Satellite Data Needs for Agriculture

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NASA ACRES PI : focus on US Domestic Agriculture

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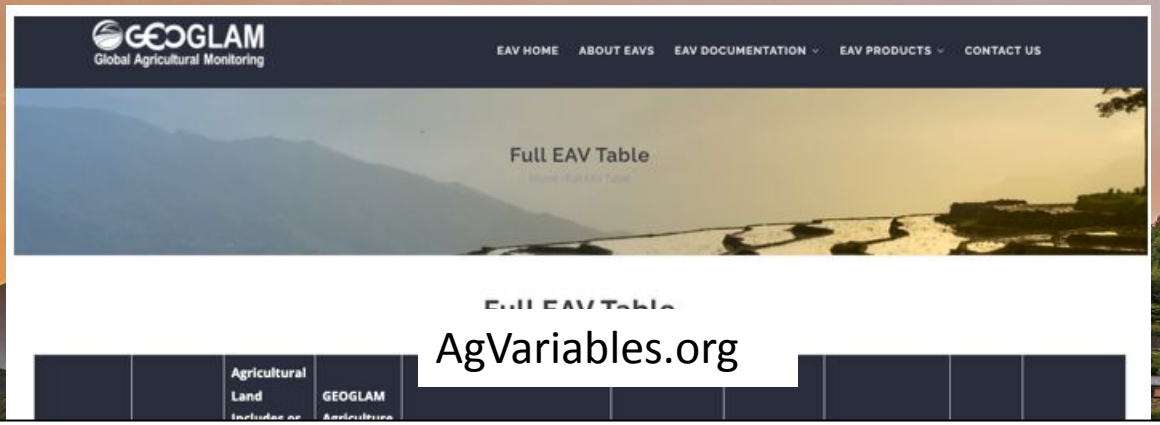
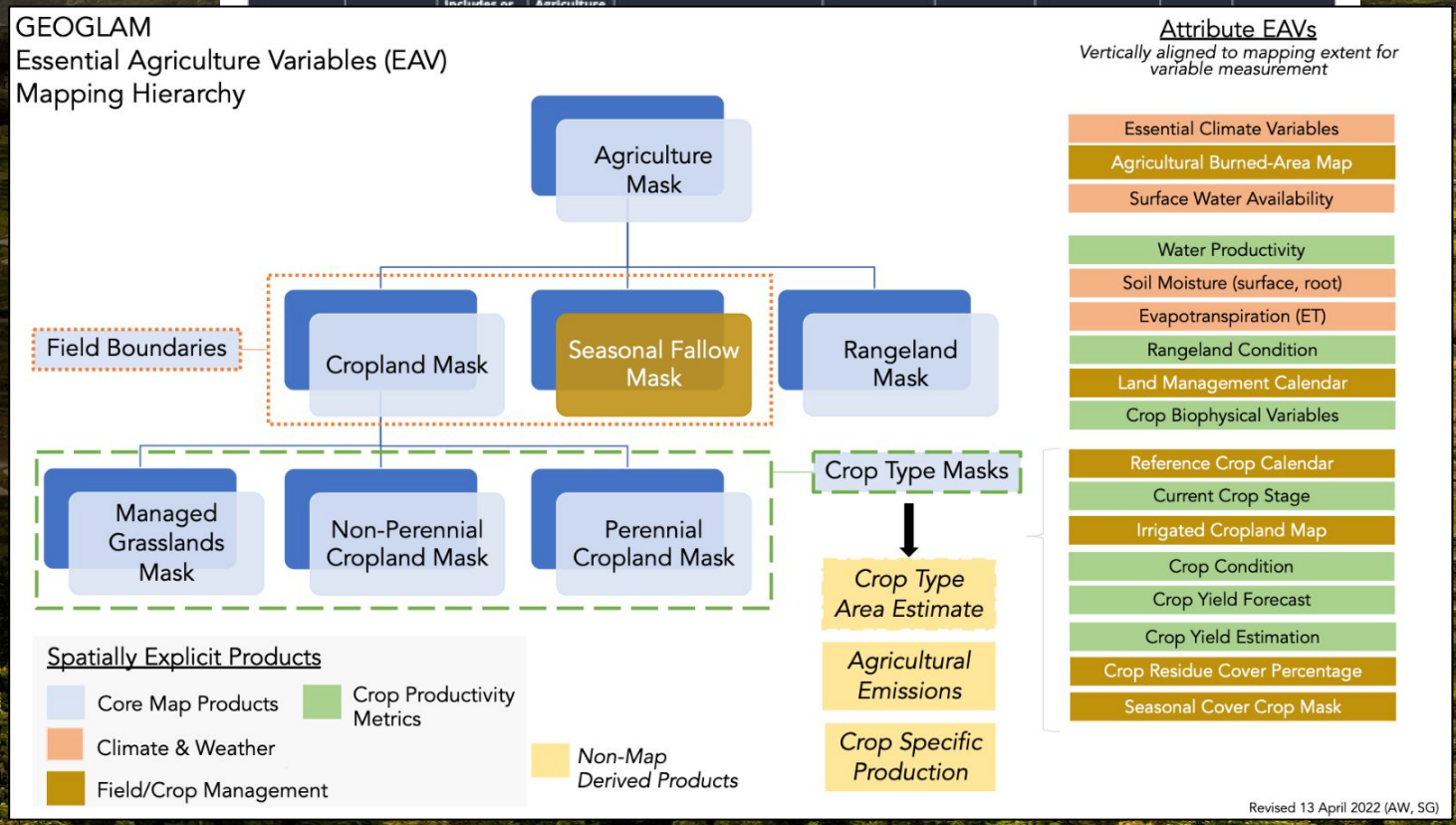
GeoXO NOAA's SATELLITE APPLICATIONS SYMPOSIUM SERIES: LAND AND AGRICULTURE (May 20, 2025)

GEOGLAM Initiative

Essential Agricultural Variables

- Addressing EO data needs
- Defining and Developing EAV's
- Operational requirements
  - Satellite Data Products
  - Product Accuracy Assessment
- Observation/Product gaps





