Meltwater routing in GEOS: current activities and plans

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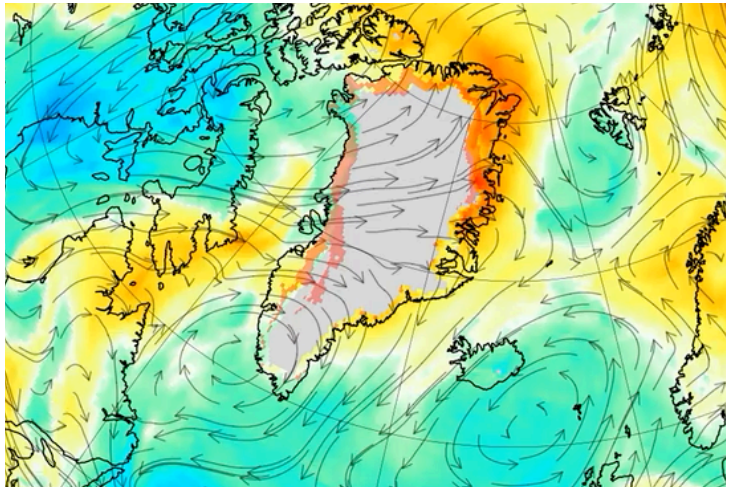
Lauren Andrews* with contributions from Richard Cullather, Kristin Poinar, Manuela Girotto, the GEOS-S2S Group, & others
*Mistakes my own

Global Modeling & Assimilation Office

Meltwater routing in GEOS: current activities and plans

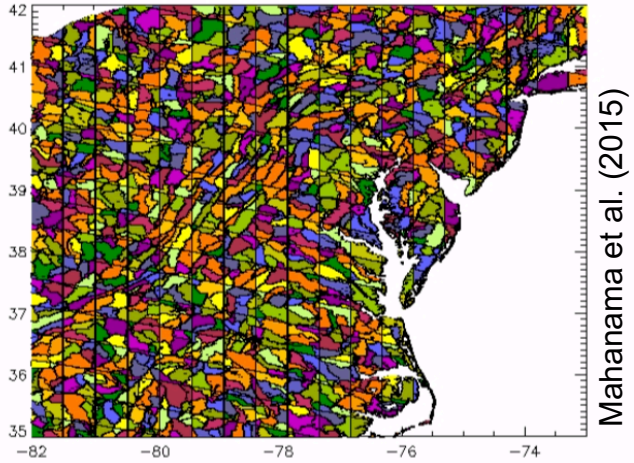
The glacial hydrologic system (in short)

Current representation in GEOS



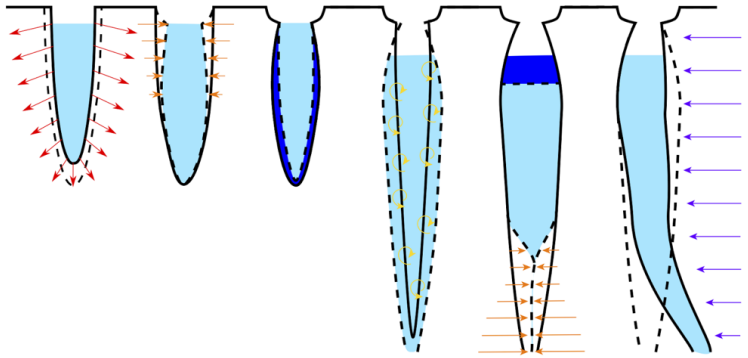
Cullather et al. (2019)

Near-term plans*

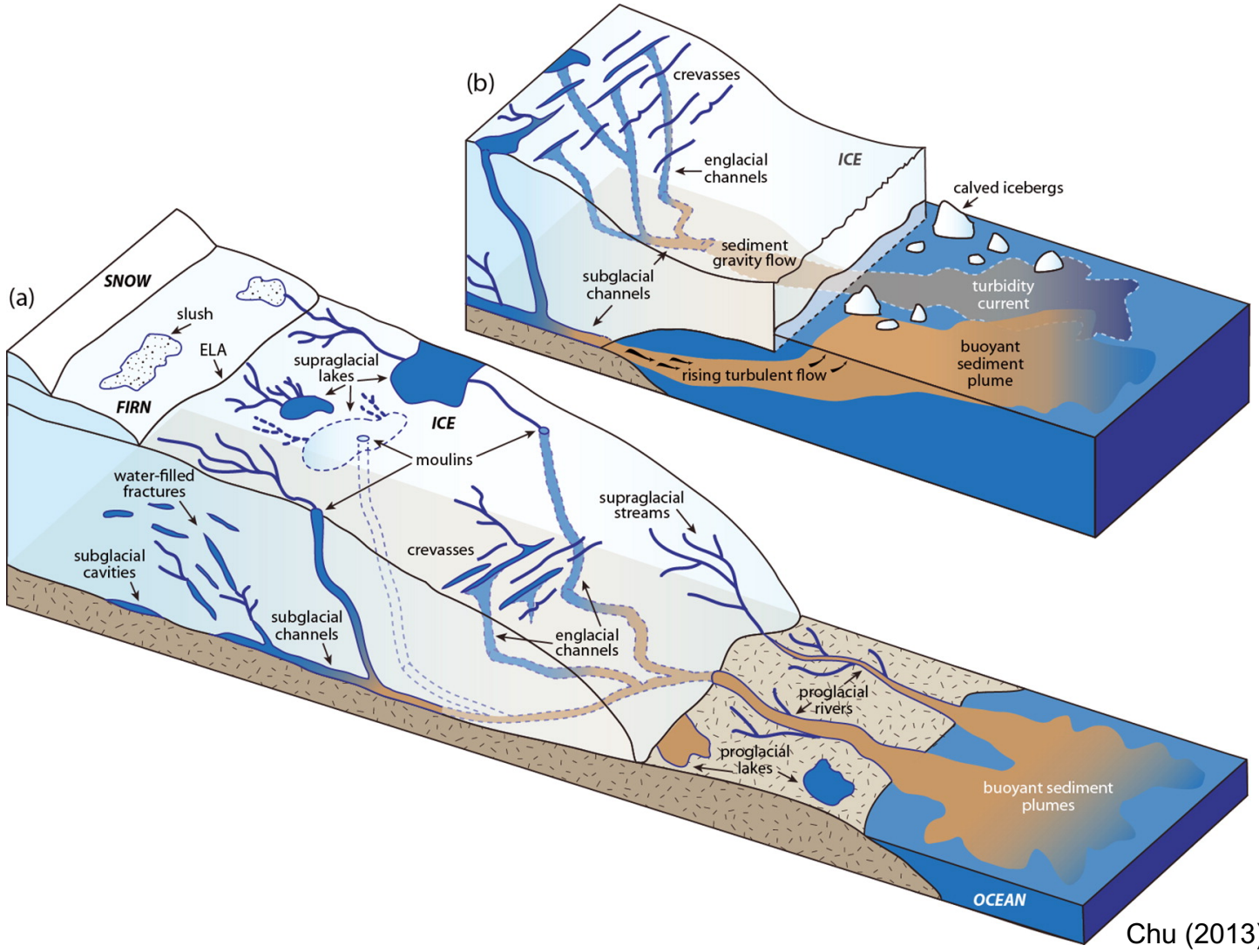


Mahanama et al. (2015)

Ongoing work and relevant projects



The glacial hydrologic system



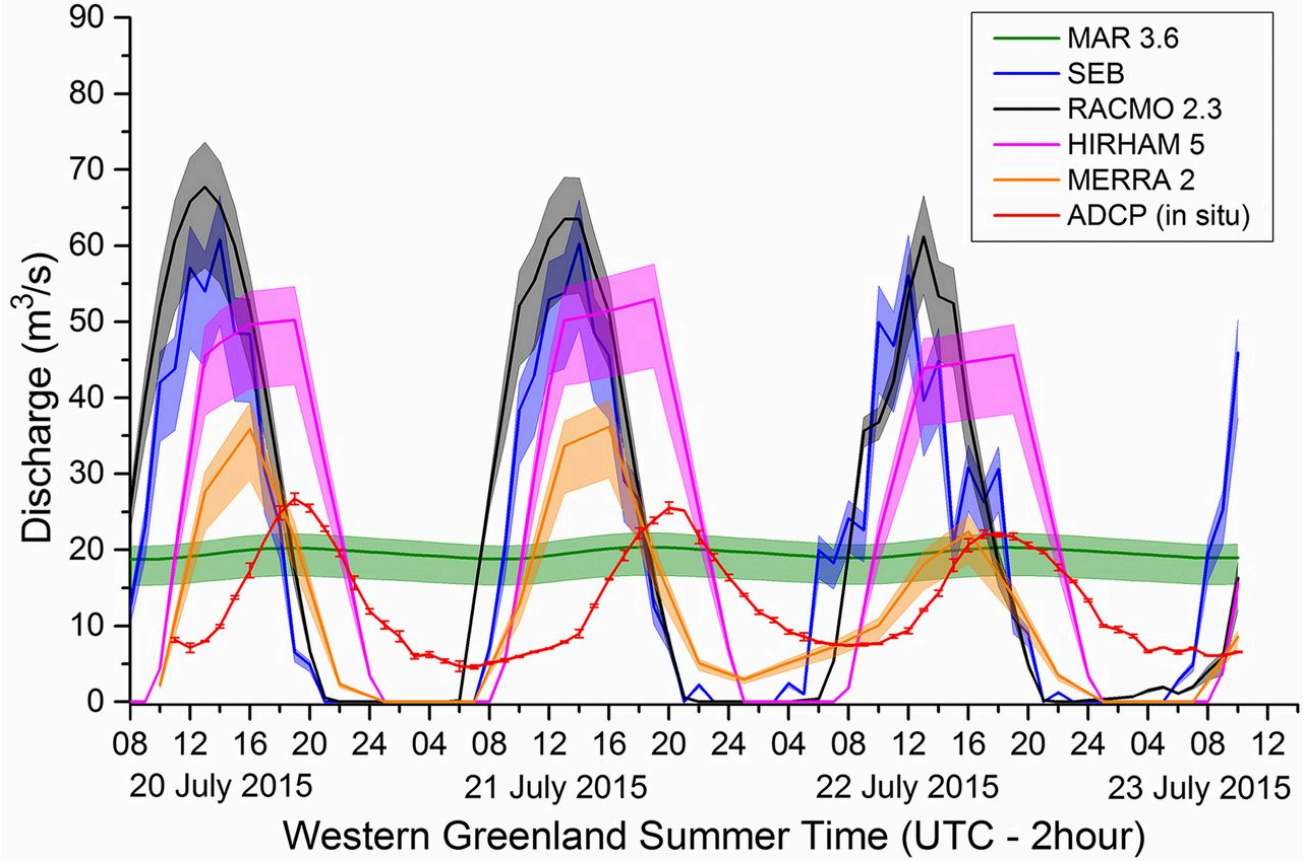
Chu (2013)

