The future sea-level contribution of the Greenland ice sheet: a multi-model ensemble study of ISMIP6

Heiko Goelzer[1,2], the ISMIP6 Team and the ISMIP6 Participants
[1]Institute for Marine and Atmospheric research Utrecht, Utrecht University, Netherlands
[2]Laboratoire de Glaciologie, Université Libre de Bruxelles, Brussels, Belgium

EGU2020: Sharing Geoscience Online, May 7 2020

This display is based on a paper in discussion in The Cryosphere:

Goelzer, H., Nowicki, S., Payne, A., Larour, E., Seroussi, H., Lipscomb, W. H., Gregory, J., Abe-Ouchi, A., Shepherd, A., Simon, E., Agosta, C., Alexander, P., Aschwanden, A., Barthel, A., Calov, R., Chambers, C., Choi, Y., Cuzzone, J., Dumas, C., Edwards, T., Felikson, D., Fettweis, X., Golledge, N. R., Greve, R., Humbert, A., Huybrechts, P., Le clec'h, S., Lee, V., Leguy, G., Little, C., Lowry, D. P., Morlighem, M., Nias, I., Quiquet, A., Rückamp, M., Schlegel, N.-J., Slater, D., Smith, R., Straneo, F., Tarasov, L., van de Wal, R., and van den Broeke, M.: The future sea-level contribution of the Greenland ice sheet: a multi-model ensemble study of ISMIP6, The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-319, in review, 2020.

https://www.the-cryosphere-discuss.net/tc-2019-319/

The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6)

- Goals:
  - Estimate future sea-level contributions from the Greenland and Antarctic ice sheets, along with associated uncertainty
  - Provide input for the current IPCC assessment cycle (AR6)

- First time ice sheet projections are fully integrated within the CMIP framework (endorsed MIP)

Experimental setup for Greenland

CMIP5 models

- selected based on performance over historical period
- maximise spread in projections (ocean and atmosphere)

Barthel et al., TC (2020)

Atmosphere forcing

- RCM (MAR) forced by GCMs
- SMB anomalies relative to 1960-1989
- SMB elevation feedback parameterized based on d(Runoff)/dz

Delhasse et al., TC (2020)

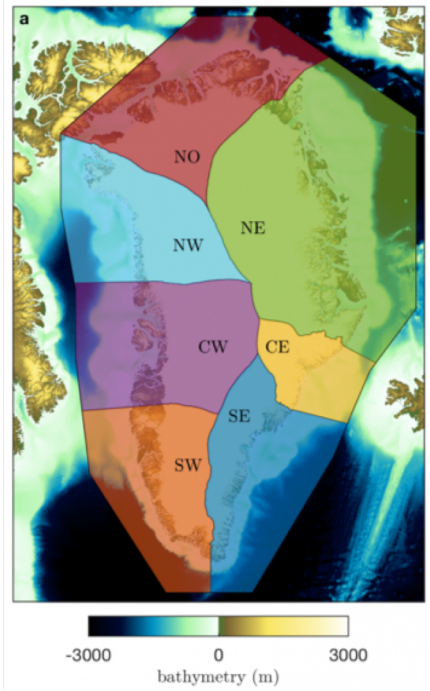
Ocean forcing

- Outlet glacier retreat scenarios
- Empirically derived retreat parameterisation based on ocean temperature and runoff
- Prescribed retreat masks

