

# sunpath – Draw Sun Path (Test Compatibility only)

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## 1 Object

This file tests if this package can be used within a `scrartcl` class.

## 2 Documentation

### 2.1 Context and Terms

The position of the sun from perspective of an observer is defined by two parameters:

- the azimuth  $\Phi$ , which tells the observer, how far (in degree) he must turn around from the North direction,
- the altitude  $\theta$ , which tells the observer, how height (in degree) about the horizon he must look to see the sun.

The azimuth can take a value in the interval  $[0, 360)$ . The altitude can take a value in the interval  $[0, 90]$ , whereas 0 is the horizon, 90 is the zenith. We do not care so much about how far is the sun, so we normalize this distance to 1.

The figure 1 shows these parameter. The coordinate system, which takes the position of the observer as the centre, and the observer's local horizon as the fundamental plane, is called horizontal coordinate system.<sup>1</sup>

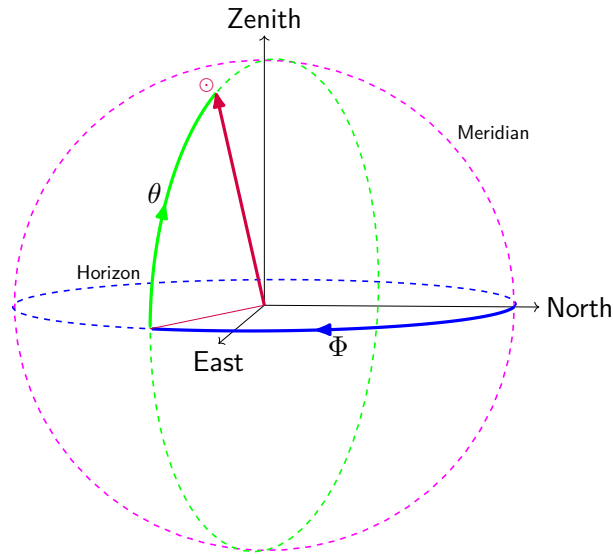


Figure 1: Horizontal coordinate system

In this package, the cardinal points have specific values of azimuth as following:

|       |      |       |      |
|-------|------|-------|------|
| North | East | South | West |
| 0°    | 90°  | 180°  | 270° |

The projection of the sun on the horizon plane is a point, which can be defined by two parameters:

- the angle  $\Phi$ ,
- the distance  $r = \cos(\theta)$  from the centre to the sun.

Figure 2 shows the projection of the sun on the horizontal plane. If we track the position of sun on the horizontal plane changes from time to time, we will get a curve. This curve is called the sun path. A chart which shows position of the sun from time to time is called a sun path chart. Of course there are many type of sun path chart. This package provides tools to plot sun path on the horizontal plane.

---

<sup>1</sup>dt.: topozentrisches Koordinatensystem

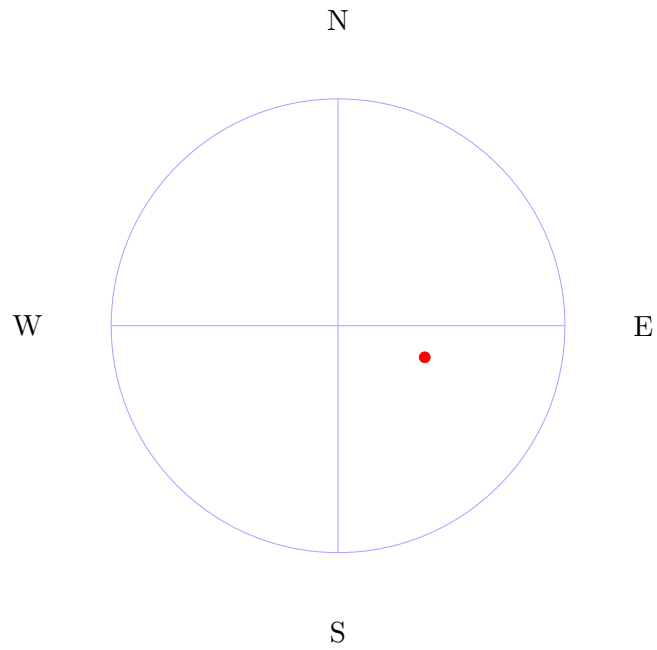


Figure 2: Projection of the sun on the horizon plane

## 2.2 Draw a Sun path chart

Figure 2 is a very rudimentary sun path chart. There is neither scalar, nor time on the chart. A more usable Sun path chart may look like one in the figure 3. In this section we will create this chart.

