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# Notes for the Observer

## Total solar eclipses of 1994 and 1995

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### 1. Introduction

Fortunate is the person who has had the opportunity to view a total solar eclipse. It is seen when the Moon comes in between the Sun and Earth and casts a shadow on the long narrow path on the surface of the Earth on a new Moon day. Before the totality begins, one sees flashes of bright pinpoints of light, photospheric light passes through the deep valleys at the rim of the Moon. The points of light are called Baily's beads, after the astronomer Francis Baily. With the further movement of the Moon, the Baily's beads disappear and the brilliant red chromosphere comes into view, coloured by the dominant emission of Hα. Finally the chromosphere too is eclipsed, and out of the darkness appears the pale white corona extending far beyond the limb of the Sun—a sight that brings a gasp from most seasoned observers. The duration of totality depends on the exact distance of the Moon from the Earth at the time of eclipse, and on the position of the observer within the path that the Moon's shadow traces along the Earth. On an average, 66 total solar eclipses occur in a century, with the longest period of totality being about seven and half minutes. Inspite of the fact that many of these tracks over sea or inaccessible places on over areas with little human habitation, a large number of total solar eclipses have been observed for a few centuries. A total solar eclipse, a dramatic celestial occurrence still arouses a great interest not only among the general public but also in astronomers. To make observations during the few moments of totality and have glimpse of the exciting and unforgettable celestial happening, the solar physicists and amateur astronomers travel with heavy equipment, thousands of kilometers.

The reason, for so much interest and making elaborate preparations to observe is that total solar eclipses have hitherto been the only occasion when studies of the Sun's chromosphere and corona could be made in great detail. With the bright light of the Sun's visible disc completely cut off, we can examine the characteristics of the faint distended outer atmosphere of the Sun. The relative brightness of the solar disc, solar corona and sky brightness can be seen in figure 1. The figure shows that under the best possible conditions at high altitudes the sky brightness is about $10^{-6}$ of the value of brightness on the centre of the solar disc and the coronal intensity close to the limb is marginally higher than that of sky. On the other

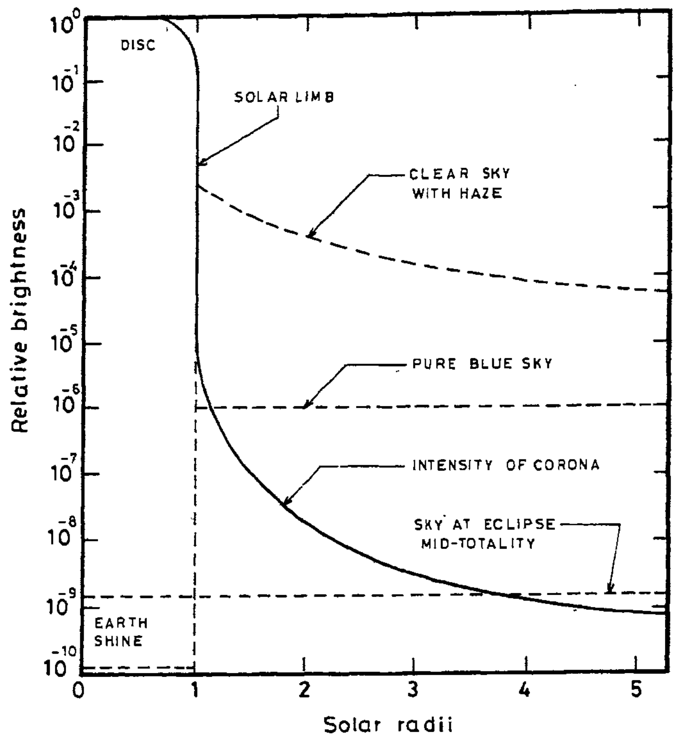


**Figure 1.** Relative sky brightness as a function of distance from the centre of the Sun. The relative intensity of the solar corona has also been shown.

hand, when the Moon blocks out the photospheric light, the sky brightness near the limb at mid-totality falls to such low levels that coronal intensities, a billionth in brightness of the solar disc, can be photographed out to almost four solar radii.

The last total solar eclipse seen from the Indian soil was on February 16, 1980. The weather conditions were excellent along the path of totality and number of experiments were conducted successfully to understand the dynamics and physical characteristics of the solar corona, effects of total solar eclipse on the Earth's atmosphere and changes in behaviour of animals and birds during the eclipse phase. Two camps, one at Jawalgera and other at Hosur, were set up by the scientists of Indian Institute of Astrophysics, Bangalore and conducted ten experiments. The high resolution multislit spectra in Fe X 6374 Å emission line, obtained to determine the temperature and velocity structure yielded the most important results. The ratios of line and continuum intensities with radial distance indicate that the mode of excitation of Fe X ions is more or less collisional for $R/R_\odot < 1.2$. Collisional as well as radiative excitation is equally important for $1.2 < R/R_\odot < 1.4$, and beyond $R/R_\odot = 1.4$ radiative excitation becomes more dominant (Singh 1985). The measurement of line widths showed the existence of turbulent velocities of the order of 30 km $s^{-1}$ in the corona at the time of the eclipse of 1980. The values of line-of-sight velocities at various locations in the corona indicate that there are no large scale systematic mass motions in the corona and corona corotates with the photospheric layers deeper down. On the other hand Raju *et al.* (1993) interpret their 1980 data in terms of large scale mass motions in the corona. Further, the computed ratios of line flux to the square of continuum flux at a coronal temperature of $1.6 \times 10^6$ K show a good fit with the observed values for Fe X line (Raju & Singh 1987). Also see Proceedings of Indian National Science Academy, Supplement volume 48A (1982) for results of 1980 eclipse observations made by various national and international teams.

