14 Upper Air

14.1 General Description

Montana's upper level climate data are limited to radiosonde (balloon soundings) taken twice daily at Glasgow and Great Falls. Winds aloft increase in velocity with height and are strongest in the winter and weakest in the summer.

14.2 Radiosonde

If the total amount of water vapor in the atmosphere were concentrated into a layer of liquid, this amount would be referred to as precipitable water (*h*). The importance of knowing what the *h* is relates to forecasting thunderstorms and making first-order predictions of the opacity of the atmosphere. Generally, for thunderstorms to occur at in western Montana, the supply of moisture in the atmosphere should be at least 0.6 inch (15 mm). Given a conditionally unstable atmosphere, isolated thunderstorms with measurable precipitation could occur and, with 0.80 inch or greater *h*, scattered thunderstorms that could generate over 0.25 inch of precipitation are possible. Figure 1 shows the range of values for *h* from 1948-2012 for the atmosphere up to 300 mb at Glasgow. Figure 2 shows the same for Great Falls. Many other factors come into play, to list a few: stability of the atmosphere, vertical wind profile, temperature, moisture advection, and the level where the most moisture is present (in Montana, ideally moisture between the 700 mb and 500 mb layer or 10,000 feet to 18,500 feet helps to produce thunderstorms). Although a warm atmosphere can hold more water than a cold atmosphere, so an unstable profile with a surface temperature of 60°F and an *h* of 0.50 inch will result in more condensation, clouds and potential for thunderstorms and rainfall, than one with a surface temperature of 90°F and the same precipitable water value.

Normals are not generally created for upper air information. A climatology for precipitable water has been created by the National Weather Service Rapid City office. These plots show the maximum precipitable water measured for each month at both locations, in addition to the minimum, “normal – 50th percentile”, and other threshold levels. It is pretty apparent that the summer months are the period with the most moisture in the atmosphere.

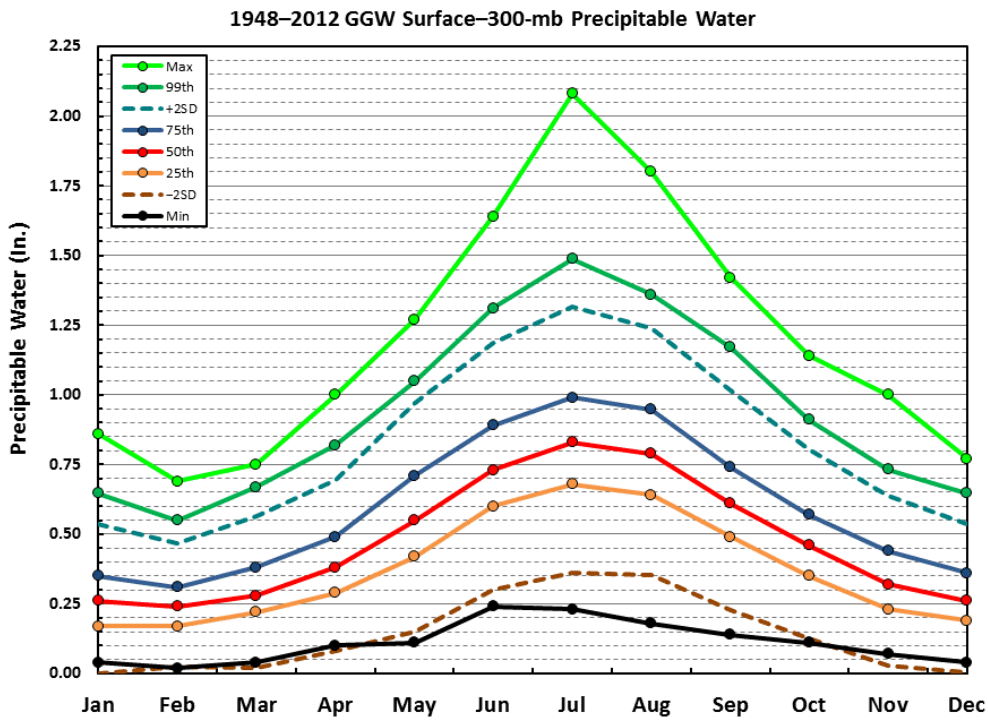

Figure 1. Precipitable water data for Glasgow.

