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Initial Speeds of CMEs Estimated by Using Solar Wind Observations Near 1 AU

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Abstract. It is an important subject of space weather to forecast accurate arrival time of interplanetary coronal mass ejections (ICMEs) at the Earth. Determination of initial speeds of CMEs is an important factor for this. Here, we estimated the initial speeds of CMEs using solar wind observations near 1 AU and compared these speeds with CME speeds measured by the SOHO coronagraph.

Keywords. Solar wind, Sun:coronal mass ejections (CMEs), solar-terrestrial relations.

1. Introduction

Intense geomagnetic storms are often initiated by arrival of interplanetary coronal mass ejections (ICMEs). Therefore it is an important subject for space weather to predict arrival time of the ICMEs accurately. For the accurate prediction, we need to get accurate initial speeds of ICMEs as an input. The coronagraph on board the SOHO spacecraft enables to measure the CME speeds based on observations (Yashiro *et al.* 2004). The problem is that the measured CME speeds are apparent ones. Zhao, Plunkett & Liu (2002) tried to determine radial speeds of CMEs using the cone model. Dal Lago, Schwenn & Gonzalez (2003) presented a relationship between CME radial speeds and expansion speeds based on the "limb CME" observations. Here, we estimated the initial speeds of CME using solar wind speeds near 1 AU and compared them with the measured CME speeds. We used a simple model (Watari & Detman 1998) based on the shock time arrival (STOA) model developed by Dryer & Smart (1984) for this.

2. Comparison between measured and estimated speeds of CMEs

We assumed distance dependence of ICME speed to be

$$V = V_o + V_b \quad \text{for} \quad R = R_s \sim R_1 \tag{2.1}$$

$$V = V_o \left(\frac{R_1}{R}\right)^{\alpha} + V_b \quad \text{for} \quad R \geqslant R_1 \tag{2.2}$$

where V is speed of ICME at distance R from the Sun. R_s is the solar radius. V_o is initial speed of ICME. V_b is background solar wind speed. Deceleration of ICME starts at R_1.

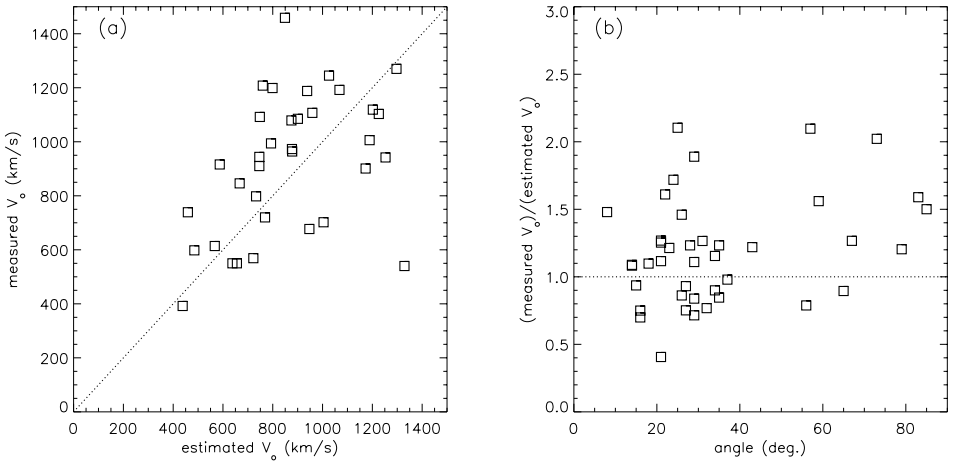

Figure 1. (a) A scatter plot of the measured and the estimated initial CME speeds. (b) A scatter plot of angles between Earth direction and main CME direction and ratios of the measured and estimated initial CME speeds.

We picked up 41 events which were clearly identified by the ACE observations between 2000 and 2003. For background solar wind speeds we choose solar wind speeds of quiet periods just before the shock arrival.

We assumed that α was 0.5 and R_1 was 0.15 AU (based on the result by Watari & Detman 1998) and estimated initial speeds of ICMEs using equation (2.2) and observed solar wind speeds near 1 AU. Figure 1a is a scatter plot of the estimated initial speeds of ICMEs and CME speeds measured by the SOHO observations. Figure 1b shows angles between Earth directions and main portions of CMEs and ratios of the measured and estimated speeds. The ratios tend to become larger as the angles increase. This shows the contribution of projection effect of CMEs in the measured CME speeds. The averaged value of the ratios for angles less than 45 degrees is approximately 1.1. This is consistent with the result of Dal Lago, Schwenn & Gonzalez (2003). This suggests the contribution of the expansion effect in the measured CME speeds.

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