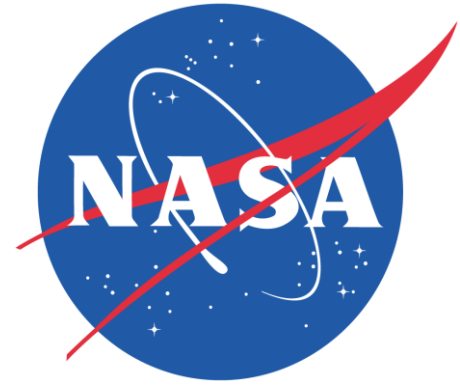# *Recent Developments in Ice Sheet Model Coupling at the NASA GMAO*

Richard Cullather, Sophie Nowicki,

Bin Zhao, Max Suarez

NASA Global Modeling and Assimilation Office

- Provides atmospheric <u>analyses</u> and <u>simulations</u> for instrument and data calibration, mission support, weather and climate analysis.

- GEOS-5 global, finite-volume model, integrated with various physical packages.

- Catchment-based land-surface representation that is semi-implicitly coupled to the atmosphere, and operates on sub-AGCM grid "tiles" that communicate with the atmosphere via an exchange grid.

- <u>Goals for ISM coupling</u>
  - Assess the dynamics and eustatic contribution of ice sheets in the satellite era.
  - Evaluate ISM sensitivity in various forcing scenarios.
  - Improve representation of oceanic freshwater inputs.

ISM Coupling Process
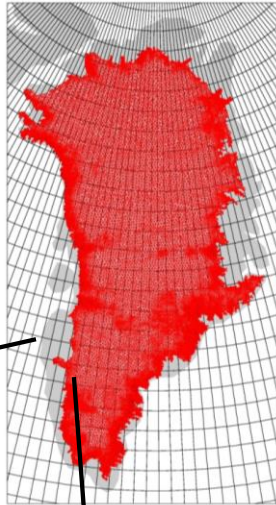
- Revise and continue to improve and evaluate ice sheet surface representation (hydrology, albedo & surface energy balance).

- Coordinate the geographical interface between the land surface and the ISM
  - Land surface tile structure that reflects ISM mesh
  - Load-rebalancing
  - Downscaling of atmospheric fields to the surface tiles

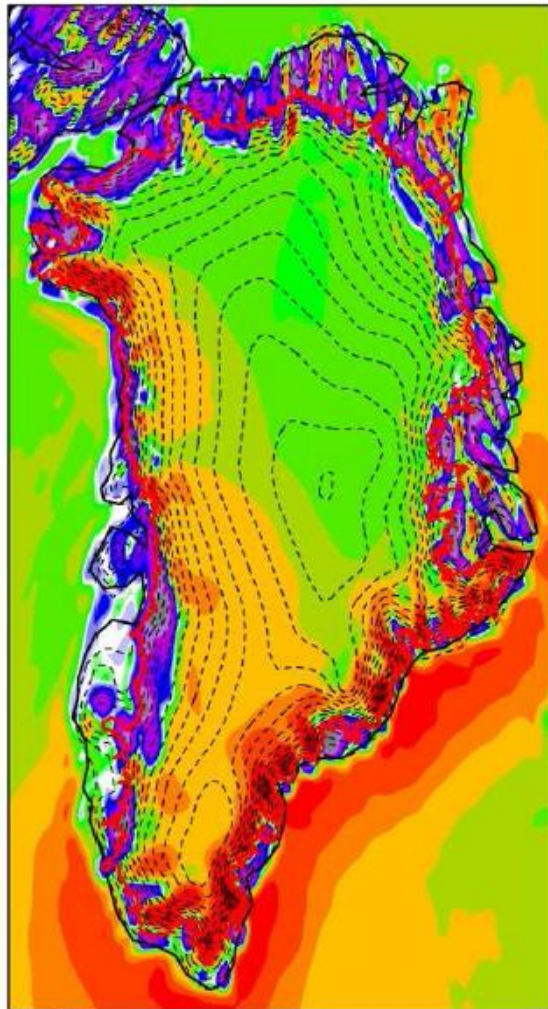- Implemented a communicator to allow control of the ISM.

