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The World's Largest Experiment Manipulating Solar Energy Input To Earth Resumed In 2003

Peter L. Ward

US Geological Survey, retired

Teton Tectonics, Jackson, WY

peward@wyoming.com

Cell phone: 307-413-4055

Two inflection points in SO_2 emissions

1. Emissions of SO_2 by humans burning fossil fuels rose rapidly until **1979** when efforts to reduce acid rain led to a 22% decrease by **2002**.

2. Rapid development in China and India caused SO_2 emissions to rise again beginning in **2003**.

These two inflection points in SO_2 emissions (1979 and 2003) are well observed in many aspects of climate change during the past eight decades.

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A. Temperatures in the northern and southern hemispheres increased rapidly as SO_2 emissions increased, but the rate of increase approached zero by 1998 as SO_2 emissions decreased. By 2010, the hottest year on record, temperature appears to be increasing again.

B. The rate of increase in methane decreased to zero by 2002 as SO_2 emissions decreased but began increasing again in 2007. SO_2 and methane are primarily oxidized by OH, formed from O_3 by UV radiation at wavelengths <0.34 µm. But O_3 and OH are in limited supply in the troposphere and SO_2 reacts with OH more quickly.

C. Global dimming (SSR) increased rapidly in Europe when SO_2 emissions were greatest and reduced as SO_2 emissions decreased. Much more intense regional dimming was well observed when tropospheric concentrations of SO_2 were particularly high following the Laki eruption in 1783.

D. Tree ring density and thickness normally increase with temperature, but since the 1940s these measures have diverged in northern forests. SO_2 is well-known to stress and even kill trees. When anthropogenic SO_2 levels began to decline in the early 1980s, wide-spread greening in northern regions was observed from satellites.

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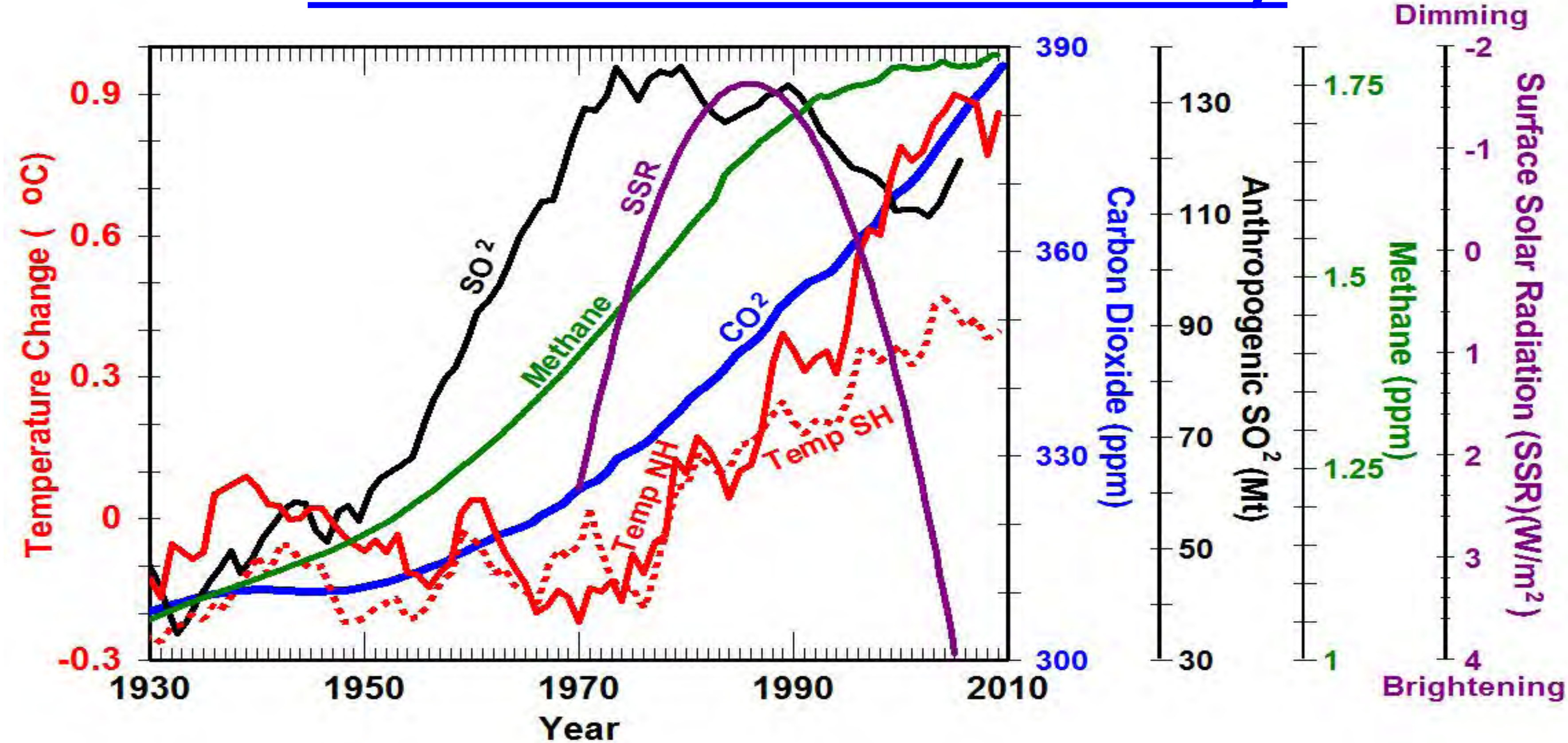
Meanwhile smoothed annual concentrations of CO_2 continue to increase monotonically.



