M13c Simulations of solar prominence formation driven by magnetic emerging flux: I. Setup of background flux rope and emergence fields

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Solar prominences are cool, dense plasma structures suspended in the hot corona. Their formation and evolution are closely linked to thermal instability, mass circulation, and coronal magnetic field dynamics, making them crucial for understanding solar atmospheric processes and space weather. In our previous studies primarily based on 1D and 2D numerical simulations, we came up with a self-consistent model that explains the two most popular models for prominence formation, which are evaporation-condensation model and direct-injection model, as a unified model driven by magnetic reconnection at the footpoint of the prominence magnetic structures. However, previous studies mainly focus on individual prominence threads, but lack a comprehensive understanding of the complete prominence structure and its fine features, such as filament barbs. To address these gaps, this research will employ 3D MHD simulations based on previous models. A magnetic emerging flux is set at the footpoint of a magnetic flux rope in the solar atmosphere. During the emerging motion, it will interact with different location of the footpoint, thus leading to various thread formation process. This work intend to investigate the collective behavior of prominence threads, their interactions, features of the footpoint magnetic reconnection and the formation of fine structures like barbs. This work aims to extend current models, provide deeper insights into prominence dynamics, and bridge the gap between theoretical predictions and observational appearance.