Spatial variation of fine particulate matter elemental concentrations in New York City

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Health

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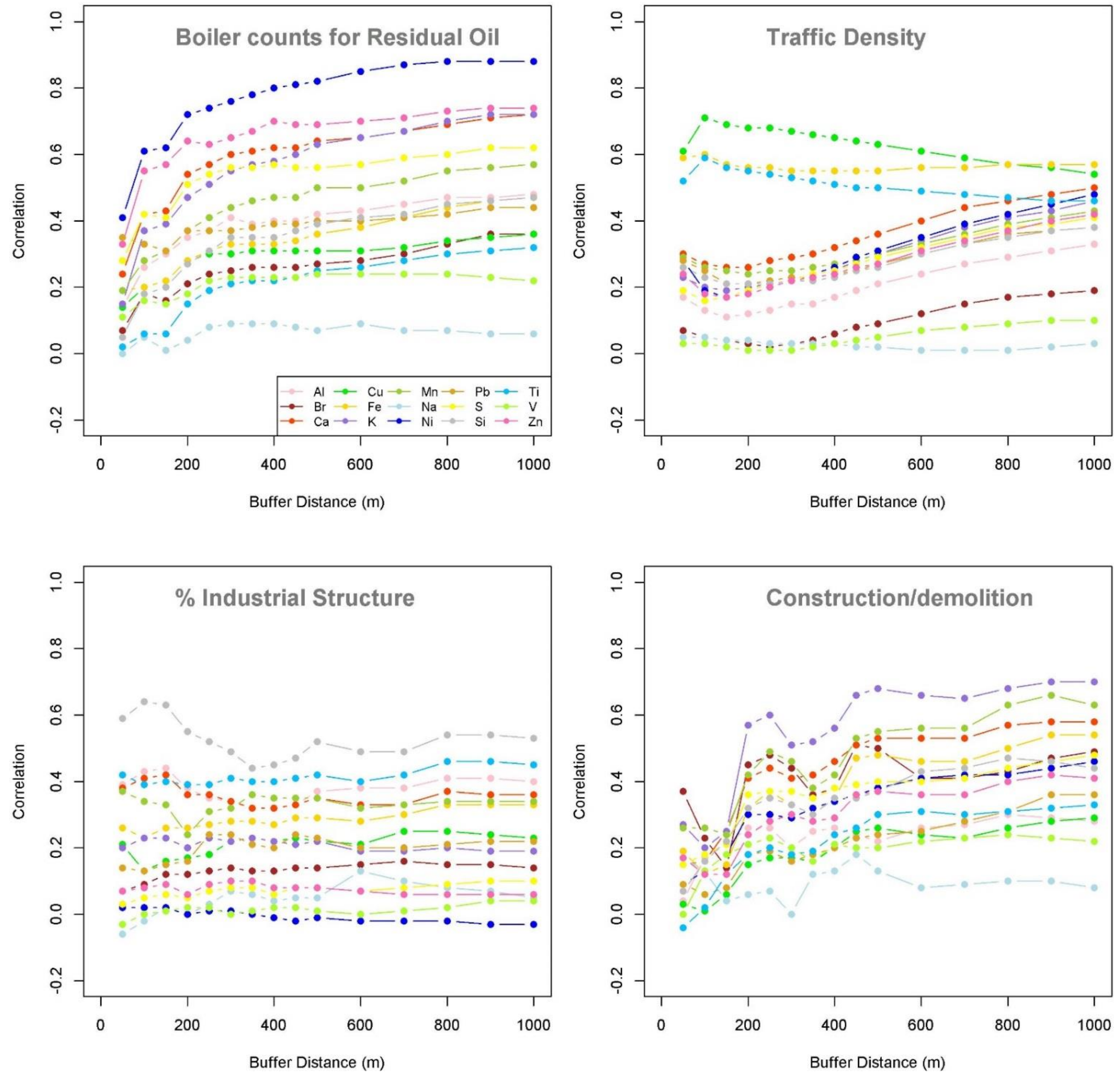
Data

- $PM_{2.5}$ filters collected as part of New York City Community Air Survey (NYCCAS) were analyzed for 50 elements by X-ray fluorescent method by Desert Research Institute
- 15 elements with 70% of measurements above uncertainty were considered for data analysis: Al, Br, Ca, Cu, Fe, K, Mn, Na, Ni, Pb, S, Si, Ti, V, and Zn
- Main analysis focused on the first year of NYCCAS, Dec. 2008 – Nov. 2009 at 150 sites
- Summer- and winter-only data were available at 99 sites in the subsequent 3 years, up to 2012
- Limited measurements of elements by ICP-MS from coarse and fine fractions at 10 locations in the fall 2009

