

Dynamic Landunits in CLM

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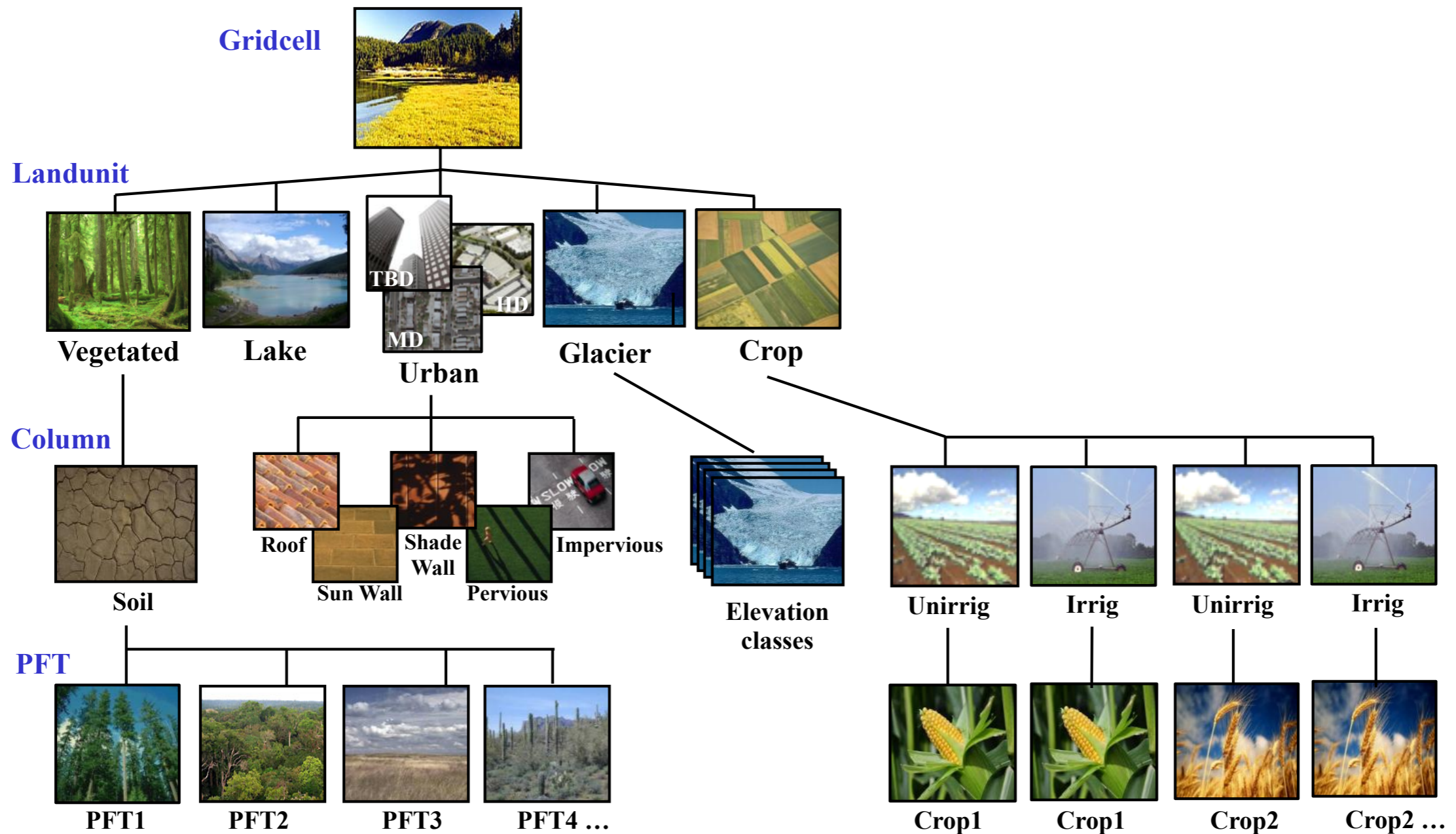
With contributions and guidance from:

Tony Craig, Alan Di Vittorio, Beth Drewniak, Jeremy Fyke, Andy Jones, Erik Kluzek, Dave Lawrence,
Bill Lipscomb, Bette Otto-Bliesner, Bill Riley, Zack Subin, Mariana Vertenstein