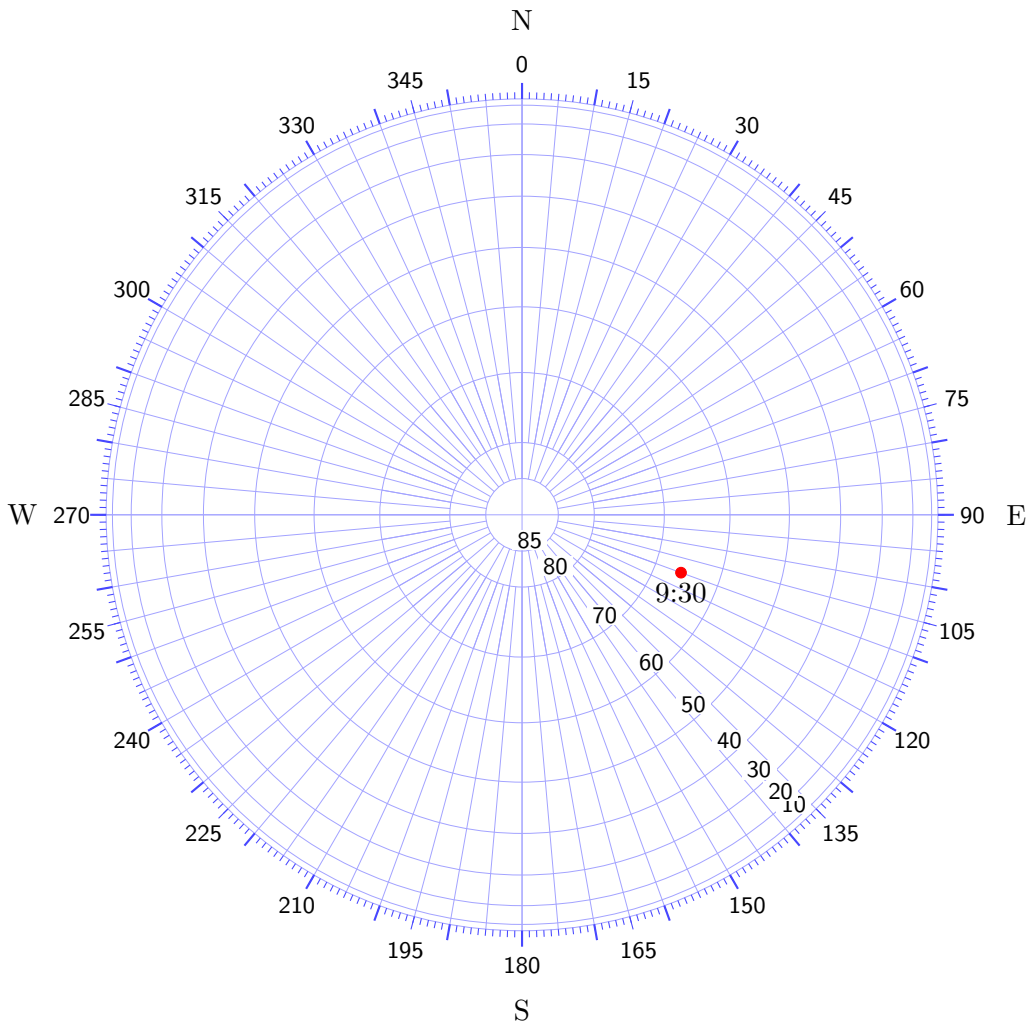


Figure 3: A Sun path chart

### 2.2.1 Outlines

The chart is a TikZ-picture, so we need a `tikzpicture`-environment. We can also customize the distance from the centre of the chart to the horizon line by setup the option `spradius`. By default it is 5.5 in PGF xy coordinate. In this example we make it a little bigger:

`spradius`

```
\begin{tikzpicture}[spradius=6]
\end{tikzpicture}
```

We also need the crosshair, the horizon line –in this chart it is a circle–, the four geographic direction. This can be done by adding more commands into the `tikzpicture`

```

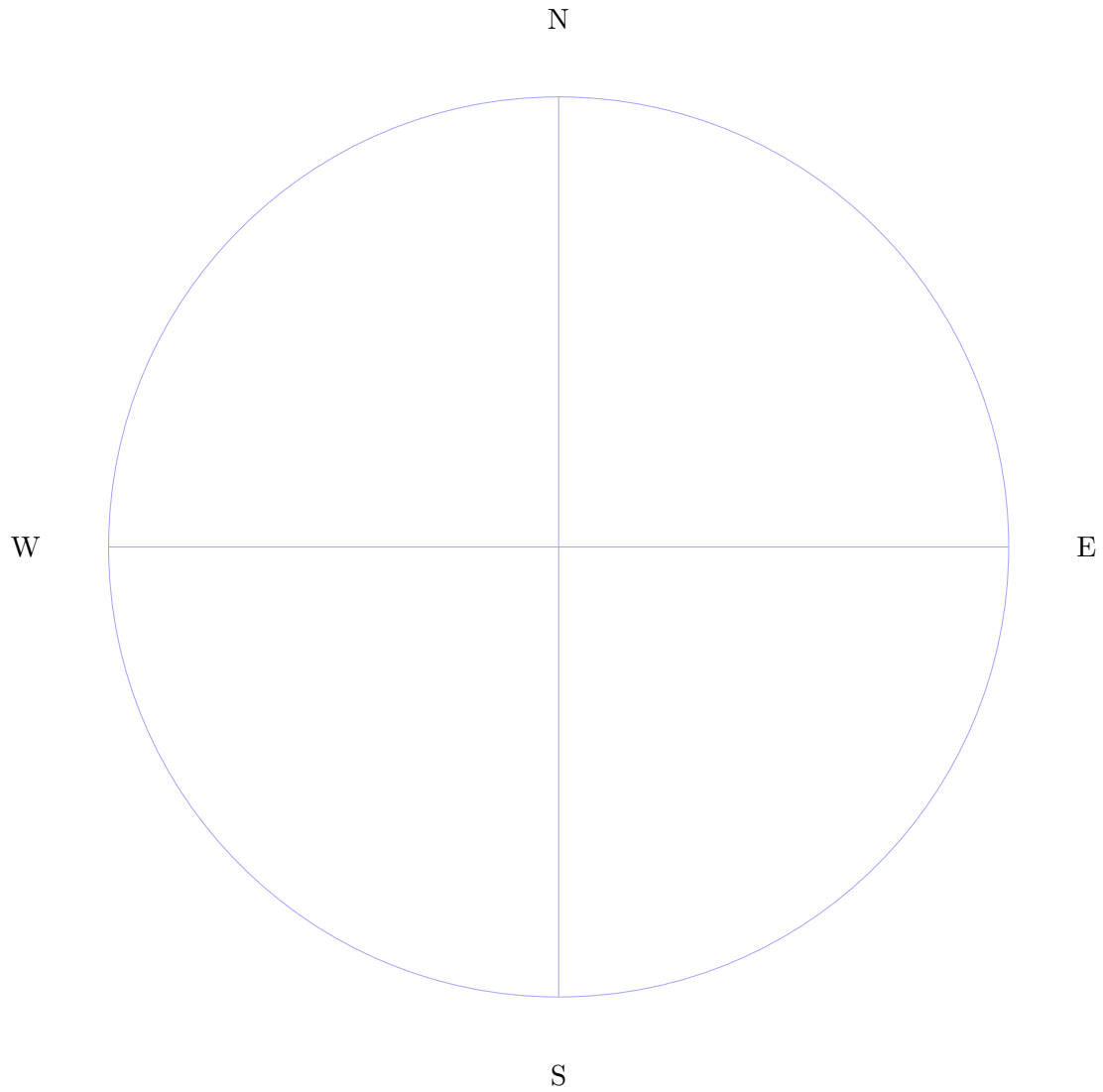
\begin{tikzpicture}[spradius=6]
\drawcrosshair
\drawaltitudecircle{{0}}
\drawgeodirection
\end{tikzpicture}

