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# Modelling past ice sheet changes to improve climate projections: the 8.2 kyr abrupt cooling event

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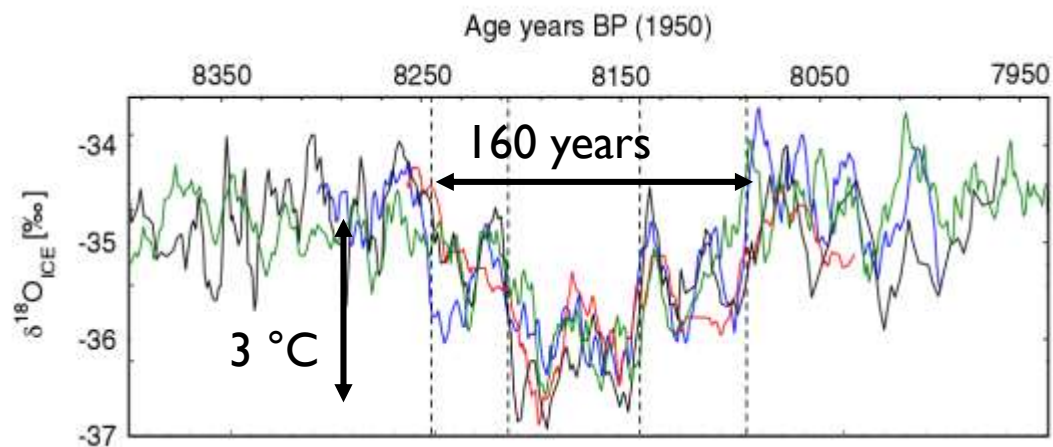
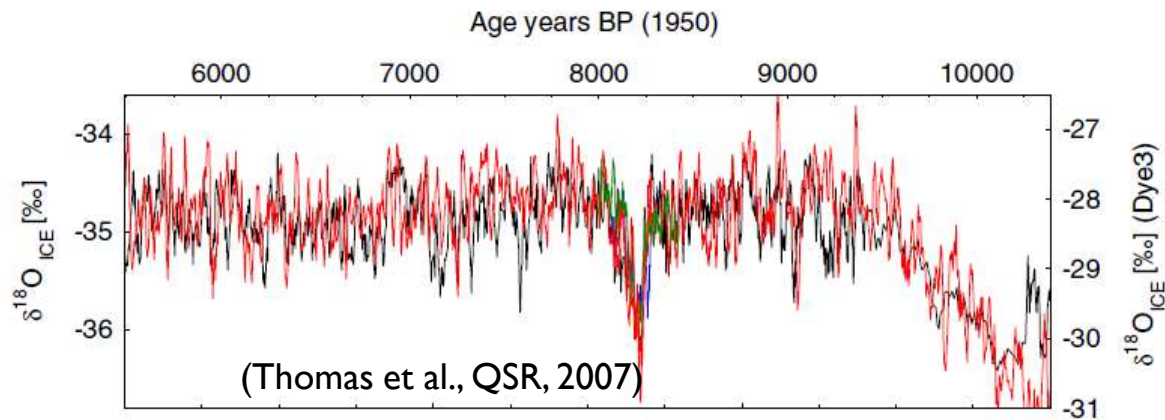
UK Research  
and Innovation

# The 8.2 kyr cooling event

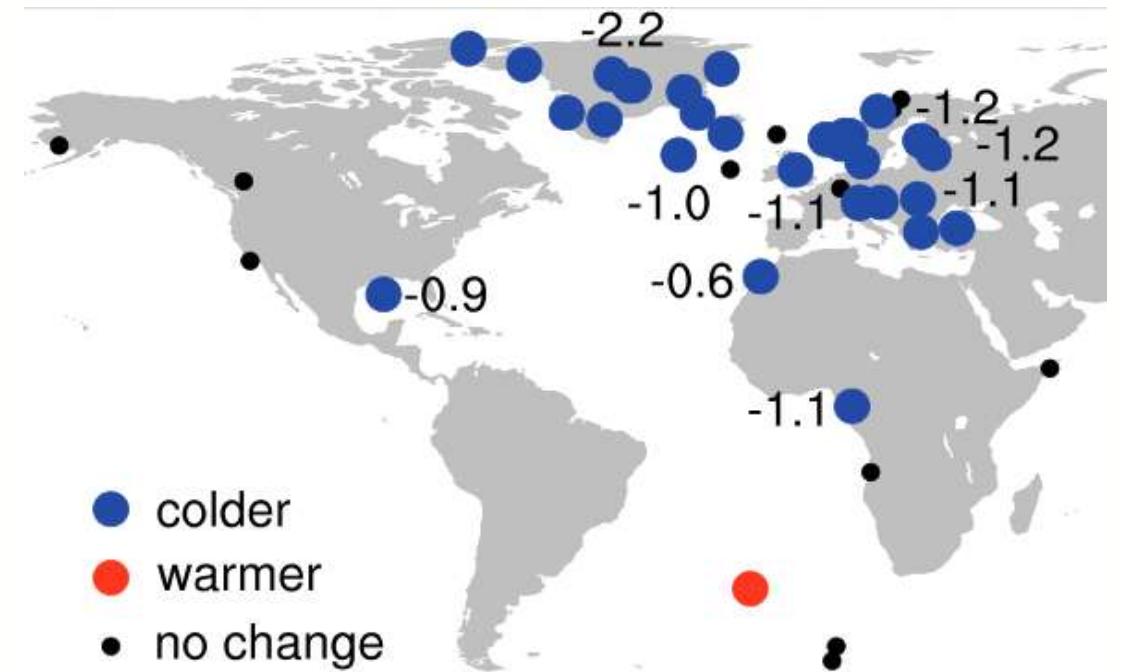


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## Greenland ice cores



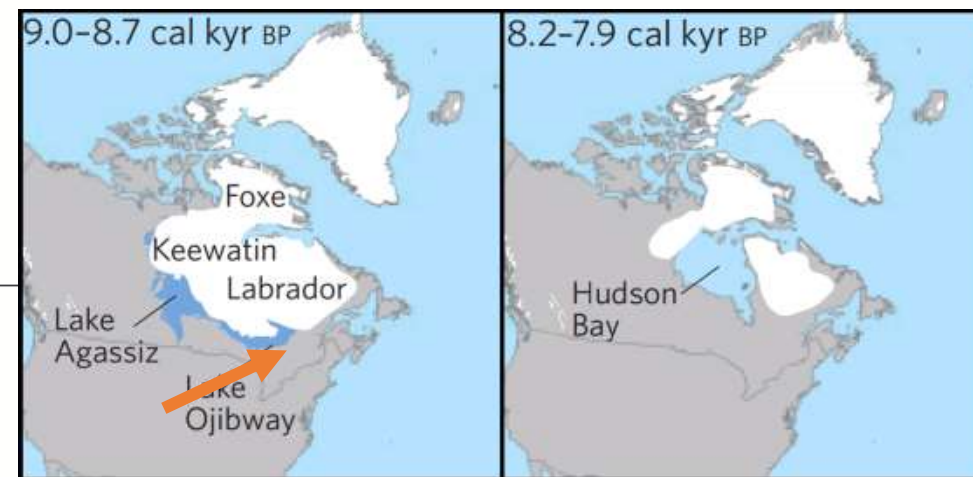
## Northern Hemisphere cooling



Morrill et al. Clim. Past (2012)

