Argue from the data.

About 50 minutes, plus review
In pairs, then swap with another pair
Pencil, ruler

The guiding question: Australia has warmed by about 1.5 °C since 1910. What is driving it, and how do we know? Three records, averaged by decade: the temperature, the carbon dioxide in the air, and the activity of the Sun. Plot them, compare their shapes, then build and defend an argument.

The data

DECADE	TEMPERATURE ANOMALY (°C)	CO_2 (PPM)	SUNSPOT NUMBER
1910s	-0.45	301	65
1920s	-0.44	305	70
1930s	-0.35	308	85
1940s	-0.45	311	109
1950s	-0.31	314	130
1960s	-0.20	320	86
1970s	-0.13	329	87
1980s	+0.23	343	114
1990s	+0.40	358	94
2000s	+0.58	376	76
2010s	+0.86	397	54

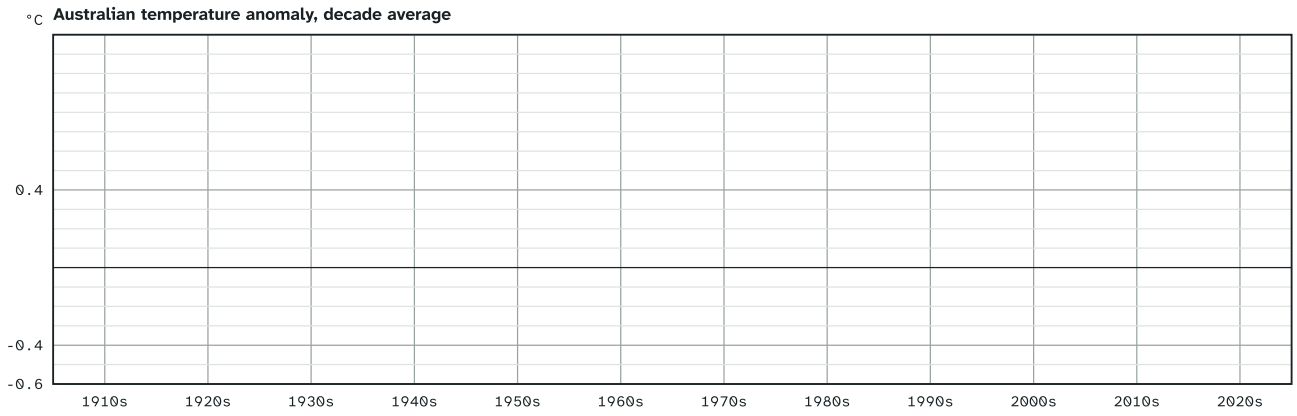
Temperature: Bureau of Meteorology ACORN-SAT annual anomalies relative to 1961 to 1990, averaged by decade (the 2010s are 2010 to 2019). CO_2: Law Dome ice core to 1975, then Cape Grim (CSIRO and the Bureau). Sunspots: SILSO yearly means, averaged by decade.