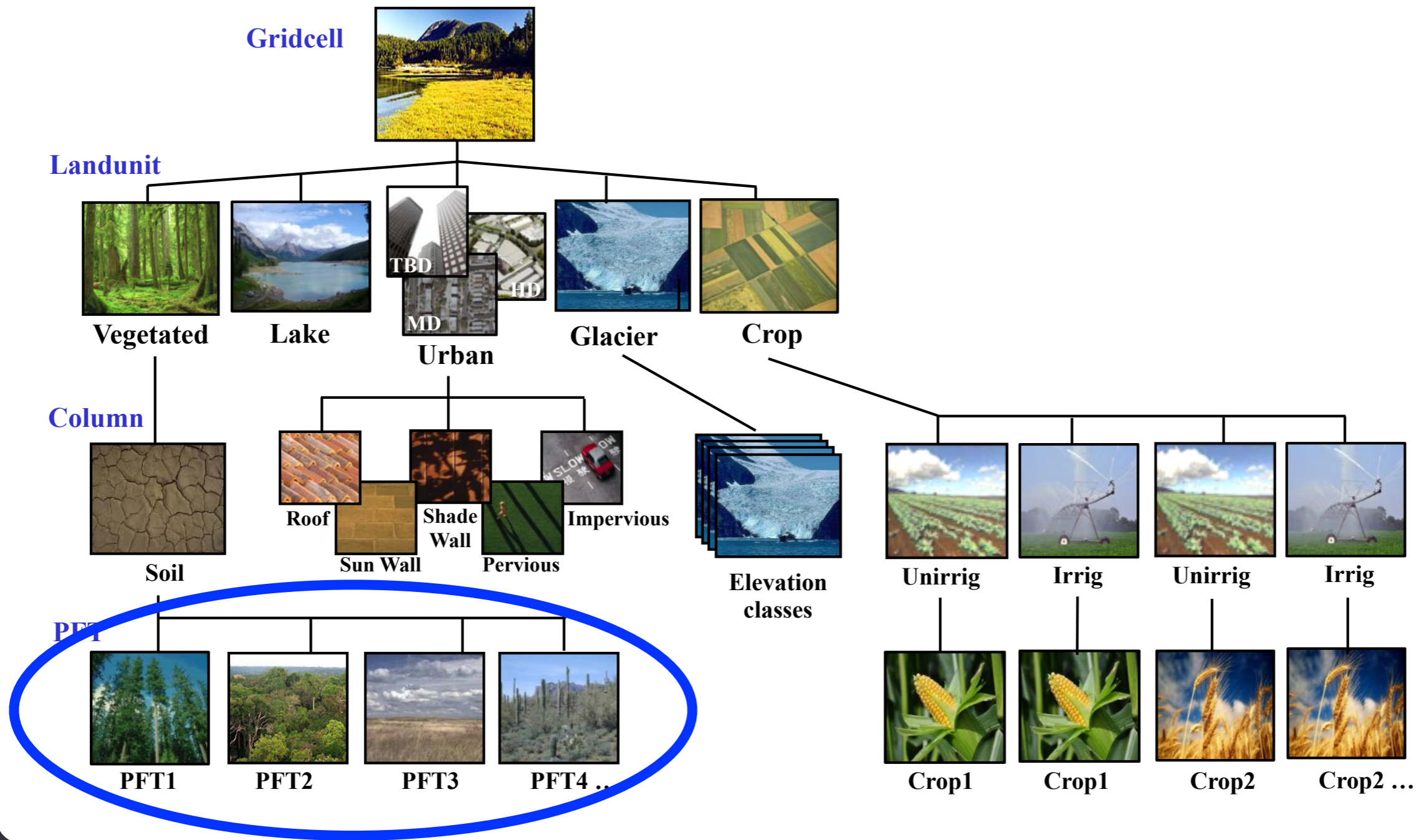
Outline

- Motivation
- Scientific challenges, and current solutions
- Status – what's done, what's left

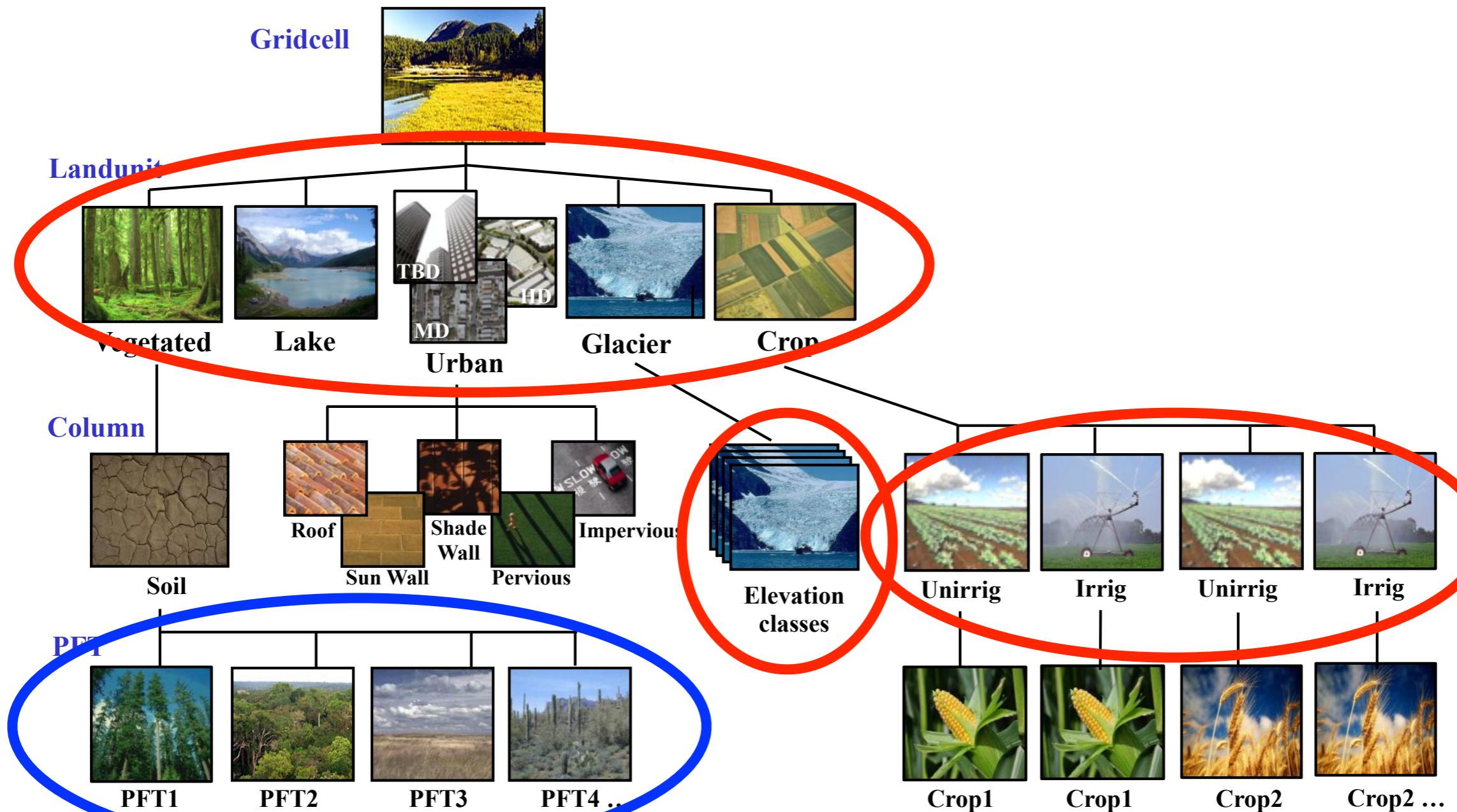
Motivation



Motivation



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Motivation

CISM

(Community Ice Sheet Model)

