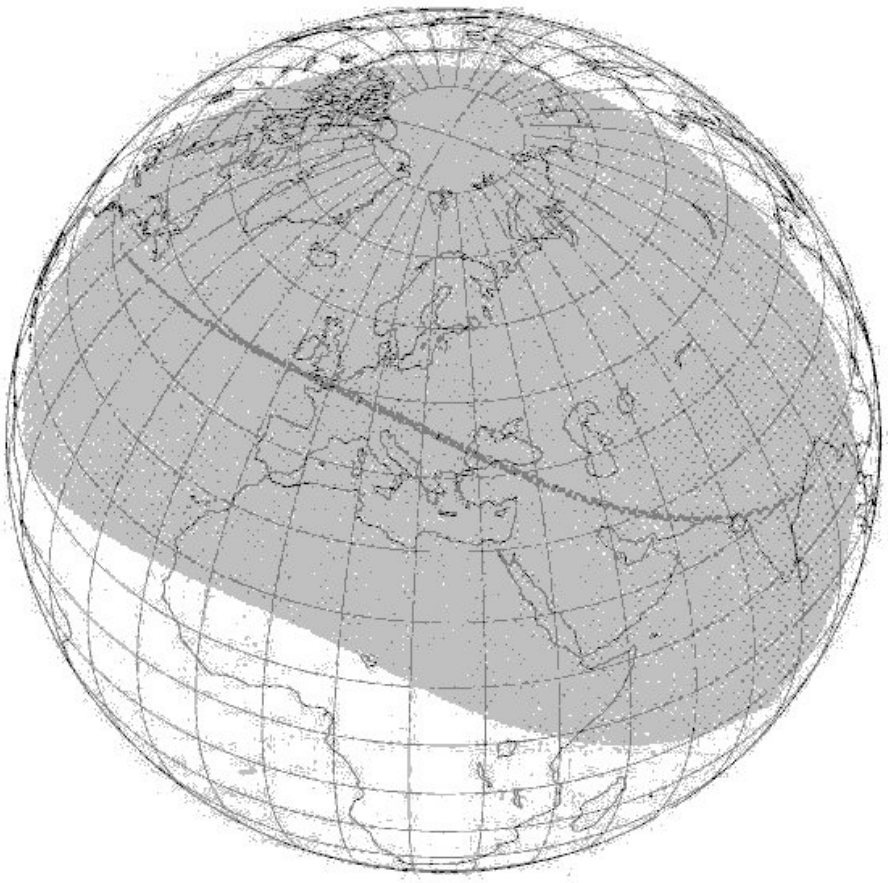
Viewing The Total Eclipse Of The Sun, Wednesday, August 11, 1999