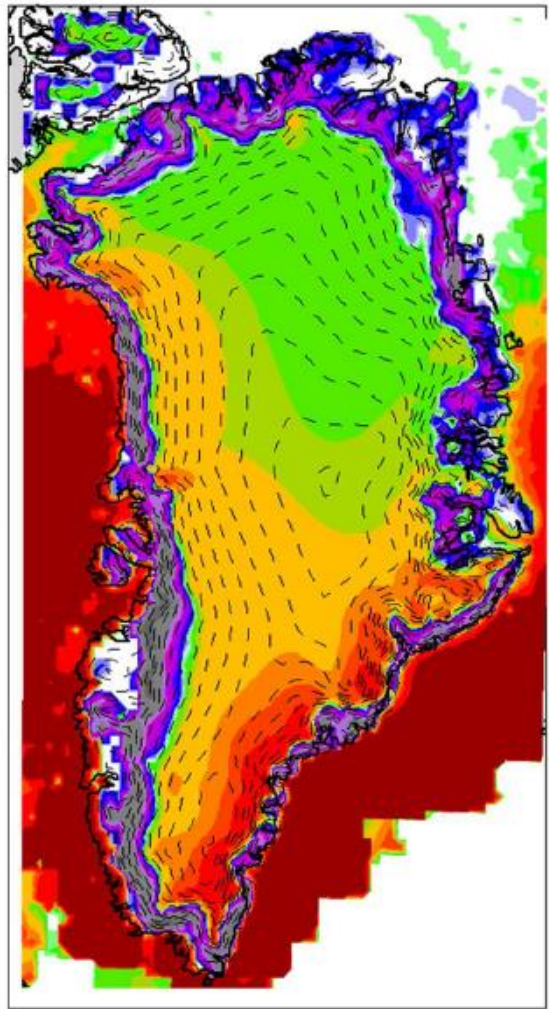- Awaiting ISM check-pointing..
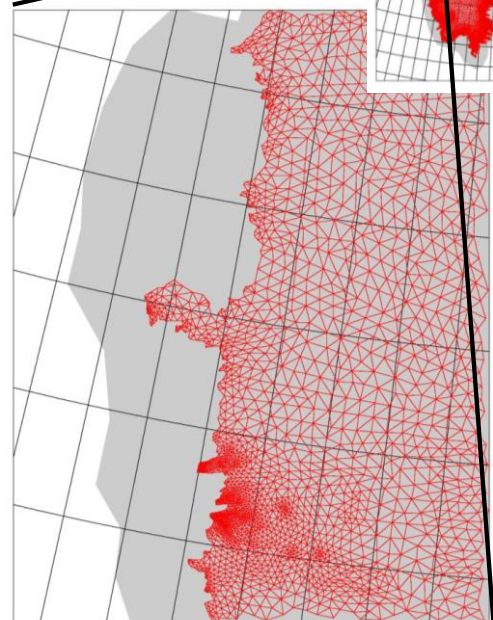
Surface Mass Balance
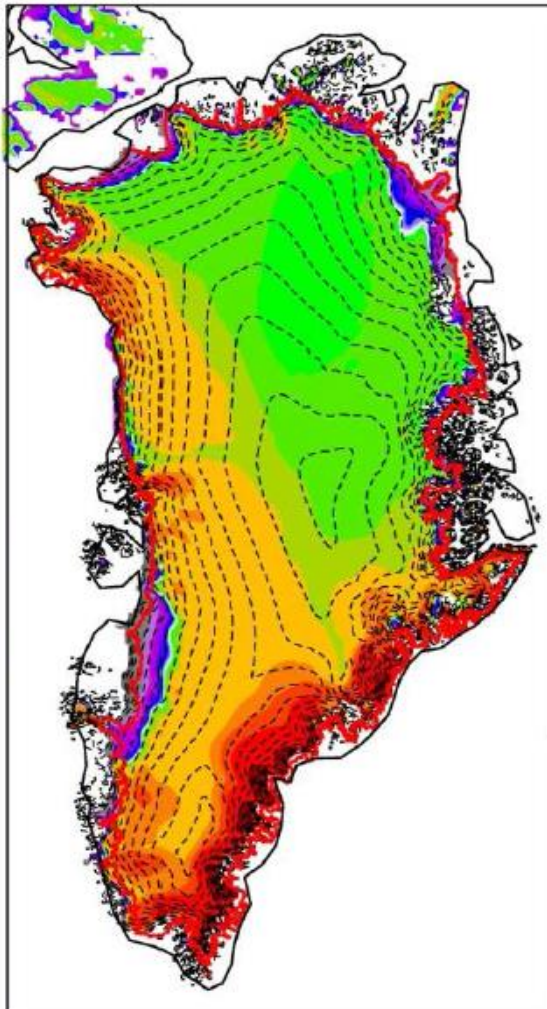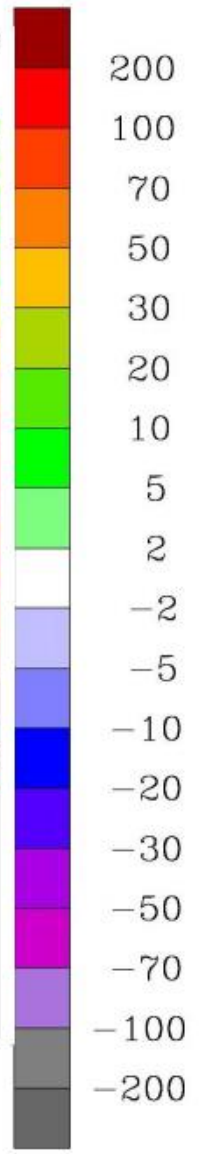
