"Hurricanes generate the most expensive property damage, the most spectacular images, and get headlines.

We name them, debate them, study them, *remember* them for generations.

Heat waves are the most lethal form of extreme weather.

They are the silent and invisible killers of silent and invisible people."

Klinenberg 2015 "Heat Wave"

Turning up the heat on urban temperature data

T Logan[a], S Guikema[a], K O'Meara[b], B Zaitchik[c]
K Liberman[a], C Zuo[a], R Nichols[a]

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[b] Architectural Design, Maryland Institute College of Art, Baltimore, Maryland
[c] Johns Hopkins University, Baltimore, Maryland

Urban Heat Island

- Cities are becoming warmer
- Trap heat
- Exacerbate the severity of heat waves (Harlan, 2008)

- Warmer weather -> increased risk

- The 1995 Chicago inferno will be an annual event by 2080 with current climate trends (Peng, 2011)

Risks of urban heat island

breaking news

Qld construction worker dies in heatwave

DECEMBER 7, 2016 5:51PM

Australian Associated Press

Heat Wave Picking Off Pakistan's Urban Poor

By Zofeen Ebrahim

Reprint | Print | Send by email | En español

Experts warn against underestimating heatwa threat

AM By Will Ockenden

Nov 2016, 3:58pm

Deadly heat wave scorches central and eastern U.S.

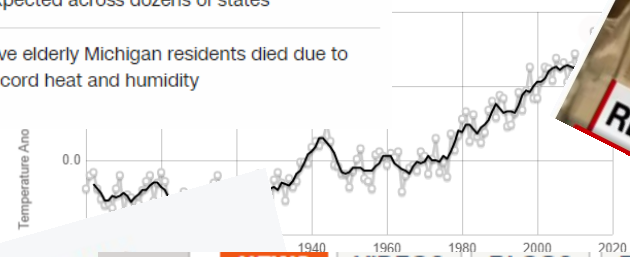
By Azadeh Ansari and Farida Fawzy, CNN

Updated 1:46 PM ET, Mon July 25, 2016

Story highlights

Temperatures close to 100 degrees are expected across dozens of states

Five elderly Michigan residents died due to record heat and humidity



NEWS | VIDEOS | BLOGS | PERSONALITIES

Dangerous heat wave to scorch France in

By By Eric Leister, Meteorologist

August 25, 2016, 10:21:35 AM EDT

Intense heat will continue to build across France this week with temperatur approaching 38 C (100 F) in many locations.

"A large area of high pressure will funnel hot air from Africa into France,"

"Hurricanes generate the most expensive property damage, the most spectacular images, and get headlines.

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Aim

- Using data from five US cities:

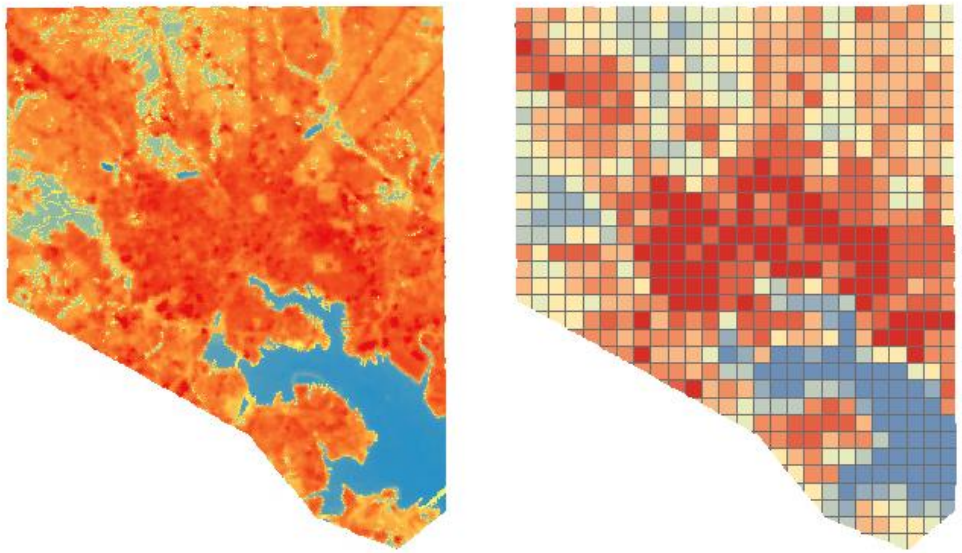
- Test fundamental hypothesis of land surface temperature and biophysical parameters
- Explore relationships between land surface temperature and biophysical parameters
- Predict land surface temperature using biophysical parameters

Why?

- Confirm existing hypotheses
- Test hypotheses' applicability to range of cities

- Predictive model so we can estimate the effect of changing the built environment on land surface temperatures

