Today's carbon cycle as revealed by observed CO_2 records

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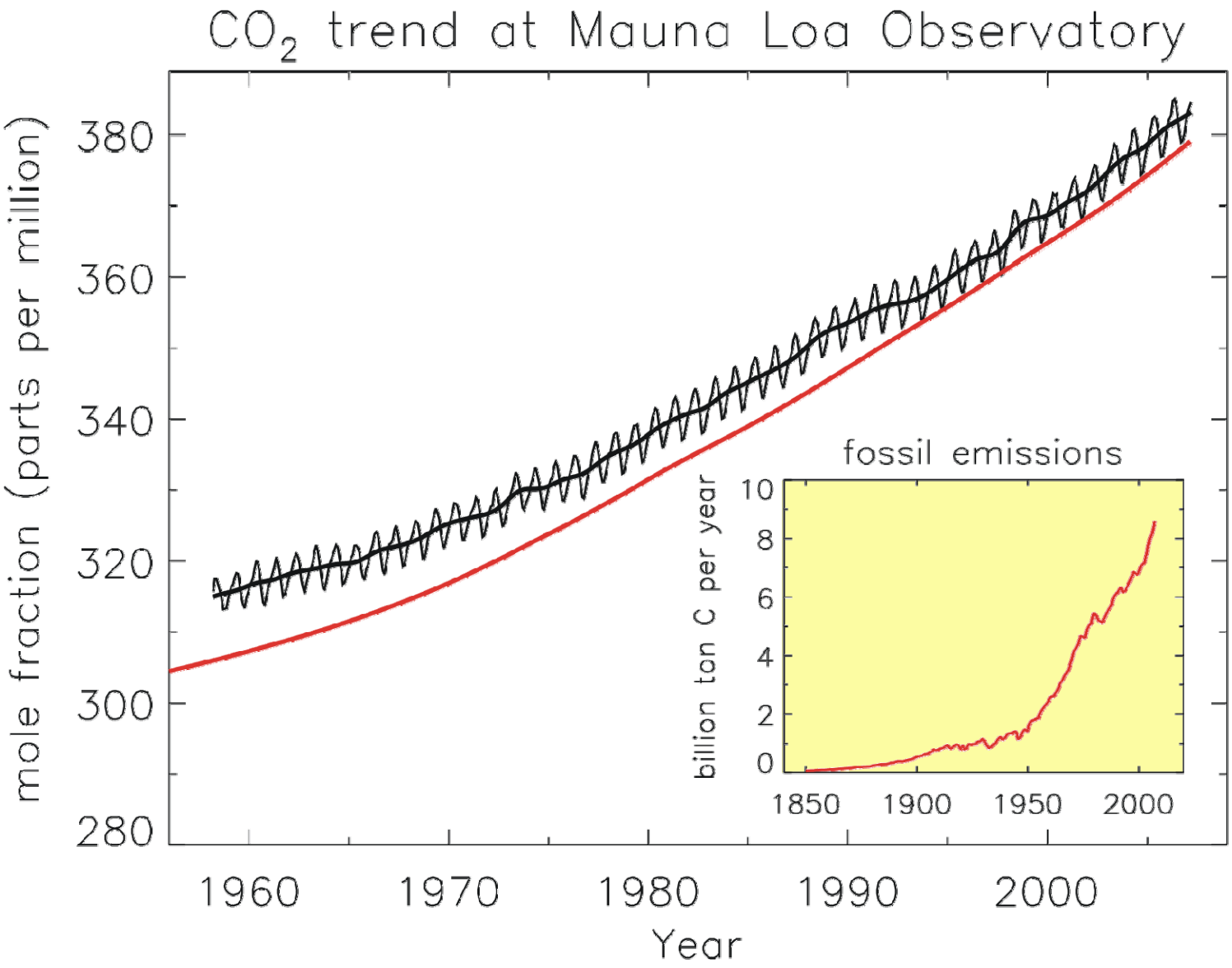
DECADAL MASS BALANCE OF CARBON



Fossil fuel data: CDIAC and BP

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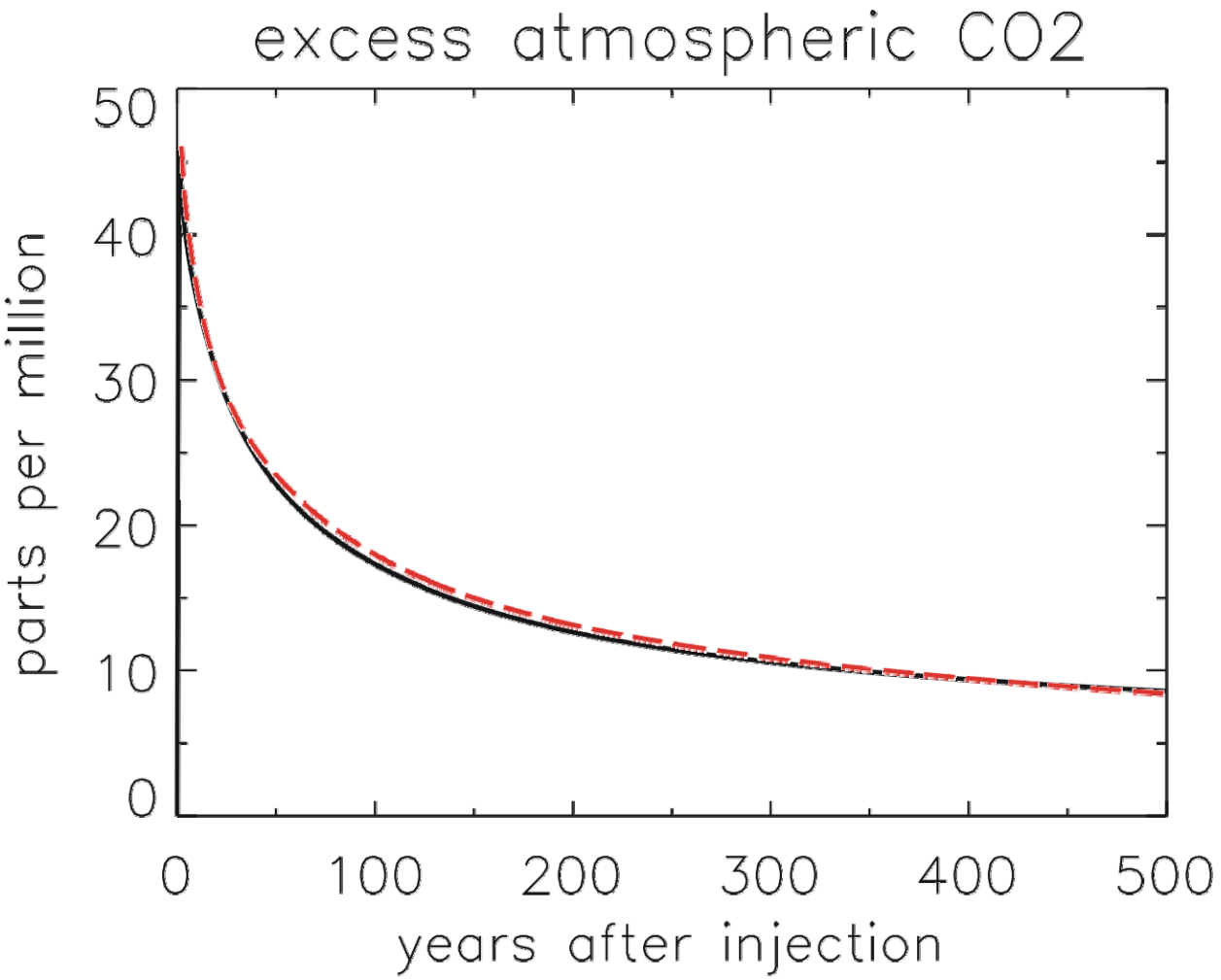

Pulse response:

$CO2_{ATM}$ = 0.131 + 0.201 exp(-t /363) + 0.321 exp(-t /74) +
+ 0.249 exp (-t /17) + 0.098 exp(-t /1.9)

