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Two solar eclipses observations in Turkey

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Summary. — In this paper, the changes in the ionosphere over Turkey due to two solar eclipses are reported. TEC on the eclipse day (26 April 1976) and the intensity of an HF radio wave during its propagation over 567 km between Ankara and Elazığ on the eclipse day (11 August 1999) exhibited a very marked decrease.

PACS 94.20.-y – Physics of the ionosphere.
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PACS 41.20.Jb – Electromagnetic wave propagation; radiowave propagation.

1. – Introduction

A station was set up in Ankara to observe variations of the total electron content (TEC) between December 1975 and June 1976. Ertac and Tulunay [1] determined the total ionospheric electron content (TEC) over Ankara from the measurements of the Faraday rotation of a plane polarized wave that have been returned from the geostationary satellite ATS 6 transmitting at a frequency of 140 MHz. To show the effect of the ionosphere on HF radio wave propagation, an experiment is set up during the total solar eclipse of 11 August 1999. An HF radio wave was transmitted between Ankara (40°N, 33°E) and Elazığ (38°N, 39°E) over an approximately 567 km distance. This experiment provided an opportunity to observe the direct effect of the eclipse on the ionosphere. Although the TEC behavior and the propagation of an HF radio wave are not directly related to each other, the authors believe that it is a unique occasion since there were two solar eclipses that can be associated with such data during solar eclipse.

2. – Ionospheric total electron content measurements from Turkey during the solar eclipse of 29 April 1976 over Ankara

A station was set up in Ankara to observe variations of the total electron content (TEC) between December 1975 and June 1976. The METU station was equipped with a switched polarimeter consisting of a 1inear cross yagi antenna, a receiver and a pen recorder recording a Faraday polarization twist of VHF radio waves which are transmitted at the 140 MHz from the geostationary satellite ATS-6. The location of the sub-ionospheric point is 36.4°N, 33.2° E. The polarization angle was measured at 15 minutes interval, and continuous data were received for almost all days except during late December and partly in January due to chart recorder failure. There were also some off signal periods due to the interruptions of the signal from the satellite. The data have been reduced by employing the method referred to in Klobuchar and Rastogi's work [2]. After being encoded the data are being sorted into hourly group. In order to remove the "$n\pi$" ambiguity the critical frequencies (f_0F_2) of the nearest ionosonde stations to the subionospheric point have been obtained from the WDC-C1.

The diurnal variations in the ionospheric TEC are shown in fig. 1 for three days in April 1976 prior to the solar eclipse. In these curves the effect of increasing magnetic activity is also seen. As K_p (daily sum of the three-hour planetary magnetic activity index) increased enhancements did occur in the TEC. Maximum TEC enhancements were observed around noon hours.

In order to investigate the changes observed during the eclipse a non-eclipse or a "control" curve is constructed by taking the arithmetic mean of TEC data of the 27th and 28th of April 1976. The K_p index was 18 during the control days, whereas it was 23 on the eclipse day. Figure 2 shows the diurnal variations in the TEC data obtained on the eclipse day. The control curve is also drawn in the same figure for comparison purposes. The TEC values were greater than those of the control curve during the morning period. The solar obscuration was clearly felt in the TEC as the data obtained on the eclipse day exhibited a very marked decrease. After 15:00 the TEC values again became greater than those of the control curve and this behavior continued until 22:00. In order to investigate the effects of the eclipse on f_0F_2 data, the diurnal variations of the f_0F_2 measured on