Surface Mass Balance, 2005-2007
"Nature Run" Global 7.5km [cm yr^{-1}]
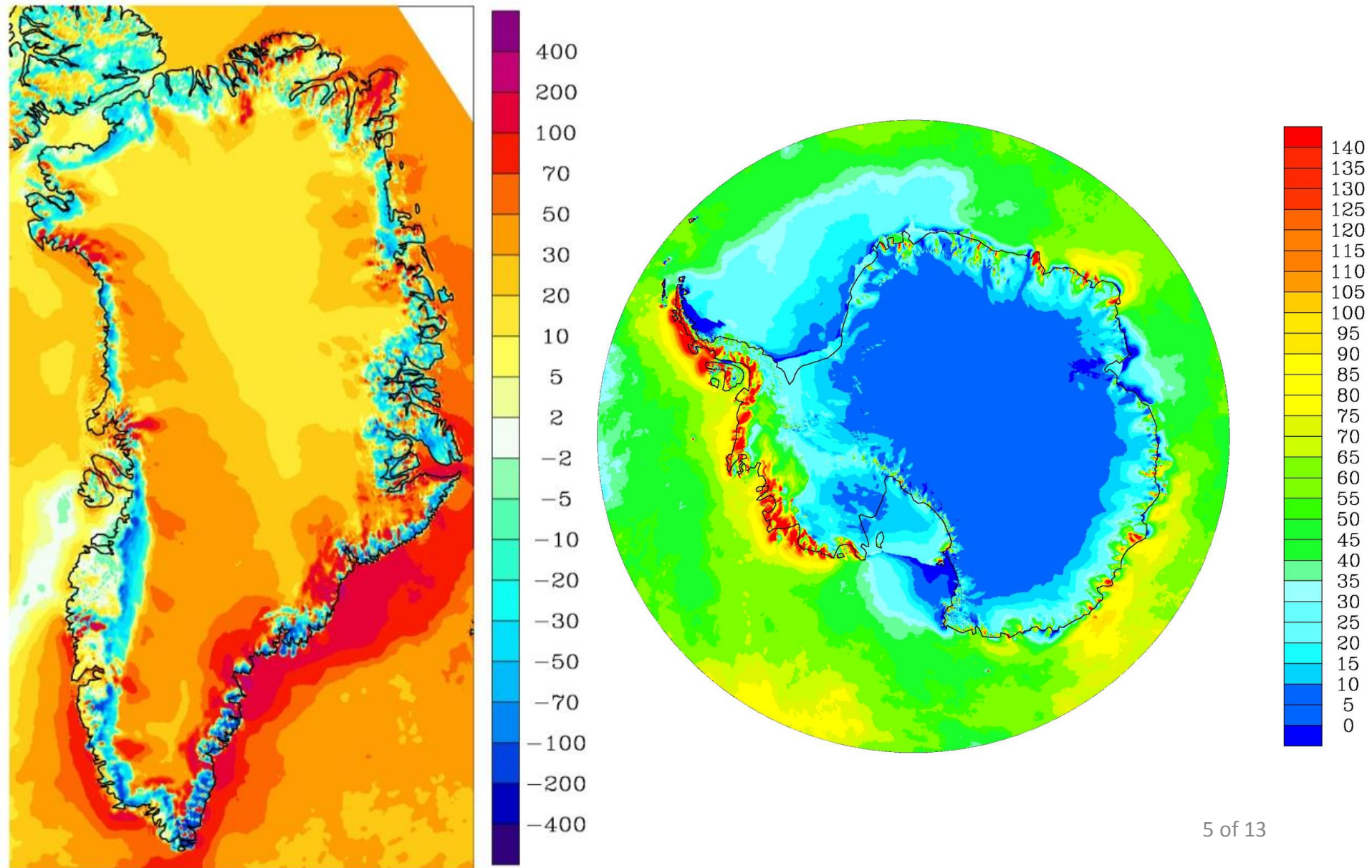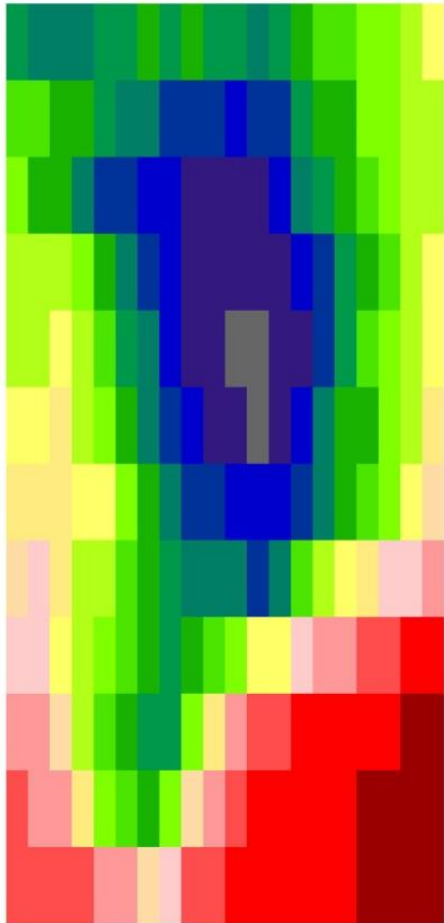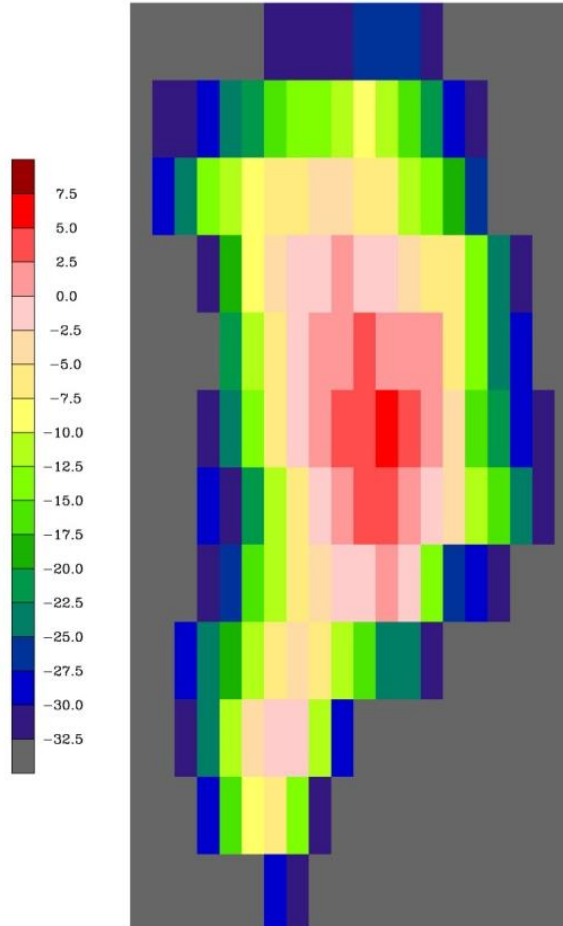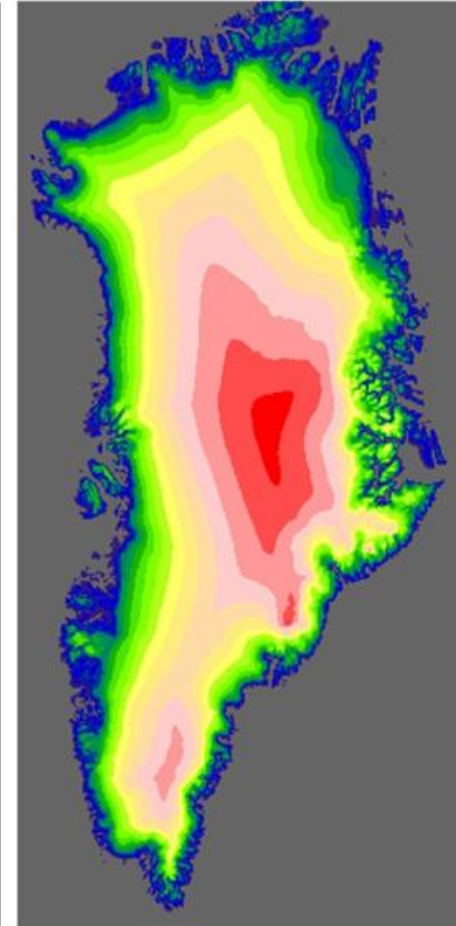
