Relationships between crop yield and landscape features

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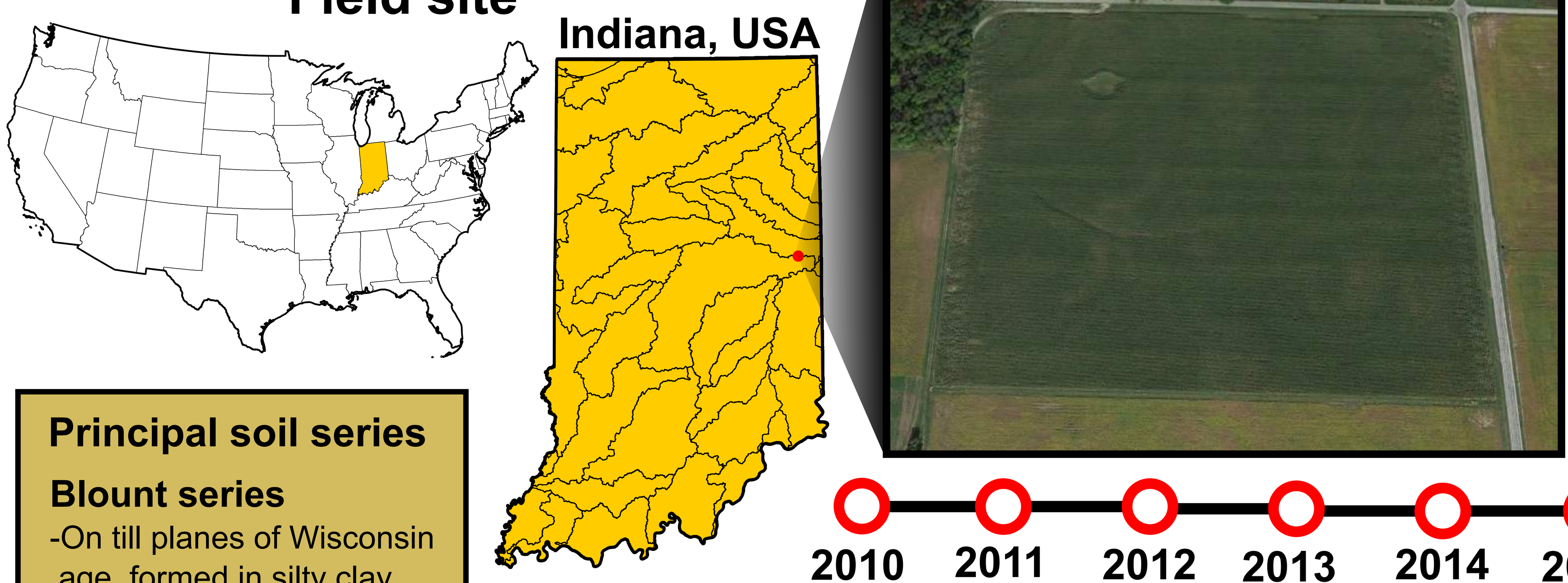
Introduction

Sound agronomic recommendations are crucial for today's agronomists as they strive for improved yields, profits, and sustainability. Determining the spatial relationships between yield and landscape variation including soil properties, soil texture, and terrain attributes may improve management decisions, particularly with regards to proper nitrogen applicaiton for minimizing both costs to farmers and environmental impacts. Here, we investigate relationships between landscape features and corn yield as part of a preliminary study to model corn yield with variations in landscape attributes, soil properties, and weather.

