

LONG-TERM ATMOSPHERIC CO₂ LEVELS

11. The Global Carbon Cycle

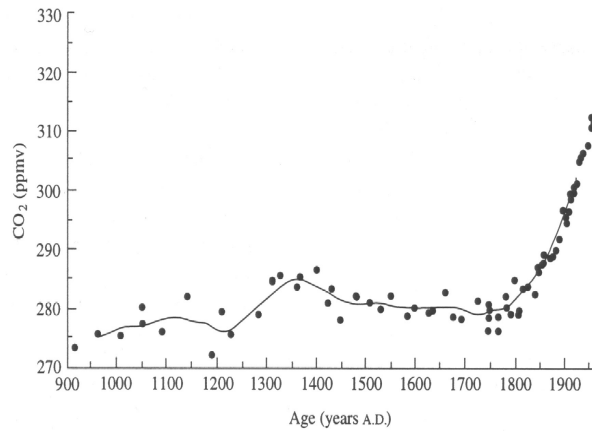
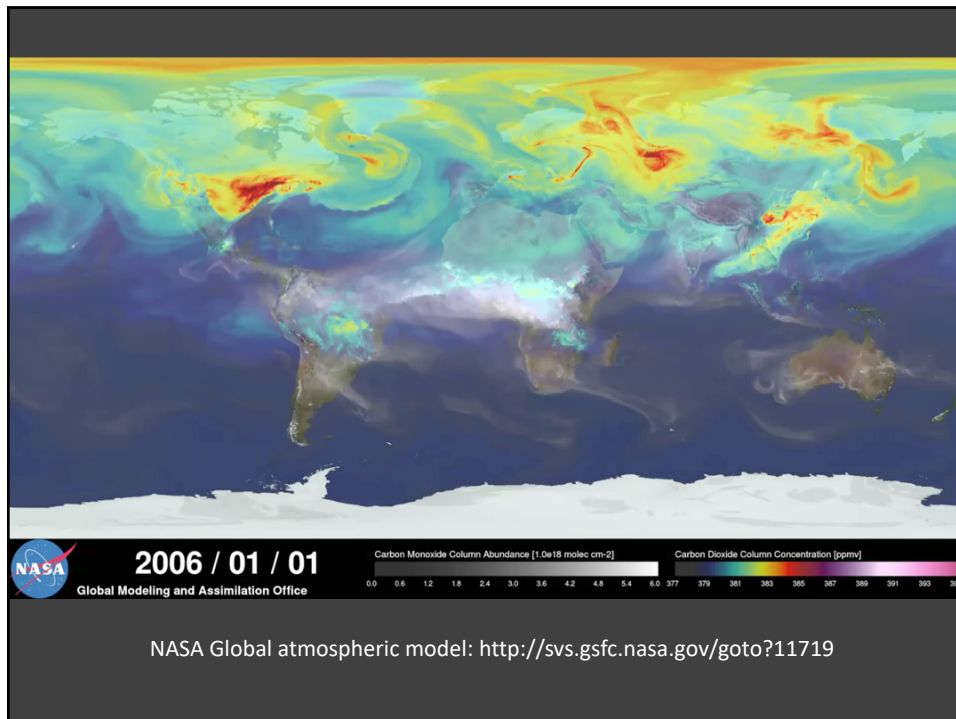
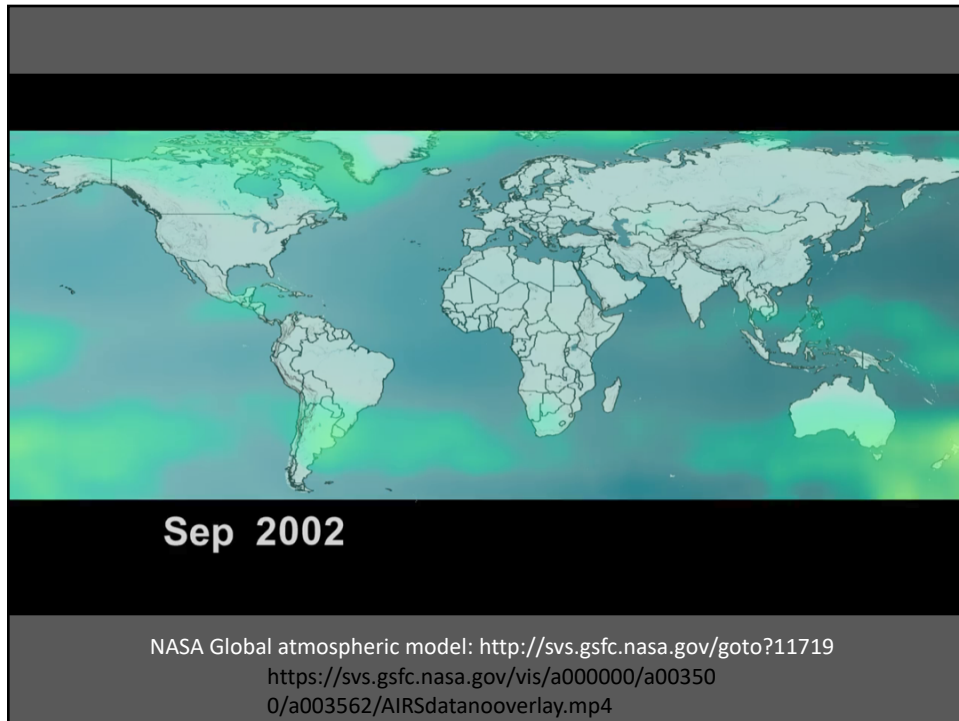


