IEM PRODUCTS & DELIVERABLES

MAY 2016

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 AR4 climate models for the mid-range A1B emissions scenario for the Gen 1 DOS-TEM coupling. For the Gen 1 DVM-DOS-TEM and Gen 2 couplings, the models are driven by the AR5 NCAR-CCSM4 and MRI-CGCM3 climate models focusing on RCP 8.5. Products are provided for the geographic extent of the IEM domain (Figure 3) and 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

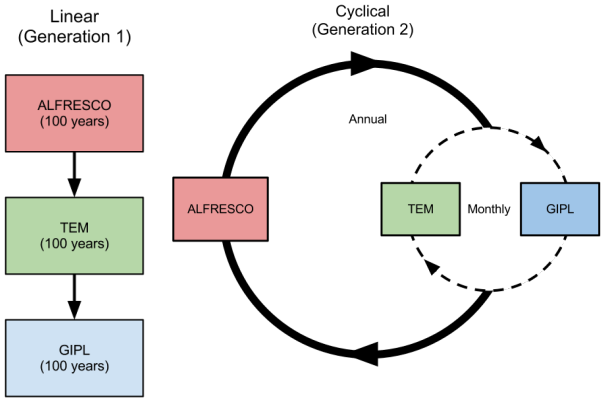

Figure 3. The Geographic Domain of the IEM

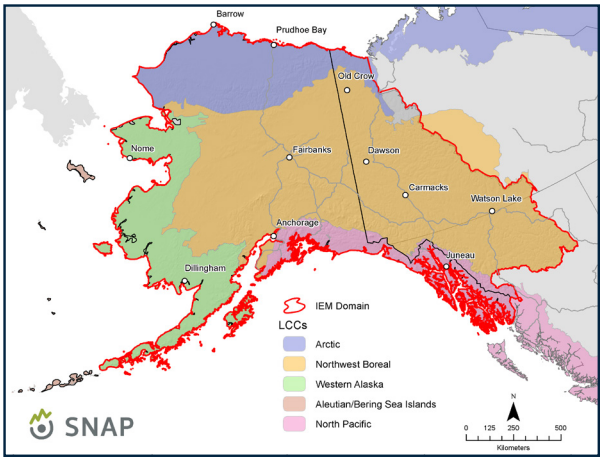

Figure 1. Product Definitions

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, radiation and vapor pressure (ECHAM5-A1B scenario)	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure from the Max Plank Institute for Meteorology, European Centre Hamburg Model 5 (ECHAM5).	2012
Projected average monthly temperatures, precipitation, radiation and vapor pressure (CCCMA-A1B scenario)	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure from the Canadian Centre for Climate Modeling and Analysis, General Circulation Model 3.1-t47 (CCCMA).	2012
Historical average monthly temperatures, precipitation, radiation and vapor pressure (CRU)	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure from the Climatic Research Unit (CRU) at the University of East Anglia time series (TS) datasets CRUTS 3.1 or CRUTS 3.1.01.	2012
Projected average monthly temperatures, precipitation, radiation and vapor pressure (AR5 models and RCPs)	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure for AR5 climate models that perform well in the Arctic.	2015

Ecosystem Dynamics Products (e.g., carbon flux)				
Dataset Name	**Data Type**	**Description**	**Generation Model Output**	**Availability**
Data from wetland field component of the IEM	Spatial (Site specific) Tables Graphs	Flux and environmental data collected from autochambers within a black spruce forest and thermokarst bog environment at the Alaska Peatland Experiment (APEX) within the Bonanza Creek Experimental Forest. Data are from 2012-2015.		**2016**
Carbon fluxes and pools (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Model output data related to carbon fluxes (GPP, Net Primary Productivity, decomposition, carbon released by fire) and carbon pools in soil and vegetation.	Gen 1 - AR4 DOS-TEM	**2016**
			Gen 1 - AR5 DVM-DOS-TEM	**December 2016**
			Gen 2 - AR5 DVM-DOS-TEM	**April 2017**