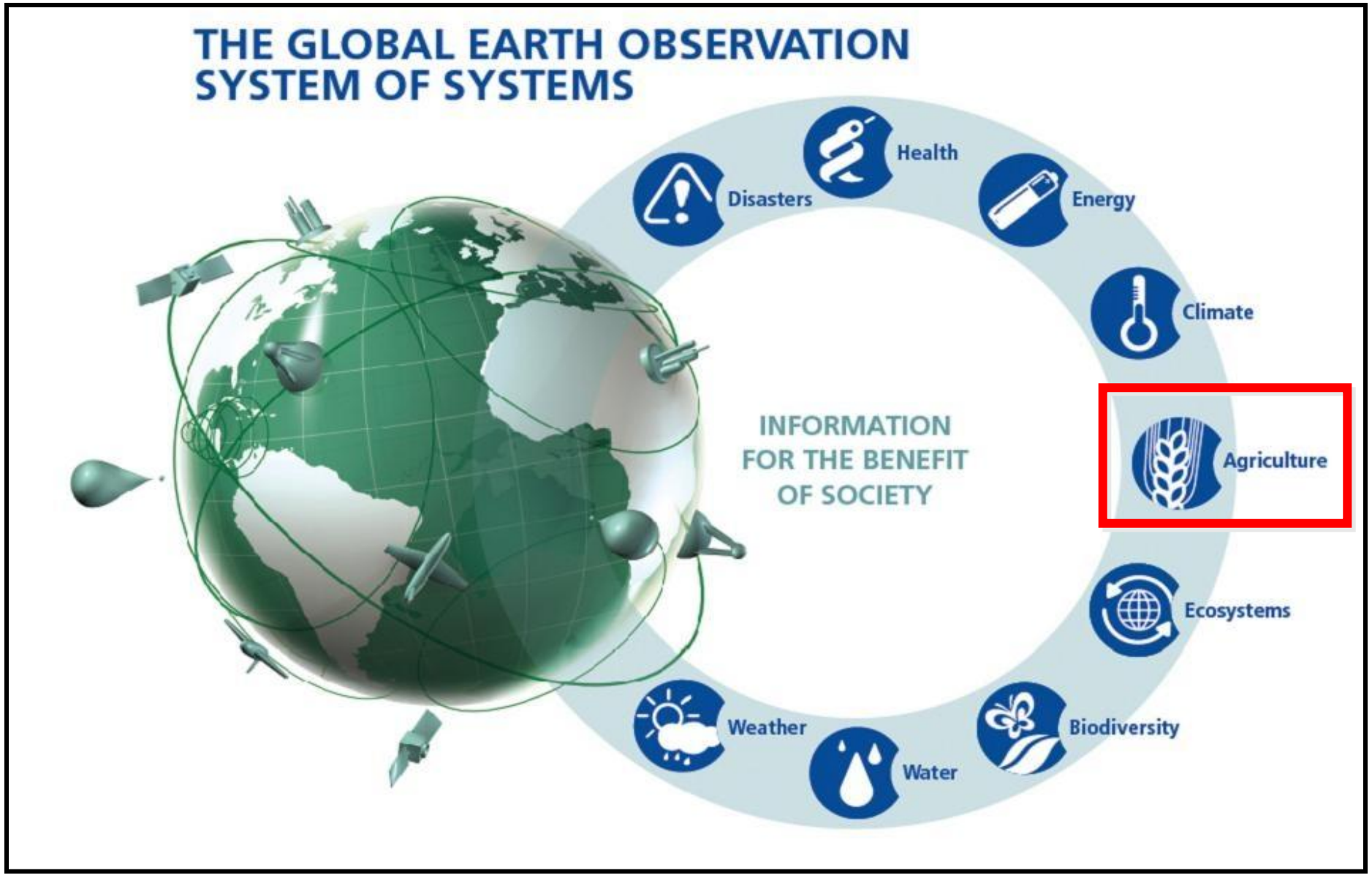
GEO the Group on Earth Observations

an Intergovernmental Organization

Meeting at the U.S. Department of State, Washington DC. July 31, 2003

Led to the Establishment of a

Global Earth Observing System of Systems (GEOSS)


THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS
Health
Disasters
Energy
Climate
INFORMATION FOR THE BENEFIT OF SOCIETY
Agriculture
Ecosystems
Weather
Water
Biodiversity

GEOGLAM Launched by the G20 Agriculture Ministers

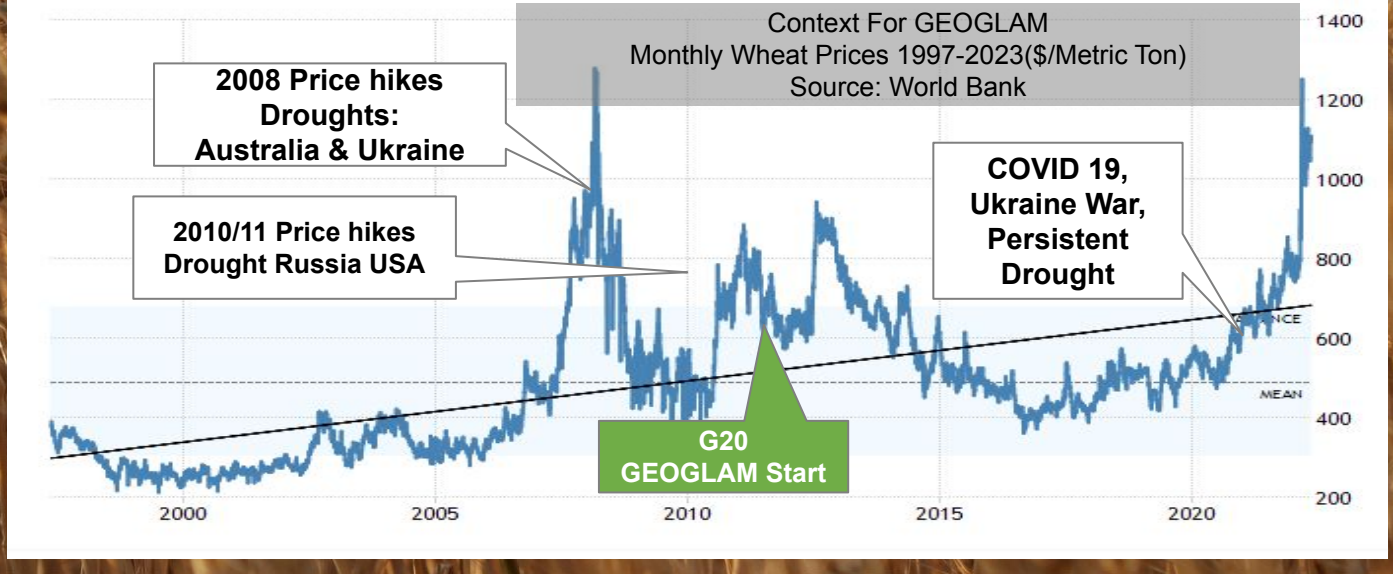
G20 Final Declaration

44. We commit to improve market information and transparency in order to make international markets for agricultural commodities more effective. To that end, we launched:

- The "Agricultural Market Information System" (AMIS) in Rome on September 15, 2011, to improve information on markets ...;
- The **"Global Agricultural Geo-monitoring Initiative" (GEO-GLAM)** in Geneva on September 22-23, 2011. This initiative will coordinate satellite monitoring observation systems in different regions of the world in order to enhance crop production projections and weather forecasting data.

