1.0 INTRODUCTION

The Earth/atmosphere system is evolving due to human activities and to natural events. The IPCC (Intergovernmental Panel on Climate Change) has concluded that "the balance of evidence suggests a discernible human influence on global climate through emissions of carbon dioxide and other greenhouse gases" [IPCC, 1997]. Activities such as deforestation, construction, biomass burning, and agricultural and industrial activities, as well as volcanic eruptions, all alter the composition of the Earth/atmosphere system by changing the planetary reflectance, adding aerosols to the atmosphere, and increasing and altering atmospheric gases. The Earth's environment has been polluted as never before in the past century, and various independent measurements indicate that the Earth's temperatures are changing, although how much is not exactly known. Burroughs [1997] reports that there has been a general warming trend of between 0.3 and 0.6 ^{o} C in the Earth's meteorological temperature throughout the twentieth century; most of this change concentrated in the period between 1920 to 1940 and since the mid-1970's. Discrepancies exist between satellite and terrestrial measurements of Earth's temperatures, and it is always possible that some of the detected changes may be attributed to the advances in measurement devices rather than truly being due to actual changes in the Earth's temperatures. Finally, the possibility exists that observed changes

are a natural part of the behavior of the dynamic Earth/atmosphere system. We approach the end of the twentieth century with more questions than answers with regard to the health of our planet. Scientists continue in the search for answers to the myriad questions about some of the most challenging issues that have ever faced our planet.

There is no question that human activity has altered the composition of the Earth's atmosphere. Human activity has sent huge quantities of pollutants such as carbon monoxide, sulfur dioxide, nitrogen oxides, hydrocarbons, and particulate matter into the atmosphere. Scientists have observed many notable changes in atmospheric gases in the second half of this century. Stratospheric ozone, important for its ability to absorb ultraviolet solar energy thus shielding the Earth, is being depleted due to human activity such as the emission of nitrous oxide and chlorofluororcarbons. One study conducted at Mauna Loa Observatory in Hawaii showed that the concentration of carbon dioxide in the atmosphere has increased by about 10 percent since 1958. Using the evidence of air bubbles trapped in polar ice, and recent observations such as those at Mauna Loa, some scientists estimate that the atmospheric concentration of carbon dioxide has increased by up to 25 percent since the early 1800's. Although there are other sources of atmospheric carbon dioxide (i.e. the decay of vegetation and volcanic eruptions), it is believed that the major culprit is the burning of fossil fuels [Ahrens, 1992]. These are but a few of the various upsets to the balance of the Earth/atmosphere system brought on by human activity.

Other evidence found in ice cores, as described by Burroughs, sways opinion in an opposite direction and adds weight to the intriguing question of how much detected changes are truly a result of human activity. These ice cores, taken from the Greenland ice sheet, reveal a history of huge fluctuations in the Earth's climate that occurred independent of man's influence. The ice cores show that the climate has been fairly stable over the past 10,000 years, but during previous years, as far back as 100,000 years ago, a picture of a highly erratic climate emerges. Assuming that the detected upward trend of less than one degree Celsius measured over this past century is an accurate figure, the earlier changes revealed by the ice cores were five to ten times greater, and

occurred over only a few years rather than over the span of a century. The evidence revealed by these Greenland ice cores has provided a new perspective in climatic thinking. Where it was previously believed that big changes in climate could only occur over a long period of time due to the thermal inertia of the oceans, it is now conceivable that the climate could undergo huge shifts in short periods of time. Because of such recent discoveries, some climatologists believe that these natural fluctuations must be strongly considered in the study of global warming. As emphasized by Burroughs, without a better understanding of the extent of past natural climatic change it is not realistic to plan on the basis that current changes are the consequence of human activities.

The detected slight rise in the Earth's temperature, the fact that the activities of mankind are altering the Earth's environment as never before, and the knowledge that the Earth's climate has undergone dramatic changes in the past independent of man's influence, all combine to pose a unique challenge to the science community in determining whether the current warming is linked to human activities, or is the result of natural mechanisms in the climate. In the quest for answers to these questions, some of the most useful tools are GCMs, or Global Circulation Models, which can be used to study cause-and-effect scenarios in the Earth/atmosphere system [Wielicki, *et al.*, 1995]. GCMs are computer models that mathematically model the extremely complex physics of the Earth/atmosphere system. These models incorporate many approximations and simplifications, and there is much room for improvement as many unknowns still exist. The importance of GCMs which can yield trustworthy conclusions as to the cause/effect of global warming is paramount. Information revealed by these GCMs is used by organizations such as the IPCC (Intergovernmental Panel on Climate Change), which serves to assess scientific information about climate change relevant for the formulation of international and national policy. Because of their importance, there is much interest in the refinement of GCMs. Refinement can be accomplished by utilizing findings from continued studies of the Earth/atmosphere system.

