Global Agricultural Monitoring International Coordination: GEOGLAM

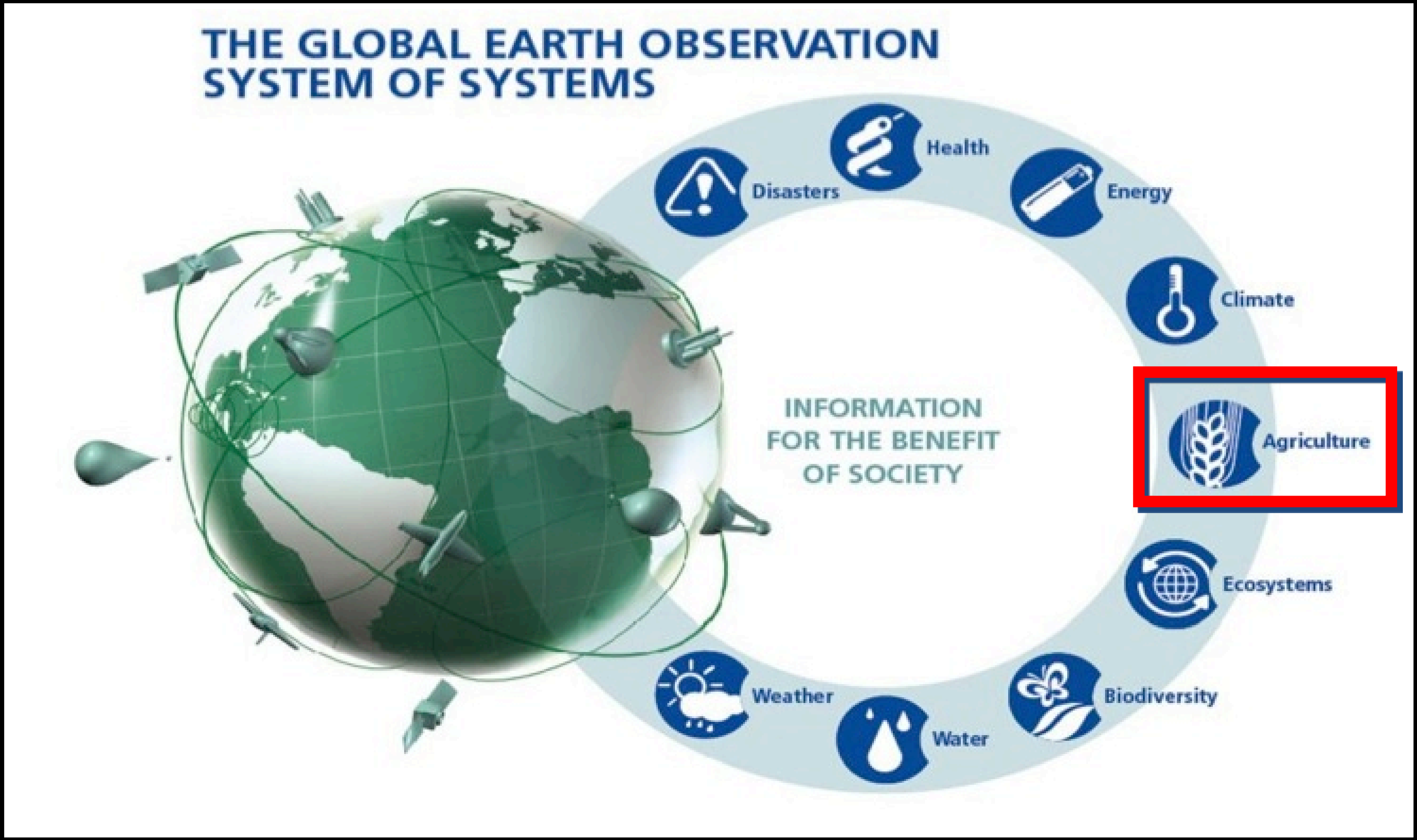
Chris Justice

Inbal Becker-Reshef, Christina Justice, Brian Barker, Michael Humber
The Center for Agricultural Monitoring Research,
Department of Geographical Sciences,

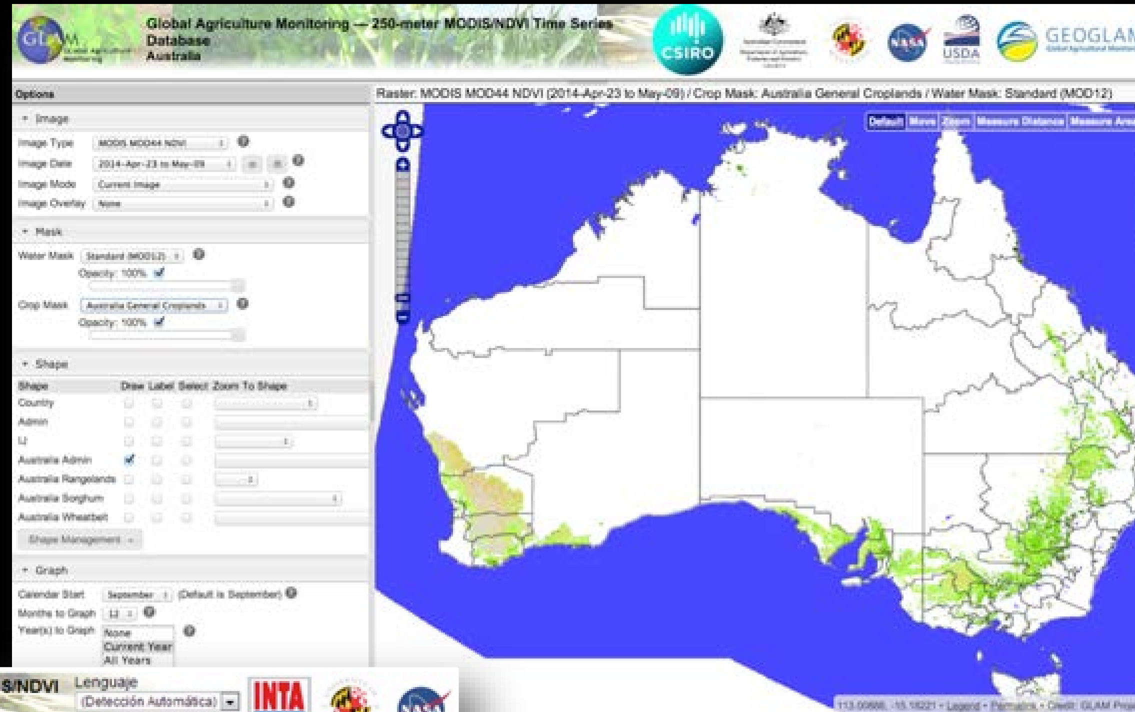
University of Maryland, USA

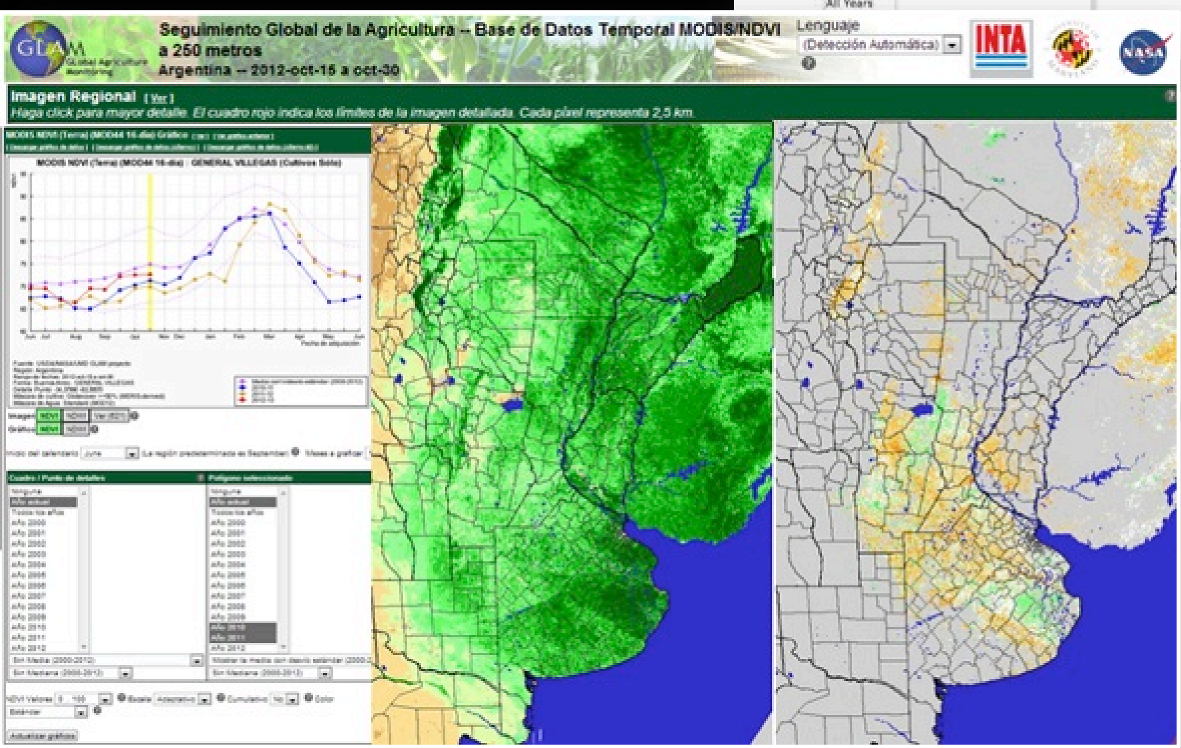
GEO is the international program focused on the use of Earth Observations for societal benefit

- GEO was initiated in 2005
- Agriculture is one of the GEO societal benefit areas
- GEOGLAM is GEO's Agricultural initiative



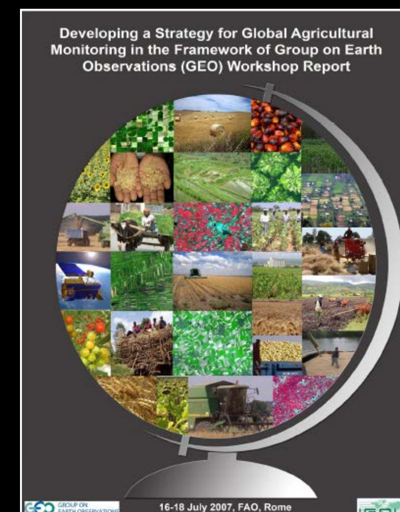
- c. 2005 UMD/NASA working with USDA to transition crop analysis from AVHRR to MODIS.
- Developed the Global Agricultural Monitoring (GLAM) System crop condition interface
- Provided to other countries e.g. **Australia, Mexico, Argentina, Brazil, Colombia**





Initial GEOSS/IGOL Agricultural Monitoring Workshop July 2007, UN-FAO

- IGOL/GEO workshop to develop a strategy for global agricultural monitoring in the framework of GEO
- 47 participants representing 25 national and international organizations attended and established the *'GEOSS/IGOL Agricultural Monitoring Community of Practice'*



- Reviewed the current state of agricultural monitoring identified gaps and developed a set of priorities and recommendations
- Recognized that international and national programs faced the same obstacles and challenges and that the full potential of EO had yet to be realized

Today the Community of Practice has over 300 members representing over 40 countries and organizations

Thematic Workshop Series to Identify "Community of Practice" Priorities and Best Practices

- **November 2009, Kananaskis, Canada: SAR data for Agricultural Monitoring**
- **May 2011, Curitiba, Brazil (SBSR): JECAM South America Workshop**
- **September 2011, Nairobi, Kenya: CRAM Agricultural Capacity Building Workshop**
- **October 2012, Beijing, China: Workshop on Agricultural Water Availability**
- **November 2012, Buenos Aires, Argentina: Regional Workshop on Agricultural Monitoring**
- **October 2013, Moscow, Russia: Workshop on Agriculture in Northern Eurasia**

Building a Community Agenda: Identifying and Addressing Common Issues facing Agricultural Monitoring

- Timeliness in obtaining EO data (satellite and in-situ)
- Accessibility to international satellite data
- Continuity of satellite data for operational monitoring
- Robustness of methods for national, regional to global application – lack of field level validation data, absence of best practices for different cropping systems and regions
- Difficulty in transitioning research methods into operational use
- Need for capacity building and support to use EO data in many operational monitoring institutions - including new sensors
- Quality and timeliness of global/national agricultural data and statistics
- Decline and privatization of in-situ weather data
- Accuracy of seasonal forecast data
- In general a low investment in agricultural research and agricultural extension services

GEOGLAM Actors
GEOGLAM Community of Practice

Open Community made up of individuals from international and national agencies concerned with agricultural monitoring including Ministries of Ag, Space Agencies, Universities, & Industry

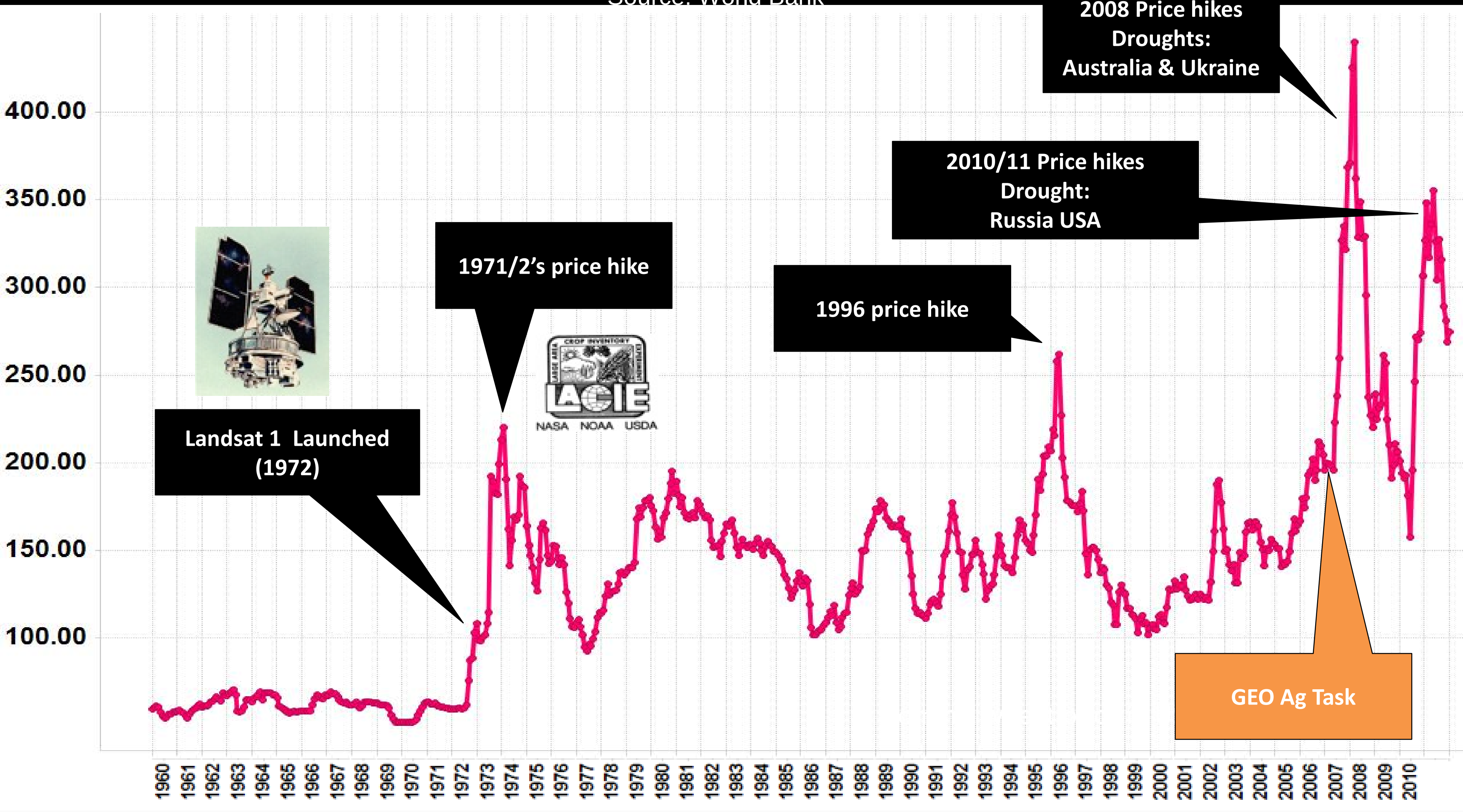
GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Context For GEOGLAM

Monthly Wheat Prices 1960-2011($/Metric Ton)

Source: World Bank



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

Critical for agricultural policies, stabilizing markets, averting food crises
and
Need to increase food production by 50%-70% by 2050 to meet demands (FAO)

Policy Framework for GEOGLAM

G20 FRANCE 2011 NEW WORLD NEW IDEAS

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.