Objective:

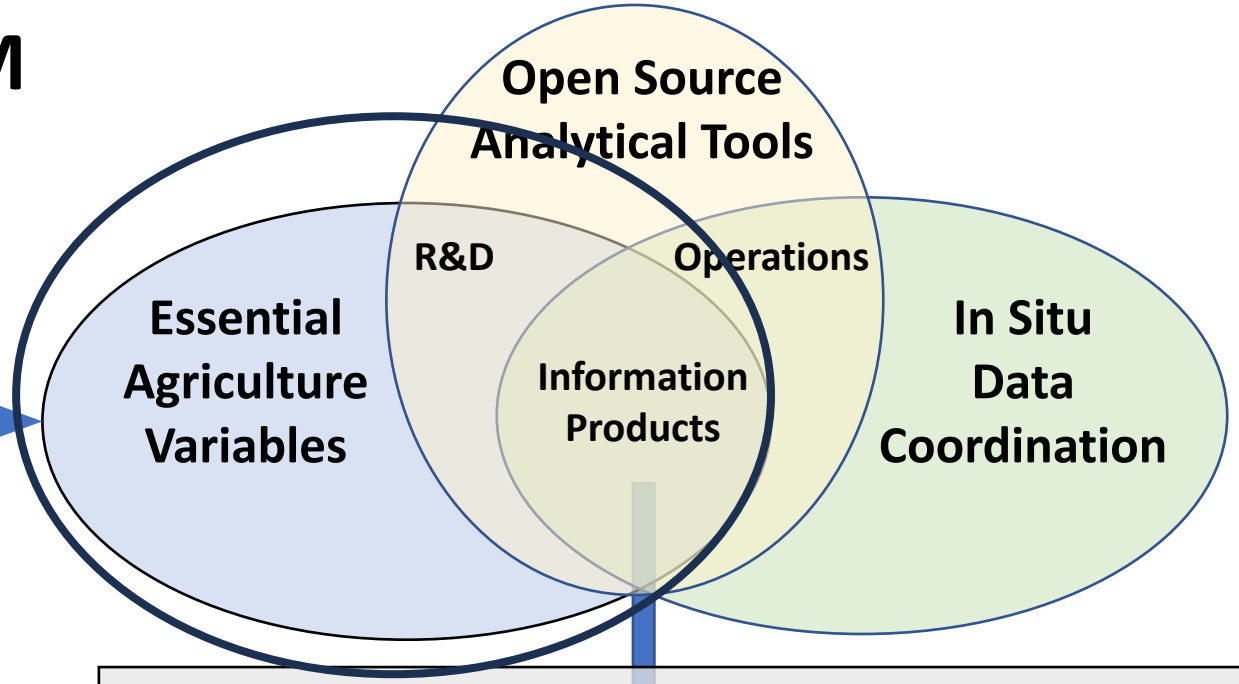
- To increase market transparency and improve food security by producing and disseminating relevant, timely, and actionable information on agricultural conditions at national, regional, and global scales
- Support markets and informing early warning for proactive response to emerging food emergencies



GEOGLAM

- **Vision:** the use of coordinated, comprehensive and sustained Earth Observations to inform decisions and actions in agriculture… through a system of agricultural monitoring systems
- **Aim:** strengthen the international community's capacity to utilize Earth Observations to produce and disseminate relevant information on agricultural production at national, regional and global scales
- **Approach:** Identifying information gaps, building on existing monitoring systems – strengthening international and national capacity -
  - Emphasis on producer countries (G20+), countries-at-risk and national capacity building
  - Fostering international cooperation and collaboration

GEOGLAM Thematic Structure



Ongoing Operations – Continue and Enhance:

- AMIS Crop Monitor
- CM4 Early Warning
- GEOGLAM Knowledge Hub
- JECAM
- Essential Agricultural Variables

Needs

Capacity (co) Development Guidance
(National and International)

Early Warning & Food Security
Crop monitor for early warning
- Seasonal Forecasts
- Special Reports

Market Information
Agricultural Markets Information System (AMIS)
- Commodity Crop Conditions
- Seasonal Forecasts

Food Security

Adaptation
National Adaptation Plans (NAP)
UNFCCC Supplemental
NAP Guidance

Mitigation
Global Stocktake (GST)
Nationally Determined Contributions (NDCs)
AFOLU Roadmap

Policy Support

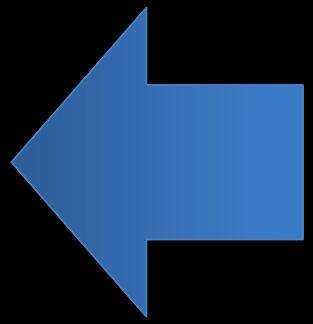
GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Identifying Information and Product Types

Information Products

- Crop outlook / Early warning
- Area estimate
- Yield forecast
- Production estimate
- Food Sec/vulnerability report
- Statistics reports



EO Data Products

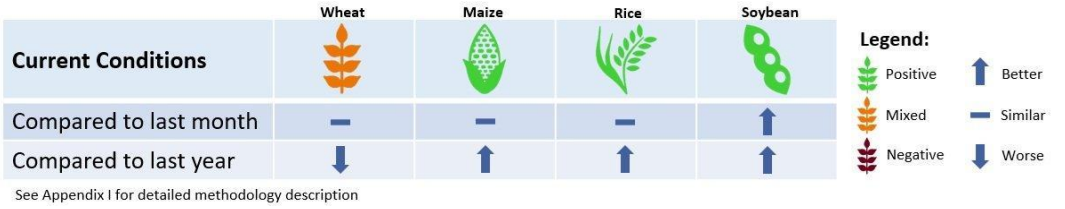
- Crop condition indicators
- Cropland mask /Pasturelands
- Ag practices (e.g. tillage, cover crops)
- Crop type
- Biophysical variables
- Environmental variables (e.g. soil moisture)
- Weather

GEOGLAM Crop Monitor

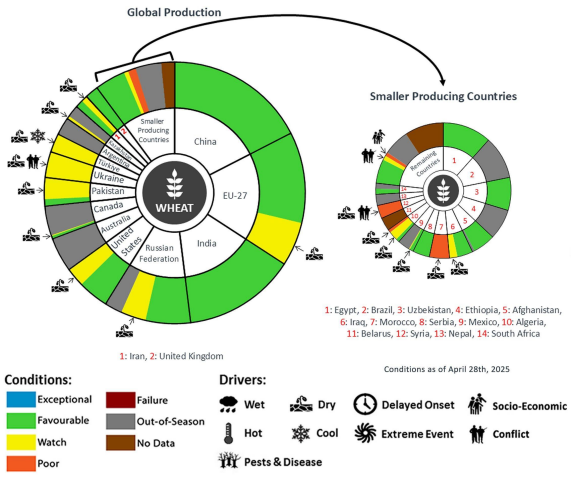
Transparent, consensus-driven and timely information on global crop conditions for policy, markets, & early warning communities since 2013

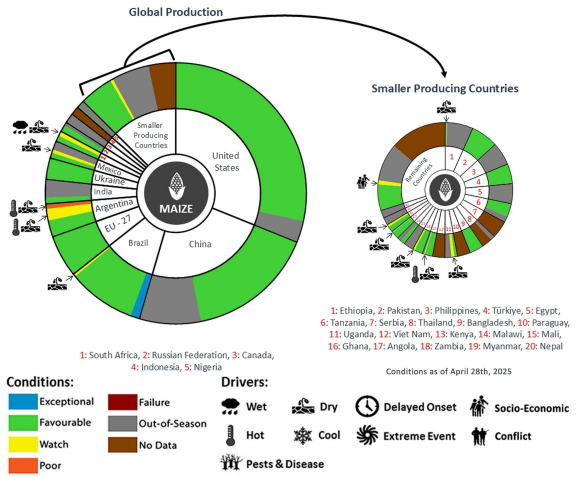
Covers 97% of global agricultural production