Temporal delay between SO_2 and temperature is most likely the time it takes to warm the ocean. Temporal delay between SO_2 and methane is most likely related to reaching a critical balance in OH availability.

Annual SO_2 emissions (Smith et al., 2010). Methane (Etheridge et al., 1998; Dlugokencky et al., 2009). Mean temperature (HadCRUT3) smoothed 5 year running mean tapered. Surface solar radiation in Europe (Makowski et al., 2009). Annual CO_2 (Keeling et al., Mauna Loa; Etheridge et al., 1998) smoothed 20 year running mean, tapered.

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But how can parts per billion of SO_2 warm the lower troposphere more than 388 parts per million of CO_2?

After all, stratospheric SO_2 cools the atmosphere!

Because SO_2 absorbs strongly the highest energy ultraviolet radiation that reaches the earth's surface.

Because there is a lot more energy in the ultraviolet than in the infrared.

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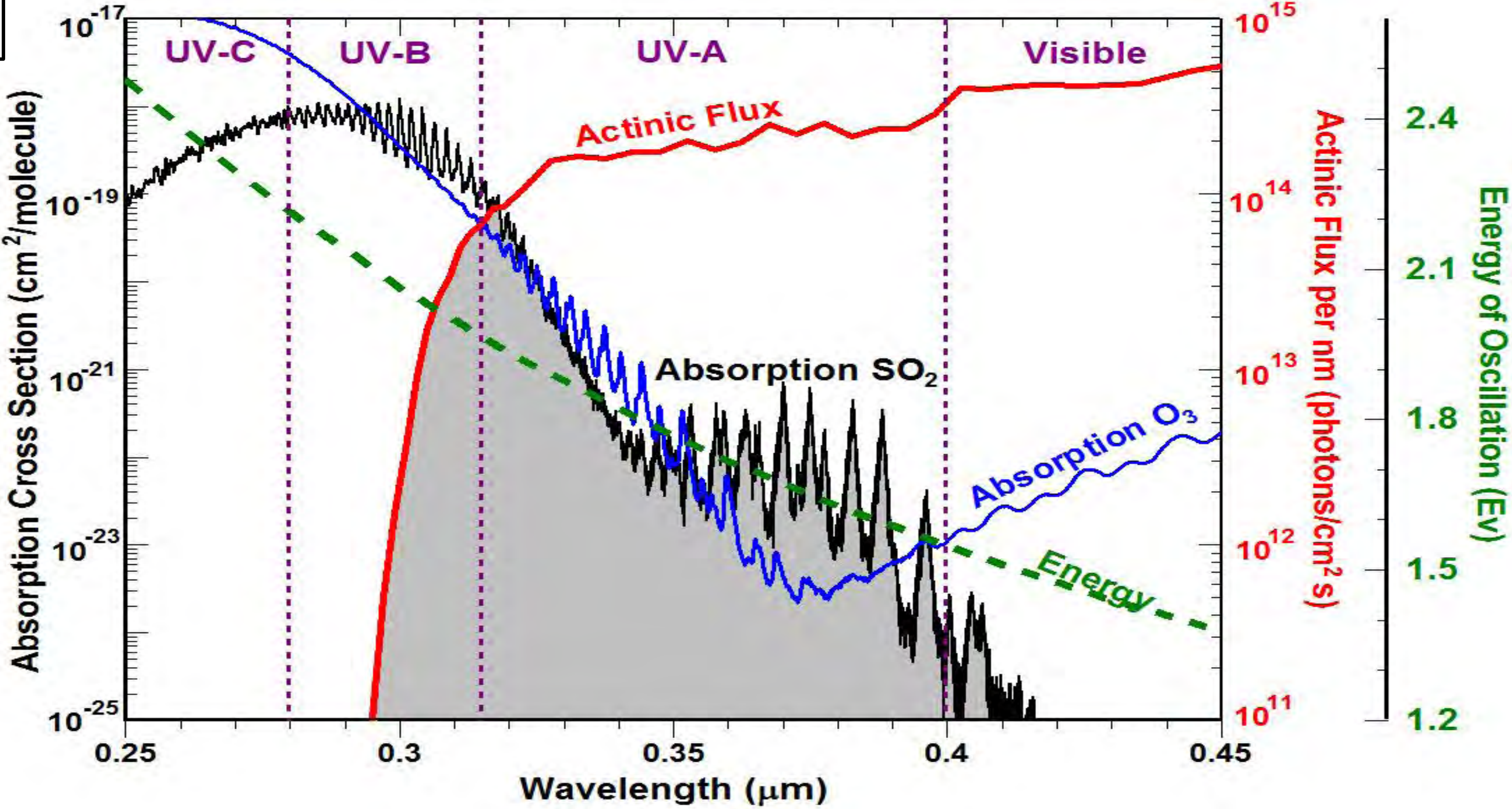

Actinic flux is the quantity of solar EMR available at the surface of the earth to drive photochemical processes . (Madronich in Finlayson-Pitts and Pitts, 1999)

Minimum energy of oscillation in a photon based on Planck's postulate E=hν

Absorption by SO_2 (Vandaele et al., 2009)

Absorption by O_3 (Rothman et al., 2009)

Specifically

1. Ultraviolet frequencies of oscillation are ~50 times higher than in the infrared, involving ~50 times more energy.
2. The minimum absorbable energy of oscillation is ~50 times greater per unit frequency in the ultraviolet than in the infrared.
3. Rotovibronic coupling in the ultraviolet significantly increases the amount of oscillatory energy absorbed through rotational and vibrational transitions.
4. The absorption cross section is along a continuum in the ultraviolet but occurs only in discrete spectral lines in the infrared.
5. Solar irradiance seen by gas molecules in the atmosphere during the day is 3.4-4.0 times larger than infrared irradiance from the earth.

