GEO Agricultural and Land Use Change

Chris Justice (GEO-AG Task Co-Chair)

Inbal Becker-Reshef

University of Maryland

GROUP ON EARTH OBSERVATIONS

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GEO, the Group on Earth Observations

An Intergovernmental Organization with 87 Members and 61 Participating Organizations

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

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The Vision for GEOSS…

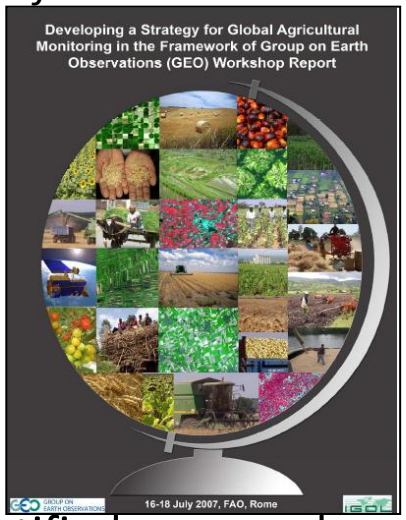
…a world where decisions and actions are informed by coordinated, comprehensive and sustained Earth observations.

GEO is focused on societal benefit

Agriculture is one of the GEO societal benefit areas

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

- 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
- ISRO agreed to establish Task Secretariat (J.S. Parihar)

Today the CoP has over 300 members representing over 40 countries and organizations

Looking Forward

Agriculture is Facing Major Challenges

- Increasing pressures on agricultural land and production from:
  - Increased severe weather events and climate change
  - Population growth & changing diets
  - Fuel vs. Food vs. Feed
  - Limited water and suitable arable land
- Higher price volatility for major grains
- Crop yield variability is a main driver of short term changes in market equilibrium
  - Weather/climatic effects on production are triggers for price hikes
- Commodity markets are increasingly linked (good and bad)
- Rising fuel prices impact food prices (transport, fertilizer)

- **NEED TO INCREASE GLOBAL PRODUCTION BY 70% BY 2050 TO MEET DEMAND (FAO)**

→ Tools for monitoring and reliably forecasting production are essential for anticipating market imbalances and enhancing policy responses

The GEO Global Agricultural Monitoring

(Restructured GEO Ag 0703 – **Now GEO Ag 01**)

Task Co-Leads:	**Chris Justice**, University of Maryland, (USA) *
	Olivier Leo, Joint Research Centre Ispra, (E.C,)
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	Wu Bingfang, IRSA, CAS (China)
GEO Secretariat POC:	**Joao Soares, GEO Secretariat, (Brazil)**
Task Executive Director:	**Jai Singh Parihar, ISRO (India)**
JECAM Comp. Lead:	Ian Jarvis, Agric. and Agri-Food Canada,
	Pierre Defourny, (Belgium)
PAY Comp. Lead:	Inbal Becker-Reshef, (USA), Meng Jihua, (China)
Cropland Mapping Lead:	Steffen Fritz, IIASA, (Austria)
GEOGLAM Lead:	Pascal Kosuth (France)
Agricultural Drought Lead:	Wu Bingfang (China)
CEOS GEO Ag POCs:	Prasad Thenkabail, (USA), Yves Crevier (Canada)

* NASA Applied Sciences supported (Brad Doorn, NASA POC)

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GEO Agriculture Monitoring Community of Practice
(an open community of Data Providers, Brokers and Users)

- Several global/regional scale systems in place – with common data needs, few common standards and protocols and inconsistent results
- Most countries have a national agricultural monitoring system

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Agricultural Monitoring Task

Focused on:

1. **Monitoring of Agricultural Production – timely information (GEOGLAM)**
2. **Quantifying Agricultural Extent and Land Use Change**
3. **Joint Experiments on Crop Assessment and Monitoring (JECAM) - global sites, method comparison**
4. **Earth observations - improving availability, frequency of observations, continuity, near real-time data w. CEOS**
5. **Developing a new Pasture/Rangeland biomass monitoring program (CSIRO lead)**

Various Nations are supporting projects within these areas

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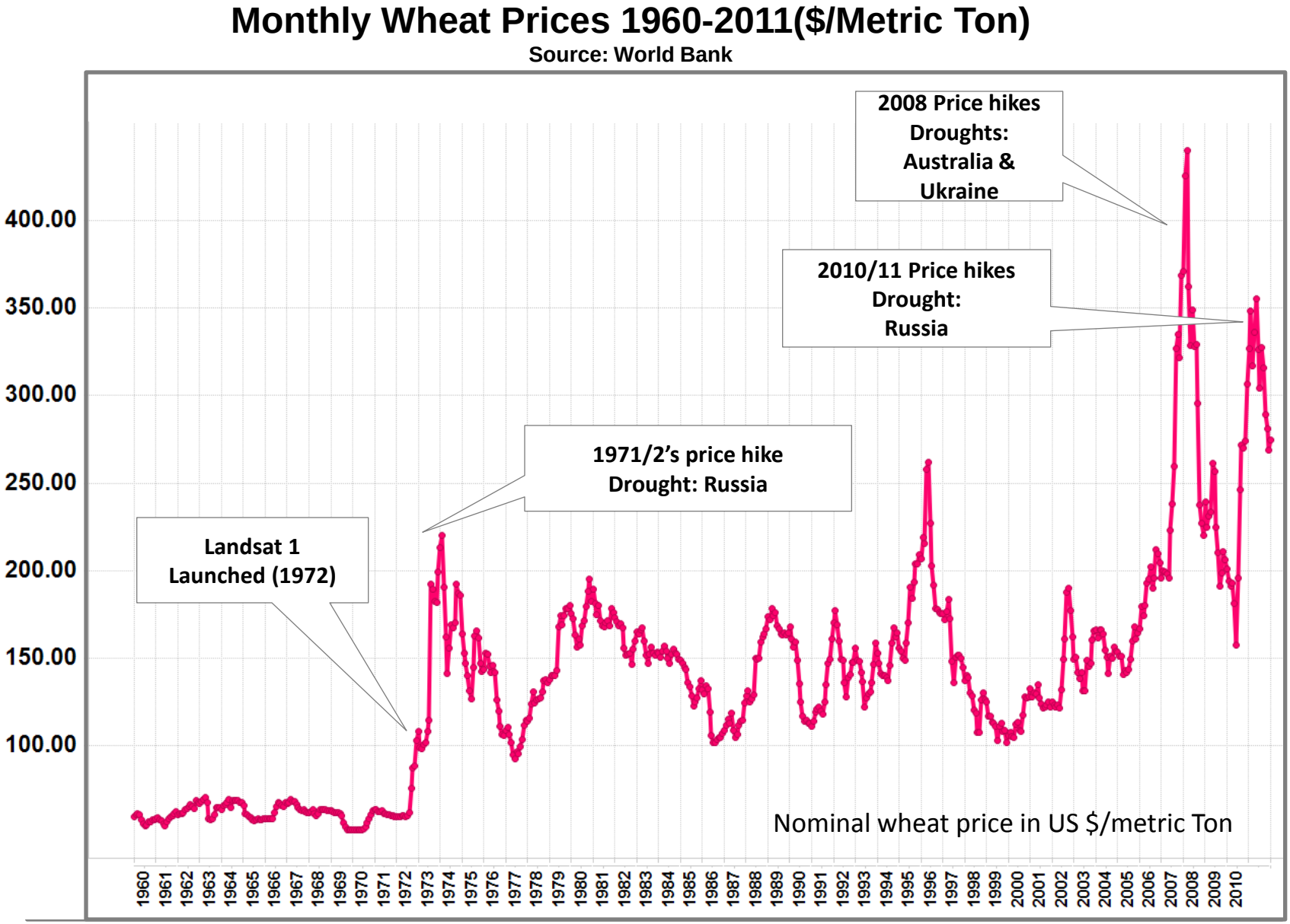
Rapid expansion of agricultural land is underway in various parts of the World, crop type and rotations are changing and the precise extent and dynamics of irrigated lands are unknown

Building on the recommendations from the IASSA 2011 Workshop an expanded global initiative is needed on mapping and characterizing (crop types/rotation) croplands using earth observations

Context for GEOGLAM



Need for Improved Agricultural Intelligence

International recognition of critical need for improved information including at the World Summit on Food Security 2009, G20 Action Plan on Food Price Volatility and Agriculture, 2011

official statement of The Extraordinary Joint Intersessional meeting of the Intergovernmental Group (IGG/FAO) on Grains, Rome 2010:

"Unexpected price hikes and volatility are amongst major threats to food security and their root causes need to be addressed, in particular regarding ***the lack of reliable and up-to-date information on crop supply and demand and export availability****…."*

The G20 Initiative: GEO-GLAM

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.