The invention of the coronograph has made it possible to study the chromosphere and the inner corona in a 'pure blue sky', the kind one can have at mountain location at altitudes of 3,000 meters or greater. A number of telescopes in space observing the outer corona in visible light and inner corona in ultra-violet radiations and the 1930 invention of the solar coronograph notwithstanding, a total solar eclipse still remains the best and less expensive means of studying the solar corona. The information about the finer details of the solar corona and especially of the middle and outer corona can be obtained only during the total solar eclipses, by making observations with large spectral and spatial resolution which are limited in space telescopes. In spite of the fact that a large body of data is available from a number of previous solar eclipses, the physical and dynamical processes in the solar corona are not fully understood yet. Still there are controversies about the temperature structure, turbulence, large scale systematic mass motions, locations of temperature maximum and intensity oscillations in the solar corona. Since the corona changes in shape, size and activity with the solar activity, the study of solar corona at different phases is required to understand the dynamics of the solar corona. Also the definite answer to the above mentioned parameters will help in understanding the heating and realistic modelling of coronal structures and the factors that contribute to the solar wind-flow. Finally, the advantage of the total eclipse lies in providing a minimum of scattered light background and Fraunhofer-line contamination, factors that normally restrict the coronograph in providing similar information with the aid of an artificial eclipse.

### 1.1. *Experiments*

To find the answers to the above mentioned open questions, some of the experiments which interest the professional astronomers are (i) high resolution multislit spectroscopy in two or more lines simultaneously (ii) narrow band photometry of solar corona in several emission lines using high efficiency and dynamic range CCD detectors, (iii) photometry of solar corona in IR and far infra-red wavelengths, (iv) photometry of solar corona with very high temporal resolution of the order of 50-100 milli-seconds to detect the short period intensity oscillations, (v) temperature and velocity structure of the solar corona using Fabry-Perot etolon, (vi) search for cooler packets of plasma in the hot ambient solar corona, (vii) study of temperature and density structure coronal loops and (viii) monitoring of the accurate timings of various phases of the eclipse and accurate location of the site of observation to detect the changes in solar diameter, if any. The other experiments generally performed during the total solar eclipses are (i) white light or broad band photography of the partial phase and the corona during the total phase, (ii) measurement of polarisation of the corona, (iii) study of chromospheric or Flash spectrum, (iv) studies of radio emissions in the centimeter or millimeter range, (v) ionosphere drifts and irregularities during the total eclipse, and (vi) study of animals and birds behaviour during the eclipse. A group of amateur astronomers can plan a very useful experiment to study the changes in the coronal structures by photographing the solar corona from number of places from west to east lying along the path of totality.

By making observations this way one will be able to record the coronal structures continuously for much longer duration than the duration of totality at a given place.

The solar physicists and eclipse chasers have already finalised their plans and started preparations to observe the total solar eclipse of 1994 November 3, with longest duration in the remaining period of this 20th century. Here we shall discuss the various locations and prospects of watching this eclipse and the total solar eclipse of 1995 October 24, whose path of totality crosses over northern India.

## 2. Total solar eclipse of 1994 November 3

This event will take place in South America where the Moon's shadow touches Peru, northern Chile, Bolivia, Paraguay, Argentina and Brazil as shown in figure 2. The path of the umbral shadow begins in the Pacific ocean about 1500 kilometers west of South American continent at sunrise. The shadow's first contact with Earth occurs at 12:02 UT where the path will be 135 km wide and total phase lasts 112 seconds. Travelling southeast, the umbra touches land at the southern coast of Peru where the totality lasts little less than three minutes, with an altitude of the Sun about 30 degree in the morning sky. Near Arica in Chile, the centre of the path passes about 10 km north east of the village of Putre at an altitude of nearly 4000 meters. Further, the shadow crosses the Peru-chile border and Sun gains in altitude rapidly

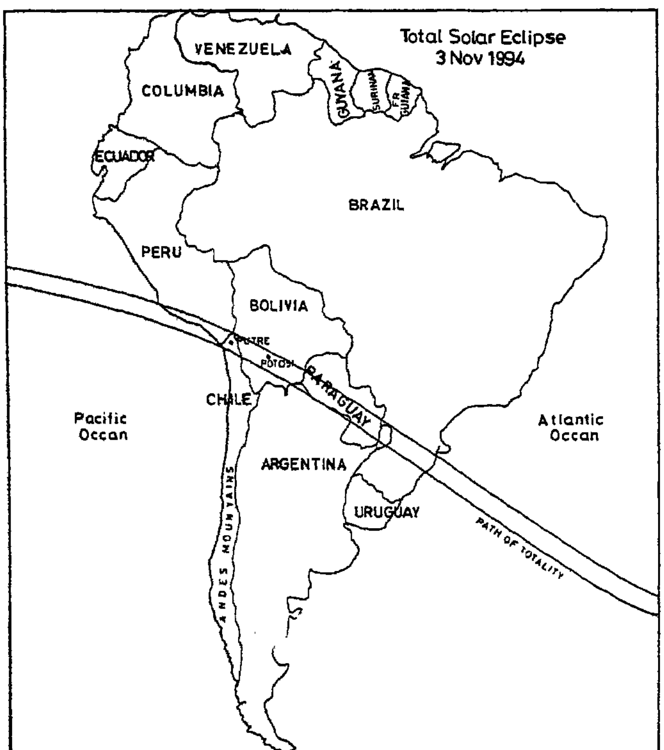


**Figure 2.** Path of totality in South America during the eclipse of 1994 November 3. Putre in Chile and Potosi in Bolivia offer excellent chances of clear sky on the eclipse day.

