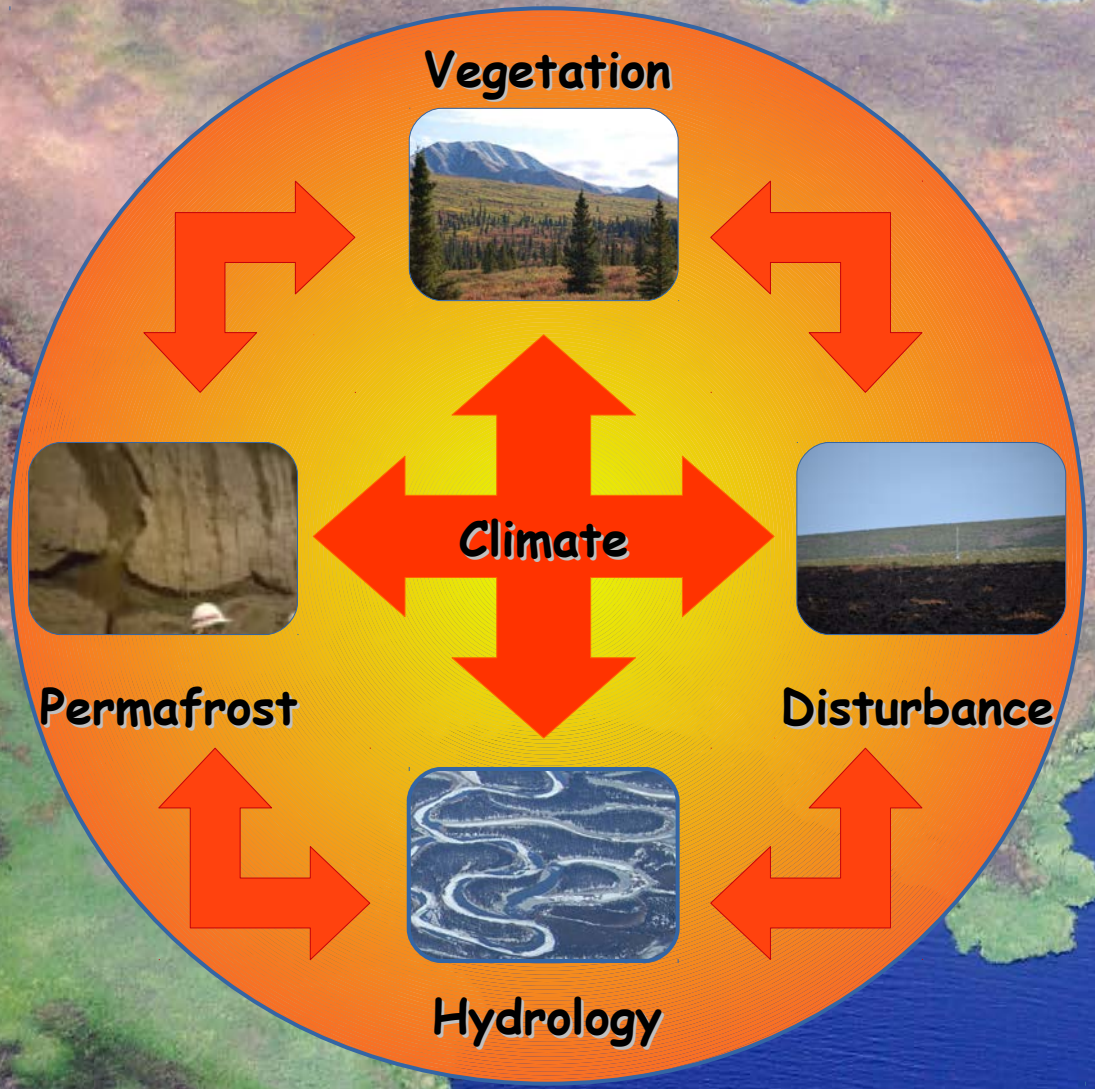
The Integrated Ecosystem Model for Alaska and Northwest Canada:

An interdisciplinary decision support tool to inform adaptation to Arctic environmental change

Amy Breen, David McGuire, Scott Rupp, Eugenie Euskirchen, Sergei Marchenko, Bob Bolton, and the IEM Team

The Ecosystem Approach to Management of Arctic Ecosystems:
Status of Implementation
International Science and Policy Conference
Fairbanks, Alaska
23 August 2016

Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada



The IEM is a decision support tool designed to:

- Aid in understanding the nature and rate of landscape change
- Illustrate how landscapes are expected to respond to climate driven changes
- The Alaska Thermokarst Model (ATM) is being developed as part of the IEM project