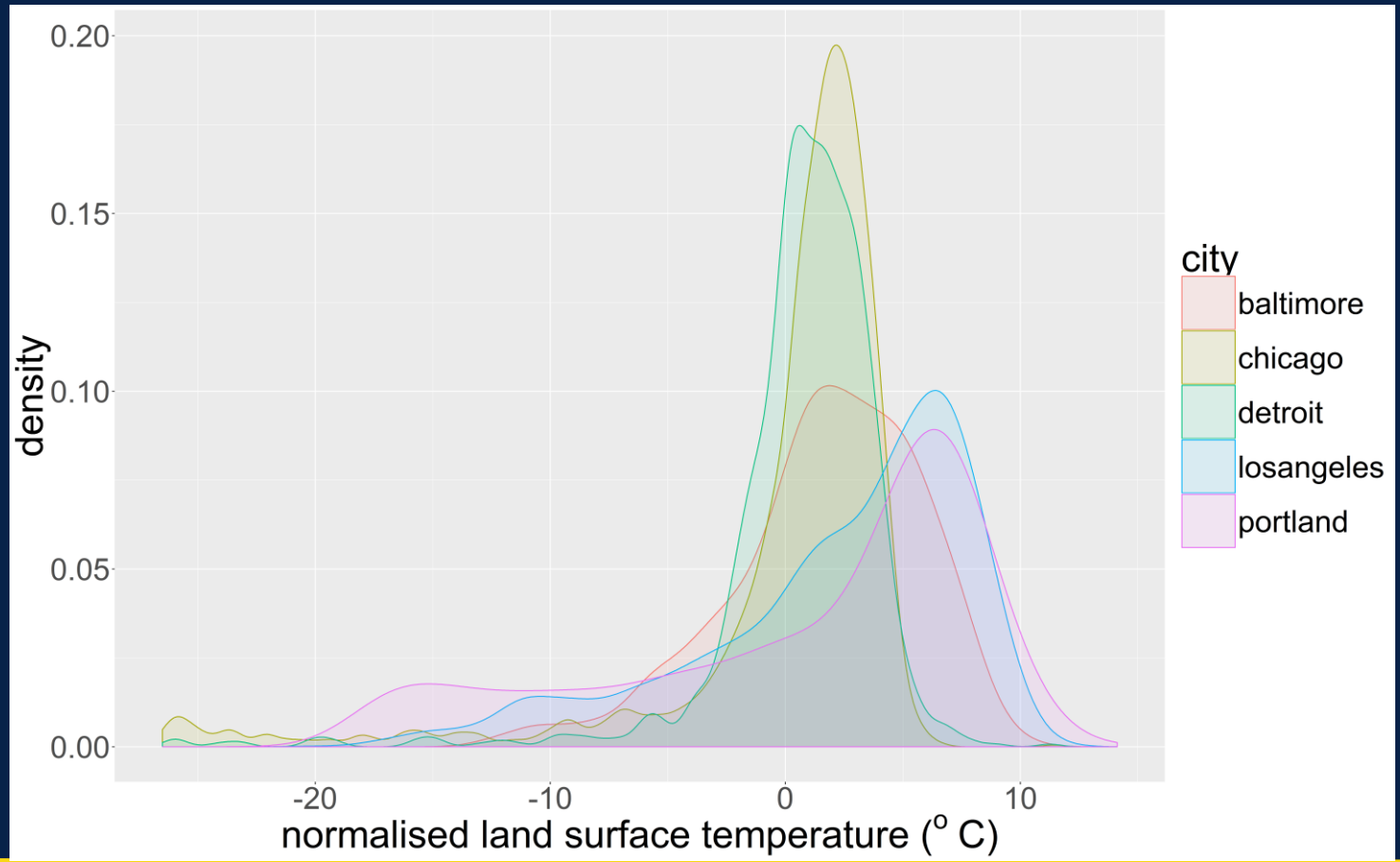
The data



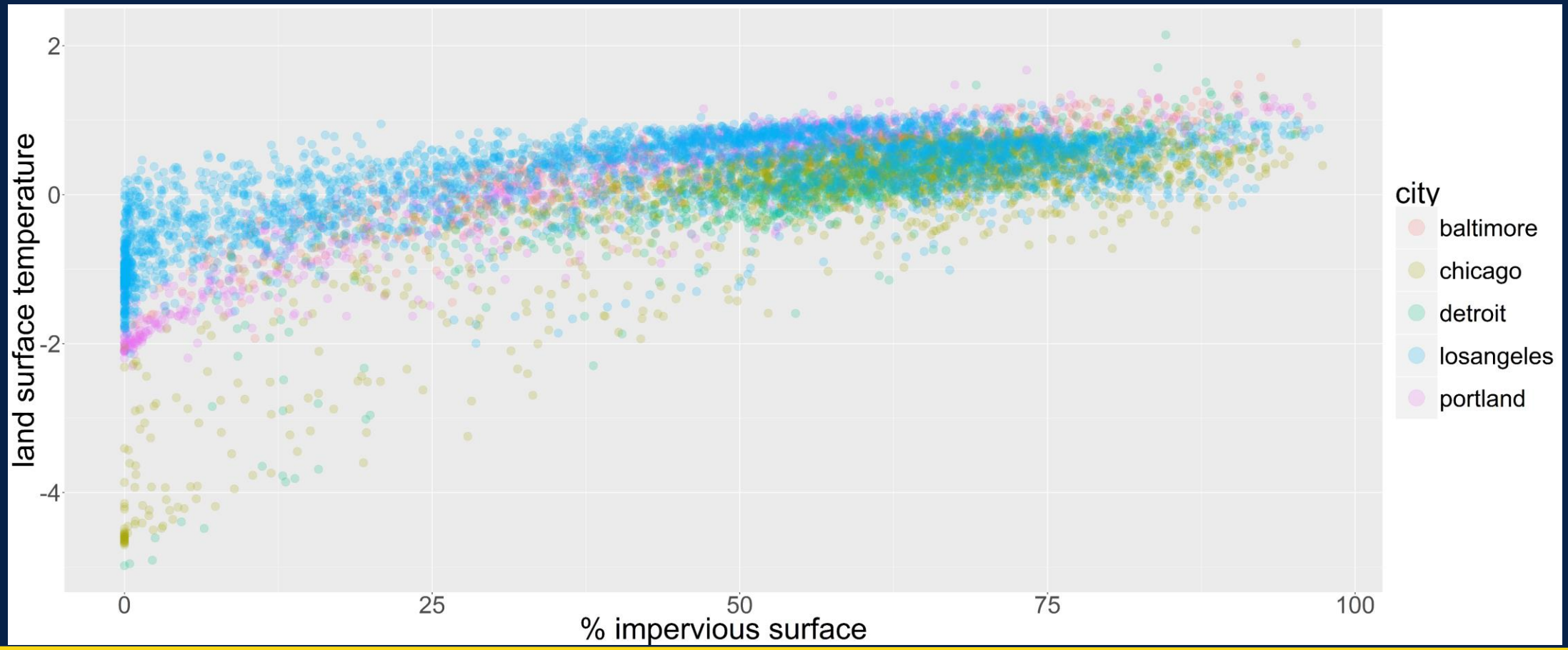
Processed landsat image of land surface temperature (oC) for a summer's day in Baltimore

