From Field to Globe: The Impact of Location-Centric Big Data Across the Value Chain

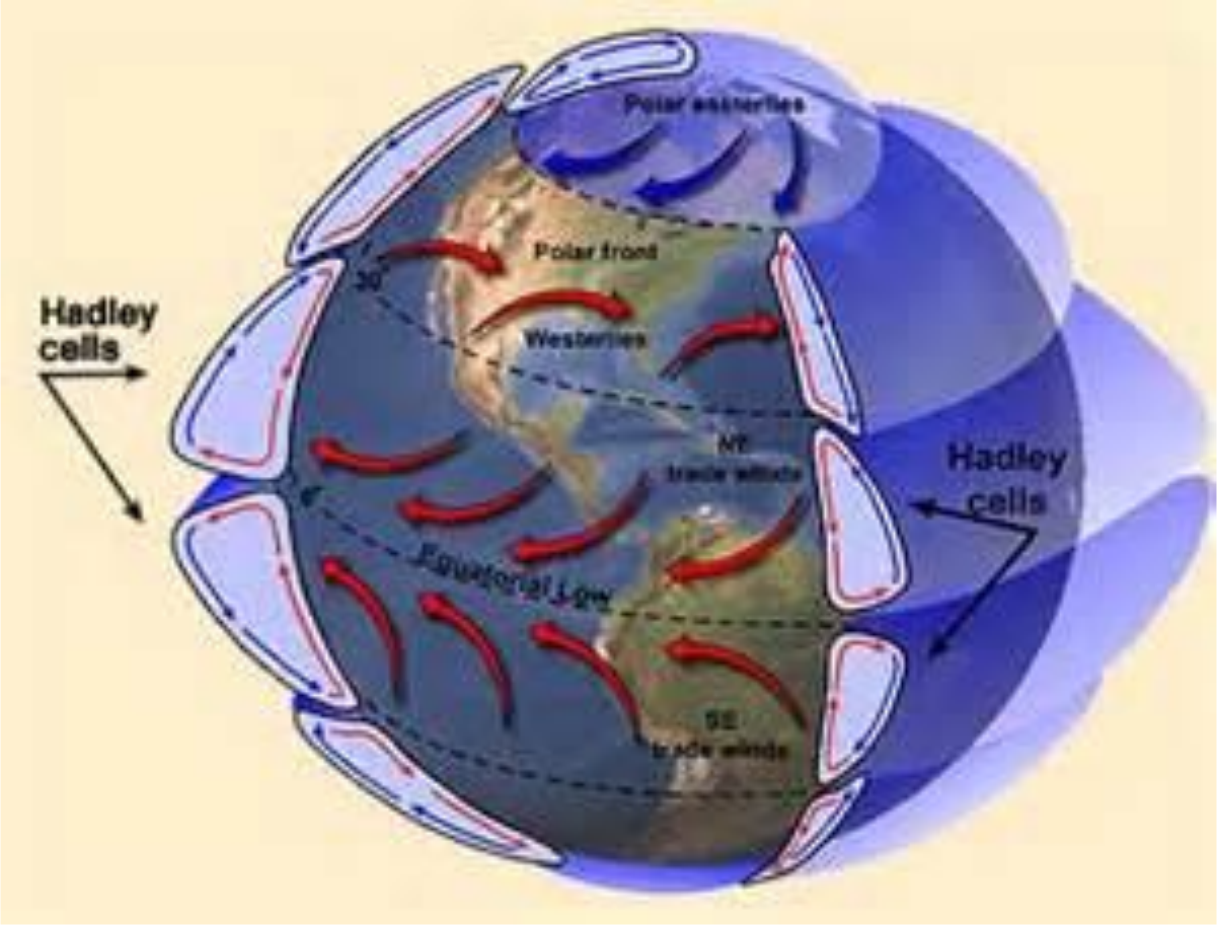
Quantitative Metrics for Better Business (& food security)

John Corbett Ph.D.

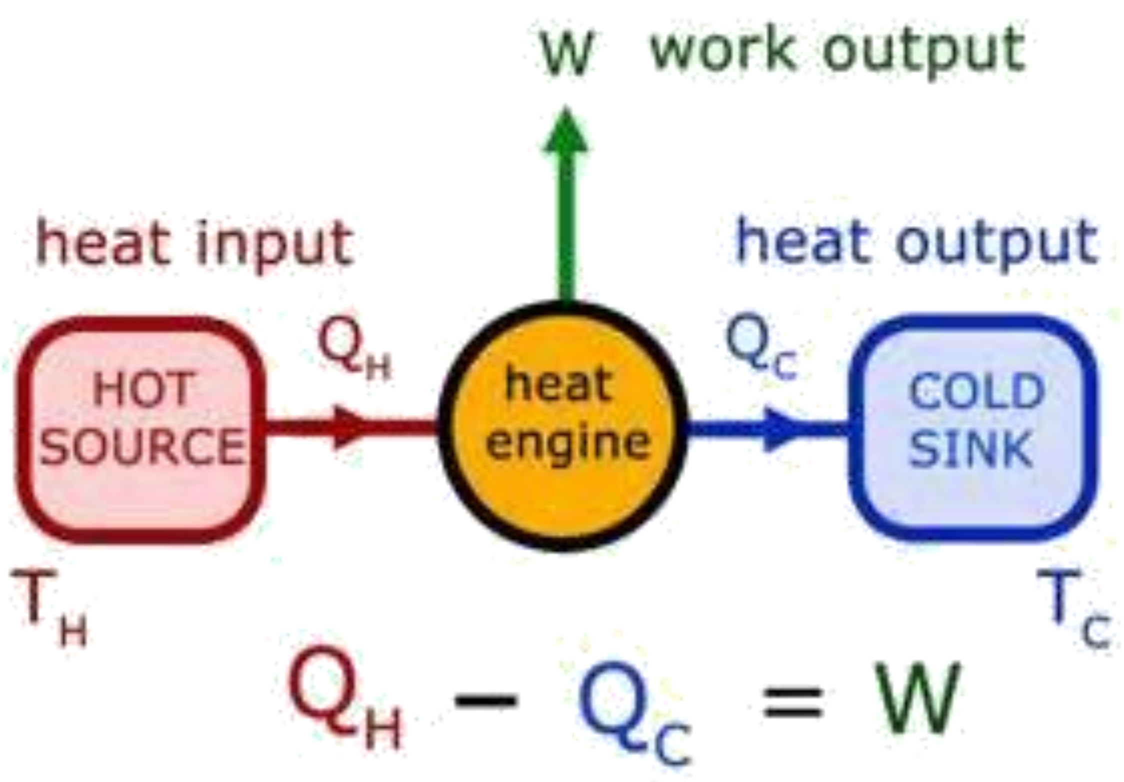
aWhere

The Problem

The Earth's Atmosphere is a Heat Engine… In transition



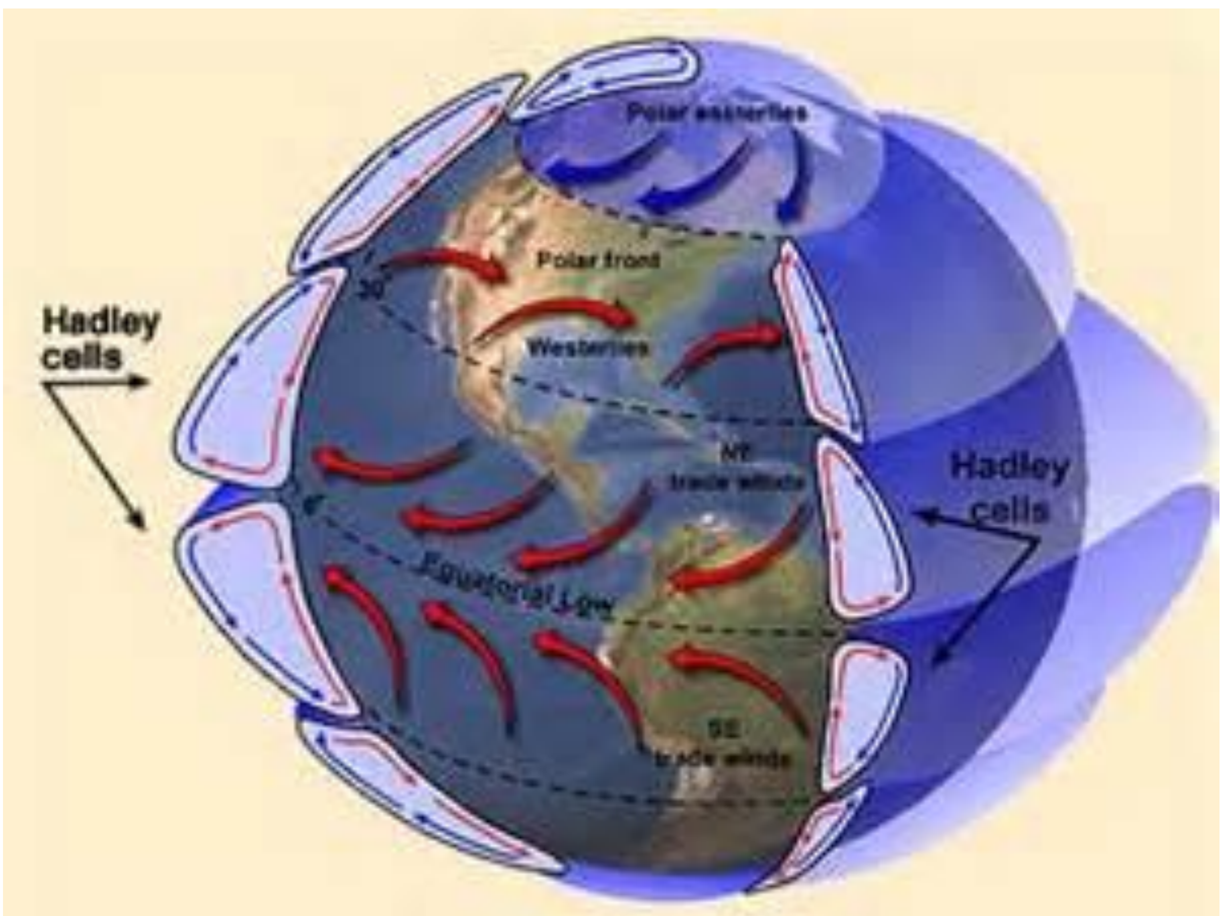
5.5 **Quadrillion Ton** Heat Engine



The Problem

1°C warming of atmosphere…
Triples weather variance

Warm gets warmer. *Cold gets colder.* *Dry gets dryer.* *Wet gets wetter.*



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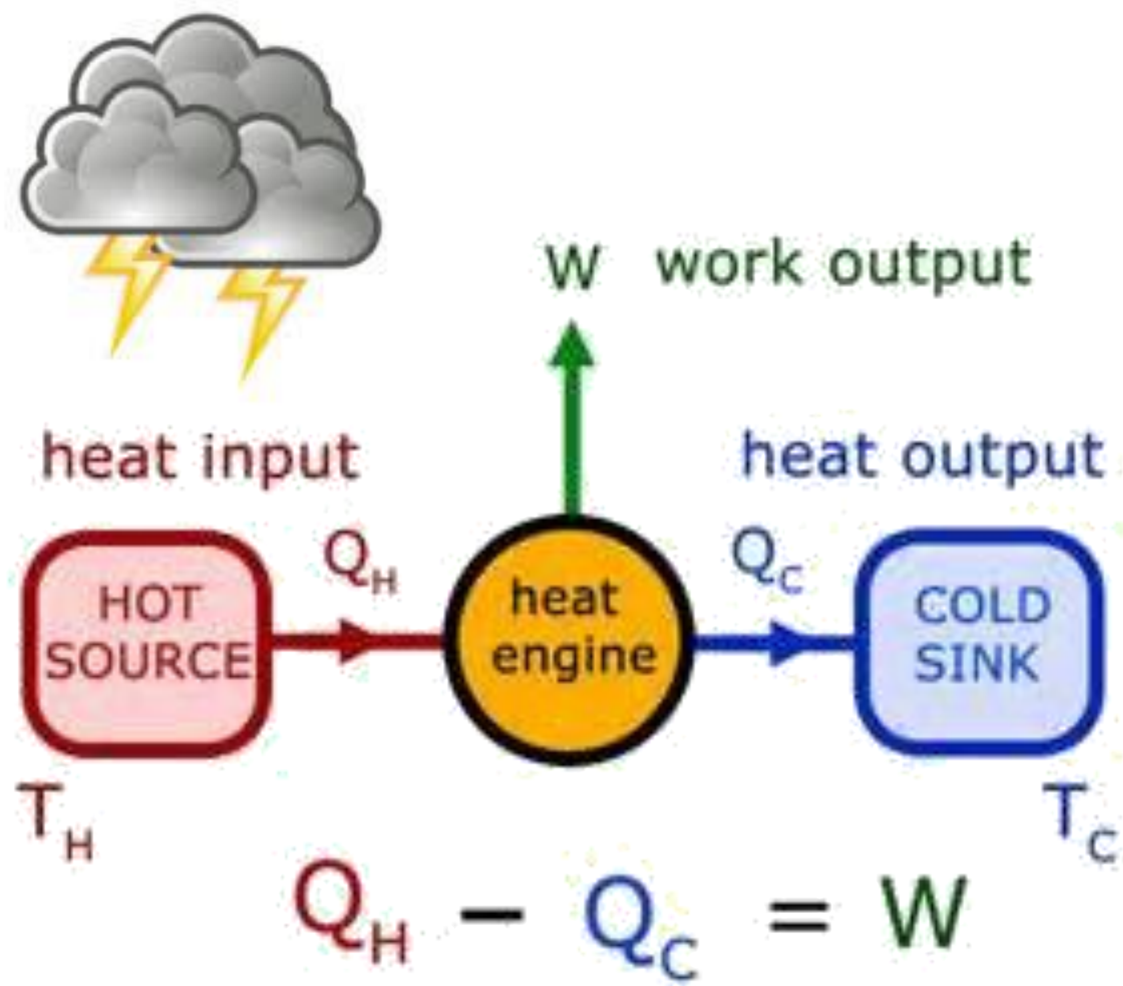


The Problem

1° of Warming:

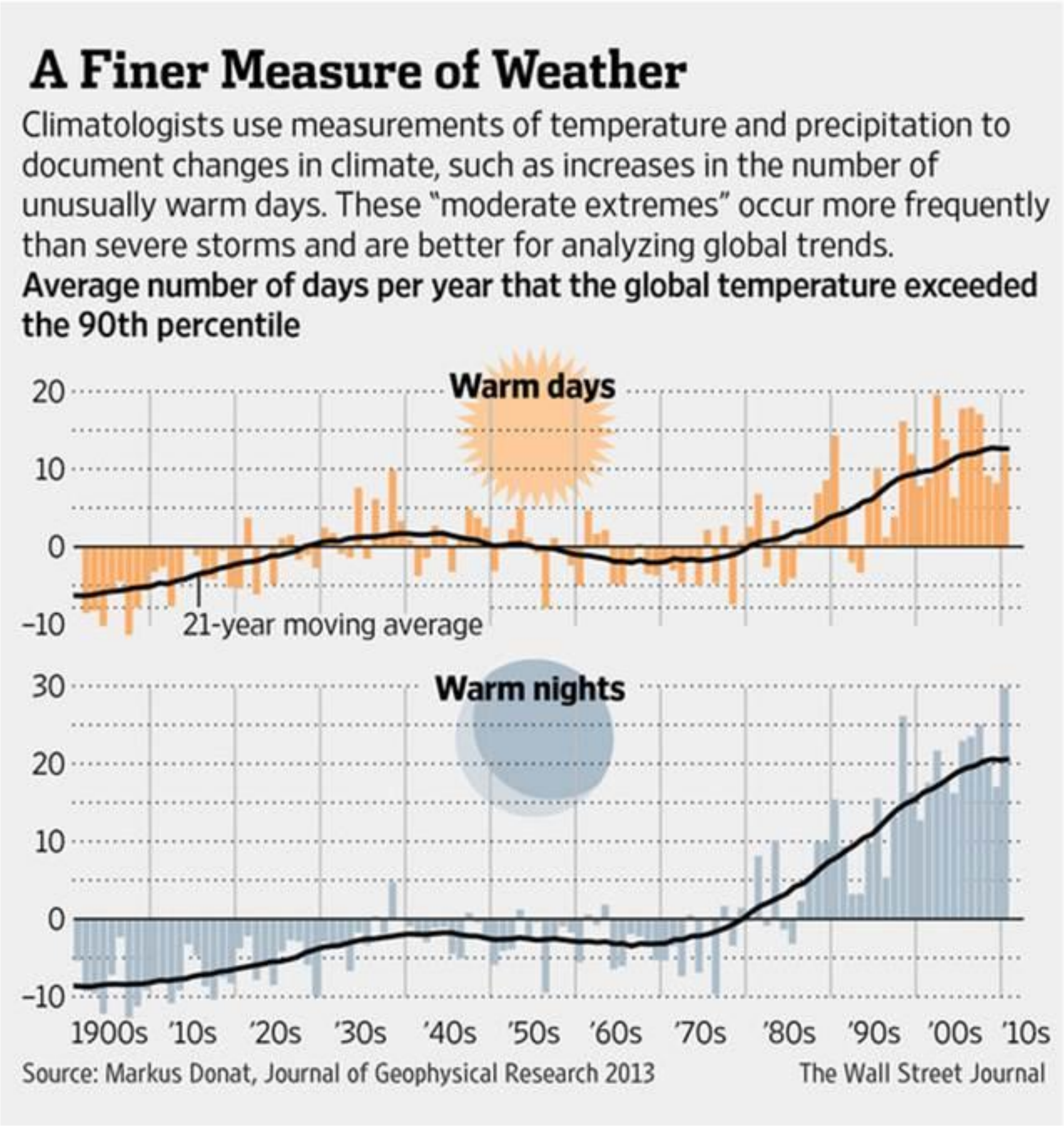
Extreme weather isn't the worst threat!

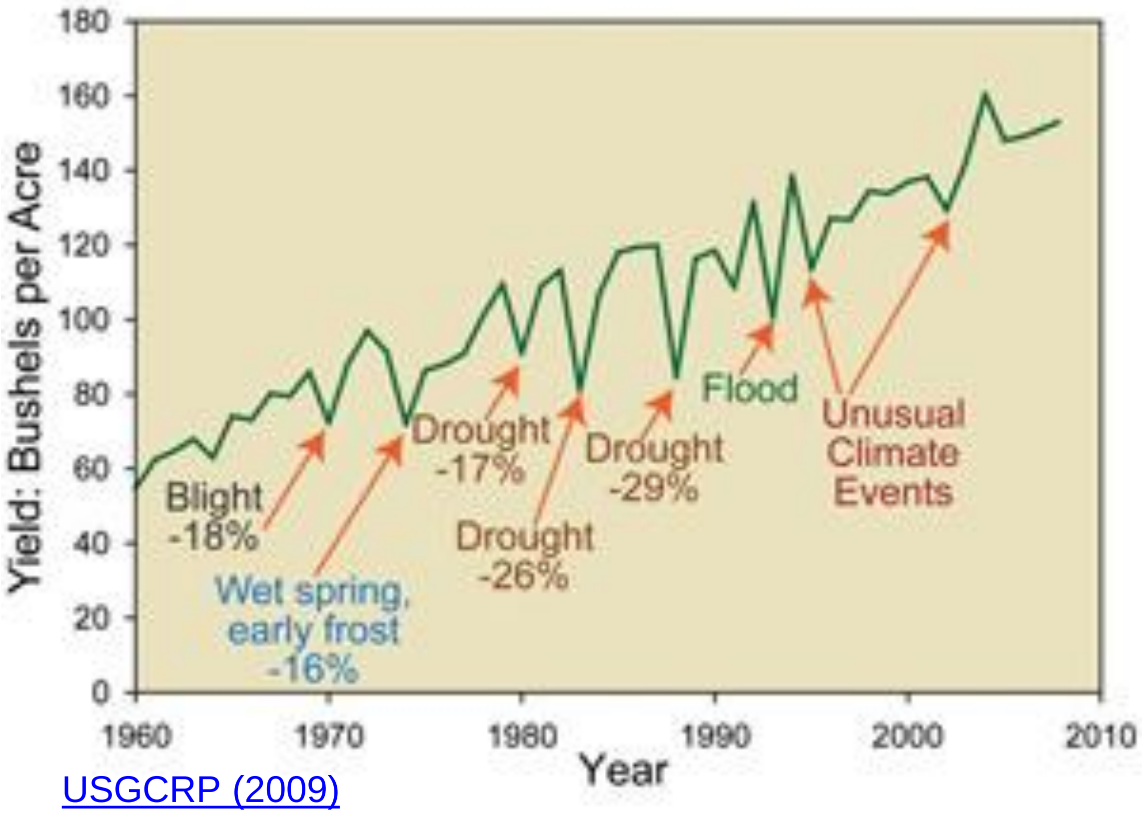
- Wall Street Journal

It's the subtle changes

e.g. "Warmer Nights"

