ERASMUS-EDU-2023-CBHE
Project number: 101129032

Duration: 36 months
(01/01/2024 – 31/12/2026)

LESLIE
LAND MANAGEMENT
ENVIRONMENT &
SOLID-WASTE

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MICRO-CREDENTIAL

Climate Change of Sustainable Land Management in Central Asia

2- Observed Climate Change and attribution

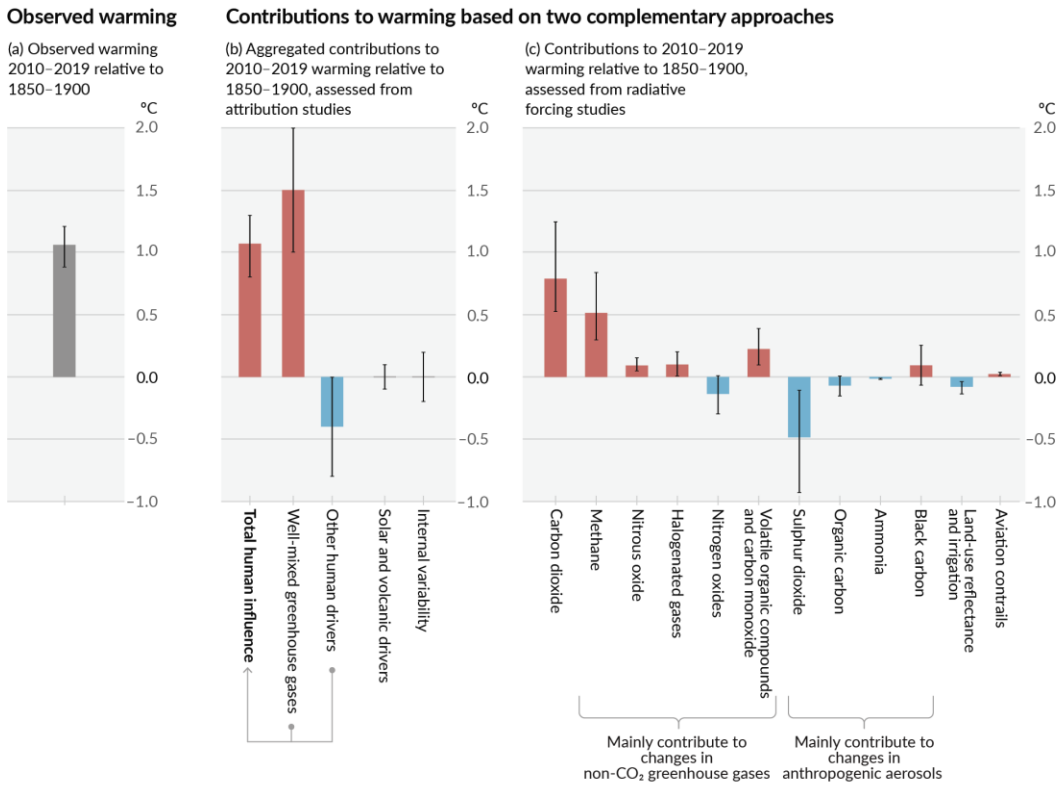
Attribution: How We Know Humans Are Driving Climate Change

