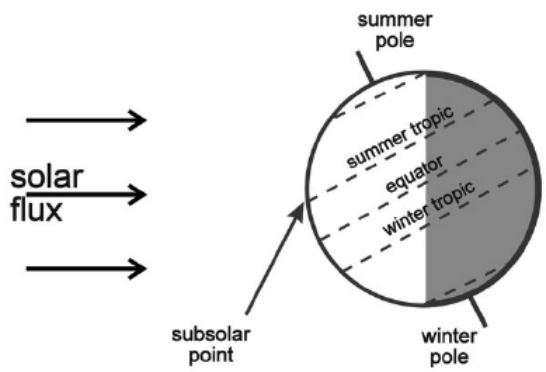
Beyond 1D

The earth is (roughly) a sphere. Its rotation axis tilts away from the normal direction to its orbital plane. This is called the obliquity and is ~23.45 degrees currently. The earth's orbit is slightly different from a circle. This deviation is measured by the eccentricity $e = \dfrac{d_a - d_p}{d_a + d_p}$, which is 0.0167 currently. Currently, the perihelion is close to the southern summer solstice. As a result, the peak top-of-atmosphere insolation is greater in the Southern Hemisphere. However, by Kepler's second law, the earth spends less time during perihelion than during aphelion. So the total amount of insolation energy for a given solar longitude interval is constant.



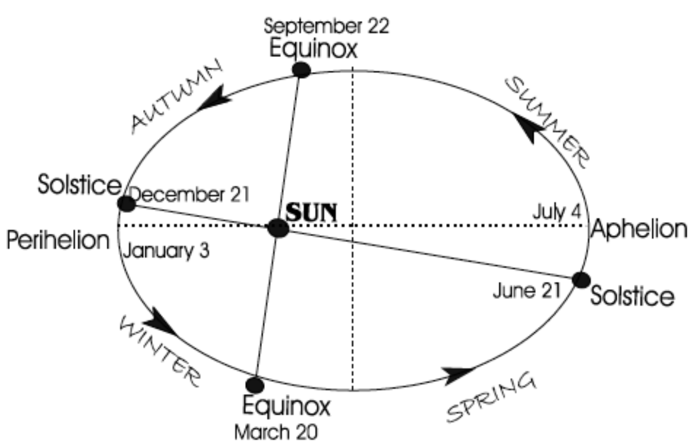


Figure 5.4: Earth describes an elliptical orbit around the Sun, greatly exaggerated in the figure. The longest (shortest) day occurs at the summer (winter) solstice when the earth's spin axis points toward (away from) the sun. The Earth is farthest from (closest to) the Sun at aphelion (perihelion). The seasons are labelled for the Northern hemisphere.

