# Air Pollution Monitoring from Climate Change Perspective

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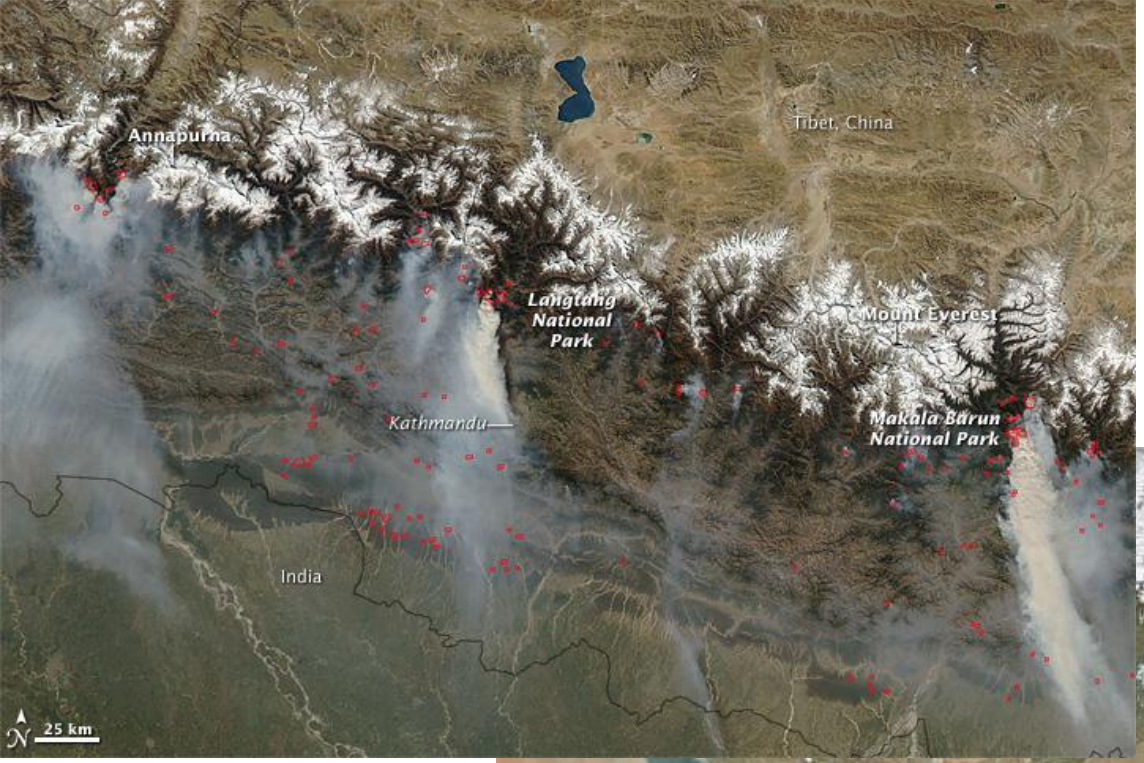
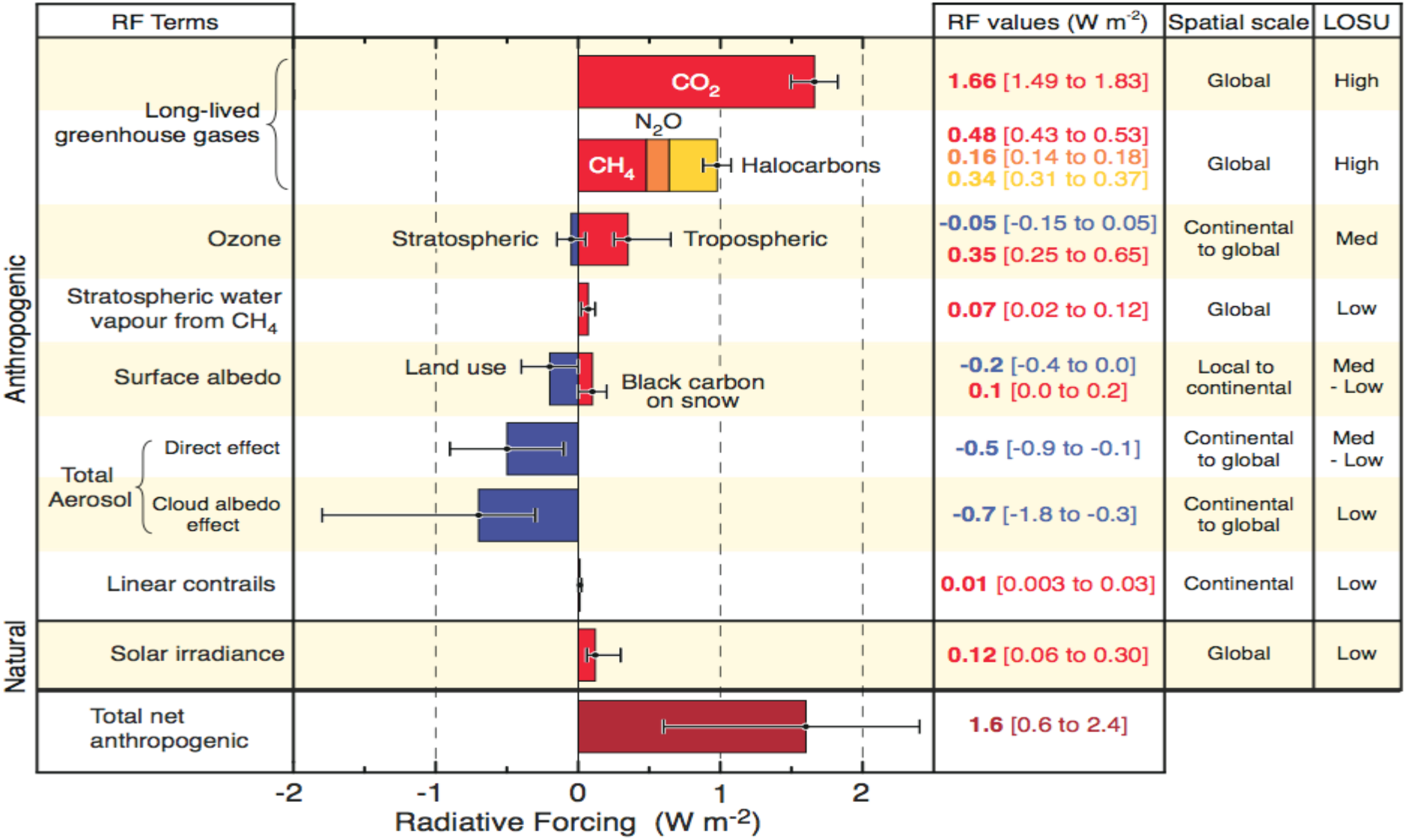