CC-W02-V07



DETECTION AND ATTRIBUTION: RELATED, NOT THE SAME

Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling



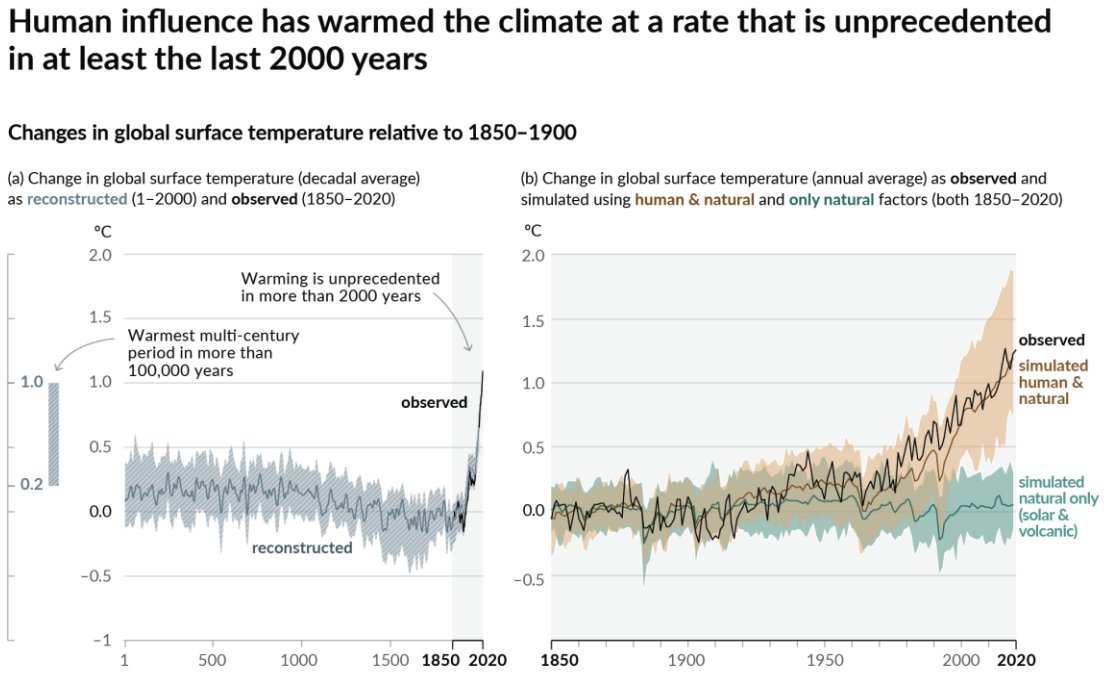
Assessed contributions to observed warming in 2010–2019 relative to 1850–1900, showing that observed warming is primarily driven by human activities, with greenhouse gas warming partly offset by aerosol cooling. Source: Climate Change 2021 (IPCC, 2021)

- Detection asks whether an observed change stands out from background climate variability.
- Attribution asks which causes best explain that detected change.
- Attribution combines observations, physical theory, and model experiments.
- So the question is not only whether warming occurred, but why it occurred.



