EARTH SCIENCE
APPLIED SCIENCES

# ENSURING FOOD SECURITY

EARTH SCIENCE APPLICATIONS WEEK 2021

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# Introduction to NASA's Agriculture Application Area

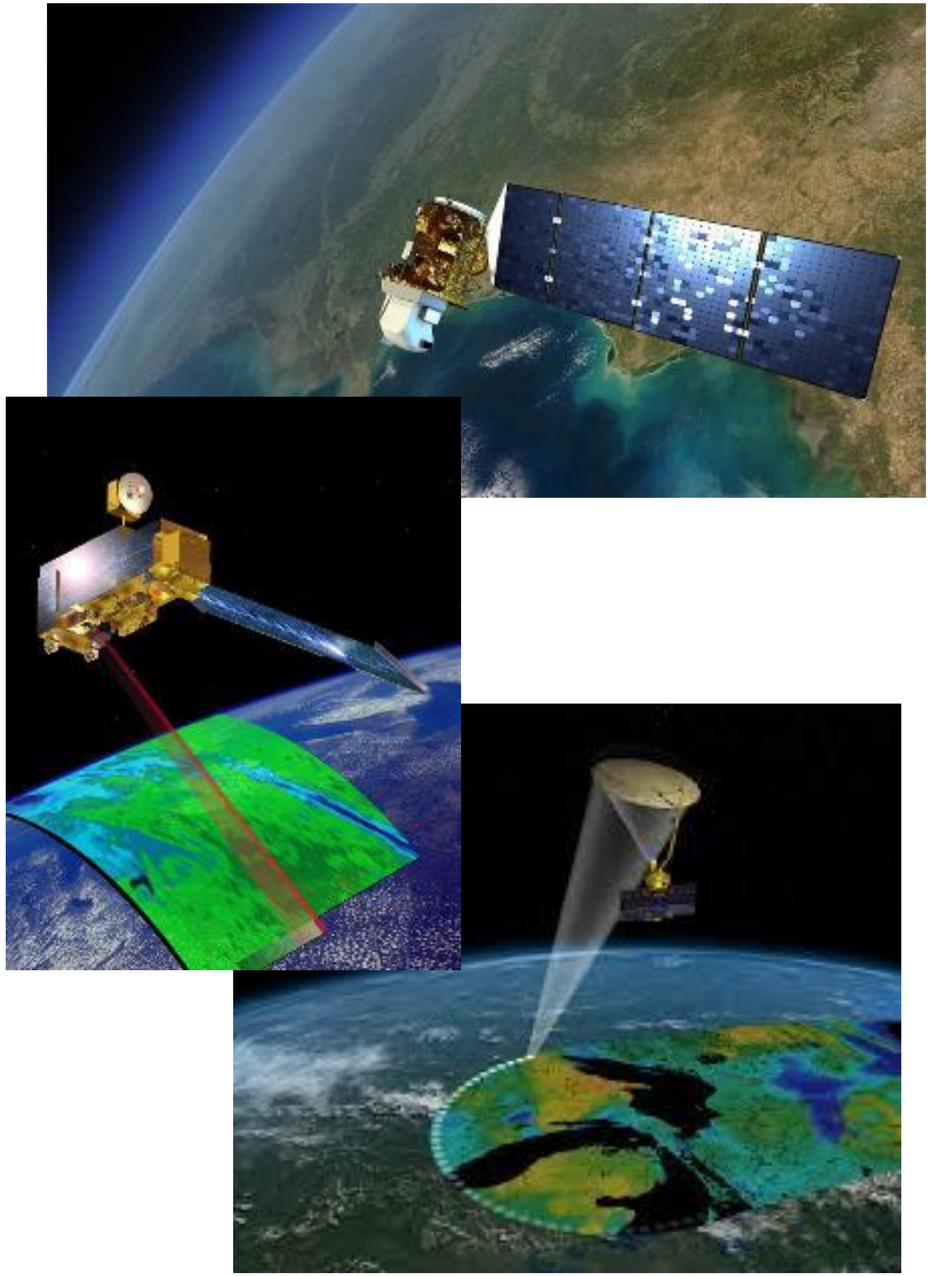
Dr. Brad Doorn

EARTH SCIENCE APPLICATIONS WEEK 2021

# FROM SPACE TO SOIL

NASA contributes to the field of Food Security and Agriculture by:

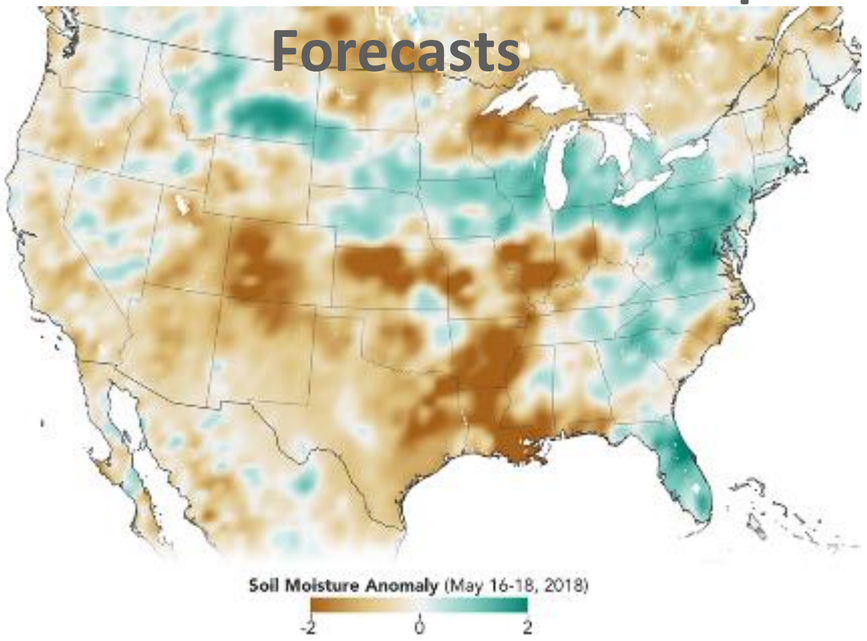
- Gathering data about agriculture relevant factors including soil moisture, evapotranspiration, plant stress, water availability for irrigation, and crop yield/type indicators
- Working with key partners, such as the United States Department of Agriculture, the United States Agency for International Development, and agriculture ministries across the globe
- Supporting applied research that connects producers, agriculture industry and governments that enable sustainable solutions
- Encouraging a community that promotes the use of Earth observations in decision- making processes for transparent, objective, and trusted solutions that meet that Nation’s and global food security needs

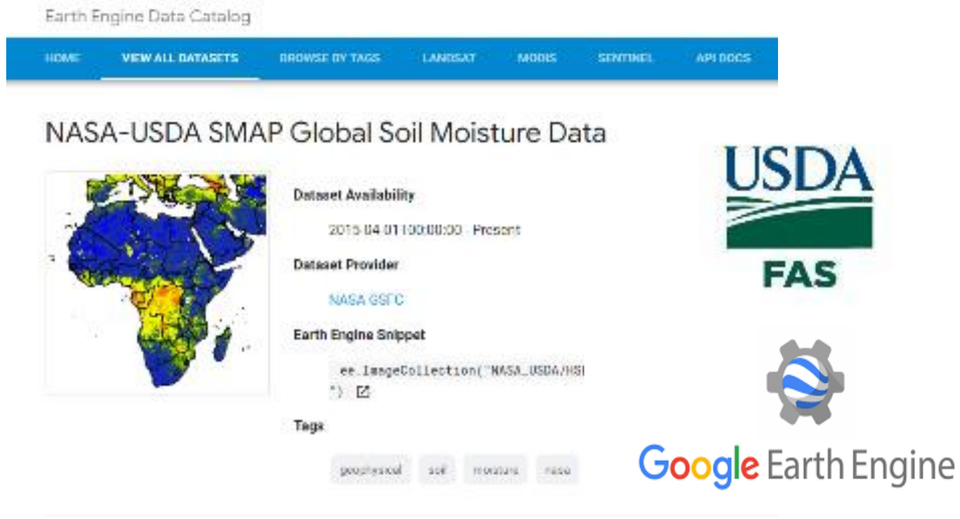



Partnering with the USDA

- This relationship began in the 1970s with the NASA-initiated Large Area Crop Inventory Program
- The relationship continues to expand and strengthen the ongoing partnership with a signed Memorandum of Understanding (MOU) that enables USDA to draw on the best scientific and technical information available from NASA research in Earth observation and systems engineering
- Since 2017, over 120 joint activities and projects

## NASA Soil Moisture Data Advances USDA Global Crop Forecasts



# NASA HARVEST

- NASA's Agriculture Application Area also includes NASA Harvest, a consortium at the University of Maryland
- *NASA Harvest's goals are to empower decisions that support food security, stable markets, economic progress, and sustainable, resilient crop production by using Earth Observations.*

https://nasaharvest.org/

HARVEST

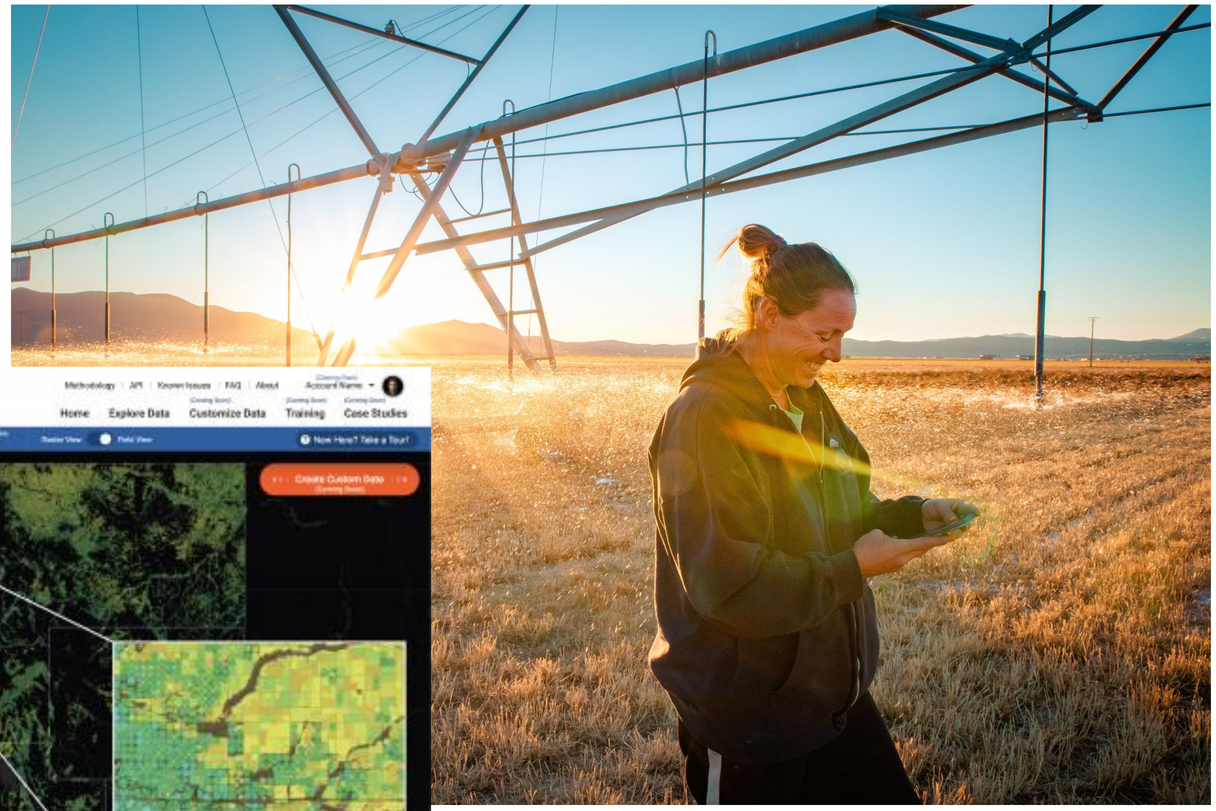
EARTH DATA FOR INFORMED AGRICULTURAL DECISIONS

# OpenET: Earth data drives smart decision-making

- Earth data allows farmers to better manage their crops, putting food on the table for you and me.

- With OpenET, producers and water managers can better understand their water loss and crop water needs through enhanced evapotranspiration information.

https://openetdata.org/



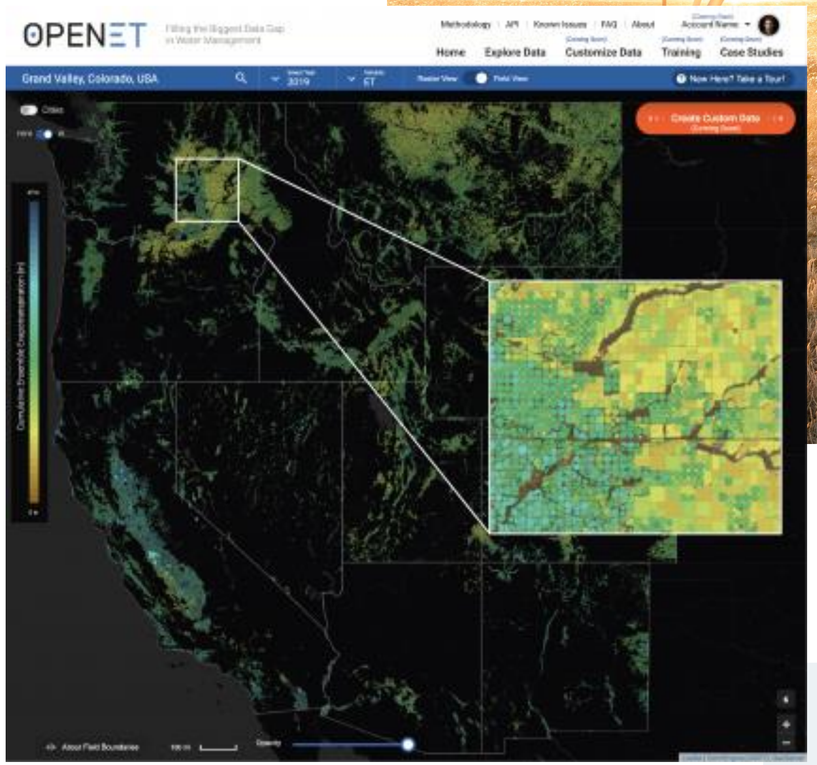



**Image top**: Nevada farmer Denise Moyle will use OpenET to plan irrigation of her alfalfa fields. Credits: Photo courtesy of Glow by G Photography
**Image left**: Screenshot of OpenET platform

# Thank You.

Bradley.doorn@nasa.gov

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# NASA Harvest

## NASA's Food Security and Agriculture Program

Dr. Inbal Becker-Reshef
Program Director

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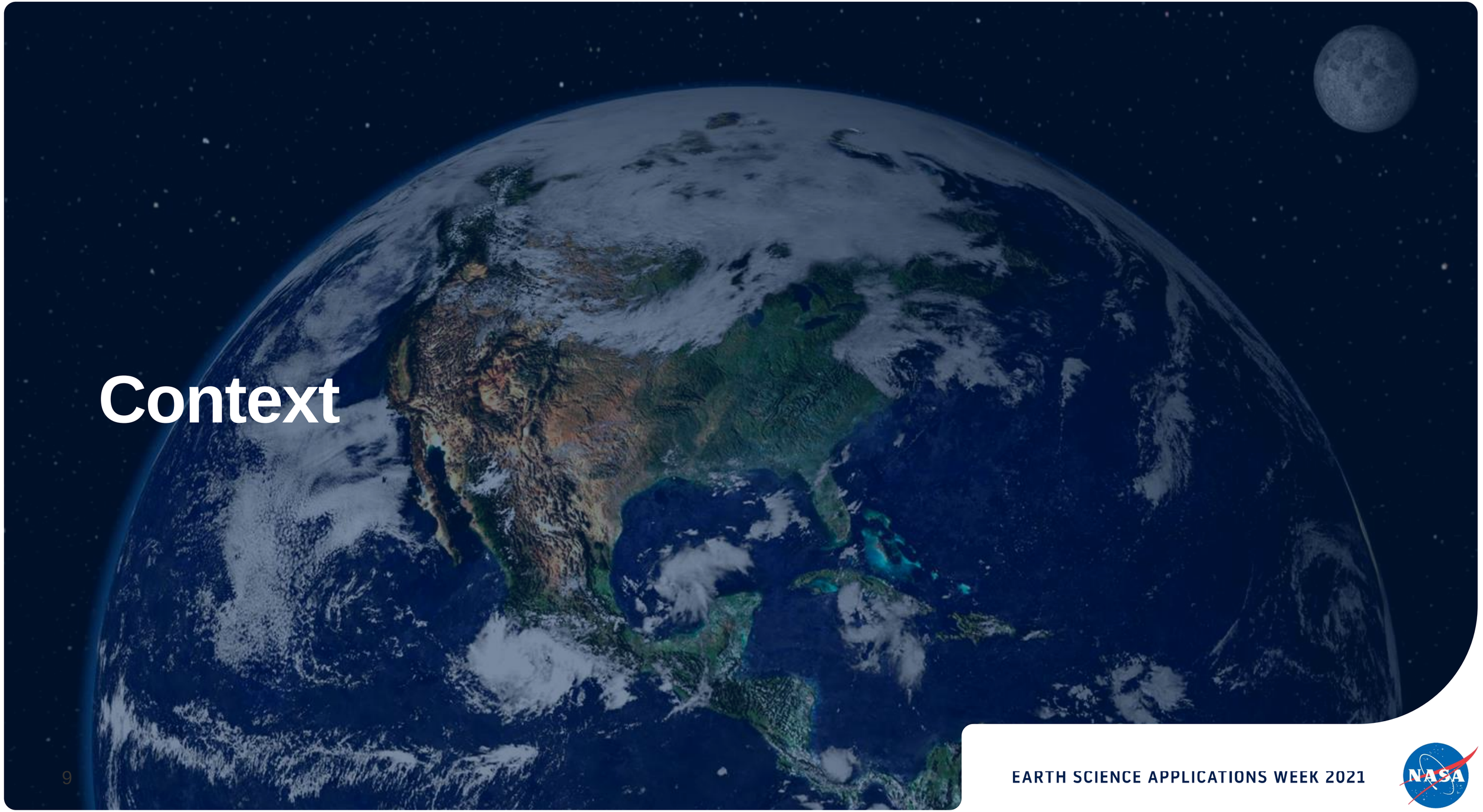
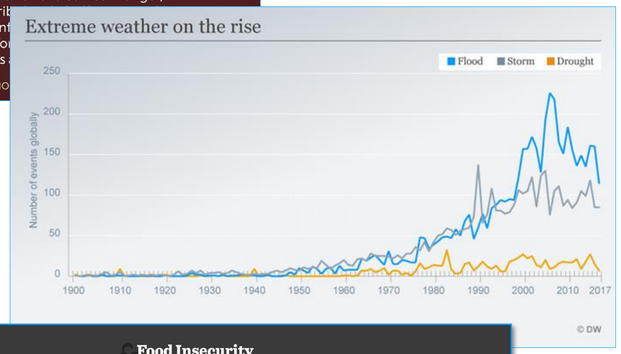
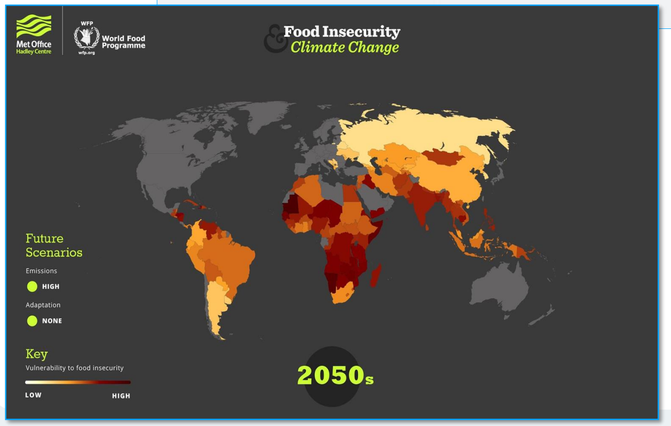
# Context



# Enhancing Food Security & Resilience are Major and Growing Challenges





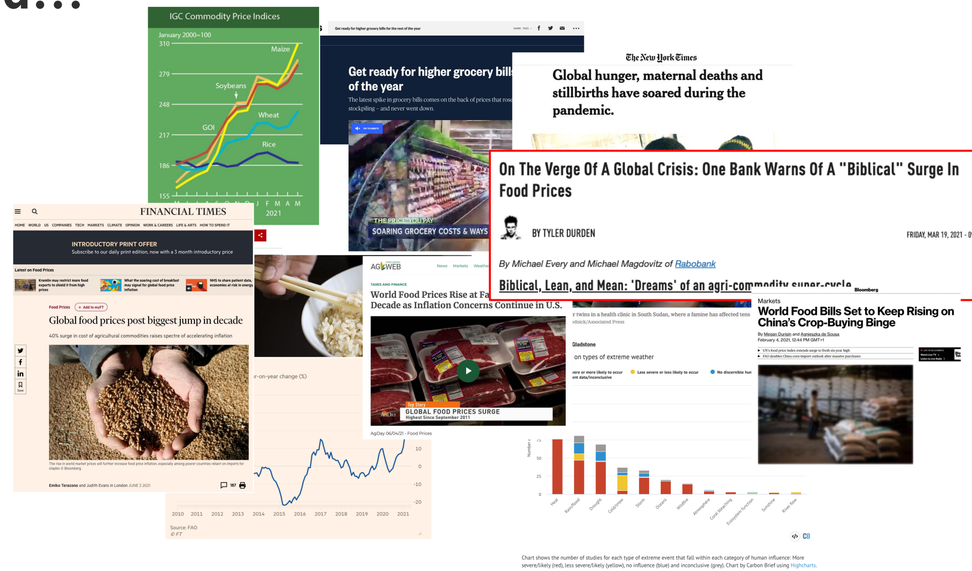




## Huge uncertainty remains around…

- Where/when food is grown
- Accurate production estimates

## Critical for:

- Early warning of shortfalls
- Stabilizing food markets
- Anticipating trade needs
- Enhancing farmer resilience
- Impacts of conflict on production




## Despite this uncertainty…

- Big-dollar food security & trade decisions are constantly being made
- Heightened pressure to increase food production sustainably under warming climate

## Remote sensing & machine learning in the spotlight…

- Increasing extreme weather & COVID-19 pandemic highlight information gaps and urgency to the need for improved agricultural information
- Exciting new era of satellite technology, advances in AI, cloud computing, and digital data collection

# Today's Trifecta: COVID-19, Rising Prices, Climate Change

## *Food Insecurity and Rising Prices Making Headlines*

FINANCIAL TIMES

HOME WORLD US COMPANIES TECH MARKETS CLIMATE OPINION WORK & CAREERS LIFE & ARTS HOW TO SPEND IT

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Latest on Food Prices

Kremlin may restrict more food exports to shield it from high prices

What the soaring cost of breakfast may signal for global food price inflation

NHS to share patient data, economies at risk in energy

Food Prices + Add to myFT

Global food prices post biggest jump in decade

40% surge in cost of agricultural commodities raises spectre of accelerating inflation

Get ready for higher grocery bills for the rest of the year

SHARE THIS

Get ready for higher grocery bills for the rest of the year

The latest spike in grocery bills comes on the back of prices that rose during last year's pandemic stockpiling – and never went down.