By D.Norris

Introduction

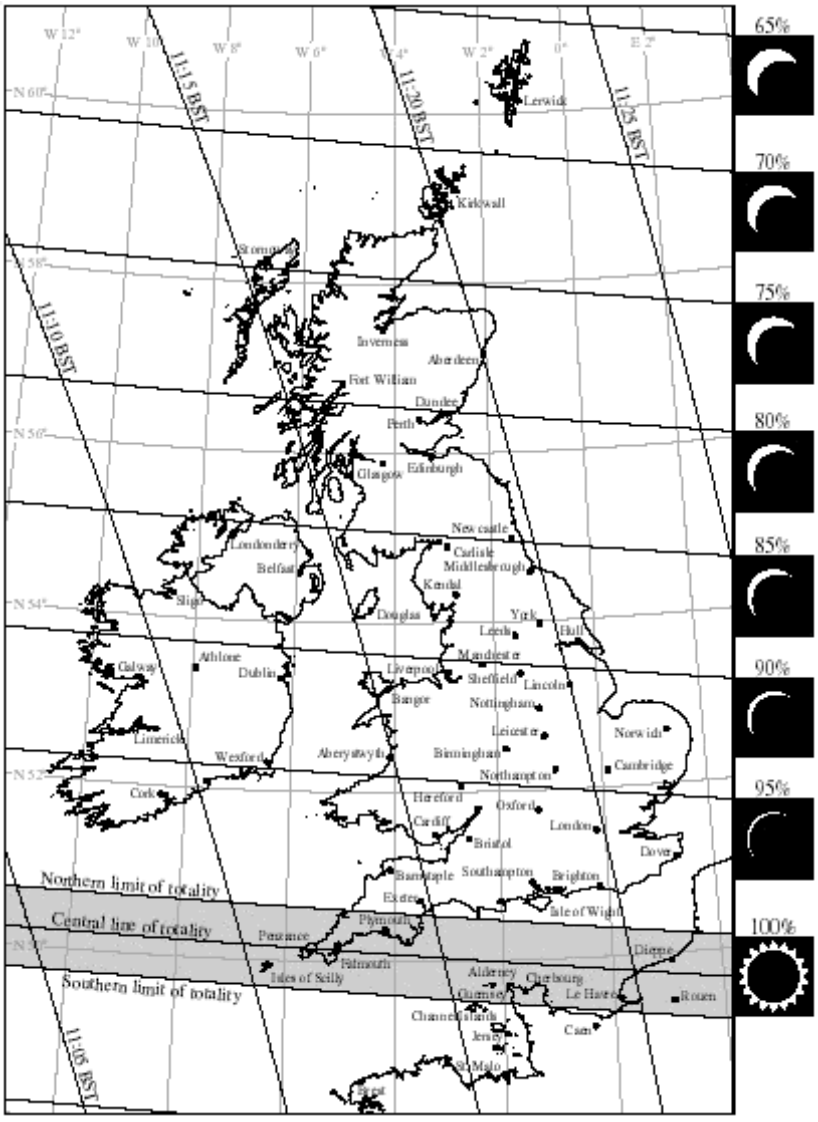
The eclipse of 1999 was to be the last eclipse of the millennium. The only parts of the British Isles to see it as a total eclipse were Cornwall, parts of Devon, Alderney and Guernsey. Globally, it began roughly 400Km south of Newfoundland just after dawn, and passed across the North Atlantic before making landfall in south-western Britain. It later passed through northern France, the southern part of Belgium, Luxembourg, southern Germany, Austria, Hungary, Romania and a small part of Yugoslavia and Bulgaria. After leaving Europe, the eclipse could later be seen in Turkey, parts of Syria, Iraq, and Pakistan, and finally India. The path of totality ended in the Bay of Bengal at sunset.
The longest duration of the eclipse was to the east of Bucharest where the sun was highest in the sky; this was where the shadow of the moon was travelling at it's slowest.



Above; Areas affected by the eclipse. The map is from the Nautical Almanac Office. The white areas are those from which the eclipse was not visible, the light grey areas experienced a partial eclipse at some stage during daylight hours, whereas the dark

shading indicates the path of totality which began shortly after dawn to the south of Newfoundland, ending to the east of India at sunset. The eclipse made landfall first in the Scilly Isles.

Below; magnitude of the eclipse as seen throughout the British Isles. The only areas to experience a total eclipse were Cornwall and southern parts of Devon, although a partial eclipse was visible throughout the British Isles. It is fair to say that on St Boniface Down we saw more of the eclipse than observers in Cornwall, where it was overcast. The best view of all was from Torbay, where it was only partially overcast with plenty of gaps in the cloud cover. The map is from the Nautical Almanac Office.



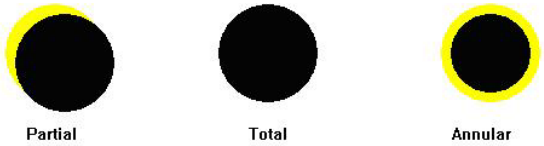
When does an eclipse occur?

An eclipse is simply caused by the Moon's shadow falling on the earth. This happens only on extremely rare occasions as will be explained later. When the moon obscures only part of the sun's 'disk', as seen in your location, the eclipse is said to be partial. For a total eclipse to be experienced, the moon has to be in precisely the right position, at precisely the right time.[1] In addition, there is a third type of eclipse, an 'annular' eclipse, which occurs when the Moon is precisely lined up with the sun, but has a slightly smaller apparent diameter than the sun. This is because it is on the furthest part of its orbit from the Earth. Confusing though it may all seem, there is a fourth type of eclipse, the annular/total eclipse, in which, during the period in which the sun & moon are aligned, the moon's apparent (or angular) size starts out as being slightly less than that of the sun, exceeds it for a time, then later reverts to being less than that of the sun. In short, the eclipse is initially annular, becomes total, and then reverts to being annular! This is extremely rare.

