Geoscientific
Model Development
Discussions

Interactive comment on "Parallel algorithms for planar and spherical Delaunay construction with an application to centroidal Voronoi tessellations" *by* D. W. Jacobsen et al.

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We would like to thank reviewer #2 for their useful comments. Responses are interleaved with originally reviewer comments.

——— Reviewer Comment ———

The paper presents a new parallel algorithm for construction of Delauney and Voronoi tessellations on sphere by employing the overlapping domain decomposition. The presented algorithm has a potential to be of a great use for the whole community dealing with the numerical modelling on unstructured meshes. I would like to recommend this paper for publications after a minor revision which still suggests some changes.

1. The method is great but the novel technique is not clear to me from the abstract and overall through the text. Is it about overlapping domain decomposition only? Also some overview over existing algorithms is deïňĄnetely missing. The authors refer them as "a few algorithms" which are limited to the planar surfaces. The approach employing stereographic projections for triangulations on the sphere has been used for example in Lambrechts et al., Ocean Dynamics 2008. Please indicate the novelty in MPI-SCVT going beyond the use of spherical caps for parallelisation of the approach. Also it's not clear which part of the code has been developed by the authors. The text indicates the Triangle software by J. Shewchuk for the construction of Delaunay tessalations. Is it actually used in the package?

——— Author Response ———-

Thank you for referring us to the Lambrechts paper. The approach taken in Gmsh is to create a triangular grid with boundaries for use in Ocean modeling on a sphere. They employ stereographic projections to perform the generation in a plane, but they only use a single stereographic projection, and have a singular point that's required.

In this approach, we are creating triangular meshes that can be converted into Voronoi meshes. Also, there aren't any singular points in the domain due to the multiple spherical caps. Because of this, the MPI-SCVT approach can also be used to generate variable resolutions for Atmospheric simulations.

The novel technique is not only using stereographic projections to triangulate the sphere, but using them in conjunction with domain decomposition techniques to enable the parallel triangulation of the full or partial sphere. However, the overlapping domains can be used without stereographic projections to triangulate a plane in parallel as well.

The Triangle software is actually used in MPI-SCVT, but it is only used to compute triangulations of some pre-defined point sets. In particular, it is not used to determine which points it should triangulate. In addition, it is the only part of MPI-SCVT that was not written by the authors, and could be replaced by any other 2D triangulation software

package.

A paragraph has been added at the beginning of the results section briefly describing the MPI-SCVT code (and linking to it). Also, a reference to Lambrechts' paper has been added in the introduction during the discussion of stereographic projections.

—— Reviewer Comment ——

2. What if the boundaries or continents are present? Can this technique be modïïňẠed to discretize ocean only? I didn't ïňẠnd any comment on it in the paper (compare remark 12).

—— Author Response ———-

We appreciate your suggestion.

There are methods that allow the inclusion of boundaries in the grid generation process (such as fixing points on a boundary, or projecting onto a boundary). Both are included in the MPI-SCVT code but have not been exercised to the fullest extent.

While these techniques present interesting challenges for a developer, they also cause the generation process to be more specialized to a specific goal. We preferred to present the most general technique, which allows the grids that are generated to be used for a variety of applications (ocean, sea ice, land ice, atmosphere, etc).

—— Reviewer Comment ——

3. In line above 5th in the abstract, mentioning sphere instead, or together with Euclidean domains would be more relevant when speak about climate modelling.

—— Author Response ———-

Thank you for the comment, we're unsure what exactly should be modified, but a mention of the use of spherical grids in climate related simulations has been added to the abstract.

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—— Reviewer Comment ——

4. When giving the references regarding existing unstructured approaches: is there any model which employs an unstructured mesh and goes beyond the test cases or shallow water study?

—— Author Response ———-

Yes, there is a manuscript that has recently been accepted for publication which utilizes meshes created with this software for Ocean model simulations.