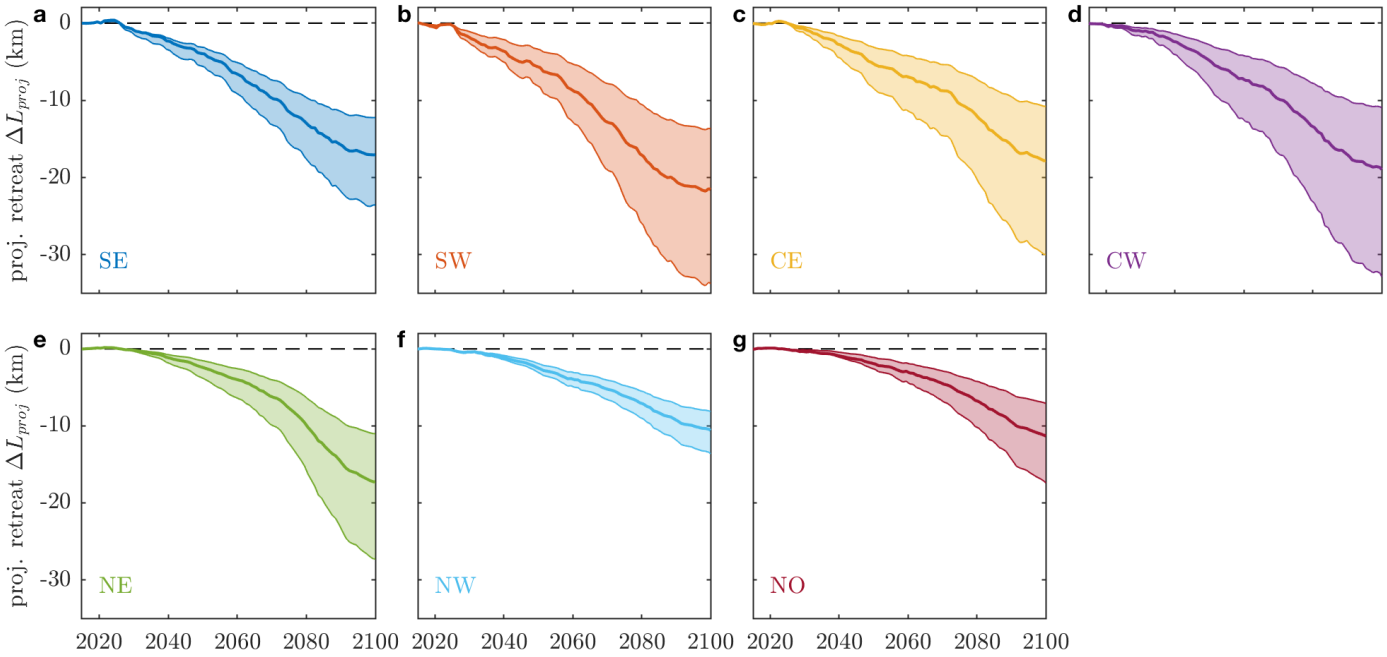
Slater et al., TC (2019, 2020)

Ocean forcing - approach

- Empirically derived retreat parameterisation based on ocean temperature, runoff and observed retreat