The sun & moon are said to be in opposition when they are on exactly opposite sides of the Earth - which implies that they cannot both be above the horizon in any one location on the Earth's surface - and a 'full' moon is visible at night. When the sun & moon are in conjunction, they are both in almost the same position when viewed from any point on the Earth's surface, and the moon is 'new'. The moon cannot be seen as the 'dark side' is turned toward the earth, the part of the moon in shadow.

A lunar eclipse happens when the moon passes through the shadow of the earth (when the sun & moon are in opposition), whereas a solar eclipse occurs when they are in conjunction, and the shadow of the moon falls upon the earth.

It is important to bear in mind that the Moon's orbit around the Earth is elliptical, i.e. not a true circle; it is slightly elongated. In addition, the Earth's orbit too is slightly elliptical, as is true of the vast majority of bodies in orbit. The appearance of the three 'types' of eclipse is illustrated below.



Please note that these illustrations are <u>not</u> to scale. The black disk of the moon is not actually visible during an eclipse except during totality; it is shown for illustration purposes.

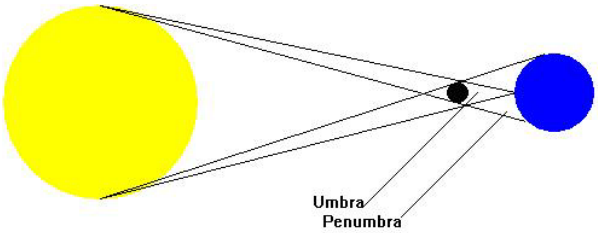
The exact size of the moon as seen from earth is known as it's angular size. This must be greater than that of the sun for a total eclipse to occur. The sun & moon have an angular size of (approximately) half a degree. These vary in magnitude by about 2% for the sun, and 8% for the moon. This actually implies that the sun sometimes appears to be slightly larger than the moon, or vice versa.

The term 'totality' refers to the period during which the sun is totally eclipsed. This happens only in a narrow path, whereas a partial eclipse is visible over a vastly greater area, which is typically half the part of the earth facing the moon.

---

[1] It is by a sheer coincidence that the sun, while it is 400 times more distant from the Earth than the Moon, has 400 times the sun's diameter, which is why from Earth, it would appear the same size as the Moon. This is only an approximation - the Moon's orbit is slightly elliptical.

It is important to remember that the shadow of the moon does not usually fall on any part of the Earth - otherwise an eclipse would occur at every single ‘new’ moon! This is because the moon’s orbit is about 5 degrees out of plane of the Earth’s.
The best solar eclipses will occur when the moon is closest to the Earth, (perihelion) as explained earlier, and when the sun is at it’s furthest (aphelion). This occurs in early July. The eclipse is of the longest duration when in the equatorial region (where the surface velocity reaches 1700Kph, partially cancelling out the movement of the moon (Approximately 3400Kph). The area under the umbra is dependent on the relative angular diameter of the sun & moon. An annular eclipse occurs when the sun has a greater angular diameter.



This is an approximation of the Sun, Earth & Moon as seen when looking down on the North pole. This is not drawn to scale. Viewers inside the penumbra will see only a partial eclipse; in order to see a total eclipse, a viewer must be under the umbra. The umbra sometimes 'falls short' of the Earth's surface; in which case, an anular eclipse ocours in which the outline of the sun will appear around that of the moon.

What is there to see during a total solar eclipse?