Gridcell



Landunit



Vegetated



Lake



TBD
MD
Urban



Glacier



Crop

Column



Soil



Roof



Sun Wall



Shade Wall



Pervious



Impervious



Elevation classes



Unirrig



Irrig



Unirrig



Irrig

PFT



PFT1



PFT2



PFT3



PFT4 ..



Crop1



Crop1

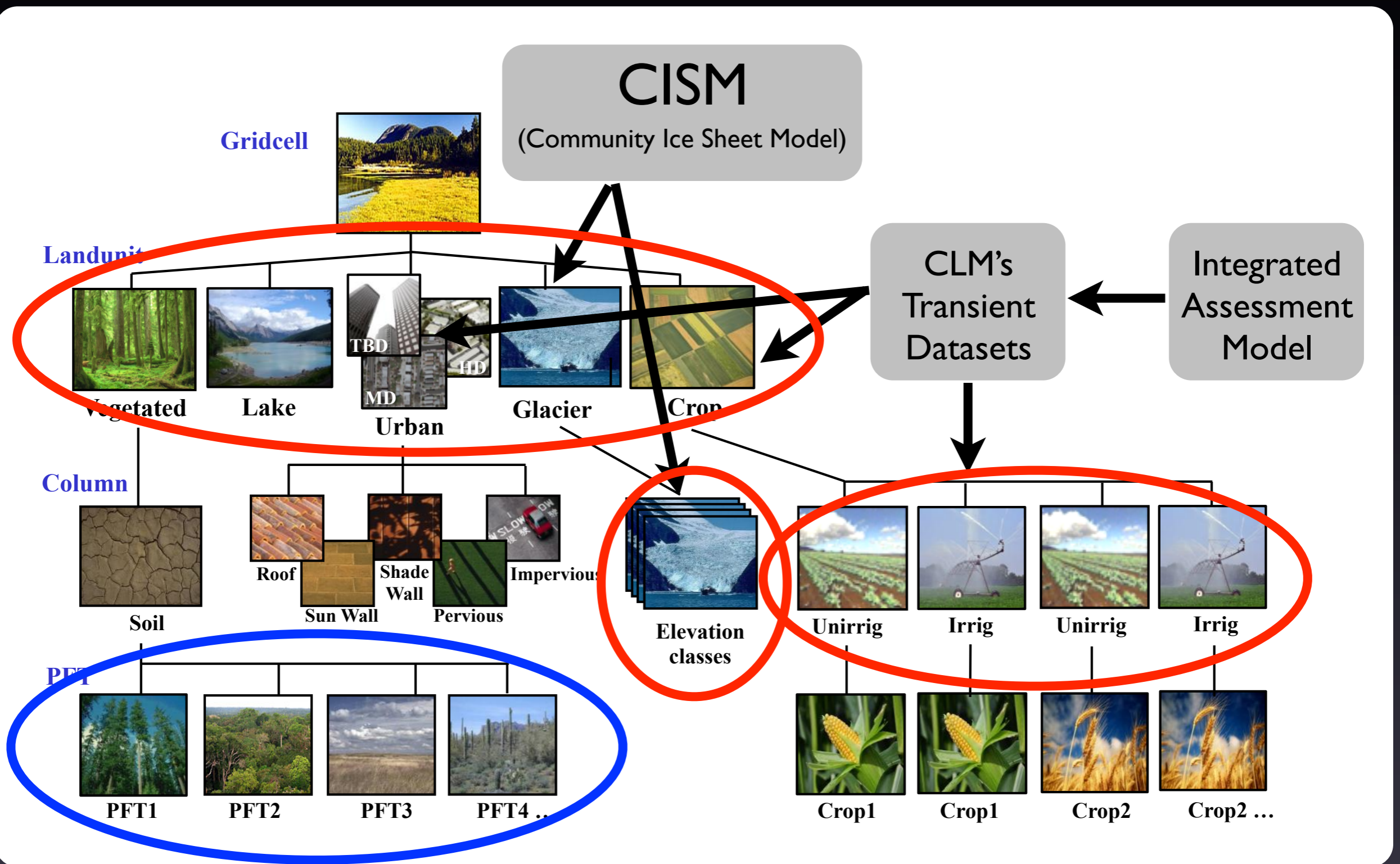


Crop2



Crop2 ...