Components of the IEM

Pilot Study: 2010 - 2011

Fire Dynamics
[ALFRESCO]
100 yrs

↓

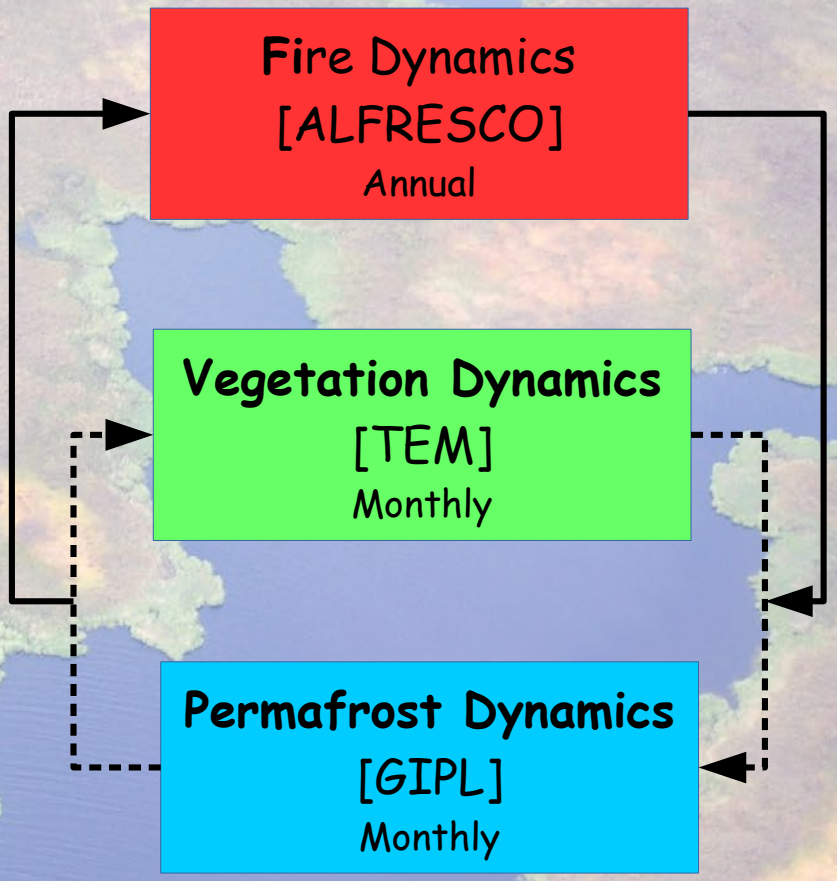
Vegetation Dynamics
[TEM]
100 yrs

↓

Permafrost Dynamics
[GIPL]
100 yrs

Generation 1 – Linear Coupling

Phase 2: 2011 – current



Generation 2 – Cyclical Coupling

Components of the IEM

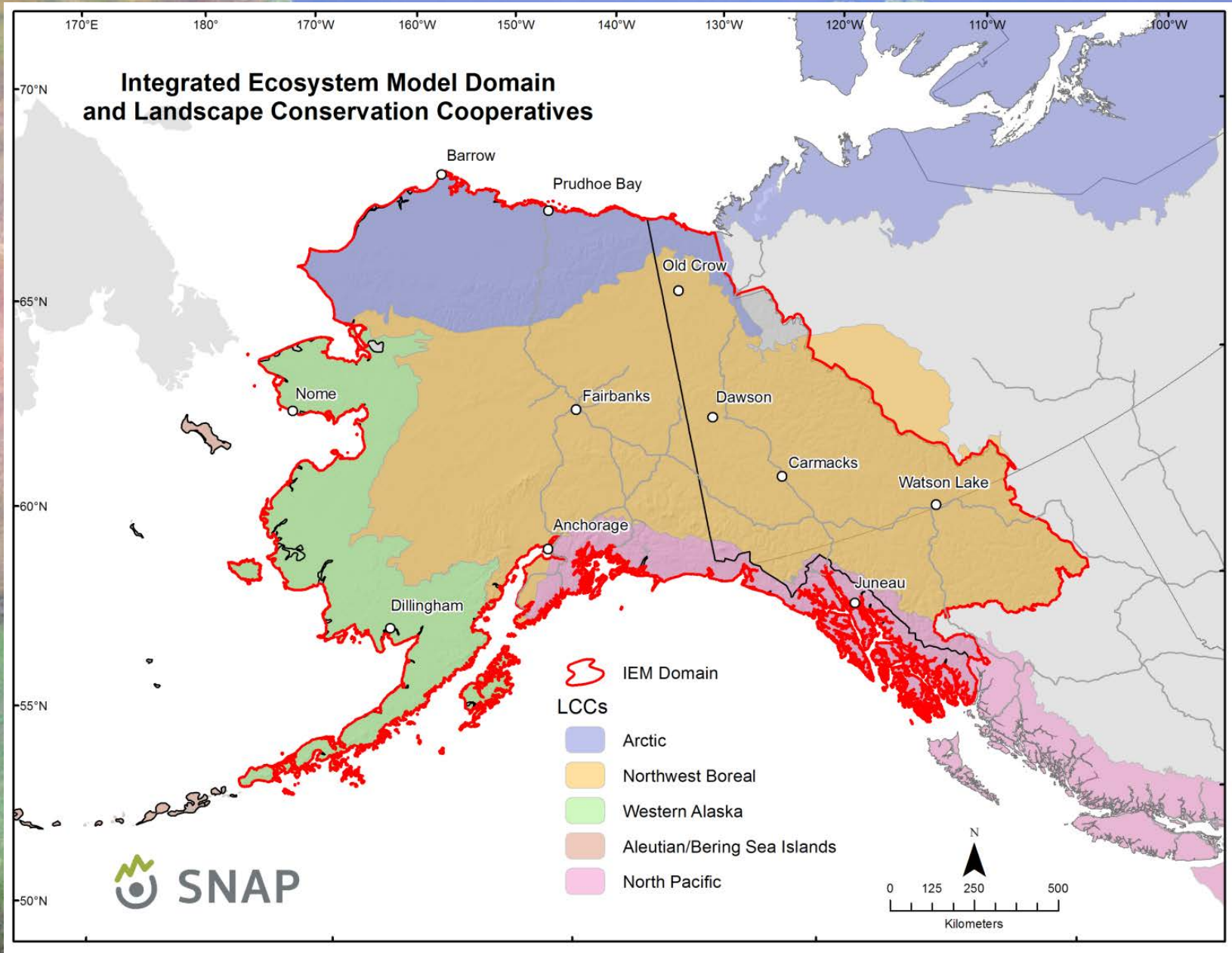
Model Inputs

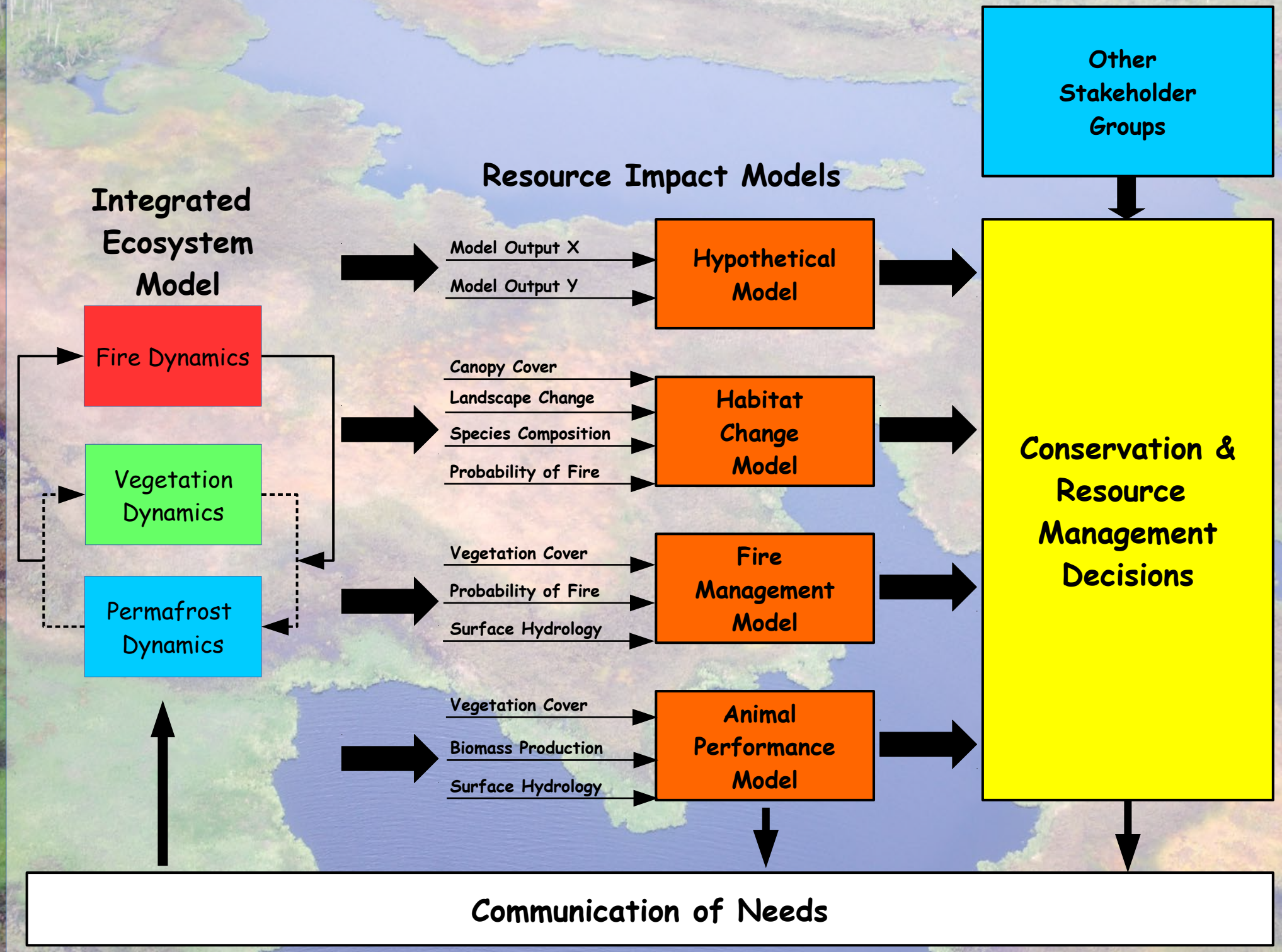
