

Introduction to sea level projection science

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1 NCAS, University of Reading

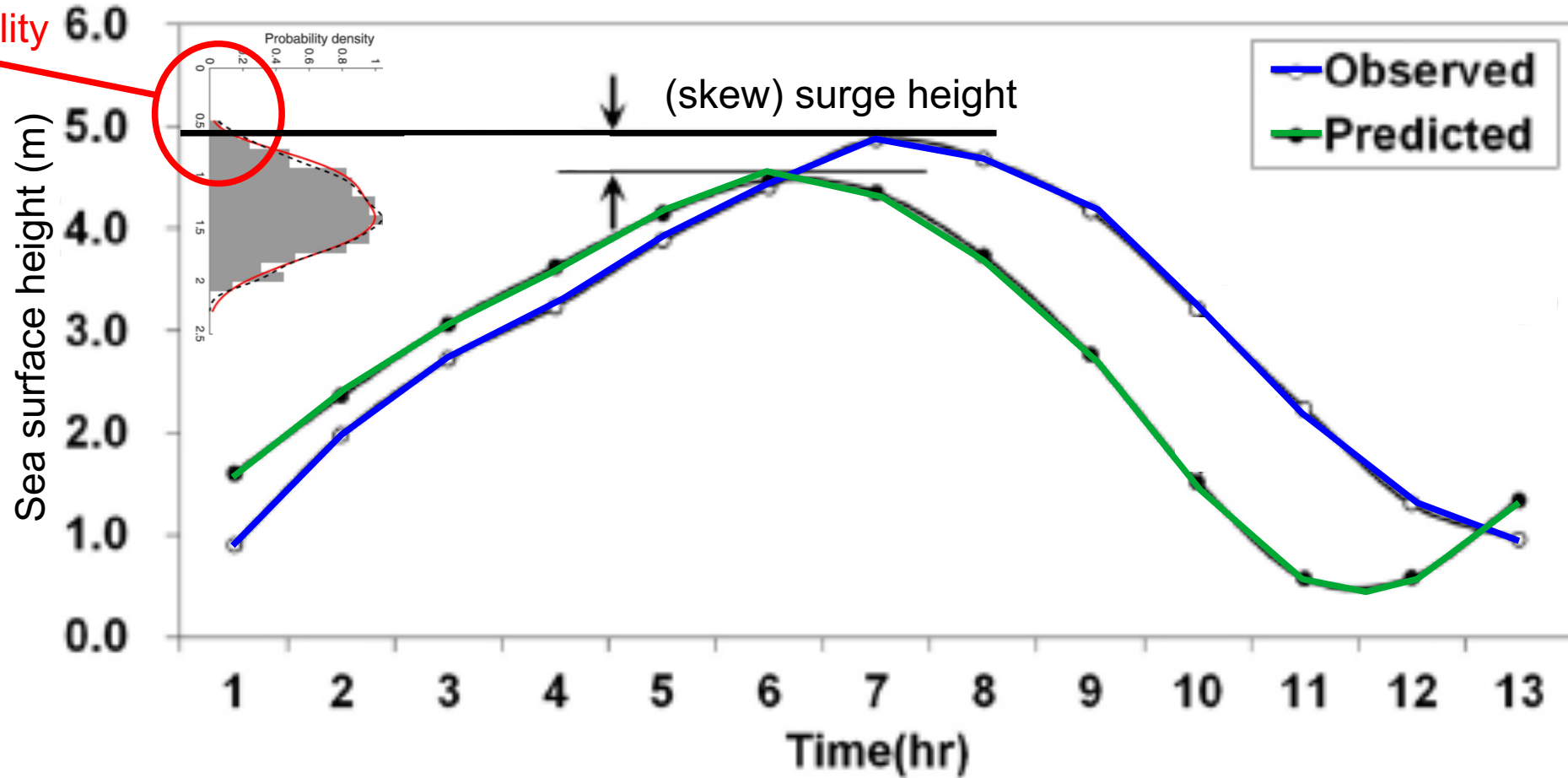
2 Met Office Hadley Centre, Exeter

Extreme sea level (or extreme coastal water level)

