EA Graphic Tools 2022

Users' Manual for

Solar Path Diagram

Drawer

"SolMap"

Meteorological Data System Co. Ltd.

May, 2022

Remarks on the use of "the Graphic Tools 2022" for the Expanded AMeDAS Weather Data

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Home Page of the Expanded AMeDAS Weather Data

Information on the Expanded AMeDAS Weather Data and the related programs will be provided by a home page of MetDS:

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Questions on the Expanded AMeDAS Weather Data and the related prorgams should be sent via an inquire form on our home page. MetDS cannot accept questions via phone-calls or faxes.

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Contents

Introduction

SolMap, which is contributed with "EA Graphic Tools 2022", is a program to draw solar position figure that is common in many textbooks for building environmental engineering course in college education as shown in Fig.1 . This program is only one program in all tool programs from a view point of relationship with the Expanded AMeDAS Weather Data. This is a quite independent program from the EA Weather Data. However, creator of this program wants you to use this program for your "environmental" design work and/or study and decided to be enclosed in the tools set.

You can select the two kind of locations to draw the solar path diagram: (1) site where the AMeDAS station recorded in the reference year of 2020 edition, "`PRY1120.wea2`"; (2) Any site where the latitude and the longitude are known. Figure 1 is an illustration of this program, SolMap at the initial situation soon after invoking.

Additionally, precise conversion function of the solar time system is also plugged in this version.

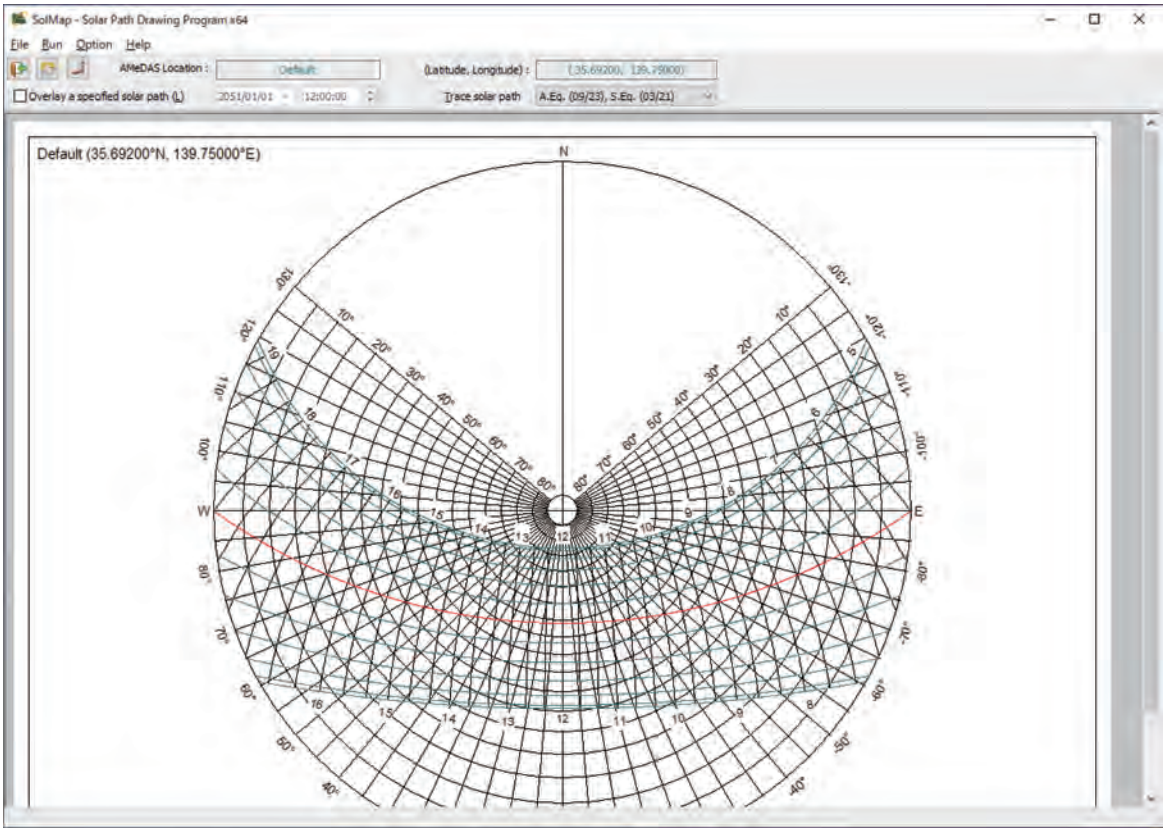


Fig. 1 Initial Main Window of SolMap (In case of OS Environment in English)

The figure is a screen shot in desktop in Japanese Edition of WINDOWS® 10. Look at the date and time edit boxes, which are depended in Japanese environment. For instance, imagine time of 12 o'clock 34 minutes and 56 seconds in May 31, 2022. Maybe in English environment, they cannot be described as "`12:34:56`" and "`2022/05/31`" like shown in Fig.1 . Because the two edit box components depend on Japanese environment, SolMap may not invoke in English

environment. If you need to use this program, tune the OS ennvironment with dialog windows displayed when you click the start button to match the calendar system to be Japanese one at your own risk.