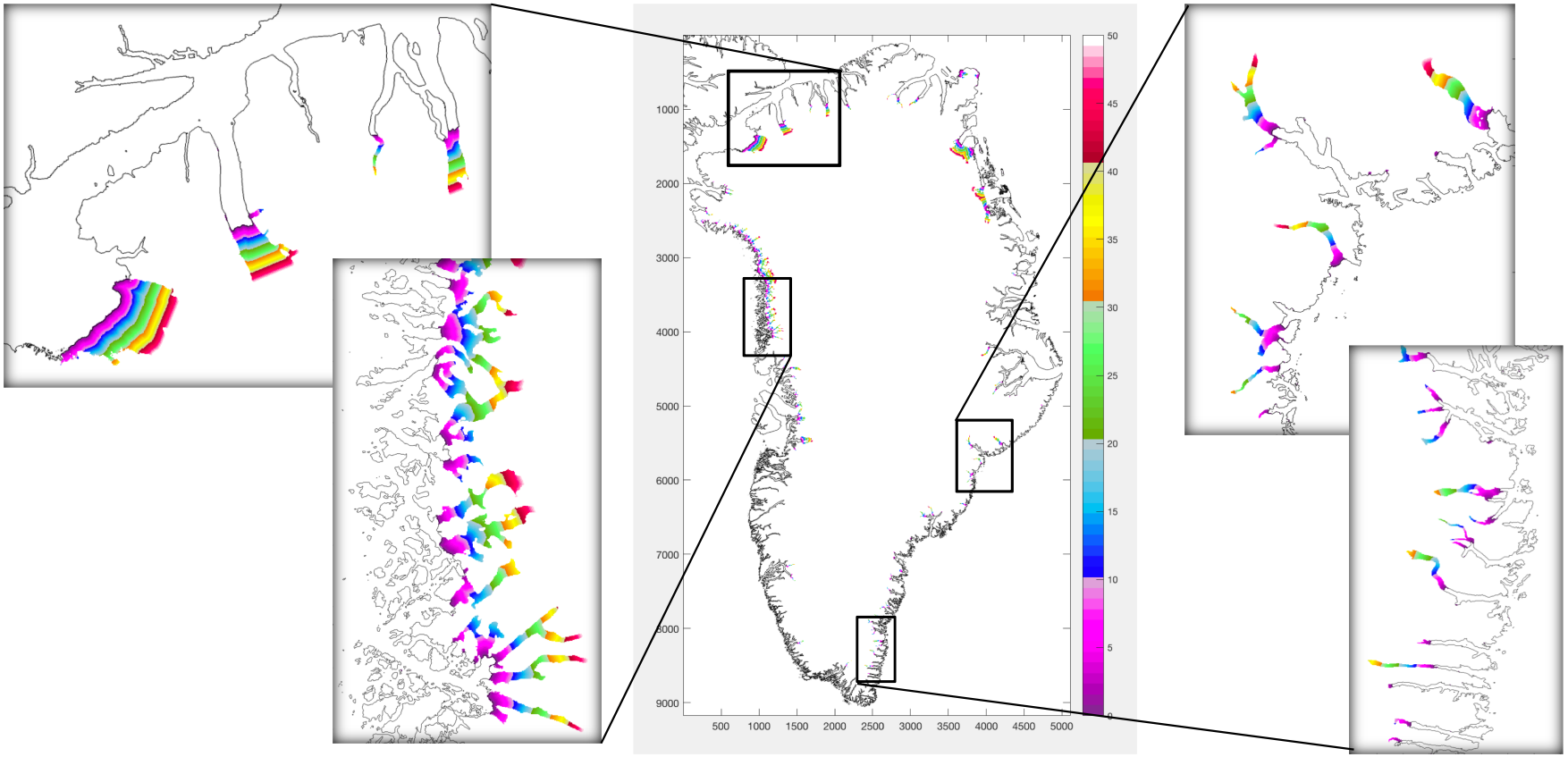


Slater et al., TC (2019, 2020)



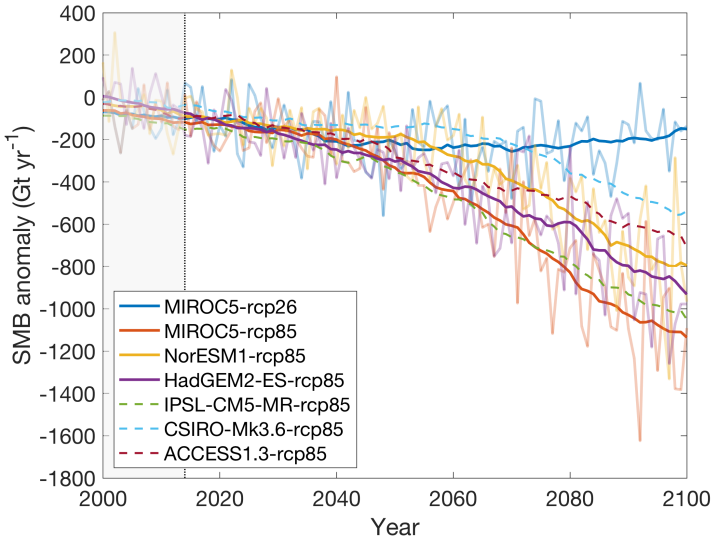
Projected retreat by sector showing median (line) and interquartile range (shading)