- **Explosion of foliar diseases**
- **Viral, bacterial, fungal**



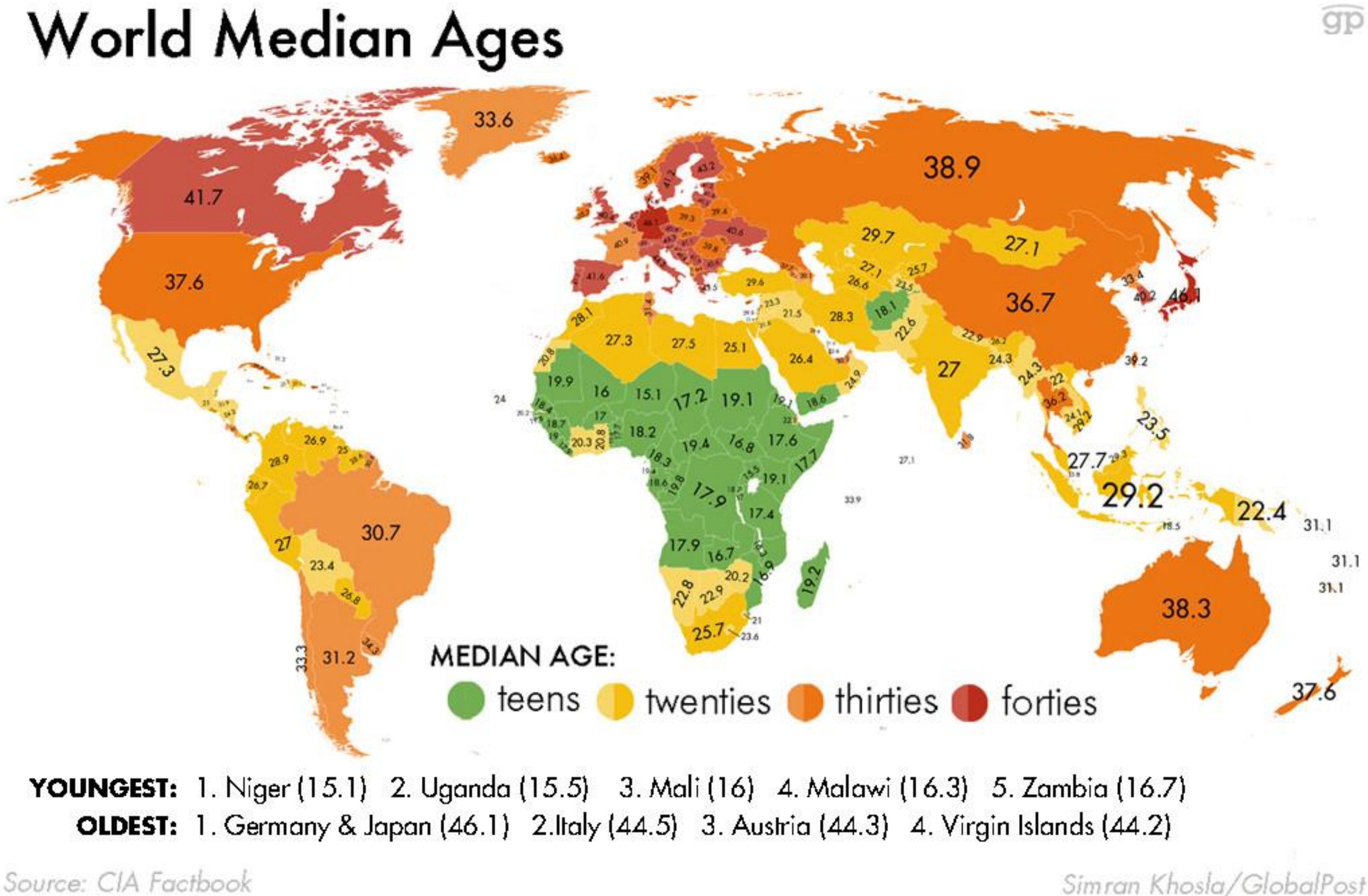


USGCRP (2009)

The Problem

By 2050, our population will gain another 2.4 billion people.

Source: United Nations Dept of Economic and Social Affairs



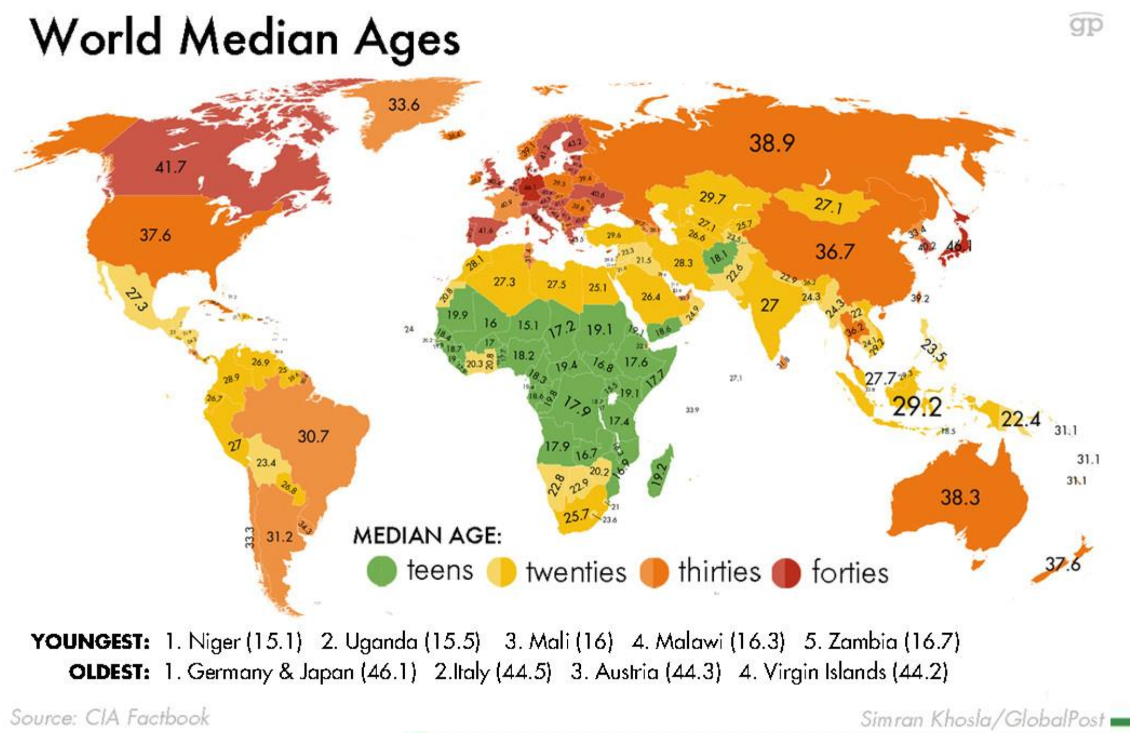
The Problem

By 2050, our population will gain another 2.4 billion people.

Source: United Nations Dept of Economic and Social Affairs

That means, **in just 35 growing seasons**, the world's **580 million farmers** must feed 9.6 billion while facing:

- Increased weather variability that renders traditional practices ineffective
- Lack of adequate and symmetrical data across the value chain
- Lack of field-level, actionable insight to prevent risk and improve production

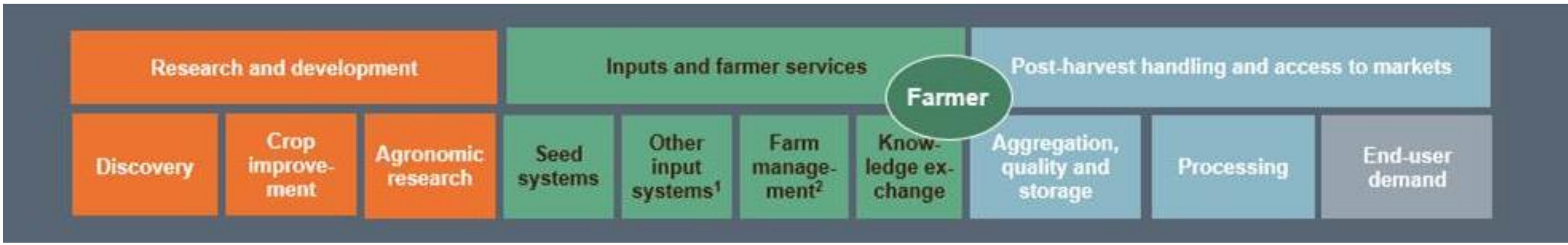


Granular data needed: Location and Time Specific

…a Big Data opportunity

Solution: Information!

Symmetrical information across the ag value chain ensures optimization

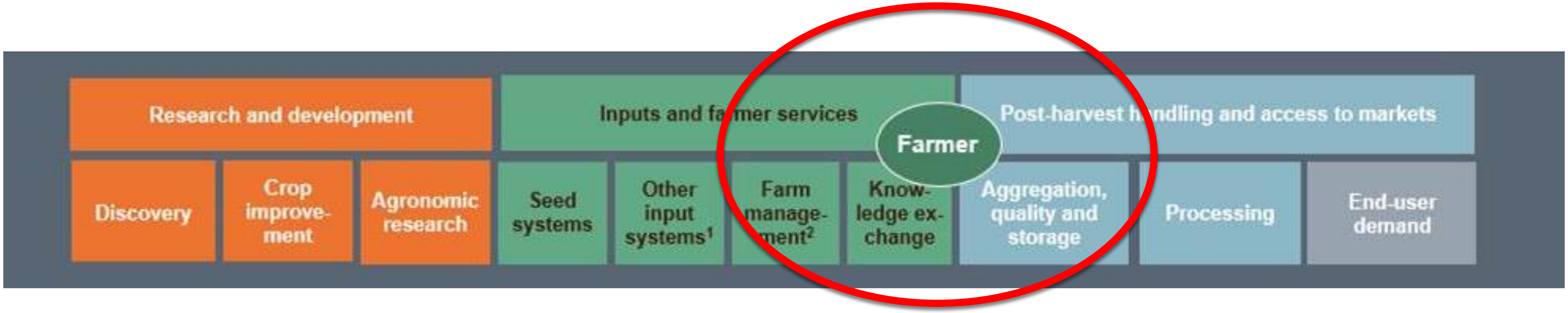


Agricultural value chain

agriculture VC's cannot function in isolation

Solution: Information!

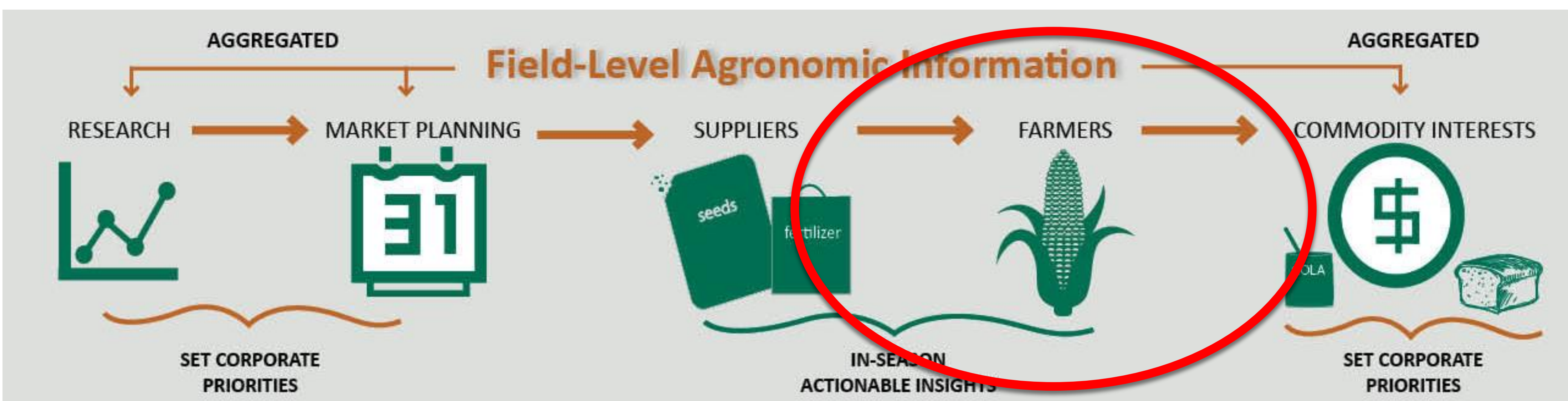
Symmetrical information across the ag value chain ensures optimization



Agricultural value chain

agriculture VC's cannot function in isolation

Target & Predict



Solution:
Localized Information!

Models
When and Where
to “do” X

Weather

Planning and pre-season - risk!

Monitor in-season

Target &
Predict

Satellite

Monitor and track

IoT - Internet of Things – sensors to monitor

Precision Ag

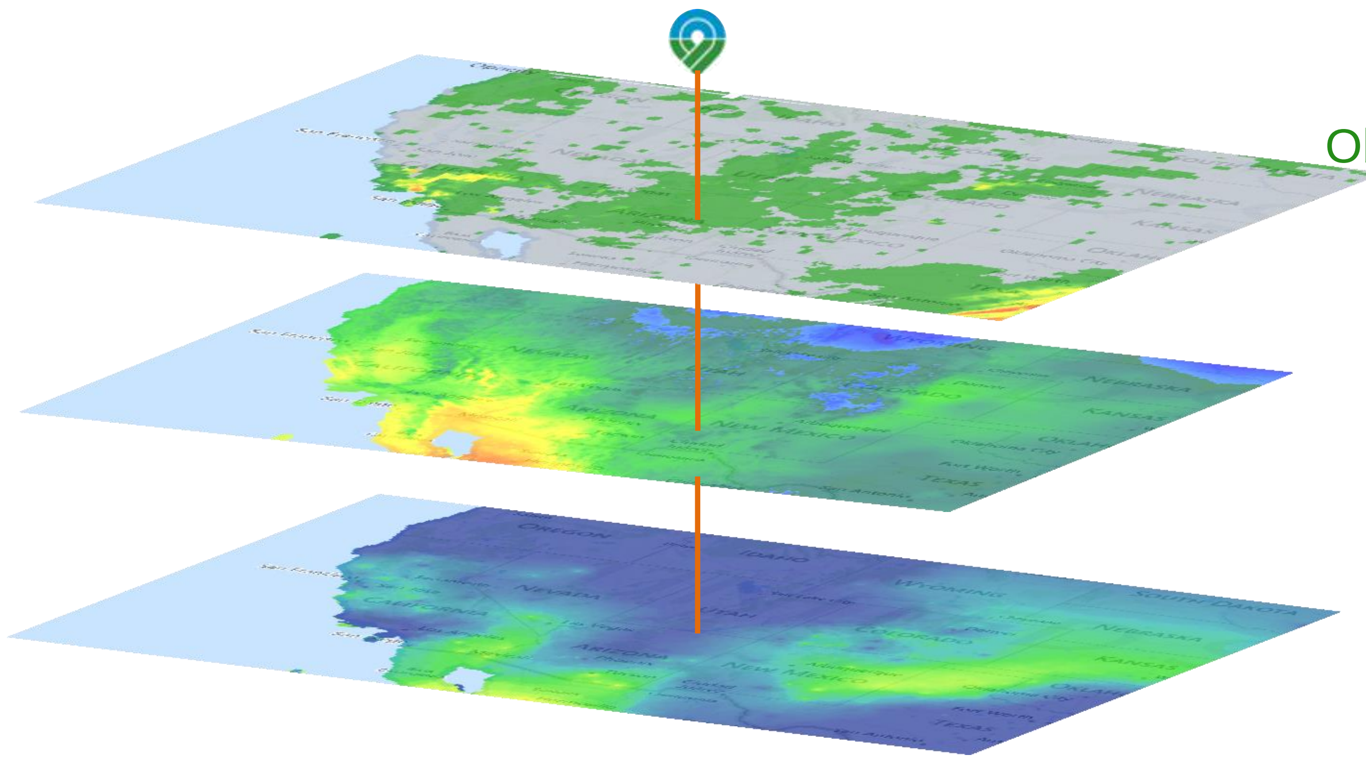
Cloud or ‘on-line’
24/7 access to info

Local Weather

Current Correct Consistent Complete – **4C's**
…and 100% of the time available on demand!

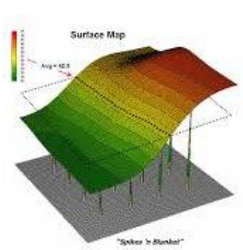
Weather Station Observations

Satellite Observations



Ground Radar

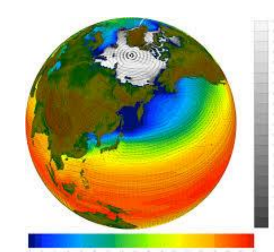
User Feedback



Spatial Interpolation Models

Download to Excel or Connect by API

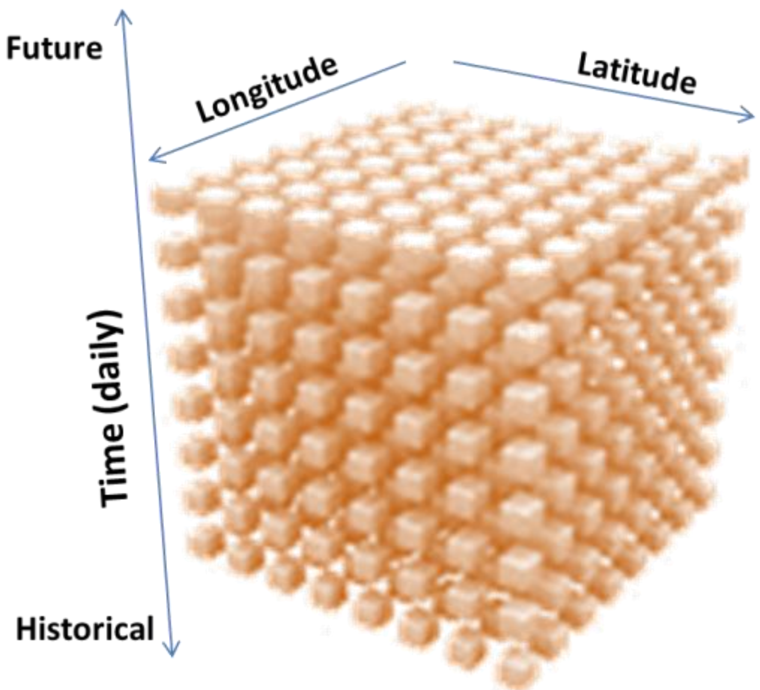
- Calculated weather risk,
- Model expected yield (crop/forage)
- Examine various weather stresses
- Simulate effective/adaptive management…



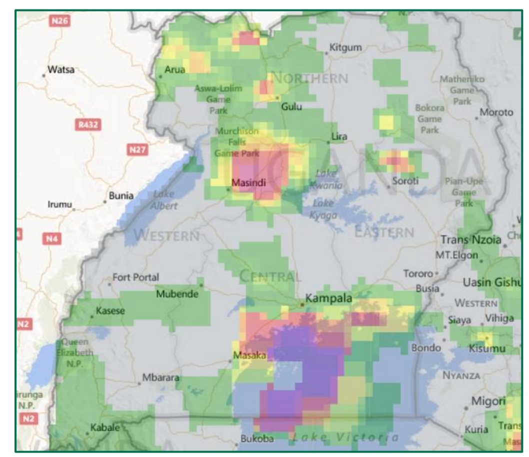
Global Forecast Models

Local Weather

Spatially-coherent weather, particularly rainfall, provides tremendous insight



Map View
Uganda Rainfall,
February 3, 2014



Satellite with ground station calibration

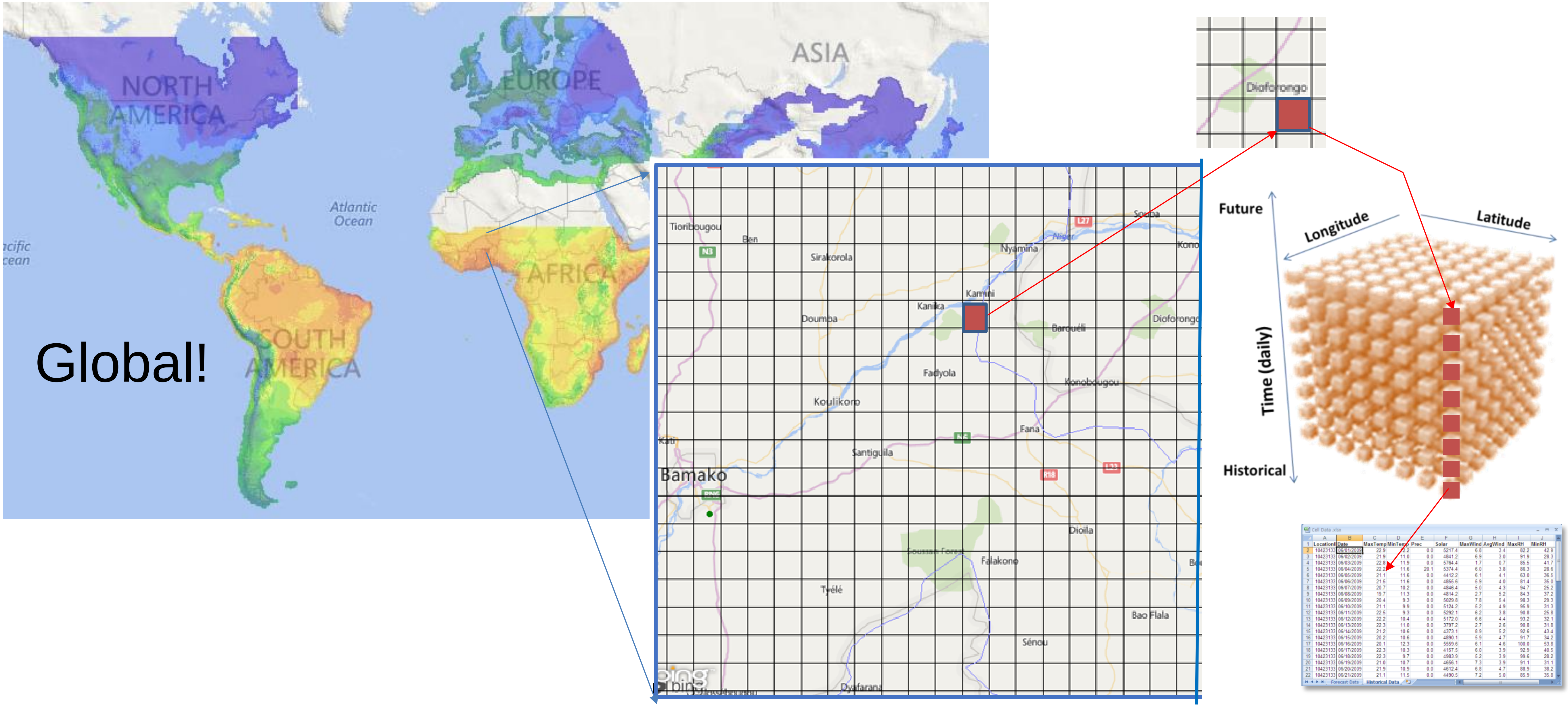
One day of gridded rainfall becomes a single gridded layer in the database.

