

Impact of Atmospheric Brown Clouds (ABCs) on Agriculture




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What are ABCs

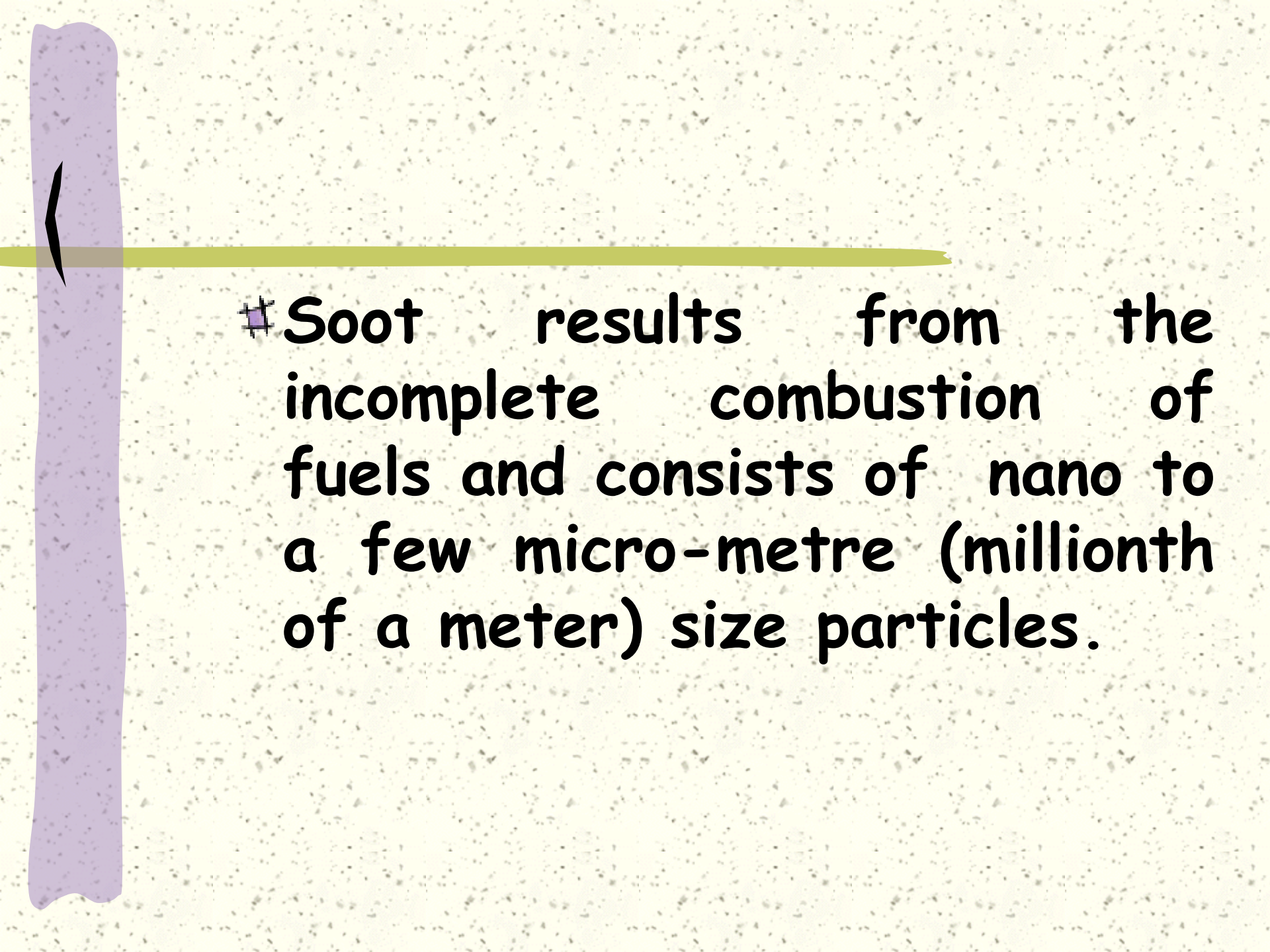
- # Atmospheric Brown Clouds (ABC's) are regional scale slums of air pollution that consists of copious amounts of tiny particles of soot, sulphates, nitrates, fly ash and many other pollutants.



