How to use the Sunrise Photos in your lessons?

Suggestions

Let the students find the location of each photograph in a map. By looking at the photos and the location on a map, they soon will find a connection between the sunrise/sunset angle and location. Arrange the locations and coordinates in a table:

Photo	Date	Location	Latitude	Longitude	Sunrise/sunset angle

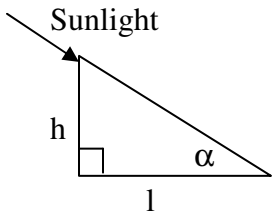
The students use a protractor to measure the sunrise angle. I have leveled the photos, i.e. the lower edge is horizontal. The students will find that the path of the Sun is not straight. The best part of the path to measure the rising angle is some way up from the sunrise, not the highest part of the path. Discuss the causes of the curving of the sunrise path (atmospheric refraction, the sinusoidal form of the sun path).

Let the students find the connection between the sunrise angle and latitude. Can they find any connection between the longitude and the sunrise angle (photos 2 and 2b)? One of the photos is taken about one month later than others. Is there any difference? Why?

You can demonstrate the seasons and equinoxes with a globe and light from an overhead or slide projector. With a globe and simple, self-made measuring tools, the students can measure the altitude of the Sun every hour at any latitude. See the attached photographs.

The altitude is

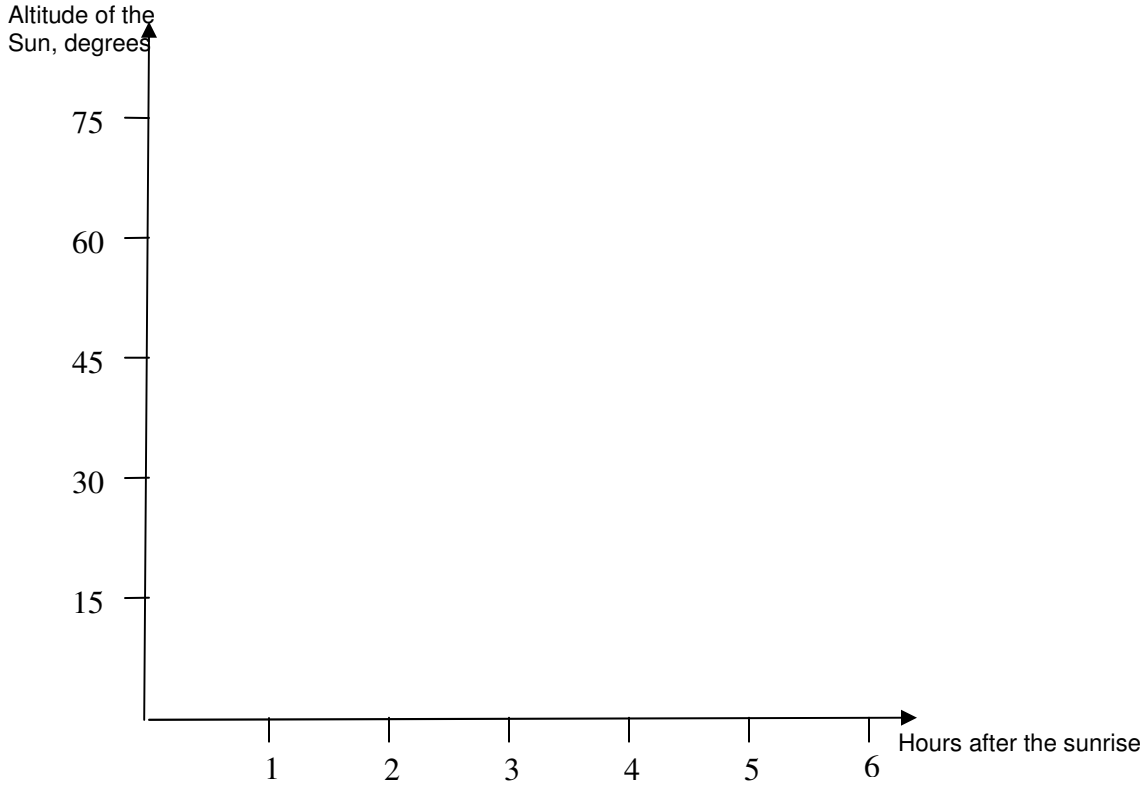
$$\alpha = \arctan\left(\frac{h}{l}\right)$$



where h = height of the gnomon (20 mm)
l = length of the shadow (mm)

If your students are not familiar with trigonometry, let them draw the triangles in a suitable scale and measure the altitude angle α.

