Using Spatial Data to Estimate Distributions to Rate Area Crop Insurance Policies

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Contribution

Using Bayesian Kriging to Estimate a Linear Regression with Heteroskedasticity

Rating Crop Insurance

- Prediction
- Calibration

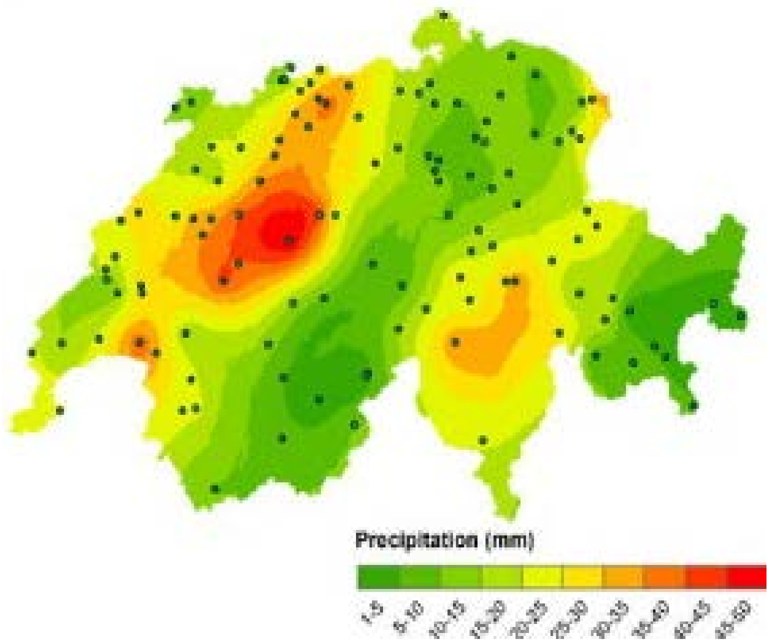
Area Yield/Revenue

What Data to Use?

- Time Series – structural change
- Spatial – structural change

Kriging

- Method of interpolation originating from geostatistics.



Alternative Spatial Models

- Spatial error model (Anselin)
- Spatially weighted regression
- Spatio-temporal model (Ozaki et al. 2008)
- Bayesian model averaging

Harri et al.

- Time trend
- Heteroskedasticity
- Spatial smoothing

County Yield Densities

- $Y_{it} \sim N\left(\mu_{it}, \sigma_{it}^2\right)$

$$\mu_{it} = \alpha_i + \beta_i t + \varepsilon_{it}$$

$$\sigma_{it}^2 = \gamma_i + \delta_i t + \nu_{it}$$

$$\boldsymbol{\theta} = (\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\delta})$$

Assume all our parameters vary by location

Harri et al. model

Procedures:

- Bayesian Hierarchical Modeling

$$\boldsymbol{Y} \sim p(\boldsymbol{Y}|\boldsymbol{\theta})$$

$$\boldsymbol{\theta} \sim p(\boldsymbol{\theta}|\boldsymbol{\lambda})$$

$$\boldsymbol{\lambda} \sim p(\boldsymbol{\lambda})$$

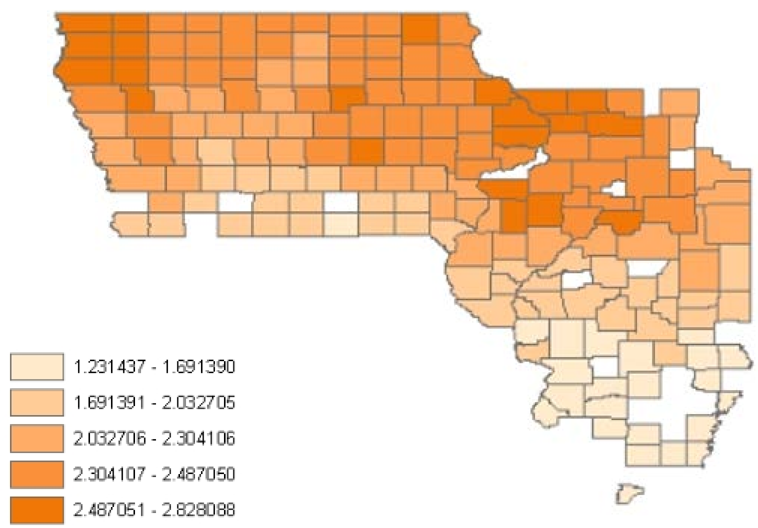
$$p(\boldsymbol{\theta}, \boldsymbol{\lambda}|\boldsymbol{Y}) \propto p(\boldsymbol{Y}|\boldsymbol{\theta}, \boldsymbol{\lambda}) * p(\boldsymbol{\theta}, \boldsymbol{\lambda})$$

$$p(\boldsymbol{\theta}, \boldsymbol{\lambda}|\boldsymbol{Y}) \propto p(\boldsymbol{Y}|\boldsymbol{\theta}, \boldsymbol{\lambda}) * p(\boldsymbol{\theta}|\boldsymbol{\lambda}) * p(\boldsymbol{\lambda})$$

