

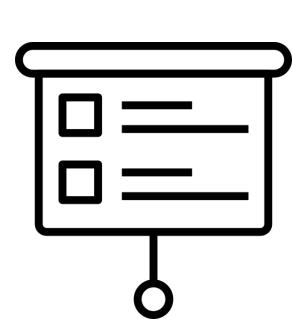
# GLOBAL HEAT & POLAR RETREAT

## TRACKING EMISSIONS, TEMPERATURES, AND ARCTIC CHANGE



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### ABSTRACT



This study analyzes global CO<sub>2</sub> emissions (from 1750 - 2024), temperature trends, and Arctic climate change. Emissions by fossil fuels, land-use change, and trade balance are compared with global and regional temperatures and Arctic sea ice records. Results show a clear warming trend and a steady Arctic sea ice decline averaging -0.48 million km<sup>2</sup> per decade since 1978. SARIMAX forecasts suggest the first seasonally ice-free Arctic (<1 million km<sup>2</sup>) could occur by mid-century, highlighting strong links between rising emissions, warming, and Arctic loss - and the urgency of climate action.

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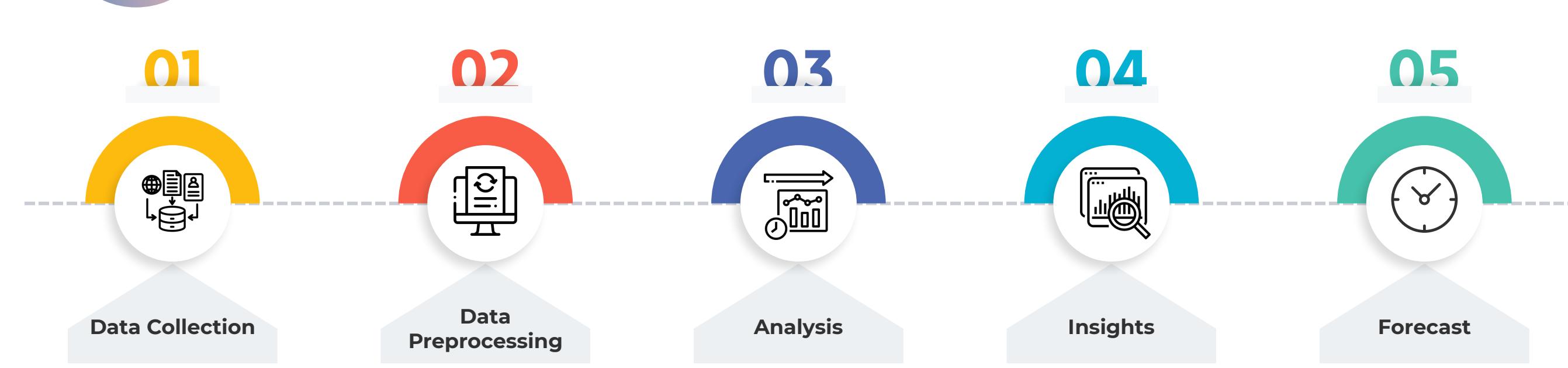
### MOTIVATION



The Arctic serves as a key indicator of global climate change, where shifts in temperature and circulation patterns have far-reaching effects. Since the Industrial Revolution, CO<sub>2</sub> emissions has pushed temperatures to record highs. By combining over 270 years of emissions and temperature data with modern Arctic climate records, this study highlights how human activity is influencing one of Earth's most vulnerable regions and the broader global system.

