Physical Metrology Assignment III

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Assigned: Sep. 25, 2017; Due: October 18, 2017. Total points: [416]

1. The instantaneous solar irradiance F at the top of atmosphere can be computed as:

$$F = S_0 \times \frac{a^2}{r^2} \times cos(\theta) \quad (1)$$

where S_0 is the solar constant (1368Wm^{-2}) and θ is the solar zenith angle. $\frac{a^2}{r^2}$ is the ratio of the instantaneous Sun-Earth distance to the average Sun-Earth distance:

$$\frac{a^2}{r^2} = 1.0 + 0.034 \times cos(\frac{(day-3)}{365} \times 2\pi) \quad (2)$$

where *day* is the julidan day number. The value of θ depends on the latitude ϕ, declination angle of the sun δ (from 23.45°N on June 22 to -23.45°S on Dec 22) and the hour angle h (from 0 at local noon time to 2π in the midnight) :

$$cos(\theta) = cos(\phi)\, cos(\delta)\, cos(h) + sin(\delta)\, sin(\phi) \quad (3)$$

$$\delta = -23.45 \times cos((day + 10.)/365 \times 2\pi) \quad (4)$$

$$h = \frac{2\pi}{24. \times 3600} \times (Lt - 12. \times 3600.) \quad (5)$$

where Lt is local time in seconds, e.g., $Lt = local\ hour \times 3600, local\ hour \epsilon [1, 24]$.

Note, in the above equation, h is unit of radiance, while δ is unit of degree. Based upon above equations, write an IDL program to calculate the *24hr-averaged F* as a function of latitude (from -90N to 90N) and Julian day (from 1 to 365) in year 2012. Use contour routine in Python to plot your results (x-axis, Julian day; y-axis, Latitude). [150]

Hint: Please think to write the Python code based upon the programs you did in assignment I and II, and use routines and modules if necessary. In the code, you need to pay attention to the calculations for high latitude and polar regions where there could be no sunlight at all in particular seasons. Also please be careful with the unit. You may compare your figure with Figure 2.9 in the textbook, and find out if yours are consistent with the textbook. Can you reproduce the exact figure in the textbook?

2. Use Python to plot the Planck's function for Earth and Sun assuming their temperature of 300 K and 6500 K, respectively. Also plot in the same figure the curve of the Wien's displacement law. X-axis: Wavelength (μm); y-axis: Radiance (W m^{-2} μm^{-1} sr^{-1}). Please be careful with unit of each variable. [70]

3. Do problems 6.4 (10 points), 6.5 (20 points), 6.9 (15 points), 6.13 (10 points), 6.20 (20 points), 6.23 (15 points). Hint, please try to use the Python program you developed in the problem above. [90]

4. Do problems 7.3 (10 points), 7.6 (18 points), 7.8 (10 points), [38]

5. Do problems 8.9 (5 points), 12.6 (18 points), 12.9 (15 points), [38]

6. Use Microtop instrument to measure the aerosol optical thickness (AOT) and precipitable water or PW (i.e., total amount of water vapor) on a cloud-free day, and record the data in text ascii format that includes the date, time, AOT at different wavelengths, and PW. For this assignment, you should take at least 3 measurements. [30]