
Extreme Ice Survey

GLACIER MELTING

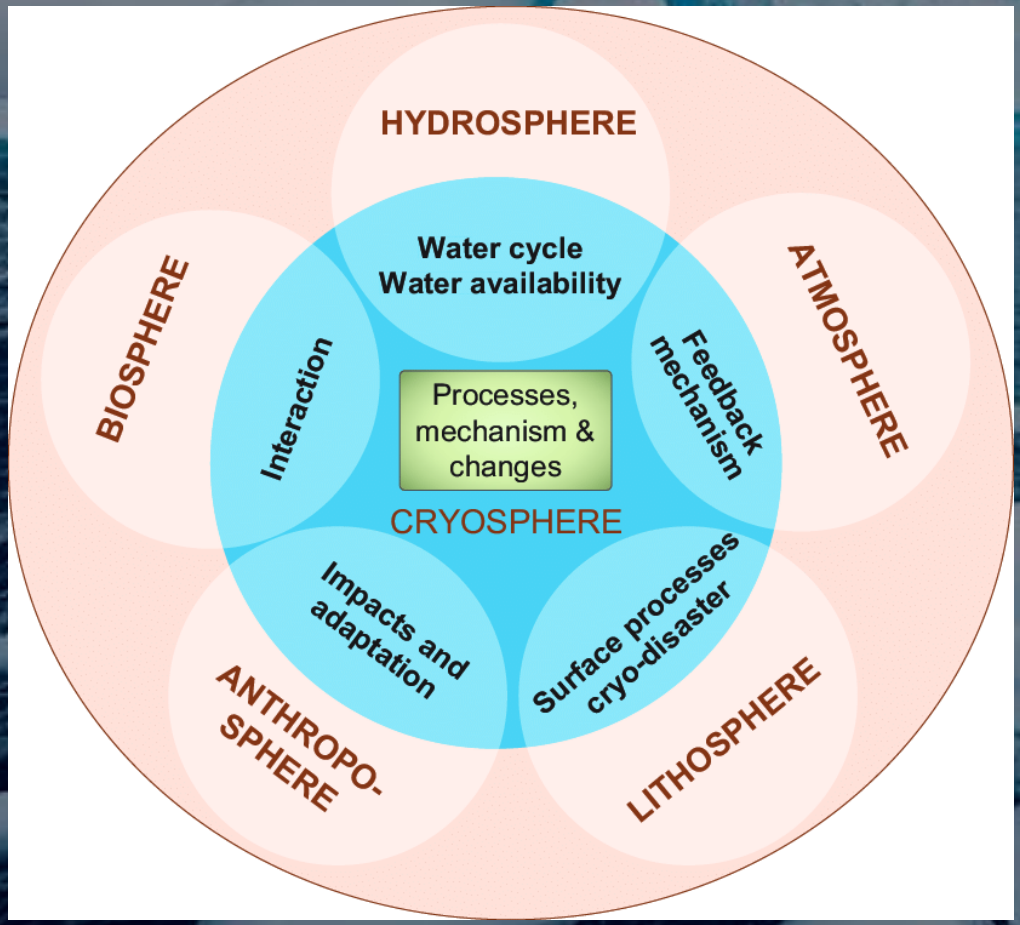
Seminar: A3: Natural Risks and Hazards

Emmanuel Adeleke
Global Change Ecology M.Sc.
University of Bayreuth
95447 Bayreuth
Germany

Outline

- Cryosphere
  - Glaciers and global distributions
  - Other compartments
- Glacier melting
  - Concept & phenomenon
  - Physical mechanisms
- Causes of glacier melting
  - Natural & Anthropogenic forcings
  - Global warming – IPCC projections
  - Feedback mechanisms
- Effects of glacier melting
- Climate-change adaptation strategies for rising sea levels
- Conclusions
- References