Figure 11.5 Concentrations of atmospheric CO₂ estimated from bubbles of gas trapped in ice cores from Antarctica. From Barnola et al. (1995).

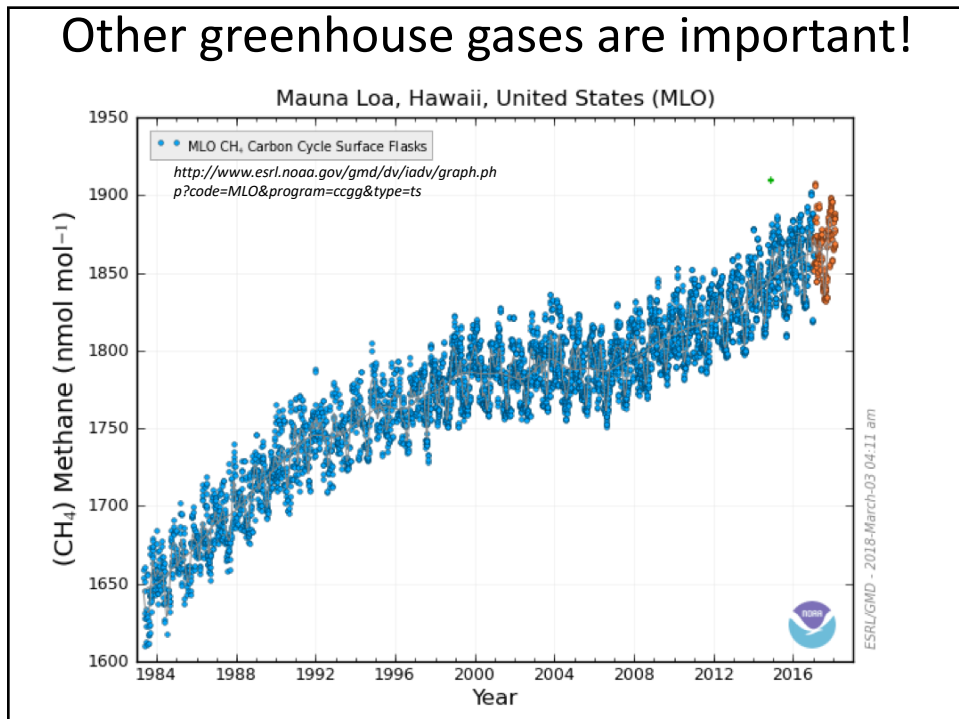
- Total emissions of C from 1850 to 1982 are estimated at $173 \pm 10 \times 10^{15}$ g C
- Massive increase in atmospheric CO₂ in industrial era
- Estimates of pre-industrial atmospheric CO₂ concentration range from 290 to 250 ppmv
- Concentration of CO₂ at Mauna Loa in 2018 is 406 ppmv



NASA Global atmospheric model: <http://svs.gsfc.nasa.gov/goto?11719>



Other greenhouse gases are important!



