SOOT:

A GLOBAL WARMING EMISSION

By

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LAYOUT

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Soot Occurence

- All combustion reactions result in Soot emissions

  Found universally:

  - in the troposphere (10-50%)
  - everywhere on the earth, oceans,
  - sediments, soil, ice sheets, meteorite

  -asteroids and comets.
- An extremely important atmospheric constituent
- Has a remarkable global influence on climate and tropospheric chemistry.

Global Warming Potential of Soot

- Under the Kyoto Protocol, 1997, black carbon was not taken into account while considering controls on green house gases emissions. (Jacobson, 2002).

- Simulation of 12 identifiable effects of aerosols on the climate reveals that any emission reduction of black carbon plus associated organic matter (i.e. soot) could slow global warming more than any emission reduction of CO_2 and CH_4.

Global Warming Potential of Soot

(Jacobson, 2002) research study reveals that:

- Eliminating the fossil fuel particulates black carbon and organic matter could eliminate 20-45% of the net global warming within 3-5 years if no other changes occur.
- Reducing CO_2 by a third would do the same but after 50-200 years.
- Worldwide soot production is on the order of 7-10 billion kilograms annually, with soot being labelled as perhaps the second-largest contributor to global warming after carbon dioxide.
- Jacobson has estimated that because of its ability to absorb and reradiate the sun's heat, soot may be responsible for 15-30% of global warming.

Climate forcing Potential of Soot

- Soot is a forcing agent for global warming.
- Comparable to the greenhouse gas methane (0.7 W/ m^2), (Hansen and Sato, 2001) (Chameides, et al., 1999).
- Half as large as that of CO_2 (1.28W/m2).
- IPCC had estimated the black carbon forcing as +0.25 W/m2.
- Hansen and Sato, 2001, consider that it is uncertain.
- Jacobson (2001) has calculated it as 0.5 W/m2.

Climate forcing potential of Soot

- Hansen (2002), suggested that an aerosol forcing of 0.5-1 W/m2.
- The net value of the forcings added since 1850 is 1.6 ± 1.0 W/m2.
- Black carbon aerosols (soot), cause a positive forcing by absorbing sunlight and heating the lower atmosphere.
- Hence soot is an extremely important atmospheric constituent because of its remarkable global influence on climate and tropospheric chemistry

Global average temperature rise

- Globally surface temperature has increased about 0.75 °C (1.35°F) during the period of extensive instrumental measurements (since the late 1800s).

- About 0.5°C (0.9°F), has occurred since 1950, (Jones, et al., 1999; Houghton, et al., 2001, Hansen, 2003).

Consequences

- Soot may be responsible for regional as well as global climate change, (Hansen, 2003), flooding in China (Menon et al.(NASA), 2002), at significant level reduces sunlight causing local surface cooling.

- At higher concentrations, the heating of the air results in surface warming, through its influence on atmospheric stability and cloud cover (Hansen, 1997).

Consequences Soot in aerosol

- Aerosols also cause an indirect climate forcing by changing the properties of cloud drops, (Hansen,2003).

- Smaller drops make the clouds slightly brighter make it more difficult for the clouds to produce rain, thus increasing average cloud lifetime. Brighter long-lasting clouds reduce the amount of sunlight absorbed by the earth, so the indirect effect of aerosols is a negative forcing that causes cooling.

Soot in aerosol

Black carbon can significantly modify the regional and global cooling effect of other aerosols

- The entrapment of highly absorbing black soot cores within liquid droplets may lead to a local warming, regional and global implications and evaporation of the clouds, known as the cloud-burning effect (Ackerman, et al., 2000; Rosenfeld, 2000; Jacobson, 2001).

Heat Trapping Emissions

- Fossil fuel based, heat-trapping emissions from transportation and other sources— have led to an increase in the earth's temperature.

- Transportation is considered the source of roughly one-third of all heat-trapping gases released in the United States.

Heat Trapping Emissions

- Each gallon of diesel fuel burned in a diesel truck engine results in emissions of 22.8 pounds of carbon and other heat-trapping gases.
- Each gallon of diesel is responsible for additional 2.4 Kg of heat-trapping gases at the time of production and delivery.
- About 6 percent of US carbon emissions comes from heavy trucks (emit nearly 400 million metric tons of heat-trapping gases annually).

