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Evolution of relative magnetic helicity in the data driven MHD simulations

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For a better understanding of the dynamics of the solar corona, it is important to analyse the evolution of the helicity of the magnetic field. Since the helicity cannot be directly determined by observations, we have recently proposed a method to calculate the relative magnetic helicity in a finite volume for a given magnetic field, which however required the flux to be balanced separately on all the sides of the considered volume. We developed a scheme to obtain the vector potential in a volume without the above restriction at the boundary. We studied the dissipation and escape of relative magnetic helicity from an active region. In order to allow finite magnetic fluxes through the boundaries, a Coulomb gauge was constructed that allows for global magnetic flux balance. The property of sinusoidal function was used to obtain the vector potentials at the 12 edges of the considered rectangular volume extending above an active region. We tested and verified our method in a theoretical fore-free magnetic field model. We applied our method to the magnetic field above active region NOAA 11429 obtained by a new photospheric-data-driven magnetohydrodynamics (MHD) model code GOEMHD3. We analysed the magnetic helicity evolution in the solar corona using our new method. We find that the normalized magnetic helicity is equal to -0.038 when fast magnetic reconnection is triggered. This value is comparable to the previous value (-0.029) in the MHD simulations when magnetic reconnection happened and the observed normalized magnetic helicity (-0.036) from the eruption of newly emerging active regions. We find that only 8% of the accumulated magnetic helicity is dissipated after it is injected through the bottom boundary. This is in accordance with the Woltjer conjecture. Only 2% of the magnetic helicity injected from the bottom boundary escapes through the corona. This is consistent with the observation of magnetic clouds, which could take magnetic helicity into the interplanetary space. In the case considered here, several halo coronal mass ejections (CMEs) and two X-class solar flares originate from this active region.