Field reversals are some of the most prominent and commonly known temporal variations of the geomagnetic field. Polarity changes have been observed in seafloor magnetisation patterns, volcanic records, sediment sequences, speleothem records, and have been reported in geodynamo simulations. However, many open questions remain concerning the phenomenology and underlying causes of this process and whether precursory signals can be detected prior to a reversal. In particular, there is currently no scientific consensus regarding the temporal scales over which geomagnetic reversals occur. Simple order-of-magnitude arguments suggest that the geomagnetic field might reverse over the magnetic diffusion timescale, which for the Earth's outer core is on the order of tens of thousands of years; numerical simulations aimed at understanding Earth's million-year evolution have predicted a time scale on the order of thousands of years. On the other hand, analysis of a lacustrine sequence in the central Italian Appennines suggests that the most recent geomagnetic reversal (the Matuyama-Brunhes transition) took place around 786,000 years ago in as short as 13 years [Sagnotti, L. et al. (2015). GJI, 204(2), 798-812.]. This extremely short decadal time scale challenges our current understanding of the geodynamo and present-day numerical models.

Here we attempt to answer the question: how fast can the axial dipole component of the geomagnetic field to reduce to zero during a magnetic reversal? To do so, we derive fluid flows at the top of Earth's outer core that optimise the rate of dipole decay, subject to a minimal number of physical ingredients. Specifically, we neglect the internal dynamics and prescribe a total flow kinetic energy that is consistent with observational bounds. This technique, previously employed for the study of paleomagnetic intensity spikes, is extremely versatile and allows us to explore a wide range of hypotheses concerning the flow geometry, its complexity, and the configuration of the geomagnetic field prior to the onset of the reversal. Although the resulting flows may not be physically realisable, this technique provides justified bounds on the fastest plausible polarity reversal time scale.