Materials and Methods

Field site

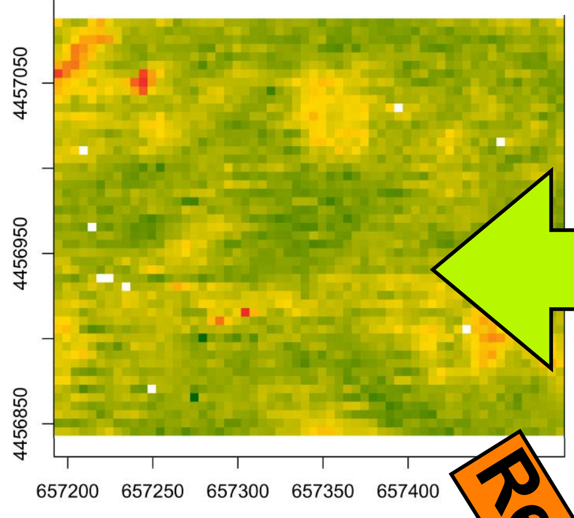


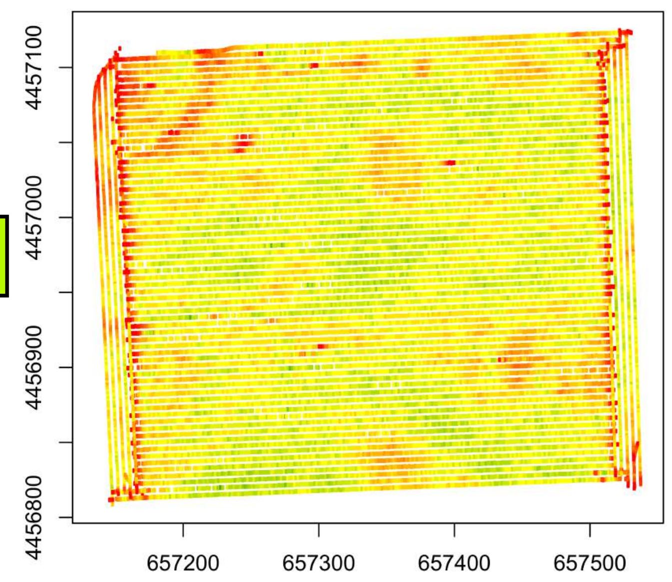
Principal soil series

Blount series
- On till planes of Wisconsin age, formed in silty clay loam or clay loam till
- Fine, illitic, mesic Aeric Epiaqualfs

Pewamo series
- On moraines, near-shore zones,and lake planes, formed in till
- Fine, mixed, active, mesic Typic Epiaqualfs

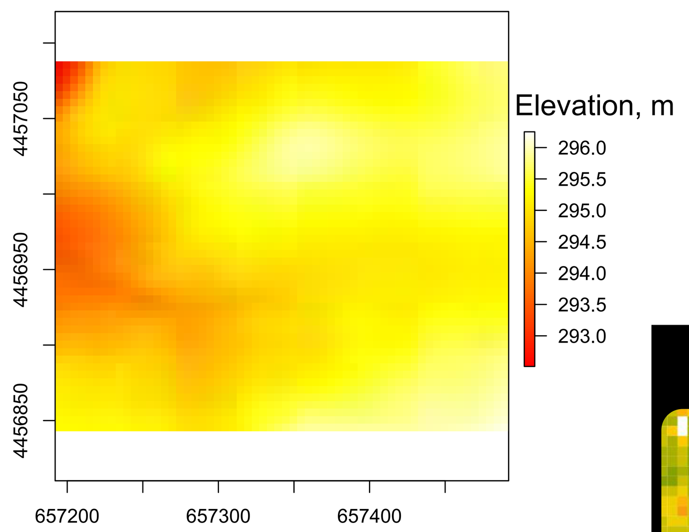
Obtain and prepare yield monitor data.


5m raster of yield


Original estimates from yield monitor

Response

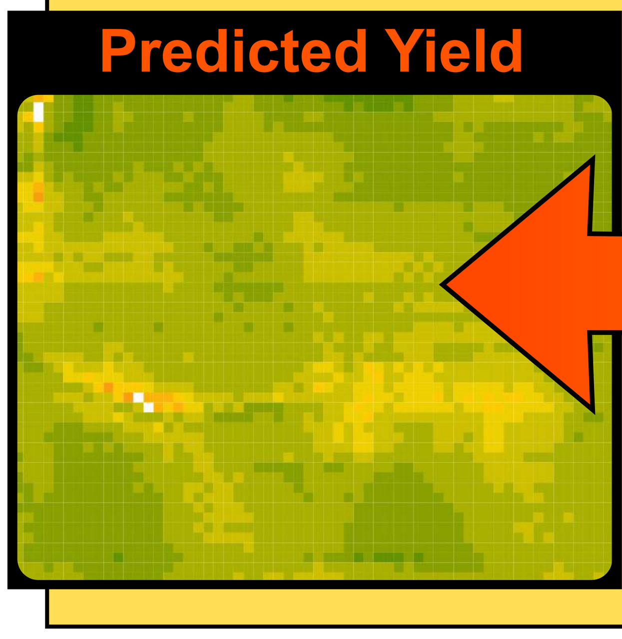
Calculate terrain attributes from digital elevation model.