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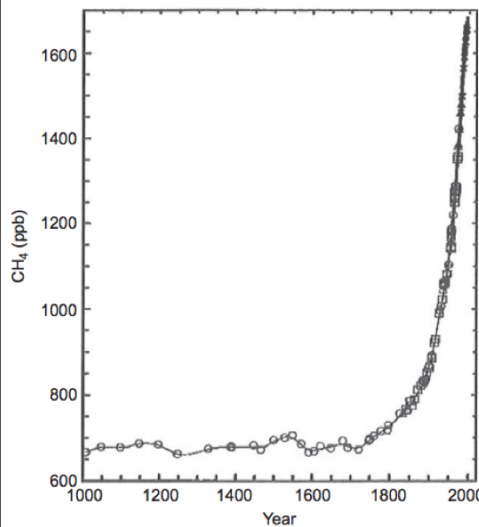


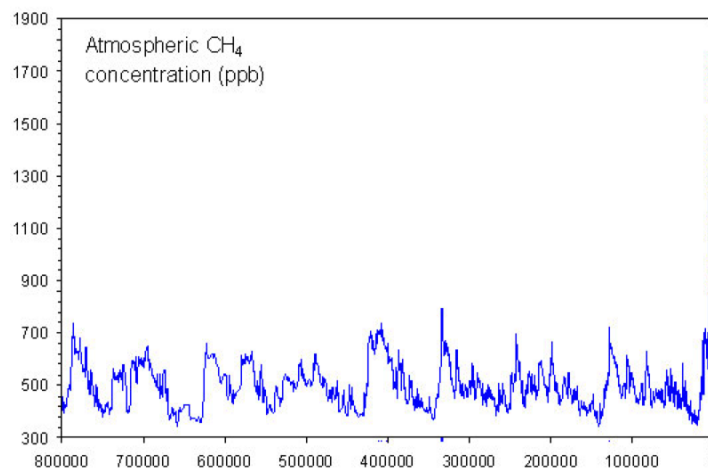
FIGURE 11.6 Concentrations of CH₄ in air extracted from Antarctic ice cores. Source: From Etheridge et al. (1998). Used with permission of the American Geophysical Union.

TABLE 11.2 Estimated Sources and Sinks of Methane in the Atmosphere in 2010

Natural sources	Flux (10 ¹² g CH ₄ /yr)	References
Wetlands	143	Neef et al. 2010
Tropics	46	Bloom et al. 2010
Northern latitude	20	Christensen et al. 1996
Upland vegetation	10 (estimate)	Megorrigal and Guenther 2008; Kirschbaum et al. 2006
Termites	19	Sanderson 1996
Oceans	10	Reeburgh 2007
Geological seepage ^a	33	Etioppe et al. 2008
Anthropogenic sources		
Fossil fuel related		
Coal mines	30	Prather et al. 1995
Coal combustion	15	Prather et al. 1995
Oil and gas	72	Neef et al. 2010
Waste and waste management		
Landfills	18	Bogner and Matthews 2003
Animal waste	25	Prather et al. 1995
Sewage treatment	25	Prather et al. 1995
Ruminants	116	Neef et al. 2010
Reservoirs	70	St. Louis et al. 2000
Biomass burning	19	Kaiser et al. 2012
Rice cultivation	40	Sass and Fisher 1997, Bloom et al. 2010
Total sources	645	
Sinks		
Reaction with OH radicals	522	Neef et al. 2010
Removal in the stratosphere	34	Neef et al. 2010
Removal by soils	25	Curry 2007
Total sinks	581	
Atmospheric increase (2007)	23	Dlugokencky et al. 2009

Note: All data in 10¹² g CH₄/yr from various sources as cited here and in the text.