GEOGLAM: a GEO Initiative

- 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: Building on existing monitoring systems – strengthening international and national capacity
- Emphasis on: producer countries (G20+), countries-at-risk and national capacity building
- http://www.earthobservations.org/geoglam.php

The GEOGLAM Components

Global Monitoring System Coordination

Monitoring System Enhancement

Earth Observation Data Coordination

GEOGLAM IT Infrastructure

Operational Research and Development

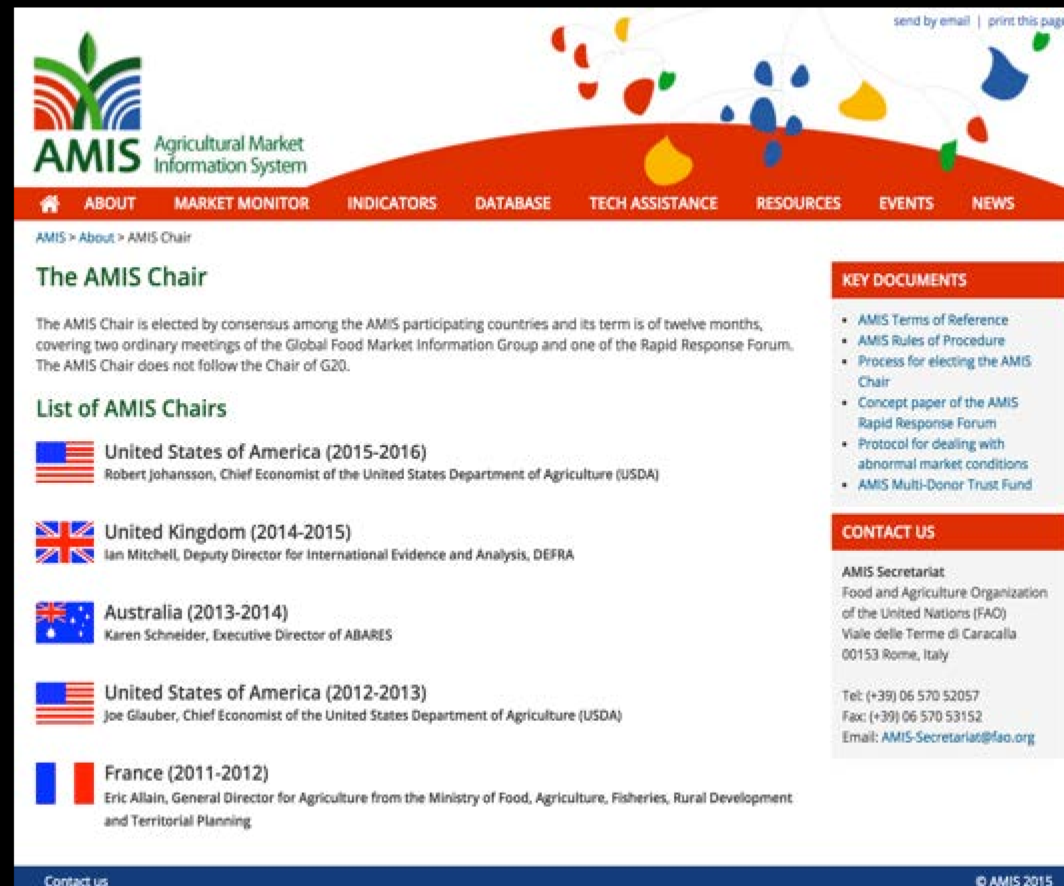
Capacity Building Coordination

GEOGLAM Regional Initiatives:
ASIA Rice
Latino America

Rangeland Monitoring Coordination (RAPP)

AMIS: Agricultural Market Information System

Improve market information and transparency



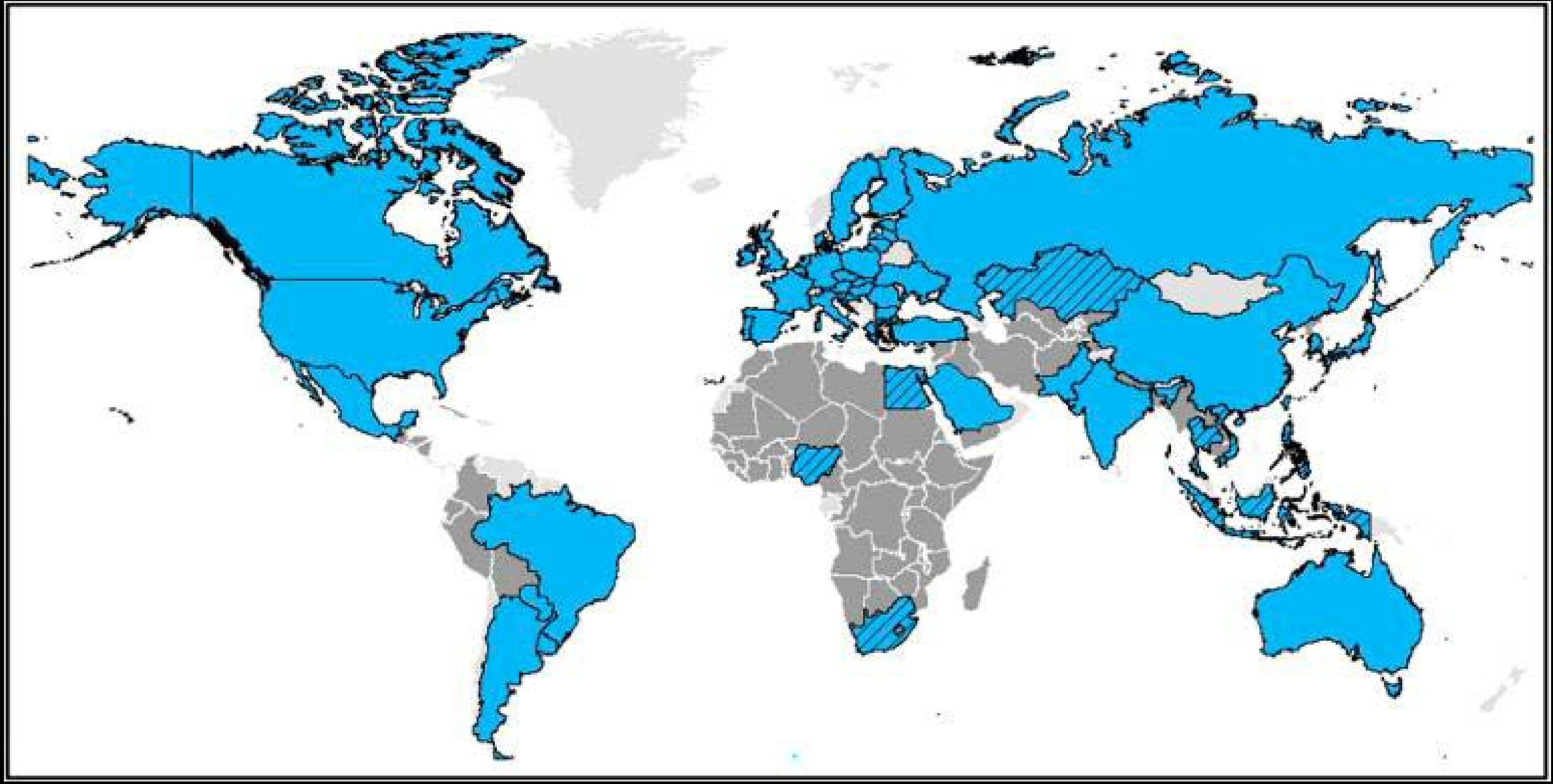
inter-Agency Platform to enhance food market transparency and encourage coordination of policy action in response to market uncertainty.

www.amis.org

GEOGLAM Crop Monitor for AMIS

- AMIS requested GEOGLAM to generate a monthly international consensus of crop conditions, from the various international/national monitoring systems
- Four major crops: wheat, maize, soybean, rice (9 total seasons)
- Focus: stabilizing/calming markets, avoid unexpected food price shocks
- http://www.geoglam-crop-monitor.org
- Consensus process, interface, submissions, telecons
- Summary information only

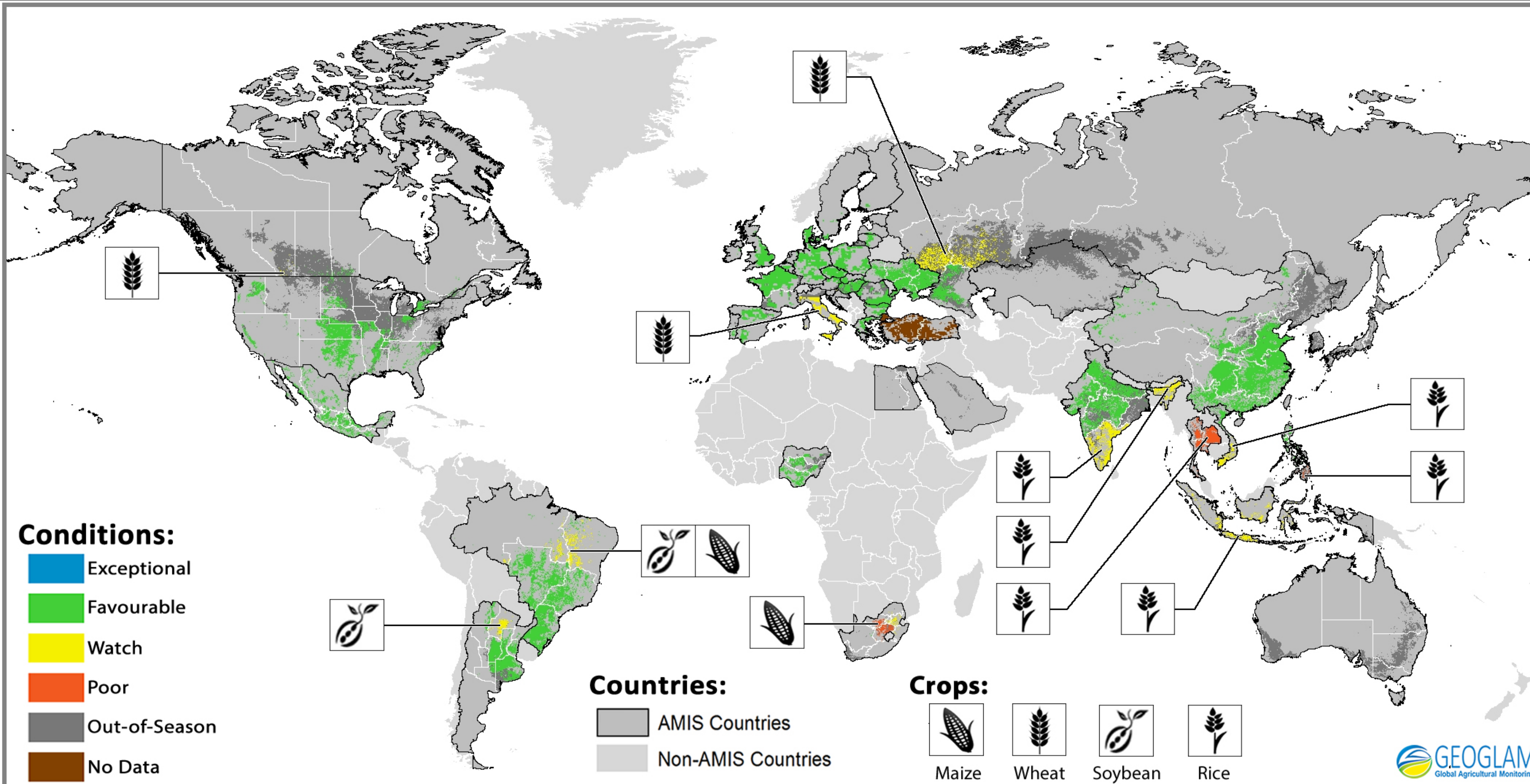
AMIS COUNTRIES



GEOGLAM AMIS Crop Monitor Partners

> 35 Partners and Growing

Crop Monitor : an international consensus assessment - March 28th

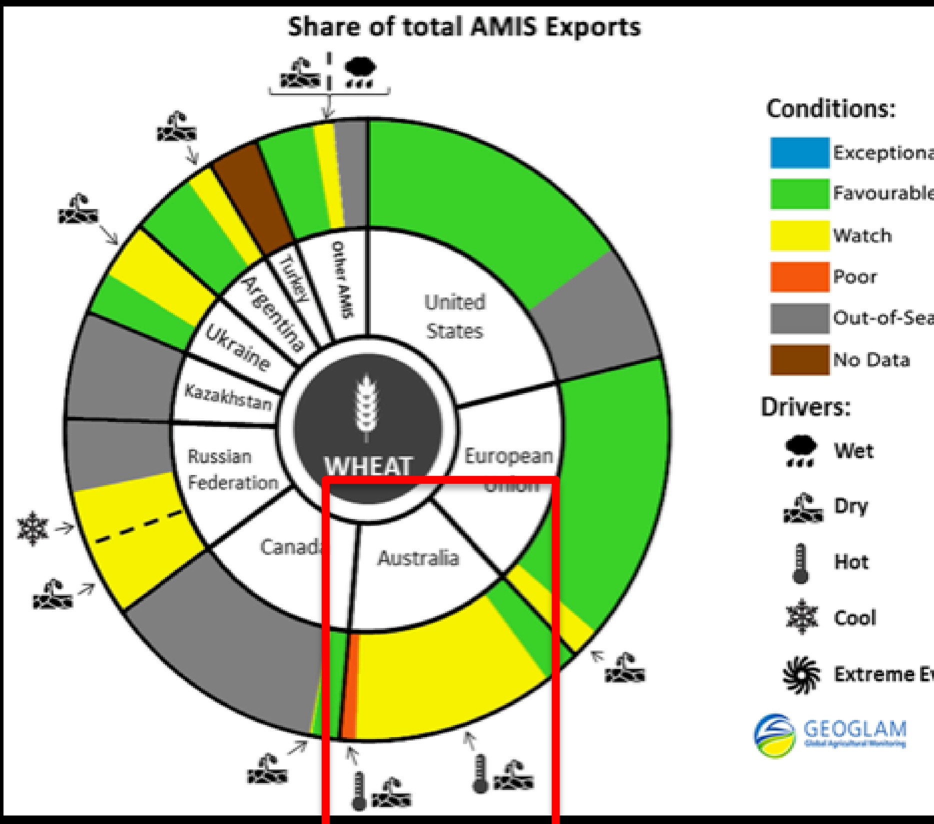


Crop condition map synthesizing information for all four AMIS crops. **Crops that are in other than favorable conditions are displayed on the map with their crop symbol.** (Cropland area shown is an aggregation of all cropland areas)

