Uncertainty Visualization on Geospatial Data for Nitrogen Leaching

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Motivation

Nitrogen (N)

- ❖Most common pure element in the earth and essential nutrient for crop
  - ➢Making up 78.1% of the entire volume of the atmosphere
- ❖Why is nitrate a problem?
  - ➢Cause cancer & other health issues, and kill fish and other aquatic life
- ❖Where are the nitrate sources?
  - ➢Agricultural lands
  - ➢Natural lands
  - ➢Urban areas with leaky sewer lines
  - ➢Wastewater

How much nitrogen does a farmer use?

- ❖Irrigation, crop type, and management practices
- ❖Grower's tradition
- ❖Soil water drainage
- ❖Rainfall
- ❖Usually 200% or more of the nitrogen harvested

Nitrogen (N) N-leaching prediction

- ❖A web-based application, named Nitrogen Leaching Calculator, developed to predict N-leaching across Nebraska in real-time
  - ➢Improve crop management
  - ➢Reduce N-leaching

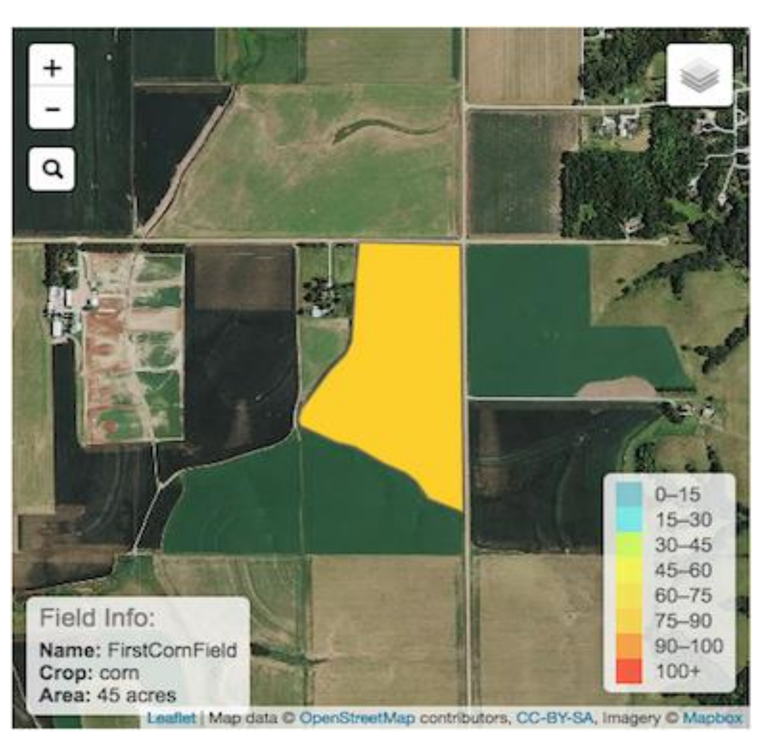

Figure 1. N-Leaching Calculator https://hprcc-agron1.unl.edu/

Uncertainty in N-leaching

- ❖Multiple input datasets for N-leaching prediction based on Maize-N model
  - ➢Weather data, soil type, fertilizer amount and type, user input data, and so on
- ❖How can we quantify N-leaching uncertainty?
- ❖How can we inform farmers about uncertainty?

Methodology

Finding uncertainty by calculating N-leaching from actual and estimated weather data

- ❖For a weather station location (the yellow point in Figure 2), we have its actual rainfall amount. We also estimate its rainfall amount by the interpolation of three closet weather stations (the blue points in Figure 2).
- ❖For each weather station location, we calculate N-leaching results using its actual and estimated rainfall amounts, and examine uncertainties caused by estimated values and impacts of different parameters.

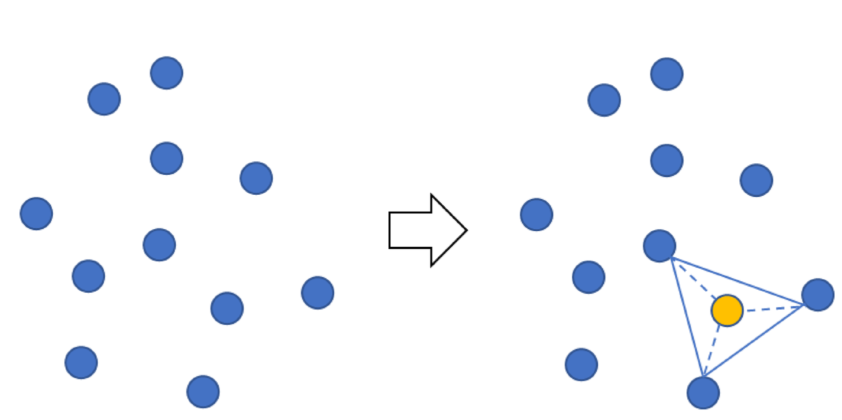

Figure 2. Weather data estimation using Inverse Distance Weighting (IDW) Interpolation.

