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Global Mean Sea-level Changes Over the Common Era

Nidheesh Gangadharan, Hugues Goosse
David Parkes, Heiko Goelzer

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UCLouvain
NORCE
BJERKNES CENTRE for Climate Research

Global Mean Sea Level (GMSL) Rise

Background

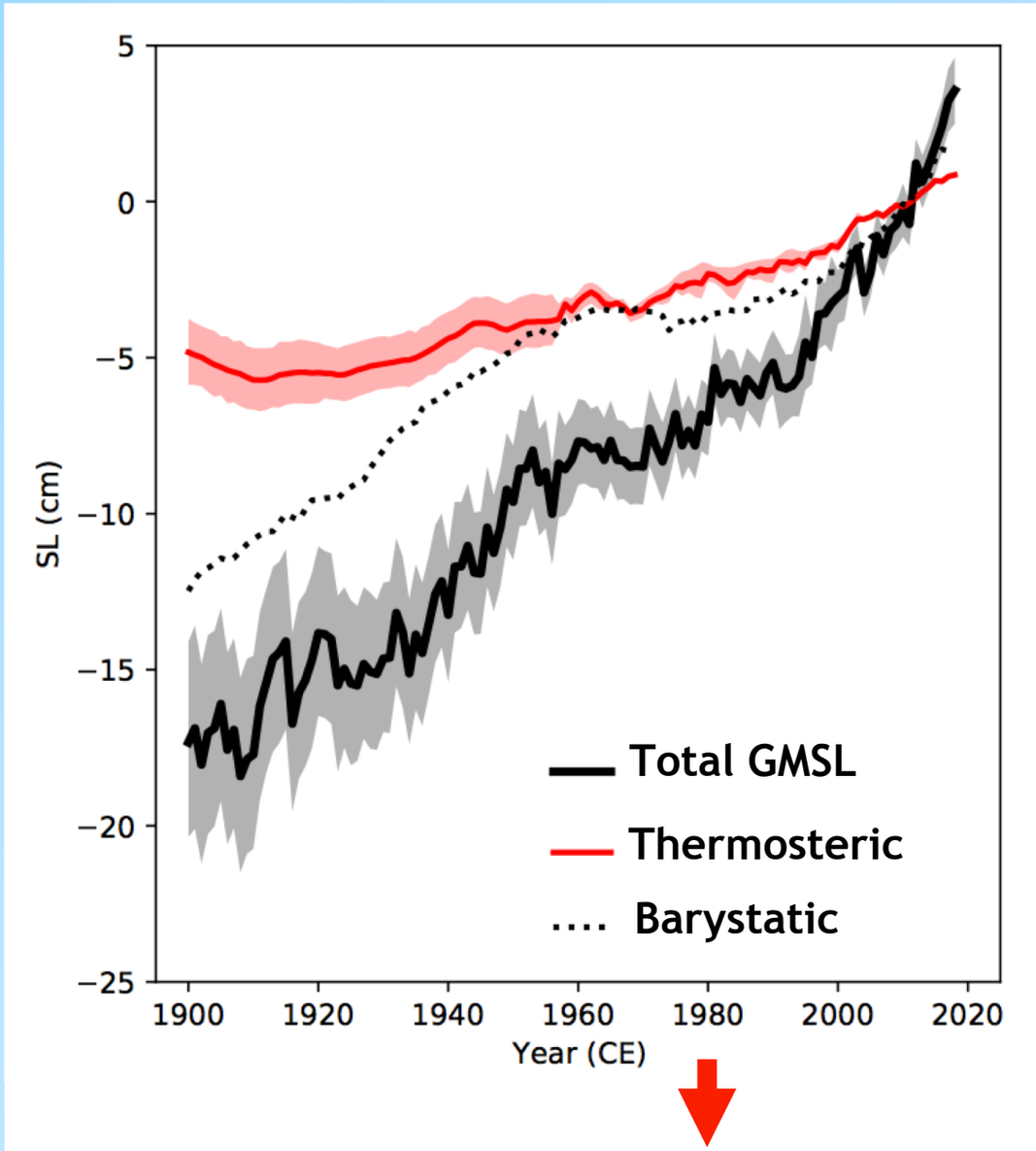
GMSL rose ~ 15 cm in the 20th Century

Thermal expansion of the ocean

Melting of continental ice ┐
Terrestrial Water Storage ┘ **Barystatic**

Objectives

- **GMSL changes during the Common Era**
- **Contributing processes**
- **Physical mechanisms**