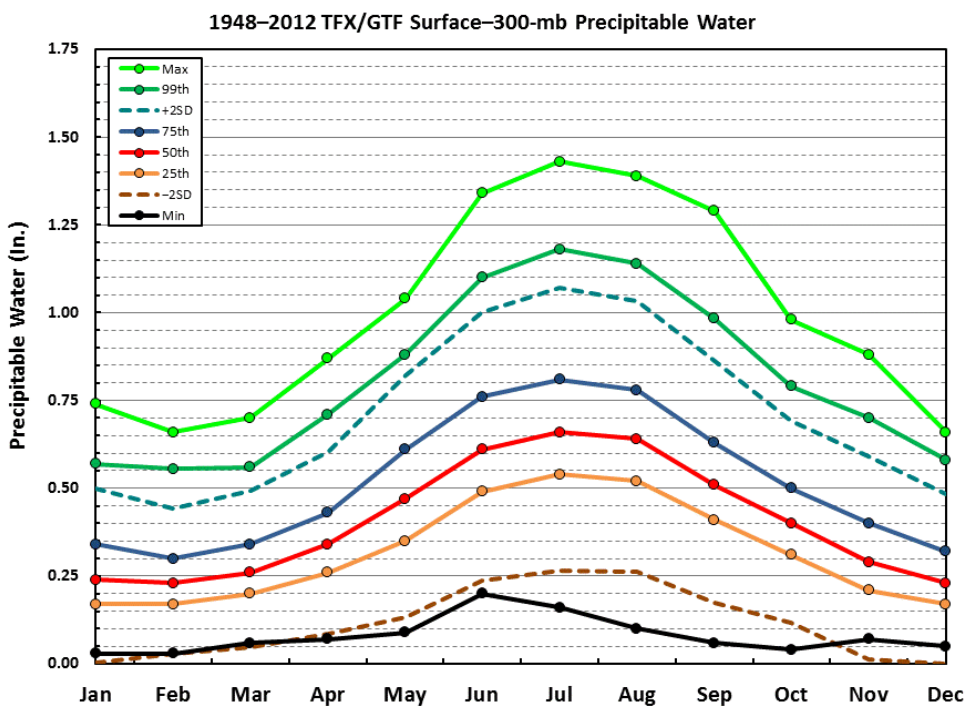

Figure 2. Precipitable water data for Great Falls.

14.3 Upper air climatology

A climatology of Great Falls upper air data is shown in the following table:

Table 1. The highest and lowest heights at 1000 mb and 850 mb (meters).

Mon	1000 mb max hgt	date	1000 mb min hgt	date	850 mb max hgt	date	850 mb min ht	date
Jan	474m	10/1962	-151	13/1980	1674	10/1962	1184	12/1972
Feb	453m	03/1989	-153	25/1958	1639	26/2002	1210	25/1958
Mar	431m	21/2002	-165	5/1991	1634	21/2002	1226	5/1991
Apr	338m	02/2002	-140	28/2010	1610	3/2004	1247	28/2010
May	310m	2/1954	-111	22/1966	1630	6/1949	1256	26/1980
Jun	262m	09/1955	-114	09/2000	1615	25/2006	1318	8/1964
Jul	249m	3/1972	-89	16/1987	1614	4/1972	1366	4/1951
Aug	243m	18/1956	-97	31/1999	1602	19/1961	1356	18/1980
Sep	304m	21/1995	-96	25/1986	1626	21/1995	1273	25/1986
Oct	327m	30/1991	-125	17/1991	1628	22/1953	1266	29/2003
Nov	387m	28/1979	-131	26/1970	1658	29/1979	1242	26/1973
Dec	478m	24/1983	-141	23/1955	1658	10/1957	1208	7/1952

Table 2. The highest and lowest temperatures at 850 mb (C), the highest recorded wind (kts), and the highest heights at 700 mb (meters).

Mon	850 mb max tmp	date	850mb min tmp	date	850 mb max wd	date	700 mb max hgt	date
Jan	15.2	20/2009	-35.9	2/1950	60kts	1/1959	3272	19/2009
Feb	16.6	28/1992	-38.7	2/1989	62	8/1960	3184	7/1987
Mar	20.0	24/1993	-33.0	7/1951	54	1/1961	3179	9/2004
Apr	25.4	21/1980	-24.3	2/1954	52	4/1967	3209	24/1977
May	27.4	13/1960	-11.2	1/1954	52	31/1984	3209	7/1987
Jun	30.8	28/2002	-2.9	1/2009	58	11/1959	3239	26/2006
Jul	34.2	20/2007	0.6	16/1999	46	9/2011	3251	4/1970
Aug	34.4	6/1961	-1.5	22/1992	42	23/1978	3257	5/1961
Sep	31.1	6/1967	-7.3	22/2000	58	8/1957	3273	4/1988
Oct	27.0	1/1992	-19.2	31/1984	87	08/1966	3247	14/1961
Nov	20.7	4/1962	-30.9	27/1985	65	3/1959	3215	25/1956
Dec	17.9	5/1989	-37.0	16/1964	58	23/1963	3204	24/1999

Table 3. All at 700 mb – the lowest height (m), highest and lowest temperatures (C), the highest recorded wind (kts).