- Air temperature, relative humidity
- Precipitation
- Initial vegetation distribution
- Slope, aspect, elevation
- Radiation, cloudiness
- Soil properties

Variables Passed Between Models

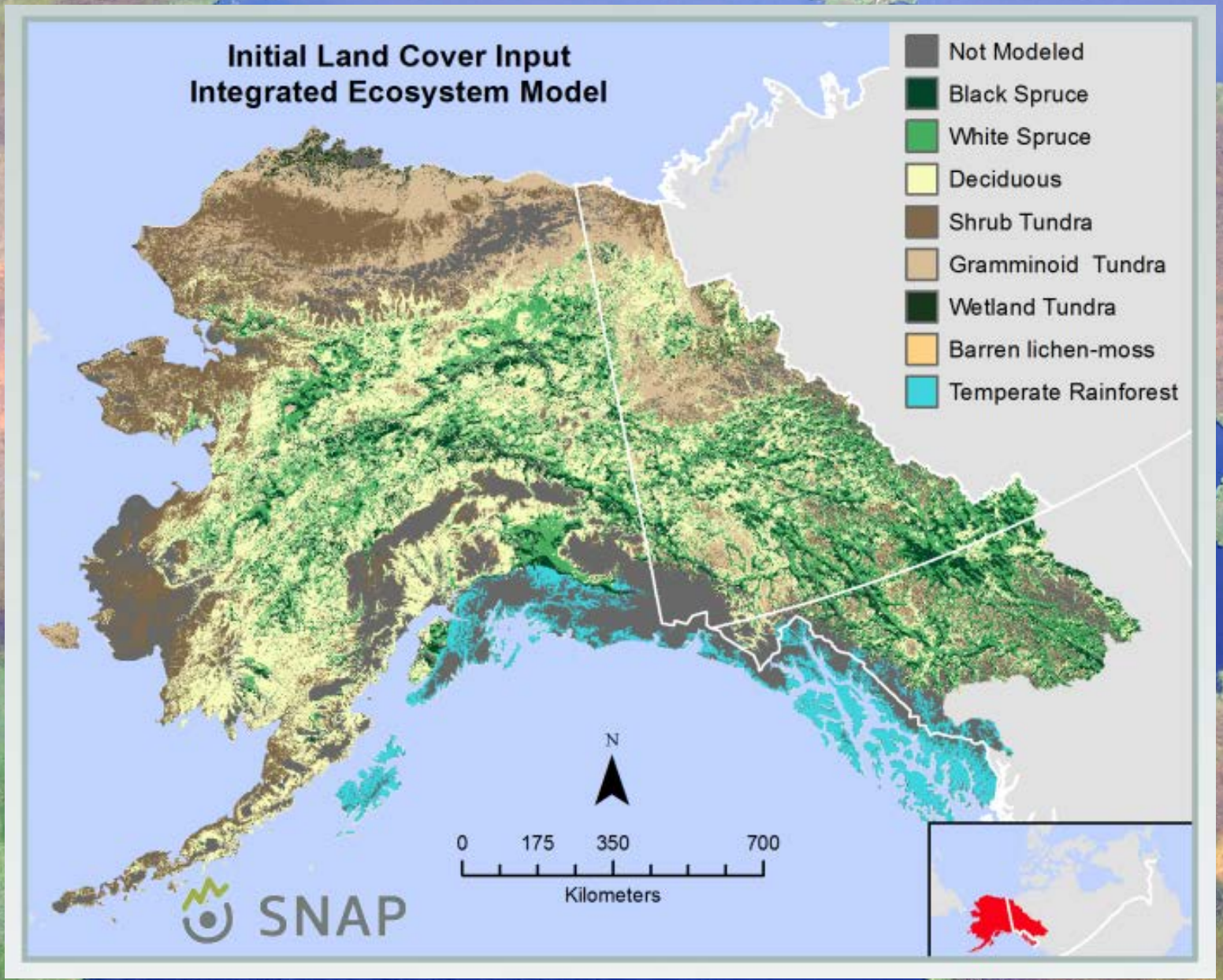
- Vegetation distribution
- Area burned, fire severity
- Vertical soil temperature, soil moisture content
- Organic layer thickness
- Biomass

