

# Operational Challenges to Contemporary Satellite Imagery Characterization

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Conference**

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**Dath K. Mita, PhD  
Bill Baker, PhD ; Michael Toomey, PhD ; Tatiana Nawrocki; Christianna  
Townsend**

**International Production Assessment Division, Office of Global Analysis,  
Foreign Agricultural Services, USDA**



# Outline:

1. Share USDA Office of Global Analysis-  
International Production Assessment  
Division's mission (*what we do and why*)
2. Share *some* operational *challenges* related to  
satellite earth observations
3. *Listen* to your perspective



# Overview:

## USDA-Office Global Analysis International Production Assessment Division

- The Foreign Agricultural Service's (FAS) Office of Global Analysis (OGA) serves as a major source of objective and reliable global agricultural production information to the World Agricultural Outlook Board (WAOB), the primary source of USDA's global commodity outlook
- The USDA's outlook reports provide public access to information and data affecting world food security and are crucial in decisions affecting U.S. agriculture, trade policy, and food aid.
- The reports provide monthly regional, national and subnational monitoring and analysis of crop conditions, yield forecasts, and the impact of events affecting crop production.
- In addition, the FAS OGA provides support and maintenance of USDA's global database of (1) Crop Area, Yields, and Production (PSD); (2) Weather and Soil Moisture; (3) Monthly Crop Growth Stage and Harvest Calendars, (4) Global Agricultural Monitoring (GLAM); (6) and others



Attaché Reports



Official Country Reports



U.S. and World Weather



USDA's Production Forecast

News and Reporting



Travel Reports



Economic and Trend Analysis



Remote Sensing

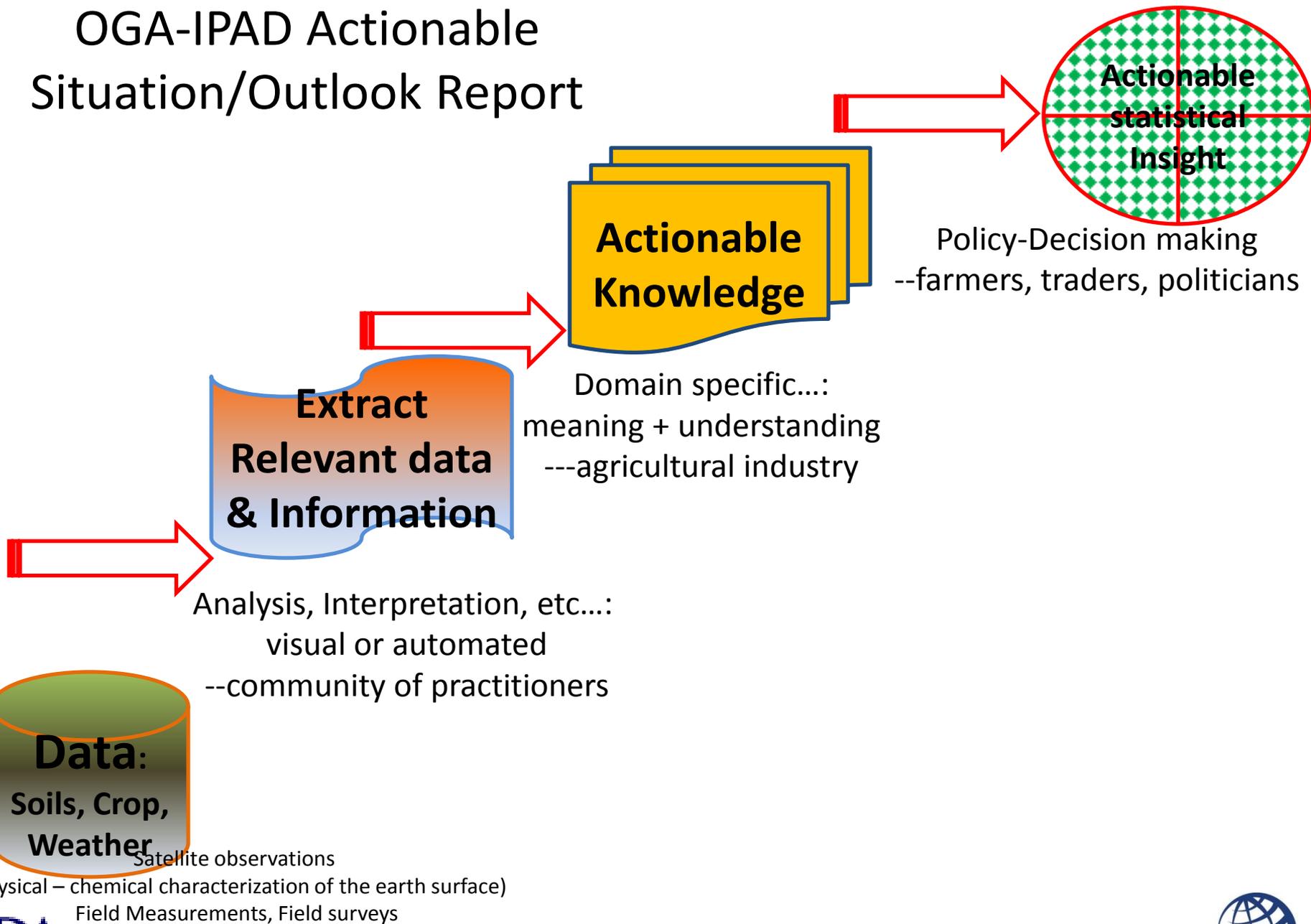


# USDA's SIA Program

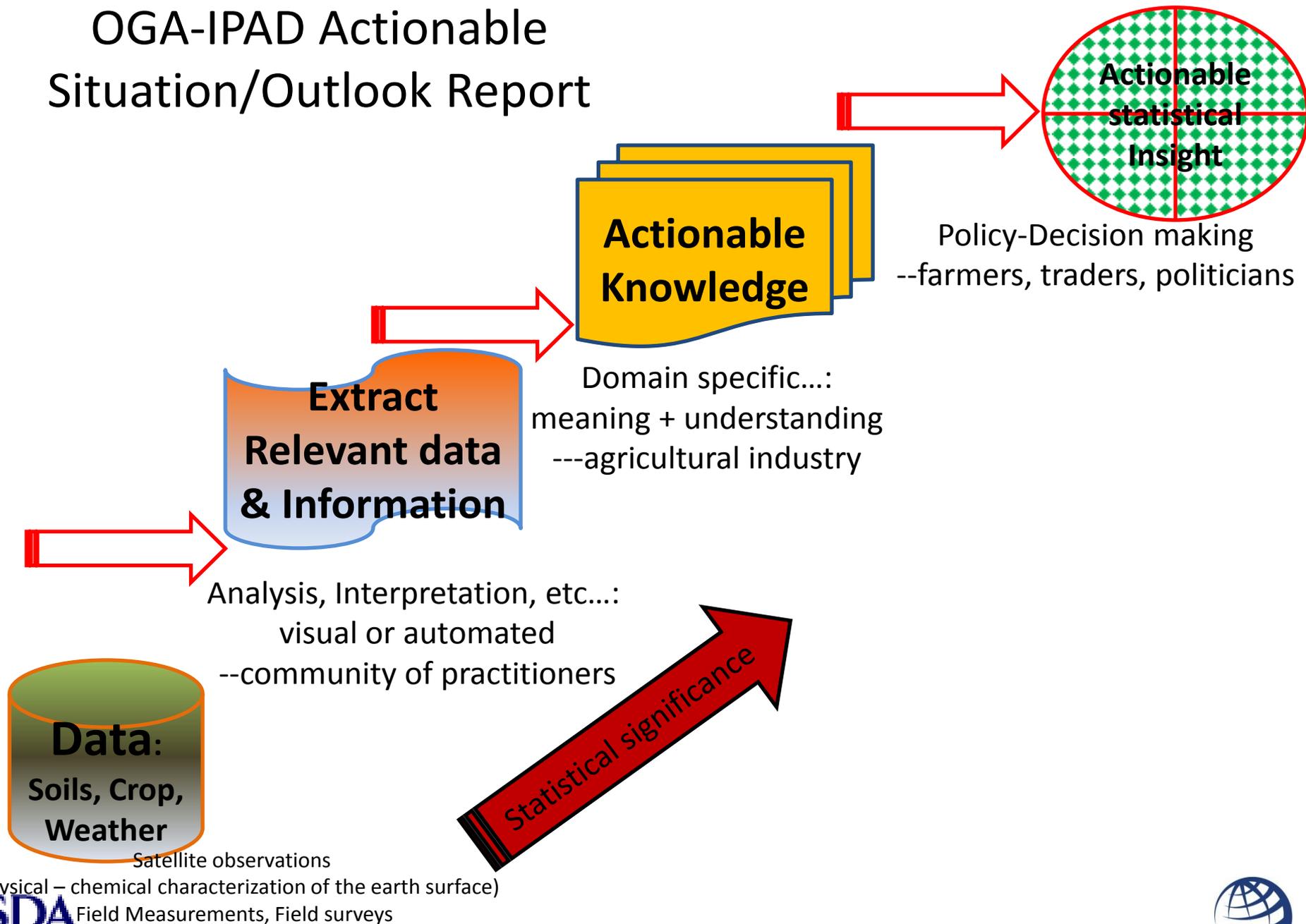
- ❖ The satellite imagery resources are managed through the USDA's **Satellite Imagery Archive (SIA)** program.
- ❖ The SIA program was established by USDA's Remote Sensing Coordinating Committee (RSCC) which is chaired by the USDA's Office of the Chief Information Officer
- ❖ The SIA fulfills its mission of providing **USDA-wide cost effective data-sharing** of satellite data through a centralized purchasing, receipt, inventory, storage, and dissemination of satellite imagery to USDA agencies and their affiliates:
  - Foreign Agricultural Service (**FAS**),
  - Risk Management Agency (**RMA**),
  - National Agricultural Statistics Service (**NASS**),
  - Forestry Service (**FS**),
  - Natural Resources Conservation Service (**NRCS**),
  - Agricultural Research Service (**ARS**), and
  - Farm Service Agency (**FSA**).
- ❖ The SIA facility is managed through the **online Archive Explorer (AE) system** at [http://www.pecad.fas.usda.gov/archive\\_explorer/default.cfm](http://www.pecad.fas.usda.gov/archive_explorer/default.cfm). The AE is a web-enabled browse and search tool, that allows users to browse, select, and retrieve the contents of the Satellite Imagery Archive



