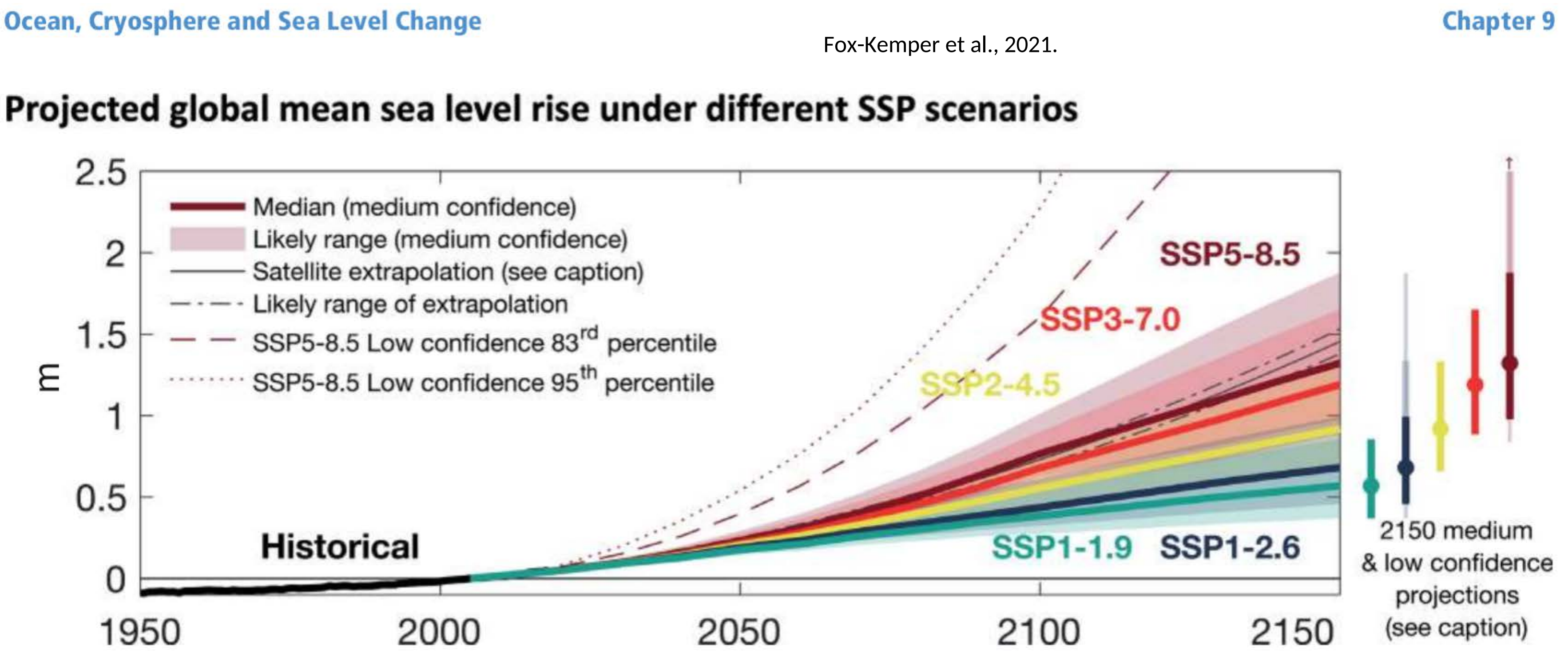
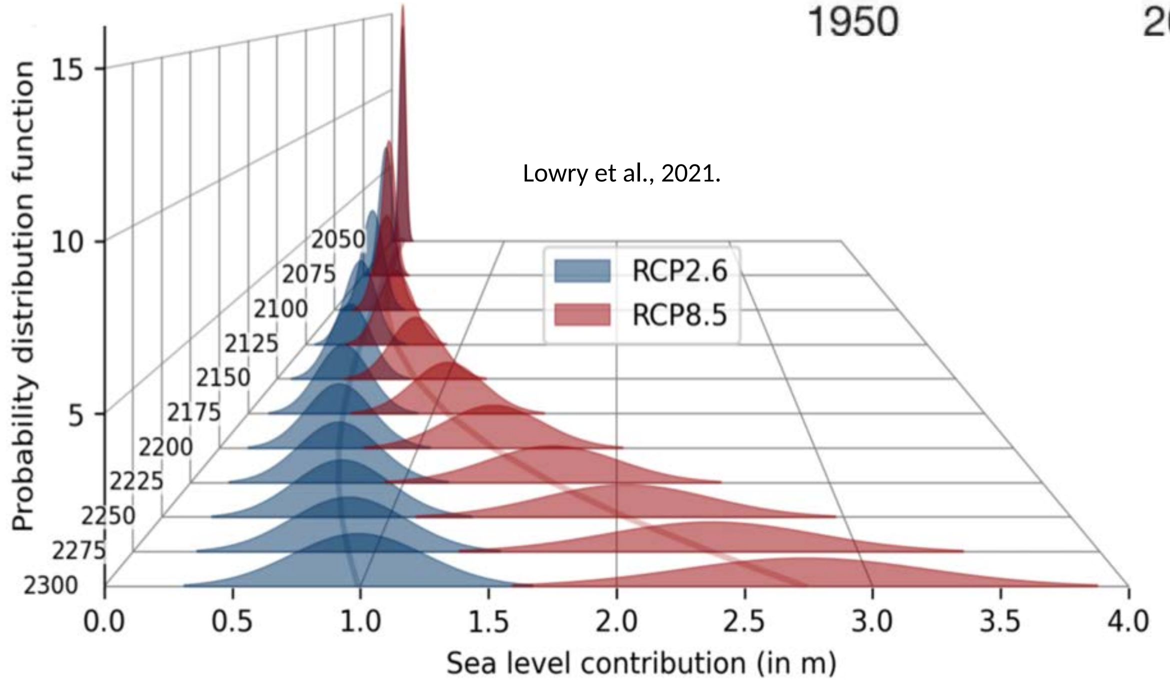
Processes missing from models

