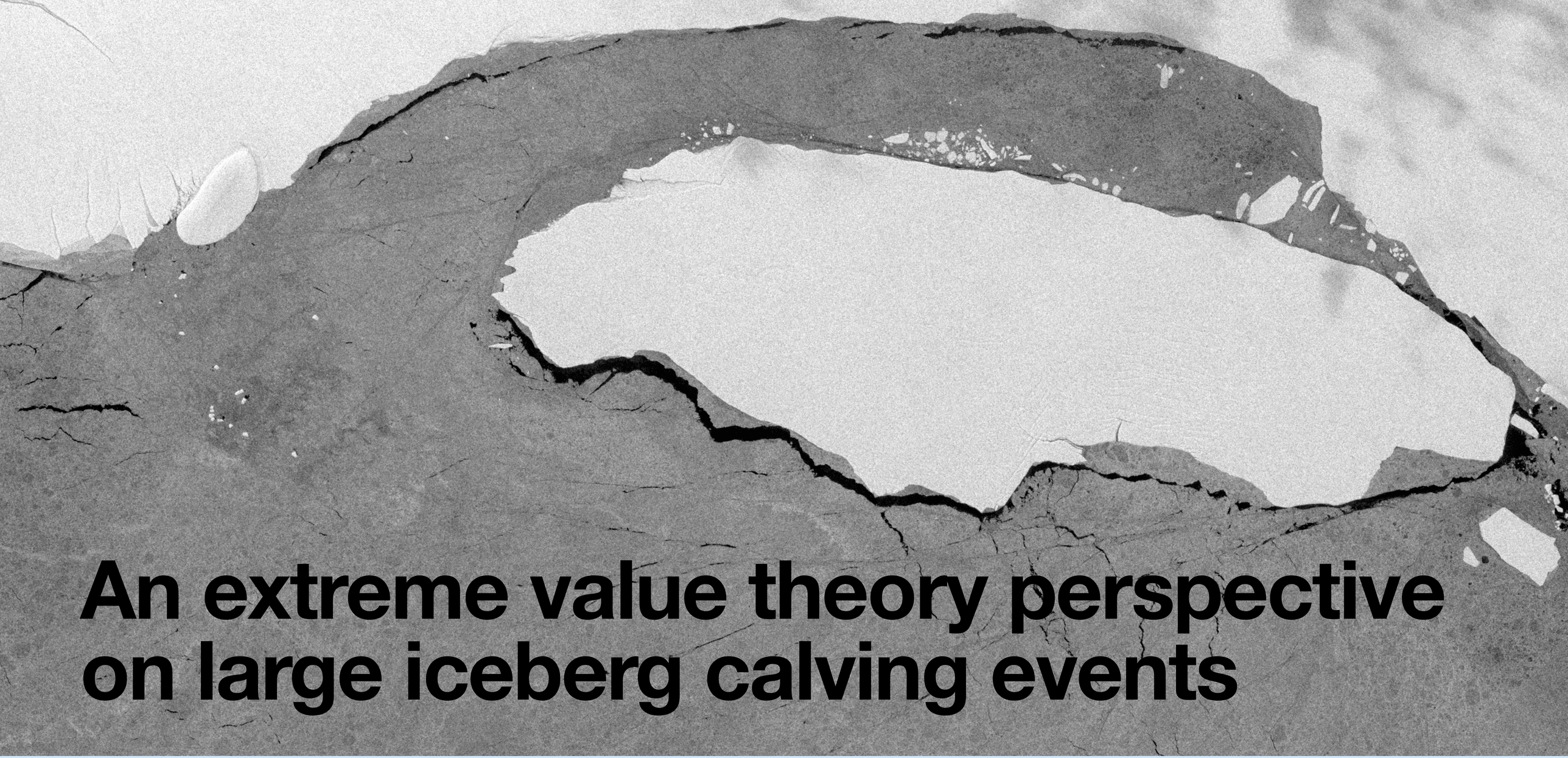


An extreme value theory perspective on large iceberg calving events

Joanna Millstein[1*], Mickey Mackie[2*], Katherine Serafin[2]