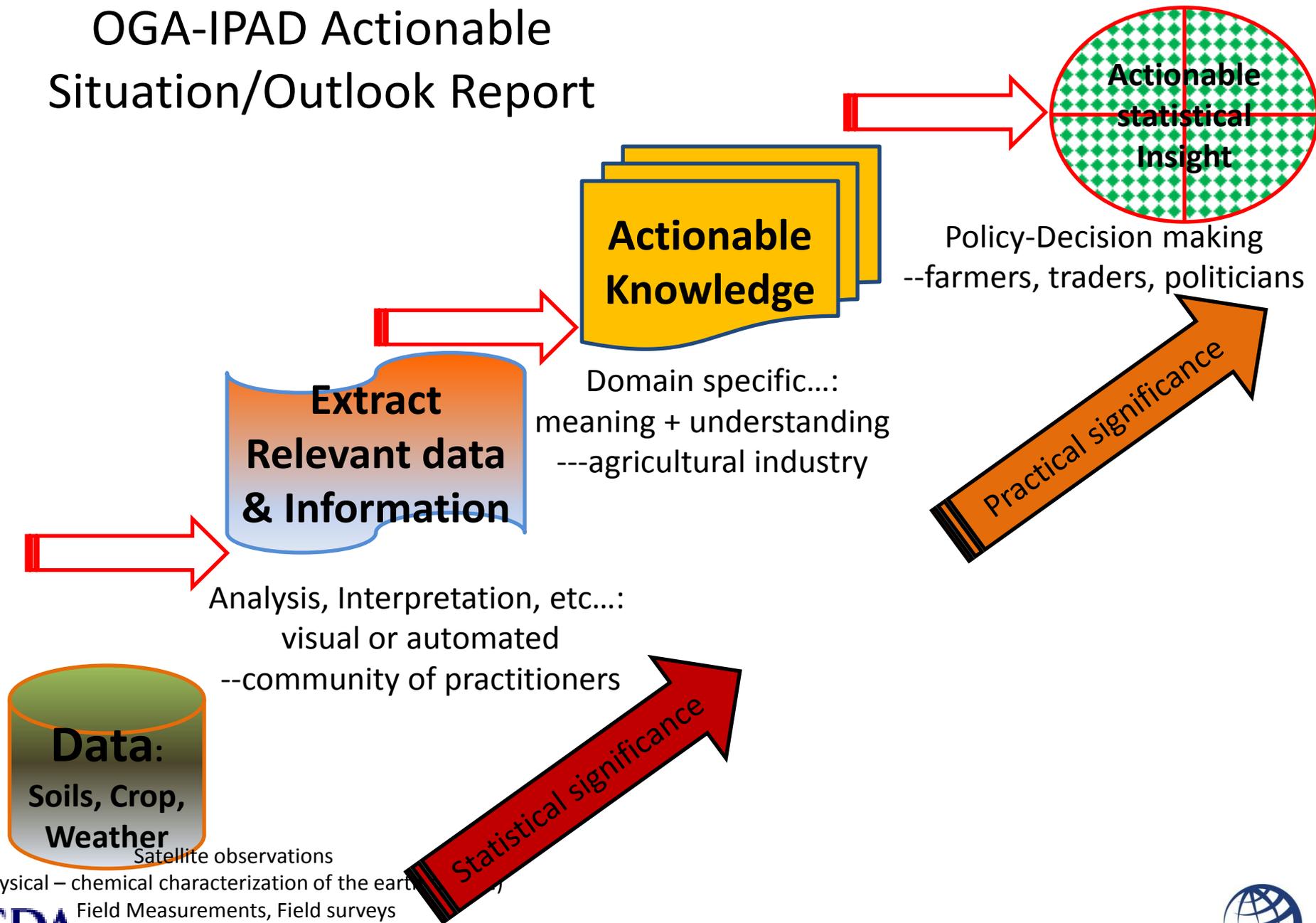
# OGA-IPAD Actionable Situation/Outlook Report



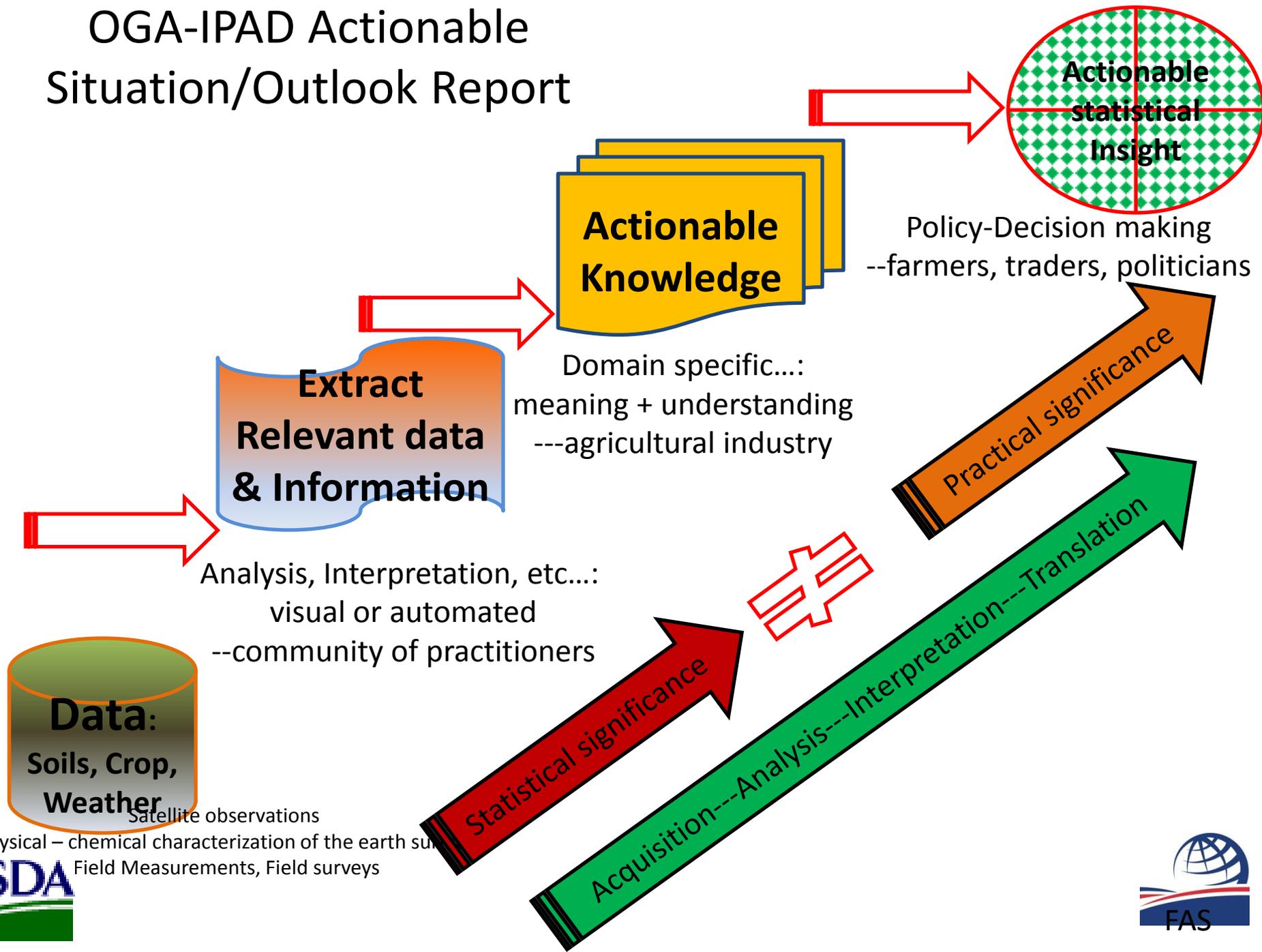
# OGA-IPAD Actionable Situation/Outlook Report