The New York Times

Global hunger, maternal deaths and stillbirths have soared during the pandemic.

UN: Cost of food rises at fastest pace in over a decade

6 days ago · Comments

GETTY IMAGES

ve jumped at their fastest monthly rate in over a the United Nations.

ndex of global food costs, which have also climbed for

AGWEB

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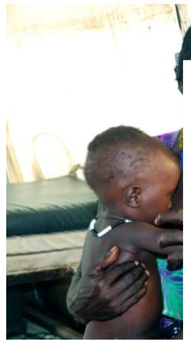
TAXES AND FINANCE

World Food Prices Rise at Fastest Pace in a Decade as Inflation Concerns Continue in U.S.


AgDay 06/04/21 - Food Prices



A woman with her twins in a health clinic in So of people. Sam Mednick/Associated Press

By Rick Gladstone

May 5, 2021

Human influence on types of extreme weather

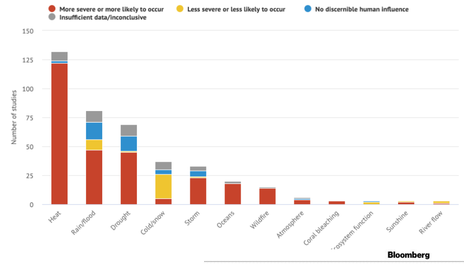



Chart shows the number of studies for each type of ext severe/likely (red), less severe/likely (yellow), no influe

On The Verge Of A Global Crisis: Food Prices

BY TYLER DURDEN

*By Michael Every and Michael Magdovitz of Rabobank*

**Biblical, Lean, and Mean: 'Dreams' of an agri-commodity super-cycle**

FRIDAY, MAR 19, 2021 - 0

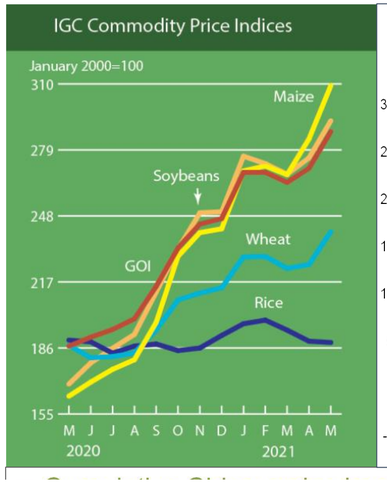
Markets

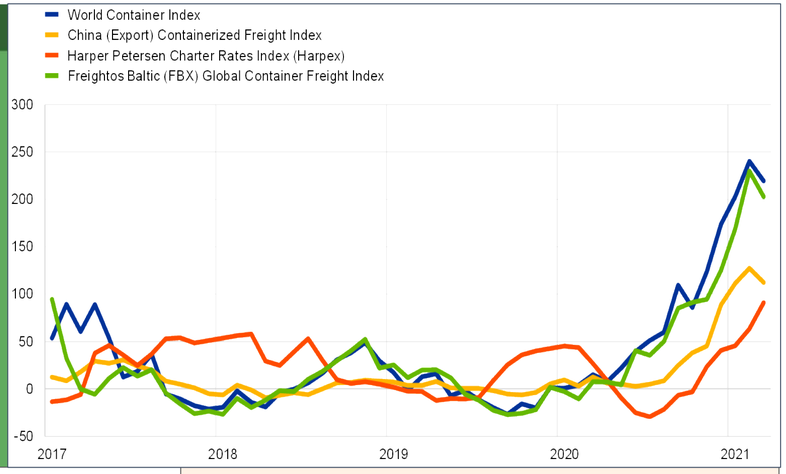
World Food Bills Set to Keep Rising on China's Crop-Buying Binge

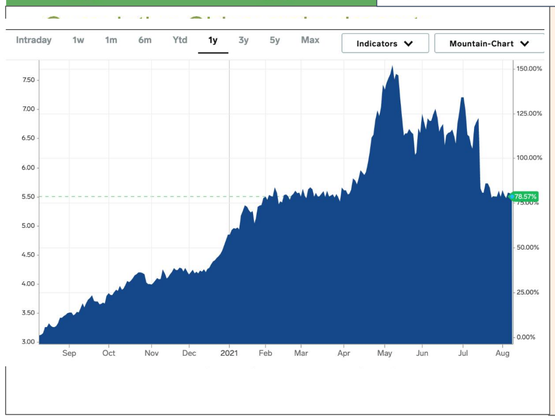
By Megan Durisin and Agnieszka de Sousa
February 4, 2021, 12:44 PM GMT+1

- UN's food price index extends surge to fresh six-year high
- FAO doubles China corn-import outlook after massive purchases

## *Analyses of Ongoing Food Market Behavior*





EARTH SCIENCE APPLICATIONS WEEK 2021

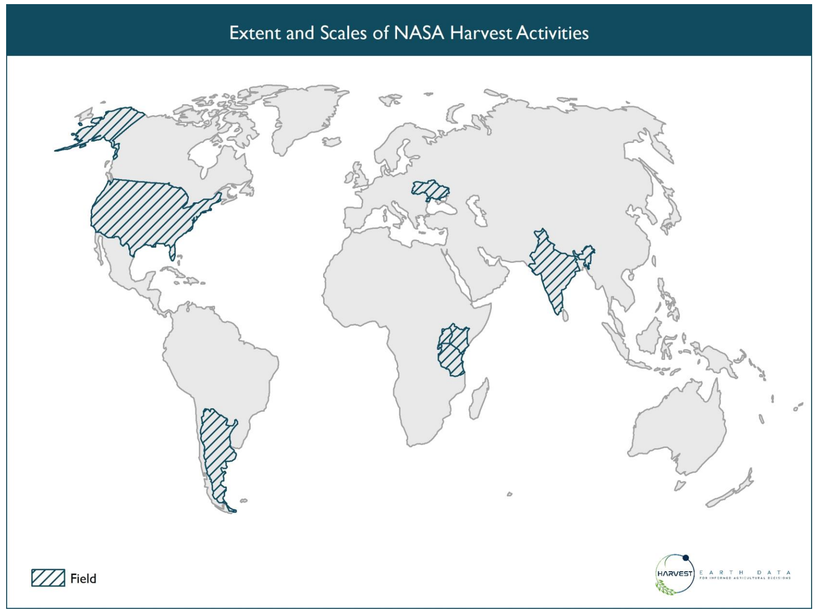
# NASA Harvest

NASA's Food Security & Agriculture Program
Advancing awareness, use, and operational uptake
of satellite-based Earth observations
to guide decisions that support food security, stable markets,
economic progress, and sustainable, resilient crop production.
NASA's Contribution to GEOGLAM

# Harvest Partners & Affiliates

**We reach our goals through strong partnerships and leveraging cross-cutting activities.**


# HARVEST PORTFOLIO



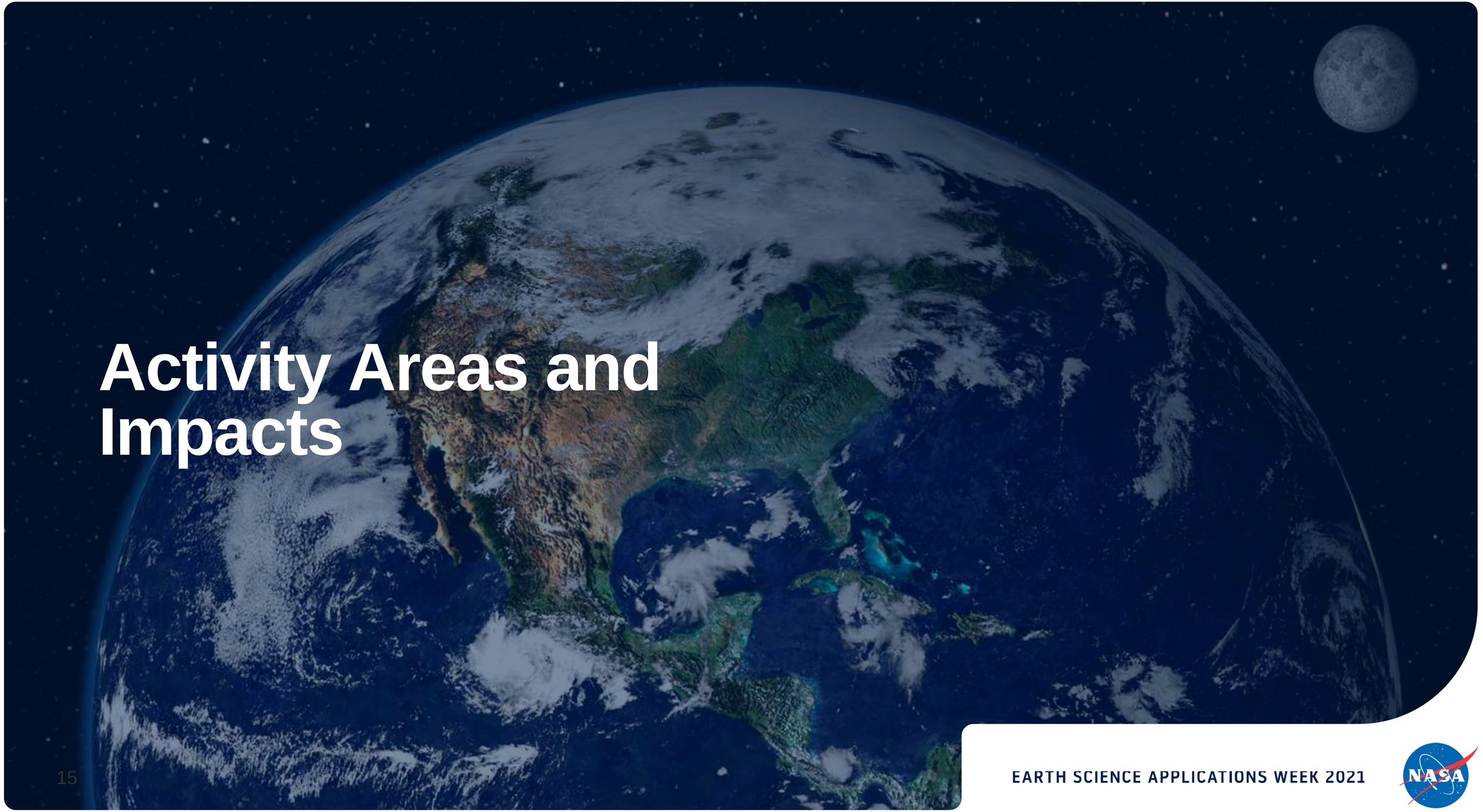

*Visit [nasaharvest.org/projects](nasaharvest.org/projects) for a list of our projects.*

**Funded Projects:**

- Productivity, Land Use & Practices, Sustainability, Information Systems
- Implemented with range of stakeholders across the agricultural sector
- Bridge between research & operations

**Initiatives:**

- U.S. Domestic Agriculture
- Harvest Africa
- Public-Private Partnerships
- Markets and Trade
- Rapid Action for Policy Support (COVID)
- Early Warning to Early Action
- Data Systems & Integration
- Sustainable and Regenerative Agriculture



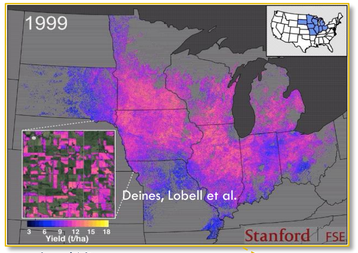
# Activity Areas and Impacts

# DOMESTIC AGRICULTURE

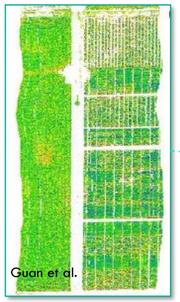
Six Focus Areas

- Sustainable land management impacts
- Scoping Emerging Tech for USDA
- Within-season yield + area (+ drivers & gaps)
- Food supply & trade tracking support
- Supporting private sector innovation
- Irrigation and fertilizer management

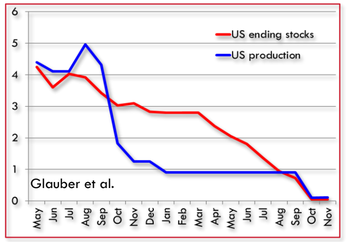
Annual maize Yield Maps (1999-2018)



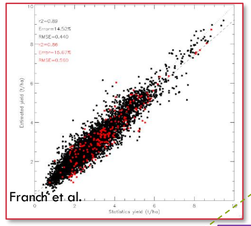

Canopy-Level Nitrogen



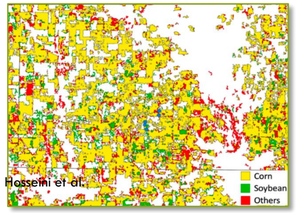

Using satellites to decrease production uncertainty



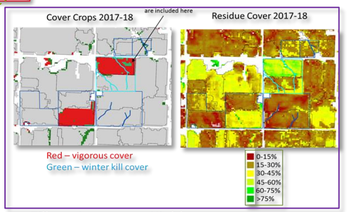

County-level Yield Forecasting



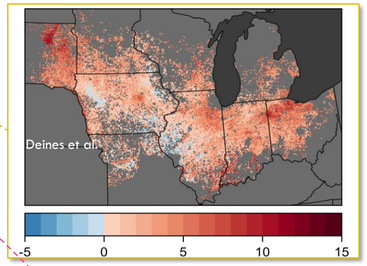

2020 Derecho Impacts

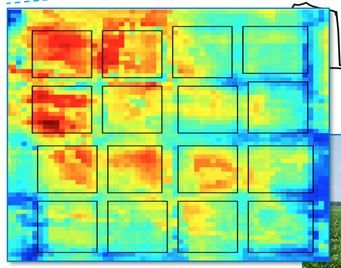



Cover Crops/Residue Cover

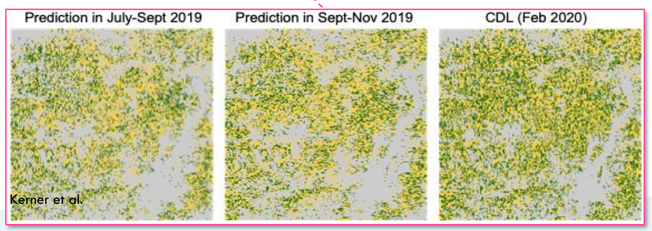



Tillage Impacts on Yield



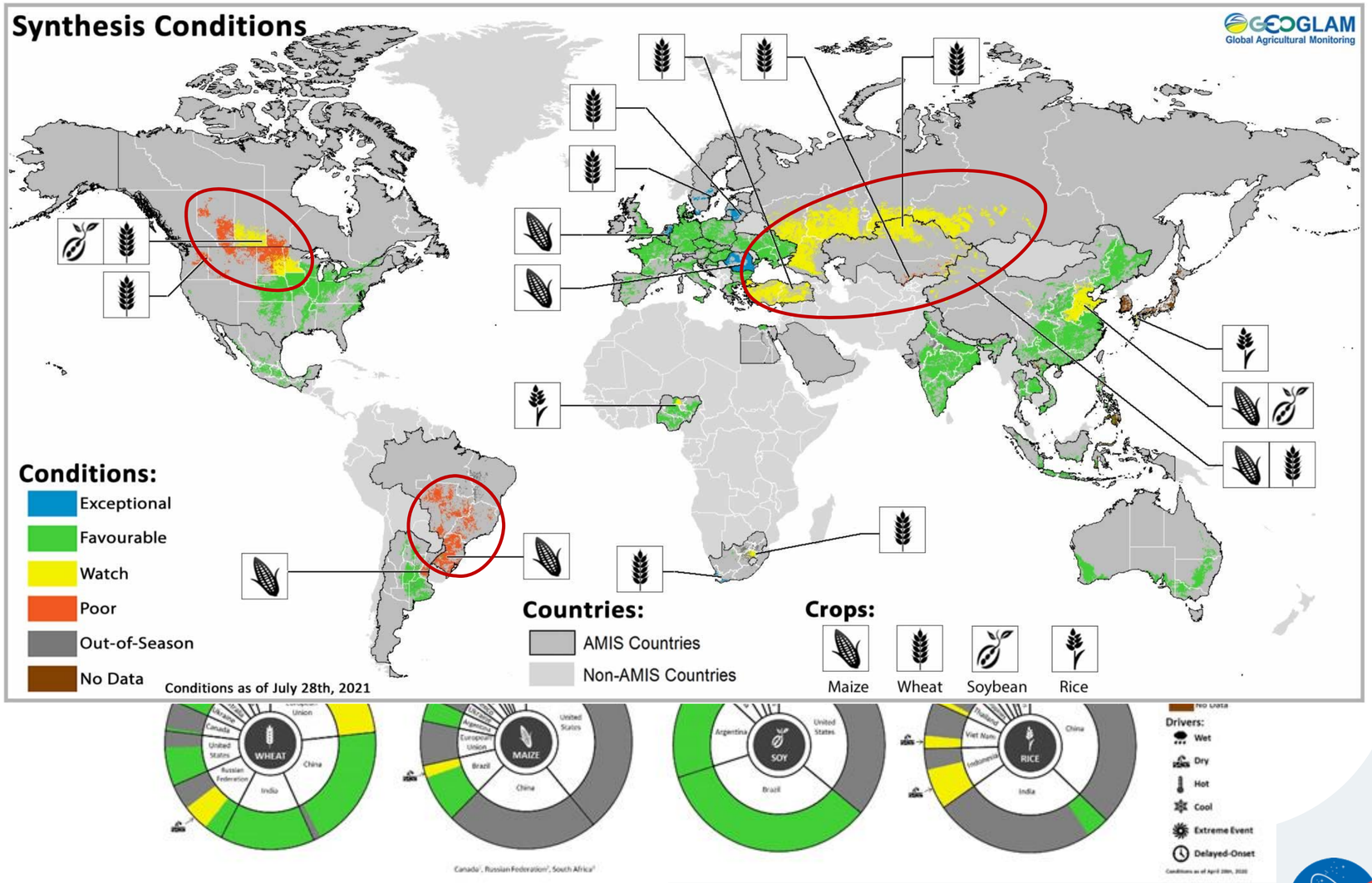
Helping farmers in mid-South improve water resource management


