American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-5, pp-144-155
www.ajer.org
Research Paper Open Access

The Case of Global Warming and Climate Change: A Study of Aksaray, Central Anatolian-Turkey

Burhan Davarcioglu
Department of Physics, Aksaray University, Aksaray, Turkey

ABSTRACT: *Climate is the average weather conditions experienced in a particular place over a long period. Turkey is one of the sensitive areas to climate variation in the world. Global warming has become familiar to many people as one of the most important environmental issues of our day. Climate change is disrupting national economies and affecting lives, costing people, communities and countries clearly today. Climate change emerges as a multifaceted global problem those results in serious environmental and socio-economic consequences. Associated with this warming are changes of climate. Climate change could well be the most severe challenge facing our planet during the 21st century. Tackling the climate challenge therefore requires bridging gaps between scientific disciplines and between science and policy. Dynamic and intensified changes in the global ecosystem result in significant disruptions to the natural environment. Most people recognize from their own experience that we have weather in all its infinite and wonderful variety, so that there are large variations in temperature and precipitation from day to day and week to week. The main income of the country is agriculture and agriculture based industry. Many of the likely characteristics of the resulting changes in climate (such as more frequent heat waves, increases in rainfall, increase in frequency and intensity of many extreme climate events) can be identified. Increase in the extreme temperatures due to natural and human driven climate change is expected to worsen each year. In this article, a study of Aksaray (Central Anatolian-Turkey) region in the case of global warming and climate change. Global warming has not stopped, it is merely manifested in different ways.*

Keywords: *Global warming, Climate change, Temperature, Environmental, Central Anatolian*

I. INTRODUCTION

The basic principle of global warming can be understood by considering the radiation energy from the sun that warms the earth's surface and the thermal radiation from the earth and the atmosphere that is radiated out to space. As commonly understood, global warming refers to the effect on the climate of human activities, in particular the burning of fossil fuels (coal, oil and gas) and large scale deforestation activities that have grown enormously since the industrial revolution, and are currently leading to the release of about seven billion tonnes of carbon as carbon dioxide into the atmosphere each year together with substantial quantities of methane, nitrous oxide and chlorofluorocarbons. Climate change is arguably the most severe challenge facing our planet during the 21st century. Human interference with the climate system (mainly through the emission of greenhouse gases and changes in land use) has increased the global and annual mean air temperature at the Earth's surface by roughly 0.8 °C since the 19th century. This trend of increasing temperatures will continue into the future: by 2100, the globe could warm by another 4 °C or so if emissions are not decisively reduced within the next decades [1]. There is broad agreement that a warming of this magnitude would have profound impacts both on the environment and on human societies, and that climate change mitigation via a transformation to decarbonized economies and societies has to be achieved to prevent the worst of these impacts [2, 3].

There is a wide range of global threats that certainly require humanity's urgent attention. These global risks include for example; water, food and energy security, population growth, infectious diseases, and international security. However, climate change is often regarded as one of the most profound global problems. This is mainly due to the sheer scale of climate change impacts both in terms of its global and temporal spread and of the variety of sectors affected by it that sets it apart from other planetary challenges. Adaptation to the inevitable impacts and mitigation to reduce their magnitude are both necessary. The international climate effort has focused predominantly on mitigation. The next stage of the international effort must deal squarely with adaptation coping with those impacts that cannot be avoided [4]. In order to establish the necessary strategies and enhance institutional capacity for Turkey to combat and manage the effects of climate change, a United Nations (UN) Joint Programme titled "Enhancing the Capacity of Turkey to Adapt to Climate Change" was carried out between 2008 and 2011. The Joint Programme aimed at integrating the climate change adaptation into national, regional and local policies within the framework of future development targets of Turkey in terms of sustainability [5].

We have seen that climate change is complex and variable both in space and time. The likely impacts on human communities and ecosystems will also be complex. There is also much variability in important factors relevant to climate change such as sensitivity (i.e. the degree to which a system is affected either adversely or beneficially), adaptive capacity (i.e. the ability of a system to adjust) and vulnerability (i.e. the degree to which a system is susceptible to or unable to cope with adverse effects). Different ecosystems, for instance, will respond very differently to changes in temperature, precipitation or other climate variables. For humans, it is the least developed countries that in general are most vulnerable; they are likely to experience more of the damaging climate extremes and also have less capacity to adapt. A few impacts of climate change will be positive so far as humans and ecosystem productivity are concerned. For instance, in parts of Siberia or Northern Canada increased temperature will tend to lengthen the growing season with the possibility of growing a greater variety of crops. However, because over centuries human communities have adapted their lives and activities to the present climate, most changes in climate will tend to produce adverse impacts. If changes occur rapidly, urgent and possibly costly adaptation to a new climate will be required by the affected community. An alternative might be for that community to migrate to a region where less adaptation would be needed a solution that has become increasingly difficult or, in some cases, impossible in the modern crowded world [6]. Further, adverse impacts are likely to lead to insecurity and conflicts particularly due to increased competition for scarce resources.

The assessment of climate change impacts, adaptations and vulnerabilities draws on a wide range of physical, biological and social science disciplines and consequently employs a large variety of methods and tools. It is, therefore, necessary to integrate information and knowledge from these diverse disciplines. Assessment of the impacts of global warming is also made more complex because global warming is not the only human induced environmental problem. Loss of soil and its impoverishment (through poor agricultural practice), over extraction of groundwater and damage due to acid rain are examples of environmental degradations on local or regional scales that are having a substantial impact now [7]. The global water cycle is a fundamental component of the climate system. Water is cycled between the oceans, the atmosphere and the land surface. Water is also an essential resource for humans and for ecosytems. During the last 60 years water use has grown over threefold [8]; it now amounts to about 10% of the estimated global total of river and groundwater flow from land to sea. Increasingly, water is used for irrigation. In Turkey about 75% of available water is so used. Water from major rivers is often shared between nations; its growing scarcity is a potential source of conflict. In many areas, groundwater extraction greatly exceeds its replenishment a situation that cannot continue indefinitely. With global warming, there will be substantial changes in water availability, quality and flow. On average, some areas will become wetter and others drier. Much of these changes will exacerbate the current vulnerability regarding water availability and use. Especially vulnerable will be continental areas where decreased summer rainfall and increased temperature result in a substantial loss in soil moisture and increased likelihood of drought [9].