Mon	700 mb min hgt	date	700 mb max tmp	date	700 mb min tmp	date	700 mb max wd	date
Jan	2695	19/1980	8.2	7/2003	-36.8	11/1963	100kts	31/1971
Feb	2755	7/1949	5.9	05/1954	-40.7	2/1989	83	10/1992
Mar	2714	5/1951	5.6	31/2004	-32.2	25/1955	73	12/2007
Apr	2804	29/2010	9.6	21/1980	-23.0	19/1966	64	1/1959
May	2817	1/1951	12.4	29/2003	-19.7	1/1954	69	31/1984
Jun	2890	11/2008	15.7	26/1988	-10.3	13/1969	58	30/1961
Jul	2945	5/1986	18.4	14/2002	-6.8	2/1972	86	01/2007
Aug	2958	23/2004	18.2	06/1961	-9.9	24/1992	54	23/1975
Sep	2849	25/1986	15.9	5/1950	-17.6	28/1985	64	29/2013
Oct	2819	29/2003	12.4	04/2010	-24.3	30/2002	79	24/1978
Nov	2762	26/1973	9.6	07/1999	-33.7	15/1955	83	20/1950
Dec	2744	23/1955	6.5	2/1959	-36.3	24/1983	83	22/1972

Table 4. All at 500 mb – the highest and lowest height (m), and the highest and lowest temperatures (C).

Mon	500 mb max hgt	date	500 mb min hgt	date	500 mb max tmp	date	500 mb min tmp	date
Jan	5870	20/2009	5086	25/1950	-9.1	17/1991	-45.6	29/1950
Feb	5833	8/1954	5167	7/1949	-9.7	5/1992	-45.0	27/1992
Mar	5800	9/2004	5174	5/1951	-11	20/1997	-45.5	24/1965
Apr	5843	28/1987	5300	21/1985	-9.3	21/1980	-39.5	1/1975
May	5894	30/1986	5371	14/1986	-7.2	27/1986	-34.5	1/2013
Jun	5940	30/2008	5467	14/1994	-5.5	25/1988	-29.1	1/1984
Jul	5990	12/2002	5479	1/1955	0.4	27/1992	-27.0	1/1955
Aug	5990	7/1983	5530	23/1960	-4.5	19/2003	-25.7	24/1992
Sep	5992	4/1988	5449	26/1986	-3.4	21/1966	-32.8	16/1965
Oct	5941	15/1961	5312	31/1955	-5.9	17/1960	-36.1	28/1971
Nov	5893	5/1949	5150	15/1955	-7.4	4/1975	-44.5	13/1955
Dec	5826	4/1988	5100	30/1968	-9.9	27/1980	-50.1	23/1983

Table 5. The highest wind at 500 mb (kts), the highest wind recorded at any level (kts), and the highest and lowest 1000-500 mb thickness values (m).

Mon	500 mb max wd	date	Max spd	date	Max thickness	date	Min thickness	date
Jan	125	16/1974	201	19/2012	5651	7/2003	4850	11/1963
Feb	166	22/1998	176	22/1998	5643	8/1954	4817	03/1989
Mar	104	10/1997	171	26/1971	5678	31/2004	4890	04/1955
Apr	96	7/1989	158	5/1989	5757	21/1980	5095	01/1975
May	92	4/1994	195	20/1984	5822	29/2003	5214	1/1954
Jun	83	8/1985	179	9/1981	5885	26/1988	5376	1/1951
Jul	77	8/1981	168	22/1984	5923	14/1953	5451	1/1955
Aug	87	27/1962	138	27/1994	5962	06/1961	5362	24/1992
Sep	110	20/1958	167	19/1983	5899	6/1967	5237	16/1965
Oct	116	23/1959	177	9/1966	5790	04/1970	5102	31/2003
Nov	119	25/1970	173	1/1960	5713	06/2010	4888	15/1955
Dec	121	4/1965	175	25/1971	5670	17/1980	4778	16/1964

Table 6. The five highest monthly precipitable water values are listed for both Glasgow and Great Falls.