- The G20 Cannes Summit (November 2011) Action Plan on Food Price Volatility and Agriculture
- Reaffirmed GEOGLAM commitment at the 2012 G-20 Los Cabos Declaration & in Agriculture Ministers Report

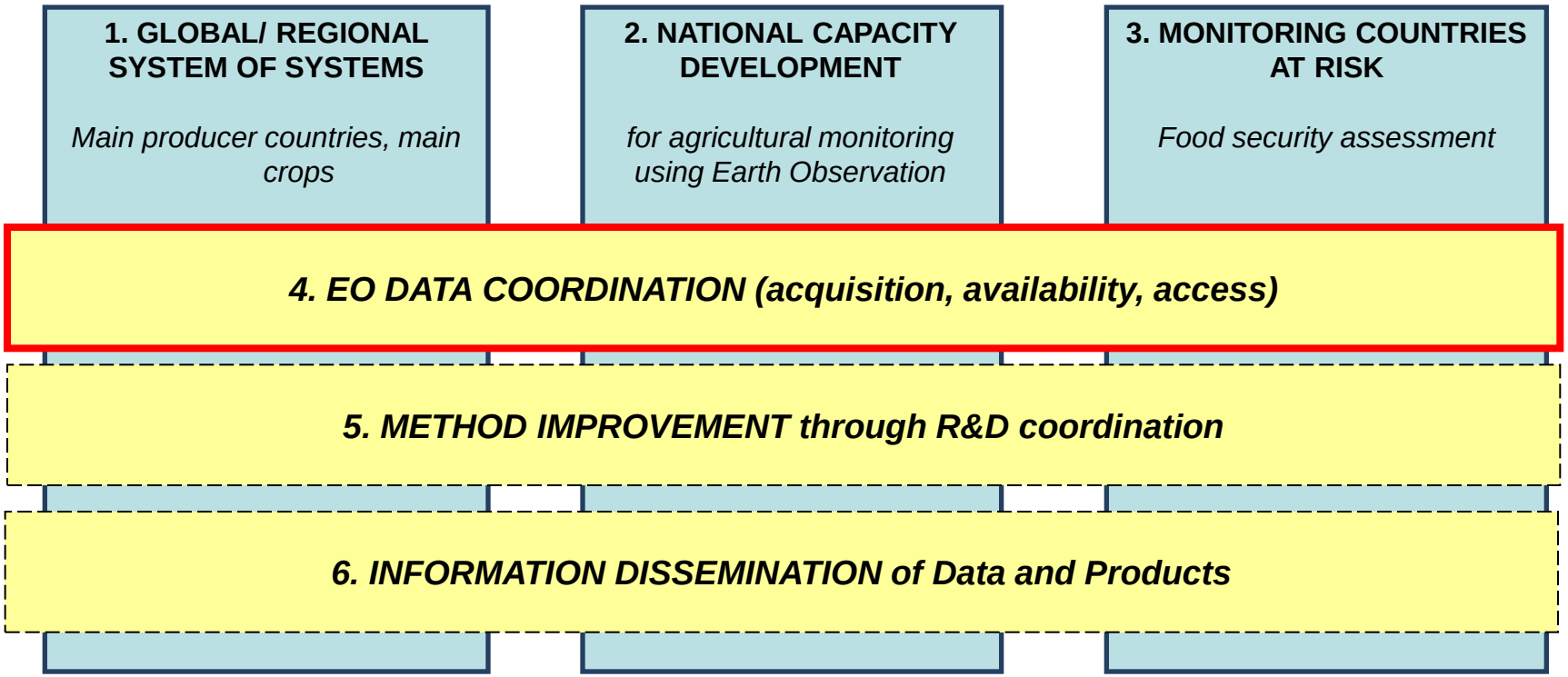
G20 GEOGLAM Goal:

To strengthen the international community's capacity to produce and disseminate relevant, timely and accurate forecasts of agricultural production at national, regional and global scales through the use of EO

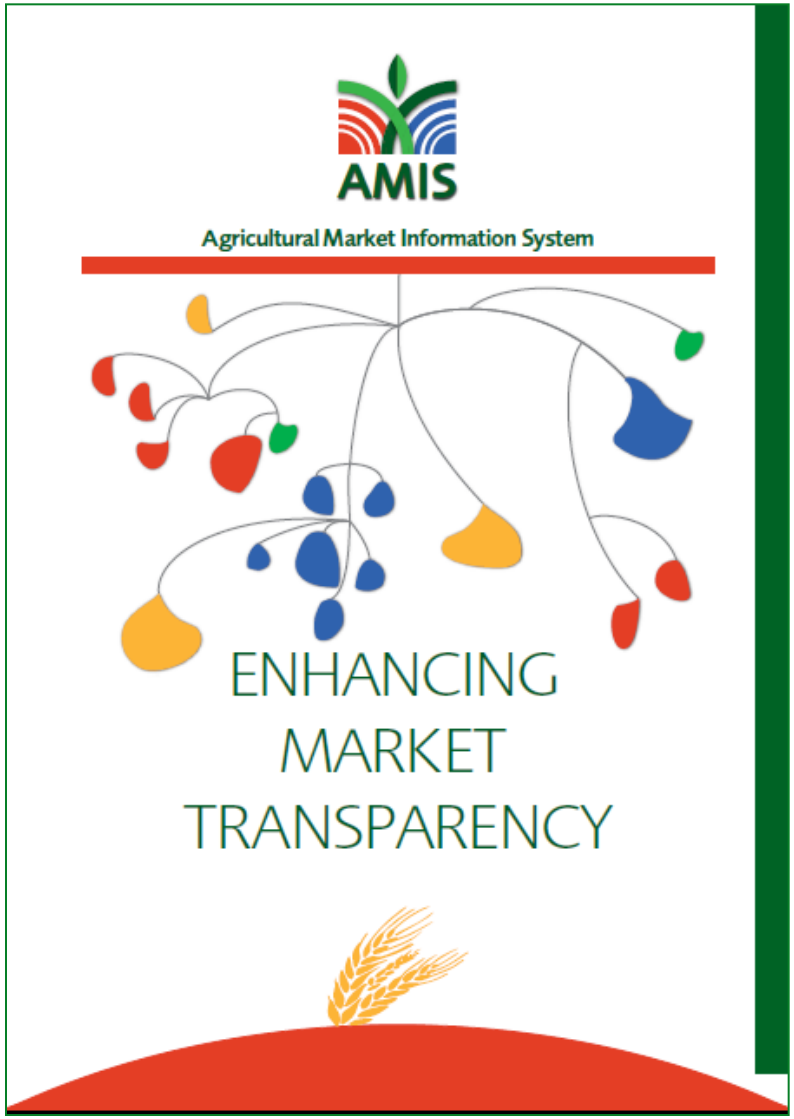
Outcome: an improved and more harmonized systems of systems taking advantage of new satellite assets and methods and a higher level of international coordination

- GEO-GLAM will be implemented in the framework of GEO

The GEOGLAM Initiative: Project Elements



Agricultural Market Information System (AMIS) hosted at the UN FAO focused on food producer countries



November 2011

Food Outlook
Global Market Analysis

INTRODUCING AMIS

FOCUS

In spite of improved supply prospects and weakening demand, agricultural commodity market conditions remain fairly tight, which is the major factor underpinning prices. Production forecasts for nearly all key food crops in 2011 have risen steadily since the previous report in June. For cereals, while the forecast for ending stocks in 2012 has also been revised up significantly, larger anticipated inventories reflect not only improved production prospects but also expectations of a slowing demand growth because of the unfavourable macroeconomic environment. In spite of these developments, however, international prices of all commodities covered in this report continue to be high and, in most cases, above the previous year. Strong underlying demand in certain countries, where economic growth is robust, is price supportive. Aside from being high, most prices are also extremely volatile, moving in tandem with unstable financial and equity markets. Fluctuations in exchange rates and uncertainties in energy markets are also contributing to sharp price swings in agricultural markets.