Impacts of climate change on fresh water resources are likely to be exacerbated by other pressures, e.g. population growth, land use change, pollution and economic growth. Some of the adverse impact on water supplies can be reduced by taking appropriate alleviating action, by introducing more careful and integrated water management and by introducing more effective disaster preparedness in the most vulnerable areas. Substantial uncertainties remain in knowledge of some of the feedbacks within the climate system (that affect the overall magnitude of change) and in much of the detail of likely regional change. Because of its negative impacts on human communities (including for instance substantial sea-level rise) and on ecosystems, global warming is the most important environmental problem the world faces [10]. The largest contribution to sea-level rise in the 21st century is expected to be from the thermal expansion of ocean water as it warms. About 10% of the world's land area is under cultivation. The rest is to a greater or lesser extent unmanaged by humans, of this about 30% is natural forest. Within this area climate is the dominant factor determining the distribution of biomes. Large changes in this distribution have occurred during the relatively slow climate changes in the past. It is the very rapid rate of change of climate that will cause excessive stress on many systems. How much it matters depends on the species and the degree of climate change (e.g. temperature increase or water availability). Two particularly vulnerable types of species are trees and coral. The viability of some large areas of tropical forests under climate change is of especial concern. Many corals are already suffering from bleaching caused by increased ocean temperatures. Further, as large quantities of extra carbon dioxide are dissolved in the oceans, their acidity increases posing a serious threat to living systems in the oceans especially to corals [4].

The Intergovernmental Panel on Climate Change (IPCC) was formed jointly by two United Nations bodies, the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) with a remit to prepare thorough assessments of climate change, its causes and effects. The panel established three working groups, one to deal with the science of climate change, one with impacts and a third with policy responses. The IPCC has produced three main comprehensive reports, in 1990, 1995 and 2001 together with a number of special reports covering particular issues. Three important factors have contributed to the authority and success of the IPCC's reports [10-13]. The first is the emphasis on delineating between what is known with reasonable certainty and what is uncertain differentiating so far as possible between degrees of uncertainty. The second is the involvement in the writing and reviewing of the reports of as many as possible of the world's climate scientists, especially those leading the field. For the third assessment report in 2001, those taking part had grown to 123 lead authors and 516 contributing authors, together with 21 review editors and 420 expert reviewers involved in the review process. The thorough debate by scientists during the assessment process ensures that the scientific community is well informed on a broad front. No previous scientific assessments on this or any other subject have involved so many scientists so widely distributed both as regards their countries and their scientific disciplines. A third factor arises because the IPCC is an intergovernmental body and governments are involved in its work [11, 14].

Research and assessment communities meet: in the absence of an internationally agreed-upon and funded climate research strategy, the World Climate Research Programme (WCRP), on behalf of the WMO, the International Council for Science, and the Intergovernmental Oceanographic Commission, assumes the daunting tasks of planning and coordinating international efforts on climate research. The WCRP, a multinational consortium established in 1980, has undergone internal refreshment and refocusing since 2011. Following extensive engagement with the research community, WCRP identified five climate science "grand challenges". These call for community focus and rapid progress on the following topics: clouds and atmospheric circulation, regional sea level, climate extremes, water availability, and rapid cryosphere changes. The WCRP seeks to understand and predict present and future flows of heat, water, and carbon in atmospheric, land, oceanic, and ice systems through skillful use, intercomparison, and sharing of models and observations.

This paper partially presents the spatial and temporal characteristics of Turkey's annual rainfall data in the context of climatic variability. However, regional and country wide changes in long-term annual rainfall totals and main characteristics of the rainfall climatology for the whole of Central Anatolian-Turkey have not been studied comprehensively as yet. In this article, a study of Aksaray (Central Anatolian-Turkey) region in the case of global warming and climate change. We recognize the need to increasingly ensure continuity and fidelity from global climate data to socially useful regionally focused information.

II. PRINCIPLES: GLOBAL WARMING AND CLIMATE CHANGE

How often have we heard "Wow it's cold, where is global warming?" How can we get a cold and snowy winter with anthropogenic climate change? Most people recognize from their own experience that we have weather in all its infinite and wonderful variety, so that there are large variations in temperature and precipitation from day to day and week to week. The biggest climate change we experience is the one from summer to winter, or from winter to summer, or in the tropics from the wet monsoon season to the dry "winter monsoon". We expect these changes and even look forward to them. Our planting and harvesting of crops depend on them. Yet every summer is different, and so is every winter. There are "regimes" of climate where one summer may be sunny, dry, and hot, whereas another may be cool, cloudy, and wet [15]. In part the answer depends on what we mean by "global warming". For many it means the global mean temperature increases. But for anthropogenic climate change, it means the climate change resulting from all kinds of human activities, and it is now well established that by far the biggest influence occurs from changes in atmospheric composition, which interfere with the natural flow of energy through the climate system.

But climate change cannot be considered isolated from other challenges. Indeed, climate change is a truly cross-cutting issue affecting many sectors and connected to other global challenges. For example, climate change has the potential to impact global water supplies, agricultural production, human health, and our energy infrastructure. In turn, the way in which we produce our energy and food has a profound effect on the earth's climate system [11]. Finally, the impacts of policies in one of the fields on the other challenges need to be explored if truly sustainable solutions to global problems shall be achieved.

Despite the fact that the terms global warming, climate change and greenhouse effect are related to one another, climate change is predominantly on the agenda today, overwhelmingly. The details of human interaction with the environment, and especially with the atmospheric environment, have become clearer in the last 30-40 years. These details include future droughts and low flows, wetness and high (flood) currents, global cooling and warming. There are countless benefits for every society, country and region in various national and international meetings about the rational and participatory solutions of climate change, as well as the study of climate change from the scientific, political, social, economic and sustainability perspectives. The assessment considers new evidence of past, present and projected future climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models.

