Computer Aided Instruction on Solar Engineering Fundamentals

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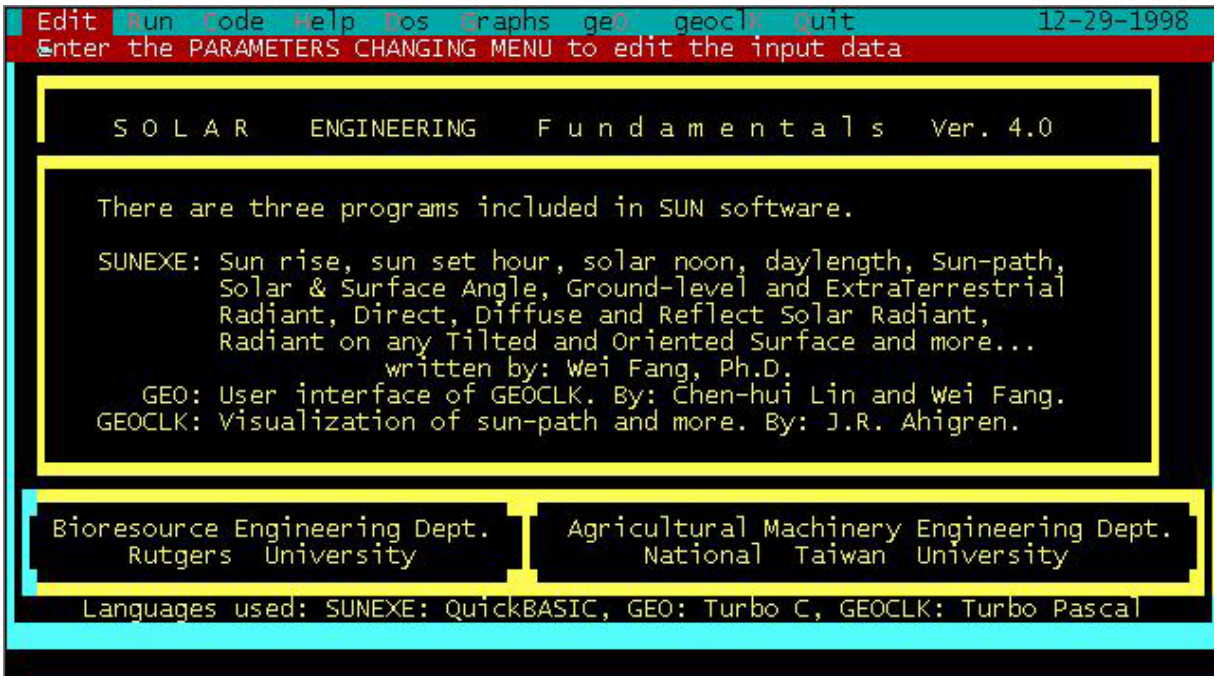
Enter 'SUNEXE' to start.

The display of the first page is shown as follows:



As shown on the 1st line, there are 9 options available. They are:

Edit	Run	Code	Help	Dos	Graphs	geO	geoclK	Quit

Follow by the arrow keys entered by the user, the TEXT in the 2nd line will give a brief illustration of each command, accordingly.

Option 1. Edit - Enter the PARAMETERS CHANGING MENU to edit the input data. Users can either enter '1' or 'E' to jump to this option.

After users select this option, another 5 sub-options will be shown on the 1st line of the monitor as follows:

```
 Main  DaylightSaving  Wave_Band  Latitude  Back
```

Sub-option 1.1. Main - Edit the major parameters

The related parameters and the default values are as follows:

```
                PARAMETERS CHANGING MENU
-----------------------------------------------
1.  Latitude  , in degree                 40
2.  Longitude , in degree                 74.5
3.  Standard longitude , in degree        75
4.  Month of the year                     5
5.  Day   of the month                    30
6.  Surface Tilted angle, Zc, in degree   0
7.  Surface Azimuth angle Ac, in degree   0
Q. ---------RETURN TO MAIN MENU----------------
```

The last line shows how to do the editing in this edit menu.

Sub-option 1.2. DaylightSaving - the DayLight SAVING for solar and local time conversion

The related parameters and the default values are as follows:

```
                      about DayLight saving
-------------------------------------------------------------
 1.  included daylight saving hour in calculation <1.Y/0.N>  0
 2.  If Yes, starting Julian date for D.Light Saving         97
 3.  If Yes, ending   Julian date for D.Light Saving         297
 Q. ------------  RETURN  TO  MAIN  MENU -----------------
```

Sub-option 1.3. Wave_Band - the assigned WAVEBAND for energy calculation

The related parameters and the default values are as follows:

```
                Assigned Wave Band and Time Frame
-------------------------------------------------------------
 1. Lower Bound (L.B) of Waveband, nm  +-------------+   300
 2. Upper Bound (U.B) of Waveband, nm  | refer to the|   1100
 3. Fraction of L.B of Waveband, deci. | table below |   .0121
 4. Fraction of U.B of Waveband, deci. +-------------+   .7395
 5. L.B. of the Time Frame, local time, hourly basis     9
 6. U.B. of the Time Frame, local time, hourly basis     18
 Q. ------------  RETURN   TO   MAIN   MENU ------------------
```

A table of helping users to enter the values in options 3 and 4 is also displayed in the same page. This table only contains limited number of wavebands. Some interpolation might be necessary if values of options 1 and 2 are not listed in the table.

Sub-option 1.4. Latitude - the assigned LATITUDE range for ET radiant calculation

This option is designed to set up the range of the latitude for options 'g', 'h', and 'I' in '6. Graphs' option.

The related parameters and the default values are as follows:

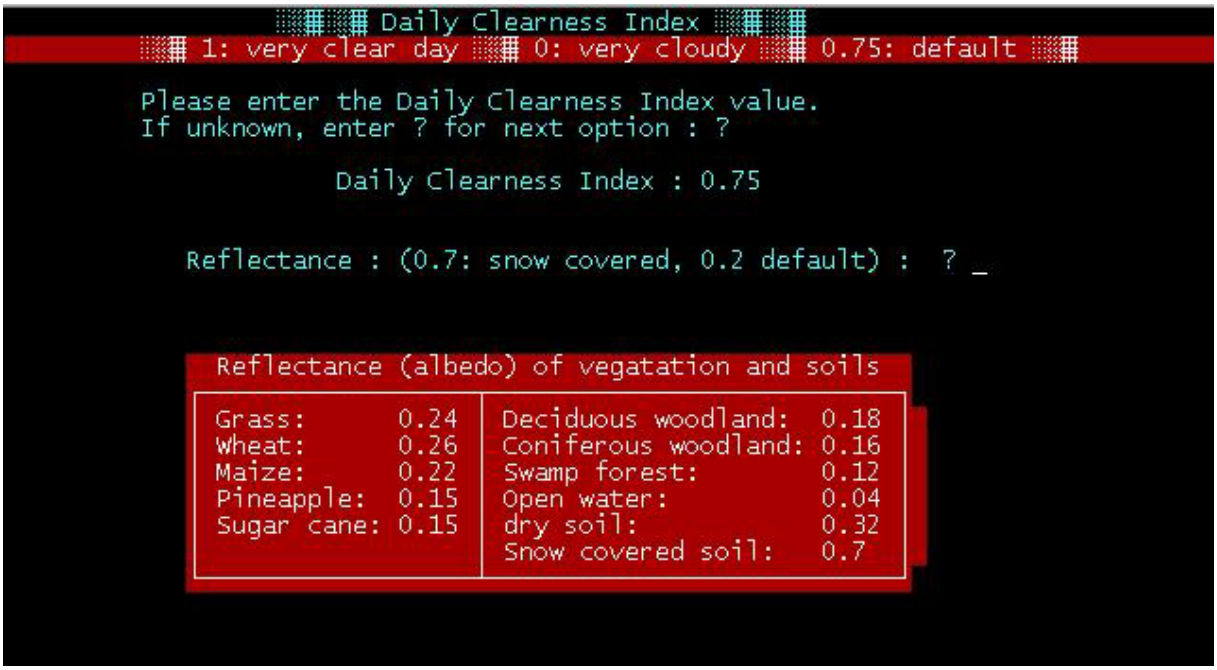
```
           Assigned Latitude Rang
-----------------------------------------
 1. Lower Bound (L.B) of Latitude,    30
 2. Interval          of Latitude,    30
 3. number of curves on graph          3
 Q. ---- RETURN TO MAIN  MENU -------
```

Sub-option 1.5. Back - Back to previous menu

Option 2. Run - General calculation, TEXT output, for GRAPHs see option 6. Users can either enter '2' or 'R' to jump to this option.

Sub-option 2.1. Hourly Radiation per day (E.T. & Ground Level)

The program will calculate based on the default values assigned in the major parameters pages (see sub-option 1.1). Besides that, more information is required to complete the calculation. These information can be seen in the next page.



