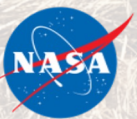


Earth Observations and Machine Learning Agricultural Monitoring

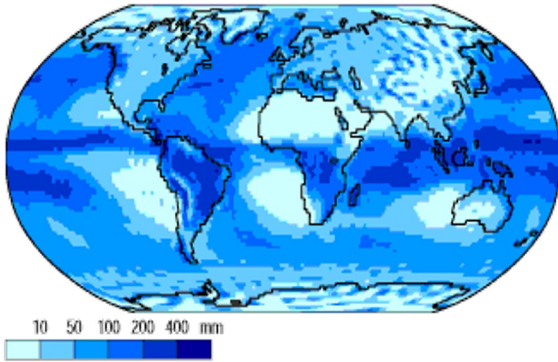
AmazonTec 2022
October 20, 2022

Dr. Catherine Nakalembe PhD.

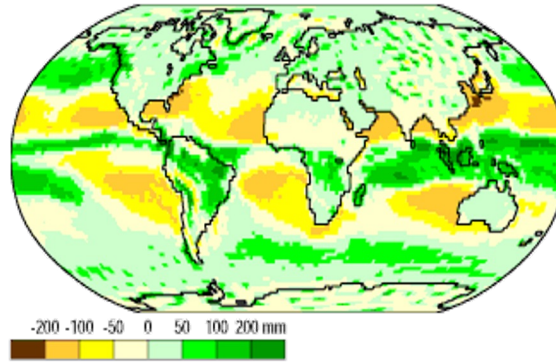
Associate Research Professor, University of Maryland
Africa Program Director, NASA Harvest
Food Security Thematic Lead, NASA SERVIR Applied Science Team



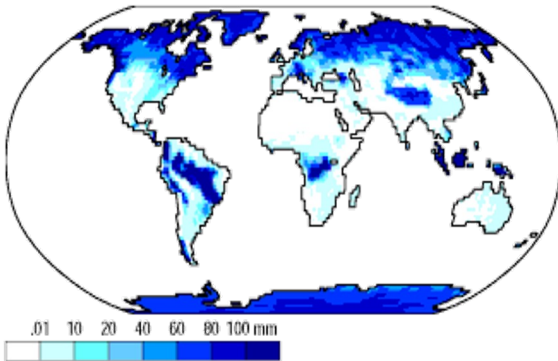
Precipitation



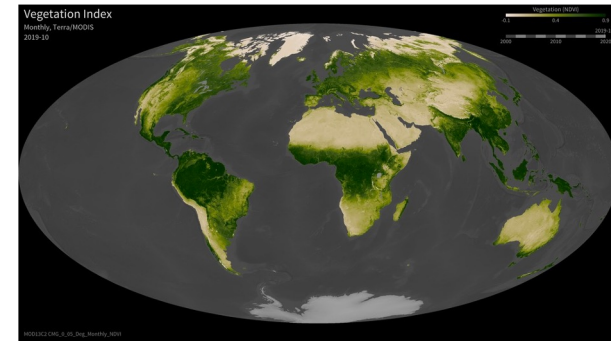
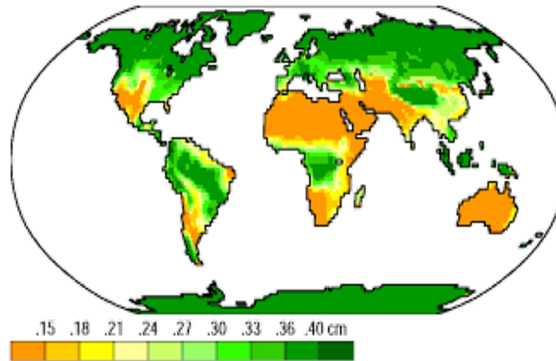
P-E



