Research to Operations in Agricultural Monitoring

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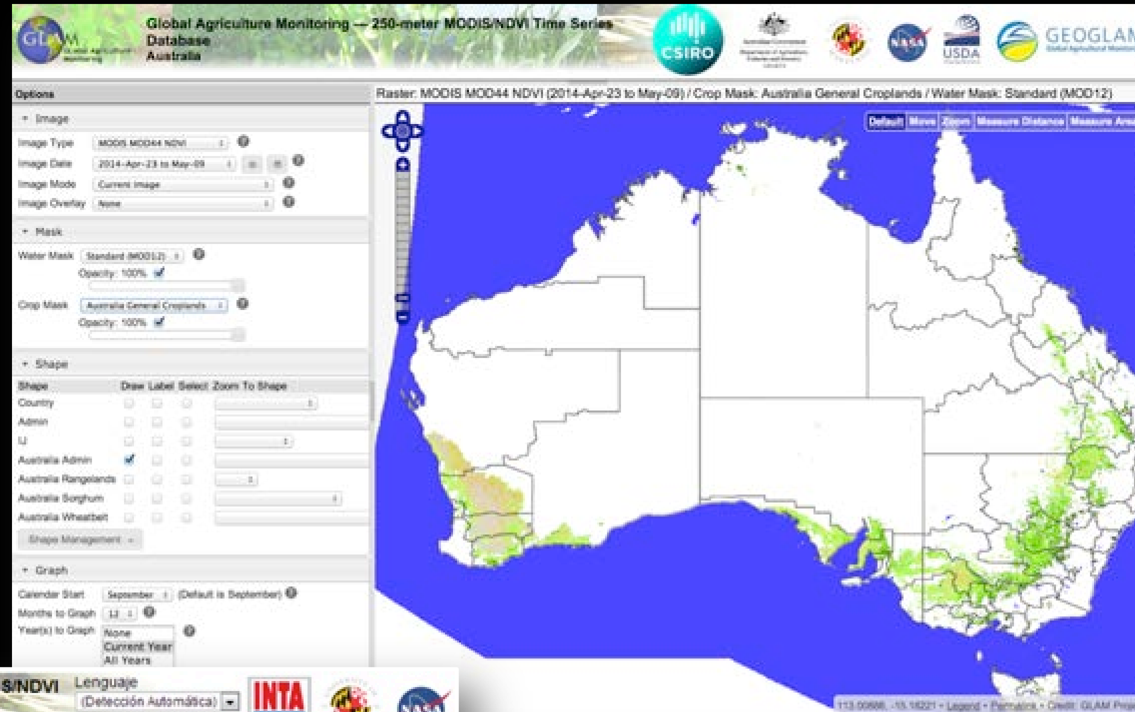
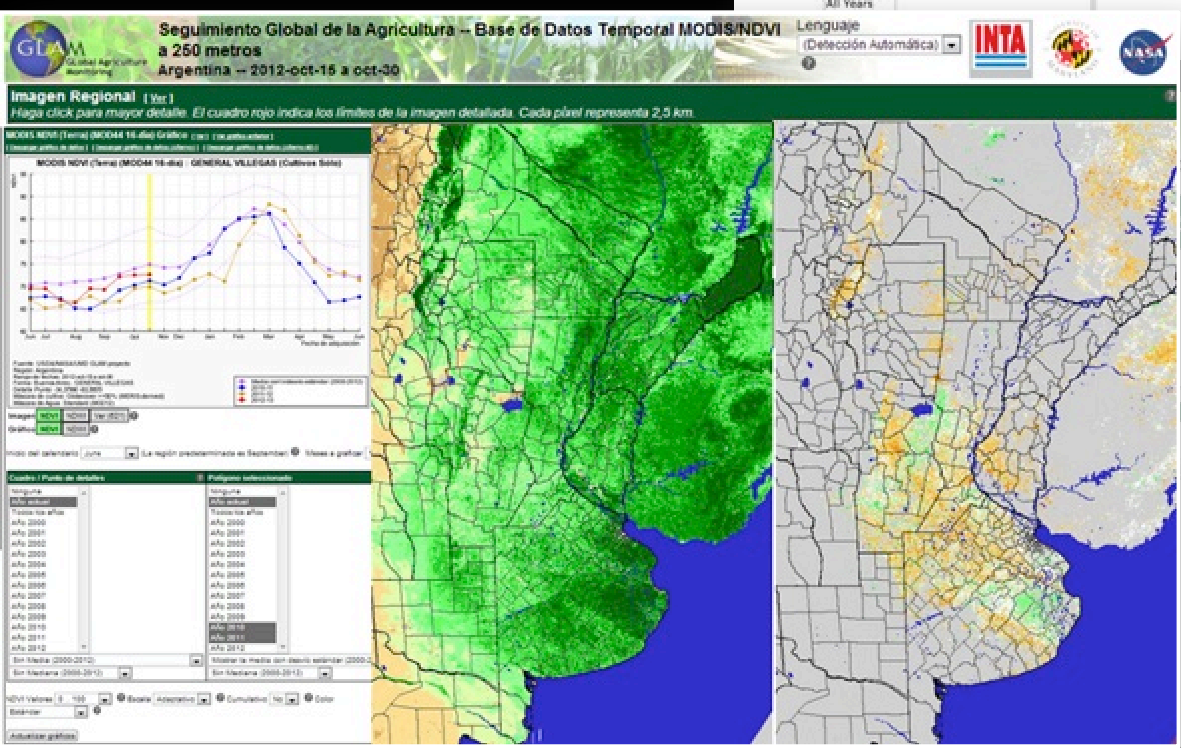
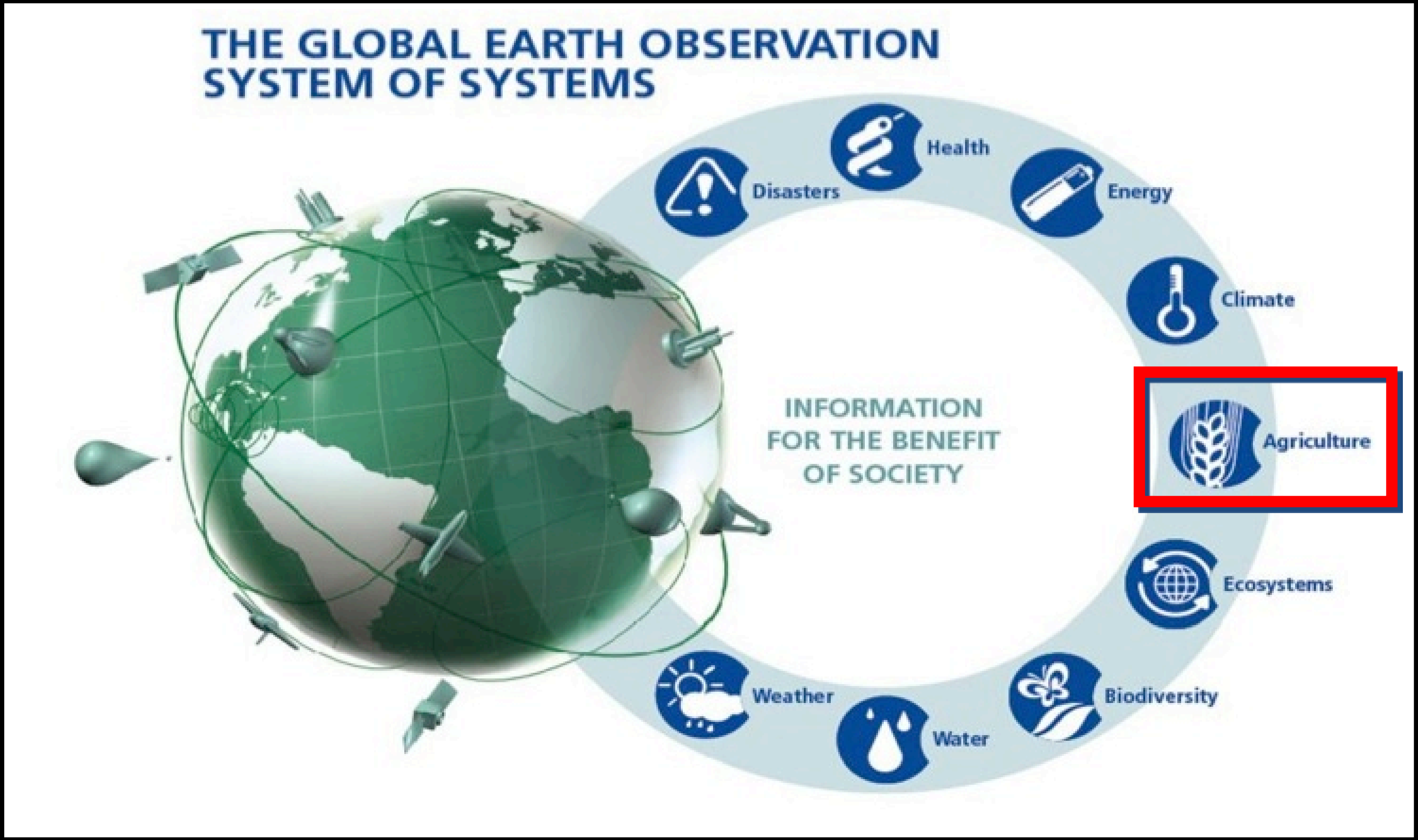
- c. 2005 UMD/NASA working with USDA to transition crop analysis from AVHRR to MODIS.
- Developed the Global Agricultural Monitoring (GLAM) System crop condition interface
- Provided to other countries e.g. **Australia, Mexico, Argentina, Brazil, Colombia**





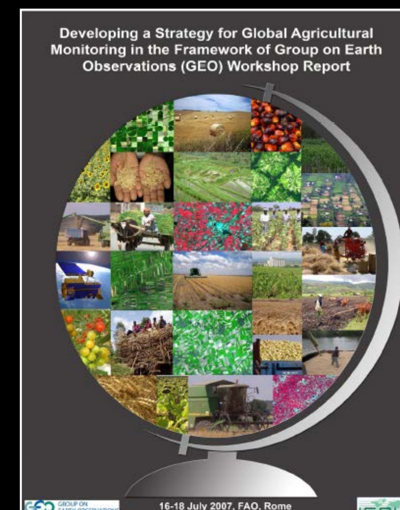
GEO is the international program focused on the use of Earth Observations for societal benefit