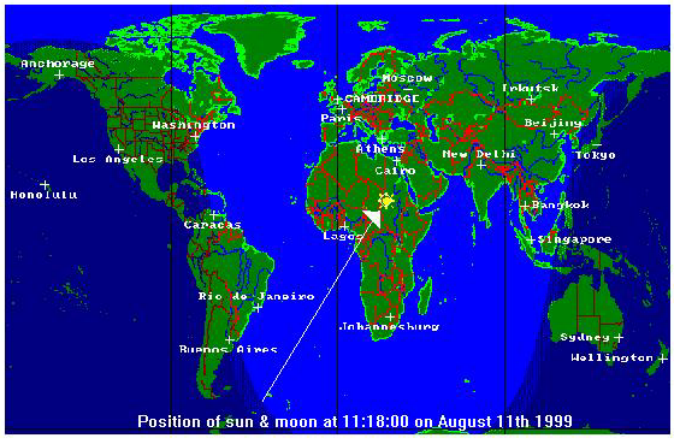
Many people wonder why so many people went out of their way to see the moon obscure the sun for two minutes! The answer is that an eclipse produces a proliferation of effects which can be experienced at no other time. There is far too much to comment on here in detail, but this is a brief description of the main effects produced.
First contact is the point at which the partial phase of the eclipse begins. This has the appearance of a ‘bite’ taken out of the sun. Over roughly the next hour, more of the sun is obscured until second contact, at which the eclipse becomes total. During the partial phase, multiple images of the shrinking crescent can be seen under trees - the ‘pinhole’ effect. The gaps in the foliage act as a pinhole camera. Animals and birds, confused by the light, may begin to go to roost as they would at nightfall.
As second contact approaches, given good visibility, it should be possible to see the shadow of the moon approach at supersonic speed. At this point, the last light of the sun breaks up into small blobs (Bailey’s Beads) caused by the last of the sun shining through gaps in the lunar mountain ranges. All except one will disappear in a few seconds.
Second contact marks the beginning of totality. During totality, the sun’s corona becomes visible. In addition, it may be possible to see solar flares (prominences) in times of high solar activity. These are normally lost in the glare. It may even be possible to see the chromosphere around the outline of the moon. The entire horizon may appear illuminated as it is outside the area of totality.
At third contact, totality is over. The Bailey’s Beads may become visible for a few seconds, and the moon’s shadow will be seen retreating towards the east. The photosphere of the sun brightens rapidly, and the eclipse is over at fourth contact. Obviously, second and third contact will occur only if you are in the path of totality.

When was the last total eclipse of the sun visible in the British Isles?

It is possible to see a total eclipse roughly every eighteen months somewhere on the Earth's surface, however on average any one location will experience one only every four hundred years. The last time one was visible in Great Britain was on 29th June 1927, when the path of totality crossed Cardigan Bay, passed to the east of Colwyn Bay, and after passing over the Irish Sea, crossed the north of England from Southport to West Hartlepool, before disappearing over the North Sea. The remainder of the United Kingdom experienced a partial eclipse. Totality lasted just 25 seconds, as the sun was so low in the sky - this eclipse occurred just after dawn.

The 1999 Total Eclipse

We were fortunate that on this occasion, the sun was fairly high in the sky. This produced an Umbral shadow just over 100km wide, as it passed the British Isles.[2] This is an illustration of the location of the sun & moon in the sky, showing the position in which both are directly overhead. This was at 11:18 AM (British Summer Time) when our location experienced its greatest magnitude of eclipse.



Above; the position of the sun & moon at 11:18 hours on August 11th 1999. The symbols indicate the location at which the sun & moon are directly overhead at 15.33 degrees north, 26.76 degrees east. *Please note that all times quoted are in British summer time, which is one hour ahead of UTC.*

Although our original intention was to camp in Cornwall to view the eclipse, the coaches and trains were fully booked, so we decided to view the eclipse from St Boniface Down near Ventnor on the Isle of Wight. Here we were 20 Miles outside the zone of totality, but on the Down with a good view out to sea, it was possible to see the zone of totality (the area under the umbra) at sea. We would miss out on many of the effects of the eclipse visible only in the path of totality, however it turned out that in Cornwall the sky was almost completely obscured by cloud! The weather around

[2] The diameter of the umbra is dependent on the magnitude of the eclipse. This can vary from less than 1.0, for an annular eclipse, which will produce no umbral shadow at all, to in excess of 100km when the moon in closest to the Earth.

the Isle of Wight during the eclipse was far from ideal - it was fairly clear to the Southeast of our location, but to the Southwest the sky was obscured by the edge of an Atlantic frontal system, which had brought cloud and rain to Cornwall! Horizontal visibility remained good throughout the event. We did get a number of views of the eclipse through gaps in the cloud cover, however, so the inability to get to Cornwall was, to some extent, compensated for!

