U.S. DEPARTMENT OF ENERGY

Office of Science

Exploiting Artificial Intelligence for Advancing Earth System Predictability

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THE TRILLION-PIXEL CHALLENGE

Session 5:
GeoAI Beyond Pixels

April 22, 2021

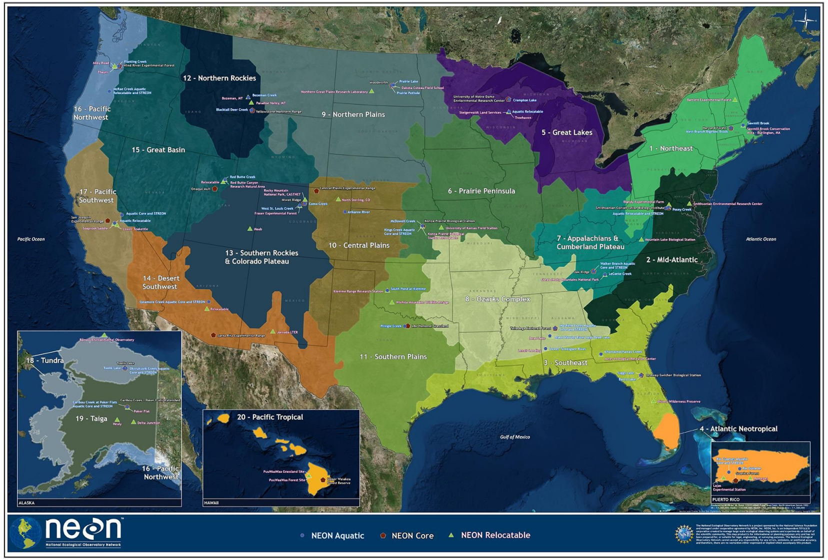
Forrest M. Hoffman, Computational Earth System Scientist

- Group Leader for the ORNL Computational Earth Sciences Group
- 32 years at ORNL in Environmental Sciences Division, then Computer Science and Mathematics Division, and now Computational Sciences and Engineering Division
- Develop and apply Earth system models to study global biogeochemical cycles, including terrestrial & marine carbon cycle
- Investigate methods for reconciling uncertainties in carbon–climate feedbacks through comparison with observations
- Apply artificial intelligence methods (machine learning and data mining) to environmental characterization, simulation, & analysis
- Joint Faculty, University of Tennessee, Knoxville, Department of Civil & Environmental Engineering

