The Expanding Role of Remote Sensing Technology in Agricultural Production and Trade Decisions

Estefania Puricelli and Brian Barker

Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium's (IATRC's) 2019 Annual Meeting: Recent Advances in Applied General Equilibrium Modeling: Relevance and Application to Agricultural Trade Analysis, December 8-10, 2019, Washington, DC.

The expanding role of Remote Sensing Technology in Agricultural production and trade decisions

Estefania Puricelli - Brian Barker

NASA Harvest UMD Hub – GEOGLAM Crop Monitor

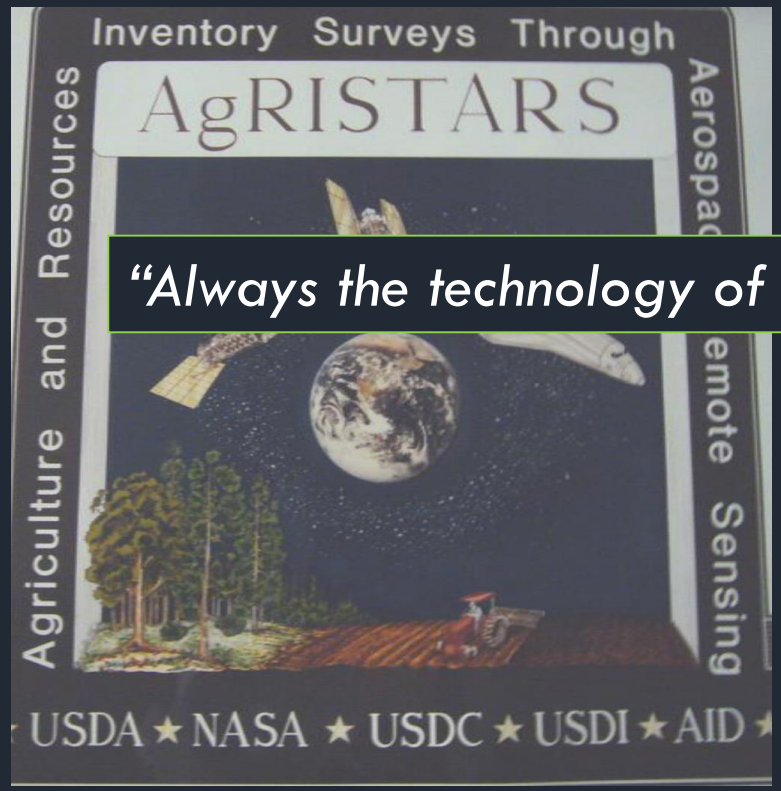
www.nasaharvest.org

https://cropmonitor.org/

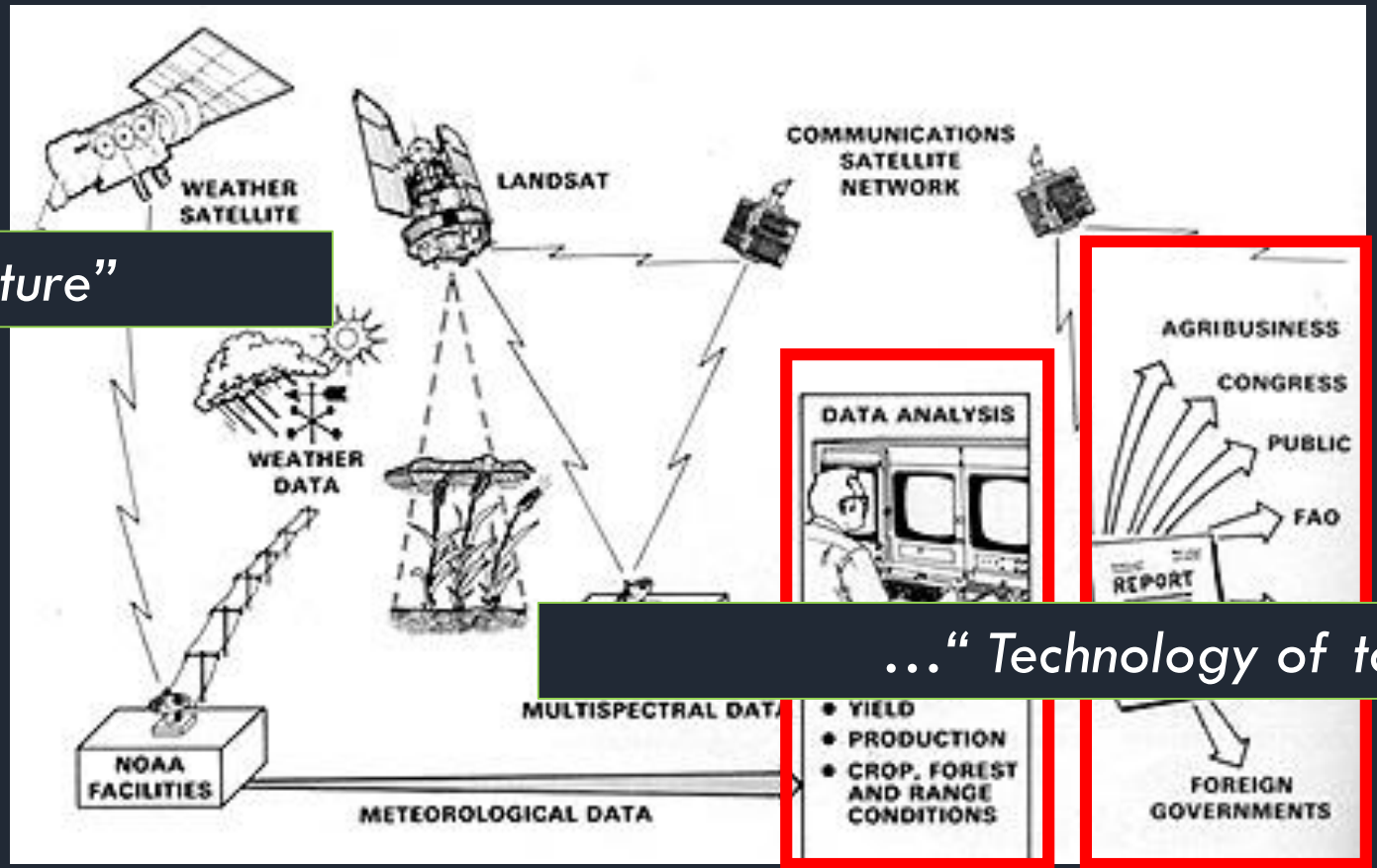
IATRC December 2019, Washington DC

The Vision for Agricultural Remote Sensing 1970s & 80s

Implementation was limited by availability of data and compute



"Always the technology of the future"



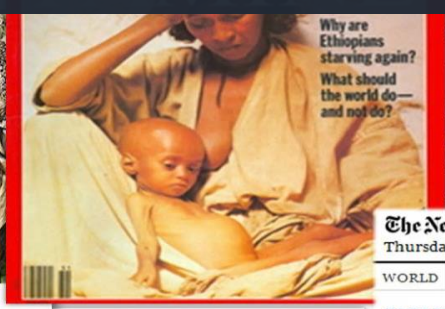
…" Technology of today!"

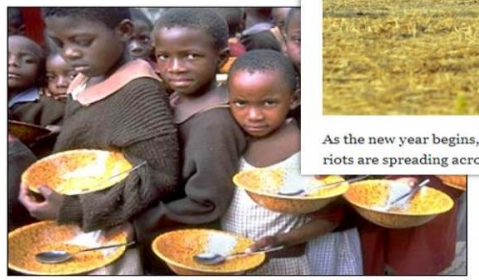
Overselling of capabilities – should be avoided with current push

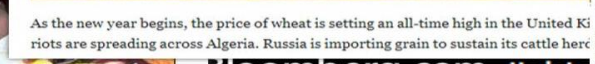
Following international market crop price Spikes (2008, 2011)

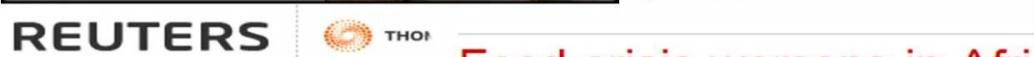
International recognition of need for improved real time, reliable, open information on global agricultural production prospects

Critical for agricultural policies, stabilizing markets, averting food crises









GEOGLAM launched as part of G20 Action Plan on Food Price Volatility and AGRICULTURE

- Launched in 2011 alongside Agriculture Market Information System (AMIS)
- Focus on stabilizing markets & enhancing food security through the use of Earth Observation
- Provides the international forum for the
  countries and 16 inter-governmental organizations
- Forged many of the partnerships that led to creation of Harvest

Harvest is NASA's contribution to the G20 GEOGLAM Program

GEOGLAM Global Agricultural Monitoring

AMIS Agricultural Market Information System

HARVEST

GEOGLAM & AMIS & NASA Harvest at a Glance

- GEOGLAM & AMIS launched by G20 Ministers of Agriculture in 2011 under Action Plan on Food Security and Agriculture
- GEOGLAM focused on the use of Earth Observations & provides the international forum for the agricultural monitoring community
  - Members from 62 organizations in 28 countries and 16 inter-governmental organizations
- AMIS focused on market information and transparency
  - Members from G20 ministries of agriculture + 7 invited countries
  - Secretariat made up of 11 international organizations

AMIS Agricultural Market Information System

GEOGLAM Global Agricultural Monitoring

- NASA Harvest is NASA's Program on Food Security and Agriculture, launched in 2017
- Focus on increased uptake of satellite data by public and private sector for agricultural applications
- NASA's contribution to the GEOGLAM Program
- Over 45 partners from public & private sector

What is NASA Harvest?

Launched December 2017

- A new innovative NASA Applied Sciences program on Food Security and Agriculture
  - domestic & international focus
- Developing & implementing agricultural applications with a wide range of stakeholders
- Carried out through coordinated multi-sectoral consortium led by University of Maryland
- Connecting across NASA Applied Sciences & research program
  - e.g. SERVIR, Water Resources, LCLUC
- Providing inputs back to NASA on requirements and priorities
- Demonstrate socioeconomic benefits of earth observations for agriculture

For NASA the consortium approach is an experiment that is so far proving to be effective

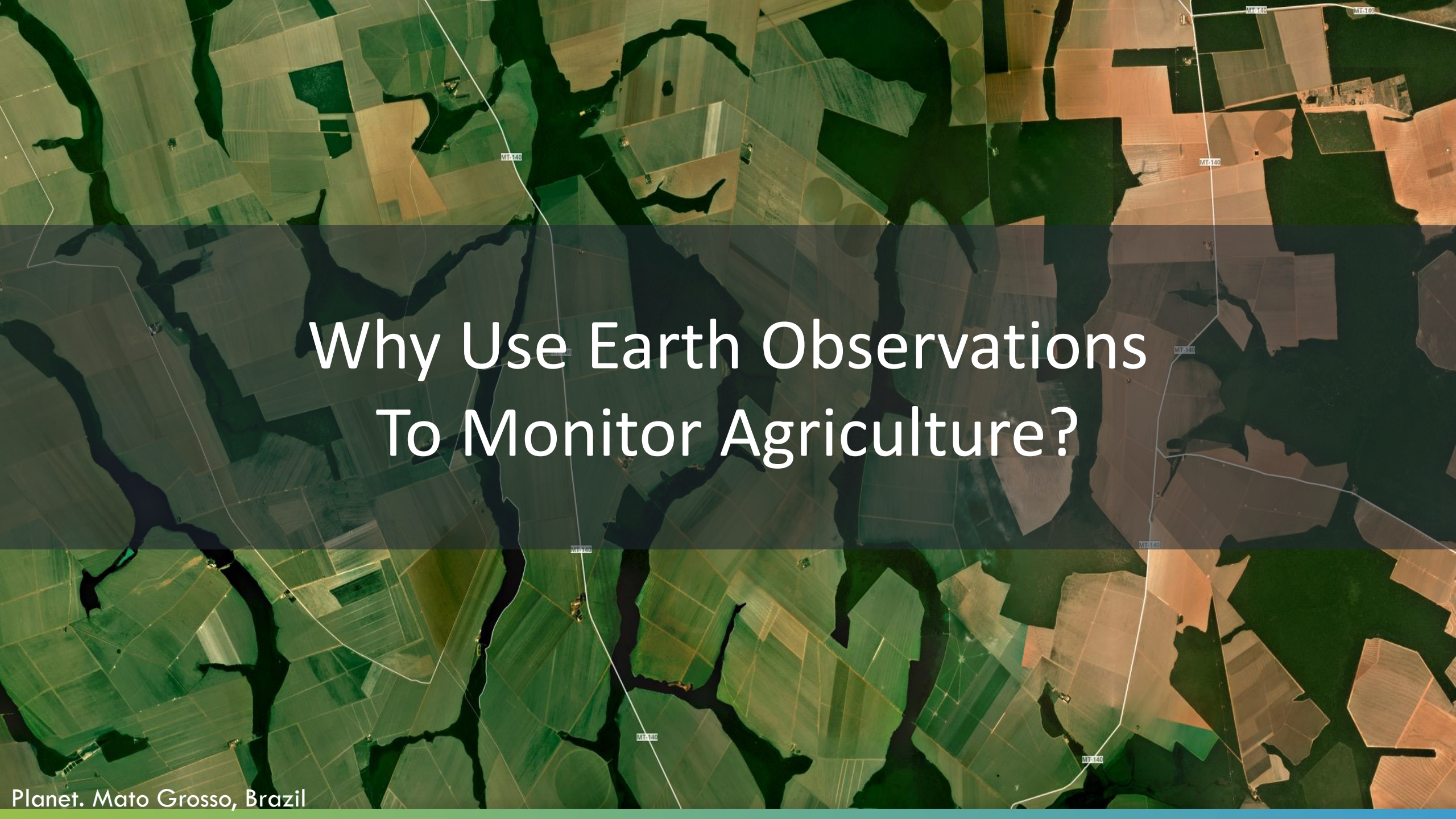
Harvest OBJECTIVE

Empower decisions that support food security, stable markets, economic progress, and sustainable, resilient crop production, through:

- Advancing awareness & operational uptake of Earth observations
- Focusing on small holder and large-scale agriculture, from field to global scales
- Working at the intersection of Earth observation, land science, social science, & policy

Harvest Approach

- End user/stakeholder driven
- Forge strategic partnerships across sectors and geographies
  - Full data to decision chain
  - Innovate in linking stakeholder networks
- Leverage ongoing activities & enhance them
  - Focus on high impact and transition of research to operations
  - Mix of “application readiness levels” (ARLs)
- Build on the progress and international partnerships forged through GEOGLAM
- Coordinate with complementary initiatives and programs
- Demonstrate value and success & adapt and scale applications
- Articulate community priorities and gaps
  - Through thematic working groups



Why Use Earth Observations To Monitor Agriculture?