Database includes:

- Intermediate Forecast (hourly and daily to 8-days, conditions)
- Daily Observed (Precipitation, temperature, humidity, windspeed, solar radiation)
- Daily Historical (Observed daily data for at least 10 years)
- Agronomic Models (Pest and Disease, Growing Degree Days)

Local Weather

Like having a complete meteorological station every **9 km**



Minimum Temperature • **Maximum Temperature** • **Precipitation** • **Minimum Relative Humidity**

Maximum Relative Humidity • **Solar Radiation** • **Wind Speed** • **Wind Direction** • **PET** • **GDD**

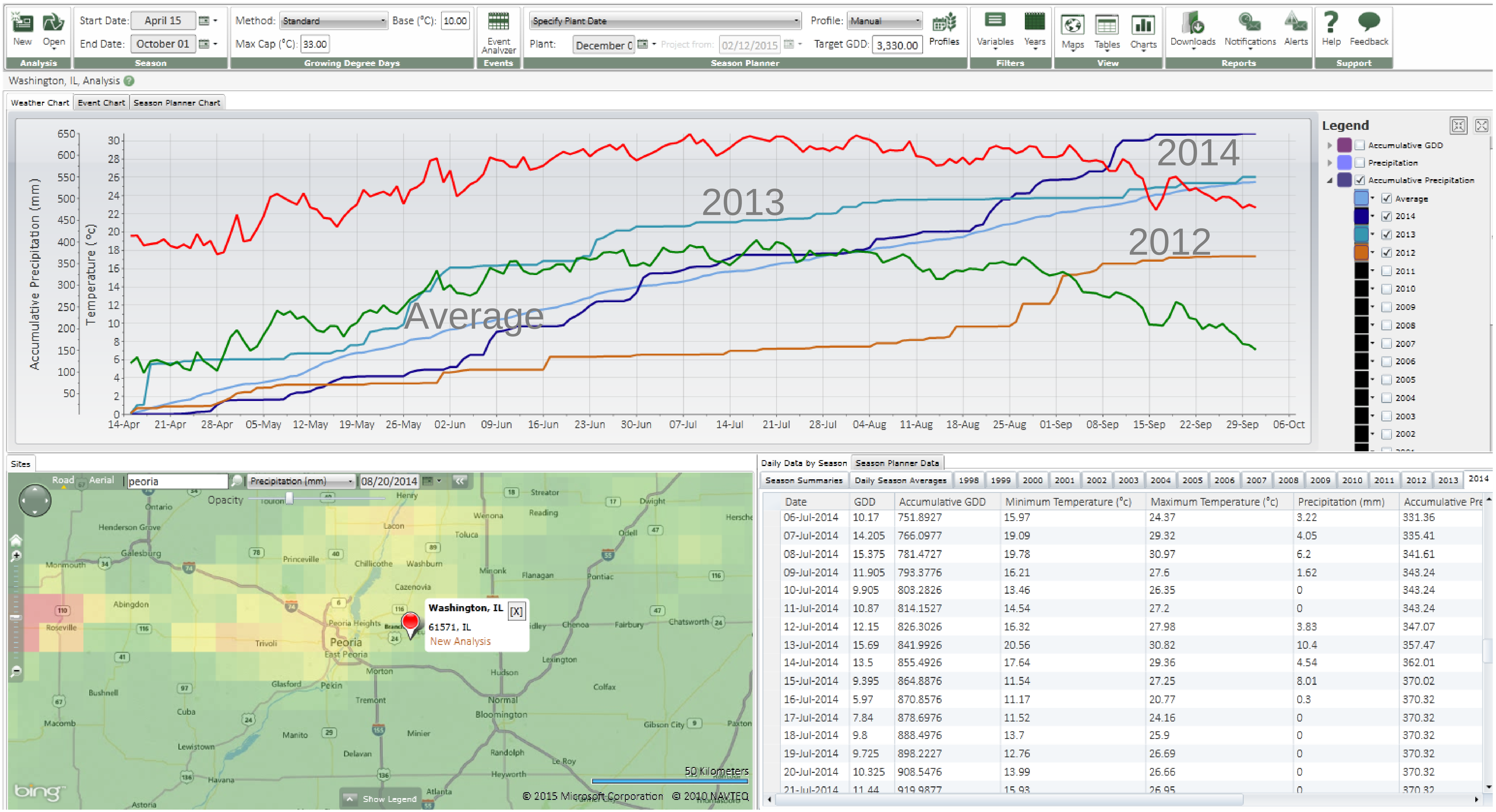
Local Weather

Ag Weather
vs "Most Weather"

- **Most** weather sources are 'for anywhere' & not Agriculturally focused
- **Ag Weather**: Optimized for ag-geographies during growing seasons
  - Improved accuracy and more relevant
  - Statistics not "watered down" by non-relevant areas
  - Utilize sensor technologies = commodity weather stations, IoT
  - API's for agronomic attributes for utilization across the ag value chain

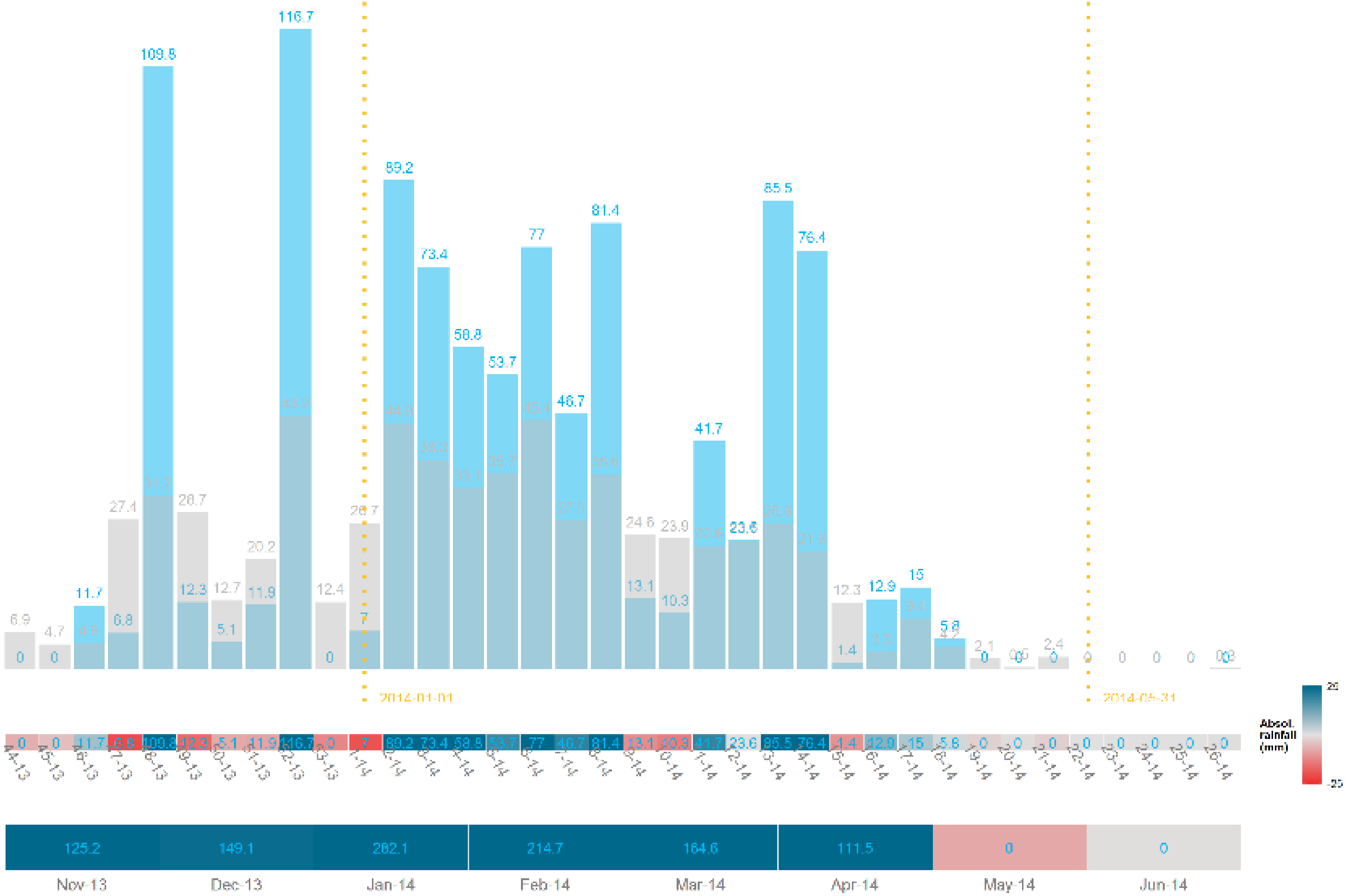
Tools – Environmental Assessment: Risk

Just east of Peoria, Illinois: 2014, 2013, 2012 and LTN precipitation, April 15-September 30



Augment existing knowledge with real-time, current monitoring

Applications – direct calls (API) or via Excel optimized for your business



Field by field
Day by day
Week by week
Over seasons &
Over Years

Risk
Opportunity

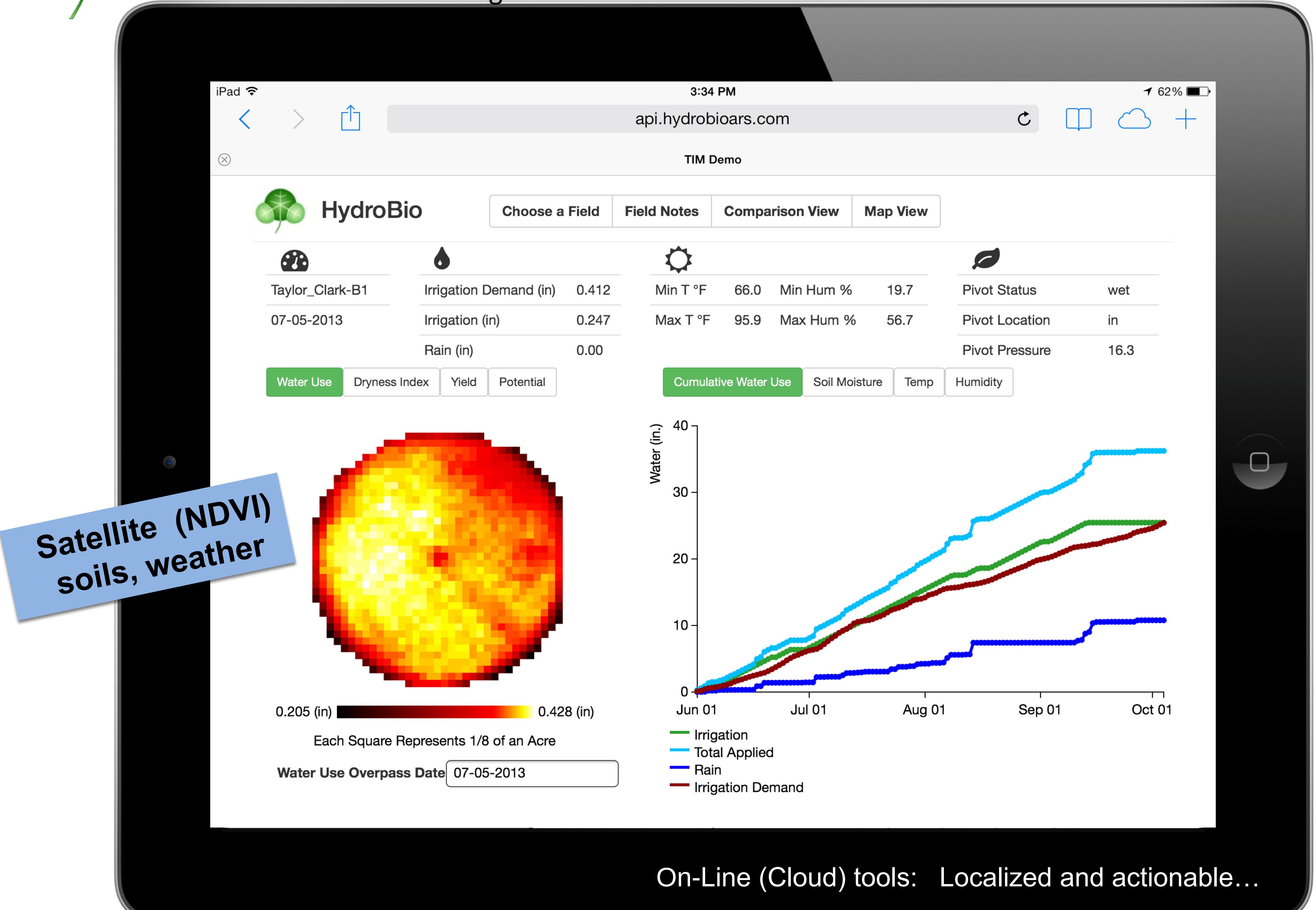
Bond to your grower customers

Support your Agents

Give 'Extension' real authority!

Songea Ruvuma, Tanzania

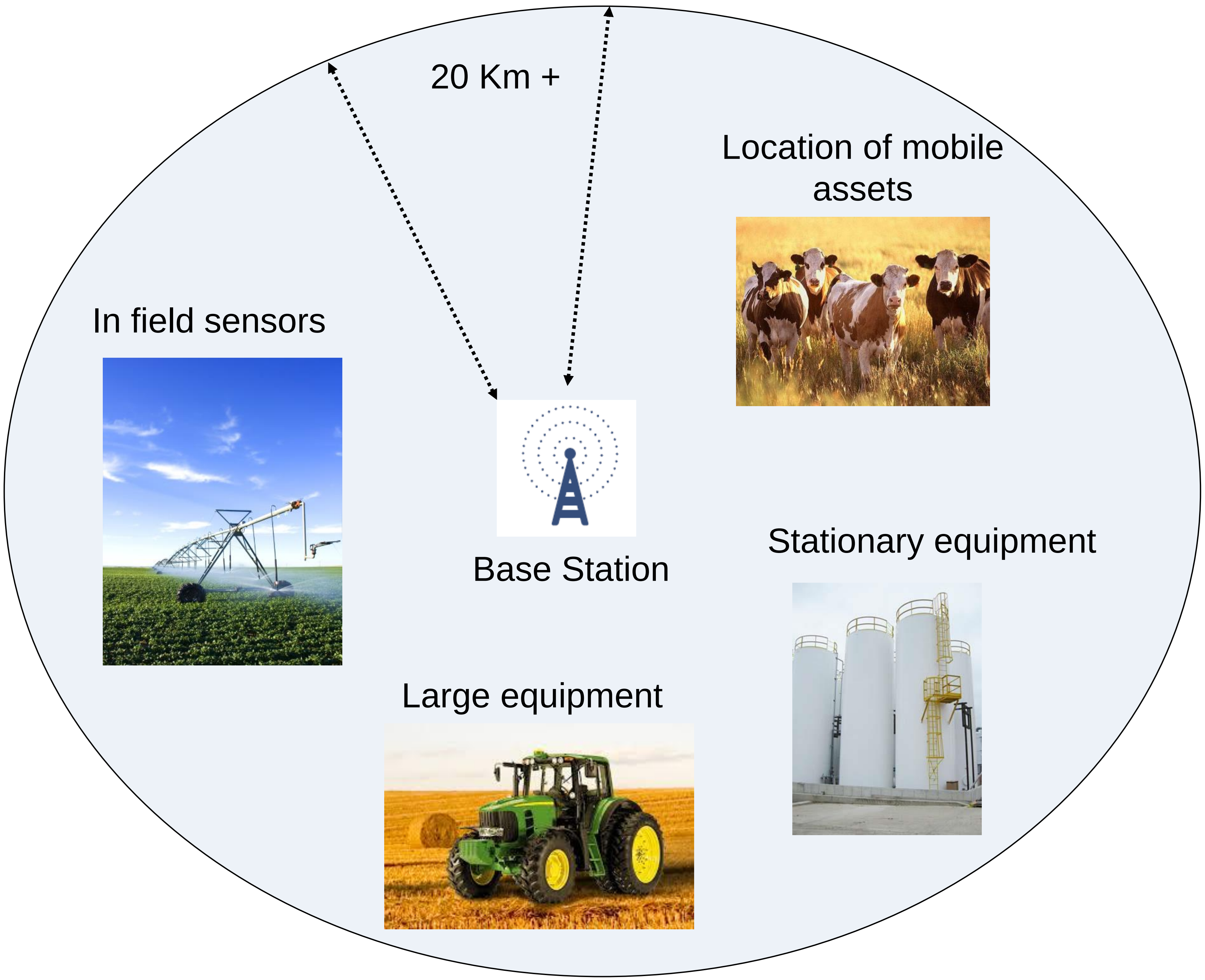
Decision driving applications



On-Line (Cloud) tools: Localized and actionable…

NWave IoT LPWANs – Smart Agriculture

…sensors to observe



Smart Farming

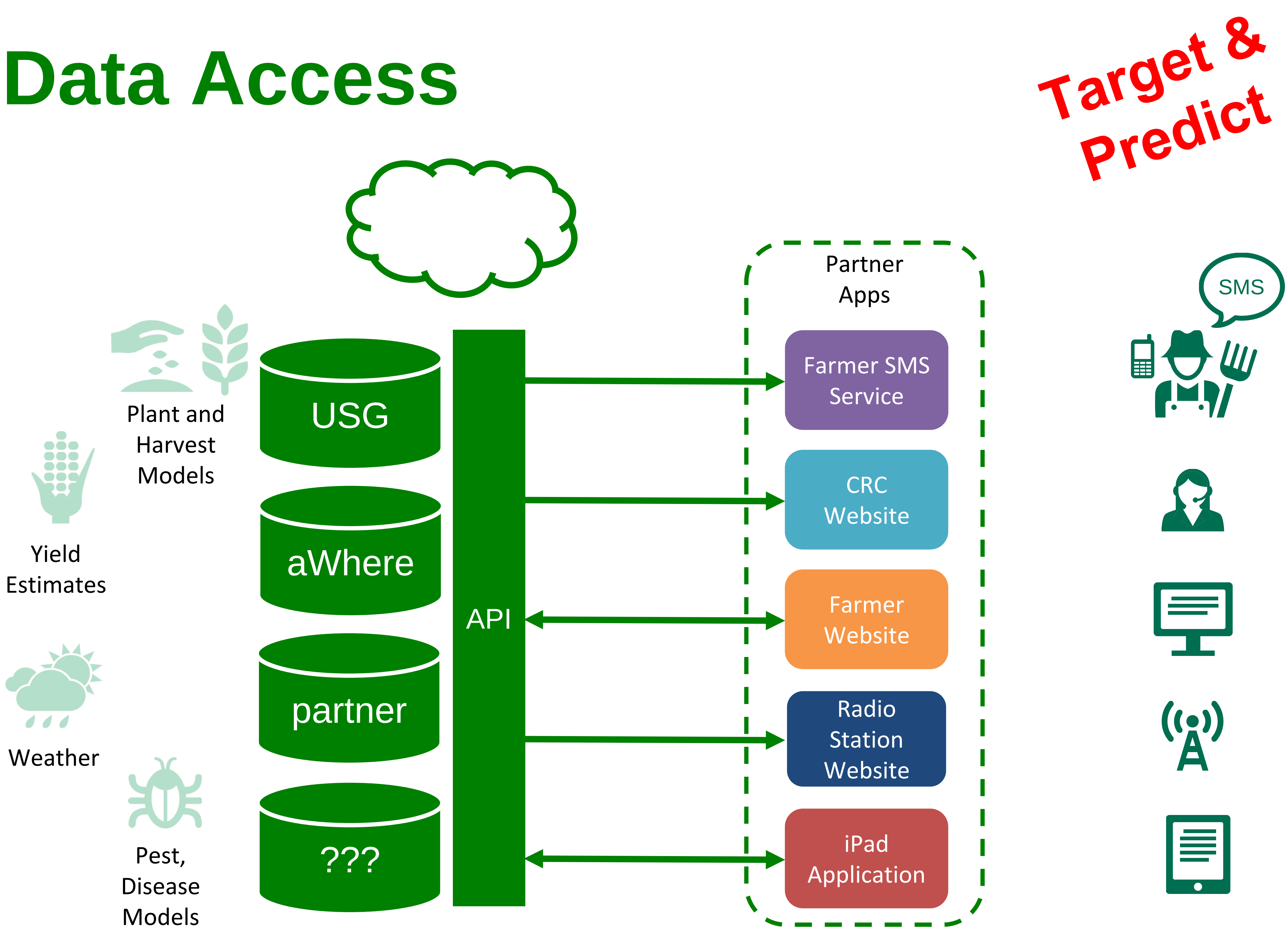
Using NWave IoT LPWANs enable cost effective deployment of multitude of IoT sensors that measure information from any place or of anything In order to increase the efficiency of faming

