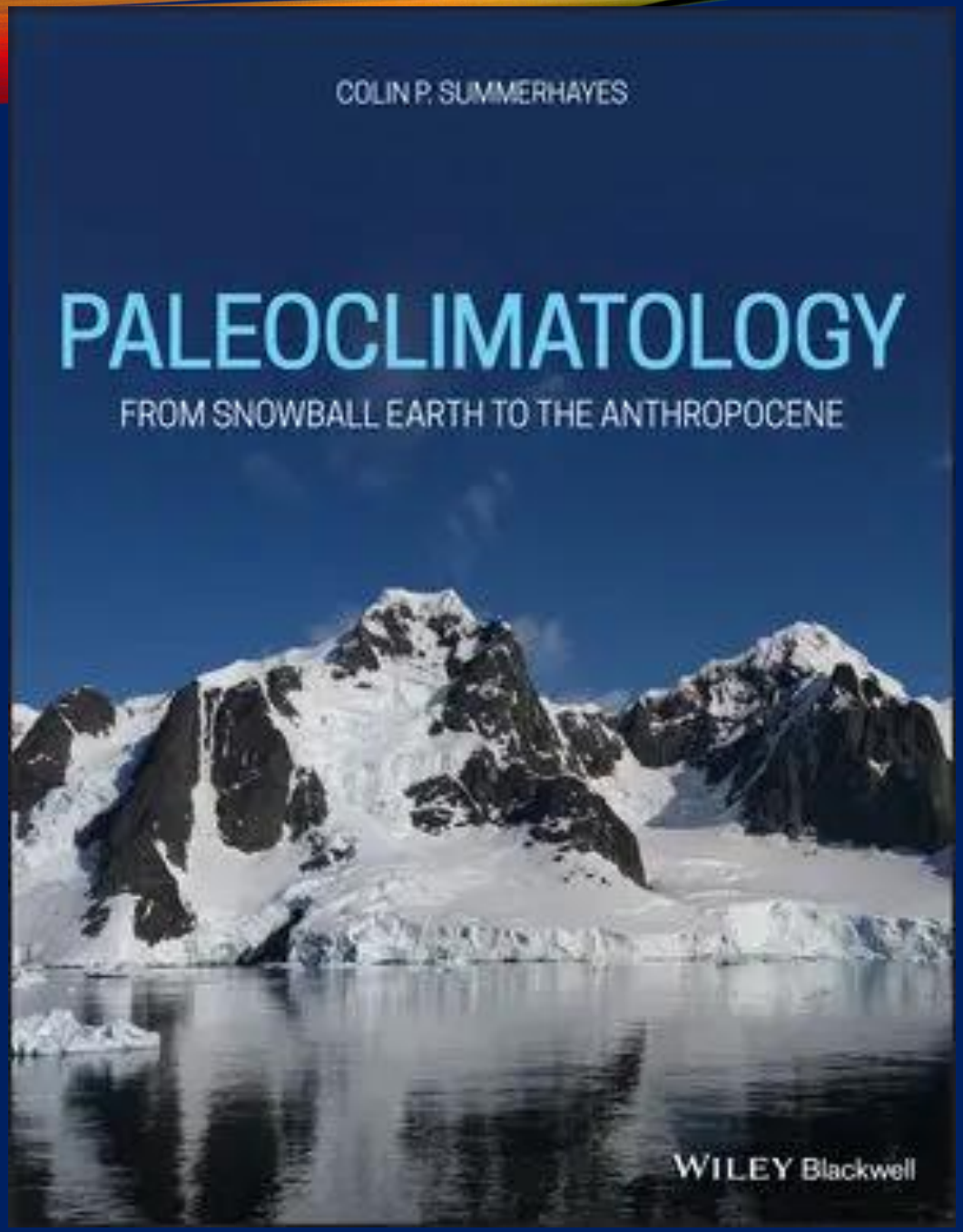
Why study past climate?

- It is interesting in its own right – a very multidisciplinary subject.

- Puts the current climate and possible climate change into perspective

- Improves understanding of how the climate behaves
  - Temperatures
  - Sea level
  - Changes in atmospheric gases
  - Effect on plants and animals and of plants and animals

- Helps explain what affects climate and how sensitive it is to changes internally or externally.



Author: Colin P Summerhayes

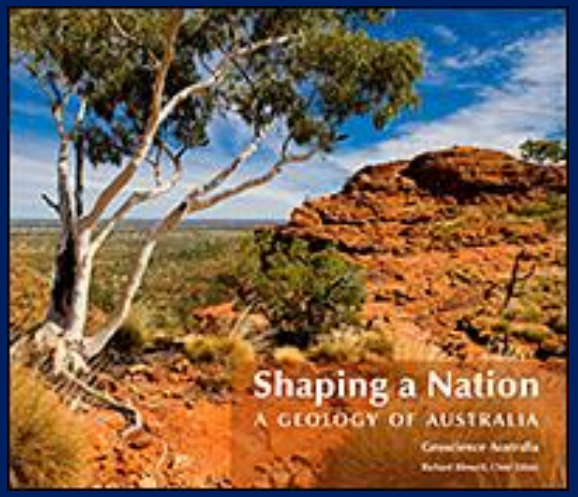
Worked for many organisations both academic and private, including Exxon and BP. He is an Emeritus Associate at the Scott Polar Research Institute at Cambridge University.

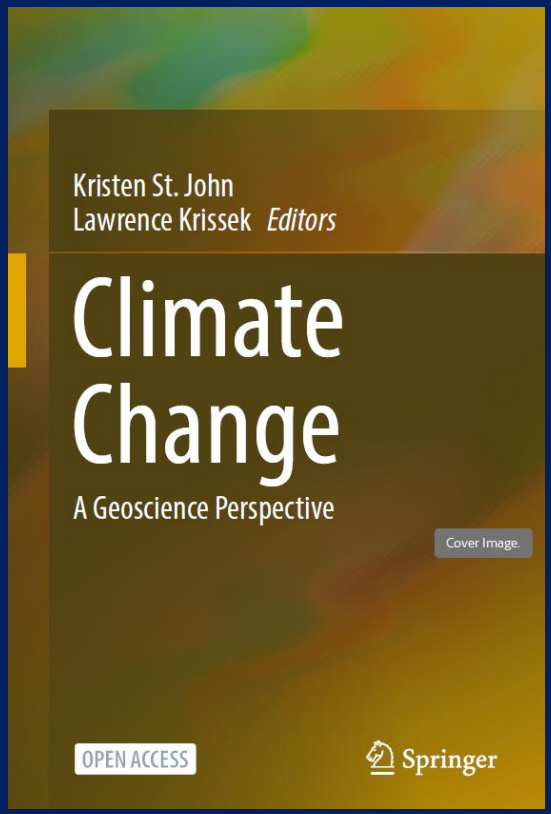
Published in August 2020
Wiley-Blackwell
560 pages

Open Access References

Shaping a Nation – A Geology of Australia – (Chief Editor: Richard Blewett). Geoscience Australia (2012)

A free pdf version available at: https://press.anu.edu.au/publications/shaping-nation





Climate Change – A Geoscience Perspective.