Source: MODIS

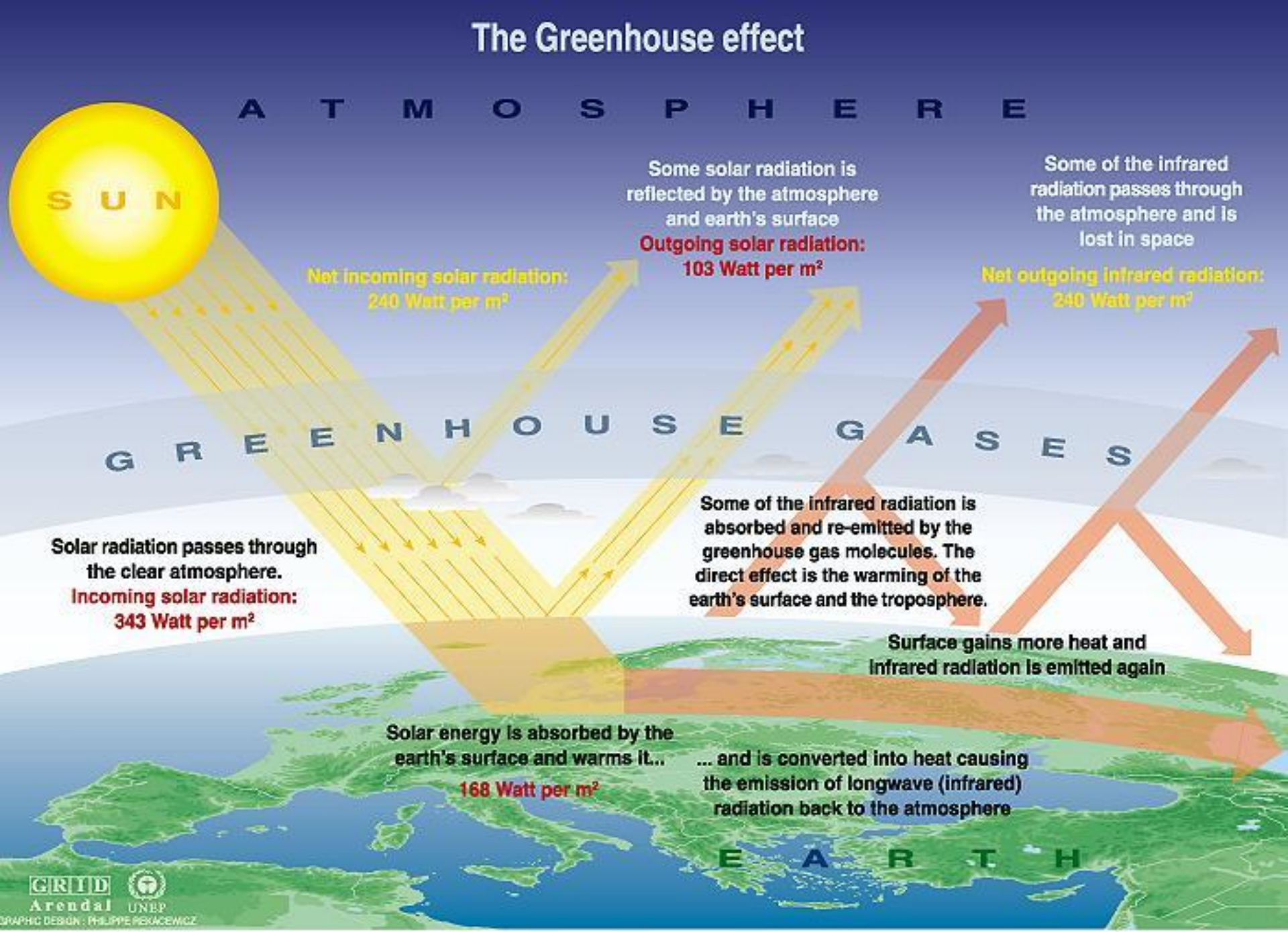
- Transboundary Air Pollution (gaseous and particulate pollution)



| GHGs | GWP20 | Air Pollutants | GWP20 |
|---|---|---|---|
| $CO_2$ | 1 | BC | 3200[b] |
| $CH_4$ | 92[a] | OC | -340[b] |
| $N_2O$ | 289[a] | CO | 15[a] |
| | | $SO_2$ | -120[b] |
| | | $NO_x$ | -448[a] |
| | | $NH_3$ | - |
| | | NMVOC | 8.6[c] |
| $O_3$ | | $O_3$ | - |