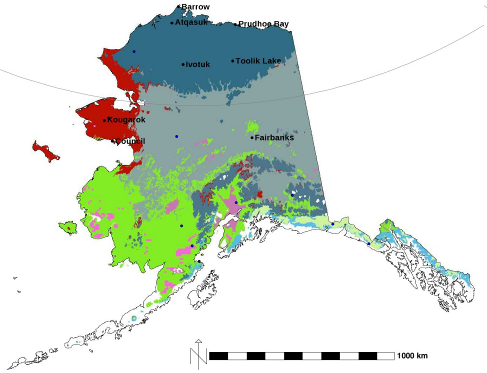
Oak Ridge National Laboratory

The University of Tennessee Knoxville

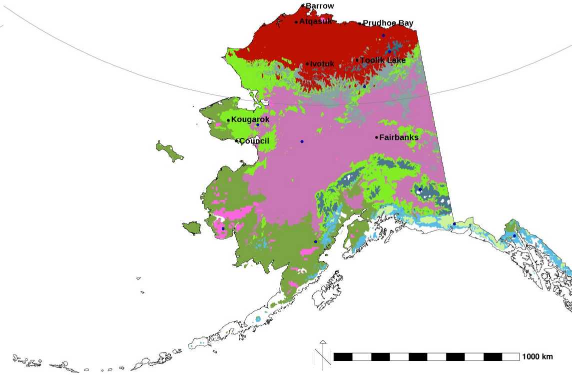
Sampling Network Design



NSF's NEON Sampling Domains



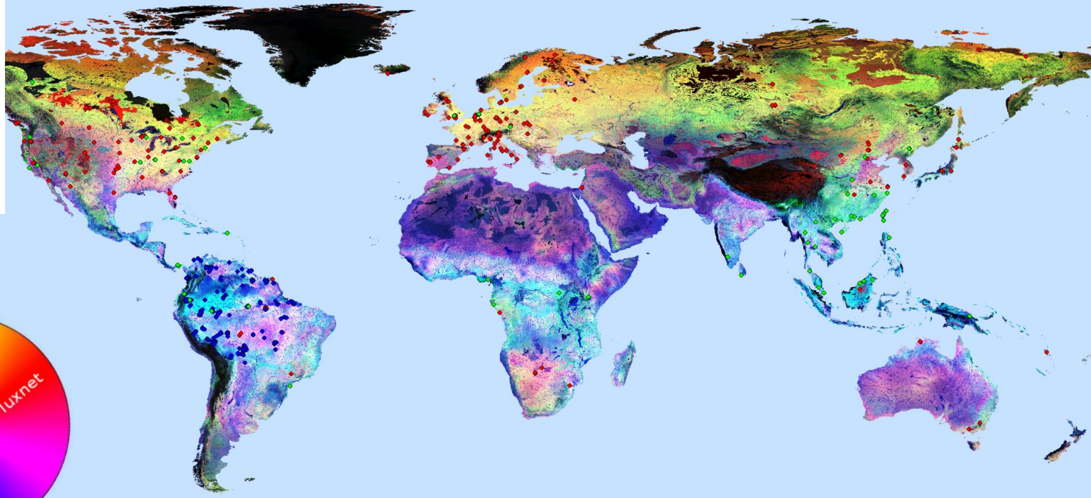
2000–2009

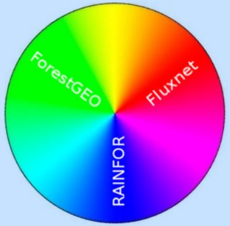


2090–2000

(Hoffman et al., 2013)

