Eclipse studies in Turkey

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Abstract. To observe the total solar eclipse, 7 candidate observing sites have inspected and five of them were choosen. These sites are: (1) Elazığ, (2) Sivas, (3) Diyarbakır, (4) Tokat and (5) Black Sea coast (Cide and Kurucaşile). Planned experiments of Istanbul University Observatory for the August 11, 1999 eclipse are outlined.

Key words: solar eclipse – site testing

1. Introduction

The last total solar eclipse of the millenium beginning in the North Atlantic and ending in the Bay of Bengal will occur on date of 11 August 1999. During the totality, shadow path of the Moon will sweep central Europe including southern England, France, Belgium, Luxemburg, Germany, Austria, Slovenia, Hungary, Yugoslavia, Romania, Bulgaria, and then Turkey, Syria, Iraq, Iran, Pakistan, India and Bay of Bangal. In this work, we present the best candidate observing sites in Turkey considering visibility, weather conditions. In addition, planned research projects for the eclipse are given.

2. Umbral path and visibility

The Moon's umbral shadow of the last total solar eclipse beginning at 09:30:57 UT of the 20th century arrives along the Black Sea coast of northwestern Turkey at about 11:20 UT and leaves Turkey's southestern border at about 11:45 UT. Kurucaşile (district of Bartın) and Cide (district of Kastamonu) which are located in northwestern parts of Turkey, first encounter with the eclipse and shadow departs from Cizre (district of Şırnak) to Iraq. The track diagonally bisects Turkey as it moves inland while the center line duration begins gradual but steady decrease, ranging from 2 minutes 20 seconds to 2 minutes 05 seconds. The total eclipse is witnessed by people living in the following major cities along the shadow path. These are Bartın, Kastamonu, Çorum, Amasya, Tokat, Sivas,

Elazığ, Tunceli, Diyarbakır, Batman, Siirt, Şırnak. Latitude and longitude of sites, elevation of the Sun and duration of totality are given in Table 3. The total length of the eclipse path over Turkey territory is about 950 km. It takes about 25 minutes. Some other major cities such as Istanbul, Ankara, and Izmir witnesses 0.950, 0.969, 0.841 magnitude partial eclipse respectively.

3. Weather prospects for the eclipse

The long term climatological statistics of the totality band of Turkey promise us a clear skies during the August month. However, when we compare the cities with each other along the path, we can see that starting from central Anatolia, the soutesthern regions of Turkey offer the best prostpects for the eclipse observation. Climatological statistics belonging to the August month along the eclipse path are listed in Table 1, 2, and 3 (Ökten et al., 1998). These Tables give meteorological informations such as mean cloud amount, mean humidity, mean rain fall, days with rain, preveil wind direction, mean wind speed, highest temperature, mean maximum temperature, mean minumum temperature, lowest temperature, mean temperature for 11:00 UT, days with the sun, days without the sun, mean sunshine, elevation of the sun, duration.

Table 1. Climatological statistics for August along the eclipse path of the total solar eclipse of 1999 August 11. M.C. stands for Mean Cloud.

Location (**City**) (Town)	Lat. (° ′)	Long. (° ′)	Period of record (years)	h (m)	M. C. 11 UT (%)	Mean hum. (%)	Mean rain (mm)	Days with rain
Bartın	41 38	32 21	24	30	28	54	95.2	5.6
Kastamonu	41 22	33 47	40	791	41	37	25.5	0.9
Çorum	40 33	34 57	41	798	35	32	10.4	2.9
Kargı	41 08	34 29	20	350	38	23	7.8	
Kargı	41 08	34 29	20	350	38	23	7.8	
Osmancık	40 58	34 48	17	410	27	27	11.9	3.0
Amasya	40 39	35 50	37	412	34	39	7.2	2
Merzifon	40 52	35 28	41	755	35	36	10.6	0.2
Tokat	40 18	36 34	61	608	34	41	8.6	0.2
Turhal	40 24	36 05	24	493	29	34	5.3	
Sivas	39 45	37 01	41	1285	26	29	4.9	0.1
Divriği	39 22	38 07	24	1250	31	35	1.7	0.1
Elazığ	38 41	39 14	41	1105	14	21	1.4	0.0
Diyarbakır	37 54	40 14	41	660	14	17	0.6	0.3
Diyarbakır	37 54	40 14	41	660	14	17	0.6	0.3
Batman	37 53	41 07	11	540	13	18	0.4	0.3
Şırnak	37 31	42 28	17	1380	7	12	1.4	0.2
Cizre	37 19	42 11	31	400	5	13	0.0	0.0

Table 2. Climatological statistics for August along the eclipse path of the total solar eclipse of 1999, August 11. M.W. stands for Mean Wind.