as it sweeps into the western Andes before entering southern Bolivia. Much of the path in this region lies above 3000 meters elevation and has relatively dry weather. The Bolivian altiplano is at an altitude of about 4200 meters and acclimatization to this altitude needs to be done. Therefore, one must arrive a few days earlier than the date of eclipse to adjust to the thin air. Leaving Bolivia and the Andes, the Moon's shadow moves onto the dry scrub forests of the Gran Chaco, an extension of the foothill plains of Argentina into western Paraguay at 12:30 UT. The duration of the total phase at the central line is 3 minutes 19 seconds as the Sun stands 41° above the horizon. After briefly crossing a small portion of land in north-eastern Argentina, the umbra enters southern Brazil at 12:38 UT. The total phase will last for about 4 minutes at the central line. Then the shadow reaches the western shore of Atlantic Ocean and travels out to sea. The remainder of the path is over open ocean with no further landfall. The greatest phase of the eclipse occurs at 13:39 UT when the duration of totality will last for 4 minutes and 23 seconds and Sun stands 69° above the ocean waves. The total phase ends in the Indian Ocean 800 kms south of Madagascar at 15:16 UT as the umbra leaves surface of the Earth at sunset. The maximum duration of the totality available at the land will be about 4 minutes in Brazil. Arequipa, Mollendo and Guerreros Estacion in Peru; Putre in northern Chile; Sevaruyo and Potosi in Bolivia; Filadelfia in Paraguay; and Iguacu falls and Criciuma in Brazil are some of the places close to the central line from where the eclipse can be observed. The frequency of clear skies along the eclipse path as a function of longitude plotted in figure 3 indicates that chances of clear weather at Putre in Chile, Altiplano and Potosi in Bolivia are more as compared to other places. Details about the circumstances of this eclipse can be seen from NASA reference publication No. 1318 on Total Solar Eclipse of November 3, 1994 by Fred Espenak and Jay Anderson.

### 2.1. *Experiments planned*

We, at Indian Institute of Astrophysics, Bangalore, are planning an expedition to Putre, Chile to conduct three experiments during the total phase.

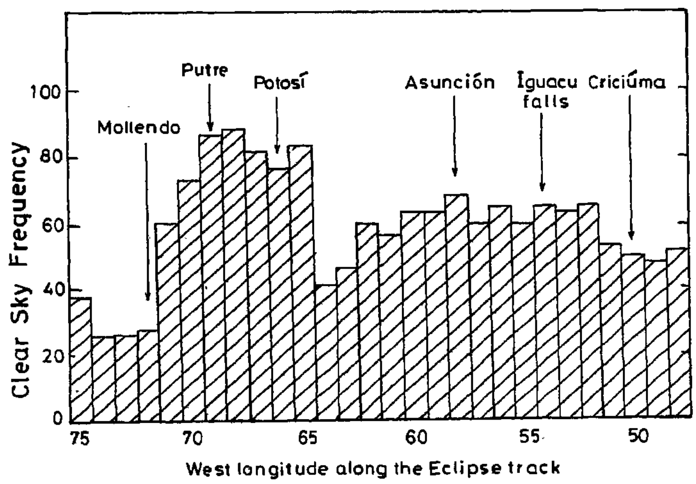


**Figure 3.** Frequency of clear skies along the totality path. Important places close to the totality track have also been marked.

### 2.1.1. HIGH RESOLUTION MULTI-SLIT SPECTROSCOPY OF SOLAR CORONA IN TWO EMISSION LINES SIMULTANEOUSLY

In this experiment spectra will be obtained in Fe X (6374 Å) and Fe XI (7892 Å) coronal emission lines along with the Neon spectra for comparison of wavelengths. The use of image intensifiers will enhance the intensity of coronal radiations and Kodak 2415 film will be used to record the final spectra. The ionization temperature for Fe X ion is ~ $1.1 \times 10^6$ K and about $1.2 \times 10^6$ K for Fe XI ion. Due to similarity in values of ionization temperatures it is possible to assume that observed emission in these two lines comes from the same coronal region. Therefore, the ratio of line intensities gives the temperature at a given location in the corona and the excess in observed line width over the thermal width gives the strength of turbulence at that location. Correlation of temperature and turbulence with position on the corona, comparison of these quantities in 'open' and 'closed' coronal structures will tell us the role of turbulence in heating of these coronal structures.

### 2.1.2. NARROW BAND PHOTOMETRY IN EMISSION LINES

Two experiments, one with low spatial resolution to cover larger portion of the solar corona and the other with high spatial resolution of study, the details of coronal structures will be performed. The coronal emission lines selected for the narrow band photometry are : 6374 Å (Fe X), 7892 Å (Fe XI), 5303 Å (Fe XIV), 6702 Å (Ni XV) and 5694 Å (Ca XV). The coronal ions corresponding to these lines are dominant emitters at temperatures of 1.0, 1.2, 2.0, 2.0 and 4.0 million degree Kelvin respectively. Narrow band interference filters of central pass band at H-alpha and above mentioned wavelengths and each of 5A band width will be used to isolate the radiations around these emission lines. The coronal pictures will be recorded using peltier cooled CCD camera.

Since the emission lines considered cover a wide temperature range, the various line intensity ratios would enable us to determine temperatures, electron densities and relative abundances of elements within coronal structures. Estimate of electron densities and temperatures are essential for understanding the energy balance of the coronal plasma. H-alpha pictures will help in detecting cool regions within the ambient hot corona. Also, the emission line intensities for coronal plasma away from coronal structures would enable one to determine spatial variation of temperature in the ambient corona and locate the temperature maximum within it.

## 3. Total solar eclipse of 1995 October 24

The total solar eclipse of October 24, 1995 is of special interest because it will be visible from the parts of northern India. The shortest total solar eclipse of this decade begins over Iran with sunrise and then the shadow of Moon crosses over to Afganistan where the position of the Sun will be only about 12° above the horizon in the morning sky. Travelling south-east, the umbra quickly reaches Afghanistan-Pakistan border near Chaman at about 8:27 IST. Duration of totality will be about 39 seconds and the width of totality being 40 km path. Leaving Pakistan and maintaining its high speed of travel the umbra enters Rajasthan, India at 8:30 IST. Figure 4 shows the path of totality in India and the places close to it.

