Homework Set 3

Due October 12, 2023

For these exercises, assume that the Earth's obliquity is a constant $23.5°$. Assume that the semimajor axis of the Earth's elliptical orbit around the Sun remains constant at 1.5×10^{11} m. Assume that the solar flux at this distance is 1368 Wm^{-2}.

For Exercise 4, assume that the annual average solar flux F is

$$F = \frac{F_0}{\sqrt{1-e^2}} s(y),$$

where $F_0 = 1368$ Wm^{-2}, e is the eccentricity, and $s(y)$ is the distribution of insolation as a function of the sine of the latitude. Use Chylek and Coakley's quadratic approximation for s:

$$s(y) = 1 - 0.241(3y^2 - 1).$$

1. Compute the maximum and minimum distances from the Sun to the Earth for eccentricities of $e = 0$, $e = 0.016$, $e = 0.03$, and $e = 0.06$. Compute the solar flux at these distances.

2. Assume that the northern hemisphere summer solstice occurs at perihelion (the point on the orbit of minimum distance to the Sun). For each of the eccentricities in Exercise 1, compute the insolation at noon on the summer solstice for latitudes of $0°$ (the Equator), $23.5°$N (the Tropic of Cancer), $45°$N (the latitude of the Twin Cities, $66.5°$N (the Arctic Circle), and $90°$N (the North Pole).

3. Repeat Exercise 2 with the assumption that the northern hemisphere summer solstice occurs at aphelion (the point on the orbit of maximum distance to the Sun).

4. For each of the eccentricities in Exercise 1 and each of the latitudes in Exercise 2, compute the annual average insolation.

5. Compare and discuss your answers to Exercises 2, 3, and 4.