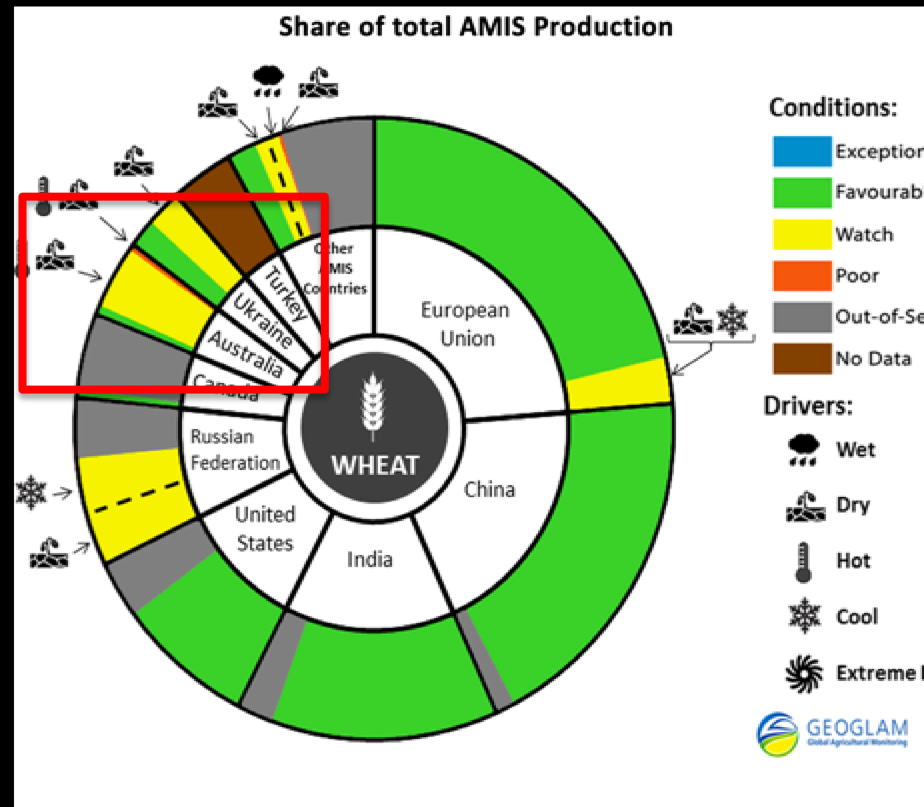
Becker-Reshef et al.

Wheat Production and Exports Pie Charts

As Share of total AMIS Exports



As Share of total AMIS Production



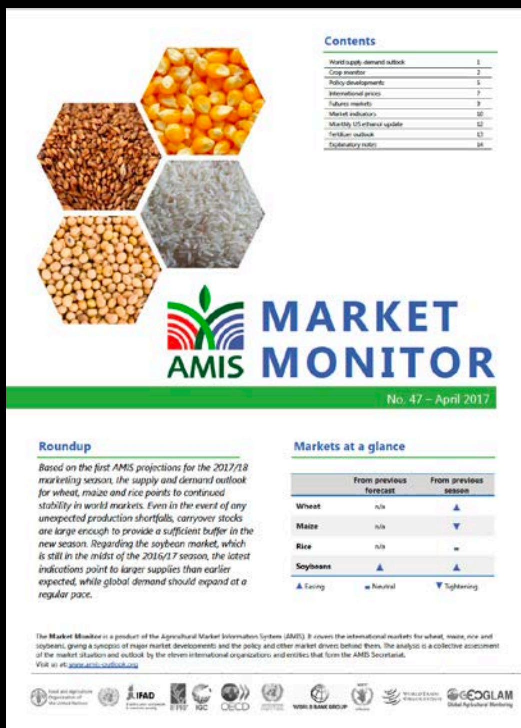
Crop Conditions as of October 28th, 2015

G20 Agricultural Ministers

2011 Action Plan on Food Price Volatility and Agriculture

AMIS – Markets/Stocks

GEOGLAM – Condition/Supply



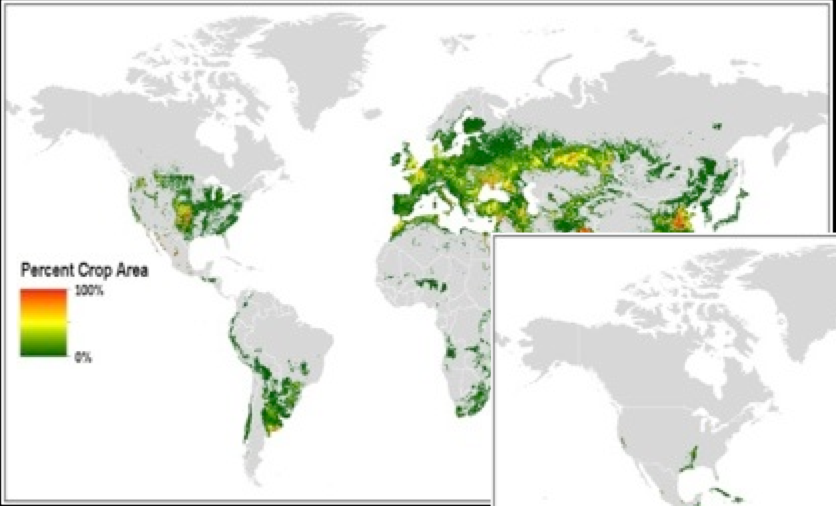
http://www.amis-outlook.org/amis-monitoring

https://cropmonitor.org/

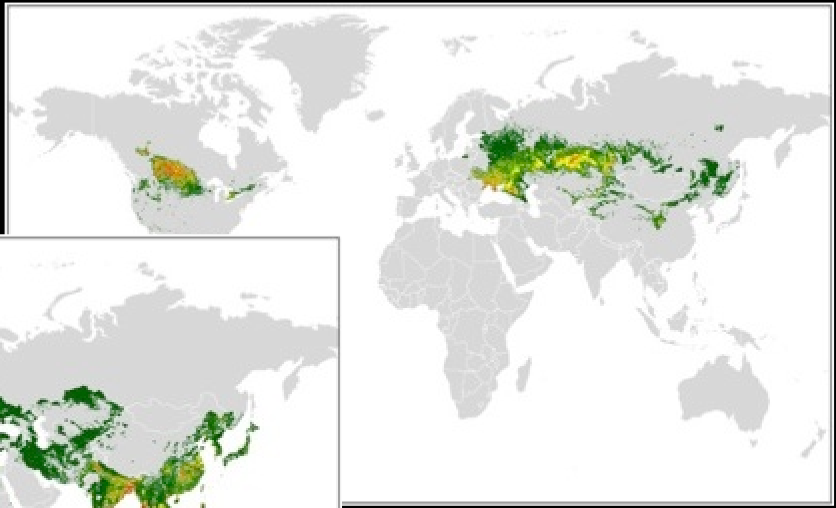
GEOGLAM Best Available Multi-Season Crop Masks

20 contributors and counting w. on going improvements

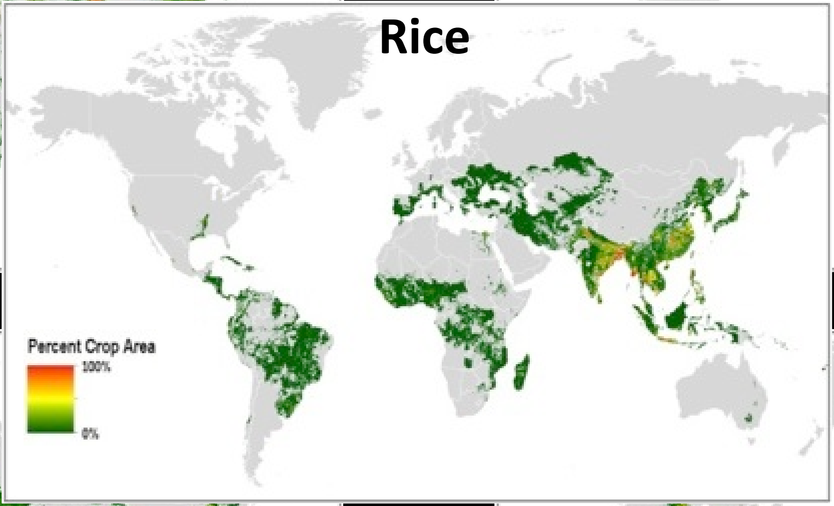
Winter Wheat



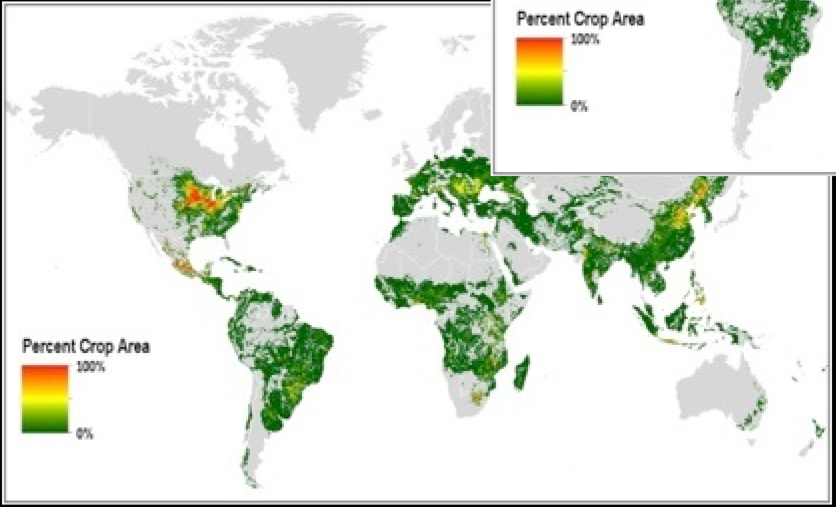
Spring Wheat



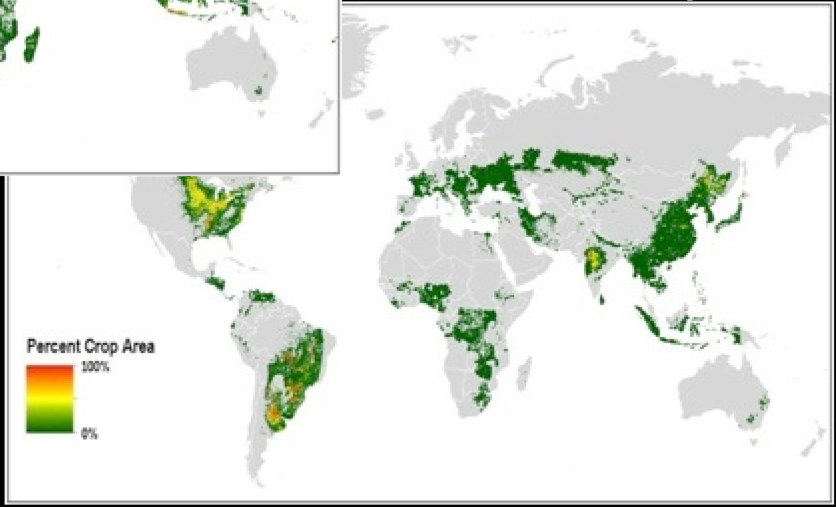
Rice



Maize

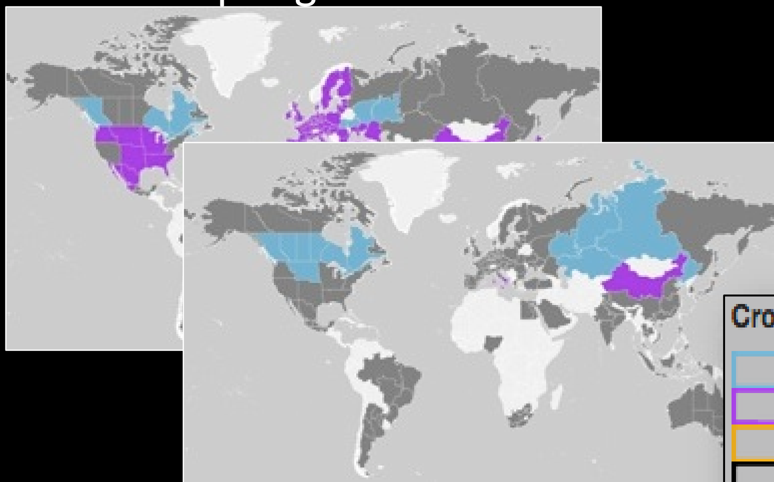


Soybeans

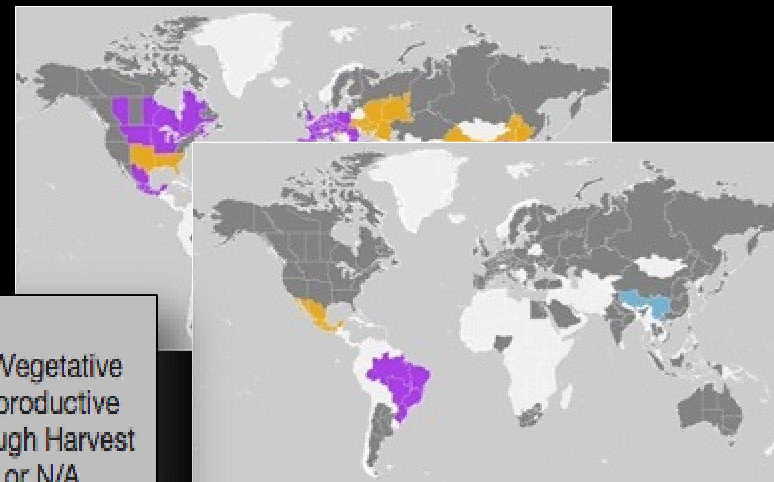


Best Available Multi-Season Crop Calendars

Winter & Spring Wheat



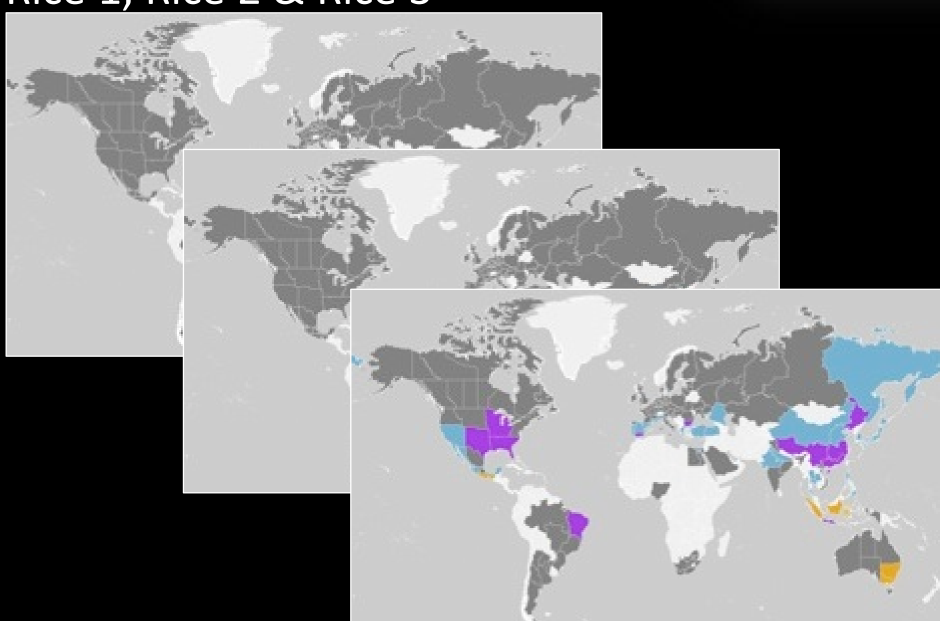
Maize 1 & Maize 2



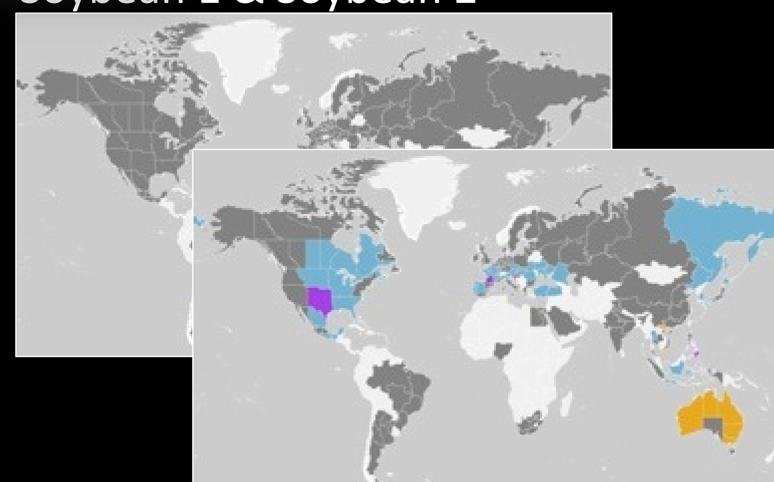
Crop Stages

- Planting-Early Vegetative
- Vegetative-Reproductive
- Ripening Through Harvest
- Out of Season or N/A