1 Fundamental Usage

1.1 Startup, Image Save / Print, and Termination

Invoking manner of SolMap is not special. It is quite same as ordinal application sofware for WINDOWS® system. Thus, for example as shown in Fig.2, launching from application list linked with the startup button on the desktop task bar. Soon after startup of SOL, the main window illustrated in Fig.1 is displayed. The main window shows a default solar position figure in Tokyo*1.

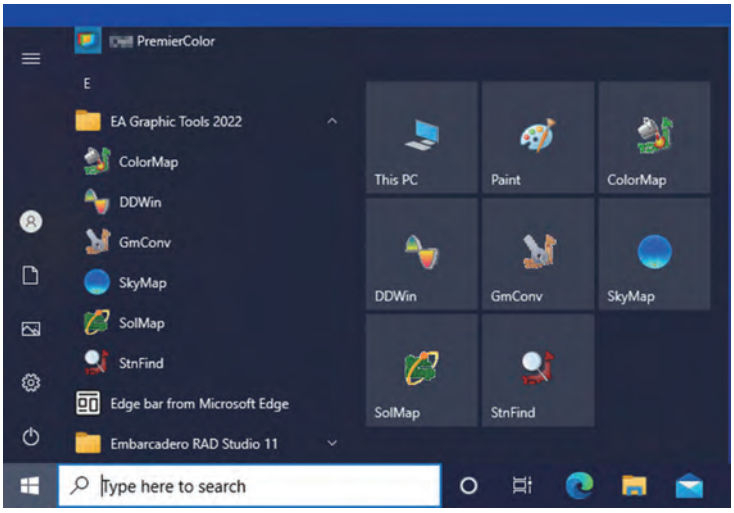


Fig. 2 Typical Execition Way of SolMap

Size of the main window can be changed as you like by dragting a grip located on the window's right bottom corner. Figure 1 shows a full paper drawing but you may get partial paper drawing if you are working with a PC having different display resolution and physical size. This is not error. SolMap is just designed with WYSIWYG (What you see is what you get) concept to obtain real size of landscape A4 size paper object in screen with any display properties.

To terminate SolMap, there are three main methods; (1) Selecting [File | Exit (X)]; (2) Clicking a system icon ; and (3) Clicking a speed button . Window size and position at ending time is recorded to be reproduced in the next time.

The solar path diagram displayed in the main window can be saved as a file with one of two kinds of image file formats (EMF: Enhances Windows Metafile; or EPS: Encapsulated PostScript file). Select [File | Save As...] menu to do so. Printing the figure is also available by selection of [File | Print] menu.

*1 Strictly speaking, same day's solar path is subtle different year by year. Thus, SolMap considers a standard year for drawing target to be year of 2051. You can see thin gray characters showing 2051 in a date edit box located in the top panel of main window because of it.

1.2 Selection on Location

1.2.1 Selection of AMeDAS Station

Simple method to indicate your target site for drawing solar path diagram is selecting one station of the AMeDAS stations which are distributed in 841 points prepared for applying the reference year edition 2020 developed by MetDS. The selection of the station is done with a sub dialogue window shown in Fig.3, which is called by clicking a speed button or selecting [Option | Location...] menu.