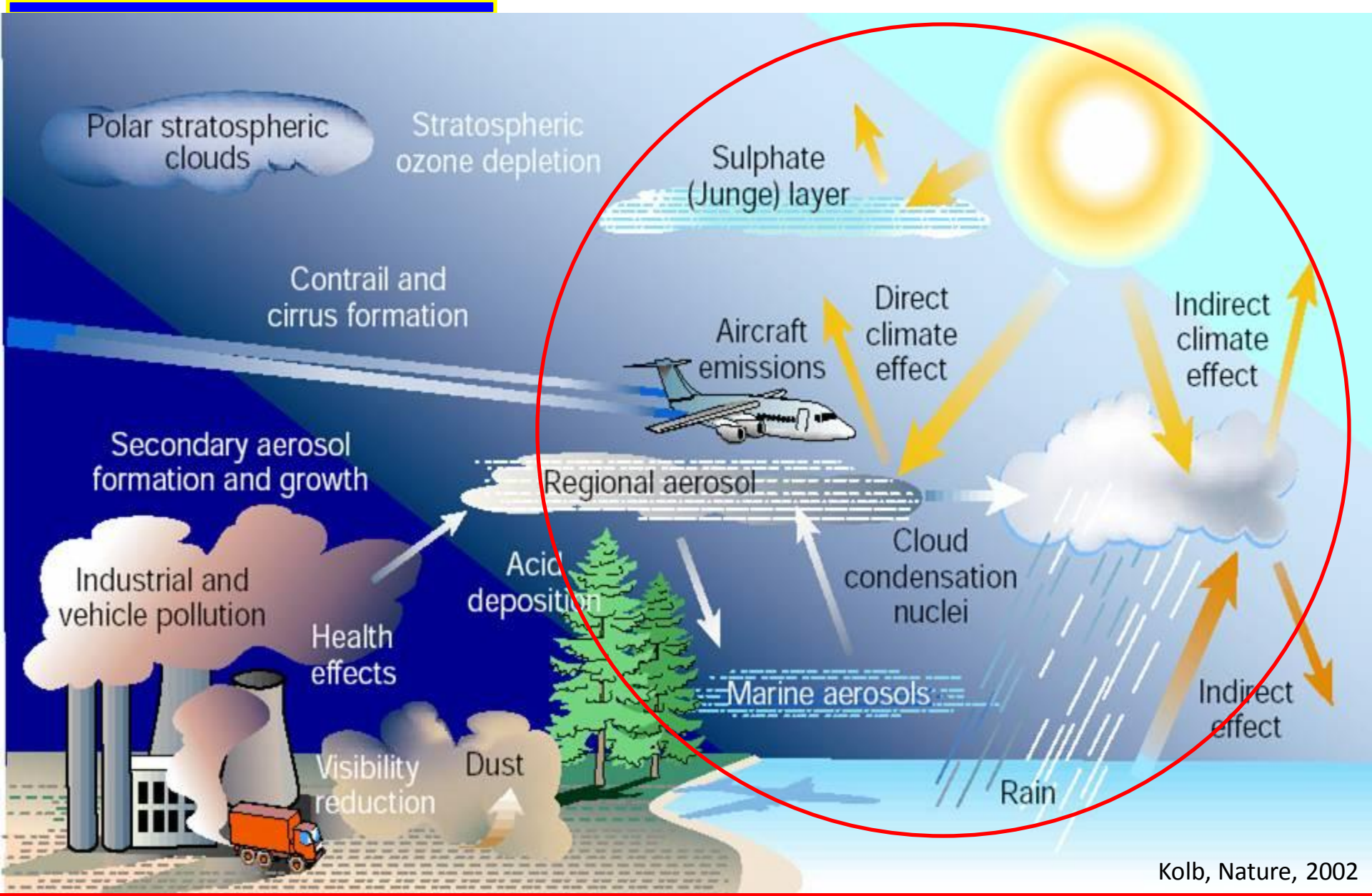
[a]Shindell et al (2009), [b]Koch et al (2007), [c]Collins et al (2002), [d]IPCC (2007)

# The Greenhouse effect



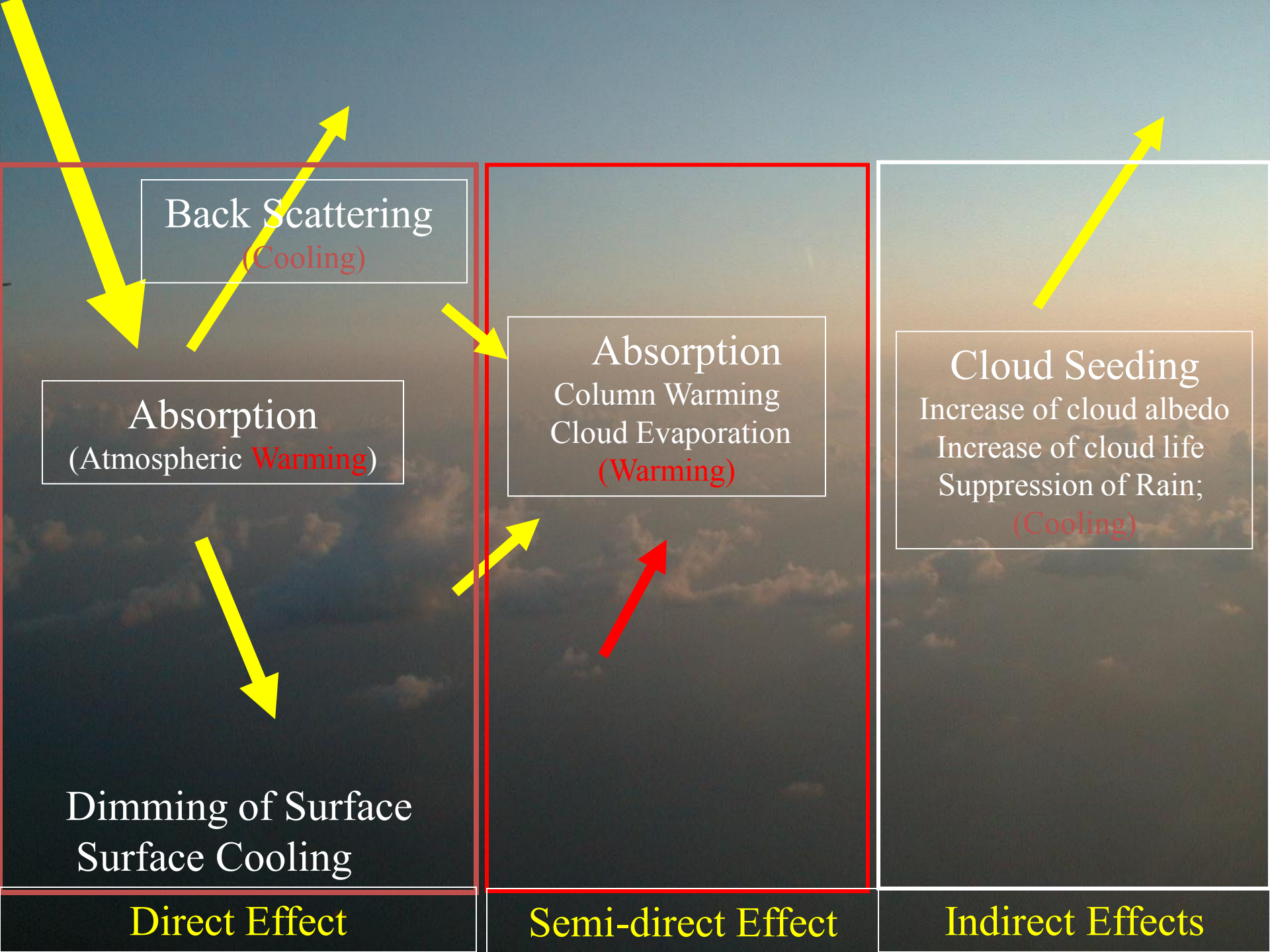

Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995. The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change. UNEP and WMO. Cambridge university press. 1996.