Consequences of Global Warming

- Within next 200 years earth is expected to face:
  Longer droughts, more coastal flooding, more frequent extreme weather events. human health, severe stress on large areas of forest, a loss of mountain and coastal-wetland habitats, plants and animals that live there.

- The expansion rate of deserts, disruption of agriculture, and a rise in sea level of anywhere from 6 to 37.5 inches above the current level with persistent coastal flooding Increased global warming may also affect fisheries, water resources, and all natural habitats. Human well being, including commerce and economic development, could well be at risk (Gresham, 2000; Washington Post, 1999).

Consequences

- Higher surface temperatures could also increase the frequency of ozone-conducive meteorological conditions making it more difficult and expensive to achieve and maintain clean and healthy air (EPA, 1996; Deul et al. 1999).

- Attributed to human activities specially combustion of fossil fuels in transportation and thermal power generation.

Consequences:
Affects of soot on snow

- Soot is twice as potent as carbon dioxide, a main greenhouse gas, in raising surface air temperature.

- Soot particles affect climate when they darken snow and ice, causing it to absorb sunlight rather than reflect it, (Kirby, 2003).

- The estimated climate forcing includes the effect of soot in reducing the reflectance of snow and ice (Hansen, 2003).

NASA Findings

- Soot may be a cause of the changes happening near the North Pole, such as accelerating melting of sea ice and snow and changing atmospheric temperatures (Gutro, 2005, Electronic Version).

- Emissions of black soot alters the way sunlight reflects off snow. According to a simulation, black soot may be responsible for 25% of observed global warming over the past century, (Hansen and Nazarenko, 2004).

Consequences

Clean ice reflects back more solar radiation

- Soot particles may be twice as bad as the greenhouse gas carbon dioxide in contributing to global warming,

- An effort towards reducing the amount of soot produced would be easier than cutting carbon dioxide and other greenhouse gas emissions (Hansen and Nazarenko, 2004).

Consequences

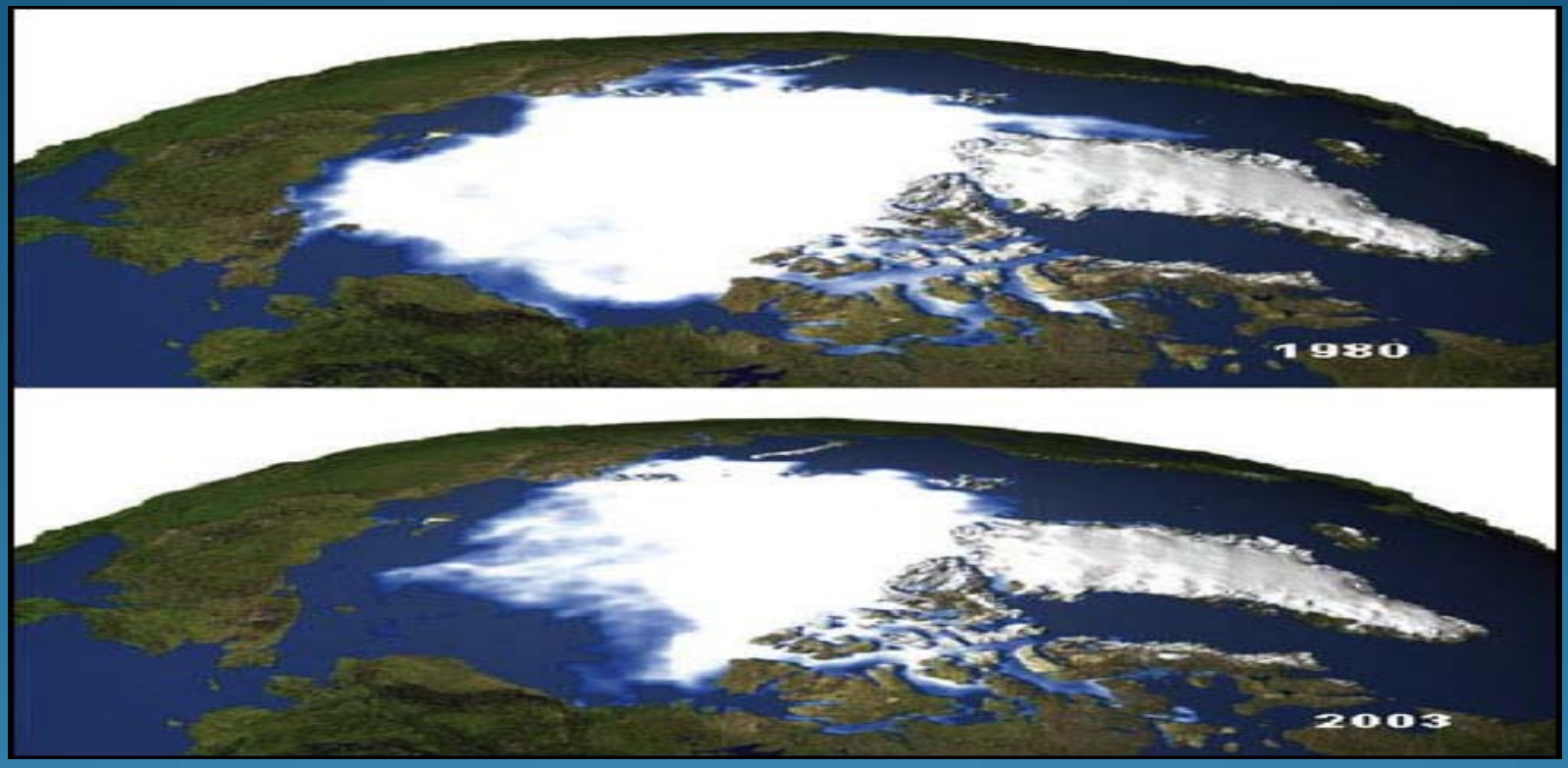
Good: Clean ice reflects sunlight, and inhibits melting,

