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Occurrence of tornado outbreaks influenced by solar wind–magnetosphere–ionosphere–atmosphere coupling

Paul Prikryl and Vojto Rušin

Correspondence to: Paul Prikryl (paul.prikryl@unb.ca)

Supplementary material

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Table S1

Tornado outbreaks in the United States in the context of solar wind

In Section 3.2 of the main manuscript, the occurrence of large tornado outbreaks (20 or more tornadoes per day) relative to arrivals of solar wind disturbances is classified into four groups: tornado outbreaks that closely followed co-rotating interaction regions (CIRs; Type A) or interplanetary coronal mass ejections (ICMEs; Type C), closely preceded the heliospheric current sheet HCS/CIR associated with high-density plasma (HDP; Type B), and tornado outbreaks that occurred within the main body of declining major high-speed streams (HSS; Type D). Table S1 lists large tornado outbreaks from 1963 to 2023 along with references to solar wind disturbances and the assigned types.

Figure S1 shows solar wind variables with the symbols on the time axis indicating HSS/CIRs arrivals, impacts of ICMEs, and the interplanetary magnetic field (IMF) sector boundary/HCS crossings. The IMF direction longitude is shown to identify magnetic sector boundaries as well as transient HCS crossings. Where available, the proxy magnetic field sectors (A: away, T: toward) are also indicated on the time axis. Large tornado outbreaks are highlighted in light green color. Outbreaks associated with recurrent HSSs are marked with asterisks.

In 1973 (Figure S1a), the arrivals of a recurrent HSS/CIR on May 6 and June 2, 1973 (one solar rotation apart) were closely followed by large tornado outbreaks (A*). Type B outbreaks were associated with HCS/HDP on May 28 and June 17, 1973. In 2009 (Figure S1b), the arrivals of a recurrent HSS/CIR on April 9 and May 6 were followed by large tornado outbreaks (A*). Type B outbreak on April 29/30 was associated with HCS/HDP at the end of April. Furthermore, a moderate outbreak occurred following the arrivals of HSS/CIRs on April 16, and two large outbreaks followed a minor and moderate HSS/CIRs on May 2 and 14, respectively.

Figure S1c shows tornado outbreak cases in May 2010 and January 2012. The arrivals of HSS/CIRs on May 10 and 19 were closely associated with large tornado outbreaks (A). Tornado outbreaks (B) on May 1-2 and 25-26 were associated with HCS/HDP on May 2 and 26, respectively. Two ICMEs on January 22 and 24, 2012, were followed by tornado outbreaks (C) on January 23 and 25, respectively.

In 2018 (Figure S1d), the arrivals of a recurrent HSS/CIR on October 7 and November 4 were followed by large tornado outbreaks as these HSSs started to decline (D*), while the next arrival of this recurrent HSS/CIR on December 1 was closely followed by a large outbreak (A*). A moderate outbreak on October 13 coincided with a strong HSS/CIR. Two large outbreaks (B) on October 2/3 and November 1 were associated with HCS/HDP.

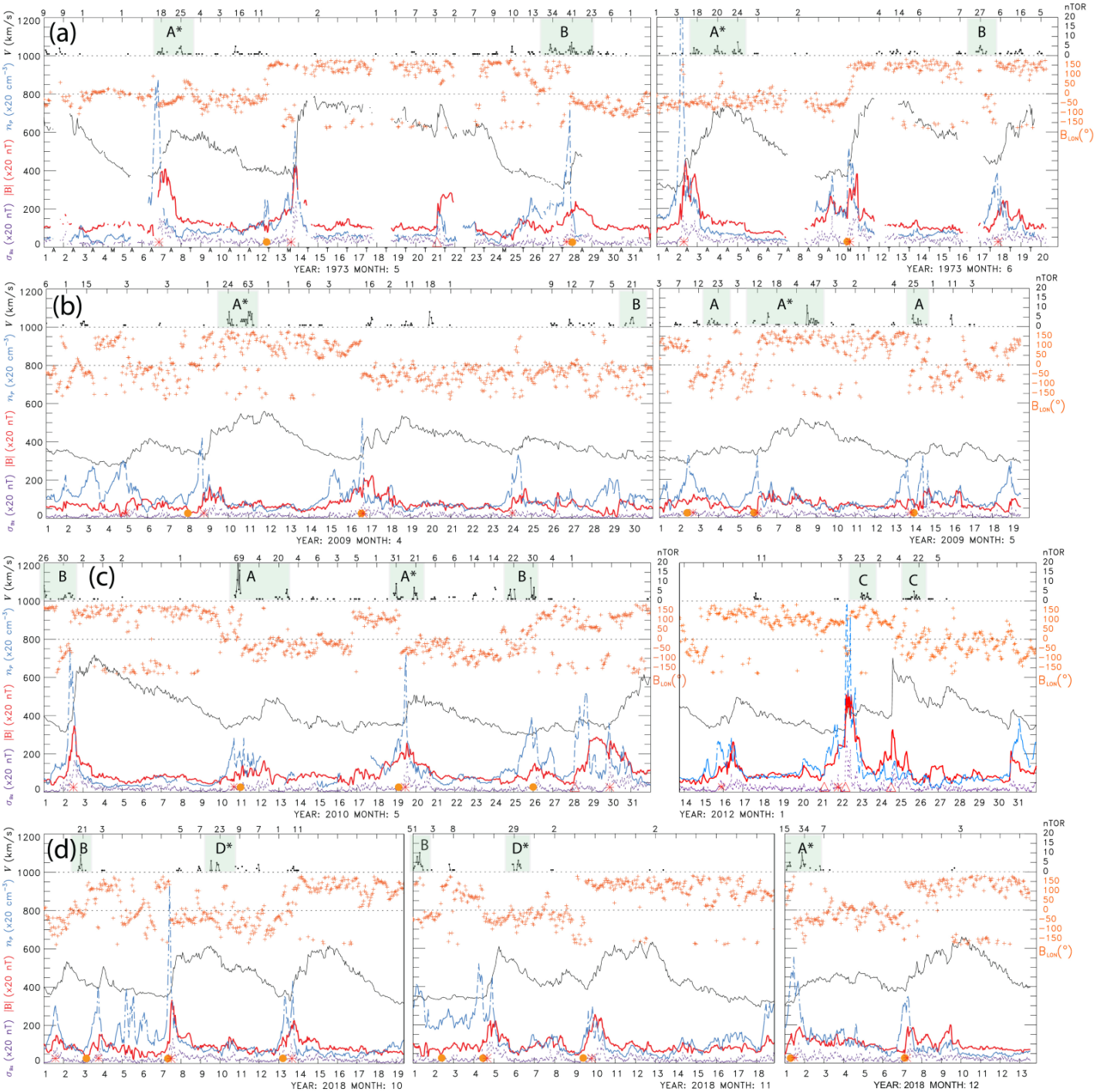

Figure S1: The OMNI solar wind V (solid black line), B (red), n_p (broken light blue line), σ_{Bz} (dotted purple line) with the y-axis scale factors shown on the left, and the magnetic field direction longitude (red crosses) with the y-axis shown on the right. The symbols at the time axis indicate (*) CIRs, (Δ) ICMEs, (●) HCS crossings, and where available, the proxy magnetic field sectors (A: away, T: toward). Hourly and daily numbers of tornadoes are shown at the top and days of tornado outbreaks are highlighted and labeled as Type A-D for periods in **(a)** May-June 1973, **(b)** April-May 2009, **(c)** May 2010, January 2012, and **(d)** October-December 2018. Outbreaks associated with recurrent HSSs are marked with asterisks.

Assessment of conditional symmetric instability and slantwise convection

To evaluate the likelihood of CSI and slantwise convection several indices were calculated for events of November 1-2, November 5-7, and December 1-2, 2018, using the ERA5 reanalysis. These indices include SCAPE, SCAPE residuals (SCAPE – CAPE), and vertically integrated extent of realizable symmetric instability. A high SCAPE, indicating high convective available potential energy for a slantwise ascending air parcel from low levels is found in the frontal zones of the cyclone, with SCAPE residuals shown in red contours (Figure S2a). Figure S2b shows hourly precipitation derived from ERA5 overlaid with the SCAPE residual contours indicating a dominance of slantwise over upright convection. The vertically integrated extent of realizable symmetric instability (VRS) shows the thickness of the air layer (measured in pressure), where CSI, high relative humidity, and vertical motion coexist (Chen et al., 2018). Figure S2c shows that in the frontal zones the high-rate precipitation is co-located with high VRS values of above 100 hPa, a strong indication that CSI is being released actively there with high VRS values matching the high precipitation derived from ERA5 (Figure S2b) that persisted for several hours. Figure S2d shows low-level southerly wind and the wind shear, evaluated between 900 and 1000 hPa levels.

