ACME
Accelerated Climate Modeling for Energy

Cryosphere Simulation Plan: Abrupt Antarctic Change and Sea-Level Rise

ACME Ocean-Ice Team

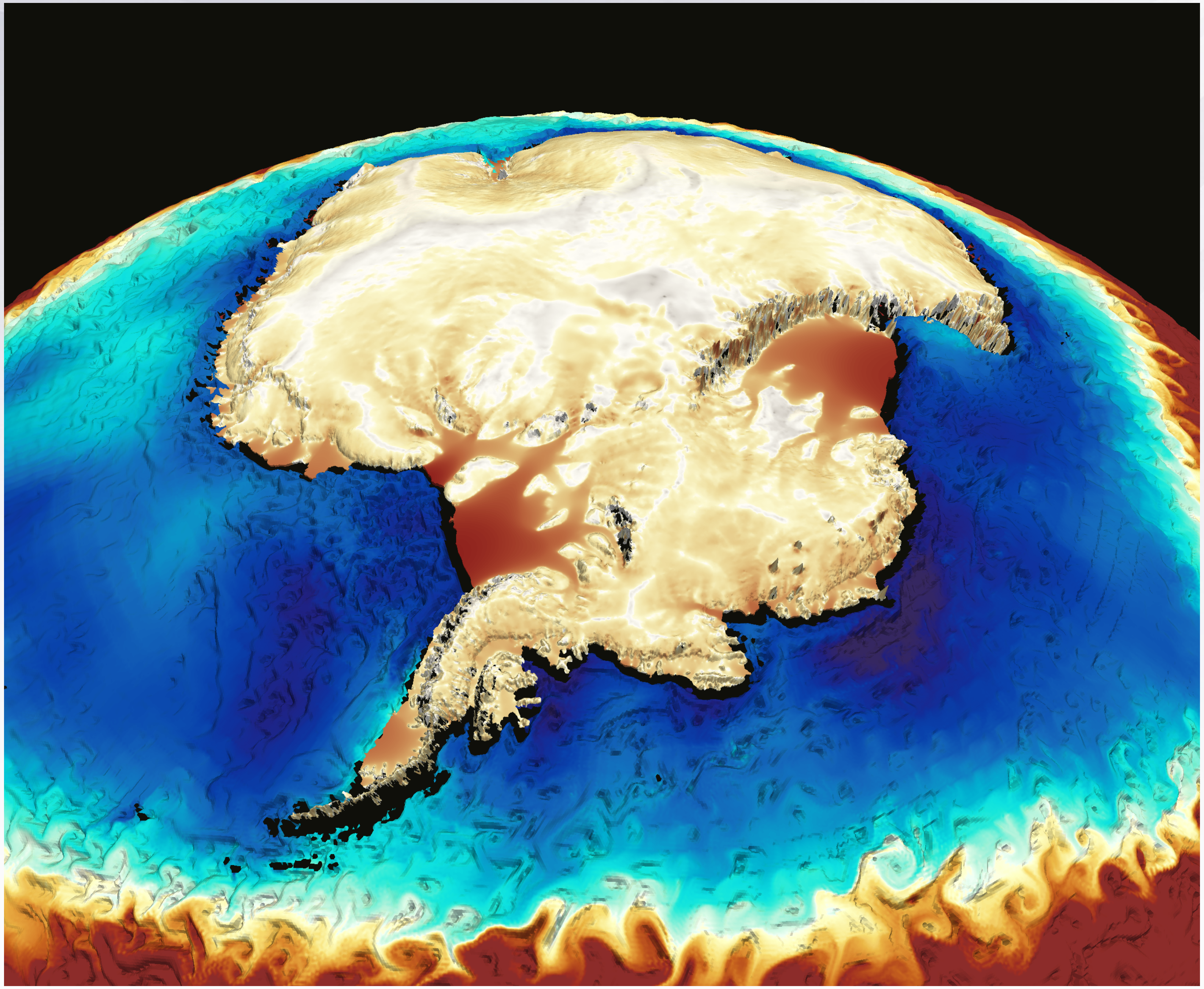
Science Driver: How do rapid changes in cryospheric systems interact with the climate system?

Effort focused on Antarctica.

Motivation is to explore likelihood of rapid sea-level rise due to ocean-land ice interaction.

Target simulations include dynamically-coupled ocean-land ice systems.

