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ISMIP6 Future Projections for Antarctica performed using the AWI PISM ice sheet model

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CR1.1 | D2573 | EGU2020-16948

For details about the ISMIP6 protocol check
http://www.climate-cryosphere.org/wiki/index.php?title=ISMIP6-Projections-Antarctica

PALMOD GERMAN CLIMATE MODELING INITIATIVE

ISMIP6 Ice Sheet Model Intercomparison Project for CMIP6

PISM Parallel Ice Sheet Model

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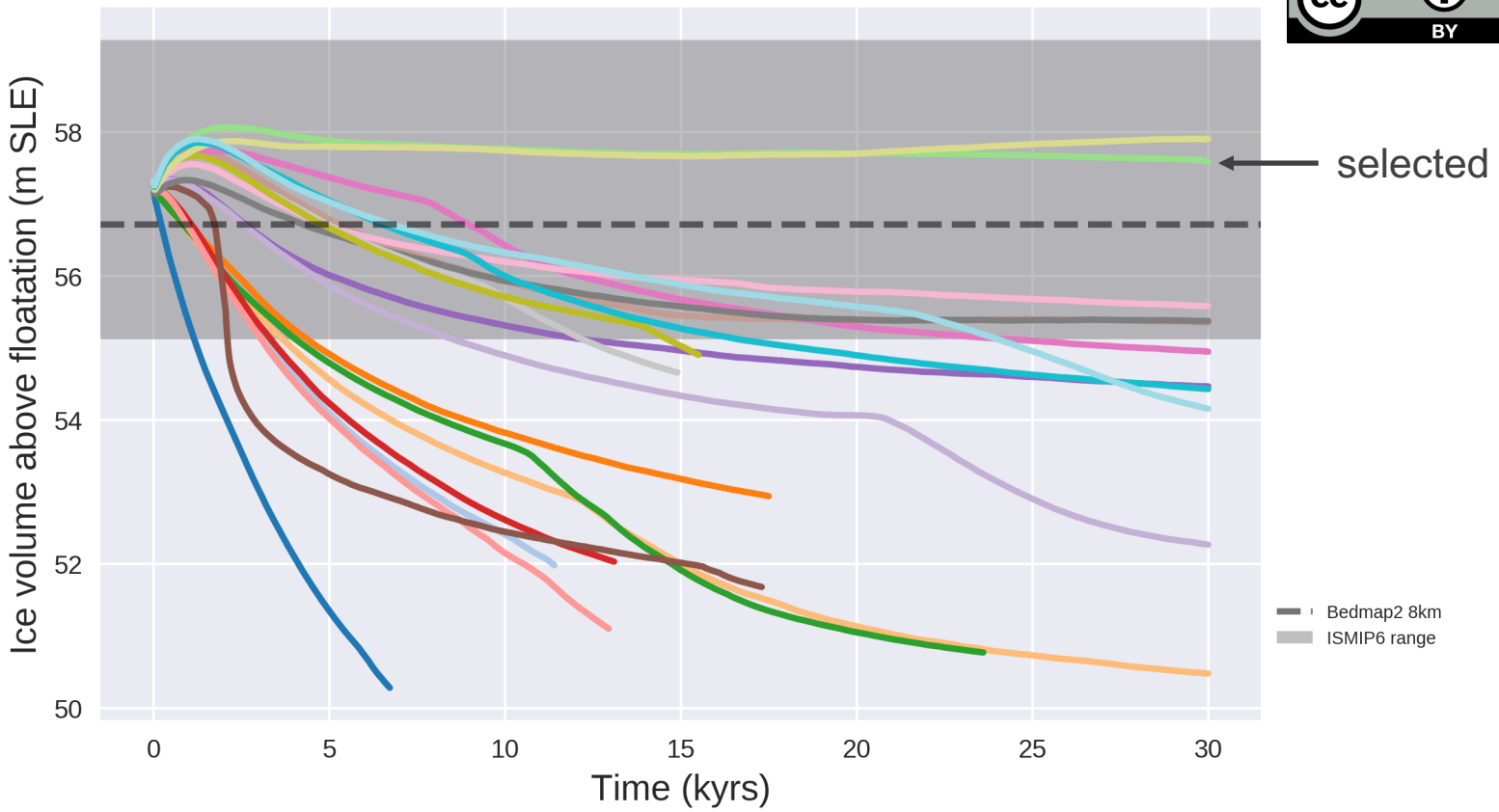
Summary

- All core (Tier 1) and extended ensemble (Tier 2) experiments for Antarctica contributed to ISMIP6 as AWI-PISM (Seroussi et al. 2020, TCD)
- Initial state after model spin-up has been improved compared to the initMIP phase of ISMIP6 (Seroussi et al. 2019, TC)
- Grounded ice mass loss only -4.9 Gt/yr and -4.4 Gt/yr (-0.01 mm/yr SLE) in 'historical' (2005-2014) and 'ctrl_proj' (2015-2100), respectively, compared to observed estimates, e.g. −137.0 ± 24.9 Gt/yr (2010–2017) (Schröder et al., 2019)
- Most of the projection runs show grounding line retreat and grounded ice mass loss.
- The simulated grounded ice mass loss does not convert into a positive sea-level contribution.
- Ocean warming induced grounding line retreat removes mainly ice that is already close to floatation. Thus, the simulated sea-level contribution is only very small.
- Increased surface mass balance, especially in areas grounded well above the sea level, dominates the model response and leads to negative sea-level contributions.