Chen et al. (2022a) identified cyclone tracks with a storm tracking algorithm performed in a region covering North America and part of the Pacific and Atlantic Oceans (20–80°N, 180–0°W) using ERA5 reanalysis data. Storm tracks of the NAEC cyclones #23305, #23311, and #23350 (November 1-2, November 5-7, and December 1-2, 2018) are superposed in Figure S2d. The intensifying cyclones reached the minimum surface low pressure of 997, 986, and 986 hPa, respectively.

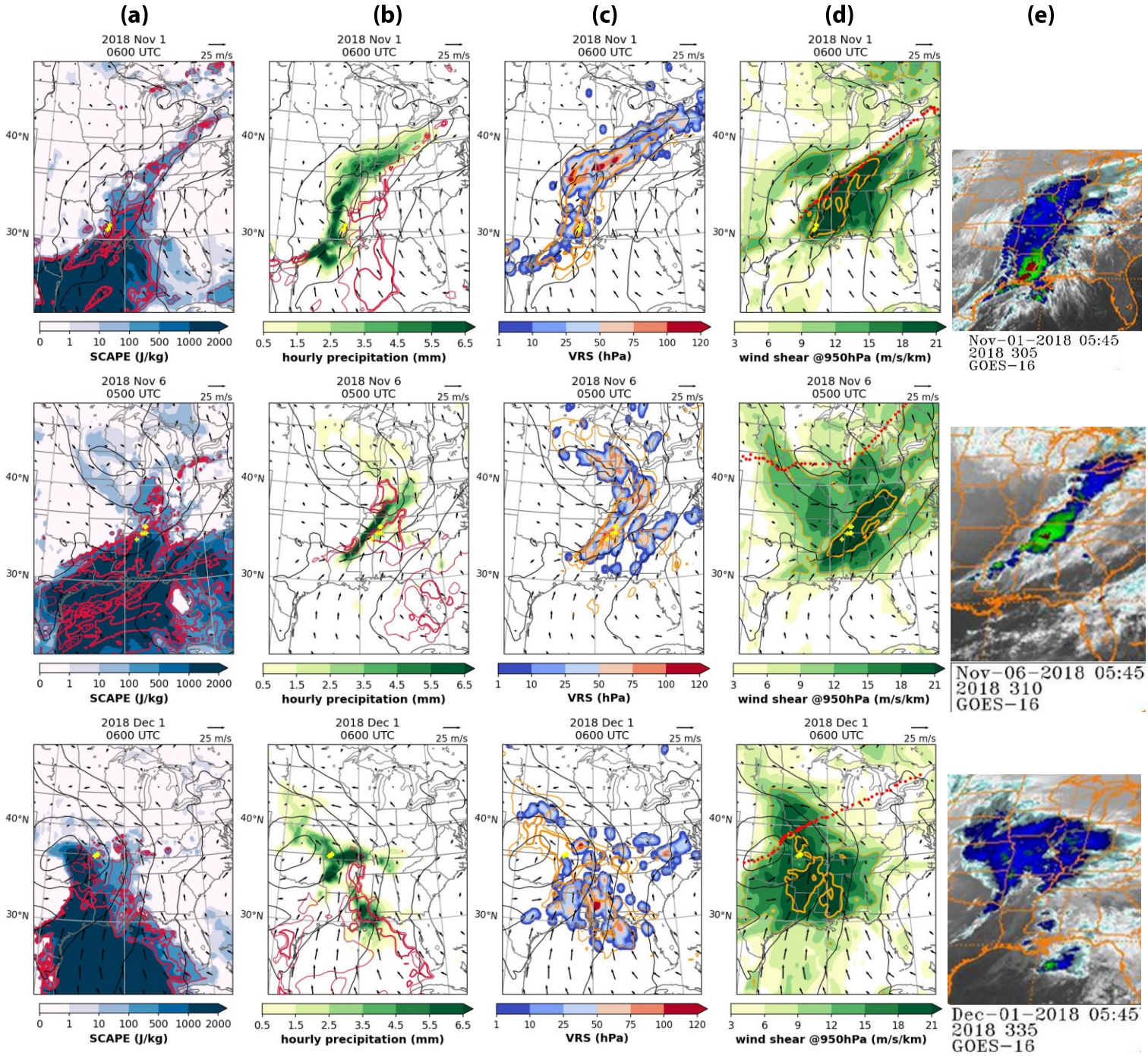

Figure S2. (a) SCAPE (shaded), SCAPE-CAPE (red contours; 100, 300, 500 J/kg), **(b)** 1-h accumulated precipitation (shaded), f_s (red contours; thin for 0.5, thick for 0.8), **(c)** VRS (shaded), precipitation (yellow contours; 0.5, 5.5 mm/h), **(d)** low-level wind shear (yellow contour; 12, 21 m/s/km). The tracks of the NAEC storms #23305, #23311, and #23350 are overlaid (red crosses). **(a-d)** All overlapped with 950-hPa wind (vectors; m/s), 950-hPa geopotential height (black contours; m; at intervals of 50 m). Tornado locations are shown by yellow crosses. **(e)** The GOES-16 infrared images of corresponding extratropical cyclones on November 1, 6, and December 1, 2018.