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GLOBAL TEMPERATURE ANOMALIES: EVIDENCE OF HUMAN INFLUENCE



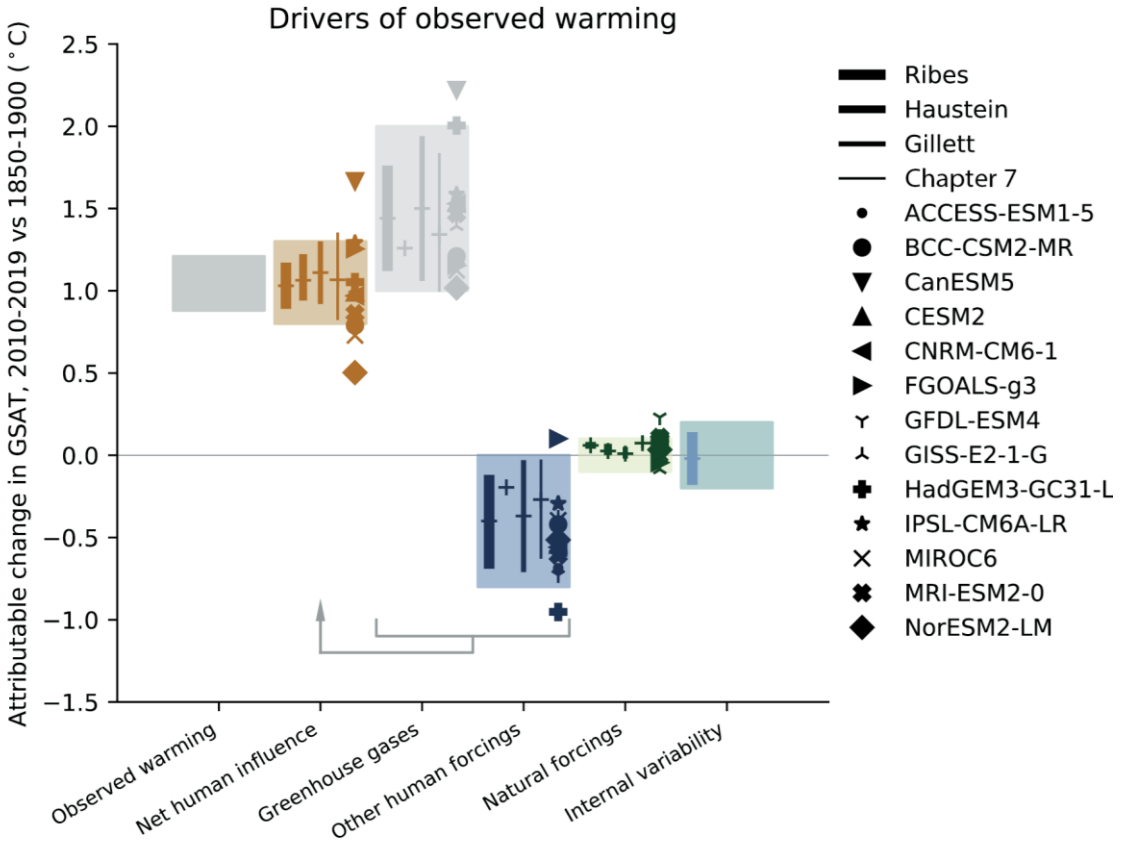
History of global temperature change and causes of recent warming. Observed warming is unprecedented in at least the last 2000 years and is consistent with simulations including human and natural drivers, but not with natural drivers alone. Source: Summary for Policymakers, Figure SPM.1. (IPCC, 2021, AR6 WG1)

- Global temperature anomalies show a clear long-term warming trend.
- The recent increase is exceptional in the context of the historical record.
- The IPCC concludes that human influence on this warming is unequivocal.
- This conclusion is supported by multiple independent lines of evidence.



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OBSERVED WARMING REQUIRES HUMAN INFLUENCE



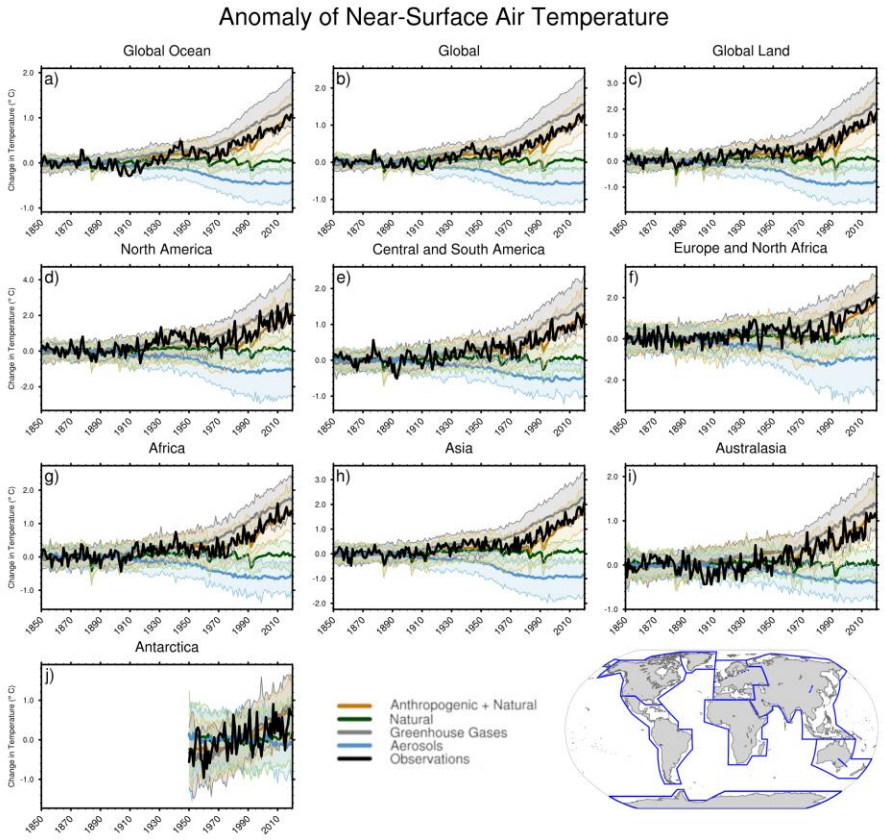
Assessed contributions to observed warming, showing that human influence accounts for most of the observed temperature increase, while natural forcings and internal variability make much smaller contributions. Source: Climate change 2021, (IPCC, 2021, AR6 WG, Chapter 3, Figure 3.8.)

