

WORLD METEOROLOGICAL ORGANIZATION ASSESSMENT OF THE PURPORTED WORLD RECORD 58°C TEMPERATURE EXTREME AT EL AZIZIA, LIBYA (13 SEPTEMBER 1922)

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Due to problems with instrumentation, siting, and observational procedures, the WMO has invalidated the 90-year-old record for the world's highest temperature.

El Azizia (many variant spellings exist) is situated at an elevation of 158 m about 40 km south-southwest of Tripoli, Libya (Fig. 1). The Tripolitania region is subject to a föhn phenomenon locally known as a ghibli, related to offshore breezes originating in the Sahara that consist of hot air from the interior being compressed and heated over north-facing slopes, in this case the Jabal Nafusah mountains in northwestern Libya. It was this phenomenon that led to the purported temperature extreme.

Many—perhaps most—past historical meteorological extremes compilations have accepted the temperature extreme at El Azizia. As Seamon and Bartlett (1956, p. 6) state, “A temperature of 136°F observed at Azizia, Tripolitania, in northern Africa on 13 September 1922 is generally accepted as the world’s highest temperature recorded under standard conditions.” Many other reputable sources have also cited the Azizia record as the world’s most extreme temperature (Anonymous 1924; Bonacina 1924; Anonymous 1930; Talman 1931; Brooks 1935; Seamon and Bartlett 1956; Riordan 1970; U.S. ESSA 1967, 1968; Krause and Flood 1997).

FIG. 1. (a) Regional locator map of El Azizia, Libya, with (b) a vertical roughly north–south cross-section profile of the site (adapted from Fántoli 1958).



One of the major physical rationales for the acceptance of this temperature record was given by Lamb (1958), who suggested that an exceptional föhn wind resulting from a severe thunderstorm far to the south could have created such a remarkable temperature.

However, within a few years of its occurrence, several researchers began to evaluate critically the temperature extreme. An editor of the *Monthly Weather Review* noted that it was “striking that a temperature so high should occur relatively near the sea and in a region of only semidesert character” (Henry 1930, p. 209).

Although personally unable to investigate the extreme’s reliability at the time it occurred, Amilcare Fántoli, the chief of the Libyan section of Servizio Meteorologico, examined the available evidence in some detail (Fántoli 1954, 1958). He concluded that, although there was an unusually violent and persistent ghibli, the most probable maximum at El Azizia on 13 September 1922 was 56°C, not 58°C. Fántoli’s conclusion was significantly influenced by the lack of excessively high temperatures at surrounding stations.

In our reanalysis, the World Meteorological Organization (WMO) Commission of Climatology (CCL) evaluation committee identified five major concerns with this extreme record,

specifically 1) potentially problematical instrumentation, 2) a probable new and inexperienced observer at the time of observation, 3) the unrepresentative microclimate of the observation site, 4) the poor correspondence of the extreme to other records, and 5) the poor comparison to subsequent temperature values recorded at the site.

First, as noted by Fántoli (1954, 1958), the type of instrument used for the extreme measurement, the Bellani-Six thermometer, was actually a replacement instrument to the standard thermometer used for observations. Although we do not have a photograph of the actual instrument used, the Bellani-Six thermometer likely resembled the one depicted in Fig. 2. This instrument, first created by James Six (1731–93), was called a Bellani-Six in Italy as Angelo Bellani was the first Italian manufacturer of such instruments. However, several experts informed the committee that this type of thermometer was more frequently used in private households rather than as official recording instruments. The Bellani-Six thermometer consists of a U-shaped tube with a sealed alcohol container and a sealed ampoule. The ampoules and the linking tubes contain alcohol, while in the middle the tube contains mercury. Steel pins within the alcohol are pushed by the mercury and subsequently retain their positions, their lower ends

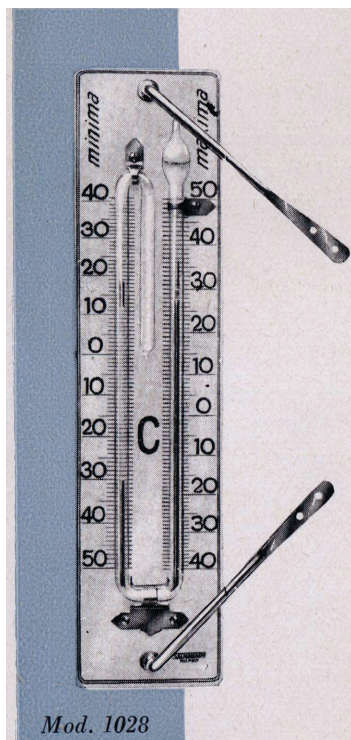


FIG. 2. A 1933 instrument catalog image of the Bellani-Six-style thermometer. (Image supplied by Paolo Brenni, president of the Scientific Instrument Commission, and courtesy of the Library of the Osservatorio Astronomico di Palermo, Giuseppe S. Vaiana.)

