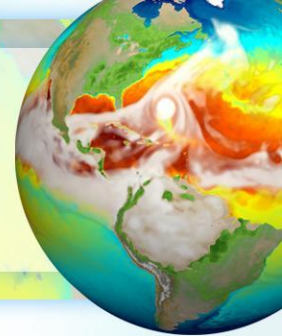


Exploring and reducing biases in sub-ice-shelf melt rates in an Earth system model

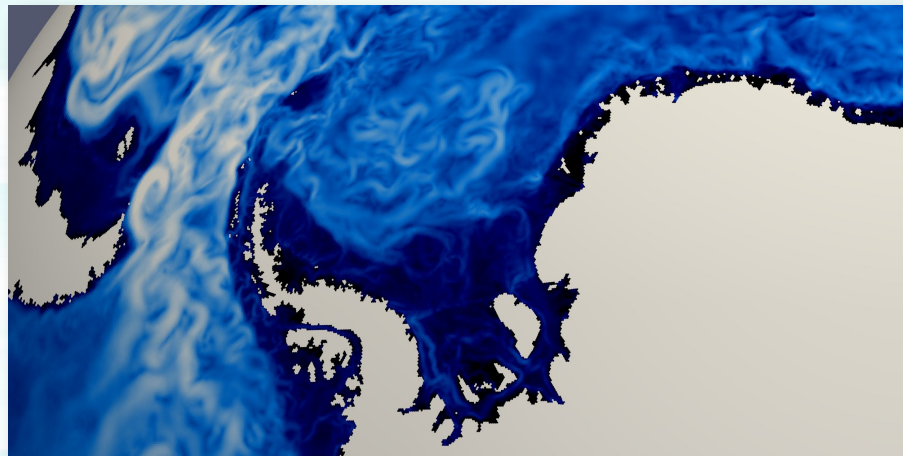


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¹Los Alamos National Laboratory

²Brookhaven National Laboratory

[Link to interactive version
with video narration](#)



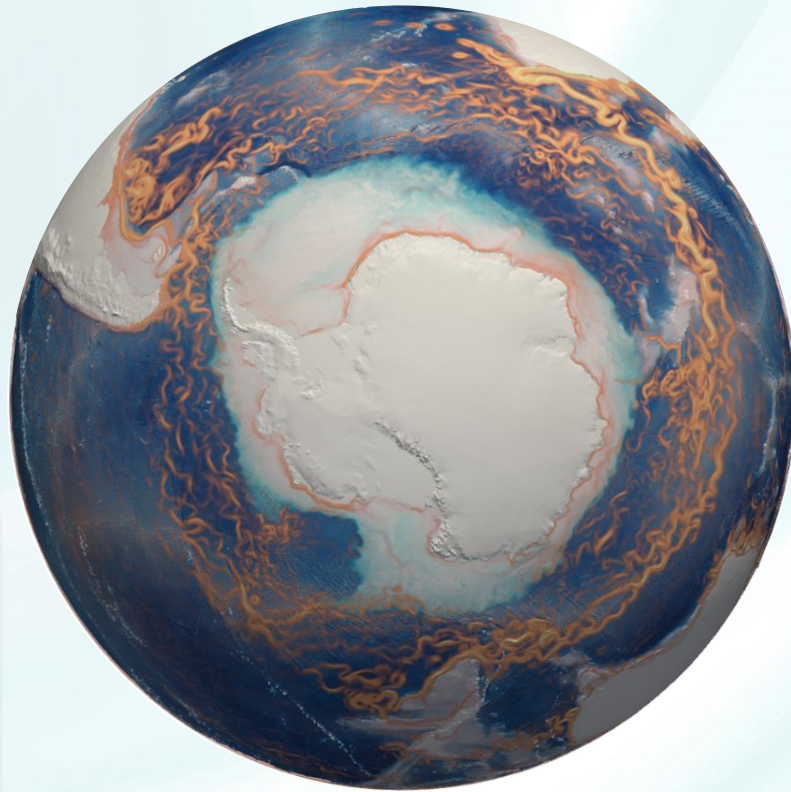
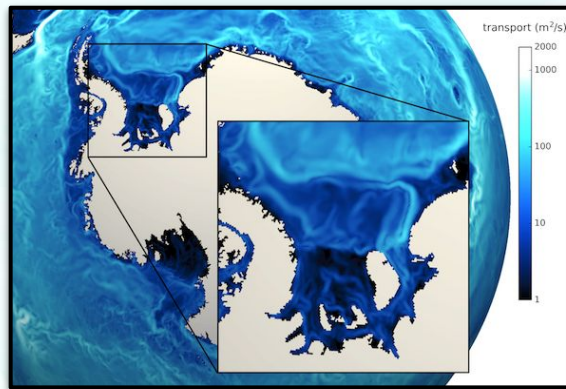
Outline with quick links

- [Energy Exascale Earth System Model \(E3SM\)](#)
- [Preindustrial simulations with ice-shelf cavities](#)
- [Melt Biases](#)
- [Melt Bias Mitigation](#)
- [Next Generation Meshes and Simulations](#)



Energy Exascale Earth System Model (E3SM)

