

# 2021 WEATHER REPORT

---

*Erik Feibert and Stuart Reitz, Malheur Experiment Station, Oregon State University, Ontario, OR*

## Introduction

Air temperature and precipitation have been recorded daily at the Malheur Experiment Station since July 20, 1942. Installation of additional equipment in 1948 allowed for evaporation and wind measurements. A soil thermometer at 4-inch depth was added in 1967. Since 1962, the Malheur Experiment Station has participated in the national cooperative weather station system of the National Weather Service. The daily readings from the station are reported to the National Weather Service forecast office in Boise, Idaho. Starting in June 1997, the daily weather data and the monthly weather summaries have been posted on the Malheur Experiment Station website at <https://agsci.oregonstate.edu/mes>.

On June 1, 1992, in cooperation with the U.S. Department of the Interior, Bureau of Reclamation, a fully automated weather station, linked by satellite to the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) computer in Boise, Idaho, began transmitting data from Malheur Experiment Station. The automated AgriMet station continually monitors air temperature, relative humidity, dew point temperature, precipitation, wind run, wind speed, wind direction, solar radiation, and soil temperature at 8-inch and 20-inch depths. Data are transmitted via satellite to a computer in Boise every 4 hours and are used to calculate daily Malheur County crop water-use estimates. The ground under and around the weather stations was bare until October 17, 1997, when it was covered with turf grass. The AgriMet database can be accessed at <https://www.usbr.gov/pn/agrimet/> and from links on the Malheur Experiment Station web page at <https://agsci.oregonstate.edu/mes>.

## Materials and Methods

The manually observed weather data are recorded each day at 8:00 a.m. Consequently, the data in the tables of daily observations refer to the previous 24 hours.

Evaporation is measured from April through October as inches of water evaporated from a standard class A pan (10 inches deep by 4-ft diameter) over 24 hours. Reference evapotranspiration ( $ET_r$ ) is calculated by AgriMet using data from the AgriMet weather station and the Kimberly-Penman equation (Wright 1982). AgriMet calculates  $ET_r$  for a theoretical 12- to 20-inch-tall crop of alfalfa assuming full cover for the whole season. Wind run is measured by the AgriMet weather station as total wind movement in miles over 24 hours at 9.8 ft above the ground. Weather data averages in the tables, except evapotranspiration, refer to the years preceding and up to, but not including, the current year.

## 2021 Weather

The total precipitation for 2021 (8.24 inches) was lower than the 10-year (10 inches) and 78-year (10.1 inches) averages (Table 1). Precipitation for all months was lower than or close to average, except for August which had higher than average precipitation (1.02 inches). Total snowfall for 2021 (20.3 inches) was slightly higher than the 78-year average (17.3 inches) (Table 2).

The highest air temperature for 2021 was 104°F on June 30, July 1, and July 7 (Table 3). The lowest air temperature for 2021 was 5°F on December 30. The months of January, June, and July had average maximum and minimum air temperatures higher than average (Table 3, Figures 1 and 2). In 2021, the average maximum air temperature in July was the highest since records began in 1943. In 2021, the average minimum air temperature in June and July were the highest since records began in 1943. Air temperatures for the other months were close to average.

The average maximum and minimum 4-inch soil temperatures in 2021 were close to average. (Table 4).

Total monthly wind runs in March, May, August, and October in 2021 were higher than the 28-year averages (Table 5). The total wind run for August in 2021 was the highest since records began in 1993.

Total pan evaporation (64.5 inches) in 2021 was the highest since records began in 1948 (Table 6). Total accumulated  $ET_r$  (67.5 inches) in 2021 was the highest since records began in 1993 (Table 7).

The year 2021 had 3671 growing degree-days (50 to 86°F), higher than the 78-year average of 3245 (Table 8). The months of June and July had substantially more growing degree-days than average. July had the highest growing degree-days since 1943. The year 2021 had a longer than average frost-free period (171 days) (Table 9). The last spring frost ( $\leq 32^\circ\text{F}$ ) occurred on May 2, the same as the 78-year-average date of May 2; the first fall frost occurred on October 15, 9 days later than the 78-year-average date of October 6.

Since 1943, the highest July average maximum air temperature and the highest June and July average minimum air temperatures were recorded in 2021 (Table 10). Since 1948, the highest annual evaporation occurred in 2021. Since 1992, the highest reference evapotranspiration occurred in 2021.

