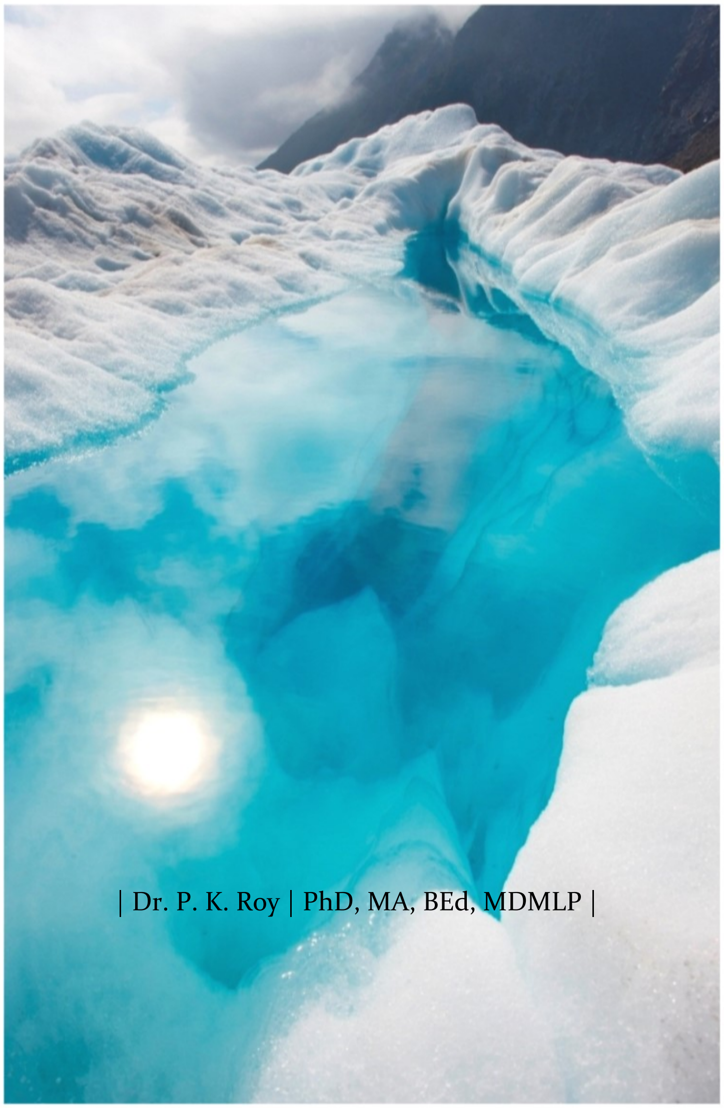
CLIMATE CHANGE: PHENOMENON, EVIDENCES AND PROBLEMS OF DISCOURSES

(LECTURE NOTES)



| Dr. P. K. Roy | PhD, MA, BEd, MDMLP |

DEPT. OF GEOGRAPHY
BHATTADEV UNIVERSITY, BAJALI

MA/MSc Fourth Semester
Course No. GGY 4176
Course Name: Environment and Climate Change
Unit II: Environment and Climate Change (40 Marks)
A Syllabus for CBCS Based PG Core Corse in Geography, 2017
Department of geography
Gauhati University

&

Sixth Semester (M) Course
Paper Code: 601
Paper Title: Environment and Development
Unit 2: Major Environmental Problems
(Two questions carrying 13 marks each, Total 26 marks)
Department of geography
Gauhati University

Course Objectives:

1. To familiarize the students with the emerging environmental problems of climate change and
2. To make the students understand about the dimensions of the problem of climate change.

Course Outcomes:

1. The students will enrich themselves with the concept of climate change.
2. The awareness and sensitisation among the society will increase through the channel of students' community.