The results of this sub-option includes 4 more pages. The 1st page is as follows:

```
+-----------------------------------------------------------------+
|  Local Latitude   :    40.00 degree |        Date:    5/30      |
|        Longitude  :    74.50 degree | Julian date:    150       |
|  Std.  Longitude  :    75.00 degree | w/o   daylight saving     |
+-----------------------------------------------------------------+
|  Sun's declination angle :    0.3796 rad =    21.7508 degree    |
|  E.T. radiation on plane NORMAL to sun ray :   1315.16  W/m*    |
|  the Sun Set Hour Angle  :  109.559  degree                     |
|  Sun Rise at   <  4: 37>  Sun Set at < 19: 13>, local time      |
|  Solar Noon at < 11: 55>  Day Length :  14 hrs 36 min           |
+-----------------------------------------------------------------+
```

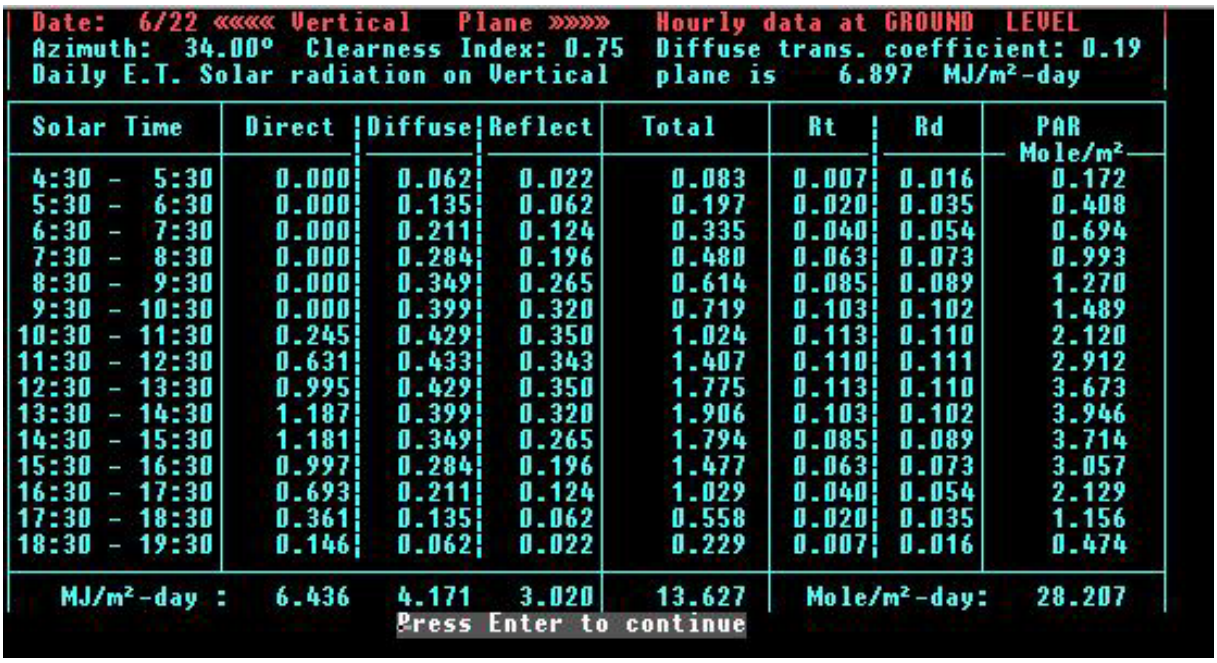
The 2nd page shows the hourly radiation data at ground level for a **horizontal plane**. The snapshot of the screen is as follows:

Date: 6/22 «««« Horizontal Plane »»»» Hourly data at GROUND LEVEL
Azimuth: 34.00° Clearness Index: 0.75 Diffuse trans. coefficient: 0.19
Daily E.T. Solar radiation on Horizontal plane is 41.457 MJ/m²-day

Solar Time	Direct	Diffuse	Reflect	Total	Rt	Rd	PAR Mole/m²
4:30 - 5:30	0.093	0.123	0.000	0.216	0.007	0.016	0.447
5:30 - 6:30	0.355	0.269	0.000	0.624	0.020	0.035	1.293
6:30 - 7:30	0.822	0.422	0.000	1.243	0.040	0.054	2.574
7:30 - 8:30	1.388	0.568	0.000	1.956	0.063	0.073	4.050
8:30 - 9:30	1.950	0.698	0.000	2.648	0.085	0.089	5.480
9:30 - 10:30	2.402	0.798	0.000	3.200	0.103	0.102	6.625
10:30 - 11:30	2.640	0.859	0.000	3.499	0.113	0.110	7.243
11:30 - 12:30	2.560	0.867	0.000	3.427	0.110	0.111	7.094
12:30 - 13:30	2.640	0.859	0.000	3.499	0.113	0.110	7.243
13:30 - 14:30	2.402	0.798	0.000	3.200	0.103	0.102	6.625
14:30 - 15:30	1.950	0.698	0.000	2.648	0.085	0.089	5.480
15:30 - 16:30	1.388	0.568	0.000	1.956	0.063	0.073	4.050
16:30 - 17:30	0.822	0.422	0.000	1.243	0.040	0.054	2.574
17:30 - 18:30	0.355	0.269	0.000	0.624	0.020	0.035	1.293
18:30 - 19:30	0.093	0.123	0.000	0.216	0.007	0.016	0.447
MJ/m²-day :	21.860	8.341	0.000	30.201	Mole/m²-day:		62.514

Press Enter to continue

The 3rd page shows the hourly radiation data at ground level for a **vertical plane**. The snapshot of the screen is as follows:

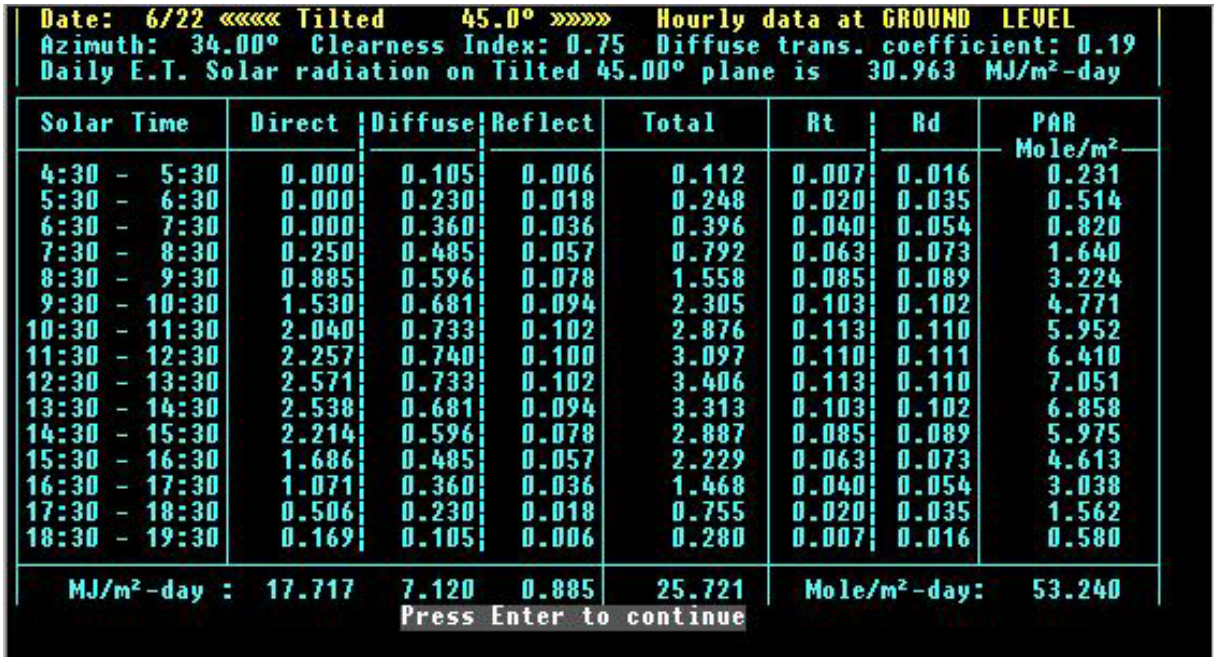


Date: 6/22 «««« Vertical Plane »»»» Hourly data at GROUND LEVEL
Azimuth: 34.00° Clearness Index: 0.75 Diffuse trans. coefficient: 0.19
Daily E.T. Solar radiation on Vertical plane is 6.897 MJ/m²-day

