Winter Quarter 2014

Atmospheric Sciences 532: Atmospheric Radiation I

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office hours to be arranged

COURSE OUTLINE

1. Introduction.
   - Composition and thermal structure of Earth's atmosphere
   - Vertical distribution of greenhouse gases
   - Solar and terrestrial radiation spectra
   - Distribution of solar radiation with season and latitude

2. Fundamentals of radiation
   - Radiation nomenclature and units: radiance, irradiance, intensity, flux, absorption coefficients, emissivity, optical depth, Beer's law
   - Radiative transfer equation
   - Blackbody radiation laws: Planck, Kirchhoff, Stefan-Boltzmann, Wien, Rayleigh-Jeans
   - Local thermodynamic equilibrium (LTE); non-LTE. Einstein relations, statistical equilibrium equation
   - Solution of longwave radiative transfer equation (Schwarzschild's equation)
   - Radiative equilibrium temperature distribution
   - Describe models for project

3. Absorption and emission of radiation by gases
   - Kinetic theory of gases
   - Molecular energy levels; electronic, vibrational, rotational transitions.
   - Spacing of lines.
   - Spectra of carbon dioxide, ozone, and water vapor. Water-vapor continuum.
   - Line shapes: natural, Doppler, pressure (collision) broadening.
   - Absorption by non-overlapping Lorentz lines: equivalent width

4. Absorption by bands of spectral lines.
   - Frequency-averaging of transmission. Band models; k-distributions
   - Pressure-averaging of transmission.
   - Angular-averaging of transmission. Exponential integrals, diffusivity factor

5. Applications
   - Radiation and climate
   - Remote sensing

ASSIGNMENTS
Homework: approximately 8 problem sets. 65%
Term project, 35%

The term project is to use an existing longwave radiative-transfer model to compute infrared radiation fluxes and cooling rates in the atmosphere. The model will be used to examine the effects of changing temperature and humidity profiles, and the vertical distribution of greenhouse gases (CO_2, O_3, CH_4, . . .) and the effect of clouds at various heights.

TEXTBOOKS *(on reserve in Chemistry library)*

Thomas, G.E., and K. Stamnes, 1999: Radiative Transfer in the Atmosphere and Ocean. Cambridge Univ. Press.

Petty, G.W., 2006: A First Course in Atmospheric Radiation. Sundog Publishing.

Liou, K.N., 2002: An Introduction to Atmospheric Radiation, second edition. Academic Press.

Bohren, C.F., and E.E. Clothiaux, 2006: Fundamentals of Atmospheric Radiation. Wiley.

Houghton, J.T., 2002: The Physics of Atmospheres, third edition. Cambridge Univ. Press.

REFERENCE BOOKS *(also on reserve in Chemistry library)*

Barrow, G.M., 1962: Introduction to Molecular Spectroscopy. McGraw-Hill.

Goody, R.M., and Y. Yung, 1989: Atmospheric Radiation, second edition. Oxford Univ. Press.

Menzel, D.H. (Ed.), 1966: Selected Papers on the Transfer of Radiation. Dover.

Paltridge, G.W., and C.M.R. Platt, 1976: Radiation Processes in Meteorology and Climatology. Elsevier.

Sears, F.W., and G.L. Salinger, 1975: Thermodynamics, Kinetic Theory, and Statistical Thermodynamics. Addison-Wesley