

Conflict Starts with Food Trucks, Not A Bang

An Advanced Remote Sensing Method & Automated Model Pipeline for Tracking MRE Supply
Chain Activity as a Strategic Warning Indicator

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Open-Source Intelligence Chinese Strategic Warning Practicum

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Introduction

Since Xi Jinping took control of the Chinese Communist Party in 2012, improving food security has been a top priority of China's national security planning.¹ The People's Republic of China (PRC) has since responded positively to President Xi's food security goals and has increased domestic production and stockpiling of foodstuffs.² Analysis of long-term trends in the PRC show their goals of total Chinese food security and sustainability are closer than ever before – including massive increases in food security for the People's Liberation Army (PLA).

With the prospects of peaceful “reunification” declining, and increasing military activity in the Taiwan strait, the PRC may resort to kinetic action to achieve its goals.³ If an invasion of Taiwan by the PLA were being planned, China's national food security and the complex logistics of moving MREs (Meals Ready to Eat) for the PLA would be *essential* for the preparation process.⁴ As such, large-scale achievements in national food security goals, coupled with massive medium & short-term increases in MRE supply chain activity, may indicate that the PRC is preparing for an invasion of Taiwan – and possibly a large-scale conflict with the United States.

¹ (The State Council of the People's Republic of China 2025)

² Reuters. “*China Food Security Law Comes into Force, Aims at ‘Absolute’ Self-Sufficiency.*”

³ (Ministry of Foreign Affairs 2022)

⁴ (Wang and Liu 2023)

Thesis

In advance of aggressive action against Taiwan, we would expect to see the PRC make long-term increases in state food security with massive medium-term increases in MRE supply chain activity around PLA logistics hubs. When MREs begin moving en masse to forward deployment sites, conflict is imminent.⁵

Addressing Assumptions

Our research study operates with several major assumptions – if they are not representative of actual conditions, our conclusions would need to be altered. Our outlined assumptions are as follows:

1. China is on a general trend toward total food security.⁶ This doesn't necessarily indicate aggressive intention, however, short-term increases in production that are out of the ordinary *may be* a positive indicator of PRC intentions.
2. Self-sufficiency and the continuous supply of MREs is *critical* to continued PLA operations in Taiwan.⁷
3. Large supply depots of MRE's, influxes of shipping activity, and arrival of portable food processors are *unnecessary* for military exercises, but *necessary* for actual conflict.⁸
4. Russian & Chinese supply line differences have a minimal effect on actual distribution effectiveness and patterns. Despite Russia's reliance on rail, the pattern of logistics

⁵ (Planet n.d.)

⁶ (U.S. Department of Agriculture, Foreign Agricultural Service 2025)

⁷ (Wong and Barnes 2022)

⁸ (RadioFreeEurope/RadioLiberty 2022)

depots to staging areas remains similar, albeit with a limited transport system compared to China's trucking network.⁹

Research Methodology

Beginning with a literature review of scholarship on the topic, relevant PRC and Russian Federation policy documents and public statements, and background knowledge on the security needs of the Chinese state, we determined that China would need to significantly enhance its food output in soy, rice, wheat, and corn preceding a potential conflict.¹⁰ These are some of the primary ingredients in PLA MREs (Meals Ready to Eat) and led our analysis to the military rations.¹¹

To highlight the Chinese MRE supply line, analysis of Russian MRE efforts and distribution activities preceding the Ukrainian war indicated that production & storage facilities, military logistics centers, and forward deployment areas are the most critical sites of interest preceding hostilities.¹² We then searched for equivalent Chinese locations, accounting for differences in national supply structures, etc.

⁹ (O'Grady, Khudov and Morgunov n.d.)

¹⁰ (China Aerospace Studies Institute 2022) (McGuire 2021) (Muzyka 2021) (Skoglund, Listou and Ekstrom 2022) (The Wall Street Journal n.d.) (Vershinin 2021) (U.S. Department of Agriculture, Foreign Agricultural Service 2025) (The State Council of the People's Republic of China 2025) (President of Russia 2020) (Putin 2015)

¹¹ (Reddit n.d.)

¹² (Skoglund, Listou and Ekstrom 2022)

Chinese General Food Security: Analysis and Methodology

In recent years, China has shown steady progress toward food self-sufficiency.¹³ The PRC is reducing reliance on imports and increasing domestic crop production to meet consumption demands. This is crucial given China's continued dependence on U.S. corn and soybean imports—key staples in the national diet.¹⁴

Satellite-based tools like the Normalized Difference Vegetation Index (NDVI) and Net Primary Production (NPP) are essential for assessing vegetation health, estimating grain yields, and monitoring biomass output.¹⁵ These tools also enable detection of shifts between active and fallow cropland. Additionally, mapping urban expansion near agricultural zones can provide indirect indicators of food stockpiling behavior.¹⁶

Key Findings:

1. NPP data, filtered using the European Space Agency's cropland classification, show a 17% increase in agricultural biomass production from 2010 to 2024.
2. Zonal statistical analysis reveals a steady cycle of fallowing up until about 2017, with key variations from the cycle beginning in 2018 – indicating that Chinese farmers are producing at a more rapid pace, *possibly* at the cost of long-term sustainability.
3. No clear signs of accelerated food stockpiling in agricultural areas were identified during this analysis period, yet increases in supply chain activity are observed in the following section.

¹³ Wang, Cong, and Yang Liu. "President XI Stresses Ensuring Grain, Other Agri-Products Supply a Top Priority." *Global Times*

¹⁴ Gu, Ting. "Why Is Xi Jinping so Worried about Food Security?" *Radio Free Asia*

¹⁵ Running, Steven, and Maosheng Zhao. 2023. *MOD17A3HGF MODIS/Terra Net Primary Production Gap-Filled Yearly L4 Global 500m SIN Grid V061*. NASA EOSDIS Land Processes DAAC.

¹⁶ European Space Agency (ESA). 2023. *Sentinel-2 MSI: MultiSpectral Instrument, Level-2A*. European Space Agency, Copernicus Open Access Hub. Accessed April 17, 2025.

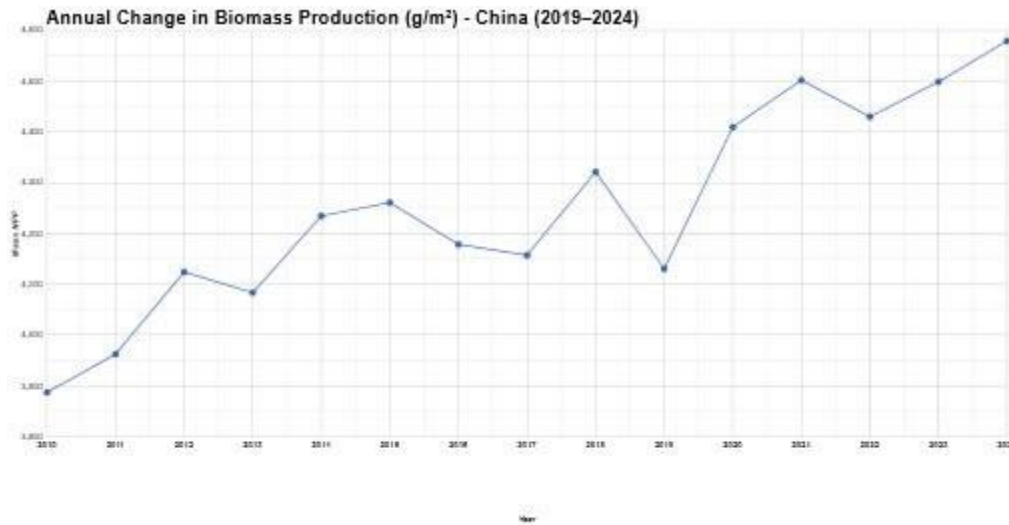


Figure 1: Graph Showing Increases in Chinese Cropland Biomass Production Measured in Grams per Square Meter