In order to be in position on the Down in plenty of time, we had to get up at 5AM, and travel to Ventnor via Newport. Once on the Down, we had some trouble finding a suitable location. Being near a golf course, we needed a location free of flying golf balls (!), as well as having an all round view. I had also wanted a location near to some trees, to attempt to photograph the 'pin hole' effect of the eclipse caused by the partially eclipsed sun shining through gaps in the branches. This proved difficult as the only trees were in sheltered locations without the required view. This was no great loss, as it became clear that there was too much cloud to attempt to capture this effect anyway.

I had already attempted to calculate the times of first and fourth contact, along with the time at which the umbra would appear. I also decided to use a GPS (Global Positioning System) receiver to store our exact location for any future reference;

50 degrees 35 minutes 50 seconds North
1 degree 13 minutes 53 seconds West
Altitude 162 Metres above Mean sea level.
(Approx. 500 feet.)

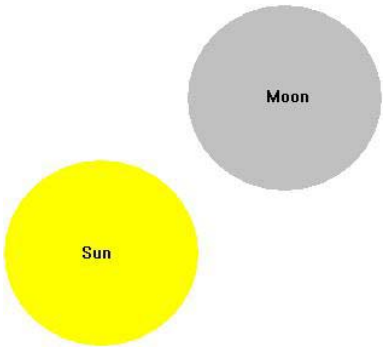
Events recorded during the eclipse

We had brought both a pinhole camera, and solar eclipse viewers, as Emma wanted to draw the partial phases of the eclipse. We inspected the condition of the viewers before the eclipse began, for any defects. I also had my camera, intending to record any light or other effects produced. One lesson we quickly learnt was that a pinhole camera is useless when viewing the sun through high cloud, whereas the eclipse viewers can be used given that the sun is partially visible through a thin layer of cloud. It must be remembered that the pinhole camera will reverse the image of the sun. This effect was corrected in order to produce the drawings below. I must also comment on an occurrence before the eclipse had even begun; whilst testing the pinhole camera, we noticed that a portion of the circular image of the sun was missing!!! This was because a piece of the card had flayed whist the hole was made. Inserting a pencil through the hole remedied the problem. It was fortunate that this defect was discovered before the eclipse had begun, as we would have obtained some very misleading results!

First contact was expected at 10:01 AM, however as it approached, the cloud began to spoil the view. The first view we got was at 10:07, when the first part of the sun was obscured as expected, giving the impression of the 'bite' taken from the sun. From now on, we made drawings of the sun whenever we got a gap in the cloud. For the next hour or so, as the moon crept into position, it was interesting that for a long time the apparent light level appeared unaffected! However, one hour after first contact, with 90% of the sun obscured, it had taken on the appearance of a golden crescent, whereas by now the light was similar to that of a November afternoon at about 3PM, although the colours were very different. By now the golfers on the course had given up trying to play in the rapidly deteriorating light! At this point, we

noticed that a flock of birds, confused by the light, were beginning to roost on the bushes, whereas some rabbits nearby had come out for their evening graze!
At 11:11AM, the time at which totality reached Cornwall, the light level on the Isle of Wight was finally dropping rapidly - by 11:17 it had the appearance of an electric light fitted with a dimming control being turned down.
It was quite a spectacular spectacle, to see the umbra (the shadow under the total Eclipse) pass over the channel from the Westcountry, first appearing from the western horizon within a few seconds of the expected time. By now it was completely dark on the horizon to the southwest, and as the umbra approached, the light level over the island was roughly equivalent to that half an hour after sunset, whilst the mainland remained in twilight.
Suddenly, it began getting lighter again to the west, as the umbra disappeared over the southern horizon to France. Light levels returned almost to normal over roughly the next ten minutes. The eclipse was not quite over yet - it was still partial until fourth contact, which was due at 12:40PM.

These illustrations shown are based on the sketches made using both the 'pinhole' camera, and the eclipse viewers.



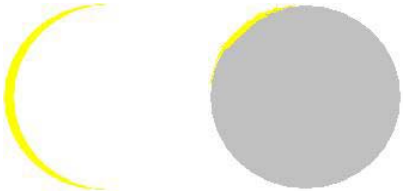
930 AM: 31 Minutes before first contact.