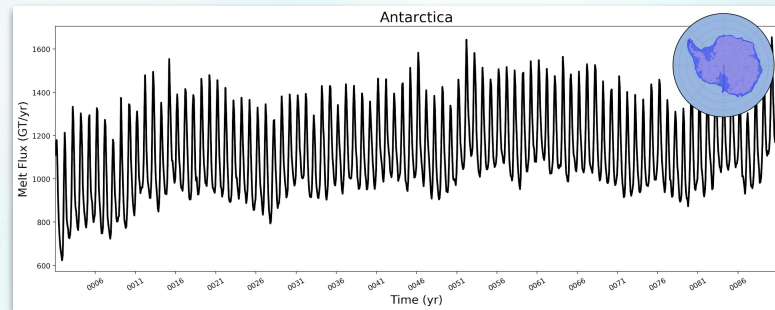
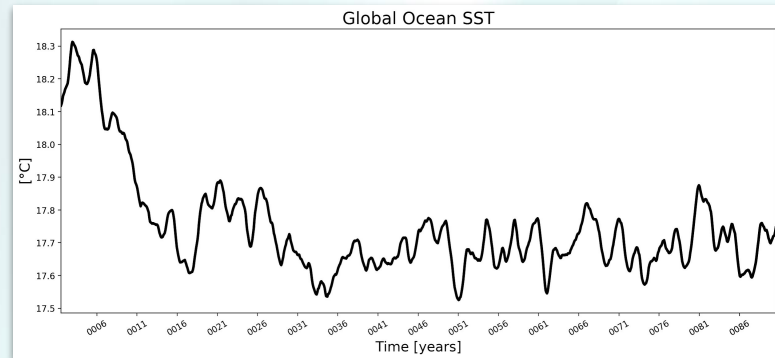
- Variable-resolution components (atmosphere, land, ocean, sea-ice, and ice-sheet)
- Focused on interactions between the climate system and the energy sectors
- Cryosphere science focus: projections of Antarctic sea-level change





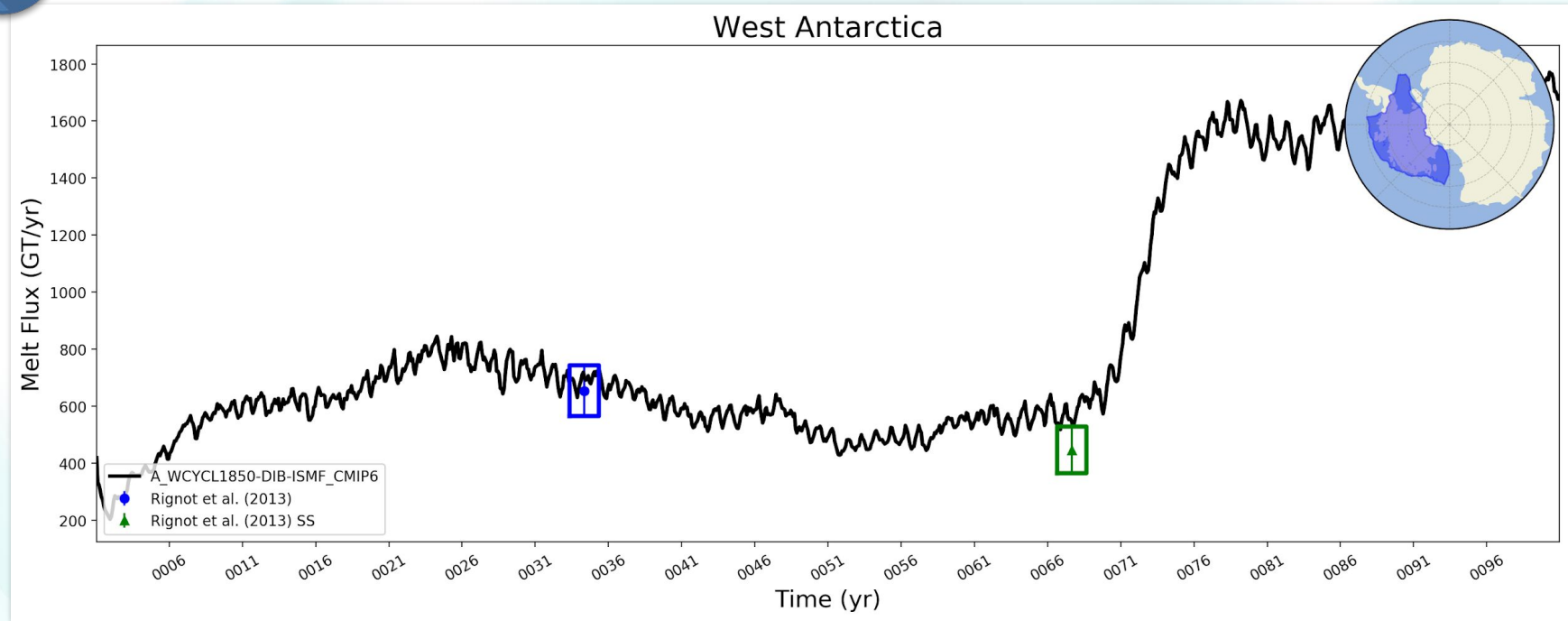
Preindustrial simulations with ice-shelf cavities

- Fully coupled atmosphere, ocean, sea ice, land and river
- Preindustrial CO₂ forcing
- Ocean: 30 to 60 km (~0.5 degree) horizontal resolution, ~35 km around Antarctica
- Thermodynamically active ice-shelf cavities (e.g. Holland and Jenkins, 1999) are used to compute melt fluxes
- Goal 1: control simulation for future studies of interactions between changing climate and ice-shelf melting
- Goal 2: coupled ice sheet-climate simulations