Solar Time	Direct	Diffuse	Reflect	Total	Rt	Rd	PAR Mole/m²
4:30 - 5:30	0.000	0.062	0.022	0.083	0.007	0.016	0.172
5:30 - 6:30	0.000	0.135	0.062	0.197	0.020	0.035	0.408
6:30 - 7:30	0.000	0.211	0.124	0.335	0.040	0.054	0.694
7:30 - 8:30	0.000	0.284	0.196	0.480	0.063	0.073	0.993
8:30 - 9:30	0.000	0.349	0.265	0.614	0.085	0.089	1.270
9:30 - 10:30	0.000	0.399	0.320	0.719	0.103	0.102	1.489
10:30 - 11:30	0.245	0.429	0.350	1.024	0.113	0.110	2.120
11:30 - 12:30	0.631	0.433	0.343	1.407	0.110	0.111	2.912
12:30 - 13:30	0.995	0.429	0.350	1.775	0.113	0.110	3.673
13:30 - 14:30	1.187	0.399	0.320	1.906	0.103	0.102	3.946
14:30 - 15:30	1.181	0.349	0.265	1.794	0.085	0.089	3.714
15:30 - 16:30	0.997	0.284	0.196	1.477	0.063	0.073	3.057
16:30 - 17:30	0.693	0.211	0.124	1.029	0.040	0.054	2.129
17:30 - 18:30	0.361	0.135	0.062	0.558	0.020	0.035	1.156
18:30 - 19:30	0.146	0.062	0.022	0.229	0.007	0.016	0.474
MJ/m²-day :	6.436	4.171	3.020	13.627	Mole/m²-day:		28.207

Press Enter to continue

The 4th page shows the hourly radiation data at ground level for **the user assigned tilted plane**. The snapshot of the screen is as follows:



Date: 6/22 «««« Tilted 45.0° »»»» Hourly data at GROUND LEVEL
Azimuth: 34.00° Clearness Index: 0.75 Diffuse trans. coefficient: 0.19
Daily E.T. Solar radiation on Tilted 45.00° plane is 30.963 MJ/m²-day

Solar Time	Direct	Diffuse	Reflect	Total	Rt	Rd	PAR Mole/m²
4:30 - 5:30	0.000	0.105	0.006	0.112	0.007	0.016	0.231
5:30 - 6:30	0.000	0.230	0.018	0.248	0.020	0.035	0.514
6:30 - 7:30	0.000	0.360	0.036	0.396	0.040	0.054	0.820
7:30 - 8:30	0.250	0.485	0.057	0.792	0.063	0.073	1.640
8:30 - 9:30	0.885	0.596	0.078	1.558	0.085	0.089	3.224
9:30 - 10:30	1.530	0.681	0.094	2.305	0.103	0.102	4.771
10:30 - 11:30	2.040	0.733	0.102	2.876	0.113	0.110	5.952
11:30 - 12:30	2.257	0.740	0.100	3.097	0.110	0.111	6.410
12:30 - 13:30	2.571	0.733	0.102	3.406	0.113	0.110	7.051
13:30 - 14:30	2.538	0.681	0.094	3.313	0.103	0.102	6.858
14:30 - 15:30	2.214	0.596	0.078	2.887	0.085	0.089	5.975
15:30 - 16:30	1.686	0.485	0.057	2.229	0.063	0.073	4.613
16:30 - 17:30	1.071	0.360	0.036	1.468	0.040	0.054	3.038
17:30 - 18:30	0.506	0.230	0.018	0.755	0.020	0.035	1.562
18:30 - 19:30	0.169	0.105	0.006	0.280	0.007	0.016	0.580
MJ/m²-day :	17.717	7.120	0.885	25.721	Mole/m²-day:		53.240

Press Enter to continue

Sub-option 2.2. Daily Radiation per Month

Basically, this option shows the E.T. radiation information which is the same with the previous option. But instead of showing one day data, this option provides the information for every day within the assigned month. The display screen is as follows:

```
Local Latitude, Longitude and std. Longitude:  40.00,  74.50 and  75.00 degree
+-------------------------------------------------------------------------+
       Julian DayLIGHT  Sun's  SunSET     E.T.    ---<local time>--- Day
mm/dd- Day -- saving  decl.ANG hourANG  SolarRad. Sun   Sun  Solar  length
-----  ------ ------- ----<degree>----- --<W/m2>- rise  set  noon  -hr-min---
 5/ 1   121    w/o     14.901  102.902   1331.12  5: 3 18:46 11:55  13  43
 5/ 2   122    w/o     15.210  103.188   1330.45  5: 2 18:47 11:54  13  45
   ...
 5/30   150    w/o     21.751  109.559   1315.16  4:37 19:13 11:55  14  36
 5/31   151    w/o     21.898  109.712   1314.76  4:36 19:14 11:55  14  37
+-------------------------------------------------------------------------+
```

Sub-option 2.3. E.T. radiant on Hori/Verti/Tilted Plane

This option shows the Daily information and the hourly energy received at the top of the atmosphere for a horizontal, vertical and tilted plane. The display format of different planes are similar, thus only one as the example is shown in here. The display screen of the hourly energy received on a horizontal plane is as follows:

```
+-------------------------------------+
|LocalTime|HORI.plane: azimuth: 0.0| M|
|From  to | ET.radiant    ET.PAR    | a|
|hhmm hhmm|    MJ/m2      mole/m2   | r|
|---------|---------- ------------ | k|
| 437  500|   0.06   0.1%    0.11  |  |
| 500  600|   0.76   1.9%    1.33  |  |
| 600  700|   1.63   4.0%    2.87  |  |
| 700  800|   2.48   6.1%    4.34  |  |
| 800  900|   3.23   7.9%    5.66  |  |
| 900 1000|   3.83   9.4%    6.73  |**|
|1000 1100|   4.26  10.5%    7.47  |**|
|1100 1200|   4.47  11.0%    7.84  |**|
|1200 1300|   4.45  10.9%    7.81  |**|
|1300 1400|   4.20  10.3%    7.38  |**|
|1400 1500|   3.75   9.2%    6.58  |**|
|1500 1600|   3.12   7.7%    5.47  |**|
|1600 1700|   2.35   5.8%    4.12  |**|
|1700 1800|   1.50   3.7%    2.63  |**|
|1800 1900|   0.62   1.5%    1.09  |  |
|1900 1913|   0.02   0.1%    0.04  |  |
+-------------------------------------+
```

```
+-----------------------------+
| E.T. solar insolation on the |
| Horizontal plane, in <MJ/m2> |
| Wave Band TimeFrame  Values  |
| ----------------------------|
|1. Total     Total!     40.72 |
|2. Total     Total@     40.72 |
|3. Total     Assig.#    31.93 |
|4. Assig.*   Total      29.62 |
|5. Assig.    Assig.     23.22 |
|6. 300-1100  Total      29.62 |
|7. 400- 700  Total      15.54 |
|8. 400- 700  Total   (  71.47)|
|----------------------------|
|9. Ratio  :  3/1 =   78.40 %  |
|10.Ratio  :  5/1 =   57.03 %  |
|----------------------------|
| Total!  : sum of hourly cal. |
| Total@  : direct calculation |
| Assig.# :  9:00 to 18:00     |
| Assig.* :  300  to 1100 nm   |
| (....)  :  in mole/m2        |
+-----------------------------+
```

The table in the left hand side is the hourly energy received by a horizontal plane on the top of the atmosphere described as followed:.

- Columns 1 and 2 are the starting and ending time for each hours start from sun rise to sun set.
- Column 3 is the total energy (in MJ/m2) received in this particular time frame listed in columns 1 and 2.
- Column 4 is the ratio of the energy received at this hour verses the total daily energy received.
- Column 5 is the amount of quantum (in mole/m2) received in PAR range which is from 400 nm to 700 nm.
- Column 6 is the MARK. All those rows with the mark '**' means that this particular hour is within the assigned range. The range was assigned in the EDIT menu (see option 1.3).

The table in the right hand side is the summary of the total energy received and some ratios described as followed:

- The 1st and 2nd rows are the daily total energy received.
- The 1st row is the sum of the calculated hourly energy received.
- The 2nd row is the same with the above yet calculated in a different equation. The equation is based on sun rise and sun set hour angle. The values in both rows should be the same yet due to some run-off error, the values might have a minor difference.
- The 3rd row is the energy received within the assigned time frame which is the sum of the hourly energy received for those values with mark '**' (see option 1.3).
- The 4th row is the energy received within the assigned wave band. The wave band assigned can also be found in option 1.3.
- The 5th row is the energy received within the assigned waveband and time frame that is the combine of 3rd and 4th row.
- The 6th row is the energy received within the 300-1100 nm wave band.
- The 7th row is the energy received within the 400- 700 nm wave band.
- The 8th row is the energy received within the 400- 700 nm wave band but in quantum unit (rule of thumb: values in row 7 times 4.6).
- The 9th row shows the ratio of row 3 to row 1.
- The 10th row shows the ratio of row 5 to row 1.