Motivation

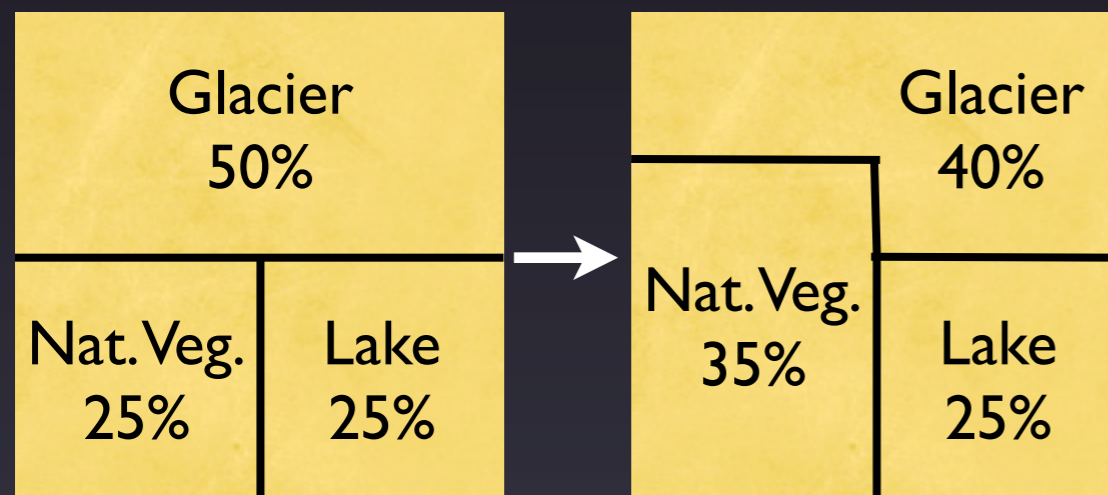


Scientific Challenges

Given areas of SOME landunits,
how should we set areas of other landunits?

Shrinking glacier / crop

Natural vegetation takes over

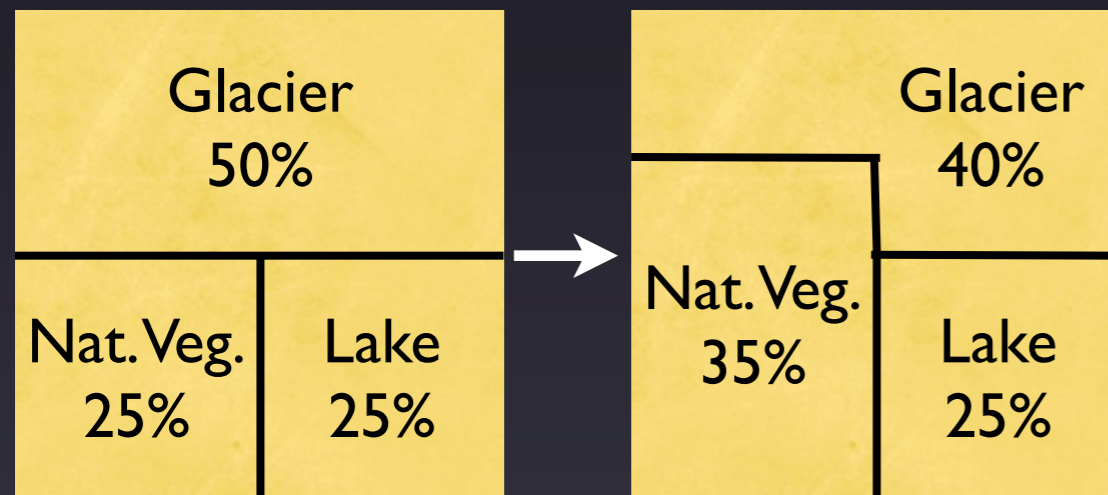


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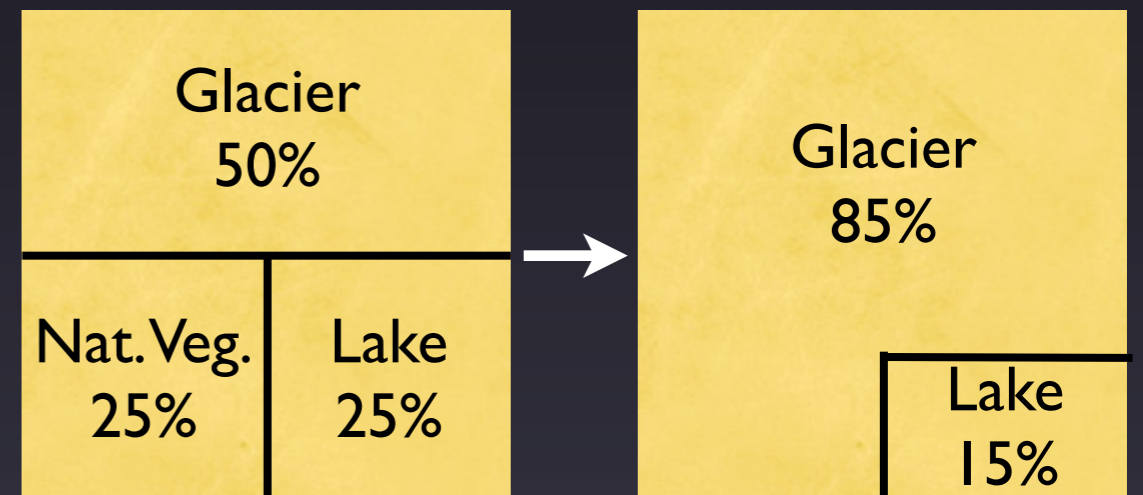
Shrinking glacier / crop