Planet. Mato Grosso, Brazil

A New Era for Satellite Data for Agricultural Monitoring

- Satellite data offers cost-effective, timely, transparent, information on crop type, plant health, stress, productivity, all at the field to global scales, on a daily basis

- Major recent advances in data, cloud & super compute, and big data analytics are revolutionizing our capabilities and enabling realization of long-held promise for agricultural applications in support of decisions and policy

TIMELY

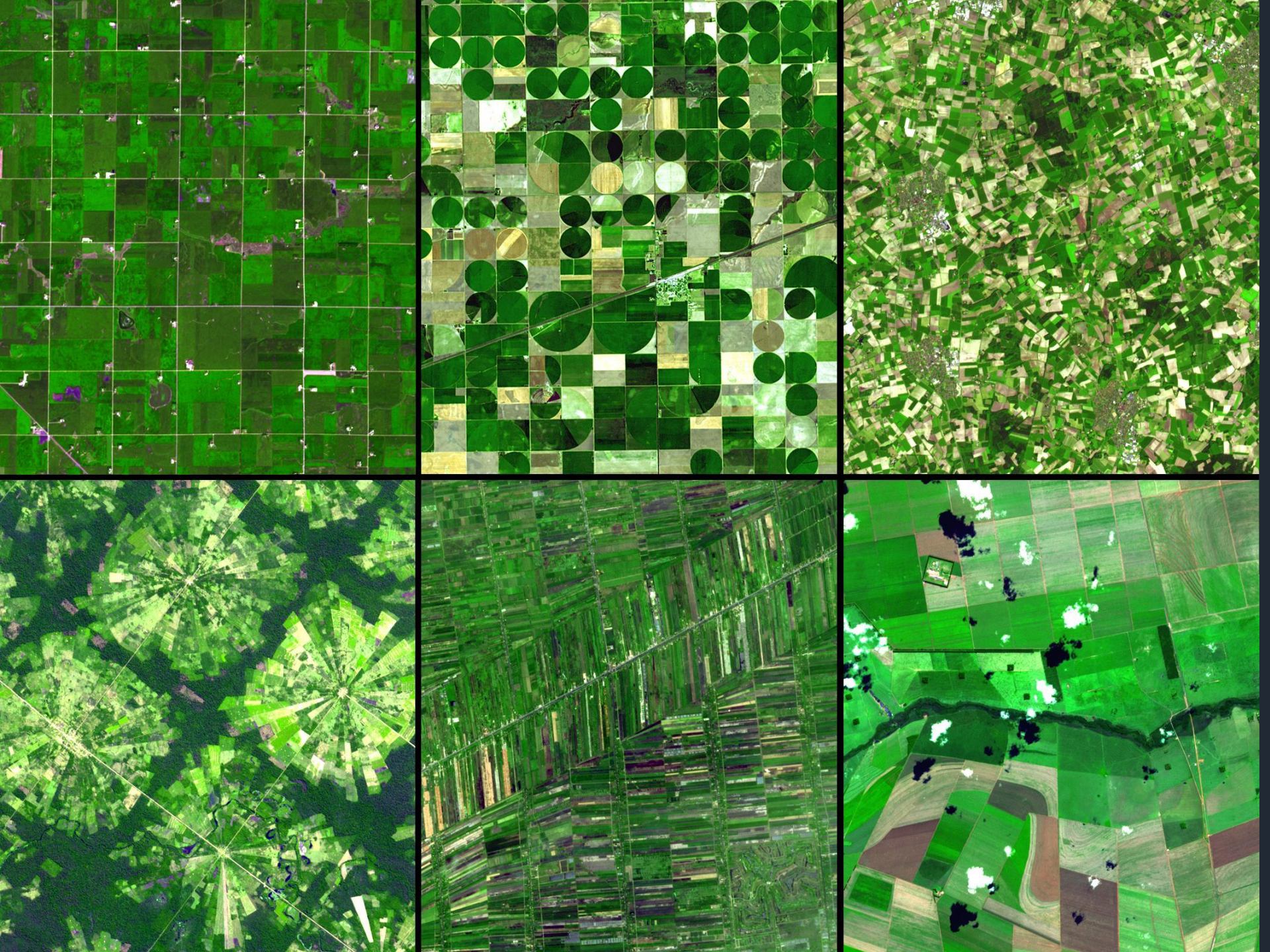
Landsat-7

GRACE-1
GRACE-2

The Whole World Yesterday...

Cheap, systematic, transparent information at scale

Timely and accurate information is fundamental for increasing market transparency



Challenge:
ROBUST
METHODS

for monitoring

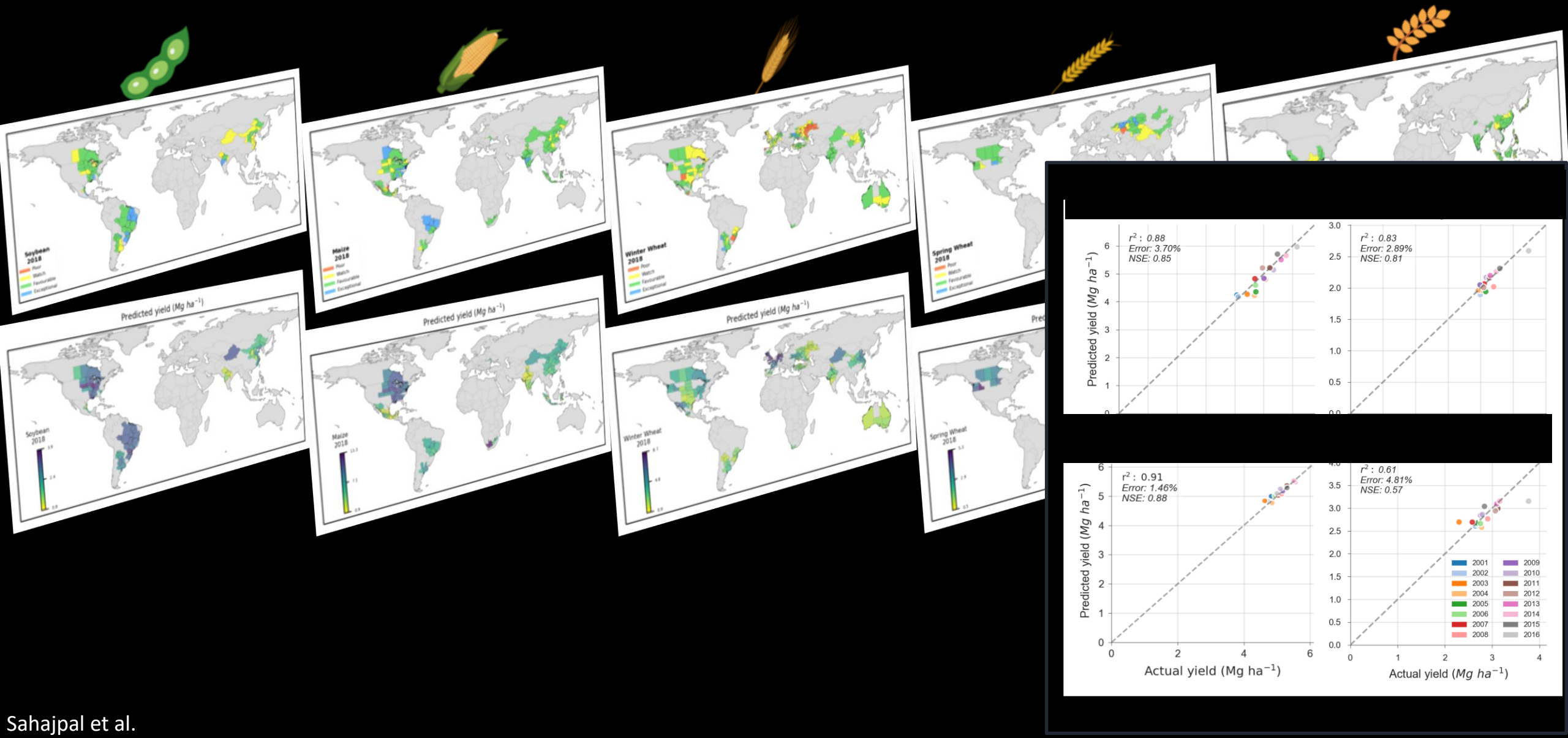
DIVERSE
LANDSCAPES

A New Era for Satellite Data for Agricultural Monitoring

New satellite constellations revolutionizing use for agriculture, enabling global monitoring at field level on a near daily basis

Traditionally relied on 1km-250m daily observations. Today we have 30m-10m every 2-5 days, and 3m daily are becoming routine!

Quantitative Yield Indicators for Major Producers: Global Scale

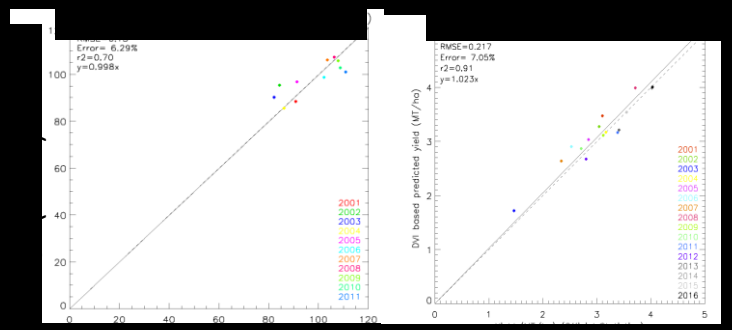


Sahajpal et al.

National to Sub-national Yield Forecasts

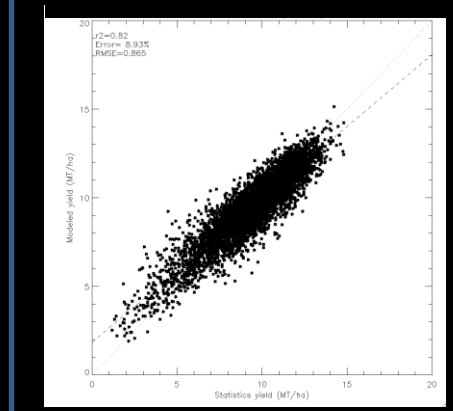
Major producers/exporters

National Scale
3-8% error 1.5- 2 months prior to harvest



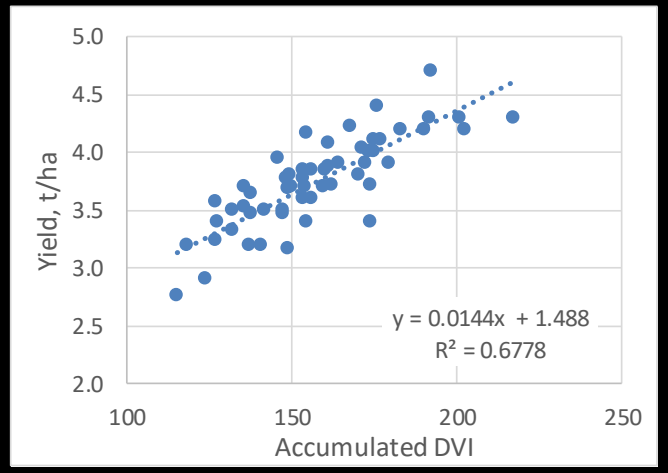
Franch et al, NASA/UMD

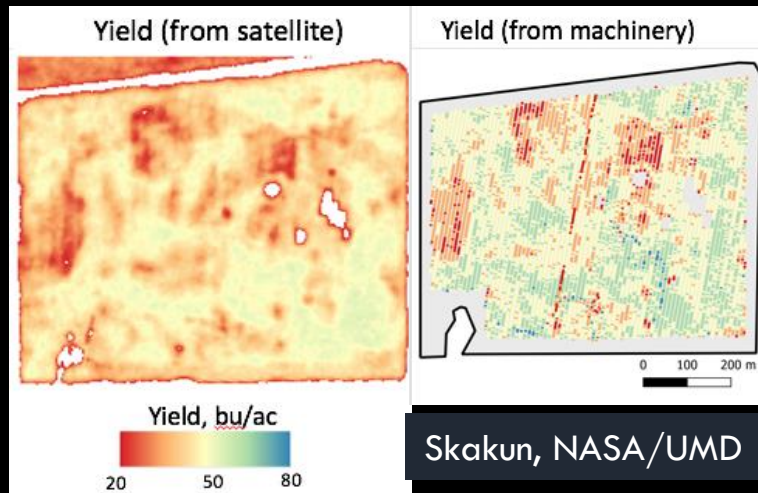
Sub-National Scale
8-14% error 1.5- 2 months prior to harvest