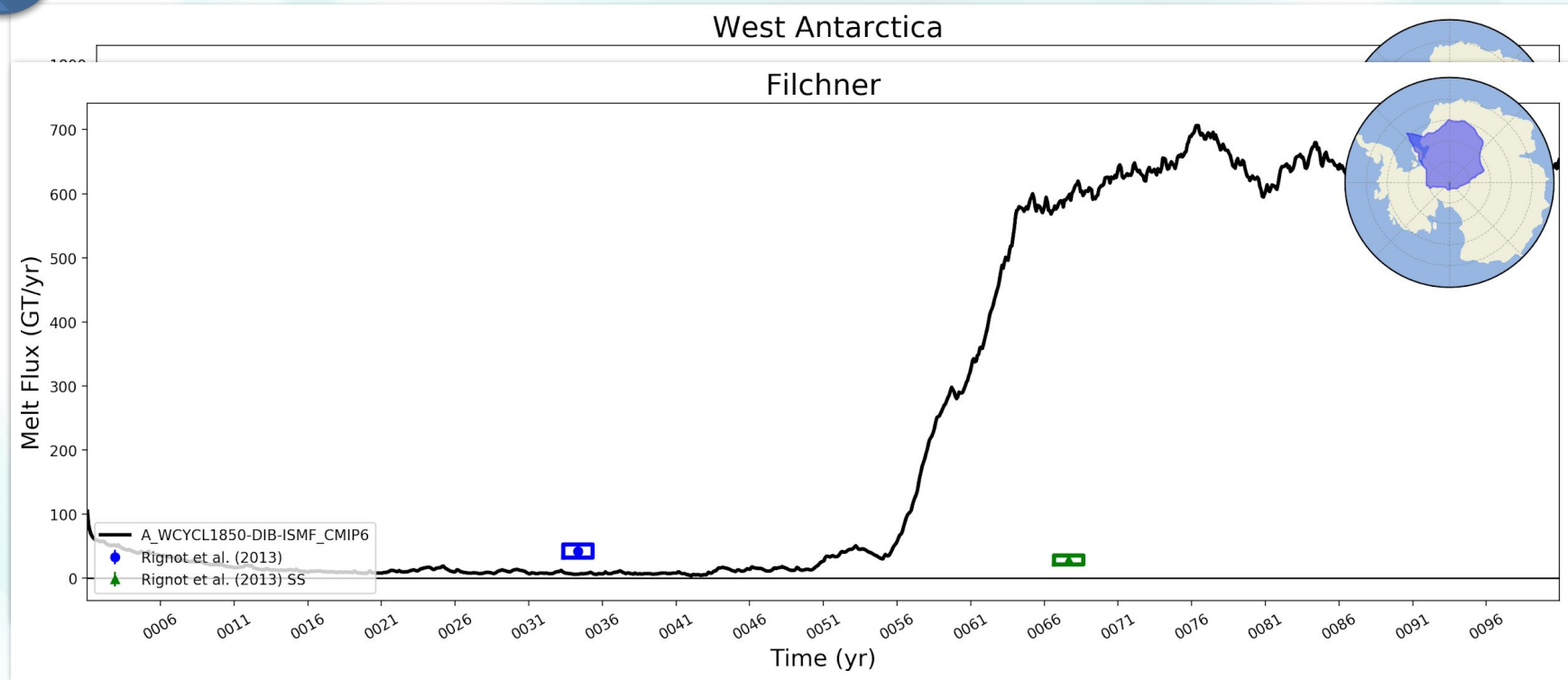
Melt Biases



Antarctic ice-shelf melt fluxes from fully coupled, preindustrial E3SM simulation, showing melt biases.