Sub-option 2.4. Solar/Surface Angle on a Tilted Surface

The program will display the Daily information first then the solar angles of the sun and surface. Some definition of the solar angles mentioned are given as follows:

- Surface zenith angle (tilted angle, Zc): The angle between the normal to the surface and the normal to the horizontal plane.
- Surface azimuth angle (Ac): The angle measured in the horizontal plane from due south to the horizontal projection of the normal of the surface. East being negative, west positive. -180° <= Ac <= 180°

- Sun's azimuth angle (As): The angle measured in the horizontal plane from due south to the horizontal projection of the sun's beam. East being negative, west positive. -180° <= As <= 180°
- Sun's zenith angle (Zs): The angle between the sun's beam and the normal of the horizontal plane.
- Sun's altitude: equal to 90° - Zs
- hour angle (h): Solar noon being zero, morning negative and afternoon positive. 15 degrees hour angle is equivalent to one hour.
- Sun-Tilted surface angle (Sc): The angle between sun's beam and the normal of the surface. Also known as Angle of Incidence.

There are 2 screens in the sub-option 2.4, the 1st one is shown as follows:

S O L A R A N G L E					
Local Time	Solar Time	Hour Angle	Sun's Zenith	Sun's Azimuth	Sun's Alititude
437	4:41	-109.60	90.00	-118.95	0.00
500	5: 4	-103.85	86.11	-115.32	3.89
600	6: 4	-88.85	75.37	-106.32	14.63
700	7: 4	-73.85	64.14	-97.52	25.86
.....					
1900	19: 4	106.15	87.69	116.77	2.31
1913	19:17	109.40	89.90	118.83	0.10

Column 3 shows the hour angle, column 4 shows the sun's zenith angle and column 5 shows the sun's azimuth angle and the last column is the sun's altitude. Sun's altitude = 90° - Sun's Zenith. The 2nd screen is shown as follows:

A N G L E OF INCIDENCE						
Local Time	Solar Time	Hour Angle	HORIZONTAL PLANE	VERTICAL PLANE	TILTED PLANE	The TILTED ANGLE of the Tilted Plane is
437	4:41	-109.60	90.00	118.95	90.00	45.00
500	5: 4	-103.85	86.11	115.26	90.00	
600	6: 4	-88.85	75.37	105.78	90.00	
700	7: 4	-73.85	64.14	96.76	76.99	The AZIMUTH ANGLE (away from due South) of both the Vertical & Tilted Plane is
800	8: 4	-58.85	52.68	88.57	63.49	
900	9: 4	-43.85	41.29	81.56	50.58	
1000	10: 4	-28.85	30.52	76.17	38.91	
1100	11: 4	-13.85	21.72	72.79	29.99	
1200	12: 4	1.15	18.28	71.76	26.77	
1300	13: 4	16.15	22.84	73.17	31.08	
1400	14: 4	31.15	32.10	76.88	40.58	
1500	15: 4	46.15	43.02	82.55	52.51	0.00
1600	16: 4	61.15	54.45	89.76	65.54	
1913	19:17	109.40	89.90	118.83	90.00	

In this page, the program shows the sun-tilted surface angle (angle of incidence) of the horizontal, vertical and tilted surfaces.

If the tilted angle of the plane equals to 0 or 90 degree, the values in column 6 should be the same with the values in column 4 or 5, respectively.

The box at the right hand side of the screen shows the tilted and azimuth angle of the surface.

Sub-option 2.5. Back TO main menu.

Option 3. Code - Information regards the source code. Users can either enter '3' or 'C' to jump to this option.

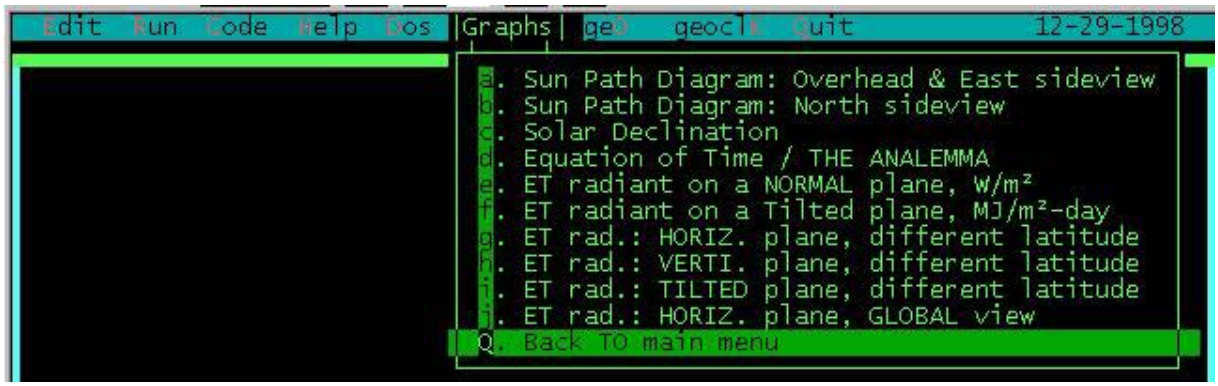
Option 4. Help - see the user manual. Users can either enter '4' or 'H' to jump to this option.

Option 5. Dos - resume system default or gateway to DOS. Users can either enter '5' or 'D' to jump to this option.There are 4 sub-options available.

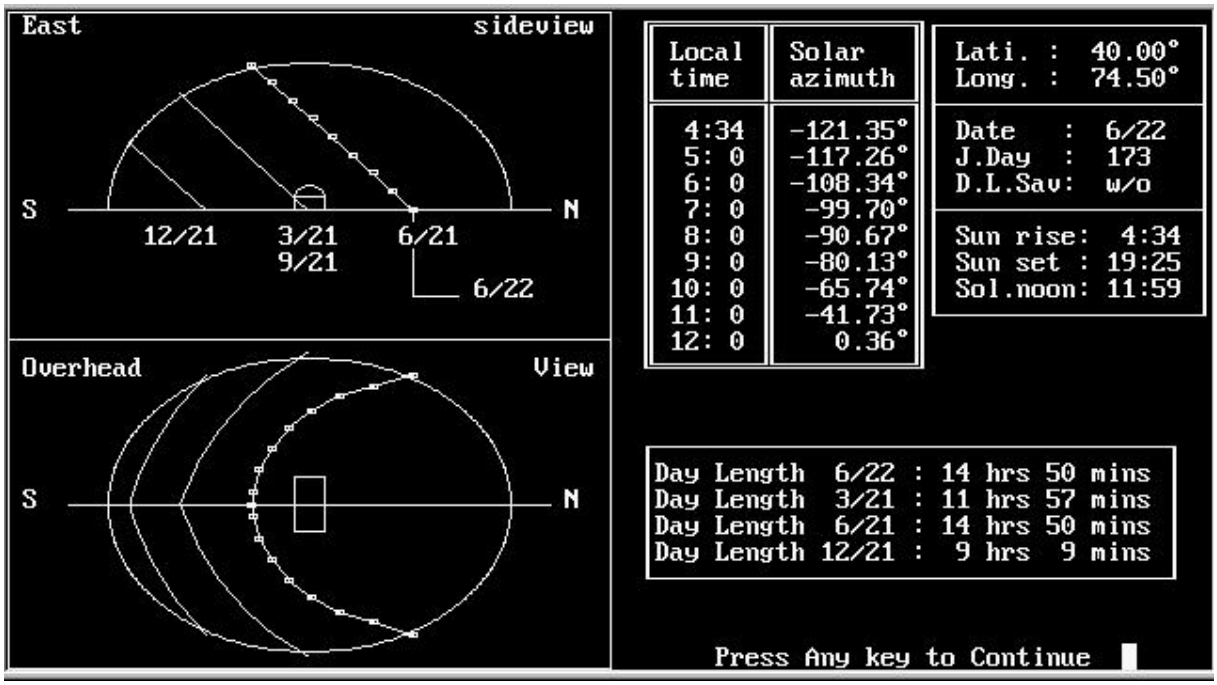
a. resume default data
b. gateway to DOS, enter 'exit' to return
c. List any text file
Q. Back TO main menu

Option 6. Graphs - View various of graphics. Users can either enter '6' or 'G' to jump to this option.

