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PARALLEL OBSERVATION OF SOLAR RADIATION CHANGES BEFORE AND DURING PARTIAL SOLAR ECLIPSE

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ABSTRACT. The aim of this research is to measure the physical parameters characteristic of solar radiation (air temperature, pressure and humidity, direct solar radiation and UV solar radiation over Belgrade area) and the comparison of values obtained for Sun eclipse phenomenon and values obtained for radiation of uneclipsed Sun in clear sky conditions. Measurements were make on August 10th and 11th, 1999 at meteorological station "Zeleno brdo" of Federal Hydrometeorological Institute of Yugoslavia in Belgrade. The obtained results show that air pressure was almost constant, drop in temperature was obvious and coincided with degree of partial eclipse and air humidity increased as expected during Sun eclipse. The results demonstrate that decrease of direct solar radiation was symmetrically proportionate to degree of partial Sun eclipse. Intensity of UV radiation decreases slower than intensity of direct radiation did, but they reached their minimums simultaneously, which could be explained by complex relations between direct and diffuse component of UV radiation. However, in spite of drastic decrease of radiation, from the obtained results it could not be concluded that the degree of partial eclipse was 97.7 %, as it was shown in astronomical evaluation.

1. INTRODUCTION

Measurements of direct and UV (ultra violet) solar radiation during the Sun eclipse were made at the meteorological station "Zeleno brdo" of FHMI (latitude +44^0 32', longitude – 20^0 32' and altitude 243 m above the sea level) in Belgrade.

Partial eclipse event started at 09h 30m 54s (universal time)
Maximum of the eclipse event (97.7 %) took place at 10h 56m 23s (universal time)
Partial ends of the eclipse event came at 12h 19m 54s (universal time)
Partial eclipse lasted 02 h 49 min

Measurements of direct and UV solar radiation and all others relevant meteorological parameters (temperature, pressure and humidity of air) were done simultaneously. Cloudy sky and rain before the eclipse were obstructing the beginning of the measurement and caused reduction of comparison possibilities (Figs. 3 and 4).

2. RESULTS AND DISCUSSION

The value of air pressure during eclipse was 986±0.5 hPa, measured by the station barometer.

Table (Ia) shows: time of measurements of direct solar radiation, partial obscuring of the Sun by the Moon in percents, output voltage from secondary standard pyrheliometer "Linke Feussner G1033", measured by galvanometer "AL–4 Mikrova", temperature of instrument (T) and the power of direct solar radiation (P) expressed in W/m^2. Temperature correction of instrument was calculated according to formula: T_k=1+0.002(T–20).

Table (1b) shows time of measuring, total value of voltage U'_{UV}, noise voltage of photodiode U'_o and difference $U'_{UV}-U'_0$. UV radiation was measured by UV radiation measurer (Kolarž Predrag: "Projecting, construction and testing of UV radiation metering instrument", practical part of graduate examination). The instrument consists of tube shaped housing with base for broadband filter with vavelength scale from 300 nm – 400 nm, silicon UV photodiodes (S1337–16QB, "Hamamatsu") for precision photometry, and stabilized current amplifier of photodiode signal. On the input of the instrument is a teflon disc diffuser. Digital voltmeter measures output voltage U'_{UV}. The voltage difference between the voltage signal when the light sensor is illuminated (U'_{UV}) and the noise signal when the light sensor diode is in dark (U'_0) shows the real value U_{UV}. Dimension of obtained signals is Volt (V). Therefore, the measuring was comparative. The UV radiation measuring unit was in the same position during all measuring.

Increased cloudiness and rain at the very beginning of the eclipse (11:31) and for the next 20 minutes (till 11:52) obstructed measuring. When the rain stopped and the sky partially cleared up, measuring was made possible.

Table (2) shows the values of mentioned parameters obtained during the measuring on August 10, 1999. in clear sky conditions.

