




Vulnerability of the Taiga-Tundra Ecotone: Predicting the Magnitude, Variability, and Rate of Change at the Intersection of Arctic and Boreal Ecosystems

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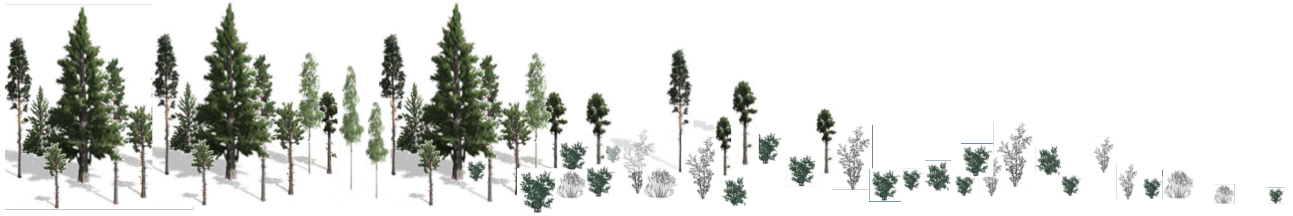
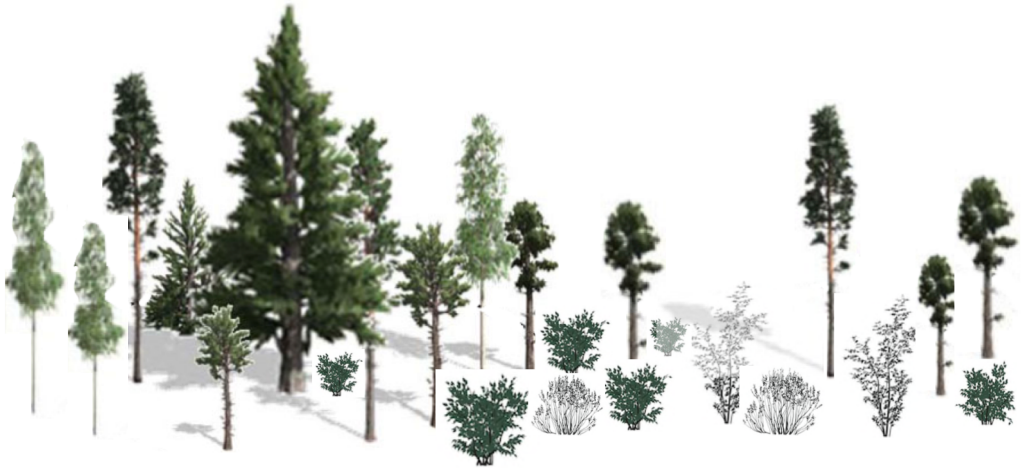


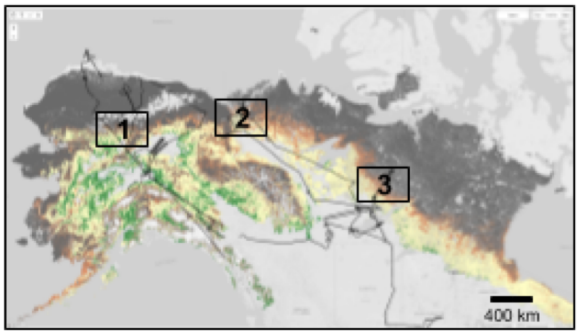
Science Objectives

- The goal of this work is to **examine and quantify** the likelihood of predicted **changes in Tundra-Taiga Ecotone (TTE)** forest structure patterns occurring within the ABoVE extended domain, using **airborne imagery and lidar observations**, site-scale forest and tundra **vegetation modeling**, and a **Landsat-derived map of the extent & pattern** of the TTE.

- Our project directly addresses the ABoVE Phase 2 science question: How are **flora and fauna responding to changes** in abiotic and abiotic conditions, and what are the impacts on ecosystem structure and function?