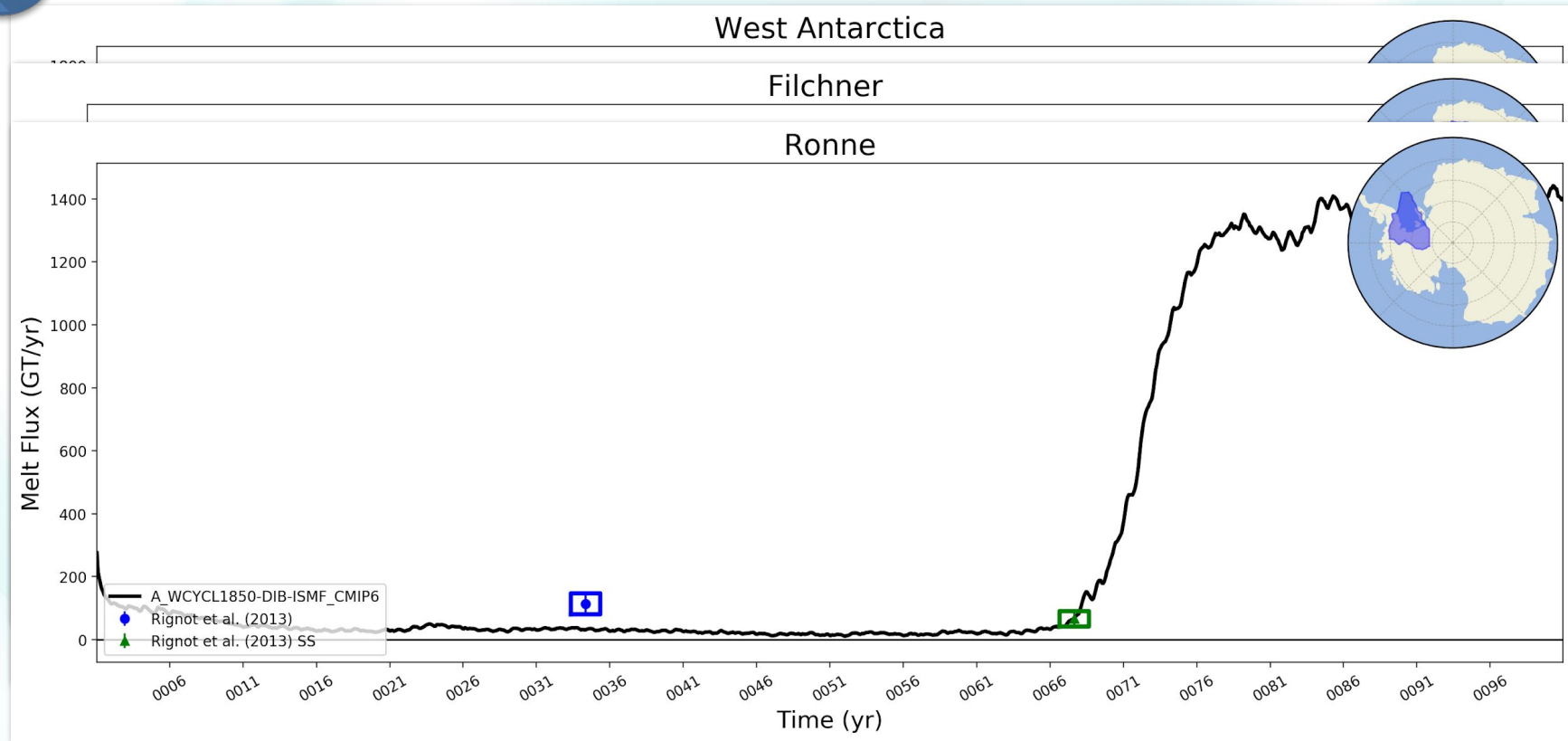
Melt Biases



Antarctic ice-shelf melt fluxes from fully coupled, preindustrial E3SM simulation, showing melt biases.



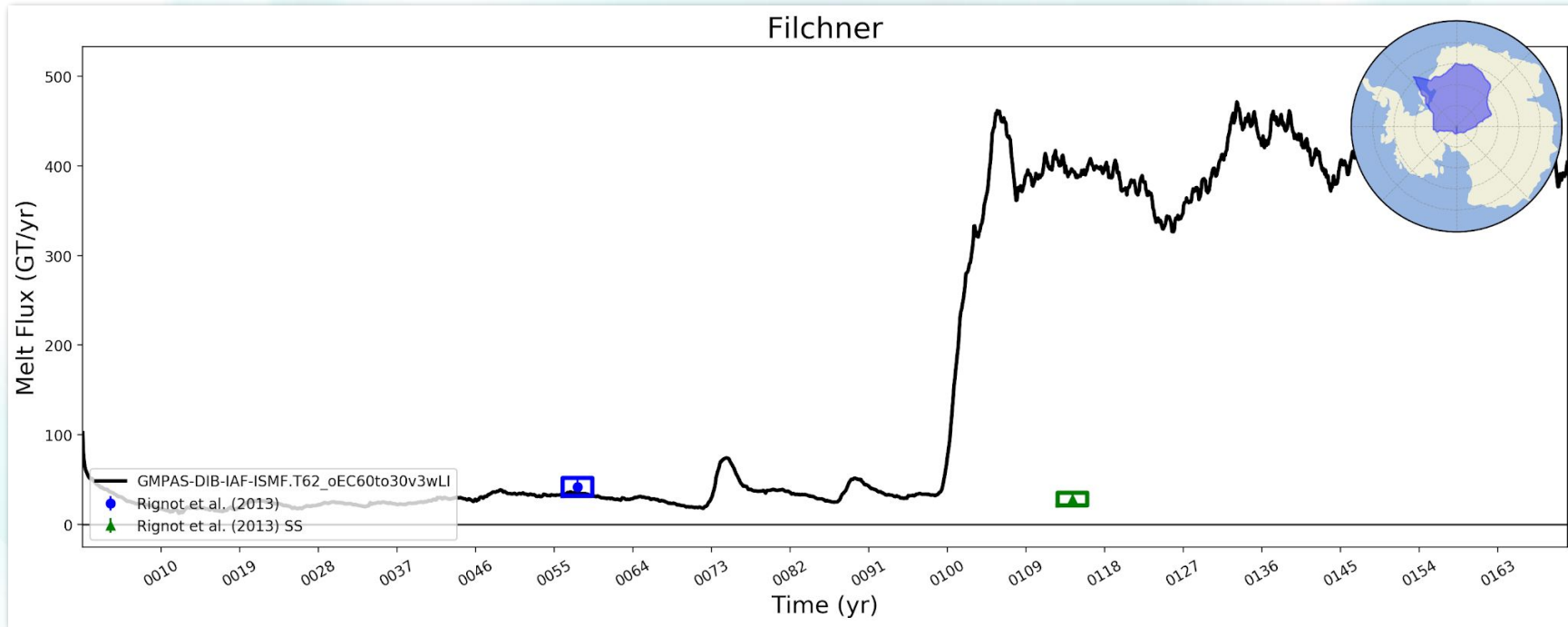
Melt Biases



Antarctic ice-shelf melt fluxes from fully coupled, preindustrial E3SM simulation, showing melt biases.



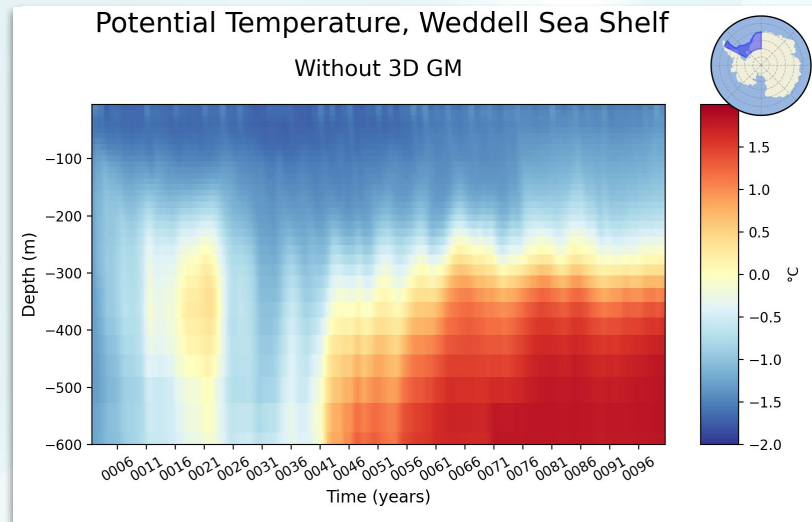
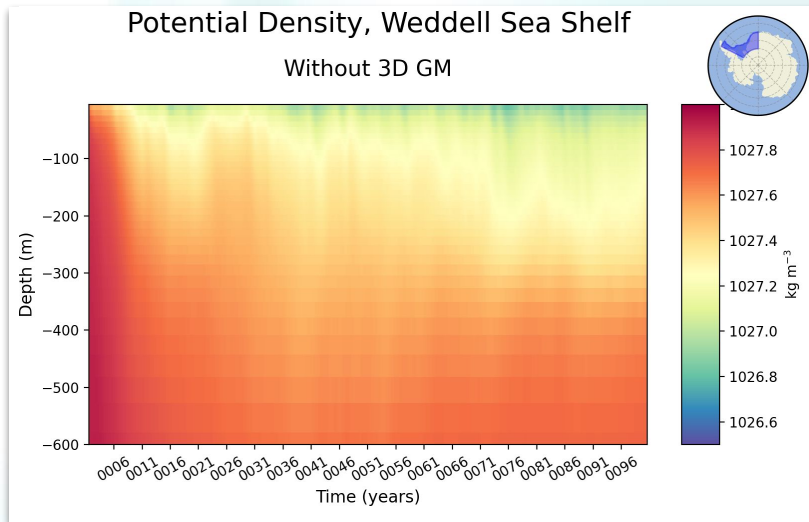
Melt Biases: Simulation with CORE-II forcing