1- Colorado School of Mines, 2- University of Florida, *- contributed equally

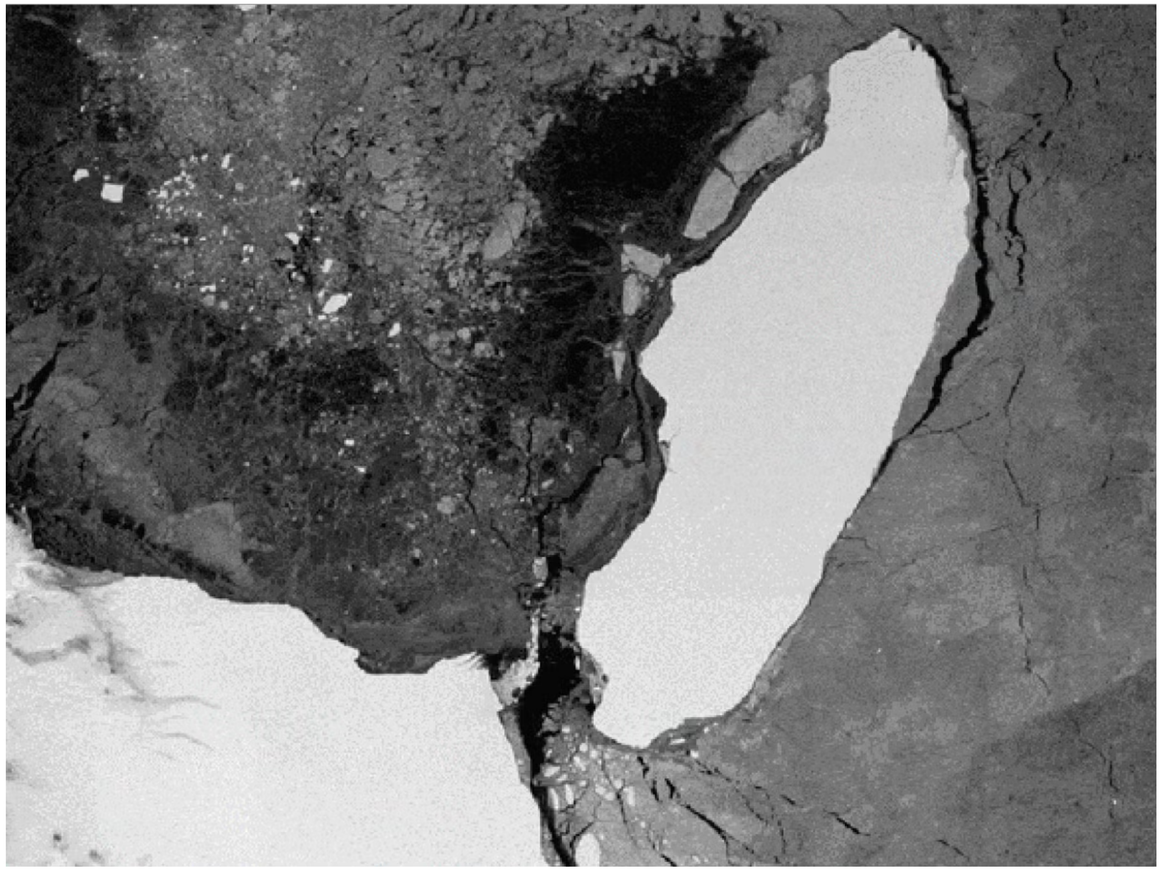
CESM Workshop - June 12, 2024

COLORADO SCHOOL OF MINES @150 | 1874-2024

Iceberg calving is a dominant process of mass loss from Antarctica

The process of calving can be described as a stochastic process, the probability an iceberg will detach in a given interval of time can be described by a probability distribution function.

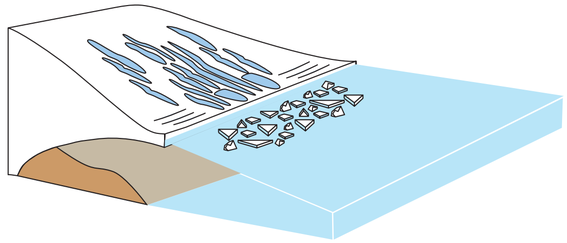
NASA OIB

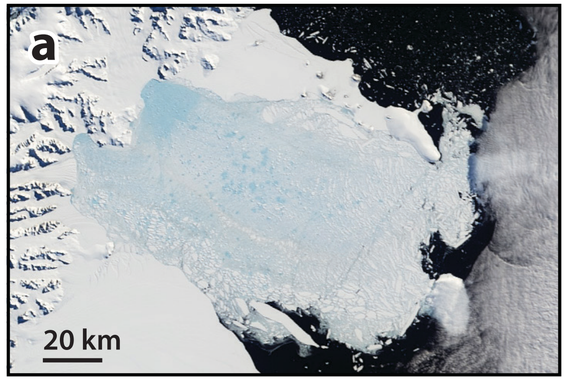


ESA

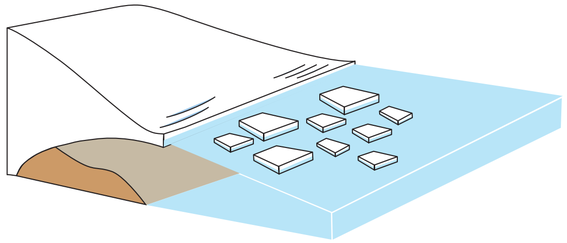
Calving of massive tabular icebergs are infrequent occurrences, difficult to observe, and complicated to properly model

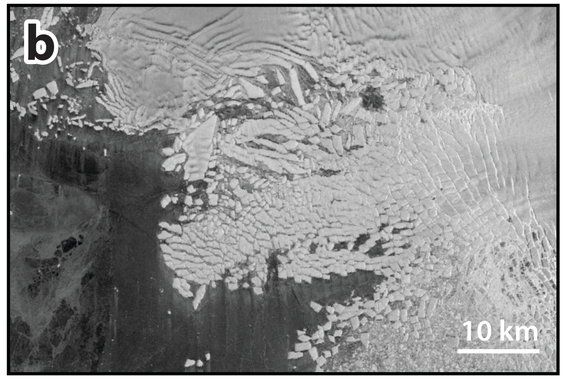
Explosive disintegration
Larsen B Ice Shelf



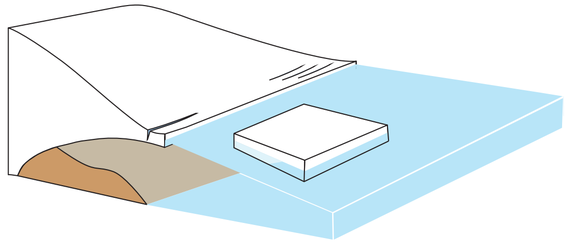


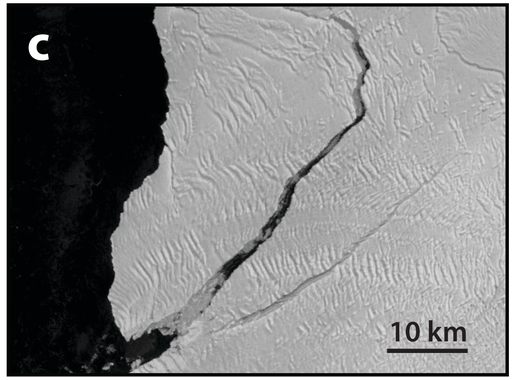
Sustained calving of icebergs
Thwaites Glacier





Rifting of tabular icebergs
Brunt Ice Shelf





Bassis et al. 2024 (in press)

We have decades of observations from the outcome of large calving events, otherwise known as icebergs

Iceberg tracking is of great interest for oceanographers and marine biologists, shipping routes and collision avoidance, and clickbait articles.