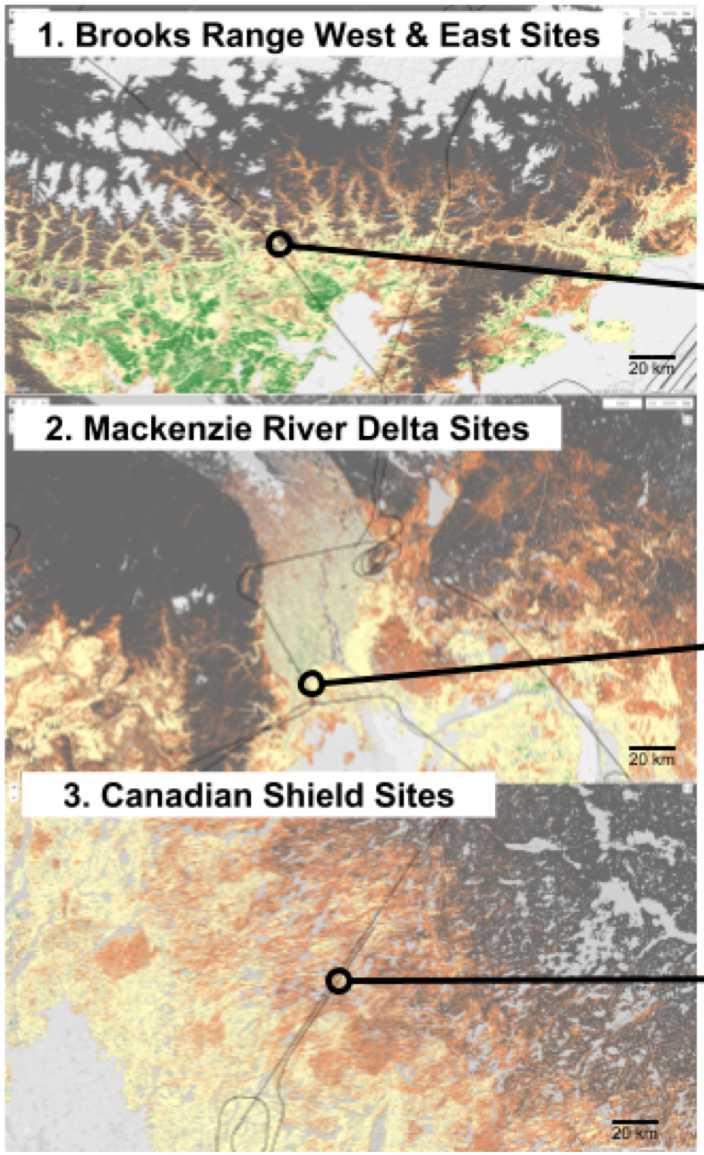
Study Sites



TTE Extent: tree cover zones in the TTE Bioclimatic Domain

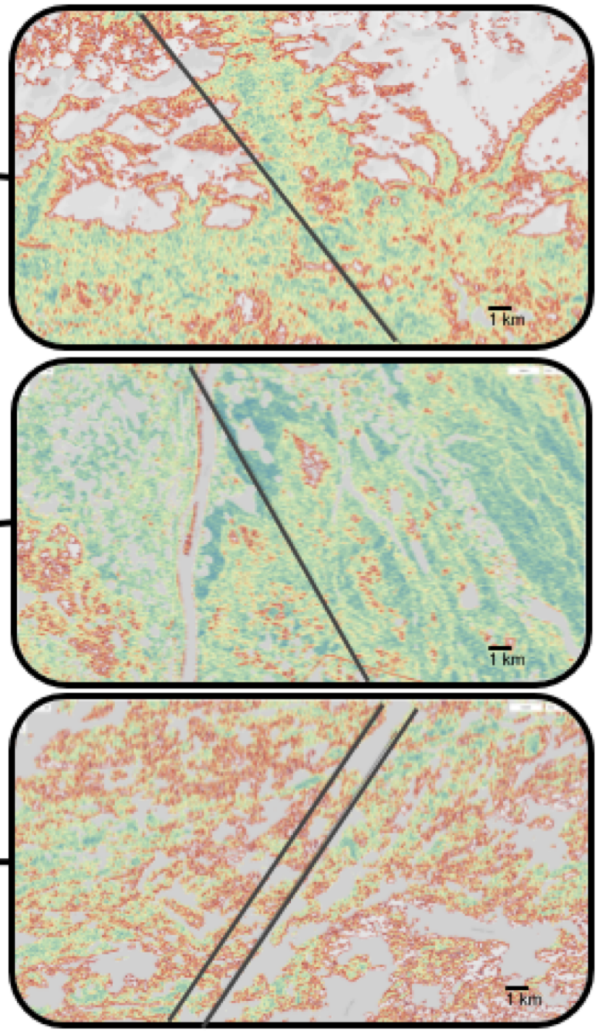
- No tree cover
- Sparse (tree cover < 5%)
- Open (tree cover 6 - 30%)
- Intermediate (tree cover > 30%)