Rice 1, Rice 2 & Rice 3



Soybean 1 & Soybean 2

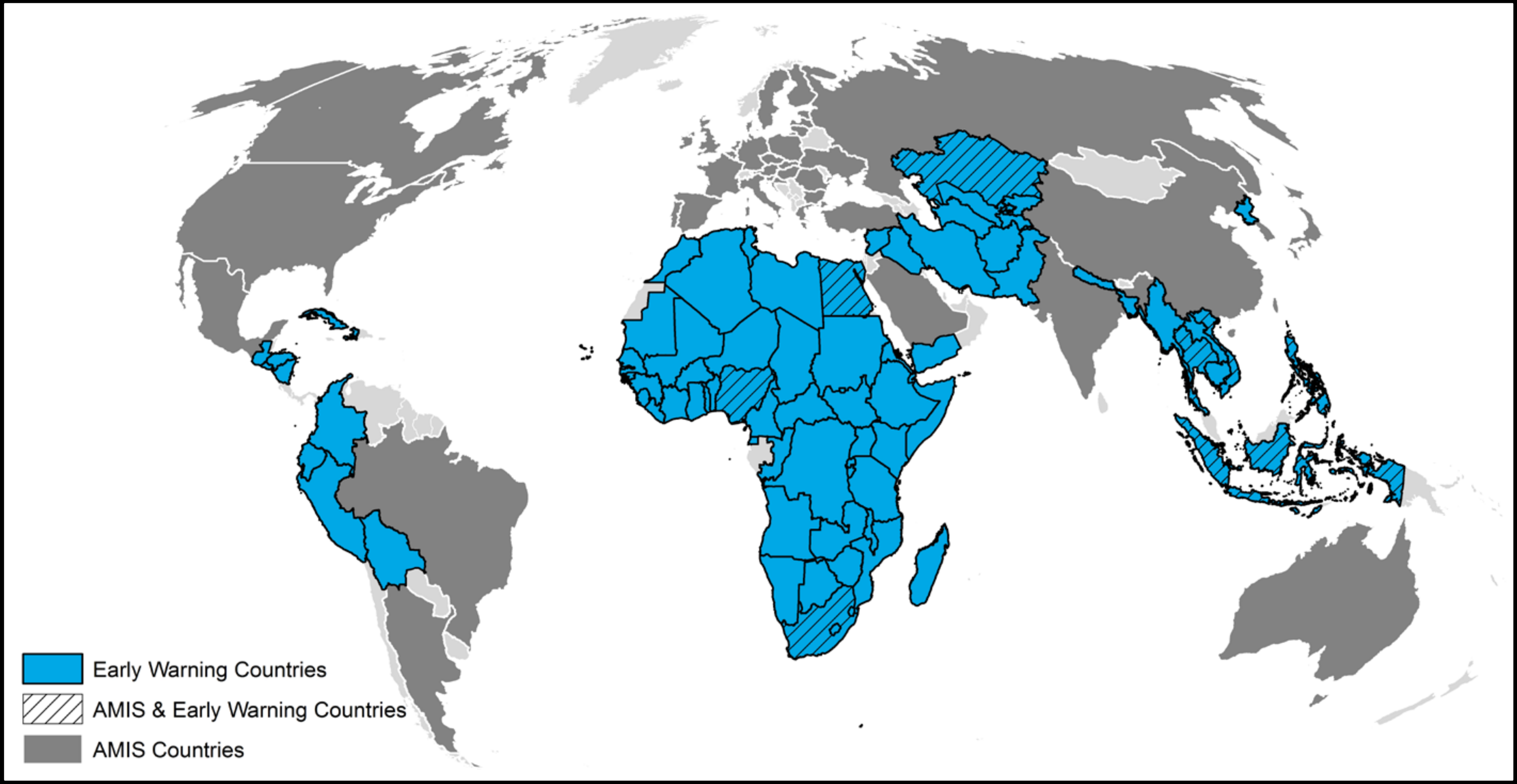


Calendars reflecting multiple cycles of the same crop

Next Steps for GEOGLAM /AMIS collaboration

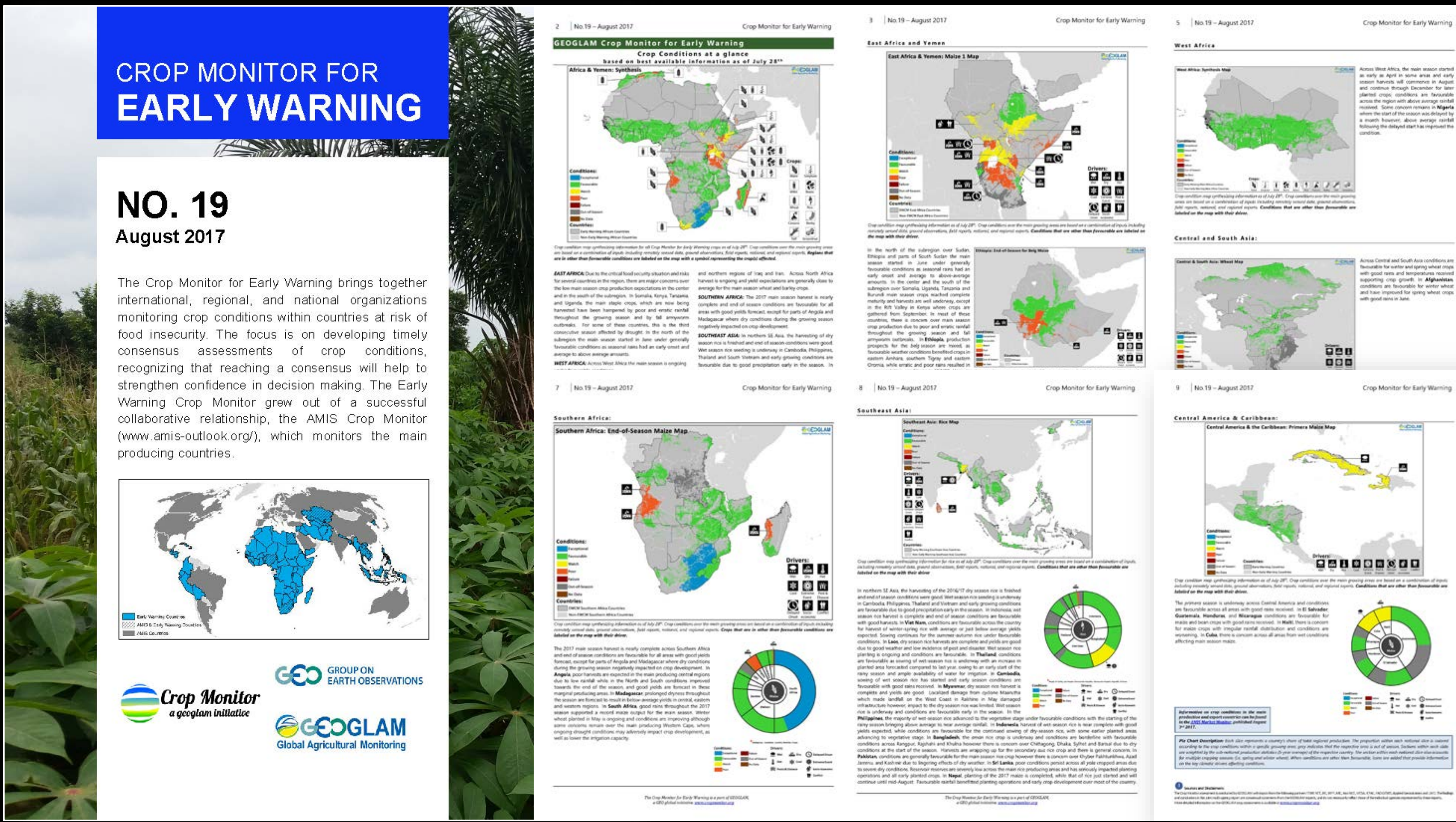
- Develop more quantitative indicators of crop growing condition and production
- Broaden national and sub-national (state) participation in the Crop Monitor providing monthly updates on crop condition
- Strengthen linkages between the EO-based ag monitoring community and the AMIS community at the national level