Microsoft Excel

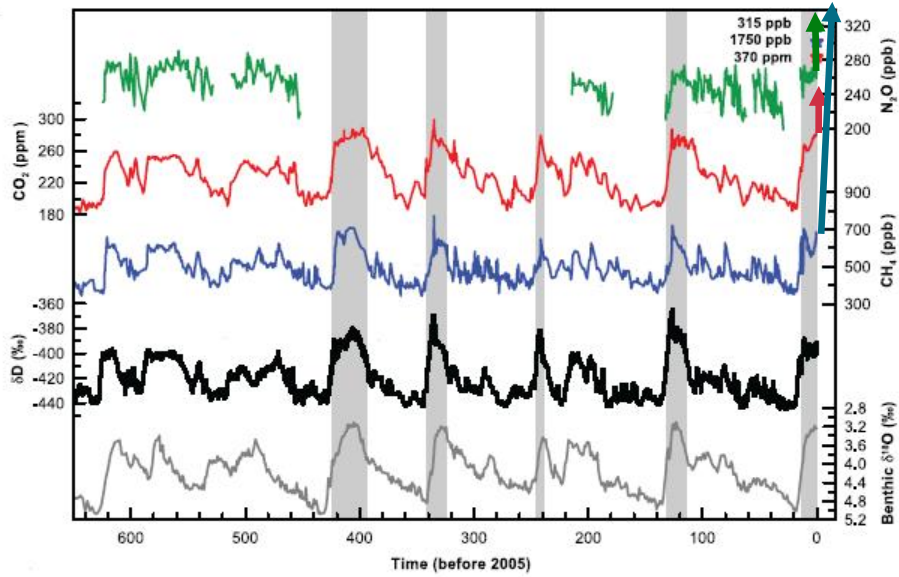


Methane concentrations over the past 800 000 years from ice cores (EPICA Dome C and Law Dome; blue) and Cape Grim Station, Tasmania (red). Time scale is years before present (2009).

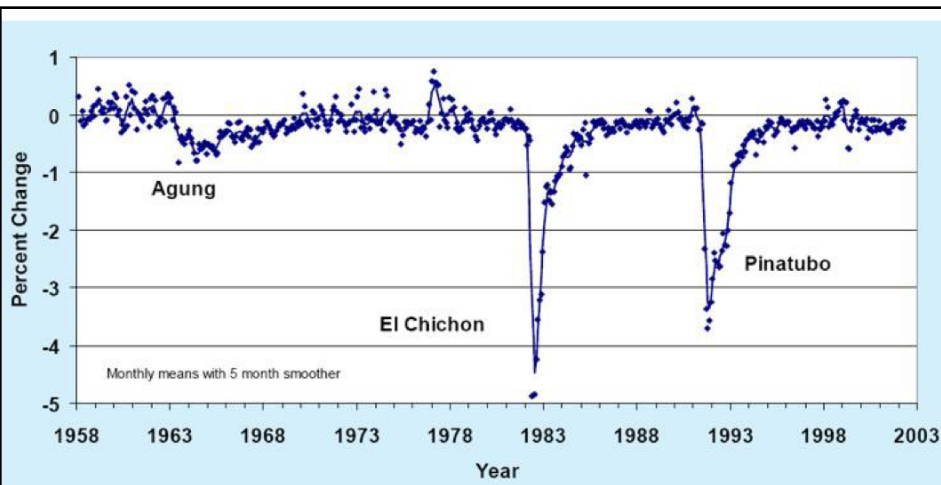
From Louergue, et al. (2008) and MacFarling Meure et al. (2006).

http://www.csiro.au/files/images/pu16.jpg&imgrefurl=http://www.csiro.au/news/Has-Methane-Stabilised--ci_pageNo-2.html&usq=__yPlw78j2S2Q16_a5WtE5S2q48Y=&h=355&w=540&sz=36&hl=en&start=5&um=1&itbs=1&tbnid=1UTherbuczo42M:&tbnh=87&tbnw=132&prev=/images%3Fq%3Dmethane%2Bepica%26um%3D1%26hl%3Den%26tbs%3Disch:1