Airborne forest structure from LVIS (2017)

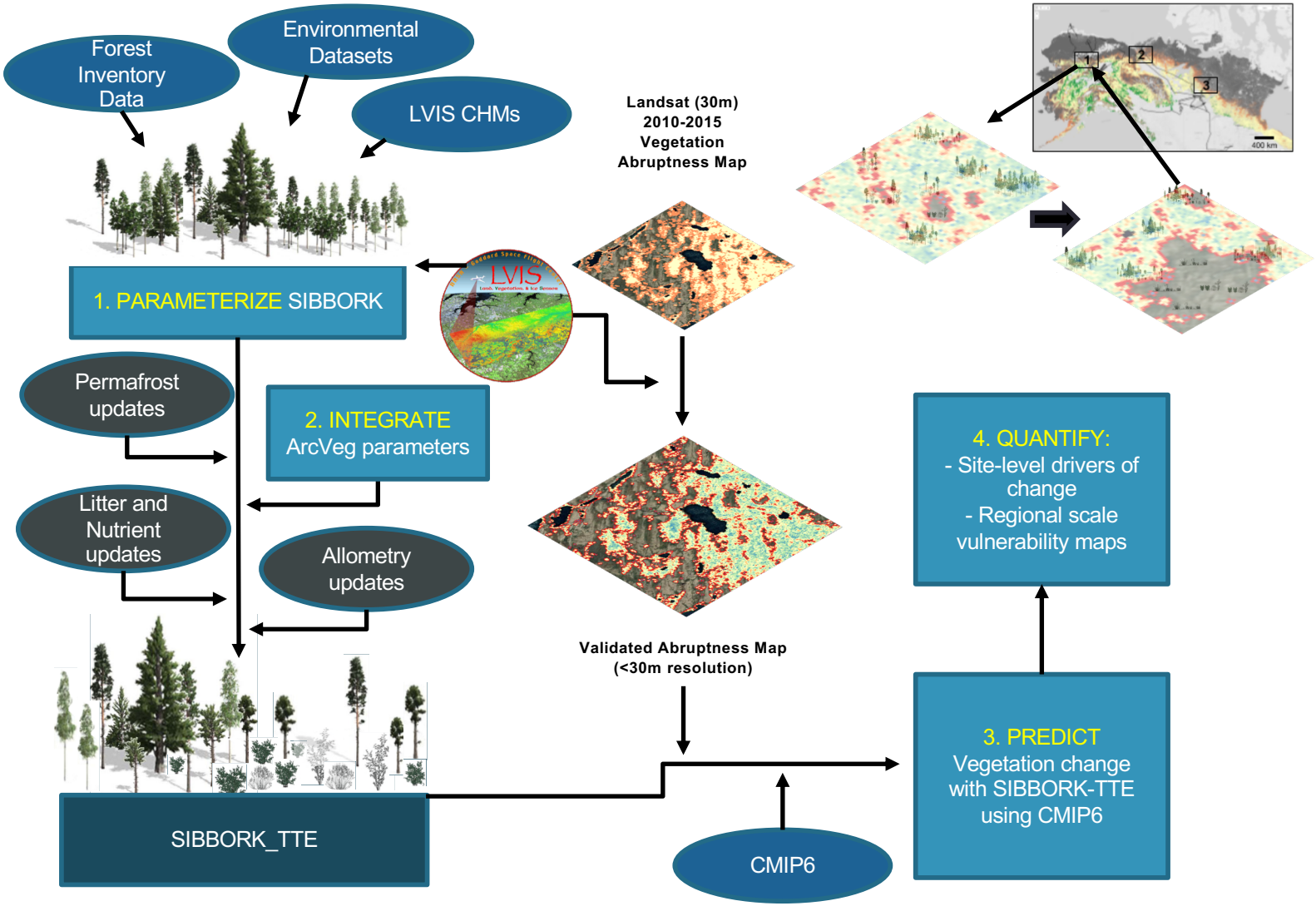


TTE Pattern: the spatial change in tree cover

uniform *diffuse* *abrupt*



Study Framework



Remote Sensing

- Airborne

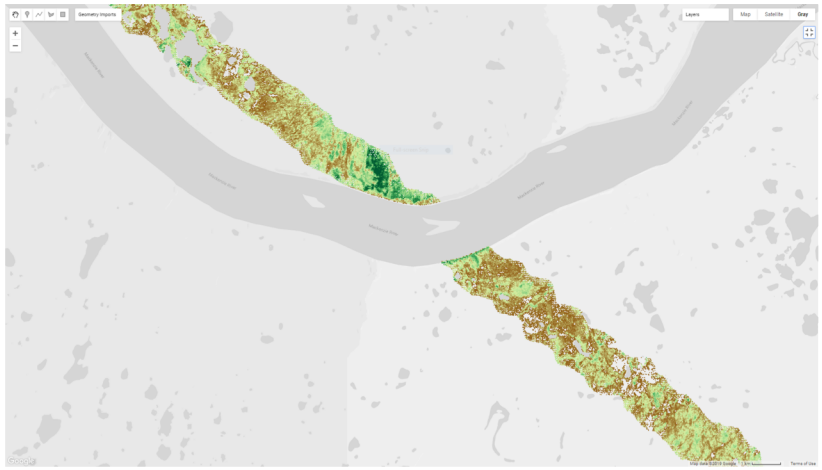
  Reference % tree canopy cover from LVIS 2017 & 2019