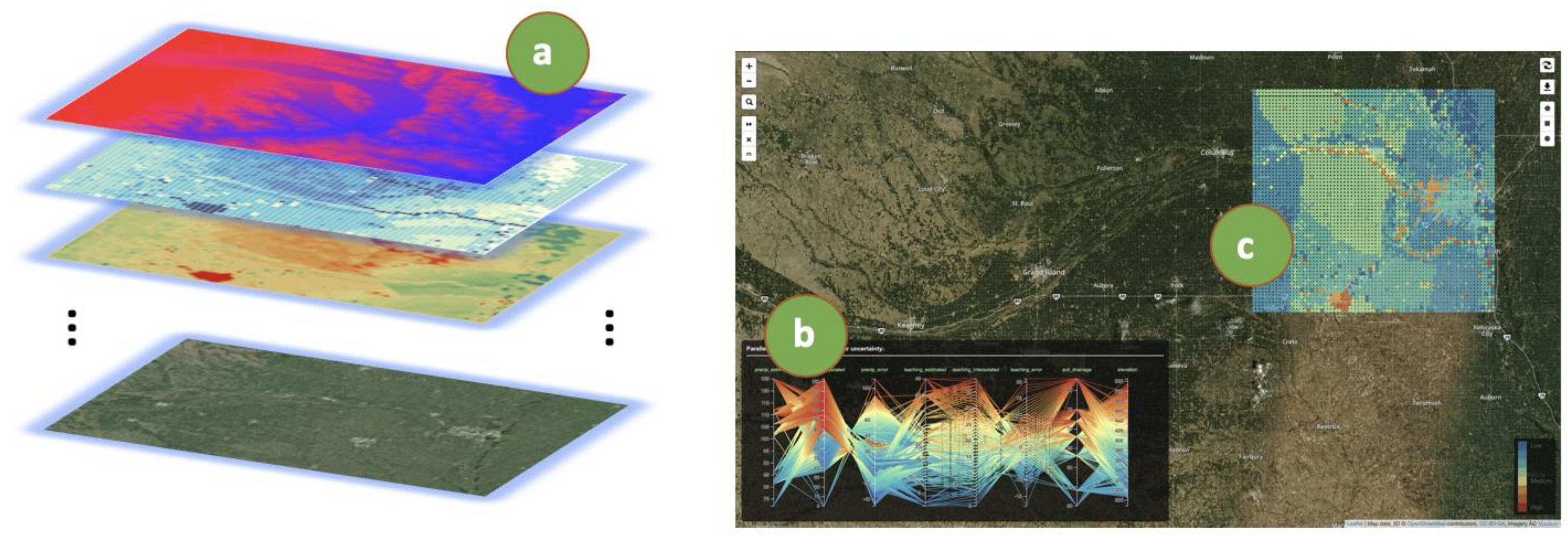

Figure 3. Main components of our visualization approach.

Visualization

Our approach allows user to display different parameters with different visualization styles.

- ❖Visualize each parameter as an individual layer superimposed on a map layer (Figure 3.a).
- ❖Visualize relationships among parameters using parallel coordinates (Figure 3.b), where a user can interactively brush parallel coordinates to examine parameter relationships.
- ❖Examine user-selected parameter ranges selected to explore their relationships and spatial distributions (Figure 3.c).

Results

Research area and preliminary results

- ❖We consider 80 weather-stations across Nebraska, and calculate uncertainty of each site using its actual and estimated weather data.
- ❖Users can select a polygon region on the map, and the calculated parameters (i.e., N-leaching, precipitation, error, elevation, etc.) of the selected region is then displayed as parallel coordinates plot.
- ❖ Users can brush different axes of parallel coordinates to examine parameter relationships and their spatial distributions (Figure 4).
- ❖Preliminary discoveries
  - ➢Highest level of precipitation may not necessarily cause highest N-leaching.
  - ➢Soil drainage can be low for small leaching amounts.
  - ➢Interpolated precipitation values can incur higher uncertainties in N-leaching prediction.