```

```

drawcrosshair
drawgeodirect:
drawaltitudec:

```

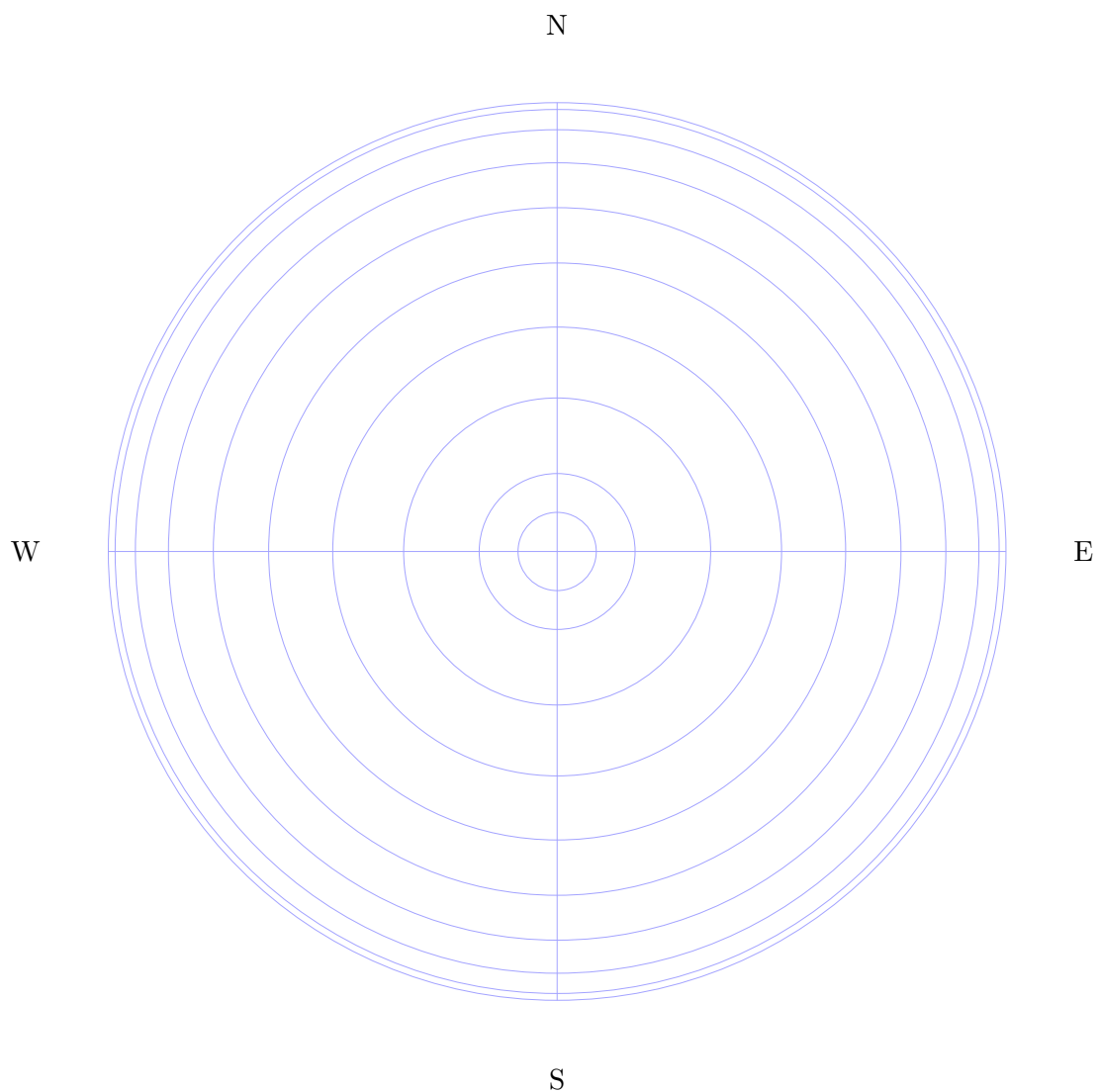


Man has to pay attention to the double curly brackets in the command `drawaltitudecircle`. The outer brackets delimit the argument of the command. The argument of the command is a valid `TikZ`-range, which is used in a `\foreach` command, so it has to be placed in between a pair of curly brackets. That is the inner brackets.

### 2.2.2 Scalar and labels

As the name of the commando says, we can also draw more than the horizon line by adding some values of altitude in the range of the argument of the command `\drawaltitudecircle`. For example `\drawaltitudecircle{{0,10,...,80,85}}` draws 10 circles of altitude.

```
\begin{tikzpicture}[spradius=6]
\drawcrosshair
\drawaltitudecircle{{0,10,...,80,85}}
\drawgeodirection
\end{tikzpicture}
```



We can use the command `\drawazimuthline{r}{h}{l}` to draw azimuth lines in range `r`, from the higher altitude `h` to the lower altitude `l`.