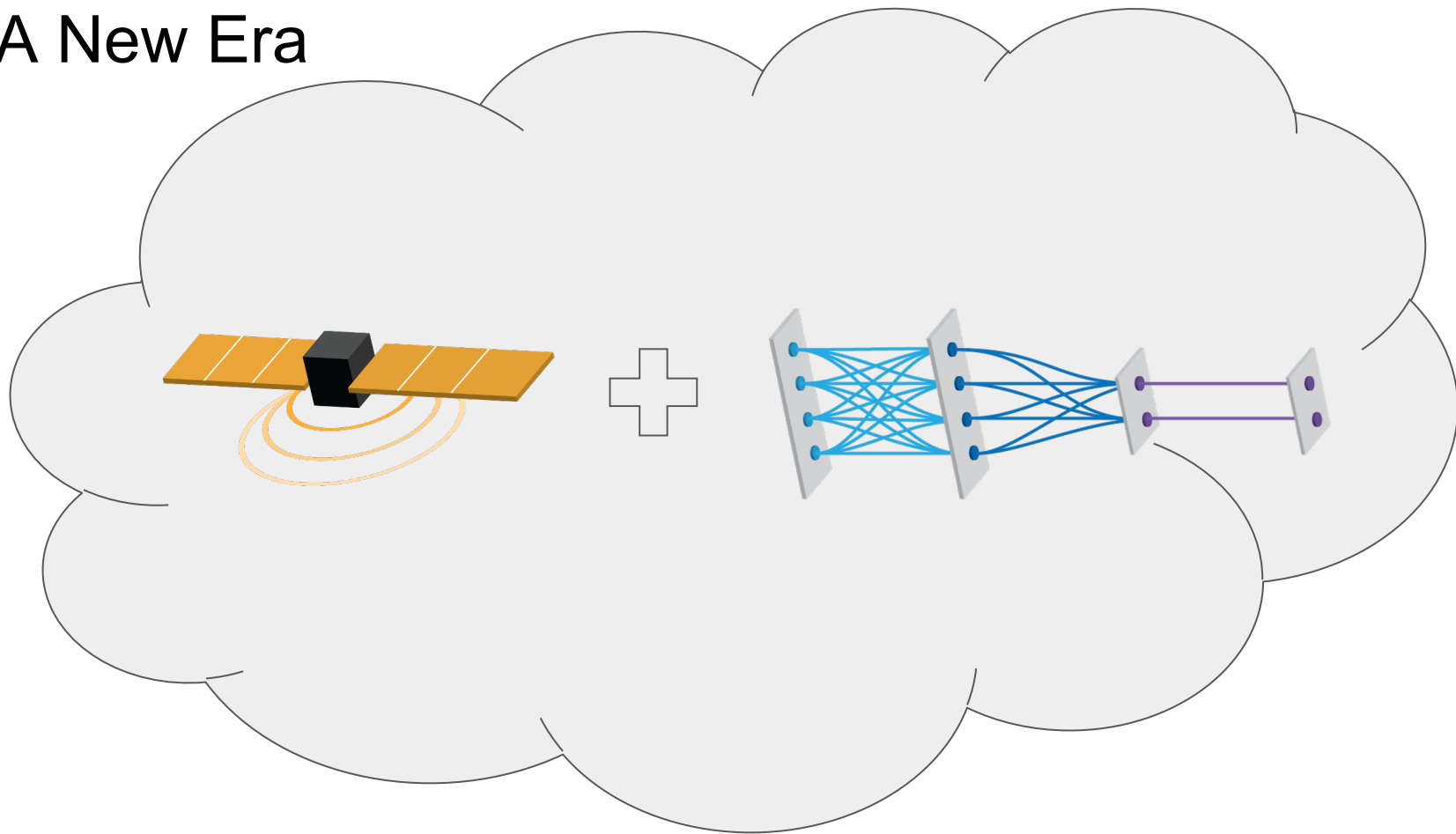
Run Off/Water Surplus

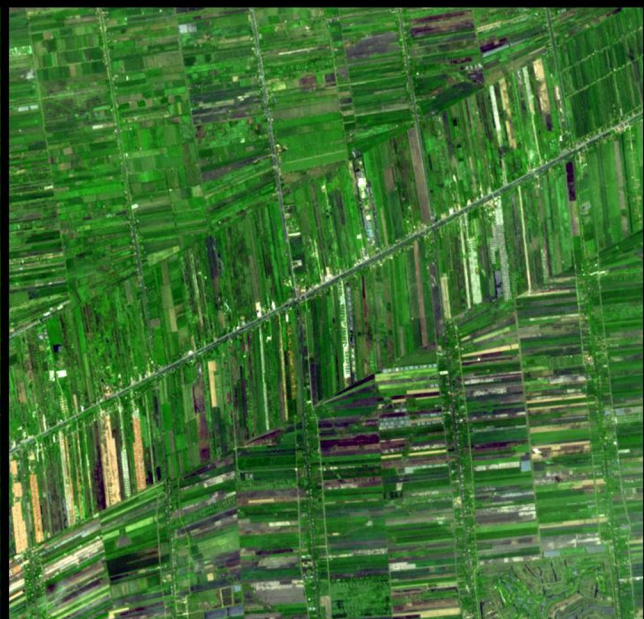
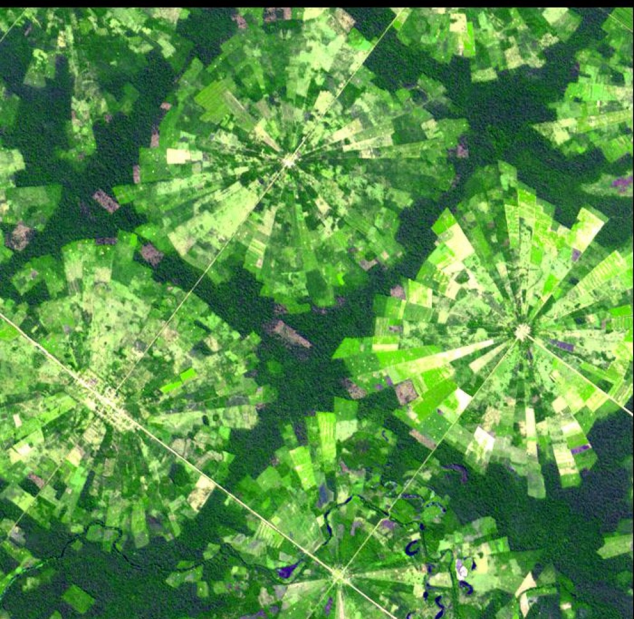


Soil Moisture

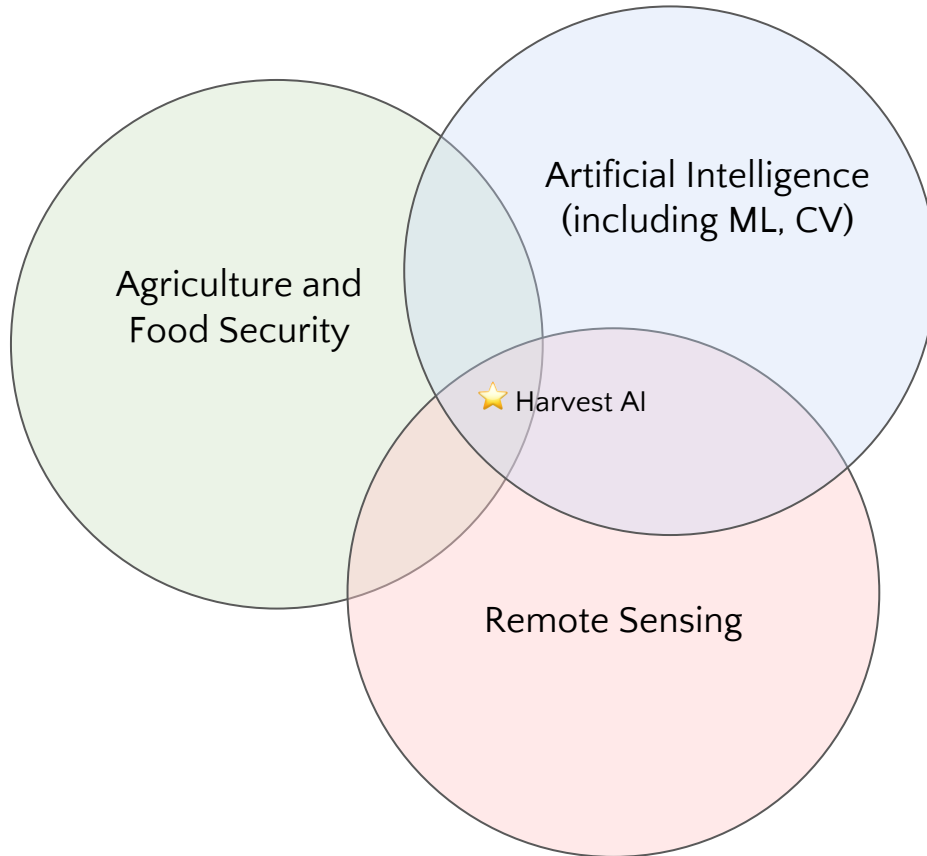


A New Era





Key topics in AI for Remote Sensing & Agriculture



Crop mapping → Binary classification

Crop type mapping → Multi-class classification

Field boundary delineation → Segmentation

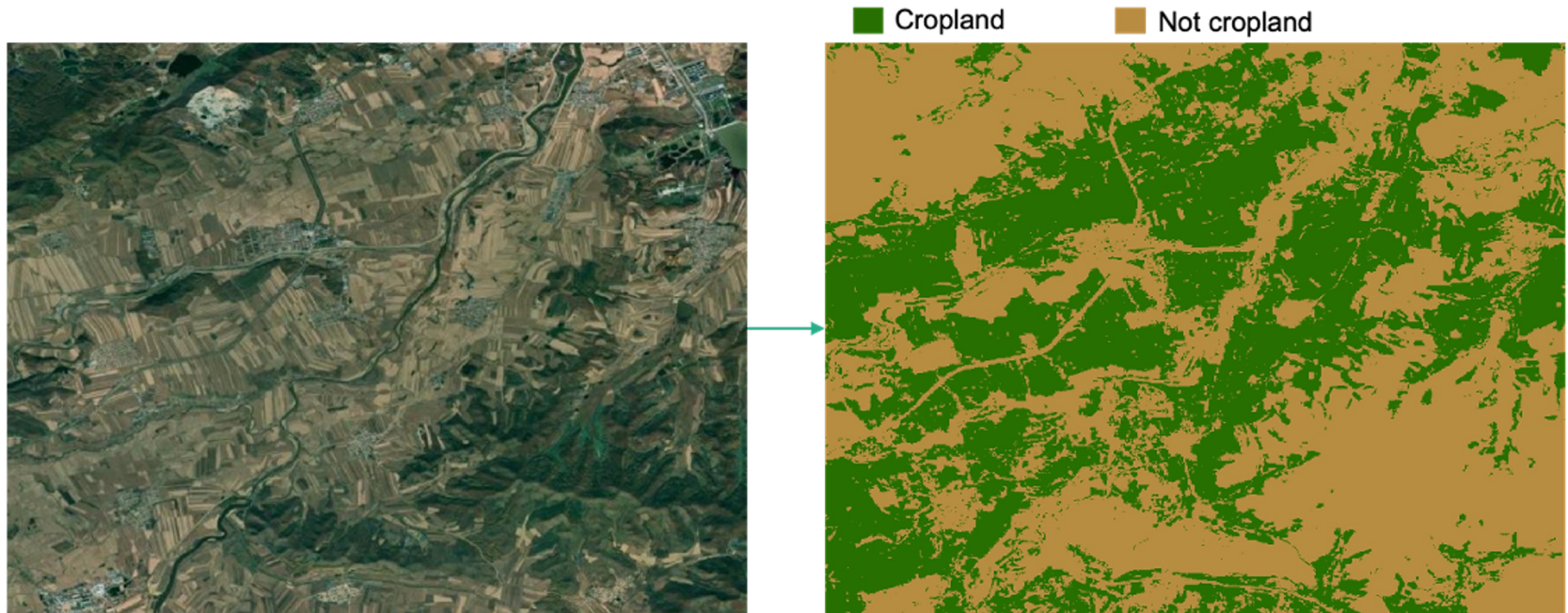
Yield estimation → Regression

Pest and disease detection → OOD detection

Domain adaptation, distribution shift, multi-fidelity data fusion, learning from limited labeled data, etc.

Crop mapping

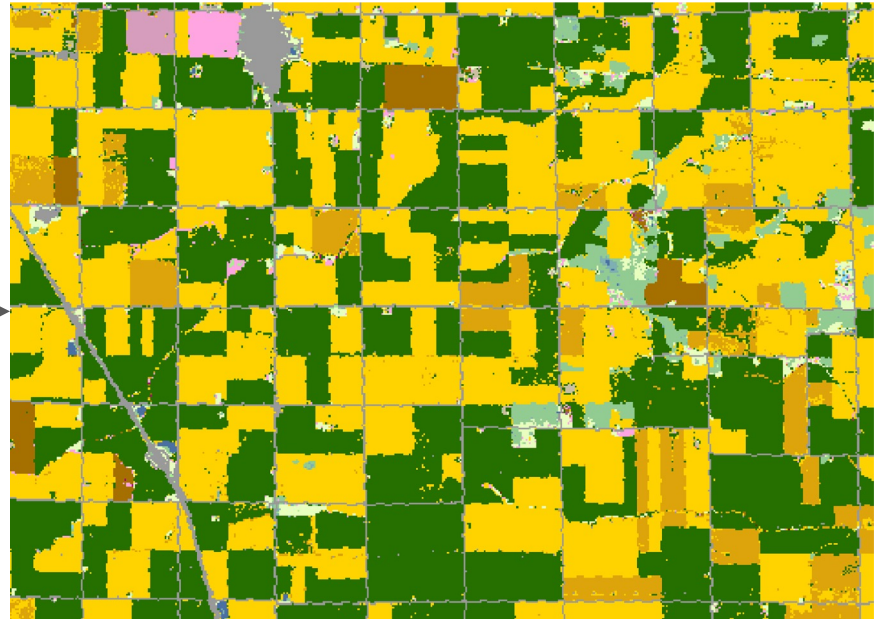
binary classification of pixels as crop or non-crop



Crop type mapping

multi-class classification of pixels into N crop types

USDA Cropland Data Layer



 Corn  Soybean  Sweet corn  Alfalfa ...

