Updates to Ice Sheet and Ocean Coupling in CESM3

Kate Thayer-Calder,
Mariana Vertenstein, Bill Sacks, Gunter Leguy, and others!

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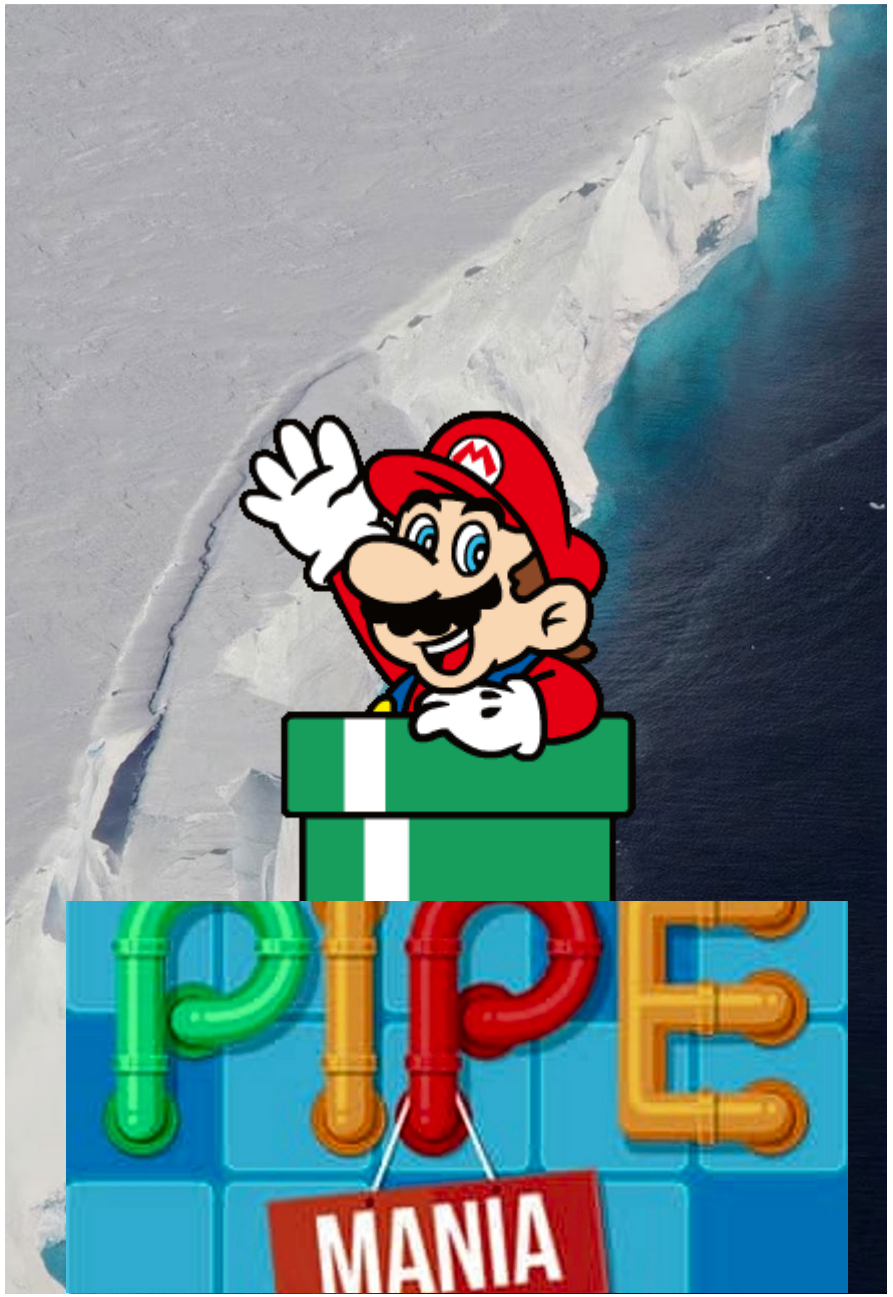
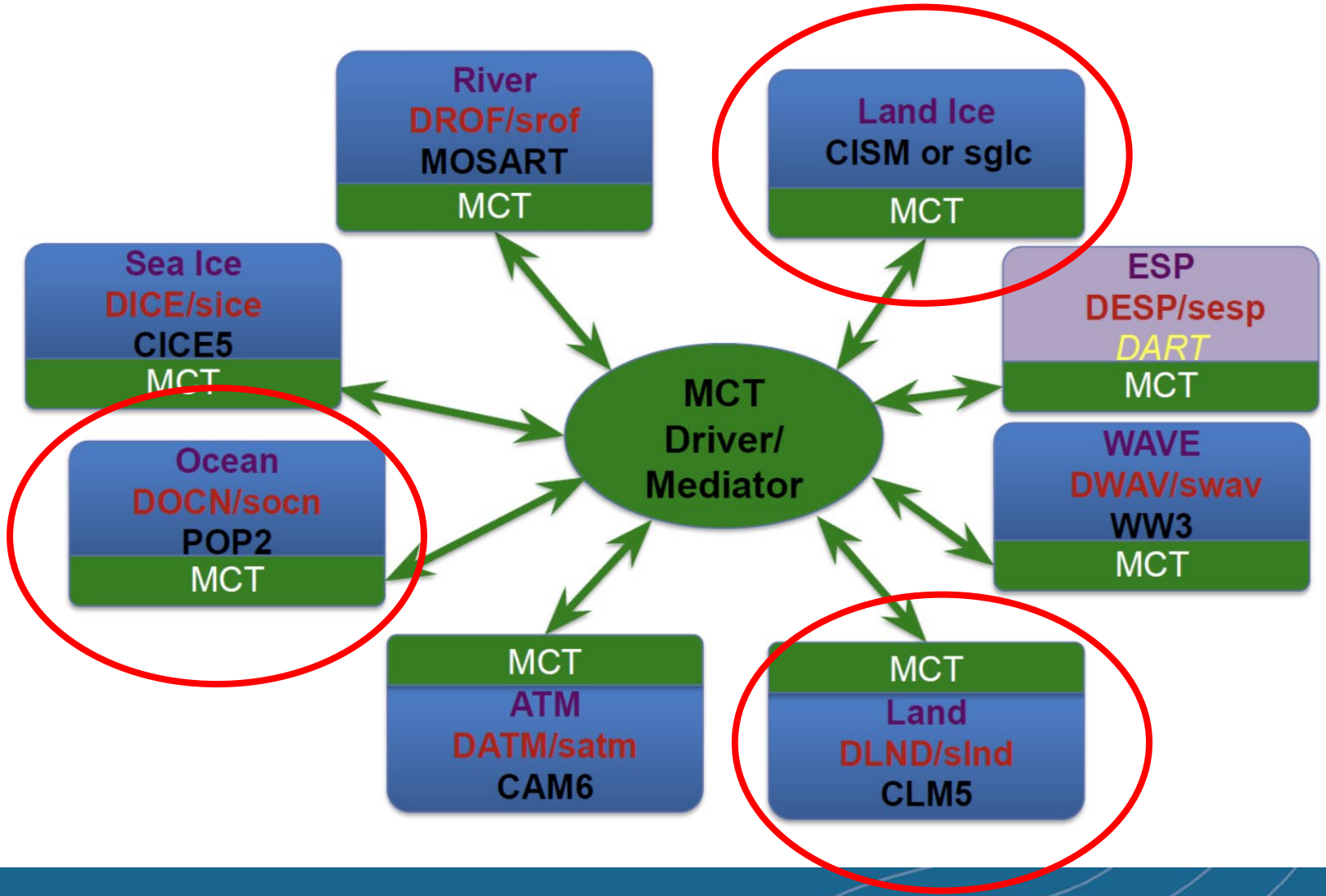
Overview