Multi-directional data

- **Tailored by the grower (crop, variety, date planted…) - real-time hyper local weather and agronomic data delivered to grower, input providers, research organizations government, buyers –
through API, widgets, and applications**

ICT’s

Data Access


Target &
Predict
Plant and Harvest Models
Yield Estimates
Weather
Pest, Disease Models
USG
aWhere
partner
???
API
Partner Apps
Farmer SMS Service
CRC Website
Farmer Website
Radio Station Website
iPad Application
SMS

Value across agricultural value chain

…since all of this can be done for the farm & field then:

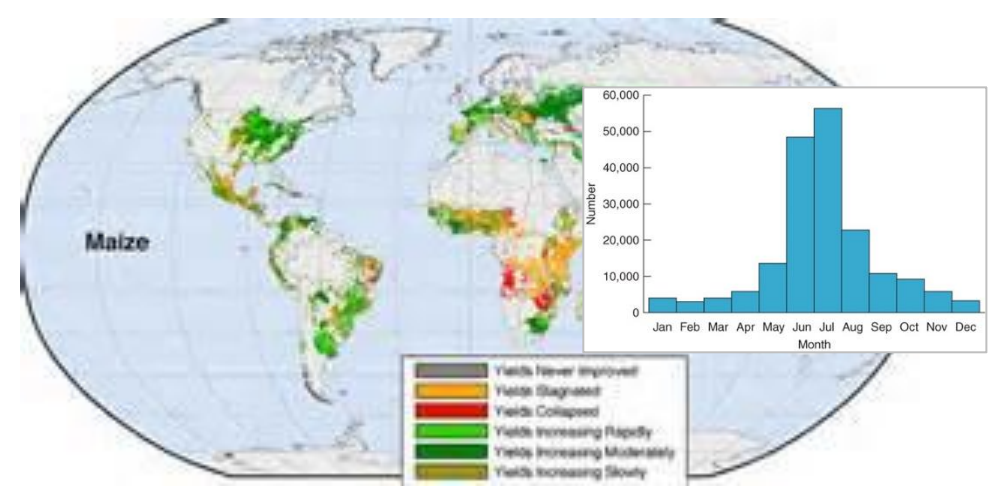
…for a more wildly changing environment

Research priorities can be better articulated
Input providers (i.e., crop protection and fertilizer) informed
Markets optimized

Spatial Characterization

Target & Predict

- ## The Problem
  - How to dynamically query and map areas of similar weather and pest/disease characteristics globally or regionally
  - Seamlessly develop, train and translate agronomic scientific knowledge into operational systems
- ## The Action
  - Use big data technologies to dynamically mine and query Local Weather database identify areas of similarity .
  - Run R in the Hadoop environment allowing iterative development of models on large datasets, deployment across broader geographies, operational runs of models.
- ## The Applications
  - Dynamic agro-ecological zones
  - Commodity analysis
  - Suitability zone mapping

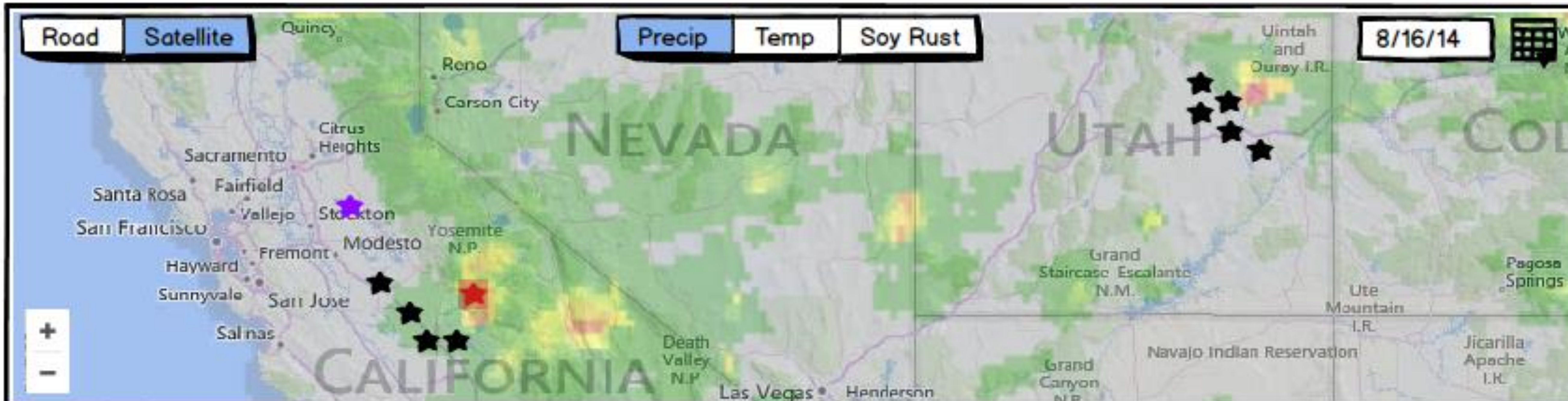


aWhere Field Dashboard

Import

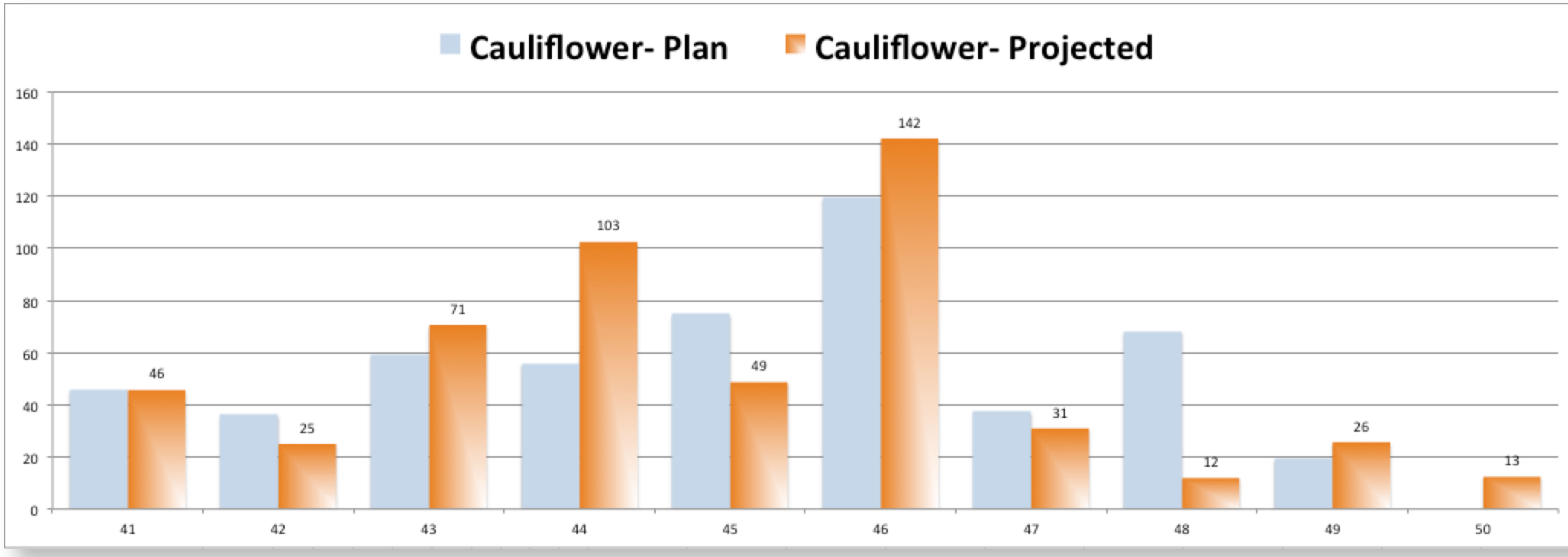
Field Mgr: Robert Palmer

Farm Info				Crop Info					Projections 7/31/14				
Farm	Field/ Plot ID	Sub Plot	Plot Size	Crop	Variety	Target Event	Plant Date	Original Target Date	Alerts	Projected Date	Event Window	Days to Go	Days Early/Late
BF	3405			Cauliflower	ABSOLUTE	Harvest	07/09/14	09/19/14		09/15/14	5	46	-4
BF	2005	B		Romain	INFERNO	Harvest	07/09/14	09/22/14		09/19/14	5	50	-3
BF	4405			Cauliflower	ABSOLUTE	Harvest	07/15/14	09/23/14		09/19/14	3	50	-4
BF	2005	C		Romain	SPARX	Harvest	07/09/14	09/22/14	Rust	09/20/14	3	51	-2
BF	2101			Cauliflower	ABSOLUTE	Harvest	07/18/14	09/26/14		09/21/14	5	52	-5
BF	2004	D		Romain	GRN THUNDER	Harvest	07/09/14	09/22/14		09/22/14	5	53	0
BF	3404			Cauliflower	ABSOLUTE	Harvest	07/16/14	09/26/14		09/22/14	5	53	-4
OF	1201			Cauliflower	ABSOLUTE	Harvest	07/24/14	09/30/14	Warm!	09/22/14	11	53	-8
BF	4602			Cauliflower	ABSOLUTE	Harvest	07/23/14	09/29/14		09/24/14	3	55	-5
BF	2005	A		Romain	GRN THUNDER	Harvest	07/09/14	09/22/14		09/25/14	3	56	3
OF	703	A		Broccoli	AVENGER	Harvest	07/20/14	10/02/14	Warm!	09/25/14	9	56	-7
BF	2102			Cauliflower	ABSOLUTE	Harvest	07/25/14	10/01/14		09/26/14	5	57	-5
BF	2006	A		Romain	INFERNO	Harvest	07/19/14	09/29/14		09/30/14	5	61	1
BF	3020			Cauliflower	ABSOLUTE	Harvest	07/29/14	10/05/14		10/01/14	4	62	-4
BF	4603			Cauliflower	ABSOLUTE	Harvest	07/30/14	10/06/14		10/01/14	5	62	-5
AMN	5718			Cauliflower	ABSOLUTE	Harvest	07/13/14	09/21/14	Cool!	10/01/14	13	62	10
BF	2005	D		Romain	GRN THUNDER	Harvest	07/19/14	09/29/14		10/02/14	4	63	3

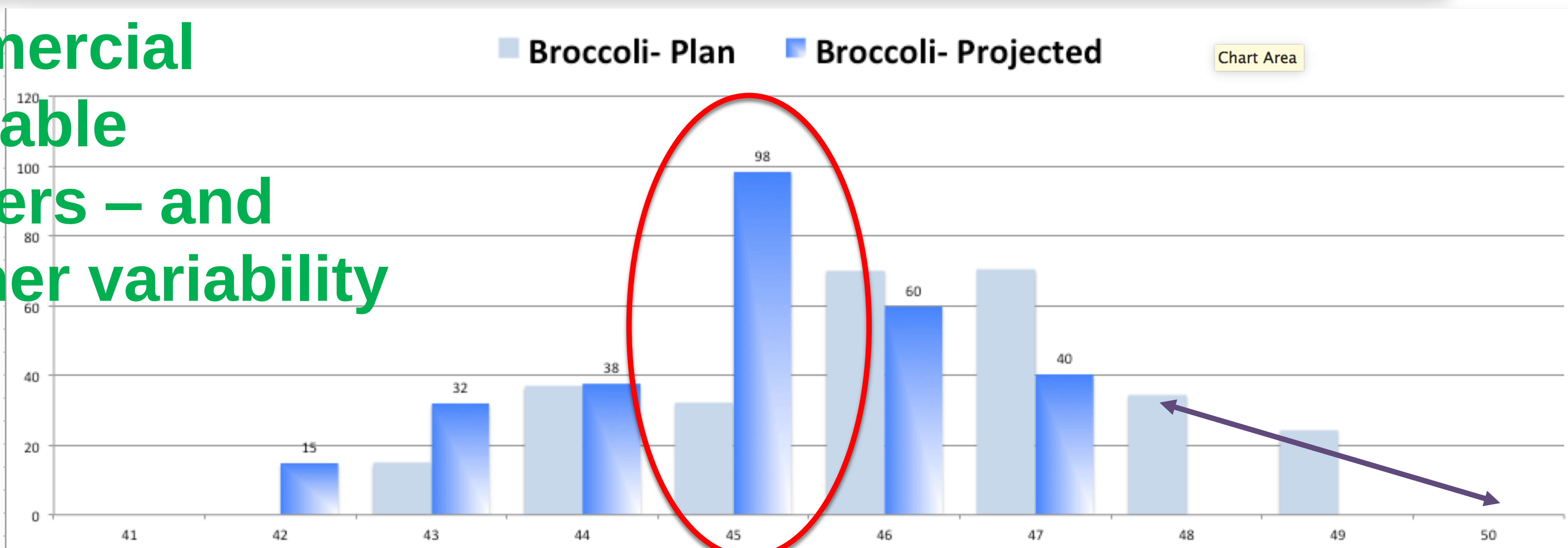


Prediction: veg crop, by variety, by plant date and location

Number of acres to harvest: Plan vs. Actual



Commercial Vegetable Growers – and weather variability



For example: Central IL (Peoria!)

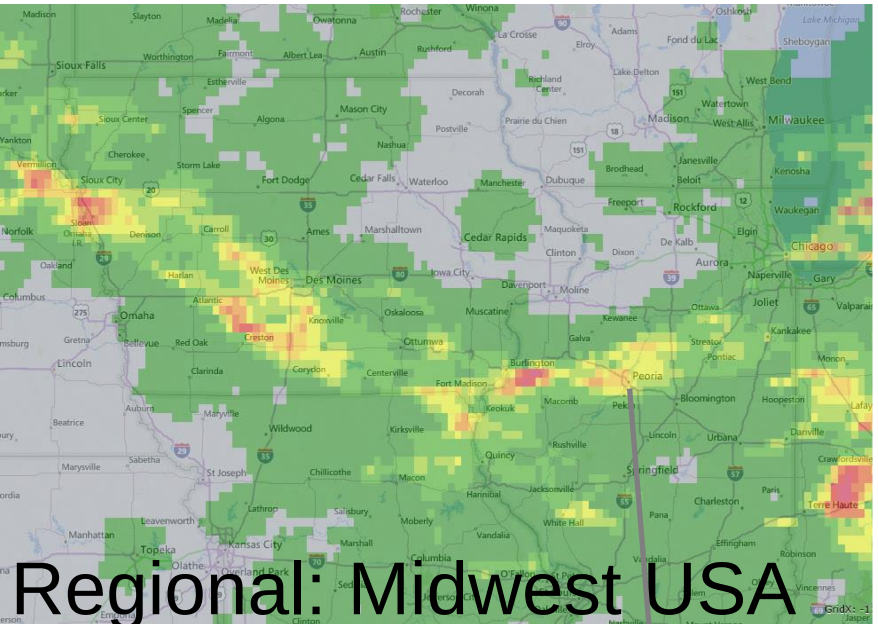
Number farms by county

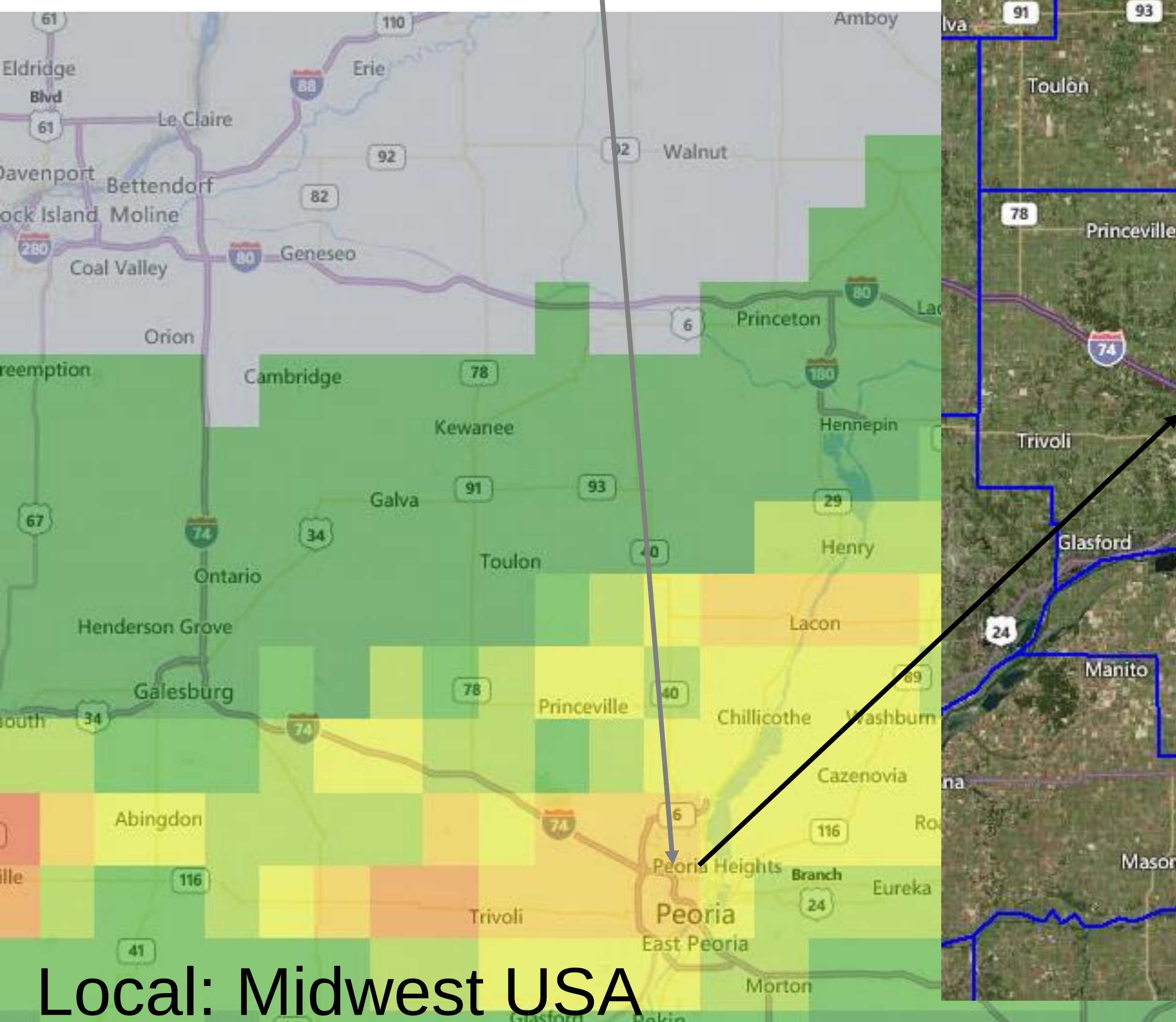
Number acres under which crop

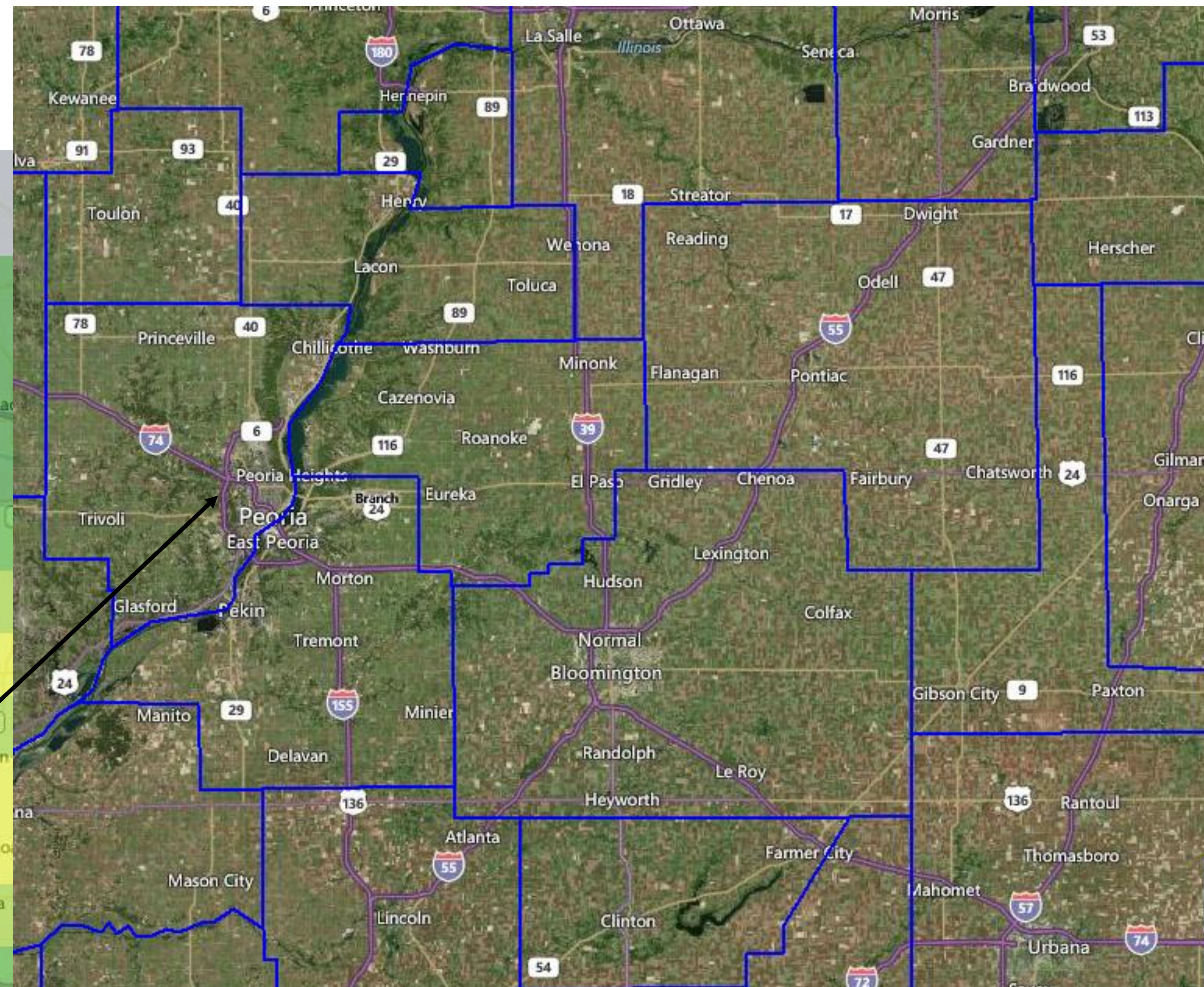
…input volume (crop protection, fertilizer)

