Next-Generation Ecosystem Experiments (NGEE Arctic)

An integrated model-data activity focused on reduced uncertainty and improved climate prediction at regional to global scales

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Land/Biogeochemistry Working Groups Meeting
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2 Los Alamos NATIONAL LABORATORY
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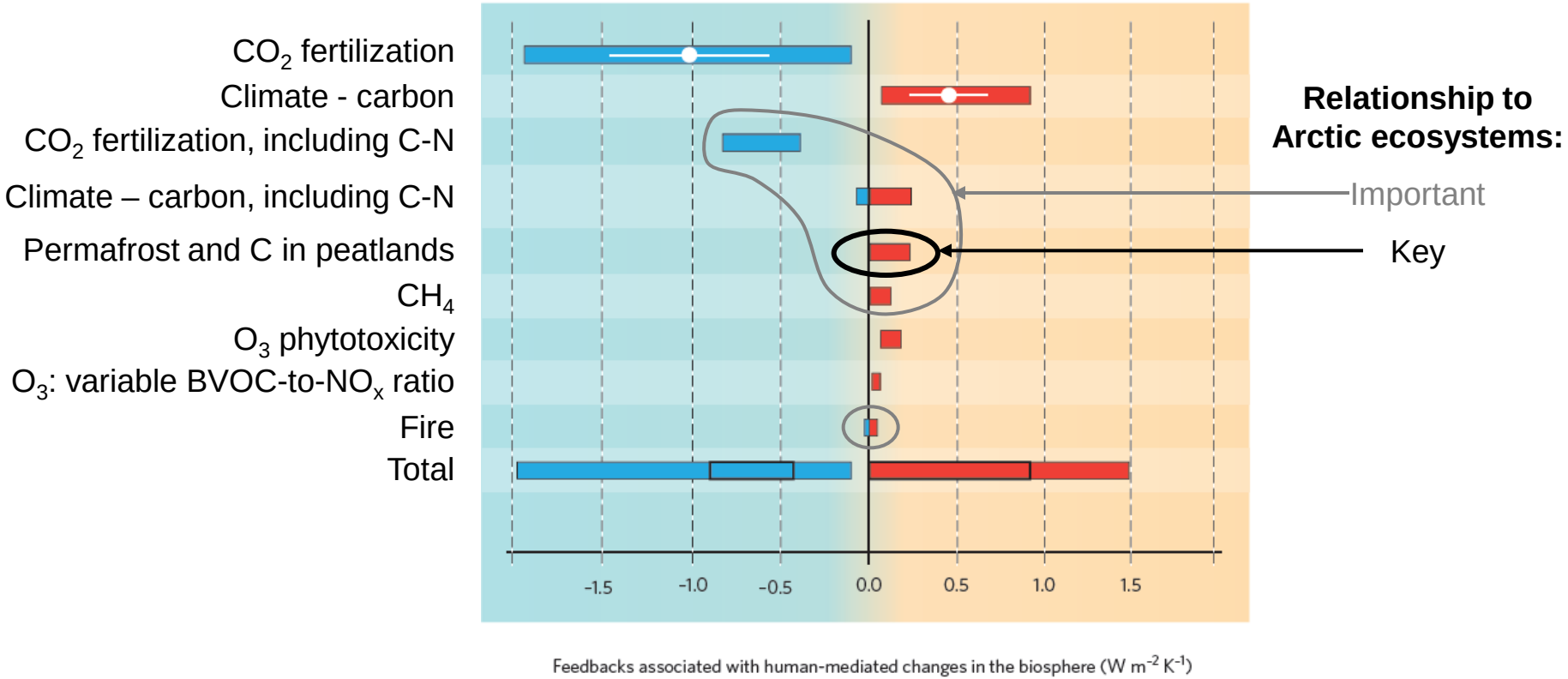
5 UAF UNIVERSITY OF ALASKA FAIRBANKS
U.S. DEPARTMENT OF ENERGY

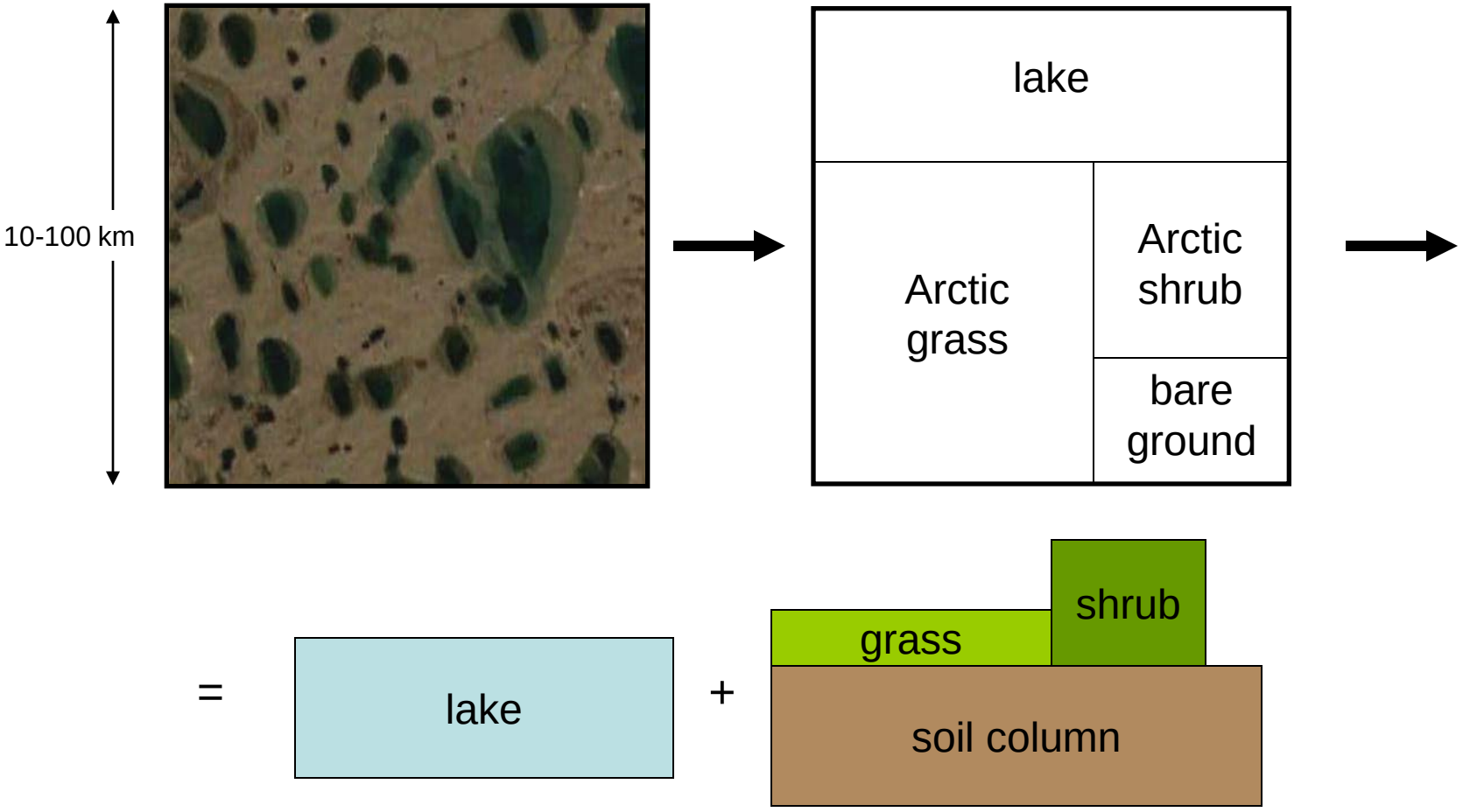
Arctic terrestrial ecosystem processes play a critical role in prediction of future climate response to GHG forcing



