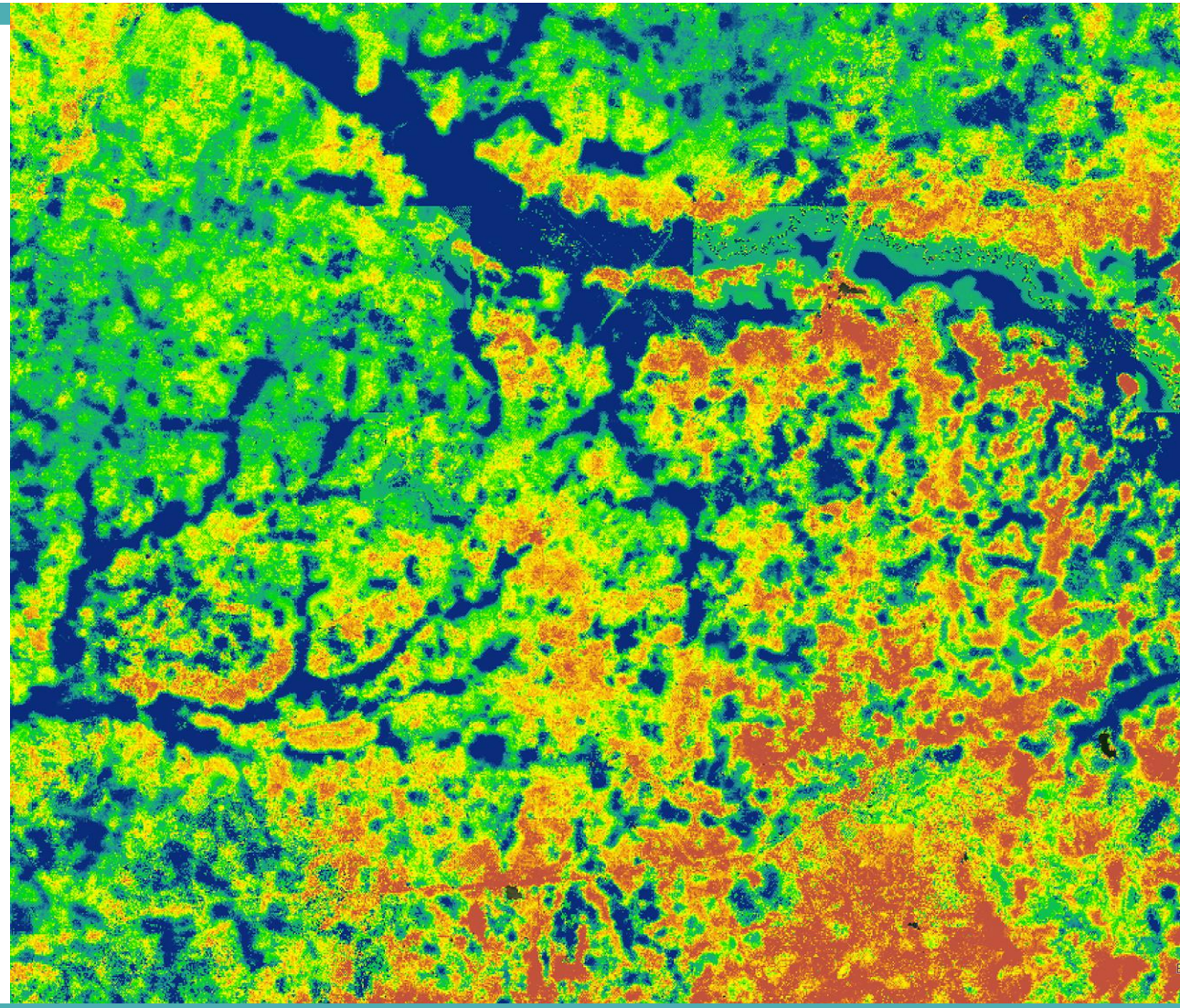
National Aeronautics and Space Administration

Western Tennessee
Water Resources

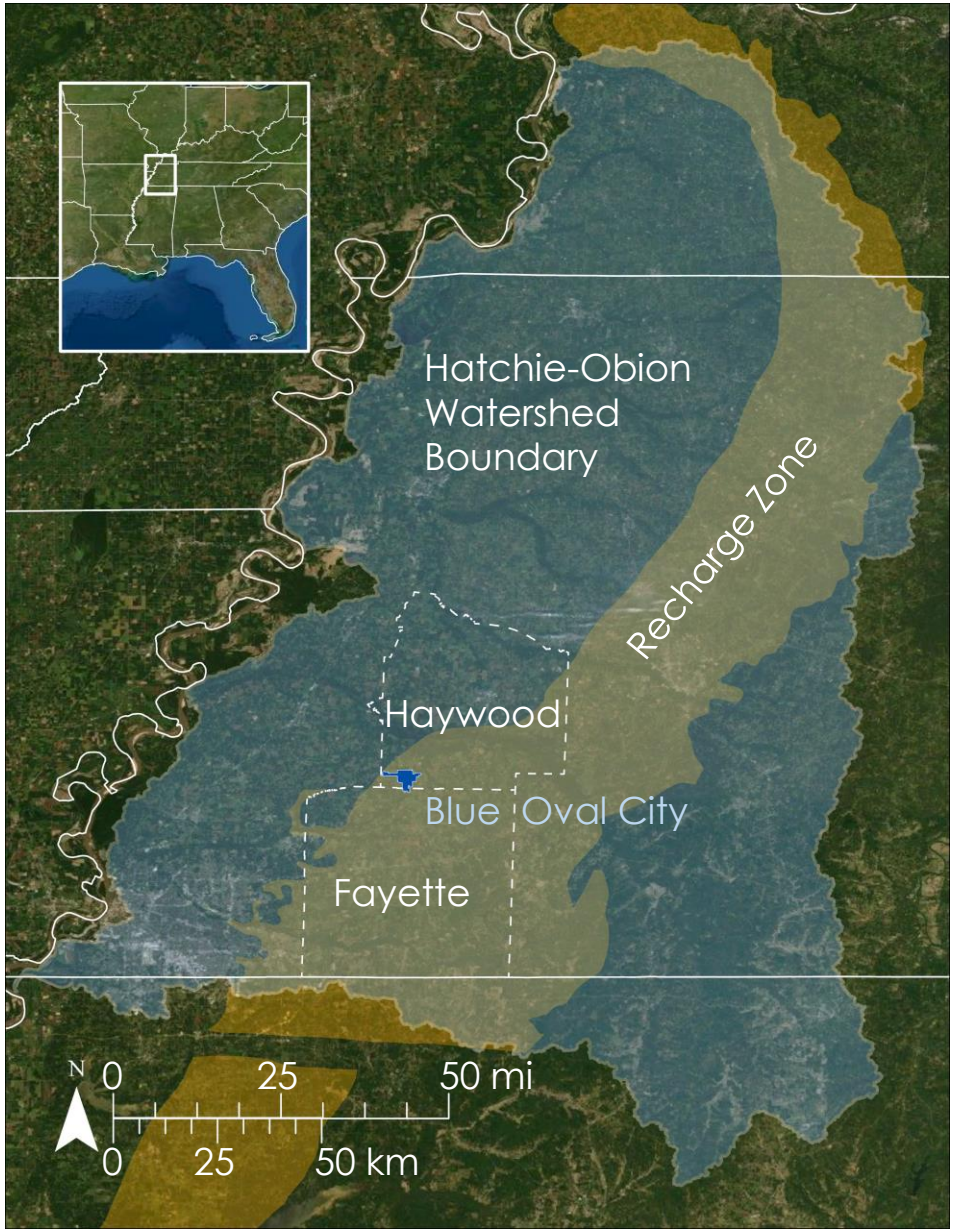
Leveraging High Resolution Remotely Sensed Data to Assess Water Availability and Vulnerability in the Memphis Aquifer Area in West Tennessee



Katera Lee
Michael Pazmino
Elena Pilch
Lauren Webster (Project Lead)

The Memphis Aquifer

- Located in the Hatchie-Obion Watershed and Mississippi Embayment
- Special attention to Haywood and Fayette counties, Blue Oval City, and the Memphis Aquifer Recharge Zone



Credits: Earthstar Geographics, ESRI, TIGERLINE, USGS

About the Aquifer

- The pristine 2,000 - 3,000 years old water is protected from contamination by confining clay layers
- The recharge zone is the only area where precipitation can directly replenish the aquifer
- Supplies water to nearly a million residents.

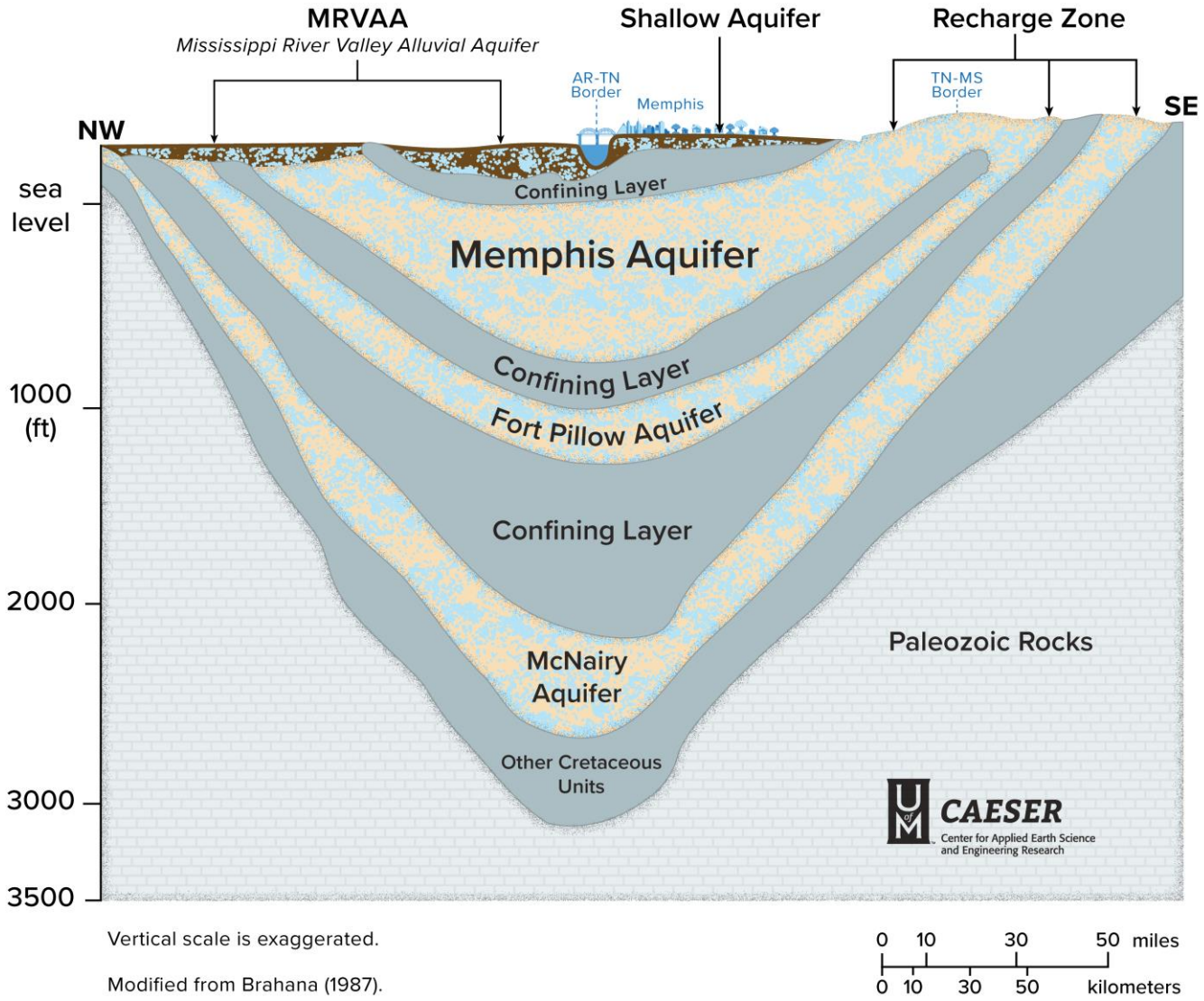


Image Credit: University of Memphis Center for Applied Earth Science and Engineering Research

Project Partners

Protect Our Aquifer

End User

University of Memphis: Center for Applied Earth Science and Engineering Research

Collaborator

Community Concerns

- With increased urbanization, water struggles to infiltrate to the aquifer to recharge the groundwater supply.
- The construction of Ford's new "Blue Oval City" battery assembly megasite may impact the recharge rate of the Memphis Aquifer.