## Acknowledgements

This work was supported by the National Oceanic and Atmospheric Administration, U.S. Bureau of Reclamation, Oregon State University, the Malheur County Education Service District, and Formula Grant nos. 2021-31100-06041 and 2021-31200-06041 from the USDA National Institute of Food and Agriculture.

## References

Wright, J.L. 1982. New evapotranspiration crop coefficients. *Journal of Irrigation and Drainage Division, American Society of Civil Engineers* 108:57–74.

Table 1. Monthly precipitation at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1990–2021.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	----- inches -----												
1990	0.44	0.35	0.72	1.52	1.70	0.36	0.04	0.61	0.00	0.49	0.69	0.29	7.21
1991	0.59	0.44	0.88	0.81	1.89	1.09	0.01	0.04	0.35	1.01	1.71	0.43	9.25
1992	0.58	1.36	0.25	0.74	0.21	1.43	0.36	0.01	0.09	0.95	1.15	1.51	8.64
1993	2.35	1.02	2.41	2.55	0.70	1.55	0.18	0.50	0.00	0.80	0.64	0.60	13.30
1994	1.20	0.57	0.05	1.02	1.62	0.07	0.19	0.00	0.15	1.23	2.46	1.49	10.05
1995	2.67	0.28	1.58	1.16	1.41	1.60	1.10	0.13	0.07	0.57	0.88	2.56	14.01
1996	0.97	0.86	1.03	1.19	2.39	0.12	0.32	0.31	0.59	0.97	1.18	2.76	12.69
1997	2.13	0.17	0.25	0.66	0.67	0.86	1.40	0.28	0.40	0.43	1.02	0.94	9.21
1998	2.26	1.45	0.95	1.43	4.55	0.36	1.06	0.00	1.00	0.04	1.07	1.11	15.28
1999	1.64	2.50	0.59	0.23	0.28	1.02	0.00	0.09	0.00	0.40	0.49	0.73	7.97
2000	2.01	2.14	0.97	0.72	0.28	0.26	0.03	0.06	0.39	1.74	0.38	0.66	9.64
2001	1.15	0.41	1.11	0.70	0.37	0.64	0.32	0.00	0.10	0.68	1.33	1.00	7.81
2002	0.77	0.27	0.49	0.77	0.09	0.60	0.14	0.10	0.36	0.29	0.44	1.86	6.18
2003	1.46	0.48	0.99	1.12	1.52	0.24	0.36	0.11	0.15	0.02	0.86	1.47	8.78
2004	1.82	1.54	0.25	0.98	1.70	0.43	0.13	0.64	0.56	2.03	0.93	0.97	11.98
2005	0.41	0.12	1.66	0.80	2.94	1.02	0.22	0.06	0.14	1.38	1.58	3.92	14.25
2006	1.91	0.67	3.33	2.00	0.62	0.45	0.00	0.08	0.55	0.28	1.14	1.76	12.79
2007	0.07	0.95	0.12	0.82	0.47	0.63	0.03	0.15	0.92	0.68	1.07	1.56	7.47
2008	0.50	0.43	0.79	0.14	0.74	0.27	0.43	0.03	1.26	0.44	1.12	1.47	7.62
2009	0.65	0.43	0.86	0.13	1.47	2.27	0.09	1.39	0.02	1.24	0.63	1.82	11.00
2010	2.13	1.19	0.59	1.21	1.18	1.95	0.02	0.86	0.19	1.16	1.09	4.19	15.76
2011	1.05	0.42	2.97	0.44	2.61	0.81	0.19	0.02	0.08	1.59	0.57	0.45	11.20
2012	1.65	0.49	1.36	1.03	0.77	0.45	0.00	0.04	0.10	0.83	1.13	1.25	9.10
2013	0.58	0.34	0.32	0.19	0.37	0.80	0.00	0.11	2.39	0.44	0.90	0.59	7.03
2014	0.69	1.58	1.22	0.92	0.45	0.24	0.02	0.28	0.62	0.52	1.46	3.04	11.04
2015	0.64	0.74	0.77	0.67	1.80	0.18	0.51	0.05	0.50	1.13	1.29	3.21	11.49
2016	0.98	0.38	0.98	0.88	0.95	0.25	0.98	0.01	0.13	0.75	0.58	2.11	8.98
2017	3.02	1.61	1.61	1.27	1.02	0.62	0.00	0.00	0.49	0.45	0.00	0.84	10.93
2018	1.41	0.26	1.12	0.62	0.56	0.47	0.00	0.00	0.01	1.23	0.51	1.13	7.32
2019	1.48	3.38	1.17	1.53	2.27	0.18	0.00	0.09	1.36	0.71	0.14	1.22	13.53
2020	1.68	0.43	0.62	0.47	1.95	2.07	0.05	0.00	0.08	0.48	1.41	0.50	9.74
2021	1.23	1.22	0.13	0.06	0.63	0.25	0.00	1.02	0.33	1.18	0.78	1.41	8.24
10-yr avg	1.32	0.96	1.21	0.80	1.28	0.61	0.18	0.06	0.58	0.81	0.80	1.43	10.04
78-yr avg	1.26	0.95	0.94	0.79	1.08	0.80	0.22	0.33	0.48	0.74	1.13	1.41	10.13

