Author comment for Anonymous Referee #1

Vijay S. Mahadevan and Jorge E. Guerra on behalf of all authors

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Dear Reviewer,

We sincerely appreciate the detailed comments and suggestions provided to improve the paper. We will address all of the major comments and fix the minor issues pointed out. To provide some context and to answer some relevant questions, please look at the selected inline discussions below.

1. The notion of grid resolutions and convergence rate (as a function of the grid refinement) are central to the paper but are not well defined

   Thanks for the comment. We understand that some of the details have not been explicitly provided in the manuscript, but rather linked through an external repository[1] containing the raw mesh files used in the study. However, we will include all the relevant details in the text to avoid any further confusion.

2. p.16, L.11 : in "uniform mesh refinement", are you talking about source or target mesh, or both ? Or do you include the "cross-resolutions", e.g. the calculations done for CS(0) - MPAS(4)?

   In the context of uniform mesh refinement, yes we are referring to uniform resolution increase for both the source and target meshes. The spatial error component is generally a function of $C_s\mathcal{O}(\mathcal{E}_s)+C_t\mathcal{O}(\mathcal{E}_t)$, where $\mathcal{E}_s, \mathcal{E}_t$ are the chosen error norms computed on source and target meshes and C_s, C_t are some constants respectively. For the convergence estimation, we utilize similar resolutions on both meshes (in terms of average element jacobian size) e.g., error metrics on $CS(i) - MPAS(i), \forall i \in [0, 4]$ were chosen for convergence rate calculations. The cross-resolutions can be utilized as well, but generally the convergence rate can plateau when the

[1] MIRA Datasets: https://github.com/CANGA/MIRA-Datasets

sampling error in either $\Omega_{h,s}$ or $\Omega_{h,t}$ starts dominating the remap errors (especially with coarse resolutions), leading to inaccurate convergence rate estimates.

3. p.24, L.6: what are exactly the 5 (uniform) and 3 (refined) resolutions used for the calculations? Please describe them more precisely as this is important for the calculation of the convergence rate.

A better description of the uniform and refined mesh resolutions will be provided. Relevant links to the mesh files in our open-source repository will be added here again.

4. p.25, L.8: How you calculate the convergence rate (as a function of h the mesh refinement)? Please give more detail, this is central to the paper.

To compute the accuracy convergence rate estimates, we utilize the average element size for each mesh (especially for the quasi-uniformly refined meshes). The slope of the curve plotted between the various error norms and the average element size in the log-log scale gives the numerical convergence rate for the method, for that combination of meshes. We will provide more context and explain this in better detail.

5. p.25, L.9: Please better justify (or refer precisely to numbers in Table 1) why you state "ESMF first-order conservative scheme yields expected rates"? What rates do you expect?

ESMF implements both the first and second order remapping methods. The statement specifically refers to the first order method. We will clarify that better since the second order method implementation in ESMF (v8.1) still only yields first order convergent method.

6. At the bottom of p.24, you provide some details on the expected convergence rates but the definition involves h and I don't think that h has been defined precisely although it is clearly linked to the grid resolution (see my comment above).

This will be described better when we make changes to the manuscript.

7. p.29, L.1: again, please detail what are the "theoretically expected rates"; how do you evaluate them? Please illustrate why you state that "theoretically expected rates are observed" by referring precisely to numbers on Table 4.

Typically, using the global error norm metrics, the theoretically expected rates are $O(h^{p+1})$, where p is the order of polynomial reconstruction. Table 4 provides the convergence rates for WLS-ENOR schemes with different polynomial orders. For $p = 2$ and $p = 4$, the rates follow the definition of $O(h^{p+1})$, while we observe some superconvergence with $p = 3$ due to some error cancellations. We can expand the text to describe the behavior.

8. p.37, L.4 and p.38, Table 6. Be more precise on the resolution used for each grid; what does "the finest CS-MPAS RRM mesh combination" mean precisely?

   Figure 7-8-9-10-11: Define more precisely CS(0), CS(4), MPAS(0), MPAS(4) (see also my comment above for p.24, L.6.

We will provide the exact resolutions used for these cases.

9. p.39, Fig. 13: Define more precisely CS-RRM(0), MPAS-RRM(0), CS-RRM(2), MPAS-RRM(2). In the caption, put "for a) coarse to fine, and b) similar refinements

Thanks for pointing this out. We will define it more precisely.

10. For all figures, the x and y axes should be redrawn with bigger and clearer fonts.

The figures will be regenerated and updated during manuscript revision.

11. Figure 6: I don't understand the y axis. How can you have negative values for those error norms? Given equations (7) and (9), I don't think this is possible.

Figure 6 is a semi-logy plot, where the error norms in Y-axis are essentially log(error). Equation (7) and Equation (9) only provide the error metric. We will make the Y-axis title clearly state this.

12. Figure 6: I suppose that each curve is for one specific pair of grids a specific resolution. For example, the left-most plot is for the grid pair CS-MPAS with a specific resolution of CS (among the 5 possible) and a specific resolution of MPAS (among the 5 possible). If I am right, please indicate which is the resolution for CS and which is it for MPAS.

That is correct. We chose the finest resolution pair in each grid combination for that study. Text will be updated to reflect the information.

13. I think Lmin should be Gmin and Lmax should be Gmax and refer to equations (12) and (13) as you are describing here global extrema and not local extrema.

This is correct. We will fix it.

14. Fig. 9 a): How can Gmin be negative (for TempestRemap)?

Yes, Gmin cannot be negative by definition. We will re-verify the results again for this metric and ensure the right data is getting plotted.

15. Fig 9 b): Please specify in the captions where is the TempestRemap curve?

The TempestRemap curve is at the zero-axis. I can see why the figure is misleading. We will explain the observed results better in the text and perhaps modify the scale to show all the lines more clearly if possible.

16. p.37, L.5: You write "The global errors with respect to all error norms are considerably smaller in WLS-ENOR and TempestRemap." This is particularly true for analytical function but not so clear for real fields. Can you comment on this on the text?

Yes we will update the text to better clarify the conclusions.

17. p.42, L.25: you completely exclude here "dynamic" grids, i.e., grids which definition evolve with time and for which the regridding weigths have to be recalculated at each timestep. No "offline" operations for those grids. Please comment on this.

For dynamic grids, the remapping cost is fully incurred at runtime. Note that while computing the linear map on the global domain for every small change could be the trivially simpler (and more expensive) option, including feature-tracking algorithms can help offset a majority of the cost by localizing recomputation work to only the adapted regions. We will add a short discussion about dynamic grids in the performance section.