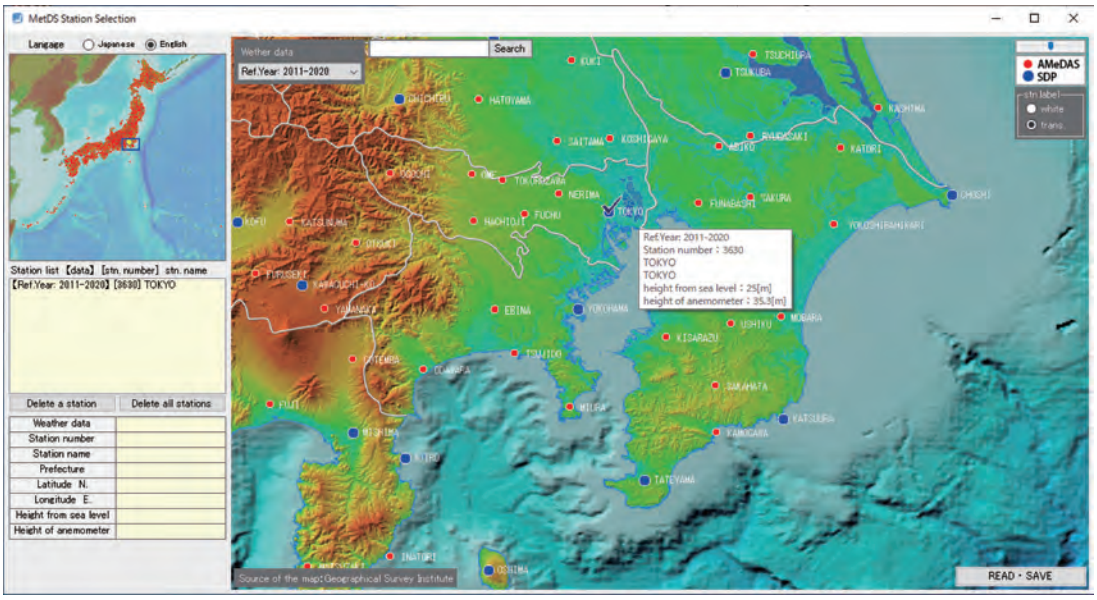


Fig. 3 Subwindow to Select AMeDAS Station (Map GUI Window) Called from SolMap

1.2.2 Manual Setting

Selection of drawing target site is not limited to the AMeDAS station. You can input specified latitude and longitude data to indicate your target site. For example, when you want to get a solar path diagram for your designing building site, this alternative method must be useful. This "manual" method is done with a sub window which is called by selecting [Option | Misc...]. Figure 4 shows the sub window for this operation.

(a) Initial View (Data Are Not Acceptable) (b) View without Check Mark (Data Are Acceptable)

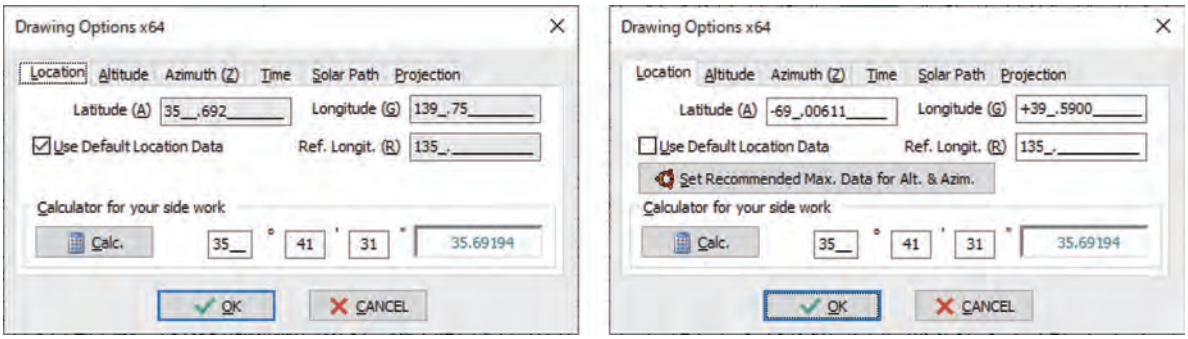


Fig. 4 Subwindow to Input Specified Location Coordinates

This sub window has six tabbed pages. One of them, a page labeled as [Location], must be displayed in front by clicking its tab like an illustration in Fig.4 (a). You can see a check box named LBLUse Default Location Data in the left center of the page. When you remove the check mark from the box, edit boxes labeled with [Latitude (A)] and [Longitude (G)], the former box is to input latitude data and the later is to input longitude data, can be enabled to accept input values. You can input the data for these two edit boxes as you like. When you click [OK] button after inputting the data, this sub window closes and the main window is displayed again with a refreshed solar path diagram based on your inputted data.

Note that zero or positive value under 90.0 for latitude means data for the Northern Hemisphere; and zero or positive value under 180.0 for longitude means data for the Eastern Hemisphere. As shown the bottom of the sub window in Fig.4 , there is a simple calculation function to convert a value with degree, minute and second system to a value with real number in degree unit. Unfortunately, the converted value can not be copied in order to avoid irregular inputs for the edit boxes mentioned in the above. You can see a wide button labeled [Set Recommended Max. Data for Alt. and Azim.] in Fig.4 (b), which is displayed when check mark has been removed and edit boxes has been enabled to edit, this is a function button to adjust axes and intervals of axes on solar altitude and azimuth angles. You can use this button if you prefer.

