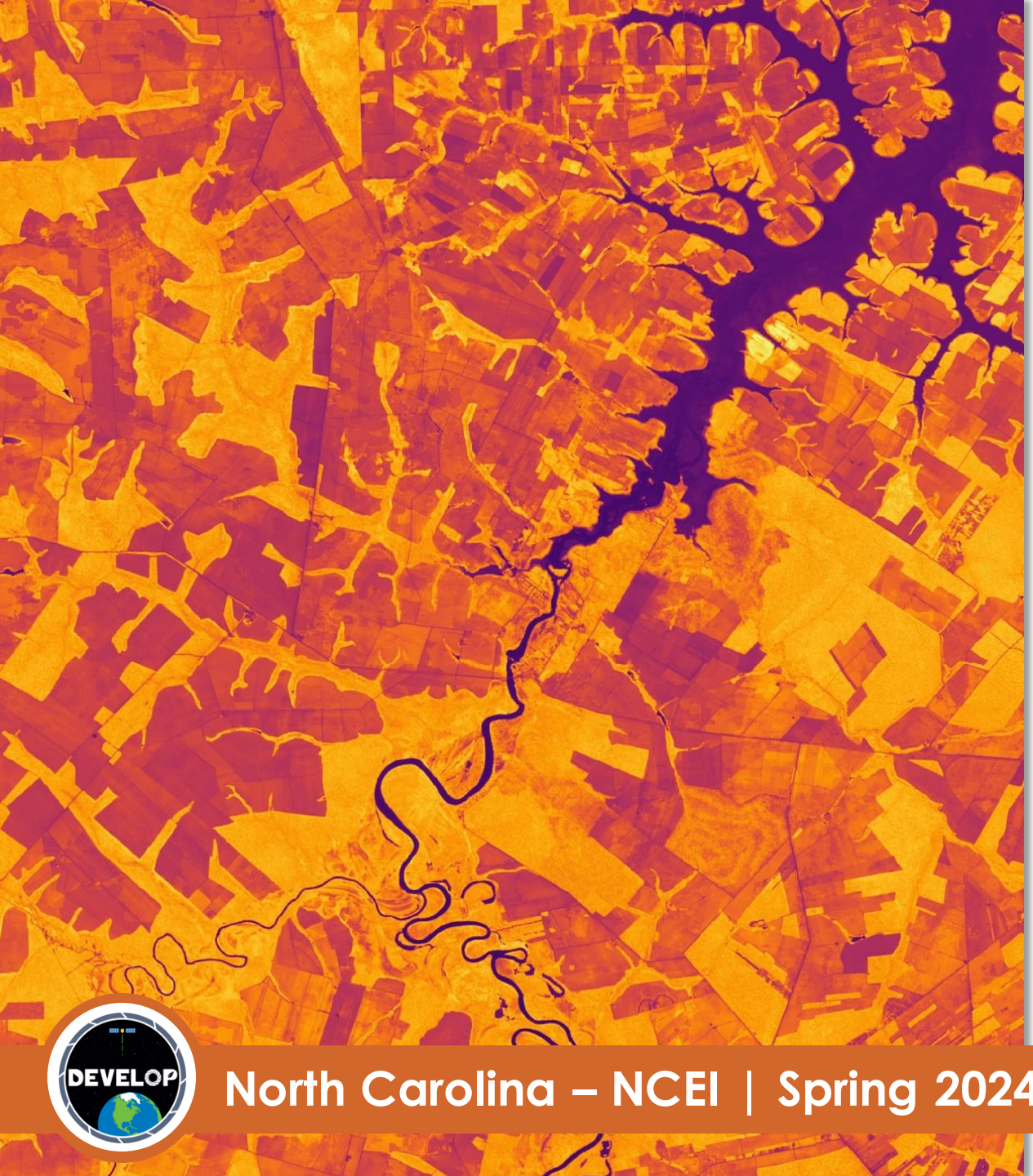


National Aeronautics and Space Administration

NORTHERN BRAZIL AGRICULTURE

Measuring Soybean Yields in Northern Brazil During El Niño-Southern Oscillation Conditions to Evaluate Trends in Agricultural Production and Support Crop Forecasting, 1984 – 2023

Devon V. Maloney

Manpreet K. Singh

Grayson Shanley Barr

Sofya Goncharenko

DEVELOP North Carolina – NCEI | Spring 2024

PRESENTATION ROAD MAP

- Study Area and Period
- Study Objectives
- Partners
- Community Concerns
- Earth Observations
- Methods
- Results
- Errors and Uncertainty
- Feasibility
- Future Recommendations
- Acknowledgements

PROJECT TEAM

Devon V. Maloney
Project Lead

Manpreet K. Singh

Grayson Shanley Barr

Sofya Goncharenko

Study Area & Period

Study Area

- Northern & central Brazilian states of Pará, Tocantins, Bahia, and Mato Grosso

Study Period

- 1984–2023
- El Niño years: 1987– 88, 1991–92, 1994–95, 1997–98, 2002–03, 2009–10, 2015–16, 2023–24

Background

- Reductions in crop yields due to climatic variability in Brazil affect food supply globally
- El Niño-Southern Oscillation (ENSO) causes variation in the Brazilian climate
- As El Niño returns, it is critical to assess the impact of ENSO conditions on crop production to inform estimates of agricultural production in the country

Image Credit: Photo by PROJETO CAFÉ GATO-MOURISCO on Unsplash

Study Objectives

- Examine the relationship between soybean production yield, normalized difference vegetation index (NDVI), and ENSO conditions
- Produce a time series analysis from 1984 to 2023 comparing crop yield and environmental conditions during ENSO phases
- Conduct statistical analysis to examine relationships at the state level

Image Credit: Photo by PROJETO CAFÉ GATO-MOURISCO on Unsplash

Community Concerns

- Brazil has emerged as one of the top exporters of agricultural commodities, supplying over 200 countries and territories around the world
- Brazil engages in 50% of world soybean trade and manages a top global corn production
- With Brazil's changing climate and the oncoming ENSO effects, global food security concerns are rising

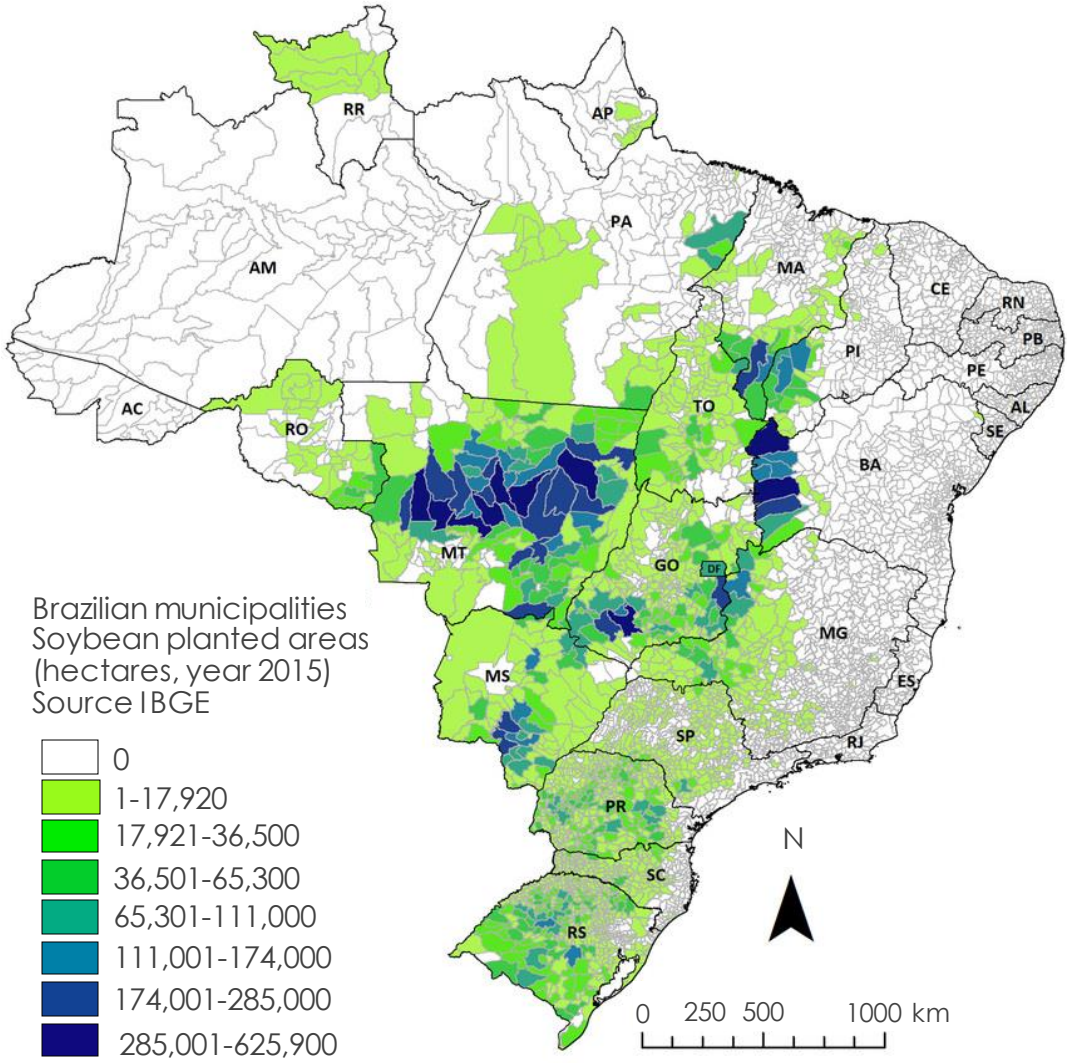
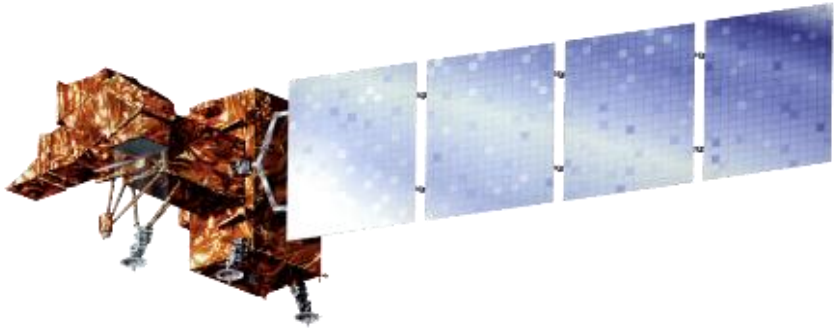


