A possible world record maximum natural ground surface temperature

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Before the forty-niners named a narrow valley in California, 'Death Valley', the Shoshone Indians called it 'Tomesha', or 'Ground afire'. It lives up to both names. It has deadly heat. On 10 July 1913, an air temperature of 134°F (56.7°C) was recorded – the highest in the world until exceeded by a temperature of 136°F (57.8°C) at El-Azizia, Libya (32°32′N, 13°01′E), on 13 September 1922. The ground surface temperature is more extreme, having risen to 201°F (93.9°C) on 15 July 1972 (Fig. 1). This is possibly the highest recorded temperature in the world. On this day, there were very light winds and a trace of cloud, and the radiation was intense as the ground surface temperature rose from a minimum of 101°F (38.3°C) to 201°F (93.9°C). The maximum air temperature peaked at 128°F (53.3°C). Prior to the 15th, ground surface temperatures ranged from 180°F (82.2°C) to 197°F (91.7°C). Of the 15 days 7 had maximum temperatures of 190°F (87.8°C) or higher.

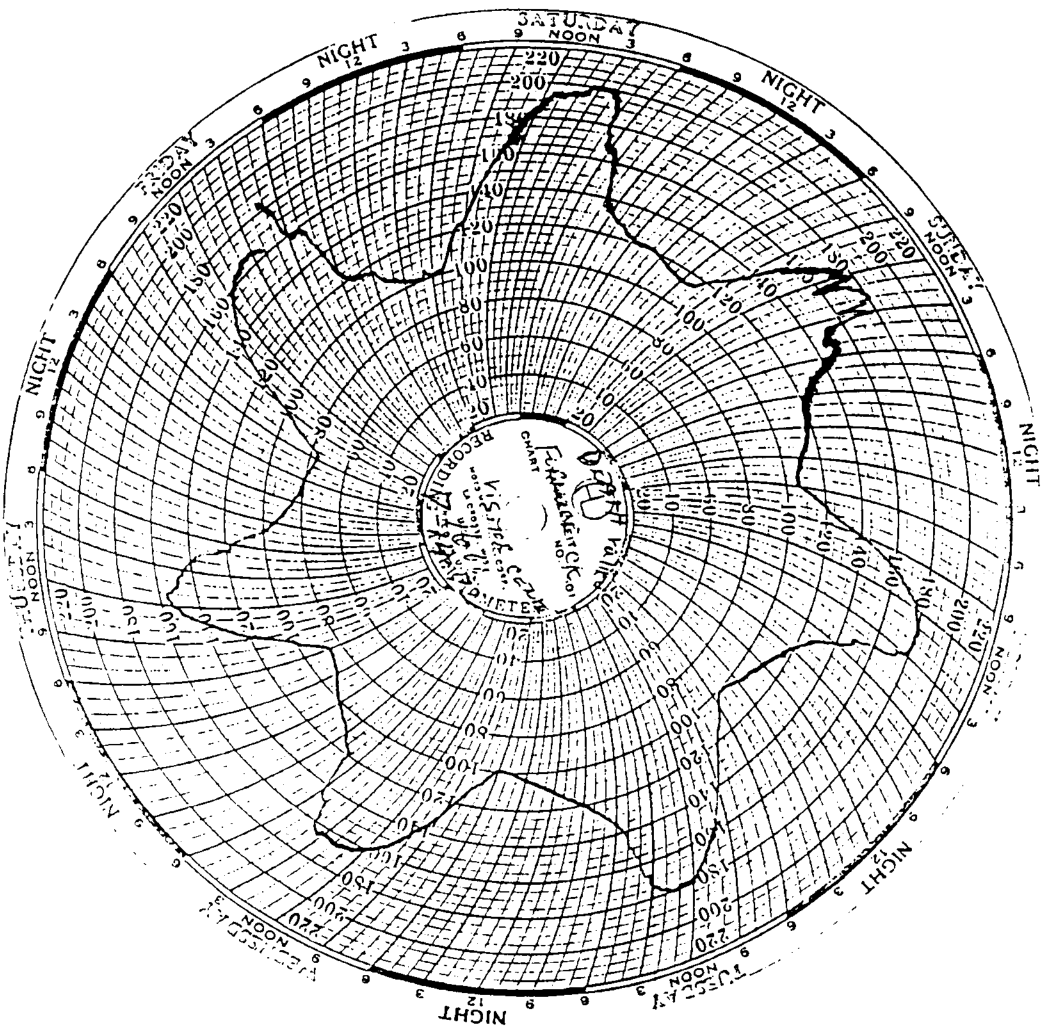

Fig. 1 The Death Valley, California, ground surface temperature chart for 14–21 July 1972, revealing the temperature of 201°F (93.9°C) on 15 July. Time is Pacific Daylight Time.