Triple-Network Global Representativeness



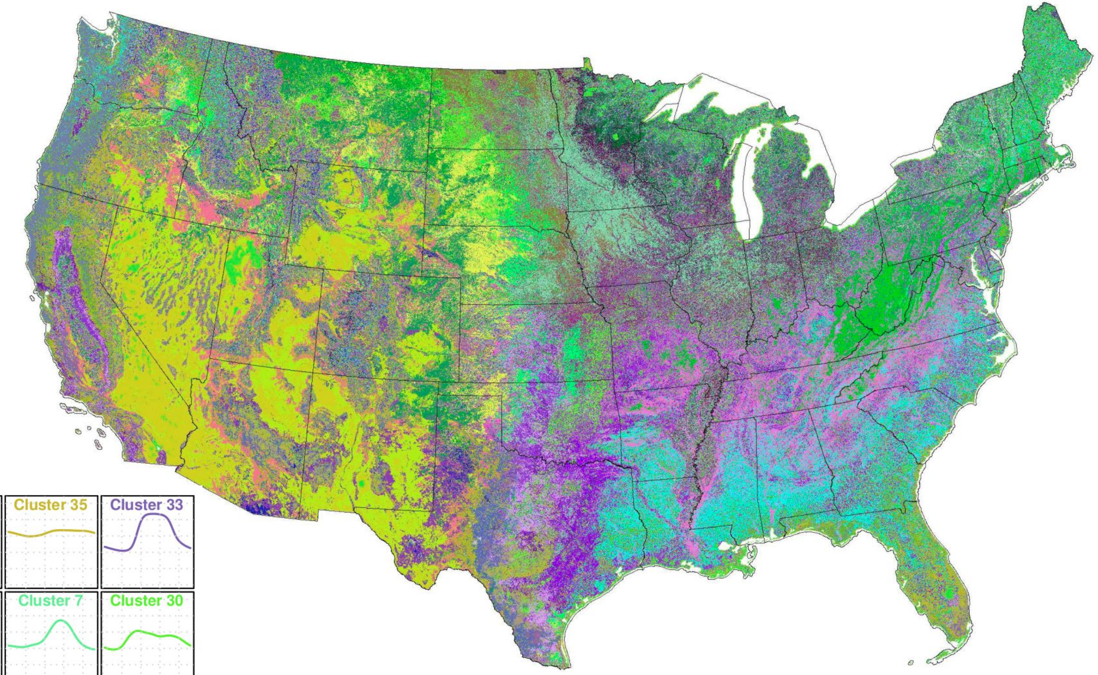


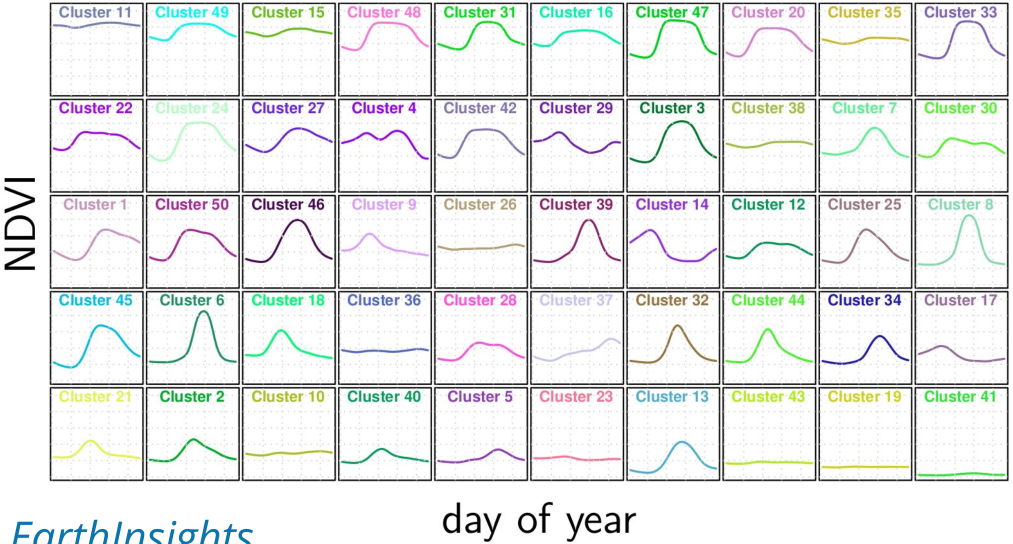
(Maddalena et al., in prep.)

Gridded data from satellite and airborne remote sensing, models, and synthesis products can be combined to design optimal sampling networks and understand representativeness as it evolves through time