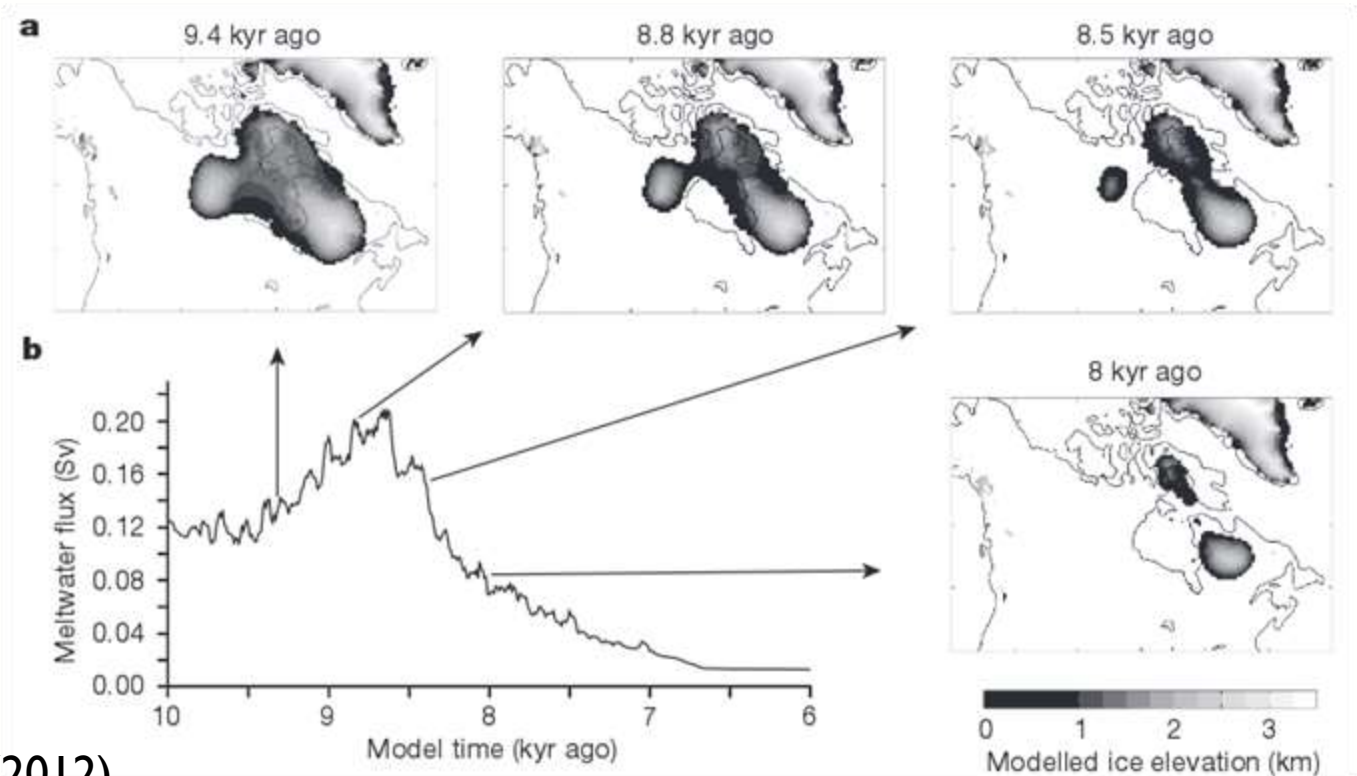
# Cause of the 8.2 kyr event ?

- Traditional hypothesis:  
Outburst of Lake Agassiz and Ojibway (<2years), possibly multiple events



# Cause of the 8.2 kyr event ?

- Traditional hypothesis:  
Outburst of Lake Agassiz and Ojibway (<2years), possibly multiple events
- Newer hypothesis:  
Hudson Bay Ice Saddle Collapse causing century-scale acceleration of meltwater flux (Gregoire et al. 2012 ; Matero et al. 2017)