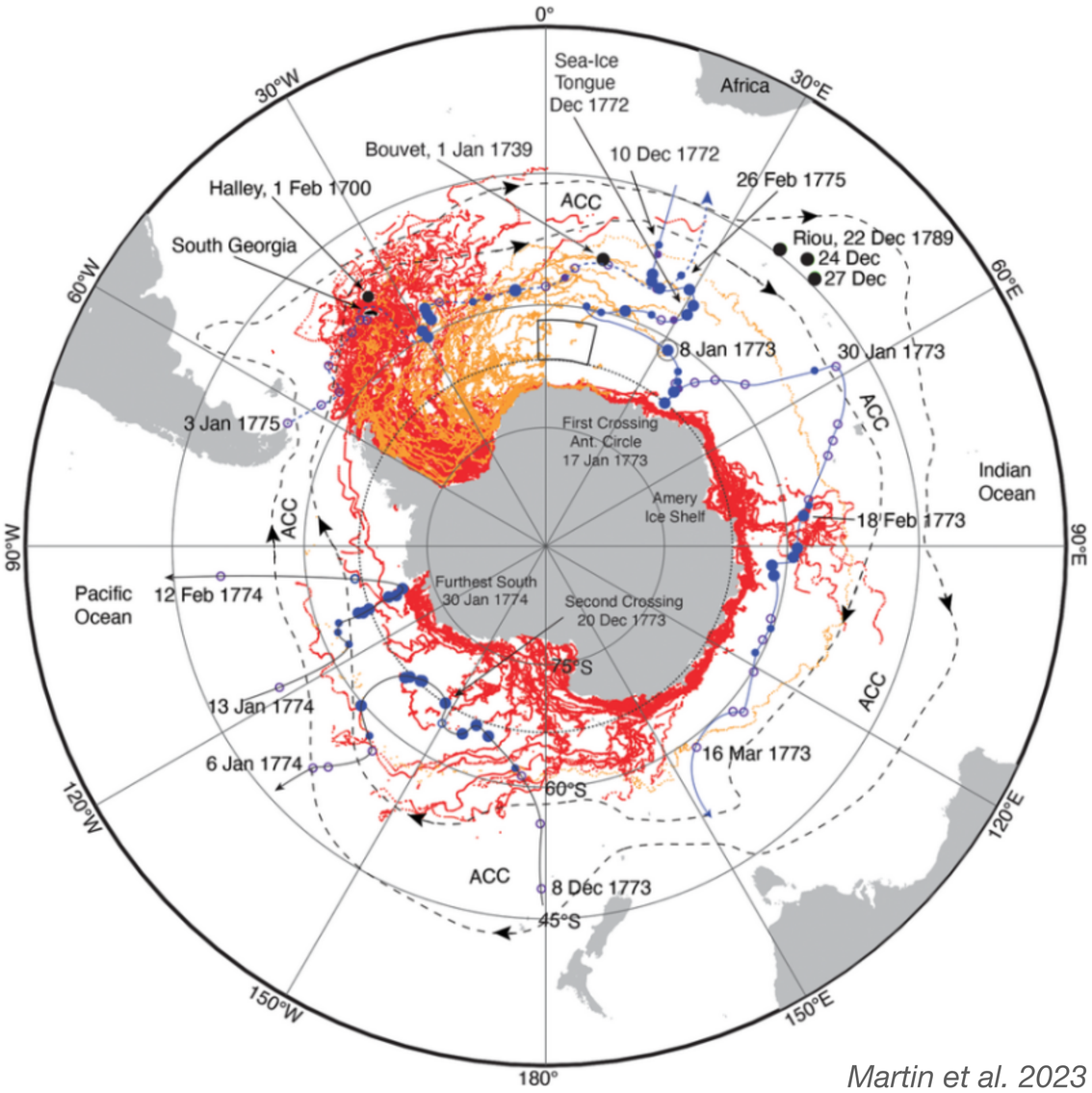
Brigham Young University - National Ice Center consolidated database (*Budge & Long, 2019*) of iceberg positions and estimated sizes from 1976 - 2023

We’re not interested in tracking icebergs, we want to identify icebergs right when they appear to have calved from the ice shelf

Data of iceberg ‘first date of appearance’ can be used to predict the recurrence of sudden, rapid mass-loss calving events in Antarctica, guiding us towards two important questions in glaciology:

What is the timeline of a typical calving lifecycle on an Antarctic ice shelf?

Is the rate of calving increasing in Antarctica?



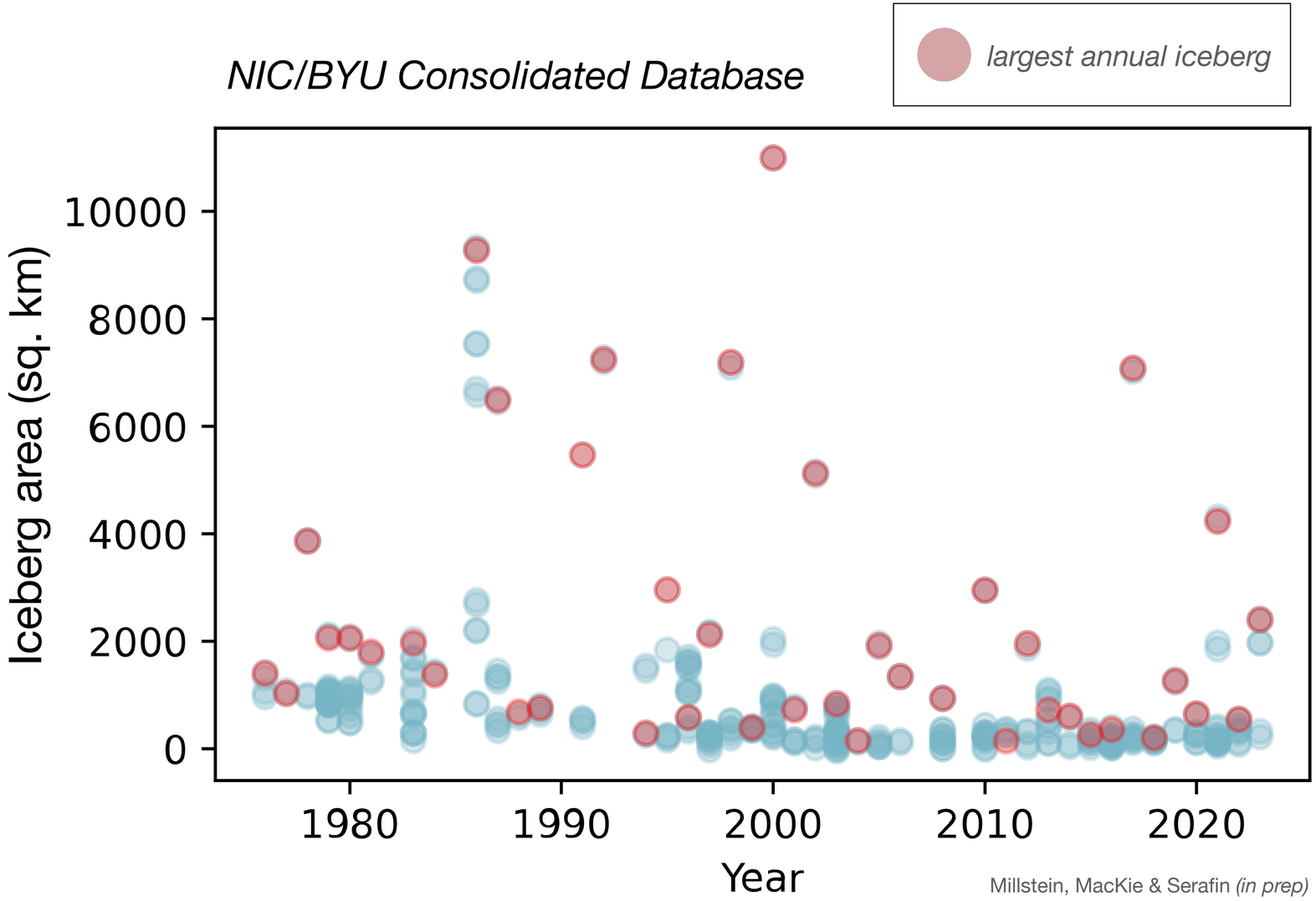
Martin et al. 2023

Extreme value analysis (EVT) assess the likelihood of future high-magnitude calving events