MRE Supply Chain: Analysis and Methodology

An adequate supply of MREs is critical in modern war, exemplified by Russia's requests for Chinese MREs just months into their invasion of Ukraine.¹⁷ In conflicts with dynamic front lines, a sustained effort cannot be made without them. While small amounts are occasionally used in military exercises, 1-2 weeks of MREs per soldier are needed for an invasion. For context, Russia only provided 3 days of rations per soldier, transporting them to forward deployment sites pre-invasion.¹⁸ Seen from satellite imagery, this was abnormal given their "exercises" casus belli, with mass movement occurring about one month before hostilities.¹⁹

¹⁷ (Wong and Barnes 2022)

¹⁸ (Rai 2022)

¹⁹ (RadioFreeEurope/RadioLiberty 2022)

As such, MREs can serve as a significant strategic warning indicator by allowing us to gain estimates of stockpiling efforts, while tracking activity within the supply chain and distribution network. Inclusion of key sites of interest & PLA forward deployment sites for a Taiwan crisis is necessary for this analysis. For our study, we identified several public and private producers of MREs, their production and storage facilities, PLA 73rd group army bases, PLA Joint Logistics Support Force (JLSF) Bases, forward deployment sites near the Taiwan strait and on Pingtan Island, and PLA navy ports.²⁰

The stockpiling estimates and supply line tracking are attempted via a custom data pipeline.²¹ It takes in SENTINEL-2 satellite imagery for the entirety of mainland China, scanning for moving class 8 trucks using a spectral detection method.²² A Convolutional Neural Network (CNN) validates and logs the locations of spectral detections. Relevant shipping activity is determined by clustering truck detections around the sites of interest. A separate CNN, still under tuning/development, can determine when trucks are going between sites about 70% of the time (Not accurate enough to be used in this case).

Clustering allows reasonably accurate visualizations of time-series distribution changes within the MRE supply line. For each model viewing period, a heatmap of truck detections and activity is generated. We have tracked the Chinese MRE supply line for March 2019-2025.

²⁰ (AiF 2024) (Erickson n.d.) (GKGZ 2021) (Pike 2021) (Planet n.d.) (Reddit n.d.) (SINOGRain n.d.) (Travel China Guide n.d.) (Wikipedia n.d.) (Running and Zhao 2023)

²¹ Appendix 3a-c

²² (Fisser 2020) (European Space Agency n.d.)

Figures 2-4, shown below, are model outputs displaying MRE supply changes year-over-year.
(Heatmap causes ocean clusters due to truck detections in Taiwan, the Philippines, etc.)

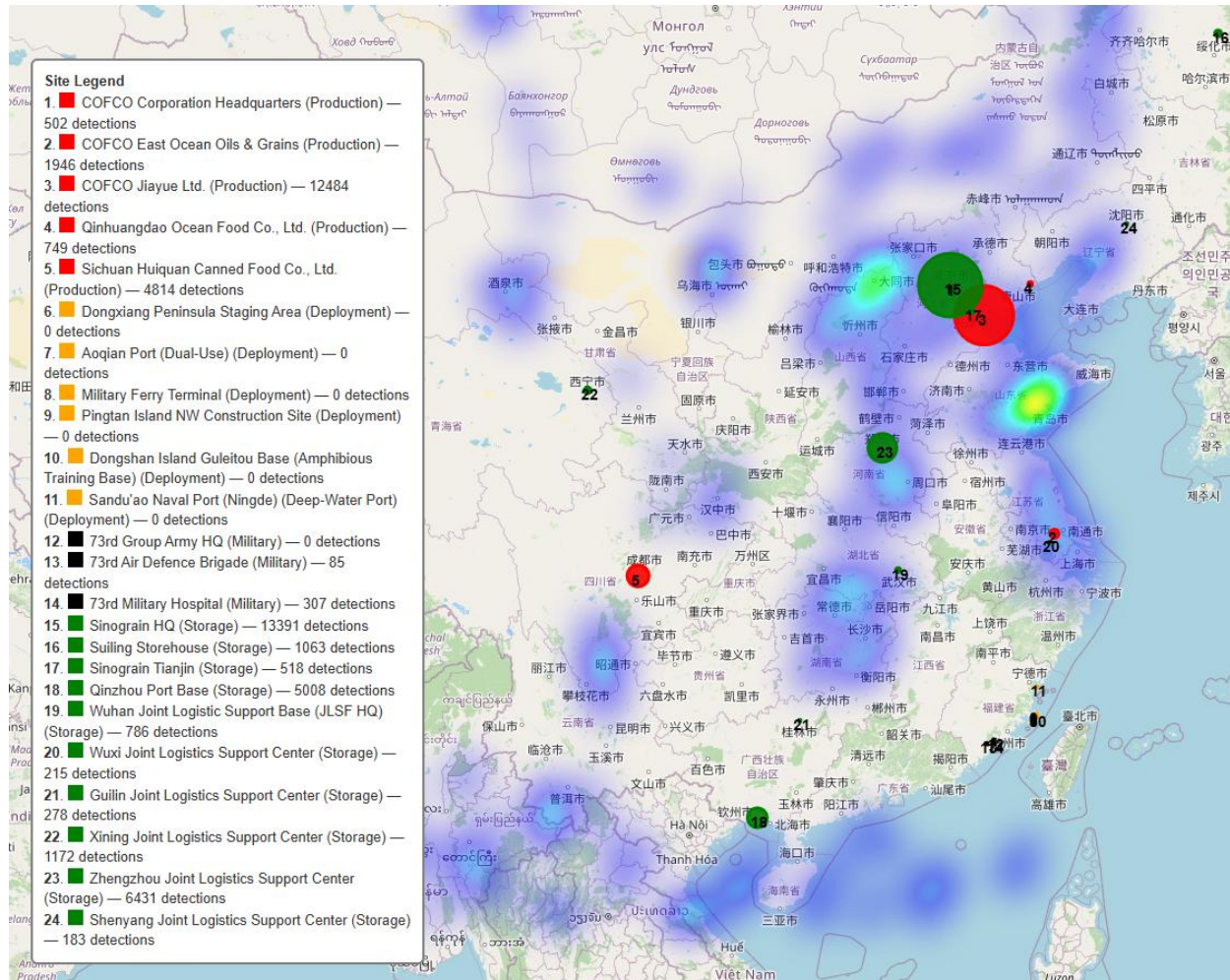


Figure 2 – Truck detection densities in mainland China – March 25-30, 2022. Northern density indicates supply chain focus on production (Map clustering system responsible for oceanic clusters).

