Fast multiscale galaxy cluster detection with weak lensing: towards a mass-selected sample

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The sensitivity and wide area reached by ongoing and future wide-field optical surveys allows for the detection of an increasing number of galaxy clusters uniquely through their weak lensing (WL) signal. This motivates the development of new methods to analyse the unprecedented volume of data faster and more efficiently. Here we introduce a new multi scale WL detection method based on application of wavelet filters to the convergence maps. We compare our results to those obtained from four commonly-used single scale approaches based on the application of aperture mass filters to the shear in real and Fourier space. The method is tested and validated on Euclid-like mocks from the DUSTGRAIN-pathfinder simulations. We introduce a new matching procedure that takes into account the theoretical signal-to-noise of detection by WL, and the size of the filter under consideration. We perform a qualitative and quantitative analysis of the methods, including a complete analysis of the filters, and a comparison of the purity and the completeness of the resulting detected catalogues. We show explicitly that equivalent results are obtained when the detection is undertaken in real and Fourier space, and when the algorithms are applied to the shear and the convergence. We show that the multiscale method applied to the convergence is faster and more efficient at detecting clusters than single scale methods applied to the shear. In particular, we obtained an increase of 25% in the number of detections while maintaining the same purity compared to the most up-to-date aperture mass filter. We analyse the detected catalogues and quantify the efficiency of the matching procedure, showing in particular that less than 5% of the detections from the multiscale method can be ascribed to line-of-sight alignments. The method is well-adapted to the more sensitive, wider-area, optical surveys that will be available in the near future, and paves the way to cluster samples that are as near as possible to being selected by total matter content.