The Cryosphere

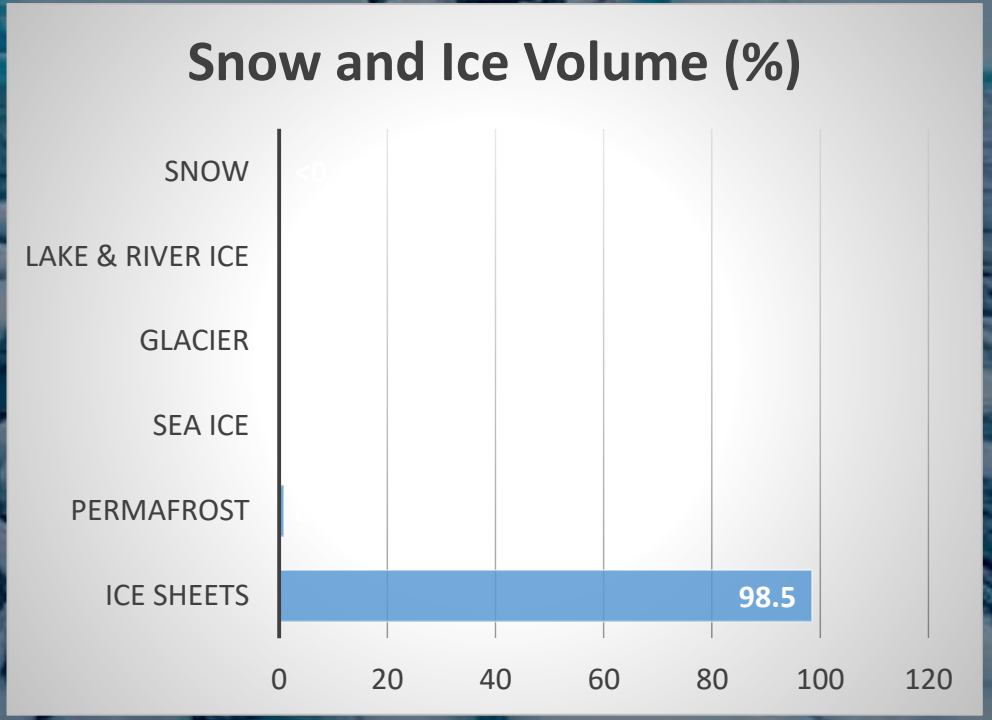


Interactions between the cryosphere and other earth spheres

Qin et al. 2017

Compartments of the Cryosphere

- Seasonal snow
- Mountain glaciers and ice caps
- Ice sheets and shelves
  - largest volume of ice proportion, about 3.3km^3
- Permafrost
- Seasonal frozen ground
  - the largest area, covers over 5.2km^2
- River and lake ice
- Sea ice



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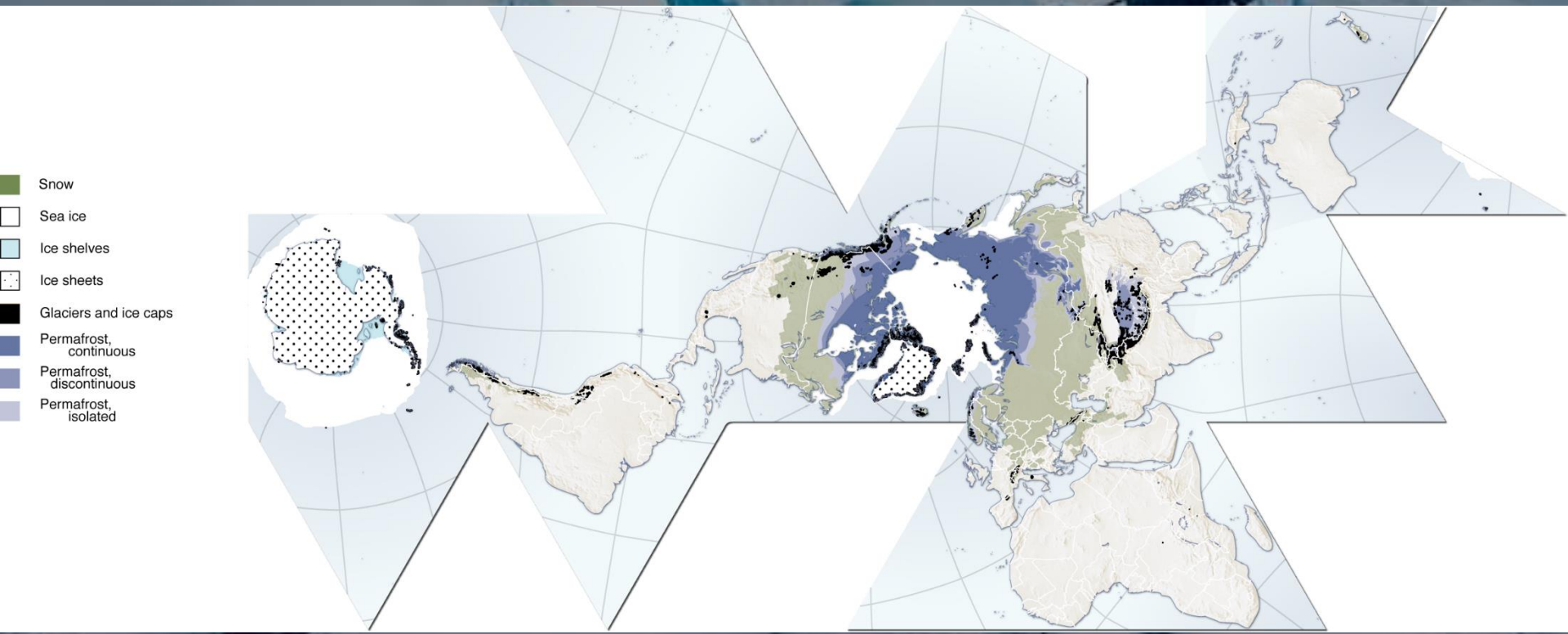