Recent assessment finds that Arctic processes make significant contributions to overall land ecosystem - climate feedbacks

Figure: Arneth et al. 2010, Nature Geosci.

Current scaling approach for land component of climate prediction model (e.g. CLM4)

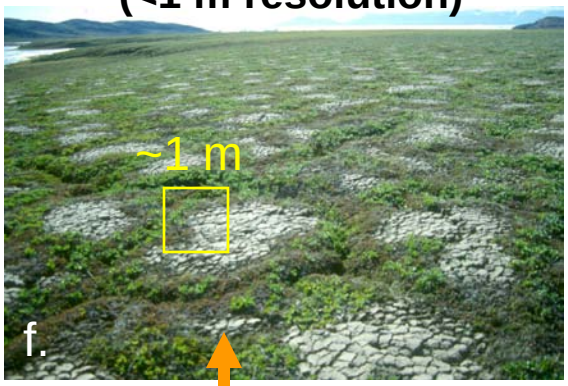


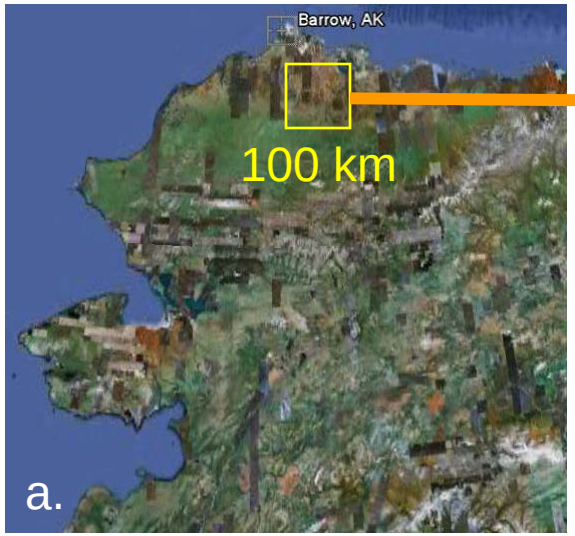
Best ESMs currently use quasi one dimensional approach, with assumption of linear scaling

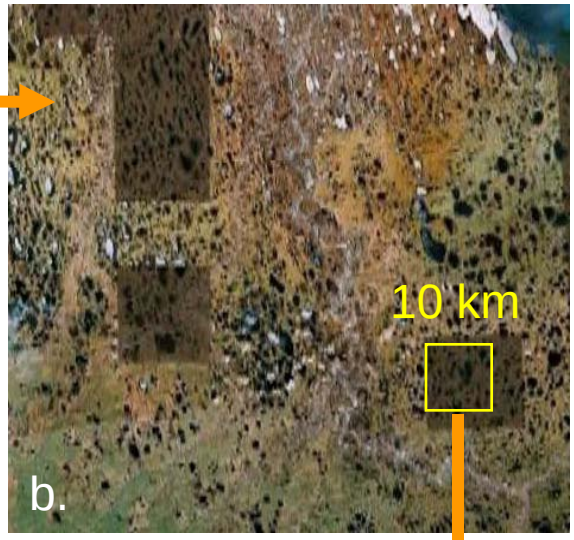
Hypothesis: Linear scaling not a good assumption in Arctic tundra landscapes under warming scenario

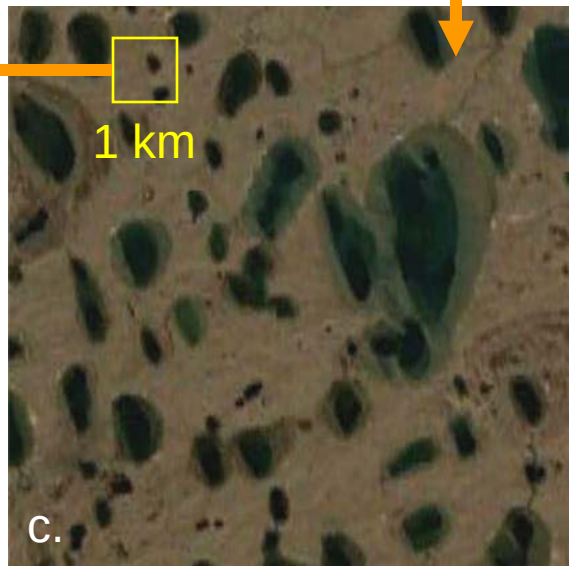
Typical GCM / ESM scales (1°x1°) ≈ 100km

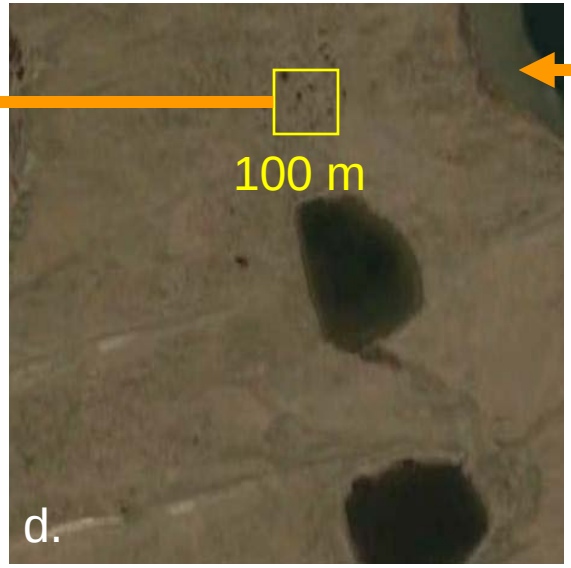
Site scale (<1 m resolution)