Natural vegetation takes over



Growing glacier / crop

Priorities for decrease,
starting with natural vegetation

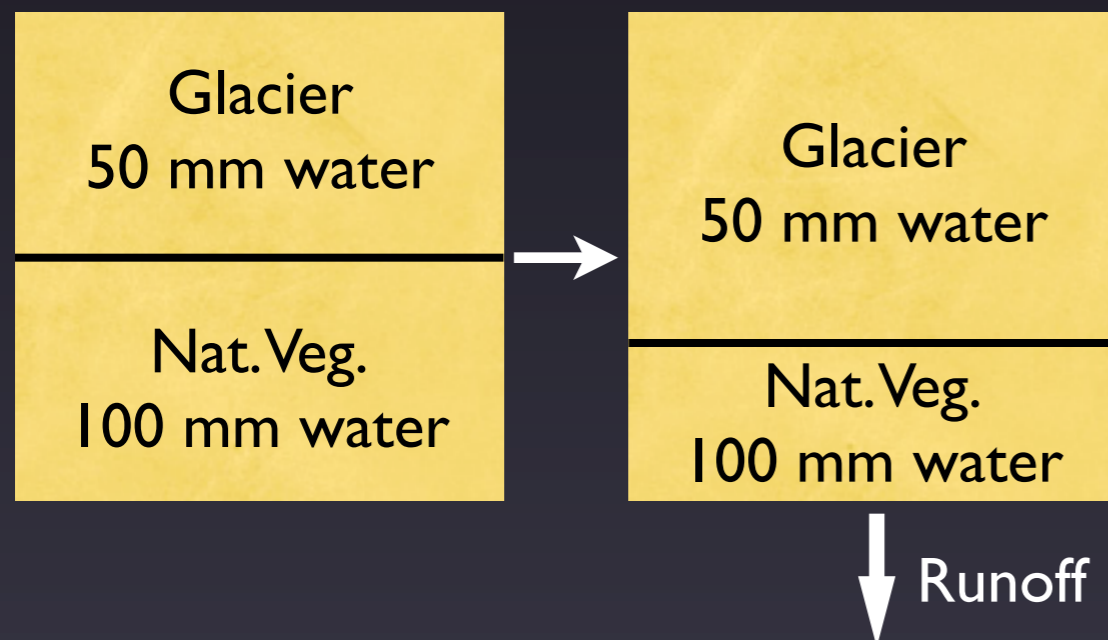


Scientific Challenges

How should we conserve water & energy?

Changing areas of
existing columns

No state adjustments;
instead, introduce adjustment fluxes

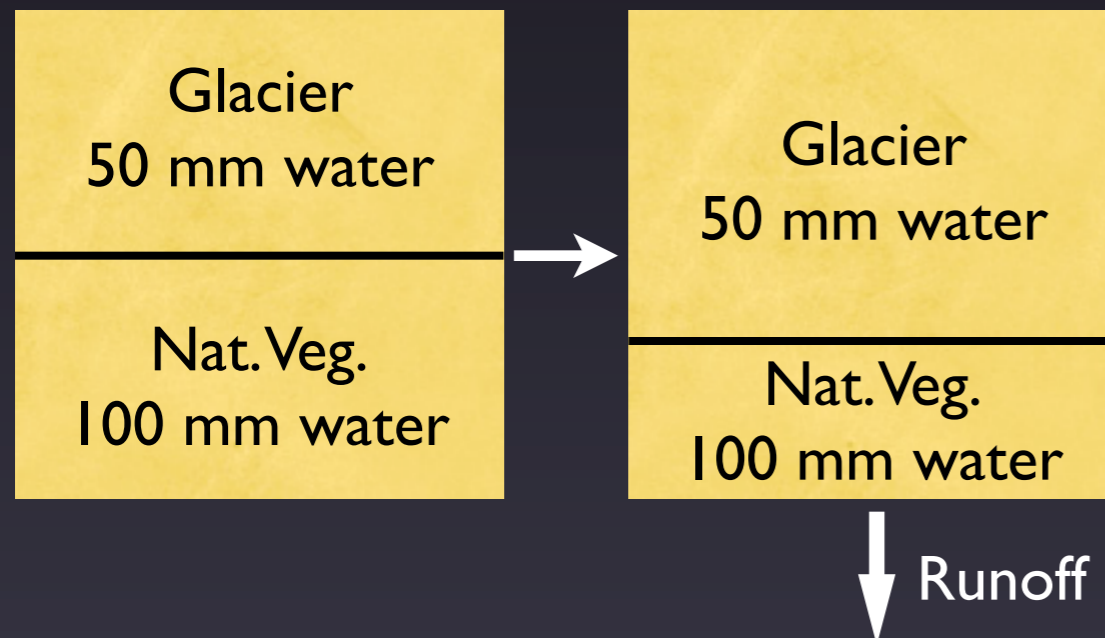


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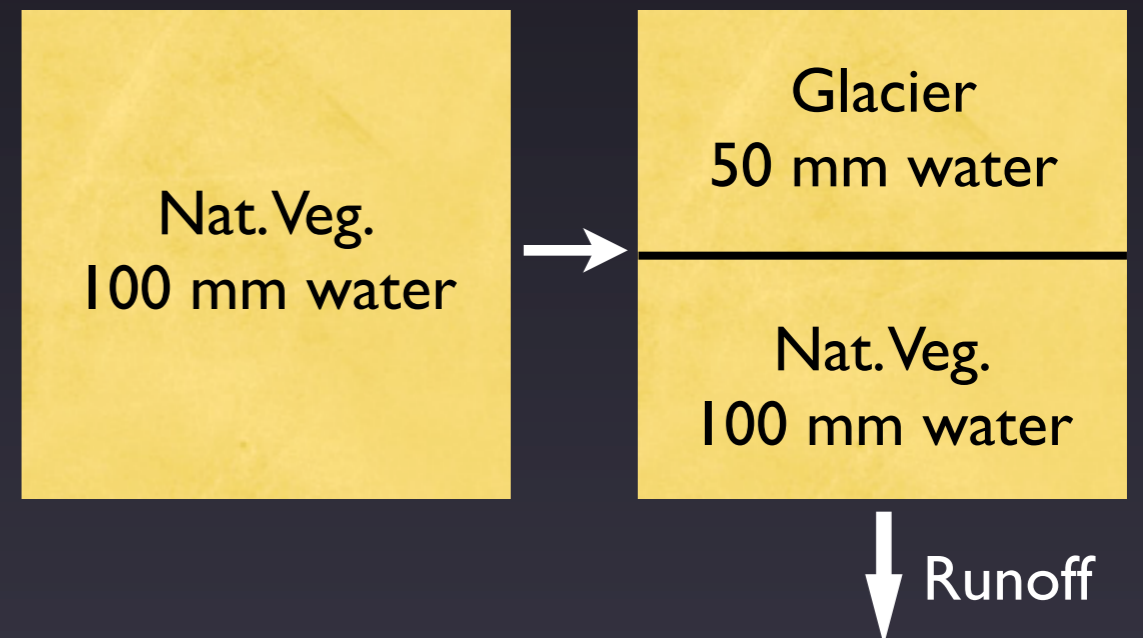
No state adjustments; instead, introduce adjustment fluxes