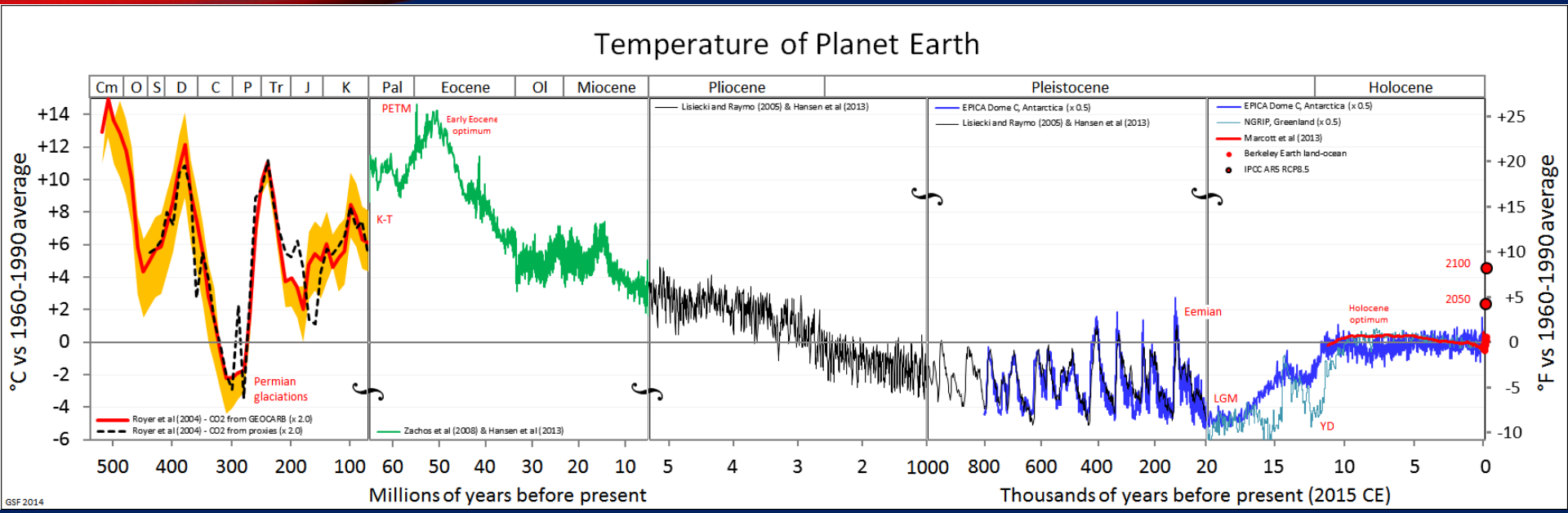
Open Access book – download pdf from: https://link.springer.com/book/10.1007/978-3-031-82869-0

Paleo – means “ancient” so Palaeoclimatology is the study of ancient climates (hundreds of millions of years if not billions).

However, much knowledge in the field of Palaeoclimatology is surprisingly recent:

- Plate tectonics – 60 years
- Ocean sediment cores – around 60 years
- Ice cores – mostly beginning around 30 years ago
- Luminescence dating techniques – 60 years
- Computer climate modelling – 60 years.

Intensive research and building it all into a coherent picture is more recent.



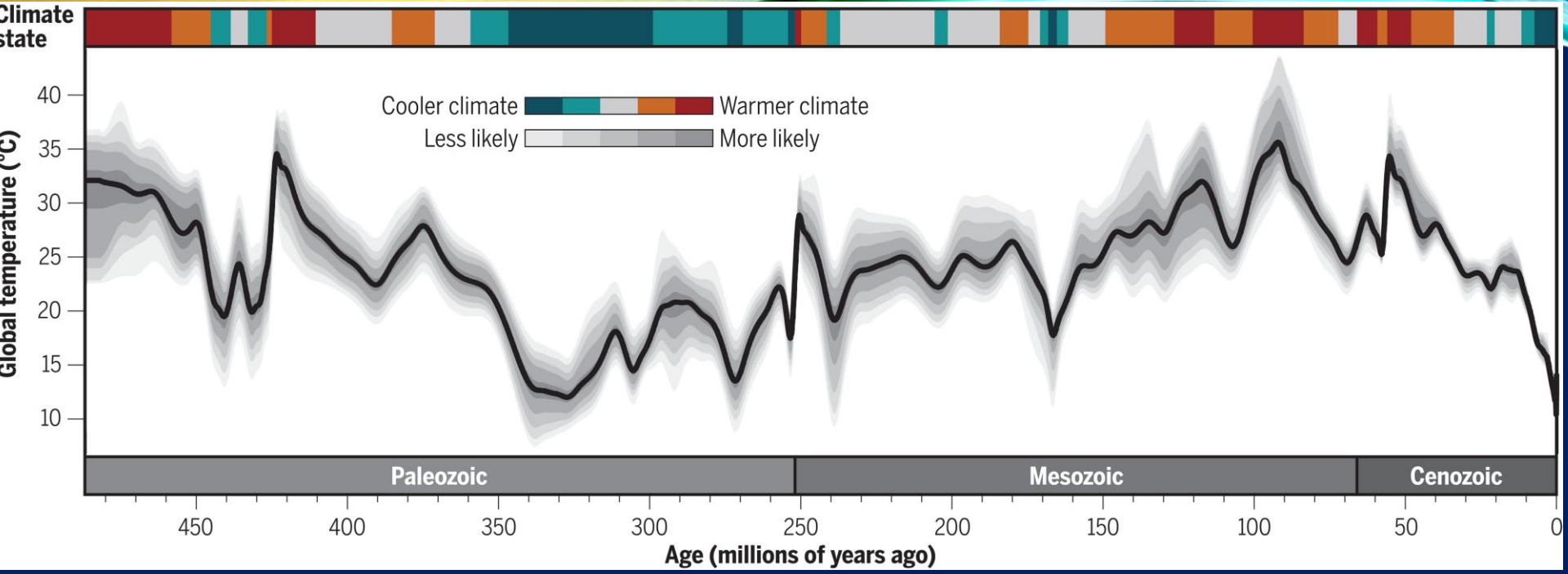
Time is plotted forward to the present, taken as 2015 CE.

Note that the scale expands towards the present. There are five separate linearly scaled segments, expanding by about an order of magnitude at each vertical break.

Surface air temperature is plotted as anomalies (differences) from the average over the reference interval 1960–1990 (which is about 14°C)

https://commons.wikimedia.org/wiki/File:All_palaeotemps.png#Data

Figure prepared by Glen Fergus.



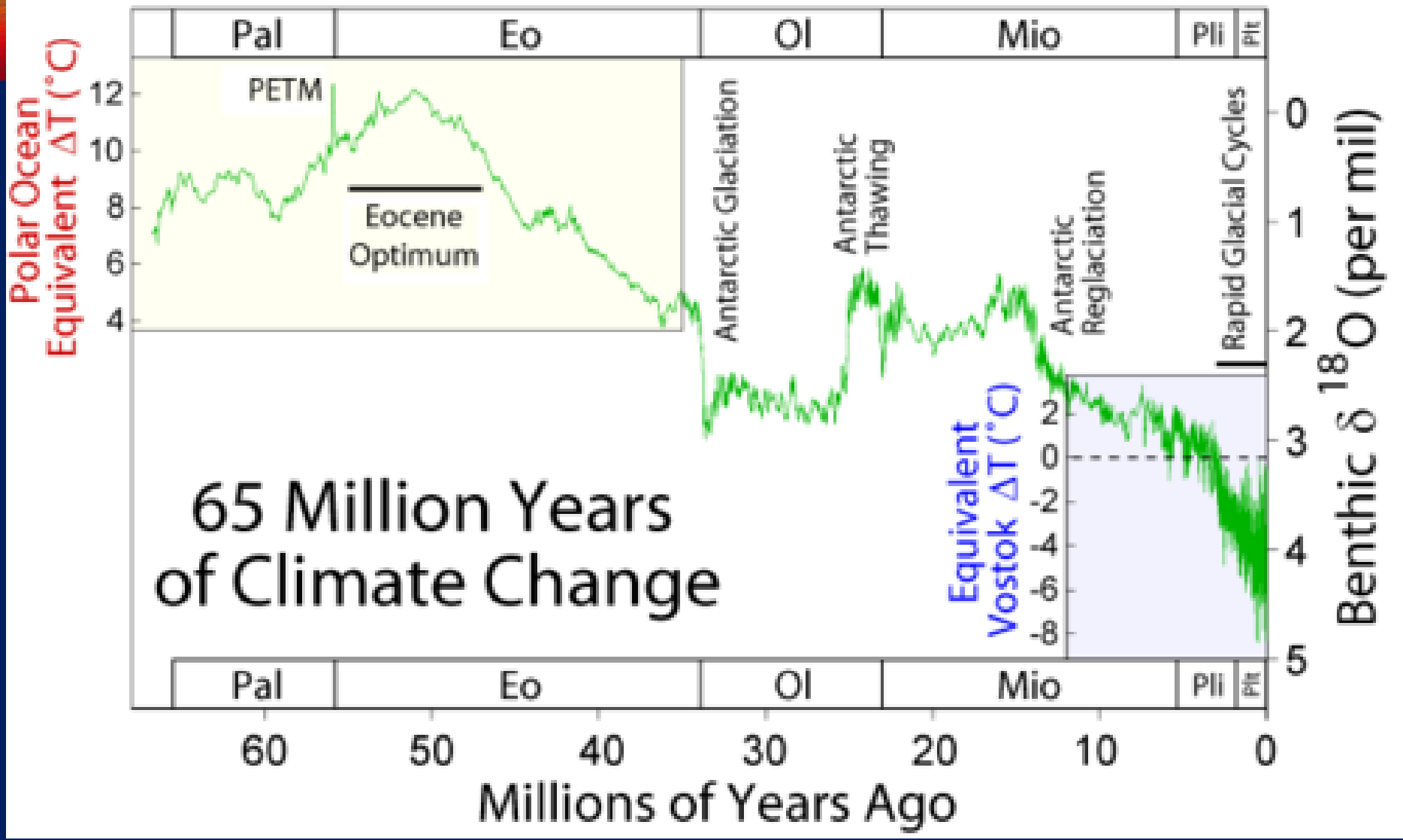
Global mean surface temperature across the last 485 million years.
Grey shading indicates confidence levels. The colored bands along the top reflect the climate state, with cooler colors indicating icehouse (coolhouse and coldhouse) climates, warmer colors indicating greenhouse (warmhouse and hothouse) climates, and the gray representing a transitional state.

