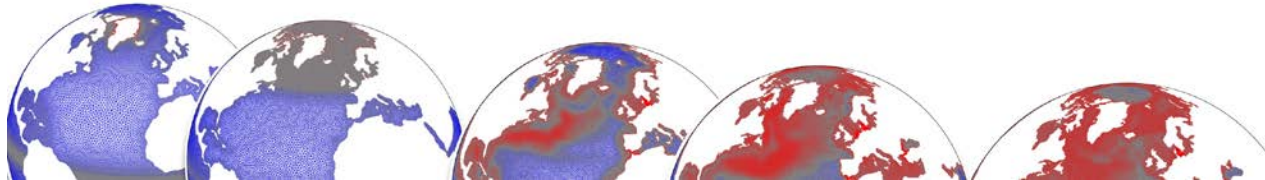# The AWI climate model: high-resolution climate modelling in CMIP6 and beyond
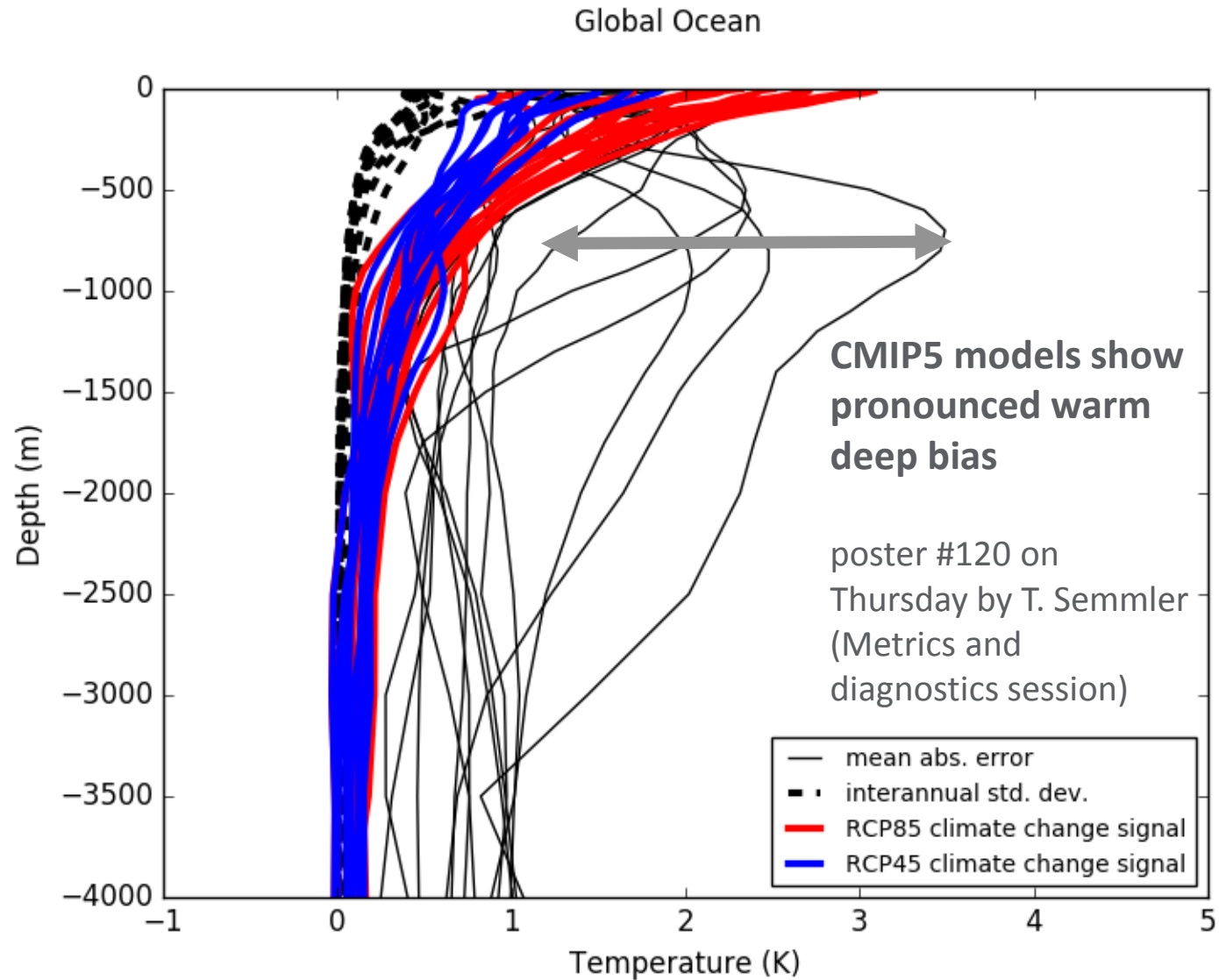
Tido Semmler,