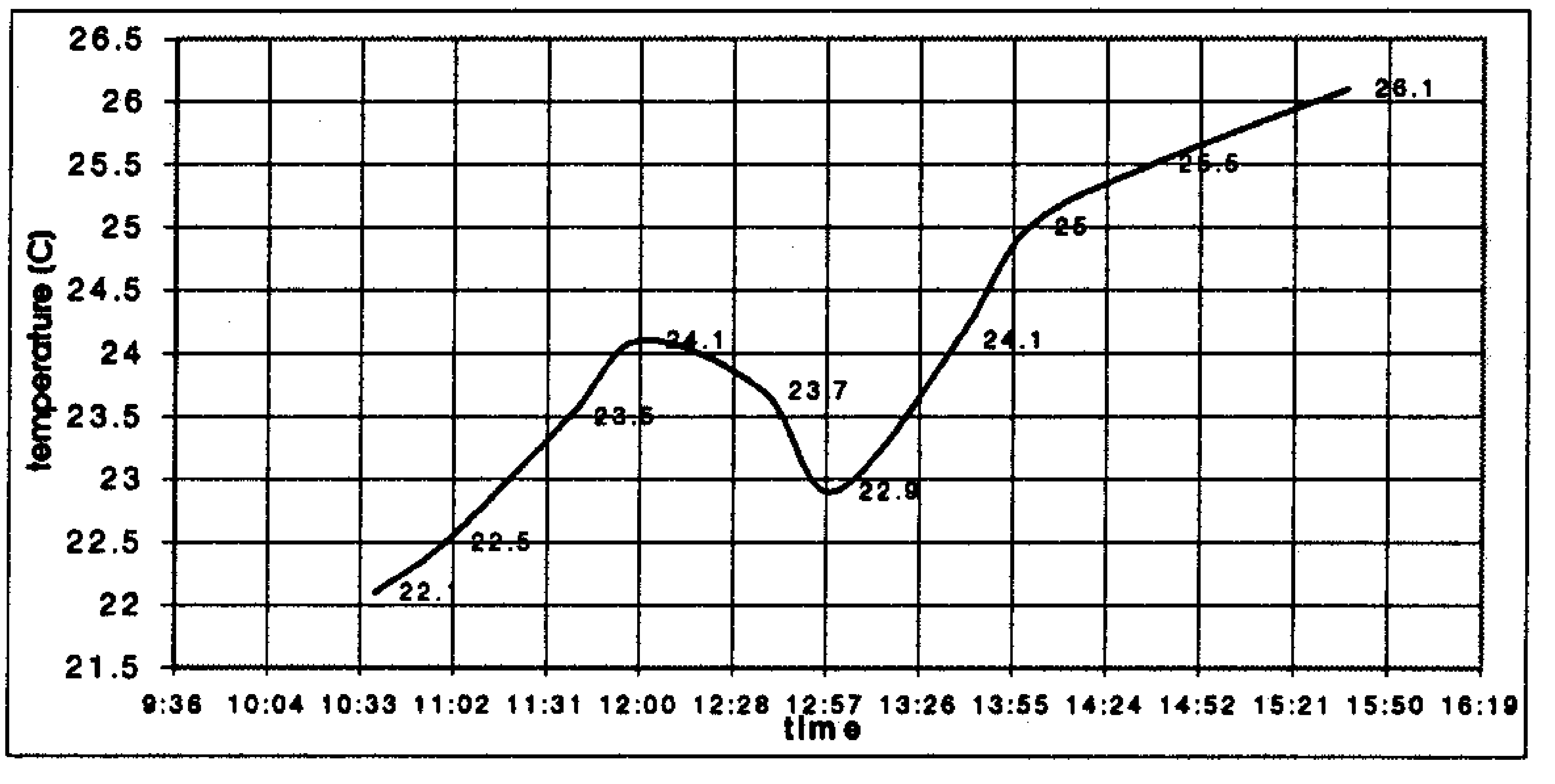

Figure 1 – Change of temperature during eclipse

Air temperature was measured with FHMI's thermograph.

