Earth Observation for Agricultural Monitoring and Food Security

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This Session - Societal Benefits of EO

Ecosystem Services and Human Wellbeing

EO INTEGRATION

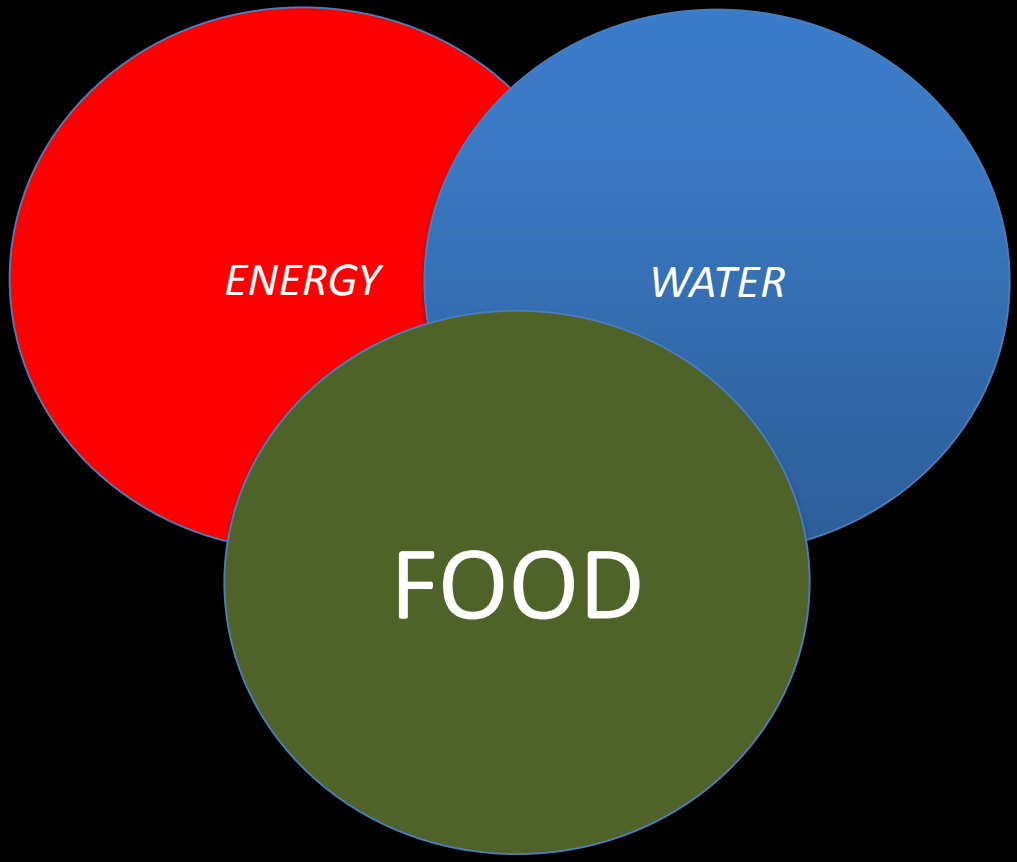
APPLICATIONS

CHALLENGES

FUTURE WORK

BIG DATA

EU/US Cooperation



The Nexus Challenge

GEO is the international program focused on the use of Earth Observations for Societal Benefit

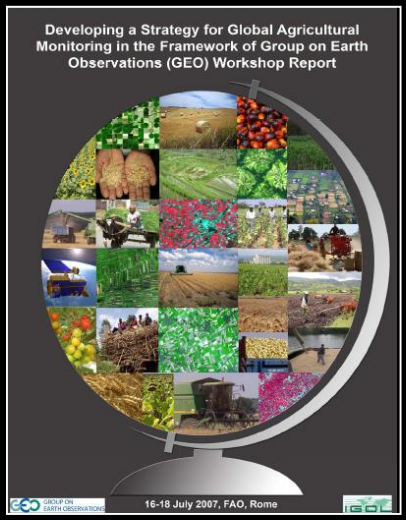
- GEO was initiated in 2005
- Agriculture is one of the GEO Societal Benefit Areas
- GEOGLAM is GEO's Agricultural initiative

What does the GEOGLAM Program provide ?

- A mechanism for International coordination on the use of Earth Observation (satellite data, in -situ data, weather forecasts) for agricultural monitoring with a focus on crop production monitoring
  - Recognizing that EO is just part of the puzzle
- A forum for the 'Community of Practice' to exchange experience – keep up on operational methods and research
- A mechanism for multi-lateral, bi lateral cooperation/collaboration for activities that cannot be done nationally
- A means for elevating the importance of Crop Production Forecasting and Monitoring within and between national agencies

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**

GROUP ON EARTH OBSERVATIONS

GEOGLAM Global Agricultural Monitoring

Within Season Agricultural Production Monitoring

Integrating

Satellite Observations

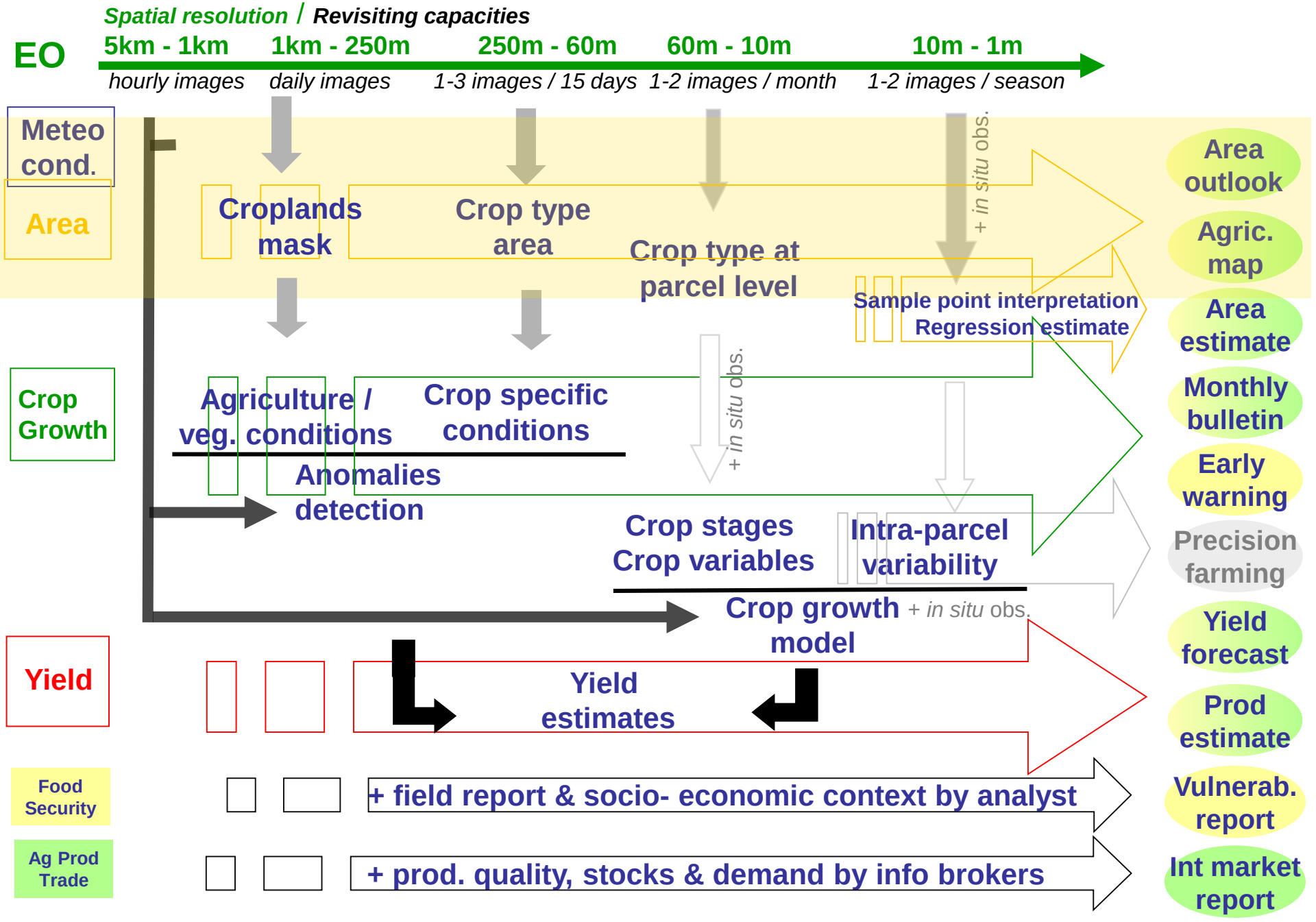
Weather Data

Ground Information

Crop Models

Agricultural Land Use Change

Agricultural Monitoring : EO data and Applications products



Major GEOGLAM Actors
GEOGLAM Community of Practice

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

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

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

GROUP ON EARTH OBSERVATIONS

GEOGLAM
Global Agricultural Monitoring

Context For GEOGLAM

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

Source: World Bank

Landsat 1 Launched (1972)

1971/2's price hike

CROP INVENTORY
LACIE
NASA NOAA USDA

1996 price hike

2010/11 Price hikes
Drought:
Russia USA

2008 Price hikes
Droughts:
Australia & Ukraine

GEO Ag Task

400.00
350.00
300.00
250.00
200.00
150.00
100.00

1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010


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 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

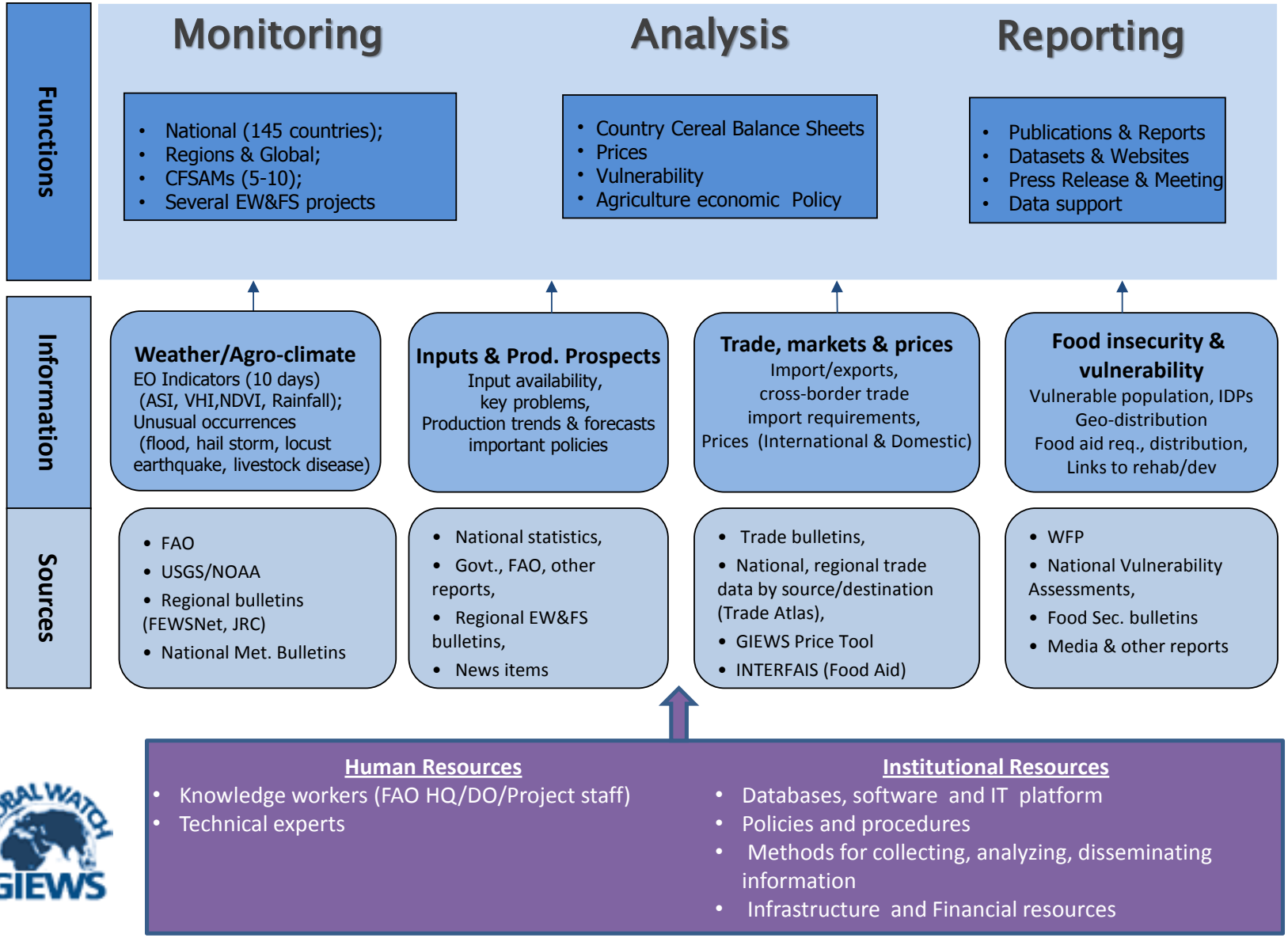
- Vision: the use of coordinated, comprehensive and sustained Earth Observations to inform decisions and actions in agriculture… through a system of agricultural monitoring systems
- Aim: Strengthen the international community's capacity to utilize Earth Observations to produce and disseminate timely, relevant information on agricultural production at national, regional and global scales
- Approach: Build 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

GROUP ON EARTH OBSERVATIONS

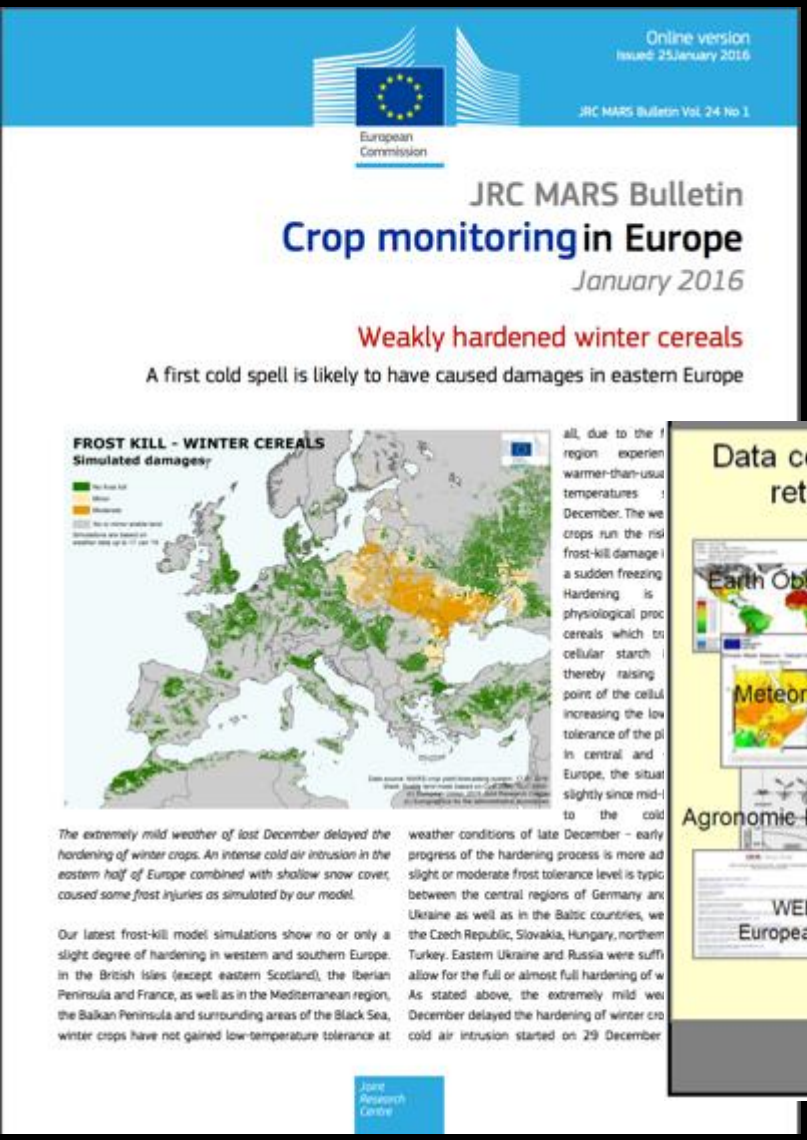
FAO Global Information and Early Warning System (GIEWS)

GEOGLAM Global Agricultural Monitoring



GLOBAL WATCH GIEWS

European Commission (JRC) MARS


Online version
Issued: 25January 2016

JRC MARS Bulletin Vol. 24 No 1

European Commission

JRC MARS Bulletin

Crop monitoring in Europe

January 2016

Weakly hardened winter cereals

A first cold spell is likely to have caused damages in eastern Europe

FROST KILL - WINTER CEREALS
Simulated damages

The extremely mild weather of last December delayed the hardening of winter crops. An intense cold air intrusion in the eastern half of Europe combined with shallow snow cover, caused some frost injuries as simulated by our model.

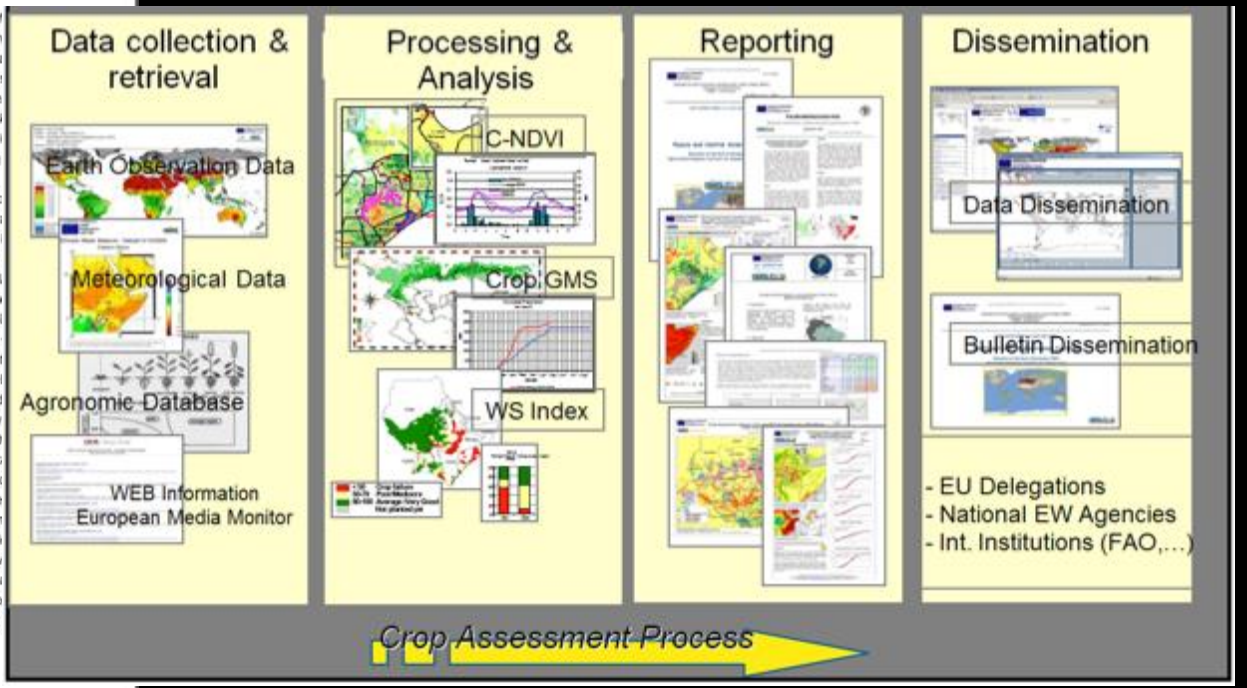
Our latest frost-kill model simulations show no or only a slight degree of hardening in western and southern Europe. In the British Isles (except eastern Scotland), the Iberian Peninsula and France, as well as in the Mediterranean region, the Balkan Peninsula and surrounding areas of the Black Sea, winter crops have not gained low-temperature tolerance at

all, due to the f
region experien
warmer-than-usua
temperatures
December. The we
crops run the risi
frost-kill damage i
a sudden freezing
Hardening is
physiological proc
cereals which tri
cellular starch
thereby raising
point of the cellul
increasing the low
tolerance of the pl
in central and
Europe, the situat
slightly since mid-
to the cold

weather conditions of late December – early
progress of the hardening process is more ad
slight or moderate frost tolerance level is typic
between the central regions of Germany an
Ukraine as well as in the Baltic countries, we
the Czech Republic, Slovakia, Hungary, northern
Turkey. Eastern Ukraine and Russia were suffi
allow for the full or almost full hardening of w
As stated above, the extremely mild wea
December delayed the hardening of winter cro
cold air intrusion started on 29 December

Joint Research Centre

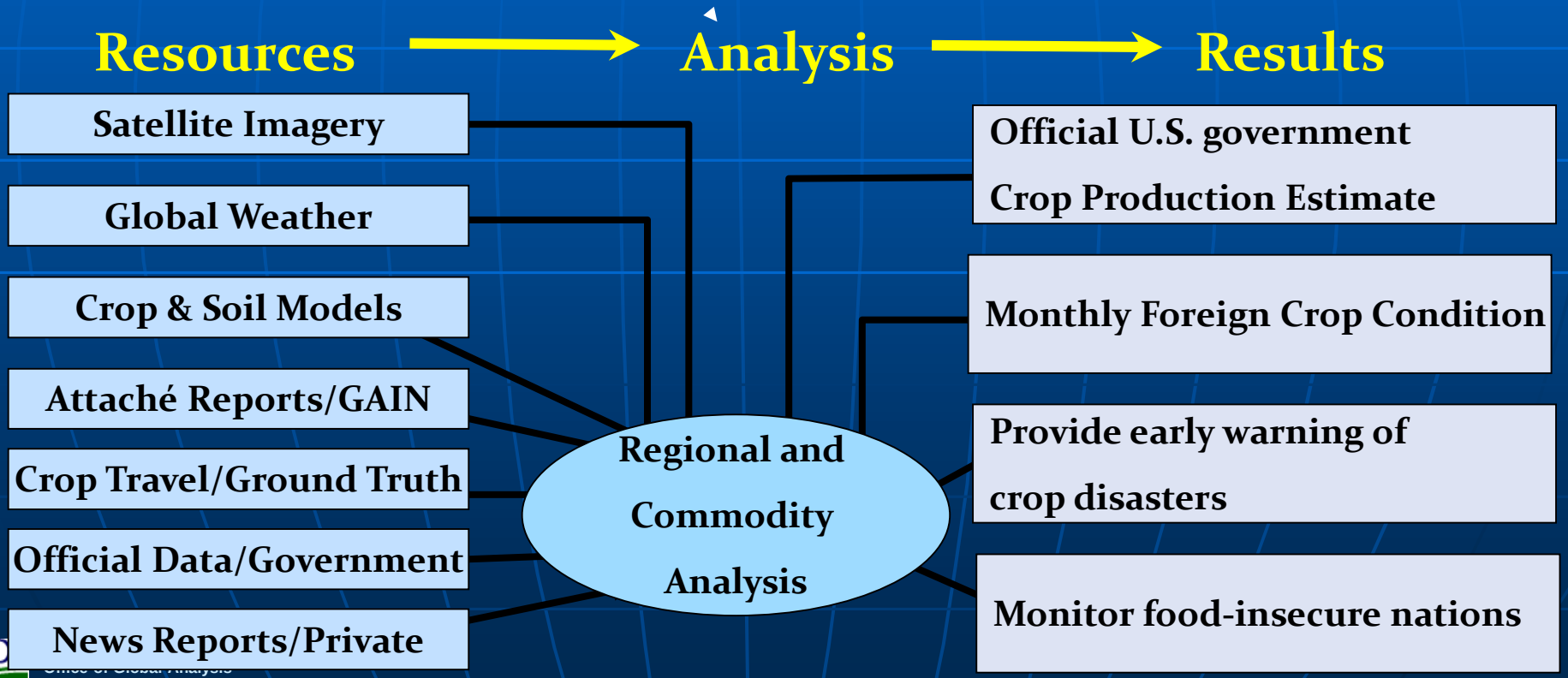
- Main Focus to date has been on Europe with special reports on areas of interest to the Commission e.g. Africa, Ukraine
- Currently expanding scope to global monitoring



