Badwater Meteorological Station in Death Valley National Park.
Version; Aug 2019
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Key to final output tables (one file for each year).
A: data sequence number
B: Time of midpoint of sampling interval
C: calibrated RTD air temperature, C [computed values]
D: Day of year (DOY) (runs to 366 for leap year)
E: Time: HHMM at end of sampling interval
F: 207 air temperature, C
G: raw RTD air temperature, C
H: 207 air RH, %
I: light W/m2
J: RTD aspirator state (12 volt = on)
K: pressure (mbars)
L: battery voltage, V
M: internal temperature, C
N: Differential voltage zero (across 10 K Res) (instrument check)

O: 207 max temperature, C
P: 207 time: HHMM
Q: RTD Max air temp, C
R: RTD Max air time: HHMM

The data are direct as recorded by the CR10 (cols D-R) Col A, B and C are added.
Column C is the calibrated RTD values. These are computed from G, the raw RTD
values, based on the calibration. For most users Columns B and C are all that is of
interest.

Station location: N36º13.770' W116º46.022'   elevation: -74 meters
Across the road from the salt flat.

The data logger was installed on 5 April 1998

To convert YYYY, DOY and HHMM into an excel date and time use the following
equation which also sets the time to the midpoint of the interval (15 min earlier).

=(YYYY-1998)*365+35796+INT((YYYY-2001)/4)+ DOY +
INT(HHMM/100)/24+(HHMM-INT(HHMM/100)*100)/(24*60) - 15/(24*60)

The station is based on a Campbell 10x data logger operated by solar recharged batteries.

The system records air temperature at 1.5 m above the surface using a YSI 41342
platinum resistance temperature device (RTD). Air flow over the RTD is achieved using
the YSI 43408 aspirated housing. There are two RTD units used. Each was calibrated
before before installation according to ISO-9002 procedures and traceable to NIST
primary temperature standards. The temperature of the RTD is measured to a relative
precision of ±0.001ºC. However, due to variations in air flow, solar heating, and other
random effects we conservatively estimate that the accuracy with which the RTD
temperature reflects the ambient air temperature is only ±0.1ºC with good calibration.
Error in daily and yearly averages is also ±0.1ºC . Without good calibration the errors are
estimated to be ±0.2ºC

From 11 October 1998 to 8 December 1998 the 207 probe failed and the relative
humidity values for that period have been set to an average value of 19.9%.

Both the raw measurement and the calibrated values are listed in the final data sets.

RTD history Calibrations:
All dates are RTD1 except
Nov 1999 - 15 Jan 2000: RTD2
Hence 2000 to 2019 are all RTD1 using the 1999 RTD calibration

Correction
    TRTD_corrected = (TRTD * 0.00375 + 1 - [intecept])/[slope]

Where intercept and slope determined from calibration

RTD sensor 1 calibration
1998 intercept = 1.000234; slope = 0.0037433
 TRTD_new = (TRTD * 0.00375 - 0.000234)/3.7433300E-03
1999 intercept = .9998642 slope = 0.0037398
 TRTD_new = (TRTD * 0.00375 + 1.D0 - .9998642)/3.7398E-03

RTD sensor 2 calibration
1999 intercept = .9998425 slope = 0.003781452
 TRTD_new = (TRTD * 0.00375 + 1.D0 - .9998425)/0.003781452

The calibration correction is small for typical values. Over a year it averages a reduction in temperature of ~0.1ºC. But for the highest temperatures it is larger, for 50ºC it increases the temperature by 0.18ºC so is important for accurately assessing the hottest temperatures.

If there is interest in the RTD maximum temperature which can be ~1ºC warmer than the 30 minute average then the value in Column Q can be calibrated with the difference between the RTD calibrated and raw value for the corresponding 30 min averages.

Pressure is measured using a PTA-427 pressure transducer with an error of ±1 mbar.

Relative humidity is measured using a Campbell 207 probe which also provides a second air temperature (un-aspirated) reading at 3 m above ground. The error in the humidity measurement is <10%. However, the Campbell 207 RH sensor has high errors for relative humidity values below 15% --- usually tending to systematically overestimate values.

Sunlight is measured with a LiCor 200S pyranometer. The error in the averaged light measurement is less than ±10 W/m2.

All sensors are sampled once every minute and averages of 30 measurements are written to final memory every 30 minutes corresponding to 48 recorded data entries each day.

To conserve power, the aspirator on the RTD is turned on only for high light or high temperature conditions. If the battery voltage drops below 12 the aspirator stops.

Shading of the light sensor. The light sensor is shaded by a pole for about 20 min each day in the late morning. It is effectively measuring only skylight when it is in the deepest shadow.

Battery voltage and the internal temperature of the unit are recorded.

The differential voltage channel is grounded and shorted with a 10 K resistor. Ideally the reading would be zero. This is recorded as an indicator of malfunctions in the instrument

amplifier. The range code is 24 (±250 mv) and the multiplier is 100. The output is mV*100, so reading of 1 indicates a noise of 0.01 mV = 10 uVolts.