- ➔ CESM Coupling Overview
- ➔ Land Ice coupling inputs and outputs in CESM2
- ➔ Issues with CESM2 coupling
- ➔ Changes in CESM3
- ➔ Future science applications

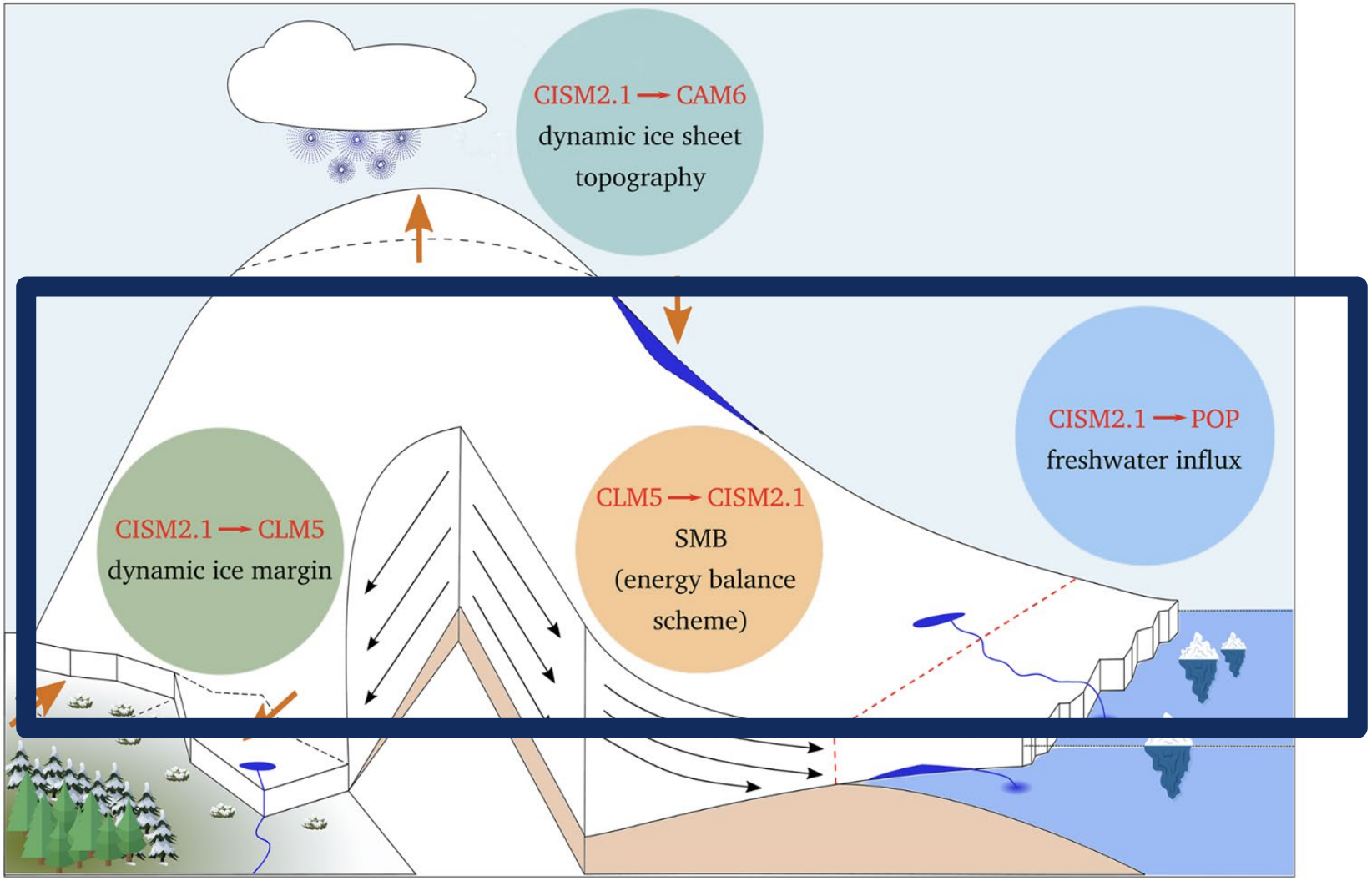


Nasa Thwaites

CESM2 Coupling