Antarctic ice sheet uncertainty

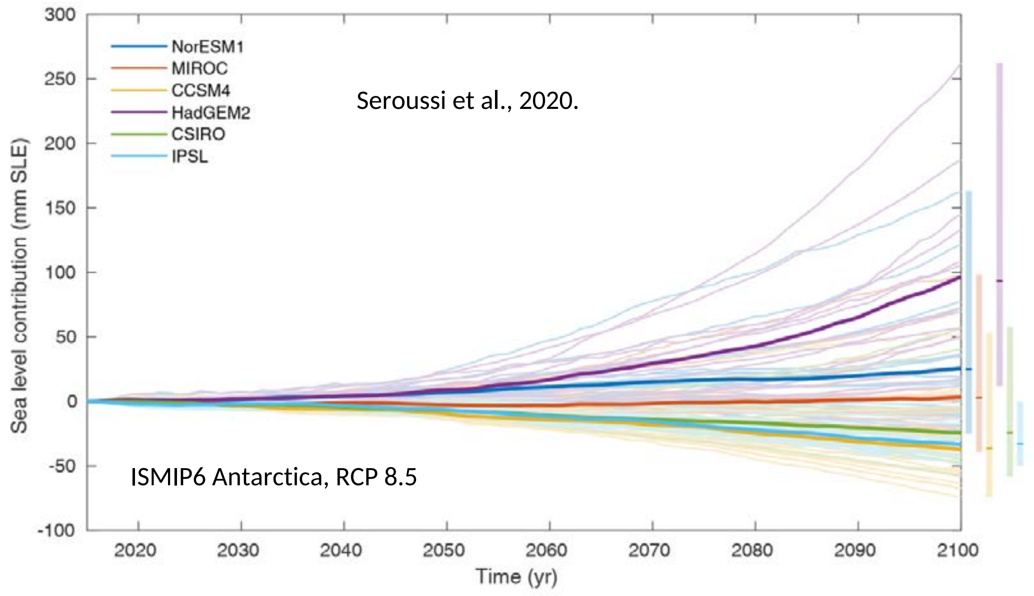
- interaction with ocean
- response to atmos. forcing



Fox-Kemper et al., 2021.