50 Phenoregions for year 2012 (Random Colors)

250m MODIS NDVI
Clustered from 2000 to present



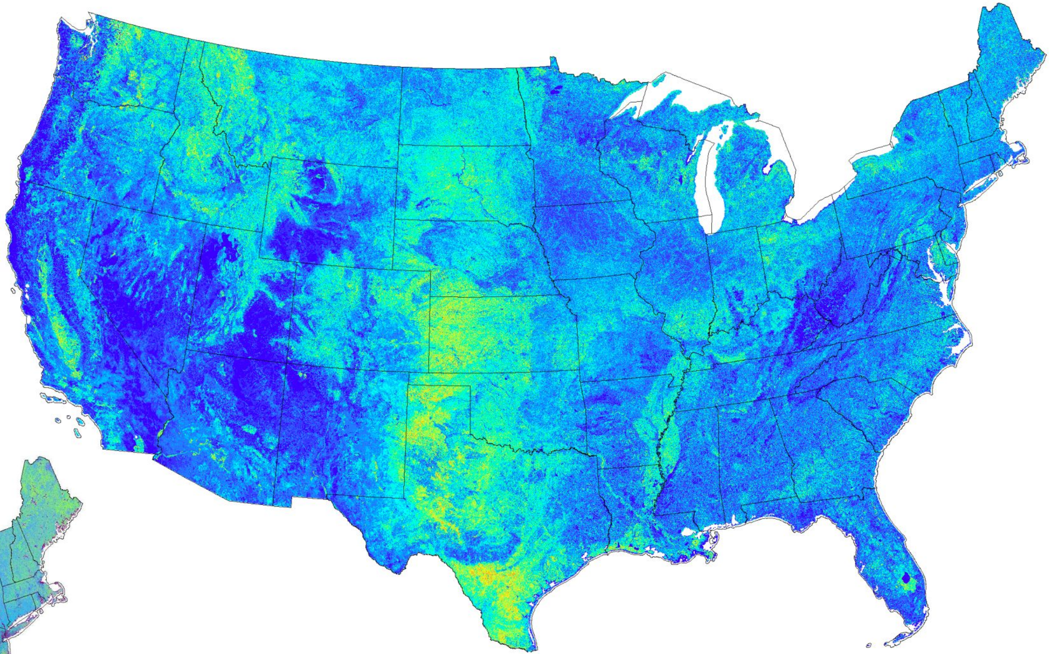


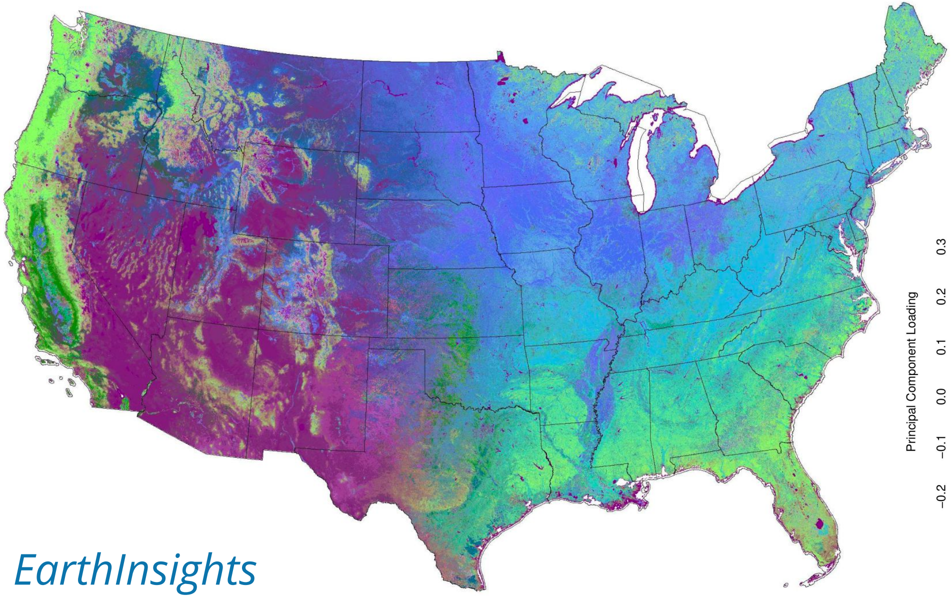
50 Phenoregion Prototypes (Random Colors)

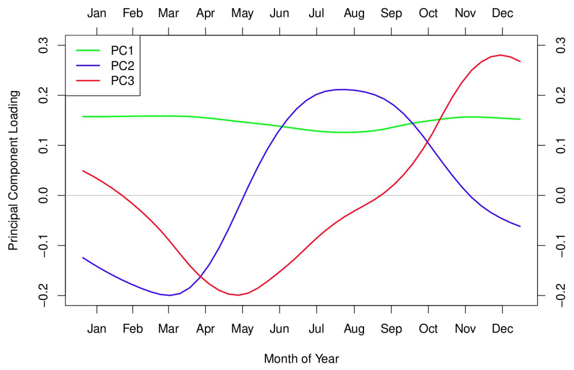
EarthInsights

(Hargrove et al., in prep.)

