Spatial Analysis of Aflatoxin Contamination Risk for Corn Grown in Texas

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Introduction

Aflatoxin is a highly carcinogenic toxin produced by *Aspergillus* fungi that can infect corn crops in hot humid areas **(Figure 1)**. Due to the severe human health impacts, the level of the toxin in corn is strictly legislated in crops of corn that are sold or exported in bulk. However, aflatoxin levels are unlikely to be tested in corn sold directly to the consumer in farmers stalls as it is expensive to test. When the corn and fungi experience drought conditions during the delicate mid-silk growth stage aflatoxin levels have been shown to be higher. Previous work in Georgia showed that the mid-silk period occurred in June and that June Maximum temperatures greater than 33°C and June rainfall < 70mm were associated with elevated aflatoxin levels in corn **(Kerry et al. 2017, Yoo et al. 2018)**. Previous work in Georgia and Alabama also shows that negative correlation and high-low bivariate local Moran's I designations for Thermal IR and NDVI data for corn fields can indicate where there is highest risk of aflatoxin contamination **(Kerry et al. 2022, 2023)**.

This study examines links between monthly weather conditions/drought conditions and insurance claims for spoiled crops in the state of Texas. High risk years for the state of Texas are identified. Links between NDVI and Thermal IR from corn growing pixels in Landsat imagery and insurance claims are also investigated. The NDVI and thermal IR of corn crops in 2011, a high-risk year, for the Texas Pan Handle or High Plains area which grows a lot of corn are investigated in detail and links with insurance claims for spoiled crops are examined.

Methods

Weather Data: Monthly maximum temperatures (TMax) and precipitation (RF) for April – July 1995-2020 were downloaded for a 1 km grid for the whole of Texas from https://daymet.ornl.gov/getdata. Average Tmax and RF values per county were then calculated for each year. Indicators were made showing if the Tmax was >33°C and the RF was <70mm for each county and year. The proportion of counties with Tmax >33°C and RF <70mm was then calculated for each year.

Corn Growing Area: The Cropscape website uses time-series LandSat imagery to identify what crops are grown/the landuse for every 30m pixel in the USA. The corn growing pixels for each year 2008-2024 **(Figure 2)** were extracted from https://nassgeodata.gmu.edu/CropScape/ as well as a corn frequency layer which showed how many years in the 2008-2024 period corn was grown in each pixel.

AgRisk Insurance Data: The AgRisk viewer provides crop specific information on agricultural insurance claims from 1989-2024. Total Insurance claims ($) for corn that was spoiled between 1989 and 2024 due to aflatoxin, drought or heat damage were downloaded from https://swclimatehub.info/decision-support/tools/ **(Figure 3a)**. For each year the percentage of counties with greater than average insurance claims was calculated.

Landsat Data: Landsat 5 data were downloaded from https://earthexplorer.usgs.gov/ for the whole of Texas for beginning of July 2011 (identified as a high-risk year) **(Figure 4c)**. The LandSat data for the 21 most north-westerly counties in Texas were masked with the corn growing pixels for 2011 from the crop data layer. NDVI was calculated for each pixel and NDVI and Thermal IR values were per pixel were extracted for analysis.

Statistical Methods: Regression lines were fit between % of counties with higher than average AgRisk insurance payments and % of counties with Tmax >33°C and RF < 70mm. The univariate Local Moran's I was calculated to identify clusters of counties with high insurance payments **(Figure 3b)**. The bivariate Local Moran's I was used to identify clusters of drought-stricken pixels with High thermal IR and Low NDVI values (HIGH-LOW, Pink in **Figure 7**) likely to be at high risk of Aflatoxin contamination.

Figure 1. Picture of Corn infected with *Aspergillus* Fungi (Texas A&M Kingsville)

