

## 1. Long-term behaviour (1970–2024): steady rise with clear acceleration phases

The raw series shows:

- A **slow, nearly linear rise from 1970 to mid-1990s.**
- A **moderate acceleration from 2000 onward.**
- A **sharp growth phase from ~2010 to 2018.**
- A **visible dip around 2020** (likely due to macroeconomic disruptions such as global lockdowns).
- A **strong rebound post-2021** reaching the highest levels by 2024.

This pattern already suggests cyclical accelerations, which the breakpoints formalize.

## 2. Structural Breaks Detected (BIC-optimized): 2004, 2015, 2020

Your piecewise model identified **three statistically optimal breakpoints**, each corresponding to major changes in the emission growth rate.

### Break 1: 2004 – Start of accelerated growth

Evidence from plot:

- The fitted slope after 2004 becomes steeper than the 1970–2004 slope.
- The actual series climbs more sharply from ~1.7 toward 2.2 by mid-2010s.

Interpretation:

- This regime change marks the transition from slow but consistent growth to a phase of higher annual increases in emissions.
- Could correspond to increased industrial/economic expansion.

### Break 2: 2015 – Peak acceleration regime

Evidence:

- Post-2015 slope is the steepest across all segments.
- Actual values rise from ~2.25 to ~2.65 in only ~3–4 years.

Interpretation:

- Indicates a **high-intensity growth regime**, with emissions rising rapidly.
- This regime likely captures a period of strong energy consumption or industrial output.

### Break 3: 2020 – Sudden downturn + regime shift

Evidence:

- Clear drop in emissions (actual dips from ~2.65 to ~2.50).
- New segment slope is flatter or negative initially.

Interpretation:

- This breakpoint captures a **structural contraction** in emissions.
- The timing aligns with global disruptions (reduced activity due to pandemic).
- Post-2021 rebound is visible but the slope remains lower relative to the 2015–2019 peak regime.

### 3. Segment-wise behaviour (from piecewise regression fit)

Although values are not shown directly here, the visual fits imply:

Segment	Years	Behaviour	Approx Trend Impact
<b>Regime 1</b>	1970–2004	Slow, steady rise	Long-term linear baseline
<b>Regime 2</b>	2004–2015	Faster growth	Structural uplift in emissions trajectory
<b>Regime 3</b>	2015–2020	Very fast growth	Strong positive shock, peak momentum
<b>Regime 4</b>	2020–2024	Drop + mild recovery	Growth volatility, weakened slope

This segmentation indicates that the emissions trend is **not homogeneous** but driven by **macro-shocks and policy/industrial cycles**.

### 4. ARIMA forecast (10-year projection from last regime)

Key observations from forecast plot:

#### Forecast Shape

- Forecasted trajectory **declines from the 2024 peak**, moving from ~3.1 down toward ~2.3–2.4 by early 2030s.
- Confidence intervals widen moderately but remain below the recent highs.

#### Interpretation

- ARIMA is capturing the **downward structural momentum** of the 2020–2024 regime.
- Because the last estimated slope post-2020 is flatter or negative, the forecast projects **mean-reversion rather than continued acceleration**.
- This indicates the model expects **stabilization or controlled emissions**, not explosive growth.

## **5. Integrated Insight: Cyclical growth, sharp structural shifts, and possible stabilization**

Combining piecewise regression and ARIMA:

1. **1970–2004:** Stable long-term baseline with predictable linear increase.
2. **2004–2020:** Two consecutive breakpoints (2004, 2015) marking strong acceleration phases.
3. **2020 onward:** High volatility and flattening of long-term slope.
4. **Future projection:** A modelled decline suggests emissions may be entering a moderation/stabilization era rather than continuing the pre-2015 exponential path.

## **6. Strongest Data-Supported Conclusions**

1. **Three major structural breaks** exist: 2004, 2015, 2020.
2. **Trend acceleration is strongest between 2015–2020.**
3. **2020 represents a significant structural reversal**, not random noise.
4. **Post-2020 regime fundamentally changes long-term trajectory.**
5. **Forecast suggests a downward correction** rather than continued growth.
6. **Emissions dynamics are regime-dependent**, not a single linear trend.
7. **Break-based segmentation improves interpretability** relative to classical trend models.
8. **Uncertainty grows into the future**, but even the upper 95% CI does not reach pre-2020 growth rates.