



## Quantifying mathematical uncertainties in Micromagnetic Tomography results

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The recently developed Micromagnetic Tomography (MMT) technique allows precise recovery of magnetic moments of individual magnetic grains in a sample. By combining high resolution scanning magnetometry and micro X-ray computed tomography (MicroCT) MMT has the potential to become an important asset in rock-magnetic and paleointensity studies. However, uncertainties in magnetic moment solutions obtained through MMT are yet enigmatic, making a geologic application of MMT results uncertain. Therefore, we have made a first attempt in addressing those mathematical uncertainties surrounding MMT, by studying the effect of five parameters that directly influence the uncertainty of magnetic moment solutions: grain concentration of the sample, thickness of the sample, size of the sample's surface, noise level in the magnetic scan, and sampling interval of the magnetic scan. The effect of MicroCT errors are not included in this study, since those errors are better solved by improving the experimental routine than by mathematical corrections. We assess how well the magnetic moments are resolved as function of the aforementioned five parameters by setting up series of numerical models in which we assign dipole magnetizations to randomly placed grains. We perturb per model the surface magnetic field with different instrumental noise levels and sample these fields with a varying interval. The MMT inversion provides the magnetic moment per grain, and additionally produces the covariance matrix and standard deviations, which are used to define a statistical uncertainty ratio and signal strength ratio for each solution. We show that the magnetic moments of a majority of grains under realistic conditions are solved with very small uncertainties. However, increasing the grain density and sample thickness carry major challenges for the MMT inversions. Fortunately, we can use the newly defined signal strength ratio to extract grains with the most accurate solutions, even from these challenging models. Thereby we have developed an quantitative routine to individually select the most reliable grains from MMT results. This will ultimately enable determining paleodirections and paleointensities from large subsets of grains in a sample using MMT.