Predicting crops planted 6+ months before official stats

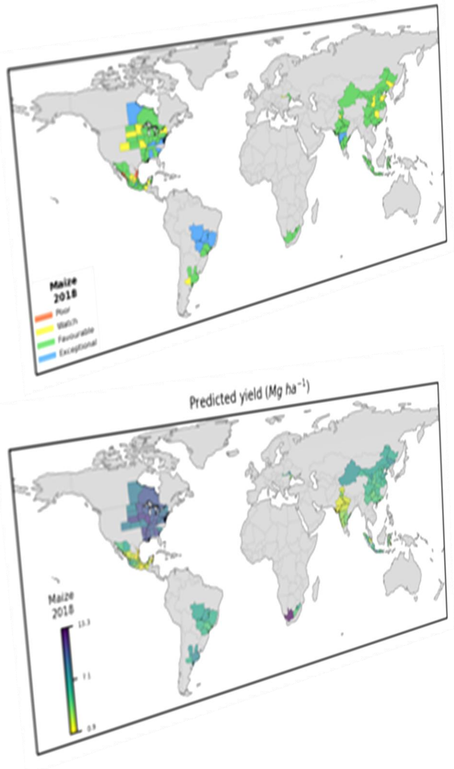
# MARKETS AND TRADE


- Response to G20 AMIS Request
  - 40 contributing partner organizations
  - First time the international community comes together to produce operational crop assessments
  - > 80 bulletins published to date



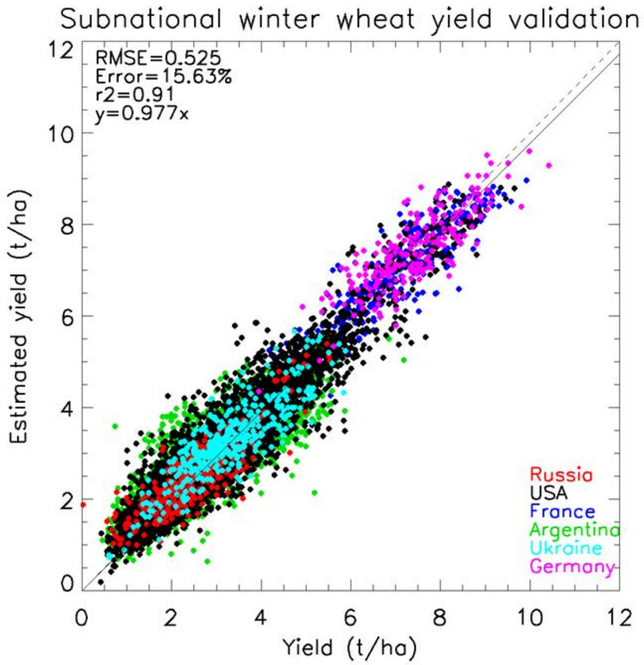
# Yield Forecast/Assessment:
# Global to National to Sub-national to Field scales

## Global Scale
Forecasts within 3-5% error, 2 months prior to harvest



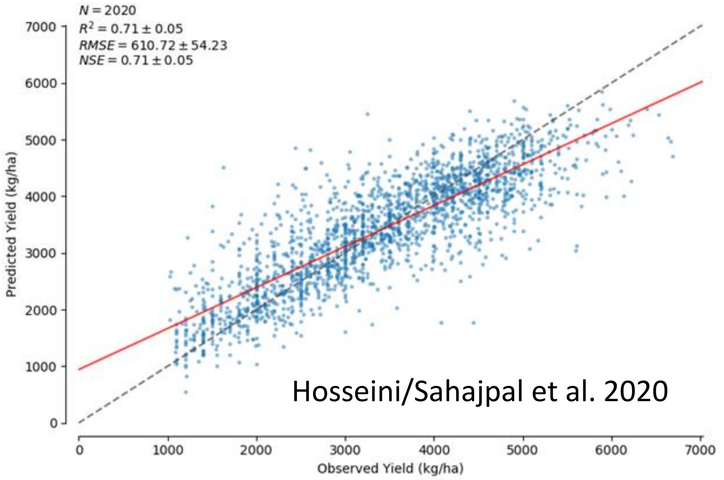

Sahajpal et al. 2020

## Sub-National Scale
8-14% error 1.5-2 months prior to harvest

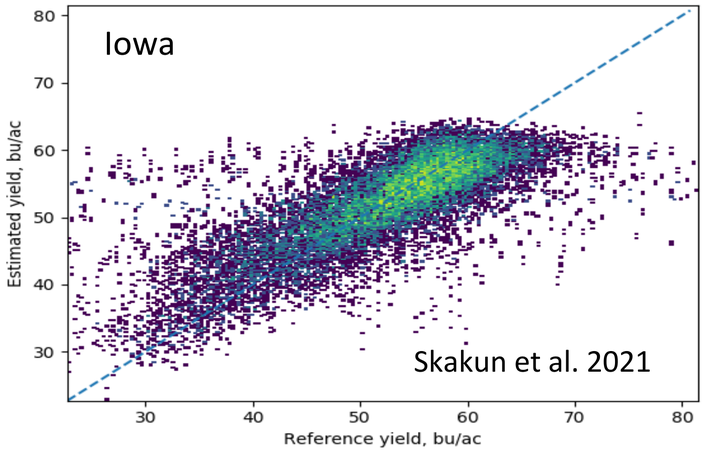



Franch et al, 2015, 2017

## Argentina/ Iowa

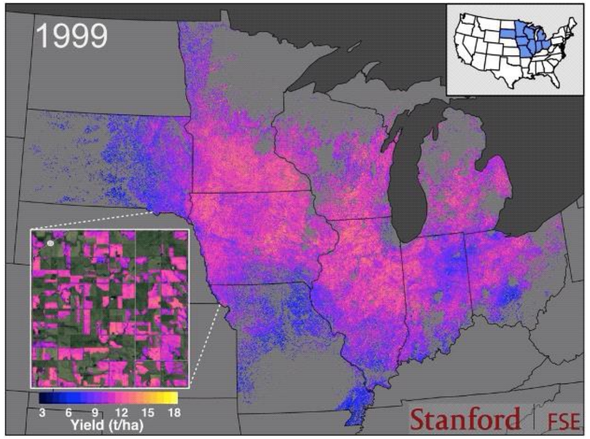



Hosseini/Sahajpal et al. 2020




Skakun et al. 2021

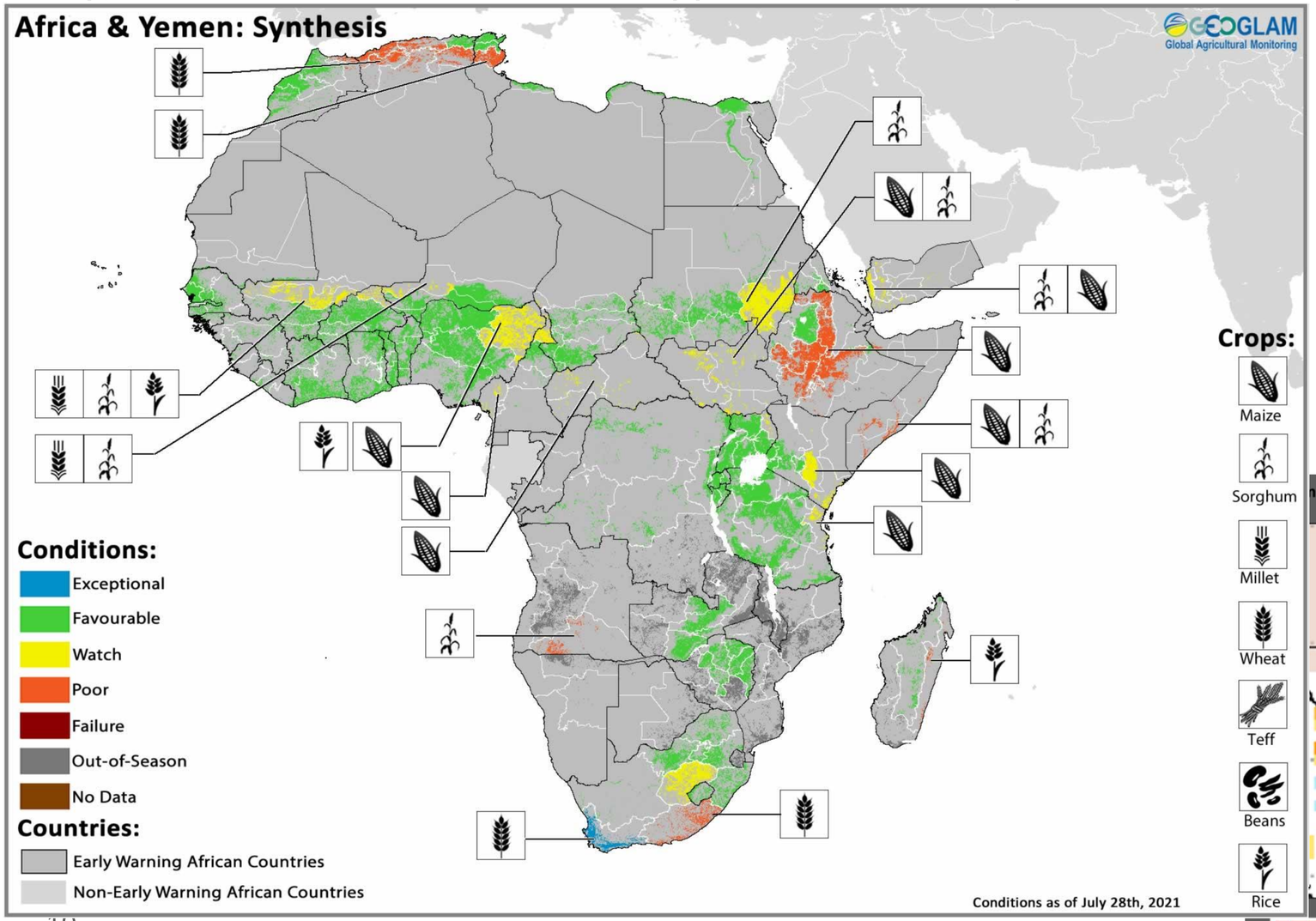
## Field Scale
US Cornbelt

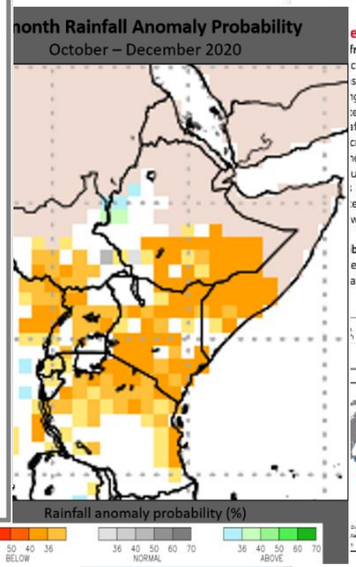


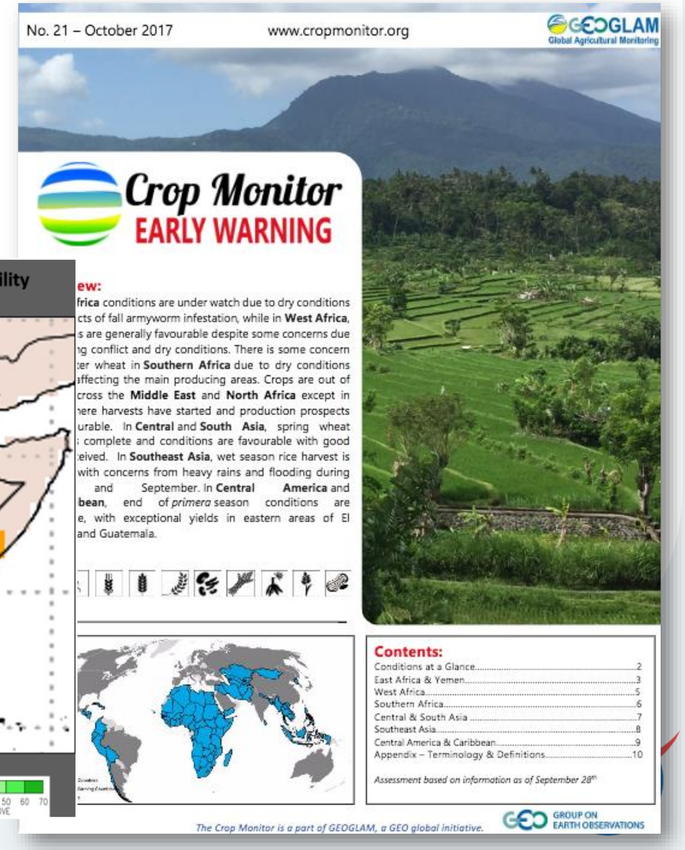

J. Deines et al. 2020

# EARLY WARNING FOR EARLY ACTION

Timely, consensus driven information in support of food security decisions






LEAD: C. JUSTICE

# Rapid Reporting in Developing Areas of Concern

Special Report: Southern Africa Below Average Rainfall forecast for Main Season Cereals, Nov 2019

SPECIAL REPORT www.cropmonitor.org GEOGLAM Global Agricultural Monitoring

**Below-average December to February rainfall is forecast for Southern Africa's main season cereals**

**Updated November 18, 2019**

**Highlights**

- Planting of the 2019/20 main season cereal crop started in mid-October in Southern Africa and rainfall from October through mid-November has been below-average across a number of areas (Figure 1).
- Seasonal rainfall normally spans from October to March across the region with December to February (DJF) rainfall being key for crop establishment and development.
- The latest seasonal forecast models indicate below-normal December to February (DJF) rainfall across the southern half of the region, spanning from southern Zambia to Namibia and south through South Africa (Figure 2).
- Persistent drier than normal conditions during this DJF period may affect crop establishment and suppress crop yields.
- This follows already dry conditions and low reservoir levels, carried over from the previous poor 2018/19 main season.
- Areas forecast to receive below-average rainfall include those areas impacted by the 2018/19 drought. Food security and access will be of increasing concern if forecast below-average rains materialize.

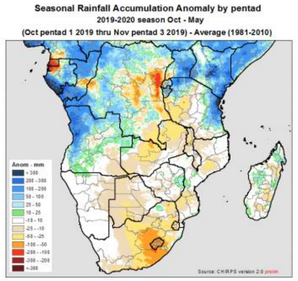


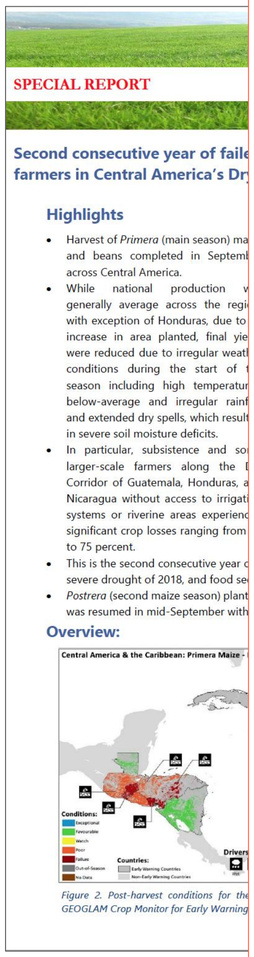

*Figure 1. Seasonal rainfall accumulation anomaly from October 1 through November 15 compared to the long-term average from 1981-2010. Source: USGS/ EROS*

**Overview**

In Southern Africa, planting of the 2019/20 main season cereals started in mid-October and November. Carryover dry conditions from the previous poor 2018/19 main season have caused concern across the region, reflecting the already low reservoir levels, soil moisture deficits, and ongoing food insecurity. From the start of the season through early November, a number of areas received below-average rainfall (Figure 1). The November 14 weather forecast from the NOAA Climate Prediction Center (CPC) predicts many of those areas could see mixed rainfall conditions during the remainder of November. Drier than normal conditions are forecast in central and southern South Africa, which constitute some of the key cereal-producing provinces of the country. The latest NOAA CPC GEFS forecasts can be viewed here, and the 5-day, 10-day, and 15-day forecast amounts relative to CHIRPS data can be viewed here.

Seasonal rainfall across Southern Africa normally spans from October to March, with key rainfall occurring during the December and February DJF period, during which the bulk of the rains are received. However, recent forecast models indicate DJF rainfall will likely be below-average across much of the region during the 2019/20 main cropping season. The latest forecast from the North American Multi-Model Ensemble (NMME) predicts below-normal DJF rainfall for the southern half of the region, spanning coast to coast from Namibia to Mozambique, and southwards from Zambia through South Africa (Figure 2). This area includes those locations impacted by the severe 2018/19 drought and many areas that have experienced recurring droughts in the last 5 years.

Special Report: Central America: Second Consecutive Year of Failed Yields in Dry Corridor, October 2019



SPECIAL REPORT

**Second consecutive year of faile farmers in Central America's Dr**

**Highlights**

- Harvest of *Primera* (main season) ma and beans completed in Septemb across Central America.
- While national production v generally average across the regi with exception of Honduras, due to increase in area planted, final yie were reduced due to irregular weat conditions during the start of season including high temperatur below-average and irregular rainf and extended dry spells, which result in severe soil moisture deficits.
- In particular, subsistence and so larger-scale farmers along the Corridor of Guatemala, Honduras, a Nicaragua without access to irrigati systems or riverine areas experienc significant crop losses ranging from to 75 percent.
- This is the second consecutive year c severe drought of 2018, and food se
- *Postrera* (second maize season) plant was resumed in mid-September with

**Overview:**



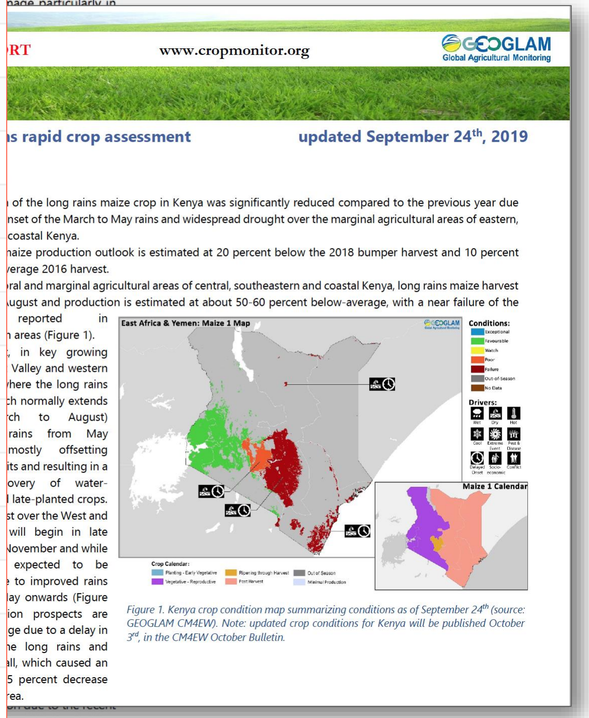

*Figure 2. Post-harvest conditions for the GEOGLAM Crop Monitor for Early Warning*

Special Report: Flooding in Iraq and Iran, April, 2019

GEOGLAM Global Agricultural Monitoring

**ed April 17, 2019**

**pecial Report: Kenya Long Rains**



RT www.cropmonitor.org GEOGLAM Global Agricultural Monitoring

**s rapid crop assessment** **updated September 24th, 2019**

of the long rains maize crop in Kenya was significantly reduced compared to the previous year due nset of the March to May rains and widespread drought over the marginal agricultural areas of eastern, coastal Kenya.

naize production outlook is estimated at 20 percent below the 2018 bumper harvest and 10 percent verage 2016 harvest.

ral and marginal agricultural areas of central, southeastern and coastal Kenya, long rains maize harvest ugust and production is estimated at about 50-60 percent below-average, with a near failure of the reported in areas (Figure 1).

, in key growing Valley and western here the long rains ch normally extends ch to August) rains from May mostly offsetting its and resulting in a overy of water- late-planted crops. st over the West and will begin in late November and while expected to be to improved rains ay onwards (Figure ion prospects are ge due to a delay in he long rains and all, which caused an 5 percent decrease rea.