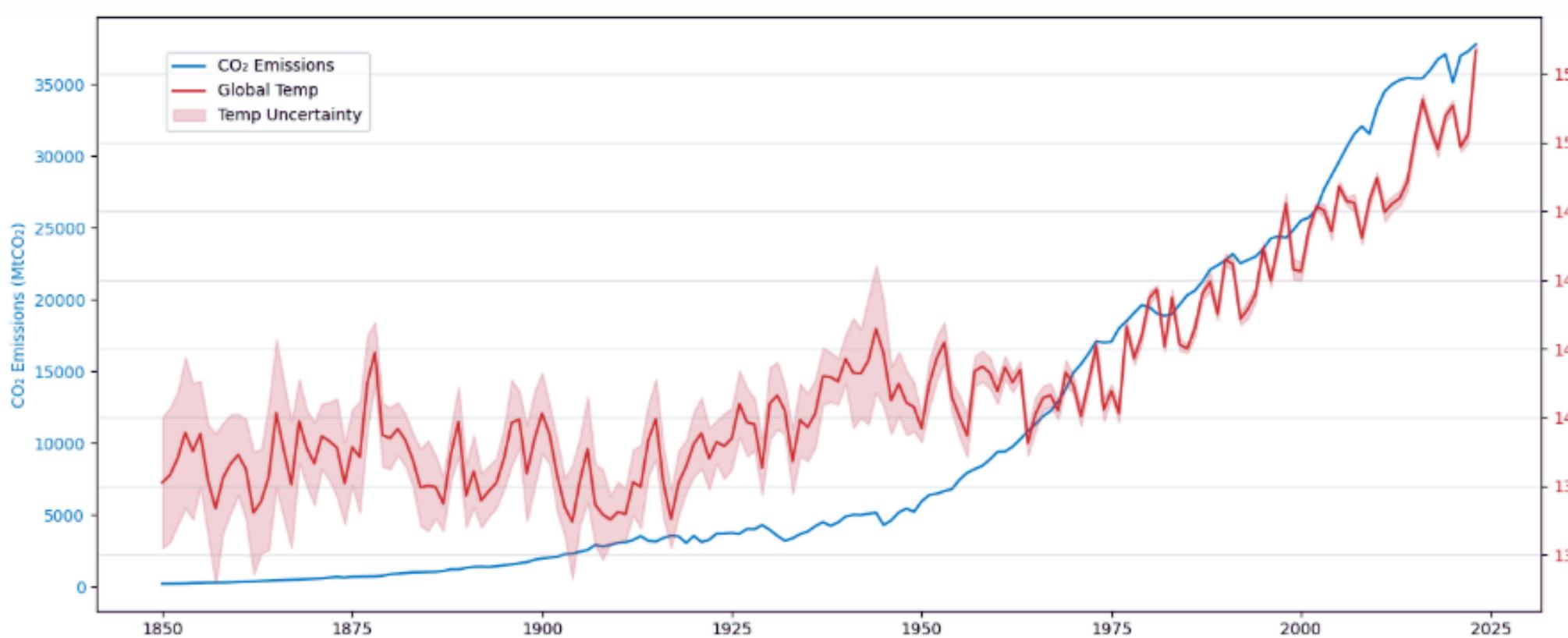
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### METHODOLOGY