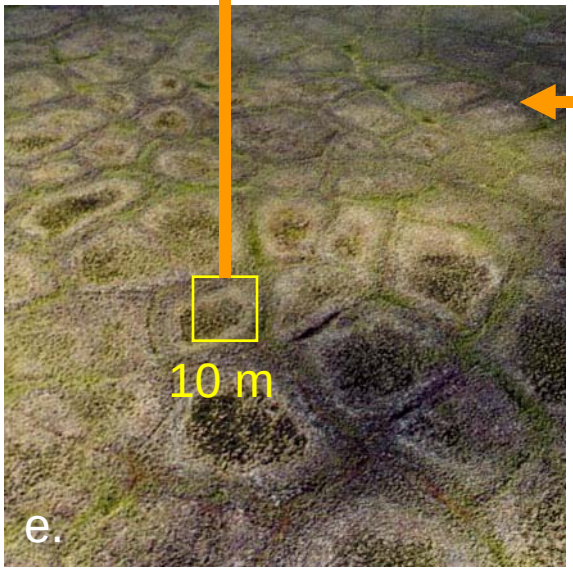










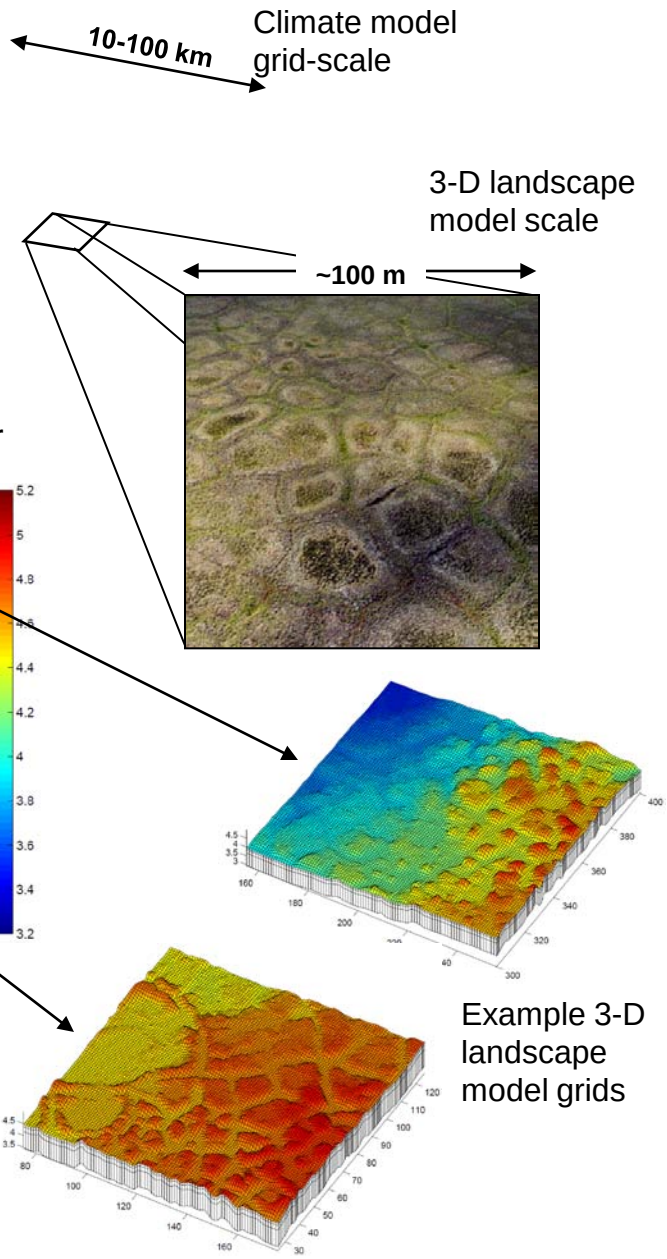


Landscape scales (100 m to 10 km)

3-D process-resolving Arctic tundra landscape simulator

Process requirements

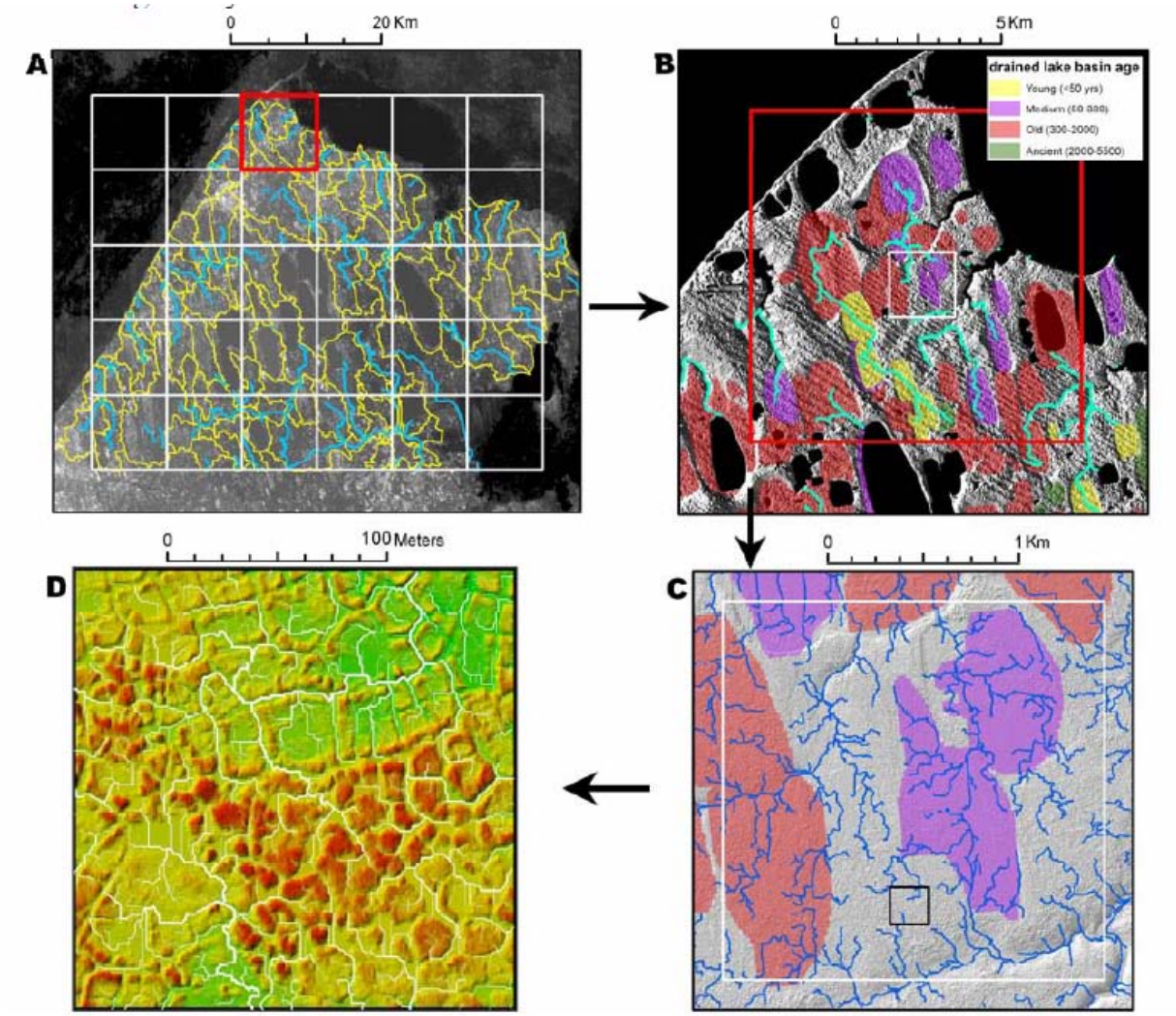
- Subsurface
  - Permafrost
  - Differential ice concentrations
  - Active layer
  - Biogeochemistry
- Surface
  - Deformable topography
  - Surface flow and dynamic flow paths
  - Snowpack dynamics
  - Vegetation dynamics
- Near-surface atmosphere
  - Canopy interactions with surface wind, humidity, temperature, and radiation balance
  - Influence of microtopography on near-surface weather



