PROBLEM 1

The solar radiation incident upon Earth’s surface plays a vital role in a number of global environmental interactions and processes, including, for example, climate, evaporation and condensation, freezing and thawing of soils, and photosynthesis. These processes depend to a large degree on the intensity of solar radiation, which is a function of latitude, time of year and time of day. The rate of energy transfer from the Sun is called the solar flux. The solar flux incident on a unit surface area can be approximated by

\[ S = S_0 \cos \theta_s \]

where,
- \( S \) = solar flux per unit area
- \( S_0 \) = solar constant = 1372 Watts per meter squared (W/m\(^2\))
- \( \theta_s \) = solar zenith angle

a) Show with a diagram and calculate the solar zenith angle, which, recall, is defined as the angular displacement of the sun from the vertical, at summer solstice and the solar flux for the following two locations: (1) Jokkmokk, Sweden and (2) Recife, Brazil.

b) At what latitude(s) is the solar flux zero at winter solstice?

c) Repeat your calculations of solar zenith angle and solar flux at the two locations at the fall equinox.

PROBLEM 2

Heat capacity is the amount of heat energy required to increase the temperature of one gram of a substance by one degree Centigrade. Because water has a much higher heat capacity than land, the oceans have a strong moderating influence on both regional and global climate (See, for example, Fig. 5-7 and Fig. 5-13 in Geosystems). This influence is clearly evident over the continental United States, where, on average, winter temperatures are colder and summer time temperatures warmer in the Midwest than on the coasts. For example, Omaha and San Francisco are at about the same latitude, yet temperatures in Omaha average 10°C lower in January, and 10°C higher in July than in San Francisco.

The importance of heat capacity is illustrated by the following example. Consider two adjacent, but isolated boxes each having the dimensions (30 cm)\( \times \) (40 cm)\( \times \) (3 cm). One box is filled with water of density 1.00 grams per cm\(^3\), and the other box is filled with dry soil of density 1.20 grams per cm\(^3\). The heat capacity of the water is four times that of the soil. Both boxes are heated by the sun. Initially the water and soil are at 20°C, and each have uniform temperatures throughout their respective volumes. Calculate the temperature of the soil if after 4 hours the
Temperature of the water is $25^\circ C$. Assume temperature is uniform throughout the soil. The general formula for heat capacity is:

$$C = \frac{H}{M(T_f - T_i)}$$

where $C =$ heat capacity, $M =$ mass, $H =$ heat energy, $T_f =$ final temperature, $T_i =$ initial temperature.

Briefly explain the significance of your results as they relate to the temperature changes of the land and the ocean in coastal environments and to the influence on large-scale atmospheric circulation patterns over large continents.

**PROBLEM 3**

Give the latitude and longitude for:

a) Pyongyang, North Korea  
b) Ouagadougou, Burkina Faso  
c) Hay River, Northwest Territories, Canada  
d) Kuala Lumpur, Malaysia  
e) Hobart, Australia