STUDY OF ATMOSPHERIC BOUNDARY LAYER TERMAL REGIME DURING TOTAL ECLIPSE OF THE SUN

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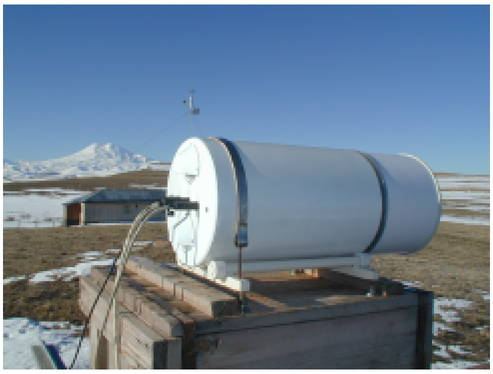
ABSTRACT

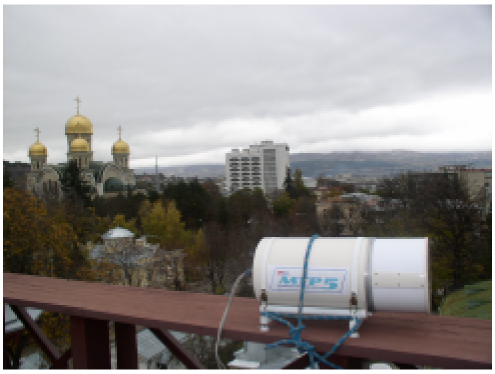
On the 29 March, 2006, at the South-West part of Russia (Kaukas Region) was observed total eclipse of the Sun (started at 3.15 p.m. local time and with the duration 2 min 32 sec – for city Kislovodsk, where different observed tequique were installed). For study of atmospheric boundary layer (ABL) thermal regime were used two microwave temperature profilers MTP-5, and as additional equipment - net-radiometer CNR-1, pyranometer CM-3, UV-radiometer UV-S-B, ultrasonic anemometer, instruments for aerosol measurements, Brewer spectrofotometer and some others equipment. One temperature profiler were installed in the center of Kislovodsk city (altitude 890 m above sea level), second profiler was installed at about 18 km from Kislovodsk city (at altitude 2070 above sea level). Hopefully weather was excellent for observations (anticyclone conditions, cloudless). Results of simultaneous measurements of temperature profiles before solar eclipse, during total solar eclipse and after solar eclipse are firstly presented in the report.

Introductions

On Wednesday, 2006 March 29, a total eclipse of the Sun was visible from within a narrow corridor which traverses half the Earth. The path of the Moon's shadow began at sunrise in Brasil and extended across the Atlantic to Africa, traveling across Chana, Togo, Benin, Nigeria, Niger, Chad, Libya, and a small corner of Egypt, from there across the Mediterranean Sea to Greece and Turkey, then across the Black Sea via Georgia, Russia, and Kazakhstan to Western Mongolia, where it ended at sunset. A partial eclipse was seen from the much broader path of the Moon's penumbra, including the northern two-thirds of Africa, the whole of Europe, and Central Asia. The total eclipse of the Sun is an important scientific opportunity for two main reason. Firstly, the Moon perfectly block out the body of the Sun, leaving its outer atmosphere, or corona, in perfect view. Secondly, it completely cuts out the Sun's light for short a time which can be precisely predicted. This means that the effect of the Sun on the Earth's atmosphere can be measured. Obviously, the Moon's shadow cools the atmosphere. There are some more meteorological aspects of the total eclipse of the Sun (Potemkin, 1983; Hanna, 2000). While temperature is decreasing, the solar eclipse wind occurs. An unwelcome meteorological phenomenon occurring during the eclipse is the clouds appearance due to air-cooling. Mostly during solar eclipse were measured near surface temperature, wind speed, solar radiation, pressure, humidity. At our experiment we firstly had possibility to measure simultaneously atmospheric boundary layer temperature profiles in two points with the two microwave temperature profilers. One point was high-altitude station Shad-Hgatmaz (43.43 N; 42.66 E, H=2070 m above sea level, Fig. 1a), second – the center of Kislovodsk city (18 km to the North from the station, H=890 m above sea level, Fig. 1b). The total eclipse of the Sun for this place started at 3.15 p.m. local time (+3 hours from GMT) and had duration 2 min 32 sec. Fortunately, weather was excellent for observations (anticyclone conditions, cloudless). It was unusually beautiful eclipse, with many or all effects visible, including Baily's pearls or beads, and a very nice corona despite proximity to solar minimum (Fig.1c). Both temperature profilers (MTP-5 was in normal operational mode ±24 hours from the moment of total eclipse. Measurement cycle was 300 sec, altitude range - 0÷600 m above surface, accuracy – 0,50C (Kadygrov and Pick, 1998).



a)



b)

c)

Fig.1 MTP-5H in Kislovods area.