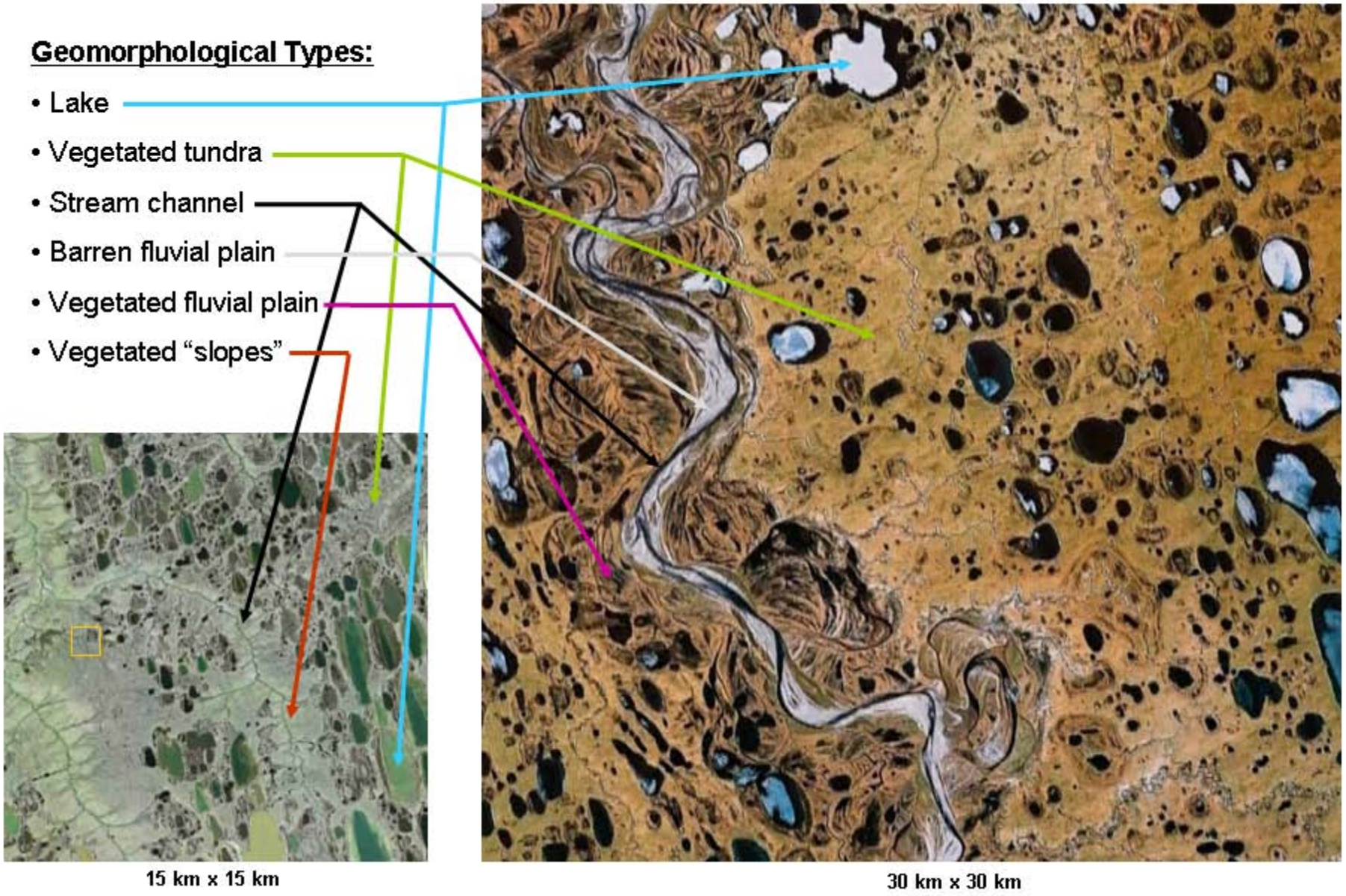
Example 3-D landscape model grids

Spatial characteristics:
Domain: approx. 100m x 100m
Resolution: ~10 cm (horiz), variable cm+ (vert)
Temporal characteristics:
Domain: decades to century
Resolution: sub-hourly