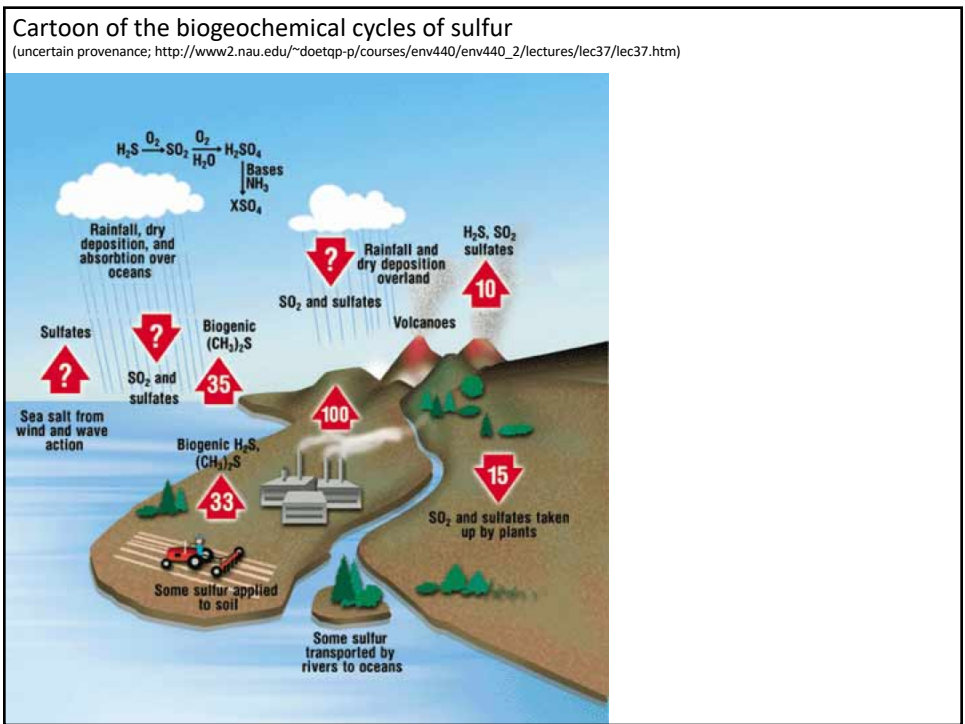
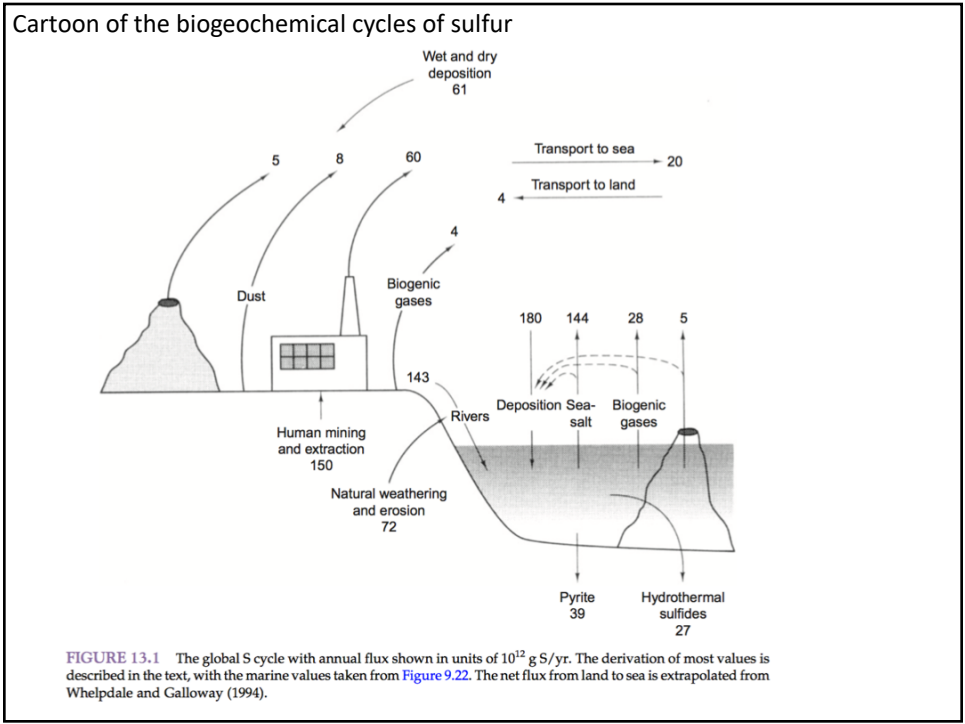
Greenhouse gases vs. climate