CLIMATE CHANGE: THE PHENOMENON, EVIDENCES AND PROBLEMS OF DISCOURSES

Dr. Pankaj Roy
E-mail: pkpathsala.roy@gmail.com

Abstract: *Global climate change is considered one of the major threats to the World Community of this earth as it has no boundary or limitations to any country. Though the recent studies prove that climate change is obvious yet, there are two groups of scientists; one accepts the phenomena of global climate change but, the other group disagrees with the previous school of thought. The climate change issue is one of the most discoursed issues in the present research context. But, the experimentation, execution and explanation of such phenomenon from one aspect are nearly impossible as it has vast dimensions. Though the evidences are available, data are limited yet, researchers are curious about the climate change issue. This paper exercises some real evidences of climate change phenomena and their logistic reasoning and scientific explanations. An attempt has also been made to analyse the problems of discourses of this phenomenon faced by the global scientific society.*

Keywords: *climate change, controversies, evidences, discourses, glacier retreat*

Introduction

How was the climate in the past? How is the climate in the present or in the 21st century? And how it will be in 100 years or 1000 years from now? Scientists are very excited to know the answers of these questions. Many researches and projects have already been done and other more research experiments are going on to find out the solutions of these issues. Climate change is a phenomenon which has been happening since the time immemorial. But now, climate change is a great concern all over the world. It's one of the biggest challenges to the global community living on the earth. If climate change is a phenomenon which has been happening since the time immemorial then, why it's a matter of worry! The real thing is that the rate of climate change has increased manifold in recent few decades especially after the industrial revolution. It's a never ending endeavour by humans as the population pressure, urbanisation, deforestation, industrialisation, luxurious standard of living are rampant in their only and one homeland i.e. the earth as they are accelerating the pace of global climate change. Despite of these it's a matter of fact that population has to increase, it may be in the slowest rate ever in the demographic history of the world but, of course population will rise, they will be urbanised and luxurious. Now question is that,are the humans capable of controlling the emission of harmful gases such as CFCs, Carbon di Oxide, Carbon Mono Oxide, Sulphur di Oxide, etc. which lead to climate change? Are the humans able to increase the vegetation cover of the globe? Are the humans capable of sustainable industrialisation and urbanisation? These are the real challenges in near future before us as the sensible people of the 21st century on this earth.

Definitions of Climate Change

Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods [1].

Climate Change can be defined as a measurable shift in climate such as marked changes in mean temperature or rainfall or altered patterns of extreme weather involving storms, floods or droughts. Such shifts are usually measured against known climate benchmarks averaged over long periods of time, typically 30 years, e.g. 1931-60; 1961-90. Climate change persists for years or longer and can occur at any spatial scale. When widespread, affecting large regions such as whole countries and continents, it becomes a major event [2].

From these two viewpoints climate change can be categorised into two types---Natural Climate Change and Anthropogenic Climate Change. Of course, depending on the time scale the classification of climate change is Long term Climate Change and Short term Climate change.The geologic record indicates that dramatic changes in climate have occurred in the past. These changes occurred in the absence of humans, for the most part, and we can call them natural climate changes. Understanding these natural climate changes is a challenging and important problem that will help us to understand and predict future natural and human-induced climate changes [3].

Controversies of Climate Change

The scientists have different opinions of Climate change among them. It is a matter of concern that climate change is accelerated by the anthropogenic activities according to a group of scientists; but in the same time for another group of scientists, they are in the opinion that climate change is obvious and quite natural as it happened long before in the geological history rather than the anthropogenic aspect and this is why the second group of scientists is not too much worry about it unlike the first group.