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



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

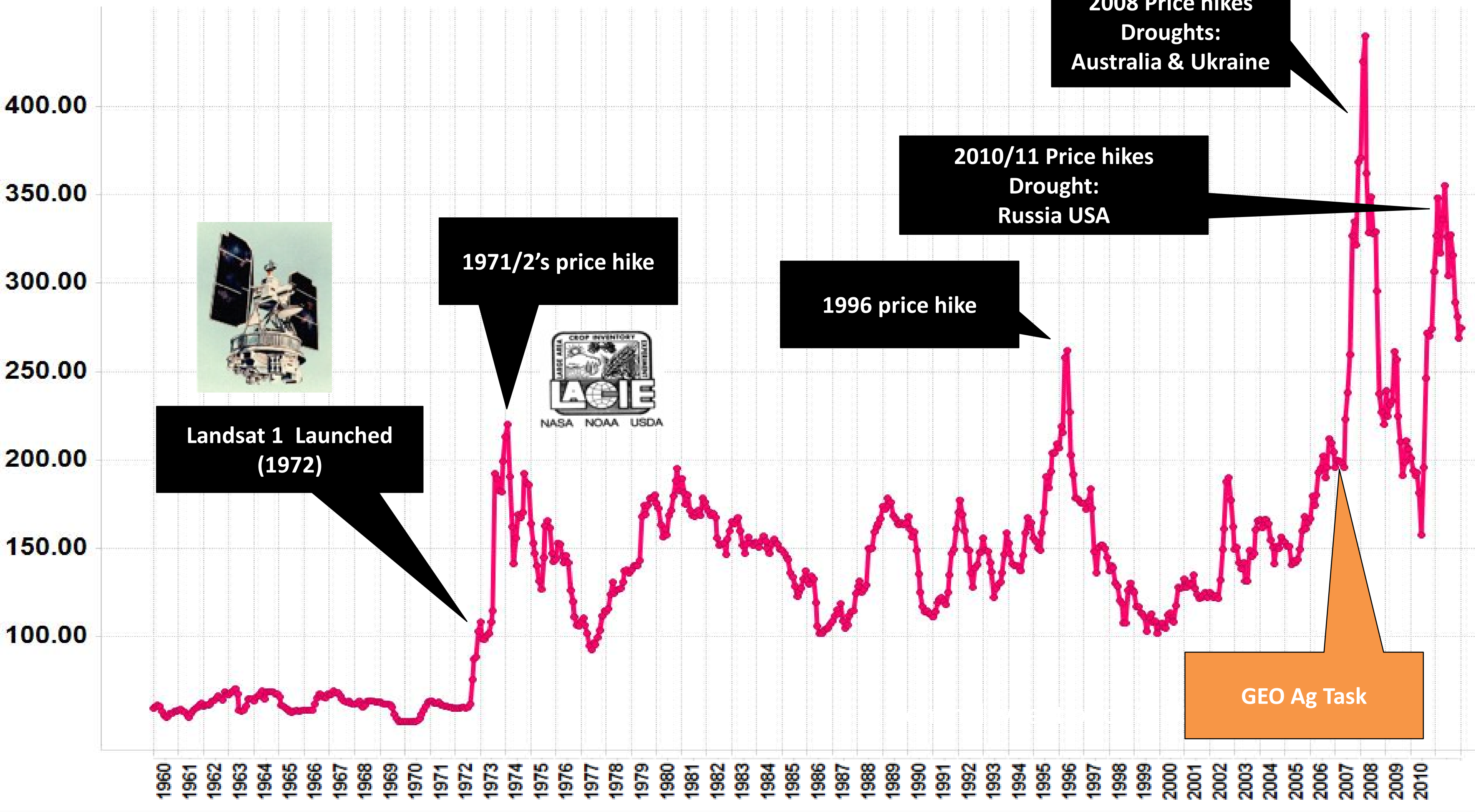
GROUP ON EARTH OBSERVATIONS

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

1. Global / Regional Monitoring Systems

International/Global

2. National Monitoring Systems

National / Subnational

3. Monitoring Countries at Risk

Food Insecure and Most Vulnerable

4. EO Data Acquisition & Dissemination Coordination CEOS

5. Research & Development toward Operations

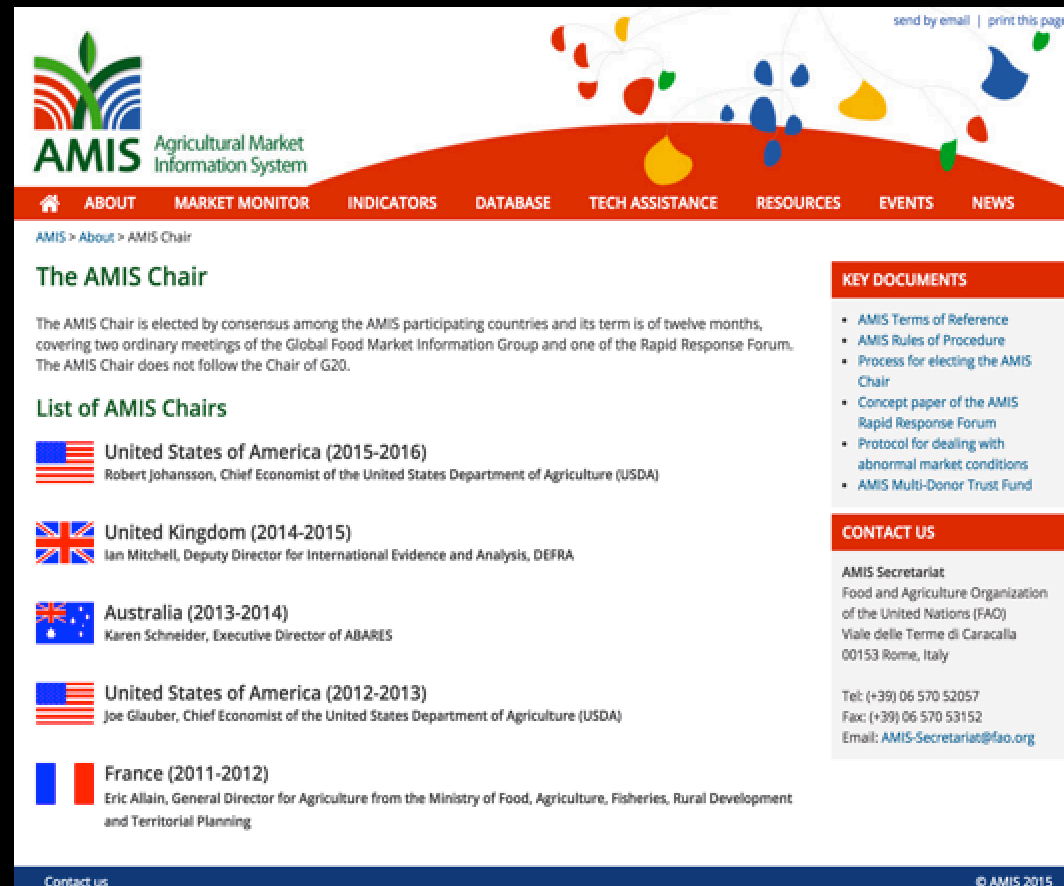
6. Capacity Development for EO

GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

AMIS: Agricultural Market Information System

Improve market information and transparency

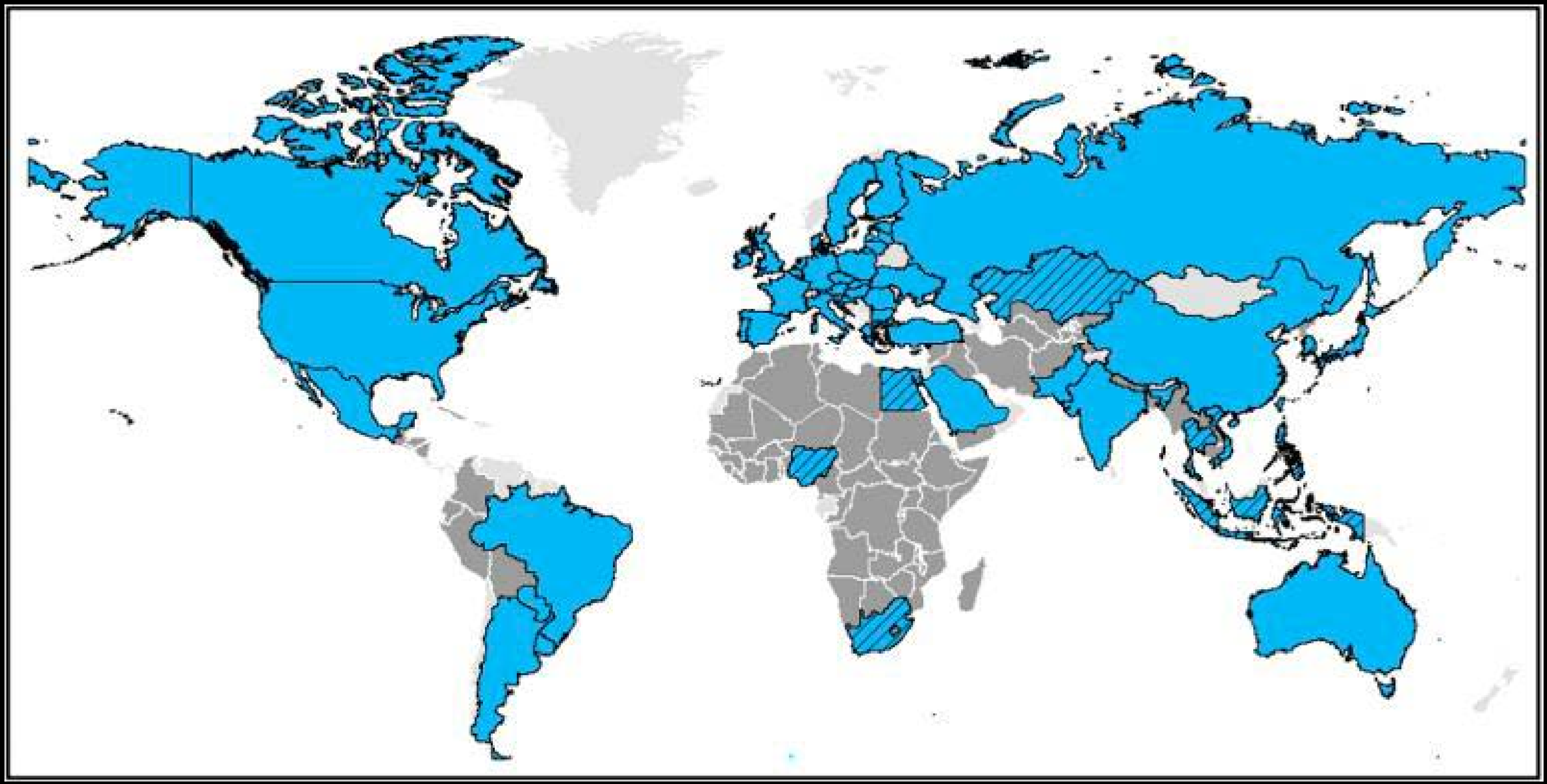


inter-Agency Platform to enhance food market transparency and encourage coordination of policy action in response to market uncertainty www.amisoutlook.org

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

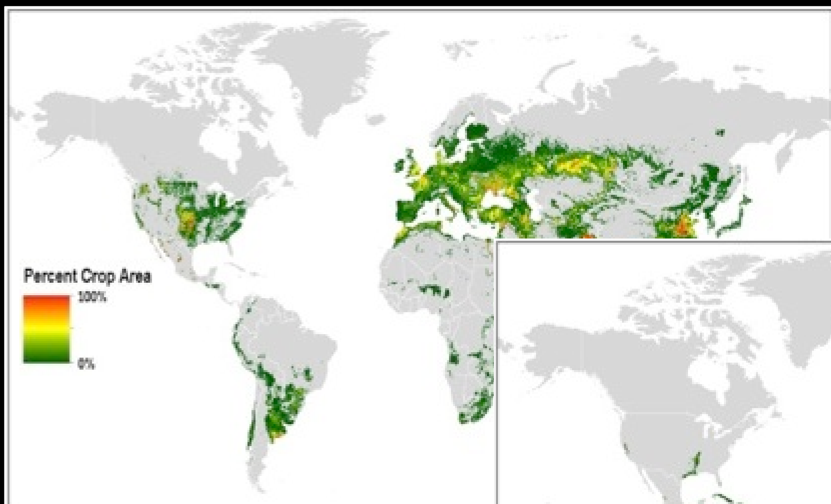
AMIS COUNTRIES



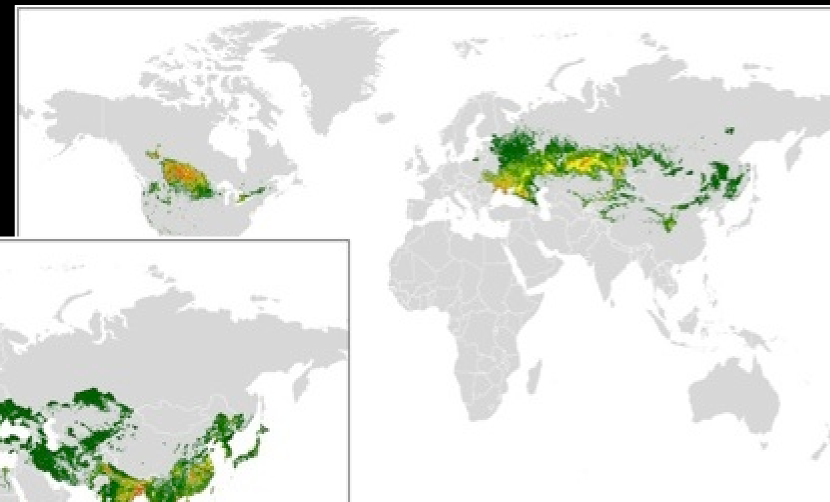
GEOGLAM Best Available Multi-Season Crop Masks

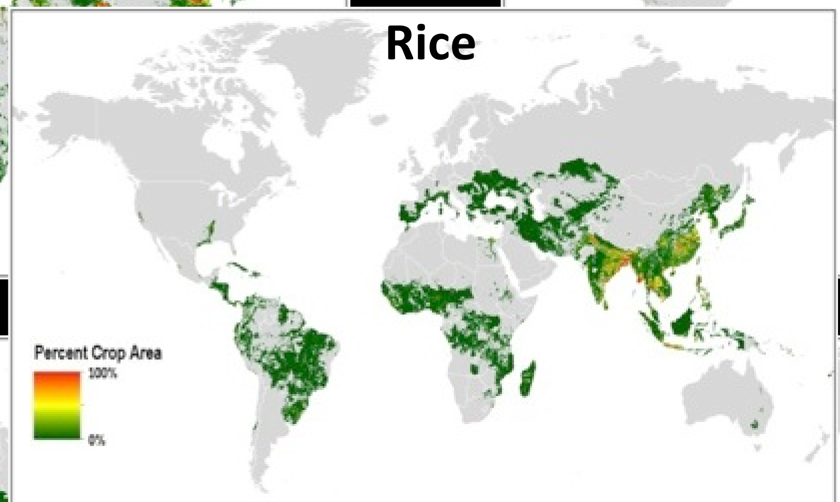
20 contributors and counting w. on going improvements

Winter Wheat

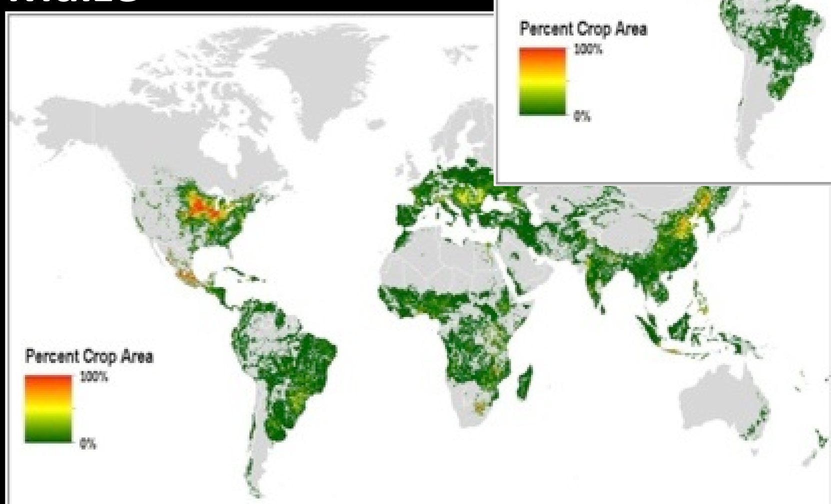


Spring Wheat

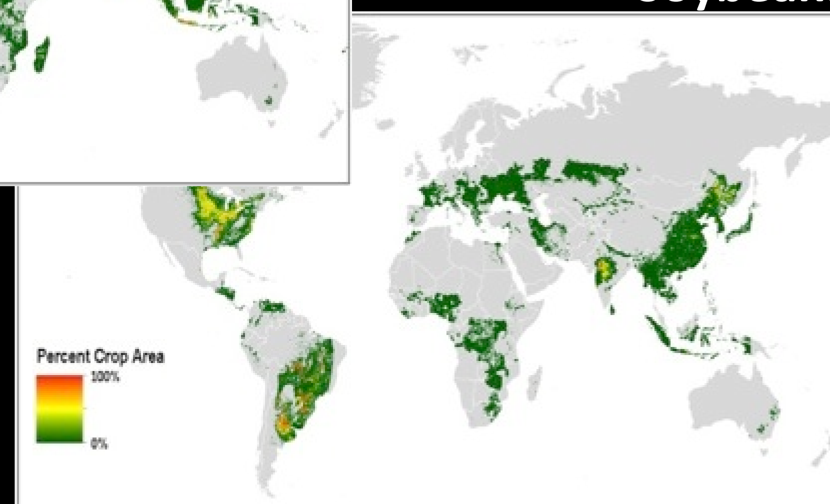




Maize

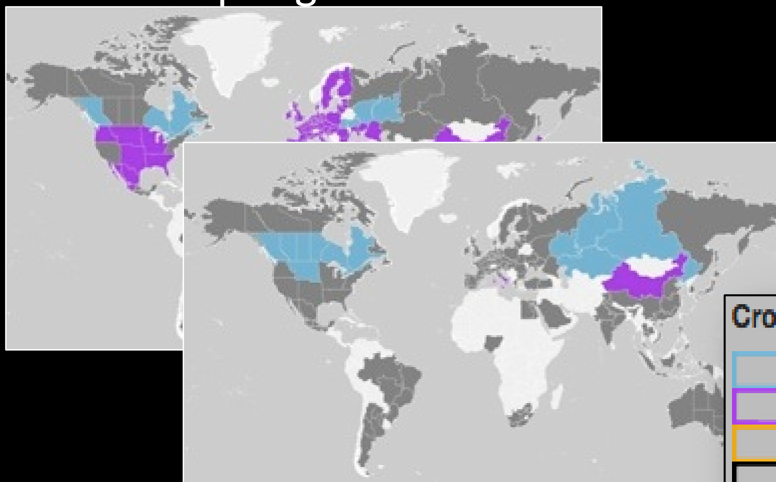


Soybeans

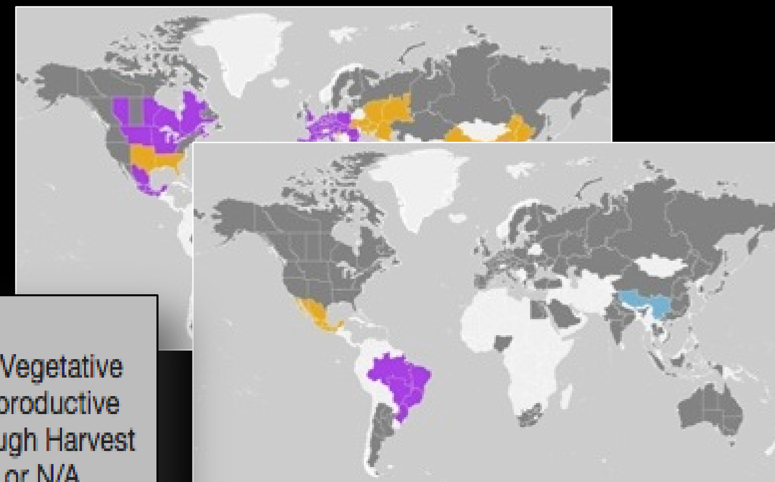


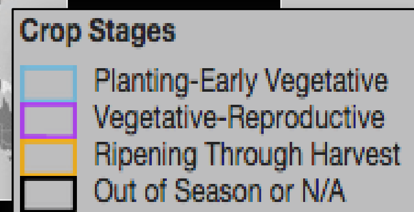
Best Available Multi-Season Crop Calendars