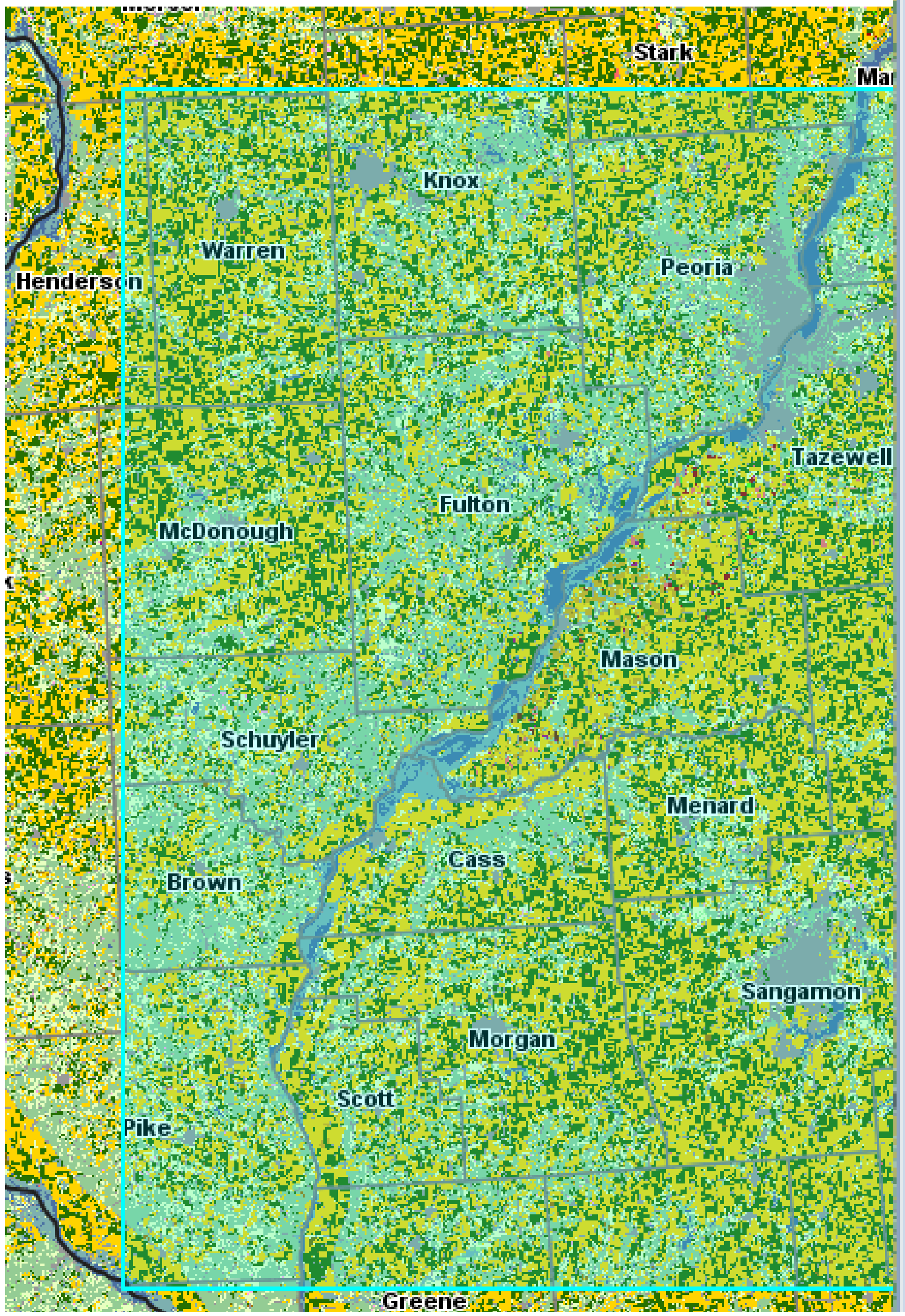
…how much produced?? (tons)

with localized weather, satellite









2014 Cropland Data Layer Statistics for the Defined Area of Interest

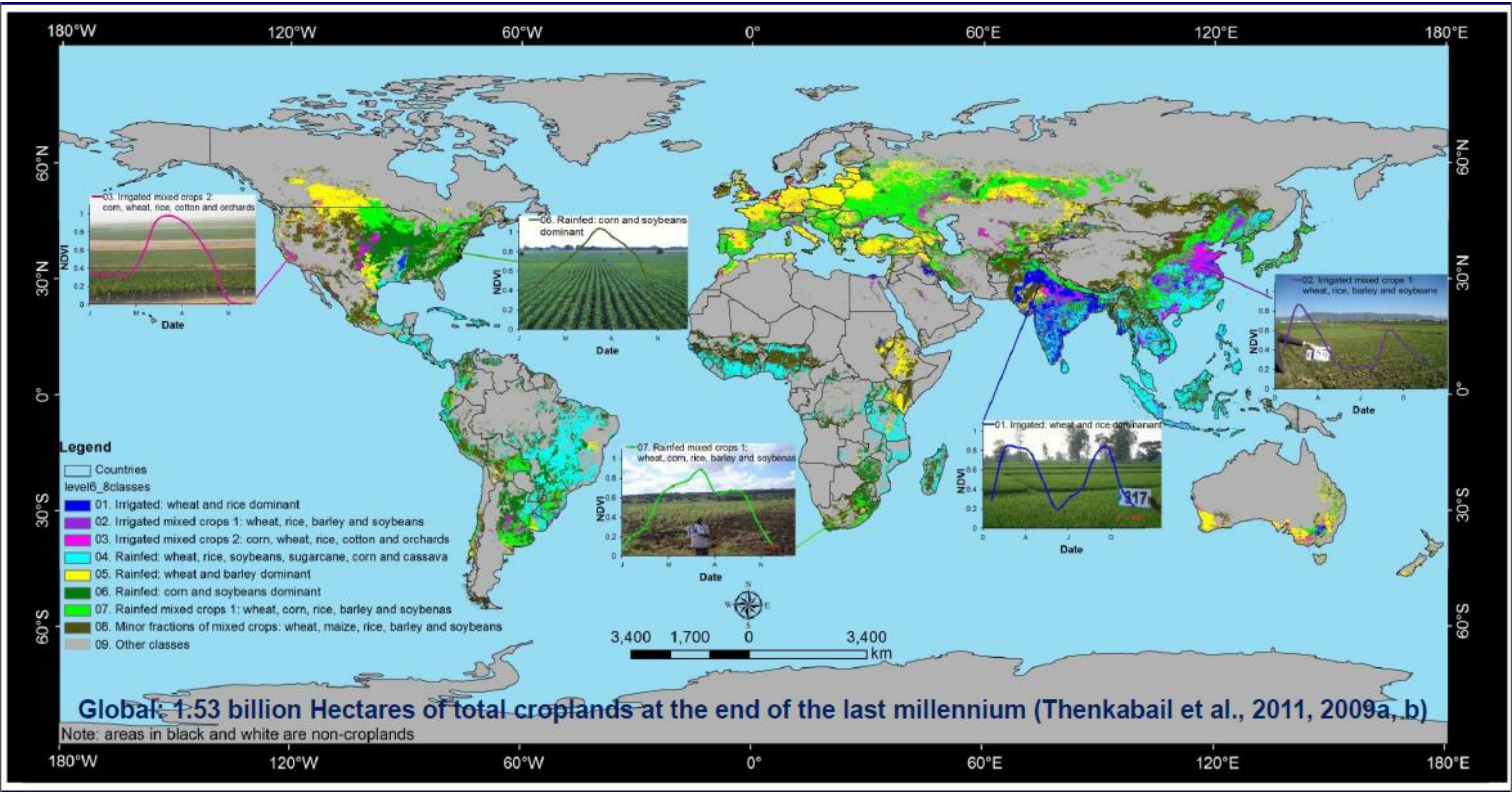
Display Crop Categories Only

Value	Category	Pixel Counts	Acreage
1	Corn	19826761	4409365.5
4	Sorghum	590	131.2
5	Soybeans	15860643	3527322.1
6	Sunflowers	418	93
11	Tobacco	2	0.4
12	Sweet Corn	6173	1372.8
13	Pop or Orn Corn	127435	28340.9
21	Barley	87	19.3
23	Spring Wheat	46	10.2
24	Winter Wheat	134598	29933.9
26	Dbl Crop WinWht/Soybeans	31800	7072.1
27	Rye	5107	1135.8
28	Oats	4343	965.9
29	Millet	13	2.9
36	Alfalfa	131625	29272.7
37	Other Hay/Non Alfalfa	36636	8147.7
39	Buckwheat	223	49.6
		13640	3033.5

FROM-GC: 30 m global cropland extent derived through multisource data integration

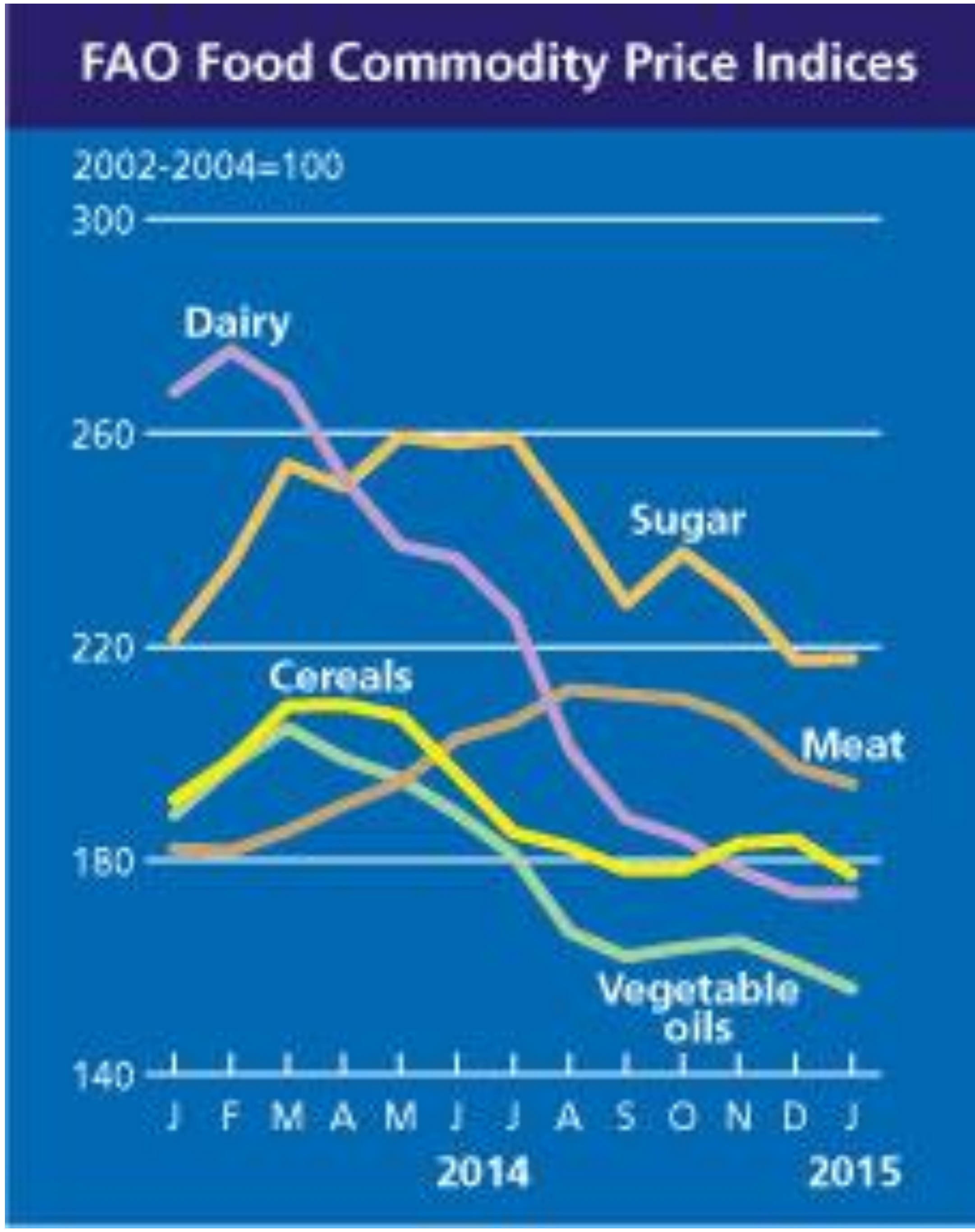
Le Yu[a], Jie Wang[b], Nicholas Clinton[a], Qinchuan Xin[a], Liheng Zhong[c], Yanlei Chen[c] and Peng Gong[a,b,c*]

Global Cropland Area Database @ 30m (GCAD30)



Global Food Supply & Price Risk Management

What to expect in 2015?



FAO food price index

		Food Price Index [1]	Meat [2]	Dairy [3]	Cereals [4]	Vegetable Oils [5]	Sugar [6]
2000		**91.1**	96.5	95.3	85.8	69.5	116.1
2001		**94.6**	100.1	105.5	86.8	67.2	122.6
2002		**89.6**	89.9	80.9	93.7	87.4	97.8
2003		**97.7**	95.9	95.6	99.2	100.6	100.6
2004		**112.7**	114.2	123.5	107.1	111.9	101.7
2005		**118.0**	123.7	135.2	101.3	102.7	140.3
2006		**127.2**	120.9	129.7	118.9	112.7	209.6
2007		**161.4**	130.8	219.1	163.4	172.0	143.0
2008		**201.4**	160.7	223.1	232.1	227.1	181.6
2009		**160.3**	141.3	148.6	170.2	152.8	257.3
2010		**188.0**	158.3	206.6	179.2	197.4	302.0
2011		**229.9**	183.3	229.5	240.9	254.5	368.9
2012		**213.3**	182.0	193.6	236.1	223.9	305.7
2013		**209.8**	184.1	242.7	219.3	193.0	251.0
2014		**201.8**	198.3	224.1	191.9	181.1	241.2
2014	January	**203.2**	182.2	267.7	191.4	188.6	221.7
	February	**208.6**	181.8	275.4	198.6	197.8	235.4
	March	**213.8**	185.5	268.5	208.9	204.8	254.0
	April	**211.5**	190.4	251.5	209.2	199.0	249.9
	May	**210.4**	194.6	238.9	207.0	195.3	259.3
	June	**208.9**	202.8	236.5	196.1	188.8	258.0
	July	**204.3**	205.9	226.1	185.2	181.1	259.1
	August	**198.3**	212.0	200.8	182.5	166.6	244.3
	September	**192.7**	211.0	187.8	178.2	162.0	228.1
	October	**192.7**	210.2	184.3	178.3	163.7	237.6
	November	**191.3**	206.4	178.1	183.2	164.9	229.7
	December	**186.2**	197.5	174.0	183.9	160.7	217.5
2015	January	**182.7**	194.3	173.8	177.4	156.0	217.7

Source: fao.org

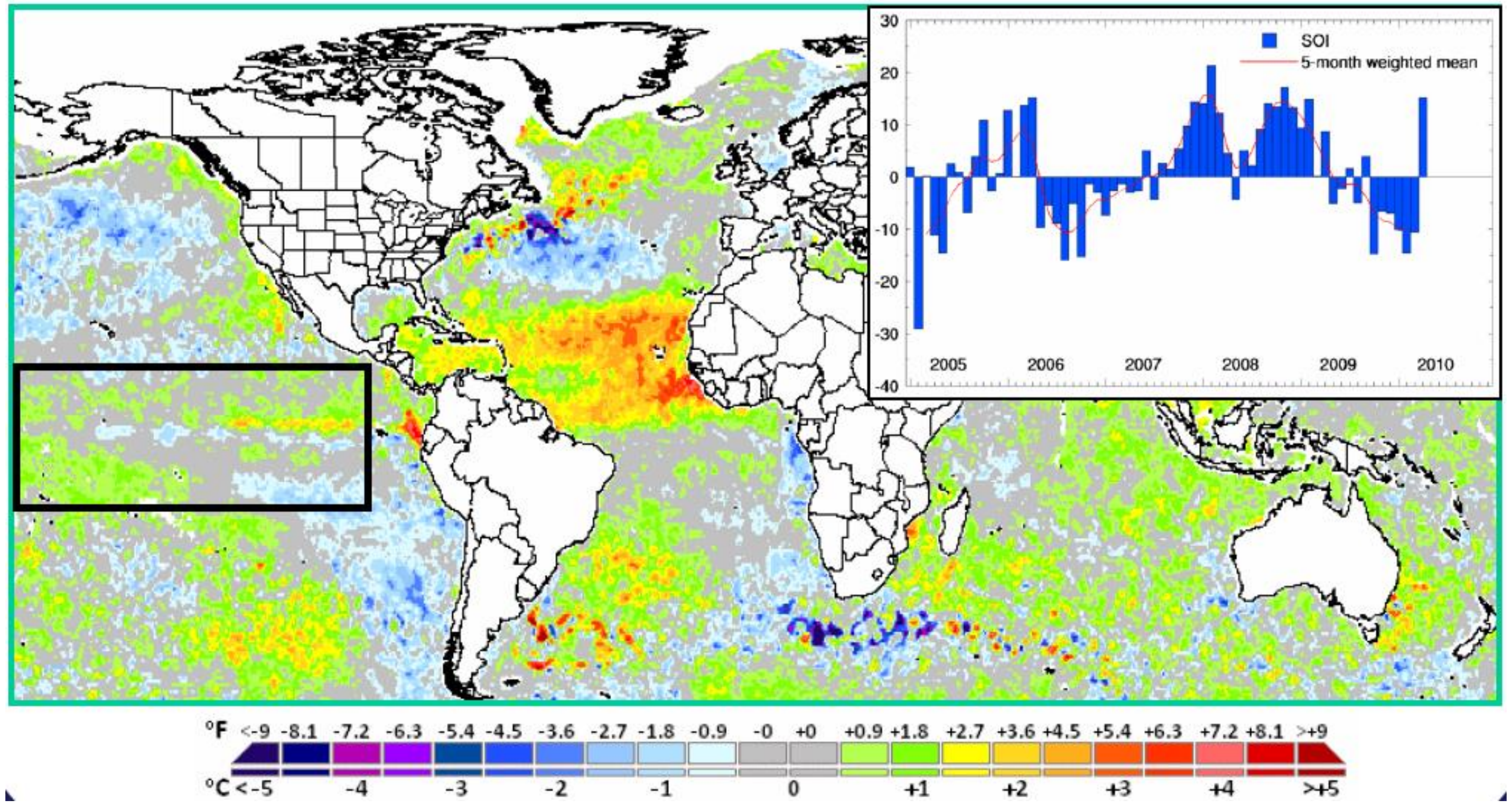
Global Food Supply & Price Risk Management

<u>For Spot Corn contract (above):</u>

- (A): Carry-over stocks from 2013 into 2014 supported a constructive market.
- (B): Cold winter (*remember the misused polar vortex term*) contributed to market fears of a late start.
- (C) Cold spring delayed planting; resulted in continued price support.
- (D/E): THEN: US weather turned favorable & market price reaction followed. Once US crop was near harvest completion, record yields softened prices to low $3 range.
- (F) ***What to expect in 2015??***