Now, look at Fig.4 (b) carefully. Inputted values there are data for the site of Japanese "Showa Station" in the Antarctic Continent. When this setting is confirmed by clicking [OK] button, the drawn figure in the main window is changed like as shown in Fig.5 .

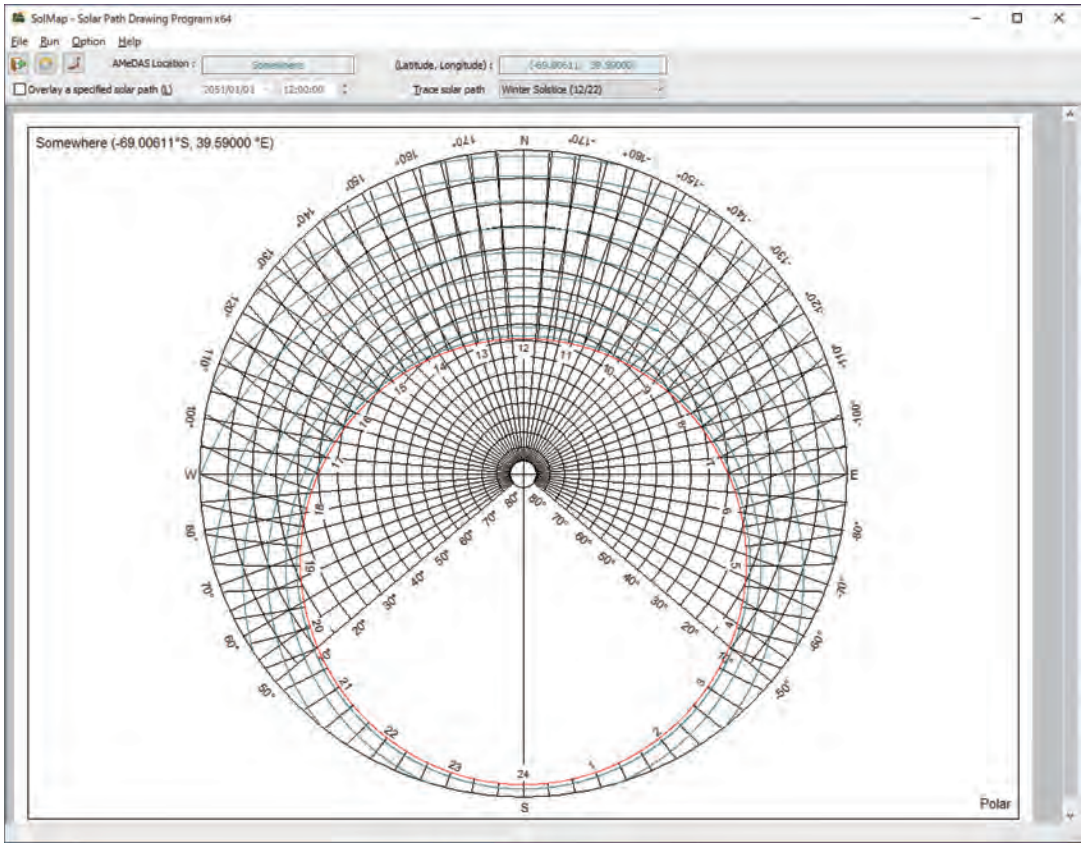


Fig. 5 Diagram at Showa Station, Antarctica, Drawn by SolMap

1.3 Emphasizing Solar Path for Specified Date and Time

1.3.1 Emphasizing Twenty-Four Solar Terms

As you may know, solar paths drawn in the solar path diagram are usually limited for specialized dates' ones as teal colored solid lines illustrated in Fig.1. Generally, the specialized dates are the twenty-four solar terms, whose annual rotation angle are multiple of 15° inlcuding zero for the Vernal Equinox Day. The value of 15° is obtained by annual rotation angle of the earth (360°) equally divided by twenty-four. The twenty-four solar terms are listed as follows:

