Atmospheric Brown Clouds

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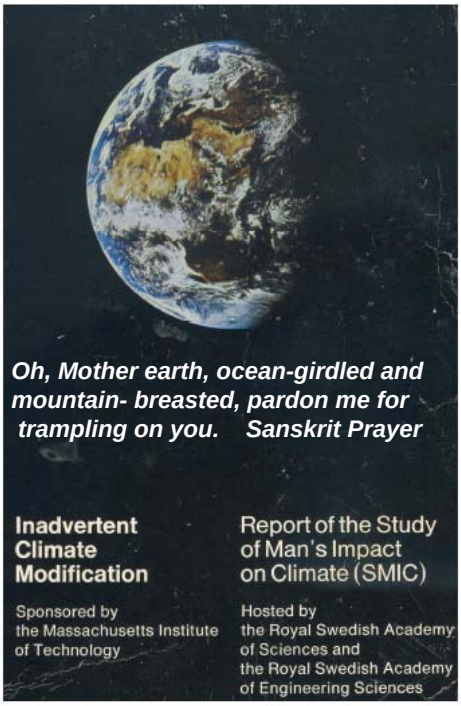
Univ of California at San Diego

INTERNATIONAL FEDERATION OF ENVIRONMENTAL JOURNALISTS (IFEJ) CONGRESS

India Habitat Centre, New Delhi, October 28-30, 2009



Reprinted from
3 October 1975, Volume 190, pp. 50-52

SCIENCE

1975

Greenhouse Effect Due to Chlorofluorocarbons: Climatic Implications

V. Ramanathan

Abstract. ***The infrared bands of chlorofluorocarbons and chlorocarbons enhance the atmospheric greenhouse effect. This enhancement may lead to an appreciable increase in the global surface temperature if the atmospheric concentrations of these compounds reach values of the order of 2 parts per billion.***

One molecule of CFC has the same greenhouse effect as the addition of more than 10000 molecules of Carbon Dioxide to the Atmosphere

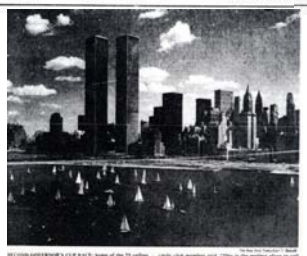
"All the News That's Fit to Print"

The New York Times

LATE CITY EDITION
Weather: Sunny, pleasant today; clear tonight. Sunny tomorrow. Temperature range: today 51-72, Saturday 52-71. Details on Page 55.

SECTION ONE

VOL. CXXIV . No. 42,967 NEW YORK, SUNDAY, SEPTEMBER 14, 1975 60 CENTS



U.S. PUTS OFF CUT IN SUPPORT FORCE IN WEST GERMANY

Concern Over a Weakening of Central Power Brings Shift on Trimming 'Fat'

U.F.T. Weighs Board Plan To Trim Class Schedules

Reduction of Two Periods Each Week Linked to Dropping of Two Periods of Preparation Time for Teachers

M.A.C. ARRANGES $100-MILLION SALE OF BOND PACKAGE

Buyers Are Savings Banks and Insurance Companies —Deal Crucial for City

PURCHASERS NOT NAMED

Three in Congress Challenge Constitutionality of New Fiscal Control Board

Climatic Changes by Aerosols in Atmosphere Feared

By WALTER SULLIVAN

Although attention in the debate regarding the role of fluorocarbon aerosol sprays has hitherto focused on public health questions, it has now been proposed that they could alter world climates.

According to calculations by Dr. Veerabhadran Ramanathan of the National Aeronautics and Space Administration's Langley Research Center in Hampton, Va., fluorocarbons in the atmosphere could have a greenhouse effect" similar to that caused by carbon dioxide.

Such an effect occurs when a gas, acting like the glass in a greenhouse, permits sunlight to pass freely, but inhibits the escape of heat in the form of infrared radiation. The result is a warming of the lower atmosphere and the earth.

It is an extreme greenhouse effect that is believed to account for the oven-hot temperature of Venus, whose atmosphere consists of a heavy blanket of carbon dioxide.

Dr. Ramanathan's warning, based on calculations to be published shortly in the journal Science, coincides with a growing number of stratospheric observations that bear on the controversy.

According to the experimenters, these suggest—but do not prove—that fluorocarbons in the stratosphere have been broken down into chlorine, which can then act to deplete the ozone of that region. The public health concern relates to the role of ozone in absorbing wavelengths of ultraviolet sunlight that otherwise cause skin cancer and other injury to earth-borne life. Dr. Ramanathan's calculations suggest the possibility of climatic effects far less dramatic than those on Venus, but nevertheless of major importance to mankind. If, he suggests, fluorocarbons reach a level of two parts per billion in the atmosphere, as predicted for the end of this century if present usage continues, global

Continued on Page 36, Column 4

15 August 1980, Volume 209, Number 4458 SCIENCE *1980*

Detecting Climate Change due to Increasing Carbon Dioxide

Roland A. Madden and V. Ramanathan

The possible climatic effects of large increases in atmospheric CO_2 due to burning of fossil fuels may constitute one of the important environmental problems of the coming decades. Research efforts are being made to reduce the large uncer-

We first discuss a long time series of surface temperatures and the rationale on which our estimates of the inherent variability or noise are based. Next we present the model results for surface warming due to the CO_2 increase. By

Summary. The observed interannual variability of temperature at 60°N has been investigated. The results indicate that the surface warming due to increased carbon dioxide which is predicted by three-dimensional climate models should be detectable now. It is not, possibly because the predicted warming is being delayed more than a decade by ocean thermal inertia, or because there is a compensating cooling due to other factors. Further consideration of the uncertainties in model predictions and of the likely delays introduced by ocean thermal inertia extends the range of time for the detection of warming, if it occurs, to the year 2000. The effects of increasing carbon dioxide should be looked for in several variables simultaneously in order to minimize the ambiguities that could result from unrecognized compensating cooling.