Field boundary delineation

segmentation of individual field/parcel boundaries

Radiant Earth South Africa Field Boundaries

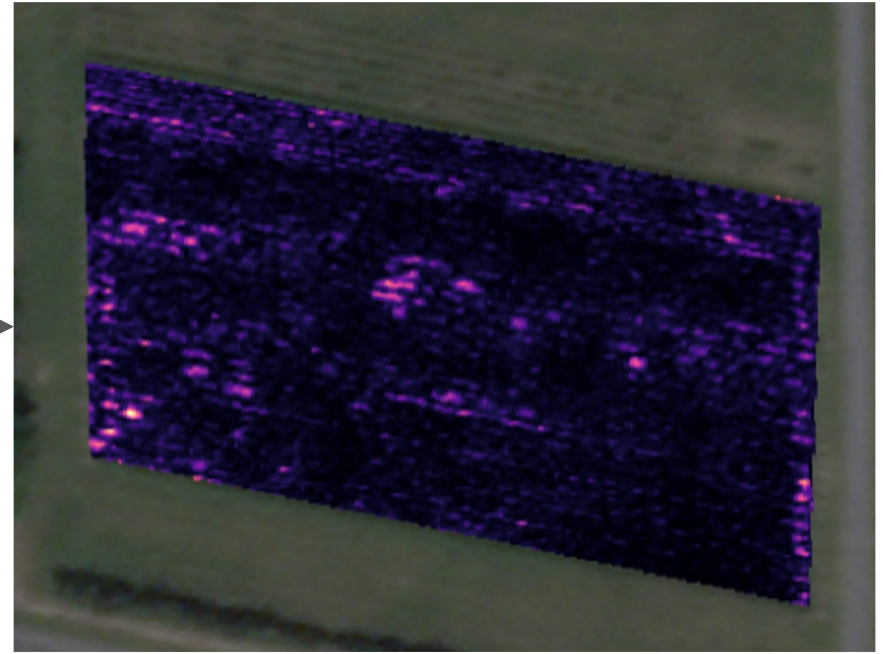


Pest, disease, and hotspot detection

detection of in-field anomalies that represent unfavorable growing conditions



Downy mildew disease

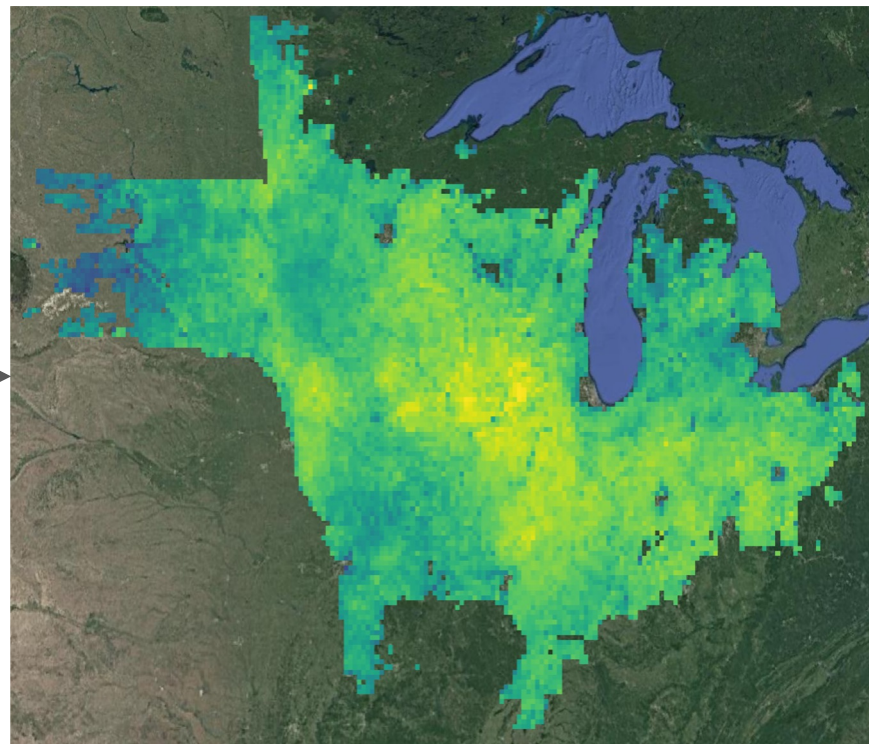
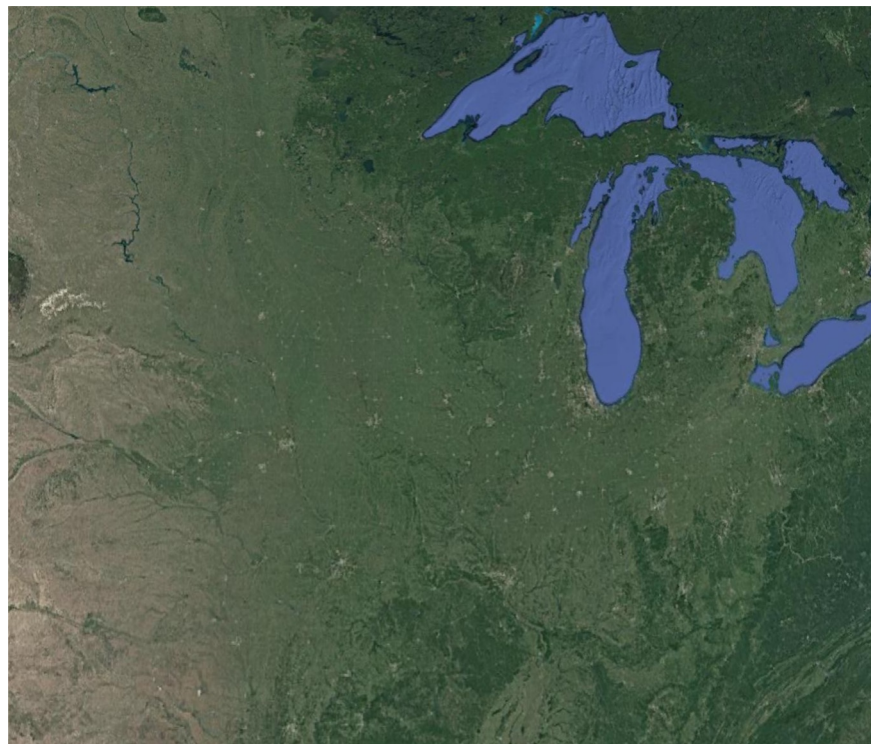