A number of villages e.g. Phulsar, Anandgarh, Chhattargarh, Mana, close to Indo-Pak border lie near the central line of totality path. But Lunkarnsar in Bikaner district is the first

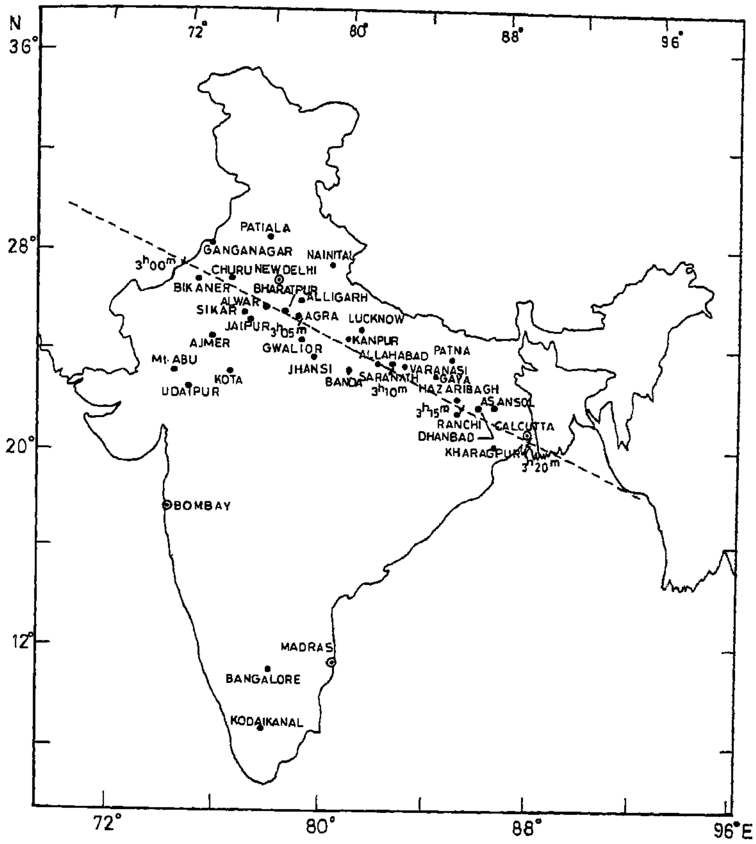


**Figure 4.** Dotted line indicates the totality path in India during the total solar eclipse of October 24, 1995. Important places close to path of totality and timings of beginning of the total solar eclipse at different places have also been shown.

town in India very close to the central line which can be approached easily by road and Rail-line. Here the shadow of Moon will reach at about 8:31 IST and will last for about 50 seconds. The width of shadow band will be 42 km. Then the central line passes very close to Patamdesar, Bhadasar, Malasar and a few other villages. A big town Ratangarh falls in the shadow band but its location is about 10 kms south of the central line. The shadow after crossing Makundgarh village reaches Nim Ka Thana located at 27.26° N; 75-78° E. Here, the total phase of the eclipse will last for about 53 seconds with Sun at an altitude of about 23° above the horizon and the width of totality track being 45 km. Nim Ka Thana lies on the central line of totality path and is a good town with a population of about forty thousand. A college and a school can provide a good logistic support to the observers and ground for setting up experiments. The available grounds will provide an excellent view of the eclipse. A far away small hill obstructs the view of the sky upto an altitude of 2-3 degree above the horizon. Nim Ka Thana is about 200 km from Delhi and 100 km from Jaipur and can be reached by road and rail from these places. The next place Pragpura which falls on the totality path, lies on the Delhi-Jaipur national highway and is about 90 km from Jaipur. Then the shadow of Moon reaches Alwar and Bharatpur at about 8:34 and 8:35 IST respectively. Both of these places are easily accessible from Delhi and each is about 15 km from the central line in the north and south respectively and only 7-10 km from the edges of totality path towards the central line.

At about 8:35 IST the Moon's shadow enters Uttar Pradesh and reaches Kalpi and Hamirpur at about 8:37 IST. Duration of totality will be about 63 seconds and the width of totality path will increase to about 50 km at these places. A religious and historically important place Allahabad also lies in totality path but very close to the northern limit. Therefore, total phase of the eclipse will last for very insignificant duration at Allahabad. Two easily accessible places Daltenganj and Patratu in Bihar will be able to provide good opportunity to the eclipse chasers in that area. Hazaribag and Ranchi, two cities with large population in Bihar are just outside the northern and southern limits of the totality path respectively. Therefore, people of these places have to travel a few tens of kms to watch this spectacular and awesome event of nature. The best place for them appears to be Ramgarh, a town on the Hazaribag-Ranchi highway. About 20 seconds after 8:45 IST the Moon's shadow leaves Bihar and enters West Bengal. Some of the places which fall in the path of totality in West Bengal are Puruliya, Ambikanagar, Ghatal, Tamluk, Diamond Harbour etc. Kharagpur, Alipur and Dum Dum lie just outside the shadow track. The duration and width of the totality path goes on increasing slowly from Rajasthan to West Bengal attaining maximum values of 82 seconds and 55 km respectively. Diamond Harbour and area around it will have maximum duration of about 80 seconds.

The Moon's shadow crosses India-Bangladesh border at 8.50 IST. The total solar eclipse will be visible only in 4-5 small islands in the south-west tip of Bangladesh. Then the shadow quickly moves on to the waters of Bay-of-Bengal. The people in the parts of Myanmar, Thailand, Combodia, Vietnam and Sarawak in Malaysia will also be able to see this great event, weather permitting. Finally, the path of the eclipse ends in North Pacific ocean with the setting of the Sun. Elaborate details about the totality track in India have been given because the meteorological data collected over the past years indicate that weather will be favourable in India and especially in northern India.

### 3.1. *Weather conditions along the eclipse path in India*

The mean cloud cover in October dips to less than 10 per cent over the great Indian Desert in Rajasthan, west of Delhi, as a result of a huge high pressure system sitting atop the Himalayas. October in India is a month of transition, when the cloudy and wet southeast monsoon is giving way to sunny and dry northwesterlies. In the following we discuss the various climatological parameters along the eclipse track in India based on the meteorological data of 1876-1900 and 1931-60. The use of back-dated data will not affect the conclusions as the general pattern of weather over the years has not changed much. The mean cloud cover, mean maximum and minimum temperature, mean relative humidity and other climatic parameters in the October month have been shown by the contour based on the data for the period 1876-1900 against the map of India. The mean values of various climatic parameters for the period 1931-60 for different longitudes were computed from the meteorological data available for the cities and towns close to the totality path. These values have been plotted in the form of histograms as a function of longitude along the eclipse track.

