Use of CMIP Atmospheric Boundary Conditions with ISMs

Richard Cullather & Sophie Nowicki

"Surface Mass Balance" ($pr - evspsbl - mrro(s)$) [cm yr^{-1} w.e.]
CMIP5 20th Century **AMIP**, 1980-2008

BCC-CSM1.1

CanAM4

CNRM CM5

GFDL HIRAM-C180

GFDL HIRAM-C360

GISS-E2-R

IPSL CM5A-MR

MPI ESM-LR

MRI CGCM3

NorESM1-M
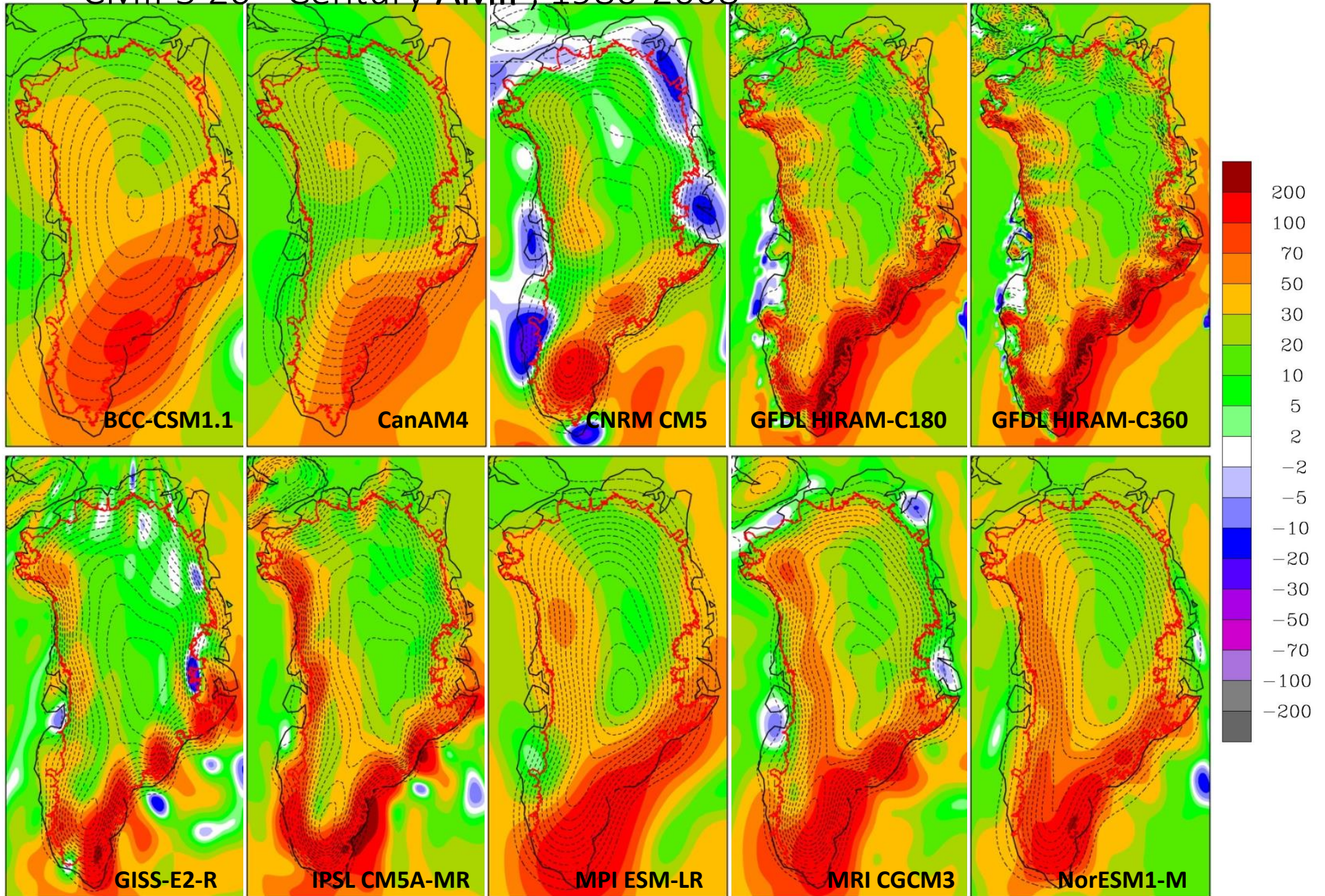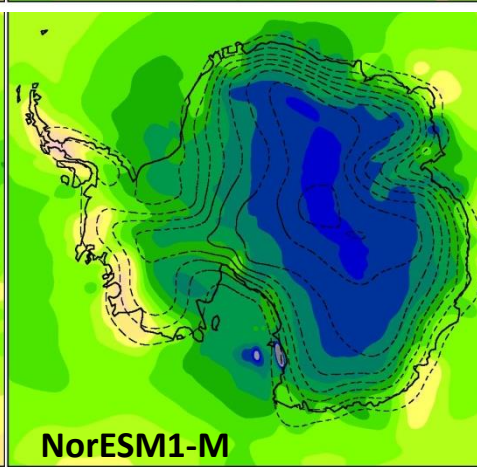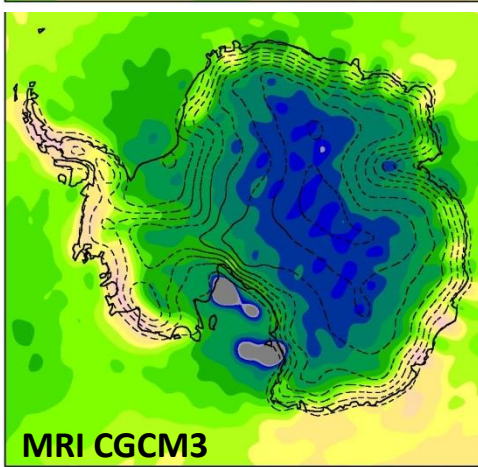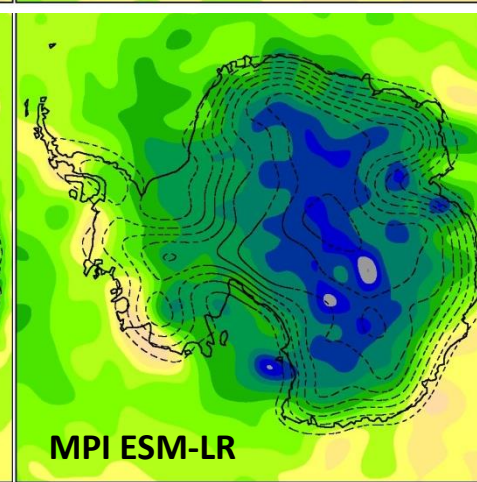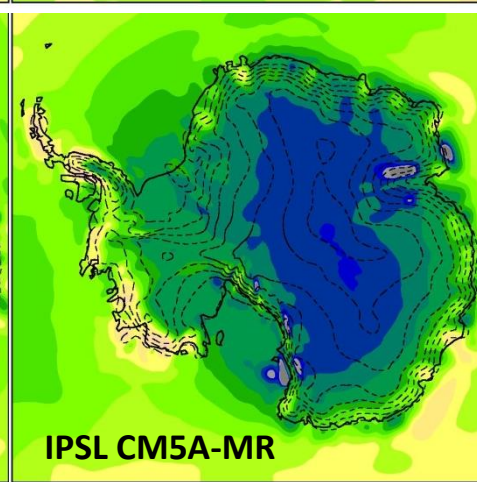