- Each city is gridded into squares of 37 hectares / 92 acres / $(2000\ ft)^2$ / $(610\ m)^2$
- Cities: Baltimore, Chicago, Detroit, Los Angeles, Portland
- Four land satellite images averaged
- For each grid cell the mean, max, and min is calculated
- Variables:
  - Land surface temperature (normalized by city mean)
  - Impervious surface
  - Tree canopy
  - Elevation
  - Land cover
  - Vegetation index
  - Albedo

Land surface temperature in our cities

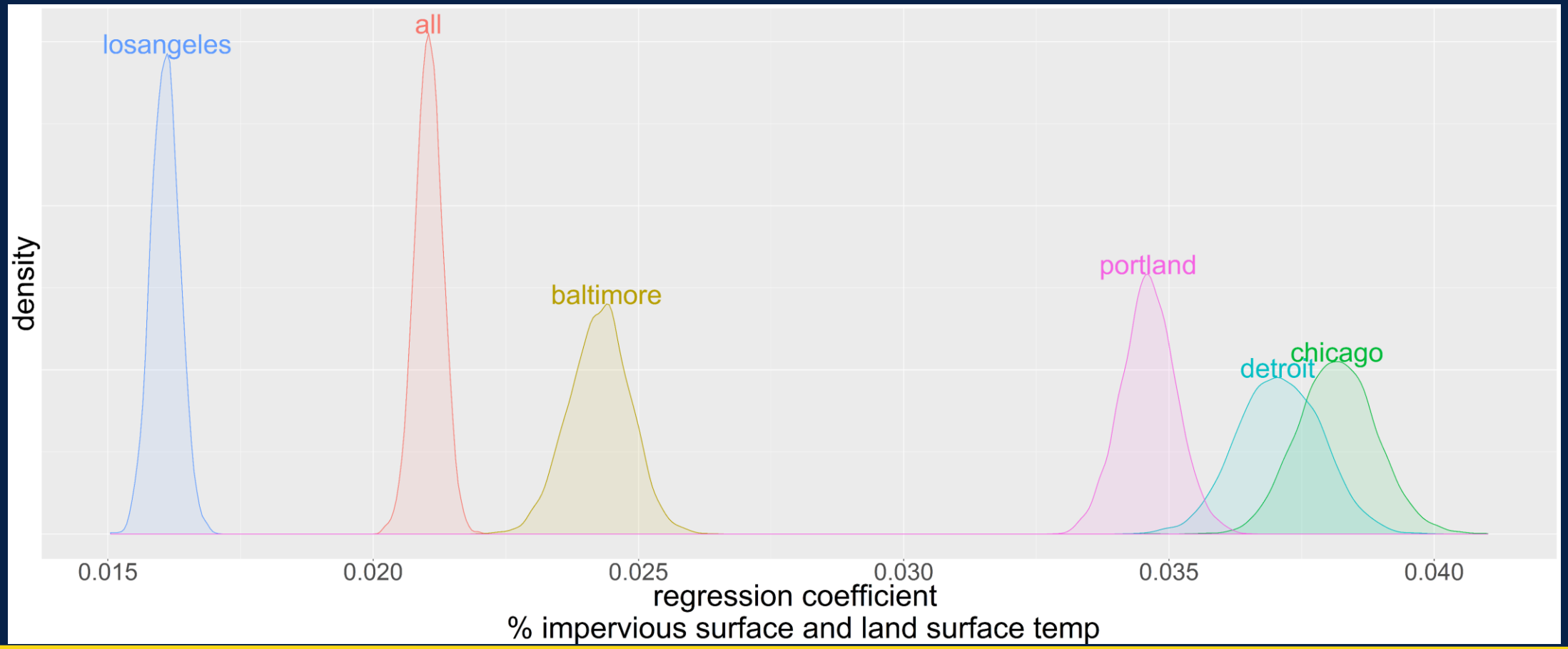


Is LST a function of impervious surfaces?