Month	Highest PW Great Falls	Date	Highest PW Glasgow	Date
Jan	0.74	1/1997 12Z	0.86	1/1997 12Z
	0.69	23/2005 12Z	0.71	17/1974 00Z
	0.66	19/2005 00Z	0.70	20/1971 00Z
	0.63	16/1974 00Z	0.69	24/2005 00Z
	0.62	22/1981 00Z	0.69	23/2005 12Z
Feb	0.66	20/1995 12Z	0.69	9/1996 00Z
	0.62	5/2007 12Z	0.64	9/1996 12Z
	0.60	13/1979 12Z	0.61	23/2002 00Z
	0.59	27/1982 12Z	0.61	28/1980 00Z
	0.58	7/1995 00Z	0.59	18/2004 12Z
Mar	0.70	14/1994 00Z	0.75	10/1989 00Z
	0.65	24/1998 00Z	0.74	1/2006 00Z
	0.64	12/2007 00Z	0.74	20/1997 00Z
	0.64	20/1997 00Z	0.71	10/1996 00Z
	0.63	16/1974 12Z	0.69	7/1987 06Z
Apr	0.87	26/2012 12Z	1.00	26/1999 12Z
	0.83	22/1994 12Z	0.93	27/1993 00Z
	0.79	30/1987 00Z	0.92	27/1974 00Z
	0.76	27/2012 00Z	0.90	22/1994 12Z
	0.76	22/1994 00Z	0.89	29/2000 12Z
May	1.04	29/1990 00Z	1.27	31/1988 00Z
	1.01	12/1994 12Z	1.25	24/2006 00Z
	0.99	26/1981 00Z	1.16	28/1956 03Z
	0.98	23/1980 12Z	1.13	22/1998 00Z
	0.95	24/1980 00Z	1.11	18/2005 00Z
Jun	1.34	27/1954 03Z	1.64	24/2012 12Z
	1.31	4/1997 12Z	1.61	9/1997 00Z
	1.25	28/2001 00Z	1.54	28/2001 00Z
	1.21	26/1988 12Z	1.52	27/1988 12Z
	1.20	27/1988 00Z	1.50	29/1988 12Z
Jul	1.43	28/1984 00Z	2.08	30/1987 00Z
	1.38	14/2012 12Z	2.04	15/1986 00Z
	1.38	31/1994 00Z	1.91	18/2007 22Z
	1.36	19/2004 12Z	1.81	28/1987 12Z
	1.36	13/1989 12Z	1.78	25/2007 12Z
Aug	1.39	12/1983 00Z	1.80	2/1992 00Z
	1.38	10/1963 12Z	1.58	4/1951 15Z
	1.35	9/1983 00Z	1.57	29/1999 00Z
	1.34	29/1999 00Z	1.55	6/1970 12Z
	1.31	10/1983 12Z	1.53	24/2009 00Z
Sep	1.29	6/1978 12Z	1.42	7/2002 00Z

	1.22	1/1992 12Z	1.38	5/1995 12Z
	1.20	5/1995 12Z	1.38	12/1985 12Z
	1.18	9/1963 12Z	1.37	3/1997 12Z
	1.14	10/1998 12Z	1.36	7/2002 12Z
Oct	0.98	5/2010 12Z	1.14	7/2001 12Z
	0.90	5/2011 00Z	1.12	5/2008 12Z
	0.89	1/2005 00Z	1.07	11/2010 12Z
	0.89	21/2003 12Z	1.06	29/1998 00Z
	0.89	6/1963 00Z	1.04	6/2006 12Z
Nov	0.88	4/1983 00Z	1.00	7/2006 12Z
	0.85	7/2006 12Z	0.95	8/2006 00Z
	0.85	4/1983 12Z	0.87	7/2006 00Z
	0.81	7/2006 00Z	0.84	5/2012 12Z
	0.78	4/1980 12Z	0.80	3/2008 12Z
Dec	0.66	15/1980 00Z	0.77	6/2003 12Z
	0.65	4/2007 00Z	0.76	18/1979 00Z
	0.65	26/1980 12Z	0.75	21/2005 12Z
	0.65	18/1979 00Z	0.75	27/1980 00Z
	0.63	6/2008 12Z	0.71	4/2007 00Z