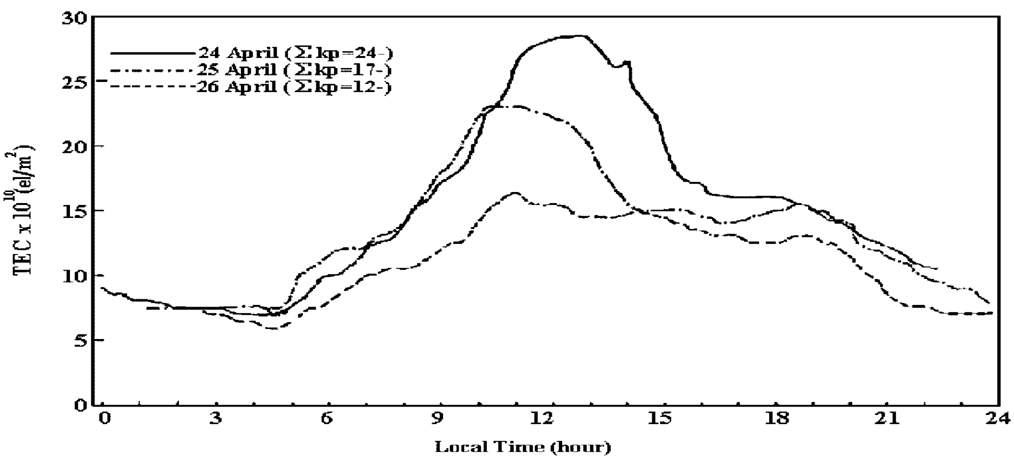

Fig. 1. – The diurnal variations in TEC obtained at the METU station.

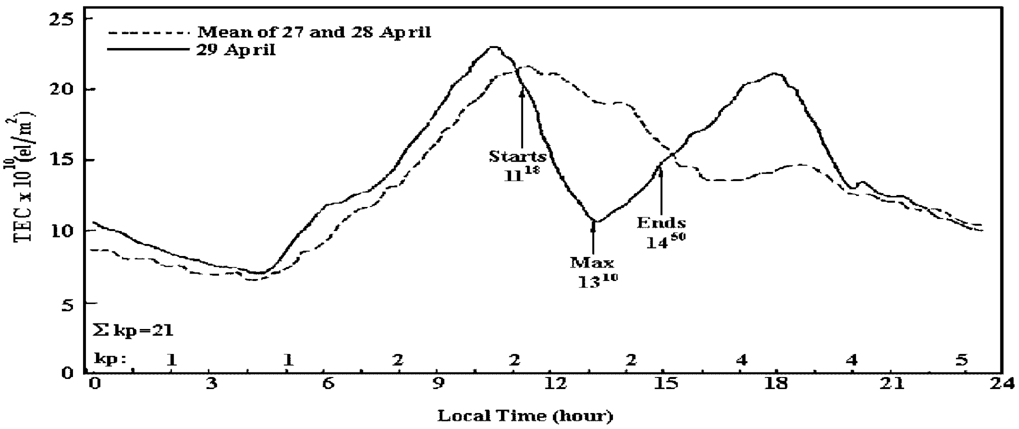

Fig. 2. – The diurnal variations in TEC obtained during the solar eclipse of 29 April 1976.

a magnetically quiet day (26 April 1976) and on eclipse (29 Apri1 1976) are plotted in fig. 3. As can be seen a very similar behavior is observed in the f_0F_2 data. On the eclipse day the f_0F_2 values started to decrease 18 minutes earlier than the first contact point and they continued to decrease till 50 minutes past the maximum obscuration. Whereas, the corresponding time intervals were 33 minutes and 5 minutes respectively in the eclipsed TEC data. Figure 4a shows the difference in TEC between the eclipse and control day values. In fig. 4b the time rates of change of both the TEC and the control curve are illustrated. The TEC on the eclipse day started to decrease at 10:45, well before the first contact time (11:18). The TEC values continued to decrease till 5 minutes past a maximum solar obscuration which took place at 13:10. The maximum change in TEC was approximately -9×10^{16} el/m^2 with respect to the control curve. Recovery took place at a rapid rate near the fourth contact and within 25 minutes following the fourth contact the TEC reached the control curve values. The increase in TEC continued until 18:15. Following this the TEC started to decrease reaching the control curve values at 20:00.