A 485-million-year history of Earth's surface temperature

EMILY J. JUDD, JESSICA E. TIERNEY, DANIEL J. LUNT, ISABEL P. MONTAÑEZ, BRIAN T. HUBER, SCOTT L. WING, AND PAUL J. VALDES

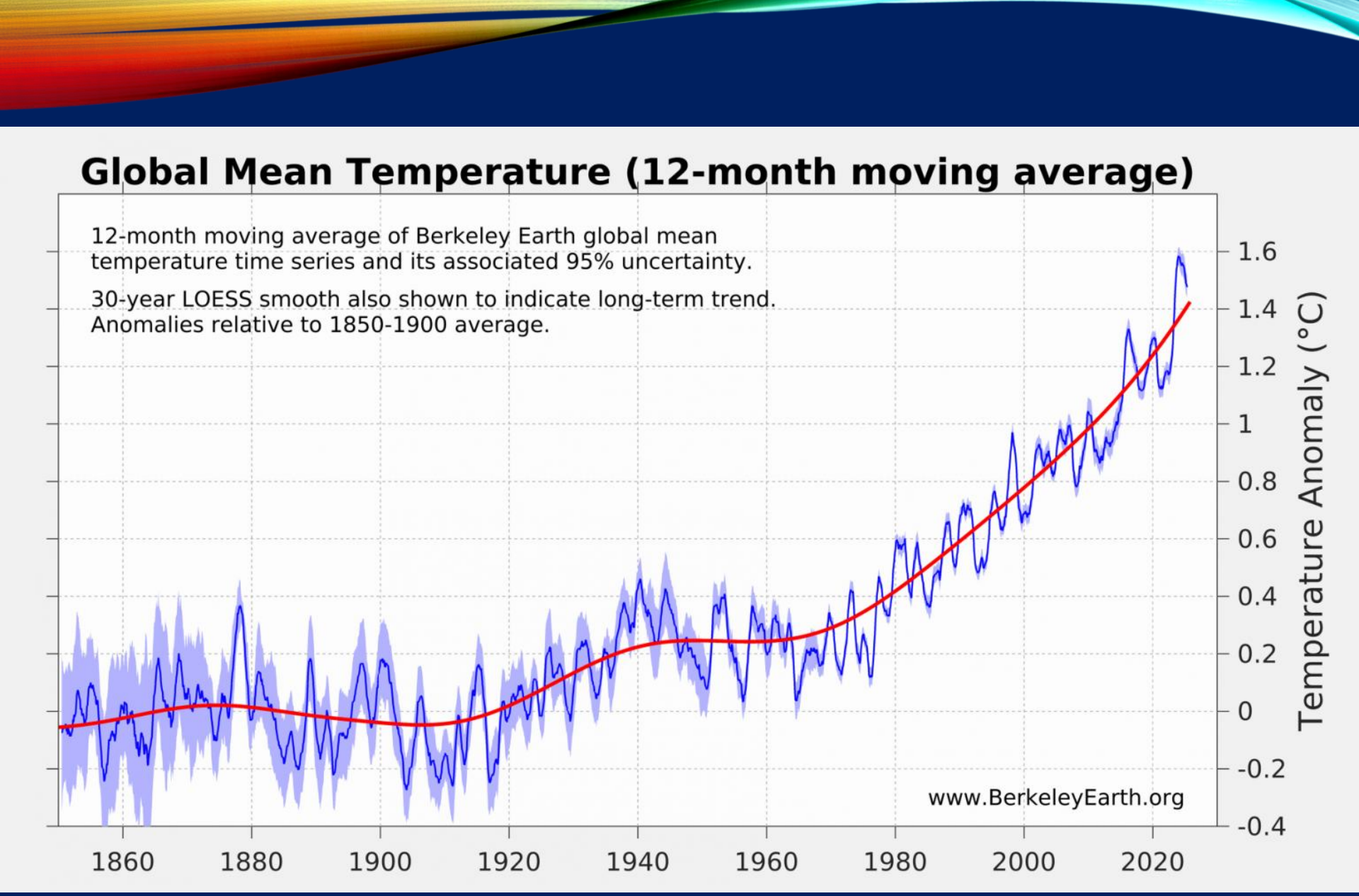
Info & Affiliations

SCIENCE • 20 Sep 2024 • Vol 385, Issue 6715 • DOI: 10.1126/science.adk3705



https://www.smithsonianmag.com/smithsonian-institution/what-happened-the-last-time-the-climate-changed-1157388/

https://en.wikipedia.org/wiki/File:65_Myr_Climate_Change.png


Global Mean Temperature (12-month moving average)
12-month moving average of Berkeley Earth global mean temperature time series and its associated 95% uncertainty.
30-year LOESS smooth also shown to indicate long-term trend.
Anomalies relative to 1850-1900 average.
www.BerkeleyEarth.org
Temperature Anomaly (°C)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1860
1880
1900
1920
1940
1960
1980
2000
2020

How do we know what past temperatures were?

How do we know beyond the period of instrumental records (about 150 years)?

Most paleoclimate evidence is indirect and based on ***proxies*** for climate property such as temperature, rainfall and sea level to **splice together** a long record:

- historical documents
- tree and coral growth rings
- deep-sea sediment cores
- ice cores
- fossils.

It needs two vital pieces of information:

- The age of the sample (rely on the geologists!)
- Some indicator of the climate property being investigated (e.g. temperature).

This evidence is **less precise** than measurements with modern instruments.

- questions about how representative spot measurements are of global temperatures
- how to splice together different types of estimates.

Good practice is to rely on independent approaches and a broad sample of sites.