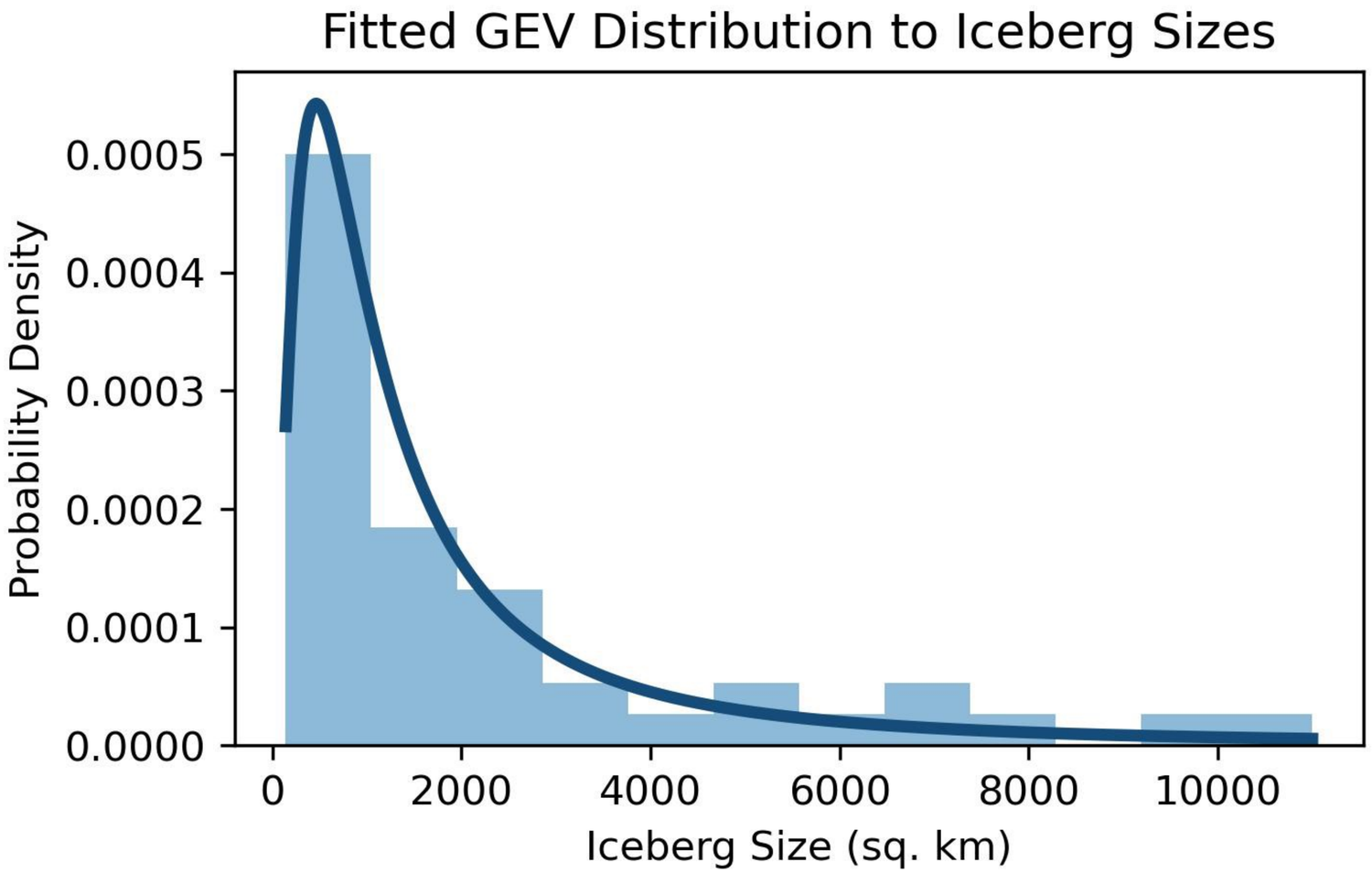
There are 632 named icebergs in the consolidated database

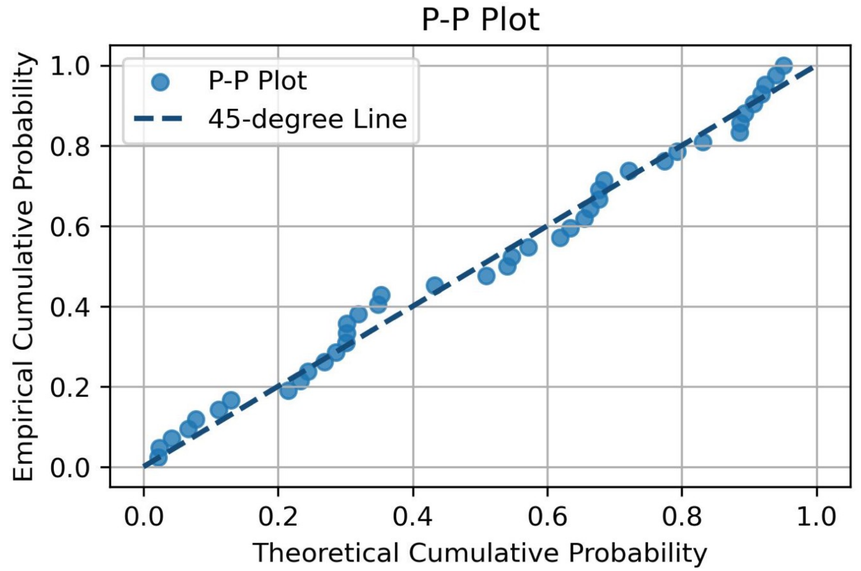
We look at the **largest iceberg in each year** so long as the iceberg is > 400 sq. km

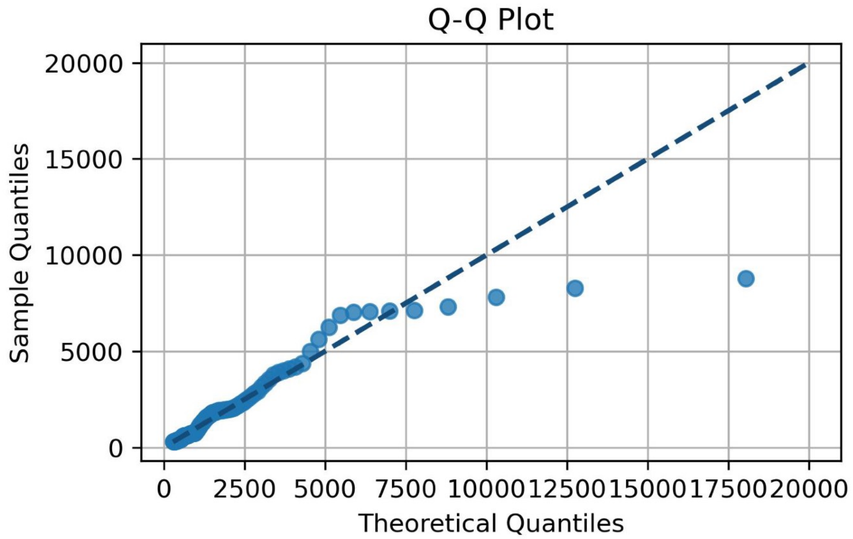
This narrows our dataset down to 42 icebergs