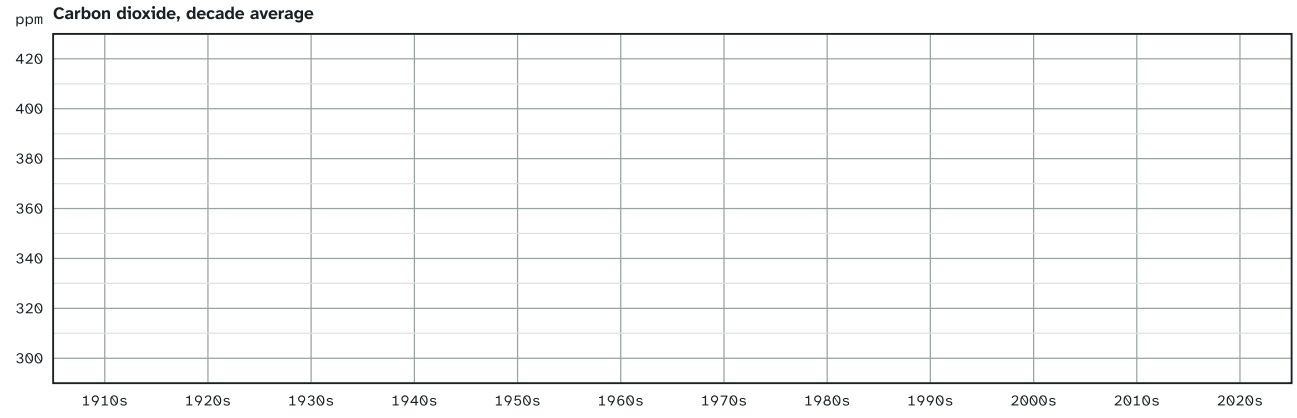
What to do

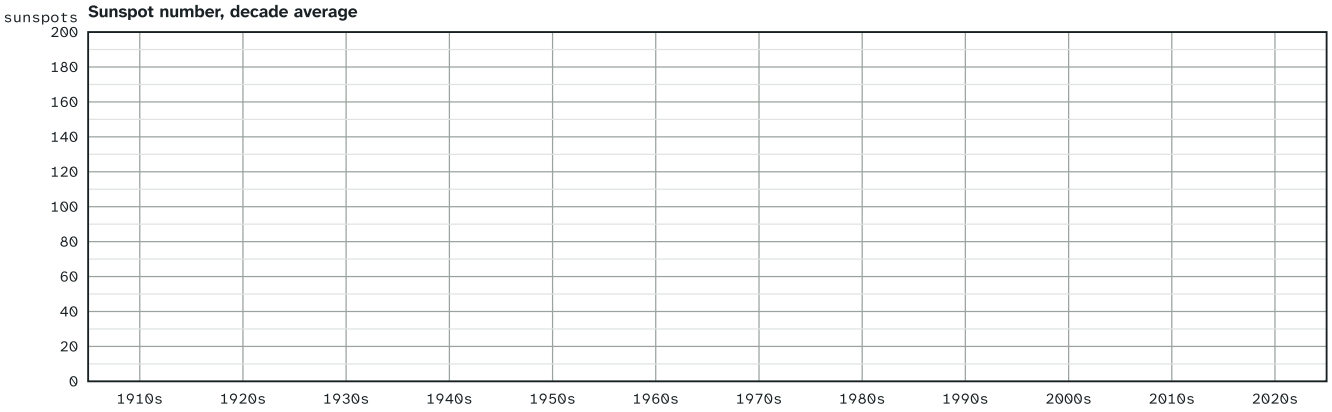
1. **Plot** each decade's value as a cross on the three grids overleaf. The grids share the same decades across the page, so the shapes line up.
2. **Join** the crosses on each grid with straight lines.
3. **Compare the shapes.** Which of the two candidate causes rises and falls with the temperature? Which does not?
4. **Build the argument** on page 3: claim, evidence with numbers, reasoning.
5. **Swap** with another pair and review each other's arguments with the sheet on page 4. Revise yours.

Two fingerprints to use as well

Satellites have measured the stratosphere (12 to 50 km up) cooling since 1979 while the surface warmed. A brighter Sun would warm both; greenhouse gases warm the surface and cool the stratosphere. And the 1963, 1982 and 1991 eruptions each cooled the planet by about half a degree for one to two years, then the warming resumed.







1. Describe the shape of each line in one sentence. Which two share a shape?

Your argument

Claim: what is driving the warming? One sentence.

Evidence. Three pieces, each with a number from the data and its source.

① _____ Source:

② _____ Source:

③ _____ Source:

Reasoning. How does each piece of evidence support the claim? Use the energy budget: what changed energy in or energy out?

The critic. Choose one objection and answer it with evidence: *"The climate has always changed."* · *"It's the Sun."* · *"CO_2 is only 0.04% of the air."* · *"The thermometers are in cities."*

Peer review

Do not write names on the argument or on this sheet. Use the codes your teacher gives you. Read the whole argument before you mark anything.

Argument code: _____ Reviewer code: _____

CRITERION	YES	PARTLY	NO	COMMENT
The claim is stated in one clear sentence.				
At least three pieces of evidence are given, each with a number and a source.				
The reasoning explains how each piece of evidence supports the claim, using the energy budget.				
At least one alternative cause is considered and ruled out with evidence.				
The critic's objection is answered with evidence, not with assertion or authority.				
Terms are used correctly: energy budget, greenhouse effect, anomaly, fingerprint.				

One thing this argument does well:

One thing it must fix before it would convince a scientist:

For the authors, after the review: what will you change?

Notes and answers.

Purpose

The paper version of the lesson's argument-driven inquiry: generate evidence by hand, build a claim, evidence and reasoning argument, face an objection, and review and revise. It goes with screens 3, 4, 7 and 9 of the online lesson but stands on its own (AC9S10U04; the Year 10 standard's "construct logical arguments based on analysis of a variety of evidence to support conclusions and evaluate claims").

Running it

- Plotting three lines of eleven points takes about 15 minutes. Pairs can split the grids.
- The decade averages smooth out El Niño years, which is the point: the shapes are what matter. Expect students to notice that temperature and CO_2 both turn upward in the 1960s.
- For the review, give each pair an argument code and a reviewer code so the exchange is double blind. Allow 10 minutes to review and 10 to revise.

Answers

- (1) Temperature: flat or slightly falling to the 1950s, then rising, steeply after the 1970s (−0.45 °C in the 1910s to +0.86 °C in the 2010s). CO_2: slow rise to the 1950s, then steeper every decade (about 300 to 400 ppm). Sunspots: up and down with no trend, highest in the 1950s, lowest in the 2010s. Temperature and CO_2 share a shape; the Sun does not.
- Claim: the warming is real and driven mostly by greenhouse gases added by human activity. Evidence: the 1.3 °C rise between decade averages; the matching rise in CO_2; the lack of any solar trend (the 2010s had the fewest sunspots of the century); the stratospheric cooling. Reasoning: more CO_2 reduces the heat radiation escaping to space, so energy in exceeds energy out until the surface warms; a brighter Sun would do it too, but the Sun has not brightened, and it would warm the stratosphere, which has cooled.
- Critic: "always changed": past changes had identifiable causes that are not changing now. "The Sun": no trend, weaker recent cycles, cooling stratosphere. "0.04%": nitrogen and oxygen do not absorb heat radiation; the trace gases and water vapour supply the 342 W/m² returned to the surface, and satellites see the extra absorption at CO_2's wavelengths. "Cities": the Bureau excludes its four big-city sites from the national trend, and the sea, sea ice and sea level have no cities.

Extension

- Add the sea surface temperature series from the lesson and ask whether a sea with no cities can show an urban heat island.
- Give students the yearly values and ask why decade averages were used; then ask what a single record year (2019) proves on its own.