Image Credit: Sarah Houston, Protect Our Aquifer

Objectives

Evaporative Stress Index Time Series

Create seasonal evapotranspiration, evaporative stress index, and precipitation maps to examine temporal variability

Evapotranspiration & Precipitation

Image Credit: NASA

Objectives

Evaporative Stress Index Time Series

Water Balance Time Series

Create water balance maps by calculating seasonal water balance using evapotranspiration and precipitation

Objectives

Evaporative Stress Index Time Series

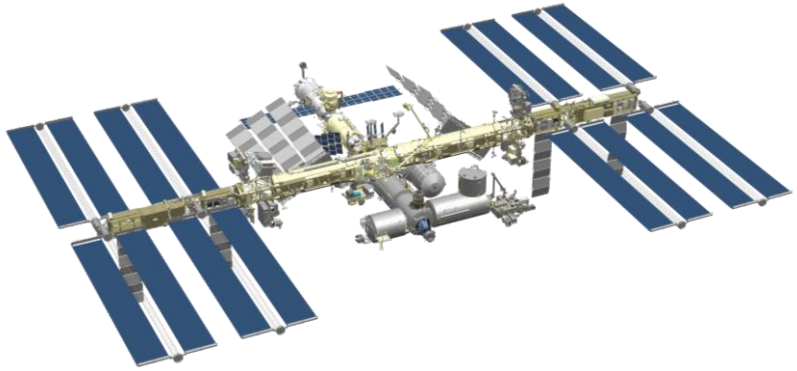
Water Balance Time Series

Thriving Areas Map

Identify thriving areas using evapotranspiration, precipitation, and landcover change

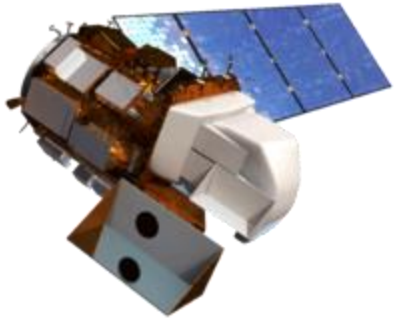
Methods

NASA Earth Observation Platforms and Sensors



International Space Station - ECOSTRESS

GPM IMERG



Landsat 8 OLI & TIRS

Image Credit: NASA

Overview of Methodology

ECOSTRESS ET/ESI

GPM IMERG Precipitation

Landsat 8 Landcover

NLDAS NOAH Model: Runoff

2019-2022

- Mask quality flags and quality control pixels
- Remove outliers
- Average daily to season

→ Seasonal composites of ET & ESI

- Clip to study area
- Average daily to season

→ Seasonal composites of Precipitation

- Cloud mask
- Classify using NLCD
- Test classification accuracy

→ Yearly composites of landcover

- Add together runoff layers
- Average monthly to seasonal

→ Seasonal composites of runoff

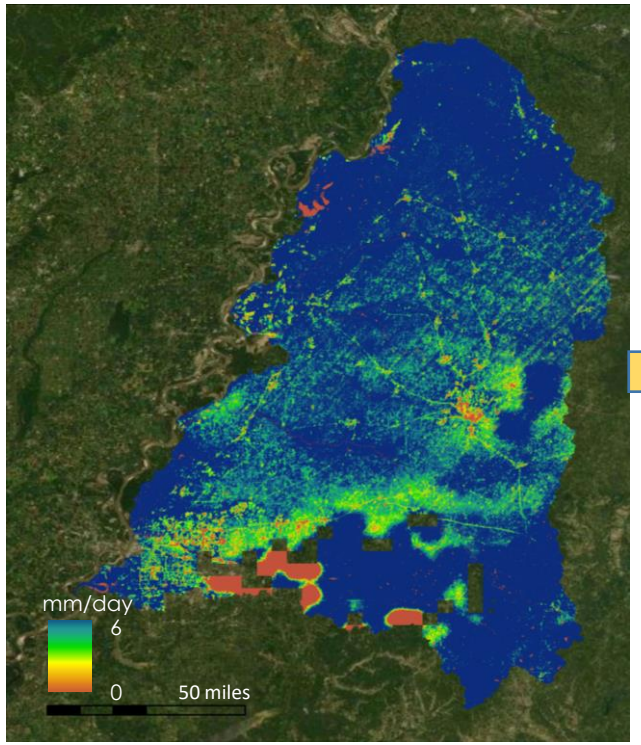
Data Processing – Evapotranspiration & Evaporative Stress Index

Download data from AppEEARS

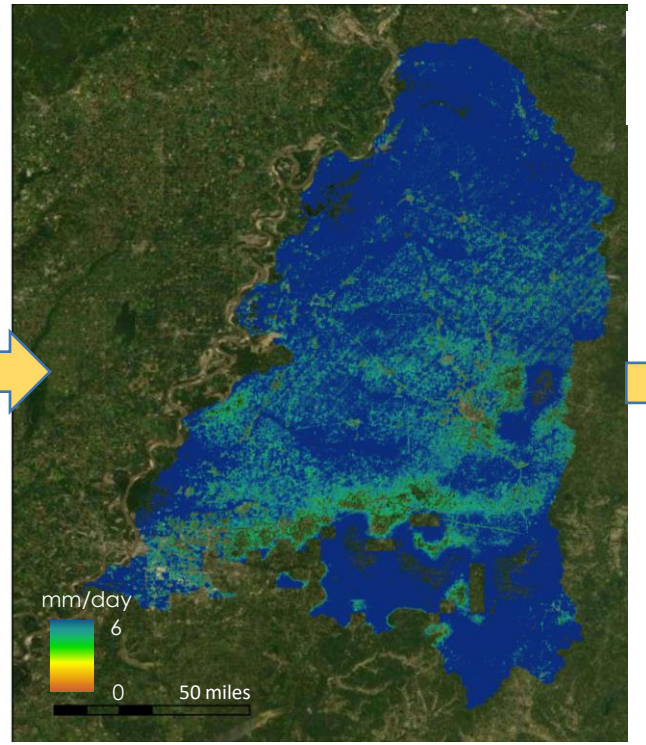
ECOSTRESS ET & ESI

Mask quality flags and quality control pixels

Remove outliers



Daily ET pre-processed



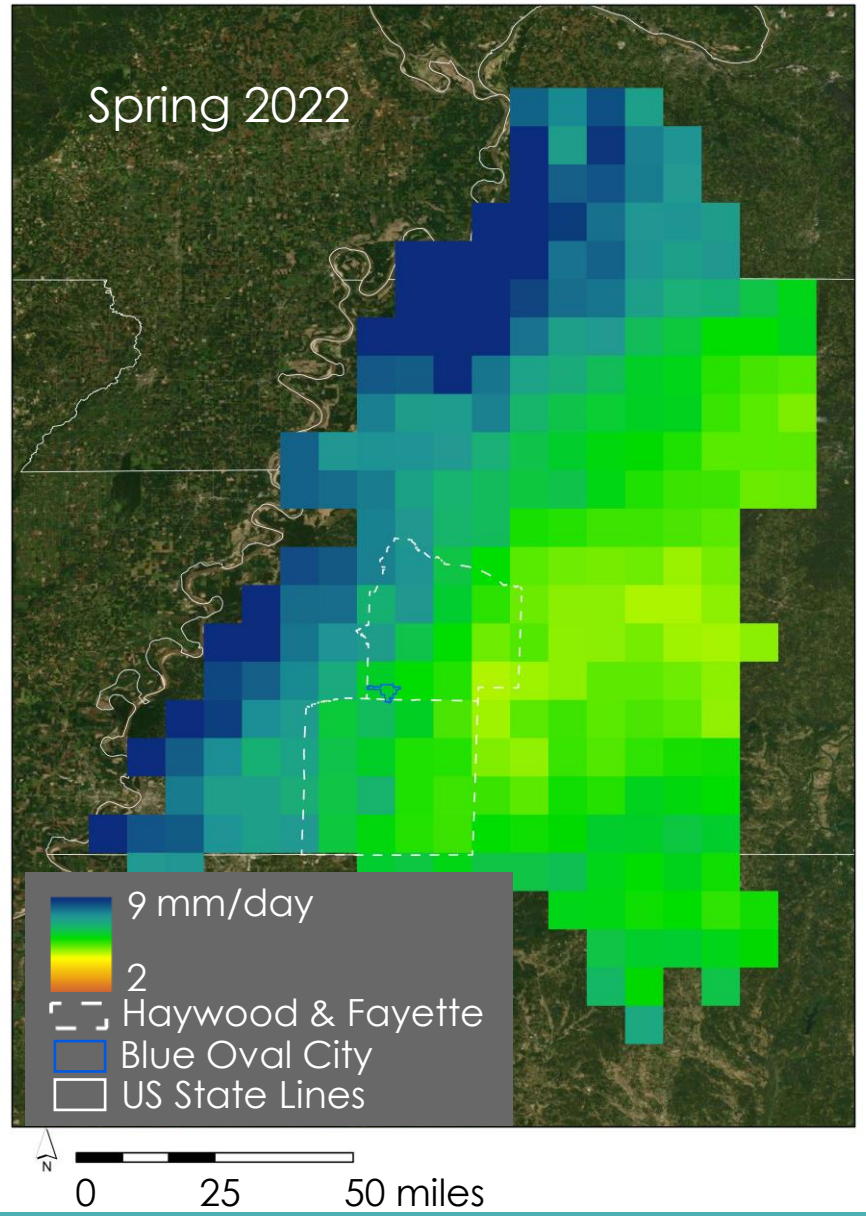
Daily ET processed

Create average seasonal composite with all daily images

Data Processing - Precipitation

- GPM IMERG: Final Run Monthly(FRM)
  - Calibrated with gauge data 3.5 months after time period
  - Study period coverage: Jan 2019- Aug 2021
- GPM IMERG: Late Run Daily (LRD)
  - Taken 14 hours after observation time
  - Study period coverage: Sept 2021- Aug 2022