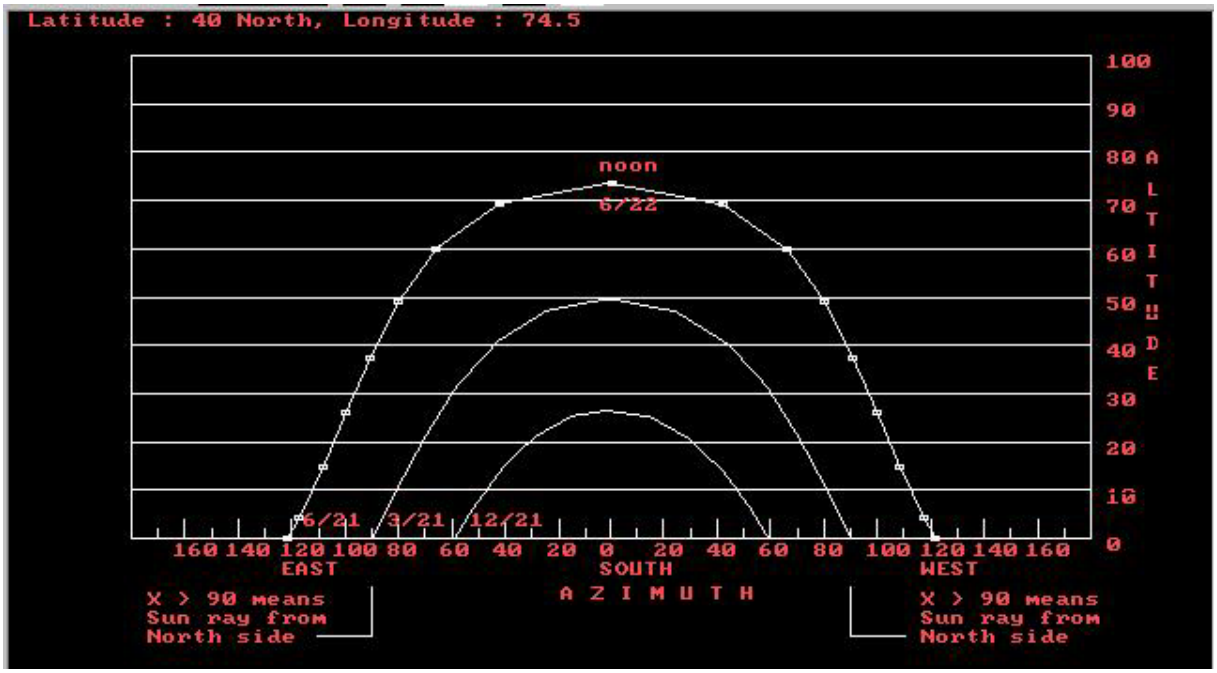
One graph is better than a thousand words. This is the main core of this program. There are 11 sub-options available shown as follows:



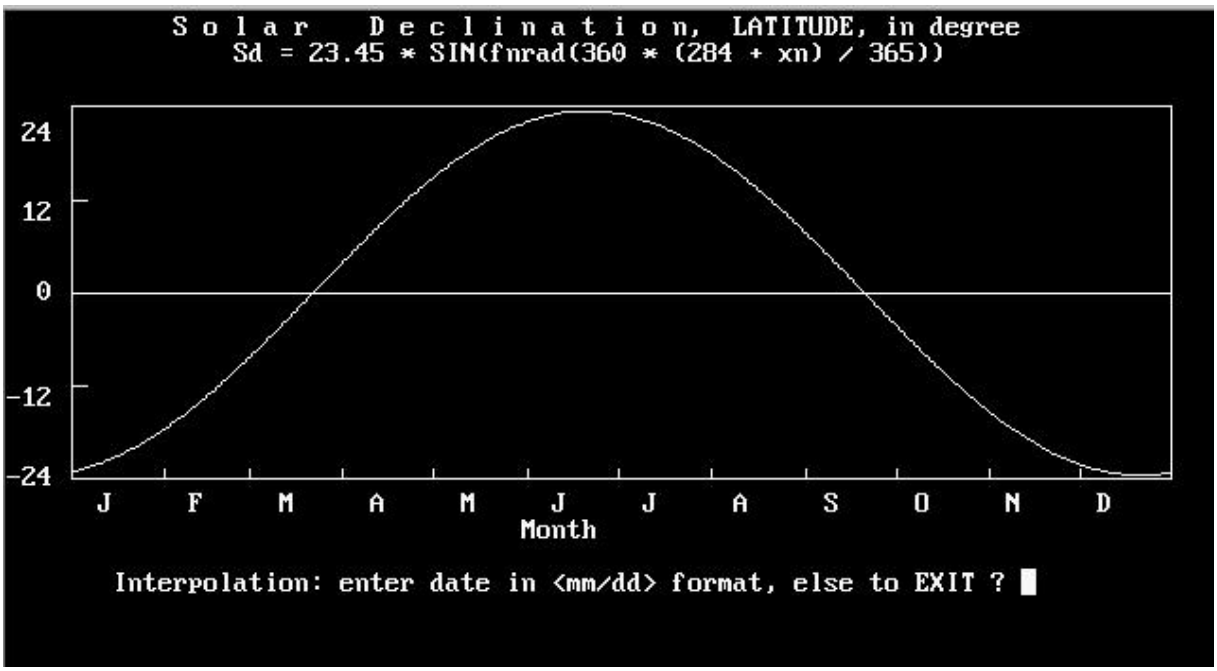
Sub-option 'a. Sun Path Diagram: Overhead & East sideview' shows the overhead and east side view of the sun path of an assigned day as well as March, June and December 21. The graphs are designed to self-explane, the users should have no problem in understanding these diagrams.



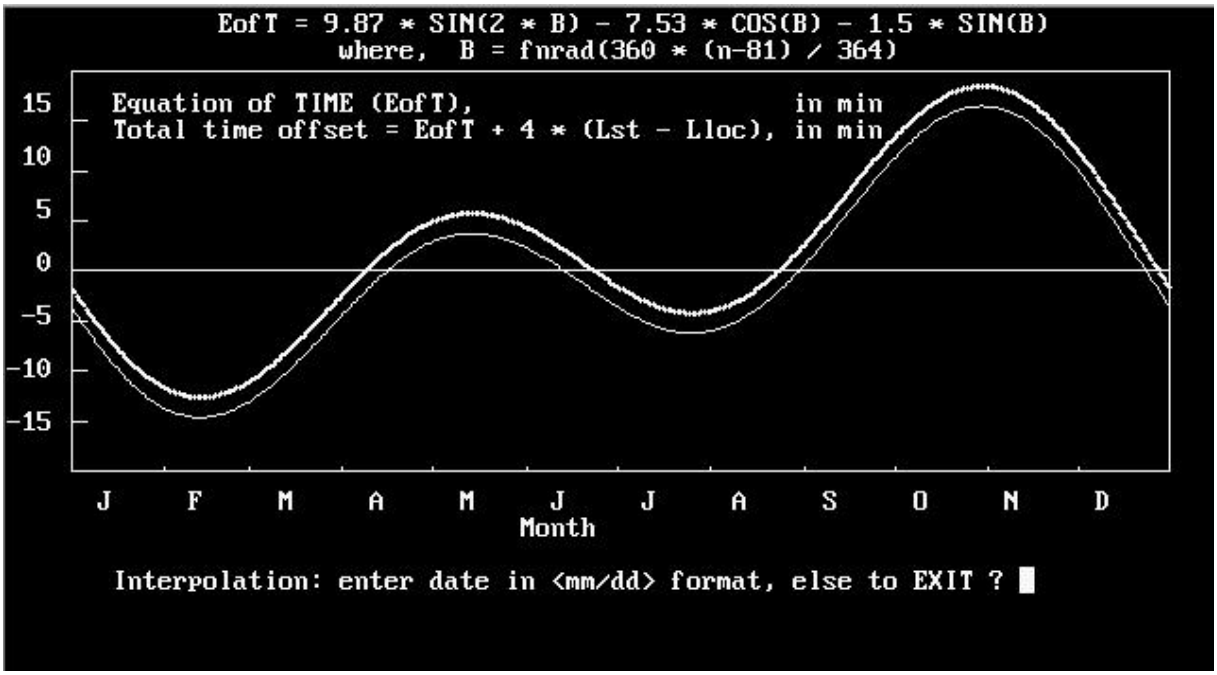
Sub-option 'b. Sun Path Diagram: North sideview' shows the north side view of the sun path of an assigned day as well as March, June and December 21.