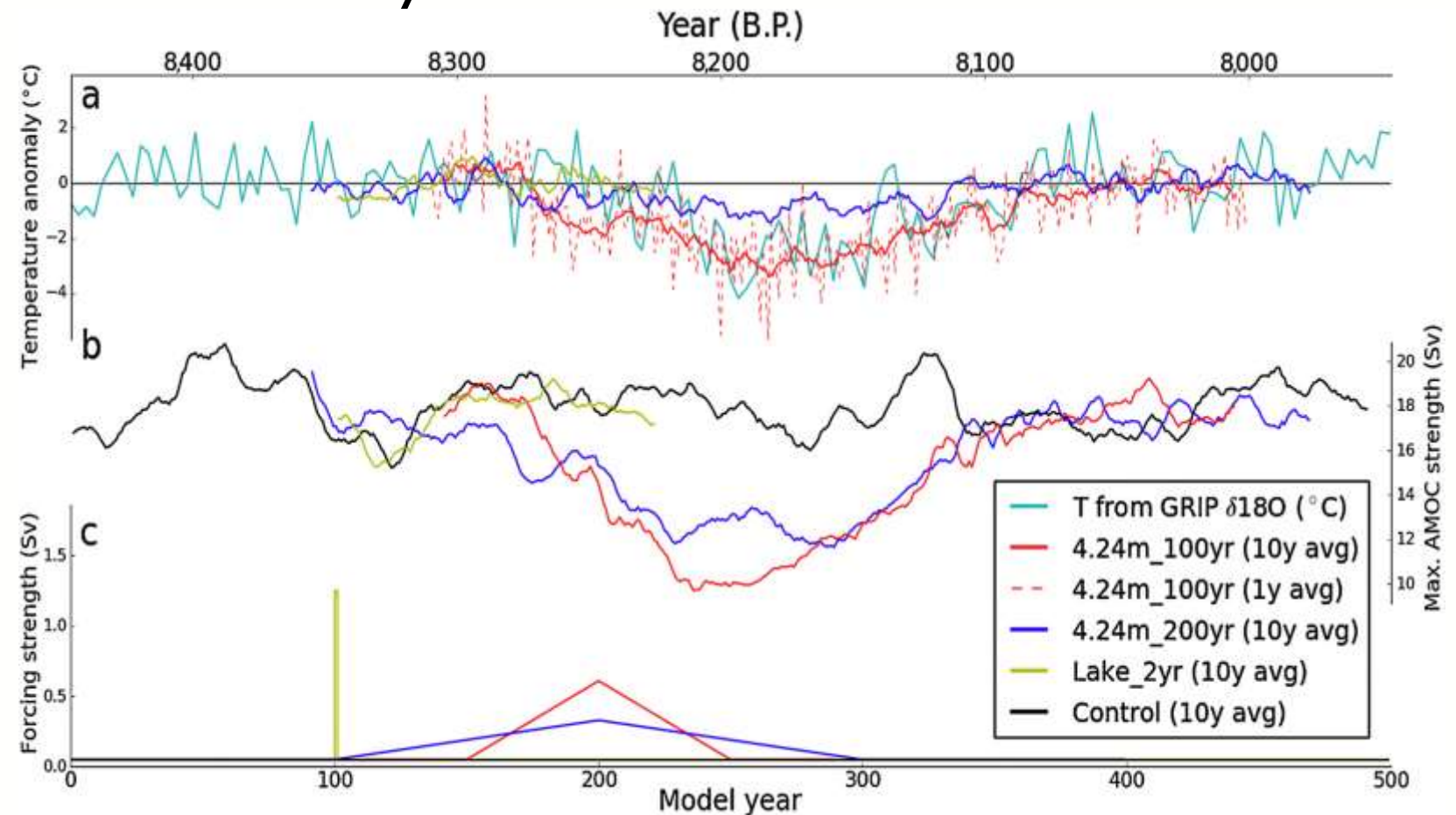


# Climatic effect of Hudson Bay Ice Saddle collapse



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- Acceleration of ice melt: ~4 m in 100 yrs
- Matches the duration, pattern and magnitude of cooling observed
- Lake release cooling too short



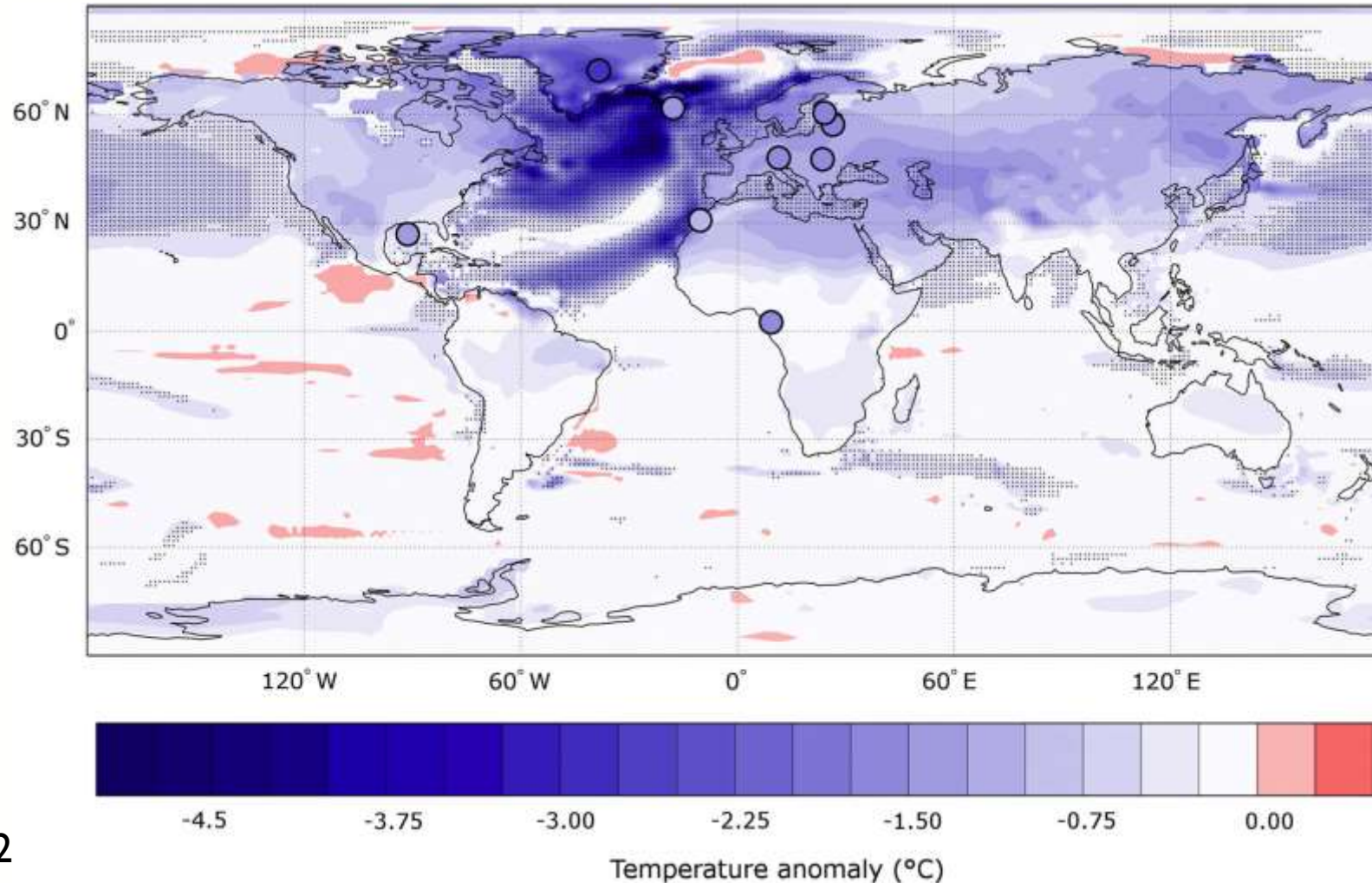
Matero et al. EPSL (2017)



