Comparison of counterstreaming suprathermal electron signatures of ICMEs with and without magnetic cloud: are all ICMEs flux ropes?

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Received 19 September 2019 / Accepted 13 November 2019

ABSTRACT

Context. Magnetic clouds (MCs), as in large-scale interplanetary magnetic flux ropes, are usually still connected to the Sun at both ends near 1 AU. Many researchers believe that all nonMC interplanetary coronal mass ejections (ICMEs) also have magnetic flux rope structures, which are inconspicuous because the observing spacecraft crosses the flanks of the rope structures. If so, the field lines of nonMC ICMEs should also usually be connected to the Sun at both ends.

Aims. We want to know whether or not the field lines of most nonMC ICMEs are still connected to the Sun at both ends.

Methods. This study examined the counterstreaming suprathermal electron (CSE) signatures of 272 ICMEs observed by the Advanced Composition Explorer (ACE) spacecraft from 1998 to 2008 and compared the CSE signatures of MCs and nonMC ICMEs.

Results. Results show that only 10 of the 101 MC events (9.9%) and 75 of the 171 nonMC events (43.9%) have no CSEs. Moreover, 21 of the nonMC ICMEs have high CSE percentages (more than 70%) and show relatively stable magnetic field components with slight rotations, which are in line with the expectations that the observing spacecraft passes through the flank of magnetic flux ropes. Therefore, the 21 events may be magnetic flux ropes but the ACE spacecraft passes through their flanks of magnetic flux ropes.

Conclusions. Considering that most other nonMC events have disordered magnetic fields, we suggest that some nonMC ICMEs inherently have disordered magnetic fields, and therefore no magnetic flux rope structures.

Key words. Sun: coronal mass ejections (CMEs) – solar wind

1. Introduction

Coronal mass ejections (CMEs) are intense solar explosive eruptions during which large amounts of plasma and magnetic field from the solar atmosphere are ejected into interplanetary space. The interplanetary manifestations of CMEs (ICMEs; Kilpua et al. 2017) can be measured by a spacecraft at about 1 AU and exhibit the following characteristics: increase in total magnetic magnitude (Cane & Richardson 2003), helium abundance (Hirshberg et al. 1972; Zwickl et al. 1982; Richardson & Cane 2004), average iron ionization (Lepri et al. 2001; Lepri & Zurbuchen 2004), and O^{7+} abundance (Richardson & Cane 2004; Wang & Feng 2016); decrease in proton temperatures and proton densities (Gosling et al. 2001; Zhang et al. 2013); counterstreaming suprathermal electron (CSE) strahls and declining speed (Zwickl et al. 1982; Gosling et al. 1987; Shodhan et al. 2000; Burlaga et al. 2001). A subset of ICMEs was defined as magnetic cloud (MC) by Burlaga et al. (1981) empirically using the following properties: (1) the magnetic field strength is higher than average, (2) a smooth change in field direction as observed by a spacecraft passing through the cloud, and (3) low proton temperature compared to that of the ambient proton. Magnetic clouds usually have magnetic flux rope structures, and they are the main source of major geomagnetic storms (Burlaga et al. 1981; Webb et al. 2000; Huttunen et al. 2002; Zhang et al. 2007). Observations at 1 AU show that 30–40% of ICMEs are MCs, and this percentage depends on the solar cycle (Richardson & Cane 2004). However, CMEs are usually assumed to have magnetic flux rope structures near the Sun

because of their helical shapes (Canfield et al. 1999; Liu et al. 2010; Rust & Kumar 1996). This begs the question of whether or not nonMC ICMEs also have flux rope structures. The journal of Solar Physics once made a special issue to address this question (Gopalswamy et al. 2013a). A comparative study of 23 MCs and 31 nonMC ICMEs was completed, and the source regions of the 54 ICMEs were located within $\pm 15^\circ$ longitude from the disk center. Yashiro et al. (2013) found no significant difference between the structures of the post-eruption arcades of MCs and nonMC ICMEs during launch. Gopalswamy et al. (2013b) observed that MCs and nonMC ICMEs have significant enhancement in Fe and O charge states, and Fe and O charge-state measurements are positively correlated with flare properties, including flare size and soft X-ray flare intensity. Their observations suggest that these CMEs have similar explosive environment and flux rope structures near the Sun. Furthermore, some studies indicate that CMEs associated with MCs tend to propagate along the Sun–Earth line, whereas nonMC events are deflected away from the Sun–Earth line (Kim et al. 2013; Mäkelä et al. 2013; Zhang et al. 2013). Therefore, many researchers believe that all ICMEs have magnetic flux rope structures and that the nonMC events are due to observational limitations, that is, that the observing spacecraft crosses the flanks of the ropes and therefore the ICMEs appear as nonMCs. This has been shown by some multi-satellite-observed ICMEs, namely spacecraft farther from the axis detect less clear flux rope signatures than centrally crossing spacecraft for the same event (Cane et al. 1997; Kilpua et al. 2011).

Moreover, some researchers believe that some ICMEs may have lost their flux rope structure due to interactions in interplanetary space (e.g., Gopalswamy et al. 2001; Liu et al. 2014; Manchester et al. 2017). In particular, sometimes multiple ICMEs can merge to form complex ICMEs where their individual characteristics are no longer identifiable (Burlaga et al. 2002). According to Rodkin et al. (2018), about 48% of observed ICMEs are associated with two or more sources; in some cases, complex ICMEs can be associated with multiple CMEs from the same active region (Burlaga et al. 2002). The interaction processes include compression and magnetic reconnection; however, the compression process does not change the overall topology of rope structures (Riley & Crooker 2004; Zhang et al. 2013). Therefore, the rope structures of CMEs are destroyed mainly through magnetic reconnection processes. A CME that was associated with complex (nonMC) ejecta may inherently have complex magnetic field structure at the Sun, as shown in the simulation results of Lynch et al. (2008). Richardson & Cane (2004) favored the view that the reconnection of multiple loop systems may result in CMEs with several complicated magnetic field structures as solar activity increases. This explanation is appropriate for the observation that a fraction of MCs vary with the phase of the solar cycle, that is, about 15% at solar maximum but almost 100% at solar minimum. However, CME source regions cluster to low latitudes at solar minimum and high latitudes at solar maximum (Hundhausen et al. 1984), thus affecting whether CMEs are expected to be crossed more centrally or at the flanks. Recently, Awasthi et al. (2018) reported a nonMC ICME that supports this view. Its pre-eruptive structure consists of multiple-braided flux ropes with different degrees of coherency, and the individual flux-rope branches appear to be connected to each other. Awasthi et al. (2018) excluded that the complex ICME can result from the merging of successive CMEs and the spacecraft they used only made a glancing encounter with an Earth-directed CME. Awasthi et al. (2018) considered that a nonMC event inherently disrupts magnetic fields.