Winter & Spring Wheat

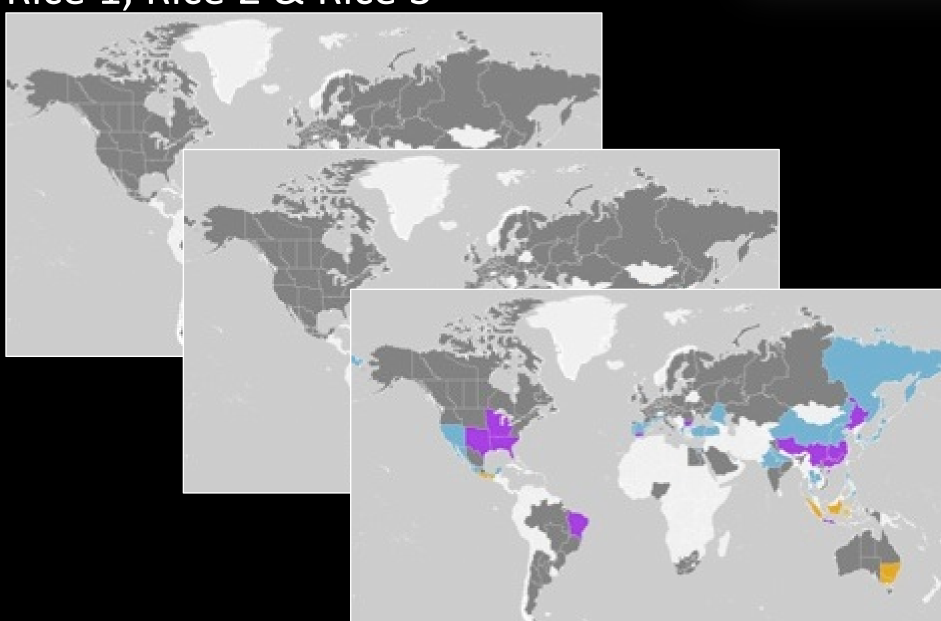


Maize 1 & Maize 2

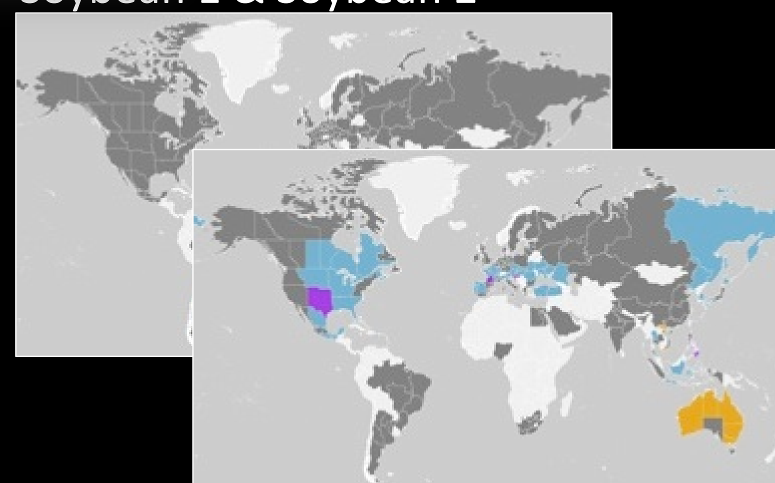




Rice 1, Rice 2 & Rice 3



Soybean 1 & Soybean 2

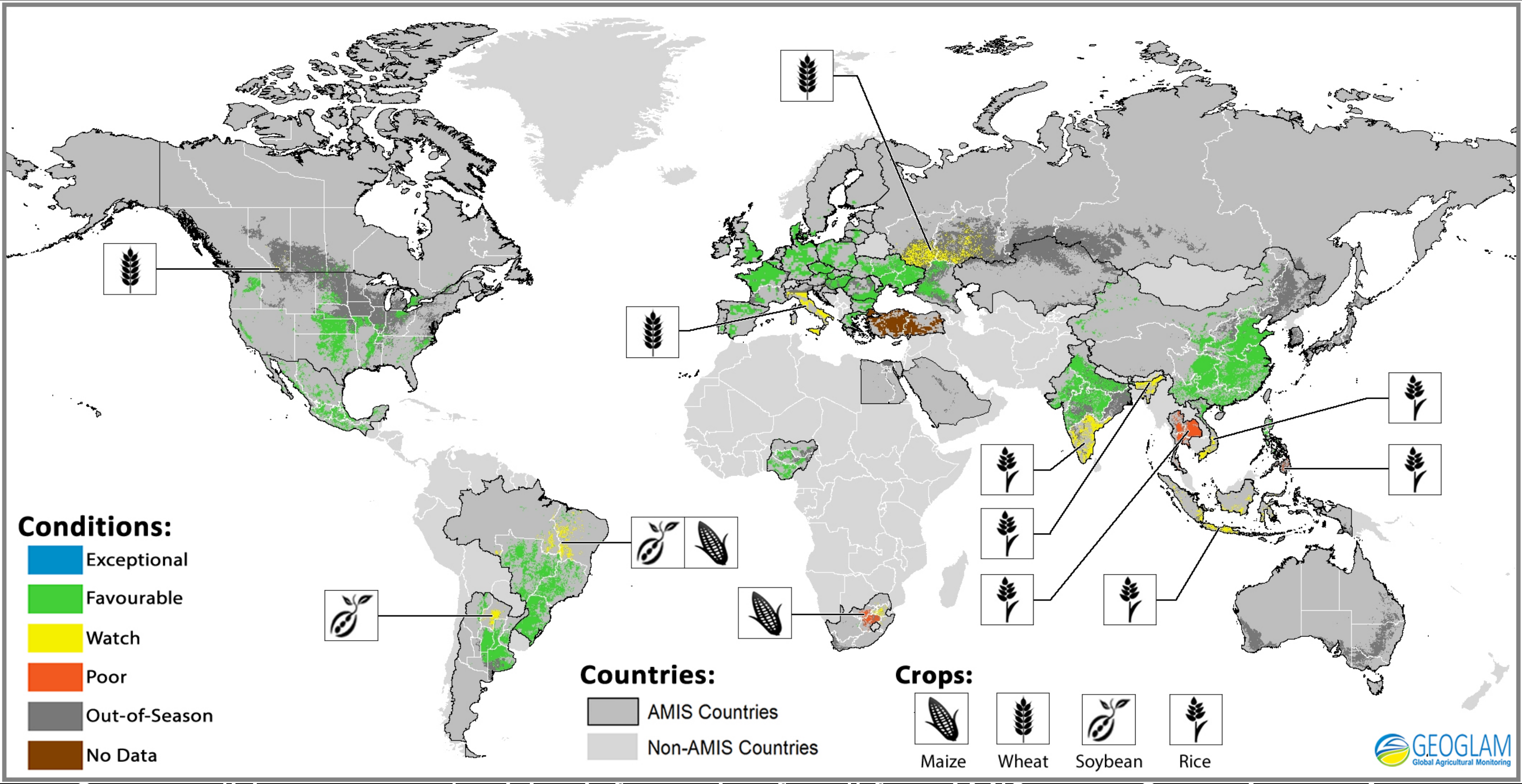


Calendars reflecting multiple cycles of the same crop

GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Crop Monitor : an international consensus assessment - March 28th

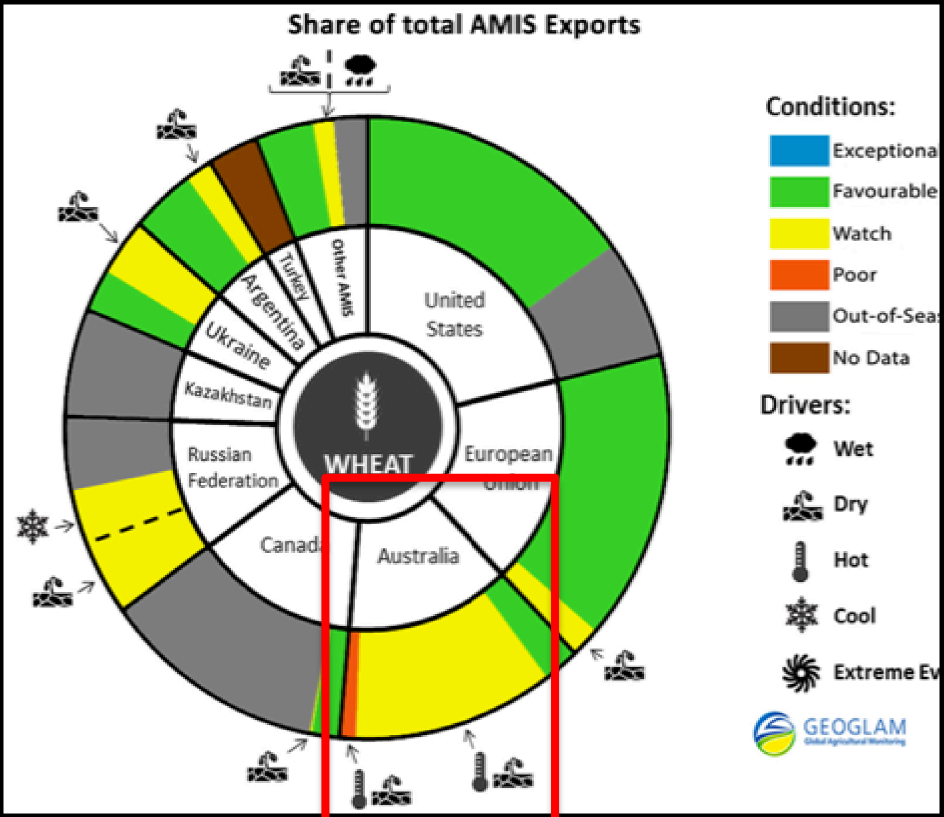


Crop condition map synthesizing information for all four AMIS crops. **Crops that are in other than favorable conditions are displayed on the map with their crop symbol.** (Cropland area shown is an aggregation of all cropland areas)

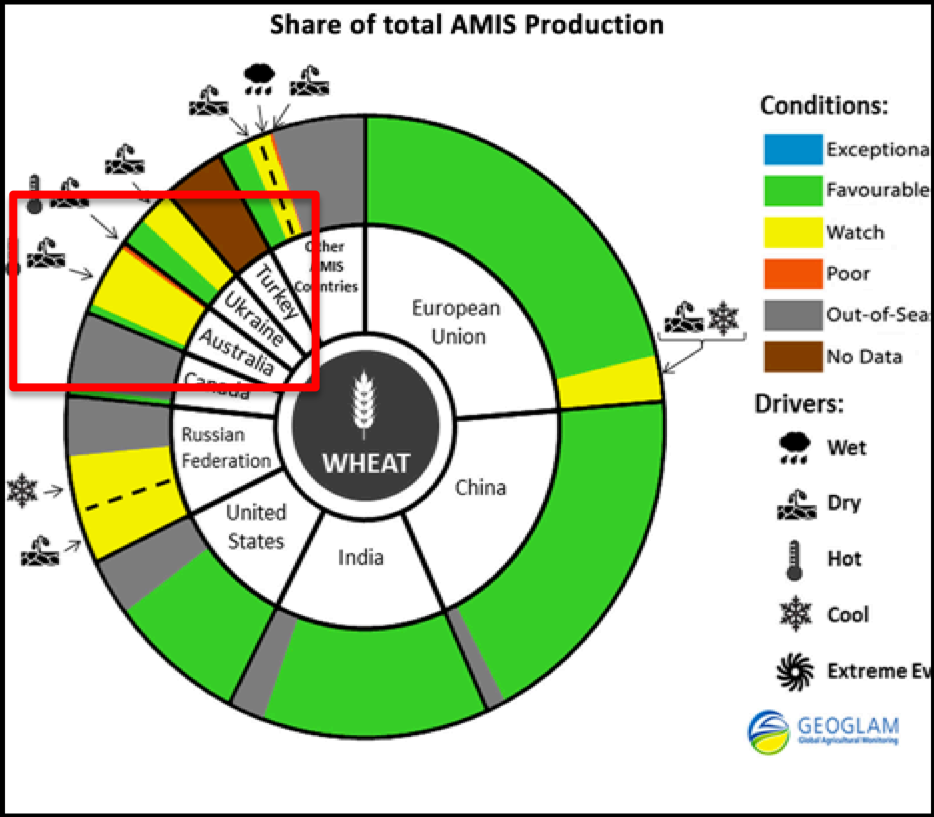
Becker-Reshef et al.

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

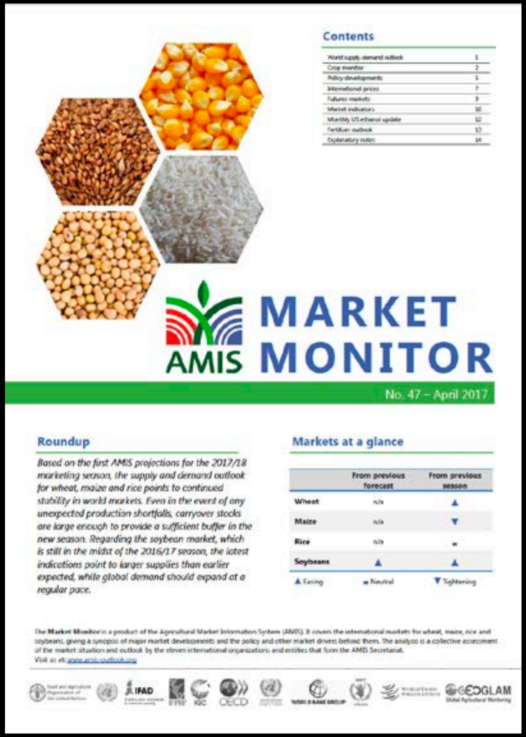
GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

G20 Agricultural Ministers

2011 Action Plan on Food Price Volatility and Agriculture

AMIS – Markets/Stocks


MARKET MONITOR

AMIS

No. 47 – April 2017

Roundup

Based on the first AMIS projections for the 2017/18 marketing season, the supply and demand outlook for wheat, maize and rice points to continued stability in world markets. Even in the event of any unexpected production shortfalls, carryover stocks are large enough to provide a sufficient buffer in the new season. Regarding the soybean market, which is still in the midst of the 2016/17 season, the latest indications point to larger supplies than earlier expected, while global demand should expand at a regular pace.

Markets at a glance

	From previous forecast	From previous season
Wheat	n/a	▲
Maize	n/a	▼
Rice	n/a	=
Soybeans	▲	▲

▲ Easing = Neutral ▼ Tightening

GEOGLAM – Condition/Supply


GEOGLAM

CROP MONITOR FOR AMIS

NO. 38

April 2017

The Group on Earth Observations' Global Agricultural Monitoring (GEOGLAM) initiative developed the Crop Monitor whose objection is to provide AMIS with an international and transparent multi-source, consensus assessment of crop growing conditions, status, and agro-climatic conditions, likely to impact global production. This activity covers the four primary crop types (wheat, maize, rice, and soy) within the main agricultural producing regions of the AMIS countries (G20+7). The Crop Monitor reports provide cartographic and textual summaries of crop conditions as of the 28th of each month, according to crop type. There is another Crop Monitoring initiative called the Early Warning Crop Monitor (geoglam-crop-monitor.org/), which has grown out of this initiative.

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

https://cropmonitor.org/

GEOGLAM AMIS Crop Monitor Partners

> 35 Partners and Growing

GROUP ON EARTH OBSERVATIONS
GEOGLAM Global Agricultural Monitoring

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

The GEOGLAM Components

1. Global / Regional Monitoring Systems

International/Global

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National / Subnational

3. Monitoring Countries at Risk

Food Insecure and <u>Most</u> Vulnerable

4. EO Data Acquisition & Dissemination Coordination CEOS

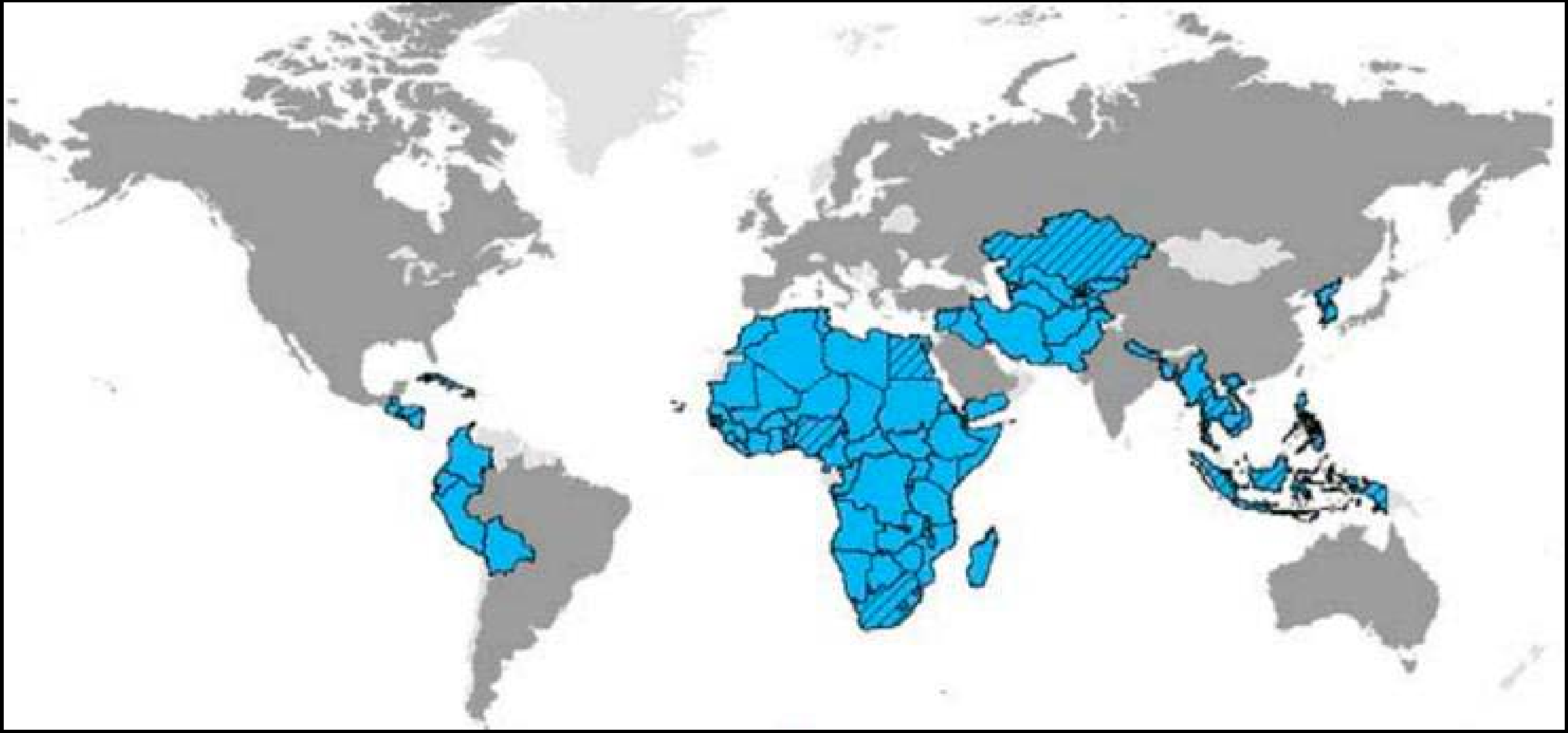
5. Research & Development toward Operations