Given all these uncertainties, it is difficult to predict how markets will evolve in the near-term. While there is some room for optimism that, for most commodities, prices could remain below their recent highs, the general picture still points to firm markets well into 2012. For most food commodities, next year's production will have to increase in order to meet the expected demand, albeit moderately. However, if this demand were to rise faster than currently envisaged, which is a possibility even assuming a slow economic recovery, then a more significant production expansion will be required. The question therefore is: do the current market signals convey the correct information for producers to adjust their production plans for next year? More critically, will there be enough time for an adequate production response in the event of an unexpected surge in demand? Input costs, from fertilizers to energy, remain high, interest rates have climbed in many emerging economies, all of which could dampen production next year and, hence, draw down stocks and boost prices further. This year's global food import bill is expected to approach USD 1.3 trillion, with the cost of food purchases for the Least Developed Countries (LDCs) soaring by over a third from last year.

Reducing market uncertainty may not be among the fastest remedies for lowering the number of hungry. Yet, letting international markets continue in their present state, volatile and unpredictable, will only aggravate an already grim outlook for world food security. This is the reason why world leaders have been dwelling at length on the issue of price volatility since the start of the year. Such discussions gained momentum in recent months as attention turned towards finding ways to improve the accuracy of supply and demand forecasts for major food crops as an important first step in promoting stable and transparent food markets.

In June 2011, the Group of 20 (G-20) established a global information system under the banner of Agricultural Market Information System (AMIS). This initiative, proposed by a number of international organizations, has been endorsed by all G-20 Members and, subsequently, by the Committee on World Food Security (CFS). This issue of Food Outlook also introduces AMIS by explaining how it came about, its structure and objectives.

TABLE OF CONTENTS

FAO Food Price Indices
(October 2010 - October 2011)

GIEWS global information and early warning system on food and agriculture

The GEOGLAM Initiative: 2011-2012 Progress

International cooperation for the definition of GEOGLAM

- 09/2011 Geneva : First GEOGLAM international Workshop (***13 countries***)
- 11/2011 Istanbul : GEO VI Plenary Assembly
- 01/2012 Geneva : GEOGLAM coord. Group meeting
- 02/2012 Rome : Present to the 1st meeting of the AMIS coord. Group
- 02/2012 Canberra : International Workshop on crop monitoring
- 03/2012 Mexico : Present. to XIIth "Foro de expectativas agropecuarias"
- 03/2012 La Hoya : CEOS Strategic Implementation Team
- 04/2012 Tokyo : GEOSS in the Asian Pacific Symposium
- 4/2012 Italy: ESA Sentinel 2 workshop
- 5/2012 Geneva: GEO Workplan Meeting
- 6/2012 Mexico City: Meeting with SIAP (Min of Ag)
- 7/2012 Montreal: CEOS-GEOGLAM data requirements workshop
- 9/2012 Buenos Aires: Regional Ag Monitoring Systems workshop
- 10/2012 Beijing: Drought Monitoring Workshop w. GEO Water Task
- 10/2012 26th CEOS Plenary, Bangalore India

+ regional and national meetings and presentations

+ **EU FP-7 Call for GEOGLAM proposal (Ag and Environment) 9 Million Euro**

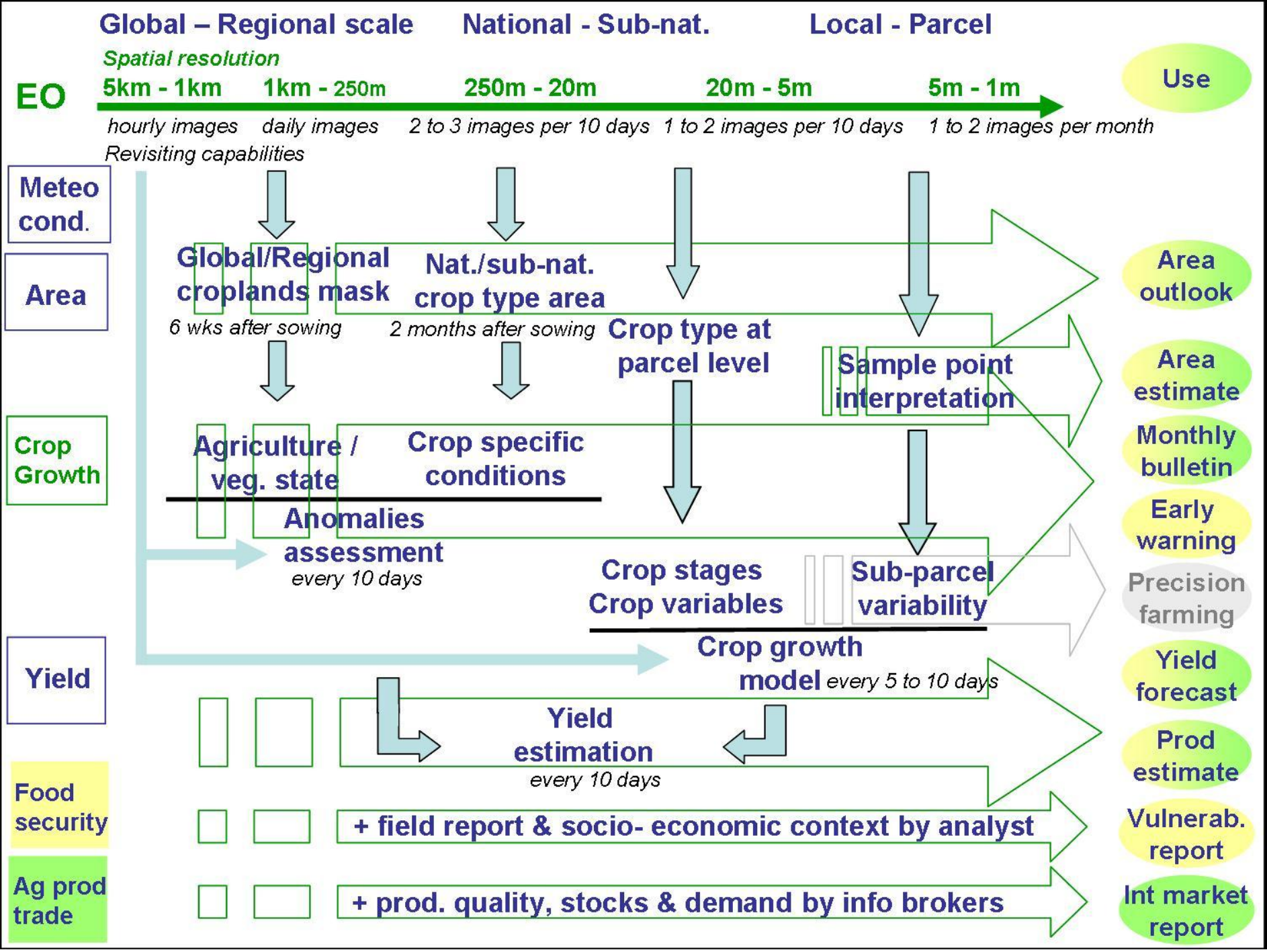
GEOGLAM Components

- **Component 1: Monitoring Global Producer Countries**
  - Focus: Crop outlooks, Production Monitoring, supporting global markets and trade, long term trends (climate change implications, extreme events, etc)
- **Component 2: National Monitoring Systems**
  - Focus: Improved national capacity for monitoring, improved statistics, supporting national policy, subsidies, insurance
- **Component 3: Countries at Risk**
  - Focus: Early Warning & Food security
- **Component 4: Observations Coordination**
  - Focus on acquisition, availability, access needed for GEOGLAM implementation – increased frequency, near real time data
- **Component 5: R&D**
  - Focus: Improved Data Sets, Operational R &D, Best practices, Joint Experiments -JECAM
- **Component 6: Information dissemination**
  - Focus on timely and transparent availability of information