50 Phenoregions Persistence
and
50 Phenoregions Max Mode
(Similarity Colors)







Principal Components Analysis

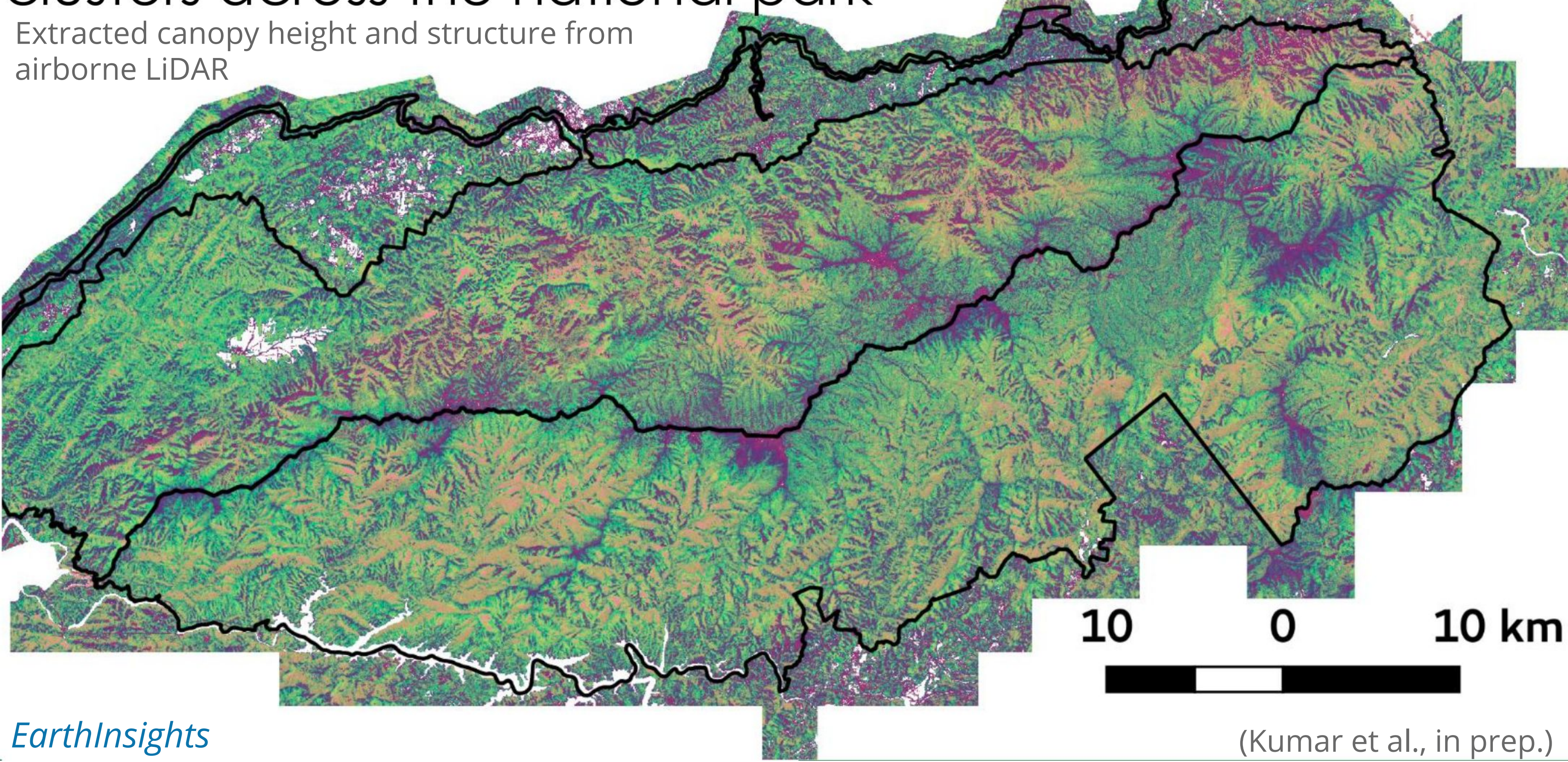
PC1 ~ Evergreen
PC2 ~ Deciduous
PC3 ~ Dry Deciduous

EarthInsights

(Hargrove et al., in prep.)

GSMNP: Spatial distribution of the 30 vegetation clusters across the national park

Extracted canopy height and structure from airborne LiDAR



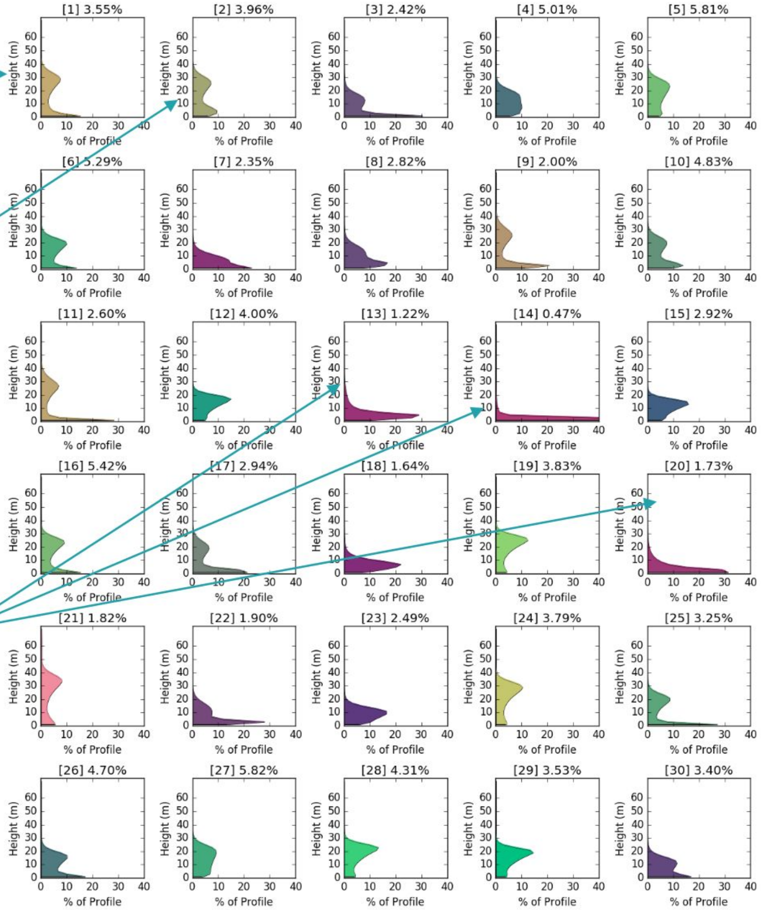
(Kumar et al., in prep.)