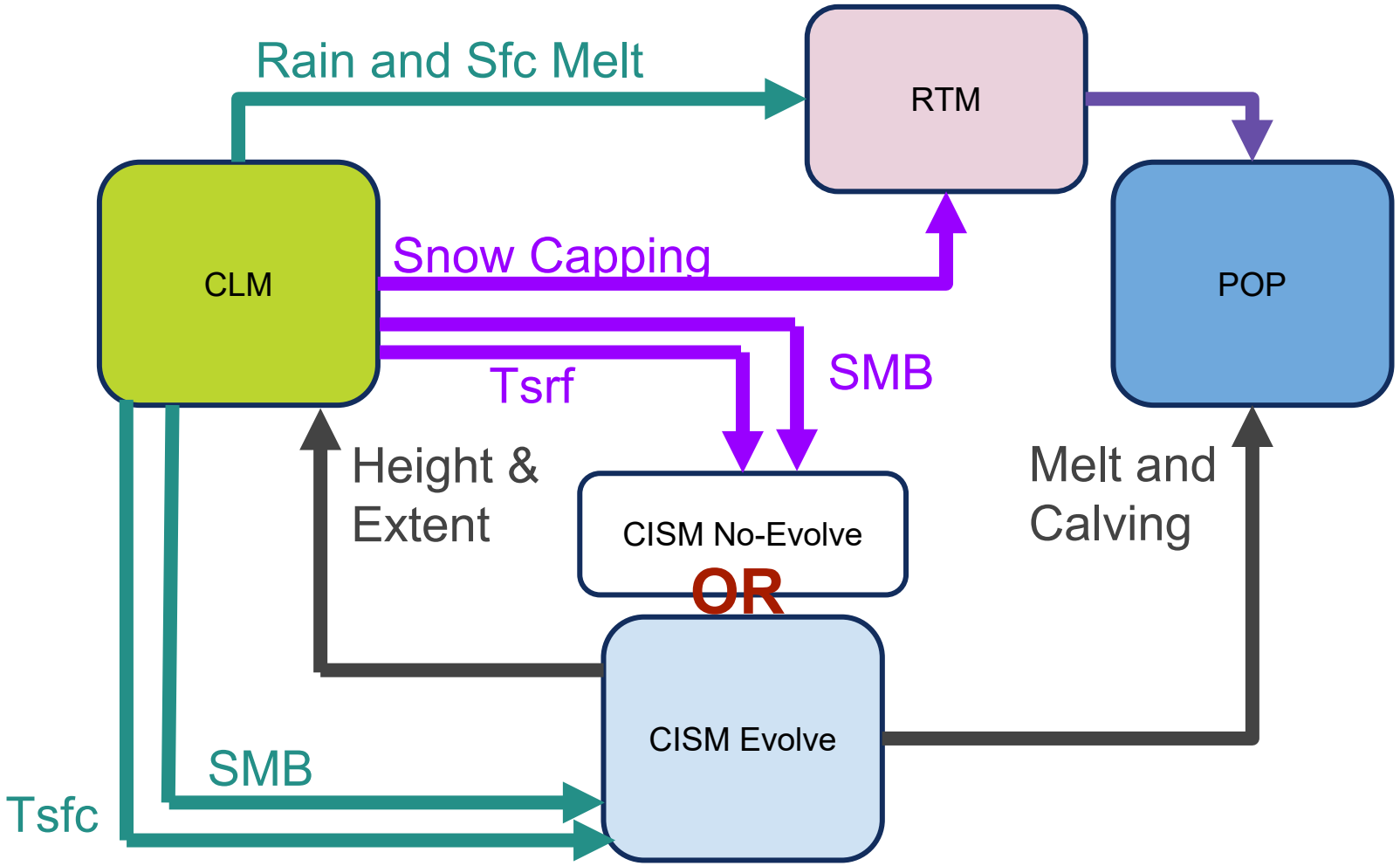
Active Land Ice Coupling in CESM2



Muntjewerf et al. 2021

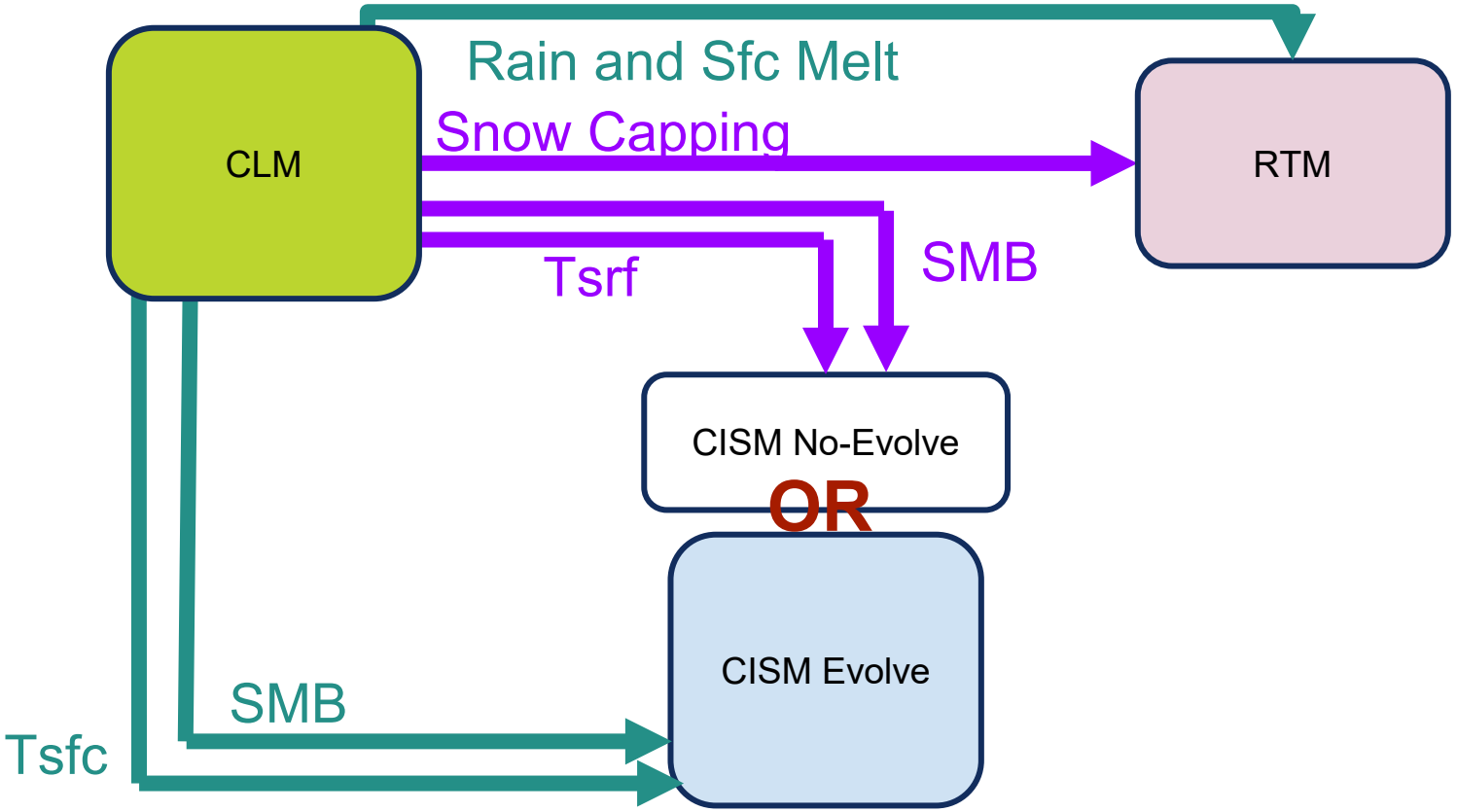
Figure 1. Schematic of four elements of coupling between ice sheets and other Earth system components, courtesy of M. Petrini.