4. EO DATA COORDINATION (acquisition, availability, access)

- **Goal: secure the international data necessary to implement GEOGLAM**
- GEOGLAM has substantive and specific observation data needs (what, where and when) which underpin its implementation – no one satellite system can meet the data needs – international cooperation is needed
- Approach: work in close partnership with CEOS ("the space arm of GEO") and other data providers to:
  - Lay out the overall program observation requirements to enable the necessary information products to be generated (building on the experience with GEO FCT and GFOI)
  - Work with data providers to establish and implement data acquisition and dissemination systems

GEOGLAM
Global Agricultural Monitoring


Global – Regional scale
National - Sub-nat.
Local - Parcel
Spatial resolution
EO
5km - 1km
1km - 250m
250m - 20m
20m - 5m
5m - 1m
Use
hourly images
daily images
2 to 3 images per 10 days
1 to 2 images per 10 days
1 to 2 images per month
Revisiting capabilities
Meteo cond.
Area
Crop Growth
Yield
Food security
Ag prod trade
Global/Regional croplands mask
6 wks after sowing
Nat./sub-nat. crop type area
2 months after sowing
Crop type at parcel level
Sample point interpretation
Agriculture / veg. state
Crop specific conditions
Anomalies assessment
every 10 days
Crop stages
Crop variables
Sub-parcel variability
Crop growth model every 5 to 10 days
Yield estimation
every 10 days
+ field report & socio- economic context by analyst
+ prod. quality, stocks & demand by info brokers
Area outlook
Area estimate
Monthly bulletin
Early warning
Precision farming
Yield forecast
Prod estimate
Vulnerab. report
Int market report

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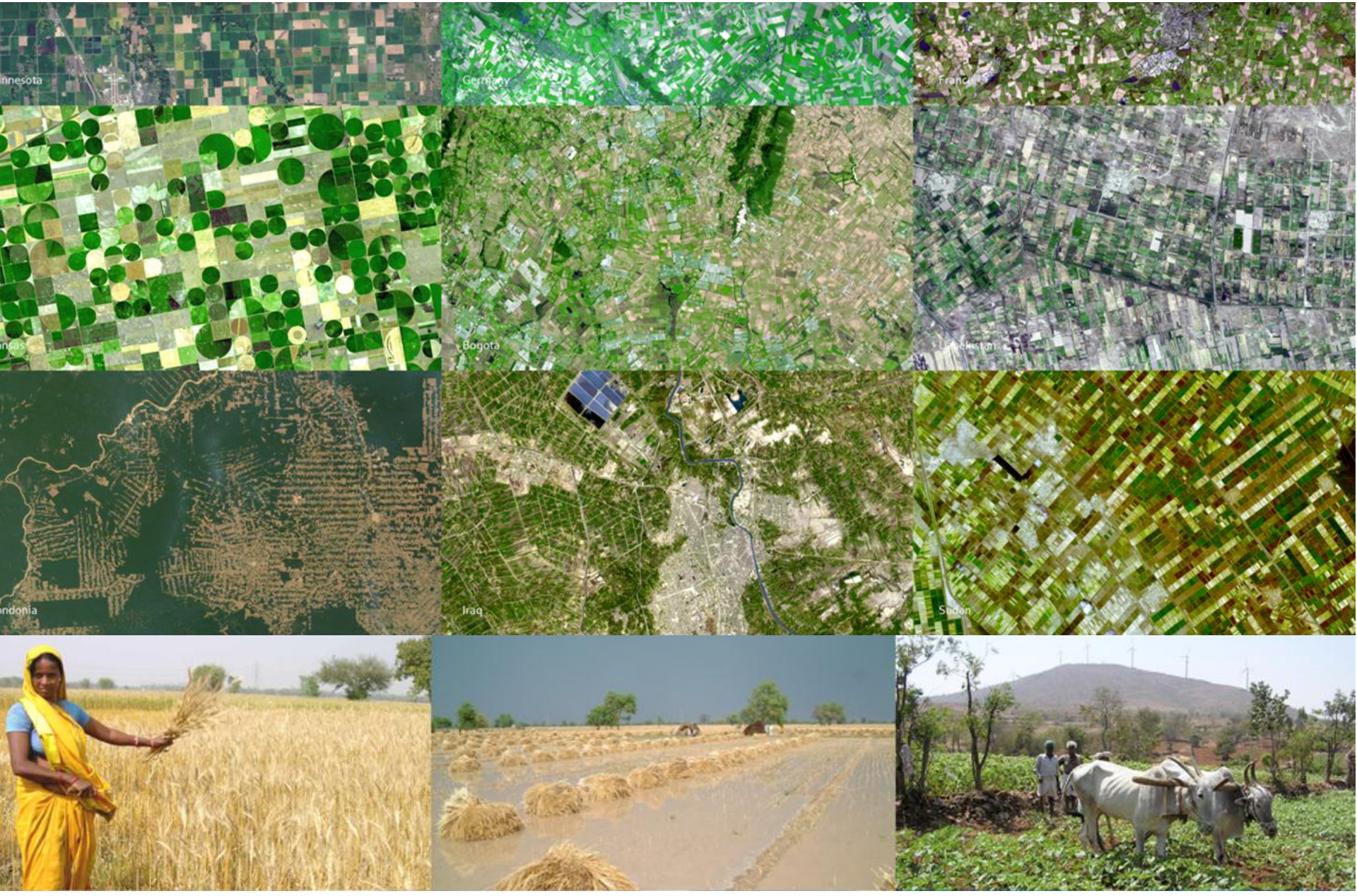
GEOGLAM Global Agricultural Monitoring

GEOGLAM/CEOS WORKSHOP ON OBSERVATION REQUIREMENTS
CSA, MONTREAL JULY 10-11, 2012

Tabulating the satellite observation requirements (spatial resolution, frequency, and period of coverage) for GEOGLAM

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



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GEOGLAM Global Agricultural Monitoring

GEOGLAM USER REQUIREMENTS WORKSHOP RESULTS

The results package includes the following elements:

a. A summary table of requirements developed taking into consideration the observation needs, the derived products they will serve, and high-level regional specificities;