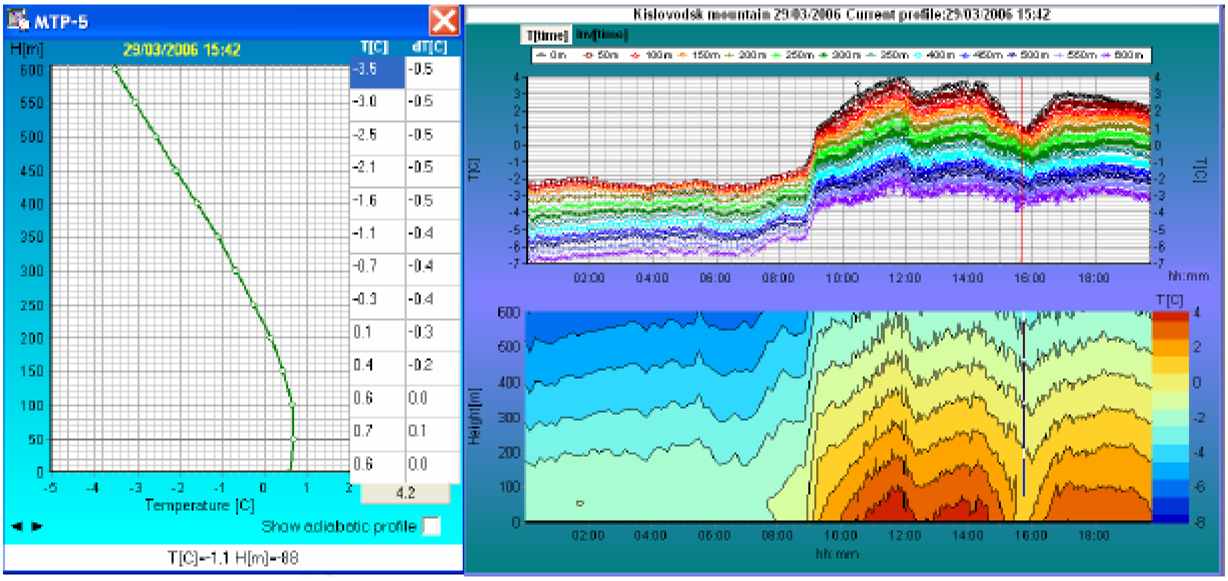
a) station Shad-Hgatmaz (43.43 N; 42.66 E, H=2070)

b) the center of Kislovodsk city (18 km to the North from the station, H=890)

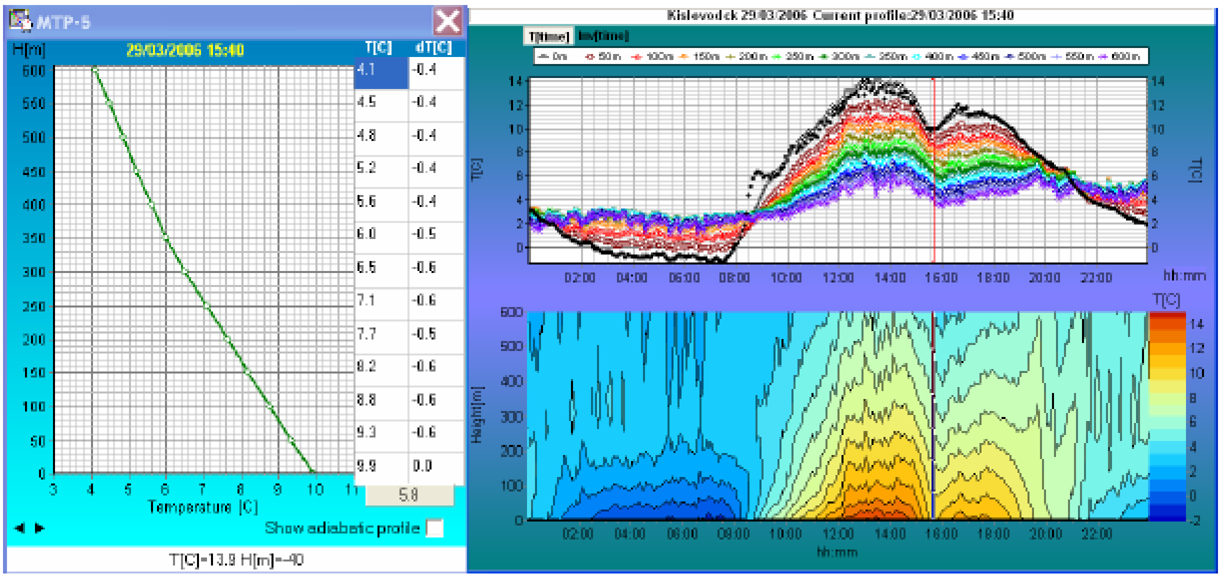
c) MTP-5H in the moment of total eclipse of the Sun.