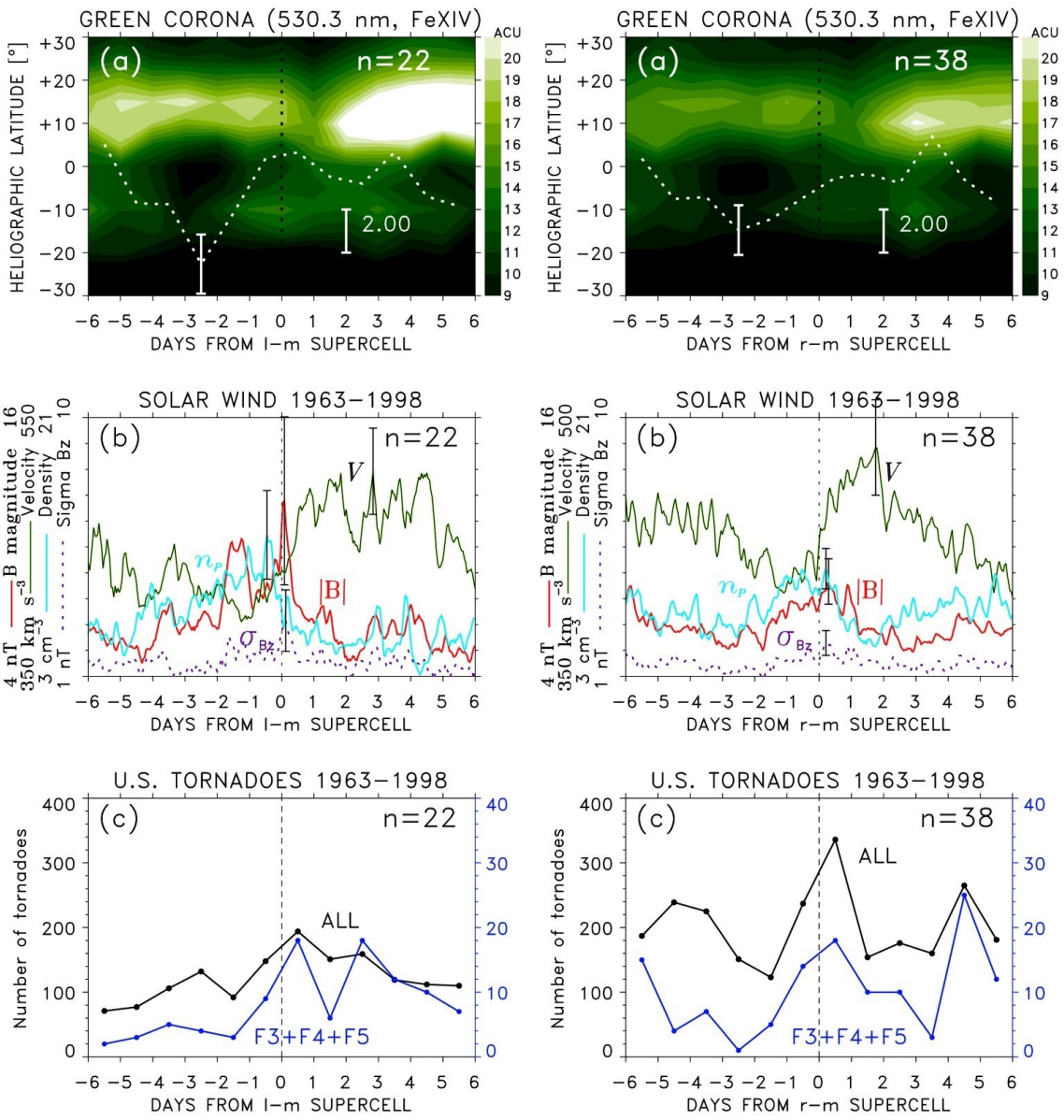

Figure S3. SPE analysis of time series of (**a**) green corona intensity I_{GC}, (**b**) solar wind plasma variables, and (**c**) U.S. tornado counts, separately keyed to times of left- and right-moving supercells. **(a)** The mean I_{GC} at heliographic latitude −5°, with the mean value over the period of 12 days subtracted, is shown by a white dotted line.

Table S1 lists cases of large tornado outbreaks in the years 1963-2023. The columns show the assigned group (Type), the outbreak dates with the 24-hourly tornado counts centered on 0 UT ± 12 h in parentheses, the principal location, and the key dates of HCS, CIR or ICME, along with notes on the presence of HDP, maximum HSS velocity, or geomagnetic storm index Dst in cases of ICMEs. Cases of large tornado outbreaks (9%) that could not be associated with any specific solar wind disturbances, mostly because of solar wind data gaps, are marked by a question mark.

Table S1: Large tornado outbreaks (* recurrent). Tornado daily counts centered on 0 UT ± 12 h for the given dates are shown in parentheses.

Type	Dates (UT) (# of tornadoes)	Location/State	Key date of HCS, CIR or ICME
?	29-30 Apr 1963 (12, 22)	Central	HCS: Apr 28 (data gap)
?	23 Apr 1964 (26)	Great Plains	HCS: Apr 23 (data gap)
?	6 May 1964 (34)	Midwest, Great Plains	HCS: May 5 (data gap)
?	12 Apr 1965 (47)	Midwest	? (data gap)
?	9 May 1965 (37)	Northern Great Plains	HCS/CIRs: May 8? (data gap)
B	25-26 May 1965 (34, 43)	Great Plains	HCS/CIR: May 27
B	24 May 1966 (24)	Midwest South	HCS: May 27
B	15 Oct 1967 (22)	Midwest	HCS: Oct 15
A	25 Jan 1967 (30)	Midwest	CIR: Jan 25
B	14 Apr 1967 (20)	South	HCS/CIR: Apr 14
B	22 Apr 1967 (46)	Midwest	HCS/CIR: April 23; HDP
A	1-2 May 1967 (21, 16)	Midwest, South	CIR: Apr 30
D	10-12 Jun 1967 (14, 25, 22)	Midwest, Southwest	CIR: Jun 8
A	14-15 Jun 1967 (16, 25)	Midwest	CIR: Jun 13
C	20-23 Sep. 1967 (18, 59, 22, 20)	TX (TC Beulah)	ICMEs: Sep. 19 and 20 (Dst: −111 nT)
B	25 Oct 1967 (21)	Midwest	HCS: Oct 25; HDP
B	4 Apr 1968 (20)	Central Midwest	HCS/CIR Apr 5; HDP
B	16-17 May 1968 (39, 7)	Central Midwest	HCS/CIR May 17; HDP
?	12-13 Jun 1970 (21, 18)	Great Plains	? (data gap)
A	31 May – 1 Jun 1971 (17, 20)	Great Plains	HCS/CIR: May 29
D	7-10 Jun 1971 (23, 14, 9, 20)	Midwest	HCS/CIR: Jun 1; HSS >600 km/s
?	18 Oct 1971 (23)	Great Plains	? (data gap)
?	15 Dec 1971 (37)	Texas, Central	? (data gap)
A	22 Apr 1972 (21)	Central, Southeast	CIR: Apr 21
B	23 May 1972 (23)	Great Plains	HCS/CIR: May 23; HDP
D	20-22 Apr 1973 (34, 22, 12)	South, Midwest	CIR: Apr 16; HSS >700 km/s
A*	7-8 May 1973 (18, 25)	Midwest, Southeast	CIR: May 6*
B	26-27 May 1973 (13, 34)	Midwest, Central	HCS/CIR: May 28; HDP
A	28-29 May 1973 (41, 23)	Midwest, Southeast	HCS/CIR: May 28
A*	3-5 Jun 1973 (18, 20, 24)	Midwest	CIR: Jun 2*; HSS >700 km/s
B	17 Jun 1973 (27)	Midwest	HCS/CIR: Jun 17; HDP
B	27 Jun 1973 (28)	Midwest	HCS/CIR: Jun 28; HDP
A	25 Nov 1973 (22)	Central, Southeast	HCS/CIR: Nov 24; HSS >700 km/s
B	2 Apr 1974 (23)	Midwest to South	HCS: Apr 3; HDP
A	4 Apr 1974 (143)	Midwest to South	HCS/CIR: Apr 3
B	8-9 Jun 1974 (17, 36)	South	HCS: Jun 9; HDP
A	21 Jun 1974 (34)	Midwest	CIR: Jun 20

D	11 Aug 1974 (25)	Illinois	HCS/CIR: Aug 2; HSS >600 km/s decl.
A	11 Jan 1975 (32)	South	CIR: Jan 10
B	30 Apr – 1 May 1975 (18, 15)	South	HCS/CIR: May 1; HDP
D	7-8 May 1975 (13, 23)	Central, South	CIR: May 5; HSS >600 km/s
B	26 Jun 1975 (23)	Midwest	HCS: Jun 27
D	13 Mar 1976 (27)	Midwest, Southeast	CIR: Mar 8; HSS>600 km/s
D	21 Mar 1976 (51)	Midwest, South	HCS/CIR: Mar15/ 16; HSS>600 km/s
D	30 Mar 1976 (20)	South	HCS/CIR: Mar 26; HSS~600 km/s decl.
D	16 Apr 1976 (24)	Great Plains, Texas	CIR: Apr 13; HSS>600 km/s declining
B	20 Apr 1976 (20)	Texas	HCS/CIR: Apr 22
A	26-27 May 1976 (12, 20)	Texas	HCS/CIR: May 25
A	5 Jun 1976 (21)	Great Plains	HCS/CIR: Jun 3
A	12-14 Jun 1976 (33, 12, 16)	Midwest	CIR: Jun 10
A	5-6 May 1977 (30, 14)	Midwest, South	CIR: May 4
D	17-19 May 1977 (13, 13, 25)	Midwest, Great Plains	CIR: May 14, 22; HSS ~600 km/s decl.
B	21 May 1977 (28)	Great Plains	HCS: May 21; HDP
B	1 Jul 1977 (29)	Midwest	HCS/CIR: Jul 1; HDP
?	7 Aug 1977 (20)	Midwest	HCS/CIR: Aug 3/4? (data gap)
A	18-20 Apr 1978 (18, 13, 9)	Southeast	HCS/CIR: Apr 17/18
A	12-13 May 1978 (25, 26)	Great Plains, Midwest, South	HCS/CIR May 11
A	11-12 Apr 1979 (29, 31)	South, Southeast	HCS/CIR: Apr 9/10
B	4 May 1979 (26)	TX, Southeast	HCS/CIR: May 5; HDP
B	20 Jun 1979 (24)	Midwest	HCS/CIR: 22; HDP
D	29 Jun 1979 (38)	Midwest	CIR: Jun 26; HSS>400 km/s declining
C	8-9 Apr 1980 (33, 27)	Great Plains, Central	ICMEs: Apr 6/9 (Dst −33/−56 nT)
A	30 May 1980 (40)	Midwest, Great Plains	HCS/CIR: May 29
A	5-6 Jun 1980 (34, 17)	Midwest	HCS/CIR: Jun 4
A	8 Jun 1980 (23)	Midwest	HCS/CIR: Jun 7
A	10-11 Aug 1980 (8, 22)	TX, Midwest	CIR: Aug 9
C	18 May 1981 (20)	Great Plains	ICME: May 17 (Dst −117 nT)
?	23-24 May 1981 (15, 28)	Great Plains	?ICME: May 23 (Dst −60 nT) (data gap)
B	14-16 Jun 1981 (29, 7, 8)	Midwest	HCS/CIR: Jun 14/15; HDP
B	21-22 Jun 1981 (12, 35)	Midwest	HCS: Jun 22; HDP
B	16 Mar 1982 (24)	Great Plains	HCS/CIR: Mar 18; HDP
C	2-3 Apr 1982 (61)	Great Plains, Midwest, South	ICME/CIR: Apr 1/3 (Dst −88 nT)
C	26-27 Apr 1982 (19, 8)	South	ICME: Apr 24 (Dst −78 nT)
D	12-13 May 1982 (38, 32)	Great Plains, South	HCS/CIR: May 9; HSS declining
A	28-31 May 1982 (22, 14, 11, 17)	Great Plains	HCS/CIR: May 26; HSS >700 km/s
C	15 Jun 1982 (26)	Great Plains, Midwest	ICME: Jun 12 (Dst −58 nT)
B	2-3 Dec 1982 (9, 25)	Mississippi River Basin	HCS/CIR: Dec 3
B	24-25 Dec 1982 (17, 26)	Mississippi River Basin	HCS: Dec 27
B	2-3 May 1983 (33, 22)	Great Lakes, MRB	HCS: May 2