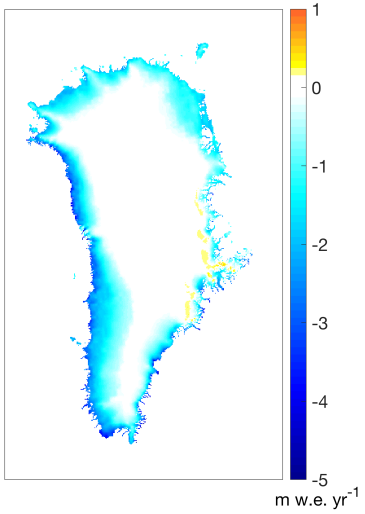
Ocean forcing - implementation

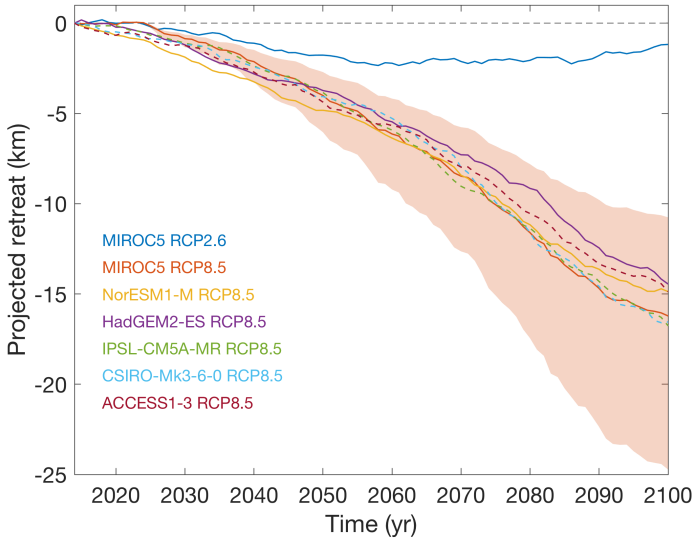


- Outlet glacier retreat implemented in ISMs as a series of masks that define the calving front positions

GCM-based forcing







- Atmospheric and oceanic forcing
- Projections until year 2100
- SMB anomaly (left, middle) and projected retreat (right) from 6 different CMIP5 GCMs

Experiments

Core experiments

- 3 CMIP5 GCMs to sample the ensemble range
- 2 scenarios (RCP8.5 and RCP2.6)
- 3 ocean forcing sensitivities

Additional experiments for groups with available resources

- 3 additional CMIP5 models
- Sensitivity experiments
- CMIP6 models as they become available

	GCM	Scenario	Sensitivity
Core	MIROC5	RCP8.5	medium
	NorESM	RCP8.5	medium
	MIROC5	RCP2.6	medium
	HadGEM2-ES	RCP8.5	medium
	MIROC5	RCP8.5	high
	MIROC5	RCP8.5	low
Extension	IPSL-CM5-MR	RCP8.5	medium
	CSIRO-Mk3.6	RCP8.5	medium
	ACCESS1.3	RCP8.5	medium

