CHAPTER 1

Introduction

Electromagnetic (EM) radiation is an omnipresent part of our daily lives. Take a look around you. The fact that you can see, and interpret in astonishing detail, both your immediate and distant surroundings is made possible by EM radiation arriving at your eyes from every possible direction. Because the properties of this radiation, including both intensity (brightness) and spectral characteristics (color), are strongly influenced by its interactions with matter, you are able to instantly distinguish objects, faces, textures, material compositions, and many other details, some as small (in relative terms) as the period at the end of this sentence or the shape of a bird perched on a distant telephone wire.

1.1 Relevance for Climate and Weather

By now, if you are a student of atmospheric science, you are probably already aware of the distinction between adiabatic and diabatic processes in the atmosphere. It is common — because it is so convenient — to idealize many dynamic and thermodynamic processes as adiabatic. That is to say, it is often assumed that there is no significant energy exchange between the air parcel under consideration and its surrounding environment. In fact, this is not a bad assumption for processes taking place in the free atmosphere on time scales of a day or less. Over longer time periods, and even over short time periods (hours or less) in close proximity to the earth's surface, diabatic processes cannot be ignored. One such process is thermal conduction, which is quite slow in air *except* in the presence of very large temperature gradients — i.e., a degree per centimeter or more. Another diabatic process is latent heating and cooling in connection with the phase changes of water – melting, freezing, evaporation, condensation, etc. Although latent heating is a very important factor in cloud and precipitation formation, it operates only intermittently and, conveniently, it can almost always be understood and computed entirely in terms of *local* thermodynamic and microphysical processes.

Atmospheric radiation, the subject of this book, is the sole energy exchange process that operates both *continuously* throughout the atmosphere and *over long distances*. The fact that net heating or cooling due to radiation depends strongly on *nonlocal* processes greatly complicates the problem of computing this diabatic heating term in weather prediction and climate models. It is also one of several reasons why an entire textbook can be devoted to the subject and still only scratch the surface in terms of both the implications and applications (e.g., satellite remote sensing) of atmospheric radiative transfer processes.

1.1.1 Solar Radiation

When you go outside and look up at the sky, you are directly observing one form of atmospheric radiation. In fact, all of the natural light you can see during the day — and a great deal that you can't — originates from the sun, and we refer to this as solar radiation. It is of course the absorption of solar radiation by the atmosphere and the earth's surface that is ultimately responsible for maintaining the and atmosphere's overall temperature structure, including the horizontal gradients that drive atmospheric circulations. If the sun were switched off, the world would quickly chill to the point where it would sustain neither life nor even wind and weather.

Not all of the radiation arriving from the sun is visible to the eye. For example, a significant fraction of solar radiation arrives in the