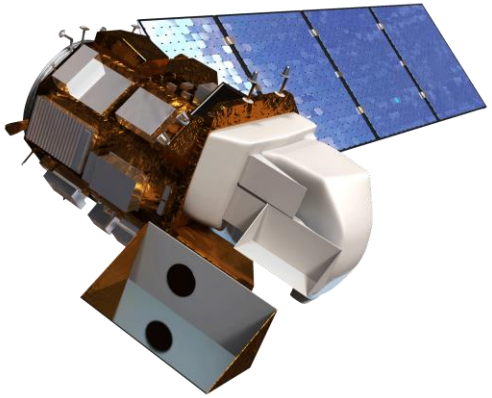
Image Credit: Martinelli et al., 2017

Earth Observations

Landsat 5 TM



Landsat 7 ETM+



Landsat 8 OLI

Image Credit: NASA

Landsat 5 Image of Mato Grosso, Brazil

Project Partners

We are working with partners at the United States Department of Agriculture (USDA):

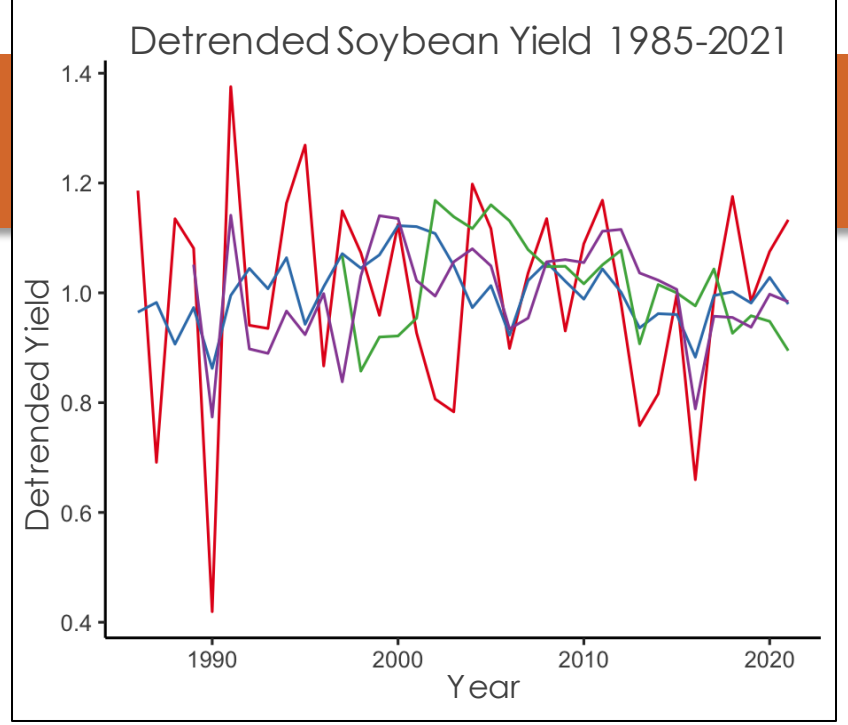
- USDA Foreign Agricultural Service International Production Assessment Division
- USDA Office of the Chief Economist and World Agriculture Outlook Board

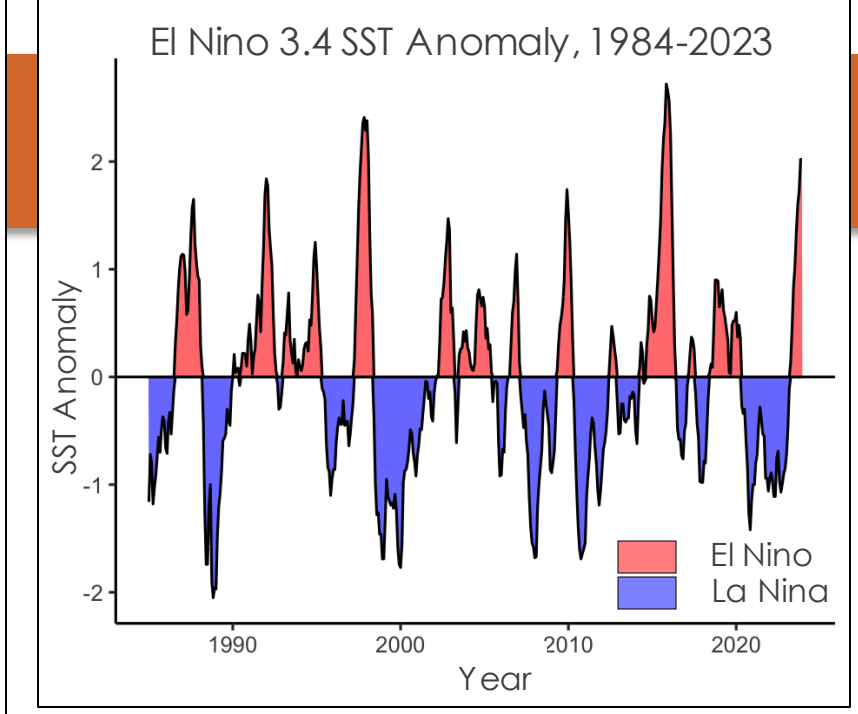
Image Credit: US Dept of Agriculture

Datasets

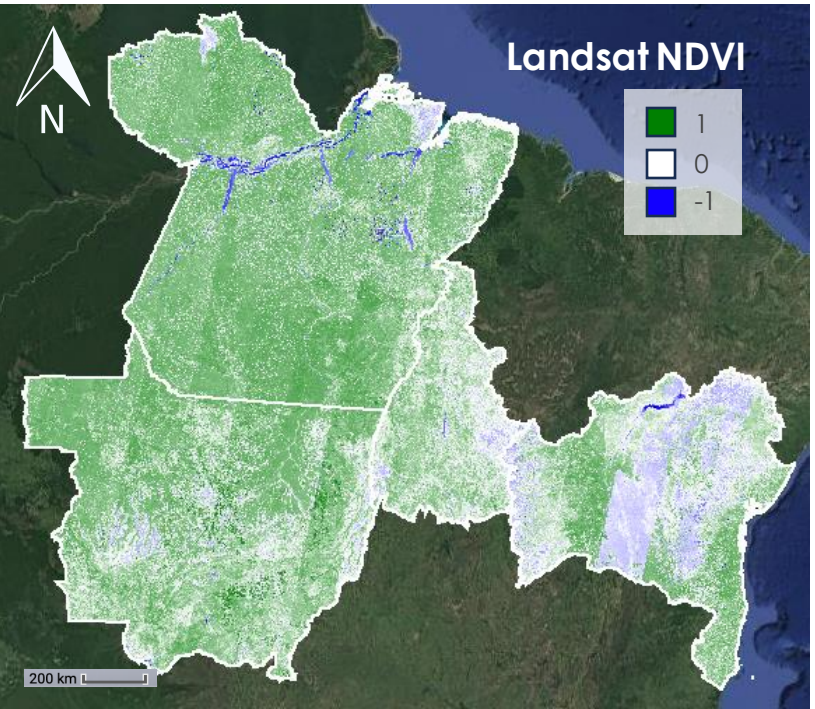
State

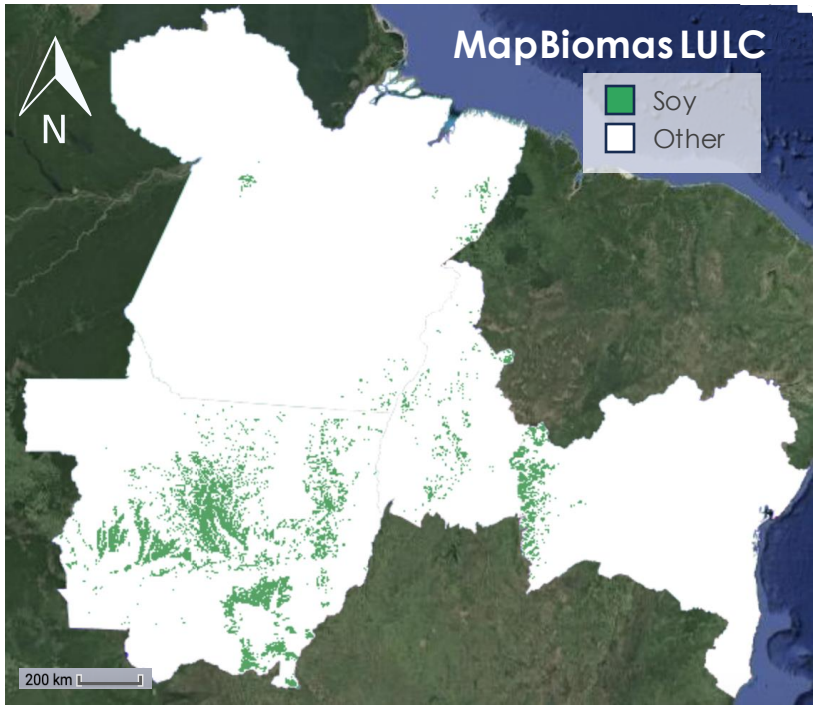
- Bahia
- Mato Grosso
- Pará
- Tocantins