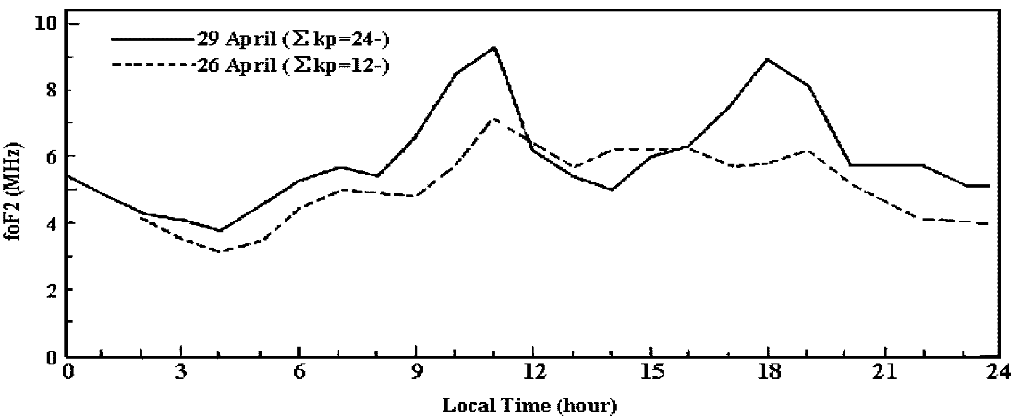

Fig. 3. – The diurnal variations in f_0F_2.

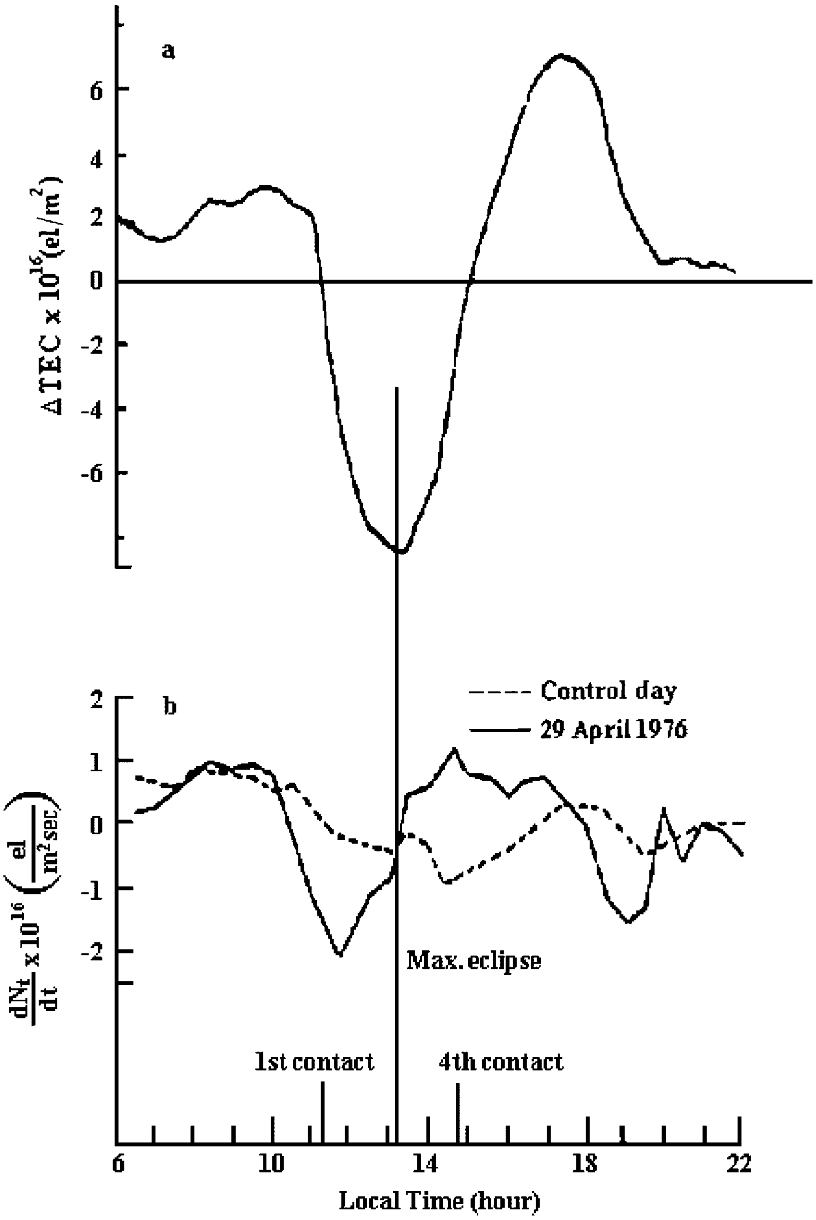

Fig. 4. – a) The difference in TEC between the eclipse and control day values. b) The time rates of change of both the TEC and the control curve.