Suprathermal electron strahls in the solar wind come from the Sun and are focused along magnetic field lines (Feldman et al. 1975; Rosenbauer et al. 1977; Pagel et al. 2005). Therefore, observations of CSE strahls within MCs can indicate that the flux rope structures are still connected with the Sun's magnetic field lines on both ends (Gosling et al. 1995; Larson et al. 1997; Shodhan et al. 2000; Feng et al. 2015, 2019). Counterstreaming suprathermal electrons can also be produced by other mechanisms, for example connection to the Earth's bowshock (Feldman et al. 1982; Stansberry et al. 1988), interplanetary shocks or corotating interaction regions (CIRs; Gosling et al. 1993; Steinberg et al. 2005; Lavraud et al. 2010), and distribution function depletions near the 90° pitch angle (Gosling et al. 2001, 2002; Skoug et al. 2006). Among these mechanisms, the depletion CSEs are often observed on closed or open field lines within ICMEs, but the depletion CSEs are centered on and roughly symmetric to the 90° pitch angle (Gosling et al. 2002), and can be distinguished from CSE strahls. Shodhan et al. (2000) examined the CSE strahl signatures of 52 MCs detected by a spacecraft near 1 AU and determined that approximately 87.5% of MCs exhibit CSE signatures, revealing that most MCs are still attached to the Sun at both ends at 1 AU. Gosling (1990) and Gosling et al. (1995) proposed explanations for how flux ropes arise in terms of three-dimensional reconnection close to the Sun. They illustrate how the original flux rope reconnects to form a helical field line connected to the Sun at both ends. The closed field lines of flux ropes can gradually open and occasionally disconnect from the corona when closed flux ropes expand from the

Sun into the interplanetary space (Gosling et al. 1995). The proposal of Gosling et al. (1995) was confirmed by statistical results of Shodhan et al. (2000), namely most MCs exhibit CSE strahls in parts of their durations, and only 6 of the 52 MCs have no CSE. We therefore want to know whether or not nonMC ICMEs have the same CSE strahl signatures. In this study, CSE signatures from the Advanced Composition Explorer (ACE) from 1998 to 2008 are compared between ICMEs with and without MCs, and we discuss whether the CSE signatures are related to the flux-rope structures.

2. Data

In this study, the 272 eV suprathermal electron pitch-angle distributions (PADs) measured by ACE are used. The electron PADs are obtained from the Solar Wind Electron Proton Alpha Monitor (SWEPAM) with angular and time resolutions of 9° and 64 s respectively (McComas et al. 1998). Here we examined 16 s average magnetic field, 64 s average plasma, 1 h average O^{7+}/O^{6+} ratio, and mean Fe charge state $\langle Fe \rangle$ data from 1998 to 2008 measured by ACE and identified 272 ICMEs in total. The ICMEs were identified by the following process: (1) We take the events in previous ICME lists of Jian et al. (2006), Chi et al. (2016), and Richardson & Cane (2004)¹ as candidate ICMEs. (2) Some lists also report short-duration (<10 h) structures as ICMEs. As the origin of these smaller-scale ICMEs and flux ropes are still debated (Feng et al. 2007; Rouillard et al. 2011; Janvier et al. 2014; Feng & Wang 2015; Wang et al. 2019), we excluded them from this study. (3) The high Fe charge states ($\langle Fe \rangle \geq 12$) and abnormally high O^{7+}/O^{6+} ratio (≥ 1) are the result of flare-related heating in the corona (Lepri & Zurbuchen 2004; Reinard 2005), and therefore they are independently reliable ICME indicators (Feng & Wang 2015). If the candidate ICMEs have high Fe charge states and/or abnormally high O^{7+}/O^{6+} ratio, they are identified as ICMEs. (4) If the candidate ICMEs have no high Fe charge states and abnormally high O^{7+}/O^{6+} ratio, we look for the following five characteristics: declining speed (apparent expansion), increasing total magnetic magnitude and helium abundance ($He/P > 0.06$) (Richardson & Cane 2004), and decreasing proton temperatures and proton densities. If the candidate ICMEs have three or more of the above characteristics they are identified as ICMEs. Given that magnetic flux ropes are special field topologies characterized by bundles of helical magnetic-field lines collectively spiraling around a common axis, the essential observational properties of magnetic flux ropes should be enhanced magnetic field strength and smooth rotations (Feng et al. 2008, 2010), namely, measured enhanced magnetic field strength, the center-enhanced magnetic components, and bipolar curve magnetic components. Therefore, if an ICME was found to have enhanced magnetic field strength, both center-enhanced and bipolar field components, it was identified as MC. Among the 272 ICMEs, 101 (37.1%) events were identified as MCs. All 272 ICMEs are listed in Table A.1. The second and third columns show the start and end times, the fourth column gives the duration of the ICMEs, and the fifth column provides the types of ICMEs (MC or nonMC).

3. Observations and results

This study analyzed the 272 eV suprathermal electron PADs to determine the CSE signatures within ICMEs. The CSE events were confirmed through their suprathermal electron PADs that

¹ [http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm#\(g\)](http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm#(g))

Fig. 1. Suprathermal electron pitch angle distributions of 272 eV, magnetic field and plasma data measured by ACE during the October 21C22, 1999 ICME passage. The two vertical dashed lines denote the boundaries of the ICME.

show significantly higher phase space densities near 0° and 180° pitch angle directions than in the 90° pitch angle direction (Lavraud et al. 2010). If the ratios of phase space densities near 0° and 180° to the phase space densities at 90° in an interval are greater than three, the interval was noted as a possible CSE interval. We then removed depletion CSEs on open field lines by eye using their symmetries. Finally, the phase space densities at 90° can obviously strengthen by scattering of strahl electrons. For some intervals within ICMEs, the ratios of phase space densities near 0° and 180° to the phase space densities at 90° are less than three, but the CSE strahls can still be recognized by eye; we also noted these intervals as CSE strahls. Counterstreaming suprathermal electron boundaries are not always recognizable, and therefore the identification of CSE intervals within ICMEs is somewhat subjective (Shodhan et al. 2000). We used the ICME in October 21–22, 1999, as an example to illustrate the process of identifying a CSE interval.