D	13-14 May 1983 (8, 32)	Great Plains	HCS/CIR: May 11; HSS >700 km/s
B	18-21 May 1983 (12, 21, 26, 19)	Great Plains, South	HCS/CIR: May 20; HDP
C	13-14 Jun 1983 (17, 28)	Great Plains, MN	ICME: Jun 13 (Dst −110 nT)
?	4 Jul 1983 (25)	Midwest	HCS: Jul 6 (data gap)
A	28-29 Mar 1984 (11, 24)	Southeast	HCS/CIR: Mar 27/28
?	27 Apr 1984 (33)	Great Plains	HCS/CIR/ICME?: Apr 24/25 (data gap)
?	30 Apr 1984 (42)	Great Plains, Midwest	HCS/CIR: Apr 30? (data gap)
?	3-4 May 1984 (25, 37)	Southeast	CIR?: May 2 (Dst: -60 nT) (data gap)
?	8 May 1984 (22)	Central	HDP/CIR: May 9? (data gap)
?	8-9 Jun 1984 (45, 13)	Midwest	CIR? (data gap)
?	12 Jun 1984 (22)	Great Plains	HSS? (data gap)
?	23 Jun 1984 (22)	Midwest	HSS? (data gap)
B	21-22 Apr 1985 (14, 23)	Southwest	HCS: Apr 22; HDP
C	29 Apr 1985 (21)	Texas	ICME: Apr 26 (Dst −98 nT)
B	11-12 May 1985 (16, 24)	Midwest	HCS/CIR: May 12; HDP
A	30-31 May 1985 (17, 30)	Midwest, Great Lakes	HCS/CIR: May 31; HDP
B	17-18 Aug 1985 (31, 10)	Southeast	HCS/CIR: Aug 18; HDP
?	11–12 Mar 1986 (20, 13)	Central, Southeast	?
?	15-17 May 1986 (20, 25, 33)	Great Plains, South, Central	HCS/CIR: May 18/19; HDP (data gap)
?	26-27 May 1987 (22, 14)	TX, Great Plains	HCS/CIR: May 22/23? (data gap)
B	7-8 Jul 1987 (28, 16)	Midwest, Great Plains	HCS/CIR: Jul 8; HDP
D	16-17 Nov 1987 (22, 28)	South	CIR: Nov 10, 19; HSS > 600 km/s
D	9 May 1988 (57)	Midwest	CIR/ICME: May 5/6 (Dst −159 nT)
?	17-18 Sep 1988 (24, 24)	TX, TC Gilbert	HCS/CIR: Sep 17? (data gap)
D	16 Nov 1988 (44)	Great Plains, MRB	HCS/CIR: Nov 11/12; HSS ~600 km/s
?	20 Nov 1988 (21)	South	? (data gap)
?	4-5 Apr 1989 (20, 19)	Central, South	HSS>700 km/s (data gap)
?	16-18 May 1989 (12, 20, 16)	Texas	? (data gap)
C	25 May 1989 (33)	Midwest	ICME: May 23 (Dst −84 nT)
C	7-9 Jun 1989 (19, 28, 23)	South	ICMEs: Jun 6/8 (Dst –81/–144 nT)
?	16-17 Nov 1989 (18, 21)	Southeast, East	HCS/HDP/ICME? (data gap)
B	10 Feb 1990 (20)	South	HCS/HDP: Feb 12
C	14-15 Mar 1990 (59, 11)	Great Plains	ICME: Mar 12 (Dst −165 nT)
?	28 Apr 1990 (29)	Great Plains, South	CIR: Apr 28; HCS: May 1 (data gap)
?	25 May 1990 (24)	Northern Great Plains	ICMEs: May 21/25 (data gap)
D	2-3 Jun 1990 (21, 68)	South, Central	CIR: May 30; HSS ~600 km/s
A	7-9 Jun 1990 (16, 23, 21)	Great Plains	CIR/HCS: Jun 6
D	17 Jun 1990 (28)	Midwest	ICME/CIR: Jun 12/14; HSS>700 km/s
B	22 Dec 1990 (23)	South	HCS: Dec 22
A	22-23 Mar 1991 (19,23)	IA, OK, AR, TN	HCS/CIR: Mar 21
C	27-28 Mar 1991 (24, 26)	CA(!), Great Plains, Great Lakes	ICME: Mar 24 (Dst −300 nT)
B	10 Apr 1991 (25)	Central, Northeast	HCS/CIR: Apr 10/11; HDP

A	13 Apr 1991 (24)	Great Plains	HCS/CIR: Apr 10/11
A	27 Apr 1991 (55)	Great Plains, Midwest, South	CIR: Apr 25
?	30 Apr 1991 (23)	Midwest	CIR: Apr 25 (data gap)
?	11-12 May 1991 (16, 22)	TX, North Great Plains	HCS/CIR: May 7 (data gap)
?	15-17 May 1991 (10, 32, 48)	Great Plains	ICMEs: May 13/16 (Dst −75/−106 nT) gap
?	29-31 May 1991 (16, 21,19)	Great Plains	HCS/CIR: May 22 (data gap)
C	6-7 Jun 1991 (19, 22)	South, Great Plains	ICME: Jun 4 (Dst −222 nT)
C	12 May 1992 (33)	OK, TX	ICME: May 9 (Dst −289 nT)
B	16-17 May 1992 (24, 12)	Midwest	HCS/CIR: May 18/19; HDP
A	15-18 Jun 1992 (58, 65, 29, 21)	TX, Great Plains, Midwest	HCS/CIR: Jun 15
B	27-28 Jun 1992 (11, 23)	Great Plains, Southwest	HCS: Jun 28; HDP
A	13-16 Jul 1992 (39, 12, 8, 17)	Great Lakes	HCS/CIR Jul 11/12
A	27-29 Aug 1992 (39, 10, 13)	South, East Coast	HCS/CIR: Aug 26
A	22-23 Nov 1992 (43, 52)	Southeast	HCS/CIR: Nov 22
A	22 Feb 1993 (22)	Southeast	CIR: Feb 20
A	6-10 May 1993 (16, 21, 46, 19, 16)	Great Plains, South	HCS/CIR: May 6; HSS >600 km/s
B	8-9 Jun 1993 (41, 57)	Midwest	HCS/CIR: Jun 10; HDP
B	22-23 Jun 1993 (9, 24)	Midwest	HCS/CIR: Jun 23; HDP
A	30 Jun – 4 Jul 1993 (16, 33, 17, 12,12)	Midwest	HCS/CIR: Jun 29
A	8-10 Jul 1993 (15, 19, 17)	Great Plains	HCS/CIR: Jul 8/9
A	6-7 Aug 1993 (6, 22)	East Coast	HCS/CIR: Aug 4
?	14 Sep 1993 (22)	Southwest, Midwest	CIR: Sep 13? (data gap)
A	28 Mar 1994 (28)	Southeast	CIR: Mar 27
B	15-16 Apr 1994 (12, 24)	Central	HCS/CIR: Apr 16
A	26-27 Apr 1994 (29, 67)	Great Plains, South, Central	CIR: Apr 25
B	14 May 1994 (29)	TX	HCS/CIR: May 14; HDP
A	30 May 1994 (23)	TX, LA	CIR: May 28
A	26-28 Jun 1994 (11, 48, 14)	Central Southeast	HCS/CIR: Jun 25/26
?	28 Jul 1994 (25)	East	CIR: Jul 28? (data gap)
D	17 Aug 1994 (32)	Southeast	CIR: Aug 13; HSS >600 km/s declining
B	18-21 Apr 1995 (21)	OK	HCS: Apr 18; HDP
B	20-21 Apr 1995 (38, 22)	South	HCS: Apr 21; HDP
D	8-10 May 1995 (32, 19, 39)	South, Midwest	CIR: May 2; HSS >700 km/s declining
C	14 May 1995 (28)	Midwest, Central	HCS/ICME: May 13 (Dst −13 nT)
A	17-19 May 1995 (25, 8, 77)	Great Plains, Central South	HCS/CIR: May 16
B	23 May 1995 (21)	Great Plains	HCS/CIR: May 23; HDP
D	28 May 1995 (29)	Midwest to East	HCS/CIR: May 23; HSS >600 km/s
B	8-10 Jun 1995 (24, 29, 31)	Great Plains	HCS/CIR: Jun 9; HDP
D	28 Jul 1995 (27)	Great Plains	HCS/CIR: Jul 24; HSS >500 km/s
A	5-6 Oct 1995 (24, 9)	Southeast	HCS/CIR: Oct 4
A	27-28 Oct 1995 (7, 22)	Southeast	HCS/CIR: Oct 26
D	8 Nov 1995 (41)	Southeast	CIR: Nov 5; HSS >500 km/s declining