National and international efforts are being made to address these uncertainties. NASA's most recent contribution to these efforts is the Mission to Planet Earth, which is part of

the United States Global Change Research Program (USGCRP). This research effort consists of a series of space-based remote sensing platforms, the largest of which is the Earth Observing System (EOS) [Anon, 1993]. EOS involves a series of Earth-orbiting satellites containing a variety of instruments designed to provide critical global observations of the Earth/atmosphere system, computing facilities, and science researchers, and is committed to data collection for at least a 15-year period. The EOS system is particularly effective, because a single satellite contains multiple instruments measuring many independent physical processes that can be observed simultaneously for a given scene type. Chapter 2.0 describes several NASA instruments, the measurements that they are used to obtain, and the data products they provide. This will serve as background to describe the current research effort. Figure 1.1 summarizes the many interrelated factors involved in the study of global warming and climate change.

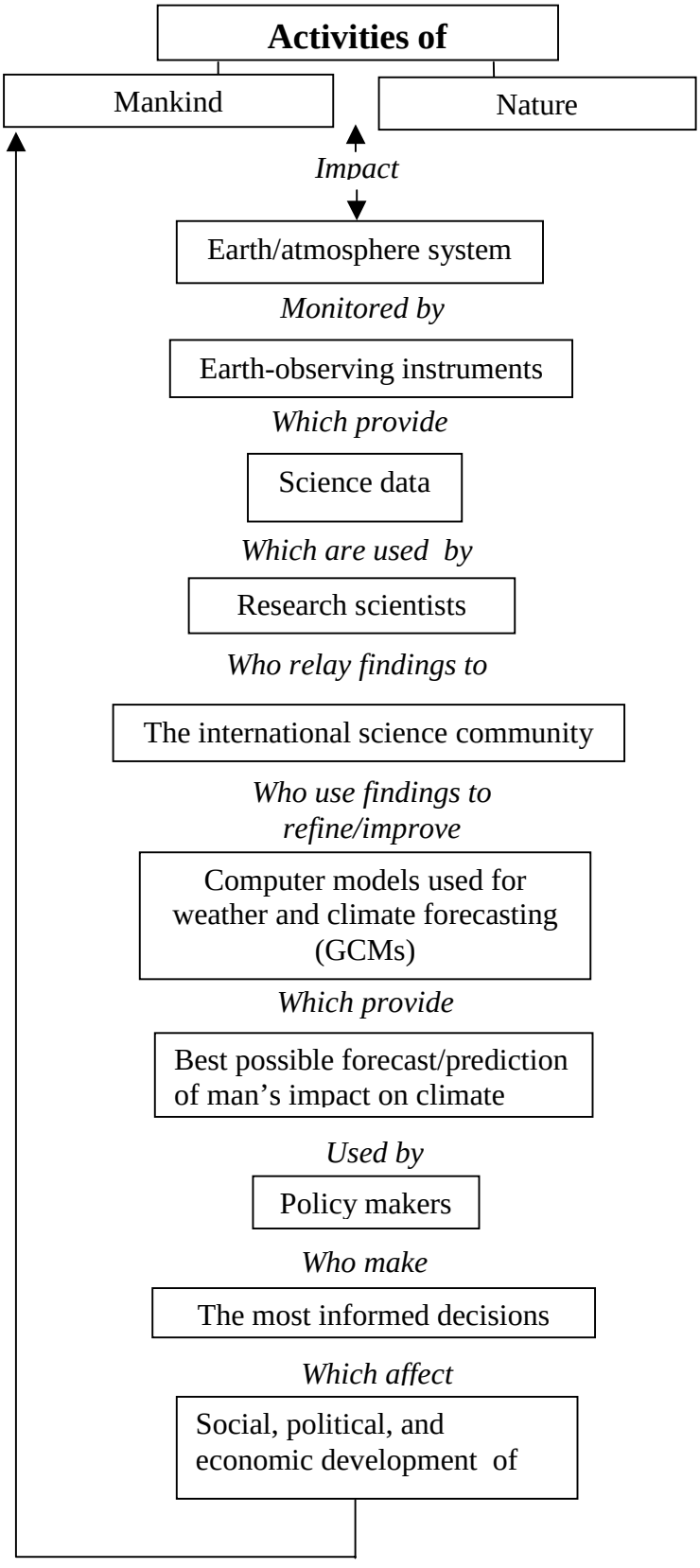

Figure 1.1 Factors involved in the study of global warming and climate change.