CESM/CISM Software Engineering Update

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Land Ice Working Group
Software Engineering Liaison

In collaboration with
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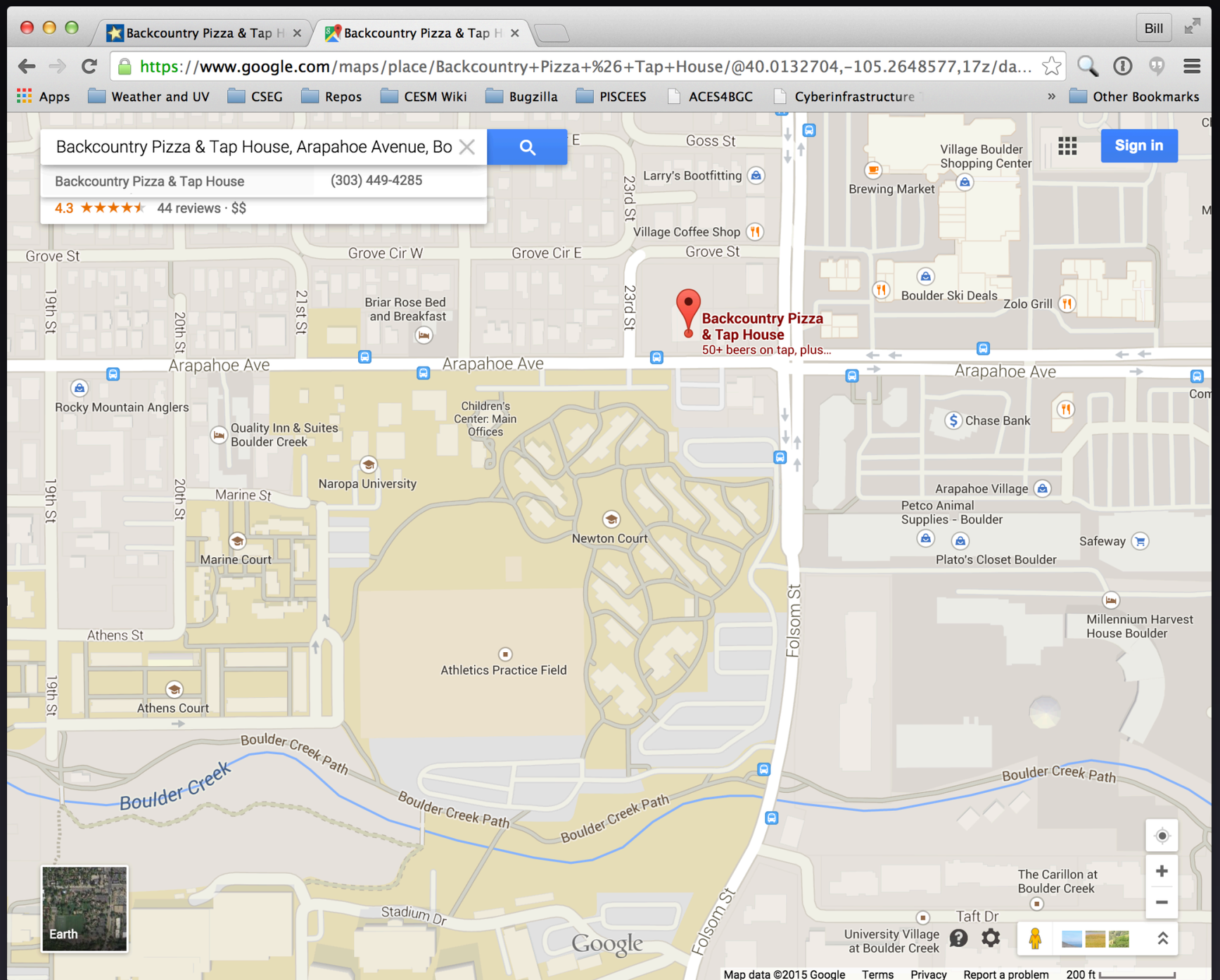
Mariana Vertenstein (NCAR)
Tony Craig & Jon Wolfe (consultants)