Franch et al, NASA/UMD

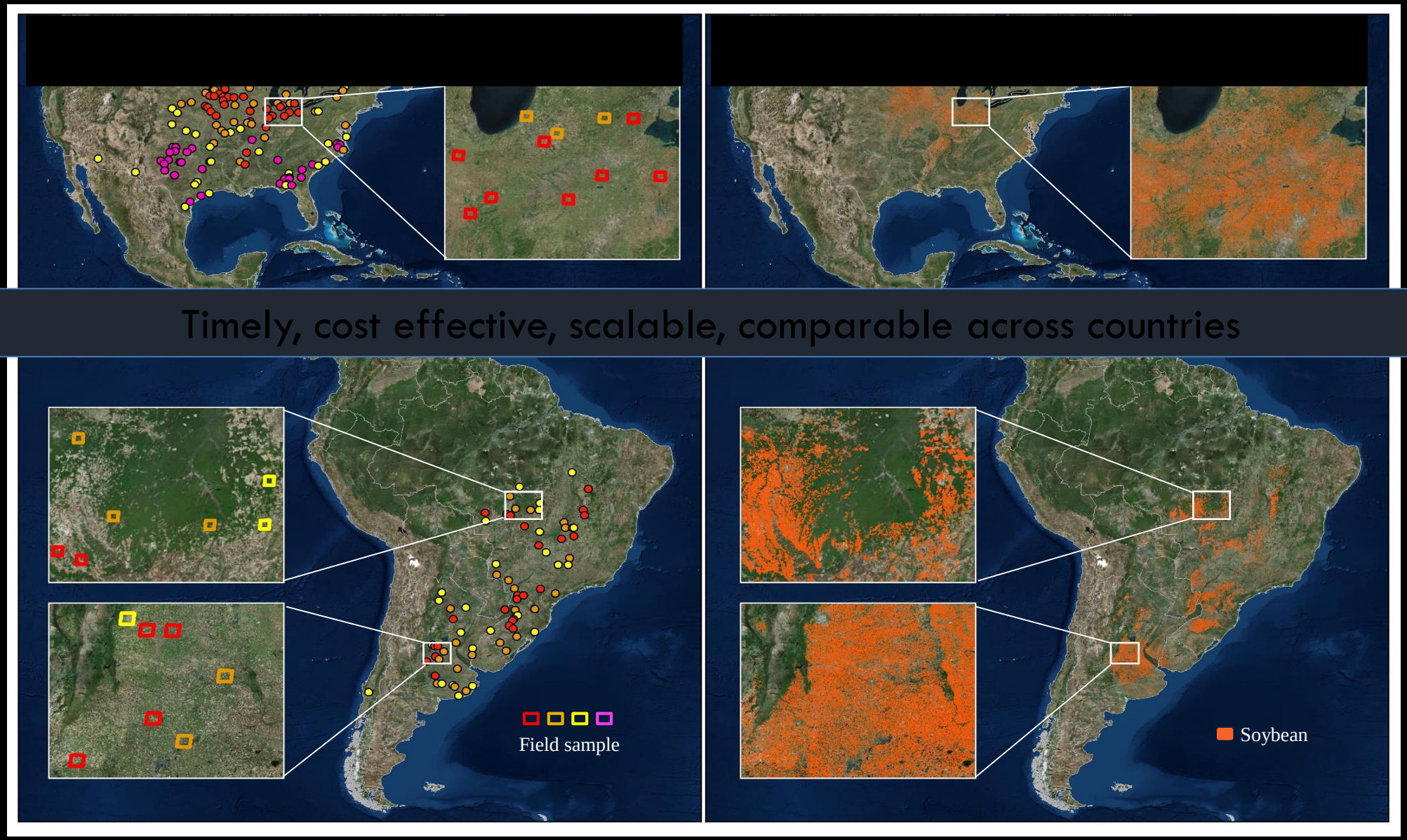
Field Scale
Iowa





Skakun, NASA/UMD

National-to-Continental Scale, In-season Crop Area Estimation & Mapping

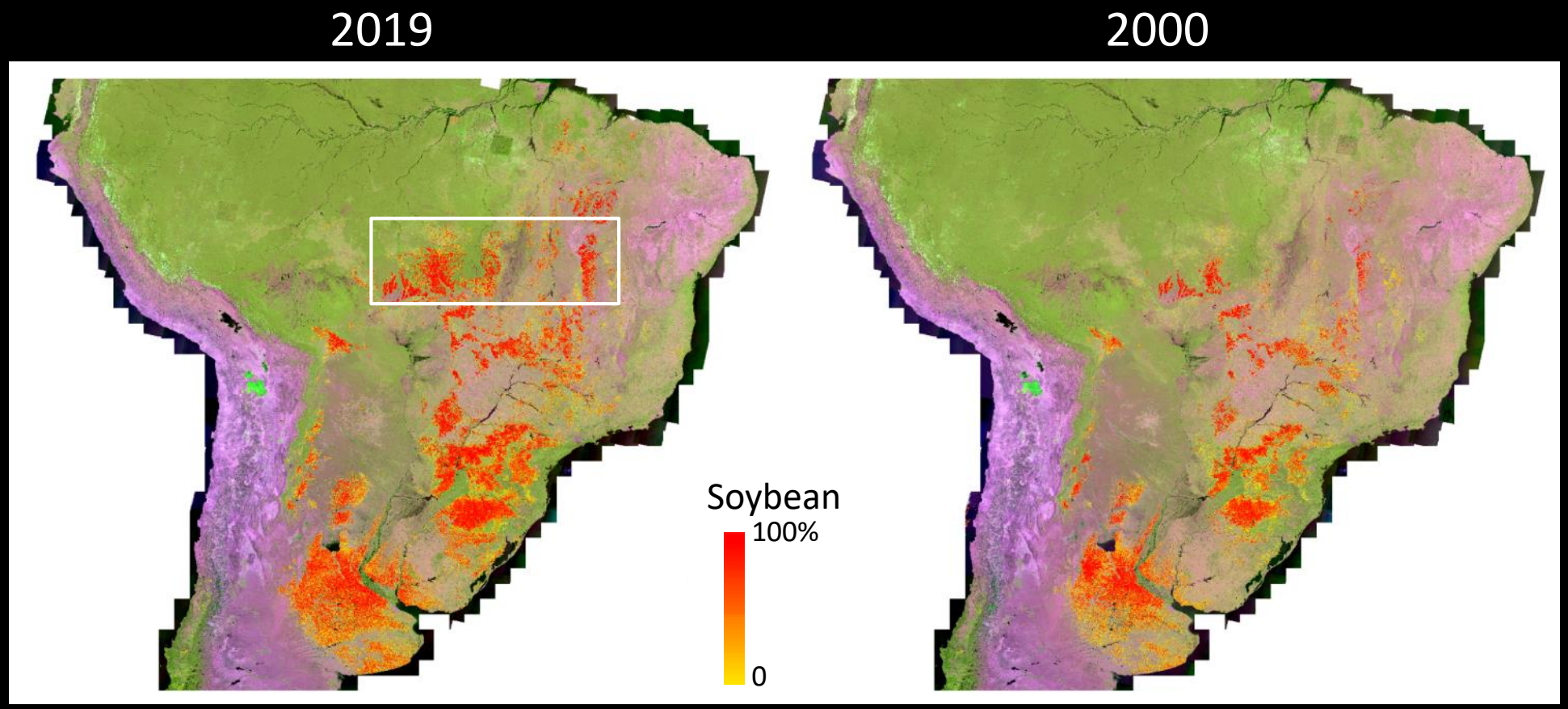


Hansen,
Song et al.

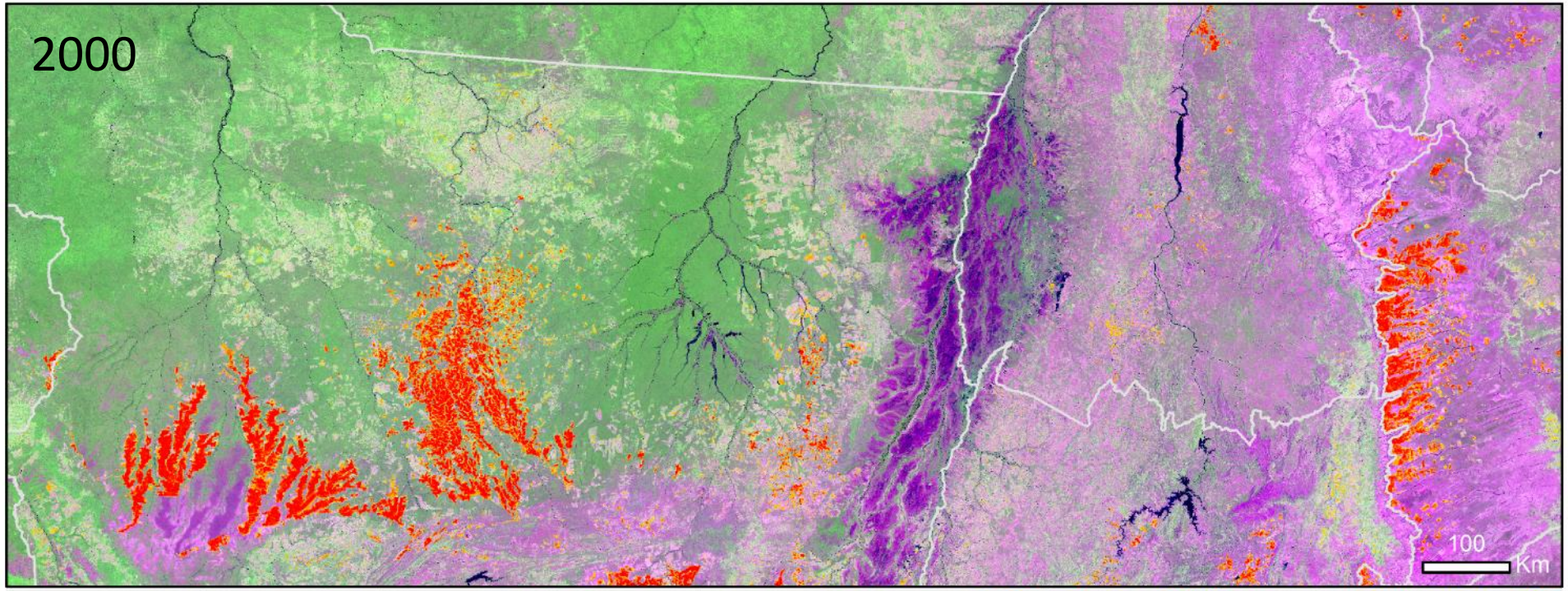
Comparison of GLAD (Satellite Driven) Soy Estimates vs. Official 2000 - 2019