Figure 1 shows the suprathermal electron PADs, magnetic and plasma data from the ICME passage of October 21–22, 1999. The two vertical-dashed lines represent the front and rear boundaries of the ICME. This ICME exhibits high Fe charge states ($\langle \text{Fe} \rangle \geq 12$), an abnormally high $\text{O}^{7+}/\text{O}^{6+}$ ratio (≥ 1), and high He/P (> 0.06) in the rear part. In addition, the event also shows the ICME characteristics of enhanced magnetic magnitude, and decreased proton temperatures and proton densities. The 272 eV suprathermal electron PADs showed that (1) the enhanced phase-space densities near the 180° direction occurred throughout the duration of the ICME; (2) the 0° suprathermal electron strahls are mainly present in the rear half. The red bars above the suprathermal electron PADs mark the intervals where the ratios of phase space densities near 0° and 180° to the phase space densities at 90° are greater than three. It is easy to see that

Fig. 2. Variation of normalized magnetic field components for the case of $d_0 = 0.9R_0$, where R_0 is radius of the flux rope and d_0 is the distance between the spacecraft trajectory and the rope axis.

strong depletions occur within the first bar, and the depletion CSE interval was removed when we estimated the percentages of CSEs. One can also see that the bars in the rear half have two short intervals, which are caused by scattering of strahl electrons. We therefore identify the two short intervals as CSE strahls, and the percentage of CSE strahls is about 35%.

Furthermore, this study examined all the suprathermal electron PADs of the 272 ICMEs and estimated the percentages of CSEs. The results are listed in the sixth column of Table A.1. Only 10 (9.9%) of the 101 MCs have no CSE, and the ratio is consistent with the results of Shodhan et al. (2000), who examined the CSE signatures of 52 MCs and concluded that 6 MCs have no CSEs. As for the other 91 MCs, the percentage of CSEs varies from 6 to 100%, with a mean value of 57%. Meanwhile, 75 of the 171 nonMC ICMEs (43.9%) do not contain CSEs. The

Fig. 3. Suprathermal electron pitch angle distributions of 272 eV magnetic field and plasma data measured by ACE during the ICME passage of February 18–19, 2005.

fraction of ICMEs without CSEs is thus clearly larger in nonMC ICMEs than in MCs. The extensive difference may imply that the two groups have different magnetic structures. For the other 96 nonMC events, their mean CSE percentage is 45%, which is smaller than for the MCs (57%). Among the 96 nonMC ICMEs, 21 have greater than 70% CSEs. Examination of the magnetic field component curves of these 21 ICMEs reveals that fields of most events have neither apparent smooth rotations nor disorder, but their magnetic field component curves have only slight rotations, and they are relatively stable or even close to the line. It is well known that most MCs can be described with a constant force-free field configuration, for example, the Lundquist solution (Lepping et al. 1990; Feng et al. 2006). According to the Lundquist solution, the shapes of measured field component curves depend on the distance d_0 between the spacecraft trajectory and the rope axis (see Figs. 2–4 of Feng et al. 2006). The spacecraft will measure center-enhanced and bipolar curves if the spacecraft trajectory is close to the rope axis; otherwise, the bipolar curves will disappear. Figure 2 shows the variations of the magnetic field components for the case of $d_0 = 0.9R_0$, where R_0 is the radius of the flux rope, z is the axial direction, x is the radial direction pointing to the satellite contact position, and the direction y is obtained from the cross product of z and x . In Fig. 2, all the three magnetic field components are relatively stable and exhibit only slight rotations. These trends indicate that the spacecraft that passes through the flank of a magnetic flux rope will measure relatively stable magnetic field variations. Therefore, the 21 highest percentage (more than 70%) events may have flux rope structures, but the spacecraft crosses the flanks of the ropes and thus the flux rope signatures do not appear. For example, Fig. 3 shows that the ICME on February 18–19, 2005, has a CSE percentage of 100%. Based on Fig. 3, one can find that

all three magnetic field component curves remain stable with little fluctuation; in particular, the z component curve is around zero. Meanwhile, the magnetic field magnitude remains at a low value. This event does not satisfy the requirements of MCs (flux ropes). Kim et al. (2013) investigated the propagation characteristics of this ICME and used the direction parameter (D) to quantify the asymmetry of CME shapes in coronagraph images and the degree of deviation from the Sun–Earth line. The value of D is between 0 and 1, and a small D indicates a large deviation from the Sun–Earth line. For this ICME, the D value is only 0.13, indicating that its propagation direction is essentially deviated from the Sun–Earth line. Thus, Kim et al. (2013) considered that this CME inherently has a magnetic flux rope structure even though the ACE spacecraft crossed the flank of the rope and did not measure the essential properties of the magnetic flux rope. For this ICME, we have the same viewpoint with Kim et al. (2013). Figure 2 demonstrates that the spacecraft that passes through the flank of the magnetic flux ropes will measure relatively stable magnetic field variations. The MC legs, which magnetically connect the flux rope to the Sun, are not recognizable as MCs and thus are unlikely to contain twisted flux rope fields. Spacecraft encounters with these nonflux-rope legs may provide an explanation for the frequent observation of nonMC ICMEs. It is also possible that the spacecraft passes through the legs of the flux rope where the flux-rope-like rotation is not observed but other flux rope signatures are present (Owens 2016). We therefore conclude that most of the 21 ICMEs with large CSE percentages may inherently have flux rope structures, but the structures do not appear as MCs because of geometric selection effects. Finally, we can draw such a conclusion that only a few MCs do not exhibit CSE signatures, but about half of the nonMC ICMEs do not exhibit CSE signatures.

4. Discussion and summary

In this study, we examined the CSE signatures of the 272 ICMEs detected by ACE from 1998 to 2008 and compared them between ICMEs with and without MC (flux rope) structure. Our study confirms the earlier results, for example those by Shodhan et al. (2000), that the overwhelming majority of MCs are still connected to the solar magnetic field on both ends for at least part of their magnetic field lines near 1 AU. The fact that the clear majority of MCs exhibit CSEs suggests that the nonMC population featuring CSEs could also have flux rope structure. We find that the MC category had 101 events with only 10 (9.9%) events having no CSEs, and that the nonMC category had 171 events with 75 (43.9%) events having no CSEs. The fraction of nonMC events without CSE is distinctly larger than that for the MC events. The highest-percentage (more than 70%) events in the nonMC category usually have stable magnetic field components accompanied with slight rotations based on our visual evaluation. These observations are in line with the expectations that observing spacecraft pass through the flank of magnetic flux ropes. The results of this study imply that some nonMC events indeed have magnetic flux rope structures. In most nonMC events, magnetic fields are disordered, and most field lines are not connected to the Sun at both ends. As in the CMEs reported by Awasthi et al. (2018), these nonMC events may inherently have disordered magnetic fields, which results from the interactions among multiple-braided flux ropes with different degrees of coherency on the Sun. In summary, this study provides information that is helpful in checking whether all ICMEs have flux rope structures. The observations in this study do not support the idea that all CMEs that arrive on Earth have flux ropes but suggests that some nonMC events indeed have magnetic flux rope structures. However, we cannot exclude the possibility that all CMEs that arrive at Earth had a flux rope structure when they were launched from the Sun. The association of the CSE signatures and the CME structures is an interesting problem and could be investigated in the future.