EVT can assess the likelihood of future high-magnitude calving events

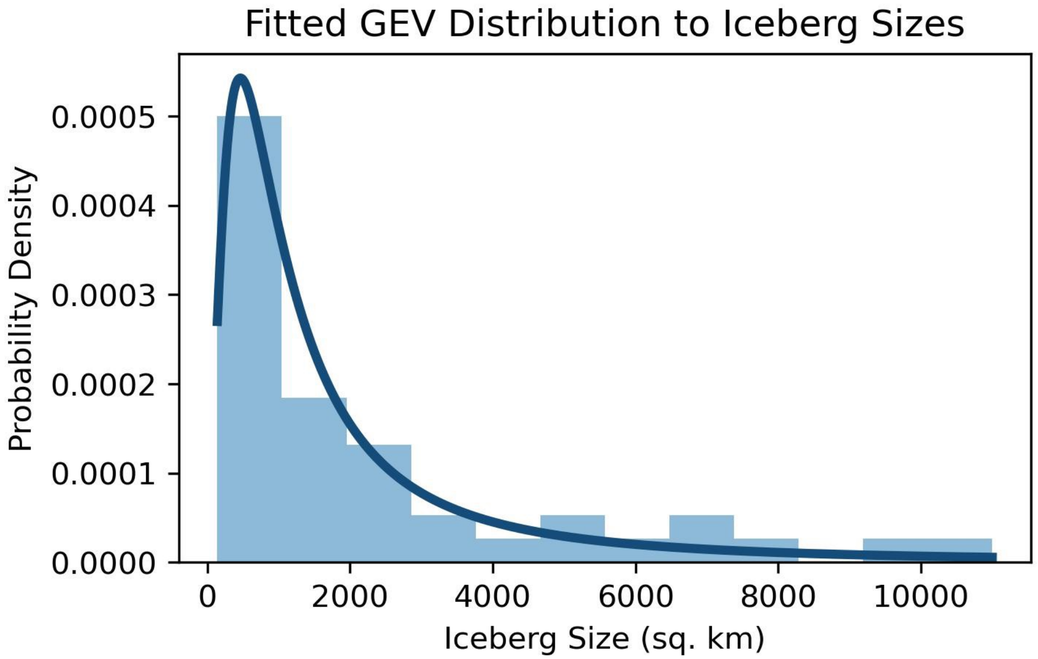


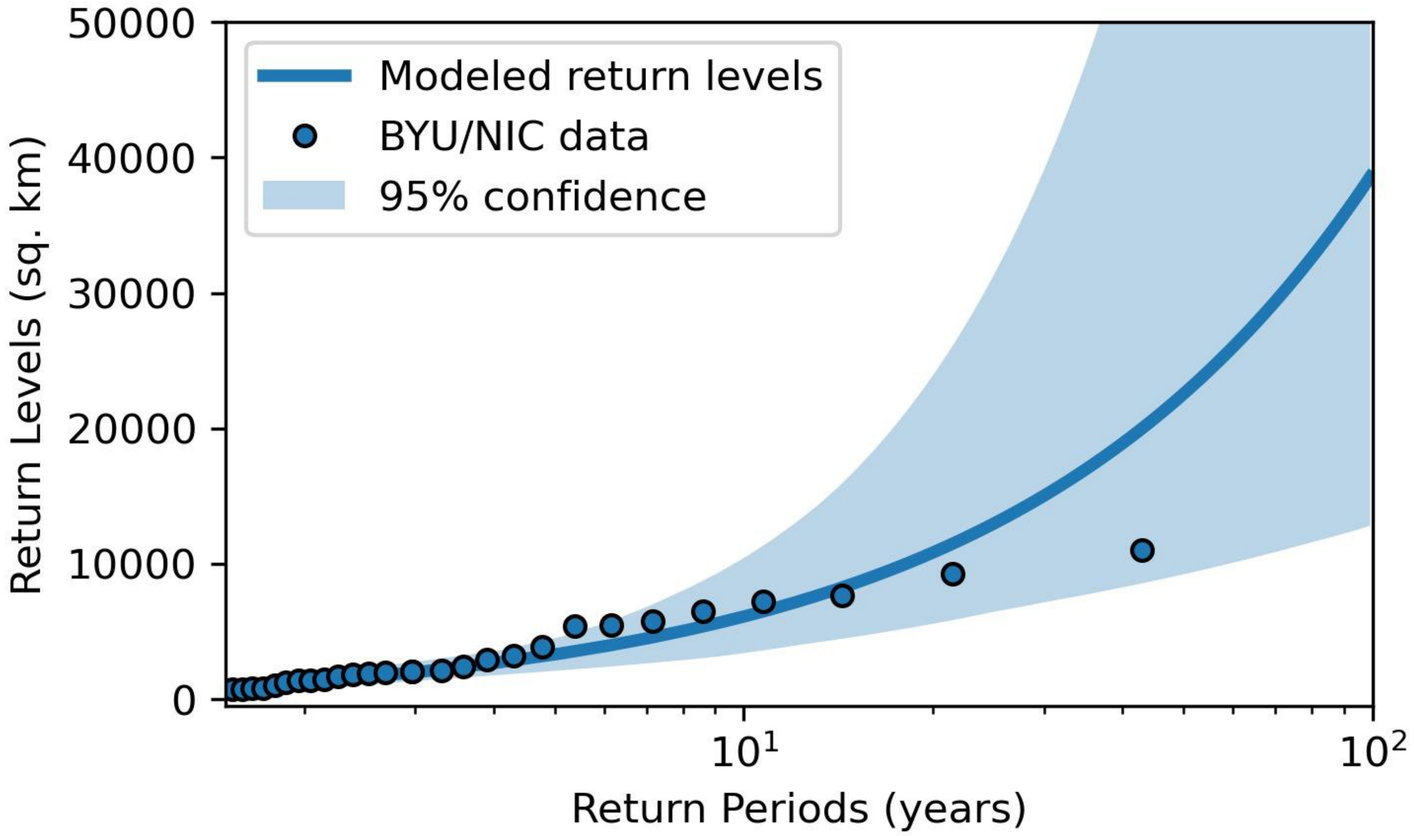




Millstein, MacKie & Serafin *(in prep)*

EVT can assess the likelihood of future high-magnitude calving events

