Magnetic clouds: An statistical study of their global magnetohydrodynamic magnitudes

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Magnetic clouds (MCs) are highly magnetized plasma structures that have a low proton temperature and a magnetic field vector that rotates when seen by a heliospheric observer. More than 20 years of observations of magnetic and plasma properties of MCs at 1 AU have provided significant knowledge on their magnetic structure. However, because in situ observations only give information along the (one-dimensional) trajectory of the spacecraft, its real 3D magnetic configuration remains still unknown. We study a set of 20 magnetic clouds observed by the Wind spacecraft at 1 AU during a solar minimum. We explore different models (force free and non-force free fields) and two different methods (one is a simultaneous fitting, that let us take the minimum distance from the cloud axis to the spacecraft, the impact parameter p, different from zero) to reconstruct the magnetic structure of clouds from in situ observations. Thus, for each cloud and for each model/method, we determine the cloud axis orientation, p, and the two physical free parameters of each model (the twist and the magnetic field intensity, both at the cloud axis). Then, for every cloud, we analyze the variation of the computed amounts of magnetic flux and helicity using the different approaches. We generate a set of synthetic clouds by changing the space of parameter that represents the possible orientations and p values for real clouds, and, then, we model them using our code to check the validity of our numerical tools. Finally, from the analysis of the synthetic clouds, we quantify the errors introduced by the minimum variance method when p is not zero.