GPM IMERG (FRM & LRD) → Clipping Images in ArcGIS Pro

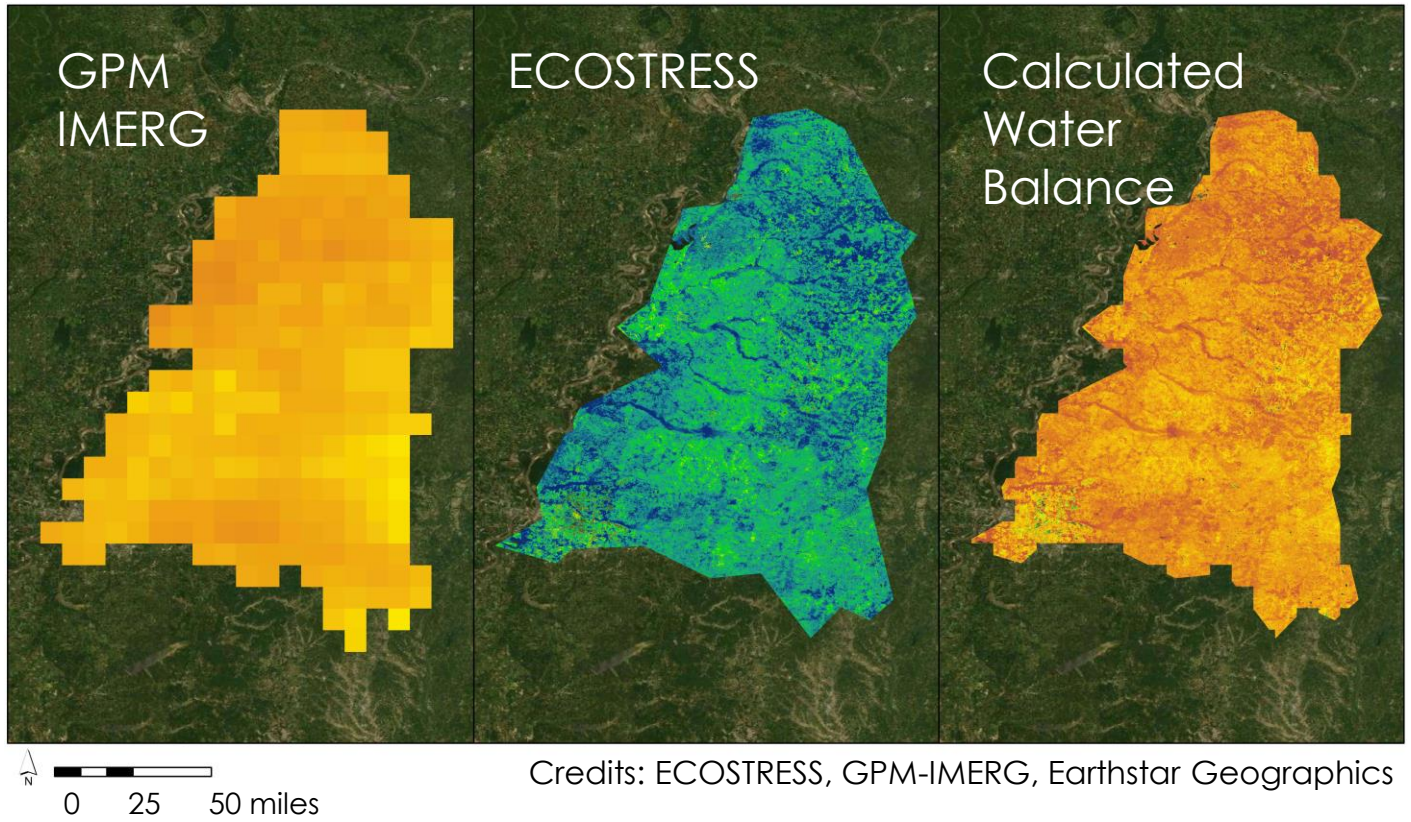


Credits: GPM-IMERG, Earthstar Geographics

Data Processing – Water Balance

PRECIPITATION − **EVAPOTRANSPIRATION** = **WATER BALANCE**

1. Rescale GPM IMERG to match ECOSTRESS
2. Subtract rasters
3. Calculate Water Balance Rasters



Credits: ECOSTRESS, GPM-IMERG, Earthstar Geographics

Data Processing – Landsat 8 and NLCD

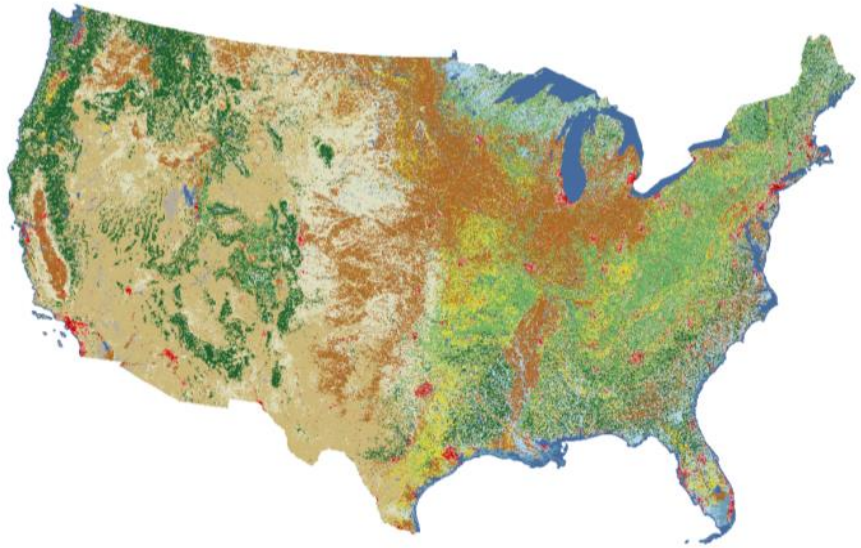
Google Earth Engine

Landsat 8 OLI / TIRS

Cloud mask Landsat images

Classify images using NLCD

Run a confusion matrix to test classification accuracy



Data Processing – NLDAS NOAH Runoff

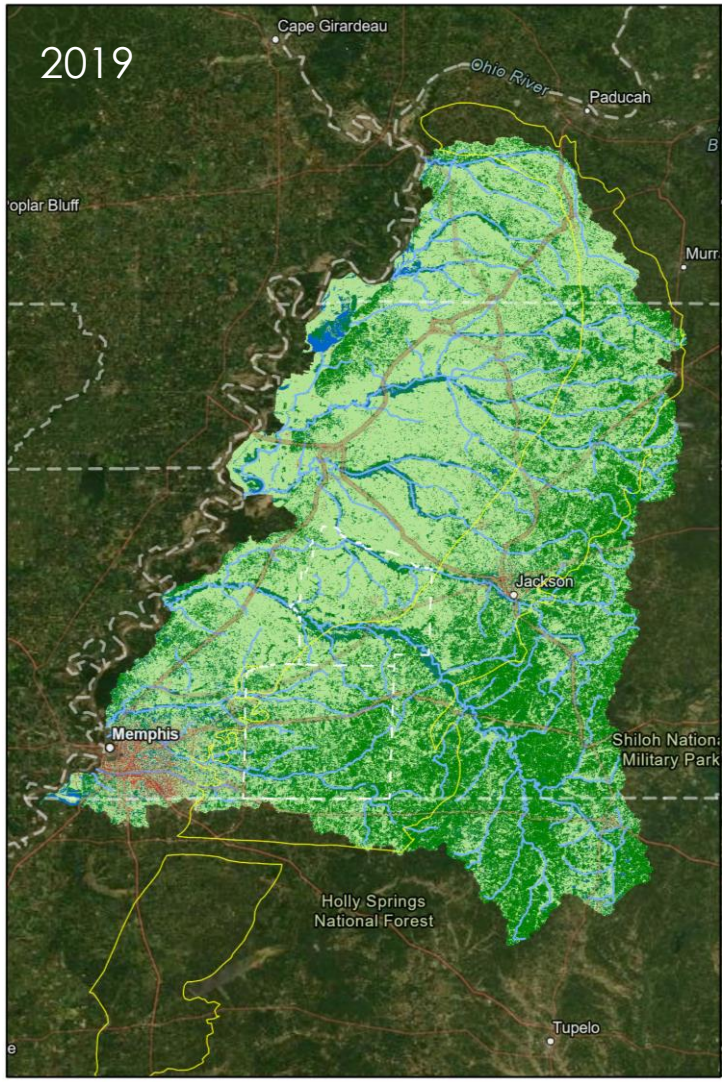
NLDAS NOAH MODEL from EarthData

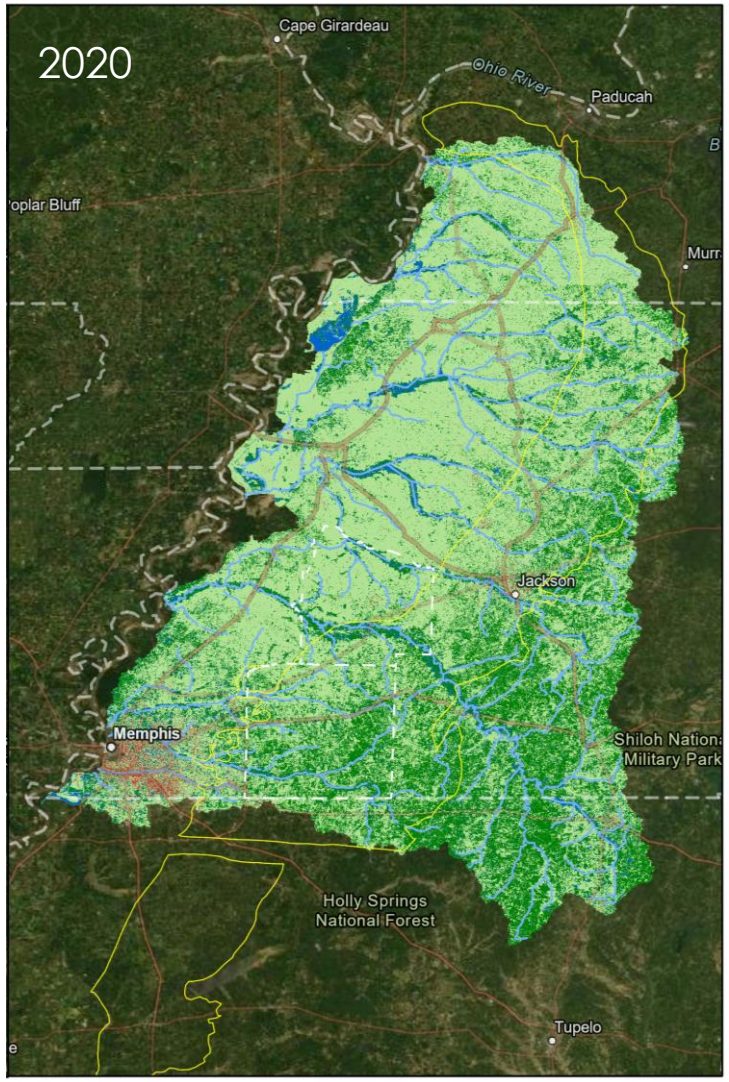
Add together Surface and Subsurface runoff layers for each month