Land Ice Coupling in CESM2 - More Detail



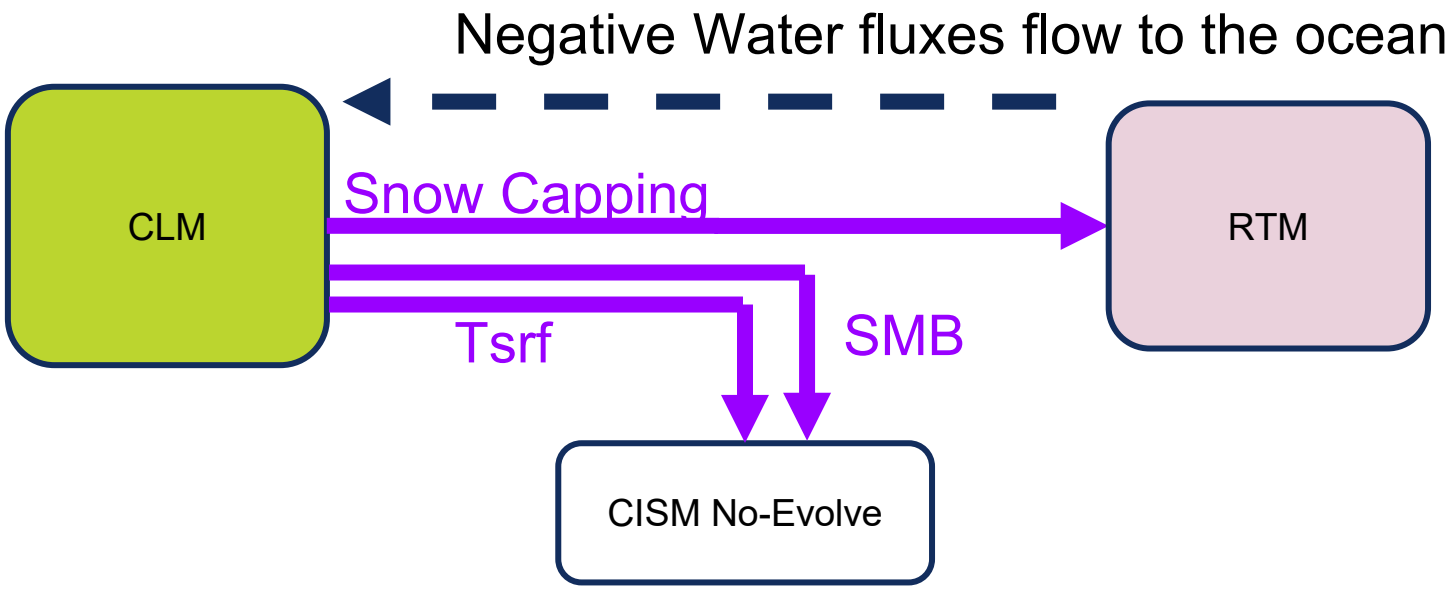
Issues with CESM2 Coupling

➔ Complicated differences when doing Evolve vs No Evolve is confusing to implement, maintain and understand scientifically.



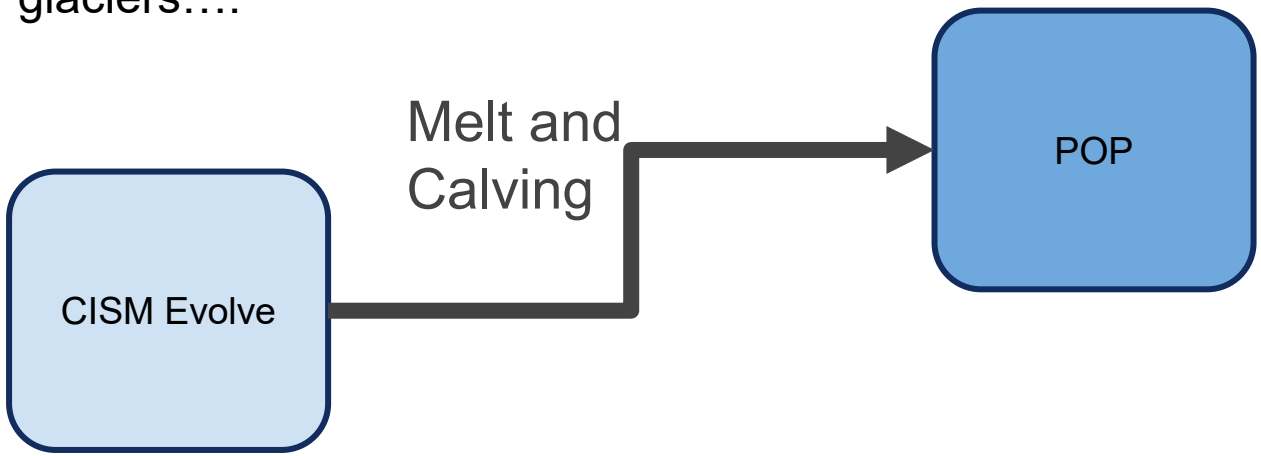
Issues with CESM2 Coupling

➔ In the case of CISM NoEvolve, the run-off fluxes are not seasonally accurate and can produce negative water fluxes to the ocean.



