Drivers of Ice Shelf Melt on Pine Island Glacier: Ocean vs Geometry?

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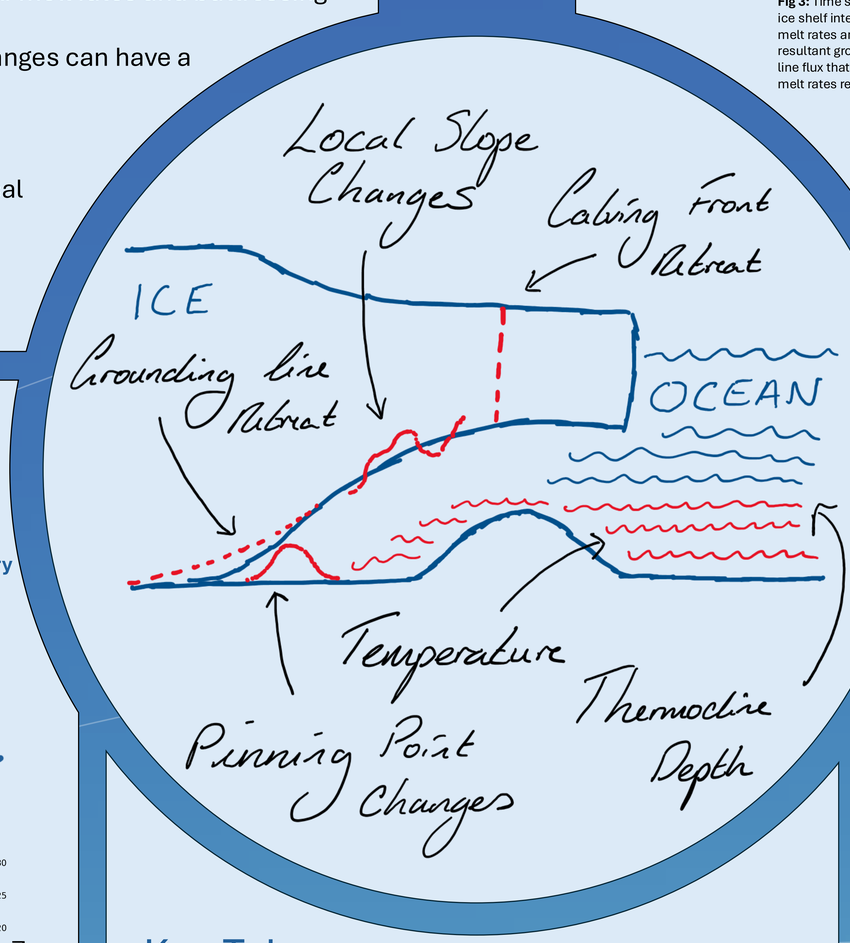
Motivation / Questions

- Both ocean conditions and ice shelf geometry impact ice shelf melt rates and buttressing capacity
- There is a growing body of evidence suggesting geometric changes can have a very important impact on ice shelf melting[1,2,3]
- Since 2011, there have been major geometric changes on Pine Island Glacier (PIG), including pinning point ungrounding, calving front retreat and a rearrangement of basal channels
- Understand the relative impact of geometric changes and ocean conditions on PIG melt and ice shelf buttressing capacity



Methods

- Annual MITgcm runs using CryoSat-2 derived ice shelf geometries and ocean conditions from moorings in Pine Island Bay (Fig 1)
- MITgcm run at 200m horizontal and 10m vertical resolutions
- 3 sets of model runs varying different boundary conditions have been complete
- We also use buttressing flux response number (BFRN) from Rydt and Naughten (2024) (Fig 2)

	Ocean	Geometry
Set 1 - Both	✓	✓
Set 2 - OCEAN	✓	✗
Set 3 - DEM	✗	✓

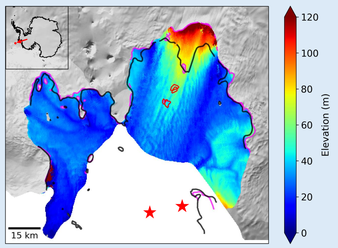


Fig 1: Example ice shelf geometry from CryoSat-2[4] and ocean mooring locations.

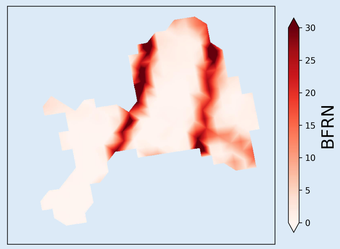
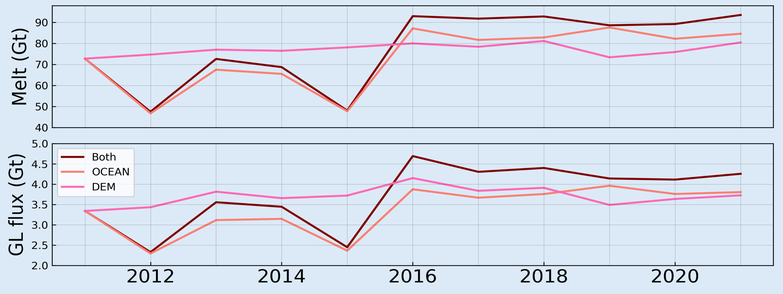


Fig 2: Buttressing flux response number on PIG ice shelf from Ryde and Naughten (2024).

Results: Temporal Variability

Fig 3: Time series of ice shelf integrated melt rates and the resultant grounding line flux that those melt rates result in.



Ocean conditions largely control temporal variability ($r = 0.98$). However, geometric changes only impact the temporal variability of melt by 10% but impact buttressing by 24%.

Results: Spatial Variability

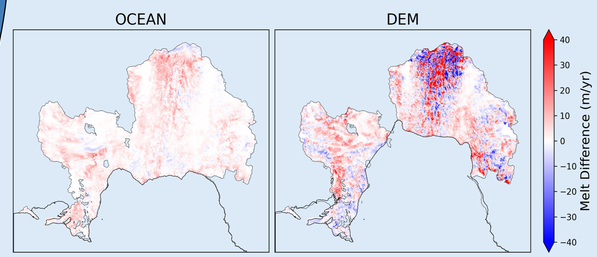


Fig 4: The change in the spatial distribution of ice shelf melt rates between 2011 and 2021 for OCEAN and DEM model runs.

Geometric changes control the spatial distribution of melt which is critical for controlling buttressing capacity

Key Takeaways

- Temporal variability of melt controlled by ocean conditions in the model
- Spatial distribution of melt controlled by geometry through changes in ocean circulation
- Geometry alone varies grounding line flux by 24%

Results: Circulation

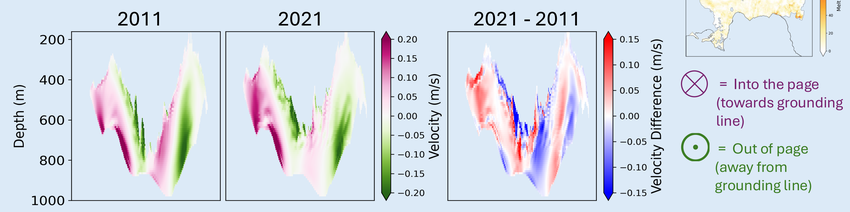


Fig 5: Ocean velocity along the transect in the top right. Showing circulation changes beneath the ice shelf due to geometric changes between 2041 and 2021.

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