The climate which has a dynamic structure is continuously variable in temporal and spatial scale. Much of the earth's is exposed to changes in the nature of the climate in the short or long term. Short-term climate change; refers to the difference between the annual measurement of any climate element and the average for many years. On the other hand, the long-term climate variability is; reveals a significant change in the long-term average of any climate element. The main elements of the earth's climate, temperature and precipitation information, have a big influence in determining the characteristics of the global climate models [16]. The oscillations in these two parameters provide important clues for understanding the general structure of the climate. For this reason, recent studies on climate change have focused on trend analysis of these two parameters.

Climate change is a long-term challenge, but one that requires urgent action given the pace and the scale by which greenhouse gases are accumulating in the atmosphere and the risks of a more than 2 °C temperature rise. Today we need to focus on the fundamentals and on the actions otherwise the risks we run will get higher with every year. Bayesian methods to constrain equilibrium climate sensitivity or transient climate response are sensitive to the assumed prior distributions. That can in principle yield narrower estimates by combining constraints from the observed warming trend, volcanic eruptions, model climatology and paleoclimate, and that has been done in some studies, but there is no consensus on how this should be done robustly. This approach is sensitive to the assumptions regarding the independence of the various lines of evidence, the possibility of shared biases in models or feedback estimates and the assumption that each individual line of evidence is unbiased. The combination of different estimates in this assessment is based on expert judgement. Accounting for short-term variability in simple models remains challenging, and it is important not to give undue weight to any short time period which might be strongly affected by internal variability.

We have been familiar for a long time with problems of air quality caused by the emissions of pollutants such as the oxides of nitrogen or sulfur into the atmosphere from local sources. That is local pollution. Measures to reduce such pollution especially in major cities are actively being pursued. Global warming is an example of global pollution. Because of the long life time in the atmosphere of many greenhouse gases such as carbon dioxide, their effects impact on everyone in the world. Global pollution can only be countered by global solutions. The greenhouse effect arises because of the presence of greenhouse gases in the atmosphere that absorb thermal radiation emitted by the earth's surface and, therefore, act as a blanket over the surface. It is known as the greenhouse effect because the glass in a greenhouse possesses similar properties to the greenhouse gases in that it absorbs infrared radiation while being transparent to radiation in the visible part of the spectrum. If the amounts of greenhouse gases increase due to human activities, the basic radiation balance is altered.

The gases nitrogen and oxygen that make up the bulk of the atmosphere neither absorb nor emit thermal radiation. If they were the only atmospheric constituents there would be no clouds and no greenhouse effect. In this case, to realize radiative balance, the average earth's surface temperature would be about -6 °C. In fact the average surface temperature is about 15 °C. The difference between these two figures of about 20 °C is because of the natural greenhouse effect due to the natural abundances of the greenhouse gases, water vapour, carbon dioxide, ozone, methane and nitrous oxide. These gases, the largest greenhouse effect is due to water vapour and the second largest to carbon dioxide. The natural greenhouse effect is clearly vital in maintaining the earth's climate as we know it, with its suitability for human life to flourish.

The observed reduction in surface warming trend over the period 1998 to 2012 as compared to the period 1951 to 2012, is due in roughly equal measure to a reduced trend in radiative forcing and a cooling contribution from natural internal variability, which includes a possible redistribution of heat within the ocean (medium confidence). However, there is low confidence in quantifying the role of changes in radiative forcing in causing the reduced warming trend. The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation. There is medium confidence that natural internal decadal variability causes to a substantial degree the difference between observations and the simulations; the latter are not expected to reproduce the timing of natural internal variability [17]. There may also be a contribution from forcing inadequacies and, in some models, an overestimate of the response to increasing greenhouse gas and other anthropogenic forcing (dominated by the effects of aerosols).

The rate and magnitude of global climate change is determined by radiative forcing, climate feedbacks and the storage of energy by the climate system. Estimates of these quantities for recent decades are consistent with the assessed likely range of the equilibrium climate sensitivity to within assessed uncertainties, providing strong evidence for our understanding of anthropogenic climate change. Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions [18].

The earth's climate system is powered by solar radiation. Approximately half of the energy from the sun is supplied in the visible part of the electromagnetic spectrum. As the earth's temperature has been relatively constant over many centuries, the incoming solar energy must be nearly in balance with outgoing radiation. The dominant energy loss of the infrared radiation from the earth is from higher layers of the troposphere. The sun provides its energy to the earth primarily in the tropics and the subtropics; this energy is then partially redistributed to middle and high latitudes by atmospheric and oceanic transport processes.

In the researches carried out in recent years around the world; It is seen that the negative effects of global climate change on the world are observed in almost every area. Climate change affects water resources in quantity and quality by changing the hydraulic cycle and systems. It is stated that Turkey will have a warmer and drier climate in the near future and a more uncertain climate structure in terms of rainfall and intensity (Figure 1). The reduction in water resources as a result of climate change will adversely affect agricultural irrigation where about 70% of the water is used. According to statistical analysis; there is an increasing trend in the time series of average and minimum temperature of the Aksaray province, Central Anatolian region [19].

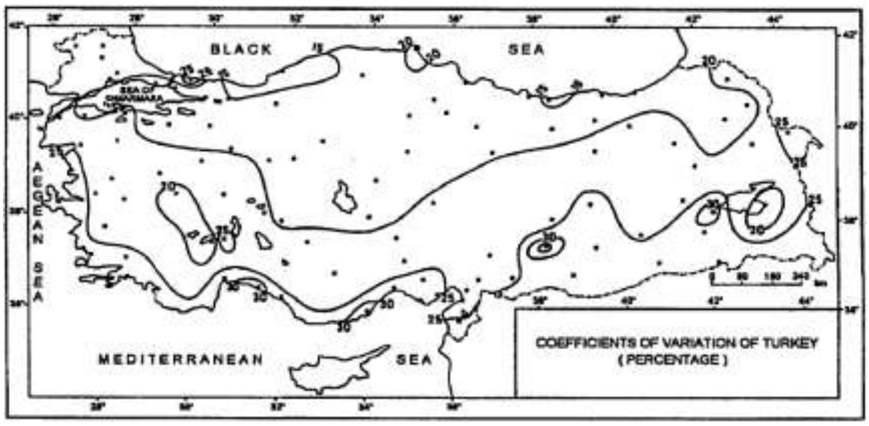


Figure 1. Geographical distribution of the coefficients of variation for annual rainfall totals in Turkey