Acknowledgements. The authors acknowledge supports from NSFC under grant Nos. 41804162, 41674170, 41974197. The authors thank NASA/GSFC for the use of data from ACE, these data can obtain freely from the Coordinated Data Analysis Web (http://cdaweb.gsfc.nasa.gov/cdaweb/istp_public/).

References

- Awasthi, A. K., Liu, R., Wang, H., et al. 2018, *ApJ*, **857**, 124
- Burlaga, L., Sittler, E., Mariani, F., & Schwenn, R. 1981, *J. Geophys. Res.*, **86**, 6673
- Burlaga, L. F., Skoug, R. M., Smith, C. W., et al. 2001, *J. Geophys. Res.*, **106**, 20957
- Burlaga, L. F., Plunkett, S. P., & St. Cyr, O. C. 2002, *J. Geophys. Res. (Space Physics)*, **107**, 1266
- Cane, H. V., & Richardson, I. G. 2003, *J. Geophys. Res. (Space Physics)*, **108**, 1156
- Cane, H. V., Richardson, I. G., & Wibberenz, G. 1997, *J. Geophys. Res.*, **102**, 7075
- Canfield, R. C., Hudson, H. S., & McKenzie, D. E. 1999, *Geophys. Res. Lett.*, **26**, 627
- Chi, Y., Shen, C., Wang, Y., et al. 2016, *Sol. Phys.*, **291**, 2419
- Feng, H. Q., & Wang, J. M. 2015, *ApJ*, **809**, 112
- Feng, H. Q., Wu, D. J., & Chao, J. K. 2006, *J. Geophys. Res. (Space Physics)*, **111**, A07S90
- Feng, H. Q., Wu, D. J., & Chao, J. K. 2007, *J. Geophys. Res. (Space Physics)*, **112**, A02102
- Feng, H. Q., Wu, D. J., Lin, C. C., et al. 2008, *J. Geophys. Res. (Space Physics)*, **113**, A12105
- Feng, H. Q., Wu, D. J., & Chao, J. K. 2010, *J. Geophys. Res. (Space Physics)*, **115**, A10109
- Feng, H. Q., Zhao, G. Q., & Wang, J. M. 2015, *J. Geophys. Res. (Space Physics)*, **120**, 10
- Feng, H. Q., Zhao, G. Q., & Wang, J. M. 2019, *Sci. China Technol. Sci.*, **1**
- Feldman, W. C., Asbridge, J. R., Bame, S. J., et al. 1975, *J. Geophys. Res.*, **80**, 4181
- Feldman, W. C., Anderson, R. C., Asbridge, J. R., et al. 1982, *J. Geophys. Res.*, **87**, 632
- Gopalswamy, N., Yashiro, S., Kaiser, M. L., et al. 2001, *ApJ*, **548**, L91
- Gopalswamy, N., Nieves-Chinchilla, T., Hidalgo, M., et al. 2013a, *Sol. Phys.*, **284**, 1
- Gopalswamy, N., Mäkelä, P., Akiyama, S., et al. 2013b, *Sol. Phys.*, **284**, 17
- Gosling, J. T. 1990, *Geophys. Union Geophys. Monograph Ser.*, **58**, 343
- Gosling, J. T., Baker, D. N., Bame, S. J., et al. 1987, *J. Geophys. Res.*, **92**, 8519
- Gosling, J. T., Bame, S. J., Feldman, W. C., et al. 1993, *Geophys. Res. Lett.*, **20**, 2335
- Gosling, J. T., Birn, J., & Hesse, M. 1995, *Geophys. Res. Lett.*, **22**, 869
- Gosling, J. T., Skoug, R. M., & Feldman, W. C. 2001, *Geophys. Res. Lett.*, **28**, 4155
- Gosling, J. T., Skoug, R. M., Feldman, W. C., et al. 2002, *Geophys. Res. Lett.*, **29**, 1573
- Hirshberg, J., Bame, S. J., & Robbins, D. E. 1972, *Sol. Phys.*, **23**, 467
- Hundhausen, A. J., Sawyer, C. B., House, L., Illing, R. M. E., & Wagner, W. J. 1984, *J. Geophys. Res.*, **89**, 2639
- Huttunen, K. E. J., Koskinen, H. E. J., & Schwenn, R. 2002, *J. Geophys. Res. (Space Physics)*, **107**, 1121
- Janvier, M., Démoulin, P., & Dasso, S. 2014, *J. Geophys. Res. (Space Physics)*, **119**, 7088
- Jian, L., Russell, C. T., Luhmann, J. G., et al. 2006, *Sol. Phys.*, **239**, 393
- Kilpua, E. K. J., Jian, L. K., Li, Y., Luhmann, J. G., & Russell, C. T. 2011, *J. Atmos. Sol. Terrest. Phys.*, **73**, 1228
- Kilpua, E., Koskinen, H. E. J., & Pulkkinen, T. I. 2017, *Liv. Rev. Sol. Phys.*, **14**, 5
- Kim, R.-S., Gopalswamy, N., Cho, K.-S., et al. 2013, *Sol. Phys.*, **284**, 77
- Larson, D. E., Lin, R. P., McTiernan, J. M., et al. 1997, *Geophys. Res. Lett.*, **24**, 1911
- Lavraud, B., Opitz, A., Gosling, J. T., et al. 2010, *Ann. Geophys.*, **28**, 233
- Lepping, R. P., Burlaga, L. F., & Jones, J. A. 1990, *J. Geophys. Res.*, **95**, 11957
- Lepri, S. T., & Zurbuchen, T. H. 2004, *J. Geophys. Res. (Space Physics)*, **109**, A01112
- Lepri, S. T., Zurbuchen, T. H., Fisk, L. A., et al. 2001, *J. Geophys. Res.*, **106**, 29231
- Liu, R., Liu, C., Wang, S., et al. 2010, *ApJ*, **725**, L84
- Liu, Y. D., Yang, Z., Wang, R., et al. 2014, *ApJ*, **793**, L41
- Lynch, B. J., Antiochos, S. K., DeVore, C. R., et al. 2008, *ApJ*, **683**, 1192
- Mäkelä, P., Gopalswamy, N., Xie, H., et al. 2013, *Sol. Phys.*, **284**, 59
- Manchester, W., Kilpua, E. K. J., Liu, Y. D., et al. 2017, *Space Sci. Res.*, **212**, 1159
- McComas, D. J., Bame, S. J., Barker, P., et al. 1998, *Space Sci. Res.*, **86**, 563
- Owens, M. J. 2016, *ApJ*, **818**, 197
- Pagel, C., Crooker, N. U., Larson, D. E., et al. 2005, *J. Geophys. Res. (Space Physics)*, **110**, A01103
- Reinard, A. 2005, *ApJ*, **620**, 501
- Richardson, I. G., & Cane, H. V. 2004, *J. Geophys. Res. (Space Physics)*, **109**, A09104
- Riley, P., & Crooker, N. U. 2004, *ApJ*, **600**, 1035
- Rodkin, D., Slemzin, V., Zhukov, A. N., et al. 2018, *Sol. Phys.*, **293**, 78
- Rouillard, A. P., Sheeley, Jr., N. R., Cooper, T. J., et al. 2011, *ApJ*, **734**, 7
- Rosenbauer, H., Schwenn, R., Marsch, E., et al. 1977, *J. Geophys. Z. Geophys.*, **42**, 561
- Rust, D. M., & Kumar, A. 1996, *ApJ*, **464**, L199
- Shodhan, S., Crooker, N. U., Kahler, S. W., et al. 2000, *J. Geophys. Res.*, **105**, 27261
- Skoug, R. M., Gosling, J. T., McComas, D. J., et al. 2006, *J. Geophys. Res. (Space Physics)*, **111**, A01101
- Stansberry, J. A., Gosling, J. T., Thomsen, M. F., et al. 1988, *J. Geophys. Res.*, **93**, 1975
- Steinberg, J. T., Gosling, J. T., Skoug, R. M., et al. 2005, *J. Geophys. Res. (Space Physics)*, **110**, A06103
- Wang, J. M., & Feng, H. Q. 2016, *Sci. China Earth Sci.*, **59**, 1051
- Wang, J. M., Feng, H. Q., Li, H. B., et al. 2019, *ApJ*, **876**, 57
- Webb, D. F., Cliver, E. W., Crooker, N. U., et al. 2000, *J. Geophys. Res.*, **105**, 7491
- Yashiro, S., Gopalswamy, N., Mäkelä, P., et al. 2013, *Sol. Phys.*, **284**, 5
- Zhang, J., Richardson, I. G., Webb, D. F., et al. 2007, *J. Geophys. Res. (Space Physics)*, **112**, A10102
- Zhang, J., Hess, P., & Poomvises, W. 2013, *Sol. Phys.*, **284**, 89
- Zwickl, R. D., Asbridge, J. R., Bame, S. J., et al. 1982, *J. Geophys. Res.*, **87**, 7379