(1)	The Summer Solstice Day	(SS, 90°,	App. June 21),			
(2)	SS+15	(90 + 15°,	App. July 7),	SS−15	(90 − 15°,	App. June 6)
(3)	SS+30	(90 + 30°,	App. July 23),	SS−30	(90 − 30°,	App. May 21)
(4)	The 1st Day of Autumn	(90 + 45°,	App. Aug. 8),	The 1st Day of Summer	(90 − 45°,	App. May 6)
(5)	AE−30	(90 + 60°,	App. Aug. 23),	SE+30	(90 − 60°,	App. Apr. 20)
(6)	AE−15	(90 + 75°,	App. Sept. 8),	SE+15	(90 − 75°,	App. Apr. 5)
(7)	Autumnal Equinox Day	(AE, 180°,	App. Sept. 23),	Vernal Equinox Day	(SE, 0°,	App. Mar. 21)
(8)	AE+15	(180 + 15°,	App. Oct. 8),	SE−15	(360 − 15°,	App. Mar. 6)
(9)	AE+30	(180 + 30°,	App. Oct. 23),	SE−30	(360 − 30°,	App. Feb. 19)
(10)	The 1st Day of Winter	(180 + 45°,	App. Nov. 7),	The 1st Day of Spring	(360 − 45°,	App. Feb. 4)
(11)	WS−30	(180 + 60°,	App. Nov. 22),	WS+30	(360 − 60°,	App. Jan. 20)
(12)	WS−15	(180 + 75°,	App. Dec. 7),	WS+15	(360 − 75°,	App. Jan. 5)
(13)	The Winter Solstice Day	(WS, 270°,	App. Dec. 22)			

There are 24 terms in the list but they can be combined in 13 solar paths because the solar paths are symmetrical to the Winter Solstice and the Summer Solstice.

Initially, when SolMap startups, the solar path for the Vernal (Spring) Equinox Day (SE) and the Autumn Equinox Day (AE) is emphasized with red colored line. But you can select emphasized path by using a dropdown list box titled with [Trace solar path], located in the center of the upper panel of main window. If you want to change the emphasized line, click the list box and choose the target item as shown in Fig.6. Additionally, you can put date labels on the figure by clicking [Option | Data Print] menu and giving radio button mark to the menu item (refer Fig.7).

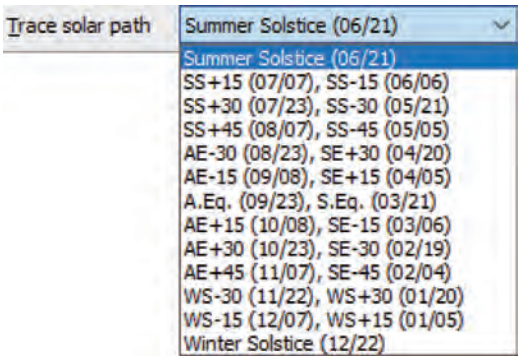


Fig. 6 List Box for Selecting One of Twenty-Four Solar Terms

1.3.2 Emphasizing Specified Date and Time

Give a check mark to the check box titled with [Overlay a soecified solar path (L)] in order to emphasize user defined date's solar path and solar position for user defined time. By giving the check mark, the date combo box and time up-down box are enabled to accept mouse and keyboard actions (See Fig.8).

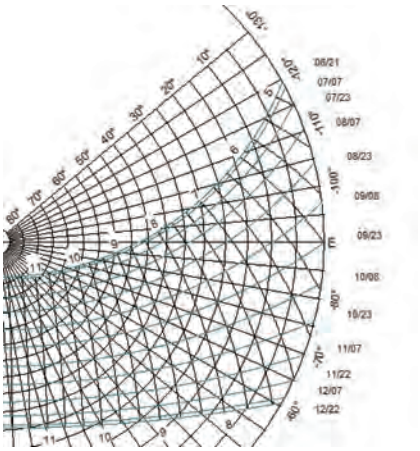


Fig. 7 Labeling of Date to Each Solar Path

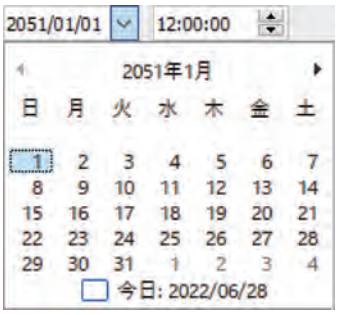


Fig. 8 Component to Specify Date (OS Environment in Japanese)

These boxes are used to choose the date and time to be emphasized. In this function, the solar position is displayed as red circle mark. Note that you can get information of the solar altitude and azimuth at the chosen time in bubble hint box appearing near the mouse cursor and bottom status line hint when you move your PC mouse cursor on the red circle mark as shown in Fig.9 .

