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Geoscientific Model Development Discussions

Interactive comment on "OceanMesh2D 1.0: MATLAB-based software for two-dimensional unstructured mesh generation in coastal ocean modeling" *by* Keith J. Roberts et al.

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Dear Reviewer,

Thank you for your comments and recommendations on the draft manuscript. We intend to incorporate many of your suggested changes in the revised submission. In all cases, we found your suggested changes very helpful and informative and look forward to incorporating them.

Overall, we agree that the manuscript could benefit from a reorganization of sections as you had suggested and the clarification of the notion of reproducibility in the context

of this coastal ocean mesh generator. We have detailed a set of changes below.

Reviewer comments are presented in red italics, our responses are included in plain-text.

The paper discusses a software suite useful to Ocean and Coastal modellers. The software aims to facilitate the generation of high-quality meshes for Ocean and Coastal modelling. Given the threats posed by climate change and the vulnerability of coastal areas, this reviewer acknowledges the potential impact of OceanMesh2D, and the paper. The particular traits and aims of the package, namely automated geospatial processing and generation of high-quality meshes could make this paper a welcome contribution. However, many important issues have led this reviewer to propose significant changes to the manuscript. Broadly, two issues led to this decision: Structural and contextual.

Thank you for recognizing that the software suite is useful for unstructured mesh Ocean and Coastal modelers. In fact, the OceanMesh2D package has already been adopted by groups that mostly use the ADCIRC solver, but also we have had interest from people working with FVCOM, SELFE, and SCHISM. Our understanding is that the issues that you bring up are related solely to the manuscript itself and how it is presented, not the technical details of the software or its useability in solving the problems its creation was intended for. We think your comments are correct in that that structural and contextual changes will bring significant improvements to the presentation quality and clarity of the manuscript. In our intended revision, besides a reorganization of sections and a transformation of some tables to figures, we also plan to highlight the key contributions to this problem such as the mesh cleaning topology algorithm that is used to simplify the shoreline (Algorithm 2) and the multiscale meshing technique (Section 5.2) to construct mesh size functions directly from high- resolution DEMs for high-resolution models of the coastal ocean.

Structurally, the paper will benefit from extensive modifications. In particular, the manuscript would benefit from presenting the test cases graphically. The three areas summarised by table 2 could be introduced more effectively through a figure with multiple panels showing the regions, in cartographic form and at various scales. The figure should also indicate data sources in different colours. Such a figure should be placed early in the paper to make it more appealing, and its discussion can be placed in a separate small section, outlining the cases, their location and reasons for selection. The figure would directly showcase the capabilities of OceanMesh2D, regarding handling multiple data sources. Also, the figure will be an "anchor point" facilitating later discussions. Table 2 could thus only summarise the meshing parameters, Mesh quality and Iterations, making it smaller, easier to typeset, more digestible to the reader, and could be placed later in the paper.

We agree that graphically introducing the example problems in carto- graphic form and presenting a standalone section termed "Example meshes" following the introduction would be a useful change to the manuscript and increase its readability. As the reviewer points out, this would improve the readability of Table 2 by reducing the amount of information that would need to be shown.

The description of the software modules would also benefit from restructuring. Section 2 could be renamed "Architecture overview", as the term framework has a different meaning in computer science. While conceding that this reviewer is now focusing on semantics, an architecture overview section will enhance the broader description of the software modules and show how their design and mutual interaction was conceived to address the specific problems outlined in earlier sections.

We agree with the reviewer on many of these suggested organizational changes to the

manuscript to improve its presentation. The pre-existing Section 2 should be renamed something like "Architecture overview" and be used to motivate the self-contained design of the software and how it helps solve the typical problems faced by coastal ocean mesh developers. At the same time, the verbiage about the object oriented framework in Section 2 would be eliminated or reduced as it would be assumed that the reader has some prior knowledge on this subject, as the reviewer points out.