Response to current climate conditions

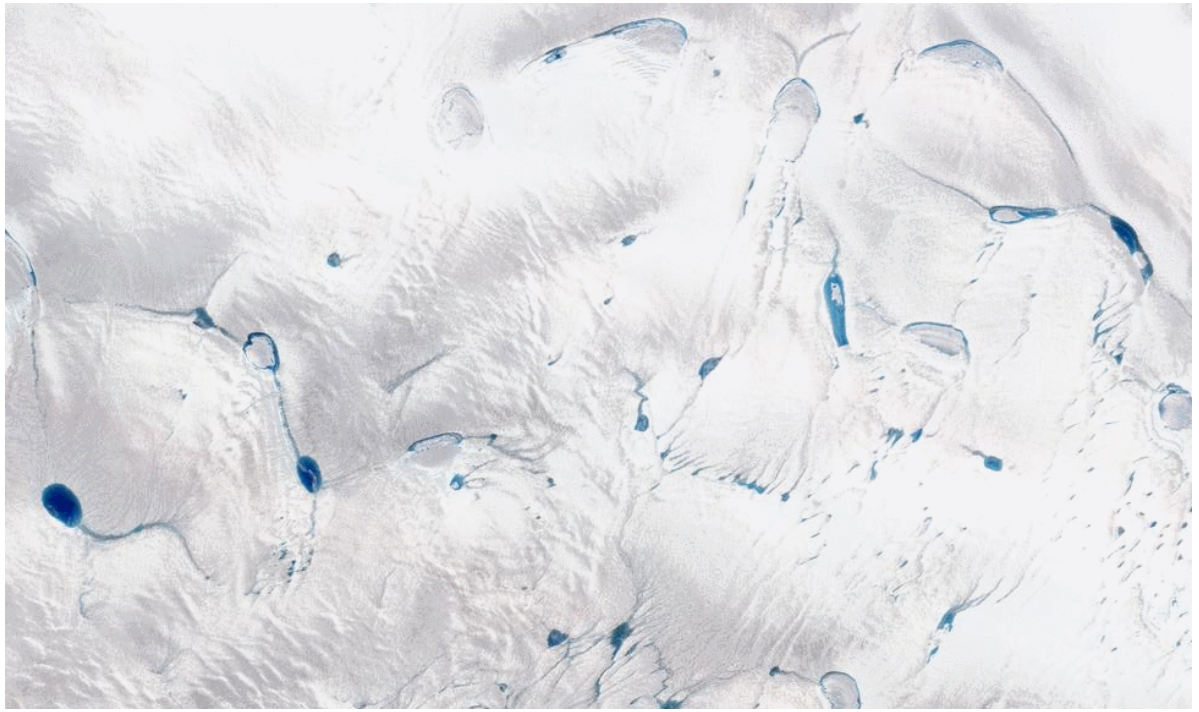
Dynamic impacts on glacier and ice sheet mass loss

Location and routing delay of glacier and ice sheet runoff

Important surface characteristics: Bare ice routing delays



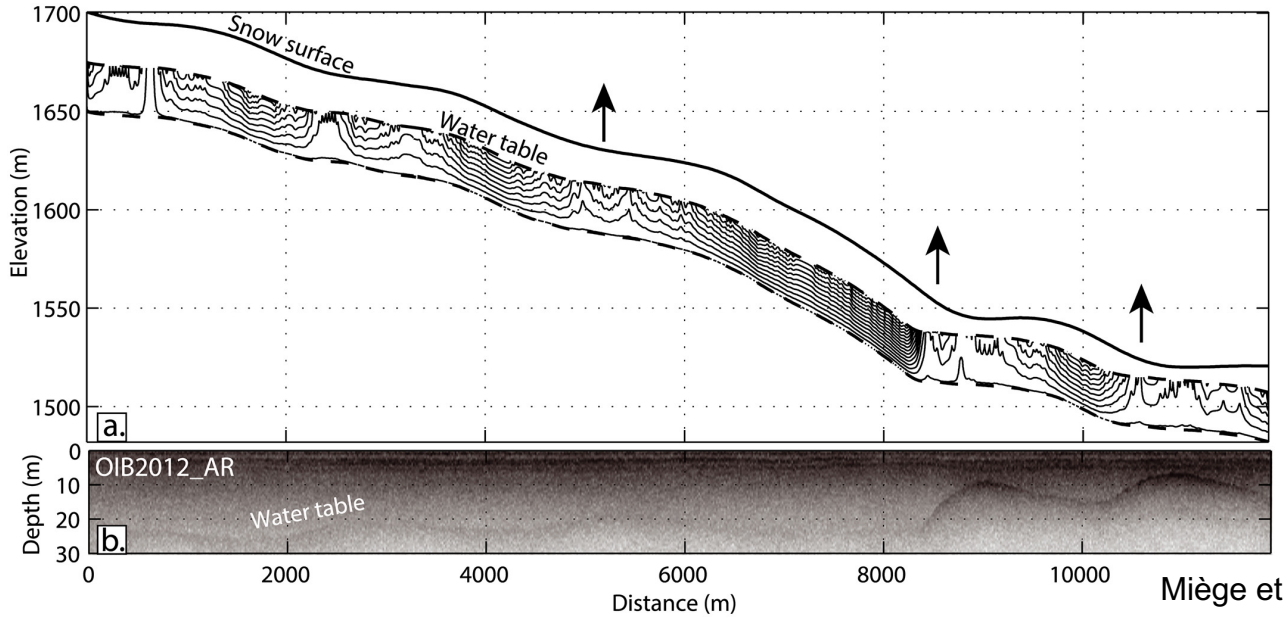
Smith et al. (2017)



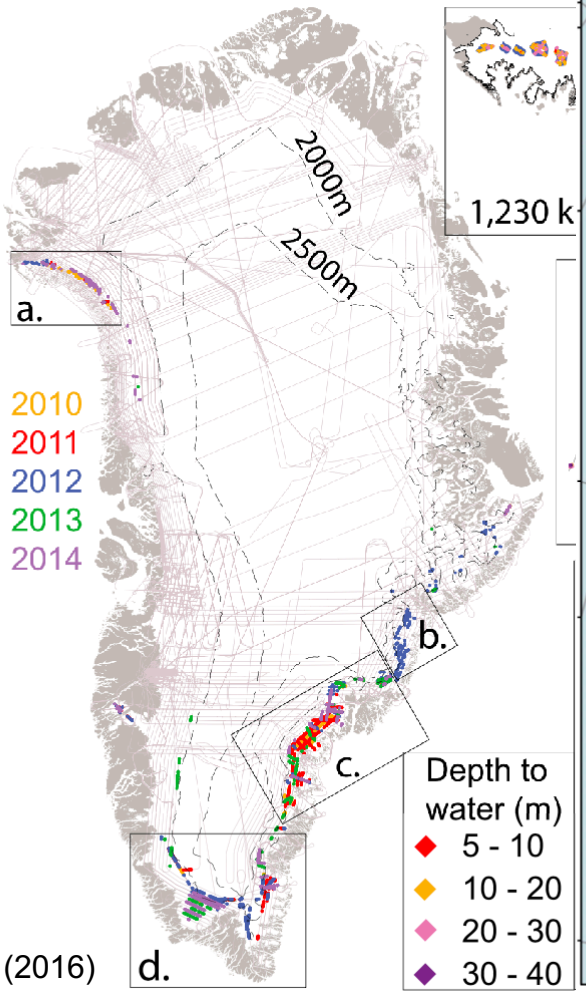
Modified from https://earthobservatory.nasa.gov/images/80677/greenland-melt-ponds

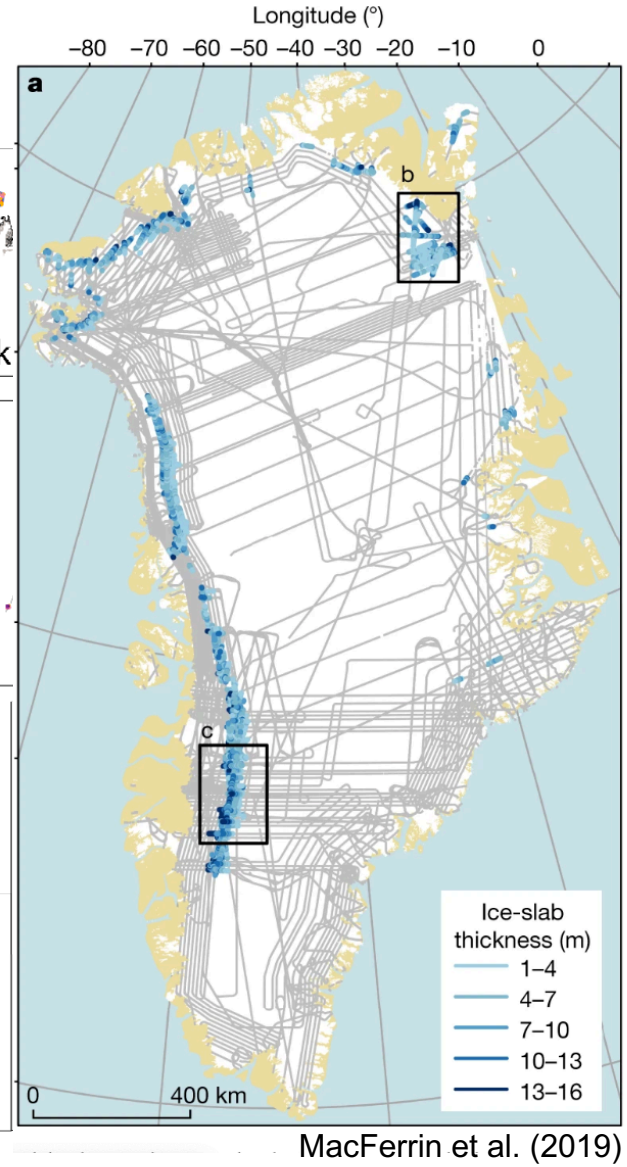
Important surface characteristics: Firn routing modifications

Firn processes and local conditions can accelerate or delay meltwater delivery to the ocean.