Source: Roger Barry and Thian Yew Gan 2011

GLACIER MELTING

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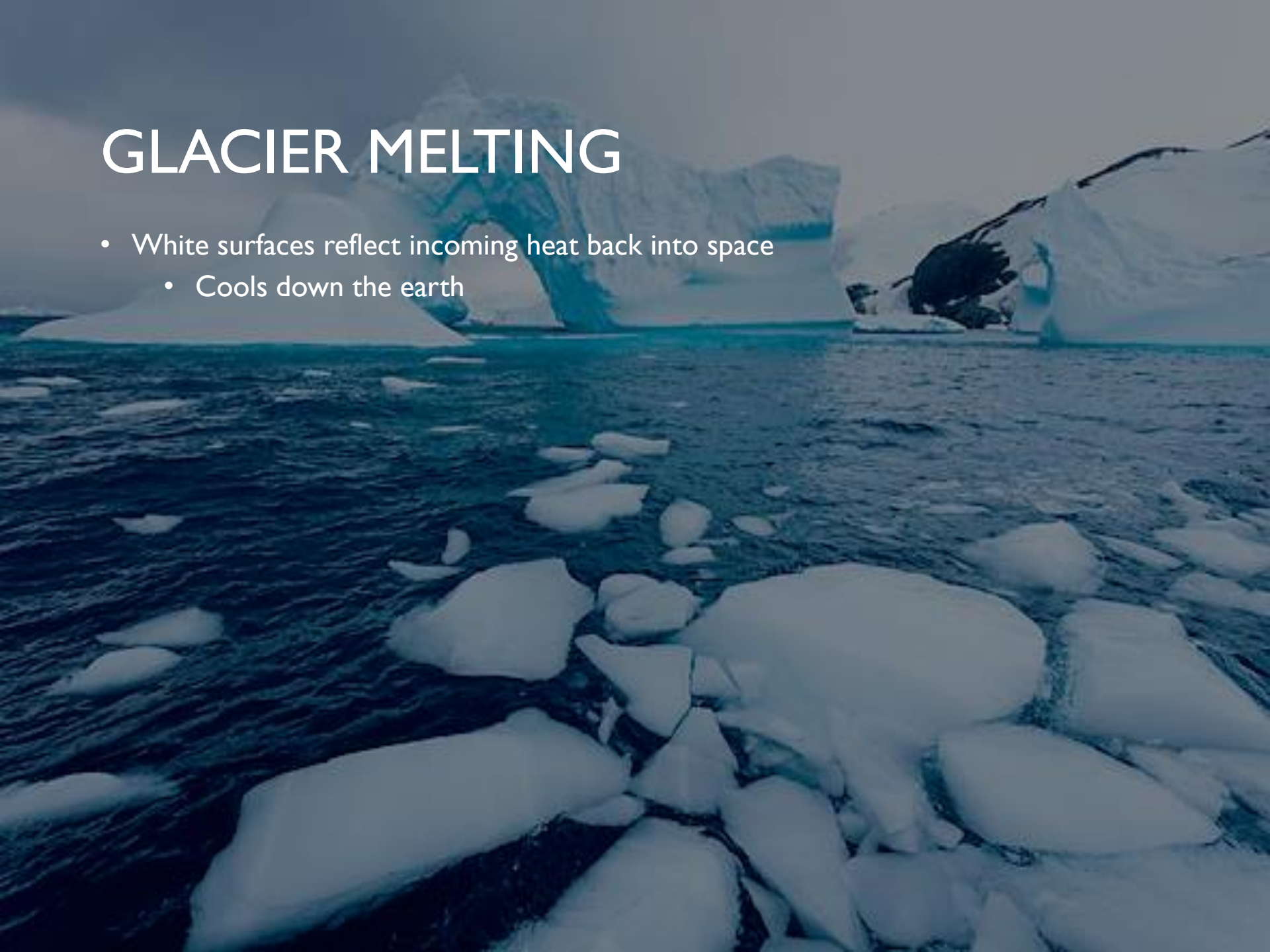

