SCI – HYDROLOGIC CYCLE

The basic hydrologic cycle consists of water rising to the atmosphere through evaporation and transpiration (the loss of water vapour as it moves from the soil through green plants and exits through leaf pores) and returning to the land and oceans through condensation and precipitation. Modern references to the hydrologic cycle distinguish between water vapour and liquid water and liquid water as green water and blue water respectively

Evaporation and Condensation

It is a weak attraction known as hydrogen bonding that holds water molecules (H_2O) together. Below 32°F (0°C), the kinetic energy of the molecules is so low that the hydrogen bonding is strong enough to hold the molecules in place with respect to one another, and the result is ice. At temperatures above freezing, but below boiling (212°F or 100°C), the kinetic energy of the molecules is such that hydrogen bonds keep breaking and reforming with different molecules. The result is liquid water. As the water molecules absorb energy from sunlight or an artificial source, the kinetic energy they gain may be enough to allow them to break away from other water molecules entirely and enter the atmosphere. This process is known as evaporation, and the result is water vapour.

Water vapour is a powerful greenhouse gas. It provides about two-thirds of the total warming from all greenhouse gases. The amount of water vapour in the air is the humidity. Humidity is generally measured as relative humidity—the amount of water vapour as a percentage of what the air can hold at a particular temperature. The amount of water vapour air can hold increases and decreases with the temperature. When warm, moist air is cooled and its relative humidity rises until it reaches 100%, further cooling causes the excess water vapour to condense back to liquid water because the air can no longer hold as much water vapour.

Condensation is the opposite of evaporation. It occurs when water molecules rejoin by hydrogen bonding to form liquid water. If the droplets form in the atmosphere, the result is fog and clouds. (Fog is just a very low cloud.) If the droplets form on the cool surfaces of vegetation, the result is dew. Condensation is greatly facilitated by the presence of aerosols in the atmosphere. Aerosols are microscopic liquid or solid particles originating from land and water surfaces. They provide sites that attract water vapour and

promote the formation of droplets of moisture. Aerosols may originate naturally, from sources such as volcanoes, wind-stirred dust and soil, and sea salts. Anthropogenic sources—sulphates, carbon, and dust—contribute almost as much as the natural sources and can have a significant impact on regional and global climates.

Precipitation

Warm air rises from the Earth's surface because it is less dense that the cooler air above. As it encounters the lower atmospheric pressure at increasing altitudes, the warm air gradually cools as it expands—a process known as adiabatic cooling. When the relative humidity reaches 100% and cooling continues, condensation occurs and clouds form. As condensation intensifies, water droplets become large enough to fall as precipitation. Adiabatic warming occurs as the air descends and is compressed by the higher air pressure in the lower atmosphere.

Precipitation on Earth ranges from near zero in some areas to more than 100inches (2.5m) per year in others. The distribution depends basically on patterns of rising or falling air currents. As air rises, it cools, condensation occurs, and precipitation results. As air descends, it tends to become warmer, causing evaporation to increase and dryness to result.

Convection. Global convection currents and the rain shadow may cause more or less continuously rising or falling air currents over particular regions with major effects on precipitation. Global convection currents occur because the sun heats the Earth most intensely over and near the equator, where rays of sunlight are almost perpendicular to Earth's surface. As the air at the equator, where rays of sunlight are almost perpendicular to Earth's surface. As the air at the equator is heated, it expands, rises and cools; condensation and precipitation occur. The constant intense heat in these equatorial areas ensures that this process is repeated often thus causing high amounts of rainfall, which along with continuous warmth, in turn supports tropical rain forests.

Rising air over the equator is just half of the convection current, however. The air, now dry, must come down again. Pushed from beneath by more rising air, it literally "spills over" to the north and south of the equator and descends over subtropical regions (25° to 35° north and south of the equator), resulting in subtropical deserts. The Sahara of Africa is the prime example. The two halves of the system composed of the rising and falling air make up a Hadley cell.

Because of Earth's rotation, wind are deflected from the strictly vertical and horizontal paths indicated by a Hadley cell and tend to flow in easterly and westerly directions—the trade wins which blow almost continuously from the same direction.

Rain Shadow. The second situation that causes continually rising and falling air occurs when moisture laden trade winds encounter mountain ranges. The air is deflected upward, causing cooling and high precipitation on the windward side of the range. As the air crosses the range and descends on the other side, it becomes warmer and increases its capacity to pick up moisture. Hence, deserts occur on the leeward sides of the mountain ranges. The dry region downwind of a mountain range is referred to as a rain shadow. The severest deserts in the world are caused by the rain-shadow effect. For example, the westerly trade winds, full of moisture from the Pacific Ocean, strike the Sierra Nevada Mountains in California. As the winds rise over the mountains, large amounts of water precipitate out, supporting the lush forests on the western slopes. Immediately east of the southern Sierra Nevada, however, lies Death Valley, one of the driest regions of North America.

Groundwater

As precipitation hits the ground, it may either soak into the ground (infiltration) or run off the surface. The amount that soaks in comparison to the amount that runs off is called the infiltration—runoff ratio.

Runoff flows over the surface of the ground into streams and rivers, which make their way to the ocean or to inland seas. All the land area that contributes water to a particular stream or river is referred to as the watershed for that stream or river. All ponds, lakes, streams, rivers and other waters on the surface of Earth are called surface waters.

Water that infiltrates has two alternatives. The water may be held in the soil, in an amount that depends on the water-holding capacity of the soil. This water, called capillary water, returns to the atmosphere either by way of evaporation from the soil or by transpiration through plants. The combination of evaporation and transpiration is referred to as evapotranspiration.

The second alternative is percolation (a blue water flow). Infiltrating water that is not held in the soil is called gravitational water because it trickles, or percolates down through pores or cracks under the pull of gravity. Sooner or later, however gravitational water encounters an impervious layer of rock or

dense clay. It accumulates there, completely filling all the spaces above the impervious layer. This accumulated water is called groundwater, and its upper surface is the water table. Gravitational water becomes groundwater when it reaches the water table in the same way that rainwater is called lake water once it hits the surface of a lake. Wells must be dug to depths below the water table. Groundwater, which is free to move, then seeps into the well and fills it to the level of the water table.

Human Impacts on the Hydrologic Cycle

A large share of the environmental problems we face today stem from direct or indirect impacts on the water cycle. These impacts can be classified into four categories.

- Changes to Earth's surface,
- Changes to Earth's climate,
- Atmospheric pollution, and
- Withdrawals for human use.