Mini Group Project I

Investigating Agricultural Burning with Remote Sensing Data

Course: CNGF 5020

Due Date: Nov 5, 2025

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1. Introduction

This project challenges you to apply your environmental modeling skills to a real-world air quality issue: the widespread burning of agricultural crop residue. While official policies often ban this practice, identifying these events from other fire sources (like natural wildfires) remains a significant monitoring challenge. Your objective is to function as an independent research group, using a combination of satellite, agricultural, and meteorological data to investigate the scale and characteristics of this phenomenon in a major agricultural region of China.

This is an exploratory project. We provide the core datasets and guiding questions, but the specific analytical methods, visualization choices, and interpretation of the results are up to you.

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2. Background Information: The Challenge of Crop Stover in China

In China, the disposal of agricultural residue, particularly corn and wheat stover left in fields after harvesting, presents a significant environmental challenge[1].

For many farmers, especially in regions with tightly packed planting schedules, burning the leftover stalks and leaves is the **quickest and most cost-effective method** to clear the land for the next crop cycle. This practice also helps remove pests and weed seeds. However, this convenience comes at a high environmental cost.

The open burning of massive quantities of crop residue releases a dense plume of pollutants into the atmosphere. These emissions are a major source of **particulate matter (PM2.5 and PM10)**, carbon monoxide, nitrogen oxides, and other harmful gases. The consequences include:

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[1] https://epic.uchicago.cn/zh-hans/insights/straw-burning-pm%E2%82%82-and-death-evidence-from-china/

- **Severe Air Pollution:** During peak harvest seasons, the smoke from widespread agricultural burning contributes significantly to regional haze and smog events, drastically reducing air quality in both rural areas and distant major cities. In some cases, it can account for up to half of the total PM10 concentrations.
- **Public Health Risks:** Exposure to the fine particulate matter from this smoke is linked to respiratory and cardiovascular diseases, posing a serious threat to public health.
- **Traffic and Safety Hazards:** The thick smoke can severely reduce visibility, leading to traffic accidents and disrupting transportation.

Although the Chinese government has implemented nationwide bans and penalties to curb this practice, enforcement is difficult. Many farmers, lacking profitable or efficient alternatives for straw disposal, continue to burn residue, sometimes at night to avoid detection. This makes it a persistent environmental issue that requires monitoring and innovative management solutions.

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3. Requirements

- **Group Project:** This project is to be completed in groups **between 3-5** students.
- **Submission:** Your submission will consist of two parts:
    1. A **10-minute in-class presentation** that synthesizes your methodology and most compelling findings.
    2. A **GitHub repository** for your group's project, which must include all provided data, well-documented Python scripts/notebooks, and a comprehensive `README.md` file that serves as your final report.

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3. Provided Datasets.

You will be given a folder containing all the necessary datasets:

1. **Satellite Fire Data:** `modis_2010_China.csv`(1 km; 4 times per day). Attributes include latitude, longitude, time, Fire Radiative Power (FRP), etc. Spatiotemporal coverage: China, 2010–2019. For detailed field descriptions, see: [Active Fire Data Attributes for MODIS and VIIRS | NASA Earthdata]
2. **Cropland distribution and phenological data:** `Heilongjiang_Maize_MA_2010.tif` and `Heilongjiang_Wheat_MA_2010.tif`. Raster datasets of maize and wheat maturity DOY (Day of Year) in Heilongjiang Province from 2010 to 2019, with a spatial resolution of 1 km. (Raster values represent the DOY of crop maturity; pixels with NoData indicate non-maize or non-wheat areas.) Reference: [ESSD - ChinaCropPhen1km: a high-resolution crop phenological dataset for three staple crops in China during 2000–2015 based on leaf area index (LAI) products].
3. **FY (Fengyun) satellite-based straw burning fire point monitoring data:** `straw burning fire point monitoring data.xslx` (August 2016 – February 2017). This dataset was validated through field surveys and cross-comparison with other satellite

observations, providing relatively high accuracy and serving as a reference for classification (note: the dataset does not specify the crop type associated with the straw burning). Data source: http://www.secmep.cn/ygyy/dqhjjc/

4. **County-level administrative boundaries of China**: `CHN_County.shp`, used for identifying the administrative regions of wildfire points.

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4. Core Tasks & Guiding Questions (80 points total)

Your primary goal is to develop and execute a workflow to analyze the provided datasets and answer the following overarching questions. You should document your methodology and justify your analytical choices in your `README.md` file.

- **What are the dominant spatiotemporal patterns of fire activity in the study region?**
  - Explore the seasonality and geographic distribution of all fire events.
  - Go beyond a simple monthly count; investigate if there are specific "hotspot" weeks or intra-seasonal patterns that stand out.
- **To what extent can the observed fire hotspots be attributed to the post-harvest burning of corn and wheat?**
  - This is the central question of the project. You need to devise a robust methodology to classify fires based on their location relative to croplands and their timing relative to harvest seasons. Your final output should include a quantitative estimate (e.g., "We classified X% of fires as likely agricultural burning") and a map showing the different fire types.
- **What are the long-term spatiotemporal trends of fire activity (2010–2019)?**
  - Using the 10-year dataset for Heilongjiang Province, analyze whether straw burning activity shows signs of reduction at the county level.
  - Identify whether there are clear turning points or shifts in the intensity and frequency of burning events.
- **Are there distinct characteristics that differentiate agricultural fires from other fires?**
  - Once you have classified the fires, compare the groups. For instance, do agricultural fires differ in terms of fire intensity (FRP), duration, or temporal distribution compared to other fires?

5. Challenge Questions (20 points total)

These questions are designed to be more challenging and open-ended. Answering them effectively will require deeper analysis and critical thinking, allowing you to distinguish your project.

- **Challenge 1: Intensity and Impact Analysis**

  - The `FRP` (Fire Radiative Power) in the MODIS data is a proxy for the energy released by a fire, and thus its intensity. Using FRP, investigate whether there is a significant difference in intensity between the fires you classified as agricultural versus those classified as "other/wildfire." Discuss the implications of your findings. For example, are agricultural fires numerous but low-intensity, or are they a source of major intense burning events?

- **Challenge 2: Methodological Limitations and Uncertainty**

    - Critically evaluate your own classification methodology. What are the primary sources of uncertainty or potential error in your analysis? Consider the limitations of the datasets (e.g., spatial resolution, accuracy of cropland maps, fixed harvest schedules). How might these limitations affect your final estimate of agricultural burning? Propose at least one additional dataset (e.g., Land use/land cover data, road networks, soil moisture) that, if available, could improve the accuracy of your classification, and explain how you would use it.

- **Challenge 3: Meteorology & Pollution**

    - How might meteorological conditions (e.g., wind speed, humidity, temperature inversions) influence both the detection and the environmental impact of straw burning?
    - If regional air pollution data (PM2.5, PM10) were available, how could you link the temporal peaks in pollution to the timing of straw burning events?