The increasing use of fossil fuels and land degradation, which has been recognized by almost everyone who is influential on climate change, clearly demonstrates that climate change is inevitable both today and in the future. In different modeling studies envisaged for Turkey, the temperature will generally increase in all seasons, but it is estimated that the maximum increase will be in summer. It is predicted that the precipitation will decrease in the southern parts of Central Anatolian-Turkey but the precipitation in the northeastern part will increase in part [20, 21]. The water cycle describes the continuous movement of water through the climate system in its liquid, solid and vapour forms, and storage in the reservoirs of ocean, cryosphere, land surface and atmosphere. In the atmosphere, water occurs primarily as a gas, water vapour, but it also occurs as ice and liquid water in clouds. The ocean is primarily liquid water, but the ocean is partly covered by ice in polar regions. Terrestrial water in liquid form appears as surface water (lakes, rivers), soil moisture and groundwater. Solid terrestrial water occurs in ice sheets, glaciers, snow and ice on the surface and permafrost. The movement of water in the climate system is essential to life on land, as much of the water that falls on land as precipitation and supplies the soil moisture and river flow has been evaporated from the ocean and transported to land by the atmosphere. Water that falls as snow in winter can provide soil moisture in springtime and river flow in summer and is essential to both natural and human systems [22]. The movement of fresh water between the atmosphere and the ocean can also influence oceanic salinity, which is an important driver of the density and circulation of the ocean. The latent heat contained in water vapour in the atmosphere is critical to driving the circulation of the atmosphere on scales ranging from individual thunderstorms to the global circulation of the atmosphere.

The influence of global climate change is perhaps felt most keenly by water. Both observational records and climate projections show that freshwater resources are particularly vulnerable and have the potential to be strongly impacted. Climate change also has the potential to increase intense rainfall and raise sea levels, both of which increase the risk of flooding. It has been estimated that flood damage across Europe could increase by 200% by the end of the century. The traditional stationarity concept that past hydrological experience provides a good guide to the future no longer holds, and this brings with it enormous challenges to managing water into the future [23]. Changes in the global energy budget derive from either changes in the net incoming solar radiation or changes in the outgoing longwave radiation. Changes in the net incoming solar radiation derive from changes in the sun's output of energy or changes in the earth's albedo. Changes in the outgoing longwave radiation can result from changes in the temperature of the earth's surface or atmosphere or changes in the emissivity (measure of emission efficiency) of longwave radiation from either the atmosphere or the earth's surface. For the atmosphere, these changes in emissivity are due predominantly to changes in cloud cover and cloud properties [24].

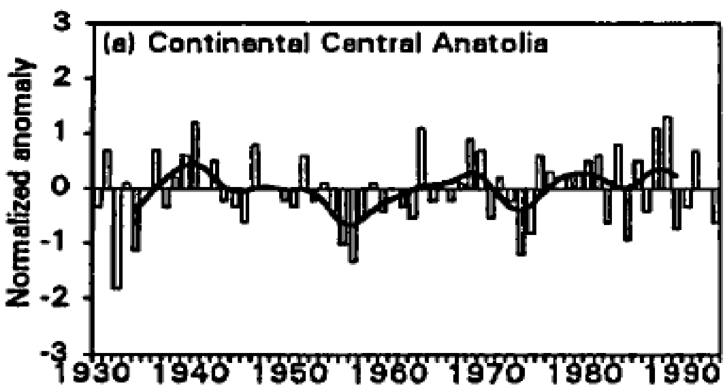
III. REGIONAL GEOLOGY: CENTRAL ANATOLIAN-TURKEY

Main physiographic factors affecting Turkey's climate are: (I) the Black Sea and Mediterranean basins, (II) west to east oriented high mountain ranges along the northern and southern coasts of the Anatolian peninsula, and (III) the Anatolian plateau with a mean elevation of 1130 m. The seas surrounding Turkey from three sides act as natural passages for the frontal cyclones shifting from west to east. The eastern Black Sea and the area between the Gulf of Iskenderun and Cyprus are the secondary source andor deepening regions for a number of cyclones. The Atlantic Ocean and the Mediterranean Sea are the primary source regions for moist air masses causing the abundant rainfall over the windward slopes of the coastal mountain ranges and the interior mountains of the country. The central and eastern parts of the Anatolian are somewhat protected from the effects of the moisture-bearing air masses, so precipitation is generally lighter than in other regions. These air masses lose their moisture content and get drier adiabatically, during their passage over the mountains and when descending along the leeward side of the mountains.

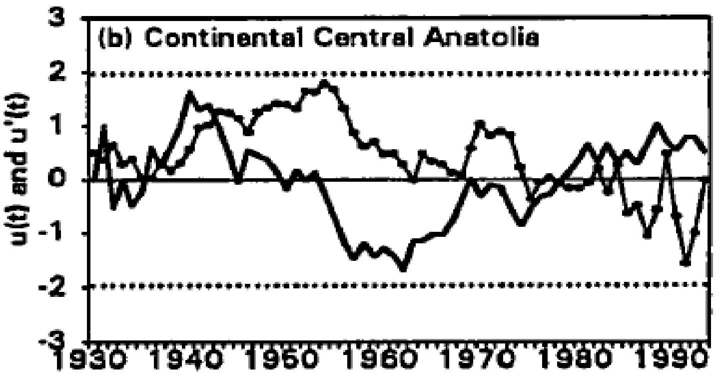
The spatial distribution of annual precipitation over Turkey that mean annual rainfall totals decrease from coastal belts to the interior, with a steep gradient over the ranges of the Northern Anatolian and Taurus mountains. At most of the stations located on the Black Sea coast, the amount of rainfall exceeds 1000 mm and reaches its maximum value on the eastern coast. Along the major part of the Mediterranean coastal belt, mean annual rainfall is above 800 mm, but it increases up to 1500 mm and more on the high southern slopes of the Taurus mountains. Deep valleys at the southern sides of the Northern Anatolian mountains and plains with low plateaux at the northern sides of the Taurus mountains are the major arid and semiarid areas of Turkey owing to processes of the leeward slope subsidence. In the semi-arid Central Anatolian region, mean annual rainfall ranges from 350 to 500 mm over a large area. Over the semi-arid South-eastern Anatolian region, mean annual rainfall increases from south, where the rainfall amount is about 400 mm, to north, where annual rainfall is 800 mm, whereas it decreases towards margin of the Syrian desert. The annual rainfall is more than 500 mm over a considerable part of the Eastern Anatolian region, with the exception of low basins and deep valleys, and increases over highlands and mountains. Annual rainfall amounts in the Marmara and Aegean regions are less than in the Black Sea and Mediterranean regions, with the means ranging between 600 and 800 mm in the Aegean region; west to east elongated deep valleys, however, allow the frontal cyclones to enter inland towards the east and to release abundant rainfall along those valleys.