# Climatic effect of Hudson Bay Ice Saddle collapse



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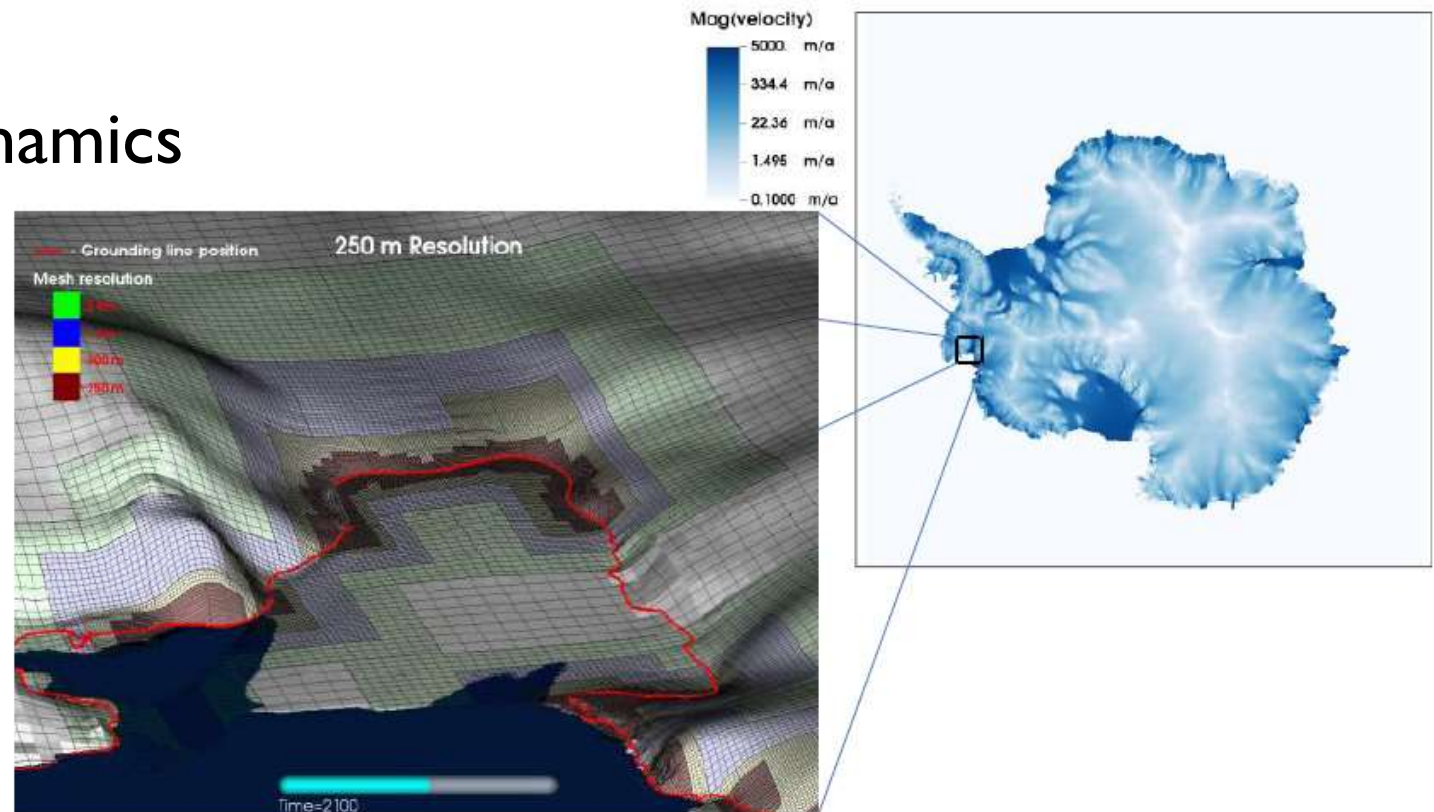


# Simulating the ice sheet evolution



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- BISICLES 3D ice sheet model with Adaptive Mesh Refinement
  - Accurate and efficient
  - Simulates marine ice sheet dynamics





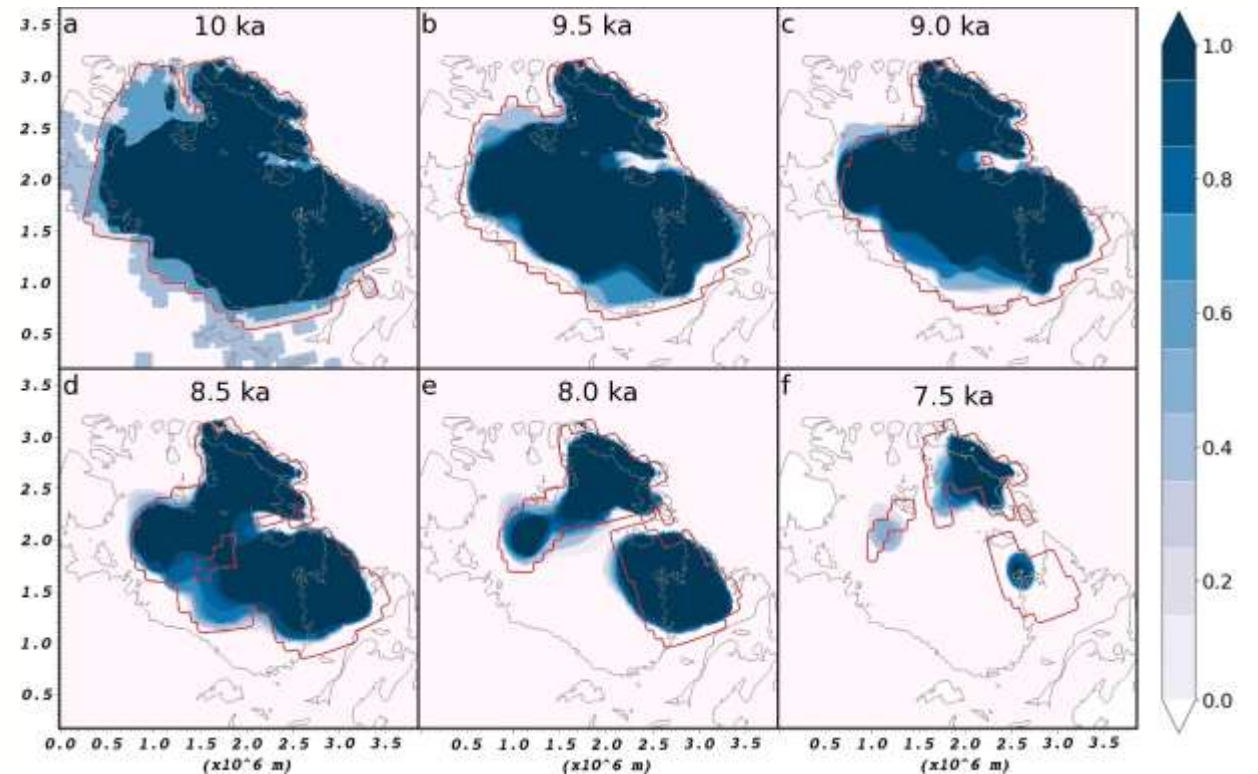


# Realistic simulations



- Ensemble of 60 simulations from 10 – 7 ka
- Uncertain inputs varied:
  - Precipitation
  - Melt parameters
  - Ice flow parameters
  - Initial conditions
- Selected simulations that match evolution of ice extent (e.g. Dyke, 2004 ...).

