Black Carbon – Exposure and Mitigation

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WEDNESDAY 7TH FLOOR BOARD ROOM
MAY 8, 2013 939 ELLIS STREET
9:00 A.M. SAN FRANCISCO, CA 94109

AGENDA: 2B
Black Carbon: Product of Incomplete Combustion
Electron Microscopy Images

*Semi-Aged BC > 1 hr*

EC/OC Mixtures

*Aged BC > 1 day*
Brown Clouds Over San Diego;
Sylvia Somerville, 2013
IS THERE ANOTHER KNOB TO SLOW THE RATE OF WARMING?

The Short Lived Climate Pollutants

Methane; Black Carbon; Ozone (Lower Atmosphere); HFCs

Life times are about a decade or less
Pollutants that lead to positive forcing

GHGs Forcing from IPCC 2007;
BC Forcing (outer Circle): Ramanathan and Carmichael, 2008
BC Forcing (inner circle): IPCC-AR4

The Greenhouse Gas Forcing- 2005 = 3 Wm⁻² (25%)

Ramanathan and Xu, PNAS, 2010
A study led by the Scripps Institution of Oceanography in Collaboration With the National center for Atmospheric Research and Climate Central.

Funded by the National Science Foundation

Mitigation of short-lived climate pollutants slows sea-level rise

Aixue Hu¹, Yangyang Xu², Claudia Tebaldi¹,³, Warren M. Washington¹ and Veerabhadran Ramanathan²*
NEAR AND LONG TERM MITIGATION

Graph showing temperature (°C) over time from 1900 to 2100.

- BAU
- Mitig: CO2
- Mitig: SLCPs
- Mitig: CO2 + SLCPs

Dashed line indicates a threshold or reference point.
PROJECTIONS OF SEA LEVEL RISE: BUSINESS AS USUAL
Effect of $\text{CO}_2$ and SLCPs Mitigation on Global Temperatures

Prepared by Ramanathan and Xu
Based on Ramanathan and Xu, 2010; Hu, Xu, Tibaldi, Washington and Ramanathan, 2013

Pre-Industrial to 2050: 1.7 C (1.3 C to 2.3 C) with mitigations

Warming Avoided = 0.7 C  Warming Avoided by SLCPs = 0.6 C
Effect of CO$_2$ and SLCPs Mitigation on Sea Level Rise (SLR)

Prepared by Ramanathan and Xu
Based on Ramanathan and Xu, 2010; Hu, Xu, Tibaldi , Washington and Ramanathan, 2013

Pre-Industrial to 2050: 97 cm (50 to 190 cm)
Avoided SLR = 35 cm
Avoided SLR by SLCPs = 25 cm (71%)
Health Impacts of Aerosols

A Major New Study was released two weeks ago:
Lin et al, LANCET, 2013

Household air pollution from solid fuels accounted for 3.5 million (2.7 million to 4.4 million) deaths.

Ambient particulate matter pollution accounted for 3.1 million (2.7 million to 3.5 million) deaths.
Black Carbon and the Regional Climate of California

Report to the
California Air Resources Board
Contract 08-323

Prepared by:
V. Ramanathan
Principal Investigator

Dr. R. Bahadur¹  Dr. K. A. Prather²  Dr. O. L. Hadley³
Dr. V. Ramanathan¹  Dr. A. Cazorla²  Dr. R. Leung⁴
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April 15, 2013
Both Urban and Rural sites show consistent declining trends

The decline is state-wide

The primary source for the decline is reduction in BC from diesel emissions
BC is about 10% to 15% of total PM
California’s BC Decreased drastically Due to mitigation of Diesel emissions

Trends in Co-emitted Cooling Species was negligible

LAKE TAHOE

BOTH RESIDENTIAL COMBUSTION AND DIESEL CAME DOWN; BUT THE DIESEL EFFECT OVERWHELMED THE WOODBUTNIG EFFECT
Figure 3.3 Statewide average BC concentrations based on COH data sets obtained from CARB and EPA and distillate fuel oil (i.e., diesel fuel) consumption, a source of BC, in California since 1960.
Now Brown Carbon?

March 18, 2013, Maharashtra, India
Photo: Ramanathan
Figure 7.3. Fraction of solar radiation absorbed by organic carbon rather than black carbon in residential wood smoke particulate matter, $f_{OC}(\lambda)$: (black line and
3. BrC emissions are likely both from biomass burning (forest fires and residential wood burning) as previously thought, and also from large age particles indicating that secondary organics may also be absorbing.
Climate’s Dark Forcings: Role of BC-Cloud Interactions
M. Andreae and Ramanathan, Science, April 2013
A cellphone based system for large-scale monitoring of black carbon

N. Ramanathan\textsuperscript{a,b,*}, M. Lukac\textsuperscript{b}, T. Ahmed\textsuperscript{c}, A. Kar\textsuperscript{d}, P.S. Praveen\textsuperscript{c,e}, T. Honles\textsuperscript{a}, I. Leong\textsuperscript{a}, I.H. Rehman\textsuperscript{d}, J.J. Schauer\textsuperscript{f}, V. Ramanathan\textsuperscript{c}
Monitoring Stove BC Emissions Using Mobile Phones

Filter, placed on reference template

Picture sent to server

Results sent back via SMS

Innovations
- $500 per unit, ultra low power.
- Low-tech: works with any camera cellphone.
- Real-time reporting.

Deployment in India for Surya Pilot Phase
Validation with four independent gold standard instruments: Error < 10%

Cookstove samples collected in India, urban samples in California (n=80), comparison with Thermal-optical and Aethalometer

Cookstove samples collected by the EPA (n=600), comparison with Thermal-optical reflectance and transmittance methods.
1. Our findings thus far suggest that policies enacted by California to reduce diesel emissions should have led to a measurable mitigation of the global warming associated with anthropogenic aerosols, equivalent to the elimination of 21 million metric tons of CO$_2$ annually.

This conclusion is derived from the following observations and model simulations:

2. The observed decrease in surface-BC by a factor of 2 from 1989 to 2008 and by a factor of 3.5 from 1960s to 2008.

3. This decrease was not accompanied by a comparable decrease in OC or other cooling aerosols such as sulfates.

4. As a result the decrease of BC was accompanied by a decrease in ratio of BC to Non-BC aerosols, which implies the warming aerosols decreased more in relation to cooling aerosols.

5. The observed BC decreases were largely attributed to the decrease in diesel emissions of BC.

6. Targeted emission controls adopted by the State of California are shown to be effective in reducing BC concentrations, by a factor of at least 2 dating back to the 1980s, and by as much as a factor of 3.5 dating back to the 1960s. At the regional level this decrease is associated with a TOA cooling of between 0.5 and 1.5 W m$^{-2}$. 
Indo-California Air Pollution Mitigation Initiative

Identifying Practical Approaches to Reduce Emissions from Transport Sector

A Collaborative Effort between UCSD, TERI and CARB

Goal: To convene stakeholders and experts concerned with public health, environmental damage and climate change, environmental justice, economic development, and transport industry competitiveness to develop an action agenda of scientific research, technology development, and innovative pilot programs to reduce black carbon and ozone precursor emissions from the transportation sector in India.