

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2021-355

Anonymous Referee #2

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Referee comment on "MPAS-Seaice (v1.0.0): sea-ice dynamics on unstructured Voronoi meshes" by Adrian K. Turner et al., Geosci. Model Dev. Discuss.,  
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This paper describes a new sea-ice model (MPAS-Seaice) that uses a Spherical Centroidal Voronoi Tessellation (SCVT) unstructured mesh. The model-calculated velocities, strain rates, and stress divergence terms are compared to those from the CICE model in idealized test cases using three different methods for representing quantities on the grid: Wachspress basis functions, piecewise linear basis functions, and the "weak" (integral) method. Global simulations are run with realistic forcing, and the resulting sea-ice extent, thickness, and volume are compared to CICE and to observations. MPAS-Seaice closely reproduces the results of CICE when a quadrilateral mesh is specified. Although MPAS-Seaice runs about 30% slower than CICE, the SCVT mesh gives it greater flexibility to provide higher resolution in selected areas. MPAS-Seaice is the current sea-ice component of the E3SM global climate model.

This is an excellent paper -- thorough, well organized, and clearly written. It provides a good description and a convincing validation of the MPAS-Seaice model. It could almost be published in present form, save for a few minor technical corrections and suggestions.

Minor technical corrections and suggestions

Line 15. MPAS "runs 70% as fast as CICE". I honestly had trouble figuring out if this means MPAS is faster or slower than CICE. If MPAS runs in 70% of the time as CICE then it's faster than CICE. But actually MPAS is slower (Table 1). Consider writing something like: "runs 30% slower than CICE" or "runs with 70% of the throughput of CICE"

Lines 15-16. "culling of equatorial model cells". I know what culling means, but I had trouble understanding it in this context until I got to page 38, where I found out that it simply means REMOVING, as stated on lines 677 and 680. To me, the word "cull" has the

connotation of selective removal due to some deficiency, such as culling sickly animals from a herd. What you really mean is "excise" -- to cut out or remove. I suggest using "remove" throughout the text rather than "cull" (lines 15, 634, 655, Figure 22 caption, 690, 709).

Line 23. Does "CICE" stand for something? If yes, spell it out on first usage.

Good Introduction.

Line 69 and Figure 1. I'm just curious, are the edge points midway between the cell centers? If yes, you could mention it.

Line 120. "consists" should be "consist"

Equation (4). On the right-hand side, in the list of arguments of the function  $D$ , the variable " $u_{sub_n}$ " should be " $u_{sub_n}_{sub_d}$ ". Same comment for equations (5), (6), (7), (8), (32), (33).

Equation (6). On the left-hand side, the cell area is denoted " $A_{sub_{ui}}$ ". Why the subscript " $u$ "? Couldn't the area just be denoted " $A_{sub_i}$ "?

Equation (19). It is misleading to write " $=0$ " at the end of this equation. If  $L_j(x,y)=0$  then according to equation (17)  $N_i$  is also zero.  $L_j(x,y)$  is only zero along the  $j$ -th edge of the polygon, not for all  $(x,y)$ . I suggest writing something like this:

" $L_j(x,y) = 1 - a_j*x - b_j*y$  (19)

where  $a_j$  and  $b_j$  are defined by the condition that  $L_j(x,y)=0$  along the  $j$ -th edge of the polygon."

Equation (21). Why not choose  $x_c$  = the cell center as shown in Figure 1?

Line 186. "can be calculated once FOR EACH CELL" (right?)

Equation (25). Delete the period (.) at the end.

Figure 4. There are a lot of letters in this figure! To improve readability, I suggest putting a small black square at the location of each vertex, as in Figures 1 and 3.

Line 364. V1 and V2 should be  $V_{sub\_1}$  and  $V_{sub\_2}$

Line 441.  $A_{sub\_di}$  should be  $A_{sub\_i}$

Lines 461-462. It should be noted after this sentence that averaging the Weak method makes the error LARGER.

Lines 469-470. "For the hexagonal cell mesh the variational methods show lower errors with better convergence rates than the weak method." I suggest deleting this sentence because it is out of place here, and it is repeated on lines 473-475 in slightly different form: "For the hexagonal cell mesh, the weak method shows only first-order convergence with significantly higher error than the variational method."

Lines 480-481. The end of this sentence, which refers to the averaged Wachspress scheme, is true for Figure 5c but not for Figures 5a,b,d.

Line 481. Wachspress is mis-spelled.

Lines 482-483. This sentence (which refers to Figure 6) is true for the hexagonal mesh (solid lines) but not for the square mesh (dashed lines).

Line 494. I think "strain rate operators" should be "strain rate component  $\epsilon_{11}$ "

Line 507 or later. It should be noted in the discussion of Figure 9 that averaging the Weak method makes the error larger.

Figure 7. Why do the velocity components  $u$  and  $v$  have primes (') on them?

Figure 7 caption, line 2. "e-f" should be "e-g" or "e,f,g"

Figure 9 caption, line 4. Add "as dotted lines" at the end of the sentence.

Figure 17 caption, line 2. Delete "a" before "short dashed"

Figure 19. To the right of panel (L), the label for the color scale should say "ice conc. diff." (not "ice conc.")

Figure 20. To the right of panel (i), the label for the color scale should say "ice thickness diff." (not "ice thickness")

Figure 22. The solid black curve has double tick-marks along its length, but this does not correspond with the legend. It looks to me like the tick-marks are not necessary on any of the curves: black denotes Global, red denotes Polar, and the line style (solid, dashed, dotted) denotes Simple, Region, or Weight. If symbols on the curves are desired, they could all be solid dots.

Lines 677-684. In the discussion of removing equatorial cells, something about boundary conditions should be mentioned. On a global grid there are no boundaries, but when equatorial cells (or any group of cells) are removed, suddenly there are boundaries to deal with. How is that handled?

Line 737. "the its" -- delete one or the other of these words.

Line 745. Note that "nearly linear" refers to log-log space.