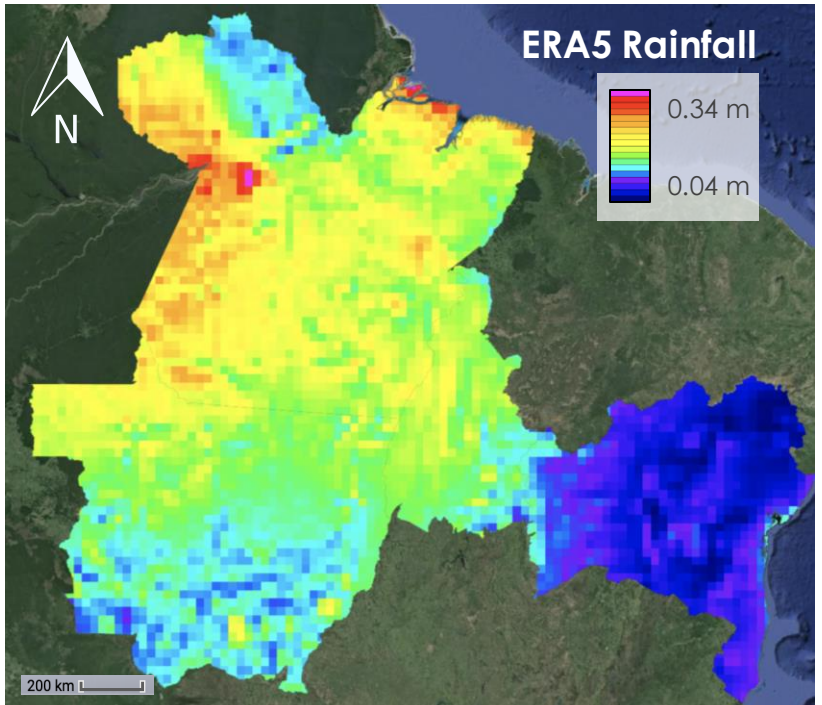




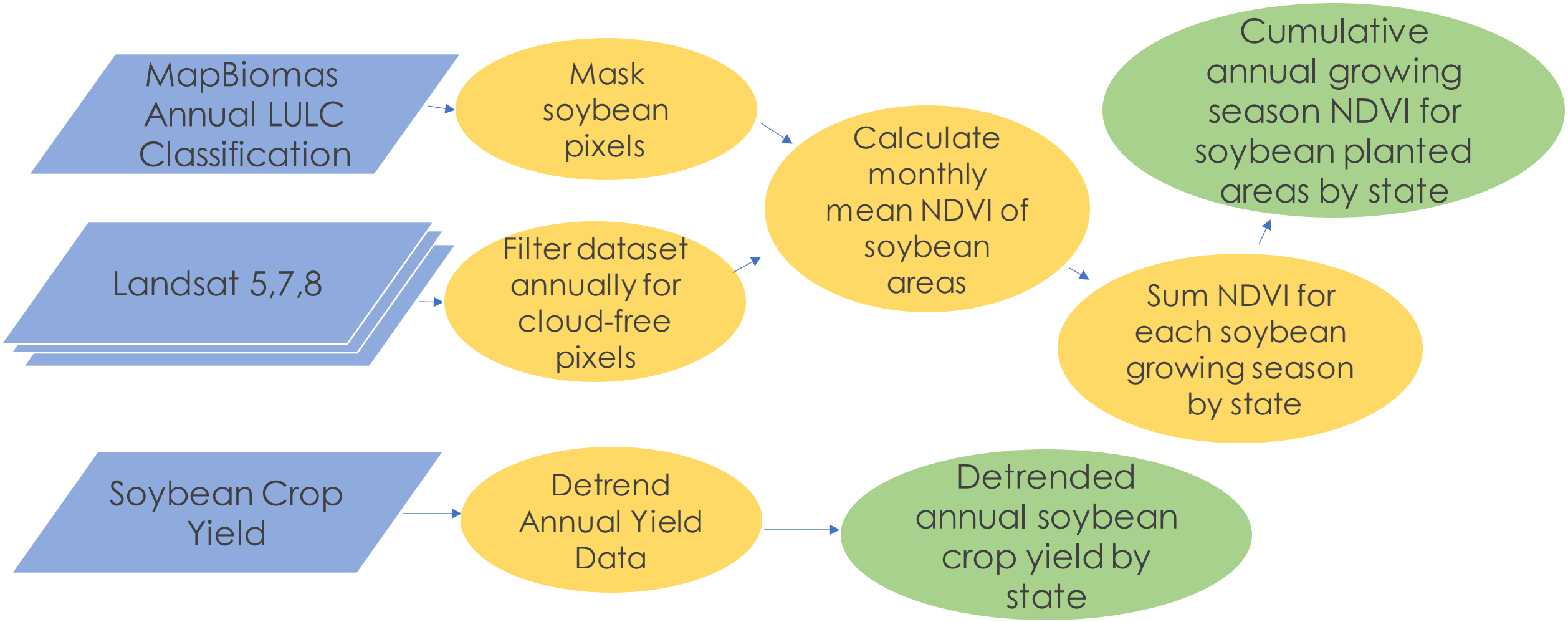
Base map credit: Google Satellite



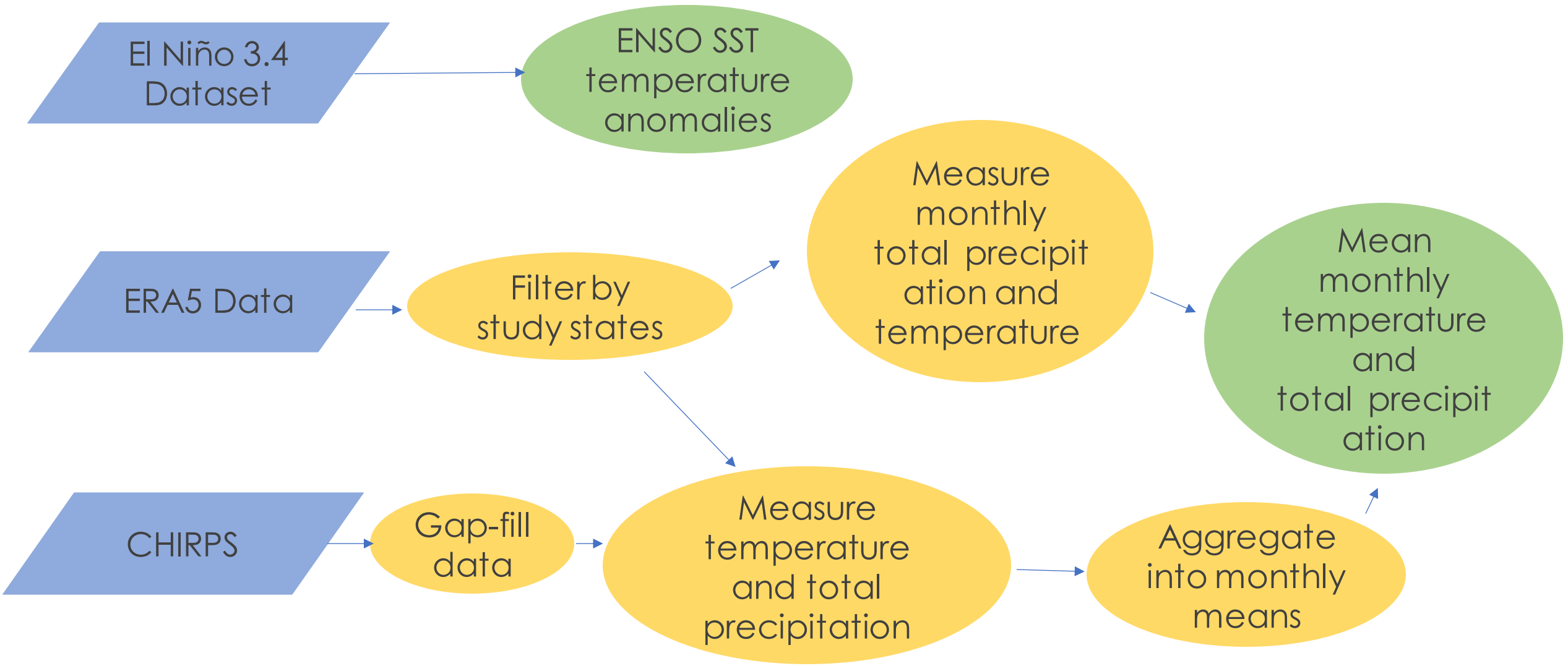




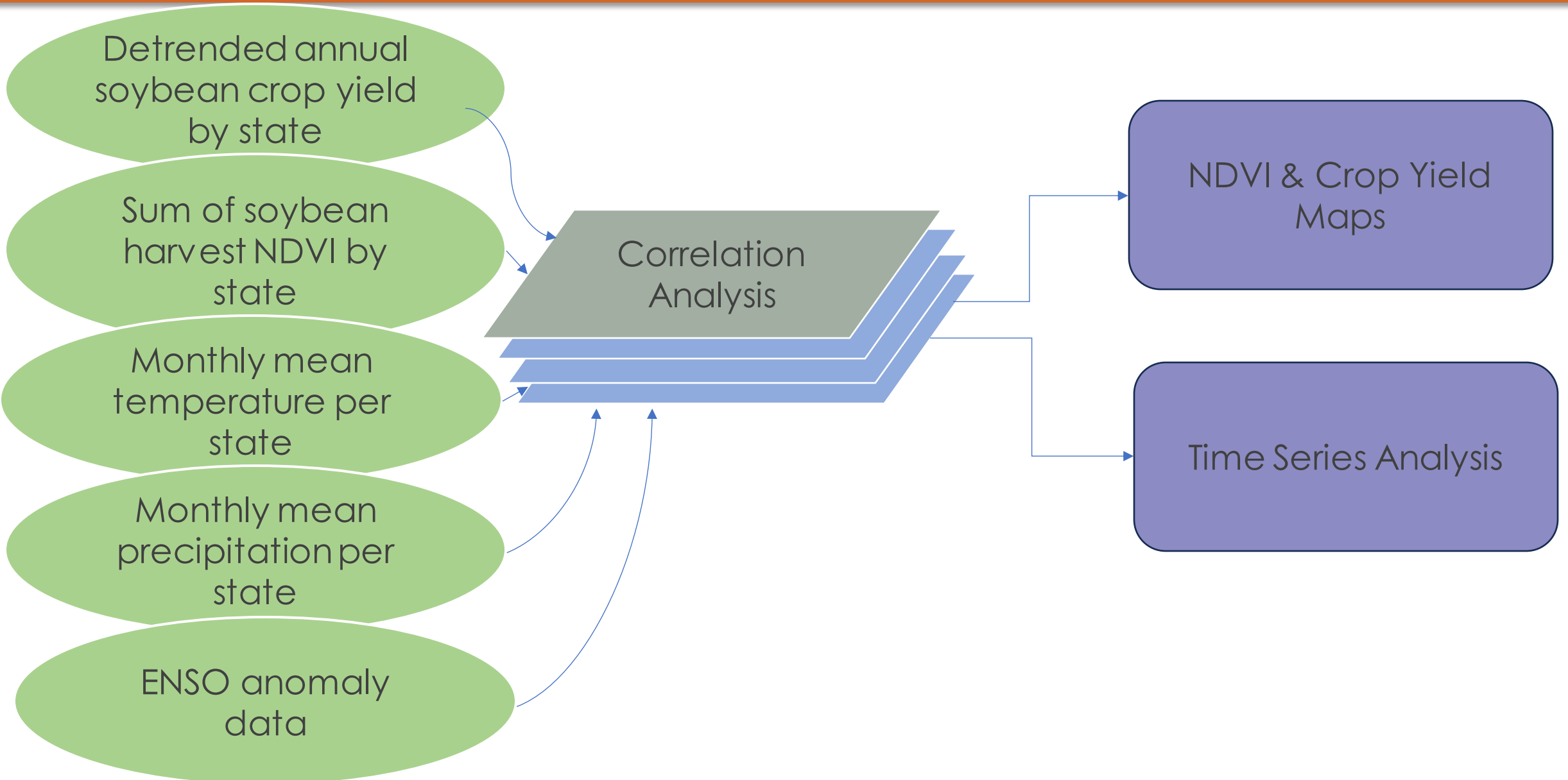
Methods: Calculating NDVI & Crop Yield



Methods: Temperature & Precipitation



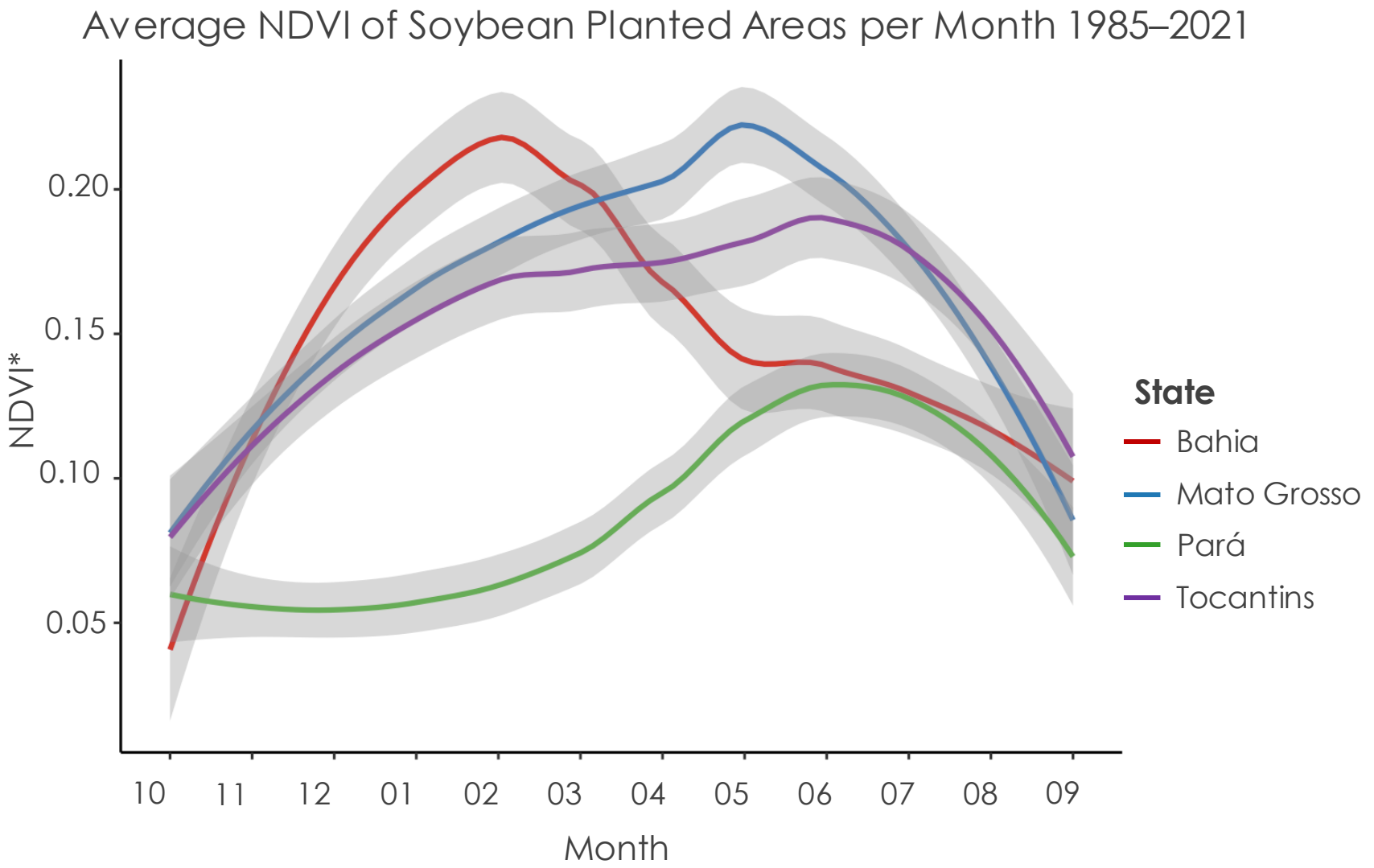
Methods: Data Analysis