Calibration and spin-up selection

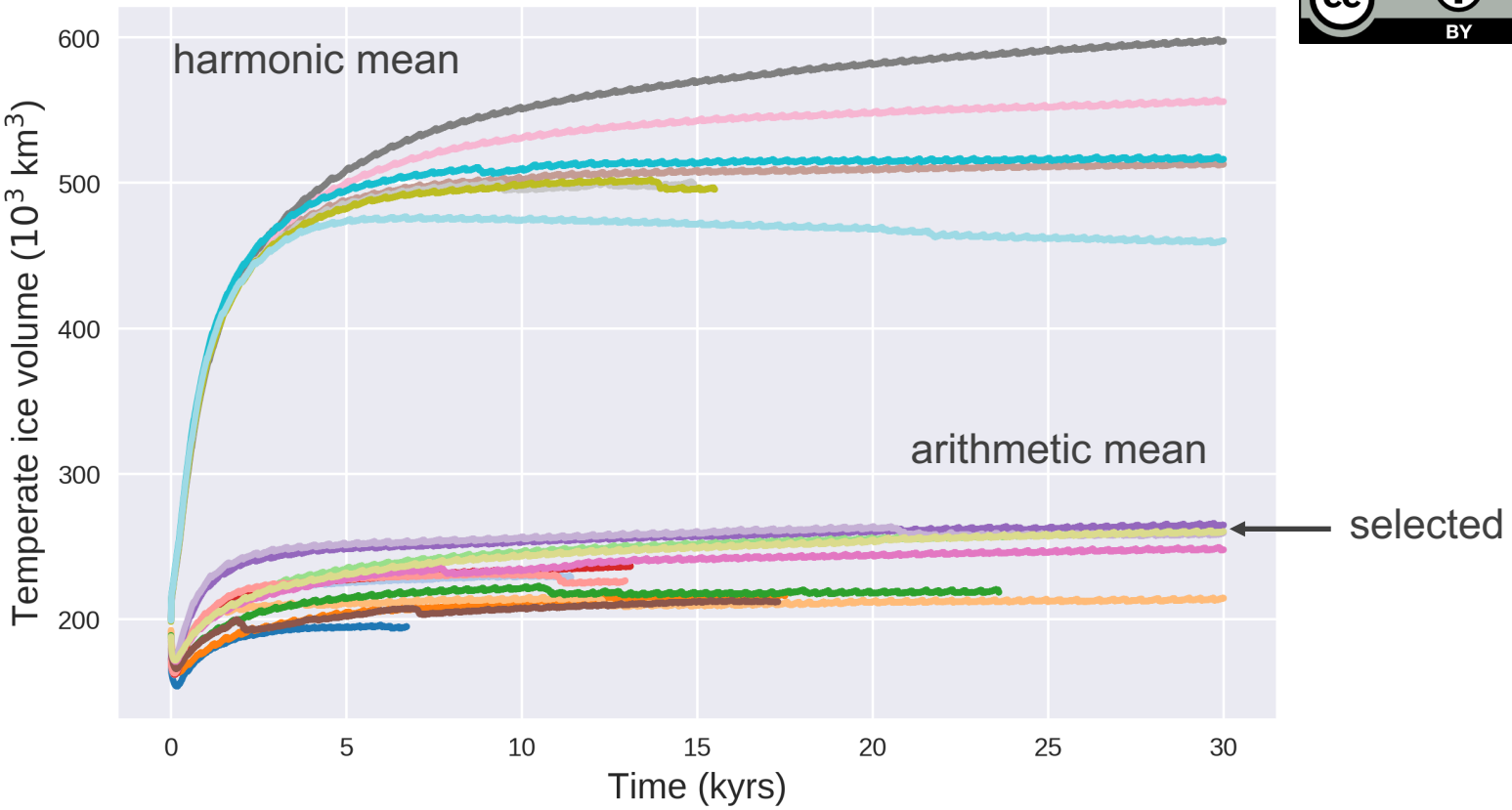
A few examples only …



- 30 kyrs spin-up with PISM running in hybrid mode (SIA+SSA) after 200 kyrs of thermal spin-up, both with steady present-day climate on 8 km grid
- tuning targets: observed ice sheet geometry, surface flow speed, total ice volume above floatation, small drift (equilibrium-type)