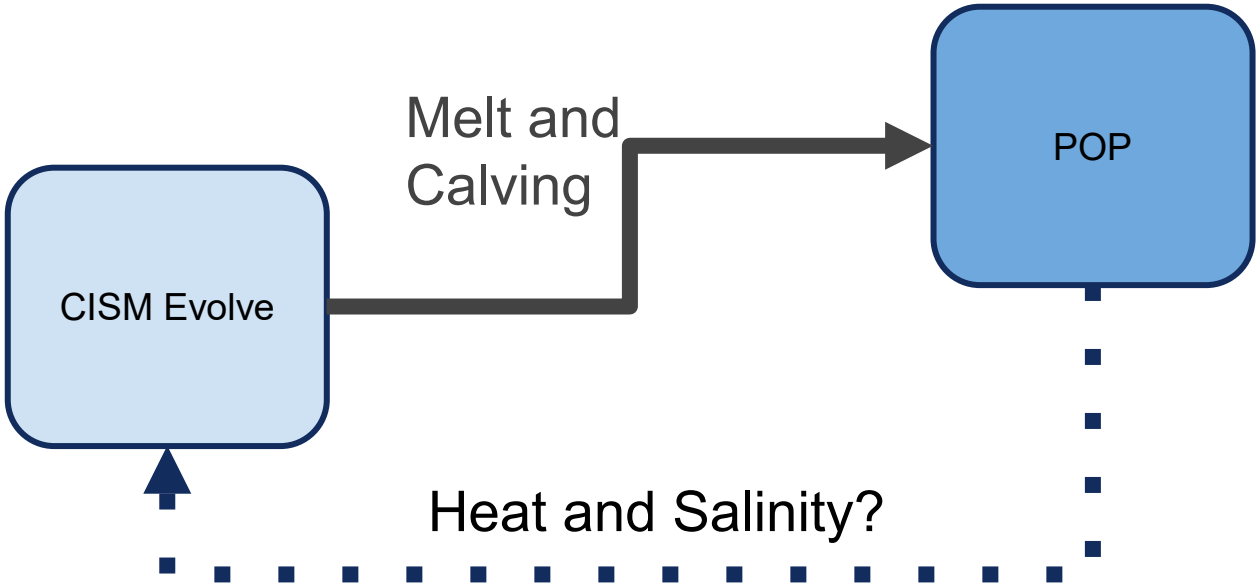
Issues with CESM2 Coupling

- ➔ Mapping from the glacier to ocean grids can become an exponentially difficult file creation process.
  - ◆ Multiple ice sheets, multiple ocean grids, multiple grids for each ice sheet and then land ice that does not touch the ocean in mountain glaciers….



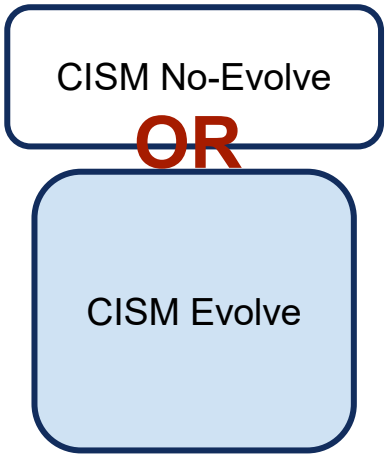
Issues with CESM2 Coupling

➔ No coupling of sub-ice shelf ocean heat and salinity, which is needed for accurately simulating Antarctica.



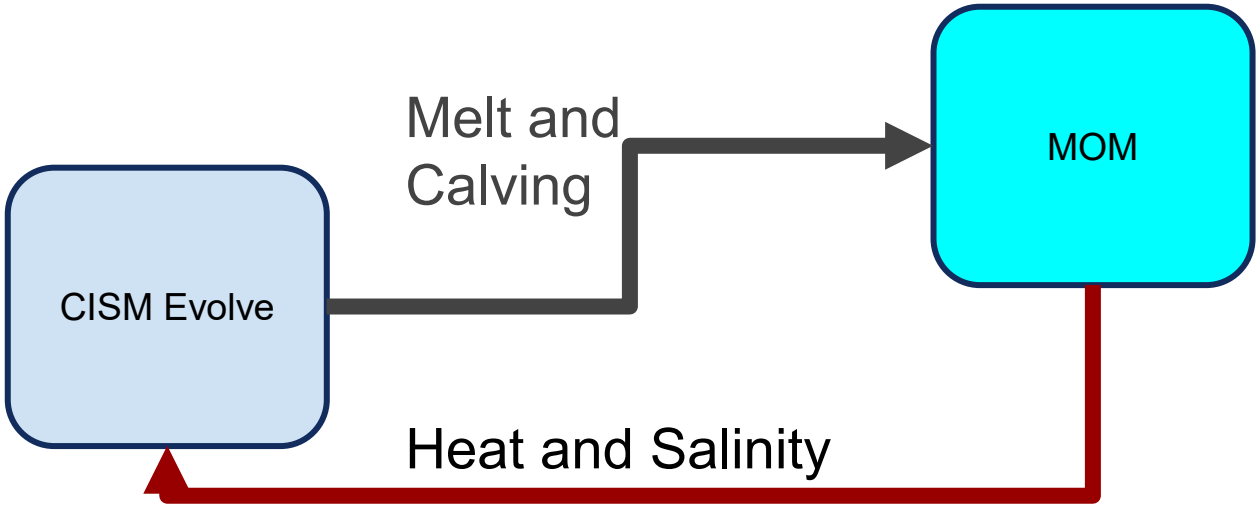
Issues with CESM2 Coupling

- In the case of CISM NoEvolve, a model with no need to manage ice sheets will still need to download and compile all of the CISM code.
  - Many component specific compsets dropped CISM for stub glaciers (SGLC) because of this
  - But several of these compsets and the all-active (B) compsets could use a stream-reading data component to simulate and test the ice sheet water fluxes correctly.