Dinner Tonight

Backcountry Pizza; 6:00 PM

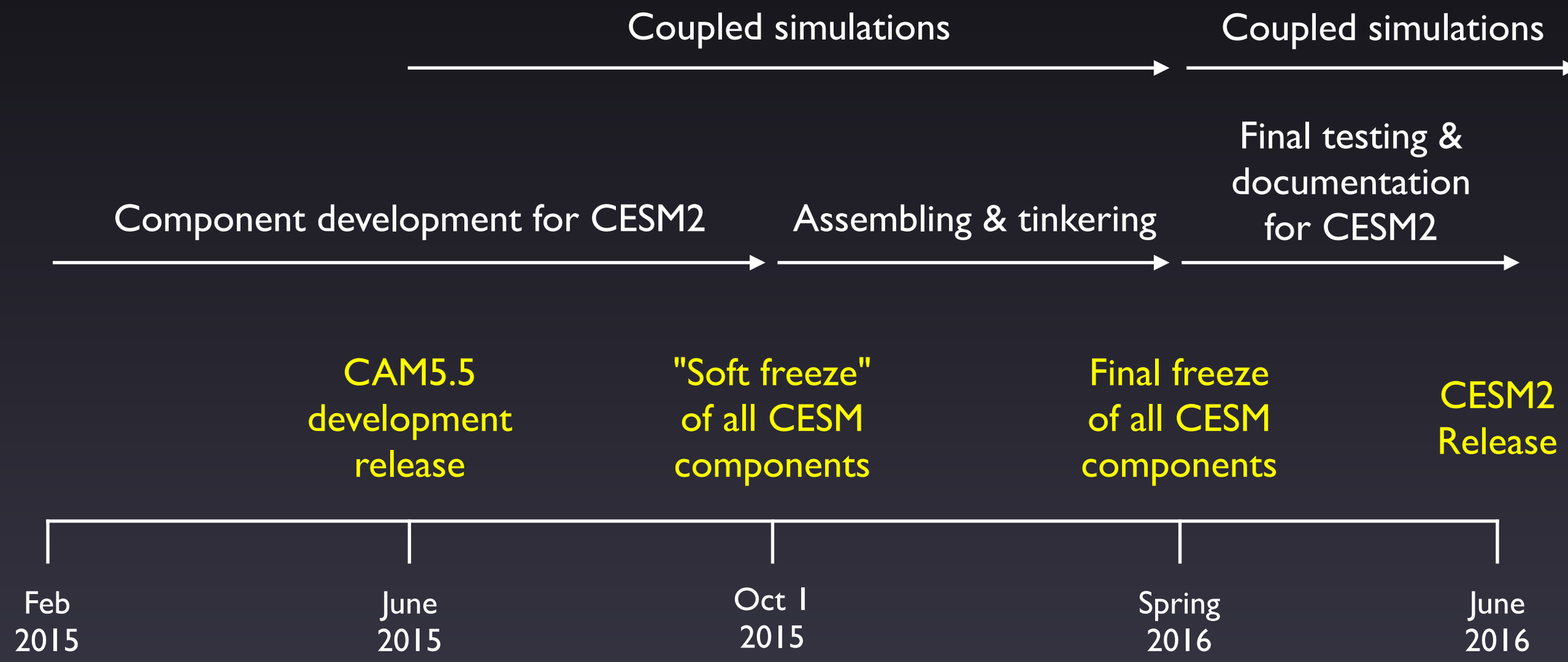
2319 Arapahoe Avenue



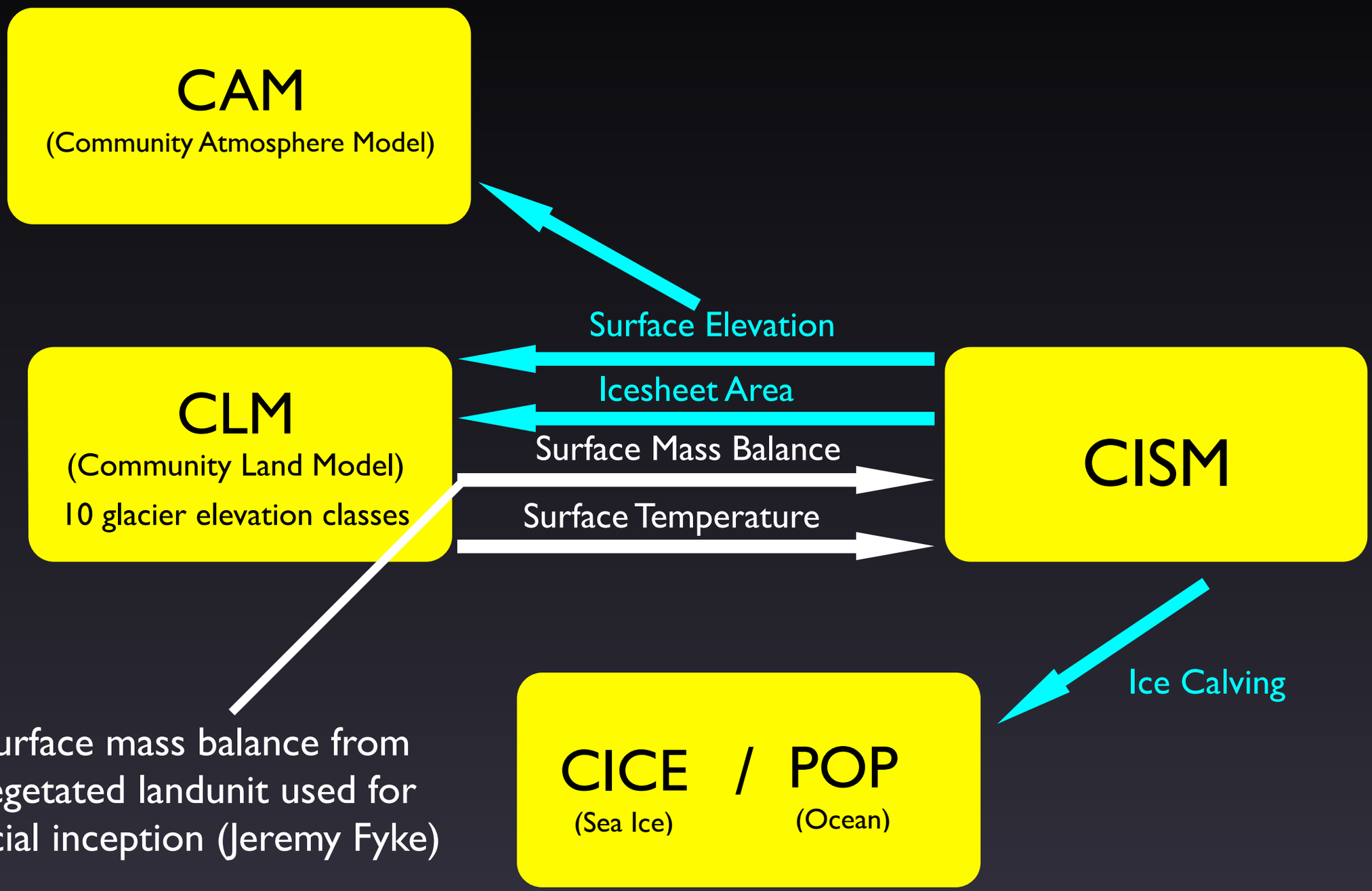
Preparing for CESM2 & CMIP6

There will be no public CESM release this summer

Timeline for the release of CESM2
– the model version that will be used for CMIP6 runs



Two-way Feedbacks Mostly Complete



What's Still Needed for Dynamic Landunits in CLM

- Water & energy conservation
  - Basic code in place. Needs scientific review and some tweaking.
  - May be fundamentally reworked to conserve without the need for fictitious fluxes.
- Carbon & nitrogen conservation
  - Prototype code written; need to plug into CLM.