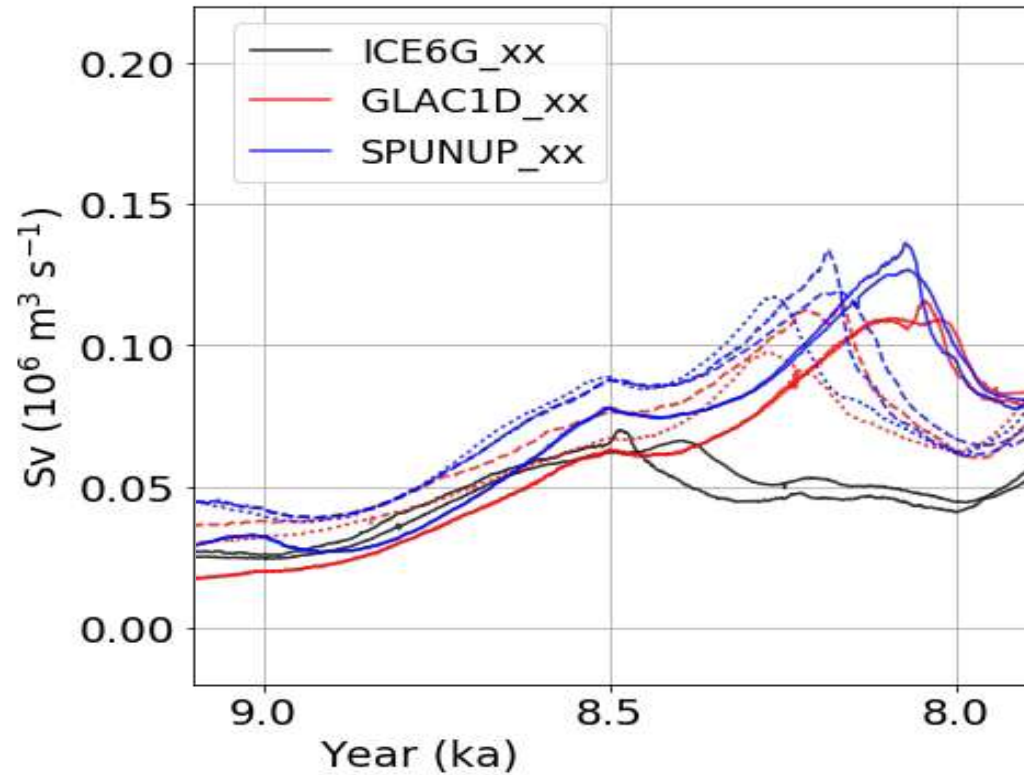
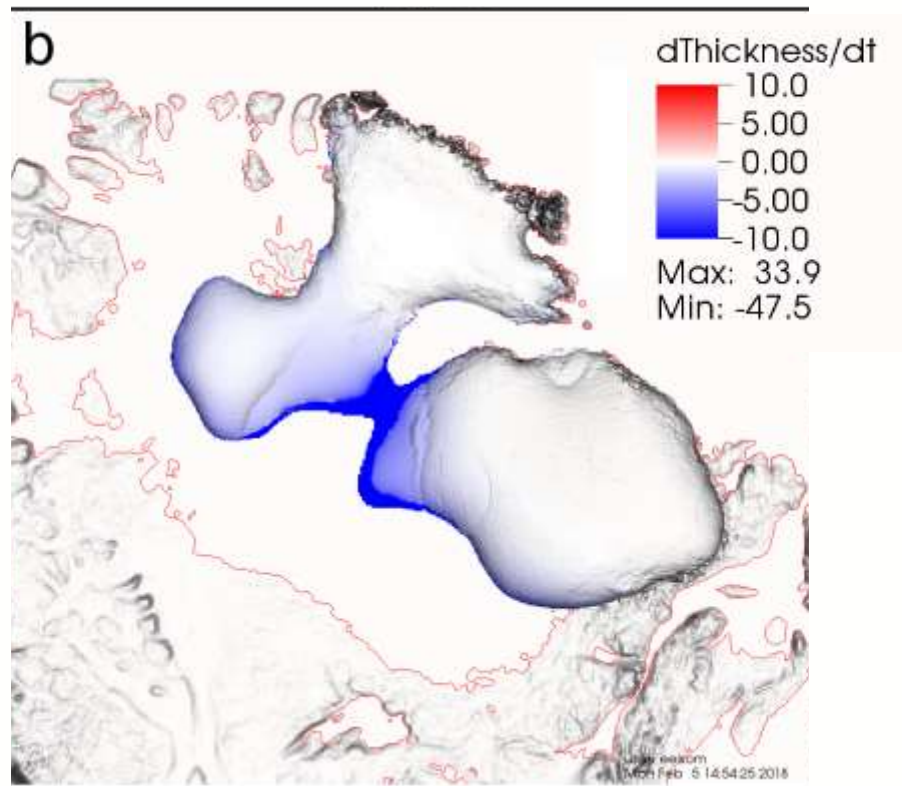
Ice sheet extent (blue) match reconstruction (red line) in 11 simulations