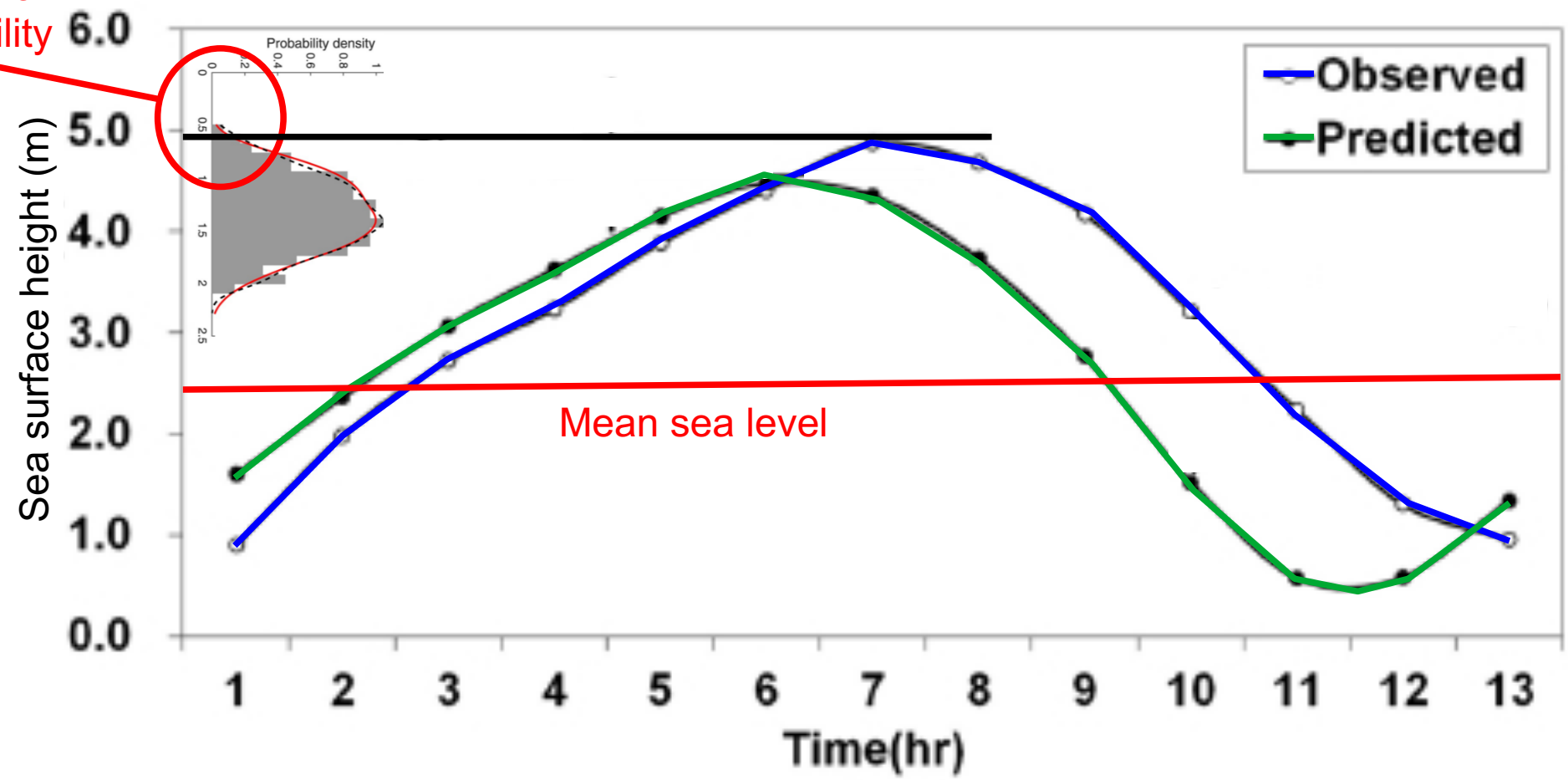


Sea surface height varies on short timescales due to tides and weather

Very small probability

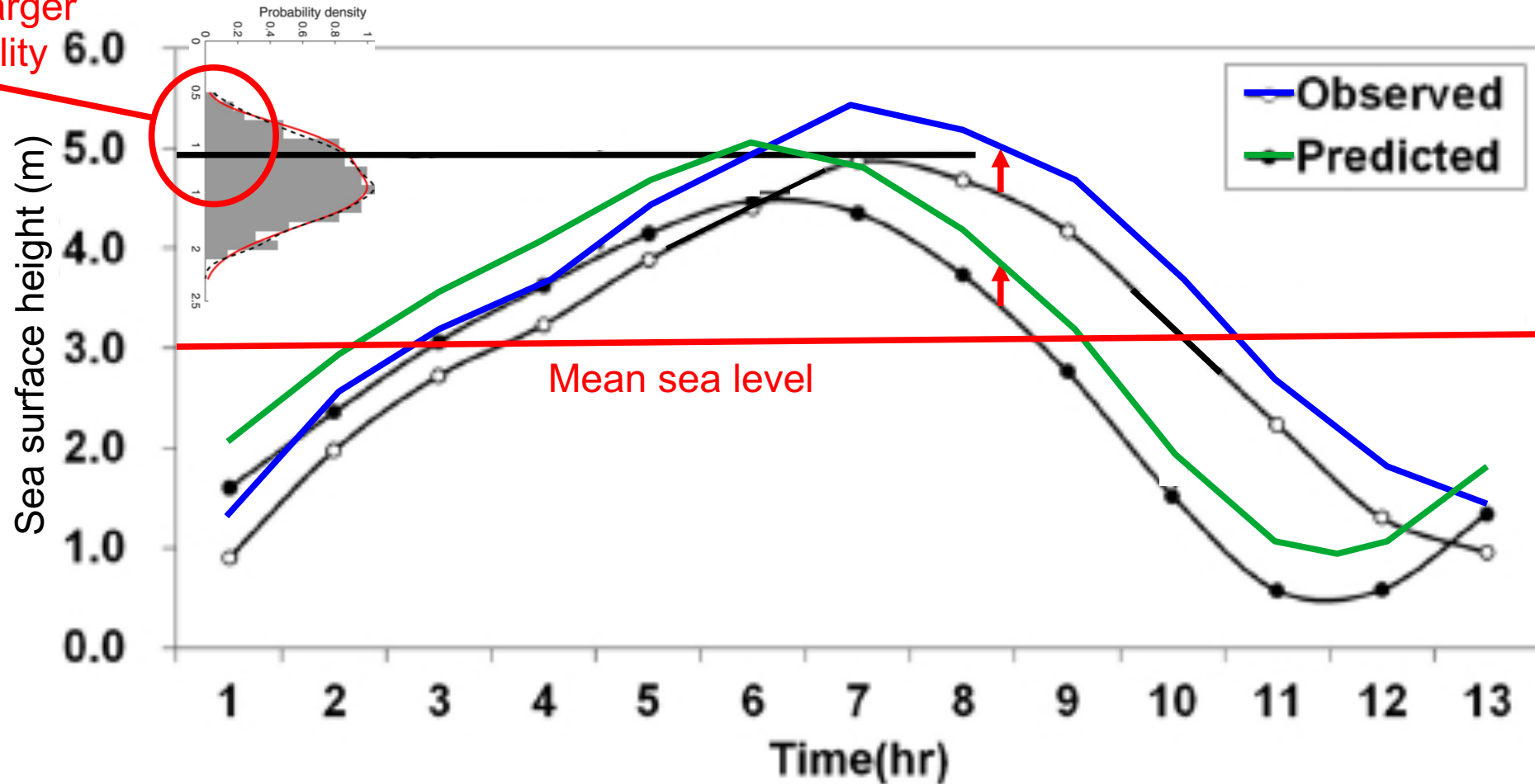


Very small probability

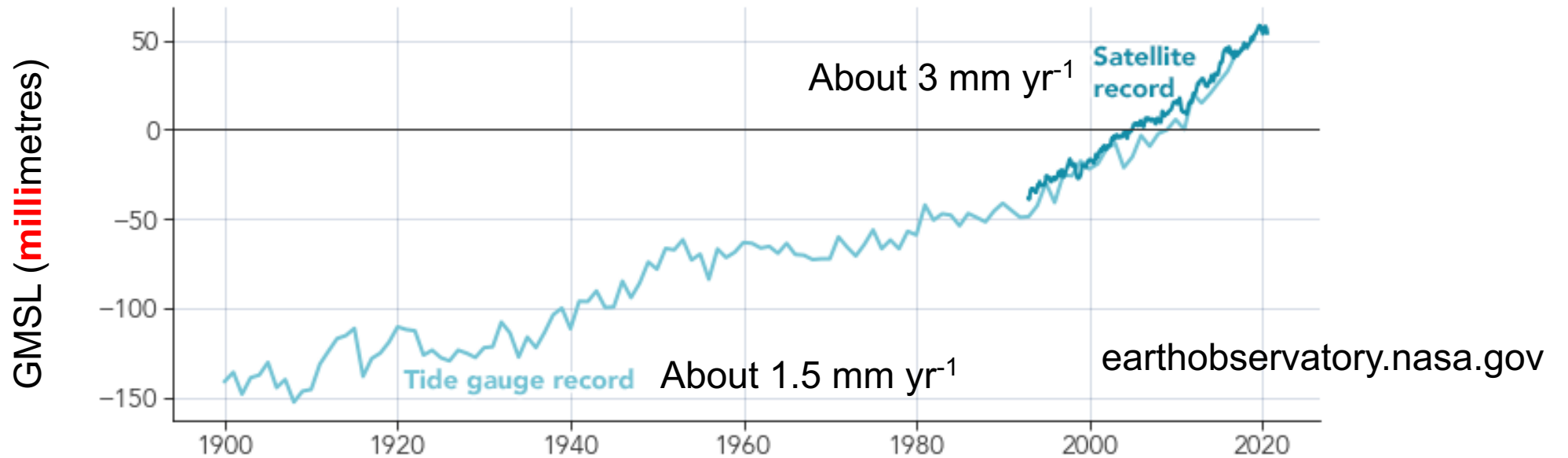
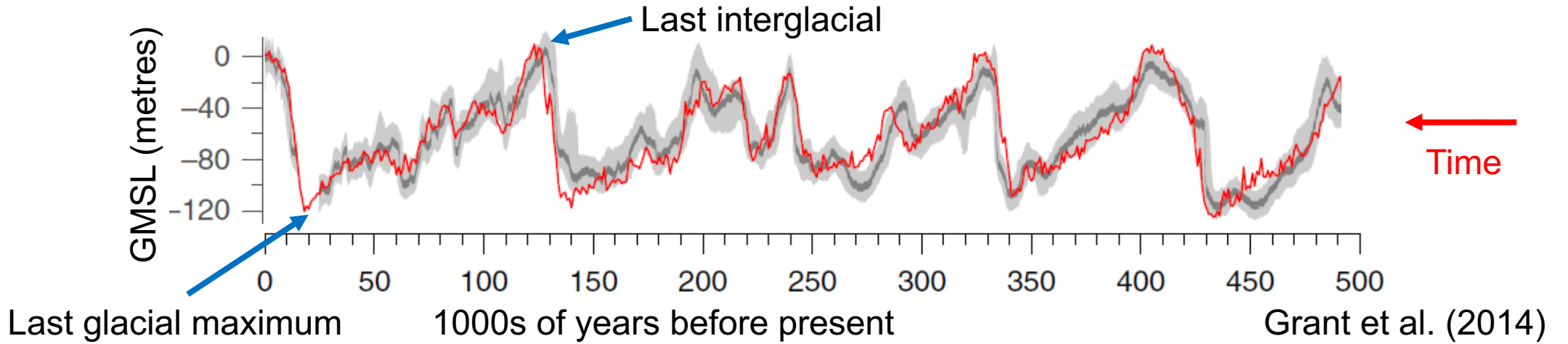


A fairly small rise in local **mean sea level** can cause a very large increase in the probability of local extreme sea level