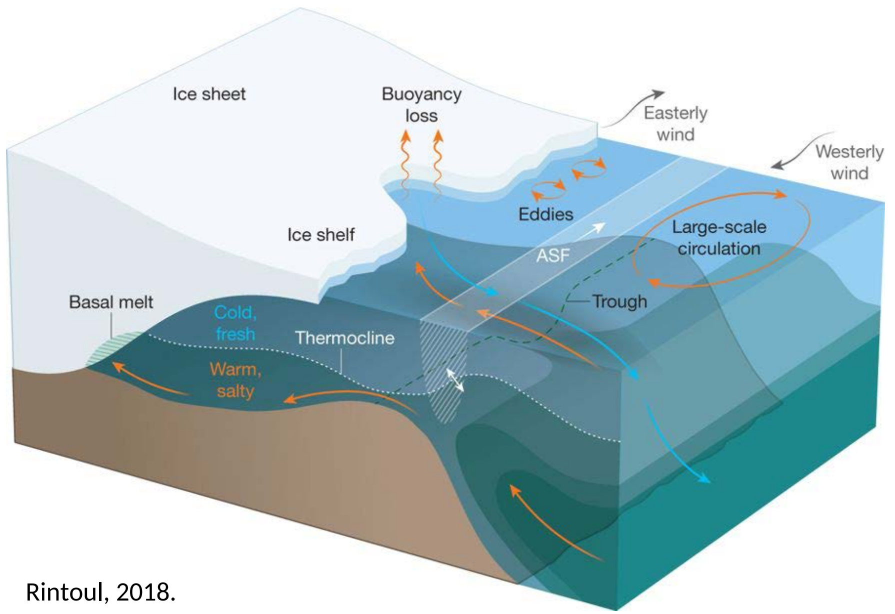
Lowry et al., 2021.



Seroussi et al., 2020.

ISMIP6 Antarctica, RCP 8.5

Ice sheet - ocean interactions



Rintoul, 2018.

PA4231 MENVIEL ET AL.: CLIMATE RESPONSE TO ANTARCTIC MELTWATER

Menviel et al., 2010.

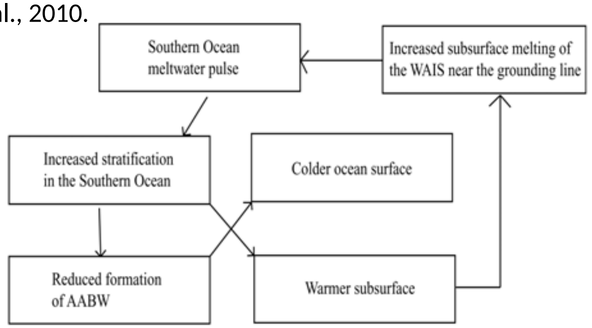
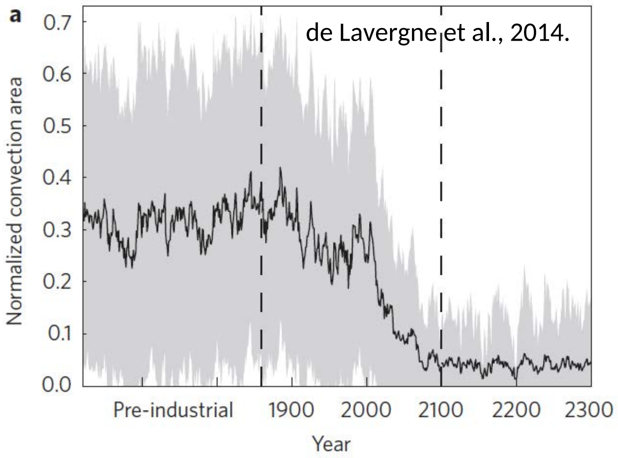


Figure 6. Schematic representation of the positive feedback involved in subsurface temperature increase and ice sheet melting.



de Lavergne et al., 2014.

LETTER

doi:10.1038/nature20582

Centennial-scale Holocene climate variations amplified by Antarctic Ice Sheet discharge

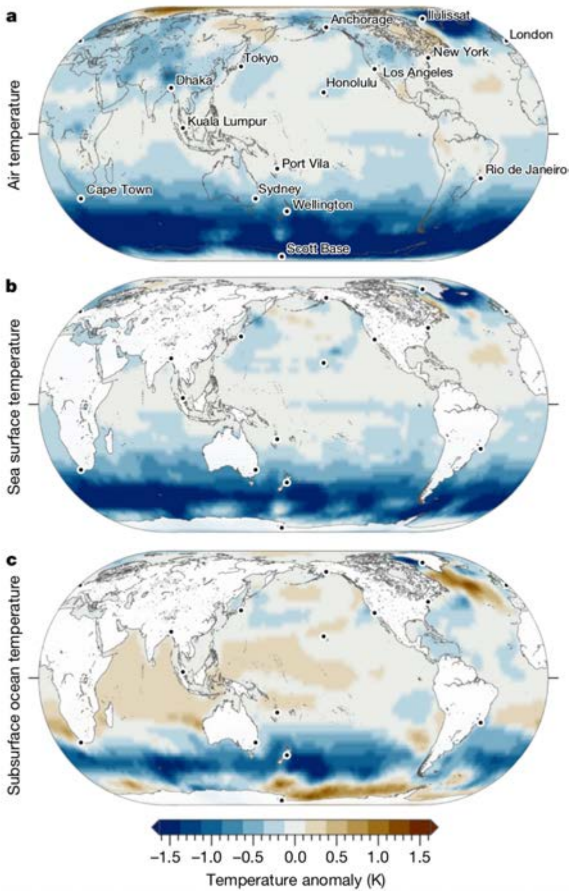
Pepijn Bakker[1]†, Peter U. Clark[1], Nicholas R. Golledge[2,3], Andreas Schmittner[1] & Michael E. Weber[4,5]