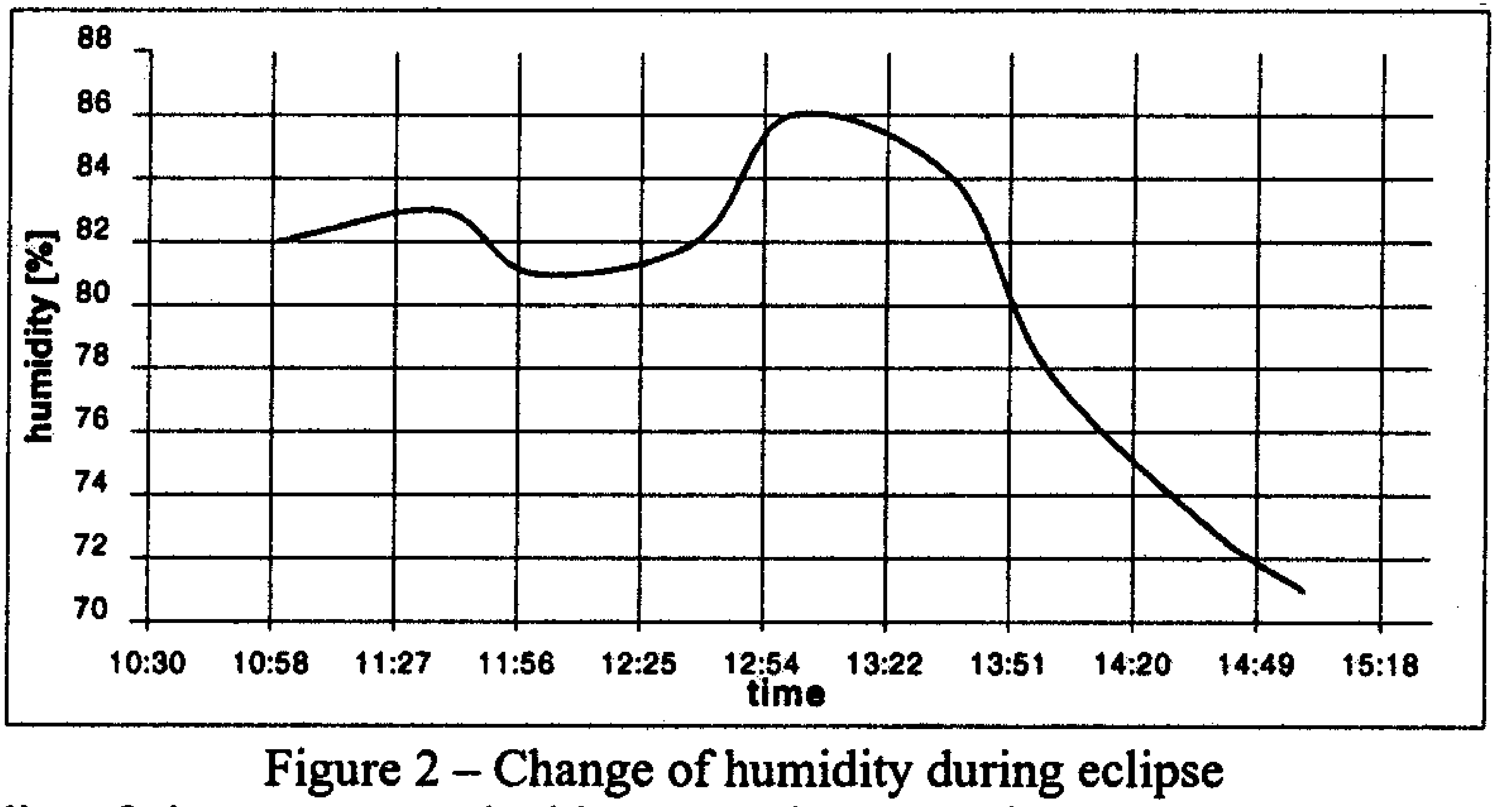

Figure 2 – Change of humidity during eclipse

Humidity of air vas measured with FHMI's hygrograph.