10:07 AM: 6 minutes after first contact

10:11 AM: 10% of sun obscured

10:29 AM: Eclipse 40% complete

11:07 AM: approx. 85% of sun obscured



11:11 AM: Totality in Cornwall

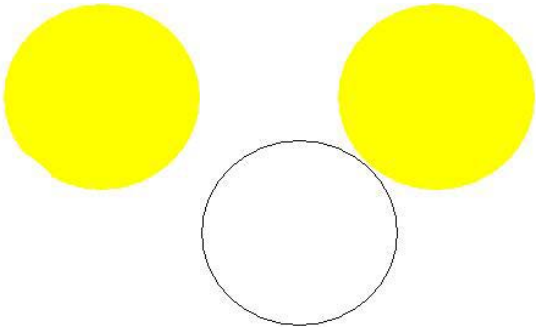
11:18 Maximum obscuration of 99.7%

11:28 AM: Light level returning rapidly to normal; moon's shadow no longer visible.

11:38 AM: Eclipse still partial

11:43 AM: Sun still 70% Obscured

12:16 AM: Over 80% of sun now visible



12:35 PM: 3 Minutes before fourth contact

12:40 PM: Fourth contact.

When will the next total eclipse be visible?

The next total eclipse to be visible in the British Isles will occur on September 3rd, 2081. This will occur in the early morning. On the shorter timescale, there are 3 solar eclipses due in the next 30 years, which are worth a mention. The first will be on May 31st, 2003 when parts of Northern Scotland will experience an annular eclipse, which in the remainder of Britain will be partial. The sky will again darken on 20th March 2015. This total eclipse will pass between Scotland & Iceland, reaching the North Pole. The maximum magnitude of this eclipse will vary from 85% in South-eastern England, to 90% in the far Northwest of Scotland. Finally, on August 12th 2026, the track of a total eclipse will pass to the west of the Irish Republic just before sunset.

To put this into a historical perspective, this particular eclipse is the 21st in a total of 77, in a series known to astronomers as Saros series 145. This lasts a total of almost 1400 years, beginning on 4th January 1639 with a partial eclipse in the northern Polar Regions, and will end on 25th June 2522 with a final partial eclipse in the southern Polar Regions. The series is improving at present, producing longer periods of totality as the track of the eclipses nears the equator. In total, Saros 145 consists of 34 partial eclipses, 41 total eclipses, 1 annular and one annular/total eclipse.
In the long term, a Saros series is composed of many Saros cycles. Each series is composed of between 69 & 86 eclipses and, on average, lasts 1400 years. Each series starts with partial eclipses at one polar region, builds up to annular or total eclipses at the equator, and terminates with partial eclipses at the opposite polar region. There are a total of 42 Saros series in progress at a given time!

Plate 1; Scene to south before first contact.

Plate 2; this is how the light level was reduced with 90% of the sun's photosphere obscured.

Plate 3 shows just how dark it was shortly before totality.

Plate 4: The umbral shadow can be seen retreating away over the southern horizon on it's way to France.