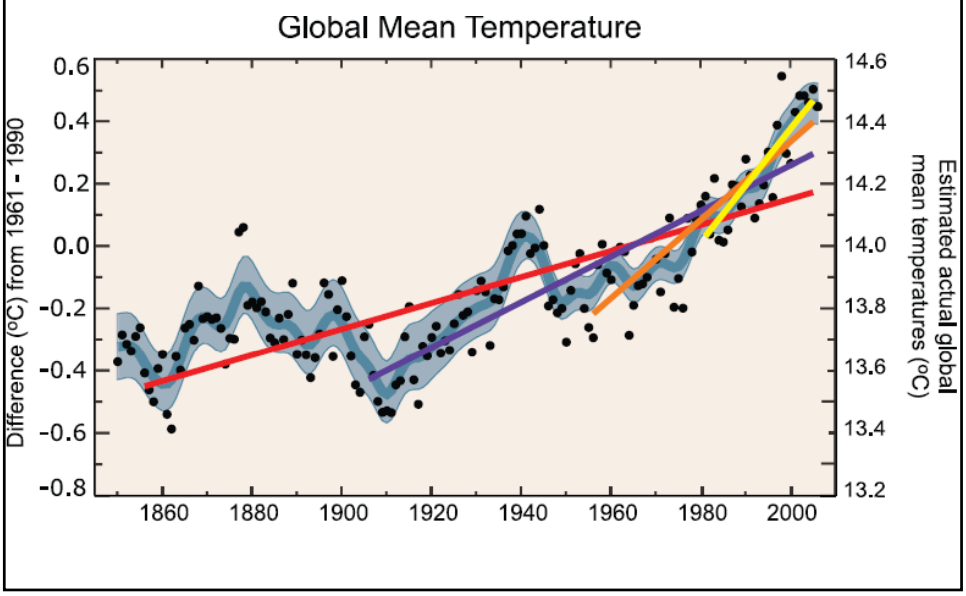
The Greenhouse Theory of Climate Change: A Test by an Inadvertent Global Experiment

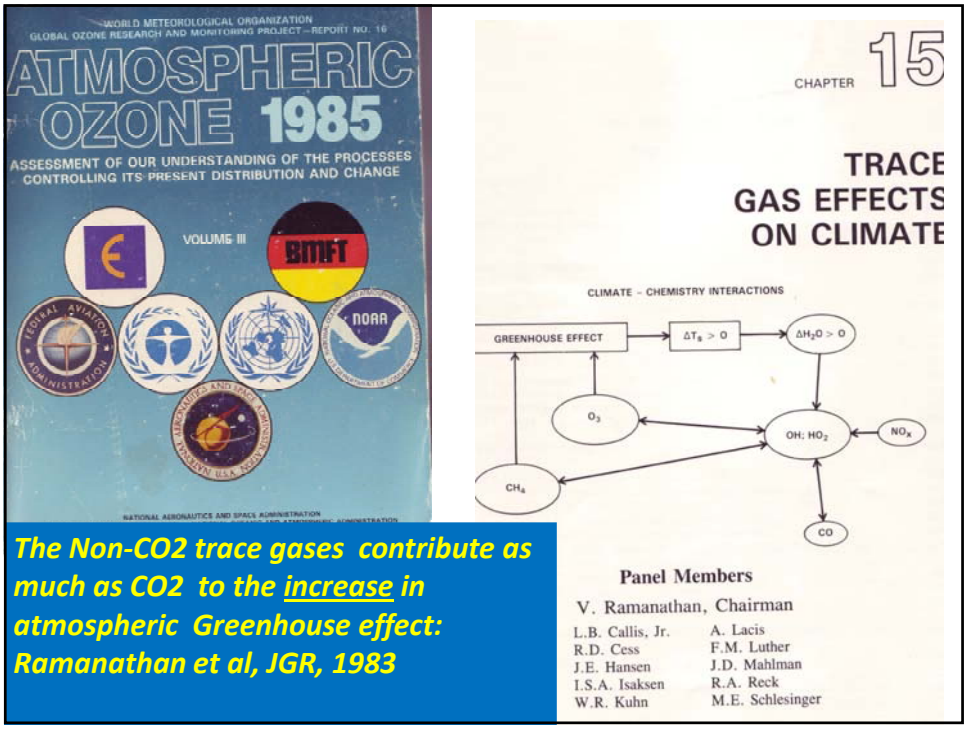
V. Ramanathan

Science
15 APRIL 1988

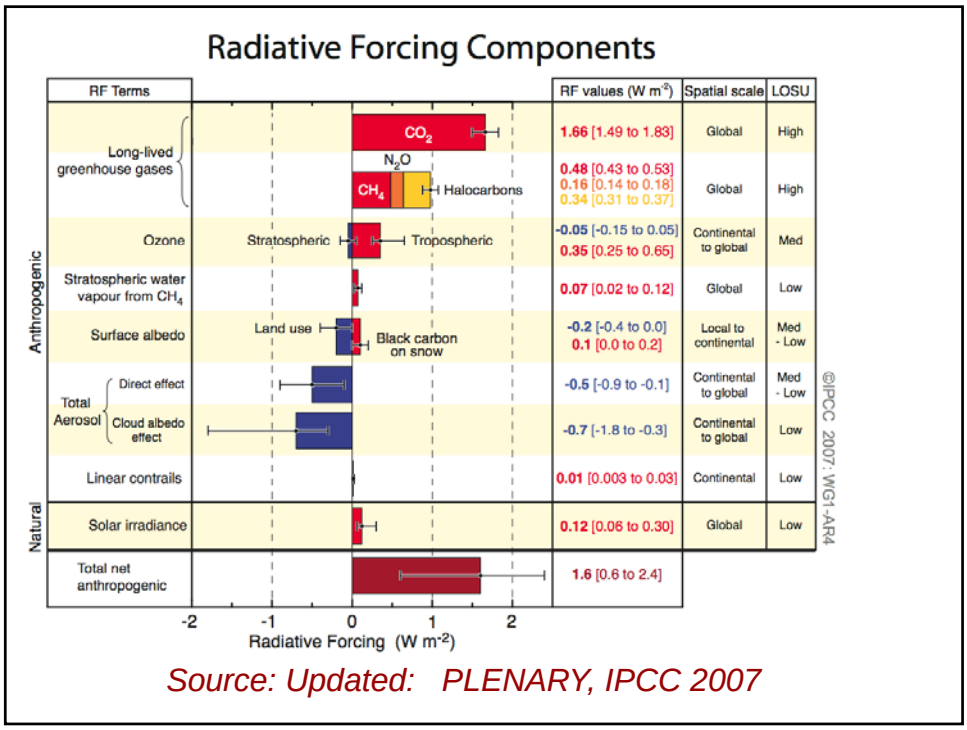
Since the dawn of the industrial era, the atmospheric concentrations of several radiatively active gases have been increasing as a result of human activities. The radiative heating from this inadvertent experiment has driven the climate system out of equilibrium with the incoming solar energy. According to the greenhouse theory of climate change, the climate system will be restored to equilibrium by a warming of the surface-troposphere system and a cooling of the stratosphere. The predicted changes, during the next few decades, could far exceed natural climate variations in historical times. Hence, the greenhouse theory of climate change has reached the crucial stage of verification. Surface warming as large as that predicted by models would be unprecedented during an interglacial period such as the present. The theory, its scope for verification, and the emerging complexities of the climate feedback mechanisms are discussed.