Proxy Techniques for estimating ages

- Radiometric (radioactive isotopes) such as uranium-lead
- Geochemical (four independent approaches))
  - Stable isotopes e.g. oxygen isotopes
  - Mg/Ca ratio
  - Alkenones (long-chained organic compounds from cell membranes of some species of algae)
  - TEX_{86} (86-tetraether-carbon chain in lipids from cell membranes of marine picoplankton)
- Biostratigraphic – using fossils of marine plankton and land plants
- Sediment cores – oceans and lakes
- Ice cores
- Geomagnetism

General comments:

- Can work backwards, splicing the different estimates
- jigsaw puzzle analogy – putting some pieces in place helps to fit in others to get the whole picture
- Need to acknowledge the likely errors bars
- A unifying idea can help make sense (e.g. Newton and gravity; Darwin/Wallace and evolution, plate tectonics, etc.)

Climate Proxies

Ice cores

Fossil clam shells

Fossils in ocean sediment cores

Tree rings

https://youtu.be/W6z_62K6A1g

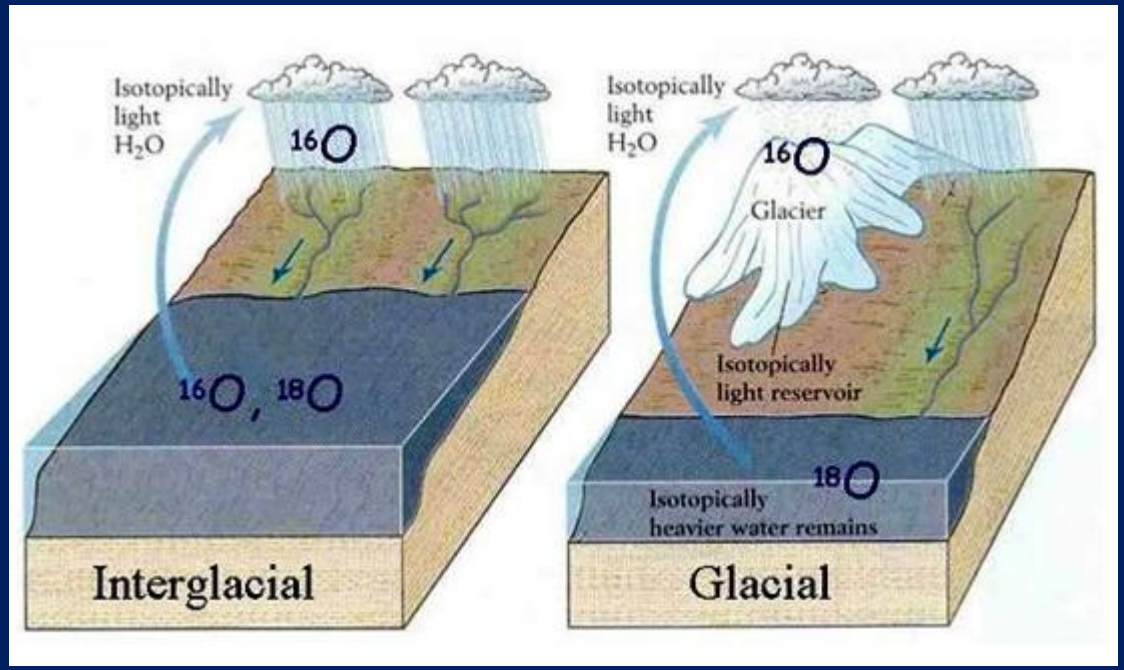
Oxygen isotopes and Earth's climate

The warmer the ocean is, the more water evaporates into the atmosphere, which is why the tropics are humid.

Water droplets rich in light water will evaporate more readily than those rich in heavy water. Winds carry moist air from the warm, tropical oceans towards the poles.

When there is not an ice age, water with light oxygen falls out as snow and rain and eventually makes its way back to the ocean.

In glacial periods (such as now) the water with light oxygen will remain as ice and snow at the poles. So the water in the oceans will gradually have water with more heavy oxygen.



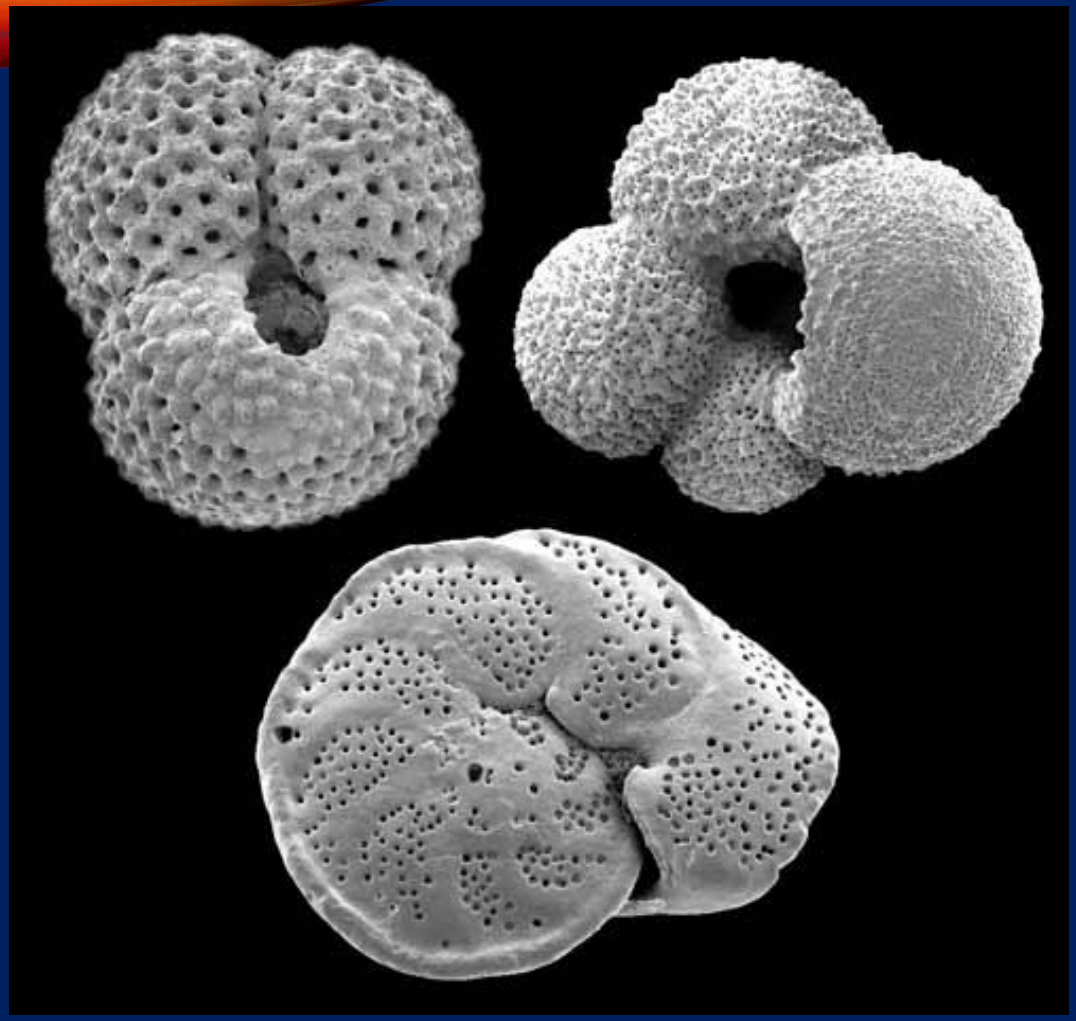
Examples of proxy records:

- Pollen found in lake sediments that can be used to reconstruct past vegetation cover, which in turn can be related to temperature and precipitation.