Initialization

Use state from spun-up 'virtual' column, followed by adjustment fluxes

Virtual Glacier:
50 mm water

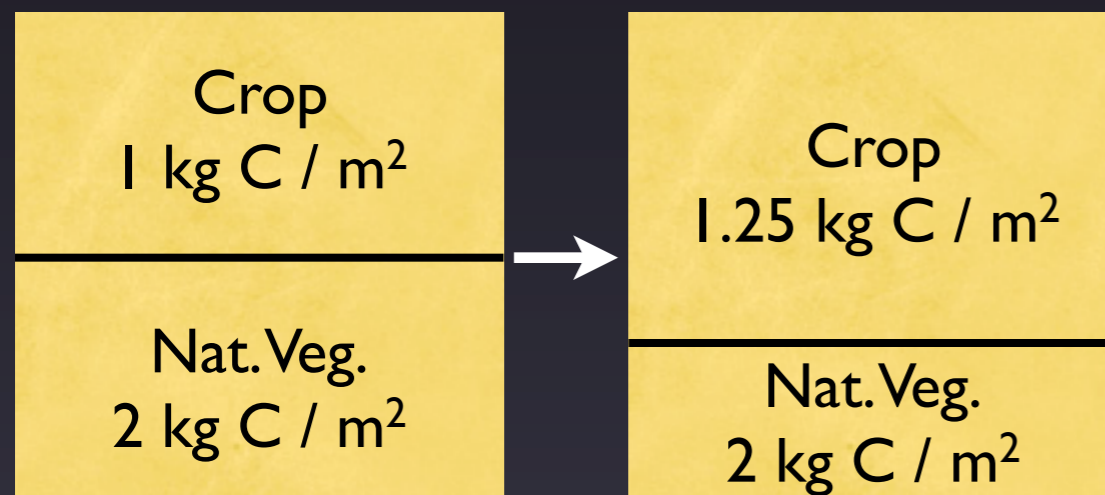


Scientific Challenges

How should we conserve carbon & nitrogen?

Changing areas of
existing columns

Weighted averages of
shrinking & growing areas
(rigorous conservation)

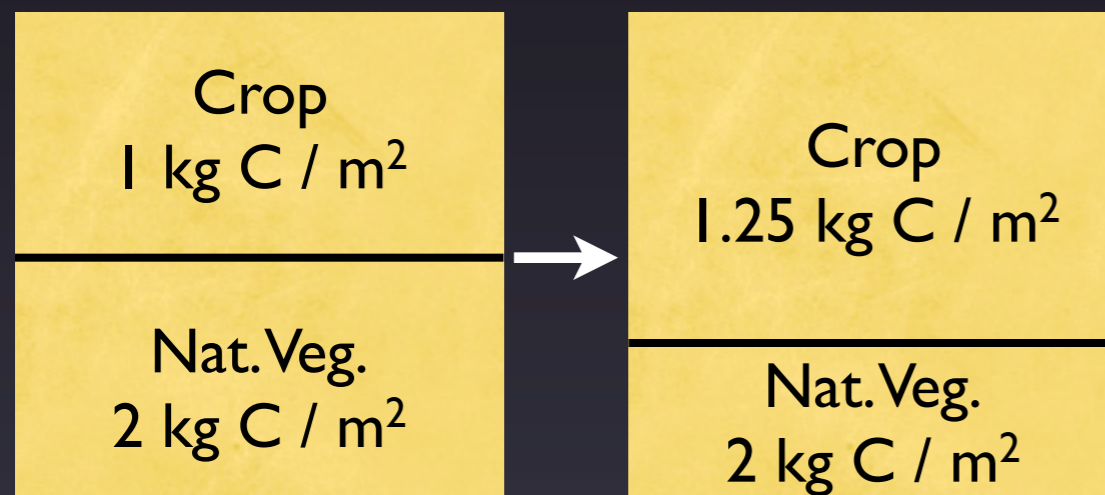


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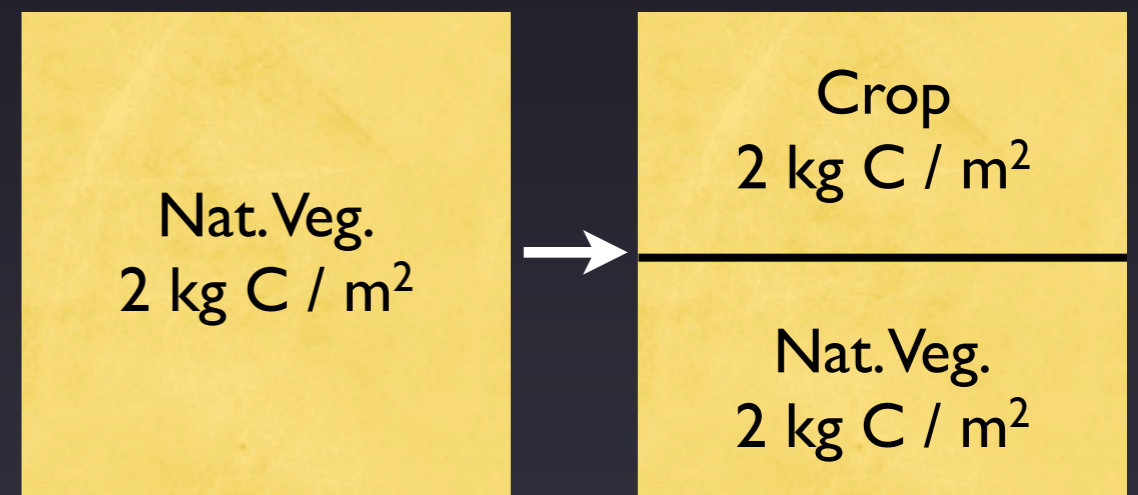
Changing areas of existing columns