Challenges include:
- new models
- spatial scales ~1 km
- ocean/ice initial conditions
- sparse observations
- equilibrium of system



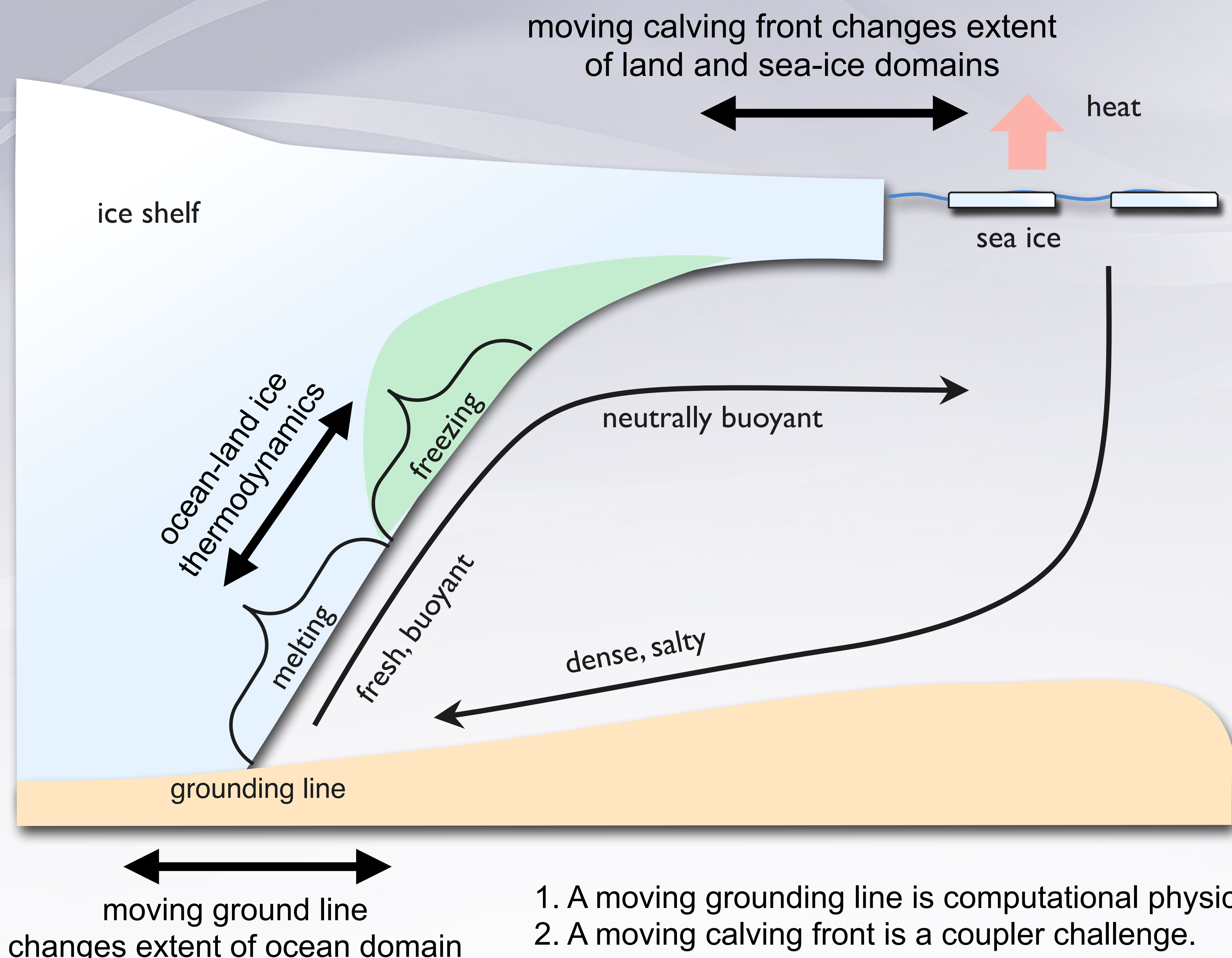
Configuration of Cryosphere Simulation

Time: 1970-2050

Components:
- atmosphere, default ACME v1
- land: default ACME v1
- land-ice: MPAS-LI, 0.5 to 1 km in regions
- ocean: MPAS-Ocean, 5 km in Southern Ocean
- sea-ice: MPAS-CICE, same mesh as ocean

Initial conditions:
- land-ice: optimized initial conditions from PISCEES
- ocean: from CORE-II spin-up
- sea-ice: from CORE-II spin-up

What does it really mean to include an evolving AIS?



1. A moving grounding line is computational physics challenge.
2. A moving calving front is a coupler challenge.
3. An evolving land-ice / ocean interface via melt/freeze is straightforward.

Over an 80 year simulation, we expect grounding lines to move less than 100 km.

Looking across the ACME v1 simulation plan ….