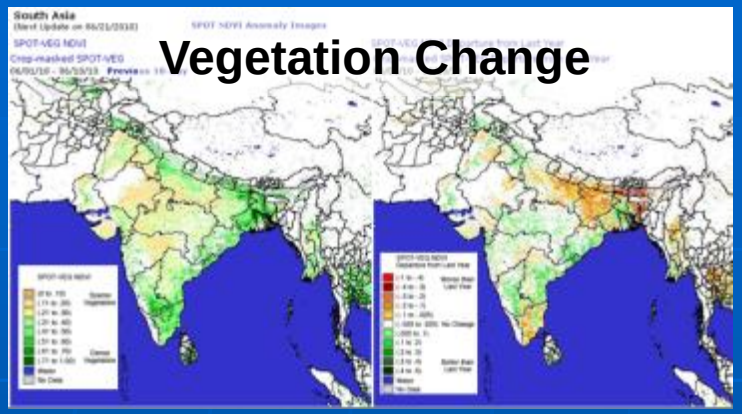
USDA FAS Provides Crop Condition Assessment, Monitoring and Crop Estimates Each Month

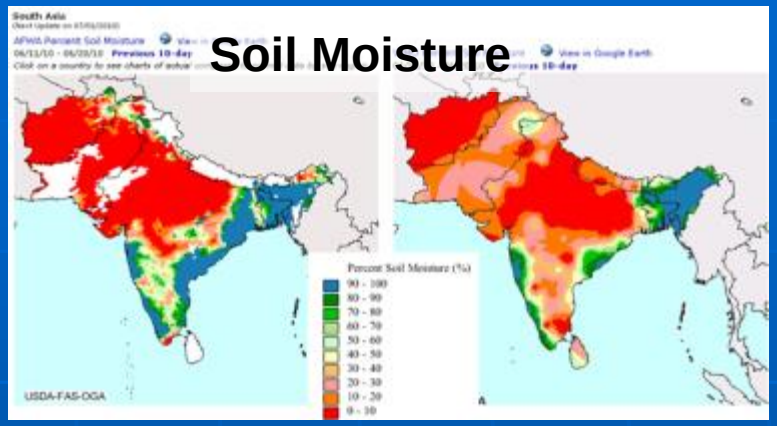
- 17 Global Commodities
- 159 Countries
- 1020 Country-Crop Pairs (e.g. Australia-Wheat)
- 3 attributes: Area, Yield and Production

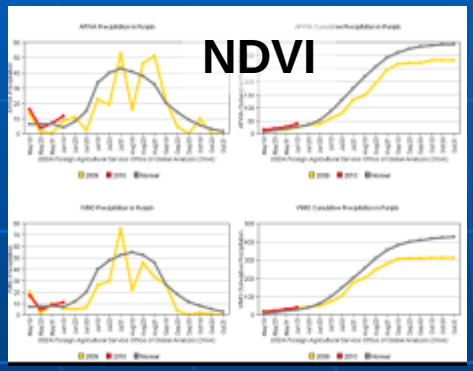
FAS IPAD Operational Approach of Global Crop Assessment and Monitoring

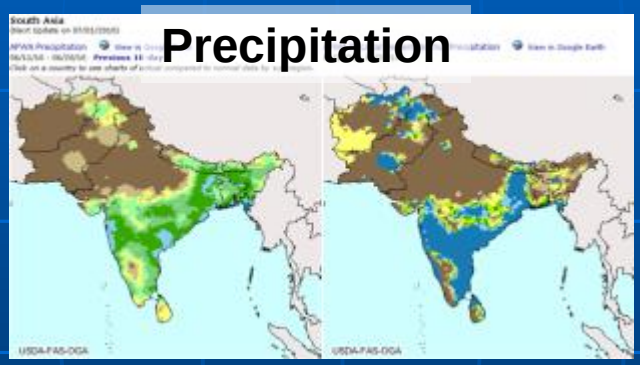


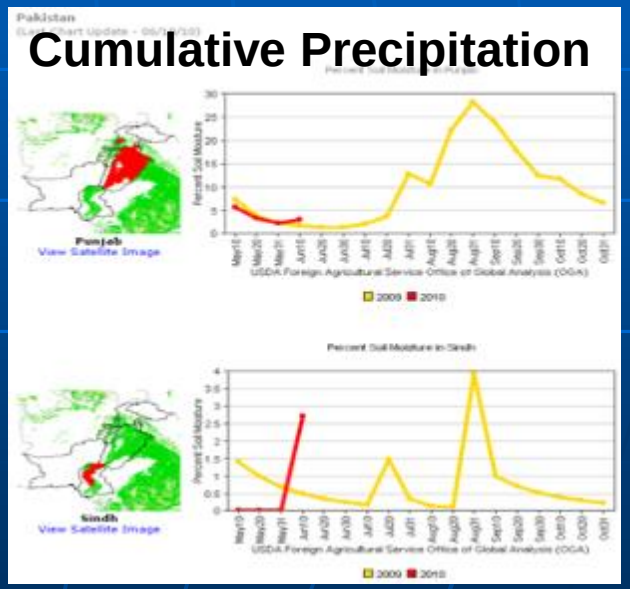
USDA FAS Crop Explorer DS System

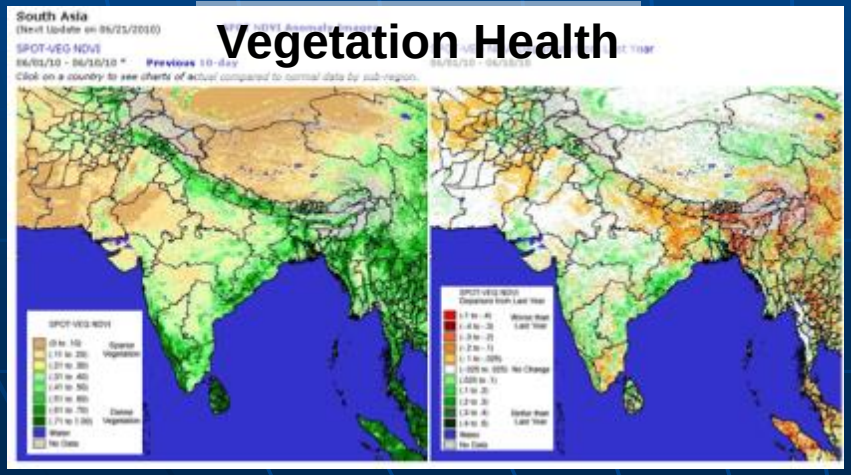












Latest observation data integrated into new maps and charts on the: 1st, 11th, 21st of each month

R. Tetrault FAS

Output: Reports and Production Supply and Distribution (PSD) database

- Principal Federal Economic Indicators: WASDE, FAS & NASS
- PSD Online http://apps.fas.usda.gov/psdonline/psdhome.aspx
- Part of Data.gov http://www.data.gov/

World Agricultural Outlook Board
waob
ISSN: 1554-9089

World Agricultural Supply and Demand Estimates

United States Department of Agriculture

Office of the Chief Economist	Agricultural Marketing Service Farm Service Agency	Economic Research Service Foreign Agricultural Service

WASDE - 484 | Approved by the World Agricultural Outlook Board | July 9, 2010

NOTE: This report adopts U.S. area, yield, and production forecasts for winter wheat, durum, other spring wheat, barley, and oats released today by the National Agricultural Statistics Service (NASS). For rice, corn, sorghum, soybeans, and cotton, area estimates reflect the June 30 NASS *Acreage* report, and methods used to project yield are noted on each table. The first survey-based 2010 production forecasts for those crops will be reported by NASS on August 12 and will be included in that day's issue of this report.

WHEAT: U.S. wheat supplies for 2010/11 are raised this month on higher area, yields, and carryin. Beginning stocks are raised 43 million bushels based on the June 1 stocks estimate. Total wheat production is forecast 149 million bushels higher with higher forecast area and a forecast record yield of 45.9 bushels per acre. Winter wheat production is up 23 million bushels as higher Hard Red Winter wheat yields more than offset lower yields for Soft Red Winter wheat. Durum and other spring wheat production are forecast higher as abundant moisture and lack of heat stress in the Northern Plains support above trend yields. Feed and residual use is projected 20 million bushels lower as higher prices limit the competitiveness of wheat in livestock and poultry rations. Exports are projected 100 million bushels higher with lower expected production in several major exporting countries and strong early season export sales. Despite increased foreign demand for U.S. wheat, ending stocks for 2010/11 are projected 102 million bushels higher and remain at an expected 23-year high. The season-average farm price for all wheat is projected at $4.20 to $5.00 per bushel, up 20 cents on each end of the range as tighter world supplies and higher corn prices support wheat values.

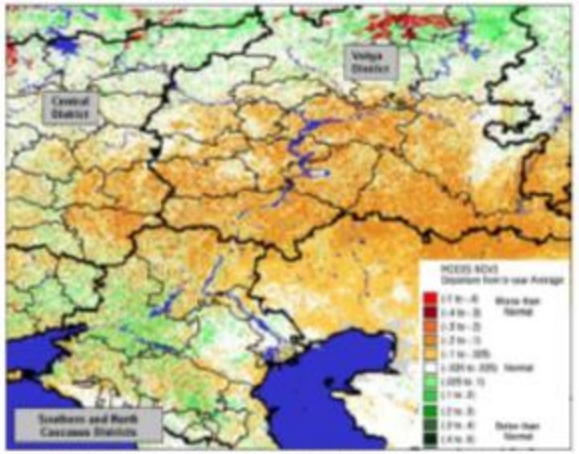
This month's 2009/10 changes reflect the latest export and seed use data and reported June 1 stocks. Projected exports are lowered 20 million bushels and estimated seed use is lowered 3 million bushels. Based on these changes, June 1 stocks indicate feed and residual use 21 million bushels lower. The 2009/10 wheat farm price is estimated at $4.87 per bushel, up 2 cents from last month's projection.

Global wheat supplies for 2010/11 are reduced with world production projected 7.5 million tons lower as smaller crops in FSU-12, Canada, EU-27, India, and Turkey more than offset higher production in the United States and China. Production for Canada is lowered 4 million tons as persistent June rains limited seeding in the Western Prairies. Production is lowered 4.5 million tons and 3.0 million tons, respectively, for Russia and Kazakhstan as continued drought and high temperatures reduce

USDA United States Department of Agriculture
Foreign Agricultural Service
Circular Series WAP 07-10 July 2010

World Agricultural Production

Russian Volga District: Withering Drought Reduces Yield Prospects for Wheat



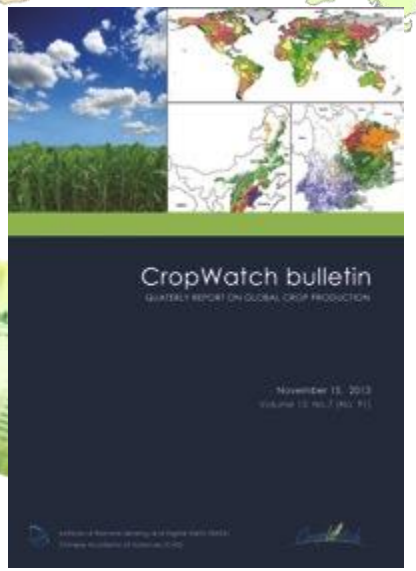
Vegetative indices (NDVI) derived from the MODIS satellite sensor indicate that crop conditions were significantly worse than average throughout the Volga District. The Volga District is one of Russia's key grain-production regions.

Russia Wheat: Severe Drought Reduces Production Prospects

CropWatch Bulletin

Wheat	Maize	Rice	Soybean
China	United States	China	United States
India	China	India	Brazil
Russia	Brazil	Indonesia	Argentina
United States	Argentina	Bangladesh	China
France	Ukraine	Vietnam	
Australia	India	Thailand	
Canada	Mexico	Myanmar	
Pakistan	Indonesia	Philippines	
Germany	France	Brazil	
Kazakhstan	Romania	Cambodia	
Ukraine	Canada	Pakistan	
Turkey	South Africa	United States	
Argentina	Nigeria		
United Kingdom	Ethiopia		
Iran			
Poland			
Egypt			
Uzbekistan			
Brazil			

http://www.cropwatch.com.cn



CropWatch Bulletin

Slightly above average crop condition in China in early March 2016

March 28, 2016

Wheat: During the monitoring period, winter wheat was at turning green to jointing stage. In general, crop condition was at the recent 5-year average level. Affected by strong cooling weather, below average winter wheat condition occurred in southern Jiangsu and eastern and southern Henan. On the contrary, crop condition was above average in eastern Sichuan, Chongqing and northern Guizhou due to proper temperature and abundant rainfall.

Rapeseed: Rapeseed was at bolting to flowering stage. In Lower Yangtze region, sufficient precipitation was beneficial for rapeseed growth and hence crop condition was just fair. However, rapeseed condition was slightly below average in Yangtze-Huaihe region.

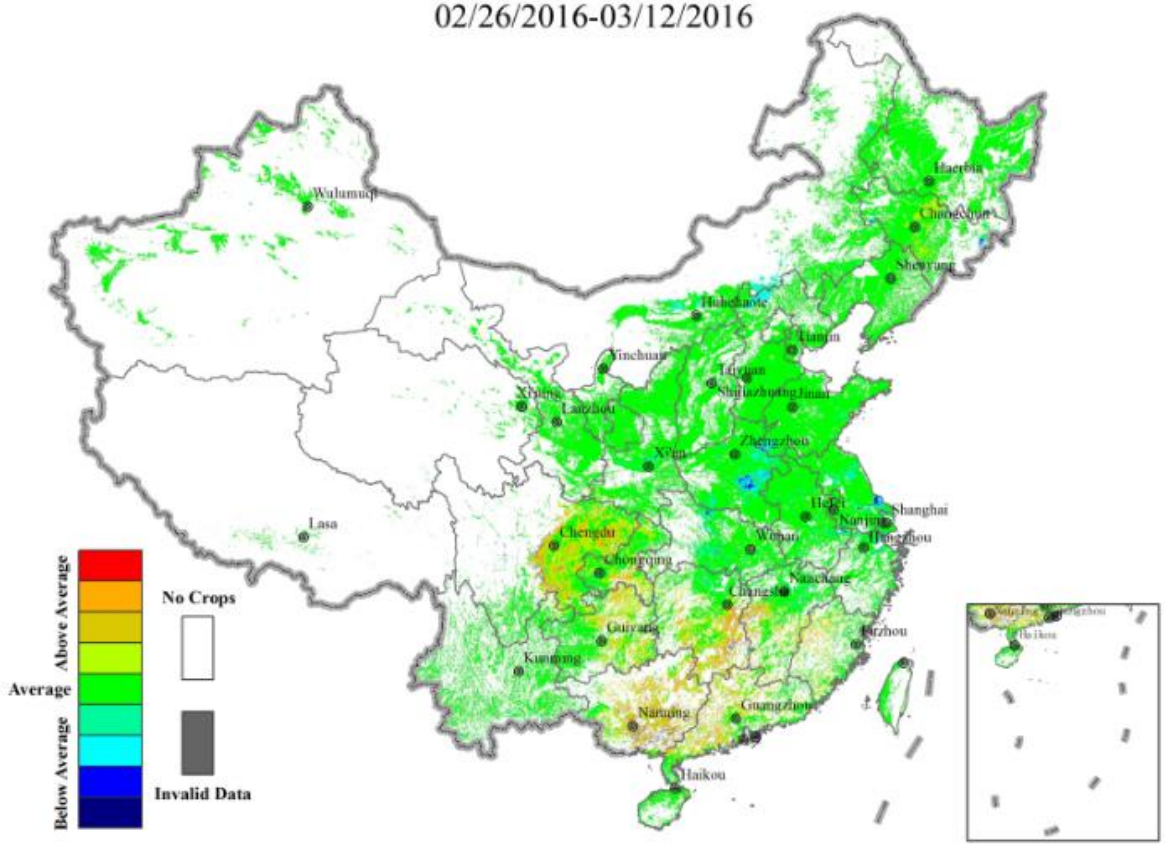
Maize: Spring maize was at seeding to three-leaf stage in Guangxi. Above average crop condition occurred in this area.

Rice: Early rice was at seeding stage in Southern China.

Soybean was out of the growing season.

NDVI MODIS AQUA departure from 5-year average

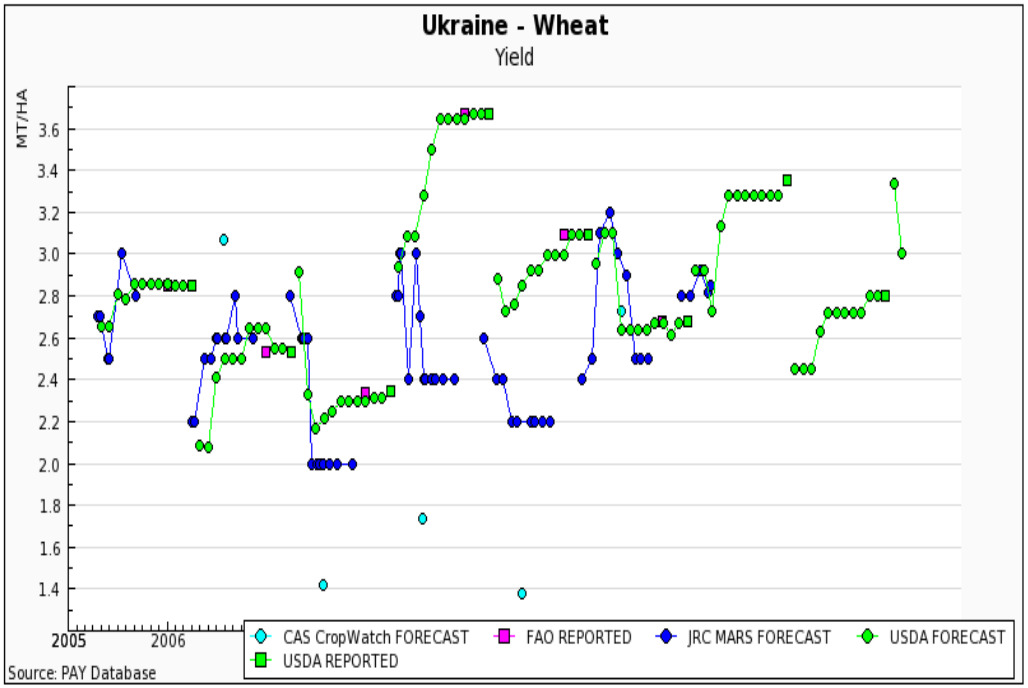
02/26/2016-03/12/2016



The need for improved forecasts & transparency

- Within season forecasts from different groups vary between agencies & years
- Critical particularly in anomalous years

Coordination is needed



Important Note - This is a preliminary, unofficial version of the PAY website. All numbers published on this website are unofficial. It is requested that users read about the data sources before using the data.

Colors indicate different agencies

Squares indicate reported end of season estimates

Circles indicate in-season forecasts

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

- In response to an AMIS request
- Requested GEOGLAM generate a monthly international consensus of crop conditions, from various international/national monitoring systems
- Summary information only
- 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

GROUP ON EARTH OBSERVATIONS

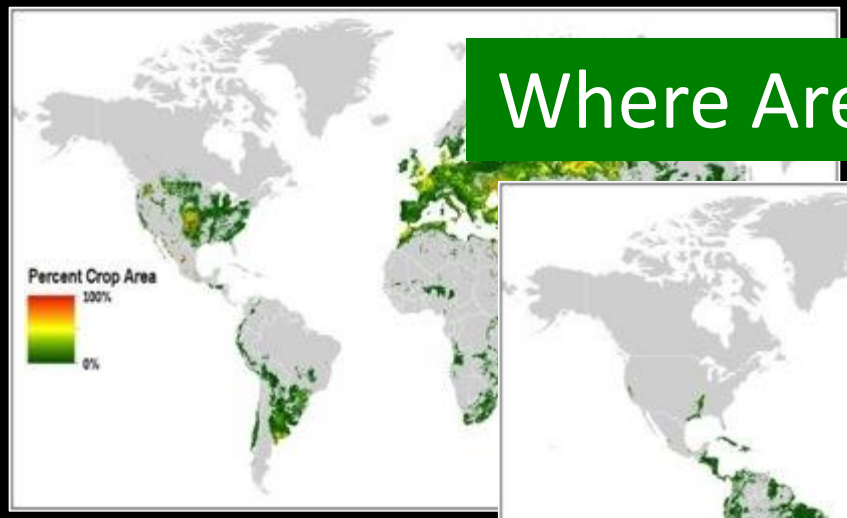
GEOGLAM Global Agricultural Monitoring

GEOGLAM Best Available Multi-Season Crop Masks

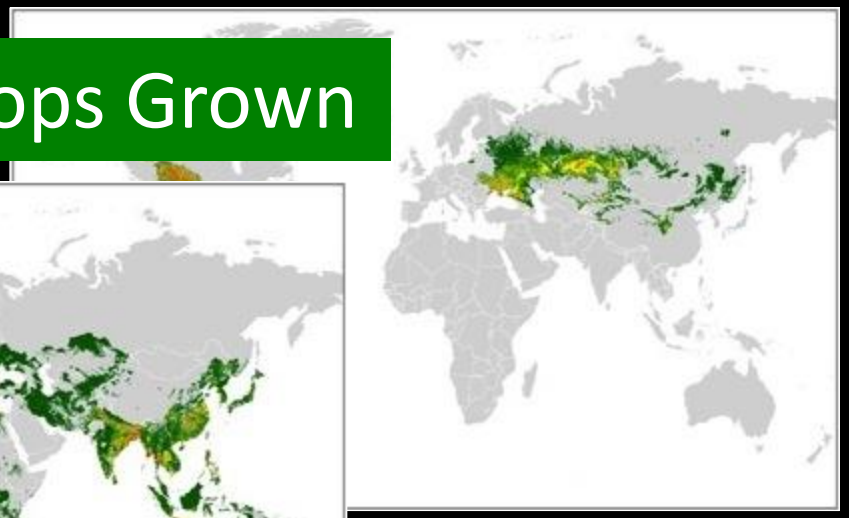
20 contributors and counting w. on-going improvements