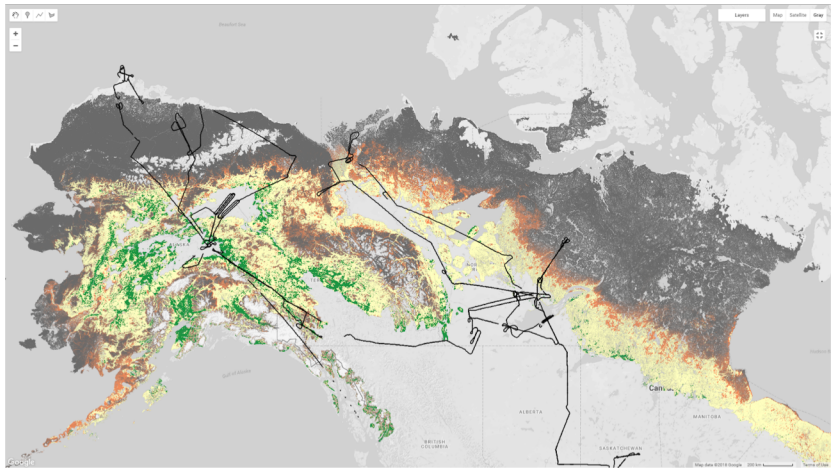
- Spaceborne

  Landsat-based % tree canopy cover products with topographic details from ArcticDEM & Tandem-X DEM

- Planned data products

  TTE forest structure patterns to constrain modelling of biome boundary & vulnerability/resilience of woody structure