Calibration and spin-up selection

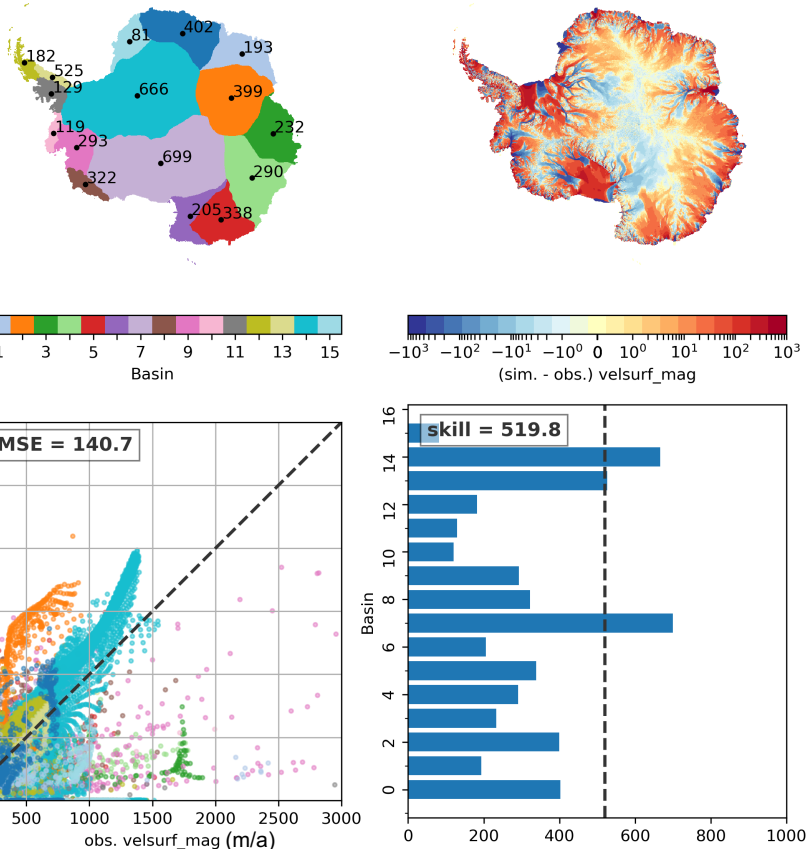
A few examples only …



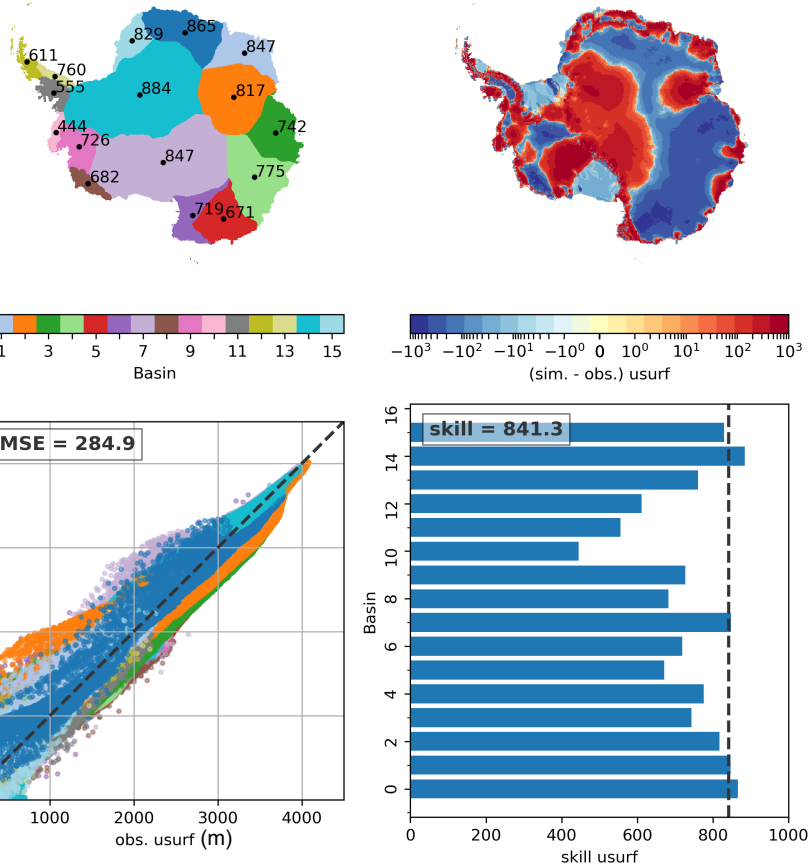
- Clear distinction between arithmetic mean (PISM default) and harmonic mean in enthalpy solver. Temperate ice volume is more than doubled for the harmonic mean.
- The conductivity ratio is CR=10^{-3} instead of 10^{-1} (PISM default).