Where Are Crops Grown

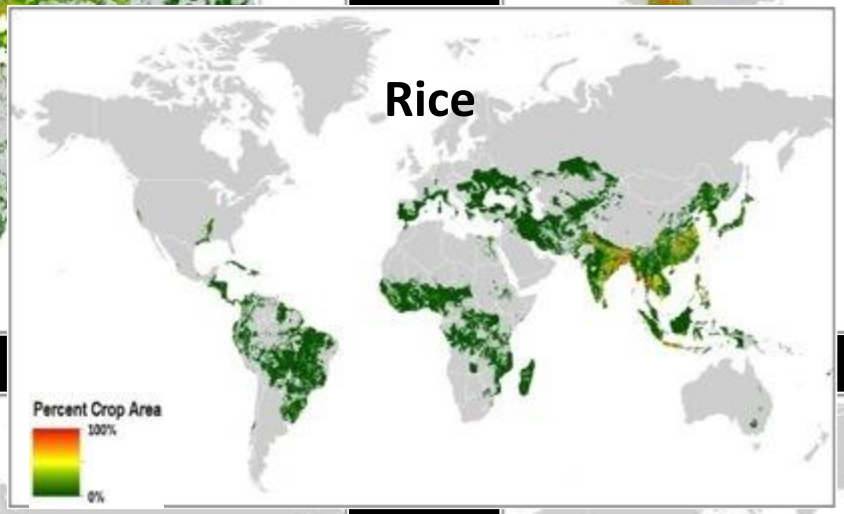
Winter Wheat



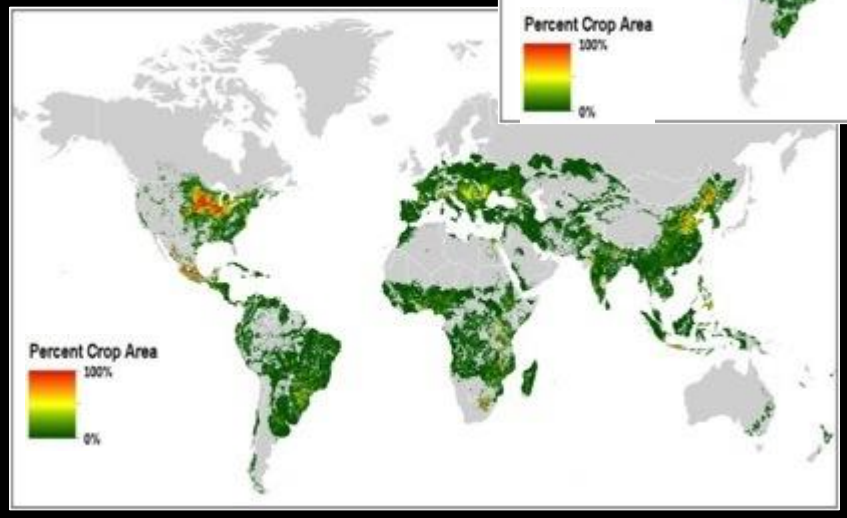
Spring Wheat



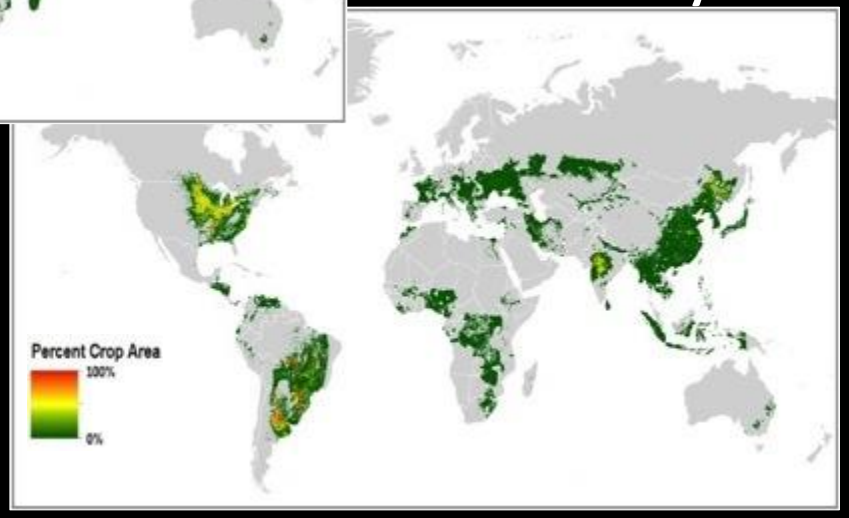
Rice



Maize



Soybeans

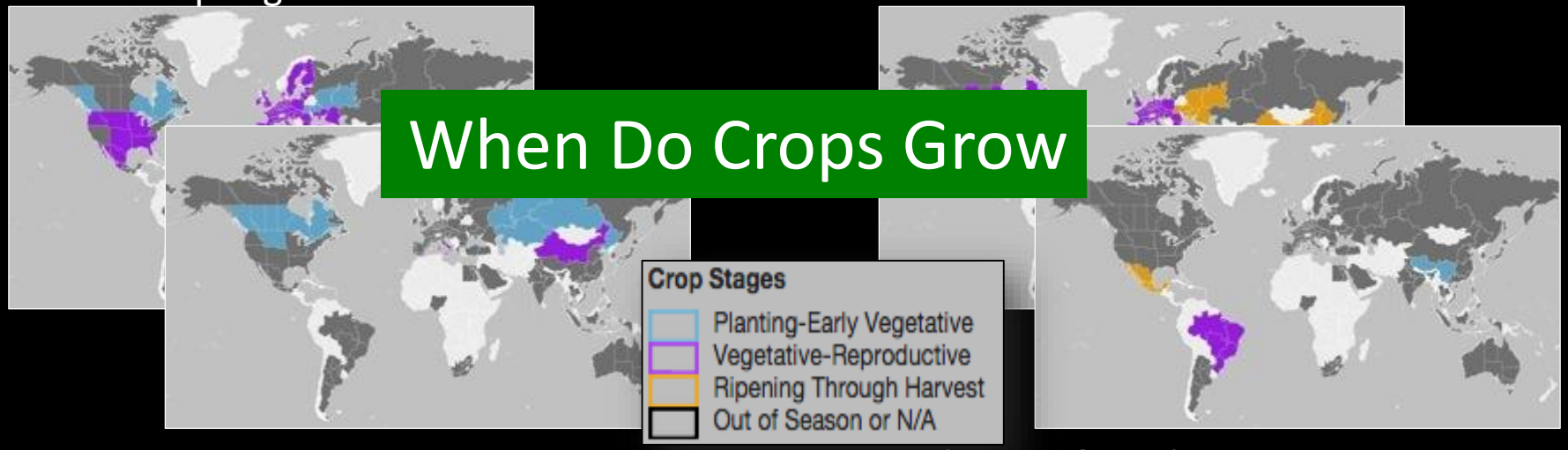


Best Available Multi-Season Crop Calendars

Winter & Spring Wheat

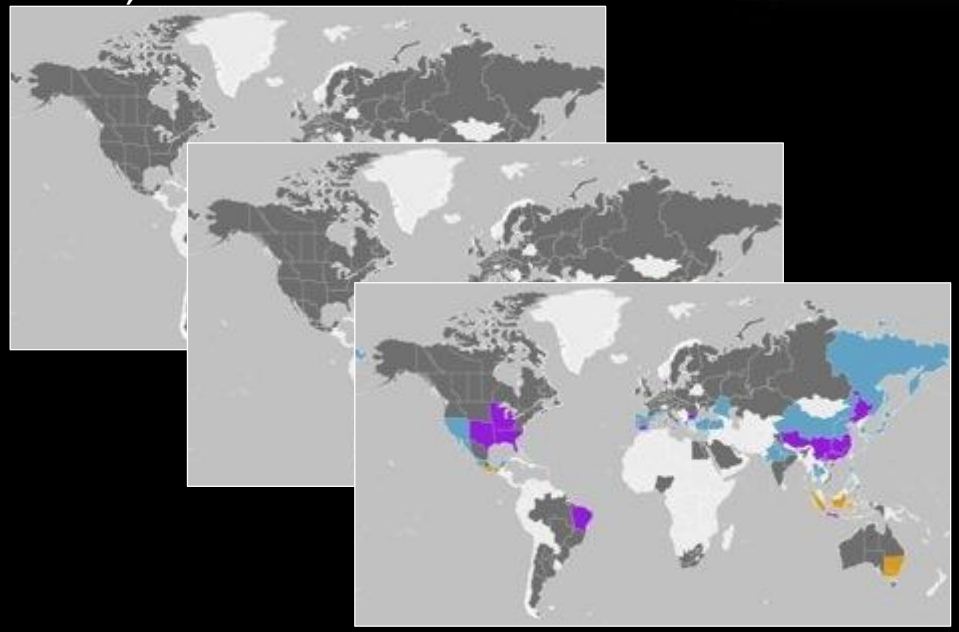
Maize 1 & Maize 2

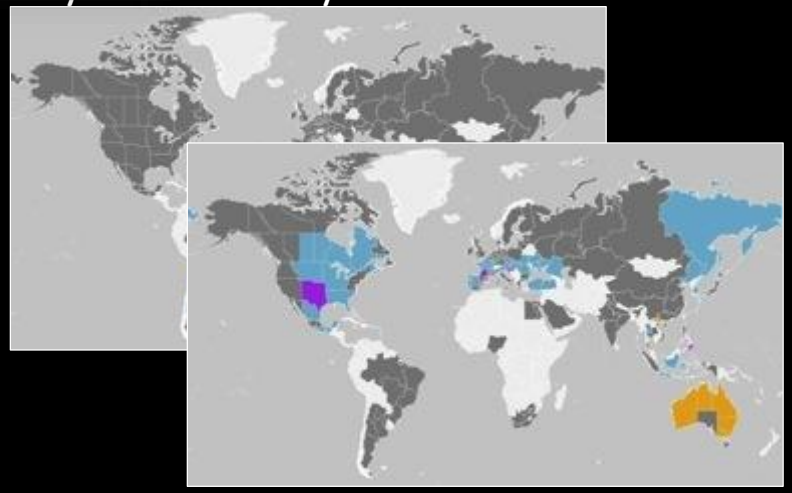
When Do Crops Grow



Rice 1, Rice 2 & Rice 3

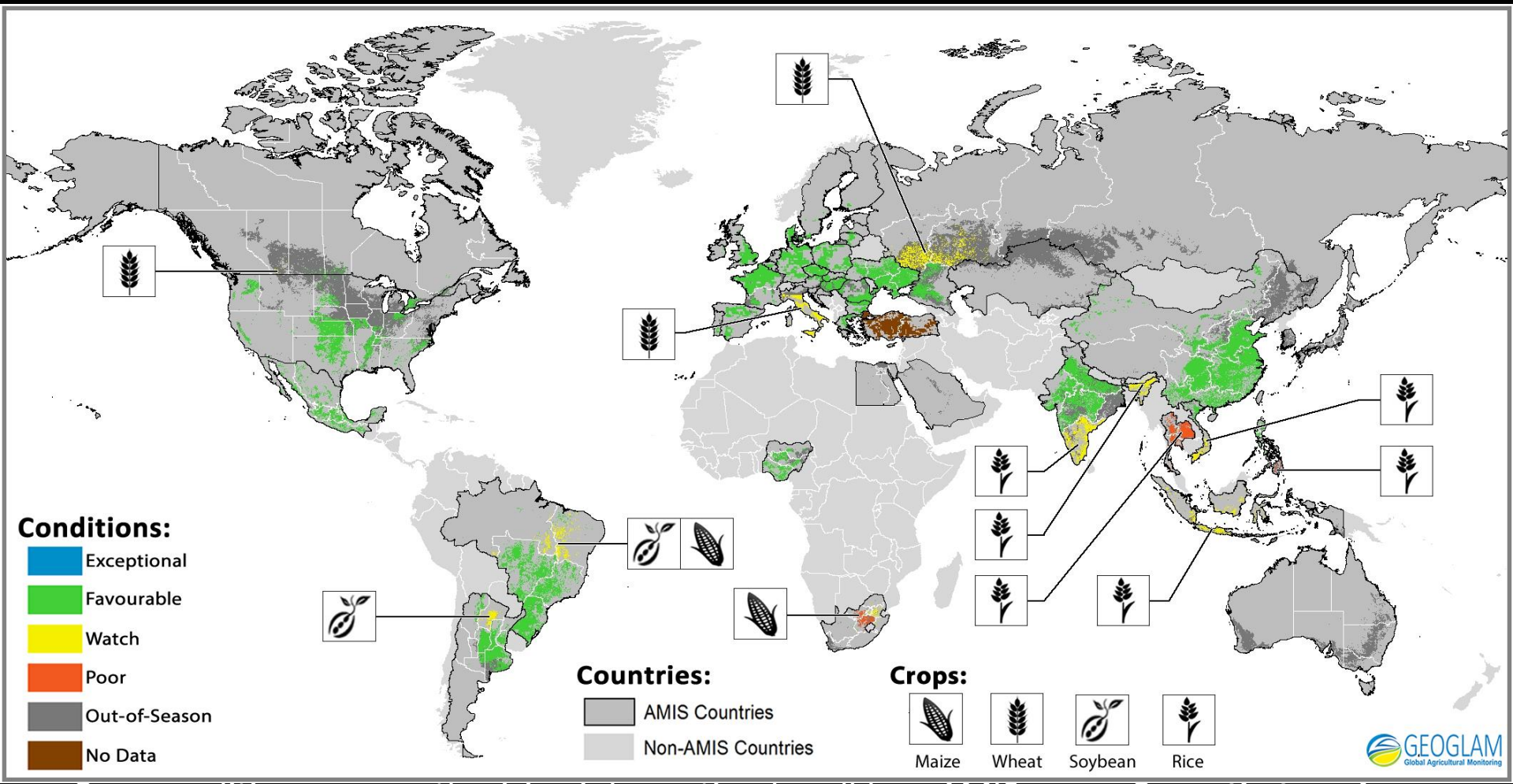
Soybean 1 & Soybean 2





Calendars reflecting multiple cycles of the same crop

Crop Monitor : an international consensus assessment - March 28th

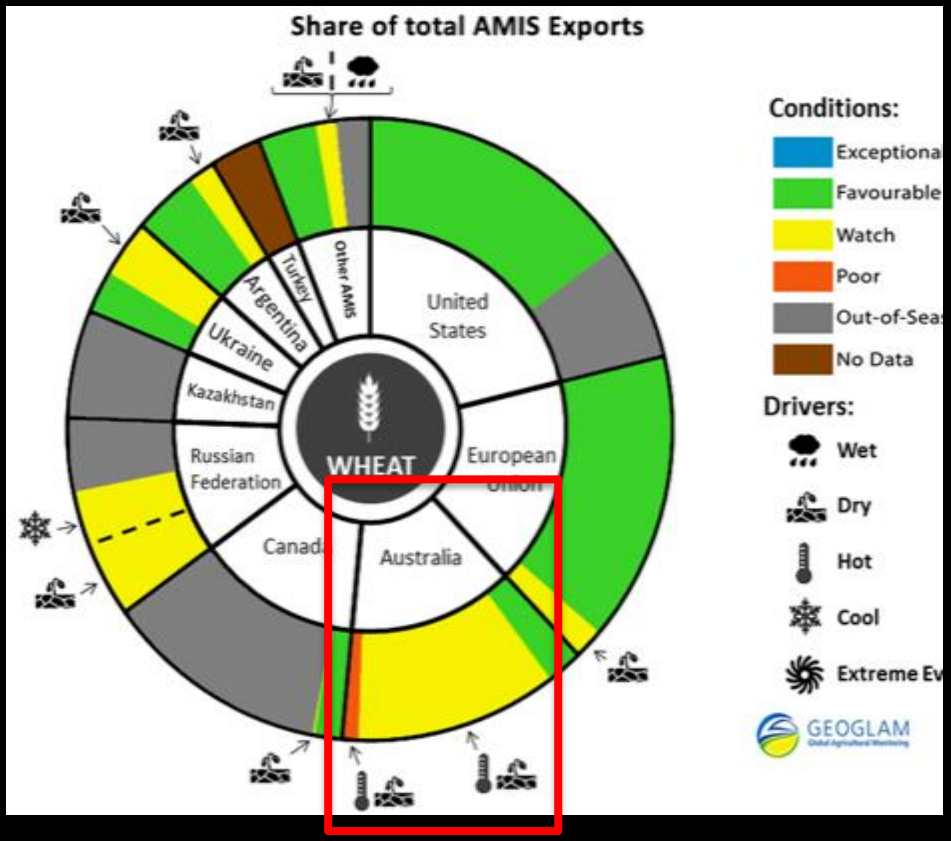


Crop condition map synthesizing information for all four AMIS crops. **Crops that are in other than favorable conditions are displayed on the map with their crop symbol.**
(Cropland area shown is an aggregation of all cropland areas)

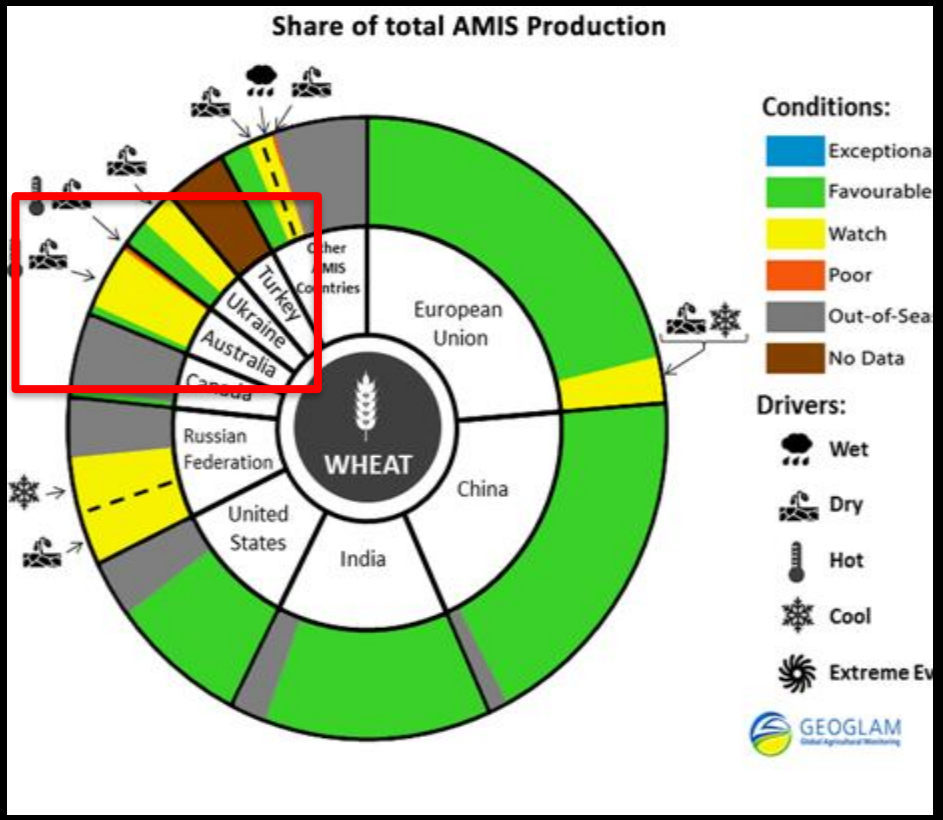
Becker-Reshef et al.

Wheat Production and Exports Pie Charts

As Share of total AMIS Exports

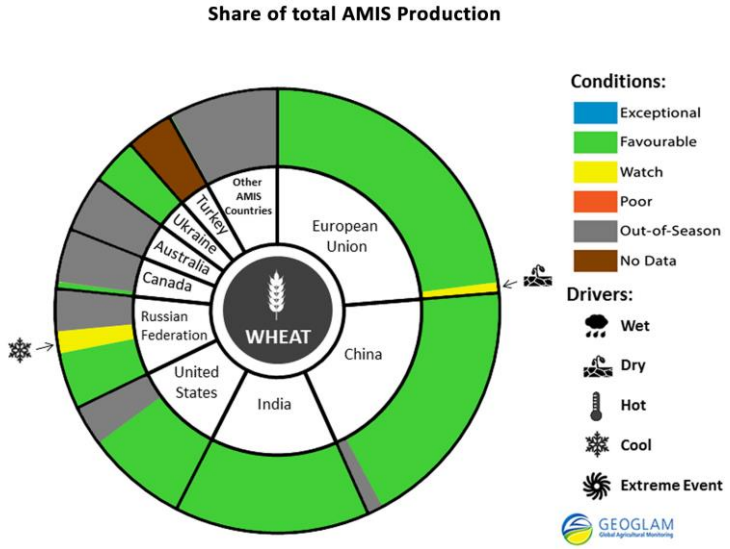


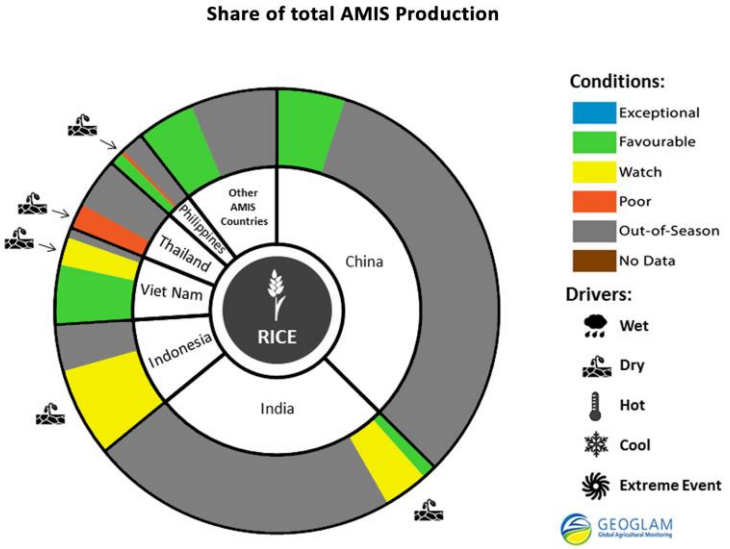
As Share of total AMIS Production



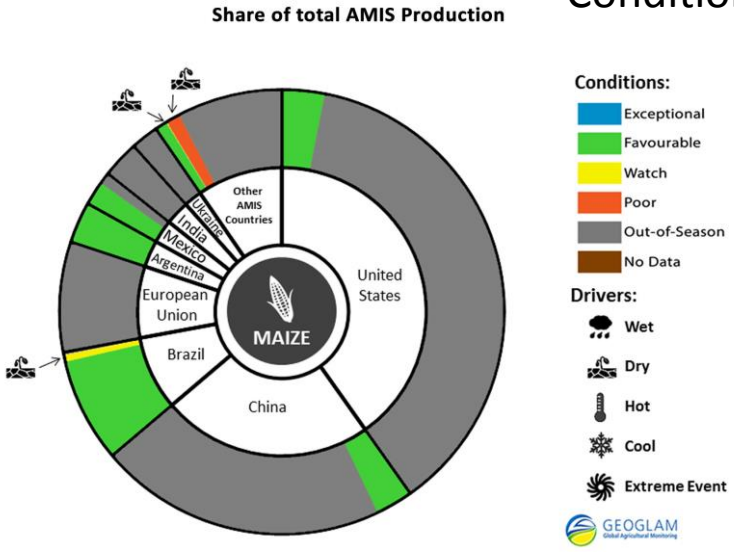
Crop Conditions as of October 28th, 2015

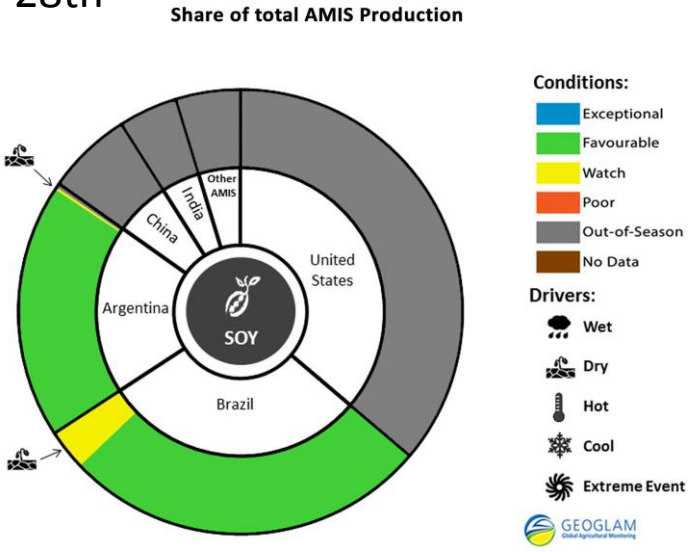
AMIS Crop Monitor March Assessment





Conditions as of March 28th





GROUP ON EARTH OBSERVATIONS

GEOGLAM
Global Agricultural Monitoring

GEOGLAM AMIS Crop Monitor Partners

> 35 Partners and Growing

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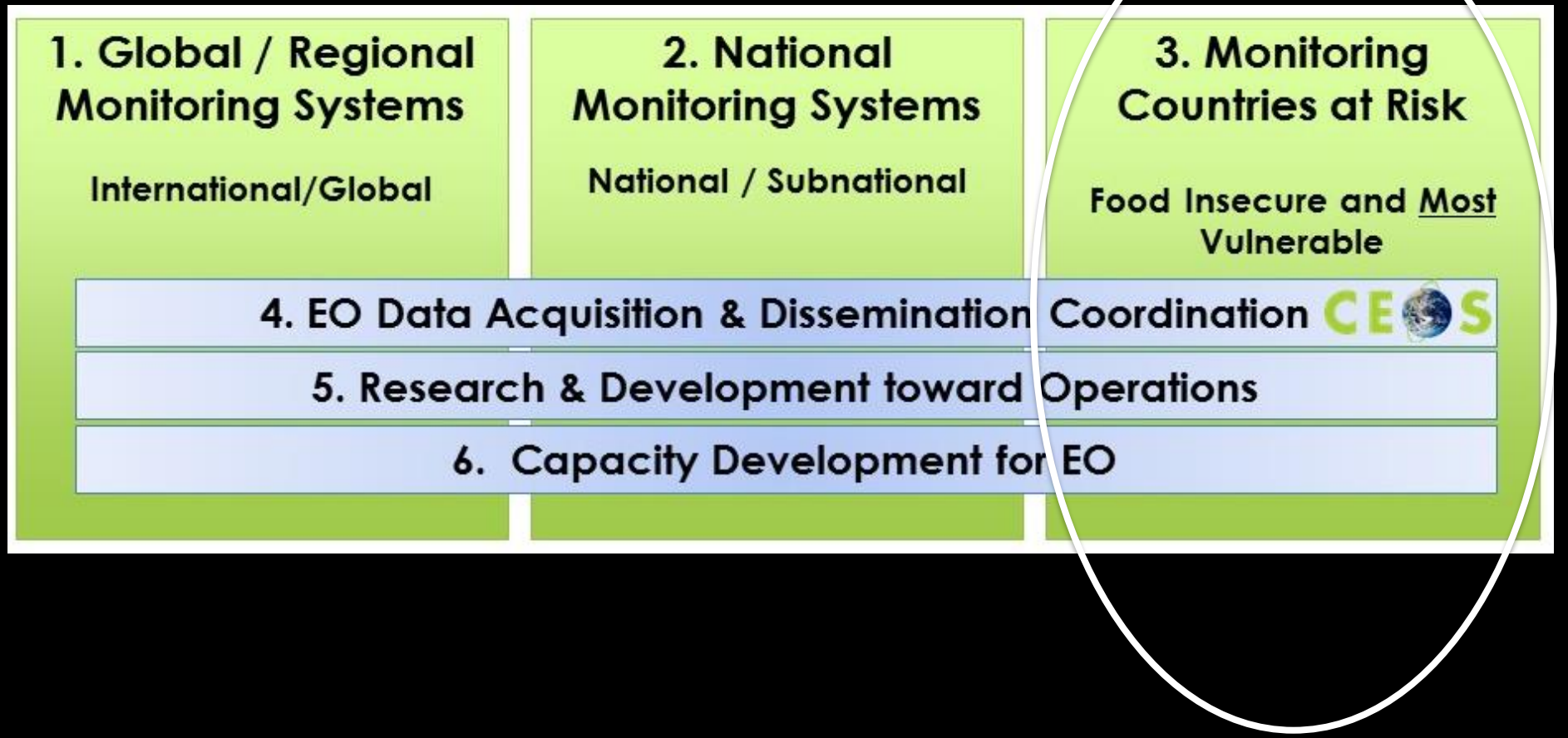
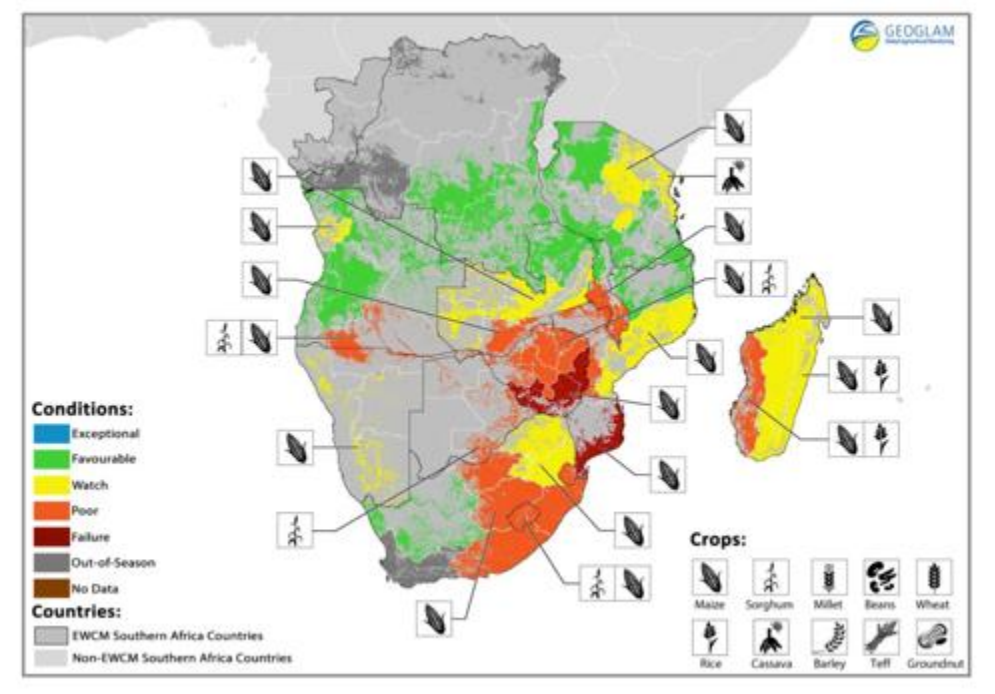
GEOGLAM
Global Agricultural Monitoring