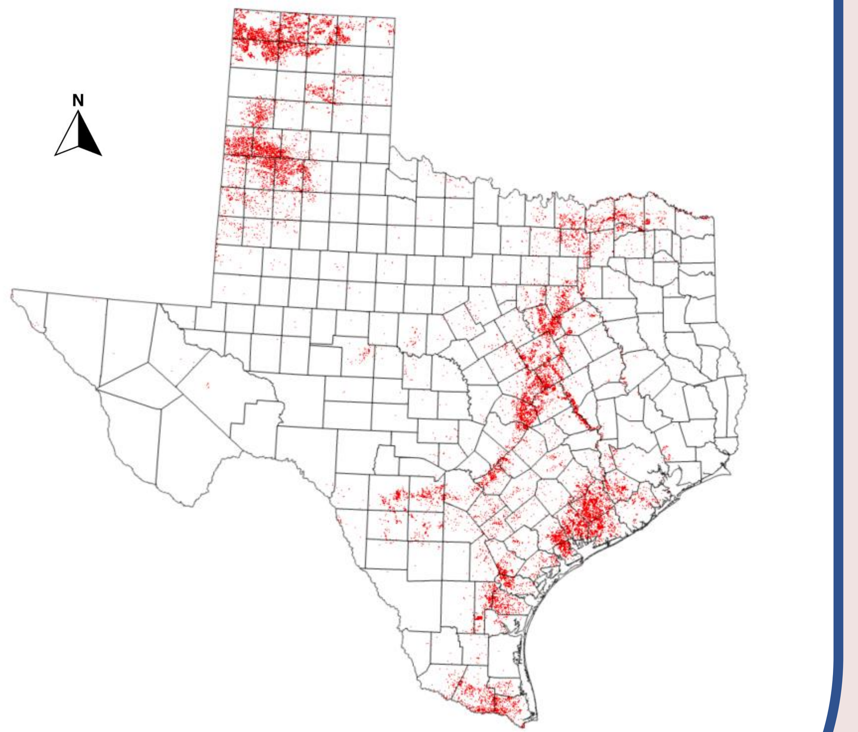

Figure 2. Map showing where corn is grown in Texas

Results

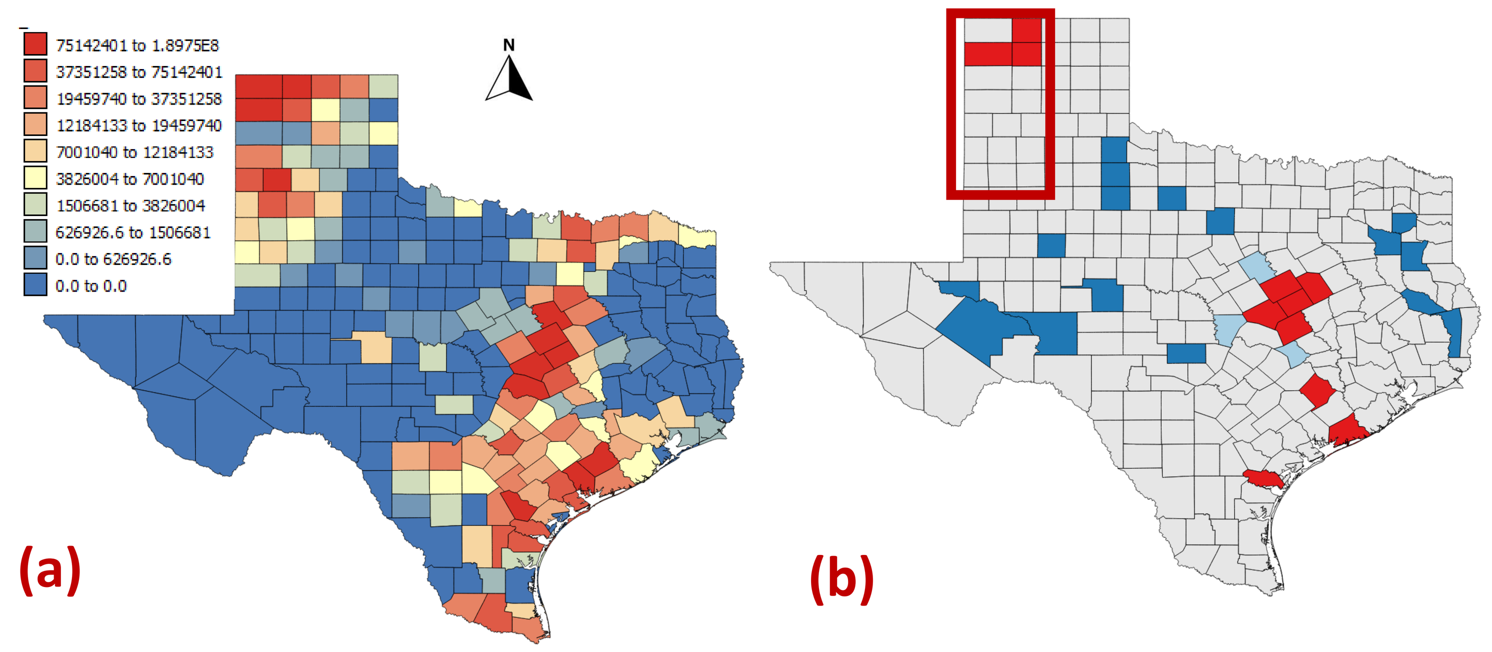

Figure 3. Maps of **(a)** Insurance Claims ($) for All Years for Corn due to Aflatoxin, Heat and Drought Loss (AgRisk viewer) and **(b)** Univariate Local Moran's I cluster analysis for Insurance Claims