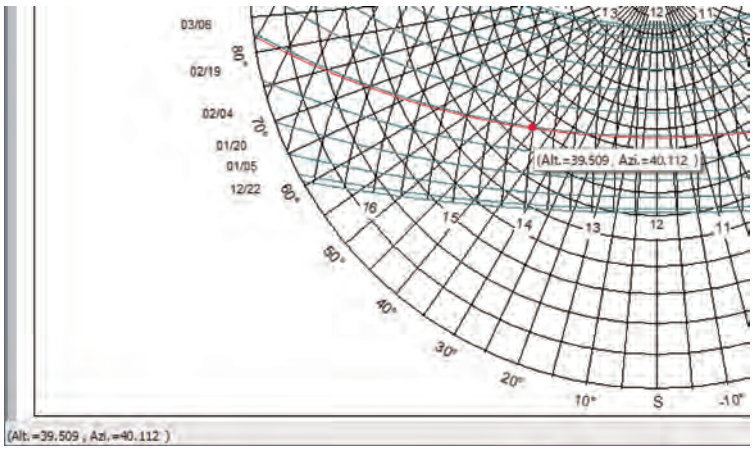


Fig. 9 Example of Emphasized Solor Path and Position

As mentioned in the previous page, usually SolMap can draw a solar path diagram for a default year (2051) but you can draw a figure for another year as you like. This will be explain in the following part (Section 2.4).

2 Functions for Changing Drawing Items

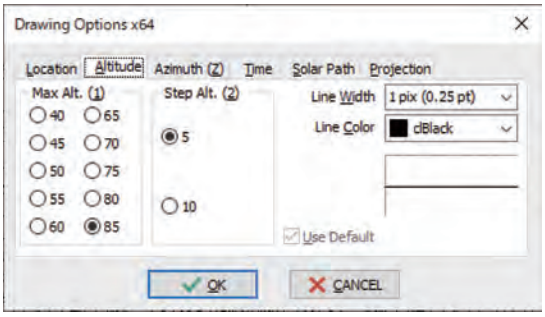
The solar path diagram is constructed with following four elements:

(1) axis of the solar altitude (altitude circles);
(2) axis of the solar azimuth (azimuth or direction lines);
(3) axis of the hour angle (time curves); and
(4) solar paths themselves

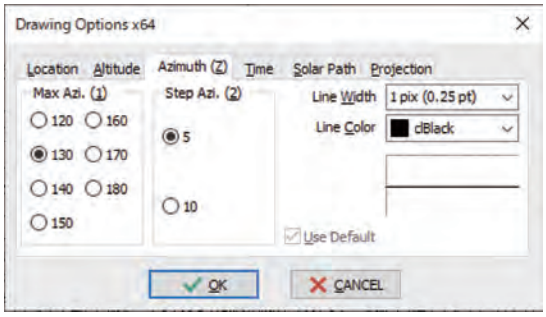
The all elements' drawing styles like line width style can be tuned by user. The line color can be changed, too[*2]. And axis range and interval can be changed for elements (1), (2), and (3). For the element (4), you can switch on/off each solar path for twenty-four solar terms to sparse the line dense.

In the following subsections, operations related tuning of configuration will be explained. Note at first that all operations are done with the sub window displayed by selecting [Option | Misc...] menu. That sub window has been explained already in Fig.4 (p.3) but other screen shots taken for displaying different tab pages are shown in Fig.10 (a)–(d). Tab page illustrated in Fig.10 (a) is used for tuning the element (1) (axis of the solar altitude). And Figure 10 (b) is used for tuning the element (2) (axis of the solar azimuth); Fig.10 (c) for the element (3) (axis of the hour angle); and Fig.10 (d) for the element (4) (solar paths).

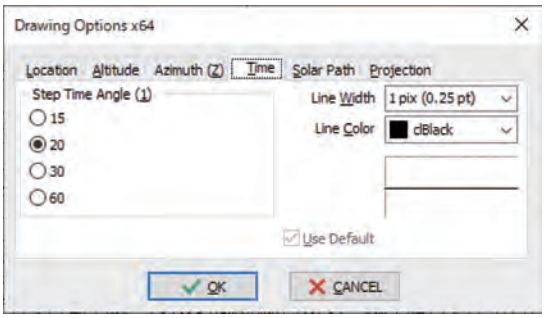
(a) [Altitude] Page



(b) [Azimuth (Z)] Page



(c) [Time] Page



(d) [Solar Path] Page

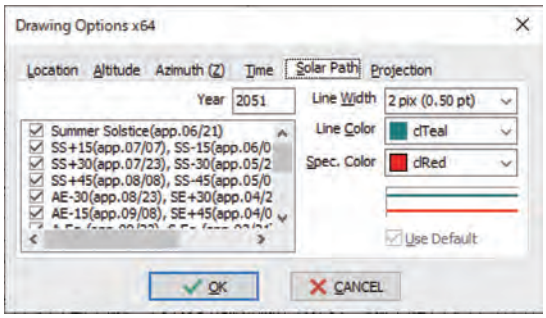


Fig. 10 Several Pages in Subwindow for Changing Drawing Items

[*2] However, these changes are effective for present executing time only. SolMap can not save the tuned and/or changed styles and can not use them in the next invoked time. Thus, description in this section is not on customization of drawing styles of SolMap.