"Unequivocal" Warming of the Planet: IPCC, 2001 & 2007

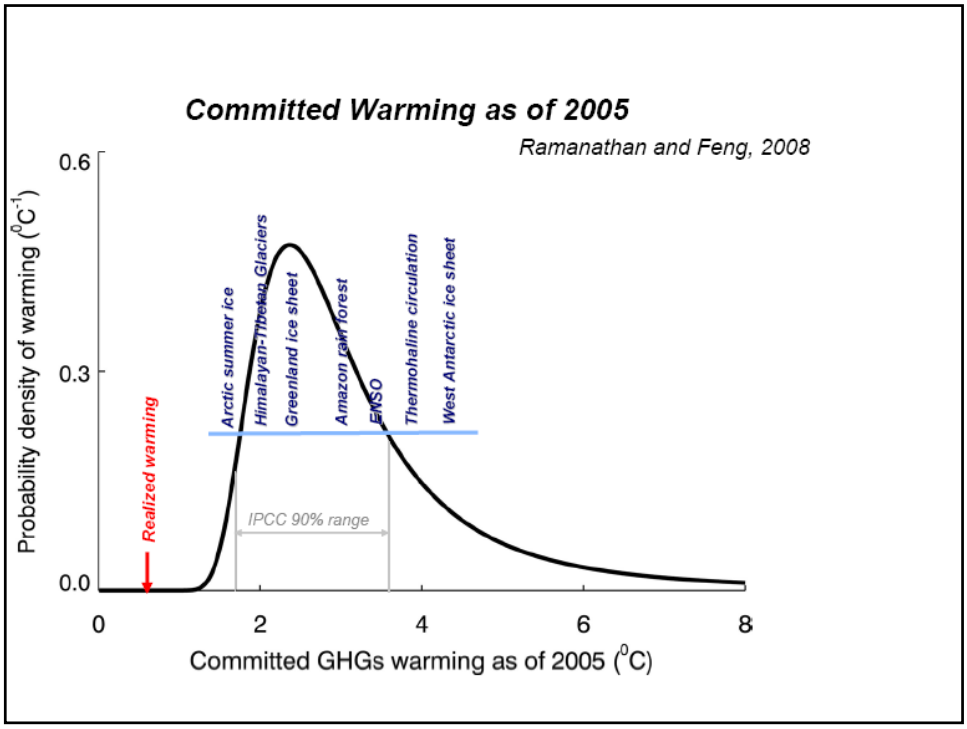




The Non-CO2 trace gases contribute as much as CO2 to the increase in atmospheric Greenhouse effect: Ramanathan et al, JGR, 1983

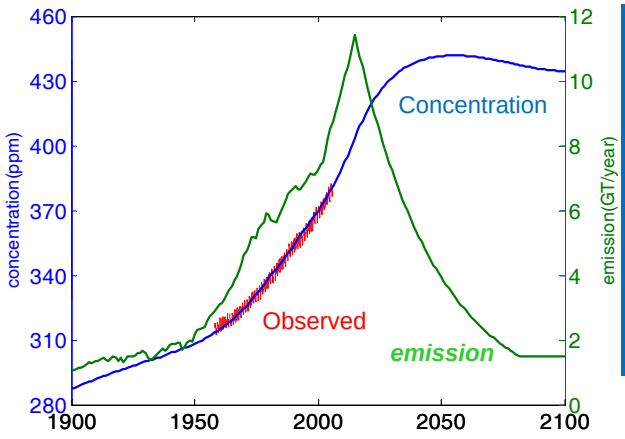


Source: Updated: PLENARY, IPCC 2007



Impact of Proposed CO_2 Reductions in 2009 G8 Meeting

Ramanathan & Xu 2009



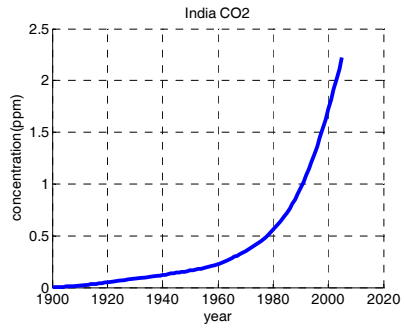
By 2050

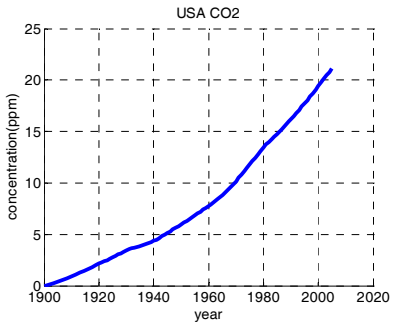
440 ppm

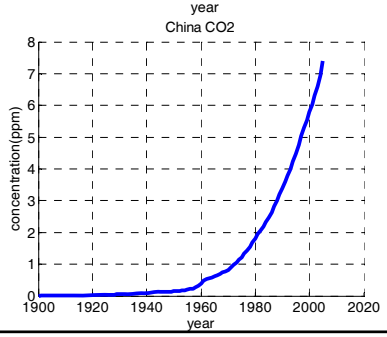
1 Wm^{-2} Heating

0.8 C warming Commited

Contribution to atmospheric CO2(ppm) & Warming







As of 2005:
India's CO_2 < 2.5% Global

Non-CO_2 climate warmers

Contribution to 2005 forcing relative to CO_2(1.66 Wm^{-2})

Greenhouse Gases

Ozone (troposphere)	: 20%
Methane	: 30%
Halocarbons	: 20%

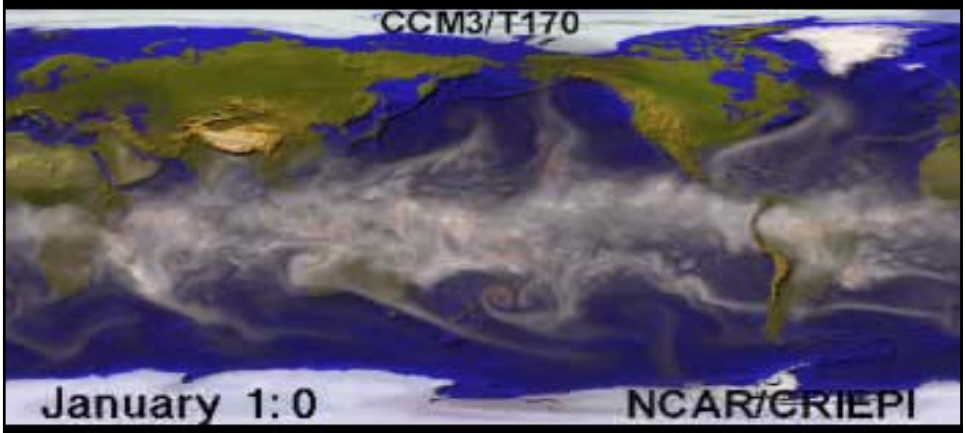
Particles (Aerosols)