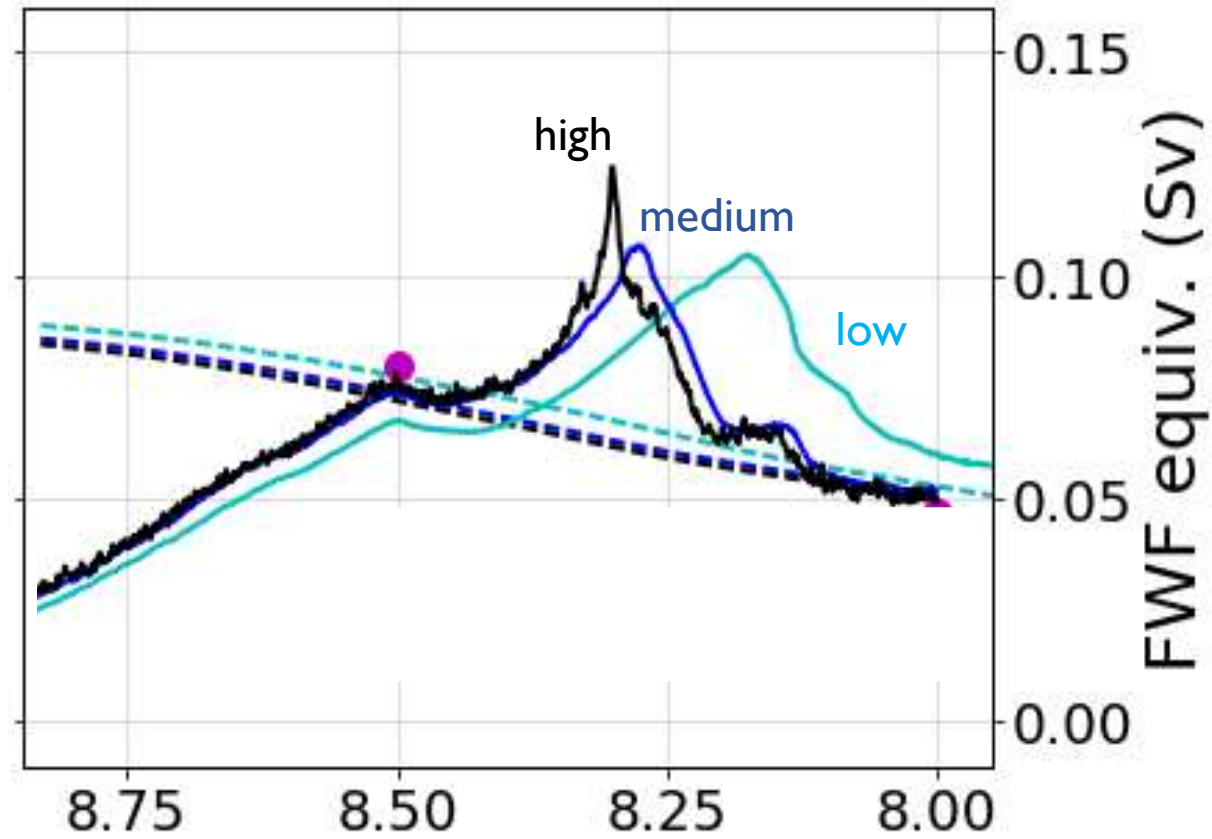
# Hudson Bay Saddle Collapse



Meltwater pulse: 2-3 m sea level rise in 200-400 years



# Effect of sub-shelf melt



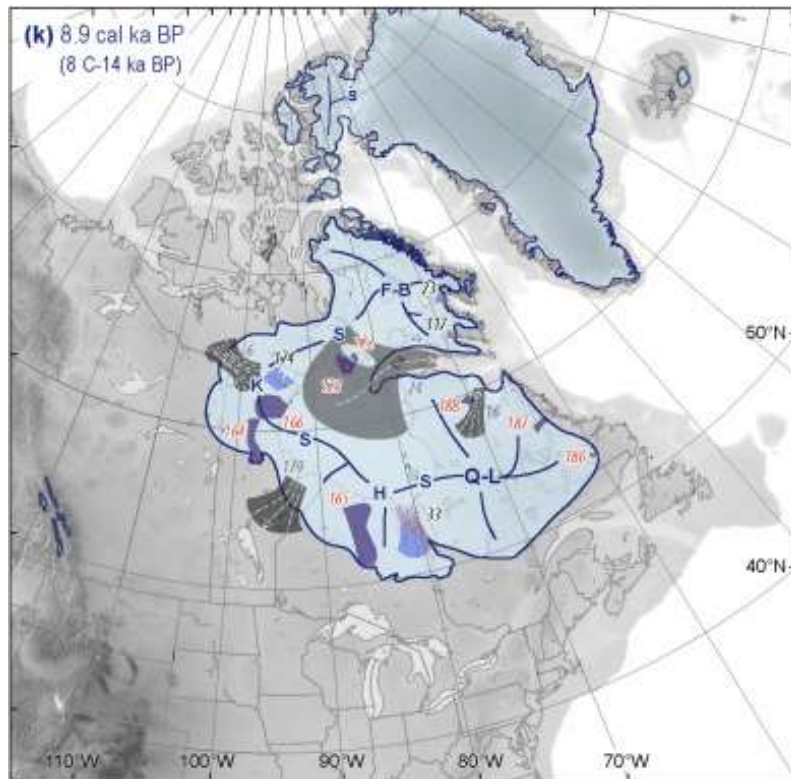