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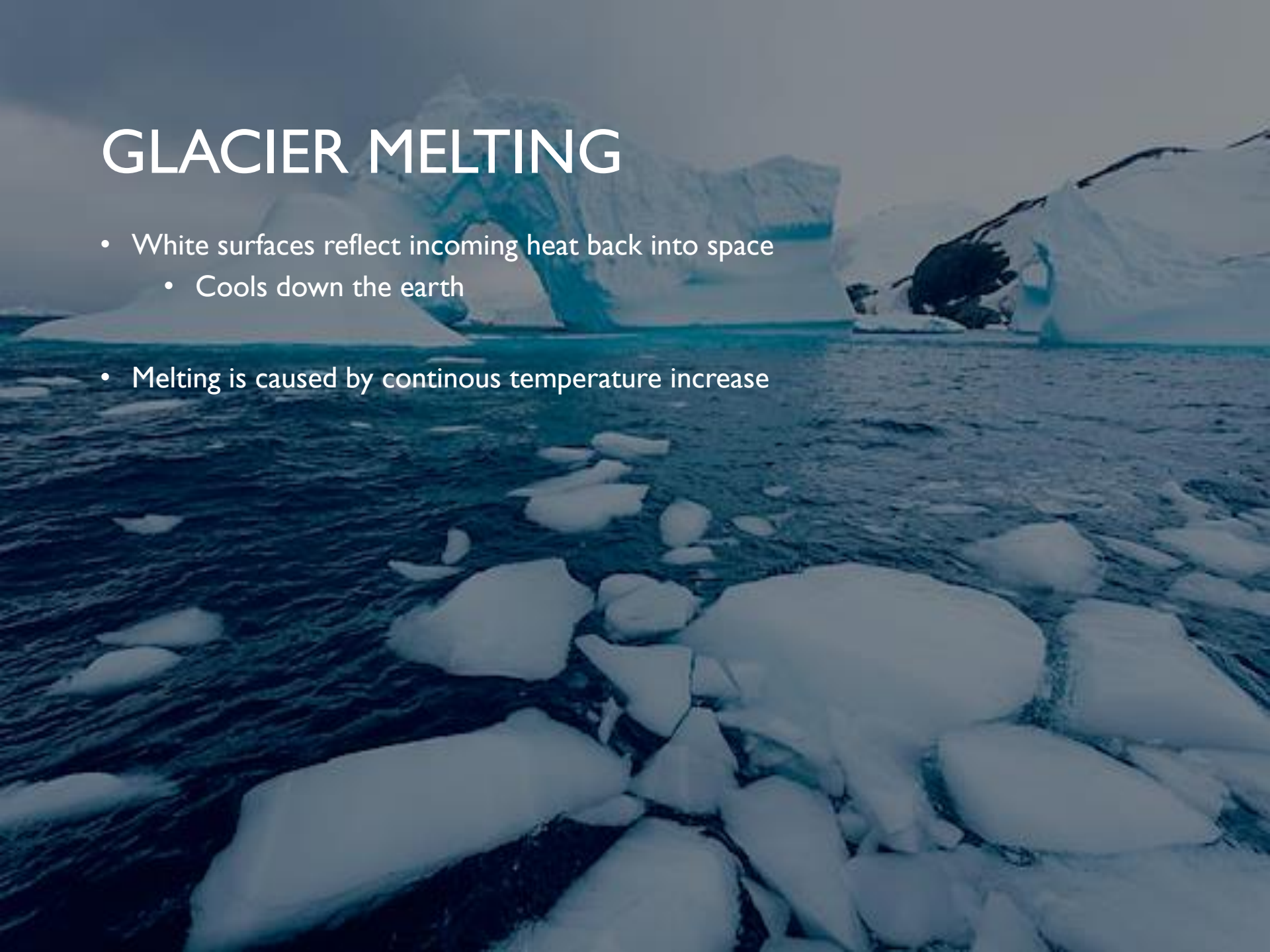

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  - Climate feedbacks
  - Long-term significant changes to ice mass, density and area
  - Thresholds of abrupt change (Tipping point)
  - Irreversibility

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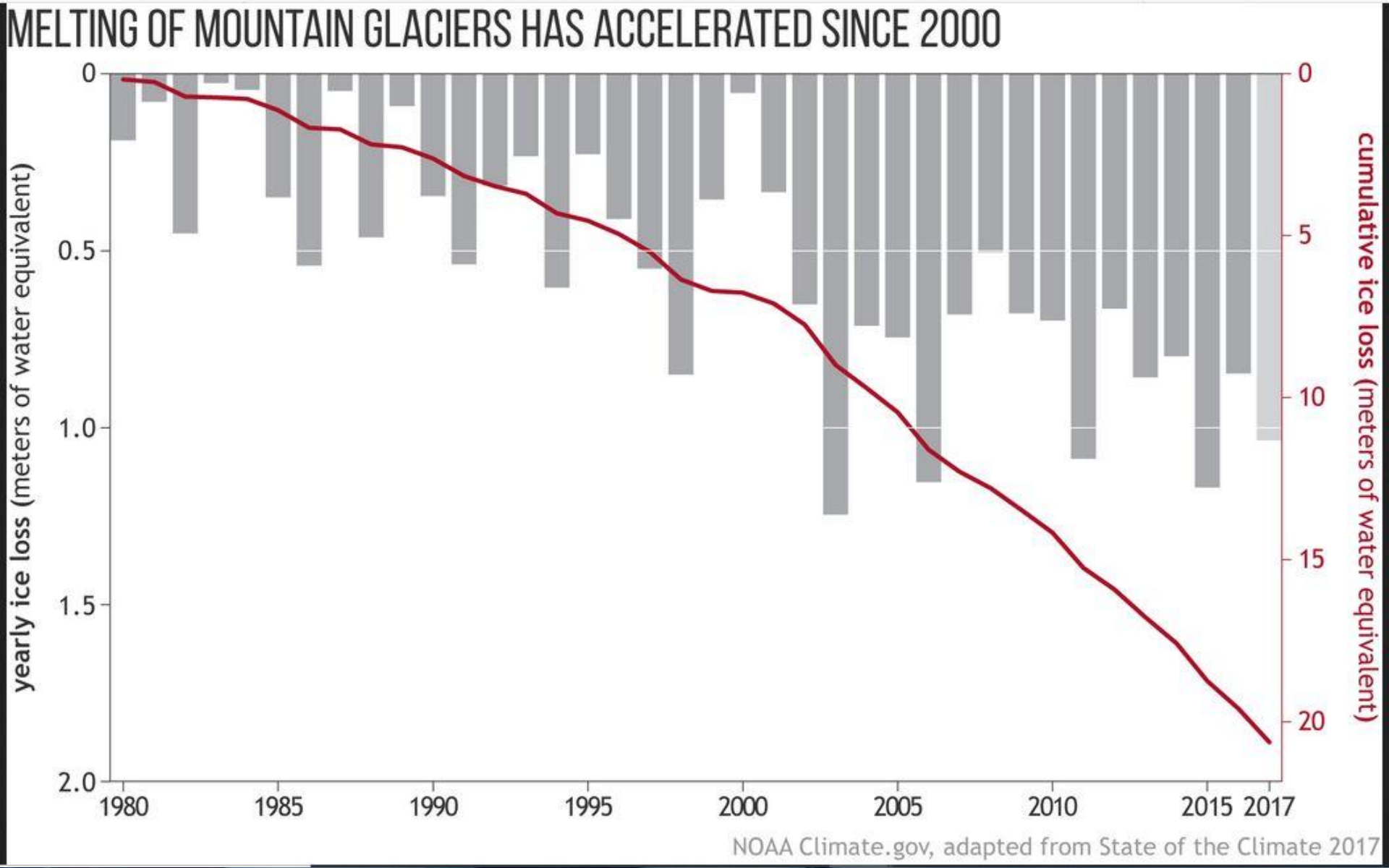
- Physical mechanisms include:
  - Evaporation
  - Sublimation
  - Calving
  - Aeolian processes