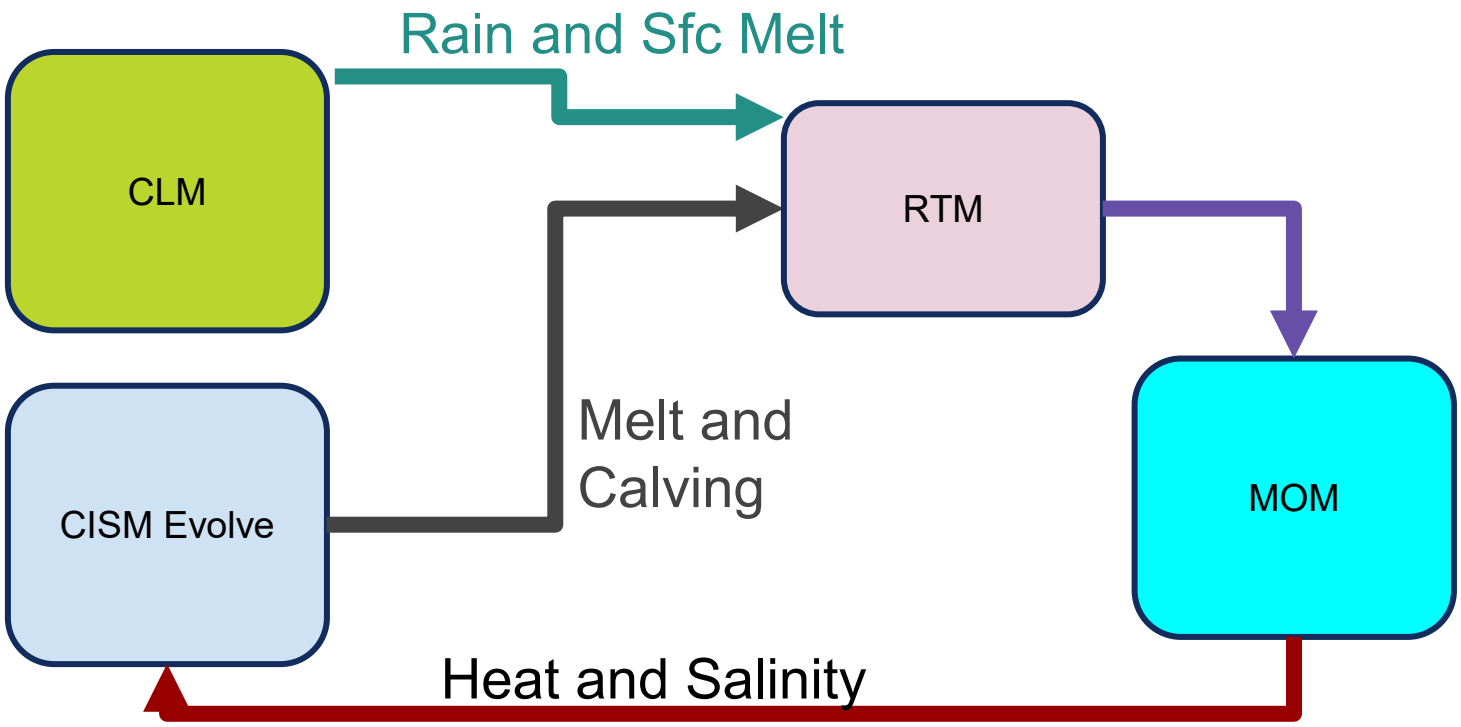
Coupling Improvements in CESM3

➔ Import ocean temperature and salinity at multiple levels below ice shelves from the MOM Ocean component.