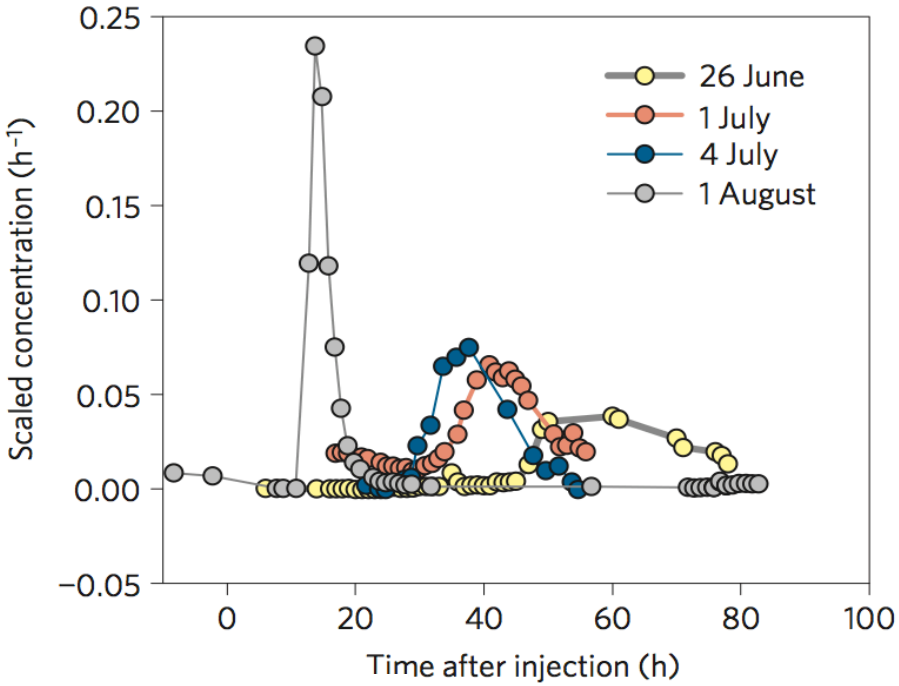
Miège et al. (2016)



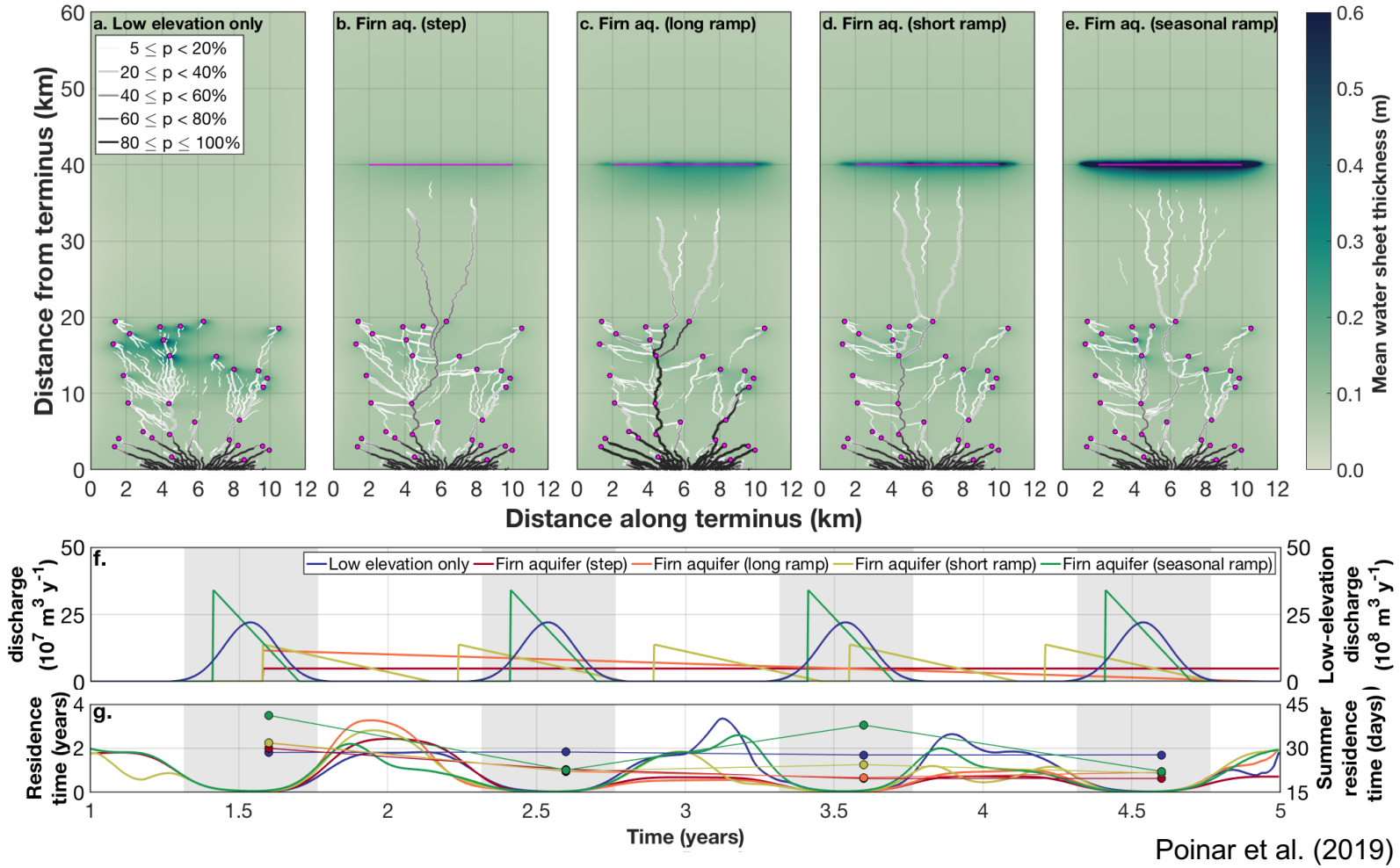


MacFerrin et al. (2019)

Important subglacial characteristics

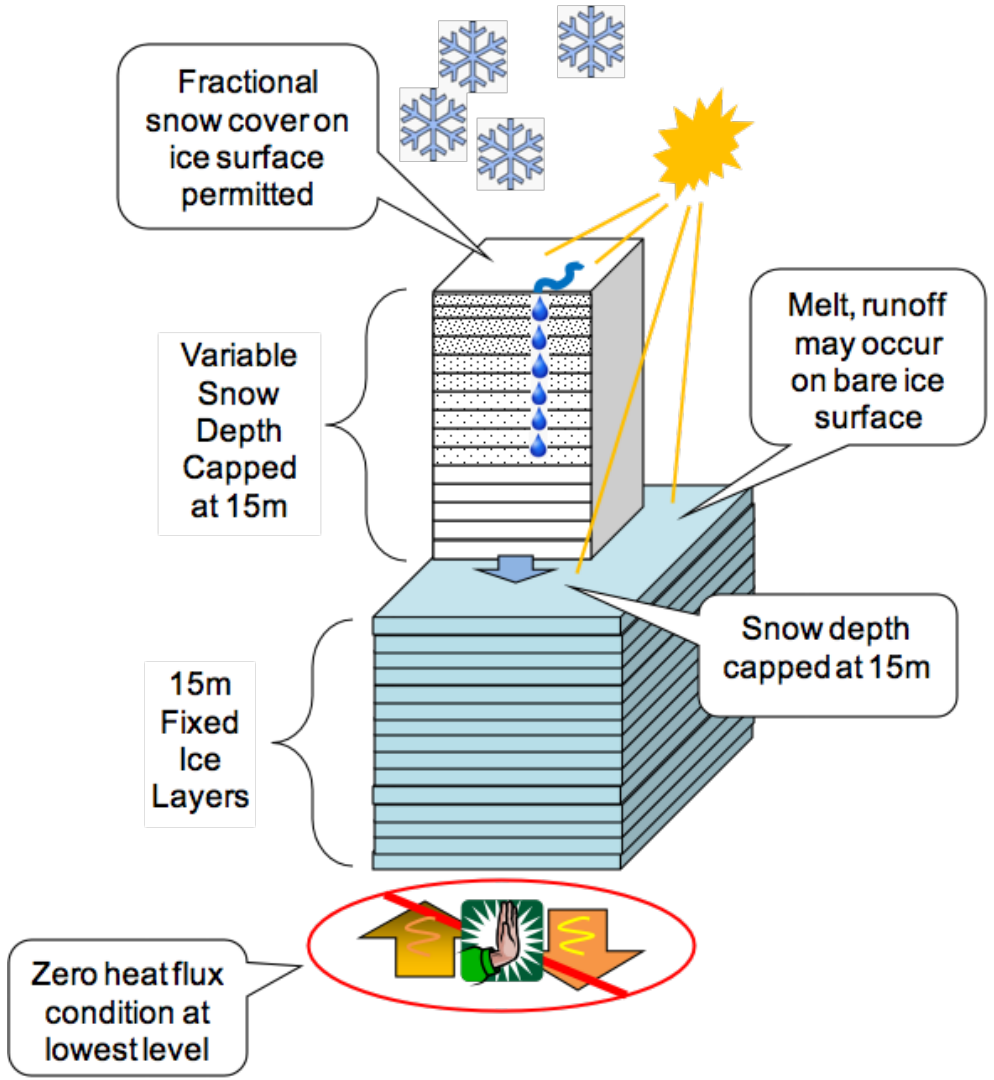


Chandler et al. (2013)

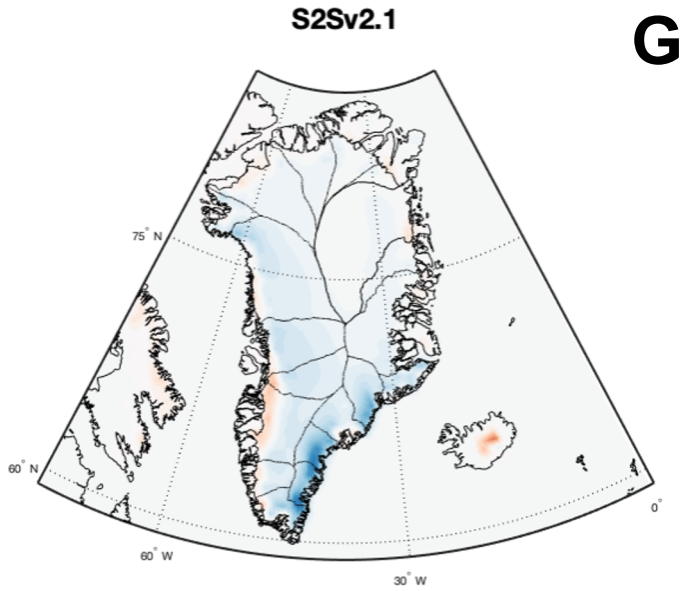


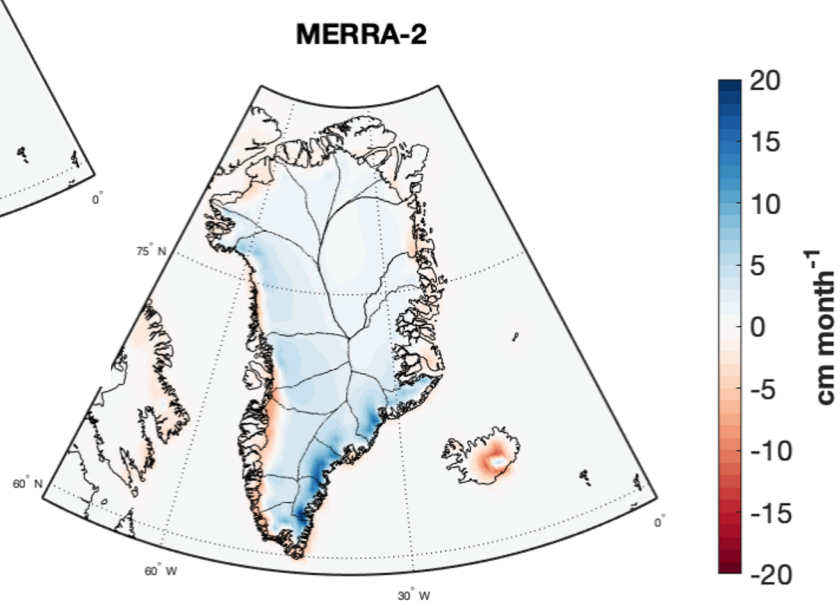
Poinar et al. (2019)