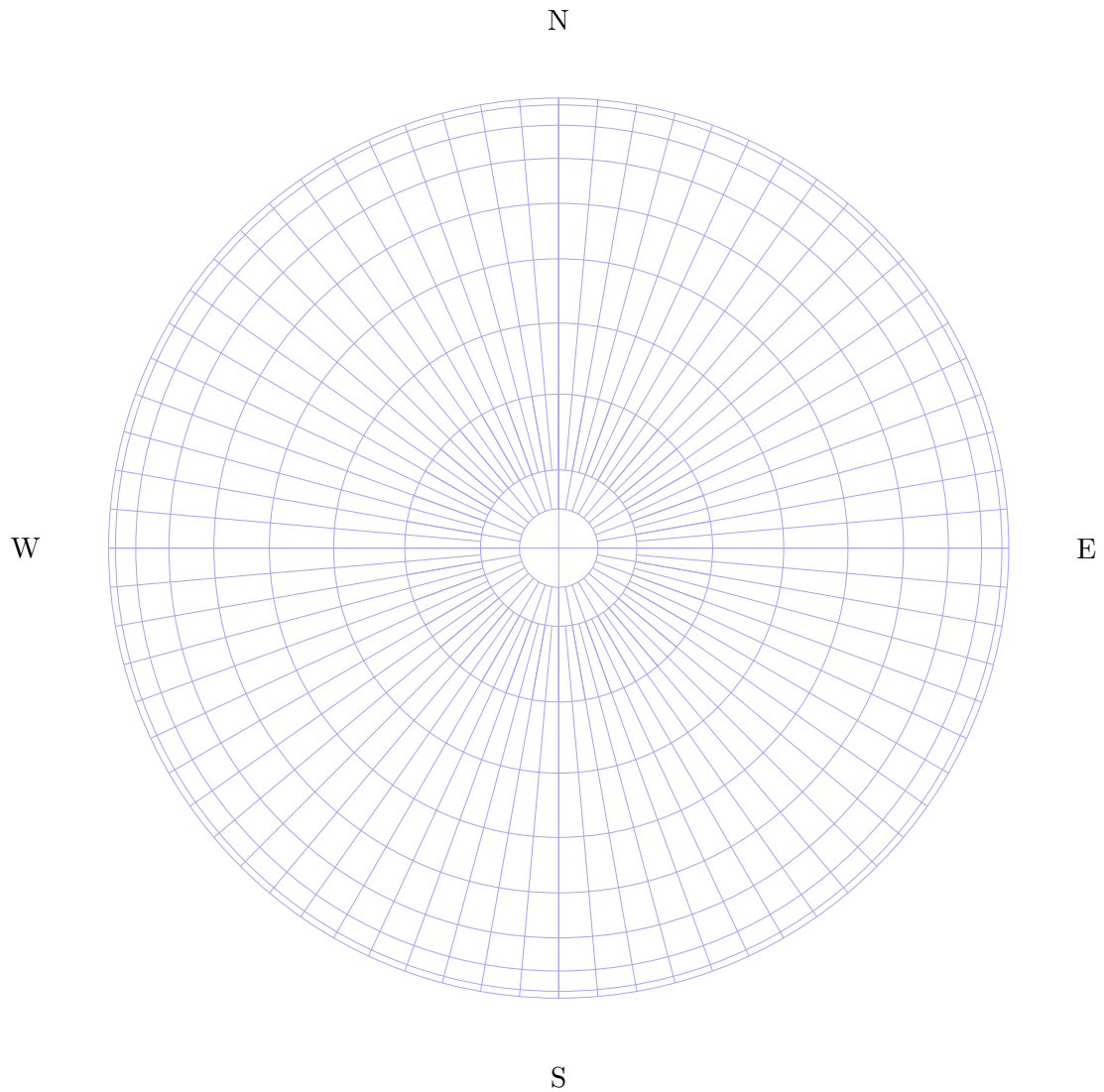
For example

- `\drawazimuthline{{0,10,...,360}}{85}{70}` draws every  $10^\circ$  azimuth from the  $85^\circ$  altitude to  $70^\circ$  altitude.
- `\drawazimuthline{{0,5,...,360}}{85}{70}` draws every  $5^\circ$  azimuth from the  $80^\circ$  altitude to  $0^\circ$  altitude.

```
\begin{tikzpicture}[spradius=6]
\drawcrosshair
\drawaltitudecircle{{0,10,...,80,85}}
\drawazimuthline{{0,10,...,360}}{85}{70}
\drawazimuthline{{0,5,...,360}}{80}{0}

\drawgeodirection
\end{tikzpicture}
```