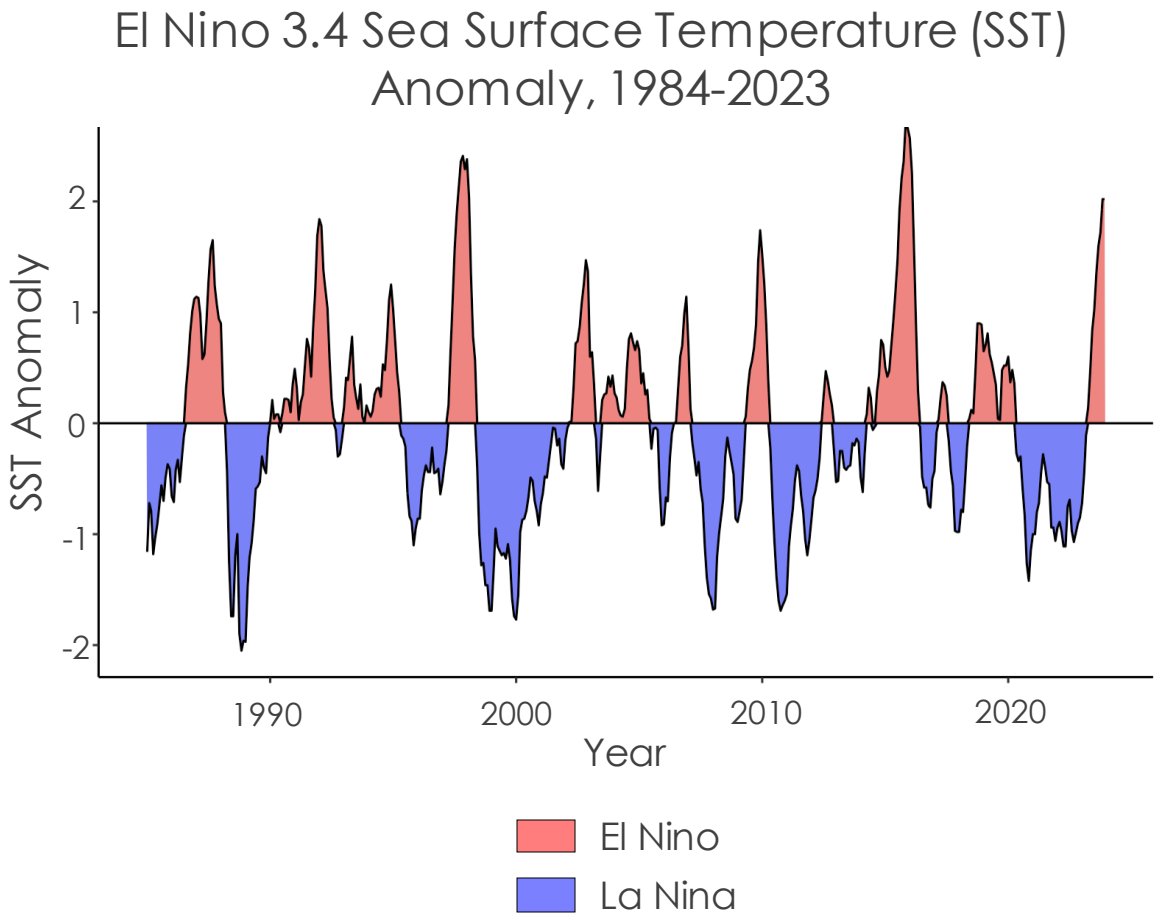
Results: NDVI Seasonality

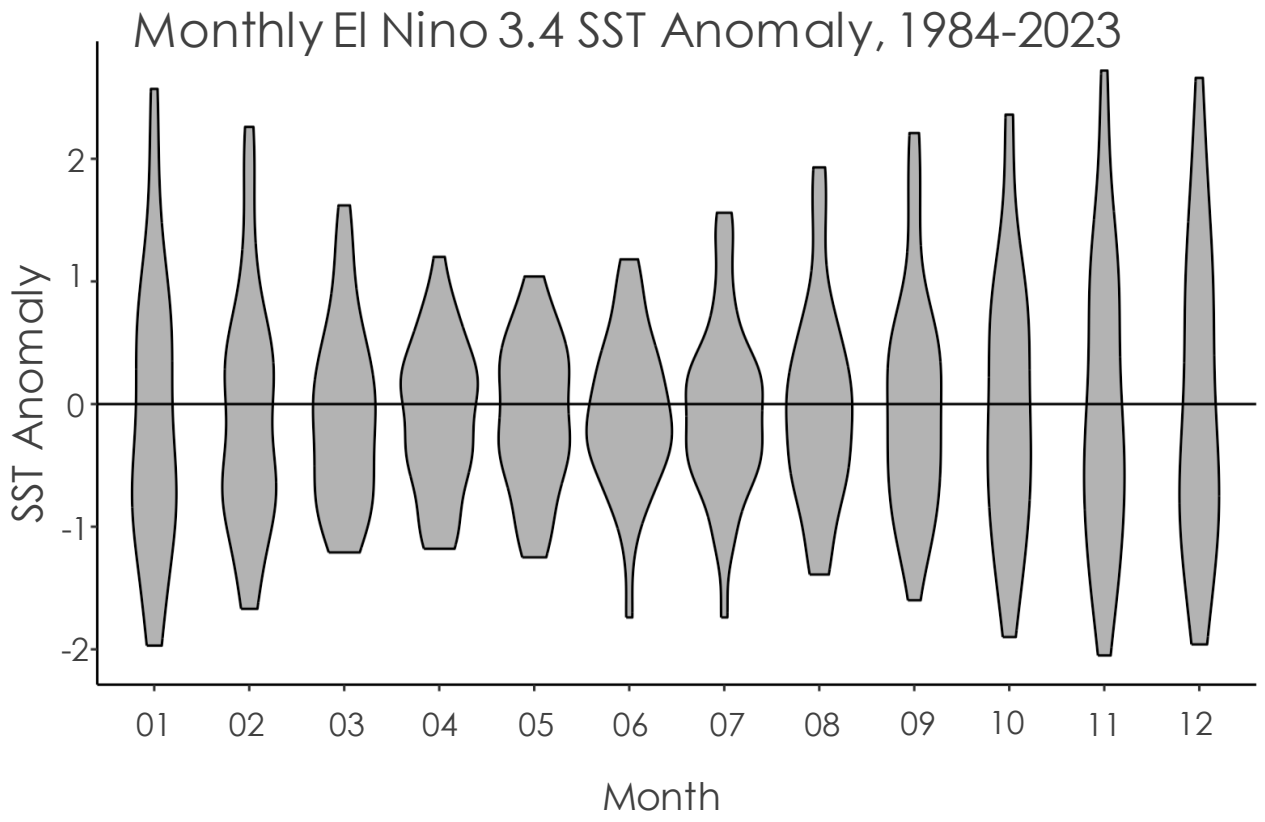
State	Growing Season
Pará	Nov–July
Mato Grosso	Oct–June
Tocantins	Oct–June
Bahia	Oct–June

*Scale of -1 to 1, values between 0 and 1 represent vegetation greenness, with higher values corresponding with increased greenness