3.1.1. CLOUDINESS

For an eclipse observer the most important parameter to know is the mean daily cloud cover and mean number of clear days available during the month of eclipse and expected sky conditions at the time of eclipse along the totality path. Figures 5 and 6 show the mean cloud cover in Oktas (including all kinds of clouds) for October month at 8 AM and 4 PM

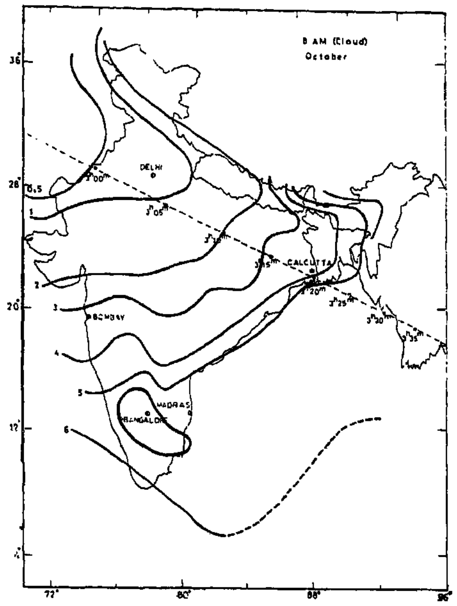


**Figure 5.** Mean cloud cover in Oktas (including all kinds of clouds) at 8 AM in October based on the data of 25 years period of 1876-1900 is shown by contours against the map of India. The straight dotted line indicates the path of totality with marking of time in UT of the beginning of total phase.

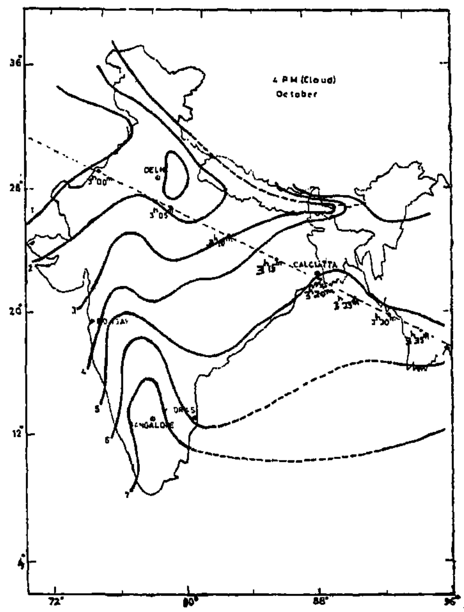


**Figure 6.** Same as that of figure 5 except for 4 PM instead of 8 AM.

respectively based on the data of 25 years period of 1876-1900. Contours indicating mean number of cloudy days in the month of October are shown in figure 7 for the period of 1876-1900. The mean cloud cover, by considering the low clouds and all kinds of clouds, is shown in figures 8 and 9 respectively with respect to longitude along the eclipse track for the period 1931-60. Figure 10 indicates the mean number of clear days available in October month at 8.30 and 17:30 IST by considering low clouds only for the period 1931-60 while figure 11 shows the same by considering all kinds of clouds. Eclipse observers will also be interested to know the general pattern of clouds in November month, since this event occurs on October 24 i.e. in later half of the month. We have, therefore, shown the mean number of clear days available at 8:30 and 17:30 IST in November in figures 12 and 13 considering low and all kinds of clouds respectively.

All these figures indicate that cloud cover goes on increasing as one moves from west to east along the totality path in India.

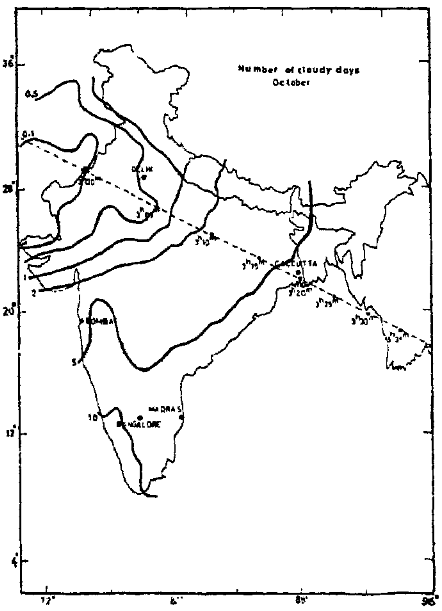


**Figure 7.** Mean no. of cloudy days in October for the period 1876-1900 are shown by contours against the map of India. The Straight dotted line indicates the totality path with marking of time in UT of the beginning of the total phase.

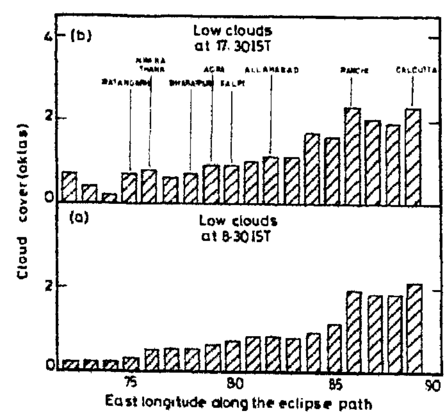


**Figure 8.** Cloud cover (low clouds only) as a function of longitude along the path of totality in India. Some important places along the totality track have been marked.