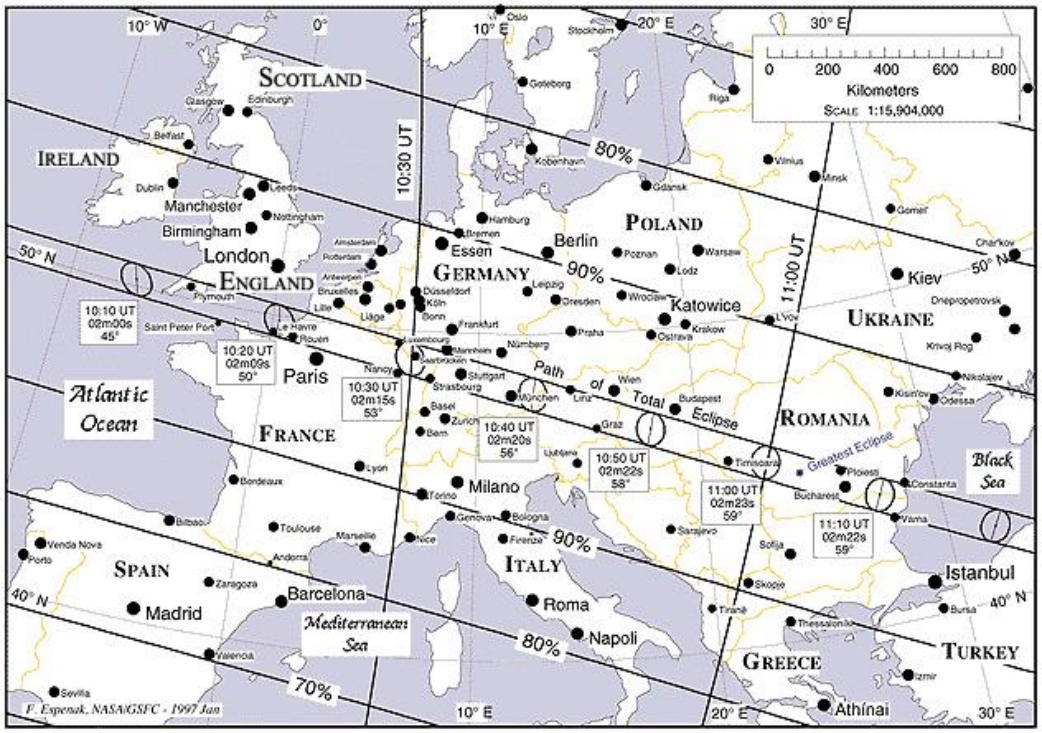


Plate 5: Circumstances of the eclipse across Europe (Courtesy of NASA)

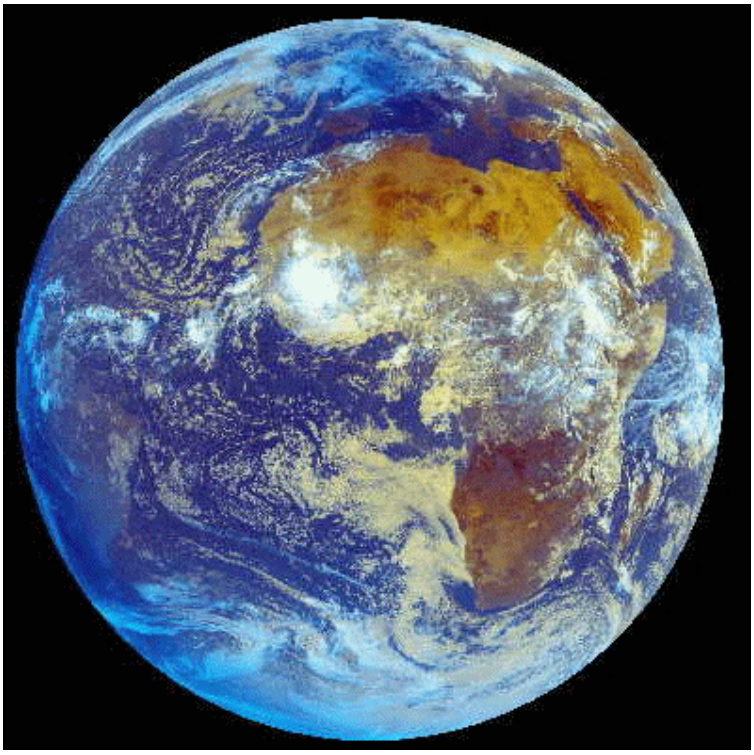


Plate 6: Totality in England (From Metosat)