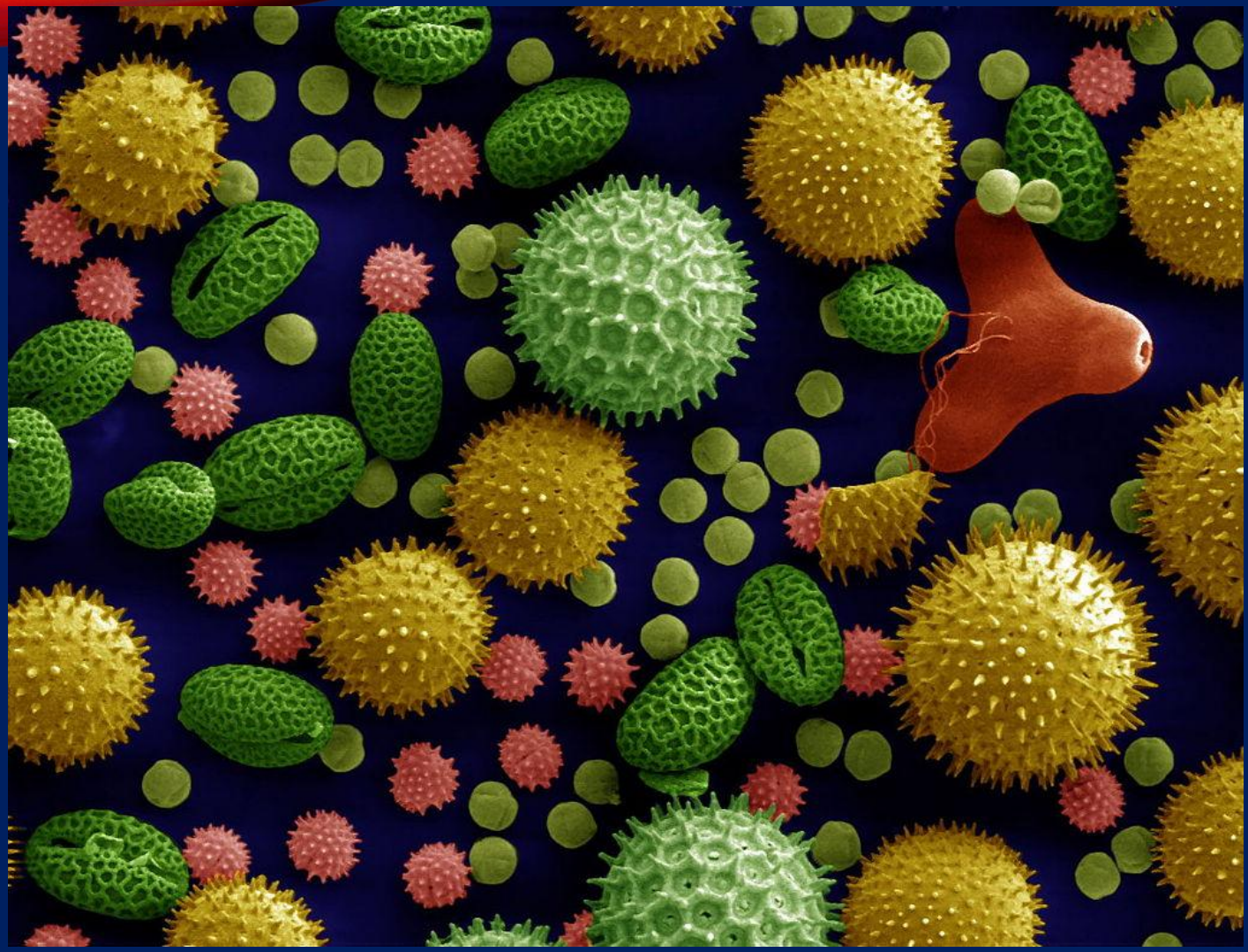
- Different species of planktic foraminifera prefer different temperatures. Some live in colder waters others prefer warmer waters. Their fossil shells accumulate in sediments, which can be retrieved with a coring device employed from a research vessel. Shells deeper in the sediment are older. If shells of cold-loving foraminfera are found at a site where currently warm-loving species live, it suggests that near surface temperatures in the past have been colder.
- Benthic foraminifera live on or in the ocean's sediments and give useful information on deep ocean properties.

- Other proxies are chemical such as the ratio of magnesium to calcium (Mg/Ca), which is related to temperature, or isotopes of oxygen or carbon in the calcium carbonate shells of foraminifera, which can be used to reconstruct temperature, salinity, ice volume and carbon cycling.

https://open.oregonstate.education/climatechange/chapter/paleoclimate/



Electron microscope pictures of fossil foraminifera: two planktic foraminifera on top and one benthic foraminifera on the bottom.



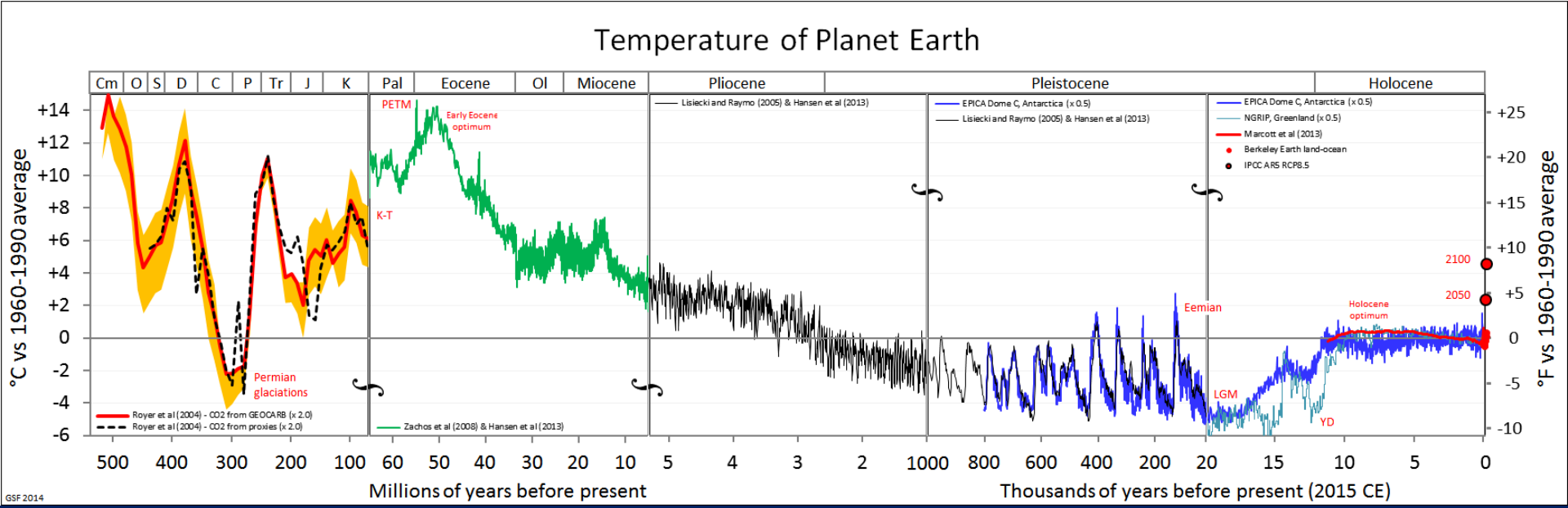
Electron microscope pictures of pollen.

https://youtu.be/J564hWVtZbU

Maureen Raymo

Table 4 Summary of common approaches to age determination of geologic materials

Category	Dating methods	Comments
"Absolute" ages, providing numerical dates	Radiometric dating	Based on the half-life of radioactive isotopes (e.g., ^{14}C, ^{40}K, ^{234}U, ^{238}U)
Relative ages based on pattern recognition and identification of regional or global events	Special horizons (e.g., ash layer, iridium layer) in the layers that mark one-time events (e.g., volcanic eruptions, meteorite impact)	Useful for correlating a time-specific horizon across a geographic region; some can also be radiometrically-dated
	Magnetostratigraphy	Paleomagnetic reversal pattern; "bar code" of time with global reversal events
	Biostratigraphy	Patterns of life (fossils); different forms of life lived at different times; extinction events
	Geochemical patterns	Useful for correlating patterns of change across a geographic region. For example, oxygen isotope, carbon isotope, and strontium isotope patterns in marine sediments