Average Monthly TIFS into each season

Results: Land Cover

Landcover Maps for 2019 & 2020





Trees

Pervious

Impervious

Water

Haywood and Fayette Counties

Memphis Aquifer Recharge Zone

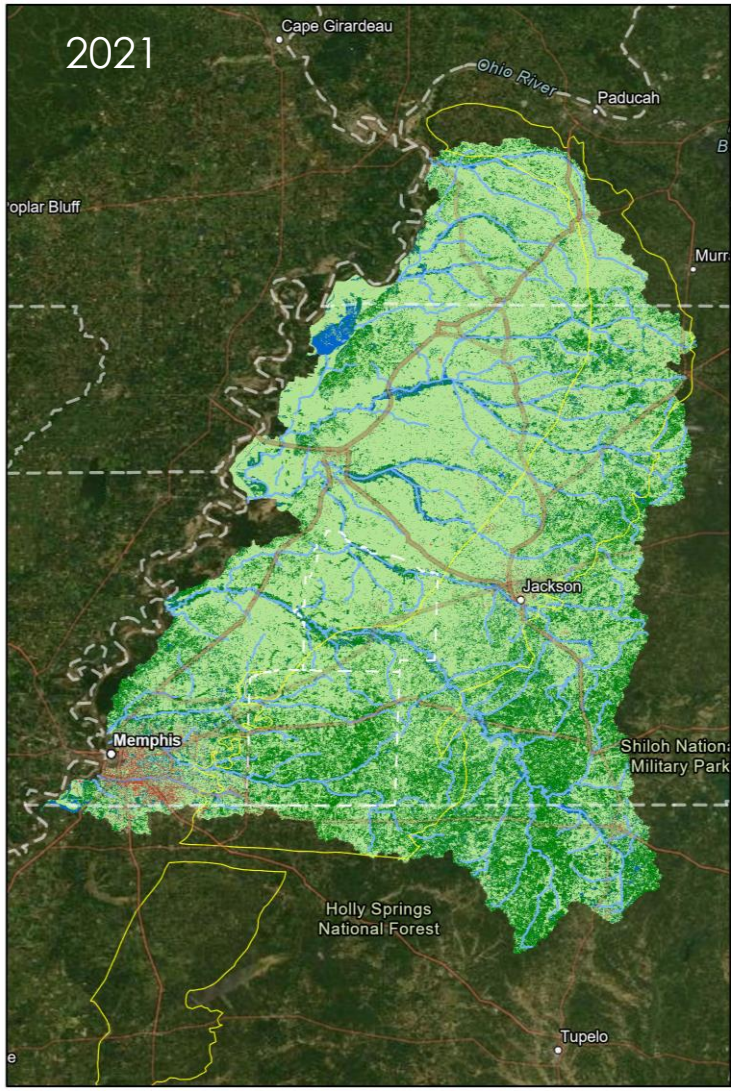
Waterways

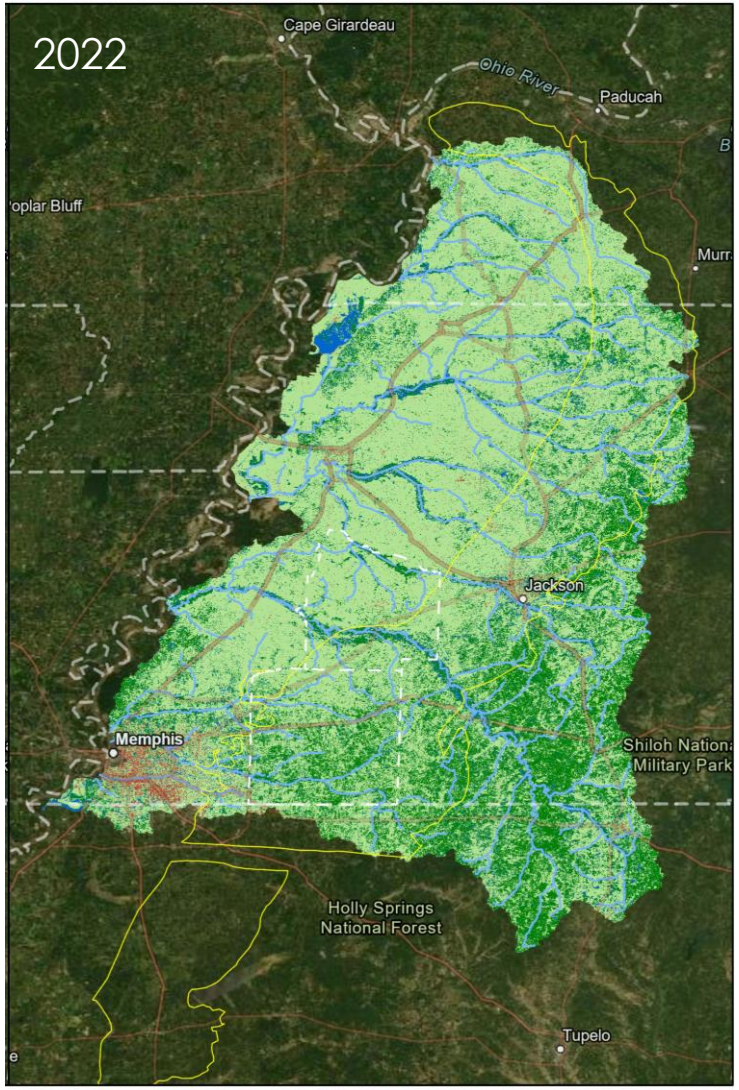
N

0 25 50 Miles

Credits: USGS, US Census, Earthstar Geographics

Landcover Maps for 2021 & 2022





Trees

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Waterways

N

0 25 50 Miles

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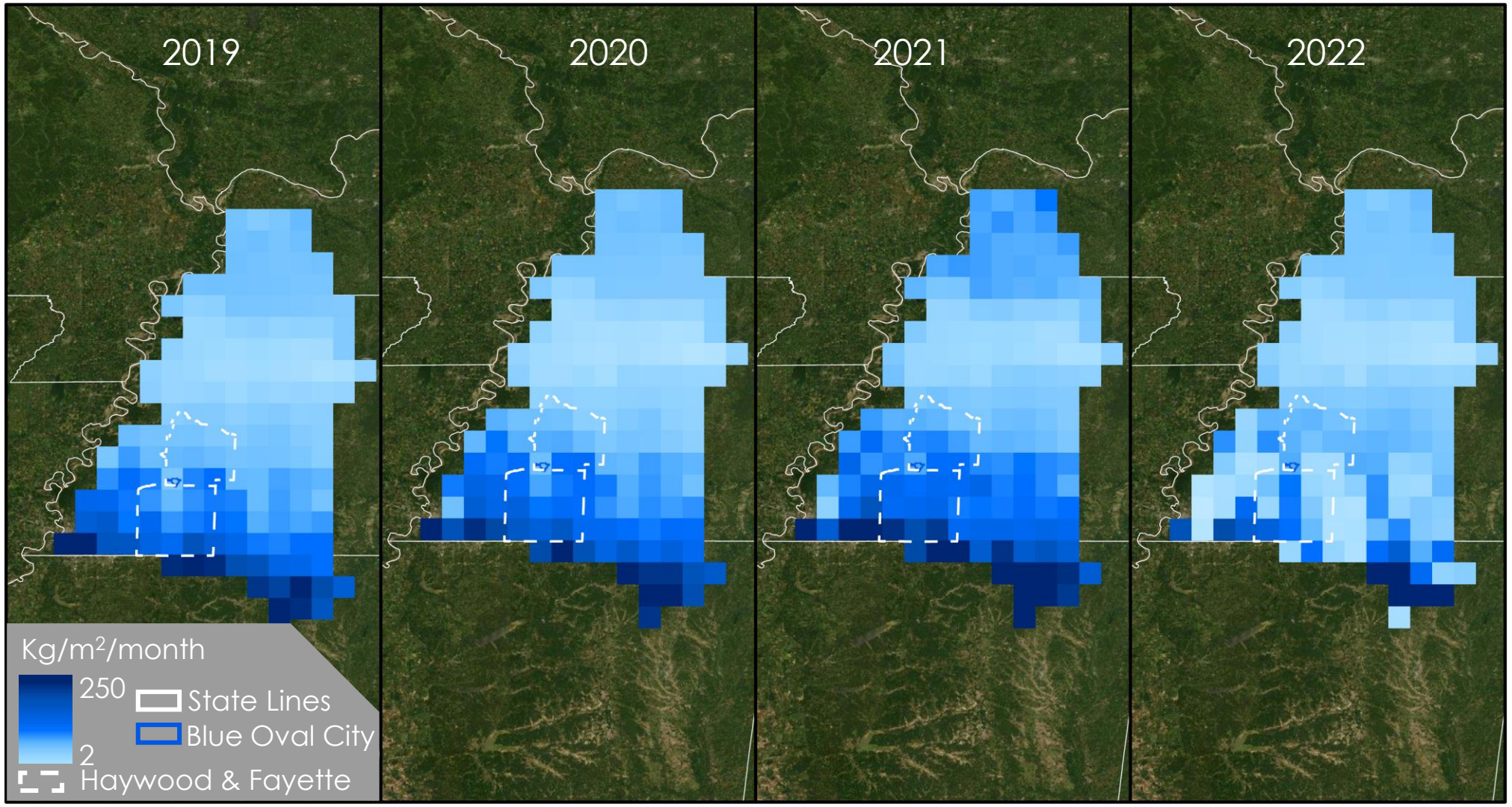
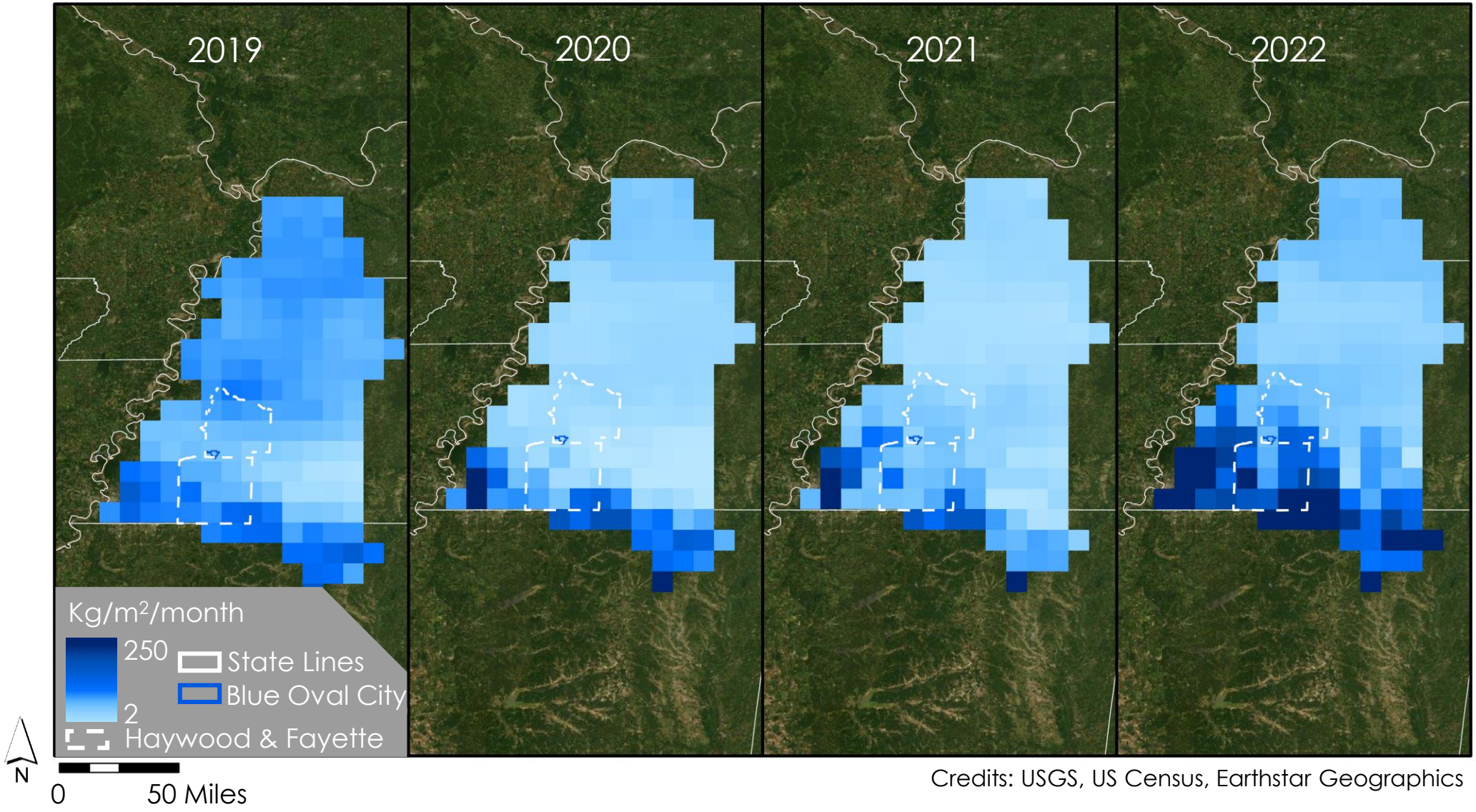
Results: Runoff