Though the climate change controversy is overwhelmed, “the greenhouse effect is not controversial. In fact, according to Stephen H. Schneider of the National Centre for Atmospheric Research in Boulder, Colorado, the phenomenon is ‘one of the best established theories in atmospheric science.’ At least a century ago, Schneider says, scientists knew that while carbon dioxide (CO_2) and other "greenhouse gases" freely allow solar radiation to enter the planet's atmosphere, these gases permit only a portion of the infrared radiation produced to escape back to space. The greenhouse effect explains, for example, why Venus, which has a dense CO_2 atmosphere, is very hot; why Mars, with only a thin CO_2 layer, is ice-cold; and why temperatures on Earth have been ideally suited for plant and animal life. Scientists also have long known that human activities, particularly the burning of fossil fuels, are artificially increasing the volume of greenhouse gases in the earth's atmosphere and that this increase eventually will make the planet the hottest it has been in human history. What remains controversial about the greenhouse effect, says Schneider, is the rate of this global warming, its regional distribution, and, most of all, what to do about the problem. Schneider spoke at a recent conference, the First North American Conference on Preparing for Climate Change: A Cooperative Approach. The meeting addressed two problems-the greenhouse effect and stratospheric ozone depletion. John C. Topping, Jr., president of the Washington, DC-based Climate Institute, which organized the conference, said that the meeting was the largest gathering ever on the subject of adapting to climate change. More importantly, he said, it was the first time that climatologists and ‘climate impact scholars’ (those who study the effects of climate change) had met with a broad array of policy makers, including representatives of state and federal government; electric utilities; chemical, oil and gas industries; forestry and agriculture; automobile makers; and leading environmental organizations. Most participants left the meeting feeling optimistic, Topping said, because the programme focused on specific actions to address a problem far too often viewed fatalistically. He said, ‘People came away seeing that they could divide the issue into chewable pieces and start working on those pieces right now.’

Gigantic environmental experiment as far back as the turn of the century, a few scientists had already begun to worry that massive amounts of CO_2 being released as a result of the Industrial

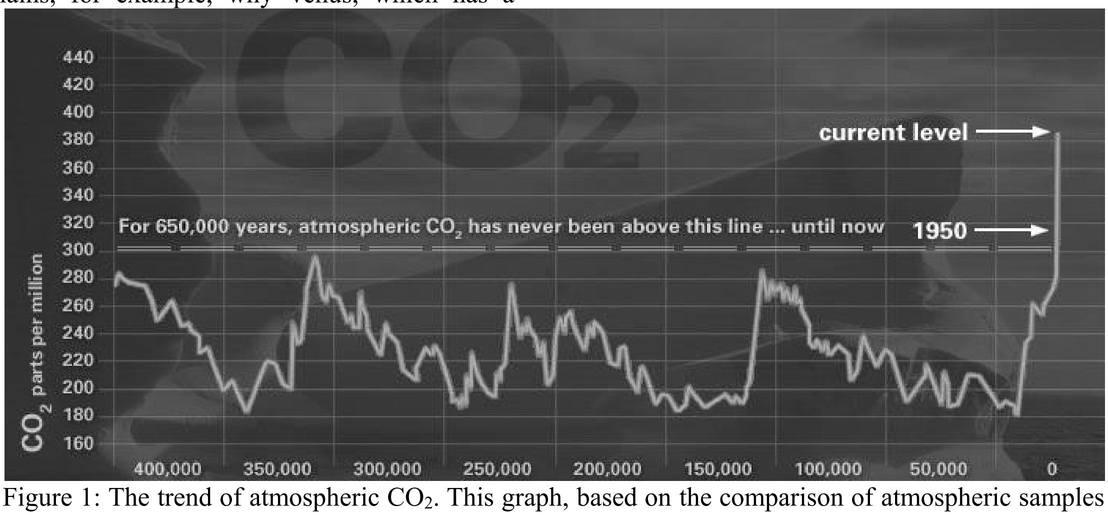


Figure 1: The trend of atmospheric CO_2. This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

Revolution would change the world's climate. In the 1950s, these concerns were supported by measurements demonstrating that atmospheric CO_2 was in fact increasing (Fig 1). In recent years, both data and worries have proliferated, coming to a head in 1985 when a distinguished international group of scientists issued dire warnings following a conference sponsored by the International Council of Scientific Unions, the World Meteorological Organization, and the United Nations Environment Programme. At a hearing the following year before the Senate Committee on Environment and Public Works, Wallace S. Broecker of Columbia University in New York City echoed the concerns of many scientists. 'The inhabitants of planet earth are quietly conducting a gigantic environmental experiment,' Broecker said. 'So vast and so sweeping will be the impacts of this experiment that, were it brought before any responsible council for approval, it would be firmly rejected as having potentially dangerous consequences.