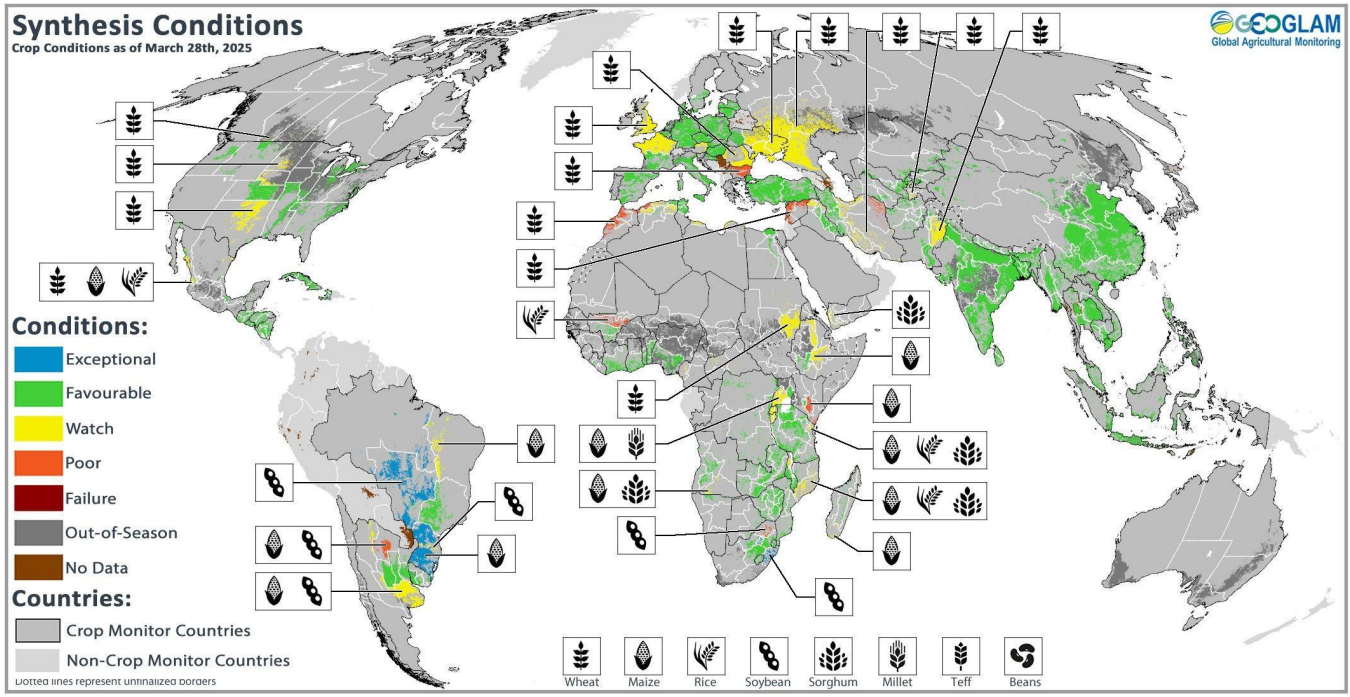
Produced in partnership with the main agricultural and food security monitoring agencies globally

