Glaciology now has clear applications. Governments should fund this critical, applied work.

University of Idaho

RICARDO ARDUENGO/AFP via Getty Images

My goal: Get your feedback on the most effective strategies/ partnerships for bringing this about
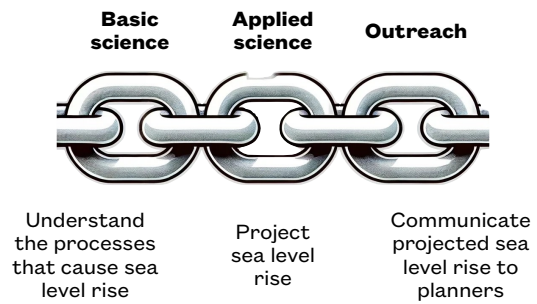
The massive, unmet need for applied ice sheet modeling

TIMOTHY C. BARTHOLOMAUS, UNIV. OF IDAHO

W/ INSPIRATION AND DISCUSSION FROM MANY
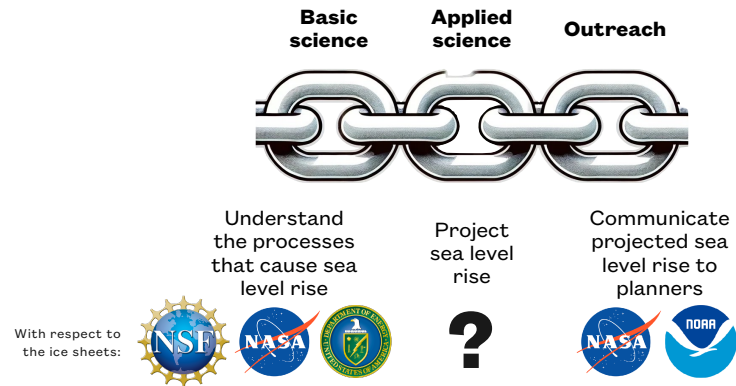
Effective planning for SLR requires 3 links

Basic science **Applied science** **Outreach**

Understand the processes that cause sea level rise

Project sea level rise

Communicate projected sea level rise to planners

Effective planning for SLR requires 3 links

WITHOUT EACH LINK,

VULNERABLE PEOPLE ARE UNLIKELY TO RECEIVE INTENDED COASTAL PROTECTION FROM DESIGNED INFRASTRUCTURE,

WHICH IS ALREADY COSTING BILLIONS OF DOLLARS

Effective planning for SLR requires 3 links

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With respect to the ice sheets: NSF · NASA · Department of Energy — ? — NASA · NOAA

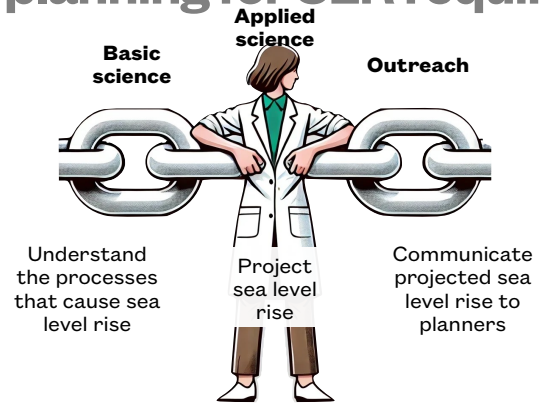TIM BARTHOLOMAUS, UNIVERSITY OF IDAHO: THE MASSIVE UNMET NEED FOR APPLIED ICE SHEET MODELING

With respect to the sea level contribution from ice sheets, who in the US is funding the elements of this chain?
For basic science these organizations include NSF, the NASA Cryosphere program, the NASA Sea Level Change, and national labs such as those of the DOE. Each of these is oriented towards basic, hypothesis-driven science.
For outreach and communication, both the NASA Sea Level Change Team and the NOAA Oceans and Coasts participate.

However, nobody in the US dedicates funding to actually apply what we know about ice sheet processes to project their future changes and contribution to sea level rise.
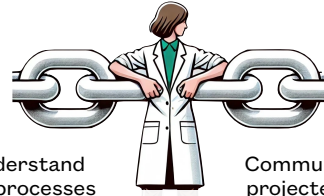
Effective planning for SLR requires 3 links

Basic science — Understand the processes that cause sea level rise

Applied science — Project sea level rise

Outreach — Communicate projected sea level rise to planners

For this Applied Science component, the chain is broken, and a group of volunteer scientists have stepped in to project the ice sheet contribution to sea level rise.

Effective planning for SLR requires 3 links

Understand the processes that cause sea level rise

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Answering the call for **Applied Science**:

the volunteer scientists of **ISMIP7**
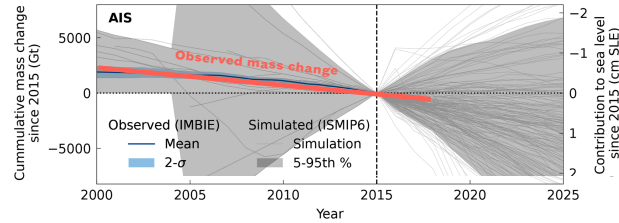Ice Sheet Model Intercomparison Project

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ISMIP7 (the Ice Sheet Model Intercomparison Project for CMIP7) is this group of volunteer scientists, led by Sophie Nowicki. Most of the ISMIP7 participants are shown in this photograph.