3. – HF relative signal strength measurement between Ankara and Elazığ

The objective of the experiment between Ankara (40°N, 33°E) and Elazığ (38°N, 39°E) was to observe the relative variations in the signal strength during the 11 August 1999 total solar eclipse. Table I shows the times relevant to the 11 August 1999 total solar eclipse.

Table I. – *Times (UT) of partial and total (or maximum) eclipse in Elazığ and Ankara during the August 11, 1999 total solar eclipse.*

	Beginning of partial eclipse	Maximum 96.7%	End of partial eclipse	
Ankara	10:58:13	12:24:58	13:45:01	
	Beginning of partial eclipse	Beginning of total eclipse	End of total eclipse	End of partial eclipse
Elazığ	11:12:23	12:36:14	12:38:18	13:2-54:02

A map showing the regions related to the total eclipse of date 11 August 1999 is presented in fig. 5. The receiver and transmitter used were both Harris RF 3200 type 150W HF transceivers. The transmitter was located in Ankara, while the receiver was located in Elazığ. The transmitting antenna was a yagi-type antenna and could be directed in any direction with remote control. The receiving antenna was a Rohde & Schwartz HE 011 calibrated active monopole. The data were recorded by laptop personal computer running software specific to the prolab multimeter, which gave an RS 232 serial output to the computer. A block diagram of the experiment set up is shown in fig. 6.

The radio was tested and an appropriate point in the circuitry of the radio was found

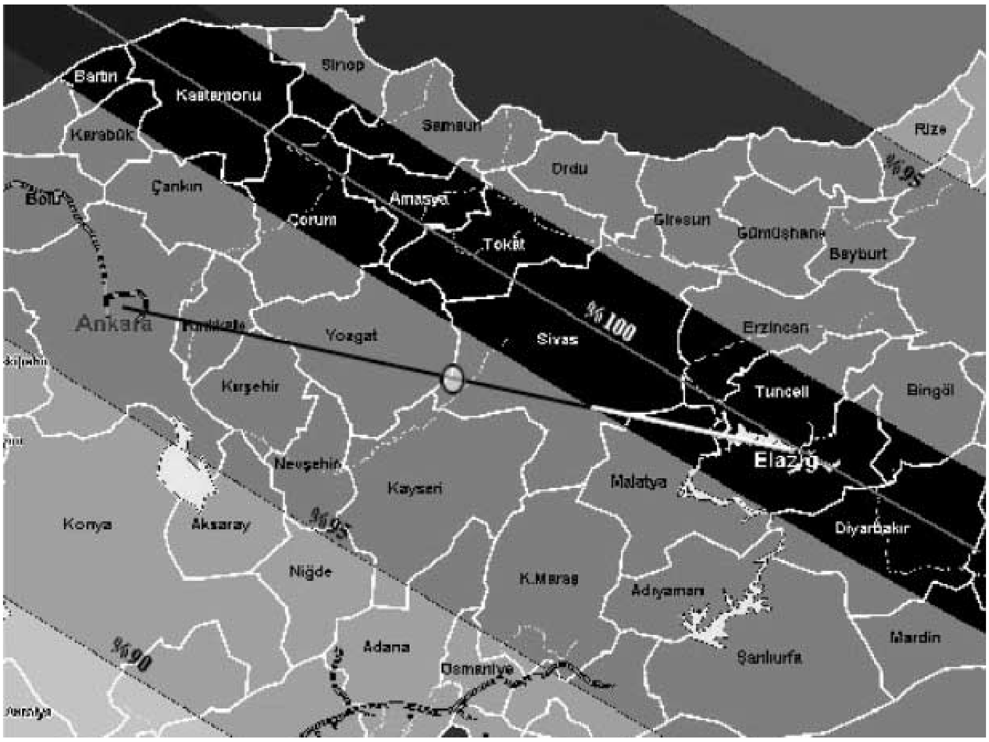

Fig. 5. – Map of regions affected by the total solar eclipse. Black region shows total eclipse area.