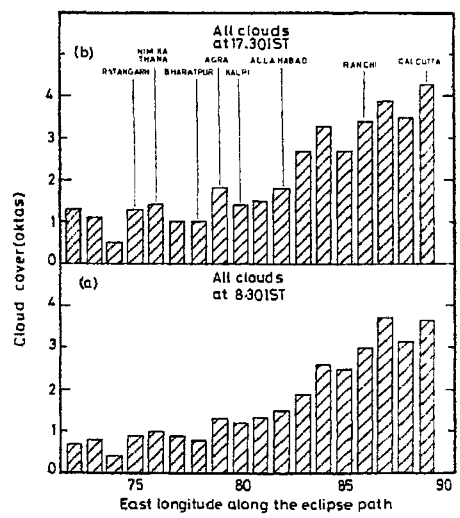


**Figure 9.** Same as that of figure 8 but for all kinds of clouds.

### 3.1.2. RAINFALL

The normal rainfall in inches in various parts of India in October month based on the data for the period 1876-1900 is shown by contours in figure 14. The Paths of deep depressions

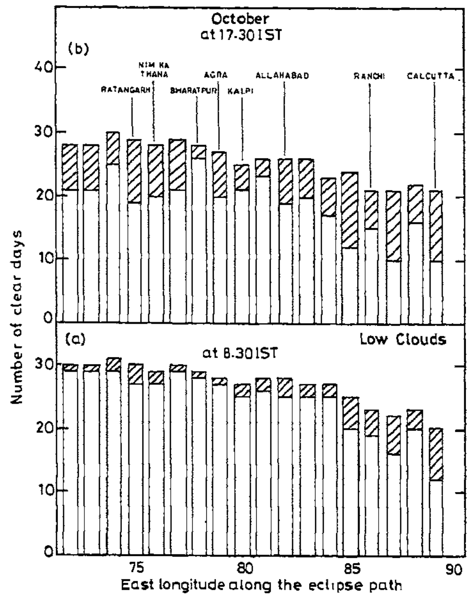


**Figure 10.** In panel (a) the lower unshaded part of the histogram shows the mean number of clear days with zero cloud, considering low clouds only, at 8:30 IST in October month based on the data for the year 1931-60 as a function of longitude along the eclipse path in India. In addition the shaded portions of the histogram indicate the average number of days with low clouds between 1-2 Oktas. The caption for panel (b) is the same as that for panel (a) except for data recorded at 17:30 IST. A few important places located in or very close to the totality path have also been marked.

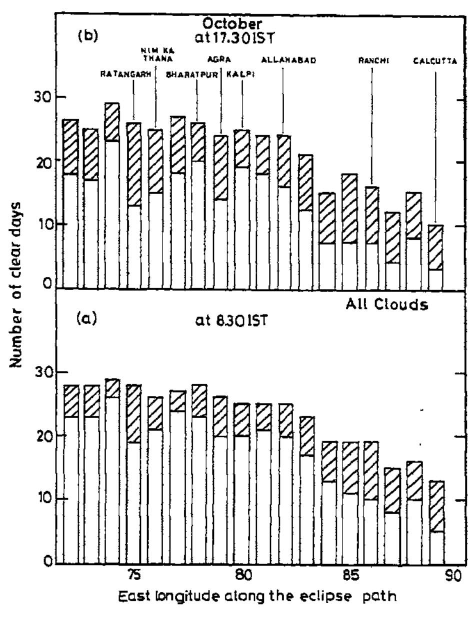


**Figure 11.** Same as that of figure 10 except that it is arrived at by considering all kinds of clouds instead of low clouds only.

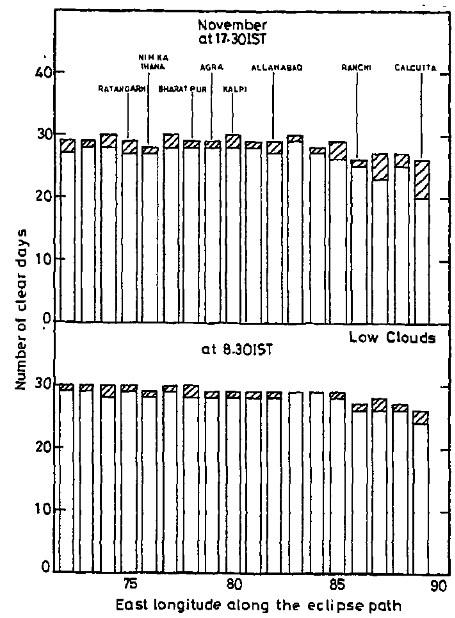


**Figure 12.** Same as that of figure 10 barring November month.

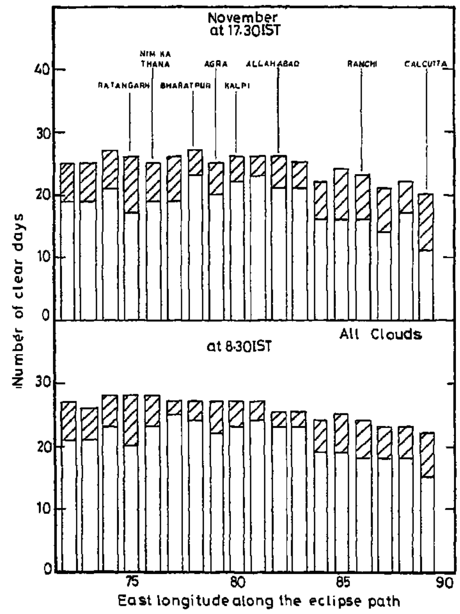


**Figure 13.** Same as that of figure 12 but by considering all kinds of clouds.

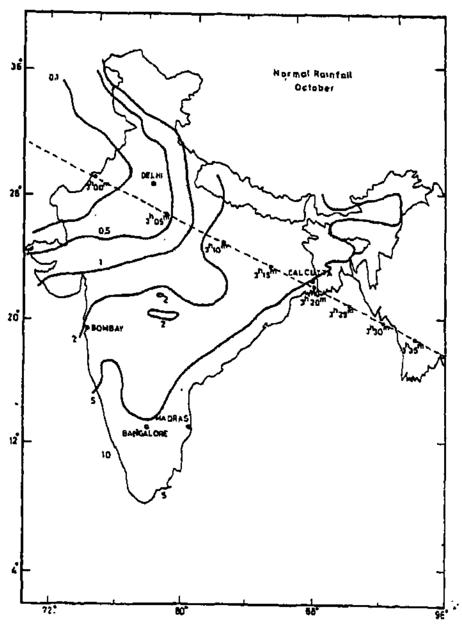


**Figure 14.** Contours show the normal rainfall in inches in India in October for the period of 1876-1900. The contour in the region of west Rajasthan indicates a rainfall of about 0.1 inch and about 5 inches of rainfall near Calcutta is indicated by another contour.

