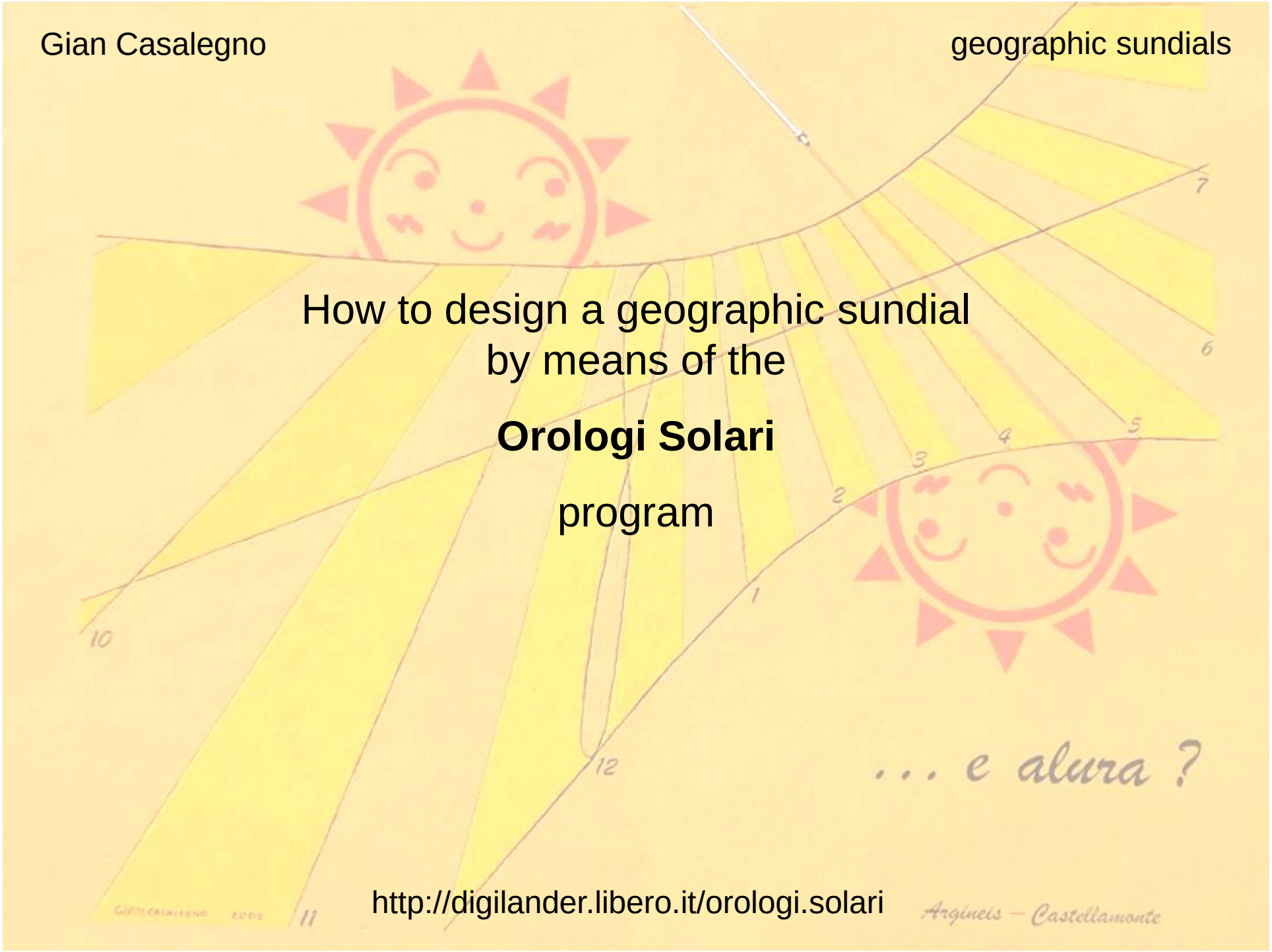


How to design a geographic sundial by means of the

Orologi Solari

program

http://digilander.libero.it/orologi.solari

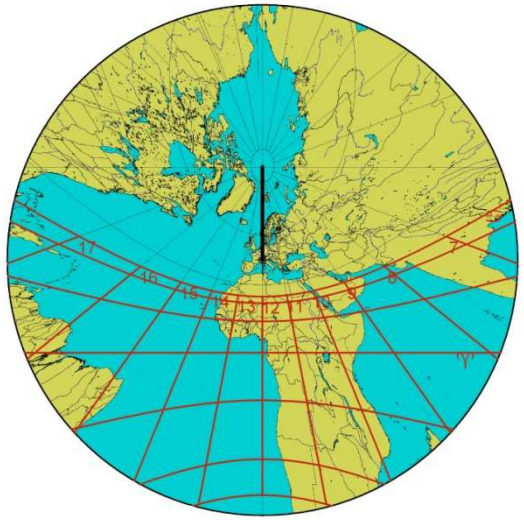
Geographic sundials show the gnomonic projection of the earth surface on the dial plane: continents, countries, cities etc.

The tip of the style shadow shows on the map the place where the sun is at the zenith and the whole style shadow marks all the places in the world where it is local noon.

In order to design such a kind of dial a gnomonic projection map must be obtained, centered at the dial place (for horizontal dials) or at the horizontal equivalent dial coordinates (for vertical dials).

This map can be obtained by means of the *Generic Mapping Tools* (GMT) program as explained in the following slides.

When the map is obtained then it can be used together with the *Orologi Solari* program as the background image on which to draw hour lines and declination lines.



Install the GMT program

1. Go to the web address http://gmt.soest.hawaii.edu/, “Download” section, “GMT Windows” page
2. Download and run the programs:

   gmt-4.5.7_install32.exe (to install the program and cartographic data)

   gmt-4.5.7_pdf_install.exe (to install documentation)

Since GMT creates maps that are in the PostScript format, we also need the Ghostscript program.

Install the Ghostscript program

1. Go to the web address pages.cs.wisc.edu/~ghost/doc/GPL/gpl902.htm
2. Download and run the program *gs902w32.exe*

It is a good idea now to re-boot the computer in order to have the installed programs working correctly.

Create a map with GMT

GMT has no graphic interface and it must be used through line commands that can be run from a DOS window.