Source: NASA

Bad: Soot-covered ice absorbs the which keeps the ice relatively cool sunlight instead of reflecting it, causing it to warm and melt more quickly, Source: NASA

http://www.thesweepers.com/jane/deepnorth/archives/2005/06/

Consequences soot, possibly could be the second largest contributor to global warming,



- The difference in ice cover, is about 1.6 million km2, between 1980 and 2003

- Source: http://www.thesweepers.com/jane/deepnorth/archives/2005/06/

Conclusion

- Soot in general and black carbon in particular have not received sufficient attention in measurements and analyses to define well their role in global climate change. The variation of black carbon during the past century is needed to interpret climate change,

- Our ignorance on soot affect needs to be rectified for the sake of understanding the practical effects of soot today as well as for monitoring future changes in the atmosphere.(Novakov and Hansen, (2004).

Conclusion

- Investigations of soot have been carried out mostly in European countries, USA, New Zealand, Australia, China, Korea, and the Arctic region.

- In order to get a snapshot from global perspective there is a need to gather soot related information on environmental issues from various sources, emissions data and other consequences.

- This could be followed up by an extensive study on various aspects of soot, such as emission, concentration, transport and deposition to be conducted simultaneously in all continents of the world, (using NASA satellites, Landsat Thematic Mapper ™ and Satellite Pour d'Observation de la Terre (SPOT).

- Homogeneity of data, using automation or manual techniques will be an effort towards generating standard methods for soot measurements. Data and recommendations may be sent to the IPCC for their consideration of the global warming potential of soot.

- A review on fate of soot has been sent to UNFCCC for their consideration on the inclusion of soot, as one of the global warming emissions, in green house gas inventories of countries of the world.

- This type of study when coupled with calculation of fuel consumption can provide a useful data set for the design of future environmental policies towards maintaining global temperature at a level that curtails sea level rise, forest fires, acid rains (Farah.N, 2006).

- There is a need to explore more and establish, from a historical perspective, tolerable limits for soot emissions. Also a regular country or regional monitoring of soot concentration in the atmosphere will help in maintaining the global warming effect of soot emissions at a certain IPCC agreed level.

Recommendation

- There is a need to explore more and establish, from a historical perspective, tolerable limits for soot emissions. Also a regular country or regional monitoring of soot concentration in the atmosphere will help in maintaining the global warming effect of soot emissions at a certain IPCC agreed level (Farah.N, 2006).

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