Hamburg Ocean Carbon Cycle Model, E.Maier-Reimer, 1987

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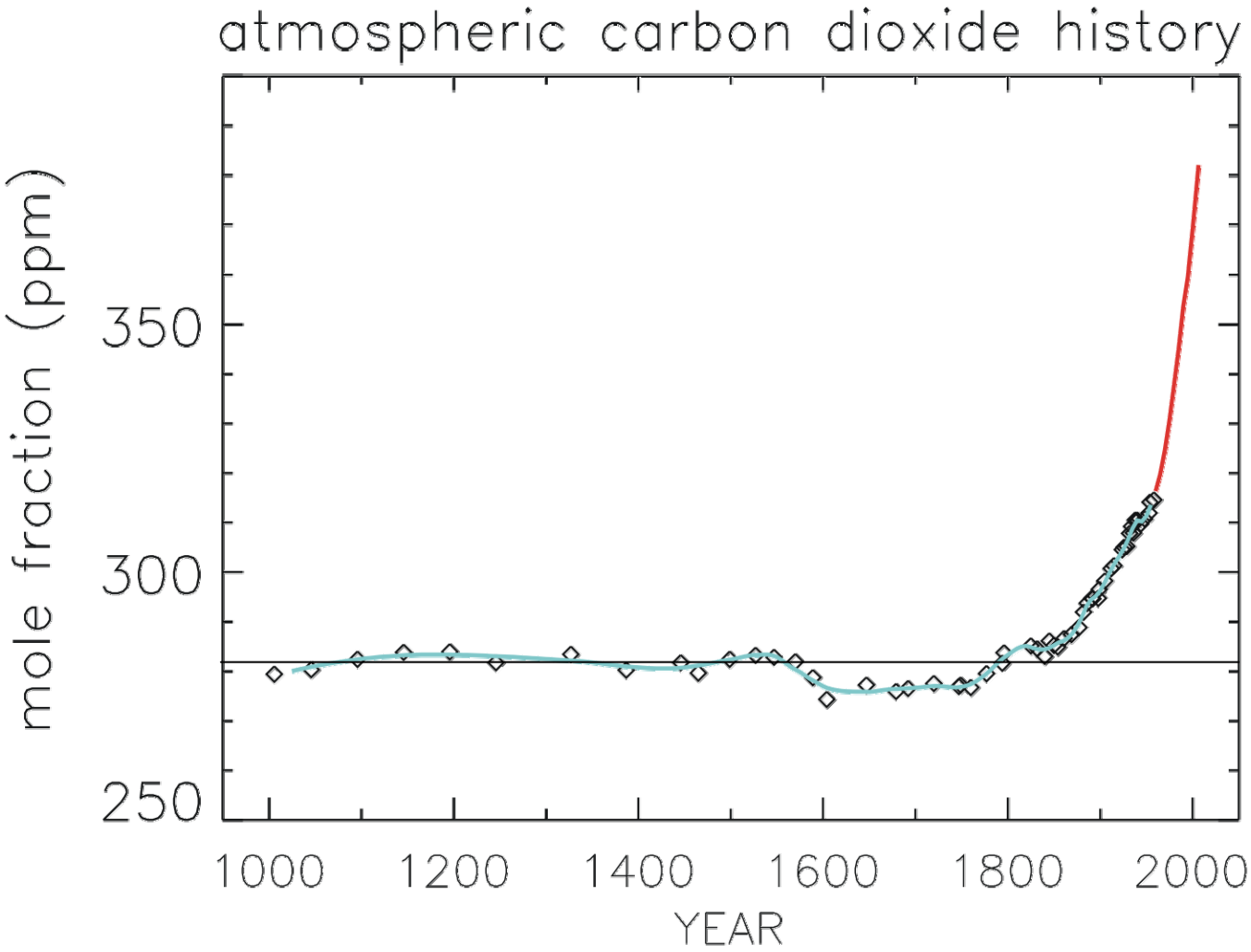
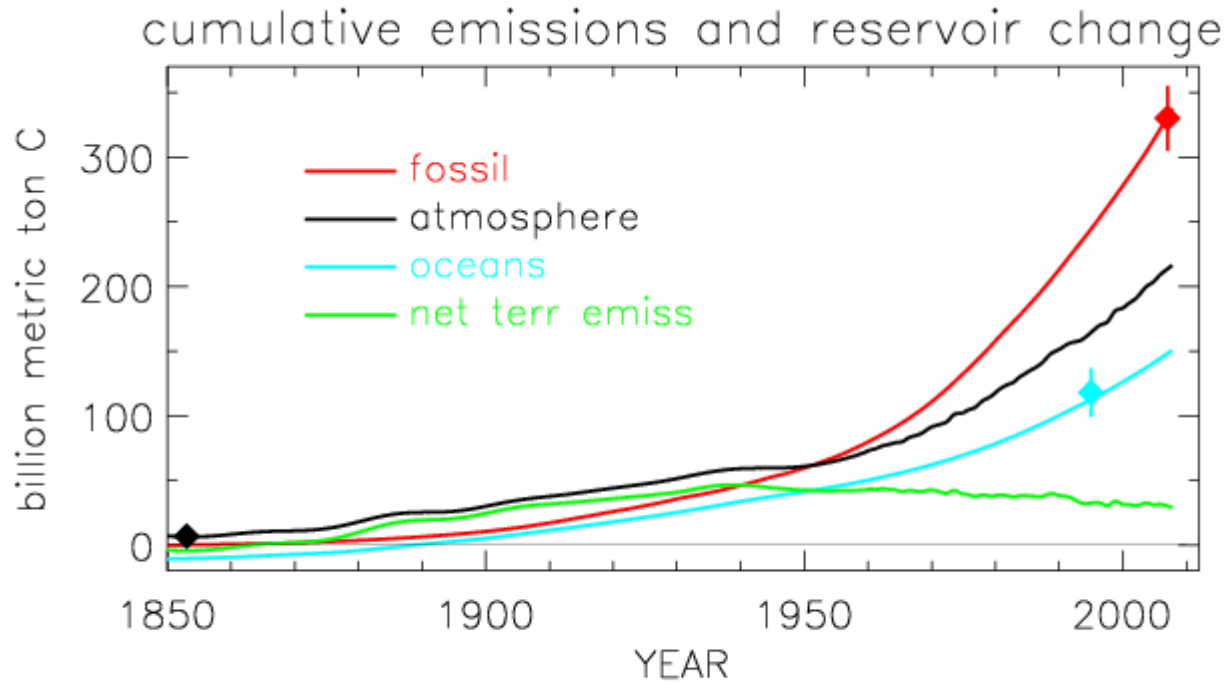


sources: David Etheridge, CSIRO, Australia; ESRL

DECADAL MASS BALANCE OF CARBON

	GtC
Cumulative fossil fuel emissions (Jan. 2007)	331 ± 25
(source: CDIAC)	
Observed atmospheric increase (Jan. 2007)	214 ± 8
(source: ESRL)	
Observed ocean increase through 1994	118 ± 19
(Sabine et al., Science 2004)	
oceans, extrapolated through 2006	148



fossil fuel emissions + terrestrial sources = atmospheric increase + ocean

DECADAL MASS BALANCE OF CARBON

Use of isotopic ratios to distinguish sources

$$\frac{^{13}C/^{12}C_{sample} - {}^{13}C/^{12}C_{reference}}{^{13}C/^{12}C_{reference}}$$

	$\delta^{13}C$ (approximate)	$^{13}C/^{12}C$ ratio	$\frac{^{14}C/C_{sample}}{^{14}C/C_{reference}}$ (approximate)
Atmosphere	-8 ‰	0.011147	1.06
From oceans	-8 ‰	0.011147	1.08
Terrestrial biosphere	-26 ‰	0.010945	1.09
Coal	-24 ‰	0.010967	0
Oil	-28 ‰	0.010923	0
Natural gas	-45 ‰	0.010732	0

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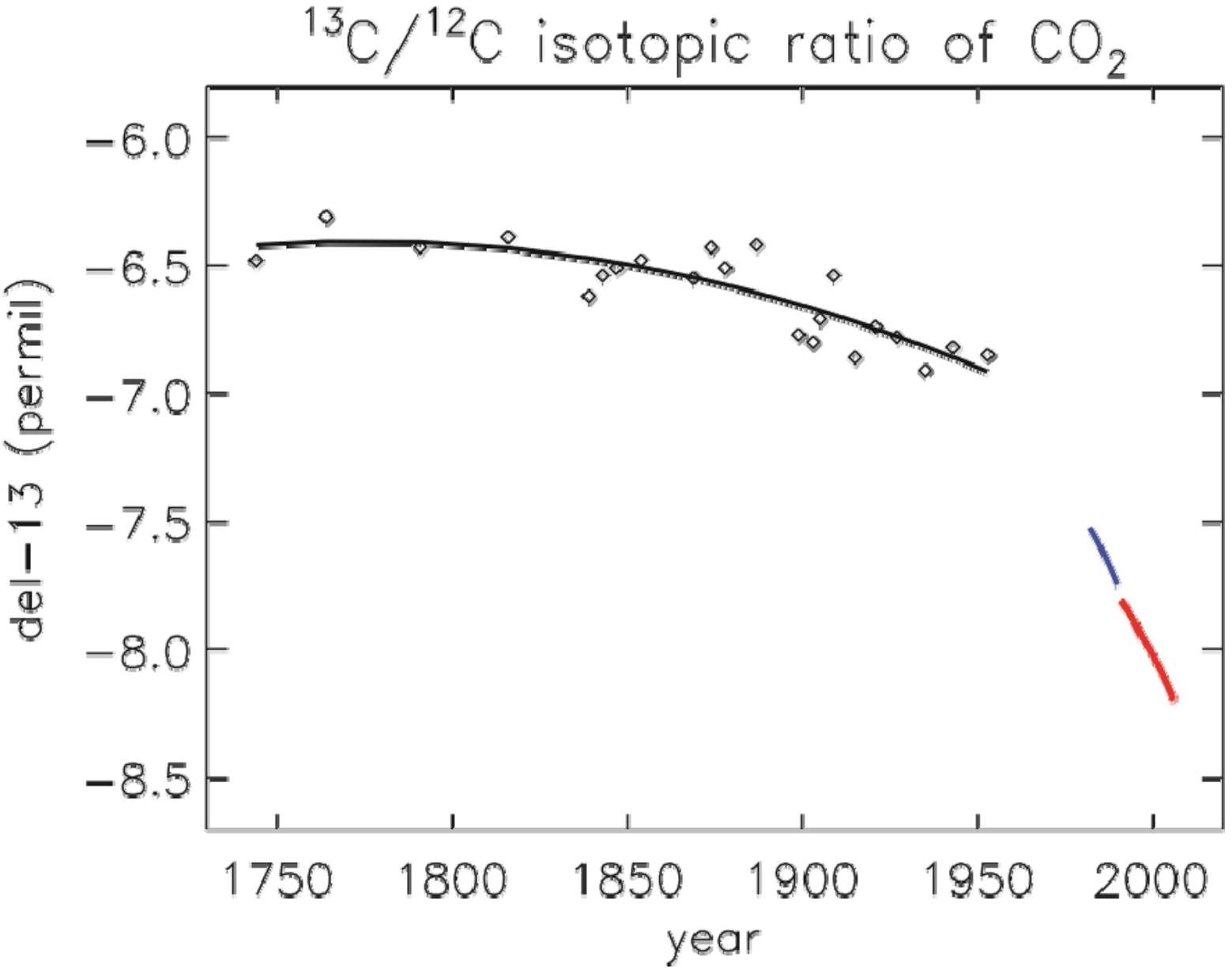