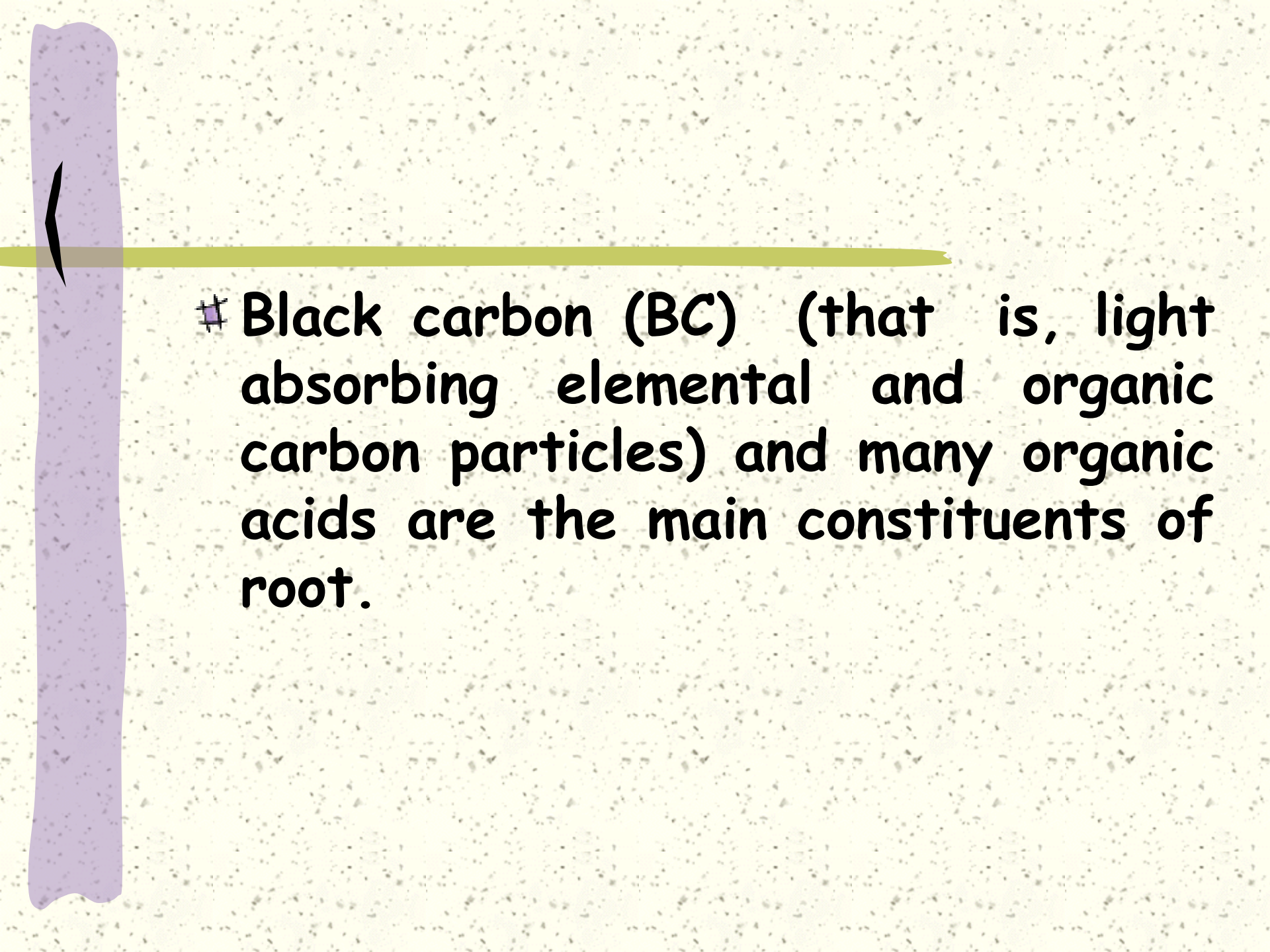
Gases, such as NO_x , CO and many volatile organic compounds (VOCs) are referred to as Ozone precursors since they lead to the production of ozone which is both a pollutant and a strong greenhouse gas.




Aerosols that are formed from gases through chemical changes (oxidation) in the air are referred to as secondary aerosols.