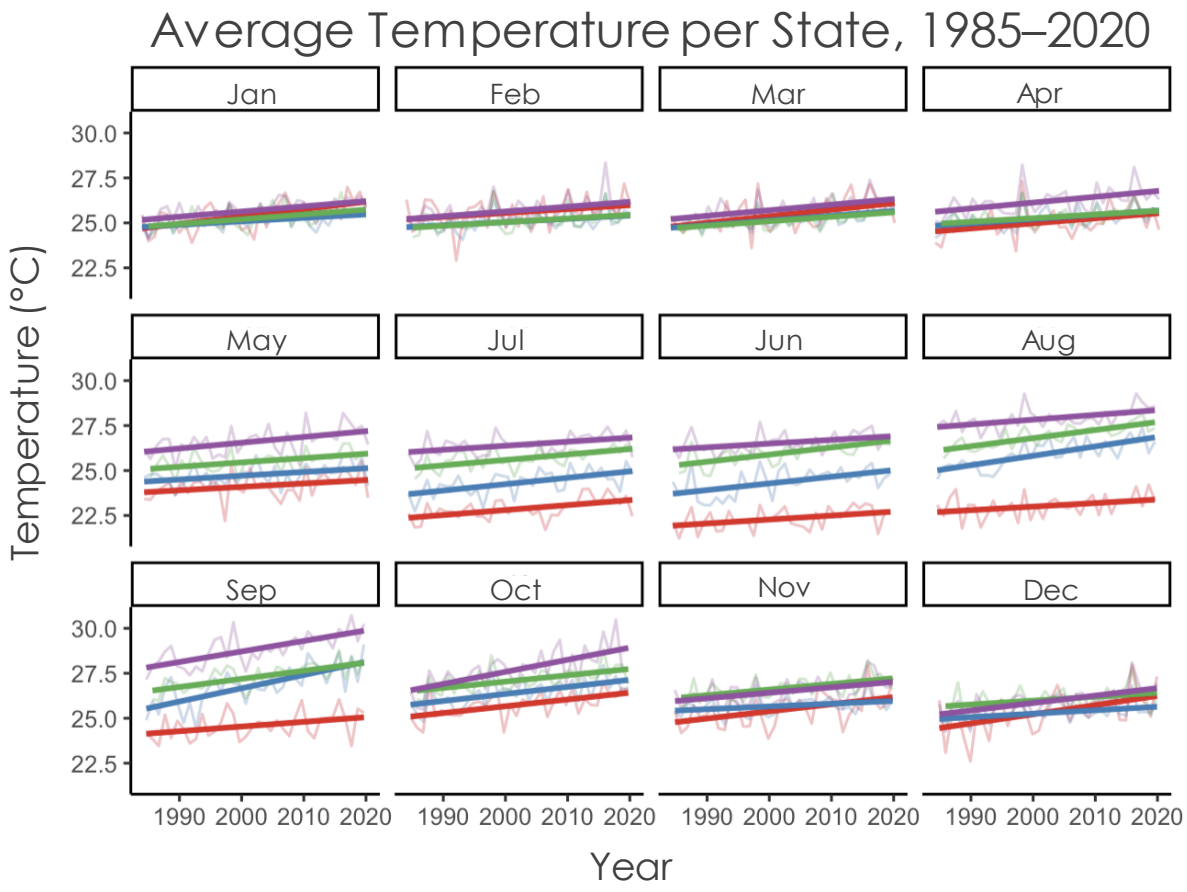


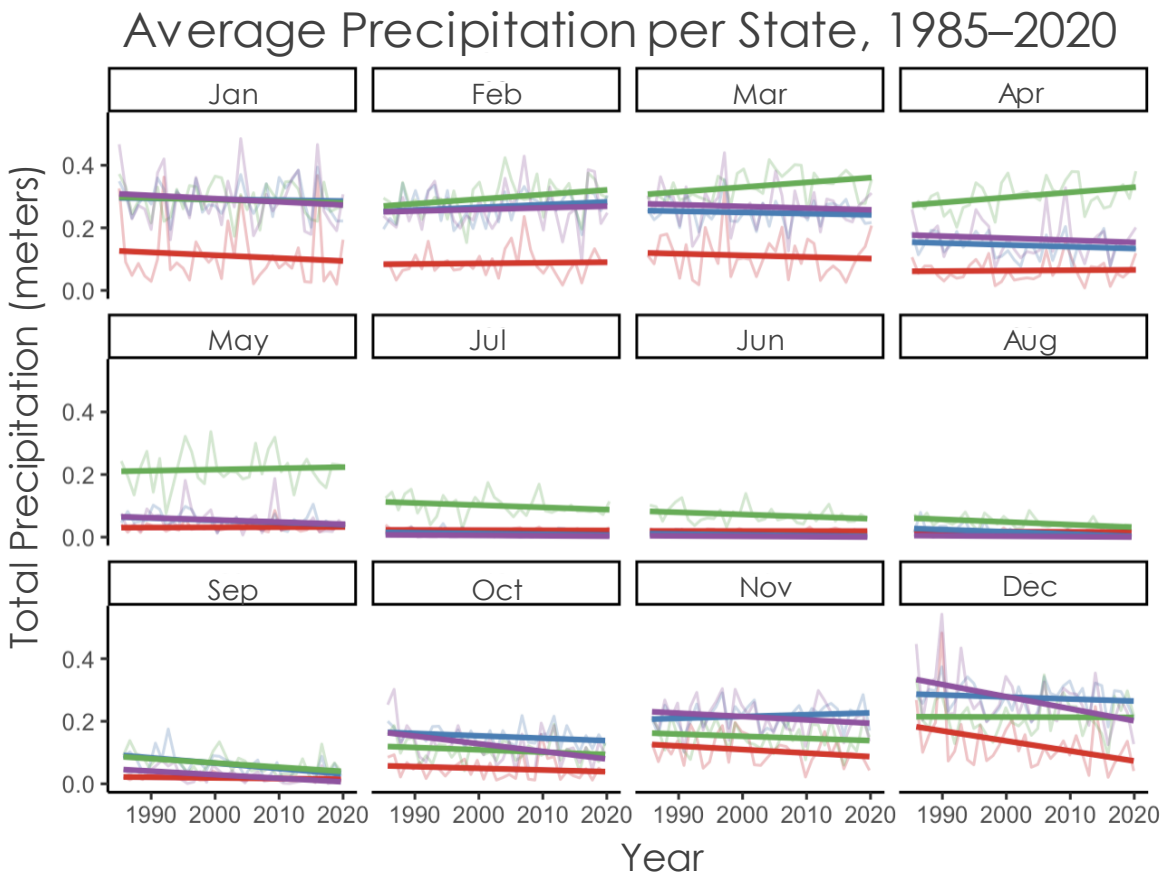
Results: ENSO Anomaly





Results: Temperature and Precipitation Trends

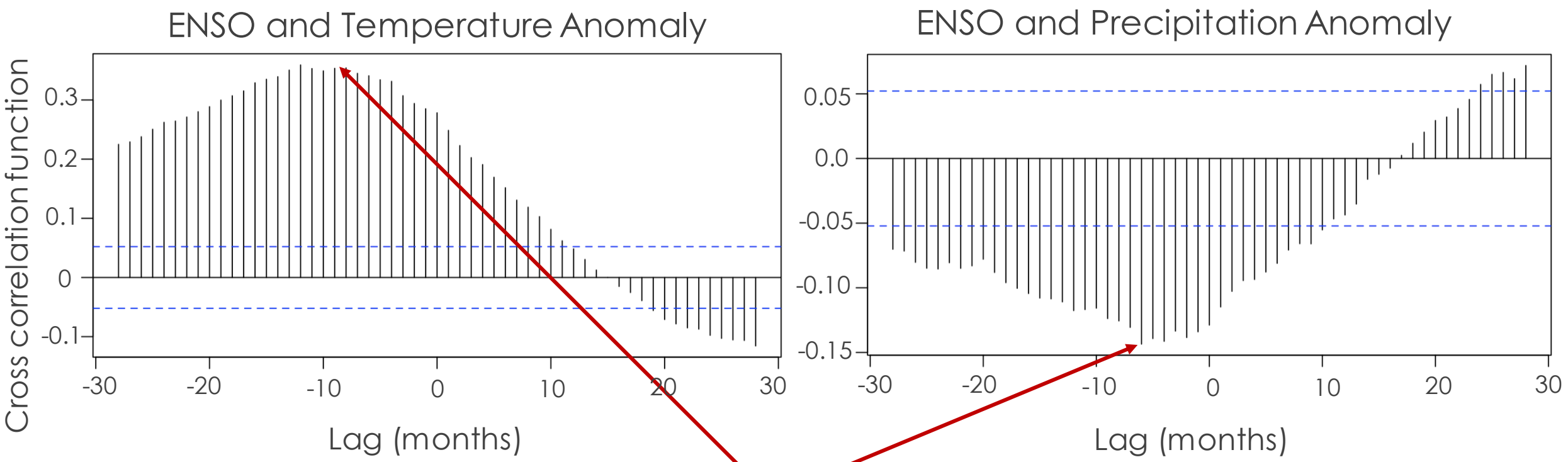




State

- Bahia
- Mato Grosso