Table 2. Annual total snowfall (inches) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1943–2021. Average annual snowfall (1943–2020) is 17.3 inches.

		1943	1944	1945	1946	1947	1948	1949	1950
		24.7	10.3	19.0	8.2	9.1	14.6	9.6	23.9
1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
32.4	22.3	7.5	10.4	40.3	15.6	26.4	9.8	12.1	21.2
1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
9.7	14.8	13.3	32.6	19.6	6.3	11.9	14.9	24.8	13.5
1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
17.1	23.7	19.2	20.3	27.3	21.3	21.3	9.3	31.0	11.5
1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
14.5	32.7	35.4	21.0	33.4	13.0	15.5	34.8	25.1	5.7
1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
7.5	15.5	36.0	32.0	15.0	14.5	5.8	14.6	13.2	13.8
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15.5	11.5	4.5	24.0	13.5	12.3	3.8	26.0	13.8	28.0
2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1.0	4.0	14.0	22.5	14.0	24.5	31.5	3.8	11.3	8.8
2021									
									20.3

Table 3. Maximum and minimum air temperatures (°F) by month, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021 and 78-year average.

Month		2021		78-year average	
		Maximum	Minimum	Maximum	Minimum
January	Mean	41	28	35	20
	Highest	51	35		
	Lowest	33	19		
February	Mean	43	24	44	25
	Highest	59	38		
	Lowest	31	11		
March	Mean	57	29	55	31
	Highest	79	37		
	Lowest	42	22		
April	Mean	67	35	64	37
	Highest	84	48		
	Lowest	49	24		
May	Mean	73	47	74	45
	Highest	90	61		
	Lowest	56	37		
June	Mean	91	59	82	52
	Highest	104	69		
	Lowest	68	46		
July	Mean	99	65	92	58
	Highest	104	72		
	Lowest	91	60		
August	Mean	89	59	91	56
	Highest	102	70		
	Lowest	78	46		
September	Mean	81	47	80	46
	Highest	91	67		
	Lowest	65	35		
October	Mean	66	40	65	37
	Highest	79	51		
	Lowest	54	29		
November	Mean	51	33	48	28
	Highest	67	41		
	Lowest	42	23		
December	Mean	39	26	37	22
	Highest	53	37		
	Lowest	24	5		