`drawazimuthline`



To draw azimuth ticks outside the horizon line, we can use `\drawazimuthtick`. This command expects for now no argument.

```

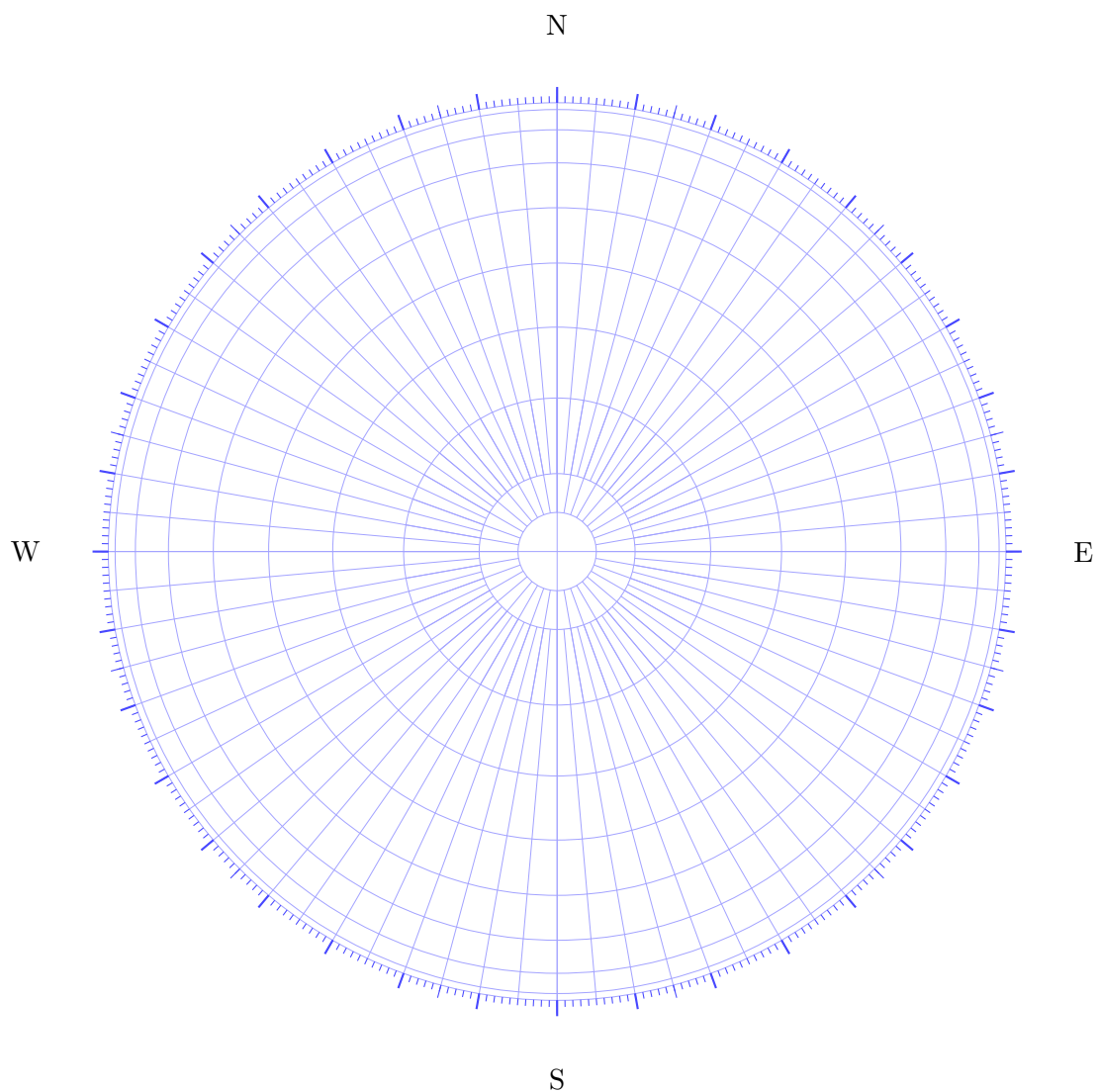
\begin{tikzpicture}[spradius=6]
\drawcrosshair
\drawaltitudecircle{{0,10,...,80,85}}
\drawazimuthline{{0,10,...,360}}{85}{70}
\drawazimuthline{{0,5,...,360}}{80}{0}
\drawazimuthtick

\drawgeodirection
\end{tikzpicture}

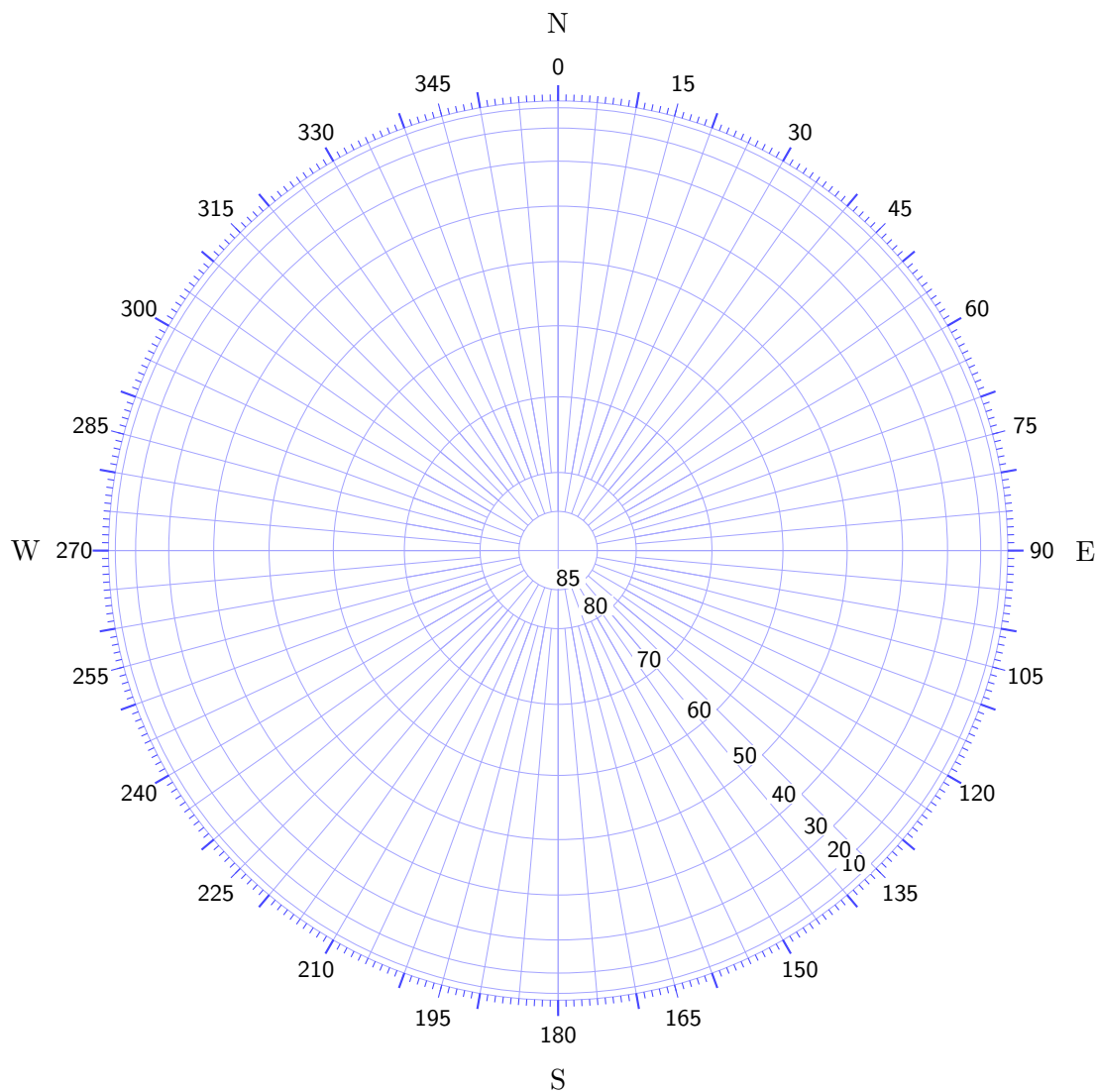
```