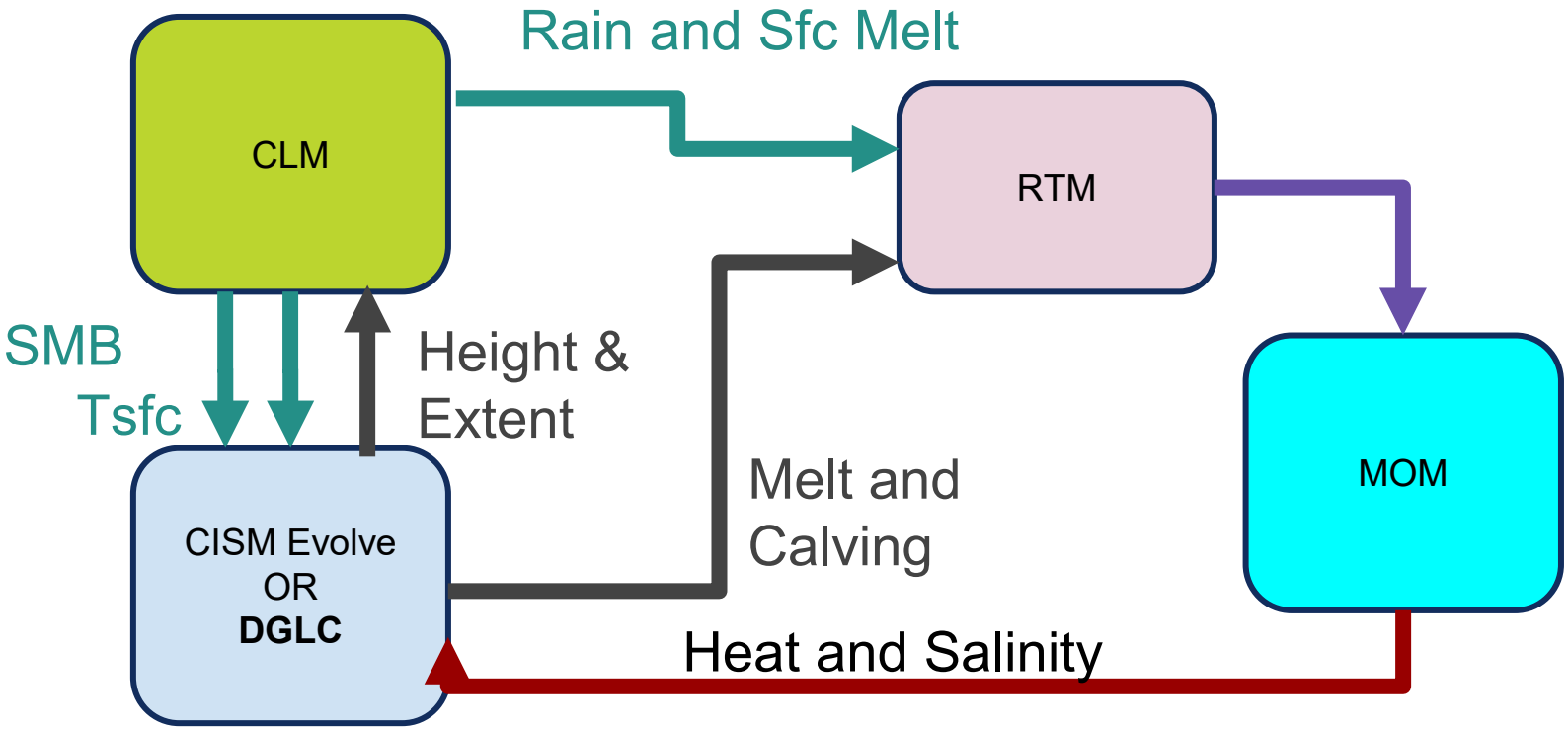
Coupling Improvements in CESM3

➔ Route all land ice water flux exports (run off, melt and calving) through the river routing model.