Appendix A: Table

Table A.1. Percentage of counterstreaming suprathermal electrons in ICMEs.

NO.	Start ^(a)	End ^(b)	Duration ^(c)	Type ^(d)	Percent ^(e)
001	1998/01/07 02:50	1998/01/08 13:08	34.3	MC	56
002	1998/01/21 05:40	1998/01/22 13:22	31.7	nonMC	6
003	1998/01/29 19:56	1998/01/30 23:08	27.2	nonMC	23
004	1998/02/02 13:10	1998/02/04 02:15	37.1	nonMC	0
005	1998/02/04 04:15	1998/02/05 15:10	34.9	MC	20
006	1998/02/17 10:00	1998/02/17 21:00	11.0	MC	88
007	1998/02/19 00:20	1998/02/20 00:10	23.8	nonMC	0
008	1998/03/04 13:00	1998/03/06 05:40	40.7	MC	0
009	1998/03/25 12:00	1998/03/26 09:50	21.8	MC	93
010	1998/04/01 01:45	1998/04/03 01:35	47.8	nonMC	8
011	1998/04/12 01:20	1998/04/13 17:50	40.5	nonMC	0
012	1998/05/02 11:47	1998/05/04 02:30	38.7	MC	53
013	1998/05/05 07:05	1998/05/06 23:20	40.3	nonMC	32
014	1998/06/14 05:10	1998/06/15 07:05	25.9	MC	56
015	1998/06/24 12:00	1998/06/25 23:15	35.3	MC	51
016	1998/06/26 07:10	1998/06/26 18:58	11.8	nonMC	94
017	1998/07/06 05:40	1998/07/09 07:12	73.5	nonMC	36
018	1998/07/11 13:54	1998/07/12 21:40	31.8	nonMC	0
019	1998/08/01 14:38	1998/08/03 09:38	43.0	nonMC	0
020	1999/08/04 03:37	1999/08/05 12:30	33.4	nonMC	33
021	1998/08/10 07:15	1998/08/11 21:52	38.6	nonMC	08
022	1998/08/11 23:50	1998/08/13 13:12	37.4	nonMC	53
023	1998/08/20 07:58	1998/08/21 19:22	35.4	MC	27
024	1998/08/26 21:30	1998/08/28 00:15	26.8	nonMC	57
025	1998/09/23 04:02	1998/09/23 17:45	13.7	MC	38
026	1998/09/25 06:04	1998/09/26 16:05	34.0	MC	100
027	1998/10/19 03:53	1998/10/20 07:45	27.9	MC	63
028	1998/10/23 15:45	1998/10/24 16:10	24.6	nonMC	90
029	1998/11/08 04:20	1998/11/09 02:55	22.6	MC	31
030	1998/11/09 02:55	1998/11/10 06:42	27.8	MC	46
031	1998/11/13 00:58	1998/11/14 13:50	36.9	MC	34
032	1998/11/30 08:56	1998/12/01 02:40	17.7	nonMC	20
033	1998/12/29 18:35	1998/12/31 01:00	30.4	nonMC	46
034	1999/01/04 04:05	1999/01/04 22:19	18.2	nonMC	41
035	1999/01/13 09:56	1999/01/14 15:31	29.6	nonMC	0
036	1999/01/23 04:50	1999/01/23 17:38	12.8	nonMC	30
037	1999/02/13 18:45	1999/02/14 15:30	20.8	nonMC	0
038	1999/02/16 14:18	1999/02/17 08:54	18.6	nonMC	0
039	1999/02/17 11:40	1999/02/18 09:42	22.0	nonMC	0
040	1999/02/18 09:42	1999/02/19 10:41	25.0	MC	90
041	1999/02/19 22:37	1999/02/20 18:05	19.5	nonMC	0
042	1999/03/10 17:38	1999/03/12 02:02	32.4	nonMC	33
043	1999/03/19 10:34	1999/03/20 16:20	29.8	nonMC	41
044	1999/04/16 17:56	1999/04/17 18:57	25.0	MC	63
045	1999/04/21 04:20	1999/04/22 13:42	33.4	MC	79
046	1999/05/16 08:45	1999/05/18 00:03	39.3	nonMC	0
047	1999/06/03 00:17	1999/06/03 21:43	21.4	nonMC	0
048	1999/06/28 04:08	1999/06/29 03:02	22.9	nonMC	0
049	1999/07/03 06:37	1999/07/05 13:38	55.0	nonMC	0
050	1999/07/06 21:25	1999/07/07 16:53	19.5	nonMC	52
051	1999/07/08 03:58	1999/07/08 22:08	18.2	nonMC	0

Notes. ^(a)The beginning of the ICME (UT). ^(b)The end of the ICME (UT). ^(c)The duration of the ICME (h). ^(d)The type of the ICME. ^(e)The percentages of counterstreaming intervals coincident with the ICME (%).

