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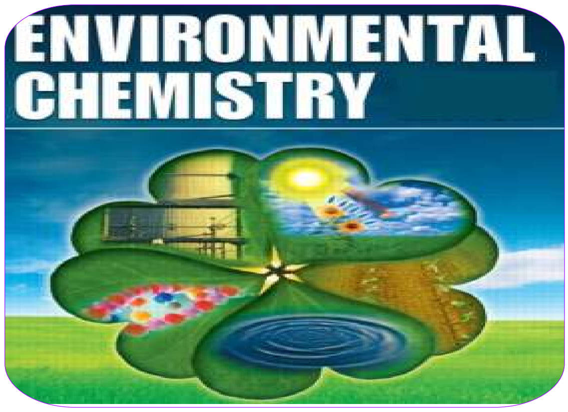
STRATEGIC ENVIRONMENTAL CHEMISTRY ASSESSMENT: KEY ISSUE



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ABSTRACT:
A model for the photochemistry of the global troposphere constrained by observed concentrations of H_20, O_3, CO, CH_4, NO, NO_2, and HNO_3 is presented. Data for NO and NO_2 are insufficient to define the global distribution of these gases but are nonetheless useful in limiting several of the more uncertain parameters of the model. Concentrations of OH, HO_2, H_20_2, NO, NO_2, NOs, N_20_5, HNO_2, HO_2NO_2, $CHsO_2$, CH_3OOH, CH_20, and CH_3CCl_3 are calculated as functions of altitude, latitude, and season. Resuits imply that the source for nitrogen oxides in the remote troposphere is geographically dispersed and surprisingly small, less than 10^7 tons N yr -1. Global sources for CO and CHn are 1.5 x 10^9 tons C yr $^{-1}$ and 4.5 x 10 s tons C yr $^{-1}$, respectively. Carbon monoxide is derived from combustion of fossil fuel (15%) and oxidation of atmospheric CH_4 (25%), with the balance from burning of vegetation and oxidation of biospheric hydrocarbons. Production of CO in the northern hemisphere exceeds that in the southern hemisphere by about a factor of 2.

KEYWORDS: *global troposphere, Atmospheric gases, biospheric hydrocarbons.*

INTRODUCTION

Composition of The Atmosphere

The atmosphere has, broadly speaking, three categories of constituents — major, minor and trace. For pollution-free dry air at ground level, the components may be expressed as per cent by volume, as follows (within parentheses):

Major components:	Nitrogen (78.09),
Oxygen (20.94)	
Watervapour (0.1-5)*.	
Minor components:	Argon (9.34 x 10^{-1}),
	Carbon dioxide (3.25 x 10^{-2})
Trace components:	Neon (1.82 x 10^{-3}),
	Helium (5.24 x 10^{-4}),
	Methane (2 x 10^{-4}),
	Krypton (1. 14 x 10^{-4}),
	Nitrous oxide (2.5 x 10^{-5}),
	Hydrogen (5 x 10^{-5}),

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Xenon (8.7×10^{-8}),
Sulphur dioxide (2×10^{-8})
Ozone (trace),
Ammonia (1×10^{-6})
Carbon monoxide (1.2×10^{-5})
Nitrogen dioxide ($1 X 10^{-5}$),
Iodine (trace)

The parameters of the atmosphere vary considerably with altitude. The density of the atmosphere shows a sharp decrease with increasing alti¬tude. Pressure drops from one atmosphere at sea level to 3×10^{-7} atmos¬phere at 100 km above sea level, while temperature varies from -92° to 1200°C. The total mass of the atmosphere is approximately $5 X 10^{15}$ tonnes, which is roughly one millionth of the earth's total mass.

The corresponding values in parts per million (ppm) are obtained by multiplying the per cent volumes by 104. Thus nitrogen (78.09×10^4) oxygen (20.94×10^4 ppm) carbon dioxide (325 ppm) etc.

ATMOSPHERE STRUCTURE

The atmosphere may be broadly divided into four regions as shown in Table 2.1. It extends up to 500 km with temperatures varying from a minimum of-92° to a maximum of 1200°C.