Source: Finviz.com

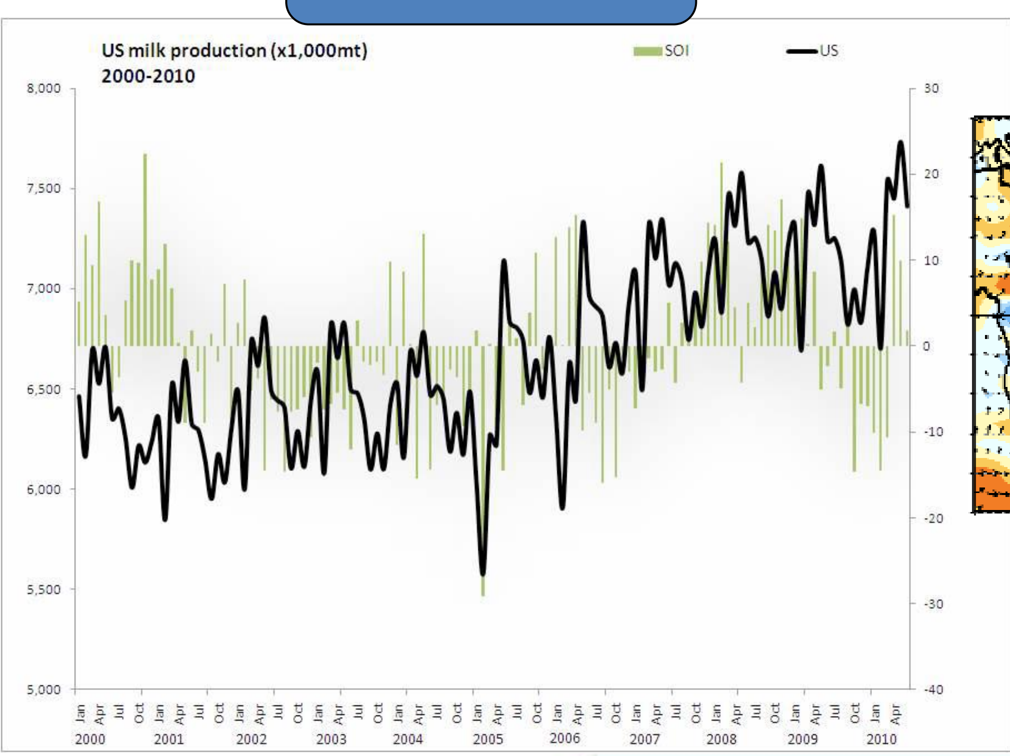
ENSO Relationships

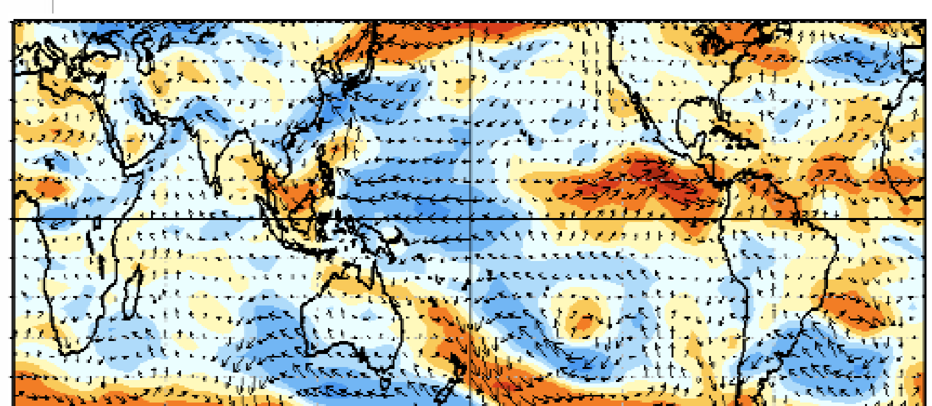


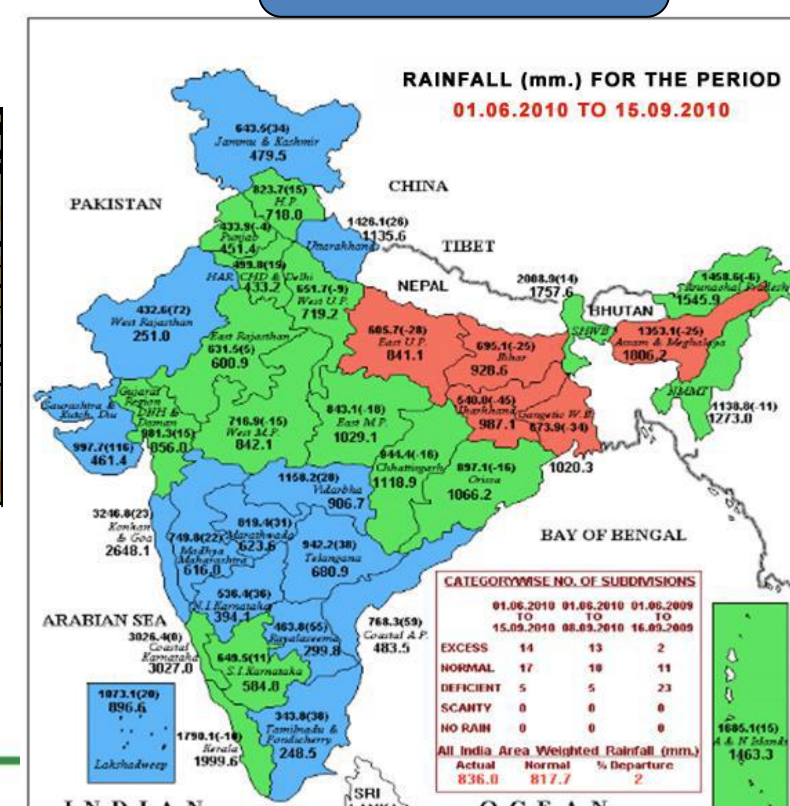
Food Production

Extreme Events (Pakistan Floods)

Monsoon Activity

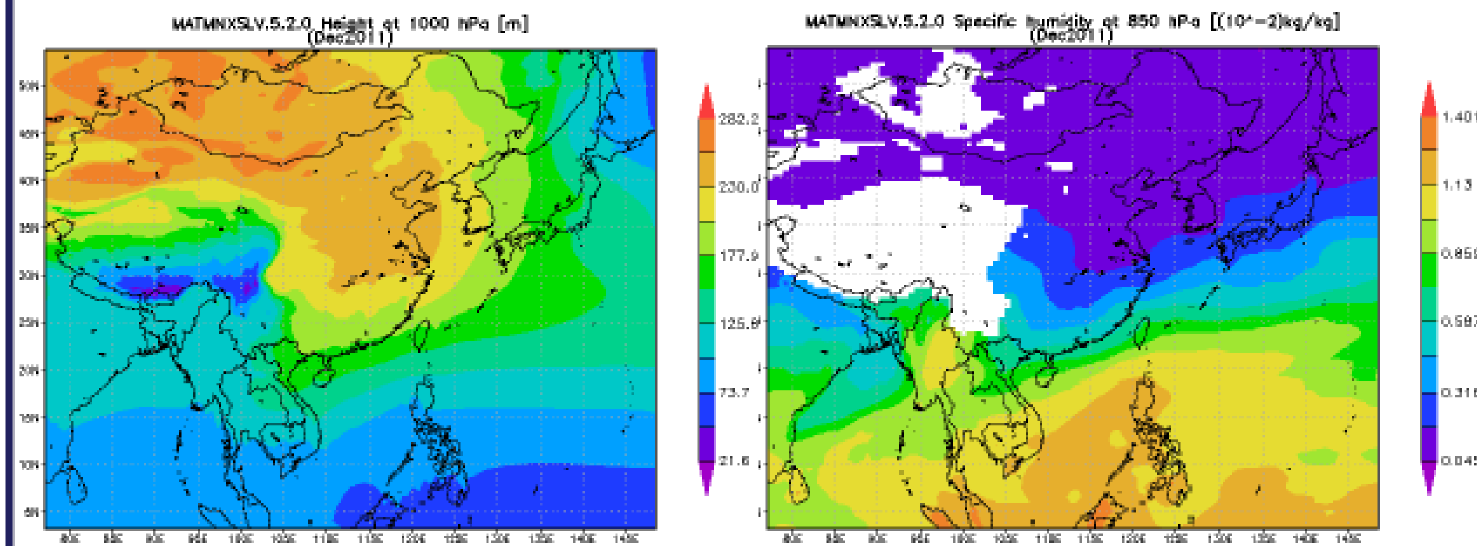




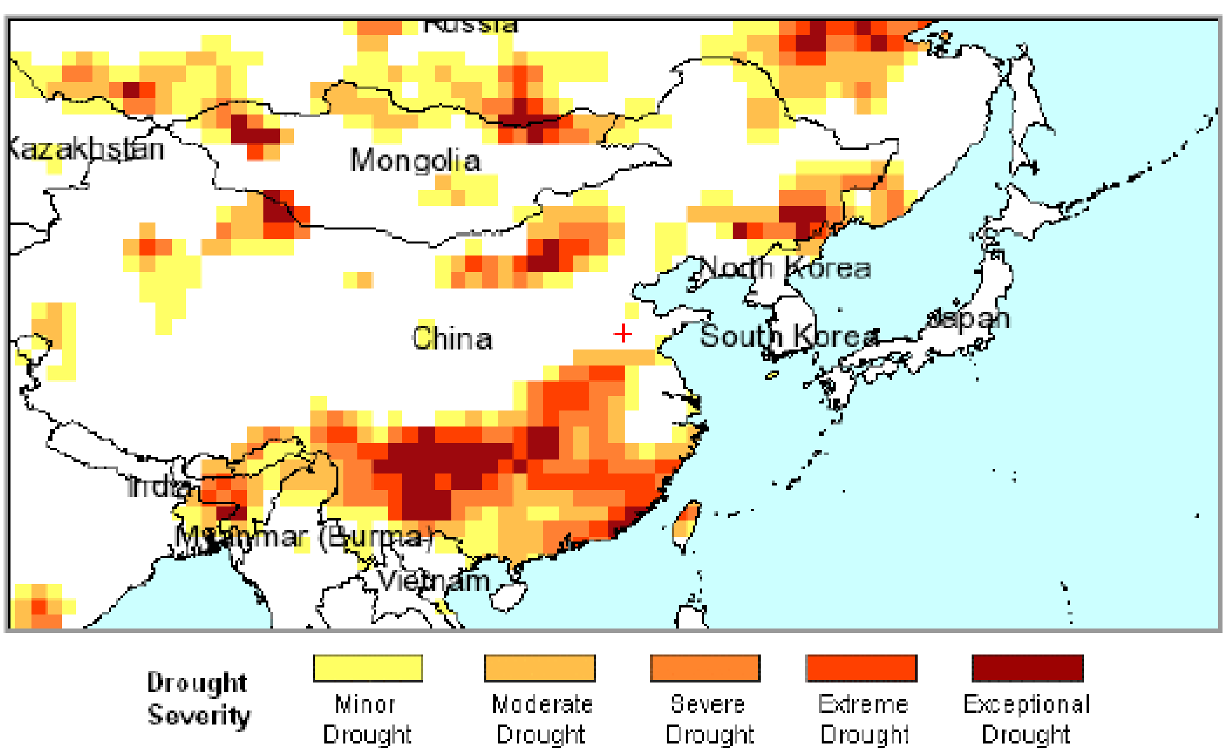


CHINA

The North China Plain region had another dry month in December; the first map from MERRA below highlights the surface pressure for December – note the higher heights from Shandong through Liaoning, where growers are in need of a more active moisture pattern this year. The specific humidity map at the 850 mb level, a good proxy for surface precipitation, notes that the north/northeastern provinces are still dry, confirmed by the February 2012 Global Drought Monitor published by University College, London.



Source: MERRA



Target & Predict

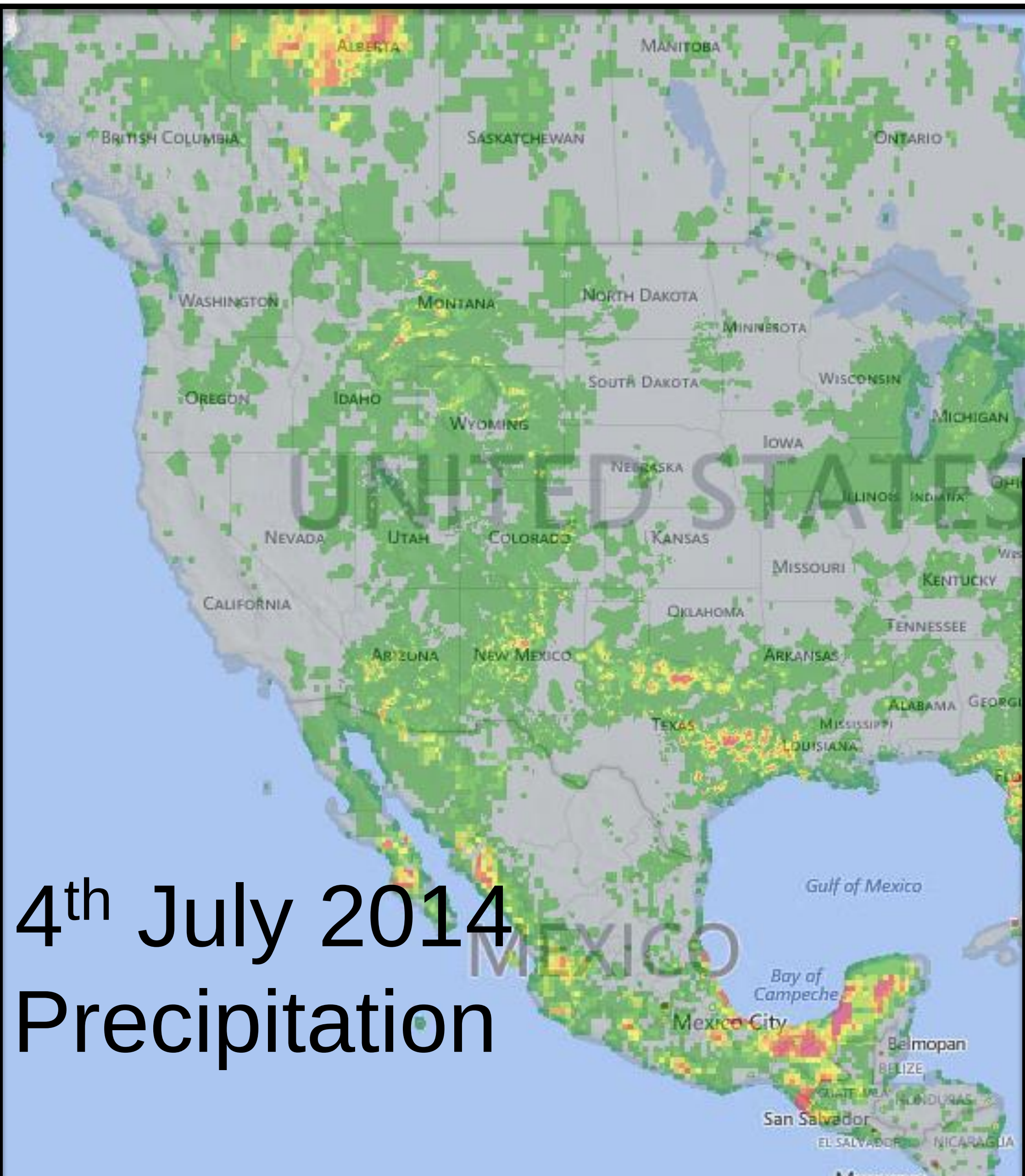
Big Data +
Models & Analytics

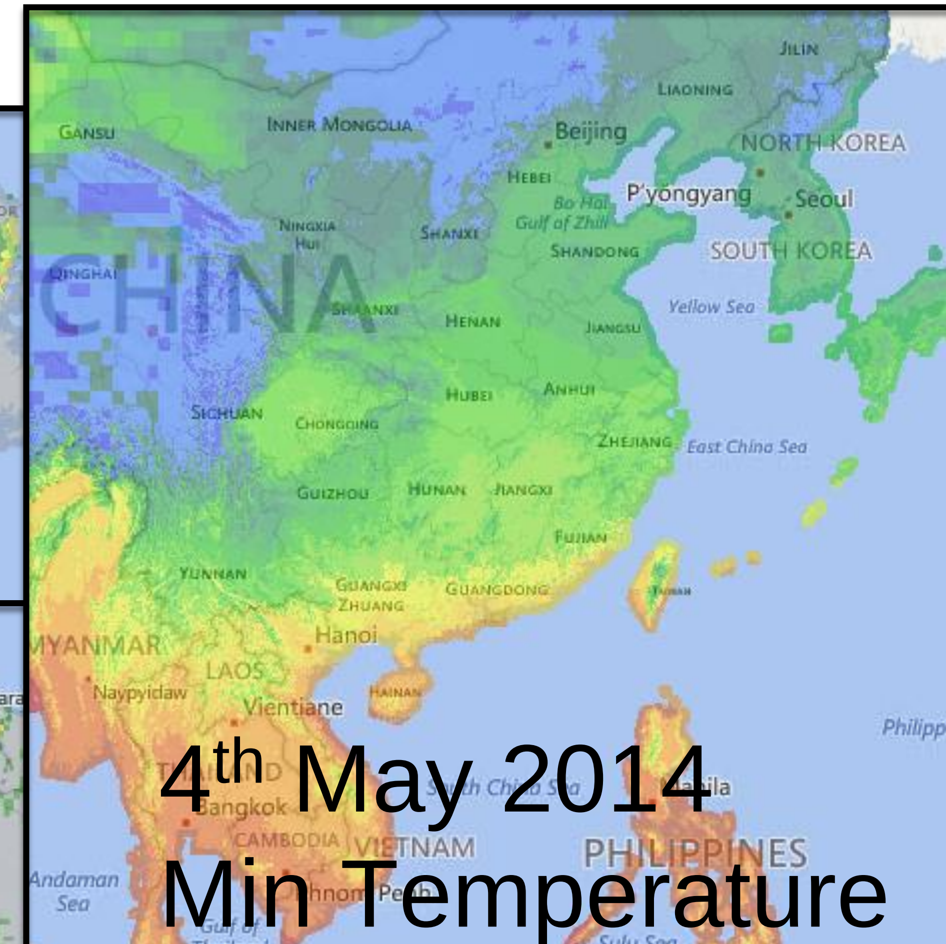
…new insight for a globally connected world

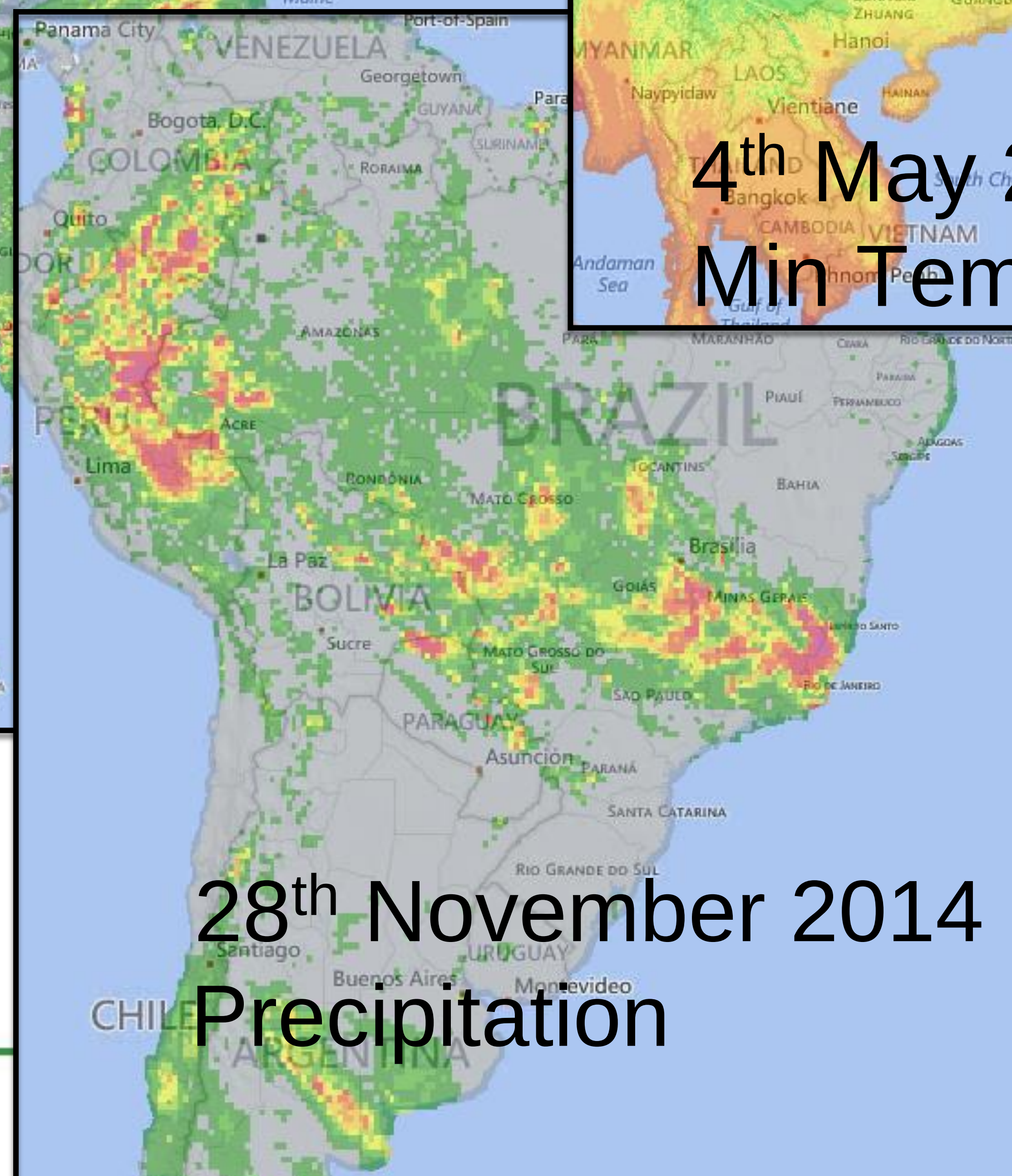
More real time
More granular
(location)

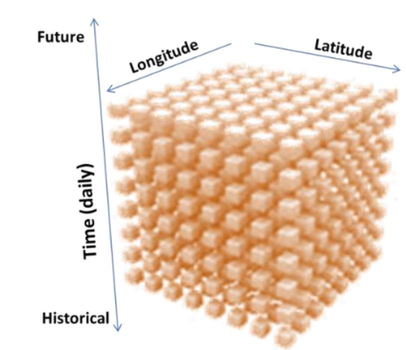
Now granular (location) and in real time…

And we know what crop, where.