Sources: Friedli (1986), Francey (1999), and ESRL & INSTAAR

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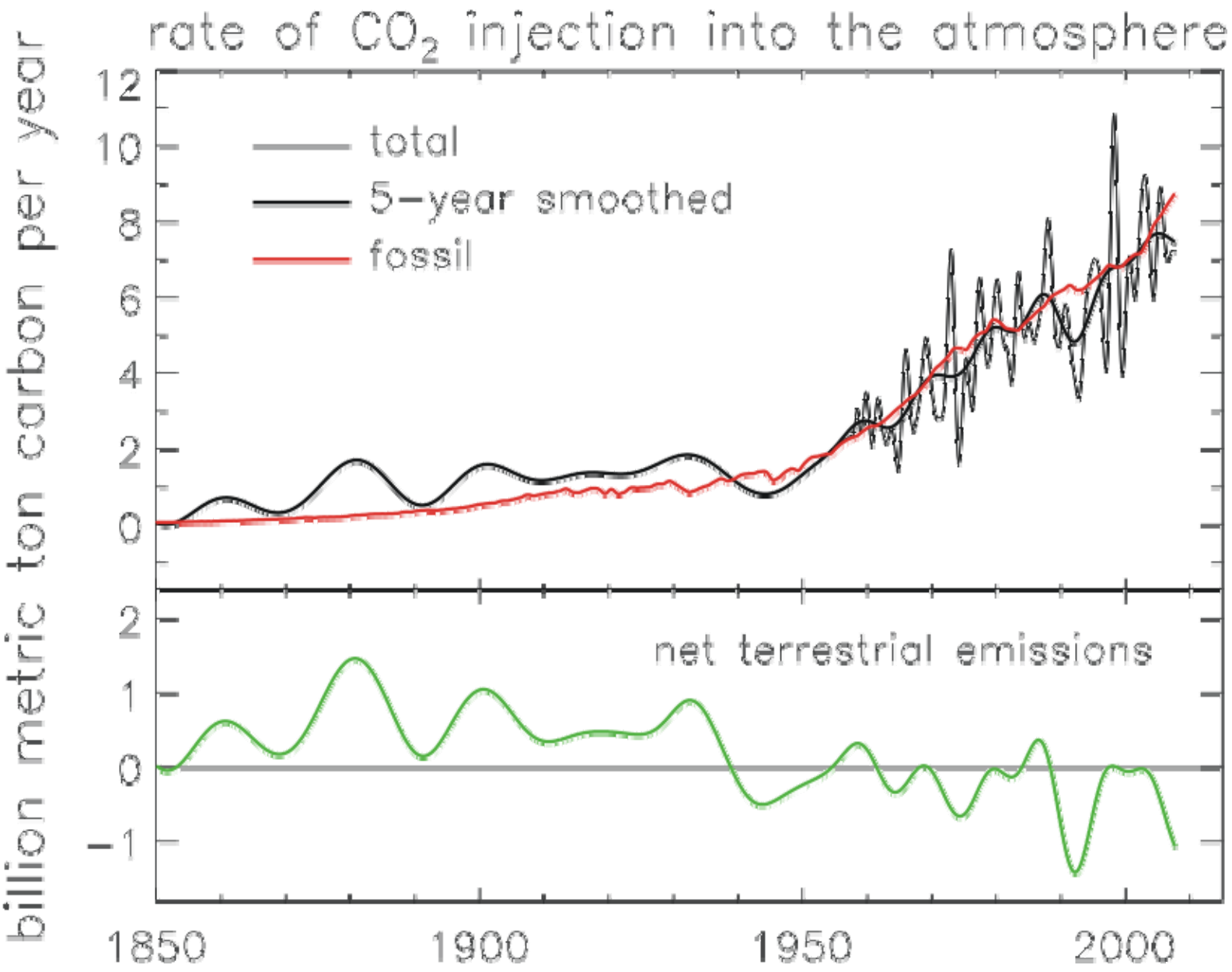

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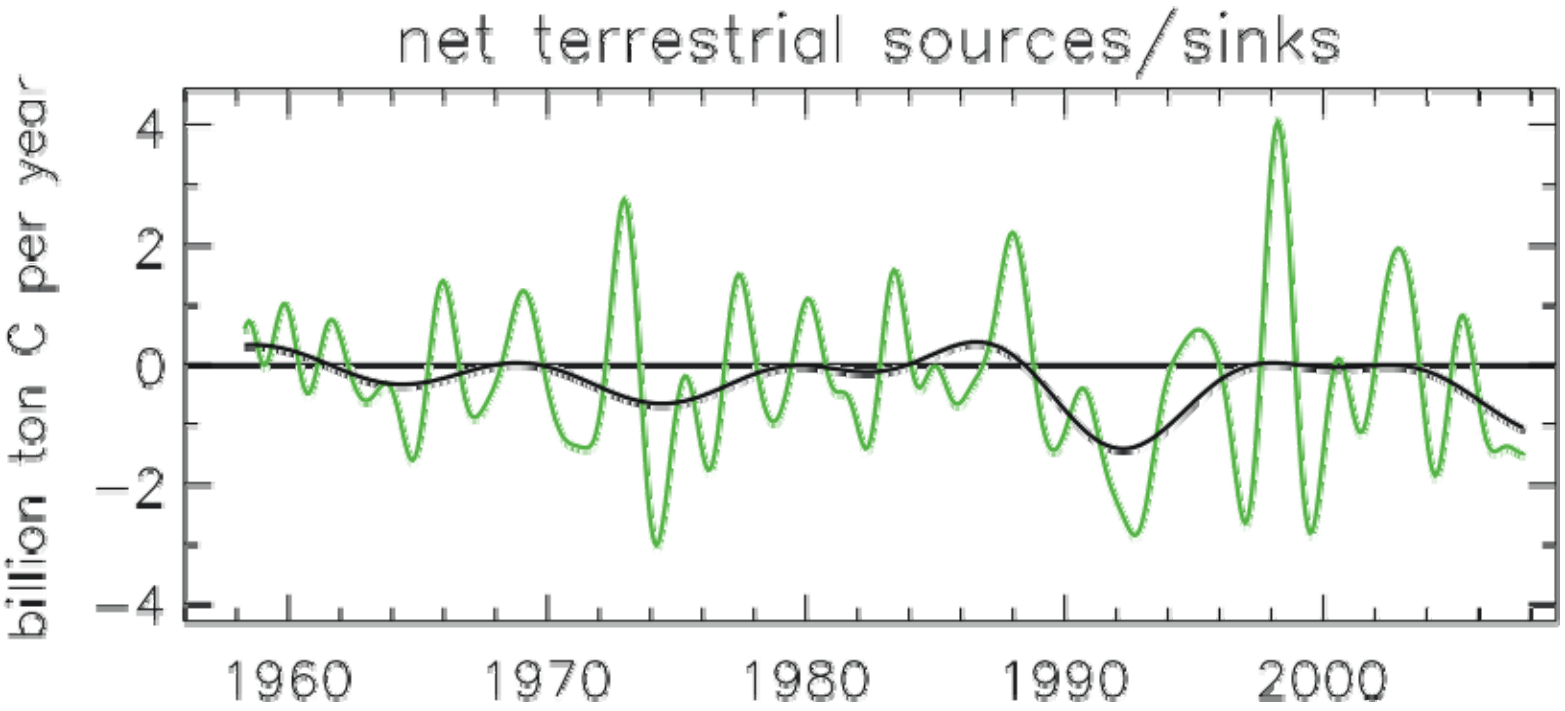
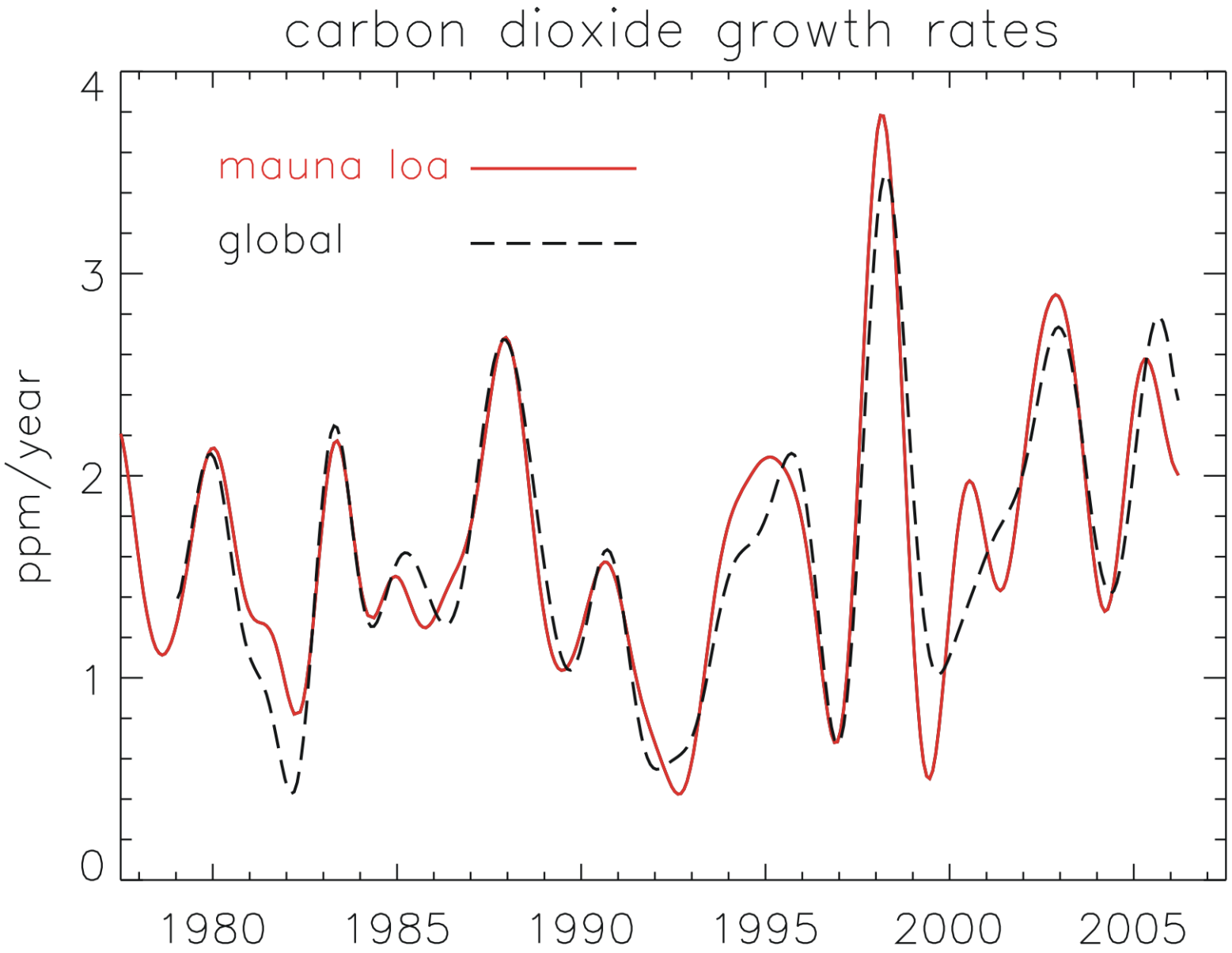