Surface Temperature
T_0
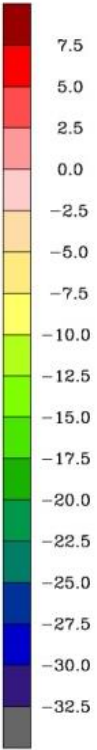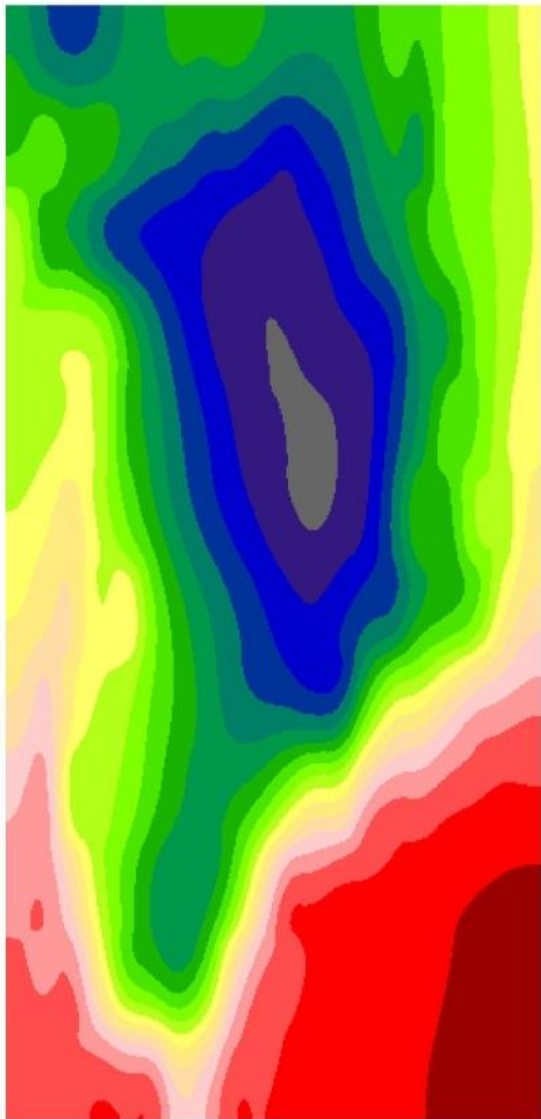225km × 75km
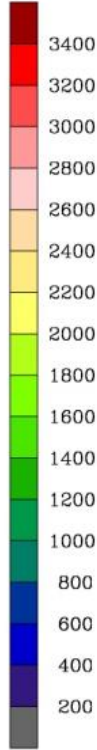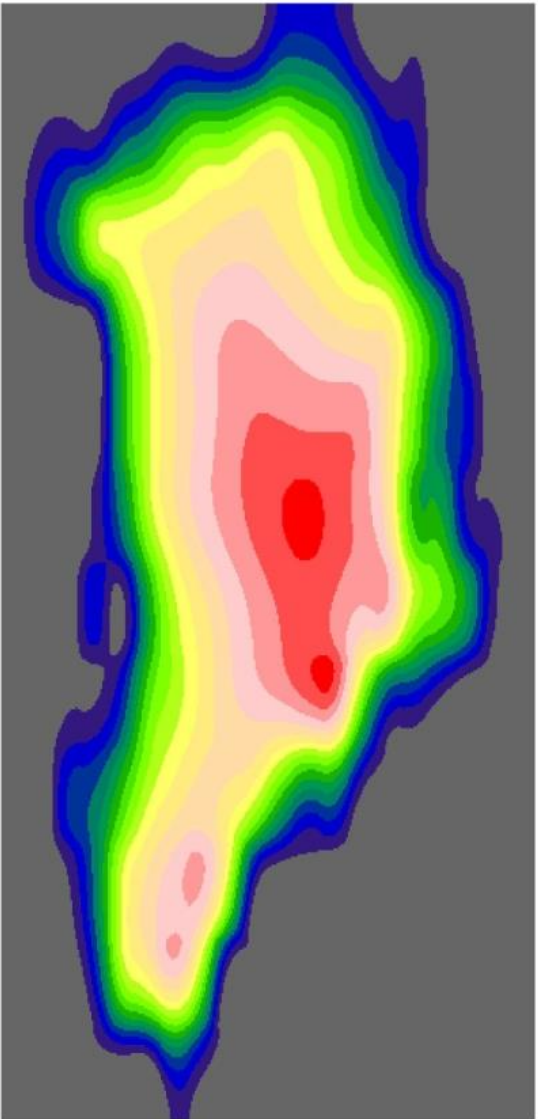
Topography
Z_0
225km × 75km