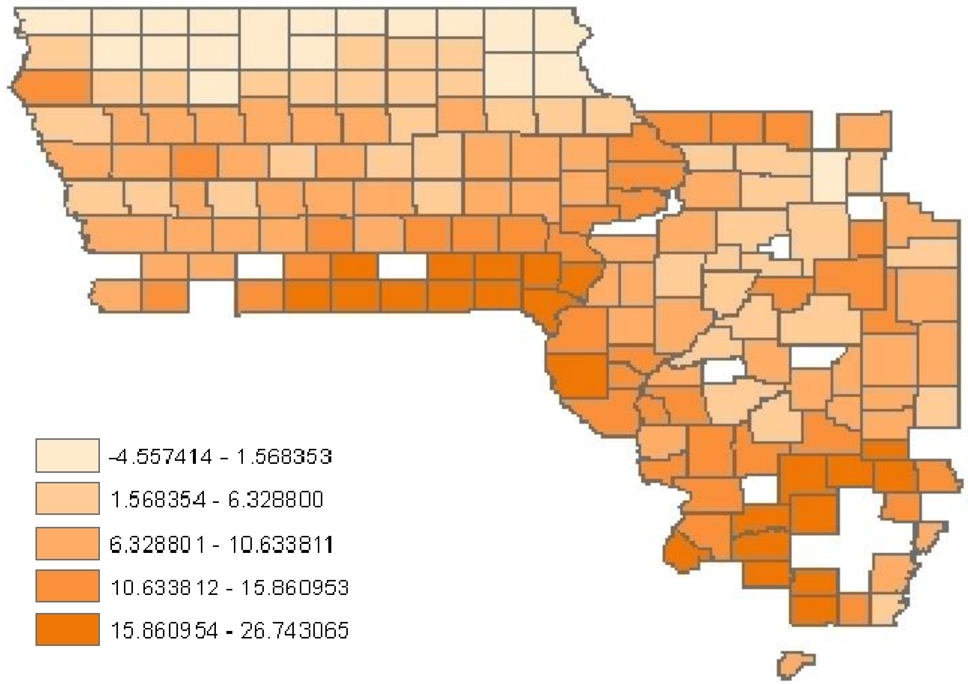
Computational Issues

- Takes 1-2 days to run
- R is notoriously slow

Results: 2015 Mean Trend

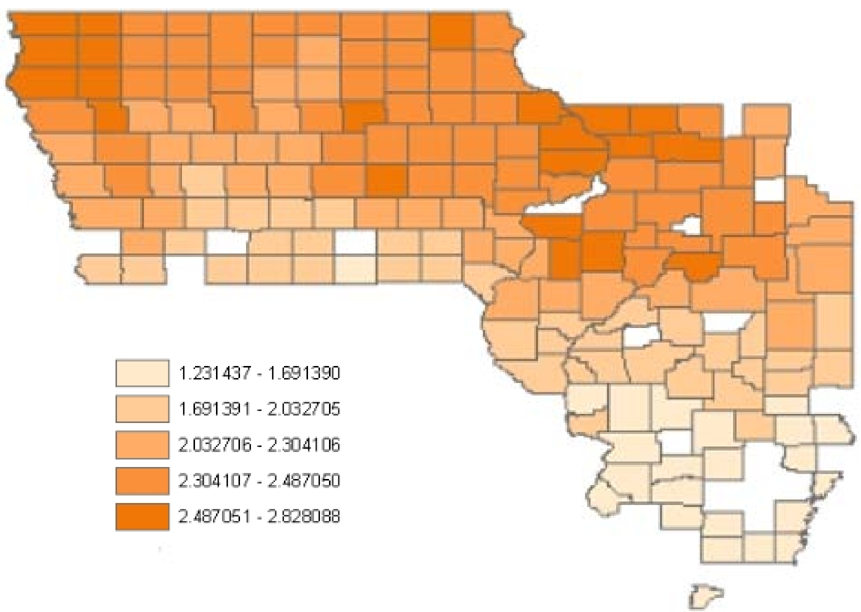


Results: 2015 Variance Trend

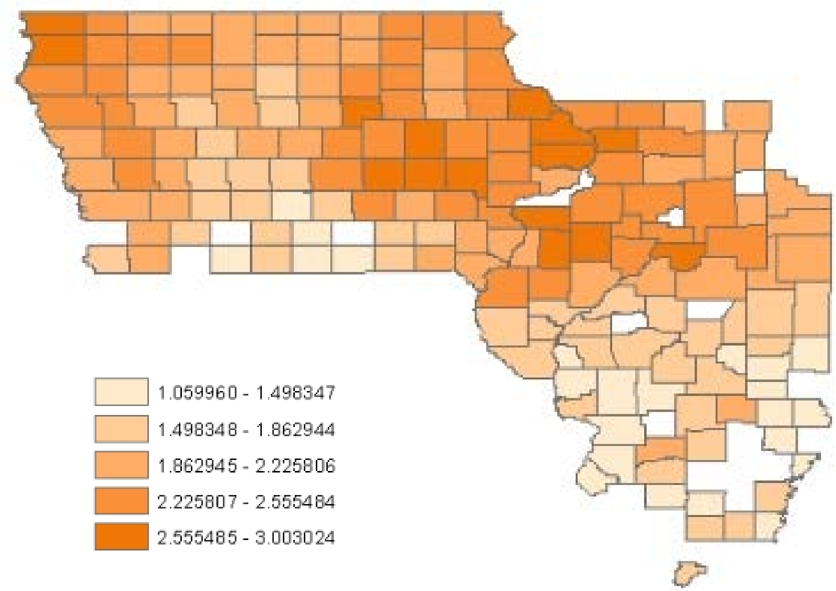


Comparing trend of mean equation

Bayesian Kriging (2015)