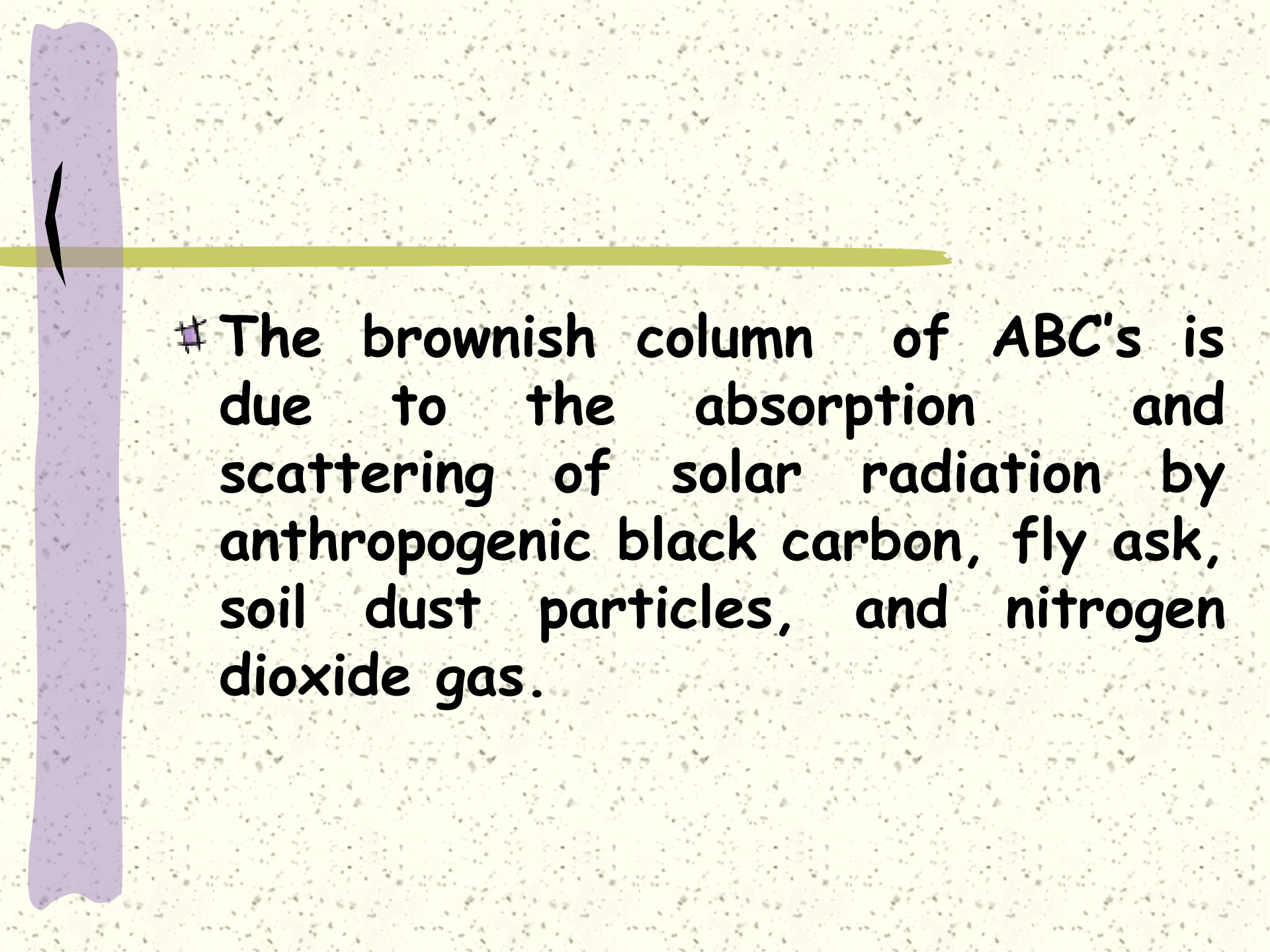
#Soot results from the incomplete combustion of fuels and consists of nano to a few micro-metre (millionth of a meter) size particles.



Black carbon (BC) (that is, light absorbing elemental and organic carbon particles) and many organic acids are the main constituents of root.



Typical background concentrations of aerosols are in the range of 100-300 cm^{-3} , whereas in polluted continental regions the concentrations are in the range 1000-10,000 cm^{-3} .