A	19 Mar 1996 (21)	MS, AL	CIR: Mar 19
A	12 Nov 1995 (25)	Southeast	CIR: Nov 11
D	20-22 Apr 1996 (74, 7, 33)	Midwest, Central	CIR: Apr 17; HSS >700 km/s
B	9-10 May 1996 (21, 18)	Midwest	HCS/CIR: May 9; HDP
A	24-26 May 1996 (9, 20, 20)	Great Plains, South	CIR: May 24
A	31 May - 24 Jun 1996 (27, 24)	Central, Great Plains	CIR: May 29
?	18-19 Jul 1996 (11, 12, 20)	Midwest, East	HCS/CIR: Jul 17?
?	17 Sep 1996 (23)	Southeast	CIR: Sep 16?
B	8 Oct 1996 (22)	Southeast	HCS/CIR: Oct 8; HDP
B	27 Oct 1996 (26)	Midwest	HCS/CIR: Oct 27; HDP
B	25 Jan 1997 (20)	Southeast	HCS: Jan 25; HDP
D	1–2 Mar 1997 (15, 47)	South Central	CIR: Feb 26; HSS >600 km/s declining
A	28 Mar 1997 (28)	Central	CIR: Mar 28
C	11 Apr 1997 (20)	TX	CIR/ICME: Apr 10 (Dst −82 nT)
A	24 Apr 1997 (24)	FL	CIR: Apr 23
B	1 May 1997 (30)	Midwest	HCS: Apr 30; CIR: May 1; HDP
C	26-28 May 1997 (53, 29, 22)	Great Plains, South	ICME: May 25 (Dst −74 nT)
B	12 Jun 1997 (22)	Great Plains	HCS: Jun 12; HDP
A	17 Jun 1997 (24)	TX, OK	CIR: Jun 15
B	2-4 Jul 1997 (19, 24, 10)	Great Lakes	HCS/CIR: Jul 3; HDP
A	24 Oct 1997 (23)	South	CIR: Oct 23
B	9 Mar 1998 (23)	Southeast	HCS/CIR: Mar 10; HDP
A	8-9 Apr 1998 (35, 15)	Midwest, Southeast	HCS/CIR: Apr 7/8
A	16-17 Apr 1998 (23, 38)	Central South	HCS/CIR: Apr 16
A	8-9 May 1998 (42, 10)	Southeast	CIR: May 7
A	16 May 1998 (26)	Midwest	HCS/CIR: May 15
A	25 May 1998 (28)	Great Plains	CIR: May 24
D	31 May - 1 Jun 1998 (25, 39)	Midwest, Northeast	HCS/CIR: May 28/29; HSS >700 km/s
B	3 Jun 1998 (36)	Northeast	HCS/CIR: 3; HDP
D	9-11 Jun 1998 (25, 8, 11)	Great Plains, Midwest	CIR: Jun 5; HSS >600 km/s declining
C	14-15 Jun 1998 (45, 22)	Southeast	ICME: Jun 13
A	19-20 Jun 1998 (23, 6)	Midwest	HCS/CIR: 18/19
B	24 Jun 1998 (22)	Midwest	HCS: Jun 24; HDP
C	27-28 Jun 1998 (11, 33)	Midwest	ICME: Jun 25 (Dst −101 nT)
B	30 Jun - 1 Jul 1998 (29, 11)	Midwest, Northeast	HCS/CIR: Jul 1; HDP
B	29-30 Sep 1998 (25, 16)	Southeast	HCS: Sep 30; HDP
D	5 Oct 1998 (28)	Great Plains	CIR/ICME: Oct 1/2; HSS >600 km/s
?	2-3 Jan 1999 (34, 12)	South	?
D	18 Jan 1999 (22)	Central	HDP/CIR: Jan 18
A	22-23 Jan 1999 (99, 30)	South	CIR: Jan 20
A	4-6 Apr 1999 (10, 8, 20)	South, Great Plains	CIR: Apr 4
B	9 Apr 1999 (55)	Midwest	HCS/CIR: Apr 9/10; HDP

B	4-6 May 1999 (75, 39, 18)	Great Plains, Southeast	HCS/CIR: May 5; HDP
B	17 May 1999 (25)	Great Plains	CIR: May 18; HDP
B	1-2 Jun 1999 (23, 30)	Great Plains, Midwest	HCS/CIR: Jun 1; HDP
D	4-6 Jun 1999 (20, 44, 21)	Midwest	CIR/ICME: Jun 2 (Dst −6 nT)
B	7 Jun 1999 (37)	Midwest	HCS/CIR: Jun 8; HDP
C	27-30 Jun1999 (11, 11, 4, 24)	Great Plains	ICME: Jun 27 (Dst –41)
A	24 Apr 2000 (37)	South, Southeast	CIR/ICME: Apr 23/24
C	18-19 May 2000 (32, 37)	Great Plains, Midwest	ICME: May 16 (Dst −92 nT)
C	24-25 May 2000 (17, 22)	Great Plains, Midwest	ICMEs: May 23 (Dst −147 nT)
A	26-27 May 2000 (23, 10)	Central	CIR: May 26
B	17 Dec 2000 (24)	Southeast	HCS/CIR: Dec 17; HDP
B	25 Feb 2001 (25)	South Central	HCS/CIR: Feb 27; HDP
C	11 Apr 2001 (46)	Midwest	ICME: Apr 8 (Dst –59 nT)
C	12 Apr 2001 (33)	Midwest	ICME: Apr 11 (Dst −271 nT)
B	21-22 May 2001 (33, 26)	Great Plains, Great Lakes, MI	HCS/CIR: May 22/23; HDP
C	28-30 May 2001 (12, 14, 29)	Great Plains, Midwest	ICME: May 27 (Dst −46 nT)
B	1-2 Jun 2001 (10, 25)	Great Plains, Midwest	HCS/CIR: Jun 2; HDP
D	10-14 Jun 2001 (19, 4, 27, 36, 40)	Midwest	CIR: Jun 9; HSS >600 km/s declining
D	18-19 Jul 2001 (12, 26)	Midwest	CIR: Jul 15; HSS >600 km/s declining
A	10 Oct 2001 (30)	Great Plains	HCS/CIR: Oct 8
C	12-14 Oct 2001 (9, 21, 28)	South	ICME: Oct 11 (Dst −71 nT)
C	25 Oct 2001 (25)	Midwest	ICMEs: Oct 21/25 (Dst –187/–43 nT)
A	16 Nov 2001 (20)	TX	CIR: Nov 15
C	24-25 Nov 2001 (23, 45)	Southeast	ICME: Nov 24 (Dst −221 nT)
A	30 Mar 2002 (23)	TX	CIR: Mar 30
A	28-29 Apr 2002 (24, 24)	Central to East	CIR: Apr 27
B	5-6 May 2002 (12, 34)	Great Plains	HCS/CIR: May 6; HDP
A	8-9 May 2002 (20, 22)	Great Plains, Midwest	HCS/CIR: May 6
C	4 Oct 2002 (25)	South	ICME: Oct 2 (Dst −146 nT)
A	10-11 Nov 2002 (11, 68)	Central, Southeast	HCS/CIR: Nov 10
B	18-19 Dec 2002 (9, 33)	Central to South	HCS/CIR: Dec 19; HDP
A	24-25 Dec 2002 (20, 12)	South	CIR: Dec 22
B	5-7 Apr 2003 (10, 7, 20)	Midwest, South	HCS/CIR: Apr 7/8; HDP
A	24-25 Apr 2003 (9, 30)	South	CIR: Apr 24
A	1-2 May 2003 (21, 13)	Midwest	CIR: Apr 29
A	5-9 May 2003 (86, 22, 75, 31, 41)	Great Plains, Southeast	HSS/HCS/CIR: May 4/5
C	10-11 May 2003 (33, 60)	Great Plains, Central	ICME: May 9 (Dst −84 nT)
D	16-17 May 2003 (49, 40)	Great Plains, South	CIR: May 11; HSS >700 km/s declining
C	31 May 2003 (21)	Midwest	ICMEs: May 29-30 (Dst −144 nT)
D	9-12 Jun 2003 (10, 21, 7, 22)	Midwest	CIR: Jun 6; HSS >700 km/s declining
B	25 Jun 2003 (95)	Midwest	HCS/CIR: Jun 26; HDP
B	10-11 Jul 2003 (21, 8)	Midwest, Great Plains	HCS/CIR: Jul 11; HDP

