Summer 9-10-2024

Big Geospatiotemporal Data Approaches to Monitoring and Mitigating Environmental Impacts in Agriculture

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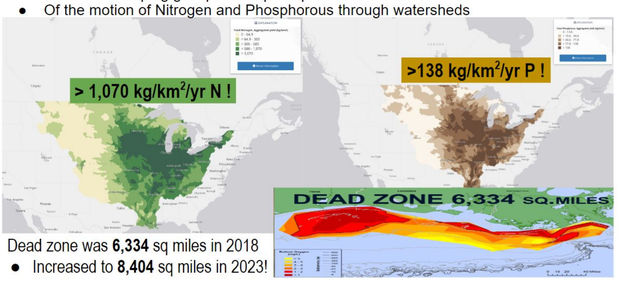
Societal Problem

Nitrogen and Phosphorus in the Mississippi Watershed

An environmental catastrophe, with broad Societal Impact

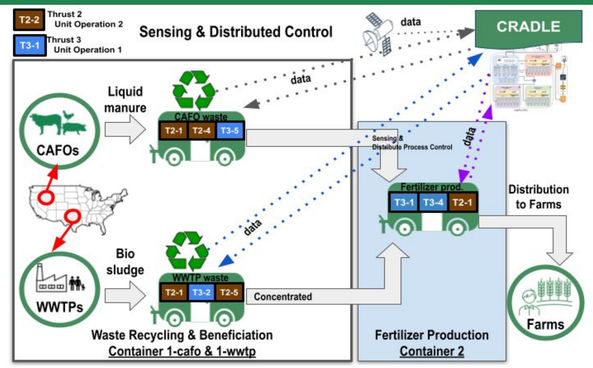
- We are developing geospatiotemporal predictive models
- Of the motion of Nitrogen and Phosphorous through watersheds



Dead zone was **6,334** sq miles in 2018

- Increased to **8,404** sq miles in 2023!

Introduction

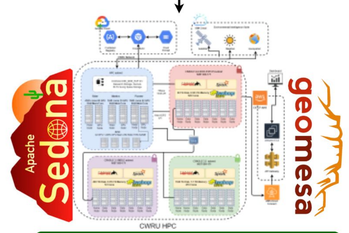


Objectives

- Monitor nutrient flow and land use in space and time
- Resolve issues relating land application and crop planting for farmers
- Enhance food security through sustainable agriculture practices
- Address runoff concerns from CAFOS/WWTPs into streams
- Build robust geospatial technology to handle real-world problems

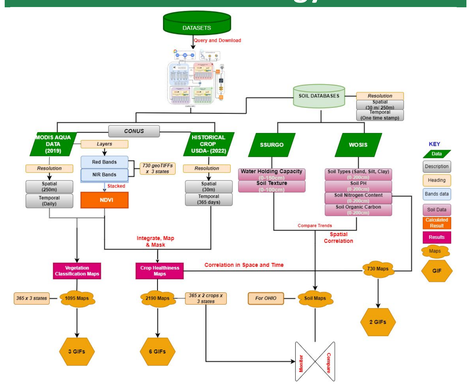
Data Sources

Query, Download, Ingest, and FAIRify

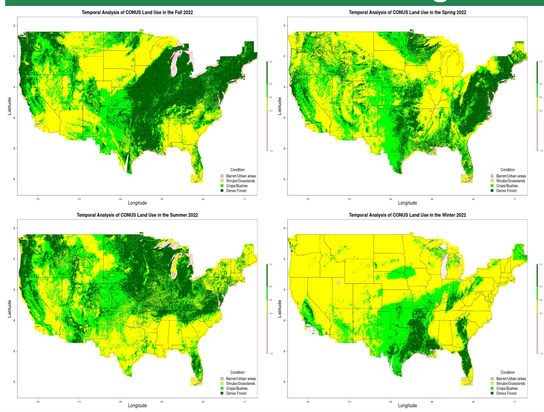


Multiscale Big Geospatiotemporal data Integration, Analytics, and Modeling

Methodology



Land Use in Contiguous United States (2022)



Vegetation Index Mapping

- Utilized MODIS Terra satellite
- Employed NDVI (**Normalized Difference Vegetation Index**) for classification

NDVI for Land Use cases

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

- NDVI used to assess greenness, varying with **seasons**, **location**, and **time**
- 365 maps were generated for the 2022 Agricultural year

Seasonal Maps

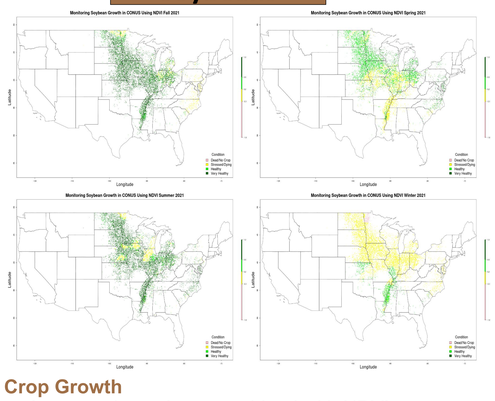
- Seasonal maps align with vegetation classification of regions
- Texas and some southern regions have comparative greeness throughout the the year