Black Carbon (soot/smoke)	: 27% to 55%*
Total Non-CO_2	: 97% to 125%

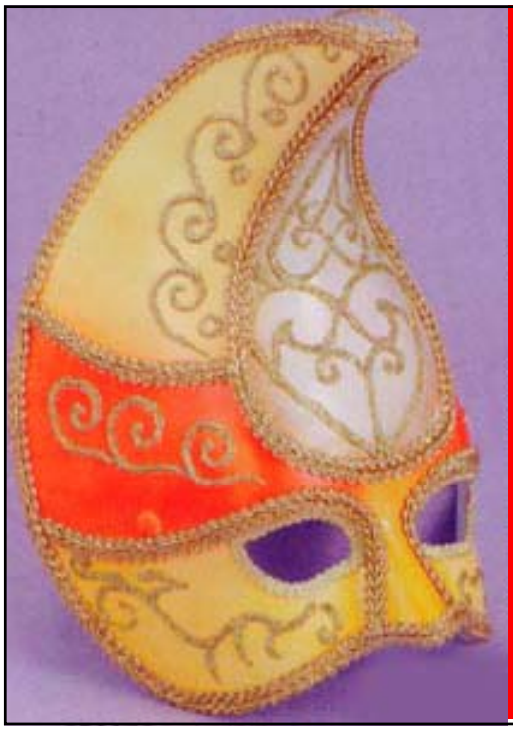
All numbers except the red are IPCC values; Long lived N_2O not included
* Ramanathan & Carmichael; 2008

Global Atmosphere

Source: Washington, NCAR, 2005



Ramanathan 2007



Masking of Global Warming
By
Atmospheric Brown Clouds
(aka particles in Air pollution)

Indian Ocean Experiment:

Europe/ India/ USA Collaboration

Lead Funding Agencies:
NSF; ISRO; MPI

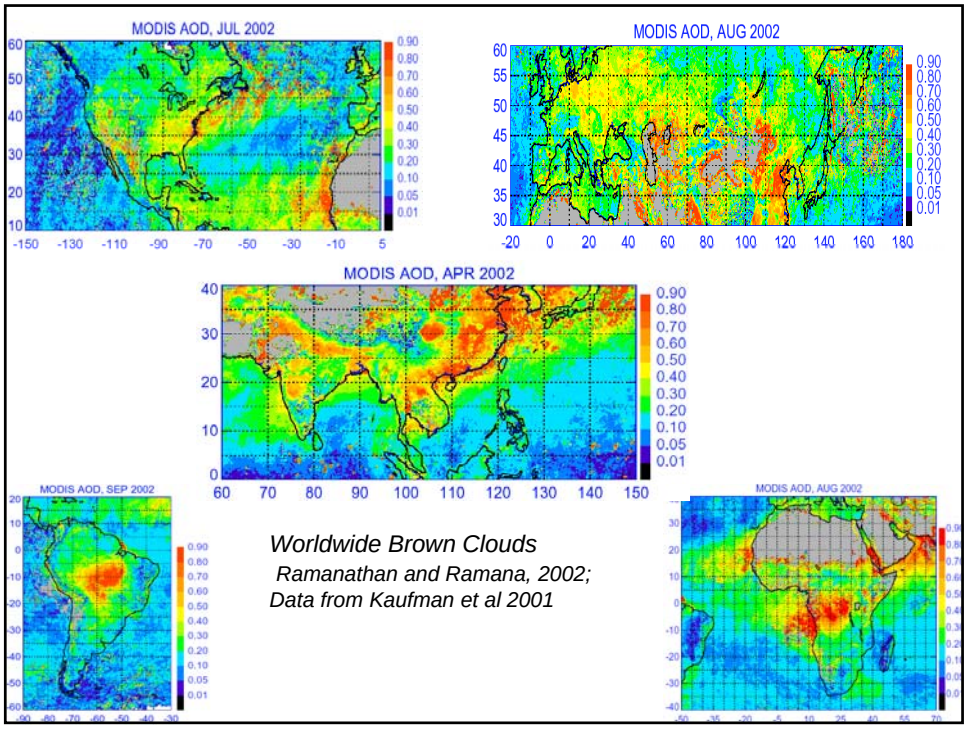
Lead Institutions:

Scripps Inst. Of Oceanography; Univ of California at San Diego, USA

National Physical Laboratory, New Delhi, India

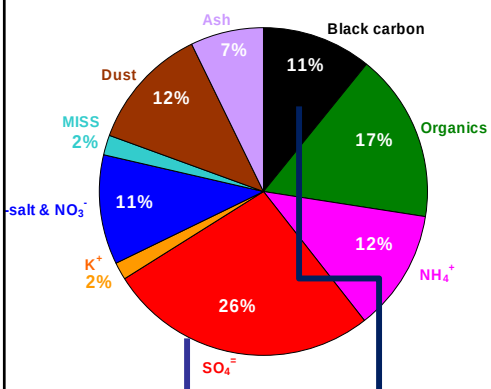
Max Planck Inst for Chemie, Mainz, Germany

Pis: Ramanathan, Crutzen & Mitra



Worldwide Brown Clouds
Ramanathan and Ramana, 2002;
Data from Kaufman et al 2001

ABCs: How do they influence climate ?



- The absorption of solar radiation by the surface and the atmosphere is the fundamental driver for the physical climate system , for atmospheric chemistry, and for all life on the planet.
- ABCs have altered this forcing significantly

Soot: Traps sunlight and heats the air

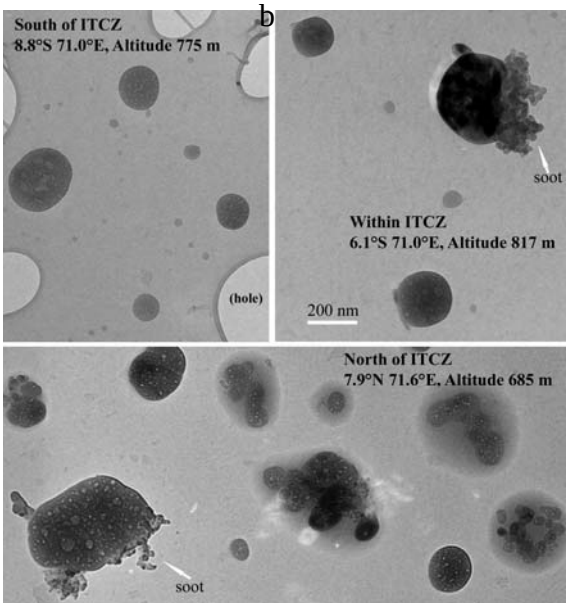
Sulfates: Reflect sunlight like mirrors and cool

What does black carbon look like?
Ramanathan et al, 2001

Clean air;