DECADAL MASS BALANCE OF CARBON

Conclusion:

The observed increase in atmospheric carbon dioxide since pre-industrial times is entirely due to human activities.

CO2 GROWTHRATE and CLIMATE ANOMALIES



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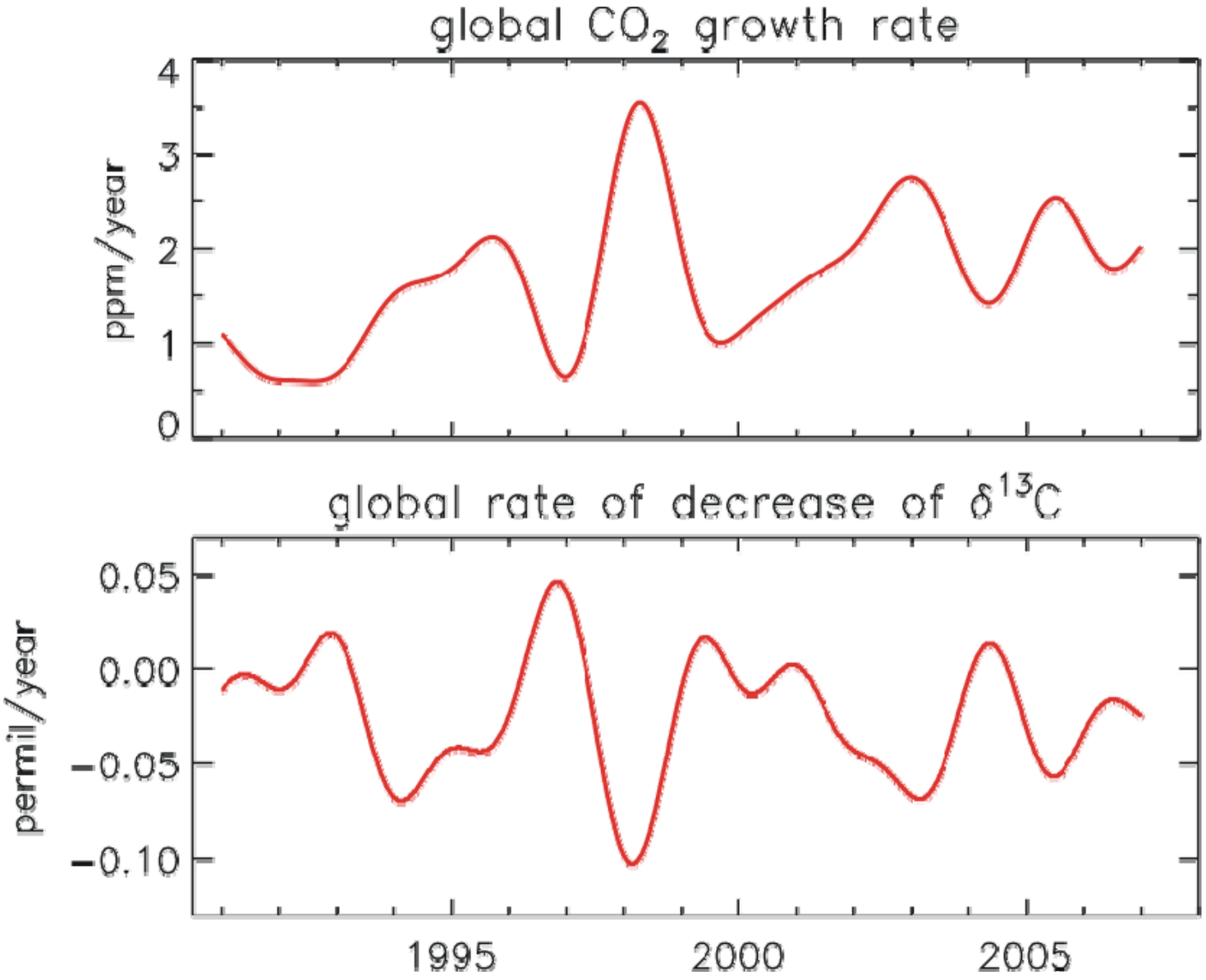

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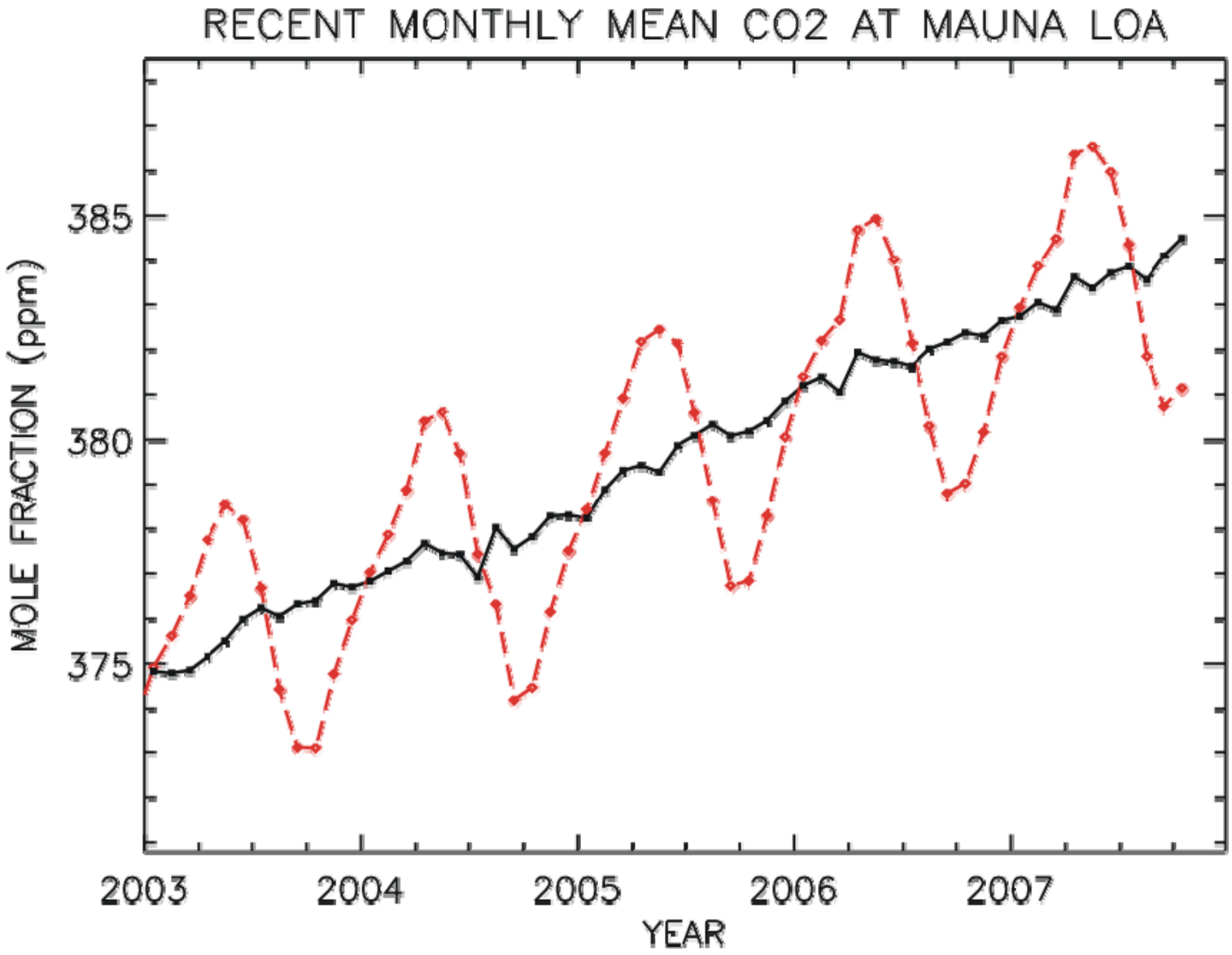