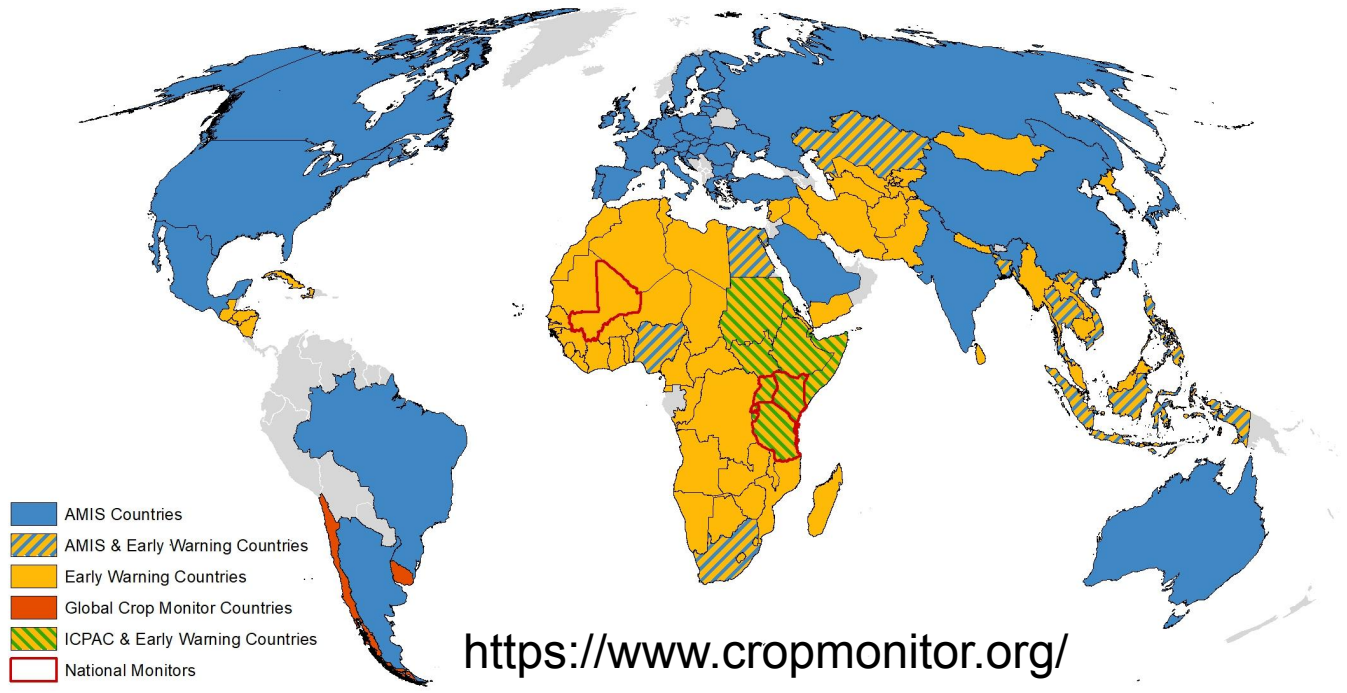


See Appendix I for detailed methodology description



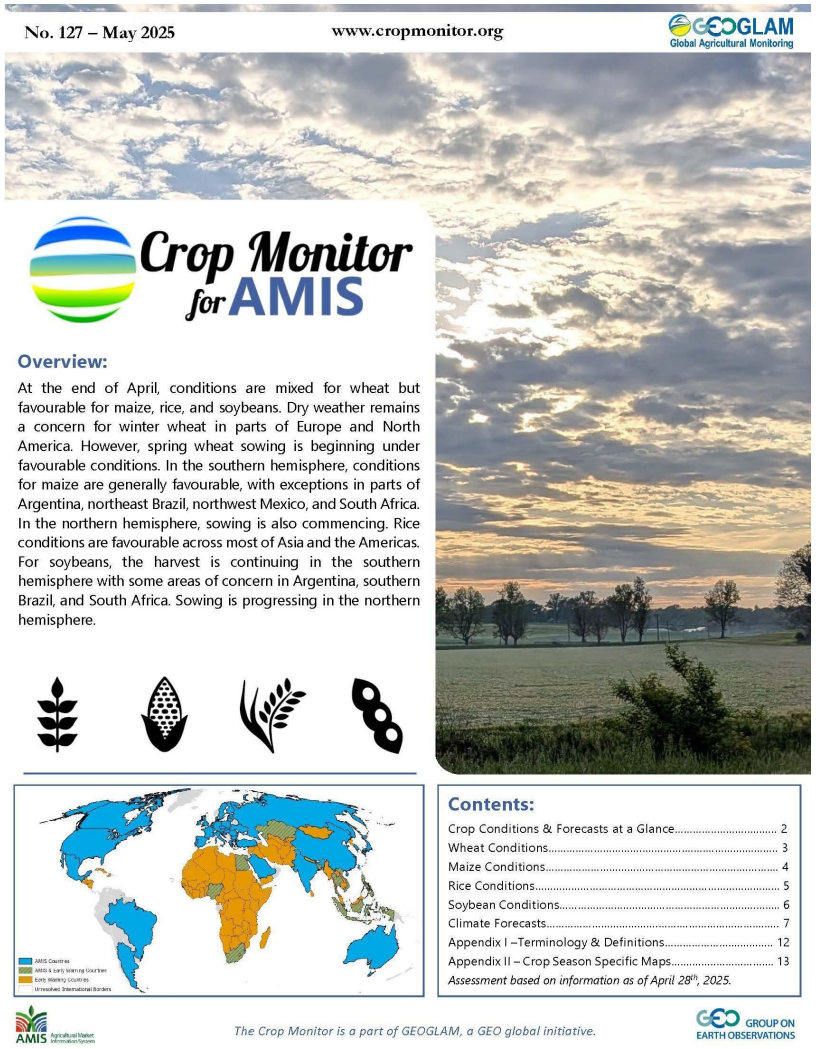




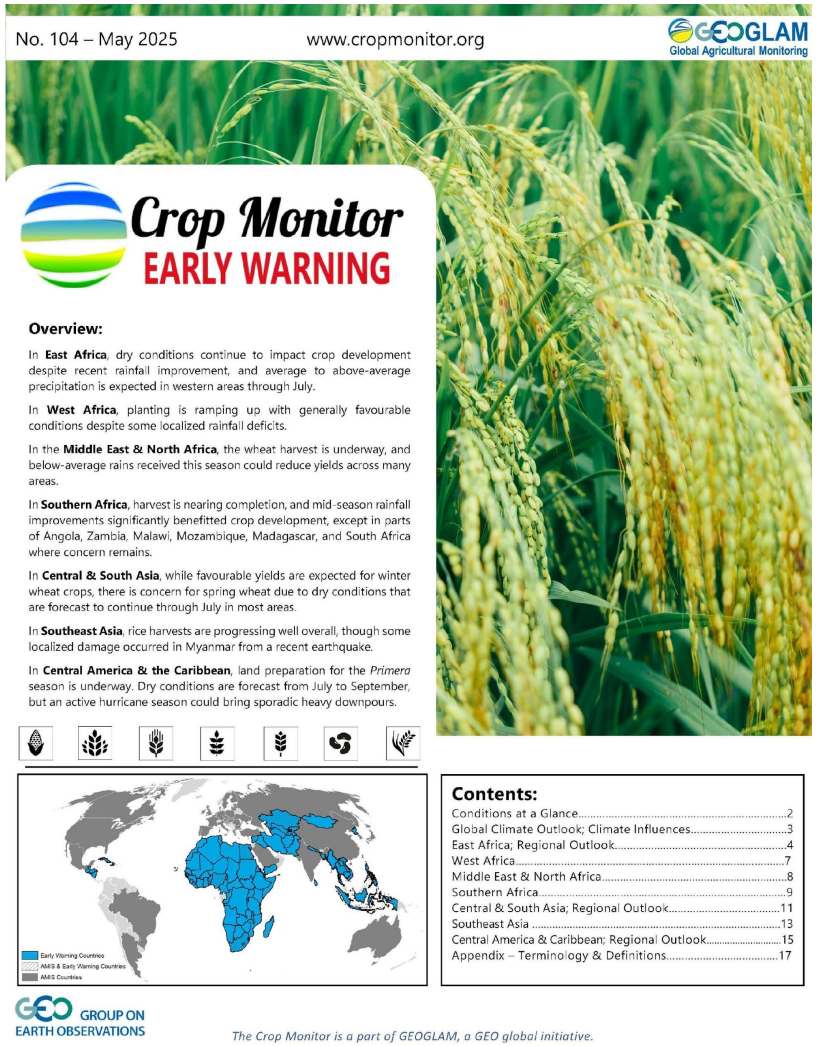


https://www.cropmonitor.org/

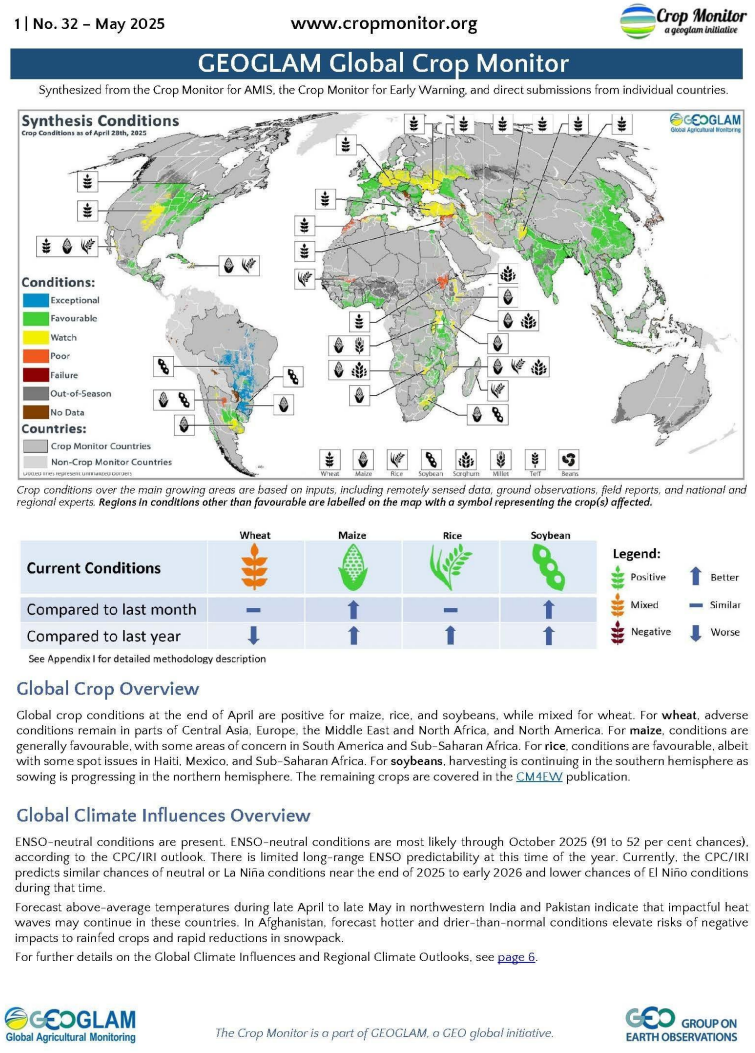
Monthly GEOGLAM Crop Monitor Publications