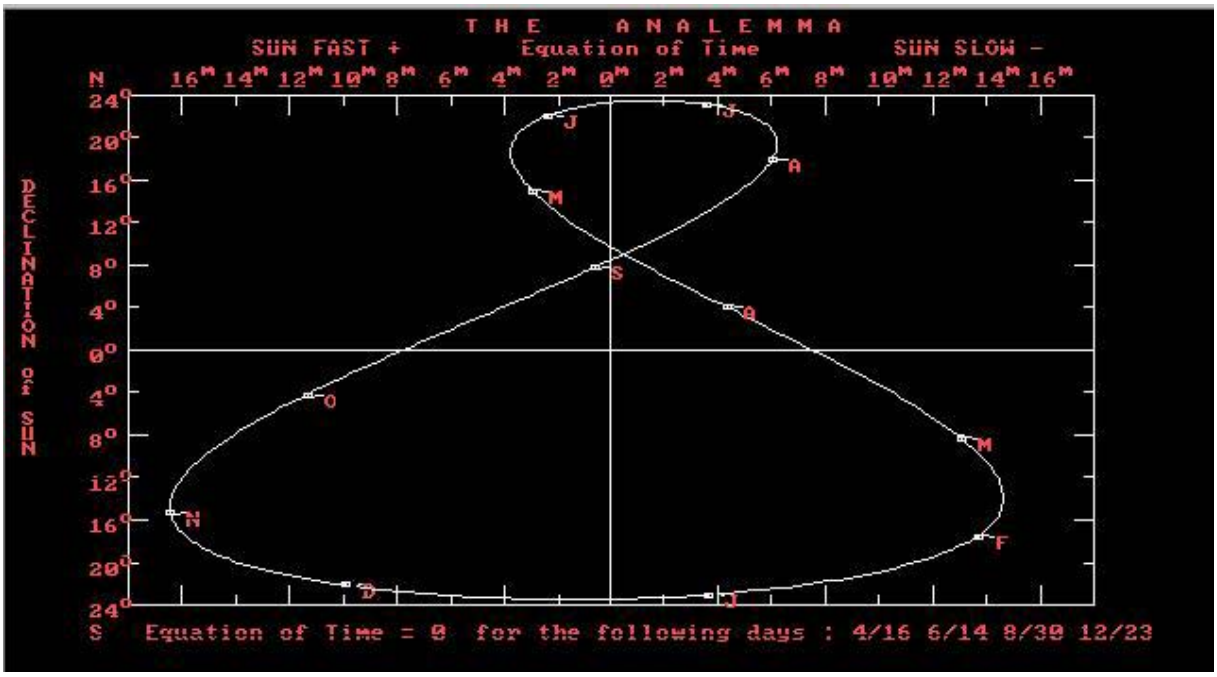
Sub-option 'c. Solar Declination' shows the graph of solar declination vs. Julian day.



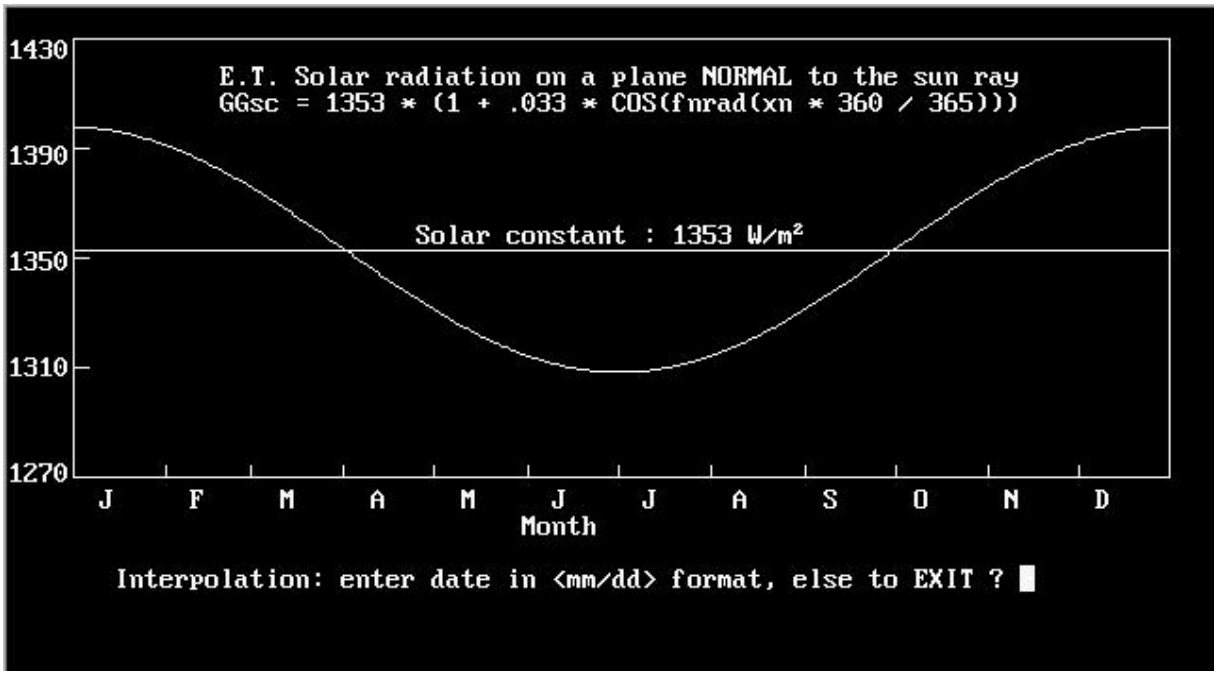
Sub-option 'd. Equation of Time / THE ANALEMMA' shows the Equation of Time vs. Julian day and the ANALEMMA.



The so-called 'THE ANALEMMA' is shown as follows:

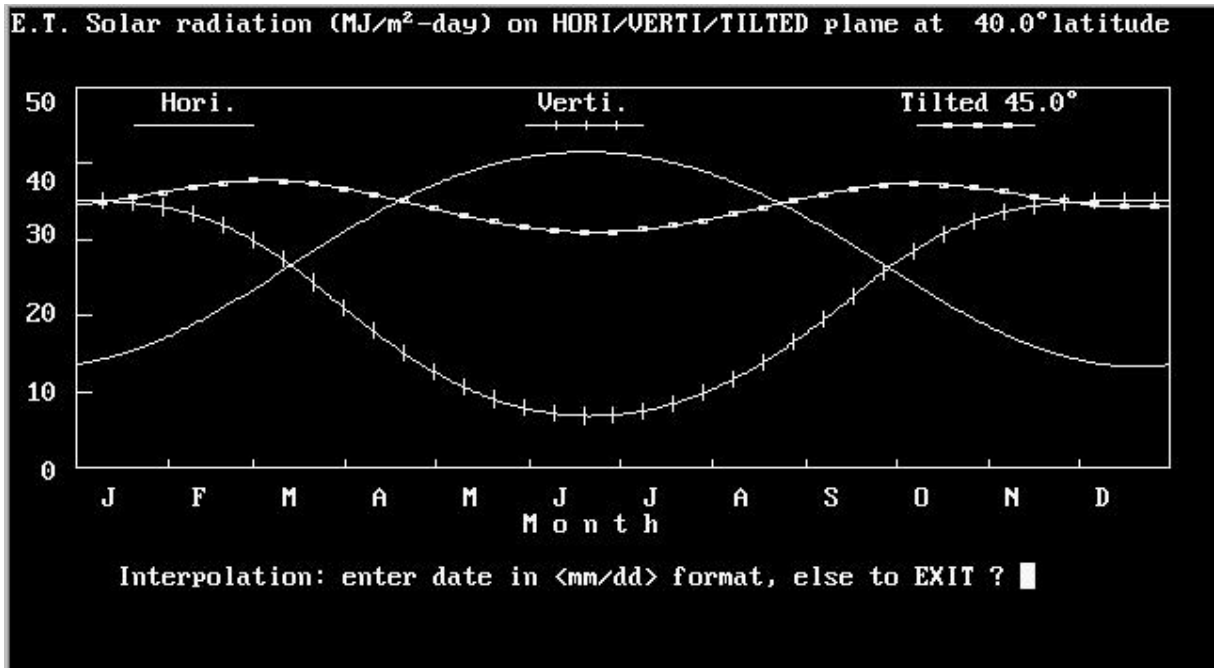


Sub-option 'e. ET radiant on a NORMAL plane, W/m²' shows the solar radiation on a plane normal to the sunray and solar constant vs. Julian day.