A nested scaling framework based on hydrology/geomorphology



Sub-grid representation of geomorphologically distinct landscape elements



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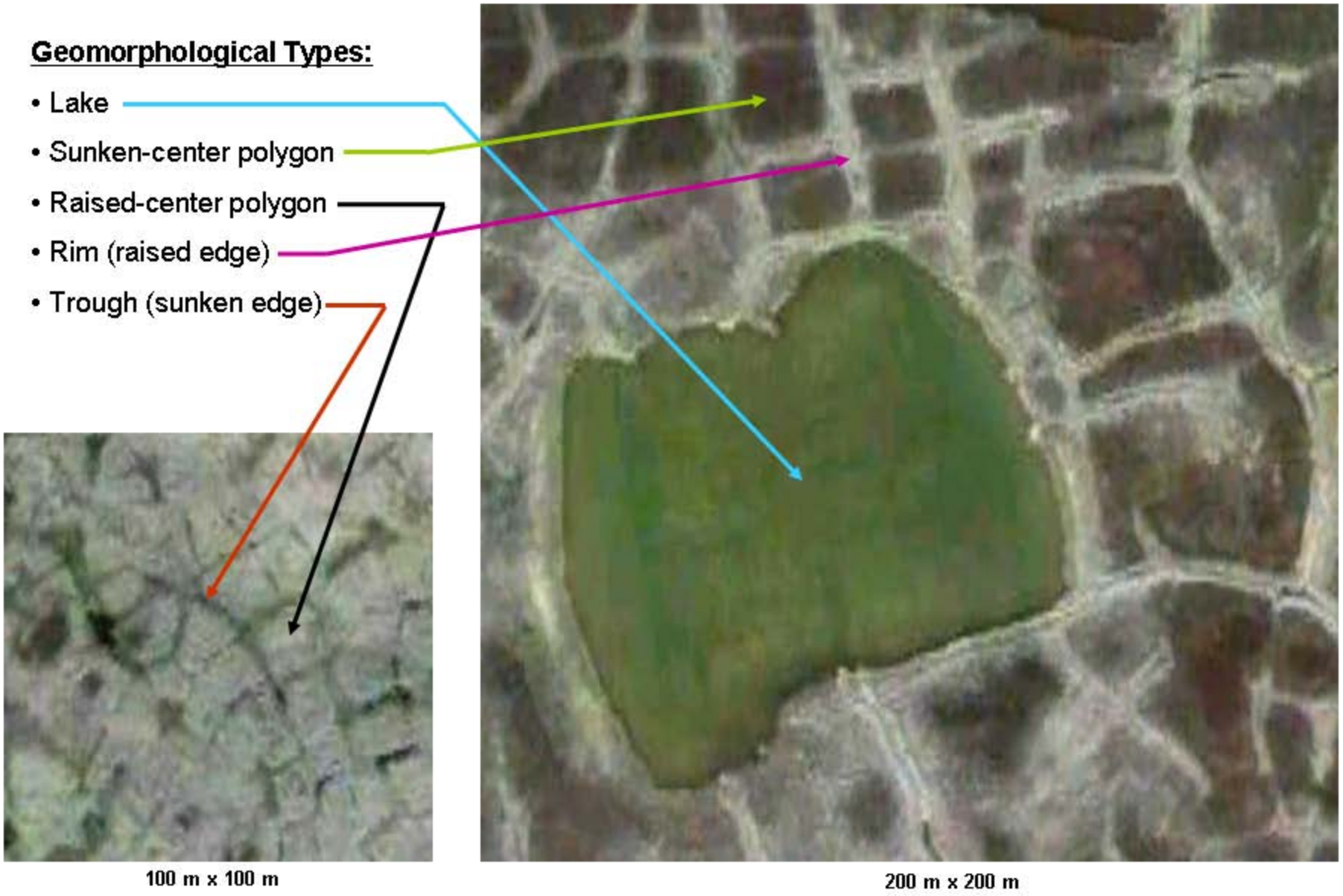
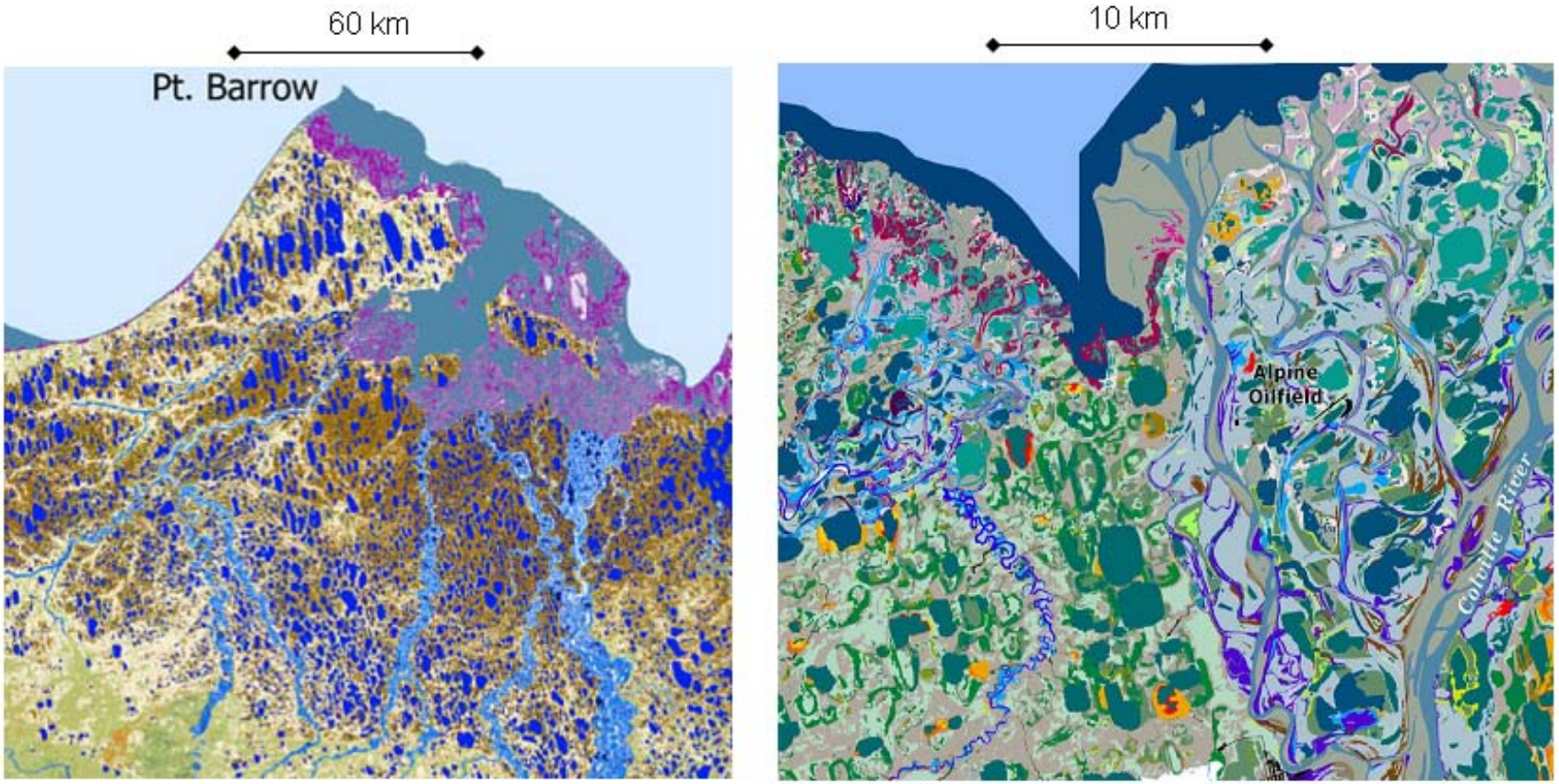
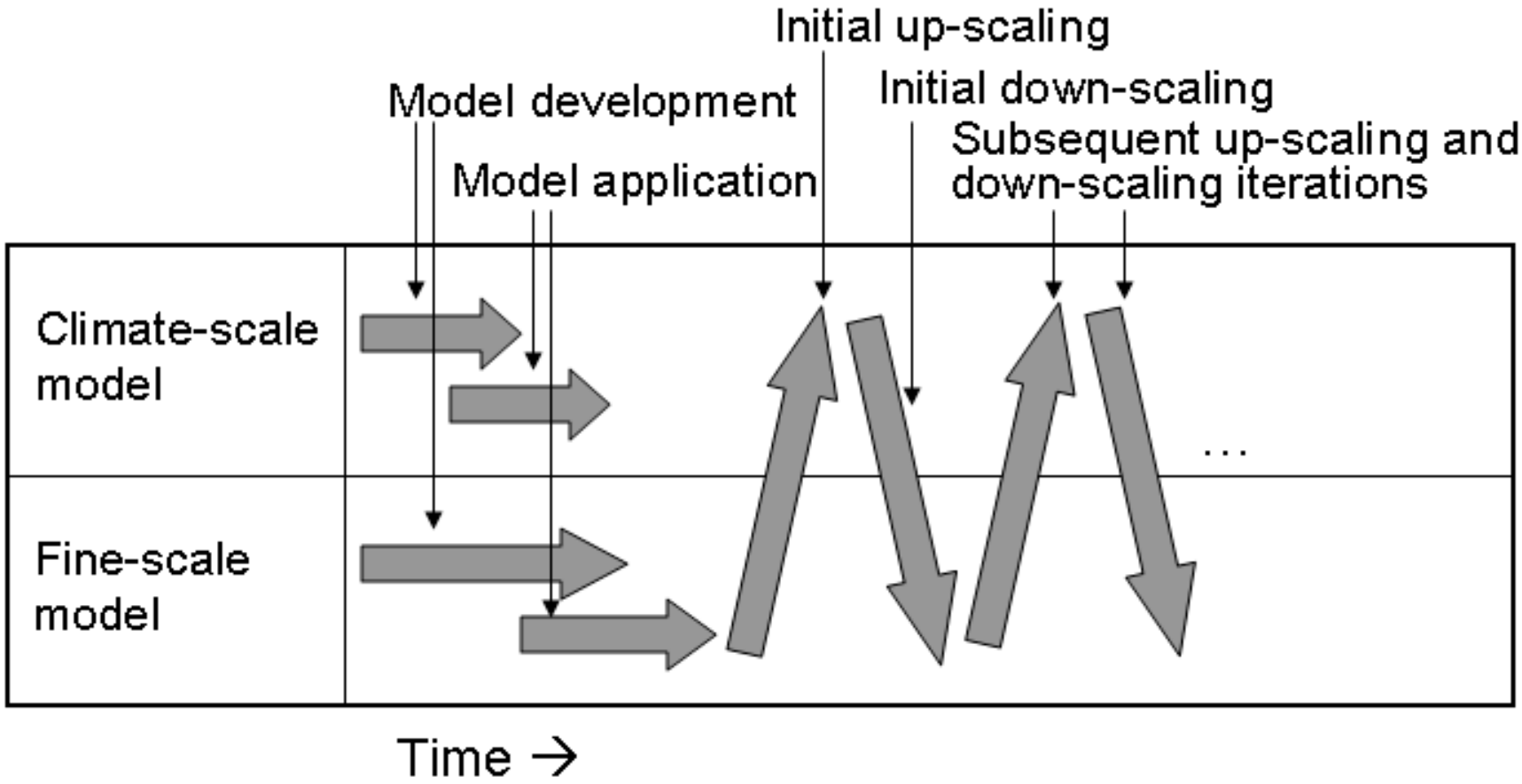