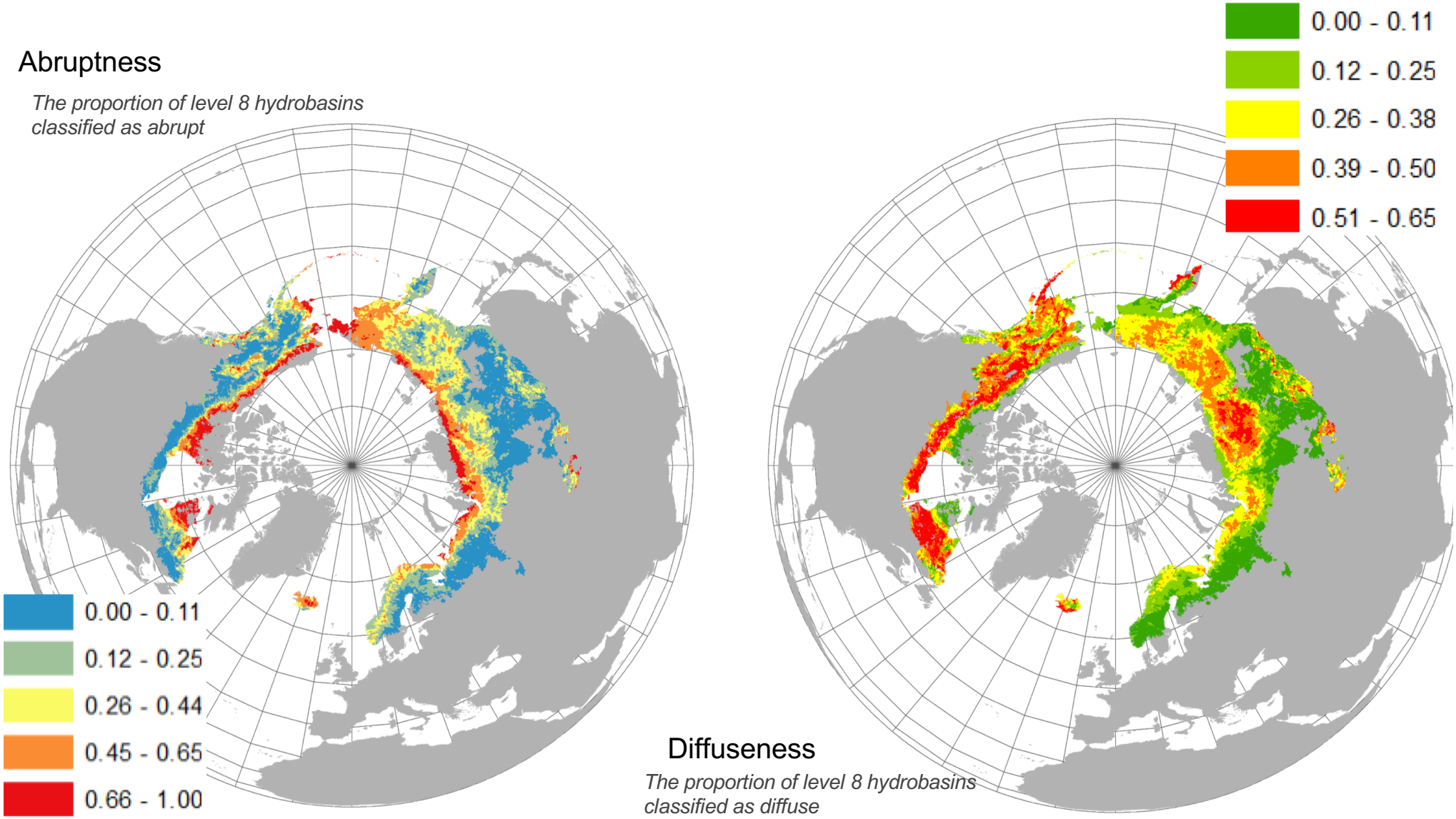


Forest structure patterns at a biome boundary

The spatial rate of change in tree canopy cover in the TTE

Abruptness

The proportion of level 8 hydrobasins classified as abrupt



Diffuseness

The proportion of level 8 hydrobasins classified as diffuse

ABoVE
ARCTIC - BOREAL VULNERABILITY EXPERIMENT

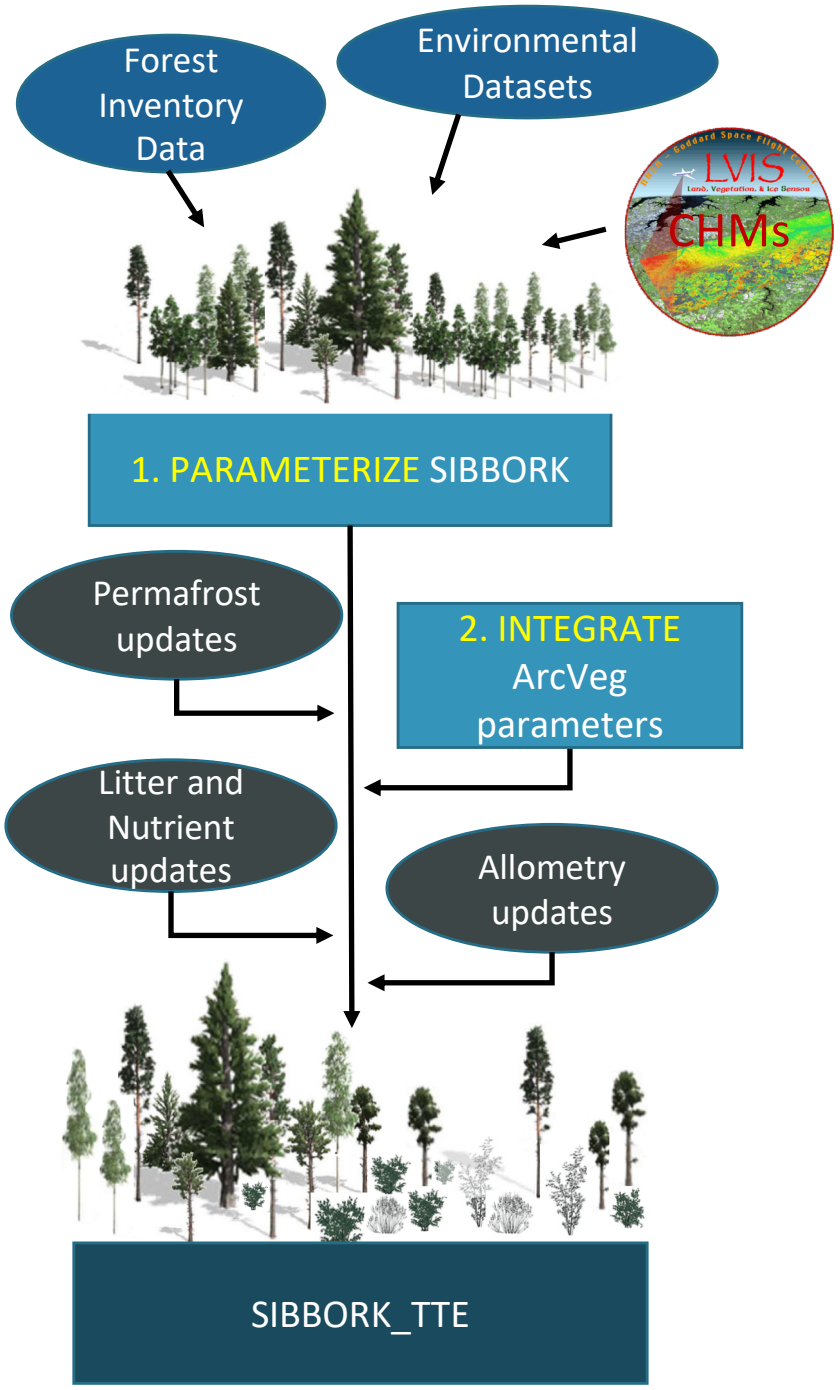
NASA

Modeling

To understand how structural responses to environmental change will vary in timing and magnitude at sites within the ABoVE study domain, we will:

1. **Parameterize** a spatially-explicit Individual-Based Gap Model (IBGM) with field data, and spaceborne and airborne vegetation structure data
2. **Integrate** tundra plant functional types from the ArcVeg tundra model

Our updated model will have the capability to simulate fine scale processes associated with TTE conditions (tundra PFTs & woody structure), and will project changes in the study region initialized with future climate scenarios.



