2022 WHI Investigator Meeting, Plenary 3:

WHI Risk It?

Spatiotemporal Prediction and Validation of Home Radon Exposures and Their Uncertainties

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Outline of This Talk

- RADON: a radioactive gas commonly found in homes; exposures may be increasing
- HEALTH EFFECTS: lung cancer, cardiovascular effects including strokes, potentially others
- PROPOSAL: investigate the relationship between home radon exposure and stroke based on WHI and other cohorts
- We need a viable method of estimating individual exposure to radon
- Unlike common air pollutants such as particulate matter and ozone, there is no national monitoring program for radon
- Nevertheless, there are large historical datasets available (previous talk)
- This talk shows preliminary results for radon exposure estimation and discusses proposed future research

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Radon Data Sources

- SRRS: Large dataset (>60,000 homes), historical (1986-1992), limited coverage
- NRRS: Smaller but more comprehensive
- Open File Reports (>200,000 homes)
- CDC surveys
- The USGS/EPA Radon Province Map, gives Geologic Radon Potential (GRP) at fine scale classified as “high” (estimated radon level >4 pCi/L), “moderate/ variable” (2--4 pCi/L) or “low” (<2 pCi/L)
- In this talk, I will concentrate on the SRRS and GRP. Other information sources will be added later.

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Geologic Radon Potential Map (GRP, pCi/L)

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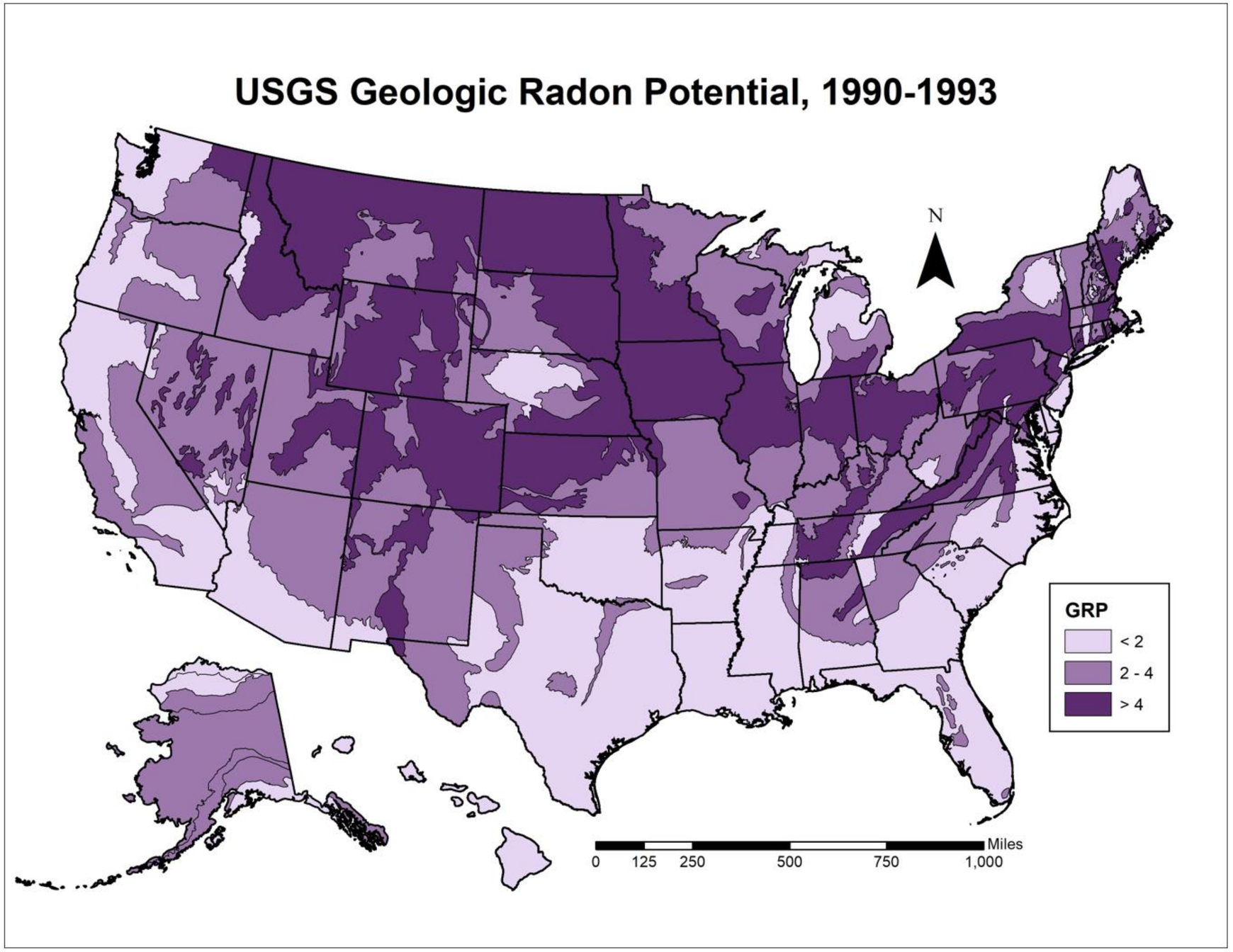