Spring Runoff 2019 - 2022



Credits: USGS, US Census, Earthstar Geographics

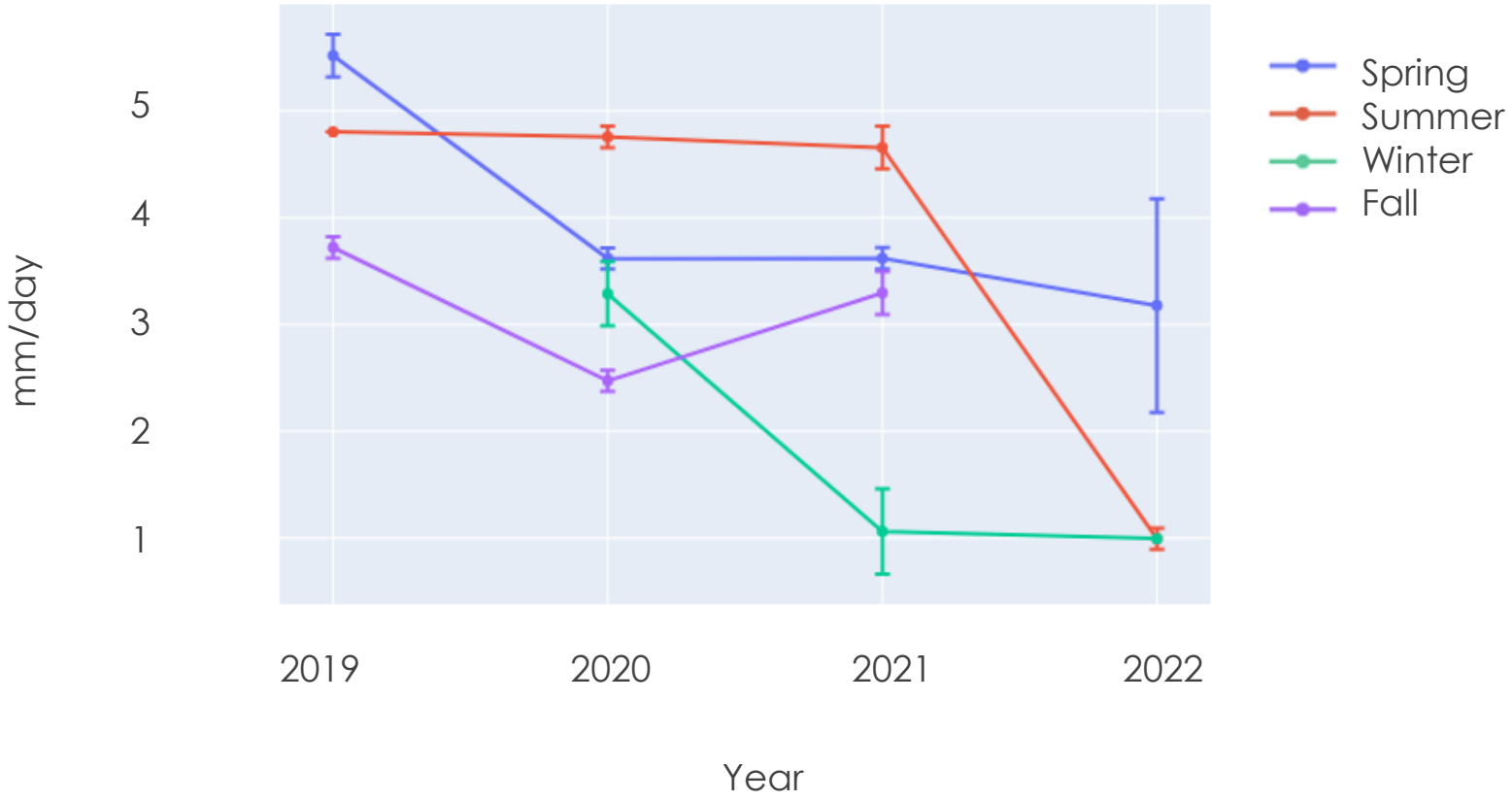
Summer Runoff 2019 - 2022



Credits: USGS, US Census, Earthstar Geographics

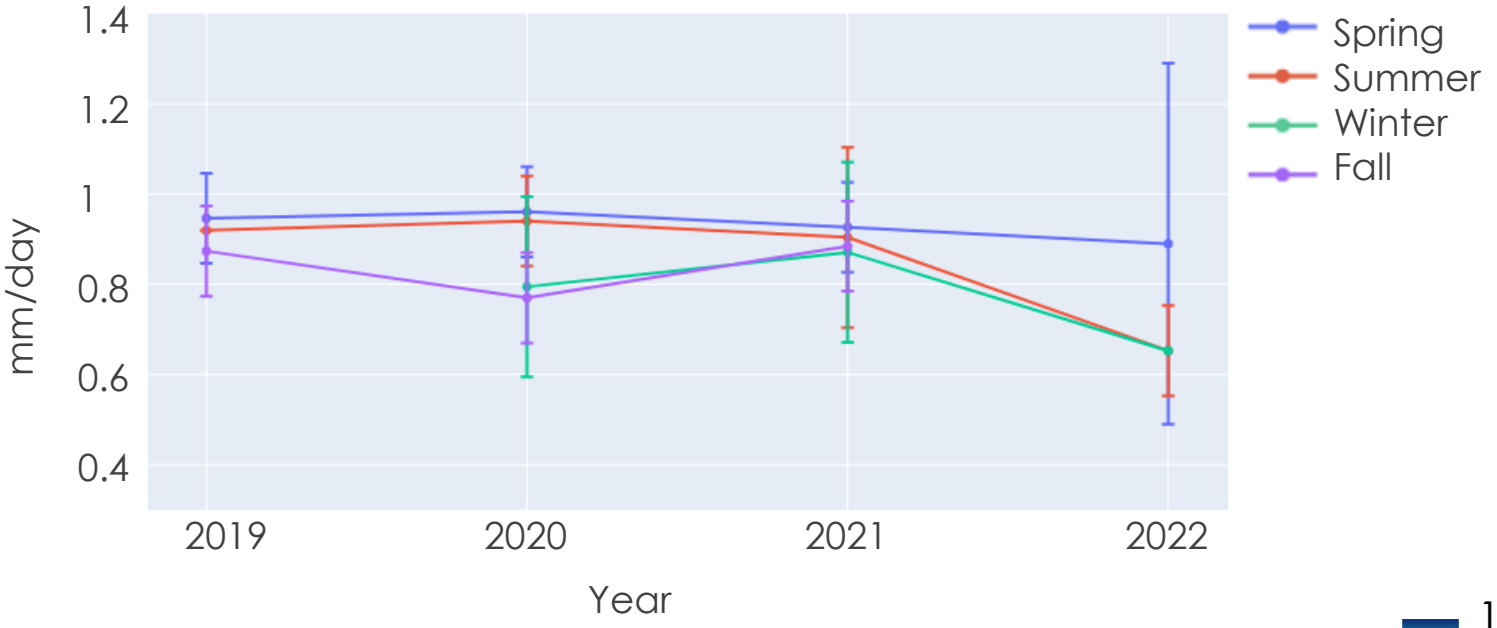
Results: ET

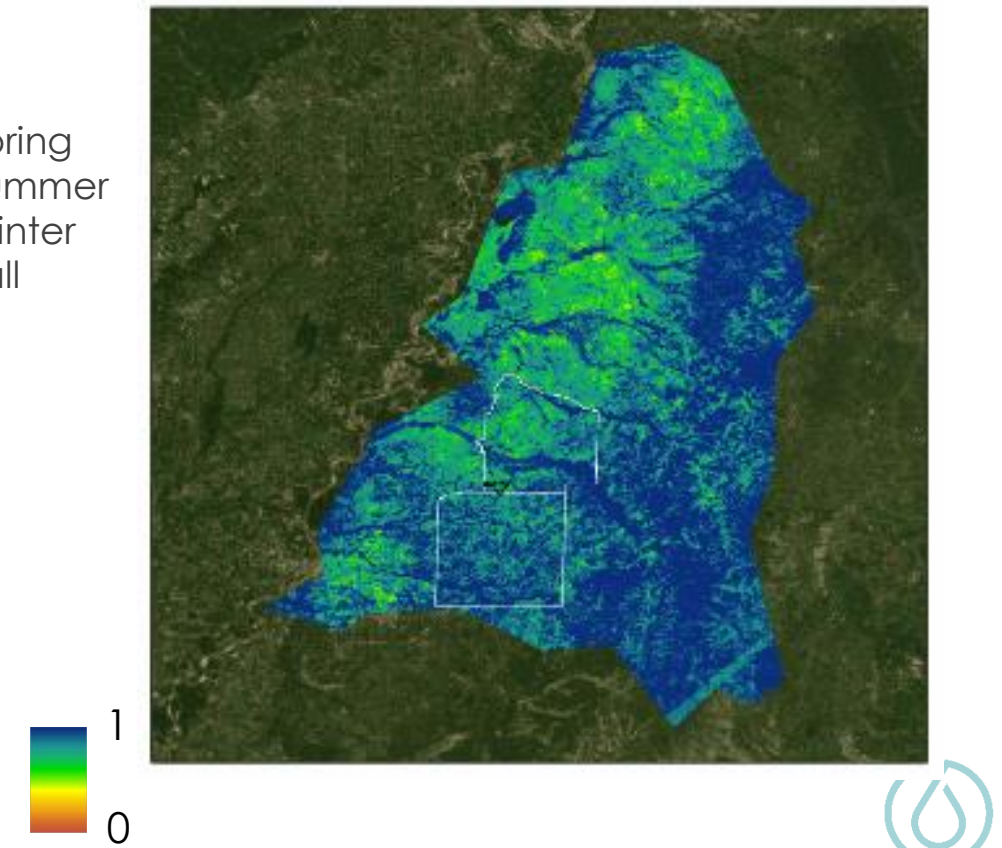
Average Seasonal Evapotranspiration



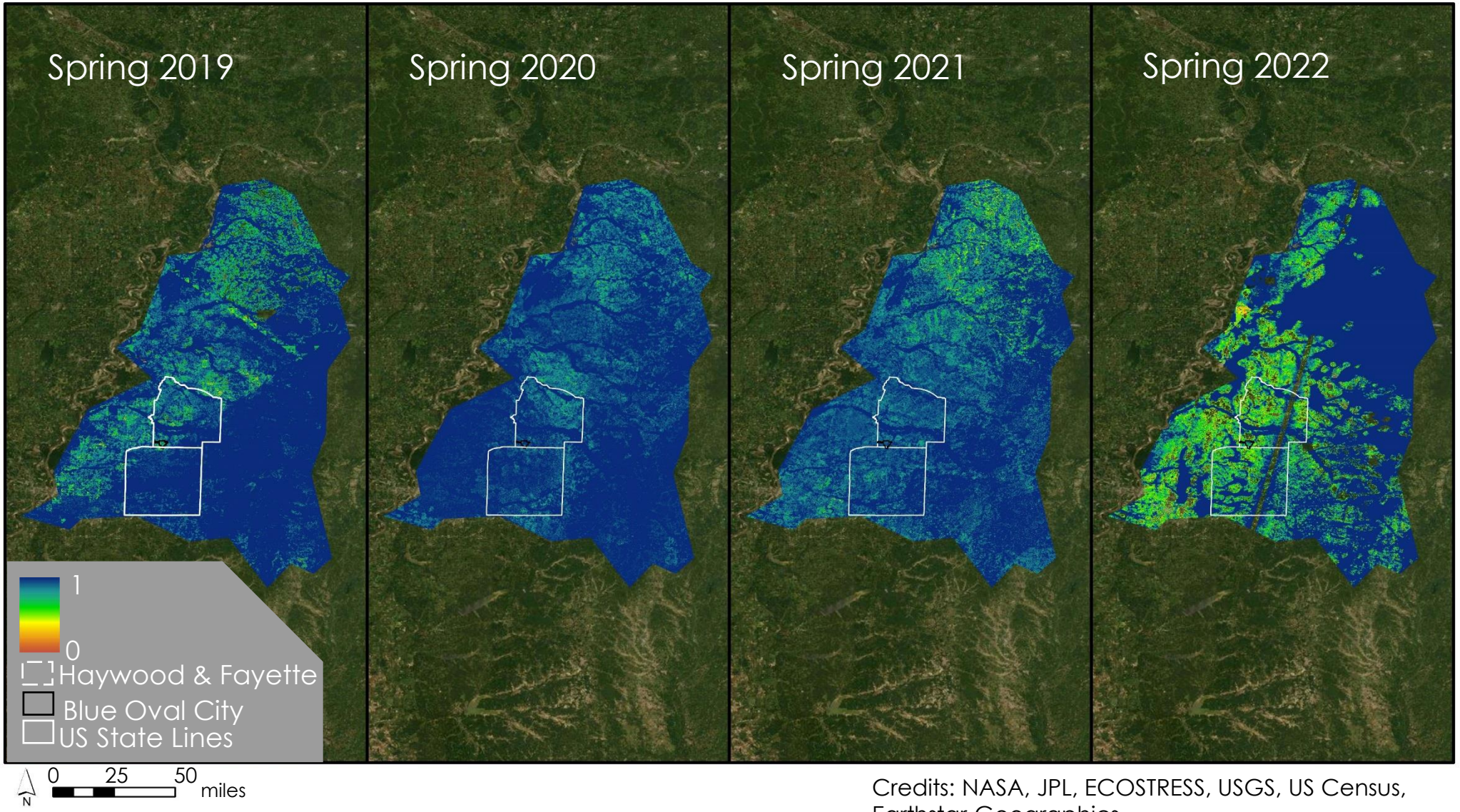
Results: ESI