Modeling and Snow

Shifting treeline and feedback loops:

- Drivers rates and patterns of treeline advancement remain poorly understood
- Multiple associated feedbacks to understand, for example:

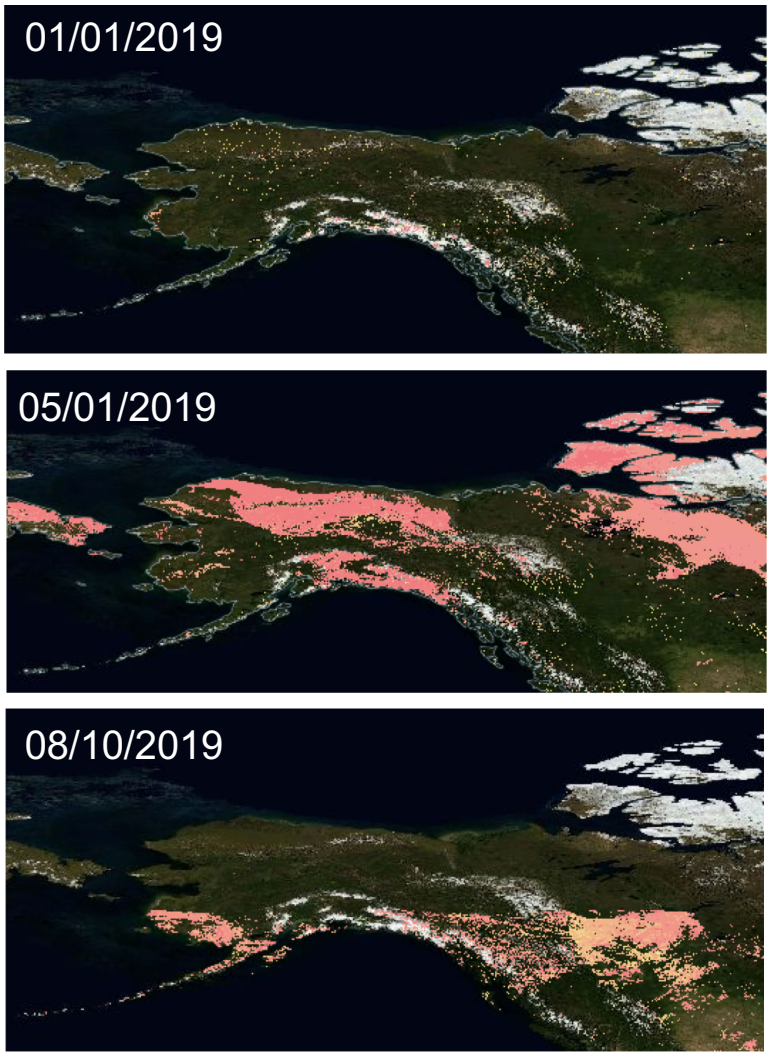
1) Earlier snowmelt -> decreasing albedo -> permafrost degradation -> woody vege growth -> ground insulation -> raising winter soil temps -> permafrost degration (Lloyd et al 2003)

2) Increased woody structure -> increased shading -> cooling effect on permafrost (Blok et al 2010)