low  high
anomaly score

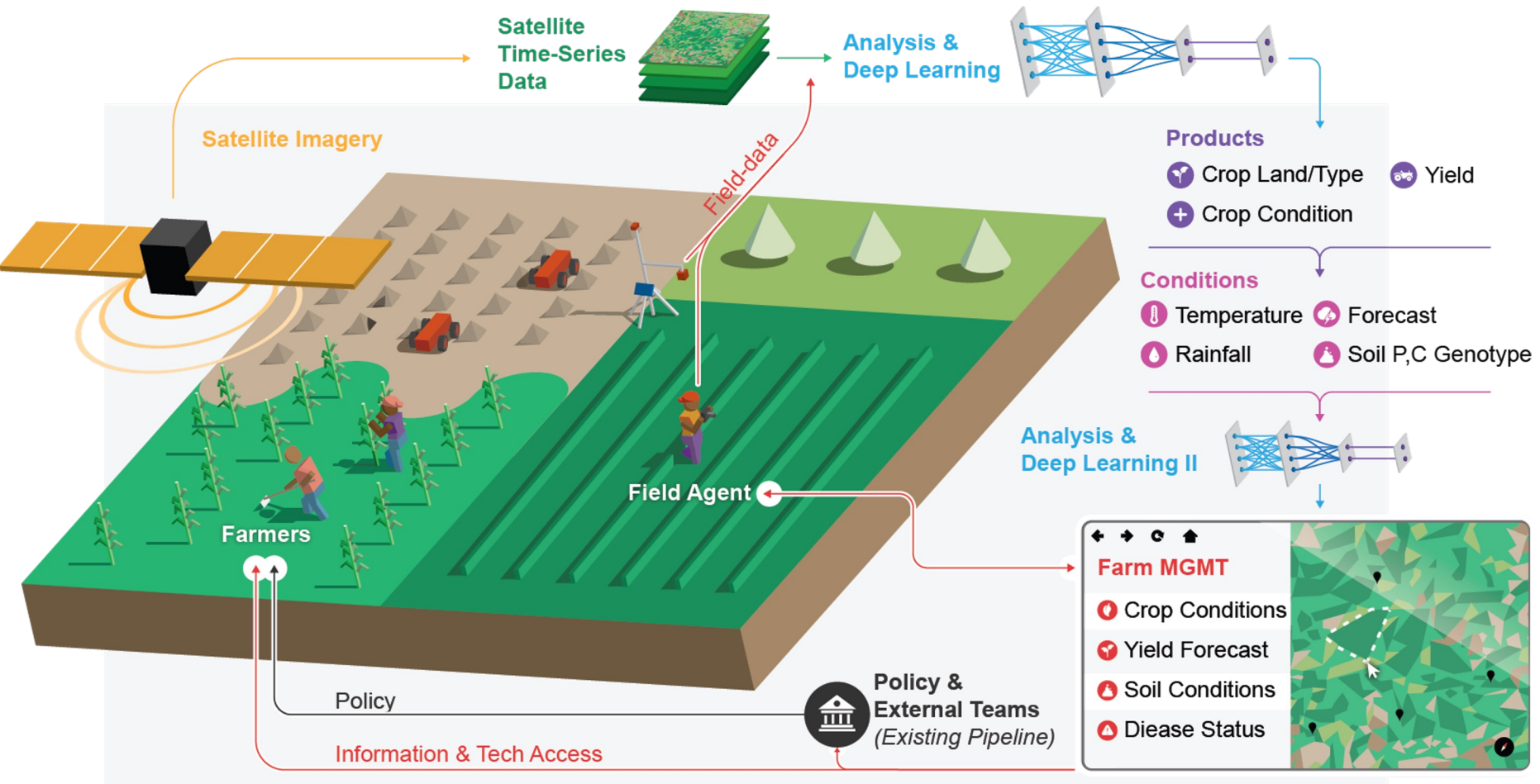
Yield estimation

estimation of crop harvested per unit area, e.g., kg/ha

Maize yields in US 2018 (Deines et al., 2020)



4 tonnes/ha  17 tonnes/ha

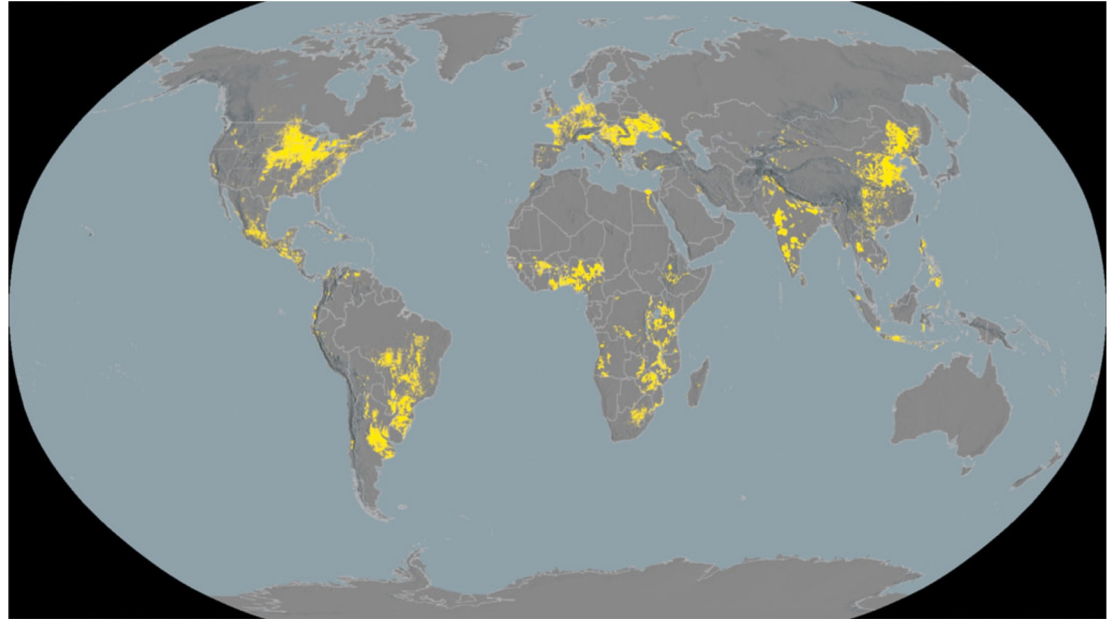
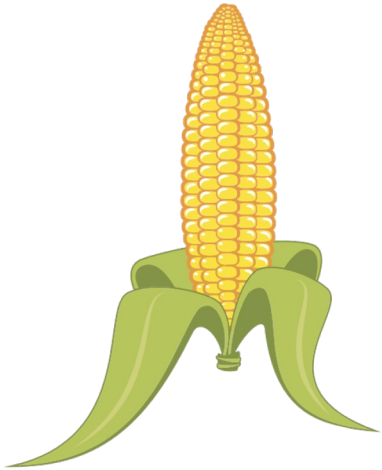


NASA Harvest Africa Program Priorities

1. Improving monitoring and early warning **systems** that provide actionable data and information on agricultural productivity and food security at multiple scales,
1. Advancing **EO-AI methods** that underpin the data and systems,
1. Developing and transferring **capacity** to national and local users that influence decision making, and
1. Developing strong long-term **partnerships**.

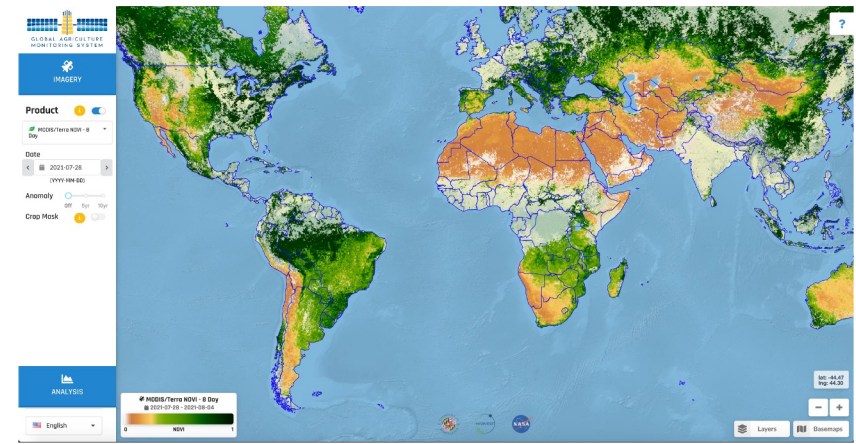
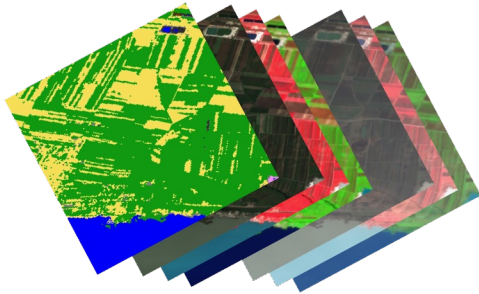


What and where it is growing?

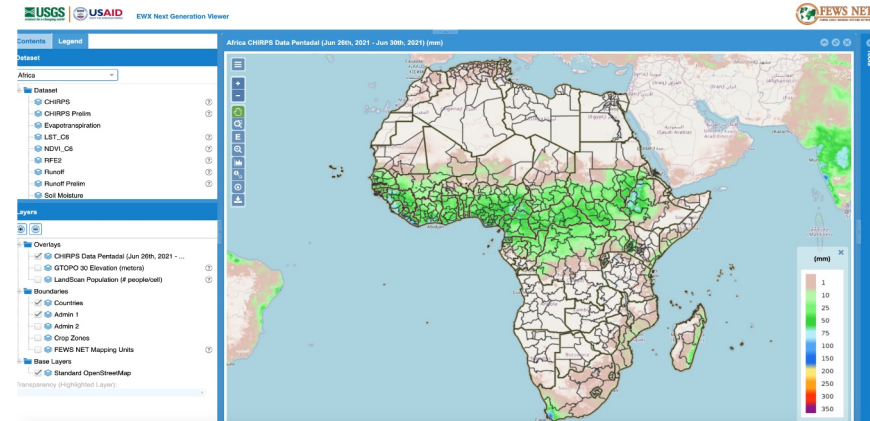


How it is growing?

