# UNDERSTANDING CLIMATE CHANGE: INTERACTIONS AND INFLUENCES

SEEMA KAUR [1]

[1] DEPARTMENT OF ZOOLOGY, PRAGJYOTISH COLLEGE, GUWAHATI, ASSAM, INDIA.

## ABSTRACT

*The earth's climate is shaped by the complex interplay of various components, including the ocean, atmosphere, geosphere, cryosphere, and biosphere. While external solar energy drives the climate system, changes within these internal components and their interactions, alongside fluctuations in solar radiation, can alter climatic conditions. These alterations, referred to as 'forcings', arise from a multitude of causes operating over diverse timescales. Long-term mechanisms include geological processes and the Milankovitch-Croll effect related to earth's orbital changes, which are linked to ice age cycles. Additionally, tectonic movements and volcanic eruptions can also impact climate patterns. The climate system is influenced by both inherent variability in its components, like ocean currents and phenomena such as El Niño/Southern Oscillation, which can significantly disrupt climate and affect biospheres. Human activities have emerged as a significant factor modifying climate, necessitating a thorough understanding of both natural and anthropogenic influences. Recognizing these complex interactions is crucial for predicting future climate changes and their potential implications.*

**Keywords:** Climate Change, Forcings, Interactions, Anthropogenic.

## INTRODUCTION:

The earth's climate results from the complex interaction of many components, the ocean, atmosphere, geosphere, cryosphere and biosphere. Although the climate system is ultimately driven by the external solar energy, changes to any of the internal components and how they interact with each other, as well as variability in the solar radiation, can lead to changes in climatic conditions. These influences are often considered as 'forcings', changes to the energy inputs and outputs that result in modifications in the climate. Therefore, there are many causes of climate change that operate on a variety of timescales. On the longest timescales are mechanisms such as geological processes and the changes in the earth's orbit around the sun (Milankovitch-Crolleffect). The latter is believed to be the mechanism underlying the cycle of ice ages and interglacial.

Geological processes resulting from the movement of tectonic plates and consequent major changes in physical relief, continental distributions and ocean basin shape and connectivity clearly have influenced global climate patterns. Geological processes can also work on a much shorter timescale through volcanism. Large explosive volcanic eruptions can eject millions of tons of soot and ash into the middle atmosphere where they reflect solar radiation, creating a "global soot veil". In addition to geological and orbital changes, the climate system is sensitive to inherent and periodic internal variability in any one of its components such as ocean currents. These can be on decadal timescales such as the Inter decadal Pacific oscillation or the variations can be on near-inter annual time scales such as the well documented El-Nino/Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO).

During ENSO events when ocean upwelling in the eastern equatorial Pacific is weaker than normal, the resulting changes to sea surface temperatures and to the wind patterns dramatically affect climate and consequently impact the biospherea cross the region.

Climate change involves the interaction of several systems with many variables that must be collectively considered. Natural climate changes have occurred throughout earth's history. Large scale natural events as abrupt as those associated with human environment impacts are known to have occurred in the past. It is now held that human activities are a major factor affecting climate as one of the components of the environment. Climate in turn affects natural vegetation and agriculture.

Only during the past few decades have the scale, intensity and permanence of human impacts on the environment been recognized and begun to be understood. The need to establish the pattern and causes of recent climate change to which human activities have contributed is the main force behind the increasing scientific interest in environmental change. The human induced changes are superimposed on natural changes. The future course of natural climate change may in some cases exacerbate human induced change in other cases such changes may neutralize the human effects (Beniston, 2000). It is essential therefore to view current and future climate change and have a sound knowledge of all the natural and human induced agents of climate change.

**Natural Forcing:** The "Milankovitch theory" suggests that normal cyclic alvariations in three of the earth's orbital characteristics are probably responsible for the past climatic changes. Slight variations in the earth's orbit lead to changes in the distribution and abundance of sunlight reaching the earth's surface. The third cyclic alvariationis related to the changes in the tilt (obliquity) of the earth's axis of rotation. At present the tilt of the earth's axis is 2.5 degrees. When the tilt is small there is less climatic variation between the summer and winter seasons in the middle and high latitude. Periods of larger tilt result in greater seasonal climatic variation in the middle and high latitudes. Colder winters produce less snow because of lower atmospheric temperatures. Moreover the warmer summers produced by the larger tilt provide additional energy to melt and evaporate the snow that fell and accumulated during the winter months. Glaciers in the Polar Regions should be generally receding with other contributing factors constant during this part of the obliquity cycle (Agarwal, 2004).

## ATMOSPHERIC CHEMISTRY VARIATIONS

(***i) Green house gases (GHGs):*** The crux of the enhanced greenhouse effect is that human modification of atmospheric concentration of the key radiation absorbing gases–$CO_2$,$CH_4$, $N_2O$ and various halocarbons – has resulted in a radiative forcing of the climate system. These gases have been released primarily as a result of industrial, transport and domestic activities and to a lesser extent from agricultural activities and land use changes (IPCC, 1996). Radiative forcings by GHGs is the primary cause of global warming. $CO_2$, $CH_4$, CO, $NO_2$, CFCs and $O_3$ have the greatest effect on our climate. Water vapour with high variability abundance (0.5 – 4%) also has strong influence on climate. These trace gases are known as GHGs or radiatively important trace species (RITS) (Hardy, 2003). Green house gas concentrations in the earth's atmosphere have undergone natural changes over time and those changes have been closely followed by changes in climate. Warmer periods were associated with higher GHGs concentrations and cooler periods with lower GHGs concentrations. The main GHGs, their anthropogenic sources and their global warming potential are given in Table 1. Motor vehicle emissions are one of the major sources of GHGs. On clear warm days with a stable atmosphere vehicle combustion hydrocarbons and $NO_2$ undergo a photochemical reaction to produce a hazy air pollution condition called smog with high concentration so fozone. While lower atmosphere (the troposphere) is warming, the upper atmosphere (the stratosphere) is cooling. As GHGs concentrations increase theory predicts that more heat will be trapped in the troposphere instead of escaping to the stratosphere and space. A warmer troposphere will increase evaporation of water from the oceans leading to a general global average increase in atmospheric water vapour and rainfall (Hardy, 2003).