Final CR10 Program ca. 2011+
60 sec interval (sensors sample once a minute)

```
1: P09 1 24 24 4 1 2500 2 1 0        ! Young platinum RTD location 2
2: P16 1 2 2 1.0267 0          ! Standart RTD calibration
3: P02 1 24 6 9 100. 0         ! Differential channel zero voltage check
4: P11 1 1 2 1 1 0             ! Air temp 207 to location 1
5: P12 1 2 2 1 3 1 0           ! Air RH 207 to location 3
6: P01 1 3 3 4 100 0           ! Light sensor output to location 4
7: P10 7                       ! Battery voltage to location 7
8: P17 8                       ! Internal temperature to location 8
9: P04 1 5 5 3 300 2500 6 .104 800   ! Pressure sensor to location 6
10: P89 4 3 100 42            ! Fan on if light (4) over 300
11: P89 4 4 100 52            ! Fan off if light (4) less than 300
12: P89 1 3 50 42             ! Fan on if temperature (1) over 50C
13: P89 7 4 12 52             ! Fan off if battery (7) less than 12
14: P01 1 5 4 5 0.011 0       ! Output Fan voltage, 12 if fan is on
15: P92 0 30 10               ! Set output flag every 30 minutes
16: P77 220                   ! Output day and hour
17: P71 9 1                   ! Output averages of first 9 channels
18: P73 2 10 1                ! Max value and minute of both air temp
19: P96 71                    ! Write to external memory module
```

CR10 program
P77 Modified in 2014 midyear, to write out year.

Year by year Notes:

2001 had two data drops, one at the beginning of the year and one mid-year.

2003 one line missing at 6/24/2003 1400 (interpolated and added)

2013 DOY up to 139/1500 needed to be increased by 1

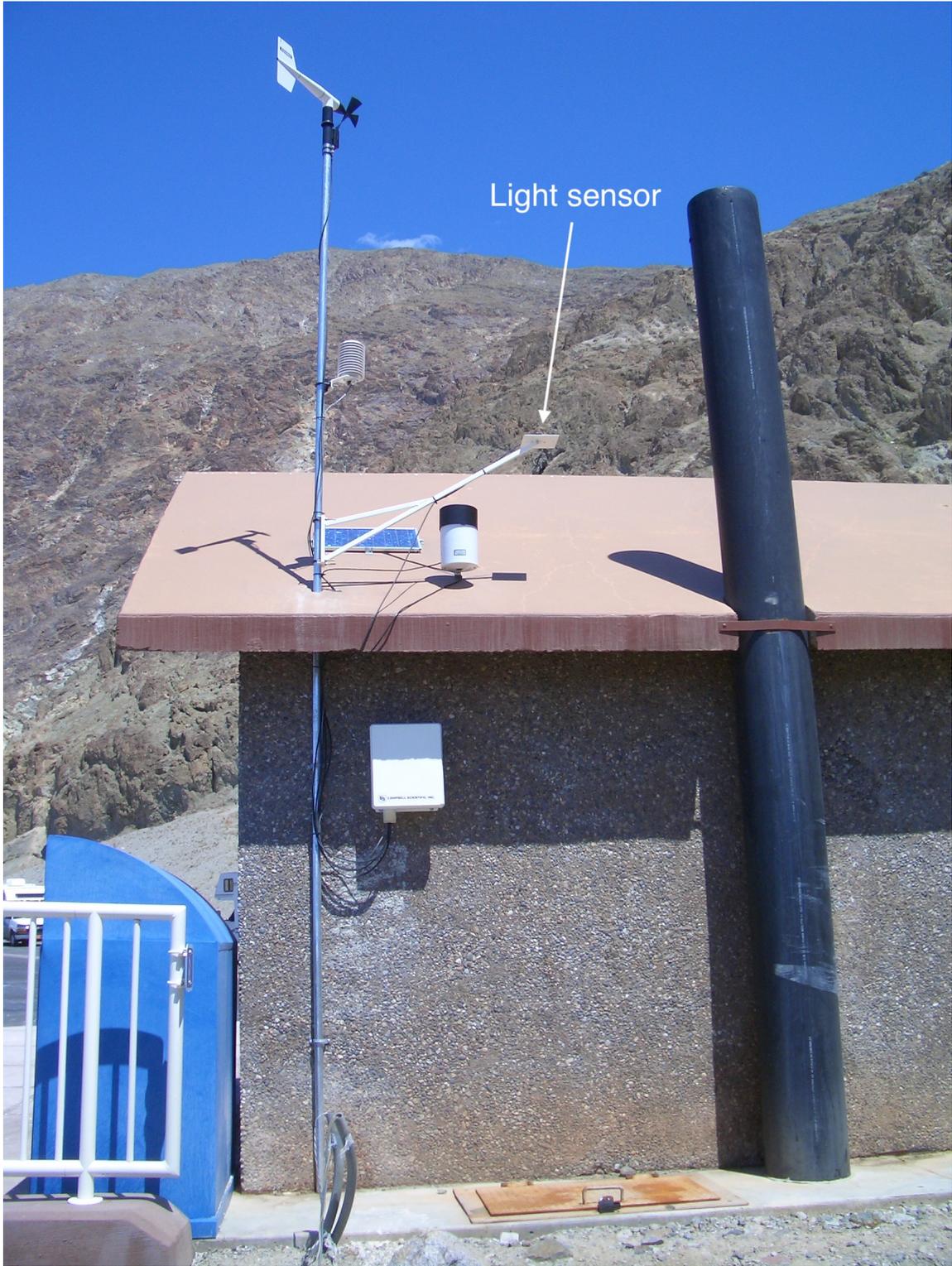2014 Small holes patched: 87,1300-1500; 89,1530; 95,1800