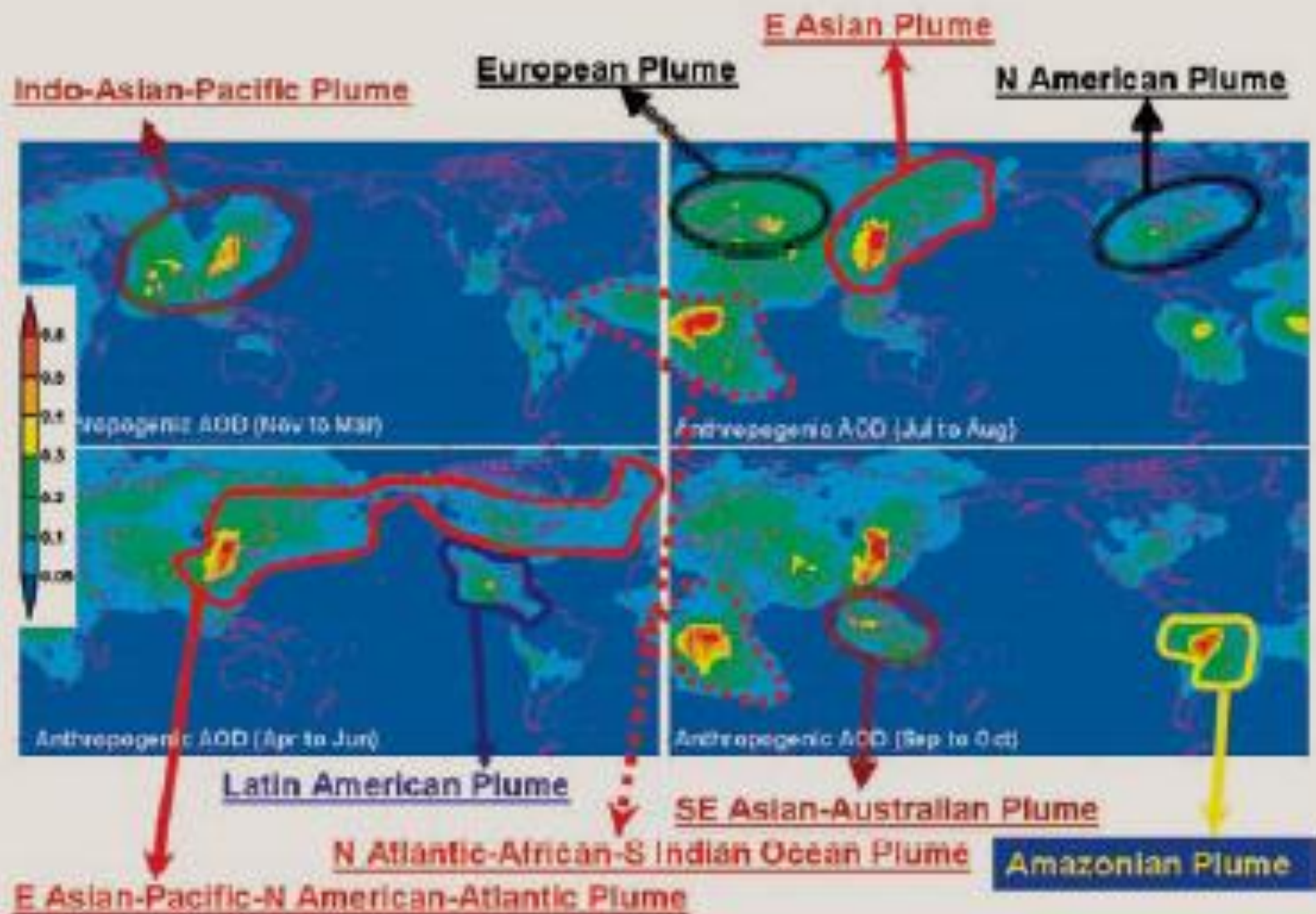


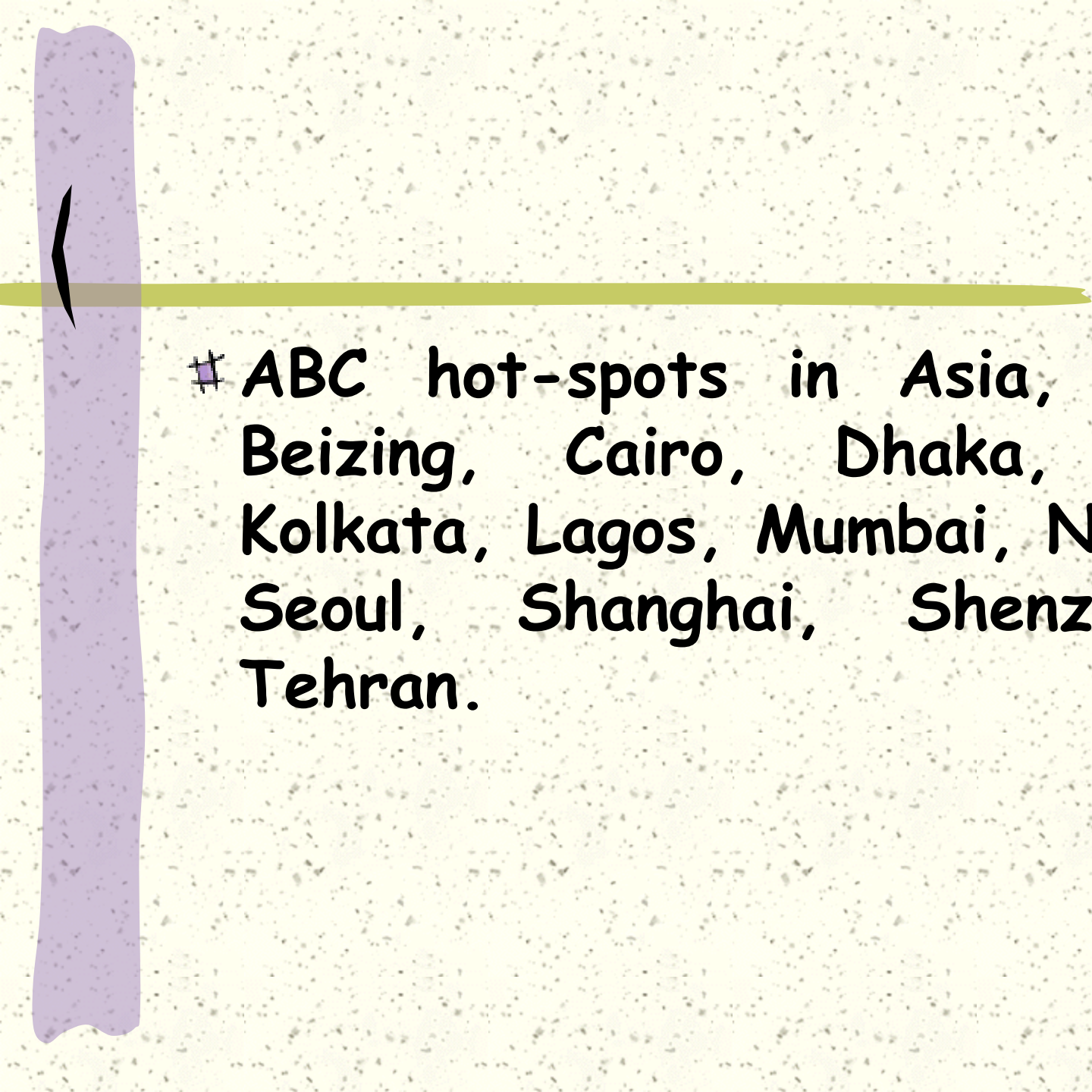
The brownish column of ABC's is due to the absorption and scattering of solar radiation by anthropogenic black carbon, fly ash, soil dust particles, and nitrogen dioxide gas.