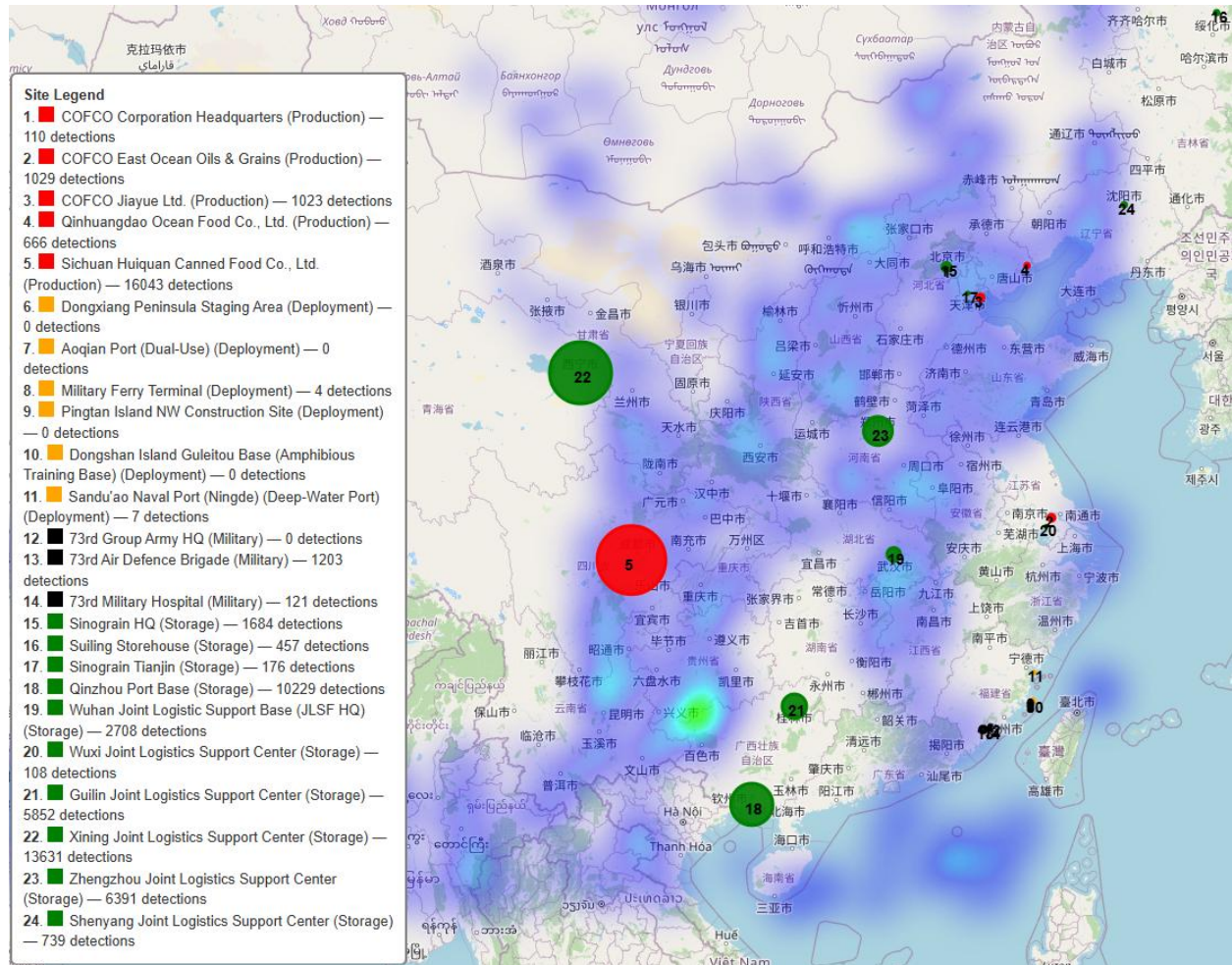


Figure 3 – Truck detection densities in mainland China – March 10-30, 2024. Note the western clustering pattern and emphasis on production & storage. (Map clustering system responsible for oceanic clusters).

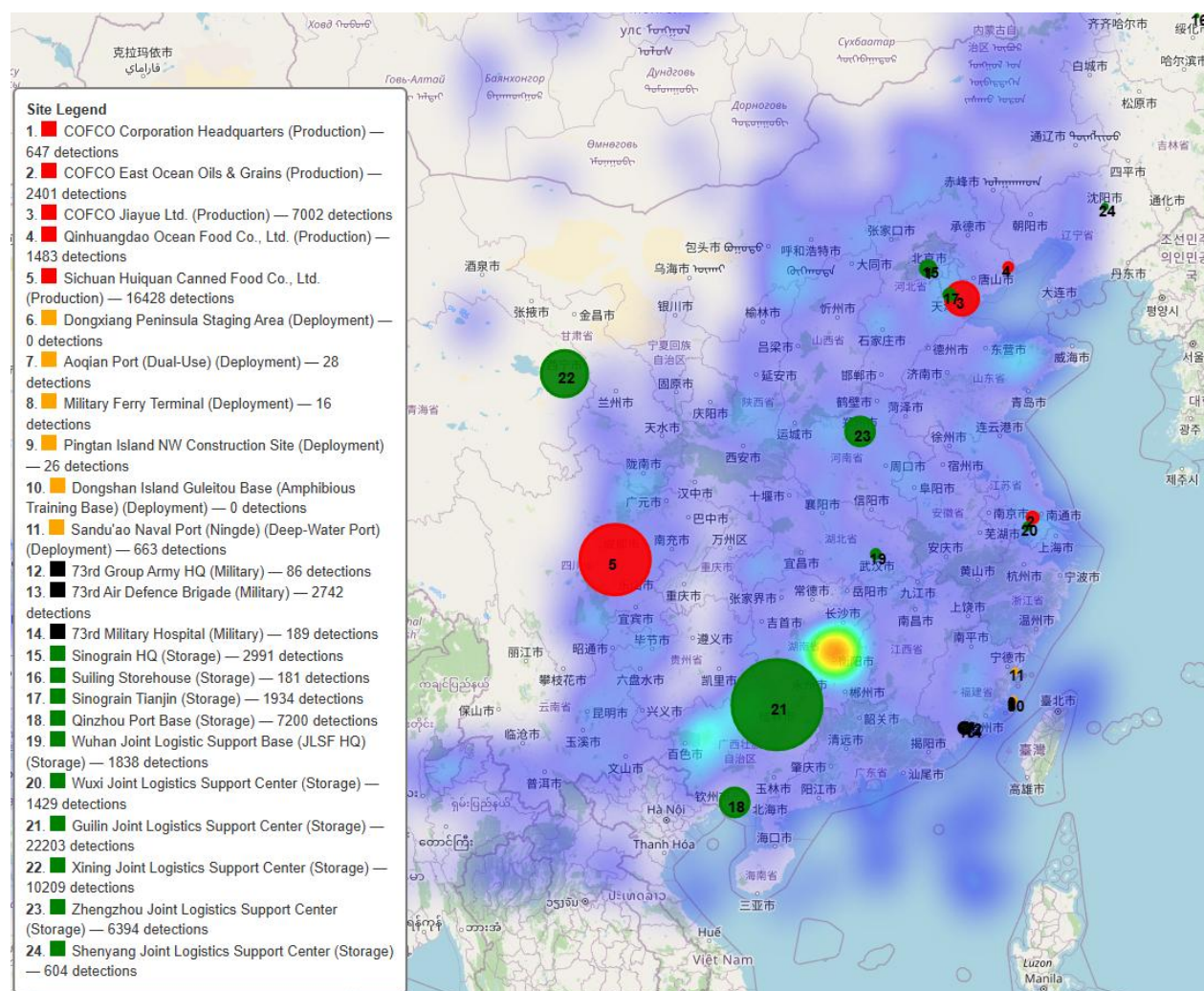


Figure 4 – Truck detection densities in mainland China – March 10-30, 2025. Notice the massive movement to site 21, one of the key logistics hubs for an invasion of Taiwan. (Map clustering system responsible for oceanic clusters).

These results indicate significant shifts in supply-line activity over the years. Production and storage were the primary supply line foci in 2022, as shown in the high activity northern regions of Figure 2. The supply line shifted to emphasize MRE production in 2024, as seen in Figure 3. In 2025, there were massive increases in movement to PLA Joint Logistics Support Force facilities in Fujian Province, shown in Figure 4. This mirrors shifts seen in Russia roughly

1-2 years before they invaded Ukraine.²³ In this context, observed mass movements toward the Guilin JLSF center in Fujian is highly suspicious.

In combination with China's other preparatory measures, current activities indicate *China could be in the tailing phase of preparations for a potential invasion of Taiwan*. Observing massive supply movements toward deployment sites at Pingtan Island and PLA Navy ports would indicate imminent conflict.

Due to limitations in compute resources, we were unable to run the model on Russia preceding their invasion of Ukraine, and Chinese MRE supply lines pre-2019. Consequently, estimation of MRE stockpiles has been impossible. Additional validation can be done by gathering data on those geographies, time periods, and sites of interest to infer similarities between distribution patterns leading up to military hostilities.

Alternative Explanations

As the PRC embraces a more robust national security framework, several factors interact with each other. Although our analysis indicates food security and MRE supply line tracking are necessary and mostly sufficient indicators, there are several alternative explanations for recent PRC actions that should be considered.

