Second Review of Li et al's Overestimation and Adjustment of Antarctic Ice Flow Velocity Fields Reconstructed from Historical Satellite Imagery

Chad A. Greene
December 19, 2021

General comments

In my first review of this paper, I commended the authors for raising awareness of an issue that could potentially introduce a systematic bias into any study of ice dynamics that compares recent satellite measurements to velocities measured decades ago, when the satellite record was sparse and image pairs were often separated by many years. The paper presented a reasonable approach for dealing with overestimation from a technical standpoint, but I felt the manuscript needed improvement in communicating
1. why the overestimation effect matters,
2. how big of a problem it is, and
3. when it should be taken into account in scientific studies.

On these three points, I don't see that much has changed in this revised manuscript. A few sentences were added in this revision to mention the effects of OE at PIG, but no attempt was made to put the effect into any greater context or generalize the findings beyond the specific case at PIG. Notably, one of the new sentences states that OE is negligible when computing GL flux at PIG. As a reader I am left wondering, if OE is negligible at PIG, does it matter anywhere?

Most of this paper is devoted to specific case studies of PIG, Totten, and David Glaciers, but the results are never generalized beyond the specific image pairs that were analyzed in this study. Readers are tasked with absorbing pages of details about tenth-of-a-meter-per-year level accelerations in some arbitrary pixels from a handful of image pairs, but the findings from these case studies are never synthesized in any way that could be applied beyond the image pairs that are analyzed in this study.

In my previous review, I suggested that readers would benefit from clear guidance on when to consider the effects of OE. The authors responded with a beautiful Figure R2-1 that for some reason is not included in the manuscript. I've recreated panel C of R2-1 below (the code is provided at the end of this review) and I find a similar overall curve for PIG. The GL flux curve for PIG takes an interesting shape—why does the OE effect appear to level off after a couple of years? That phenomenon is worth exploring and discussing in the manuscript.

Is the same effect seen elsewhere around Antarctica? When I synthetically "measure" GL flux as a function of dt for the entire continent*, it doesn't appear to matter much on the whole. This suggests that while overestimation is in effect at PIG, there is some compensating

---

* My GL flux values for "the entire continent" are low, because I excluded GL datapoints that would calve into the ocean within 15 years.

underestimation elsewhere around Antarctica. Where does this happen? A discussion of the physical phenomena that affect ice velocity measurements would be insightful.
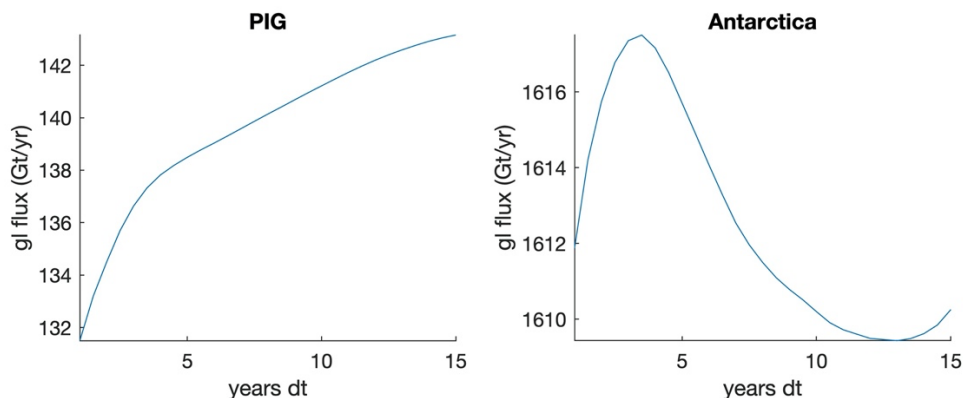
Summary: I don't believe there's any particular harm in publishing the manuscript in its current form, but I do believe an opportunity has been missed for the authors to share the insights and intuition they have surely developed over the course of this work.

Specific comments

Line 394 alludes to experiments that were performed on Jakobshavn Isbrae and introduces the acronym JI for the glacier, but the experiments at Jakobshavn are not described anywhere in the paper, and the acronym is never used. Am I missing something?

Line 399 starts a new section with the word "Furthermore,..." as if a thought is being continued from a previous section. Section breaks are often where readers pause to grab a cup of coffee, so as a general rule I recommend starting each section in such a way that readers can pick up where they left off, without having to re-read the previous section.

Line 339 says GL flux was computed. How? What grounding line and ice thickness products were used?

Line 440 says "OEs in velocity can further cause an overestimation in GL flux, which is negligible within a 3-year span" but no evidence or rationale for this statement is presented in the manuscript.

Line 443 says "Therefore, the influence of the velocity OEs on the GL flux appears to be not very significant." Does this mean the main thesis of the paper is more theoretical than practical?

Lines 445-449 offer concluding remarks on the Jakobshavn experiments that are not described in this paper. This paragraph can be removed.

Matlab code

```matlab
% Load velocity data:
[vx,x,y] = itslive_data('vx');
vy = itslive_data('vy');

vx = double(vx);
vy = double(vy);

[X,Y] = meshgrid(x,y);

% Fill data gaps:
isn = isnan(vx);
vx(isn) = measures_interp('vx',X(isn),Y(isn));
vy(isn) = measures_interp('vy',X(isn),Y(isn));

ground = ismember(bedmachine_interp('mask',X,Y),[1 2 4]);

% mask2outline is in the Climate Data Toolbox
[glx,gly] = mask2outline(x,y,imfill(isfinite(vx) & ground,'holes'),...
    'buffer',-1000,'regions',1);

glx = glx';
gly = gly';

% Load thickness data:
H = bedmachine_interp('thickness',glx,gly);

dt = 0.5; % time step for advection
t = (0:dt:15)'; % time (years)

% Passively advect the GL points downstream, one dt at a time:
for k=2:length(t)

    % Grow the array with a new column for each dt:
    glx = [glx;glx(k-1,:)+dt*interp2(x,y,vx,glx(k-1,:),gly(k-1,:))];
    gly = [gly;gly(k-1,:)+dt*interp2(x,y,vy,glx(k-1,:),gly(k-1,:))];

end

% Measured velocity:
vxi = (glx-glx(1,:))./t;
vyi = (gly-gly(1,:))./t;

% fix the 0/0 problem for time zero:
vxi(1,:) = interp2(x,y,vx,glx(1,:),gly(1,:));
vyi(1,:) = interp2(x,y,vy,glx(1,:),gly(1,:));
vi = hypot(vxi,vyi);

% "Measure" flux each year:
flux = [];
for k = 1:length(t)
    flux = [flux;(gradient(glx(1,:)).*H.*vyi(k,:) -
gradient(gly(1,:)).*H.*vxi(k,:))*917*1e-12];
end
```

```matlab
% Indices of data points that are good for the entire record:
% (Caveat: Most Thwaites and many Antarctic Peninsula GL points end up in
% the ocean within 15 years, so they aren't counted in Antarctica's total.)
allgood = all(isfinite(flux));

% Indices of PIG points:
pig = inbasin(glx(1,:),gly(1,:),'imbie refined','pine island');

figure
subplot(1,2,1)
plot(t(3:end),sum(flux(3:end,allgood&pig),2))
box off
axis tight
xlabel 'years dt'
ylabel 'gl flux (Gt/yr)'
title PIG

subplot(1,2,2)
plot(t(3:end),sum(flux(3:end,allgood),2))
box off
axis tight
xlabel 'years dt'
ylabel 'gl flux (Gt/yr)'
title Antarctica
```