Crop Monitor for AMIS
Launched 2013
127 publications to date



Crop Monitor for Early Warning
Launched 2016
104 publications to date



Global Crop Monitor
Launched 2022
32 publications to date

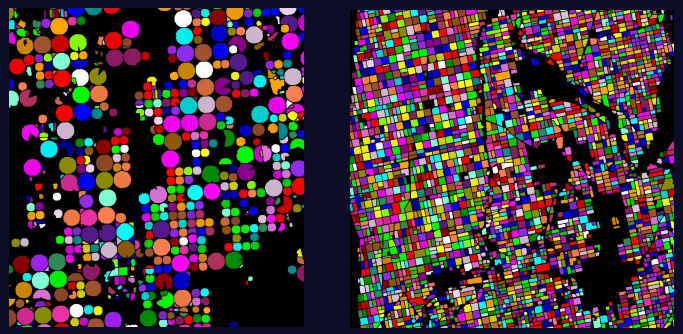
What can satellites *(help)* tell us about agriculture?

Essential Agriculture Variables

Measurable "building blocks" to understand state and change in agriculture

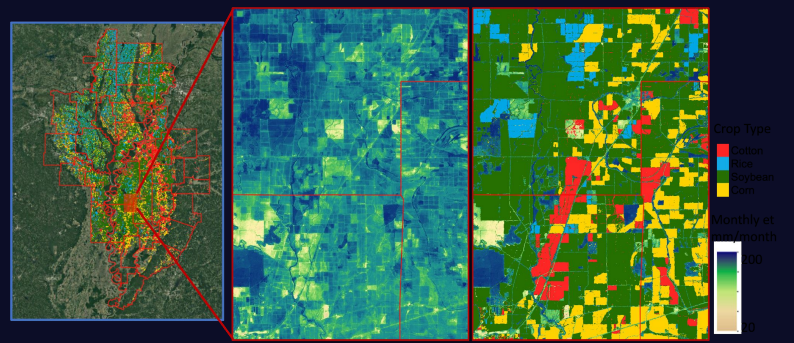
- **What nature is doing** ***(what, when, where)***
  - Temperature, precipitation, flooding, wind speed, extreme weather, drought, water availability, soil moisture, evapotranspiration…
  - Disease early detection
- **What humans are doing** ***(what, when, where)***
  - Cropland and crop type mapping; area estimation
  - Crop & field management; e.g. ~planting & harvest dates, irrigation, cover crop, tillage
  - Rotational grazing
- **What resulted**
  - Canopy nitrogen content and requirements
  - Yield (forecast and final)
  - Cover crop performance (N, C)
  - Forage quality
  - Emissions and sequestration**
  - Water use efficiency
- **What we can expect in the future**
  - Pest & disease risk
  - Within-season field forecast
  - Long-term responses to climate change

Field Boundaries and Sizes



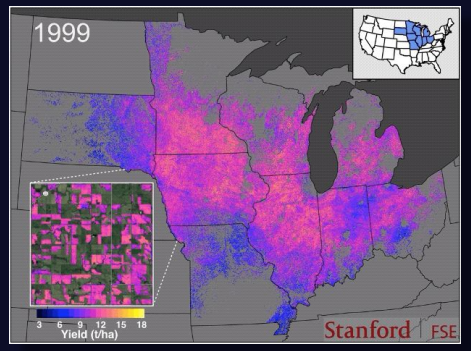
Yan & Roy, Mich State

Evapotranspiration



Y. Yang, Mississippi State;

Field Scale Yield Forecast & Estimation



Lobell Lab; Jin et al., 2015, Stanford

GEOGLAM CEOS: Earth Observations Requirements Table

developed taking into consideration the observation needs, the derived products they will serve, and regional specificities; CEOS-GEOGLAM July 2012 Montreal)

	OBSERVATION & SENSOR TYPE			REGIONAL CHARACTERISTICS & GEOGRAPHICAL EXTENT						DERIVED PRODUCTS & MONITORING APPLICATONS							
	SPATIAL RES.	SPECTRAL RES.	TEMPORAL RES.	WHERE? (+ cropland mask & sampling scheme)				WHEN?									
Sensor Mission	Spatial resolution	Spectral range	Effective observ. frequency (cloud free)*	Swath / Extent	Sample (s), Refined (rs) or Wall -to-Wall (w2w)	Large, Medium, Small fields	Crop types diversity	Calendar/ Multiple cropping	Cloud coverage	Use (Primary or Secondary Source)	Cropland s mask	Crop type area	Crop cond. indicators	Crop bioph. var.	Env. variables (reservoir, water, soil moisture)	Ag. Practices / Cropping systems	Crop yield
MODIS (aqua/Terra), VIIRS(NPP), Vegetation (SPOT-5)	2000 - 500 m	thermal IR + optical	few per day	global	w2w					NRT products (PS)			x	x (L)			
MODIS (optical not SWIR), Sentinel 3? (future), CMA FY series?, Proba-V (future)	100-300m	optical + SWIR	2 to 5 per week	global	w2w	L/M/S		*		NRT products (PS)	x	x	x	x (L)		x (L)	x (L)
FUTURE	1-15km	passive microwave	daily	global	w2w					NRT products (PS)					x		
FUTURE	50-150 m	SAR dual pol. (X,C,L) ****	5 per season	main crops	s	L/M/S	rice area	entire growing season	high cloud cov.	NRT products (SS/PS)*	x	x	x	x (L)	x	x (L)	
FUTURE	5-20m	SAR dual pol. (X,C,L) ****	5 per season	main crops	s	L/M/S	rice area		high cloud cov.	NRT products (SS/PS)*		x	x	x	x	x	
FUTURE	Footprint	RADAR Altimetry	weekly		s					NRT products (PS)					x		
ETM+ (Landsat-7), ASTER (Terra), TIRS(LDCM), IRMSS (CBERS-3)	50-100m	thermal	daily ?	main crops	s	L/M/S		entire growing season		NRT products (PS)			x				
All Optical Mid-Resoltuion (Landsat, Terra, EO-1, ResourceSat-2, CBERS-3, Sentinel-2)	20-70m	optical + SWIR	1 per month (if possible same sensor) (min 2 out of season + 3 in season)	croplands	w2w	all M/S		year-round, focus on growing season		annual products (PS)	M/S	M					
All Optical Mid-Resoltuion (Landsat, Terra, EO-1, ResourceSat-2, CBERS-3, Sentinel-2)	20-70m	optical+SWIR	1 per week (min. 1 per 2 weeks)	main crops	s	country specific (see phasing) L/M/S		entire growing season		NRT products (PS)	L/M/S	M/S	x	x	x	x	
HGR (SPOT-5), Rapid Eye (optical)	5-10 m	optical (+SWIR)***	1 per month (if possible same sensor) (min 2 out of season + 3 in season)	croplands	rs	L/M/S (focus on S)		year-round, focus on growing season		annual products (PS)	L/M/S	L/M/S					
HGR (SPOT-5), Rapid Eye (optical)	5-10 m	optical (+SWIR)***	1 per week (min. 1 per 2 weeks)	main crops	rs2	country specific (see phasing) S		entire growing season		NRT products (PS)			x	x	x	x	
HIRI (Pleiades), IKONOS, GeoEye, WorldView2 (optical)	< 5 m	optical	1 to 2 per month	croplands	rs3	demo. case (2 - 5% of croplands L/M/S)		2 - 4 coverages per year		annual products (PS)		x				x	x