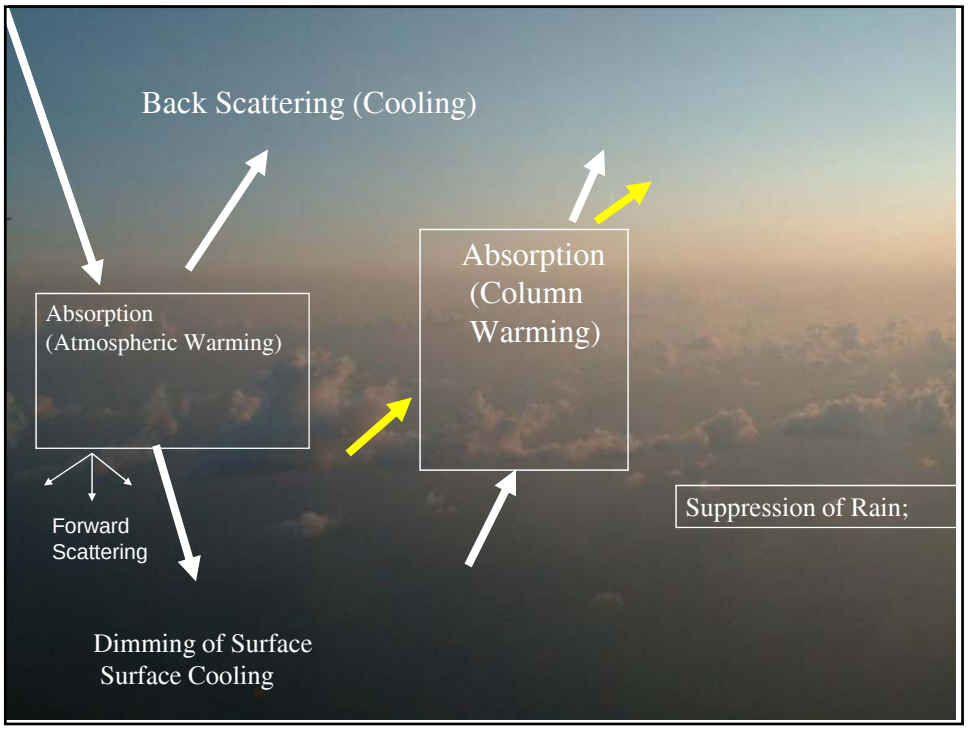
Southern Indian Ocean,

8S



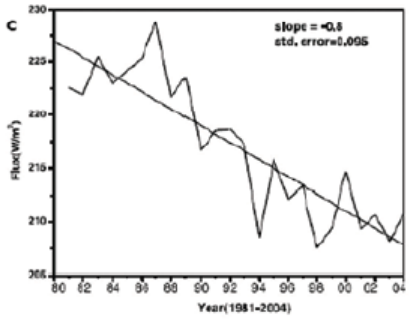
Southern Indian Ocean, 6S Polluted

Arabian Sea Polluted

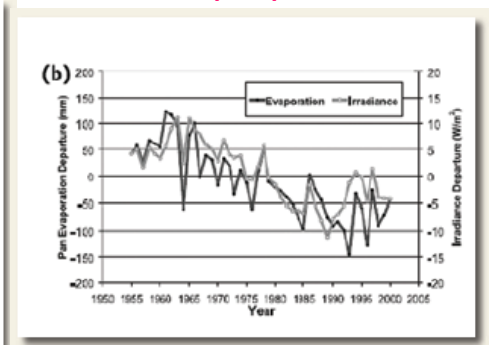


OBSERVED DIMMING TRENDS OVER INDIA ND CHINA

India : Kumari et al, IITM (2007)



China: FU et al (2006)



IABCs have led to large dimming over Asia;
At least by 6% over China and India

5326–5333 | PNAS | April 12, 2005 | vol. 102 | no. 15

Proceedings of the National Academy of Sciences, April 2005

PNAS

Atmospheric brown clouds: Impacts on South Asian climate and hydrological cycle

V. Ramanathan*†, C. Chung*, D. Kim*, T. Bettge‡, L. Buja‡, J. T. Kiehl‡, W. M. Washington‡, Q. Fu§, D. R. Sikka¶, and M. Wild‖

*Scripps Institution of Oceanography, University of California at San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0221; ‡National Center for Atmospheric Research, Boulder, CO 80307; §University of Washington, Box 351640, Seattle, WA 98195-1640; ¶40 Mausam Vihar, New Delhi, 110 051, India; and ‖Swiss Federal Institute of Technology, Winterhurerstrasse, 190 CH-8057 Zurich, Switzerland

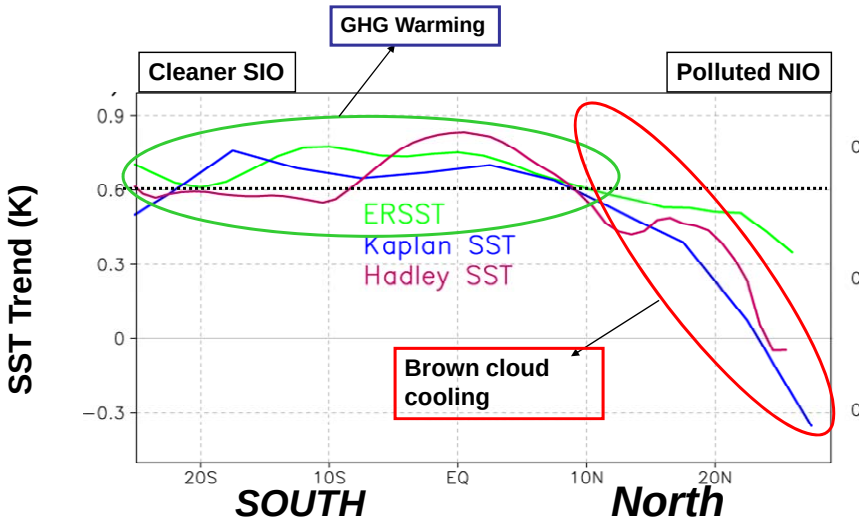
This contribution is part of the special series of Inaugural Articles by members of the National Academy of Sciences elected on April 30, 2002.

Contributed by V. Ramanathan, January 25, 2005

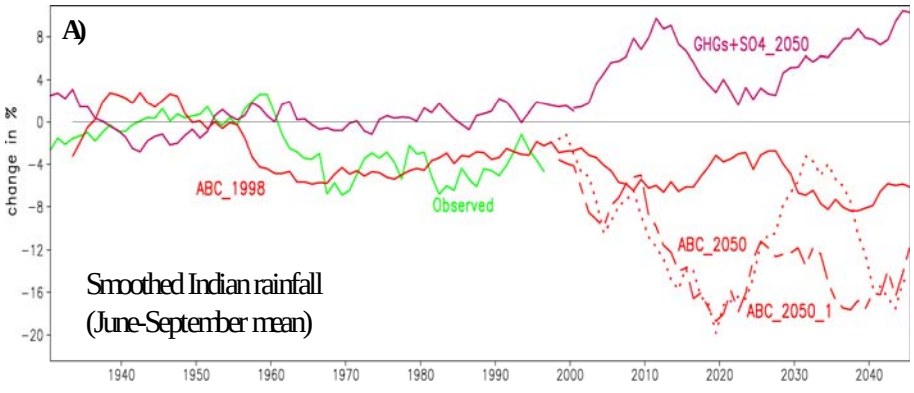
A Fully Coupled Ocean-Atmosphere Model Study from 1870 to 2025; Five Ensemble Runs:
The NCAR Parallel Climate Model;
GHG gas and volcanic forcing from 1870;
ABC forcing from INDOEX and past emissions histories

Observed Trend in Indian Ocean Surface Temperatures 1951 to 2002

Chung & Ramanathan J Clim, 2006



Changes in Summer Monsoon Rainfall averaged over India



Ramanathan et al 2005

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, D10109, doi:10.1029/2008JD010572, 2009

Click Here for Full Article

Changes in the characteristics of rain events in India

S. K. Dash,[1] Makarand A. Kulkarni,[1] U. C. Mohanty,[1] and K. Prasad[1]

Received 10 June 2008; revised 23 January 2009; accepted 23 February 2009; published 29 May 2009.