The easiest way to do that is to create a .bat file using a text editor and then to insert all the required commands one after the other. With a double click on the file all the commands will be executed.

As an example let's see the sequence of commands needed to create a gnomonic map centered on the coordinates 7.5°E and 45°N (all the available commands a re fully described in the file GMT_Manpages.pdf) :

pscoast -Rg -JF7.5/45/70/18c -Bg15+7.5/g30 –Di -A5000 -Glightgray -Swhite -P –Na -T7.5/45/1c:: -W > output.ps

ps2raster output.ps –Tb -GC:\Programmi\gs\gs9.02\bin\gswin32c.exe

pause

pscoast creates the map in the ***output.ps*** file; command options are explained in the following slide.

ps2raster trasforms the ***output.ps*** file to the bitmap image ***output.bmp***.

pause suspends the execution of the .bat file waiting for a key pressure; it allows to analyze any error message before the DOS window is closed.

***pscoast* command options**

The main options of the command are the following:

–JF7.5/45/70/18c specifies a gnomonic projection centered on 7.5°E e 45°N, re quires 70° as the maximum distance α from the center and 18 cm as the dimension of the map.

-Bg15+7.5/g30 specifies a 15° longitude grid (shifted of 7.5°) and a 30° lat itudine grid.

-T7.5/45/1c:: draws a little 1 cm wide symbol in the position 7.5°E and 45°N.

> output.ps redirects the PostScript output to the “output.ps” file.

Note that GMT considers an eastern longitude as positive.

ps2raster command options

The main option is the following:

-GC:\Programmi\gs\gs9.02\bin\gswin32c.exe specifies the position of the gswin32c.exe file, installed with Ghostscript, in the file system. In the example the typical position is shown.