Method

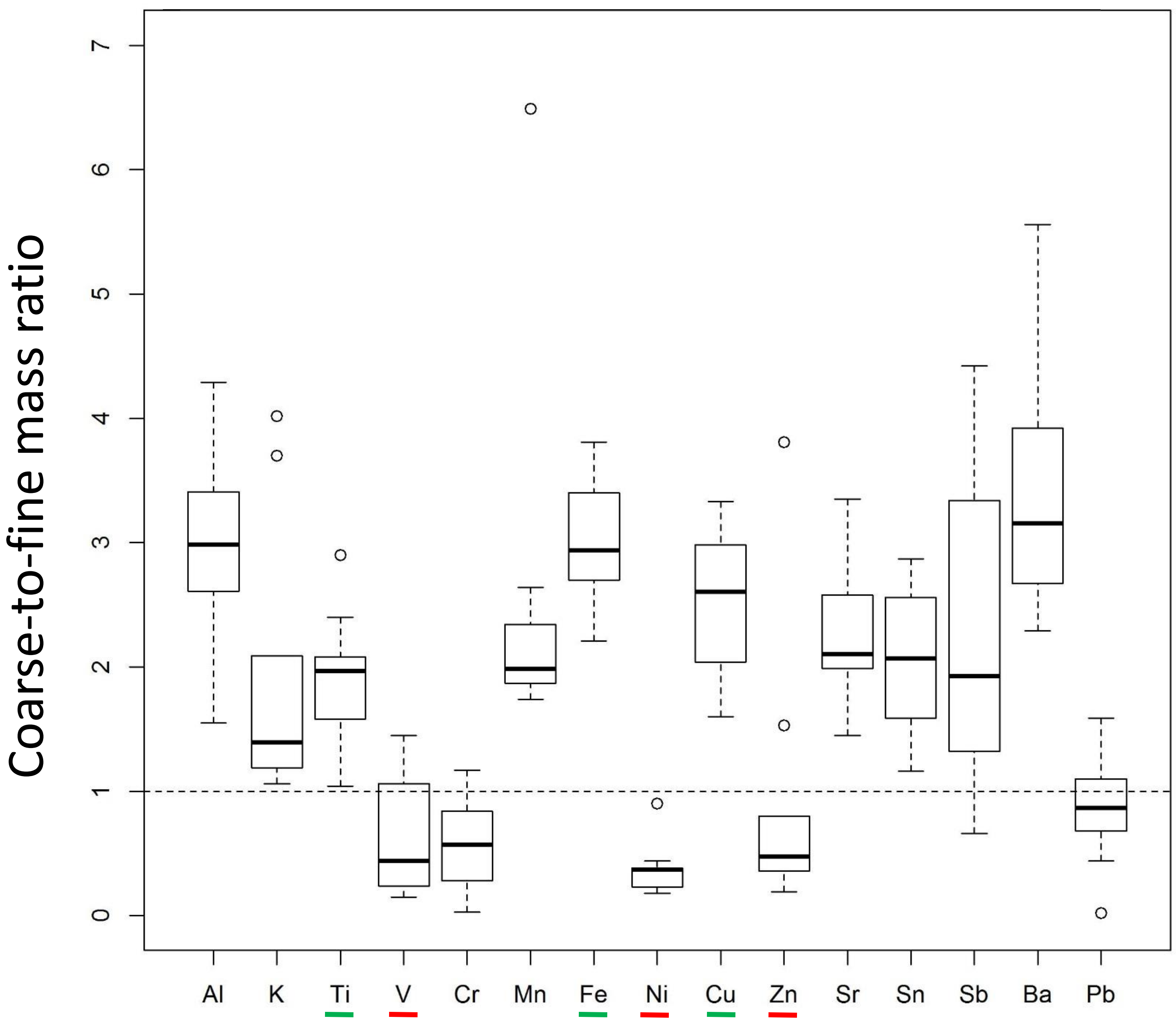
- Temporal adjustment of the two-week samples at 150 sites
- Each element was examined for its association with each of the six spatial emission indicators:
  (1) the number of permitted sources for fuel type # 4 and 6 (i.e., residual oil)
  (2) kernel weighted traffic density
  (3) land-use area of industrial structures
  (4) construction/demolition activity
  (5) ship emission
  (6) commercial charbroiling

  * For (1) – (4), 15 buffers between 50 to 1000 meters
- Forward step-wise Land-Use Regression (LUR) models with the emission indicators entering the model in the order above.
- Adjusted for spatial auto-correlation when necessary; leave-one-out cross validation
- Repeated for each of the four winter/summer data sets in the 99-site data set.



Correlation between $PM_{2.5}$ elements and four buffer-based emission indicators