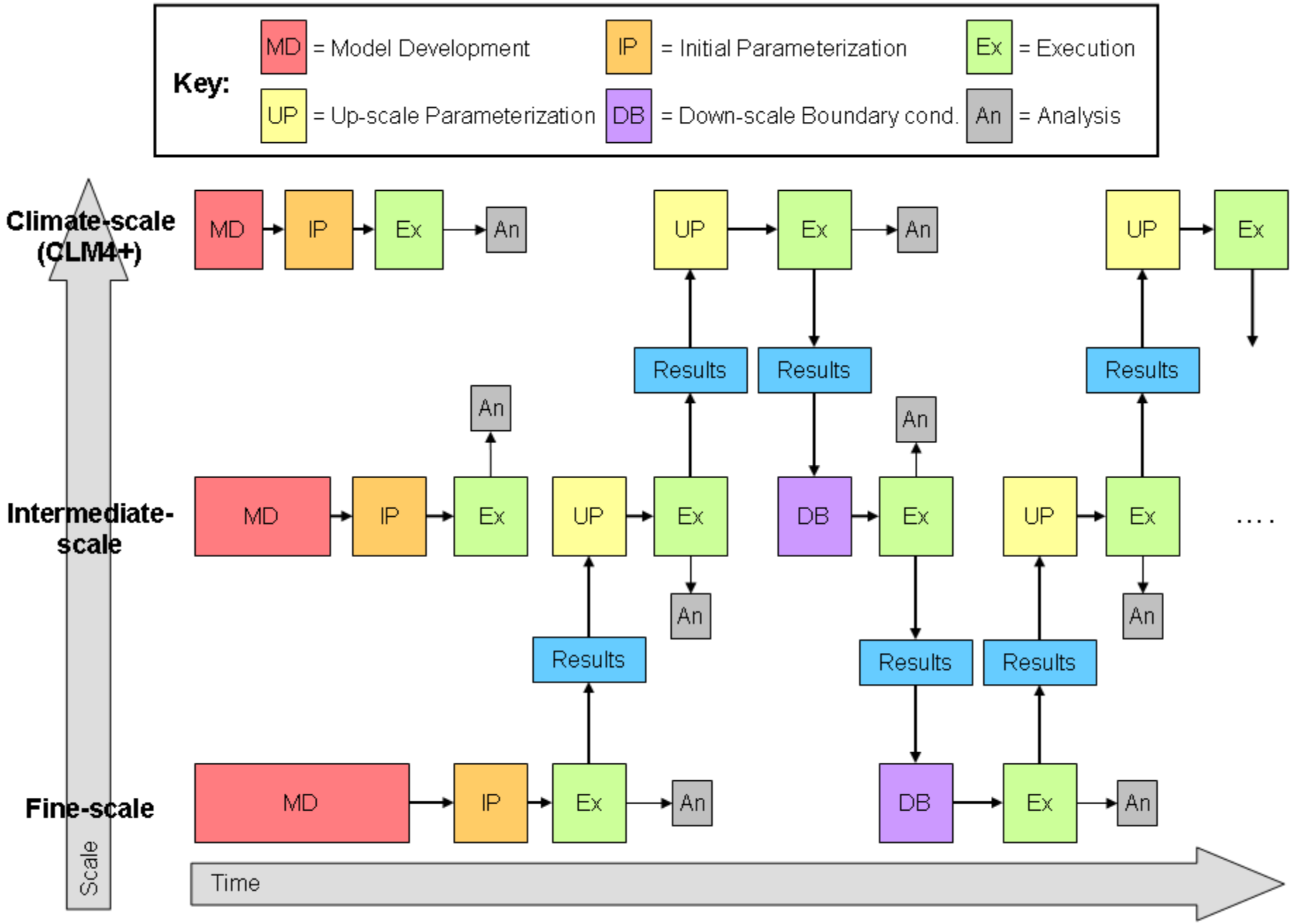
Automated mapping of geomorphological units on Arctic coastal plain



Subsets from two recent remote sensing based efforts to map geomorphological units across the Alaskan North Slope tundra region. Left: from Jorgensen and Heiner, 2004. Right: from Jorgensen et al. 2005.