D	20-22 Jul 2003 (8, 17, 23)	Midwest, Northeast	CIR: Jul 19; HSS >600 km/s declining
D	18-19 Nov 2003 (30, 9)	TX, LA	CIR: Nov 15; HSS >700 km/s declining
D	5 Mar 2004 (25)	TX	HCS/CIR: Feb 26/27; HSS>700 km/s decl
A	21-23 Apr 2004 (32, 5, 11)	Midwest, Great Plains	HCS/CIR: Apr 21
D	22-25 May 2004 (24, 66, 9, 53)	Midwest	HCS/CIR: May 20; HSS declining
A	28-31 May 2004 (26, 15, 81, 88)	Midwest	HCS/CIR: May 28
B	11-12 Jun 2004 (20, 38)	Great Plains, Midwest	HCS/CIR: Jun 12/13; HDP
B	24 Jun 2004 (24)	Midwest	HCS/CIR: Jun 25; HDP
B	8 Jul 2004 (25)	KS	HCS/CIR: Jul 9; HDP
B	13-15 Aug 2004 (21, 14, 14)	Southeast	HCS/CIR: Aug 14; HDP
A	6-9 Sep 2004 (28, 23, 43, 20)	Midwest, Southeast, TC Frances	HCS/CIR: Sep 5
D	16-18 Sep 2004 (34, 25, 59)	Southeast, TC Ivan	HCS/CIR/ICME: Sep 14; HSS >500 km/s
A	27-28 Sep 2004 (10, 25)	Southeast	HCS/CIR: Sep 27
A	19 Oct 2004 (36)	Central	HCS/CIR: Oct 18
A	24-25 Nov 2004 (76, 22)	South	HCS/CIR: Nov 23/24
D	6-7 Apr 2005 (15, 23)	South	CIR: Apr 4; HSS >600 km/s
B	11 Apr 2005 (21)	Great Plains	HCS/CIR: Apr 11; HDP
A	4-8 Jun 2005 (13, 40, 15, 13, 16)	Great Plains, Midwest, TX	HCS/CIR: Jun 4
B	10-12 Jun 2005 (38, 13, 24)	Great Plains, Midwest, TX	HCS/CIR: Jun 12; HDP
B	7-8 Jul 2005 (25, 22)	South to East (TC Cindy)	HCS/CIR: Jul 9; HDP
D	19 Aug 2005 (28)	WI	CIR: Aug 15; HSS >700 km/s declining
B	30-31 Aug 2005 (40, 14)	Southeast, East (TC Katrina)	HCS/CIR: Aug 31; HDP
A	25-26 Sep 2005 (60, 38)	South (TC Rita)	HCS/CIR: Sep 24/25
D	16 Nov 2005 (49)	Central	HCS/CIR: Nov 11; HSS declining
B	28 Nov 2005 (67)	Great Plains	HCS/CIR: Nov 28/29; HDP
D	12-14 Mar 2006 (16, 57, 16)	Central to Southeast	HCS/CIR: Mar 9; HSS declining
?	31 Mar 2006 (26)	Great Plains	?CIR: Mar 27
B	3 Apr 2006 (67)	Central	CIR: Apr 4; HDP
B	7-8 Apr 2006 (12, 56)	Great Plains to Southeast	CIR: Apr 9; HDP
A	14-17 Apr 2006 (18, 6, 14, 14)	Midwest	HCS/CIR/ICME: Apr 13 (Dst −88 nT)
B	6 May 2006 (20)	TX	HCS/CIR: May 6 ; HDP
B	22-23 Jun 2006 (14, 23)	Great Plains, Midwest	HCS: Jun 24; HDP
B	22-23 Sep 2006 (15, 34)	Great Plains to Central	HCS/CIR: Sep 23; HDP
B	27 Oct 2006 (31)	Great Plains	HCS/CIR: Oct 27/28; HDP
B	15-16 Nov 2006 (12, 22)	South	HCS/CIR: Nov 15; HDP
A	30 Dec 2006 (27)	TX	HCS/CIR: Dec 29
D	1-2 Mar 2007 (13, 41)	Southeast	HCS/CIR: Feb 26; HSS >600 km/s
D	29-31 Mar 2007 (59, 3, 14)	TX, Great Plains	CIR: Mar 27
B	14-16 Apr 2007 (7, 21, 9)	Southeast	HCS/CIR: Apr 17; HDP
B	22 Apr 2007 (24)	TX, Great Plains	HCS/CIR: Apr 22; HDP
A	24-25 Apr 2007 (24, 24)	Great Plains, South	HCS/CIR: Apr 22
B	5-7 May 2007 (32, 90, 14)	Great Plains, Midwest	HCS/CIR: May 7; HDP