The concurrences of the dry conditions between the rainfall regions and the rest of Central Anatolian-Turkey have appeared generally during the early 1930s, the late 1950s, the early 1970s, around the 1980s and the early 1990s and of wet conditions generally during the period 1935-1945, around the 1960s and the late 1970s. The change points for the beginning of drier than normal conditions occurred in the early 1970s and early 1980s over most of the country (Figure 1).

Although land suitable for farming in the basins is extremely limited; forest areas are being destroyed and converted into agricultural land. It has been observed that in the lower and middle parts of the basins, the land has been destroyed very seriously during the full field trips made throughout the basin. Taking into consideration the global climate change, modeling studies should be carried out considering the temporal distribution of the temporal distributions of the rainfall projected to each basin in Central Anatolian and the relations between different types of future rainfall, flow and flood and the possible damage and risks should be analyzed.



(a)



(b)

Figure 2. Variations and trends in annual rainfall series over Turkey and the rainfall regions: (a) Normalized annual rainfall anomalies with ninepoint Gaussian filter (b) sequential values of the statistics, with the critical significance value for the 5 per cent level

Many years ago, the time series plots of the Continental Central Anatolian region depict a high-frequency variability rather than a low-frequency fluctuation (Figure 2 a and b). This is the only regional mean rainfall series that tends to increase more in wet years than it decreases in dry years, and to have a greater frequency of wet years than dry years, during the period 1970-1993. Certain dry and wet spells were pronounced, even though regional rainfall anomalies exhibit a high year to year variability over the region. Wet conditions dominate during the periods of 1936-1942, 1963-1969, and 1975-1988, with the highest wet anomaly in 1988, whereas dry conditions occur during the periods of 1930-1935, 1949-1962, and 1970-1974. Wet conditions during the periods of 1936-1942 and 1975-1988 are significant at the 5 per cent level. The year of 1932 is the driest year of the regional mean series, with a high negative anomaly of −1.80.

Summer dryness, which is recognized as a normal climate characteristic of the Central Anatolian macroclimate region, and long-lasting dry episodes that can occur in every season associated with the high interannual variability in rainfall have been creating great pressure on the water resources of Turkey. Various human activities and particularly misuse of water owing to urbanization and agricultural practices make this pressure more severe. At a research, annual normalized rainfall series have been analysed to prove the long-term variations in time and space by using mainly non-parametric statistical methods. The main concern is to investigate the nature and extent of the non-randomness in the normalized rainfall series. The form of non-randomness for this study consists of some types of persistence (serial correlation), trend and fluctuations, but not periodicity [19].

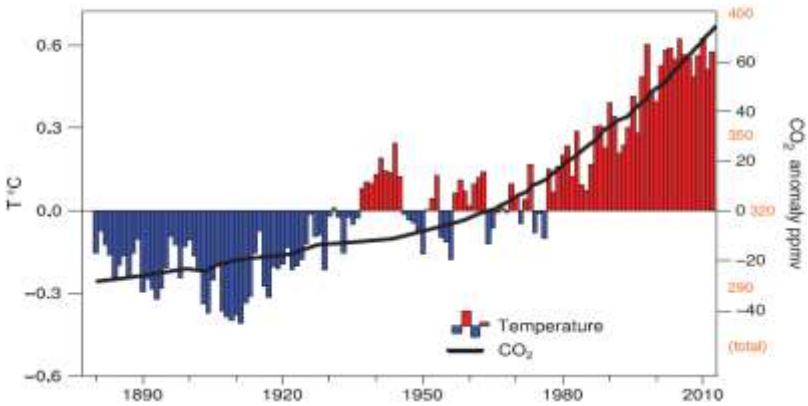


Figure 3. Estimated changes in annual global mean surface temperatures (°C, color bars) and CO_2 concentrations (thick black line) since 1880, the changes are shown as differences (anomalies) from the 1901 to 2000 average values [3]

The 2000s are by far the warmest decade on record (Figure 3). Before then the 1990s were the warmest decade on record. Since global warming really reared its head in the 1970s in the sense that the global warming signal emerged from the noise of natural variability, every decade has been warmer than the previous ones and increasing evidence suggests that the past few decades are warmer than any others in the past 2000 years [3]. However, there has been a slowing in the rise of global mean temperature over the past decade, often referred to as a hiatus or plateau.

Global mean temperatures have been reconstructed by several groups over the past century or longer (Figure 4). In spite of the agreement globally, there are some differences among global land and global ocean values. In Figures 3 and 4, we note the overall rising global mean temperatures after the 1960s but with a slowing rate in the 2000s.

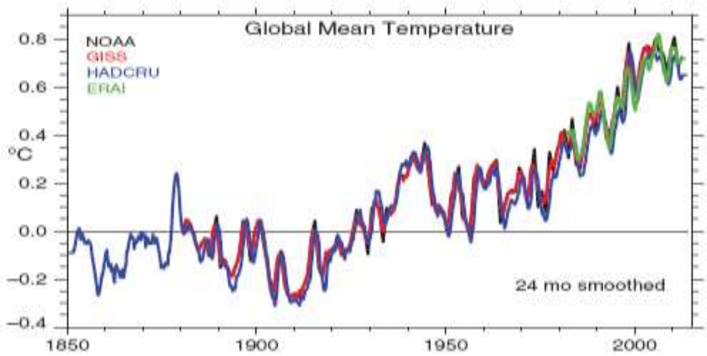


Figure 4. Global mean temperature time series as 24 month running means from several sources: NOAA, GISS, HADCRU, and ERAI

Examining the seasonality of the global mean temperatures (Figure 5) reveals that the biggest hiatus in warming is in the northern winter season (December-January-February, DJF) owing to a few quite cold winters, especially 2008 and 2012.