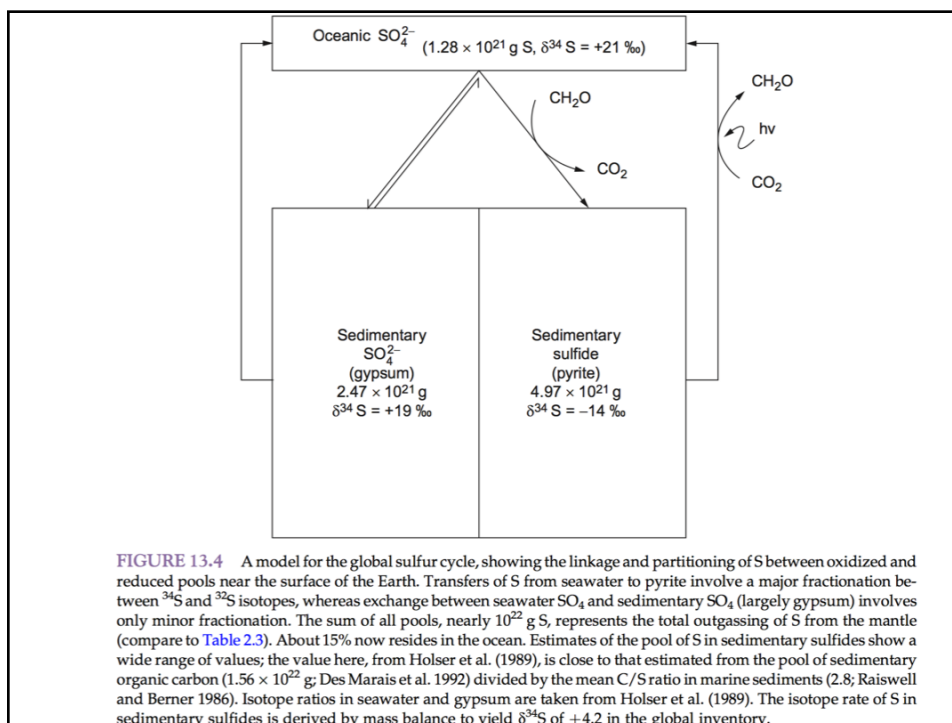
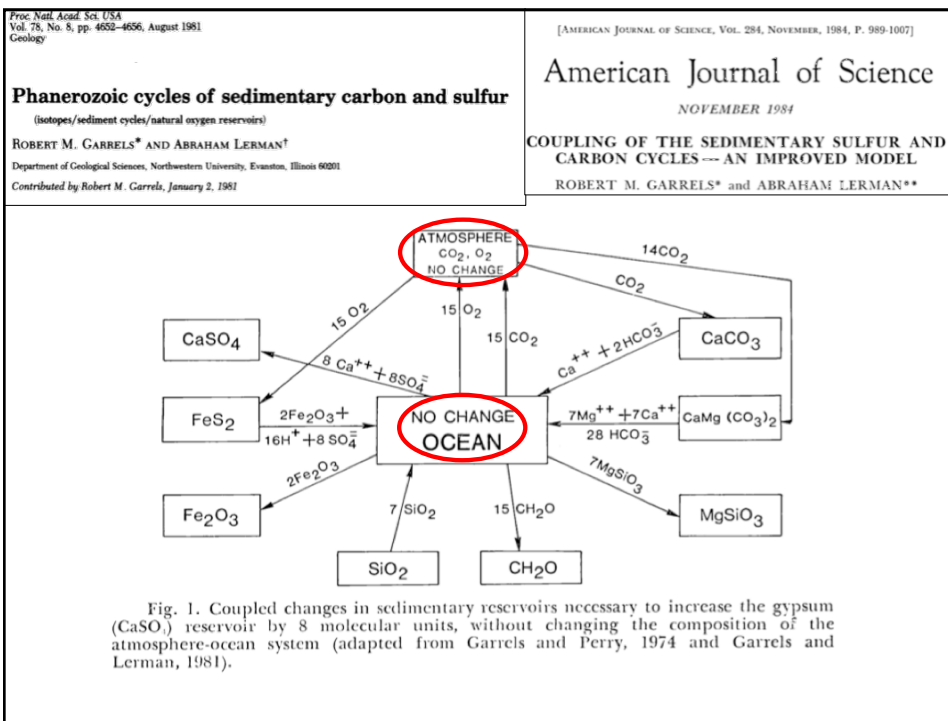