# OGA-IPAD Actionable Situation/Outlook Report



# OGA-IPAD Actionable Situation/Outlook Report



# Data-Information Translation:

reference points or benchmarks:

all about relativity: previous year, average, record, drought year

 **World Agricultural Supply and Demand Estimates**  
United States Department of Agriculture

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

WASDE-459      Approved by the World Agricultural Outlook Board      June 10, 2008

**NOTE:** Because planting of spring crops is still underway in the Northern Hemisphere and remains several months away in the Southern Hemisphere, these projections are tentative. Variation in area and yields may result from weather developments, economic factors, and policy changes. National Agricultural Statistics Service (NASS) forecasts are used for U.S. winter wheat. For other crops, planted acreage reflects the March 31 NASS Prospective Plantings report. Methods used to project harvested acreage and yield are noted on each table.

**WHEAT:** U.S. 2008/09 wheat supplies are projected higher this month on higher production and increased carryin. Winter wheat production is forecast 40 million bushels higher with higher yields expected in most states. Beginning stocks are projected 15 million bushels higher as 2007/08 exports are lowered the same amount on slower-than-expected shipments in recent weeks. Feed and residual use for 2008/09 is raised 25 million bushels with increased supplies, particularly for soft red winter wheat, and higher expected corn prices. Exports are raised 25 million bushels on strong new-crop sales. Ending stocks are projected at 487 million bushels, up 5 million from last month. The 2008/09 marketing-year average farm price is projected at \$6.75 to \$8.25 per bushel, up 15 cents on both ends of the range. Wheat prices are expected to remain supported by early season demand and higher corn prices.

Global wheat production for 2008/09 is raised 6.9 million tons this month with higher output expected from FGU-12, China, and the United States. Nearly ideal weather continues to support crop prospects for Russia and Ukraine with production raised 2.0 million and 1.0 million tons, respectively. Production for China is raised 5.0 million tons for 2008/09 on good growing conditions for this year's crop and in line with recently released estimates for 2007/08 and 2006/07 from China's National Bureau of Statistics. Production for 2007/08 is raised 3.9 million tons, and 2006/07 production is revised 4.0 million tons higher on reported yields. Partly offsetting the 2008/09 increases are reductions for Afghanistan, Argentina, and Syria due to dry conditions. Production is also lowered 0.5 million tons for Canada as cool, dry early season conditions have slowed crop emergence and establishment.

Global wheat imports, exports, and consumption for 2008/09 are all raised this month with increased supplies. World exports are raised 1.0 million tons with increases for Ukraine and the United States more than offsetting reductions for Canada and Syria. World consumption is raised 3.9 million tons mostly reflecting higher feeding and food use in China and higher feeding in the United States. World ending stocks are projected 8.1 million tons higher this month at 132.1 million, up 16.9 million from 2007/08 and the highest since 2005/06. Ending stocks for 2007/08 and 2006/07 are raised 5.1 million tons and 2.6 million tons, respectively, mostly on increases for China following the large revisions made to production.

**COARSE GRAINS:** U.S. 2008/09 feed grains supplies are projected lower and prices higher with reduced prospects for corn production this month. The 2008 corn crop is projected at 11.7 billion bushels, down 390 million from last month based on lower expected yields. The national average yield is projected at 148.9 bushels per acre, 5 bushels below last month, and 6 bushels below the 1990-2007 trend. This month's reduction reflects slow planting progress, slow crop emergence,

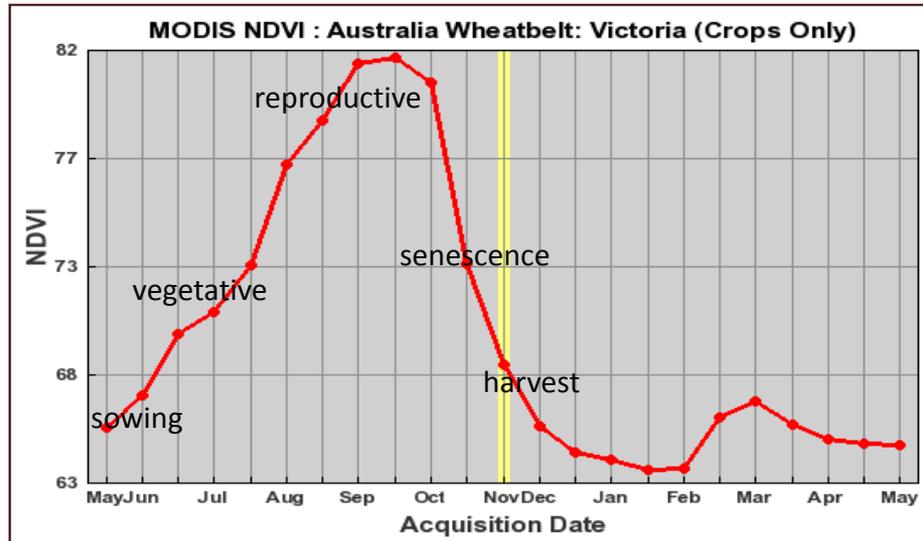
- ✓ Statistics: Area, Yield, Production
- ✓ Time of sowing: early, late, normal...
- ✓ Seasonal crop & weather anomalies: normal, favorable, unfavorable (excess, drought, etc.)
- ✓ State of plant growth and development
- ✓ Phenological phase: vegetative, flowering, physiological maturity, harvest

# Major Crop Monitoring Parameters

What We Monitor and the Underlying Assumptions:

## 1. Crop Growth:

- Driven by temporal (seasonal) soil moisture (rainfall)
- We generate global vegetation conditions to monitor photosynthetic activity
- NDVI, ET provide metrics of crop growth, agricultural ecosystem functions and health



## 2. Crop Yields:

- Dependent on accumulated biomass, available soil moisture, etc
- A function of time and rainfall (length of growing & harvest period)

## 3. Planted/Harvested Cropland

- Dependent on start of sowing rains
- Length of planting window
- Socio-economic factors (market prices, government incentives, etc.)

# Operational *Challenges* Related to Satellite Earth Observations

1. **Workflow integration**
2. **Data quality**
3. **Data processing**
4. **Data archive: big data  
problem**

# Goals:

## Operational vs. Science/Research/Deployment

### ➤ Operational:

- High quality deliverables (*reliability, credibility, legitimate*)
- Data value defined in terms of the accuracy and quality of the outputs and outcomes: similarity/dissimilarity to reality
- Ensure effectiveness/seamless protocols
  - fitting data seamlessly into existing workflows
- Too time consuming or cumbersome data integration routines result in limited or no use