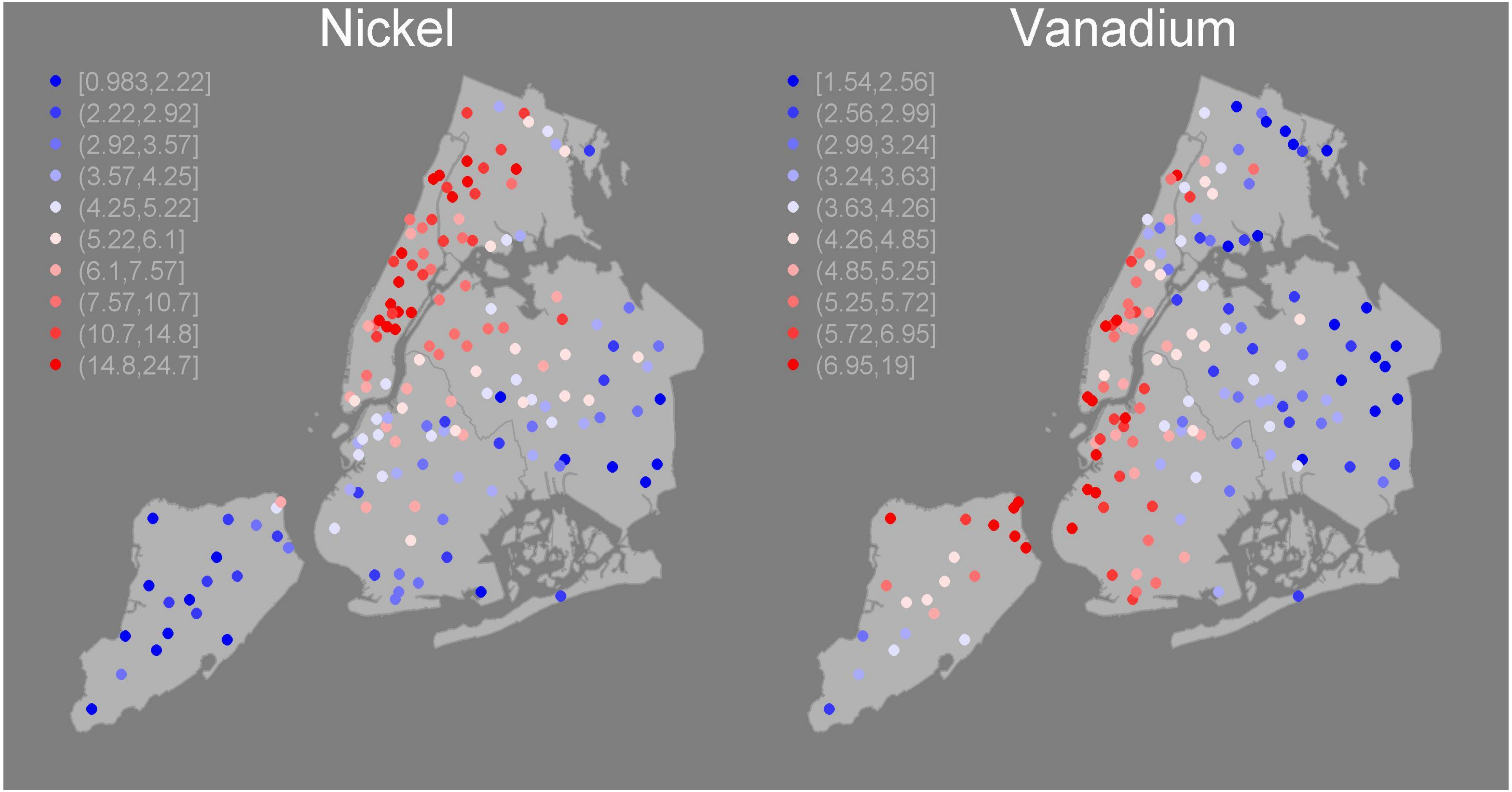
- Ni, Zn, and Ca show high correlations with the residual oil indicator as buffer distance increases
- Cu, Fe, and Ti showed high correlations with traffic density at shorter buffer distances
- Si showed the highest correlation with the industrial structure indicator
- Br showed the highest correlation with the construction/demolition indicator