Similar biases were seen in CORE-II (ocean-sea ice with prescribed atmospheric forcing) simulations.



Melt Biases: Stratification and Temperature

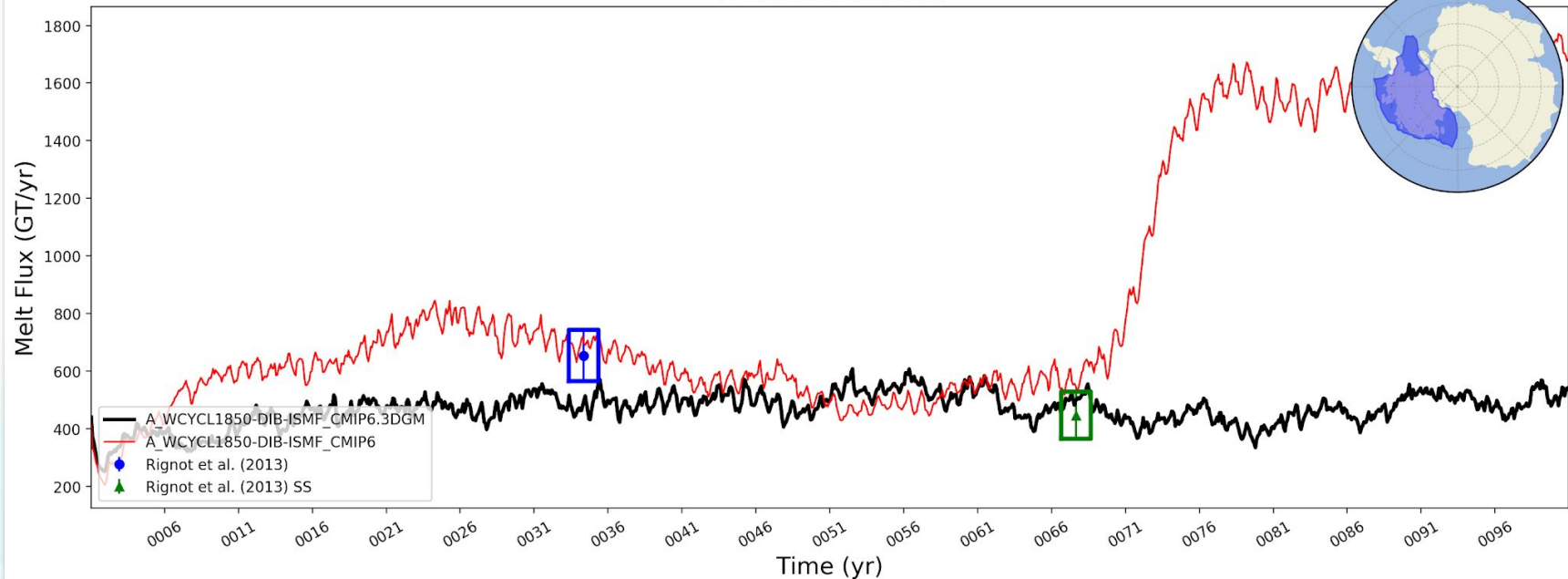


- Melt “instability” results from warm Weddel Deep Water accessing the Filchner Trough
- Periods of warm-water intrusion (right) follow periods of increased stratification of the Weddell Sea continental shelf (left)
- The Weddell Sea is also freshening and becoming less dense
- We will show that this does not seem to be enough to trigger the “instability”



Melt Bias Mitigation: 3D Gent-McWilliams (3DGM)