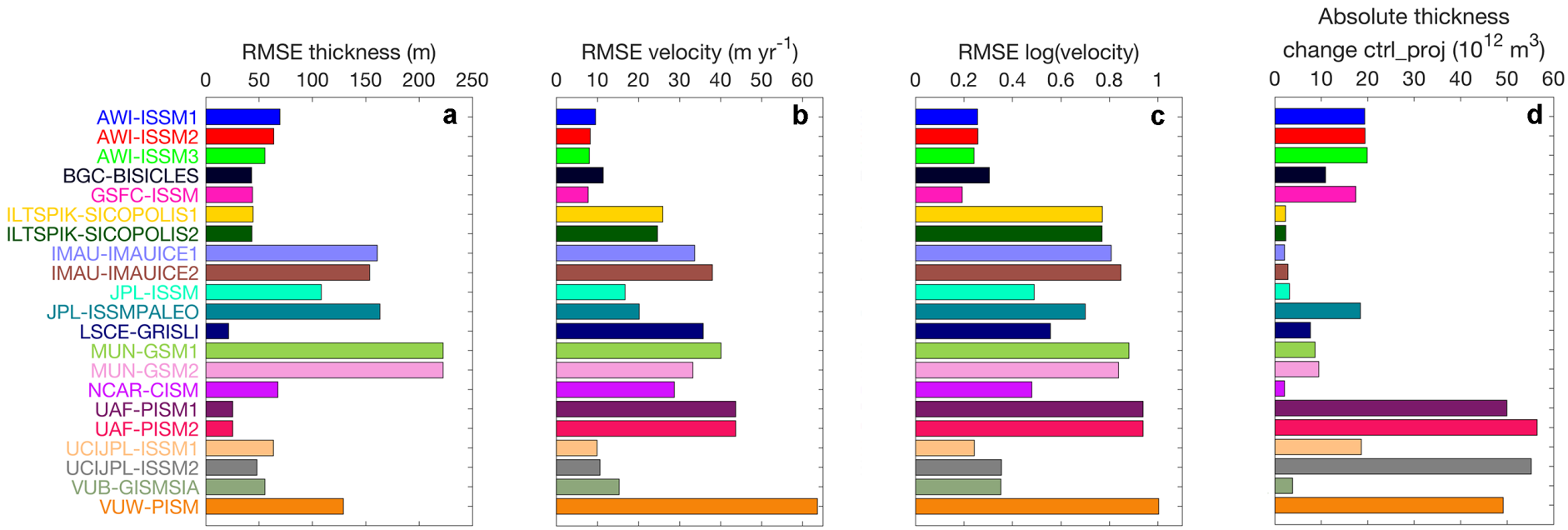
Participants

- AWI-ISSM
- ILTSPIK-SICOPOLIS
- IMAU-IMAUICE
- JPL-ISSM
- LSCE-GRISLI
- MUN-GSM
- UCIJPL-ISSM
- BGC-BISICLES
- GSFC-ISSM
- NCAR-CISM
- JPL-ISSMPALEO
- UAF-PISM
- VUW-PISM
- VUB-GISM

- 21 models of different resolution and complexity

- Initialization to the year 2015 is the responsibility of the modellers → various different initialization strategies

Evaluating the initial states

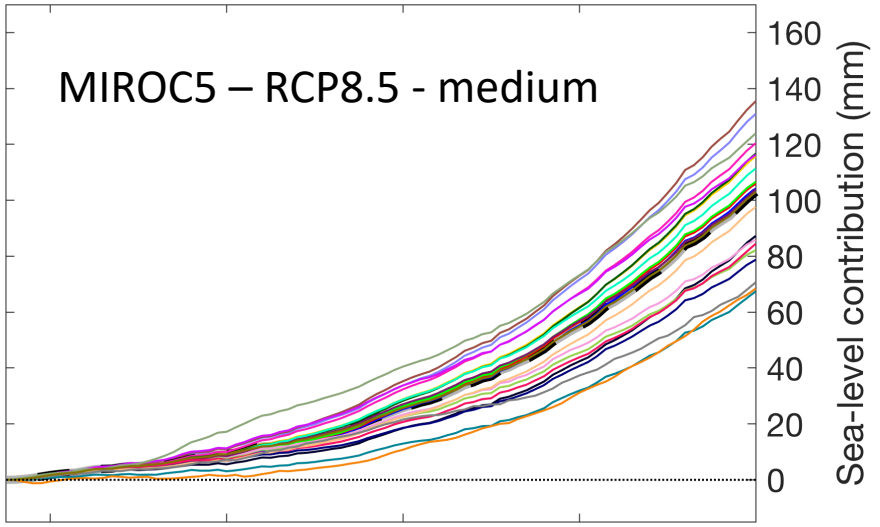


- Possible to evaluate models compared to observations
- Complementary metrics required!