Glacier and ice sheet representation in GEOS



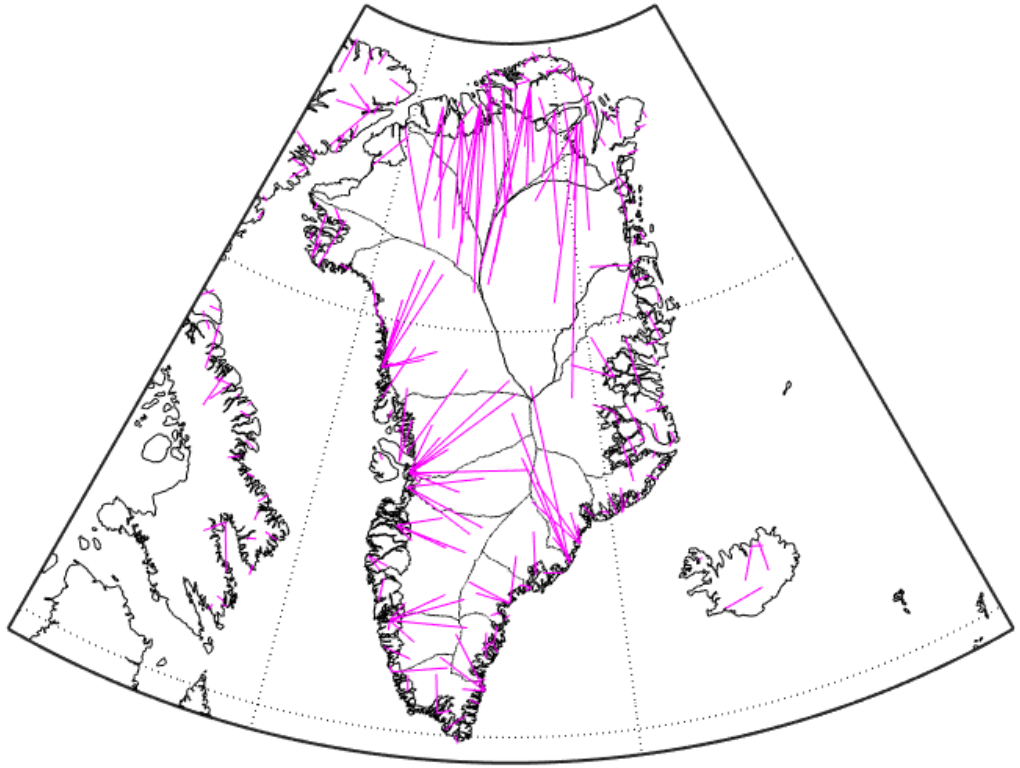
What's missing in GEOS (for ice sheets are glaciers)?



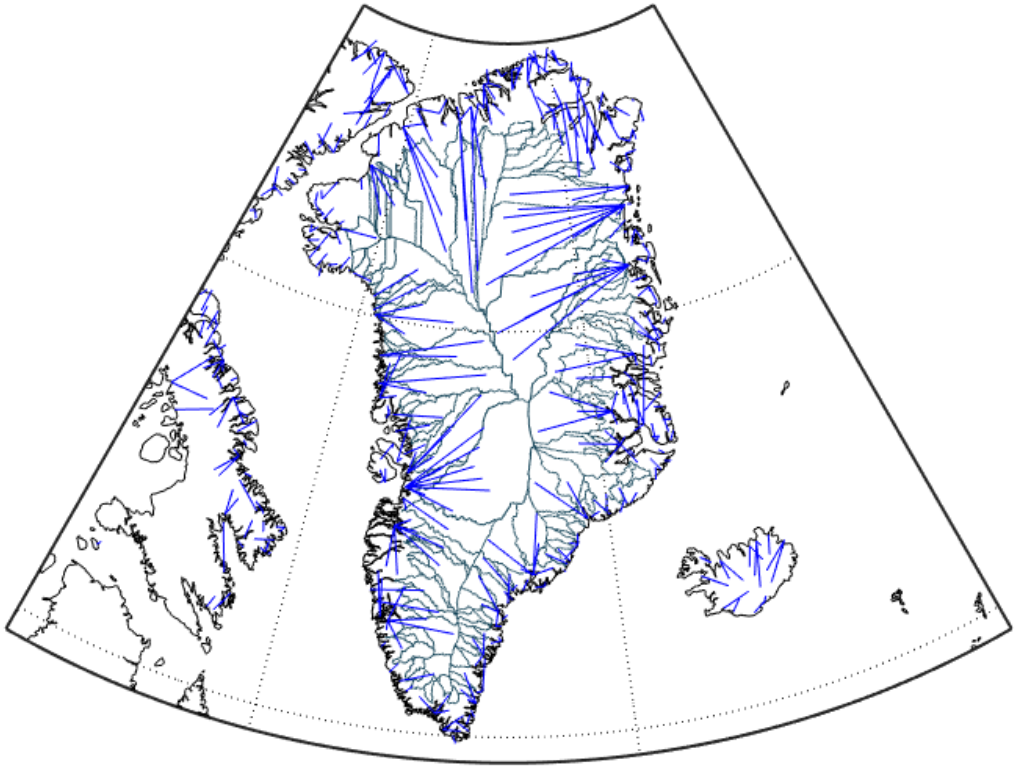


Glacier and ice sheet representation in GEOS: surface routing improvements

Previous surface routing



What GEOS can do now (GEOS-S2S v3)



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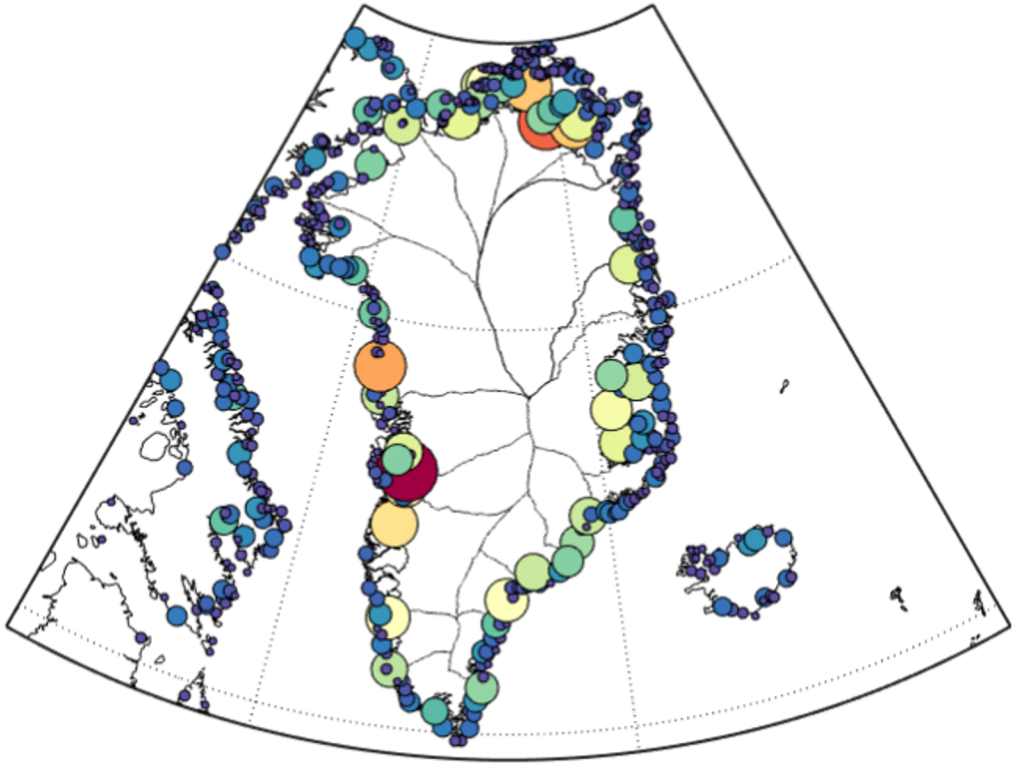