- Cropland & crop-type
- Rainfall
- Temperature
- Soil moisture
- Evapotranspiration

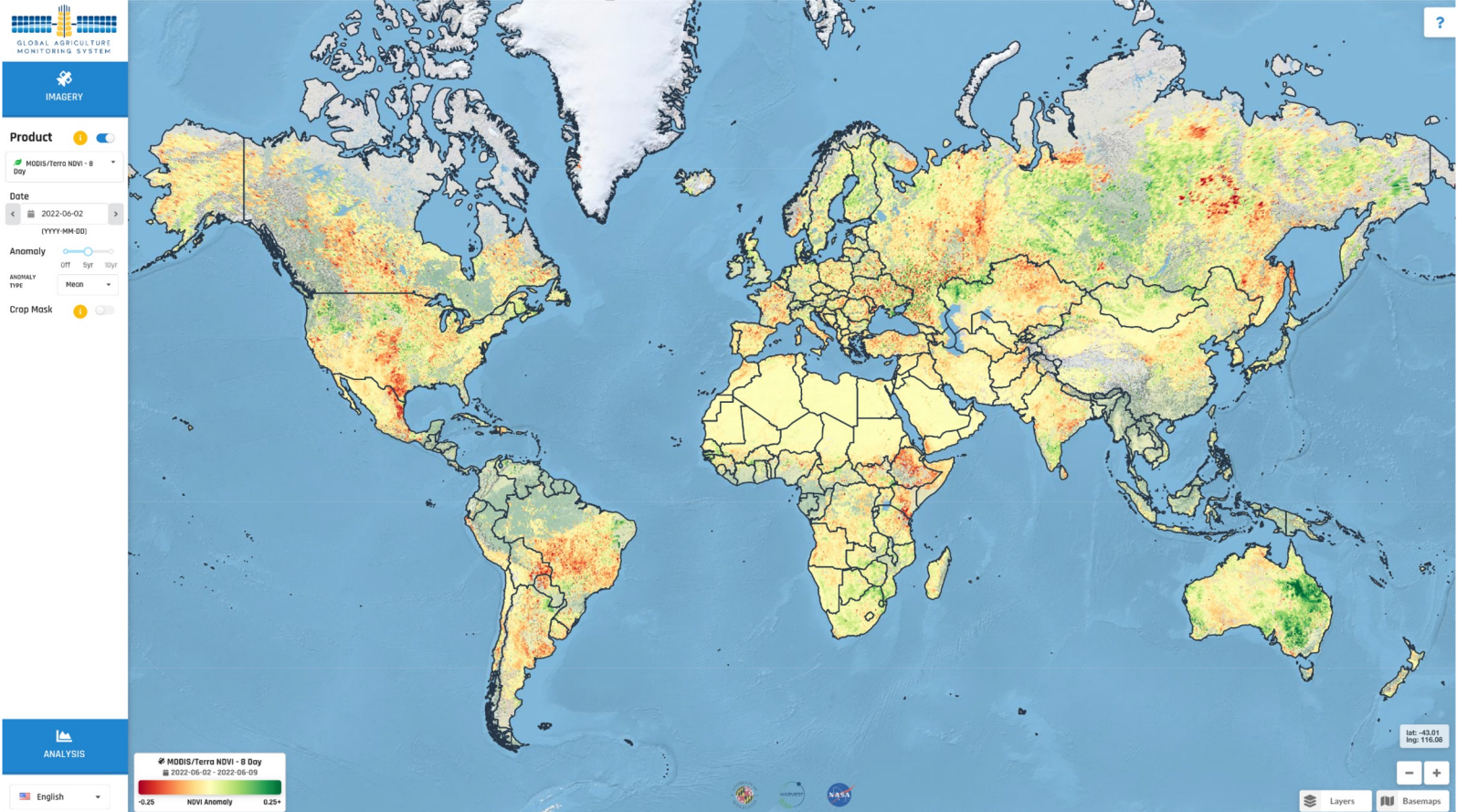


<https://glam.nasaharvest.org/>



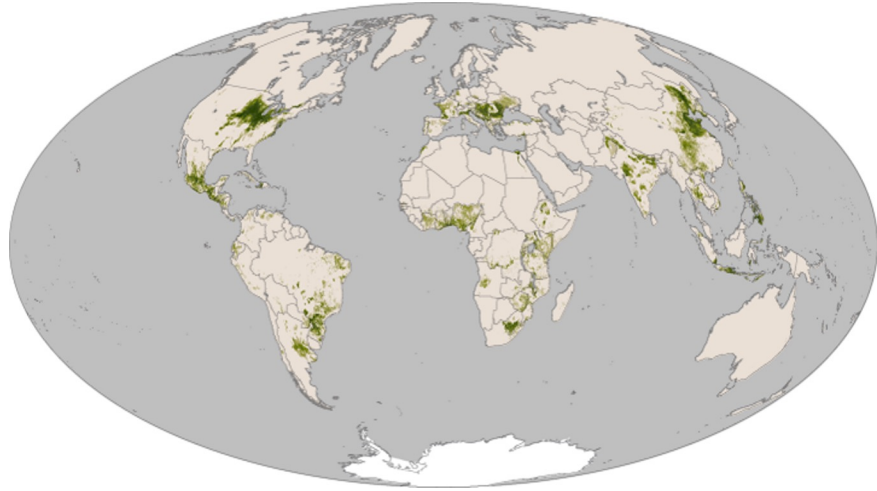
<https://earlywarning.usgs.gov/fews/ewx/index.html?region=af>

Data Available Globally



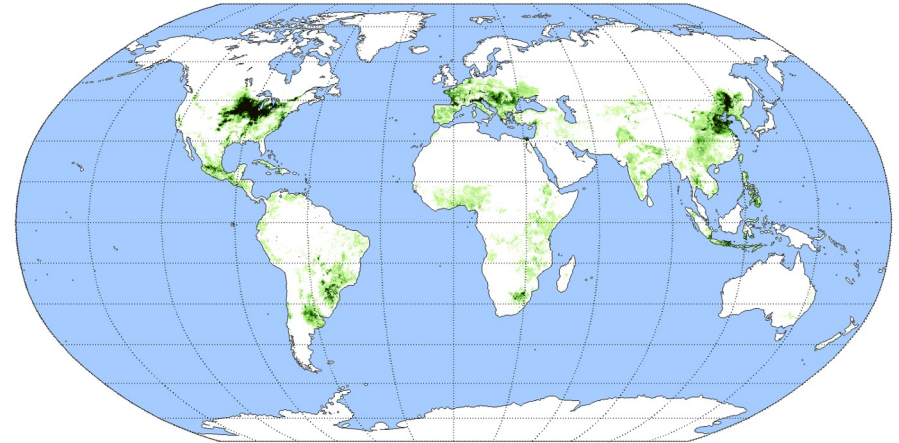
<https://glam.nasaharvest.org/>

Production



Maize area

<https://earthobservatory.nasa.gov/>



0 200 400 600 800 1000 1200

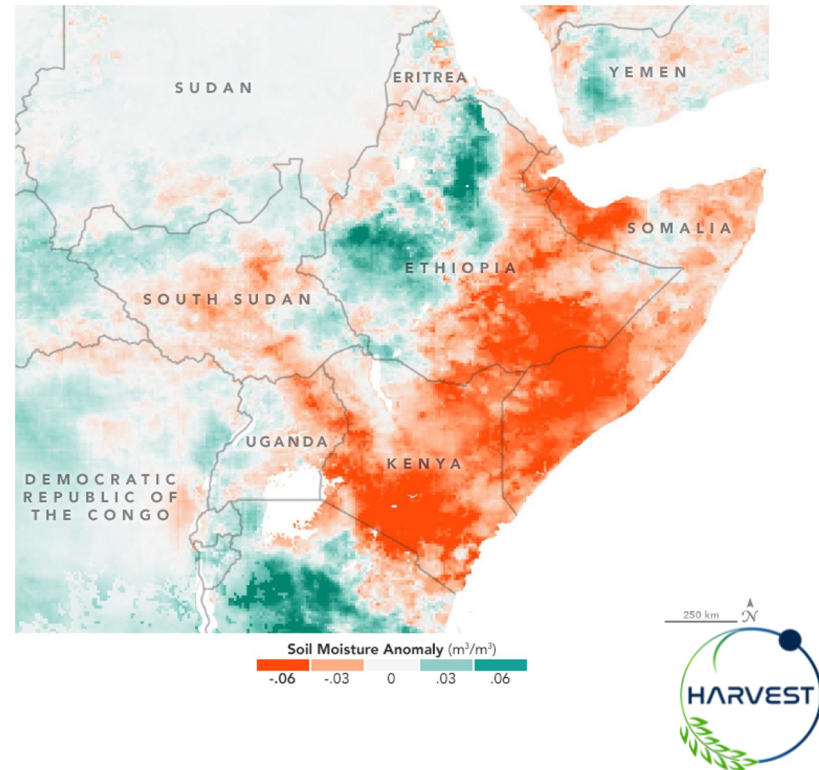
Average regional maize output (kg/ha)

Worldwide Corn Production, by AndrewMT

Track and Forecast Threats in near-real-time

Where and when are droughts likely to happen?