Thomas Rackow, Dmitry Sein, Dmitry Sidorenko, Thomas Jung, Qiang Wang, Jan Hegewald, Christian Rodehacke
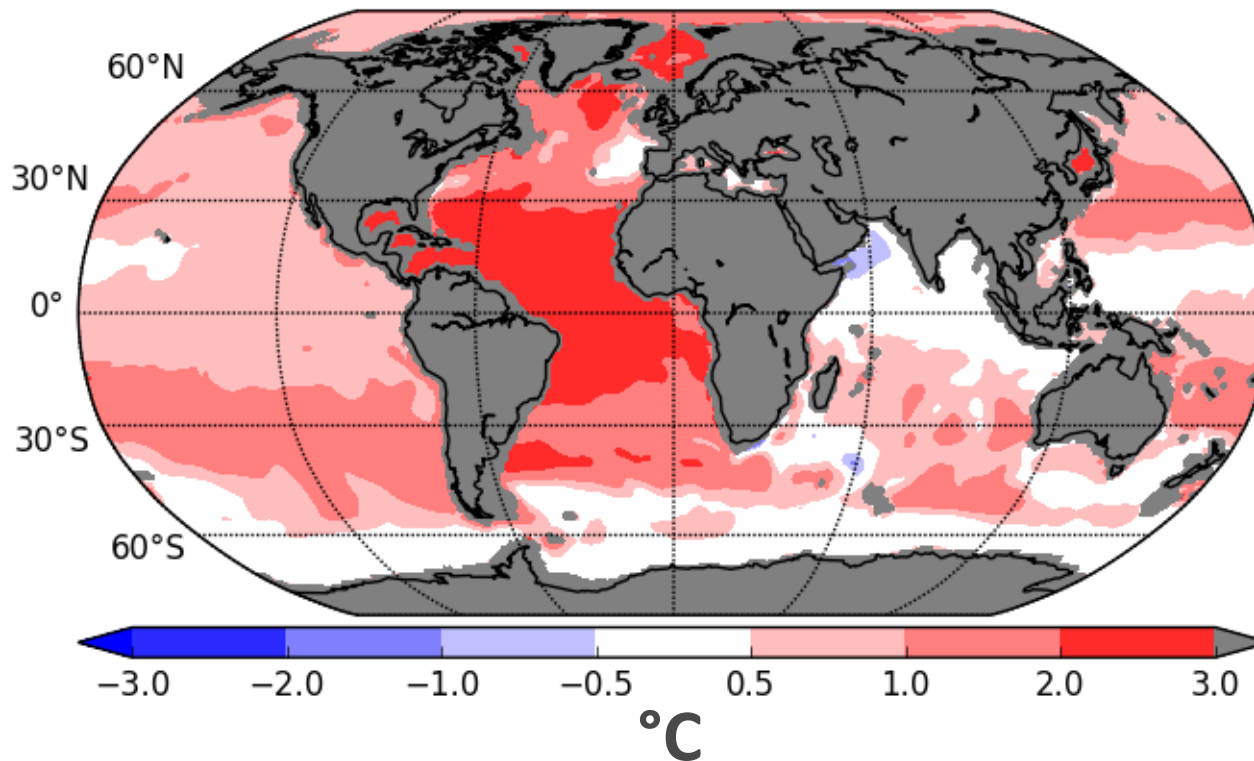

Workshop Polar Climate Change: Driving Processes, Extreme Events, and Global Linkages

Global Ocean

CMIP5 models show pronounced warm deep bias

poster #120 on Thursday by T. Semmler (Metrics and diagnostics session)

Legend:
- mean abs. error
- interannual std. dev.
- RCP85 climate change signal
- RCP45 climate change signal

ensemble mean
pot. temperature bias @ 1000m
in CMIP5 models

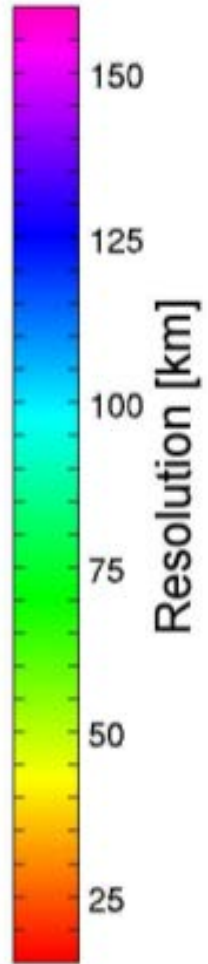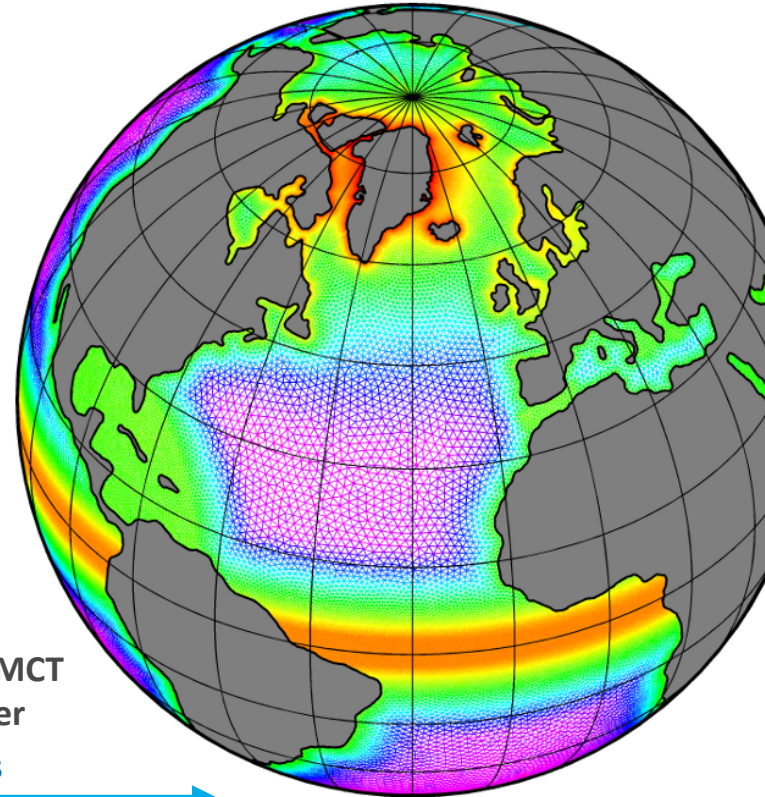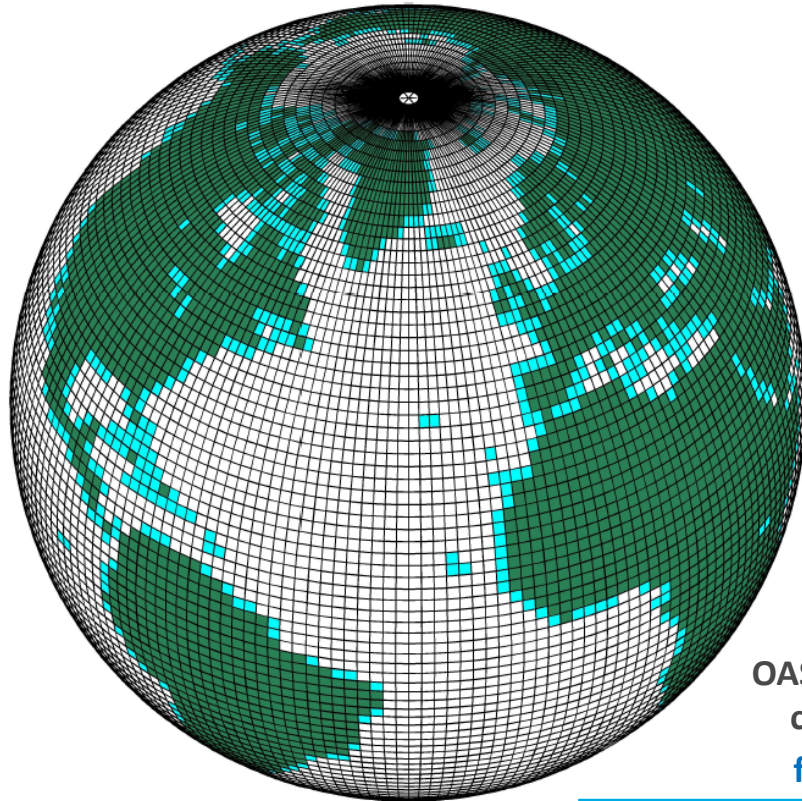**Q: Do we need to resolve smaller scales? Can resolution help?**