6. Capacity Development for EO

GROUP ON EARTH OBSERVATIONS

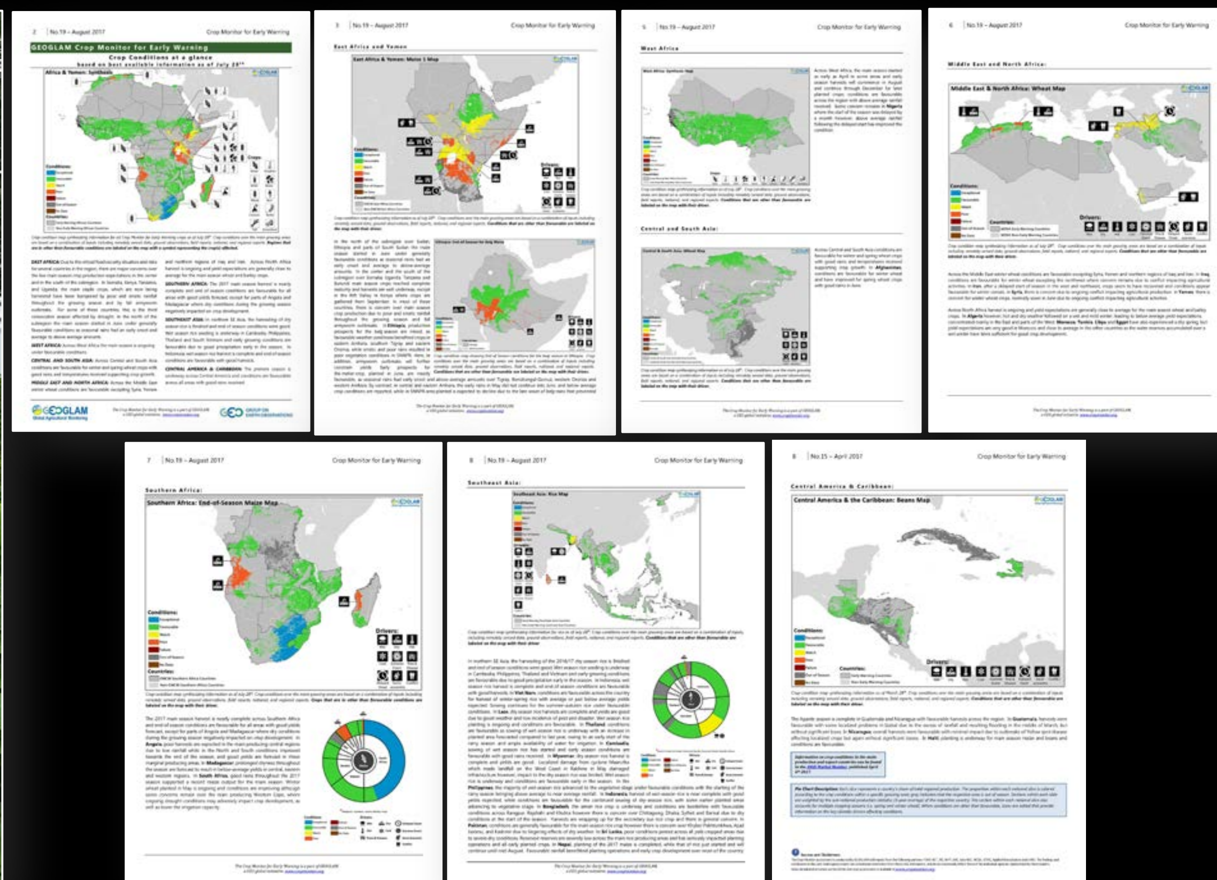
GEOGLAM Global Agricultural Monitoring

Early Warning Crop Monitor Countries



Crop Monitor for Early Warning Bulletin

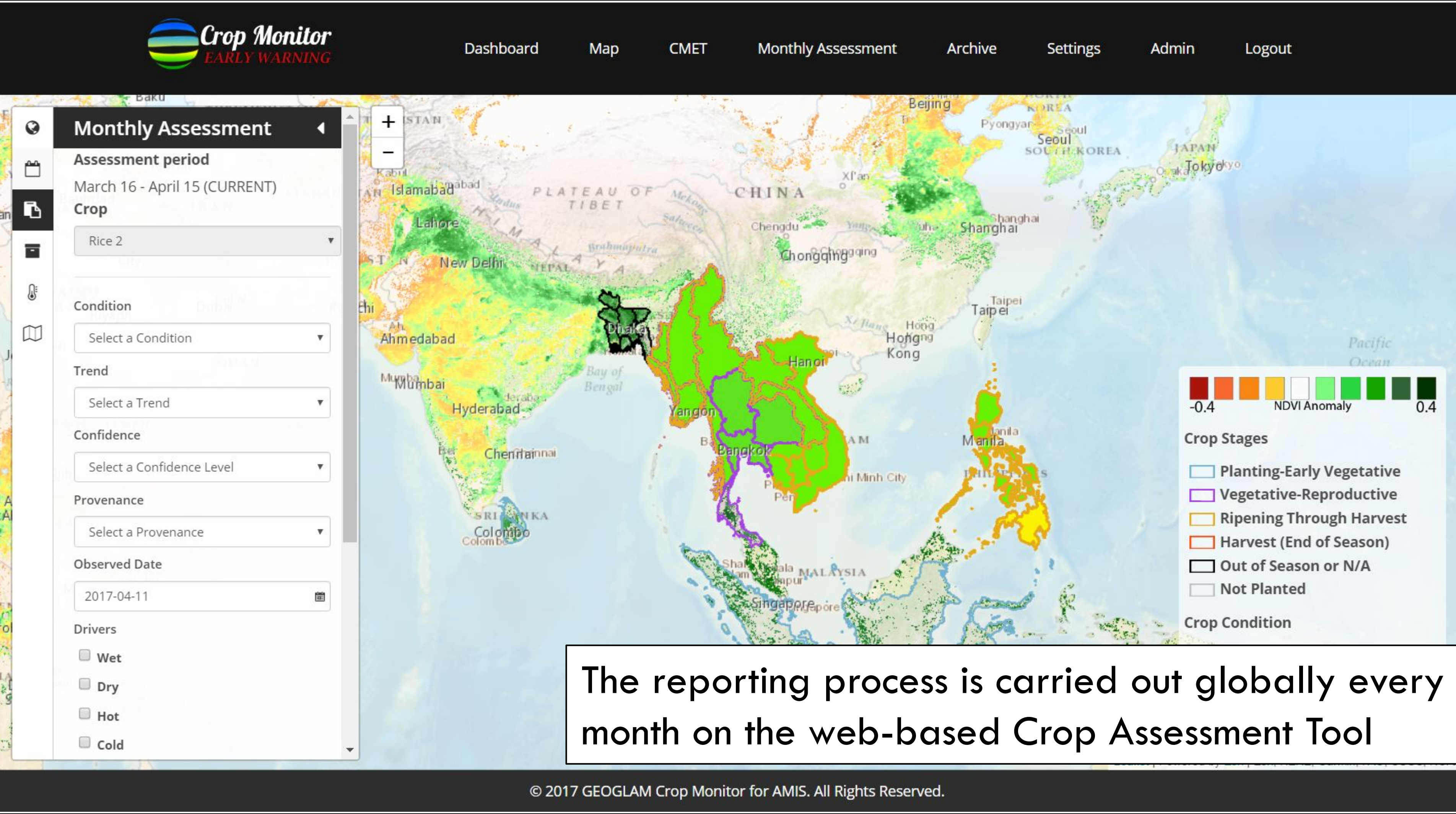
www.cropmonitor.org



GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

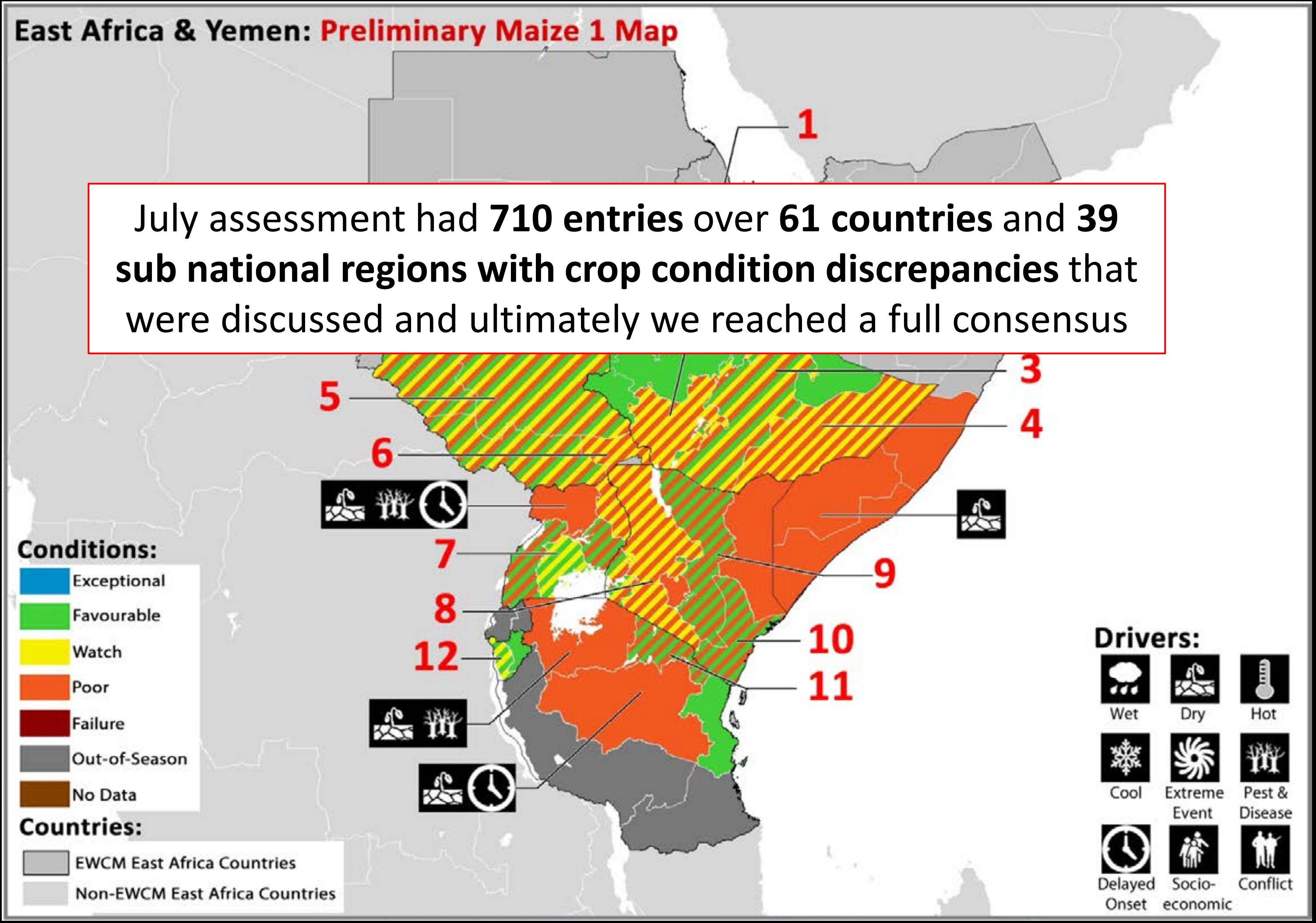
Crop Condition Reporting Interface



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

Example discrepancy map

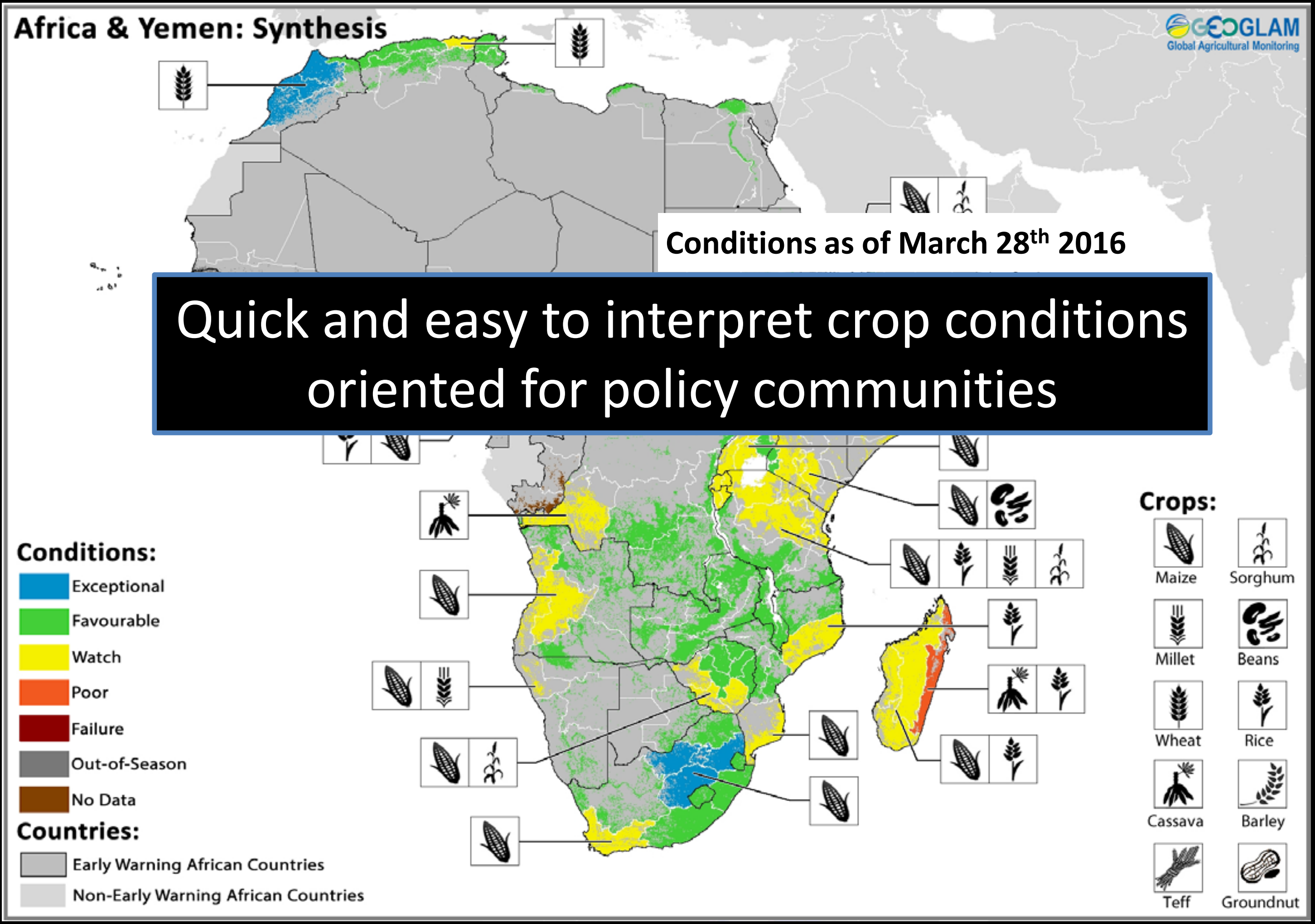
- Hashed areas show conflicting crop condition entries from different agencies



Map Products

Crop specific & regional synthesis map

- Synthesis maps provide an overview of regional conditions
- Crop specific maps convey the drivers behind those conditions



Already informing agricultural decisions

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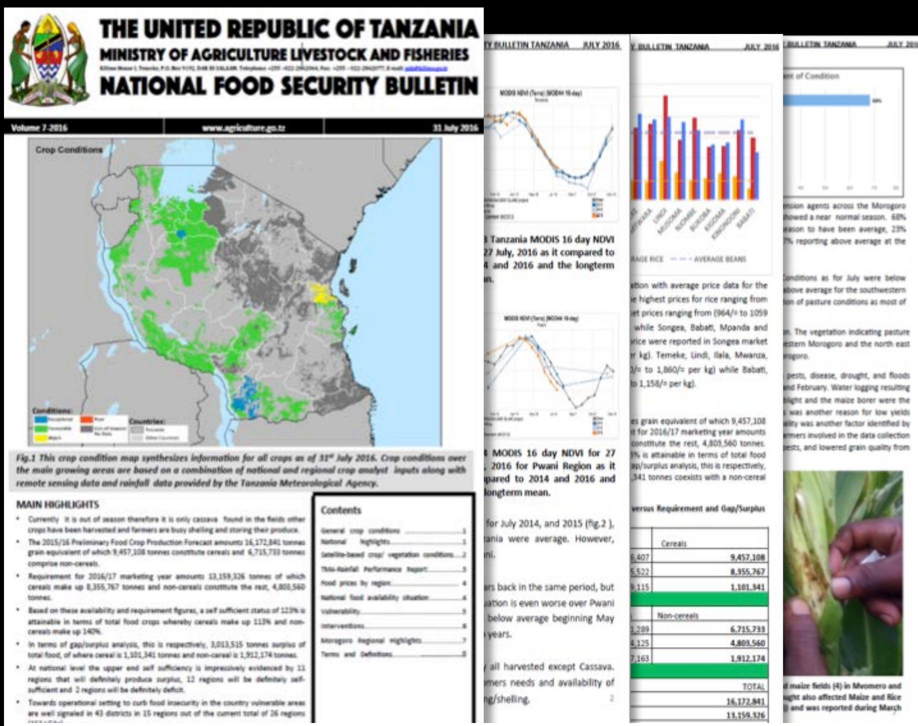
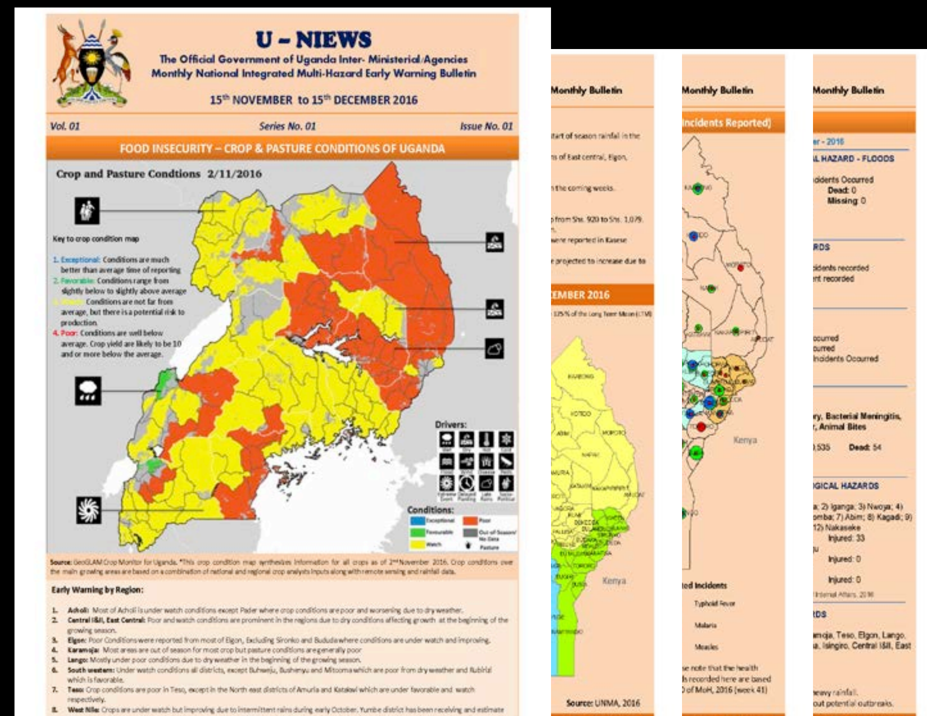
Example: Development of National Crop Monitors, Facilitating National Food Security Reports



National Food Security Bulletin, published by the Tanzania Ministry of Agriculture Food Security, National Food Security Division

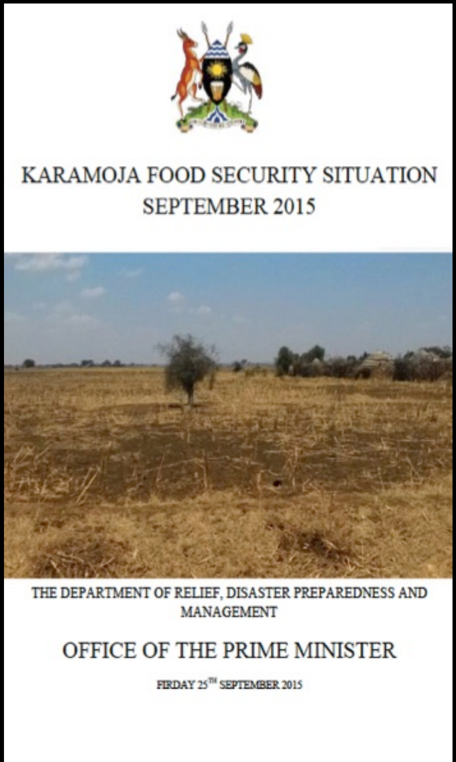


The Inter-Ministerial/Agencies Monthly National Integrated Multi-Hazard Early Warning Bulletin, published by the Uganda Office of the Prime Minister

Informing Decisions in Uganda: September 2015

"**Karamoja Food Security Situation**" report used to justify mobilization of food aid in the Karamoja region.