- Natural forcings alone do not account for the magnitude of observed warming.
- Greenhouse gases provide the largest positive contribution to warming.
- Other human forcings, especially aerosols, offset part of that warming.
- Observed warming is therefore primarily attributable to human influence.



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GREENHOUSE GAS FORCING LEAVES DISTINCTIVE CLIMATE FINGERPRINTS



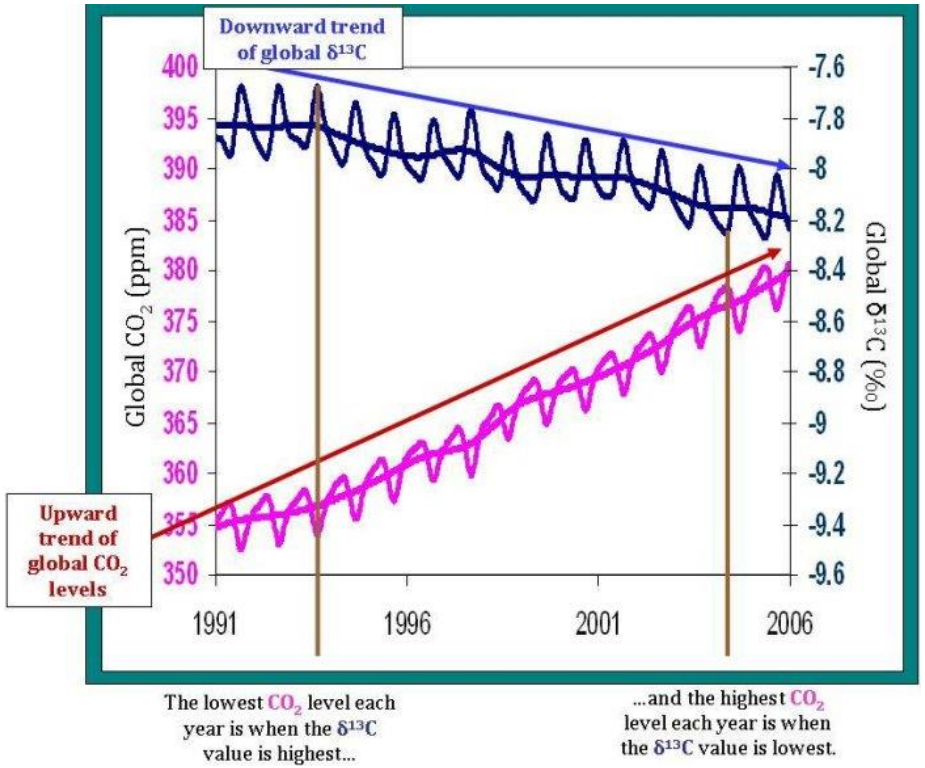
Observed and simulated temperature changes over global, land, and ocean areas show a distinct anthropogenic fingerprint, including stronger warming over land than ocean and close agreement between observations and simulations that include human forcing. Source Climate Change 2021, (IPCC, 2021, AR6 WG1, Chapter 3, Figure 3.9)

- Greenhouse gas forcing produces a distinct vertical temperature pattern: tropospheric warming and stratospheric cooling.
- Observed warming is stronger over land than over ocean.
- The ocean absorbs most of the excess heat in the climate system.
- Together, these features are consistent with greenhouse-gas forcing.