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indicating the minimum and maximum temperatures recorded. Daily reset of the instrument is accomplished by use of a magnet.

The displayed image (Fig. 2) is of a type manufactured by Filotecnica Salmoiraghi in the late 1920s. Although this image exhibits a maximum temperature of only 50°C, we assume that the on-site thermometer had a higher range. Judging by Fantoli's remarks, it is unlikely that the Italian Colonial Meteorological Service would have had professional use for such an instrument, so it is probable that it was found elsewhere in the military fort and put into operation when the official maximum thermometer was broken.

The committee also discovered that in 1966, a respected instrument meteorologist, W. E. Knowles Middleton, wrote that, "The difficulty with the Six's thermometer, and indeed with all thermometers containing both spirit [alcohol] and mercury, is that the spirit wets the glass and can at length pass between the glass and the mercury [leading to error in readings]. This was clearly recognized by the middle of the nineteenth century and led to the abandonment of such thermometers as serious meteorological instruments" (Knowles Middleton 1966, p. 161).

Based on this and other knowledge of the instrument, the committee concluded that an individual who was unfamiliar with the Bellani-Six thermometer would likely experience difficulty in accurately reading such a device. The committee deemed it plausible that inaccurate determination of which end of the recording pin (choosing the higher end rather than the correct lower end) to use for temperature evaluation created substantial error in measurement as well as other potential additional reading errors (e.g., slippage of the scale). Our committee consensus is that a total error of approximately 7°C in reading a Bellani-Six thermometer by an inexperienced observer is probable.

Second, the observer's potential inexperience raised concerns for the evaluation committee. The committee deems it probable that a new and/or inexperienced observer started recording at the Azizia site beginning 11 September 1922 and misread the Bellani-Six thermometer. The original data entry sheet (Fig. 3) shows an abnormality beginning on 11 September 1922 and continuing through the month, when the daily temperature maximums and minimums were misplaced in adjoining columns on the log, indicating that the observer was not familiar with the recording process. According to Italian members of the WMO committee, the observer would have been associated with the Italian military but no specific name, rank, or other identification exists.

In addition, beginning on 11 September 1922, the maximum temperature readings increase dramatically, while the minimums continue more or less within range. The daily excursions of temperature therefore suddenly increase, for example, the 24 September 1922 diurnal temperature range from 11° to 45°C. Although a 34°C daily excursion is possible, it does indicate a major shift from the norms, which were established before and after the event.

Third, the microclimate of the observation site was not typical of the area in several aspects. As noted by Fantoli (1954, 1958), the temperature observations

GIORNI	BAROMETRO										TERMOMETRO			Tensione del vapore	Umidità relativa
	D h			S h			N h			Media diurna	Tensione del vapore	Umidità relativa			
	Term.	Bar. osserv. o applicata al barometro	Ridotto a 0°	Term.	Bar. osserv. o applicata al barometro	Ridotto a 0°	Term.	Bar. osserv. o applicata al barometro	Ridotto a 0°						
1											24.0	40.0	34.6		
2											24.8	45.0	39.0		
3											22.0	46.0	40.3		
4											23.0	48.0	38.0		
5											28.0	40.0	34.0		
6											32.0	39.0	29.0		
7											30.0	38.0	28.5		
8											29.0	36.0	26.5		
9											20.0	39.0	30.5		
10											34.0	40.0	38.0		
Somma											112.8	400.0	323.5		
Media											11.28	40.00	32.35		
11											x 50.0	24.0	38.0		
12											x 50.0	24.0	38.5		
13											x 50.0	22.0	36.0		
14											x 53.0	17.0	31.5		
15											x 53.0	21.0	34.2		
16											x 44.0	22.0	36.0		
17											x 45.0	15.0	26.2		
18											x 46.0	22.0	36.0		
19											x 40.0	14.0	34.0		
20											x 44.0	13.0	35.0		
Somma											144.0	118.0	345.7		
Media											14.40	11.80	34.57		
21											x 42.0	14.0	32.0		
22											x 44.0	15.0	33.0		
23											x 41.0	15.0	35.0		
24											x 45.0	11.0	31.0		
25											9	9	9		
26											9	9	9		
27											x 44.8	23.0	37.0		
28											x 48.5	24.4	38.0		
29											x 48.0	20.0	37.0		
30											x 42.0	17.0	28.0		
Somma											131.4	359.3	274.0		
Media											13.14	35.93	27.40		
Somma											149.4	118.0	345.7		
Media											14.94	11.80	34.57		

FIG. 3. A portion of the original meteorological observation sheet for El Azizia for Sep 1922 (source: LNMC). Note the mislabeling occurring in the maximum/minimum temperature columns starting on 11 Sep 1922 ("x's" and ink marking added at an indeterminate time likely long after the original daily observations).