# Effects of Atmospheric Aerosols (PM)

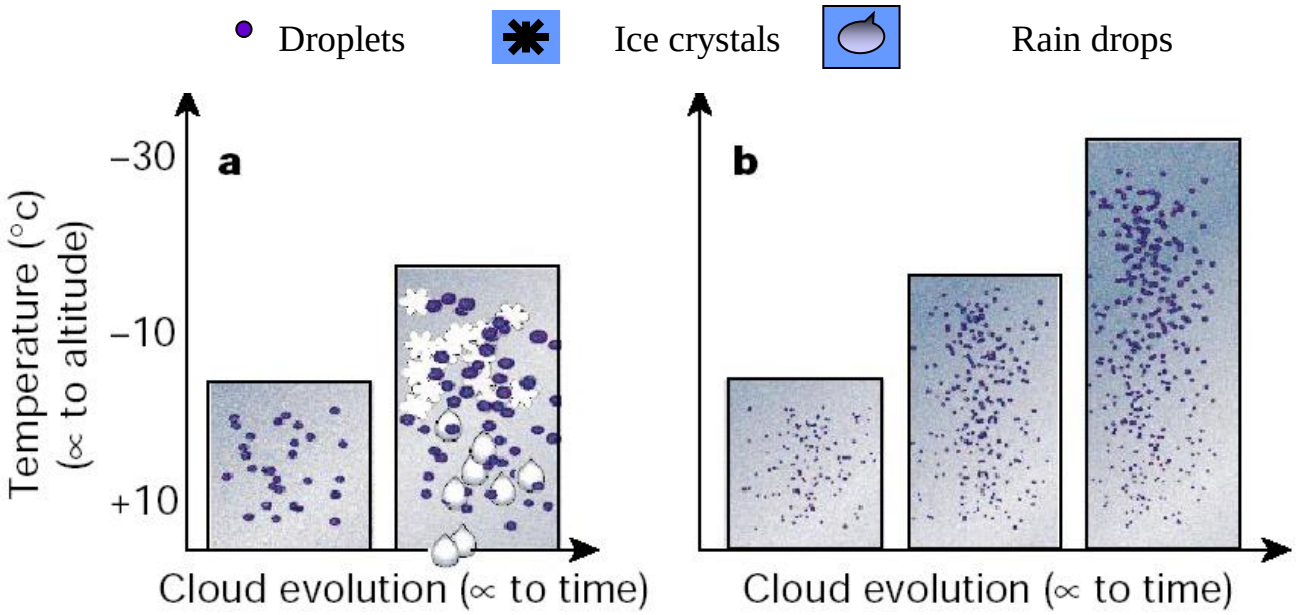



Kolb, Nature, 2002

Impacts: Air quality, Acid Rain, Climate, Hydrological Cycle, Agriculture, and Health


Back Scattering
(Cooling)
Absorption
(Atmospheric Warming)
Dimming of Surface
Surface Cooling
Absorption
Column Warming
Cloud Evaporation
(Warming)
Cloud Seeding
Increase of cloud albedo
Increase of cloud life
Suppression of Rain;
(Cooling)
Direct Effect
Semi-direct Effect
Indirect Effects

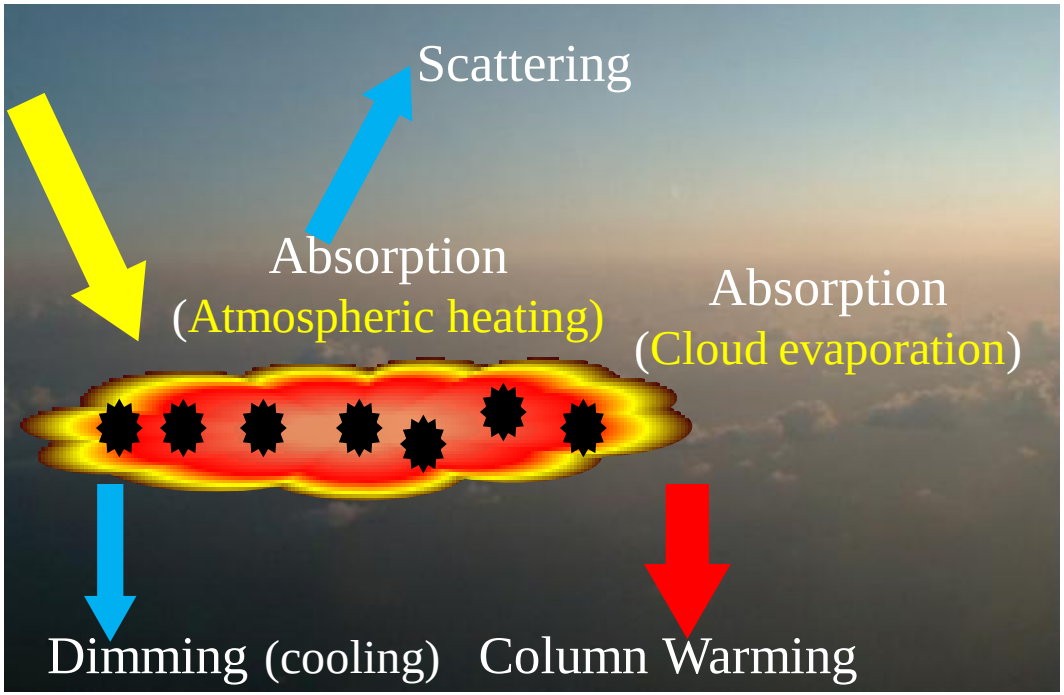
# Aerosol Indirect effects: acting as cloud condensation nuclei (CCN)