²³ (RadioFreeEurope/RadioLiberty 2022) (Vershinin 2021) (Skoglund, Listou and Ekstrom 2022)

The alternative explanations we have deemed most likely are:

1. The PLA Logistics Support Force could simply be performing an overhaul of the military preparedness system – maybe the current MRE stores require total replacement.²⁴
2. China is attempting to protect against the effects of a trade war with the United States.²⁵
3. The PRC could be building up logistic capabilities in anticipation of supporting allied nations or causes.²⁶

In addition to the alternative explanations, there are also several notable counter thoughts and confounding factors outlined below:

1. Perhaps the PLA wouldn't move MREs to forward staging areas due to the potential for protracted conflict, where staging sites will become primary targets.
2. There is no modern example of a large-scale amphibious invasion followed by immediate urban resistance. Thus, it is difficult to accurately predict logistical planning and staging behaviors from historical precedent.

Conclusion: Is this Indicator Necessary and Sufficient?

The quality of a strategic warning indicator is assessed by its necessity and sufficiency. First, it should be determined if it is necessary for this indicator to be present for the invasion of Taiwan to take place. Second, it should be determined if the indicator provides enough insight into the PRC's intentions to be considered sufficient.²⁷

²⁴ (Reuters 2024)

²⁵ U.S. Department of Agriculture, Foreign Agricultural Service. *“China Number One Document Provides Beijing's Thoughts and Highlights on Food Security and Rural Policy.”* February 2025

²⁶ (Wong and Barnes 2022)

²⁷ (Grabo and Goldman 2015)

Understanding the basic food security details of the PRC and their official doctrine provides the basis of this research study. Analysis of long-term production and stockpiling trends across China is important – but does not fit entirely within the parameters of a *necessary and sufficient* indicator. The alternative explanations are too numerous for food security trends to be considered a purely strategic warning indicator.

However, the analysis of production and logistics surrounding the MRE supply chain *is a necessary indicator*. PLA soldiers will need to be well fed, and dynamic front lines require MREs. As stated previously, large movements of MREs and related materials to staging areas are necessary before conflict. The combination of both analyses provides a sufficient level of indication as to PRC long & medium-term planning regarding food security and conflict preparedness.

As a lone short-term indicator, MRE movements are difficult to rely on. While Chinese activity mirrors Russian activity in 2020-2021, the severe shortcomings of Russian logistics & subsequent lessons learned by China, differences in transportation needs, and the amphibious nature of the Taiwan crisis make it near-impossible to place a granular time frame on Chinese hostilities before massive movement to deployment sites begins.²⁸ It's unlikely that the PRC will build up storage at the sites over a longer period to avoid raising suspicion.²⁹ As such, once this movement accelerates, hostilities are *no more than 4-6 weeks away*, and it should be considered

²⁸ (Global Times 2024) (Gu 2024) (Reuters 2025) (Skoglund, Listou and Ekstrom 2022) (SINOGRain n.d.)

²⁹ (RadioFreeEurope/RadioLiberty 2022)

a significant indicator of imminent conflict. In a vacuum, this short window limits the value of MREs as a warning indicator. In combination with other indicators, it may substantially increase the short-term predictive power of MRE supply changes.

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[0%B8%D1%82](https://aif.ru/society/army/hleba-gorbushku-i-tu-popolam-armiya-rf-poluchila-suhpay-kotoryy-ne-gorit#:~:text=%D0%9F%D0%BE%D0%BD%D1%8F%D1%82%D0%BD%D0%BE%D0%B3%D0%BD%D1%8F%20%D0%BD%D0%B5,%D0%BF%D1%80%D0%BE%D1%82%D0%B8%D0%B2%D0%BD%D0%B8%D0%BA%20%D0%BF%D1%80%D0%BE%D1%86%D0%B5%D1%81%D1%81%20%D0%BF%D1%80%D0%B8%D0%B3%D0%BE%D1%82%D0%BE%D0%B2%D0%BB%D0%B5%D0%BD%D0%B8%D1%8F%20%D0%BD%D0%B5%20%D0%B2%D0%B8%D0%B4%D0%B8%D1%82).

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[1%81%D0%BE%20%D1%81%D0%BC%D0%B5%D0%BD%D0%BE%D0%B9%20%D0%BA%D0%BE%D0%BC%D0%B0%D0%BD%D0%B4%D1%8B%20%D0%9C%D0%B8%D0%BD%D0%BE%D0%B1%D0%BE%D1%80%D0%BE%D0%BD%D1%8B,%D0%9E%D1%87%D0%B5%D0%BD%D1%8C%20%D1%83%D0%B4%D0%BE%D0%B1%D0%BD%D0%BE%2C%20%D0%BF%D1%80%D0%B0%D0%B2%D0%B4%D0%B0.](#)

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[with#:~:text=One%20of%20the%20defendants%20in,reports%2C%20without%20giving%20his%20name](https://eadaily.com/en/news/2024/09/25/one-of-the-defendants-in-the-case-of-dry-rations-for-the-ministry-of-defense-of-the-russian-federation-made-a-deal-with#:~:text=One%20of%20the%20defendants%20in,reports%2C%20without%20giving%20his%20name).

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Appendix 2 – Index of Output Graphs, Images

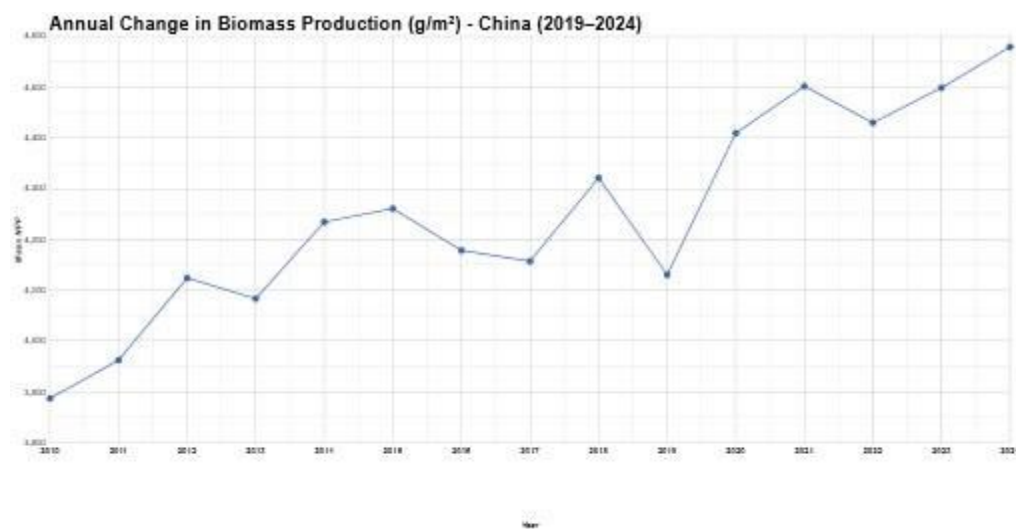


Figure 1: Graph Showing Increases in Chinese Cropland Biomass Production Measured in Grams per Square Meter