Earlier, in August 1958, the US Geological Survey measured a temperature of 190 °F (87.8 °C) on the surface of the massive gypsum at Tule Springs 8 km west of Badwater (Hunt *et al.* 1966). The ground surface temperature of 201 °F was measured at Furnace Creek in Death Valley, California (see Fig. 2), near the edge of an alluvial fan consisting of a mixture of sand and silt covered by a layer of gravel. The temperature site was located at 36°27′47″N, 116°52′01″W on the North American Datum of 1983 (NAD83), and 58.52 m below sea-level on the North American Vertical Datum of 1988 (NAVD88).

Southern California was under the influence of a strong upper-air ridge from 1 to 15 July. It contributed to mostly clear skies for much of the period, allowing intense radiation. At the surface, a thermal low was located over south-east California, which was responsible for a weak airflow.

Solar radiation was not measured at Death Valley but it was at Daggett, California (34°52′N, 116°47′W), and Las Vegas, Nevada (36°05′N, 115°10′W), both around 177 km from Death Valley. The most intense radiation was recorded between the 10th and 15th, when the average daily radiation for the two stations was 8560 Wh m^{-2}. On the 15th, Daggett recorded 8534 Wh m^{-2} and Las Vegas 8606 Wh m^{-2}. The highest daily totals were 8839 Wh m^{-2} for Las Vegas and 8734 Wh m^{-2} for Daggett on the 12th and 10th respectively. The normal (1961–90) July daily mean solar radiation is 7869 Wh m^{-2} for Daggett and 8007 Wh m^{-2} for Las Vegas.

With the weak circulation of the thermal low, the average wind speed during the 15-day period, and for the 10th to 15th, was 2.3 kn and 1.6 kn respectively. For the 24-hour period ending at 4.00 p.m. Pacific Daylight Time (PDT) on the 15th, the average speed was 1.7 kn. The air movement was registered by a three-cup, contact, mechanical, totalising anemometer located around 2.44 m from the temperature sensor. The centre of the cups was approximately 0.46 m above the ground.

There had been no rainfall since 22 June 1972, when 2.5 mm fell. Due to the very dry soil, the loss of latent heat by evaporation was almost non-existent. Also, the soil had a low albedo, making it a good absorber of solar radiation, and a low thermal diffusivity, which slowed the rate of temperature penetration into the soil. These three soil characteristics combined to concentrate the heat in its uppermost layer.

The instrument that measured the temperature was a circular chart recorder with a 6 in x 1/4 in (152 x 6 mm) mercury-in-steel, stainless steel sensor. The recording chart was 6 in (152 mm) in diameter, graduated from 20 °F (−6.7 °C) to 220 °F (104.4 °C) in 5 degF (2.8 degC) intervals, and had a 7-day recording period. It was calibrated on 7 December 1971 by the Instrument Laboratory, Naval Weapons Center, China Lake, California.

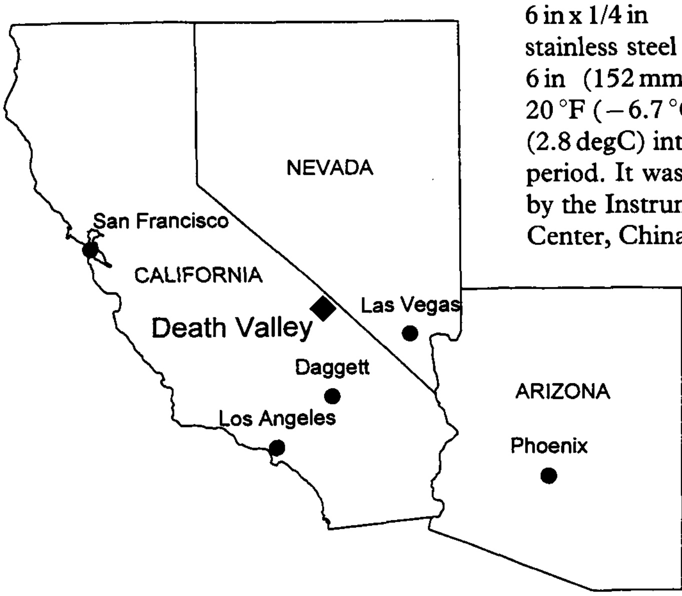

Fig. 2 Death Valley is located in the Mojave Desert of south-east California, which is in the extreme south-western USA. It has the lowest elevation in the USA of 85.3 m below sea-level.

The sensor was to be half-buried in the soil, but due to wind effects it may have been covered with a coating or thin layer of soil or just lying on the soil. It is not known which of these conditions existed on 15 July 1972. Ideally, the radiation should be allowed to pass freely to and from the soil and the sensor should be protected from radiation. In reality this is difficult to accomplish.

Gloyne (1952) considered the 'surface temperature' as the mean temperature of a shallow layer and the 'skin temperature' as the true surface temperature, sometimes called the 'air–soil interface'. He also noted that Vaartaja (1949), in Finland, measured soil skin temperatures with a fine thermocouple and was of the opinion that they were about 9 degC (16.2 degF) higher than the surface temperature. Perhaps Death Valley's temperature would have been higher if the skin temperature had been measured.