6. **Fluorescence and Rayleigh scattering diffuse ultraviolet EMR, keeping more energy in the atmosphere to be re-absorbed.**
7. **Most solar-ultraviolet-energy-absorbing gases have permanent electric dipoles enhancing interaction with EMR, while important greenhouse gases such as CO_2 and methane do not.**
8. **A greater percent of the energy absorbed by gases in the lower troposphere is converted to increased temperature because of the higher rates of molecule collisions.**

Calculating the precise difference in absorptive heating in the ultraviolet versus the infrared requires many assumptions; it would be far more reliable to measure the difference in the laboratory.

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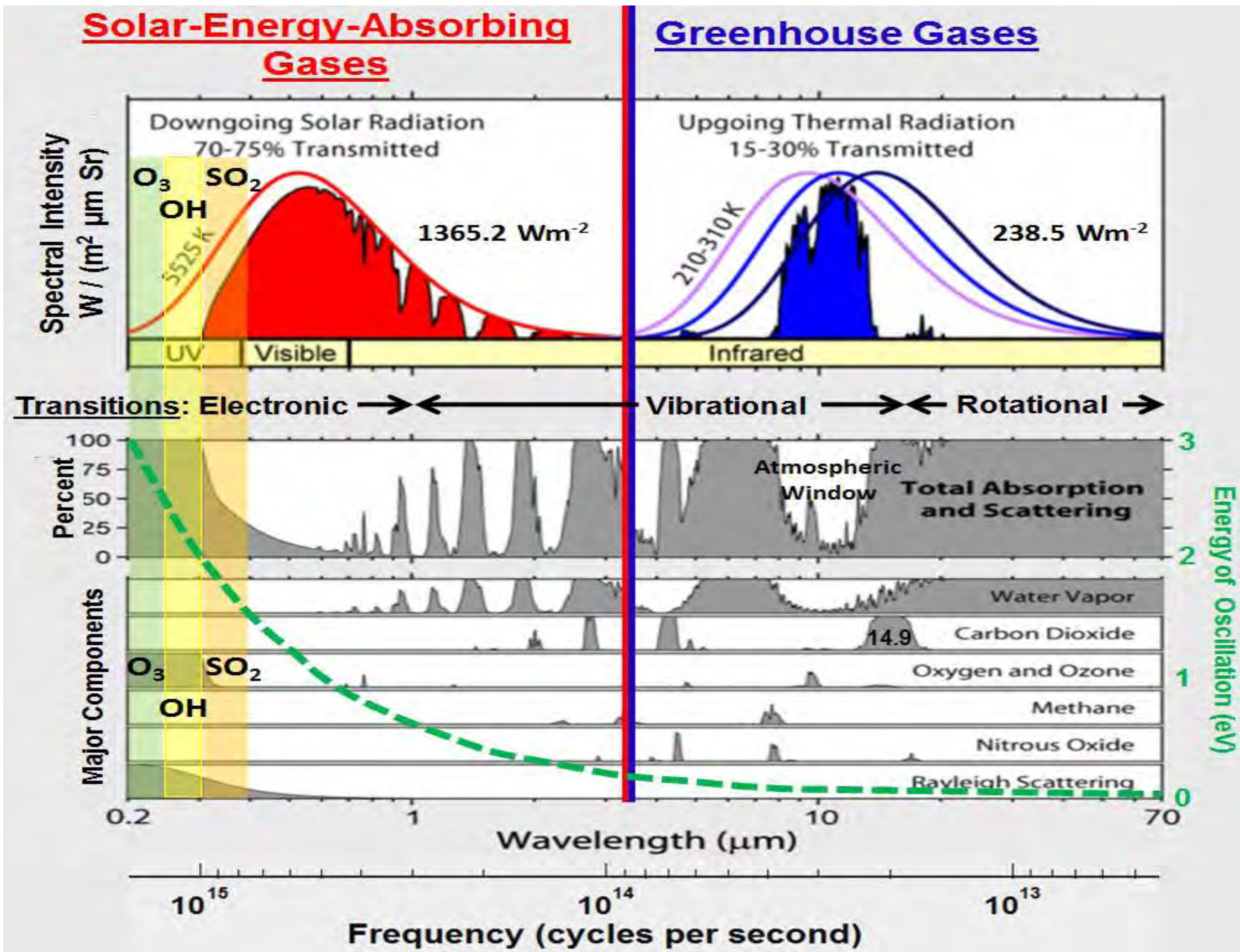
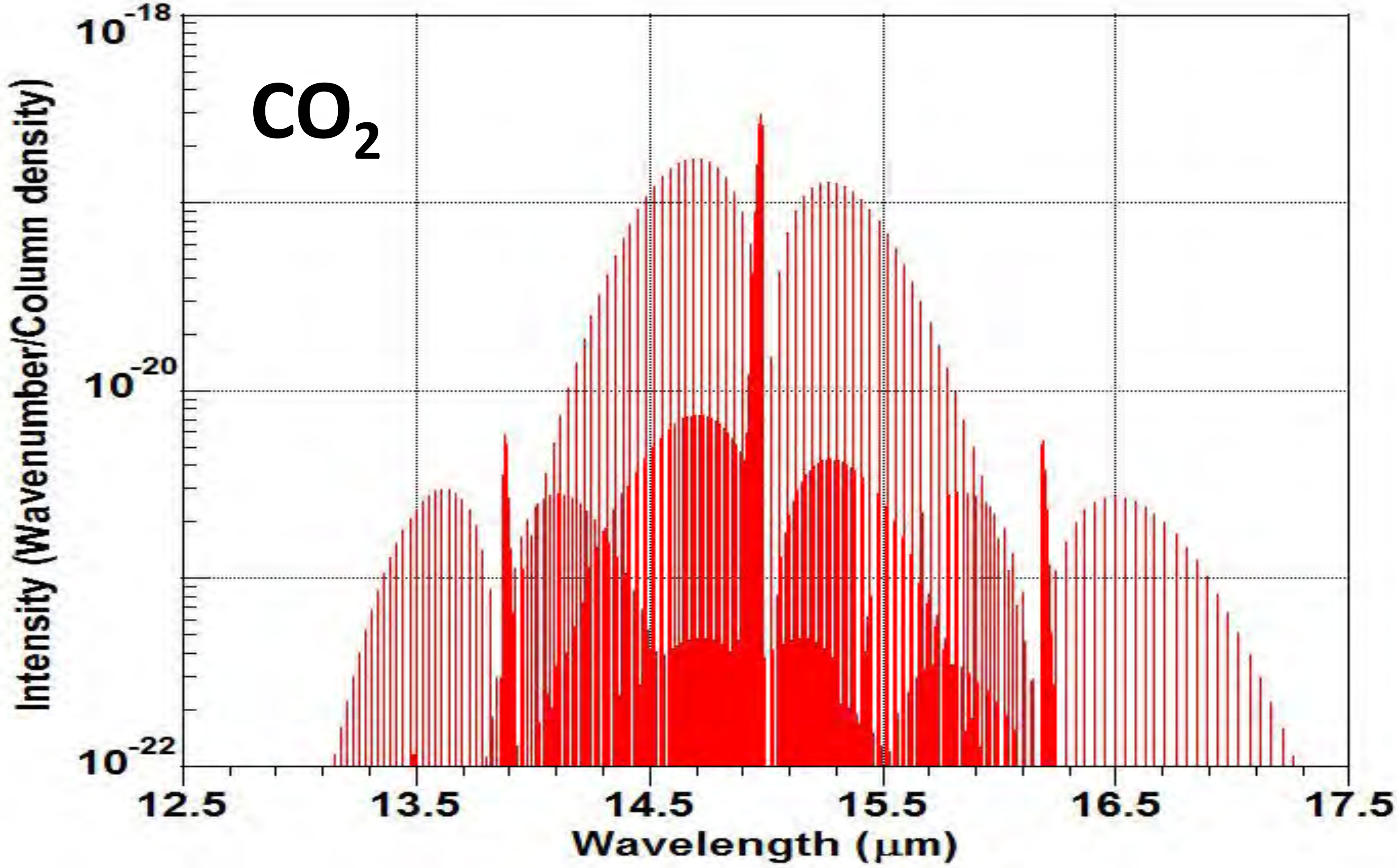
SO_2 in the troposphere absorbs the highest energy solar ultraviolet radiation available after higher energy UV forms O_3 from O_2 and OH from O_3