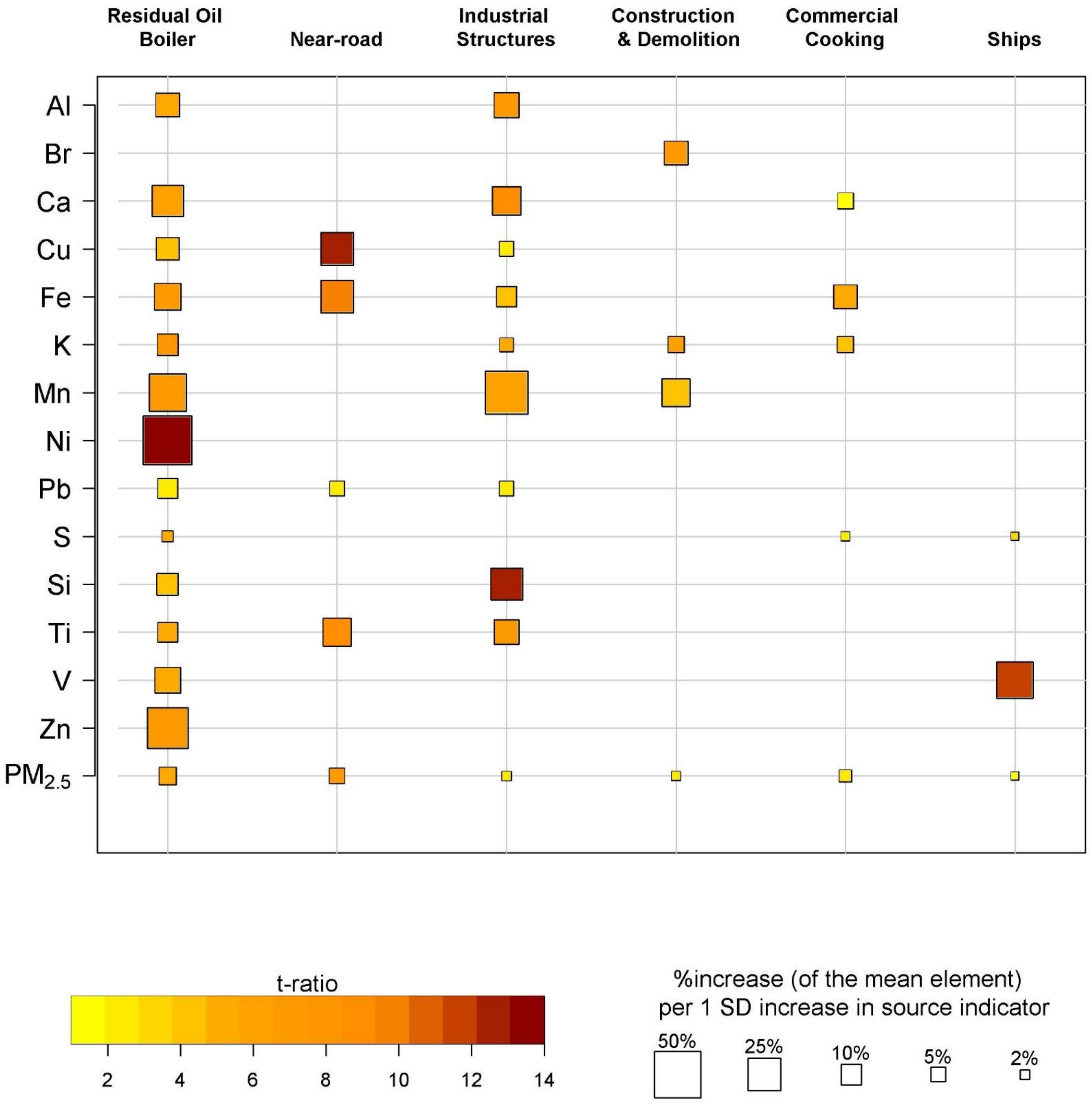


Ratio of $PM_{10-2.5}$ to $PM_{2.5}$ element mass concentrations at 10 NYCCAS sites

- A limited special study at 10 NYCCAS sites during six days in September 2009 with co-located PM_{10} and $PM_{2.5}$ samplers
- Samples were analyzed using ICP-MS by Desert Research Institute
- Ni, V, and Zn show low coarse-to-fine mass ratios, indicating that these elements are combustion-related
- Cu, Fe, and Ti show high coarse-to-fine mass ratios, indicating non-exhaust related traffic source (i.e., brake wear)