In a clean atmosphere, In polluted clouds,

1. First indirect effect (cloud albedo effect): ↑ aerosol number → ↑cloud droplets → ↓ size of droplets → ↑ cloud albedo → cooling
2. Second indirect effect (cloud lifetime effect): ↑aerosol number → ↑ cloud droplets → ↓ size of droplets → ↑ cloud lifetime → cooling

# Aerosols Effects on Glacier Melting




**Direct Radiative effect**

**Snow-albedo**

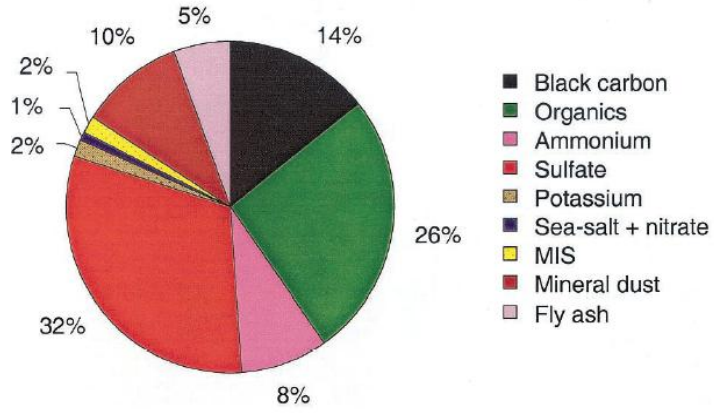
# Aerosol Parameters for Radiative Forcing estimates

Sources/Emission: Natural vs Anthropogenic ,Primary vs Secondary

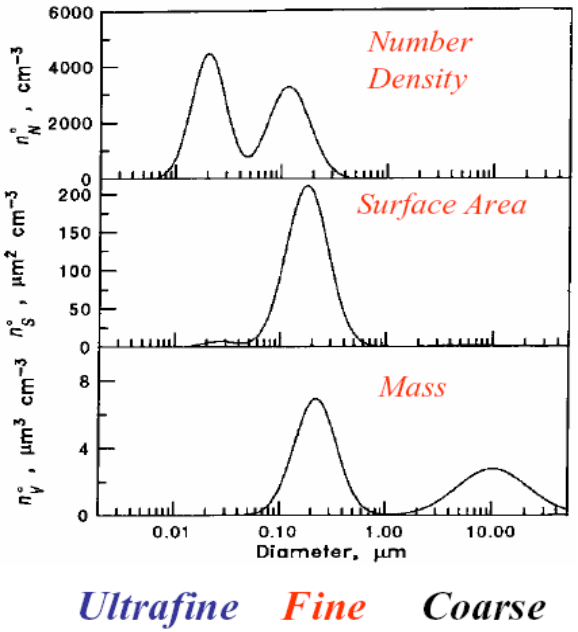
Physical Properties: Number concentrations, size, number size distribution, mass size distributions, mixing state, dry and wet scavenging rates,

Chemical properties: Chemical composition, size distributed composition

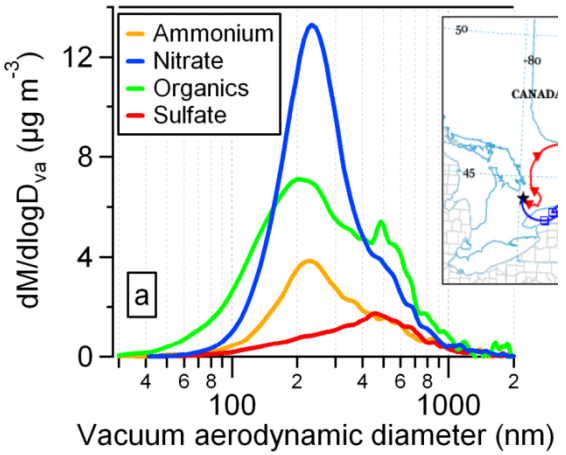
Optical Properties: Scattering coefficients, absorption coefficients, AODs