www.esrl.noaa.gov/gmd/ccgg/trends/

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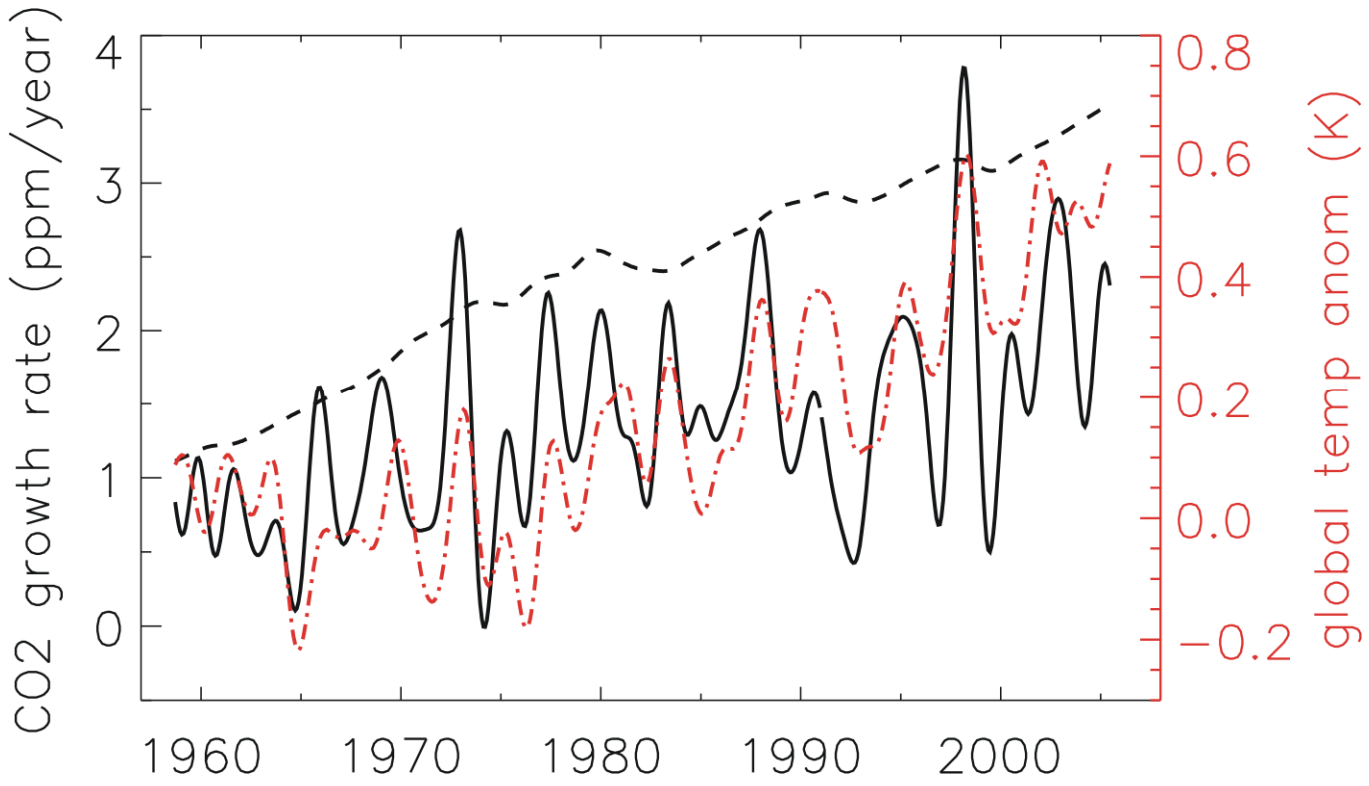

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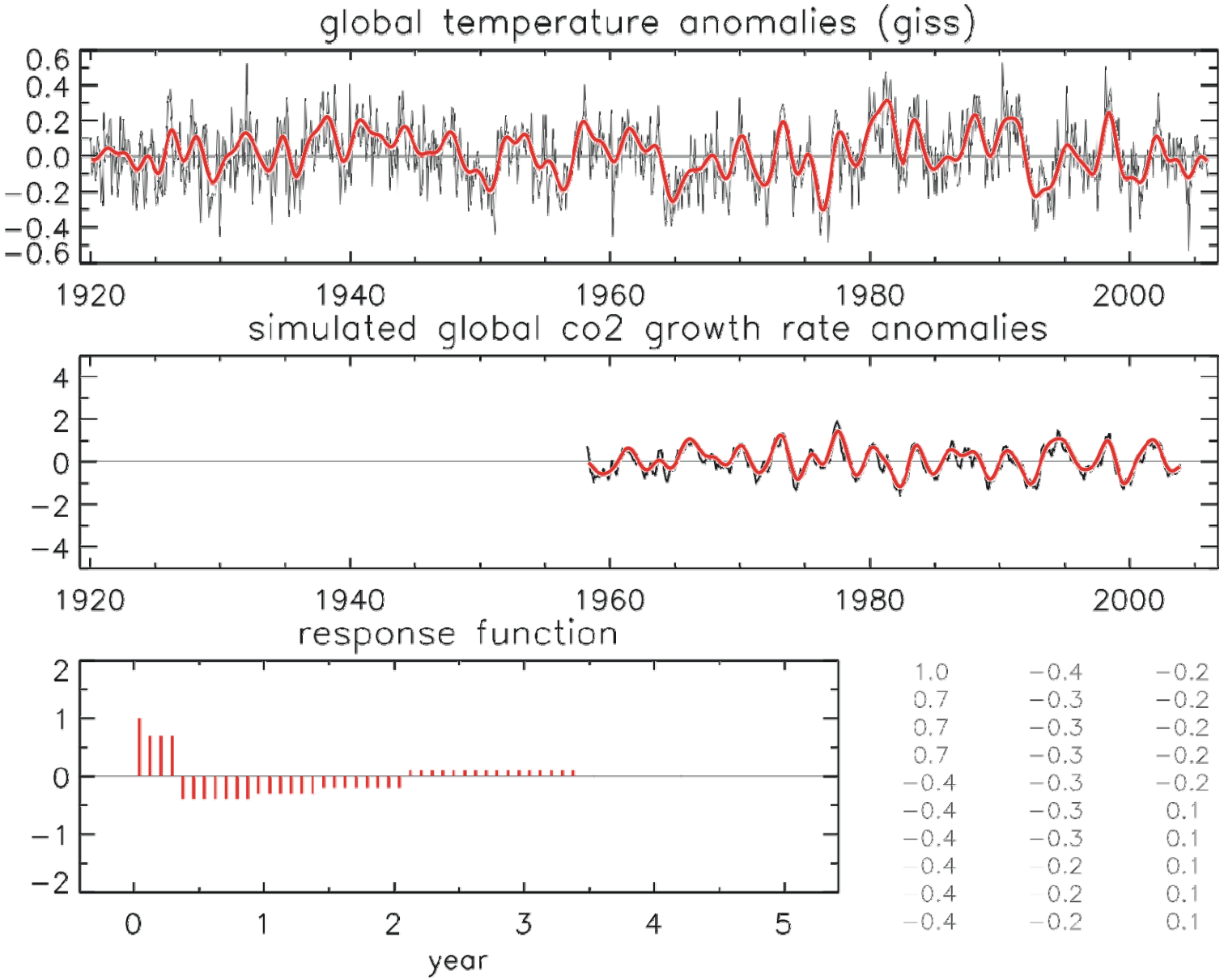