OBSERVATIONS					DERIVED PRODUCTS							GLOBAL	REGION SPECIFIC ACQUISITIONS**			
Spatial resolution	Spectral range	Effective observ. frequency (cloud free)	Swath	Use (Primary Source /Secondary S.)	Croplands mask	Crop type area	Crop cond. indicators	Crop bioph. var.	Env. variables (reservoir, water, soil moisture)	Ag. Practices / Cropping systems	Crop yield	Agricult. coverage	Large, Medium, Small fields	Crop types diversity	Calendar/Multi-ple cropping	Cloud coverage
2000 - 500 m	thermal IR + optical	few per day	global	NRT products (PS)			x	x (LF)				x				
100-300m	optical + SWIR	2 to 5 per week	global	NRT products (PS)	x	x	x	x (LF)		x (LF)	x (LF)	x	all L			
1-15km	passive microwave	daily	global	NRT products (PS)					x			x				
150-75 m	SAR dual pol. (X,C,L)	5 per season	main crops	NRT products (SS/PS)*	x	x	x	x (LF)	x	x (LF)			all L	rice area	entire growing seasons	high cloud cov.
5-10m	SAR dual pol. (X,C,L)	5 per season	main crops	NRT products (SS/PS)*		x	x	x	x	x			L/M/S	rice area		high cloud cov.
20-70m	optical + SWIR	1 per month (if possible same sensor)	croplands	annual products (PS)	x	x							all M		year-round, focus on growing season	
Footprint	RADAR Altimetry	weekly		NRT products (PS)					x							
50-100m	thermal	daily ?	main crops	NRT products (PS)			x						L/M/S		entire growing seasons	
20-70m	optical+SWIR	1 per week (min. 1 per 2 weeks)	main crops	NRT products (PS)			x	x	x	x			country specific (1) L/M		entire growing seasons	
5-10 m	optical (+SWIR)***	1 per month (if possible same sensor)	croplands	annual products (PS)	x	x							all S		year-round, focus on growing season	
5-10 m	optical (+SWIR)***	1 per week (min. 1 per 2 weeks)	main crops	NRT products (PS)			x	x	x	x			country specific (1) S		entire growing seasons	
< 5 m	optical	1 to 2 per month	croplands	annual products (PS)		x				x	x		demo. case (2 to 5% of		2 to 4 coverages per year	

Working to have the program endorsed by CEOS (SIT)

Requirements from Asian Rice Crop Monitoring Team

		Fine (1m-100m) 4-5 images/year			Moderate (100-1000m) daily - Monthly	Coarse (4km-25km) Hourly - Daily	
		VIS/IR	SAR (Fine Mode)	SAR (ScanSAR)	VIS/IR	VIS/IR	Microwave Rad. RADAR, Sounder
Crop Calendar					MODIS, GCOM-C1,		Aqua, GCOM-W1
Rice Paddy Field Mapping	Timing of sowing/harvesting	Landsat, ASTER, ALOS, THEOS, IRS, ALOS-3	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X	MODIS, GCOM-C1		
	Cultivated Area (every year)	Landsat, ASTER, ALOS, THEOS, IRS, ALOS-3	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X (dual poliarization or full polarimetric data)	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X	MODIS, GCOM-C1,		
	Inventory of agricultural facilities such as tertiary irrigation network audit	ASTER, ALOS, THEOS, IRS, ALOS-3	-	-			
Early Warning	Agro-meteorology	-	-	-	MODIS, GCOM-C1,	MTSAT, Meteosat	TRMM, Aqua, GCOM-W1
	Crop Growth	-	-	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X	MODIS, GCOM-C1,		
Yield Estimation	Agro-meteorology				MODIS, GCOM-C1,	MTSAT, Meteosat	TRMM, Aqua, GCOM-W1
	Statstical mode-based		ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X (dual poliarization or full polarimetric data)	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X			
	Crop Growth		ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X (dual poliarization or full polarimetric data)	ALOS, ALOS-2. Radarsat, sentinel-1, terrasar-X	MODIS, GCOM-C1,		

5. R and D in support of operational monitoring systems

- **Goal: to expand the investment in User-Driven 'operational' R and D activities for agricultural monitoring:**
  - Quantify Agricultural Area extent and change
  - Automated cropland and crop-type mapping
  - Improved satellite retrievals of Soil Moisture and ET
  - Improved global Ag Drought indices and alerts
  - Inter-comparison of EO-driven methods for yield estimation (JECAM)
  - Enhance procedures for EO data inter-use
  - Increase timeliness of delivery systems
  - Increased use of Geospatial and Information Technologies e.g.
    - Satellite data dissemination systems
    - Mobile phone (in situ) data collection and dissemination

NASA Near Real Time EOS Data for Agricultural Monitoring

Timely data is critical for crop monitoring!!

NASA EOS near-real-time daily observations are processed and integrated into USDA FAS system (< 3 hours from observation)

A contribution to GEO-GLAM

GEOGLAM
Global Agricultural Monitoring

New Data Initiative for Agricultural Landuse from Landsat and Sentinel 2 (NASA, CNES, ESA)

Goal 1: Create consistent, merged Landsat and Sentinel-2 reflectance dataset

- builds on MODIS, MERIS, and Landsat processing heritage
- builds on previous data initiatives among NASA, ESA, and USGS
- establishes consistent radiometric data set for land phenology

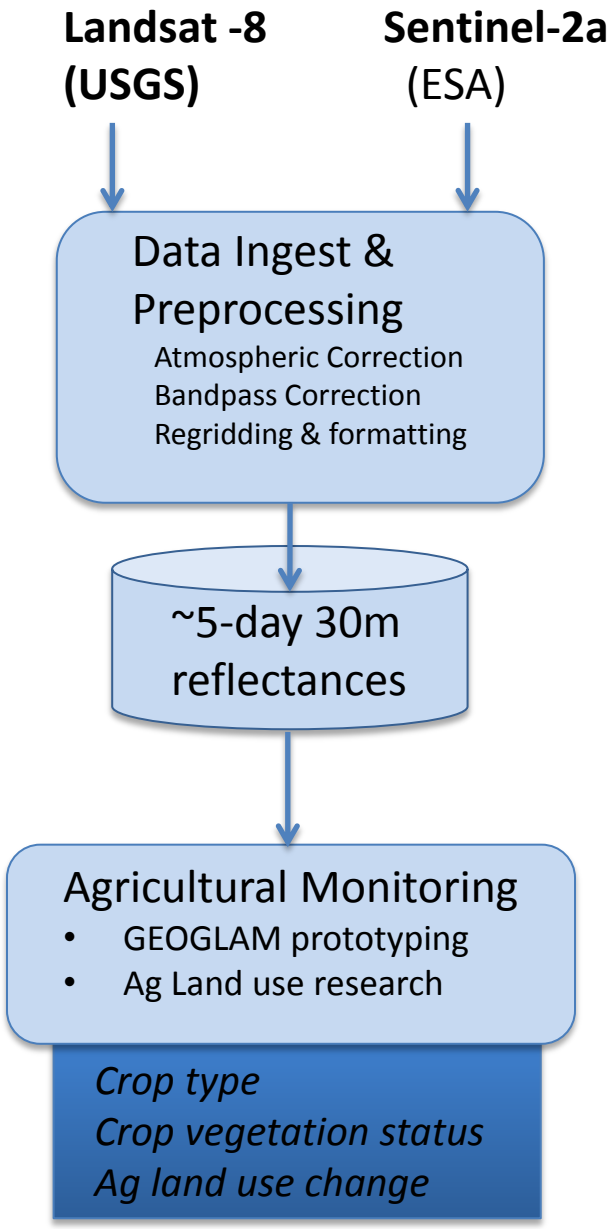
Goal 2: Leverage new datasets for agricultural monitoring (e.g. GEOGLAM prototyping)