ARTICLE

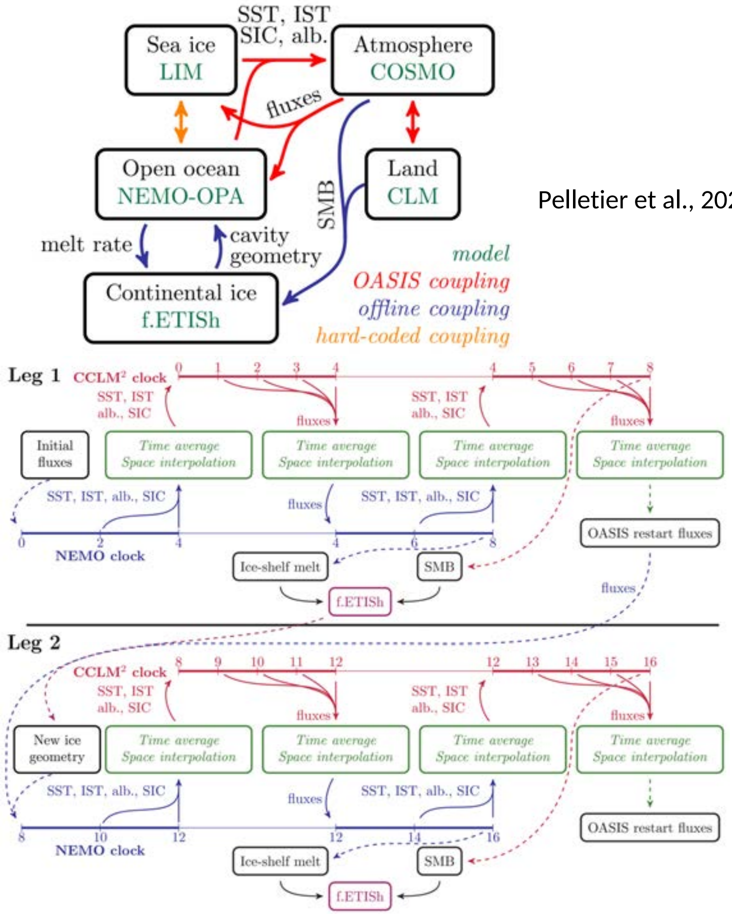
https://doi.org/10.1038/s41586-019-0889-9

Global environmental consequences of twenty-first-century ice-sheet melt

Nicholas R. Golledge[1,2]*, Elizabeth D. Keller[2], Natalya Gomez[3], Kaitlin A. Naughten[4], Jorge Bernales[5], Luke D. Trusel[6] & Tamsin L. Edwards[7]



Golledge et al., 2019.