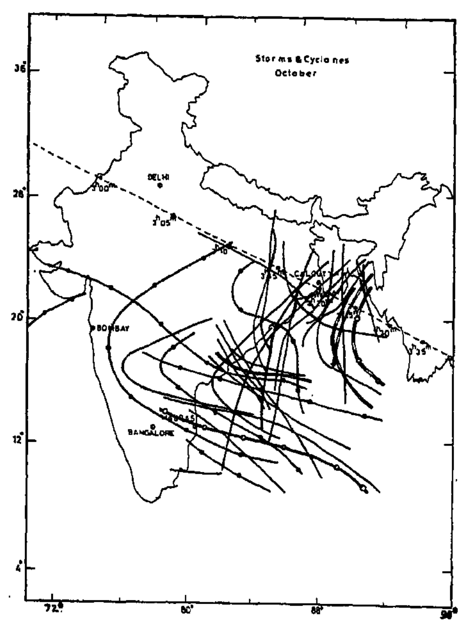


**Figure 15.** The paths of deep depressions and cyclones which occurred during the October months in 25 years period of 1876-1900. The thicker lines indicate the cyclones.

and cyclones occurred during the October months in 25 years from 1876 to 1900 are plotted in figure 15 against the map of India. The histograms in panel (a) of figure 16 indicate the mean monthly rainfall in October along the path of totality for the period 1931-60 and mean number of rainy days in October in panel (b) of this figure.

From an examination of these figures one may say that rainfall goes on increasing from west to east along the eclipse track in India and depressions and cyclones generally do not affect the northern parts of India.

### 3.1.3. TEMPERATURE

The histograms of mean minimum and maximum temperature for October for the period 1931-60 are plotted in figure 17 against the longitudes along the totality path. The data indicate that the mean variation in day and night temperature during this month is about 16° C in Rajasthan, 13° C in Uttar Pradesh, 11°C in Bihar and about 10°C in West Bengal along the totality track. The mean maximum and minimum temperatures appear to be comfortable for the stay along the whole path of totality.

### 3.1.4. RELATIVE HUMIDITY

Figures 18 and 19 show the contours of mean percentage relative humidity for October month for the period of 1876-1900 at 8.00 AM and 4.00 PM respectively. The values of

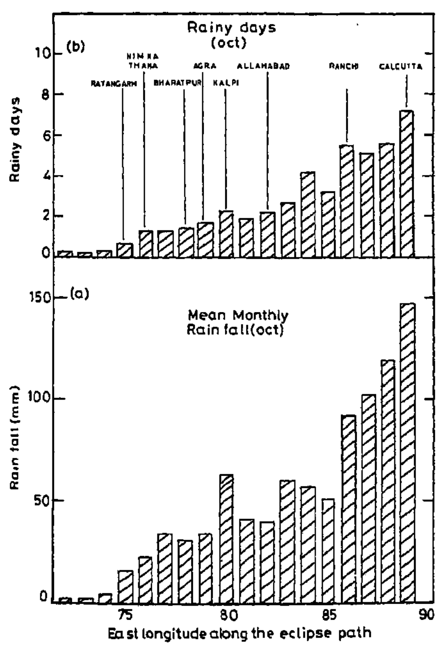


**Figure 16.** Panel (a) shows the mean monthly rainfall in mm in October based on the data for the years 1931-60 against the longitude along the path of totality in India. Mean Number of rainy days in October are shown in Panel (b).

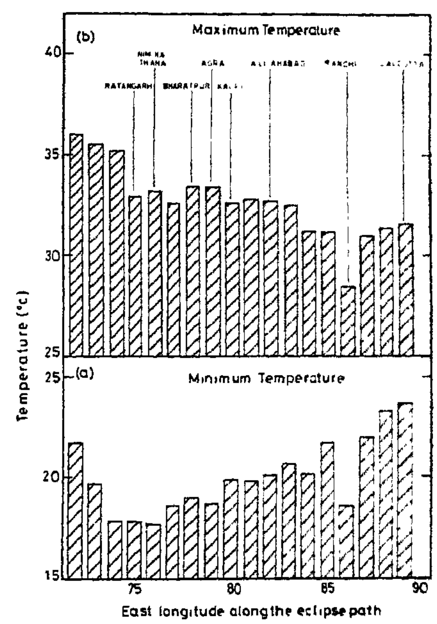


**Figure 17.** Mean maximum and minimum temperatures in October as a function of longitude along the path of totality in India.

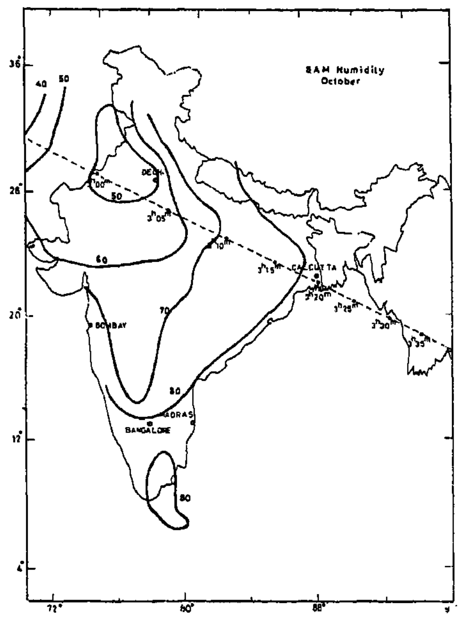


Figure 18. Mean percentage Relative humidity in October in India at 8.00 AM for the period 1876-1900. The value of percentage humidity has been marked on each contour.

