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Connecting speeds, directions and arrival times of 22 coronal mass ejections from the Sun to 1 AU

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Forecasting in situ properties of coronal mass ejections (CMEs) from remote images is expected to strongly enhance predictions of space weather, and is of general interest for studying the interaction of the solar wind with planetary environments. We study the feasibility of using a heliospheric imager (HI) instrument, which is able to image the solar wind density along the full Sun to 1 AU distance, for connecting remote images to in situ observations of CMEs. Such an instrument is currently in operation on each of the two STEREO spacecraft. We compare the predictions for speed and arrival time for 22 different CME events (between 2008-2012), each observed remotely by one STEREO spacecraft, to the interplanetary coronal mass ejection (ICME) speed and arrival time observed at in situ observatories (STEREO PLASTIC/IMPACT, Wind SWE/MFI). We use croissant modeling for STEREO/COR2, and with a single-spacecraft STEREO/HI instrument, we track each CME to 34.9 ± 7.1 degree elongation from the Sun with J-maps constructed with the SATPLOT tool. We then fit geometrical models to each track, assuming different CME front shapes (Fixed-Φ, Harmonic Mean, Self-Similar Expansion), and constant CME speed and direction. We find no significant preference in the predictive capability for any of the three geometrical modeling methods used on the full event list, consisting of front- and backsided, slow and fast CMEs (up to 2700 km s^{-1}). The absolute difference between predicted and observed ICME arrival times is 8.1 ± 6.4 hours (rms value of 10.9h), and speeds are consistent within 284 ± 291 km s^{-1}, including the geometric effects of CME apex or flank encounters. We derive new empirical corrections to the imaging results, enhancing the performance of the arrival time predictions to 6.1 ± 5.0 hours (rms value of 7.9h), and the speed predictions to 53 ± 50 km s^{-1}, for this particular set of events. The prediction lead time is around 1 day (-26.4 ± 15.3h). CME directions given by the HI methods differ considerably, and biases are found on the order of 30-50 degree in heliospheric longitude, consistent with theoretical expectations. These results are of interest concerning future missions such as *Solar Orbiter* or a dedicated space weather mission positioned remotely from the Earth.