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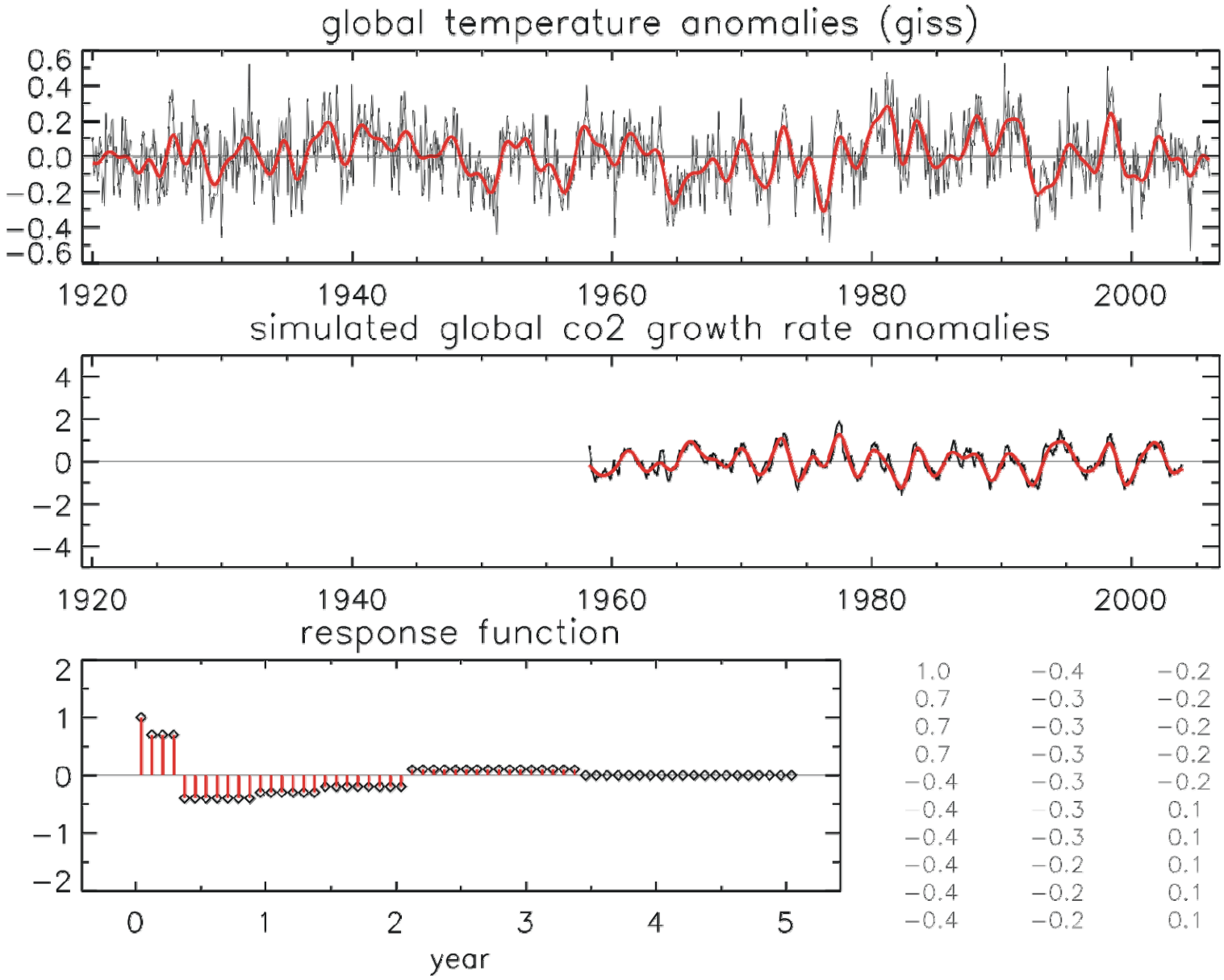

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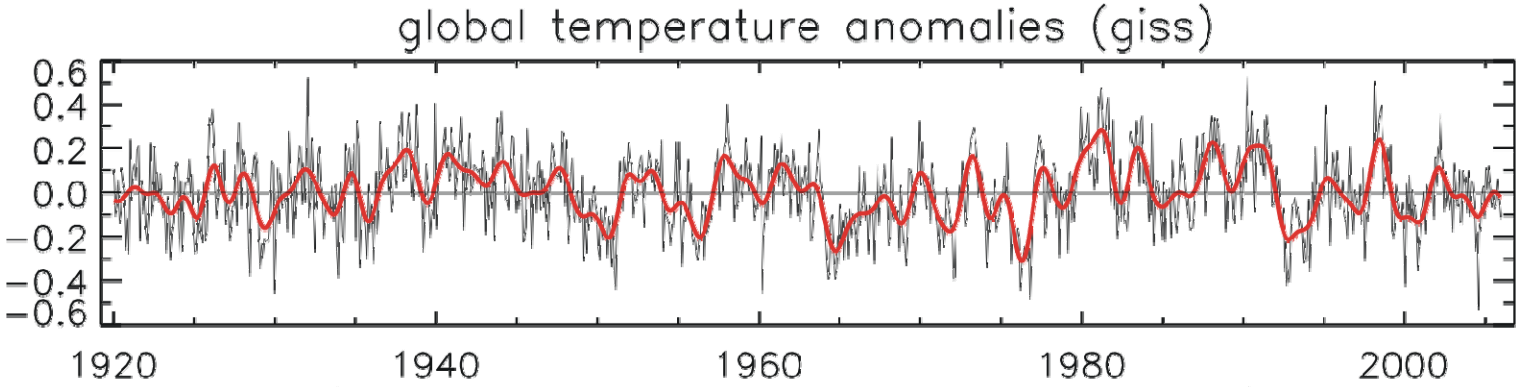