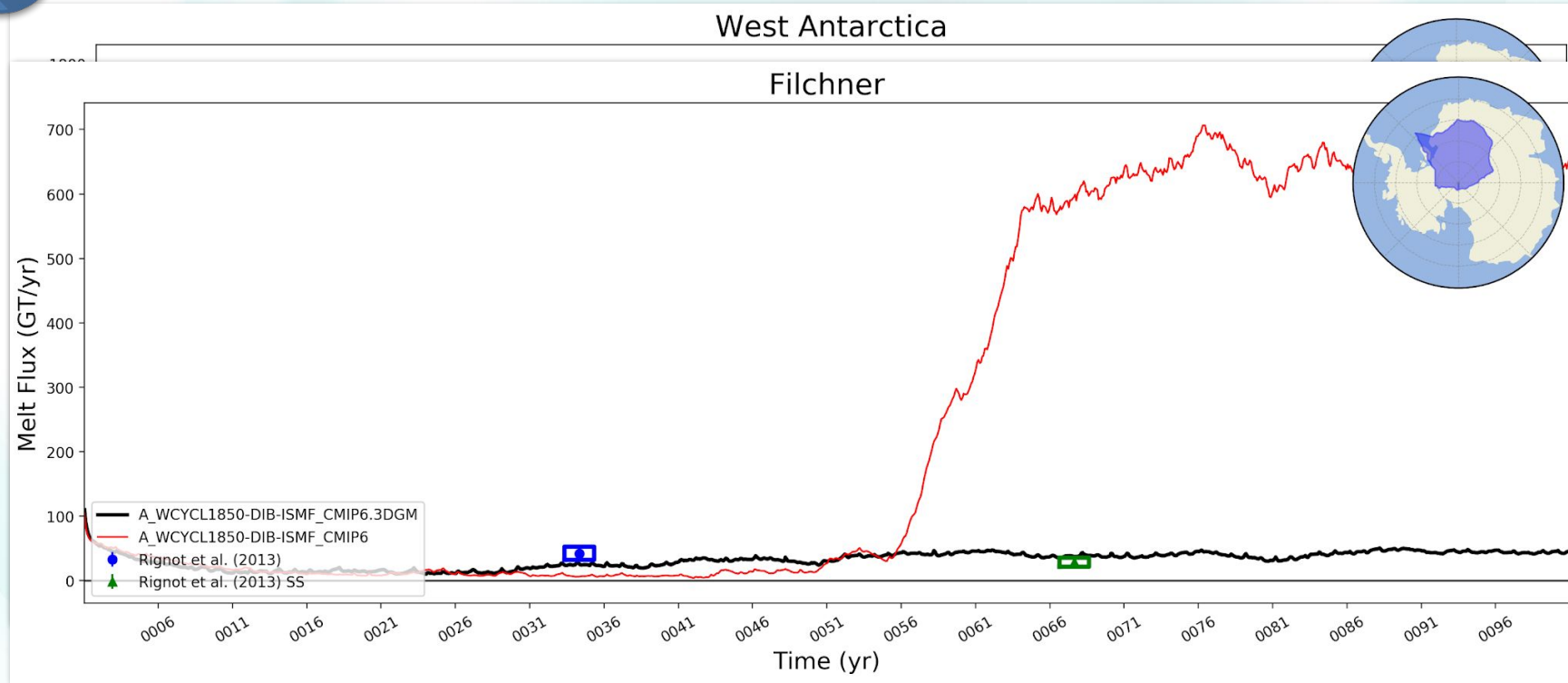
West Antarctica



Preindustrial E3SM simulation with 3DGM coefficient (black) and the previous simulation without (red).



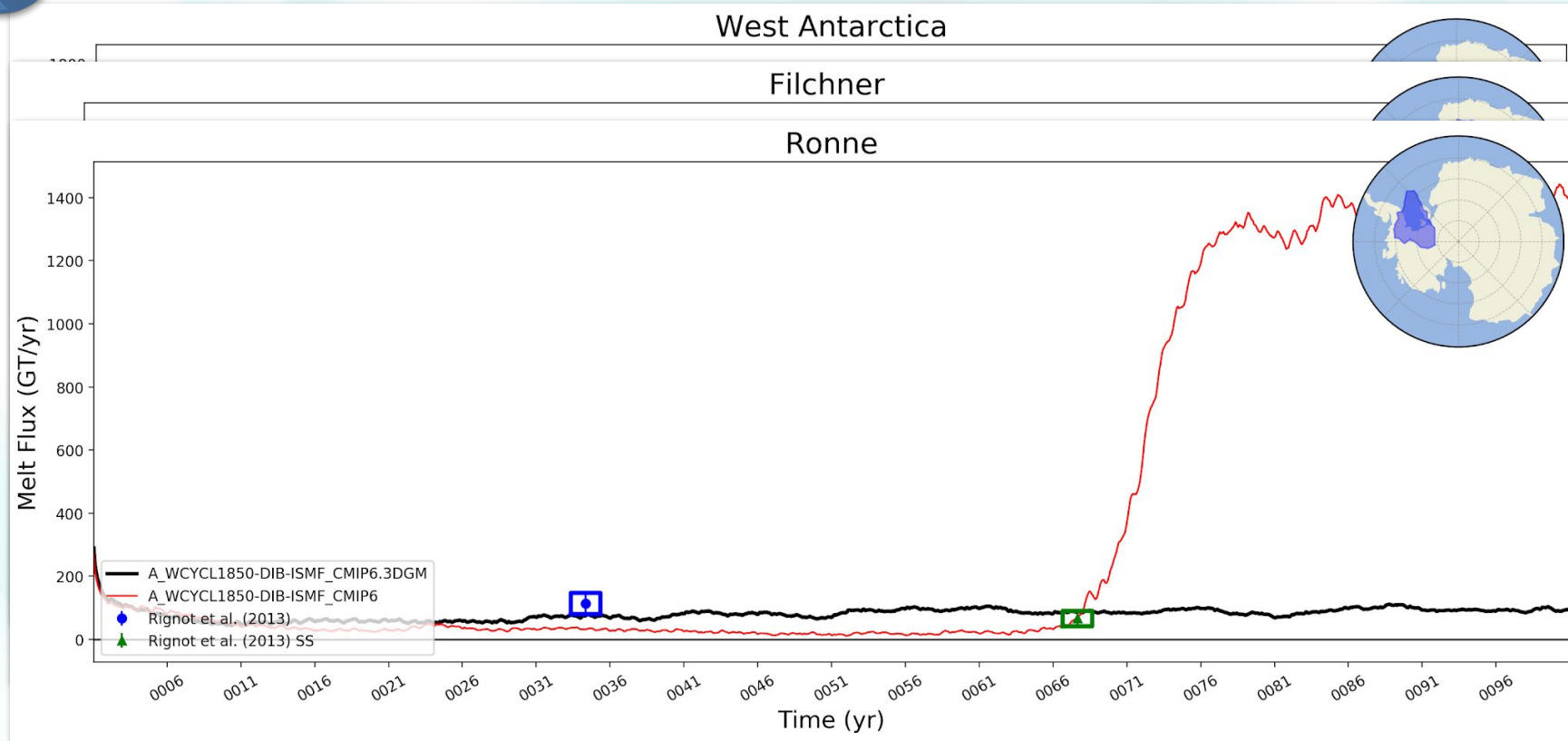
Melt Bias Mitigation: 3D Gent-McWilliams (3DGM)



Preindustrial E3SM simulation with 3DGM coefficient (black) and the previous simulation without (red).



