Hydrologic characteristics of an area depend primarily on its climate and geology. Climate is particularly important, because it determines the distribution of rain water for agriculture, hydropower generation, and other human activities with significant economic consequences. Hence, it is essential to have a basic knowledge of the factors that make our climate what it is.

Climate is defined as the long-term average (usually 30 years or longer) of the variations in daily weather in the atmosphere over an area. Weather in the atmosphere at a place is caused by the composite effect of several atmospheric or meteorological variables. The values of these meteorological variables depend upon the composition of the earth’s surface and the exchange of heat and moisture between the earth and the atmosphere resulting from the interaction of many physical processes (see Fig. 4.1).

The various interactive physical processes determining weather and climate are: (a) the motion of earth (orbiting around the sun and the rotation around its own axis); (b) variability in solar radiation; (c) radiation budget; (d) atmospheric circulation; (e) oceanic circulation; (f) the atmospheric content of gases, aerosols, and dust; (g) changes in the land surface, (h) hydrologic cycle; (i) air-sea interaction; and (j) energy exchange. Most fundamental of these processes are radiation and temperature and they constitute the subject matter of this chapter.

The orbital motion of the earth around the sun affects the seasonal amount of radiation received by each hemisphere. Solar radiation varies over time and affects the energy received at the top of the atmosphere. The radiation balance accounts for the heat energy coming from the sun and that radiated by the earth system. Atmospheric circulation determines the flow patterns of air as well as the exchange of heat and moisture over the land and ocean surface. Oceanic circulation strongly affects the temperature of the sea surface and the rate of energy exchange between the atmosphere and oceans. Atmospheric concentration of gases, aerosols and dust affect the amount and type of radiation emitted or absorbed by the atmosphere. Changes...
on the land surface affect the distribution and exchange of energy and moisture, and the albedo (reflectivity). The hydrologic cycle determines the interchange of moisture between earth, oceans and atmosphere. The energy exchange process explains the heat transfer through evaporation, condensation and turbulence. The air-sea interaction involves upwelling and the El Nino and La Nina phenomena.

The above processes and other factors affect atmospheric and oceanic circulation. Hence climate processes are replete with combinations of interactions, feedbacks, and changes. Apparently, changes in these processes and factors affect the distribution of heat and moisture of the earth system and lead to weather and climate variability. During the last two decades, the complexity of atmosphere, land and ocean interactions and the potential for climate change caused by increasing human activities have prompted the development of numerical models to assess the impact of changes in climate in many areas, including agriculture, water resources and land use.

4.1 SUN: THE SOURCE OF HEAT AND LIGHT

Life on earth depends on the immense nuclear furnace we call sun. Larger than a million earths, the sun is practically the main source of heat to drive the climate system. It is a gaseous sphere, and the gases are mostly hydrogen and helium. The sun derives its energy by the gradual conversion of hydrogen into helium by thermonuclear fusion in its deep interior under the extreme conditions of pressure and temperature prevailing there. The radius of the sun is $6.96 \times 10^5$ km ($6.96 \times 10^{10}$ cm) which is about 109 times the radius

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**Fig. 4.1.** Earth’s climate system and interactions among its components.