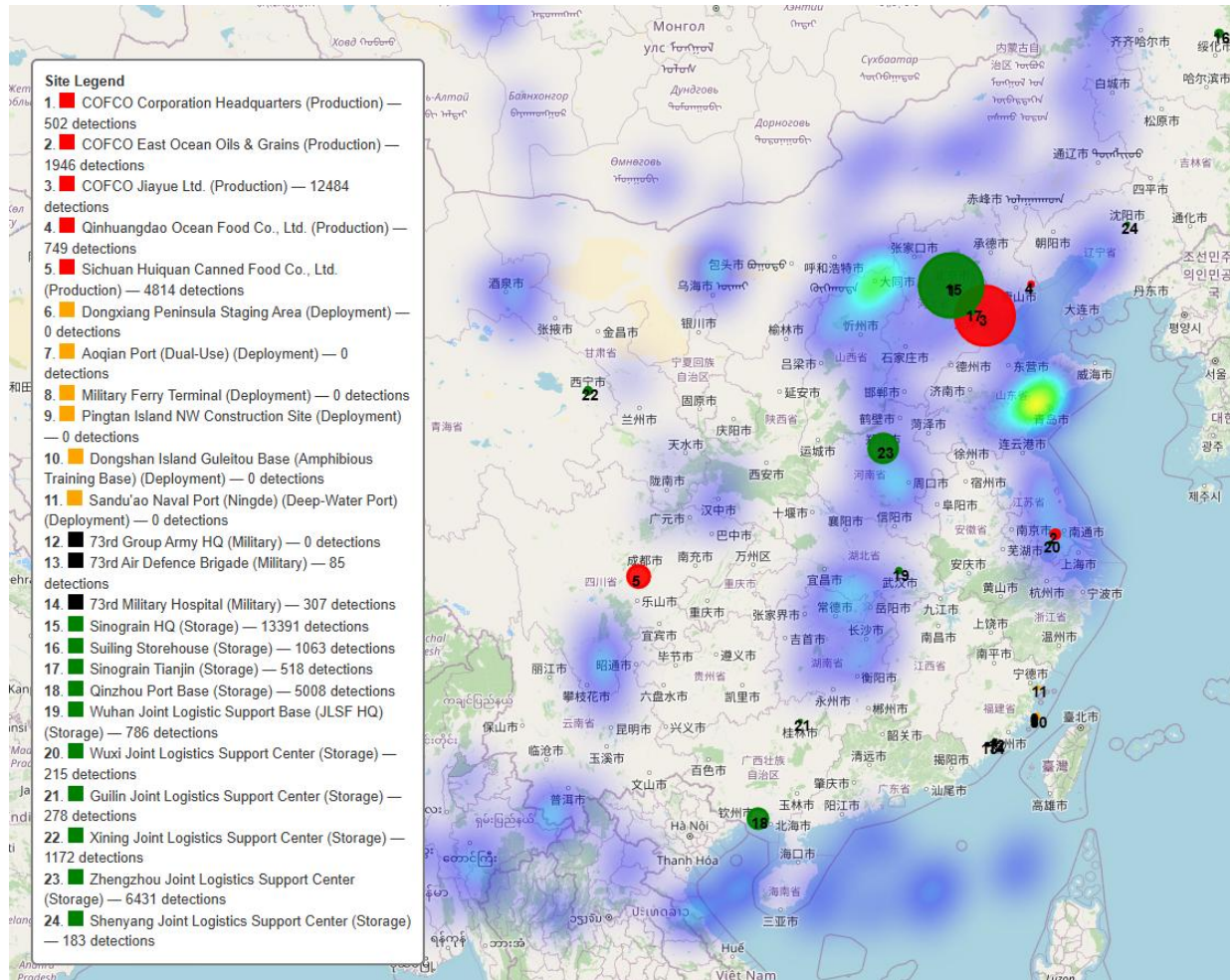


Figure 2 – Truck detection densities in mainland China – March 25-30, 2022. Northern density indicates supply chain focus on production (Map clustering system responsible for density clusters in ocean).

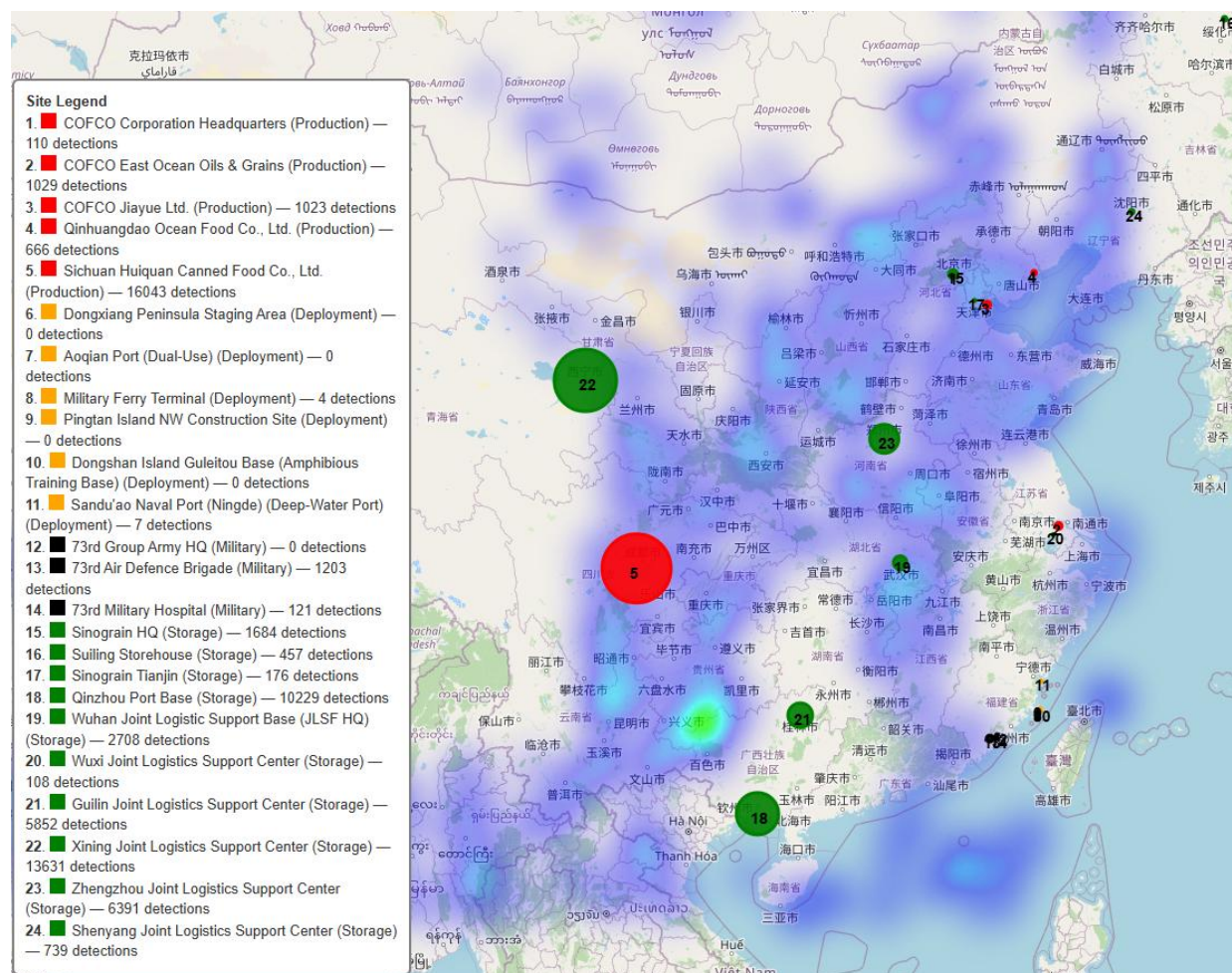


Figure 3 – Truck detection densities in mainland China – March 10-30, 2024. Note the western clustering pattern and emphasis on production & storage. (Map clustering system responsible for density clusters in ocean).