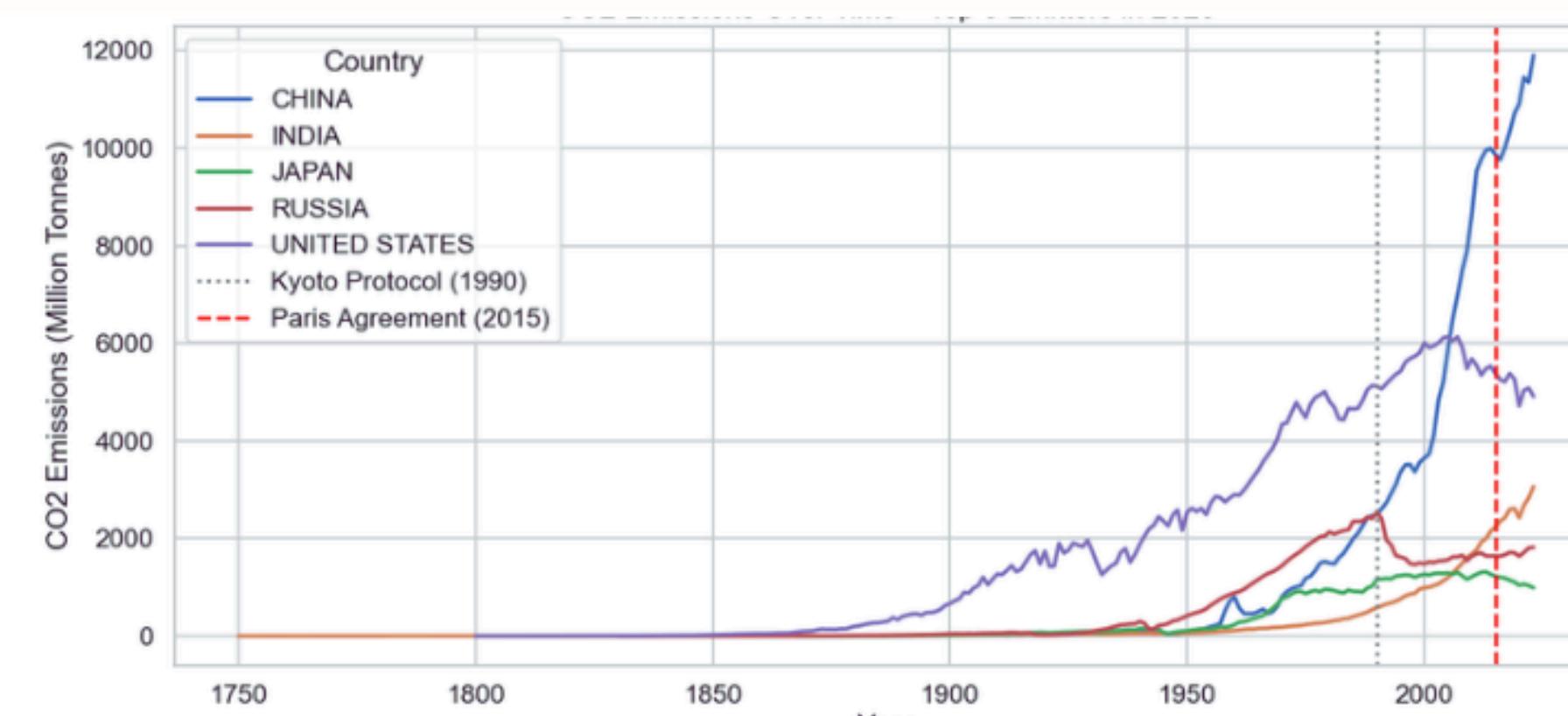
## CO<sub>2</sub> EMISSIONS AND TEMPERATURE RISE