Levels of CO_2 have already increased approximately 25% since 1900. Today most atmospheric scientists agree that, even if fossil fuel emissions are reduced somewhat, CO_2 levels will double by the second half of the 21st century. This doubling will powerfully affect not only global temperatures, but also other physical phenomena, including rain-fall, winds, ocean currents, sea level, and storm patterns. Because the effects of doubled CO_2cannot be studied directly, researchers have relied on global climate models--mathematical representations of the atmosphere that simulate, on computers, climate change under various scenarios. These models generally predict that a doubling of CO_2 levels will cause global mean temperatures to rise between 2^o and 5 ^{o} C. One of the most widely used climate models was developed at the Goddard Institute for Space Studies (GISS) in New York City. According to James E. Hansen, one of the creators of the GISS model, support for the predicted 2^o-5^o C warming comes from empirical as well as theoretical evidence. For example, he said, recently developed palaeoclimate records which show fluctuations in atmospheric CO_2 over the past 100,000 years and correlate these fluctuations with various climate parameters have provided "remarkable confirmation" of the models' predictions.

Still, many uncertainties remain. Oceans, for example, have a tremendous capacity to store heat. Their ability to delay global warming, while considered in the models, remains somewhat uncertain. Clouds are another important yet unpredictable variable. Changes in global temperature and precipitation patterns will certainly alter the number, distribution and kinds of clouds, yet the precise changes and how they will affect climate are unknown. There also are many uncertainties concerning human behaviour, said Schneider. These include population growth, per capita fossil fuel consumption, deforestation and reforestation rates, and the possibility of new technology to mitigate CO_2 build-up. Despite these uncertainties, Schneider says, "there is no disagreement that large climatic changes are highly probable and at rates that are fast relative to rates that have caused significant ecological changes in the past." These changes will dramatically affect both human and natural systems, threatening such crucial activities as agriculture, forestry, fisheries, pollution control, and the protection of parks and preserves. At the conference, scientific panels considered the effects of climate change on these and more than a dozen other activities. It was clear that researchers are just beginning to understand the effects of greenhouse climate changes; it will be many years at least before they are able to tell society how to prepare for those changes" [4].

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. The current warming trend is of particular significance because most of it is very likely human-induced and proceeding at a rate that is unprecedented in the past 1,300 years. Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. Studying these climate data collected over many years reveal the signals of a changing climate [5].

Certain Undisputed Facts of Climate

The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid-19th century. Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many instruments flown by NASA. Increased levels of greenhouse gases must cause the Earth to warm in response [5].

Ice cores drawn from Greenland, Antarctica, and Tropical Mountain glaciers show that the Earth's climate responds to changes in solar output, in the Earth's orbit and in greenhouse gas levels. They also show that in the past, large changes in climate have happened very quickly, geologically-speaking: in tens of years, not in millions or even thousands [6].

Evidences of Climate Change

The Earth's climate has warmed 0.3° to 0.6° C over the last 100 years [7]. The rate of change has varied, with warming occurring most rapidly during the periods 1925-1944 and 1978-1997. Although an average increase of 0.5 ° C is significant for many physiological and ecological systems, this single value understates the magnitude of the changes to which species have been exposed. Temperature changes vary geographically and tend to be greatest during the coldest months. Between 1950 and 1993, for example, winter minimum temperatures rose almost 3° C and spring maximum temperatures increased 1.4 ° C in the northern hemisphere. Changes in precipitation have also occurred [7].

The observation that climate is already changing has promoted re-evaluation of long-term data sets. A number of high-profile papers have resulted, establishing a plausible link between recent changes in climate and observed changes in species and communities (e.g. Parmesan 1996; Brown et al. 1999; Parmesan et al. 1999; Pounds et al. 1999; C. D. Thomas & Lennon 1999). Given the unavoidable constraint on establishing a definitive causal link between large-scale climate patterns and species and communities, the overall picture provided by the combination of these studies is needed to best evaluate the insights this emerging body of work can provide to conservation biology [8].