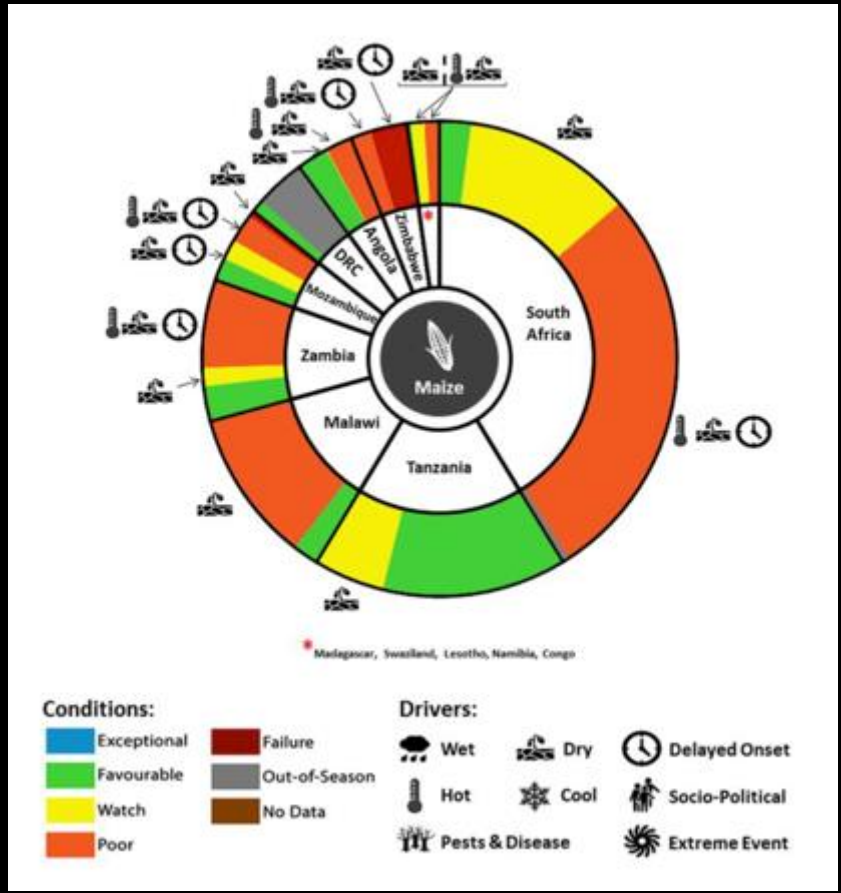
The GEOGLAM Components



Early Warning Crop Monitor

January 28th 2016





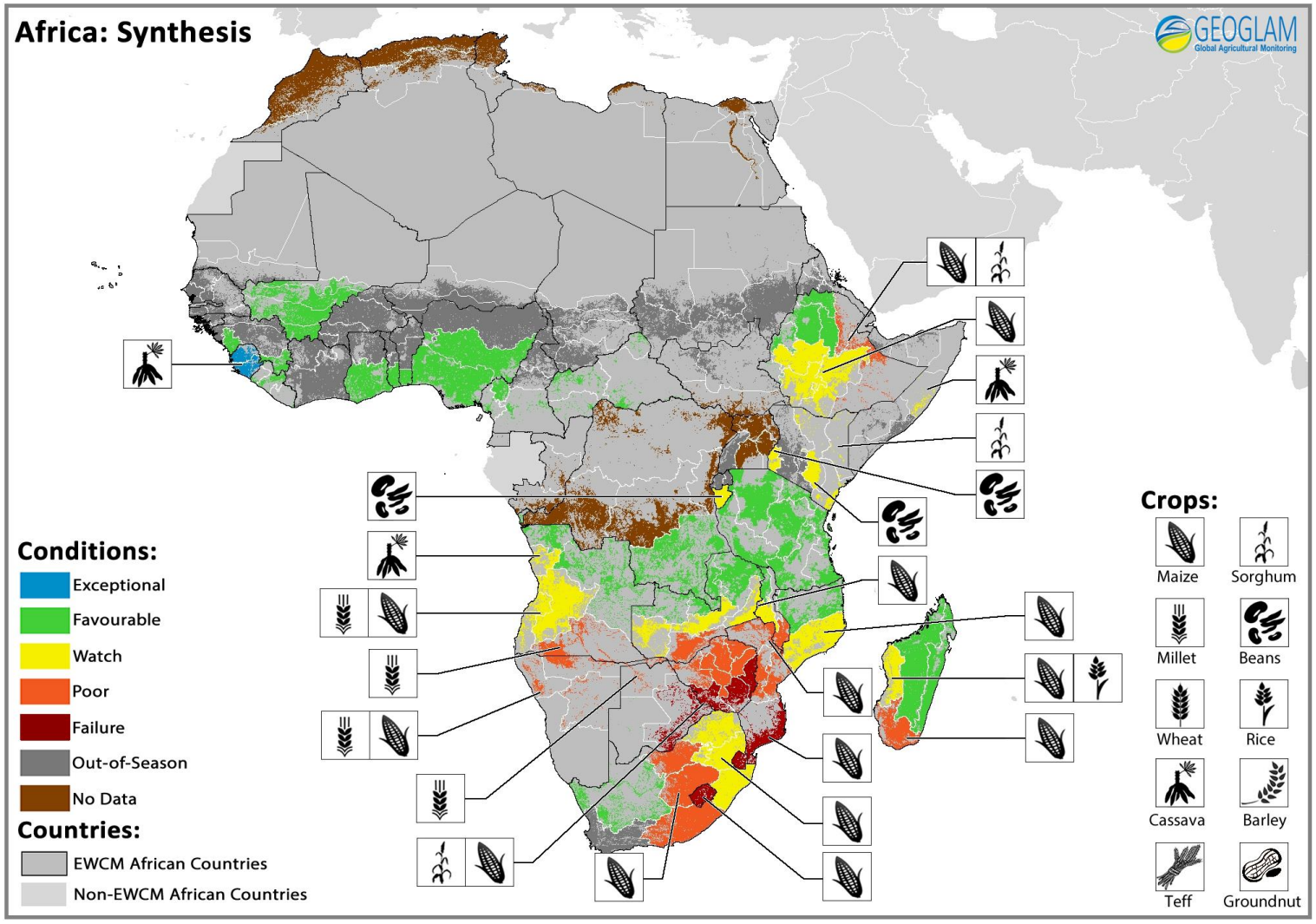
Current main Partners: FEWS NET, WFP, JRC, UMD
Objective is to expand to include regional networks and national partners

First bulletin released on February 5th, 2016

GROUP ON EARTH OBSERVATIONS

GEOGLAM
Global Agricultural Monitoring

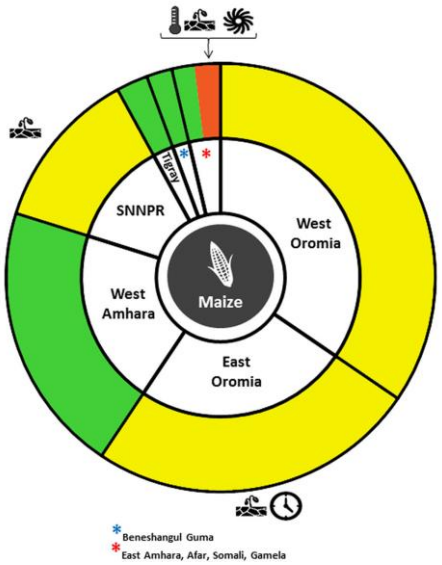
Early Warning Crop Monitor Assessment



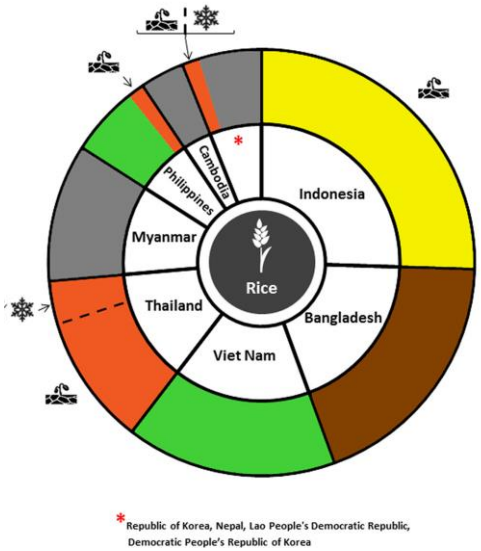
Conditions as of March 28th

Early Warning Crop Monitor April Assessment

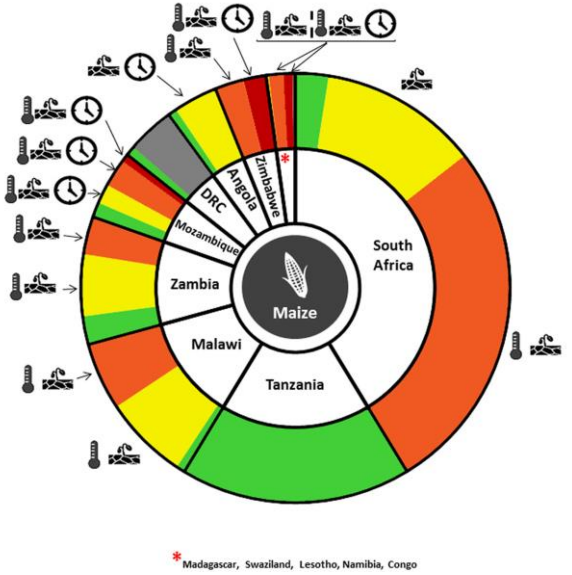
Ethiopia Maize



South East Asia Rice



Southern Africa Maize



Conditions:

- Exceptional
- Favourable
- Watch
- Poor
- Failure
- Out-of-Season
- No Data

Drivers:

- Wet
- Dry
- Delayed Onset
- Hot
- Cool
- Socio-Political
- Pests & Disease
- Extreme Event

Conditions as of March 28th

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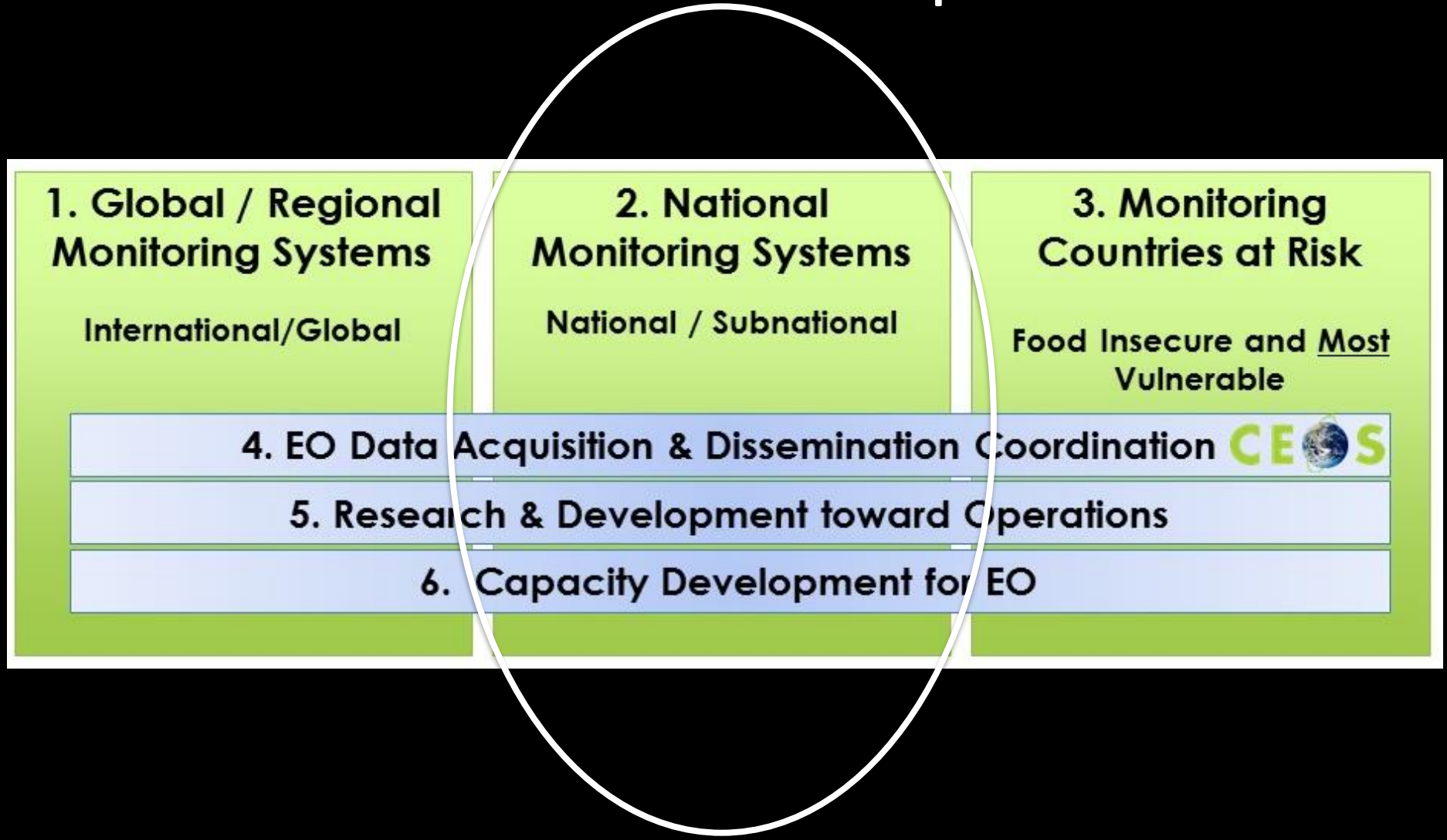
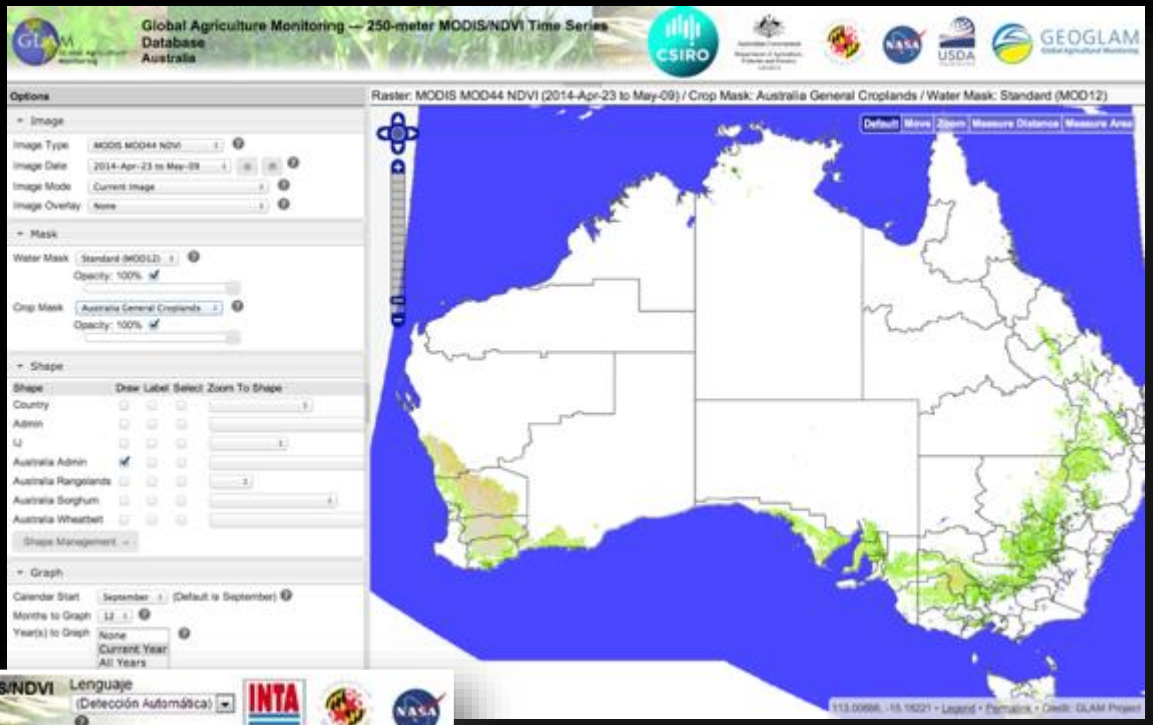
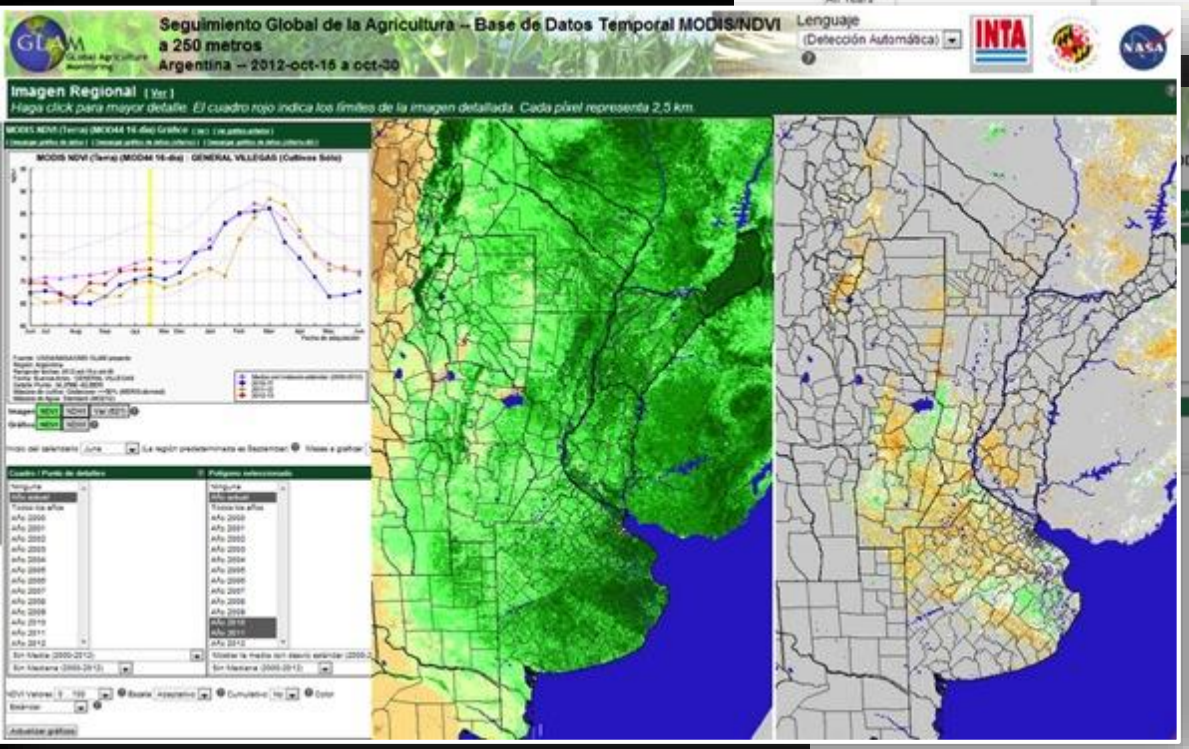
Global Agricultural Monitoring

The GEOGLAM Components



Transitioned UMD/NASA/USDA **MODIS Global Agricultural Monitoring (GLAM)** System for Crop Condition Monitoring System to other countries e.g. **Australia, Mexico, Argentina, Brazil, Colombia**
(Supported by NASA Applied Sciences Program – Doorn)





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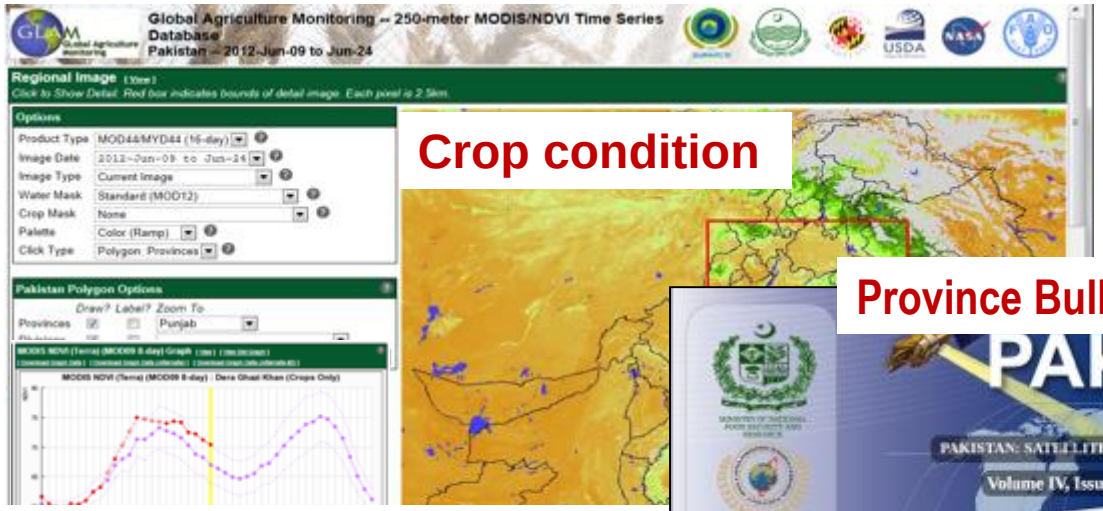
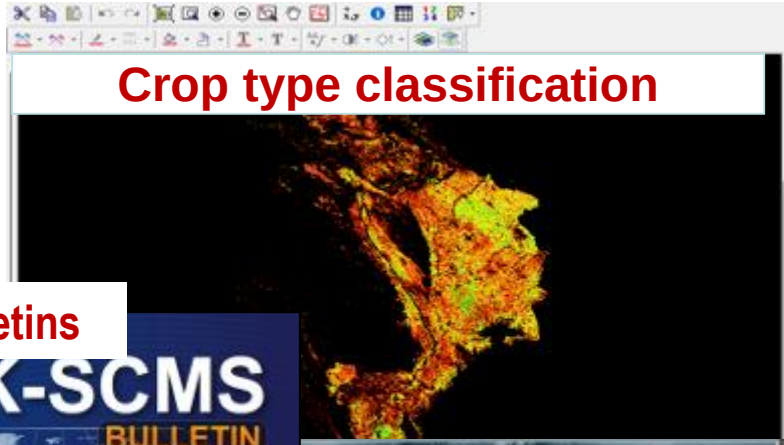
GEOGLAM Global Agricultural Monitoring