Table 2.1 Major regions of the atmosphere

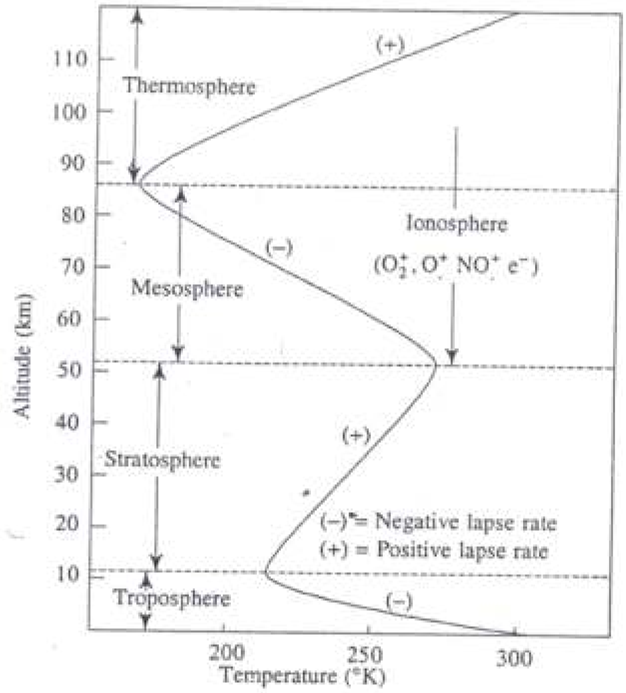
Region	Altitude range, km	Temperature range °C	Important chemical species
Troposphere	0-11	15 to -56	N_2, O_2, CO_2, H_20
Stratosphere	11-50	-56 to -2	O_3
Mesosphere	50-85	-2 to -92	O_2^+, NO^+
Thermosphere	85-500	-92 to 1200	O_2^+, O^+, NO^+

The troposphere contains 70% of the mass of the atmosphere. The upper limit of the troposphere may vary by kilometer or more, depending on, factors such as temperature, nature of terrestrial surface, etc. Air is far from uniform, with respect to density and temperature. Density decreases exponentially with increasing altitude. In respect of composition, the tropo¬sphere is more or less homogeneous in the absence of air pollution, mainly due to the constant circulation of air masses in this region. The water content, however, varies due to the hydrological cycle. The tropo¬sphere is also a turbulent region due to the global energy flow arising from imbalances of heating and cooling rates between the equator and the poles.

The temperature in the troposphere falls off uniformly with increasing altitude. The air near ground level is heated by radiation from the earth. The cold layer (-56°C) at the top of the troposphere is called the tropopause, which marks temperature inversion, i.e. transition from nega¬tive to positive lapse rates (slopes of temperature—altitudes curve: Fig. 2.1).

The stratosphere is the quiescent layer having a positive lapse rate. The temperature increases with increases in altitude, with a maximum of -2°C at the upper limit of the stratosphere. Ozone in this region absorbs ultraviolet radiation and raises the temperature causing a positive lapse rate (Fig. 2.1).

It plays an important role in the stratosphere. It acts as a protective shield for life on earth from the injurious effects of the sun's ultraviolet rays and at the same time, supplies the heat source for partitioning the atmosphere into a quiescent stratosphere and turbulent troposphere. $O_3 + hv(220-330\ mm) \rightarrow O_2 + O$



Major regions of the atmosphere, with temperature profile

Because of slow mixing in the stratosphere, the residence times of mocules or particles in this region are quite long. If the pollutants can somehow reach or are injected into the stratosphere, they pose long-term global hazards compared to their impact in the much denser troposphere.

The mesosphere shows negative lapse rate, i.e. temperature falls with increasing altitude. This is due to low levels of ultraviolet absorbing species, particularly ozone.

In the thermosphere immediately above the mesosphere, the tempera¬ture rises once again, giving a positive lapse rate (maximum temperature 1200°C). Here, the atmosphere gases, particularly oxygen and nitric ox¬ide, split into atoms and also undergo ionization after absorption of solar radiation in the far ultraviolet region.

Carbon Oxides Chemistry

Carbon dioxide (present level 356 ppm), although a relatively insignifi¬cant non-pollutant species in the atmosphere, is of serious environmental concern. It has the potential to rival nuclear wars in terms of massive irreversible damage to the environment.

Among the constituents of the atmosphere, only carbon dioxide and water vapour strongly absorb infrared radiation (14000 to 25000 nm) and effectively block a large fraction of the earth's emitted radiation. The radiation thus absorbed by CO_2 and H_2O vapour is partly re-emitted to the earth's surface. The net result is that the earth's surface gets heated up by a phenomenon called the greenhouse effect.

The current global trend indeforestation along with increased combus¬tion of fossil fuels have a cumulative effect on the net increase in carbon dioxide content. Forests are the areas where a great deal of photosynthe¬sis occurs. Moreover, they maintain vast reservoirs of fixed but readily oxidisable carbon in the form of wood and humus. The overall result is that they serve to maintain a balance in the atmospheric CO_2 level. The combustion of fossil fuel has little effect on the oxygen stock of the atmosphere, which is relatively large, but it has considerable impact on the carbon dioxide content which is only 356 ppm at present. How¬ever, the rate of increase of carbon dioxide is only about 50% of the expected magnitude. The removal mechanisms, i.e. sinks of carbondioxide .