Weighted averages of shrinking & growing areas (rigorous conservation)



Initialization

Take state from shrinking areas (this is just the edge case of the first scenario)



Current Status

Fast deglaciation experiment: 100% to 0% in 5 years

Year 1

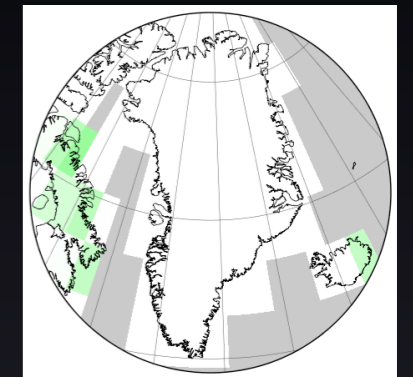
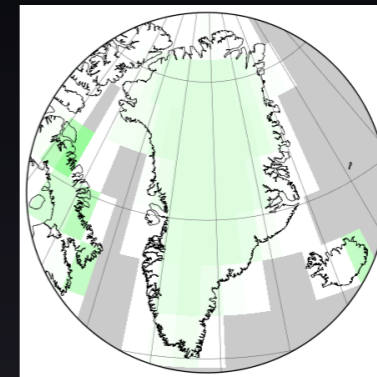
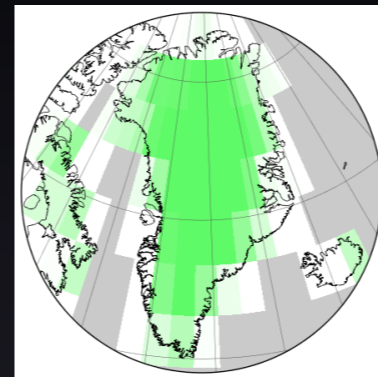
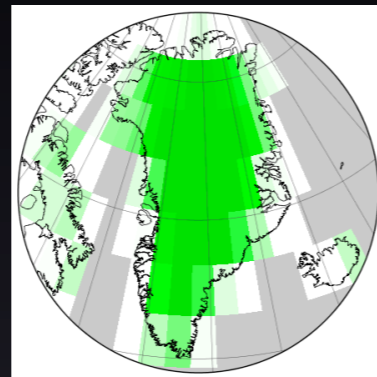
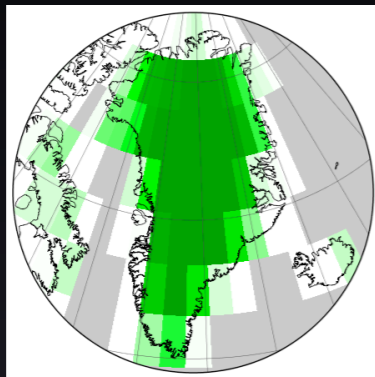
Year 2

Year 3

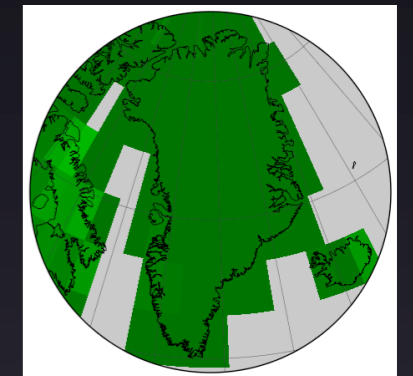
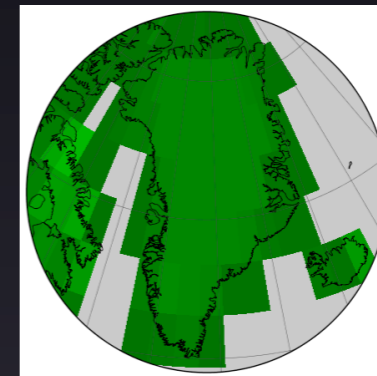
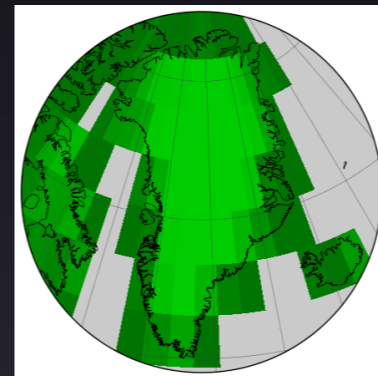
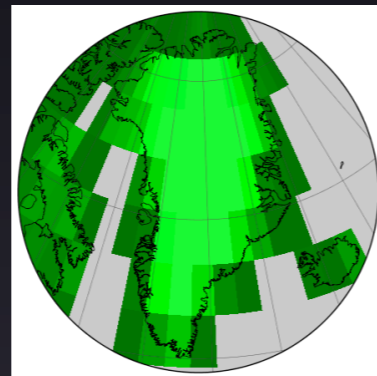
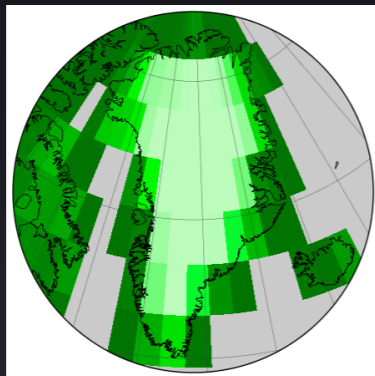
Year 4