spatial & spectral

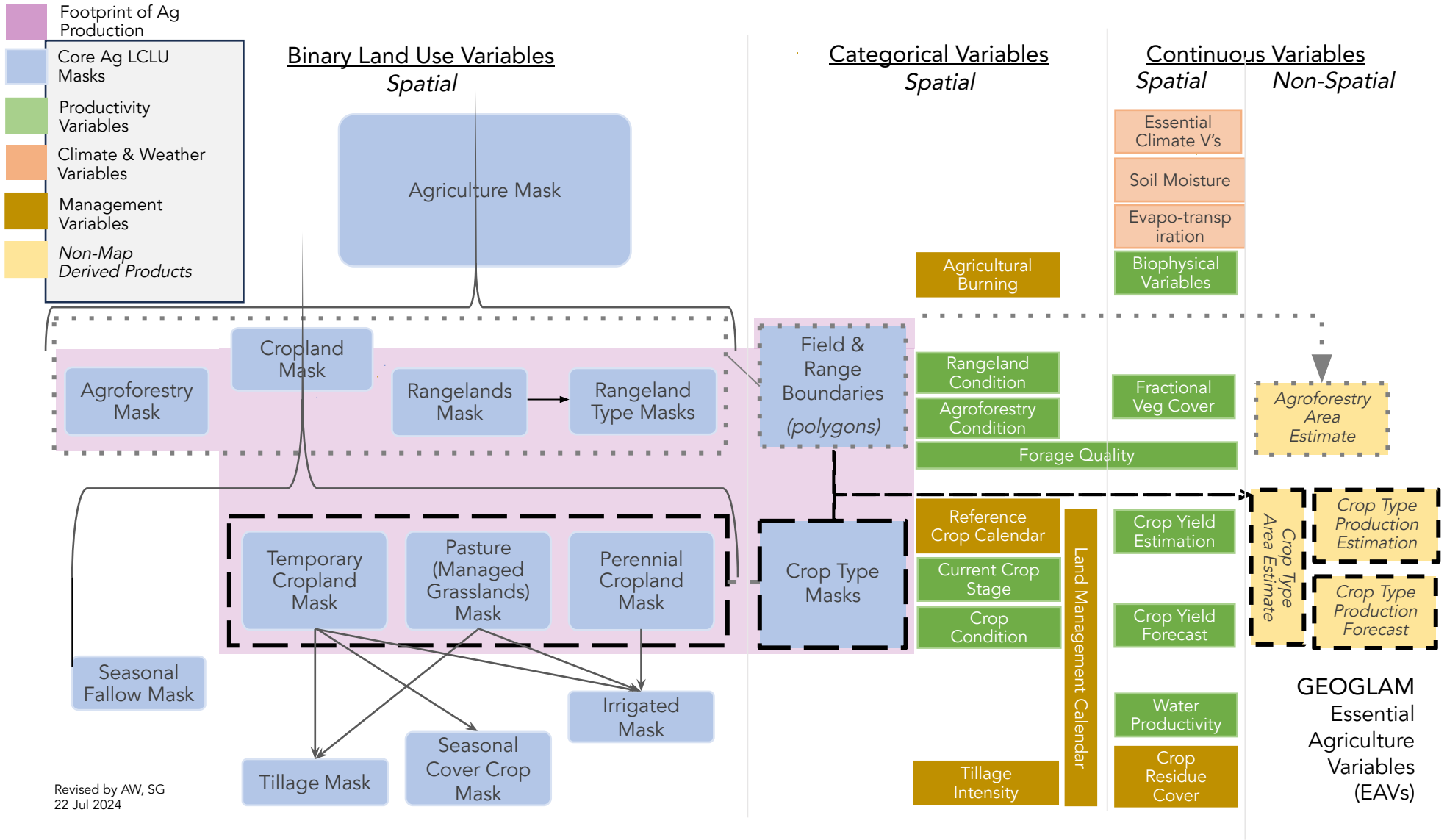
How often ?

Where?

When?

For What?

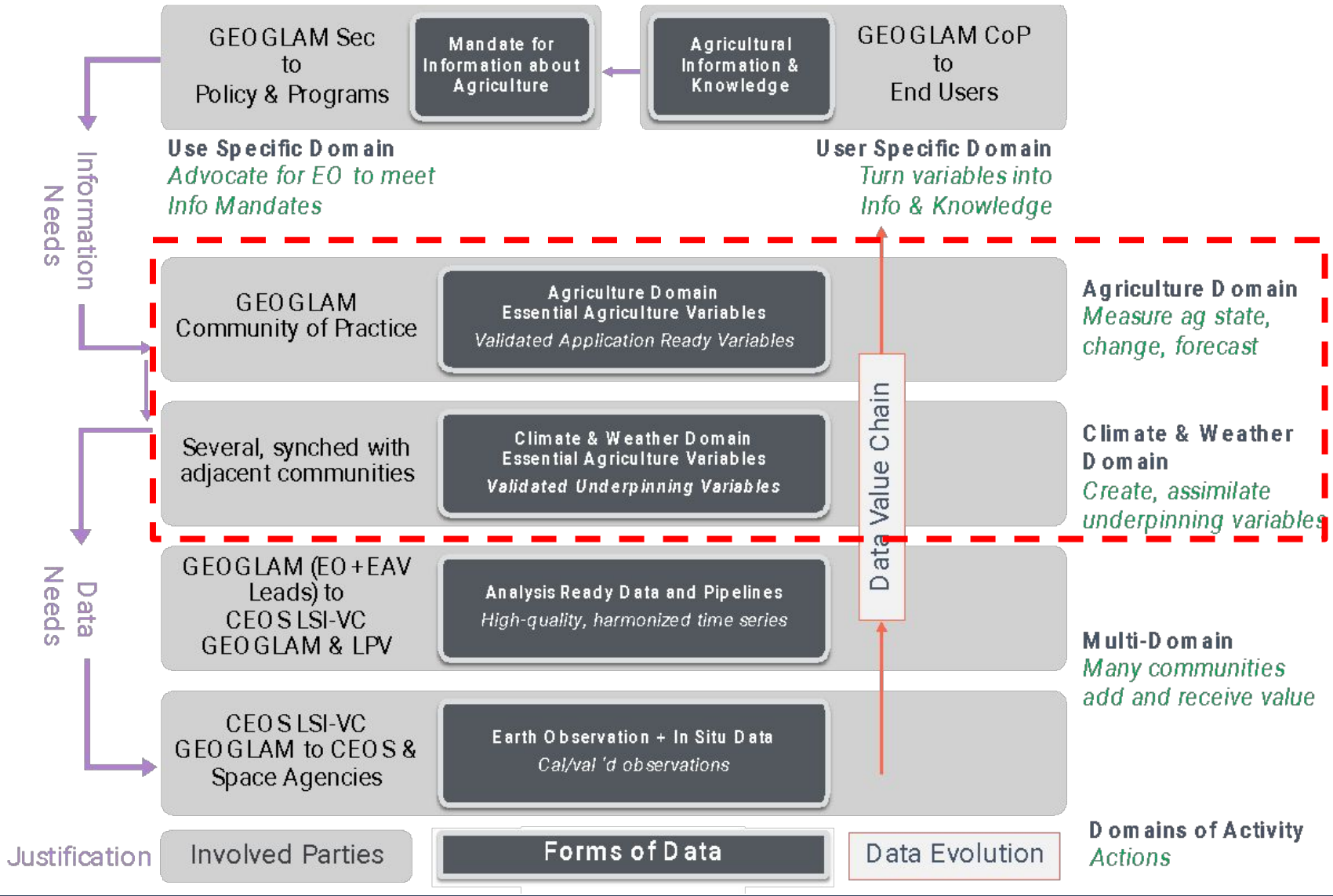
GEOGLAM data submitted to the CEOS plenary in 2013