### ➤ Science/Research/Deployment:

- Often related to **spatial, spectral, radiometric, temporal sensitivity**

# Challenge 1: Data Quality

## MONITORING CROP CONDITIONS

### .....INDIA MONSOON SEASON



# India: Monitoring *Kharif* (monsoon) Season Crops

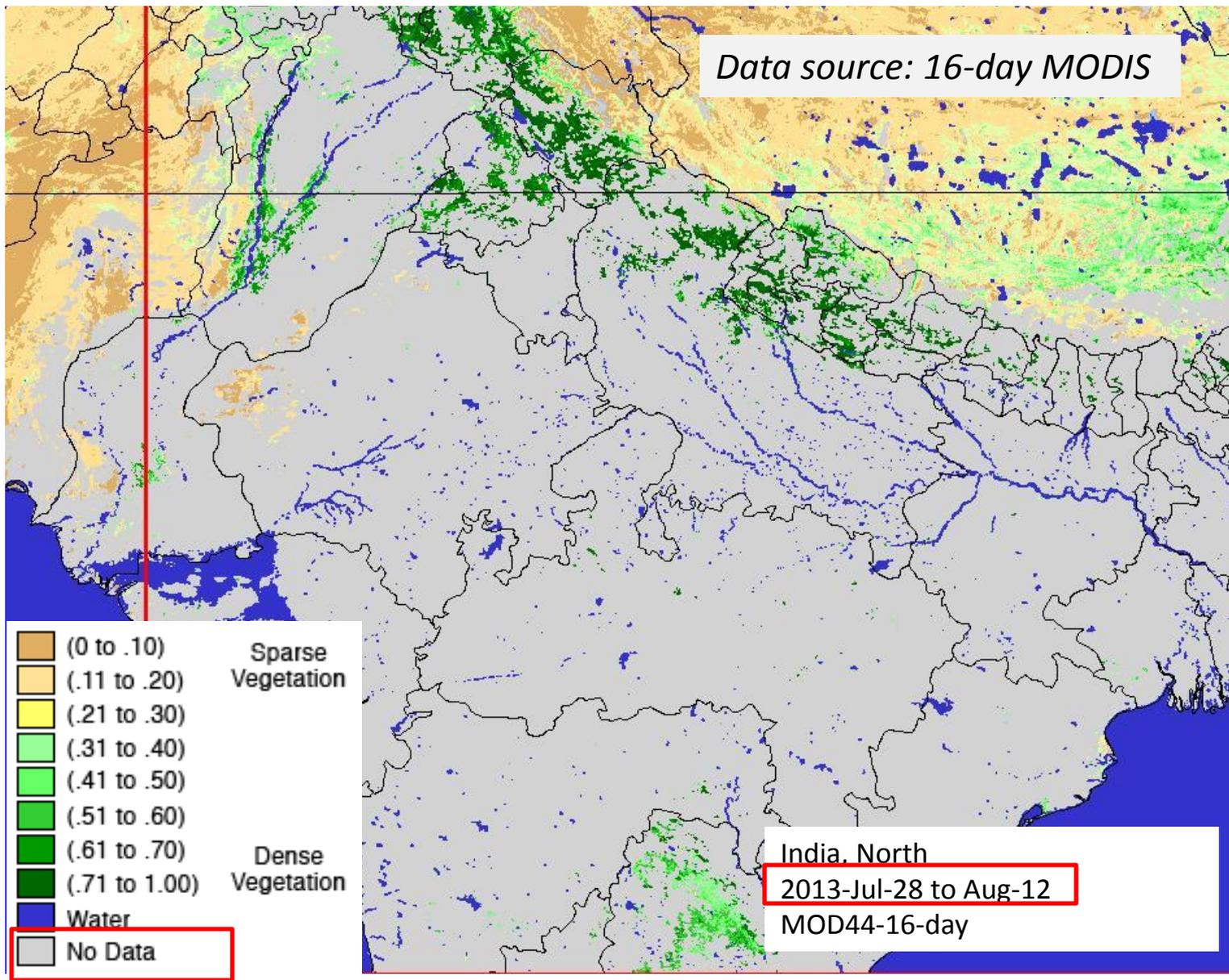
- *Landsat, MODIS, + Other*
  - India's major crop season, *kharif* (monsoon season)
    - Data gaps almost the entire season makes it difficult to generate reliable + consistent indicators/deliverable products
    - Cloud minimizing protocols (in-house) much more time consuming and costly to fix
    - More rework and assumptions resulting in extremely poor overall quality of deliverables

***A simple case with serious crop forecasting implications: cotton, rice, soybeans  
....India's monsoon reason data gaps***



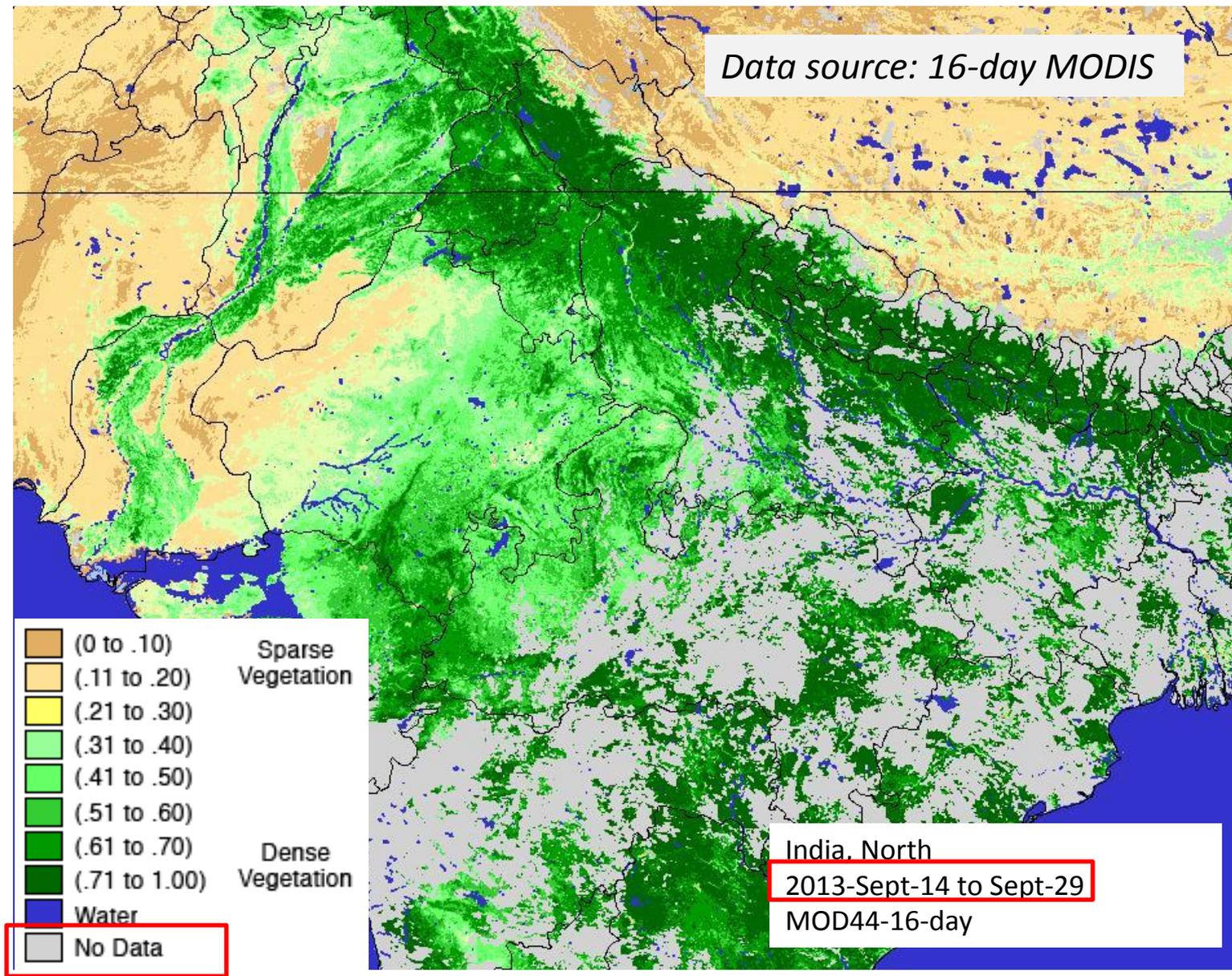
No meaningful data interpolation, extrapolation, manipulation, etc.