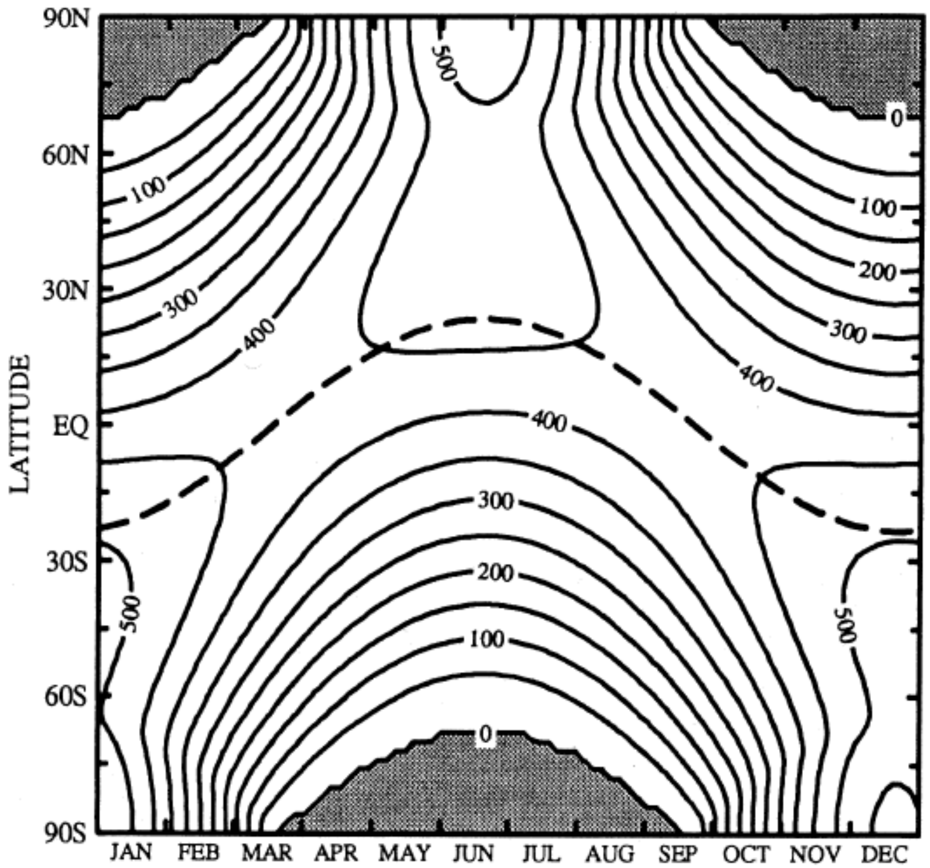


Fig. 2.6 Contour graph of the daily average insolation at the top of the atmosphere as a function of season and latitude. The contour interval is 50 W m^{-2}. The heavy dashed line indicates the latitude of the subsolar point at noon.

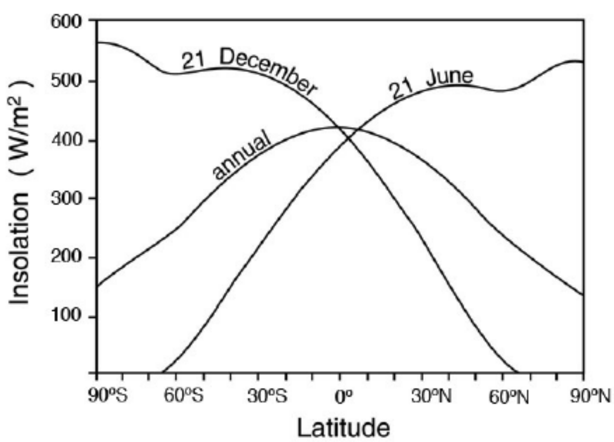


Figure 5.2: Distribution of annual mean and solstice (see Fig.5.4) incoming solar radiation. The slight dip in the distribution at, for example, the winter solstice (December 21st) in the southern hemisphere, corresponds to the edge of the polar day.

Note that incoming solar radiation is largest during polar summer. Why is the pole not warmer than the tropics during polar summer? (high albedo, small greenhouse effect, large thermal capacity).

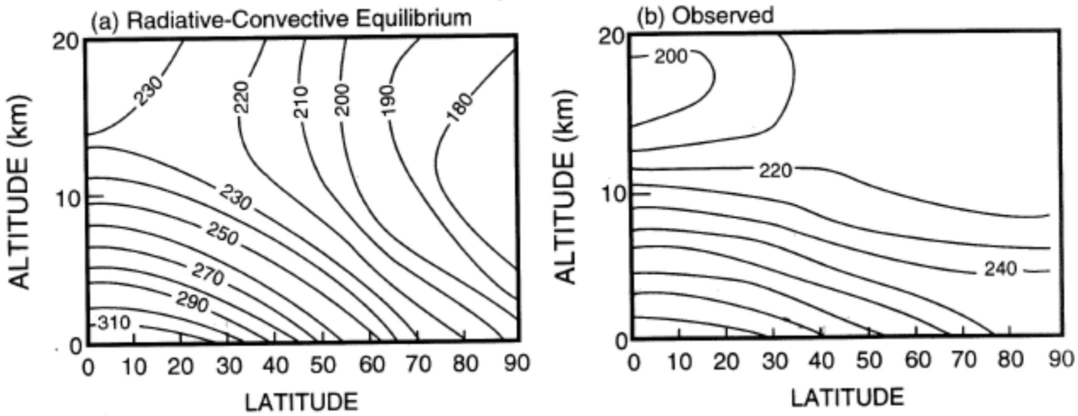


Figure 10.1 Zonal–mean temperature as a function of latitude and height (a) under radiative–convective equilibrium and (b) observed during northern winter. Without horizontal heat transfer, radiative–convective equilibrium establishes a meridional temperature gradient that is much stronger than observed. Sources: Liou (1990) and Fleming *et al.* (1988).

The solar radiation on average is larger in the tropics than at high latitudes. If we do the radiative-convective equilibrium calculation, we should find that the atmosphere is warmer in the tropics and colder in the higher latitudes. Can the atmosphere remain at rest? Within a column of air, being at rest requires hydrostatic equilibrium. With this, we deduce that there must be horizontal pressure gradient somewhere, which will drive motion.