Report applied remote sensing for timely, accurate, actionable in-season monitoring of crop conditions.


KARAMOJA FOOD SECURITY SITUATION
SEPTEMBER 2015

THE DEPARTMENT OF RELIEF, DISASTER PREPAREDNESS AND MANAGEMENT

OFFICE OF THE PRIME MINISTER

FIRDAY 25TH SEPTEMBER 2015

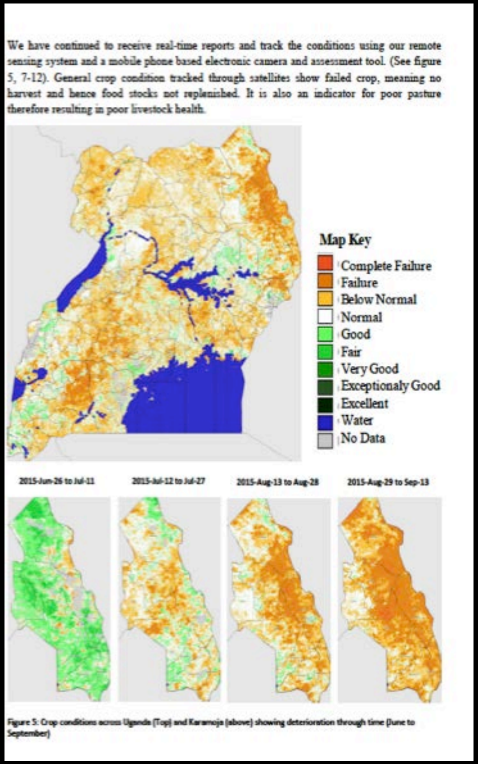

We have continued to receive real-time reports and track the conditions using our remote sensing system and a mobile phone based electronic camera and assessment tool. (See figure 5, 7-12). General crop condition tracked through satellites show failed crop, meaning no harvest and hence food stocks not replenished. It is also an indicator for poor pasture therefore resulting in poor livestock health.

Figure 5: Crop conditions across Uganda (Top) and Karamoja (above) showing deterioration through time (June to September)

Food security report presented to Inter-Ministerial Committee
September 25, 2015

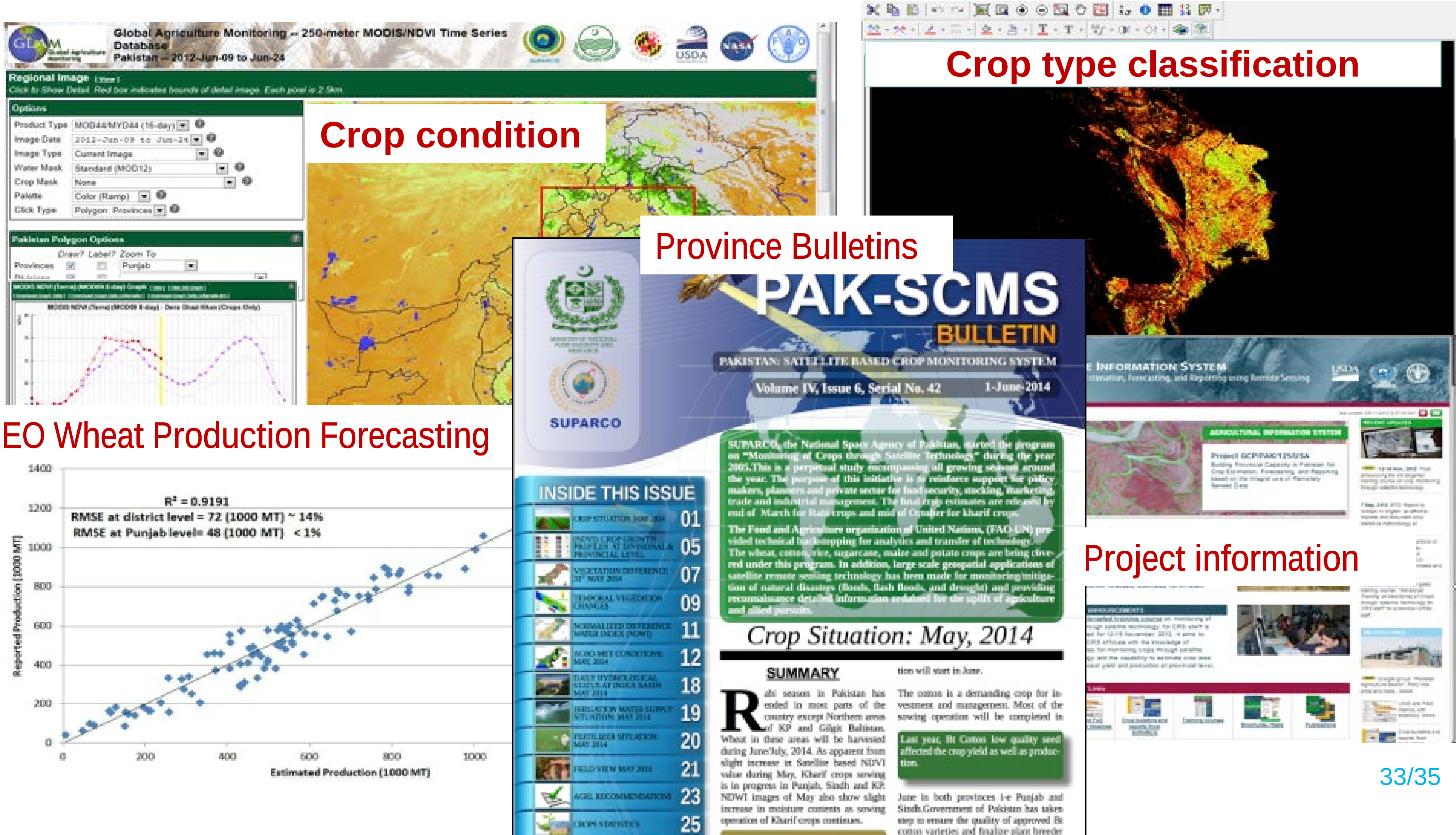
First trucks of relief food dispatched to Karamoja
September 26, 2015

GEO GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Example : Pakistan Agricultural Information System

(Collaboration among CRS, USDA, FAO, SUPARCO & UMD)



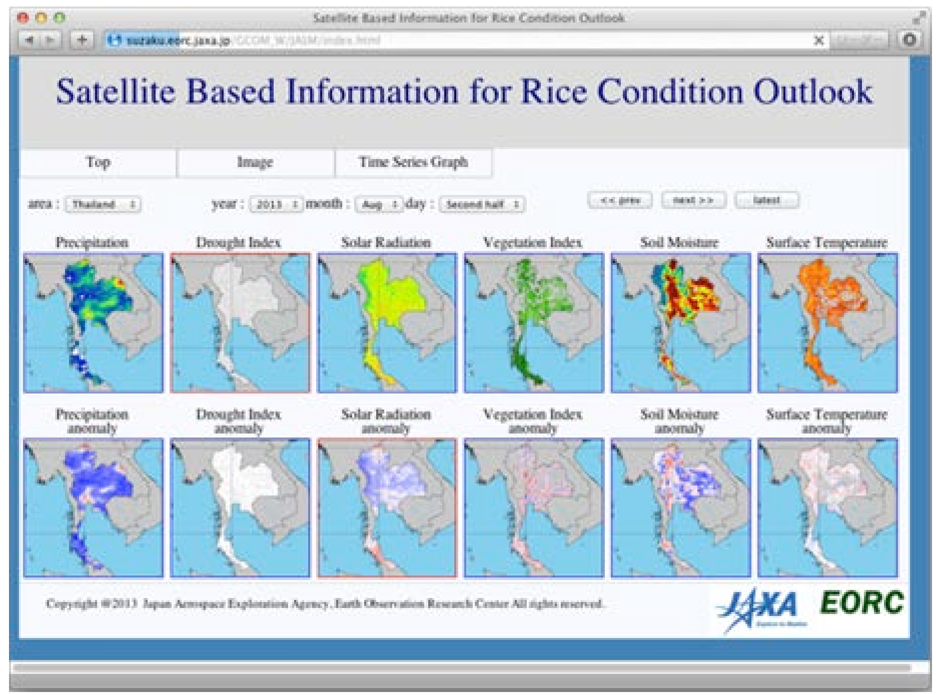
GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Asia-RiCE Crop Estimation and Monitoring

Asia-RiCE Regional Monitoring

- A multi-national project led by Japan (JAXA), with collaborations in ASEAN+3 countries and India
- A regional view using agro-meteorological data derived from low resolution optical satellite imagery (MODIS, GCOM-W, TRMM and others)
- A local view to estimate rice crop area and production using available radar and other satellite data with ground observation data and statistical information (test-sites in Indonesia, Thailand and Vietnam)

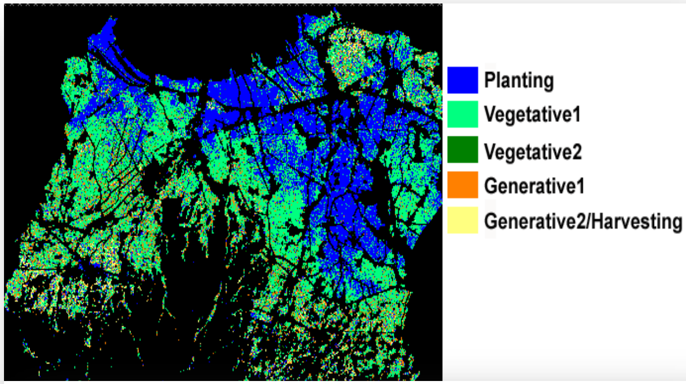


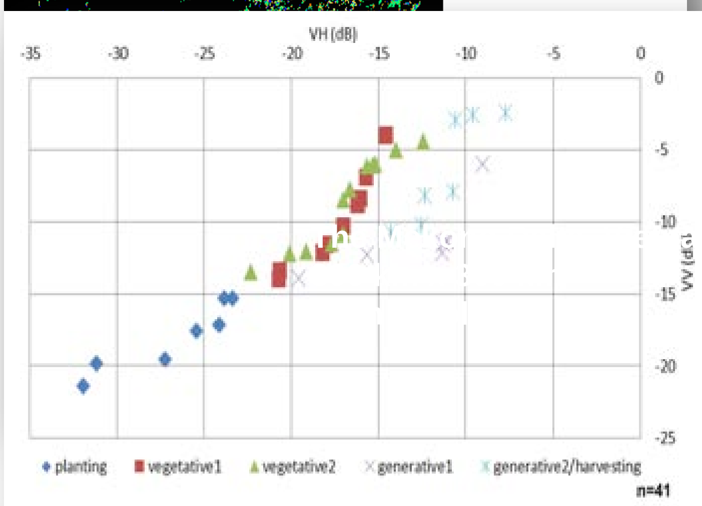
http://www.asia-rice.org

GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

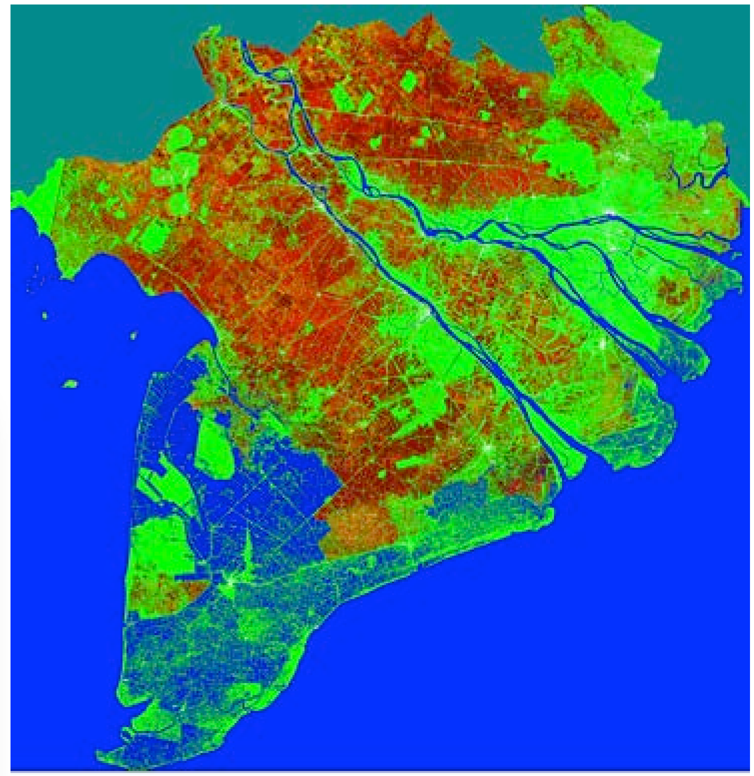
Vietnam Rice Crop Area Estimates/Maps





Rice Phenological Stages Classification using Radarsat-2 Data (VH_VV)
29 July 2014 (Subang Area, West Java) by MOA, LAPAN with JAXA

Setinel-1a rice crop monitoring in Vietnam



GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

The GEOGLAM Components

1. Global / Regional Monitoring Systems

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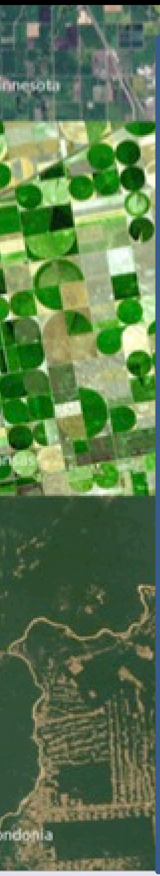
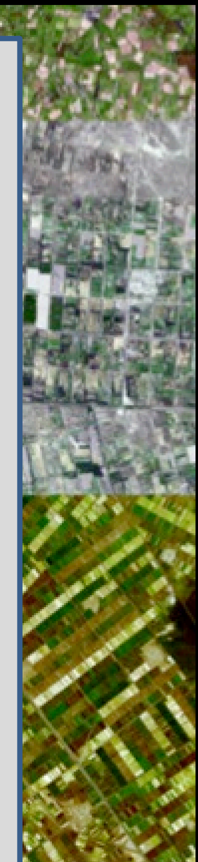
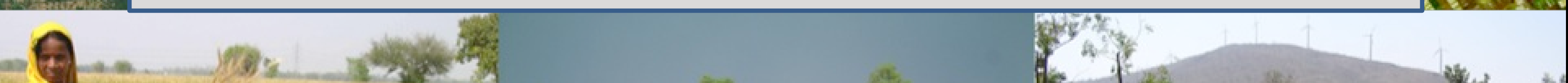
Developing the EO Data Requirements for GEOGLAM: through a CEOS/GEOGLAM Ad Hoc Working Group



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

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)	Croplands 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), IRNSS (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?

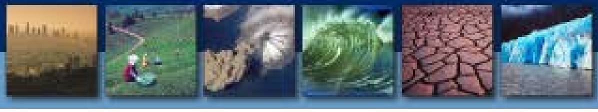
When?

For What?

GEOGLAM data plan submitted to the CEOS plenary in 2013

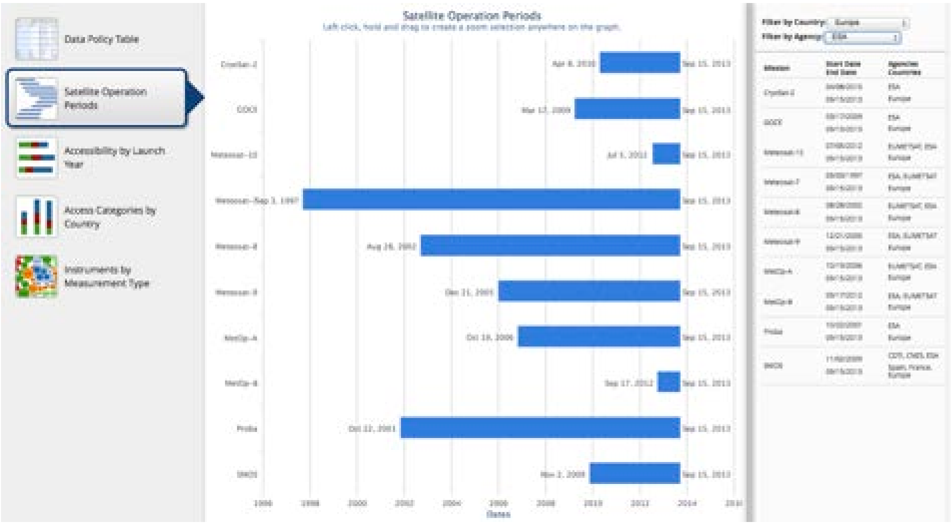
Data Policy Study and Portal

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.