Topography
$Z_{0-HIRES}$
5km × 5km

Conservatively-Interpolated
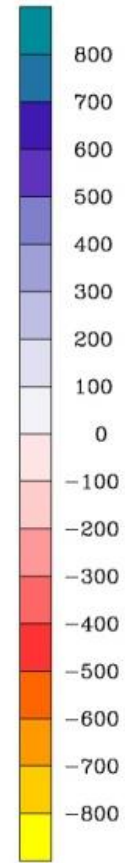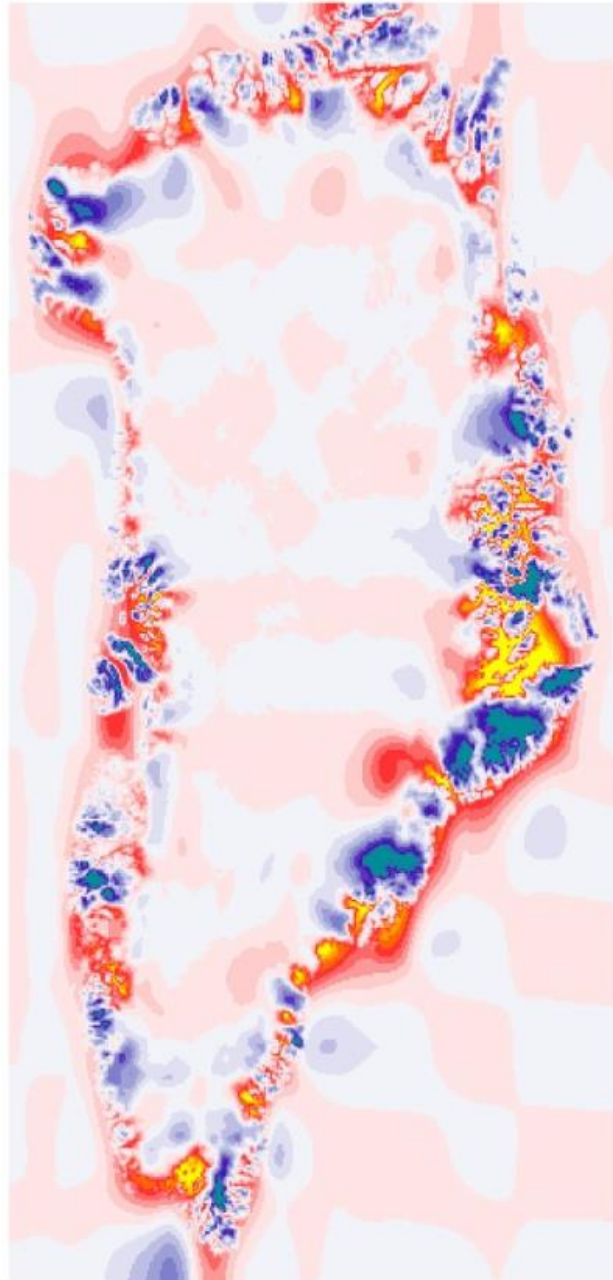Surface Temperature
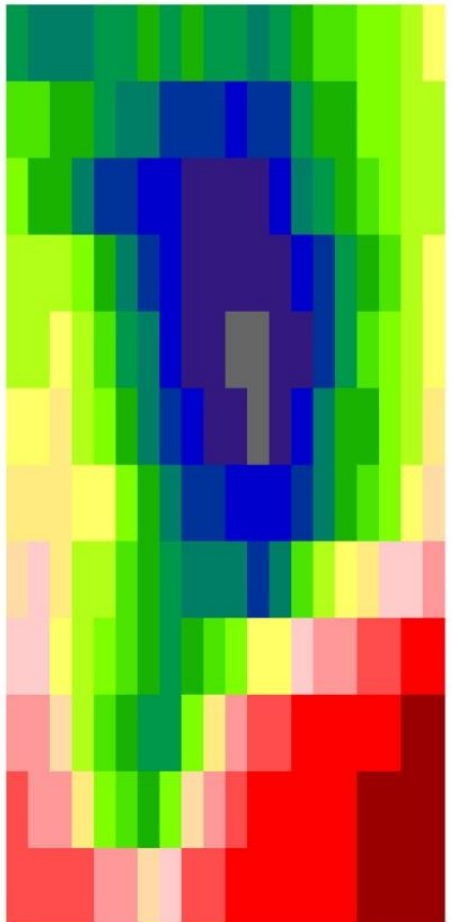T_{SMOOTH}