Spatial variation of nickel and vanadium in New York City

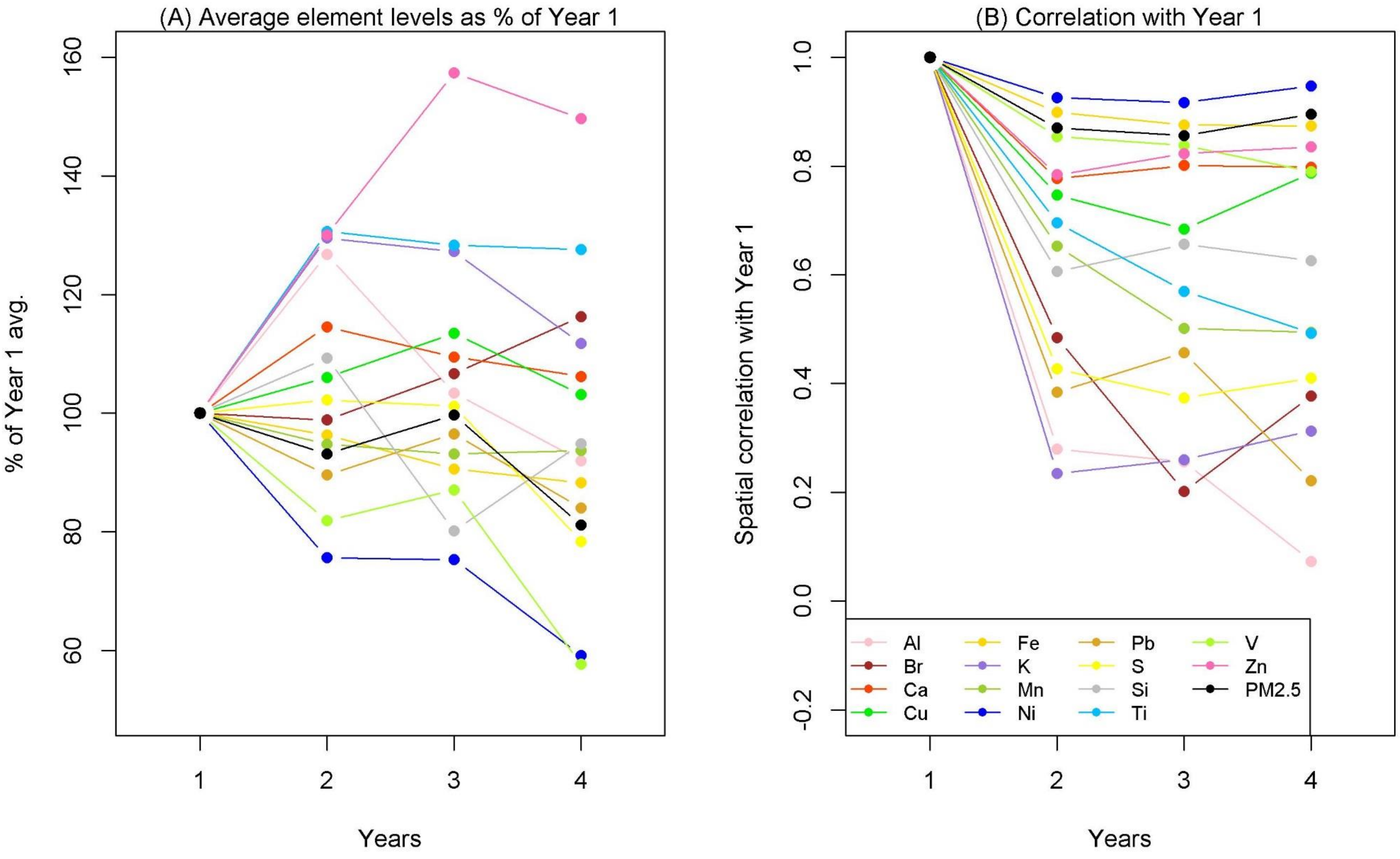




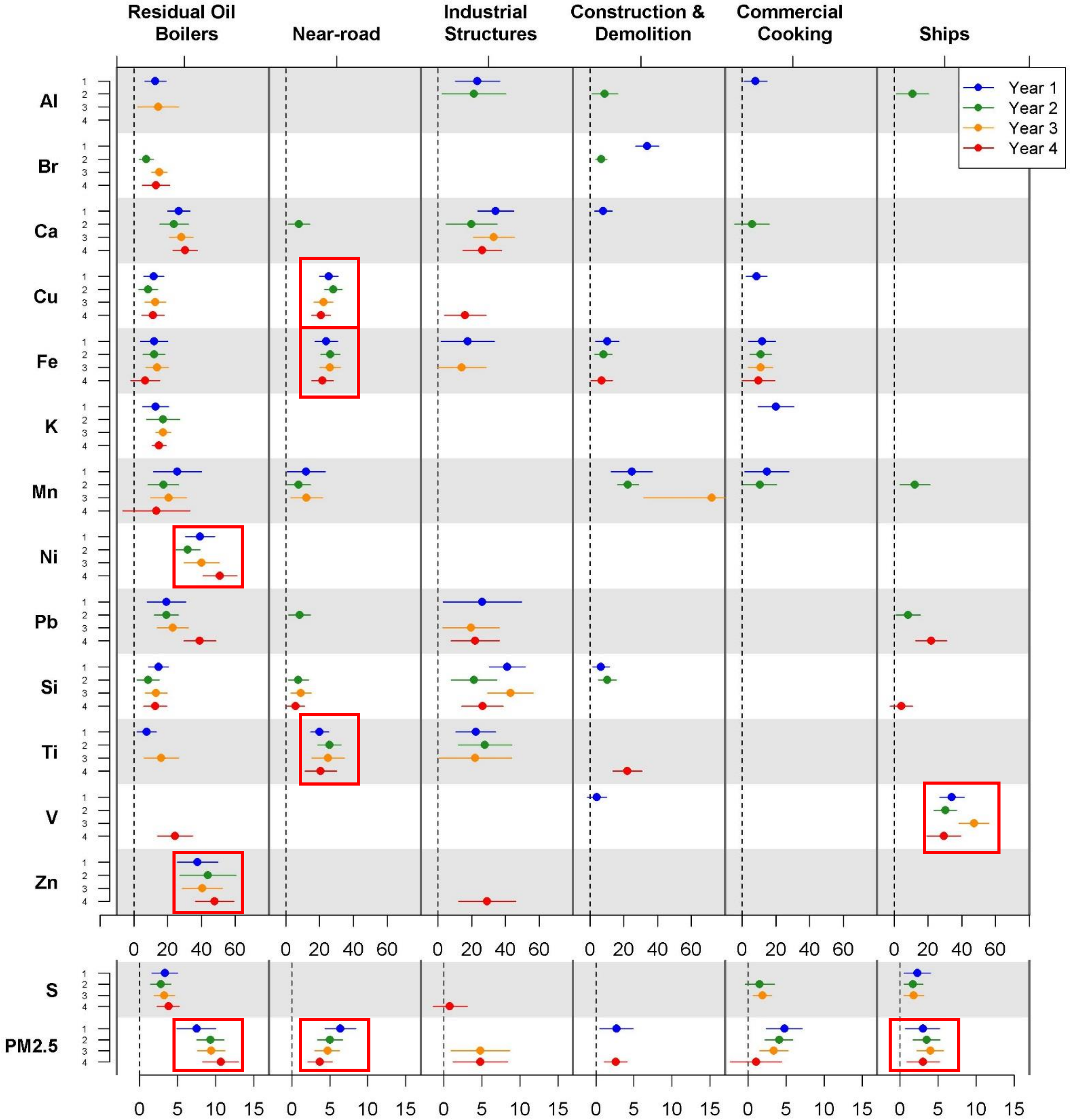
Land-use regression result

- Percent increase in mass from the mean per 1 standard deviation increase in source indicator
- Residual oil indicator was associated with most of the elements, especially strongly with Ni and Zn
- Near-road indicator was strongly associated with Cu, Fe, and Ti
- Area of industrial structure was associated with multiple elements, most strongly with Si
- Ship emission indicator was strongly associated with V

Trends in $PM_{2.5}$ elements concentrations and spatial correlations over four years