`drawazimuthti`





To draw labels of azimuth lines and altitude circles in the chart, we can use the commands `\drawaltitudelabel{r}` and `\drawazimuthlabel{r}`.



That it's, now we have a nice chart, on which we can draw positions of the sun from time to time.

### 2.2.3 Position of the sun

We can easily plot the position of the sun in the chart with the coordinate `sunpath`, if the azimuth and the altitude are given. For example, to plot the position of the sun with 150° Azimuth and 22° Altitude, we just use the `path` command as following:

```
\path[fill=red,draw=red] (sunpath cs:azi=150,alt=22);
```

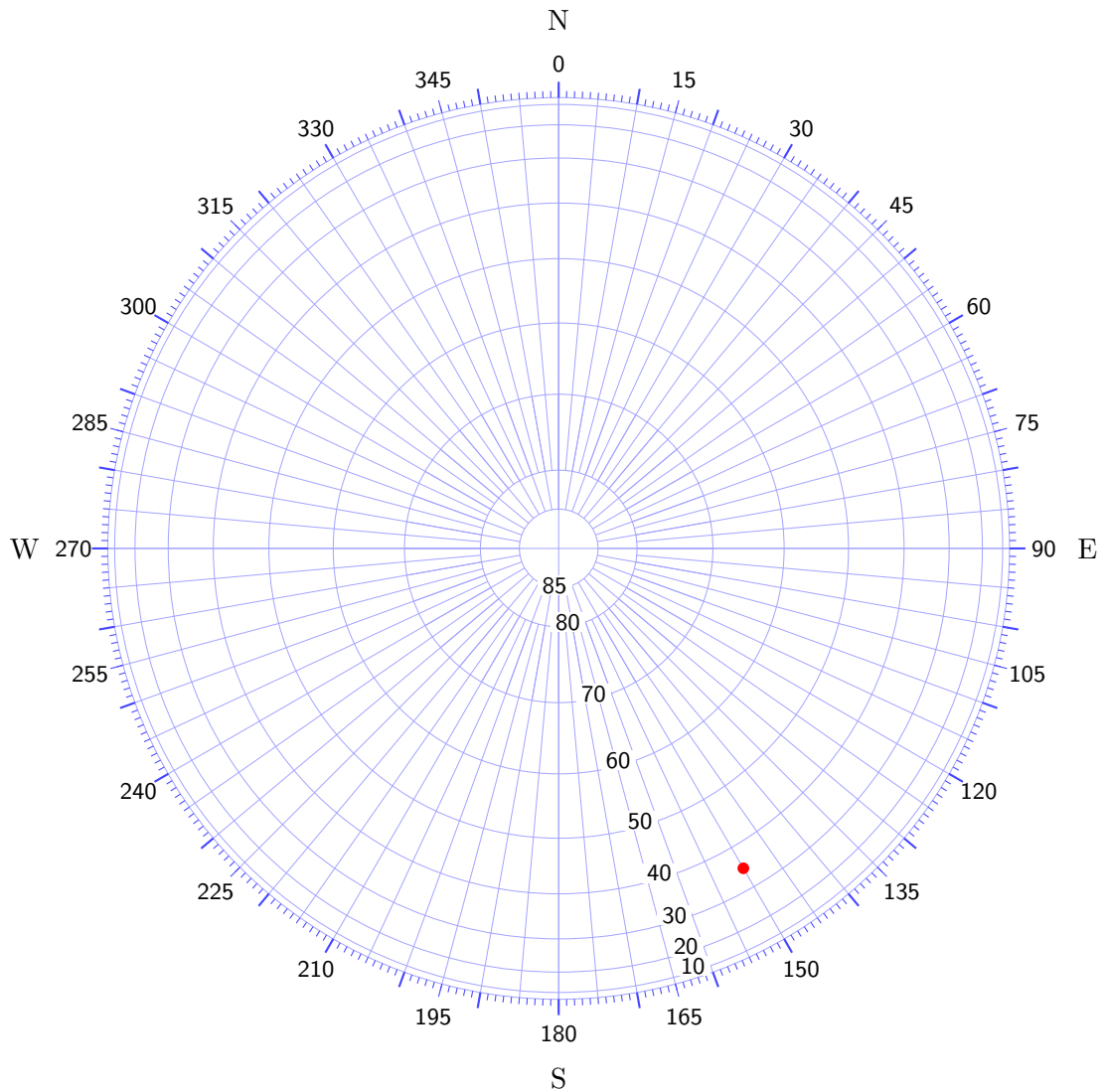
The result would be

```
% ...
```

```
\path[fill=red,draw=red] (sunpath cs:azi=150,alt=35) circle[radius=2pt];
```

```
\drawaltitudelabel[160]{{10,20,...,80,85}}
% ...
```