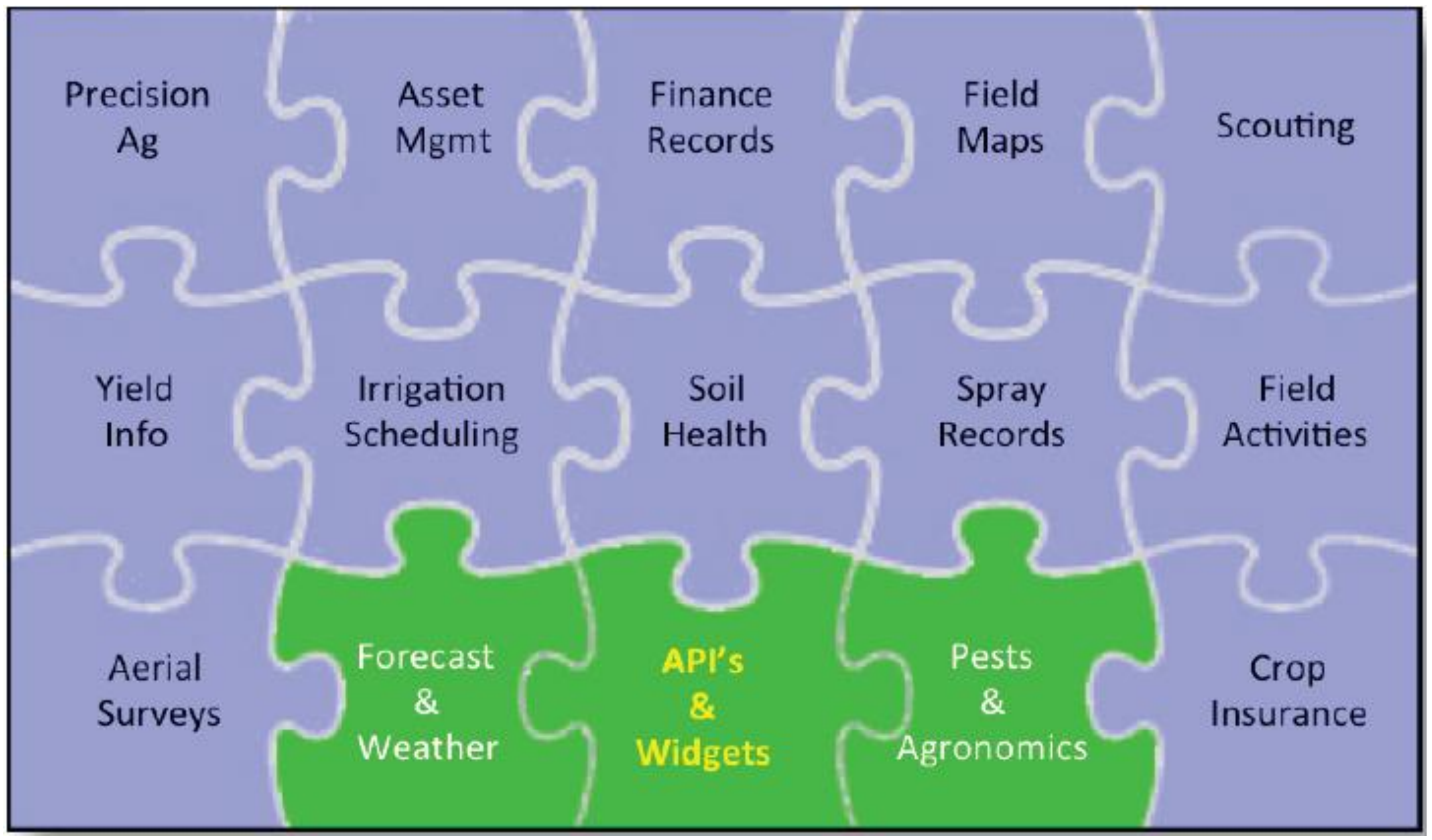






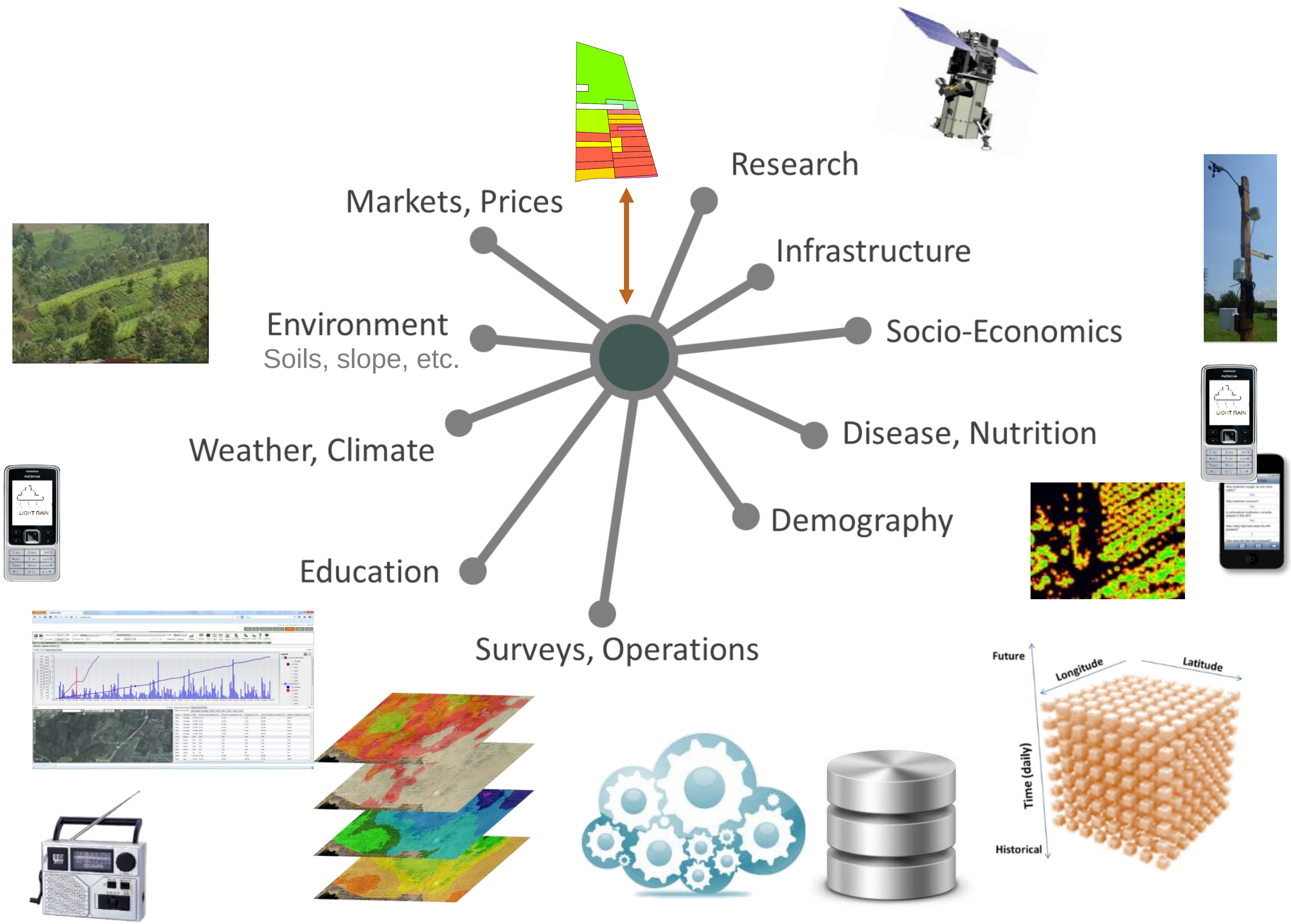
Big data: the questions we can address…

Weather & Satellites
…Big data is part of the solution

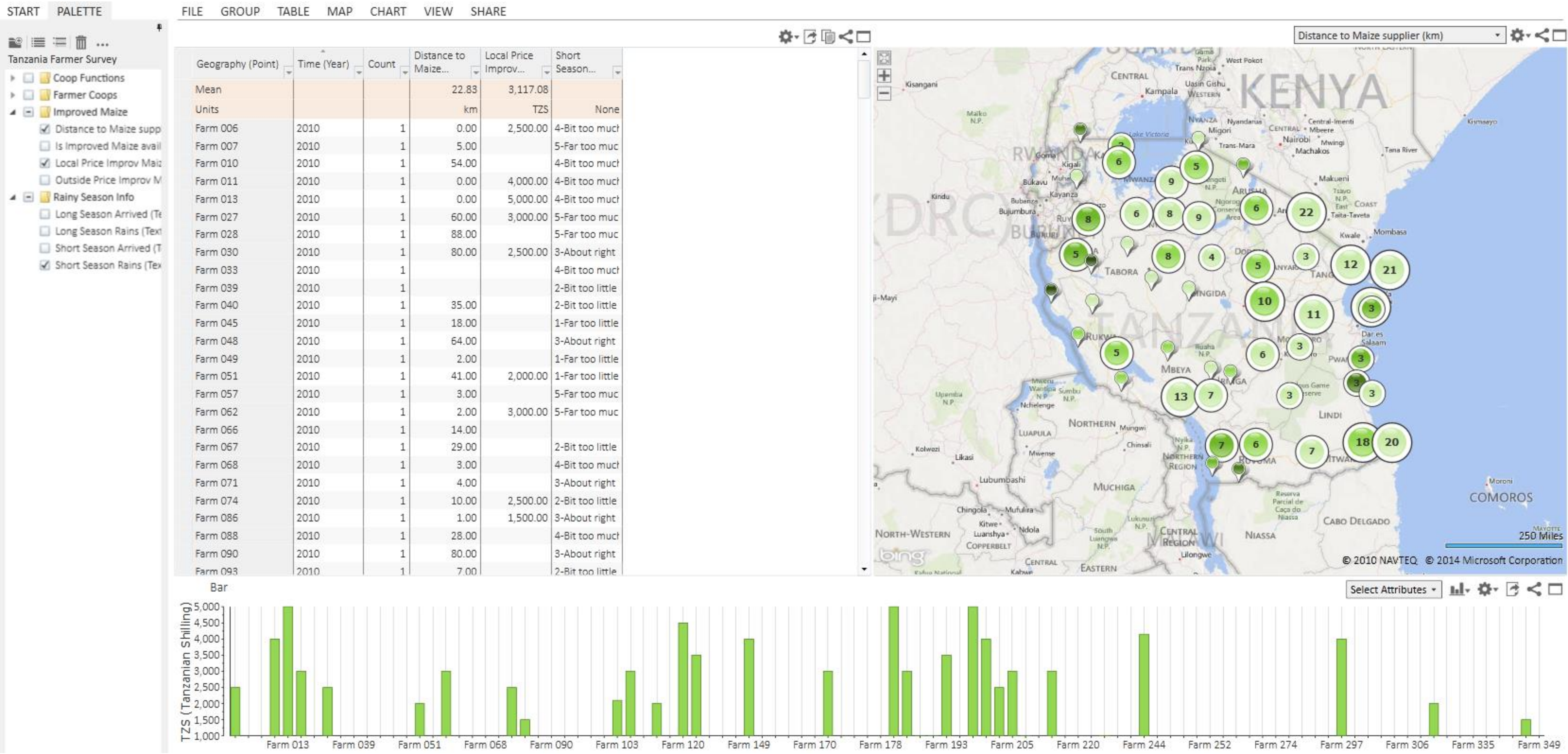


Harnessing the Power of Data
for
Evidence-based Decisions

Location Intelligence for Agriculture



1,000s of fields?   1,000s of farmers??



Geography (Point)	Time (Year)	Count	Distance to Maize...	Local Price Improv...	Short Season...
Mean			22.83	3,117.08	
Units			km	TZS	None
Farm 006	2010	1	0.00	2,500.00	4-Bit too muct
Farm 007	2010	1	5.00		5-Far too muc
Farm 010	2010	1	54.00		4-Bit too muct
Farm 011	2010	1	0.00	4,000.00	4-Bit too muct
Farm 013	2010	1	0.00	5,000.00	4-Bit too muct
Farm 027	2010	1	60.00	3,000.00	5-Far too muc
Farm 028	2010	1	88.00		5-Far too muc
Farm 030	2010	1	80.00	2,500.00	3-About right
Farm 033	2010	1			4-Bit too muct
Farm 039	2010	1			2-Bit too little
Farm 040	2010	1	35.00		2-Bit too little
Farm 045	2010	1	18.00		1-Far too little
Farm 048	2010	1	64.00		3-About right
Farm 049	2010	1	2.00		1-Far too little
Farm 051	2010	1	41.00	2,000.00	1-Far too little
Farm 057	2010	1	3.00		5-Far too muc
Farm 062	2010	1	2.00	3,000.00	5-Far too muc
Farm 066	2010	1	14.00		
Farm 067	2010	1	29.00		2-Bit too little
Farm 068	2010	1	3.00		4-Bit too muct
Farm 071	2010	1	4.00		3-About right
Farm 074	2010	1	10.00	2,500.00	2-Bit too little
Farm 086	2010	1	1.00	1,500.00	3-About right
Farm 088	2010	1	28.00		4-Bit too muct
Farm 090	2010	1	80.00		3-About right
Farm 093	2010	1	7.00		2-Bit too little

Dynamic aggregation… Decision driving

Target & Predict

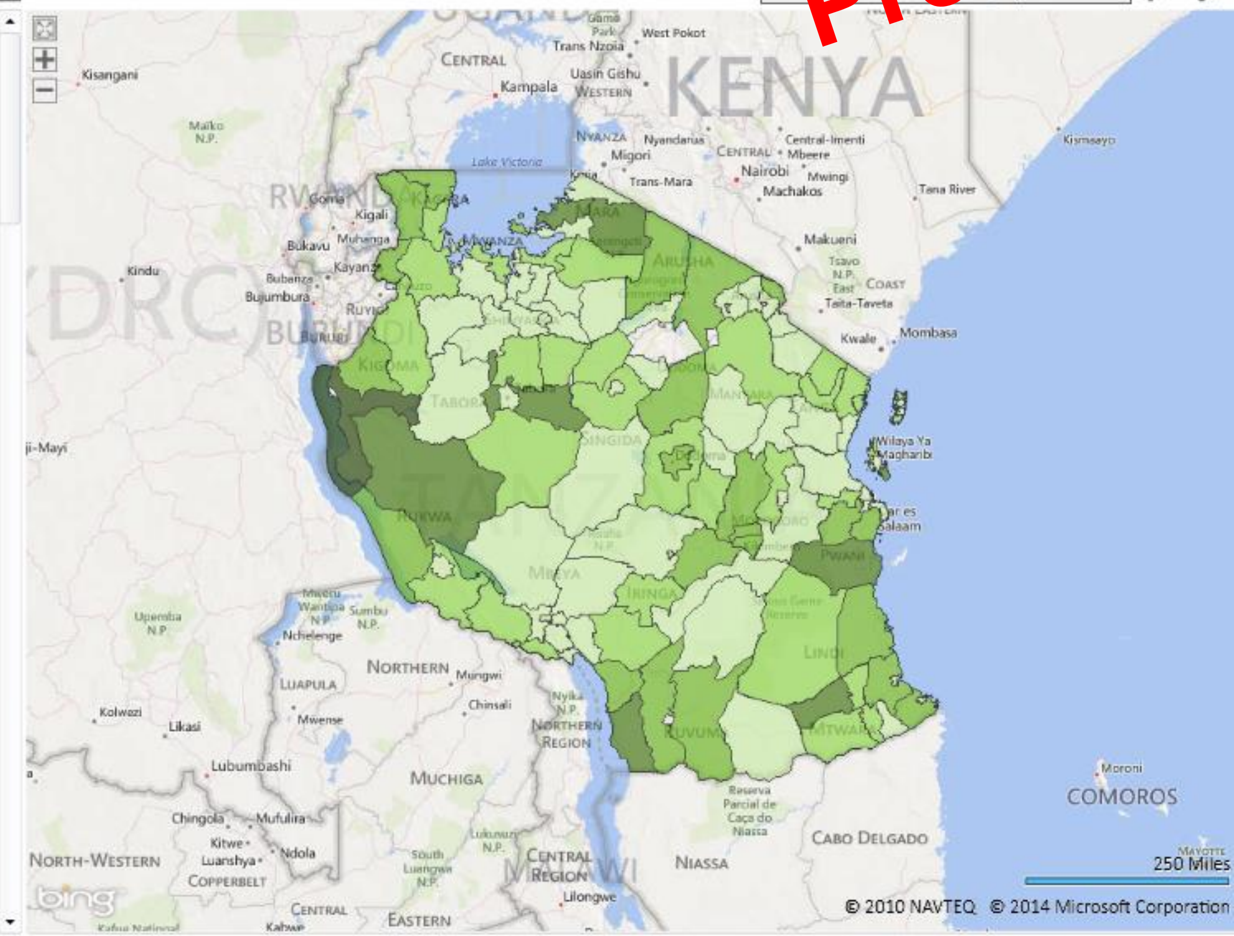
START PALETTE

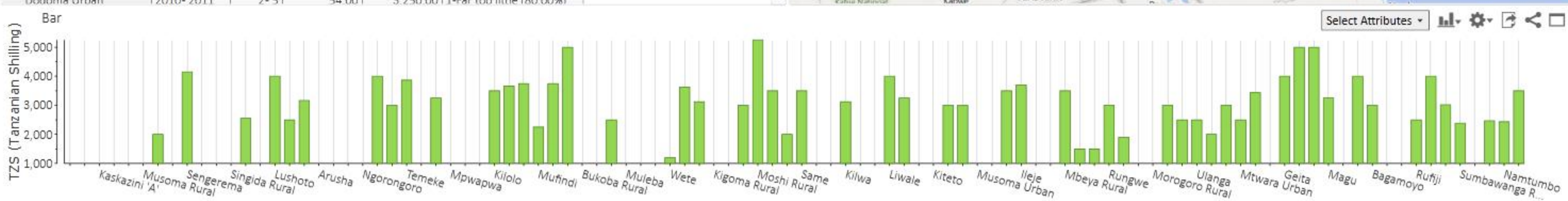
Tanzania Farmer Survey

- Coop Functions
- Farmer Coops
- Improved Maize
  - Distance to Maize supp
  - Is Improved Maize avail
  - Local Price Improv Maiz
  - Outside Price Improv M
- Rainy Season Info
  - Long Season Arrived (Te
  - Long Season Rains (Text
  - Short Season Arrived (T
  - Short Season Rains (Tex

