Brief overview

This manuscript proposes an adaptive, unstructured gridding framework for HF radar surface current mapping. Based on constrained K-means clustering and Voronoi tessellation, the method adapts the spatial distribution of grid nodes to highly heterogeneous distribution of radial velocity observations and produces finer resolution in densely sampled coastal areas and coarser resolution offshore.

The authors compare surface current velocity maps obtained on the adaptive grid and on a conventional regular grid, using HF radar observations from the Gulf of La Spezia in the Mediterranean Sea. Radar derived current velocities are also compared with surface drifter measurements. The adaptive approach provides a more homogeneous distribution of radar observations among grid cells and a more continuous visual representation of the reconstructed current field. However, the comparison with drifter observations shows similar RMSE and correlation statistics for the two gridding approaches, with no systematic improvement in pointwise reconstruction accuracy.

The main reported benefits of the adaptive grid are therefore related to spatial representation, data availability, and computational/storage efficiency rather than to a clearly demonstrated improvement in the reconstructed from radar measurements coastal circulation.

General comments

The manuscript presents a technically detailed methodology for constructing an adaptive unstructured grid for HF radar surface current mapping, based on constrained K-means clustering and Voronoi tessellation. The topic is relevant to the processing of HF radar observations, and the proposed methodology is clearly described and illustrated by very good quality figures. However, I have substantial concerns regarding the scientific added value of the approach and its relevance to the scope of Ocean Science journal.

1/ In my opinion, the manuscript is predominantly methodological and technical. The main result is that an adaptive grid uses a more homogeneous distribution of radar observations and provides a visually more continuous representation of the velocity field. The adaptive grid indeed produces a more homogeneous number of observations per cell and modifies the spatial density of reconstructed vectors. Of course, this generates some visual effects. However, this does not by itself demonstrate an improvement in the reconstructed velocity field. And similar visual effects (but not new features of circulation) can be also obtained by increasing the regular grid resolution.

2/ The validation against surface drifters is particularly important in this respect. The authors show that the two approaches have very similar RMSE and correlation statistics (Fig. 11), and explicitly state that pointwise accuracy is only weakly sensitive to the choice of gridding approach. Moreover, the analysis of RMSE as a function of GDOP (Fig. 7) does not reveal a systematic improvement of the velocity on the adaptive grid, and therefore provides no evidence of an improved representation of the coastal circulation.

3/ The authors mention rotational structures and shear zones as being more clearly represented with the adaptive grid. However, no quantitative diagnostic is provided (how large is the difference in velocity? where the structures are located?). Comparison with independent drifter observations did not demonstrate that new dynamic structures are more accurately reproduced on the adaptive grid. Again, no quantification is provided. Diagnostics, such as mean separation distance (between real and virtual drifters) or mean Lagrangian error could be potentially used to support the Author's considerations.

4/ A more fundamental issue concerns the subsequent use of HF radar velocity fields for analysis of dynamic fields. Many quantities of interest in physical oceanography require a spatially regular velocity field. This is particularly true for diagnostics such as divergence and vorticity, for comparison with numerical model outputs, as well as for a number of Lagrangian diagnostics, including absolute and relative dispersion, and FSLE, used in oceanographic applications. The direct calculation of spatial derivatives and Lagrangian diagnostics become considerably less straightforward than on a regular grid. In practice, one would need to interpolate the adaptive-grid velocity field back onto a regular grid before performing analyses of these quantities. This raises an important question**:** if the adaptive field ultimately has to be interpolated onto a regular grid for subsequent oceanographic analyses, what is the effective scientific advantage of using the adaptive grid in the first place?

5/ Spatial interpolation method used in this work is a local interpolation that represents a rather classical approach and is less commonly used in recent HF radar current mapping studies. More advanced non-local interpolation methods (OMA, 2dVar) are widely used by the HF radar community. This should at least be discussed.

Overall assessment

The manuscript presents a technically interesting approach to the spatial discretization of HF radar observations using the unstructured adaptive grid. It contains a considerable amount of methodological detail concerning K-means clustering, Voronoi tessellation, etc etc. While the proposed methodology is technically interesting, the manuscript does not demonstrate a substantial new oceanographic result that could not be obtained using conventional gridding approaches.
In its present form, I do not find that the manuscript provides a significant advance in our understanding of coastal ocean dynamics. I therefore question whether the manuscript is sufficiently aligned with the scope of Ocean Science journal. The work may be more appropriate for publication in a journal focusing on oceanographic instrumentation and technology.