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CARBON ISOTOPES PROVIDE CHEMICAL EVIDENCE OF FOSSIL-FUEL CO_2



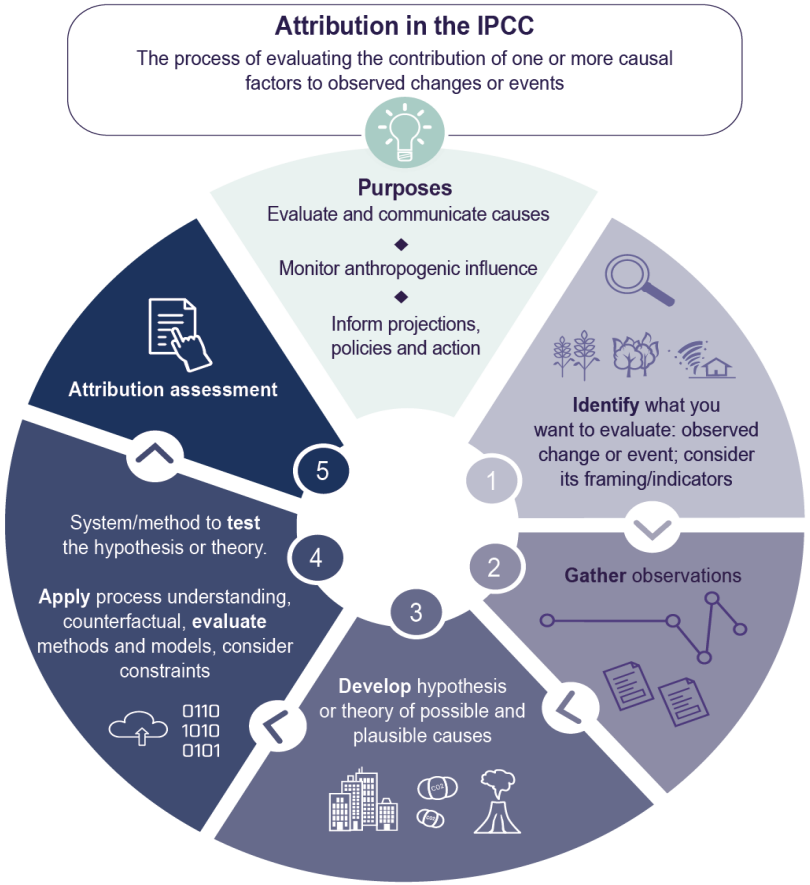
Long-term atmospheric CO_2 increase accompanied by declining atmospheric $\delta^{13}C$, consistent with the isotopic signature of fossil-fuel emissions (the Suess effect). Source: Compiled records of carbon isotopes in atmospheric CO_2 for historical simulations in CMIP6. (Graven, h. et al, 2017)

- Atmospheric carbon isotope ratios have shifted in the direction expected from fossil-fuel emissions.
- Fossil fuels are relatively depleted in carbon-13 because they come from ancient organic matter.
- As fossil-fuel CO_2 rises, atmospheric δ13C declines — the Suess effect.
- This is independent evidence that the added carbon is coming largely from human combustion of fossil fuels.



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ATTRIBUTION IS STRONG BECAUSE MULTIPLE LINES OF EVIDENCE CONVERGE



Schematic of the attribution process, showing how multiple methods and independent lines of evidence are combined to test and strengthen attribution assessments. Source: Climate Change 2021 (IPCC, 2021, AR6 WGI, Cross-Working Group Box: Attribution, Figure 1).

- Observed warming is clearly detected above natural variability.
- Natural forcings alone do not explain the magnitude or pattern of recent warming.
- Physical fingerprints and atmospheric chemistry independently support human influence.
- Attribution confidence is high because multiple lines of evidence converge.



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