Example : Pakistan Agricultural Information System

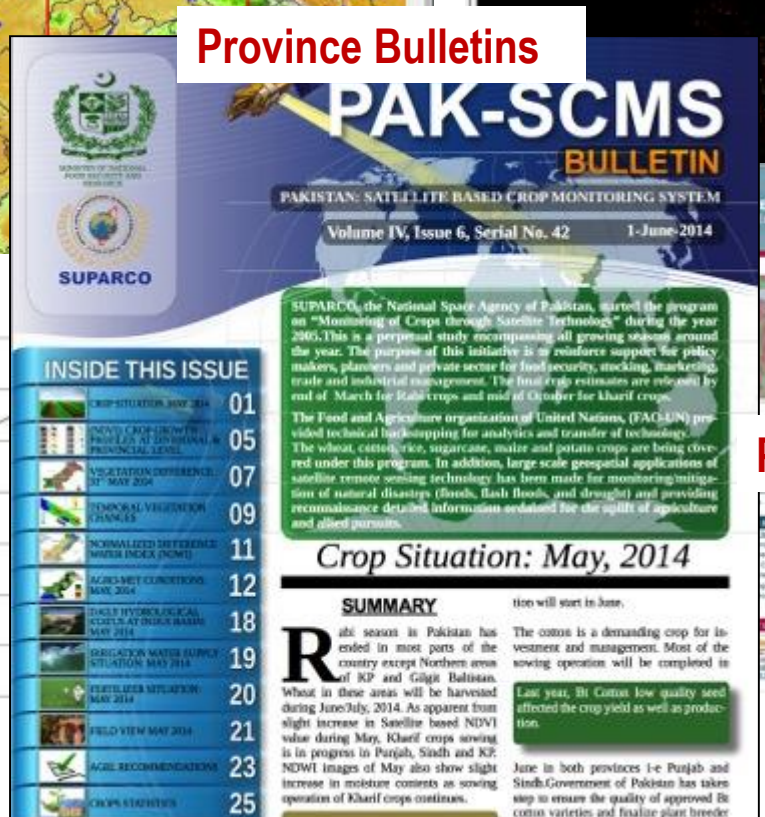
(Collaboration among CRS, USDA, FAO, SUPARCO & UMD)



Crop condition

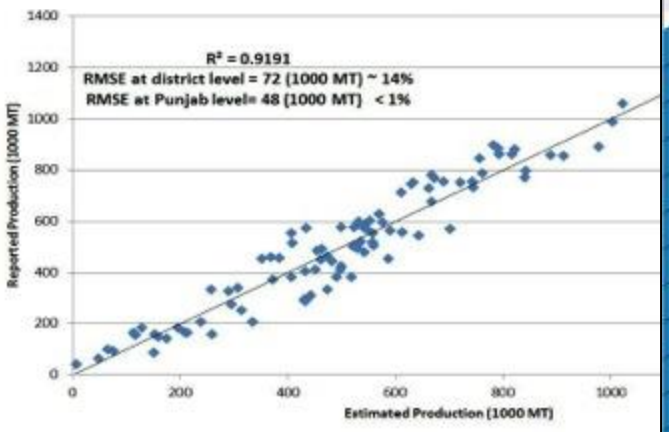


Crop type classification



Province Bulletins

EO Wheat Production Forecasting



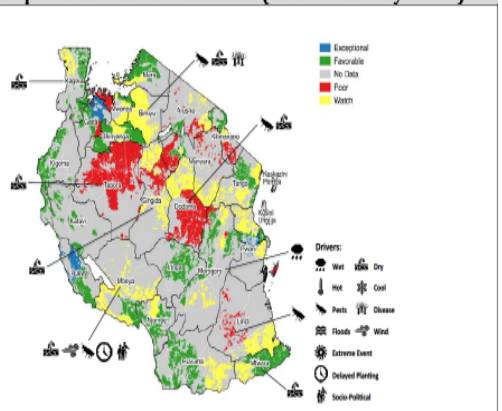
Project information

Prototype National Food Security Bulletin-Tanzania

Bringing RS, tablets & online GIS tools together

THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF AGRICULTURE FOOD SECURITY AND COOPERATIVES
Kilimo House I, Temeke, P.O. Box 9192, DAR ES SALAAM. Telephone: +255 -022-2862064, Fax: +255 - 022-2862077, E-mail: pskf@kilimo.go.tz
NATIONAL FOOD SECURITY BULLETIN
Volume 2015: No. 05 www.agriculture.go.tz 30th May, 2015

Major Crop Conditions in Tanzania (as of 30th May 2015)



This crop condition map synthesizes information for all crops as of 30th May 2015. Crop conditions over the main growing areas are based on a combination of national and regional crop analyst inputs along with remote sensing data and rainfall data provided by the Tanzania Meteorological Department. Areas that are in other than favorable conditions are displayed on the map with their drivers

NATIONAL HIGHLIGHTS

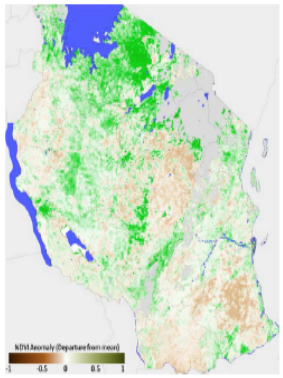
The maize crop growing areas of the southern highlands conditions are fair to favorable with the exception of **Mbeya** where conditions are poor. The region experienced a delayed start to the rainy season, which has created earl moisture deficits in many areas.

Poor conditions persist in **Tabora**, **Lindi** and parts of **Geita**, **Arusha**, **Kilimanjaro** and **Dodoma**. There h reports of pests and diseases in **Simiyu, Dodoma, Lin** and **Mbeya**. The common crop pest is the Larger Gr (Dumuzi) affecting maize crops in all the districts in **Simiyu** and **Morogoro**. The Common pest and disease in Mara region are Maize Leaf Necrosis (MLND), Cassava Mosaic Virus and Cassava Brown Streak

Seasonal rains have begun to intensify in the last two dekads, however the effects early season rainfall deficits are still evident. April is the peak month for the long-rain season and given a positive two-week forecast, some relief is expected

Contents

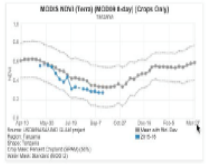
Wizara ya Kilimo NATIONAL FOOD SECURITY BULLETIN TANZANIA MAY 2015

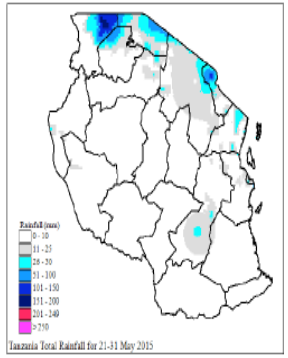


NDVI Summary:

NDVI anomaly data for the country show above average conditions for the country with **Simiyu, Shinyanga, Tabora** and some parts of **Mbeya** and **Rukwa** performing relatively above average conditions compared to the long-term average for the month of May. Some parts of **Iringa, Lindi** and **Dodoma** current vegetation conditions fall slightly below average.

Remaining regions portrays normal vegetative conditions





Agro-meteorological outlook:

The Tanzania Meteorological Agency (TMA) reports that with the observed synoptic conditions during May 21-31, 2015, Masika continued to feature over some of the bimodal areas especially north-eastern highlands and Lake Victoria Basin. However, parts of those areas and much of the northern coast experienced dry conditions. The uni- mostly d including over the normal t and Lake rainfall. (was mair (mostly p **Morogor**

Wizara ya Kilimo NATIONAL FOOD SECURITY BULLETIN TANZANIA MAY 2015

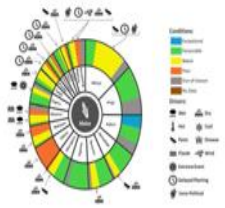
Highlights by Major Food Crop

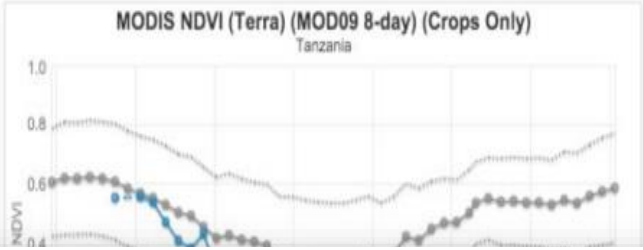
Maize:

A delayed start of the 2015 Masika for maize has led to significant rainfall deficits in parts of **Njombe** and **Iringa**. A major proportion of the maize growing areas of Dodoma are experiencing poor conditions. The three crop growing areas **Singida, Kilimajaro**, and **Tabora** are currently in a watch status due to abnormally hot temperatures and reduced rainfall. The maize growing area of SNNPR has been significantly impacted by these same drivers, but also experienced a more significant delay in the onset of seasonal rains, thus owing to the areas poor cropping conditions. Stalk borer has been reported in **Morogoro** (see image)

Evidence of damage from stalk borer in Ilakala - Kilosa, Morogoro 11/3/15

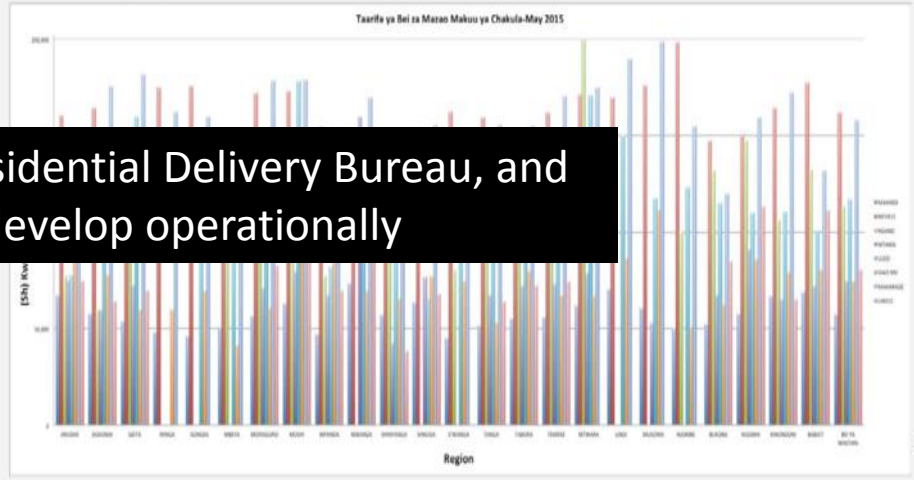
Maize conditions for Tanzania as of 30th May





Wizara ya Kilimo NATIONAL FOOD SECURITY BULLETIN TANZANIA MAY 2015

Food Prices by region:



Strong interest from Ministry, Presidential Delivery Bureau, and Permanent Secretary to develop operationally

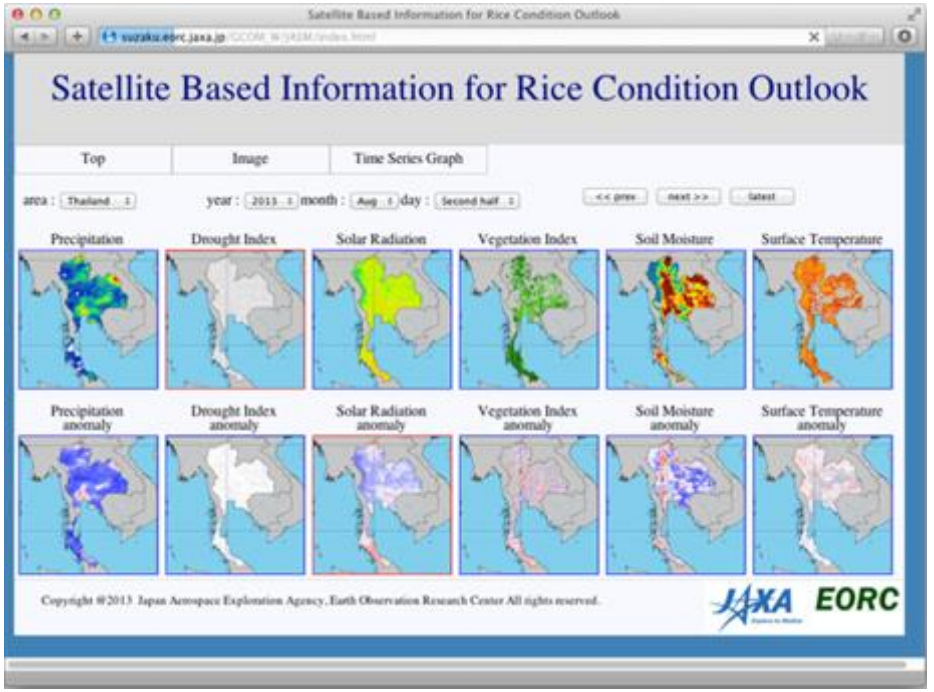
GROUP ON EARTH OBSERVATIONS

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

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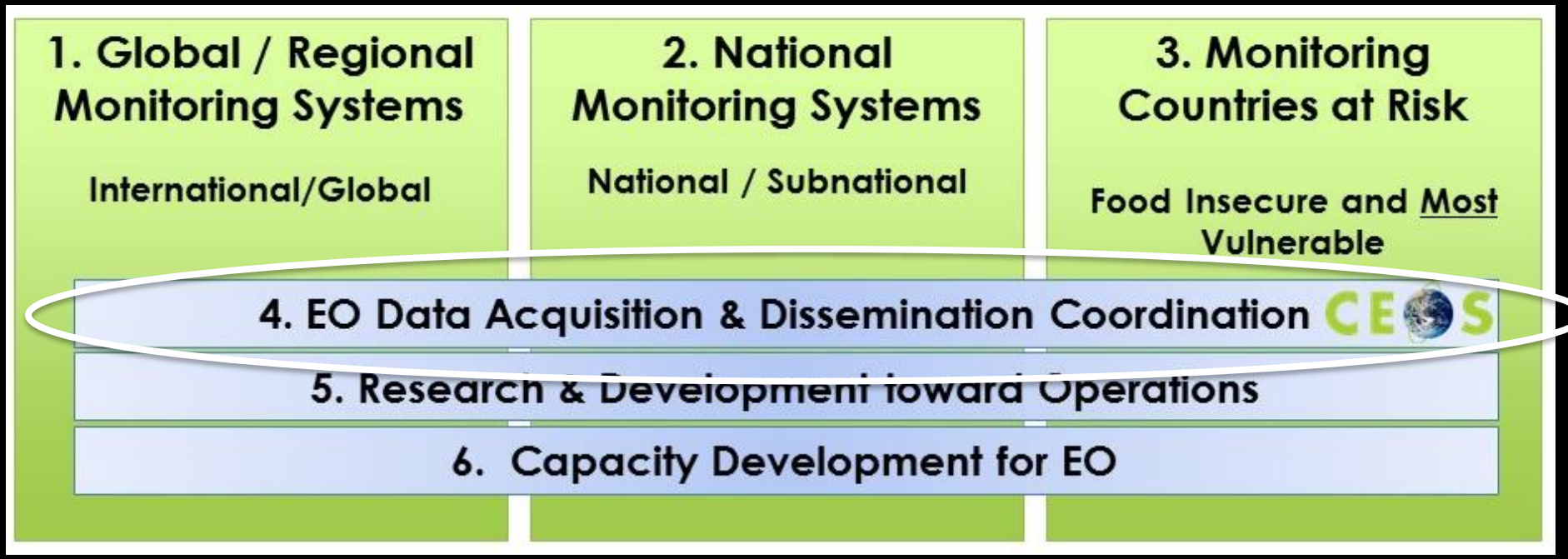
GEOGLAM
Global Agricultural Monitoring

The GEOGLAM Components



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)	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?, Probe-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		
	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	
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?

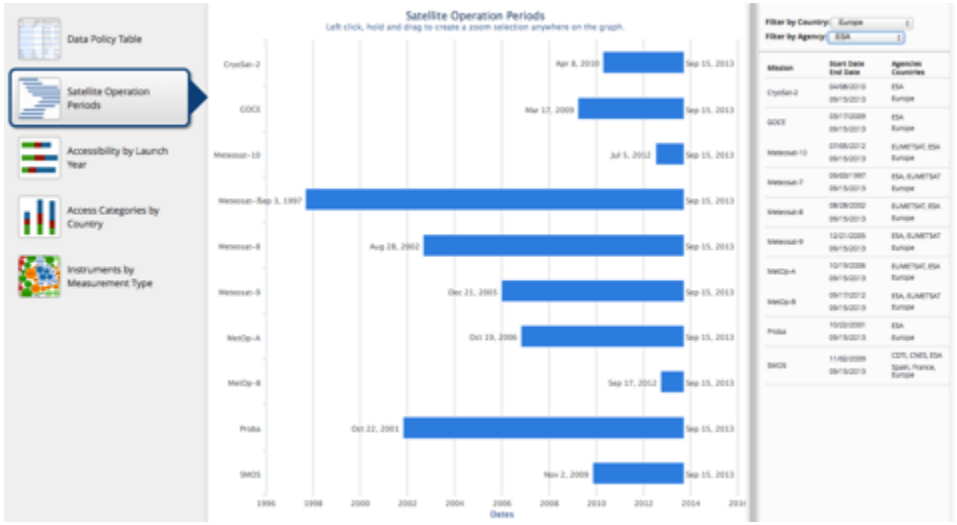
GEOGLAM data plan submitted to the CEOS plenary in 2013

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 ?

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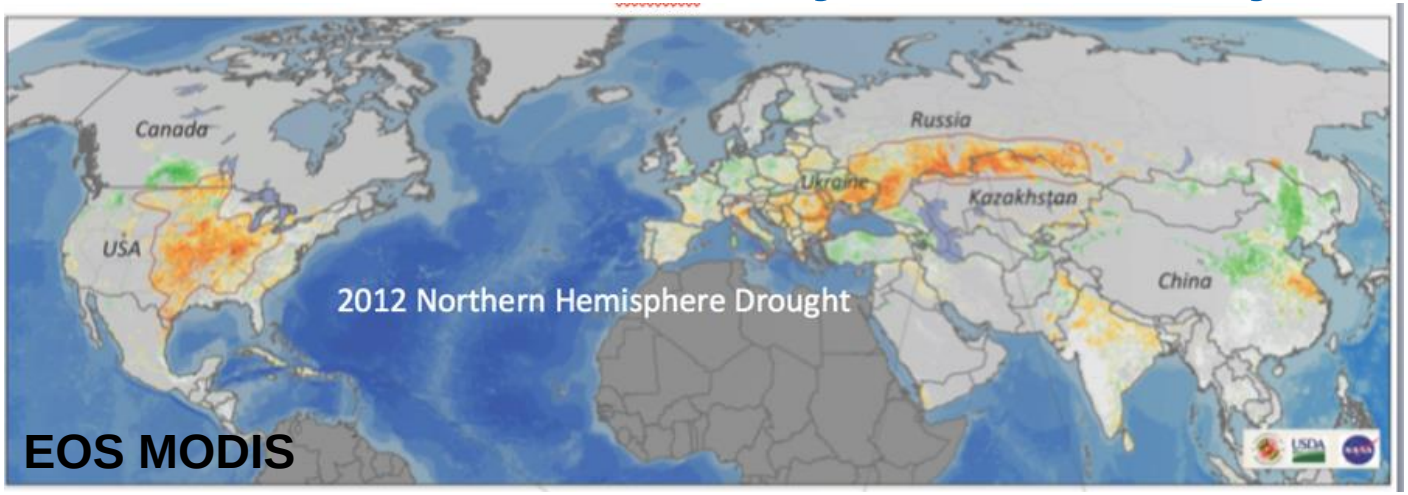
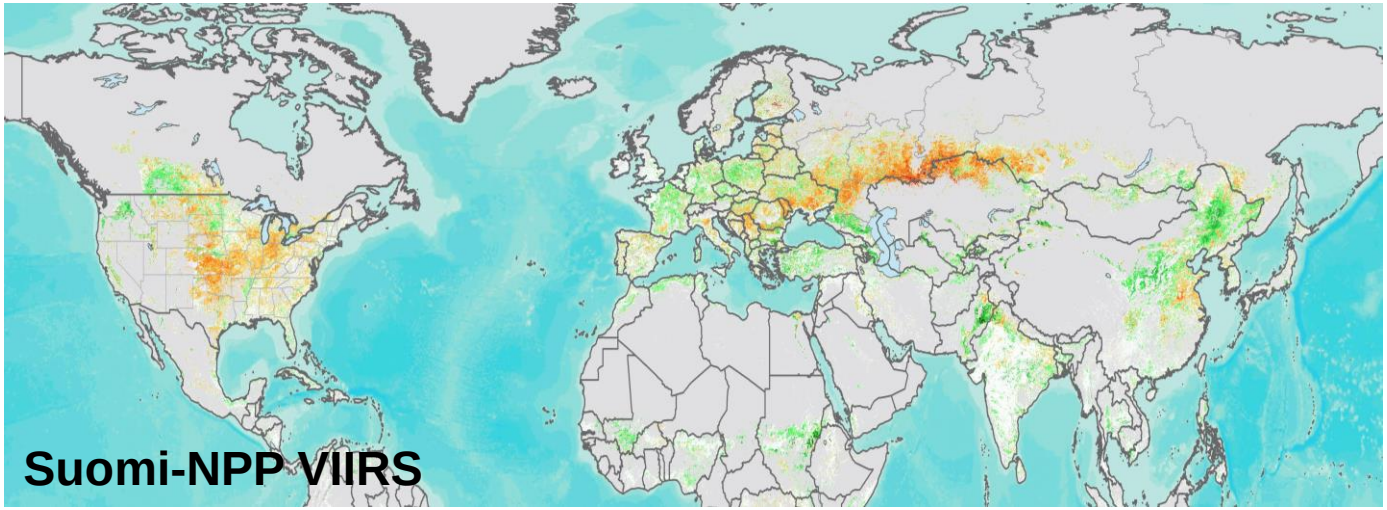
GEOGLAM Global Agricultural Monitoring

Coarse Resolution Anomaly Product Continuity/Consistency





July 30 2012

EOS MODIS

↓

Suomi-NPP

↓

JPSS VIIRS

Vermote (GSFC)

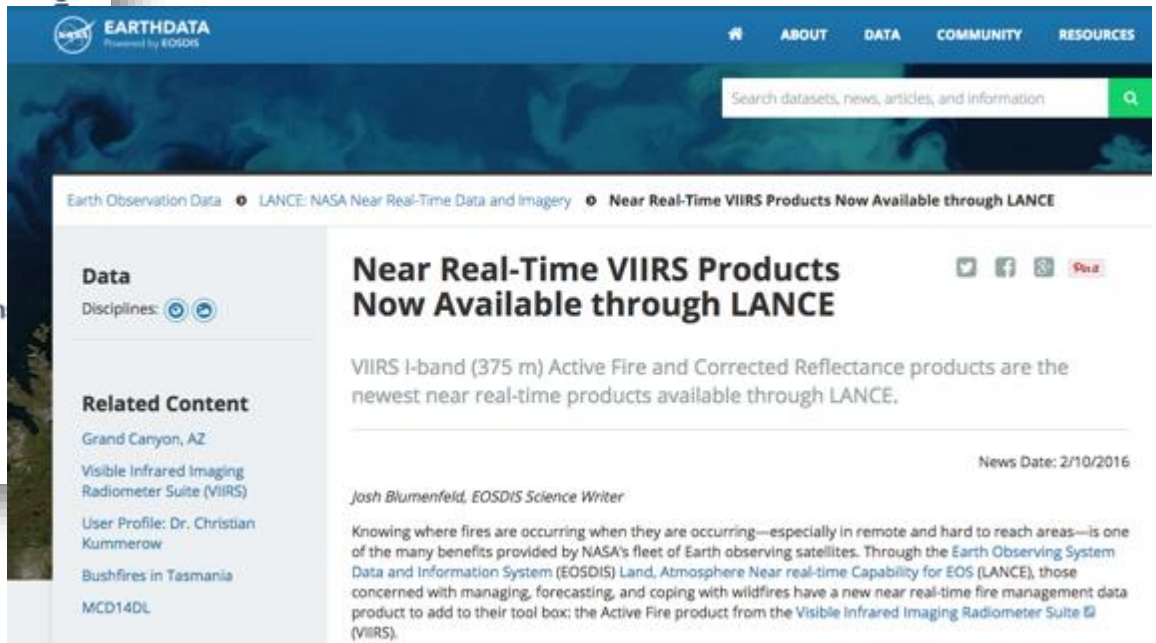
NASA

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
- Current support to make this happen for VIIRS 2016