We can find evidence of the Earth’s past climates from the distant geological past to the most recent millennium. For example, coal deposits tell us of a tropical climate that existed in the Carboniferous period, while we can find signs that ice once existed in certain areas in the way it has shaped the landscape and the deposits it has left behind. Direct instrumental records really began about 200 years ago with the advent of modern instrument like thermometers, rain gauges and anemometers. While they provide a fairly accurate record, they have been around for too short a period to sample the whole range of climate changes that have taken place in the past, and that could occur again in the future [9].

Some Evidences of Climate Change

Muir Glacier melt, Alaska

The Muir Glacier has undergone very rapid, well-documented retreat since its Little Ice Age maximum position at the mouth of Glacier Bay around 1780 [10]. Between 1941 and 2004 the glacier retreated more than twelve kilometres and thinned by over 800 meters. The evidences of Muir Glacier (Fig. 2) clearly depicts that ocean water has filled the valley replacing the ice.

O'Higgins Glacier Melt, Chile

Almost all the glaciers in the southern Patagonian ice field, in the south of Chile and Argentina, are melting. O'Higgins Glacier, which makes up a quarter of the ice field, is one of those that have changed the most. Its leading edge remained stable until the start of the twentieth century, when it began a retreat that measured 15 kilometres (about 9 miles) by 1995. Some 12 kilometres (over 7 miles) of ice were lost between 1945 and 1980 alone. While some of the reduction in the glacier’s thickness and area is due to the dynamics of the ice itself, global warming speeds up the rate of melting. In the 2007 satellite image, the glacier's retreat is quite visible relative to the 1973 image (Fig. 3), when it extended several kilometres into O'Higgins Lake (purple-blue area).

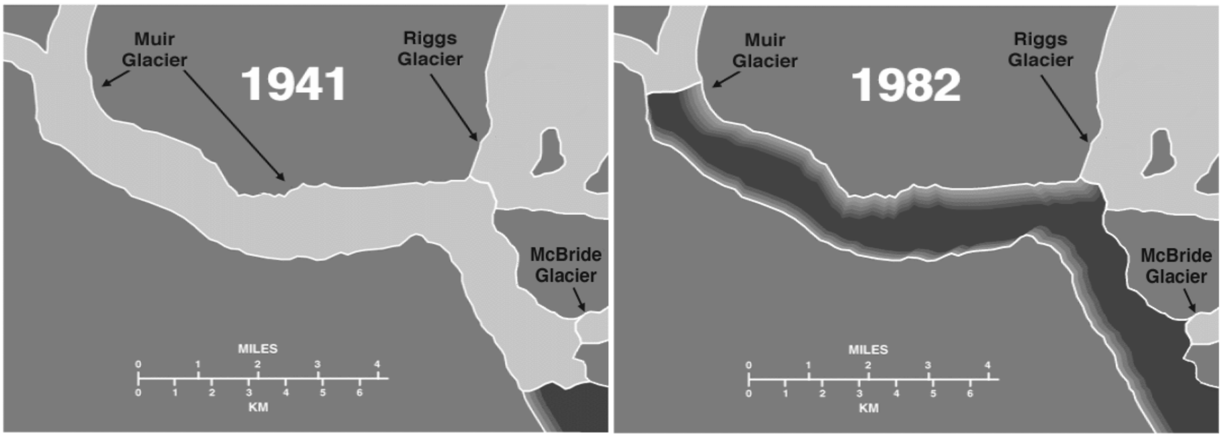


Figure 2: The retreat of Muir Glacier, Alaska between 1941 and 1982 of National Snow and Ice (Adopted from Wikipedia)