LST = land surface temperature

Is LST a function of impervious surfaces? Regression coefficient



LST = land surface temperature

Is LST a function of impervious surfaces? Remarks

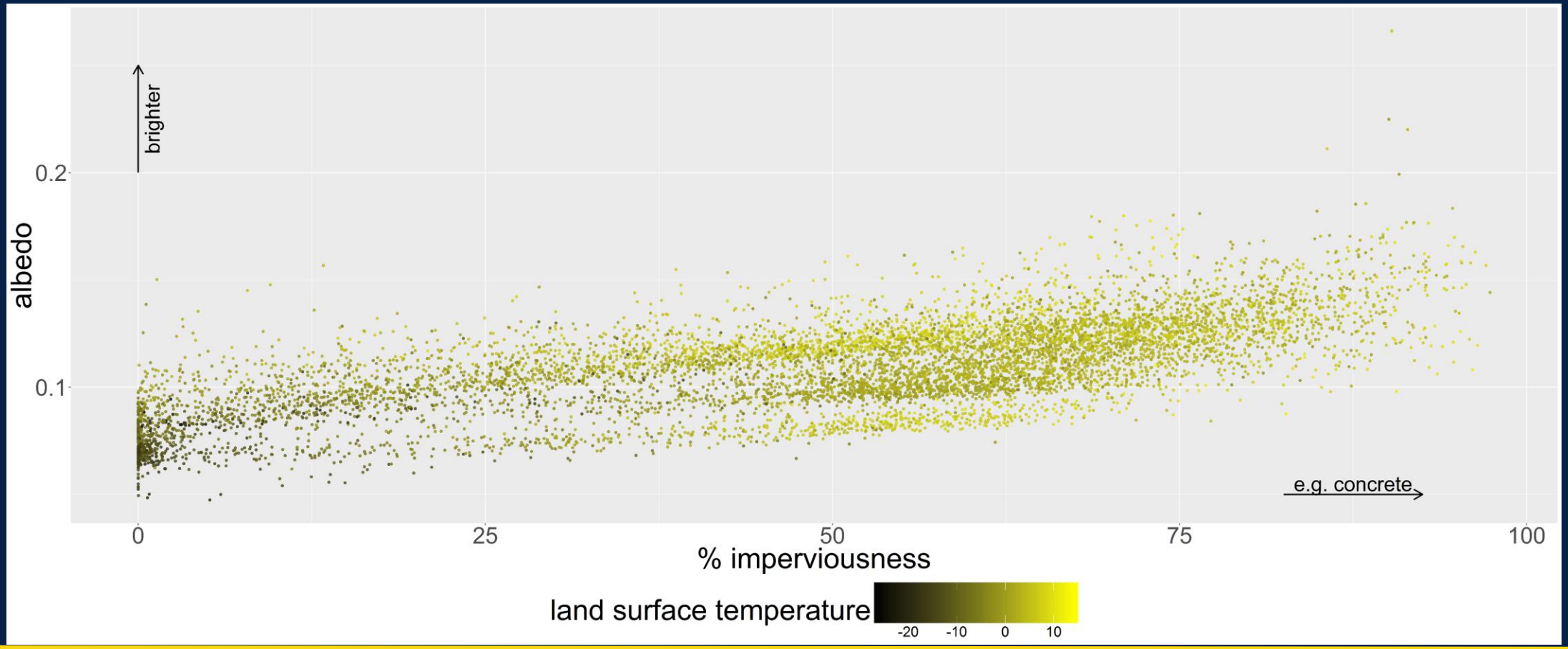
- Bayesian linear regression
- Prior was a Cauchy distribution based on the distribution of the combined dataset (we expect the effect to be similar)

- Reject that effect of impervious surfaces is the same between cities
- Always positively correlated with land surface temperature

Are darker impervious surfaces hotter than impervious brighter surfaces?

- Albedo is a measure of “whiteness” of a surface
- Are whiter surfaces (such as concrete) better for reducing land surface temperature than darker (e.g. asphalt)

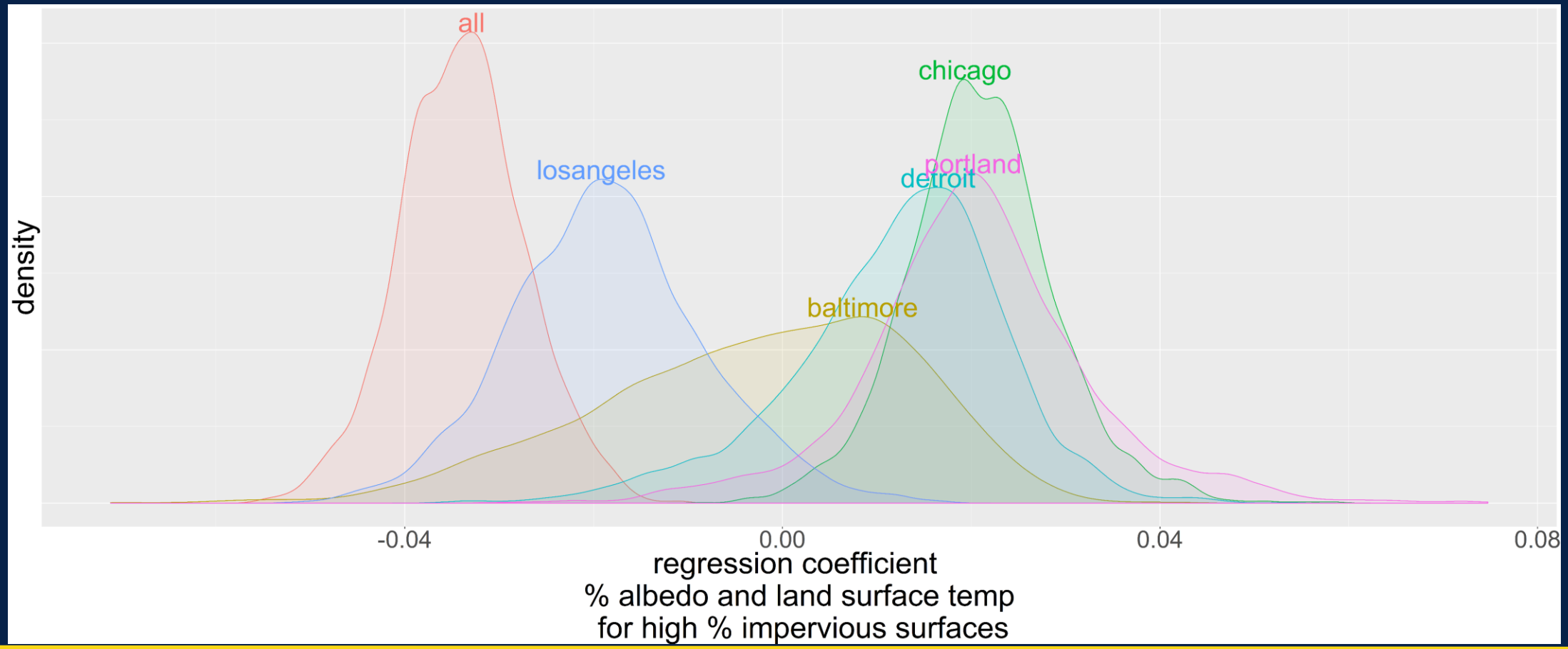
Are darker impervious surfaces hotter than impervious brighter surfaces?