Spatial Domain of the IEM

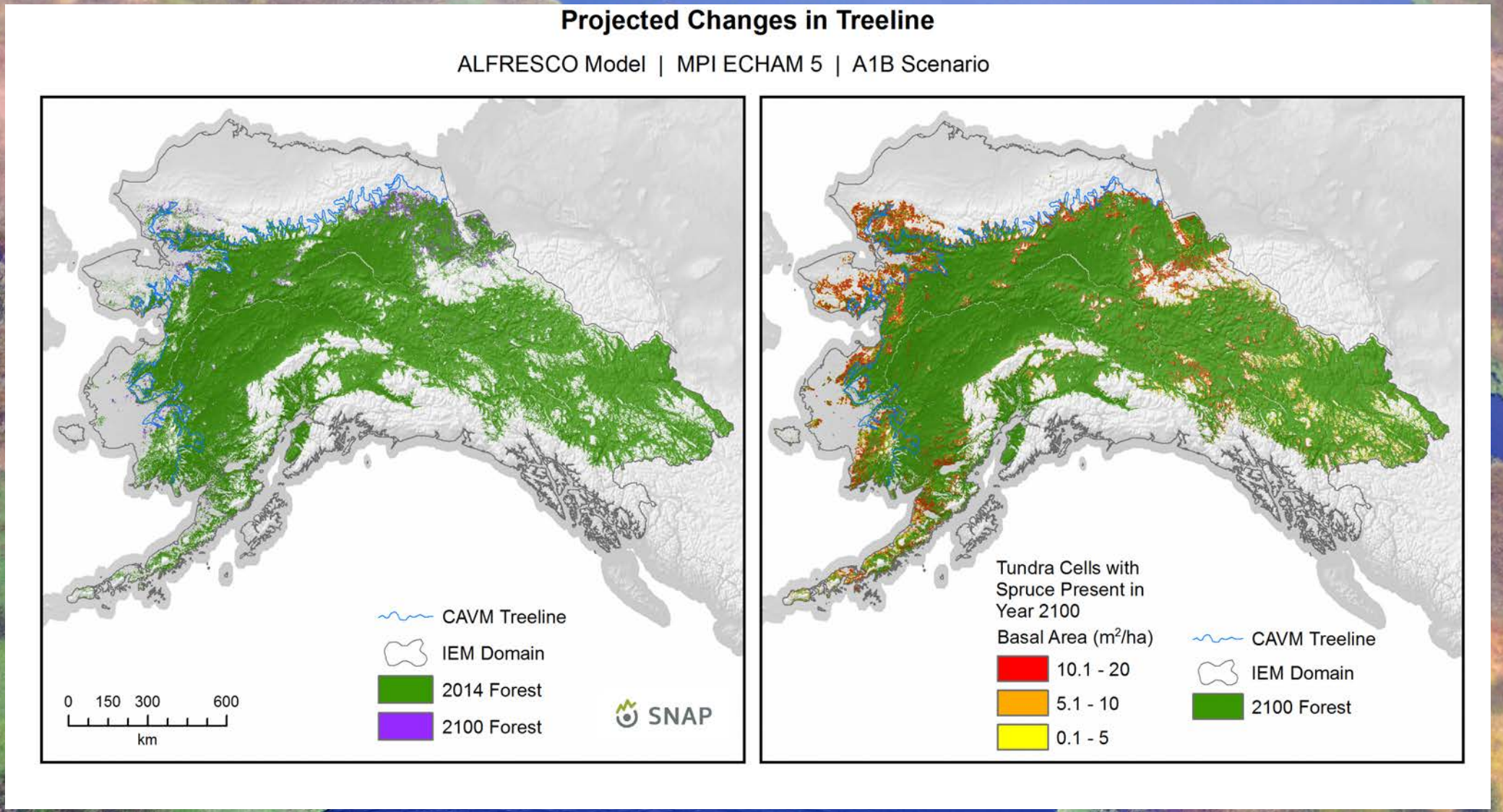



Other Stakeholder Groups
Resource Impact Models
Integrated Ecosystem Model
Fire Dynamics
Vegetation Dynamics
Permafrost Dynamics
Model Output X
Model Output Y
Hypothetical Model
Canopy Cover
Landscape Change
Species Composition
Probability of Fire
Habitat Change Model
Vegetation Cover
Probability of Fire
Surface Hydrology
Fire Management Model
Vegetation Cover
Biomass Production
Surface Hydrology
Animal Performance Model
Conservation & Resource Management Decisions
Communication of Needs

Example output - Initial Land Cover



Example output - Changes in Treeline



IEM Products and Deliverables

IEM PRODUCTS & DELIVERABLES — SEPTEMBER 2015

The Integrated Ecosystem Model (IEM) is designed to help resource managers understand the nature and expected rate of landscape change. Products generated by the IEM (Figure 1) will illustrate how landscapes are expected to shift due to climate-driven changes to vegetation, disturbance, hydrology, and permafrost. The following tables describe the anticipated products and deliverables for the IEM over the 2012–2016 period.

The IEM links three different models, including the Alaska Frame-Based Ecosystem Code (ALFRESCO), the Geophysical Institute Permafrost Lab model (GIPL), and the Terrestrial Ecosystem Model (TEM) [which includes the Dynamic Vegetation (DVM) and Dynamic Organic Soil (DOS) models]. The Alaska Thermokarst Model (ATM) is also being developed and will be integrated into the IEM at a later date.

In **Generation 1 (Gen 1)**, the models are linked linearly (Figure 2), which allows for the exchange of information between models to occur in series. For example, data generated by the first model is used as input for a second model, and that output is the input for the next model. In **Generation 2 (Gen 2)**, the models are linked cyclically, which allows data outputs to be exchanged among all the models and incorporates the outputs into the next time step.

The models are driven by the ECHAM-5 and CCCMA climate models for the mid-range A1B emissions scenario. The IEM products are developed for the full geographic extent of the IEM domain (Figure 3), and provided on an annual time-step unless otherwise indicated.

For questions about IEM data and products, please contact the IEM data manager, Tom Kurkowski at takurkowski@alaska.edu.

IEM data products are listed below.
Delivered products are **green.**
Download available data at:
WWW.SNAP.UAF.EDU/PROJECTS/IEM

Figure 2. Linear & Cyclical Coupling

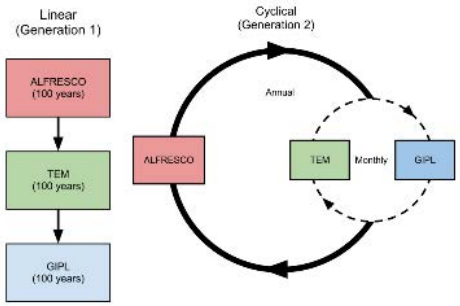


Figure 3. The Geographic Domain of the IEM

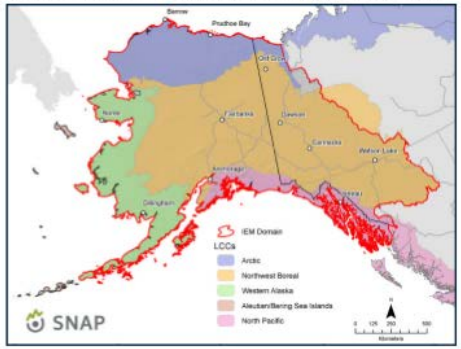


Figure 1. Product Definitions

Spatial	GIS data (generally in raster .geotiff format or occasionally shape files)
Tables	A summarization of a metric over specific region (generally in .csv format for ease of use in spreadsheet or statistical programs).
Graphs	A time series of a metric across a region (generally in .png image file).
Code	Programming code of the models.