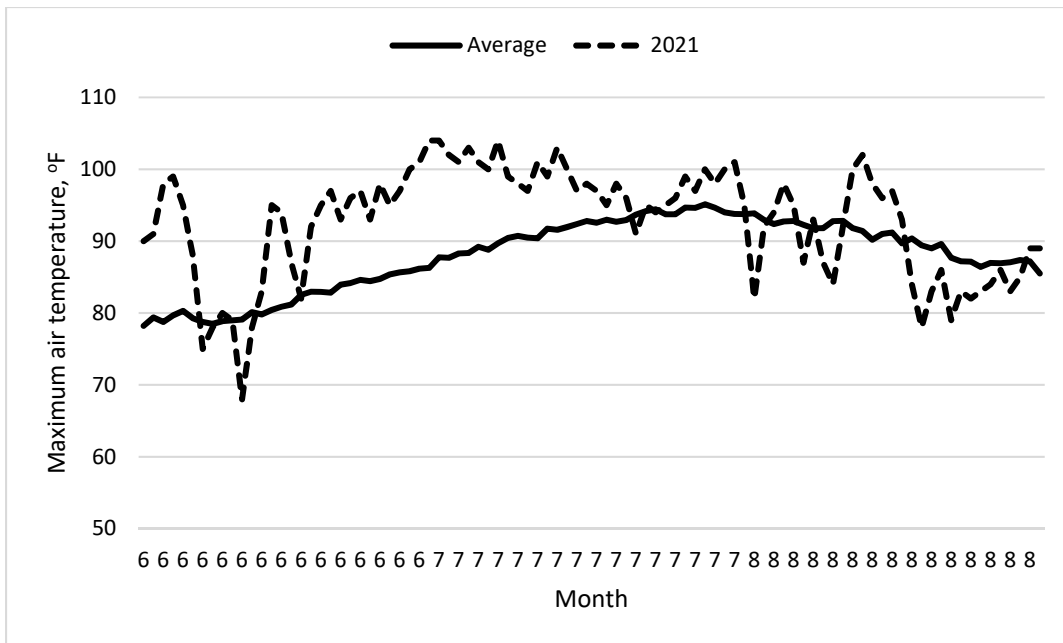


Figure 1. Maximum daily air temperature for June, July, and August in 2021 and the 79-year average. Malheur Experiment Station, Oregon State University, Ontario, OR.

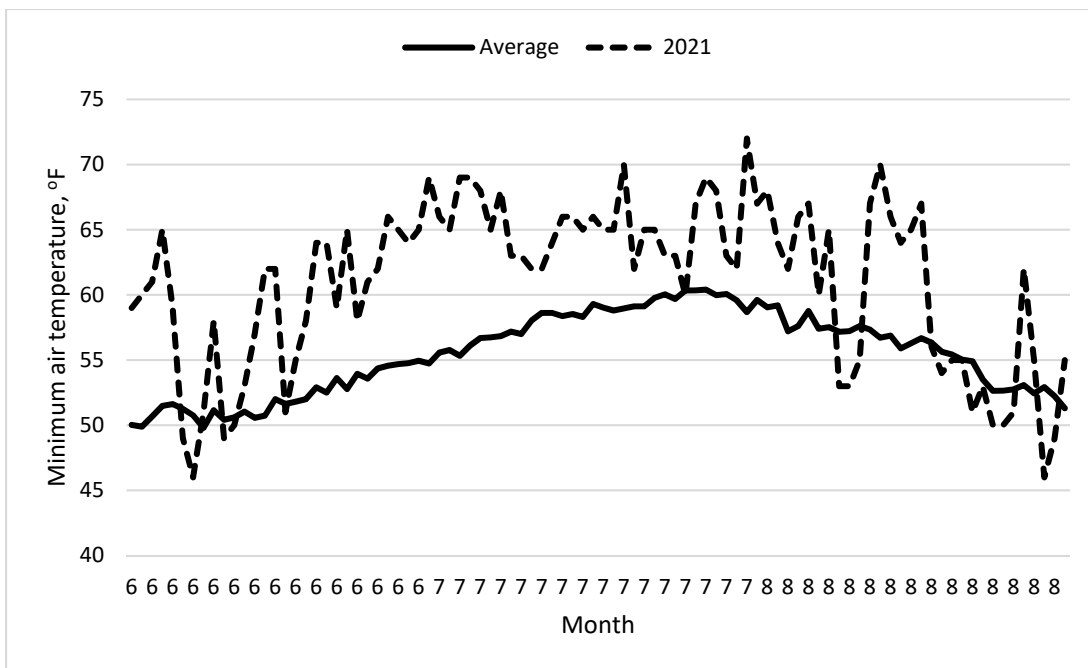


Figure 2. Minimum daily air temperature for June, July, and August in 2021 and the 79-year average. Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 4. Monthly mean maximum and minimum soil temperatures (°F) at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021 and 22-year average.