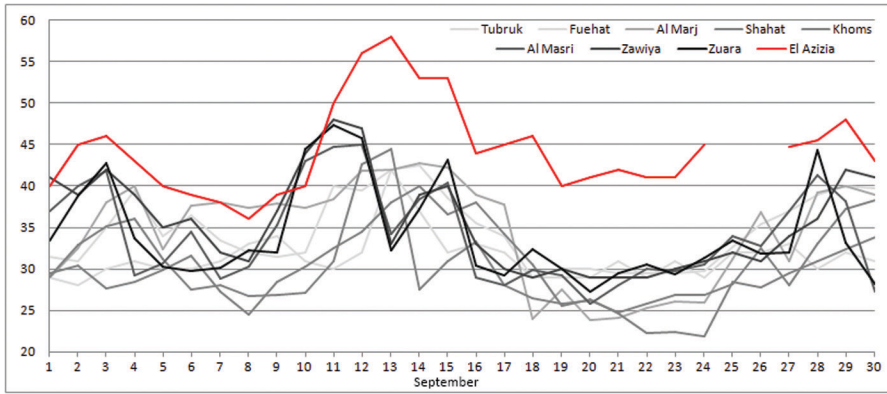


FIG. 4. Maximum temperatures for Sep 1922 recorded at El Azizia (32.5°N, 13.0°E) as compared to nearby stations (Zuara, 32.8°N, 12.1°E; Zawia, 32.8°N, 12.8°E; Sidi al Masri, 32.9°N, 13.2°E; Khoms, 32.6°N, 14.3°E; El Fuehat, 32.1°N, 20.1°E; Shahat, 32.8°N, 21.9°E; and Tubruk, 32.1°N, 23.9°E).

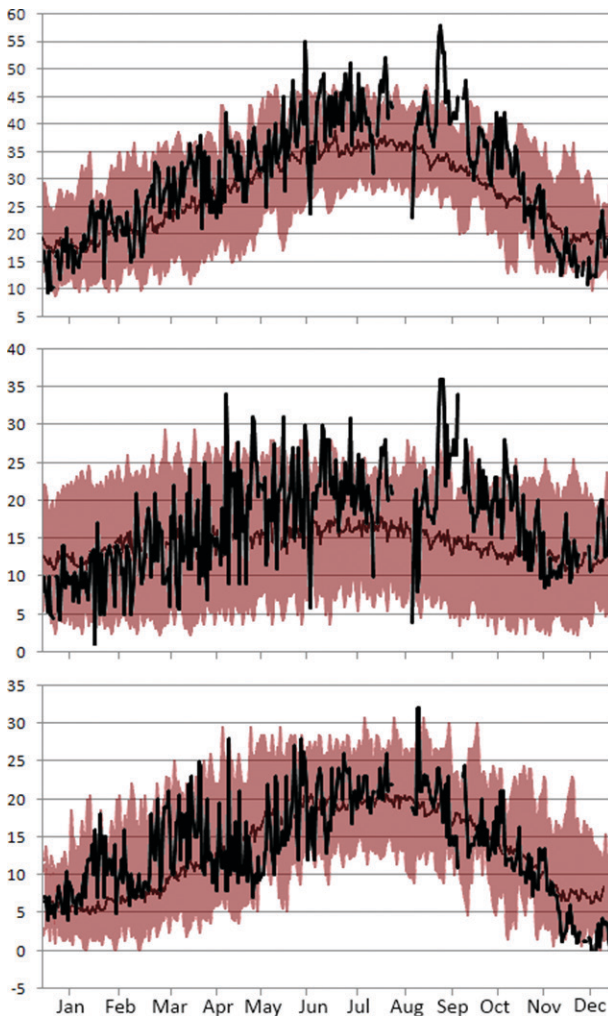


FIG. 5. Meteorogram of El Azizia (top) maximum temperature (°C), (middle) diurnal range (°C), and (bottom) minimum temperature (°C) for 1922 with 1961–90 daily average (red solid line) and 1961–90 daily 99th and 1st percentile limits (delineated in shading). The 13 Sep 1922 maximum in (top) is four sigma deviations off of the 1961–90 average.

were made over a concrete-coated plaza of a small military fort on a hill. The plaza coating of tarred concrete could accentuate surface heating beyond the norms for a natural desert environment. After the instrument shelter in El Azizia was relocated in 1927, only two other temperature readings above 50°C (in the ensuing 48 yr of record) were measured at the site. Besides, the

consistent reduction shown by mainly maximum temperature post-1927 observations cannot be explained by the station relocation, since changes in both altitude and exposure are negligible.