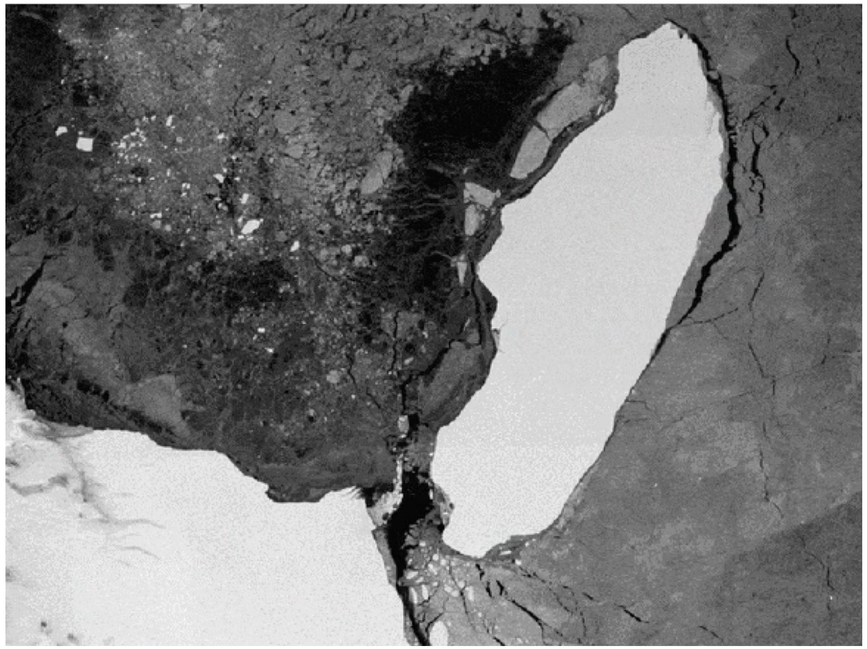




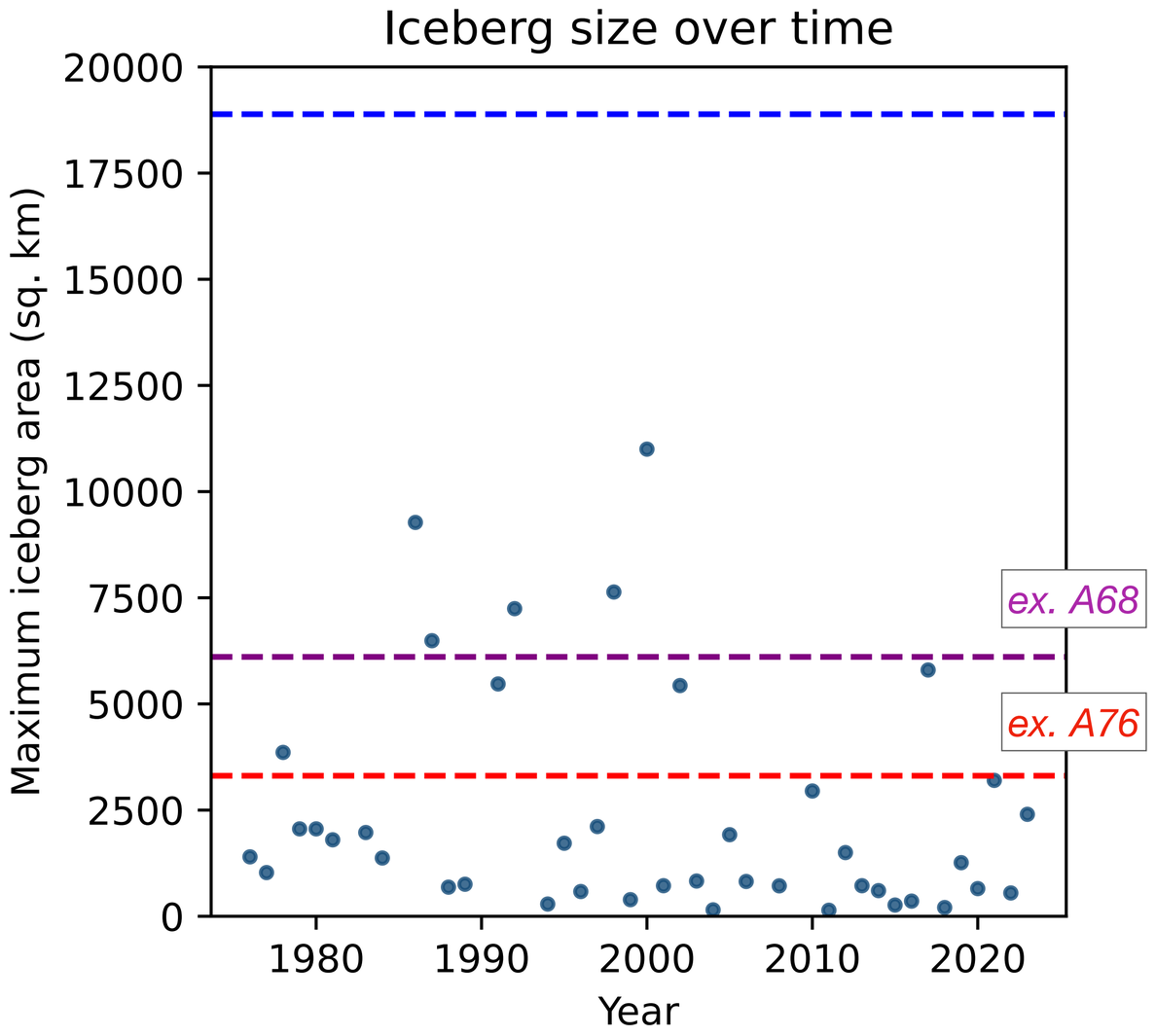
Millstein, MacKie & Serafin *(in prep)*

Recurrence intervals constrain expected future iceberg sizes

We can expect to see an A68-like iceberg every 10 years



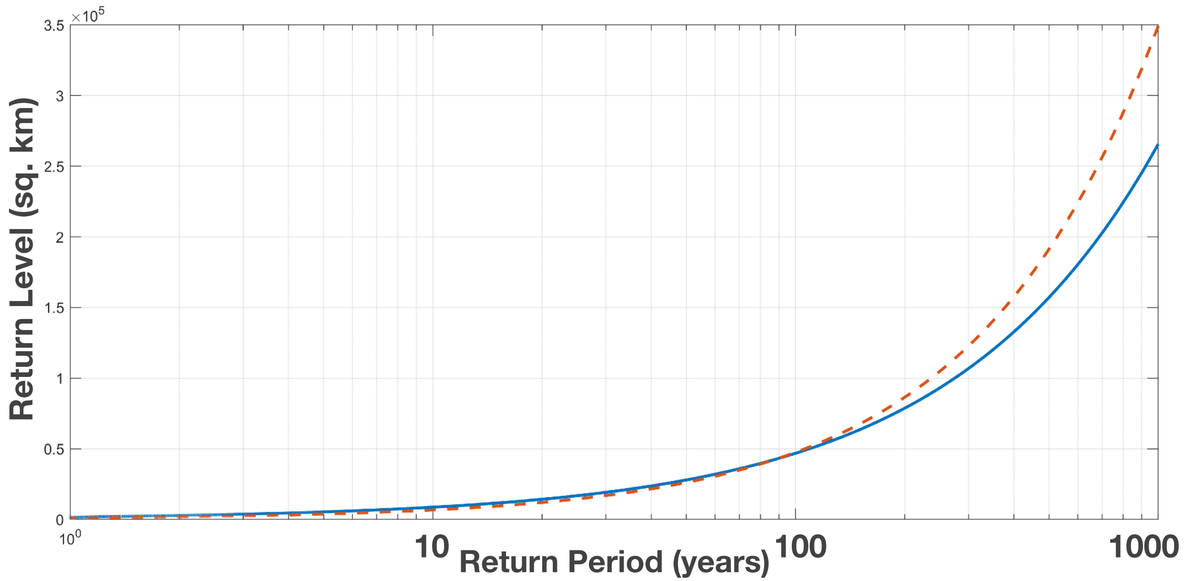