Conservatively-Interpolated
Topography
Z_{SMOOTH}

$$\Delta Z = Z_{0\text{-}HIRES} - Z_{SMOOTH}$$

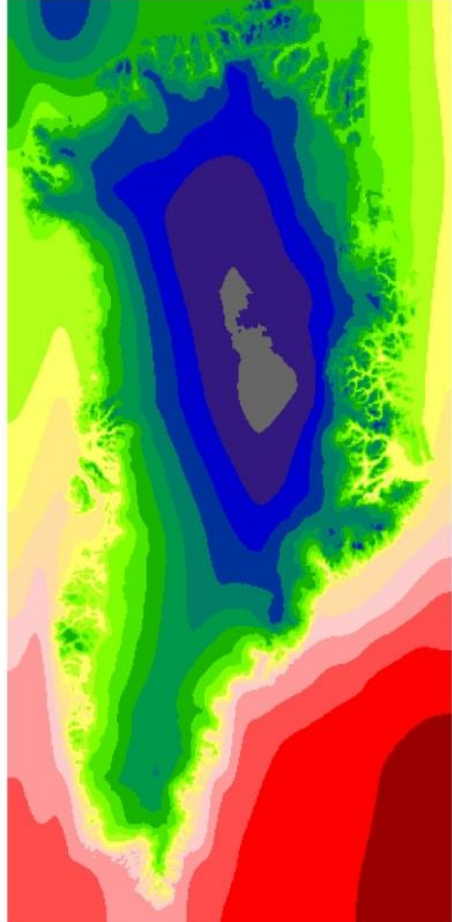Surface Temperature
T_0
225km × 75km

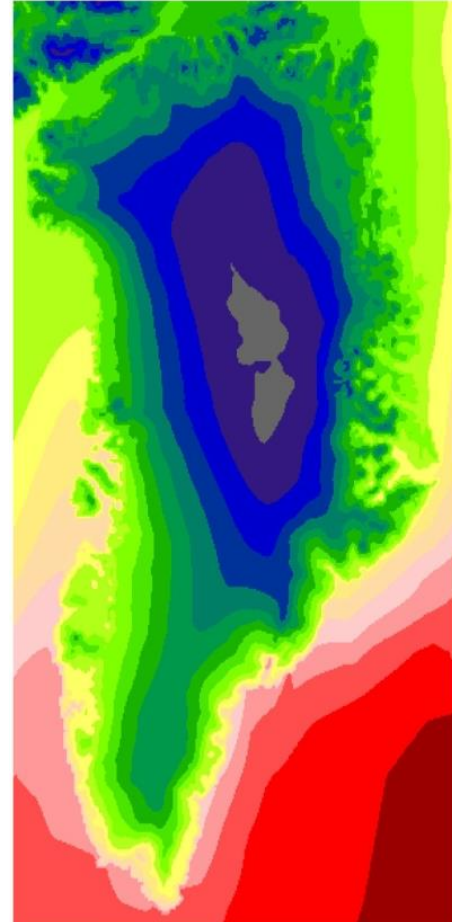Surface Temperature
$T_{DOWNSCALE} = T_{SMOOTH} - \Gamma \cdot \Delta Z$
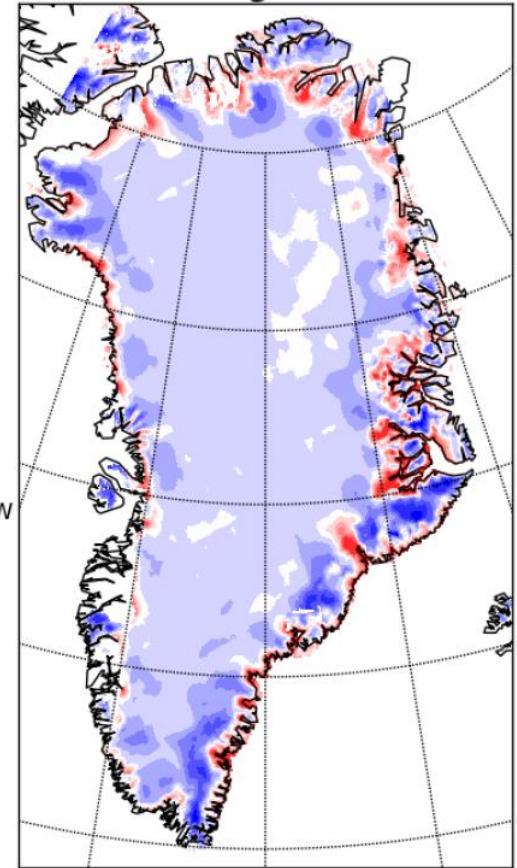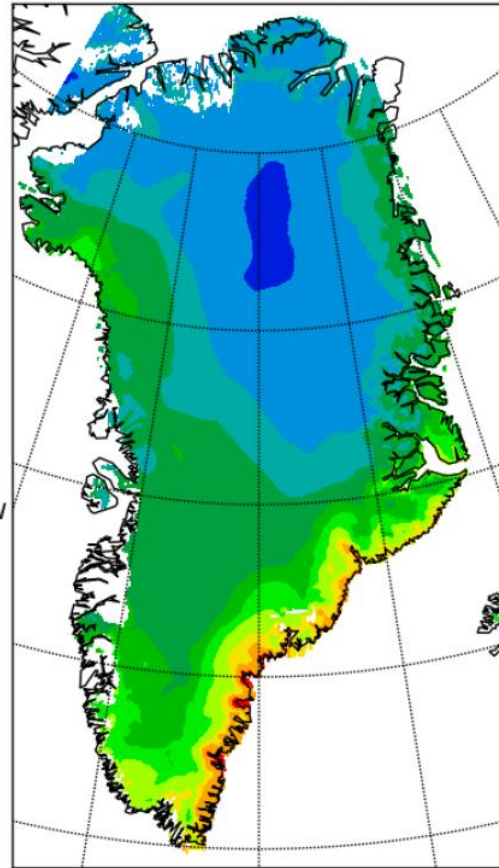5km × 5km