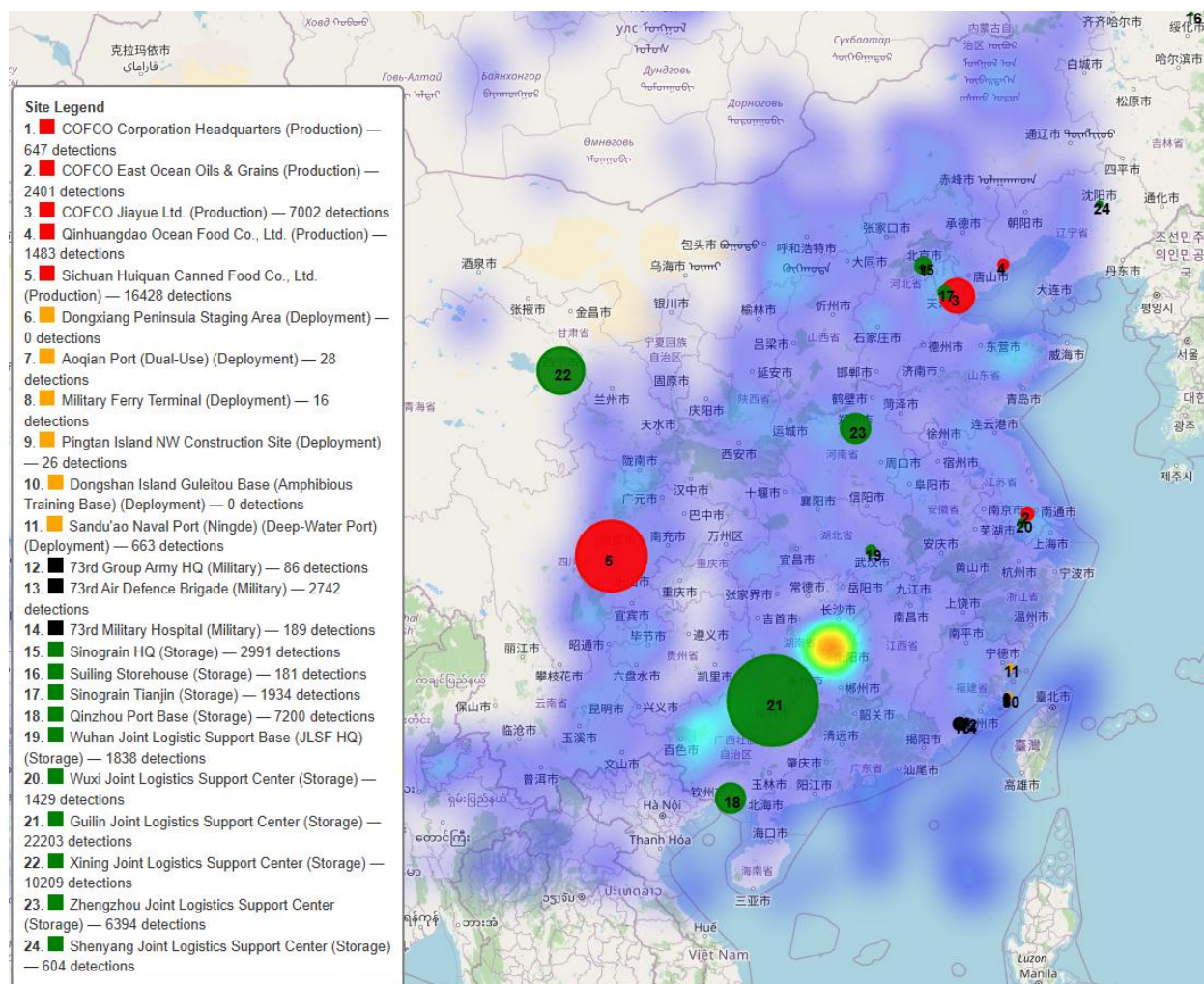


Figure 4 – Truck detection densities in mainland China – March 10-30, 2025. Notice the massive movement to site 21, one of the key logistics hubs for an invasion of Taiwan. (Map clustering system responsible for density clusters in ocean)