Are darker impervious surfaces hotter than impervious brighter surfaces?

- Cluster data by % imperviousness
- Bayesian regression on the most impervious cluster

Are darker impervious surfaces hotter than impervious brighter surfaces?



Are darker impervious surfaces hotter than impervious brighter surfaces?

- Maybe? (regression coefficient is not < 0 for all cities)
- This indicates that as albedo increases, so does land surface temperature
- Significant variation between the cities

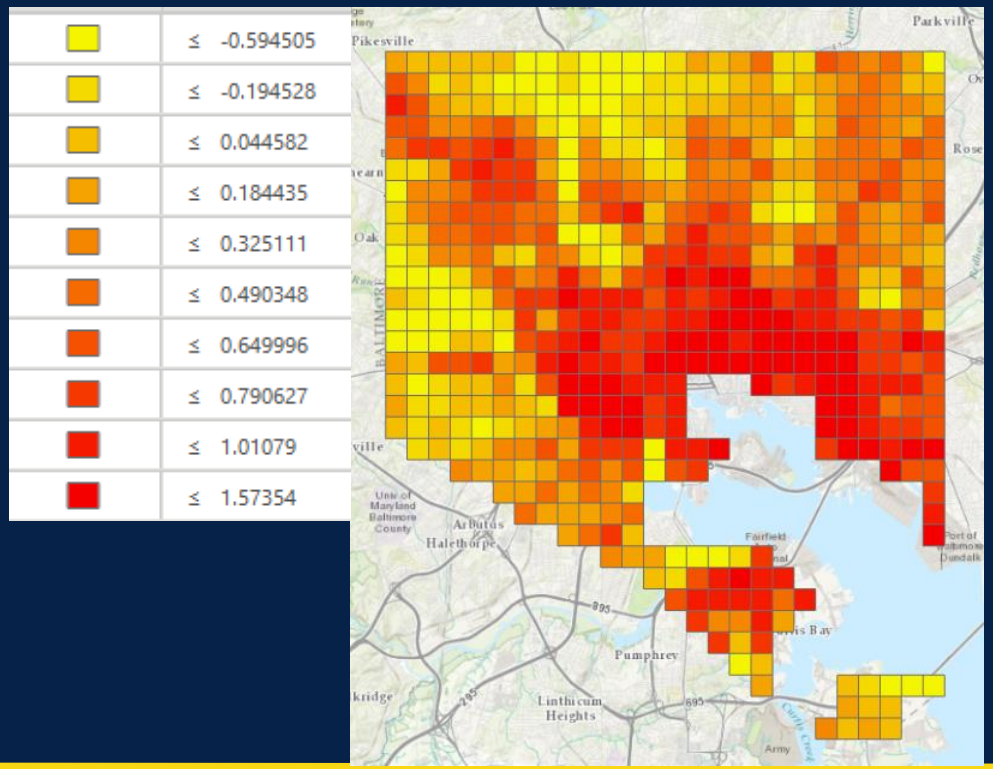
- This is a surprising result
- Prior was negative (reflecting the “all city” evidence)
- Sensitive to threshold of impervious %