Melt Bias Mitigation: 3D Gent-McWilliams (3DGM)



Preindustrial E3SM simulation with 3DGM coefficient (black) and the previous simulation without (red).

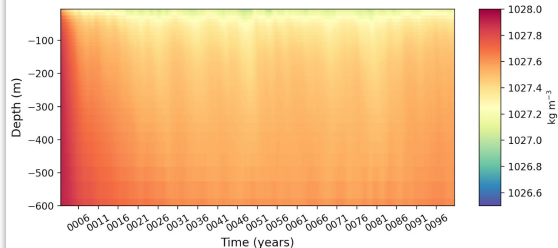


Bias Mitigation: Stratification and Temperature

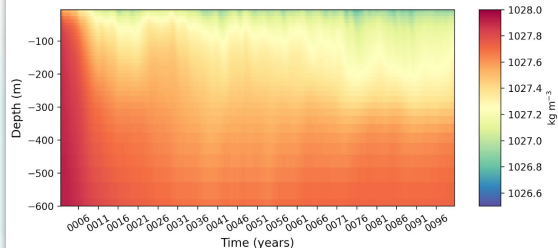
Potential Density, Weddell Sea Shelf



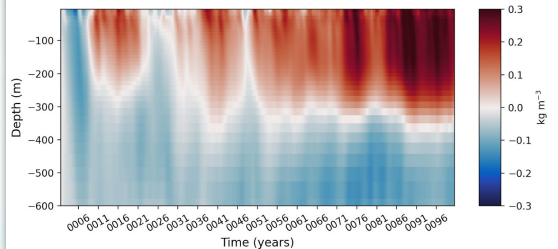
With 3D GM



Without 3D GM



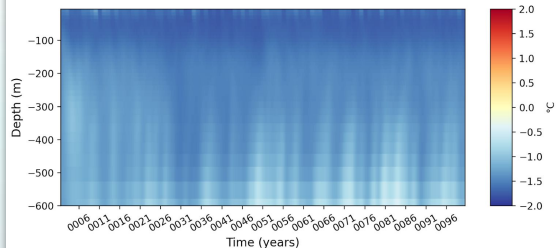
Main - Control



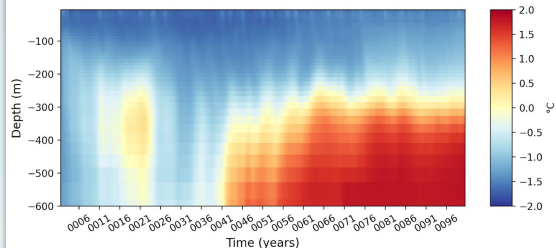
Potential Temperature, Weddell Sea Shelf