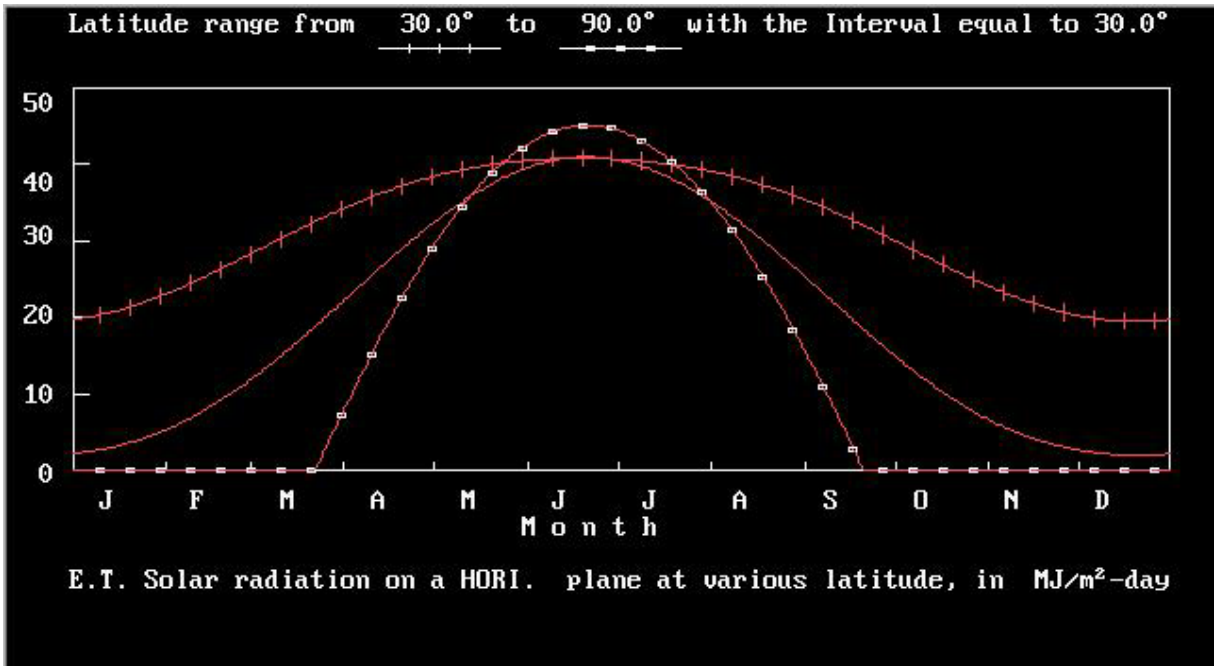


Sub-options 'c','d','e' and 'f' show not only the graphs but also allow users to do the interpolation. By entering a date in 'month/day' format, users can see the exact values for that particular date on the graph.

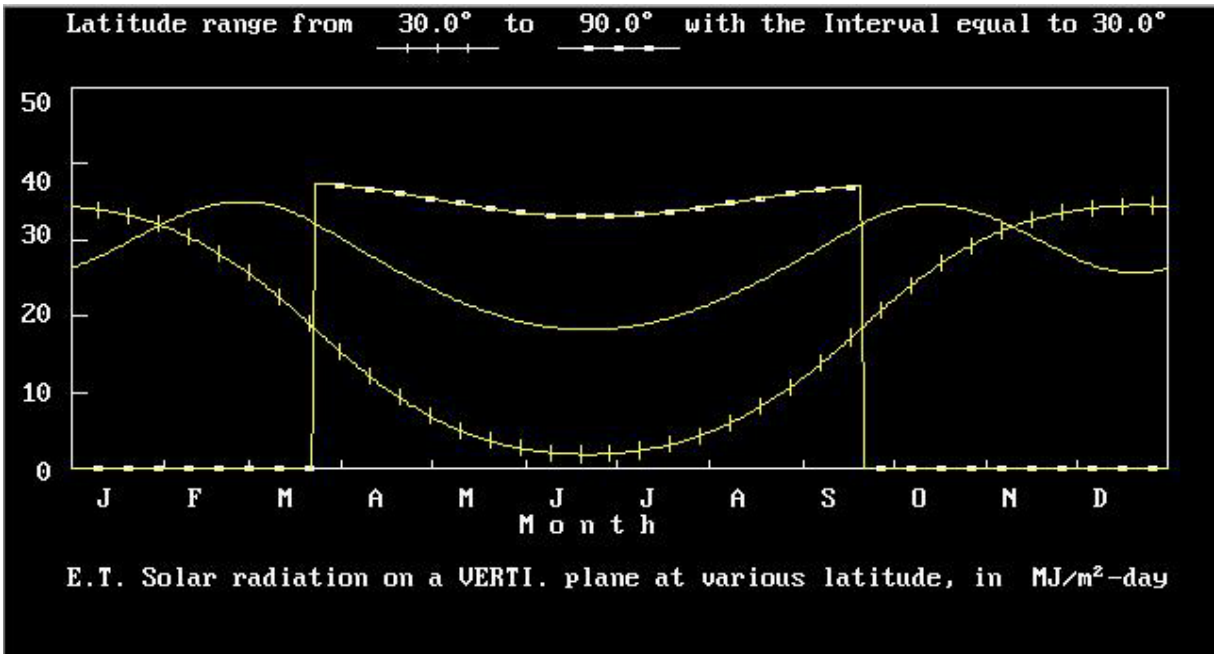
Sub-option 'f. ET radiant on a Tilted plane, MJ/m²-day' shows values of the ET radiant on a horizontal, vertical, and tilted plane under assigned latitude.



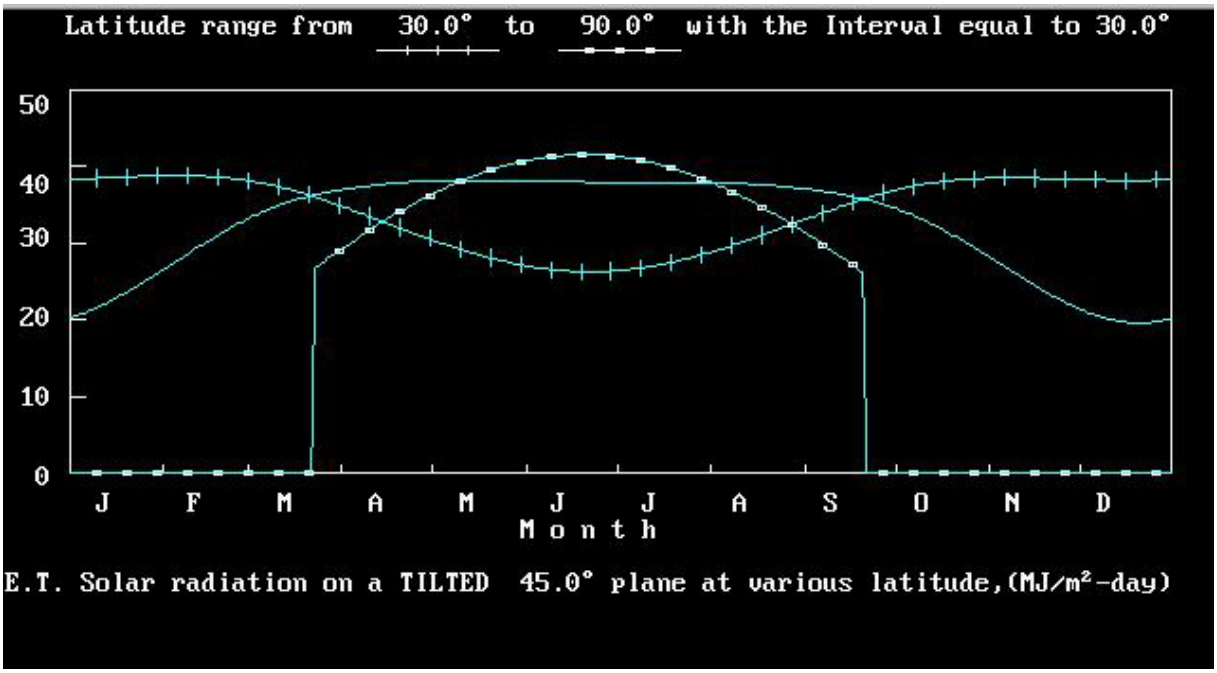
Sub-option 'g. ET rad.: HORIZ. plane, different latitude' shows the ET radiant on a horizontal plane under 'a range of' assigned latitude (see option 1.4).