Surface Temperature
T_{TRUE}
5km × 5km

GEOS-5 Precipitation
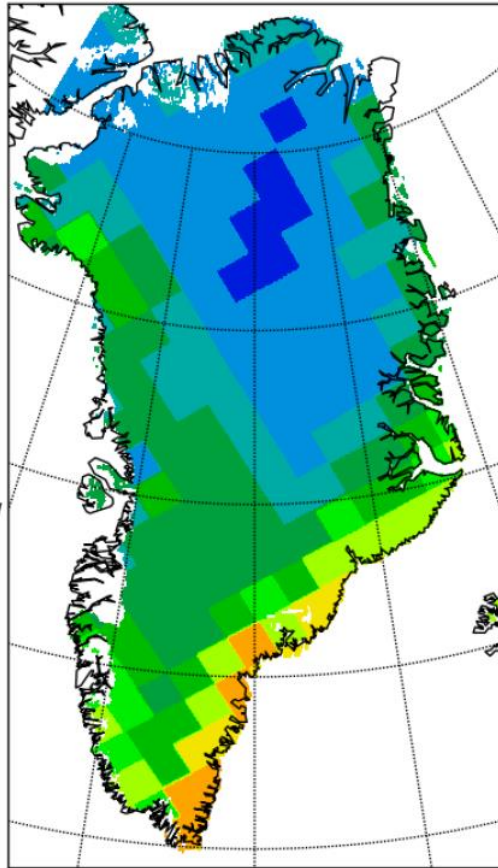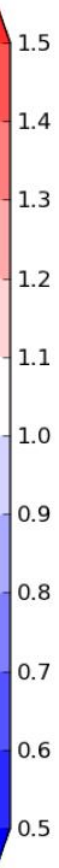
Southeast GrIS Precipitation Versus Elevation
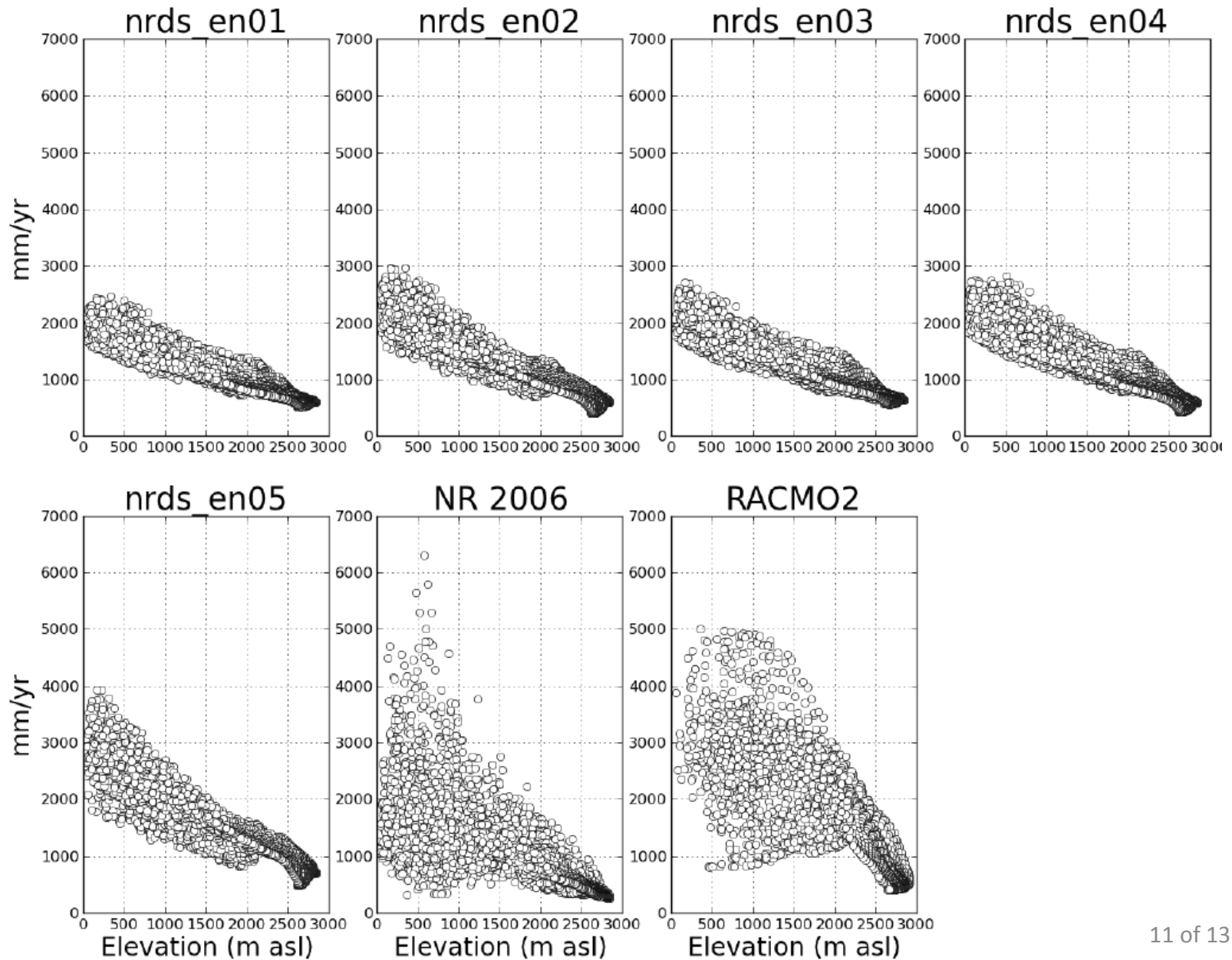
Simulated Runoff
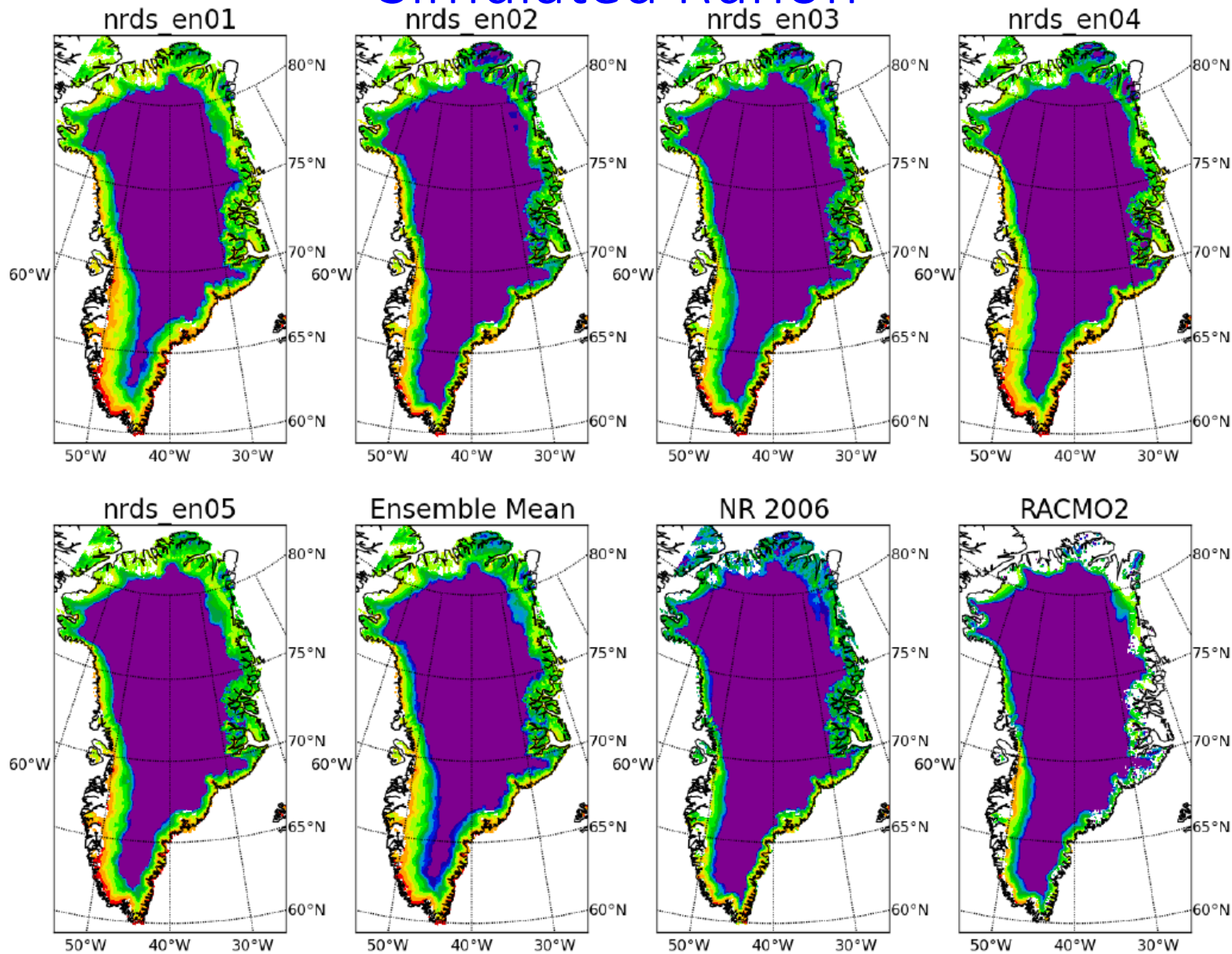
- Downscale atmospheric variables (horizontal interpolation plus elevation)
  - Air Temperature, turbulent fluxes, downwelling longwave after Glover (1999).
  - Precipitation is conserved regionally.
  - Surface winds are interpolated.
- Conservative downscaling method provides reasonable SMB field with expected caveats.
- Downscaling to be used to augment high-resolution simulations.
- Most components for a coupled AGCM/ISM simulation have been assembled.

Glaciated Surface Representation

- Adapted legacy snow hydrology model; prognostic variable is snow density.

- Firn is not explicitly represented

- Continue to explore
  - Aerosol deposition
  - Blowing snow sublimation
  - MODIS-derived bare ice albedo

Fractional snow cover on ice surface permitted

Melt, runoff may occur on bare ice surface

Variable Snow Depth Capped at 15m

Snow depth capped at 15m

15m Fixed Ice Layers

Zero heat flux condition at lowest level