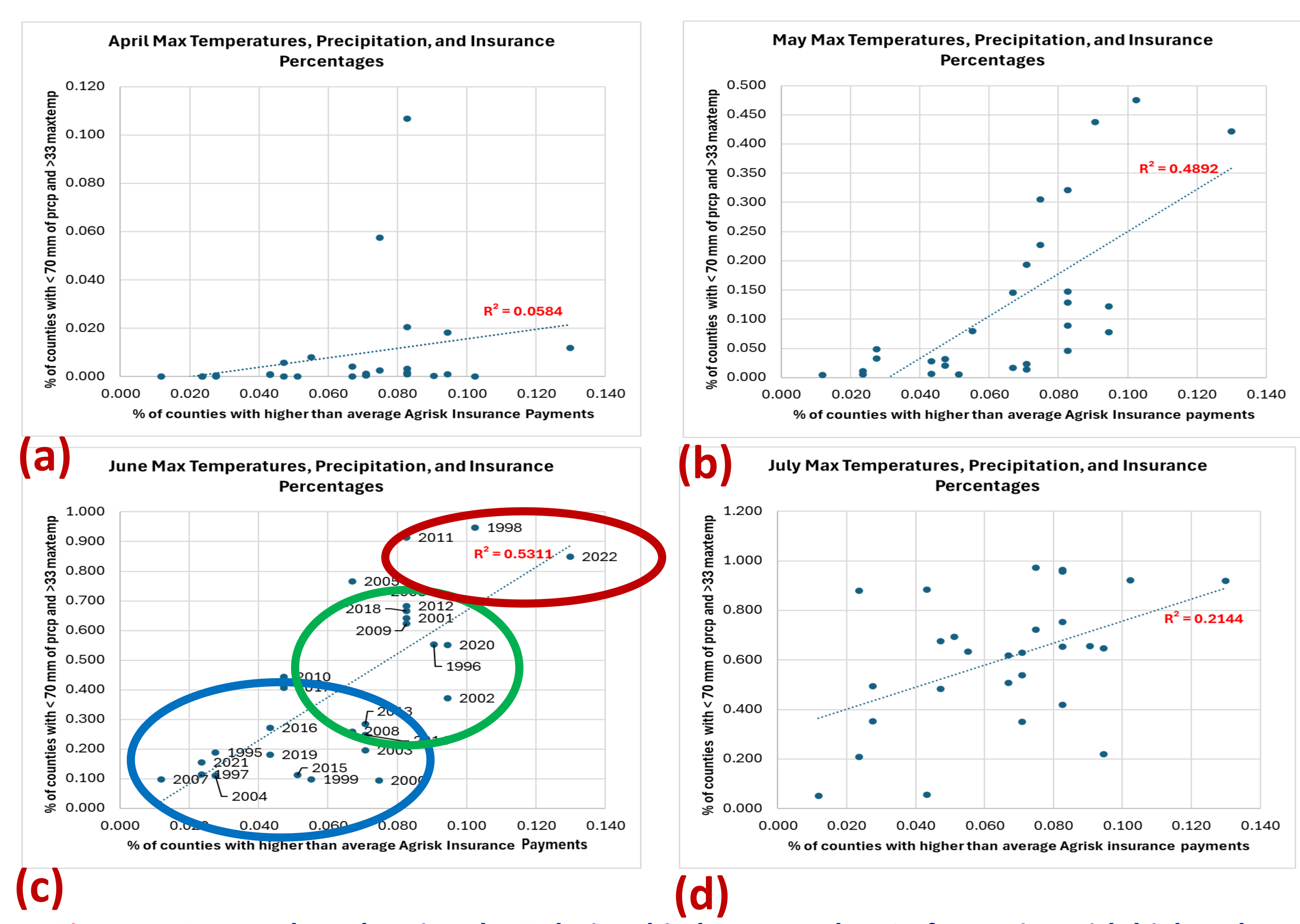

Figure 4. Scatterplots showing the Relationship between the % of counties with higher than average AgRisk insurance payments and % of counties with Tmax >33°C and RF < 70 mm for **(a)** April, **(b)** May, **(c)** June and **(d)** July

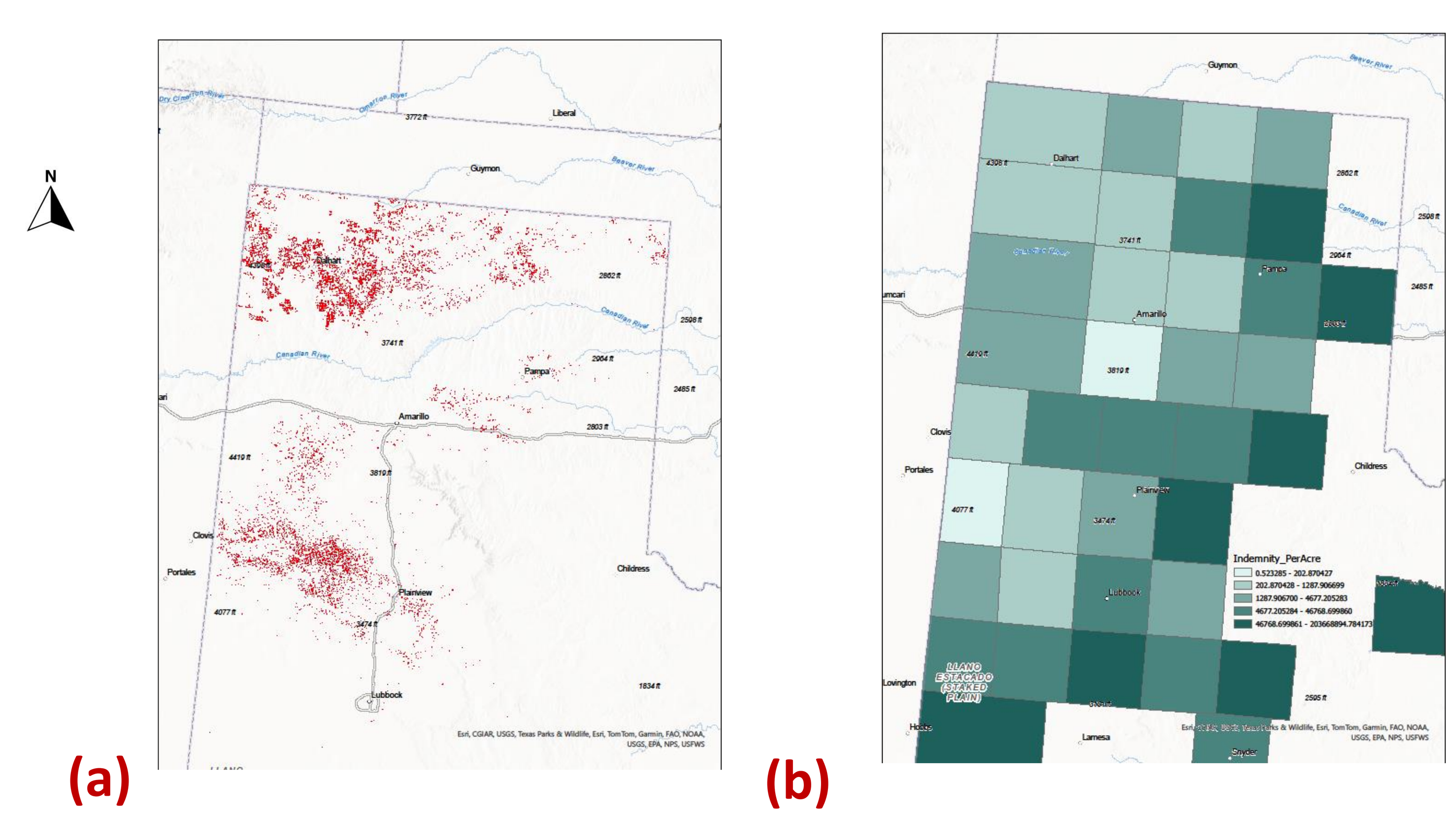

Figure 5. Maps showing **(a)** Corn growing frequency and **(b)** Agrisk Insurance claims from aflatoxin, heat and drought in Northern counties of Texas