Disturbance Products (e.g., area burned, burn severity, thermokarst)				
Dataset Name	**Data Type**	**Description**	**Generation Model Output**	**Availability**
Historical area burned	Spatial	Historical area burned.		**2013**
Area burned and burn severity (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Model output of area burned and burn severity. Graphs and tables showing annual area burned through time.	Gen 1 - AR4 ALFRESCO	**2015**
			Gen 1 - AR5 ALFRESCO	**August 2015**
			Gen 2 - AR5 ALFRESCO	**April 2017**
Relative flammability (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting relative flammability, which is the likelihood of a pixel to burn, summarized for three time periods (1900-2100, 1900-1999, and 2000-2099).	Gen 1 - AR4 ALFRESCO	**2015**
			Gen 1 - AR5 ALFRESCO	**August 2015**
			Gen 2 - AR5 ALFRESCO	**April 2017**
Potential susceptibility to thermokarst	Spatial	Modeled data used to identify areas susceptible to thermokarst disturbance. Datasets may include contemporary fractional coverage of thermokarst/wetland landforms, distance from surface to ice rich permafrost, amount of ice in the soil column, drainage efficiency (parameter that describes the ability of the landscape to store water), and soil water content.		**2014**
Thermokarst disturbance on the Arctic Coastal Plain	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Arctic Coastal Plain.	ATM	**September 2016**
Thermokarst disturbance on the Tanana Flats	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Tanana Flats.	ATM	**December 2016**
Thermokarst disturbance on the Yukon Flats	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Yukon Flats.	ATM	**March 2017**

Landcover and Landscape Products (e.g., vegetation type, treeline extent, topography)				
Dataset Name	**Data Type**	**Description**	**Generation Model Output**	**Availability**
Model input land cover	Spatial	Model input landcover for the IEM domain. This data layer is a greatly modified product derived from the "2005 Land Cover of North America at 250 meters, Edition 1.0" dataset produced as part of the North America Land Change Monitoring System (NALCMS). This data was developed as, and focused solely on, model input data requirements, which is a simplification of the landscape.	Version 0.2	**2012**
			Version 0.4, Southeast and Southcentral Alaska update	**2015**
Elevation, aspect, and slope	Spatial	Modeled elevation (m), aspect, and slope derived from elevation data developed by the PRISM climate group and distributed by ClimateSource via www.climatesource.com or www.prism.oregonstate.edu.		**2012**
Treeline extent (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting projected treeline migration.	Gen 1 - AR4 ALFRESCO	**2015**
			Gen 1 - AR5 ALFRESCO	**August 2015**
			Gen 2 - AR5 ALFRESCO	**April 2017**
Vegetation distribution (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Modeled distribution of six vegetation types (white spruce, black spruce, deciduous forest, graminoid tundra, shrub tundra, wetland tundra). Graphs and tables showing changes in area of vegetation types through time.	Gen 1 - AR4 ALFRESCO	**2015**
			Gen 1 - AR5 ALFRESCO	**August 2015**
			Gen 2 - AR5 ALFRESCO	**April 2017**
Relative vegetation change (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting relative vegetation change, which is the likelihood of a pixel to transition among vegetation classes, summarized for three time periods (1900-2100, 1900-1999, and 2000-2099).	Gen 1 - AR4 ALFRESCO	**2015**
			Gen 1 - AR5 ALFRESCO	**August 2015**
			Gen 2 - AR5 ALFRESCO	**April 2017**
Growth dynamics of vegetation (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Maps and graphs showing changes in biomass over time of different plant functional types within six vegetation types (white spruce, black spruce, deciduous forest, graminoid tundra, shrub tundra, wetland tundra).	Gen 1 - AR4 DOS-TEM	**2015**
			Gen 1 - AR5 DVM-DOS-TEM	**December 2016**
			Gen 2 - AR5 DVM-DOS-TEM	**April 2017**
Tanana Flats vegetation map	Spatial	Model input landcover for the Alaska Thermokarst Model (ATM) domain. The developed product is derived from both Landsat 7 ETM+ and JERS1 satellite imagery, at 30 m resolution.		**2015**
Barrow Peninsula geomorphology map	Spatial	Model input landcover for ATM and DVM-DOS-TEM domains. The developed product was derived from the following data products: Landsat-7 ETM+, Quickbird, and IFSAR/LIDAR Digital Elevation Models. Map resolution is at 30 m.		**2015**
Yukon Flats vegetation map	Spatial	Model input landcover for the ATM domain. The developed product is modified from the National Land Cover Database 2001 for Alaska, at 30 m resolution.		**June 2016**