Use a coordinate grid with a horizontal axle for hours after sunrise and vertical axle for the altitude in degrees. One hour corresponds 15 degrees; use the same division for both axles. This is the situation in the camera: the vertical and horizontal scale is the same. This is an approximation, but accurate enough for our purposes.



Plot the altitudes in the coordinate grid and draw a line from the bottom left corner (sunrise point) through the altitudes for the three first hours after the sunrise. Compare the result with a photo taken at the same latitude.

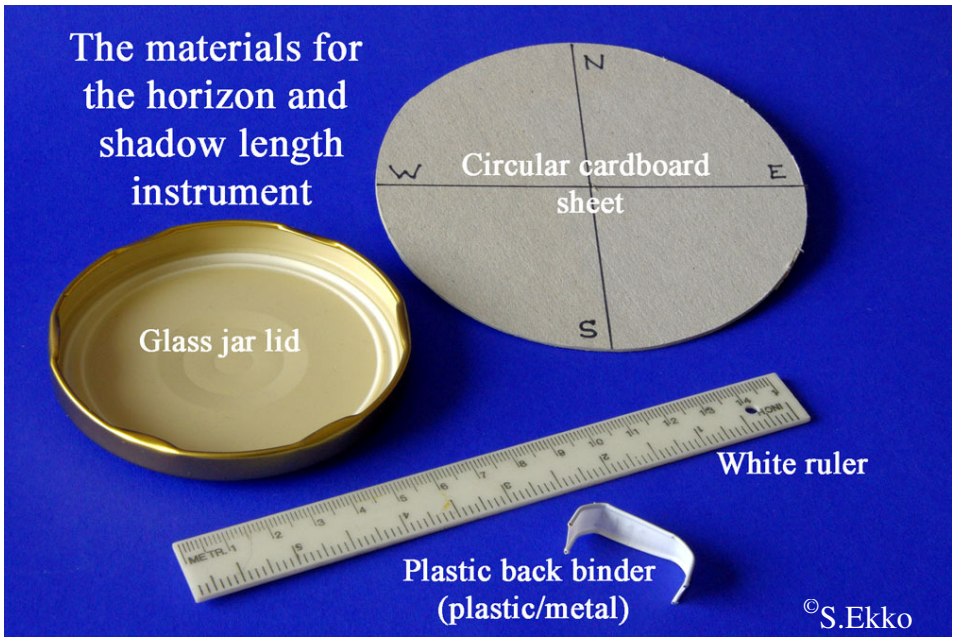
Measure the rising angle from the graph and compare it with the rising angle obtained from the photo.

Make the globe measurement for all the photo locations and draw the lines in the same graph.

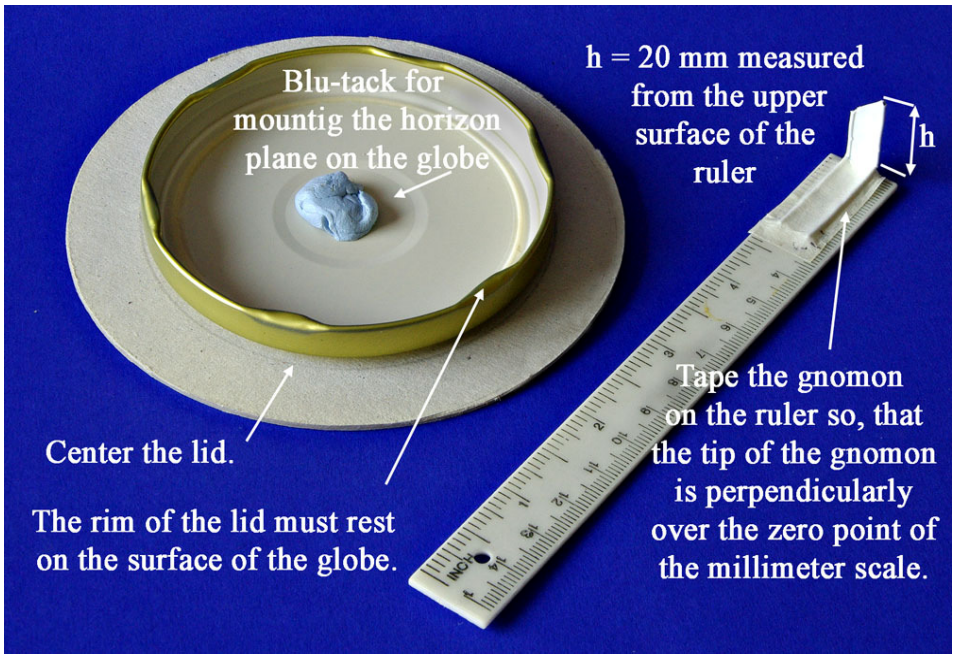
The astronomical twilight is the time before the sunrise or after the sunset when the Sun is less than 18^{o} under the horizon. The sky is dark enough for astronomical observations, when the Sun is more than 18^{o} under the horizon. Find the end and beginning of astronomical twilight by extending the sunrise/sunset line in the graph