Ramanathan et al. JGR, 2001

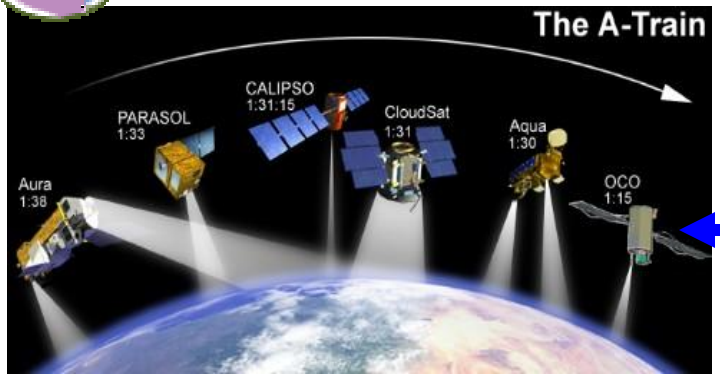



D. Worsnop, 2006




Rupakheti et al, 2005

# Atmospheric Monitoring




***Surface Stations***

***Satellites***

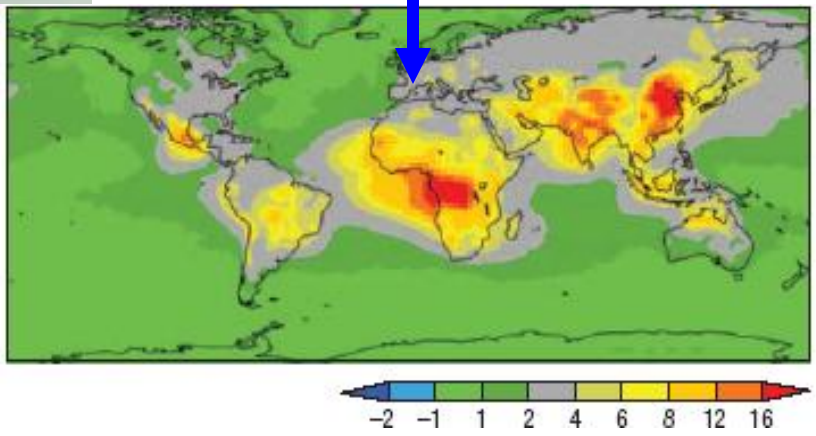
***Aircraft***

***Balloons***

***Ships***

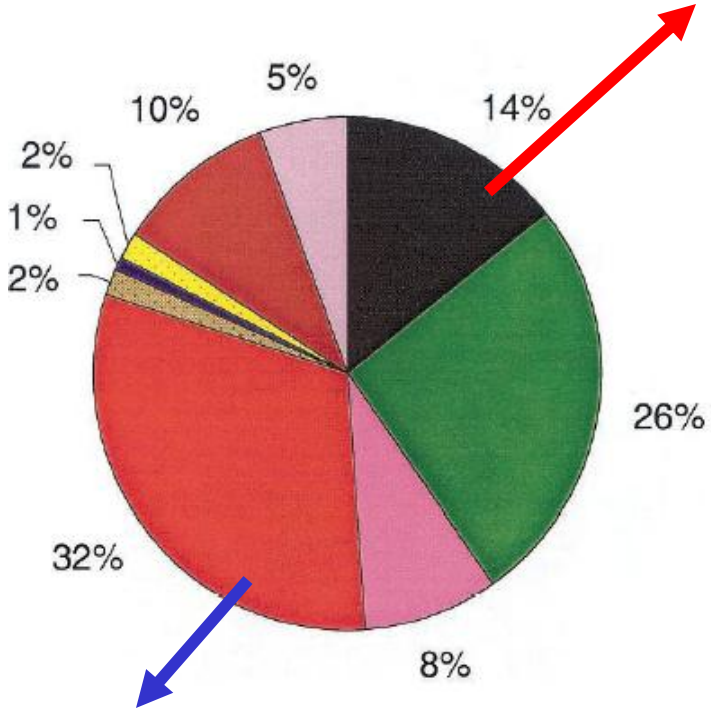
***UAVs:***

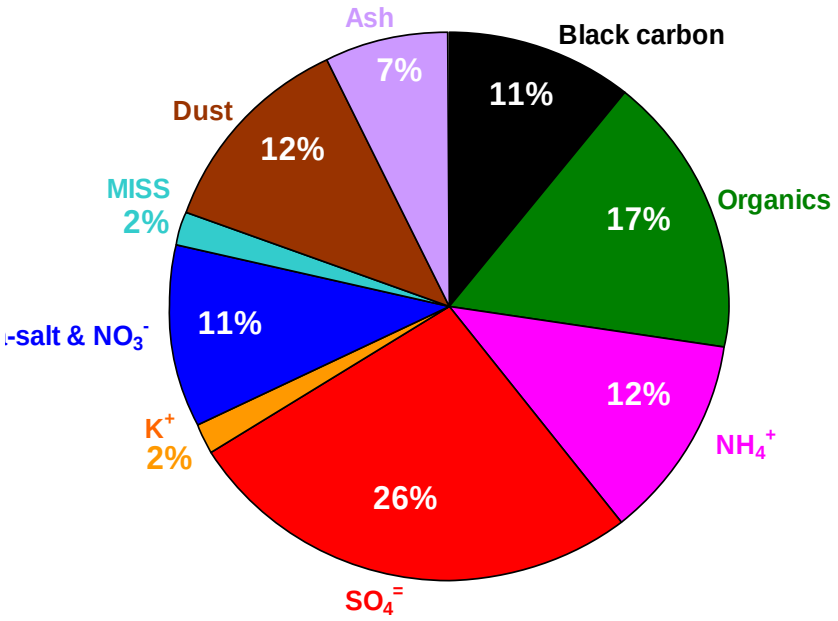
***Assimilation Models***


# Aerosol chemistry and radiative effect

Traps sunlight and heats the air




Reflects sunlight and cool

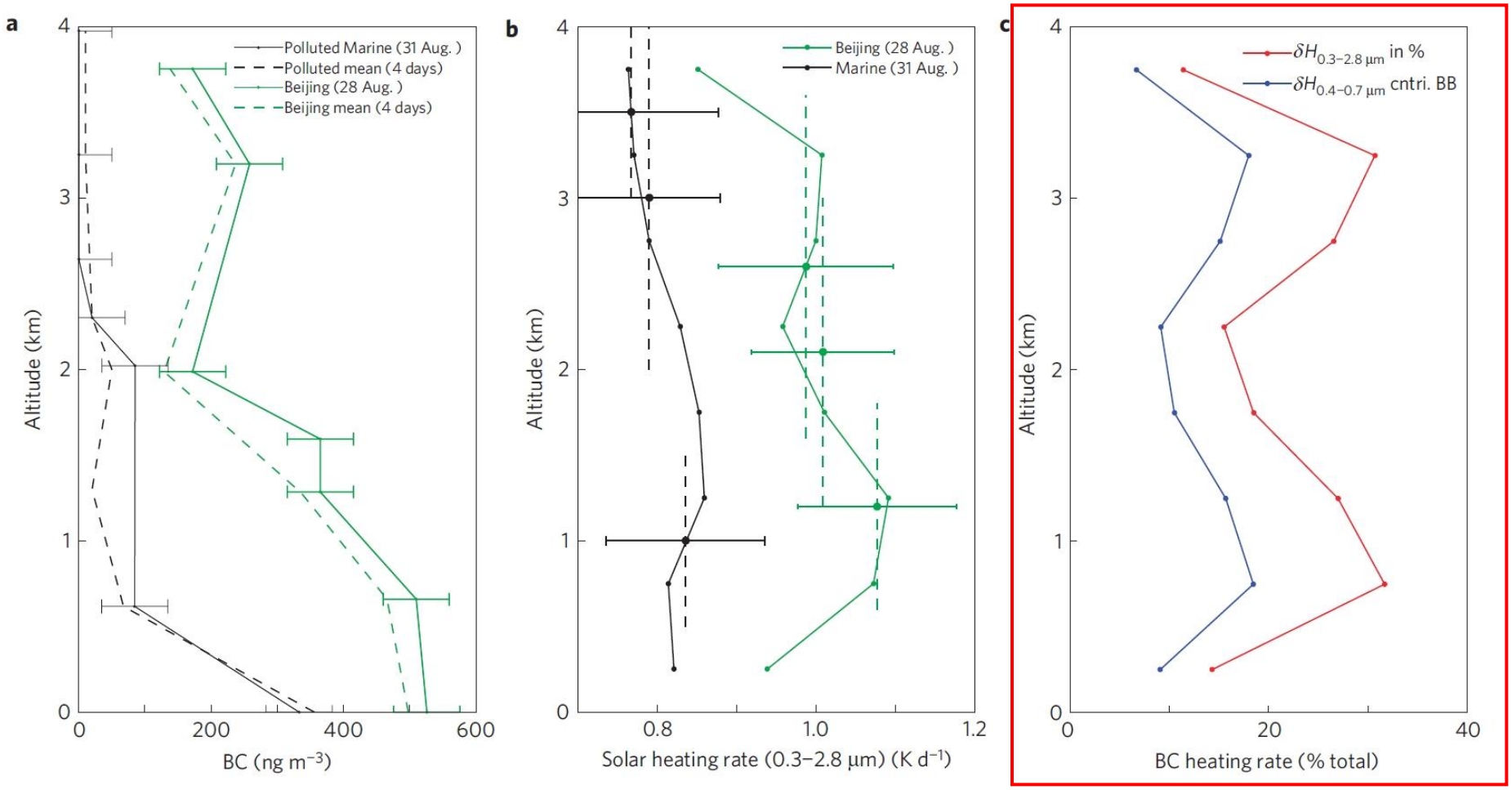
PM2.5 composition and contribution of aerosol constituents to AOD