SAGA GIS

Catchment area
Catchment slope
Convergence index
Cross-sectional curvature
Diurnal anisotropic heating
Flow accumulation
Longitudinal curvature
Modified catchment area
Relative slope position
Slope
Topographic position index
Topographic wetness index
SAGA topographic wetness index
Valley depth
Vertical distance to channel network

Run two models for spatial processes:



1. **Spatial lag model:**

$$Y = \rho WY + X\beta + \varepsilon$$

Lowest AIC (Akaike Information Criterion)

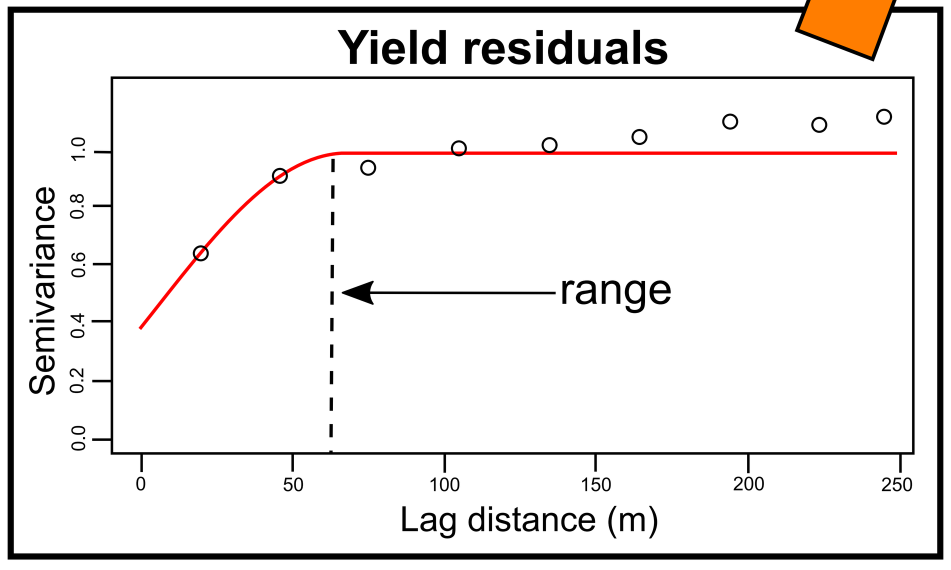
2. **Spatial error model:**

$$Y = X\beta + \eta,$$
$$\eta = \lambda W\eta + \varepsilon$$

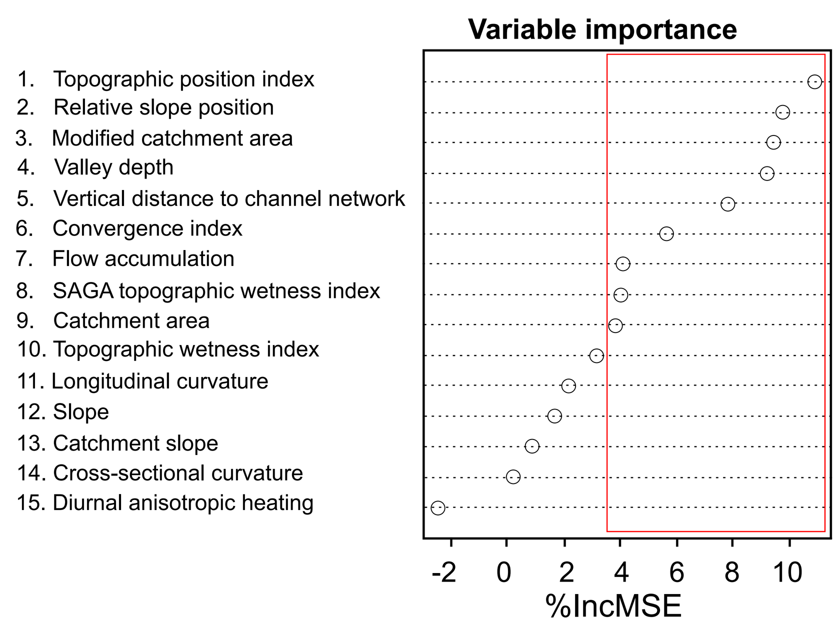
W

Predictors

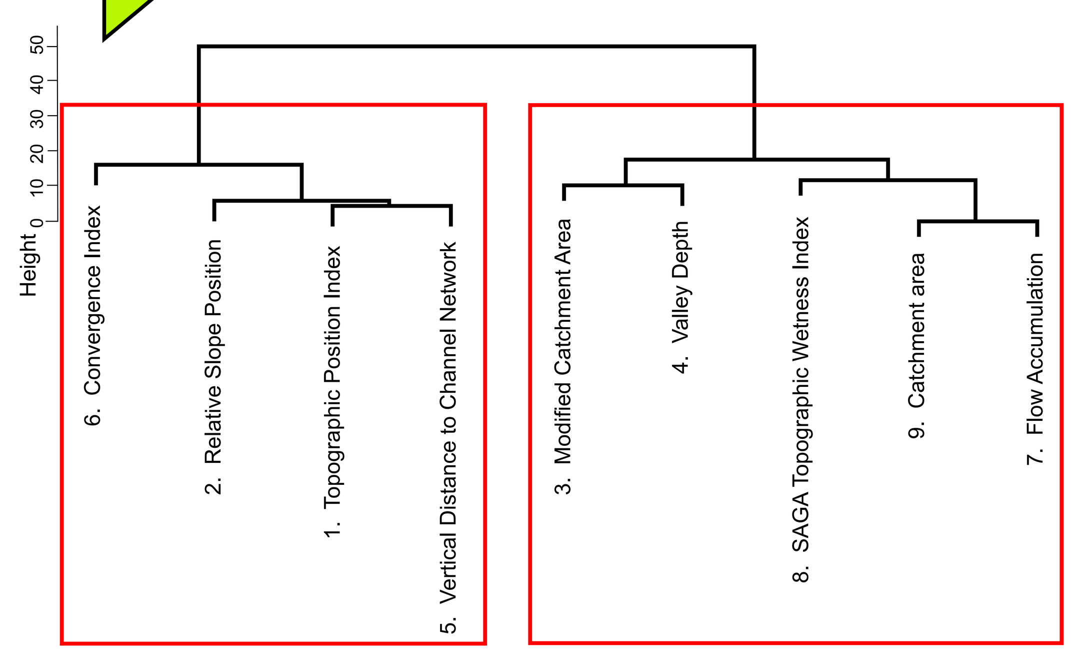
Use variogram range as distance for spatial weight matrix