CISM2 in CESM

- CISM2 release version now in CESM
  - Starting in cesm1_3_beta15 – last month's development beta tag
- Multi-year Greenland simulations give reasonable results
  - CISM-only (TG compset)
  - Fully coupled, with two-way feedbacks (BG1850C5L45BGCIS2 compset)
- Still needs tweaking of configuration settings & initial conditions

Moving Remapping into the Coupler

Currently: Remapping happens in CISM's glint package

Limitations

- Only works with regular lat/lon land grids
  - Would not work with CAM-SE grids
- Bilinear interpolation – not conservative
- Mapping happens in serial
- Any alternative ice sheet model (e.g., MPAS - Land Ice) needs to reimplement glint
- Ocean – land ice coupling would have to be done via the land grid

Solution: Move remapping into the CESM coupler

Implementation of Downscaling

Remapping from land to ice sheet grid

Standard coupler mapping:

$$b_j = \sum_i L_{ij} b_i$$

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elevation difference between ice cell and land column

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estimated vertical gradient
- allows for smoother vertical remapping

elevation difference between ice cell and land column

$$\beta_{ik} = \frac{b_{i,k+1} - b_{i,k-1}}{h_{i,k+1} - h_{i,k-1}}$$

Development with Unit Tests

Leverages new unit testing framework in CESM

- Uses pFUnit
- CESM infrastructure developed by Sean Santos

$$\beta_{ik} = \frac{b_{i,k+1} - b_{i,k-1}}{h_{i,k+1} - h_{i,k-1}}$$

```
@Test
subroutine test_calc_vertical_gradient_ECmid(this)
  ! Test calc_vertical_gradient with an elevation class in the middle of the range
  ! (standard case, not an edge case). This uses a single grid cell.
  class(TestVertGradCalc2ndOrder), intent(inout) :: this
  type(vertical_gradient_calculator_2nd_order_type) :: calculator
  real(r8), parameter :: topo(1,3) = reshape([50._r8, 125._r8, 275._r8], [1,3])
  real(r8), parameter :: data(1,3) = reshape([11._r8, 12._r8,  13._r8], [1,3])
  real(r8) :: vertical_gradient(1)
  real(r8) :: expected_vertical_gradient(1)

  calculator = this%create_calculator(topo=topo, data=data)

  call calculator%calc_vertical_gradient(2, vertical_gradient)

  expected_vertical_gradient(1) = (data(1,3) - data(1,1)) / (topo(1,3) - topo(1,1))
  @assertEqual(expected_vertical_gradient, vertical_gradient, tolerance=tol)

end subroutine test_calc_vertical_gradient_ECmid
```

Turning on CISM by Default in CESM2

- Most CESM runs do NOT include CISM or the calculation of surface mass balance
- We would like to include CISM as a diagnostic component beginning with CESM2 and all CMIP6 runs
- Prerequisites:
  - Coupling rework described earlier
  - Variety of other rework to make it possible to run CISM with any CLM resolution

Other Near-term Plans

- Allow deeper snow pack
- Put in a fix for the snow radiation absorption problem in Antarctica
- Develop a data GLC model, allowing simulations with prescribed transient glacier areas
- Generate new TG forcing datasets
- Improve CLM's diagnostic output capabilities