2. The AWI Climate Model (AWI-CM)

ECHAM6

Very useful for spatial resolution studies!

FESOM
(REF: „CMIP5-type" mesh)

OASIS3-MCT
coupler

fluxes →

← **ocean/ice state**

Resolution [km]

coupling schematic from Sidorenko & Rackow et al. (2015), Cli. Dyn.

2. AWI-CM: ocean-only frontier run

- simulated global circulation at 100 m depth ("XR" mesh)

FESOM YouTube channel

3. Hierarchy of "prototype CMIP6 simulations"
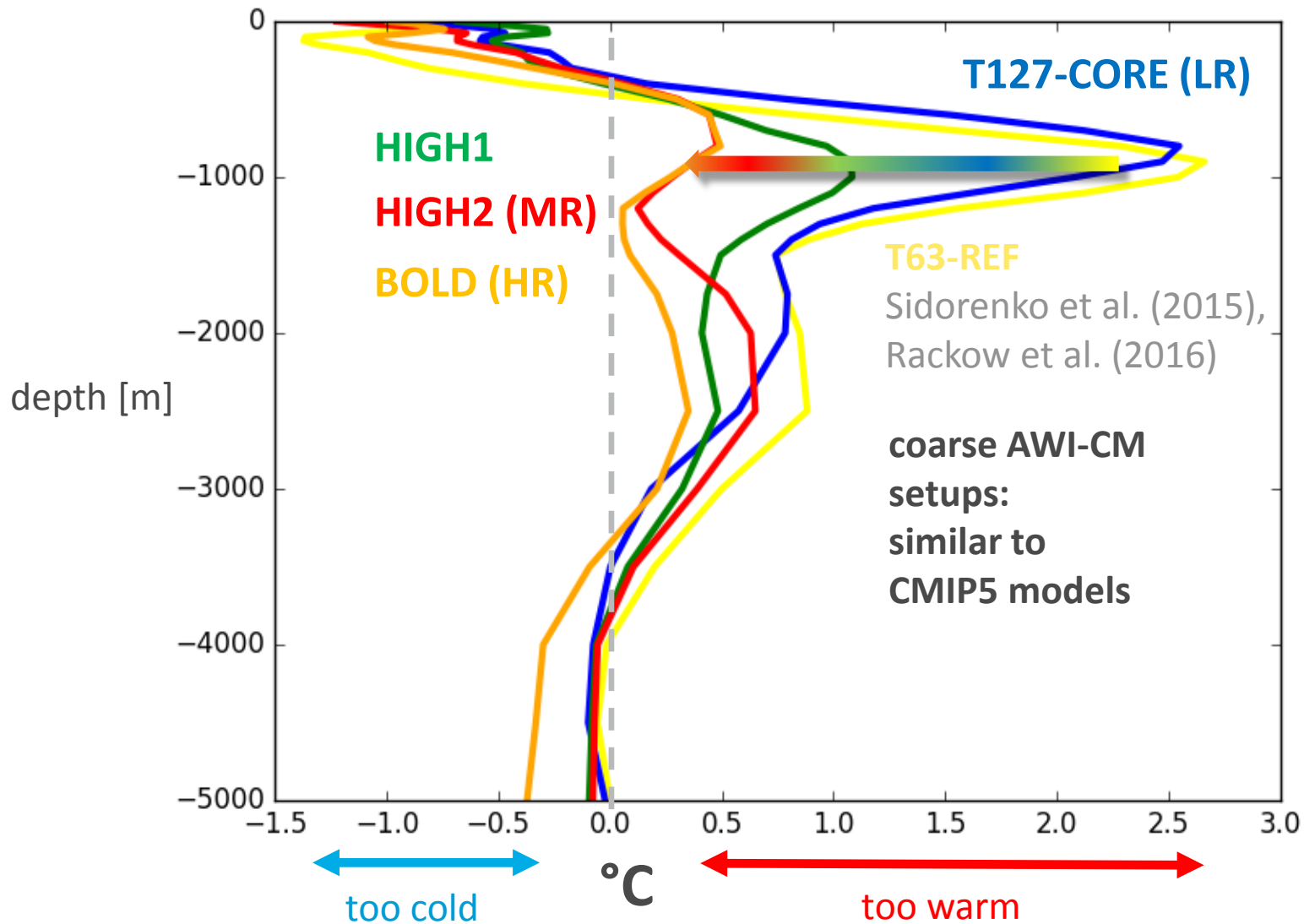
- The flexible layout of AWI-CM allows to use eddy-resolving resolutions in key ocean areas.
  We exploit this capability in the North Atlantic (NA) **with a hierarchy of ocean model grids** in order to reduce long-standing biases
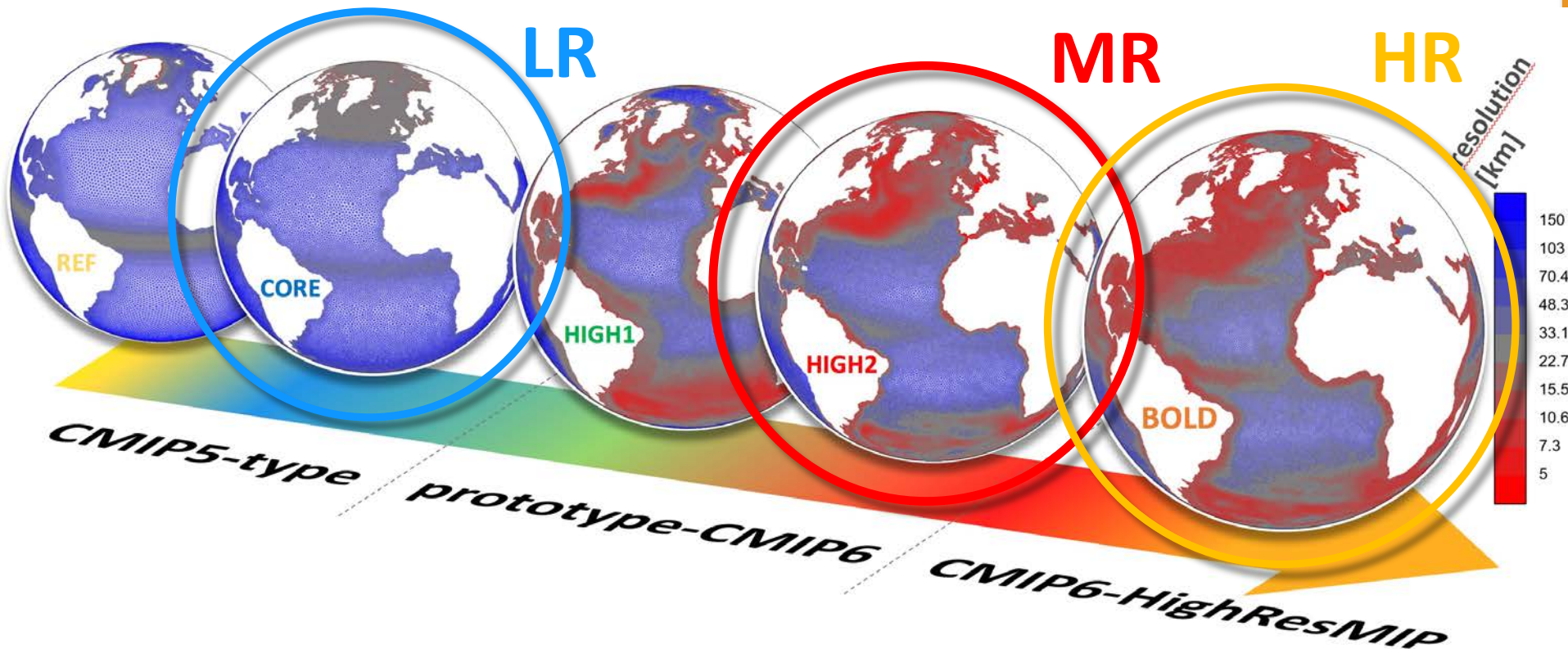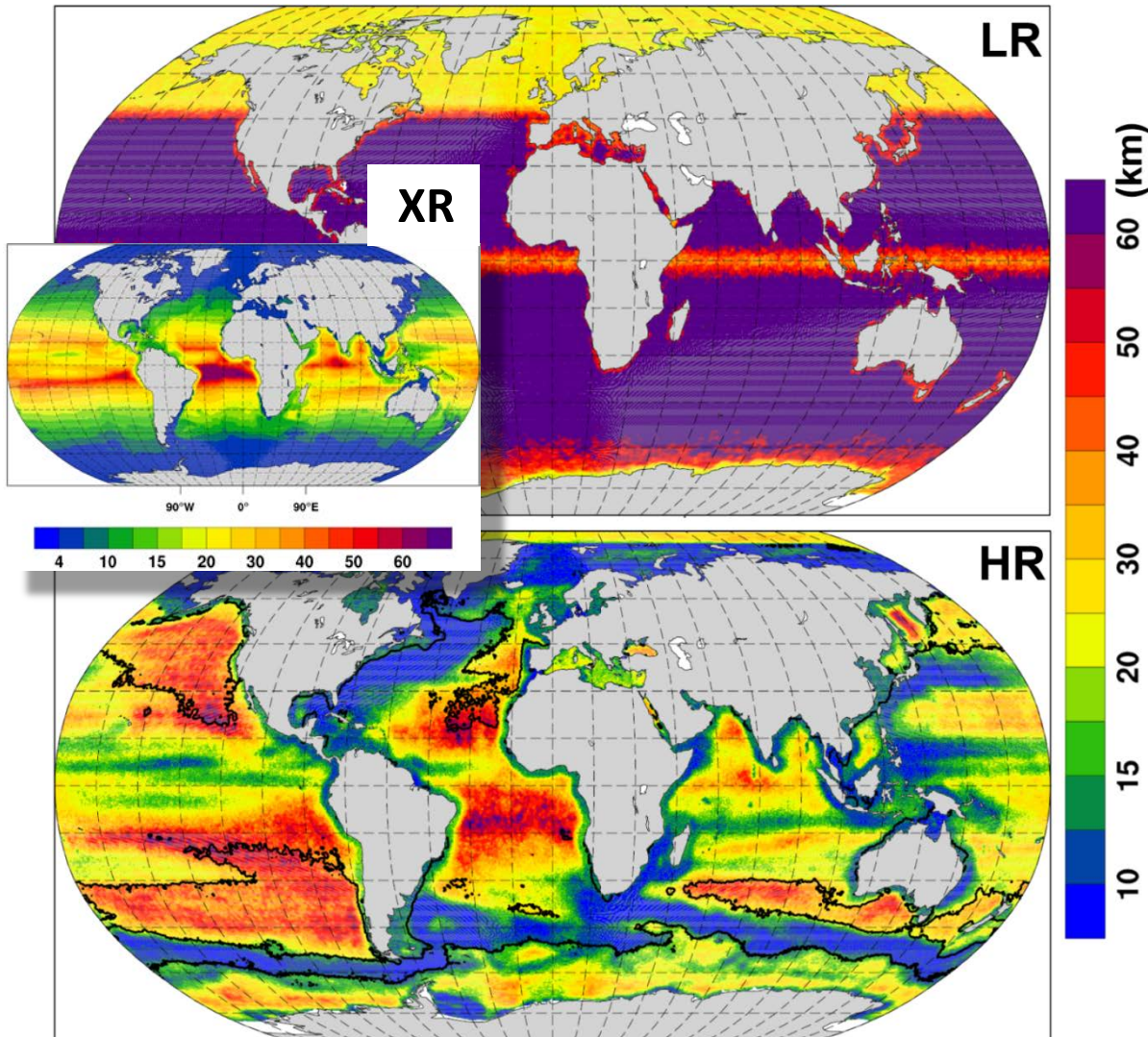