Monsoon season: June - September



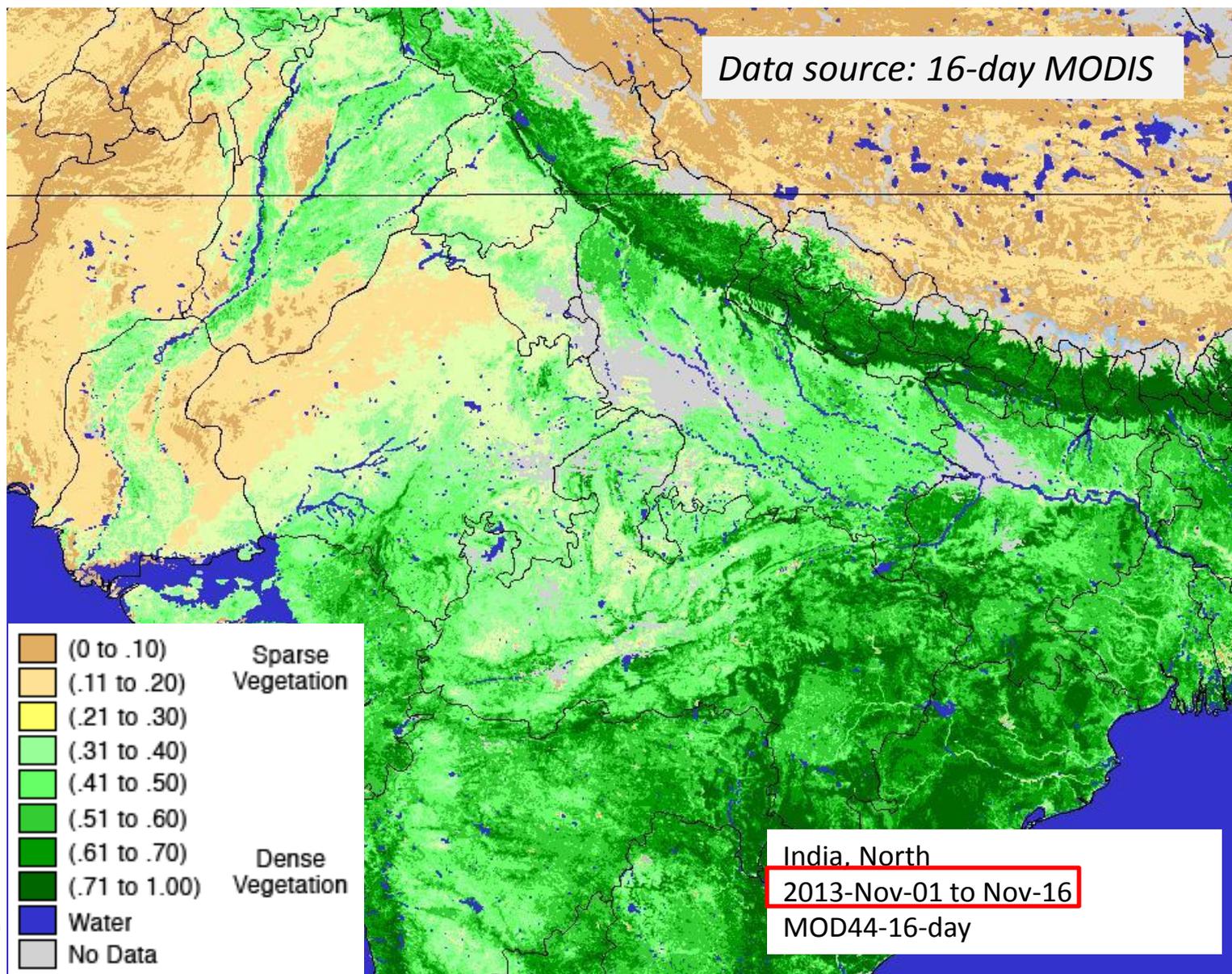
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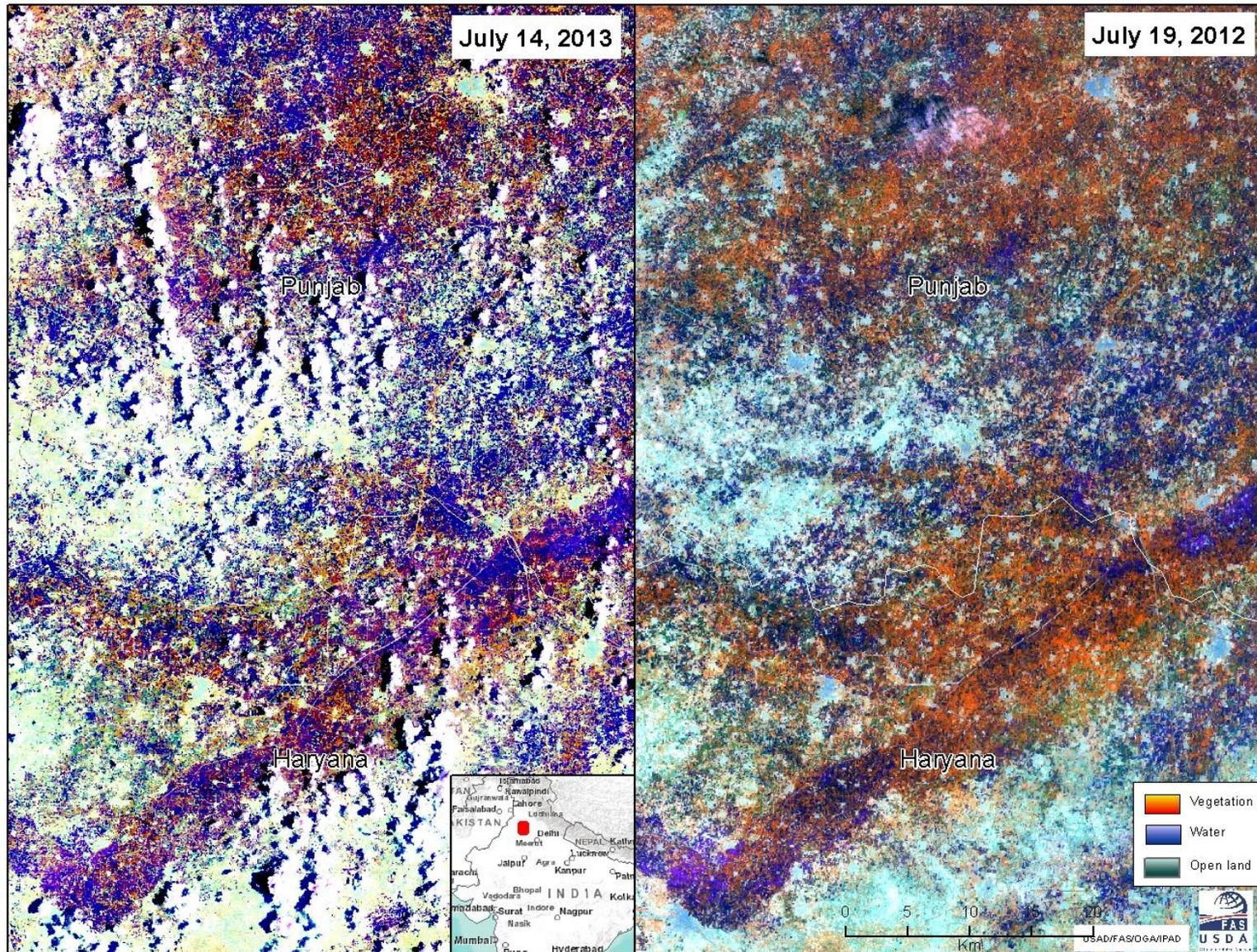


No meaningful data interpolation, extrapolation, manipulation, etc.