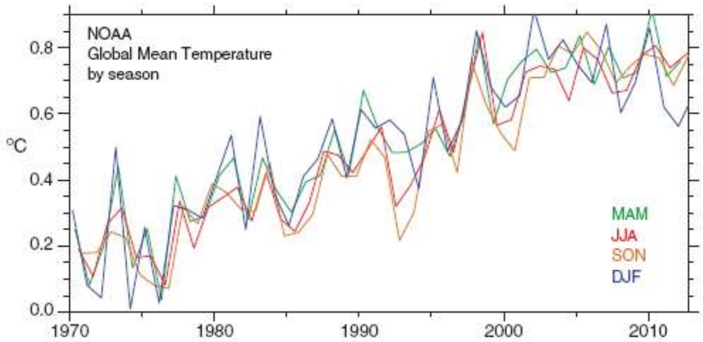


Figure 5. Global mean temperature anomalies after 1970 for the four seasons: DJF, MAM, JJA, and SON

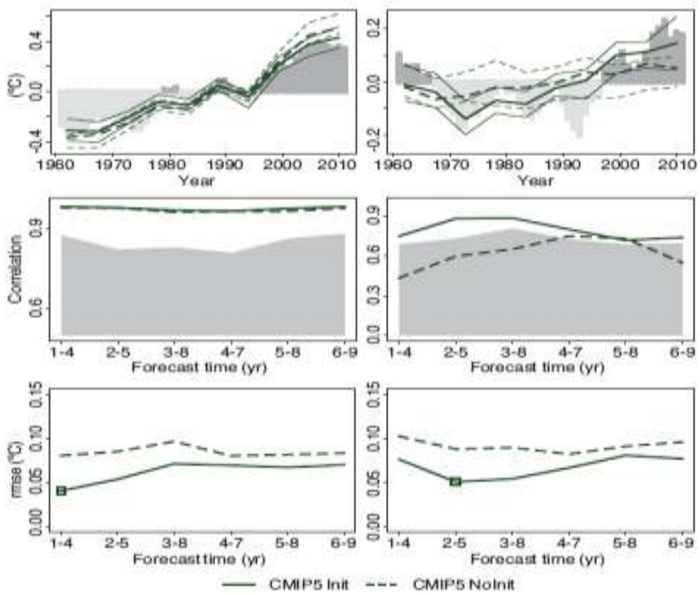


Figure 6. Decadal prediction forecast quality of several climate indices, CMIP5: Coupled Model Intercomparison Project Phase 5 [14]

The estimates from the observed warming, paleoclimate, and from climate models are consistent within their uncertainties, each is supported by many studies and multiple data sets, and in combination they provide high confidence for the assessed likely range. Even though this assessed range is similar to previous reports, confidence today is much higher as a result of high quality and longer observational records with a clearer anthropogenic signal, better process understanding, more and better understood evidence from paleoclimate reconstructions, and better climate models with higher resolution that capture many more processes more realistically [25, 26]. Near-term decadal climate prediction provides information not available from existing seasonal to interannual (months to a year or two) predictions or from long-term (mid 21st century and beyond) climate change projections. Prediction efforts on seasonal to interannual time scales require accurate estimates of the initial climate state with less focus extended to changes in external forcing12, whereas long-term climate projections rely more heavily on estimations of external forcing with little reliance on the initial state of internal variability. Estimates of near-term climate depend on the committed warming (caused by the inertia of the oceans as they respond to historical external forcing) the time evolution of internally generated climate variability, and the future path of external forcing. Near-term predictions out to about a decade (Figure 6) depend more heavily on an accurate depiction of the internally generated climate variability.

The North Atlantic Oscillation (NAO) and Atlantic Multidecadal Oscillation (AMO) index (Figure 7) depicts the strength of the westerlies from the North Atlantic into Europe and correlates well with temperatures in Eurasia and inversely with those over Mediterranean, as well as precipitation as a north-south dipole over Europe: wet in the north and dry in the south in the positive phase.

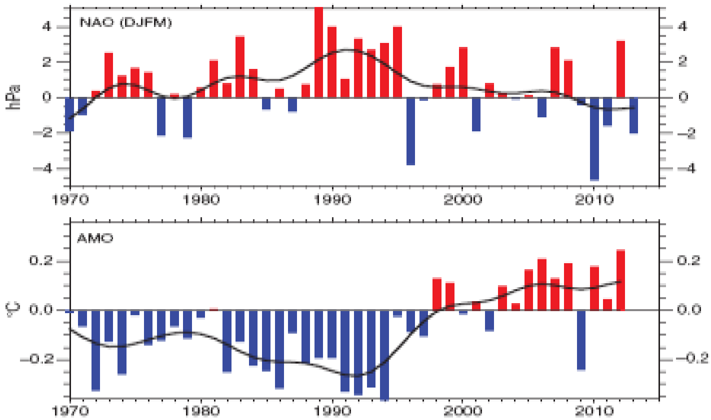


Figure 7. Time series of values of the NAO in northern winter (December-January-February-March, DJFM) and annual mean AMO along with a low-pass (13-term) decadal filter used in IPCC [27]

Significant positive correlations and large positive concurrence values between the series of the rainfall regions and the series for the rest of Turkey show that rainfall variations over most of the rainfall regions are closely linked with those of the rest of the country. However, in addition to the likely effects stemming from the relative weaknesses of the statistical procedures used in the study, some segments of the trends and abrupt changes, particularly in the individual station series, may have been affected by urbanization and relocation of the stations. Many of these significant downward trends appear to have occurred as a result of abrupt decreases during the last 20-25 years of the study period. Only two stations in the Continental Central Anatolian region have shown a significant increasing trend in the mean. Fifteen of the station based annual series have a significant positive serial correlation. This result supports the observed lowfrequency fluctuations in the time series plots of these stations. Graphical plots of the regional mean rainfall anomalies exhibit low-frequency fluctuations over the Mediterranean and Mediterranean transition regions and some high-frequency variation over the continental type rainfall regions.