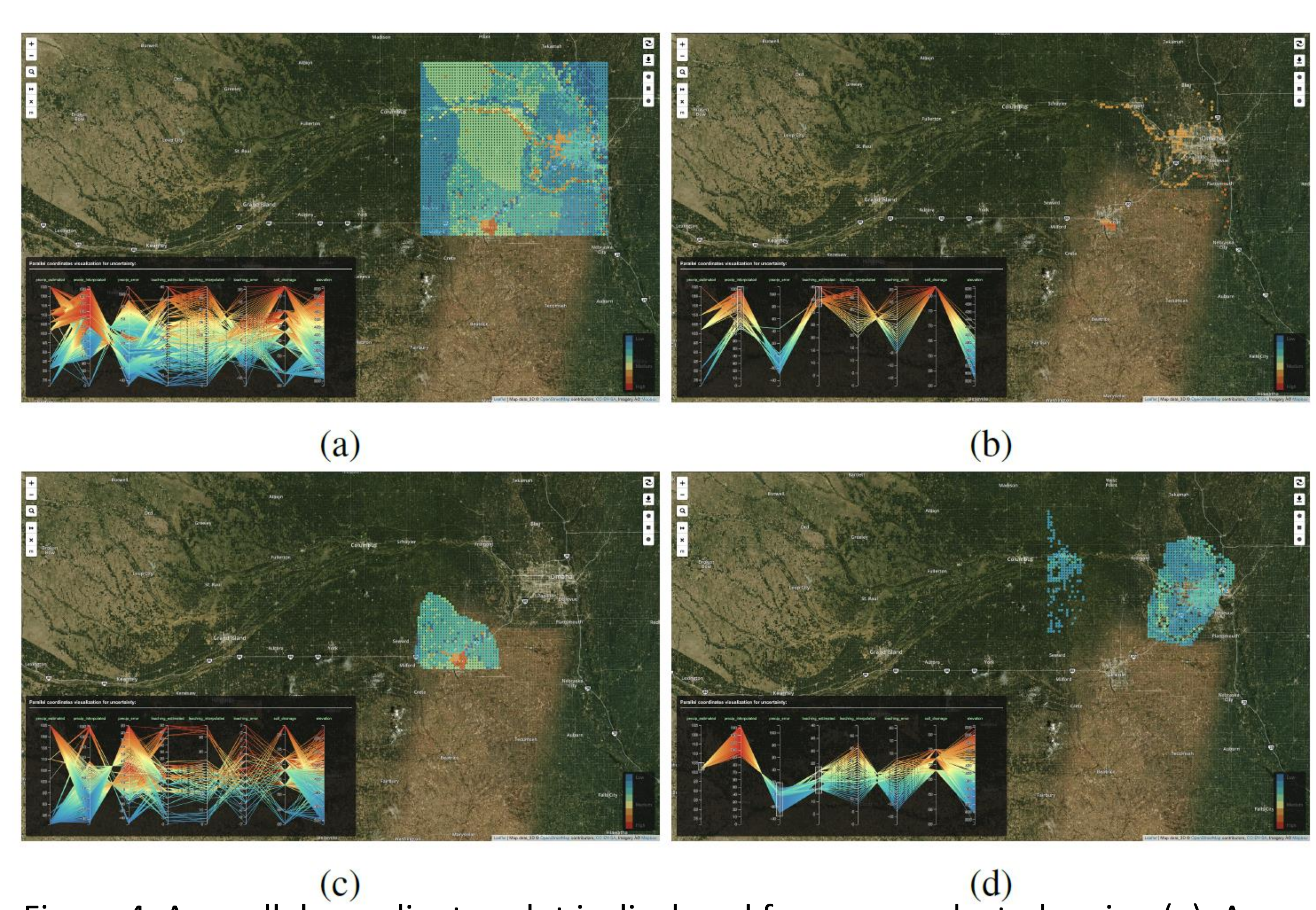

Figure 4. A parallel coordinates plot is displayed for a user-selected region (a). A user can brush different axes of the parallel coordinates plot to explore their relationships and corresponding spatial distributions (b)-(d).

Conclusion

- ❖ Visualize uncertainty in N-leaching prediction.
- ❖ Gain a better understanding of how different parameters (e.g., elevation, soli type, weather data, etc.) would impact N-leaching prediction and its uncertainty in different areas.