Previous Analyses

- Several papers from Lawrence Berkeley National Lab in 1990s*
- County-level data; Bayesian hierarchical models, but not "spatial"
- Current epidemiological analyses are based on county-level interpolations or the GRP/EPA three-level classification (next talk)
- Our objective: interpolate radon levels on a continuous scale

* e.g. C. Lin, A. Gelman, P. Price, and D. Krantz, Analysis of local decisions using hierarchical modeling, applied to home radon measurement and remediation. Statistical Science, 14(3):305-337, 1999.

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Methods of Spatial Interpolation

- Classical approach: Optimal linear interpolation based on estimated covariance structure (a.k.a. “kriging”)
- Many extensions in last 20 years, e.g. methods based on splines and wavelets, multiresolution approximations, fixed rank approximations, Bayesian methods
- Modern implementations of Bayesian methods allow for much more general models, including Gaussian processes as a latent process (the STAN package)
- Our strategy is to start with kriging and then extend it to accommodate the multiple sources of data

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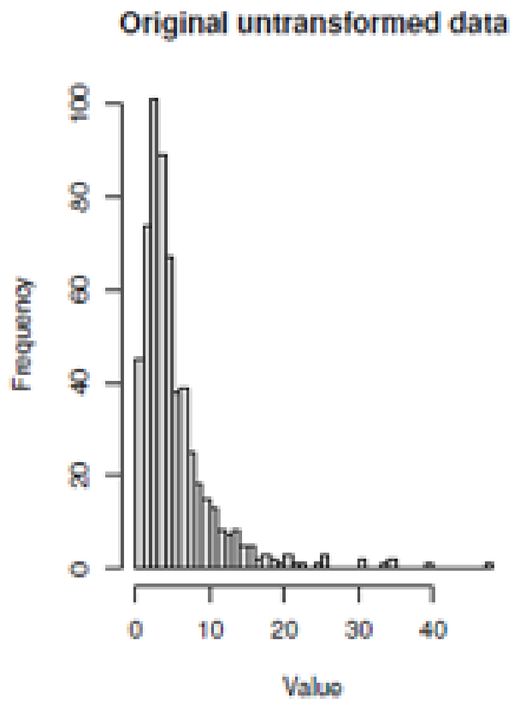
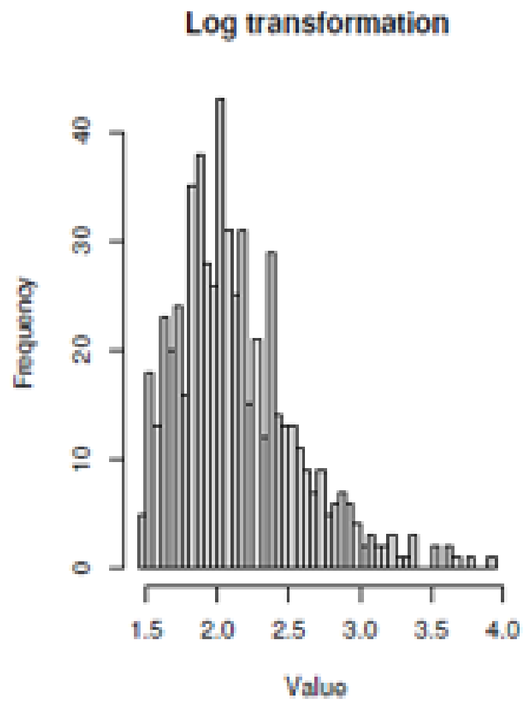
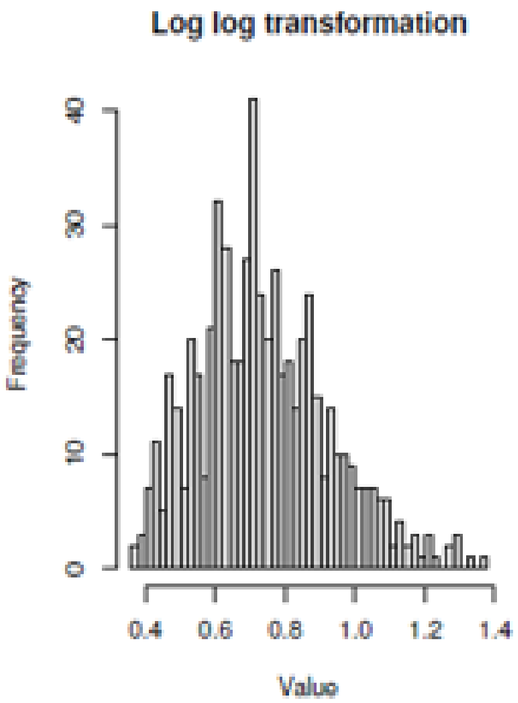
One issue is the extreme skewness of the data