ESA

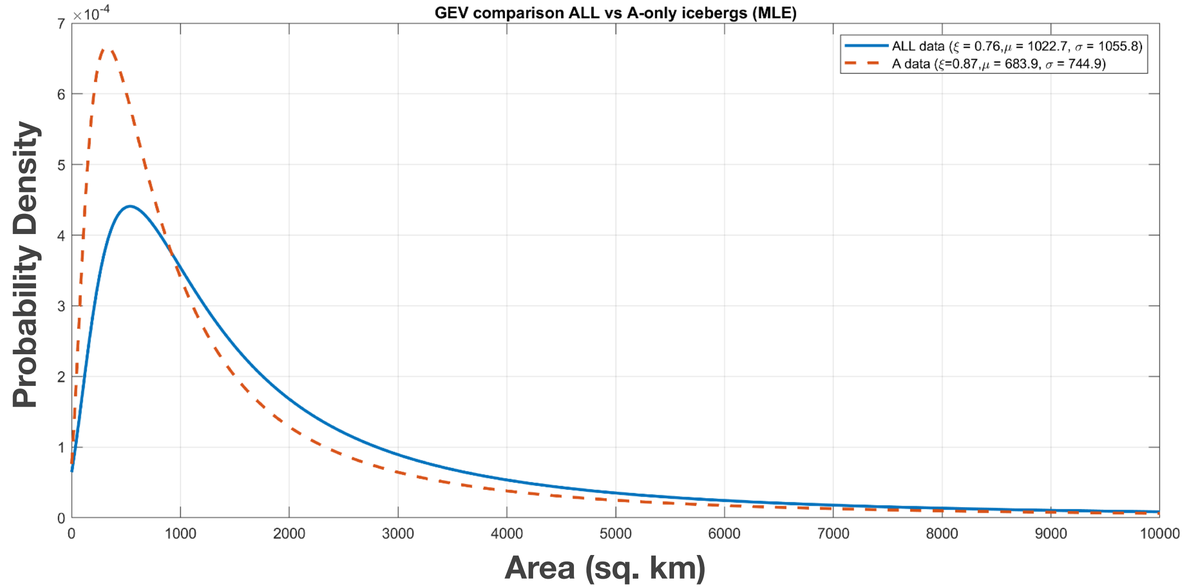


Millstein, MacKie & Serafin *(in prep)*

Parameters differ across continental and regional quadrant analysis

GEV comparison of all data (blue line) and Quadrant A icebergs (red dashed line) using a MLE fit