*Figure 1. Kenya crop condition map summarizing conditions as of September 24th (source: GEOGLAM CM4EW). Note: updated crop conditions for Kenya will be published October 3rd, in the CM4EW October Bulletin.*

## REPORT ARCHIVE

AMIS | Early Warning | Special Reports | Conflict Reports | Climate Forecast

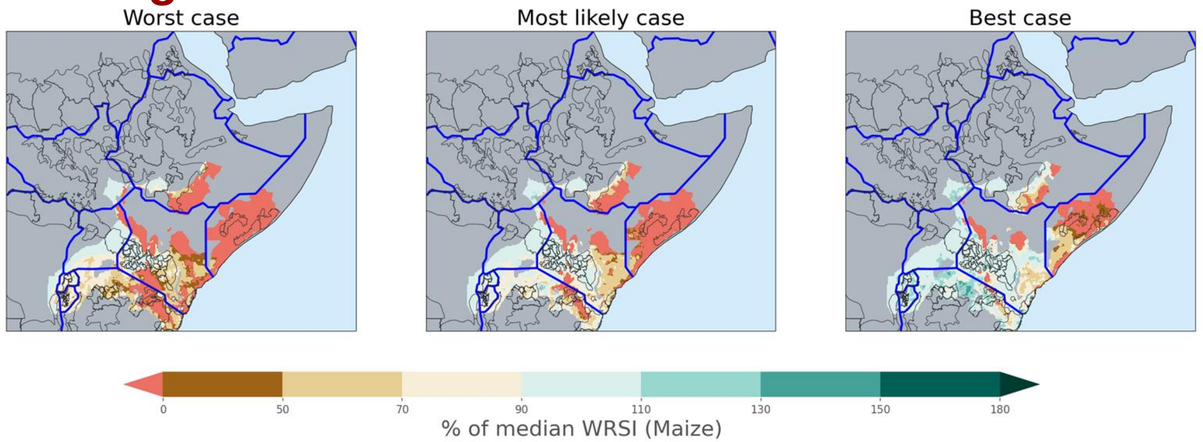
| Date | Download Link |
|---|---|
| 2021 - January | Special Report La_Nina |
| 2020 - December | Special Report Central_America |
| 2020 - September | Special Report DPRK_Flooding |
| 2020 - August | Special Report Lake_Chad_Basin |
| 2020 - May | Special Report East_Africa |
| 2020 - April | Special Report South_Sudan |
| 2020 - February | Special Report Zimbabwe |
| 2020 - January | Special Report Southern_Africa |
| 2019 - November | Special Report Southern_Africa |
| 2019 - October | Special Report Central_America |
| 2019 - September | Special Report Kenya |
| 2019 - June | Special Report East_Africa |
| 2019 - April | Special Report Southern_Africa |
| 2019 - April | Special Report Iran_Iraq |
| 2019 - April | Special Report US |

# Extended Outlook Crop Conditions

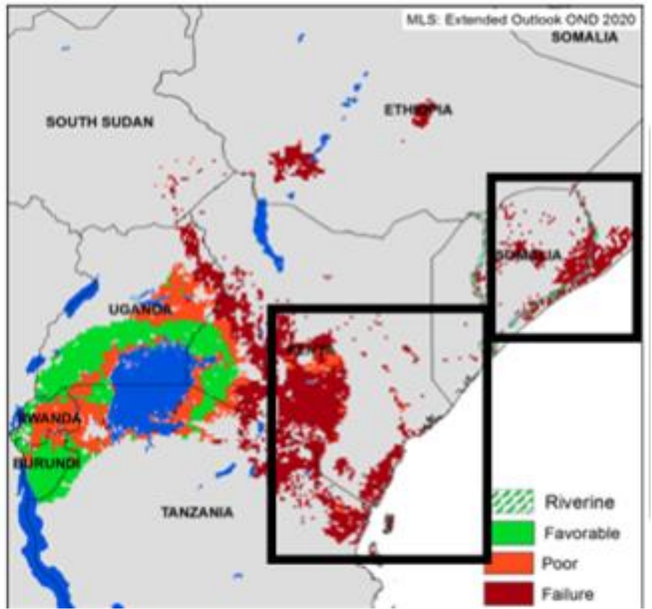
**GOAL:** Develop framework to provide crop conditions maps at extended scale (18-24 months forward) to reveal potential synchronous and/or sequential adverse/drought conditions which could lead to devastating food insecurity conditions.

**Funders:** USGS/USAID **Project period**: 2020-2023

## Agroclimatic indicators based scenarios




## Crop classification for East Africa OND 2020 season generated in June 2020




**Key points:**

New research has indicated skill in forecasting climate oscillations (e.g. ENSO) up to 18-24 months in advance.

These climate outlooks are being used in partnership with FEWSNET, UCSB CHC, NOAA and NASA to generate end of season crop condition maps prior to the start of the season and in-season, following Crop Monitors existing framework, to test the capacity of these outlooks to provide early awareness of potential synchronous shortfalls.

G. Husak, C. Justice, B. Barker et al.

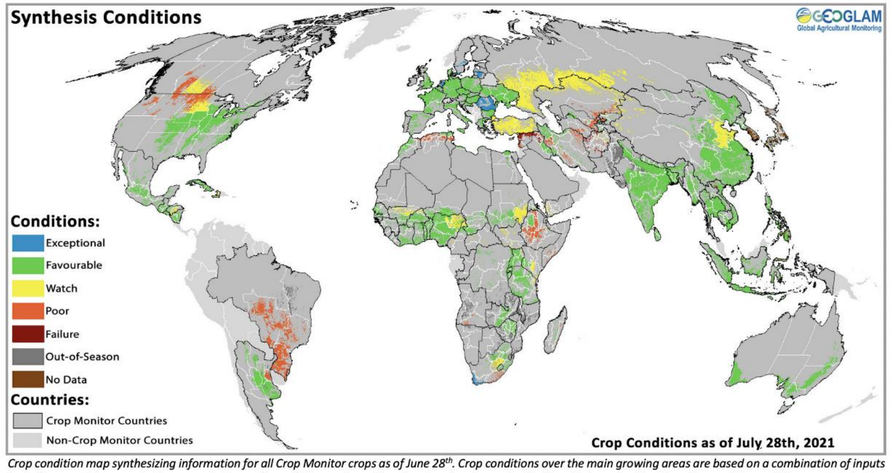
# Lead to the development of a range of Crop Monitors, national, regional and global scales


1 | No. 1 – July 2021 www.cropmonitor.org

Crop Monitor
a geoglam initiative

## GEOGLAM Global Crop Monitor

### Global Conditions at a Glance (as of July 28th)




*Crop condition map synthesizing information for all Crop Monitor crops as of June 28th. Crop conditions over the main growing areas are based on a combination of inputs including remotely sensed data, ground observations, field reports, national, and regional experts.* ***Regions that are in other than favourable conditions are labeled on the map with a symbol representing the crop(s) affected.***

| Current Conditions | | | | |
|---|---|---|---|---|
| Compared to last month | ↑ | – | – | – |
| Compared to last year | ↑ | – | ↑ | ↓ |

Legend: ↑ Improving; – Stable; ↓ Deteriorating

See Appendix I for detailed methodology description

### Global Crop Overview

Global conditions are generally mixed for wheat and favourable for maize, rice, and soybeans with a few areas of concern. For **wheat** in the northern hemisphere, harvesting of winter wheat is wrapping up while spring wheat harvesting is beginning. For **maize**, harvesting is nearing completion in the southern hemisphere and is underway in the northern hemisphere. **Rice** conditions are favourable throughout Southeast Asia, transplanting of Kharif season rice continues in India, and single and late-season rice continues to develop in China. **Soybeans** are developing under generally favourable conditions in the northern hemisphere.

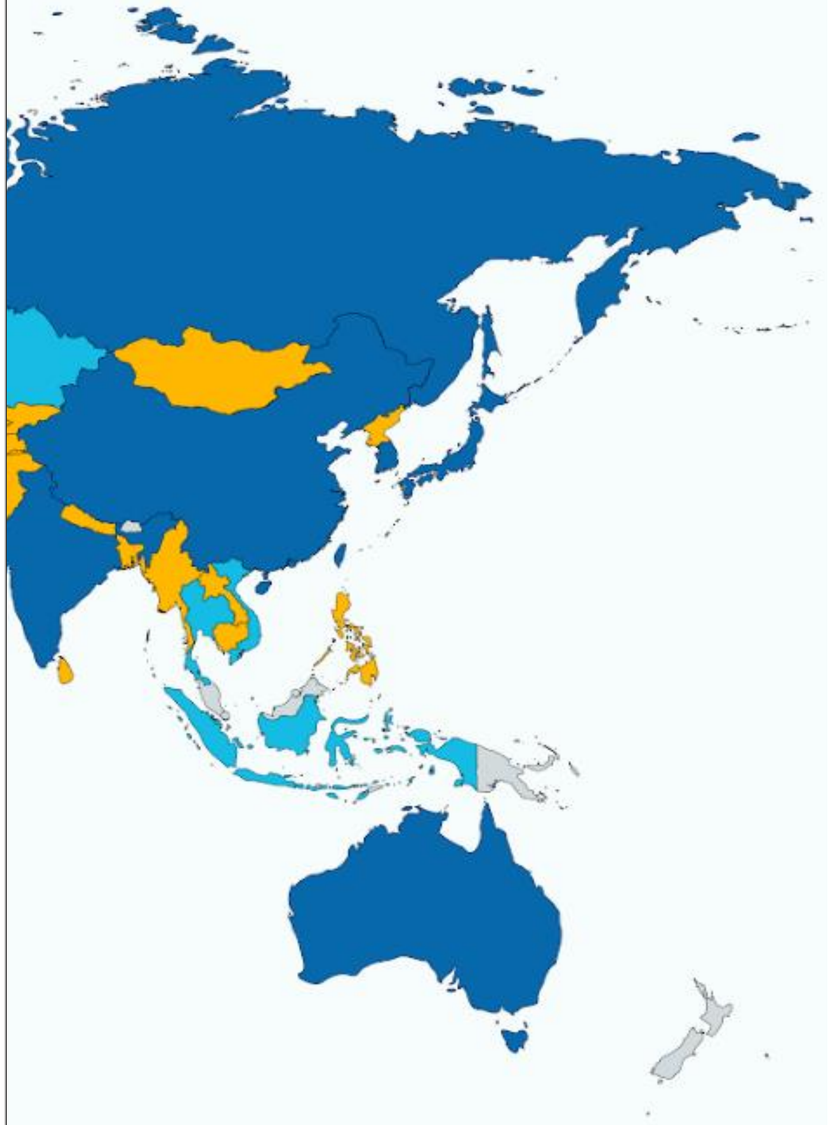
### Global Climate Influences

Neutral El Niño-Southern Oscillation (ENSO) conditions are present and are expected to continue into September. A La Niña event will potentially develop during the September-to-November season and last through early 2022 (62% chance for October to December; 66% to 54% chance for November to March). The IRI/CPC has issued a La Niña Watch.

A negative Indian Ocean Dipole (IOD) event is underway. Negative IOD conditions are expected to continue through November or December, according to the Australia Bureau of Meteorology forecast (96% to 63% chance for August to December). Negative IOD conditions typically increase the chances of above-average rainfall in parts of southern and eastern Australia during August to December and below-average rainfall in parts of East Africa and other regions from September to December.

*Source: UCSB Climate Hazards Center*





# HARVEST AFRICA

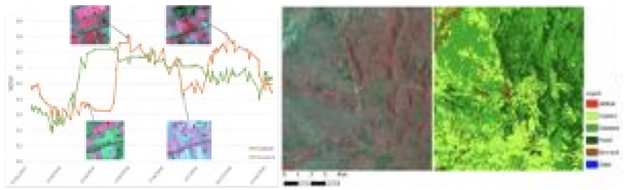
*Led by 2020 Africa Food Prize winner, Dr. Catherine Nakalembe. Efforts in the region focus on capacity building, providing training and support for bolstering an independent African food system.*

**Ongoing Work:**

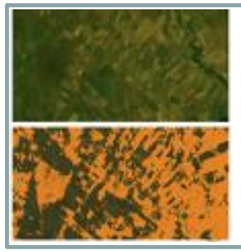
- Mali: Relief2Resilience, FTF Zones of Influence
- Kenya: joint activities with SERVIR, Swiss Re
- Crop Monitors: Crop Monitor for Early Warning, East Africa Crop Monitor (Rwanda, Uganda, Tanzania)
- Rwanda: USDA/USAID/Harvest joint field boundary delineation

**Examples:**

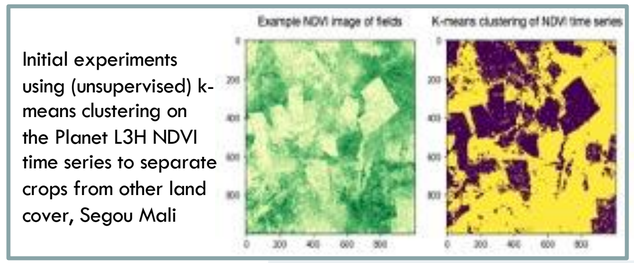
- Togo country-wide cropland map
- Cropland + GEOCIF yield model for Kenya, in-season for Busia
- First results for Karamoja, Uganda cropland
- Online training and ground data collection in Mali and Uganda



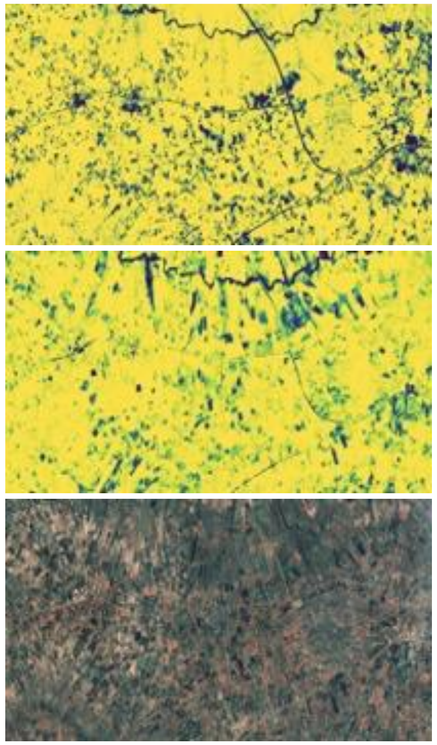
**Top Left:** NDVI profiles for a double crop and natural vegetation in the Namalu region in Uganda derived from Planet's Dove Classic
**Bottom Left:** False-color composition Planet acquired on 31 March 2018) and land cover map (***right***) for the Namalu region in Uganda



Overall did not observe major changes in planted area between 2019-2020 but varies locally. **Orange** regions detected as planted in 2019 and 2020. **Transparent** fields detected as planted in 2019 but not 2020.




Initial experiments using (unsupervised) k-means clustering on the Planet L3H NDVI time series to separate crops from other land cover, Segou Mali



**Methods for high and very high resolution mapping**
**Top:** 3m cropland map based on PlanetScope
**Middle:** 10m cropland map based on Sentinel-2
**Bottom:** Google Satellite basemap for ROI in Busia

# RAPS: RAPID ACTION FOR POLICY SUPPORT

**Cina Lawson**
*Togolese Minister of Post, Digital Economy and Technological Innovation*

"This map provides unmatched clarity into the nature and distribution of agricultural land nationwide [and helps] provide decisive knowledge being used to design social protection policies aimed at improving the livelihoods of agrarian rural communities."

## Satellite data help Togolese Government allocate aid to farmers under COVID 19 loan Program


YOLIM has supported over 57,000 small holder farmers across Togo with interest free loans!

## Covid-19: Lomé launches agricultural response plan to help farmers cope amidst the pandemic

AGRICULTURE Friday, 01 May 2020 12:01

Kerner, H. R., Tseng, G., Becker-Reshef, I., Barker, B., Munshell, B., Paliyam, M., Hosseini, M. (2020). Rapid Response Crop Maps in Data Sparse Regions. ACM SIGKDD Conference on Knowledge Discovery and Data Mining Workshops.

EARTH SCIENCE AP

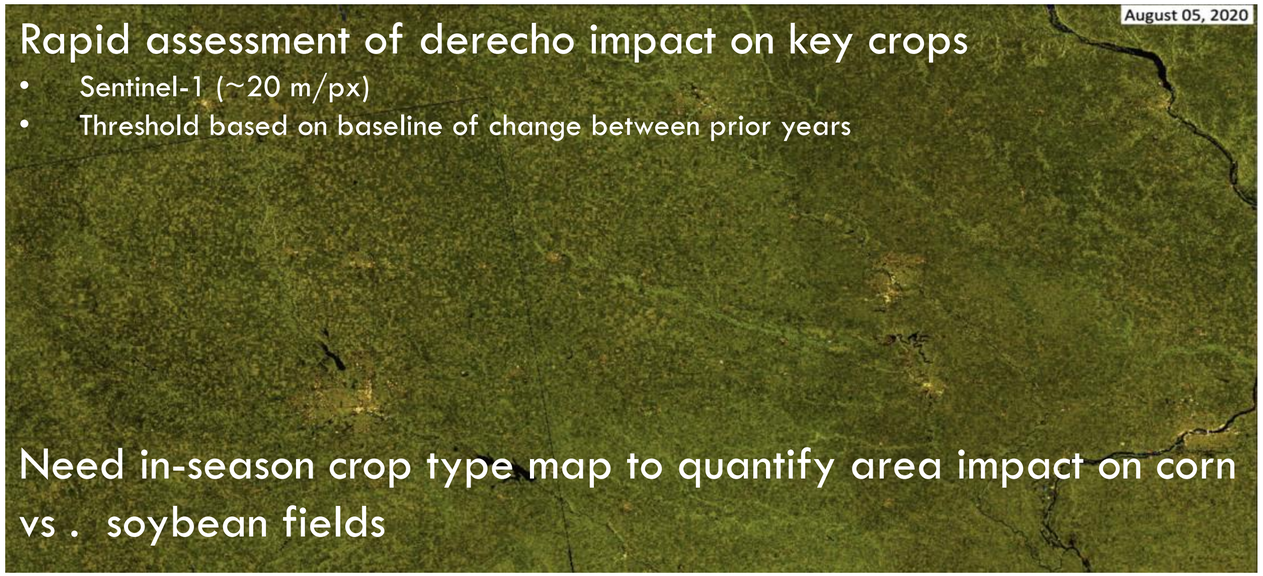
# Disasters Impact Assessment: US Derecho

U.S. example: using ML models to create predicted cropland maps in the face of uncertainty.

Derecho (strong wind storm) swept across Iowa, the largest corn/soy growing state, causing widespread damage.

**Total loss** was estimated at **$31 Million**

Loss adjustment took 4 months to manually assess the damage caused and over 100,000 'man-hours' at a cost of $2.5 Million



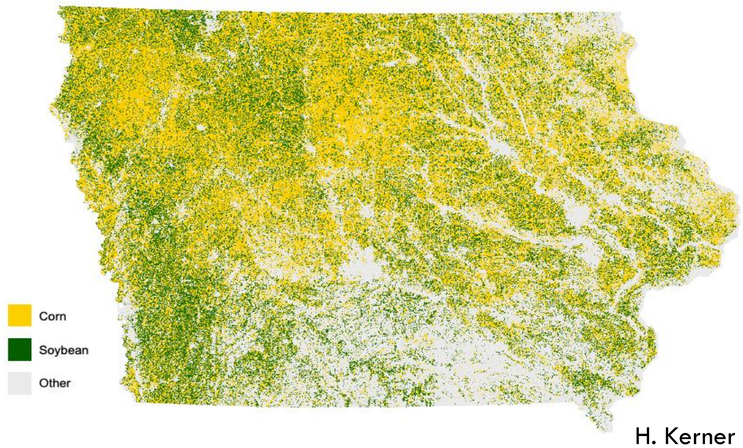

Open Access Article

**Evaluating the Impact of the 2020 Iowa Derecho on Corn and Soybean Fields Using Synthetic Aperture Radar**

by Mehdi Hosseini [1,*], Hannah R. Kerner [1], Ritvik Sahajpal [1], Estefania Puricelli [1], Yu-Hsiang Lu [1], Afolarin Fahd Lawal [1], Michael L. Humber [1], Mary Mitkish [1], Seth Meyer [2] and Inbal Becker-Reshef [1]

[1] NASA-Harvest, Department of Geographical Sciences, University of Maryland, College Park, MD 20740, USA
[2] Food and Agricultural Policy Research Institute, University of Missouri, Columbia, MO 65211, USA
* Author to whom correspondence should be addressed.