The initial state (year 2005)

Surface flow speed

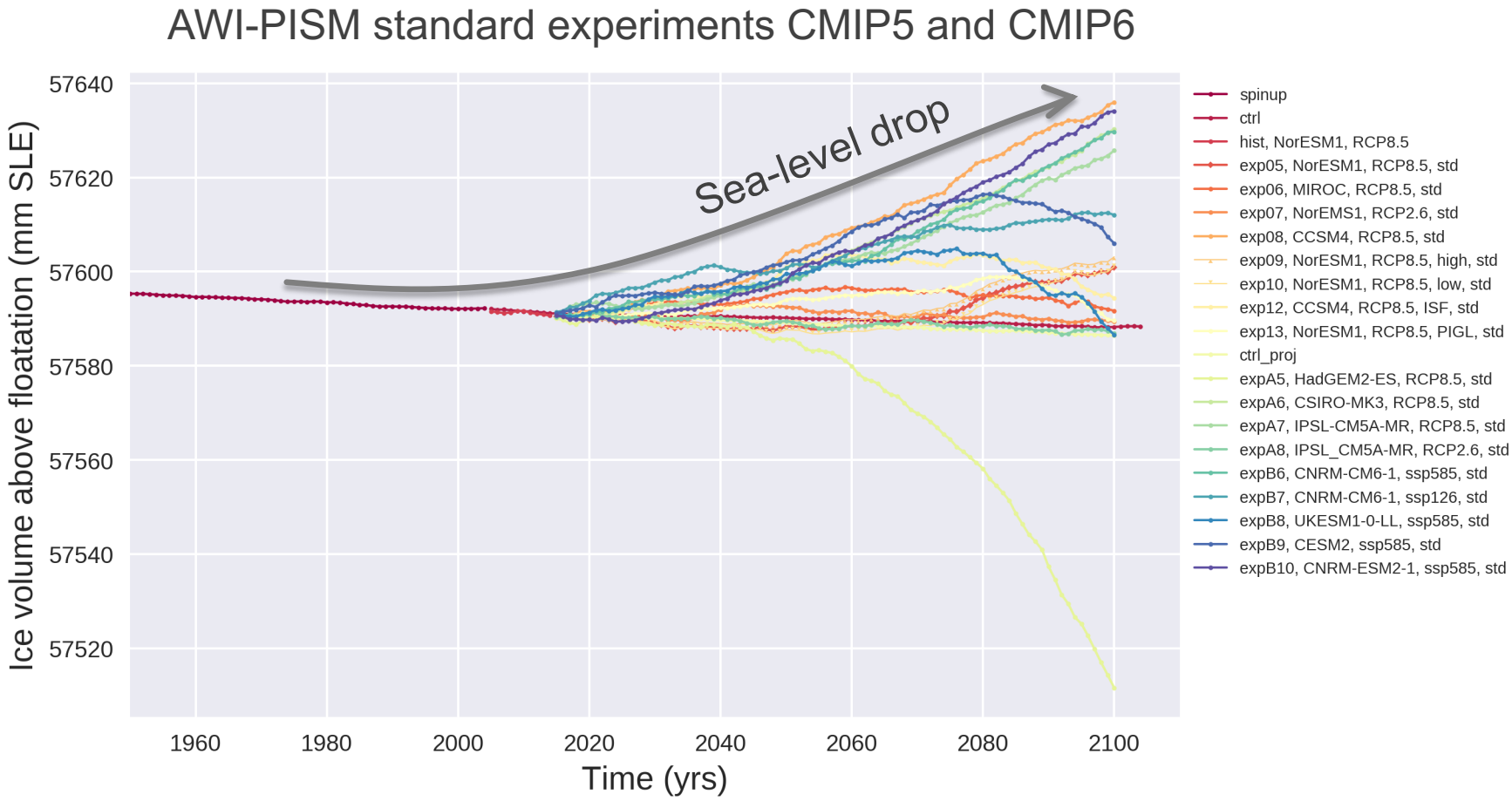


Geometry

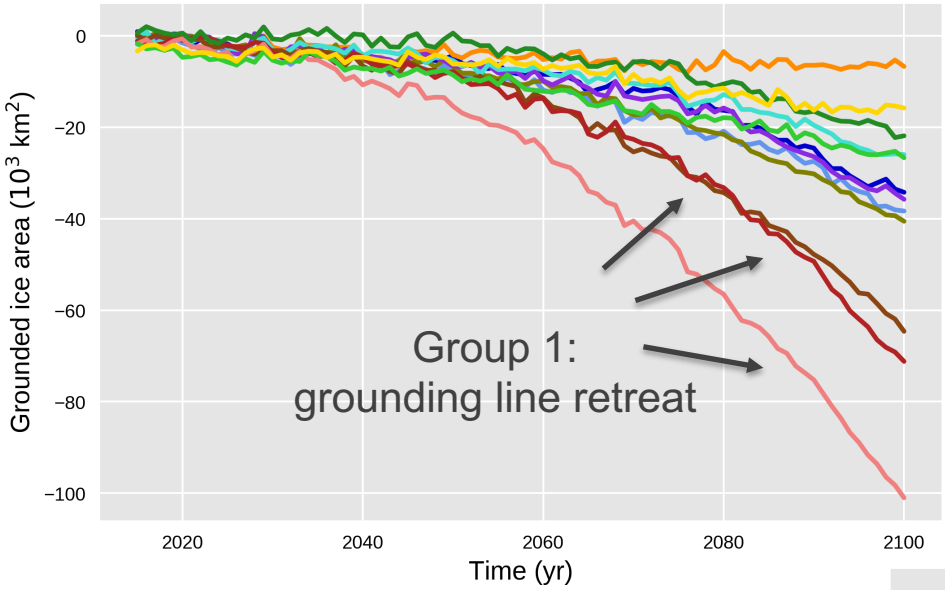


We use Watterson et al. (2014) skill scores for surface flow speed and upper surface elevation (or ice thickness). The used datasets are Bedmap2 (Fretwell et al., 2013) and MEaSUREs (Rignot et al., 2011), respectively.