Early Warning Crop Monitor Countries



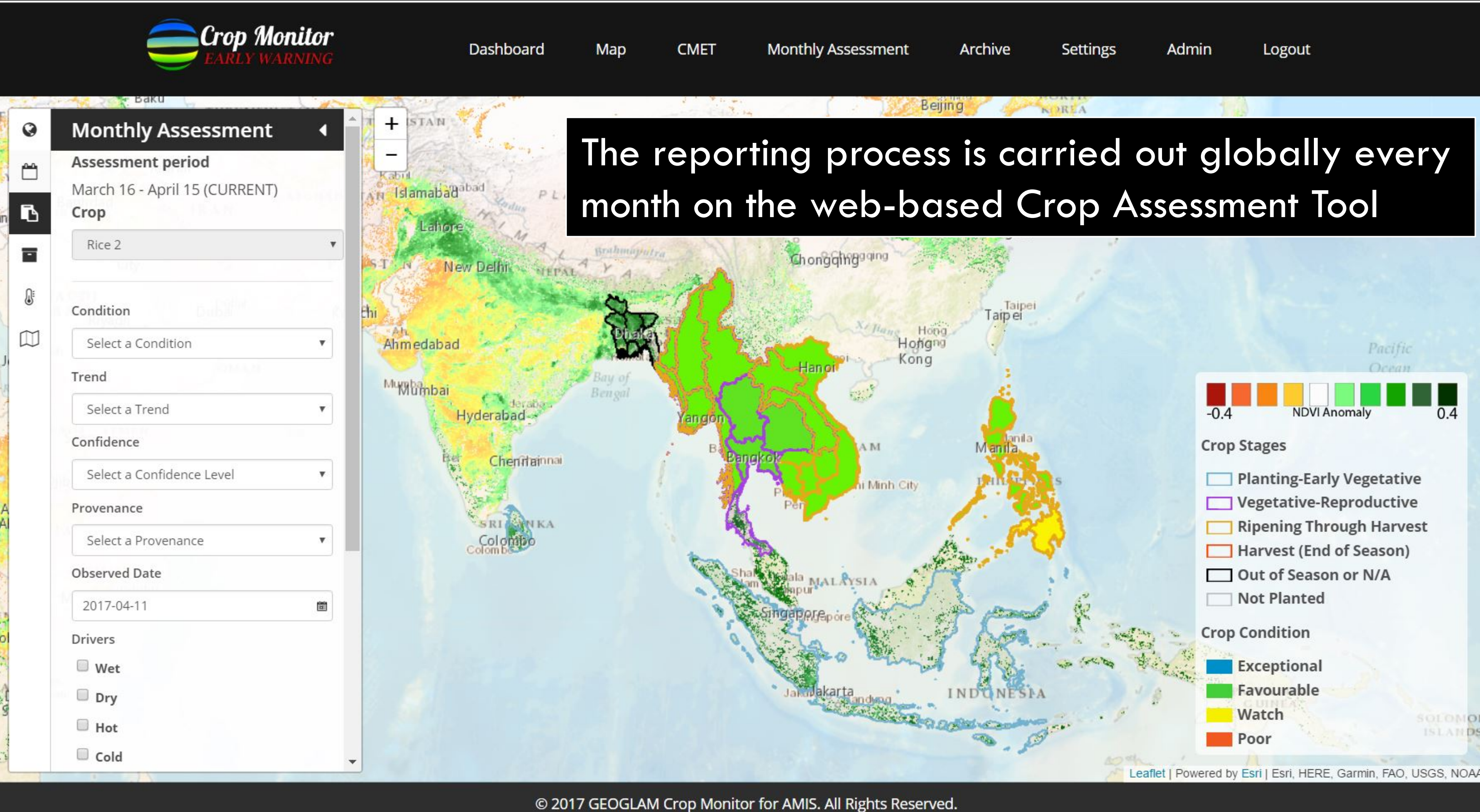
Crop Monitor for Early Warning Bulletin

www. cropmonitor.org



Crop Condition Reporting Interface

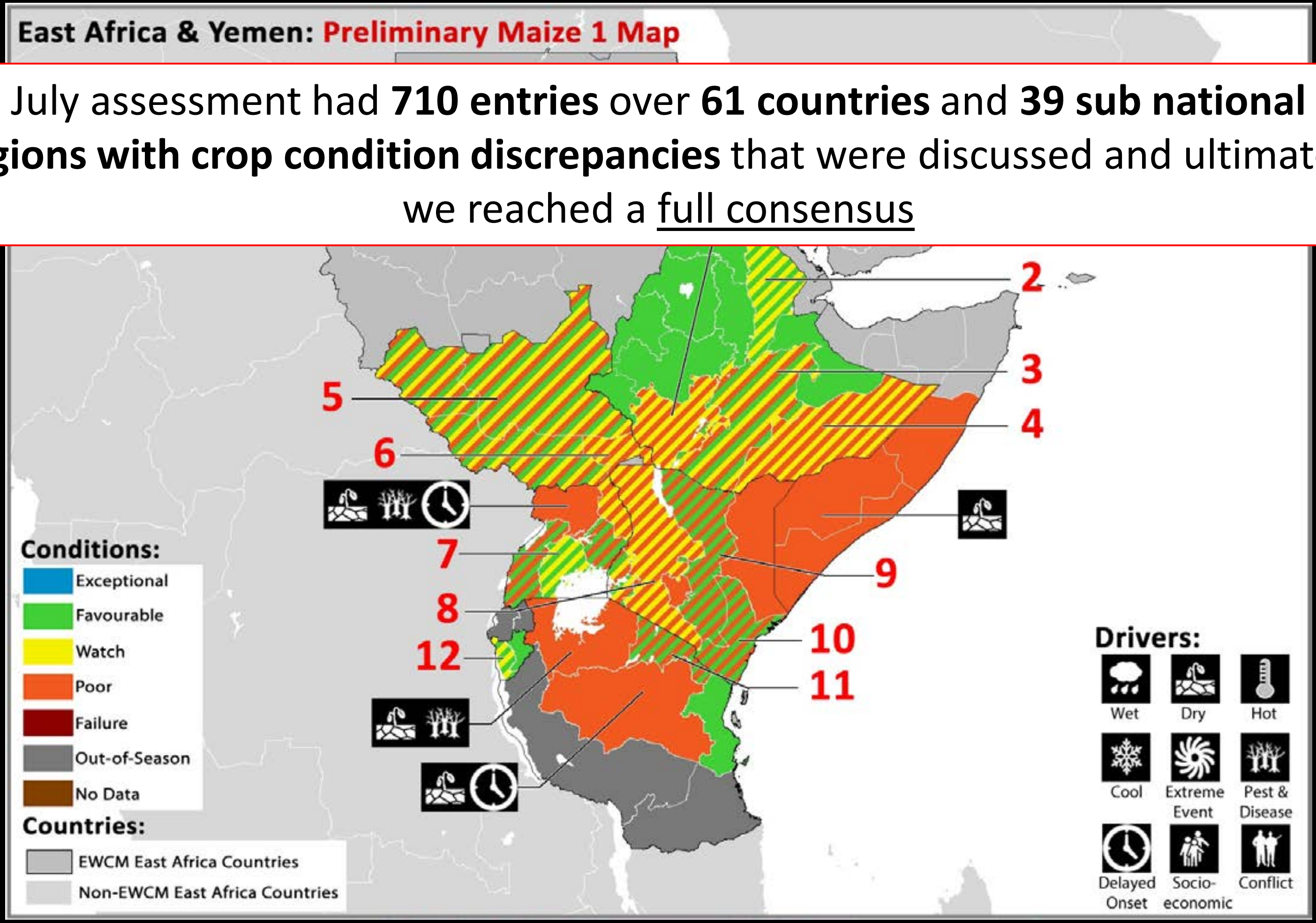
The reporting process is carried out globally every month on the web-based Crop Assessment Tool



Example discrepancy map

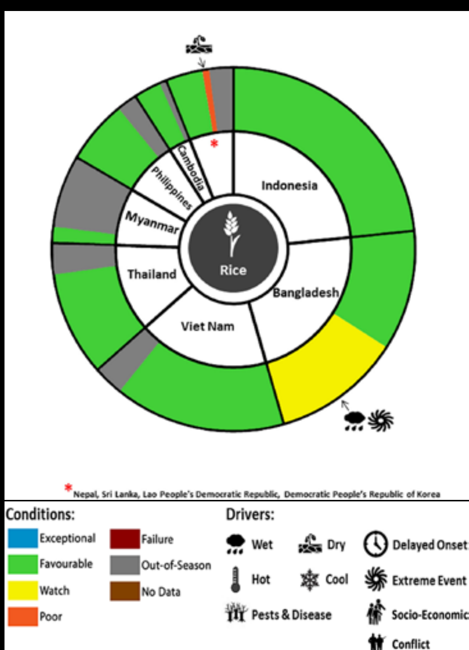
- Hashed areas show conflicting crop condition entries from different agencies

July assessment had **710 entries** over **61 countries** and **39 sub national regions with crop condition discrepancies** that were discussed and ultimately we reached a <u>full consensus</u>

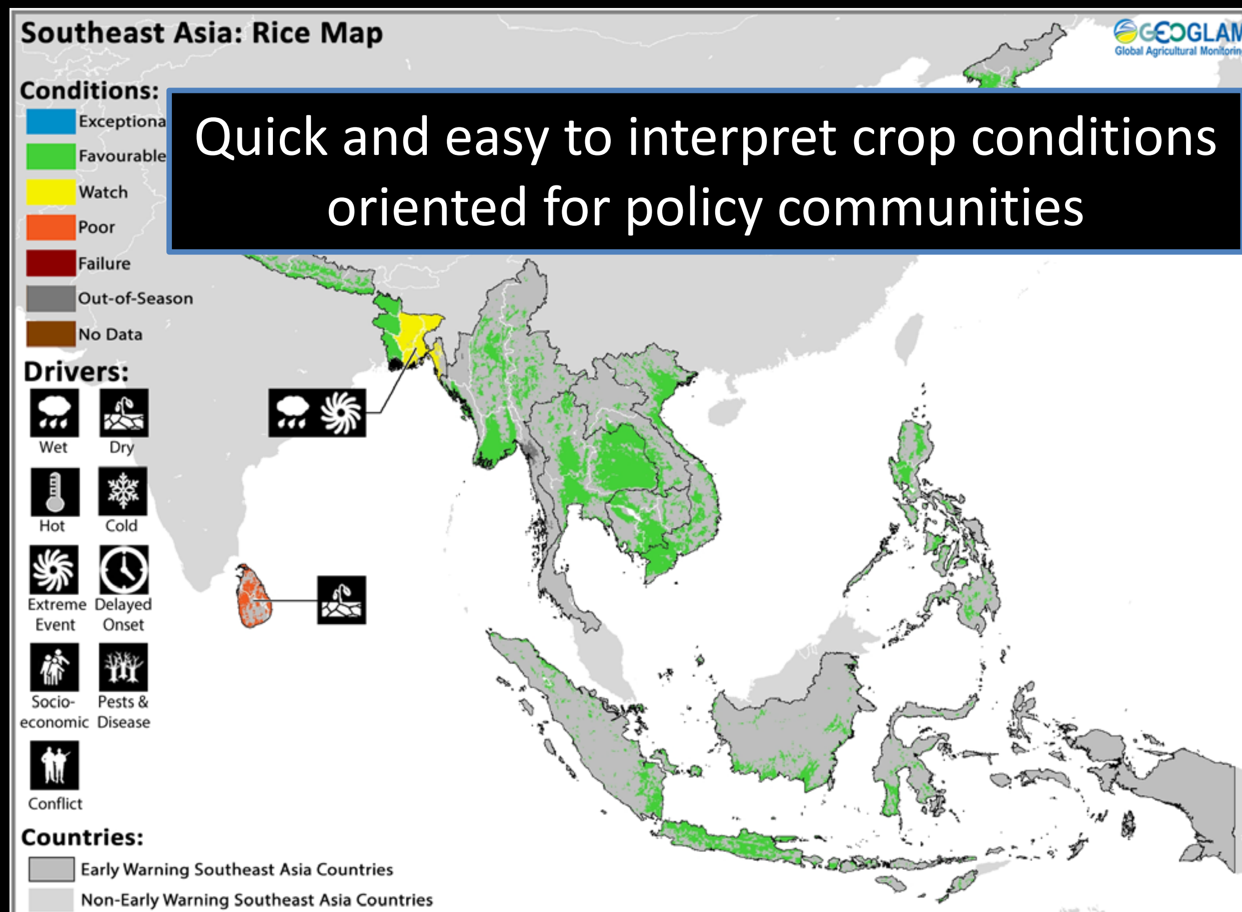


Crop Specific Maps and Pie Charts per Region

- Crop specific & regional synthesis map
- Pie charts inform users as to the percent production per country in each crop conditions and why



Quick and easy to interpret crop conditions oriented for policy communities



CM4EW as a consensus bulletin

- Need for expanded participation and increased national representation – monthly national reporting on crop condition

The GEOGLAM Components

Global Monitoring System Coordination	Monitoring System Enhancement	Earth Observation Data Coordination
GEOGLAM IT Infrastructure	Operational Research and Development	Capacity Building Coordination
GEOGLAM Regional Initiatives: ASIA Rice Latino America	Rangeland Monitoring Coordination (RAPP)	

Developing the EO Data Requirements for GEOGLAM: through a CEOS/GEOGLAM Ad Hoc Working Group

Goals of the EO Data Coordination Component.

- Articulate data requirements for agricultural monitoring
- Coordinate international satellite acquisition over agricultural areas during the growing season
- Promote near-real time data availability
- Increase the frequency of moderate resolution data
- Standardize processing of data, facilitating data interoperability
- Promote easy data access for operational users
- Advocate for continuity of critical data streams/products

Recognition that cropping systems are inherently diverse which dictates the monitoring observations and methods

No one system can meet agricultural monitoring needs

GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

GEOGLAM CEOS: EO Data 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-Resolution (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-Resolution (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	
HRI (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?

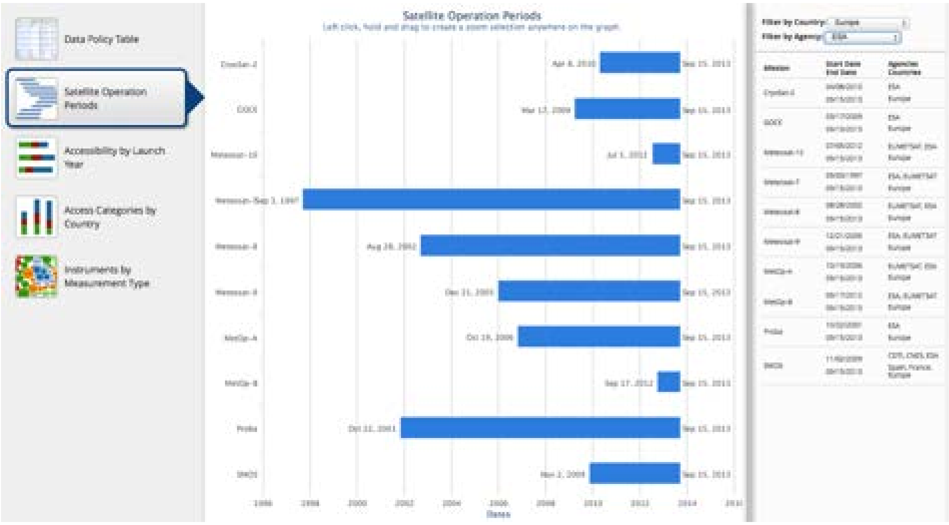
GEOGLAM data plan submitted to the CEOS plenary in 2013

Data Policy Study and Portal

www.ceos-datapolicy.org

Access Summary

- Open (no registration) = 36%
- Open (simple registration) = 21%
- Open (advanced approval) = 5%
- Restricted = 33%
- Unknown = 5%



Comments

- This summary includes **205 missions** launched since 1990 and 615 mission-instrument combinations.
- 62% of CEOS mission data is OPEN and accessible.

Are the data acquired for Ag areas during the growing season ?

Are they easily accessible ?

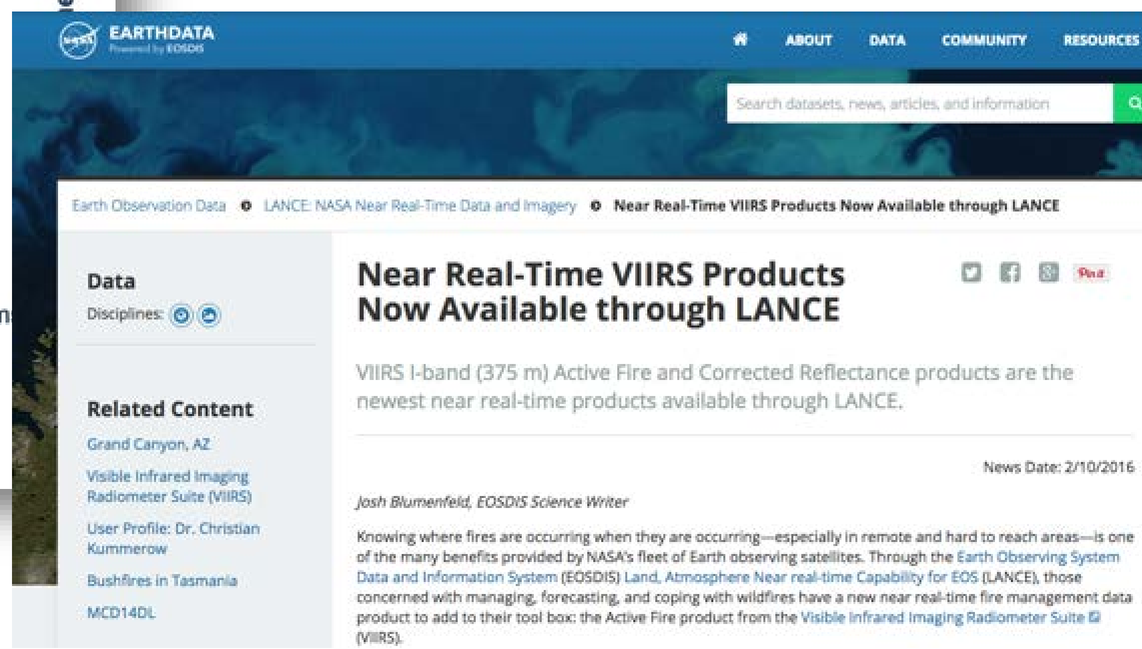
B. Killough, CEOS SEO

Requirement for Near Real Time Data for Agricultural Monitoring

GEOGLAM
Global Agricultural Monitoring

Timely data are critical for crop monitoring

- NASA EOS near-real-time daily observations are processed and provided < 3 hours from observation
- VIIRS now available



NASA

Sentinel contribution to JECAM & GEOGLAM
Primary missions for all targets Products

Req#	Spatial Resolution	Spectral Range	Effective observ. frequency (cloud free)*	Sample Type	Field Size	Target Products						
						Crop Mask	Crop Type Area and Growing Calendar	Crop Condition Indicators	Crop Yield	Crop Biophysical Variables	Environ. Variables	Ag Practices / Cropping Systems
Coarse Resolution Sampling (>100m)												
1	500 - 2000 m	thermal IR + optical	Daily	Wall-to-Wall	All			X		L		
2	100-500 m	optical + SWIR	2 to 5 per week	Cropland Extent	All	X	X	X	L	L		L
3	5-50 km	microwave	Daily	Cropland Extent	All			X	X	X	X	
Moderate Resolution Sampling (10 to 100m)												
4	10-70m	optical + SWIR + TIR	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	Cropland Extent	All	X	L/M					X
5	10-70m	optical + SWIR + TIR	Weekly (min. 1 per 16 days)	Sample	All	X	X	X	X	X	X	X
6	10-100m	SAR	Weekly (min. 1 per 2 weeks)	Cropland Extent of persistant cloudy areas/Rice	All	X	X	X	X	X	X	X