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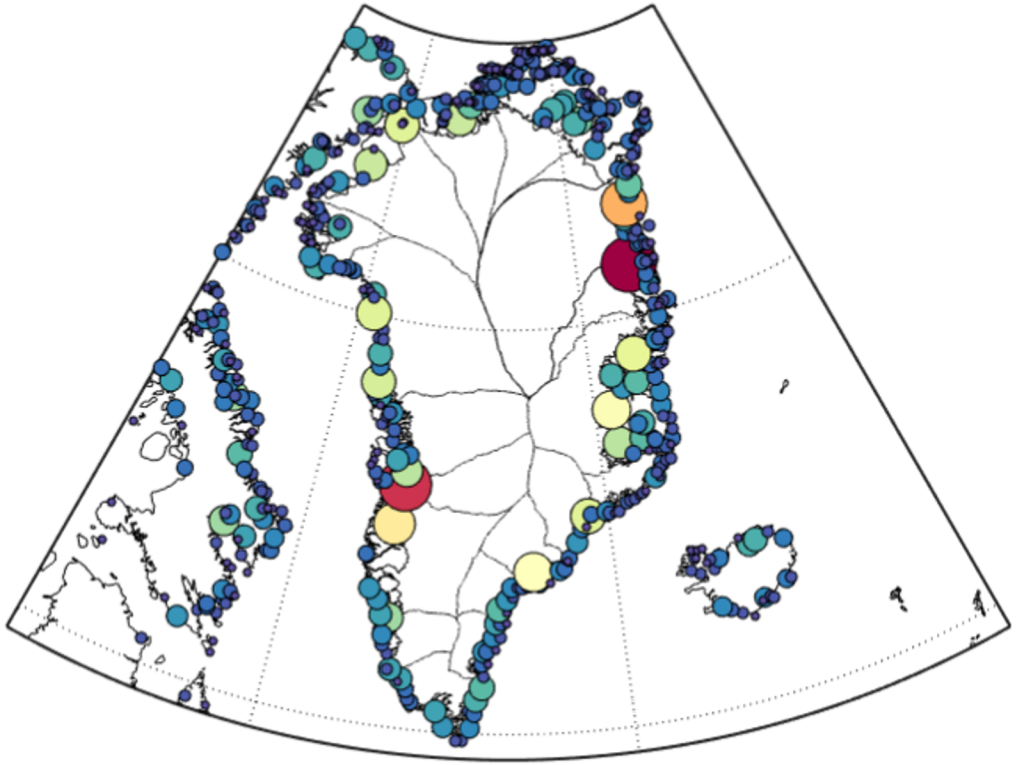
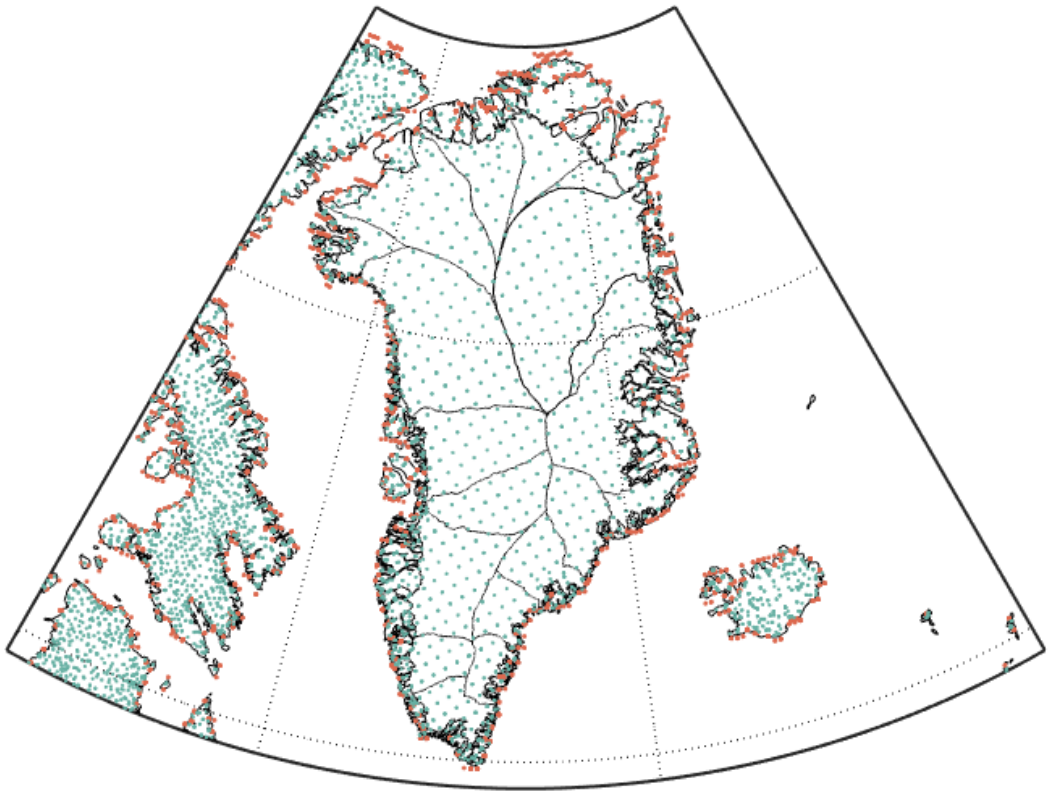
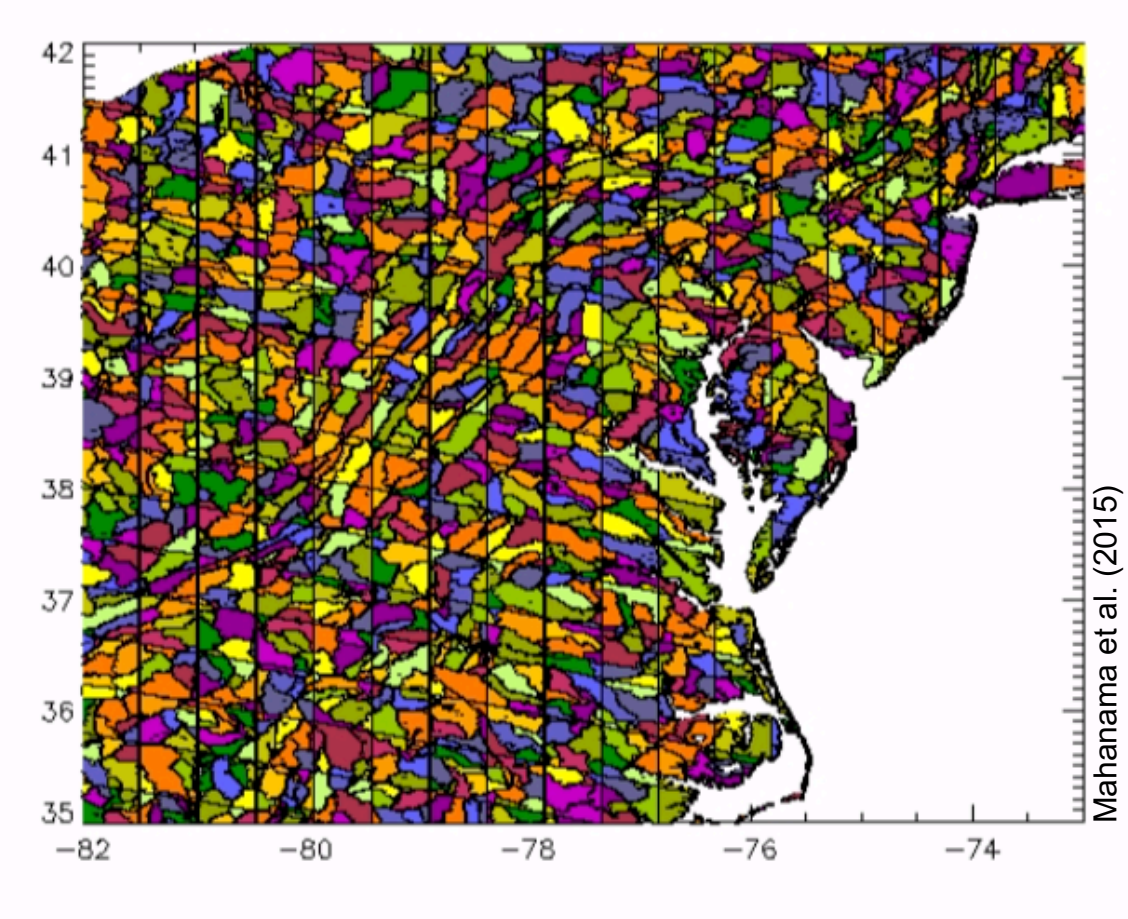


Glacier and ice sheet representation in GEOS: near term improvements

Improved ice surface catchment representation





Glacier and ice sheet representation in GEOS: near term improvements

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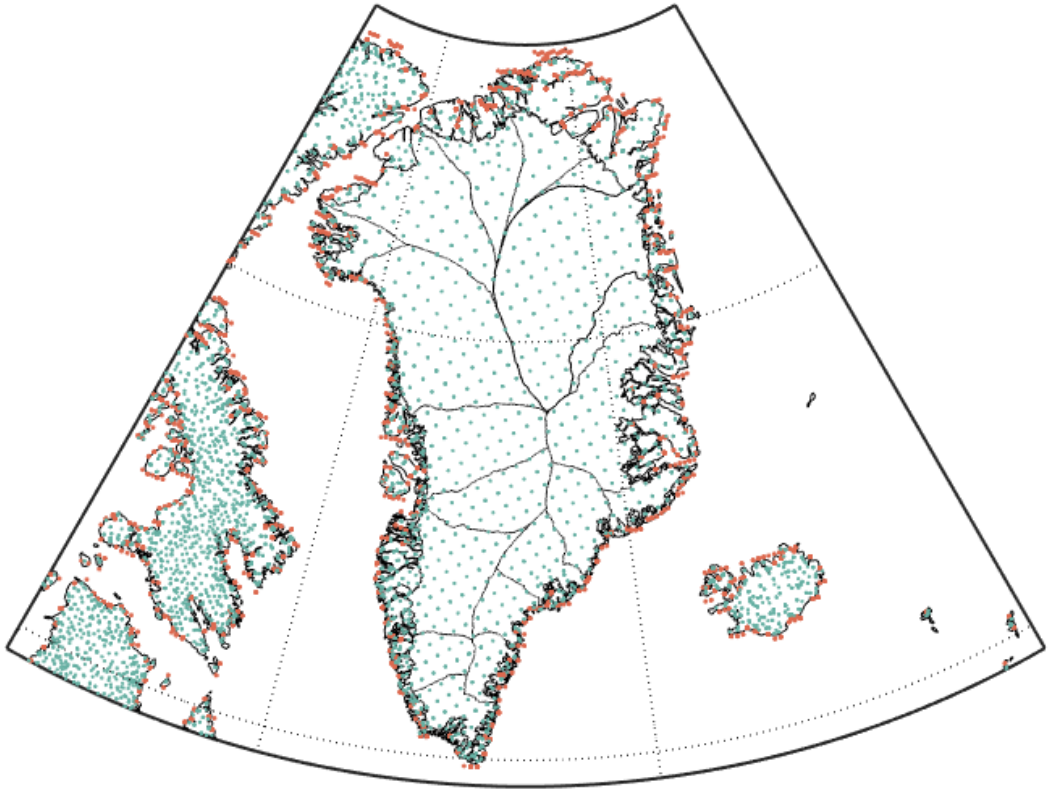
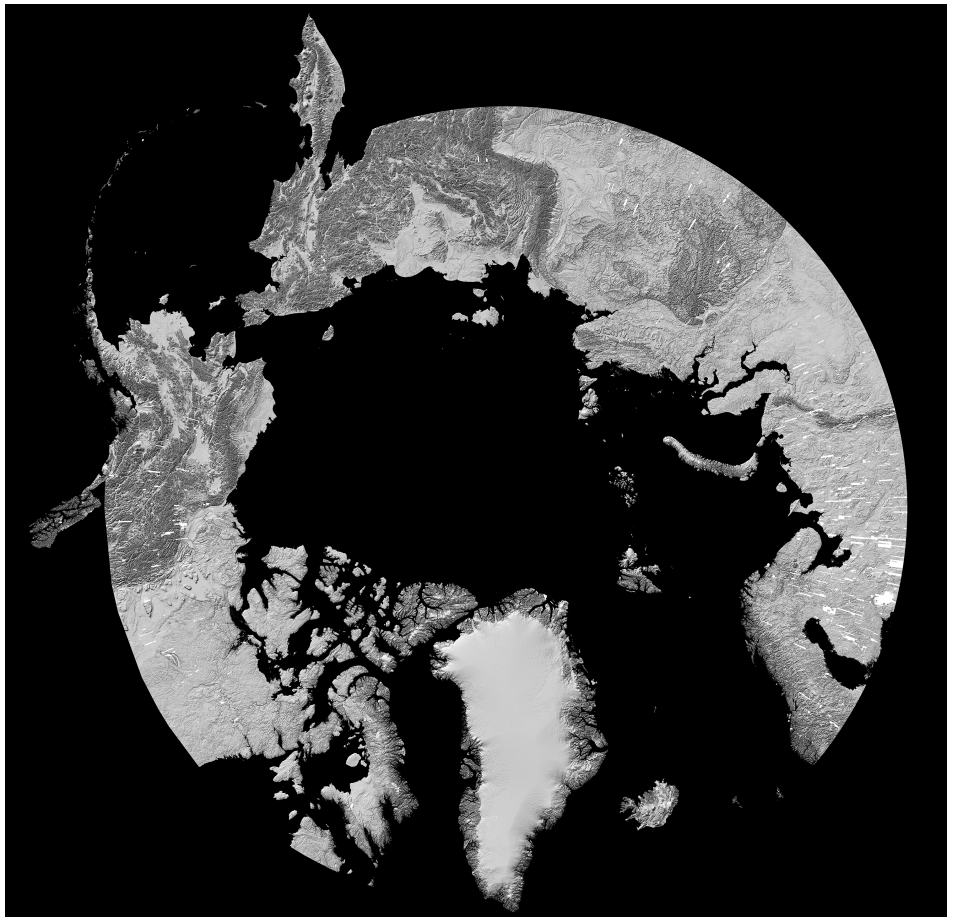