CO<sub>2</sub> - Temperature Warming Link



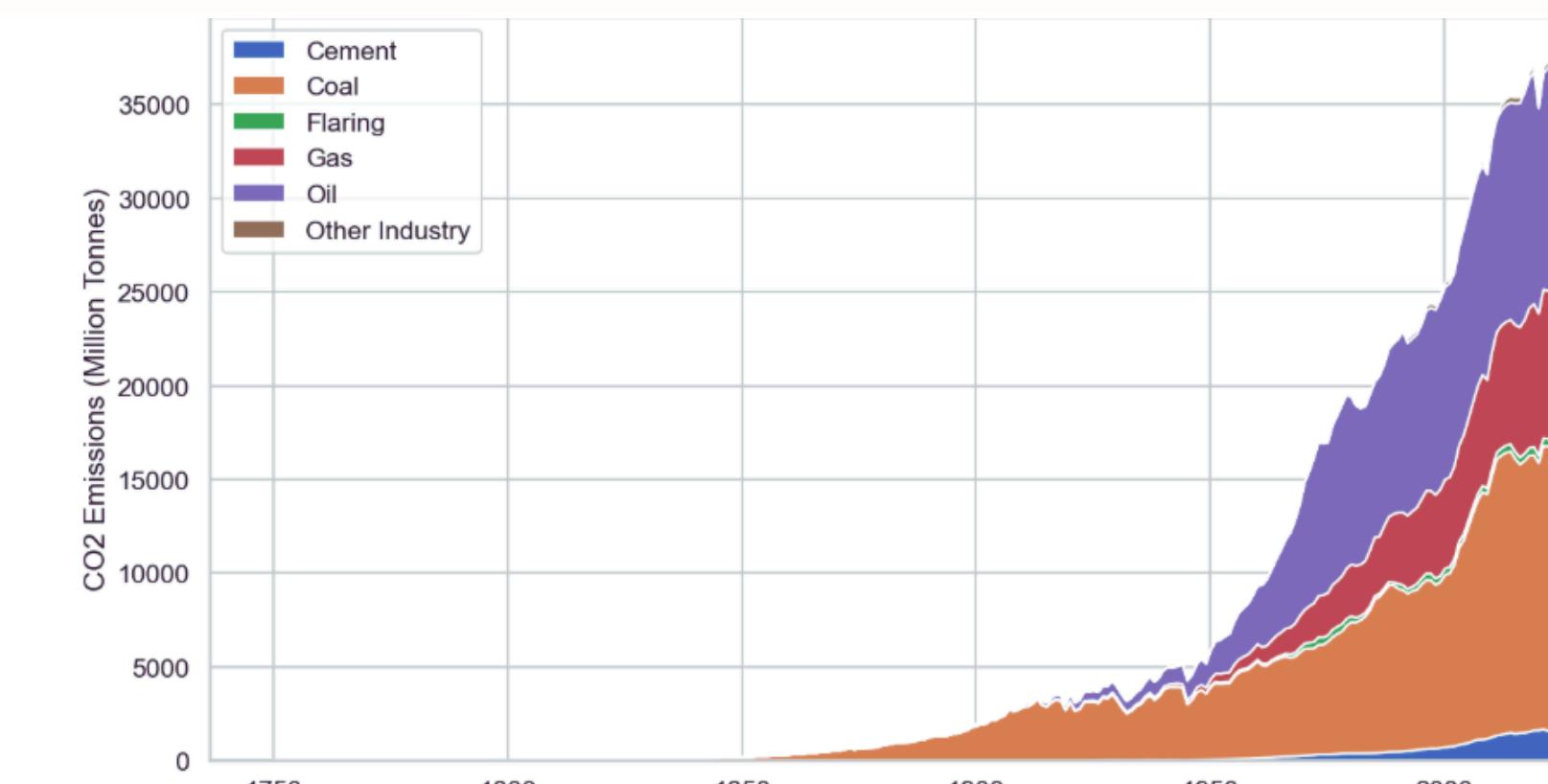
- CO<sub>2</sub> emissions surged after 1950's post - WWII industrial boom, now exceeding 35 Gt/year.
- Global temperatures have risen about **1.3 °C** since pre-industrial levels, mirroring CO<sub>2</sub> growth.
- Early data (1850 - 1900) shows high uncertainty due to limited measurements.
- Since 2000, both CO<sub>2</sub> and temperatures have reached record highs.

Rising CO<sub>2</sub> in Key Nations



- China's CO<sub>2</sub> emissions rose steeply after 2000, surpassing 11,000 Mt/year.
- The US peaked around 2005 (~6,000 Mt/year) before declining.
- India shows continuous growth, especially post 1990.
- Kyoto Protocol (1990) and Paris Agreement (2015) had limited visible impact on major emitters' trends.

Global CO<sub>2</sub> by Fuel Type



- **Coal** has been the largest contributor to CO<sub>2</sub> emissions, with sharp growth after 1950.
- Oil emissions rose steeply from the mid - 20th century, becoming the second largest source.
- Gas emissions have steadily increased, especially after 1970.
- Cement and other industries contribute smaller but steadily rising shares.
- Flaring remains a minimal but consistent source over time.