Climate Products (e.g., temperature, precipitation, radiation, vapor pressure)			
Dataset Name	**Data Type**	**Description**	**Availability**
Projected average monthly temperatures, precipitation	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure from the Max Plank Institute for Meteorology, European	2012

- https://www.snap.uaf.edu/projects/iem

- Climate Products
- Ecosystem Dynamics Products
- Disturbance Products
- Landcover and Landscape Products
- Soil Properties Products
- Model Code and Documentation

- Indication of availability (date)

Alaska Thermokarst Model

Alaska Thermokarst Model

Alaska Dispatch News

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Obituaries Nation-World Anchorage Fairbanks Mat-Su Crime Business Energy Science Cannabis Nor

Wildlife

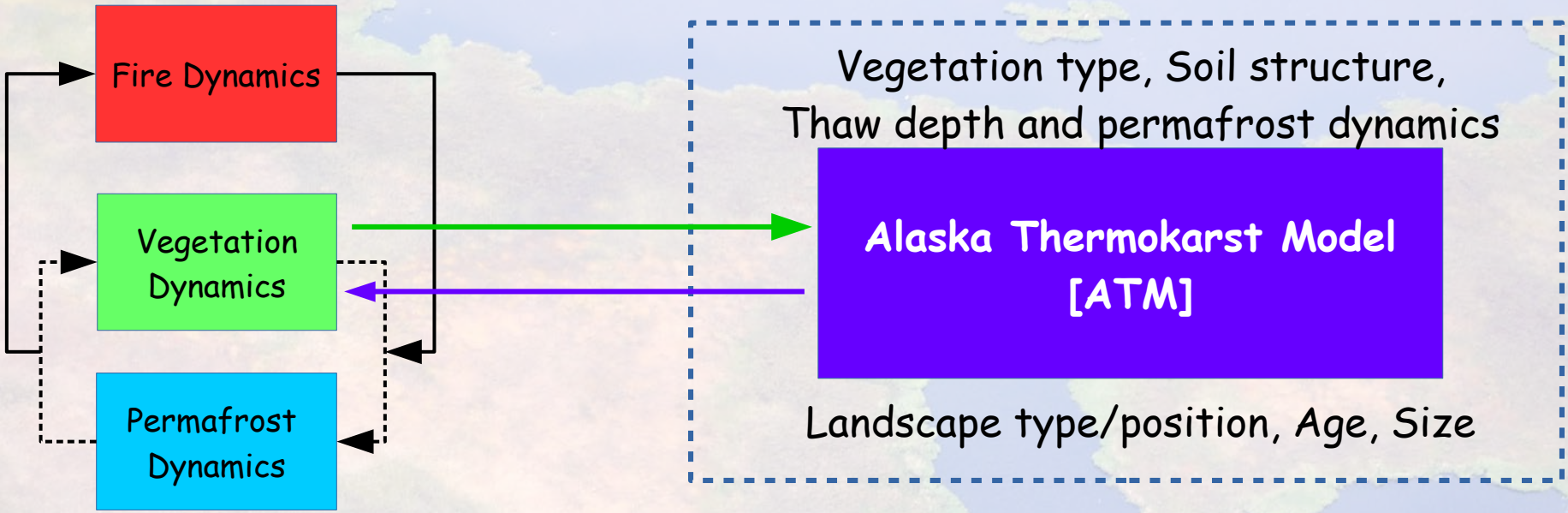
As spring comes sooner, geese arriving earlier to Colville River Delta nesting sites

Yereth Rosen | Alaska Dispatch News | October 23, 2015

"Black brant have increased dramatically in number on the North Slope...sags in permafrost are changing hydrology and favoring the salt-tolerant plants that are most beneficial to brant..."