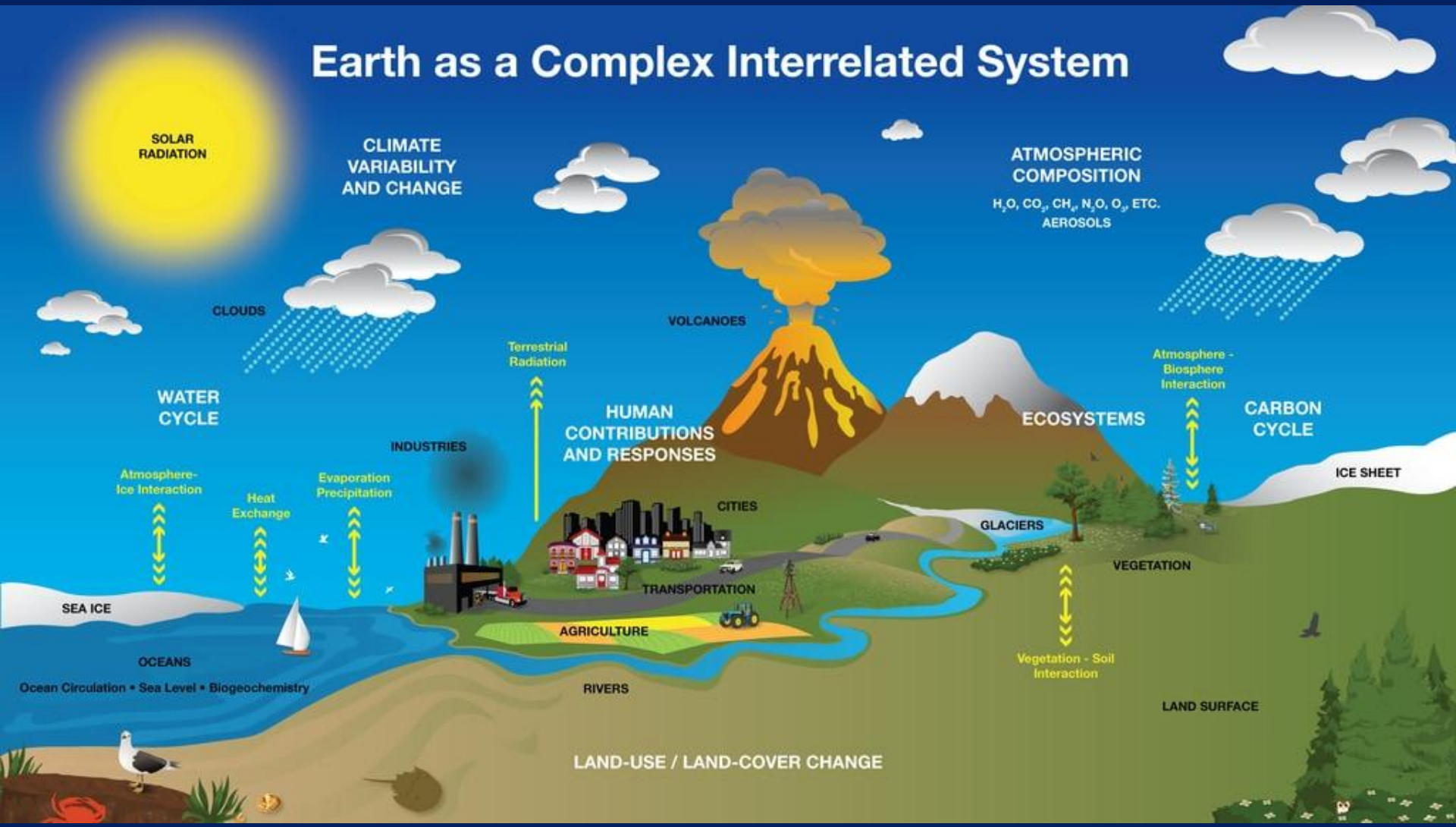
Panel 1 (540 to 65 million years ago) from stable oxygen isotope measurements from the shells of macroscopic marine organisms.

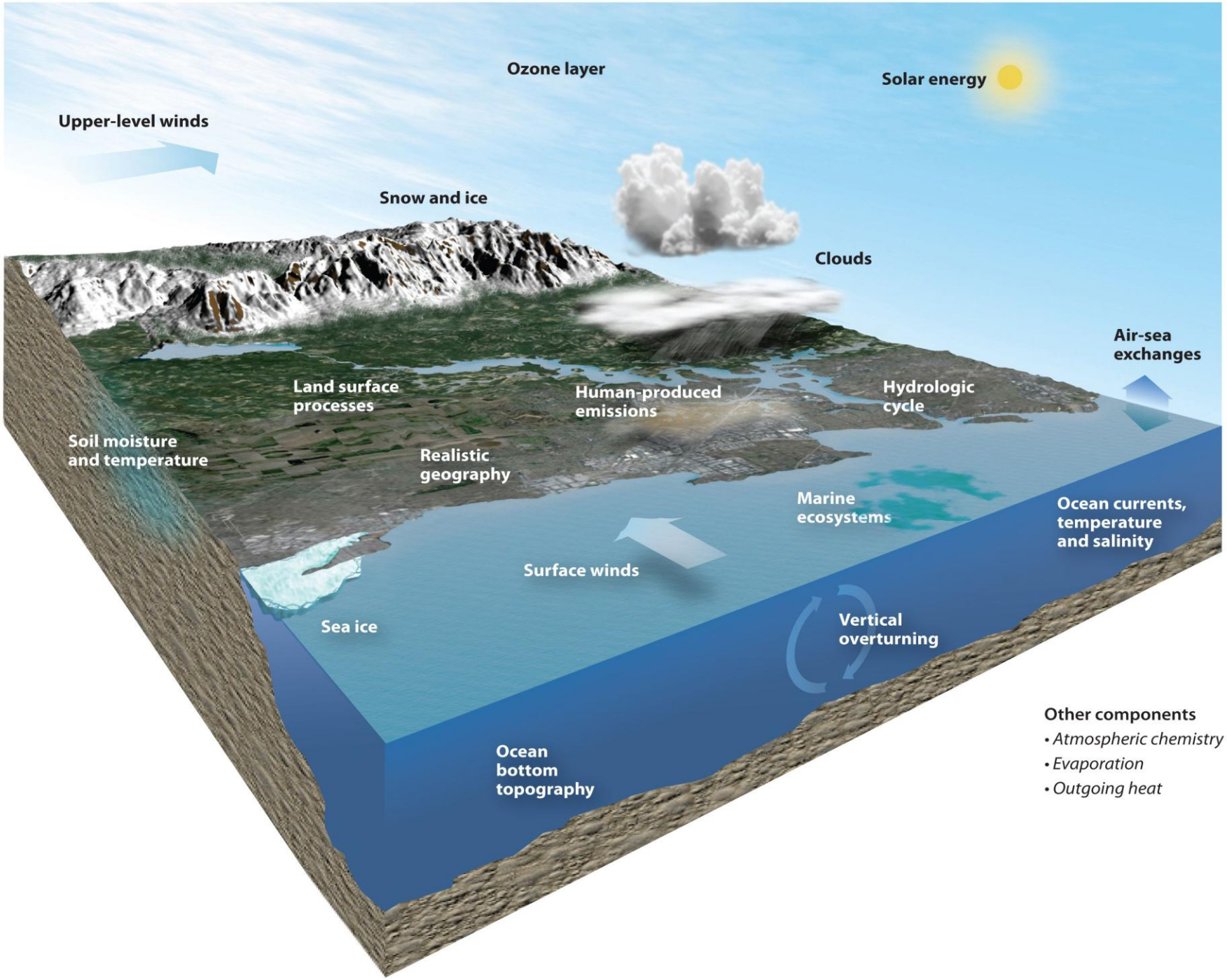
Panel 2 (65 to 5.3 million years ago): interpretation of the global collection of oxygen isotope data from microscopic marine organisms.