2.1 How to Change the Thichness and Color of Solar Path Line

There are two edit boxes for each page of the sub window: [Line Width] combobox; and [Line Color] combobox, as shown in Fig.10 (a)–(d). These comboboxes have several selective variations' items.

Use these components to tune line width and color. When you click [OK] button, the figure will be displayed on the basis of your selection. However, sometime the figure may not be redrawn soon after clicking [OK] button, in such case, click speed button or select [Run | Redraw (D)] menu to force to redraw. You can see another line color combo box in Fig.10 (d). That is used for changing solar path's emphasis color.

2.2 How to Change the Range and Inverval of Coordinates

Tuning of axes ranges and intervals are done with selection of radio button option switches. The followings are summary of selective items. Note that bold face values are default settings.

- Axis of solar altitude (altitude circles) [Upper Limit]: 40, 45, 50, 55, 60, 65, 70, 75, 80, or **85**°
- Axis of solar altitude (altitude circles) [Interval]: 5, or **10**°
- Axis of solar azimuth (azimuth lines) [Range]: ±120, ±**130**, ±140, ±150, ±160, ±170, or ±180°
- Axis of solar azimuth (azimuth lines) [Interval]: 5, or **10**°
- Axis of hour angle (hour circles) [Interval]: 15, **20**, 30, or 60 min.

Including line width and color settings mentioned in Subsection 2.1, if you want to cancel your selection and recover them to be default, give a check mark in a check box labeled with [Use Default].

Tuned results are affected to the main window figure by clicking [OK] button located in the bottom of the sub window. As shown in Fig.10 (d), each path of 24 solar terms can be switched on/off as you like.

2.3 How to Change the Projection Method

The projection method, which is a fundamentally inportant matter on drawing solar path diagram also can be selected from following four methods*3:

(a) Polar Projection,
(b) Parallel Projection,
(c) Isometric Projection (or Equidistance Projection), and
(d) Isostereometric Projection.

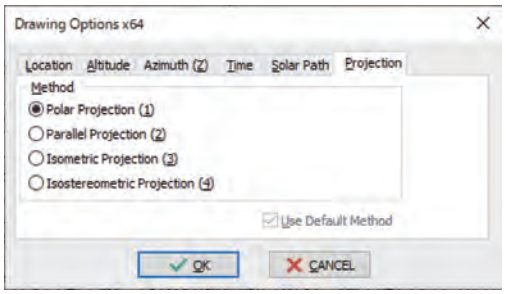


Fig. 11 Subwindow to Change Projection Method ([Projection] Page)

See Fig.12 for getting outline of each projection method.

*3 The polar projection is default. This function is prepared for educational aim by the creator of SolMap. In many cases, you may not have concern on projection method, excepting in case that solar path diagram should be overlaid on fish-eye image of the sky. As you may know, many fish-eye lenses are following equidistance projection mathematically.