ISMIP6-Projections



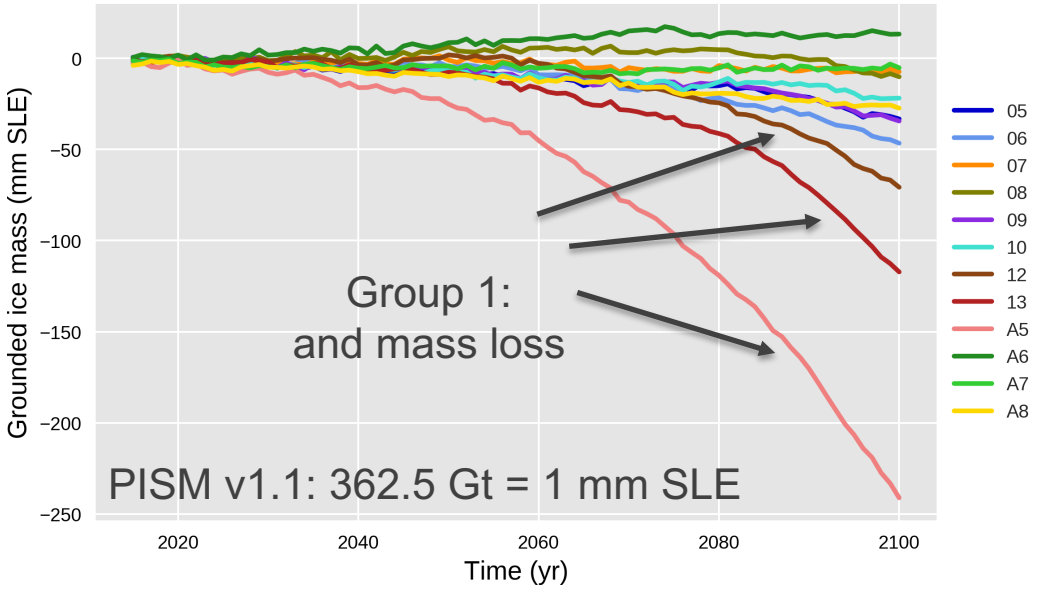
ISMIP6-Projections



- Grounding line retreat and grounded ice mass loss for all but one (expA6) simulations.
- Strongest for experiments with
  - Ice shelf collapse (exp12)
  - PIGL calibration (exp13)
  - extreme end-of-21st-century ocean warming (expA5)

Note:

- All is relative to the “ctrl_proj” simulation.
- Colours have changed for the CMIP5 “standard” subset of experiments on this slide.