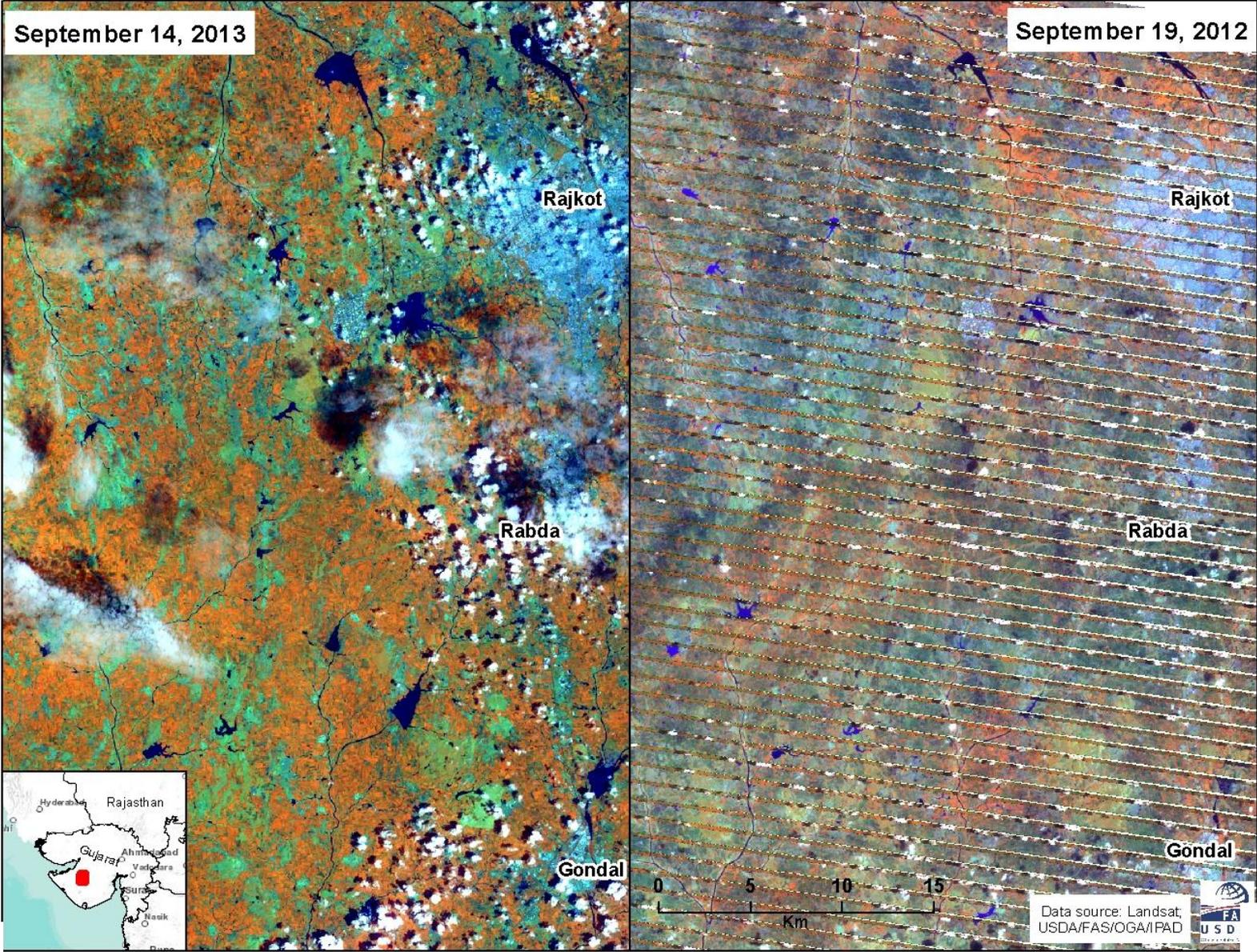
Monsoon season: June - September



# India *Kharif* (monsoon) Season Landsat Imagery



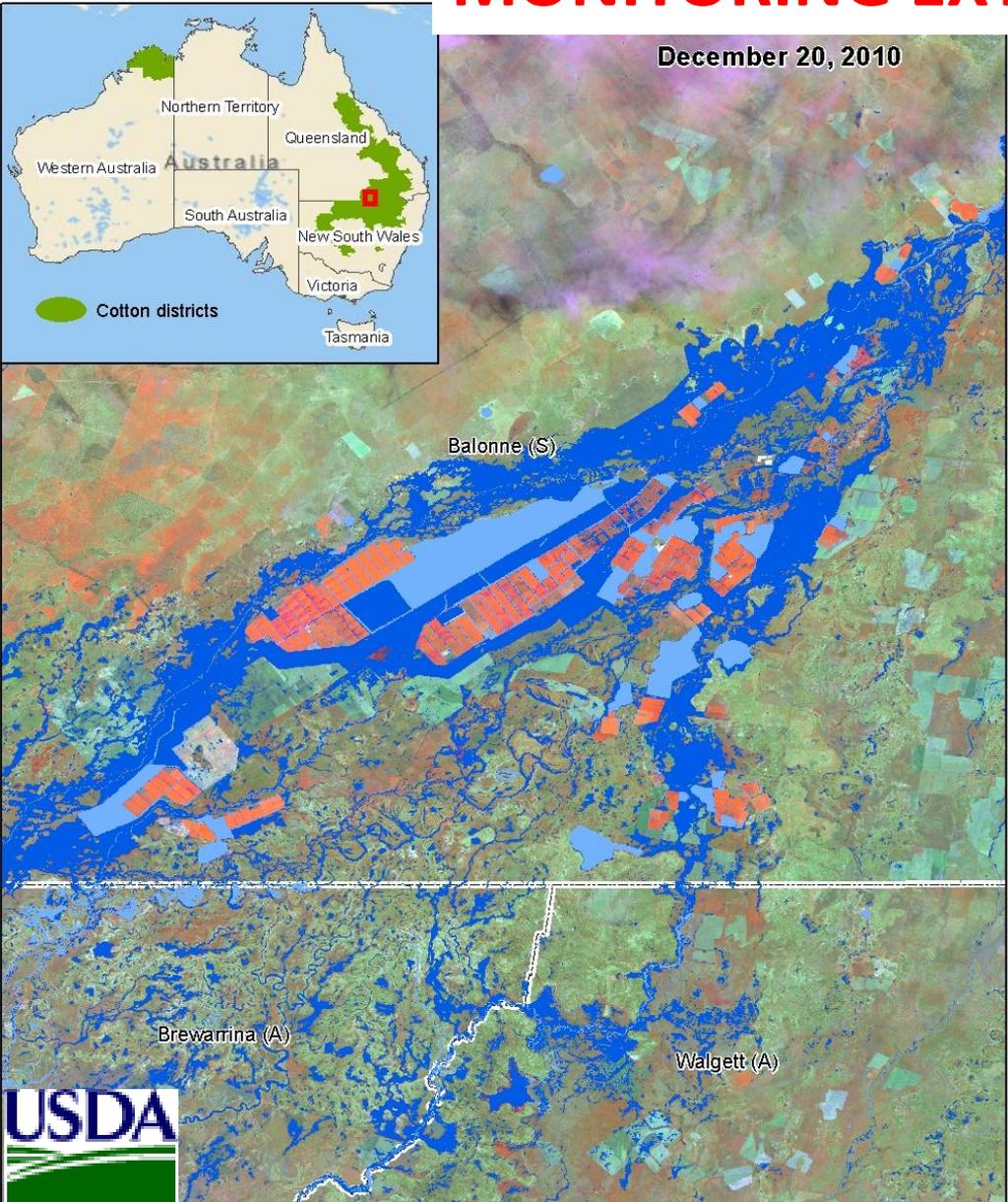
# India *Kharif (monsoon)* Season Landsat 8, 7 Imagery



# Challenge 2: Massive datasets

## MONITORING EXTREME EVENTS

...excess rainfall,  
flooding, drought...

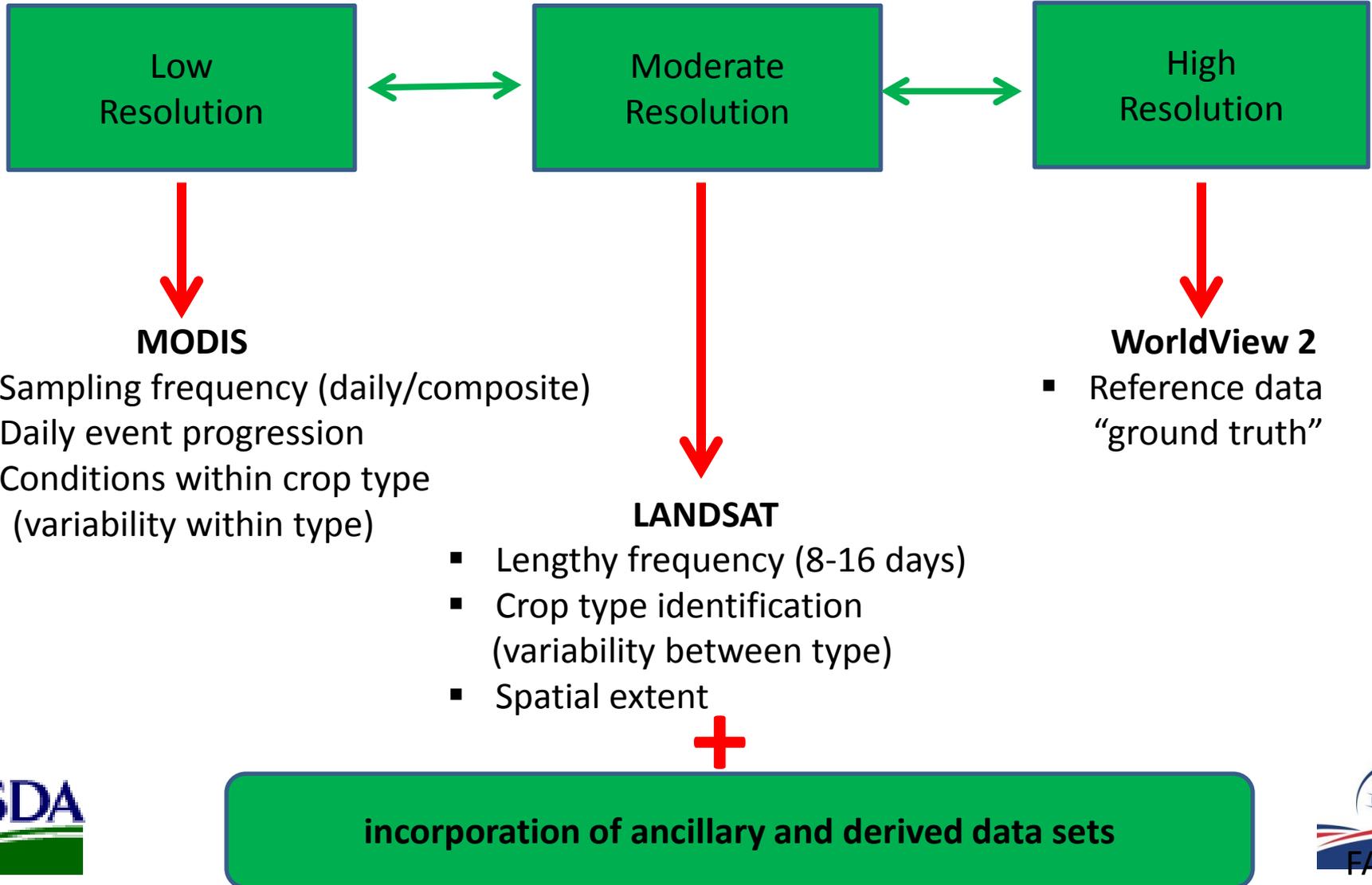


# Monitoring Crop Impacting Events:

- ❖ **Event progress:** determine reasonable-practical frequency
  - daily, weekly, etc...
  - spatial extent; depth, length of time
  
- ❖ **Crop Monitoring:**
  - Crop types (major) identification
  - Crop stage identification
    - Resilience, survival rate, compensatory growth etc..
  