Five regional ABC hotspots around the world have been identified.

- # East Asia
- # Indo-Gangetic Plain in South Asia
- # Southeast Asia
- # Southern Africa; and
- # The Amazon Basin.





ABC hot-spots in Asia, Bangkok, Beijing, Cairo, Dhaka, Karachi, Kolkata, Lagos, Mumbai, New Delhi, Seoul, Shanghai, Shenzhen and Tehran.

Facts

- # Brown haze extends over south, southeast and east asia
- # Haze is concentrated 3 kilometers above the surface and can travel halfway around the globe in less than a week
- # Large surface cooling due to reduced sunlight perturbs the hydrological cycle

Brown haze composition

- # Black carbon and ash
- # sulfates
- # Nitrates
- # Mineral dust
- # 75% of the cloud is man-made

Causes

- # Forest fires
- # Inefficient cooking fuels
- # Factories
- # Motor vehicle use

Effects

- # Significant reduction of solar radiation to the surface by as much as 15%
- # Altered regional monsoon patterns (less sea evaporation from sunlight means less rain)
- # Less rain in northwest India, Pakistan, Afganistan & western PRC by as much as 40%
- # More rain and flooding in other areas
- # Reduction in photosynthesis (drop in agricultural productivity)
- # Acid deposition and plant damage
- # Respiratory ailments

Impacts

The 2002 study indicated nearly two million people die each year in India alone from conditions related to brown cloud

The second assessment study published in 2008, highlighted regional concerns

- # Changes of rainfall patterns with the Asian monsoon. The observed weakening Indian monsoon and in China northern drought and southern flooding is influenced by the clouds
- # By displacing the thermal equator southwards via cooling of the air over East Asia, the monsoon which brings most of the rain to these regions has been intensified and displaced southward.

Retreat of the Hindu Kush-Himalaya-glaciers and snow packs. The cause is attributed to rising air temperature that are more pronounced in elevated regions, a combined warming effect of greenhouse gases and the Asian Brown Cloud. Also deposition of black carbon decreases the reflection and exacerbates the retreat. Asian glacial melting could lead to water shortages and floods for the hundreds of millions of people who live down stream

Decrease of crop harvests. Elevated concentrations of surface ozone is likely to affect crop yields negatively. The impact is crop specific.



Geography of Asia, the Hindu Kush-Himalayan - Tibetan glaciers and their river basin

Effects

- # Cities from Beijing to New Delhi are getting darker, glaciers in ranges like the Himalayas are melting faster and weather systems becoming more extreme, in part, due to the combined effects of man-made Atmospheric Brown Clouds (ABCs) and greenhouse gases in the atmosphere.
- # The cloud is also having impacts on air quality and agriculture in Asia increasing risks to human health and food production for three billion people.
- # Prof. Veerabhadran Ramanathan, head of the UNEP scientific panel which is carrying out the research said : "We believe today's report brings ever more clarity to the ABC phenomenon and in doing so must trigger an international response- one that tackles the twin threats of greenhouse gases and brown clouds and the unsustainable development that underpins both," added Prof. Ramanathan who is based at the Scripps Institution of Oceanography, La Jolla, California.