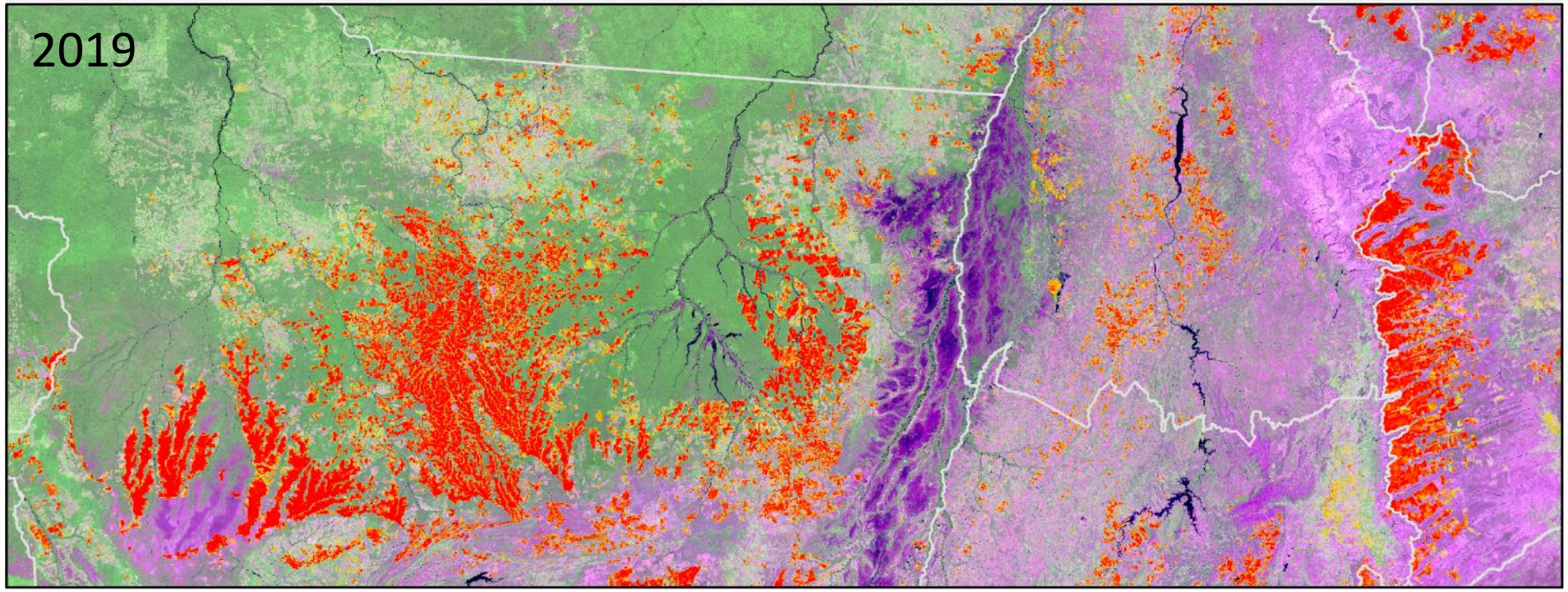
GLAD
GLOBAL LAND ANALYSIS & DISCOVERY

Soybean expansion 2000 vs. 2019



GLAD
GLOBAL LAND
ANALYSIS & DISCOVERY

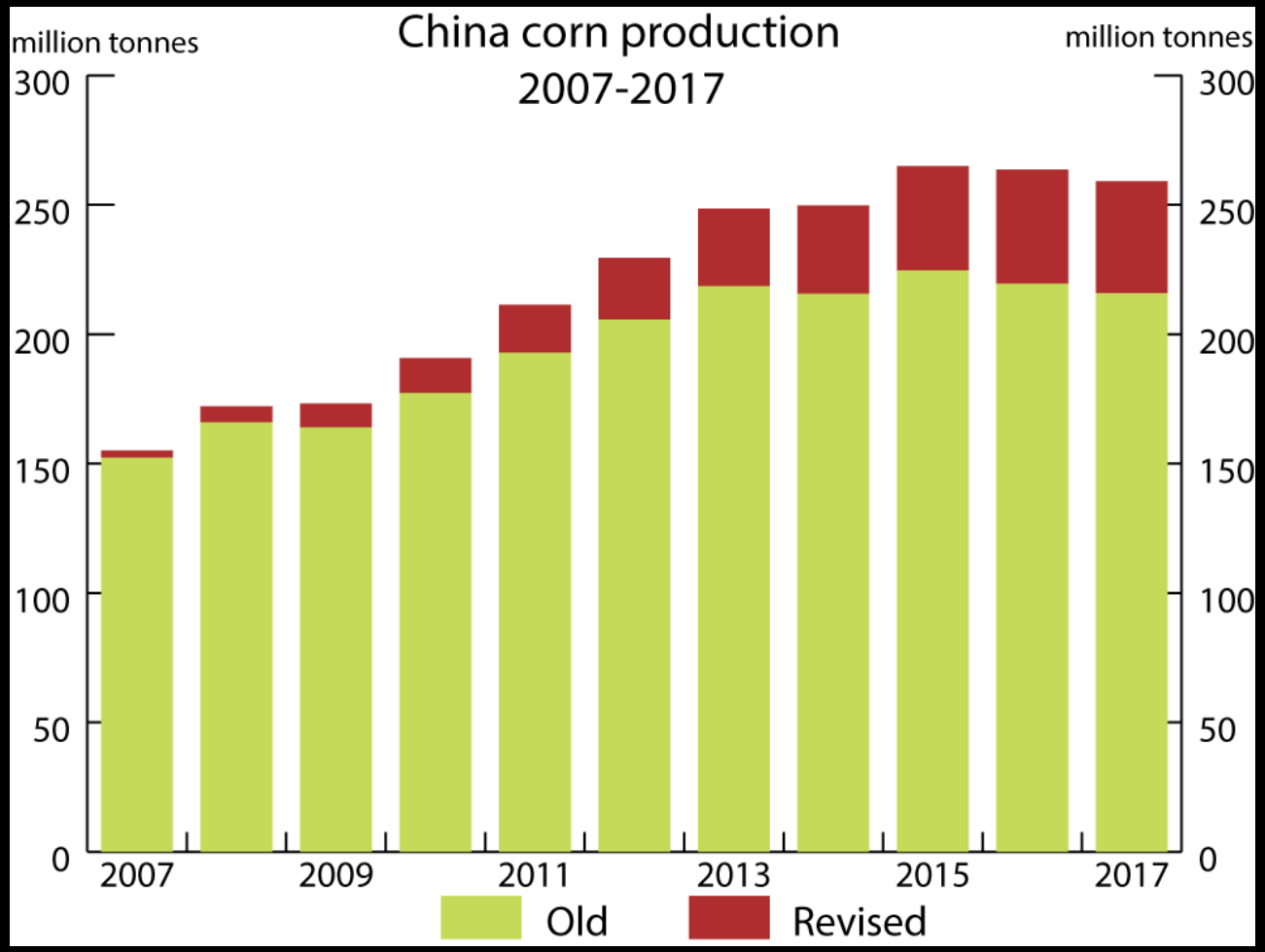




GLAD
GLOBAL LAND
ANALYSIS & DISCOVERY

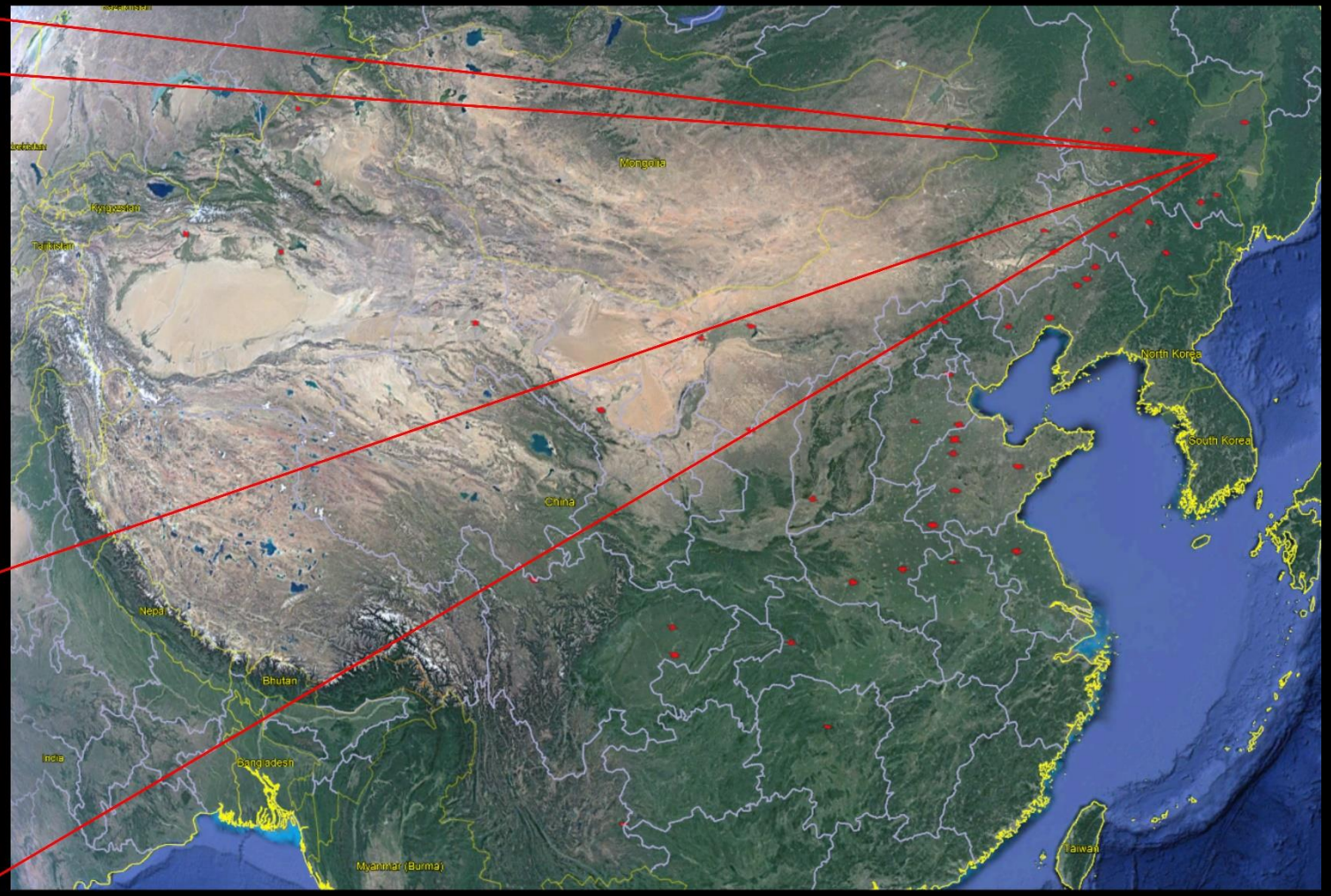
Soybean
100%
0

Application of same approach to the China maize area question

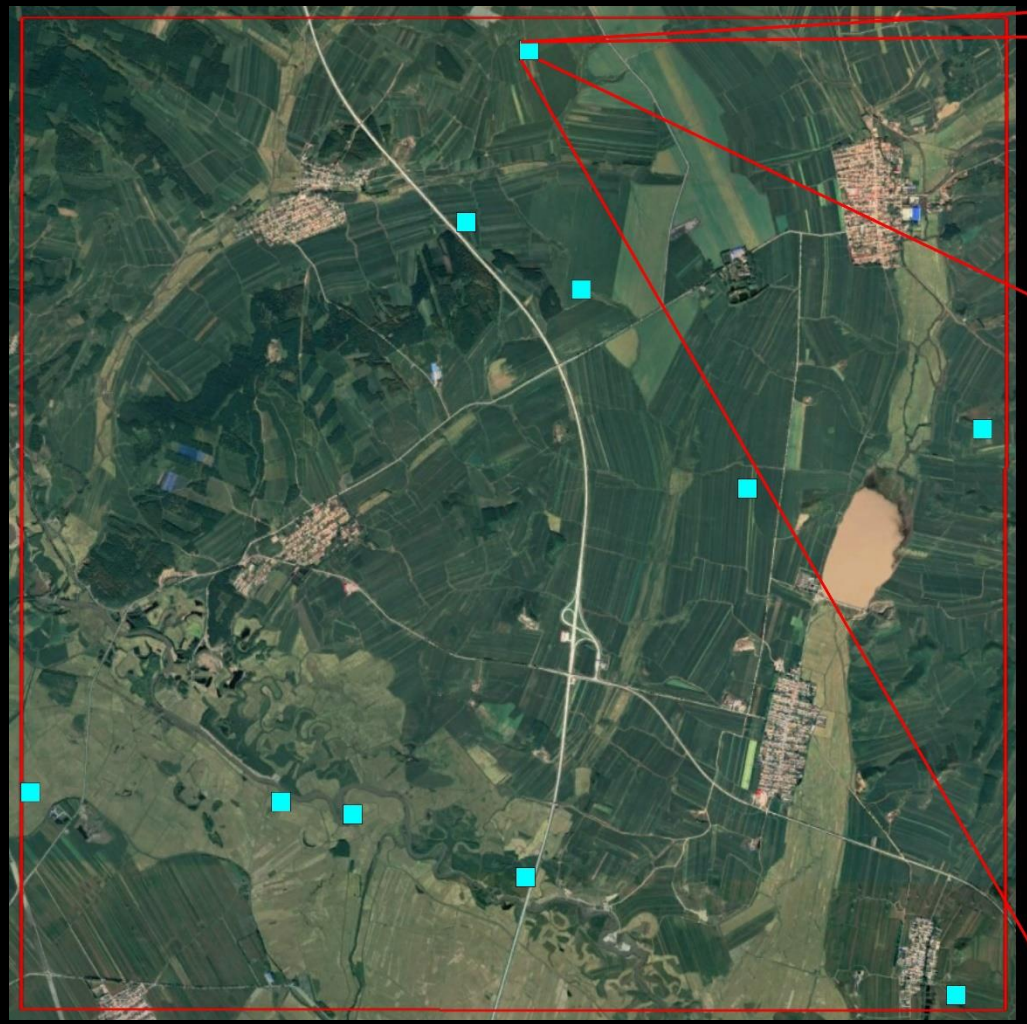


- In its 2017 Census, China sharply revised a decade of its agricultural statistics
- Given the uncertainty this sparked, AMIS asked GEOGLAM to look at the satellite data evidence to understand the current crop area in China and its distribution
  - Is the additional area concentrated primarily in the northern growing areas?
- Applying methodology implemented for continental scale soy area estimation in South America to estimate maize area in China using satellite data