ArcticDEM Mosaic v7 (Polar Geospatial Center)

Glacier and ice sheet representation in GEOS: routing delay implementation

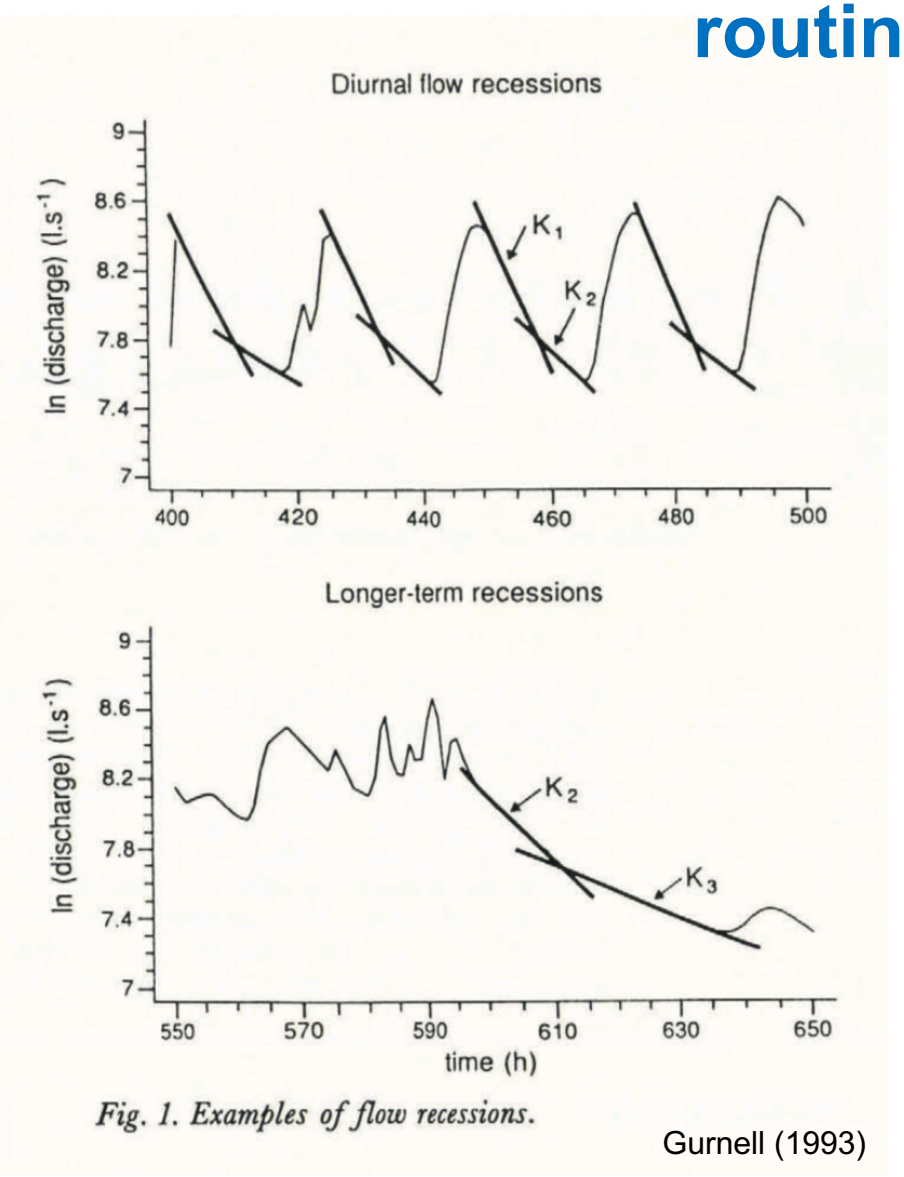
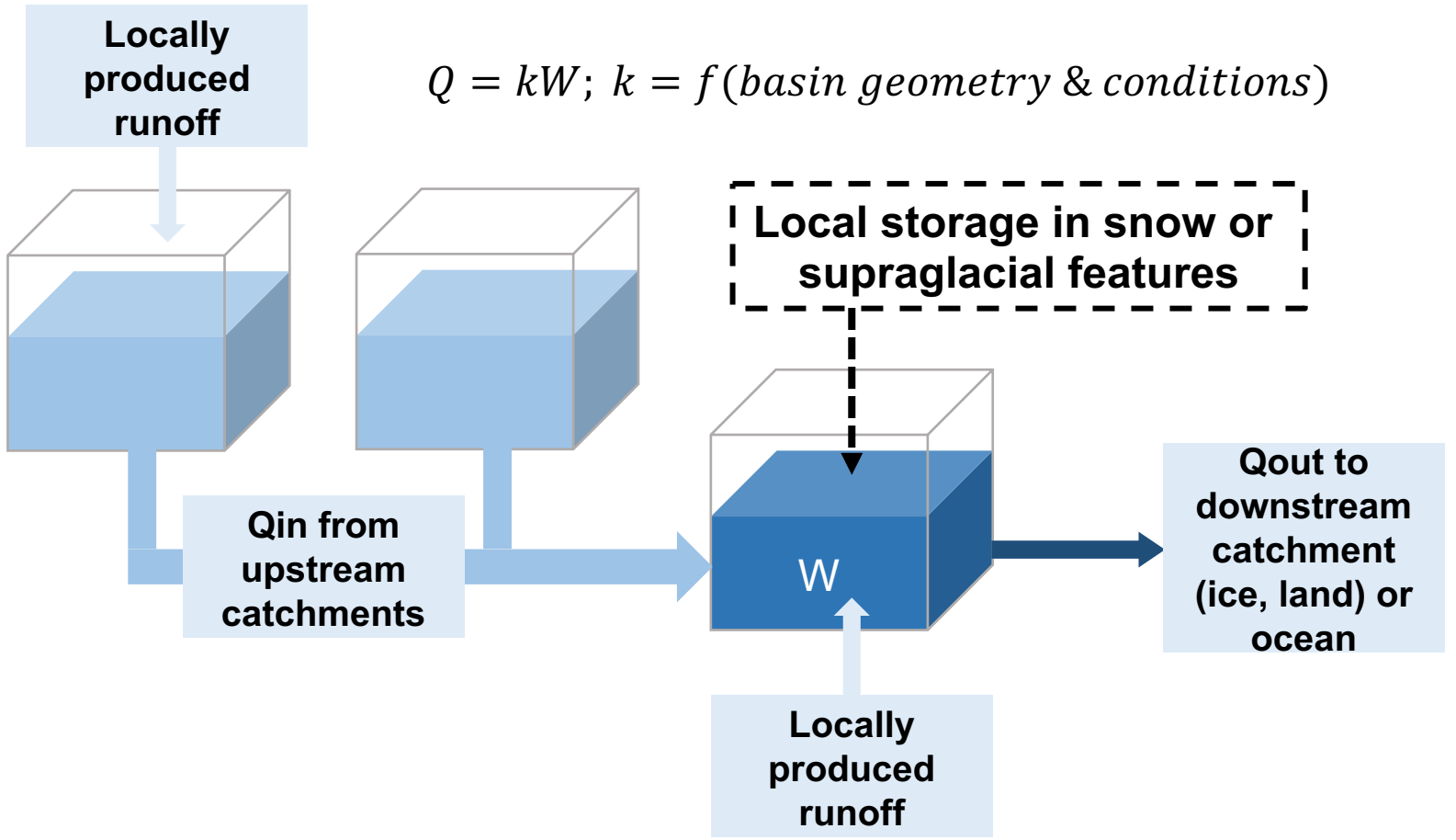


Fig. 1. Examples of flow recessions.