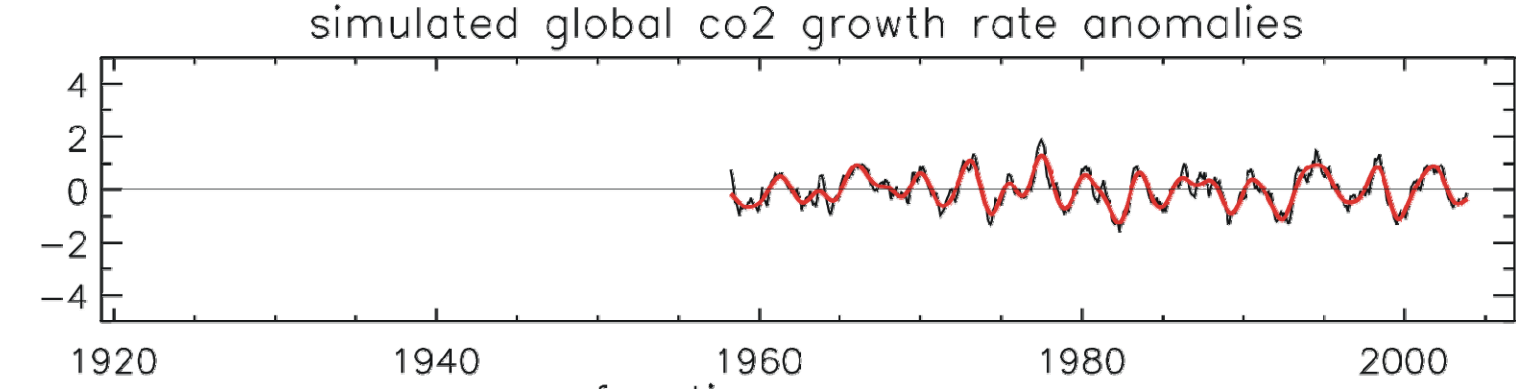

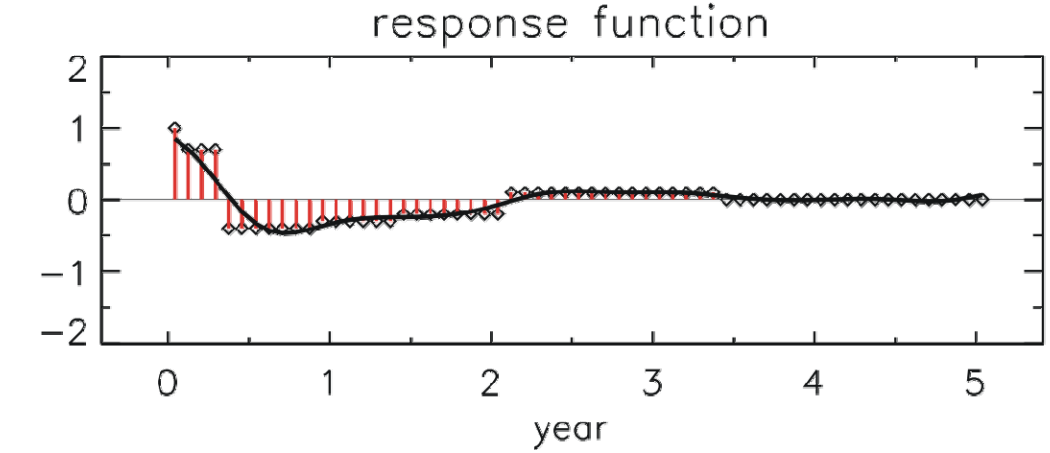

1.0	−0.4	−0.2
0.7	−0.3	−0.2
0.7	−0.3	−0.2
0.7	−0.3	−0.2
−0.4	−0.3	−0.2
−0.4	−0.3	0.1
−0.4	−0.3	0.1
−0.4	−0.2	0.1
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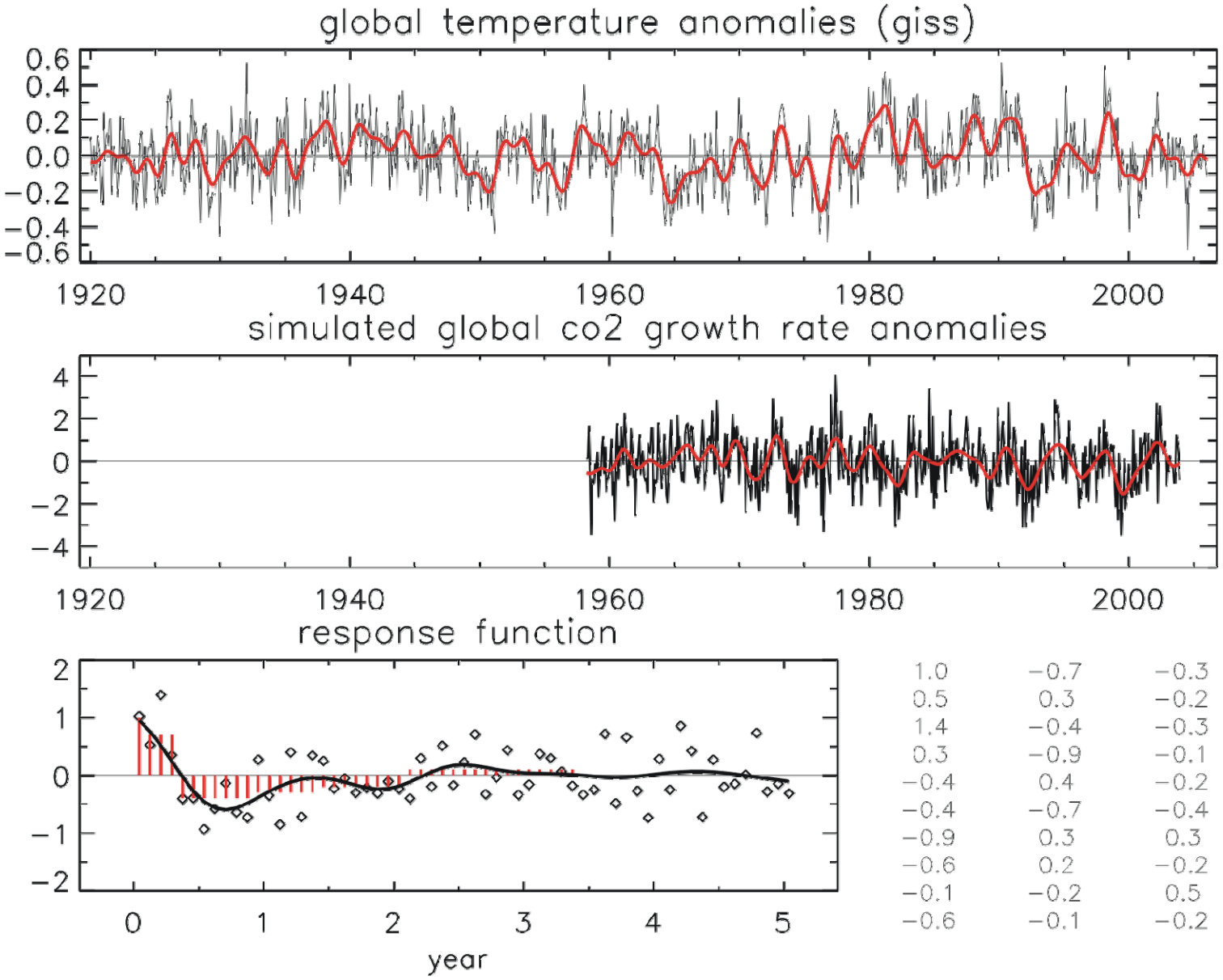
CO2 GROWTHRATE and CLIMATE ANOMALIES



1.0	−0.7	−0.3
0.5	0.3	−0.2
1.4	−0.4	−0.3
0.3	−0.9	−0.1
−0.4	0.4	−0.2
−0.4	−0.7	−0.4
−0.9	0.3	0.3
−0.6	0.2	−0.2
−0.1	−0.2	0.5
−0.6	−0.1	−0.2

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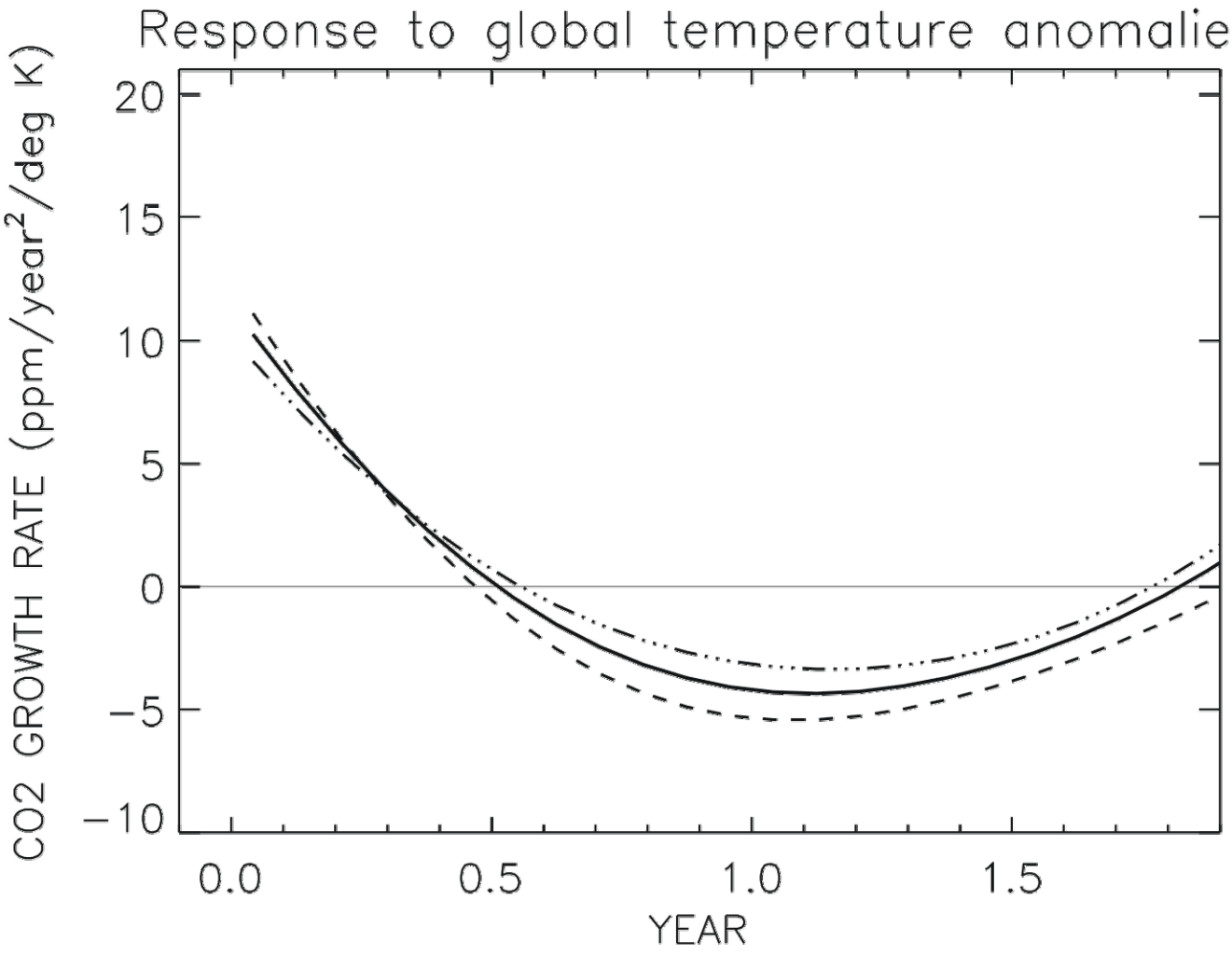
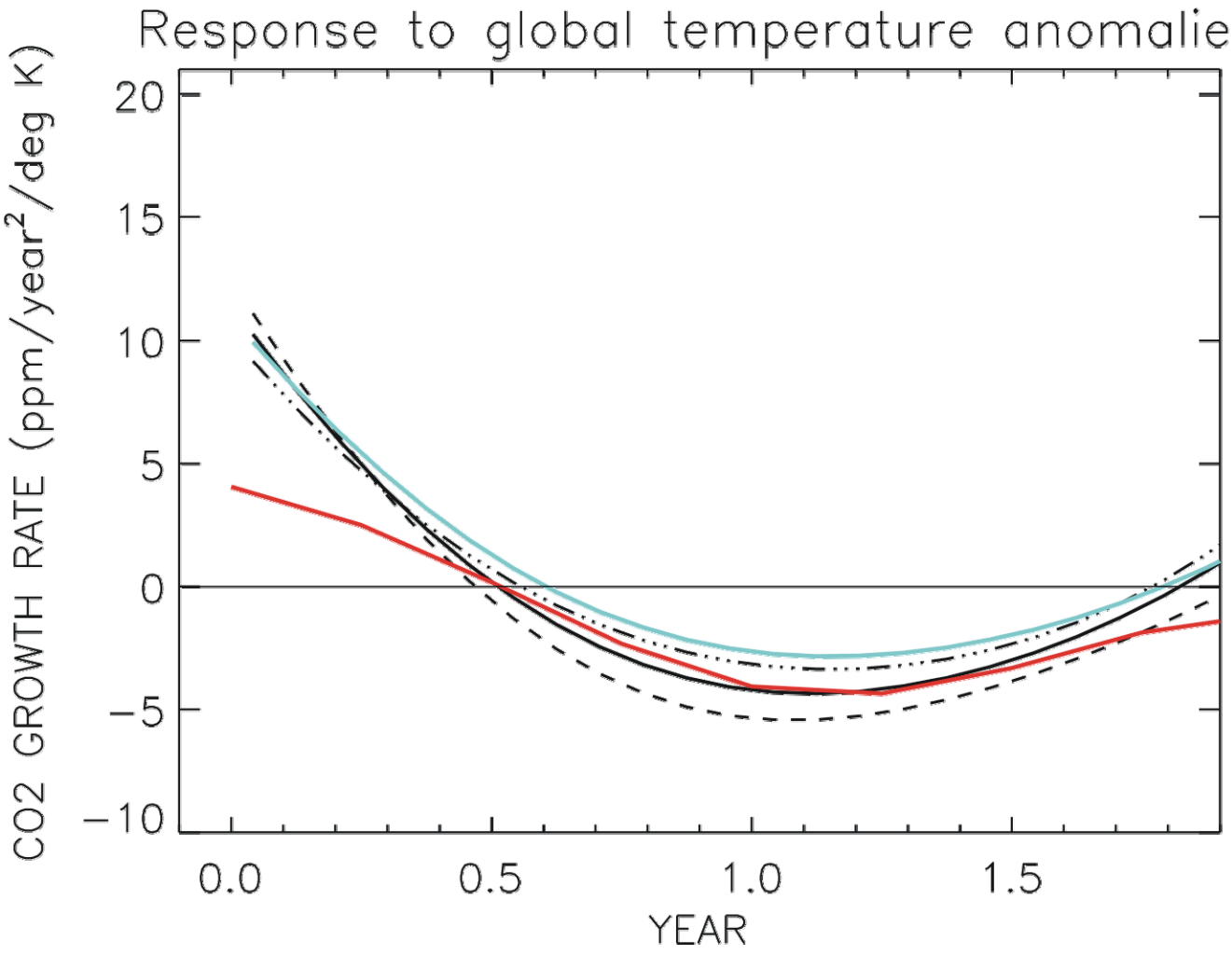