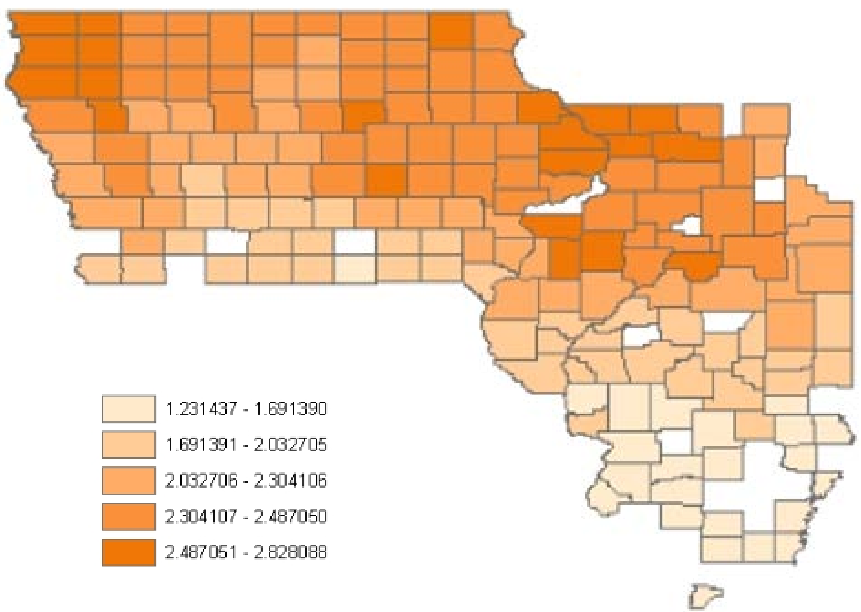


OLS for each county (2015)

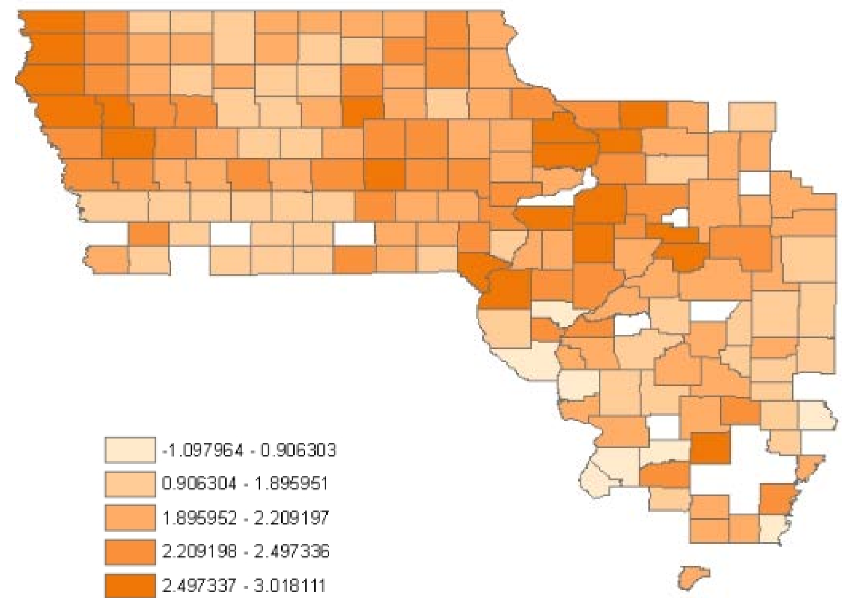


Comparing trend of mean equation

Bayesian Kriging (2015)



BMA (2015)



Conclusions

- Bayesian Kriging leads to smoother maps
- Out of sample forecasting?
- Tool that could work with a wide variety of spatial data