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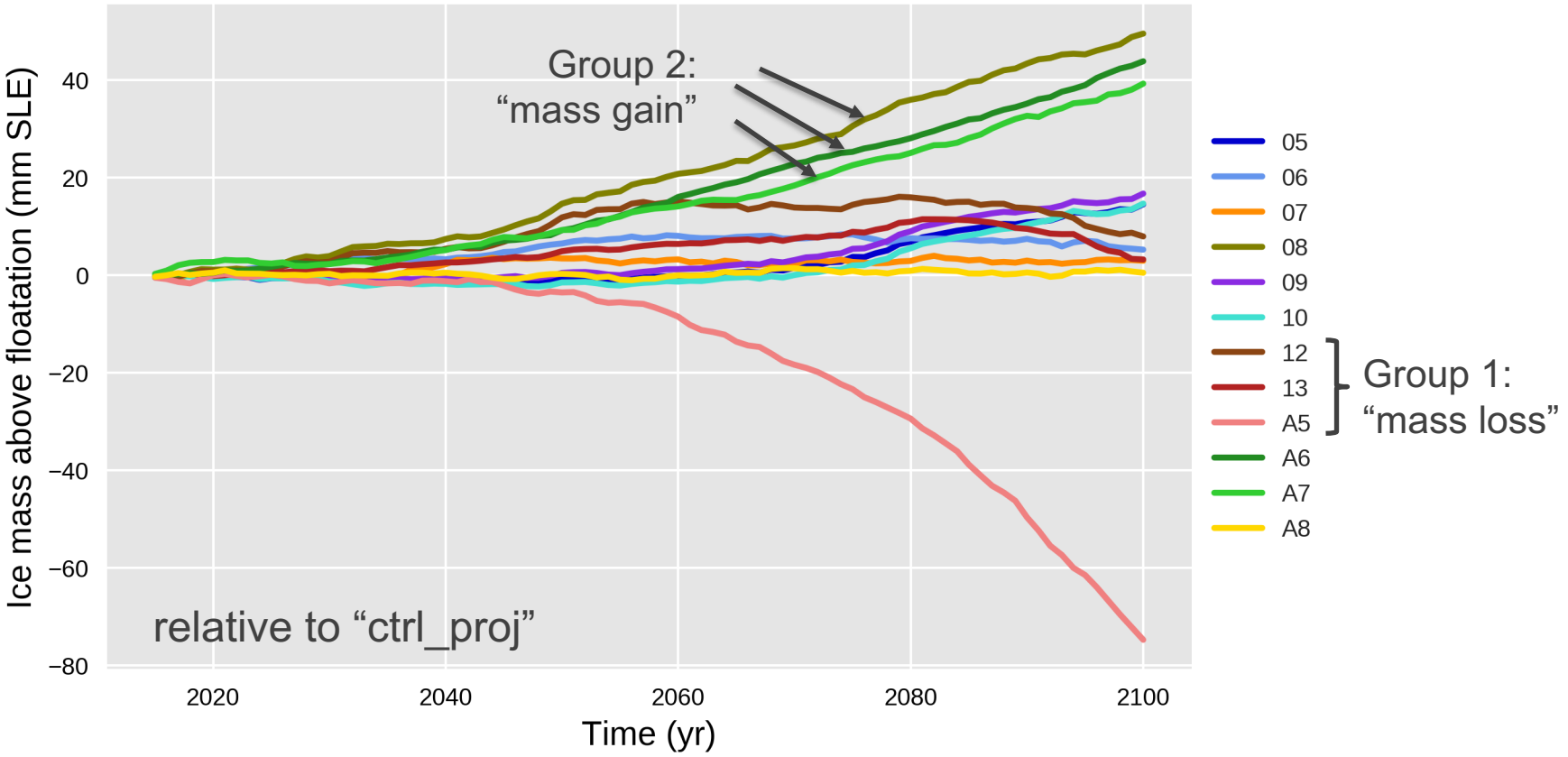
ISMIP6-Projections

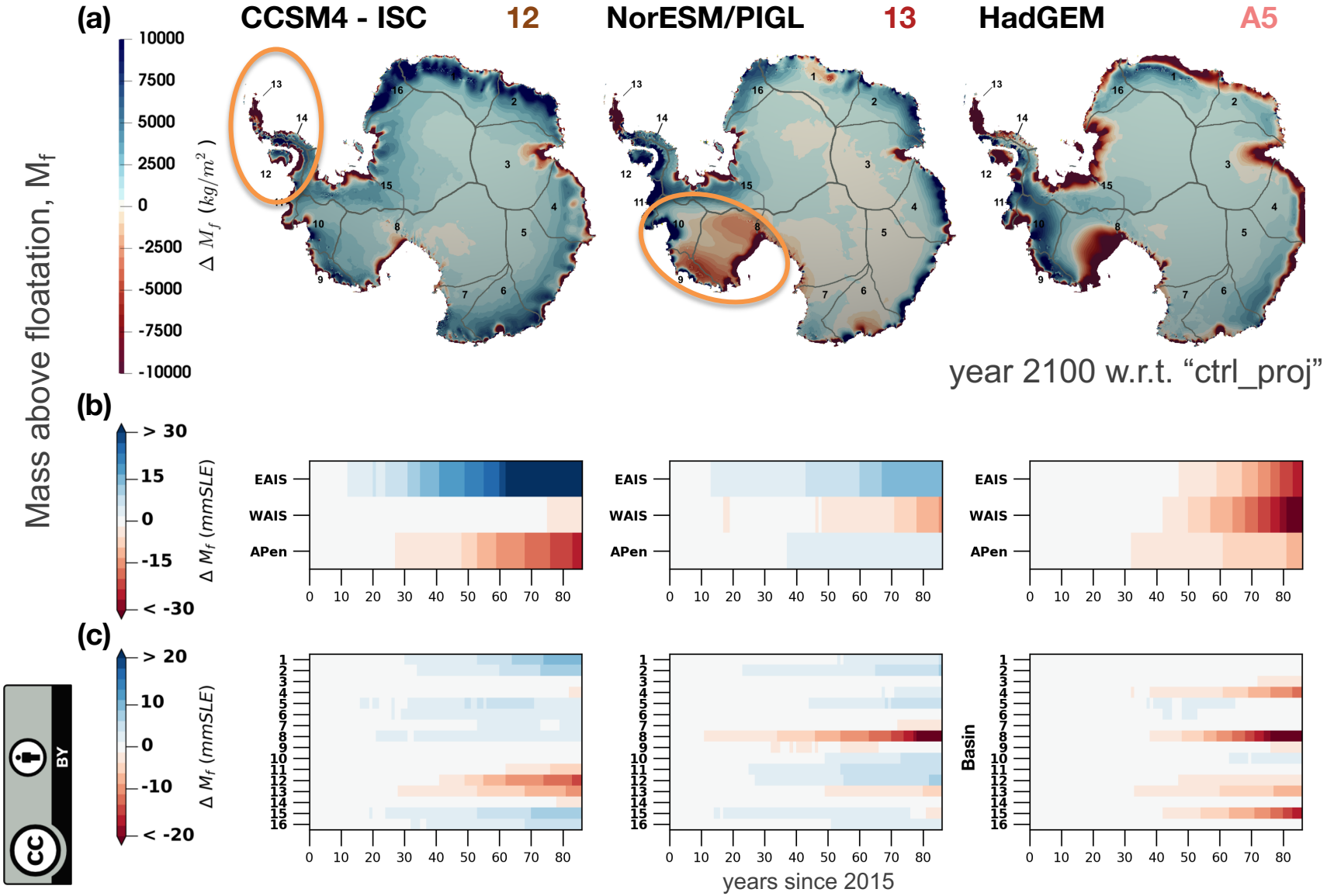
AWI-PISM standard experiments CMIP5 only