A	18-19 Oct 2007 (17, 45)	Midwest to South	CIR: Oct 18
D	8-9 Jan 2008 (47, 9)	Midwest	HCS/CIR: Jan 4/5; HSS >600 km/s decl.
B	6 Feb 2008 (85)	Central, South	HCS: Feb 8; HDP
D	18 Feb 2008 (23)	Southeast	CIR: Feb 10; HSS>700 km/s declining
D	16 Mar 2008 (46)	Southeast	HCS/CIR: Mar 8; HSS >600 km/s decl.
D	10-12 Apr 2008 (34, 20, 23)	South, Midwest	CIR: Apr 4; HSS >600 km/s declining
A	24-26 Apr 2008 (20, 8, 9)	TX	HCS/CIR: Apr 22/23; HSS >600 km/s
A	2-3 May 2008 (29, 32)	Great Plains, South	HCS/CIR: Apr 30
B	11-12 May 2008 (59, 20)	Southeast	CIR: May 13; HDP
B	15 May 2008 (20)	South	CIR: May 16; HDP
D	23-26 May 2008 (27, 79, 23, 32)	Great Plains, Midwest	HCS/CIR: May 19; HSS ~600 km/s decl.
A	30-31 May 2008 (40, 16)	Great Plains, Midwest	HCS/CIR: May 28; HSS ~600 km/s
B	5-8 Jun 2008 (40, 40, 10, 33)	Great Plains, Midwest	HCS/CIR: Jun 6; HDP
B	12-13 Jun 2008 (40, 26)	Midwest	HCS/CIR: Jun 14; HDP
B	2-3 Sep 2008 (19, 21)	South	CIR: Sep 3; HDP
B	13-14 Sep 2008 (13, 31)	Great Plains, South	HCS/CIR: Sep 14/15; HDP
B	10 Dec 2008 (25)	Southeast	HCS/CIR: Dec 11; HDP
A	8-9 Mar 2009 (8, 26)	Midwest	CIR: Mar 8
A	24 Mar 2009 (20)	Great Plains, South	CIR: Mar 24
A*	10-11 Apr 2009 (24, 63)	South to Southeast	HCS/CIR: Apr 8*
A	30 Apr 2009 (21)	Great Plains	CIR: Apr 29
A	3-4 May 2009 (12, 23)	Southeast	HCS/CIR: May 2
A*	6-9 May 2009 (12, 18, 4, 47)	Southeast, West North Central	HCS/CIR: May 5/6*
A	14 May 2009 (25)	Great Plains	HCS/CIR: May 13
B	16-17 Jun 2009 (31, 22)	Great Plains, Midwest	HCS/CIR: Jun 17; HDP
A	20 Aug 2009 (30)	Midwest	CIR: Aug 19
C	30 Oct 2009 (32)	South	ICME: Oct 29 (Dst −41 nT)
D*	23-25 Apr 2010 (42, 13, 35)	Great Plains to Southeast	CIR/HCS: Apr 20/21*
B	1–2 May 2010 (26, 30)	Midwest to Southeast	CIR/HCS: May 2; HDP
A	11 May 2010 (69)	Great Plains	HCS/CIR: May 10
A*	19-20 May 2010 (31, 21)	Great Plains	HCS/CIR: May 19*
B	25-26 May 2010 (22, 30)	Midwest, Great Plains	HCS/CIR: May 25/26; HDP
B	6 Jun 2010 (46)	Great Lakes	HCS: Jun 6; HDP
D*	18 Jun 2010 (74)	Midwest	HCS/CIR: Jun 15*
A	22 Jun 2010 (27)	Midwest, Great Plains	CIR: Jun 21
A	26-27 Jun 2010 (22, 13)	Midwest	HCS/CIR: Jun 25/26
D	25-28 Oct 2010 (19, 3, 60, 9)	South, Midwest, Southeast	CIR: Oct 22; HSS >600 km/s declining
D	30 Nov 2010 (22)	South	HCS/CIR: Nov 27
B	1 Jan 2011 (33)	Midwest to South	HCS/CIR: Jan 2; HDP
B	28 Feb - 1 Mar (33, 12)	Midwest, Southeast	HCS/CIR: Jan 1; HDP
B	5 Apr 2011 (46)	Southeast	CIR/HCS: Apr 5; HDP
B	10-11 Apr 2011 (27, 20)	Midwest	HCS/CIR: April 11; HDP

B	15-17 Apr 2011 (56, 67, 55)	Great Plains, Southeast	HCS/CIR: Apr 17/18; HDP
A	20 Apr 2011 (80)	East North Central	CIR: Apr 20
D	26 Apr 2011 (50)	South	CIR: Apr 24; HSS declining
B*	27-28 Apr 2011 (110, 173)	Southeast	HCS/CIR: Apr 28/29*; HDP
A	22-24 May 2011 (18, 48, 17)	Midwest, Great Plains	CIR: May 21
B*	25-26 May 2011 (49, 93)	Midwest, Great Plains, South	HCS/CIR: May 26*; HDP
B*	19-21 Jun 2011 (17, 10, 37)	Great Plains, Midwest	HCS/CIR: Jun 21*; HDP
C	23 Jan 2012 (23)	Central	ICME: Jan 22 (Dst −73 nT)
C	26 Jan 2012 (22)	South	ICME: Jan 24 (Dst −80 nT)
C	29 Feb 2012 (27)	Eastern	ICME: Feb 29 (Dst −12 nT)
C	3 Mar 2012 (71)	Eastern	ICME: Mar 2 (Dst -32 nT)
B	4 Apr 2012 (21)	South	HCS: Apr 5; HDP
D*	14-16 Apr 2012 (14, 84, 14)	Great Plains	CIR: Apr 12*; HSS ~600 km/s declining
B	1-2 May 2012 (23, 16)	Great Plains, Midwest	HCS: May 3; HDP
D*	11 May 2012 (20)	TX	HCS/CIR: May 8*; HSS >600 km/s decl.
B	2 Jun 2012 (26)	Mid Atlantic	HCS/CIR: Jun 3; HDP
A	25 Jun 2012 (22)	FL	HCS/CIR Jun 23/24
?	26 Dec 2012 (30)	South	HCS: Dec 23; HSS declining
B	30-31 Jan 2013 (60, 5)	Central South	HCS: Jan 31
A	16 May 2013 (20)	Southwest	CIR: May 15
B	20-21 May 2013 (27, 38)	Midwest, Central, South	HCS/CIR: May 22; HDP: May 15-22
D	28-30 May 2013 (16, 25, 25)	Great Plains, Midwest	CIR/ICME (Dst −51 nT): May 24/25
B	31 May - 1 Jun 2013 (30, 36)	South, Midwest South	HCS/CIR: May 22; HDP
D	13-14 Jun 2013 (21, 15)	Midwest, East Central	CIR: Jun 10; HSS declining
B	1 Nov 2013 (33)	Central, South	HCS/CIR: Nov 2; HDP
D	18 Nov 2013 (74)	Midwest, Central	CIR: Nov 16; HSS declining
C	21 Feb 2014 (35)	Central, South, East	ICME: Feb 19, 20 (Dst -116, −91 nT)
B	28-29 Apr 2014 (20, 57)	Central, South	HCS: Apr 30; HDP
A	12 May 2014 (36)	Great Plains	CIR: May 11
A	17-19 Jun 2014 (36, 19, 18)	Midwest	HCS/CIR: Jun 16/17
A	1 Jul 2014 (42)	Midwest	CIR: Jun 30
A	13-14 Oct 2014 (7, 35)	Central South	CIR: Oct 13
B	20 Apr 2015 (22)	Southeast	HCS/CIR: Apr 20; HDP
B	25-27 Apr 2015 (27, 4, 20)	Mid Atlantic, Great Plains	HCS/CIR: Apr 27; HDP
C	7-11 May 2015 (47, 10, 11, 29, 25)	Great Plains, South	ICMEs: May 6, 7, 10 (Dst −51 nT)
B	17 May 2015 (59)	Great Plains, Midwest	HCS: May 17; HDP
C	20 May 2015 (37)	South	ICME/CIR: May 18
B	24-26 May 2015 (26, 14, 34)	South, Great Plains	HCS/CIR: May 26; HDP
B	5 Jun 2015 (20)	Great Plains	HCS/CIR: 7/6; HDP
C	22-23 Jun 2015 (9, 24)	Midwest, Great Lakes	CIR/ICME: Jun 21/22 (Dst −204 nT)
C	28 Jun 2015 (28)	Midwest	ICME: Jun 27 (Dst −56 nT)
D	12 Nov 2015 (23)	IA	CIR: Nov 9; HSS ~700 km/s declining