**Sulfur reduction requires matching BC emission reduction**

Understand role of other aerosols

*Ramanathan et al., 2001*

# Air pollution and regional climate impact



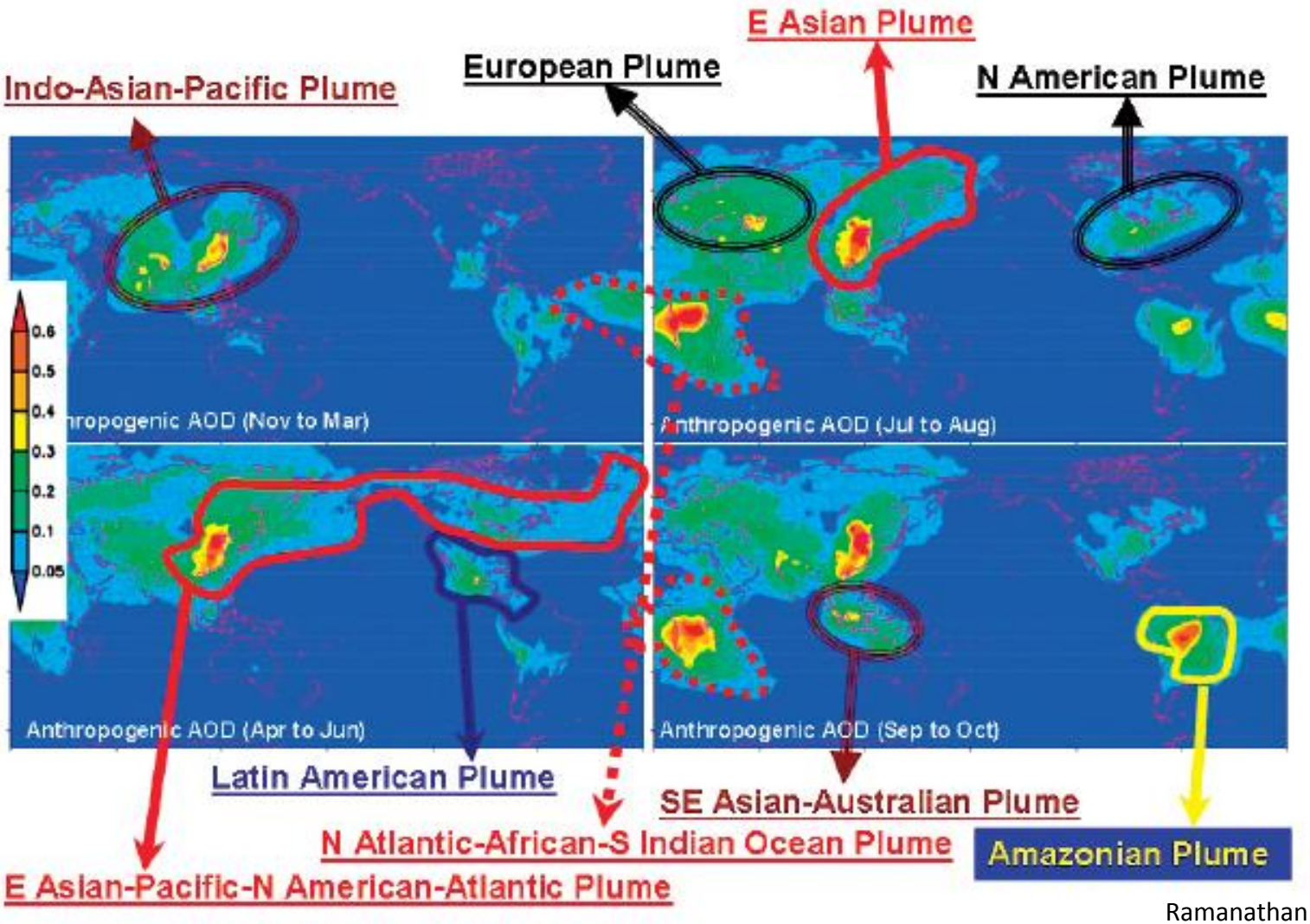

- The enhancements in $H$ between the two periods ($\delta H$) at 0.75 km and 3 km altitudes are about 0.26($\pm$0.13) K d$^{-1}$ and 0.24($\pm$0.11) K d$^{-1}$, respectively.

- Comparison of diurnal mean solar heating rate per unit BC mass:
  - N. Indian Ocean (Ramanathan et al., 2007) : 0.6($\pm$0.15)x10$^{-3}$ K d$^{-1}$ per (gm$^{-2}$)
  - Beijing-plume : 0.5 ($\pm$0.2)x10$^{-3}$ K d$^{-1}$ per (gm$^{-2}$)

Ramana et al., *Nature Geoscience* 2010.