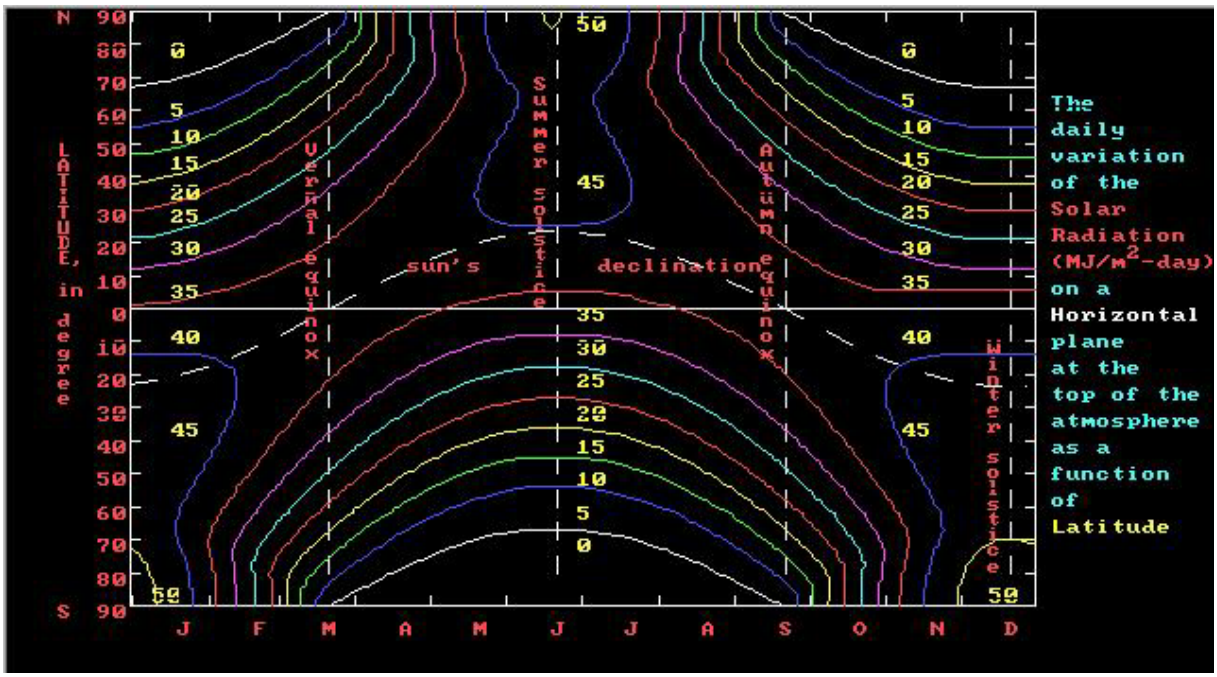
Sub-options 'h. ET rad.: VERTI. plane, different latitude' shows the ET radiant on a vertical plane under 'a range of' assigned latitude (see option 1.4).



Sub-option 'i. ET rad.: TILTED plane, different latitude' shows the ET radiant on a tilted plane under 'a range of' assigned latitude (see option 1.4).

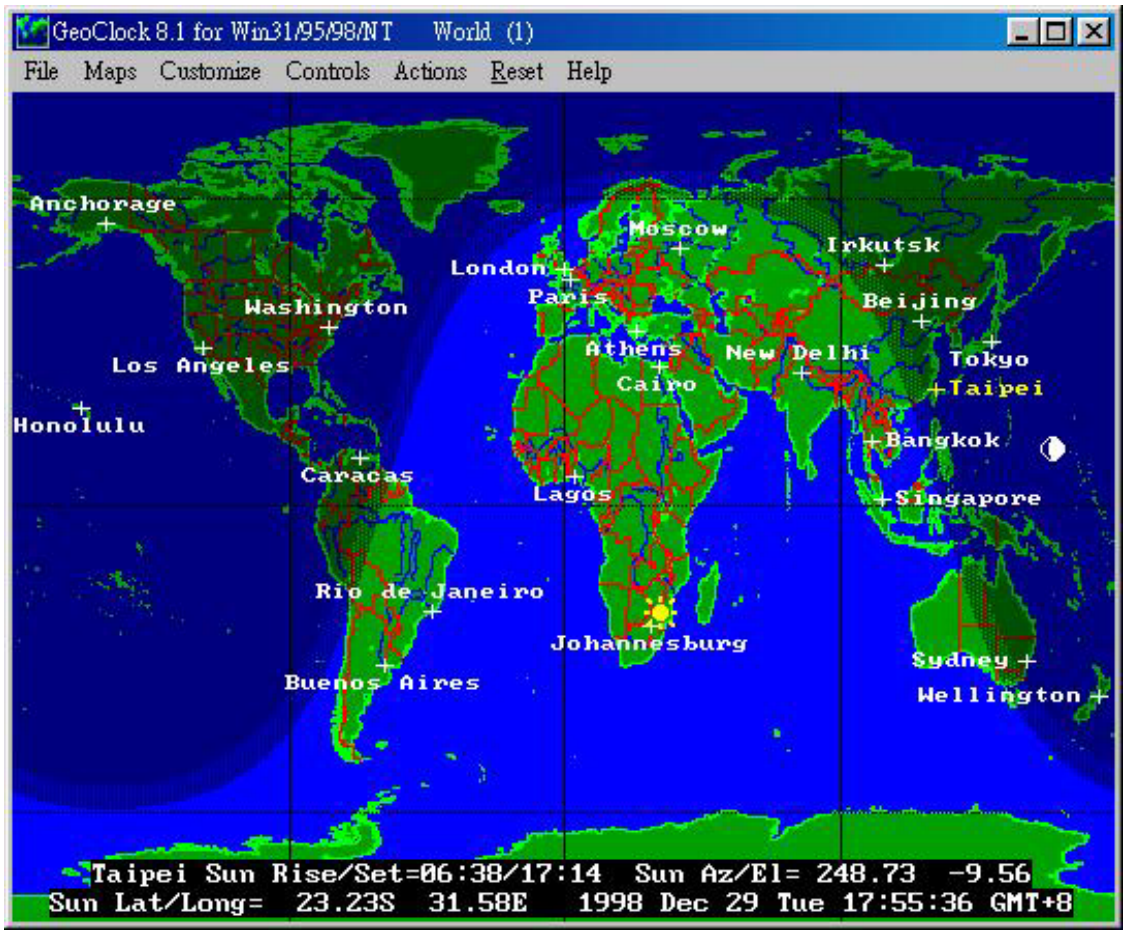


Sub-option 'j. ET rad.: HORIZ. plane, GLOBAL view' shows the daily variation of the solar radiation at the top of the atmosphere (ET) as a function of latitude. The values are measured in MJ/m2-day.



Option 7. ge0 - This option provide the user interface for GEOCLOCK™. Users can either enter '7' or '0' to jump to this option.

Option 8. geoclK - This option allows users to execute the GEOCLOCK™ software which is a shareware written by Mr. J.R. Ahlgren. Users can either enter '8' or 'K' to jump to this option.



Some practices in using GEOCLOCK:

(1). 圖中太陽的位置之緯度值即為赤緯(declination, d), 3/21 至 9/21 期間 d>=0。
(2). 經度為 0 的線經過 Greenwich, England。
(3). 夏至, at solar noon, 太陽在正南方, 位置在北緯 23.5 度上(緯度 + 23.5 度)。高度角 =90-當地之緯度+d = 90 - 25 +23.5 = 88.5 度。
(4). 冬至, at solar noon, 太陽在正南方, 位置在南緯 23.5 度上(緯度 - 23.5 度)。高度角 =90-當地之緯度+d = 90 - 25 -23.5 = 41.5 度。
(5). 春分、秋分, at solar noon, 太陽在正南方, 位置在赤道上(緯度 0 度)。
(6). 春分、秋分, at solar noon, 太陽頂角(Zenith)= 當地之緯度, 高度角 =90-當地之緯度。

台北緯度為 25 度，此時之高度角為 65 度。

(7). 觀察春分、夏至、秋分、冬至，4 天中，每小時之太陽方位角。(在軟體中以正北方為 0 度，與課程中所教授之計算公式以正南方為 0 度有所不同)。

(8). Time control, 每 1 小時 update 一次，觀察太陽與月亮的軌跡。

(9). Time control, 每 24 小時 (1day) update 一次，觀察太陽與月亮的軌跡。

(10). Time control, 每 720 小時 (1 month) update 一次，觀察太陽的軌跡。

(11). Time control, 輸入 3/21, 6/21. 9/21, 12/21，觀察太陽的位置。

(12). Time control, 輸入 3/21, 5:58 ，觀察太陽的位置，包括方向與經緯度。

(13). 同上，改輸入當日日落時間，觀察太陽的位置，包括方向與經緯度。

(14). Time control, 輸入 6/21, 5:05 ，觀察太陽的位置，包括方向與經緯度。

(15). 同上，改輸入當日日落時間，觀察太陽的位置，包括方向與經緯度。

(16). Time control, 輸入 12/21, 當日日出時間 ，觀察太陽的位置，包括方向與經緯度。

(17). 同上，改輸入當日日落時間，觀察太陽的位置，包括方向與經緯度。

(18). Map list, 選北極圈，重複 1,2,3 的動作，觀察太陽的軌跡，注意永夜與永晝現象。

(19). 同上，改輸入 3/21, 9/21 觀察晨昏線是否通過北極。

(20). 同上，改輸入 6/21, 12/21 觀察晨昏線的位置。

Option 9. Quit - Quit this program. Users can either enter '9' or 'Q' to jump to this option.

Reference

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2. Fang, W., K.C. Ting and G.A. Giacomelli. 1992. Computer Aided Instruction on Solar Engineering Fundamentals. ASAE paper No. 927031.
3. Frank Kreith and Jan F. Kreider , 1974. "Principles of Solar Engineering" McGraw-Hill Pub..
4. Greenwald, M.L. and T.K. McHugh. 1985. Practical Solar Energy Technology. Prentice-Hall, Inc.
5. Ahlgren, J.R. 1998. GEOCLOCK™ User manual. Shareware.