Philip Martin

Alaska Thermokarst Model

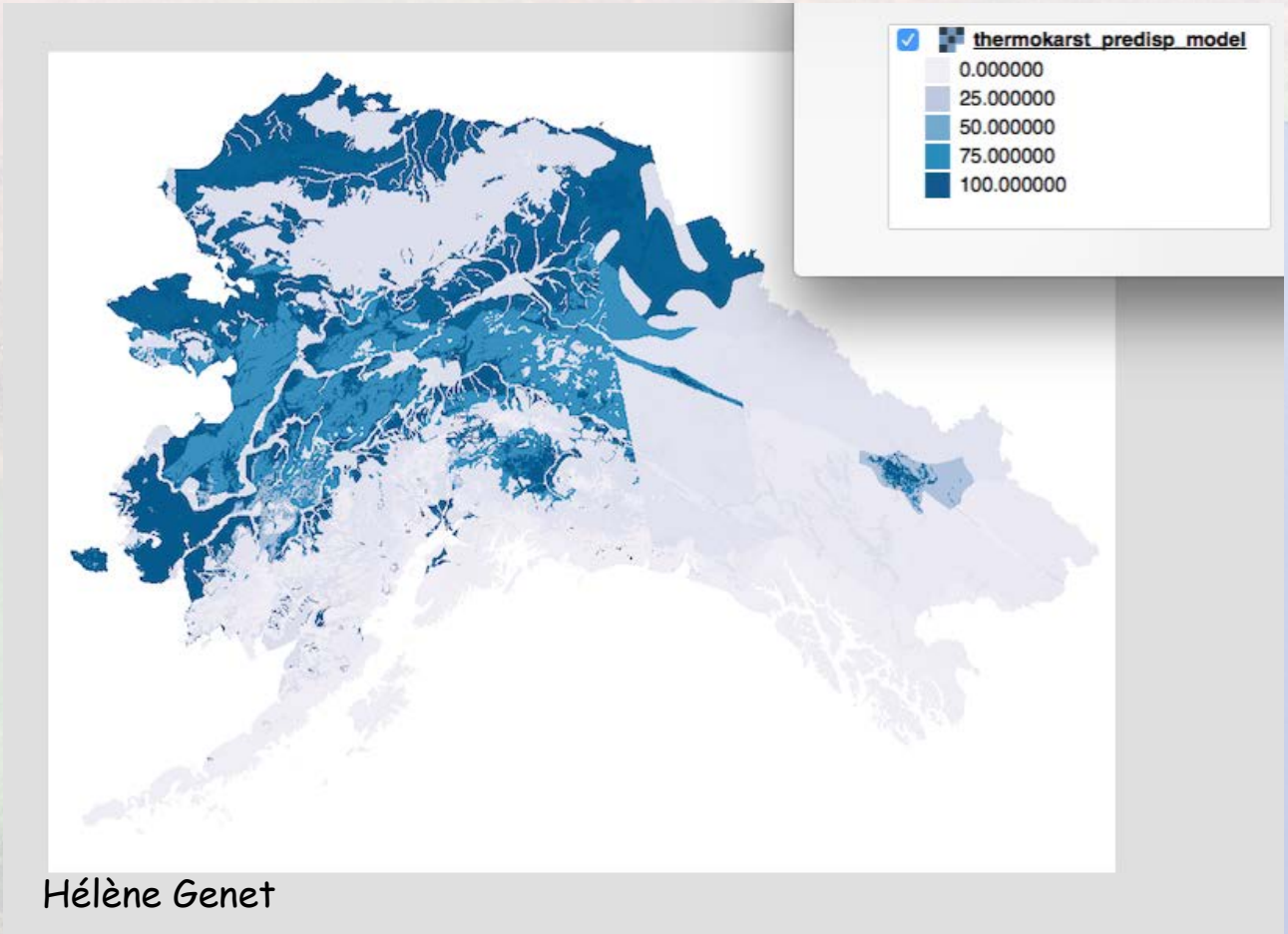


- State-and-transition model
- Framed-based methodology to track cohorts
  - Unique representative landscape unit
- Tracks cohorts by fractional area of a model element (NOT spatially-explicit)

- 1 km^2 resolution, annual time step
- Simulation period ~100 years from present
- Landscape transitions for the arctic tundra, boreal forest, and lakes

Predisposition Model

Proportion of the landscape where thermokarst could initiate and expand.



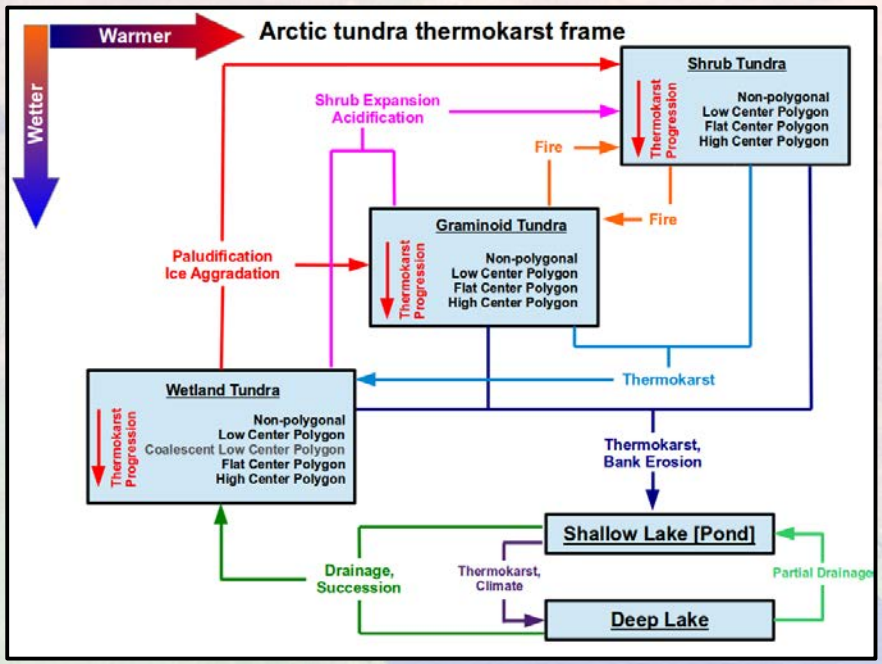
Hélène Genet

- Presence of permafrost
- Ice content of the soils
- Physiography (upland vs lowland)
- Presence of histels (organic layer > 40 cm overlying permafrost)

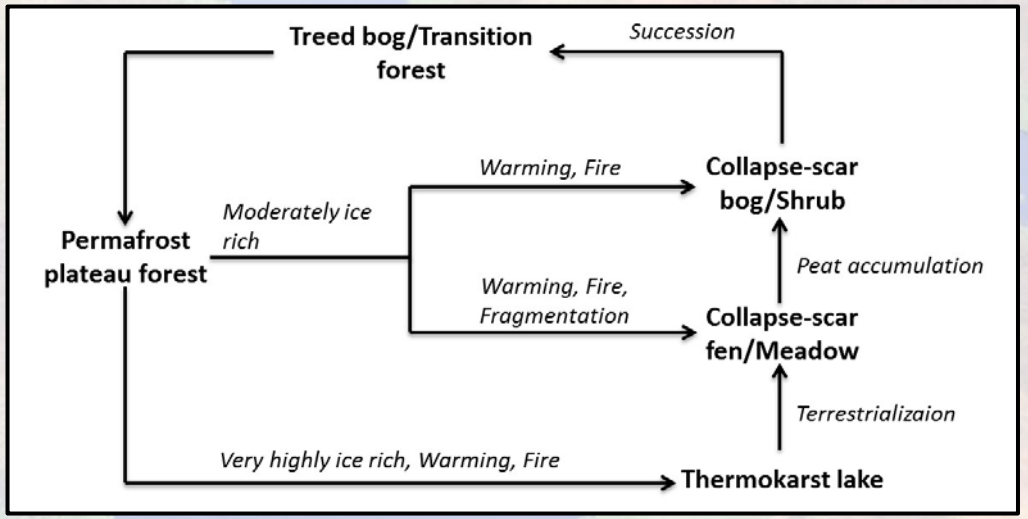
http://ckan.snap.uaf.edu/dataset/thermokarst-formation