Reproduced from Frederikse et al. (2020)

CMIP5/PMIP3
LOVECLIM

ICE-SHEET MODEL
GLACIER MODEL

THERMOSTERIC
SEA LEVEL

BARYSTATIC
SEA LEVEL

PROXY-BASED
RECONSTRUCTION

GMSL
(1 – 2005 CE)

Thermosteric sea level (TSL)

$$TSL = \frac{1}{A}\iint_{z=-H}^{0} \alpha\, \Delta\theta\, \Delta z\, dA$$

α = Thermal expansion coefficient
A = Ocean surface area

H = 700 m for PMIP/CMIP
H = Full depth for LOVECLIM

Antarctic and Greenland Ice sheets

- ✓ ISM IMAUICE (de Boer et al. 2014)
- ✓ Positive-degree-day model SMB
- ✓ TA from PMIP/CMIP & ice-core Rec.
- ✓ Greenland - No ice-ocean interaction
- ✓ Antarctic – 400 m ocean temperature for basal-melt estimates

Monte Carlo Method (1000 members)

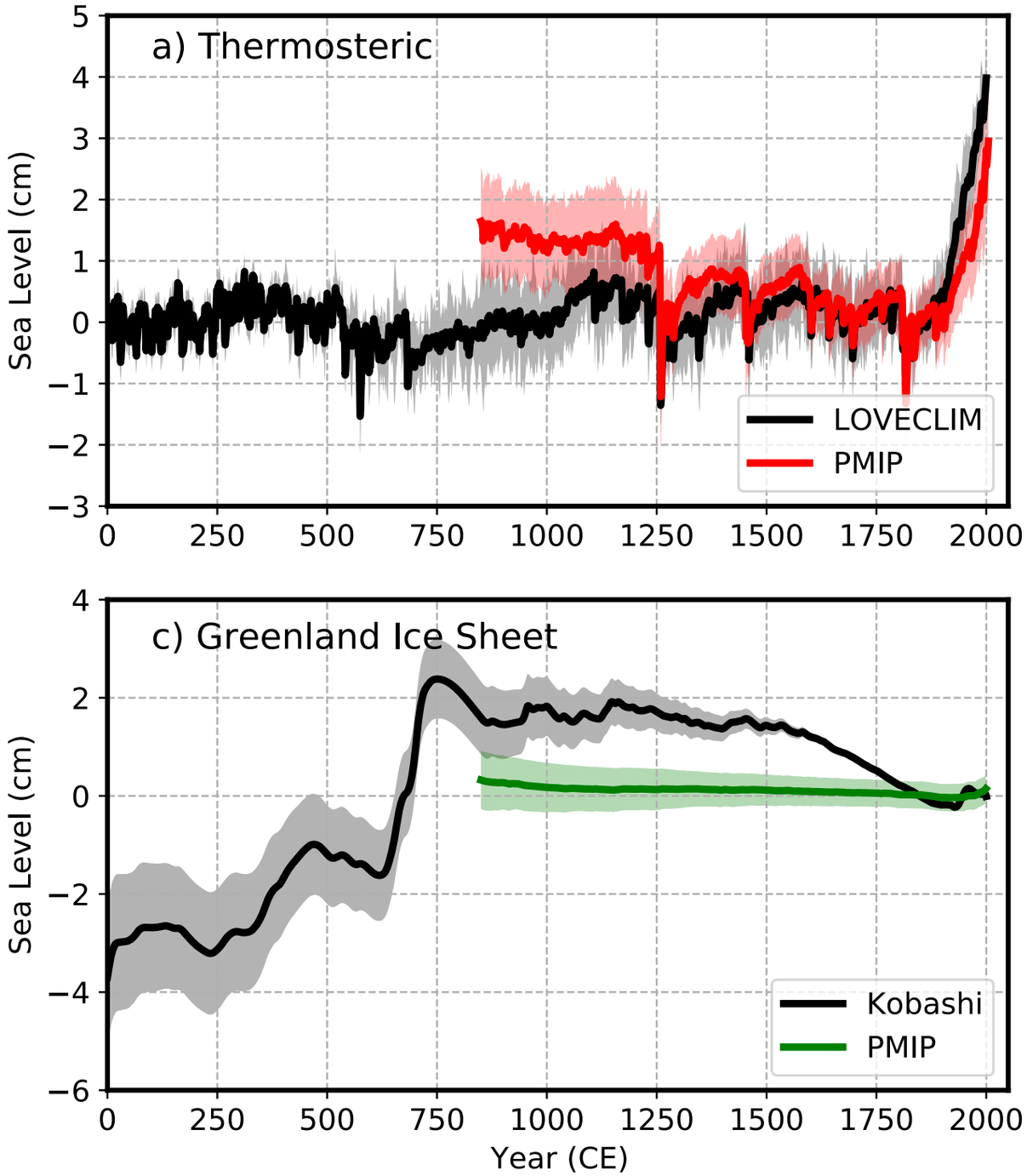
Glacier mass balance

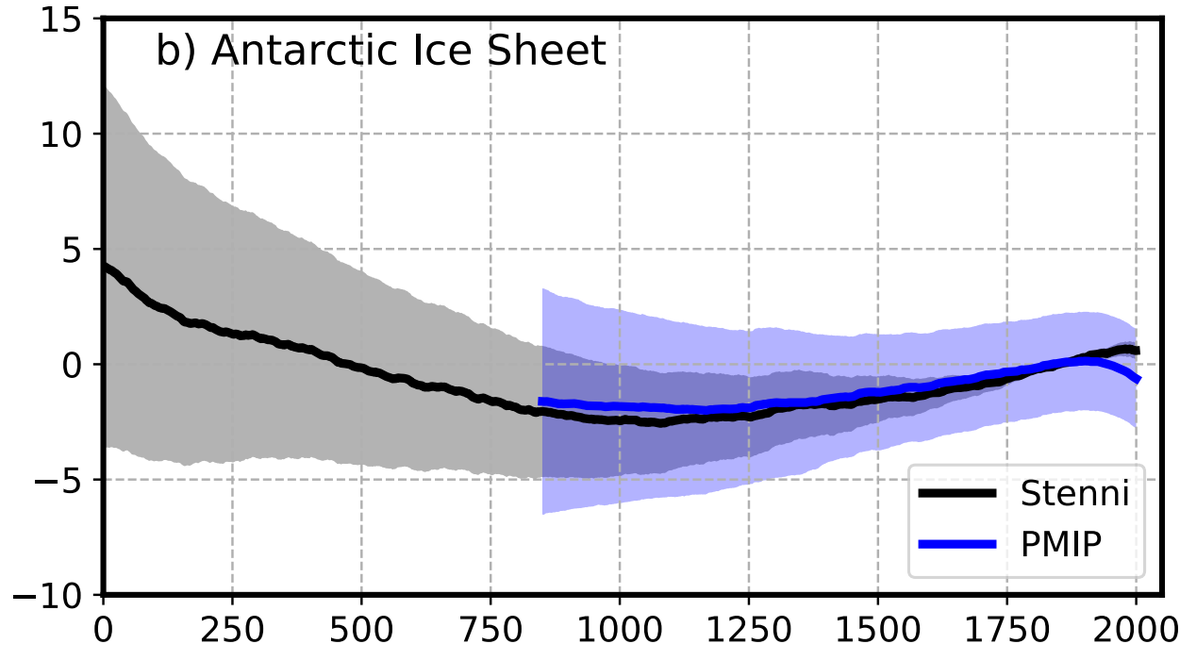
- ✓ Open Global Glacier Model v1.1
- ✓ SMB + Dynamics (Maussion et al., 2019)
- ✓ Randolph Glacier Inventory (19 regions)
- ✓ Last Millennium Reanalysis (input)
- ✓ Climate Research Unit (Initial state)