Current Coupling

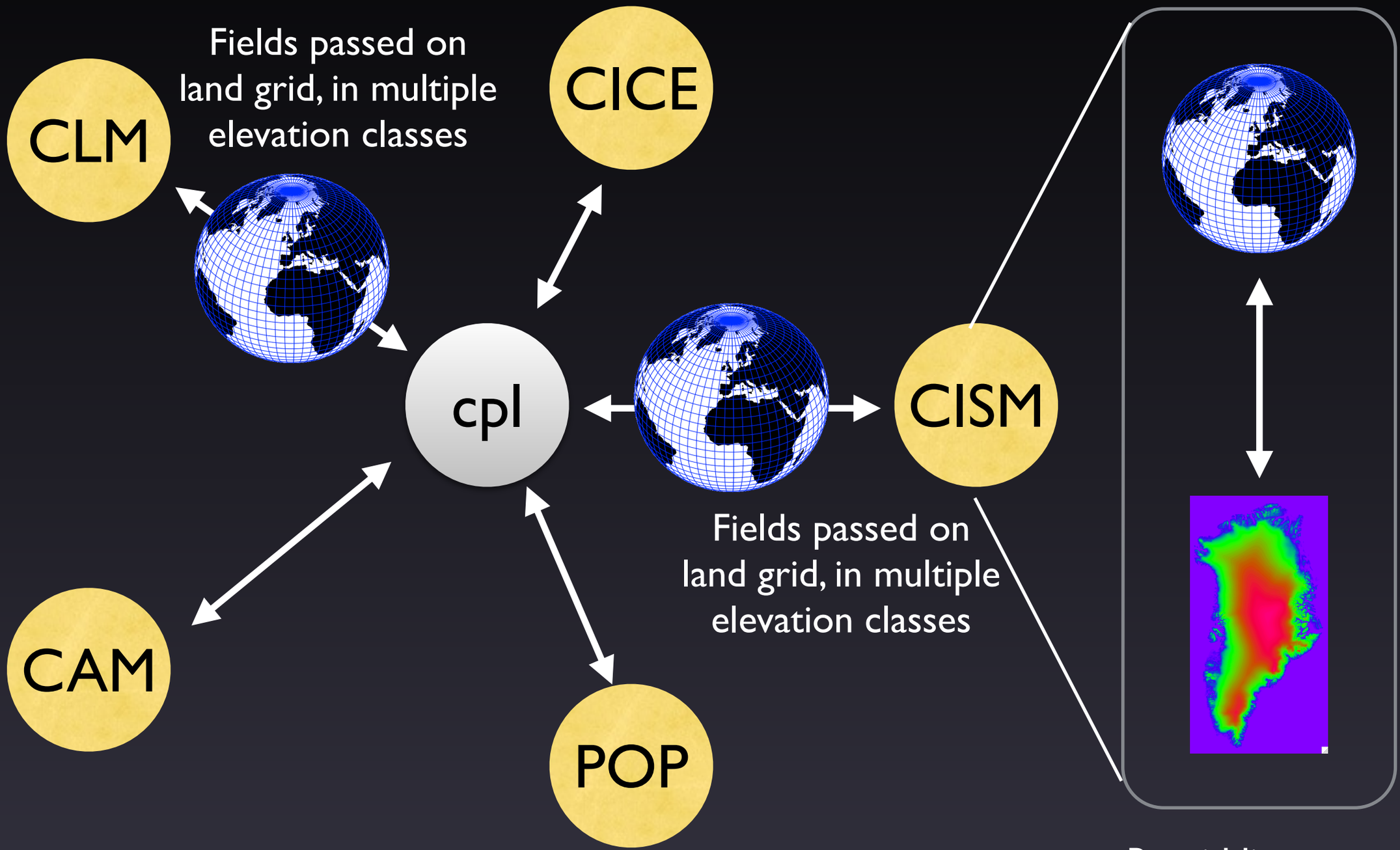
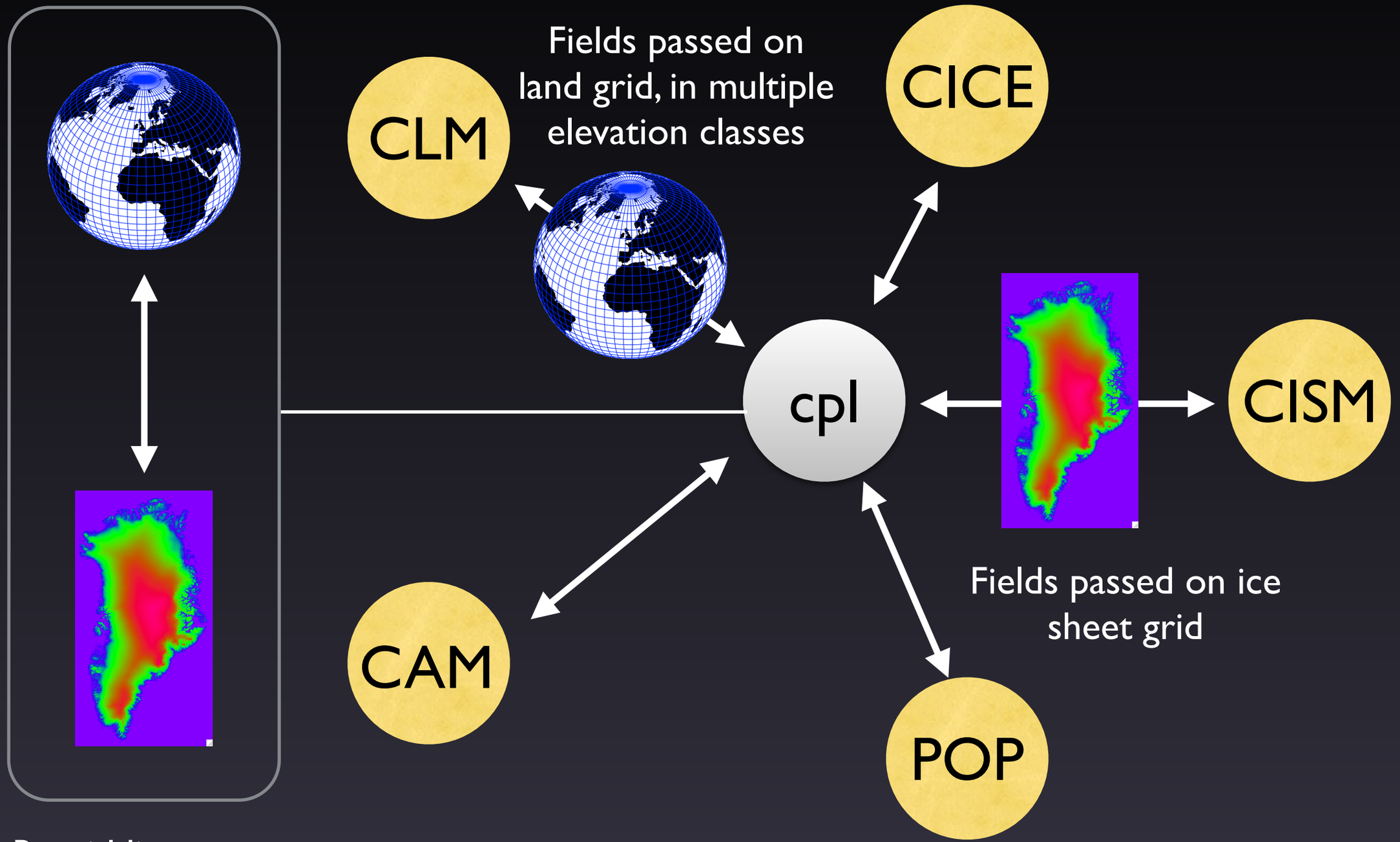


Image credit: http://www-personal.umich.edu/~paullric/research.html

Moving Coupling into the Coupler



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