GSMNP: 30 representative vertical structures (cluster centroids) identified

tall forests with low understory vegetation

forests with slightly lower mean height with dense understory vegetation

low height grasslands and heath balds that are small in area but distinct landscape type



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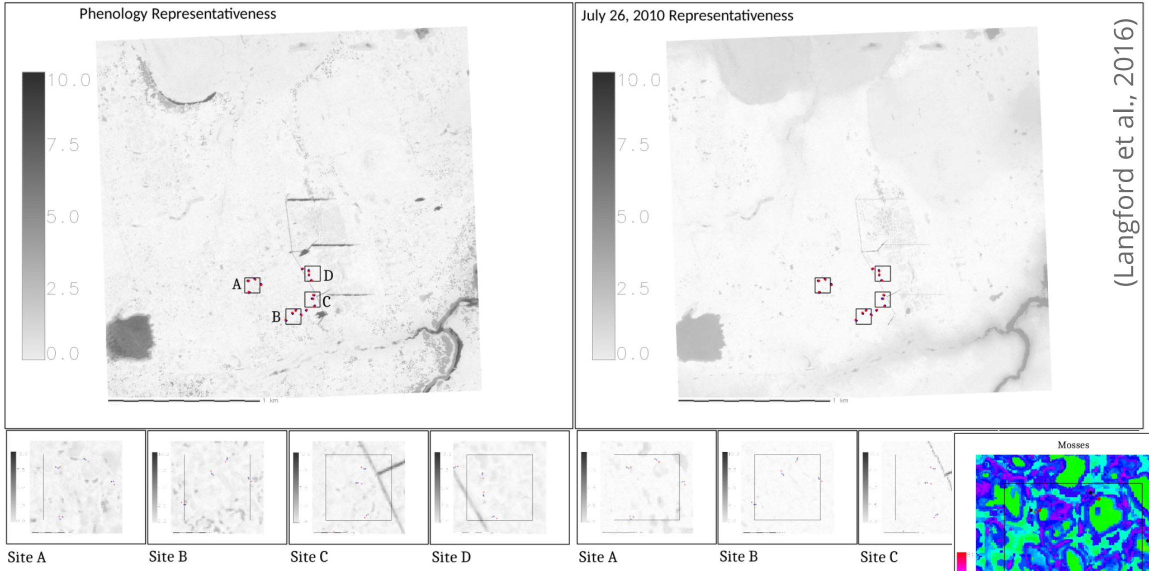
(Kumar et al., in prep.)

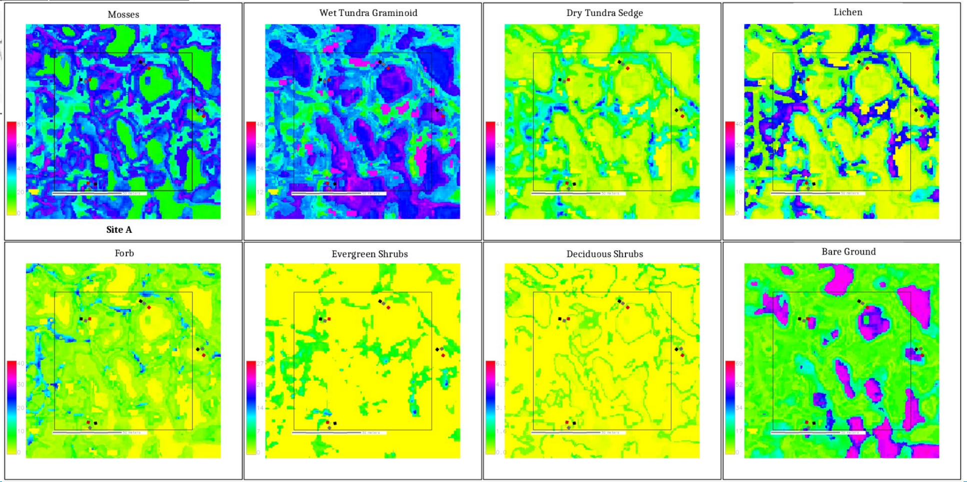
Vegetation Distribution at Barrow Environmental Observatory