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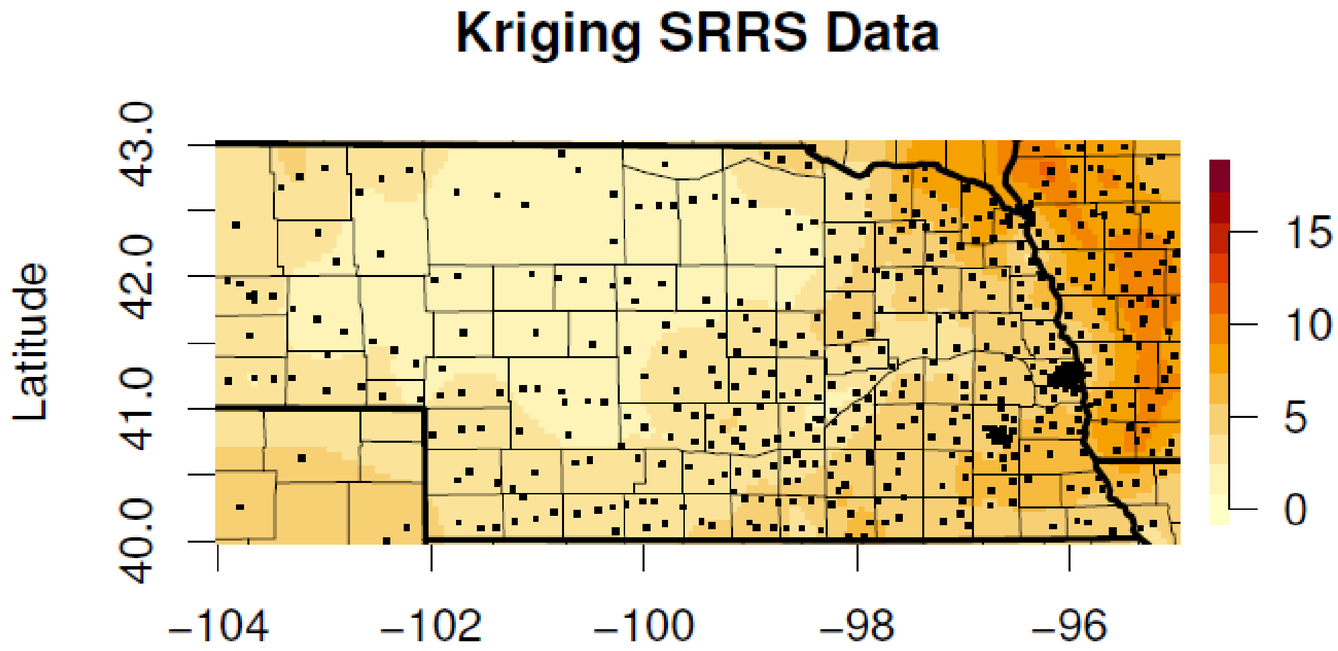
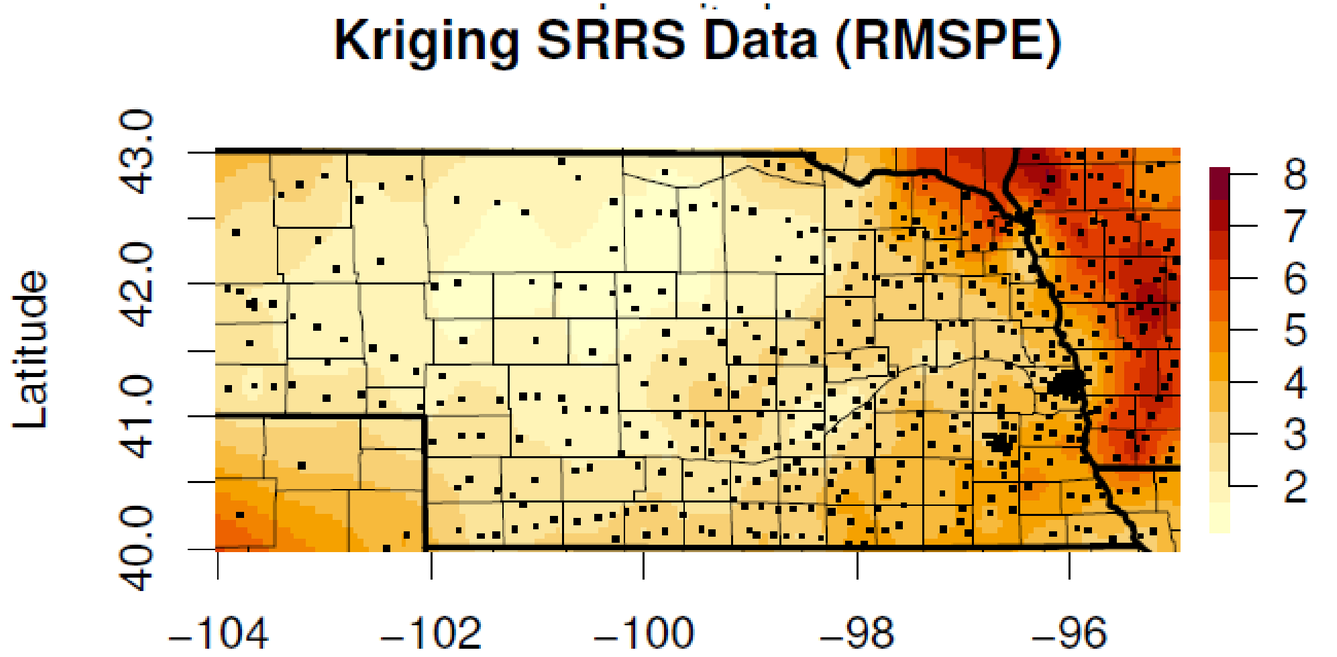
Spatial map (and error estimates) for Nebraska