Goal 3: Support transition to operational agencies

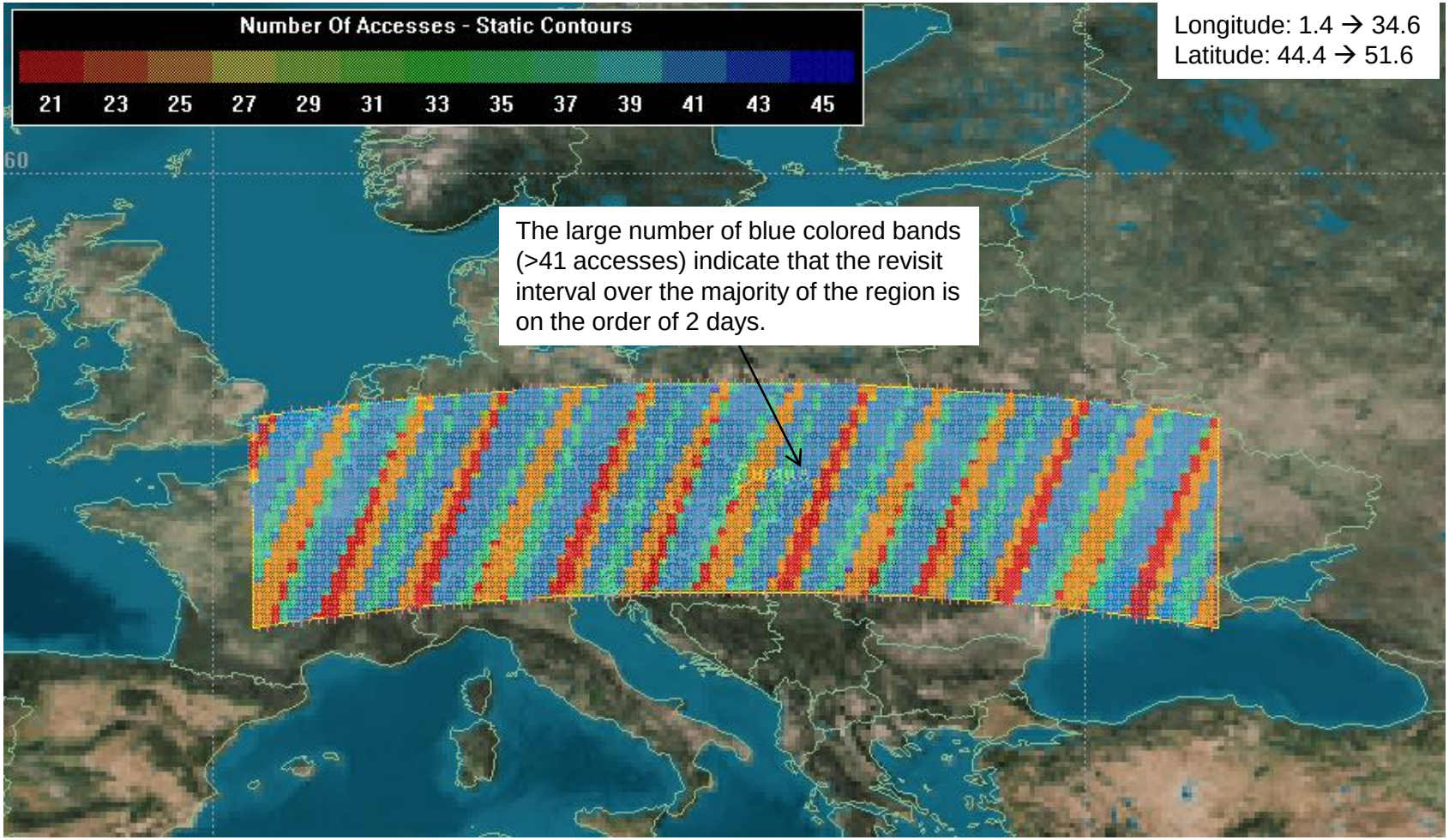
- GEOGLAM, USDA FAS and EC JRC MARS programs
- examples: UMD/USDA MODIS GLAM – MODIS LANCE

Four year effort (2013 – 2016)

- Phase 1: prototype with limited geographic scope (4-5 demonstrator countries);
- Phase 2: expand to support global Ag monitoring with demonstration of success



Ag 01 need for high frequency moderate resolution observations: Sentinel 2A and B – LDCM



- 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

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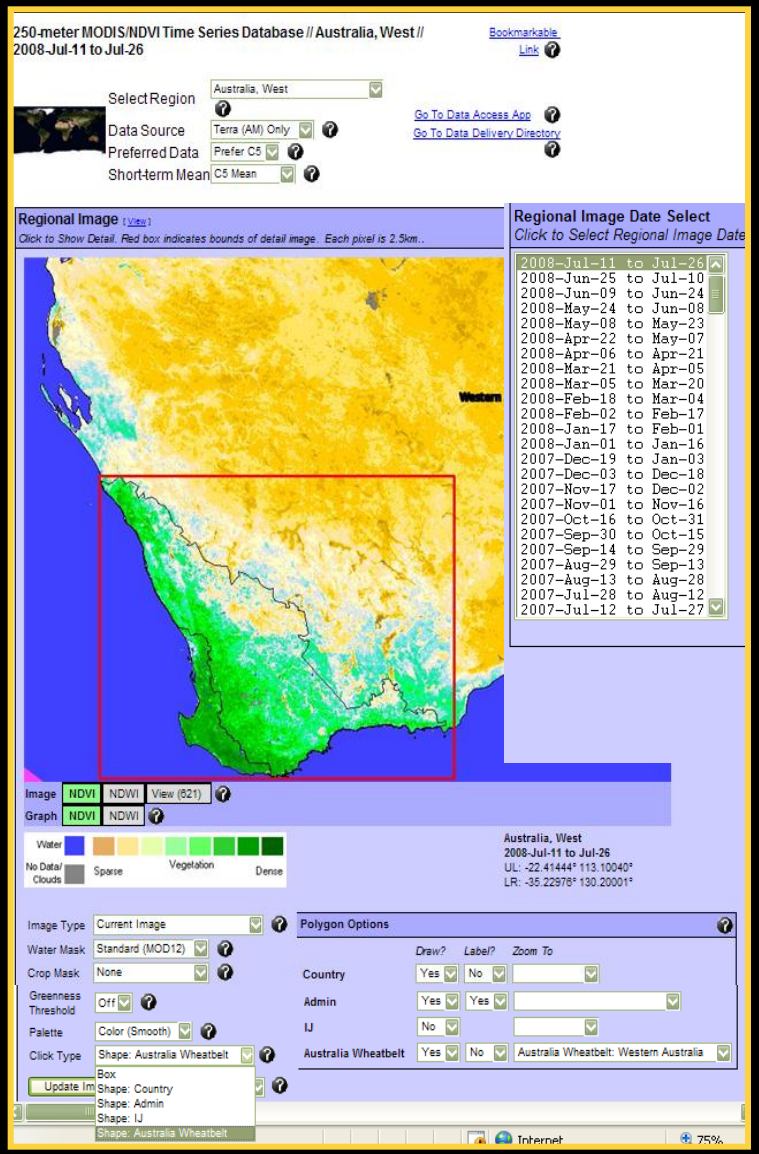
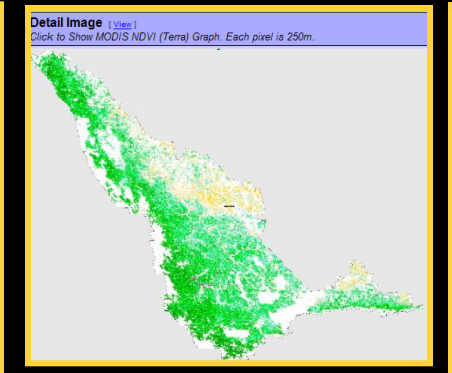
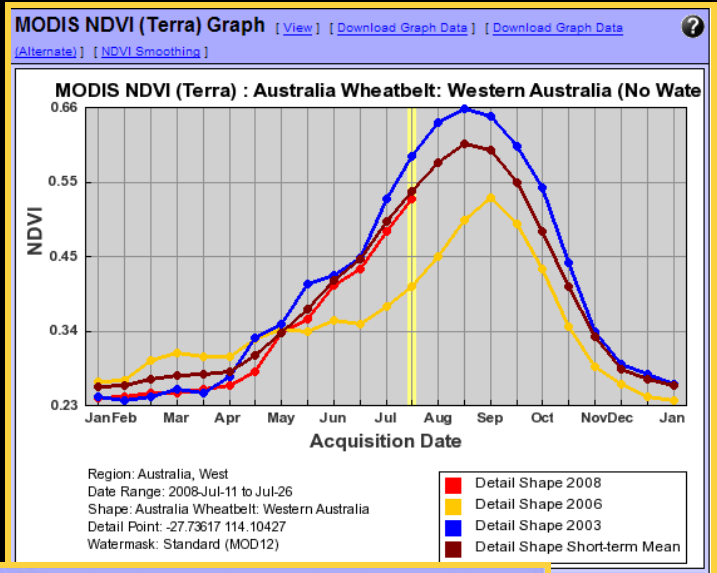
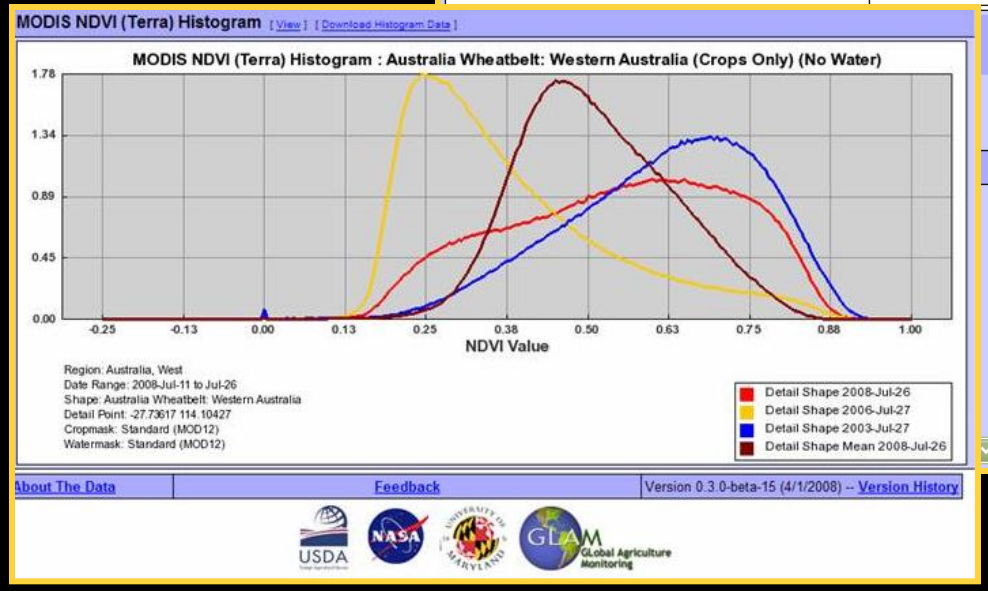
Courtesy Brian Killough, NASA LARC