Average Seasonal Evaporative Stress Index



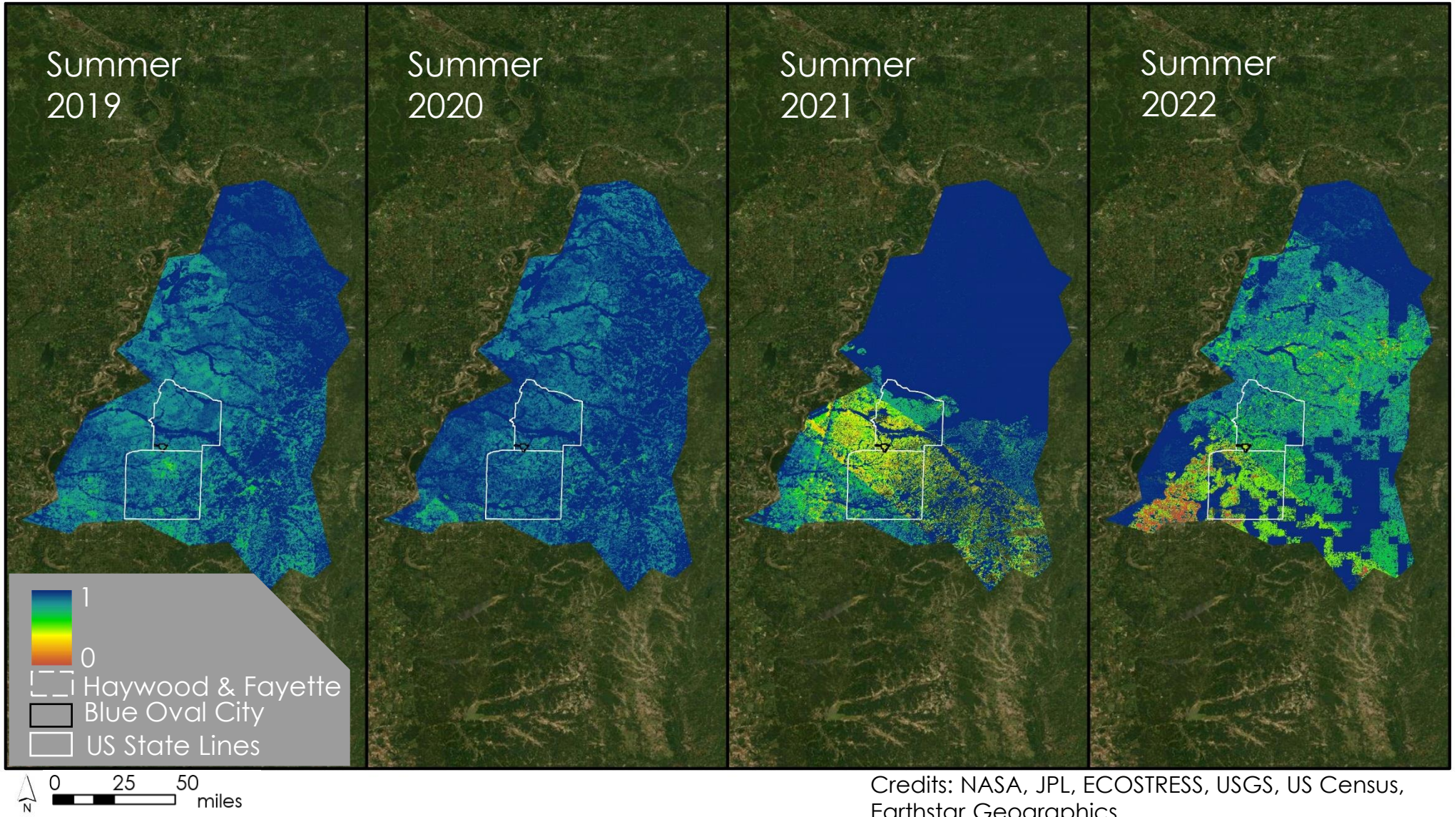


Spring Seasonal Evaporative Stress Index



Credits: NASA, JPL, ECOSTRESS, USGS, US Census, Earthstar Geographics

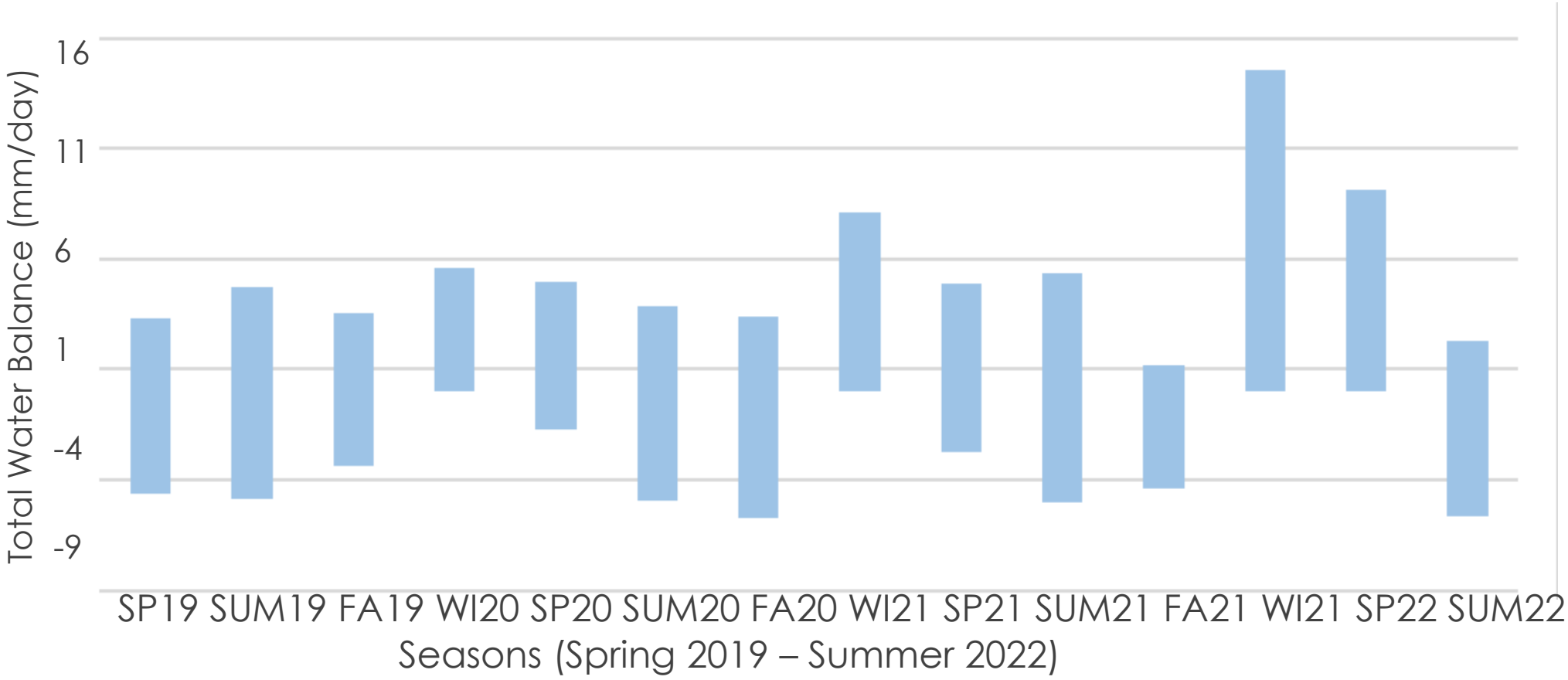
Summer Seasonal Evaporative Stress Index



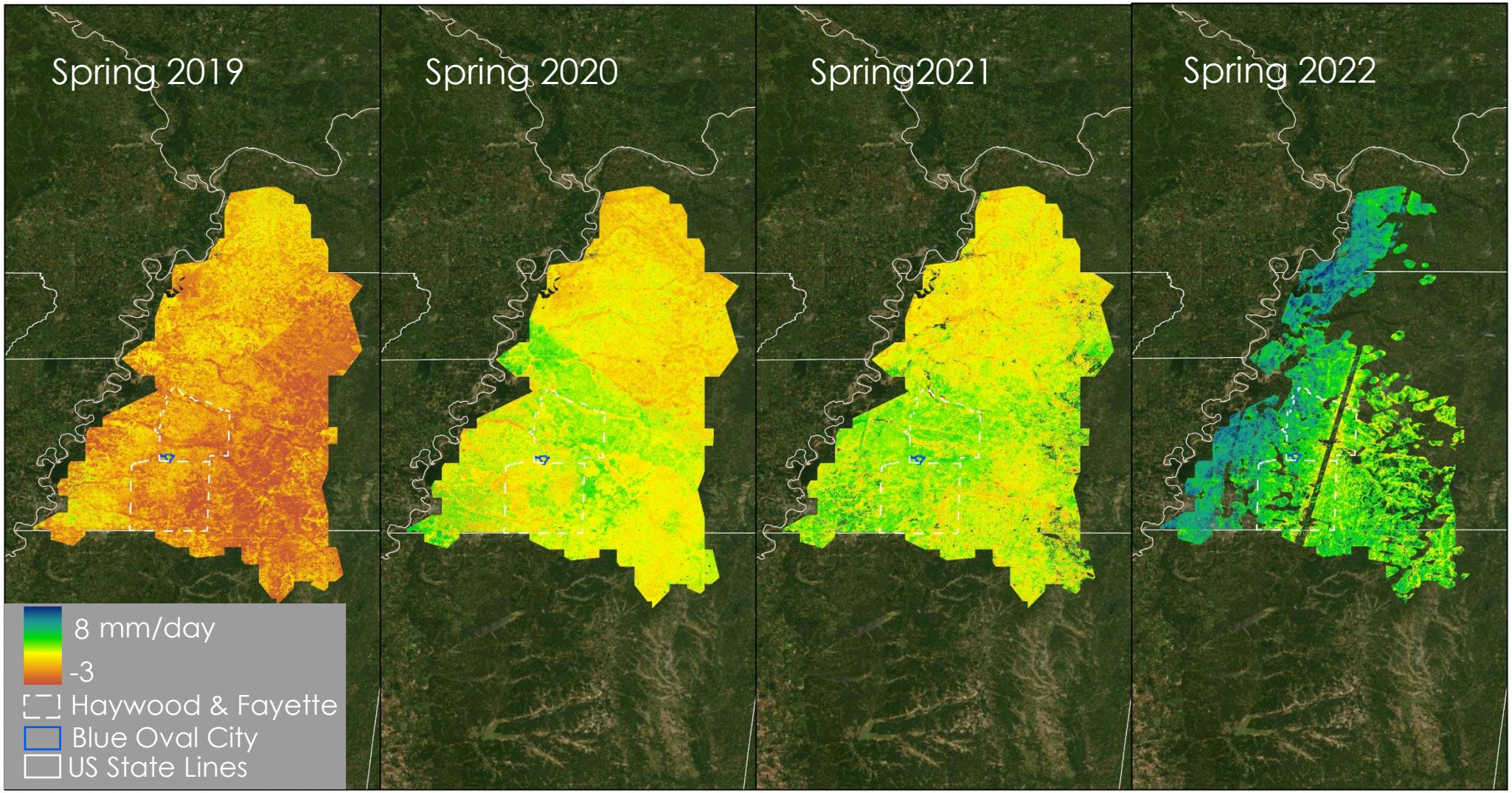
Credits: NASA, JPL, ECOSTRESS, USGS, US Census, Earthstar Geographics