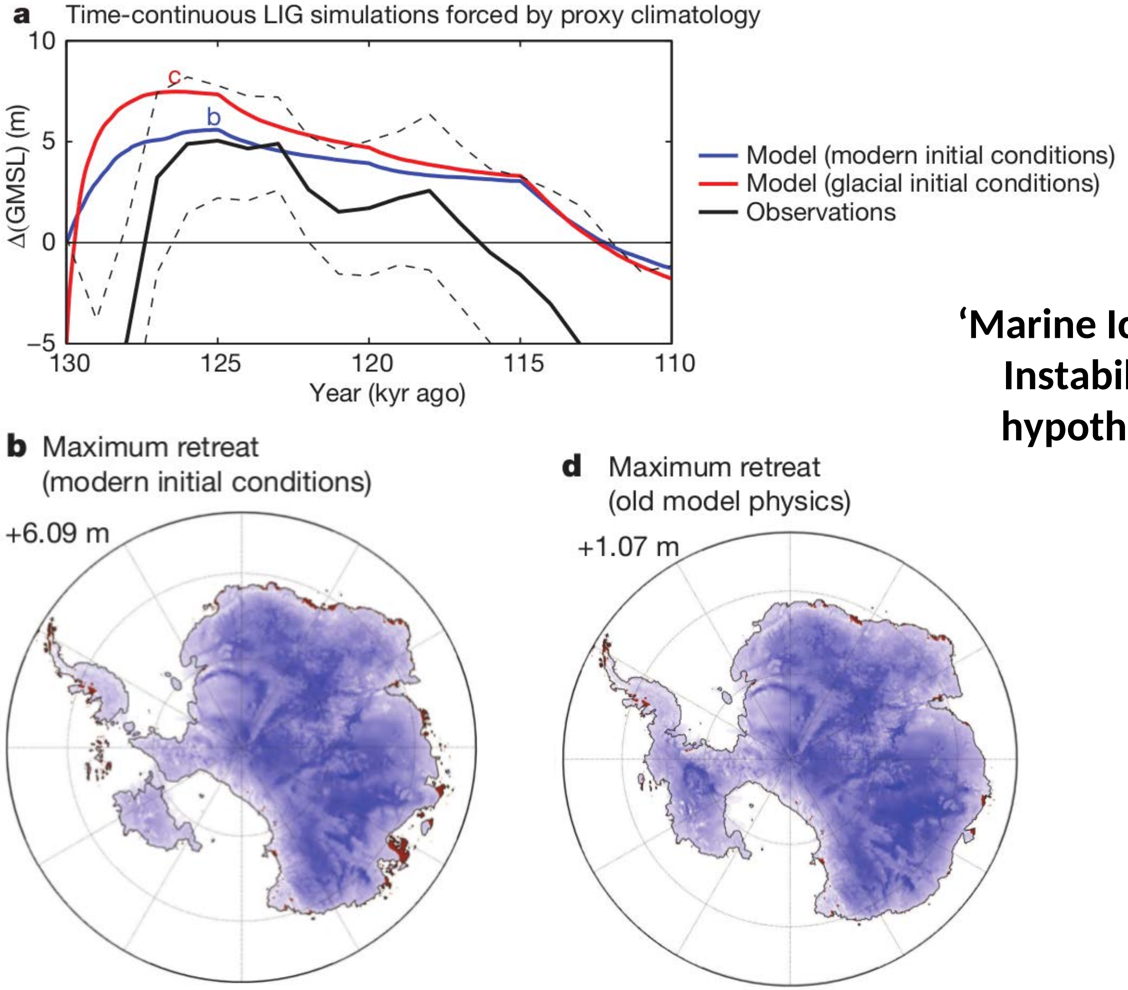
Pelletier et al., 2022.

ARTICLE

doi:10.1038/nature17145

Contribution of Antarctica to past and future sea-level rise

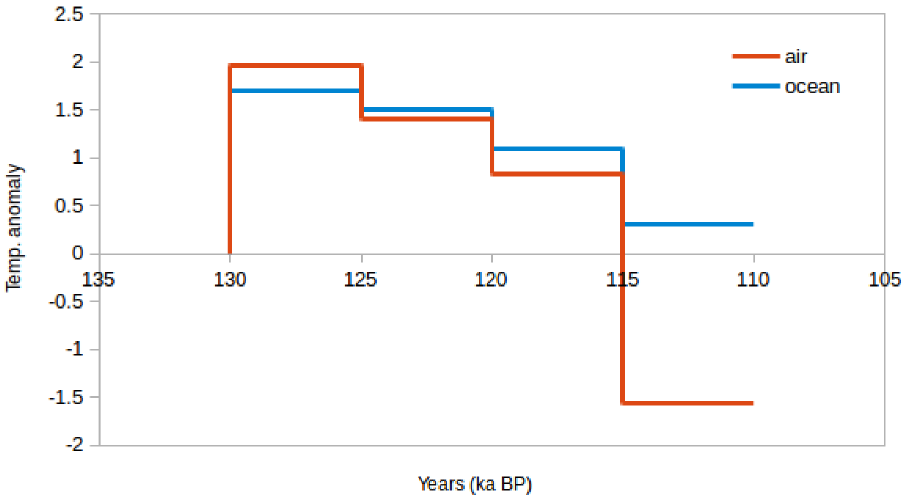
Robert M. DeConto[1] & David Pollard[2]



