PLANETARY ATMOSPHERES

Preamble: Why study planetary atmospheres?

There are obvious practical reasons why we study the weather and climate of the Earth. But why should we study planetary atmospheres? Understanding how atmospheres are formed, evolve, and respond to perturbations is essential for addressing a number of broad intellectual goals, which in the long run have practical human benefits (see below). However, the intellectual goals are sufficient reasons in themselves: We study planetary atmospheres because they are intrinsically interesting, we're curious about nature, curious about where we and our environment came from, and all that's enough.

Overall, the general implications of studying planetary atmospheres are as follows:

- By understanding the evolution of planetary atmospheres, we can gain an appreciation of how the Earth's atmosphere is different from atmospheres on uninhabited planets and how Earth's atmospheric composition has co-evolved with life on Earth. Geochemical evidence in old rocks shows that the Earth's atmosphere has been altered by the biosphere and this altered atmosphere has, in turn, facilitated complex forms of life (including us) to evolve. Studying Earth's atmospheric evolution also concerns the evolution of the biosphere; they are intertwined.

- How planetary atmospheres respond to perturbations is important for gaining a comparative appreciation of the Earth's atmosphere. For example, studies of radiation and heat in the atmospheres of Venus and Mars help us understand comparative greenhouse effects. Similarly, the radiative effects of dust in the atmosphere of Mars arising from global dust storms led to thinking about analogous events on Earth and the "nuclear winter" hypothesis. The rate constants for photochemical reactions of certain chlorine species were first determined for understanding the atmosphere of Venus long before they proved essential in understanding the chemistry of ozone depletion. A success of theory is that dynamics applied to Titan's atmosphere proves critical in understanding why Titan's lakes are at the poles, not the naïve expectation of at low latitudes.

- Understanding the atmospheres of planets in our own Solar System is also the logical path towards planning and evaluating future observations of exoplanet atmospheres. For example, will it mean life is present if we detect an O_2-rich atmosphere on an Earth-like extrasolar planet through spectroscopy?

Current observations show that planets and moons in the Solar System have diverse atmospheres with a number of shared characteristics. Comparing and contrasting these atmospheres provides the only means of understanding their physical nature and addressing the above issues.

Course Overview

This course is loosely divided up into three sections:

1) **The static atmosphere**: atmospheric fundamentals (thermodynamics, radiation and chemistry) with reference to the atmospheric structure on the planets.

2) **Atmospheric evolution**: where atmospheres come from and how they reached their present state.

3) **The moving atmosphere**: Planetary atmospheric circulations and observations.

The subject is so broad that it is simply impossible to cover everything, so sometimes I have to say "please read such and such for more info".
Because this course is co-listed in different departments, Part 1 will also provide background to atmospheric physics/chemistry that will be substantially new material for some students. Even if it's familiar to you, it's important to return to fundamentals to see them in the context of other planets.

Notes & Handouts

When available, notes and handouts will be placed on-line at a website e-mailed to the class. This field can move rapidly, so notes are updated every time the course is taught.

Assignments

There are 4 problem sets spread over the quarter, plus a short term paper.