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Combining SRRS and GRP data

- GRP data combine SRRS with several other sources of data, e.g. geological
- However it quickly became apparent that the nominal cut points (2 and 4 pCi/L) did not correspond to the SRRS data in our samples
- In this analysis, we consider the SRRS data to represent the true model and GRP as a noisy version of that
- Future latent process model will allow for multiple data sources to be combined

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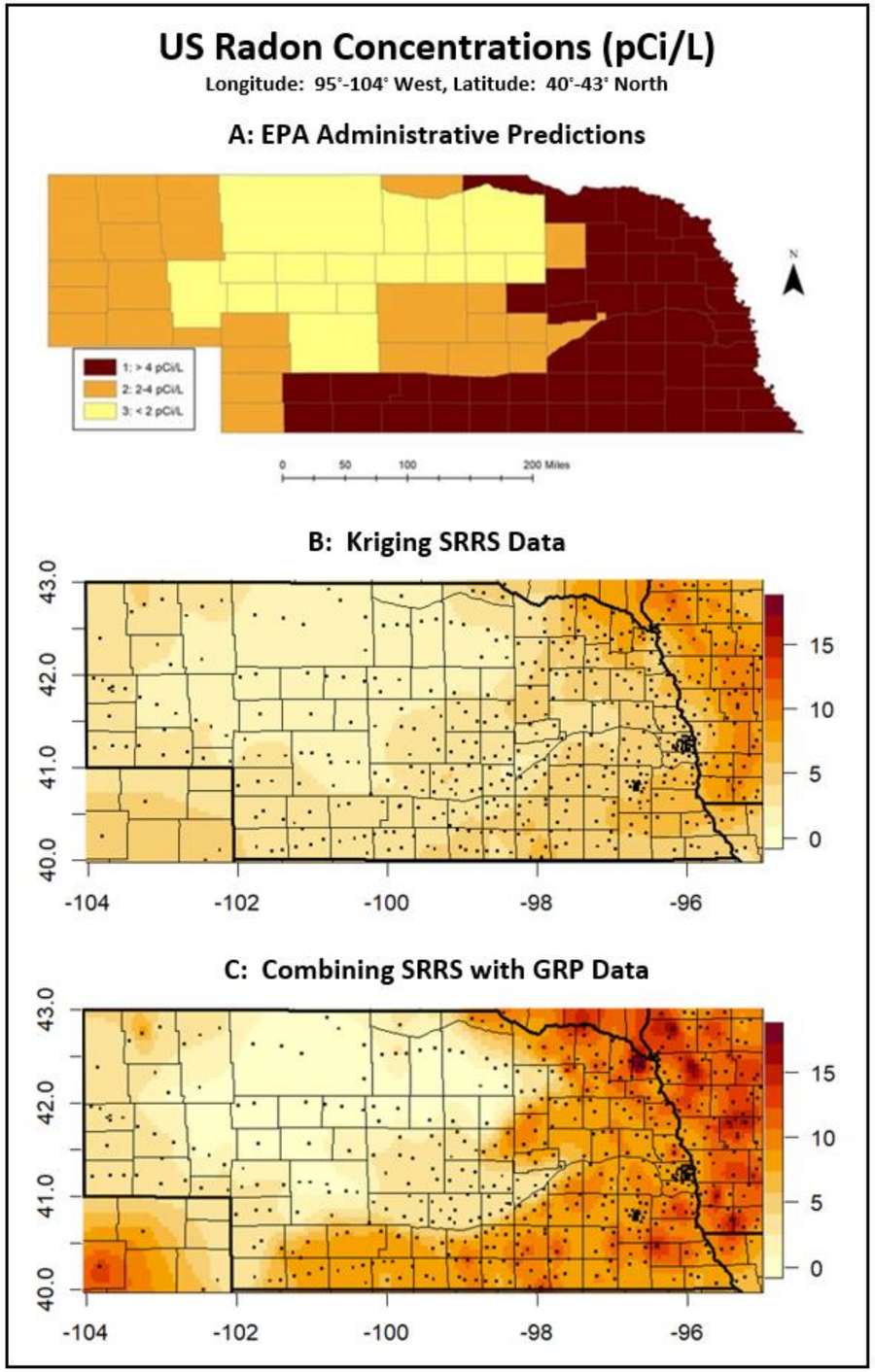
Reprise Nebraska