GEOGLAM EAV's Current Structure

Whitcraft and Gilliams. 2024

Satellite Data Value Chain

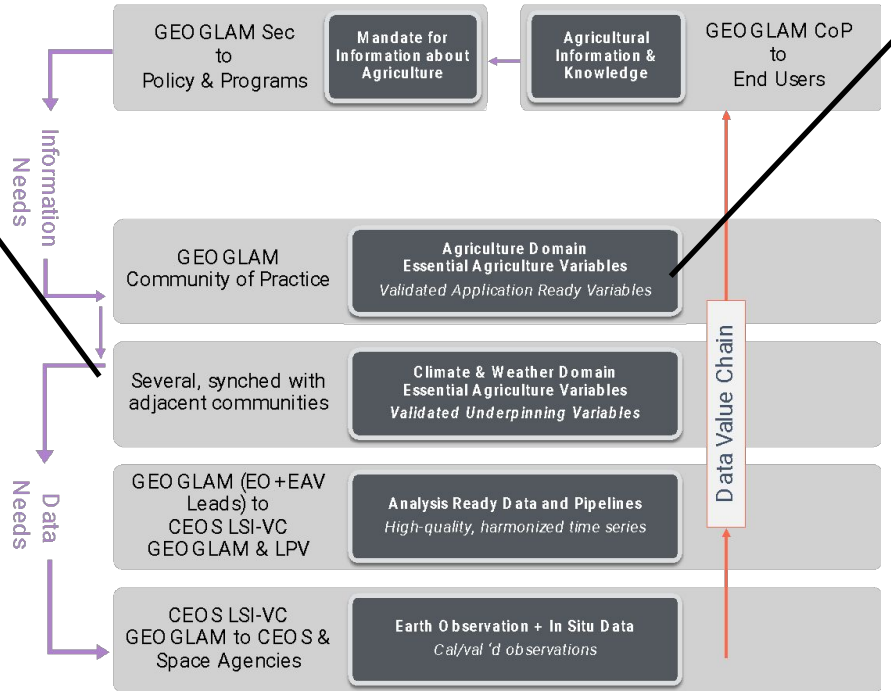


- "Data produced must be policy-relevant and not exist for its own sake." (UN Statistics Division, 2017)
  - Clear mandate to harmonize and synergize
- "Essential Agriculture Variables" (EAVs) emerged as a unifying framework to maximize EO value and meet multiple information and decision needs

~50% the EAVs are related to ECVs

(**either exact same, same physical quantity but different resolution requirement, or linked/referenced in some way but not specified)

Met & Land Domain EAV
Land surface temp (ECV)
Air temperature (ECV)
Surface Soil Moisture (ECV)
Root Zone Soil Moisture (ECV)
Wind Speed (ECV)
Precipitation (ECV)
LAI (ECV)
fAPAR (ECV)
Incoming radiation (ECV)
Relative humidity (ECV)
Reference Evapotranspiration**
Actual Evapotranspiration**
Seasonal Dynamics of Surface Water Availability**
Aboveground Agricultural Biomass
Fractional Cover
Soil Carbon (ECV)
Runoff**
Residue Cover
Surface roughness



Ag Domain EAVs
Water Productivity**
Irrigated Cropland Map**
Reference Crop Calendars
Current Crop Stage
GDD
Crop condition assessment
Crop yield forecast
Crop Yield estimation
Rangeland Condition assessment
Land Management Calendar
Agriculture Mask (likely ECV)
Cropland Mask (likely ECV)
Rangeland Mask
Seasonal Fallow mask
Seasonal Cover Crop Mask
Non-Perennial Cropland Mask
Perennial Cropland Mask
Managed Grasslands Mask
Crop Type Masks
Field Boundaries
Crop Type Area Estimation
Agricultural Burned-Area Map**

GEOGLAM EAV Working Group

EAV Workshop, JRC
Ispra, May 13-15, 2025

Thoughts on GeoXO Instrument (early 2030's)

- In addition to the Land Domain Meteorological Variables – there would be an interest in the Land Imaging capability of GeoXI to provide Land Domain GEOGLAM EAV's

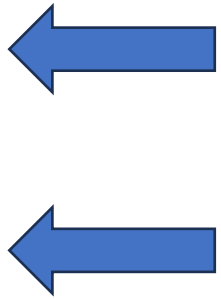
From the GeoXI Web site >

Benefits of a Geostationary Imager

High-resolution imagery is the backbone of Earth observations. Geostationary satellite imagery provides a constant view of the same area, helping forecasters and emergency officials identify and track severe weather conditions and environmental hazards as they happen to aid real-time decision-making and short-term forecasts and warnings. GXI will provide critical data for the protection of life and property and the enhancement of the national economy.

- Of particular interest for the Land and EAV community is the increased spatial resolution of 250m (.64 mic. band), **there would be considerable benefit to include a 250m (.86 mic. band)** like VIIRS and MODIS – daylight observations (the initial MODIS 250m rationale was also for small clouds).

VIIRS			MODIS		
M4	0.545 - 0.565	750	4 12	0.545 - 0.565 0.546 - 0.556	500 1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
M5	0.662 - 0.682	750	13 14	0.662 - 0.672 0.673 - 0.683	1000 1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250



Closing Remarks

- For the land surface there would be a number of potential applications for GeoXO - especially from the imager (GeoXI)
- We would be interested in the capability to generate GEOGLAM EAV's to meet needs of the agricultural monitoring community of practice
- There is interest to better understand and engage on NOAA's plans for future agriculture product development
- Similarly, GEOGLAM would welcome a broader engagement with the Coordination Group for Meteorological Satellites (CGMS) – similar to what we are currently doing with CEOS.