Lab. Principles of Remote Sensing
Lap(2) : Radiation outside the atmosphere

Experiment ami : Calculation of daily and monthly averages of solar radiation reaching the top of the atmosphere

Experience theory: The value of solar radiation outside the atmosphere, Ra, for each day of the year and for different latitudes, is estimated through the solar constant, the angle of inclination of the sun, and the sequence of the day in the year and is given by the following equation:

$$R_a = \frac{24(60)}{\pi} G_{sc} d_r [\omega_s \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\cos(\omega_s)] \quad (1)$$

whereas:
Ra: radiation from the atmosphere (Wm^{-2}).
Gsc: The solar constant is equal to (1368 Wm^{-2}).
dr: The inverse of the relative distance between the Sun and the Earth.
***ω*s: sunset hour (rad).**
***φ*: latitude (rad).**
***δ*: the angle of inclination of the sun (rad).**

The inverse of the relative distance between the Sun and the Earth and the Sun's tilt are calculated using the following equations:

$$d_r = 1 + 0.033\cos\left[\frac{2\pi}{365} J\right] \quad (2)$$

$$\delta = 0.409\sin\left[\frac{2\pi}{365} J - 1.39\right] \quad (3)$$

whereas:

J: Sequence of the day in the year between 1 (1 January) and 365 or 366 (31 December).

The hour angle is calculated using the following equation:

$$\omega_s = \arccos[-\tan(\varphi)\tan(\delta)] \quad (4)$$

The arcos function is not available in all computer languages, so the hour angle is calculated using the arctan function, as shown in the following equation:

$$\omega_s = \frac{\pi}{2} - \arctan\left[\frac{-\tan(\varphi)\tan(\delta)}{X^{0.5}}\right] \quad (5)$$

whereas:

$$\mathbf{X = 1 - [\tan(\varphi)]^2[\tan(\delta)]^2} \quad \textbf{(6)}$$

or

$$\mathbf{X = 0.00001 \text{ if } X \leq 0} \quad \textbf{(7)}$$

Required:
Implementation of a program (TOA) to calculate the daily average solar radiation at the top of the atmosphere as a function of latitudes from -90 to 90 and for each day

days of the year and discuss the results.