*Remote Sens.* **2020**, *12*(23), 3878; https://doi.org/10.3390/rs12233878




H. Kerner

# PUBLIC-PRIVATE PARTNERSHIPS

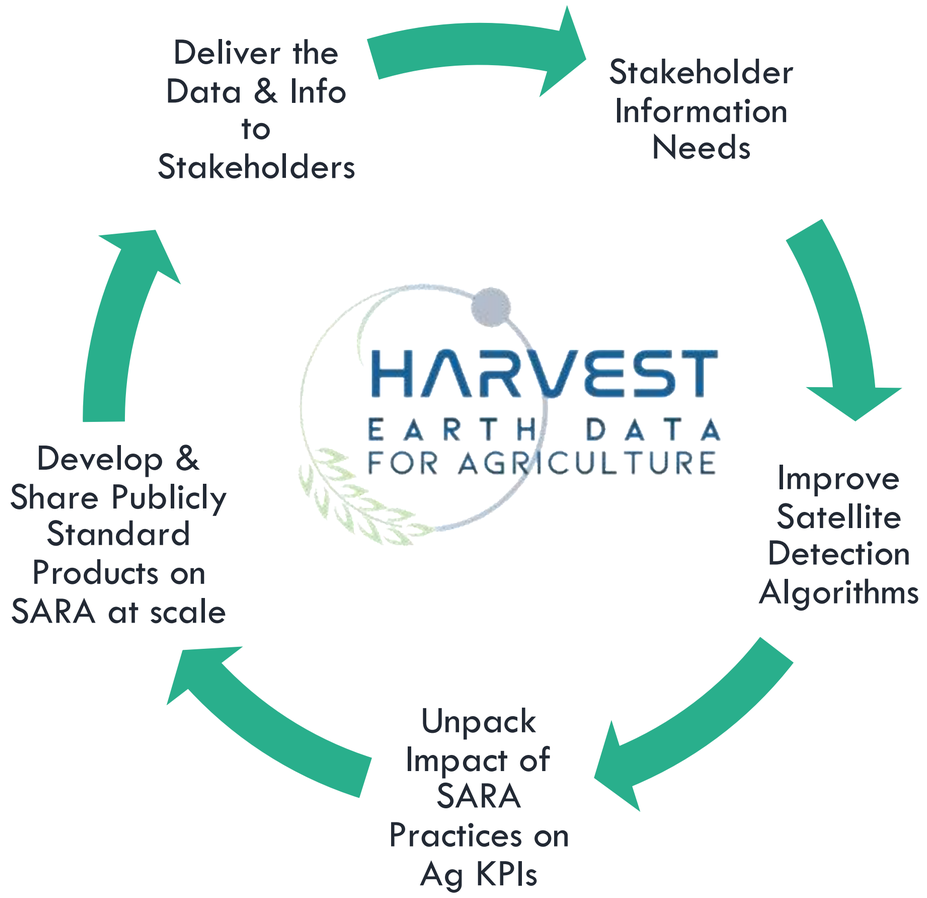

*PPP are high-priority innovation mechanisms for reaching Harvest's goals.*

**Harvest has 3 PPP objectives:**

1. Establish successful partnerships with diverse actors and engagement modalities (e.g. Swiss Re, Planet, Bolsa de Cereales, CropX, SIMA, Corteva, Regrow)
2. Convene key actors to facilitate collaboration via forthcoming pre-competition collaborative forum for agricultural industry partners
3. Document outcomes, successful business models, & best-practices as a community good

# SUSTAINABLE AND REGNERATIVE AGRICULTURE [SARA]

*SARA is a public-good, multi-stakeholder, pre-competitive forum to invest in the development of common yard sticks for sustainable and regenerative agriculture.*




**Why an initiative on SARA?**

- Climate is changing, food insecurity is growing, and soil is being degraded.
- Farmers need incentives & guidance to cultivate natural capital.
- Policy & agribusiness alike require quantitative metrics at scale.

**What does SARA do?**

- Work with agricultural stakeholders to identify key knowledge priorities.
- Convene top scientists to answer critical questions about agricultural land use (ie. Which practices work where?)
- Develop map products of agricultural land use practices and outcomes.

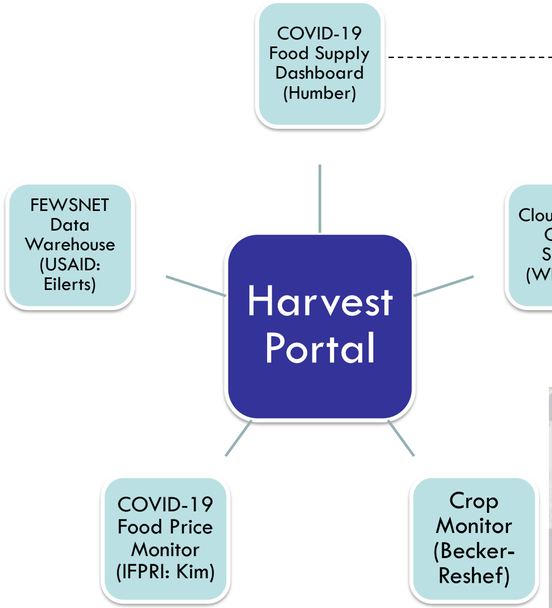


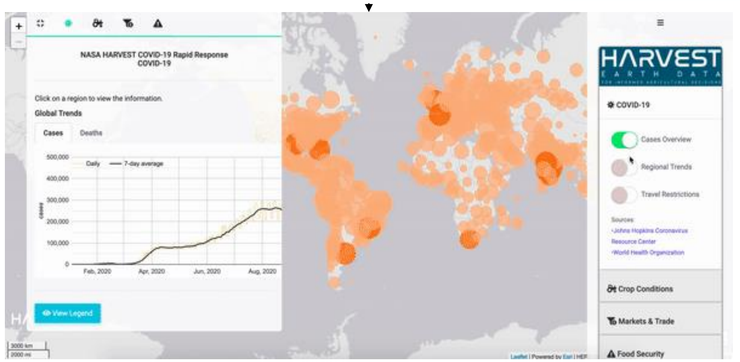
A. Whitcraft

# DATA SYSTEMS SUPPORT & INTEGRATION

## NASA Harvest Portal

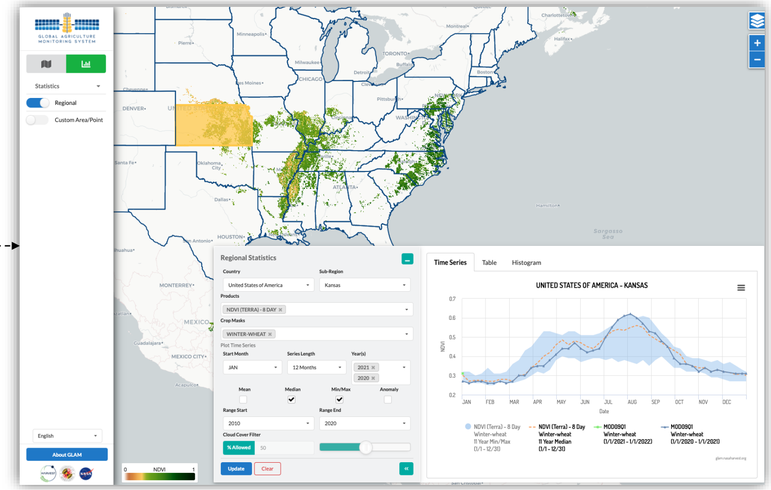
*Vision: NASA Harvest Portal will be the authoritative and complete source of intercomparable transdisciplinary food security and agriculture information.*




harvestportal.org/dashboard

## GLAM 2.0




The GLAM system – operational since 2015 – has been updated to incorporate more datasets on a serverless “cloud” architecture.

Faster and developed in close contact with users, GLAM 2.0 is nearing operational deployment.

# THANK YOU.
# QUESTIONS?

## CONTACT US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Chris Justice, Chief Scientist, cjustice@umd.edu
Alyssa Whitcraft, Deputy Director, alyssakw@umd.edu
Mary Mitkish, Assistant Manager, mmitkish@umd.edu


WWW.NASAHARVEST.ORG
@HARVESTPROGRAM

EARTH SCIENCE
APPLIED SCIENCES

# SAR for Derecho Damage Assessment in Iowa

Mehdi Hosseini, Hannah R. Kerner, Ritvik Sahajpal, Estefania Puricelli, Yu-Hsiang Lu, Afolarin Fahd Lawal, Michael Humber, Mary Mitkish, Seth Meyer, Inbal Becker-Reshef

EARTH SCIENCE APPLICATIONS WEEK 2021

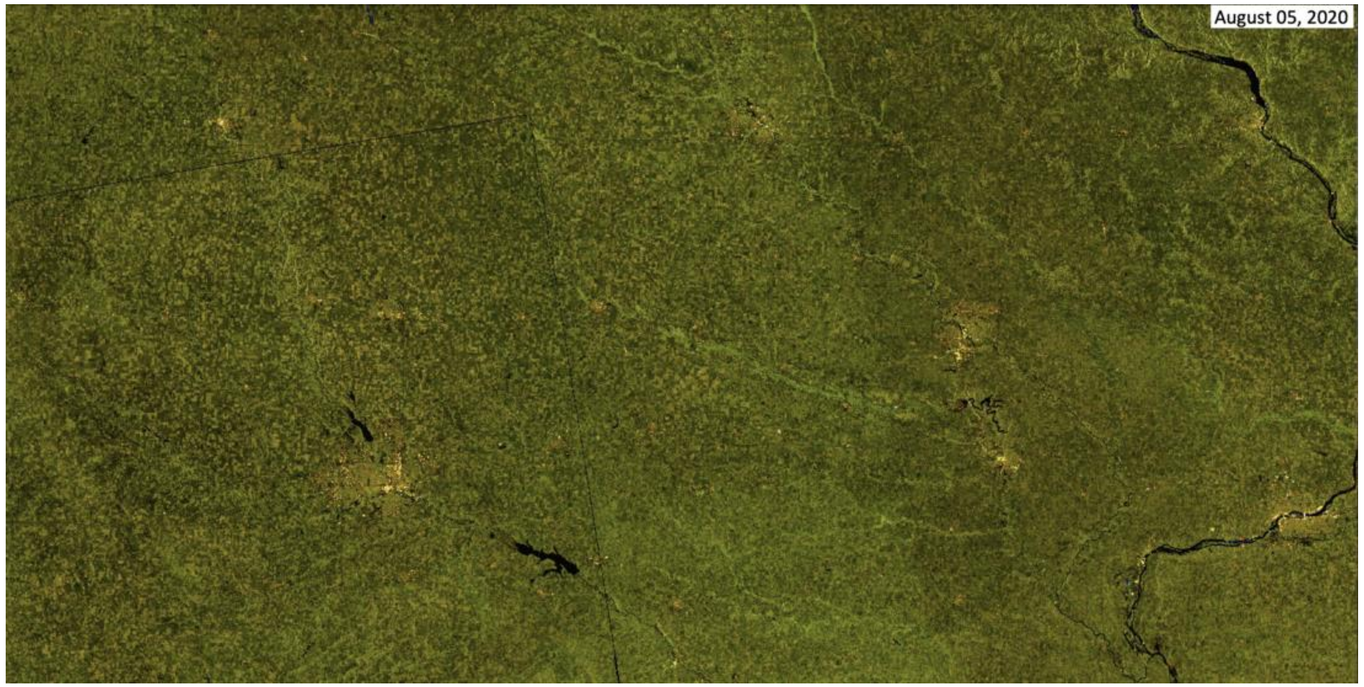
# Derecho over Iowa

Photo credit: Lance Lillibridge (Iowa farmer).

- Happened on August 10, 2020
- 770-mile stretch from Nebraska to Indiana.
- There was the hardest hit in Iowa whose winds reached 110-140 mph.
- Iowa is the biggest producer of corn and the second-largest producer of soybeans in the United States.
- About one-sixth of the total corn production and one-seventh of soybean production nationwide (USDA-NASS).

# NASA-Harvest Approach

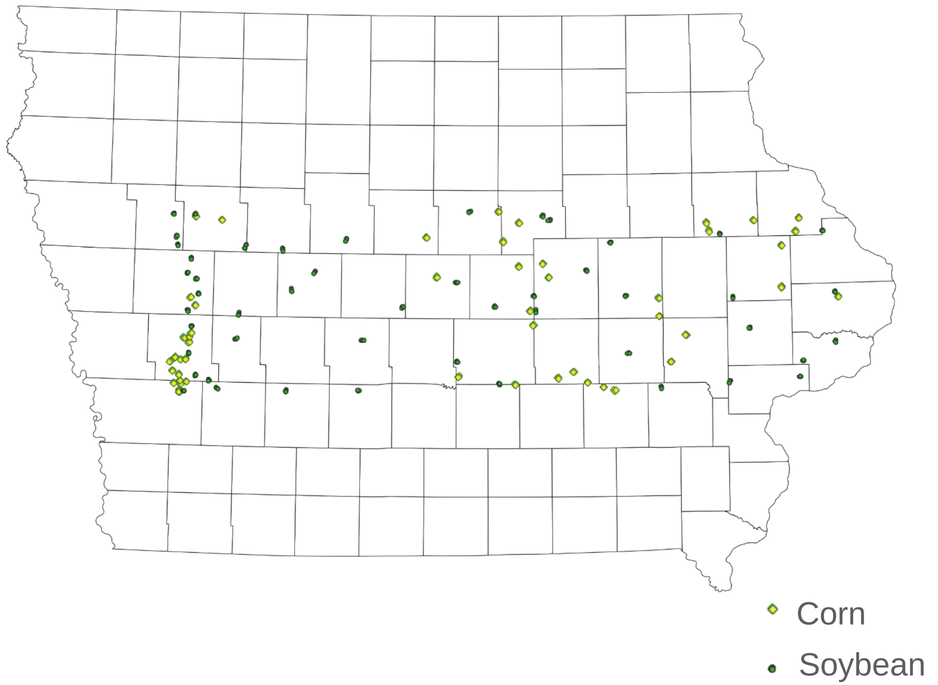
- We used Sentinel-1:
  - SAR is operational during cloudy weather.
  - SAR is sensitive to the geometry of the crop.




Sentinel-1 - Enhanced VH Band

# Methodology

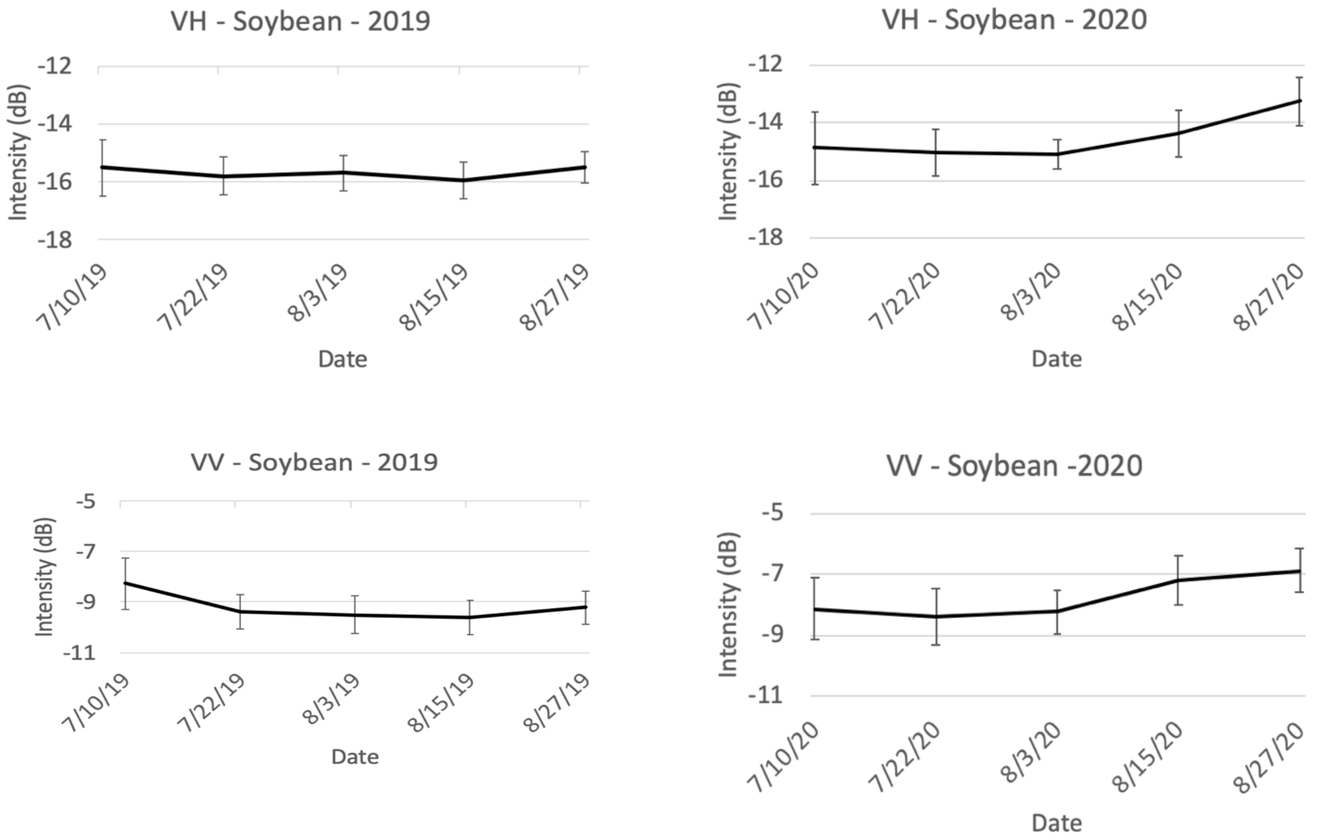
- Time-series of Sentinel-1 images from 10 July to 27 August for both 2019 and 2020.
- We randomly selected 50 corn fields and 50 soybean fields over the affected region, then selected 3 sites in different parts of each field (resulting in 150 corn and 150 soybean sites total).
- The 50 corn fields and the 50 soybean fields were distributed from East-Iowa to the West-Iowa to have good spatial distributions.
- We extracted the VV and VH intensities at each site using an average 5 by 5 window.
- We used the in-season 2020 crop type map that was generated in this study and the 2019 Cropland Data Layer (CDL) produced by the USDA [19] to identify locations of corn and soybean fields.



# Sensitivity Analysis of VV & VH for Soybeans

- Given the higher sensitivity of VH polarization to crop structure variations, this polarization was used for the change detection operation.

- The VH intensity changes more than 1.5 dB within a 12-day time-frame was selected for detecting the storm impacts on crops.

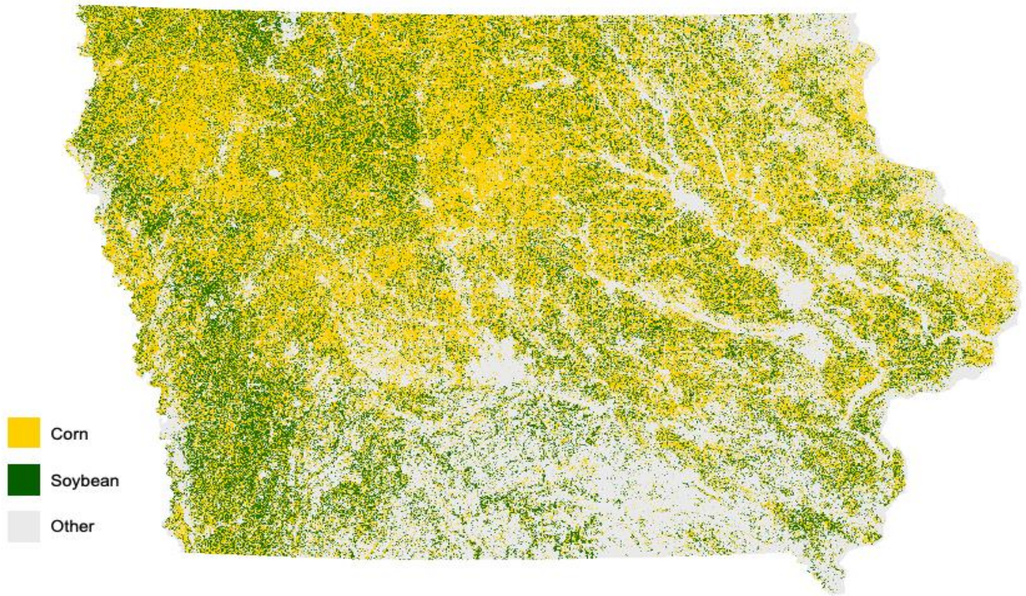



Time-series of mean intensities for 150 soybeans sites for 2019 and 2020.