time	eclipse [%]	U [mV]	T [°C]	T_k [°C]	P [W/m²]
11:00	0	9.7	29.2	1.0184	597.747
11:52	28	8.05	30.3	1.0206	497.14
11:58	36	8	30.3	1.0206	494.052
12:10	40	4.43	30.5	1.021	273.689
12:15	45	1.51	30.9	1.0218	93.362
12:20	53	0.52	31.2	1.0224	32.17
12:22	56	2.31	31.2	1.0224	142.909
12:24	59	1.72	30.5	1.021	106.263
12:30	66	3.15	29.7	1.0194	194.304
12:37	72	2.83	30	1.02	174.668
12:40	78	2.23	30.2	1.0204	137.69
12:45	83	0.2	28.2	1.0164	12.3005
12:50	89	0.42	28.2	1.0164	25.831
12:53	96	0.001	27.9	1.0158	0.06147
12:54	97	0.12	27.5	1.015	7.37012
12:55	98	0.16	2.4	0.9648	9.34081
13:00	94	0.172	27	1.014	10.5534
13:05	89	0.84	27.1	1.0142	51.5502
13:10	83	0.52	27.1	1.0142	31.912
13:15	78	2.51	26.2	1.0124	153.763
13:20	72	1.2	25.5	1.011	73.4107
13:24	67	2.6	25.2	1.0104	158.962
13:26	61	4.15	25.4	1.0108	253.829
13:30	56	1.7	25.9	1.0118	104.081
13:35	50	6.05	26	1.012	370.479
13:40	44	6.95	26	1.012	425.591
13:45	39	7.8	26.9	1.0138	478.491
13:50	33	8.8	27.2	1.0144	540.156
13:55	28	9.32	27.3	1.0146	572.187
13:00	22	9.9	28	1.016	608.634
14:05	17	10.12	28.4	1.0168	622.649
14:10	11	11.3	28.7	1.0174	695.66
14:15	5	11.38	28.9	1.0178	700.861
14:20	0	11.25	29.2	1.0184	693.263
14:25	0	11.12	30	1.02	686.329
14:30	0	11.1	30.1	1.0202	685.229

Table 1a

time	U'_{iw} [V]	U'_o [V]	$U'_{iw}-U'_o$ [V]
11:20	1.2222	0.0038	1.2184
11:30	1.2208	0.0035	1.2173
11:43	1.325	0.0026	1.3224
11:50	1.3658	0.0033	1.3625
11:54	1.5001	0.0039	1.4962
12:00	0.8262	0.0037	0.8225
12:05	0.7847	0.0036	0.7811
12:10	0.9782	0.0036	0.9746
12:15	0.6831	0.0036	0.6795
12:20	0.5438	0.0026	0.5412
12:22	0.6389	0.002	0.6369
12:24	0.6289	0.0019	0.627
12:30	0.3909	0.0013	0.3896
12:37	0.3462	0.0001	0.3461
12:40	0.3019	0	0.3019
12:45	0.1238	0.0004	0.1234
12:50	0.0678	0.0004	0.0674
12:53	0.0238	0.0004	0.0234
12:54	0.0201	0.0023	0.0178
12:55	0.0203	0.0023	0.018
13:00	0.0296	0.0023	0.0273
13:05	0.0996	−0.0024	0.102
13:10	0.1606	−0.0015	0.1621
13:15	0.354	−0.0013	0.3553
13:20	0.377	−0.0013	0.3783
13:24	0.4587	−0.001	0.4597
13:26	0.5767	0	0.5767
13:30	0.5531	0	0.5531
13:35	0.8023	0.0011	0.8012
13:40	0.9064	0.0011	0.9053
13:45	0.9903	0.0011	0.9892
13:50	1.1045	0.0032	1.1013
13:55	1.1732	0.0041	1.1691
14:00	1.2735	0.0043	1.2692
14:05	1.3256	0.0051	1.3205
14:10	1.3511	0.0051	1.346
14:15	1.377	0.0051	1.3719
14:20	1.3488	0.0088	1.34
14:25	1.365	0.0088	1.3562
14:30	1.3059	0.0088	1.2971

Table 1b

Table 1 – The results of measurements on August 11,1999.