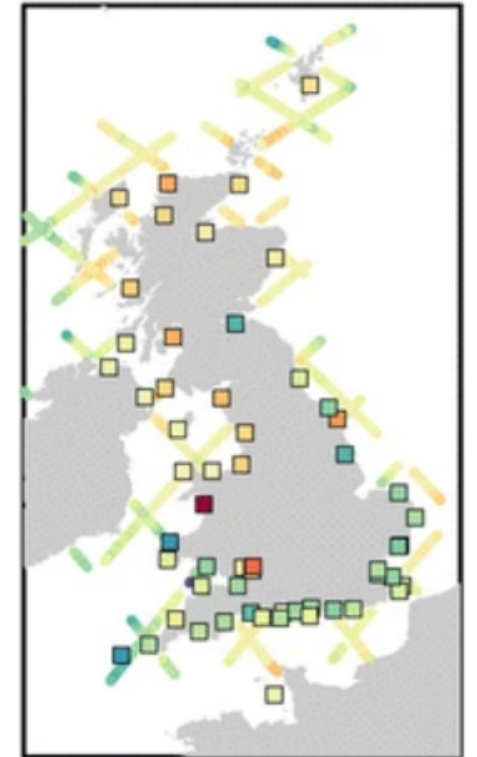
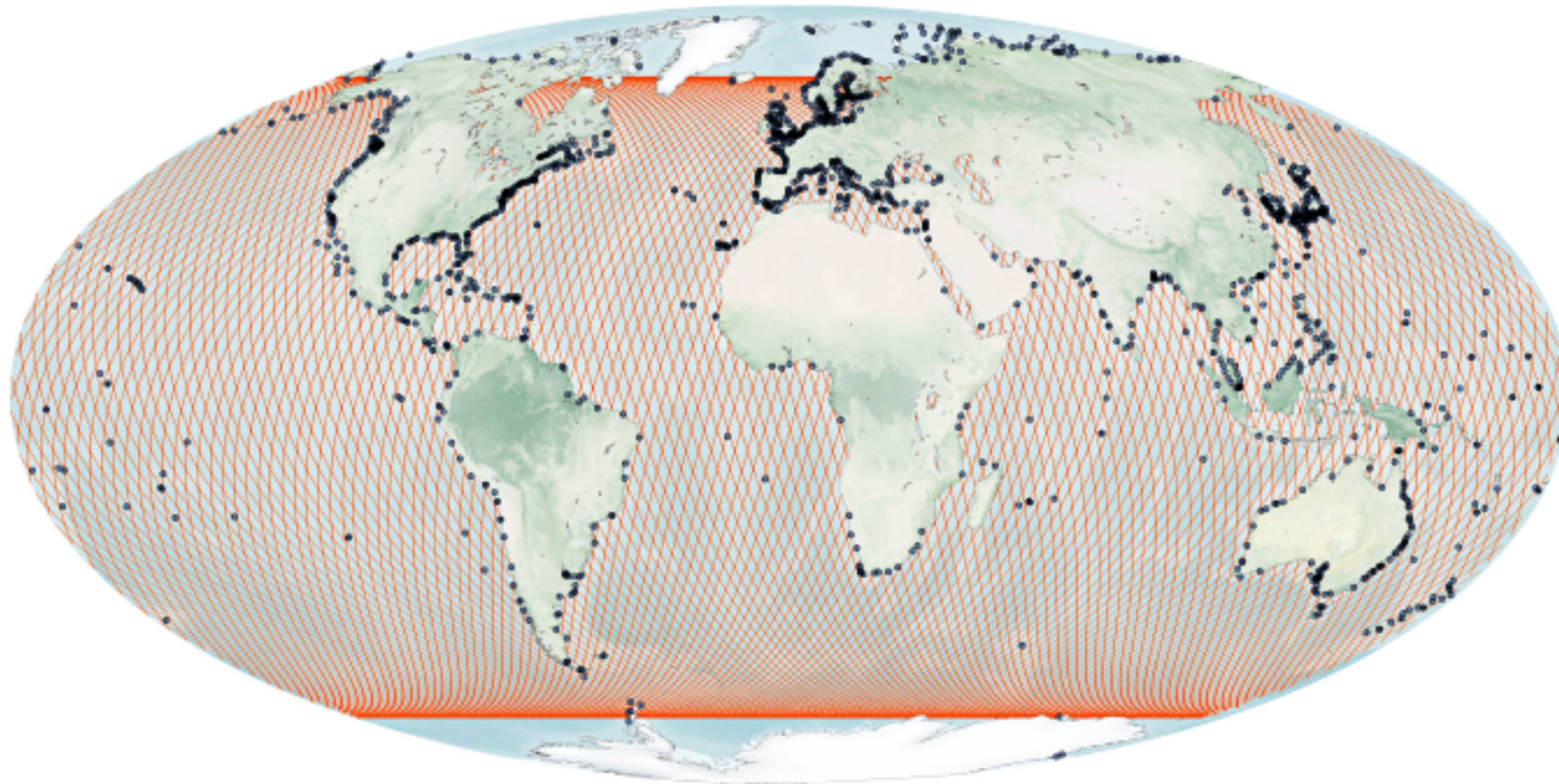
much larger probability



Variation of global-mean sea level over time



Geographical coverage by tide gauges and altimetry



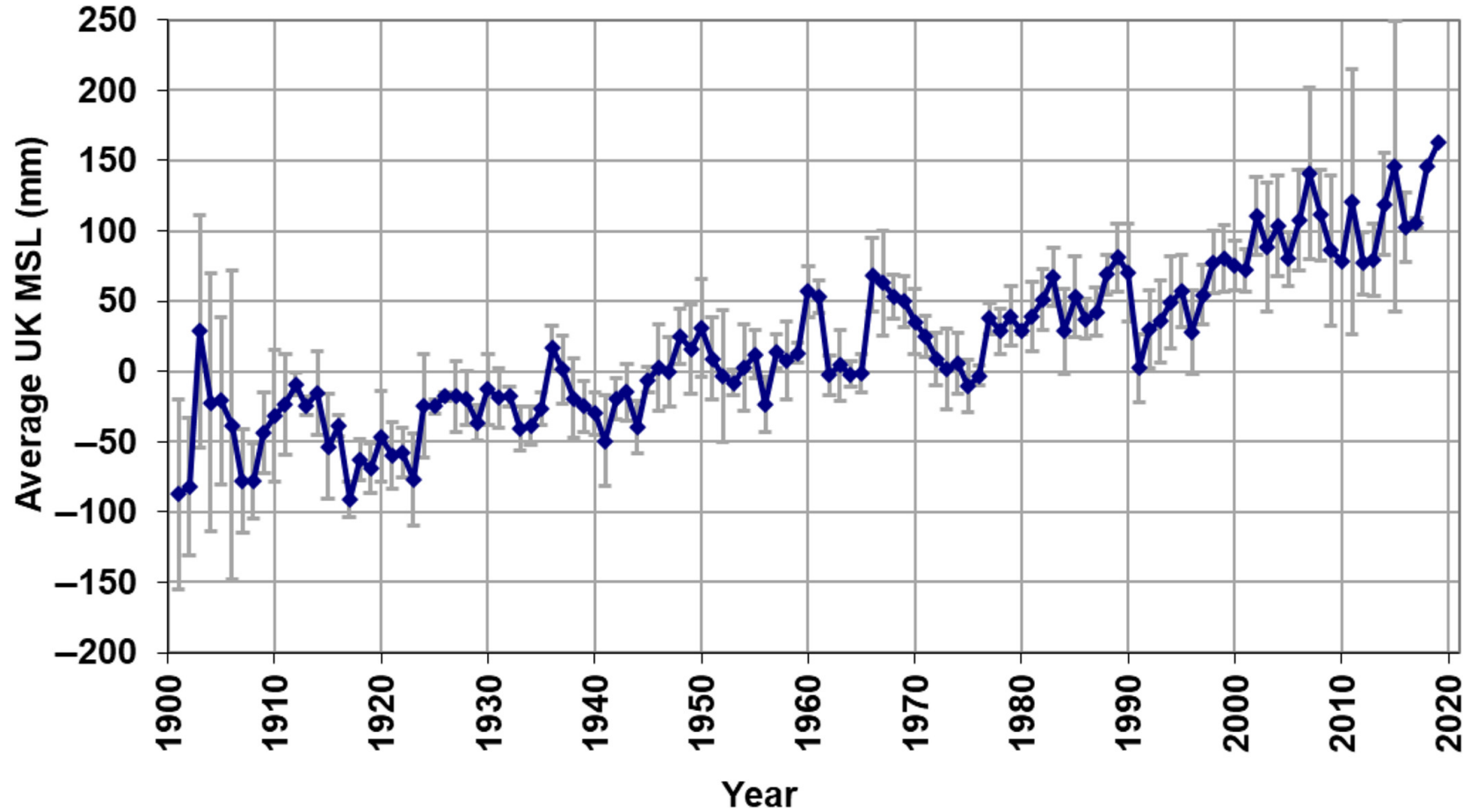
• PSMSL Tide Gauges

Jason-3 Orbits (10 days)

earthobservatory.nasa.gov

Cipollini et al. (2016)