Table A.1. continued.

NO.	Start ^(a)	End ^(b)	Duration ^(c)	Type ^(d)	Percent ^(e)
052	1999/07/27 17:45	1999/07/29 09:43	40.0	nonMC	91
053	1999/07/30 11:40	1999/07/31 08:20	20.7	nonMC	8
054	1999/08/01 03:35	1999/08/02 03:50	24.3	nonMC	0
055	1999/08/02 16:32	1999/08/03 17:10	24.6	nonMC	0
056	1999/08/09 09:36	1999/08/10 17:44	32.1	MC	92
057	1999/08/12 08:55	1999/08/14 00:15	39.3	nonMC	25
058	1999/08/21 11:50	1999/08/23 11:30	47.7	nonMC	49
059	1999/09/15 07:20	1999/09/15 19:42	12.4	MC	24
060	1999/09/21 19:46	1999/09/22 11:44	16.0	MC	75
061	1999/09/22 19:08	1999/09/24 04:56	33.8	nonMC	23
062	1999/10/21 03:51	1999/10/22 05:56	26.1	nonMC	35
063	1999/11/12 09:10	1999/11/13 19:39	34.5	nonMC	0
064	1999/11/14 00:42	1999/11/14 23:26	22.7	nonMC	0
065	1999/11/22 00:48	1999/11/23 01:00	24.2	nonMC	56
066	1999/11/23 06:12	1999/11/23 18:42	12.5	nonMC	0
067	1999/11/23 19:20	1999/11/24 06:20	11.0	MC	0
068	1999/12/12 19:32	1999/12/13 16:28	20.9	nonMC	98
069	1999/12/14 03:40	1999/12/14 19:21	15.7	MC	74
070	1999/12/27 18:40	1999/12/28 04:43	10.1	nonMC	46
071	2000/01/22 17:00	2000/01/25 08:20	61.3	MC	80
072	2000/02/12 12:15	2000/02/13 00:10	11.9	MC	59
073	2000/02/14 12:18	2000/02/16 07:51	43.6	nonMC	0
074	2000/02/21 05:21	2000/02/22 12:13	30.9	MC	74
075	2000/03/01 03:08	2000/03/02 02:30	23.4	nonMC	100
076	2000/03/19 03:32	2000/03/19 15:20	11.8	nonMC	0
077	2000/03/28 03:10	2000/03/29 19:28	40.3	nonMC	0
078	2000/03/30 01:27	2000/03/30 13:00	11.6	nonMC	0
079	2000/03/31 02:58	2000/04/01 02:15	23.3	nonMC	6
080	2000/04/07 08:26	2000/04/08 05:32	21.1	nonMC	45
081	2000/04/18 20:05	2000/04/19 13:45	17.7	nonMC	0
082	2000/05/07 06:05	2000/05/08 00:10	18.1	nonMC	31
083	2000/05/13 16:51	2000/05/14 17:48	25.0	nonMC	0
084	2000/05/15 18:32	2000/05/16 14:51	20.3	nonMC	0
085	2000/05/23 08:58	2000/05/23 20:32	11.6	nonMC	0
086	2000/05/24 11:56	2000/05/26 16:00	52.1	nonMC	16
087	2000/06/04 23:50	2000/06/06 22:00	46.2	nonMC	38
088	2000/06/08 15:15	2000/06/10 17:05	49.8	nonMC	100
089	2000/06/13 12:08	2000/06/14 06:25	18.3	nonMC	5
090	2000/06/24 06:32	2000/06/26 00:12	41.7	nonMC	0
091	2000/06/26 10:14	2000/06/26 23:28	13.2	nonMC	0
092	2000/07/01 07:30	2000/07/03 08:43	49.2	MC	6
093	2000/07/11 22:48	2000/07/13 02:16	27.5	nonMC	35
094	2000/07/13 12:28	2000/07/14 15:00	26.5	nonMC	17
095	2000/07/14 17:17	2000/07/15 14:15	21.0	nonMC	0
096	2000/07/15 19:52	2000/07/16 23:22	27.5	MC	47
097	2000/07/20 09:10	2000/07/21 07:08	22.0	nonMC	0
098	2000/07/23 19:20	2000/07/26 02:42	55.4	nonMC	0
099	2000/07/27 08:52	2000/07/27 21:12	12.3	MC	8
100	2000/07/28 13:03	2000/07/29 10:12	21.2	MC	38
101	2000/08/10 19:21	2000/08/11 18:10	22.8	nonMC	100
102	2000/08/12 05:19	2000/08/13 22:11	40.9	MC	82
103	2000/09/02 21:48	2000/09/03 12:50	15.0	nonMC	0
104	2000/09/06 00:44	2000/09/06 16:12	15.5	nonMC	0
105	2000/09/17 23:20	2000/09/19 03:10	27.8	MC	100
106	2000/10/03 15:08	2000/10/05 02:33	35.4	MC	43
107	2000/10/05 16:36	2000/10/07 06:28	37.9	nonMC	17
108	2000/10/13 16:17	2000/10/14 17:03	24.8	MC	73
109	2000/10/28 21:08	2000/10/29 22:20	25.2	MC	100

Table A.1. continued.