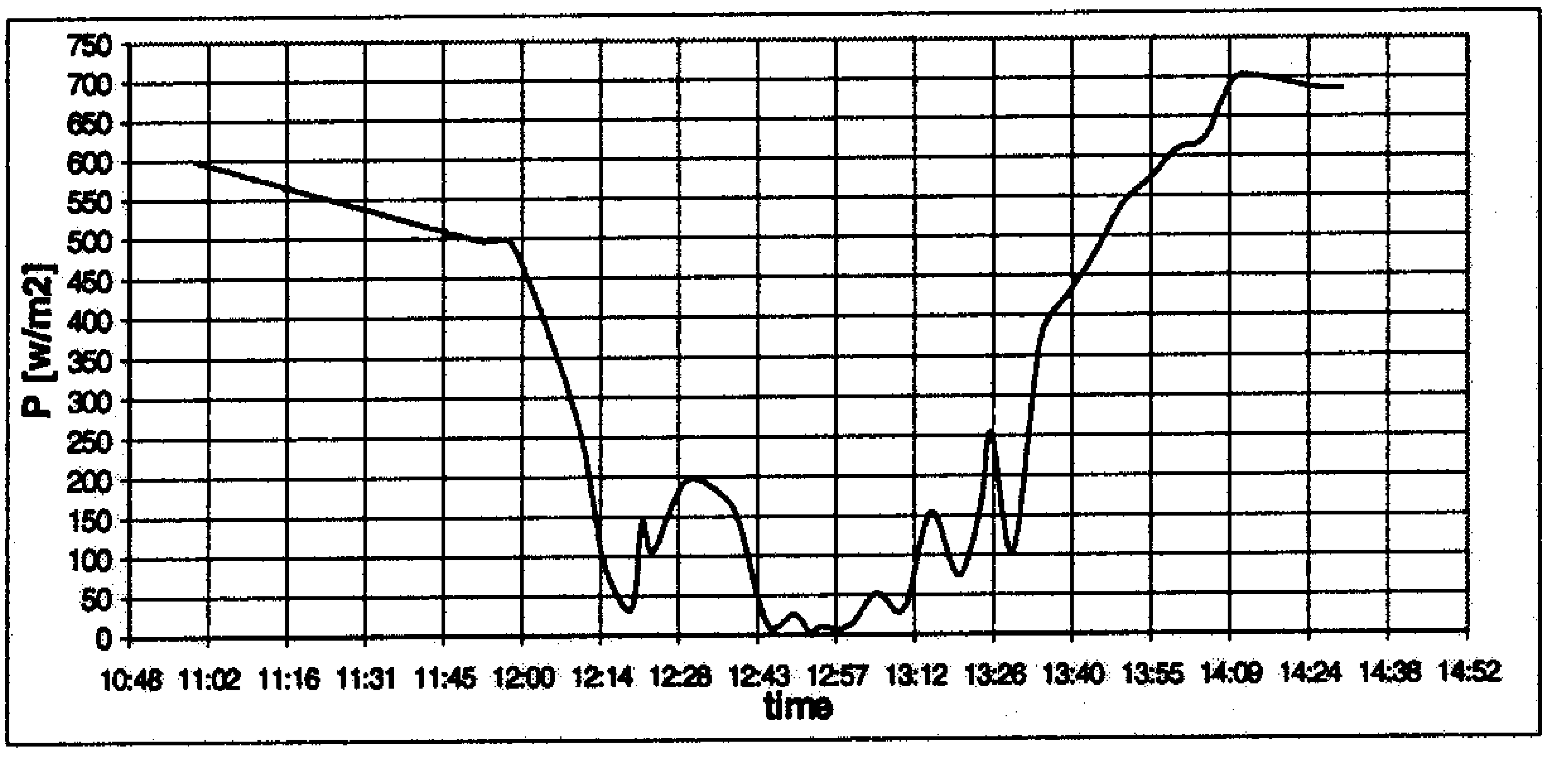

Figure 3 – Change of direct solar radiation during partial Sun eclipse

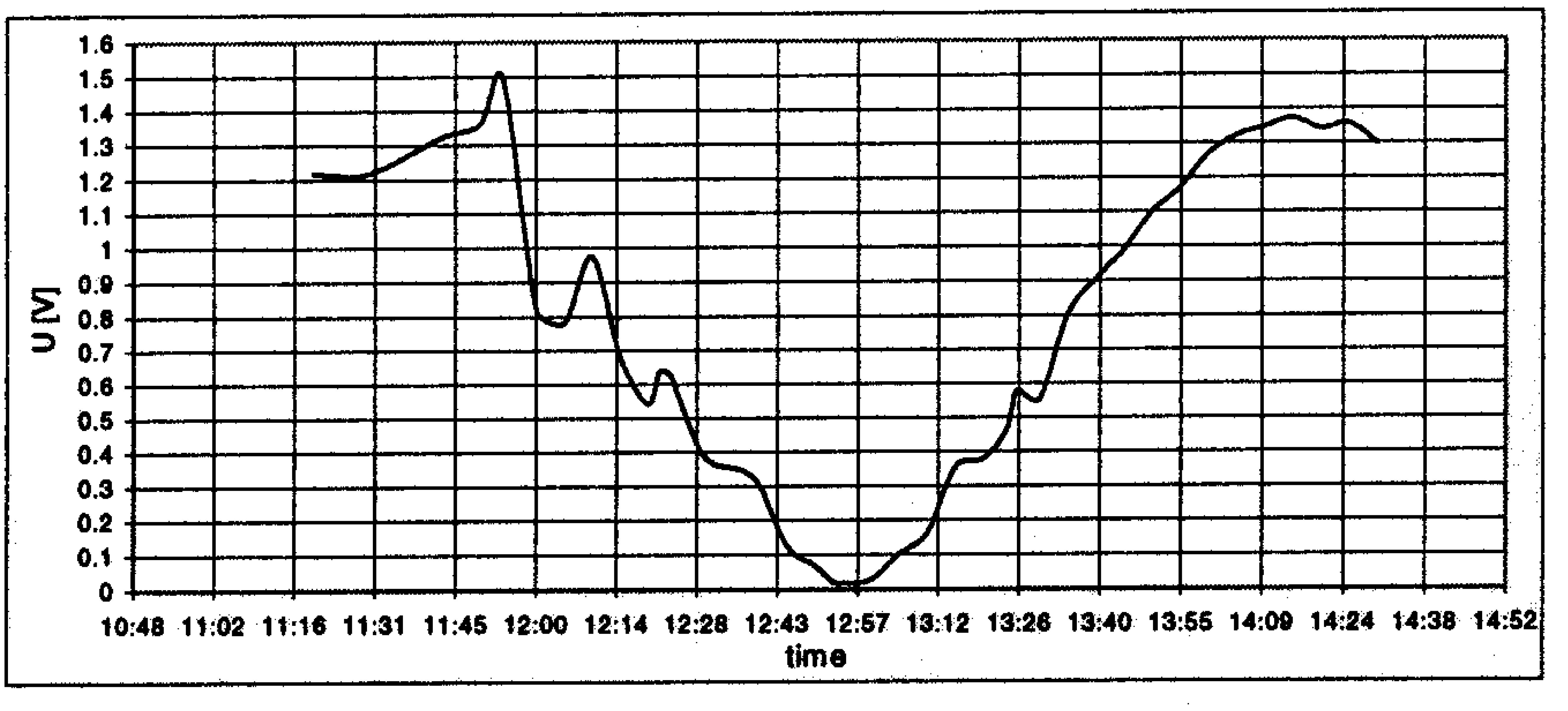

Figure 4 – Change of UV radiation during partial Sun eclipse

time	t [°C]	t_s [°C]	U [mV]	P [W/m2]	time	U'_{UV} [V]	U_n [V]	$U'_{UV}-U_n$ [V]
11:20	37.2	1.0344	8.66	542.0428	11:21	1.195	0.013	1.182
11:34	38.2	1.0364	9.09	570.0572	11:35	1.224	0.012	1.212
12:15	38	1.036	10.29	645.0632	12:00	1.301	0.014	1.287
12:30	38.1	1.0362	10.48	657.1008	12:10	1.333	0.014	1.319
12:45	38.1	1.0362	10.6	664.6249	12:15	1.345	0.015	1.33
13:00	38.3	1.0366	10.61	665.5087	12:30	1.362	0.014	1.348
13:15	38.6	1.0372	10.5	658.9902	12:45	1.37	0.017	1.353
13:30	40.1	1.0402	10.46	658.3786	13:00	1.38	0.018	1.362
13:45	40.9	1.0418	10.5	661.9128	13:15	1.355	0.018	1.337
					13:30	1.346	0.018	1.328
					13:45	1.338	0.018	1.32

Table 2 – The results of measurements on August 10,1999.

