Dynamic Landunits in CLM

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Outline

• Motivation

• Scientific challenges, and current solutions

• Status – what’s done, what’s left
Motivation
Motivation
Scientific Challenges

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

Shrinking glacier / crop
Natural vegetation takes over
Scientific Challenges

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

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

- Glacier 50 mm water
- Nat.Veg. 100 mm water
- Glacier 50 mm water
- Nat.Veg. 100 mm water
- Runoff
Scientific Challenges

How should we conserve water & energy?

Changing areas of existing columns

No state adjustments; instead, introduce adjustment fluxes

Initialization

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

Virtual Glacier: 50 mm water

Runoff

Glacier 50 mm water

Nat. Veg. 100 mm water

Glacier 50 mm water

Nat. Veg. 100 mm water

Nat. Veg. 100 mm water

Nat. Veg. 100 mm water
Scientific Challenges

How should we conserve carbon & nitrogen?

Changing areas of existing columns

Weighted averages of shrinking & growing areas (rigorous conservation)

<table>
<thead>
<tr>
<th></th>
<th>Crop</th>
<th>Nat.Veg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighted Ave.</td>
<td>1 kg C / m²</td>
<td>2 kg C / m²</td>
</tr>
<tr>
<td>Shrinking Area</td>
<td>1.25 kg C / m²</td>
<td>2 kg C / m²</td>
</tr>
</tbody>
</table>
Scientific Challenges

How should we conserve carbon & nitrogen?

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

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glacier Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Veg. Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of grid cell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Grid cell</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>2</th>
<th>2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landunit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**New**

<table>
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<th>2</th>
<th>1</th>
<th>2</th>
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<td>2</td>
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24% performance improvement