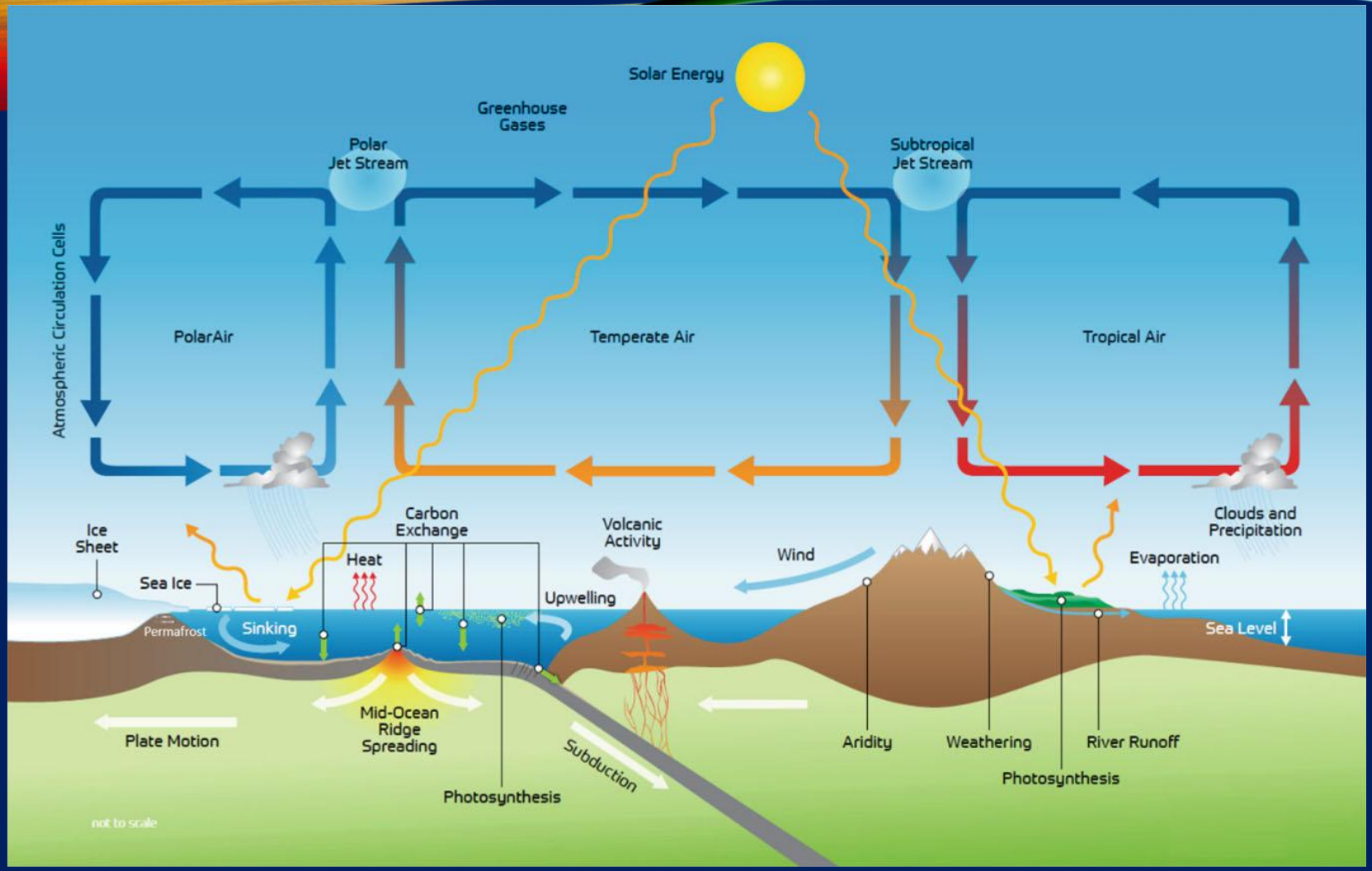
Panel 3 (5.3 to 1 million ya): oxygen isotope data from microscopic marine organisms.

Panel 4 (1 million to 20,000 ya): Combining Panel 3 type data with temperature estimates from stable hydrogen isotope measurements from the Dome C ice core from central Antarctica.

Panel 5 (20,000 ya to present (2015)): ice cores, other proxies plus instrumental records.


Earth as a Complex Interrelated System
SOLAR RADIATION
CLIMATE VARIABILITY AND CHANGE
ATMOSPHERIC COMPOSITION
H_2O, CO_2, CH_4, N_2O, O_3, ETC.
AEROSOLS
CLOUDS
VOLCANOES
Terrestrial Radiation
WATER CYCLE
HUMAN CONTRIBUTIONS AND RESPONSES
ECOSYSTEMS
Atmosphere - Biosphere Interaction
CARBON CYCLE
INDUSTRIES
ICE SHEET
Atmosphere-Ice Interaction
Heat Exchange
Evaporation Precipitation
CITIES
GLACIERS
VEGETATION
TRANSPORTATION
SEA ICE
AGRICULTURE
Vegetation - Soil Interaction
OCEANS
Ocean Circulation • Sea Level • Biogeochemistry
RIVERS
LAND SURFACE
LAND-USE / LAND-COVER CHANGE


Ozone layer
Solar energy
Upper-level winds
Snow and ice
Clouds
Air-sea exchanges
Land surface processes
Human-produced emissions
Hydrologic cycle
Soil moisture and temperature
Realistic geography
Marine ecosystems
Ocean currents, temperature and salinity
Surface winds
Sea ice
Vertical overturning
Ocean bottom topography
Other components
• Atmospheric chemistry
• Evaporation
• Outgoing heat



Representation of the Earth's climate system, which includes five subsystems: the atmosphere, hydrosphere, cryosphere, biosphere, and geosphere (sometimes also called the lithosphere). The Earth's climate system also includes processes and interactions among these systems.
(Geoscience book)