Observation results

For temperature profiles measurements were used two stationary instruments MTP-5H- an-angular scanning single-channel radiometers with the central frequency 60 GHz (Westwater et al, 1999; Kadygrov, 1994). One week before eclipse both instruments were installed at one place (at the center of Kislovodsk city, "Kislovodsk") and was in continuous simultaneous operation for comparison. Altitude of installation was 890 m above sea level. At the morning 28 March 2006 one of the instruments was installed at Shad-Hgatmaz ("Kislovodsk mountains") which is 18 km to South from the city. In both places of installation were also meteorological stations for measurement near-surface meteorological parameters (temperature, pressure, humidity, wind speed and direction. At "Kislovodsk-city" was also net-radiometer CNR-1, pyranometer CM-3, UV-radiometer UV-S-B and in the "Kislovodsk-mountains" – Brewer spectrophotometer, microwave ozone profiler, the nearest aerological station was 47 km from Kislovodsk city (37054 URMM Mineralnye Vody). At Fig. 2a shown result of temperature profiles measurements at the "Kislovodsk-mountains" and at Fig. 2b – at the "Kislovodsk".



a)



b)

Fig.2 Result of temperature profiles measurement by MTP-5 instruments at 29 March 2006.

a) Kislovodsk mountains
b) Kislovodsk city

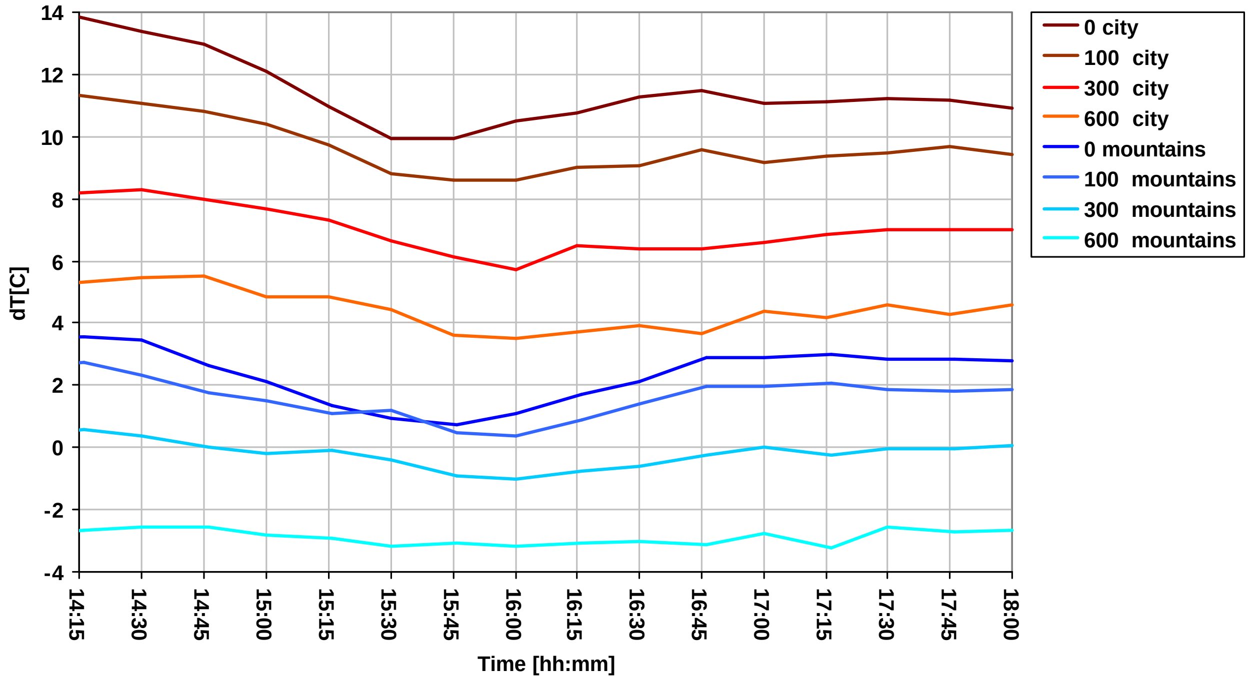


Fig.3 The changing of temperature at different altitudes in Kislovodsk city and at Kislovodsk mountains stations during eclipse of the Sun.

Tabl.1 Temperature gradients for Kislovodsk city

	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00
0 m	0,12	-0,48	-0,37	-0,92	-1,11	-1	0	0,54	0,27	0,52	0,22	-0,46	0,1	0,1	-0,07	-0,25
100 m	0,29	-0,27	-0,26	-0,37	-0,7	-0,92	-0,19	-0,04	0,46	0,02	0,5	-0,41	0,24	0,08	0,21	-0,25
300 m	0,19	0,11	-0,31	-0,35	-0,33	-0,69	-0,49	-0,43	0,75	-0,1	0	0,24	0,24	0,18	-0,01	0,02
600 m	0,36	0,21	0,02	-0,66	-0,02	-0,41	-0,81	-0,11	0,21	0,2	-0,21	0,66	-0,2	0,42	-0,32	0,34