- Pará
- Tocantins

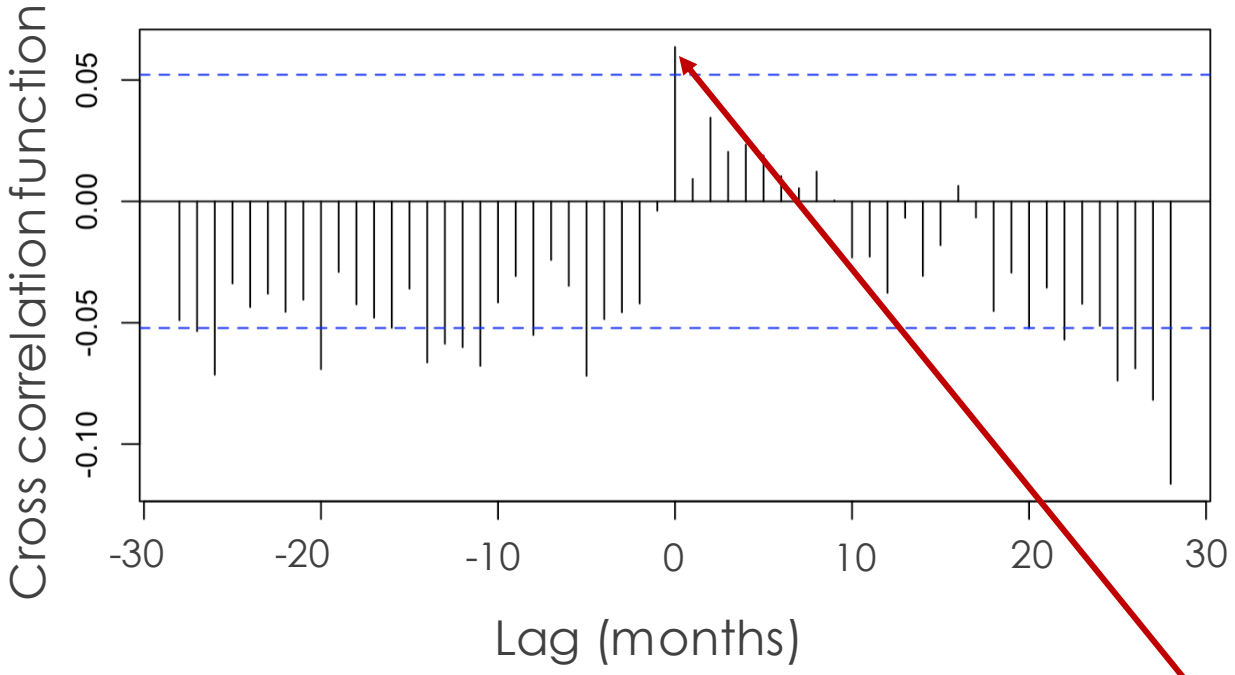
Results: ENSO and Local Climate Lag



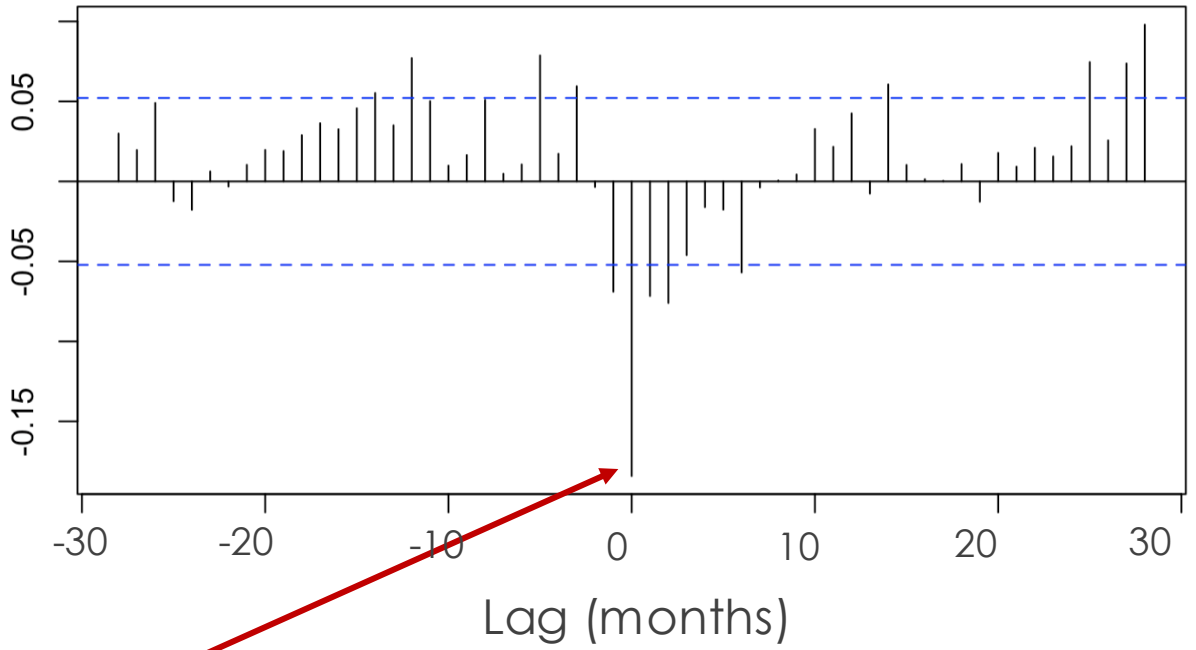
8-month lag between ENSO anomalies and precipitation and temperature anomalies in study region