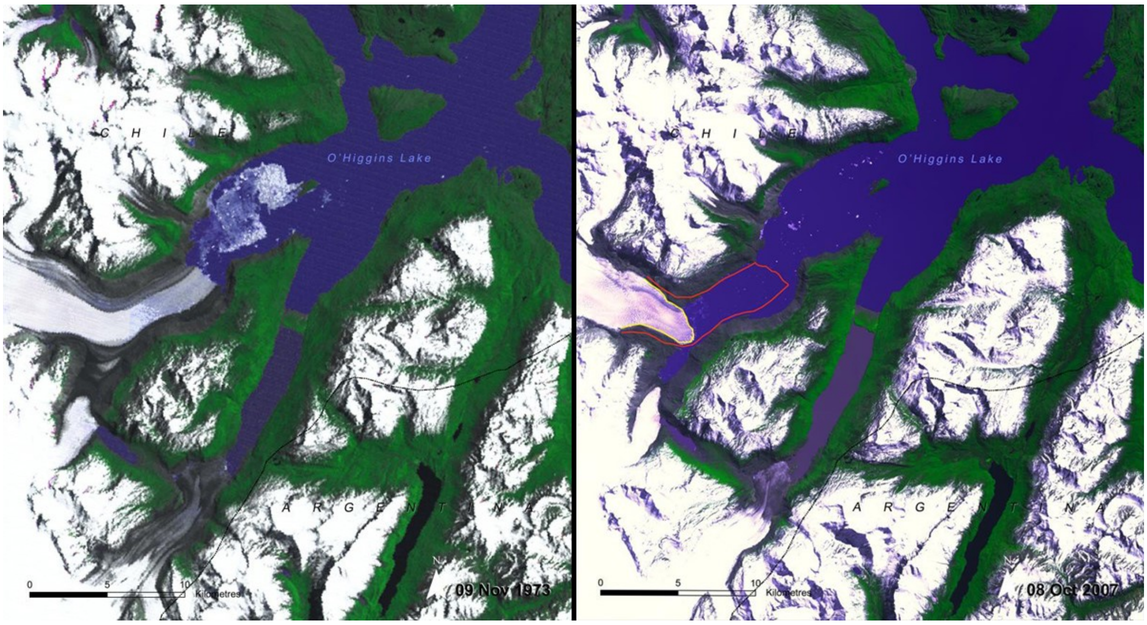


Figure 3: O'Higgins Glacier melt, Chile between 1973 and 2007(Left image is of 1973 and right image is of 2007) Source: United Nations Environment Programme (UNEP) From Latin America and the Caribbean Atlas of our Changing Environment (2010)

Ice Melt, Uganda and Democratic Republic of Congo

It may seem strange to think of glaciers on the equator, but they do exist on the Rwenzori Mountains between Uganda and Democratic Republic of the Congo. But the glaciers atop Speke, Stanley and Baker peaks have been diminishing, as is evident from the images (Fig. 4). They shrank by half between 1987 and 2003. Though seasonal changes account for some of the difference seen here, increased air temperature and decreased snow accumulation are generally blamed for most of the loss. Also, decreased cloud cover may have contributed to a higher rate of sublimation, in which ice vaporizes without first melting. A century ago, the glaciers covered nearly 6.5 square kilometres (2.5 square miles). At their current rate of recession, they will be gone within the next two decades according to researchers' estimate.