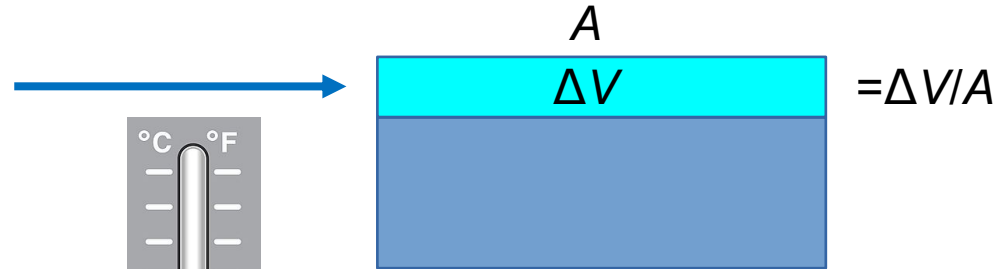
Variation of UK mean sea level over time



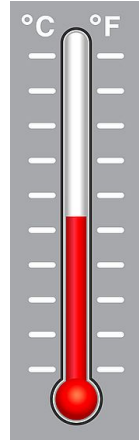
Not updated to 2020 because too few tide gauge remain in operation

Contributions to global-mean and local mean sea-level change

Global-mean sea-level change or rise (GMSLR)



Global-mean *thermosteric* SLC (thermal expansion)

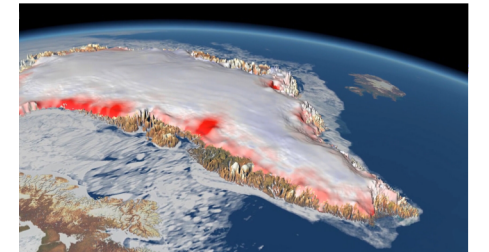


Increase of mass
barystatic

Land water storage (lakes, reservoirs, groundwater)

Glaciers

Ice sheets of Greenland and Antarctica



Contributions to global-mean and local mean sea-level change

Global-mean sea-level change or rise (GMSLR)

Effects on the geographical pattern of local MSL change

Local vertical land movement (tectonics, subsidence)

Global-mean *thermosteric* SLC (thermal expansion)

Sterodynamic

Ocean dynamic SLC (ocean circulation)

+

Increase of mass
barystatic

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Glaciers

Ice sheets of Greenland and Antarctica

cause

Contemporary *GRD* (Earth gravity, Earth rotation, solid-Earth deformation)



Ice sheets which no longer exist

cause

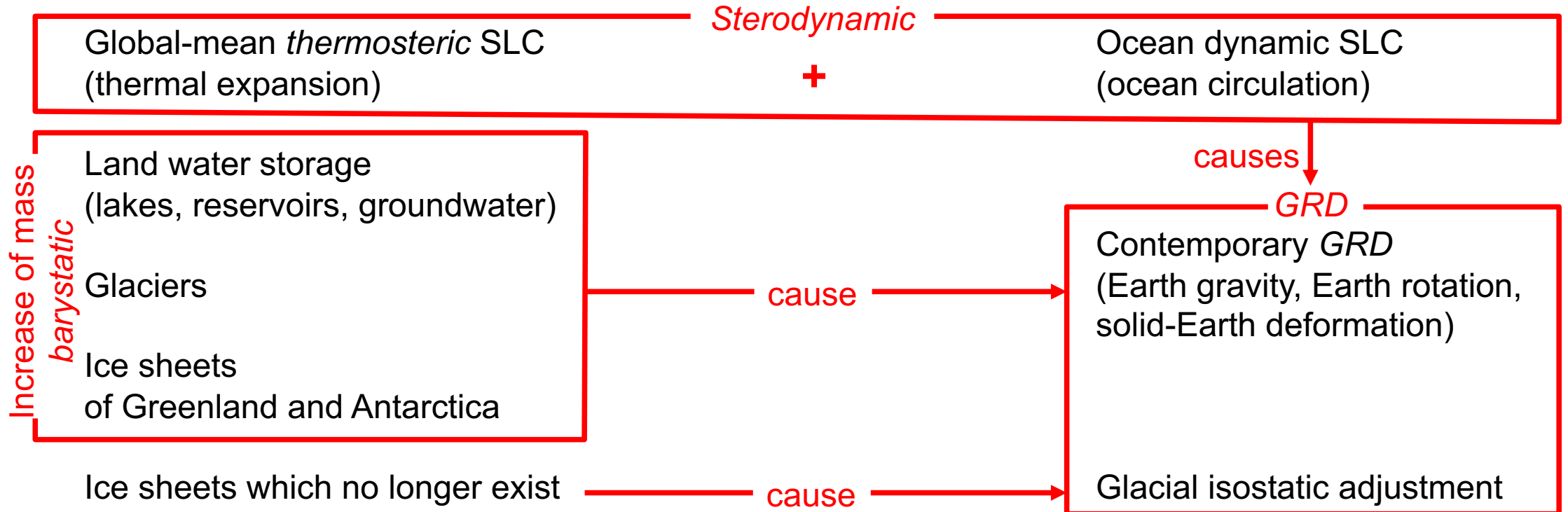
Glacial isostatic adjustment

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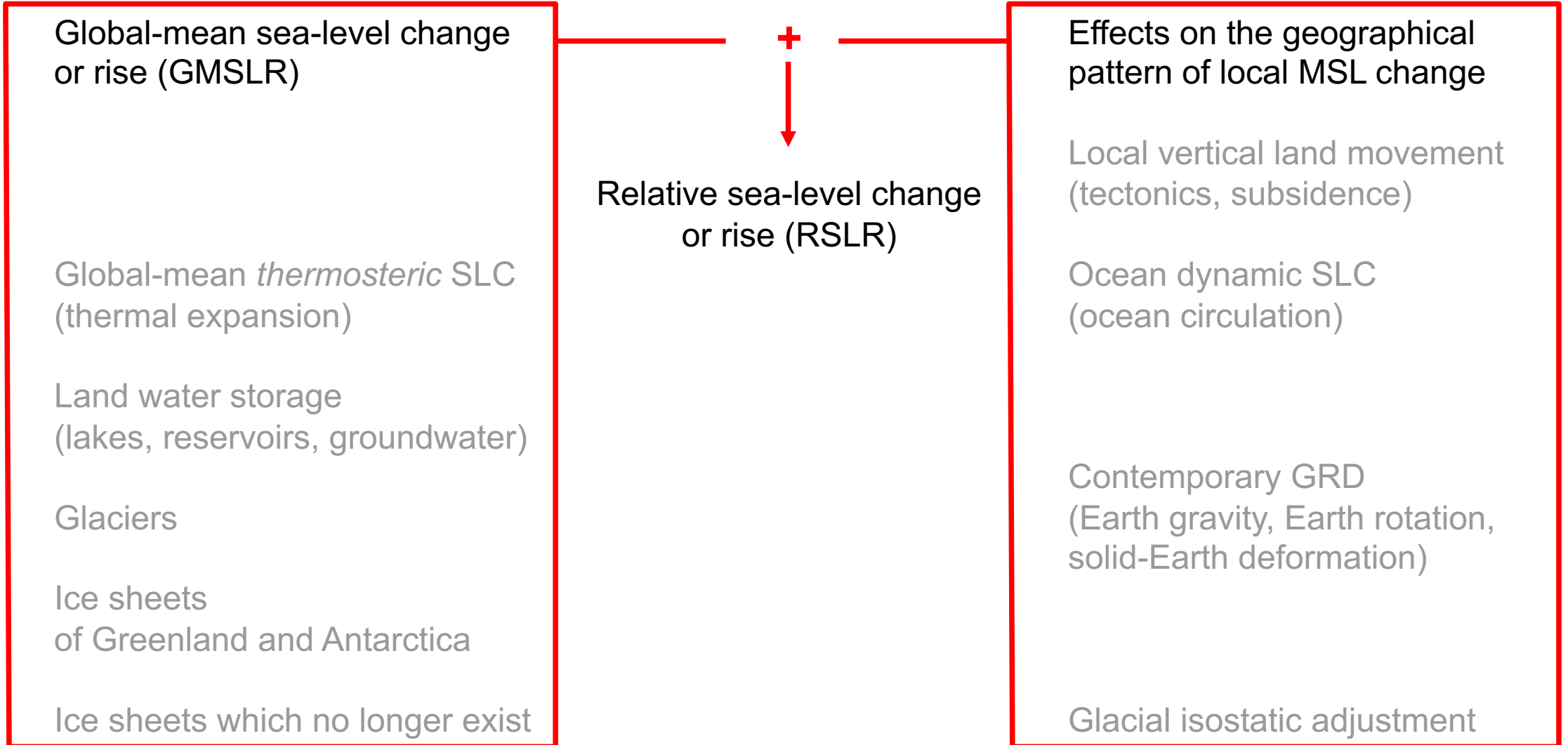
Local vertical land movement
(tectonics, subsidence)