NASA

Landsat-9

- Landsat-9 will rebuild Landsat-8, but with upgraded TIRS
  - Capitalizes on design heritage and minimizes time to next mission
  - TIRS upgraded to Class B
  - Stray light issue in TIRS Band 11 corrected
- Interagency Partnership between NASA & USGS with same roles as Landsat-8
- Launch in 2020/21
- Current Status
  - Ball Aerospace under contract to build OLI-2 sensor
  - TIRS-2 to be built at GSFC
  - Spacecraft draft RFO issued

USGS

Masek et al

US Land Imaging Evolution

While recognizing the scientific need for continuity with the 43-year Landsat record, we are seeing new trends & opportunities in land remote sensing

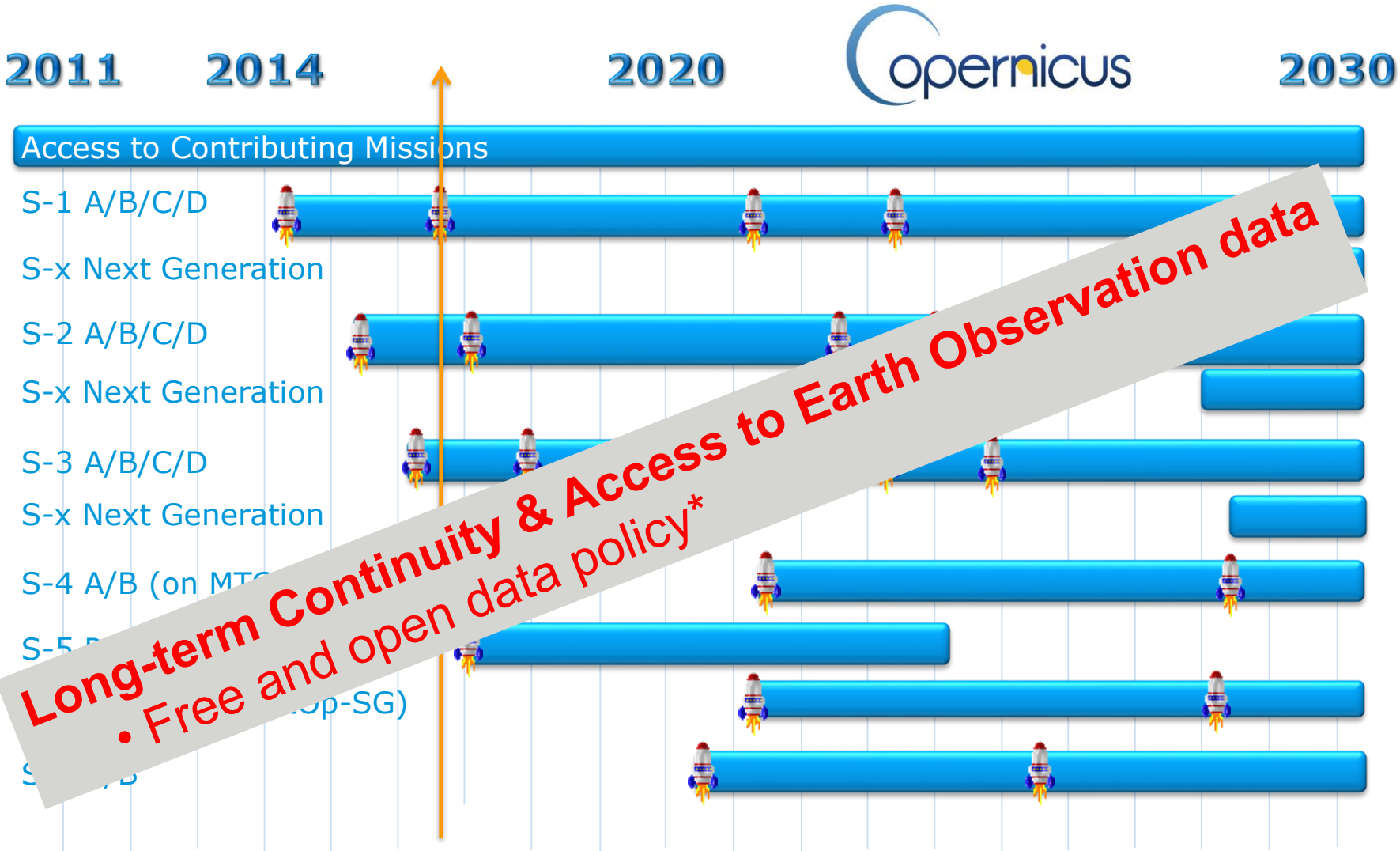
- *Evolving user needs for…*
  - *Improved temporal revisit*
  - *Additional spectral coverage & resolution*
  - *Integration with other modalities (lidar, radar)*
- *Increasing use of "small sat" platforms and distributed architectures*
- *Increasing number of commercial imaging systems*
- *Potential synergy with international systems (e.g. Sentinel-2)*
- *High-performance computing and increased emphasis on information rather than images*

Our challenge is to advance the measurement capability, while preserving continuity and constraining program costs

NASA USGS

Masek et al

Sentinels – New Era of Observations
EU-ESA Copernicus Space Programme



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				
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

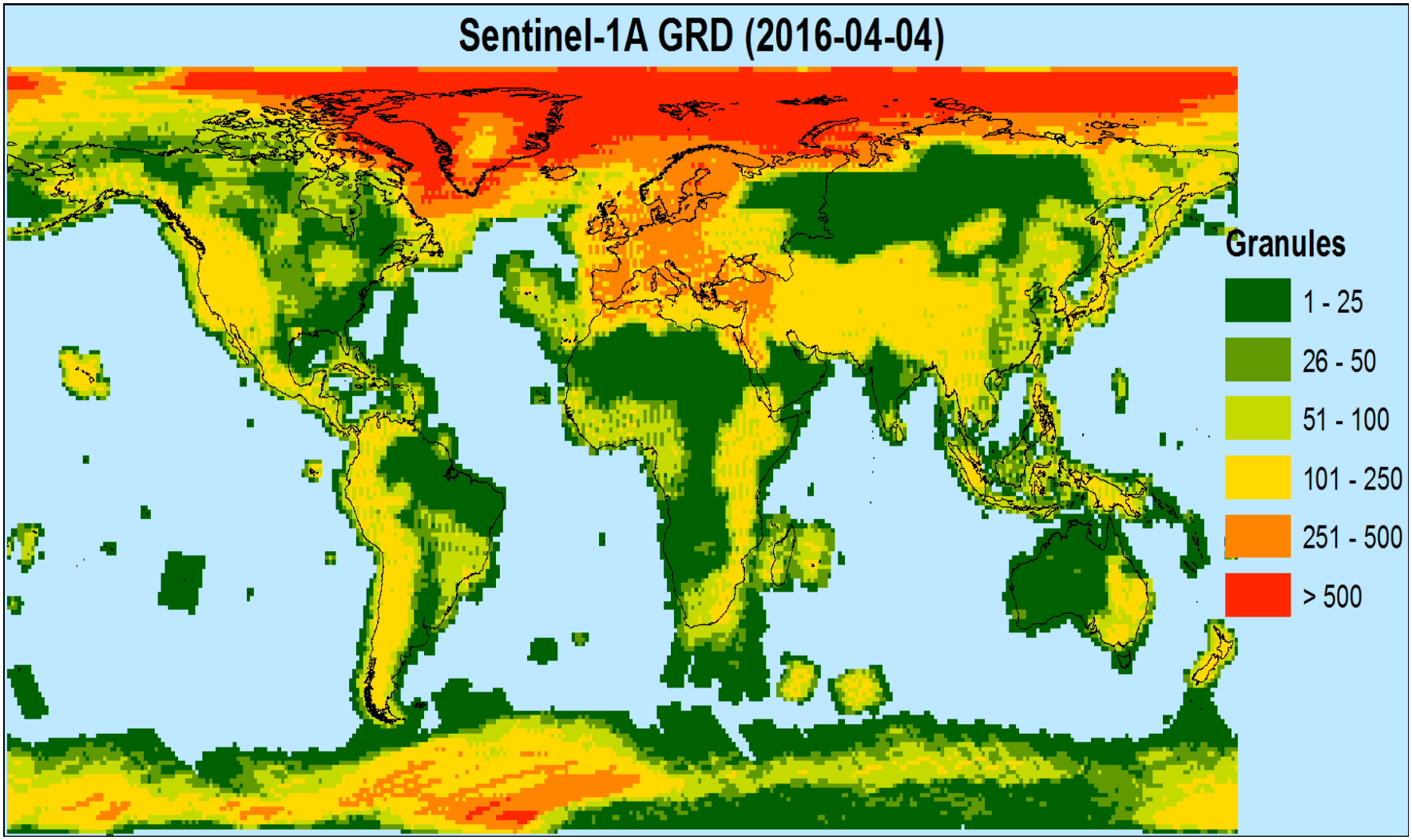
Sentinel-2

Sentinel-2

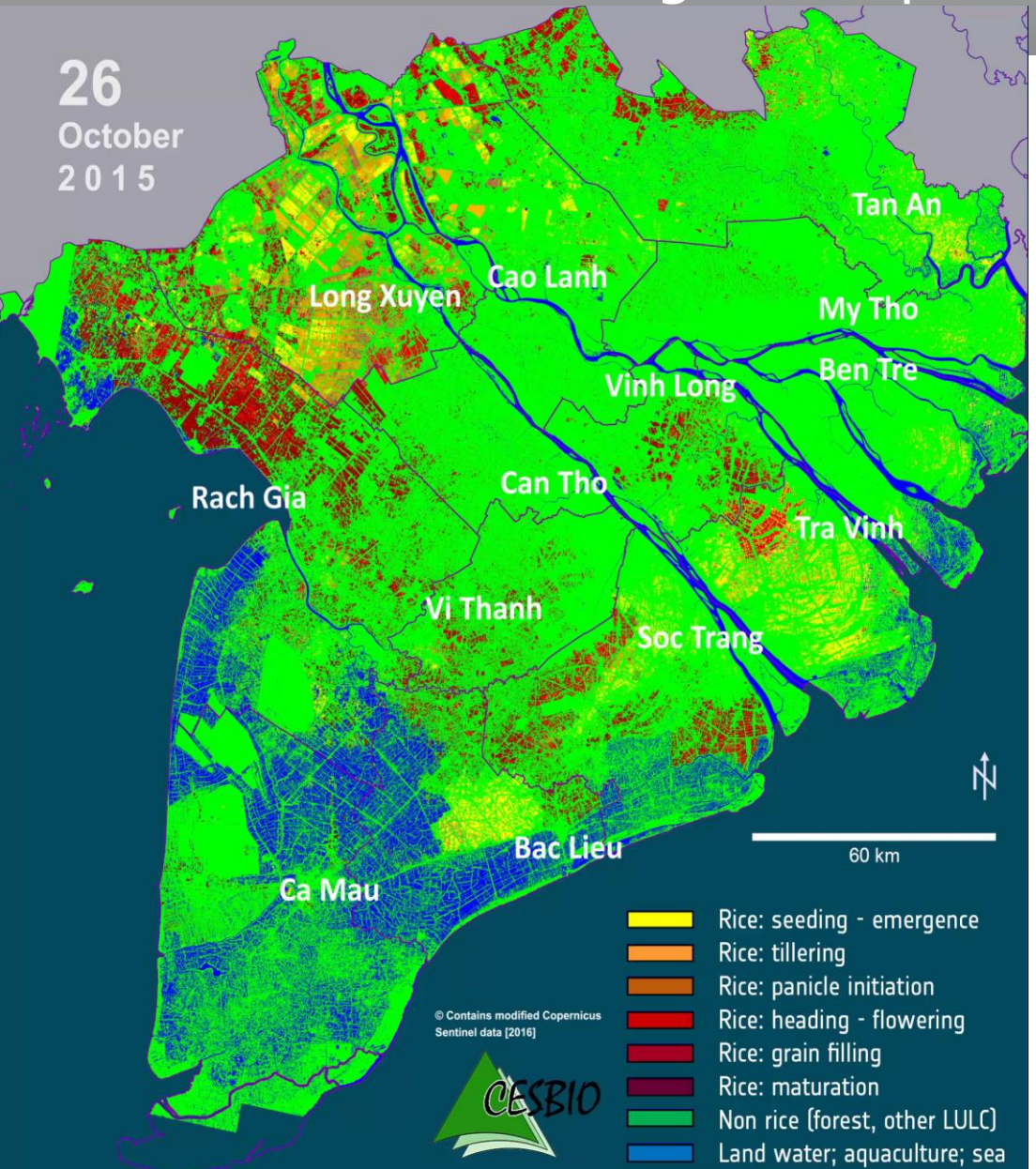
Sentinel-1

Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM

Depth of coverage in the archive of the globe for the mission



Rice Monitoring
Monitoring of Crop Stages



Winter-Spring Rice 2015/16

- March 2016: 1.4 Million ha rice
- March 2015: 1.7 Million ha rice
- **16.5% loss in rice area** due drought and salt water intrusion caused by El Nino
- 976.000 people affected, 67 Mil. $ estimated damage

- Based on unprecedented S1 timeseries

The Mekong Delta, Vietnam
300 km x 300 km, 20 m resolution

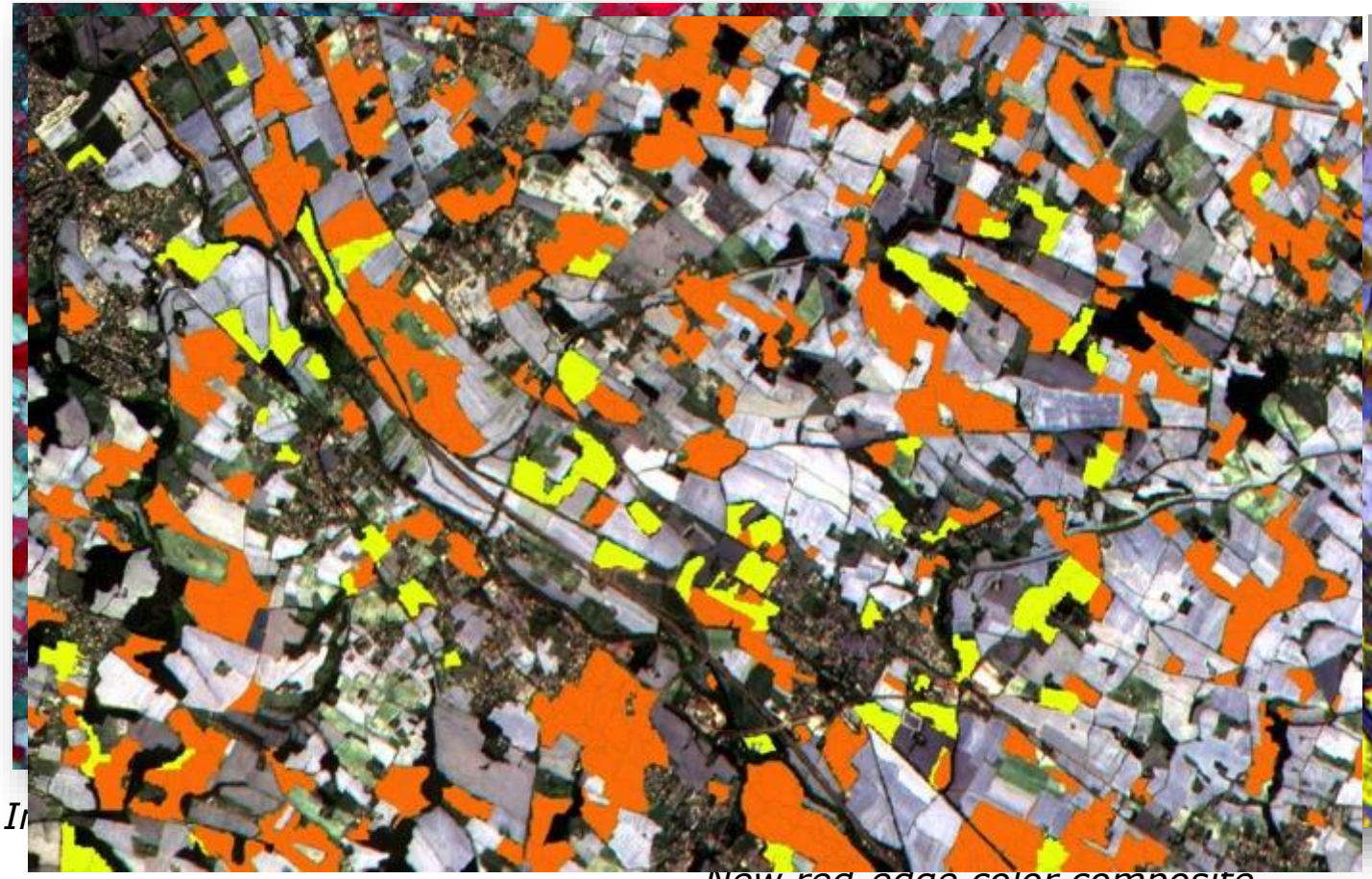
GEOGLAM Global Agricultural Monitoring
Asia-RiCE Crop Estimation and Monitoring
V.A.S.T
European Space Agency

First S2-based prototype product

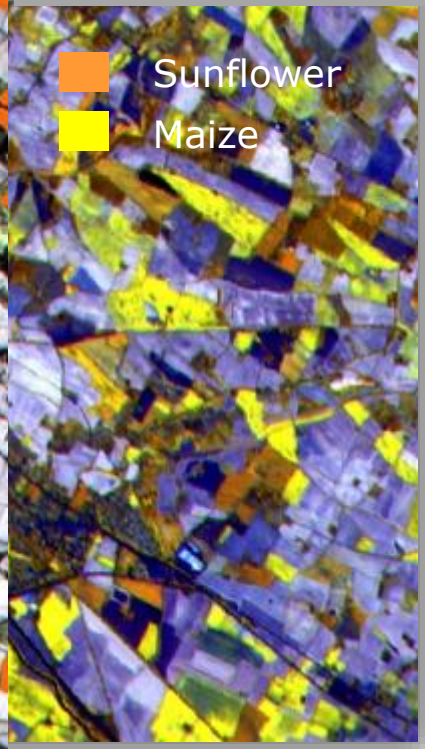
Toulouse area (France) - Sentinel-2 – 06 July 2015

esa

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



New red-edge color composite
orange versus yellow



sentinel-2

AGRICULTURE

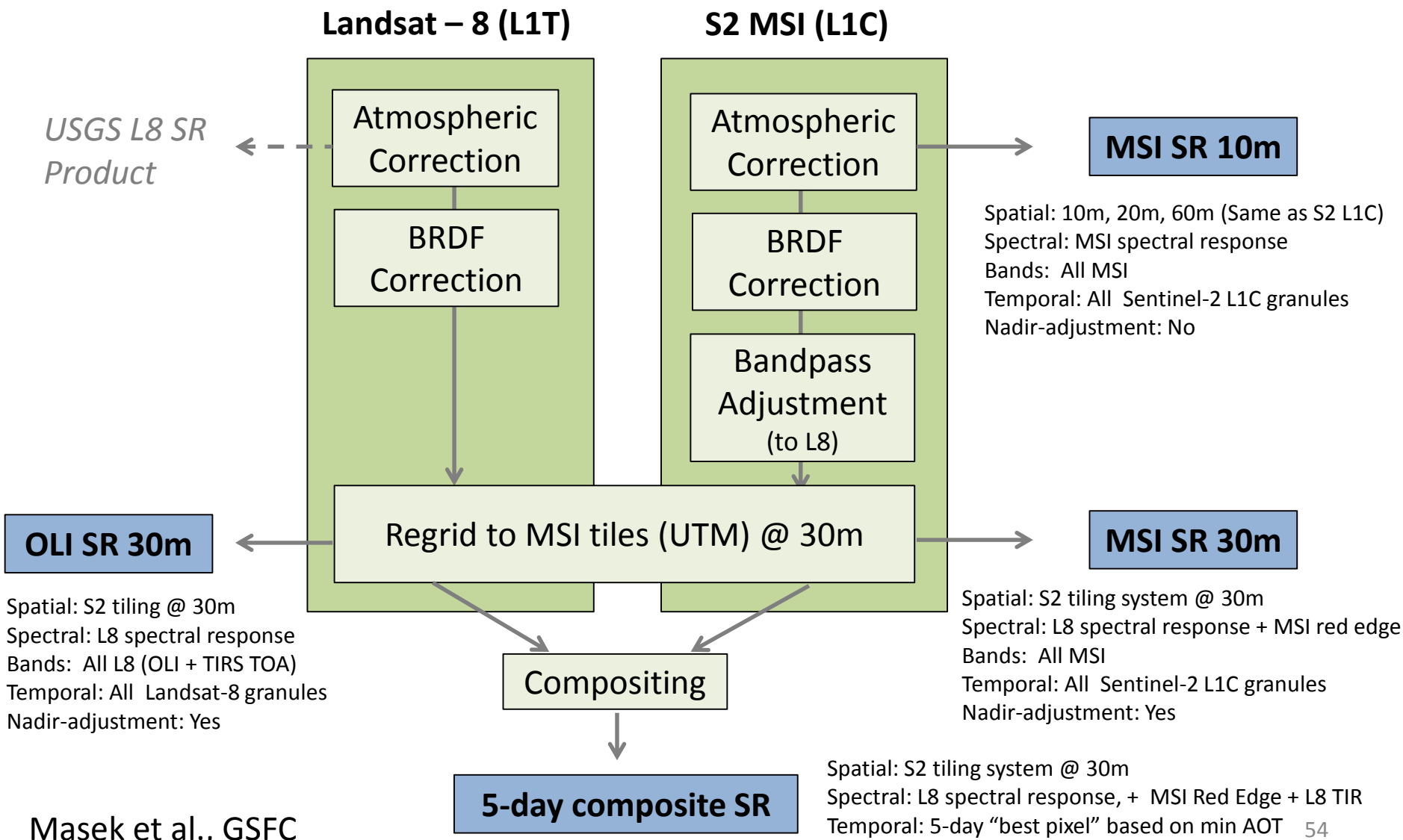
UCL Université catholique de Louvain

CESBIO

ES

ES ROMÂNIA

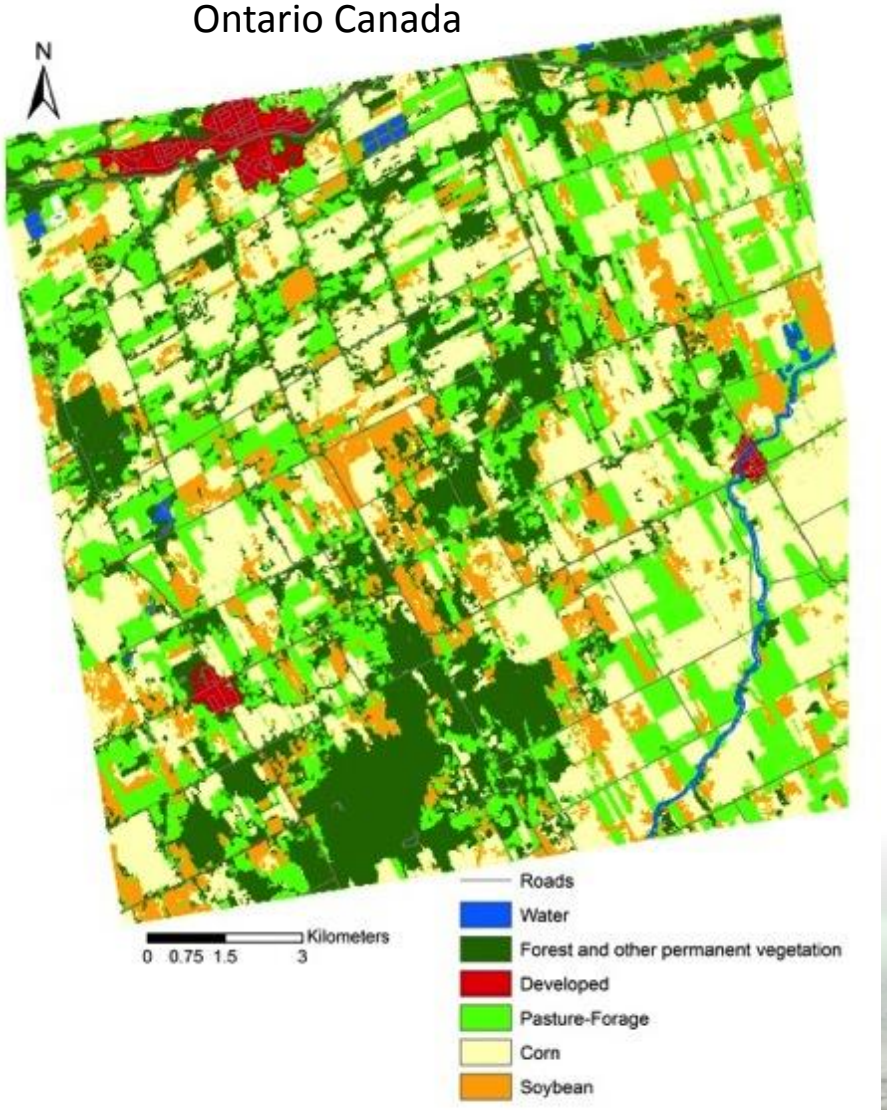
NASA HLS Processing & Products



Masek et al., GSFC

In Development: Early Season Crop Identification

South Nation Watershed,
Ontario Canada



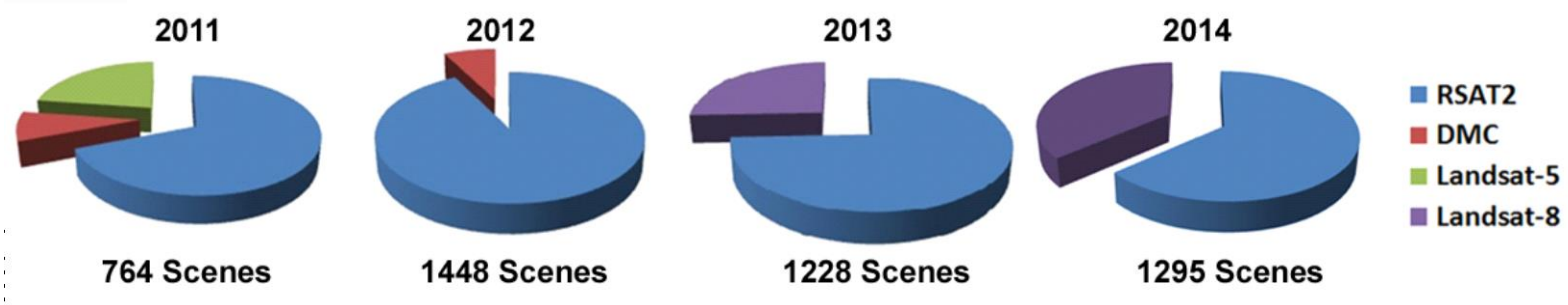
End of season TerraSAR-X crop classification: Ottawa 2012
Overall accuracy: **97.2**%

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.