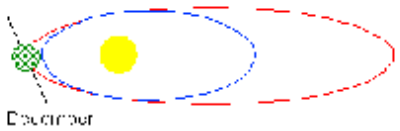

MELTING OF MOUNTAIN GLACIERS HAS ACCELERATED SINCE 2000
yearly ice loss (meters of water equivalent)
0
0.5
1.0
1.5
2.0
cumulative ice loss (meters of water equivalent)
0
5
10
15
20
1980
1985
1990
1995
2000
2005
2010
2015
2017
NOAA Climate.gov, adapted from State of the Climate 2017

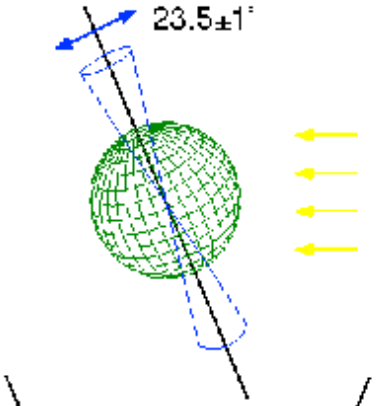
Careser Glacier, Italy

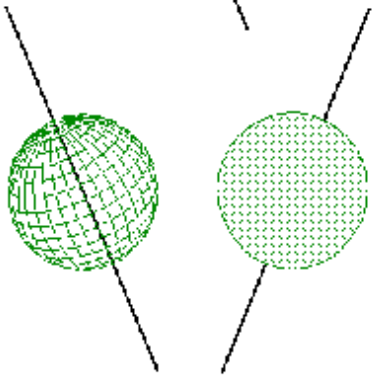
Causes of Glacier melting

- Natural causes
  - Glacial-interglacial cycles
    - Changes in orbital parameters (Milankovitch cycle)
- Anthropogenic causes
  - Global warming
    - Increase in atmospheric GHG
    - Greenhouse effect

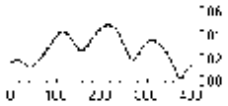
Milankovitch cycles



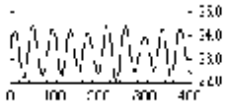




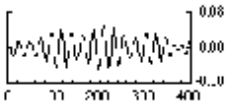
Eccentricity: 100 kyr



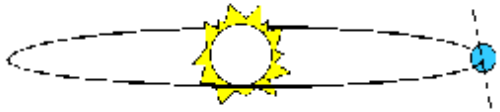
Tilt: 41 kyr



Precession: 23-19 kyr



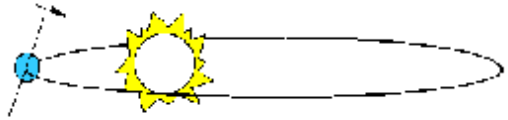
Glacial



Ice Growth Configuration: Low eccentricity
Low tilt
Large Earth-Sun Distance in Summer