Fourth, this extreme is inconsistent with other temperature analyses and records of the area. Using reliable sea surface temperatures and European, Mediterranean, and limited African surface pressure data, the Twentieth Century Reanalysis (20CR) (Compo et al. 2011) reconstructs daily-mean near-surface air temperatures of approximately 31°C for 13 September 1922. The committee considers this temperature too low to support the Azizia extreme of 58°C, which also would require a physically highly unlikely lapse rate, roughly 2 times dry adiabatic, between the surface and the 20CR 850-hPa temperature. Furthermore (Fig. 4), the maximum temperatures at El Azizia abruptly departed from those of neighboring stations on 12 September 1922, the day after the errors on the recording log sheet began, and remained far higher than the neighbors for the rest of the month. Conversely, modern correspondence between El Azizia and the surrounding stations is high.

Fifth and finally, the 1922 temperature extreme is unrepresentative of the overall behavior of temperature at the site (Fig. 5). During 1920–26 at El Azizia, nine different months recorded 50°C+ absolute maximum temperature readings (including a 56°C reading in August 1923). However, after the instrument shelter was relocated in 1927, only two other temperature readings above 50°C (in the ensuing 48 yr of record) were measured at the site: 51.9°C in June 1928 and 51.0°C in August 1941. Indeed, no reading above 45.9°C was recorded in September following the site change. Variations in T_{max} for the

station in September 1922 are not consistent with those of T_{min} and, consequently, the diurnal temperature range demonstrates an abnormality as well. Daily-mean 20CR 2-m temperatures for the closest grid point to El Azizia (31.43°N, 13.125°E) confirm the unrepresentativeness of the reported temperatures for September 1922. The two highest temperature days in the 20CR record for that grid point were not in 1922 but in June 1995, when reported El Azizia temperatures did not exceed 50°C.

The WMO evaluation committee concludes the most compelling scenario for the 1922 event was that a new and inexperienced observer, not trained in the use of an unsuitable replacement instrument, a Bellani-Six thermometer that can be easily misread, did inadequately record the observation using the wrong end of the recording pin and was consequently off in the observation by about 7°C. Such a scenario is consistent with the sudden departure in correspondence of the maximum temperature observations at El Azizia with those of neighboring stations and the subsequent poor correspondence with earlier and later observations at the site.

Because no conclusive on-site evidence, beyond the original observer log sheet, exists, no definitive determination of the extreme can be made at this late date. However, the WMO panel of experts unanimously concur that the five above-mentioned areas of concern are sufficient to invalidate the temperature extreme of 58°C at El Azizia as the world's official highest recorded temperature. In consequence, in the determination of the WMO World Archive of Weather and Climate Extremes (Cervený et al. 2007a,b), the new official highest temperature recorded on the planet is 56.7°C (134°F) and was measured on 10 July 1913 at Greenland Ranch (Death Valley), California (Court 1949; Roof and Callagan 2003). The new African highest temperature is now 55.0°C (131°F), recorded on 7 July 1931 at Kebili, Tunisia, according to Service Météorologique, Tunis, Tunisia. Fundamentally, investigations of this type will aid in the continued formation and development of reliable high-quality datasets that can be used in climatic change studies.

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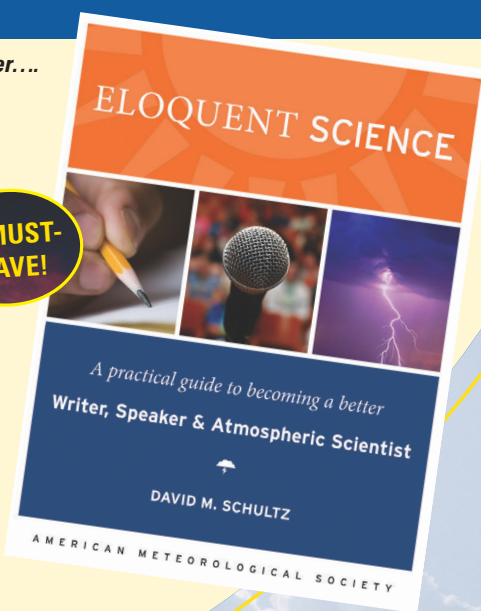
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