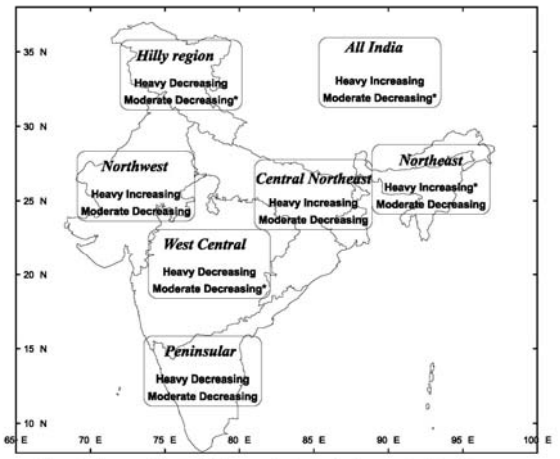
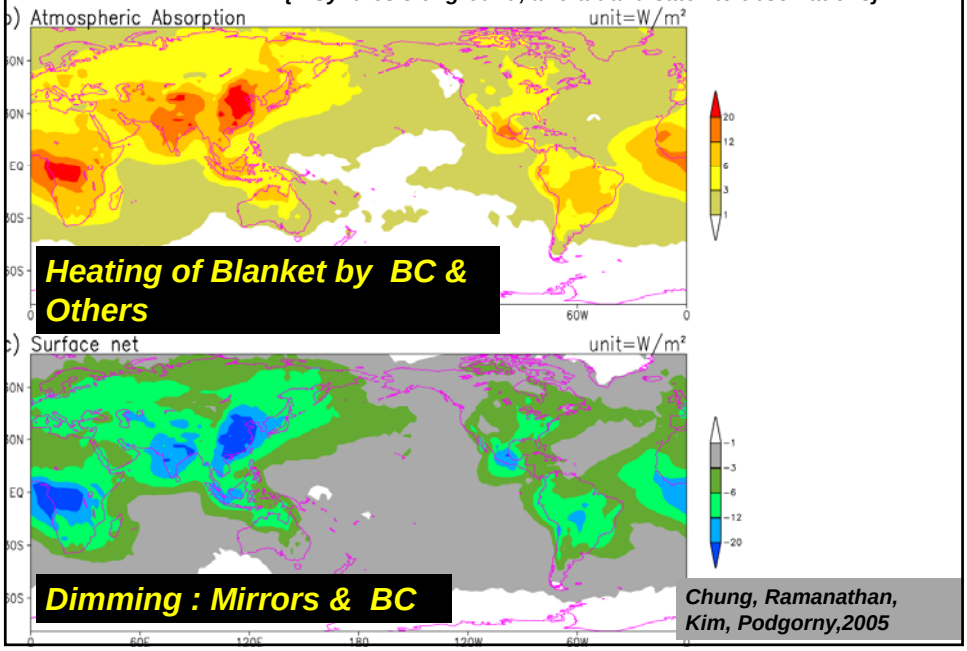


Figure 3. Summary of the trends in heavy and moderate rain days occurring during the summer monsoon season in different regions. Asterisks denote a significant trend at the 5% level.

Ramanathan et al, Nature, 2007.

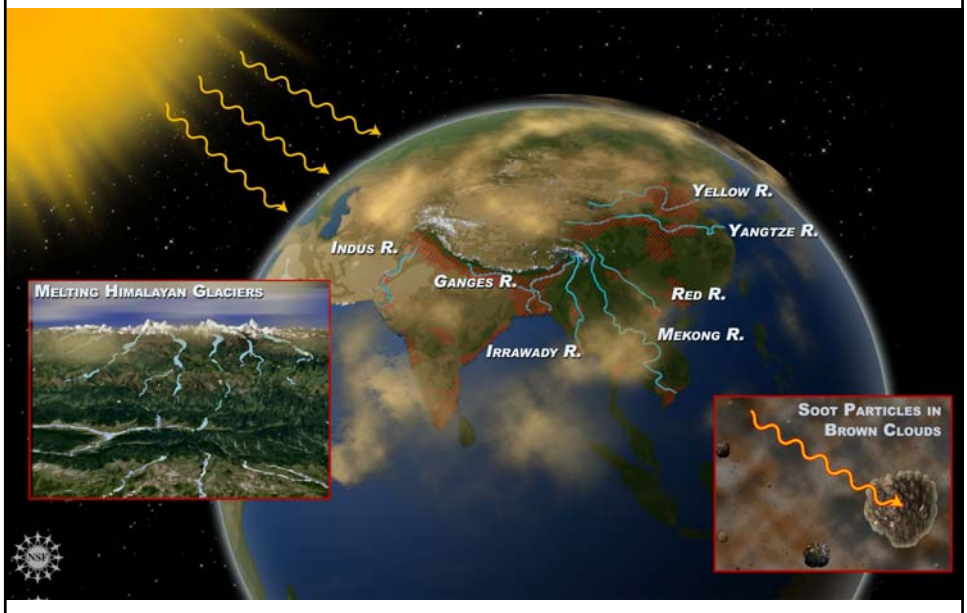
Masking of Global Warming: 2002

{A Synthesis of ground, aircraft and satellite observations}



Chung, Ramanathan, Kim, Podgorny,2005

Hindu Kush-Himalayan-Tibetan Glaciers: Water Fountain of Asia



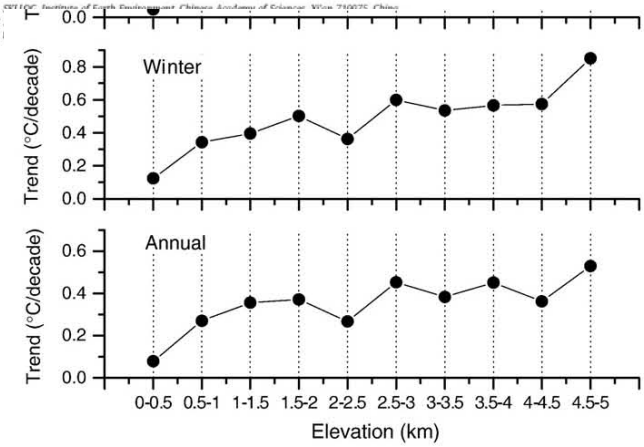
Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Elevation dependency of recent and future minimum surface air temperature trends in the Tibetan Plateau and its surroundings