Results: Water Balance

Water Balance Time Series

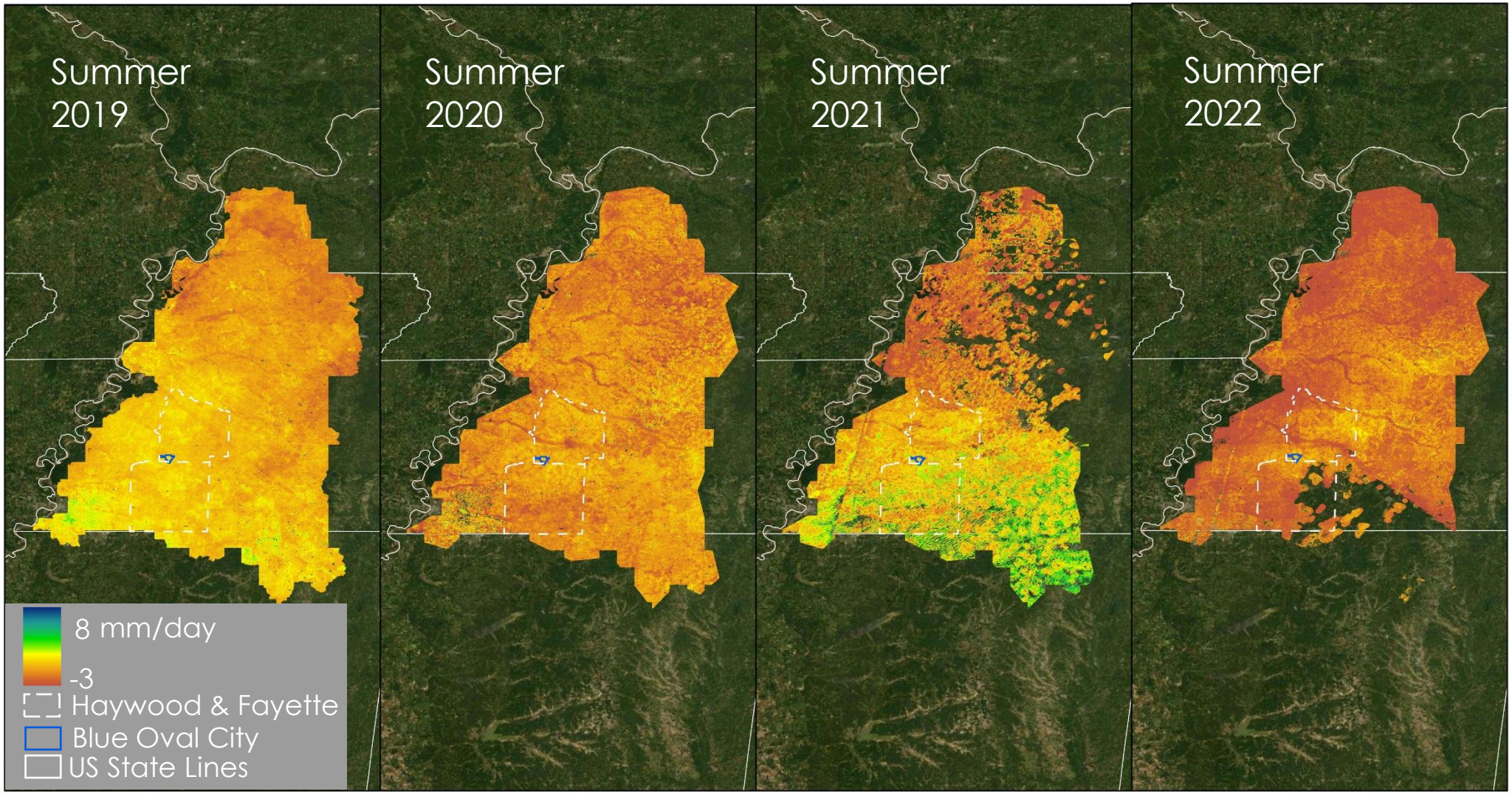


Spring Seasonal Water Balance



Credits: NASA, JPL, ECOSTRESS, GPM IMERG, USGS, US Census, Earthstar Geographics

Summer Seasonal Water Balance



Credits: NASA, JPL, ECOSTRESS, GPM IMERG, USGS, US Census, Earthstar Geographics

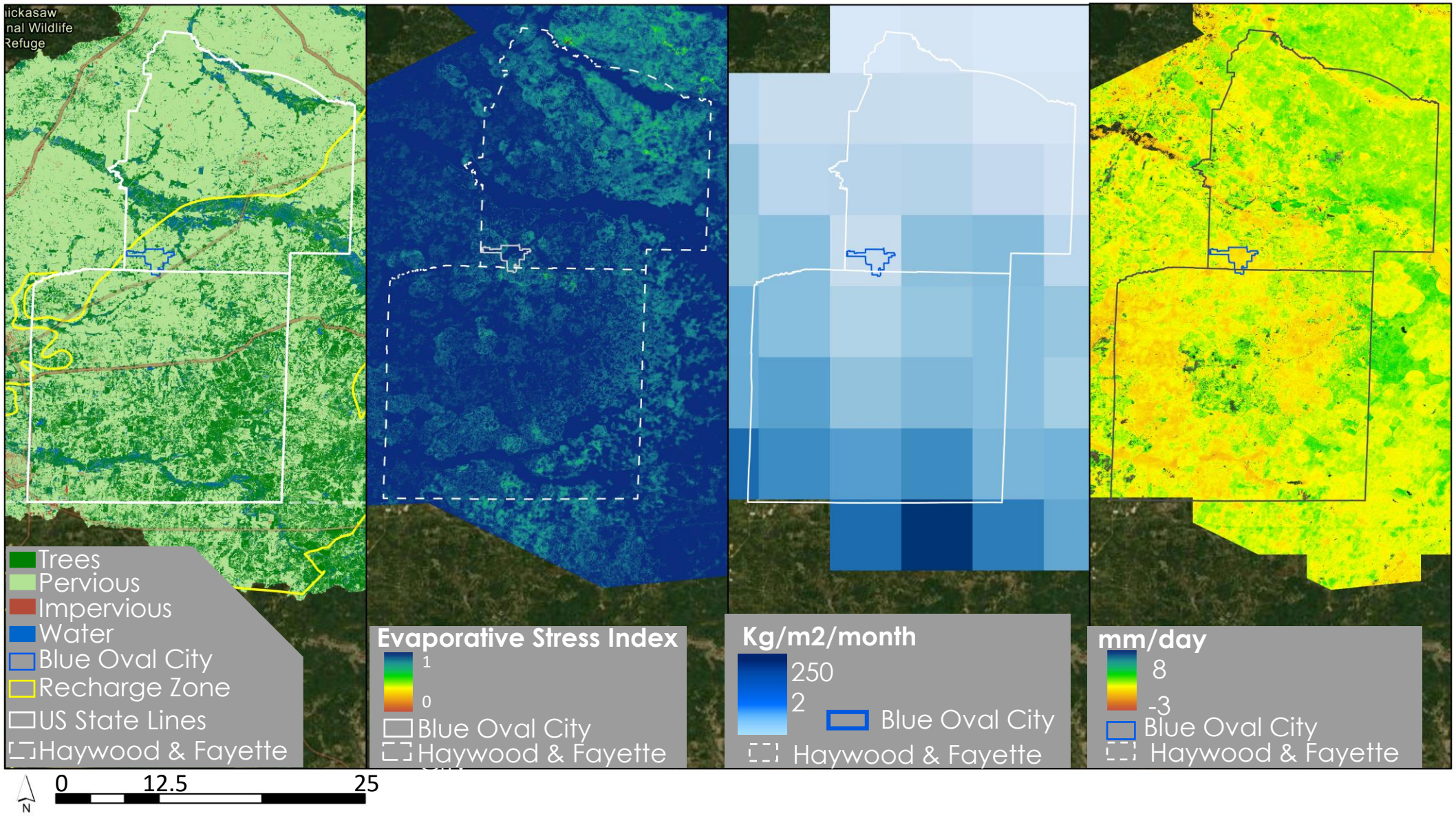
Results: Thriving Areas

Land Cover 2020

Evaporative Stress Index Spring 2020

Run Off Spring 2020

Water Balance Spring 2020



Errors and Uncertainties

Data gaps in ECOSTRESS

GPM IMERG Final Run vs Late Run

Future Work

Validate water balance and thriving index results with final run GPM-IMERG

Explore other factors that influence groundwater recharge

Create a tool for real-time groundwater monitoring

Evaluate changes to ground subsidence

ACKNOWLEDGEMENTS

Partners

- **Protect Our Aquifer**
  - Sarah Houston (Executive Director)
  - Ward Archer (President)
  - Jim Kovarik (Board Member)
- **University of Memphis Center for Applied Earth Science and Engineering Research**
  - Brian Waldron (Director)
  - Scott Schoefernacker (Associate Director)
- **Tennessee Department of Environment and Conservation**
  - Brian Ham (Environmental Consultant)

Past Contributors

- Lauren Mahoney
- Brenna Hatch
- Lauren Webster
- Claire Villanueva-Weeks

NASA DEVELOP

- Kathleen Lange (NASA DEVELOP JPL Fellow)

Science Advisors

- Madeleine Pascolini-Campbell (NASA Jet Propulsion Laboratory, California Institute of Technology)
- Kerry Cawse-Nicholson (NASA Jet Propulsion Laboratory, California Institute of Technology)
- BenjaminHolt (NASA Jet Propulsion Laboratory, California Institute of Technology)

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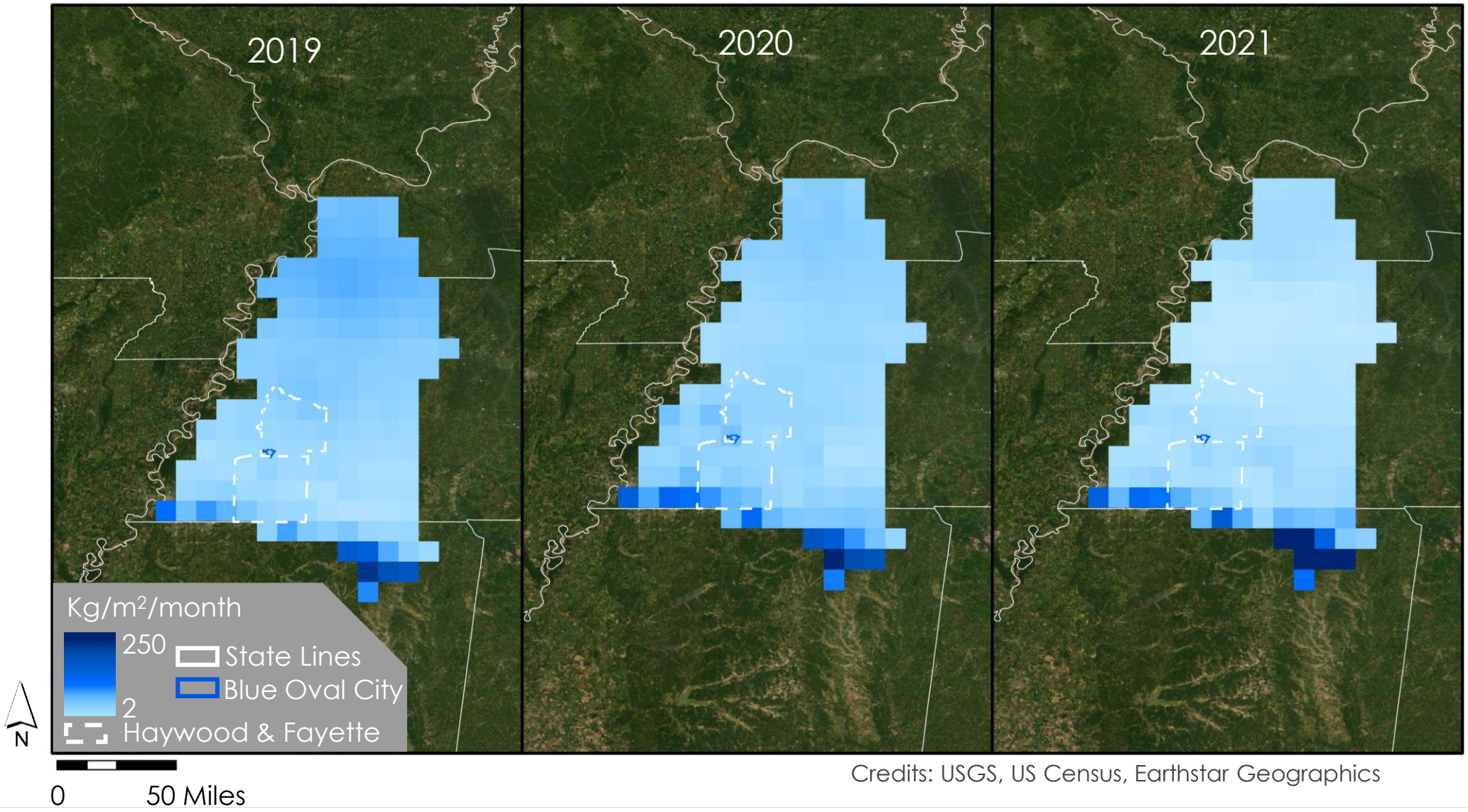
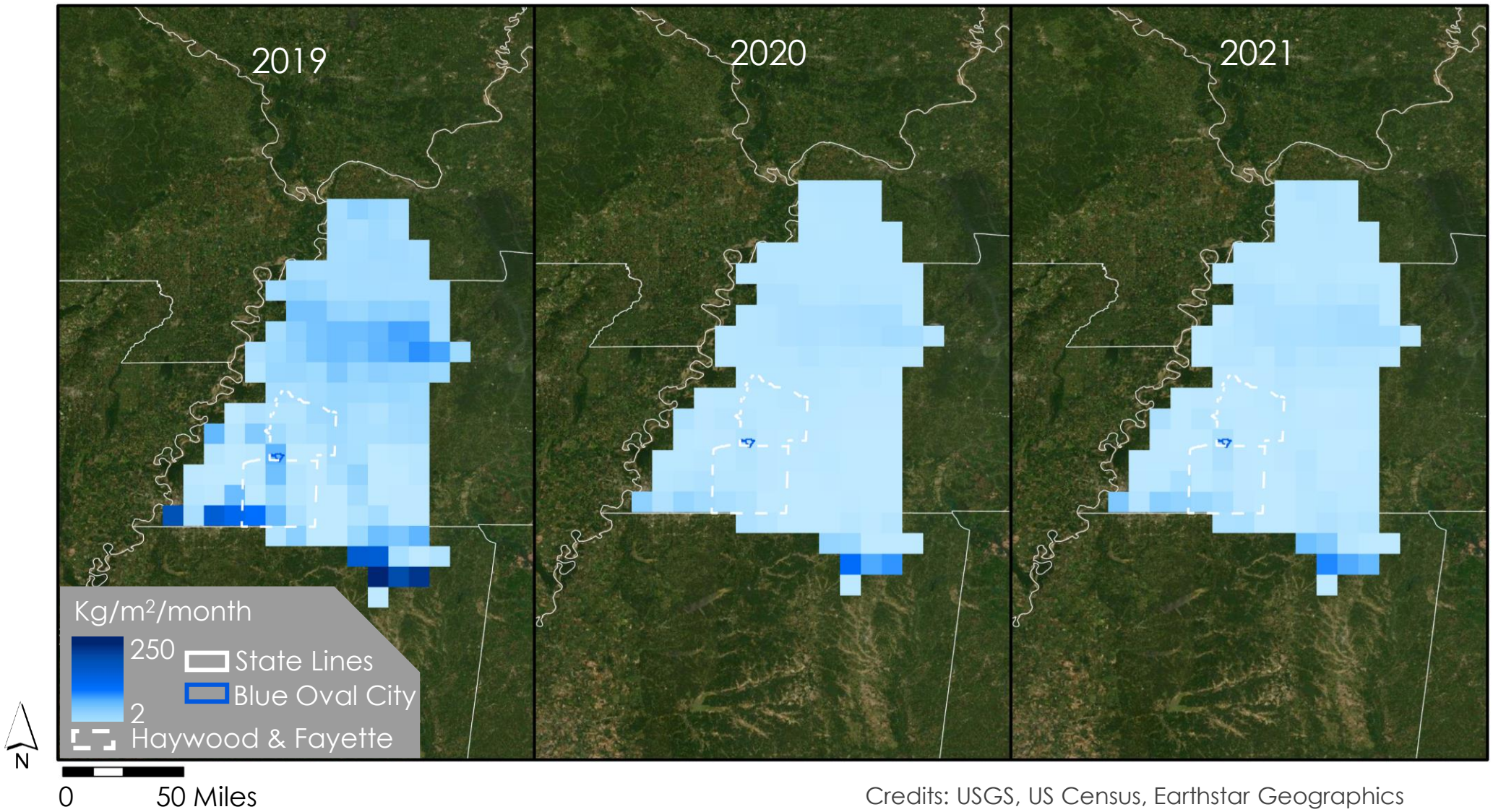
Backup Slides

Fall Runoff 2019 - 2021



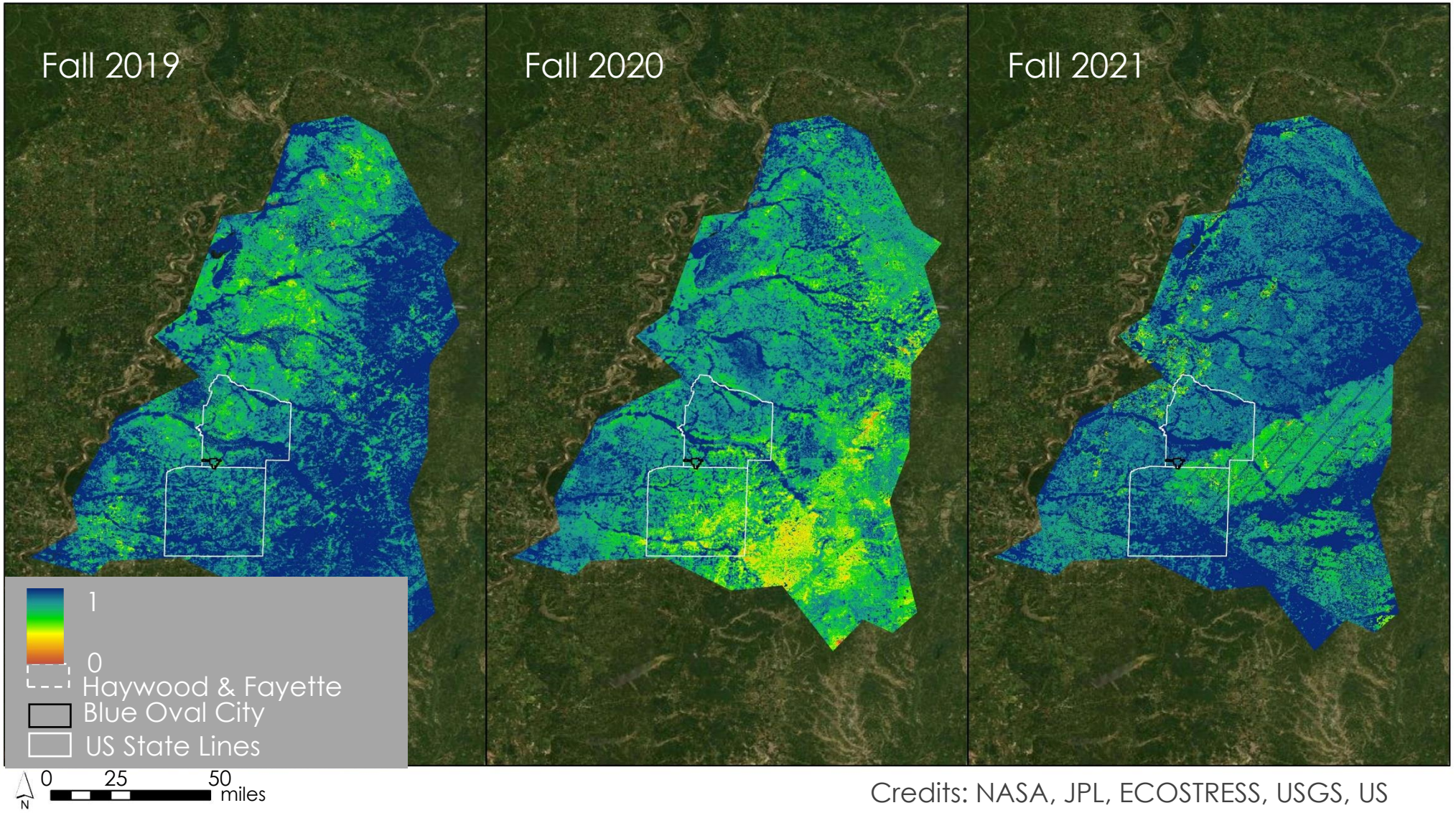
Credits: USGS, US Census, Earthstar Geographics