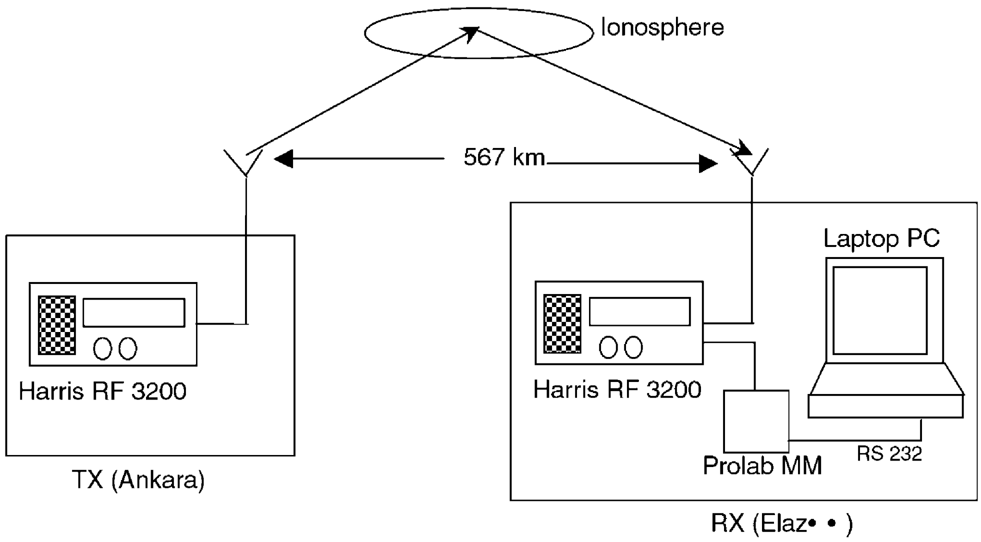

Fig. 6. – Set-up of equipment in HF relative signal strength experiment.

from which it was possible to obtain a measure of the relative strength of the received signal. A suitable point which provides a DC voltage between 0.7 and 6.5 V representing the relative signal strength in the range from 0 to −120 dBm was located on the receiver electronic card.