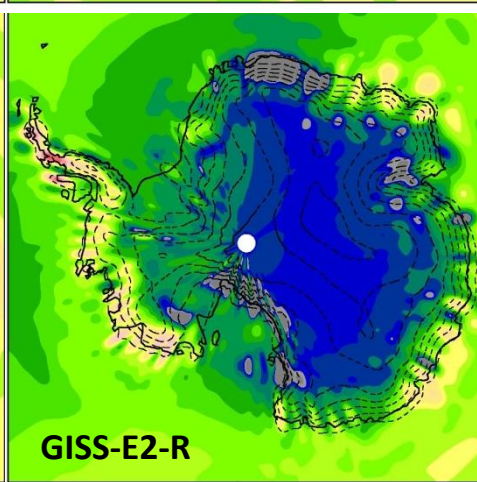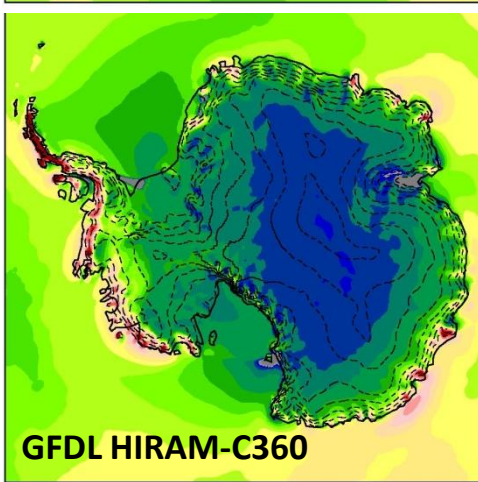
- **Why are we interested in using forcing from Earth System Models?**
  - CMIP integrations represent the best available picture of future climate.
  - Interest in coupled systems to obtain:
    - Interactive feedbacks between ice sheets and external forcing.
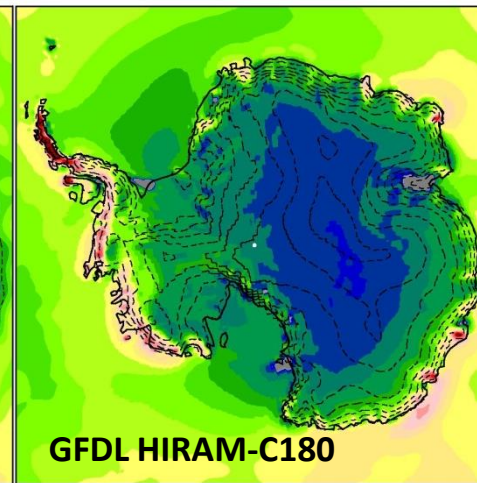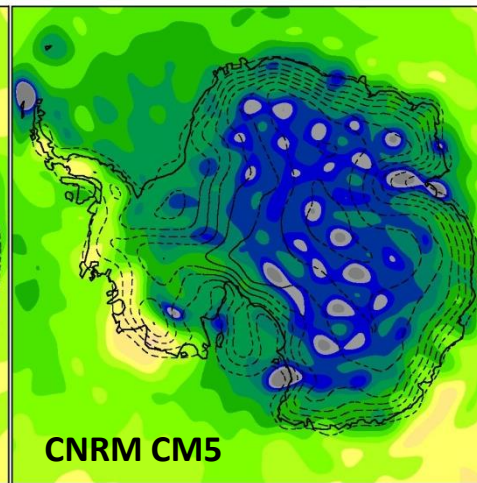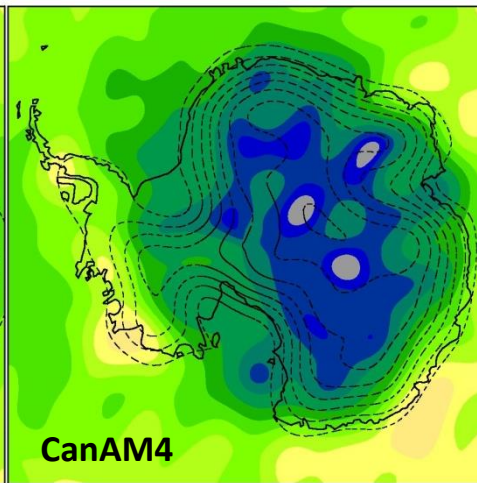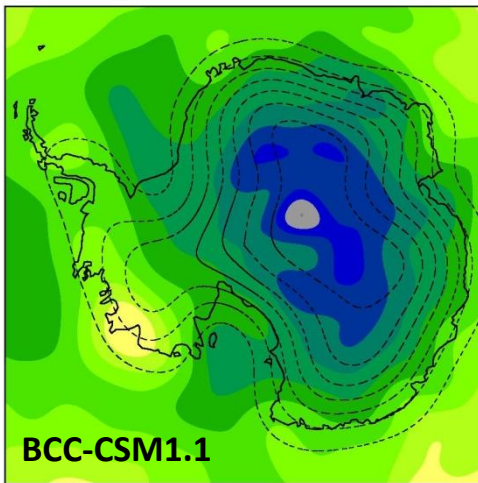   - Quantification of the relative impacts of ice sheet changes in the context of the global climate system.
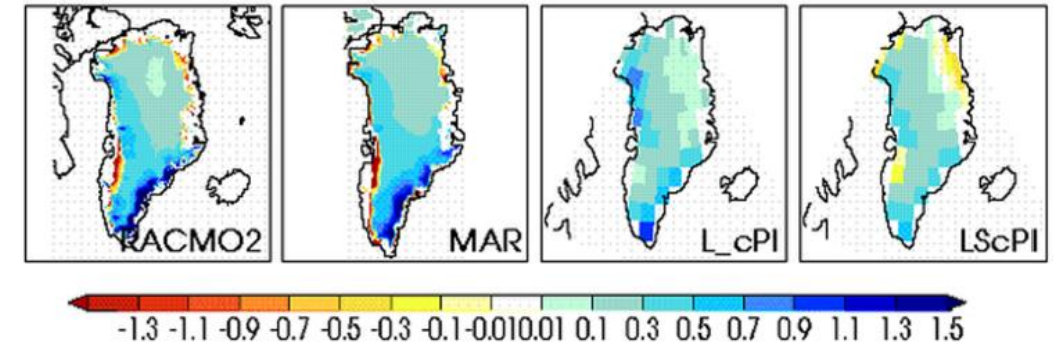
- **What is difficult about this?**
  1. The variables are not output.
  2. The overall magnitude is wrong.
  3. The spatial distribution is wrong: Resolution of SMB (and T_{sfc}) is too coarse, does not adequately resolve topographic gradients.
  4. The time-evolution is wrong: Climate model representation may not incorporate important local physical processes.