IV. RESULTS AND CONCLUSION

In the near-term, it is likely that the frequency and intensity of heavy precipitation events will increase over land. These changes are primarily driven by increases in atmospheric water vapour content, but also affected by changes in atmospheric circulation. The impact of anthropogenic forcing at regional scales is less obvious, as regional scale changes are strongly affected by natural variability and also depend on the course of future aerosol emissions, volcanic forcing and land use changes. There are various mechanisms that could lead to changes in global or regional climate that are abrupt by comparison with rates experienced in recent decades. The likelihood of such changes is generally lower for the near-term than for the long term. It is virtually certain that, in most places, there will be more hot and fewer cold temperature extremes as global mean temperatures increase. These changes are expected for events defined as extremes on both daily and seasonal time scales. Increases in the frequency, duration and magnitude of hot extremes along with heat stress are expected; however, occasional cold winter extremes will continue to occur. Twenty-year return values of low temperature events are projected to increase at a rate greater than winter mean temperatures in most regions, with the largest changes in the return values of low temperatures at high latitudes. Twenty-year return values for high temperature events are projected to increase at a rate similar to or greater than the rate of increase of summer mean temperatures in most regions.

Climate change and its impacts on agricultural systems and rural economies are already evident throughout the Eastern Europe and Central Asia region. There is a growing interest among governments and many of their development partners to gain a better understanding of the exposure, sensitivities and impacts of climate change at the landscape level, and to develop and prioritize mitigation/adaptation measures to build resilience to the potentially adverse effects as well as to mitigate the consequences of climate change. In Turkey, stressed in a short statement that it was important to focus on the impacts of climate change on biodiversity and on fostering the cooperation of scientists and forest managers. The lack of biodiversity perspectives in mitigation activities created mid- and long-term problems for the sustainability of forest ecosystems. Another important point was to support the adaptation of forest ecosystems to climate change. The adaptation process should be considered in a wider term, as mentioned in the ecosystems based approach in the convention on biodiversity, to maintain the resilience of socio-ecological systems.

However, the intensification of disruptions caused by global climate change requires organizations to start adapting to them immediately. Consequently, it is important that organizations acknowledge the strategic relevance of ecological issues such as climate change and accelerate their efforts to develop and deploy capabilities required for the adaptation process. Notably, it is vital to emphasize that specific knowledge is required regarding both the sources of a changing natural environment and their consequences for business. As such, an organization's absorptive capacity regarding knowledge about global warming, corresponding effects on the business environment, and related corporate response options has to be viewed as an essential component of a successful long-term strategy in terms of the organization's climate change exposure as well as in terms of its sustained competitiveness.

Research and assessment communities meet: in the absence of an internationally agreed-upon and funded climate research strategy, the World Climate Research Programme (WCRP), on behalf of the WMO, the International Council for Science, and the Intergovernmental Oceanographic Commission, assumes the daunting tasks of planning and coordinating international efforts on climate research. The WCRP, a multinational consortium established in 1980, has undergone internal refreshment and refocusing since 2011. Challenges ahead; as WCRP pursues new directions, we confront four interlinked obstacles: (I) funding is decreasing generally, and it is increasingly earmarked and allocated for purposes other than fundamental climate research, (II) despite confirmation of the validity, indeed urgency, of the WCRP grand challenges, we have only a mixed record of implementation and a weak record of public engagement, (III) our tendency across WCRP is to overload and overwork a few key individuals, especially female individuals, and (IV) our most careful and creative products continually and increasingly clash with social or political comfort and convenience [17, 28].

A spectrum of models is used to project quantitatively the climate response to forcings. The simplest energy balance models use one box to represent the earth system and solve the global energy balance to deduce globally averaged surface air temperature. At the other extreme, full complexity three dimensional climate models include the explicit solution of energy, momentum and mass conservation equations at millions of points on the earth in the atmosphere, land, ocean and cryosphere. Climate change commitment is defined as the future change to which the climate system is committed by virtue of past or current forcings. The components of the climate system respond on a large range of timescales, from the essentially rapid responses that characterise some radiative feedbacks to millennial scale responses such as those associated with the behaviour of the carbon cycle and ice sheets [29-31].

Climate change commitment is indicative of aspects of inertia in the climate system because it captures the ongoing nature of some aspects of change. These actions require clear policies, commitment and resolve on the part of governments, industries and individual consumers. Urgent action is required for three reasons. The first is scientific. Because the oceans take time to warm, there is a lag in the response of climate to the increase of greenhouse gases. A commitment to substantial climate change already exists, much of which will not be realized for several decades. The second reason is economic. Energy infrastructure, for instance, in power stations, lasts typically for 30 to 50 years. It is much more cost effective to begin now to phase in the required infrastructure changes rather than having to make them much more rapidly later. The third reason is political. Countries like China and India are industrializing very rapidly. They need to do so in ways that are much more efficient and with much smaller greenhouse gas emissions than has been done in the developed world.

Science and technology have a large part to play as the world community meets the challenge posed by anthropogenic climate change. All the natural sciences are involved in research to reduce the uncertainties regarding the details, extent and timing of climate change. To reduce scientific uncertainty in projections of climate change for the 21st century, it is particularly required to achieve improved knowledge and understanding of cloud radiation feedback and climate carbon cycle feedbacks, more quantitative information about climate extremes, and better performance from both global and regional climate models. Social and economic sciences need to explore imaginative ways of harnessing the energies and potential of financial and political institutions. Especially important are the following emphases: First, global warming is a global problem and global solutions are required. Second, an integrative, holistic approach is needed that seeks to integrate perspectives from both the natural and the social sciences. Third, the aim must be to find solutions not just characterize problems. Applied research seeking solutions is just as challenging and worthy as so-called fundamental research identifying and describing the problems. Fourth, since action by everybody is required, everybody needs to be made aware and adequately informed.