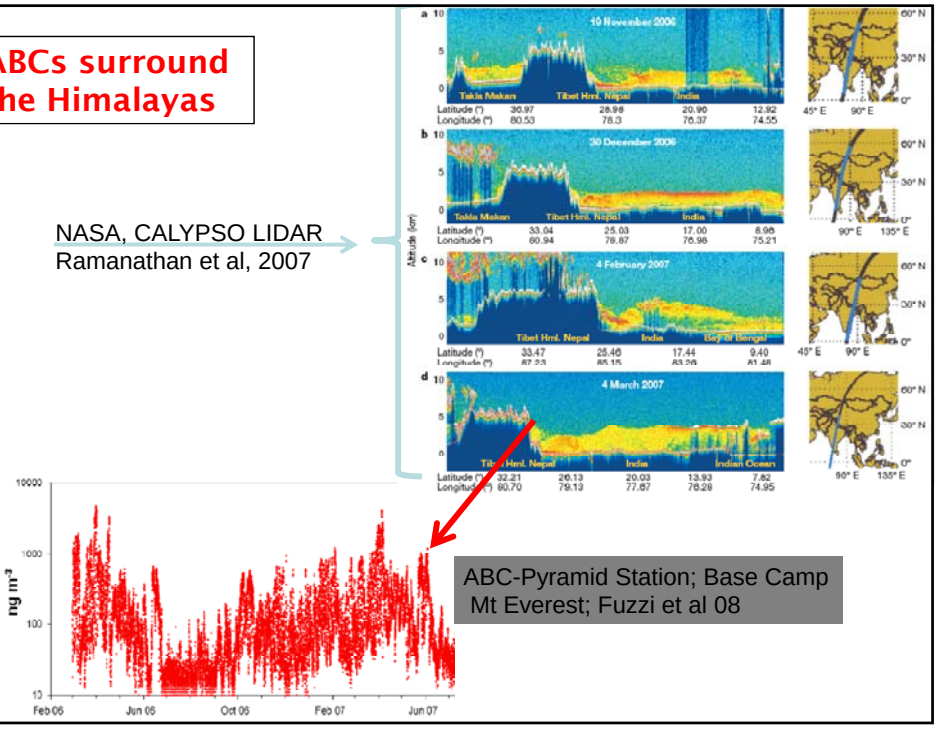
Xiaodong Liu [a,b], Zhigang Cheng [a], Libin Yan [a], Zhi-Yong Yin [c,*]



1961 to 2006 Trend

ABCs surround the Himalayas

NASA, CALYPSO LIDAR
Ramanathan et al, 2007



ABC-Pyramid Station; Base Camp Mt Everest; Fuzzi et al 08

Available online at www.sciencedirect.com
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Journal of Environmental Sciences 21(2009) 914–919

JOURNAL OF ENVIRONMENTAL SCIENCES
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CN 11-2629/X
www.jesc.ac.cn

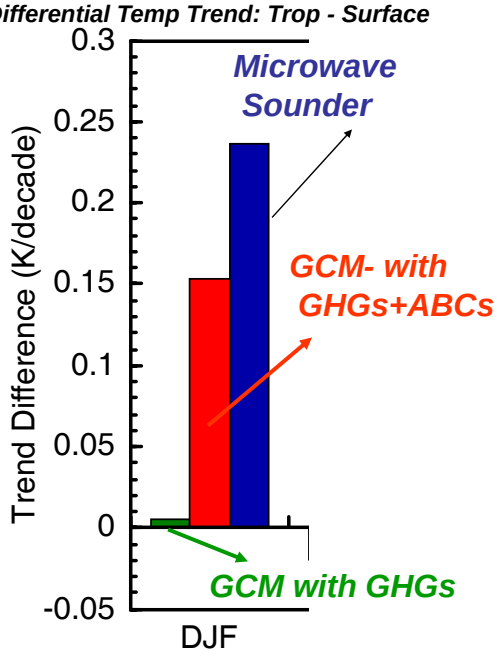
Seasonal features of aerosol particles recorded in snow from Mt. Qomolangma (Everest) and their environmental implications

CONG Zhiyuan[1,3], KANG Shichang[1,2,*], QIN Dahe[2]

1. Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100085, China. E-mail: zhiyuancong@itpcas.ac.cn
2. State Key Laboratory of Cryospheric Science, Chinese Academy of Sciences, Lanzhou 730000, China
3. Graduate University of the Chinese Academy of Sciences, Beijing 100049, China

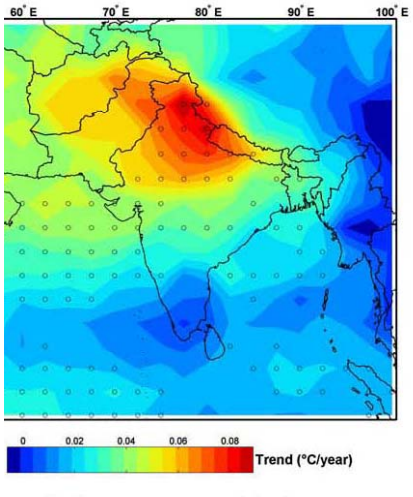
Received 29 August 2008; revised 06 November 2008; accepted 14 November 2008

Differential Temp Trend: Trop - Surface



Ramanathan et al 2005

Observed Tropospheric Temp Trend: 1979-2007



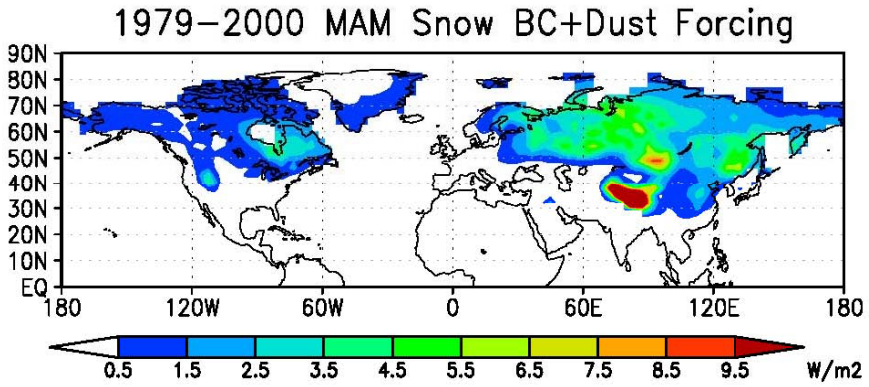
Gautam et al, GRL, 2009

Atmos. Chem. Phys. Discuss., 8, 19819–19859, 2008
www.atmos-chem-phys-discuss.net/8/19819/2008/