- Only very small and negative contribution to sea-level from exp12 and exp13.
- A strong negative sea-level contribution from exp08, expA6 and expA7.

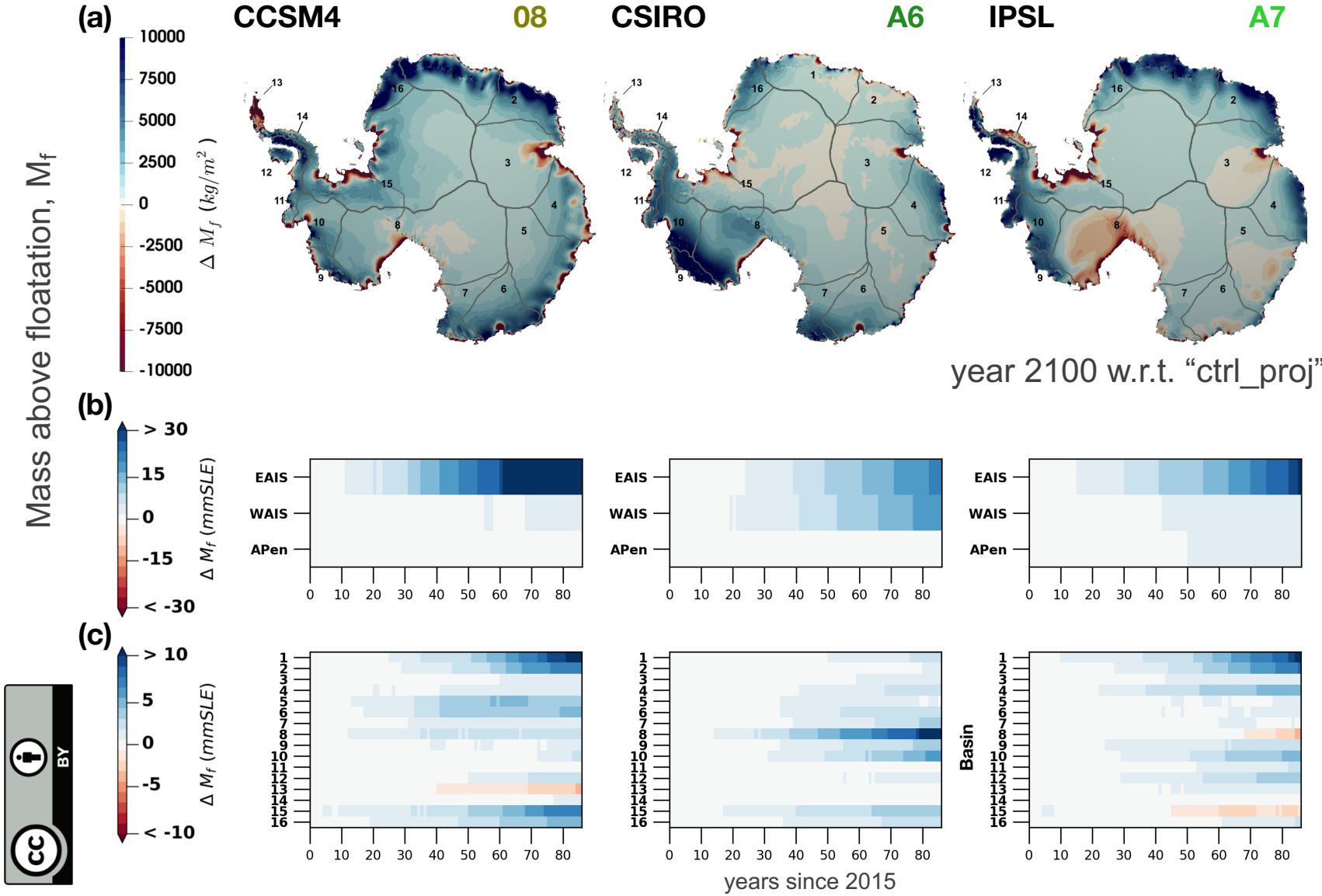
Local and basin-scale mass changes

Group 1 (“mass loss”)