(Langford et al., 2016)

Representativeness map for vegetation sampling points in sites A, B, C, and D with phenology (left) and without (right) from WoldView2 multispectral imagery for the year 2010 and LiDAR data

Example plant functional type (PFT) distributions scaled up from vegetation sampling locations

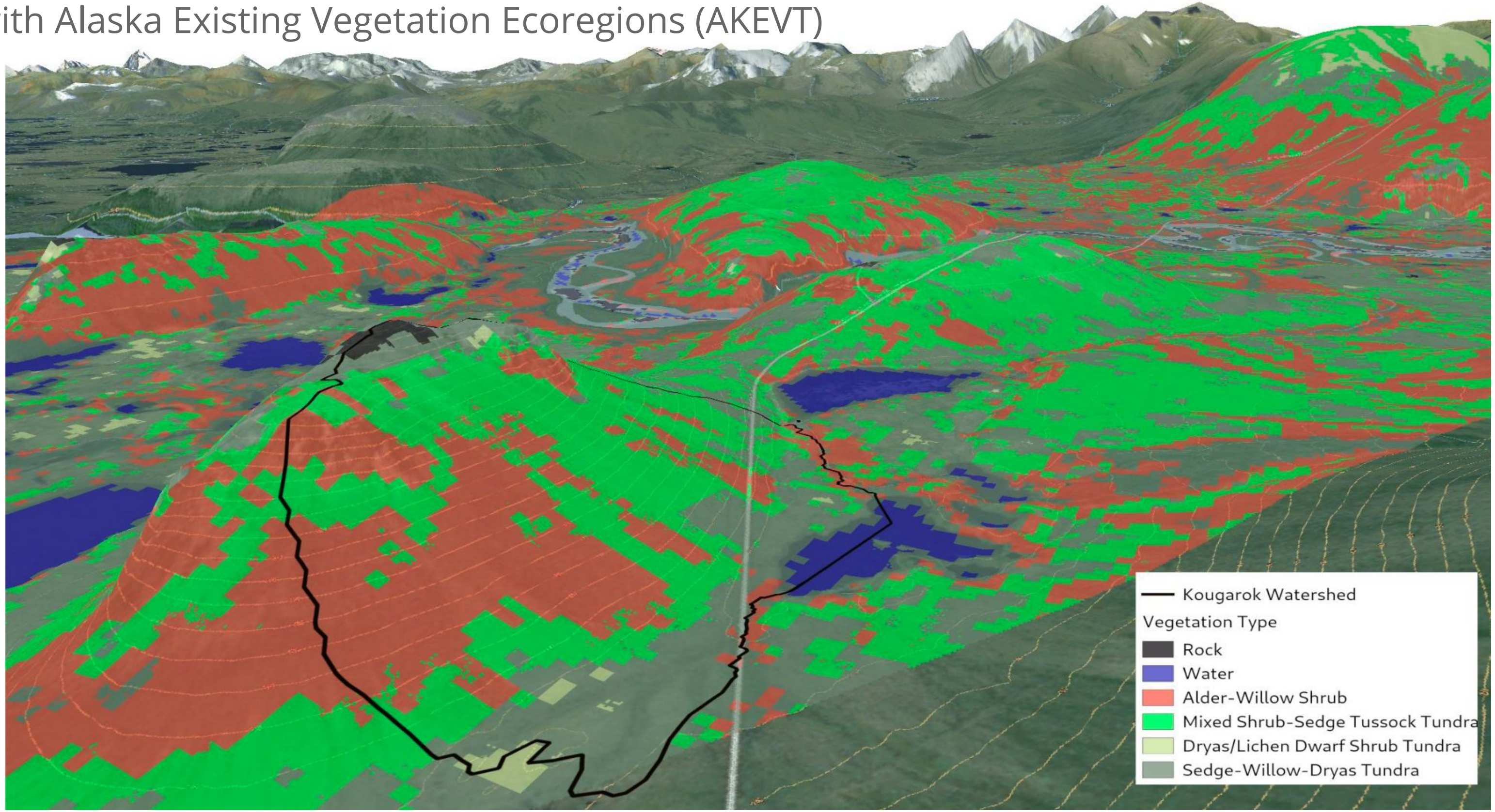


In situ data from field measurement activities inform the development of wide-scale maps of vegetation distribution through inference using remote sensing data as surrogate variables, and relationships with environmental controls can be extracted