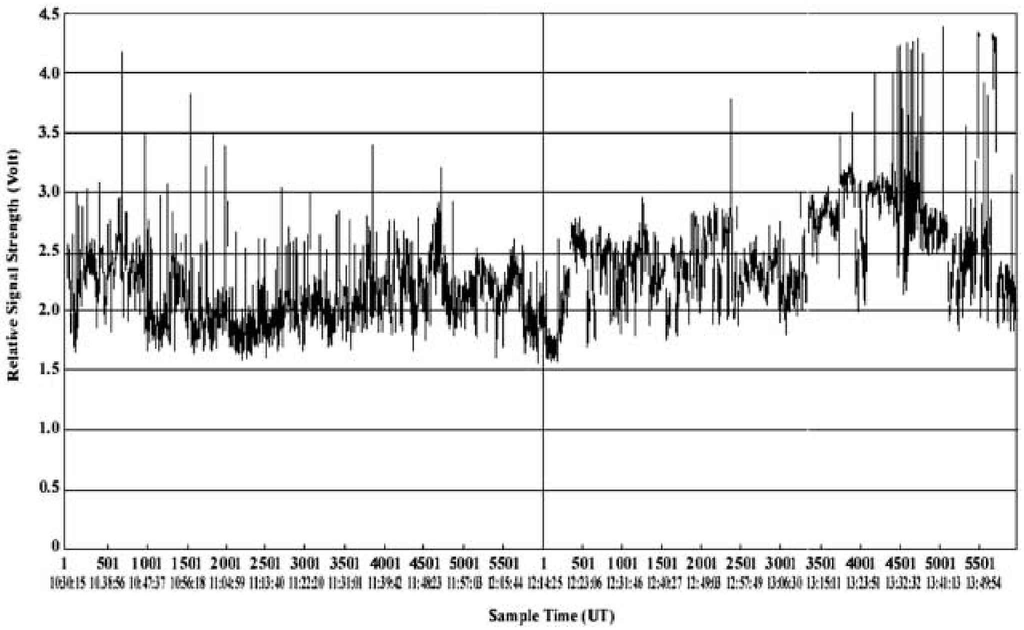

Fig. 7. – Plot of relative signal strengths measured during the total solar eclipse.

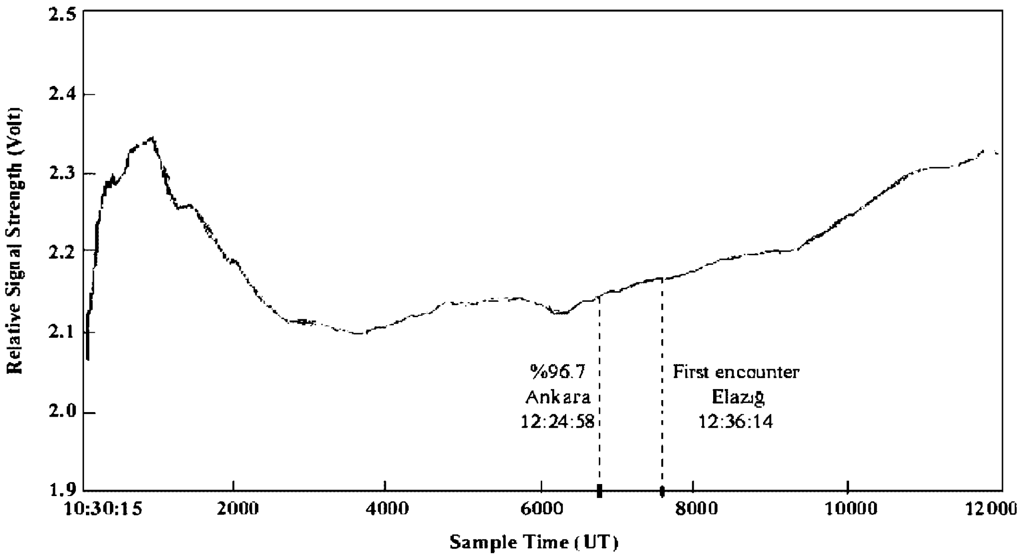

Fig. 8. – Plot of running mean of relative signal strengths measured during the total solar eclipse.

A link was made at 18.111 MHz and a 12000 seconds recording of data was made. The results are displayed in fig. 7. The time was synchronized with universal time (UT) through an atomic clock timeserver on the Internet. When the running mean of the recorded data shown in fig. 8 is taken in order to eliminate the oscillations observed on fig. 7, a clear decrease of strength during the eclipse became very obvious. The HF relative field strength reached a minimum near the times at which the total eclipse occurred at Elazığ and it began to rise to a value near the value observed at the beginning of the eclipse.

4. – Discussion

How difficult is to interpret the effects of an eclipse on the topside ionosphere is a known fact. However, in general terms, the TEC level decrease well before the first contact and the ionosphere recovers after the fourth contact on 29 April 1976. Similarly, Jakowski *et al.* [3] reported that TEC level decreased considerably on 11 August 1999 reacting abruptly the switching off of the solar radiation.

The HF radio wave experiment as revealed in fig. 8 indicates that the relative signal strength decreases due to the total solar eclipse of 11 August 1999. The opposite type of variation would have been expected since the rate of absorption in the ionosphere decreases due to decrease of photoelectrons in the shadow of the moon. It is believed that since the HF radio wave frequency of 18.111 MHz is near to the natural ionospheric critical frequency, the probable thinning of the ionosphere caused the part of the HF wave to be transmitted into space above the ionosphere instead of being reflected back to the Earth.

It is hoped that these cases reported here could provide some experimental insight, which are rare to be experienced.

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