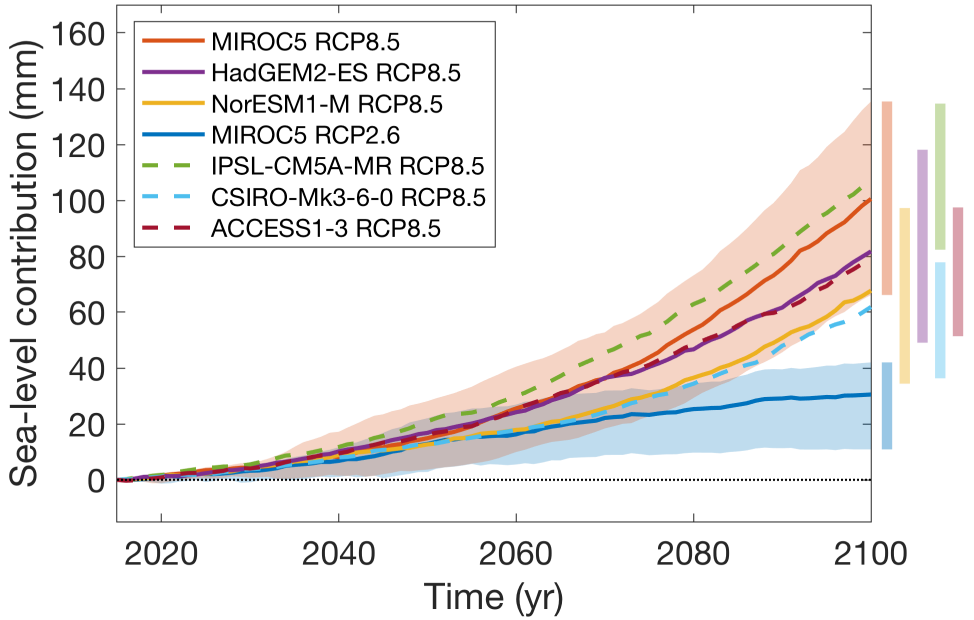
Projections

Projections

- For MIROC5-RCP8.5 (2100) between 67 mm and 135 mm
- ISM ensemble mean (n=21): 101 ± 41 mm