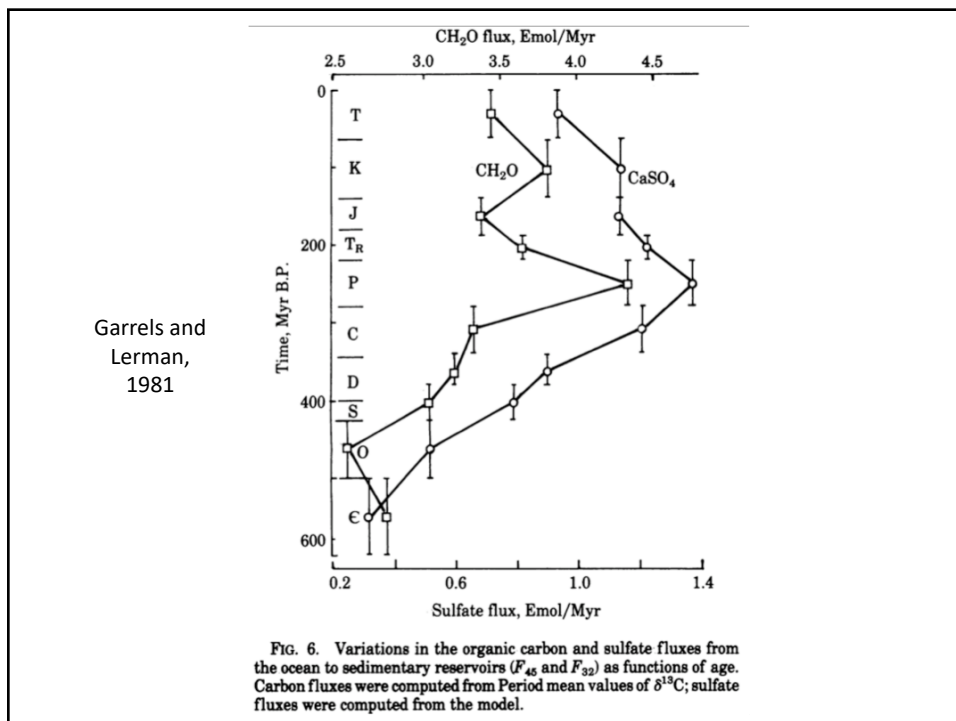
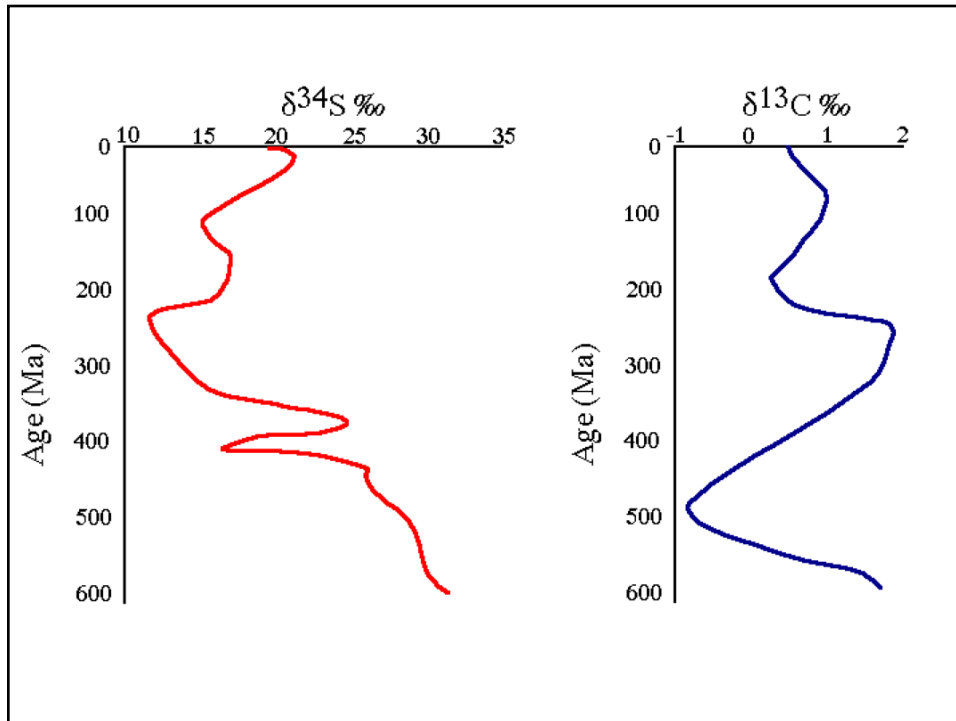
NOAA/IPCC figure, Public Domain, <http://www.ncdc.noaa.gov/paleo/pubs/ipcc2007/fig63.html>



Mauna Loa solar irradiance, http://www.oar.noaa.gov/climate/images/greenhouse_graph.jpg