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

Image Data



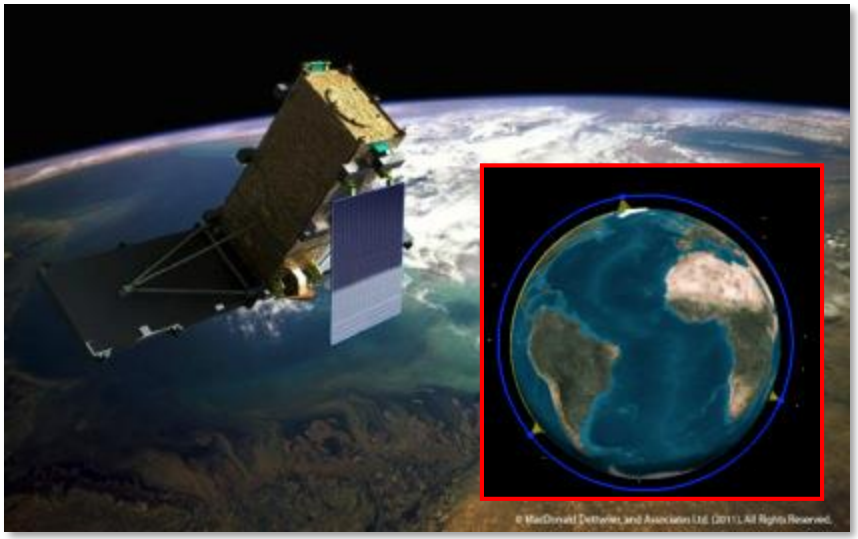
- Multispectral optical data can adequately classify crop if available during critical time periods
- Accuracies decrease significantly when gaps in data collection occur
- Operational burden of cloud masking
- Accuracy increases with SAR; magnitude depends on crop, timing of acquisitions and amount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

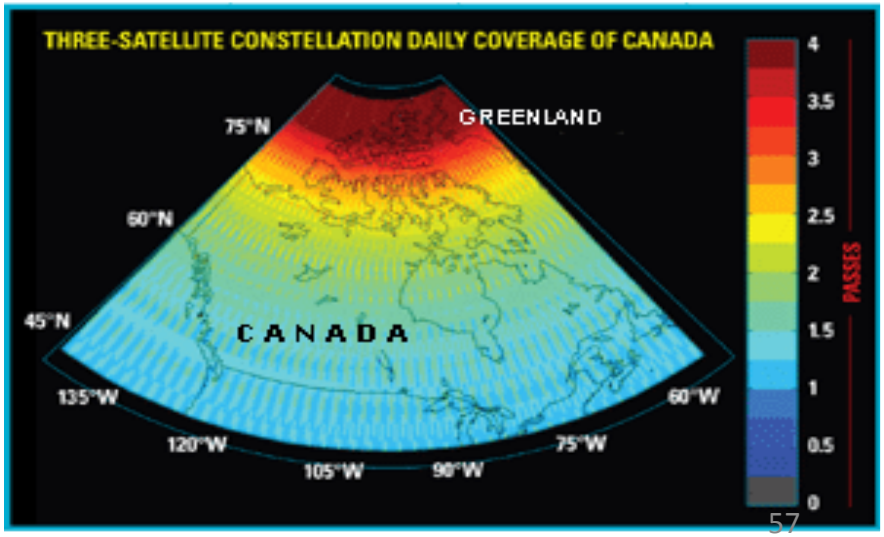
Courtesy Thierry Fisette and Leander Campbell, AAFC

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 ?





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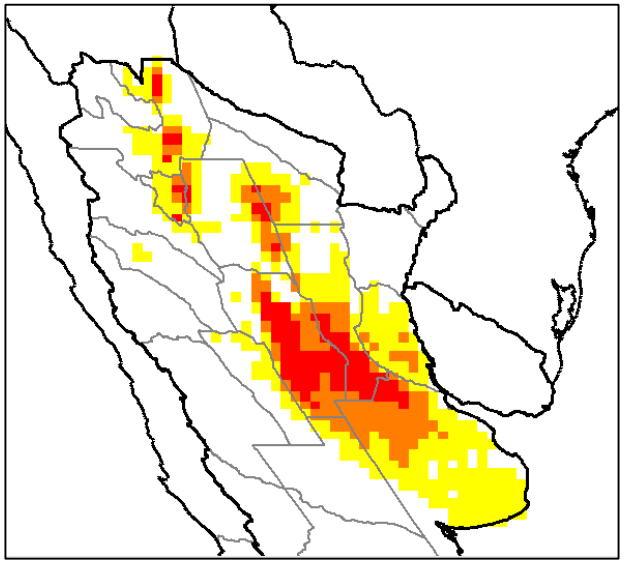
High Resolution Sampling Strategy for Soybean Area in Argentina

- 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):

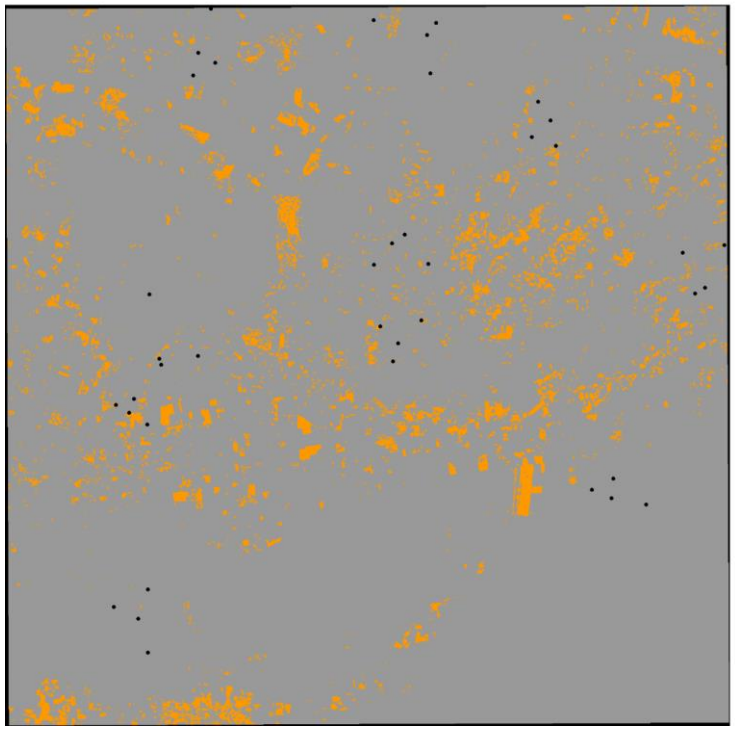


Argentina Sample Strata

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

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

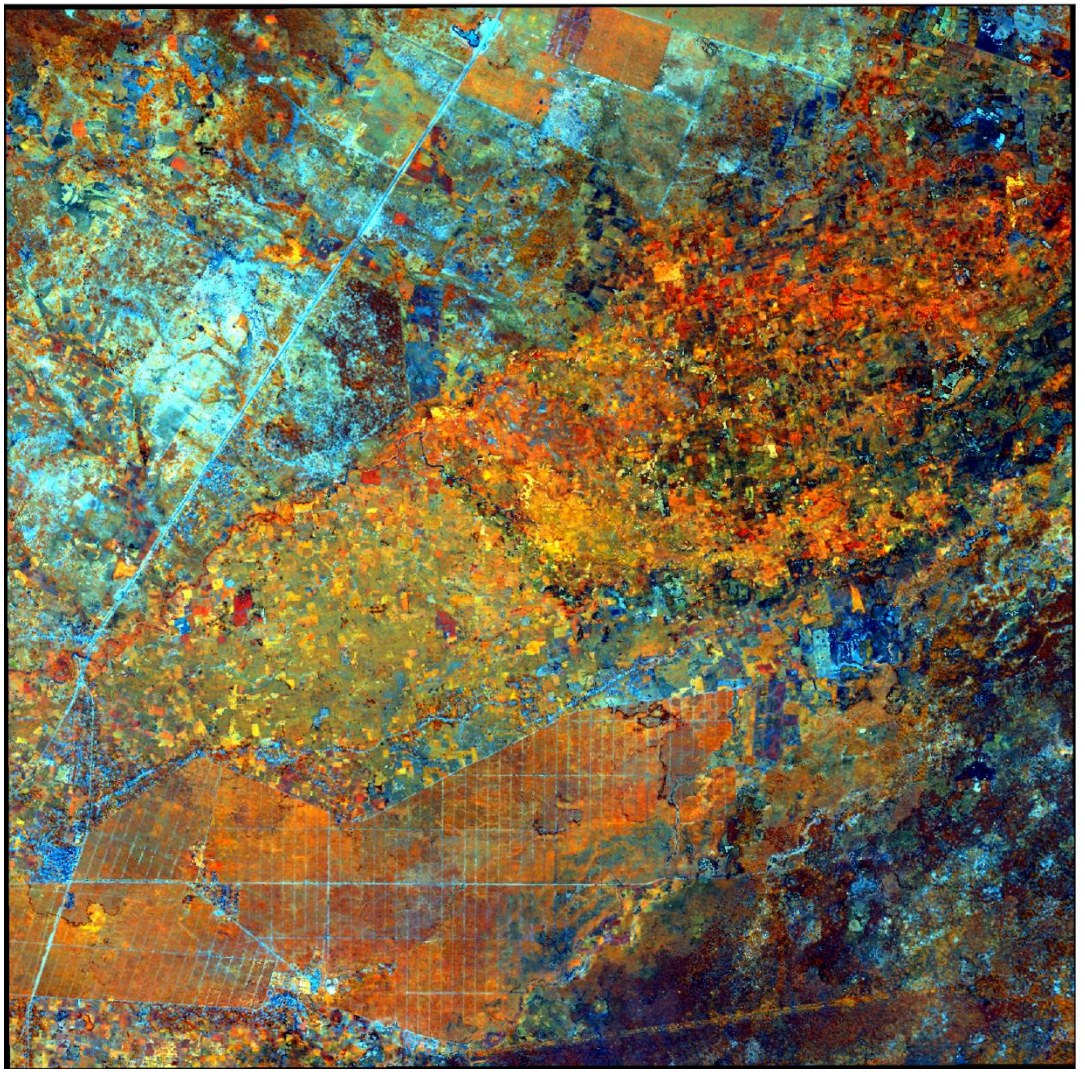
Smallholder crop type (maize) mapping using RapidEye: preliminary results for Tanzania



Maize

Not maize

Field site



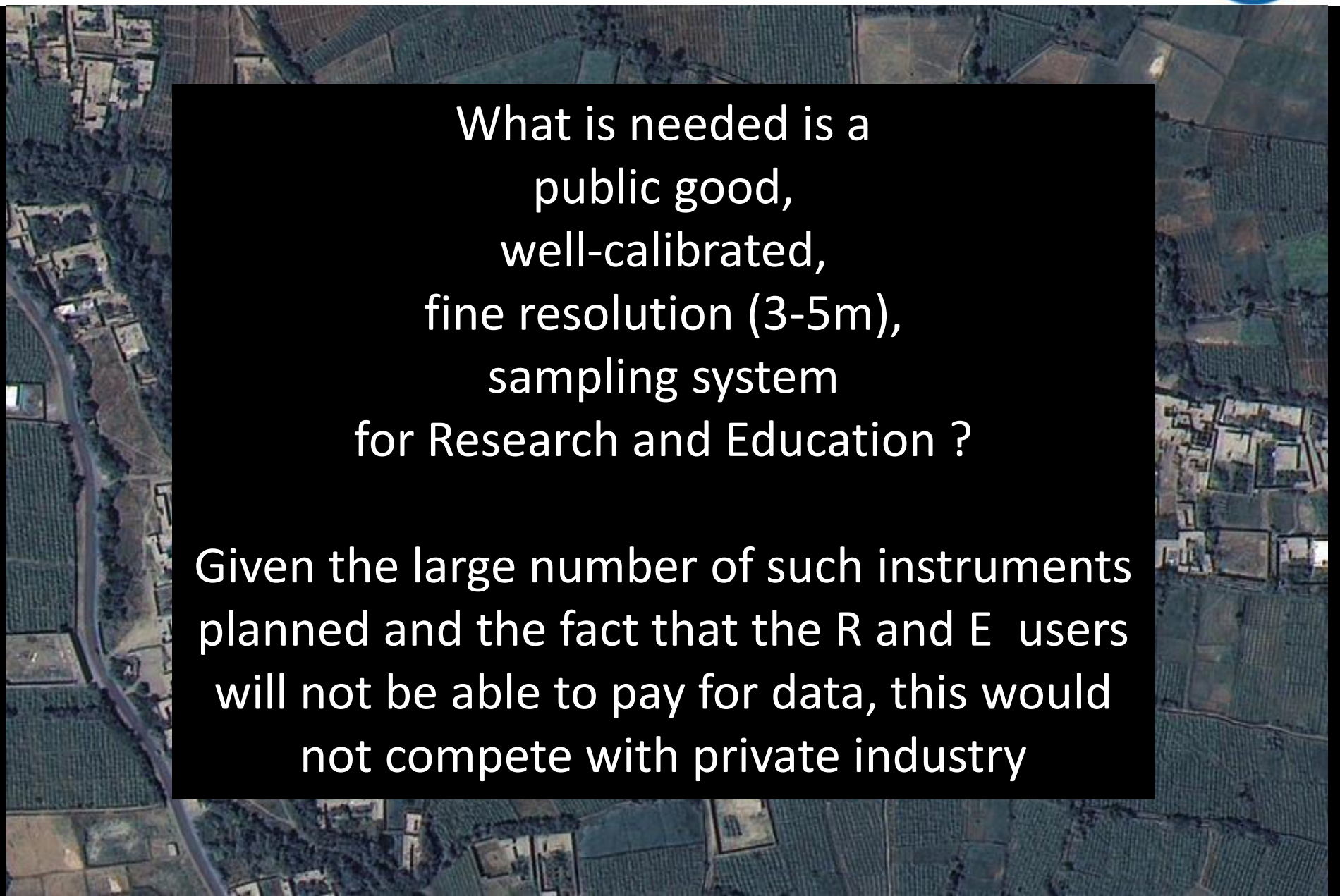
Near Infrared

Red edge

Red

Maximum NDVI composite > RGB

Hansen et al.



What is needed is a
public good,
well-calibrated,
fine resolution (3-5m),
sampling system
for Research and Education ?

Given the large number of such instruments planned and the fact that the R and E users will not be able to pay for data, this would not compete with private industry

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The GEOGLAM Components

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GEOGLAM Global Agricultural Monitoring

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

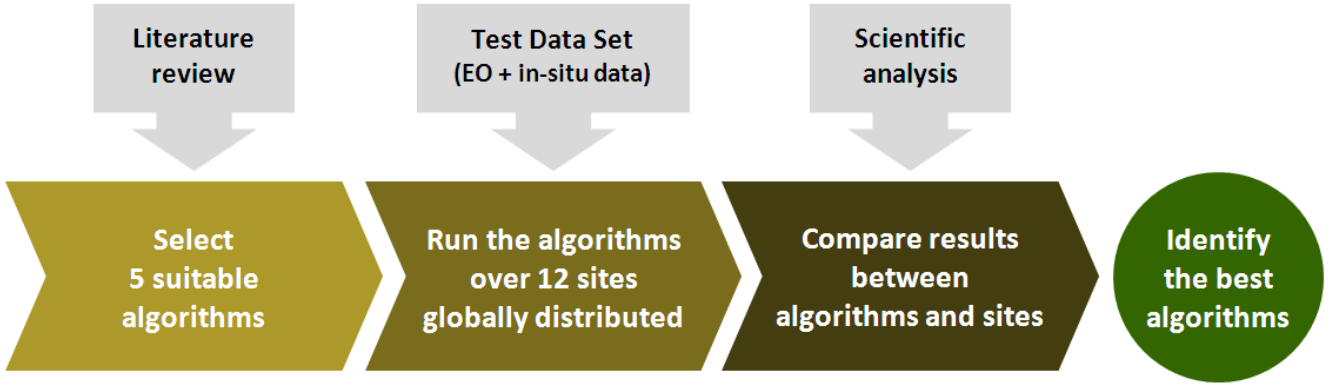
Developing Methods for:

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

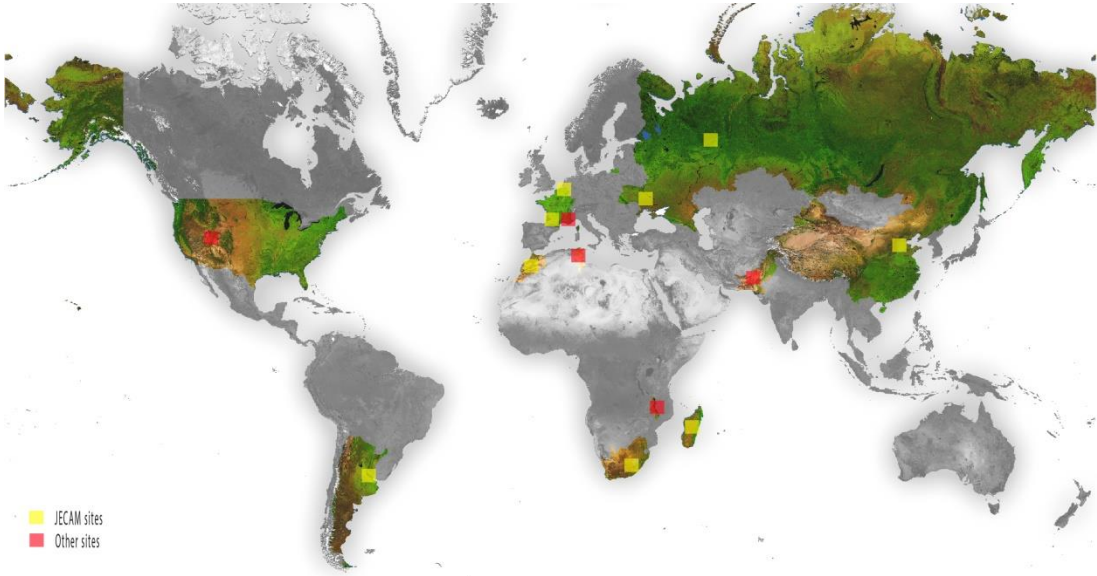
JECAM.org

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

Benchmarking for selecting the best algorithms for each product



12 test sites, relying on JECAM network, spread over the world, which represent more than 17 major crop types



JECAM
Joint Experiment for Crop Assessment and Monitoring

sentinel-2

→ AGRICULTURE

JECAM
Joint Experiment for Crop Assessment and Monitoring

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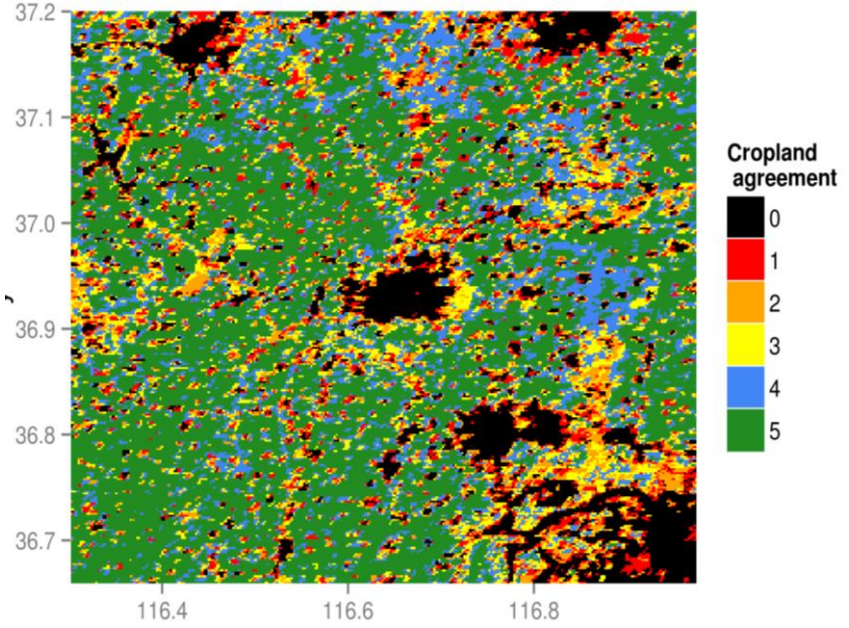
JECAM – SIGMA methods benchmarking results

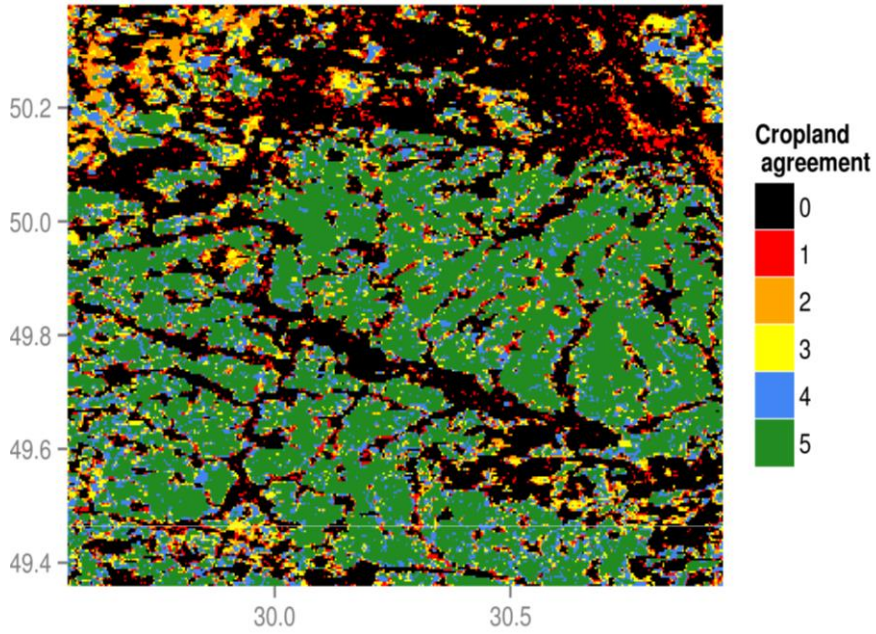
→ Similar cropland mapping accuracy performances of all methods for a site