- Rainfall deficits +
- High temperatures =
- Dry soils =
- No water for vegetation/ crops =
- Poor conditions /drought conditions =
- Failed crops =
- Reduce food availability =
- Food insecurity



Drought in East Africa 2019

Impact example;

The GEOGLAM Crop Monitor Systems

No. 61 - November 2012 www.cropmonitor.org

Crop Monitor for AMIS

Overview:

By the end of October, conditions for the four AMIS crops remain mixed. Winter wheat sowing in the northern hemisphere begins under mixed conditions. In the southern hemisphere, conditions remain mixed due to adverse weather while the crop is mostly in vegetative stage. For maize, conditions are generally favourable during harvest in the northern hemisphere, and favourable for sowing in the southern hemisphere. For rice, conditions have improved in Southeast Asia, however heavy rains have still affected parts of Viet Nam and Thailand. Soybean prospects are good with an increase in expected production from the US and Canada, while there are generally favourable sowing conditions in the southern hemisphere.

Contents:

- Conditions at a Glance
- Global Climate Outlook: Climate Influences
- East Africa & Yemen, Regional Climate Outlook
- West Africa
- Middle East & North Africa
- Southern Africa
- Central & South Asia, Regional Climate Outlook
- Southeast Asia, Regional Climate Outlook
- Central America & Caribbean, Regional Climate Outlook
- Appendix - Terminology & Definitions

The Crop Monitor is a part of GEOGLAM, a GEO global initiative.

No. 73 - July 2012 www.cropmonitor.org

Crop Monitor EARLY WARNING

Overview:

In East Africa harvest is underway for many dry crops in Ethiopia under poor conditions, and conditions are mixed for maize season cereals due to rainfall deficits and ongoing insecurity. In the south of the subregion, several consecutive failed rainy seasons are impacting crops in many areas, and poor conditions have resulted in parts of Kenya, Uganda, and Somalia for main season crops. In West Africa, planting and development of main season cereals is underway, and conditions are generally favourable except in southern Mauritania where the rainfall season has yet to begin and in conflict-affected regions. In the Middle East and North Africa, harvesting of winter wheat is nearing completion. Crops have failed in Morocco, and below-average yields are expected in many areas due to persistent drought throughout the season. In Southeast Asia, harvesting of main season cereals mostly finished last month with below-average yields. In many areas due to persistent drought throughout the season and tropical storm damage. In Central and South Asia, harvesting of winter wheat crops is underway while spring wheat crops continue to develop. Crops in Afghanistan are unable to recover from another below-average rainfall season, and concern remains in parts of Kazakhstan, Tajikistan, and Turkmenistan. In Southeast Asia, harvesting of dry season rice finished under generally favourable conditions in the north. In Indonesia, harvesting of wet season rice is nearing completion with good yields and increased harvested area. In Central America and the Caribbean, planting and development of primary season cereals is underway, and conditions are generally favourable. In South America, crops are unable to recover from irregular rainfall distribution and above-average temperatures throughout the country.

Contents:

- Conditions at a Glance
- Global Climate Outlook: Climate Influences
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The Crop Monitor is a part of GEOGLAM, a GEO global initiative.

Issue No. 1 www.cropmonitor.org

EASTERN AFRICA CROP MONITOR BULLETIN

Overview

- Eastern Africa has been experiencing average to above average rainfall resulting in overall favourable crop conditions.
- Wheat conditions prevailed in Rwanda, Burundi for size and beans and in Kenya for maize season mostly due to water logging and flooding.
- Poor conditions have been reported in Rwanda due to extensive damage to rice and beans.
- Prices of grain staples in the region were below the 5-year average for quarter 1 as a result of adequate stocks. With wheat stocks from Tanzania and Uganda reported prices are expected to decrease towards the end of quarter 2 of 2012.

Crop Conditions

Contents

- Regional Crop Conditions
- Regional Grain Markets and Trade Overview
- National Crop Conditions
- Burundi
- Kenya
- Rwanda
- Tanzania
- Uganda
- Climate Outlook and Impacts on Agriculture
- Definitions
- Partners

Market Information Grain Trade (US\$)

Issue No. 01 March 2012 <http://www.moa.gov.tz> Ethiopia National Crop Monitor

SUMMARY ON THE ASPECT OF THE RAIN SEASON

Land preparation for maize sowing for the first season is progressing with plans for planting in April. Farmers have received fertilizer and seeds. In Tigray, land preparation did not begin as time was also for the security situation. The irregular rains in the last 2 weeks of rain in the Tigray region is negative crop and soil water. The biomass of the area is expected to result in a 25% reduction of the Season's Production.

Crop Conditions

Contents:

- Assessment by Region
- Climate outlook
- Market Information
- Definitions
- Partnership

May downing regional crop conditions information in Ethiopia is in 27th March 2012 for maize. The crop Monitor map is based on a combination of ground-based monitoring covering several data, ground observations, field reports, national and regional reports. Crop with conditions that are other than favourable are marked on the map with their colour.

The Belg rainfall is expected to be average, and this is already evident from the late onset of the season, and also in the 'Spectacular' La Niña phenomenon. However, it is expected that the late onset will benefit the Belg crop. Normal to above normal rainfall is expected in Eastern, Central, Western and North Eastern parts of the country. While normal to below normal rainfall is expected in the South and South Eastern regions.

PRESIDENCE DE LA REPUBLIQUE REPUBLIQUE DU MALI
COMMISSARIAT FEDERAL AGRICULTURE
SYSTEME NATIONAL SECURITE ALIMENTAIRE
On People On Our Soil

BP 2160, Bamako Mali
Tel: 00223 20 90 39 38
Avenue email: info@snas.mli / snas@snas.mli
Adresse Web: www.snas.mli

REPUBLIQUE DU MALI
Ministère National de l'Agriculture, de l'Élevage et de la Pêche
Système National Sécurité Alimentaire

Contents:

- Assessment by Region
- Climate outlook
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THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF AGRICULTURE LIVESTOCK AND FISHERIES
NATIONAL FOOD SECURITY BULLETIN

17th September 2012

Contents:

- Assessment by Region
- Climate outlook
- Market Information
- Definitions
- Partnership

U - NEWS
The United Nations Office of Spreadsheets
Monthly National Food Security Early Warning Bulletin

17th September 2012

Contents:

- Assessment by Region
- Climate outlook
- Market Information
- Definitions
- Partnership

CRIP CROP MONITOR BULLETIN January 2012

National Synthetic (Maize, Beans and Wheat)

Contents:

- Assessment by Region
- Climate outlook
- Market Information
- Definitions
- Partnership

Issue No. 04 March 2012 www.cropmonitor.org Rwanda National Crop Monitor

Contents:

- Assessment by Region
- Climate outlook
- Market Information
- Definitions
- Partnership

Impact example; The Kenya Crop Monitor

The Kenya Crop Monitor was customized for reporting by the State Department of Agriculture (SDA).

SDA to assess a specific crop type at the county level and make a report on the crop condition and related drivers such as climatic conditions, extreme events or pests and diseases, and information on the expected outlook depending

Lead agency: State Department of Agriculture
Product: Kenya Crop Conditions Bulletin
Systems utilized: GLAM, Tanzania Crop Monitor, Early Warning Explorer

Republic of Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation www.kilimo.go.ke Issue 15 August 1

KENYA CROP CONDITIONS BULLETIN: July 2019

National Synthesis (Maize, Beans and Wheat)

Overview

- The month of July had good rains in the major crop growing areas in the Western and North Rift regions.
- Crop performance was poor with crop failure experienced in parts of Lower Eastern, Coast, Narok West.
- Early planted crops were affected by water stress resulting in below average yields being realized.
- FAW infestation, drought and MRLD affected crops in Narok West, Bomet and Bungoma. Kilifi and Kiambu also experienced FAW infestation.
- A reduction in total area planned for maize, beans and wheat observed due to late onset of the rains.
- Harvesting of beans is ongoing in Meru, Nandi, West Pokot and Elgeyo Marakwet. Maize harvesting is ongoing in parts of Nyanza, Western and Rift Valley regions.
- Slight reduction in the prices of maize, while a slight increase in beans and wheat prices was observed in selected markets.

Crop Conditions

Map showing regional crop conditions information in Kenya as at 20th July 2019 for maize, wheat, beans, green grams and cowpeas. The crop Monitor map is based on a combination of several variables including remotely sensed data, ground observations, field reports, national and regional experts. Crops with conditions that are other than favourable are labeled on the map with their driver.

OUTLOOK (Kenya Meteorological Department (KMD)/State Department of Crops Development (SDC))

The expected enhanced rainfall in Western Highlands and parts of the Rift Valley is expected to result in further improvement in crop performance in July. In August, generally sunny and dry weather conditions are expected in most parts of the country, providing conducive environment for harvesting. However, enhanced rainfall is expected in Western Highlands and in the Rift Valley regions.