Loc. (**City**) (Town)	M. W. speed (m/sec)	Mean T_{max}	Mean T_{min} (C)	Mean T (C) 11 00 UT	Days with sun	Days without sun	Mean Sunshine (hrs/days)
Bartın	1.9	27.6	15.0	26.6	12.4	3.4	9.50
Kastamonu	2.3	27.9	11.7	26.5	13.3	2.4	10.30
Çorum	3.7	29.3	12.6	27.9	14.9	0.6	
Kargı		31.7	18.2	30.2	13.9	1.6	
Osmancık	2.0	31.2	16.0	29.9	13.6	1.5	
Amasya		31.2	16.4	30.4	15.0	0.7	
Merzifon	4.7	28.4	14.4	27.3	14.0	1.0	10.30
Tokat	3.2	28.7	15.1	27.6	13.2	2.3	9.36
Tokat	3.2	28.7	15.1	27.6	13.2	2.3	9.36
Turhal		30.7	13.7	29.7	14.4	2.0	
Sivas	4.0	28.0	10.5	26.8	20.4	0.4	11.40
Divriği	3.2	31.0	15.0	23.4	18.3	0.0	
Elazığ	2.8	33.7	19.6	32.2	25.2	0.0	12.06
Diyarbakır	3.8	38.2	20.9	37.0	25.1	0.1	12.07
Batman		38.9	18.5	38.1	26.2	0.0	
Şırnak	2.6	32.2	22.7	31.6	28.8		
Cizre	1.4	41.1	22.1	40.3	28.2	0.0	12.3

4. General information about observing cities

BARTIN (41° 38′ N, 32° 21′ E): Bartın is a newly established city and its beautiful surroundings embrace 59 km of the Black Sea Coast. The main river is the Bartın River, mentioned in Homer's Illiad, and known as Parthenious in ancient times. The river has given its name to the city. Ankara-Bartın is 368 km. Istanbul-Bartın is 414 km.

KASTAMONU (41° 22′ N, 33° 47′ E): Kastamonu is a West Black Sea city. It is a holiday resort presenting various alternatives with its panoramic mountains, evergreen forest, emerald shores and rich cultural wealth. Kastamonu region, which is an ancient settlement area, had been the country of Kashkas in the 18th century B.C. and then it had been ruled by Hittites, Phrygians, Cimmerians, Lydians, Persians, Pontus, Roman and Byzantine Empires. Kastamonu is one of the rare cities where a large number of traditional Turkish houses and samples of Ottoman architecture are found.

AMASYA (40° 39′ N, 35° 50′ E): Amasya, capital city of its province, lies in the Yeşilırmak Valley in the central Black Sea region of Anatolia. For thousands of years, from the Bronze Age through the Hittite, Phrygian, Hellenistic, Roman, Byzantine, Seljuk and Ottoman Periods, Amasya has been an open-air museum of Anatolia, similar to Cappadocia.

Table 3. Climatological statistics for August along the eclipse path of the total solar eclipse of 1999, August 11.

Loc. (**City**) (Town)	Prevail wind direction	Highest T (C)	Lowest T (C)	Elevation of the sun (deg)	Duration m , s
Bartın	NNE	40.0	8.5	58	1 40
Kastamonu	SW	37.7	0.9	57	2 17
Çorum	NE	39.4	3.0	56	1 51
Kargı	SE	40.8	10.5	–	–
Osmancık	E	40.4	8.9	56	2 16
Amasya	–	40.4	9.9	56	2 10
Merzifon	NNE	39.8	7.2	56	2 05
Tokat	ENE	40.0	7.5	55	2 09
Turhal	–	39.4	9.0	56	2 15
Sivas	N	37.6	3.2	55	2 07
Divriği	N	37.0	7.4	54	2 12
Elazığ	NW	40.6	10.2	53	2 04
Diyarbakır	NW	45.9	8.4	53	1 20
Batman	–	43.4	11.8	52	2 07
Şırnak	N	37.9	15.0	–	–
Cizre	SW	46.4	16.0	51	2 06

TOKAT (40° 18′ N, 36° 34′ E): Tokat is situated in the Yeşilırmak basin, which witnessed the sovereignty of 14 states and many principalities since 3000 BC, occupies a central position in the fertile Yeşilırmak basin. The city has many cultural and historical places. One can see the traces of civilizations of the Hittite, Phrgian, Hellenistic, Roman, Byzantine, Anatolian Seljuk up to Ottoman periods. Whoever goes to Tokat, must not miss visiting the Ballica cave.

SIVAS (39° 45′ N, 37° 01′ E): Sivas is located in the middle of Anatolian Peninsula in upper Kızılırmak zone. Kızılırmak is the most important river of the region. A great part of the city area lies in upper Kızılırmak (Halys), the other parts lie in Yeşilırmak (Iris) and Firat (Euphrates) basin. Climate during August is extremely hot and dry. Sivas has an airport. There will be some special places in the city for observation.