Application of Approach to Cultivated corn area estimation of China



Example field site from Heilongjiang province



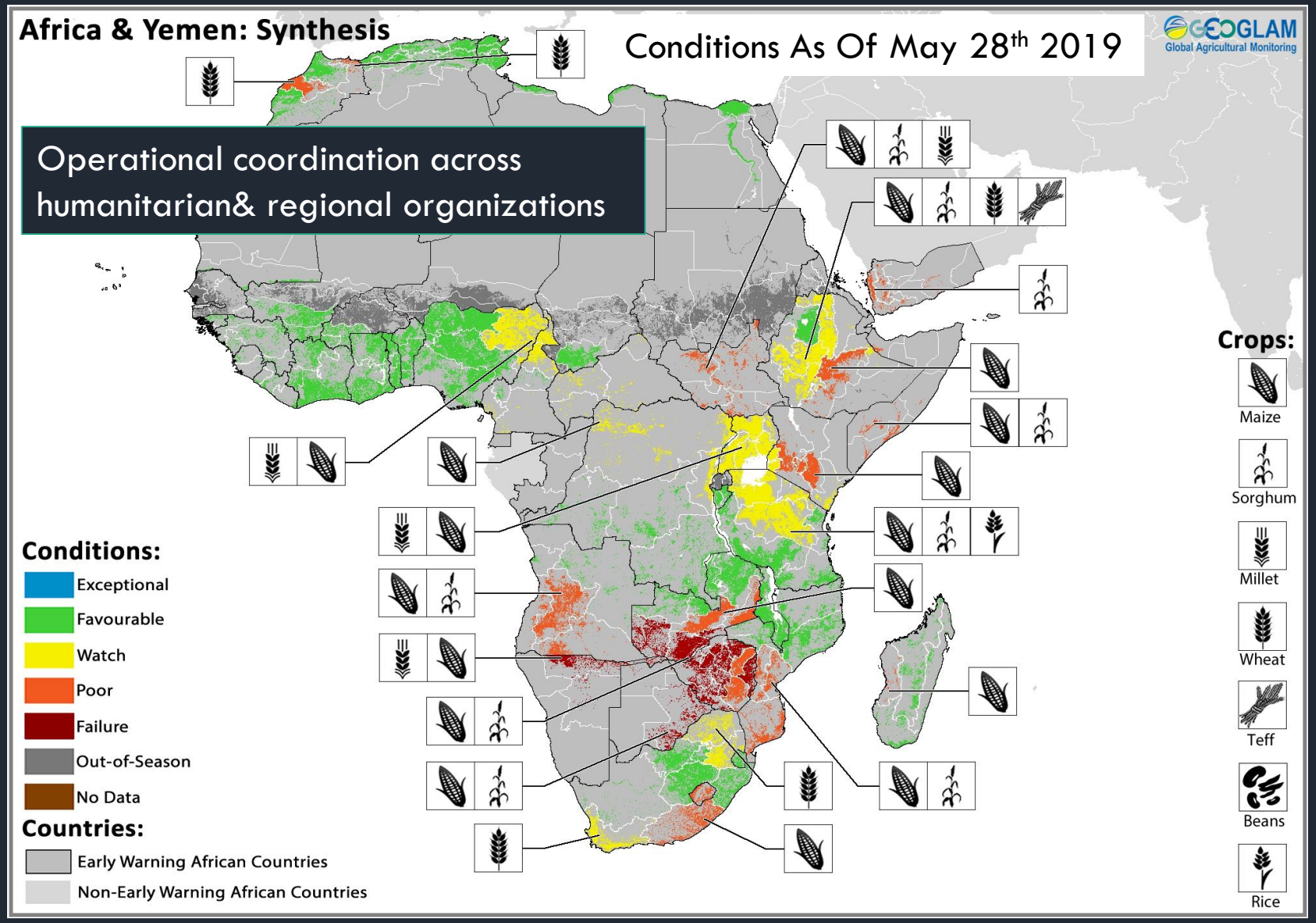
Example Harvest Activities

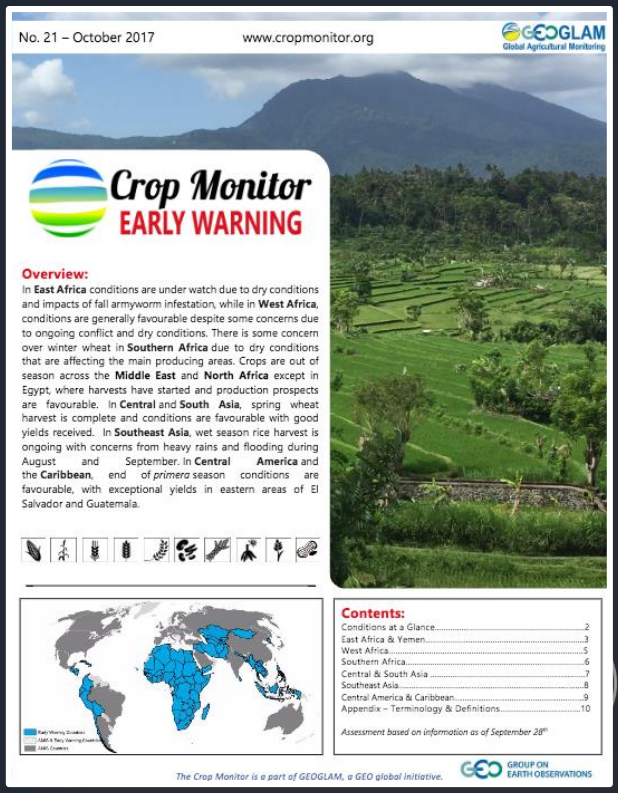
Food Security & Early Warning

Enhancing data and building capacity in support of food security decisions

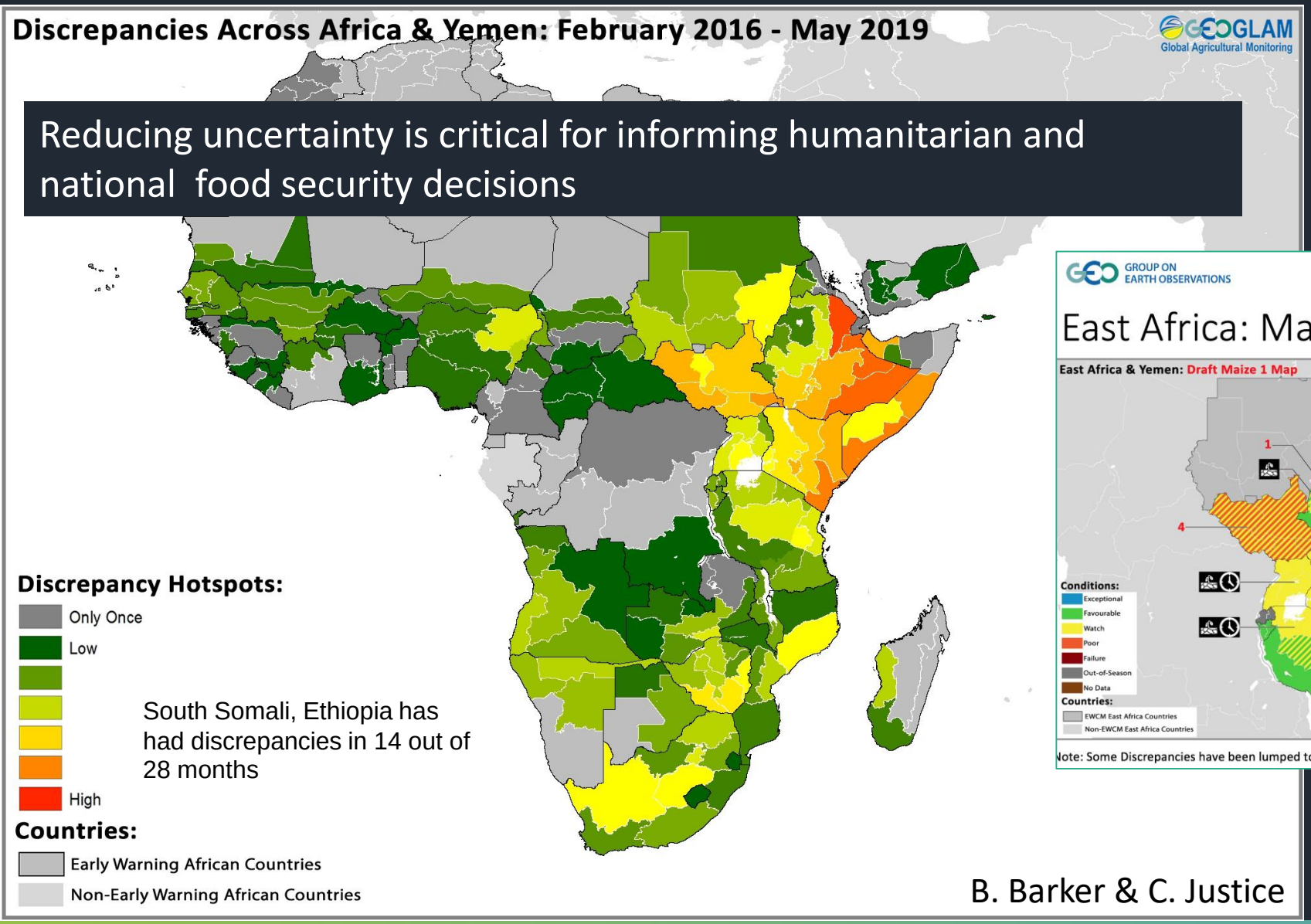
GEOGLAM CROP MONITOR FOR EARLY WARNING

Timely, reliable, information on crop conditions, reducing uncertainty in support of food security decisions





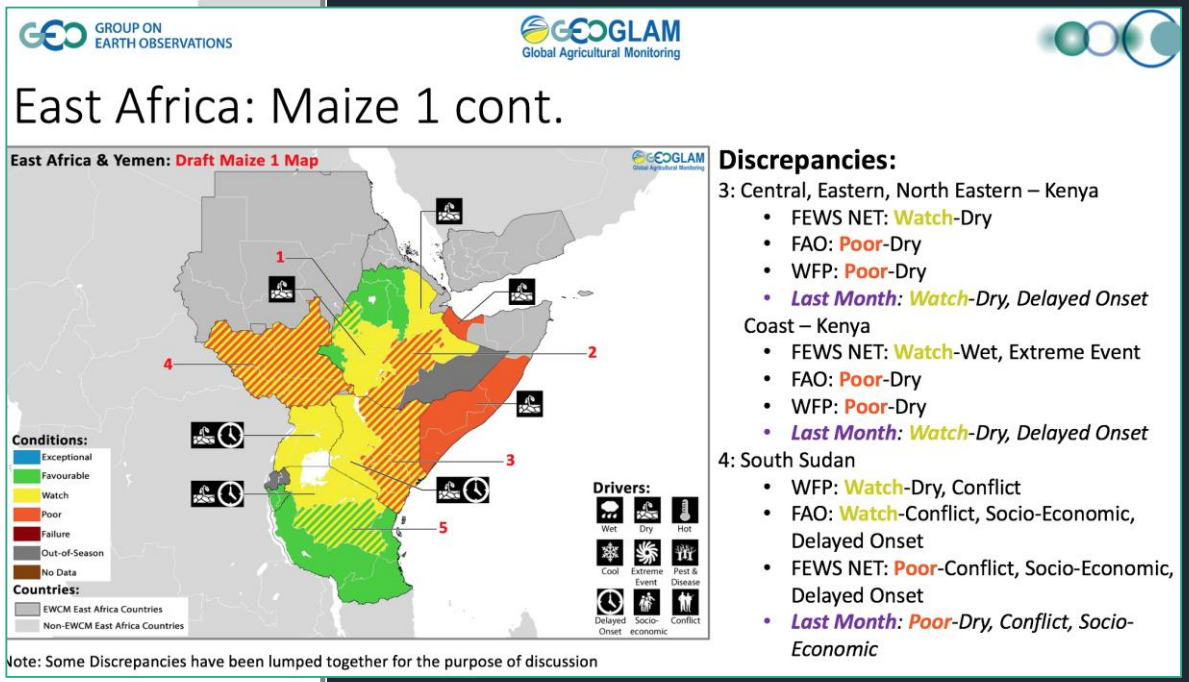
Inter-Agency Discrepancy Hotspots: April 2016- Sept 2018



Reducing uncertainty is critical for informing humanitarian and national food security decisions

South Somali, Ethiopia has had discrepancies in 14 out of 28 months

Interagency Discrepancy example



B. Barker & C. Justice

Business / Land & Agriculture

Dry and brown Southern Africa will need food ai

BY EMIKO TERAZONO AND ANDREW ENGLAND, FEBRUARY 15 2016, 05:52

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Vegetation Status and Crop Production Perspectives

Africa: A Season of Regional Drought

WFP VAM Report

Southern Africa Growing Season 2015-2016:

A Season of Regional Drought

vam food security analysis

FEWS NET

SOUTHERN AFRICA Spe

Illustrating the

FEWS NET Special Rep

United Nations Office for the Coordination of Humanitarian Affairs

OCHA

Figure 2: Crop Monitor (Source: GEOGLAM) (https://cropmonitor.org

USED TO INFORM DECISIONS ABOUT ALLOCATION OF SPECIFIC RESOURCES BY NATIONAL GOVERNMENTS & HUMANITARIAN ORGANIZATIONS

Trump Other Perceptions Of The Migrant Caravan

Poor crop yields in El Salvador FAO

Financial Times

corn withers a

ecord

eather on food prices

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Special alert: Food and Nutrition Security Worki

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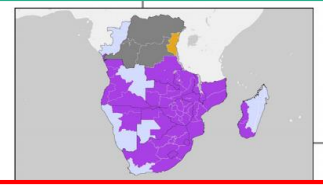
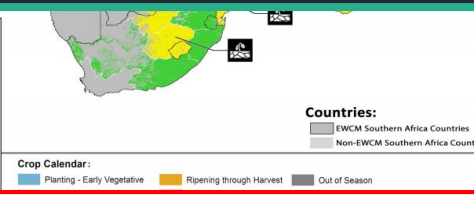
Highlights





Urgent Actions:

"There is urgent need for members states and development partners to **determine the scale and extent** of the possible impact of the prolonged dry spell on the agricult season (crop and livestock) to inform appropriate response actions for food security and nutrition and build the resilience of vulnerable populations in the region. **Recommended actions include increased monitoring of the situation**, ascertaining available cereal stocks, fast-tracking of planned crop assessments and annual vulnera assessments for early warning and early action and increasing off season production where possible."

Joint Statement

WFP World Food Programme

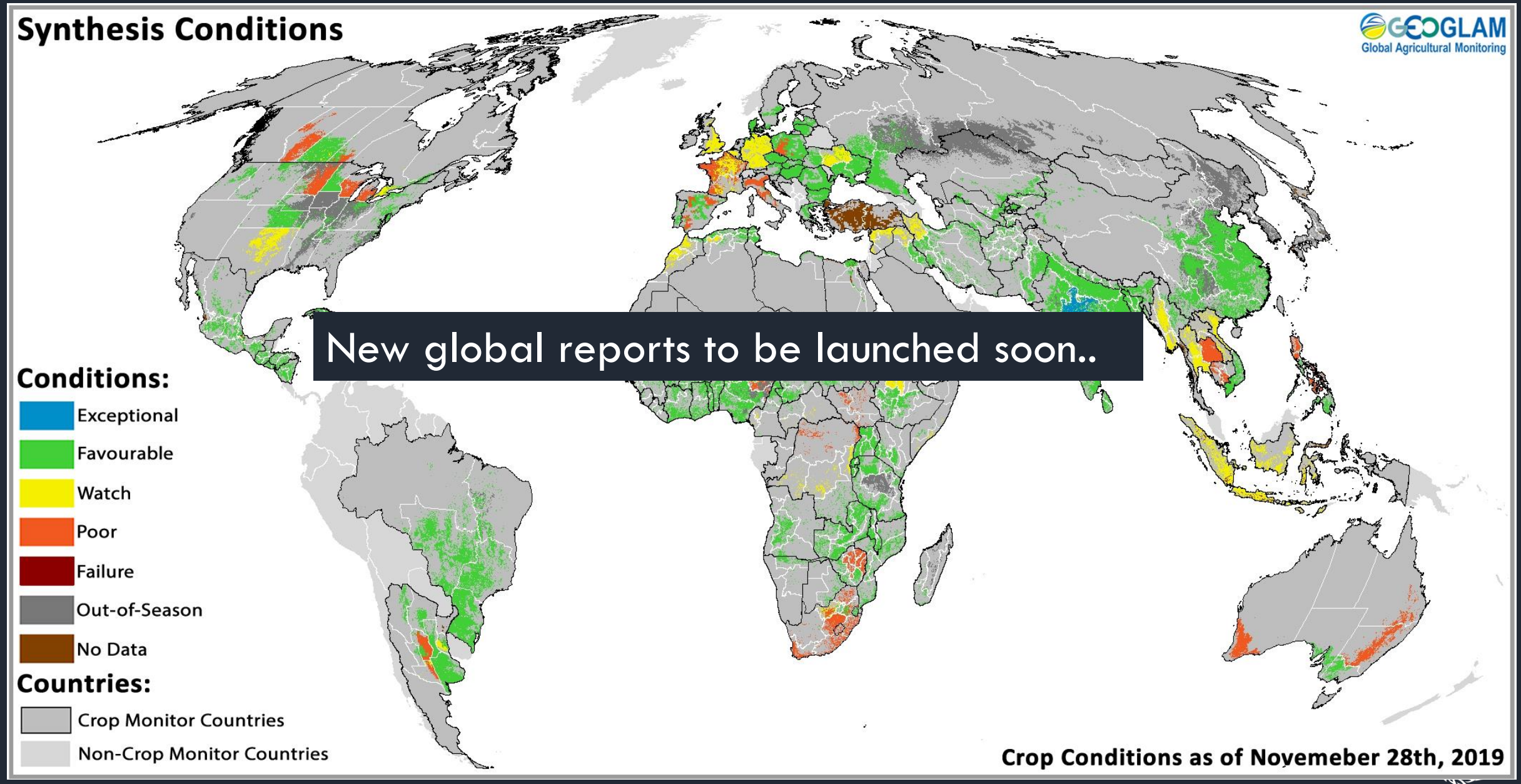
FEWS NET

Food and Agriculture Organization of the United Nations

El Niño Set to Have a Devastating Impact on Southern Africa's Harvests and Food Security

in April/May, the GEOGLAM Early Warning Crop Monitor (EWCM) had that as of February 28, crop failure had been confirmed in Lesotho, Swaziland, m Mozambique, southern Zimbabwe and eastern Botswana.