Shrinking Ice Sheets of Greenland and Antarctic

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity

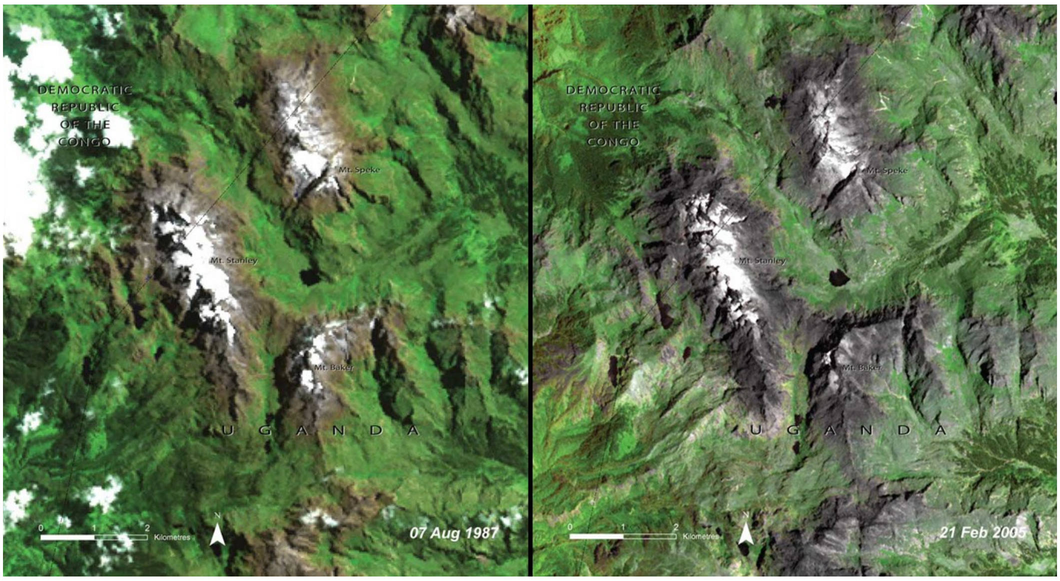


Figure 4: Stanley and Baker peaks have been diminishing, as is evident in these images. They shrank by half between 1987 and 2005. Source: United Nations Environment Programme (UNEP) From Africa Atlas of our Changing Environment (2008)

Figure 4: Ice melt in Alaska and Greenland over the years

FACT BOX: Status of Global Forest Cover

The global forest cover is 3952 million ha (Table 1), which is about 30 percent of the world's land area. Most relevant for the carbon cycle is between 2000 and 2005, gross deforestation continued at the rate of 12.9 million ha/yr. This is mainly as a result of converting forests to agricultural land, but also due to expansion of settlements, infrastructure and unsustainable logging practices. In the 1990s, gross deforestation was slightly higher, at 13.1 million ha/yr. Due to afforestation, landscape restoration and natural expansion of forests, the most recent estimate of net loss of forest is 7.3 million ha/yr. The loss is still largest in South America, Africa and Southeast Asia. This net loss was less than that of 8.9 million ha/yr in the 1990s. Thus, carbon stocks in forest biomass decreased in Africa, Asia, and South America, but increased in all other regions. According to FAO, globally net carbon stocks in forest biomass decreased by about 4,000 MtCO2 annually between 1990 and 2005 (Table 1). The area of forest plantation was about 140 million ha in 2005 and increased by 2.8 million ha/yr between 2000 and 2005, mostly in Asia (quoted FAO, 2006a). According to the Millennium Ecosystem Assessment (quoted 2005b) scenarios, forest area in industrialized regions will increase between 2000 and 2050 by about 60 to 230 million ha. At the same time, the forest area in the developing regions will decrease by about 200 to 490 million ha. In addition to the decreasing forest area globally, forests are severely affected by disturbances such as forest fires, pests (insects and diseases) and climatic events including drought, wind, snow, ice, and floods. Degradation defined as decrease of density or increase of disturbance in forest classes, affected tropical regions at a rate of 2.4 million ha/yr in the 1990s [11].

Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometres (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometres (36 cubic miles) of ice between 2002 and 2005 [5].

Bear Glacier Melt, Alaska

The Bear Glacier of Alaska is a clear indication of increasing temperature in the higher altitude which marks the global climatic change. The series of images from Fig. 5 shows the shrinkage of Bear Glacier from 1980 to 2011. Warming in the region has caused less build-up of snow and therefore less material for glacial growth. As the glacier has receded, ice at the end of the glacier has broken off the main body, forming icebergs in the open water. The left image was taken in 5^{th} June, 1980 by the Multispectral Scanner on-board Landsat 3. The centre image was taken in 16^{th} May, 1989 by the Thematic Mapper sensor on-board Landsat 4 and the right image was taken in 13^{th} May, 2011 by the Enhanced Thematic Mapper Plus sensor on-board Landsat 7. The 2011 image shows considerable retreat of the glacier's "tongue." The massive shrinkage can be observed from the image of 1980 and 2011of the same glacier.