Atmospheric Chemistry and Physics Discussions

Springtime warming and reduced snow cover from carbonaceous particles

M. G. Flanner[1], C. S. Zender[2], P. G. Hess[1,3], N. M. Mahowald[1,3], T. H. Painter[4], V. Ramanathan[5], and P. J. Rasch[1]



Smoke and BC have Major Impacts on Health; Water Security and Food Security

- **Greatest advantage for Policy Actions**
  1. *Short Lived in the air (about a week or less)*
  2. *Immediate response to mitigation laws*
  3. *Response felt locally by improved air quality*
  4. *Will reduce fatalities due to indoor and outdoor air pollution*

Global Black Carbon Emissions 2000
(8 Mtons/Yr)

Non-Residential (Fossil Fuels) ***2600 (33%)***

Residential: Cooking and Heating ***2050 (25%)***

Bio-Fuels (1480); Coal & Diesel (565)

Open Burning: ..... ***3325 (42%)***

Forest Fires (1240)
Savanna Burning (1720)
Crop Residues (325)

Source: Bond et al, 2004; Uncertainty: about a factor of 2 or more

Suggested Approach

Mitigation Technology is Available

1) Start with Fossil Fuel BC: Major reductions

Diesel Particle Filters are in Market
$250 Euros for diesel passenger car
More than 99% reduction in BC

2) Initiate mitigation of Biofuel Cooking

But Science is needed to refine numbers

India and Black Carbon

Uncertainty at least factor of 2

Percent of Global Emissions : 6% (Source: Bond et al, 2004)

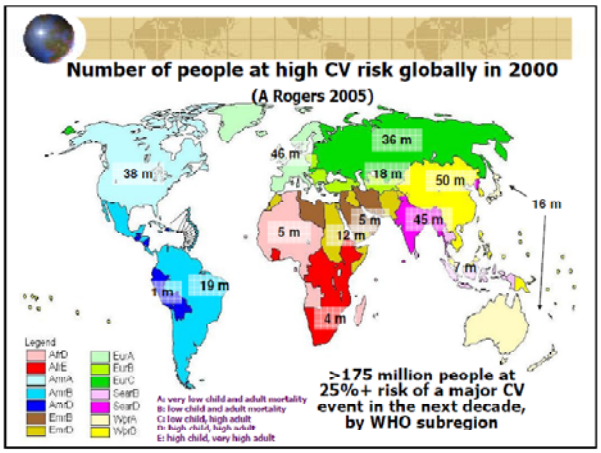
Biomass cooking : 3% (Venkatraman et al, 2006)

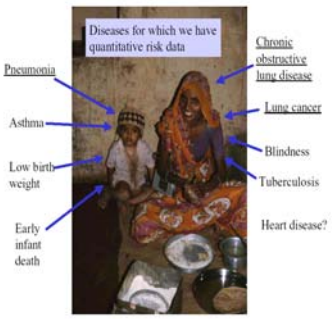
Role of Biomass cooking to Global Warming: : Less than 1%

So, Why am I focusing on Cooking Source of Black Carbon?

Health Burdon Of ABCs Is Enormous

No region is immune!

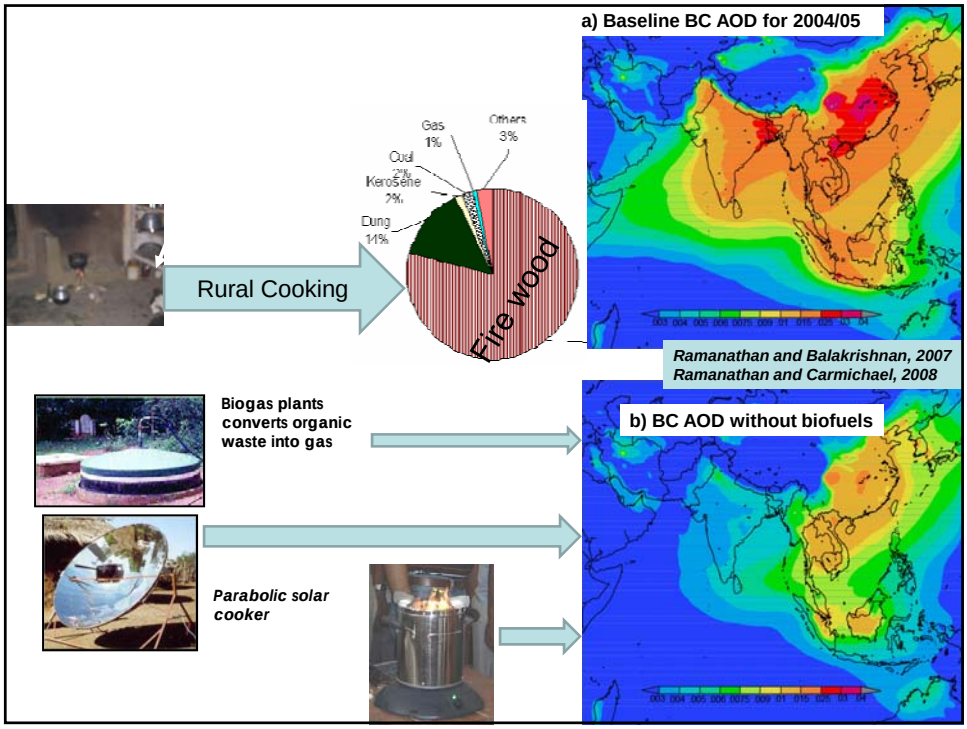




~800,000 excess deaths per year (in USA >50,000 deaths; $100B/yr)

Strong Motivator For Change!

38



Env Sci & Technology, 2008

Policy Analysis

Climate Impacts of Air Quality Policy: Switching to a Natural Gas-Fueled Public Transportation System in New Delhi

CONOR C. O. REYNOLDS† AND MILIND KANDLIKAR*,‡

New Delhi's Pioneering Efforts

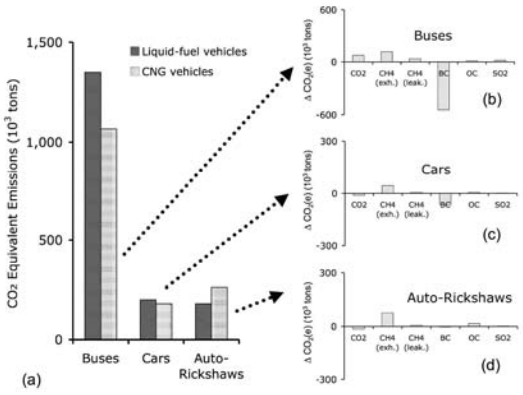
Switching to LPG resulted in:

Increase in CO2
Increase in Methane

But, when black carbon reductions from Buses were accounted for,

There was on overall reduction in CO2 of

300,000 tons of CO_2 Eq.



Need a personal reason for wanting to solve the problem
Lead by USA and Europe is critical for reducing committed warming
Engagement of Asia is critical for reducing future commitment