Ocean dynamic SLC
(ocean circulation)

Contemporary GRD
(Earth gravity, Earth rotation,
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Glacial isostatic adjustment

Contributions to global-mean and local mean sea-level change



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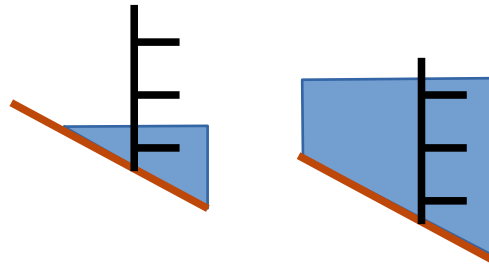
Ice sheets of Greenland and Antarctica

Ice sheets which no longer exist

+

↓

Relative sea-level change or rise (RSLR)
=
Change in local MSL wrt sea floor



Effects on the geographical pattern of local MSL change

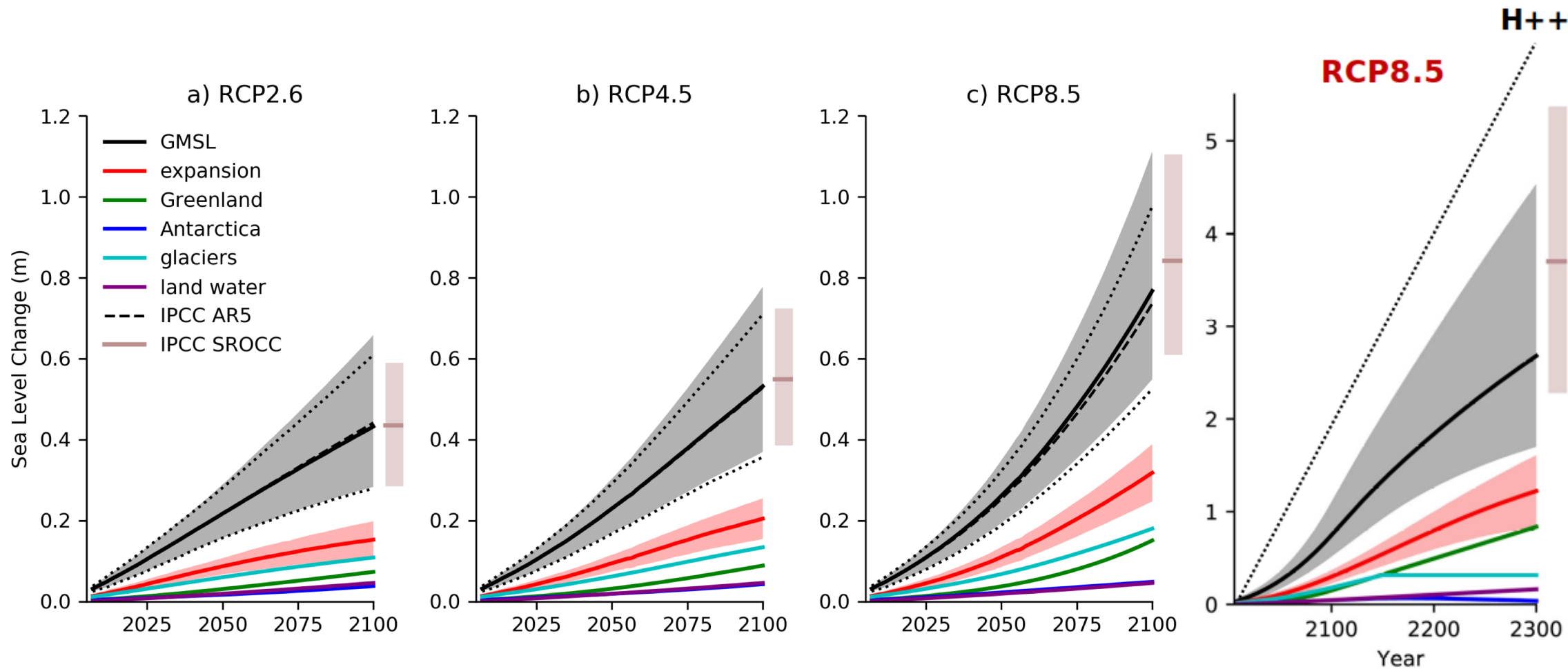
Local vertical land movement (tectonics, subsidence)

Ocean dynamic SLC (ocean circulation)

Contemporary GRD (Earth gravity, Earth rotation, solid-Earth deformation)

Glacial isostatic adjustment

GMSLR projections from AR5 and UKCP18

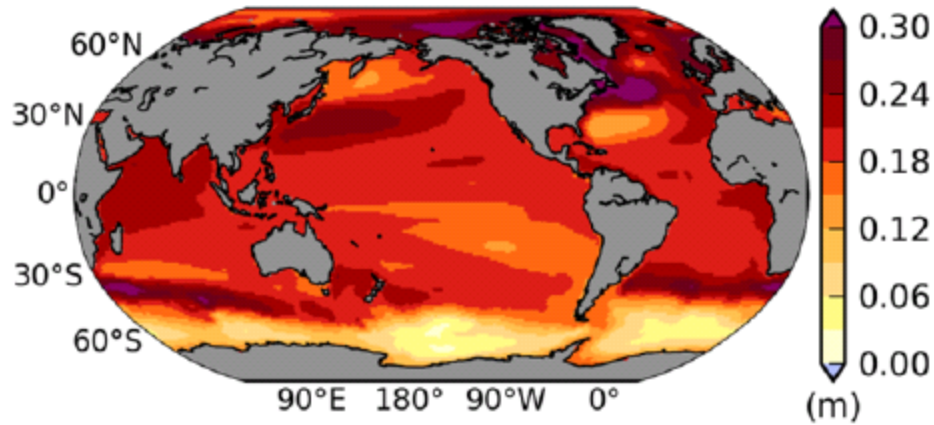


UKCP18 and Palmer et al. (2020)

Contributions to the geographical variation of RSLR

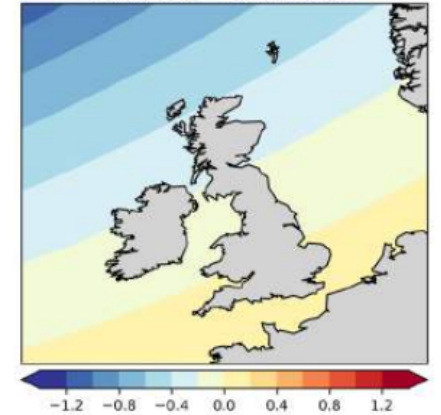
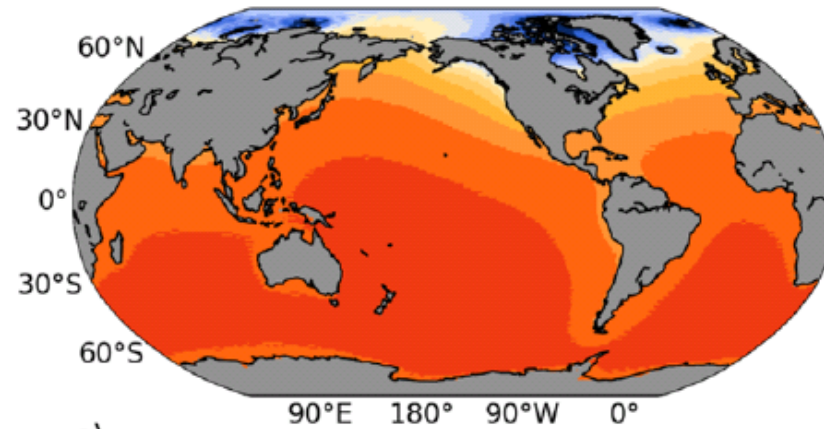
Sterodynamic SLC