Winter Runoff 2019 - 2022



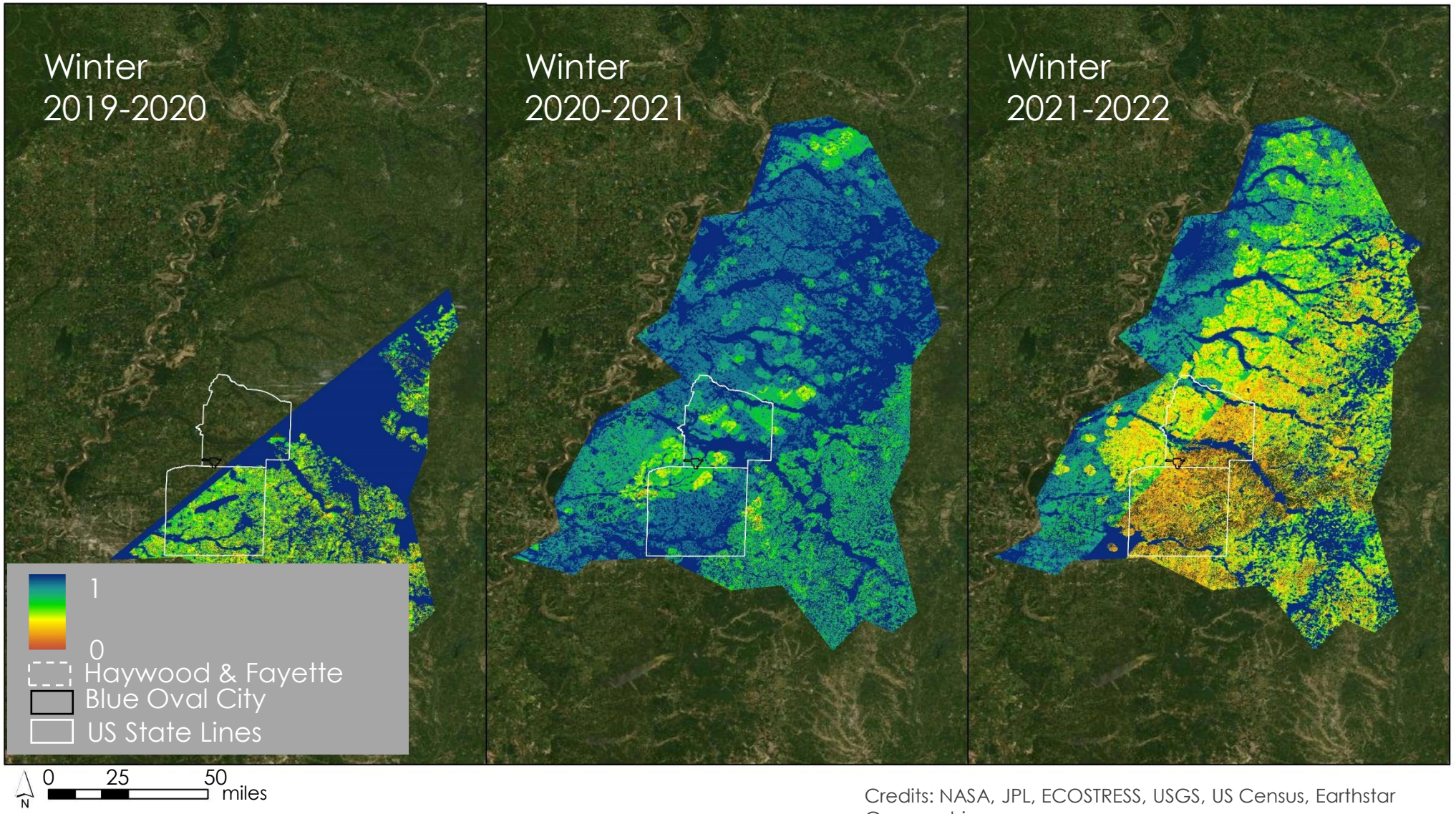
Credits: USGS, US Census, Earthstar Geographics

Fall Seasonal Evaporative Stress Index



Credits: NASA, JPL, ECOSTRESS, USGS, US Census, Earthstar Geographics

Winter Seasonal Evaporative Stress Index



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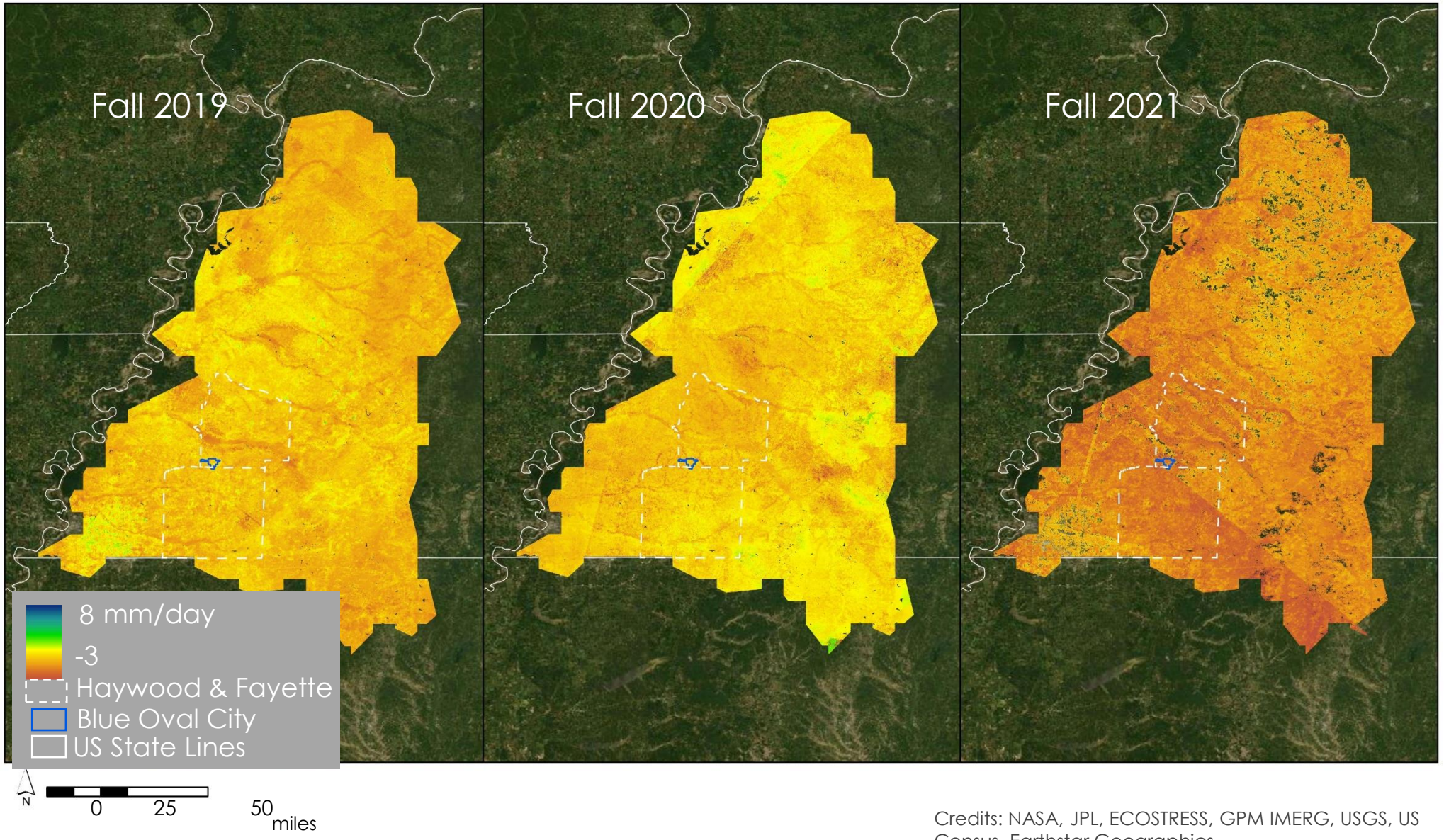
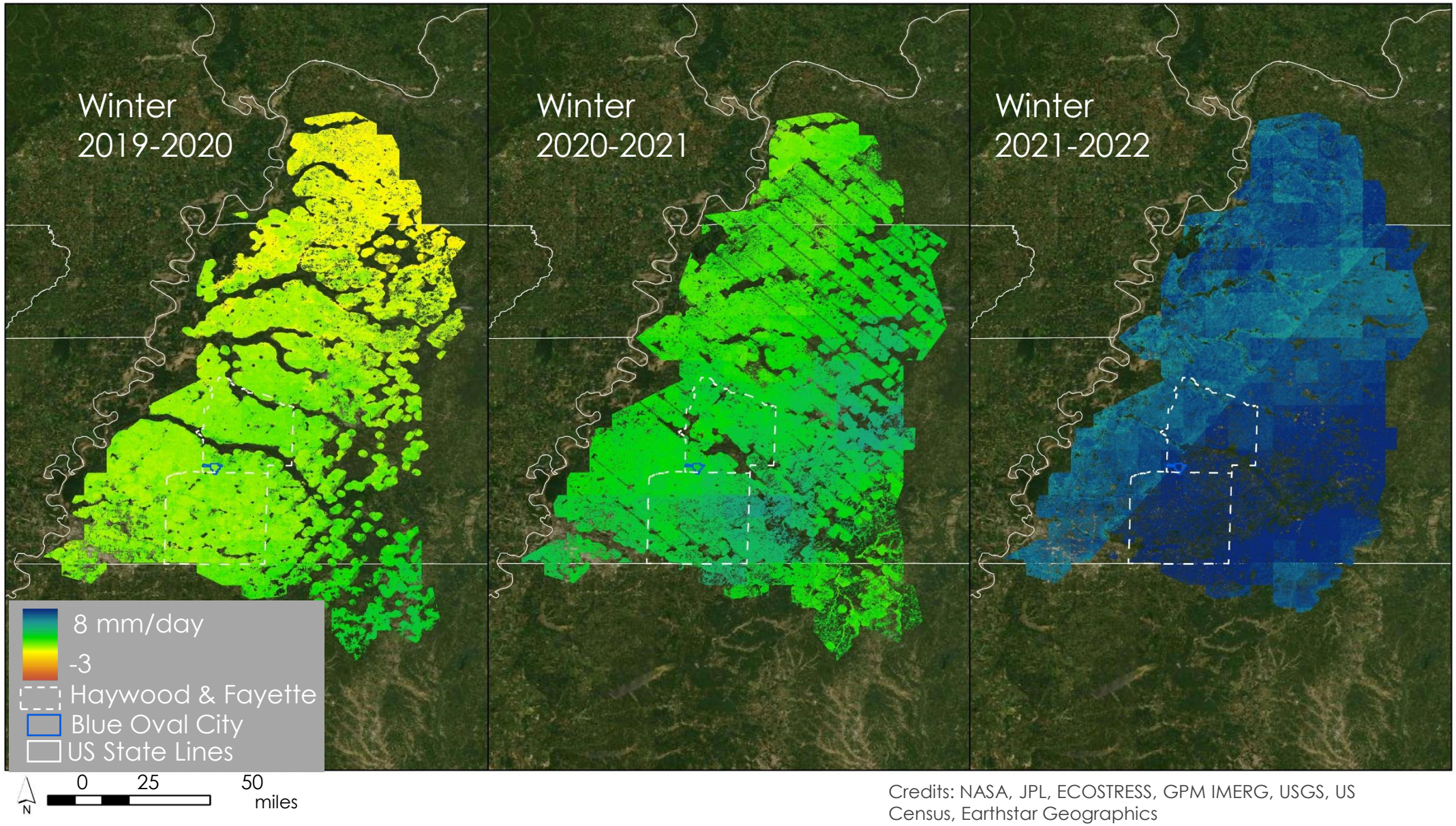
Fall Seasonal Water Balance



Credits: NASA, JPL, ECOSTRESS, GPM IMERG, USGS, US Census, Earthstar Geographics

Winter Seasonal Water Balance



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