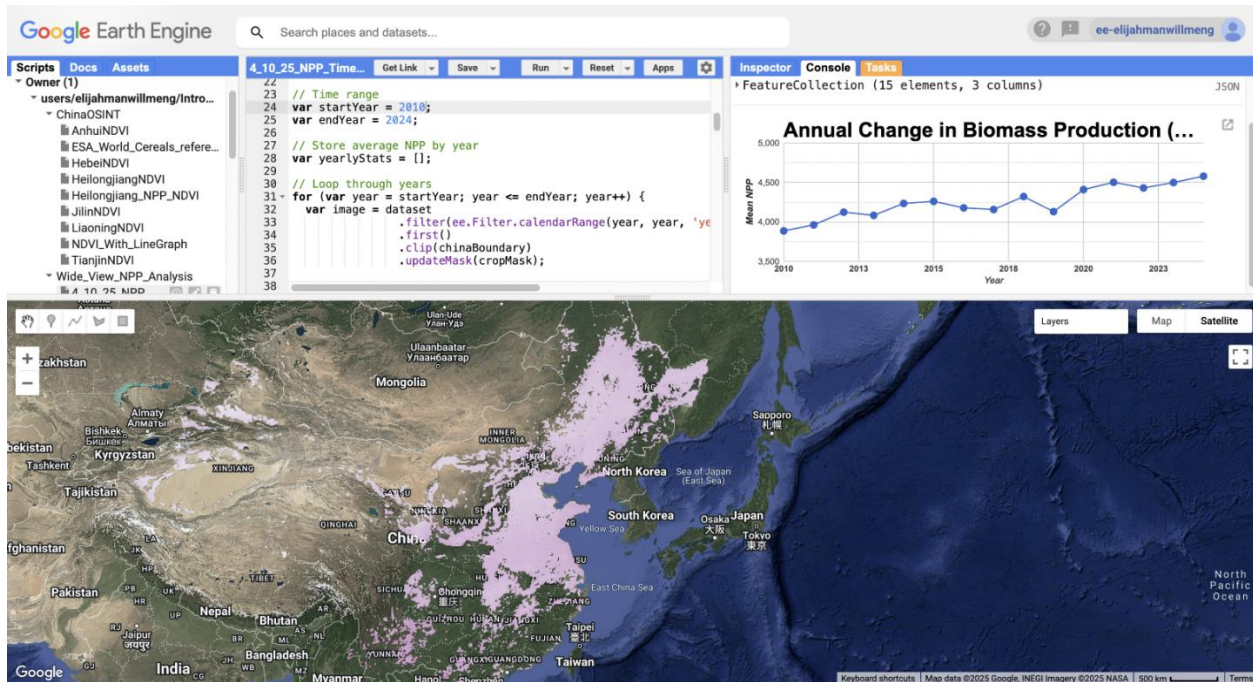
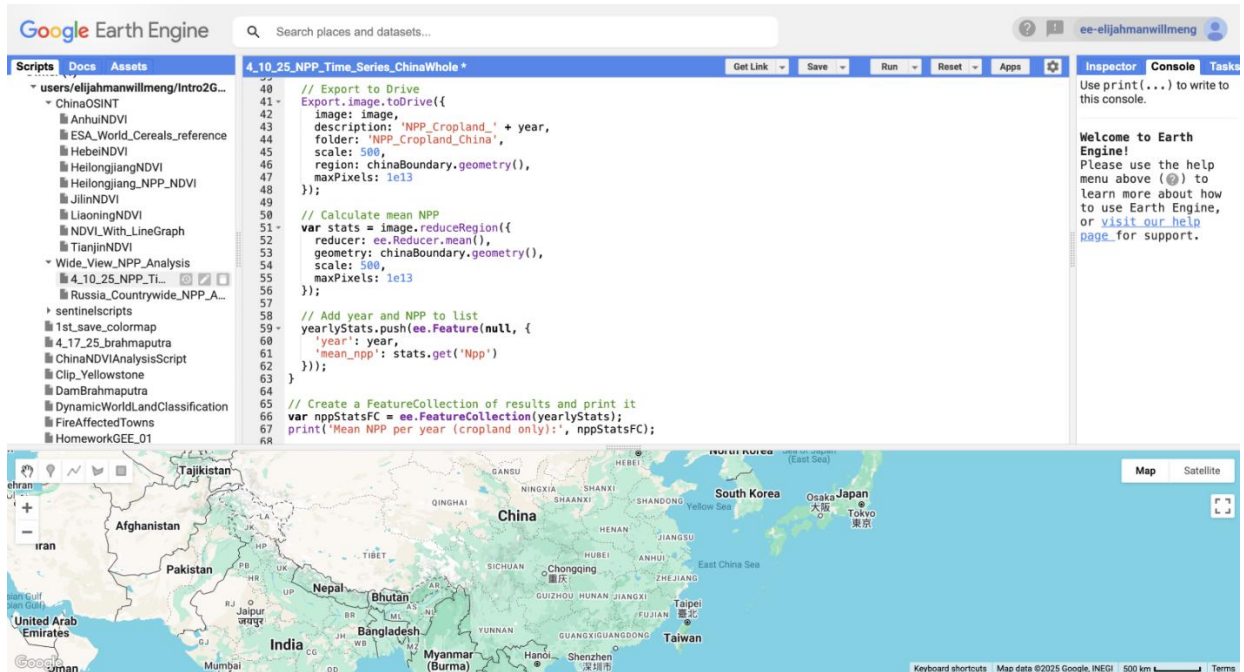
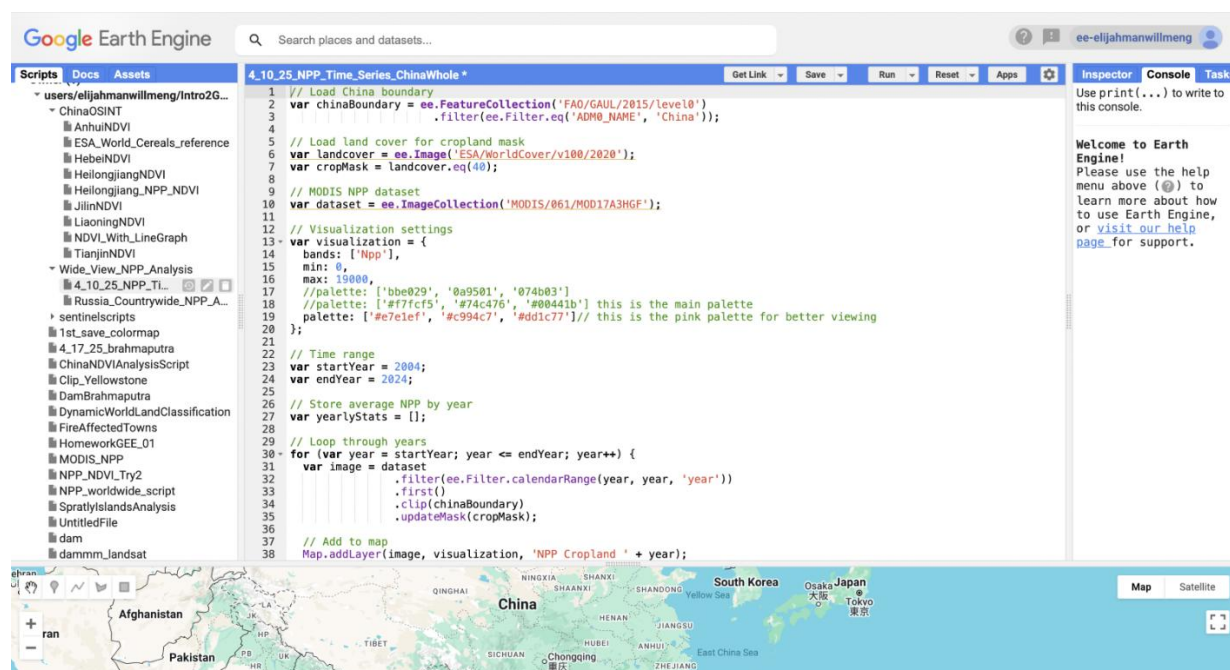
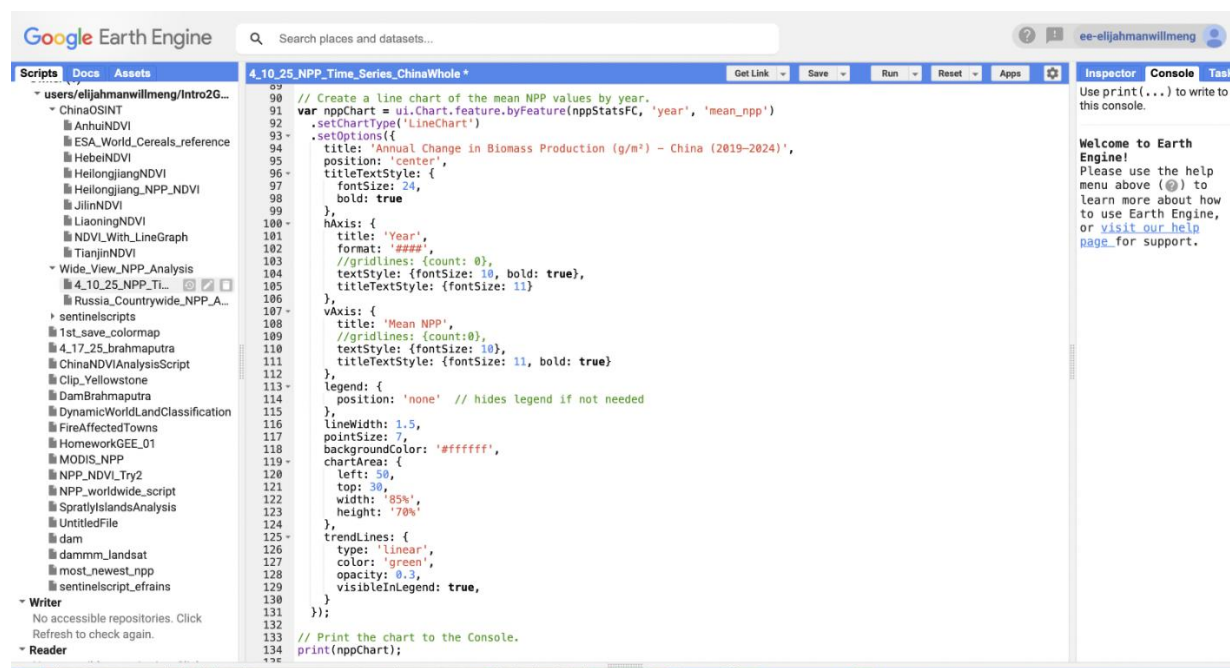


Figure 5: Google Earth Engine Dashboard Used to Determine Long Term Biomass Production Across China





Figures 6-8: Google Earth Engine Javascript Code Snippets for NPP Analysis Attributed to Elijah Manwill