Predicting land surface temperature

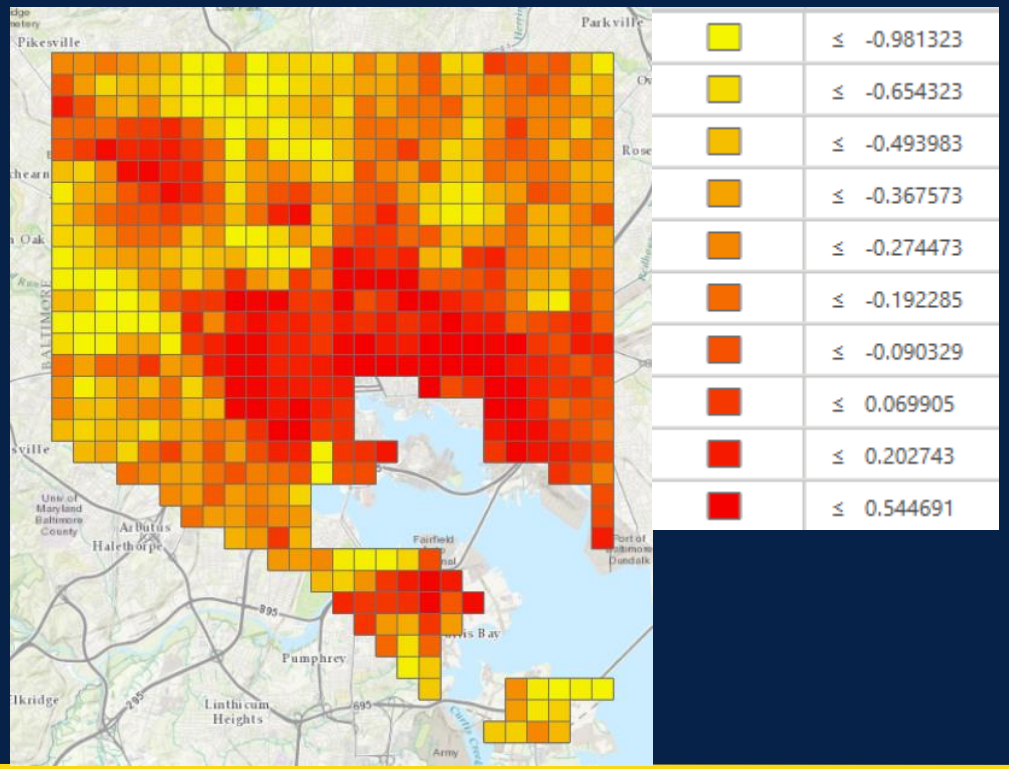
- Attempt to predict the land surface temperature using biophysical parameters
- Compare Bayesian Additive Regression Trees (BART) against other models
- BART
  - Tree based model e.g. categorises response based on inputs
  - Each tree has a noninformative prior
  - Fitting is based on MCMC, which generates samples from posterior
  - Can be used for probabilistic forecasts

Predicting Baltimore's surface temperature (spatially independent)

