EPS 238 Class 1: Introduction

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University Museum 103A

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Syllabus

- Note dates of projects
  - 1st project is primarily atmospheric spectroscopy
  - 2nd project adds radiative transfer details
- Some syllabus details subject to change as the course progresses

Website: `www.cfa.harvard.edu/~kchance/EPS238-2012/EPS238-2012.html`

- atmospheric properties
- basic reference data, physical constants
- solar data
- spectroscopic data
- code examples and subroutines
- class notes
- problems and solutions

Class philosophy: To develop the capability to synthesize atmospheric spectra from various:

- platforms (ground-based, airplane, balloon, satellite);
- geometries (zenith, limb, nadir);
- modes (emission, absorption, scattering);
- wavelengths (microwave, infrared, visible, ultraviolet).

In order to: understand what field measurements mean in a rigorous and quantitative sense, so that for **atmospheric modeling** (*e.g.*, GEOS-Chem) you will be aware of the details, strength and weaknesses of the measurement sources; for **atmospheric measuring**, you will understand the information content of the spectra (with implications for uncertainties and for design of retrieval algorithms); and for **instrument proposal and design** you will be able to proceed quantitatively.

Class participation and interaction is welcomed and encouraged.

The course is intended to be accompanied by the development of increasing sophisticated **atmospheric and spectroscopic modeling** capability (the student develops a computer model for simulation of atmospheric spectra from microwave through ultraviolet, including a stable of databases and programming procedures). Students should have access to appropriate computers, compilers (*e.g.*, FORTRAN or c), and printing and plotting capability. I strongly recommend that a higher level language be used; matlab/ mathematica/IDL will run out of capability for the more detailed assignments; also, models (like GEOS-Chem) are written in higher-level languages, often FORTRAN. Might you be writing code for a model in the future? We will schedule a FORTRAN programming tutorial if the class desires.

Survey of students

- computing and plotting capability and resources
- quantum mechanics, spectroscopy, statistical mechanics
- scientific background, majors

email me answers by January 25, COB

Initial reading: basic atmospheric structure and properties

- Houghton: Chapter 1 (some basic ideas: hydrostatic equilibrium, scale heights, adiabatic lapse rate); Chapter 5, sec. 1 (Upper atmospheric temperature structure)
- Goody and Yung: Chapter 1. Introduction

Initial problems (due February 2), to get up and running computationally:

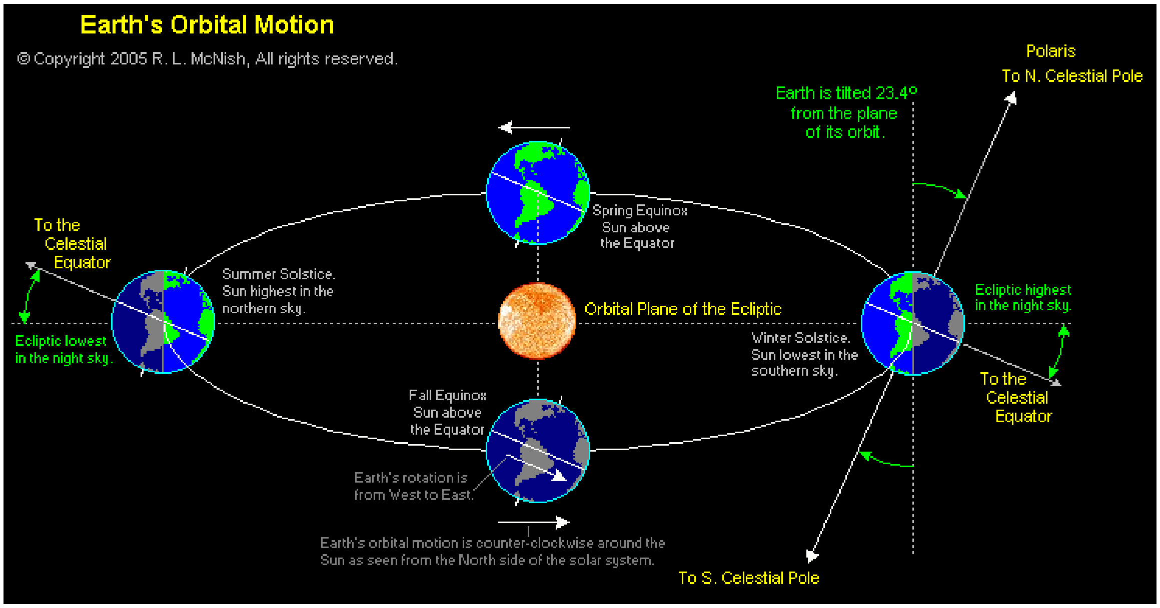
1. Nadir look from space at a 100 km-thick spherical atmosphere: Program, calculate, and plot the total geometric path through the atmosphere versus solar zenith angle (SZA) for SZA = 0-90^o (later, we will add refraction to calculations).
2. Limb view from space, 100 km spherical atmosphere: Program, calculate, and plot the path through the atmosphere versus tangent height over the range 0-100 km (later we will add refraction and a more realistic atmosphere).