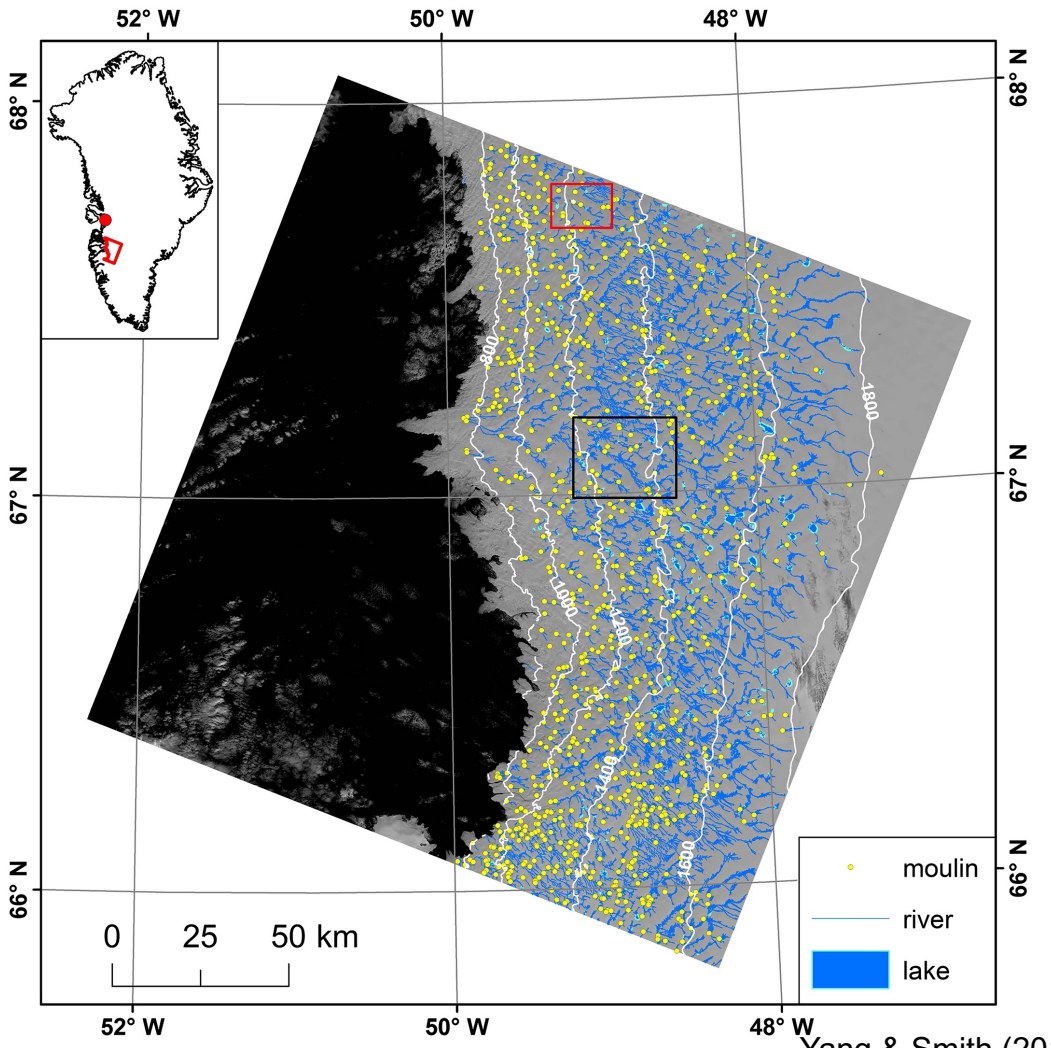
Gurnell (1993)

Linear reservoir model

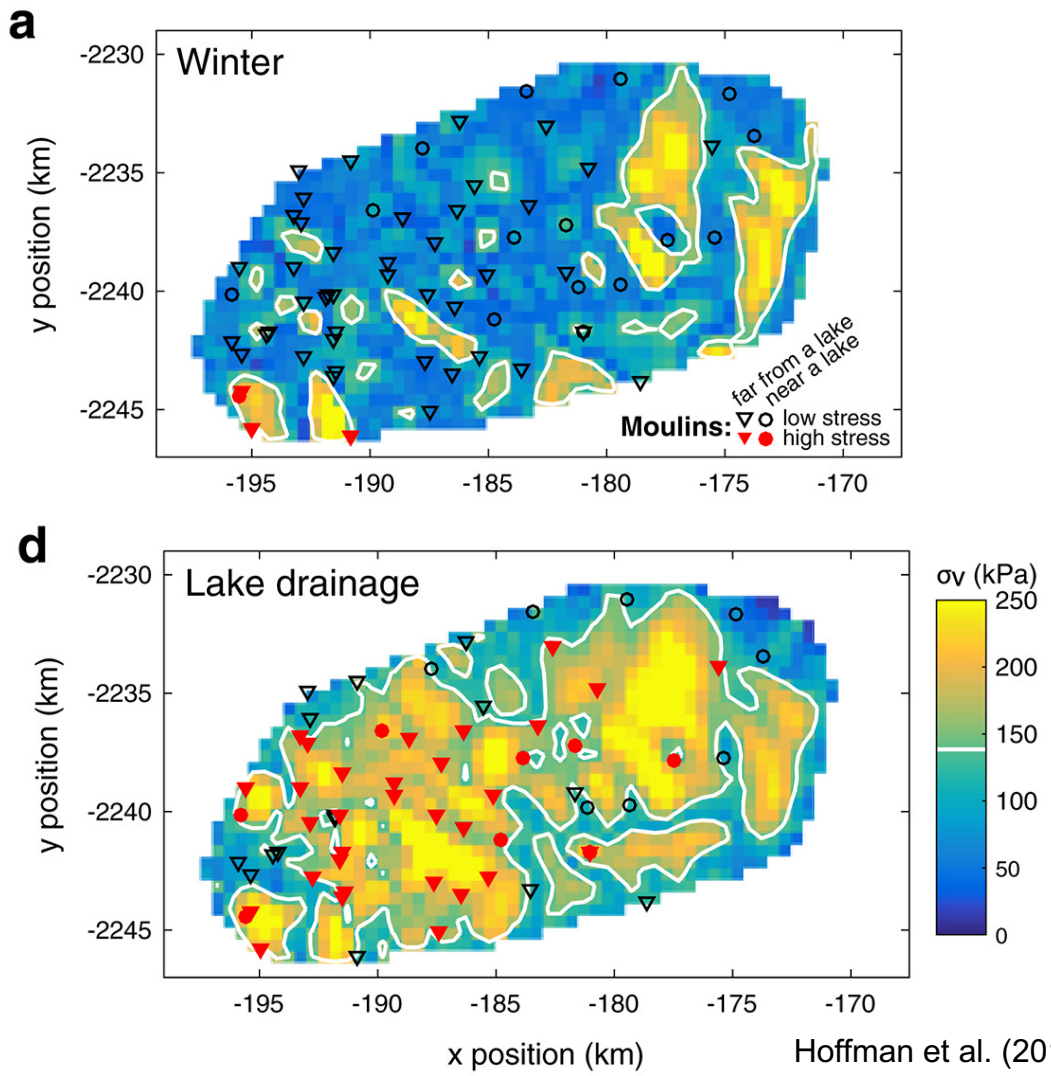
$$Q = kW;\ k = f(basin\ geometry\ \&\ conditions)$$



Related work: parameterizing surface to bed connections



Yang & Smith (2018)



Hoffman et al. (2018)