Tabl.2 Temperature gradients for Kislovodsk mountains

	14:16	14:30	14:46	15:00	15:16	15:30	15:46	16:00	16:16	16:30	16:46	17:00	17:16	17:30	17:46	18:00
0 m	0,06	-0,11	-0,81	-0,49	-0,81	-0,38	-0,21	0,37	0,62	0,39	0,77	0,01	0,08	-0,14	-0,02	-0,01
100 m	0,17	-0,41	-0,56	-0,31	-0,35	0,06	-0,70	-0,09	0,47	0,53	0,57	-0,01	0,09	-0,15	-0,07	0,05
300 m	0,21	-0,20	-0,35	-0,23	0,08	-0,26	-0,52	-0,11	0,25	0,13	0,36	0,28	-0,26	0,21	0,03	0,09
600 m	0,16	0,11	-0,01	-0,24	-0,12	-0,22	0,09	-0,12	0,13	0,01	-0,06	0,35	-0,47	0,68	-0,20	0,10

At Fig. 3 are shown the changing of temperature at different altitudes in Kislovodsk city and at Kislovodsk mountains stations during eclipse of the Sun, and in Tabl.1 and Tabl.2 temperature gradient during eclips of the Sun at Kislovodsk city and Kislovodsk mountains respectively.

Conclusion

A total solar eclipse is not a frequent phenomenon at all. It recurs after approximately 350 years for a given place on Earth. Fortunately at 28 March 2006 total eclipse of the Sun was in the region of High Altitude Scientific Shad-Hgatmas station of Institute of Atmospheric Physics, Russian Academy of Science, which is well equipped by the different instruments of atmosphere study. Firstly were provided during total eclipse of the Sun continuous simultaneous temperature profile measurements for altitude range 0-600 m for the two points with different altitude above sea level (890 m-city, 2070 m-station). As it was shown the maximum decreasing of the temperature during eclipse was in city (at 0 m-3.9°C, at 100m-2.8 °C , at 300 m-2,6 °C, at 600 m-2.0 °C) than in the station (0 m-2.8 °C, at 100 m-2.4 °C, at 300 m-1,5 °C, at 600 m-0.7 °C).At the station decreasing of temperature was started simultaneously for different altitudes (from the beginning the eclipse), but in the city it was delay about 30 minute at the altitude 600 m relative to the surface layer.

Acknowledgements

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