Month		2021		22-year average	
		Maximum	Minimum	Maximum	Minimum
January	Mean	37	36	34	34
	Highest	39	37		
	Lowest	34	34		
February	Mean	37	36	37	36
	Highest	41	39		
	Lowest	35	34		
March	Mean	44	42	46	42
	Highest	49	46		
	Lowest	36	34		
April	Mean	54	50	54	50
	Highest	61	57		
	Lowest	48	44		
May	Mean	62	59	65	59
	Highest	68	65		
	Lowest	57	55		
June	Mean	73	69	73	67
	Highest	81	78		
	Lowest	66	63		
July	Mean	78	74	79	72
	Highest	80	78		
	Lowest	74	66		
August	Mean	75	72	77	71
	Highest	81	77		
	Lowest	71	67		
September	Mean	68	65	68	64
	Highest	71	69		
	Lowest	63	60		
October	Mean	58	56	57	54
	Highest	63	60		
	Lowest	54	52		
November	Mean	48	46	45	43
	Highest	56	54		
	Lowest	41	40		
December	Mean	39	38	36	35
	Highest	43	41		
	Lowest	34	34		

Table 5. Daily and monthly wind run, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

Daily	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	----- miles/day -----											
Mean	94	121	154	143	171	131	109	124	102	135	76	104
Max	348	258	375	366	397	253	182	311	250	479	246	261
Min	29	45	58	60	76	56	55	50	50	43	32	21
Monthly total	----- miles/month -----											
2021	2636	3374	4774	4288	5304	3942	3374	3834	3065	4177	2270	3227
28-yr average	2802	3297	4185	4592	4212	3700	3368	3307	3141	3264	2987	3140

Table 6. Daily and monthly pan evaporation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

Totals	April	May	Jun	Jul	Aug	Sep	Oct	Total
	----- inches/day -----							
Daily								
Mean	0.26	0.32	0.43	0.41	0.33	0.23	0.15	
Max.	0.48	0.54	0.58	0.54	0.48	0.36	0.30	
Min.	0.06	0.10	0.24	0.25	0.15	0.11	0.01	
Monthly	----- inches/month -----							
2021	7.44	9.78	12.84	12.86	10.20	6.81	4.54	64.47
10-yr avg	6.48	8.69	10.41	12.55	10.62	6.82	3.87	59.43
73-yr avg	5.78	7.87	9.18	11.41	9.82	6.38	3.38	53.81

Table 7. Total accumulated reference evapotranspiration (ET<sub>r</sub>) (acre-inch/acre) over the past 29 years, Malheur Experiment Station, Oregon State University, Ontario, OR, 1993–2021.

Year	ref ET	Year	ref ET
1993	52.0	2008	63.2
1994	57.8	2009	59.3
1995	49.9	2010	56.2
1996	53.2	2011	57.4
1997	55.4	2012	62.9
1998	55.2	2013	65.8
1999	58.8	2014	64.5
2000	60.5	2015	64.8
2001	58.8	2016	65.0
2002	59.0	2017	58.6
2003	61.4	2018	62.8
2004	57.7	2019	60.0
2005	58.3	2020	60.6
2006	64.0	2021	67.5
2007	66.0	Average	59.9



Table 8. Monthly total growing degree-days (50–86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1990–2021.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	4	24	144	317	326	504	696	611	565	217	46	0	3451
1991	0	38	82	184	294	436	687	666	485	296	6	2	3174
1992	2	42	212	283	520	573	609	647	436	281	15	0	3617
1993	0	0	54	160	445	402	481	526	457	269	24	5	2820
1994	0	4	190	265	414	505	704	689	518	230	8	0	3524
1995	2	68	75	186	340	459	647	566	482	201	22	19	3064
1996	0	21	109	211	311	485	664	582	403	245	50	10	3088
1997	4	15	149	189	435	509	623	613	484	241	53	0	3313
1998	1	9	106	186	289	434	730	666	524	254	48	12	3256
1999	0	10	97	184	326	470	618	650	460	292	83	4	3193
2000	2	19	87	283	395	509	684	659	420	227	12	0	3294
2001	0	0	129	178	434	493	687	691	515	246	73	0	3444
2002	0	6	72	220	376	563	735	601	473	243	39	13	3337
2003	0	17	135	182	371	569	747	706	478	361	30	11	3605
2004	0	1	198	271	343	520	706	652	422	259	10	2	3381
2005	0	21	136	210	343	451	666	673	437	239	11	0	3185
2006	0	17	58	209	407	588	775	638	444	244	62	5	3445
2007	0	23	186	225	439	535	778	629	456	204	52	7	3532
2008	0	2	46	157	390	503	711	654	442	242	46	8	3199
2009	2	7	72	222	406	514	699	632	536	142	44	0	3274
2010	2	2	109	171	267	454	651	600	445	287	57	0	3042
2011	0	9	42	122	276	411	625	645	514	232	18	5	2896
2012	2	11	115	252	347	466	728	675	490	235	54	14	3386
2013	0	8	119	233	392	501	709	666	466	214	21	7	3334
2014	0	22	111	226	238	409	754	685	490	299	42	13	3288
2015	1	74	178	232	396	643	705	659	448	333	39	8	3715
2016	0	39	122	304	398	530	627	612	433	243	80	0	3387
2017	0	0	108	165	359	552	767	707	480	197	23	0	3357
2018	1	29	99	227	480	529	738	687	478	218	38	0	3521
2019	0	4	90	216	369	540	711	704	459	139	52	0	3283
2020	1	22	125	243	376	486	667	709	459	279	55	0	3419
2021	1	15	117	251	371	640	795	684	478	249	48	2	3648
Average 1943-2021	1	15	96	216	372	504	676	637	451	242	36	3	3250