Actual land surface temperature

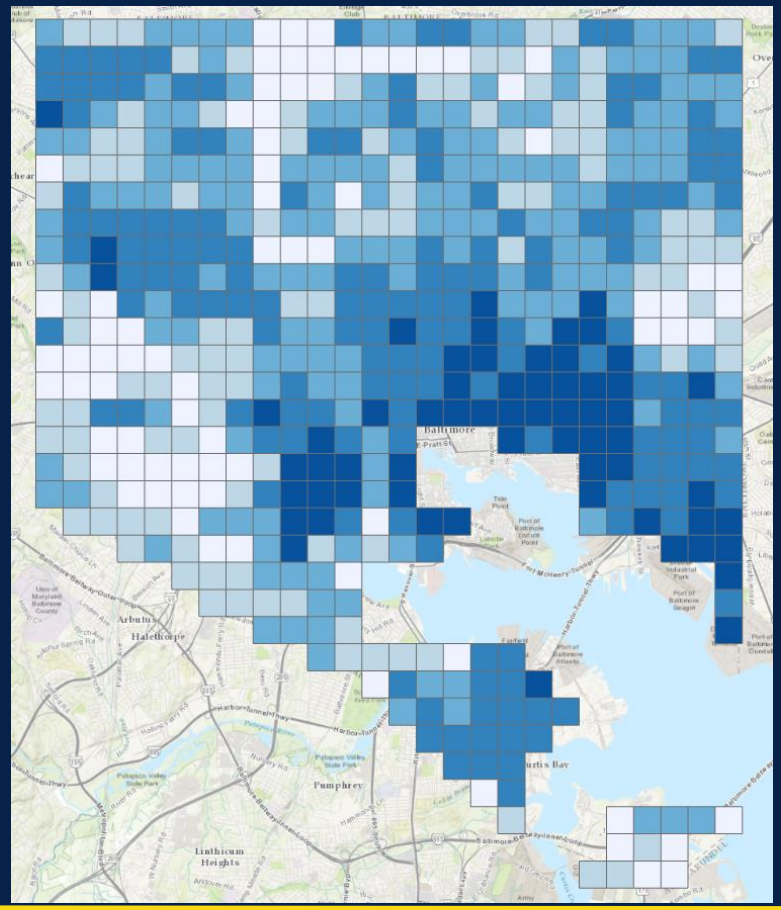


BART predicted land surface temperature



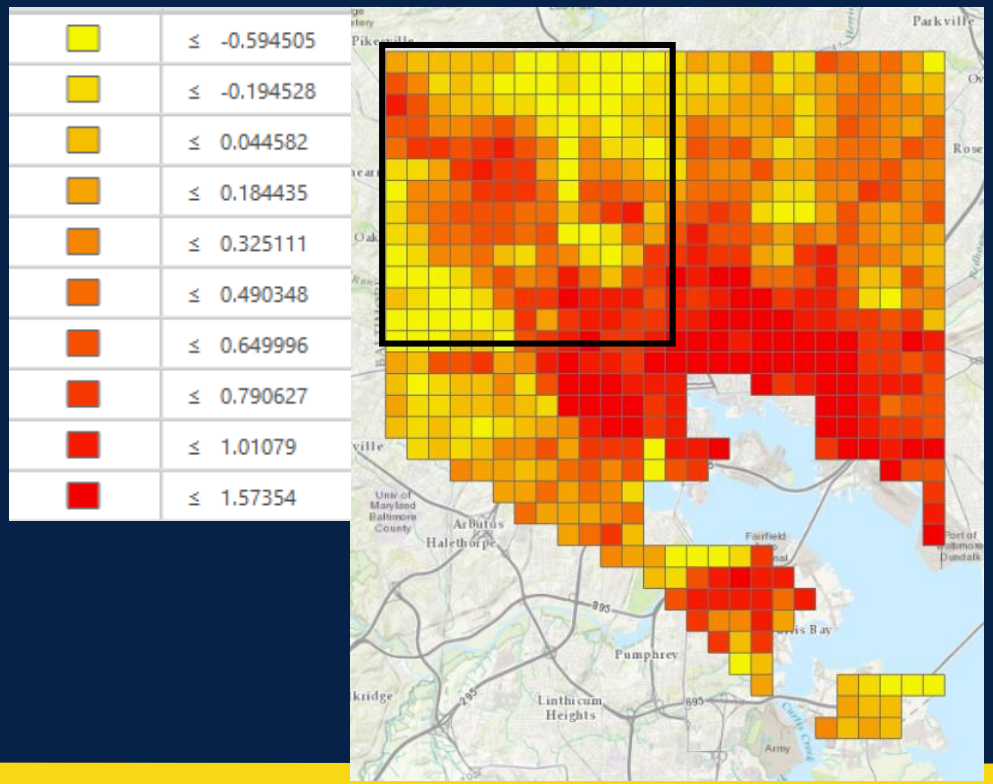
Predicting Baltimore's surface temperature: spatially independent, actual - predicted

	≤ 0.154863
	≤ 0.296416
	≤ 0.405583
	≤ 0.50652
	≤ 0.595239
	≤ 0.677637
	≤ 0.771835
	≤ 0.895448
	≤ 1.063647
	≤ 1.309898

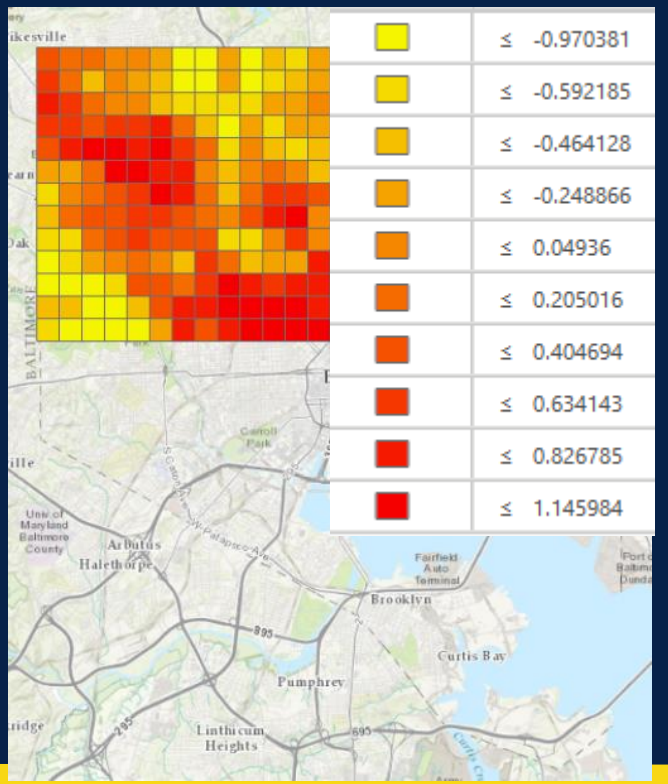


Predicting the northwest corner of Baltimore (spatially dependent)