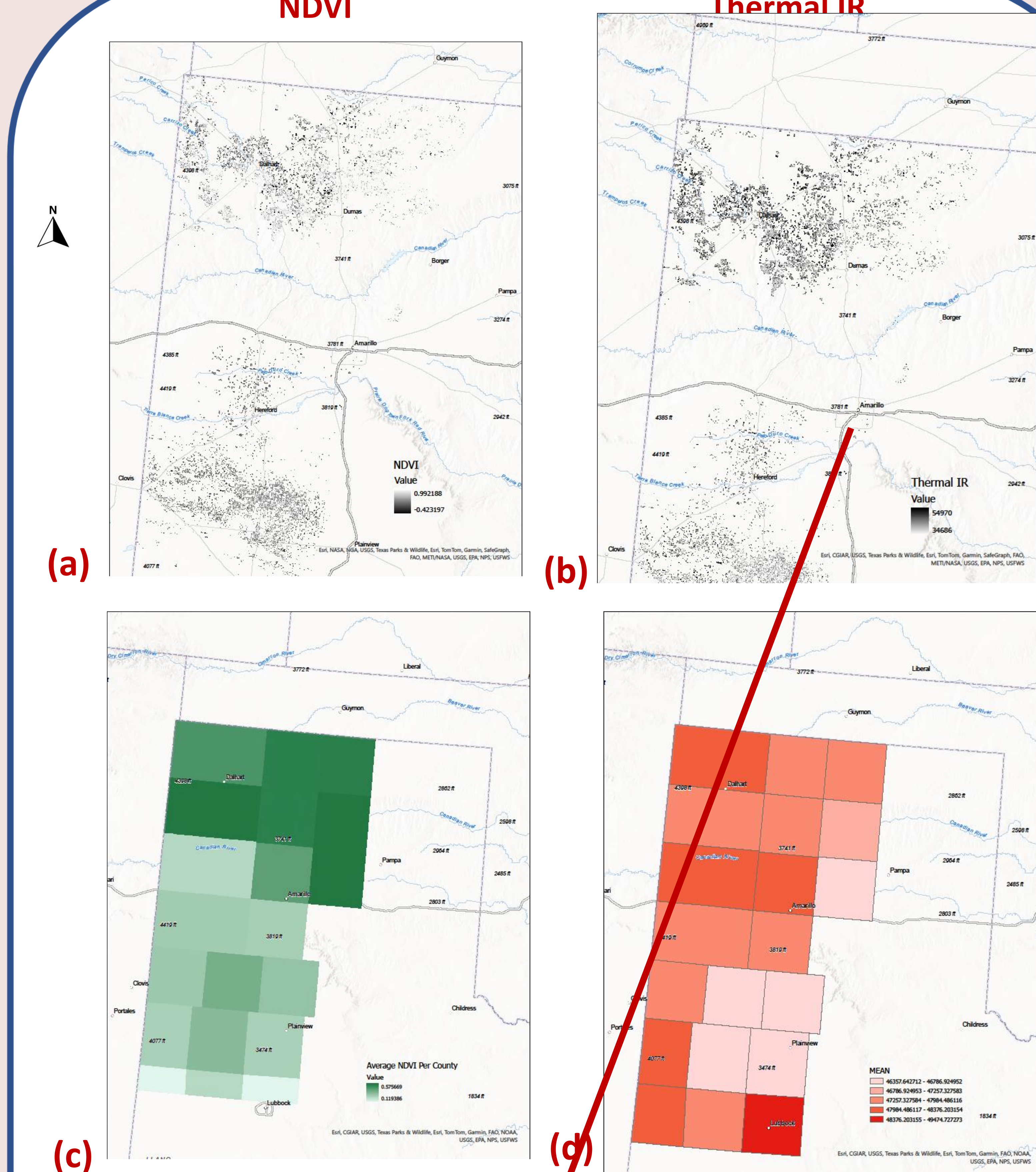

Figure 6. Maps showing **(a)** NDVI of Corn Crops, **(b)** Thermal IR of corn crops, **(c)** Average NDVI and **(d)** Average Thermal IR of corn crops by county in Northern Texas