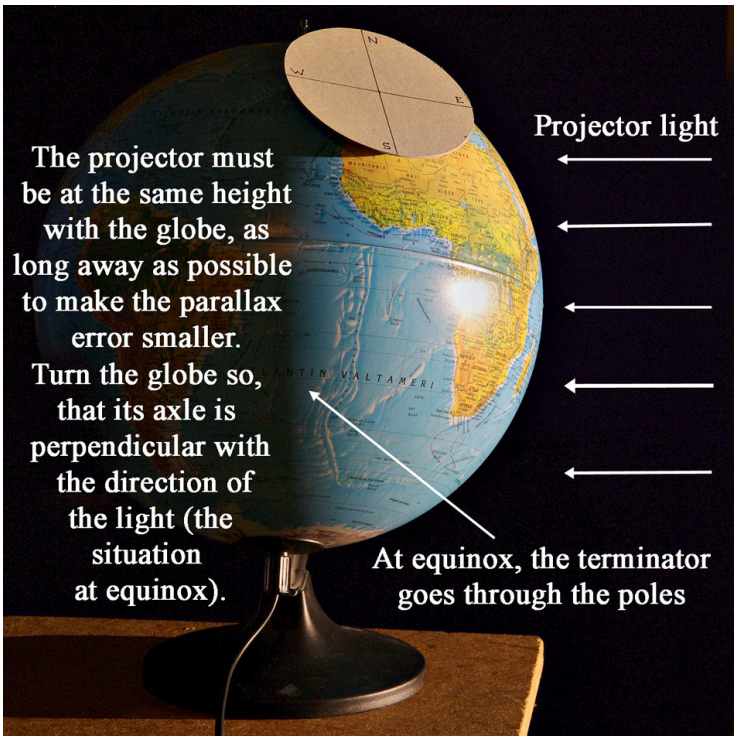
under the horizon and to the left or right. How the latitude does affect the length of twilight?

Note: The “globe-graphs” obtained by the method described above only accurate to some degrees, but the method demonstrates the general idea very well.



Cut the end of the gnomon obliquely as shown




Projector light
The projector must be at the same height with the globe, as long away as possible to make the parallax error smaller.
Turn the globe so, that its axle is perpendicular with the direction of the light (the situation at equinox).
At equinox, the terminator goes through the poles