Rackow et al. (in prep.)

Rackow et al. (in prep.)

4. Fresh results: HighResMIP runs (LR and HR)

LR: ECHAM6-T63L95
HR: ECHAM6-T127L95

HighResMIP protocol:

Initialisation: EN4 1950-1954
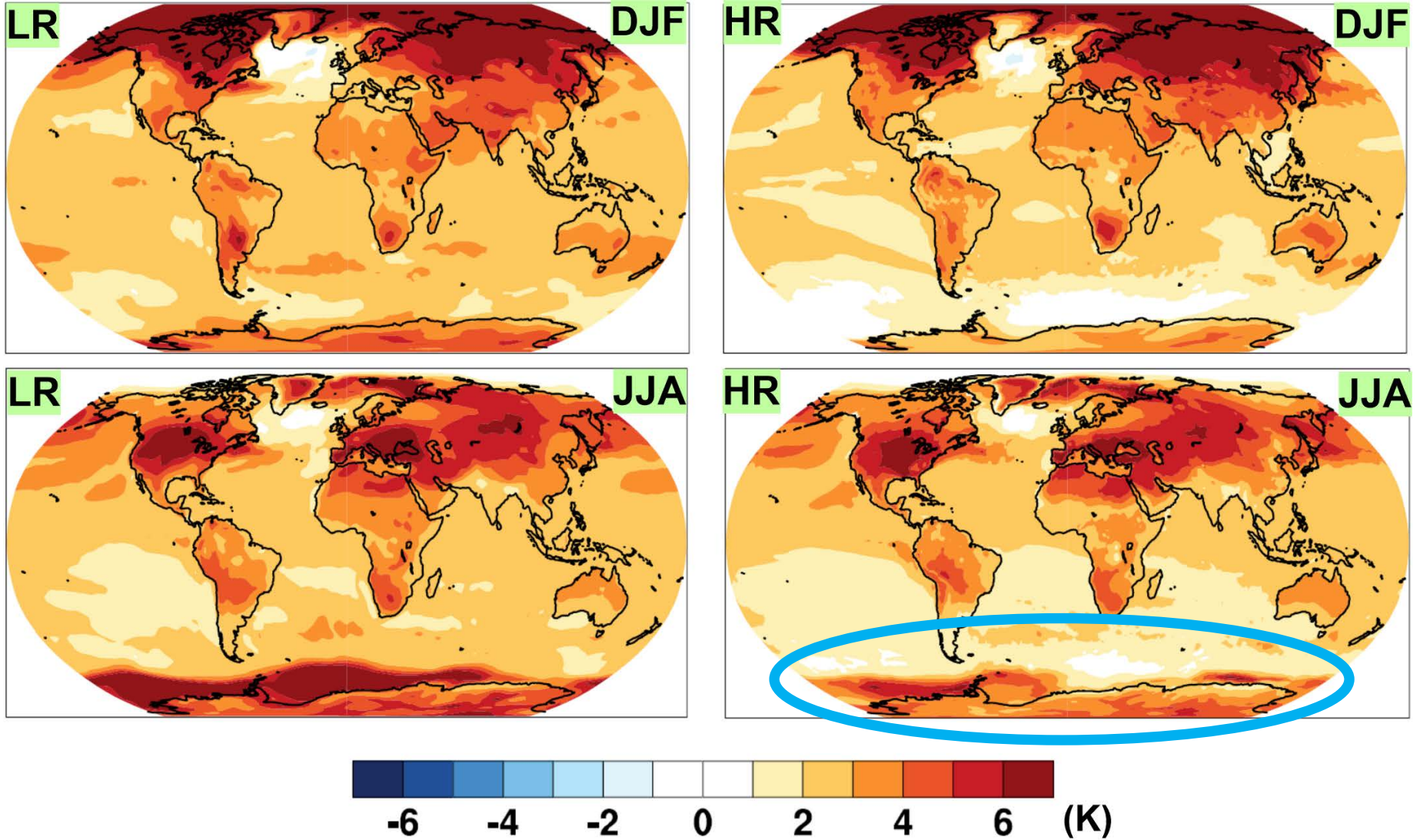
Ocean-only spin-up 5 years

Coupled spin-up 50 years with constant 1950 forcing

Scenario (RCP8.5) and control (1950) runs for the next 100 years (1951-2050)

HR grid: resolution is function of variability of sea surface height, sea ice extent and mixed layer depth (Sein et al. 2016, JAMES)

4. Mean 2m RCP8.5 temperature change
## (2070-2099) – (1976-2005)

CMIP6: Organization

- Variety of CMIP-Endorsed Model Intercomparison Projects (MIPs)
  - Depending on scientific interest modelling groups may or may not take part in some or all of them