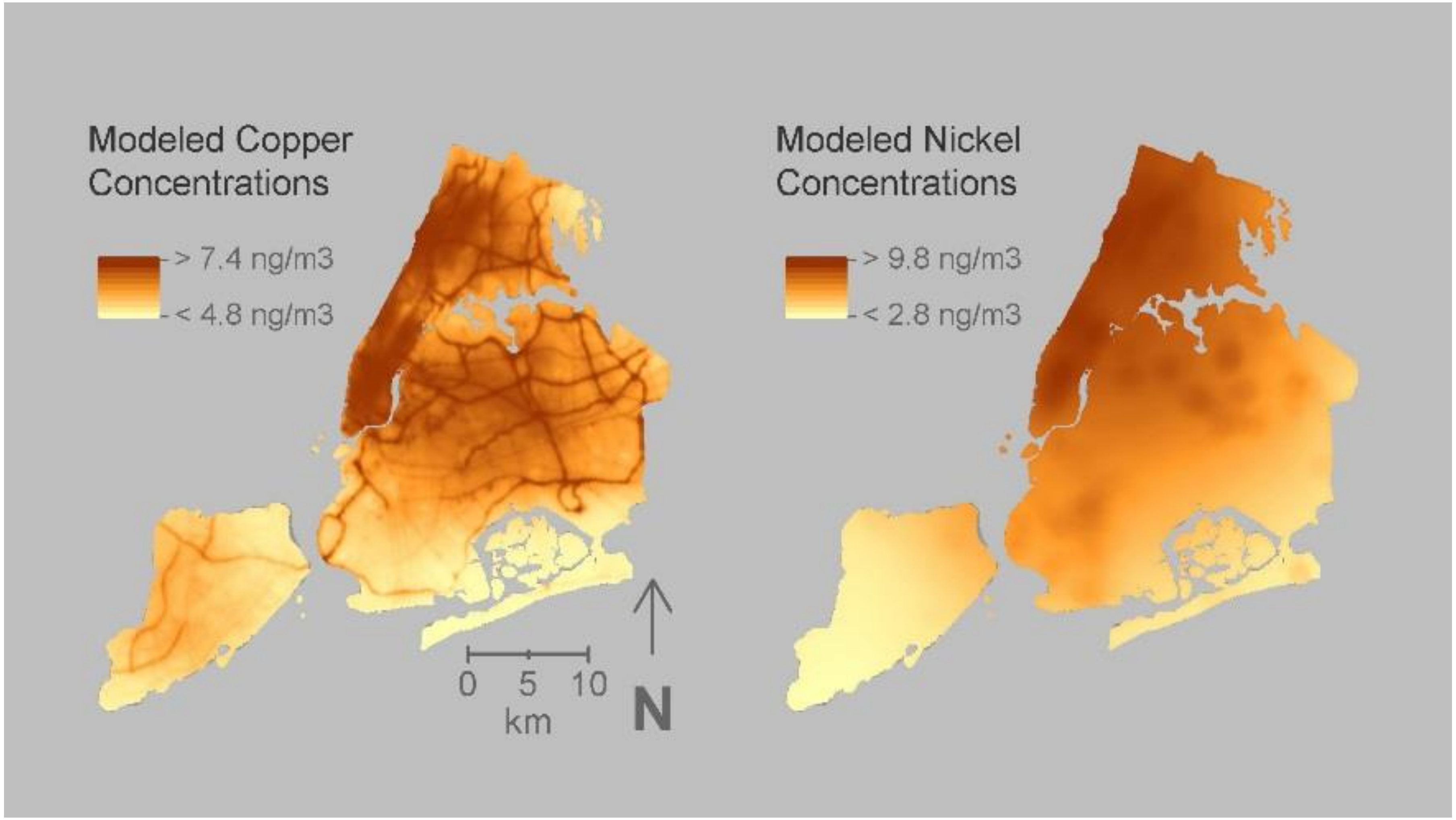
- Levels of Ni and V declined by ~40% over the period
- Despite the declines, spatial patterns for both Ni and V show strong correlations (r > 0.8) between Year 1 and Year 4.
- Zn showed an increase (> 50%) over the period, but their spatial patterns are highly correlated over time.
- $PM_{2.5}$ mass declined by ~18% in Year 4, but the spatial patterns were highly correlated across years.



Consistency of LUR results across Years 1 through 4

- Residual oil indicator’s associations with Ni and Zn were consistent across years
- Near-road indicator’s associations with Cu, Fe, and Ti were consistent across years
- Ship emission indicator’s association with V was consistent across years

Modeled Cu and Ni from LUR results



- Using the emission indicators' values at 100m x 100m lattice cells in NYC (~80,000 lattice cells) and the LUR models, PM2.5 elemental concentrations could be predicted at these lattice cells.

Summary:

- Land-use regression models were useful in describing spatial variation of $PM_{2.5}$ elemental concentrations in New York City