# Role of ice streams ?

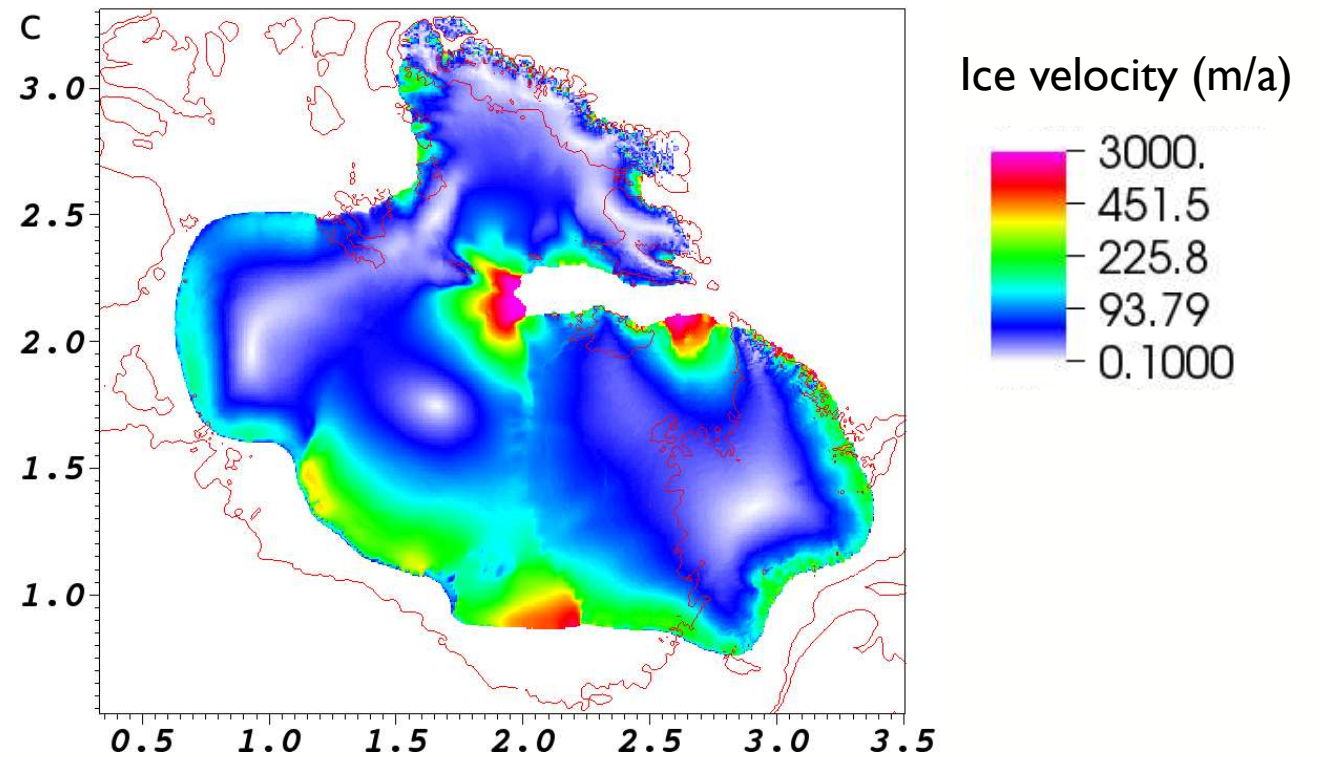


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Reconstruction



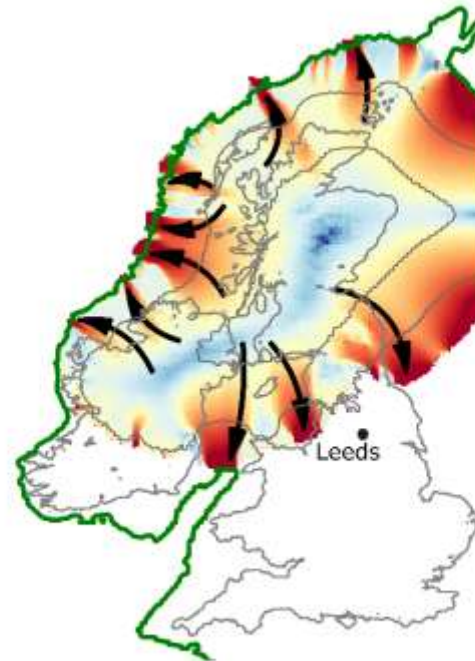
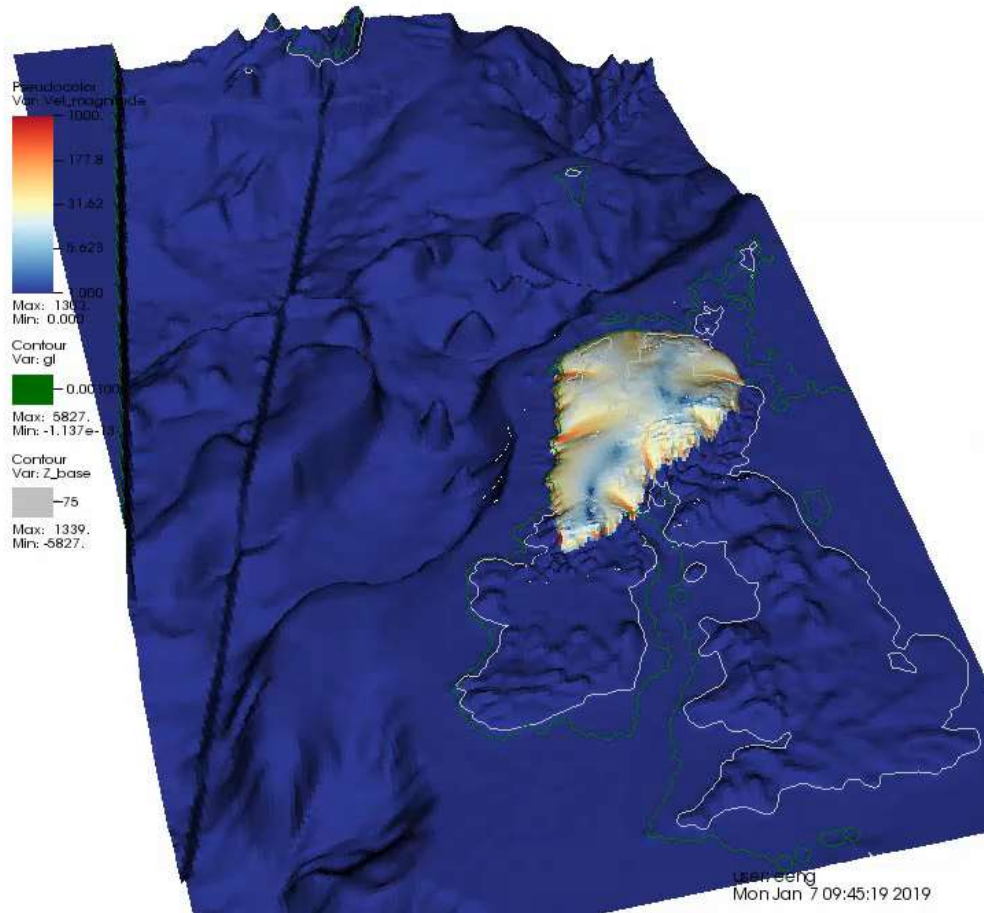
Modelled