NO.	Start ^(a)	End ^(b)	Duration ^(c)	Type ^(d)	Percent ^(e)
110	2000/11/06 22:15	2000/11/07 17:22	19.1	MC	100
111	2000/11/08 13:20	2000/11/09 14:31	25.2	nonMC	15
112	2000/11/11 08:11	2000/11/12 00:08	16.0	nonMC	5
113	2000/11/27 08:10	2000/11/28 02:45	18.6	nonMC	100
114	2000/11/28 22:26	2000/11/29 21:14	22.8	nonMC	68
115	2000/12/03 13:10	2000/12/05 07:41	42.5	nonMC	5
116	2000/12/22 06:42	2000/12/22 18:46	12.1	nonMC	0
117	2000/12/23 00:48	2000/12/23 11:53	11.1	nonMC	14
118	2001/01/24 08:42	2001/01/24 20:15	11.6	nonMC	76
119	2001/03/04 05:08	2001/03/05 01:38	20.5	nonMC	0
120	2001/03/19 19:39	2001/03/21 23:42	52.1	MC	25
121	2001/03/27 21:46	2001/03/28 08:18	10.5	MC	52
122	2001/03/28 17:12	2001/03/30 18:03	48.9	nonMC	0
123	2001/03/31 05:31	2001/03/31 21:39	16.1	nonMC	0
124	2001/04/01 05:12	2001/04/03 16:08	58.9	nonMC	50
125	2001/04/04 18:02	2001/04/05 10:31	16.5	MC	33
126	2001/04/08 13:16	2001/04/09 03:31	14.3	nonMC	24
127	2001/04/12 08:10	2001/04/13 07:08	23.0	MC	100
128	2001/04/13 10:31	2001/04/14 11:08	24.6	nonMC	48
129	2001/04/18 11:52	2001/04/20 11:17	47.4	nonMC	0
130	2001/04/21 23:38	2001/04/23 03:02	27.4	MC	8
131	2001/04/28 16:38	2001/05/01 21:43	77.1	MC	0
132	2001/05/07 17:50	2001/05/08 07:48	14.0	MC	5
133	2001/05/09 11:54	2001/05/10 21:19	33.4	nonMC	0
134	2001/05/11 13:05	2001/05/12 00:07	11.0	nonMC	0
135	2001/05/28 04:38	2001/05/29 21:26	40.8	MC	63
136	2001/05/29 21:26	2001/05/31 14:52	41.4	nonMC	0
137	2001/06/07 17:19	2001/06/08 06:52	13.6	nonMC	0
138	2001/06/18 23:40	2001/06/19 14:02	14.4	MC	0
139	2001/06/27 03:02	2001/06/28 16:56	37.9	nonMC	13
140	2001/07/09 02:22	2001/07/11 04:18	49.9	MC	64
141	2001/08/15 06:00	2001/08/16 14:31	32.5	nonMC	0
142	2001/08/18 01:28	2001/08/19 05:45	28.3	nonMC	45
143	2001/08/30 17:15	2001/08/31 09:34	16.3	MC	83
144	2001/09/01 13:57	2001/09/02 18:02	28.1	MC	6
145	2001/09/13 17:36	2001/09/14 20:58	27.4	nonMC	35
146	2001/09/24 00:16	2001/09/24 19:13	19.0	nonMC	0
147	2001/09/25 05:40	2001/09/25 20:03	14.4	nonMC	0
148	2001/09/26 09:52	2001/09/27 01:36	15.7	nonMC	0
149	2001/09/29 12:10	2001/09/30 18:45	30.6	nonMC	75
150	2001/09/30 22:26	2001/10/01 11:00	12.6	nonMC	29
151	2001/10/02 04:04	2001/10/03 16:27	36.4	nonMC	18
152	2001/10/22 00:13	2001/10/22 18:44	18.5	MC	90
153	2001/10/27 00:40	2001/10/28 02:42	26.0	nonMC	73
154	2001/10/29 21:32	2001/10/31 12:51	39.3	nonMC	22
155	2001/10/31 20:38	2001/11/01 14:26	17.8	MC	100
156	2001/11/14 05:12	2001/11/15 14:01	32.8	nonMC	0
157	2001/11/24 16:46	2001/11/25 16:07	23.4	MC	84
158	2001/12/27 23:40	2001/12/29 04:47	29.1	nonMC	43
159	2001/12/30 02:23	2001/12/30 19:31	17.1	MC	0
160	2002/02/28 16:49	2002/03/01 09:43	16.9	nonMC	30
161	2002/03/19 04:46	2002/03/20 13:05	32.3	MC	0
162	2002/03/21 16:37	2002/03/22 06:27	13.8	nonMC	68
163	2002/03/22 13:45	2002/03/23 10:53	21.1	nonMC	0
164	2002/03/24 11:50	2002/03/25 14:02	26.2	MC	57
165	2002/04/12 01:10	2002/04/13 13:19	36.2	nonMC	11

Table A.1. continued.

NO.	Start ^(a)	End ^(b)	Duration ^(c)	Type ^(d)	Percent ^(e)
166	2002/04/17 23:08	2002/04/19 08:02	32.9	MC	85
167	2002/04/20 04:42	2002/04/21 15:23	34.7	nonMC	66
168	2002/05/11 13:18	2002/05/12 01:13	11.9	nonMC	0
169	2002/05/19 02:45	2002/05/20 02:55	24.2	MC	33
170	2002/05/20 09:08	2002/05/21 20:54	35.8	MC	78
171	2002/05/23 21:36	2002/05/25 17:48	44.2	MC	56
172	2002/07/18 12:00	2002/07/19 09:31	21.5	MC	85
173	2002/07/20 02:28	2002/07/22 04:53	50.4	nonMC	0
174	2002/08/01 08:45	2002/08/01 22:20	13.6	MC	33
175	2002/08/02 06:12	2002/08/04 00:30	42.3	MC	35
176	2002/08/19 18:21	2002/08/21 17:12	46.9	nonMC	37
177	2002/09/07 16:08	2002/09/08 18:38	26.5	nonMC	43
178	2002/09/08 22:10	2002/09/10 20:32	46.4	nonMC	32
179	2002/09/19 21:00	2002/09/20 22:15	25.3	nonMC	46
180	2002/09/30 21:18	2002/10/01 15:23	18.1	MC	0
181	2002/10/03 04:42	2002/10/04 18:20	37.6	nonMC	0
182	2002/11/17 16:30	2002/11/19 12:48	44.3	MC	96
183	2002/12/17 20:14	2002/12/19 01:31	29.3	nonMC	93
184	2002/12/21 02:43	2002/12/22 18:08	39.4	nonMC	0
185	2003/01/27 01:58	2003/01/27 23:38	21.7	nonMC	65
186	2003/02/01 18:06	2003/02/03 07:22	37.3	nonMC	21
187	2003/02/18 04:08	2003/02/19 15:45	35.6	nonMC	0
188	2003/03/20 12:26	2003/03/20 23:00	10.6	MC	35
189	2003/05/09 07:04	2003/05/11 23:01	64.0	nonMC	8
190	2003/05/29 18:32	2003/05/30 15:53	21.4	nonMC	22
191	2003/05/30 23:42	2003/05/31 22:23	22.7	nonMC	31
192	2003/06/15 21:38	2003/06/16 20:31	22.9	nonMC	28
193	2003/06/17 11:53	2003/06/18 08:43	20.8	nonMC	0
194	2003/07/06 12:25	2003/07/07 11:42	23.3	nonMC	0
195	2003/07/23 14:00	2003/07/24 13:52	23.9	nonMC	0
196	2003/08/04 23:51	2003/08/06 01:08	25.3	MC	33
197	2003/08/16 02:00	2003/08/17 13:40	35.7	nonMC	8
198	2003/08/18 01:51	2003/08/19 14:30	36.7	MC	78
199	2003/10/22 16:39	2003/10/24 02:28	33.8	MC	100
200	2003/10/24 18:32	2003/10/25 11:24	16.9	nonMC	66
201	2003/10/25 13:55	2003/10/26 08:08	18.2	nonMC	76
202	2003/10/26 18:32	2003/10/28 01:30	31.0	nonMC	28
203	2003/10/29 11:21	2003/10/30 16:18	29.0	MC	31
204	2003/10/31 02:18	2003/11/01 17:20	39.0	nonMC	80
205	2003/11/20 10:06	2003/11/21 00:20	14.2	MC	0
206	2004/01/10 06:00	2004/01/11 04:40	22.7	nonMC	0
207	2004/01/22 09:47	2004/01/23 14:16	28.5	MC	71
208	2004/01/24 07:33	2004/01/25 02:57	19.4	MC	61
209	2004/02/17 18:14	2004/02/18 15:51	21.6	nonMC	0
210	2004/04/03 23:56	2004/04/05 13:30	37.6	MC	51
211	2004/04/26 17:15	2004/04/27 19:20	26.1	nonMC	0
212	2004/05/01 00:27	2004/05/01 11:49	11.4	nonMC	0
213	2004/05/01 14:56	2004/05/02 20:55	30.0	MC	77
214	2004/06/25 11:57	2004/06/26 09:27	21.5	nonMC	0
215	2004/07/22 20:08	2004/07/24 05:37	33.5	MC	87
216	2004/07/24 16:50	2004/07/25 12:10	19.3	MC	21
217	2004/07/25 21:10	2004/07/26 22:27	25.3	MC	13
218	2004/07/27 02:12	2004/07/27 18:34	16.4	MC	61
219	2004/08/01 08:32	2004/08/02 04:28	19.9	nonMC	0
220	2004/08/29 18:50	2004/08/30 20:15	25.4	MC	54
221	2004/09/14 20:25	2004/09/16 11:30	39.1	nonMC	28
222	2004/09/18 12:18	2004/09/19 23:57	35.7	nonMC	57
223	2004/11/08 04:21	2004/11/09 09:12	28.9	MC	71