- AWI (with AWI-CM: ECHAM6.3-FESOM):
  - ScenarioMIP
  - OMIP (Ocean)
  - PMIP (Paleo climate)
  - HighResMIP (High Resolution)
  - CORDEX (Coordinated Regional Climate Downscaling Experiment) – only diagnostic
  - SIMIP (Sea Ice) – only diagnostic
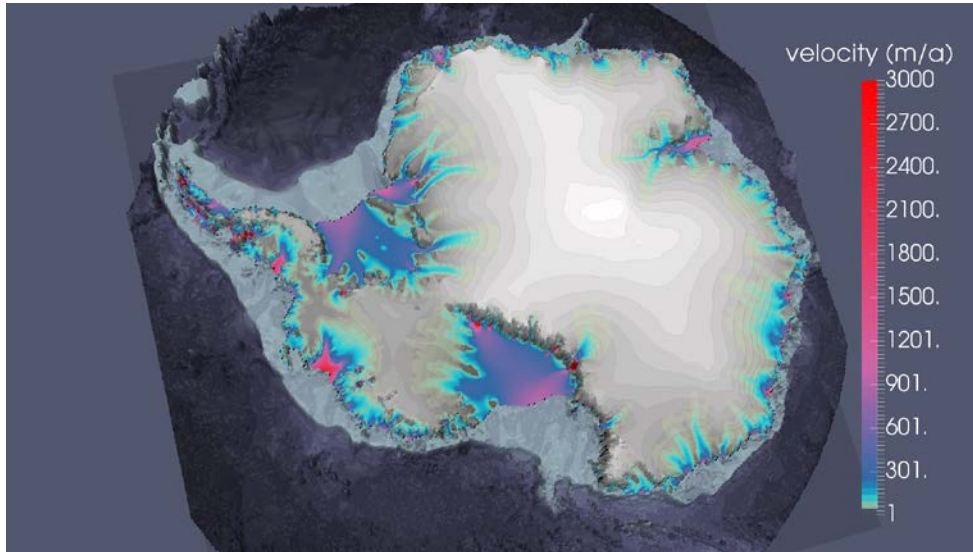 - PAMIP (Polar Amplification)

Beyond CMIP6

New project: Reaching the 1.5 degree limit: what does it mean for West Antarctica and the global mean sea level?

Climate Model

Atmosphere and Ocean forcing

Meltwater Topography

Ice sheet model
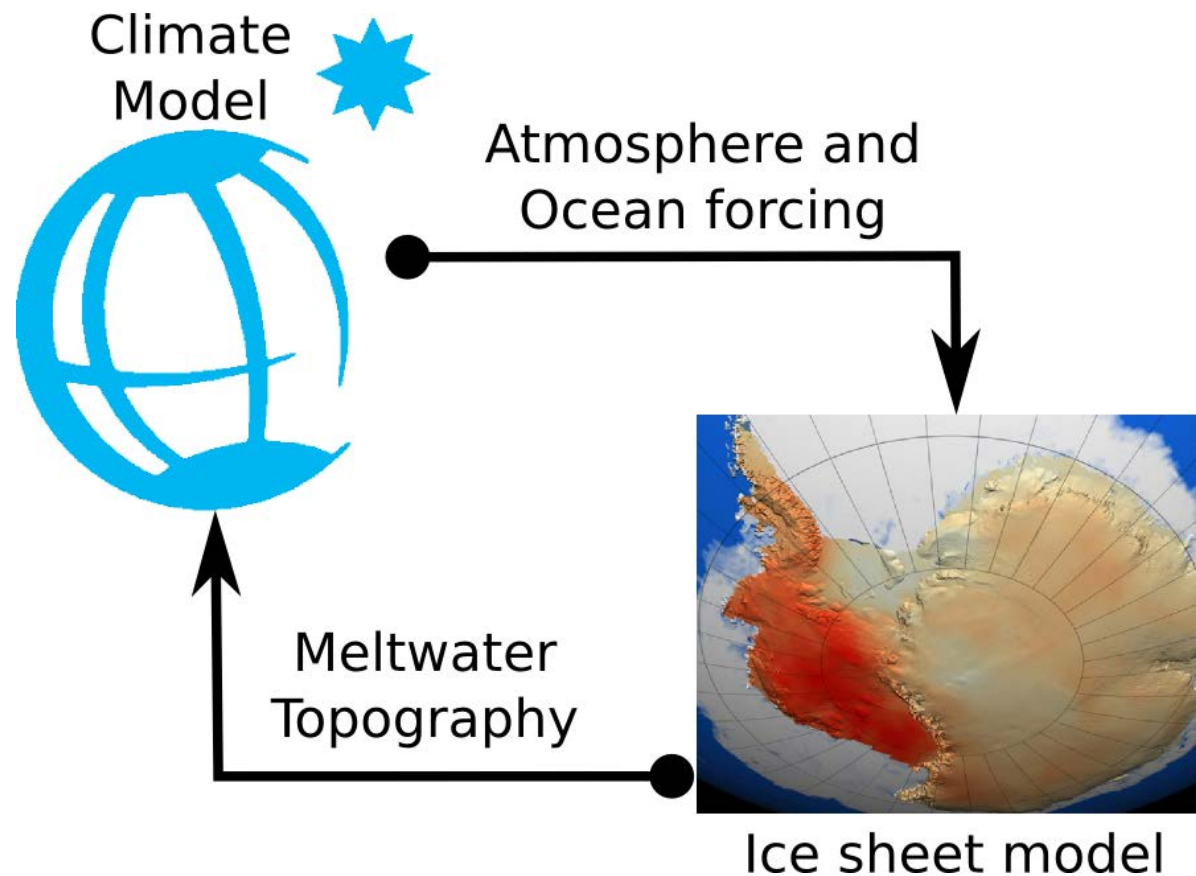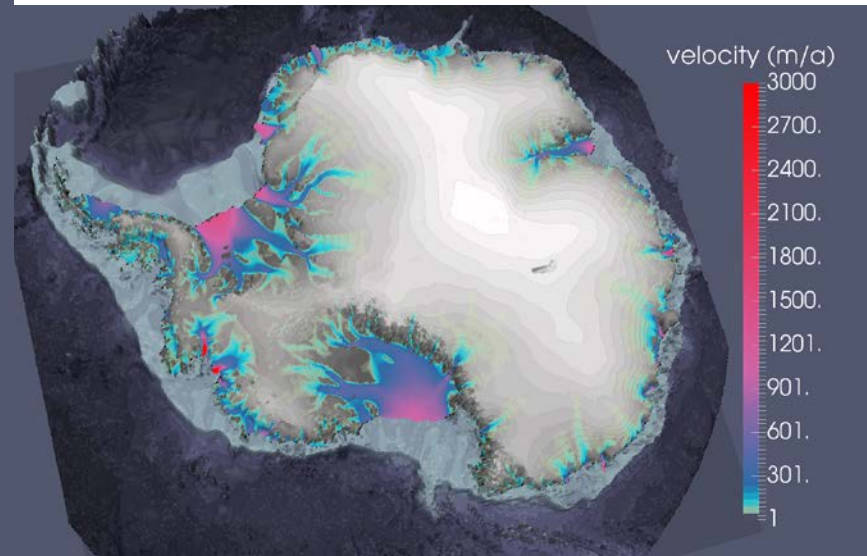
PISM spin-up simulation