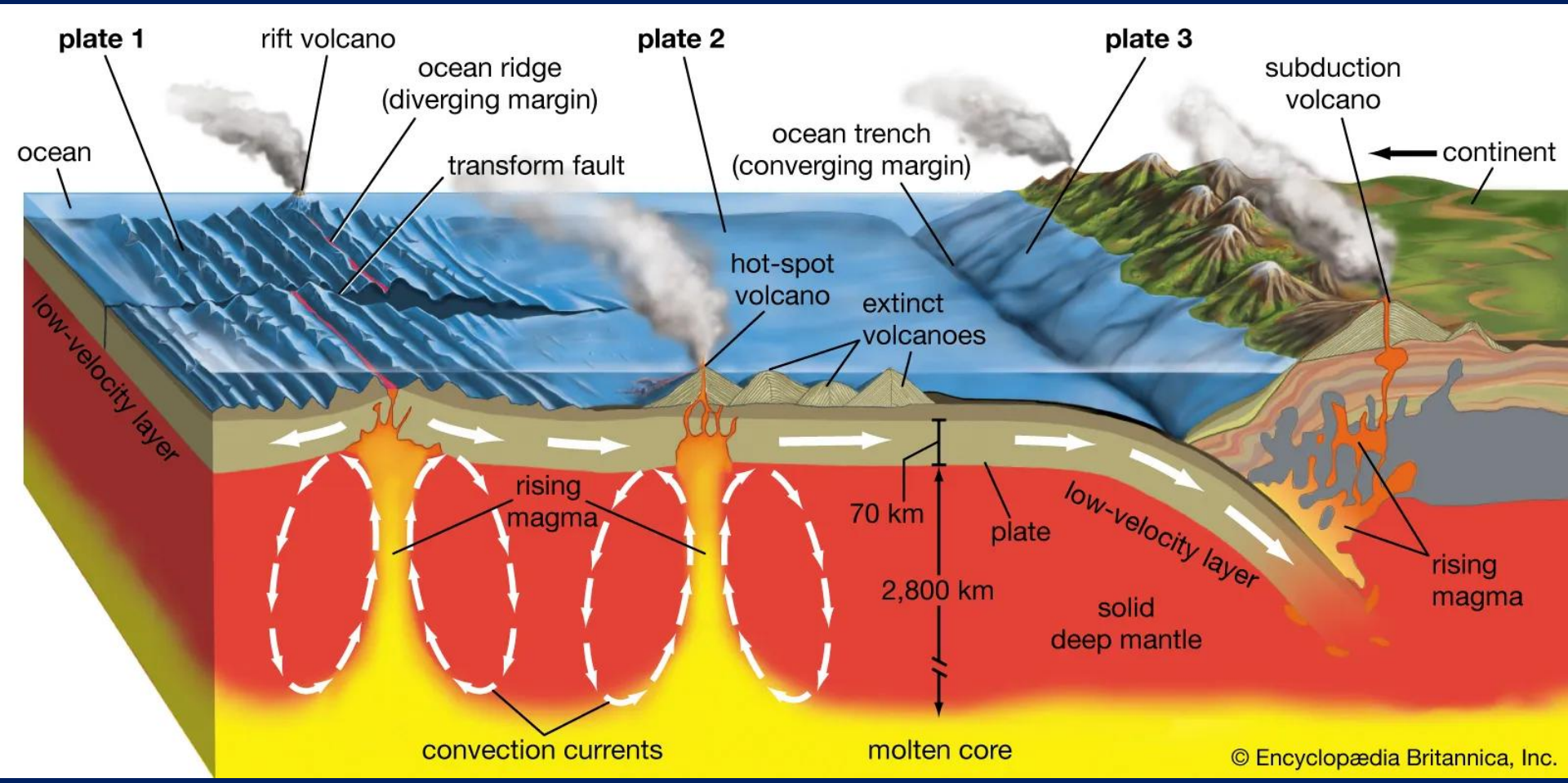


plate 1
rift volcano
ocean ridge
(diverging margin)
plate 2
plate 3
subduction
volcano
ocean
transform fault
ocean trench
(converging margin)
continent
hot-spot
volcano
extinct
volcanoes
low-velocity layer
rising
magma
70 km
plate
low-velocity layer
rising
magma
2,800 km
solid
deep mantle
convection currents
molten core
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CONTINENTAL DRIFT

Pangaea

Laurasia and Gondwana

Modern world

Table 1 General response times of the various climate system "spheres"

Climate system sphere	Area responding	Response time
Atmosphere	Local to regional, few 100 km x few 100 km	Hours
	Continent-scale	Days
	Hemisphere-scale	Few weeks to few months
Hydrosphere	Surface ocean, few 100 km x few 100 km	Days
	Surface ocean, subtropical gyre	Months to years
	Surface ocean, global	Decades to centuries
	Deep ocean	1000 s of years
Cryosphere	Sea ice	Months to decades
	Mountain glaciers and icefields	Decades
	Continental-scale icesheets	Decades to 10,000 s of years
Geosphere	Continent-scale, surficial processes	Decades to 1000 s of years
	Global, plate tectonic processes	Millions of years
Biosphere	Local to regional, few 100 km x few 100 km	Months to decades
	Continent-scale	Months to 1000 s of years
	Global	Months to 1000 s of years

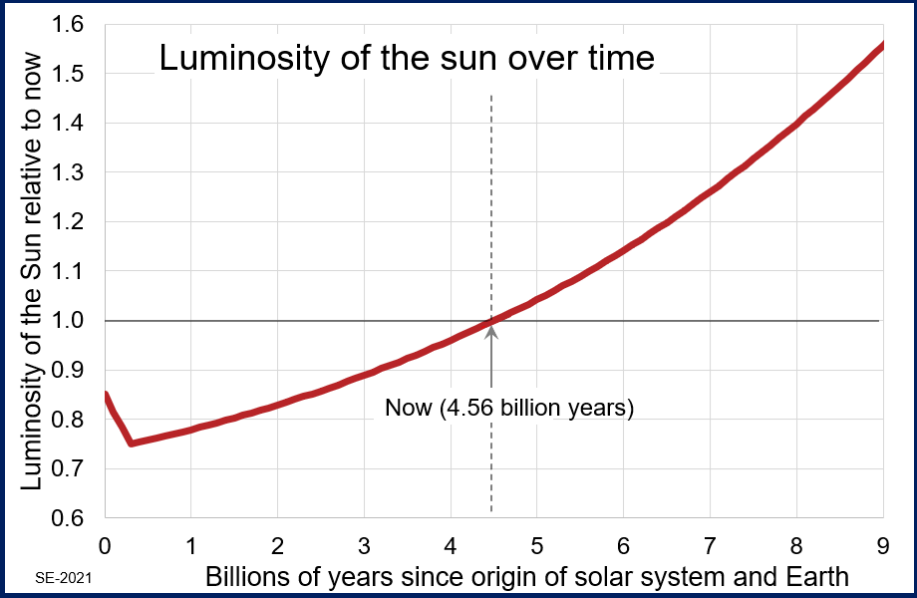
For global-scale responses, the atmosphere responds most quickly, followed by slower responses of the surface ocean and the deep ocean, an even slower response of the continental ice sheets of the cryosphere, and the extremely slow plate tectonic response of the geosphere

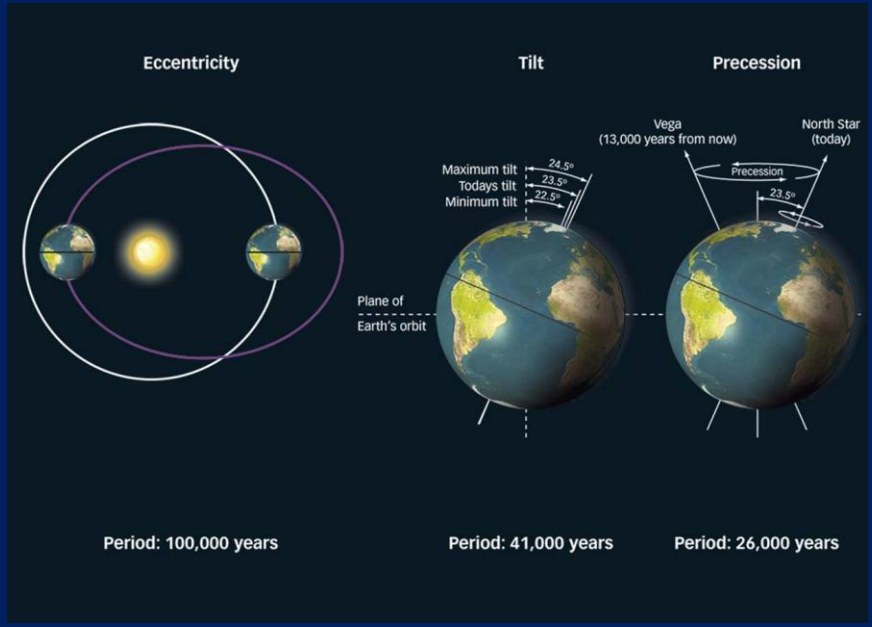
The Earth's climate system (atmosphere, hydrosphere, cryosphere, biosphere, and geosphere (lithosphere)) is very complex and there are many interactions among its components.

So, there is scope for changes in the overall climate from **internal changes** (natural variability) and from **forces external to it**.

"External" factors:

- Variations in the sun's output
- Earth's orientation to sun – Croll/Milankovitch theory





“Internal” factors

- Volcanoes
- Plate tectonics – positions of continents, changing ocean currents
- Mountain building – silicate weathering
- Life – role of oxygen.
- Changes in the composition of the atmosphere, especially in the “greenhouse gases”
- Snow/ice changes – changing the reflectivity of the earth.

What are “internal” and “external” factors depends on where we draw the boundaries. If we focus only on what we normally regard as the climate, then some of the “internal” factors become “external”.

Excellent resources:

https://open.oregonstate.education/climatechange/chapter/paleoclimate/

https://interactive.carbonbrief.org/how-proxy-data-reveals-climate-of-earths-distant-past/index.html