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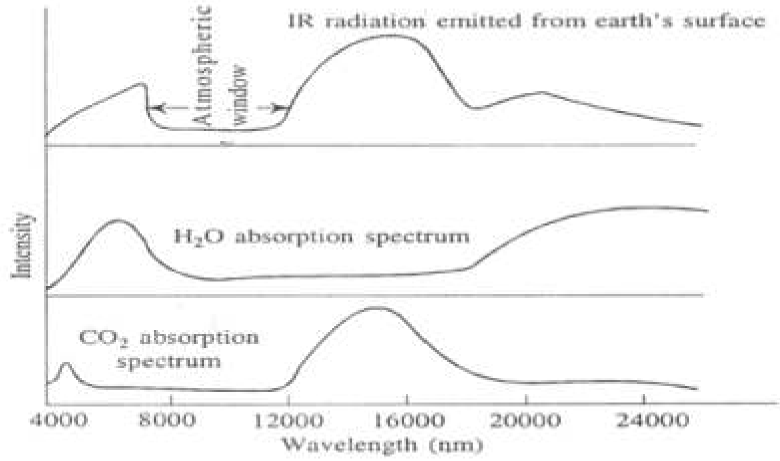
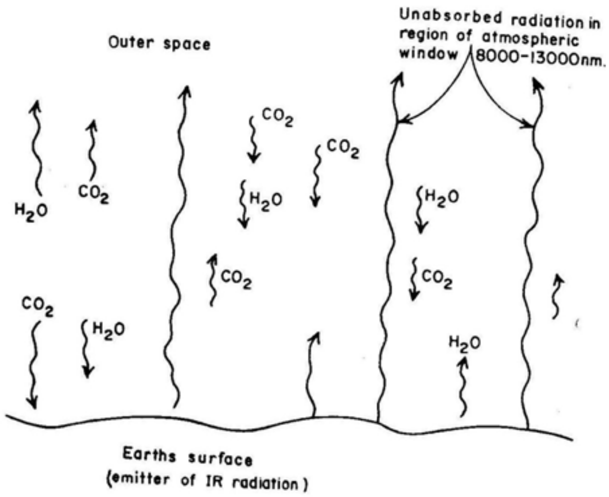
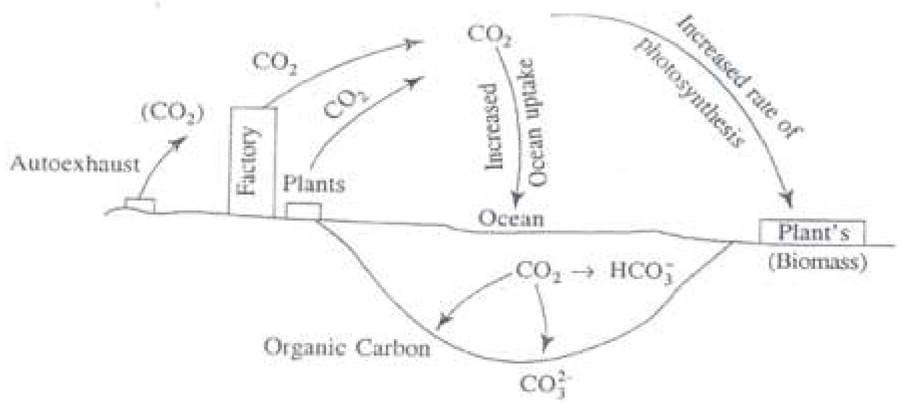


Absorption of terrestrial radiation by water and carbon dioxide



The greenhouse effect

The major sink is the ocean which contains the bulk of dissolved carbon dioxide as bicarbonate. Another important sink is the biomass, viz, living green plants, in which the photosynthesis rate is known to accelerate with increase in the carbon dioxide level.



Sources and sinks of carbon dioxide

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The temperature effects of carbon dioxide and water vapour combine together to have a long range impact on the global climate. As the surface temperature increases with increase in level of carbon dioxide, the evapo¬ration of surface water increases, thereby raising the temperature further. It has been estimated that this combined effect will bring about a 3°C rise in surface temperature for a doubling of the carbon dioxide concen¬tration, which may occur around 2050 A.D.

CONCLUSION

The projected growth in emissions of greenhouse gases and other pollutants in the IPCC SRES scenarios for the 21st century is expected to increase the atmospheric burden of non-CO2 greenhouse gases substantially and contribute a sizable fraction to the overall increase in radiative forcing of the climate. These changes in atmospheric composition may, however, degrade the global environment in ways beyond climate change.

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