A couple of observations:

The ocean and sea-ice will likely be called upon to diagnose and remedy biases in the water cycle and BGC simulations.

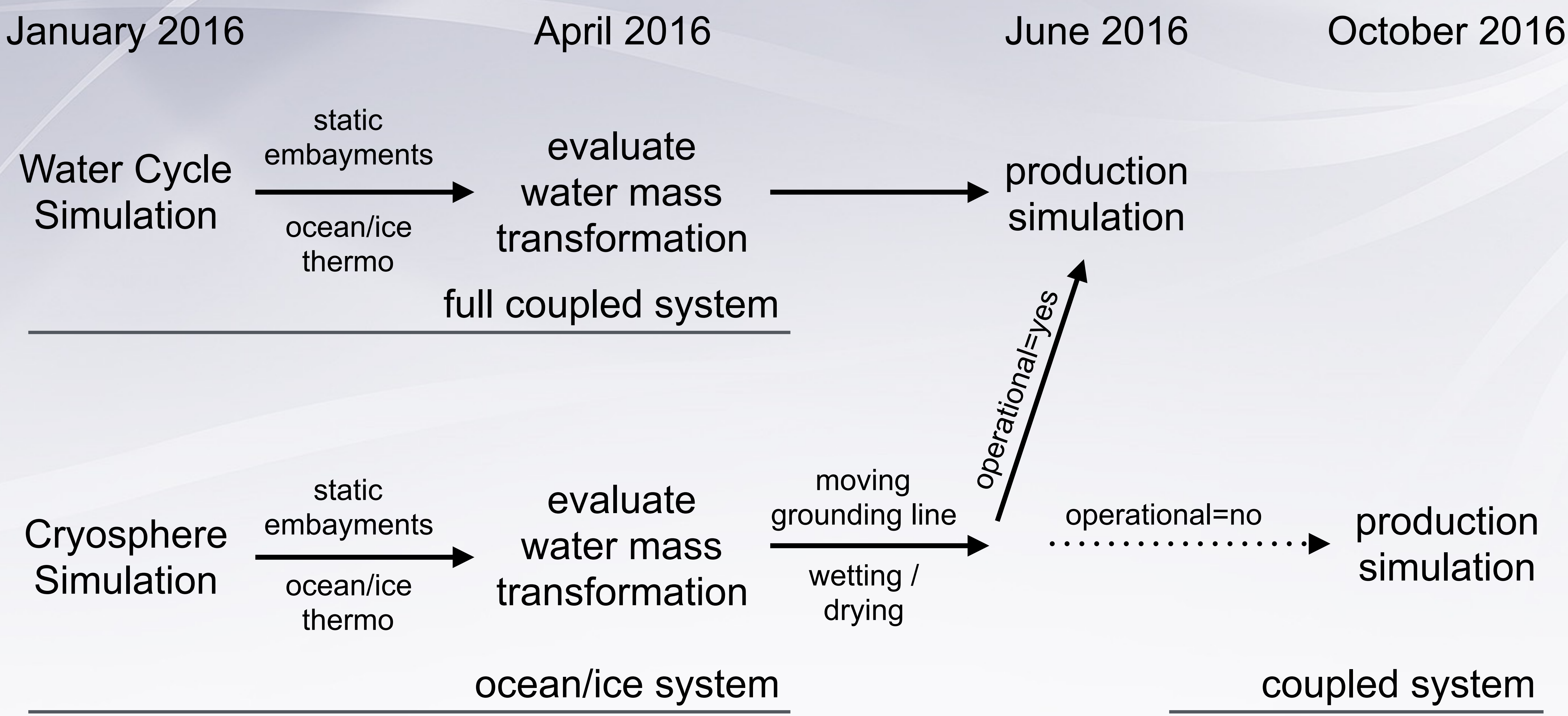
The cryosphere simulation shares a great deal with the water cycle simulation. In terms of the coupled model system, the two could only differ through the configuration of the land ice component.

A couple of questions:

Does overall success of ACME v1 depend more on getting tropical SSTs correct for the water cycle simulation or having moving grounding lines in the cryosphere simulation?

Does it makes sense to coordinate the water cycle and cryosphere simulations in order to leverage resources within the ocean and sea-ice modeling teams?

A low-risk proposal to coordinate Water Cycle and Cryosphere Simulations



In June 2016, a proposal to merge water cycle and cryosphere simulations would only be offed iff:

1. moving grounding lines will not “get in the way” of hydrological cycle simulations.
2. moving grounding lines will not change the climate of the hydrological cycle simulations.