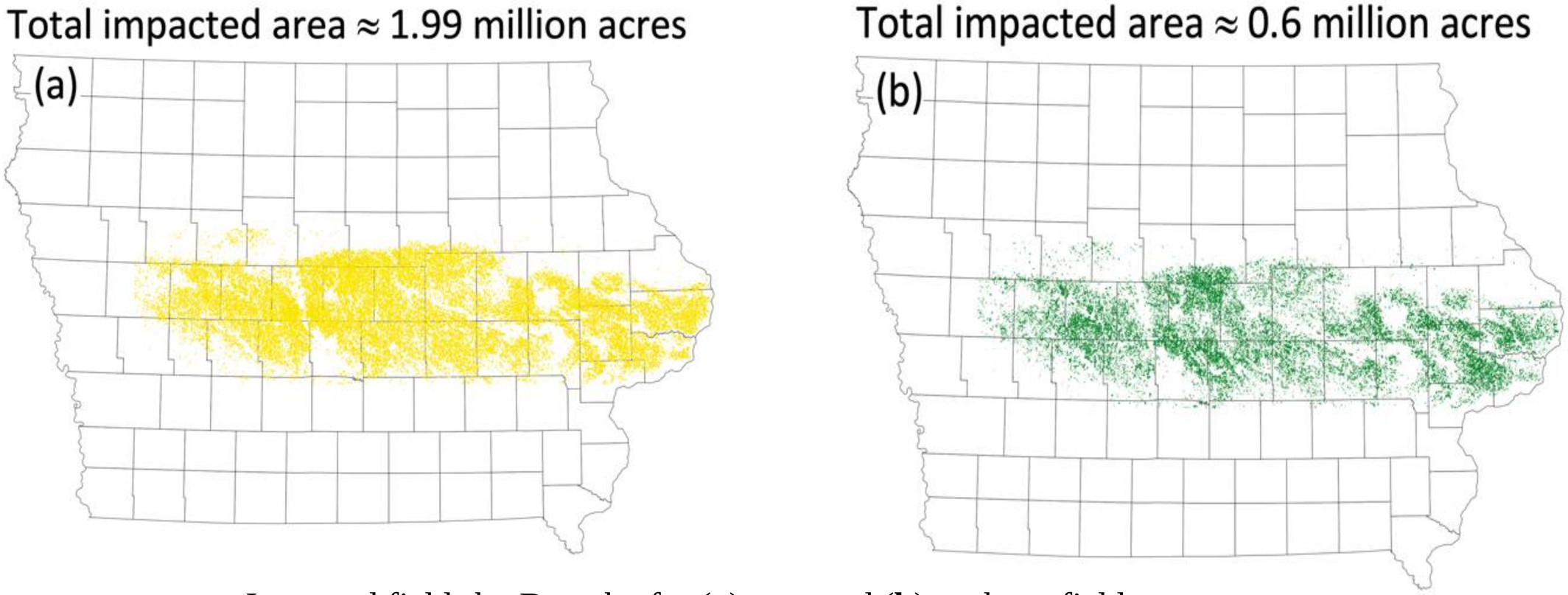
Hosseini M., Kerner H., Sahajpal R., Estefania I. P., Lu Y.H., Lawal A., Humber M., Mitkish M., Meyer S., Becker-Reshef I., 2020, Evaluating the Impact of the 2020 Iowa Derecho on Corn and Soybean Fields Using Synthetic Aperture Radar, Remote Sensing, 12, 3878.

# In-season Crop Map

- HLS data available between January and August 2020 were used for the in-season crop type classification method.
- Ten of the 14 ground reference points were correctly classified as corn.
- we compared the pixel-wise classifications to the 2018 CDL.
  - ~26% of pixels classified as “other” in our in-season 2020 map should have been classified as either corn or soybeans.



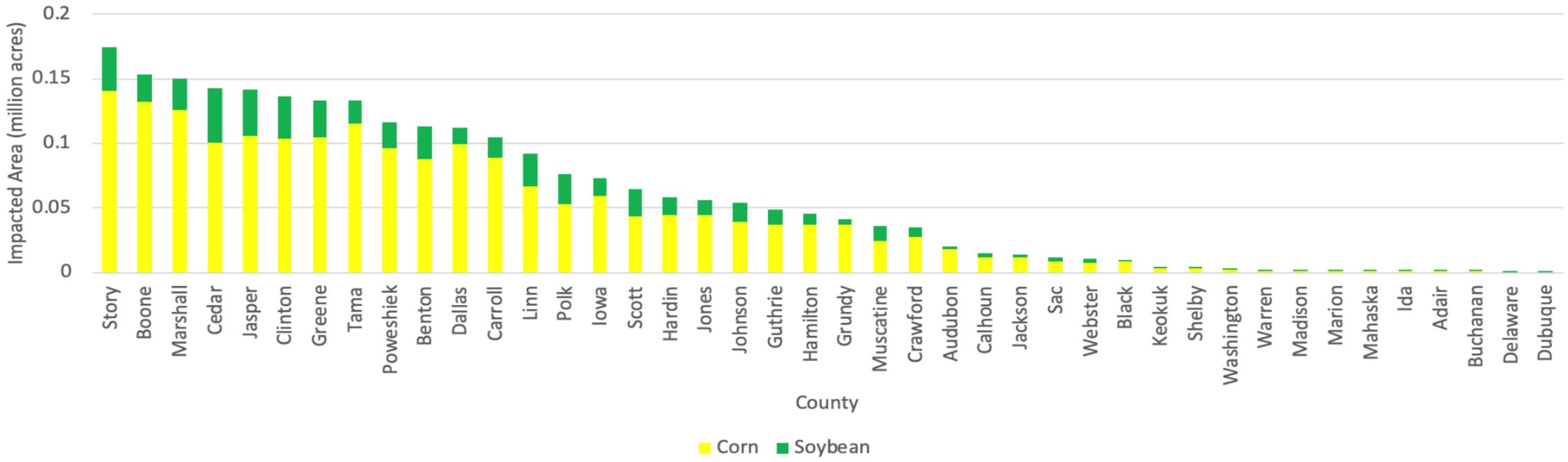
# Impacted Area




Impacted fields by Derecho for (**a**) corn and (**b**) soybean fields.

Hosseini M., Kerner H., Sahajpal R., Estefania I. P., Lu Y.H., Lawal A., Humber M., Mitkish M., Meyer S., Becker-Reshef I., 2020, Evaluating the Impact of the 2020 Iowa Derecho on Corn and Soybean Fields Using Synthetic Aperture Radar, Remote Sensing, 12, 3878.

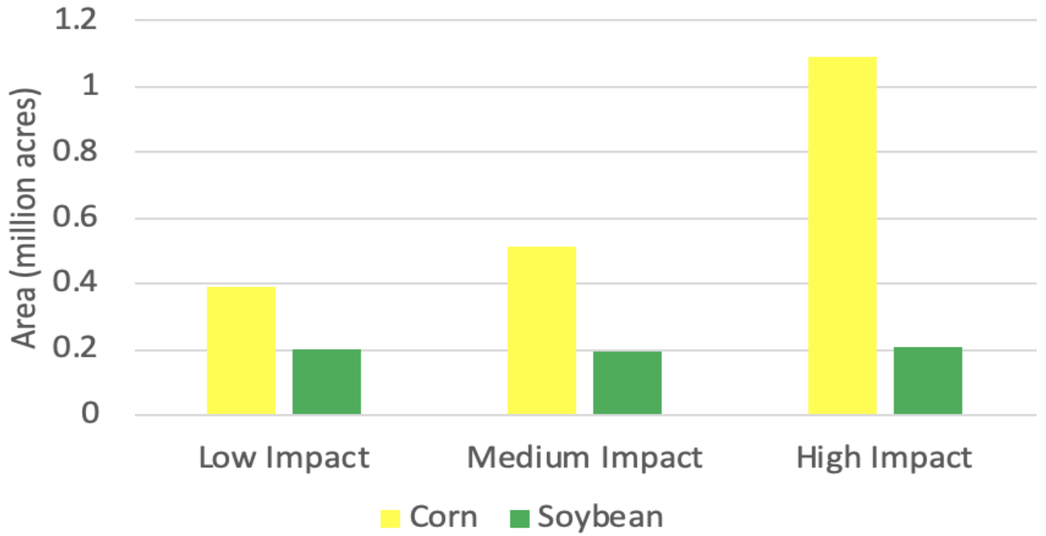
# Estimates at the County Level




Total impacted areas for each county.

# Damage Severity Estimates

- First class includes 0.39 million acres of corn and 0.2 million acres of soybean.
- Second class includes 0.51 million acres of corn and 0.2 million acres of soybean.
- Third class includes 1.08 million acres of corn and 0.2 million acres of soybean.




Derecho damage severity estimates.

# Yield Loss

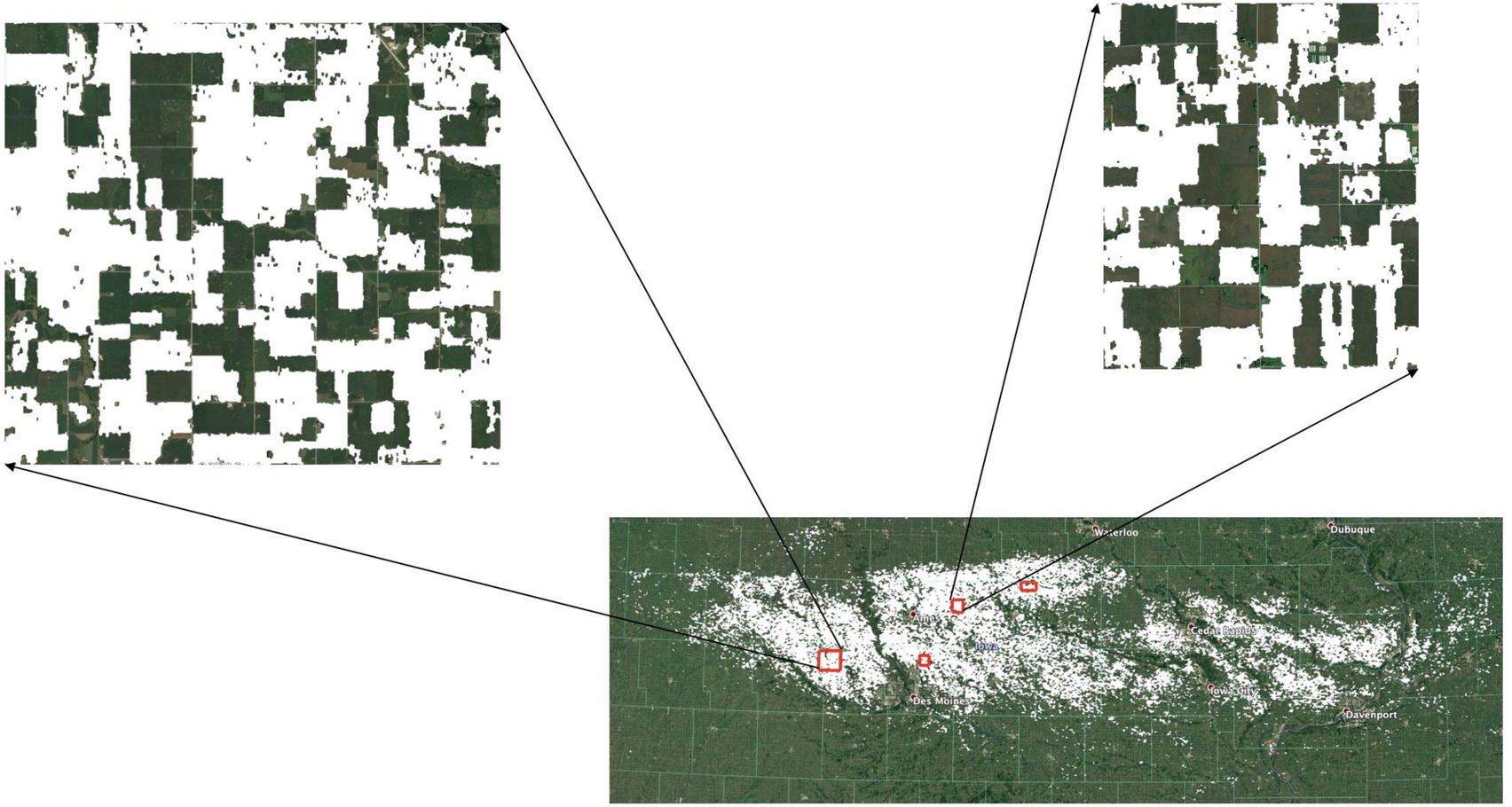
- Our estimates were two weeks after the storm.

| | NASA-Harvest Aug 2020 (million acres) | USDA Nov 2020 (million acres) | USDA Jan 2021 (million acres) |
|---|---|---|---|
| Total | 1.28 | 1.08 | 0.78 |
| Corn | 1.08 | 1 | 0.7 |
| Soybean | 0.2 | 0.08 | 0.08 |


Corn and soybean fields that are highly impacted by the storm.

# The Impacted Fields

# The Impacted Fields



# Conclusions

- We showed that when optical satellite images are unsuitable due to high cloud coverage, no signal, or saturated signal, SAR satellites can provide timely, reliable and actionable information for rapid response scenarios.

- We demonstrated the time-series analysis can be used to determine the approximate thresholds for the crop damage assessment.

- As extreme weather events become more frequent and severe due to global climate change, increased capacity for satellite monitoring of natural disasters will be critical to provide the necessary maps and analyses for rapid response actions.

EARTH SCIENCE
APPLIED SCIENCES

# NASA Harvest Africa

## Update 2020-2021

EARTH SCIENCE APPLICATIONS WEEK 2021

# Harvest Africa

HARVEST
EARTH DATA FOR INFORMED AGRICULTURAL DECISIONS



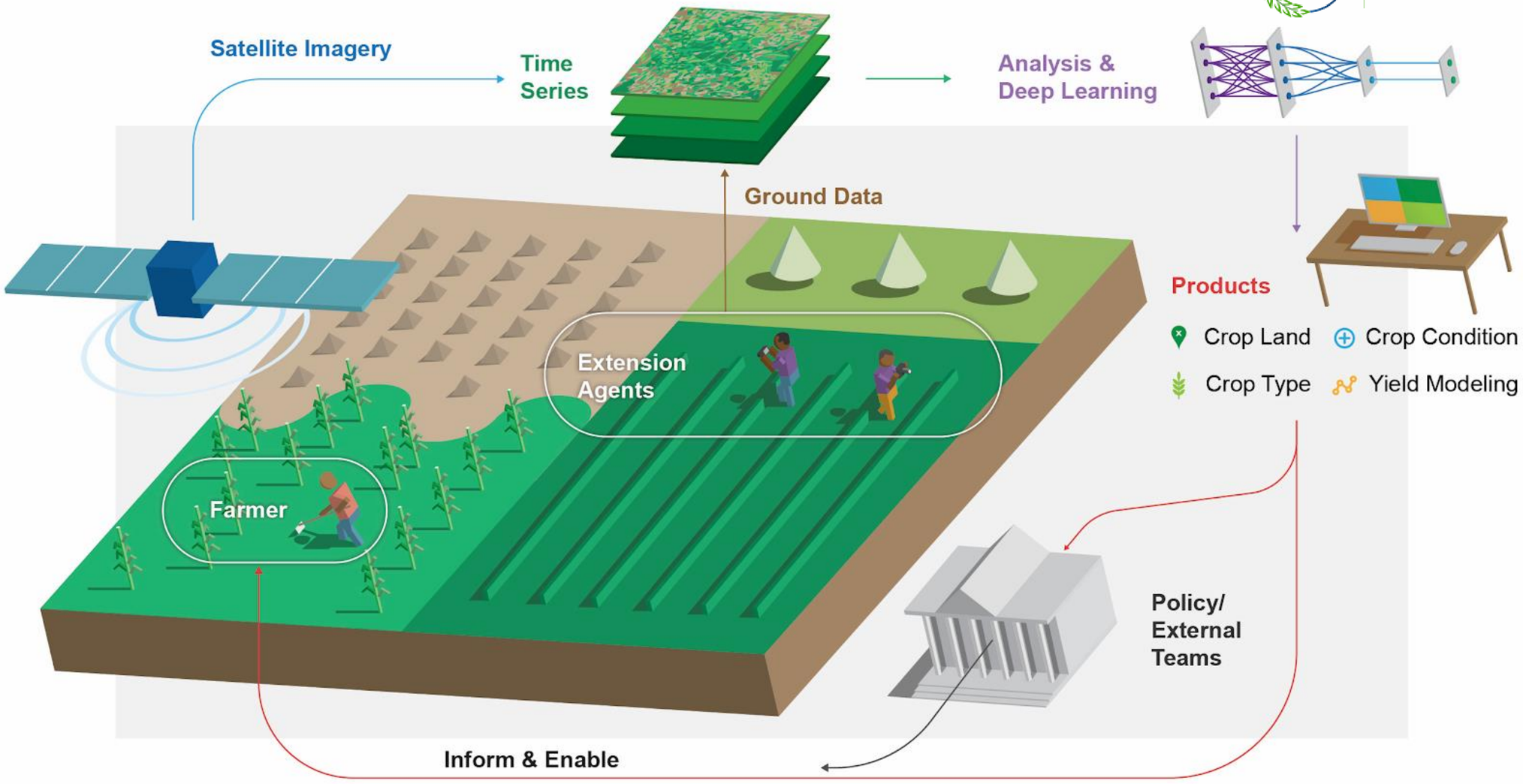
NASA

# HARVEST Africa


Innovation, collaboration and capacity building use EO and Machine Learning to improve outcomes for smallholder farmers, reduce hunger, and alleviate food insecurity in sub-Saharan Africa

- Improving monitoring and early-warning systems that provide actionable data and information about agricultural productivity and food security at multiple scales
- Advancing methods that underpin the relevant EO data and systems
- Developing and transferring capacity to national and local users in Africa who influence decision making
- Developing strong, long-term, sustainable partnerships

Nakalembe, C., Justice, C., Kerner, H., Justice, C., & Becker-Reshef, I. (2021). Sowing Seeds of Food Security in Africa. *Eos*, *102*. https://doi.org/10.1029/2021EO153329

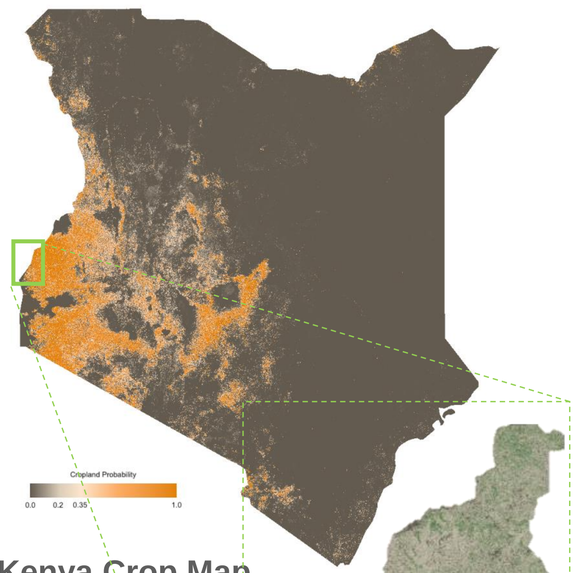

Satellite Imagery
Time Series
Analysis & Deep Learning
Ground Data
Products
Crop Land
Crop Condition
Crop Type
Yield Modeling
Extension Agents
Farmer
Policy/ External Teams
Inform & Enable

# Summary Updates:

1. Baselines (SERVIR/ SwissRe Foundation)
   - In-season cropland and crop-type mapping
   - Yield and conditions monitoring
2. Support to National Crop Monitor Development
3. Helmets Labeling Crops
4. Resources: New items and publications
5. What's next/ Recent
   - AGRA: Strengthening Agri-Foods Data Systems to Inform Food Security Policies and Trade in Sub-Saharan Africa
   - Rwanda-EO-FARM: USDA
   - Upcoming: Enabling Crop Analytics at Scale - Tetra Tech-> Rice Yield Tanzania
- GLAM 2.0 release (Johns presentation)

