Quiz: Assuming a potentially causal relationship between the atmospheric temperature (T) and atmospheric concentration of carbon dioxide ($[CO_2]$), which is the cause and which the effect?

Hint: Use the graphs below without mathematical analyses.

Explanations:

1. The values plotted are annual averages of differenced time series for differencing time step of 1 year; in particular $[CO_2]$ is logarithmically transformed.

2. Each point represents the time average for a duration of one-year ending at the time of its abscissa. The two time series are lagged with a time difference of six months. That is, each green square is half-way (in time) between two consecutive red dots (the annual average for ΔT is taken from January to December and that for $\Delta \ln[CO_2]$ from July to June).

3. *T is* the global average of the atmospheric temperature from the NCAR/NCEP reanalysis; $[CO_2]$ is the atmospheric concentration of carbon dioxide of the Mauna Loa observatory (Hawaii, USA).

4. The quantity μ_v subtracted from $\Delta \ln[CO_2]$ is determined by equation (10) in Koutsoyiannis et al. (2023, "On hens, eggs, temperatures and CO₂: Causal links in Earth's atmosphere"), i.e., $\mu_v = 0.0034 \, (T_4/K - 285.84)$, where T_4 is the average temperature of the previous 4 years and K is the unit of kelvin.