Year 5

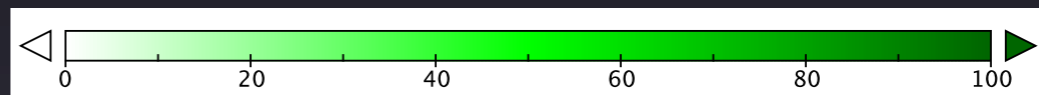
Glacier Area



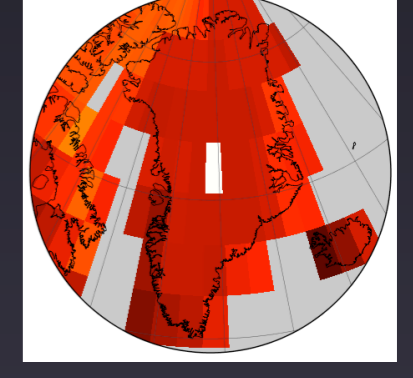
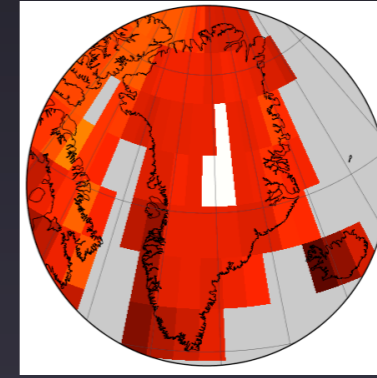
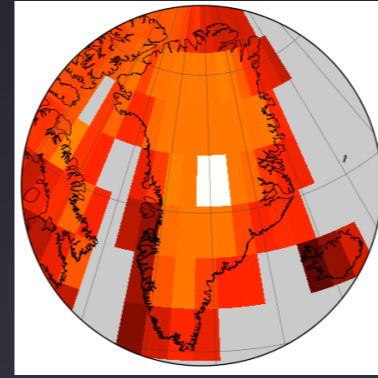
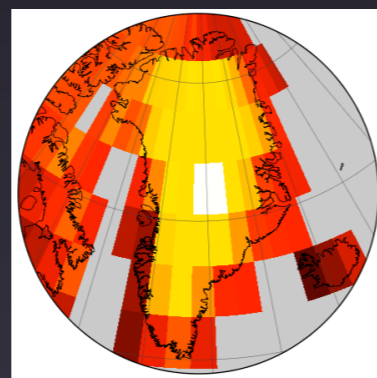
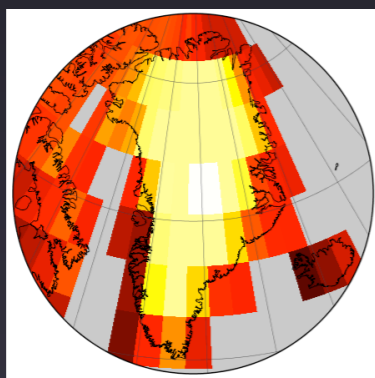
Natural Veg. Area



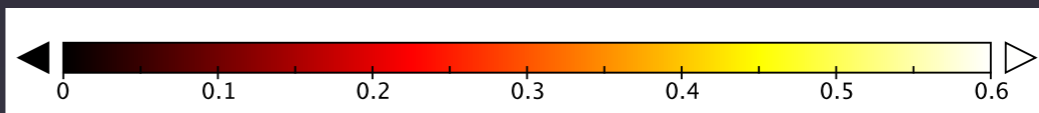
% of grid cell



No-snow Albedo



Albedo (fraction)



Current Status – What's Done

- Worked through design issues – conceptual & technical
- Extensive rework of CLM infrastructure
- Adjust landunit and column areas in response to changing glacier areas
- Water & energy states of new columns initialized reasonably

Rework of CLM Infrastructure

- Allocate memory for any landunit & column that might be needed
- Reordered CLM's internal memory structures for performance
- Introduced 'active' flags
 - ▶ Replace checks like "if (pwtgcell > 0)" sprinkled throughout code
 - ▶ Needed for introducing rules about 'virtual' columns
 - ▶ Confirmed that answers are the same for virtual and non-virtual columns, at least for glacier & natural vegetation
- Reworked surface dataset
 - ▶ Changed convention from % of grid cell to % of landunit
 - ▶ Ensured that necessary parameters are set everywhere
- Major refactoring of CLM's existing code for dynamic subgrid areas, to support bringing in dynamic landunits
 - ▶ Introduced top-level driver for dynamic subgrid areas
 - ▶ Introduced lower-level classes shared between different code
 - ▶ Unified handling of water conservation by CNDV & prescribed transient PFTs
 - ▶ Introduced first unit tests into CLM

Current Status – In Progress

- Respond to changes in crop area (and later urban)
 - ▶ Infrastructure is in place; need a small amount of additional CLM code, plus adding fields to the transient land cover dataset ('pftdyn' file).
- Water & energy conservation
 - ▶ Code in place to compute change in state; needs scientific review. New code needed for adjustment fluxes.
- Carbon & nitrogen conservation
 - ▶ Prototype code written; need to plug into CLM. Need to review list of state variables that will need adjustment.
- Create test cases

Memory reordering for dynamic landunits

Old

Grid cell	1	1	1	2	2	2
Landunit	1	2	3	1	2	3

New

Grid cell	1	2	1	2	1	2
Landunit	1	1	2	2	3	3

24% performance improvement