sunpath cs

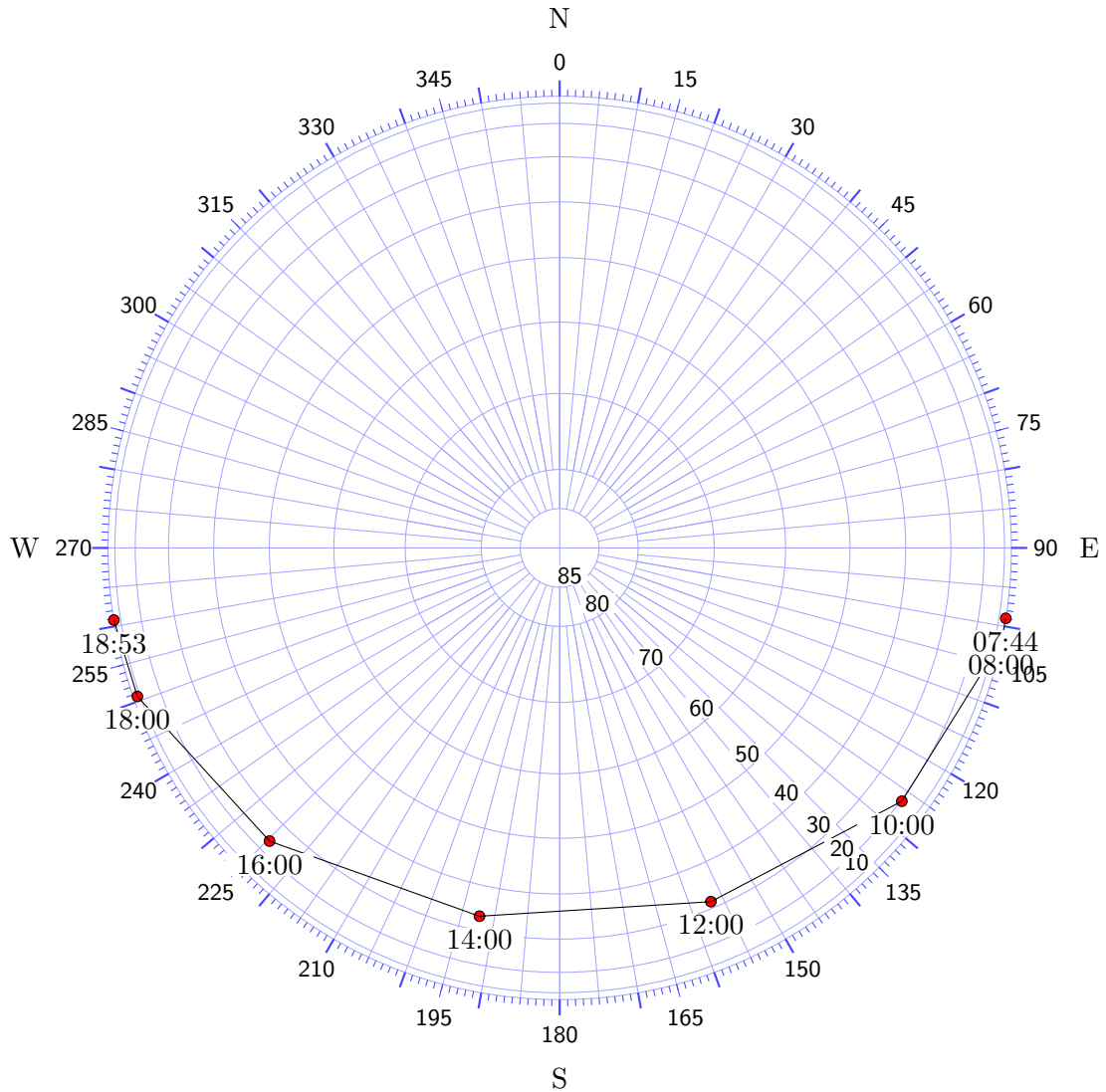


The command `\drawaltitudelabel` can also take an optional argument to set altitude label on other azimuth. This can be useful if the labels cover distract important points on chart. In this chart it is set to be  $160^\circ$ . So one can easily read the azimuth of the sun on the chart.