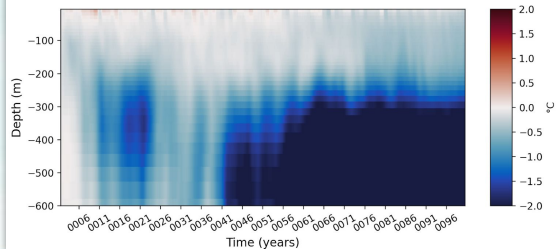
With 3D GM



Without 3D GM



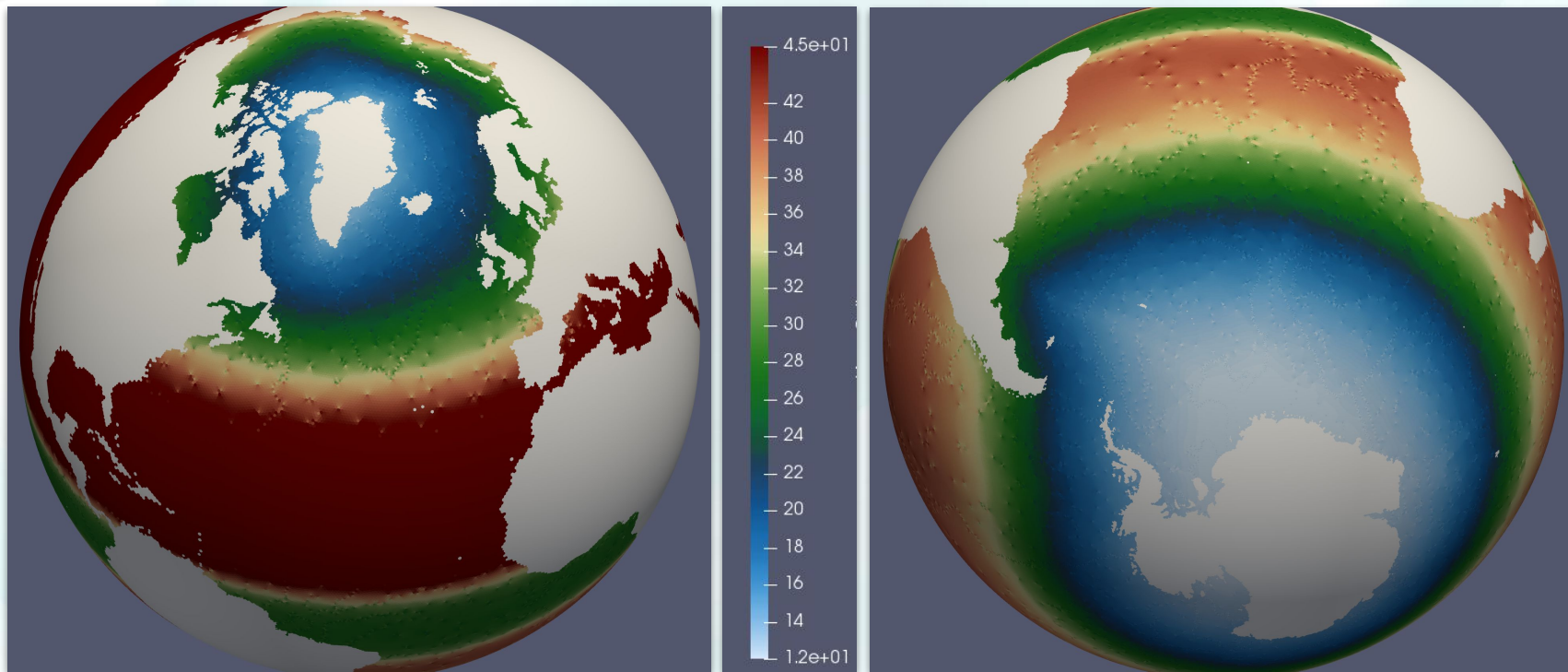
Main - Control



- Melt “instability” suppressed when a 3D Gent-McWilliams (3DGM) coefficient is used (top) compared with the previous run (middle)
- Stratification is significantly reduced with 3D GM (left)
- Perhaps as a result, warm water does not reach the Weddell Sea continental shelf (right)
- Both simulations show significant freshening and reduced density, suggesting that this is not what triggers the “instability”



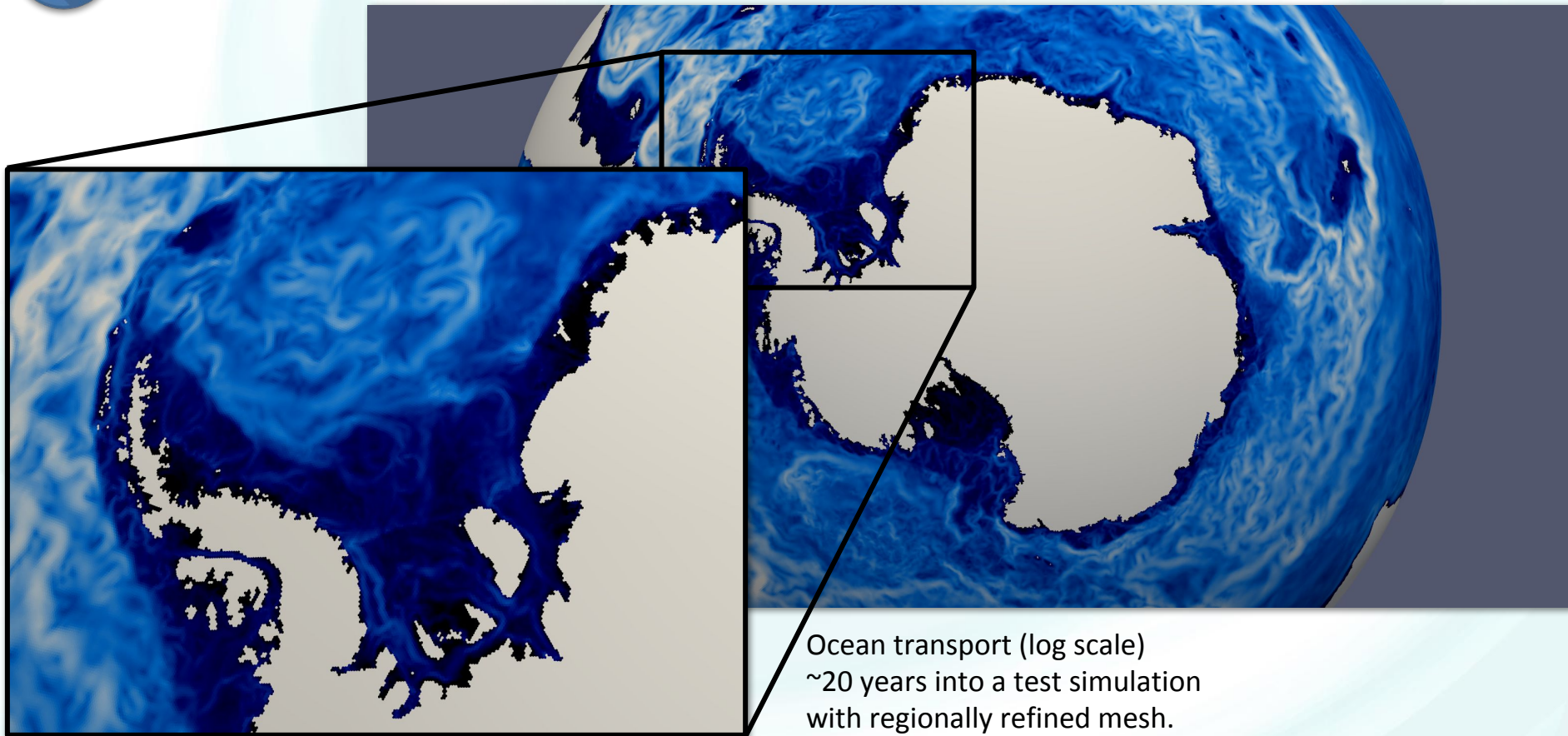
Next Generation Meshes and Simulations



- New regionally refined mesh for polar regions in development
- ~10-15 km resolution around ice sheets, 30-60 km elsewhere



Next Generation Meshes and Simulations



Ocean transport (log scale)
~20 years into a test simulation
with regionally refined mesh.