→ Different performance according to site: ag.landscape impact

→ Influence of the satellite data quality used as input



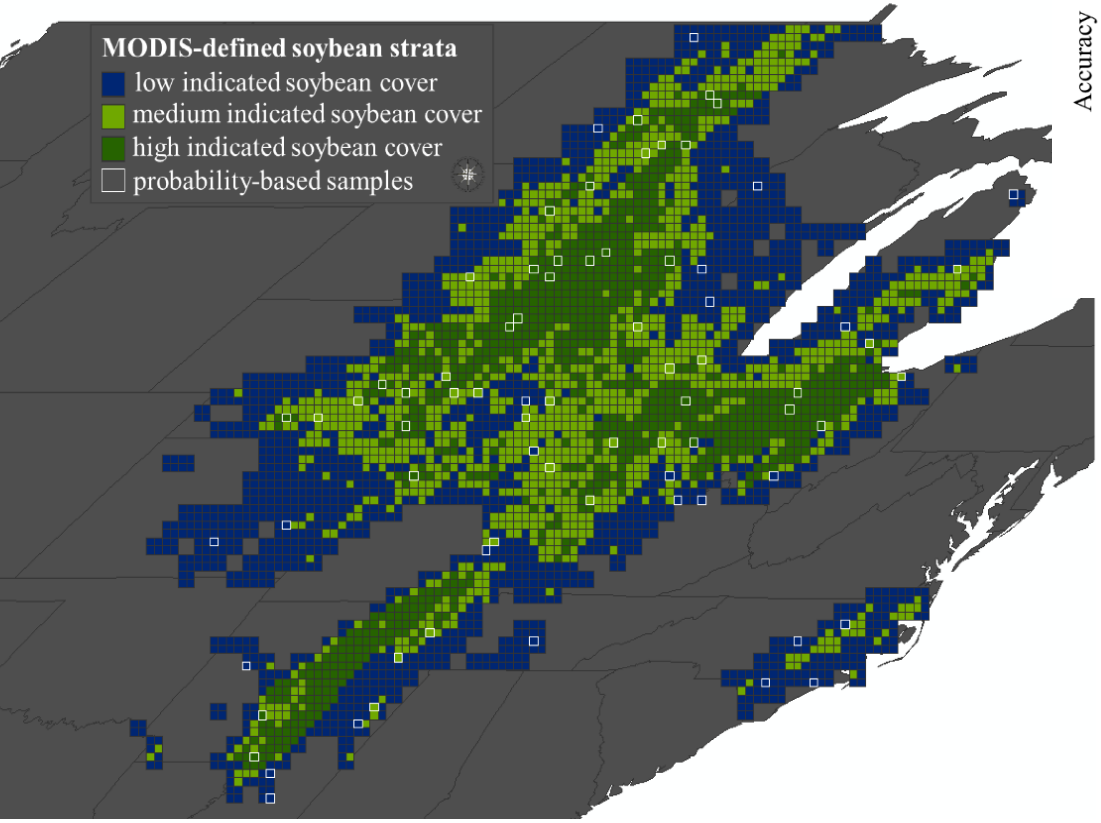
China

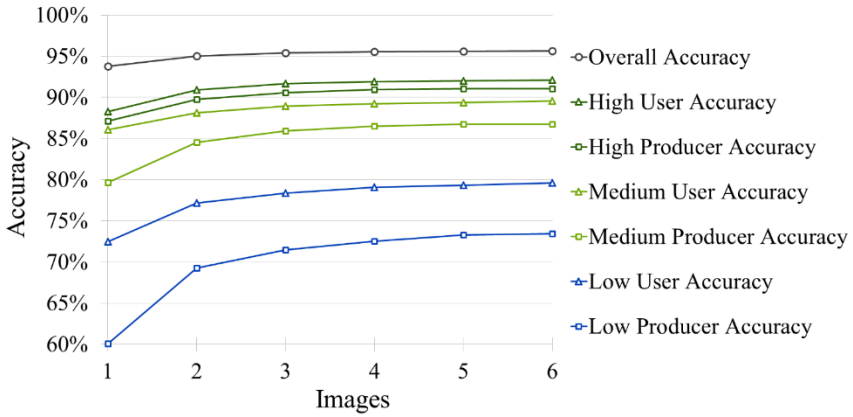


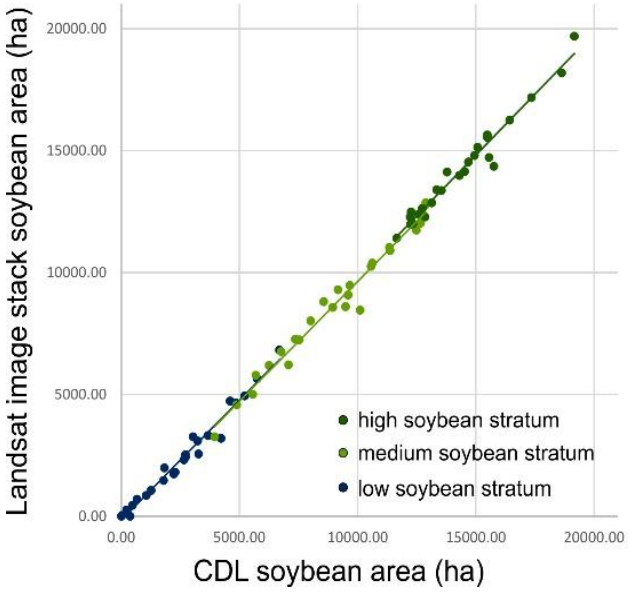
Ukraine

SIGMA
Stimulating Innovation for Global Monitoring of Agriculture

MODIS strata and Landsat sample-based mapping of Soybean Area





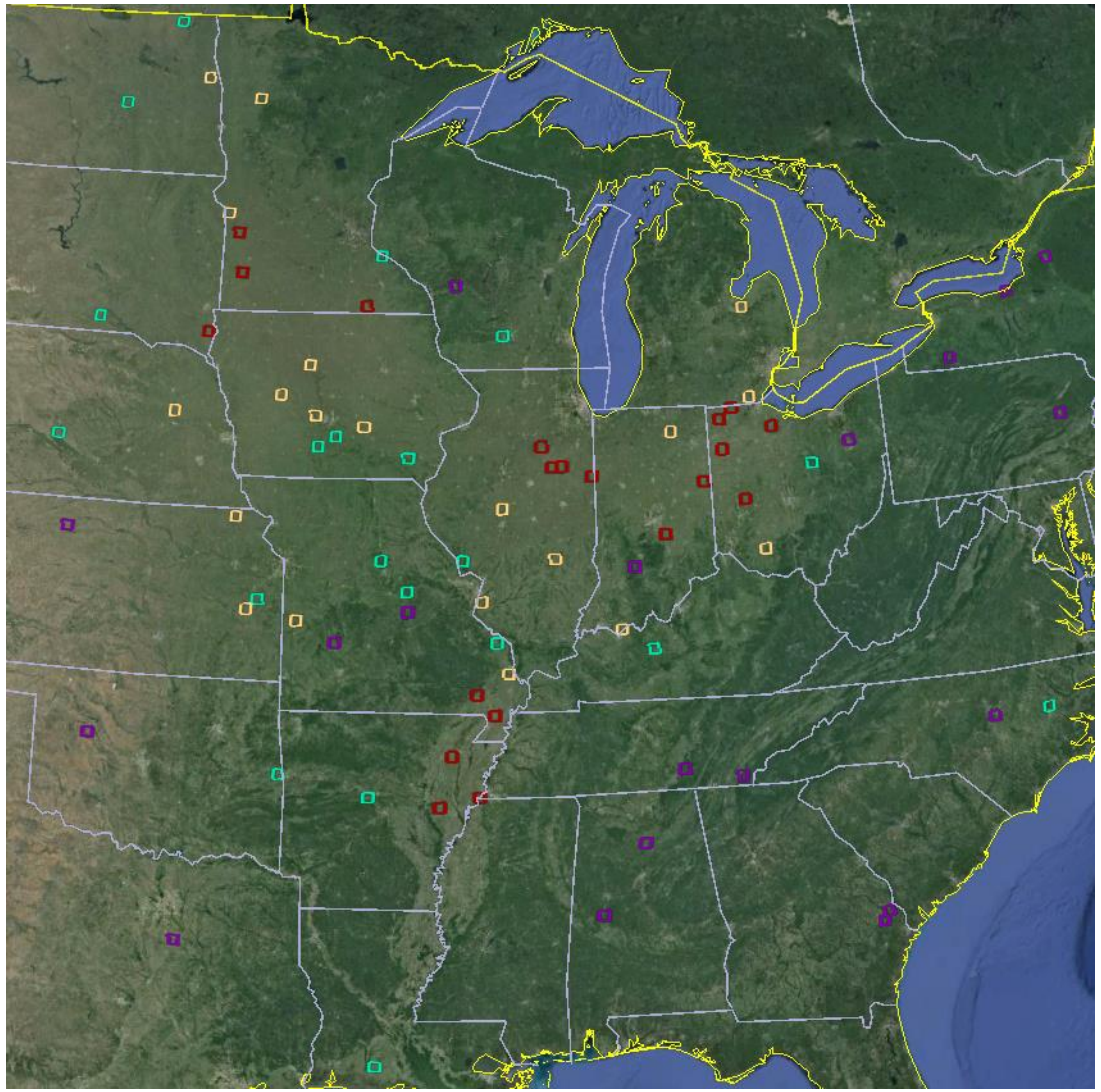


Hansen et al.

Soybean Area estimation in 2015 growing season

70 sample blocks with 10 pixels visited per block to estimate soybean cultivated area

Stratum	Area soy (km^2)	SE
1	28,438	11,285
2	122,818	18,228
3	99,549	8,162
4	100,512	9,722
Total	**351,317**	24,915



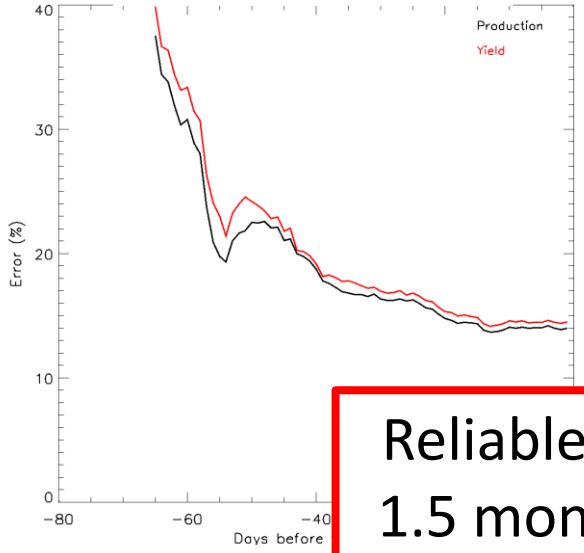
USDA NASS 2015 Soybean estimate: 334, 000 km^2

Hansen et al.

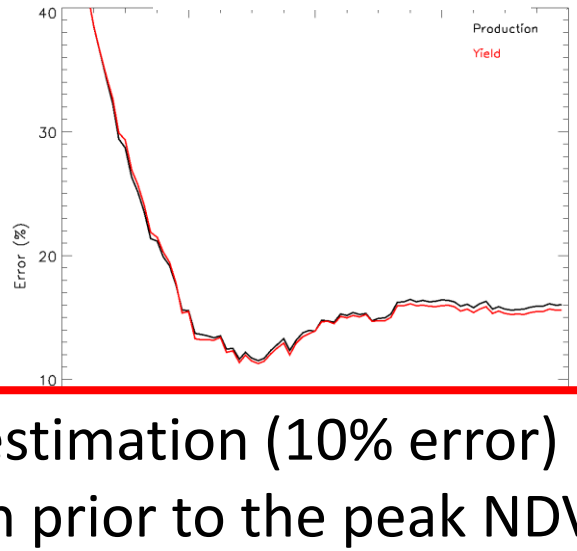
MODIS Empirical Regression Yield Forecasting

Franch et al. (2015) method (Becker-Reshef et al. (2010) improvement)

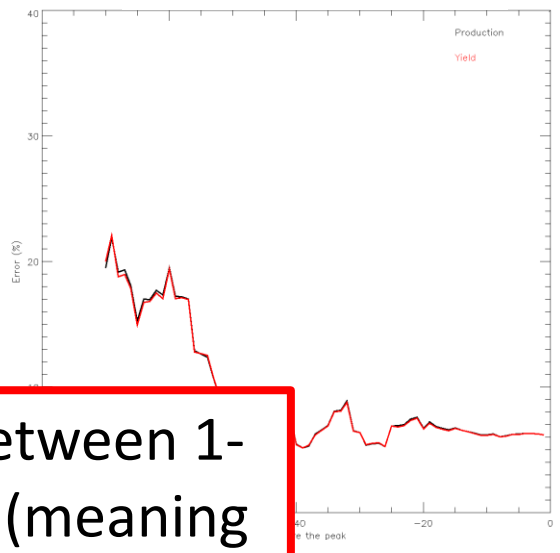
Ukraine winter wheat



US winter wheat

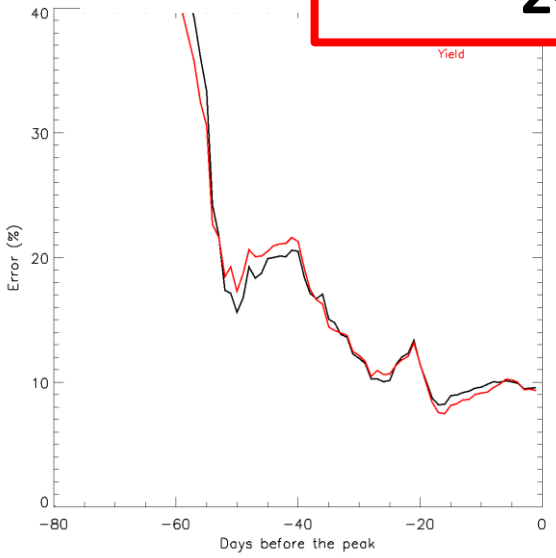


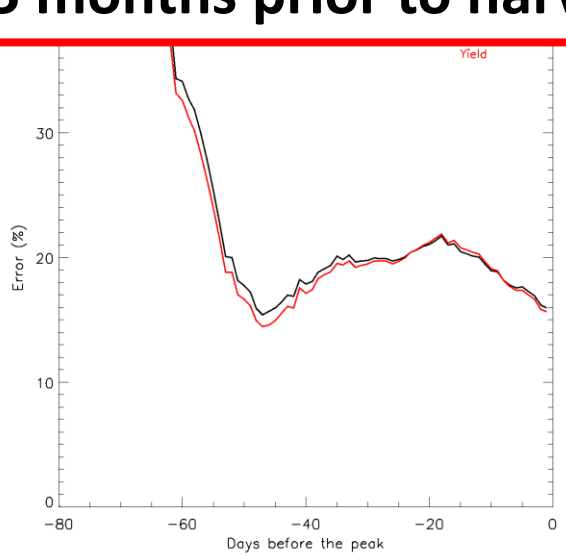
China winter wheat



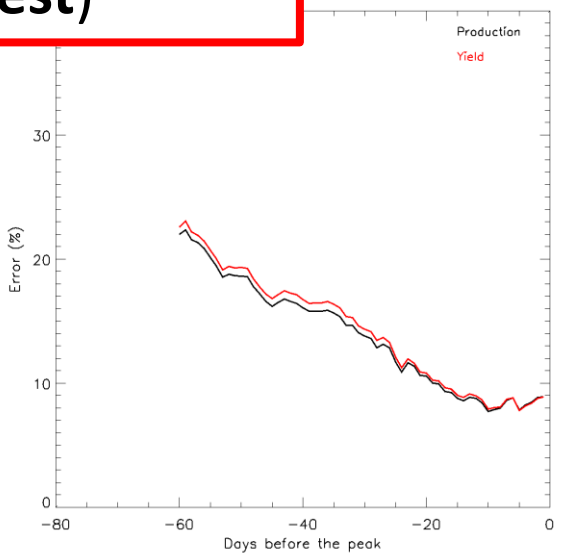
Reliable estimation (10% error) between 1-1.5 month prior to the peak NDVI (meaning **2-2.5 months prior to harvest**)

Canada winte





winter wheat

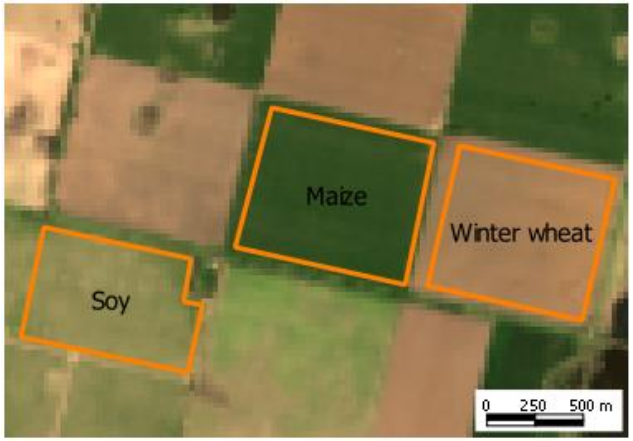


Franch, B., E. F. Vermote, I. Becker-Reshef, M. Claverie, J. Huang, J. Zhang, C. Justice and J. A. Sobrino, 2015. Remote Sensing of Environment

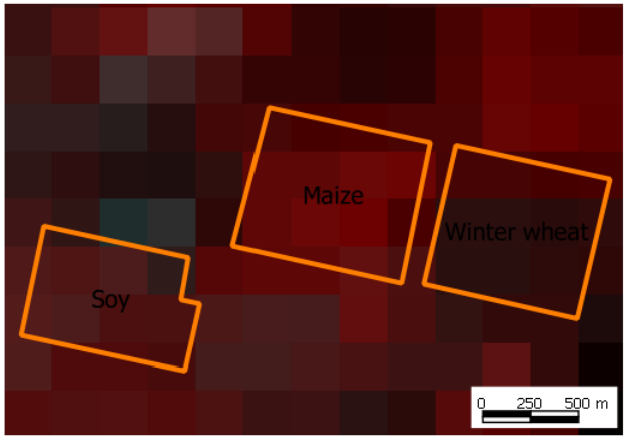
Potential application Landsat Sentinel: Yield Monitoring

NDVI aggregated at field level (Argentina, S2A tile 20HNH).

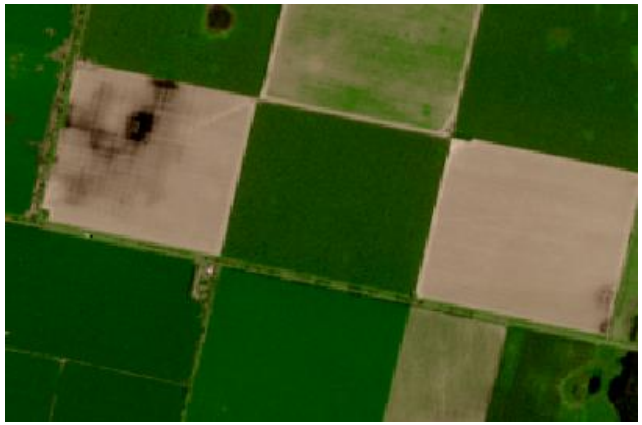
Sentinel-2A image acquired on 04-Dec-15, 10m, true color B04-03-02 (SR, scaled 0-0.15)



Landsat-8 image acquired on 04-Dec-15, 30m, true color B4-3-2 (SR, scaled 0-0.15)



MOD09GQ image acquired on 04-Dec-15, 250m, false color B2-1-1, SR



Sentinel-2A image acquired on 23-Jan-16, 10m, true color B04-03-02 (SR, scaled 0-0.15)

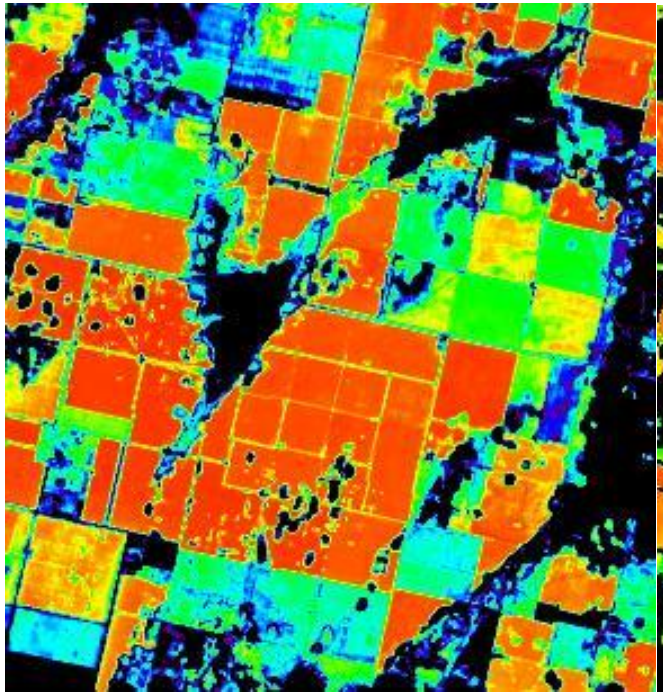
Landsat-8 image acquired on 21-Jan-16, 30m, true color B4-3-2 (SR, scaled 0-0.15)

Franch/Skakun, UMD

Potential application within HLS project: Yield Monitoring

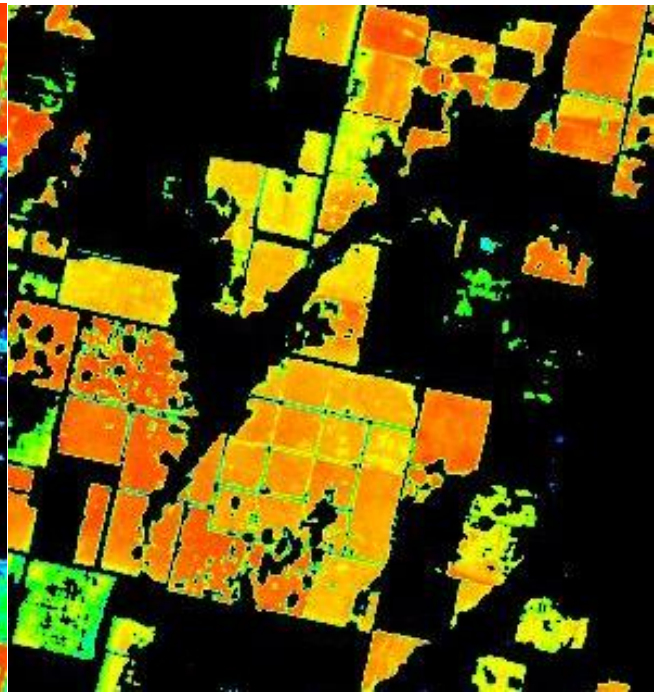
30m Landsat-Sentinel2 product

Empirical model based on the strong correlation between NDVI peak and yield



NDVI

0.5 0.9



Yield (tons/ha)

4.0 5.3

Year	Yield (tons/ha) of the Department of General Lopez (Santa Fe)
2010/2011	3.4
2011/2012	2.7
2012/2013	3.7
2013/2014	2.9
2014/2015	4.1

Becker-Reshef I, Vermote E, Lindeman M, Justice C. 2010. In Remote Sensing of Environment, 114, 1312–1323.

Community Challenges

- Getting the data required for agricultural monitoring
  - CEOS Moderate Resolution Acquisition Strategy (Landsat, Sentinel 1 and 2, IRS, CBERS, …)
  - Data Continuity (JPSS, Landsat 9, Sentinel 1, 2)
  - Sampling (time/space) using Fine Resolution Data
  - Availability and distribution of rain gauge data (Africa)
- Securing the funding for
  - Test site satellite and field data sharing for method and algorithm comparison and validation (EU Sigma, CEOS LPV)
  - International program coordination (GEOGLAM Sec)
  - Broader National Agricultural Agency Participation
  - Developing country capacity building (BMGF Stars…..)
  - Broader monitoring community participation
- European and US Research Cooperation on Methods
  - NASA/ESA MUSLI
  - EARSeL

Go
Starting to go or stop
Stop

So in Summary
What is GEOGLAM doing?

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