Table 1Table 1: Estimates of forest area, net changes in forest area, carbon stock in living biomass and growing stock in 1990, 2000 and 2005

Region	Forest area (mill. ha)	Annual change (mill. ha/yr)		Carbon stock in living biomass ($MtCO_2$)			Growing stock in 2005 (million m^3)
	2005	1990-2000	2000-2005	1990	2000	2005	
Africa	635.412	-4.4	-4.0	241,267	228,067	222,933	64,957
Asia	571.577	-0.8	1.0	150,700	130,533	119,533	47,111
Europe*	1001.394	0.9	0.7	154,000	158,033	160,967	107,264
North & Central America	705.849	-0.3	-0.3	150,333	153,633	155,467	78,582
Oceania	206.254	-0.4	-0.4	42,533	41,800	41,800	7,361
South America	831,540	-3.8	-4.3	358.233	345,400	335,500	128,944
World	3,952,026	-8.9	-7.3	1,097,067	1,057,467	1,036,200	434,219

* Including all of the Russian Federation. Negative numbers indicate decrease. Source: FAO, 2006a (Adopted from Climate Change 2007 Mitigation, p.545)

Problems of Climate Change Discourses

A mere talking about climate change is so easy but, the realization of real facts comes from scientific studies which need various databases across the globe in temporal resolution and their systematic statistical analysis. But the real challenge ahead of the global scientific community is that the shortage of relevant data especially in the third world countries. Some of the problems of scientific study about climate change are highlighted here taking from the Synthesis Report on Climate Change 2007. These are:

i. Climate data coverage remains limited in some regions and there is a notable lack of geographic balance in data and literature on observed changes in natural and managed systems, with marked scarcity in developing countries.

ii. Analysing and monitoring changes in extreme events, including drought, tropical cyclones, extreme temperatures and the frequency and intensity of precipitation, is more difficult than for climatic averages as longer data time-series of higher spatial and temporal resolutions are required.

iii. Effects of climate changes on human and some natural systems are difficult to detect due to adaptation and non-climatic drivers.

iv. Difficulties remain in reliably simulating and attributing observed temperature changes to natural or human causes at smaller than continental scales. At these smaller scales, factors such as landuse change and pollution also complicate the detection of anthropogenic warming influence on physical and biological systems.

v. The magnitude of CO_2 emissions from land-use change and CH_4 emissions from individual sources remain as key uncertainties [1].

Conclusion

Despite of the on-going controversies, climate change is a fact of reality which has been proved by evidences available worldwide. The challenges before the global scientific community involved in climate change studies is to find out the solutions so that the global society can tackle the problem with the limited resources at hand and technology available to them despite of problems faced and acute data shortages.

References

[1] Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Davidson, O., et al. (2007). *Climate Change 2007: Synthesis Report.* Cambridge: Cambridge University Press.

[2] O'hare, G., Johnson, A., & Pope, R. (2005, Autumn). Current shifts in abrupt climate change: the stability of the North Atlantic Conveyor and its influence on future climate. *Geography,* 90(3), 250-266.

[3] Hartmann, D. L. (1994). *Global Physical Climatology* (1st ed., Vol. 56). (R. D. Holton, Ed.) Washington, Seattle, USA: Academic Press.

[4] Tangley, L. (1988, January). Preparing for climate change. *BioScience,* 38(1), 14-18.

[5] http://climate.nasa.gov/evidence/. (n.d.). Retrieved 07 30, 20013, from NASA: http://climate.nasa.gov/evidence/

[6] National Research Council, (. (2006). Surface temperature reconstructions for the last 2,000 years. *National Research Council (NRC).* Washington, DC: National Academy Press.

[7] IPCC. (1996). *Intergovernmental Panel on Climate Change (IPCC).* New York: Cambridge University Press.

[8] McCarty, J. P. (2001, April). Ecological consequences of recent climate change. *Conservation Biology,* 15(2), 320-331.

[9] Huddart, D., & Stott, T. (2010). *Earth Environments: Past, Present and Future* (1st ed.). Chichester, West Sussex, UK: Wiley-Blackwell.

[10] Hall, D. K. (1995). Changes of glacier in Glacier Bay, Alaska, using ground and satellite measurements. *Physical Geography,* 27-41.

[11] Nabuurs, G. J., Masera, O., Andrasko, K., Benitez-Ponce, P., Boer, R., Dutschke, M., et al. (2007). Forestry. In O. D. B. Metz, *Climate Change* (p. 545). Cambridge, New York, NY, United Kingdom, USA : Cambridge University Press.