due to ocean density and circulation change



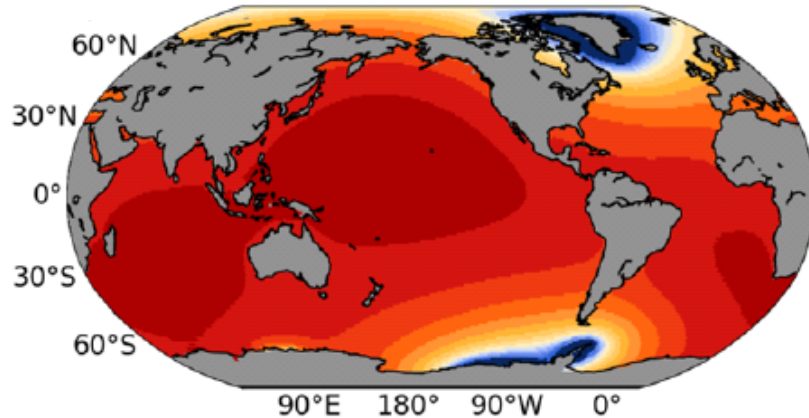
GRD-induced + barystatic SLC

due to glacier mass loss

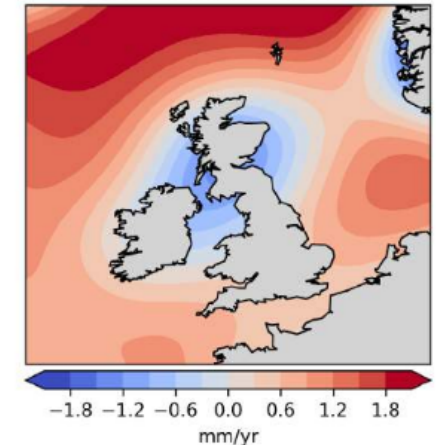
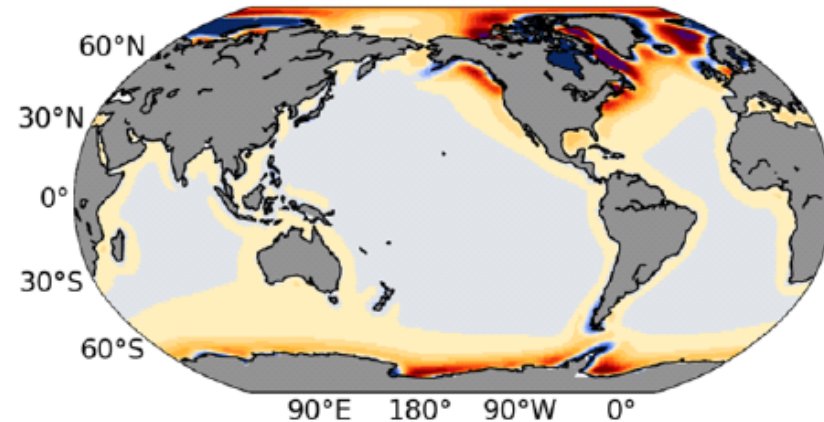