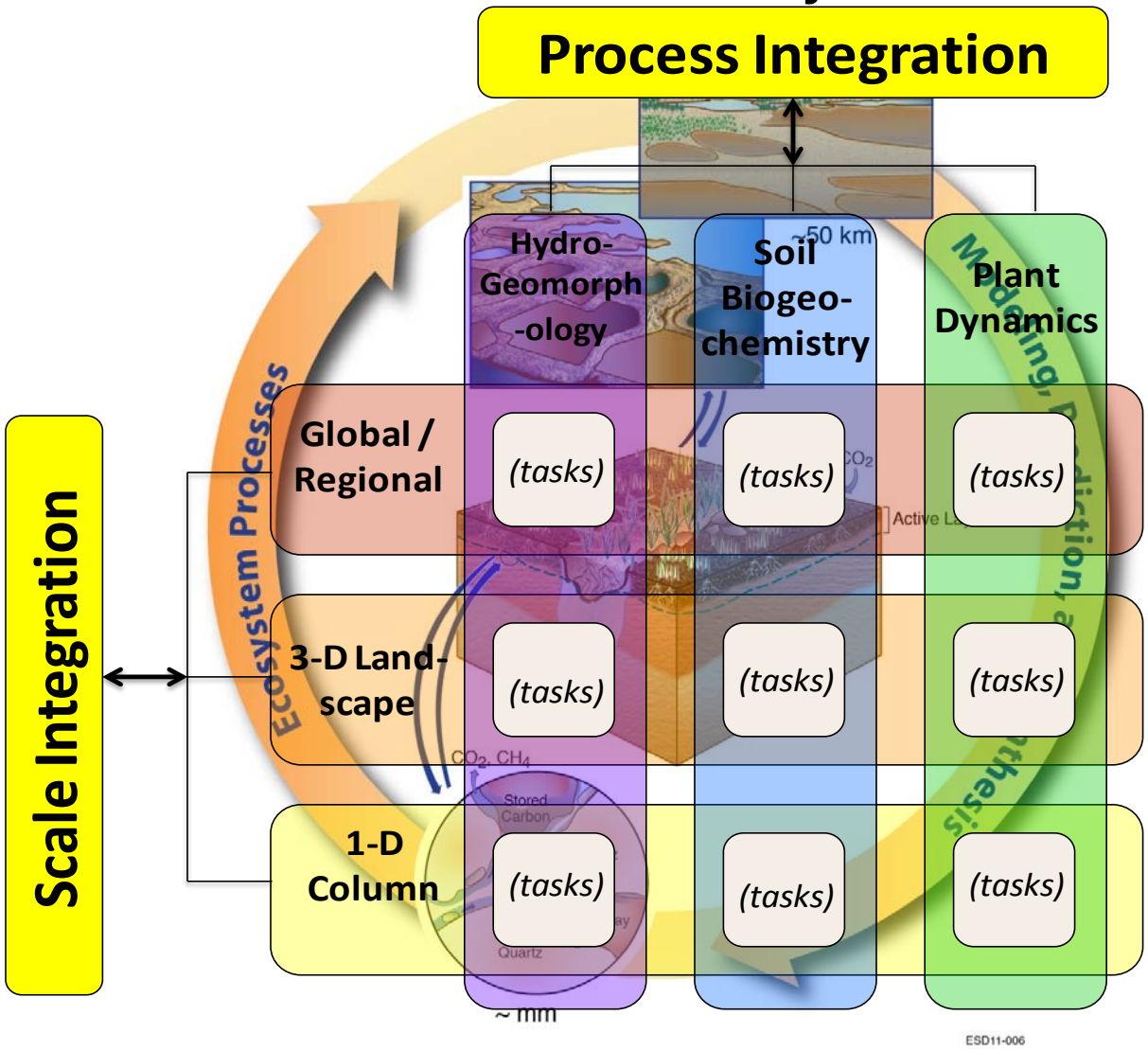
Up-scaling and down-scaling to achieve improved climate prediction




Key:
MD = Model Development
IP = Initial Parameterization
Ex = Execution
UP = Up-scale Parameterization
DB = Down-scale Boundary cond.
An = Analysis
Climate-scale (CLM4+)
Intermediate-scale
Fine-scale
Scale
Time
Results
....