Use the map with OS

The map we have just created can be considered the gnomonic projection on a horizontal plane placed in the north of Italy.

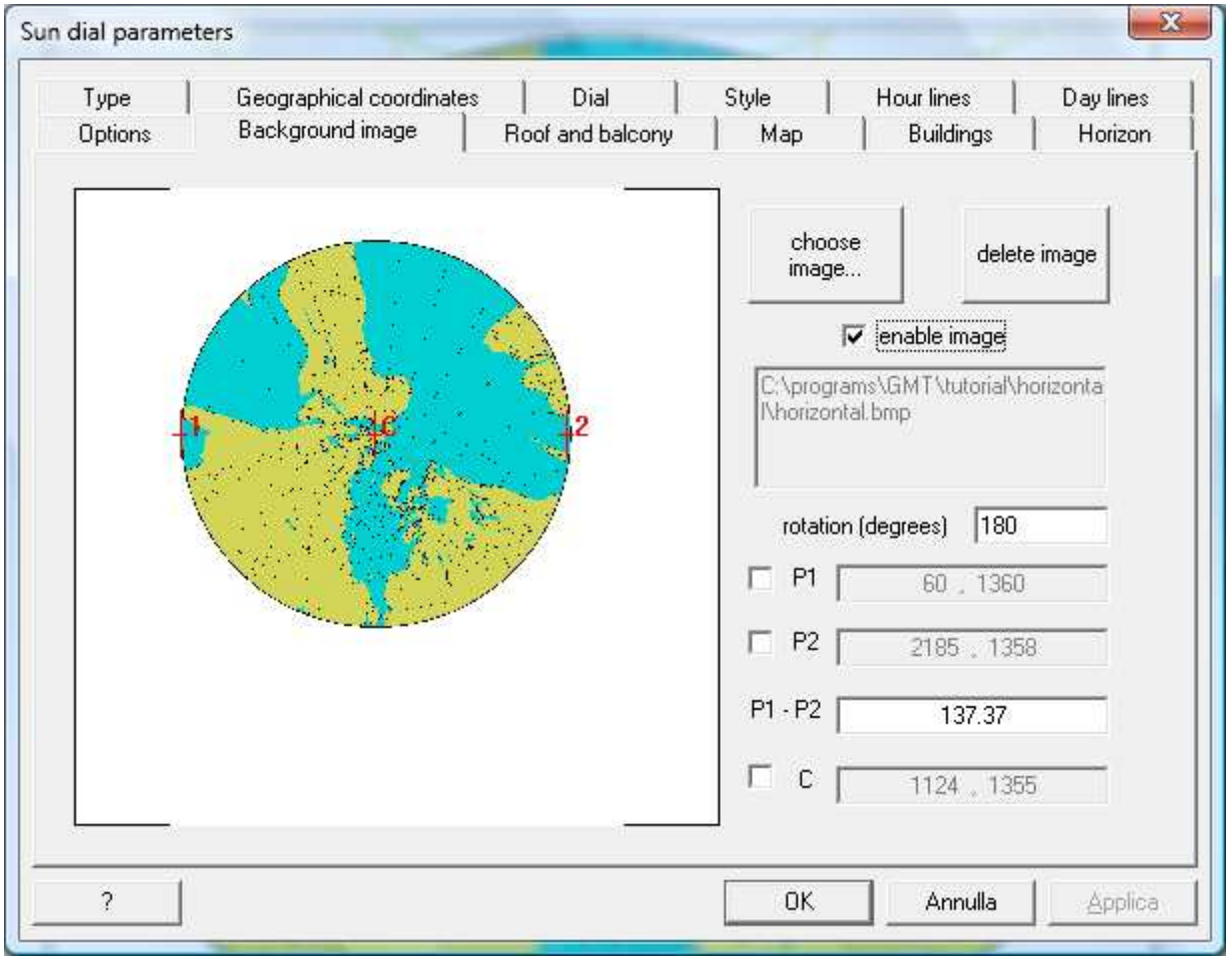
Therefore define a horizontal dial in OS at the coordinates 7.5°E and 45°N.