Millstein, MacKie & Serafin *(in prep)*

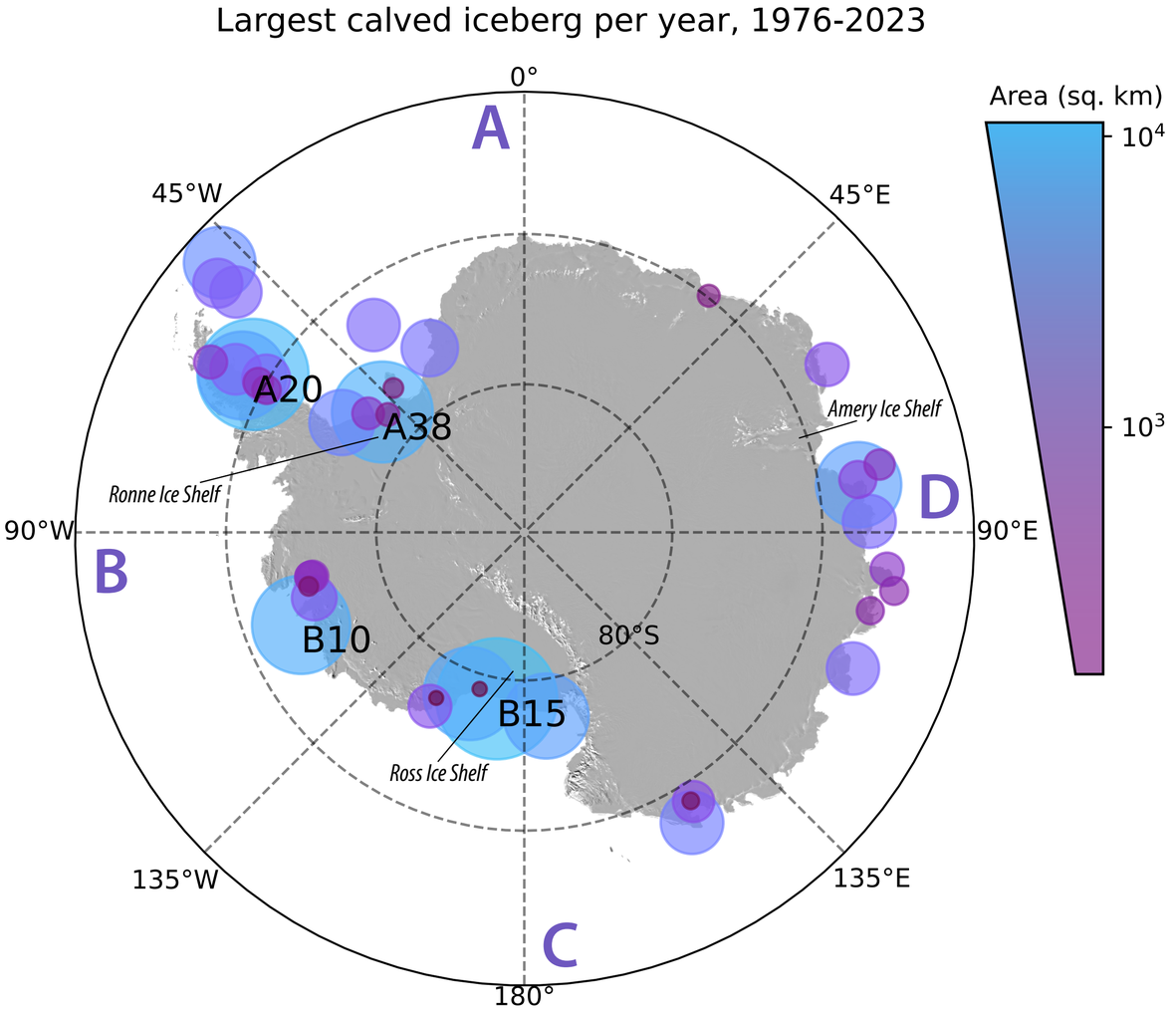
Wrapping up

- Incorporating time as a covariate and modeling non-stationary iceberg sizes **does not show a significant increase in massive icebergs through time**

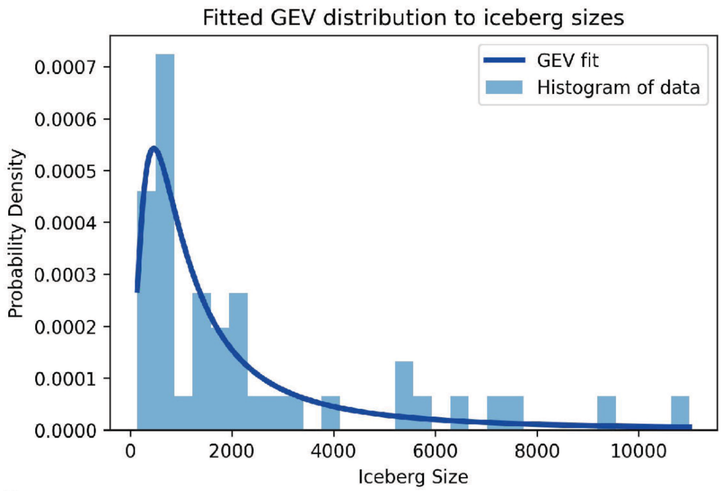
- Positive SAM ***is*** correlated with larger iceberg calving events

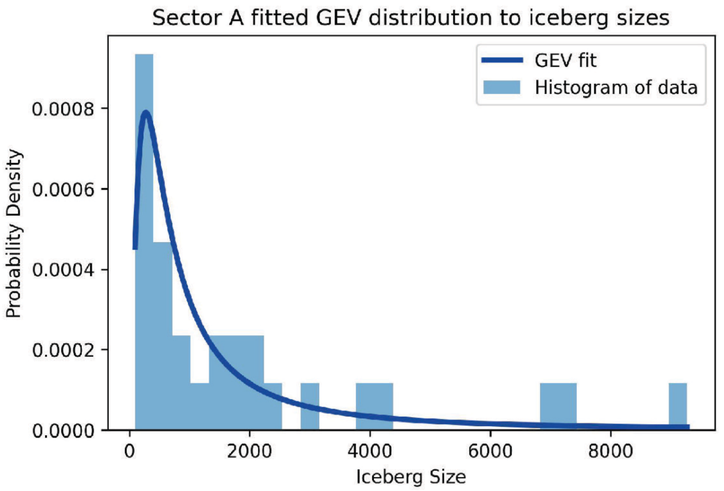
- The parameters for the continental dataset model are **different** than the parameters for Quadrant A

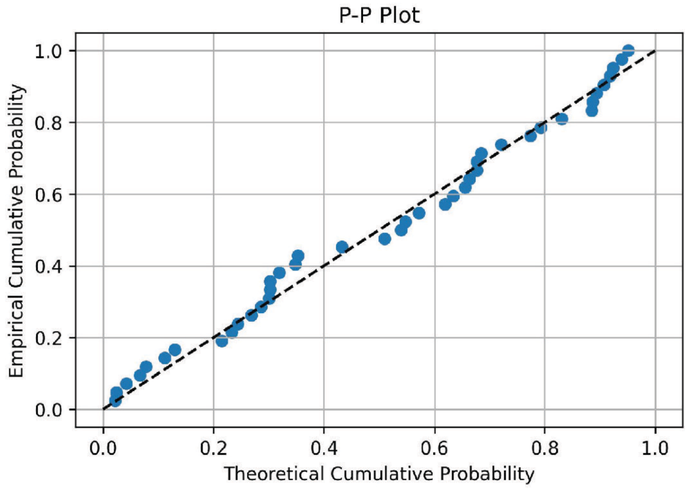
- EVT is useful specific form of stochastic modeling to broaden our approach for incorporating calving into ice sheet models

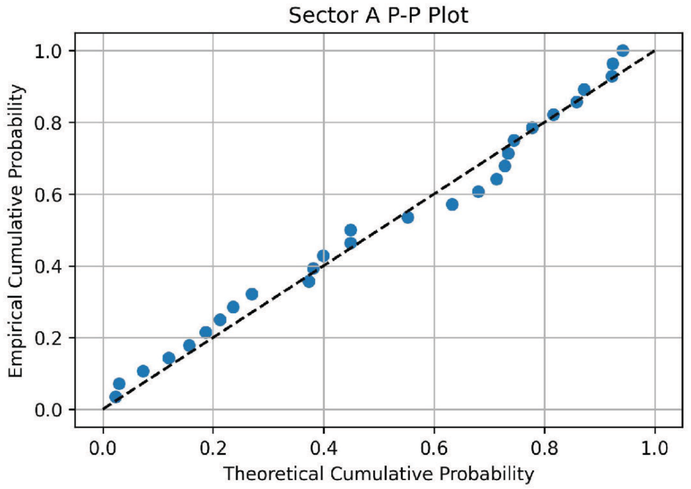


Millstein, MacKie & Serafin *(in prep)*


Fitted GEV distribution to iceberg sizes
GEV fit
Histogram of data
Probability Density
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0
2000
4000
6000
8000
10000
Iceberg Size


Sector A fitted GEV distribution to iceberg sizes
GEV fit
Histogram of data
Probability Density
0.0008
0.0006
0.0004
0.0002
0.0000
0
2000
4000
6000
8000
Iceberg Size


P-P Plot
Empirical Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Theoretical Cumulative Probability


Sector A P-P Plot
Empirical Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Theoretical Cumulative Probability