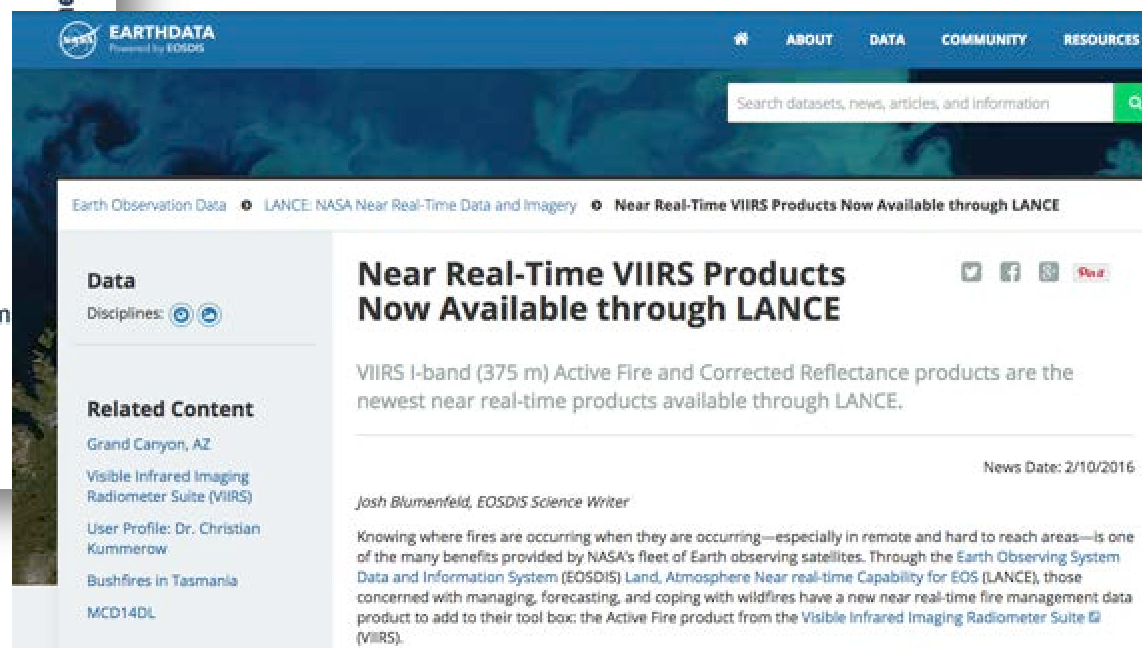
Are the data acquired for Ag areas during the growing season ?

Are they easily accessible ?

B. Killough, CEOS SEO

Requirement for Near Real Time Data for Agricultural Monitoring

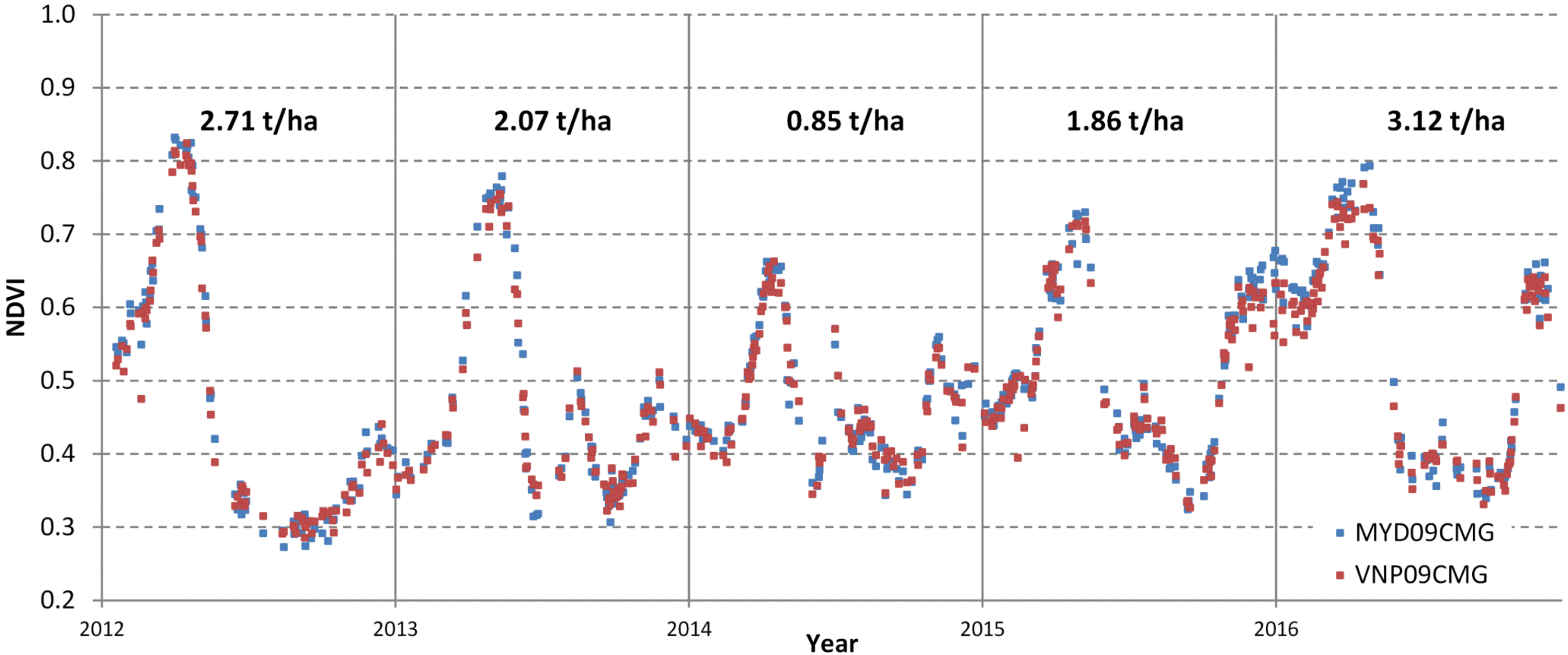
GEOGLAM Global Agricultural Monitoring



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

Transitioning from VIIRS to MODIS: Agricultural applications

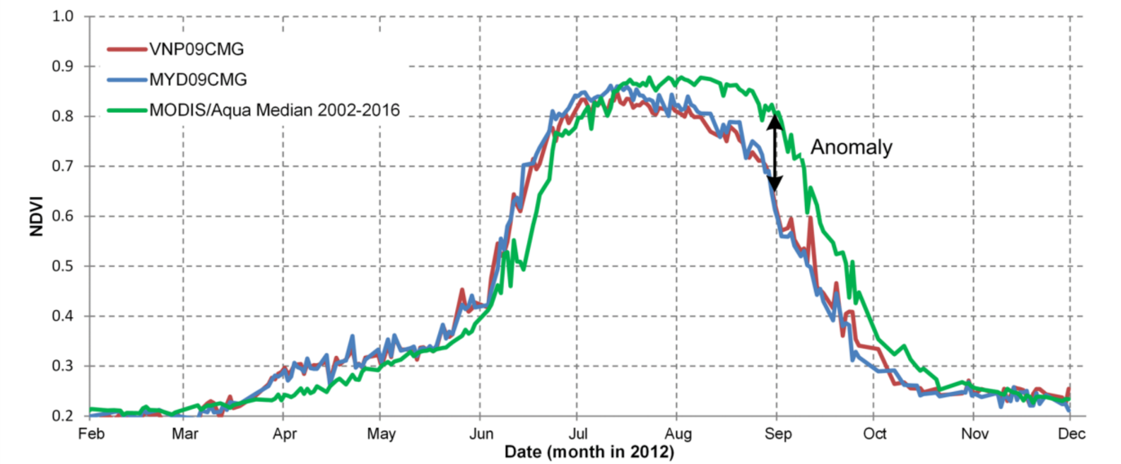


A time series of NDVI values derived from MODIS/Aqua (MYD09CMG) and VIIRS/SNPP (VNP09CMG) daily products at 0.05° resolution for Harper County, Kansas, USA. Shown also are final winter wheat yields derived from USDA NASS statistics. The figure shows that the yield values co-vary with the maximum NDVI values from each season.

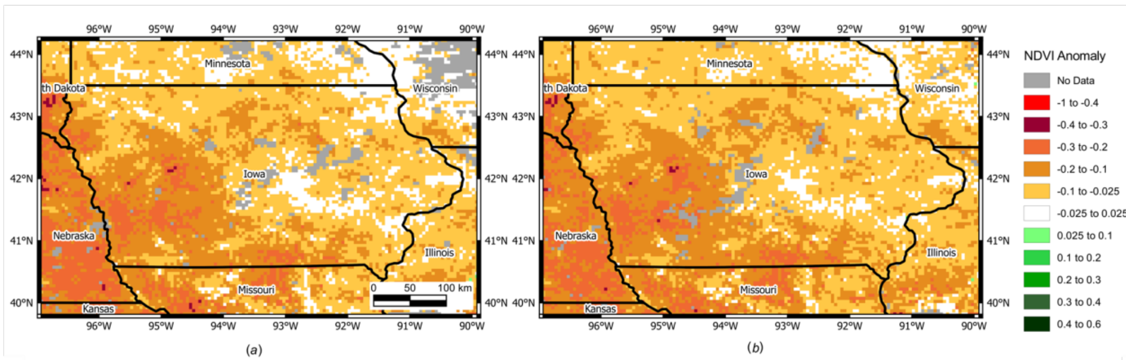
MODIS and **VIIRS NDVI** data can be **used interchangeably** for applications with an **uncertainty of less than 0.02 to 0.05** (NDVI units), depending on the scale of spatial aggregation, which is typically the uncertainty of the individual dataset.

Skakun et al. 2017 (in review)

Transitioning from VIIRS to MODIS:Agricultural applications



Corn growth dynamics derived from MODIS/Aqua and VIIRS in 2012 in Iowa (US) compared to the median NDVI values for 2002–2016 derived from MODIS/Aqua. Due to a drought, corn growth started to decrease significantly from June which resulted in a 25% yield reduction.

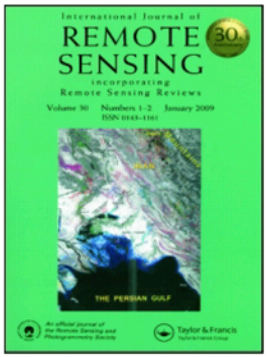


NDVI anomalies at 0.05° spatial resolution for the state of Iowa (US) derived from MODIS/Aqua (*a*), and adjusted VIIRS (*b*) data on August 21, 2012. Anomalies were computed by subtracting NDVI values from the median NDVI values for 2002–2016 derived from MODIS/Aqua.

There is a good both **temporal** and **spatial consistency** between MODIS and VIIRS derived surface reflectance and NDVI products.

Skakun et al. 2017 (in review)

Transitioning from MODIS to VIIRS



Taylor & Francis
Taylor & Francis Group

International Journal of Remote Sensing

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Transitioning from MODIS to VIIRS: an analysis of inter-consistency of NDVI data sets for agricultural monitoring

Sergii Skakun, Christopher O. Justice, Eric Vermote & Jean-Claude Roger

To cite this article: Sergii Skakun, Christopher O. Justice, Eric Vermote & Jean-Claude Roger (2018) Transitioning from MODIS to VIIRS: an analysis of inter-consistency of NDVI data sets for agricultural monitoring, International Journal of Remote Sensing, 39:4, 971-992, DOI: 10.1080/01431161.2017.1395970

To link to this article: http://dx.doi.org/10.1080/01431161.2017.1395970

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 (row 1)

SMOS (row 3)

Sentinel-2 (row 4)

Sentinel-2 (row 5)

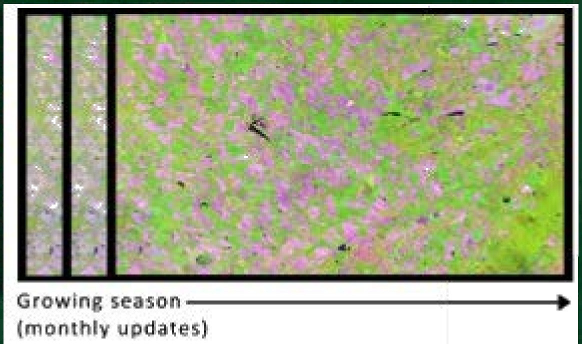
Sentinel-1 (row 6)

Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM PHASE 1

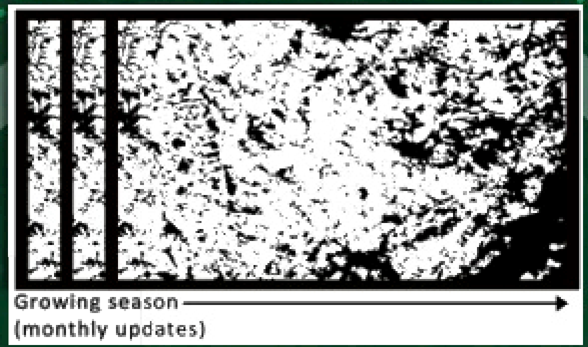
Toolbox for 4 S2-based products in line with the GEOGLAM core products

Monthly cloud free surface reflectance composite at 10-20m

CLOUD FREE SURFACE REFLECTANCE COMPOSITES



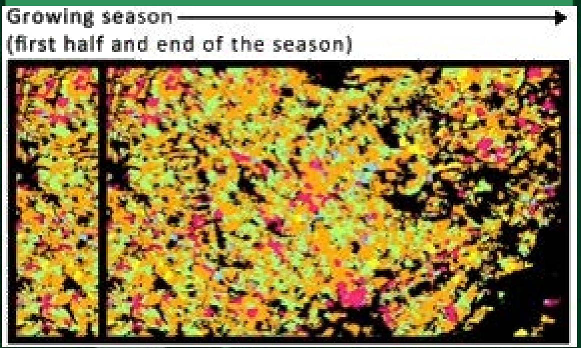
DYNAMIC CROPLAND MASK



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

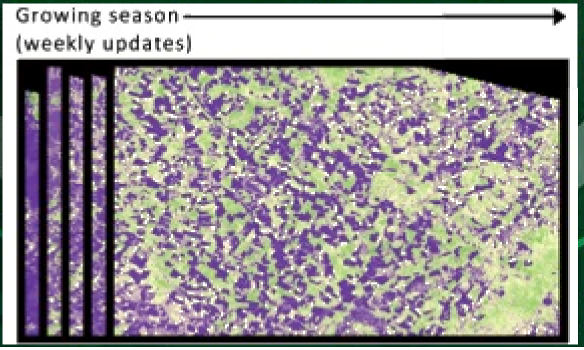
Open source toolbox
Capacity building and training

CULTIVATED CROP TYPE MAP



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

VEGETATION STATUS

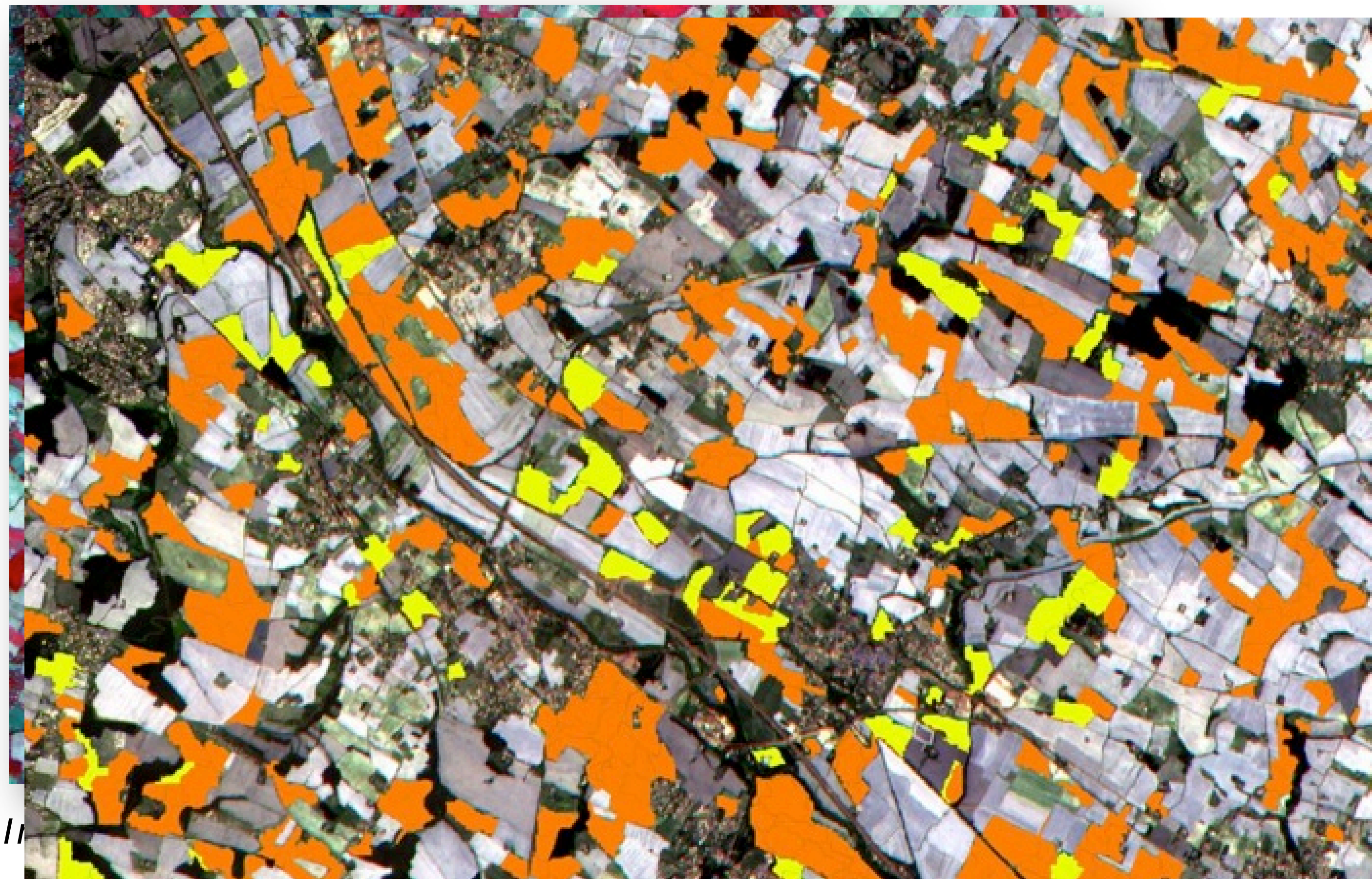


Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index)