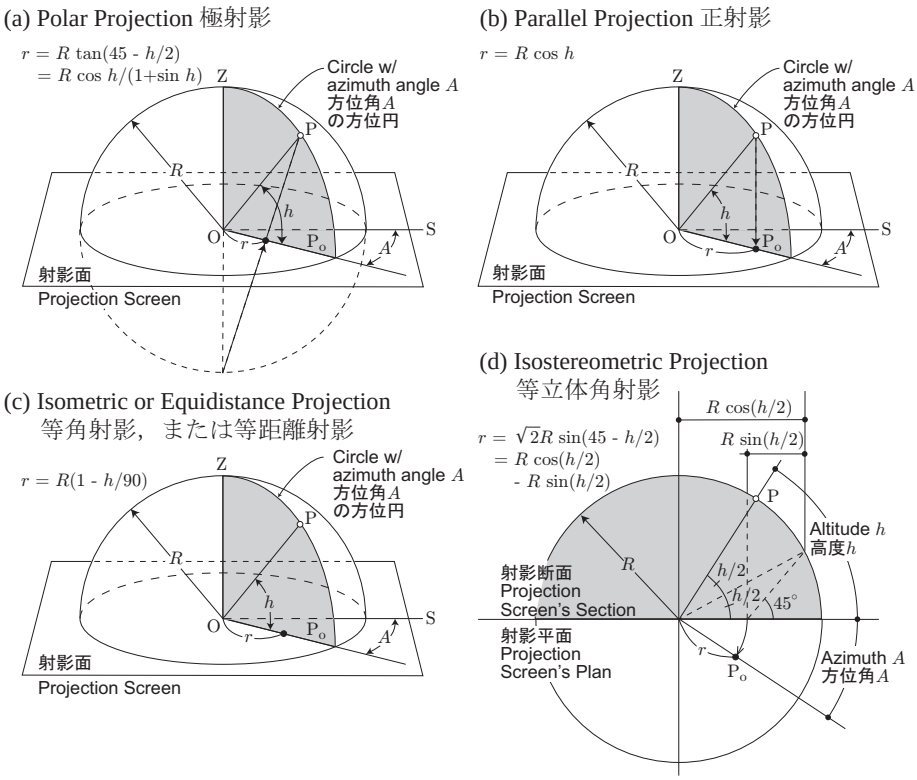


Fig. 12 Projection Methods Applied to Draw the Solar Path Diagram

2.4 How to Change the Target Year

In fact, as you can see an edit box named as [Year], you can select another target year excepting the default year of 2051. However, the precision of the drawn figures for years before 1600 and for years after 2100 is out of assurance.

3 Conversion of Time — An Additonal Function

Needless to say, apparent solar time (AST) system is applied for the solar path diagram and it is quite different from our common time system, *i.e.*, zonal standard time (ZST). Thus, we want to convert the time from AST to ZST or from ZST to AST frequently when we use the solar path diagram. Additionally, other time systems like coordinated universal time (UTC) and dynamical time (TD)[*4] may be your concerns.

SolMap has time conversion function, which is basically independent from drawing functions of SolMap, called from [Run | Time Conversion...] menu. When you select the menu, a sub window shown in Fig.13 appears.

Don't forget to set a suitable value for an edit box named [Reference Longitude of the ZST [Deg.]], which has a value of 135° in default for representing Japanese Standard Time (JST), in case that you want use this function for foreign sites. Convert directions (AST→ZST

[*4] Now, astronomical scientists (members of IAU) uses a new time system named "Terrestial Time" (TT), which may be considered to be the same time system to TD.

or ZST→AST) are indicated with toggled radio buttons. Input value of date and time to be converted must be given by a date combo box and time up-down box located in the upper center of this sub window.

When you click a button labeled [Calc.], the converted results are displayed in wide list box. The site is limited to the place for drawing solar path diagram. When you want to change the site, change the setting by the main window's functions (Refer Chapter 1, p.2).

See references [3] and [4] for getting theoretical information on the time conversion applied in SolMap.

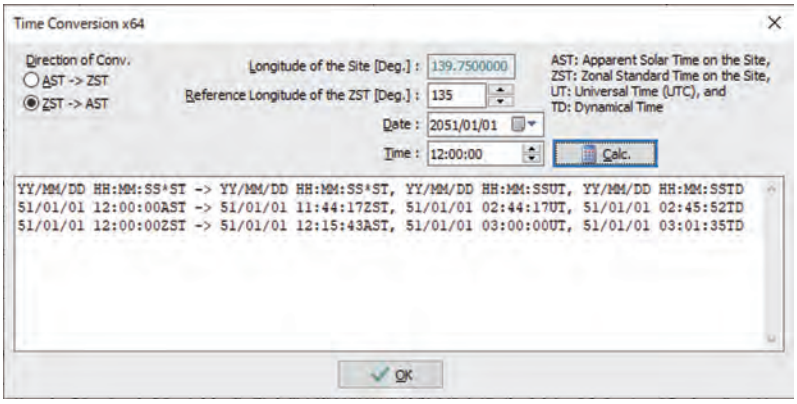


Fig. 13 Subwindow for Convaesion of Time

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[1] MetDS: EA Graphic Tools 2022 General Uers' Manual with a Manual of the Environment Setting Program, EA_SetEnv2022, Meteorological Data System Co. Ltd. (Kagoshima, e-book), 2022.5.

[2] Shin-ichi Matsumoto (Ed. MetDS): Calculation of the Solar Position, Technical report PDF (TE–XXJ/E), http://www.metds.co.jp/download, 2022.8.

[3] Shin-ichi Matsumoto: A Calculation Method of the Solar Declination and Equation of Time — Revision of Matsumoto's Method (Rev. 2022) (in *Japanese*), Proc. of AIJ Tohoku Chapter Architectural Resaerch Meeting, Vol.85, pp.27–34, Architectural Institute of Japan, 2022.6.

[4] Shin-ichi Matsumoto: Critical Review of Four Calculation Methods of the Solar Declination and the Equation of Time and Comparison of Their Accuracy (in *Japanese*), Papers of SHASEJ Annual Meeting 2022 (R4), Vol.5, pp.000-999, The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, 2022.9 (TBA).

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