Results: Climate and Soy NDVI Lag

Temperature Anomaly and Soy NDVI Anomaly



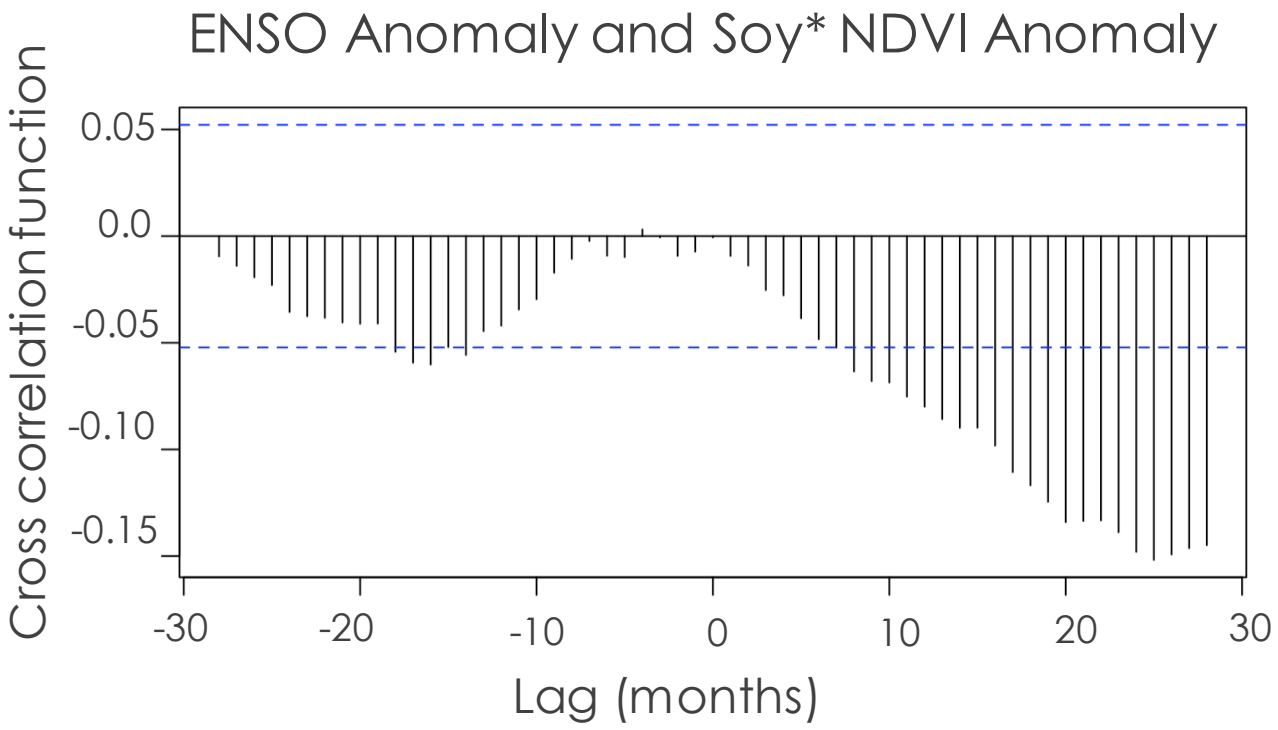
Precipitation Anomaly and Soy NDVI Anomaly

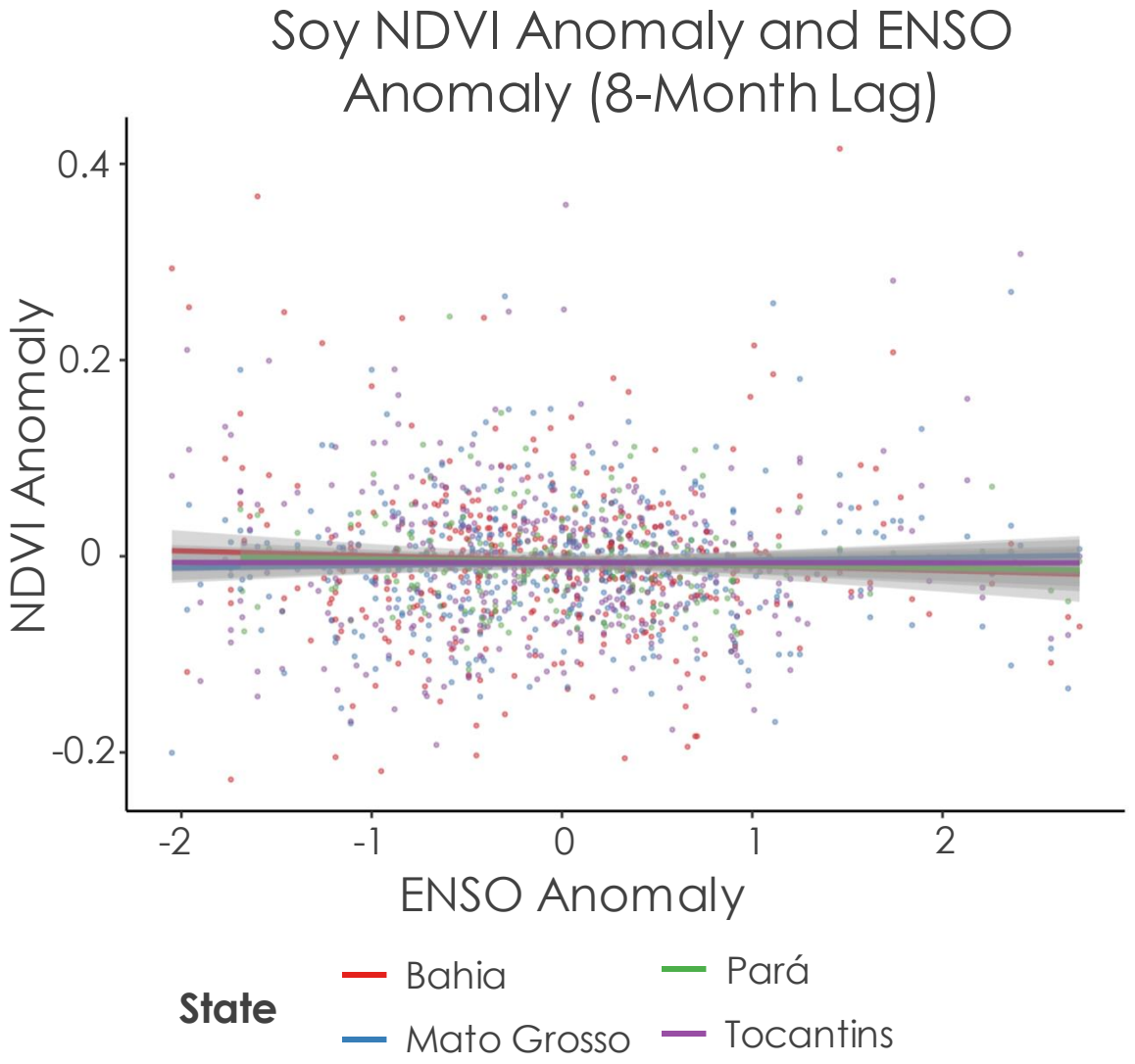


No lag (0-month) between precipitation and temperature anomalies and NDVI anomaly in study region

*Soy crop mask by MapBiomas

Results: ENSO and NDVI lag

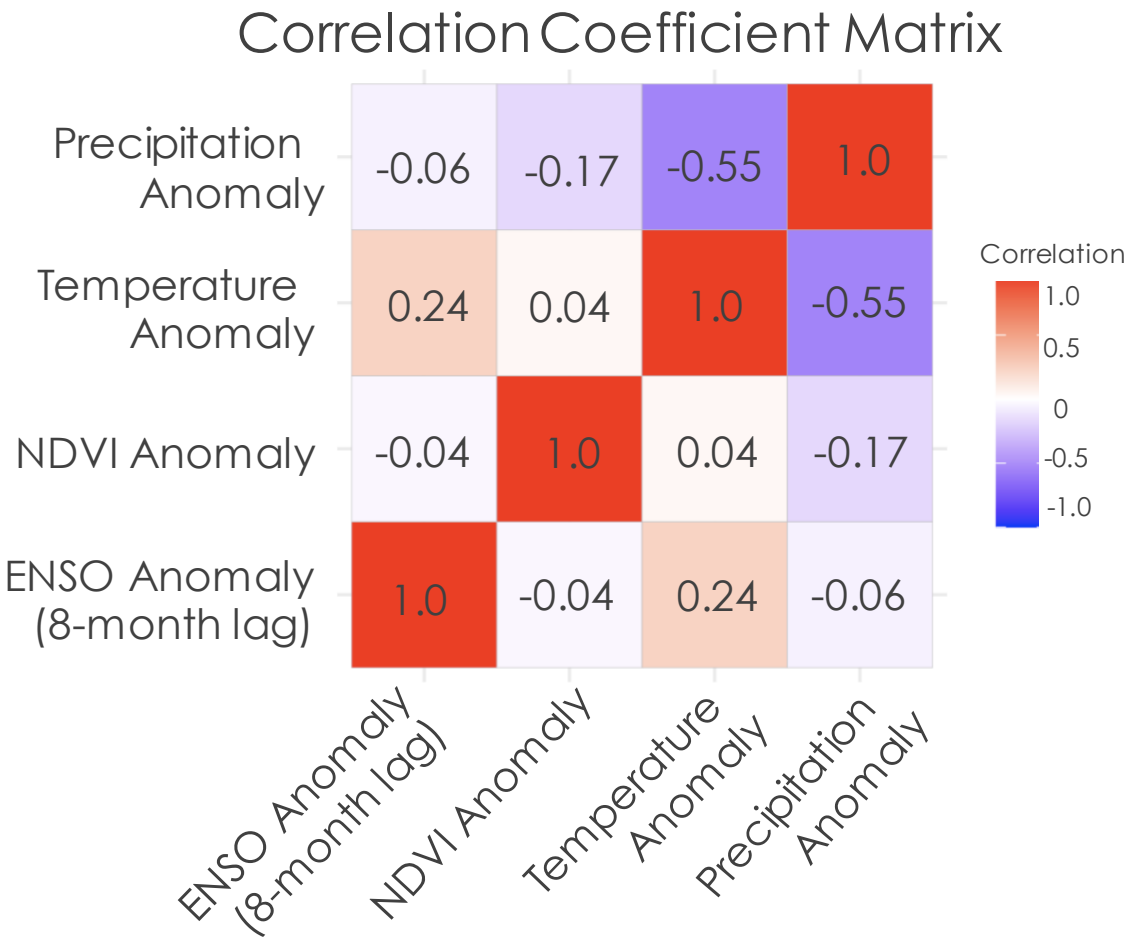




No clear lag or statistically significant relationship between ENSO Anomaly and NDVI