Takeaways

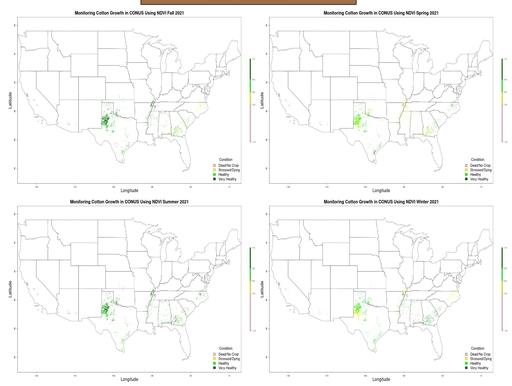
- **Planting Recommendations**
  - Plant crops based on soil suitability in the US
  - Recommend best soil types for planting
- **Monitoring Nutrient Flow**
  - Track metrics for efficient nitrogen use in national scale
  - Identify hotspots to mitigate risks
- **Optimizing Soil Nutrients**
  - Determine optimal times for land application
  - Align crop choice with suitable soil and timing
  - Recognize soil properties influencing nutrient distribution
- **Next Steps**
  - Integrate weather, CAFOS, precipitation data and other datasets at the National scale
  - Daily crop monitoring at the US scale
  - Use spatiotemporal Graphical Neural Networks for flow and nutrient movement prediction

Crop Growth Monitoring and Digital Elevation in Contiguous United States (2021)

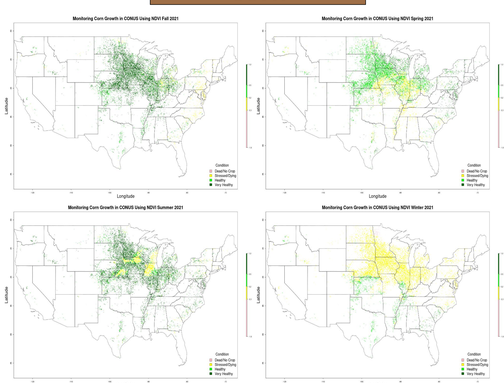
Soybeans



Cotton



Corn



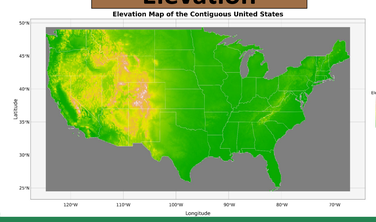
Crop Growth

- Integrated crop layer combined with NDVI to assess specific crop growth across the CONUS.
- Major crops selected: Soybeans, Cotton, and Corn.
- White areas indicate regions where these crops were not planted during the growing season.
- 365 Maps generated for the growing year

Seasonal Maps

- Seasonal maps correspond to the specific cropping patterns of regions across the country.

Elevation

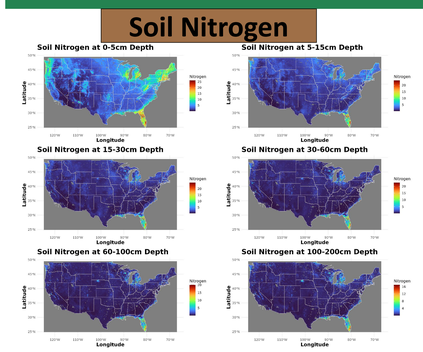


ASTER GDEM for CONUS (30 m resolution)

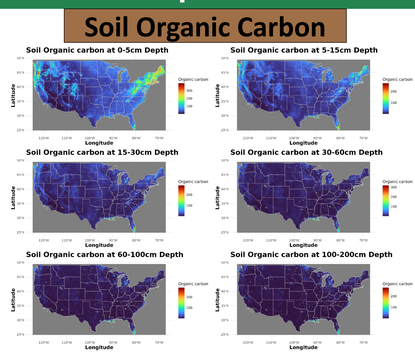
- High-resolution Digital Elevation Model (DEM) used to assess terrain across the contiguous United States.
- Facilitates analysis of nutrient flow by modeling how water and nutrients move across the landscape.
- Watershed delineation: Defined watershed boundaries for effective resource management and study of hydrological systems.
- Supports environmental monitoring and agricultural planning by integrating terrain data with other geospatial layers.

Soil Chemical Properties Distribution at Different Depths

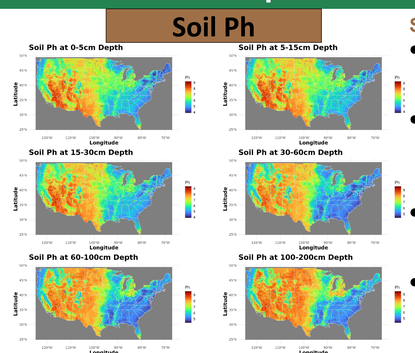
Soil Nitrogen



Soil Organic Carbon



Soil Ph



Soil Chemical Properties

- Soil Nitrogen and Soil Organic Carbon exhibit similar spatial distribution patterns.
- Soil pH increases progressively from the western to central regions of the CONUS.
- Soil chemical properties vary with depth, influencing nutrient availability.
- Understanding these chemical properties is crucial for mapping nutrient accumulation and flow.

Acknowledgement

- This material is based upon work supported by the National Science Foundation under Grant No. 2133576.
- Hendrik Hamann and IBM Environmental Intelligence Suite acknowledged
- This work made use of the High Performance Computing Resource in the Core Facility for Advanced Research Computing at Case Western Reserve University.

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Animations

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