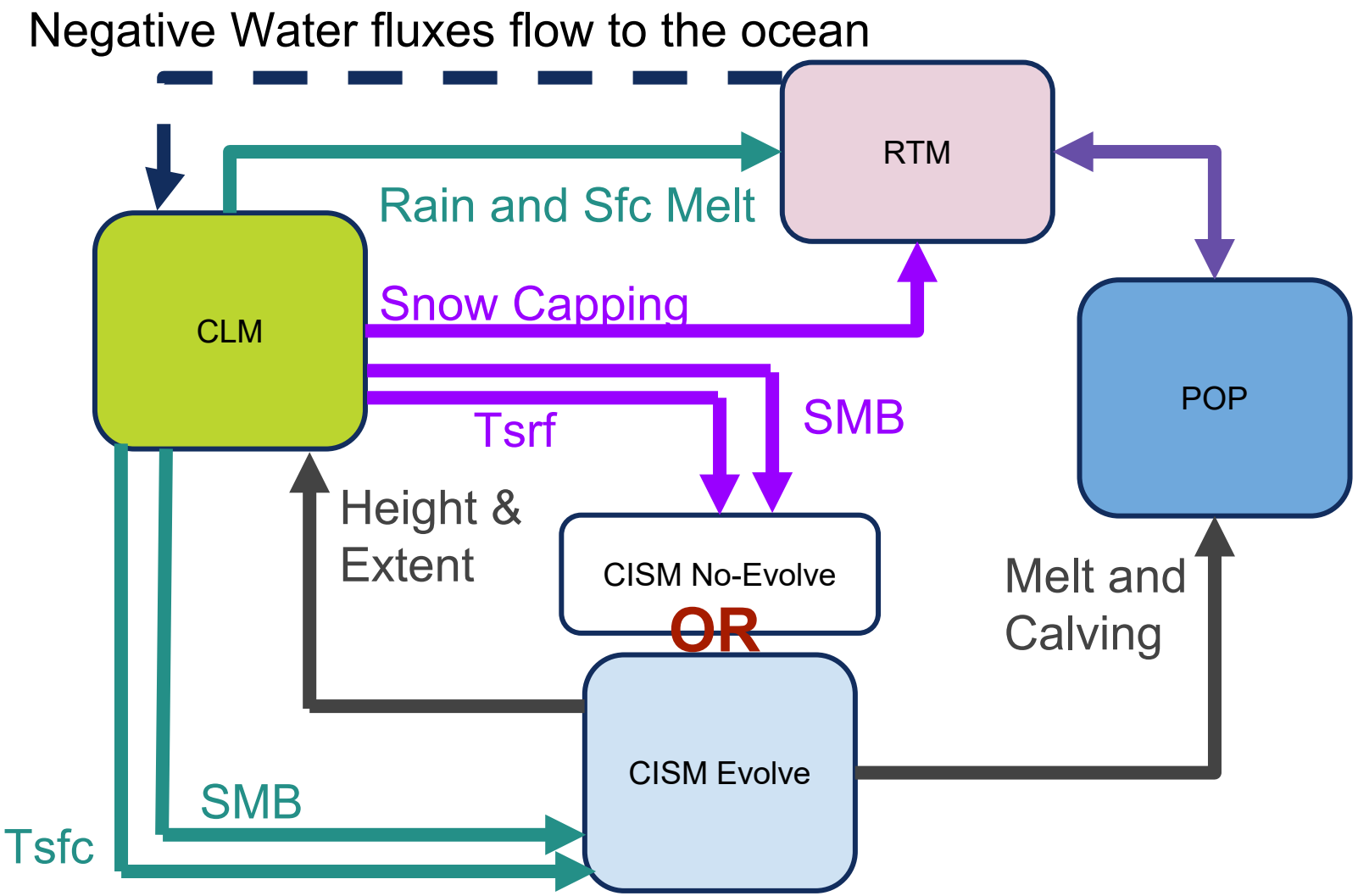


Coupling Improvements in CESM3

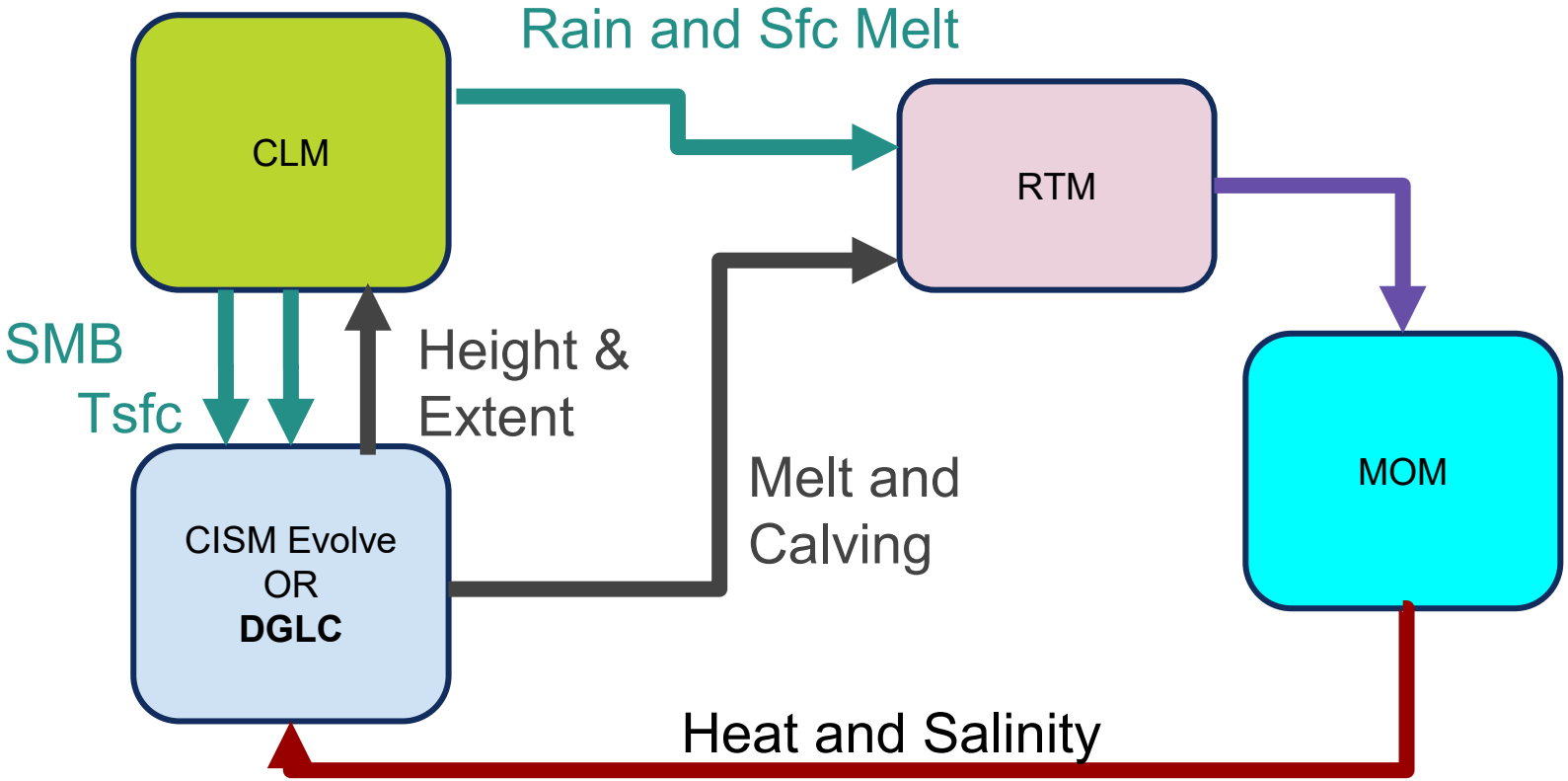
- ➔ Addition of the **Data Glacier Model**
  - CTSM interacts with only one “type” of ice sheet now, no more Evolve/NoEvolve
  - Can encapsulate logic to handle seasonality of fluxes from CTSM in this component and produce more realistic water fluxes.
  - Ocean fluxes available below ice shelves in DGLC



CESM2

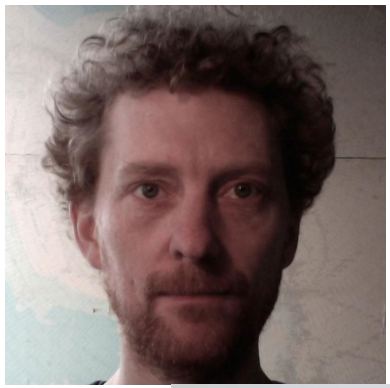

Negative Water fluxes flow to the ocean
RTM
Rain and Sfc Melt
CLM
Snow Capping
POP
SMB
Tsrf
Height &
Extent
CISM No-Evolve
OR
Melt and
Calving
CISM Evolve
SMB
Tsfc

CESM3


Rain and Sfc Melt
CLM
RTM
MOM
SMB
Tsfc
Height &
Extent
Melt and
Calving
CISM Evolve
OR
DGLC
Heat and Salinity

Working with NorESM!

➔ Thanks Mariana and NorESM scientists



https://www.noresm.org/

Future science this will support

- ➔ CESM3 default all-active compsets include Evolving Greenland Ice Sheet.
- ➔ Ability to run out-of-the-box with evolving Greenland AND Antarctica ice sheets.
- ➔ Experimental coupled compsets with mountain glaciers
- ➔ Better sea level rise predictions due to sub-shelf heating in simulations with active AIS.
- ➔ ISMIP7 simulations
- ➔ And many others…….

Useful Documentation

- Muntjewerf, L., Sacks, W. J., Lofverstrom, M., Fyke, J., Lipscomb, W. H., Ernani da Silva, C., et al. (2021). Description and demonstration of the coupled Community Earth System Model v2 – Community Ice Sheet Model v2 (CESM2-CISM2). Journal of Advances in Modeling Earth Systems, 13, e2020MS002356. https://doi.org/10.1029/2020MS002356
- Land Ice in CESM2: https://escomp.github.io/cism-docs/cism-in-cesm/versions/release-cesm2.0/html/index.html
- Glaciers in CLM 5.0: https://escomp.github.io/ctsm-docs/versions/release-clm5.0/html/tech_note/Glacier/CLM50_Tech_Note_Glacier.html