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Interactive comment on "Locally-orthogonal unstructured grid-generation for general circulation modelling on the sphere*" *by* Darren Engwirda

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Dear reviewer,

Thank you for your additional comments. I include my response below. Reviewer comments are presented in italics, my responses are included in plain-text.

My main concern is still about the novelty of the method. You say:

In the current work, it's shown that a combination of Frontal-Delaunay refinement and hill-climbing optimisation is an effective strategy — able to produce very high-quality well-centred Voronoi-Delaunay grids even when complex, highly non-uniform grid sizing constraints are imposed. I believe this to be a new result of benefit to the unstructured oceanic/atmospheric modelling communities. Public availability of the associated JIGSAW-GEO grid-generator is also thought to be a further benefit to the community.

I do not believe that the methods presented in the present work are preexisting. The hybrid Frontal-Delaunay surface meshing technique described here, able to guarantee worst-case bounds on element quality and sizing conformance are, in my view, new. I am not aware of another algorithm with the same properties — able to produce smoothly varying Voronoi-Delaunay grids with very high mean element quality (similar to advancing front type schemes), while also guaranteeing worst-case bounds on element angles and conformance (a'la standard Delaunay-refinement techniques). Existing methods for unstructured oceanic/atmospheric modelling appear to either lack provable worst-case bounds [Jacobsen et al., 2013], or generally produce grids with somewhat lower overall quality [Lambrechts et al., 2008]. The combination of the Frontal-Delaunay scheme with a coupled hill-climbing optimisation strategy to generate 'well-centred' grids is also, in my view, new.

EVERY mesh generator (edge, face, volume) has a main engine (Delaunay, Frontal, Octree, coupled) and an optimization phase that follows [1], so there is nothing new to that. The facts that you apply it to oceanic/atmospheric communities or that it is publicly available do not make these techniques new. I have added a list of references on high quality surface mesh generation that present the same high quality based on the same techniques [2,3,4,5] on top of the coupled Delaunay advancing front variants which are not fully referenced. Feel free to include them or not.

Nevertheless, I completely agree with the fact that the application of these techniques to the oceanic/atmospheric communities is new and interesting and therefore, the paper should be published.

[1] Frey,P.J. and George,P.L., Meshing, applications to finite elements, Hermes, Paris, 1999.

[2] J. Tristano, S. Owen, S. Canann, Advancing front surface mesh generation in para-

metric space using a Riemannian surface definition, in: IMR, 1998, pp. 429–445.

[3] D. Rypl, P. Krysl, Triangulation of 3D surfaces, Eng. Comput. 13 (1997) 87–98.

[4] C. Lee, Automatic metric advancing front triangulation over curved surfaces, Eng. Comput. 17 (1) (2000) 48–74. 642–667.

[5] Löhner R. Regridding surface triangulations. Journal of Computational Physics 1996; 126:1–10.

I agree with much of what is stated here. After also considering the comments of other reviews/readers, I suggest making a number of changes to address these concerns:

1. I am very happy to add reference to [1–5] as suggested. A brief discussion of these methods will be added in Section 2, throughout the description of the Frontal-Delaunay algorithm.

2. I will include a more detailed description of the Frontal-Delaunay algorithm, and additional pseudo-code descriptions for the full grid-generation process. I will explicitly describe the 'off-centre' point-placement strategy and the way in which it leverages the mesh-spacing function. This material is already available in Engwirda and Ivers (2016), but I will include a summary of the algorithmic detail here.

While the suggested references [1–5] all describe high-quality approaches for surface grid-generation, they do, in some cases, differ in the details. I aim to better position and contrast the methods described in the current work through this extended description.

3. To better emphasise the novelty of the proposed approach, I additionally suggest a slight reorganisation of the paper. I suggest to move the discussion currently contained in Sections 2.6 (i.e. Figure 3 and accompanying text — description of the staggered unstructured C-grid formulation) and pages 16–17 (benefits of 'well-centred' staggered orthogonal grids) to the beginning of Section 2.

This change will better motivate the remaining discussions — explaining that such

numerical schemes (i.e. the MPAS framework) require grids that are locally-orthogonal, centroidal and well-centred — a set of constraints that are, in the general case, difficult to satisfy and are not reliably achieved by conventional grid-generation techniques.

This change will therefore better showcase the performance of the algorithms presented in the current work — demonstrating that such locally-orthongonal, centroidal and well-centred grids can be generated for complex cases, such as the highly nonuniform grids shown in Figures 9–11. Such capability will allow the multi-resolution capabilities of a framework such as MPAS to be better utilised.

Please let me know if you have further suggestions or comments regarding the submission.

Kind regards,

Darren Engwirda

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