2015 Gap not patched: 1,1730 to 79,300

2017 two Gaps 1,1700 to 79,230 and 237,1400 onward

2018 both ends Gap before 27,830 and after 301,1700

2019 gaps at both ends. Gaps in the middle. (Station getting old).

Outhouse station.

The column assignments for the new station are:

Station ID

Day of Year
HH:MM
Light
Air Temp,C
Air RH
Rain output in mm for initial 9" collector, but $(6/9)^2 = 0.395$ with 6"
Wind, m/s
Pressure, mb
Battery
Temp-instrument
Wind Direction
113,1,30,-.265,6.194,18.88,0,.083,1034,13.1,9.58,225.3

Outhouse program & Notes,   22 Feb 2010/cpm
CR10x serial number:??

60 sec interval

1: P01 1 3 1 **1** 100 0	Light senor output to 1
2: P11 1 2 1 **2** 1 0	Air temp 207 to 2
3: P12 2 3 1 2 **3** 1 0	Air humidity 207 to 3
4: P03 1 1 2 **4** 0.1 0	Rain gauge to 4 (0.1 mm/tip initial 9 inch collector)
5: P04 1 5 5 3 2 2500 **9** 0.142 0	Wind direction to 9 (05-103-L)
6: P03 1 2 21 **5** .0989 0	Wind speed 5
7: ??	Barometric pressure to 6
8: P10 **7**	battery
9: P17 **8**	internal temperature
10: P92 0 30 10	if time
11: P77 220	time code: DOY, HHMM
12: P71 8 1	average 8 reps starting ch 1
13: P70 1 9	sample ch 9 (wind direction)
14: P96 71	write to storage module

Wiring notes:
Wind: Green-ch#5; Black-excit#2; Red-pulse #2; Clear-ground; White-AG; Black-AG
207: ??
??

History:
First installation 3 Dec 2004
Wind added: 1 May 2005, DOY 119

2 April 2005 Rain collector changed to Onsett small black unit 6inch collector diameter, reducing from Campbell TE525MM with 9 inch collector.

Note: Box to ground distance 4'10"
Sidewalk is 2'5" wide
Sidewalk to instrument site 11'6"

22 ft of cable needed total

GPS 36º13.772'N; 116º46.042W Elev: -90 m EPE 6 m

PowerSonic batteries: PS12120 F2 Date:??

Data:

2004
107,338,1930,0,13.12,16.68,0,12.52,16.38
107,366,2400,0,16.49,19.93,0,13.04,16.55

2005
107,1,30,0,16.3,20.16,0,13.04,16.35
107,85,1800,7.57,23.72,12.71,0,13.34,29.35

113,119,1500,357.4,29.69,11.19,0,2.242,1022,13.77,35.56,240.1
113,365,2400,-.533,12.76,39.31,0,1.023,1020,12.86,15.31,105.5

2006
113,1,30,-.563,13.41,36.42,0,1.495,1021,12.84,14.82,117.7
113,365,2400,-.671,5.743,19.62,0,.481,1029,12.79,8.91,270

2007
113,1,30,-.671,6.114,19.44,0,.776,1029,12.77,8.42,211.9
113,33,800,7.18,7.49,20.52,0,.601,1032,11.95,7.87,104.1

113,335,1230,258.8,19.04,14.24,0,3.802,1013,13.79,18.24,30.36
113,365,2400,-.671,12.7,16.51,0,1.908,1043,12.85,13.23,201.8

2008:
113,1,30,-.671,12.1,16.73,0,1.208,1043,12.83,12.88,178.6
113,366,2400,-.671,8.27,28.43,0,.545,1029,13.06,11.46,92.1

2009
113,1,30,-.671,6.048,35.81,0,.264,1029,13.04,10.9,244
113,365,2400,-.671,8.18,19.15,0,.259,1039,13.1,10.99,111

2010

113,1,30,-.671,8.19,19.16,0,.124,1040,13.09,10.61,114.3

ID, DOY, HHMM, LIGHT, TEMP, RH, RAIN, W-SPEED, PRES, BAT, T, W-DIR

113,12,1200,289.8,17.31,14.85,0,.945,1039,13.97,10.45,139.3

113,12,1230,288.4,18.79,14.32,0,.845,1038,13.92,13.33,183.4

113,12,1300,279,20.15,13.83,0,.86,1037,13.72,16.65,149.5

113,12,1330,262.3,21.82,13.23,0,.615,1037,13.64,19.91,179.6

113,12,1400,238.3,23.52,12.62,0,.603,1036,13.7,22.64,249.2