Current Global Crop Conditions



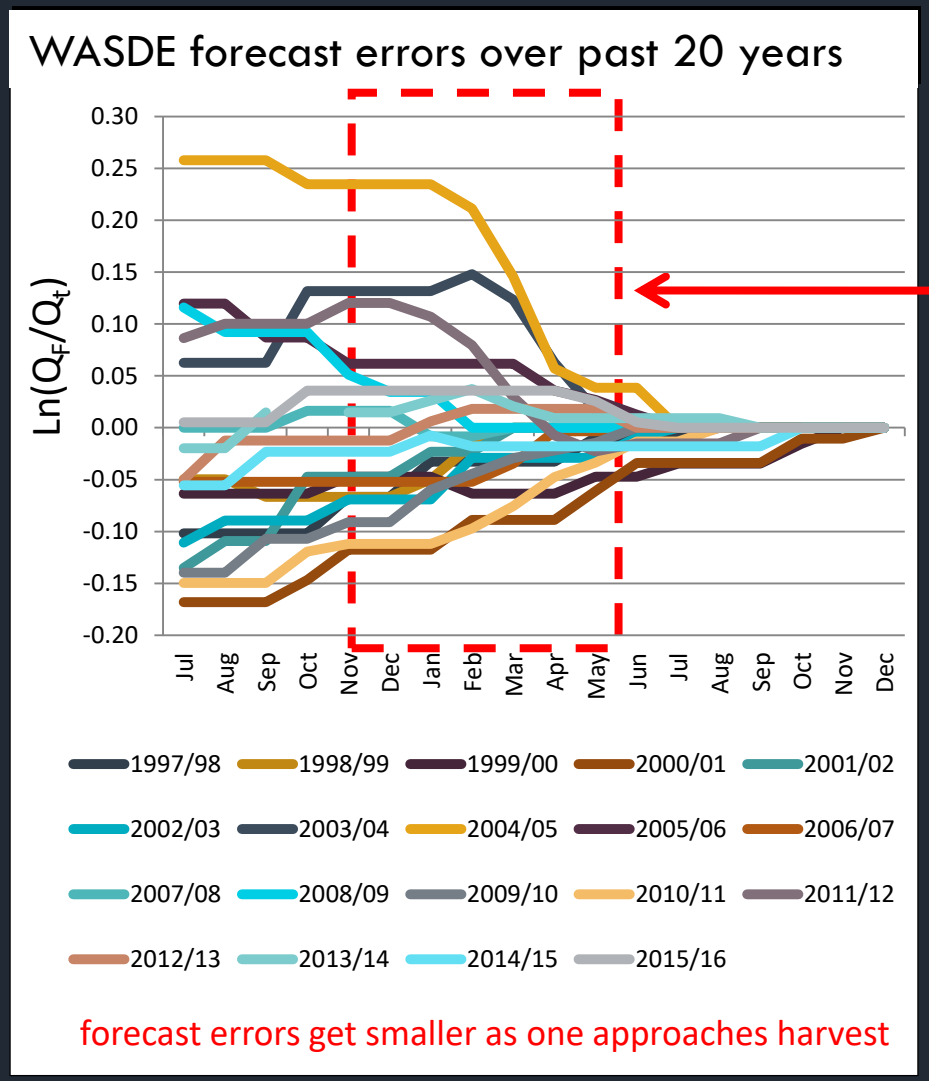
Example Harvest Activities

INTERNATIONAL MARKETS & TRADE

Reducing uncertainty & enhancing market transparency

Reducing Uncertainty During The Growing Season

Brazil Soybean Example



Opportunity window for Remote Sensing

J. Glauber

Case Study: US Corn Belt, in-season estimations using Machine Learning and Artificial Intelligence

Credit: Julius Schaaf (Iowa farmer)

Importance of the in-season estimations
US 2019/20

Table 1. NASS Planted Acreage Estimates (Thousand Acres)

Commodity	*Prospective Planting:* Mar-19	*Acreage:* Jun-19	*Crop Production* (Re-survey of Acreage): *Aug-19*
CORN	92,792	91,700	90,005
SOYBEANS	84,617	80,040	76,700
WHEAT	45,754	45,609	

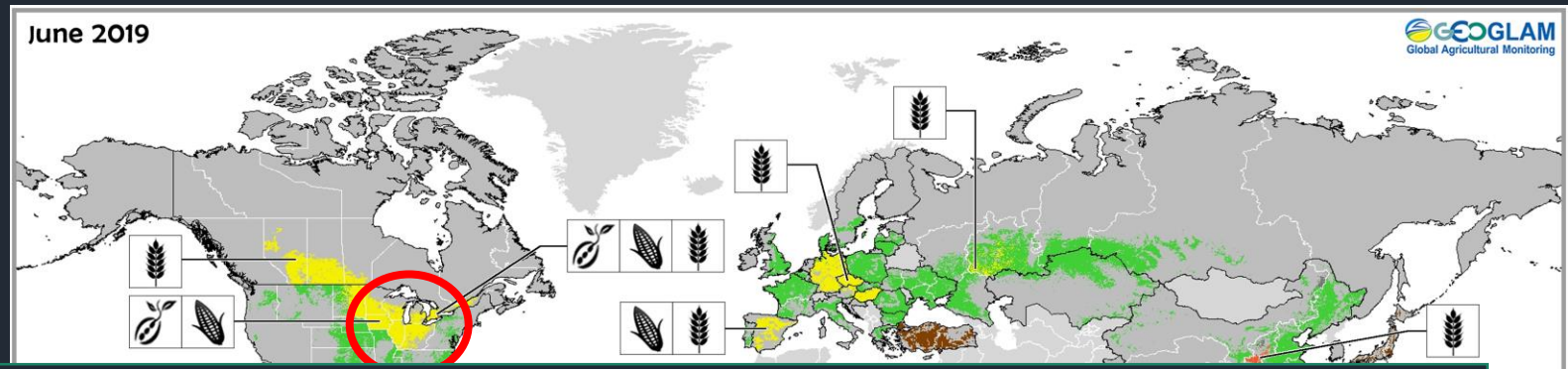
Data: United States Department of Agriculture – National Agricultura