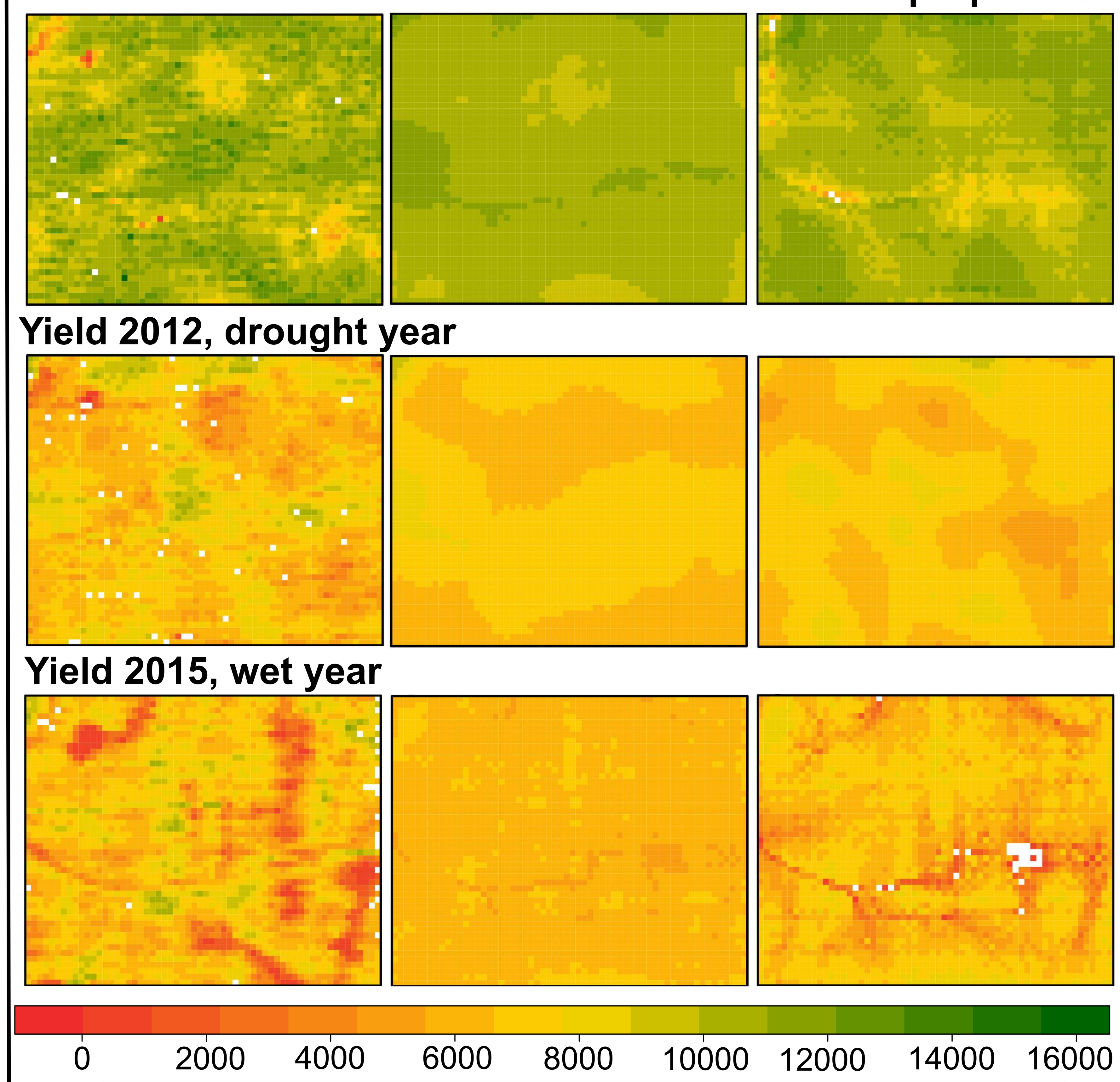
Select most important variables for model using Random Forest.



Use cluster analysis to select unique terrain attributes.



Results



	AIC	Standardized coefficient	Estimate	p-value
2011	Lag: 309.30 **Error: 303.47**	Topographic position index	-0.49	5.51e-05
		Catchment slope	-0.19	0.03
	Lag: 203.05 **Error: 199.22**	Silt	0.70	2.20e-16
		Topographic wetness index	0.30	9.00e-04
		Longitudinal curvature	-0.34	4.70e-07
		Diurnal anisotropic heating	0.28	1.28e-08
		Convexity	0.12	5.42e-02
		Organic matter	0.31	6.68e-04
2012	Lag: 325.59 **Error: 323.10**	Topographic position index	-0.46	2.66e-06
	Lag: 205.24 **Error: 204.87**	Silt	0.64	8.73e-14
		Topographic wetness index	0.28	2.80e-04
		Vertical dist. to channel index	-0.40	2.79e-06
		% Carbon	0.35	6.93e-04
2015	**Lag: 239.97** Error: 240.08	Topographic wetness index	-0.25	2.00e-03
	Lag: 329.36 Error: 330.45	Silt	0.15	0.14
		Topographic wetness index	-0.69	3.00e-11
		Diurnal anisotropic heating	0.19	0.02
		% Carbon	0.56	5.89e-06
		Surface area	-0.13	0.21

Terrain attributes only

Terrain attributes with soil texture and soil properties

Model	Nagelkerke pseudo-R-squared	
2010	0.18	0.50
2011	0.32	0.62
2012	0.18	0.55
2013	0.15	0.36
2014	0.32	0.43
2015	0.14	0.40

Discussion

The most important terrain attributes for predicting corn yield were relative slope position, topographic wetness index, topographic position index, and catchment slope. These results demonstrate that models for predicting corn yield in Indiana need to include landscape features for increased model performance. Since this preliminary study, we have added soil texture and soil properties to the models at the Davis Purdue Agricultural Center. This has substantially improved all models. This analysis met one objective of a larger investigation that will incorporate soil properties, soil texture, and weather patterns into models of corn yield across Indiana landscapes. The focus of future work will investigate relationships between yield and terrain attributes, soil properties, and weather patterns aross Indiana, USA.

Questions?

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