SMB Validation

(a) Modelled surface mass balance (m i.e. / yr)

RACMO2   MAR   L_cPI   LScPI

-1.3 -1.1 -0.9 -0.7 -0.5 -0.3 -0.1 -0.01 0.01 0.1 0.3 0.5 0.7 0.9 1.1 1.3 1.5

e.g., Punge et al. 2012

- Primarily through comparison with gridded data sets: RCM/reanalysis output.

- Those data sets are validated through a variety of means:
  - Ice cores/ or glaciological methods.
  - Accumulation radar.
  - Surface Mass Balance and Snow on Sea Ice Working Group (SUMup).
  - SurfAce Mass Balance of Antarctica (SAMBA).
  - AWS.
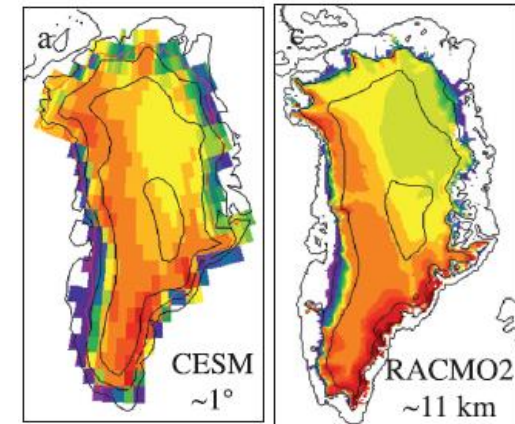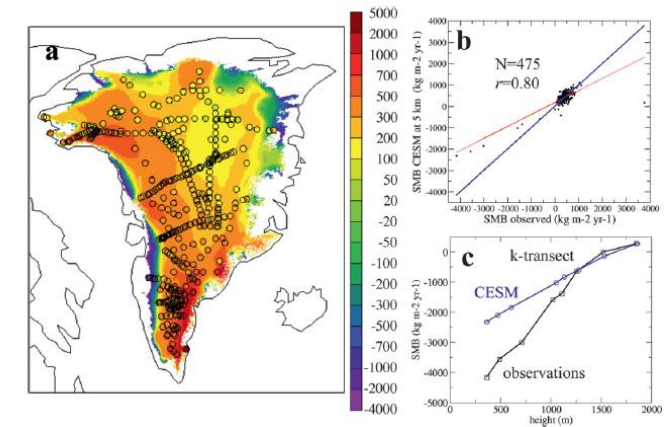 - Evaluation of related variables: temperature, energy budget.