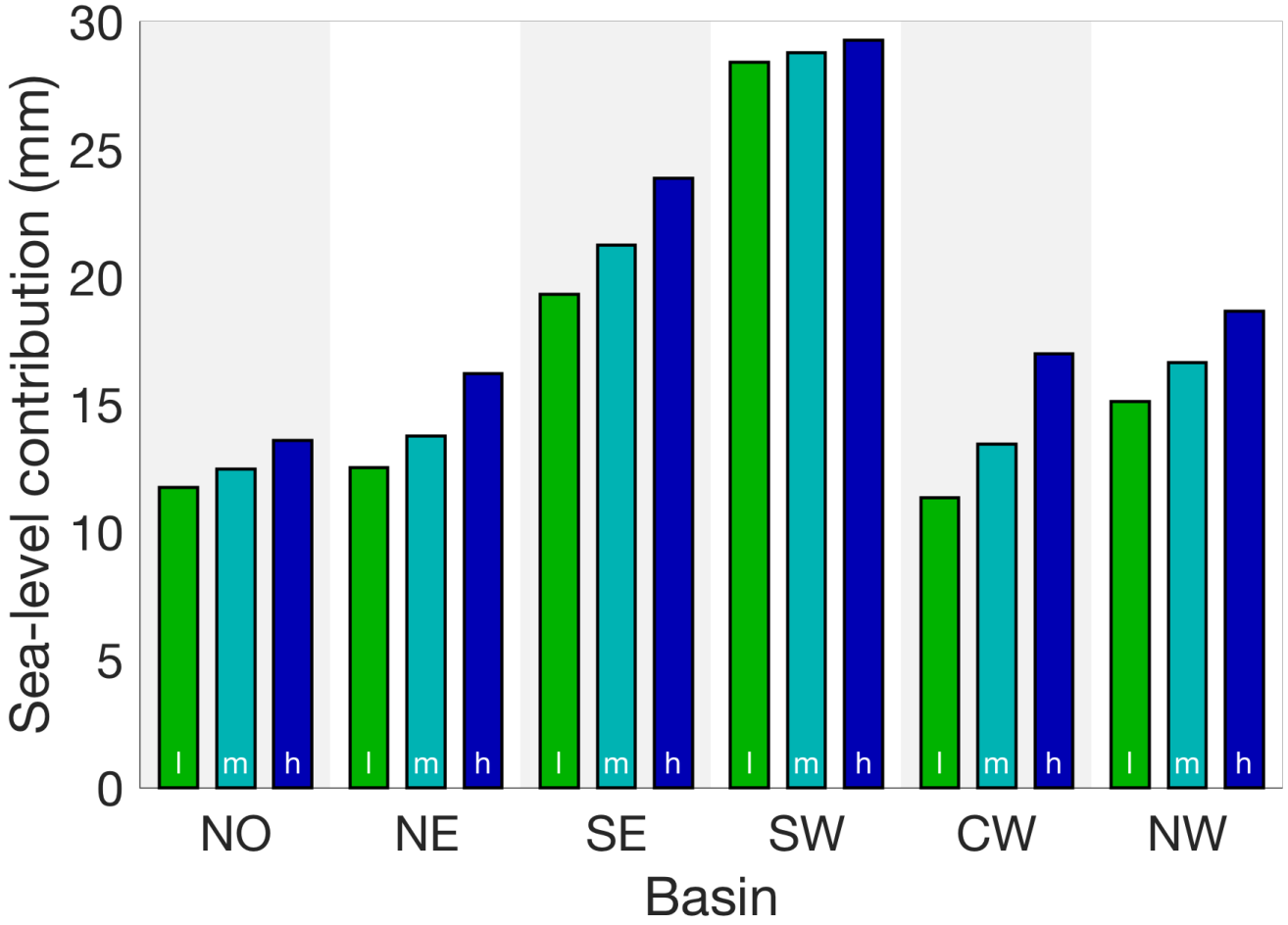


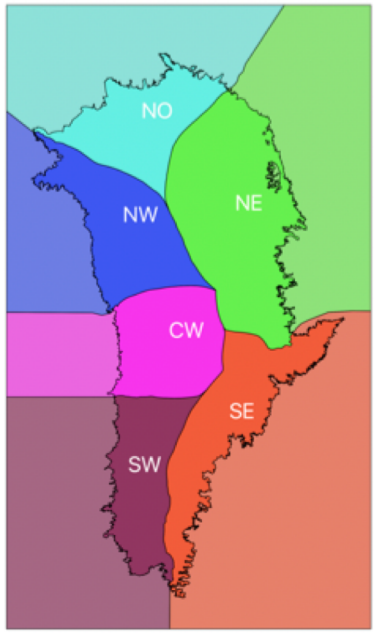
- For RCP2.6: 31 ± 16 mm (stabilizing)
- For RCP8.5 with all 6 GCMs 89 ± 51 mm



Uncertainty

- Comparison between three different ocean sensitivities (l=low, m=med, h=high) per basin