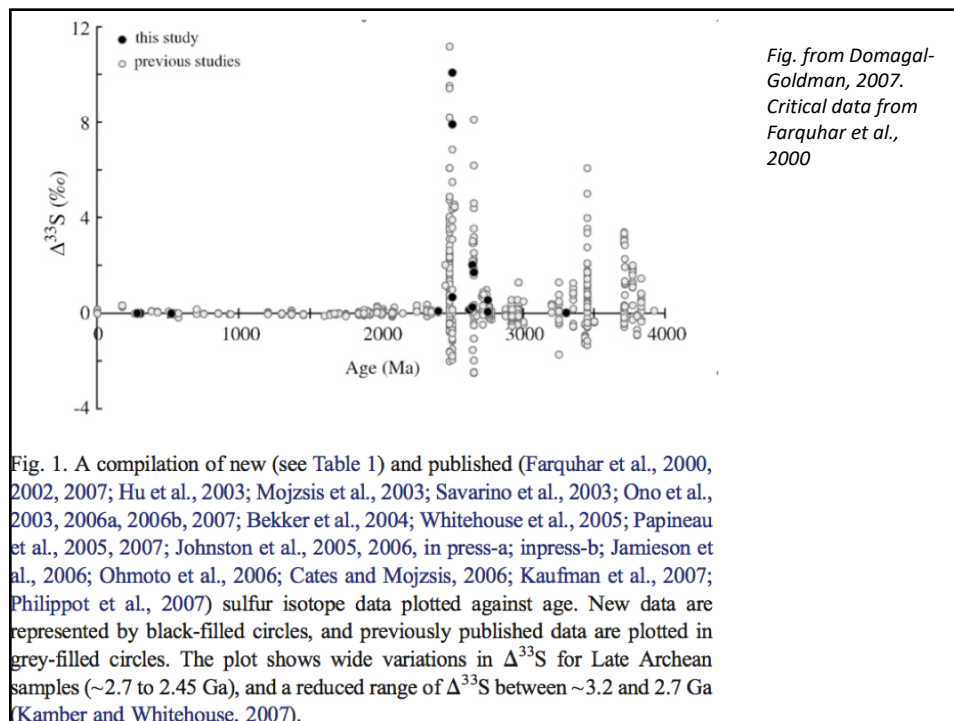
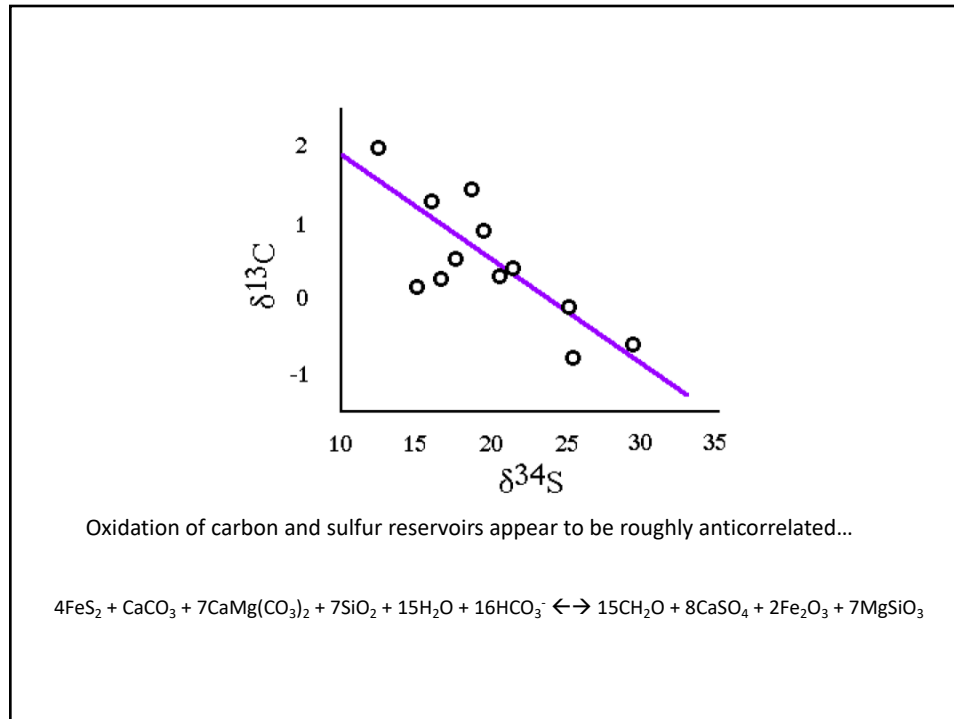


Fig. 1. A compilation of new (see Table 1) and published (Farquhar et al., 2000, 2002, 2007; Hu et al., 2003; Mojzsis et al., 2003; Savarino et al., 2003; Ono et al., 2003, 2006a, 2006b, 2007; Bekker et al., 2004; Whitehouse et al., 2005; Papineau et al., 2005, 2007; Johnston et al., 2005, 2006, in press-a; inpress-b; Jamieson et al., 2006; Ohmoto et al., 2006; Cates and Mojzsis, 2006; Kaufman et al., 2007; Philippot et al., 2007) sulfur isotope data plotted against age. New data are represented by black-filled circles, and previously published data are plotted in grey-filled circles. The plot shows wide variations in $\Delta^{33}\text{S}$ for Late Archean samples (~2.7 to 2.45 Ga), and a reduced range of $\Delta^{33}\text{S}$ between ~3.2 and 2.7 Ga (Kamber and Whitehouse, 2007).