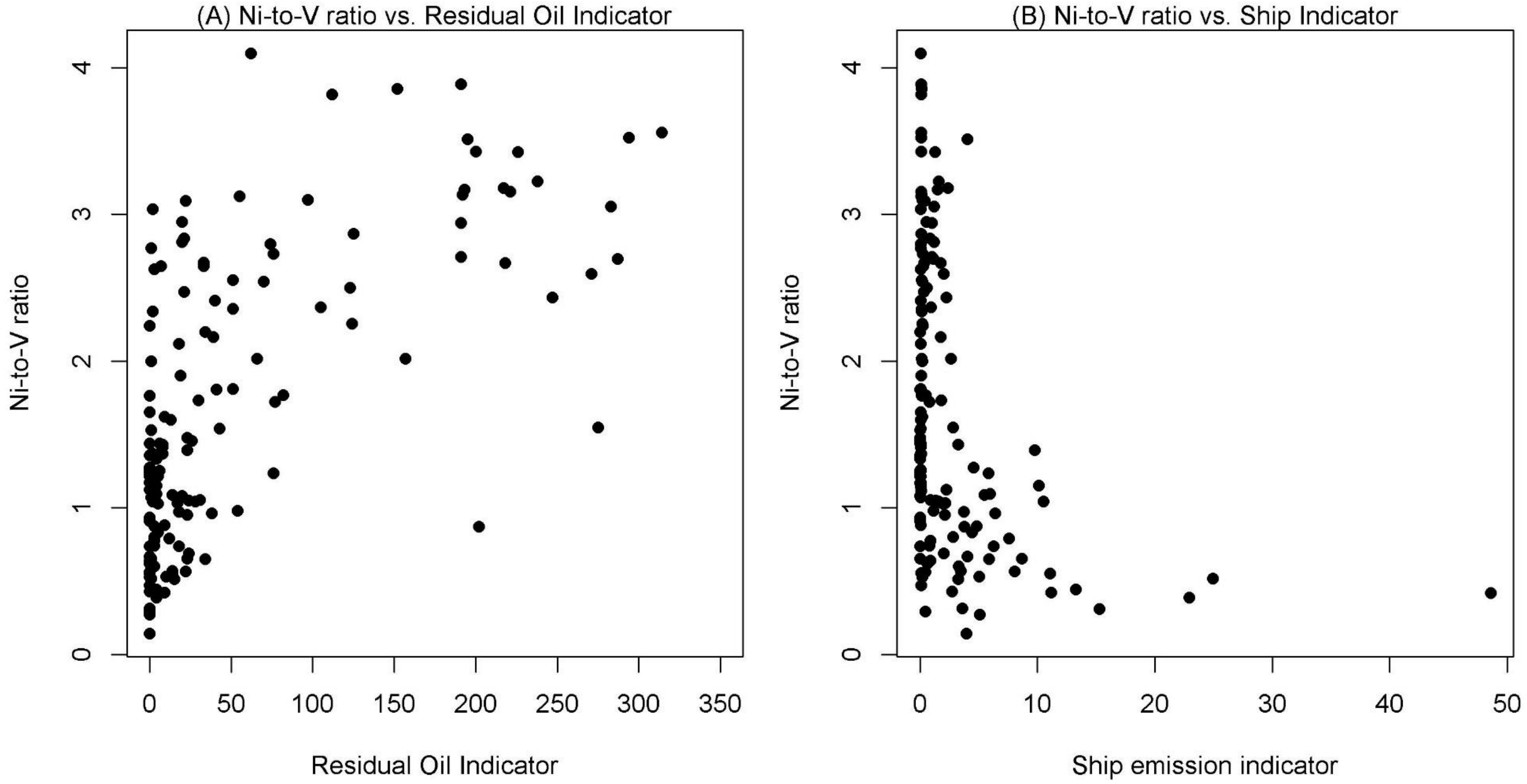
- Strong source-element associations, persistent across years, were found for:
  - residual oil burning (Ni, Zn);
  - near-road non-exhaust traffic (Cu, Fe, Ti); and,
  - ship traffic (V).

- These emission source indicators were also significant and consistent predictors of $PM_{2.5}$ concentrations across years.

- These estimated PM2.5 elemental concentrations can be used to estimate exposures in epidemiological analyses

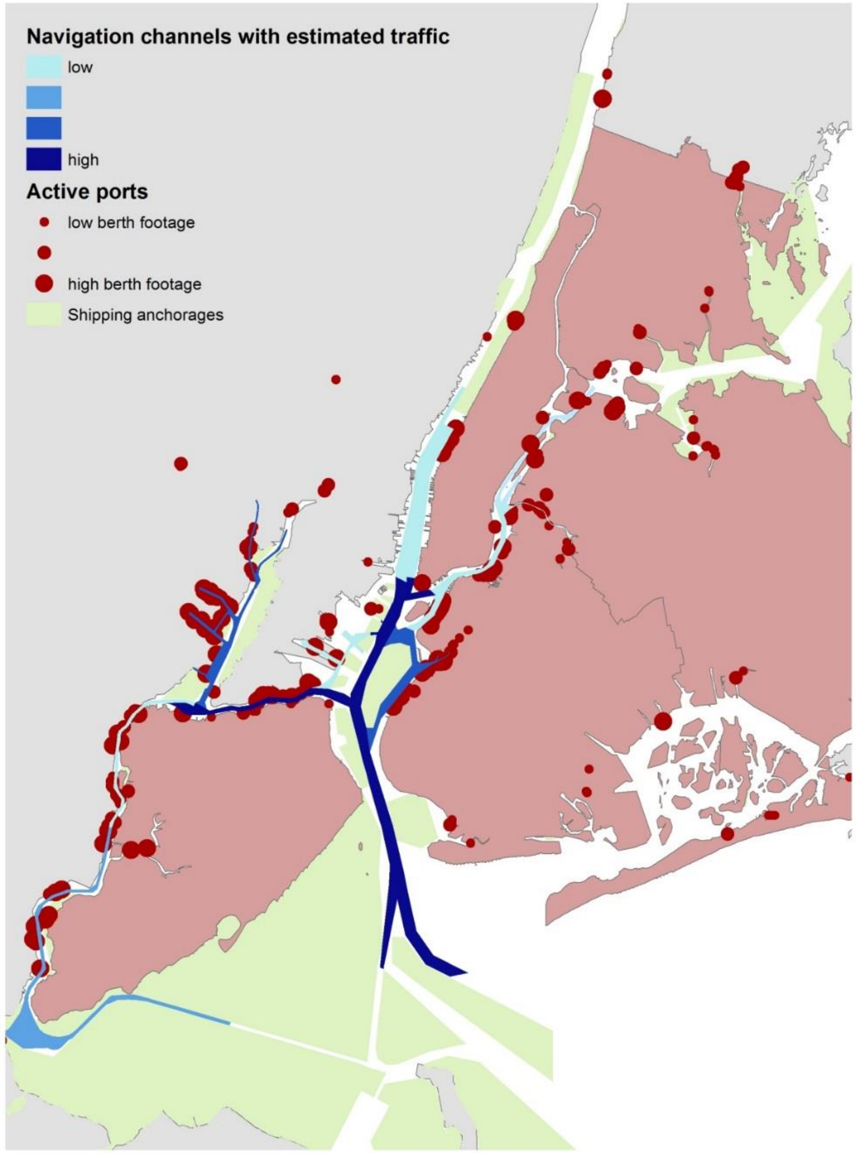
Extra slides:

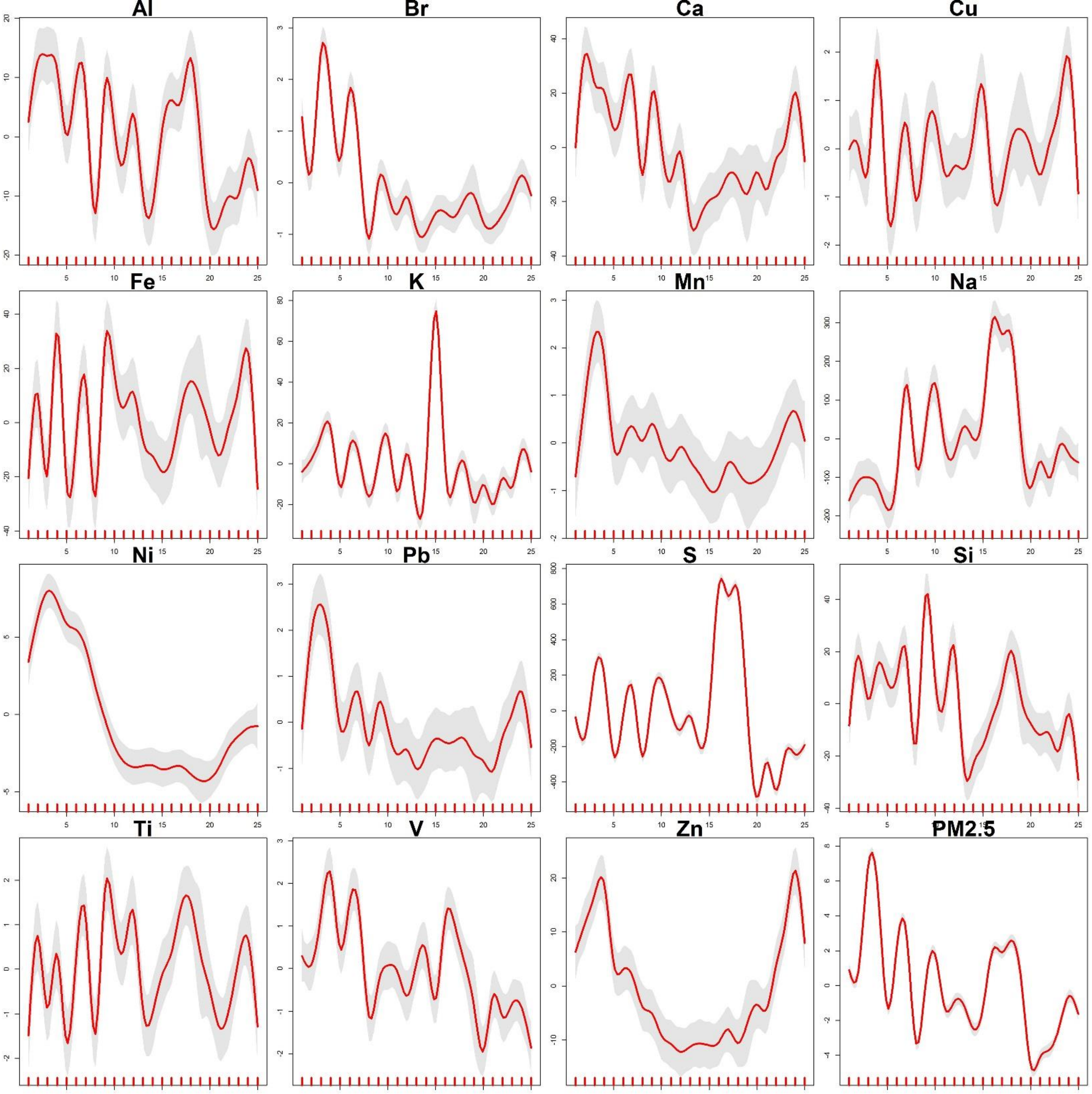
Ni-to-V ratios at 150 sites and their relationships to residual oil and ship emission indicators



- Higher Ni/V ratio is associated with residual oil indicator
- Lower Ni/V ratio is associated with ship emission indicator

New York Harbor Spatial Variables Construction





Smoothed temporal pattern of PM2.5 elements in the first year (25 sessions).