ILLINOIS

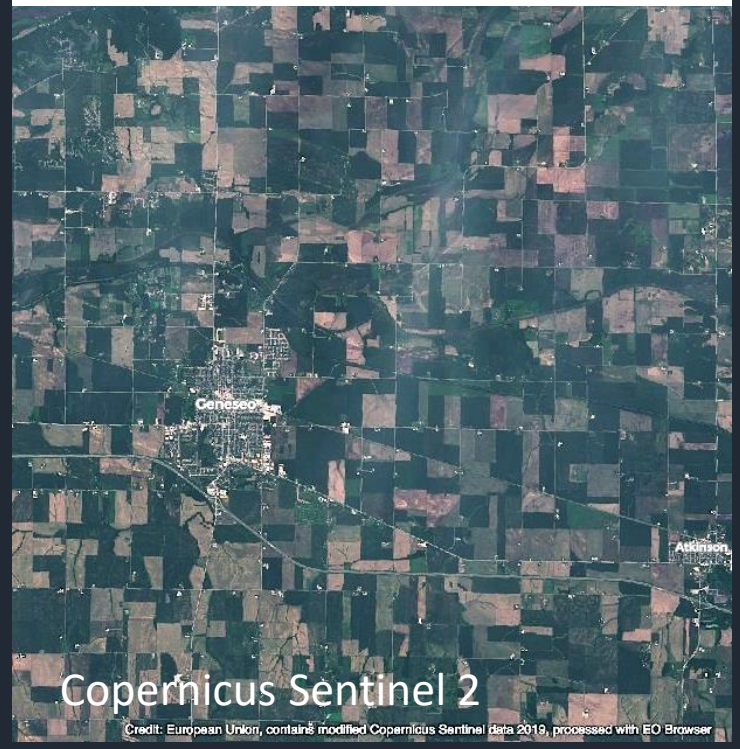
farmdocDAILY

HARVEST

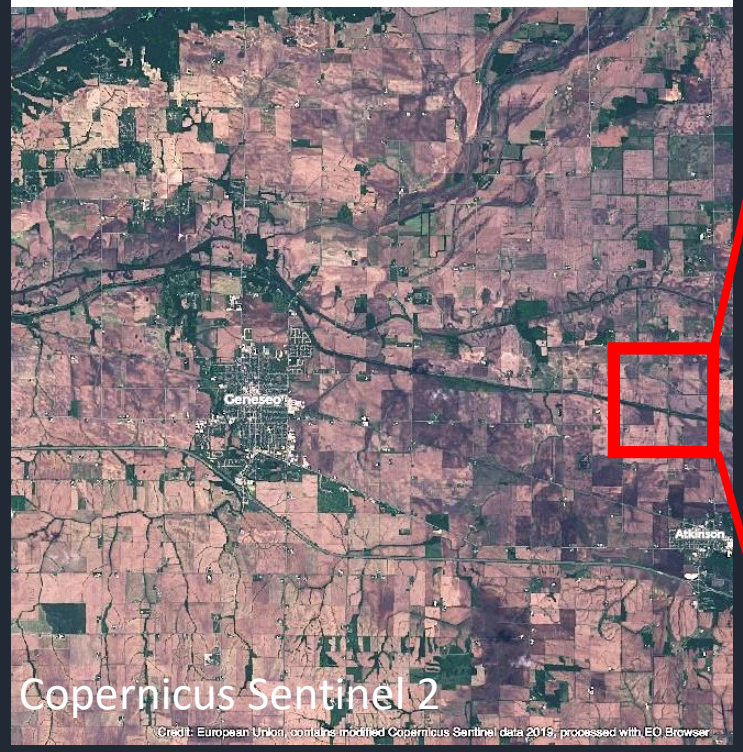
GEOGLAM Crop Monitor for AMIS



JUNE 13th 2018
Northern Illinois



JUNE 13th 2019
Northern Illinois

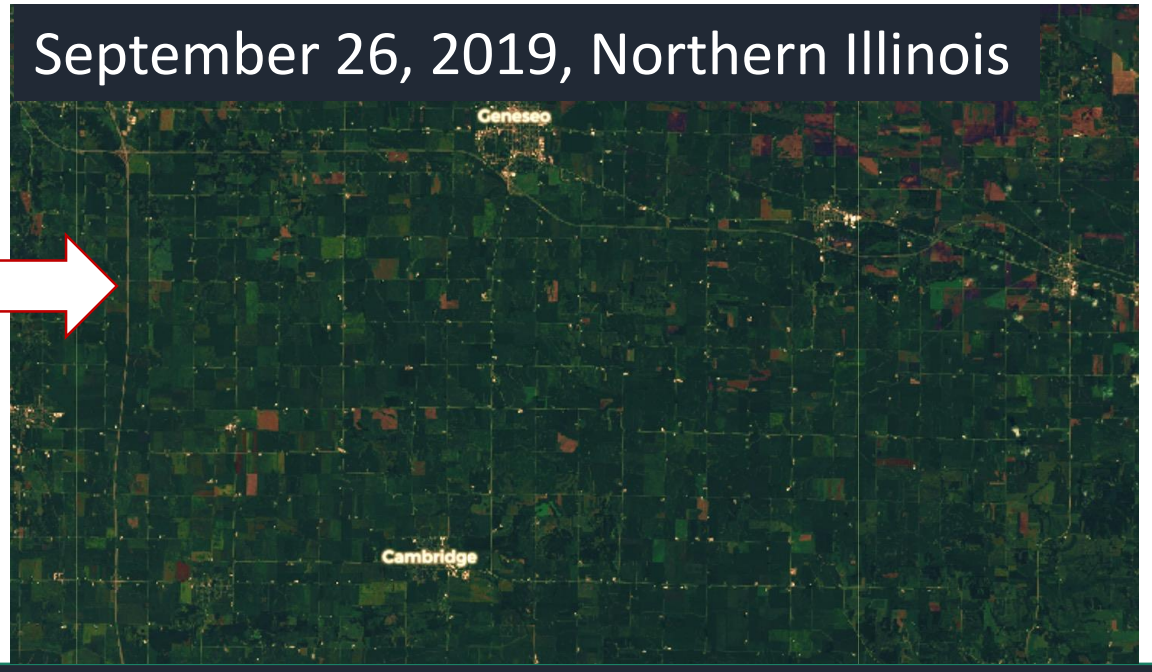


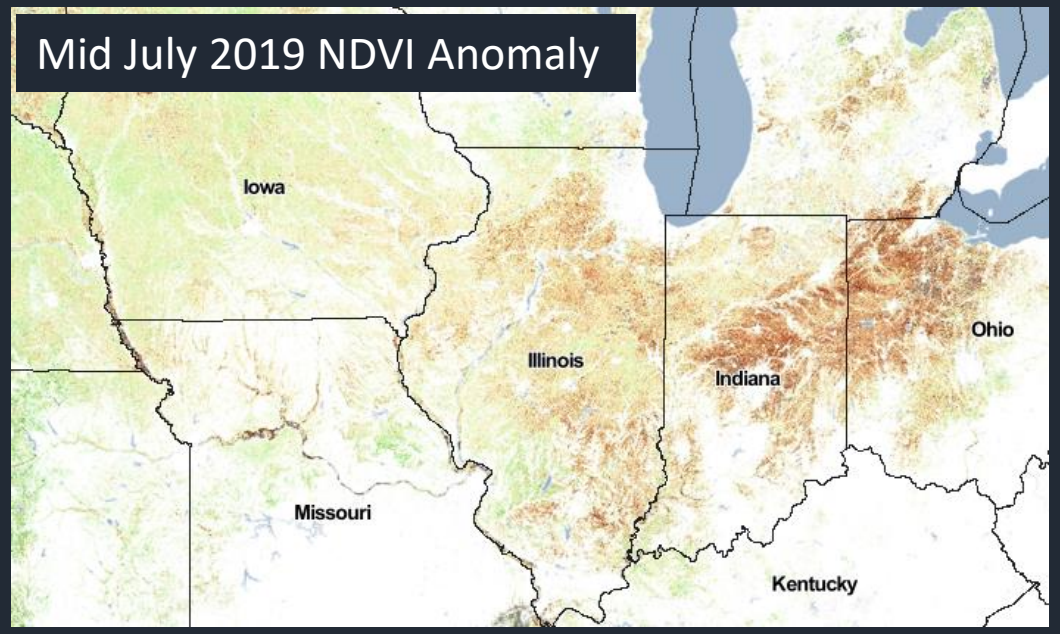
July 25, 2018, Northern Illinois

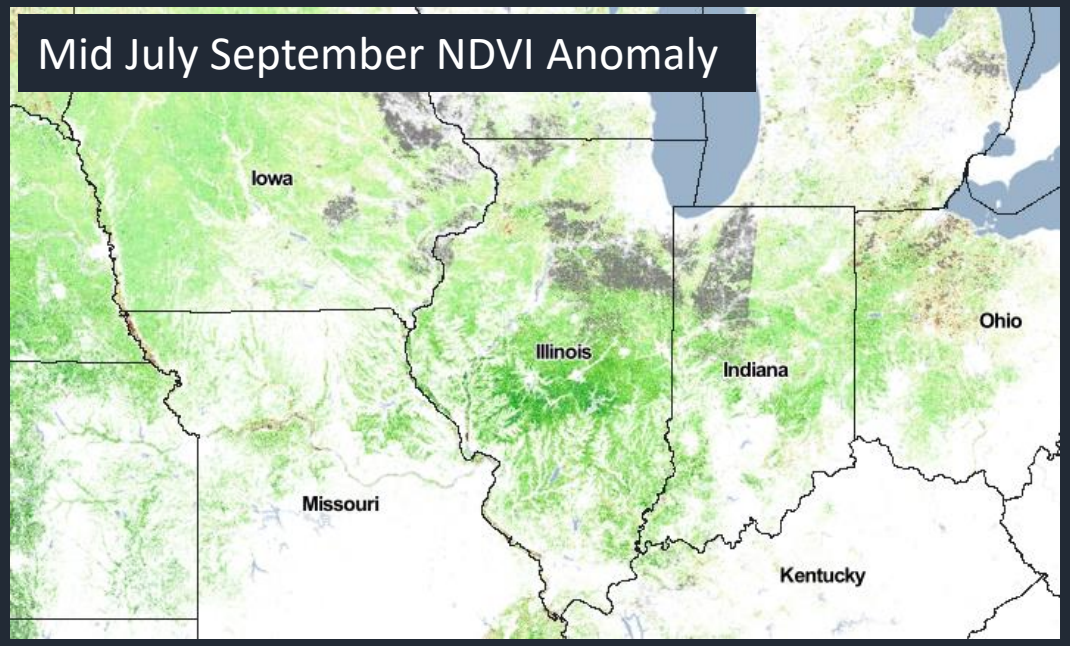
July 25, 2019, Northern Illinois

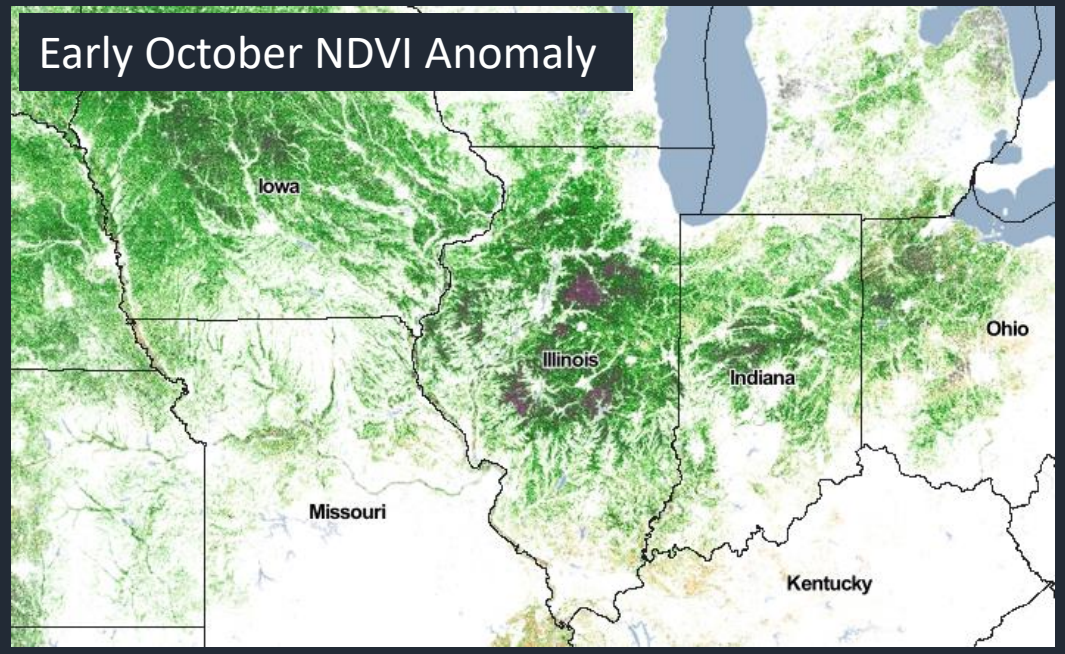
September 26, 2018, Northern Illinois

September 26, 2019, Northern Illinois





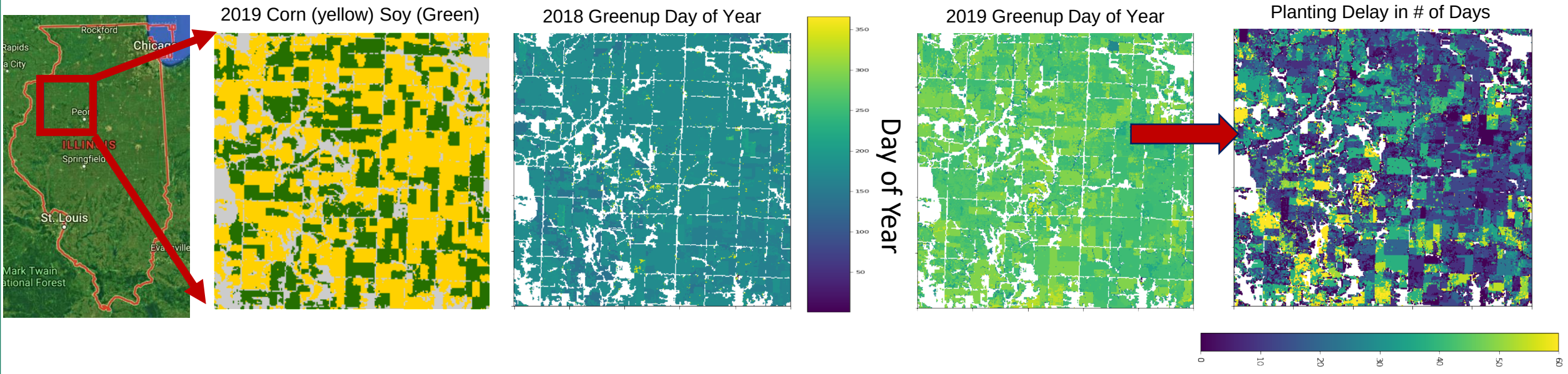




- Comparison of crop vegetation in mid July, mid September and early October 2019 vs. average conditions over croplands
- Brown indicates crop biomass below average, green & purple are above average

HOW DELAYED WAS THE 2019 US Season?

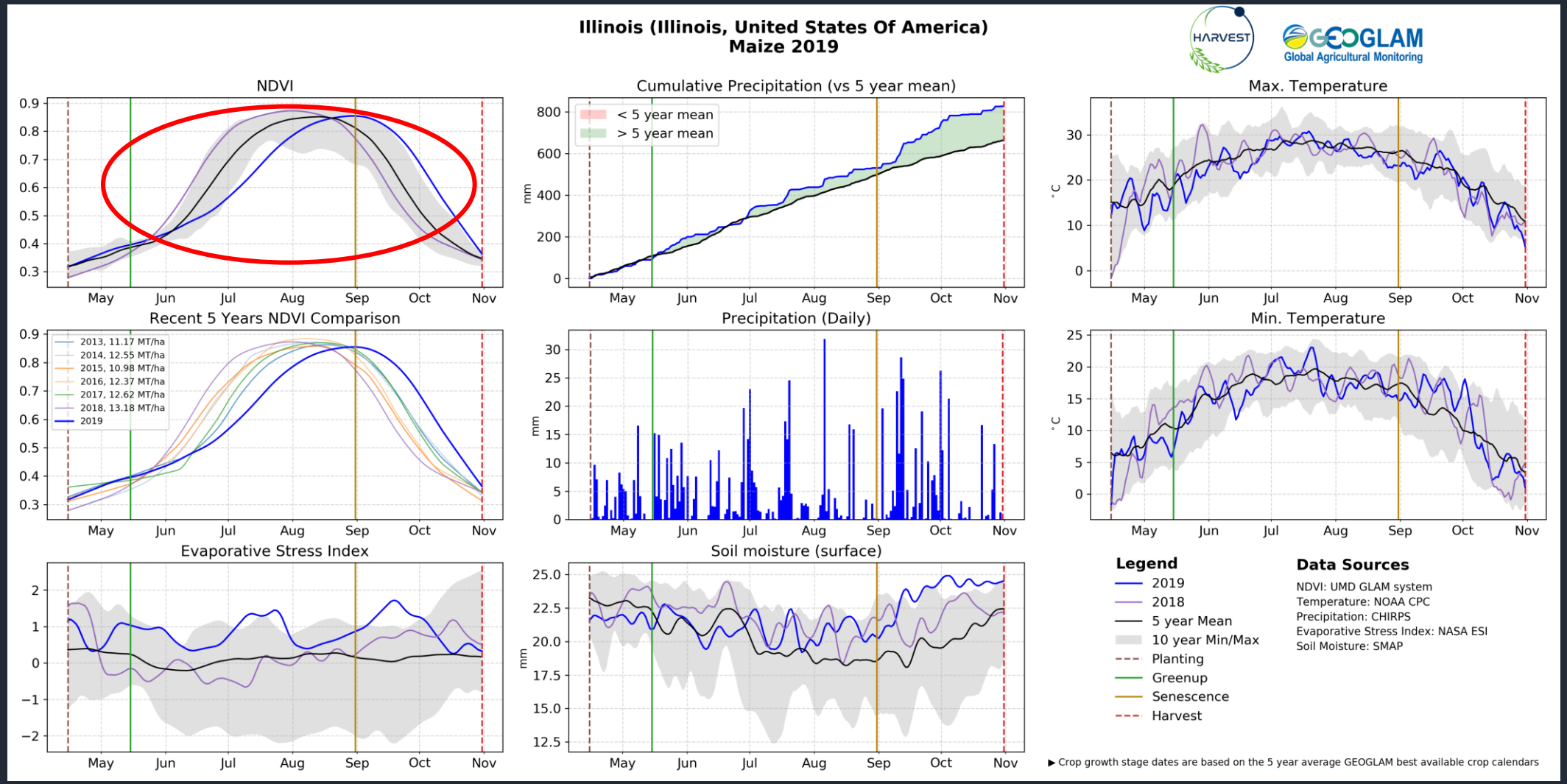
Field scale analysis of emergence dates, crop progress, and harvest dates
2019 Vs. 2018 crop emergence, Northern IL



- 2019 crops were planted much later
- Mean planting delay in 2019:
  - 26 days later than 2018 with some fields up to 60 days later