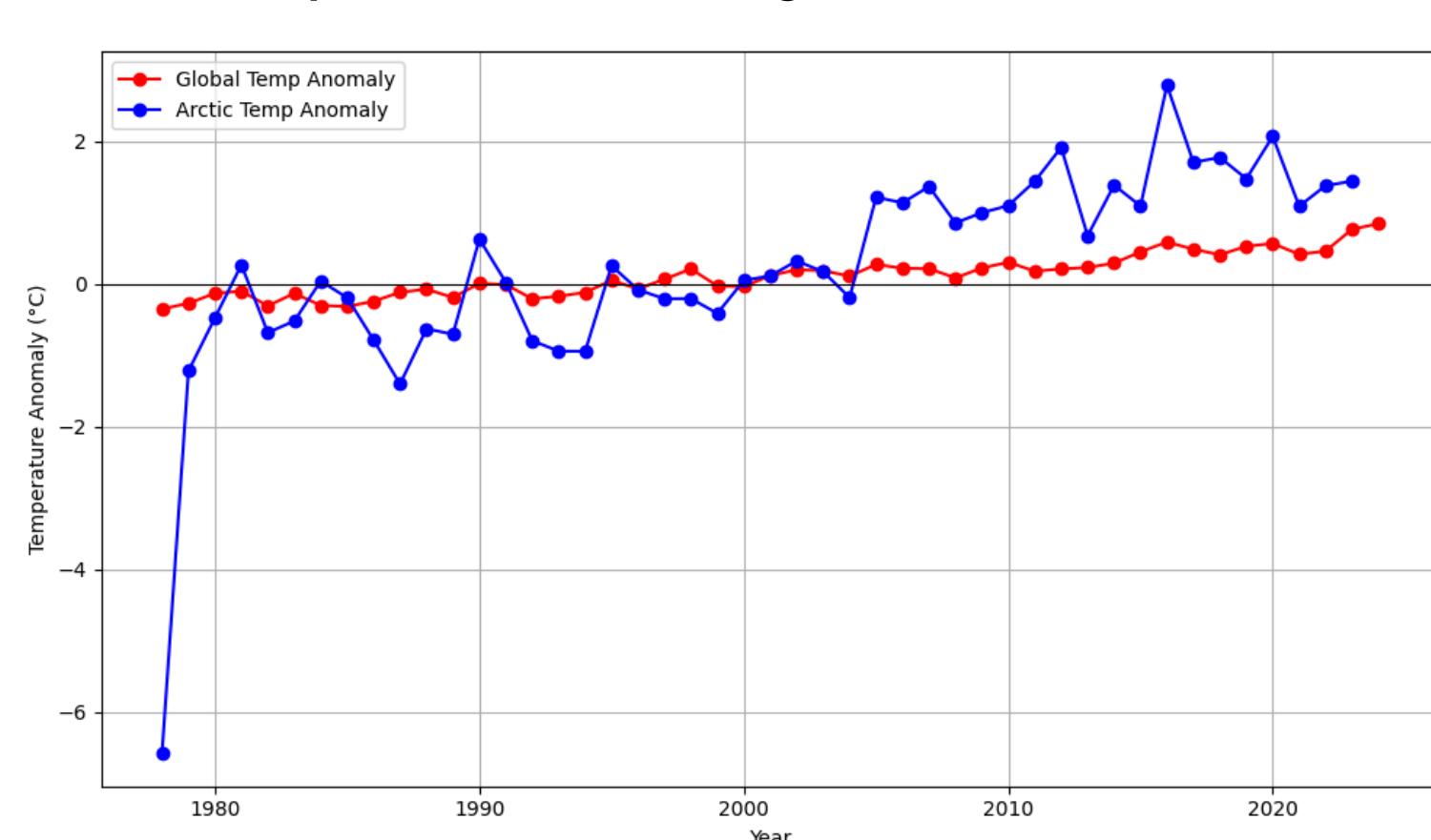
## DID YOU KNOW



- The **UK** is a major net **importer** of CO<sub>2</sub> - outsourcing much of its carbon footprint to manufacturing giants like China.
- Many African and island nations - such as DR Congo and Somalia get over **90%** of their emissions from **land use changes** like deforestation and agriculture.