Green House Gases (GHGs)

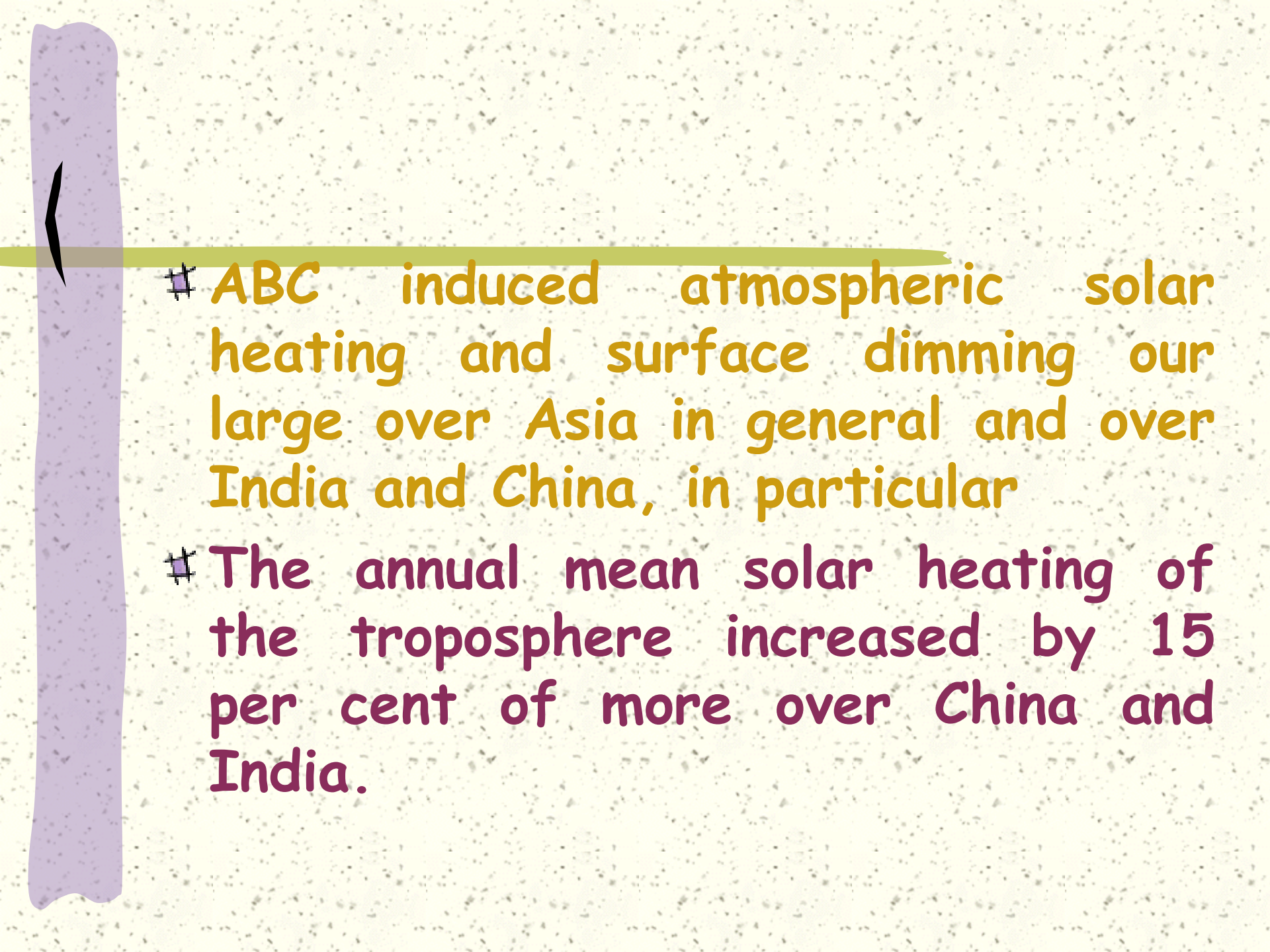
- # Act like a blanket and trap some infra-red (IR) radiation
- # Addition of GHGs enhances this heat trapping effect and reduces the outgoing IR, which leads to warming of the surface and the atmosphere GHG's add energy to both the atmosphere and the surface.

Atmospheric Brown Clouds

- # Aerosols in ABCs intercept solar energy before it reaches the surface and thus perturb temperature, precipitation and biomass production
- # ABCs intercept sunlight by both absorbing it in the atmosphere and by reflecting it (Also referred to as scattering) back to space.
- # Absorption enhances the solar heating of the atmosphere
- # Both absorption and reflection of solar radiation lead to dimming at the surface, that is they reduce the amount of solar energy absorbed at the surface.

