Response to Comment #1, #2 and the editor comment:

Comment #1: We would like to thank George Haller for pointing out this manuscript to us, which we were indeed not aware of. We first got to know that he and his group are working on similar things as us on a workshop in Potsdam, were the first author of the manuscript (R.V.-K.) presented a poster about the content of this manuscript. The method suggested by Haller et al. 2016 is very similar to ours, which has been developed independently based on a different concept. There are several differences between the two methods. Each of them has still difficulties in finding all eddies, which are partly short lived. Haller et al. 2016 show with their examples that one can indeed nicely identify eddies in ocean flows, which are large and long lived. However, for many applications the real challenge is to identify and track small and short-lived eddies. Our method is a contribution in this direction and as such a step forward towards finding robust methods dealing with the census of eddies.
In the revised version we have included the analysis of an oceanographic flow in the western Baltic Sea. We computed all eddies including their shapes and compare our results to the ones obtained by an eddy tracking tool box by Nencioli et al. (2010). This example reveals the advantages and disadvantages of both methods.

Comment #2 and editors comment: The main problem, which has been addressed by the second comment and answered partly by the editor comment, is the problem of objectivity. This discussion is going on in the community for a long time and is reflected by the comments and the reviewer #1 suggestions. We would like to emphasize that objectivity is not the main focus of our manuscript and it is not our goal to resolve this long-lasting debate. Our goal is to provide oceanographers with a tool, which makes it possible to do a reasonable census of vortices in oceanographic flow fields. This can be provided by several methods and we have added another one which is in fact the same as proposed by Mancho et al. (2013) but using another quantity for the construction of the Lagrangian descriptor.
Objectivity is an important mathematical property as pointed out by George Haller, since it allows to define Lagrangian coherent structures independent of the frame. But in her answer Ana Mancho discusses, that one has of course to expect that a coordinate transformation would change M, but would still give the right answer in the coordinate system used (cf. frame invariance section in Mendoza and Mancho (2012)). Therefore, we think that both approaches are valid in the context of their framework and one has to see them in relation to the coordinate system in which they are computed. The same applies in principle to local Lyapunov exponents as another method to identify Lagrangian coherent structures. They are also not invariant with respect to coordinate transformations. After a coordinate transformation one would get other local or finite time Lyapunov exponents, which still give reasonable answers to the original problem. Only the long-term Lyapunov exponents computed as time goes to infinity are unique characteristics of a chaotic process.
From the application point of view, it is in many cases important, that a certain suitable coordinate system is used to analyze a problem in this particular coordinate system. This is for instance true for oceanographic problems which are given in the earth's coordinates where e.g. coastlines are well defined boundary conditions. Talking to oceanographers it turns out that they find objectivity of being of secondary importance since the coordinate system of the earth is given and rotations of this coordinate system means e.g. rotations of coastlines, which might not be useful in many contexts. When identifying eddies in ocean flows one always has to deal with those boundary conditions since the computation of trajectories of particles contains the problem that particles reach those boundaries. One has to solve this problem by either reflecting them or losing them for the rest of the computation. This poses an additional problem which has not been addressed in many algorithms.

The submitted manuscript does not claim to solve this problem of objectivity and this is not at all the aim of this submission. The aim is to step forward in providing suitable tools for the census of eddies, a problem, which is of increasing interest in oceanography. None of the tools we have checked including ours so far are good enough to solve those problems in oceanography, they all have their pro's and con's, they might be frame-dependent or not. The deficiencies become even more pronounced when looking at data, which are corrupted by large noise. Despite of that one still wants to get some reasonable results on the lifetime, the tracks and the shape of vortices. To solve this problem is a task for the whole community working on the identification of Lagrangian coherent structures.