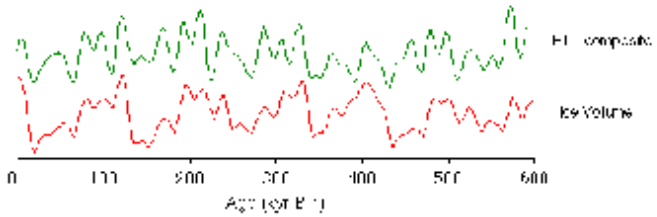
- Net effect: Less seasonal contrast

Interglacial



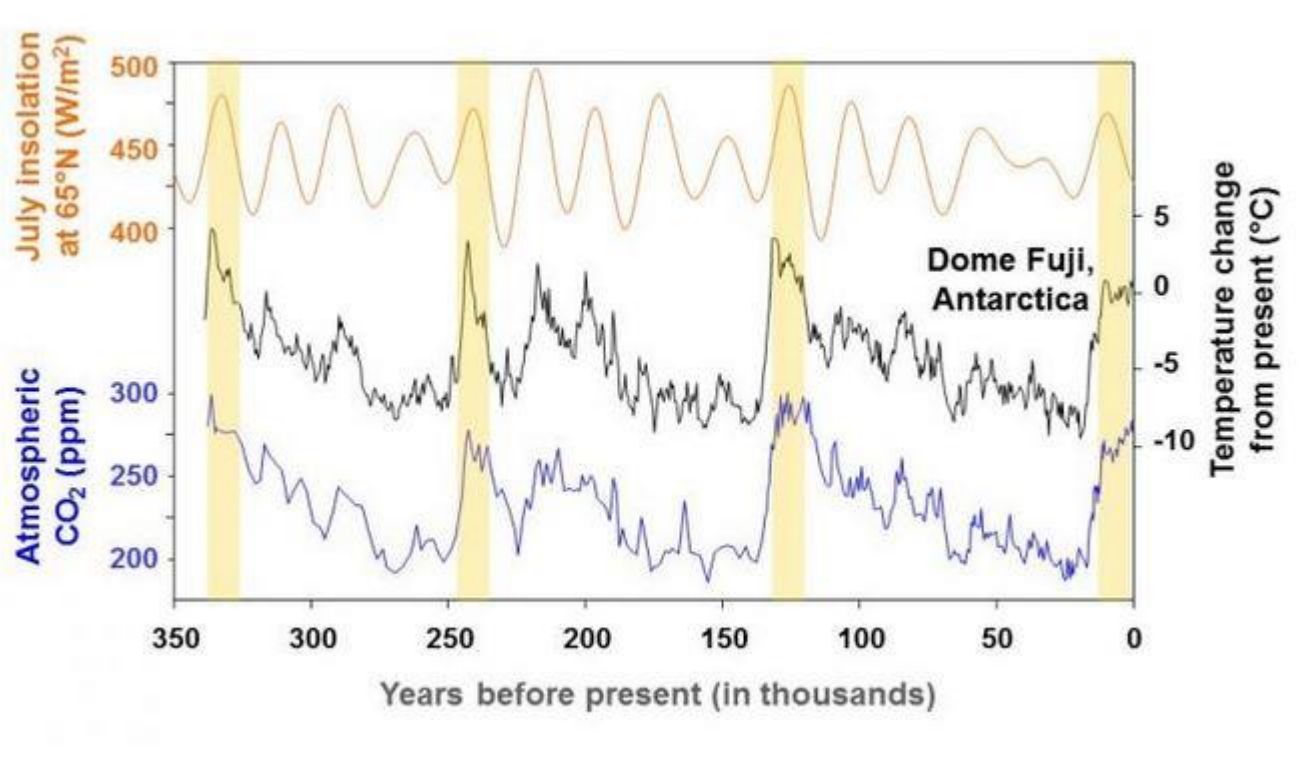
Ice Decay Configuration: High eccentricity
High tilt
Small Earth-Sun Distance in Summer