Base plot by Rohde, wikipedia

SO_2 absorbs at every frequency on a continuum

CO_2 absorbs only along discrete spectral lines



HITRAN, Rothman et al. 2009

Proving the importance of SO_2

The greatest need is for experimental studies that measure and contrast the actual heat generated by the absorption of ultraviolet and infrared radiant energy by SO_2, H_2O, and CO_2 under lower tropospheric conditions.

A second need is for simultaneous measurements of solar energy attenuation at different levels in the troposphere downwind from the most polluted air in China and India.

12 The importance of molecular collisions

Kirchhoff's law states that a blackbody at thermal equilibrium emits the same energy as it absorbs implying that gas molecules might diffuse electro-magnetic radiation rather than be heated by it.

But molecular collisions cause much of the absorbed energy to be converted to kinetic energy of all gas molecules and thus to increased temperature. The rate of collisions is greatest in the lowermost troposphere.

The efficiency of conversion also depends on the quantum properties of rotational, vibrational, and electronic transitions.

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The world's largest geoengineering experiment manipulating solar energy

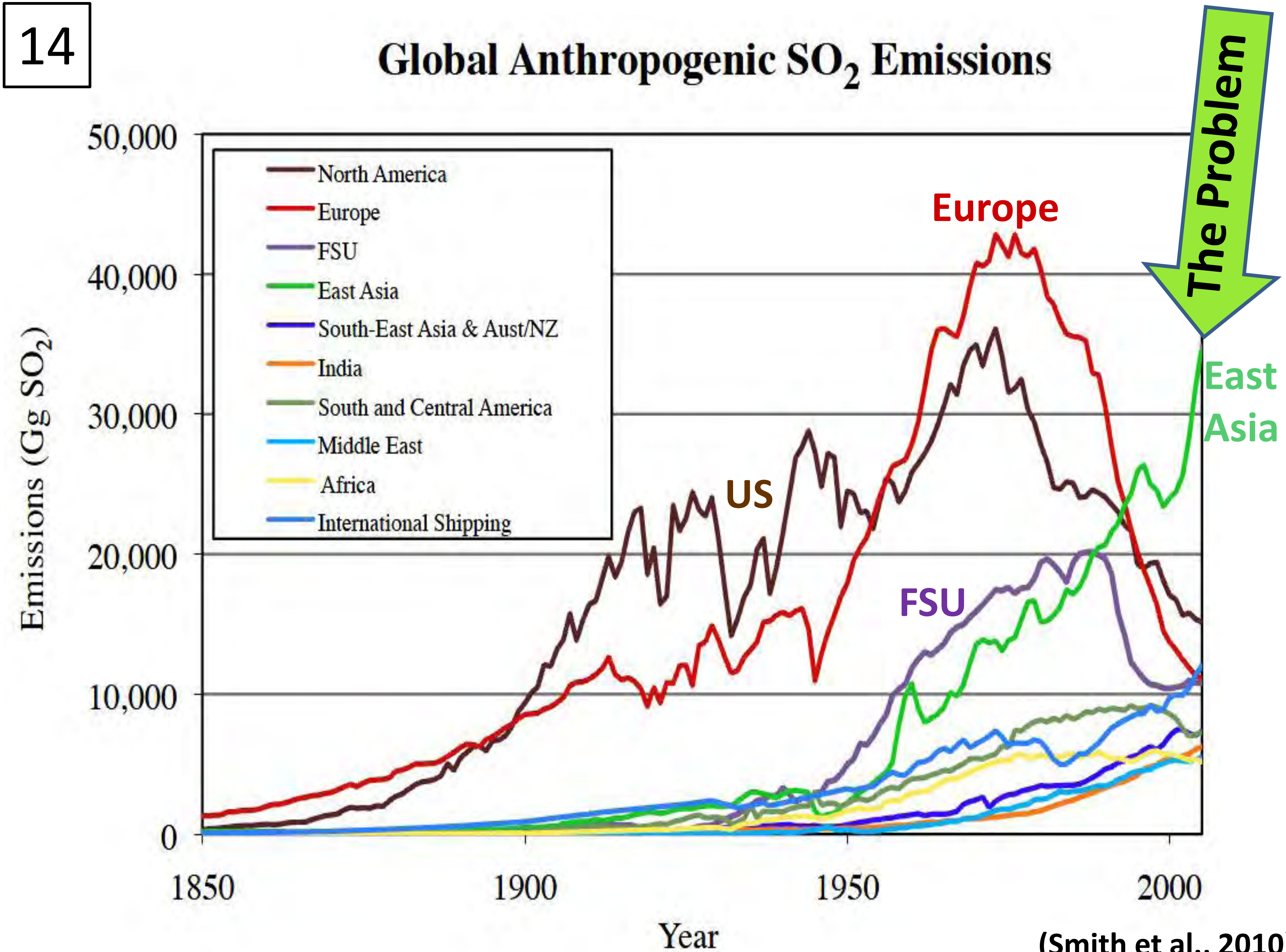
A. Global emissions of SO_2 began increasing again in 2003.