# Cropland + Crop-type Mapping

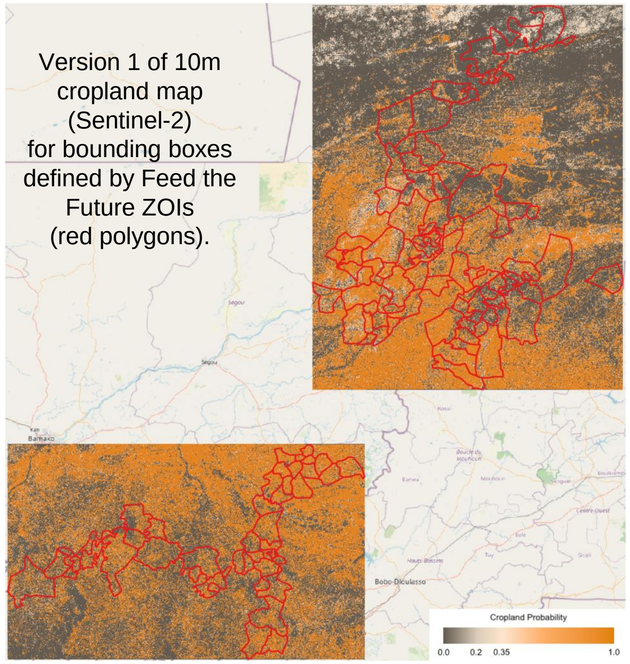
HARVEST | EARTH DATA FOR INFORMED AGRICULTURAL DECISIONS



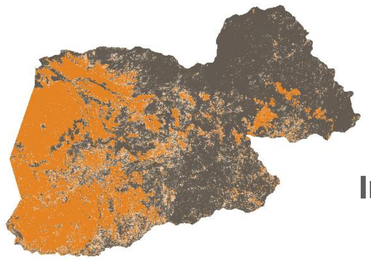

Kenya Crop Map
(10m, 2019)

Busia, Kenya
Common Bean Map
(10m, 2019)

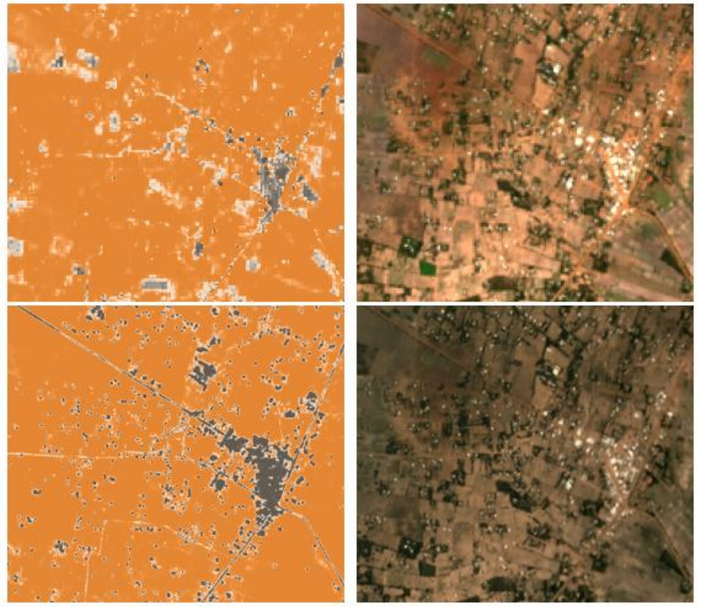

Togo Crop Map
(10m, 2019)



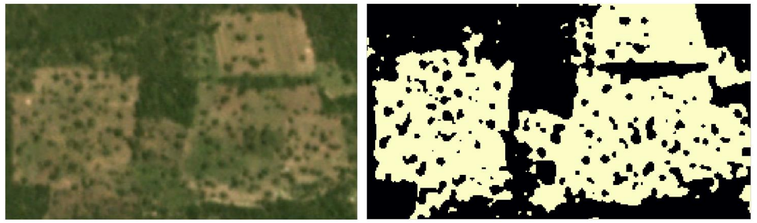

Mali Crop Map (10m, 2019)



Humera, Ethiopia
In-Season Crop Map
(10m, 2019)



Zoomed-in region of 10m (Sentinel-2) cropland map (top) vs. 3m (PlanetScope) cropland map (bottom), with corresponding RGB.



Zoomed-in region of 3m cropland map (Planet Fusion) showing good separation of trees from crop pixels within field boundaries.

Lead: H. Kerner

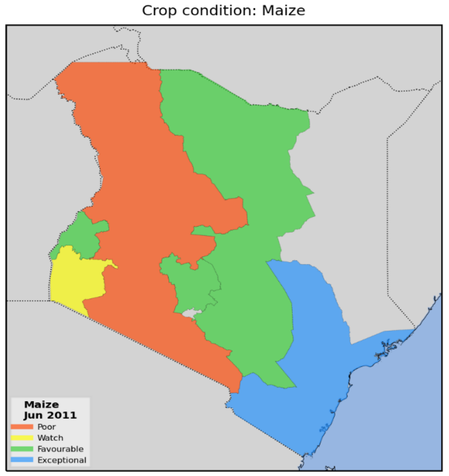


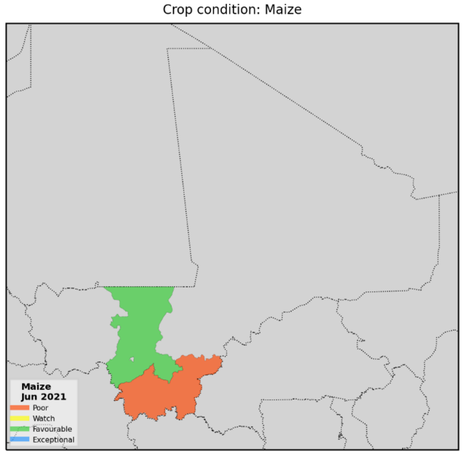
SERVIR GLOBAL | RCMRD | LUTHERAN WORLD RELIEF | FEED the FUTURE | Swiss Re Foundation | FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

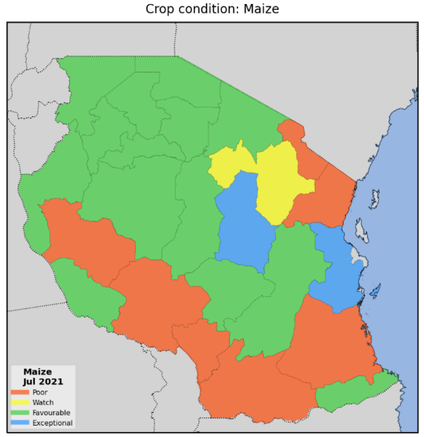


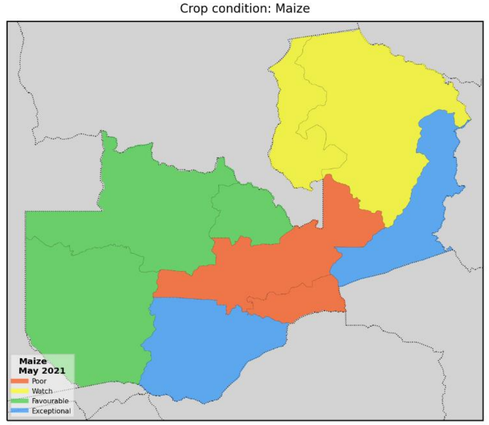
NASA

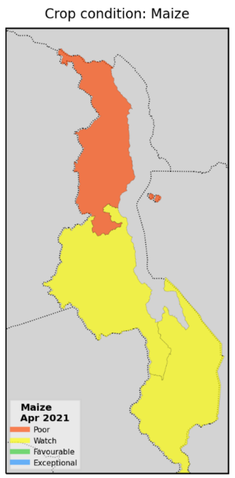
# Yield and Conditions

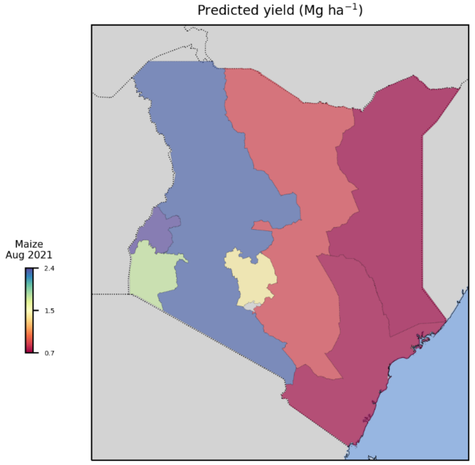


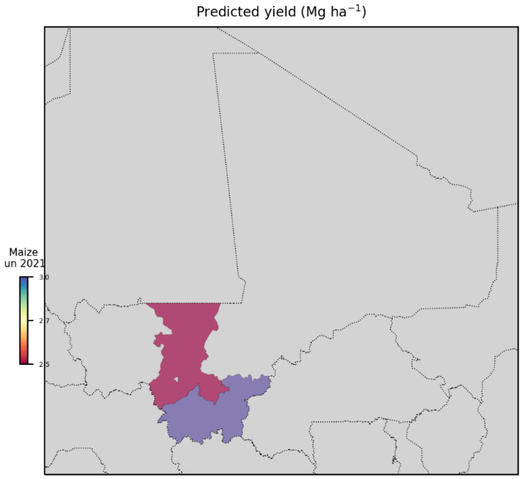



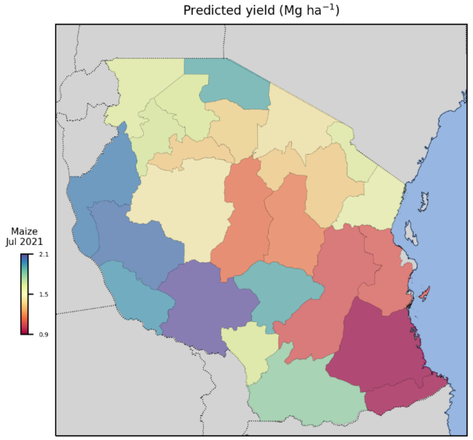



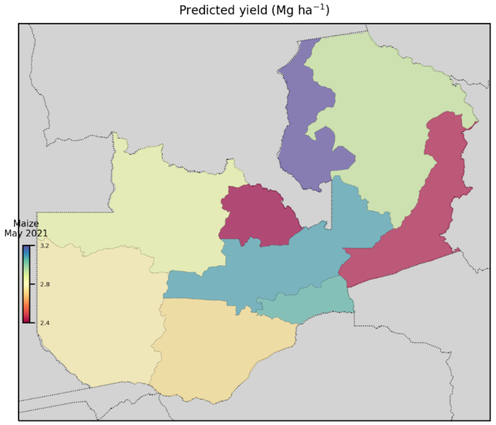



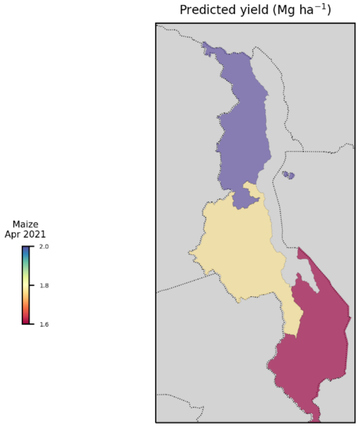



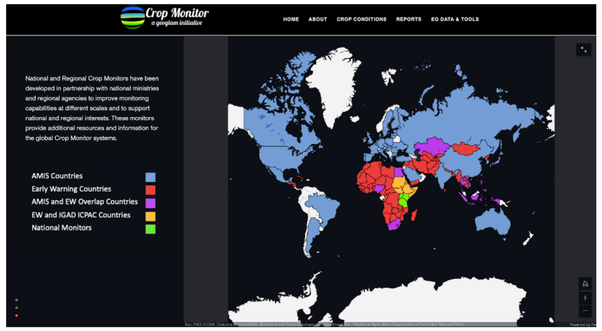



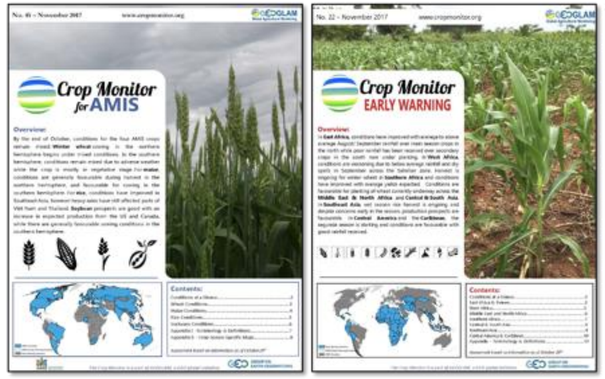

**Lead: R. Sahajpal**

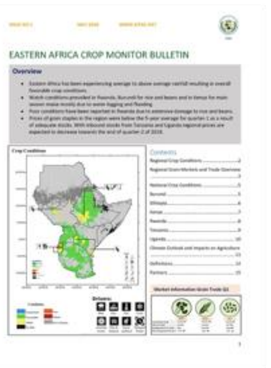
TOP: EO-based Crop Condition Middle, Bottom: Predicted Yield

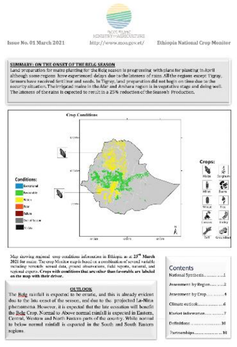
# National Crop Monitors

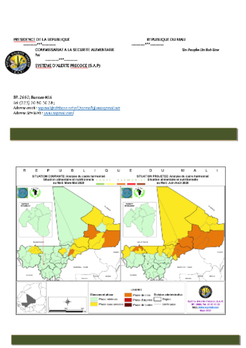
HARVEST
EARTH DATA FOR INFORMED AGRICULTURAL DECISIONS

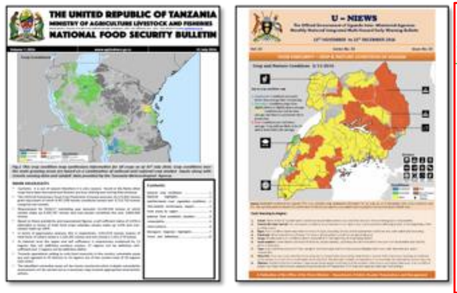


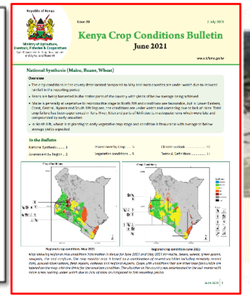














## Support to National Crop Monitors Development

- Ethiopia May 24-28
- Rwanda May 31 to June 1
- Kenya – June 6-8
- Uganda & Tanzania continue to publish

Lilian Ndungu (RCMRD/ SERIVR E&SA ) led all the training sessions



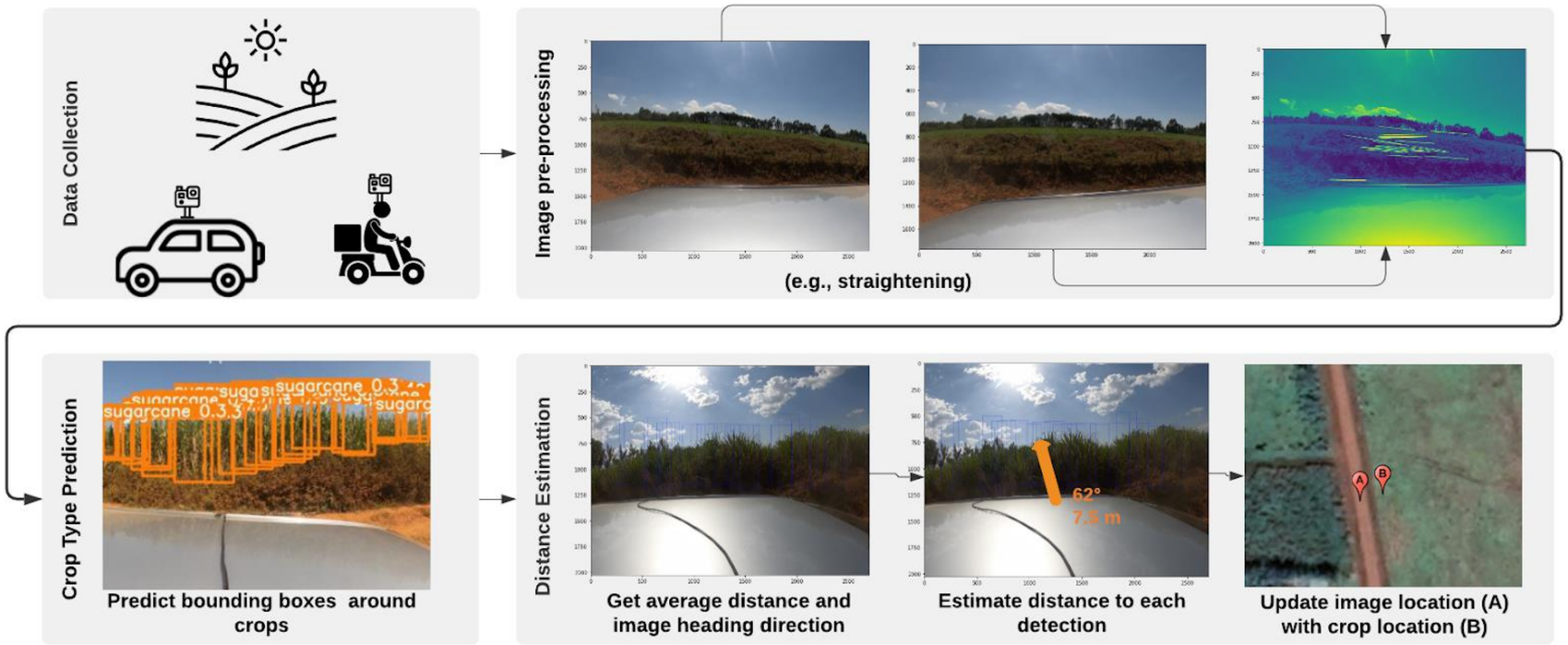
GEOGLAM Global Agricultural Monitoring
IGAD Climate Prediction and Applications Centre
"Fostering Climate Prediction and Applications"
RCMRD
LUTHERAN WORLD RELIEF
SERVIR GLOBAL CONNECTING SPACE TO VILLAGE

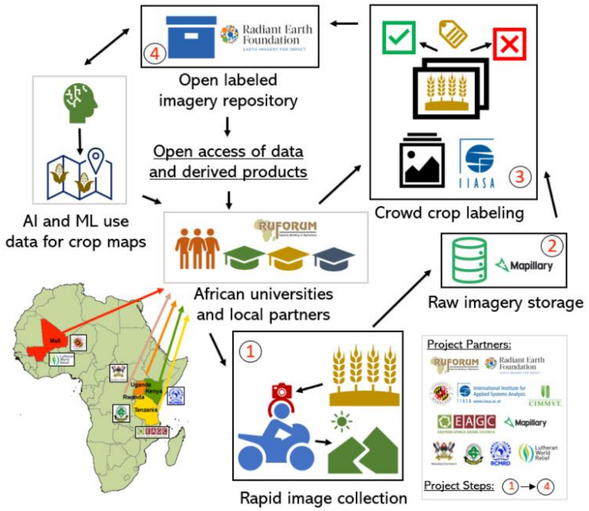


NASA

# Project Highlights: Helmets Labeling Crops- Lacuna Fund

## Street2Sat framework

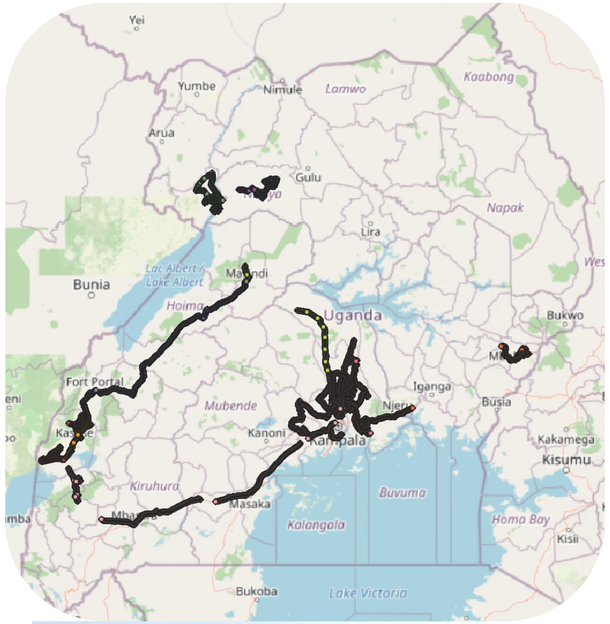



Lacuna Fund
Our voice on data

Paliyam, M., Nakalembe, C., Liu, K., Nyiawung, R., & Kerner, H. (2021). *Street2Sat: A Machine Learning Pipeline for Generating Ground-truth Geo-referenced Labeled Datasets from Street-Level Images*. Retrieved from https://github.com/ultralytics/yolov5

# Project Highlights: Helmets Labeling Crops





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- The Next Step: Prioritizing Global Food Security, Be the Solution Magazine Summer 2021, Published on Jun 11, 2021
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- NASA Earth Observations Help Kenya Aid Program Reach More Farmers, NASA Applied Sciences, 30 January202112.
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- Soil Data Aids Prediction of Locust Swarms, NASA Earth Observatory, 15, May 2021

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APPLIED SCIENCES

# Thank You

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# GLAM 2.0

## A New and Improved Global Agriculture Monitoring System

John Keniston

EARTH SCIENCE APPLICATIONS WEEK 2021

# About GLAM


The Global Agriculture Monitoring System (GLAM) is a web-based platform to enable near-real-time monitoring of global croplands, primarily using NASA MODIS satellite data. After years of operational use and valuable feedback from partners, it was time to redesign this system to be faster, more flexible, and to capitalize new datasets coming online and new computing architectures available.