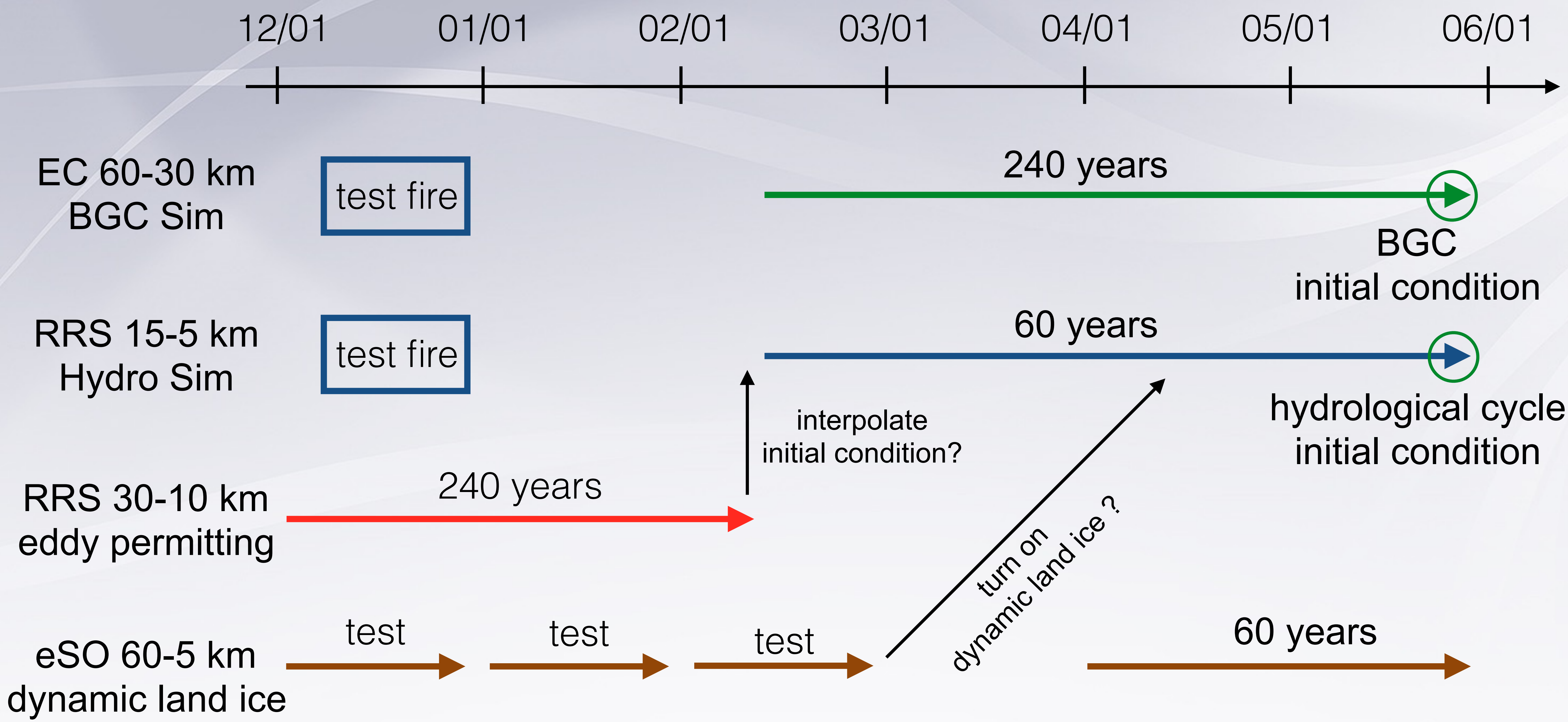
Proposed CORE-II simulations
(note, cost per year should come down with help from performance team)

water cycle configuration with data atmosphere and land (i.e. CORE-II forcing):
- Rossby Radius Scaling (RRS) 15-5 km ocean/sea-ice resolution
- static land-ice embayments
- 60 years
- cost per simulated year: 400K (ocean-only: 1 SYPD on 12K Edison cores)
- total cost: 25M core hours

water cycle configuration with data atmosphere and land (i.e. CORE-II forcing):
- Rossby Radius Scaling (RRS) 30-10 km ocean/sea-ice resolution
- static land-ice embayments
- 240 years
- cost per simulated year: 60K (ocean-only: 7 SYPD on 12K Edison cores)
- total cost: 15M core hours

cryosphere configuration with data atmosphere and land (i.e. CORE-II forcing):
- enhanced Southern Ocean (eSO) grid
- moving grounding line
- 100 years
- cost per simulated year: 200K
- total cost: 20M core hours