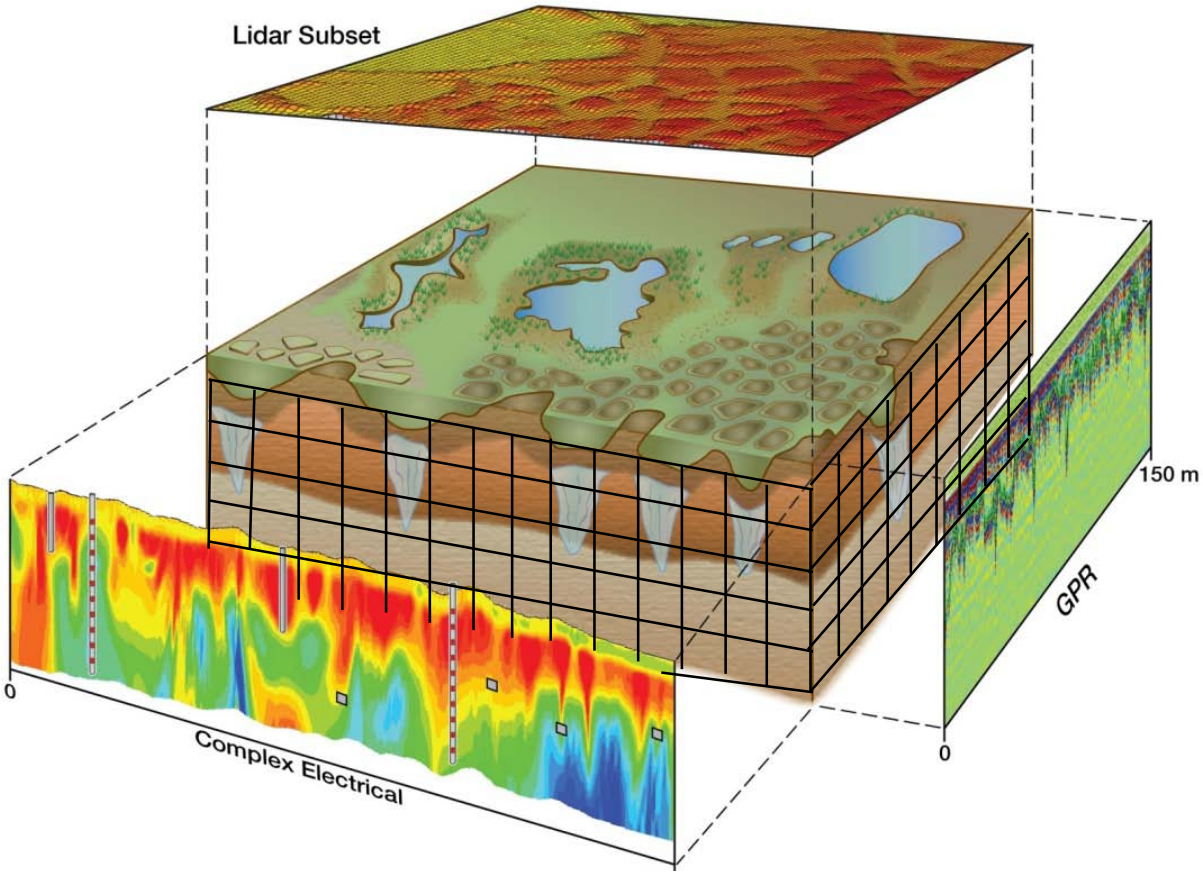
NGEE Organization & Approach

Model driven approach that recognizes the complex, hierarchical nature of the Arctic System



Iterative and multi-scale experiments, observations and simulations

New approaches to parameterization and validation

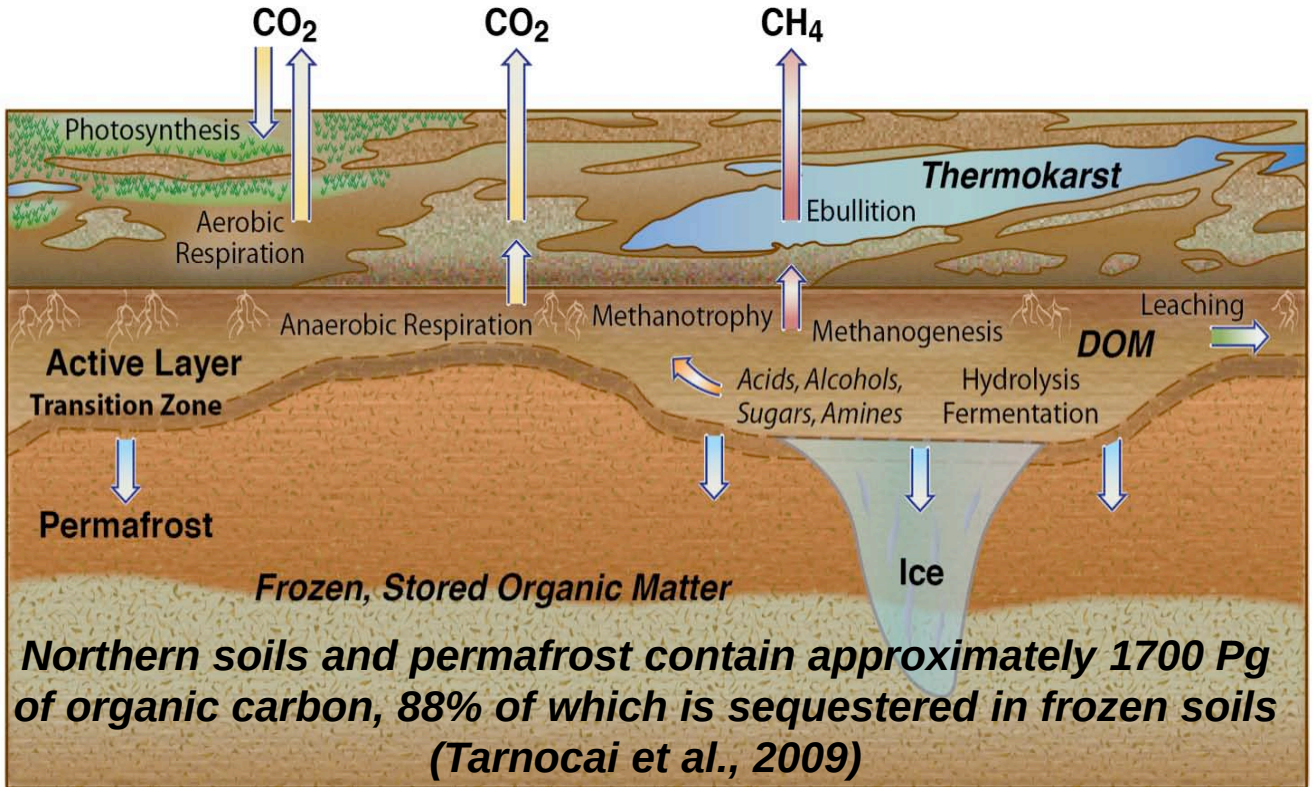


Soil Biogeochemistry Challenge

GOAL: Develop a quantitative model of organic matter decomposition rates in high latitude soils as needed to improve predictions of CO_2, CH_4 and N_2O greenhouse gas feedbacks on changing Arctic ecosystems

Microbial decomposition occurs within an expanding active layer.

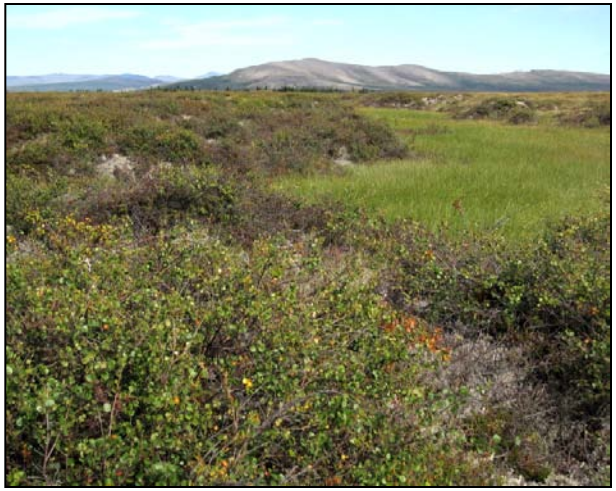
There is a great **uncertainty about the decomposition processes, rates, and impact on GHGs.**



Example task: **Arctic Plant Functional Types**

- Develop improved representations of **plant functional types** that consider nitrogen and water acquisition strategies

- Test **dynamic vegetation models with improved PFTs** against observed patterns across thermokarst gradients



Implications for CLM

- Starting point: CLM4.x, ~10km grid
- Reconfigure and redeploy the current subgrid scheme
  - Landunits used to represent sub-grid basins (explicit topology for basins)
  - Columns used to represent sub-basin geomorphological units (statistical)
  - PFTs still represent multiple plant types within a geomorphologically consistent column
- Dynamic PFT **and** column weights, explicit sub-grid routing from landunits.
- Parameterizations developed from 3D models