Compare kriging maps with EPA predictions



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Results for Tennessee

Compare kriging maps with EPA predictions

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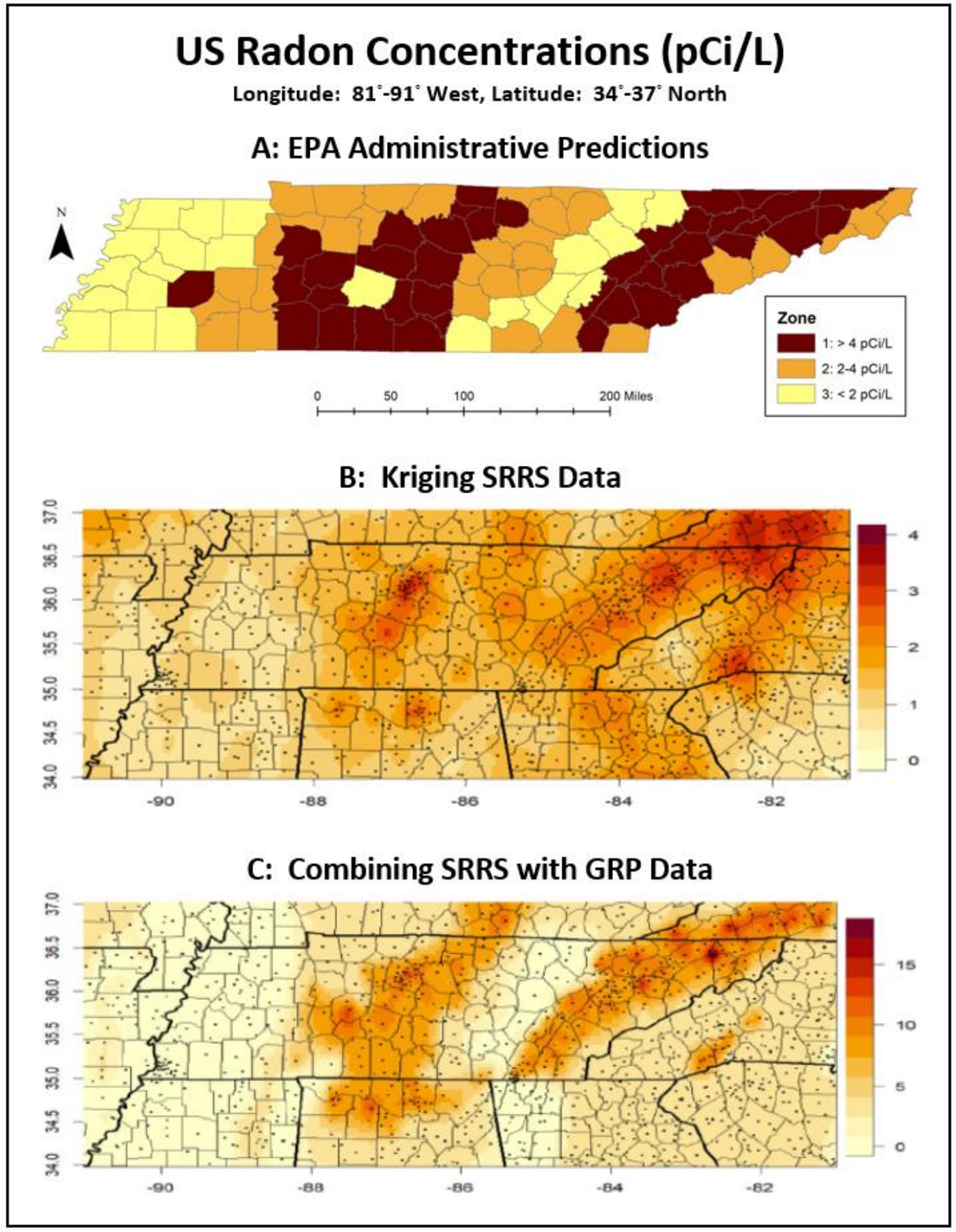
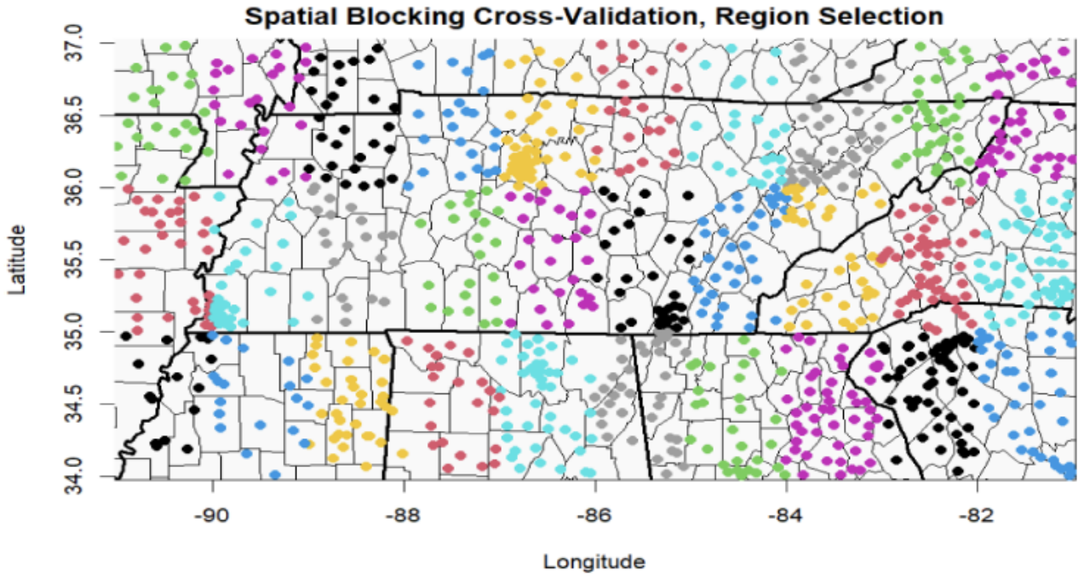
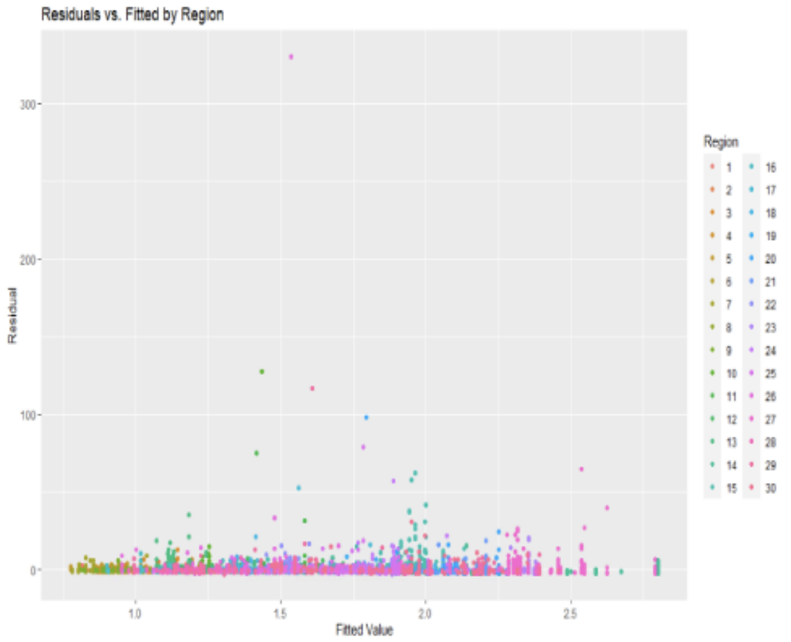