The details of specific classes should be placed in a section named "Component design" where each class is presented in a separate subsection. Note, currently the msh class is described in section 2, while all other classes are described in a separate section each. The authors could consider placing section 5.2 in "Architecture overview" or "Component design" as it repeats points made in those sections. In general, the authors are encouraged to revise the manuscript and avoid making the same arguments multiple times. Also, the meshgen class should be presented first, rather than last. The meshgen class is the core of the package. Therefore, it seems appropriate to describe it first, followed by the description of other classes. Thus the need for sections to refer to later sections is eliminated. The only exception to this is section 5.2, as discussed above. Two further points relevant to the meshgen class description are: i) The way Algorithm 2 is presented could leave readers uninterested, as it clouds the algorithm's aim with data assignment and other operators. The pseudo-algorithm presentation is better suited to the User Manual. A figure with multiple panels and a more straightforward representation of the algorithm will be more effective at making the same point. ii) In page 27 the description of various methods (or are those functions?) is also poorly presented. The identifiers of the methods could be listed in a table, while a couple of figures could showcase the problematic cases that are targeted by the functions. It seems substantial effort has been invested into developing the methods outlined in page 27, and the present description will leave readers uninterested.

As the reviewer suggests, a new section called "Component design" would be made

containing first the descriptions of each module's core functionality starting with the mesh generator, then the geodata pre-processor, then descriptions of the included mesh size functions, and finally a sub-section on the msh class.

However we believe that the core functionality of the software is much more than the mesh generator (meshgen) class, given the utility of the other modules that were described throughout the manuscript. We do agree with your rationale regarding why you think that a section describing it should be placed first in the proposed "Component Design". The descriptions of the mesh improvement strategies that accelerate convergence using the DistMesh2D algorithm would then become compressed into one paragraph as much of these contributions overlap with prior works. Algorithm 2 would be the focus of this proposed section since this "automatic mesh cleaning" algorithm is salient for mesh generation with the DistMesh2D (signed distance function) algorithm. We agree that the current presentation of Algorithm 2 may leave readers somewhat uninterested and thus we would replace it with a multi-panel figure that illustrates an application that clearly indicates why it is necessary. Some new text will be introduced in the meshgen subsection of "Component Design" that describes how the usage of a signed distance function, which is instrumental to the DistMesh2D algorithm, to implicitly define the boundary relaxes the boundary simplification requirements prior to mesh generation that are otherwise necessary for Delaunay refinement schemes. Coastline boundary simplification for mesh generation is not straightforward and especially so for regional modeling applications that often require fine mesh sizes along small localized of the domain and coarser mesh sizes elsewhere. With the new organization of the manuscript, our solution to the problem of shoreline simplification will thus be focused early on in the manuscript as we believe this to be a significant algorithmic contribution.

The proposed section "Component Design" would then terminate with a description of the msh class. The Table 3 that now describes some of msh classes associated functions and methods would be simplified to retain only a handful of the most important methods (e.g., interp,CalcCFL/CheckTimstep, plus operator, and makens). A

multi-panel figure would be created that highlights the problem that each method (or function) solves in the model development process.

The other algorithmic contribution that will be focused on comparatively earlier on in the manuscript than in the current version is the multiscale mesh- ing technique (that was originally described in Section 5.2). The reviewer makes a good comment that the current location of Section 5.2 in the manuscript leads to the repetition of some points that are made at the start of the mesh size function Section 4; namely that building mesh size functions on structured grids is computationally infeasible for large, multiscale domains that coastal ocean modelers are often concerned with. The relocation of the multiscale meshing technique into the description of the meshgen module in the "Component Design" section would reduce this repetition and better highlight a key ability of the software to build regional multiscale meshes early on in the manuscript.

Far more important than the above structural problems, the paper makes statements on reproducibility that are not supported. Reproducibility is conflated with automation and replication. In the article, reproducibility seems to be defined as the ability to produce a given output, with given inputs exactly. However, the output of mesh-generation algorithms can vary, due to differences between various platforms. Seeding point coordinates with a random number generator is one such example. Unless the authors have built a system that eliminates such variations, claiming this type of reproducibility is invalid...