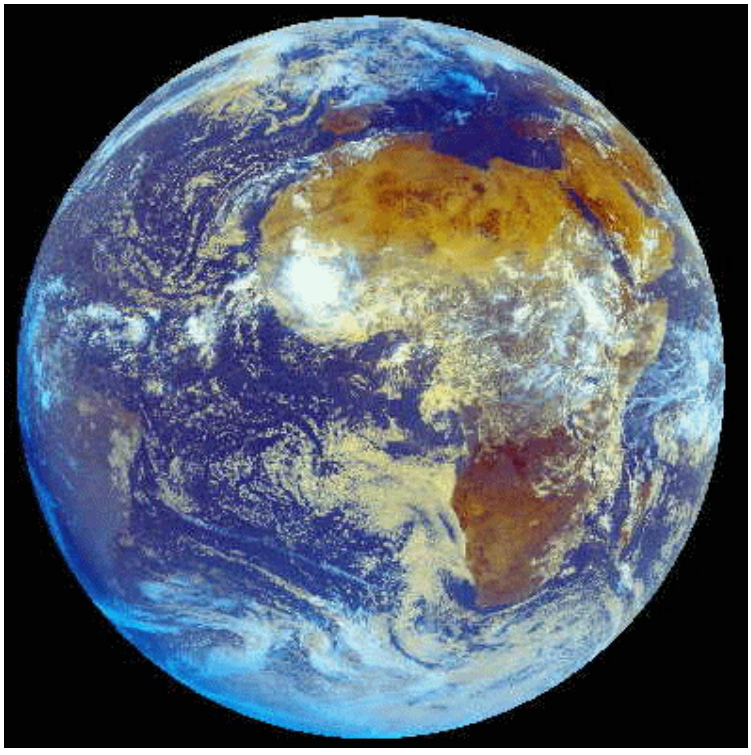


Plate 7: Totality in Hungary (Metosat)

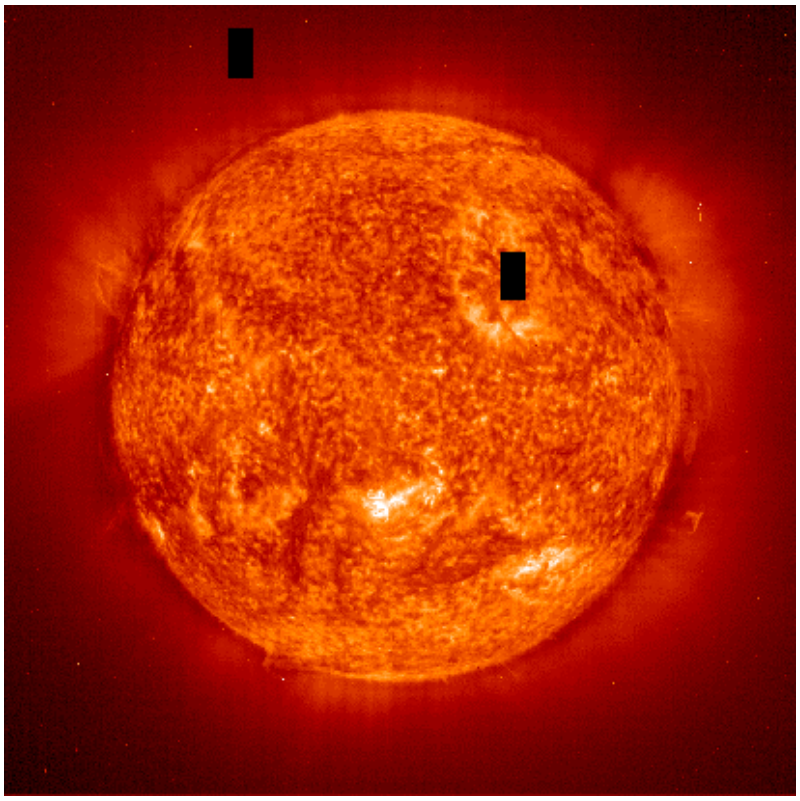
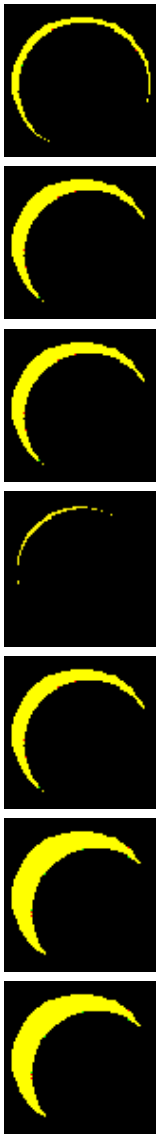


Plate 8: Soho's view of the sun at 10:12 AM UT (NASA)

Views of the Partial Eclipse of the Sun as seen from some major UK cities.

Although not as spectacular as a total eclipse, a partial eclipse was visible over the remainder of the United Kingdom. This is the maximum obscuration of the sun as seen from some major UK cities:

Birmingham	**95%**
Leeds	**91%**
Liverpool	**91%**
London	**97%**
Manchester	**91%**
Newcastle	**85%**
Glasgow	**83%**



Some pictures taken from Cornwall

These pictures were taken by people lucky enough to get a glimpse through the cloud:

80% Obscuration

96% Obscuration

Many pictures were taken from locations in mainland Europe also.