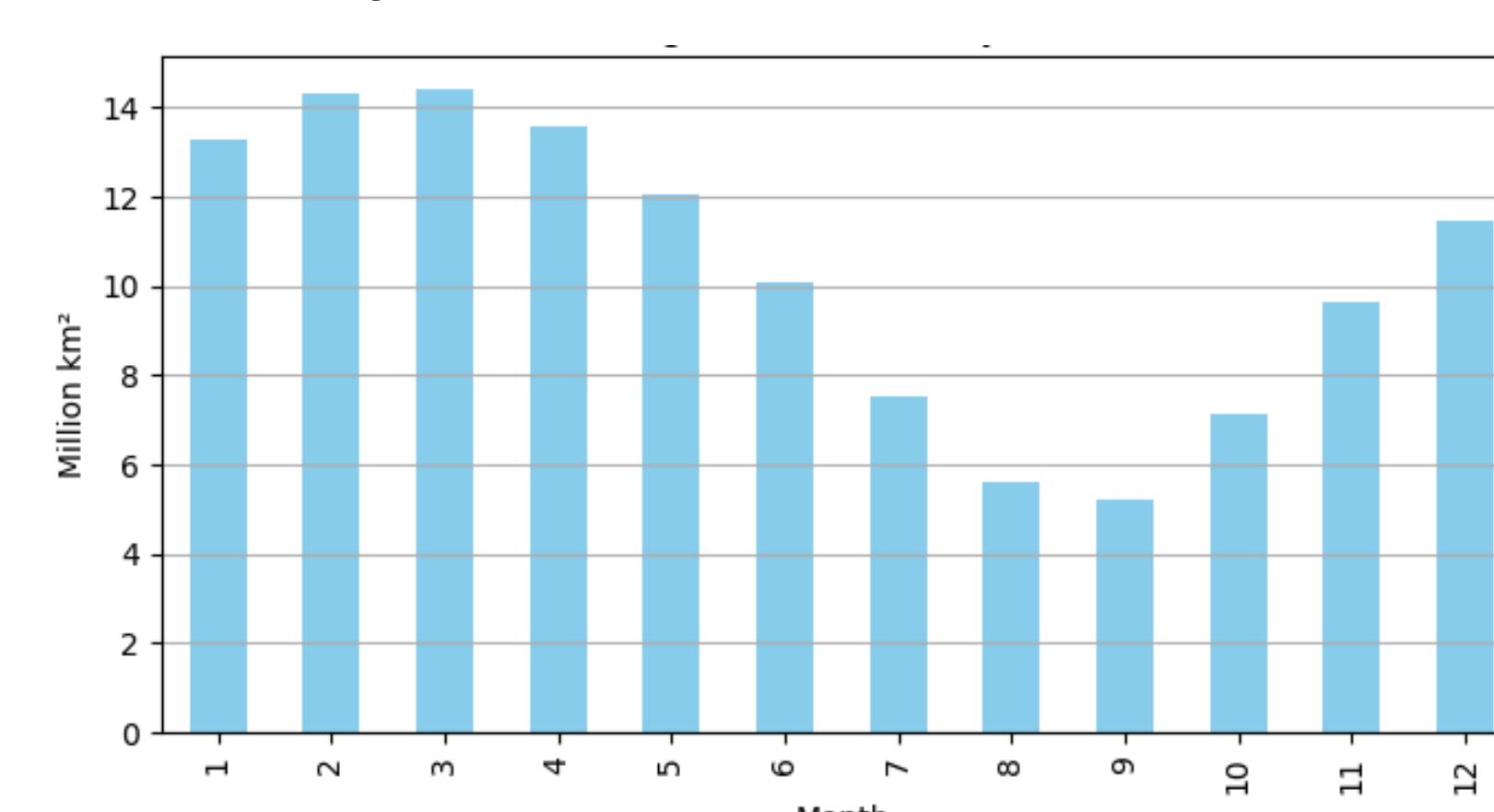
## ARCTIC CHANGE: PAST TO FUTURE

Arctic Amplification in Warming



- Arctic warming is much faster than global since early 2000s
- Recent **Arctic anomalies > +2 °C** whereas **global < +1 °C**
- Both show steady warming relative to 1981-2010 baseline
- Arctic temperatures show higher year-to-year variability

Seasonal Cycle of Arctic Sea Ice



- Average sea ice area peaks in March (~14.4 million km<sup>2</sup>) at the end of winter.
- It reaches its average **minimum** in **September** (~5.2 million km<sup>2</sup>) after summer melt.
- The average cycle shows a steady decline from spring to late summer, followed by regrowth into winter

Correlation Matrix of Arctic Data

year	month	sia_million_km2	se_million_km2	thick_m	cdr	uvb	shf	sf	t2m	sst	ist1	ist2	ist3	ist4	skt	ishf	tcc	tsn	year	month	sia_million_km2	se_million_km2	thick_m	cdr	uvb	shf	sf	t2m	sst	ist1	ist2	ist3	ist4	skt	ishf	tcc	tsn
1.00	0.01	-0.19	-0.20	-0.43	0.00	0.00	-0.16	0.01	0.09	0.27	0.09	0.09	0.09	0.09	0.09	-0.12	-0.18	0.09	0.01	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30					
-0.01	1.00	0.63	-0.65	0.61	-0.10	-0.14	-0.25	0.32	0.40	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	-0.18	0.09	0.01	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30					