'Marine Ice Cliff Instability' hypothesis

Atmosphere - ice sheet interactions

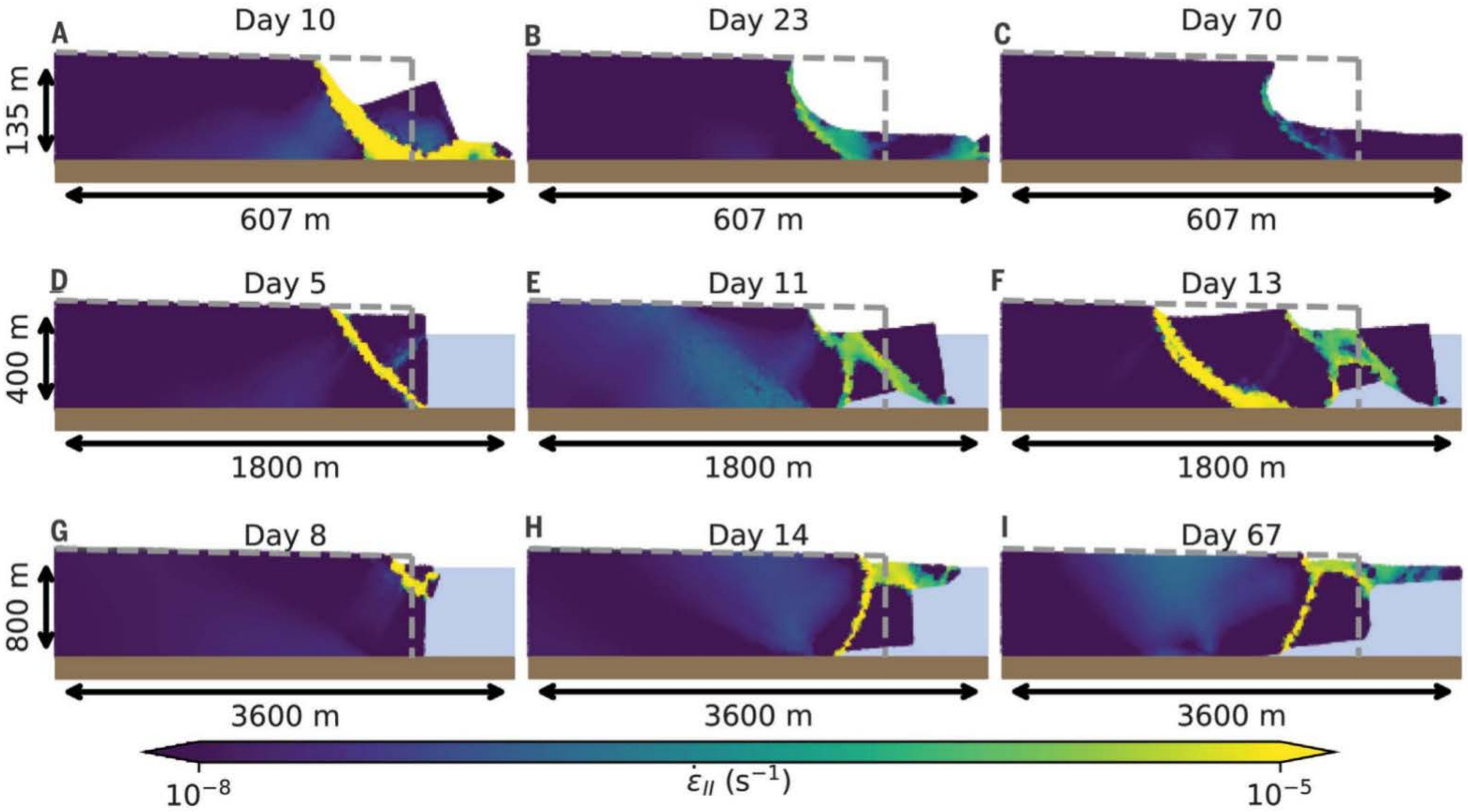
"Summer air temperatures in the RCM … remain below freezing … with ***little to no surface melt***. As a result, substantial oceanic warming … is required to initiate WAIS retreat"