B	17-18 Nov 2015 (43, 13)	Great Plains, South	HCS/CIR: Nov 17/18; HDP
A	24 Dec 2015 (32)	Central, South	CIR: Dec 22; HSS
B	24-25 Feb 2016 (41, 23)	South, Mid Atlantic	HCS/CIR: Feb 25/26; HDP
B	1 Apr 2016 (20)	IN, South	HCS/CIR: Apr 2; HDP
D	27-28 Apr 2016 (43 23)	Great Plains, Midwest	CIR: Apr 23; HSS declining
A	10-11 May 2016 (28, 12)	Great Plains, Central	HCS/CIR: May 8
D	23-25 May 2016 (25, 5, 45)	Great Plains, Midwest	CIR: May 21; HSS ~600 km/s declining
A	23 Jun 2016 (23)	Midwest	HCS/CIR: Jun 22
A	25 Aug 2016 (22)	IN, OH, ON	CIR: Aug 23
D	30 Nov 2016 (29)	Southeast	CIR: Nov 24; HSS>600 km/s declining
B	3 Jan 2017 (36)	South	HCS/CIR: Jan 3; HDP
D	22-23 Jan 2017 (61, 19)	South	CIR: Jan 18; HSS ~600 km/s declining
A	1-2 Mar 2017 (55, 14)	Midwest, Central	CIR: Mar 1
D	7 Mar 2017 (62)	Midwest	CIR: Mar 1; HSS ~700 km/s declining
D	29-30 Mar 2017 (20, 15)	South	CIR: Mar 27; HSS >600 km/s declining
B	3-4 Apr 2017 (25, 38)	South, Southeast	HCS: Apr 4; HDP
A	6 Apr 2017 (24)	Southeast	ICME/CIR: Apr 4/5
B	30 Apr – 1 May 2017 (29, 32)	Central, Southeast, Northeast	HCS: May 1; HDP
A	5 May 2017 (22)	Southeast	CIR: May 4
D	17 May 2017 (21)	Great Plains	CIR: May 17; HSS>600 km/s declining
A	19-20 May 2017 (58, 34)	Great Plains	CIR: May 19
D	25 May 2017 (25)	Midwest, Southeast	CIR: May 19; HSS>600 km/s declining
A	13 Jun 2017 (21)	Midwest	HCS/CIR: Jun 11
D	29 Jun 2017 (26)	Midwest	CIR: Jun 25; HSS declining
B	6 Nov 2017 (24)	Midwest	HCS/CIR Nov 7; HDP
D	25 Feb 2018 (30)	Southeast	CIR: Feb 21; HSS>500 km/s declining
D	20 Mar 2018 (20)	Southeast	CIR: Mar 14; HSS ~600 km/s declining
B	4 Apr 2018 (22)	Eastern	CIR: Apr 4; HDP
D	14-16 Apr 2018 (40, 16, 18)	South, Southeast	HCS/CIR: Apr 8/9; HSS ~600 km/s decl.
B	3 May 2018 (33)	Great Plains	HCS/CIR: May 4/5; HDP
A	29 May 2018 (29)	Great Plains	CIR: May 27
A	20-21 Jul 2018 (23, 9)	Midwest	CIR: Jul 19
D	29 Aug 2018 (26)	Midwest	HCS/CIR: Aug 25/26; HSS ~600 km/s
B	21 Sep 2018 (30)	Midwest, Great lakes	HCS/CIR: Sep 21; HDSP
B	2 Oct 2018 (21)	Northeast	HCS/CIR: Oct 3
D*	10 Oct 2018 (23)	Great Plains, Midwest	HCS/CIR: Oct 7*; HSS ~600 km/s decl.
B	1 Nov 2018 (51)	South	HCS: Nov 2; HDP
D*	6 Nov 2018 (29)	Central South	HCS/CIR: Nov 4*; HSS ~600 km/s decl.
A*	1-2 Dec 2018 (15, 34)	Great Plains, Midwest, IL	HCS/CIR: Dec 1*
D	4 Mar 2019 (44)	Southeast	CIR: Feb 27; HSS ~600 km/s declining
A	15 Mar 2019 (31)	Midwest, South	CIR: Mar 15
B	14-15 Apr 2019 (46, 28)	South, Northeast	CIR: Apr 15; HDP

B	19-20 Apr 2019 (45, 43)	South, Southeast	HCS/CIR: Apr 19
B	1 May 2019 (57)	Great Plains	HDP/CIR: May 1
B	8-9 May 2019 (23, 18)	South	HDP/CIR: May 9
D	18-19 May 2019 (27, 32)	Great Plains, South	CIR/ICME: May 13; HSS>500 km/s decl
B	21-23 May 2019 (52, 21, 36)	Great Plains, Midwest	HCS: May 22; HDP
B	26 May 2019 (28)	Great Plains, Midwest	HCS/CIR: May 26/27; HDP
C	27-28 May 2019 (34, 62)	Great Plains, Midwest	ICME: May 26 (Dst −16 nT)
A	30 May 2019 (41)	TX, Midwest, East	CIR: May 29
D	16-17 Jun 2019 (29, 13)	Great Plains, Midwest	HCS/cir; Jun 12; HSS declining
B	21 Oct 2019 (33)	Great Plains, South	HCS/CIR: Oct 21; HDP
B	17 Dec 2019 (36)	South	HCS: Dec 18; HDP
D	11-12 Jan 2020 (50, 30)	Central South, Southeast	CIR: Jan 8; HSS >500 km/s declining
A	6-7 Feb 2020 (19, 12)	Central South, Southeast	CIR: Feb 6
?	29 Mar 2020 (22)	Midwest	CIR: Mar 30; HDP ?
A	8-9 Apr 2020 (7, 25)	Central North	CIR: Apr 8
A	12-14 Apr 2020 (5, 113, 24)	Southeast	CIR: Apr 11
C	20 Apr 2020 (19)	South	ICME: Apr 20 (Dst −59 nT)
D	23-24 Apr 2020 (32, 17)	South, Southeast	CIR: Apr 21; HSS~500 km/s declining
D	4-5 Aug 2020 (30, 13)	Mid Atlantic	CIR: Aug 2
?	11 Aug 2020 (27)	Midwest	?
B	15 Aug 2020 (32)	Midwest	HCS/CIR: Aug 16; HDP
A	28-29 Aug 2020 (22, 6)	SD, AR, Northeast	HCS/CIR: Aug 25/26
A	14 Mar 2021 (21)	TX, Southwest	HCS/CIR: Mar 12/13
B	18 Mar 2021 (40)	Southeast	HCS/CIR: Mar 18/20; HDP
A	26 Mar 2021 (20)	Southeast	CIR: Mar 24
A	28 Mar 2021 (20)	Southeast	CIR: Mar 27
A	3-5 May 2021 (27, 52, 18)	Great Plains, Southeast, Midwest	CIR: May 3
A	27 May 2021 (21)	Great Plains	HCS/CIR: May 26
A	15 Jul 2021 (26)	Midwest	CIR: Jul 14
A	29-30 Jul 2021 (18, 29)	Midwest, Northeast	CIR: Jul 27
A	9-10 Aug 2021 (10, 20)	Midwest	HCS/CIR: Aug 9/10
A	11 Oct 2021 (21)	OK	CIR: Oct 10
C	13 Oct 2021 (24)	OK, KS	ICME: Oct 12 (Dst −64 nT)
A	11 Dec 2021 (68)	Central	HCS/CIR: Dec 10
A	16 Dec 2021 (125)	Midwest	CIR: Dec 15
A	6 Mar 2022 (22)	Midwest	CIR: Mar 5
B	22-23 Mar 2022 (37, 40)	TX, South, Southeast	HDP/CIR: Mar 21/22
C	31 Mar 2022 (78)	Southeast	ICME: Mar 31 (Dst -19 nT)
D	5 Apr 2022 (65)	Southeast	CIR: Apr 2; HSS >500 km/s declining
C	13-14 Apr 2022 (28, 40)	Midwest	ICMEs: Apr 12/14 (Dst -24/-81 nT)
D	30 Apr 2022 (21)	Midwest, South, Southeast	CIR: Apr 27; HSS >500 km/s declining
B	13 May 2022 (32)	Midwest	HCS/CIR: May 12/14

D	31 May 2022 (31)	Midwest	CIR: May 27; HSS >600 km/s declining
D	5 Nov 2022 (30)	South, Southeast	CIR: Nov 2; HSS >600 km/s declining
D	30 Nov 2022 (23)	Southeast	CIR: Nov 25; HSS >700 km/s
D	14-15 Dec 2022 (25, 18)	South, Southeast	CIR: Dec 7; HSS >500 km/s declining
B	3-4 Jan 2023 (17, 29)	Southeast	HCS/CIR: Jan 4
B	13 Jan 2023 (41)	Southeast	CIR: Jan13
D	1 Apr 2023 (138)	Midwest, Southeast	CIR: Mar 30; HSS >600 km/s declining
B	20 Apr 2023 (32)	Great Plains, Midwest	HCS: Apr 20
C	11-12 May 2023 (9, 32)	Northern Great Plains	ICME: May 9 (Dst -18 nT)
C	13-14 May 2023 (34, 20)	Northern Great Plains	ICME: May 12 (Dst -16 nT)
A	16 Jun 2023 (39)	South, Southeast, Midwest	HCS/CIR: Jun 15
A	22 Jun 2023 (45)	Great Plains South	CIR: Jun 21
A	24 Jun 2023 (24)	Northern Great Plains	CIR: Jun 23
?	29 Jul 2023 (22)	Midwest	?CIR: Jul 30 (data gap)
A	7-8 Aug 2023 (10, 20)	Northeast, Southeast	CIR: Aug 7
A	25 Aug 2023 (24)	Midwest, Northeast	CIR: Aug 24