Table A.1. continued.

NO.	Start ^(a)	End ^(b)	Duration ^(c)	Type ^(d)	Percent ^(e)
224	2004/11/09 20:26	2004/11/11 05:45	33.3	MC	9
225	2004/11/12 08:46	2004/11/13 07:17	22.5	nonMC	54
226	2004/12/12 22:31	2004/12/13 19:16	20.8	MC	50
227	2004/12/27 16:26	2004/12/29 04:16	35.8	nonMC	83
228	2005/01/07 15:09	2005/01/08 12:00	20.9	MC	28
229	2005/01/08 11:40	2005/01/09 17:49	30.2	MC	29
230	2005/01/16 13:50	2005/01/17 07:15	17.4	MC	17
231	2005/01/19 00:36	2005/01/20 03:08	26.5	nonMC	79
232	2005/02/18 15:08	2005/02/19 05:15	14.1	nonMC	98
233	2005/02/20 12:34	2005/02/21 01:36	13.0	nonMC	0
234	2005/02/21 04:08	2005/02/22 02:43	22.6	nonMC	0
235	2005/02/22 14:56	2005/02/23 18:18	27.4	nonMC	7
236	2005/05/15 05:30	2005/05/17 09:32	52.0	MC	95
237	2005/05/17 09:32	2005/05/19 02:51	41.3	nonMC	61
238	2005/05/20 03:04	2005/05/21 15:40	36.6	MC	11
239	2005/05/28 23:23	2005/05/29 14:50	15.5	nonMC	32
240	2005/05/30 01:05	2005/05/30 15:19	14.2	nonMC	67
241	2005/05/31 04:00	2005/06/01 02:53	22.9	nonMC	0
242	2005/06/12 15:00	2005/06/13 11:42	20.7	nonMC	0
243	2005/06/15 05:10	2005/06/16 08:08	27.0	MC	56
244	2005/06/16 17:00	2005/06/17 19:05	26.1	nonMC	33
245	2005/07/10 10:18	2005/07/12 04:23	42.1	nonMC	45
246	2005/08/08 23:12	2005/08/09 11:33	12.4	nonMC	97
247	2005/08/24 20:33	2005-08-25 13:08	16.6	nonMC	74
248	2005/09/02 18:29	2005/09/03 04:27	10.0	MC	74
249	2005/09/11 05:32	2005/09/12 06:02	24.5	nonMC	94
250	2005/09/12 20:39	2005/09/13 13:31	16.9	nonMC	57
251	2005/09/15 15:56	2005/09/16 17:37	25.7	nonMC	18
252	2005/09/20 20:50	2005/09/21 17:56	21.1	nonMC	0
253	2005/10/31 01:55	2005/10/31 18:33	16.6	MC	33
254	2005/12/31 14:45	2006/01/01 13:28	22.7	MC	100
255	2006/02/05 19:16	2006/02/06 11:35	16.3	MC	42
256	2006/04/13 15:45	2006/04/14 11:02	19.3	MC	50
257	2006/07/10 20:06	2006/07/11 17:42	21.6	nonMC	30
258	2006/08/20 14:05	2006/08/21 15:51	25.8	nonMC	0
259	2006/09/30 08:08	2006/09/30 19:40	11.5	MC	36
260	2006/11/01 17:03	2006/11/02 13:32	20.5	nonMC	92
261	2006/11/18 11:02	2006/11/20 02:10	39.1	nonMC	0
262	2006/11/29 10:20	2006/11/30 09:00	22.7	MC	18
263	2006/12/14 22:34	2006/12/15 19:21	20.8	MC	90
264	2006/12/15 20:48	2006/12/16 19:00	22.2	nonMC	0
265	2006/12/17 01:35	2006/12/17 23:49	22.2	nonMC	0
266	2007/01/14 11:47	2007/01/15 07:06	19.3	MC	15
267	2007/05/21 22:22	2007/05/22 13:12	14.8	MC	59
268	2007/11/19 23:12	2007/11/20 11:39	12.5	MC	0
269	2008/09/17 03:52	2008/09/18 07:47	27.9	MC	88
270	2008/10/08 04:30	2008/10/08 19:43	15.2	nonMC	0
271	2008/12/04 12:37	2008/12/05 11:00	22.4	nonMC	0
272	2008/12/17 03:38	2008/12/17 17:28	13.8	MC	0