Chapter 1
Atmospheric Processes and Climate Change

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ABSTRACT

The atmosphere has a significant impact on the physical environment and the people. The atmospheric processes go hand in hand with surface processes and affect the climate and contribute to the changing climate. The adversely altering environment is not the only issue that comes with climate change, but the impact it has on human and other biological populations is also worrisome and needs to be addressed. Geospatial technologies, which combine remote sensing and geographic information systems, provide flexible cross-scale tools for examining climate change, the long-term evolution of the climate system, and its effects on social and ecological systems. In order to better understand how the Earth, ocean, biosphere, cryosphere, and atmosphere have changed over time, scientists have used long-term satellite data sets. The chapter discusses the various atmospheric processes, their implications, their inter-relationship with land processes, and the application of geospatial methods, in particular remote sensing, for the observation and monitoring of the atmosphere.

1. INTRODUCTION

The atmosphere's state at any given location and time is known as weather. The long-term average range of weather, or the accumulation of daily and seasonal weather events, is what is meant by climate. However, the idea of climate encompasses much more than this, since it also refers to the weather extremes that are specific to a region,

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such as summer heat waves and winter cold spells. The physical environment and how it functions are greatly impacted by the weather. Atmospheric processes, which include the solar influx, scattering, cloud formation, condensation, heat retention, and wind patterns, individually and jointly affect the climate and contribute to the changing climate (Ahrens & Henson, 2018).

The structure of atmosphere changes with elevation. With increasing height from Earth surface, the layers of atmosphere are troposphere (~upto 10 km), stratosphere (from 10 km to 52 km), mesosphere (from 52 km to 85 km), thermosphere (from 85 km to 692 km), and exosphere (from 692 km to 9,978 km) (Ahrens & Henson, 2018). Each of these layers have different composition and concentration of gaseous elements, and with height and concentration, their properties and functioning also changes (Khvostikov, 1965). There are different gas molecules present in all the strata of the atmosphere and based on the gravitational energy, these gases move about and interact with each other. The gravitational fractionation is however, obliterated by turbulence and convective winds (Fleagle & Businger, 1981). The major components of atmosphere are nitrogen and its di-oxides (78.08%), oxygen (20.95%), and argon (0.93%) and the minor components are water (0-4%), carbon-di-oxide, neon, helium, methane, hydrogen, carbon monoxide, ozone and halogen derivatives of organochlorine compounds, with trace components such as ammonia and nitrous oxide (Thompson R., 1998). The concentration of these gases varies with the increasing strata of atmosphere.

Troposphere, the lowest layer of the atmosphere, is primarily made up of N_2, O_2, H_2O and Ar. Majority of the atmospheric processes leading to the formation of weather and climate occur in this layer. One of the main factors affecting global mean climate of the Earth is its energy budget, the equilibrium between the energy the Earth is receiving from the Sun and the energy it is radiating back into space (Krishnan, et al., 2020). The composition of the atmosphere varies the incoming and outgoing radiative flow at the surface thereby affecting the climate. It is clear that variable trace gases contribute significantly to both short-term climate change and how weather systems work. Recently, it is found that role of carbon dioxide in the greenhouse effect and global warming has increased significantly, but other gases like methane, nitrous oxide, and chlorofluoro carbons (CFCs) also play a significant role (Malhi, Kaur, & Kaushik, 2021).

The main causes of the current climate change are human-caused (anthropogenic) emissions of greenhouse gases (GHGs), aerosols, and changes in land use and land cover (LULC) (Krishnan, et al., 2020). GHGs warm the surface by limiting much of the terrestrial radiation of Earth that is lost to space. According to ice core records, atmospheric concentrations of the main GHGs—carbon dioxide, methane, and nitrous oxide—are now higher than they have ever been in the last 800,000 years and there

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