Sentinel-3

SMOS

Sentinel-2

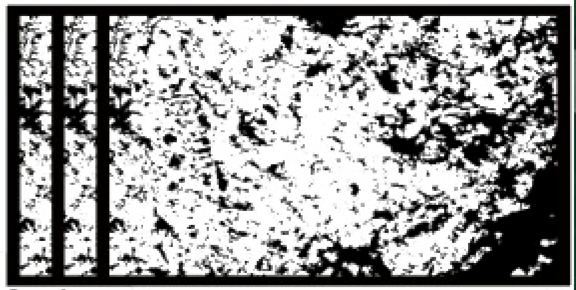
Sentinel-2

Sentinel-1

Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM PHASE 1

Toolbox for 4 S2-based products in line with the GEOGLAM core products

DYNAMIC CROPLAND MASK

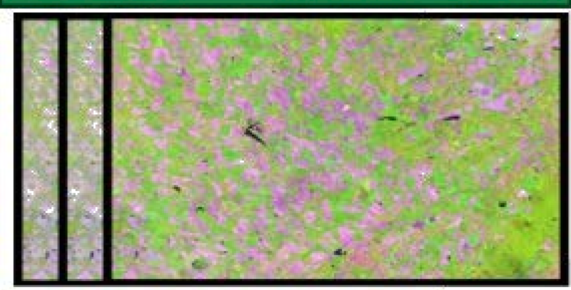


Growing season (monthly updates)

Binary map identifying annually cultivated land at 10m updated every month

Monthly cloud free surface reflectance composite at 10-20m

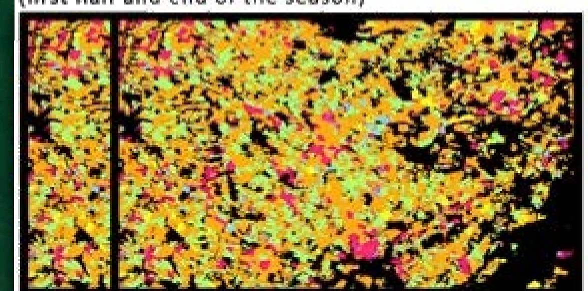
CLOUD FREE SURFACE REFLECTANCE COMPOSITES



Growing season (monthly updates)

CULTIVATED CROP TYPE MAP

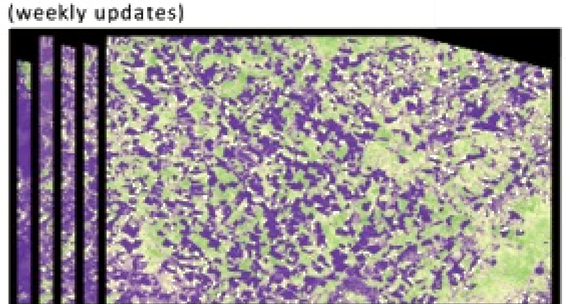
Growing season (first half and end of the season)



Open source toolbox
Capacity building and training

VEGETATION STATUS

Growing season (weekly updates)



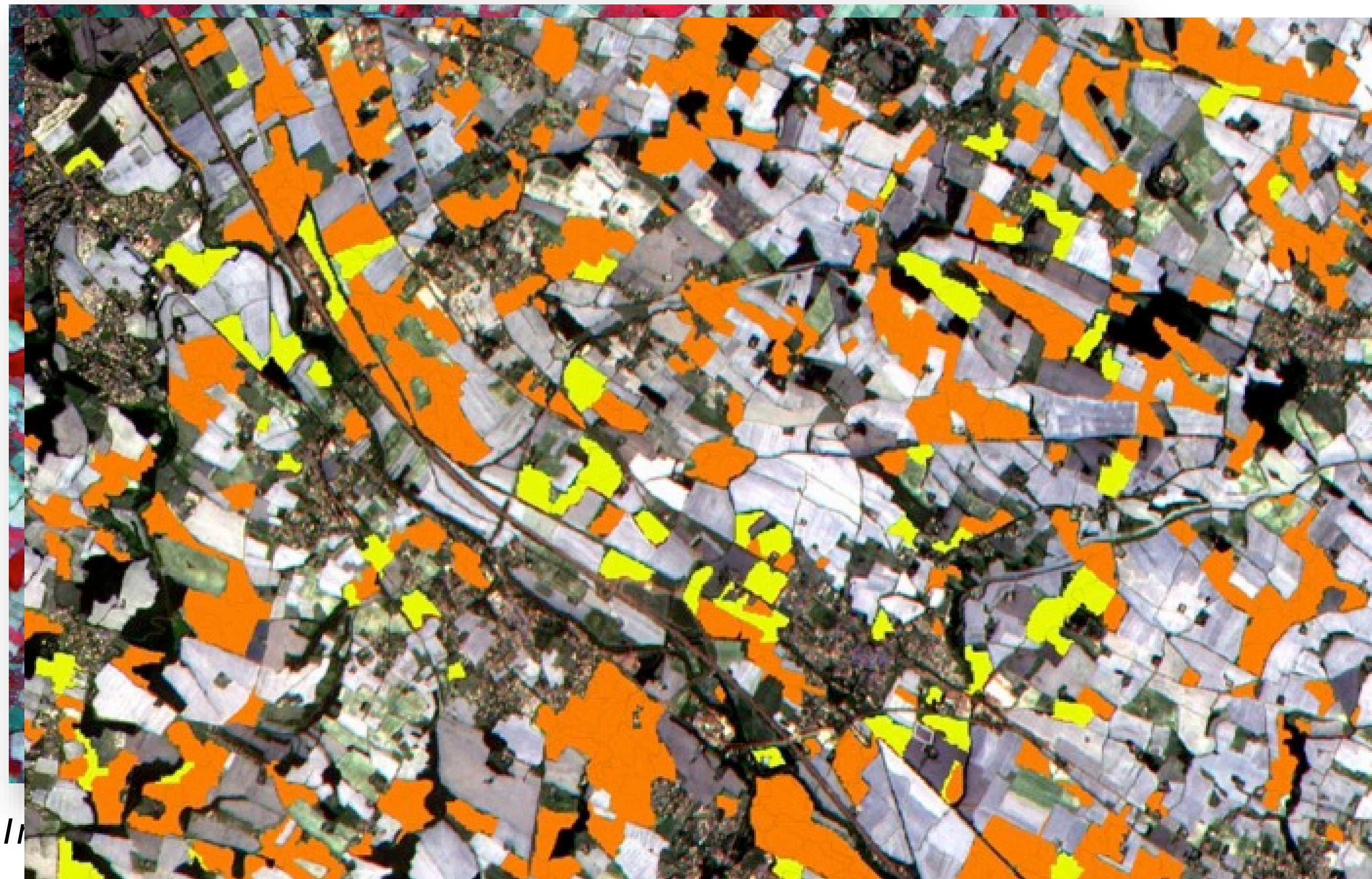
Crop type map at 10m for the main regional crops including irrigated/rainfed discrimination

Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index)

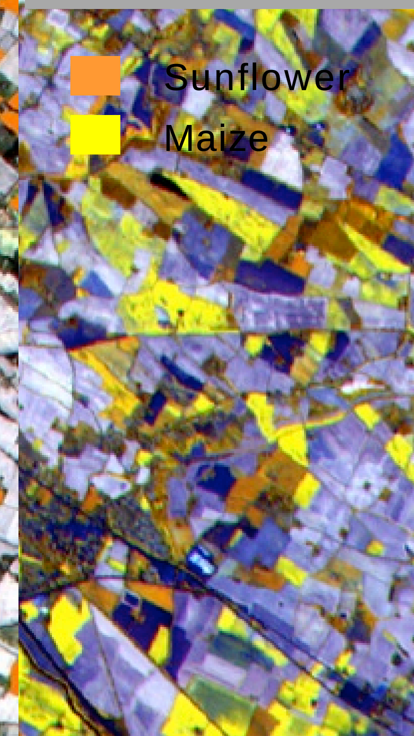
First S2-based prototype product

Toulouse area (France) - Sentinel-2 – 06 July 2015

New red-edge band to discriminate summer crops : maize *vs* sunflower



Summer Crops Map – 6 July 2015



New red-edge color composite
orange versus yellow

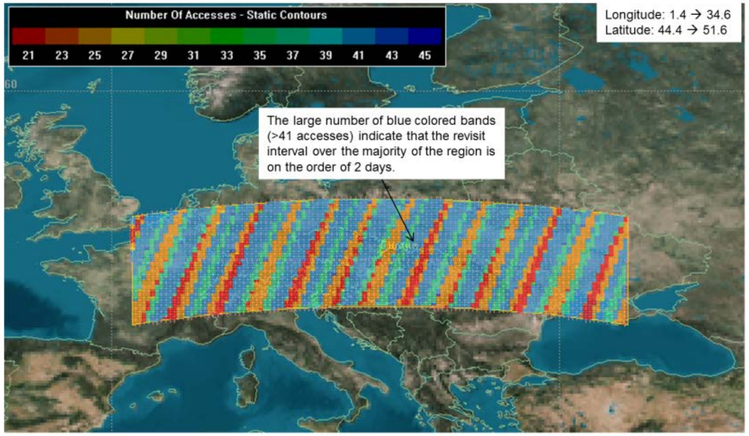
sentinel-2

AGRICULTURE

Harmonized Landsat Sentinel-2 (HLS) Project

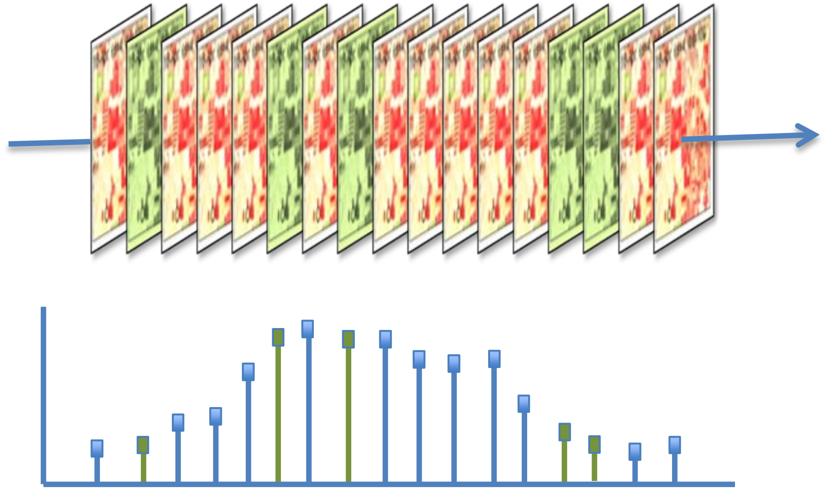
- Merging Sentinel-2 and Landsat data streams can provide **2-3 day global coverage**
- Goal is "seamless" near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding
- Project initiated as collaboration among GSFC, UMD, NASA Ames

Sentinel 2A and B - LDCM Europe

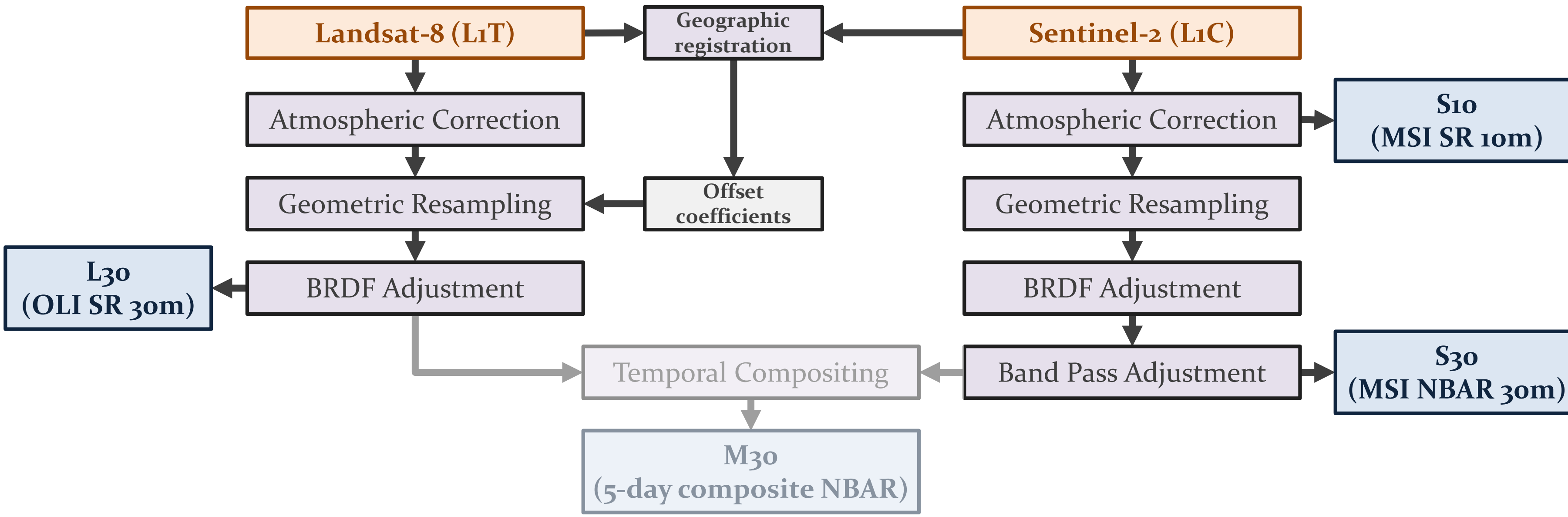


- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

Courtesy Brian Killough, NASA LARC



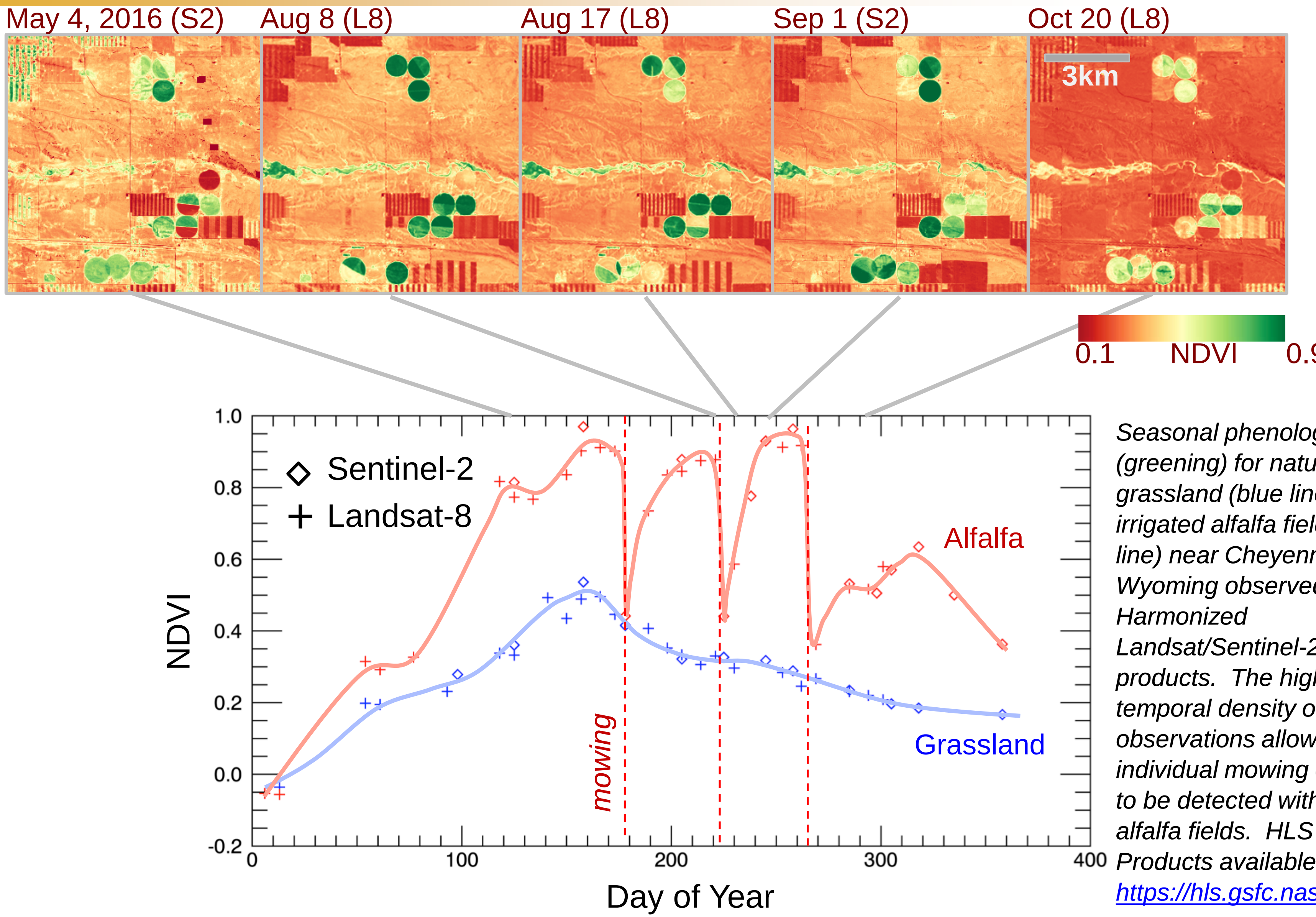
HLS Algorithms overview and status



Algorithm	Current (V1.2)	Other Options
Geographic registration	AROP (Gao et al. 2009, JARS)	-
Atmospheric Correction	OLI and MSI: Landsat-8 6S algorithm	CNES MACCS
Cloud/Shadow Mask	OLI: Landsat-8 6S algorithm output MSI: BU MSI Fmask	CNES MACCS
BRDF Adjustment	Fixed BRDF (Roy et al. 2016, RSE)	Downscaling MODIS BRDF + Fixed BRDF as Backup
Band Pass Adjustment	Fixed, per-band linear regression	Regression-tree (based on spectral shape)
Temporal Compositing	TBD	-