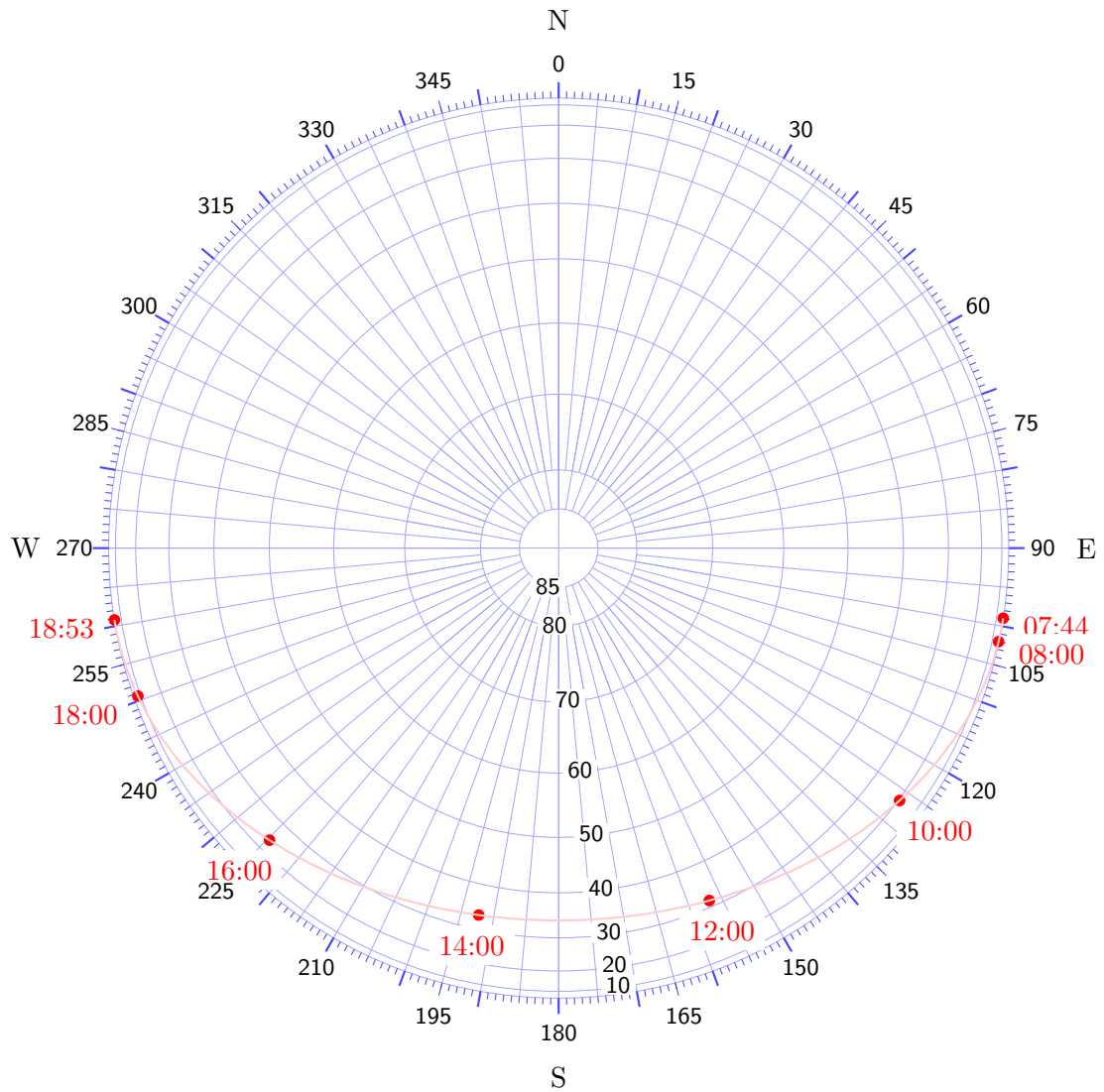
We can also connect the position of the sun to a path, for example with the position

| Time  | Azimuth    | Altitude  |
|-------|------------|-----------|
| 07:44 | 98.968673  | -0.208672 |
| 08:00 | 102.009695 | 2.035492  |
| 10:00 | 126.513583 | 19.499874 |
| 12:00 | 156.854847 | 31.593335 |
| 14:00 | 192.292832 | 33.425294 |
| 16:00 | 224.708002 | 24.034984 |
| 18:00 | 250.626597 | 7.619801  |
| 18:53 | 260.810553 | -0.244637 |

we can get a sun path like this:



But this chart is not nice. If the data is machine readable, we can generate all stuffs of the chart automatically. This chart below is generated from the table above. Just use your favourite programming language to process sun data.



The part, which makes the chart nicer, is there:

```
%...
\coordinate (P0) at (sunpath cs:azi=98.968673,alt=-0.208672);
\coordinate (P1) at (sunpath cs:azi=102.009695,alt=2.035492);
\coordinate (P2) at (sunpath cs:azi=126.513583,alt=19.499874);
\coordinate (P3) at (sunpath cs:azi=156.854847,alt=31.593335);
\coordinate (P4) at (sunpath cs:azi=192.292832,alt=33.425294);
\coordinate (P5) at (sunpath cs:azi=224.708002,alt=24.034984);
\coordinate (P6) at (sunpath cs:azi=250.626597,alt=7.619801);
\coordinate (P7) at (sunpath cs:azi=260.810553,alt=-0.244637);
\path[sun point] (P0) circle;
\path[sun point] (P1) circle;
```

```

\path[sun point] (P2) circle;
\path[sun point] (P3) circle;
\path[sun point] (P4) circle;
\path[sun point] (P5) circle;
\path[sun point] (P6) circle;
\path[sun point] (P7) circle;
\node[sun label,anchor=270-98.968673] at (P0) {07:44};
\node[sun label,anchor=270-102.009695] at (P1) {08:00};
\node[sun label,anchor=270-126.513583] at (P2) {10:00};
\node[sun label,anchor=270-156.854847] at (P3) {12:00};
\node[sun label,anchor=270-192.292832] at (P4) {14:00};
\node[sun label,anchor=270-224.708002] at (P5) {16:00};
\node[sun label,anchor=270-250.626597] at (P6) {18:00};
\node[sun label,anchor=270-260.810553] at (P7) {18:53};
\path[sun path curve] (P0) to [curve through={
    (P1) .. (P2) .. (P3) .. (P4) .. (P5) .. (P6)
}]
(P7) ;
%...

```