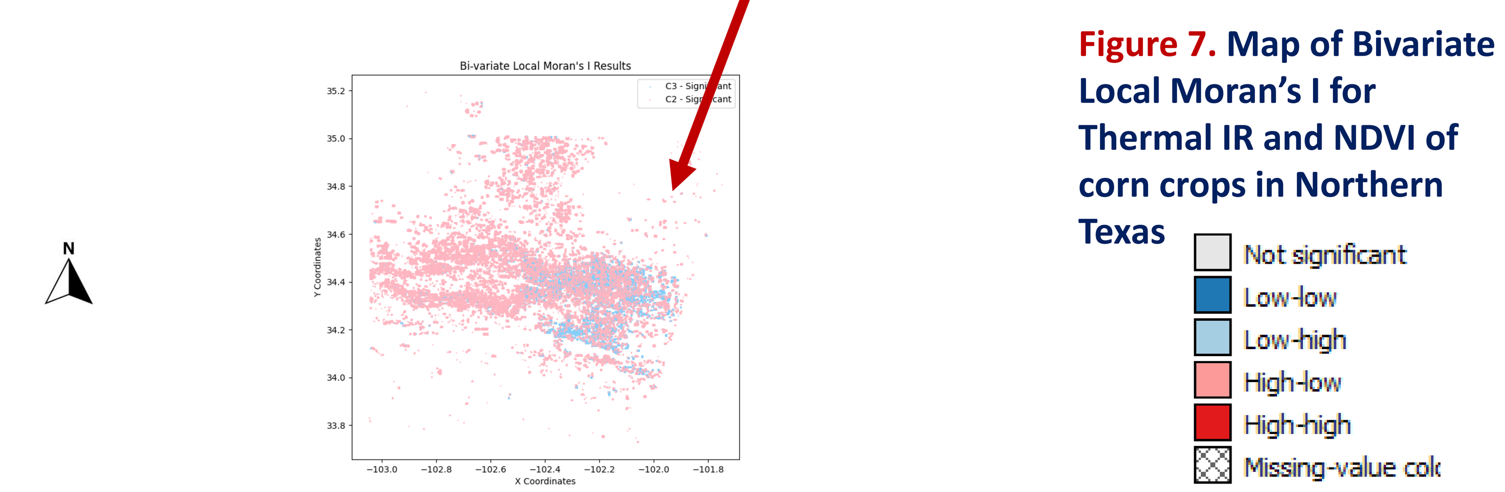

Figure 7. Map of Bivariate Local Moran's I for Thermal IR and NDVI of corn crops in Northern Texas

Discussion and Conclusions

Larger percentages of counties with Tmax >30°C and RF <70mm are associated with a higher frequency of greater than average insurance claims for April, May, June and July over the 1995-2024 period. The relationship is strongest for June which is consistent with previous work done in Georgia **(Kerry et al. 2017)**. The June graph **(Figure 4c)** shows clusters of high, medium and low-risk years. 2011 is a high-risk year. **Figure 5** shows that the counties with the highest corn insurance claims grow corn most often. NDVI and Thermal IR from corn growing pixels in July 2011 Landsat imagery for the 21 most north-westerly counties in Texas show a strong negative relationship **(r = -0.935) (Figure 6a and b)**. At the county level, this inverse relationship is moderate **(r = -0.525)**. The pink areas in the bi-variate Local Moran's I map **(Figure 7)** show where the corn is experiencing drought at the start of July (high thermal IR and low NDVI) and is most likely to be contaminated by aflatoxin. About 50% of the corn growing area is affected and the pink areas correspond with the areas where insurance claims are high. Corn from the high-risk areas should be harvested and stored separately so that both public safety and farmer's incomes can be preserved. Temporal analysis of several years of imagery is needed to determine if the highest risk areas remain stable over time and are related to particular topographic positions or soil particle sizes as **Kerry at al. (2022)** found to be the case within fields in Alabama.

Reference List available from First Author upon request