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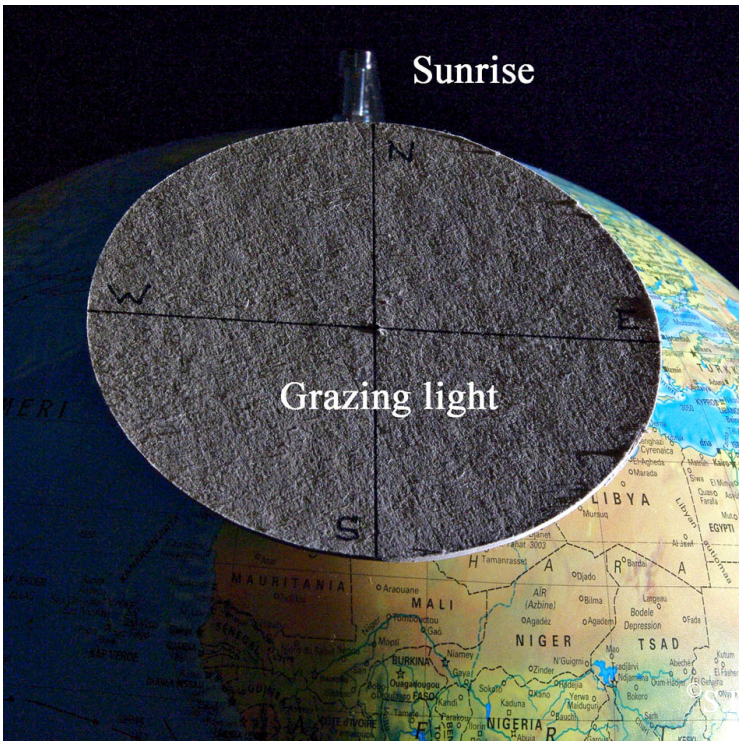