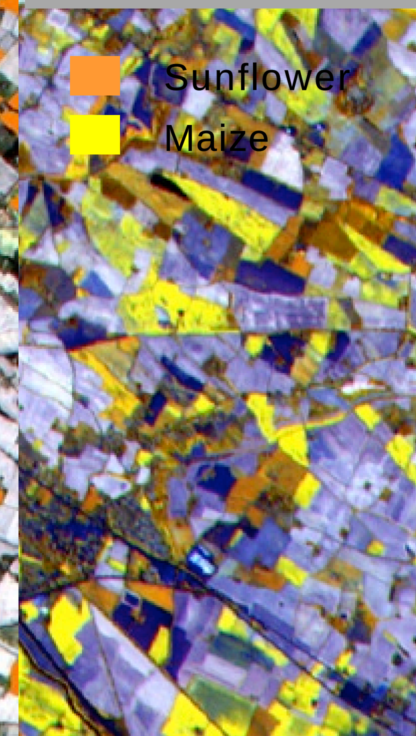
First S2-based prototype product

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



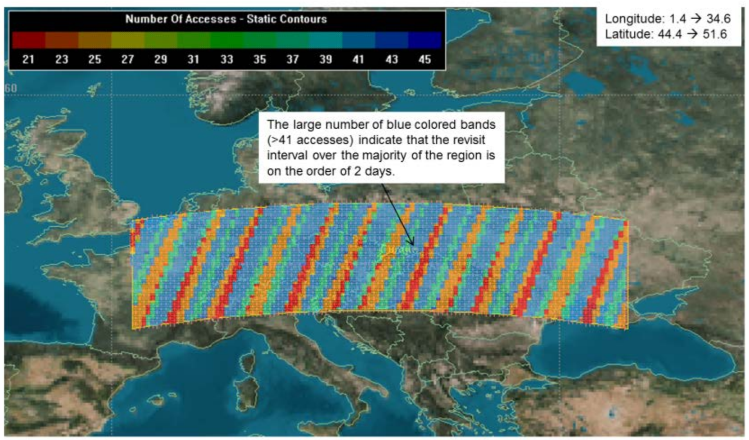
New red-edge color composite
orange versus yellow

Group on Earth Observations | GEOGLAM Global Agricultural Monitoring

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**

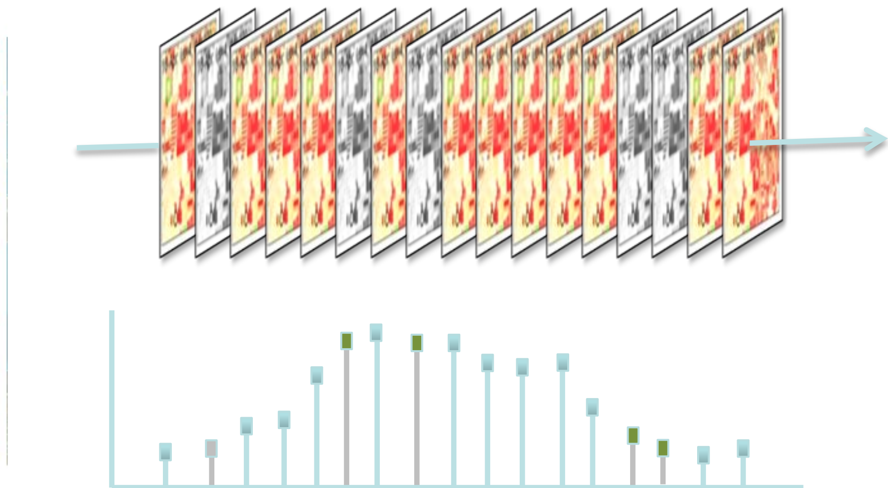
Sentinel 2A and B - LDCM Europe



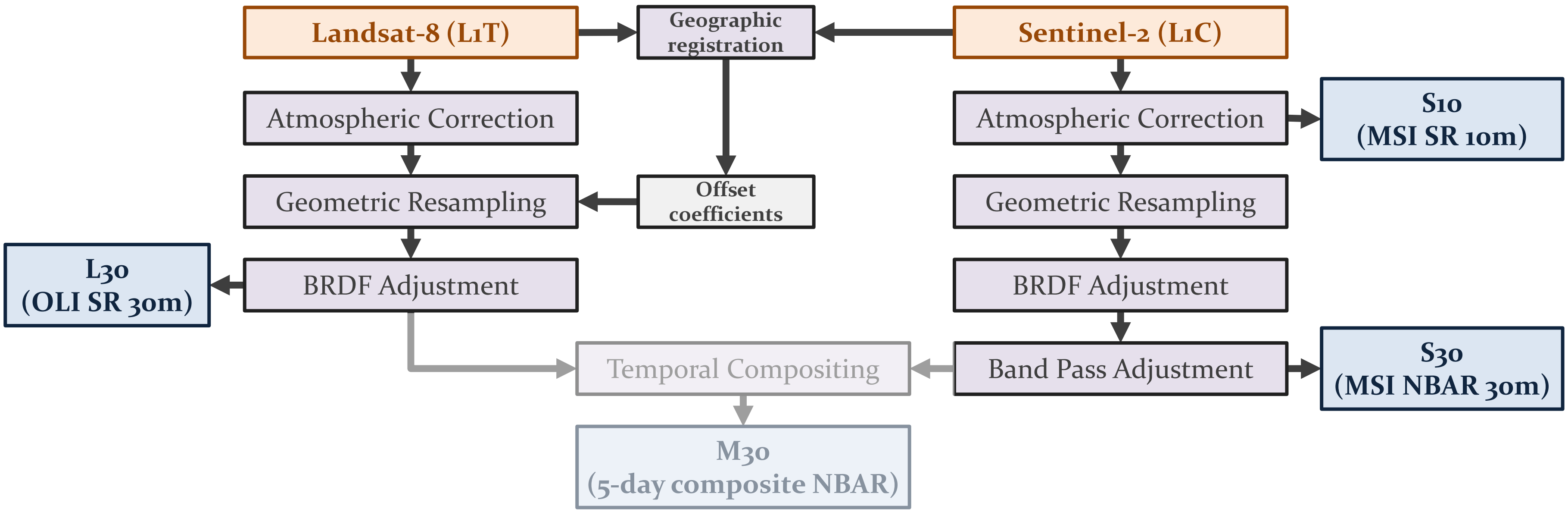
- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

7

Courtesy Brian Killough, NASA LARC



HLS Algorithms overview and status

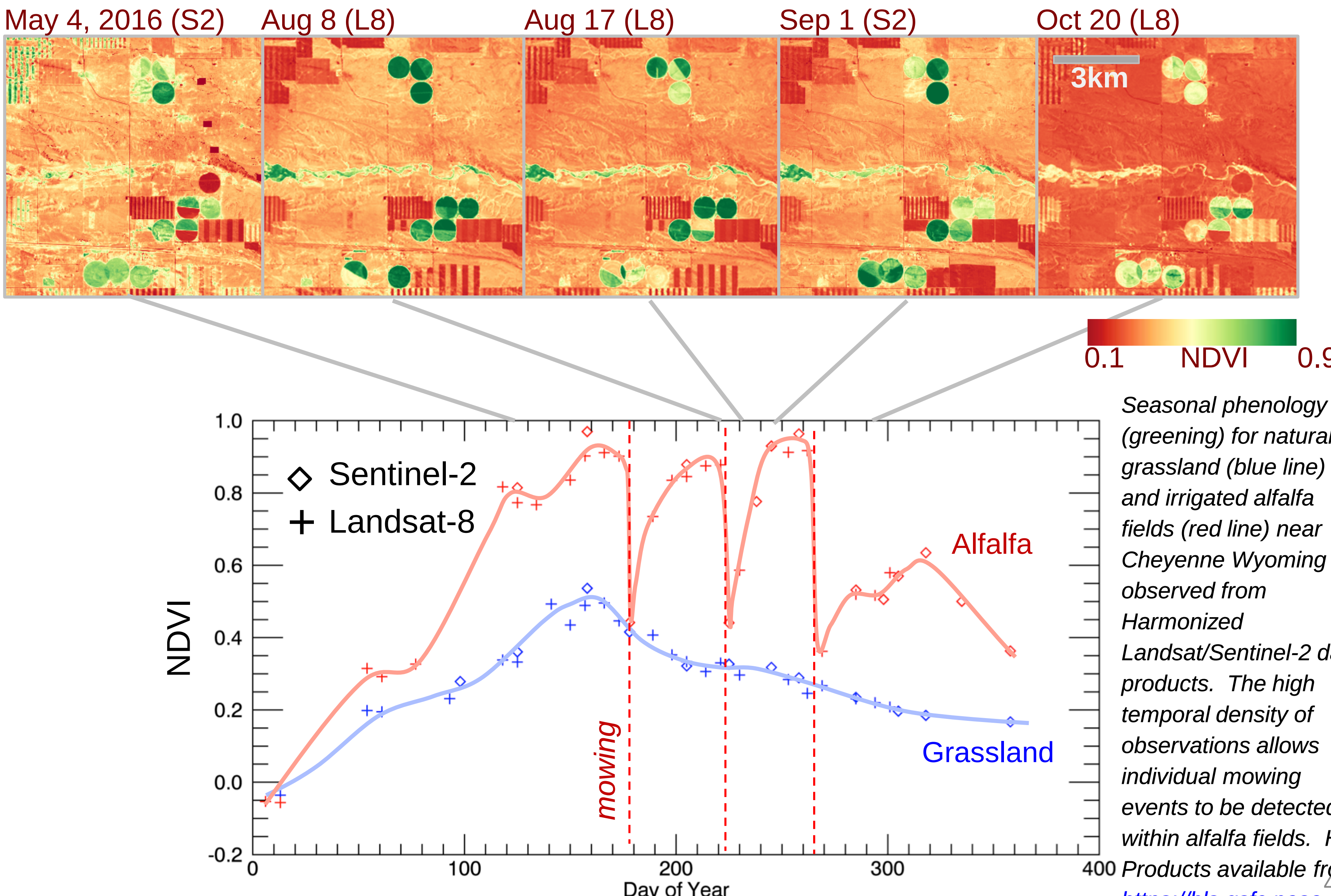


Algorithm	Current (V1.2)	Other Options
Geographic registration	AROP (Gao et al. 2009, JARS)	-
Atmospheric Correction	OLI and MSI: Landsat-8 6S algorithm	CNES MACCS
Cloud/Shadow Mask	OLI: Landsat-8 6S algorithm output MSI: BU MSI Fmask	CNES MACCS
BRDF Adjustment	Fixed BRDF (Roy et al. 2016, RSE)	Downscaling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

Masek et al.

Harmonized Landsat / Sentinel-2 Products

Laramie County, WY

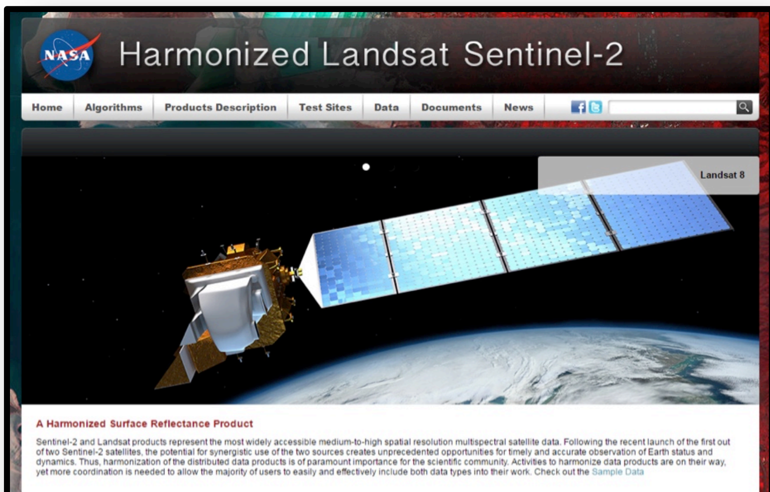


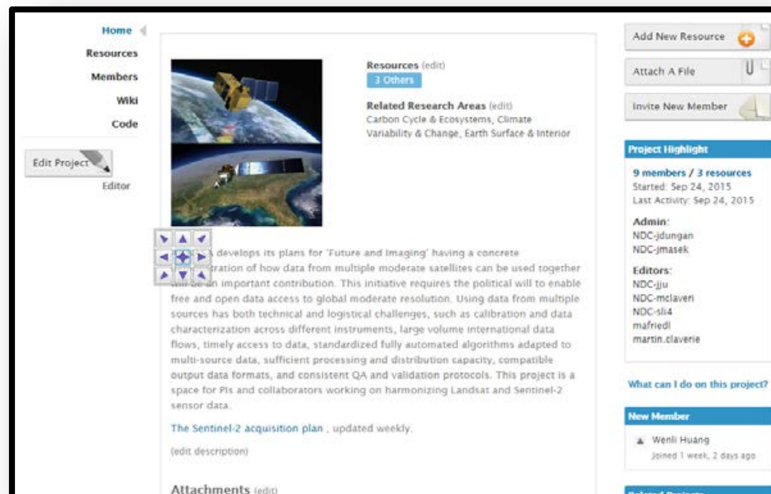
Seasonal phenology (greening) for natural grassland (blue line) and irrigated alfalfa fields (red line) near Cheyenne Wyoming observed from Harmonized Landsat/Sentinel-2 data products. The high temporal density of observations allows individual mowing events to be detected within alfalfa fields. HLS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

HLS Websites and Public Interface

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

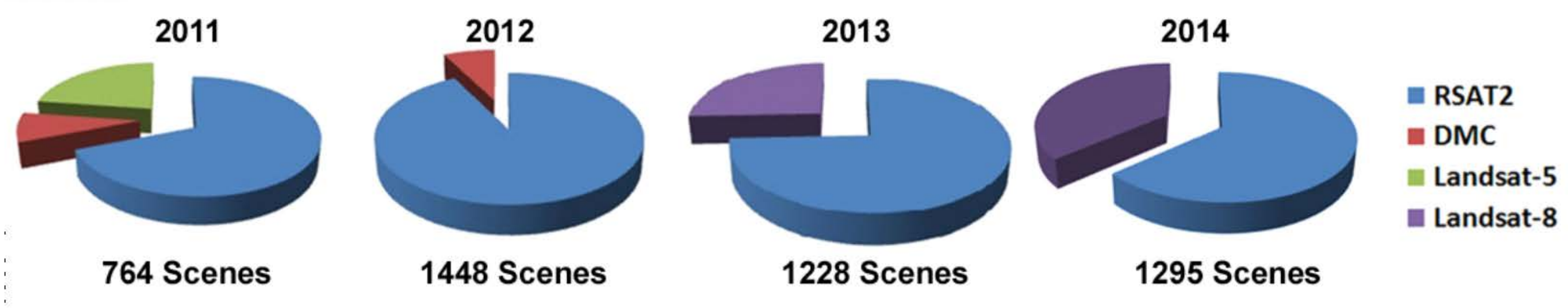
- https://nex.nasa.gov/nex/projects/1371
- Registered user access
- All HLS data available
- Documents (slides, user guides)