1 | Page State Department of Crops Development

Republic of Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation www.kilimo.go.ke Issue 15 August 1

Assessment by crop

Maize Conditions

Maize production in the upper rift region was favorable due to improved rains which prompted a recovery and improvement in crop conditions and resulted in a reduction in FAW. However other parts of the country were under watch due to delayed onset of the rains, dry conditions, erratic and poorly distributed rains. In the Lower Eastern region and Coast, the maize crop was poor with total crop failure experienced in parts of Malindi, Machakos and Kitui. In Bungoma, Bomet, Homu Bay and Narok West, the maize crop was affected by the FAW. The crop is between vegetative and harvesting stages. Harvesting is ongoing in most parts of the country.

Beans Conditions

White conditions were favorable for beans production in parts of the North Rift Region; in Lower Eastern and Coast, the crop was poor with crop failure experienced in some areas. In Western, Nandi and Elgeyo Marakwet, harvesting of the crop is ongoing. In Central, wet conditions caused rotting of beans.

4 | Page State Department of Crops Development

Crop Monitor KENYA Home Map Monthly Assessment Archive Settings Admin Logout

Powered by University of Maryland

User information

Username: cnaakalembe
 First Name: Catherine
 Last Name: Nakalembe
 e-mail: cnaakalem@umd.edu
 User Country: United States
 Organization: University of Maryland
 Registration Date: July 20, 2017
 Provenance: International/Regional
 Source

Latest submitted reports

District: Mandera
 Region: Upper Eastern
 Crop: Wheat Long Rains
 Condition: Favourable
 Date Observed: May 08, 2018

District: Marsabit
 Region: Upper Eastern
 Crop: Wheat Long Rains
 Condition: Favourable
 Date Observed: May 08, 2018

District: Isiolo
 Region: Upper Eastern

Welcome to the national Crop Monitor for Kenya

Tweets by @IG20_GEOGLAM

GEODGLAM @IG20_GEOGLAM
 How are #EarthObservations & #GEODGLAM contributing to attaining & measuring progress toward the #SDGs? A new article details current state & opportunities to reach #SDGs/2030. <https://www.evernote.com/public/1900...> cc: @IG20SDG @Data4SDGs @UNGIGM @IG20Dev @IG20ECS2020

USAID FROM THE AMERICAN PEOPLE
GEODGLAM Global Agricultural Monitoring

NASA

EV Eco-Innovation
 The second day of #EAG2019 is about to start! [kampus.nyu.edu/735u](https://kampus.nyu.edu/) Check our Data Hub datahub.org to discover all the #EAG2019 projects working on #EarthObservation [@EarthObs](https://twitter.com/EarthObs) and learn about their developments! [@EarthObs](https://twitter.com/EarthObs) [@EarthObs](https://twitter.com/EarthObs) [@EarthObs](https://twitter.com/EarthObs)

Republic of Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation www.kilimo.go.ke Issue 15 August 1

Vegetation Conditions

The Vegetation map represents a 16-day anomaly image for 2019-July-27 to July-27. The brown areas represent areas where the vegetation conditions are worse than "normal" (long term average for the 2000 to 2018). The green color represents areas where conditions are better than "normal". The white color represents values where normal conditions are being experienced. Gray areas are areas where no data was collected due to cloud cover.

MODIS NDVI (Terrestrial) (MOD44 16-day) - Kenya

The Graph provides a comparison between current vegetation conditions and the average conditions (yearly) defined by the historical average. The dotted line displays the standard deviation showing how values tend to spread-out from the mean and can be used to gauge the severity of the current conditions.

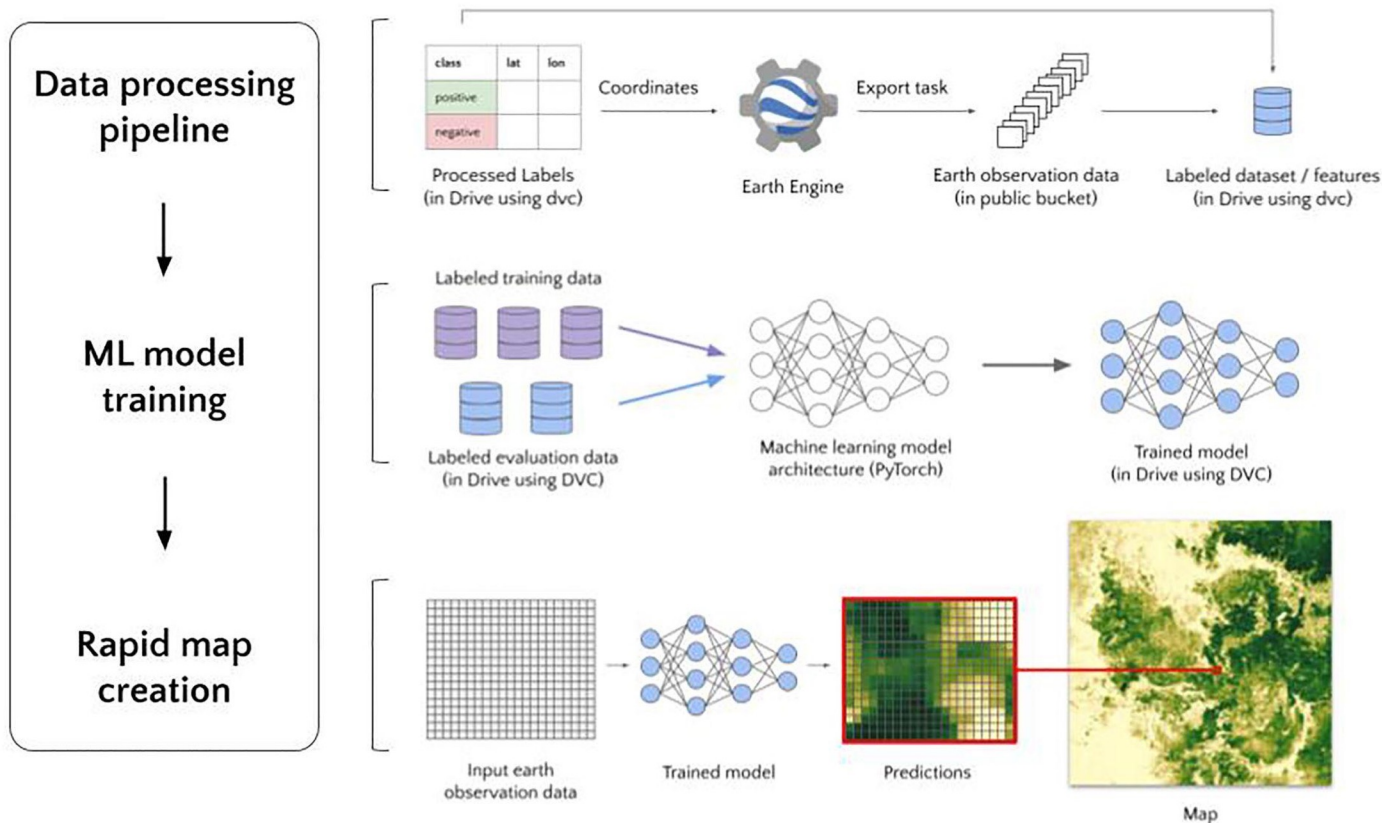
HIGHLIGHTS

Improvements noted in the major crop growing areas. Looking at the graph, conditions in July (red) are now at the normal range which is represented by the long-term (measured). Despite the recovery and notable greenness in the vegetation in all the crop growing areas, the late onset and variation in frequency and intensity of rainfall affected the crops and provided conducive environment for pests and diseases.