Results by email or anonymous ftp cfa-ftp.harvard.edu
cd incoming/kchance/EPS238 login: anonymous password: full email

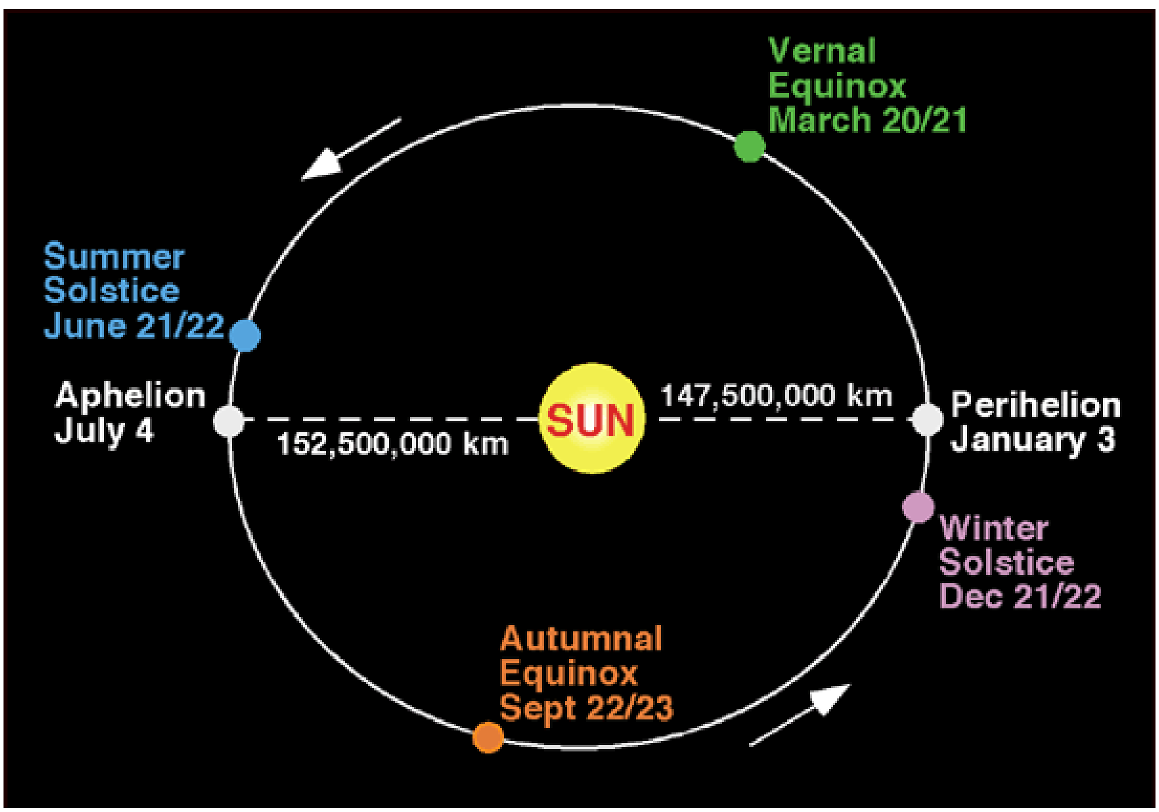
Overview of measurement programs (with a prejudice for mine).

- FIRS OH
    - FIRS (SAO) is a balloon-borne middle-atmospheric emission spectrometer which operates in the far infrared. It measures the Earth's limb at different angles to resolve altitude profile of gases, chiefly in the stratosphere.
- GOME, SCIAMACHY, and OMI nadir NO_2, HCHO, O_3, and BrO
    - GOME (European Space Agency) measures in the nadir geometry over the spectral range 240-790 nm (ultraviolet, visible, near infrared). It provides total columns of gases which may be further analyzed to extract tropospheric pollution using techniques from 3-D modeling and radiative transfer, and also directly-retrieved profiles of O_3 and tropospheric O_3 measurements.
    - SCIAMACHY (Dutch/German/Belgian) measures in the nadir geometry over the spectral range 240-1700 nm (ultraviolet, visible, near infrared), plus in the infrared at 2.0 and 2.4 *microns* (μm). It also measures in *limb-scattering* and in solar and lunar *occultation*.
    - OMI (Dutch/Finnish/U.S.) measures in the nadir geometry over the spectral range 270-500 nm (ultraviolet, visible).

- Orbiting Carbon Observatory
  - OCO (Jet Propulsion Laboratory) will measure CO_2 and O_2 (to correct the CO_2 measurements for clouds), in order to determine atmospheric sources and sinks.
- ATMOS occultation
  - ATMOS (JPL) has measured a wide range in the infrared using solar occultation from several space shuttle flights in order to measure atmospheric profiles of a substantial number of stratospheric trace gases.
- THz astronomy
  - Terahertz astronomy is a potentially important extension of radioastronomy to higher frequencies. It is being developed at the SAO (and other places). SAO measurements are made from the Atacama Desert in Chile. Measurements are made in emission in the zenith direction.



http://www.aapscience7.net/Chapter%20Work/radec_earth_orbit.gif, from Bowie Jr. High School, Odessa, TX.



http://earthguide.ucsd.edu/images/bas/sun/helions.gif, Geosciences Research Division, Scripps Institution of Oceanography

Also, see EPS238-2012/refdata/solar/solar.dat