Is the volunteer effort sufficient?

For the Antarctic Ice Sheet:
- Simulations are so varied that it suggests naivety about current or future mass loss

(Aschwanden et al., 2021)

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If the volunteer effort by ice sheet modeling scientists is meeting the goal of reproducing observations and therefore credibly projecting sea level rise, then that is great and we have nothing to worry about. The lack of funding for this effort would then not be a problem. Unfortunately, that is not what we find when we look at the simulations. The simulations of the ice sheets do not match observations. This is a problem and seriously throws into question the current projections of sea level rise, which are based on these simulations of ice sheet change.

The naivety reflected in the Antarctic simulations does not at all capture what we know about Antarctic change.
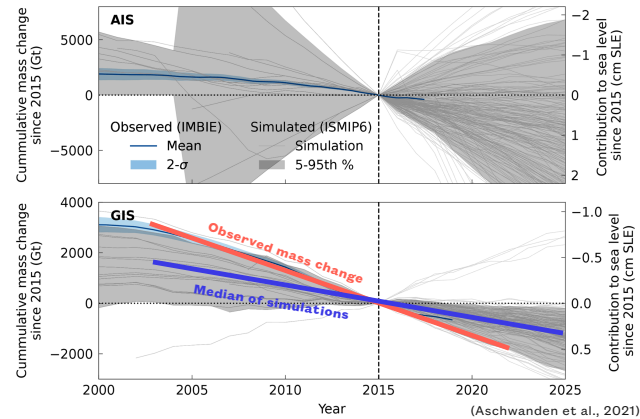
Is the volunteer effort sufficient?

For the Antarctic Ice Sheet:
- Simulations are so varied that it suggests naivety about current or future mass loss

For the Greenland Ice Sheet:
- Simulations barely contain observations
- Median simulation underestimates observed rate of mass loss by 2x

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(Aschwanden et al., 2021)

In Greenland, we also find stark deficiencies with the simulations, but a different set of problems than for the Antarctic Ice Sheet. In the Greenland case, we see that the almost none of the simulations reproduce the changes we've observed, and that, on average they underestimate changes by a factor of two.

## Is the volunteer effort sufficient?

For the Antarctic Ice Sheet:

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For the Greenland Ice Sheet:

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THIS DOES NOT "PROVE" THAT THE ICE SHEET MODELS ARE WRONG,

BUT IT'S NOT ENCOURAGING
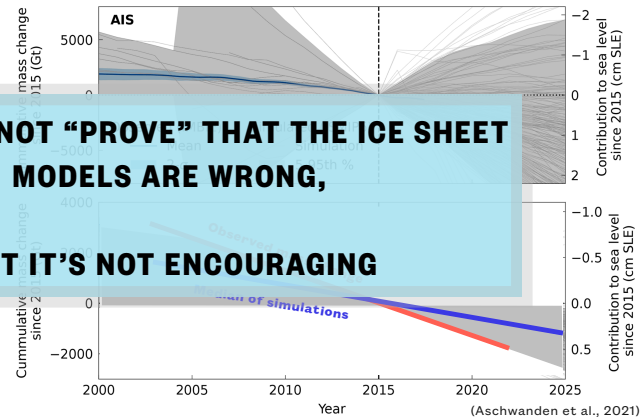
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There are many reasons why these simulations might be failing to reproduce observations, and the shortcomings don't necessarily mean that the models are wrong. But the misfit is certainly not what we would like to see. It does not at all give the community of ice sheet modelers confidence that their simulations of future ice sheet and sea level change are reliable or trustworthy.

Misfit stems from novelty and lack of funding

- This was the first time this was EVER done

- It was a volunteer effort

- Lack of funding is not surprising:

  - Until now, there was no globally-relevant applied glaciology.

Re: the lack of ice sheet dynamics in projections of sea level rise in IPCC AR4:

"The present [ice sheet mass] imbalance might be a response to recent climate change, perhaps through oceanic or surface warming. No models are available for such a link, …"

- IPCC AR4 § 10.6.5 (2007)

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This misfit is not anybody's fault. The ice sheet modelers who have produced these simulations are the best in the world. The field of ice sheet modeling is just so very young. In the IPCC report from 2007, it was impossible to realistically project the future contribution of the ice sheets to sea level rise. The field of glaciology has come a very, impressively long way in less than 20 years.

Also, it's not surprising that there isn't yet applied funding for glaciology because glaciology didn't have broad application until very recently- really just since the IPCC AR6 in 2021. The existing funding structures (focused on basic, discovery science) are a legacy of a history that was limited to basic science.