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

Image Data

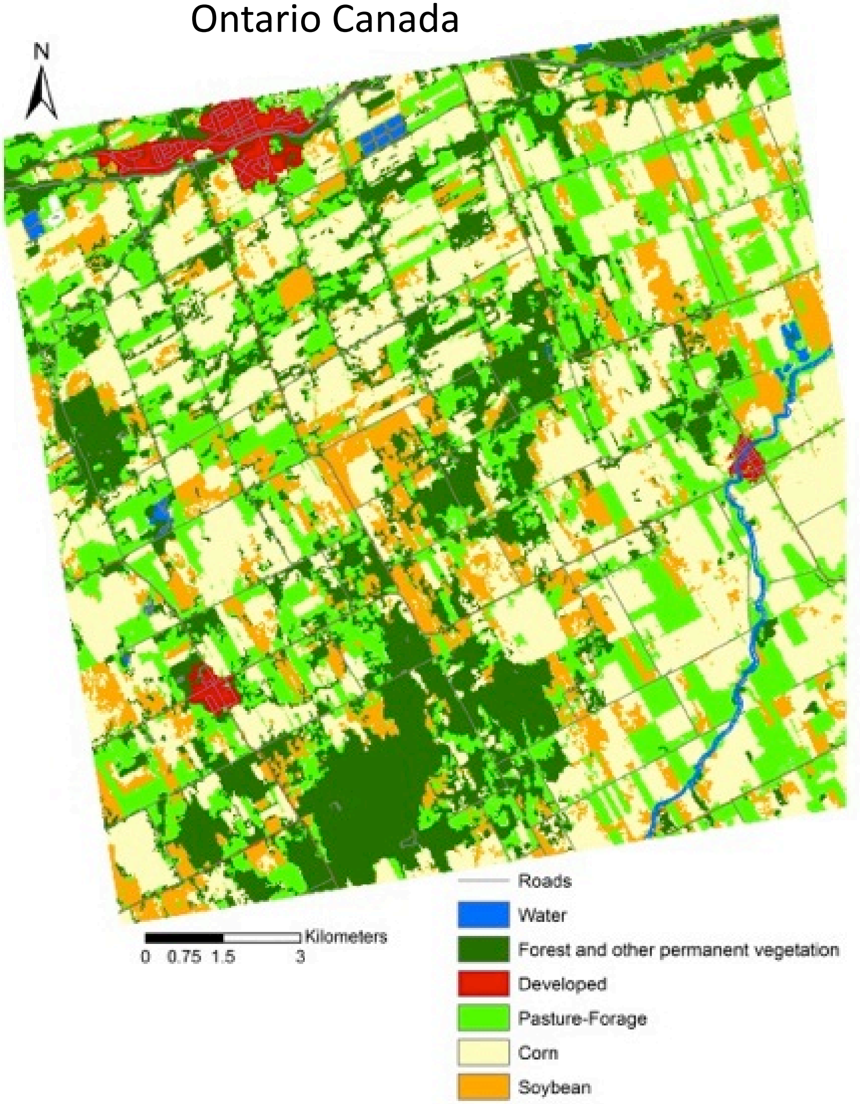


- Multispectral optical data can adequately classify crop if available during critical time periods
- Accuracies decrease significantly when gaps in data collection occur
- Operational burden of cloud masking
- Accuracy increases with SAR; magnitude depends on crop, timing of acquisitions and amount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

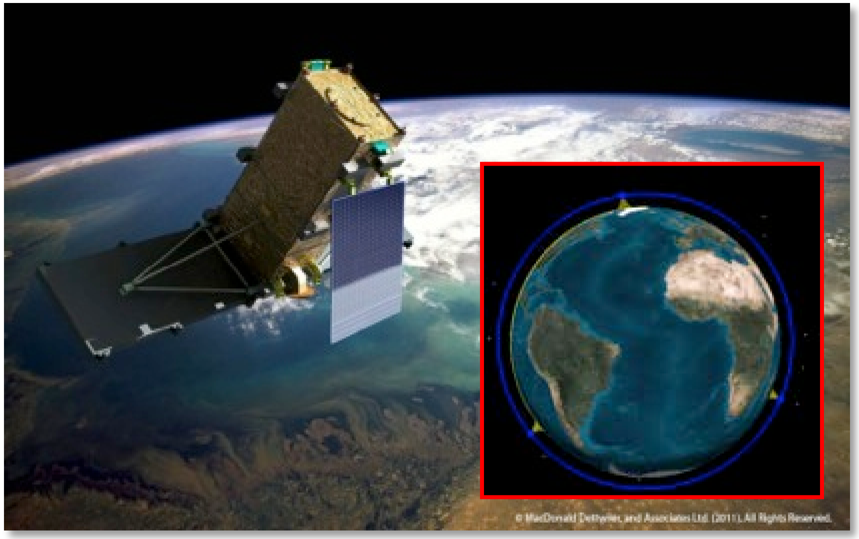
Early season: Corn can be identified at V6 or 6th leaf collar stage (about 6 weeks after planting)

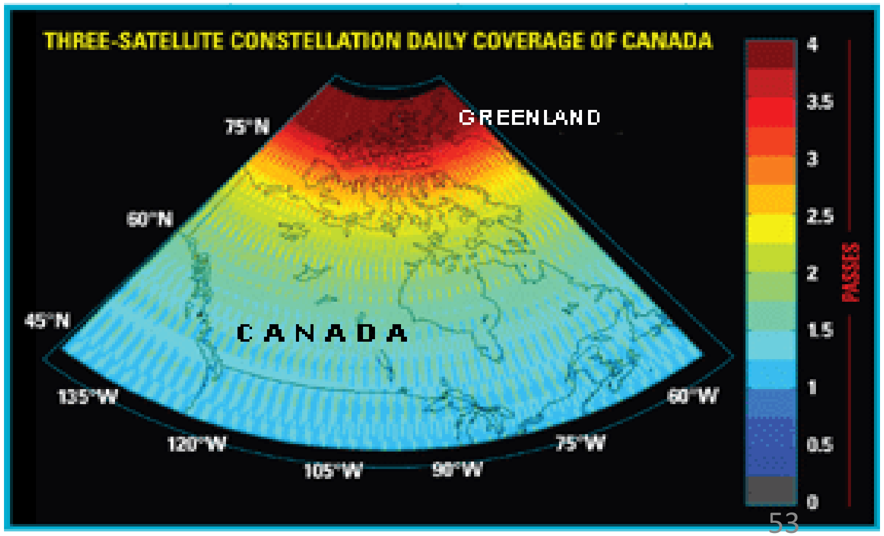
McNairn, H., Kross, A., Lapen, D., Caves, R., and Shang J. 2014. Early season monitoring of corn and soybeans with TerraSAR-X and RADARSAT-2, International Journal of Applied Earth Observation and Geoinformation 28 (2014) 252–259.

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 ?





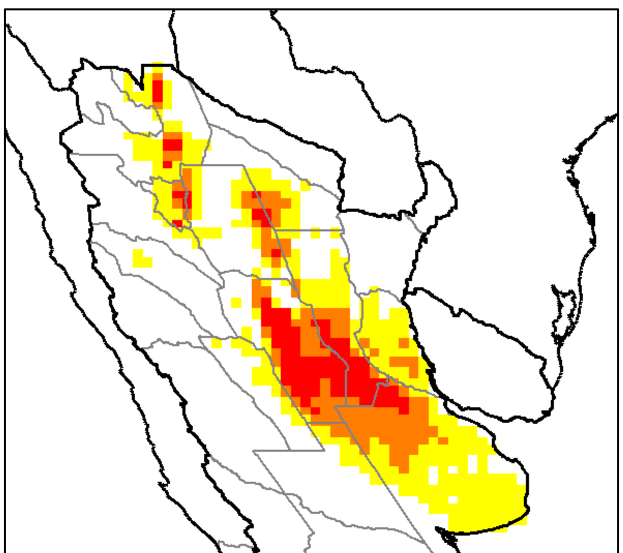
GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Seeing a Changing Playing Field – Small Sat optical systems

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):



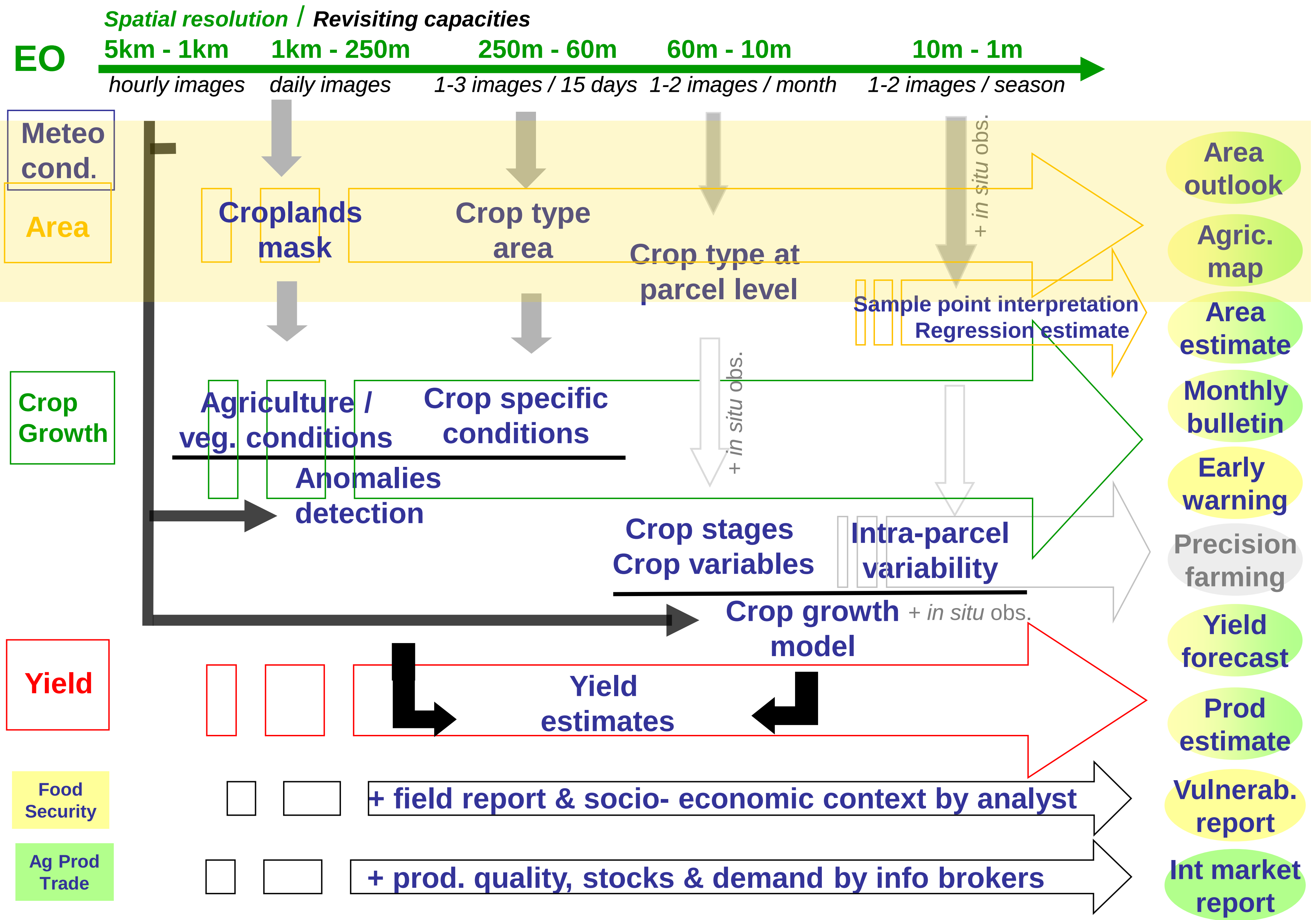
Argentina Sample Strata

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

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

The GEOGLAM Components

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

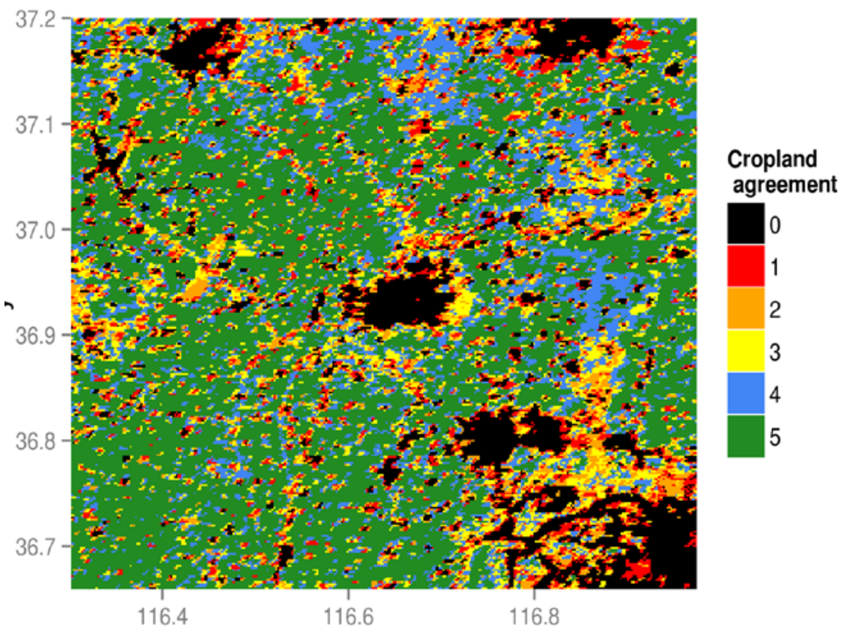
- EC SIGMA Project, Sentinel 2 Agri and BMGF STARS are strengthening the JECAM field data collection protocols and intercomparison

JECAM
Joint Experiment for Crop Assessment and Monitoring

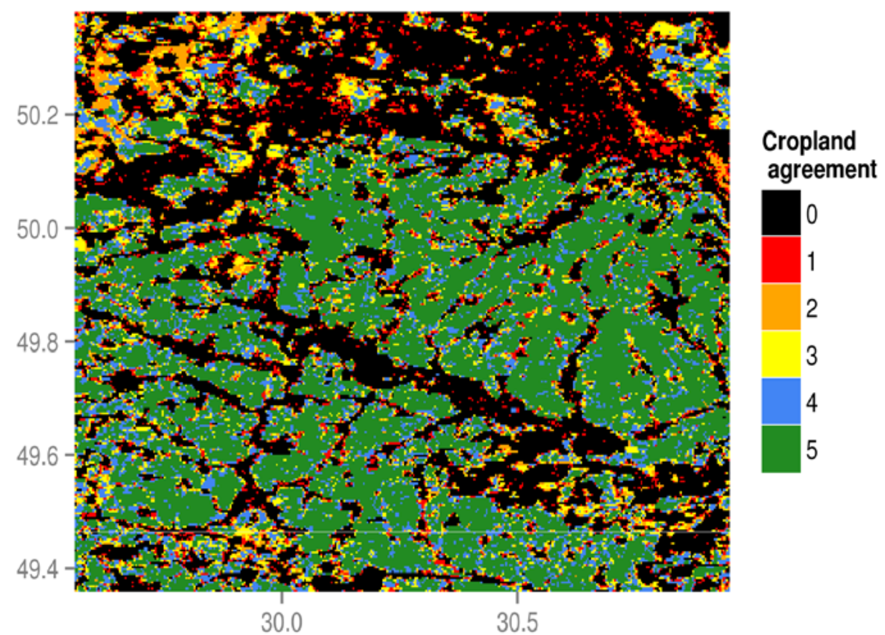
GROUP ON EARTH OBSERVATIONS

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

So in Summary
What is GEOGLAM doing?

- Increasing communication and sharing experience amongst the Ag Monitoring Community of Practice and with related programs
- Helping improve national agricultural monitoring systems
- Translating EO data into policy relevant information
- Promoting EO-based approaches to agricultural monitoring and raising the importance of agricultural remote sensing
- Articulating and advocating for community requirements to the EO data providers
- Increasing the awareness of EO by the econ/policy community
- Method testing and inter-comparison, developing best practices
- Developing new monitoring capabilities and products

The NASA Food Security and Agriculture Consortium (FSAC)

Inbal Becker-Reshef, Chris Justice et al.,
University of Maryland,
Center for Global Agricultural Monitoring Research

The NASA Roses A.51 Call For Proposals

Broad, comprehensive call for developing NASA's program on Food Security and Agriculture

- Pilot a program of activities for applying RS to improve food security & agriculture
- Transdisciplinary, multi-sectoral team interacting as a Consortium
- Advance uses of EO data and models through:
  - Applied R&D and applications development
  - End user characterization and engagement
  - Innovative communications work
  - Socioeconomic impact assessment
- International & domestic food security
- Understanding the value of EO applications
- Focus on adoption and sustained use of EO based on solid business models
- NASA contribution to the GEOGLAM flagship
- Agility in responding to changing priorities

FSAC key objectives and approach

- **Objective: develop a coordinated program to enhance decision support (domestically & internationally) through utilization of EO**
  - Working closely from the start with a range of stakeholder communities
- Leveraging successful domestic and international activities
- Utilizing public & private EO data alongside socioeconomic, agmet. & ground data to develop information products
  - In support of a range of management and decisions, planning, investments, assessments, and policy at scale
- Foundation in user-driven operational R&D
- Emphasis on transitioning applications to operations & capacity building
- Implemented through a large multi-sectoral, multi disciplinary consortium
  - 45 partners, over 70 participants
  - UMD Hub
  - Partnership with the NASA GSFC Food Security Office (FSO)
- In final negotiations with NASA HQ and GSFC FSO, expect to launch at AGU

The Consortium

- Leading individuals/institutions from public, private NGO, inter-governmental, humanitarian sectors working in Agriculture and Food Security
- Consortium Partners named explicitly
  - Have both experience and on-going funded activities in the agricultural application of EO data
  - Represent a range of end-user communities, & includes socio-economic, outreach and communication expertise
  - Link to wide range of networks, key organizations, service providers, & end users
- Seed Starter Program, to engage new users and partners
- Advisory Committee, advise & facilitate new partnerships, review progress & provide guidance
- Work in close partnership with the new GSFC Food Security Office

End Users

- Range of end users included in Consortium, & involved in its development:
  - From farmers to national agricultural ministries, international food security agencies, domestic market and trade sectors, NGOs, agribusiness, insurance and financial sector stakeholders
- Areas of focus for End User Engagement
  - International Crop Production Forecasts, Markets, and Trade
  - Domestic Commercial Agriculture and Farm Management
  - Regional and National Level Food Security, Early Warning, and Policy
  - Smallholder Agriculture Farm Management and Resilience Micro-Insurance
  - Strategic Targeting of New, Non-traditional End Users