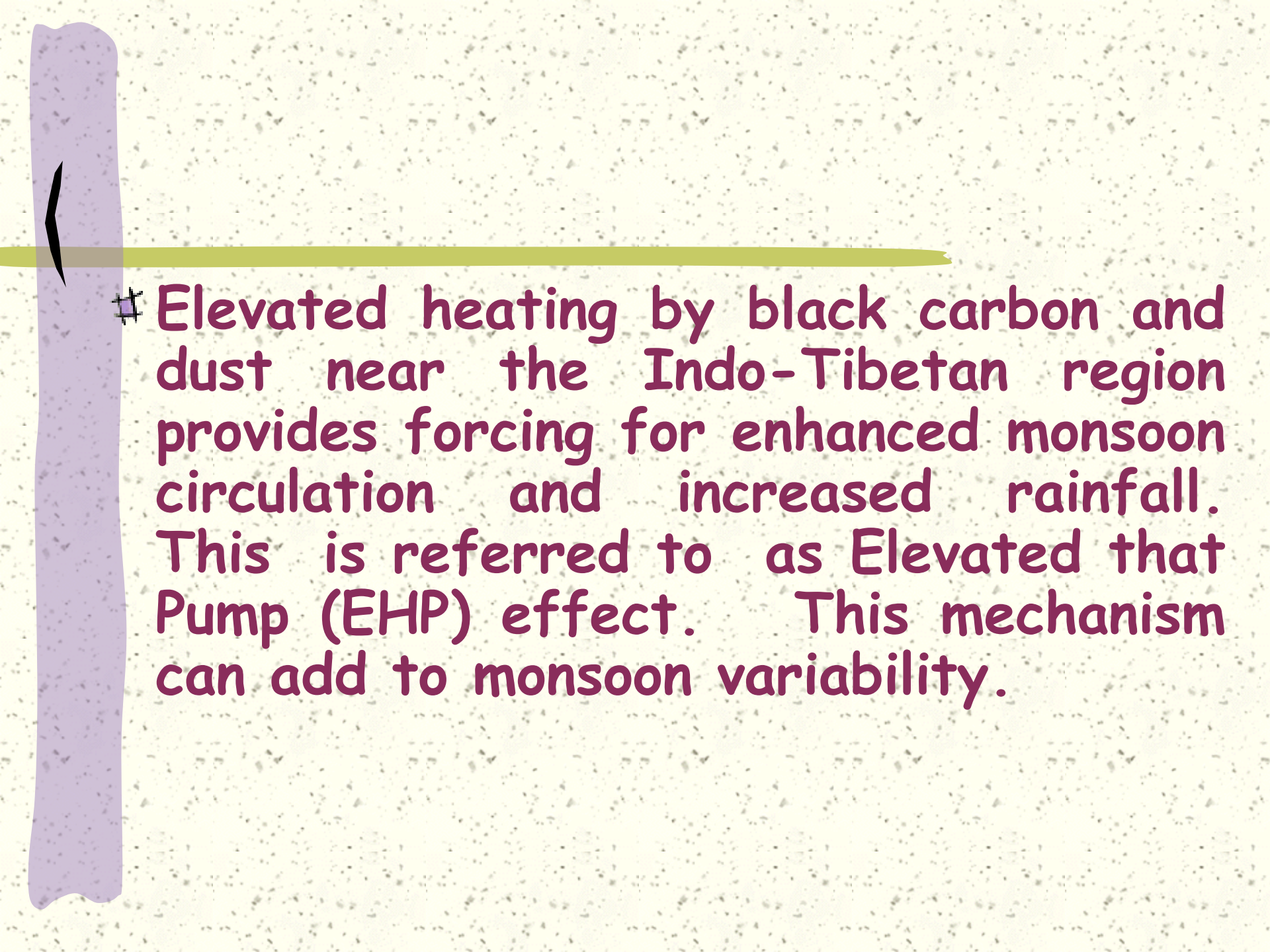
Impact on water, rainfall & photosynthesis

- # Energy from the sun (also referred to as solar radiation or sunlight) is the fundamental forcing agent of the climate system, agriculture and life itself.
- # Sunlight heats the surface and leads to the evaporation of water, which ultimately falls back as rainfall and snowfall.
- # Sunlight is the energy source for photosynthesis.




ABC induced atmospheric solar heating and surface dimming over large over Asia in general and over India and China, in particular

The annual mean solar heating of the troposphere increased by 15 per cent or more over China and India.