Harmonized Landsat / Sentinel-2 Products

Laramie County, WY

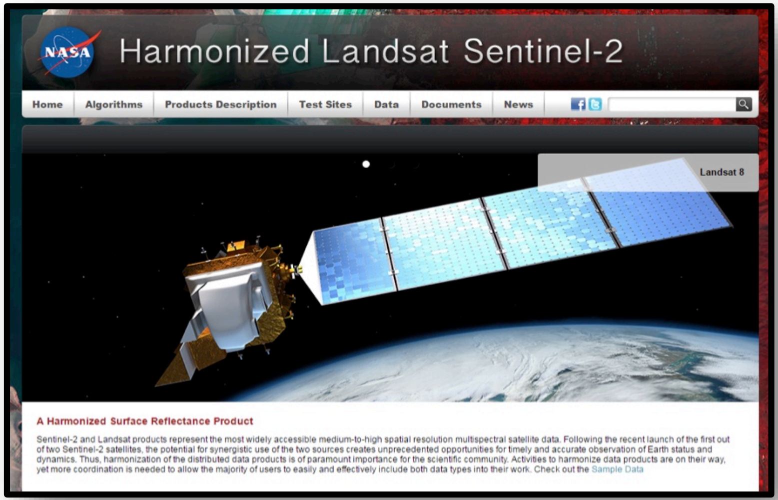


Seasonal phenology (greening) for natural grassland (blue line) and irrigated alfalfa fields (red line) near Cheyenne Wyoming observed from Harmonized Landsat/Sentinel-2 data products. The high temporal density of observations allows individual mowing events to be detected within alfalfa fields. HLS Products available from [*https://hls.gsfc.nasa.gov*](https://hls.gsfc.nasa.gov)

Websites and Public Interface

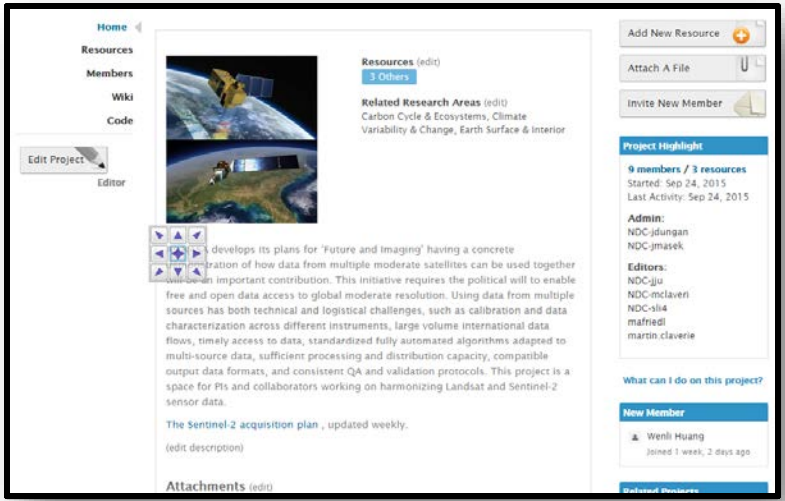
HLS website

- https://hls.gsfc.nasa.gov
- Public access
- Sample data available (via FTP)
- Algorithm & Product descriptions



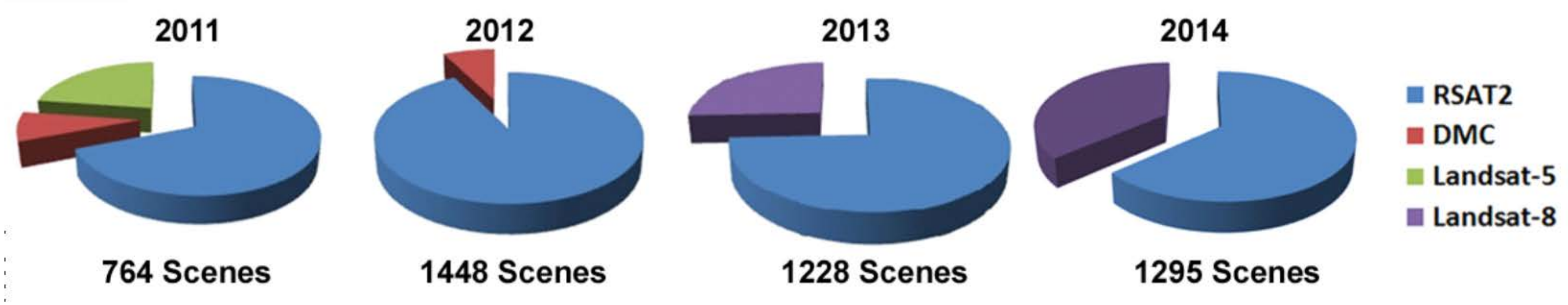
NEX project page

- https://nex.nasa.gov/nex/projects/1371
- Registered user access
- All HLS data available
- Documents (slides, user guides)



Canada's Annual Crop Inventory: Integration of Optical and Synthetic Aperture Radar Data

Image Data

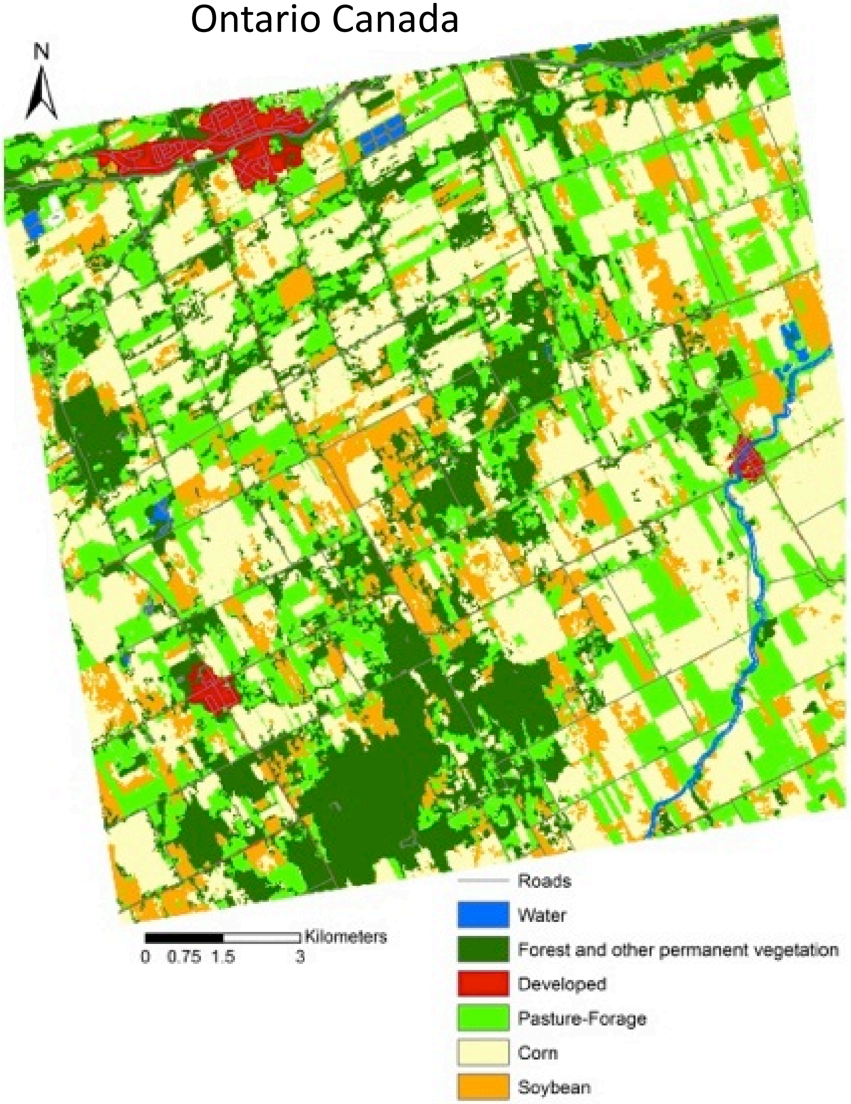


- Multispectral optical data can adequately classify crop if available during critical time periods
- Accuracies decrease significantly when gaps in data collection occur
- Operational burden of cloud masking
- Accuracy increases with SAR; magnitude depends on crop, timing of acquisitions and amount of optical data available

Courtesy Thierry Fisette and Leander Campbell, AAFC

In Development: Early Season Crop Identification

South Nation Watershed,
Ontario Canada



End of season TerraSAR-X crop classification: Ottawa 2012
Overall accuracy: **97.2**%

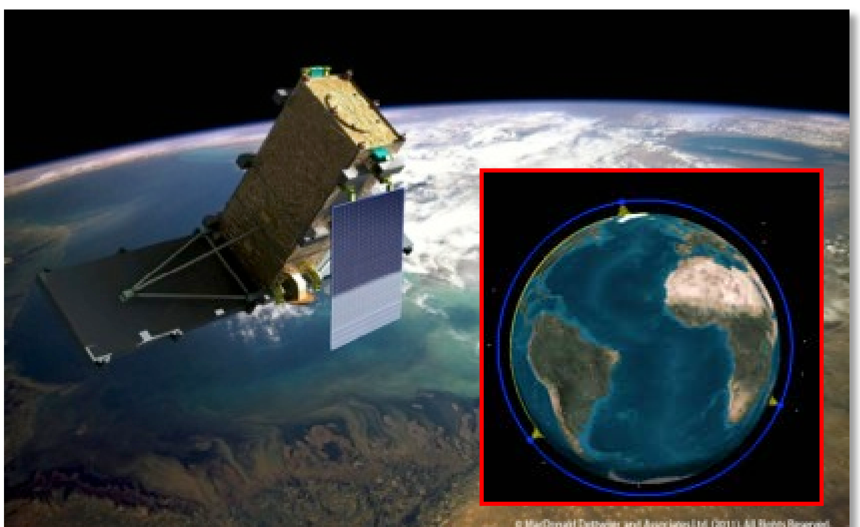
Early season: Corn can be identified at V6 or 6th leaf collar stage (about 6 weeks after planting)

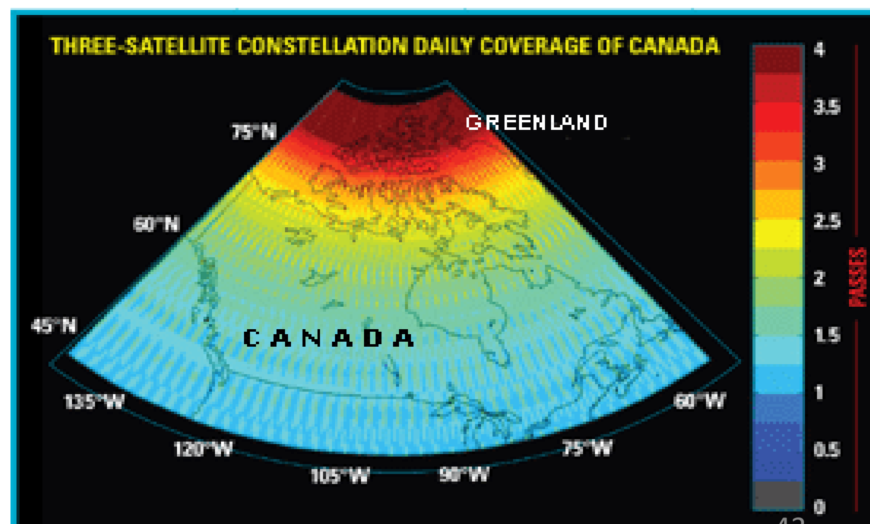
McNairn, H., Kross, A., Lapen, D., Caves, R., and Shang J. 2014. Early season monitoring of corn and soybeans with TerraSAR-X and RADARSAT-2, International Journal of Applied Earth Observation and Geoinformation 28 (2014) 252–259.

RADARSAT Constellation Mission

http://www.asc-csa.gc.ca/eng/satellites/radarsat/default.asp

- Evolution of the RADARSAT Program →3 satellites – 600 km orbit, 32 minutes separation
- Multi-pol and fully polarimetric, high-resolution
- 15 min/orbit imaging (avg) x 3 satellites
- Average daily global access; 4-day exact repeat
- Focus on Marine Surveillance, Disaster Management and Ecosystem Monitoring (*including Agriculture*)
- Open data policy ?