15 OCTOBER 2013   VIZCAÍNO ET AL.

e.g., Vizcaino et al. 2013

Potential Remedies – Simple Downscaling

- Flux-corrected (anomaly): similar techniques were first used in atmosphere/ocean coupling.

- Methods could also incorporate topographic downscaling (e.g., Helsen et al., 2012).

- Application is specific to a particular ESM.

- These methods may not work in a transient climate.

- Does not adequately compensate for missing physics.

Coupled ocean-atmosphere models with flux correction

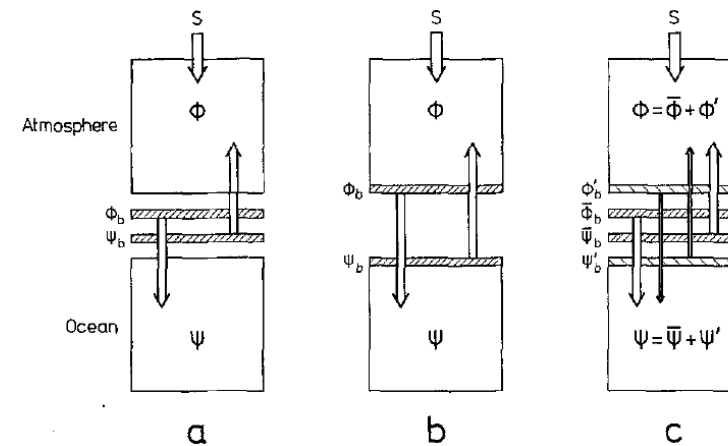R Sausen[1], K Barthel[2], and K Hasselmann[3]

Fig. 1a–c. Boundary or coupling conditions of atmosphere and ocean models in different modes: **a** uncoupled; **b** fully coupled and **c** flux corrected

Influence of Spatial Resolution and Treatment of Orography on GCM Estimates of the Surface Mass Balance of the Greenland Ice Sheet
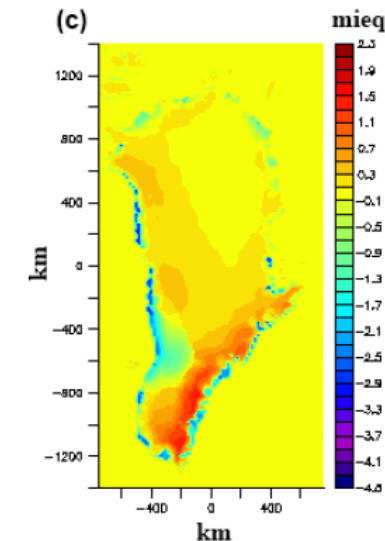
Robin W. Glover

Potential Remedies – Intermediate Complexity Models (e.g., PDD)

- Development of a surface "wrapper" to interface between ESM output and ISM.

- Physics might be better controlled in-house.

- Not specific to particular ESM.

- Development by the ISM, may be considerable investment.

COUPLING AN ICE SHEET MODEL TO
EC-EARTH

Jeroen VAN LENT

19 January 2013

Potential Remedies – Offline Dynamical Downscaling

- Use of RCM for providing fields.

- Arguably the most comprehensive physical representation.

- Time consuming, computationally expensive.

- Potentially dependent on differences among RCMs.