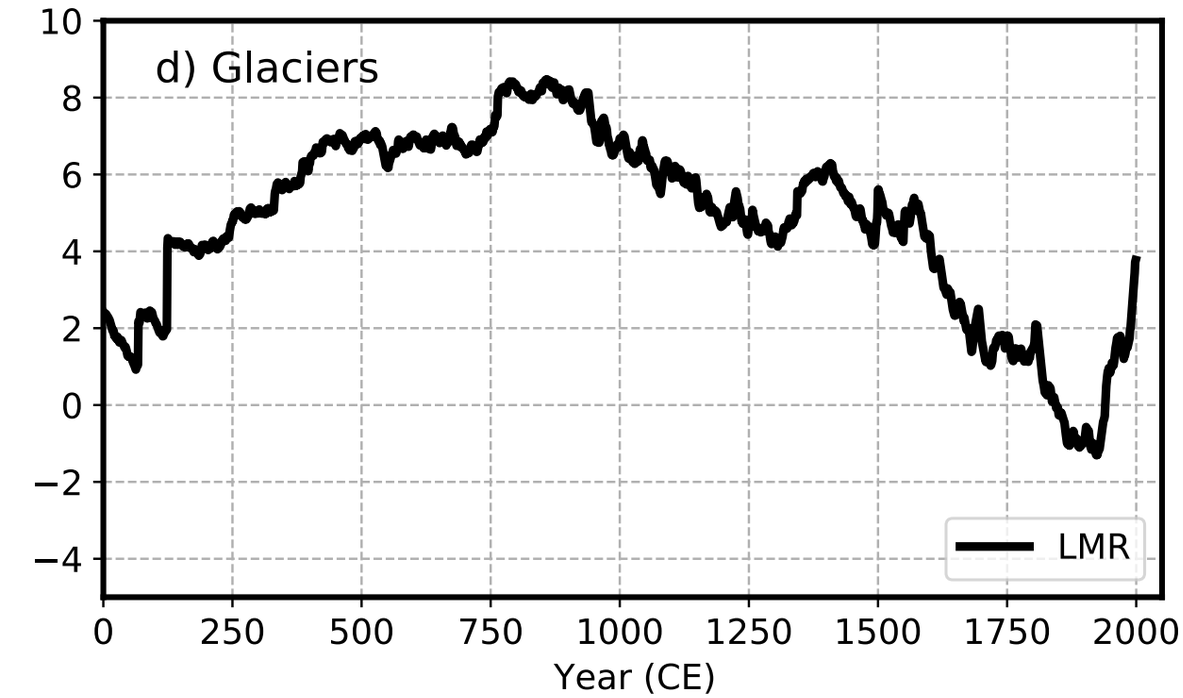
Complementary data

- ✓ GMSL : Kopp16, Kemp-18, Walker-21
- ✓ Zanna-19 (TSL), Frederikse-20 (GMSL)
- ✓ Kobashi- 11 (GrIS), Stenni-17 (AIS)
- ✓ Marzeion-12 (20thC glacier volumes)
- ✓ Ocean Temp from CMIP/PMIP