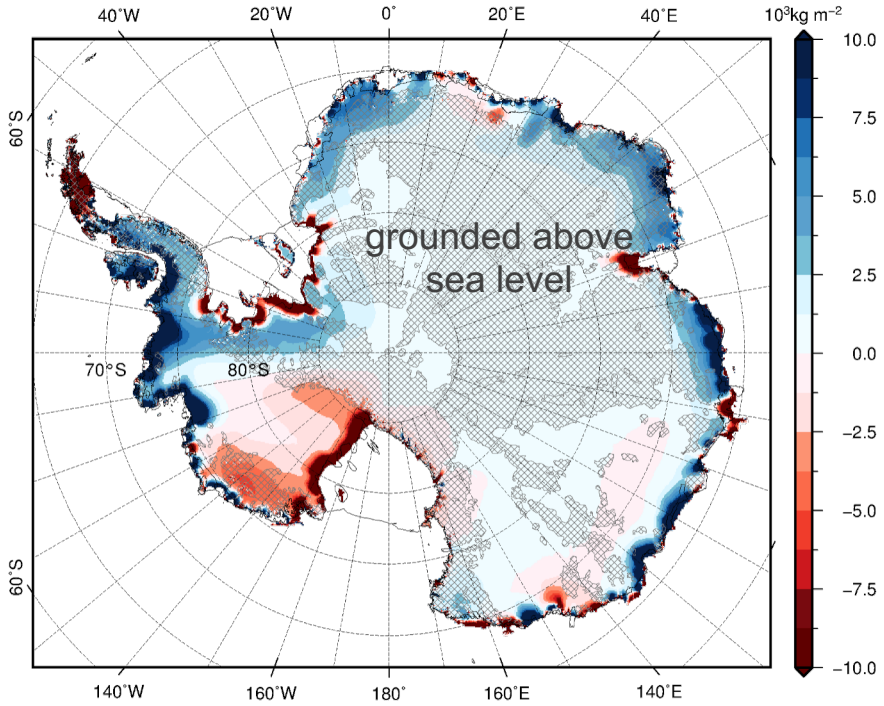


Local and basin-scale mass changes

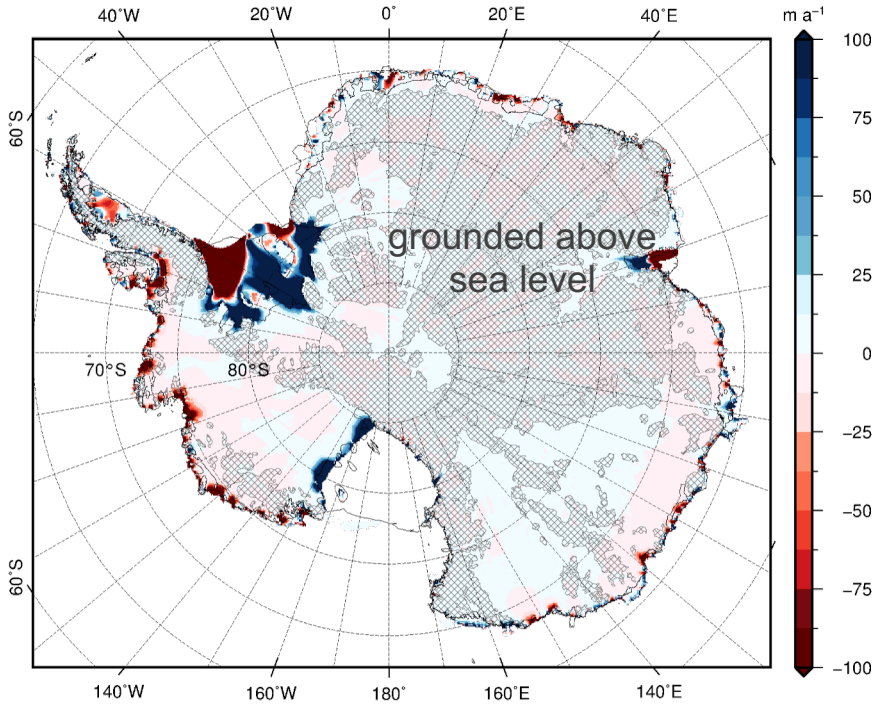
Group 2 (“mass gain”)



Example: NORESM1-M/PIGL (exp13)



Grounded ice mass change (10^3 kg/m^2)
w.r.t "cntr_proj" in year 2100



Surface velocity change (m/yr)
w.r.t "cntr_proj" in year 2100

- Ocean warming induced grounding line retreat removes mainly ice that is already close to floatation. Thus, the simulated sea-level contribution is only very small.

- The model results in glacier slow down in the Amundsen Sea Embayment area instead of the observed accelerated ice discharge (Mouginot et al., 2014) that predominantly drives the Antarctic mass loss today (e.g. Shepherd et al., 2018).