Improvements in ice sheet modeling are not fast enough

- But basic science is slow

  - Projects testing single hypotheses take 3-5 years

  - Modelers lack capacity to explore uncertainties

- We need viable projections now

New York City has already allocated $900M in infrastructure projects to protect neighborhoods from flooding.

Financial District and Seaport Climate Resilience Master Plan

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The ice sheet models are clearly improving, however, these improvements are not fast enough. Existing research is focused on improving one small component of an ice sheet model at a time, and those studies take 3-5 years. In the week of AGU, there are >900 presentations on poorly understood topics in the cryosphere, many of which pertain to the ice sheets. We cannot wait until all of these unknowns are resolved before we make projections of ice sheet change and sea level rise. NYC is already spending nearly $1B on coastal infrastructure plans to prepare for sea level rise, using the existing, flawed projections of ice sheet change. Another project in NYC, also using the same flawed projections is estimated to cost $52B.

We need mission-dedicated, applied ice sheet modelers

We need modelers to:

- work on tasks most likely to yield improvement in projections, not the discovery of new processes

- have job security such that they won't be distracted by job searches

- work with supervision and incentives committed to the mission, not the tenure track (like publication count, grant dollars, or student mentorship)

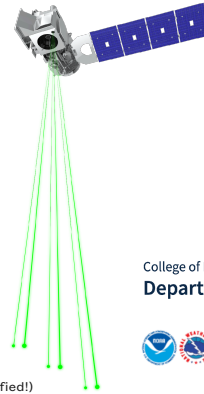(btw- this isn't for me! I'm not even qualified!)

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Current funding is oriented towards deep study of single processes, not the foundational model improvements that would lead to overall improvements in projecting sea level. Traditional funding is limited to 1-2 years, and often attracts applicants who are looking for traditional academic positions, such that they start looking for their next job 6 months after they begin and are likely to leave before the project is complete. Dedicated funding would fix this, and if we make it clear that the expectations are that work will be oriented towards the mission of projecting sea level change (not writing first-author papers or other traditional academic prestige activities), then we will be using our funding as efficiently as possible.

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College of Liberal Arts & Sciences | School of Earth, Society & Environment
Department of Atmospheric Sciences

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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I think of this like NASA building a satellite that can measure the shape of the Earth's surface to mm precision. To build it, they don't hire academics who will discover the best way to meet this goal after they finish grading their final exams, but hire engineers with expertise and singular focus to achieve the mission. With our nation's economy contingent on knowing the severity of storms likely to strike next week, we don't ask members of the Department of Atmospheric Science for a forecast once they finish applying for their next grant. We go to professionals working with dedicated focus on meeting the mission to forecast the weather.

We should be doing the same with projecting ice sheet change to inform a trillion dollars of infrastructure construction.
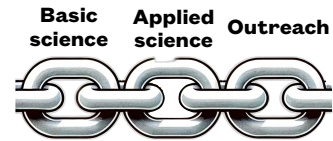
We could achieve this goal with a relatively modest investment, that would allow one professional modeler committed to sea level rise projection to embed with each of the major ice sheet modeling groups. This would mean ~8 individuals in the US and ~15 individuals oversees. Full funding would be on the order of $4M per year, or $16M total for 4 years. Funding could occur through the Federal government or a philanthropy, but there is already a Federal agency who's mission is to predict changes in the ocean and coasts, and who I believe would be a perfect fit for this work. This agency is NOAA.

A singular, critical mission deserves mission-focused staff

- ~$1 trillion and ~100 million people depend on projections of SLR

- Current volunteer efforts for the ice sheets have been insufficient

- The path to success is clear, with payoff of 1,000,000 : 1

- A clearly-defined, government effort would help with practitioner "whiplash" of fluctuating high-end projections
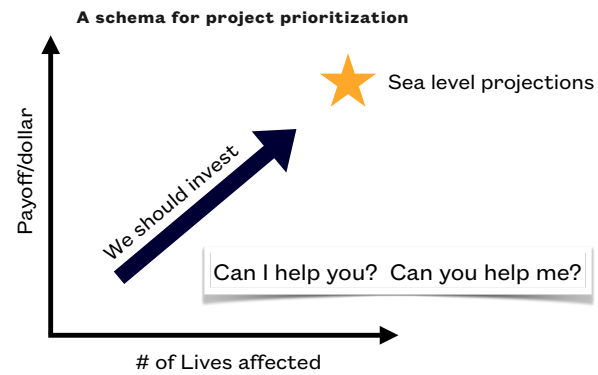
A schema for project prioritization

Payoff/dollar

We should invest

Sea level projections

Can I help you? Can you help me?

# of Lives affected

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To conclude, this is a projecting affecting the lives of ~100 million people and expected to cost $1T to address by 2100, and the status quo is not working. With an investment of ~$1M, you can drive $1T in spending. A clearly defined govt effort would produce credible projections of sea level rise so that sea level practitioners and planners are not getting jerked around and getting whiplash from single, basic science studies (that aren't designed to drive adaptation).

Can we work together to solve this problem?