- ❖ USGS Hazards Data Distribution System is key for major disasters

# Evaluation-Monitoring Crop Impacting Events

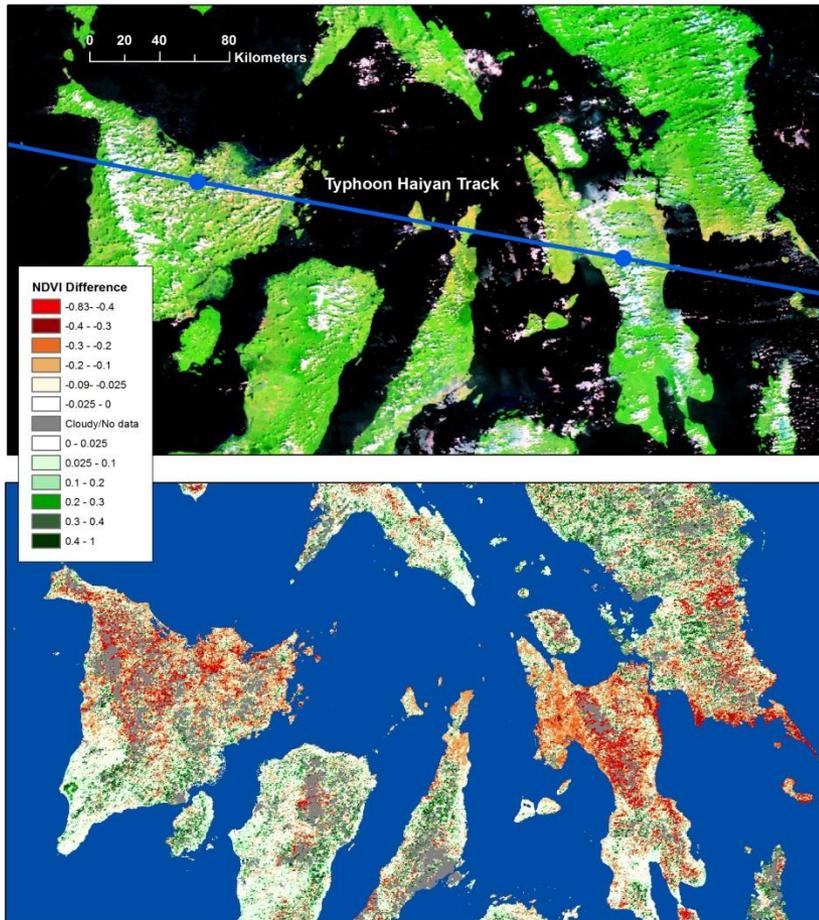
Data Selection, Processing, Analysis:  
.....for regional, national, subnational analysis



# Category 5 Typhoon Haiyan in Philippines, Nov 8<sup>th</sup>, 2013

## Synoptic Scale Assessment: MODIS (500m)

PHILIPPINES: Visayas region - Regional Vegetation Damage and NDVI Difference Following Super Typhoon Haiyan, Detected by MODIS



➤ Composites of rapid-response/daily imagery

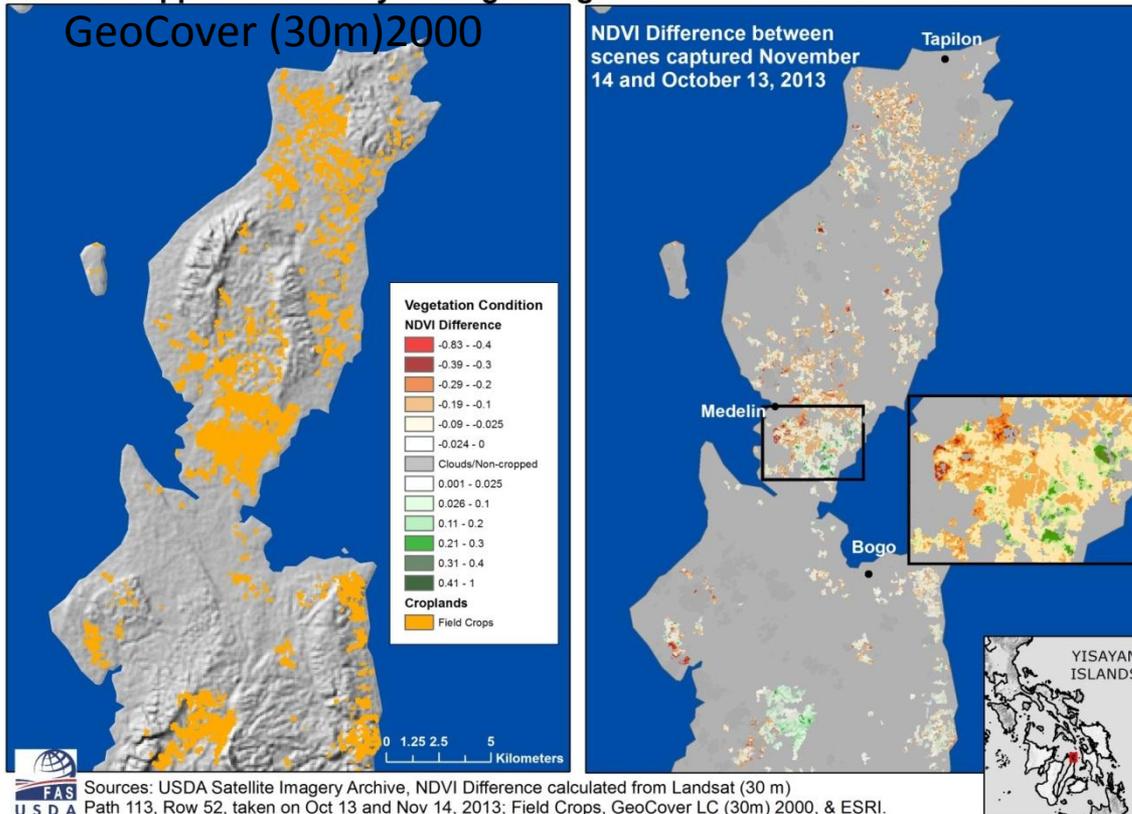
➤ Pre-Post Storm NDVI difference

Sources: MODIS Rapid Response, USDA Satellite Imagery Archive, Terra satellite (500 m). False color composite (bands 7, 2, 1). Image is a composite of November 11 and 15, 2013. NDVI difference based on MODIS 8-day composites on October 16-23 (before) and November 9-17, 2013 (after).

# Cropland Identification

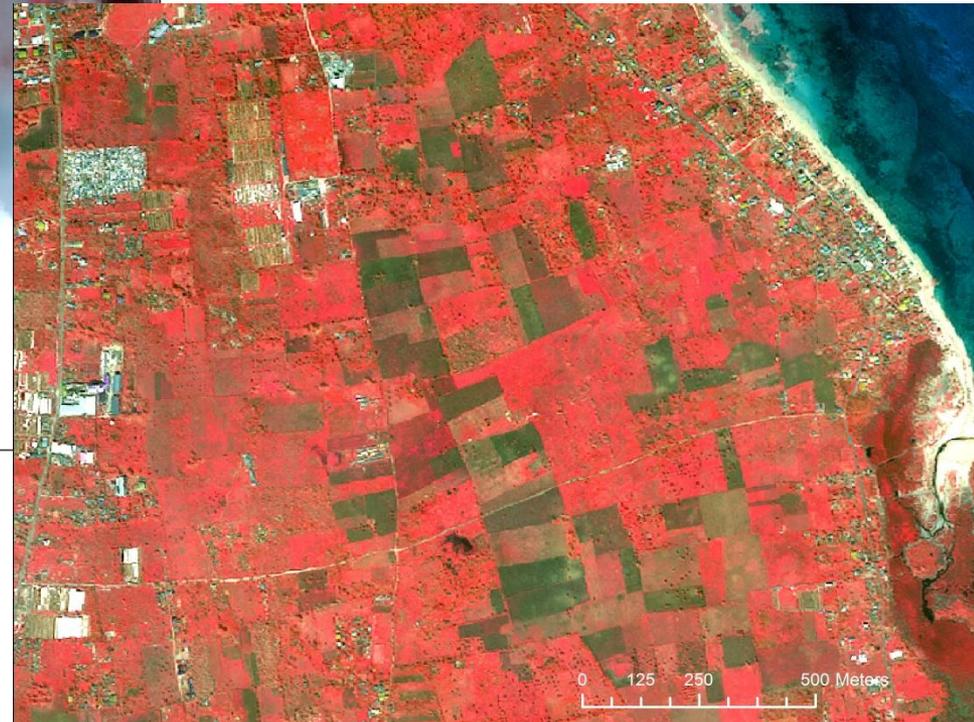
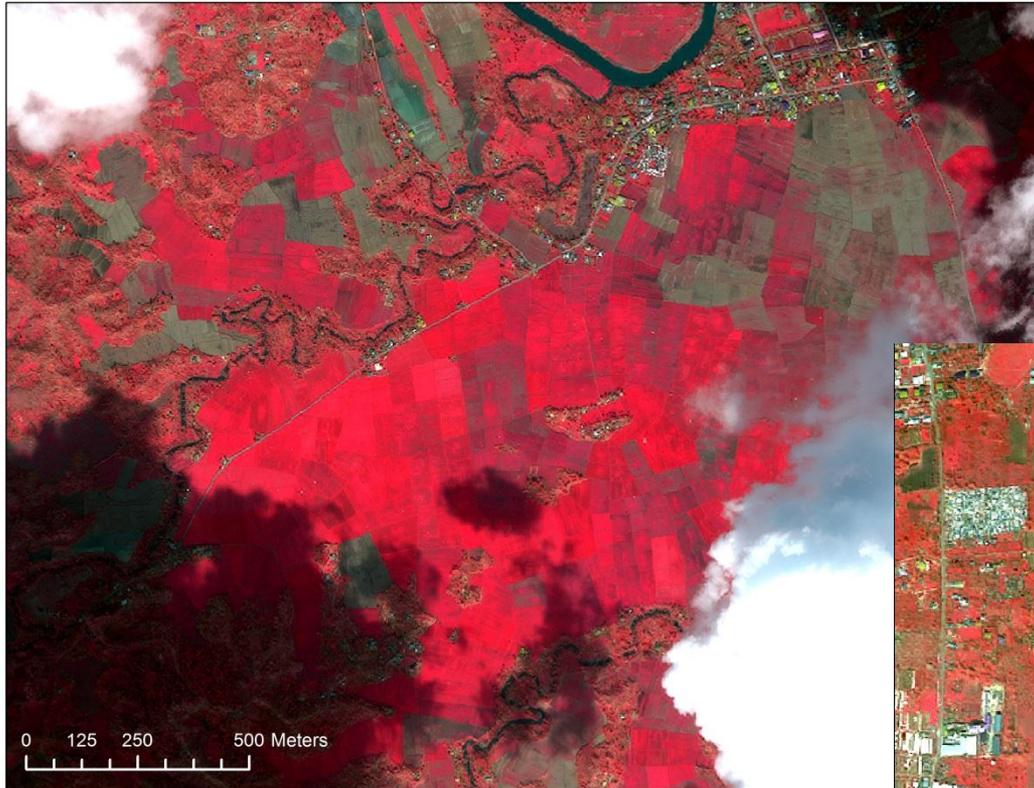
## Crop Condition Assessment: Landsat