H. Kerner et al. UMD

Development of the 2019 season in Illinois

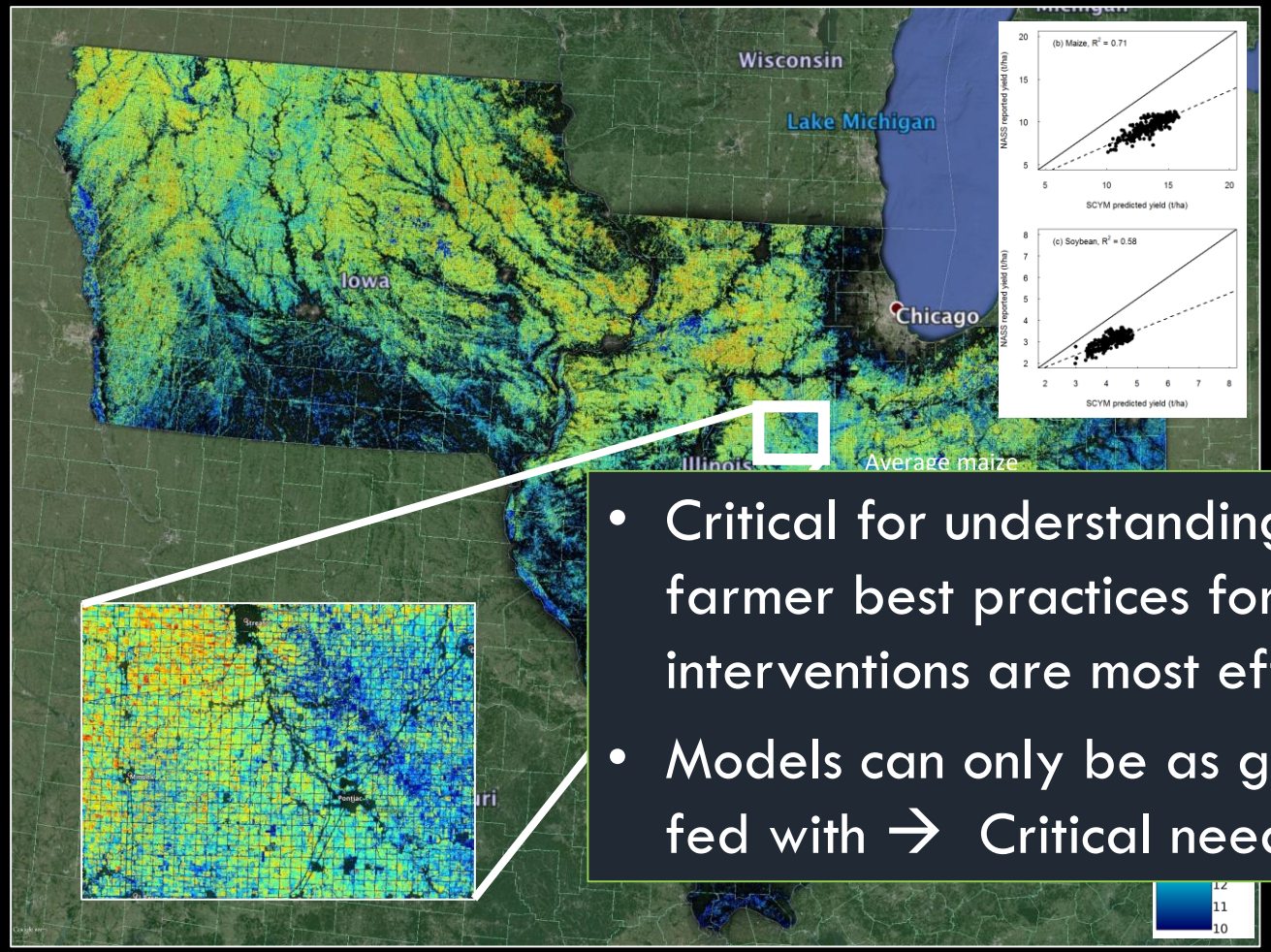


NASA Harvest GEOCIF forecast for US Corn: 166.1 bu/ac vs. USDA 167 bu/ac

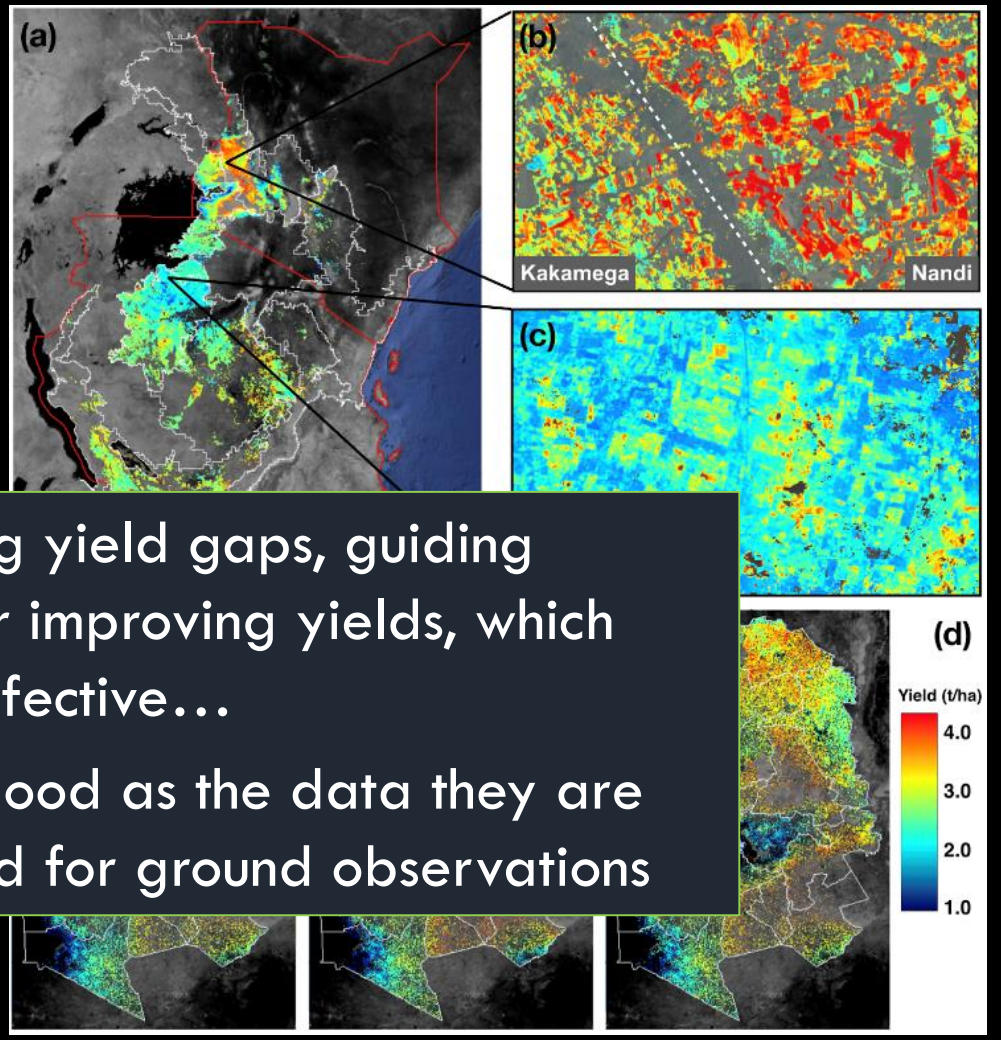
Sahajpal et al. UMD

End of season Field Yield Indicators at Scale

US Corn Belt



Tanzania and Kenya



- Critical for understanding yield gaps, guiding farmer best practices for improving yields, which interventions are most effective…
- Models can only be as good as the data they are fed with → Critical need for ground observations

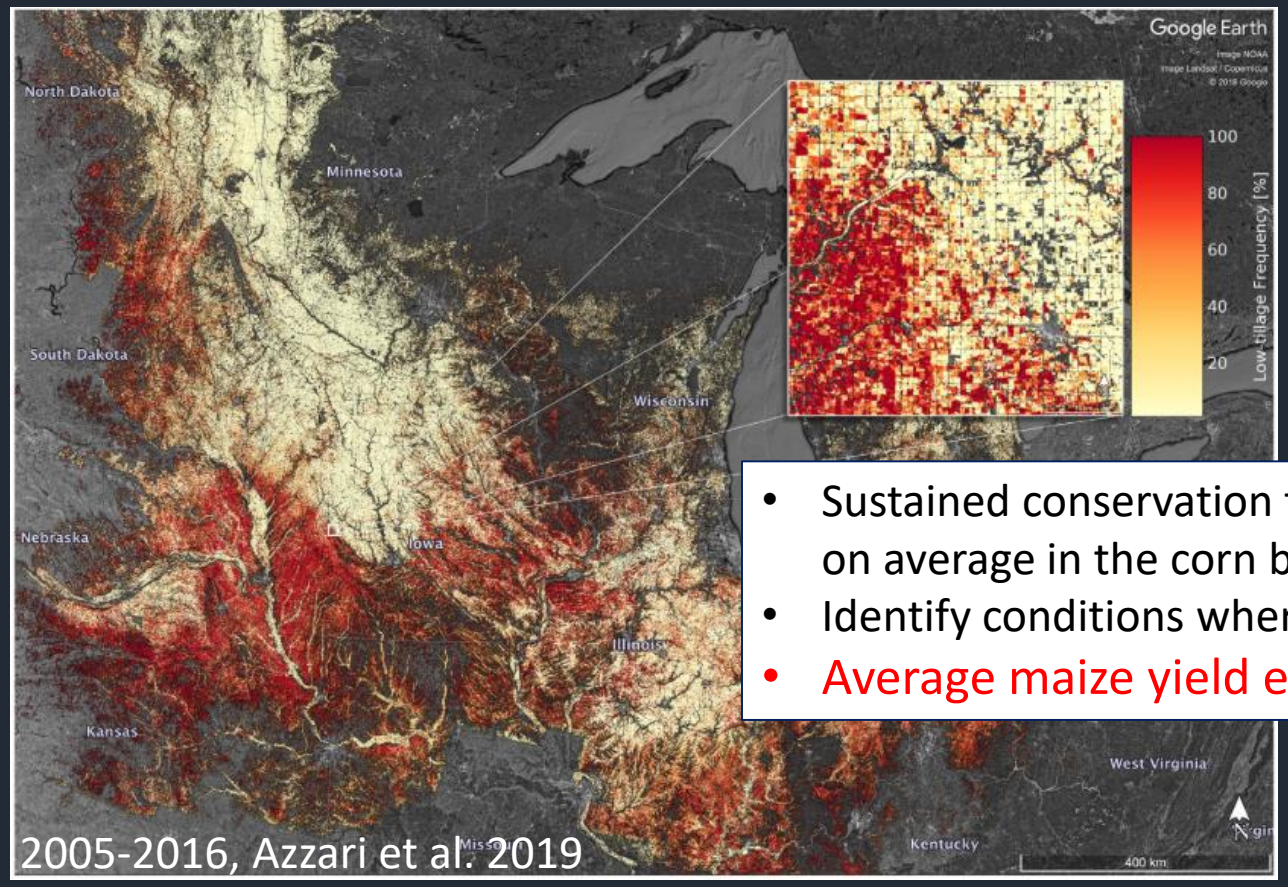
Lobell, Azzari, Stanford

Stanford | FSE Center on Food Security and the Environment

HARVEST

Assessing Conservation Tillage Impacts on Yields

Annual Field Scale Tillage Intensity Maps



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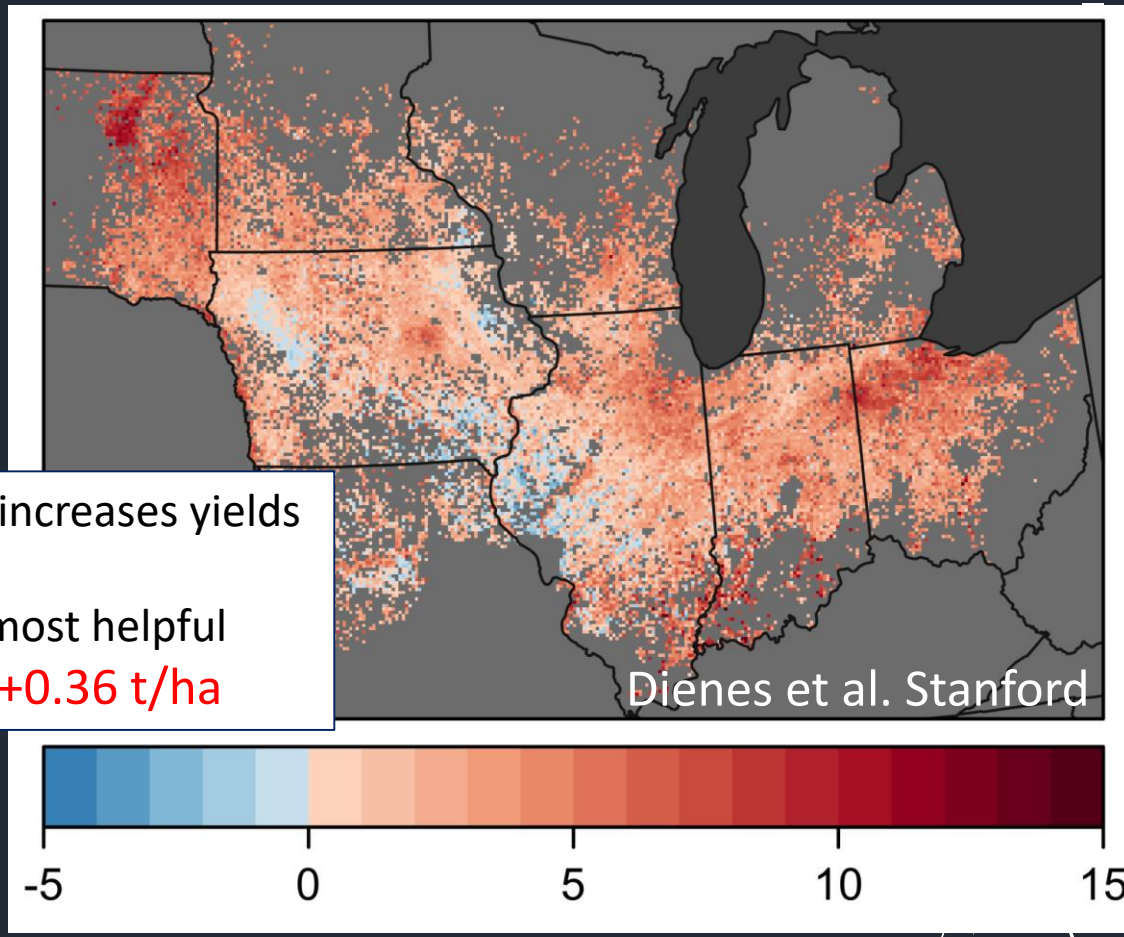
Impact of Conservation Tillage on Yields



- Sustained conservation tillage increases yields on average in the corn belt
- Identify conditions where it's most helpful
- Average maize yield effect: +0.36 t/ha

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Summary & Key Takeaways

- It's an exciting time for satellite-based agricultural monitoring
  - New era revolutionizing ability to provide accurate, timely, actionable info at scale
- Satellite data is playing an increasingly critical role across the agricultural sector, with a tangible impact on markets and trade.
- Realizing full potential & promise of satellite data requires:
  - Open sharing of data, information, methods and experiences
  - Stakeholder communities to drive the research and development
  - Innovation in science and technology
  - International collaboration and partnerships across countries, organizations, sectors, & disciplines
- NASA Harvest building on decades of investments by NASA & international community to radically advance uptake of satellite data for informing agricultural decisions across the globe

New data & technologies enable huge potential for progress, realizing it, requires close partnerships across research, policy and stakeholder communities

THANK YOU!

For More Information
Website: www.nasaharvest.org
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