The MODIS GLAM System Web Interface Available for Querying and Analyzing Time Series Data









Prototyping: tracking impacts of 2012 droughts on crop condition through daily satellite observations

- Severe drought conditions are hampering crop production across the northern hemisphere.
- The US, which is the world's largest corn and soy producer, is currently experiencing its worst drought in over 50 years.
- **Compounding the effects of the US drought, large areas of the Black Sea region (Russia, Ukraine and Kazakhstan) are also in the midst of a wide spread drought.** The Black Sea countries account for a quarter of the world's wheat exports
- **Focus on agricultural area only and sensitive crop stage for 4 primary crops (wheat, corn, soy, rice)**

Northern Hemisphere Crop NDVI Anomalies, Aug 13th, 2012

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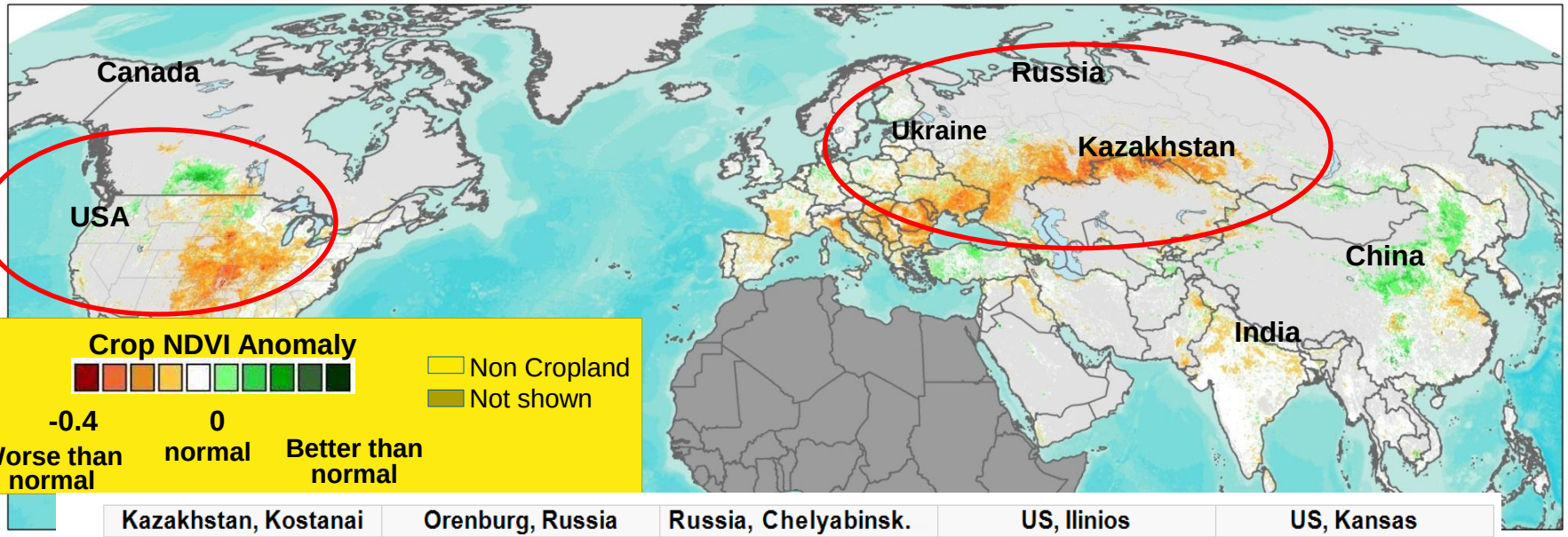
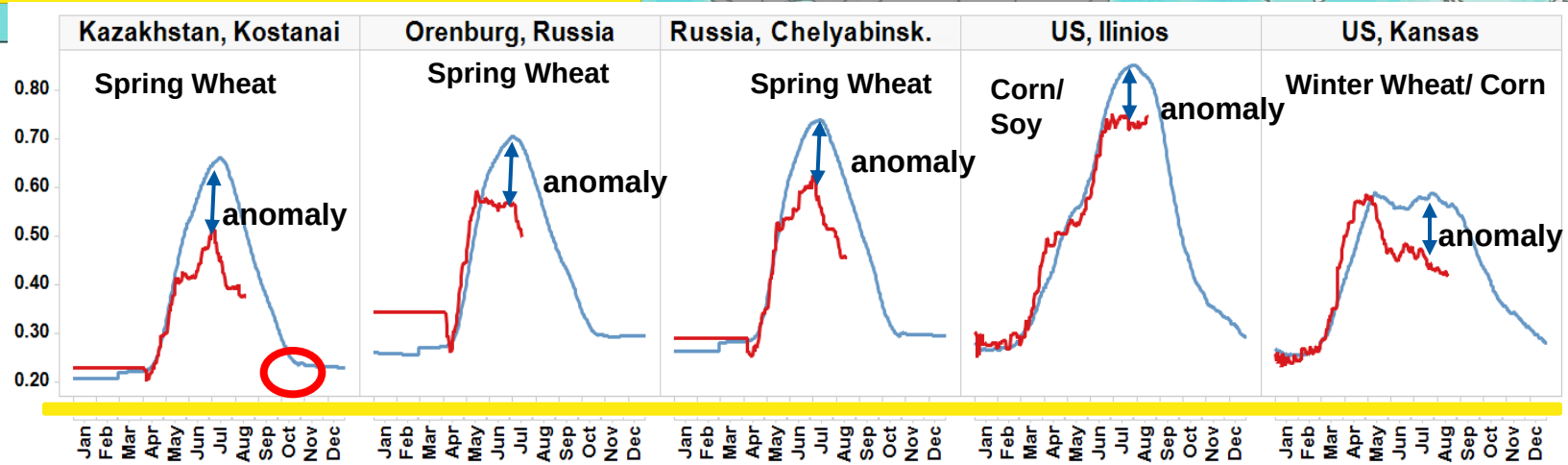
GEOGLAM Global Agricultural Monitoring

