The Sources and Sinks of Carbonyl Sulfide

Sources and sinks of carbonyl sulfide

Source	Rate (Mt/yr)
Open ocean	**+0.10**
Coastal ocean, salt marshes	**+0.20**
Anoxic soils	**+0.02**
Wetlands	**+0.03**
Volcanism	**+0.05**
Precipitation	**+0.13**
DMS oxidation	**+0.17**
Anthropogenic CS2 oxidation	**+0.21**
Natural CS2 oxidation	**+0.21**
Biomass burning	**+0.07**
Anthropogenic production	**+0.12**
Oxic soils	**-0.92**
Vegetation	**-0.56**
Reactions with OH	**-0.24**
Reactions with oxygen	**-0.02**
Photodissociation	**-0.05**

The important source of aerosols in the stratosphere (altitude from 11 to 50 km) is the formation of carbonyl sulfide (COS) droplets. Although volcanism injects millions of tons of SO_2 into the atmosphere every few years, scientists have found that during other times, COS is by far the biggest source of sulfur compounds in the stratosphere, leading to the production of sulphuric acid aerosols. Just 1 kilogram of COS is over 720 times more damaging than the same amount of carbon dioxide in altering global climate.

The table to the left gives the known sources and sinks of COS in terms of millions of tons per year (Mt/yr).

Problem 1 - In the table, sources of COS are indicated by positive rates, and systems that remove COS from the atmosphere, called sinks, are indicated by negative rates. What are the total rates for the sources and sinks, and what is the net change in atmospheric COS in megatons/year?

Problem 2 – What percentage of the sources for COS are related to human activity (anthropogenic) according to the data?

Problem 3 – 6.0×10^{23} molecules of COS has a mass of 60 grams, and 1 year equals 3.1×10^{7} seconds. What is the net change each year in the number of COS molecules in one cubic meter of the atmosphere if the volume of the atmosphere is about 4.23 billion cubic kilometers?

COS data from 'The role of carbonyl sulphide as a source of stratospheric sulphate aerosol and its impact on climate', C. Br¨uhl, J. Lelieveld, P. J. Crutzen, and H. Tost Journal of Atmospheric Chemistry and Physics, v.12, pp. 1239–1253, 2012 www.atmos-chem-phys.net/12/1239/2012/doi:10.5194/acp-12-1239-2012

Problem 1 - In the table, sources of COS are indicated by positive rates, and systems that remove COS from the atmosphere, called sinks, are indicated by negative rates. What are the total rates for the sources and sinks, and what is the net change in atmospheric COS in megatons/year?

Answer: **Total sources = +1.31 Mt/yr. Total sinks = -1.79 Mt/yr. The net change is the sum of the sources and sinks, or -0.48 Mt/yr**. This means that COS is being reduced in concentration each year at the current known rates.

Problem 2 – What percentage of the sources for COS are related to human activity (anthropogenic) according to the data?

Answer: Anthropogenic CS2 oxidation from wood burned in stoves, and direct production of this compound account for +0.21 and +0.12 Mt/year or a total of +0.33 Mt/yr. The total production is +1.31 Mt/yr, so anthropogenic sources are 100% x (0.33/1.31) = **25% of all sources.**

Problem 3 – 6.0×10^{23} molecules of COS has a mass of 60 grams, and 1 year equals 3.1×10^{7} seconds. What is the net change each year in the number of COS molecules in one cubic meter of the atmosphere if the volume of the atmosphere is about 4.23 billion cubic kilometers?

Answer: From Problem 1, the net change is a reduction by 0.48 Mt/yr.

Net reduction in tons = 480,000 tons / year x (1 year) = 480,000 tons.
Number of molecules:

$$480{,}000 \text{ tons} \times \frac{1000 \text{ kilograms}}{1 \text{ ton}} \times \frac{1000 \text{ grams}}{1 \text{ kilogram}} \times \frac{6.0\times10^{23} \text{ molecules}}{60 \text{ grams}} = 4.8\times10^{33} \text{ molecules}$$

Volume of atmosphere in cubic meters

$$= 4.23\times10^{9} \text{ km}^3 \times \frac{1.0\times10^{9} \text{ m}^3}{1 \text{ km}^3} = 4.23 \times 10^{18} \text{ m}^3$$

So: $4.8\times10^{33}/4.23\times10^{18} \text{ m}^3$ = **1.1×10^{15} molecules <u>removed</u> each year.**