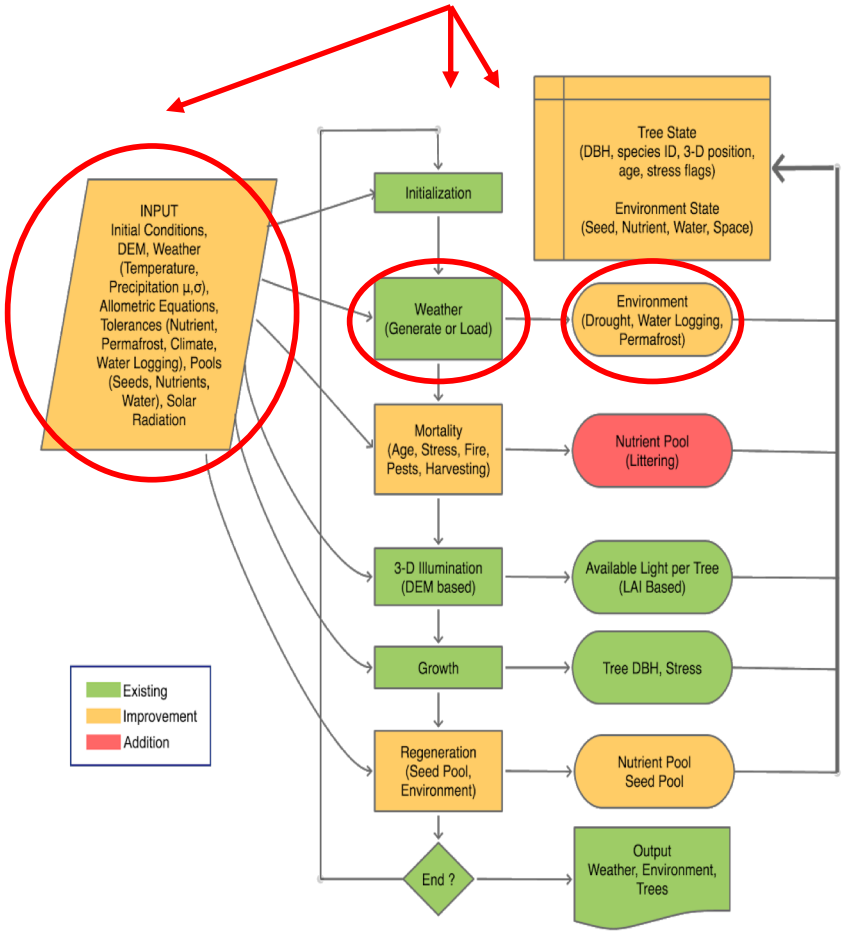
SnowEx goal: Fill key gaps in snow retrieval performance, including: 1) Quantify retrievals of SWE, albedo, depth, and melt status over heterogeneous tundra and boreal forest landscapes and 2) Understand and quantify uncertainties, ancillary data requirements, synergies and limitations of snow remote sensing methods

Modeling and Snow

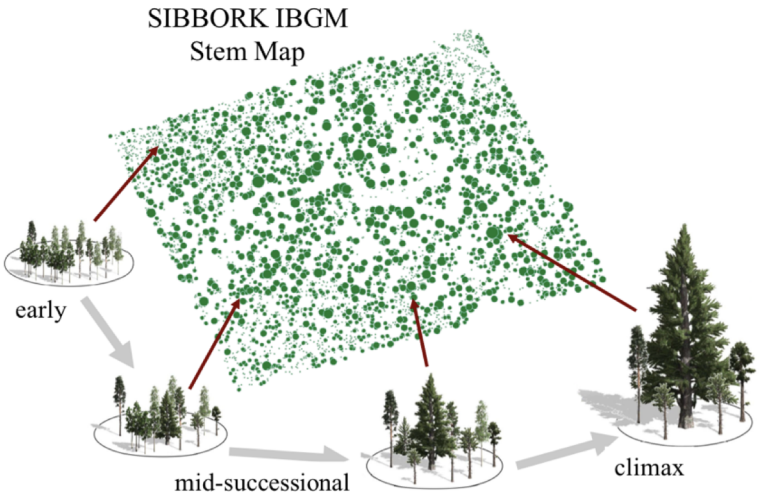
MODIS Snow



SWE, Albedo, Snowcover depth/timing, Cloudcover



Expected Products



Our research will provide a deeper understanding of the current productivity dynamics along the TTE, and allow for informed prognostication about the shift in the extent of tree cover, and spatial variability in the direction, rate, and magnitude of these shifts.

Products:

1) Updated Landsat (30m) Vegetation Abruptness Map
2) Validated Abruptness Map (<30m) using LVIS
3) Spatially-explicit IBGM capable of simulating TTE structure and dynamics
4) Regional scale (1ha) vulnerability hotspot maps

Stakeholders and Opportunities:

- Local and Native communities associated with change hotspots
- State and Federal Policymakers and decision-making bodies developing policy using informed predictions of change in the TTE
- Disturbance prediction researchers
- NASA Globe Observer opportunity to collaborate with local community stakeholders

Questions?

Holtmeier and Broll 2017