Actual

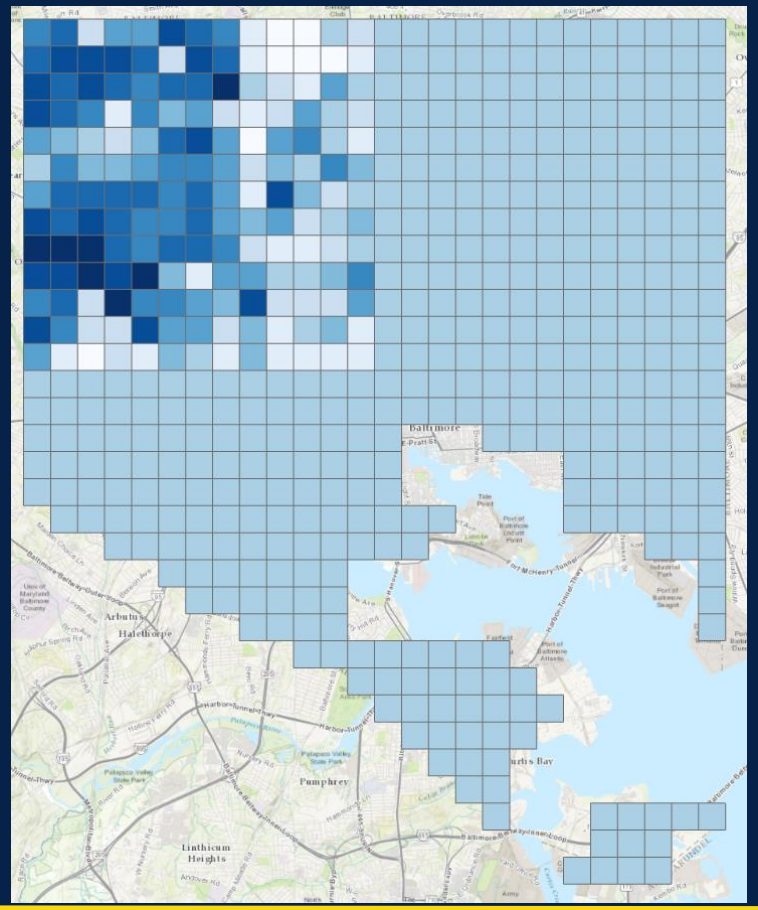


BART prediction



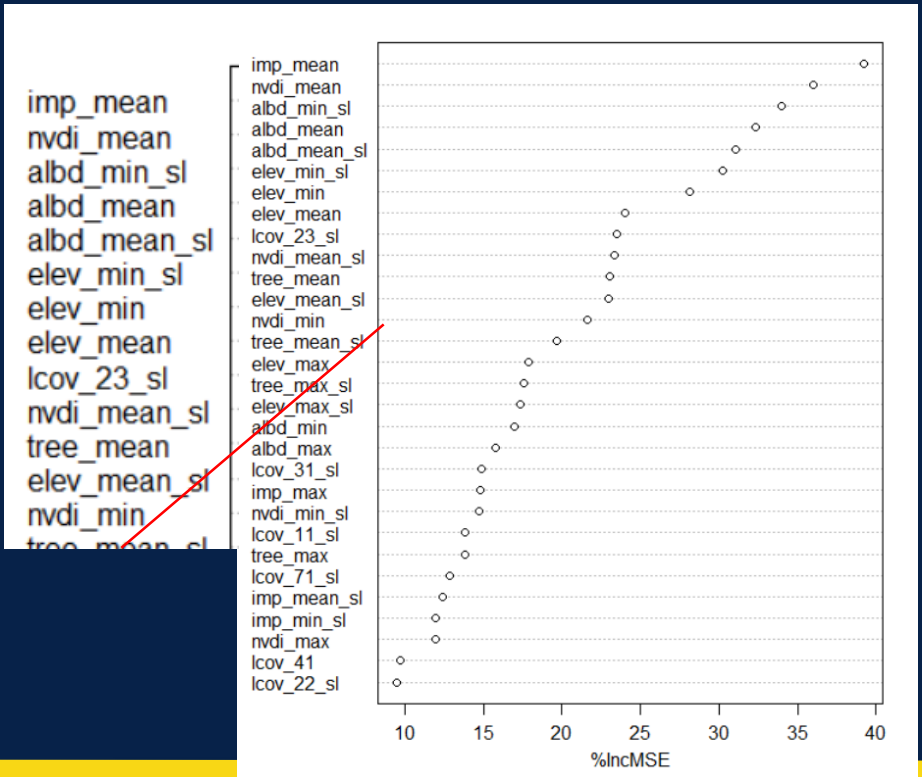
Predicting the northwest corner of Baltimore: spatially dependent, actual - predicted

	≤ -0.352774
	≤ -0.141848
	≤ -0.043596
	≤ 0.020331
	≤ 0.065919
	≤ 0.122773
	≤ 0.184618
	≤ 0.274735
	≤ 0.37127
	≤ 0.487109

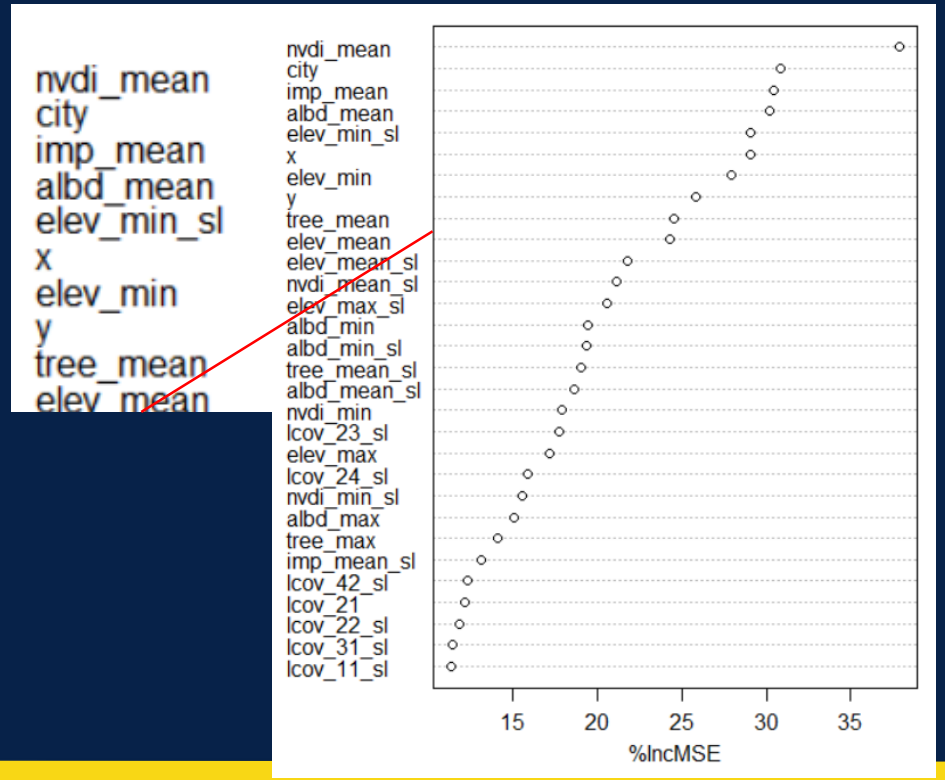


Predicting surface temperature: Variable importance

Spatially independent



Spatially dependent



Further steps?

- Investigate the collinearity in data from land satellite images
- Incorporate demographic data into the analysis to understand people's vulnerability
- Understand the importance of green space in the city
- Probabilistic prediction and uncertainty

Questions?

tomlogan.co.nz