Initiation and Expansion Modules

Arctic Tundra Frame

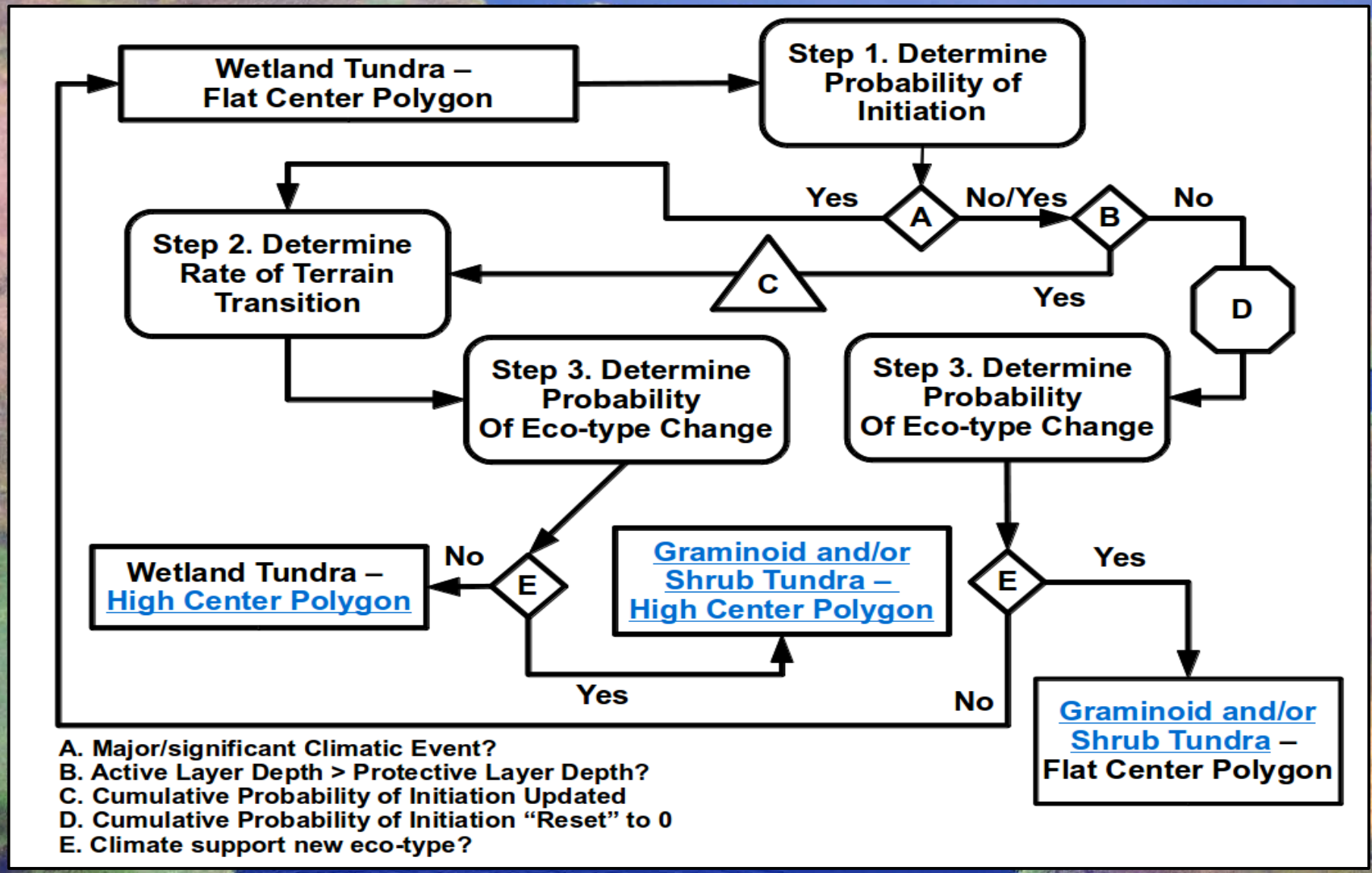


Boreal Forest Frame

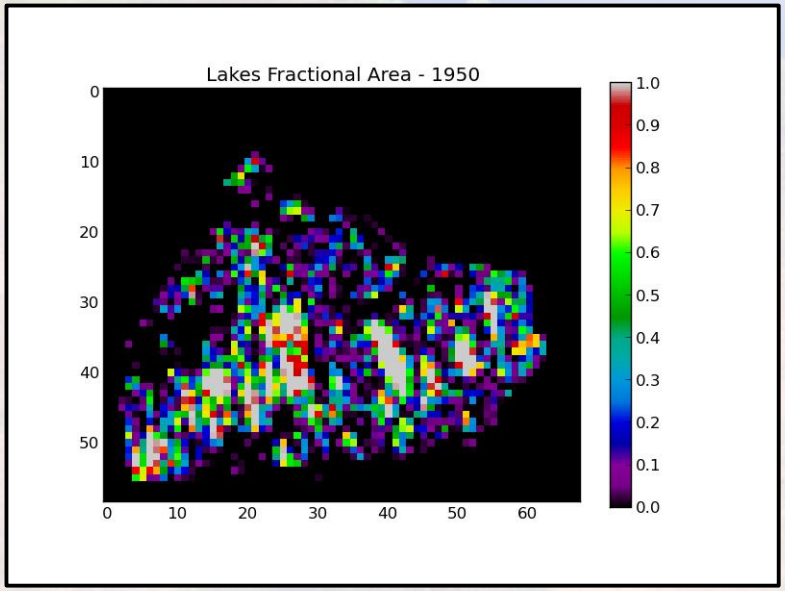


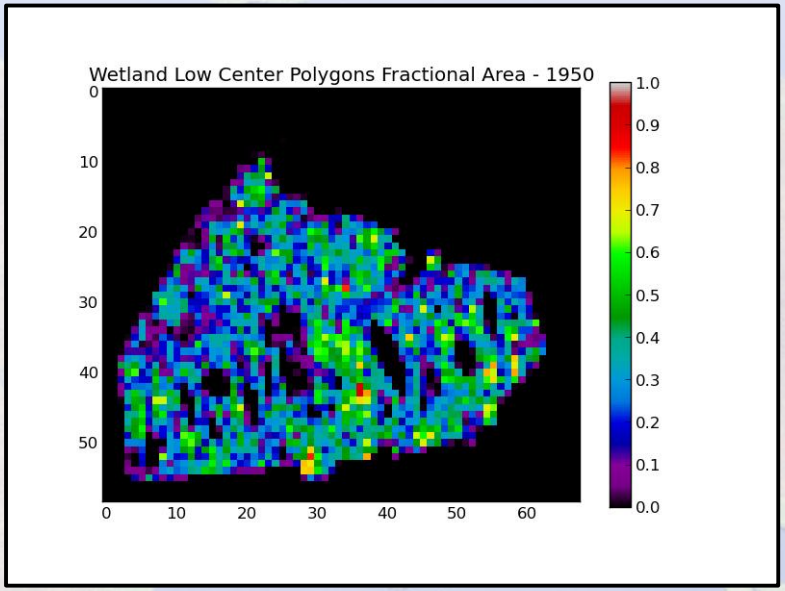
Landscape Examples

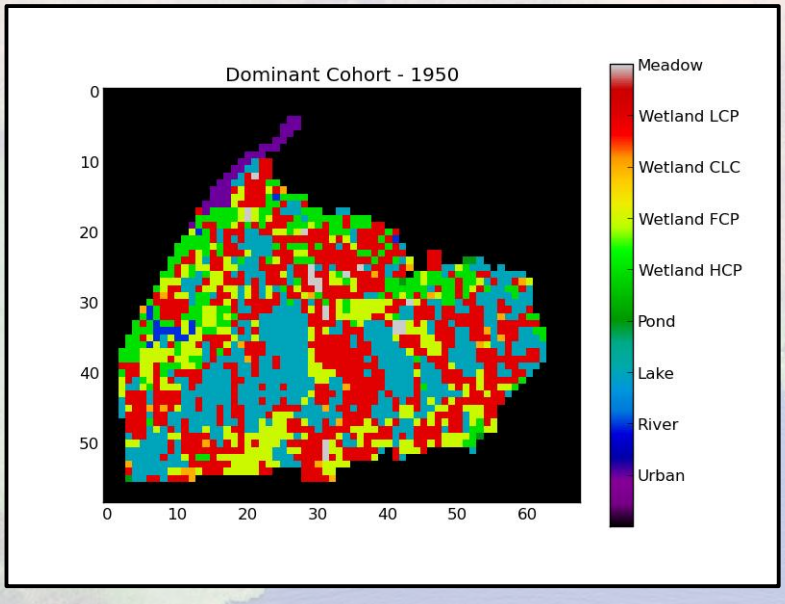
Cohort Frame Example

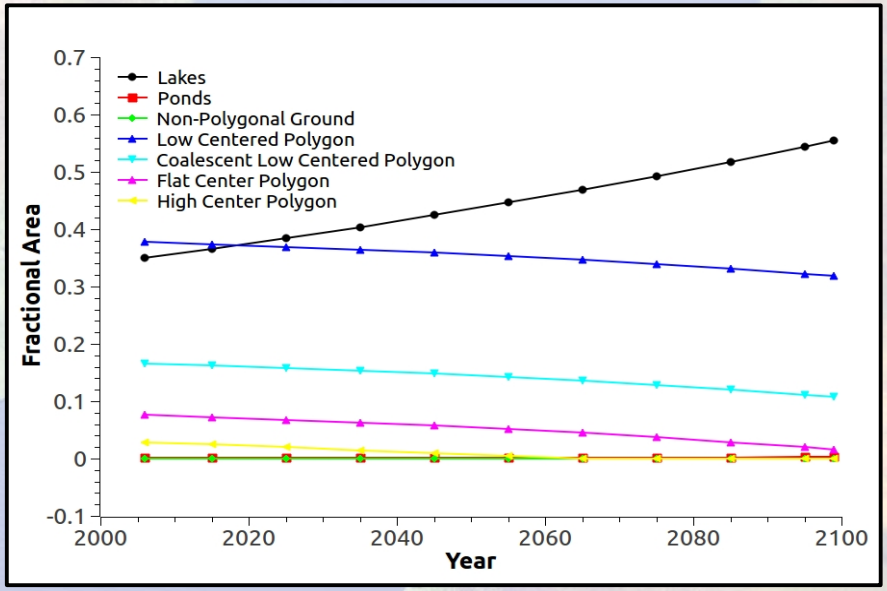


Expected Output (examples)



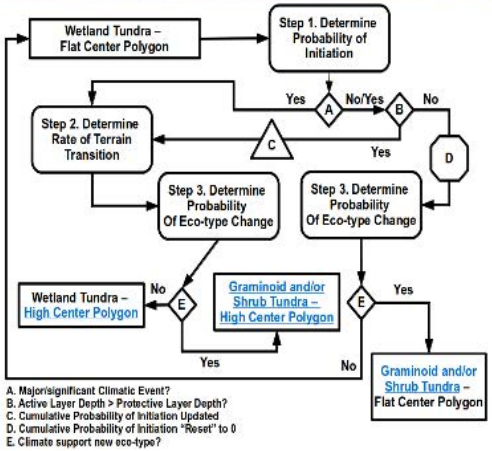


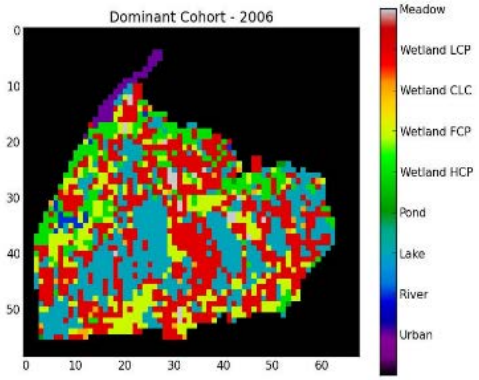




Discussion

- **IEM Phase 3**
  - Focus on code completion/coupling
  - Application of IEM to address specific resource manager needs
- **ATM**