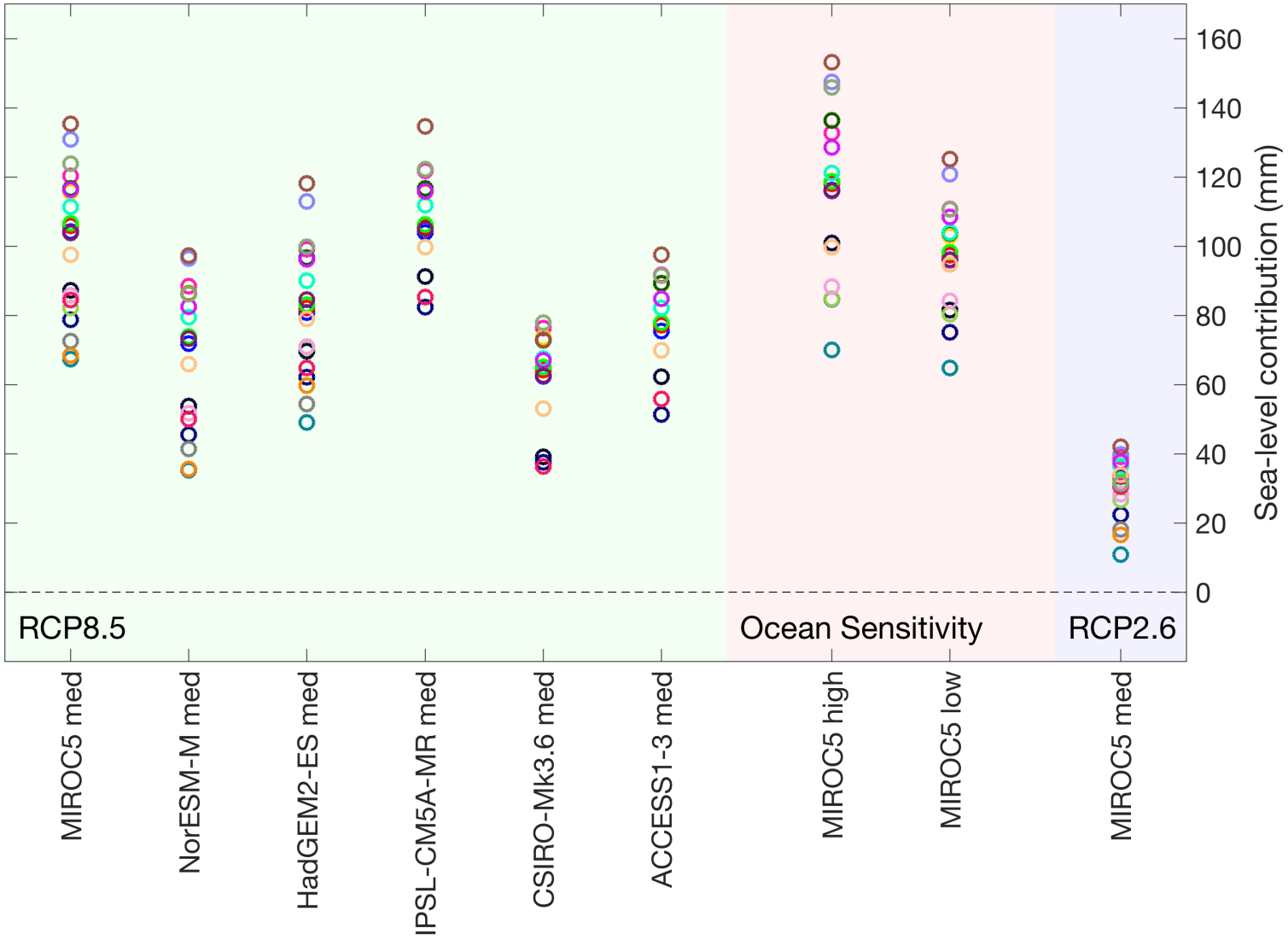




Summary

- The Greenland ice sheet will continue to lose mass until 2100 with contributions of 89 ± 51 mm (RCP8.5) and 31 ± 16 mm (RCP2.6) to sea-level rise.
- Under RCP8.5 forcing, ice sheet model uncertainty explains an ensemble spread of 40 mm, the climate model uncertainty 36 mm and the ocean forcing uncertainty 19 mm.
- The largest gap in our knowledge is about the physical understanding and implementation of the calving process, i.e. the interaction of the ice sheet with the ocean.

Overview

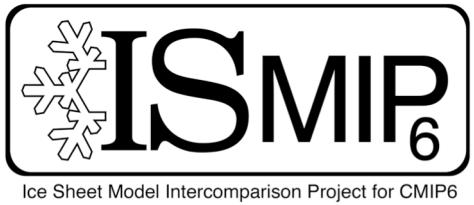

RCP8.5
Ocean Sensitivity
RCP2.6
Sea-level contribution (mm)
0
20
40
60
80
100
120
140
160
MIROC5 med
NorESM-M med
HadGEM2-ES med
IPSL-CM5A-MR med
CSIRO-Mk3.6 med
ACCESS1-3 med
MIROC5 high
MIROC5 low
MIROC5 med

Thank you

- CMIP model evaluation: Alice Barthel, Chris Little, Cécile Agosta, Jamie Holte, …
- Atmosphere forcing: Bill Lipscomb, Robin Smith, Xavier Fettweis, Patrick Alexander, …
- Ocean forcing: Fiamma Straneo, Donald Slater, Denis Felikson, Mathieu Morlighem, …
- ISM model results: All ice sheet modellers contributing to ISMIP6

And, thank you … for your attention!

ISMIP6 information and contact



- **ISMIP6** web page:
http://www.climate-cryosphere.org/mips/ismip6/about

- **ISMIP6** wiki page:
http://www.climate-cryosphere.org/wiki/index.php?title=ISMIP6_wiki_page

- Contact the **ISMIP6** team
ismip6@gmail.com