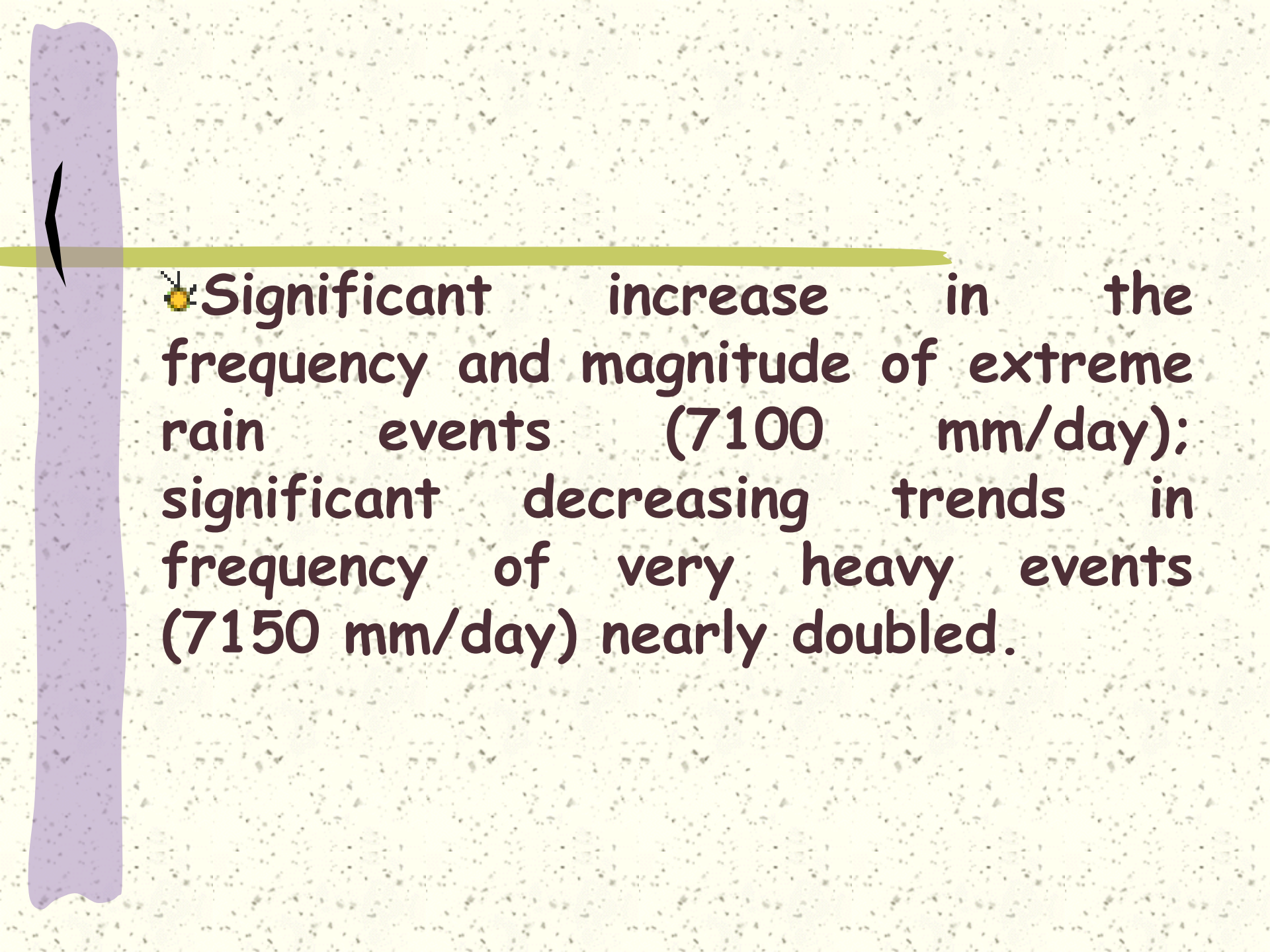
Elevated heating by black carbon and dust near the Indo-Tibetan region provides forcing for enhanced monsoon circulation and increased rainfall. This is referred to as Elevated that Pump (EHP) effect. This mechanism can add to monsoon variability.







A review paper by Lau and others (2008) concluded that EHP (Elevated Heat Pump) can lead to increased rainfall during May-June and the coupled Ocean-Atmosphere effects of dimming, SST gradients and reduced evaporation will take over during the monsoon period of July-August and decrease rainfall.

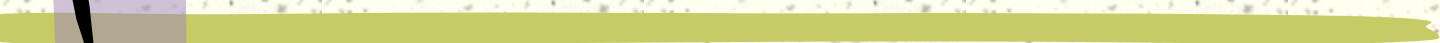

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- # Large (>25%) decrease in early and late season rainfall; and decrease in the number of rainy days (>25%)
 - # Concluded that the monsoon season is shrinking. Spatial coverage of rainfall is also shrinking.




✦ Significant increase in the frequency and magnitude of extreme rain events (7100 mm/day); significant decreasing trends in frequency of very heavy events (7150 mm/day) nearly doubled.



Predicted a substantial increase in hazards due to heavy rainfall events in India.



Used station precipitation data to show that summer precipitation decreased over India by about 5%, model simulated this trend if it included ABC effects.



India averaged rainfall decreased by 4-8% since the 1950s. Predicted a doubling of drought frequency in the next few decades if ABC emissions increase at current rates.



Thanks