6 | Page State Department of Crops Development

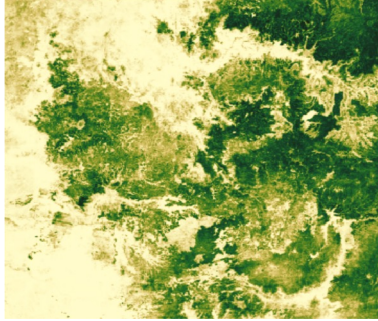
OpenMapFlow

Rapid map creation with machine learning and earth observation data- Main applications- cropland and crop-type mapping

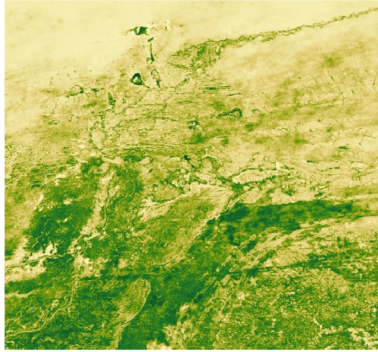


Results

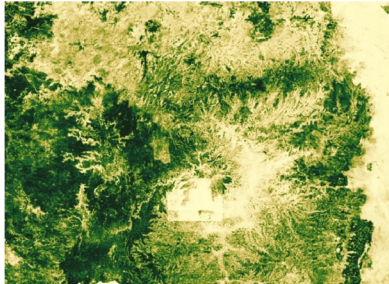
Ethiopia
Bure Jimma
2020



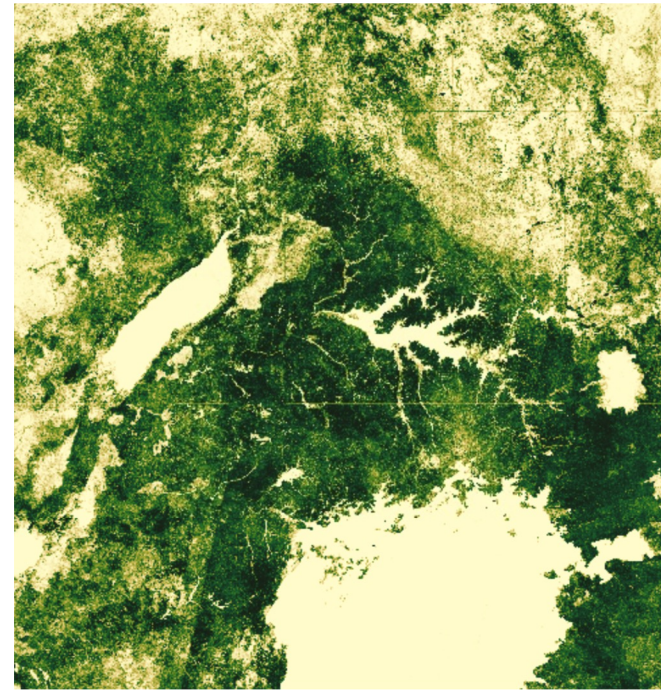
North
Mali
2019



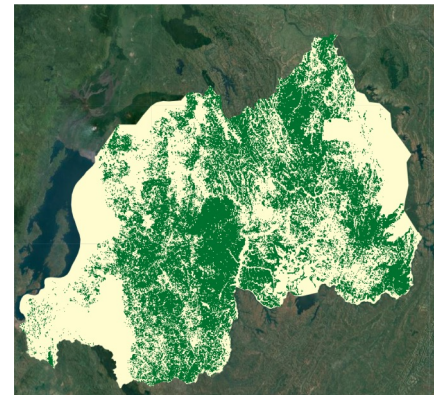
Ethiopia
Tigray
2021



Malawi 2021

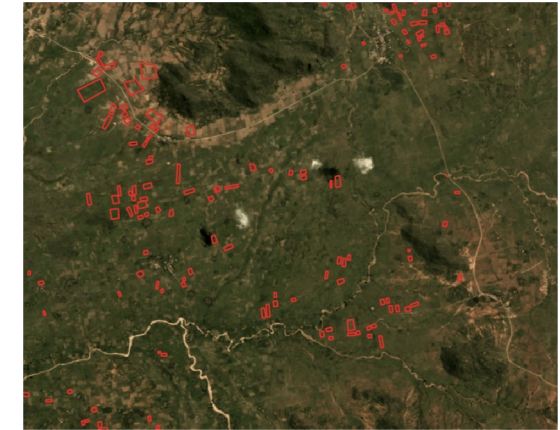
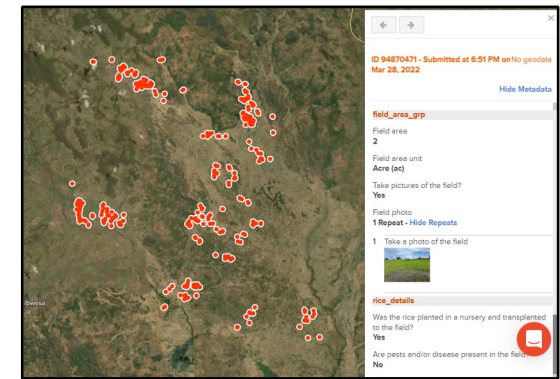


Uganda
2019

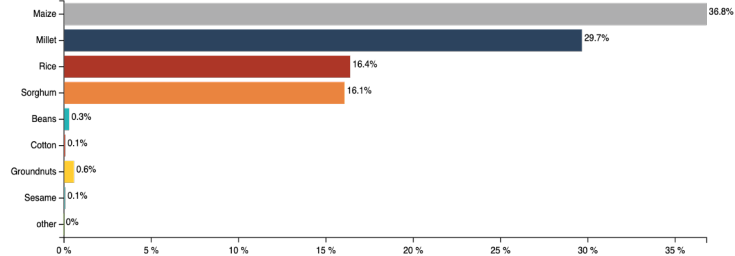


Rwanda
2019

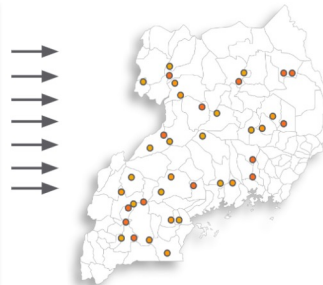
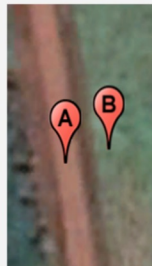
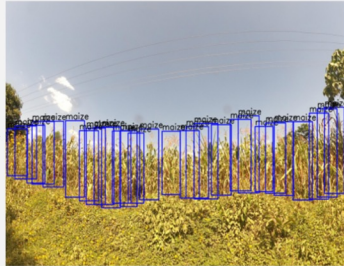
Data Collection



Select MAIN crop in the field:*



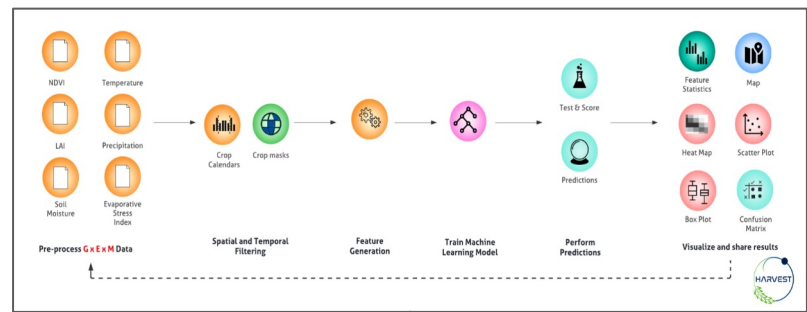
Helmets Labeling Crops + Street2Sat



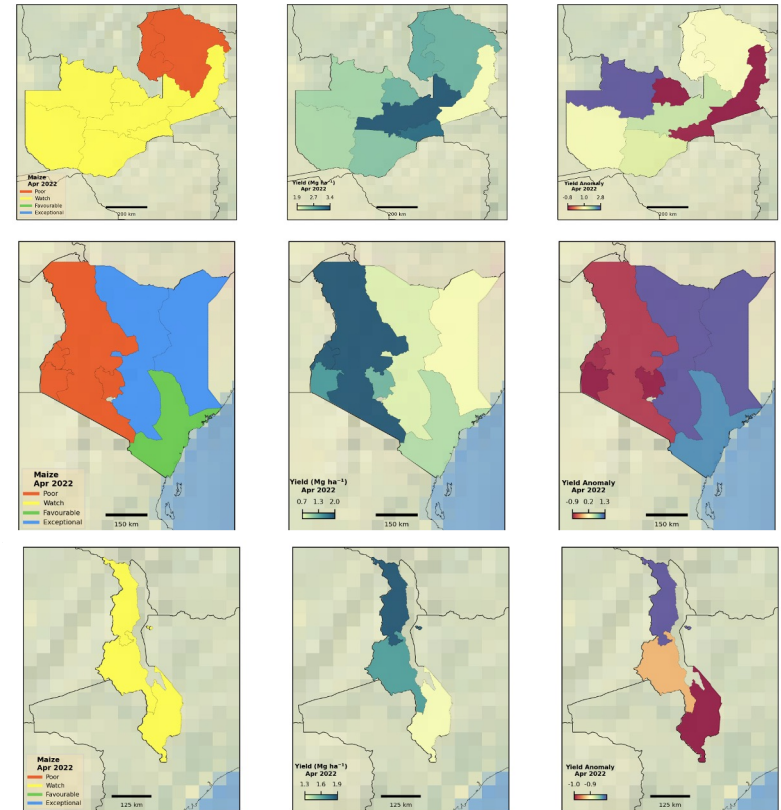
Partners



Yield Estimation- Global Earth Observations for Crop Inventory Forecasting (GEOCIF) system



Crop Yield Forecast Estimates April 2022
In support of The Regional Food Balance Sheet



Capacity Development and Innovation- With National and regional Analysts and Extension Agents