# GLAM 2.0


The Updated GLAM system has captured and replicated the functionality of the original system, while also boasting new features and capabilities. Some of these new features include:

- Public REST API
- Modern web map & new design
- Highly customizable and sharable charts
- Regional or country specific interfaces
- Additional datasets beyond NDVI
    - Precipitation, Temperature, Soil Water Index, etc.

# Live Demo – glam.nasaharvest.org

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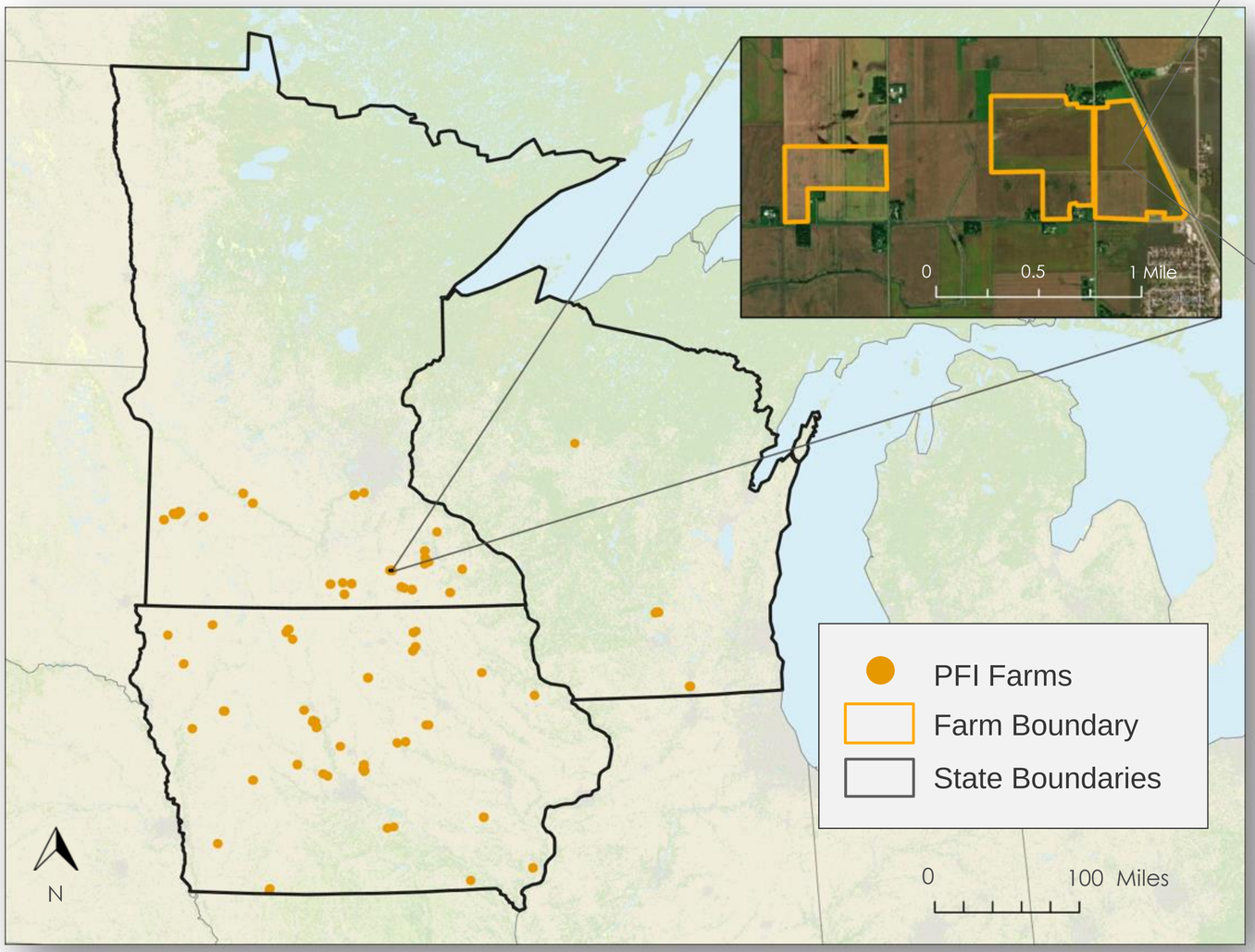
# Midwest Food Security & Agriculture II

## Leveraging NASA Earth Observations to Analyze and Display Crop Phenology Data and Weather Conditions to Support Expansion of Small Grain Crops in the Midwest

Joel McClure*, Sophie Barrowman, Abena Asare-Ansah, Cameron Levine, & Julianne Liu

EARTH SCIENCE APPLICATIONS WEEK 2021

# CONCERNS & PARTNERS




## Community Concerns

- Consequences of monocultures
- Socioeconomic risks of diversification
- Limited data about small-grains

## End User

- Practical Farmers of Iowa (PFI)





Image Credit: Practical Farmers of Iowa

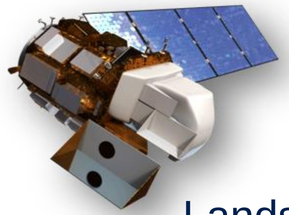
# OBJECTIVES & METHODOLOGY

**Spring 2021 Team:**
NDVI phenology curves & climate comparison graphs

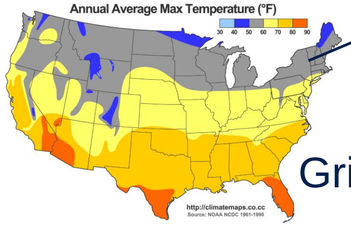
**Summer 2021 Team:**
User Interface of the PhenoloGEE App

NDVI and small-grain crop yield regression model

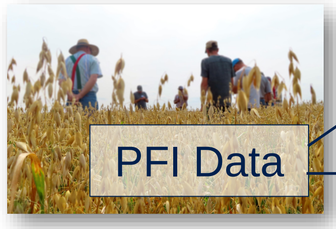
Landsat 7 ETM+



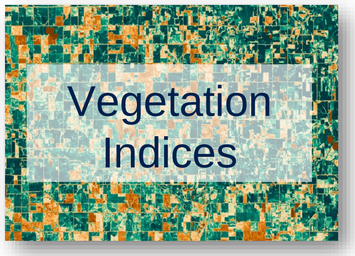
Landsat 8 OLI



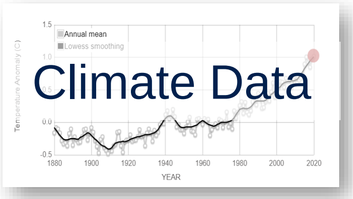

GridMET



PFI Data



Vegetation Indices




Farm Boundaries

Yield Data

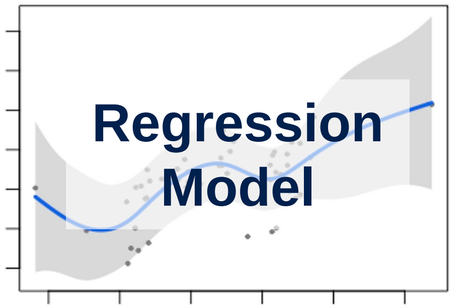
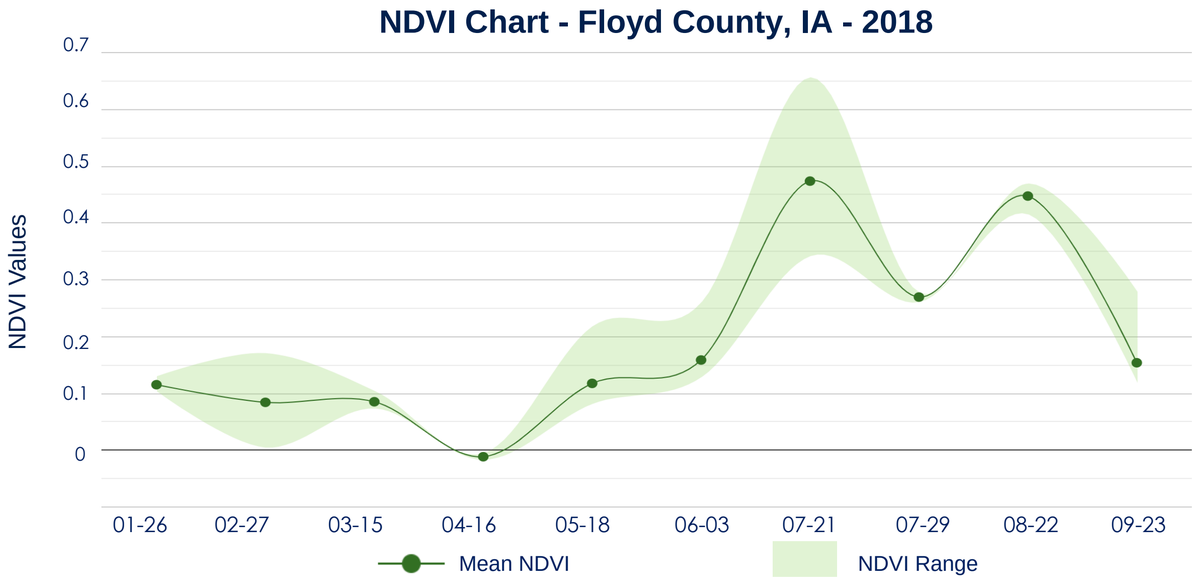



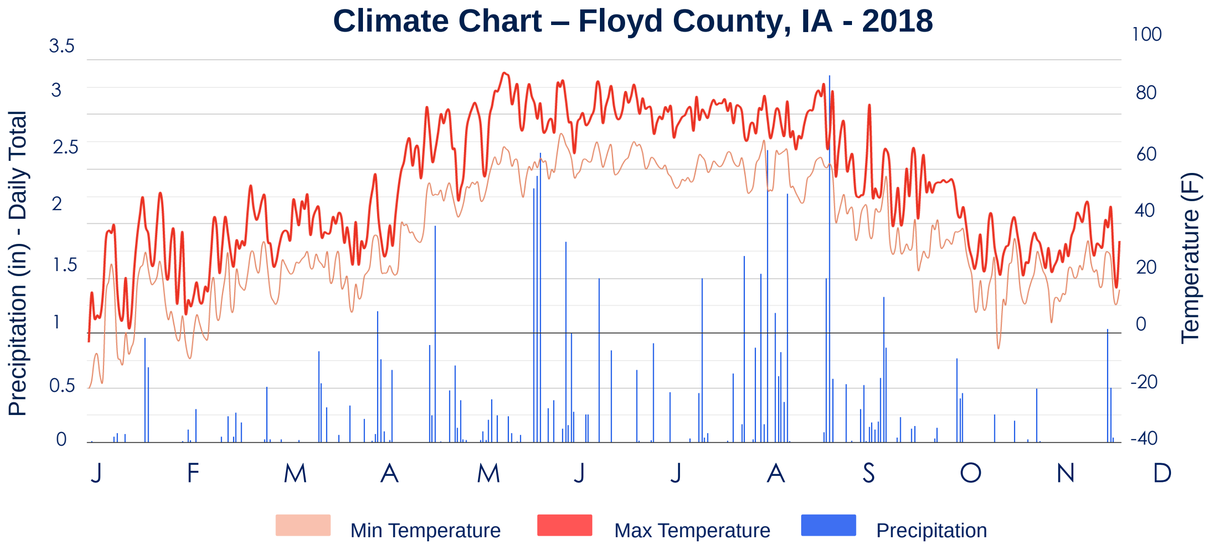


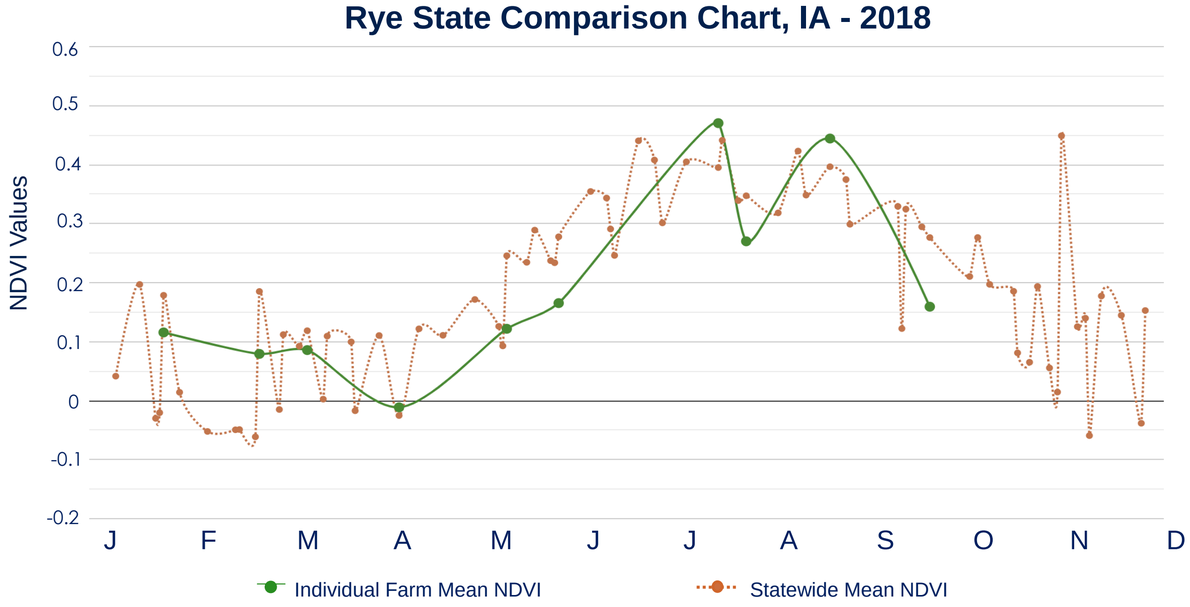



Image Credit: NASA, Practical Farmers of Iowa, Alex Matus

# PHENOLOGEE APP

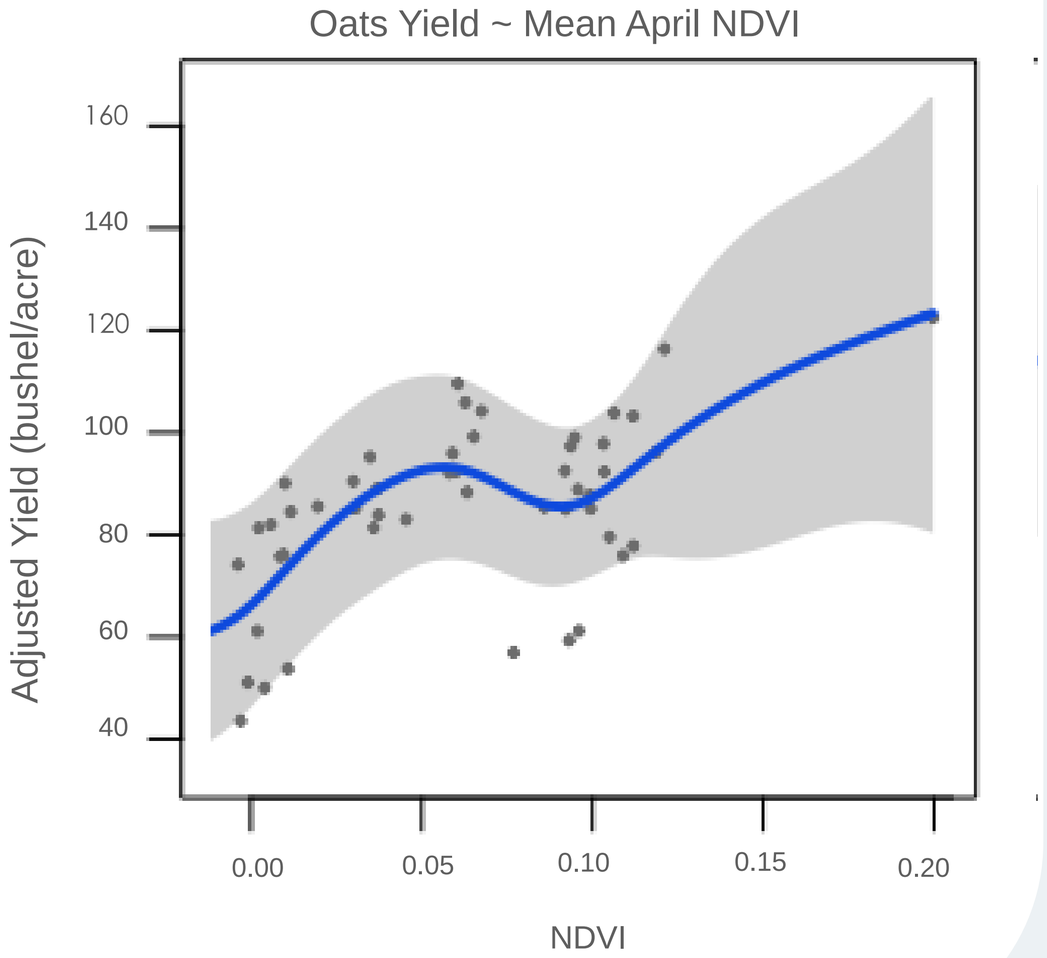



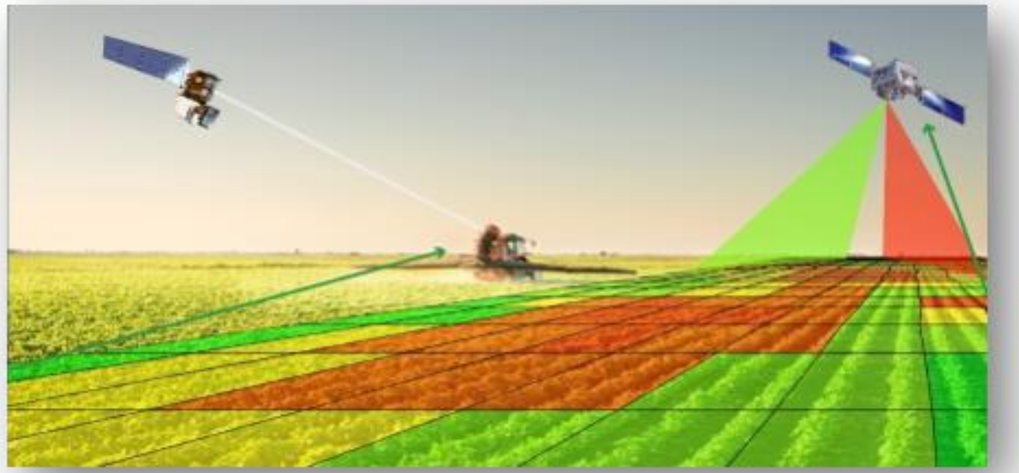



# REGRESSION MODEL

| Variables | $R^2$ | Model Fit Explained |
|---|---|---|
| Mean NDVI | 0.061 | 10.0% |
| Mean Vegetation Indices | 0.183 | 35.3% |
| NDVI, EVI, SAVI, NDWI, SR | | |
| Combination of NDVI Metrics | **0.626** | **77.6%** |
| Sum of Monthly Mean, Day with First Positive Value, Day with Maximum Value, Variance, April Mean, May Mean | | |



# END USER BENEFITS




- PhenoloGEE App User Interface
- Yield ~ Vegetation Indices Regression Model





Image Credit: Practical Farmers of Iowa, ESA

# ACKNOWLEDGEMENTS


## Project Partners

**Dr. Stefan Gailans** – Practical Farmers of Iowa
**Dr. Dawn Browning** – USDA Agricultural Research Service
**Dr. Peter O'Brien** – USDA Agricultural Research Service
**Dr. Theresa Crimmins** – USA National Phenology Network

## Science Advisors

**Dr. Marguerite Madden** – University of Georgia
**Dr. Kunwar Singh** – College of William & Mary

## Leaders at the Georgia–Athens Node

**Darcy Gray** – Center Lead/Fellow

## Past Contributors

**Olivia Landry**
**Liam Bhajan**
**Otto Castillo Altun**
**Owen Smith**

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# THANK YOU!

EARTH SCIENCE APPLICATIONS WEEK 2021