- 50,000 years of PISM spin-up to bring ice sheet into equilibrium

Simulated and observed ice sheet velocity (m/a)

Observation

Simulation
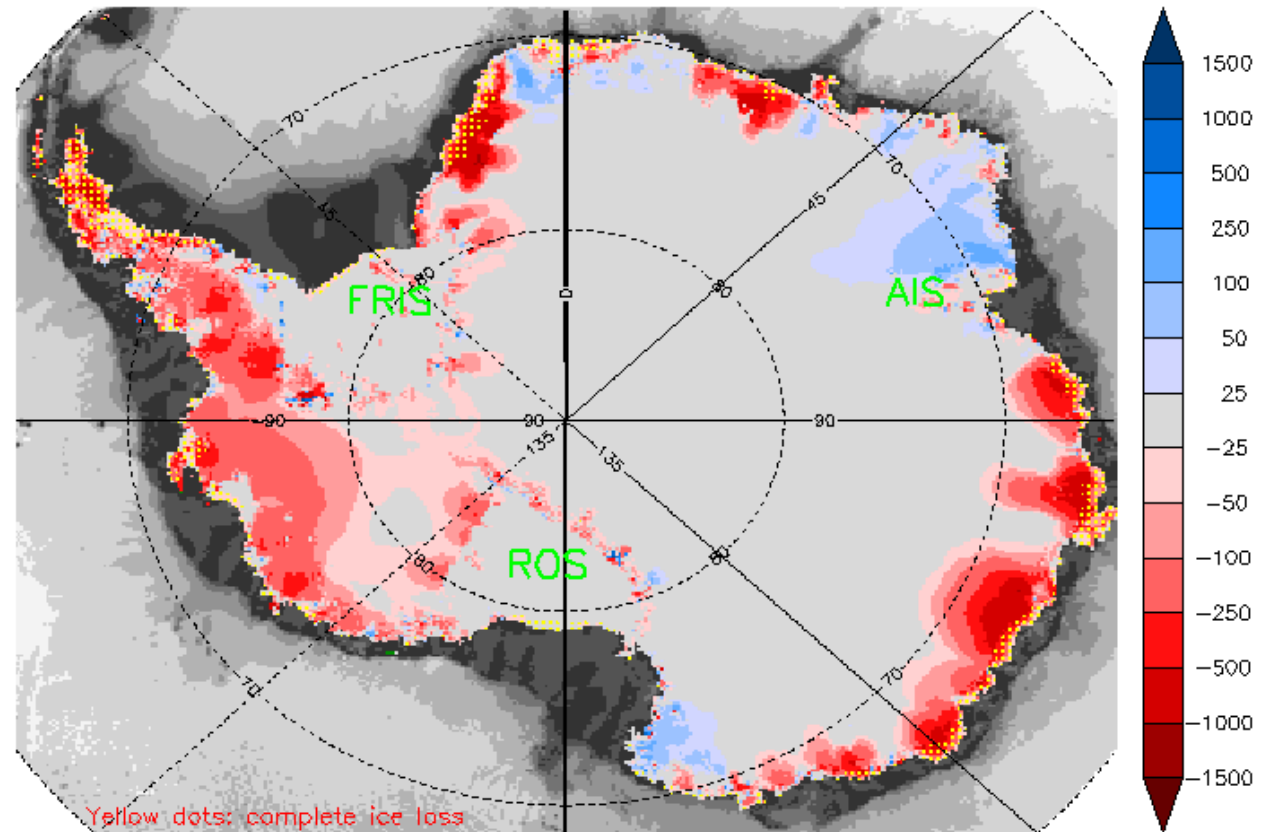
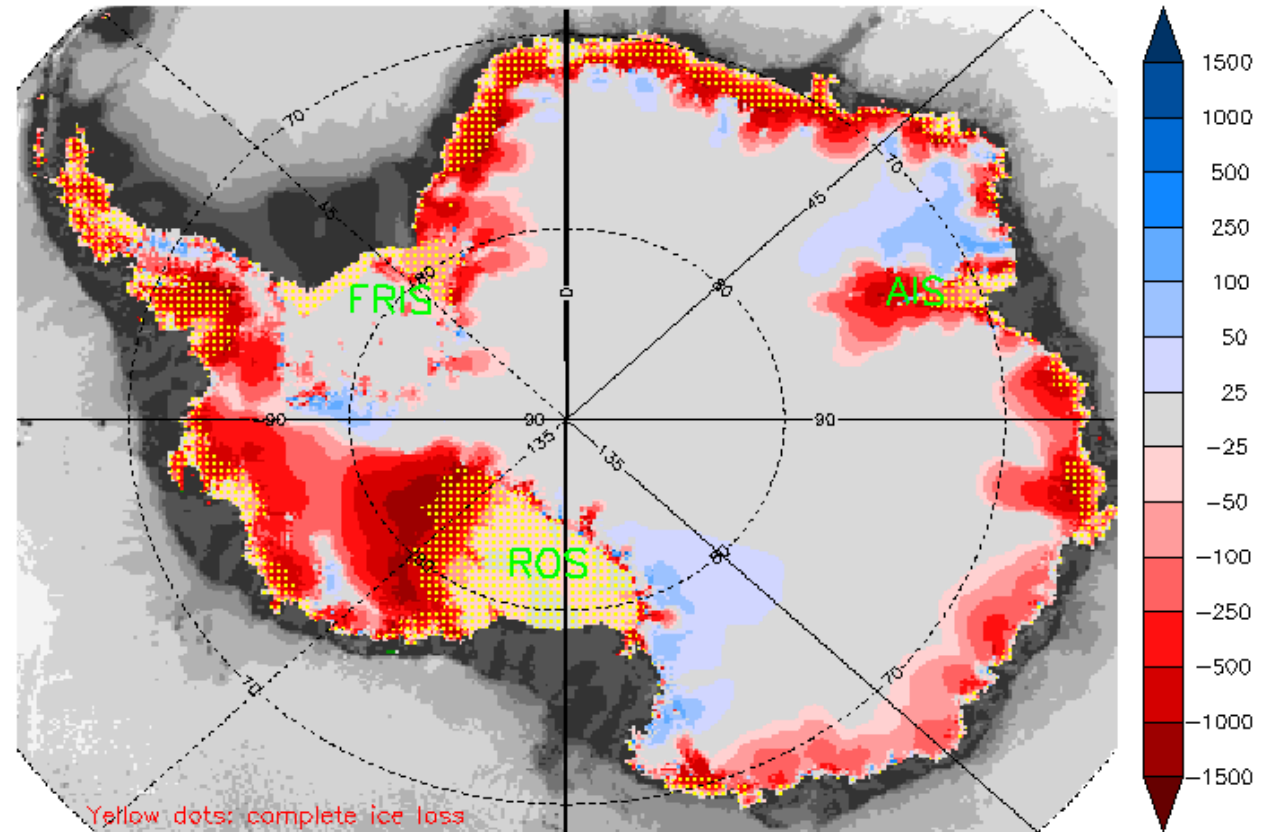# Results: PISM driven by CCSM4