EarthInsights

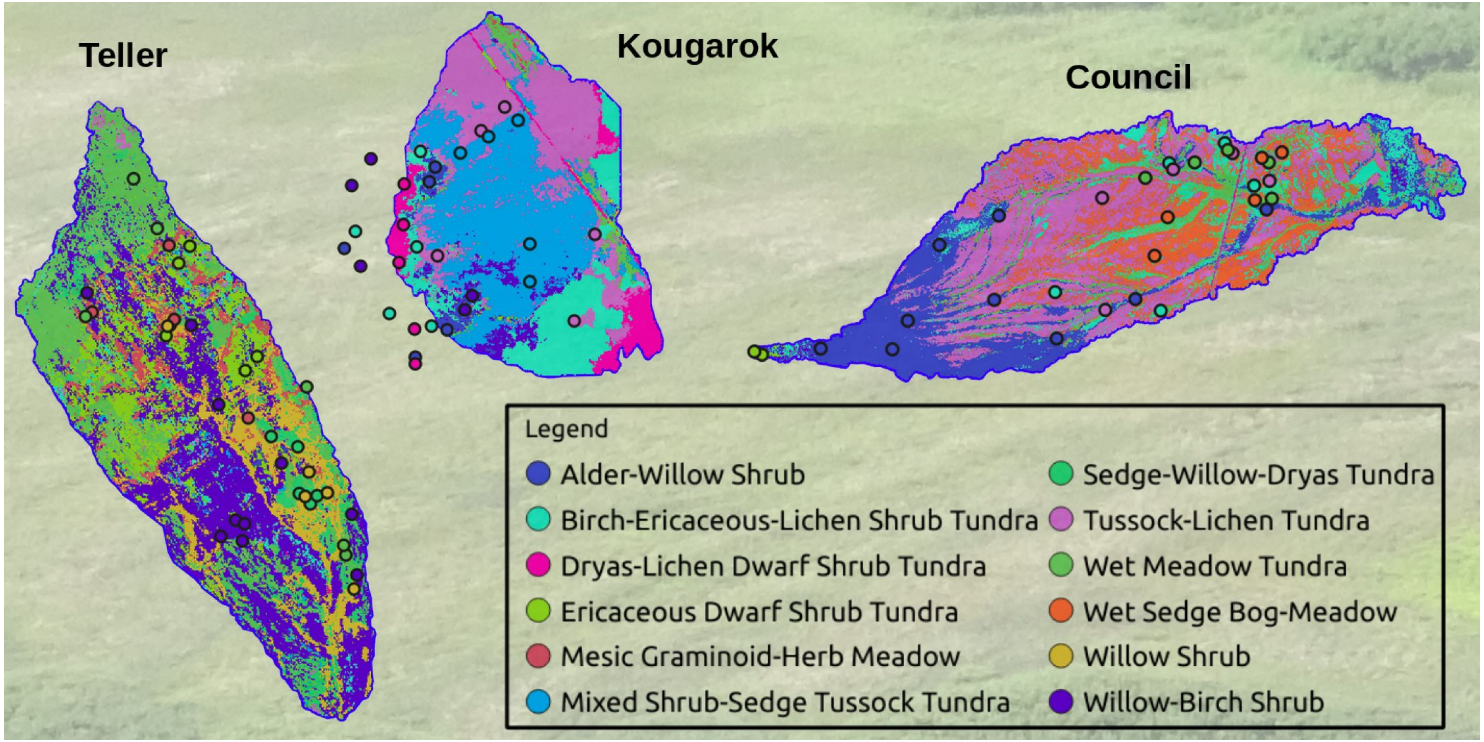
Arctic Vegetation Mapping from Multi-Sensor Fusion

Using Hyperion Multispectral and IfSAR-derived Digital Elevation Model
Trained with Alaska Existing Vegetation Ecoregions (AKEVT)



(Langford et al., 2019)

Watershed-Scale Plant Communities Determined from DNN and AVIRIS-NG



At the watershed scale, vegetation community distribution follows topographic and water controls.
At a fine scale, nutrients limit the distribution of vegetation types.

(Konduri et al., in prep.)