As the reviewer points out, we recognize that in this context that absolute reproducibility (i.e., exact vertex locations between identical calls to the generator) is not achieved by default because the initial point distributions are made based on a random number

generator. However, on the same given machine with the same initial point distribution (which can be passed as a name-value argument) or with the same seeding of the random number generator, the mesh generation process is deterministic and is absolutely reproducible. The reviewer is encouraged to test this point. Regardless, the authors propose to replace their usage of of the word "reproducible" with the words "automatic" and "approximately reproducible" given the default behavior of the software. The spatial distributions of mesh vertices between calls to the mesh generator, for a given set of inputs, is approximately reproducible in the sense that the differences in the simulation results between two meshes can be expected to be much less than the data and measurement uncertainty.

The authors contend that the qualities of automation, especially in regard to the automated geospatial data processing capabilities of shoreline datasets (geodata) and the included mesh size functions (edgefx) to guide spatial distributions of resolution all help considerably to ensure approximate reproducibility and automation. The authors contend that the qualities of automation and approximate reproducibility are already very strong points by themselves; points that are not achieved without considerable carefulness and effort by the many graphical user interface (GUI) based mesh generation software that are currently widely used by researchers and in industry. As was described in the introduction, a GUI-based software often encourages users to arbitrarily zone mesh resolution and mouse-trace shorelines from satellite imagery; these are the aspects of the mesh generation process we would like to automate with the software's functionality. Further, the included mesh size functions ensure that the spatial distributions of mesh resolution are highly similar between identical calls to the mesh generator by placing resolution distributions according to known functions of shoreline geometry and seabed data rather than have the users make these up on-the-fly.

Also, the term reproducibility is today explored within the context of provenance and attribution, aiming to accurately define the processes and inputs leading to specific outputs, while disseminating outputs, processes and citing data, collectively termed

Research Data Management (RDM). The software presented in the paper makes no explicit effort to distribute, trace provenance and make attributions. While a script will inherently contain information on the mesh generation process, such pointers are weak as they do not adequately describe the environment or other inputs and processes. Also, the authors state that the distribution of the script file with other supplementary data helps establish reproducibility (line 5 page 5). However, one of the main obstacles targeted by RDM practices is the distribution of such complementary data trough persistent and open platforms. If the authors are suggesting that Revision Control Systems (RCS) could be used to address reproducibility, then that is an effect of RCS, rather than the software described in the paper. Besides, even with an RCS reproducibility in the context of RDM is not immediately achieved, often requiring more steps. For example pointing to very large datasets that are impossible to distribute, due to size or licence restrictions.

As was pointed out in the previous paragraph, the scripting-based approach even with "weak" pointers to geospatial datasets and mesh size functions parameters provides a stronger sense of reproducibility than the CAD-GUI approach with considerable less effort. Since the architecture of the OceanMesh2D software encourages a pre-defined pattern of use, which while somewhat restrictive for non-standard workflows, simplifies the record-keeping and compartmentalizes the steps necessary to generate a high-resolution model. The recent Shingle 2.0 package that was featured on GMD attempts to make the reproducible aspect of ocean mesh generation much more formal in the context that the reviewer goes on to discuss. We do not attempt this here, and it is not our goal because the Shingle Library already does this well and it would significantly increase the amount of associated software dependencies and complicate its use more. In future applications, OceanMesh2D could be used under in the GIS-inclusive framework and with sophisticated third-party libraries like SPUD data descrip- tor that would help facilitate the notion of RDM that the reviewer alludes to. Our goal here,

that is stated in the introduction and discussion and conclusions section, is far more focused toward simplicity and the development of practical tools to help engineers and scientists that need to generate coastal meshes develop them more quickly in “approximate” reproducible ways. The reviewer’s comments with regards to the structure of the paper and its presentation such as including more figures (omitting tables) and replacing overly mathematical and formulaic components will certainly help us to achieve the stated goal in the previous sentence.

Please see specific comments in the text. I have used Okular (https://okular.kde.org/) to embed the comments in a copy of the pdf. The authors are encouraged to scrutinise the paper for grammatical corrections. There are plenty of corrections to be made (not all are pointed out), unfortunately distracting the review process from its purpose and adding a reason to opt for major corrections.

These specific annotated comments are extremely helpful and will surely improve the quality of the manuscript. We intend to incorporate the suggested changes that you provide. We will make sure to structinise the paper more closely for grammatical mistakes.