In the “Background image” tab insert the name of the map file and ask for a 180° rotation (GMT draws the map on a plane that is tangent to the place, so the result is a map that is 180° rotated with respect to the map we would have on the dial plane).

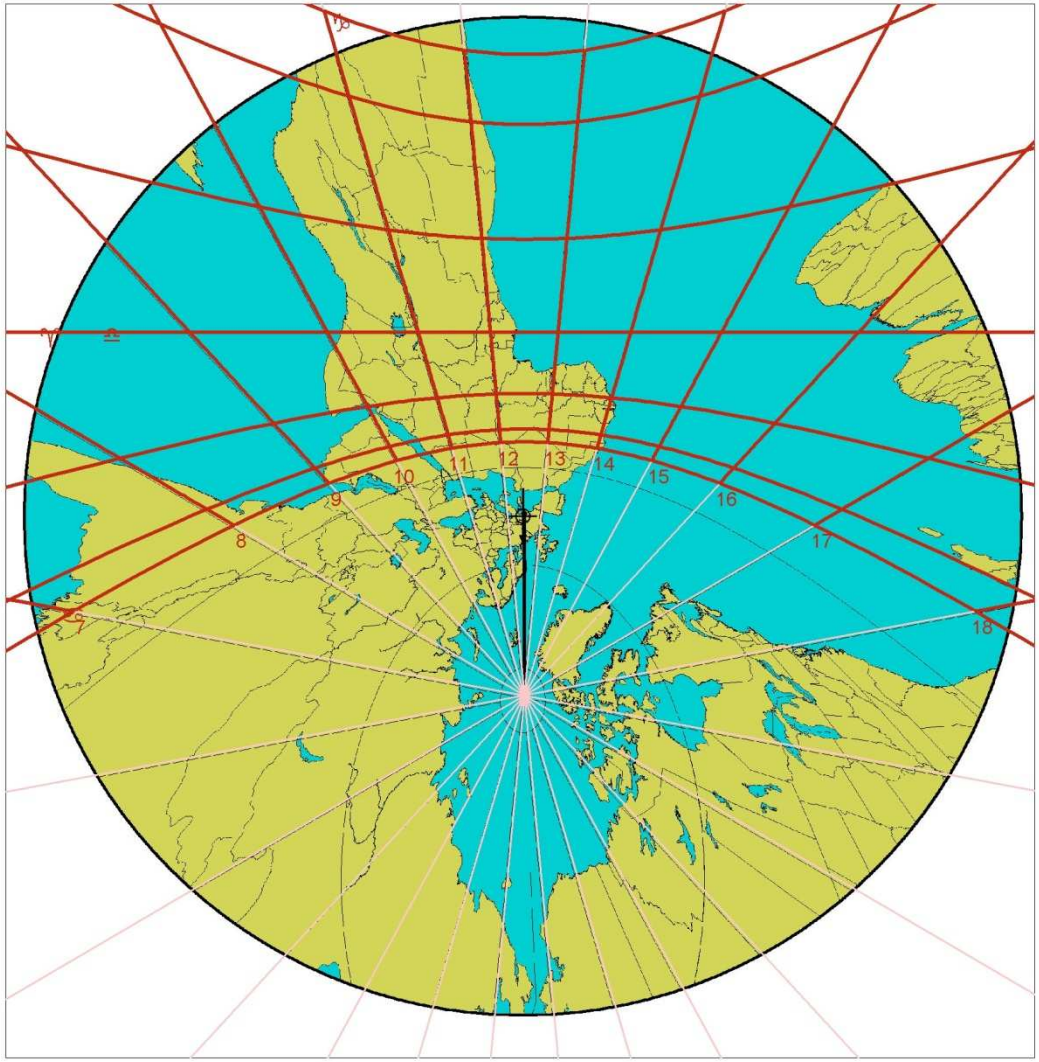
Give a dimension to the map: place the C point on the symbol we have drawn at the center of the map, and put points 1 and 2 on the two ends of the map diameter.