ELAZIĞ (38° 41′ N, 39° 14′ E): Elazığ, an Anatolian city and province, is located in the upper Firat region. Its altitude is 1067 meters above sea level. Harput is a small hill about 5 km northeast of Elazığ. The city, where central continental climate prevails, is surrounded by Keban and Karakaya dams and the natural beauty of lake Hazar. Important rivers such as Euphrates (Firat), Murat, Tigrus (Dicle) and Karasu run through the province, which is covered by mountains and plains. The city has an airport with flights from Istanbul and Ankara. In the city, a few suitable places were selected for eclipse observations.

These are Yurtbasi (38° 38′ N, 39° 20′ E, 860 m); Harput (1375 m) and the Firat University Campus (38° 40′ N, - 39° 12′ E, 1070 m).

DIYARBAKIR (37° 54′ N, 40° 14′ E): Diyarbakır is an southeastern Anatolian city. Its altitude is 660 meters. As with many Turkish cities, this one has grown beyond its ancient walls only in the last few decades. Though the city has grown, your concern is with the old part within the walls, except for the bus and rail stations west of the old city. Turkish Airlines flights to Diyarbakır are from Istanbul and Ankara. Istanbul Airlines has inaugurated service from Istanbul to Diyarbakır. In summer it is hot here; avoid hotel rooms just beneath the building's roof, or rooms that get full late afternoon sun.

Travelling eastward from Diyarbakır 50 km brings you to the district of Bagdere (38° 04′ N, - 40° 35′ E). The local province will arrange this region for scientific and turistic purpose to the eclipse observation. Its altitude is about 1390 meters.

5. Experiments

Istanbul University Observatory Research and Application Center and Department of Astronomy and Space Sciences are planning to perform the following research projects during the eclipse with Abastumani Astrophysical Observatory of Georgian Academy of Sciences:.

1. Investigation of Ionic and White-Light Corona and Flash Spectra of Chromosphere During the 1999 Total Solar Eclipse.

2. Photographic and Photoelectric Investigation of Coronal Polarization During the 1999 Total Solar Eclipse.

3. Investigation of Polar Plumes.

In this expedition, we are collaborating with the following Georgian colleagues, M. Sh. Gigolashvili, V. Kulijanishvili, Ts. S. Khetsuriani, E. V. Khutsishvili, L. A. Geondjan, V. Kakhiani, A. Mayer.

In order to carry out these investigations, we will use the instruments listed below.

a) Four Channel Coronagraph (D=100 mm, F=1000 mm). This coronagraph is operated with narrow-band filters at the red (6374 Å), yellow (5694 Å), green (5303 Å) and H_α lines for investigation of knot-like, arc and loop formations of the inner and upper corona.

b) A coronagraph (D = 110 mm, F = 2500 mm) will be used for getting images of the white corona with the help of radial filter for investigation of structural components of the corona.

c) Two camera polarimeter (D = 100 mm, F = 1000 mm) will be carried out for investigation of the polarization degree of the corona.

d) Flash spectrocinematograph (D = 70 mm, F = 1600 mm) with directive vision objective prism and cinema camera 'Konvas' for investigation of vertical distribution of the chemical elements and their ionisation degrees in upper layers of the chromosphere.

e) The instrument for measurement of the solar oblateness (F = 5000 mm) with scanning device, photometer and data acquisition system.

f) Lyot type solar coronagraph with external discs and CCD camera for photoelectric polarization measurements outer corona.

g) Electropolarimeter. This instrument will be used to measure the total flux of the solar corona along the radii and azimuth (Kulijanishvili et al., 1998).

h) One-meter photographic polarimeter. This telescope equipped with an electric-motor drive will be used to take pictures of the solar corona in three different positions of the polaroid.

i) One-meter telescope with beam-splitter. Images of the solar corona in the red coronal line (6374 Å) and in continuum will be obtained simultaneously with the instrument.

j) A reflector (D = 209.6 mm, F = 1280 mm). Using the high resolution (0.56 arc sec) ability of the telescope, we will try to determine wheather polar plumes are in coronal holes.

6. Concluding remarks

Long-term climatological data suggest that to get any better weather prospects, the eclipse location will have to move from the northwestern to southeastern parts along the path of Turkey. On the other hand, within northern and southern borders, the duration of totality decreases by a value of 10 seconds. As a results, when we seek the best observing sites in terms of specifications mentioned above and the local conditions, we have selected five suitable places for observation. They are as follows 1) Elazıĝ, 2) Sivas, 3) Diyarbakır, 4) Tokat, 5) Black Sea coast (Cide and Kurucaşile). However, we decide to perform our projects in Elazıĝ and Turhal (district of Tokat).

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Discussion

Question (I. Vince): *What is the aim of your flash spectra observations?*

Answer (M. Turker Özkan): At the time of the total solar eclipse usually so-called the white-light corona is observed and this makes possible to study the part of the solar corona which is formed in the result of scattering of the photospheric radiation on free electrons and dusty particles. Thus, in order to investigate a distribution of the material in the upper photosphere, it is necessary to get the flash spectra during the total solar eclipse.