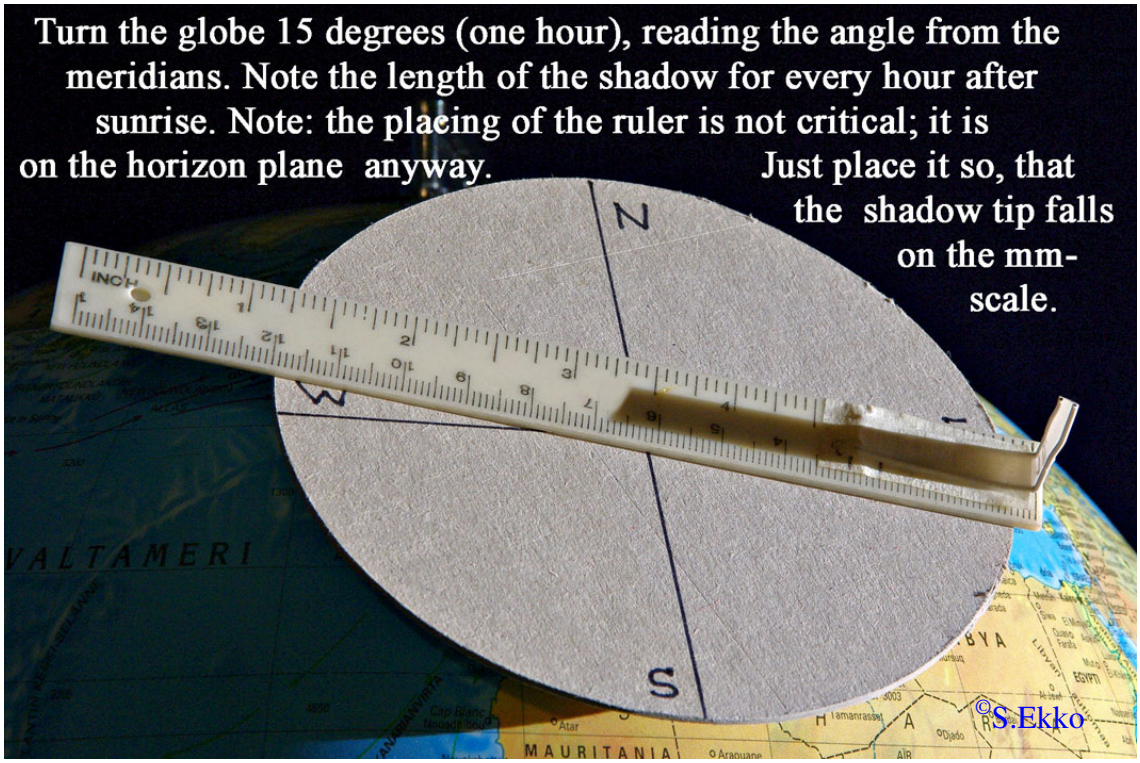
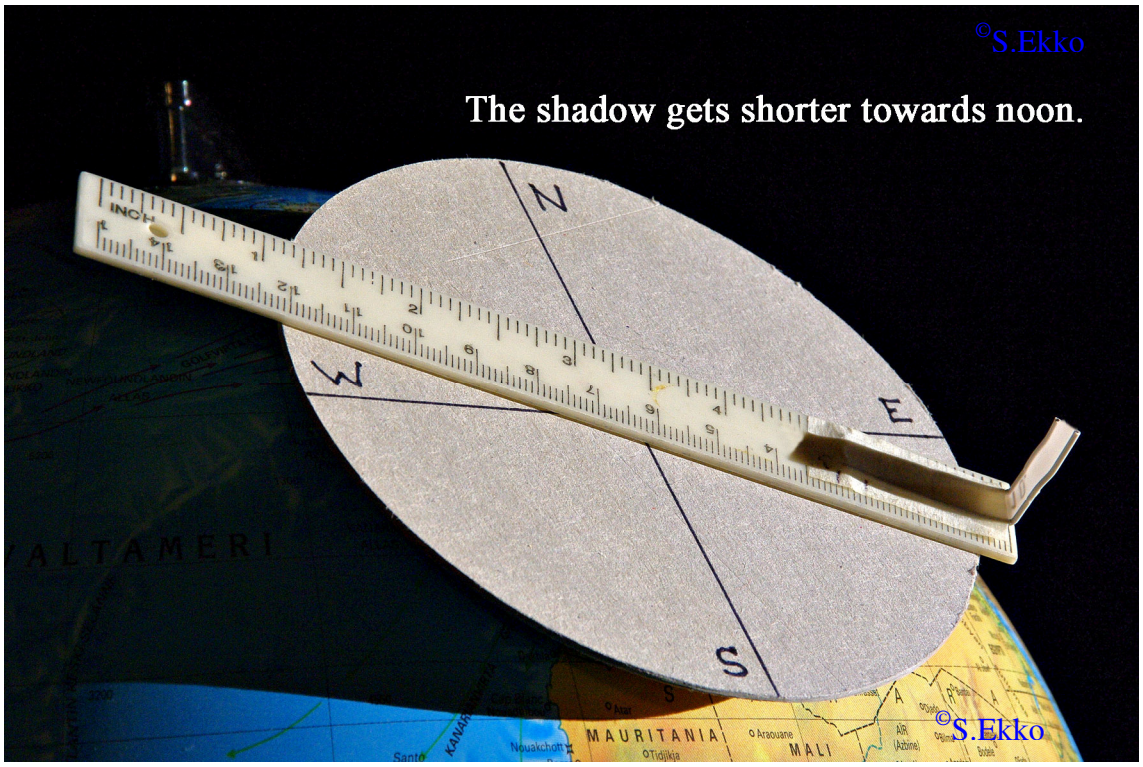
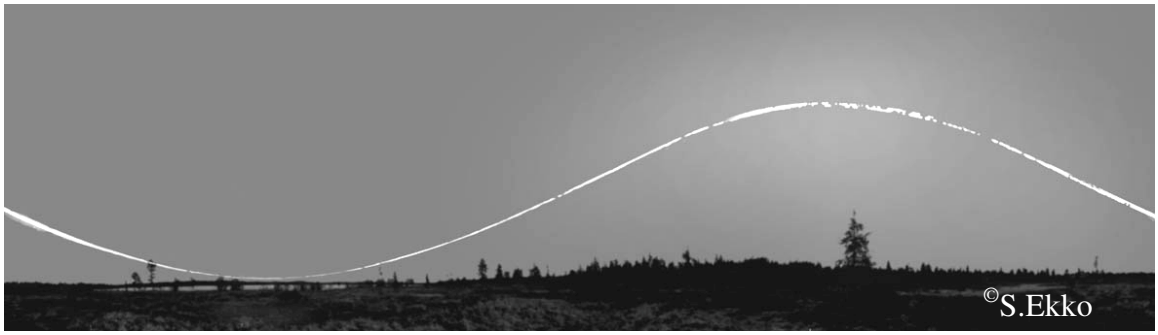