GRD-induced + barystatic SLC

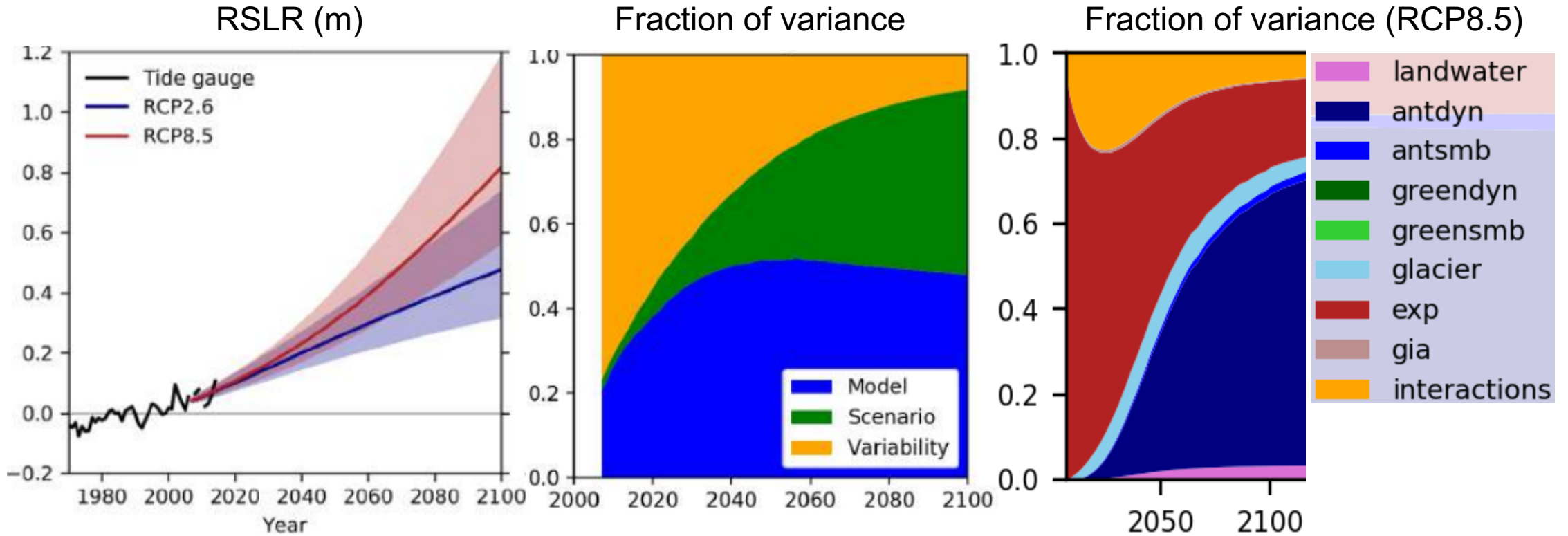
due to ice sheet mass loss



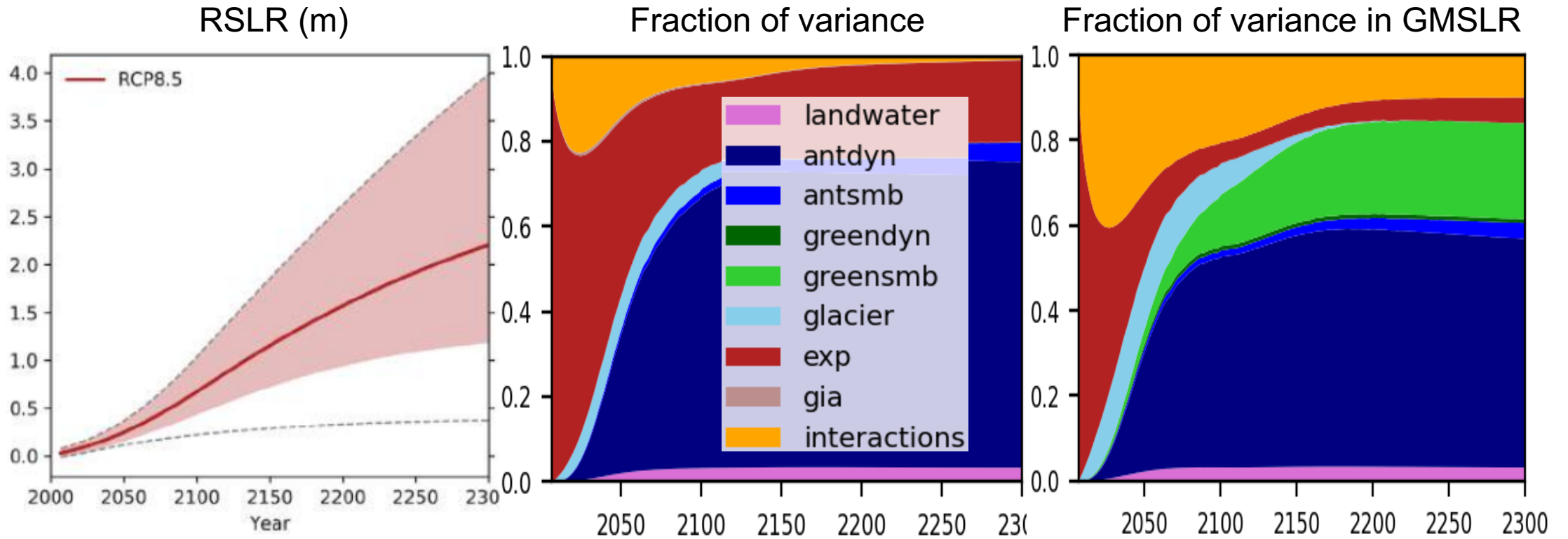
Glacial isostatic adjustment



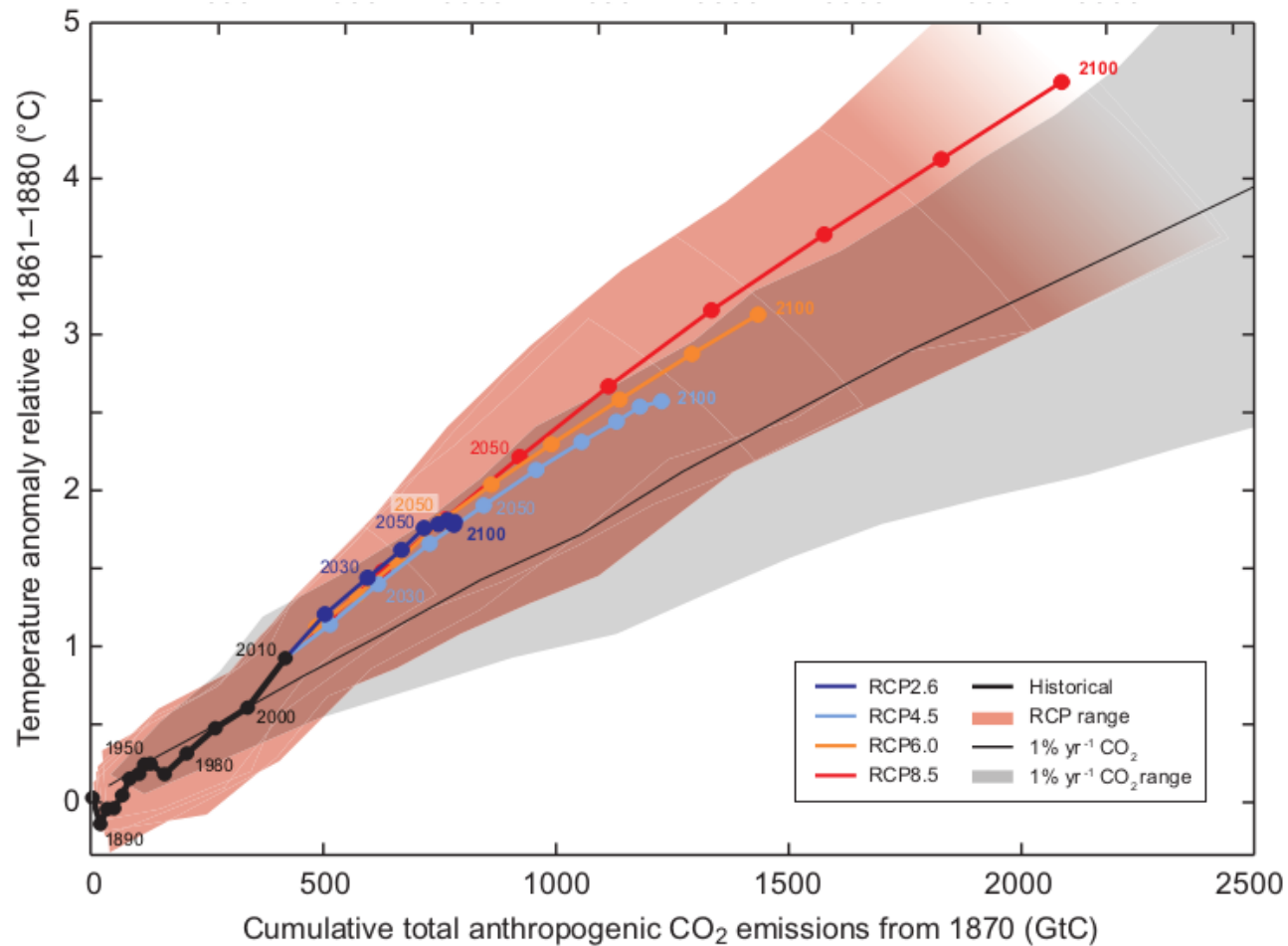
Projection of relative sea level rise and its uncertainties (for Newlyn as an example)



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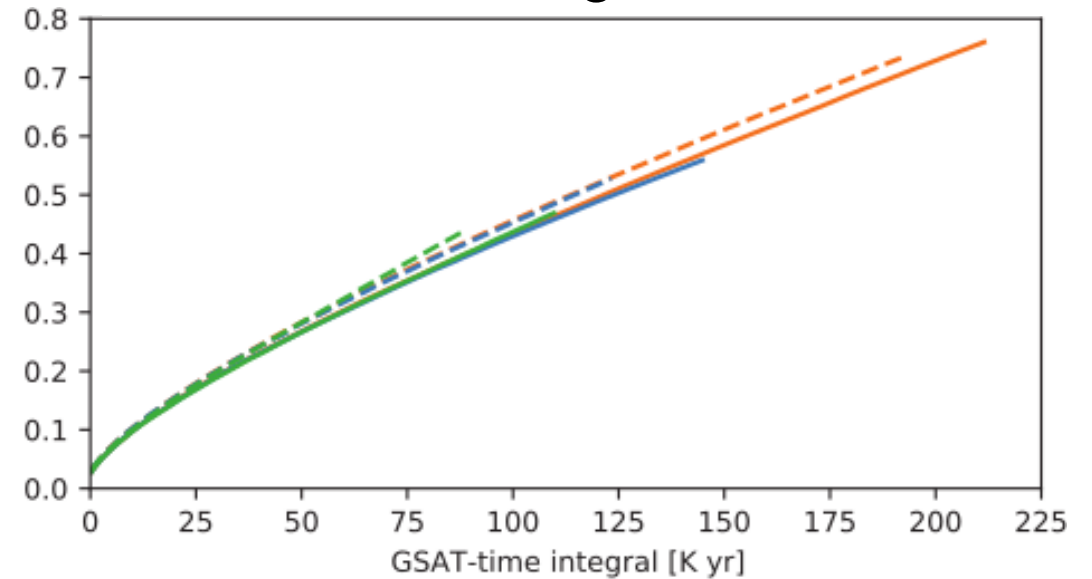
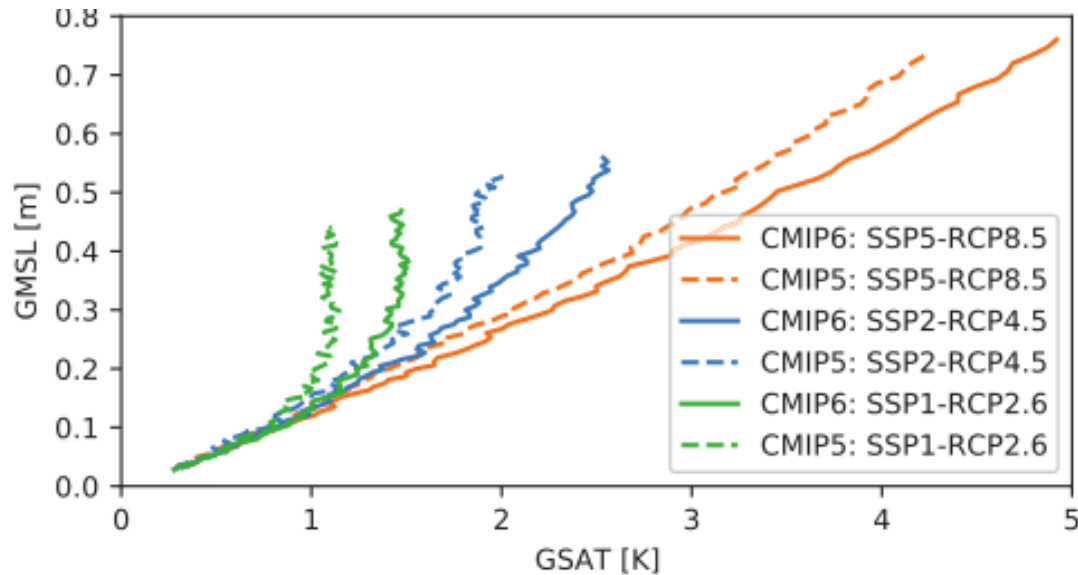