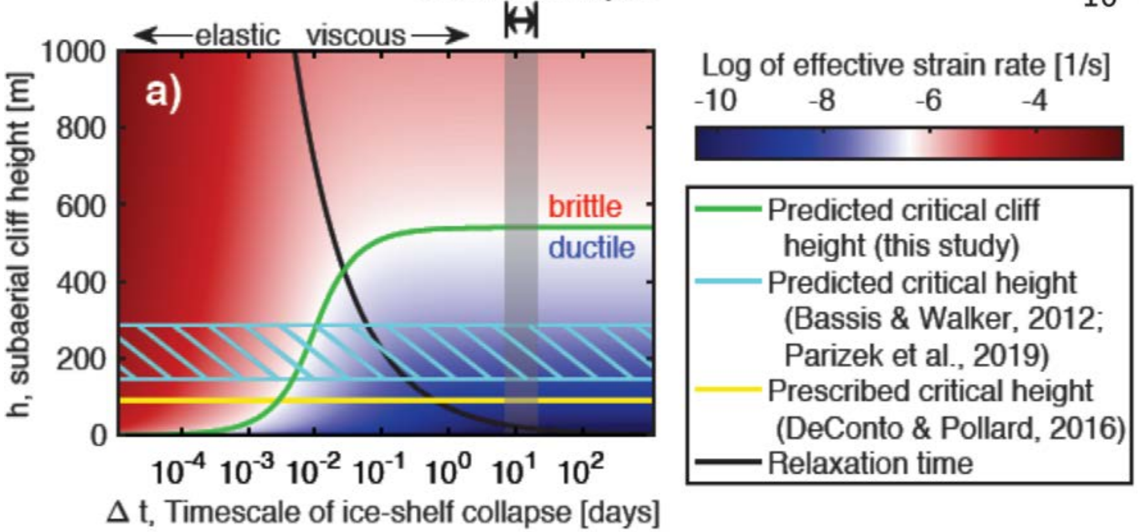
"Antarctic contributions to … LIG sea level are in much better agreement with geological estimates than previous versions of our model, which ***lacked these new treatments of meltwater-enhanced calving and ice-margin dynamics***, suggesting that the new model is better suited to simulations of future ice response"

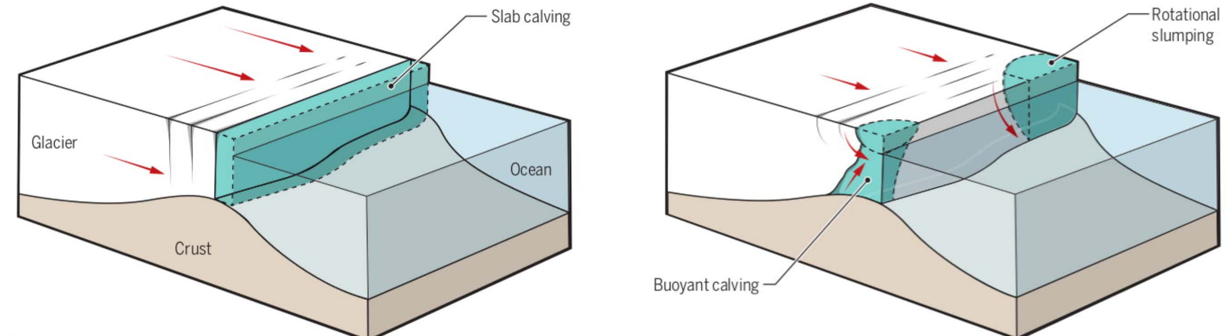
Ice shelf hydrofracture & cliff collapse

Bassis et al., 2021



Clerc et al., 2019





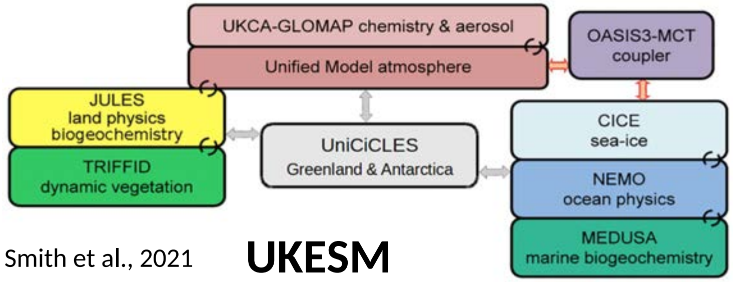
Standard model
Standard ice cliff modeling assumes no vertical difference in the internal stress. This leads to failure at a critical height above the ocean surface as a result of tensile stresses. The whole ice column retreats by a time-averaged horizontal wastage rate.

Dual-mode model
Dual-mode modeling simulates differences in the internal stress regime within the vertical ice column. This continually tracks the accumulation of plastic strain during deformation and allows zones of damaged ice to develop, which localize subsequent failure. The failure occurs by slumping, or by slumping and buoyant uplift of submerged blocks if the water is deeper.