$$\frac{d[CO_2]}{dt} = \int^{t} dt' \, R(t-t') \, \Delta T(t')$$

CO2 GROWTHRATE and CLIMATE ANOMALIES



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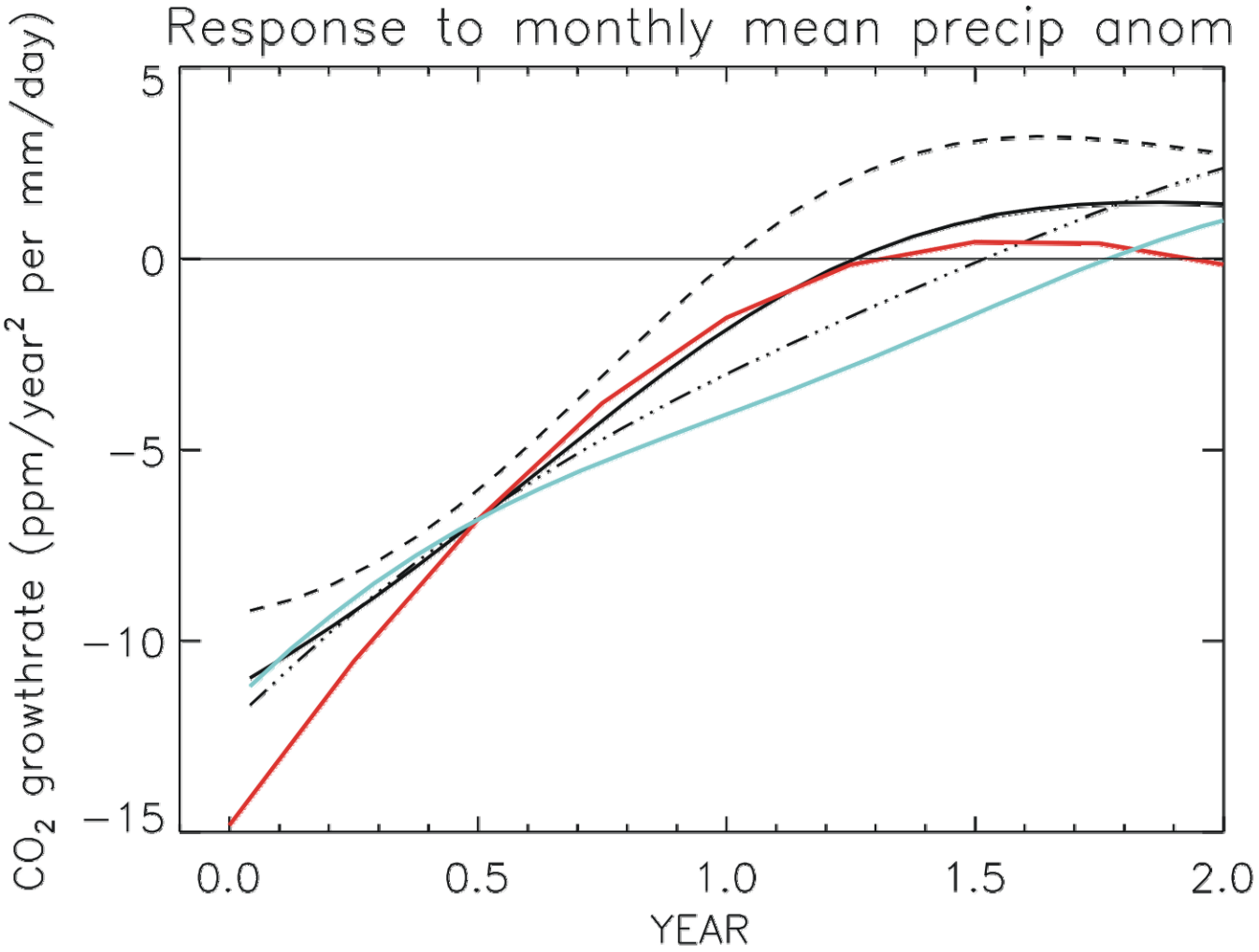

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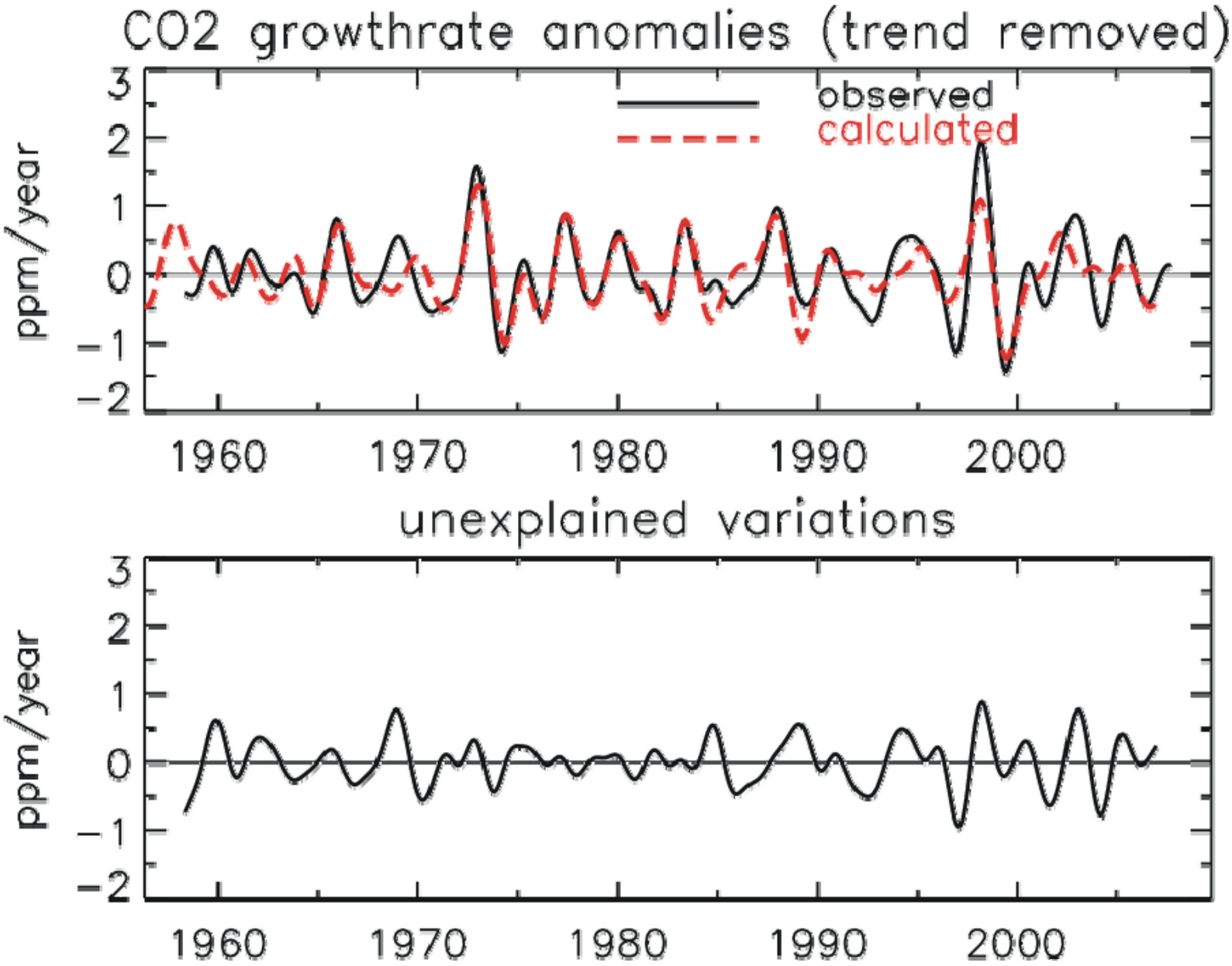

CO_2 GROWTHRATE and CLIMATE ANOMALIES

Conclusion:

2/3 of the interannual variance of the CO_2 growth rate is explained by the delayed response of the terrestrial biosphere to interannual variations of temperature and precipitation.