Sunrise
N
W
E
S
Grazing light
LIBYA
EGYPT
MAURITANIA
MALI
NIGER
TSAD
NIGERIA


Turn the globe 15 degrees (one hour), reading the angle from the meridians. Note the length of the shadow for every hour after sunrise. Note: the placing of the ruler is not critical; it is on the horizon plane anyway. Just place it so, that the shadow tip falls on the mm-scale.
N
S
©S.Ekko

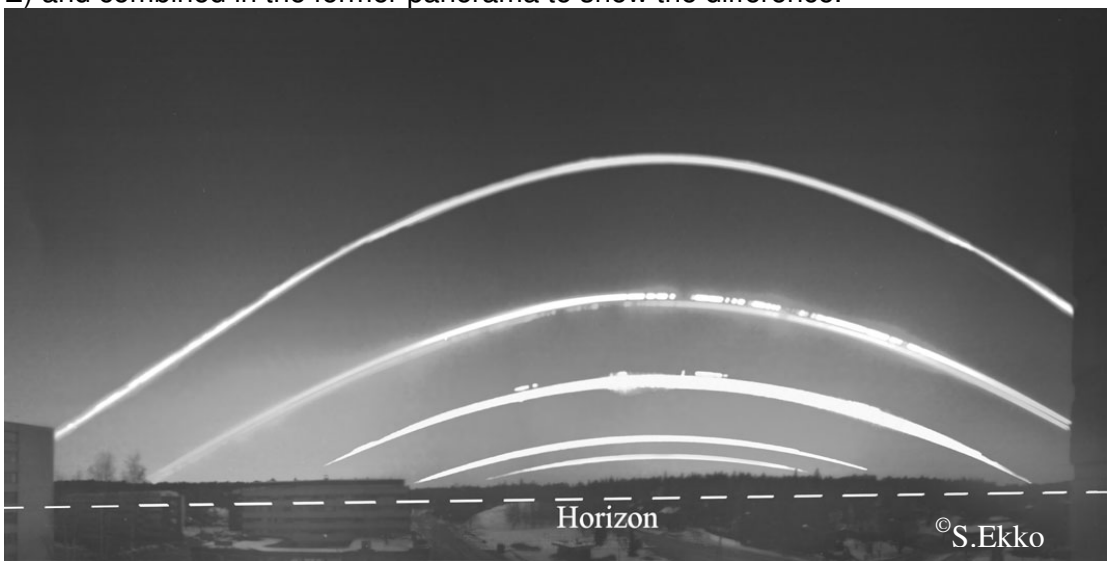

©S.Ekko
The shadow gets shorter towards noon.
N
S
E
©S.Ekko

You can use the images below to explain the differences at different latitudes and seasons.

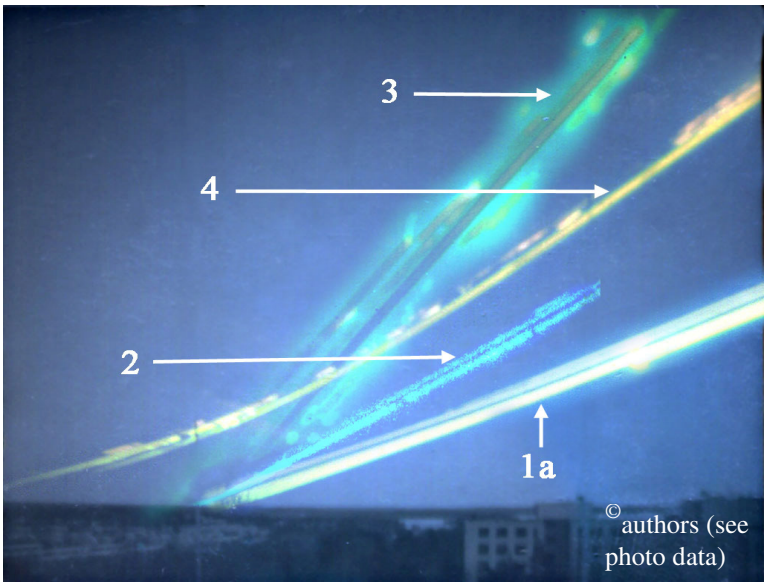


The path of the Sun during the whole day and "night" in Finnish Lapland (68° 25'N 24° 06' E). A full 360° panorama taken with four curved-back cameras 10.-22.6.2009.

Another 360° Sun path exposed 11.-18.7.2009 in southeastern Finland (62° 02' N28° 40' E) and combined in the former panorama to show the difference.



Five exposures with two curved-back cameras taken around the middle of January – April and December 2009 in Turku, Finland (60° 28' N 22°15 E). Each exposure about a week.



Four images combined in the same photo, using the image with best defined horizon (N:o 4) as a background. To get the results comparable, the sunset images are mirror-reverted. At equinoxes, the Sun rises due east everywhere. You can demonstrate this with the globe in projector light.

The effect of atmospheric refraction. The even line shows the apparent path of the setting Sun, the dotted line the calculated real path of the Sun, as if there were no atmosphere. Multiple exposure made 5.8.2006 in Southern Finland, 62° 02' N 28° 40' E.