Margold et al. 2018

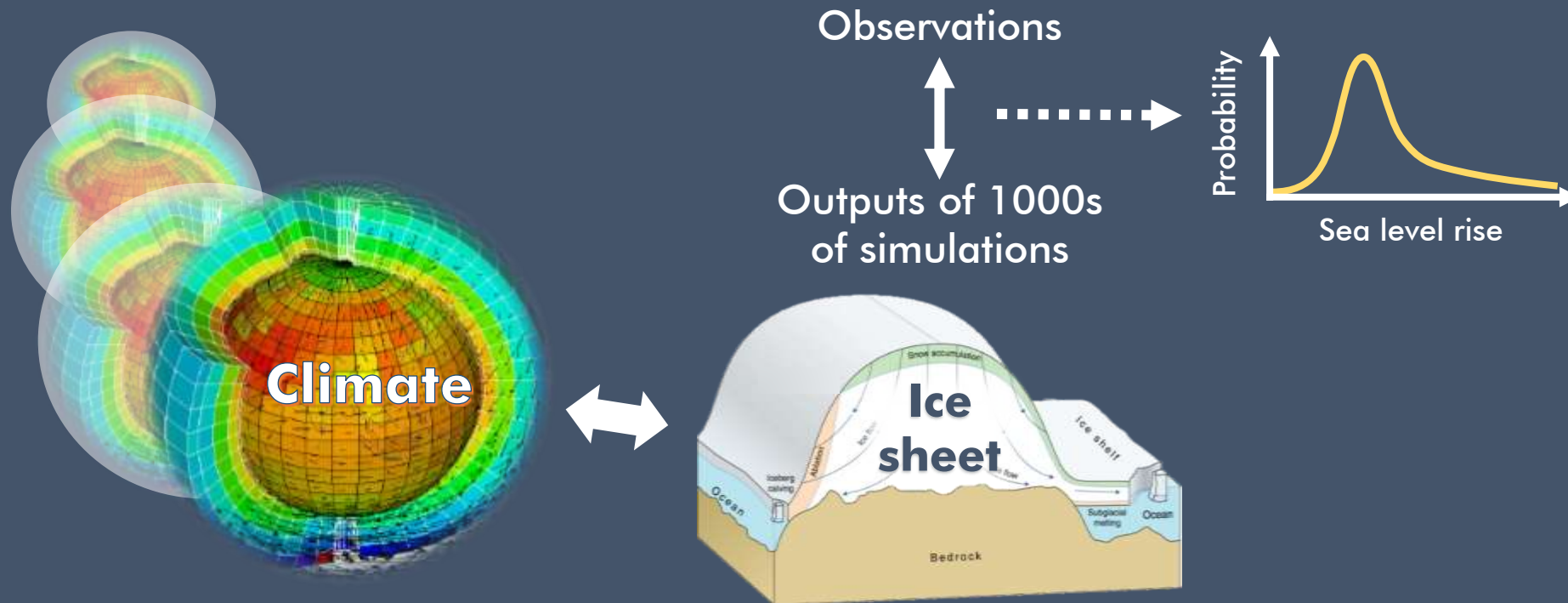


# Modelling Ice Streams



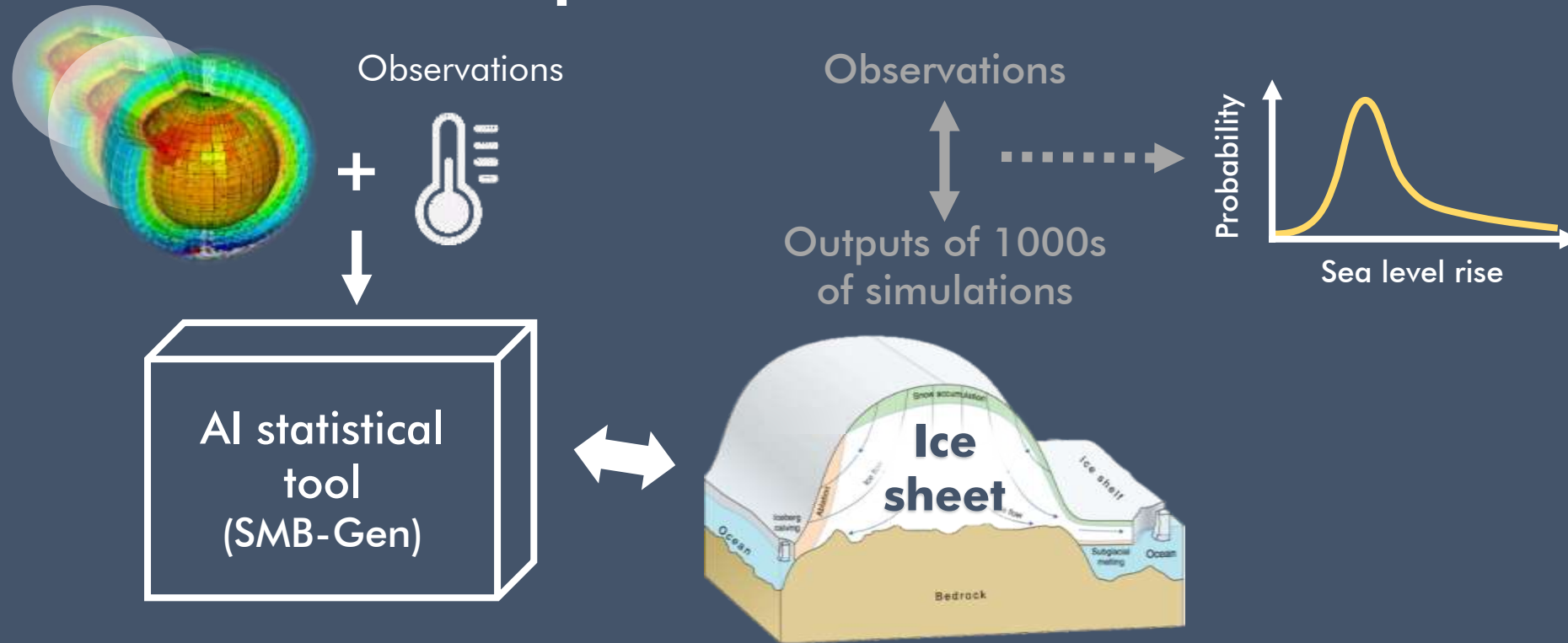
- Incorporated a basal sliding scheme in BISICLES
- Coulomb sliding in warm based areas.
- Good match to geological evidence of past ice stream positions/direction (Gandy et al., QSR, 2019)

# The Challenge: Tackling climate uncertainty



- Climate is the largest source of uncertainty
- Billions of numbers to generate
- Requires new Artificial Intelligence techniques

# Future plans: New AI tools



- Novel Artificial intelligence tool (Bayesian uncertainty quantification)
- Combine climate models and observations to generate plausible past/future climates and ice surface mass balance.

# Conclusions



- Hudson Bay Saddle collapse can explain the 8.2 kyr cooling event.
- Simulation of Laurentide ice sheet with latest generation ice sheet model
  - Unprecedented match to reconstruction of ice extent.
  - Saddle collapse produces 2-3 m sea level rise in 200-400 years.
  - This mostly depends on surface mass balance.
  - Meltwater pulse is smaller than is needed by HadCM3 to produce event.
- Further model developments to evaluate the role of ice sheet dynamics in the Hudson Bay Saddle collapse.
- Future Leaders Fellowship to develop a surface mass balance emulator.