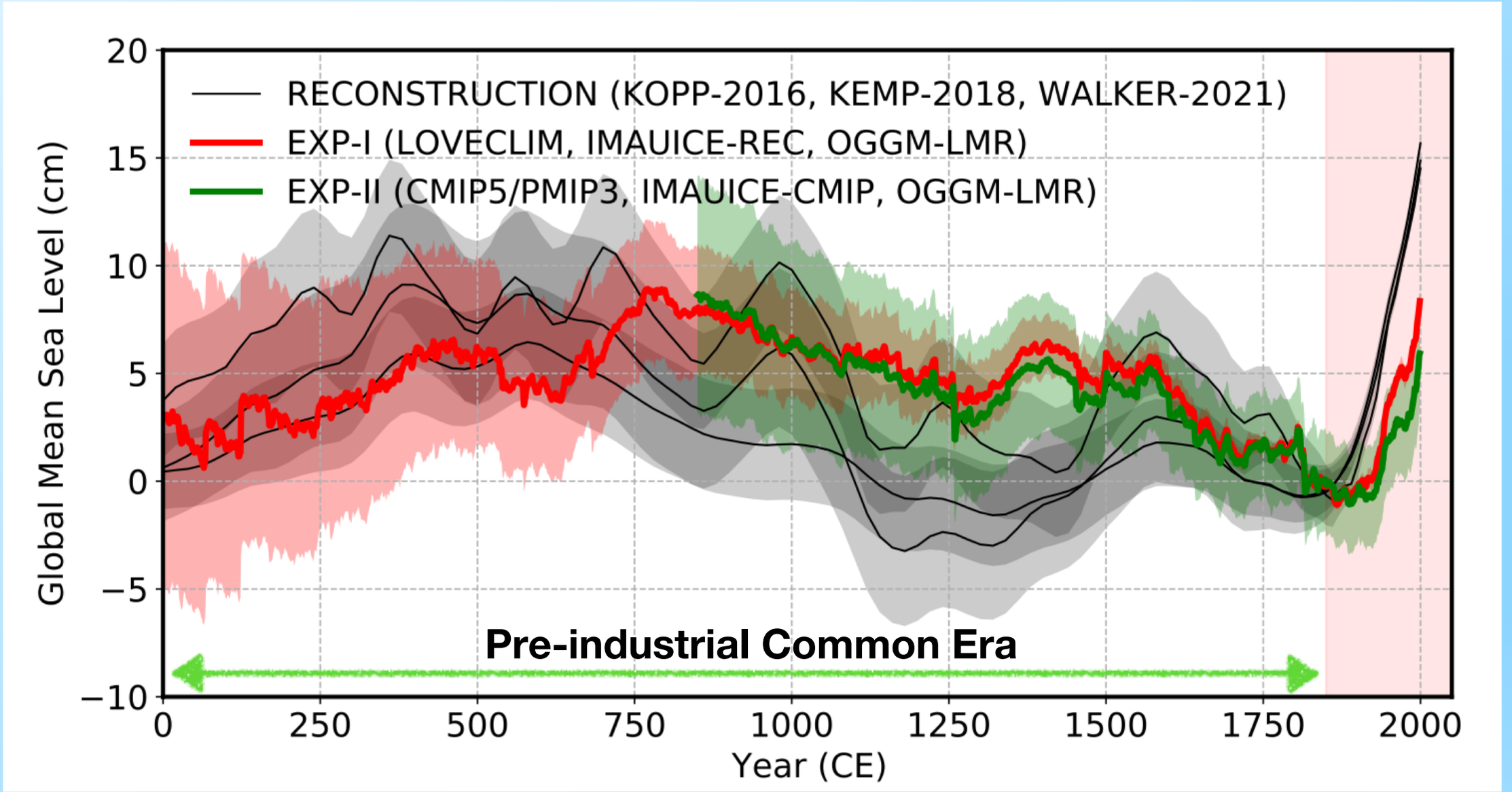
Contributing components of GMSL







Combined estimates of GMSL



Summary

- Weak thermosteric contribution during the PCE
- Potential contribution of Antarctic and Greenland peripheral glaciers
- Glacier contribution is large over the entire common era
- Larger uncertainty for the first millennium

Additional Information

List of climate models used in this study

	Model name	Ocean Model Resolution (Lat, Lon, Lev)	Institution	Reference
1	HadCM3	144, 288, 20	University of Edinburgh, School of Geosciences, UK	Collins et al. (2001)
2	MPI-ESM-P	220, 256, 40	Max Planck Institute for Meteorology, Germany	Marsland et al. (2003)
3	GISS-E2-R	180, 288, 32	NASA/GISS (Goddard Institute for Space Studies) New York, NY	Hansen et al. (2007)
4	CCSM4	384, 320, 60	NCAR (National Centre for Atmospheric Research) Boulder, CO, USA	Gent et.al. (2011)
5	BCC-CSM1	232, 360, 40	Beijing Climate Centre (BCC), China Meteorological Administration, China	Wu et al. (2014)
6	MRI-CGCM3	368, 360, 51	Meteorological Research Institute, Tsukuba, Japan	Yukimoto et al. (2012)
7	FGOALS-S2	196, 360, 30	LASG, IAP, CAS, Beijing, China	Bao et al. (2013)
8	CESM1	384, 320, 60	National Centre for Atmospheric Research (NCAR)	Otto-Bliesner et al. (2015)
9	LOVECLIM	65, 120, 20	Georges Lemaitre Centre for Earth and Climate Research, Belgium	Goosse et al. (2010)