# Aerosol pollution: Global Phenomenon

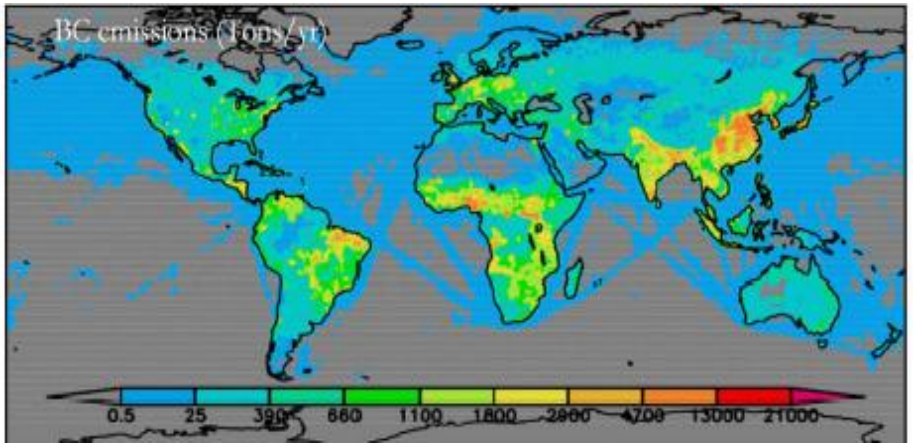
- **Regional scale plumes of air pollution** [particles: (Black carbon, sulfates, nitrates etc.), and precursor gases that form aerosols and ozone]



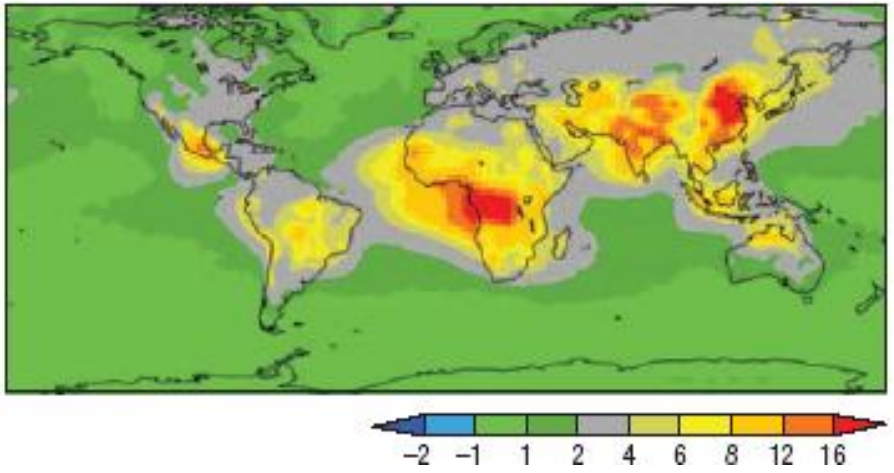

Ramanathan et al., 2008

# Aerosol-Climate Impact

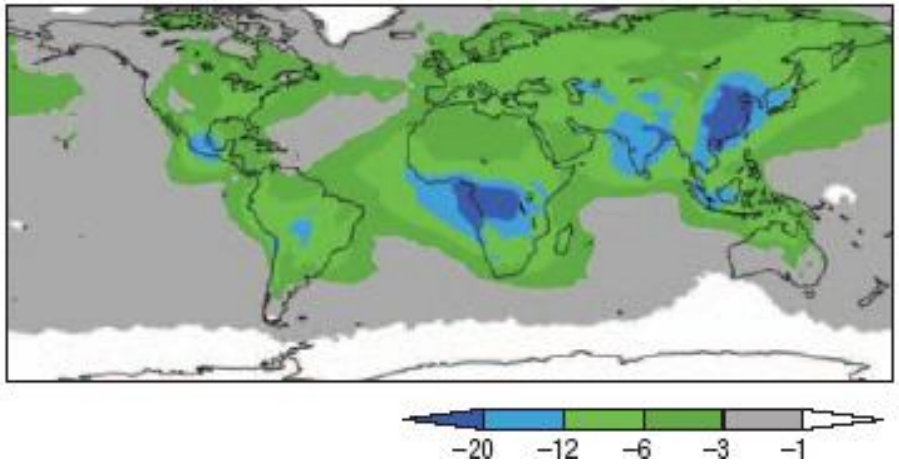
BC emission ( tons/year)




Atmospheric heating ( $W/m^2$)




Surface dimming ( $W/m^2$)

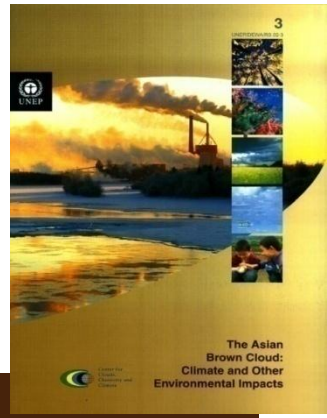


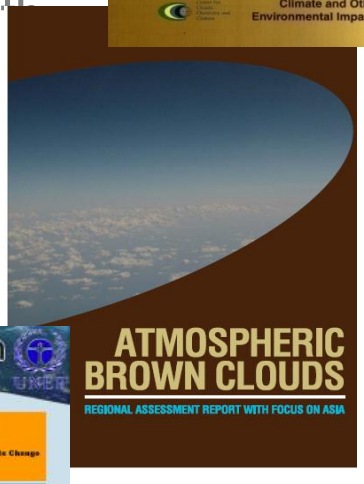

Ramanathan & Carmichael *Nature Geoscience* 2008.

# Project Atmospheric Brown Cloud (ABC)

**ABC-Asia,** ABC-Africa and ABC-Latin America

- **ABC -Asia**
  - 1. Observation — Aerosol and climate, precipitation chemistry, High altitude observatories
  - 2. Impact Assessment — Climate Change, Water Budget, Agriculture and Human Health
  - 3. Mitigation — Emission Inventory and Project SURYA
  - 4. Knowledge Management
  - 5. Awareness and Consensus for policy




# Summary

- **Interaction between aerosols and build-up of GHGs** is an outstanding problem which prevents from complete understanding of climate change and its impacts, and needs to be more fully explored.

- **Aerosol impact on regional climate change is** an emerging regional climate change issue (disproportionate impacts due to inhomogeneous distribution: higher near to the sources)

- **Air pollution (PM, BC, $SO_2$, NOx, CO, NMVOC, $O_3$, etc.) monitoring** will help **understand the level of pollution** and also can be used to validate satellite monitoring and model simulations

# THANK YOU

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