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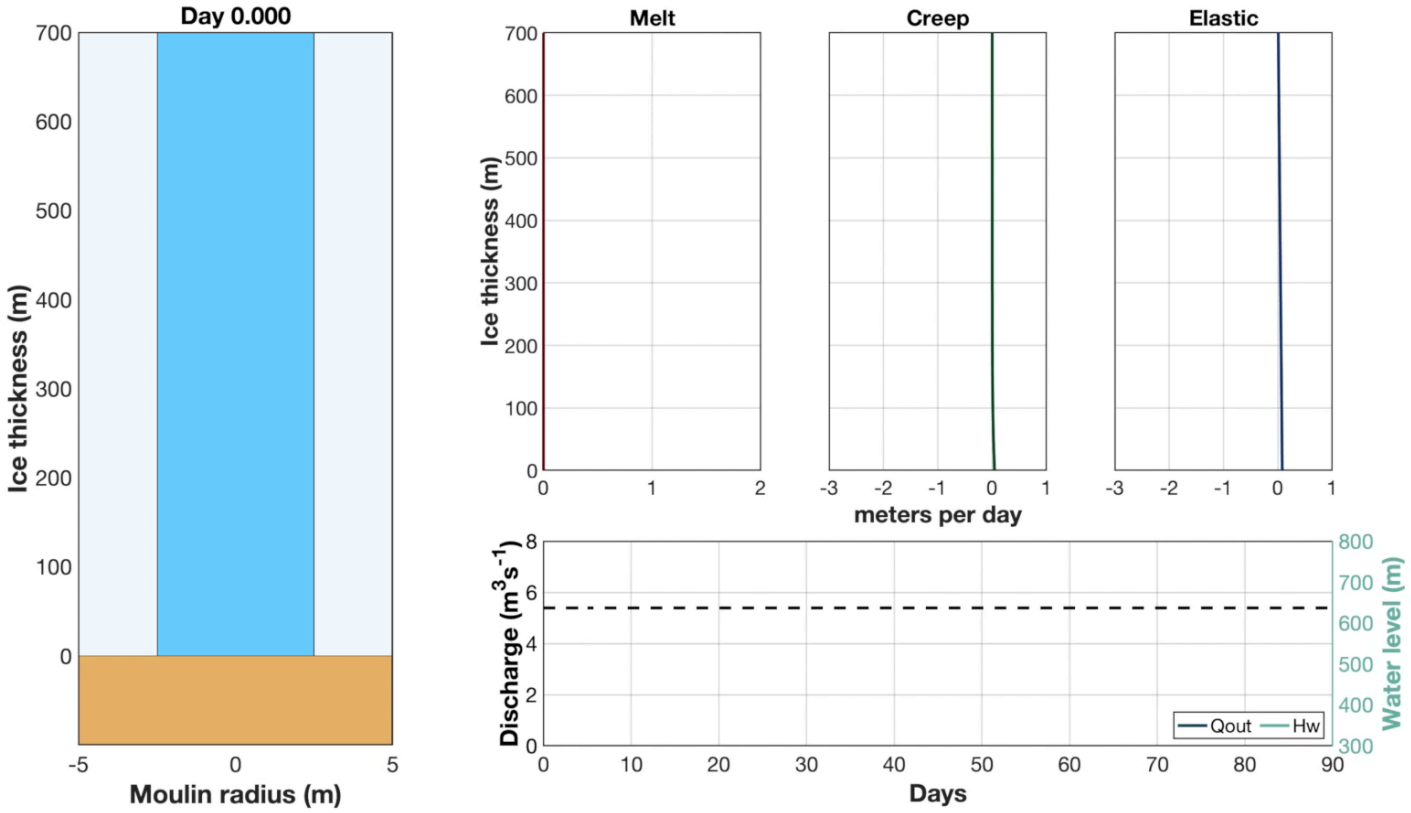
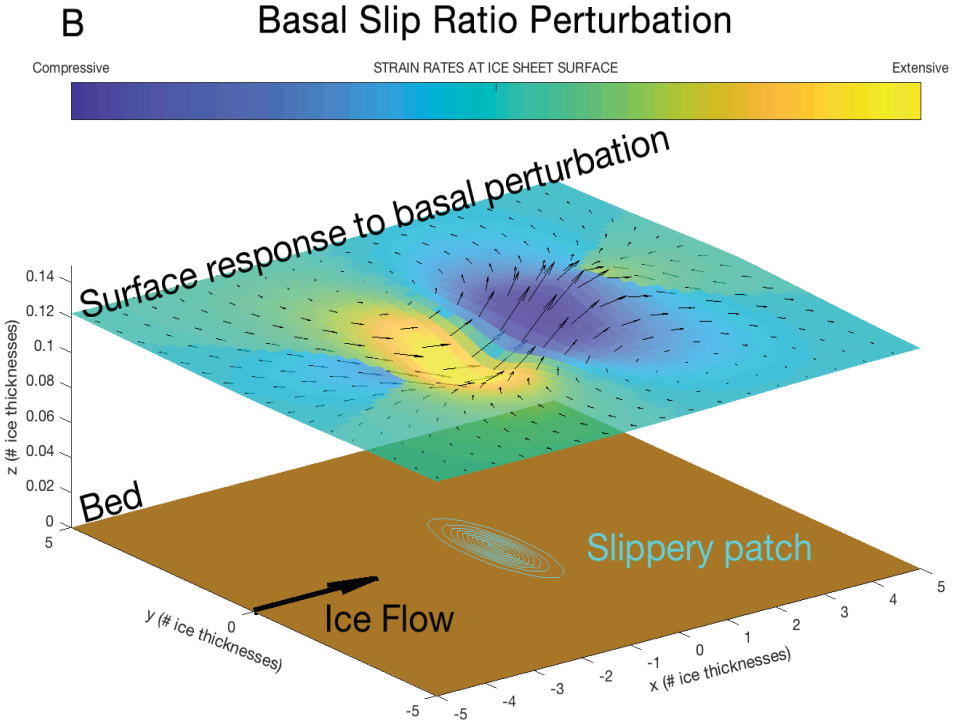
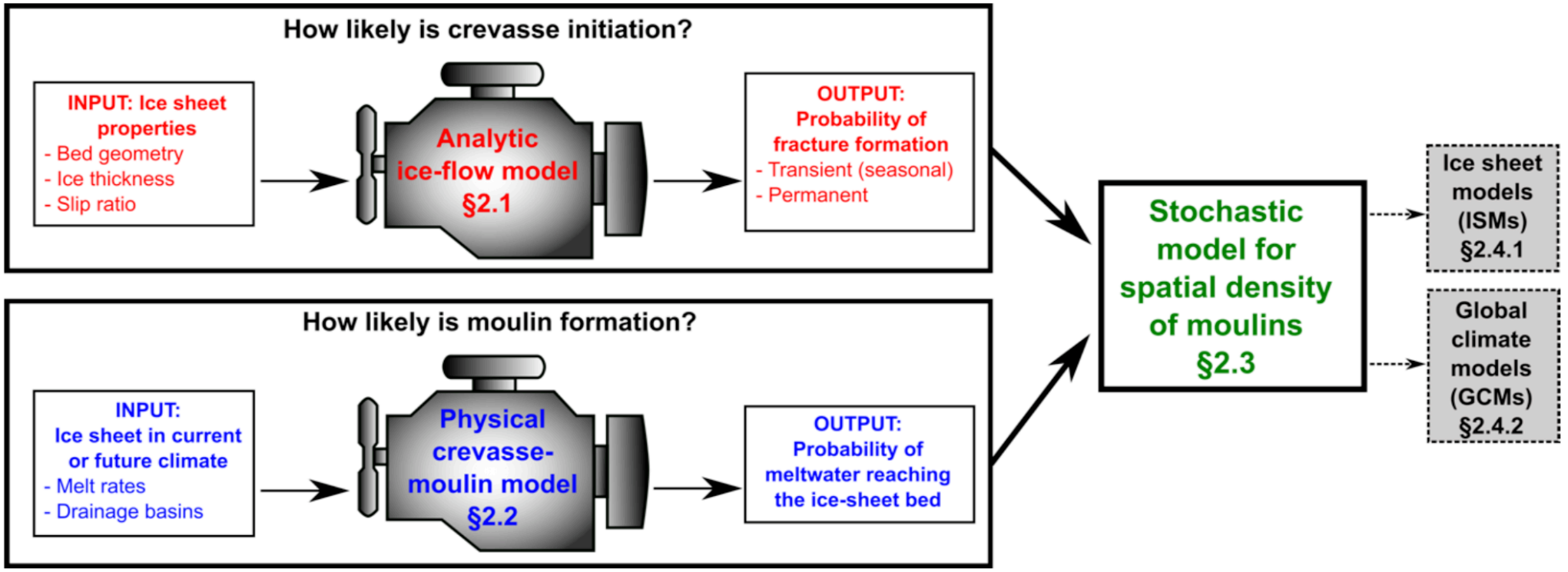




Andrews & Poinar (2019)

Related work: parameterizing surface to bed connections

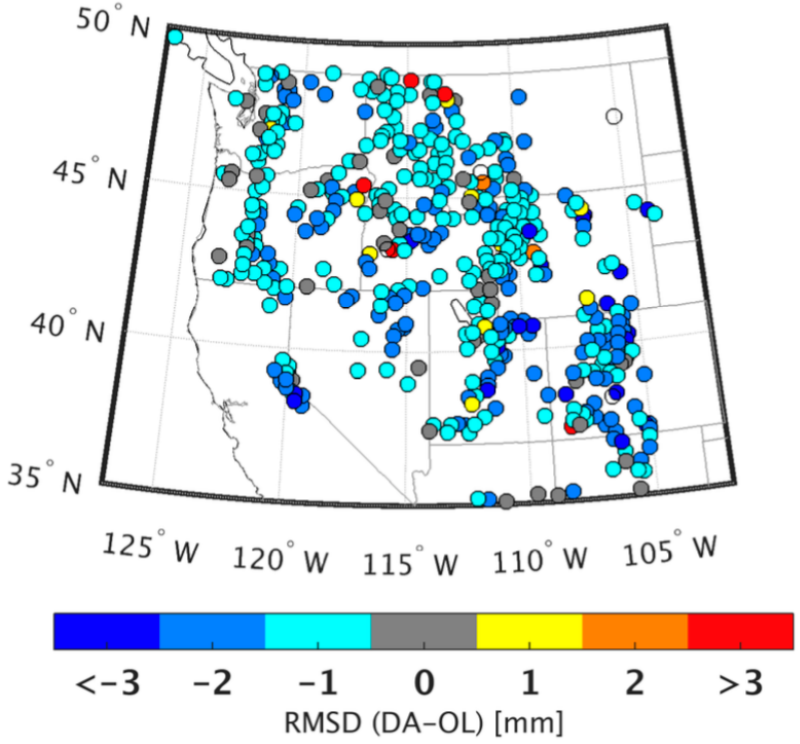


Andrews & Poinar

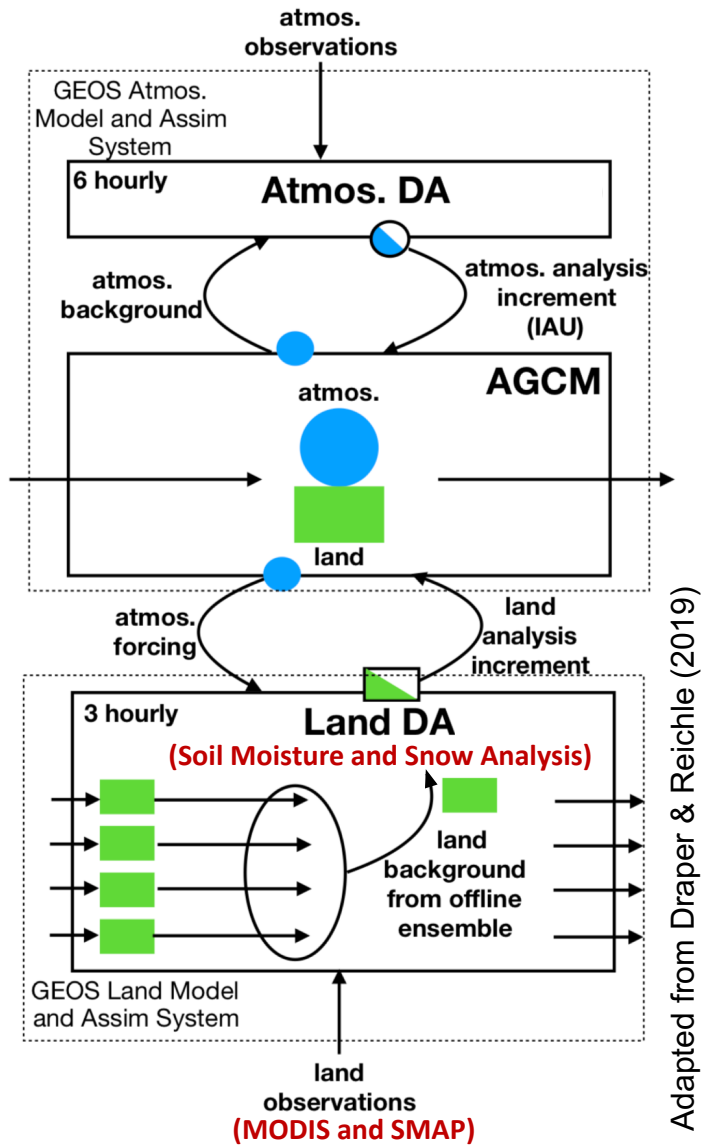
Related work: snow data assimilation

Land–climate interactions, including snow–atmosphere coupling, are important sources of weather and climate predictability.

High Mountain Asia Program Project (M. Girotto & L. Andrews) will develop a coupled Land- Atmosphere- and Ocean- S2S framework with a primary goal of snow observation assimilation.



Toure et al. (2018)



Adapted from Draper & Reichle (2019)

Expected issues and final thoughts

Goals

- Development of physically consistent ice catchments
- Implementation of time delayed routing scheme
  - ‘seamless integration’ with current land routing scheme
- Firn model/processes
- Aerosol snow/ice darkening
- **Reanalysis integration**

Likely issues

- Calibration and validation of *k* and ice sheet/glacier runoff
- Differences between model ice extent and natural ice extent
- Runoff and calving integration with ocean model

Thoughts

- Subglacial hydrology is not relevant for the current versions of GEOS, but this structure and a stochastic model for englacial drainage features should readily allow its treatment within GEOS-ISSM coupled framework.