Article: A Multi-Resolution Approach to Global Ocean Modeling Corresponding author: Dr. Todd Ringler E-mail address: todd.ringler@mac.com;ringler@lanl.gov Journal: Ocean Modelling Our reference: OCEMOD813 PII: S1463-5003(13)00076-0 DOI: 10.1016/j.ocemod.2013.04.010

—— Reviewer Comment ——

5. Chapter 2.1 can be either visualized or simplïïňẠed or deleted at all. Why to provide basic matherial if it is not used further in the paper? Also the practical importance of this work as well as provided examples are limited to 2D and 3D cases. I would just shortly mention somewhere that the technique might be extended to RЁȨk.

—— Author Response ———-

Thank you for the suggestions. The background material has been removed from the revised manuscript.

—— Reviewer Comment ——

6. I fully agree with the 1st reviewer, that some discussion on the optimal choice of radius (chapter 2.2, n25) must be included.

—— Author Response ———-

We modified the paper to have a section dedicated to describing sort methods, imme-

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diately following section 2.2. It describes two sort methods, the distance based sort (which used the radius) and the Voronoi based sort.

In addition to describing both of the sort methods, we describe the requirements a sort method needs to satisfy, and the bounds for radius choice. We also briefly describe cases where the decomposition methods fail in practice. Which can largely be described as the decomposed point set being too small for Triangle to triangulate.

—— Reviewer Comment ——

7. In chapter 2.3/n25 giving extra formula of CE norm is irrelevant at this place. I would rather delete it or move to the other norms.

—— Author Response ———-

This has been removed from the manuscript.

—— Reviewer Comment ——

8. Is chapter 3.1 introducing stereographic projection really needed? especially second part of it? This may be found in wikipedia (compare remark 1).

—— Author Response ———-

The stereographic projection described on wikipedia is not general enough for use in this algorithm. We required a definition that allows for arbitrary focus and tangent points, that project into arbitrary tangent planes. Although this is easily derived from the understanding of a stereographic projection, we felt it was necessary for building an understanding of the algorithm.

—— Reviewer Comment ——

9. Sorting to optimize the load balance (chapter 4.2.2) is ïňА̧rst mentioned in the result path. Wouldn't it be proper to say something about it already in the description part.

—— Author Response ———-

A short discussion about load imbalances and a note about sorting with Voronoi cells rather than dot products has been added to section 2.2.

—— Reviewer Comment ——

10. All through the chapters 4.x the total amount of different generators used is mentioned. Wouldn't it be better to introduce labels for them like 'coarse', 'medium', 'ïňА̧ne', for instance. Also the corresponding resolutions are ïňА̧rst mentioned in 4.4.

—— Author Response ———-

Thank you for the suggestion. A table has been added relating the generator counts to approximate resolutions and labels such as 'coarse', 'medium', and 'fine'

—— Reviewer Comment ——

11. Concerning ïňА̧gures, I would say, that ïňА̧gures 1,2,3 are too trivial, also I would suggest to combine ïňА̧g. 11 and 12 into subplots

—— Author Response ———-

Thank you for the suggestion. Figures 2 and 3 are removed from the revised manuscript. We feel figure 1 is necessary to illustrate the partial triangulation in the tangent plane.

Figures 11 and 12 present vastly different information, and would create a rather large caption so we chose not to modify them.

—— Reviewer Comment ——

12. Since the approach aims at meshes for climate simulations it would be very desirable to include examples for a more realistic density function than the one indicated in Eq. (6). Are there results for topography based meshes and how are the regions chosen in such a general case with respect to optimal load balancing.

—— Author Response ———-

As this manuscript is intended as an introduction to the parallelization method, data driven density functions have not been implemented within MPI-SCVT yet. While this is a goal, it presents its own unique challenges. As such, we do not have any results related to realistic density functions (e.g. topography based). Though some simulations have been carried out using the provided density function focusing resolution within the North Atlantic (see response to #4).

—— Reviewer Comment ——

13. Please rephrase the ïňĄnal sentences in section 4.4 page 1448, starting in line 5. Expressions like "More efïňĄciency gains ... could result in linear scaling" are highly speculative and are not supported by the current performance, especially for small generators. I agree that improvements may be obtained by optimized communication however I would suggest to be more precise in the statements.

—— Author Response ———-

These sentences have been expanded to provide more discussion of possible gains.