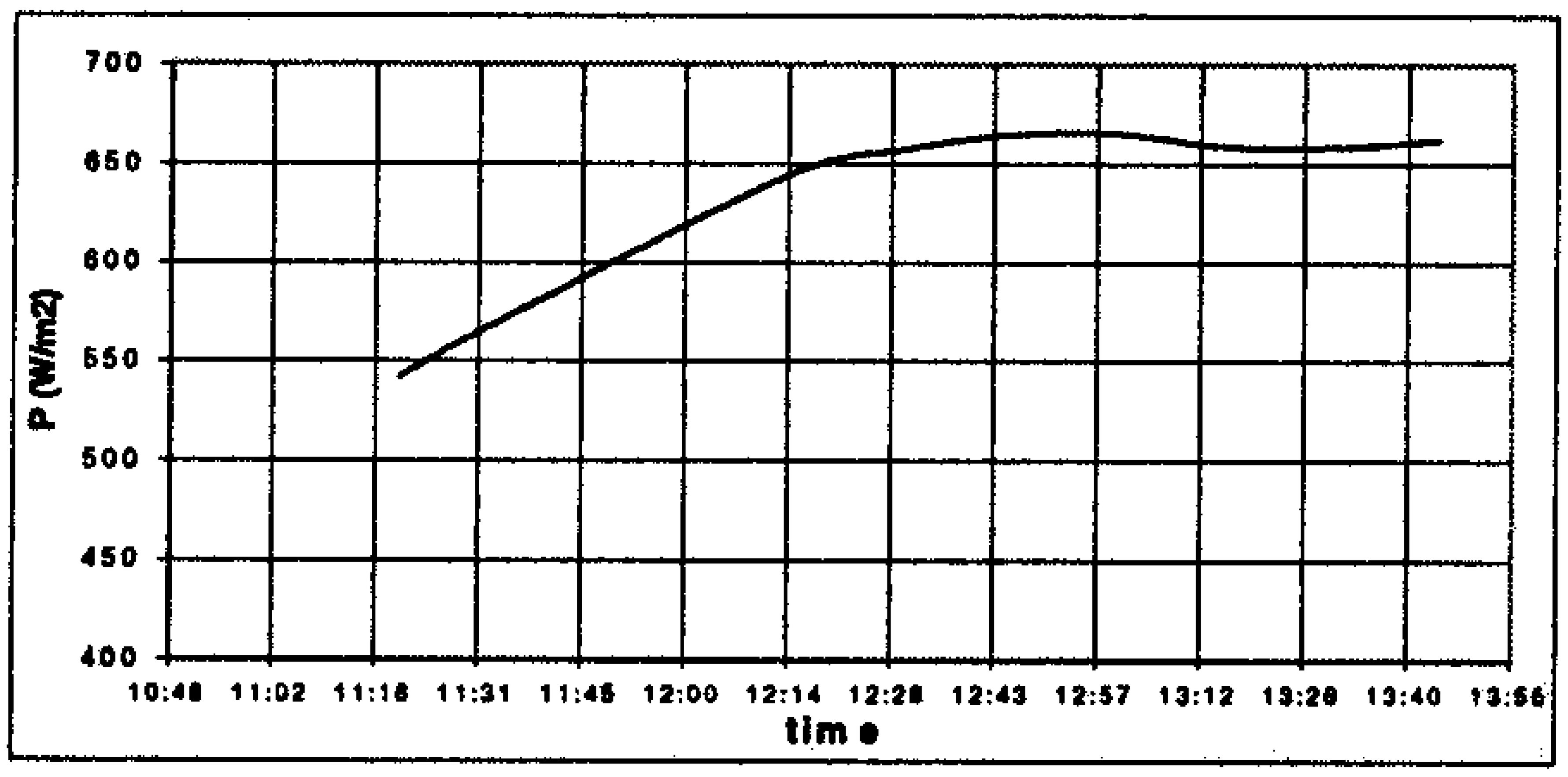

Figure 5 – Direct solar radiation measured on August 10,1999.