- Net effect: Warmer summers, Cooler winters



figures drawn by P. DeMenocal/LDEO

Glacial-interglacial cycles

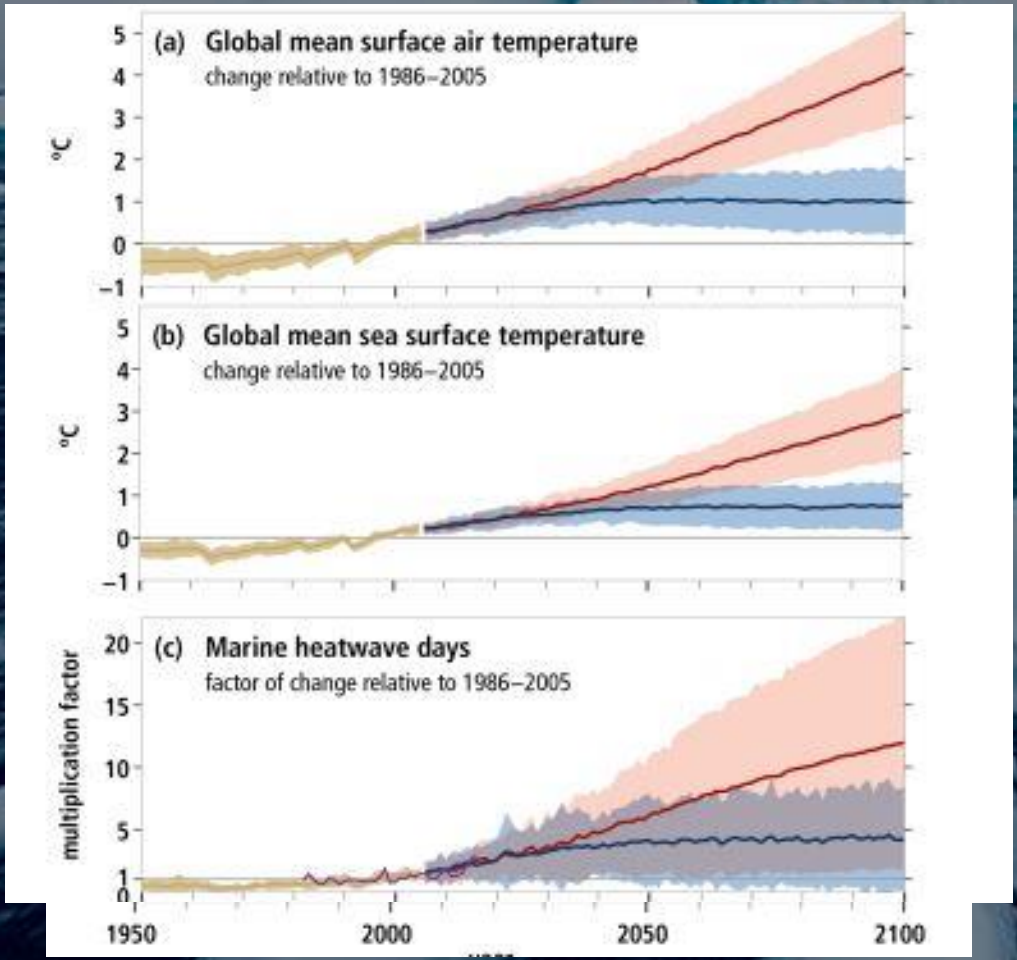


Warming during the glacial periods:

- Ice-albedo feedbacks
- CO2 feedback

The growth of ice sheets in the N.H has more important influence on global climate

Natural forcings are exacerbated by human impacts



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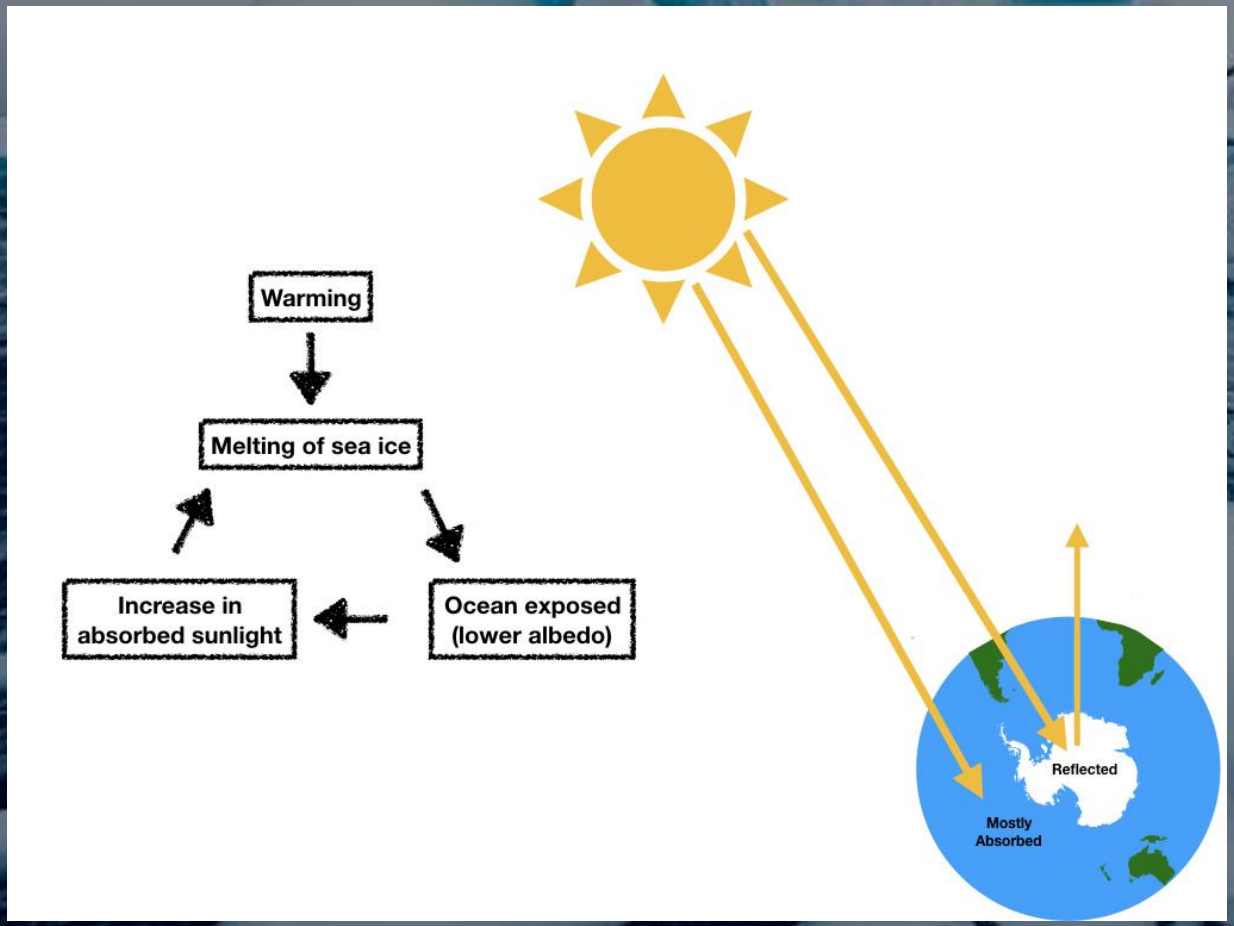
- glacial response times takes decades or longer (Marzeion et al. 2014)
  - Mixed response to past & current natural forcing
  - Responses to current anthropogenic forcing