-0.19	0.63	1.00	1.00	0.86	-0.22	-0.19	-0.50	-0.12	0.73	-0.89	-0.72	-0.73	-0.76	-0.77	-0.73	0.44	-0.26	-0.78	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.63	-0.65	1.00	1.00	0.86	-0.22	-0.19	-0.50	-0.12	0.73	-0.89	-0.72	-0.73	-0.76	-0.77	-0.73	0.44	-0.26	-0.78	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.61	0.61	-0.22	-0.17	0.13	1.00	0.99	0.73	0.27	0.43	0.92	0.42	0.43	0.47	0.49	0.43	0.14	0.39	-0.44	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
-0.22	-0.17	0.13	0.08	0.22	0.99	1.00	0.70	0.54	0.74	0.16	0.79	0.79	0.76	0.74	0.74	0.01	0.39	-0.44	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.08	0.08	0.22	0.08	0.22	0.99	1.00	0.70	0.54	0.74	0.16	0.79	0.79	0.76	0.74	0.74	0.01	0.39	-0.44	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.86	0.86	0.88	0.89	1.00	0.13	0.14	0.22	0.27	0.43	0.92	0.42	0.43	0.47	0.49	0.43	0.14	0.39	-0.44	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.89	0.89	0.90	0.90	0.90	0.10	0.10	0.20	0.27	0.43	0.92	0.42	0.43	0.47	0.49	0.43	0.14	0.39	-0.44	0.01	0.00	0.00	0.00	-0.25	0.27	0.28	0.29	0.29	0.32	0.34	0.28	-0.12	0.37	0.30				
0.90	0.90	0.90	0.90	0.90	0.10	0.10	0.20	0.27	0.43	0.92	0.42	0.43	0.47	0.49	0.43	0.14	0.39	-0.44	0.01	0.00	0.00	0.															