  - Arctic Coastal Plain
  - Yukon & Tanana Flats
  - Yukon-Kuskokwim Delta
  - Seward Peninsula
- **Alaska Climate Science Center Pilot Project**
  - Co-production of science framework
  - Working with resource managers to ensure useful science / products





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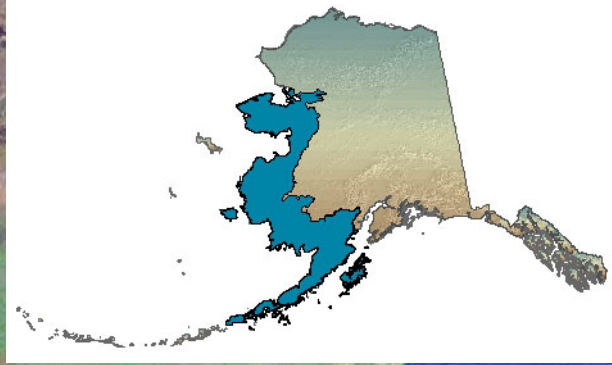
Acknowledgements

ALF TEM GIPL

Western Alaska LCC



Arctic Landscape Conservation Cooperative

Northwest Boreal Landscape Conservation Cooperative

Next-Generation Ecosystem Experiments: Arctic
Ecosystem Processes
Modeling, Prediction
Systems Understanding