Staging of CORE-II Simulations



CORE-II is a 60-year cycle of 6-hourly atmosphere data
Simulations will include dynamic ocean, dynamic sea ice and (sometimes) dynamic land ice.
All simulations at planned to include land-ice covered ocean embayments.

slides that follow are working drafts and/or idea slides

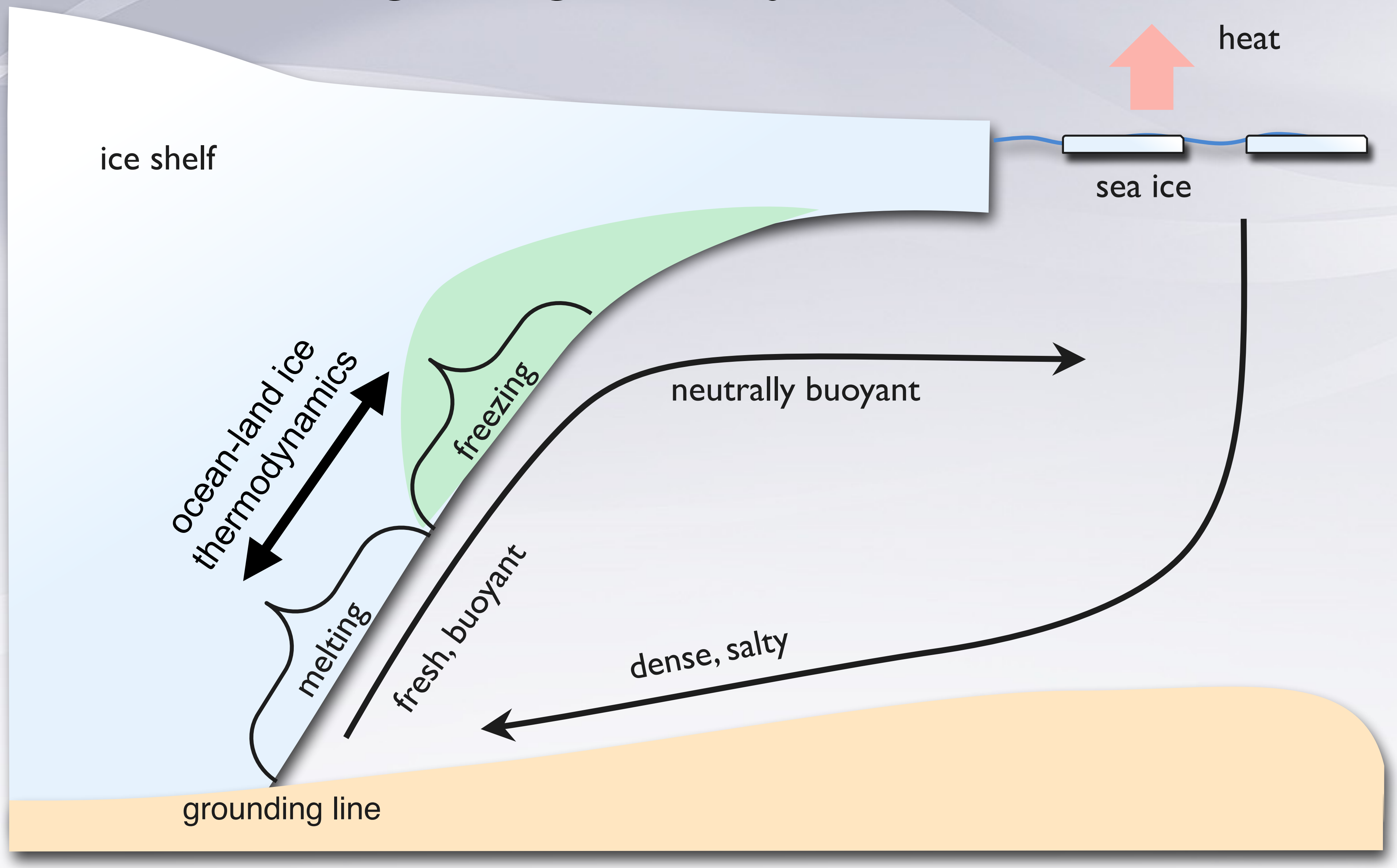
Things to track

systematic way to interpolate initial conditions to high-resolution meshes

definition and implementation of region mask

definition of output streams (file increment, write increment, directory tree)

This system is begging to be studied using Large Eddy Simulation.



Land-ice / ocean embayments can be interpreted as heat exchangers.
The efficiency of these heat exchangers mediates sea-level rise.
Non-hydrostatic plumes descend, exchange heat with land ice and are expelled from cavity.