Use of CMIP Atmospheric Boundary Conditions with ISMs

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“Surface Mass Balance” (pr – evspsbl – mrro(s)) [cm yr\(^{-1}\) w.e.]
CMIP5 20\(^{th}\) Century AMIP, 1980-2008
• 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

• 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.
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.
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.
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.
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.
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?