Estimated and calculated maximum ground surface temperatures found in the literature find the upper limit to be around 200 °F (93.3 °C). Johnson and Davies (1927) stated, ". . . it is unlikely that the surface temperature of the soil will ever exceed 200 °F [93.3 °C]." Also, Garratt (1992), using numerical atmosphere–soil schemes, said, "Together with the observational evidence, they serve to set a probable upper limit to the maximum land surface temperature in the range 80–93 °C [176–199.4 °F]." Therefore, Death Valley's temperature is about the probable upper limit.

For the remainder of July after the 15th, the ground surface temperatures were lower, ranging from 157 °F (69.4 °C) to 196 °F (91.1 °C). On only two days were temperatures 190 °F (87.8 °C) or higher. Maximum ground surface temperatures in Death Valley for the summer months (June–August 1972–80) ranged from 97 °F (36.1 °C) to 201 °F (93.9 °C).

The lowest maximum ground surface temperature of 97 °F (36.1 °C) occurred on 17 August 1977 after a minimum of 80 °F (26.7 °C). A combination of 24.1 mm of rain for the 24 hours ending at 4.00 p.m. PDT and weak radiation at Las Vegas, Nevada, and Daggett, California, of 3687 $Wh\,m^{-2}$ and 2579 $Wh\,m^{-2}$, respectively, suppressed the temperature that day. Also, the maximum air temperature reached only 85 °F (29.4 °C).

Ground surface temperature observations are scarce. The highest found is 183 °F (83.9 °C), which was measured at Wadi Halfa, Sudan (21°53′N, 31°19′E), and Loango, Congo (4°38′S, 11°50′E), and reported by Cloudsley-Thompson (1977). However, Loango's temperature is questionable because Chang (1958) lists this temperature as 180 °F (82.2 °C).

There are other Death Valley ground surface temperatures of interest from 7 December 1971, the date of instrument calibration, to 1980. The largest daily ground surface temperature range was 108 degF (60 degC). The temperature rose from 58 °F (14.4 °C) to 166 °F (74.4 °C) on 1 May 1972, and from 88 °F (31.1 °C) to 196 °F (91.1 °C) on 28 July 1972. On 22 July 1974, the temperature plummeted 98 degF (54.4 degC) from 180 °F (82.2 °C) to 82 °F (27.8 °C) in about one hour, apparently during a heavy rain shower.

Acknowledgements

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UV section introduction

The Royal Meteorological Society Saturday Meeting is designed to present interesting scientific topics within a meteorological framework to the general public. The aim is to provide the scientific background and latest information on developments within aspects of meteorology. The subject of ultraviolet (UV) radiation was chosen for the meeting held on 7 October 2000. It was considered to be an appropriate choice as UV radiation represents a phenomenon that plays an important role in many processes in the biosphere, and affects everyone on the planet to varying degrees.

UV radiation forms a small part of the full range of electromagnetic radiation (which includes visible and infrared radiation) emitted by the sun. UV radiation will undergo significant absorption by the atmosphere. As a direct consequence of the depletion of stratospheric ozone, higher intensities of UV radiation will reach the earth's surface. The perceived impact of this increased intensity is considered to be so serious that it formed the major topic for discussion at the World Environment Conference in Rio de Janeiro in 1992. A recommendation of the Agenda 21 initiative adopted by the Conference was to "undertake, as a matter of urgency, research on the effects on human health of the increasing ultraviolet radiation reaching the earth's surface as the consequence of depletion of the stratospheric ozone layer." It is this issue that underpins the need to better understand the potential health and environmental risks of UV exposure.

After an extensive literature review of the effects of UV radiation exposure on human health and the environment, a monograph entitled *Environmental Health Criteria 160 'Ultraviolet Radiation'* was published in 1994. The authors were the World Health Organisation in collaboration with the United Nations Environment Program and the International Commission on Non-Ionizing Radiation Protection. At the time, the review was considered to be very timely as more information emerged about the consequences of increasing levels of UV at the earth's surface.

Such was the level of international concern about UV radiation exposure that research projects under the Co-operation in Science and Technology (or COST 713) Initiative of the European Commission were begun in 1996. Within the scientific community, it has been accepted that there is a need to convey much information about UV radiation and the detrimental effects associated with overexposure to the general public. This need resulted in the development of the UV Index, which can be used as an indicator of UV exposure for the different skin types.

This particular Saturday Meeting was therefore designed to give an insight into the relevant issues concerning UV radiation and exposure. The invited speakers gave presentations that covered a wide spectrum of topics relevant to the science of UV radiation and the effects of overexposure right through to more social aspects of trends associated with sunbathing and public awareness campaigns.

Here, we gather together some of the talks, plus an additional paper on the ozone hole from one of its finders. I hope that this collection sparks as much interest amongst the readership of *Weather* as the Saturday Meeting did last year.

Meeting Organiser **Noel Nelson**

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