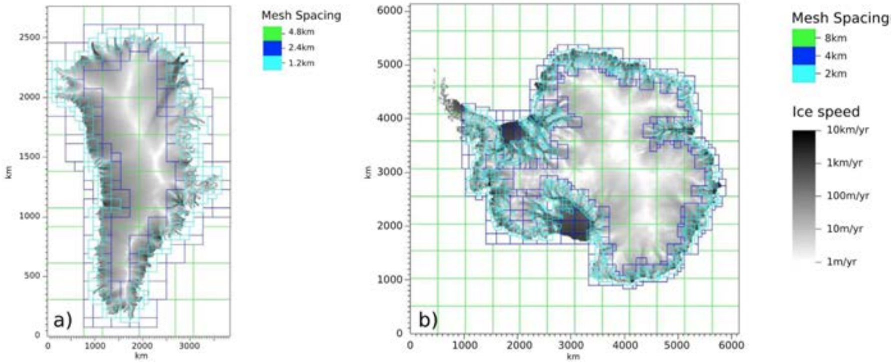
Golledge & Lowry, 2021

Future outlook

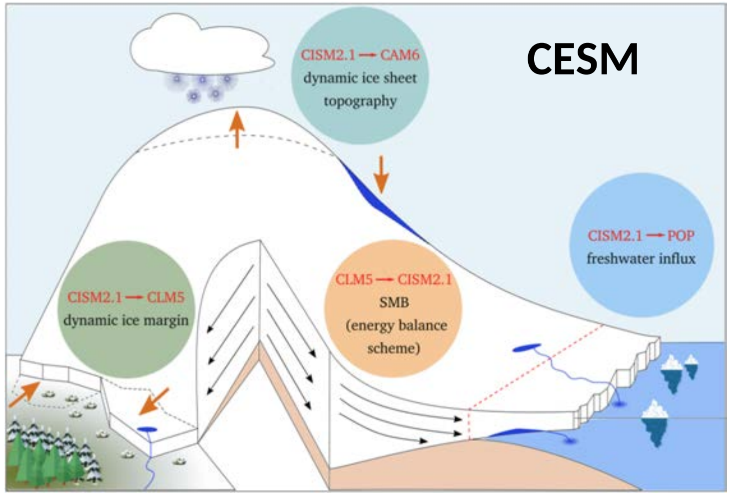
Model coupling, physics & resolution:



Smith et al., 2021 **UKESM**



Muntjewerf et al., 2021



Atmos. forcing / MICI:

RESEARCH | REPORTS

ICE SHEETS

Transition to marine ice cliff instability controlled by ice thickness gradients and velocity

J. N. Bassis[1]*, B. Berg[1,2], A. J. Crawford[3], D. I. Benn[3]

ARTICLE

https://doi.org/10.1038/s41586-019-0901-4

Revisiting Antarctic ice loss due to marine ice-cliff instability

Tamsin L. Edwards[1]*, Mark A. Brandon[2], Gael Durand[3], Neil R. Edwards[2], Nicholas R. Golledge[4,5], Philip B. Holden[2], Isabel J. Nias[6], Antony J. Payne[7], Catherine Ritz[3] & Andreas Wernecke[2]

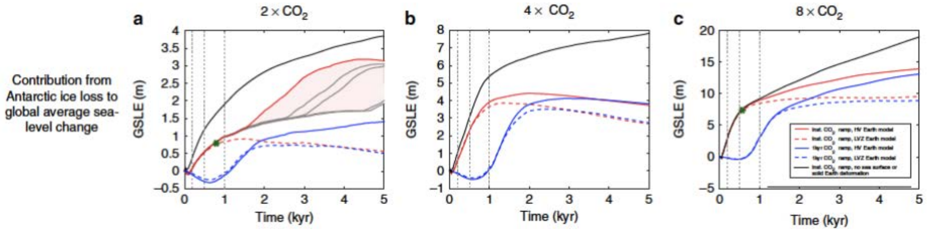
Rotational / gravitational feedback:

ARTICLE

Received 2 Jun 2015 | Accepted 6 Oct 2015 | Published 10 Nov 2015 DOI: 10.1038/ncomms9798 OPEN

Sea-level feedback lowers projections of future Antarctic Ice-Sheet mass loss

Natalya Gomez[1,2], David Pollard[3] & David Holland[1]



Ice-ocean feedback:

ARTICLE

https://doi.org/10.1038/s41586-018-0712-z

Change in future climate due to Antarctic meltwater

Ben Bronselaer[1,2,3]*, Michael Winton[2], Stephen M. Griffies[2,3], William J. Hurlin[2], Keith B. Rodgers[3], Olga V. Sergienko[2,3], Ronald J. Stouffer[1,2] & Joellen L. Russell[1]