Philippines: Severely Damaged Vegetation on Northern Cebu Island

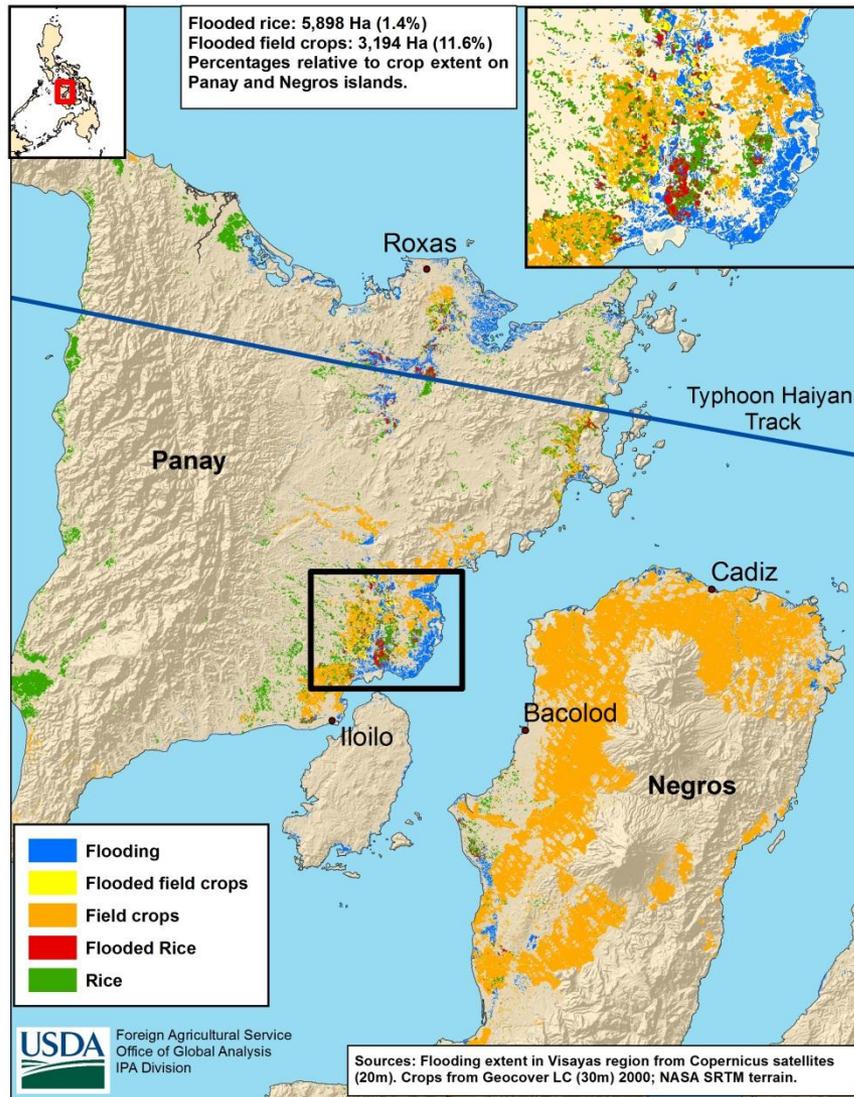


- Compiled cloud-free Landsat imagery
- Cross-referenced with high-resolution crop masks
- Assessed crop condition and potential damage

# WorldView2: Reference data (“ground truth”) provided large/local scale cropland assessment:



# Use of Ancillary Data



- Assess potential flooding damage using derived flooding maps (UNOSAT)



## **Challenge 3: Satellite Imagery Archive: BIG DATA PROBLEM**

# Satellite Imagery Archive Program: Big Data Problem

The amount of imagery in SIA and being collected is presenting:

- ❖ Storage capacity problems
- ❖ A daunting high storage cost

# SIA Big Data Problem:

## ❖ Landsat 5; 7:

- ❖ VNIR Spectral bands:
  - ❖ **6 optical, 1 thermal**
  - ❖ **6 optical, 2 thermal**
- ❖ Radiometric resolution /information depth
  - ❖ **8 bit imagery**

❖ SIA pack: 3 bands  
(2 visible + NIR)

## ❖ Landsat 8:

- ❖ VNIR Spectral bands:
  - ❖ **8 optical, 1 pan, 2 thermal**
- ❖ Radiometric resolution /information depth
  - ❖ **16 bit imagery**

❖ SIA pack: ?????

>More bands better characterize the physical and chemical nature of earth observations

>lower resolution color bands (multispectral) can be enhanced/pan-sharpened with the panchromatic band

# The issue is: ...How Do We.....

## ❖ Handle & manage the volume of imagery we already have:

- ❖ What should be stored & processed, given storage costs and limited storage resources
- ❖ Storage Scalability: e.g. retention period: 0, 1, 2, 3 years?

## ❖ Handle & manage the volume of new imagery we are adding every day:

- ❖ What should be stored & processed, given limited storage resources
- ❖ Storage Scalability: e.g. retention period: 1, 2, 3 years?

# Proposed Solutions

- ❖ No more storage of L5, L7 datasets
  - ❖ must be removed completely
- ❖ Take advantage of image access developments:
  - ❖ USGS infrastructure, ArcGIS Online, Google Earth, etc.
  - ❖ ?Conform with the need to process large areas at near-real-time speeds
- ❖ Adopt low-volume storage strategies (zip?)
- ❖ Reduce storage retention period, 3 to 2 years

- Cloud computing
  - proposition



# Cloud Computing Model: .....Things to consider.....

- ❖ Continued fast access and processing capabilities
- ❖ Does it affect applications: hardware-software
- ❖ Re-locating datasets plus processing infrastructure
- ❖ Short-long term impact on SIA members' workflows

- ❖ Sharing pool computing resources, e.g. SIA members, other users (licensing implications)
  - ❖ Cloud computing model provides network access to networks, servers, storage, applications, services, etc.
- ❖ Determine who the primary Service Provider or else??
  - ❖ How to manage interactions



Applications: access + processing



Storage - Infrastructure



...Cost, time, efficiency, sustainability,

## Contact :

USDA Foreign Agricultural Service  
Office of Global Analysis  
International Production Assessment Division  
1400 Independence Ave., S.W.  
Washington, DC 20250  
Tel: 202-720-7339

Browse Our Extensive Web Content at:

<http://www.pecad.fas.usda.gov/>

See Our Global Crop Explorer Site at:

<http://www.pecad.fas.usda.gov/cropexplorer>



# Thanks...

## Questions

## Comments



11/05/2009 04:48