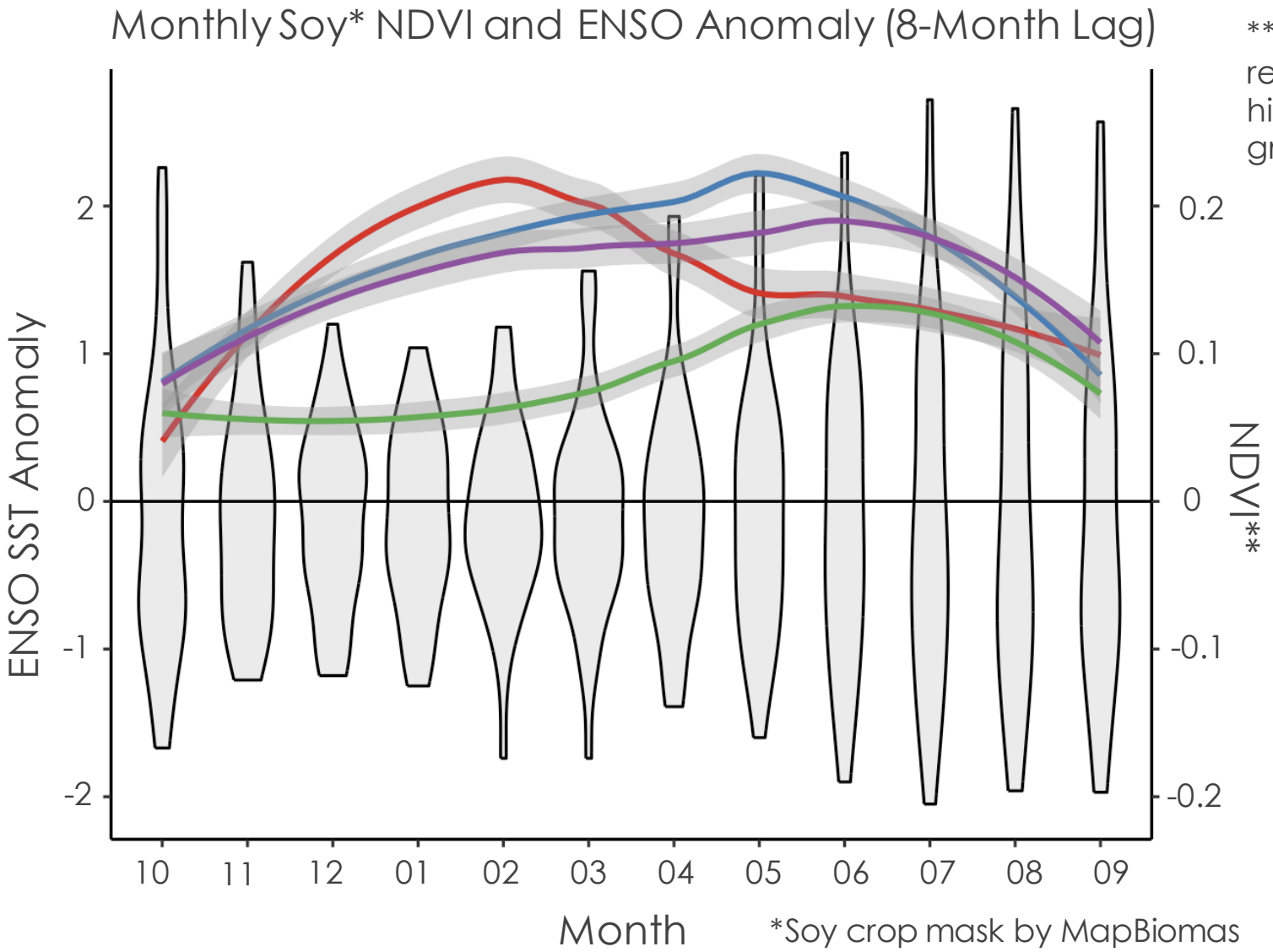
*Soy crop mask by MapBiomas

Results: Principal Component Analysis



- Little to no correlation between NDVI and the 8-month lag ENSO
- This suggests that ENSO anomaly cannot be used to forecast NDVI anomaly

Results: Soy and Local ENSO Seasonality

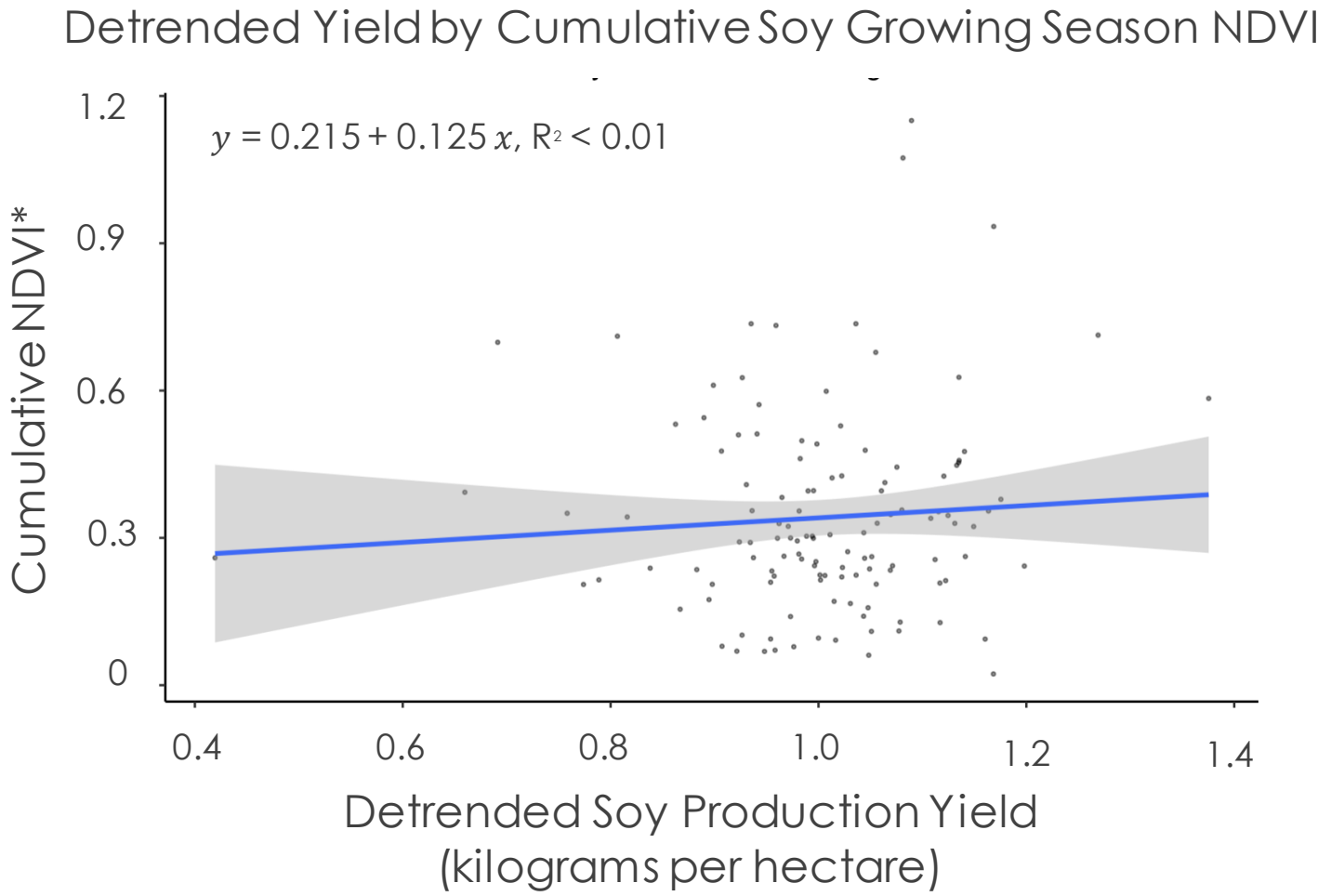


**Scale of -1 to 1, values between 0 and 1 represent vegetation greenness, with higher values corresponding with increased greenness

State

- Bahia
- Mato Grosso
- Pará
- Tocantins

Results: Production Yield



*Scale of -1 to 1, values between 0 and 1 represent vegetation greenness, with higher values corresponding with increased greenness

- No correlation between cumulative soy growing season NDVI and the detrended production yield statistics
- This suggests NDVI is not a feasible indicator for forecasting soy production yield

Errors and Uncertainties

Missing values:

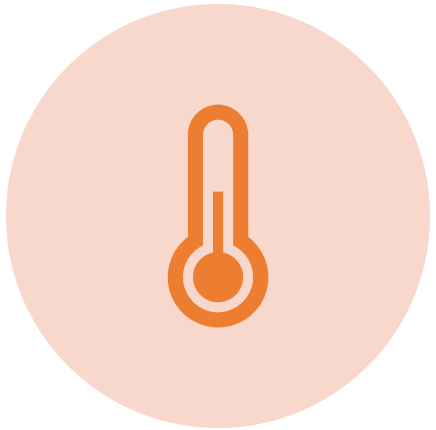
- Some missing monthly NDVI values due to clouds, so we relied on gap - filling
- Due to missing temperature and precipitation years in ERA5, we supplemented with data from CHIRPS

Methodological limitations:

- MapBiomas LULC classification
- Changing crop seasonality

Feasibility

Challenges using ENSO conditions to forecast soybean crop productivity



Temperature and precipitation data is viable to examine relationships between NDVI and seasonality

Correlation analyses can assist with producing time series and crop yield maps to examine factors that affect production yield

Conclusions

Correlation and time-series analysis can identify trends and determine which factors are affecting soy NDVI

Temperature and precipitation data can provide insights into the relationships between NDVI and seasonality through a temporal analysis

Monthly soy NDVI anomaly had little to no correlation with monthly ENSO anomaly. ENSO have complex impact on soy in the study area and period warranting further study

Monthly ENSO anomaly cannot be used to forecast monthly soy NDVI anomaly nor soy yearly production yield

Future Recommendations

- Conduct analysis with a multivariate ENSO index
- Examine multi-year events
- Assess methods on 2nd season corn production
- Focus on a smaller geographic region – state, sub-state level

Acknowledgments

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Dr. Mark Brusberg, USDA Office of Chief Economist and World Agriculture Outlook Board

Science Advisors

Dr. Garrett Graham, North Carolina Institute for Climate Studies

Dr. Boyin Huang, NOAA's National Centers for Environmental Information

Molly Woloszyn, NOAA's National Integrated Drought Information System

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