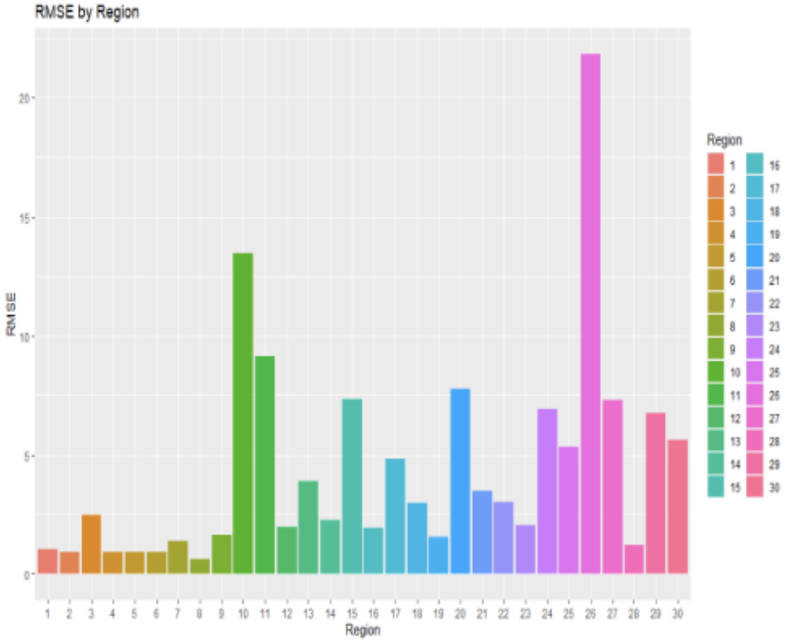
Evaluating the Results



- Cross-Validation
- Spatial Blocking (Roberts et al, 2017)
- 30 Blocks cover Tennessee



(a) Residuals against fitted values



(b) RMSE by region

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Exposure Validation

- We will validate the exposure models by sampling WHI homes using AirChek samplers
- Random sample of 1,008 current participants
- These new samples will be combined with the previous spatial analysis to derive updated individual-household level estimates of radon

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Conclusions

Spatial interpolation of radon data (with uncertainty estimation) is feasible

The results may be sharpened by combining different data sources, e.g. SRRS and GRP

Future work will consider different statistical methods to combine multiple sources of data, to explore temporal changes in exposure, and how the estimates may be sharpened using survey data from WHI participants

Acknowledgments

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