- Snapshot control

Ice elevation anomaly (m)
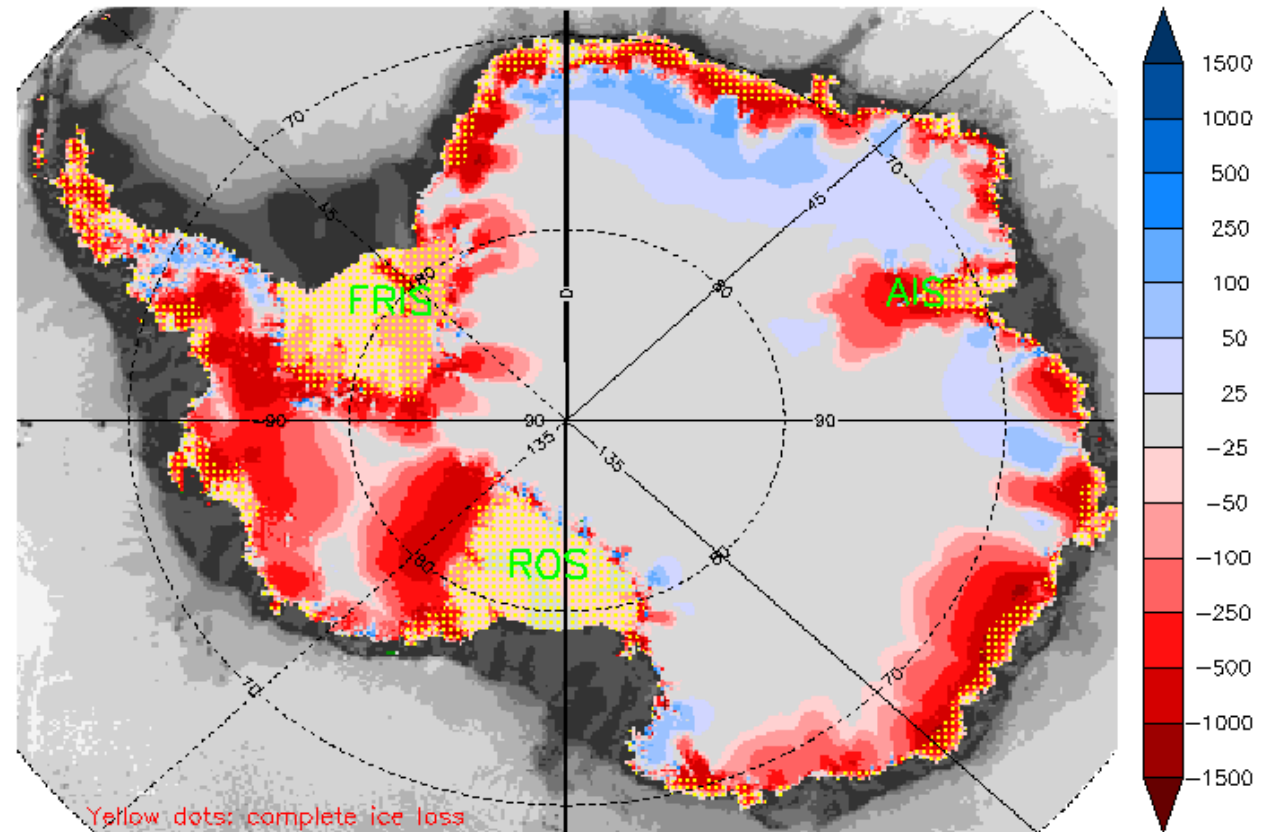
Results: PISM driven by CCSM4

- Snapshot RCP 4.5

Ice elevation anomaly (m)

Results: PISM driven by CCSM4

- Snapshot RCP 8.5

Ice elevation anomaly (m)

5. Summary/Outlook

- Many CMIP5 models show strong warm and saline biases in the deep North Atlantic Ocean

- AWI-CM at „CMIP5-type" resolution shows a similar bias, which is systematically reduced when going to successively higher resolution (up to locally eddy-resolving)

- AWI-CM ready to participate in CMIP6; CMIP6-HighResMIP simulations practically finished

- AWI-CM is being coupled to the Parallel Ice Sheet Model PISM – towards an Earth System Model with polar perspective

- AWI-CM is being used for Arctic-Northern mid-latitude linkages studies – see our poster!