1. **Assigned January 31, due February 12**

To get up and running computationally:

a. 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).

b. 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).

2. Assigned February 5, due February 14

Use the data in us**76.dat** to determine the atmospheric scale height from the ground to the stratopause. Plot it against altitude and also against temperature.

3. Assigned February 5, due February 14

On units – MKS versus cgs, wavelengths versus wavenumbers and frequencies. Construct a table showing wavelengths and frequencies (nm, µm, cm^{-1}, MHz, GHz, and THz) for: CO 1→0 and 2←0 band centers (2143.272 cm^{-1}; 4260.063 cm^{-1}); ClO MLS emission line (204.35 GHz); O_2 *A* band center (13120.909 cm^{-1}); CO_2 15 µm "greenhouse" band (667.380 cm^{-1}); O_3 TOMS "on" wavelength (317.35 nm).

4. Assigned February 7, due February 19

Determine BB ***ster***radiancy (erg s^{-1} cm^{-2} sr^{-1}) by invoking Lambertian emission and integrating over solid angle.

5. Assigned February 7, due February 19

Construct an example where one observes an extended source (*e.g.*, a cloud) with an instrument having a given étendue. Show that the étendue is the same for the cloud observing you.

6. Assigned February 12, due February 21

a. Using a 100-meter radio telescope, calculating the beam in radians as the diffraction limit ($1.22\lambda/d$ where λ is the wavelength and d the telescope diameter), what T_{sys} is needed to detect Jupiter to 10% @ 10 cm wavelength in 5 hours? Ignore the cosmic microwave background (CMB).

b. At what angular resolution does Jupiter match the CMB? If I include the CMB, can I make the measurement with this telescope?

7. Assigned February 14, due February 26

Calculate and plot the intensity of blackbody radiation arriving at the Earth from the mean solar distance for temperatures corresponding to the bottom and the top of the solar photosphere. Do this for 1 nm intervals, 300-500. Compare these results with the solar irradiance spectrum of **rkurucz-solar-irrad.jpeg**. Your conclusions?

8. Assigned March 11, due March 20

Calculate the Doppler hw1e and pressure broadening HWHM for the following lines, using the temperature/pressure profile of the US1976 atmosphere:

Molecule	position	Pressure broadening coefficient (cm^{-1} atm^{-1})
ClO	650 GHz	0.06
HCl	125 cm^{-1}	0.08
O_3	9.6 μm	0.05
H_2O	1.02 μm	0.08
O_2	762 nm	0.03

Calculate for sea level, tropopause, mid-stratosphere (25 km), and stratopause.

Where does which type of broadening dominate in the atmosphere and versus frequency?

9. Assigned March 20, due April 3
Select a combination of spectral line and atmospheric location from problem #6 where the Doppler and Lorentz widths are comparable. For a range of (line intensity, *S*) × (column density, *N*), ranging from very small to quite large (optically thin to optically very thick), calculate the Voigt function, *V*, versus position and plot the results as either an emission line ($1-e^{-SNV(\sigma)}$) or an absorption line ($e^{-SNV(\sigma)}$).

10. Extra homework problem

"The Lunar CRater Observation and Sensing Satellite (LCROSS) mission to look for water on the moon will be a 'secondary payload spacecraft.' LCROSS will begin its trip to the moon on the same rocket as the Lunar Reconnaissance Orbiter (LRO), which will conduct a different lunar task."

"LCROSS will impact the moon near its south pole early in 2009. The LCROSS mission is to search for water and other materials that astronauts could use at a future lunar outpost."

"The lunar impactor will share a rocket ride into space with a second satellite, the Lunar Reconnaissance Orbiter (LRO). After the orbiter separates from the Atlas V launch vehicle for LRO's own mission, LCROSS will use the spent Centaur upper stage rocket as a 4,400-pound (1,980-kilogram) lunar impactor, targeting a permanently shadowed crater near the lunar South Pole." (NASA)

The impact will eject about 10^6 Kg of material, some of which may be water (hopefully the impact will not produce water). It should "send up a plume of vapor and debris … rising 30 to 40 miles above the surface." For simplicity's sake, assume the cloud is spherical and 25 km in diameter, and that it consists of x % H_2O and (100 - x) % dust, by weight. Assume that the cloud is optically thin in dust and H_2O (then you only need to calculate the BB and H_2O spectra once).

There is a nice infrared band of water at 6.3 μm (actually centered at 1594.7498 cm^{-1}). Calculate the emission spectrum for this band, plus the dust. Assume spectra are taken when the cloud of gas and dust has cooled to the temperature where the Wien's Law maximum in power is at the band center. Assume Doppler broadening only. I have put **01_hit04.4eps238.par** on the website. It contains the parameters for this band, $H_2{}^{16}O$ only, from 1300 – 1900 cm^{-1}, with many, many weak lines weeded out.

The lunar albedo is about 0.07 in the infrared: assume that the dust emission is 93% of blackbody. Assume the dust density is 2.5 grams cm^{-3}. Put the dust into 10 μm particles, to calculate emitting surface.

Assume the CMB is completely negligible (it is). I propose an instrument with 40 cm^{-1} hw1/e Gaussian lineshape (although you may wish to try something else). Place a detector element to cover every 15 cm^{-1}.

Detectors and instrument: Rather than working out detector properties, instrument size, etc., assume that measurements can be made with signal-to-noise ratio (S/N) of 100 for 1 second of integration time, *t* (improving as $\sqrt{t}$) for the blackbody at the temperature determined above. Then you only need the column density through the cloud. **noise-for-extra-problem.dat** contains a 2000-point noise spectrum with RMS = 0.01 (*i.e.*, S/N=100). You can also calculate you own with **noise.f90**.

Set the problem up with 10% H_2O, plot the result, and see if you see anything. If not, what combination of H_2O fraction and integration time would give you a reasonable observation (say S/N = 5)? Do we need better detectors, or a larger instrument?