Estimating the Greenland ice sheet surface mass balance contribution to future sea level rise using the regional atmospheric climate model MAR

X. Fettweis[1], B. Franco[1], M. Tedesco[2], J. H. van Angelen[3], J. T. M. Lenaerts[3], M. R. van den Broeke[3], and H. Gallée[4]
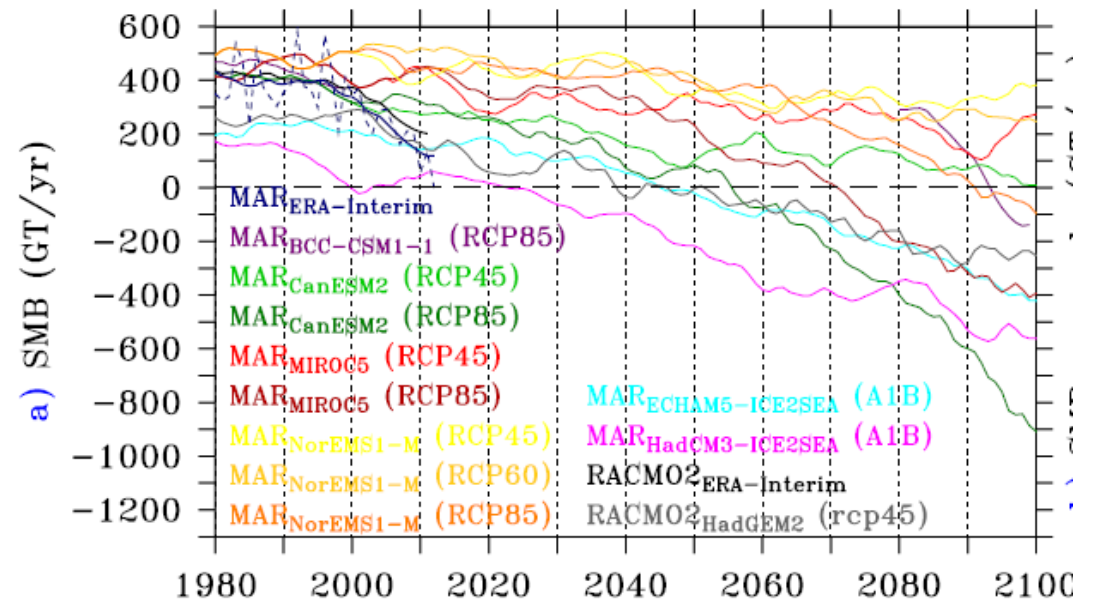
Potential Remedies – Embedded Dynamical Downscaling

- Height classes, etc.

- In development among several ESM groups. But not all.

- Provides the most reliable SMB directly from the ESM.

- There remain difficulties/artifacts in methods.

- ESM-dependent.

Greenland Surface Mass Balance as Simulated by the Community Earth System Model.
Part I: Model Evaluation and 1850–2005 Results

Miren Vizcaíno,[*,+] William H. Lipscomb,[#] William J. Sacks,[@] Jan H. van Angelen,[**]
Bert Wouters,[++] and Michiel R. van den Broeke[**]
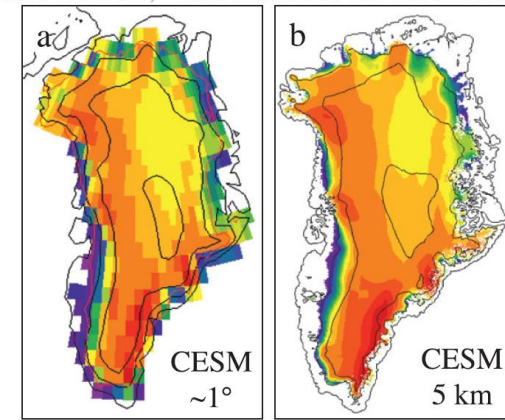
A system of conservative regridding for ice–atmosphere coupling in a General Circulation Model (GCM)

R. Fischer[1,2], S. Nowicki[3], M. Kelley[2,4], and G. A. Schmidt[2]

Discussion

- In model integrations we have:
    1. Uncertainty in the performance of the ISM.
    2. Uncertainty in the boundary forcing fields.
    3. Uncertainty in the *downscaling of the boundary forcing fields* (!?!).
    Which methods are more likely to add the third layer of uncertainty?

- Liability: who is responsible for deficiencies in boundary forcing fields?

- Should integrations be restricted to a sub-set of ESMs that provide realistic, high resolution SMB? What is lost in doing so?

- SMB is validated using the contemporary (or past) climate.
  How do we evaluate conditions for the future climate?