Agriculture : Oil palm & Rubber

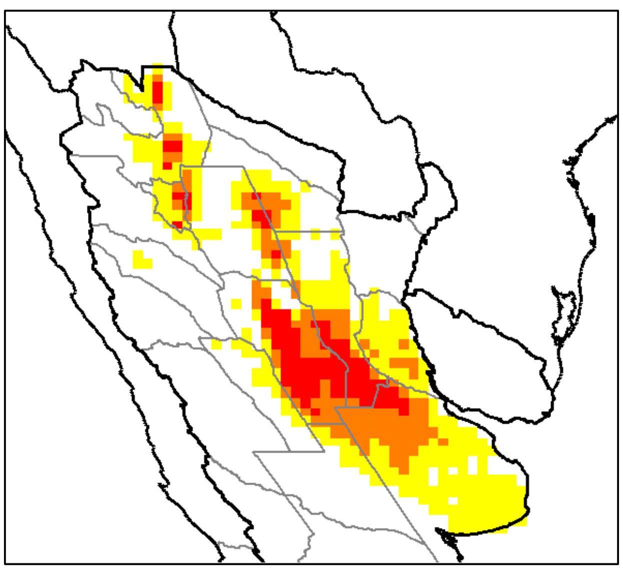
THEOS 191208

1 Oil palm
2 Para rubber
99 Miscellaneous
500 Water body

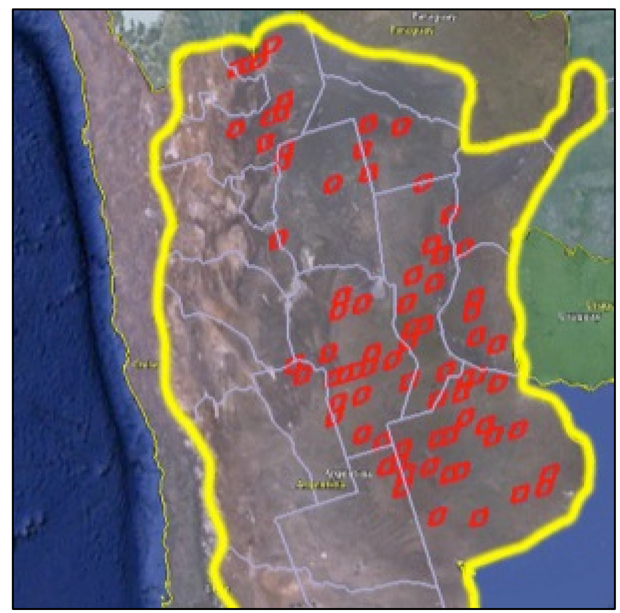
GISTDA

High Resolution Sampling Strategy for Soybean Area in Argentina

- Some requirements (high temporal and/or spatial resolution) are for entire **cropland extent**; others are on a **sampled basis**
  - **Sampling strategy** in development;
  - For Phase 1A (e.g. Argentina):



Argentina Sample Strata



Derived Rapid Eye Sample Blocks
40 km x 40 km ; n = 75

(Matt Hansen, Carlos Di Bella, et al.)

The GEOGLAM Components

Global Monitoring System Coordination

Monitoring System Enhancement

Earth Observation Data Coordination

GEOGLAM IT Infrastructure

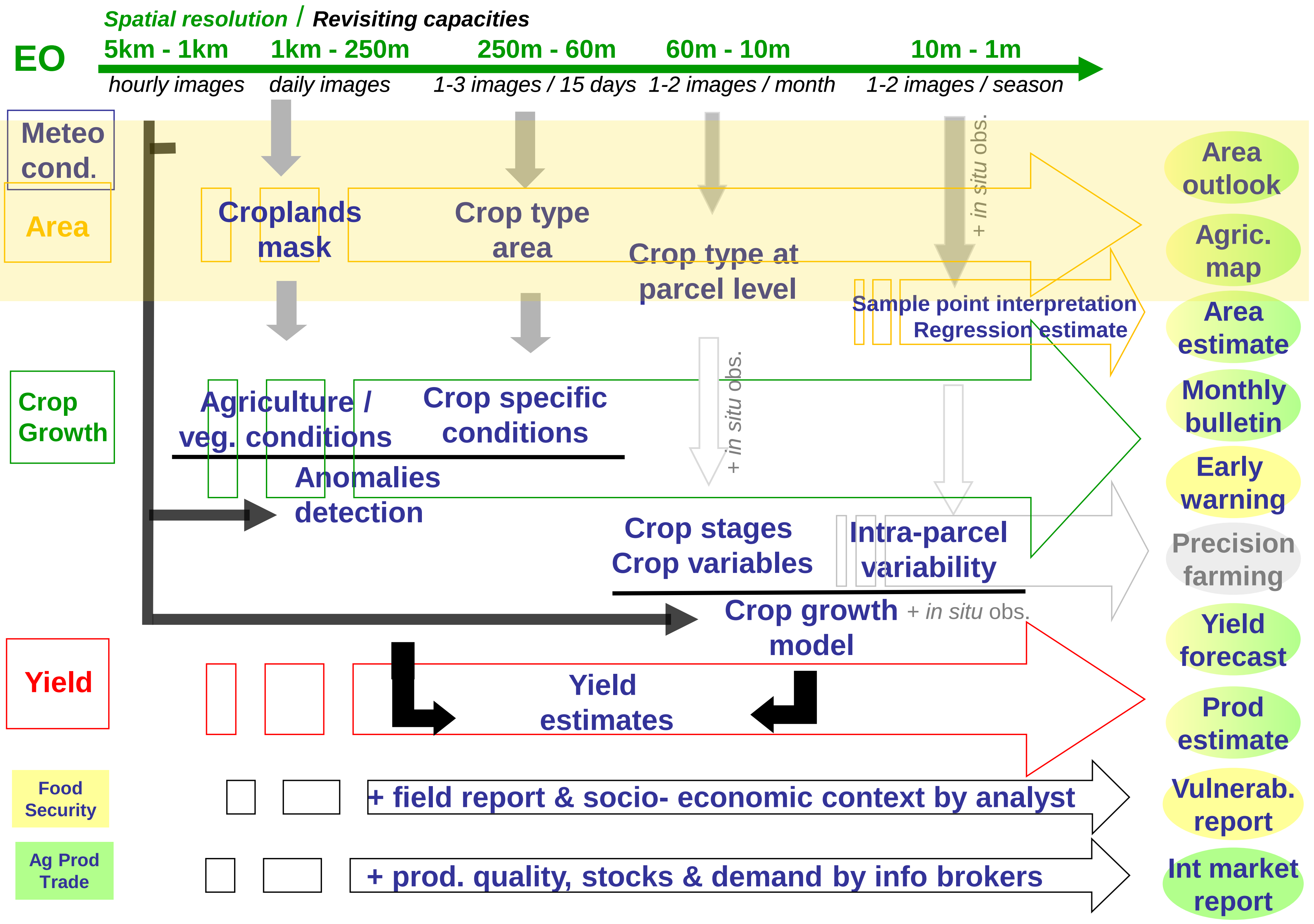
Operational Research and Development

Capacity Building Coordination

GEOGLAM Regional Initiatives:
ASIA Rice
Latino America

Rangeland Monitoring Coordination (RAPP)

Agricultural Monitoring : EO data and Final products



GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Research Foci at the Joint Experiment for Crop Assessment and Monitoring (JECAM) Sites

Developing Methods for:

- Crop Type mapping
- Crop Condition monitoring
- Yield Estimation modeling
- Soil Moisture estimation
- Residue and Tillage monitoring

JECAM.org

- EC SIGMA Project, Sentinel 2 Agri and BMGF STARS are strengthening the JECAM field data collection protocols and intercomparison

JECAM
Joint Experiment for Crop Assessment and Monitoring

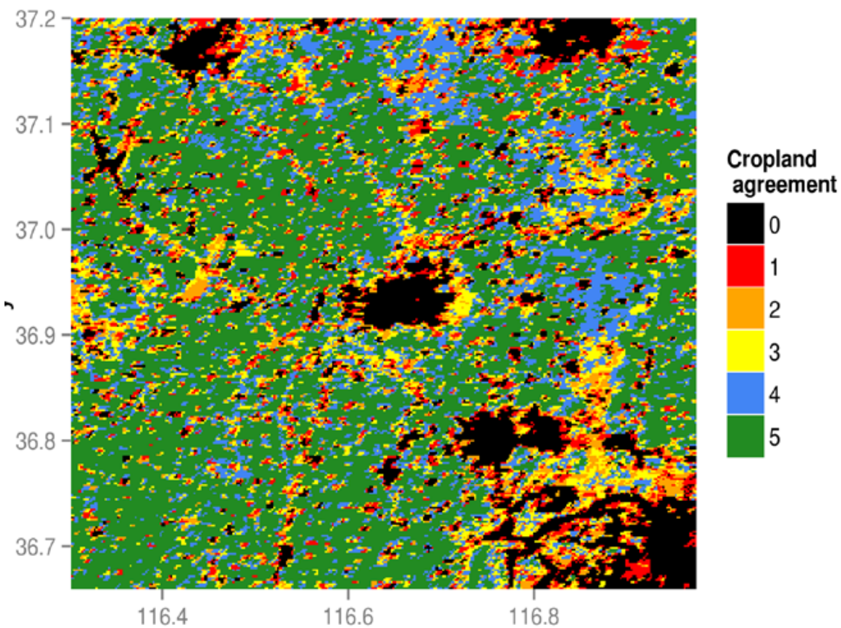
GROUP ON EARTH OBSERVATIONS

JECAM – SIGMA methods benchmarking results

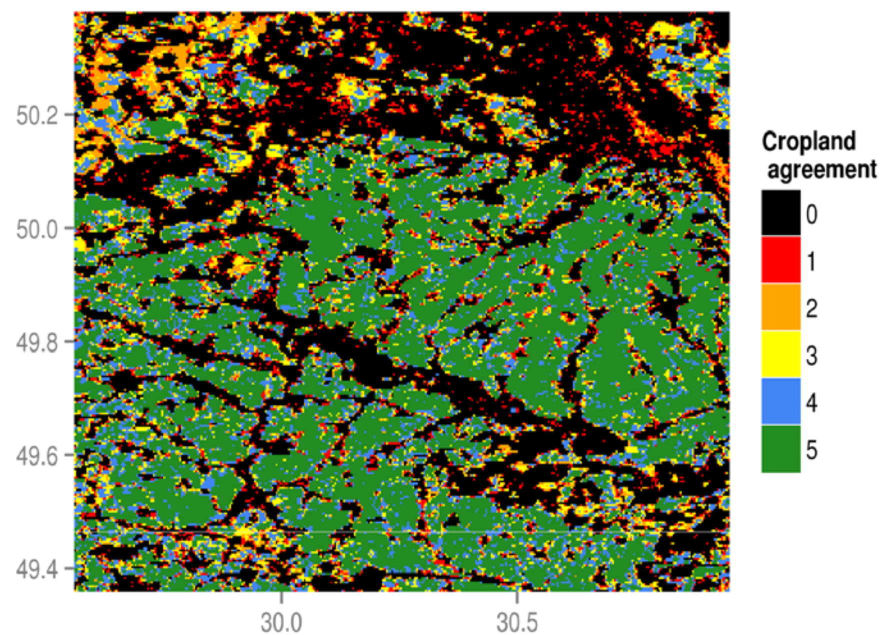
→ Similar cropland mapping accuracy performances of all methods for a site

→ Different performances according the site : ag.landscape impact

→ Influence of the satellite data quality used as input

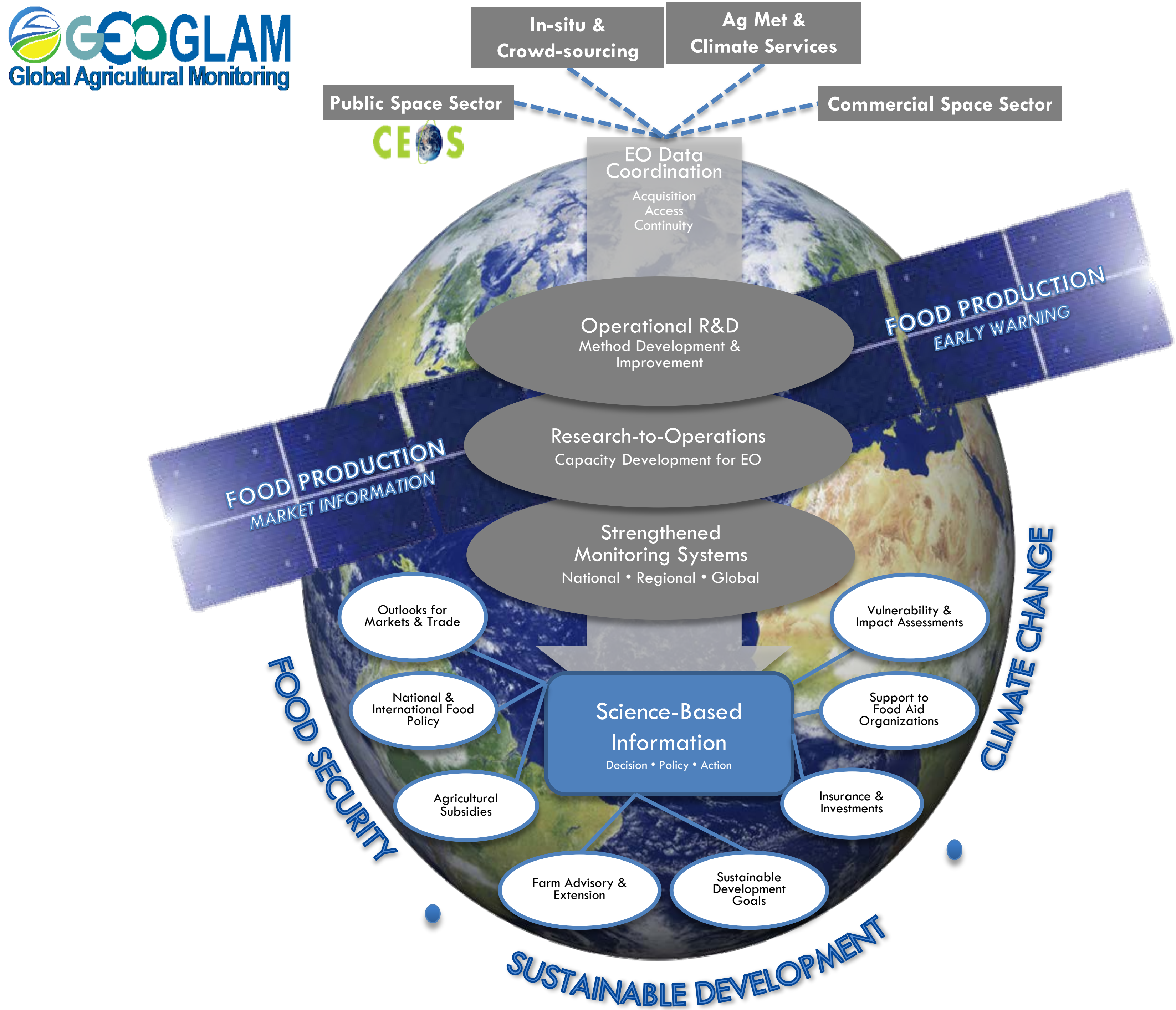


CHINA



UKRAINE

SIGMA
Stimulating Innovation for Global Monitoring of Agriculture



GEOGLAM
Global Agricultural Monitoring
In-situ & Crowd-sourcing
Ag Met & Climate Services
Public Space Sector
CEOS
Commercial Space Sector
EO Data Coordination
Acquisition
Access
Continuity
FOOD PRODUCTION
EARLY WARNING
Operational R&D
Method Development & Improvement
FOOD PRODUCTION
MARKET INFORMATION
Research-to-Operations
Capacity Development for EO
Strengthened Monitoring Systems
National • Regional • Global
Outlooks for Markets & Trade
Vulnerability & Impact Assessments
National & International Food Policy
Science-Based Information
Decision • Policy • Action
Support to Food Aid Organizations
Agricultural Subsidies
Insurance & Investments
Farm Advisory & Extension
Sustainable Development Goals
FOOD SECURITY
CLIMATE CHANGE
SUSTAINABLE DEVELOPMENT

So in Summary
What is GEOGLAM doing?

- Increasing communication and sharing experience amongst the Ag Monitoring Community of Practice and with related progra…
- Helpi… …s
- Transl…
- Promo… …ing and raising…
- Articu… …s to the EO da…
- Increasing the awareness of EO by the econ/policy community
- Method testing and inter-comparison, developing best practices
- Developing new monitoring capabilities and products

ขอบคุณ