Global mean surface temperature change is proportional to cumulative carbon emissions



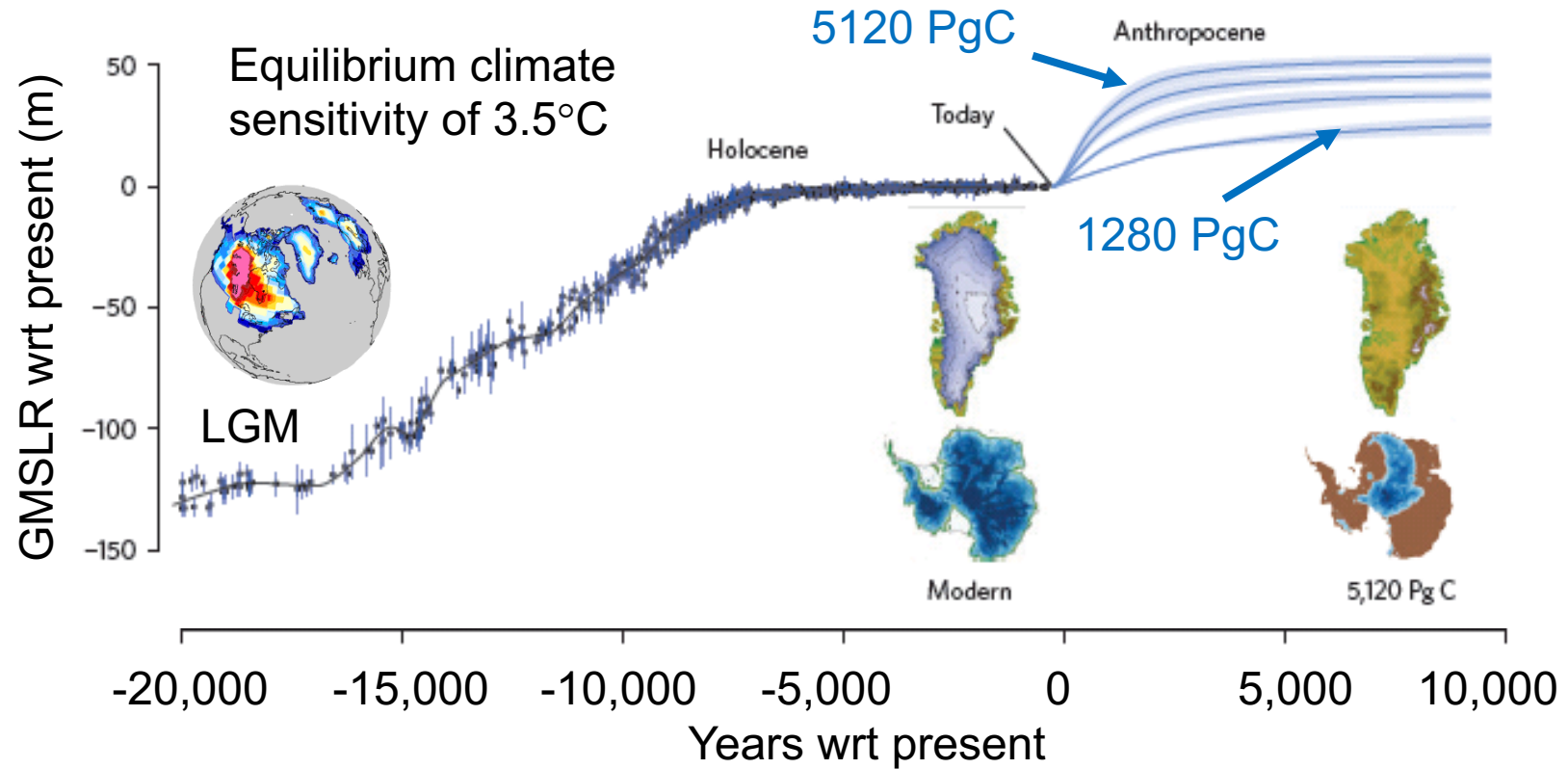
Global mean surface temperature change and cumulative carbon emissions are **not** good predictors of global mean sea level rise

but the time-integral works well

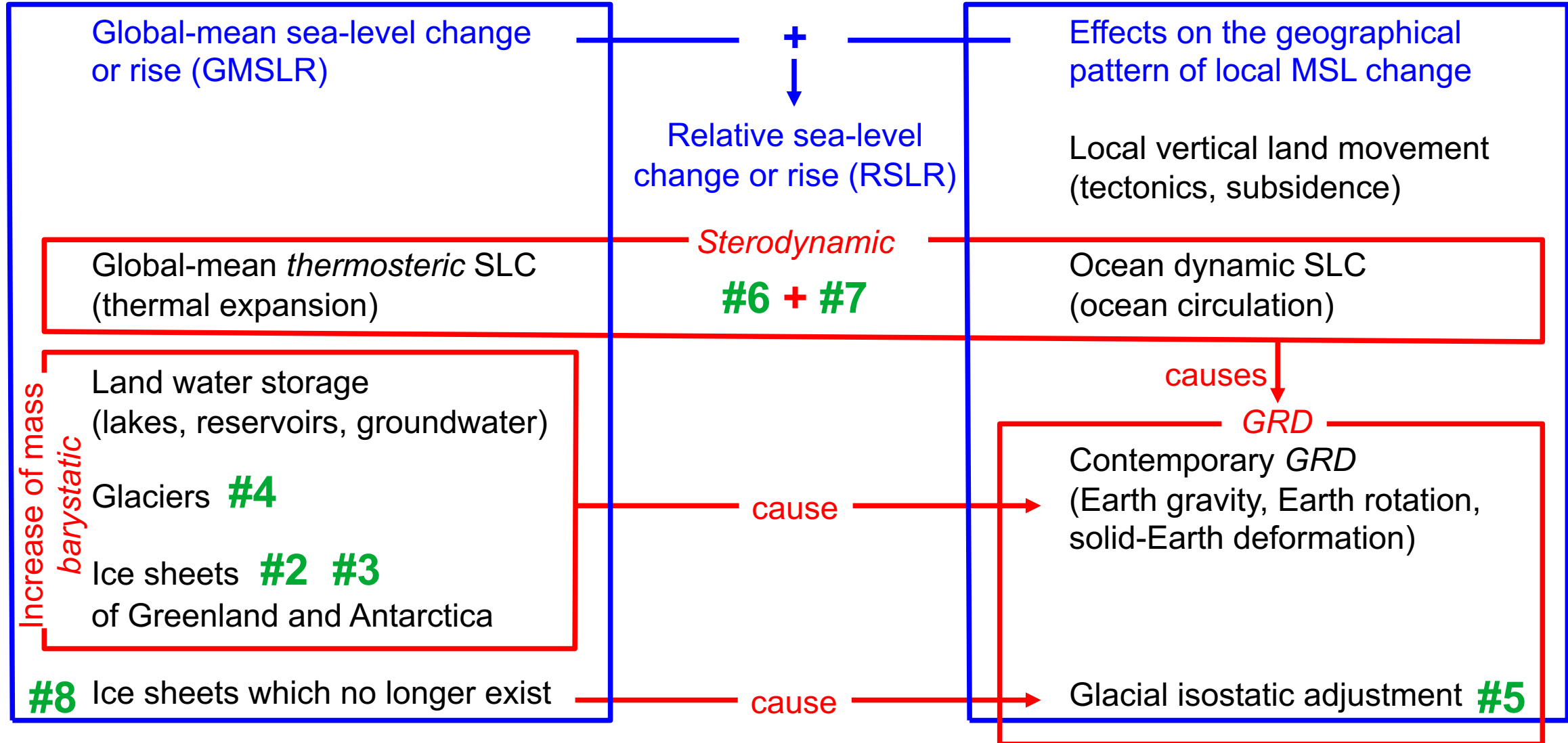


This means early emissions cause more GMSLR

Very long-term GMSLR is dominated by the equilibrium response of ice-sheets to climate change



Contributions to global-mean and local mean sea-level change



The weight of evidence

IPCC WG1 Assessment Reports