Table 9. Last and first frost (32°F) dates and number of frost-free days, Malheur Experiment Station, Oregon State University, Ontario, OR, 1990–2021.

Year	Date of last spring frost	Date of first fall frost	Total frost-free days
1990	8-May	7-Oct	152
1991	30-Apr	4-Oct	157
1992	24-Apr	14-Sep	143
1993	20-Apr	11-Oct	174
1994	15-Apr	6-Oct	174
1995	16-Apr	22-Sep	159
1996	6-May	23-Sep	140
1997	3-May	8-Oct	158
1998	18-Apr	17-Oct	182
1999	11-May	28-Sep	140
2000	12-May	24-Sep	135
2001	29-Apr	10-Oct	164
2002	8-May	12-Oct	157
2003	19-May	11-Oct	145
2004	16-Apr	24-Oct	191
2005	15-Apr	6-Oct	174
2006	19-Apr	0ct 22	186
2007	4-May	11-Oct	160
2008	2-May	13-Oct	164
2009	13-May	1-Oct	141
2010	7-May	12-Oct	158
2011	4-May	25-Oct	174
2012	29-Apr	4-Oct	158
2013	23-May	5-Oct	135
2014	29-Apr	22-Oct	176
2015	15-Apr	27-Oct	195
2016	28-Mar	12-Oct	198
2017	13-May	10-Oct	150
2018	19-Apr	14-Oct	178
2019	1-May	2-Oct	154
2020	18-Apr	16-Oct	181
2021	27-Apr	15-Oct	171
avg 1943-2019	2-May	6-Oct	157

Table 10. Record weather events at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Record event	Measurement	Date
----- Since 1943 -----		
Highest annual precipitation	16.87 inches	1983
Lowest annual precipitation	5.16 inches	1949
Highest monthly precipitation	4.55 inches	May 1998
Highest June precipitation	2.27 inches	June 2009
Highest December precipitation	4.19 inches	December 2010
Highest 24-hour precipitation	1.52 inches	September 14, 1959
Highest annual snowfall	40 inches	1955
Greatest snow depth	28 inches	January 17, 2017
Highest 24-hour snowfall	10 inches	November 30, 1975
Earliest snowfall	1 inch	October 25, 1970
Highest air temperature	110°F	July 22, 2003
Total days with maximum air temp. $\geq 100^\circ\text{F}$	18 days	2013, 2021
Lowest air temperature	-26°F	January 21 and 22, 1962
Total days with minimum air temp. $\leq 0^\circ\text{F}$	35 days	1985
Lowest average maximum air temperature for October	58°F	2019
Lowest average minimum air temperature for October	29°F	2019
Lowest minimum air temperature in October	10°F	October 31, 2019
Highest July average maximum air temperature	99°F	July 2021
Highest June average minimum air temperature	59°F	June 2021
Highest July average minimum air temperature	65°F	July 2021
Longest frost-free period	198 days	2016
----- Since 1948 -----		
Highest annual evaporation	64.5 inches	2021
----- Since 1967 -----		
Lowest soil temperature at 4-inch depth	12°F	December 24, 25, and 26, 1990
----- Since 1993 -----		
Most yearly growing degree-days	3876	2015
Fewest yearly growing degree-days	2768	1993
Fewest growing degree-days in March	39	2008
Fewest growing degree-days in April	106	2011
Most growing degree-days in April	305	2016
----- Since 1992 -----		
Highest annual reference evapotranspiration	67.5 inches	2021