Ice-albedo feedback



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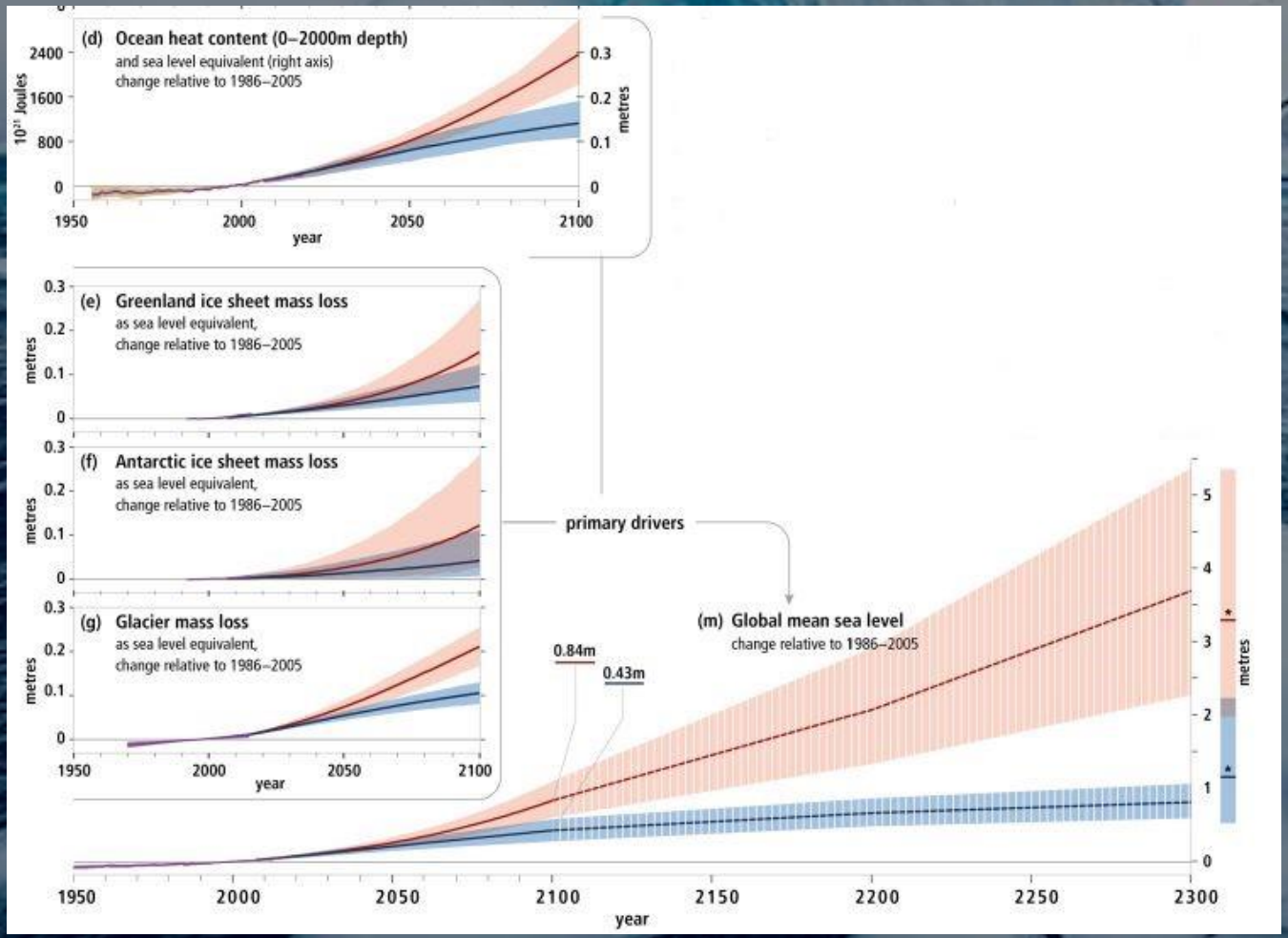
Positive effects

- ✓ Provide drinking water
- ✓ Irrigate crops
- ✓ Help generate hydroelectric power

Sea level continues to rise at an alarming rate



Source: IPCC SROCC 2019

Responses to rising mean and extreme sea levels

- Hard protection (e.g. dikes)
- Ecosystem-based adaptation
  - Coral conservation & restoration
  - Wetland conservation & restoration
- Coastal accommodation measures
  - Early warning systems
  - Flood proofing of buildings
- Coastal advance
- Planned relocation & forced displacement

IPCC SROCC 2019

Conclusions

- Melting glaciers are an icon of anthropogenic climate change.
- Increases in atmospheric GHGs creates positive feedbacks which continually warms the Earth's climate system
- Global warming will lead to the disappearance of many of the world's glaciers.
- Glacial melt is a significant contributor to sea-level rise, which is one of the biggest threat to modern civilization

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DISCUSSIONS

- Will increasing greenhouse gas emissions stop the on-set of the next glaciation or extend the interglacial period we‘re currently experiencing?

- Climate change adaptation isn‘t a technical problem, it is a societal one! Beate Ratter 2019
  - Do we need the support of the local populace to implement climate change adaptation measures?