PLANETARY ATMOSPHERES   Winter 2003
(ATMS 555/ASTR 555, ESS 581)

Instructor: David Catling   Office (Phone): ATG 422 (206-543-4576)
E-mail: davidc@atmos.washington.edu
Office Hours: Make an appt. in class or via e-mail

Lectures: Lecture time to be decided. Note: Instructor is away Week 2 (January 13-17) and part of Week 6 (Feb 10-12), so there will be no classes during these times.

Syllabus:

The schedule reflects approximate timing only. If we need more time on a particular topic and less on others then we will fall behind or get ahead as needed.

1. Atmospheric Structure on the Planets: The static structure (Wks 1-4)

1.1 Hydrostatic equilibrium. Stability and convection. Lapse rates on the planets. Water vapor in planetary atmospheres (Earth, Venus; Mars as a case study). Methane on Titan.
1.2 Energy Sources on Planets. Thermal balance. Greenhouse effect. Runaway greenhouse effect (early Venus, future Earth?). Radiative time constant on planets.
1.3 Radiative transfer. Solar/ UV (Mars as case study). Infrared. Radiative-convective equilibrium.
1.4 Photochemistry on Earth, Mars, Venus.
1.5 The upper atmosphere: Mesosphere, thermosphere, homopause, exosphere.
1.6 Escape processes: Jean's escape, hydrodynamic escape, impact erosion, sputtering.

2. Atmospheric Evolution (Wks 4-8)

2.1 The solar nebula. Planetary formation processes and chemical equilibrium/mixing in the nebula.
2.2 Early steam atmospheres. Ocean-vaporizing impacts on Earth.
2.3 Noble gases and isotopes as indicators of atmospheric evolution. More atmospheric escape.
2.4 Evolution of Earth's atmosphere and climate over geologic history.
2.5 Evolution of Mars' atmosphere and climate
2.6 Evolution of Venus's atmosphere and climate
2.7 Evolution of Titan's atmosphere
2.8 Atmospheric spectroscopy of extrasolar planets

3. Planetary Atmospheric Circulations: The moving structure (Wks 8-10)

3.1 Fluid mechanics basics. Geostrophic balance on Earth & Mars. Cyclostrophic balance. Rossby number.
3.2 Large-scale vertical motion. Richardson number.
3.3 Vorticity, potential vorticity. Atmospheric waves. Thermal tides.
3.4 Mars: observed circulation
3.5 Venus: observed circulation; superrotation
3.6 Titan: observed circulation
3.7 Triton and Pluto atmospheres. Thin atmospheres, e.g., Io.
3.8 Jupiter & extrasolar planet gas giants.

Recommended Textbooks:

Broadly speaking, we will follow the material in De Pater and Lissauer. However, our coverage follows a slightly different order and also the De Pater & Lissauer book is sometimes insufficient for our purposes. Consequently, I will refer to other books as listed below from time to time.

1) I. de Pater and J. Lissauer, *Planetary Sciences*, Cambridge University Press, 2001.
Chapters 1, 3 & 4 cover introductory material, energy transport and planetary atmospheres, respectively.

2) J. S. Lewis, *Physics and Chemistry of the Solar System*, Revised Edition , Academic Press, 1997.
This book covers the whole Solar System and its coverage of atmopheres is biased towards a geochemical viewpoint.
An older book is: **J. S. Lewis and R. G. Prinn, *Planets and their Atmospheres: Origin and Evolution*, Academic Press, 1984**. This also takes a geochemical viewpoint of planetary atmospheres.

3) J. W. Chamberlain and D. M. Hunten, *Theory of Planetary Atmospheres*, 2nd Ed., Academic, 1987.
Although the title sounds broad, this book focuses on upper atmospheres and aeronomy, where it has very good coverage.

4) Y. L. Yung and W. B. DeMore, Photochemistry of Planetary Atmospheres, Oxford University Press, 1999.
Planetary atmospheres with a focus on the photochemistry.

5) J. C. G. Walker, *Evolution of the Atmosphere*, Macmillan, 1977. This old book is extremely well-written and lucid, but is now very out-of-date.

6) J.K. Beatty and A. Chaikin, eds., *The New Solar System*, 4th Edition, 1998.
This book gives a non-mathematical, but accurate, coverage of the Solar System. It is good introductory reading.

Good textbooks that concisely cover the basic principles of atmospheric physics and chemistry to a level used in this course are:
(a) Andrews, D. G., *An Introduction to Atmospheric Physics*, CUP, 2000.
(b) *Houghton, J., *Physics of Atmospheres* (3rd Ed), CUP, 2002.
(c) Salby, M L., *Fundamentals of Atmospheric Physics*, Academic, 1996.
(d) *Visconti, G., *Fundamentals of the Chemistry and Physics of the Atmosphere,* Springer, 2001.

*These books have a more “planetary” perspective compared to the others, especially Visconti.

Grade Components: Homework (60%). Paper on a planetary atmosphere topic of your choice (40%).