B. 2010 appears to be the hottest year on record.

C. Methane concentrations began rising again in 2007.

D. Is global dimming increasing, especially in East Asia?

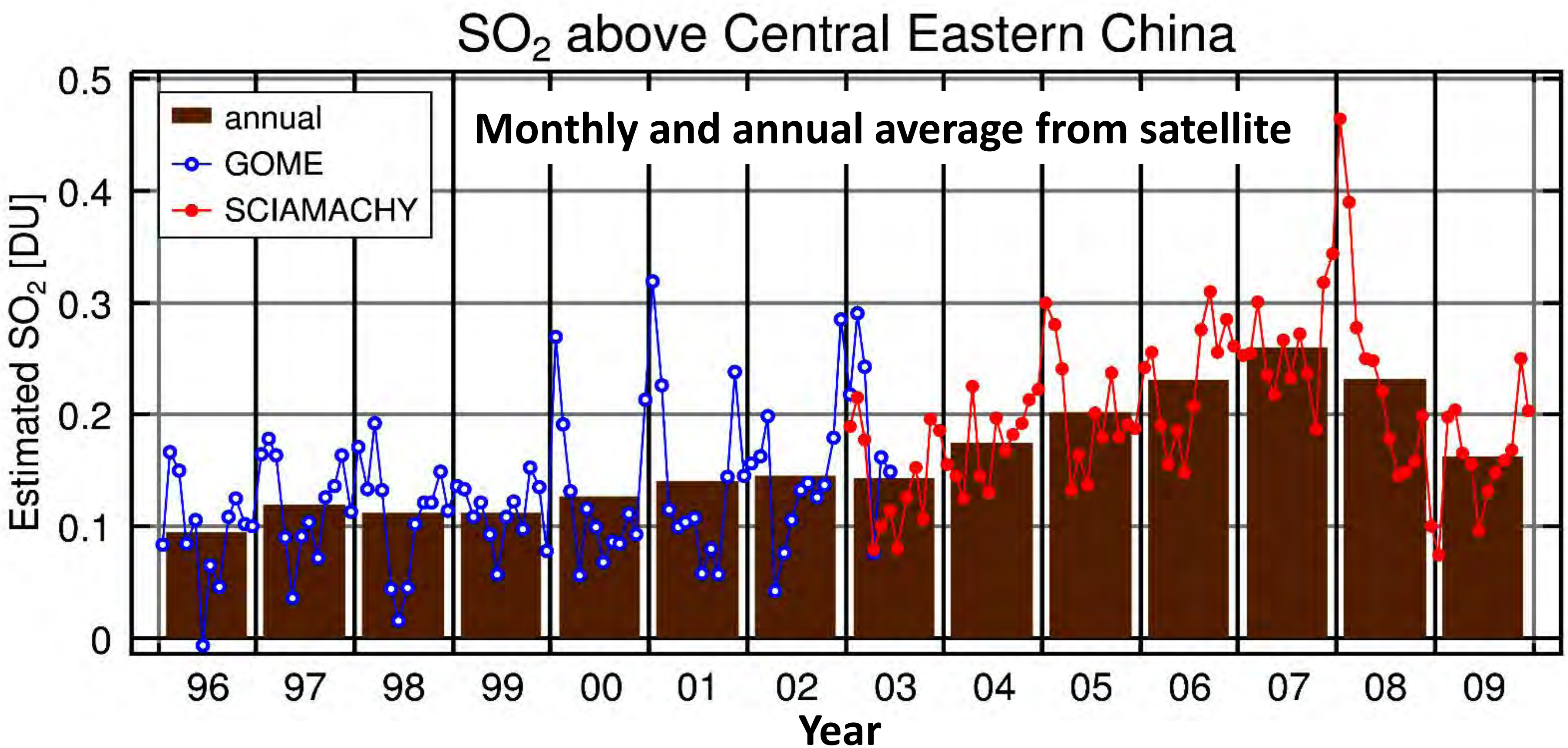
If we decrease SO_2 emissions, will temperature and methane level off again?



(Smith et al., 2010)

There is hope

An aggressive cap and trade program in China led to reduced SO_2 emissions beginning in 2008



(Gottwald et al., 2010 from Smith et al., 2010)

This paper is nearly ready for submission.

If you would be willing to provide a review, please contact me immediately.

peward@wyoming.com

The Primary Role of Solar-Ultraviolet-Energy-Absorbing Gases In Global Warming

Peter L. Ward

Abstract

Less than 8 ppmv ozone and related exothermic photochemical reactions absorb sufficient solar ultraviolet energy (SUVE) to maintain the temperature of the stratosphere as much as 50^{o}C above the temperature at the tropopause. While SUVE readily oxidizes stratospheric sulfur dioxide (SO_2) to form an aerosol that reflects sunlight and cools the earth, tropospheric SO_2 absorbs slightly less energetic, non-oxidant-forming SUVE to cause increases in temperature. SO_2 absorbs up to 100 times more strongly than ozone throughout much of the most energetic band of SUVE reaching the surface of the earth (0.3-0.4 µm), a band containing 10.3% of solar irradiance. Solar irradiance is 3.4-4.0 times greater on a gas molecule in the atmosphere during the daytime than irradiance from the earth causing more intense absorption. An photon of SUVE contains ~50 times more oscillatory energy than a photon of infrared absorbed by greenhouse gases. SO_2 absorbs many more photons over a continuum than greenhouse gases absorb over distinct spectral lines.

Increases, decreases, and recent increases again in anthropogenic SO_2 emissions during the past century are contemporaneous with major changes in temperature, methane concentrations, global dimming, Arctic warming, acid rain, and tree-ring growth. Between 46,000 and 10,000 years BP, the 14 largest prolonged increases in volcanic sulfate measured in Greenland ice are contemporaneous with the 14 known abrupt global warmings.

The warming effects of SO_2 should be verifiable experimentally and imply that we can reduce global warming economically using existing technology.