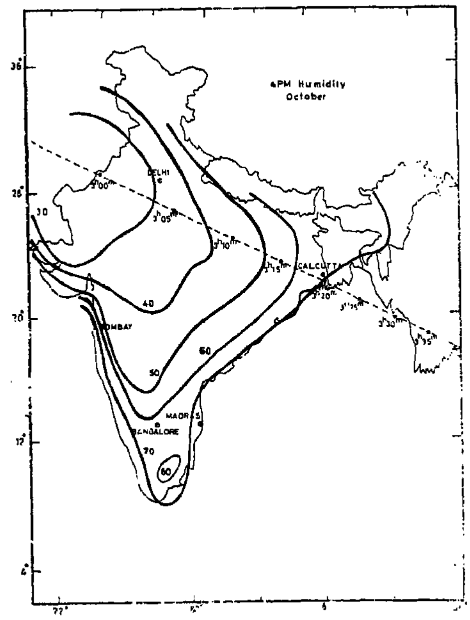


Figure 19. Same as that of Figure 18 but for 4 PM.

mean percentage relative humidity at 8:30 and 17:30 IST as a function of longitude along the eclipse track are shown in panels (A) and (b) of figure 20 respectively for the period 1931-60 and mean vapour pressure at 8:30 and 17:30 IST in figure 21. These figures indicate that percentage relative humidity increases from about 50 in Rajasthan to 80 in West Bengal.

### 3.1.5. WIND SPEED

The mean wind speed for October month for the period 1931-60 against the longitudes along the totality path in India is shown in figure 22. There does not appear to be any specific pattern in the wind speed in relation to the direction from west to east. The strong winds generally do not prevail along most of the totality track in India during this month. The mean wind speed ranges between around 2 and 9 km/h.

### 3.2. *Experiments*

Indian Institute of Astrophysics is planning to establish two camps-one at Nim Ka Thana in Rajasthan and the other near Kalpi or Hamirpur in Uttar Pradesh-to make observations during the total solar eclipse. Both of these sites lie vary close to the central line of totality path. We plan to conduct some more experiments in addition to the three experiments proposed for the 1994 eclipse. The new experiments will be to study the short period oscillations in the solar corona, temperature structure in the photosphere by taking high

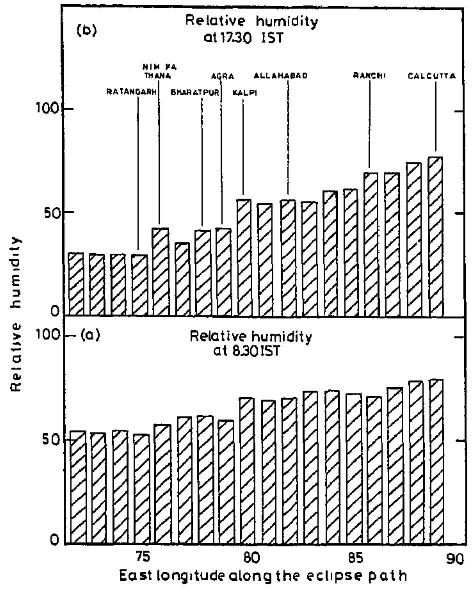


Figure 20. Histograms of percentage relative humidity in October for the period 1931-60 as a function of longitude along the path of totality in India.

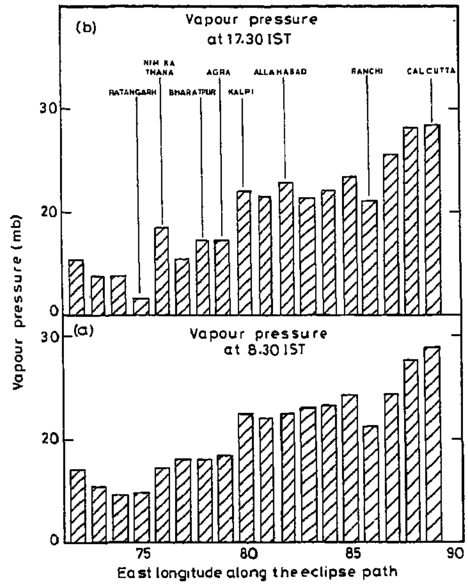


Figure 21. Mean vapour pressure in October for the period of 1931-60 with respect to longitudes along the totality track in India.

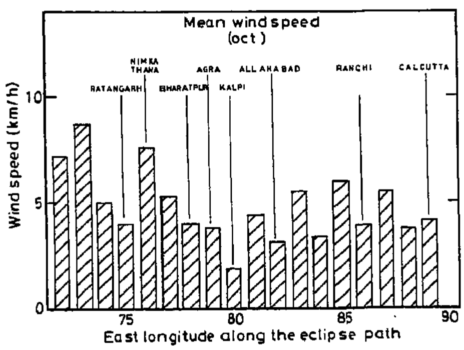


Figure 22. Mean wind speed in October for the period of 1931-60 against the longitudes along the totality track in India.

temporal and spectral resolution spectra of a temperature sensitive line at different locations near the solar limb, bi-dimensional temperature and velocity structure of the emission corona using Fabry-Perot etalon to obtain interference fringes, and a few others. Teams from PRL, Ahmedabad; Hopkins Observatory, USA; Johnson Space Centre, NASA USA; England; amateur astronomers from India and other countries have already started preparations to conduct experiments during this eclipse to find answers to many questions and understand in detail the physical processes and dynamics of the solar corona.

3.3. *Summary*

A look at the data indicates that chances of getting clear sky in Rajasthan and Uttar Pradesh are about 90 percent where the totality will last for less than a minute and the altitude of the Sun being about 22° above the horizon. Diamond Harbour in Calcutta, on the central line, has fair weather prospects with a mean cloud cover of about 40 percent. Here the duration of totality will be about 30 seconds longer than that in the region over the deserts of Rajasthan and altitude of the Sun will be 40° as compared to 20 degrees in Rajasthan at the time of eclipse.

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