The distance between points 1 and 2 must be set to a value that is dependent on the maximum distance α from the center (70° in the example) and the length R of the ort ho-style through the formula *2*R*tan(α)*.

This is the window when defining the map in OS:



This is the result:



Inclined / declining dials

For non horizontal dials (inclined / declining dials) the map must be centered on the coordinates of the horizontal equivalent dial and rotated of the σ angle that is the substyle distance of the original dial.

Consider φ_0 λ_0 being the sundial latitude and longitude, i the inclination and d the declination of the vertical dial and φ_x λ_x the coordinates of the center of the map. We have:

$$sen(\varphi_x) = cos(i)\, sen(\varphi_0) - sen(i)\, cos(\varphi_0)\, cos(d)$$

$$tan(\lambda_x - \lambda_0) = sen(d)\, tan(i) / [\, cos(\varphi_0) + sen(\varphi_0)\, cos(d)\, tan(i)\,]$$

$$sen(\sigma) = sen(d)\, cos(\varphi_0) / cos(\varphi_x)$$

Let's draw for instance a vertical dial placed at 7.5°E and 45 °N with a declination of 10°W.

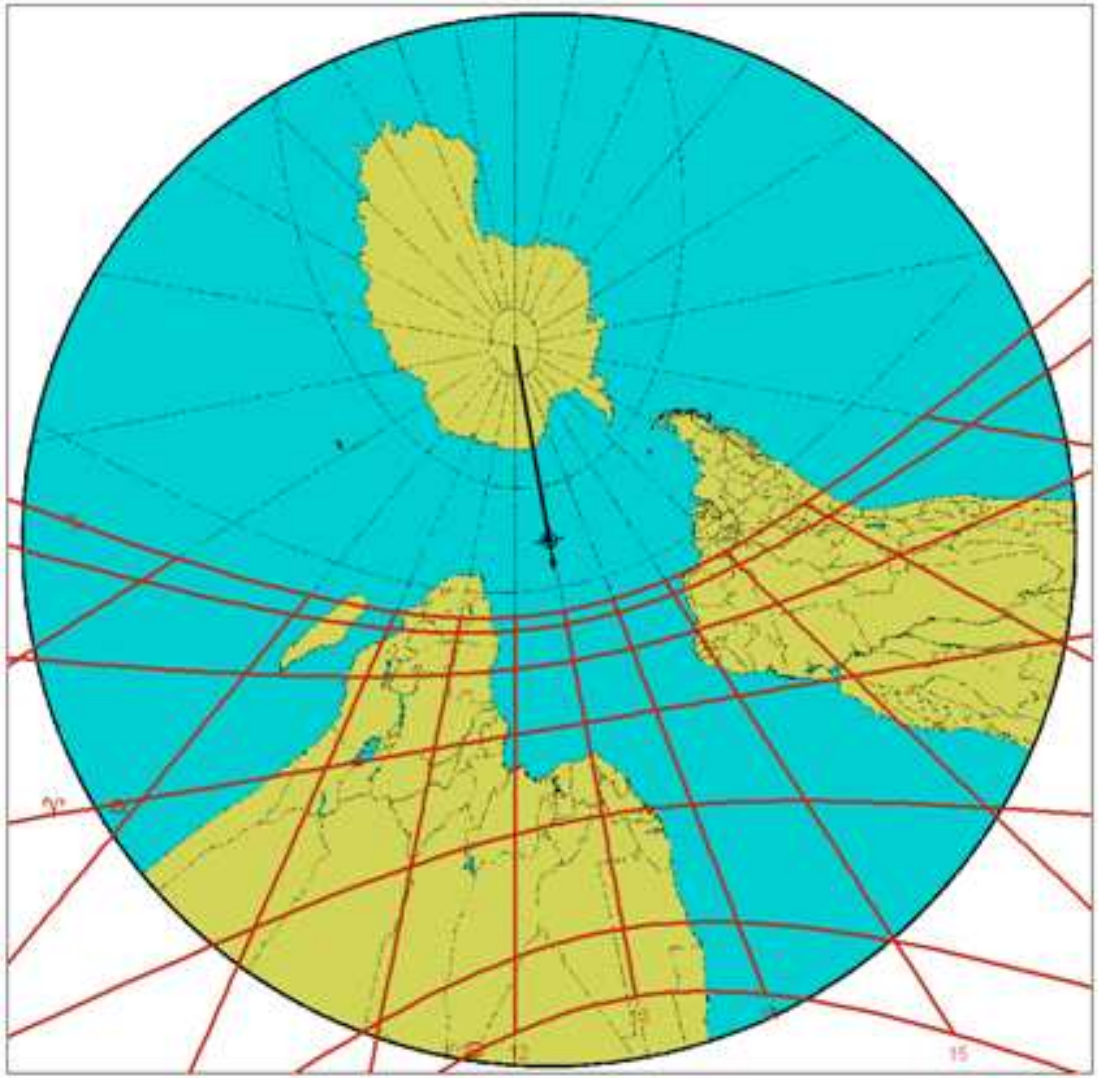
We obtain:

φ_x = 44.14°S

λ_x = 6.50°W

σ = 9,85°

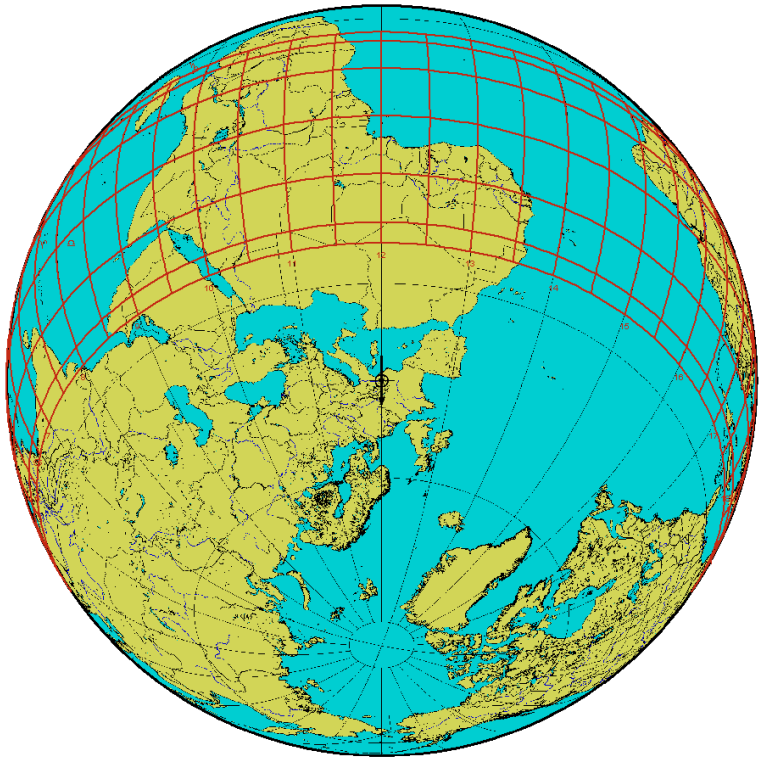
This is the result as obtained with previous data (vertical dial, 7.5°E, 45°N, declination 10°W):



Other projection types

The GMT program can be used for other types of sundials too.

Replace the **–JF** option with **–JG** in order to obtain an orthographic projection map that can be used, as explained before, to create an azimuth orthographic sundial.



In this case the P1-P2 distance to be set in the «Background image» tab is equal to the «celestial sphere radius» as set in the «dial» tab.

Replace the **–JF** option with **–JS** in order to obtain a stereographic projection map that can be used, as explained before, to create an azimuth stereographic sundial (sometimes called “horizontal astrolabe”).