CROP CONDITION GLOBAL OUTLOOKS: BUILDING INTERNATIONAL CONSENSUS

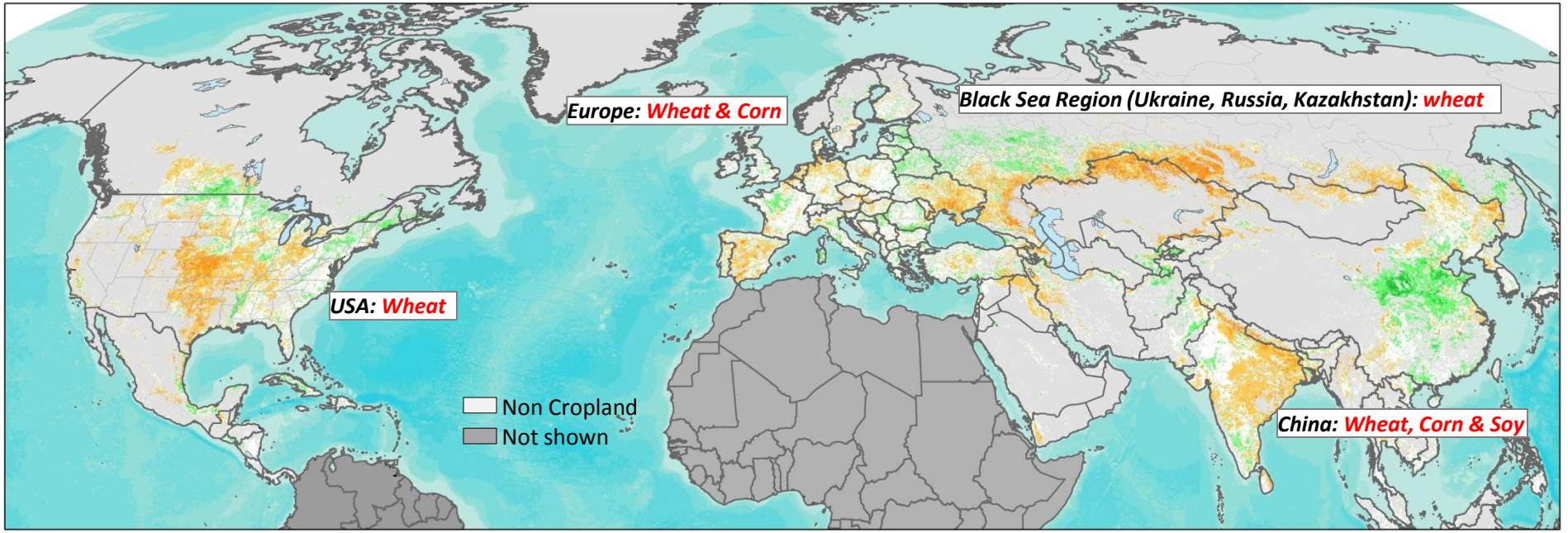




Current season crop development (2012)
Average season development (2000-2011)

UNIVERSITY OF MARYLAND

Northern Hemisphere Crop Condition Anomaly, June 1st, 2012



Crop Anomaly

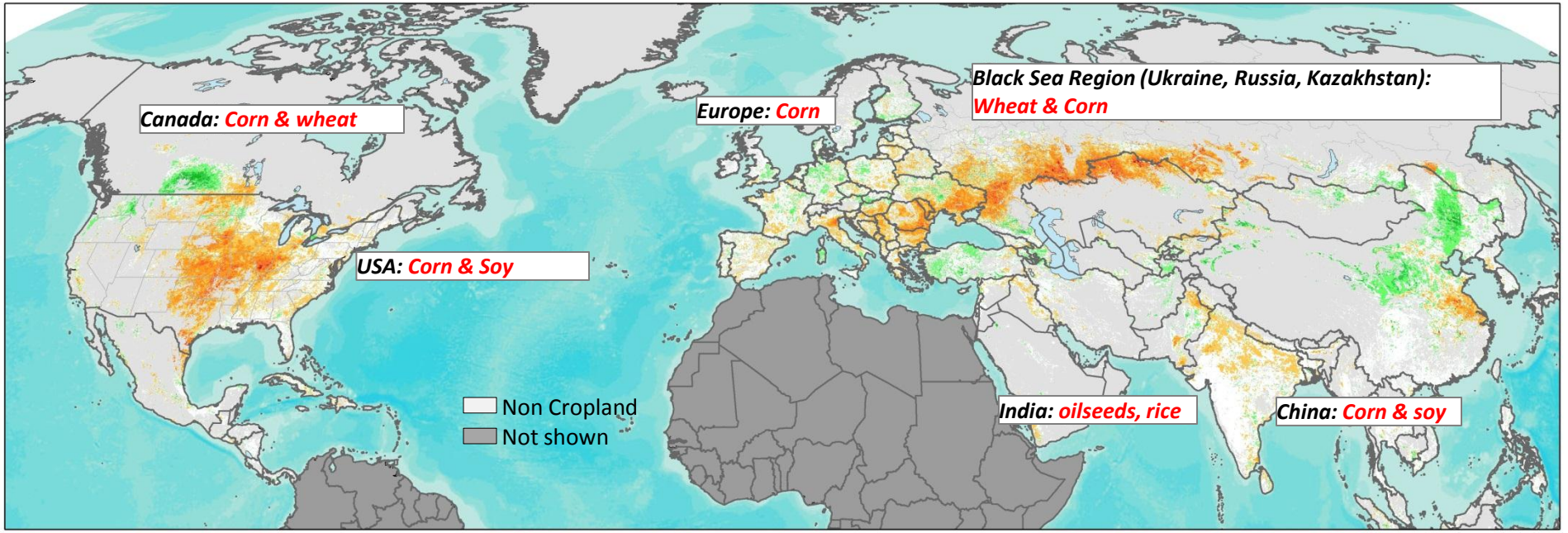
-0.4	0	0.4
Worse than normal	normal	Better than normal

Highlights:

- US drought developing
- Drought in Ukraine affecting winter wheat
- Drought in Spain affecting winter wheat
- Drought in Russia, Kazakhstan during planting
- Dry conditions in India during planting

- *Crop stage sensitive to moisture and temperature*
- Crop stages largely based on USDA/NOAA Joint Agricultural Weather Facility (JAWF

Northern Hemisphere NDVI Crop Anomaly, August 1st, 2012



Crop Anomaly

-0.4	0	0.4
Worse than normal	normal	Better than normal

- *Crop stage sensitive to moisture and temperature*
- Crop stages largely based on USDA/NOAA Joint Agricultural Weather Facility (JAWF

Highlights:

- US drought continues to spread and intensify
- Drought in Ukraine continues to intensify in south east
- Drought in Russia, Kazakhstan intensifying, affecting spring wheat and corn
- Rains in India mitigate dry conditions, during the sensitive stages of the growing season
- Rains mitigate dry conditions in Ontario, good conditions in the western Canada

The GEO Agriculture Task

- Increased participation of South Asian scientists and practioners in any aspect of the GEO Agricultural Task would be most welcome
- Active involvement of ISRO in the design and implementation of a coordinated GEOGLAM Data Acquisition Program with CEOS is needed
  - NASA LCLUC would also be interested in developing an IRS component to the Sentinel 2/ LDCM Study

Thank You for your Attention