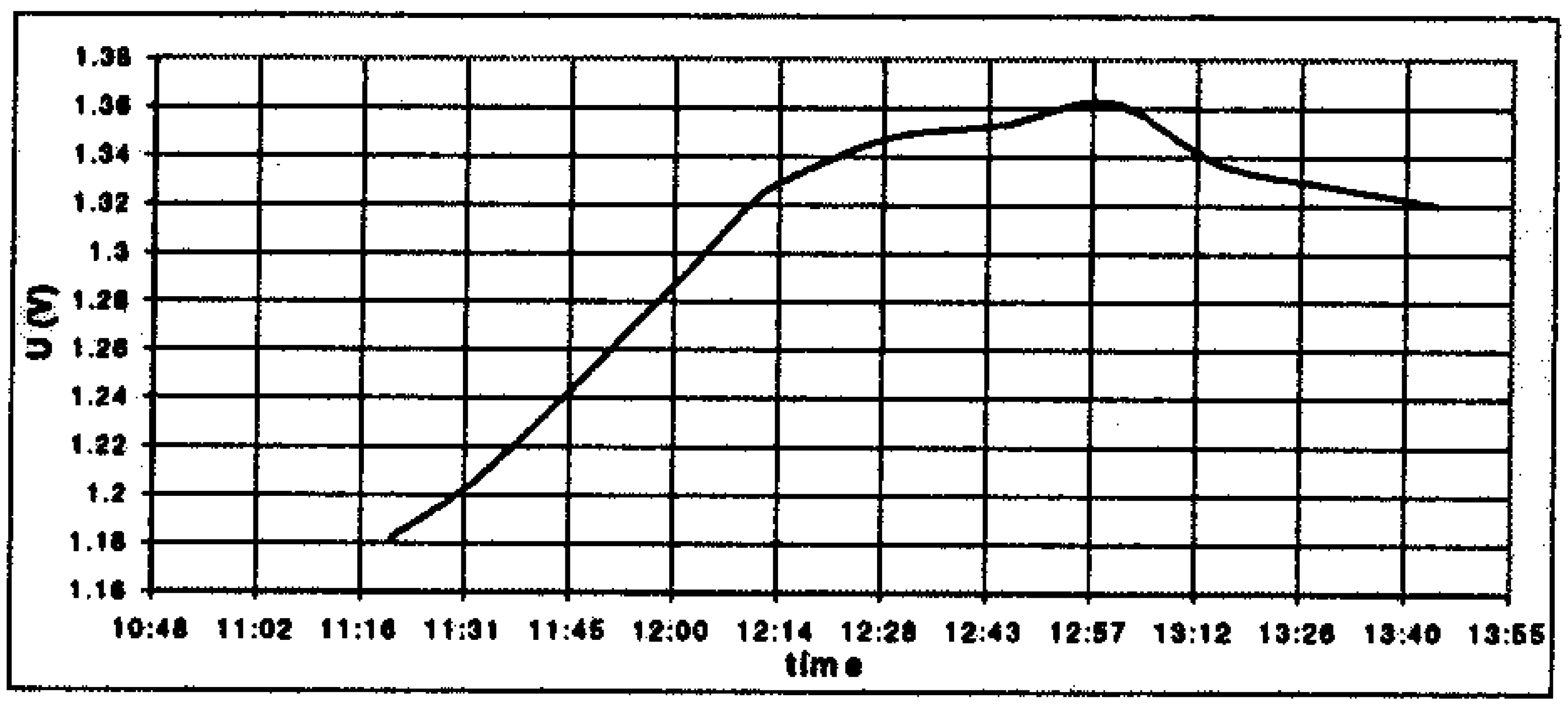

Figure 6 – UV radiation measured on August 10,1999.

3. CONCLUSION

Temperature variation was not of expected level, because of penetration of cold front and weather instability. Decreasing of UV radiation intensity and direct solar radiation intensity were simultaneously followed by the drop in temperature was obvious and coincided with degree of partial eclipse.

During the observed intervals, air humidity increased as expected, although the increase was not extreme, probably because of shortness of observed interval and bad meteorological conditions during the measuring.

The obtained results show that the decrease of direct solar radiation was symmetrically proportionate to the degree of partial solar eclipse.

Intensity of UV radiation decreased slower than intensity of direct solar radiation did, but they reached their minimums simultaneously. Also local peaks of UV radiation were less expressed than local peaks of direct solar radiation. These facts can be explained by the following: flux of global UV solar radiation consists of two components, flux of the direct solar radiation and flux of the diffuse solar radiation. During the day, diffuse radiation suppresses direct solar radiation, depending on the Sun altitude and atmosphere translucence. Probably, these facts induce the mentioned changes of radiation intensity during the solar eclipse. Analyses of the peaks in Figures 3 and 4 show that the value of optical turbidity during partial solar eclipse was smaller than the value of optical turbidity obtained the day before, so the signal obtained before and after eclipse was stronger, in spite of increased cloudiness. From to these results, in spite of drastic decrease of radiation, it could not be concluded that the degree of partial solar eclipse was 97.7 %. But, in clear sky conditions, the degree of partial solar eclipse could be estimated precisely on the base of measured direct solar radiation parameters.