***(ii) Aerosols:*** These are fine particles suspended in the air. Some of these such as sulphate which comes from the sulphur released in coal and oil burning is white so they scatter sunlight and causes cooling. Sulphate aerosols increase acidity of the atmosphere and form acid rain (Hardy, 2003). Black carbon soot is a product of incomplete combustion especially of diesel fuel and coal. Soot absorbs sunlight and thus warms planet. Aerosols tend to increase the number of cloud droplets thus making the clouds brighter and longer lived. Similarly, cement manufacture contributes $CO_2$ when calcium carbonate is heated producing lime and $CO_2$ and also as a result of burning fossil fuels. The cement industry produces 5% of global man made $CO_2$ emissions of which 50% is from chemical processes and 40% from burning fuel. The amount of $CO_2$ emitted by the cement industry is nearly 900kg of $CO_2$ for every 1000 kg of cement produced (Wikipedia.org, 2009).

**El Nino/ Southern Oscillation:** This external for cingh as far reaching implications for many regions including mountains. El Nino/Southern Oscillation (ENSO) represent a huge interplay of coupled ocean atmosphere phenomena. Mountain regions are affected by ENSO events through extreme ees either of drought or floods because of the general reversal of normal precipitation patterns. There is speculation that global warming may enhance the frequency and intensity of ENSO events (Beniston, 2000).

**Volcanic Activity:** A single major eruption that occurs several times per century can affect climate causing cooling for a period of a few years. Huge eruptions known as large igneous provinces occur only a few times every hundred million years but can reshape climate for millions of years and cause mass extinctions. Dust emitted into the atmosphere from large volcanic eruptions is responsible for the cooling by partially blocking the transmission of solar radiation to the earth's surface.

**Anthropogenic Pressure**: The human induced changes are called 'enhanced radiative forcings' and they lead to changes in temperature, precipitation and other climatic variables. Human activities are having major impact on biogeochemical cycles and ecosystems worldwide. Rapid urbanization and changes in rural populations are affecting ecosystems in often drastic ways. Mismanagement of urban development has resulted in unplanned settlements, increase in natural disasters and depletion in natural resources. Proximate drivers are the immediate human activities that drive a particular environmental change, underlying drivers are related to the fundamental needs and desires of individuals and groups (Table 2). Proximate and underlying drivers are the end points in a linked sequence with such intermediate linkages as markets, institutions, infrastructure, policy, political systems and cultural values.

**TABLE 1:** THE MAIN GHGS, THEIR ANHROPOGENIC SOURCES AND THEIR GLOBAL WARMING POTENTIAL FOR 100- YEAR TIME HORIZON. (SOURCE: MODIFIED AFTER UNEP 2001).

| Greenhouse gases | Chemical formula | Anthropogenic Sources | Global warming potential (GWP) |
|---|---|---|---|
| Carbondioxide | $CO_2$ | Fossil fuel combustion, | 1 |

| | | | |
|---|---|---|---|
| Methane | $CH_4$ | Fossil fuels, Rice paddies, Waste dumps, Livestock | 21[a] |
| NitrousOxide | $N_2O$ | Fertilizer, Industrial processes, Combustion | 310 |
| CFC-12 | $CCl_2F_2$ | Liquid coolants, Foams | 6200-7,100[b] |
| HCFC-22 | $CHClF_2$ | Liquid coolants | 1,300–1400[b] |
| Perfluoromethane | $CF_4$ | Production of aluminium | 6,500 |
| Sulfurhexa-fluoride | $SF_6$ | Dielectric fluid | 23,900 |

**TABLE 2:** PROXIMATE AND UNDERLYING DRIVERS OF HUMAN TRANSFORMATION OF EARTH (STEFFEN AND TYSON, 2001).

| | **Proximate Driver** | **Underlying Driver** |
|---|---|---|
| Land | Clearing (cutting forests and burning), agricultural practices (e.g. tillage, fertilization, irrigation, pest control, highyielding crops), abandonment | Demand for food, recreation, and other ecosystem goods and services. |
| Atmosphere | Fossil fuel burning, land use change, biomass burning, industrial technology | Demand for mobility, consumer products, food. |
| Water | Dams, impoundments, waste disposal techniques, management practices | Demand for water (direct human use), food (irrigation), consumer products (water usage in industrial processes). |

## REFERENCES


1. *Agarwal, S.K. 2004. Global warming and climate change. Past, present and future. A.P.H. Publishing Corporation, New Delhi. pp. 364.*

2. *Beniston, M. (ed.) 2000. Environmental Change in Mountains and Uplands. Arnoldand Oxford University Press, pp. 172.*

3. *Hardy, J.T. 2003. Climate change causes, effects and solutions. John Wiley & Sons Ltd. England, pp. 247. http://en.wikipedia.org/wiki/Climate_change,accessed on12.1.2009.*

4. *IPCC, 1996. Climate change: the IPCC second assessment report, 3 volumes. Cambridge University Press, Cambridge.*

5. *Steffen, W. and Tyson, P.(ed.) 2001.Global change and the earth system: a planet under pressure. IGBP Science No. 4: pp. 2–18.*

6. *United Nations Environment Programme (UNEP), 2001. Introduction to climate change. www.grida.no/climate/vital/intro.html*