Soil Properties Products (e.g., permafrost, active layer, soil temperature)				
Dataset Name	**Data Type**	**Description**	**Generation Model Output**	**Availability**
Modeled soil characteristics used to drive GIPL (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Modeled soil-related output data , such as soil moisture and organic horizon thickness.	Gen 1 - AR4 DOS-TEM	**2015**
			Gen 1 - AR5 DVM-DOS-TEM	**December 2016**
			Gen 2 - AR5 DVM-DOS-TEM	**April 2017**
Permafrost distribution Active layer thickness Mean annual ground temperature (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Maps and graphs depicting modeled permafrost distribution, simulated active layer thickness (m), and simulated mean annual ground temperature (°C).	Gen 1 - AR4 GIPL	**August 2016**
			Gen 1 - AR5 GIPL	**February 2017**
			Gen 2 - AR5 GIPL	**April 2017**

Model Code and Documentation Products				
Dataset Name	**Data Type**	**Description**	**Generation Model Output**	**Availability**
IEM program code	Source Code	IEM model code and installable Linux packages will be available through http://github.com.	Gen 1	**December 2016**
			Gen 2	**April 2017**
ATM program code for the Arctic Coastal Plain	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		**September 2016**
ATM program code for the Tanana Flats	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		**December 2016**
ATM program code for the Yukon Flats	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		**March 2017**

WHAT CAN WE EXPECT FROM THE IEM TEAM IN THE FUTURE?

Long-term objectives for the IEM team are to develop datasets for the IEM domain and phase in refinements to the model that are necessary to better understand the potential effects of climate change. The table below outlines the 2013-2016 research activities.

Expectations and Deliverables			
Year	Model Coupling and Data Development	Tundra Fire and Treeline Dynamics	Thermokarst and Wetland Dynamics
2013	▪ Continued development of Generation 1 IEM with new fire and vegetation dynamics. ▪ Continued preparation of all data sets required to drive fully Generation 1 IEM with AR4 climate scenarios. ▪ Begin development of Generation 2 (fully coupled) IEM.	▪ Incorporation of new tundra fire and treeline dynamics program code into the IEM. ▪ Begin study of Generation 1 IEM application to model changing ecosystem services in the Nuiqsut region (collaboration with EPSCoR Northern Test Case). ▪ Support development of Generation 2 (fully coupled) IEM.	▪ Continued development of the Thermokarst Predisposition Model and the Alaska Thermokarst Model. ▪ Recruit postdoctoral scientist for development of wetland dynamics aspects of the IEM.
2014	▪ Complete development of Generation 1 IEM with new fire and vegetation dynamics. ▪ Complete preparation of all data sets required to drive fully Generation 1 IEM with AR4 climate scenarios. ▪ Support assessment using Generation 1 IEM over the complete IEM domain driven by AR4 climate scenarios. ▪ Continued development of Generation 2 (fully coupled) IEM. ▪ Begin preparation of all data sets required to drive Generation 2 IEM with AR5 climate scenarios.	▪ Begin assessment using Generation 1 IEM with new fire and vegetation dynamics over the IEM domain driven by AR4 climate scenarios. ▪ Continued study of Generation 1 IEM application to model changing ecosystem services in the Nuiqsut region. ▪ Support development of Generation 2 (fully coupled) IEM.	▪ Complete development of the Permafrost Predisposition Model. ▪ Continued development of Alaska Thermokarst Model.
2015	▪ Support assessment using Generation 1 IEM over the complete IEM domain driven by AR4 climate scenarios. ▪ Complete preparation of all data sets required to drive Generation 2 IEM with AR5 climate scenarios.	▪ Support development of Generation 2 (fully coupled) IEM. ▪ Begin collaboration with the three resource impact models funded by the Alaska Climate Science Center.	▪ Continue development of the Alaska Thermokarst Model. ▪ Begin proof of concept studies for the ATM over the Barrow Peninsula, Tanana Flats, Arctic Coastal Plain, and Yukon Flats driven by AR4 climate scenarios.
2016	▪ Develop an operational "beta" version of the Generation 2 (fully coupled) IEM. ▪ Support assessment using Generation 2 IEM over the complete IEM domain driven by AR5 climate scenarios. ▪ Support applications for the coupling of IEM outputs to resource impact models.	▪ Begin assessment using Generation 2 IEM over the IEM domain driven by AR5 climate scenarios. ▪ Continue collaboration with the three resource impact models funded by the Alaska Climate Science Center. ▪ Complete study of Generation 1 IEM application to model changing ecosystem services in the Nuiqsut region.	▪ Continue development of the Alaska Thermokarst Model. ▪ Complete proof of concept studies for the ATM over the Barrow Peninsula, Tanana Flats, and Arctic Coastal Plain driven by AR5 climate scenarios. ▪ Continue development of wetland dynamics model being designed for incorporation into the IEM framework and begin proof-of-concept study.