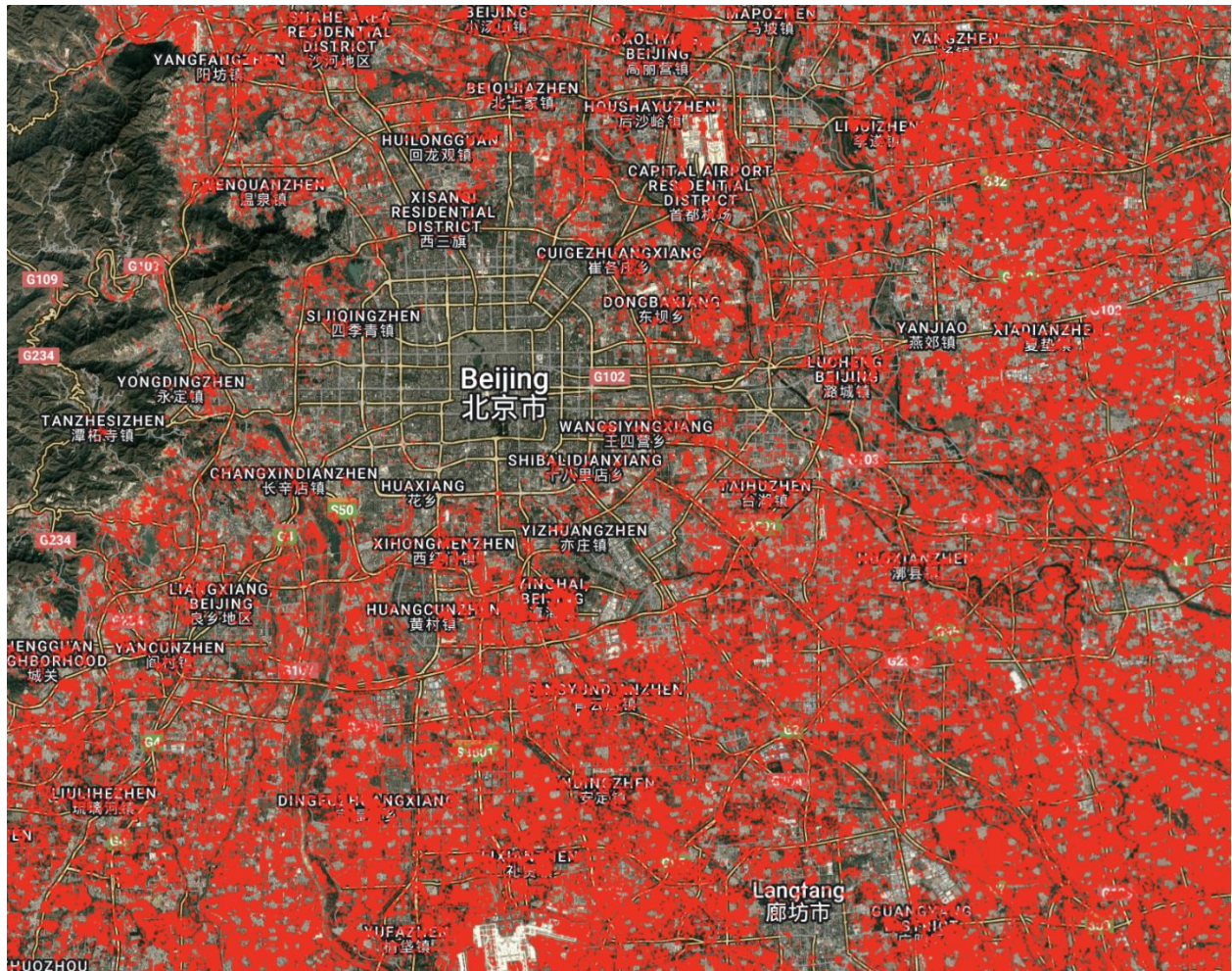


Figure 9: Map of Active Agricultural Production Land Around Beijing City, Grain Producing Plots Symbolized with Red Pixels

Appendix 3a. – Model Pipeline Documentation

Truck detection via band masking provided by Henrik Fisser, Sentinel 2, 2020

https://github.com/hfisser/Truck_Detection_Sentinel2_COVID19/blob/master/Detect_trucks_sentinel2_COVID19.ipynb

Truck detection validation CNN overlay provided by Seth Stock, 2025

Resources accessed - API – ESA Copernicus OData

Search dates

- Baseline - From Mar 10 2024 @12AM- Mar 30 2024 @ 11:59 PM

- Recent - Mar 10 2025 @12AM - Mar 30 2025 @11:59 PM

Max Cloud Cover - 20%

Bounding Box (excluding Xinjiang + Tibet) - `region_min_lat = 18.0`

`region_max_lat = 54.0`

`region_min_lon = 73.0`

`region_max_lon = 135.0`

`xinjiang_bbox = (73.0, 35.0, 96.0, 49.5)`

`tibet_bbox = (78.0, 26.0, 99.0, 37.0)`

Areas of Interest

- Five Categories of Locations of Interest

- MRE Production Centers (Civilian and Military) - [\(link\)](#)

https://s204.q4cdn.com/636391999/files/doc_financials/2024/ar/2024-AR-Final.pdf

- https://www.chinadaily.com.cn/kindle/2016-01/19/content_23148212.htm#:~:text=,owned%20assets%20management%20authority

- - Logistics Centers - PLA Joint Logistics Support Force, along with important civilian shipping companies, etc
 - - JLSF
- - Storage Centers - Areas where MRE's and Raw Materials are stored for stockpiling - https://www.grainsilo.com/project-cases/sinograin-suiling-subordinate-storehouse-renovation-project.html?utm_source=chatgpt.com
- - Deployment - Areas of forward deployment for Taiwanese invasion, including Pingtan island and Dongshan Island - (add link)
 - - Pingtan - <https://jamestown.org/program/potential-military-implications-of-pingtang-islands-new-transportation-infrastructure/#:~:text=In%202018%2C%20the%20PRC%E2%80%99s%20National,Pingtang%20Times>
 - https://chinamilitarydb.miraheze.org/wiki/Dongshan_Island_Guleitou_Joint_Training_Base#:~:text=Dongshan%20Island%20Guleitou%20Joint%20Training,Dacheng%20Bay%20Joint%20Training%20Base
 - <https://www.travelchinaguide.com/cityguides/fujian-ports.htm?srltid=AfmBOoqi4Pf8HB2cjPwvC4ILBkRCd7qUzUs1Ael90J4Qs2zlhjfwy-g#:~:text=Bay%20around%20the%20Minjiang%20River,to%20the%20military%20port%20there>
- - Military - PLA 73rd group army bases, along with a few other sites - (add link)
- <https://www.globalsecurity.org/military/world/china/73ga.htm>

Underpinning Idea

- - As Copernicus data is not high-res enough to track individual trucks moving between sites, (planet dataset is), we used an approximation method to track the levels of shipping/trucking activity around our areas of interest
- - Detect trucks in images and extract their location data and dates. Log all hits per image. Validate detections
- - Do this for the entirety of mainland China.
- - Using the location data of the trucks, and the location data of the sites, make two sets of maps and a CSV
 - - A truck is near a site if it is within 1 kilometer of the site coordinates
 - - Use clustering to determine general centers of movement.
- - CSV contains all raw data, sorted by date.
 - - Maps
 - - Map plotting the number of trucks detected on a folium map, with areas of interest highlighted
 - - Heatmap showing activity around sites. Baseline heatmap shows raw activity, standard date heatmap shows activity relative to test period.

PIPELINE

- Break China bounding box into 5X5 degree tiles
 - - Query individual images from those tiles.
 - - Save all images in one tile to an image directory
 - - Process the entire image directory using Henrik Fisser's method with some modifications

- - Validate detections with custom CNN
 - Optional, separate CNN with LSTM sequential layer to detect if a truck is moving between sites of interest. Due to the requirement of hand-labeling data, I have been unable to gather enough images to properly train the model. Currently, it is 70% accurate, with a precision of just 62%. This is not good enough to be used.
- - Save all metadata
- - Repeat until all tiles are complete
 - - Generate maps
- - Code exits

Processes about 1.4 terabytes of data per day. This is limited by API. Theoretically, with bulk access, this would only take 5 hours to run for 1 month of data with current network speed and compute resource access. Current speed is 3.5 days per one month of data

Appendix 3b. – Model Pipeline

Visit the GitHub link to view/download the model pipeline, you can run it yourself using your Copernicus API key. The uploaded version does not contain the CNN validation layers. (Still under development. Please reach out to Seth Stock if you would like to review these versions.)

<https://github.com/sethstock/MRESupplyChainPipeline>

Appendix 3c. – Further Developments & Improvements to Model

Further hand labeling of satellite data and detections is underway to increase the accuracy of the validation and between-site prediction deep-learning models. Detections are being compared with the actual image, where we then hand label the truck detection and false positives. Further, we are looking at imagery where we can clearly define one truck going between two sites. Using a CNN with an LSTM, a model is being trained to detect if a truck is going between sites of interest. While outside the scope of this project, it could be possible to determine from an image roughly how long it would take to get from point a to the next point in the MRE supply chain. Several instances of this have been hand labeled, but we need several hundred to several thousand more images to successfully tune the models.

All Neural Networks have been defined and trained using PyTorch in Python 3.12.3, with CUDA 3.12 and adjacent CUDNN packages. They use custom architectures, each with a kernel size of 3, 4-7 layers, with inputs and output nodes ranging from 32 to 512. The truck detection bounding boxes are set to 64x64 pixels. The Adam optimizer was used, as well as binary cross-entropy loss metrics. Performance is still middling.

Appendix 4 – Request for Interest

Those who would like to further aid in the development of the model by direct participation, financial support, or by purchasing/licensing the intellectual property, please notify us. This model is currently open to purchase and/or licensure to interested parties. Data labelers and other co-authors for further fine-tuning are welcome as well.

Appendix 5 – Disclaimers & Intellectual Property

The automated model pipeline for the tracking of MRE supply lines (AMP-TMSL) is the exclusive intellectual property of Elijah Manwill and Seth Stock. The spectral truck detection method is not ours and has been licensed properly from the original author. The CNN validation methods and all other parts of the algorithm are subject to U.S. Intellectual Property law. For further usage, model development, and validation, please contact the authors for express permission, and use full, industry-accepted citations.