ACKNOWLEDGEMENTS

I would like to thank the United Nations Foundation of Sustainable Energy and Climate Change for the financial supported some part of this study, and to Professor Dr. K. Jyrki KAUPPINEN (Physics Department, Laboratory of Optics and Spectroscopy, University of Turku, Turku-Filland) for him useful advice and help stimulating discussions.

REFERENCES

[1] T.F. Stocker, D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley (Ed.), *Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change* (Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press, 2013) 216-1535.

[2] C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Ed.), *Climate change 2014: impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press, 2014) 805-1132.

[3] O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel, and J.C. Minx (Ed.), *Climate change 2014: Mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change* (Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press, 2014) 900-1304.

[4] I. Ian Burton, E. Diringer, and J. Smith, (Ed.), *Adaptation to climate change: International policy options. PEW center on global climate change* (Arlington, VA, USA, Wiley, 2006) 380-507.

[5] E. Alkaya, M. Bogurcu, F. Ulutas, and G.N. Demirer, Adaptation to climate change in industry: Demonstration projects for water saving through eco-efficiency approach, *SCP Meets Industry-15th ERSCP Conference Bregenz*, Austria, May 2-4, 2012, pp. 62.

[6] T. Busch, Organizational adaptation to disruptions in the natural environment: The case of climate change, *Scandinavian Journal of Management, 27(4),* 2011, 389-404.

[7] J. Houghton, Global warming, *Reports on Progress in Physics, 68(6),* 2005, 1343-1403.

[8] J.M. Broadus, Possible impacts of, and adjustments to, sea-level rise: The cases of Bangladesh and Egypt climate and sealevel change: Observations, projections and implications, in R.A. Warrick (Ed.), *Environmental and economic implications of rising sea-level and subsiding deltas,* (Cambridge, UK, Cambridge University Press, 1993) 263-275.

[9] R. Mendelsohn, A. Andronova, W. Morrison, and M. Schlesinger, Country-specific market impacts of climate change, *Climatic Change, 45(3-4),* 2000, 553-569.

[10] I. Ian Burton, E. Diringer, and J. Smith, *Adaptation to climate change: International policy options* (PEW Center on Global Climate Change, Arlington, VA, USA, Wiley, 2006).

[11] J. Houghton, An overview of the IPCC and its process of science assessment, in R.E. Hester and R.M. Harrison (Ed.), *Global environmental change,* (Issues in Environmetnal Science and Technology, No 17, Royal Society of Chemistry, UK, 2002) 85-103.

[12] J. Houghton, The intergovernmental panel on climate change has a creditable record of developing a scientific consensus and delivering it to policy-makers. What its critics really object to are the facts, *Nature, 412(6843),* 2001, 103-104.

[13] J. Houghton, Consensus science, consensus politics, *Nature, 412(6843),* 2001, 112-114.

[14] J. Park, N. Hopkins, and N. Safavieh, *Business and climate change adaptation: Towards resilient companies and communities* (A Caring for Climate Report by the United Nations Global Compact and United Nations Environment Programme in Cooperation with the CEO Water Mandate. Caring for Climate-UNEP, New York, NY, USA, Published by the UN Global Compact Office, 2012).

[15] K.E. Trenberth, and J.T. Fasullo, An apparent hiatus in global warming, *AGU Earth's Future, 1(1),* 2013, 19-32.

[16] O. Canli, A study of global climate change in the eastren Black Sea region, *Proc. Symp. on National Landslide*, Ankara, April 27-29, 2016, pp. 455-488.

[17] I.A. Shilomanov, and J.C. Rodda J C (Ed.), *World water resources at the beginning of the twenty-first century* (Cambridge, UK, Cambridge University Press, 2003) 1-22.

[18] C. Parmesan, Climate and species' range, *Nature, 382(6594),* 1996, 765-766.

[19] M. Turkes, Spatialand temporal analysis of annual rainfall variations in Turkey, *International Journal of Climatology, 16(9),* 1996, 1057-1076.

[20] T. Yuksek, An overview of the events of Hopa and Borca (Turkey) in the global climate change and land degradation perspective, *Proc. Symp. on National Landslide*, Ankara, April 27-29, 2016, pp. 27-42.

[21] M. Demircan, O. Demir, H. Atay, B. Yazici, O. Eskioglu, A. Tuvan, and A. Akcakaya, Climate change projections for Turkey with new scenarios, *Proc. Conf. on The Climate Change and Climate Dynamics*, Istanbul, September 8-10, 2014, pp. 72-81.

[22] K.D. Frederick, D.C. Major, and E.Z. Stakhiv, Climate change and water resources planning criteria, *Climatic Change, 37(1),* 1997, 1-313.

[23] B.C. Bates, Z.W. Kundzewicz, S. Wu, and J.P. Palutikof, *Climate change and water* (Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008).

[24] M.B. Davis, *Ecological Systems and Dynamics in Toward an Understanding of Global Change.* (Washington, DC, USA, National Academy Press, 1988) 69-106.

[25] J. Alcamo, *Integrated modeling of global climate change,* (Dordrecht, The Netherlands, J. Kluwer Academic Publishers, 1994).

[26] K. Kocak, Climate change and flow change of the Carsamba river (Bozkir, Konya-Turkey), *Proc. Symp. on International Bozkir from Past to Present*, Konya, May 6-8, 2016, pp. 1517-1526.

[27] K.E. Trenberth, and J.T. Fasullo, Tracking Earth's energy, *Science, 328(5976),* 2010, 316-317.

[28] M. Winn, M. Kirchgeorg, A, Griffiths, M. K. Linnenluecke, and E. Gunther, Impacts from climate change on organizations: A conceptual foundation, *Business Strategy and the Environment, 20(3),* 2011, 157-173.

[29] M. Hulme, and O. Brown, Portraying climate scenario uncertainties in relation to tolerable regional climate change, *Climate Research, 10(1),* 1998, 1-14.

[30] M.E. Porter, and F L. Reinhardt, A strategic approach to climate, *Harvard Business Review, 85(10),* 2007, 22-26.

[31] T.L. Root, and S.H. Schneider, Ecology and climate: Research strategies and implications, *Science, 269(5222),* 1995, 334-341.