Chapter 1

Introductory remarks

Motion is manifest in the atmosphere in an almost infinite variety of ways including wind chill factors, anomalously cold winters, summer droughts, and so forth. We shall in these lectures somewhat loosely distinguish between motion systems themselves and the things motion systems do. A motion system will be defined by the distributions in space and time of velocity, $\vec{v}$; mean density, ρ; pressure, p; temperature, T; and constituent densities, ρ_i. Examples of what we will consider to be motion systems are cyclonic storms and stationary planetary scale patterns. The latter are intimately associated with anomalous seasonal weather patterns. Examples of things motion systems do are the reduction of the pole–equator temperature differences to about half of what would be expected from purely radiative considerations, and the creation of maximum column densities of ozone at high latitudes rather than in the tropics as would have been expected on the basis of photochemical equilibrium.

In attempting to discuss this topic in one semester, there is no hope of completeness. Moreover, any attempt to begin at the beginning will barely transcend the beginning itself. Although some background in hydrodynamics is helpful, these lectures are formally self-contained. Also, from the beginning, we will deal with the integration of dynamics with other components of atmospheric physics. Clearly, these lectures cannot be comprehensive. The use of additional references (Houghton, 1977, Holton, 2004, Pedlosky, 1987, and Gill, 1982, Pedlosky, 2003) will be helpful though not essential.

We will begin these lectures by considering the rôle of dynamics in several problems where this rôle can be established without detailed reference to the dynamics. The problems we will study are:

1. The rôle of dynamics in simple climate models; and
2. The rôle of dynamics in determining the distribution of chemically active minor constituents.

Having demonstrated the importance of dynamics in the behavior of the atmosphere, we will turn to the motions themselves. The observations will be reviewed with primary, *but not exclusive*, emphasis on specific motion systems rather than on measurement techniques and problems – though these issues will, of necessity, be referred to.

Finally, we will turn to the development and use of the equations of motion. It will be in these lectures that the text material will prove most useful. Our emphasis will *not* be on the multitude of interesting (and less interesting) properties of the equations themselves, but on the use of what the equations tell us in order to understand various phenomena. Among the phenomena we will discuss are:

1. The global distribution of surface easterly and westerly winds;
2. Gravity waves and turbulence in the upper atmosphere;
3. Atmospheric tides;
4. The quasi-biennial oscillation of the stratosphere;
5. Travelling and stationary weather systems;

Don't worry if some of the above terms are unfamiliar to you. They will be explained in the remainder of these notes.

The above discussions will emphasize physical concepts, with the hope that interested students will delve further into the solution details (insofar as they exist). Finally, formal problems are set at the end of each chapter, and informal questions are proposed throughout the text. Dealing with both is integral to learning the material.

It should be noticed that the next four chapters do not even use the equations of motion. These are not, in fact, introduced until Chapter 6 – following the discussion of observations in Chapter 5. Some hydrostatics relevant to the atmosphere are introduced in Chapter 4, because they are essential to the discussion of observations. Chapters 2 and 3 deal with two problems where dynamics is essential, but where the rôle of dynamics can be delineated without specific reference to details. The hope in introducing the subject in this manner is to avoid the notion that dynamic meteorology is simply the derivation of equations and their subsequent solution. Rather, as the title of these notes suggests, dynamics is a central part (but still only a part) of the total physics of the atmosphere.

Finally, I hope, through this book, to communicate the obvious fact that dynamic meteorology is not so much a body of canonical results, but rather an active research field in a state of flux.