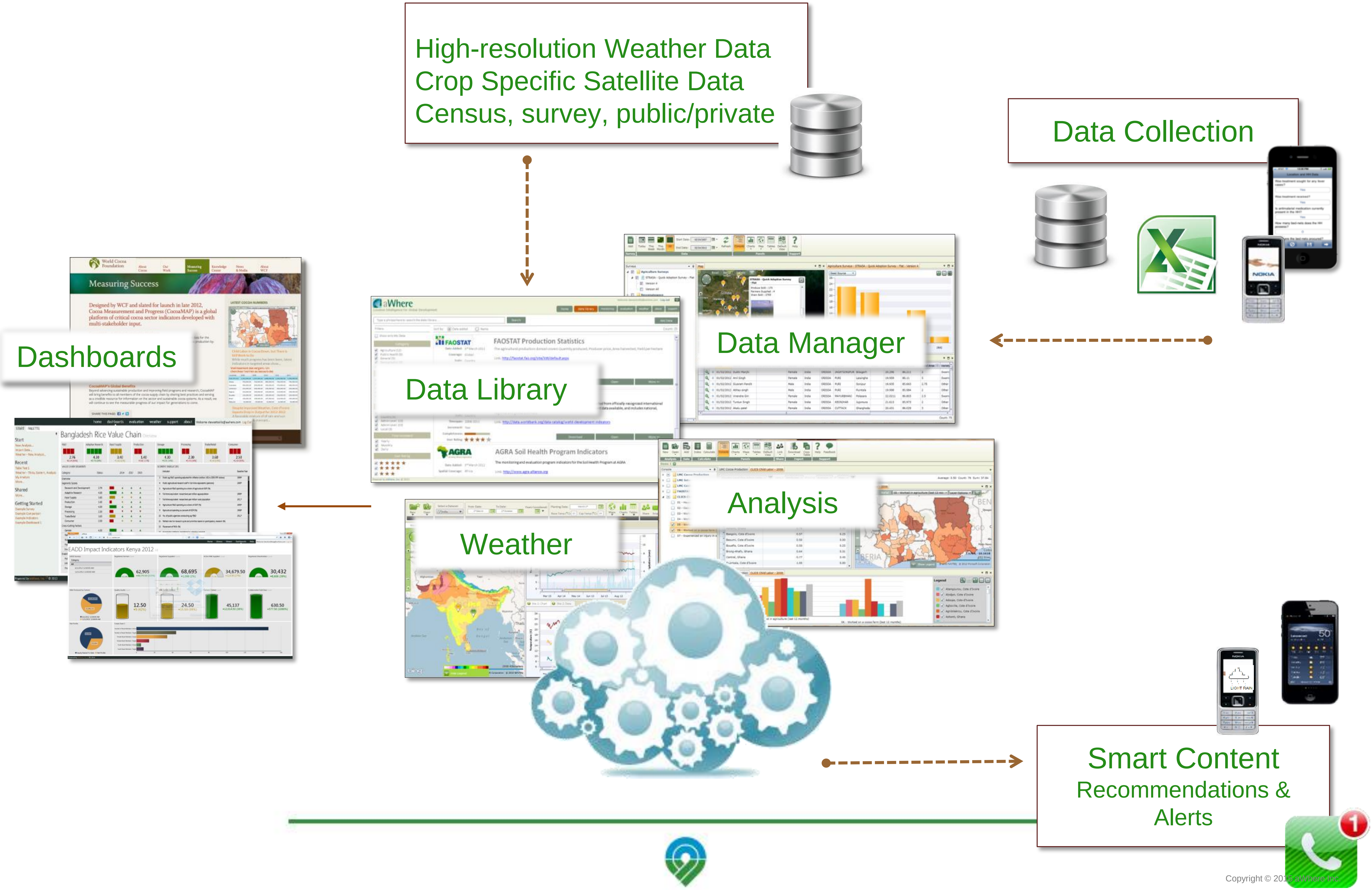
FILE GROUP TABLE MAP CHART VIEW SHARE

Geography (Admin 2)	Time (Year)	Count	Distance to Maize…	Local Price Improv…	Short Season Rains (Text)
Mean			25.59	3,149.46	
Units			km	TZS	None
Kondoa	2010	3	38.33		1-Far too little (66.67%)
Kongwa	2010	1	2.00		1-Far too little
Kaskazini 'A'	2010	3	14.33		3-About right (66.67%)
Kaskazini 'B'	2010	5	19.60		3-About right (100.00%)
Nachingwea	2010	1	96.00	1,000.00	
Musoma Rural	2010	1	80.00		3-About right
Serengeti	2010	1	70.00	2,000.00	2-Bit too little
Misungwi	2010	1	13.00		4-Bit too much
Sengerema	2010	1	27.00	4,150.00	4-Bit too much
Kisarawe	2010	1	54.00		4-Bit too much
Manyoni	2010	1	6.00		1-Far too little
Singida Rural	2010	1	30.00		1-Far too little
Sikonge	2010	2	23.00	2,550.00	1-Far too little (100.00%)
Kilindi	2010	1	5.00		5-Far too much
Lushoto	2010	1	24.00	4,000.00	3-About right
Pangani	2010	1	10.00	2,500.00	2-Bit too little
Arumeru	2011	3	2.00	3,166.67	2-Bit too little (33.33%)
Arusha	2011	4	5.25		4-Bit too much (50.00%)
Karatu	2011	3	8.33		2-Bit too little (66.67%)
Monduli	2011	2	41.50		1-Far too little (100.00%)
Ngorongoro	2011	2	57.00		3-About right (50.00%)
Ilala	2010- 2011	2- 3	0.50	4,000.00	4-Bit too much (100.00%)
Kinondoni	2010- 2011	2- 9	1.83	3,000.00	3-About right (44.44%)
Temeke	2010- 2011	4- 9	7.30	3,866.67	4-Bit too much (33.33%)
Dodoma Rural	2011	3	31.67		1-Far too little (100.00%)
Dodoma Urban	2010- 2011	2- 5	54.00	3,250.00	1-Far too little (80.00%)





Location Intelligent Platform



Big Data - Business Model

Technology & Data Platform

- SaaS-based Location Intelligence – **BI for Agriculture**
- Real-time, hyper-local agro-meteorological modeling – generate agile content
- Bi-directional content flow– Last Mile Integration

EVERY ***farmer*** reachable direct or channels – ***partners***!

- Big data – **terabytes of high resolution weather and other key data –** growing everyday

Domain Knowledge

- Agriculture
- Agri-business
- Food security / commodities

Symmetrical Information across the Ag Value Chain

Weather & Satellite data *are* big data: Farm and model data too…

Billions of new data points every day

for real-time, **hyper-local information**

Information for

Weather agile agriculture™

…wherever ag-information is needed

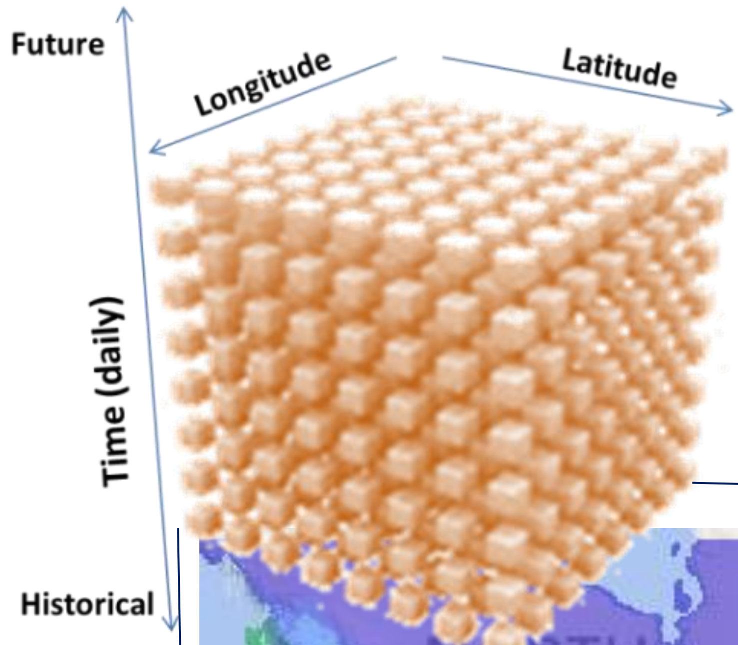
Help Farmers Feed the World

aWhere

The Power of Agricultural Intelligence

Current Correct Consistent Complete – **4C's**
…and 100% of the time available on demand!

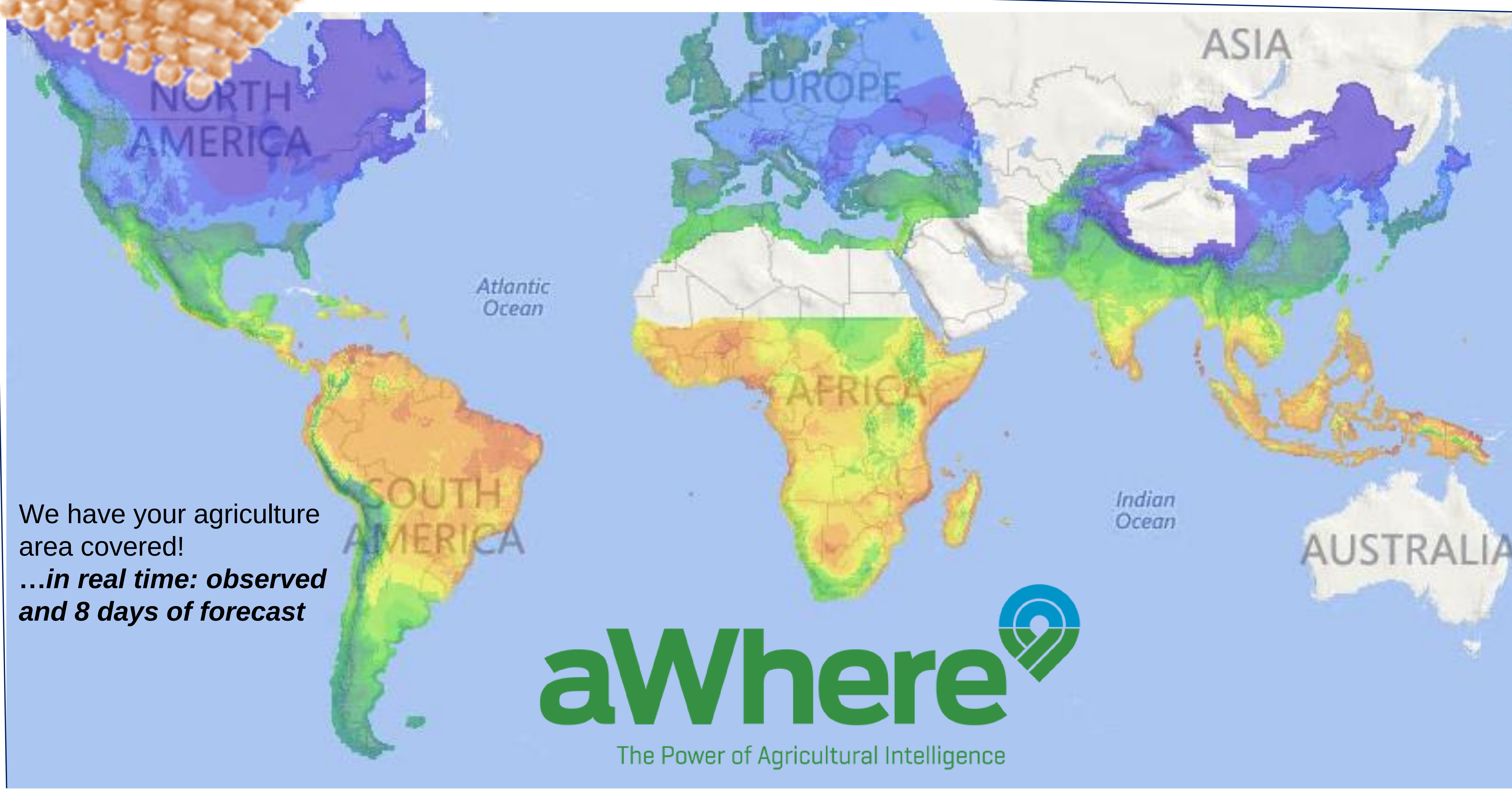
weather@awhere.com



Current, Correct, Consistent, Complete

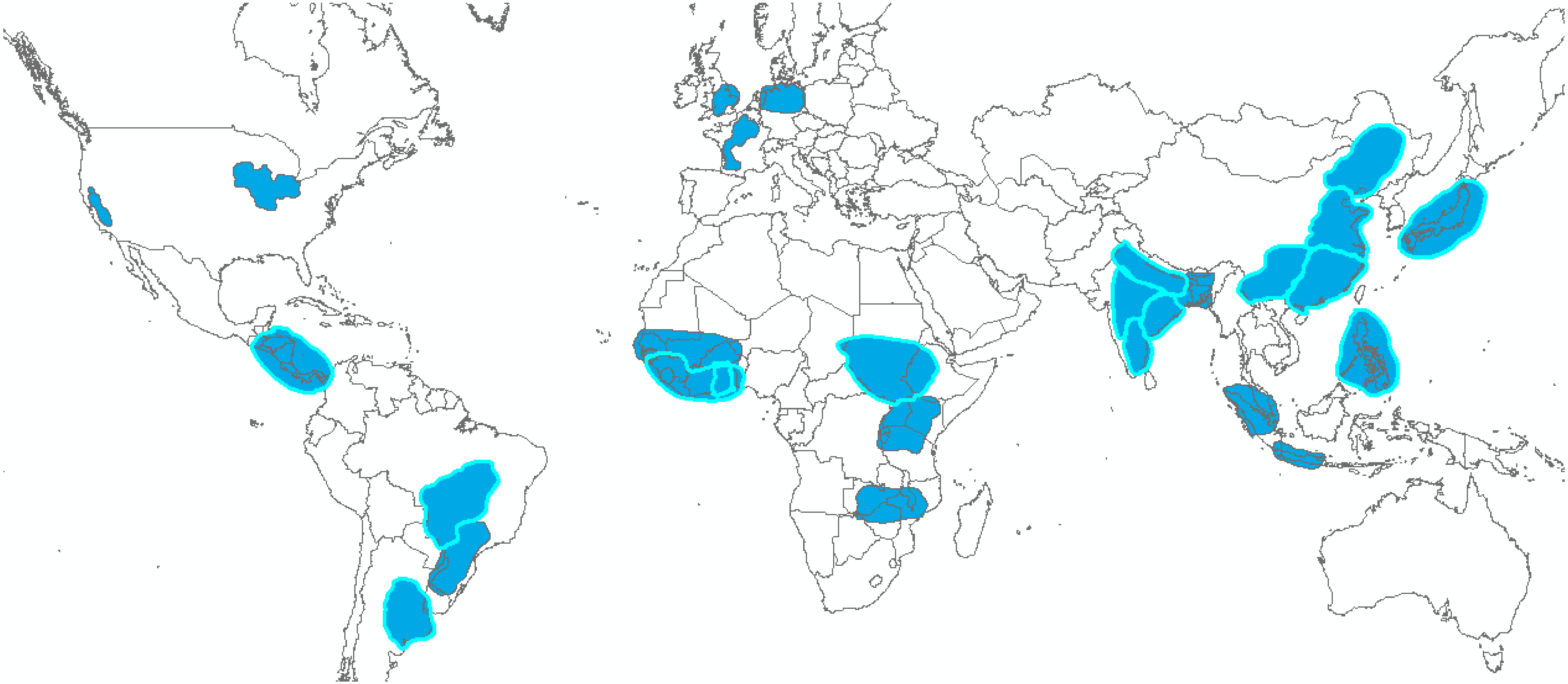
Each of 8 agro-met variables, EVERY day
…a virtual weather station every ~9x9km – GLOBALLY

Access via API, ftp push, or various aps



Contact: weather@awhere.com

aWhere tailors our weather accuracy assessments by agro-eco types (spatial) – and season (temporal).



Unabashedly agricultural – and growing season - focused

Agricultural Service: utilization of weather data

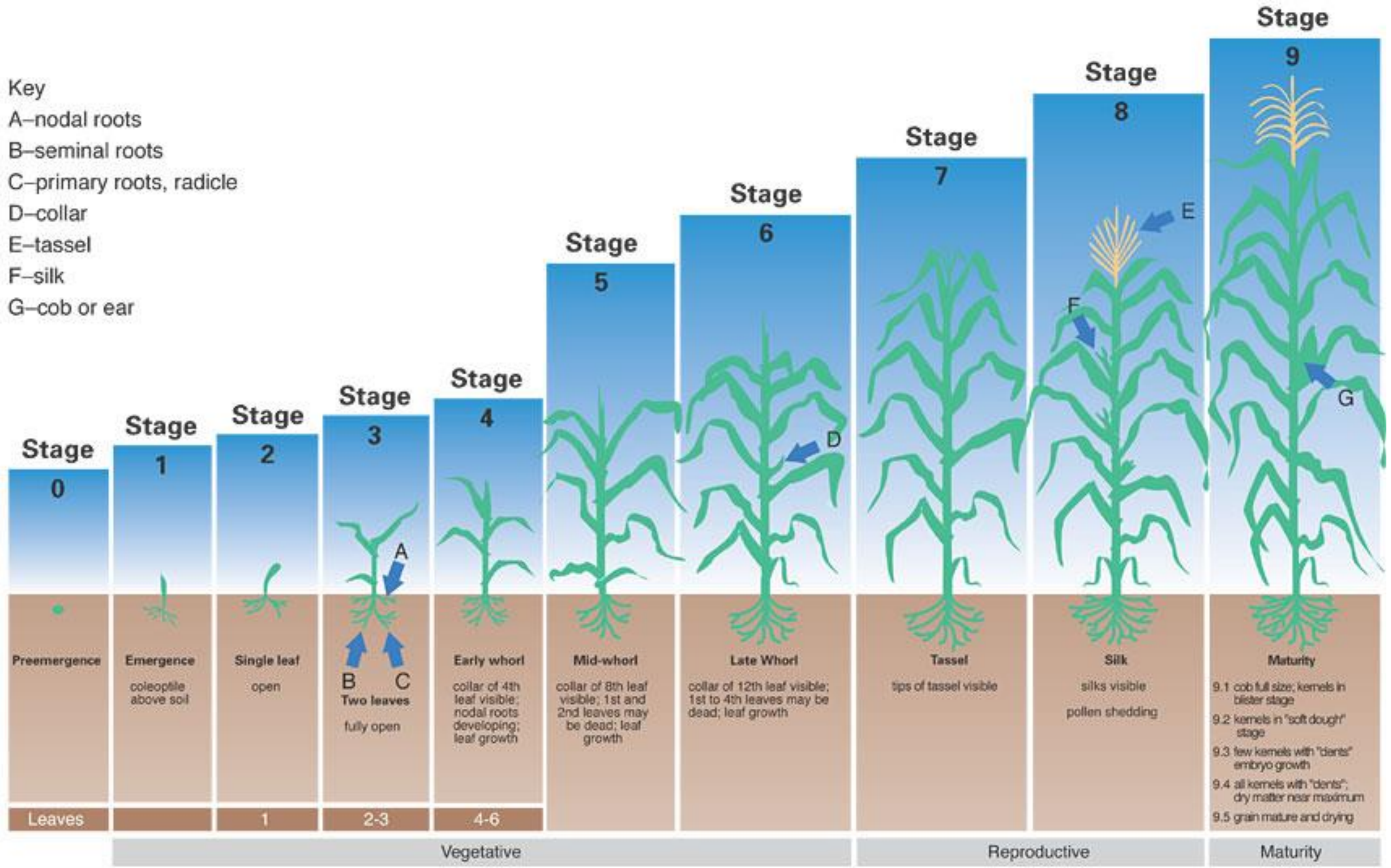
Questions:

- Understand the influence of weather:
  - Simulation: How does weather influence weed/crop competition?
  - Statistical analysis: What is the ROI for each kg of N applied?
- Where to invest (and invest in what?):
  - Yield maps / Yield gap
- Predict the impact of changing weather patterns on distribution of crop pests

Decision models – farmers and advisors:

- Recent weather:
  - Which field is most at risk for pest impact?
- Historical weather:
  - What crops to grow given the uncertainty of precipitation?
- Short-term forecast:
  - Should I apply insecticide? N? When is optimal harvest?
  - Will it rain tomorrow afternoon? Morning after tomorrow?

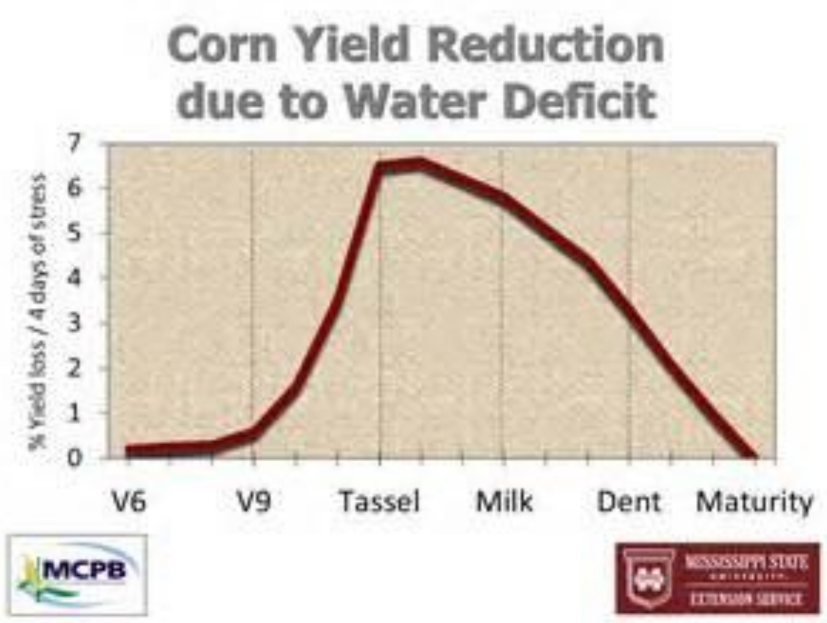
Agricultural Service: utilization of weather data



Source: *U.S. Department of Agriculture Technical Bulletin 976* and Honway, J. J., *1966 Special Report 48*, Iowa State University

Maize

When to plant?
Add N? How much?
Field work – rains in forecast?
Growth stage and ROI (pests)



Connect with your growers
Inform your R&D
Expand your extension…

aWhere
The Power of Agricultural Intelligence

Our Background

- Agricultural intelligence business since 1999
- Cloud-based big data and analytics for agriculture
  - Analytics platform for global development
  - Big Data for agriculture - large farmers & small holder farmers
- Long-term customers and growing

Offices in: USA
Kenya, Malaysia

Our Expertise

- John Corbett, Ph.D — CEO **Agricultural Climatologist**, U of MN
- Michael Ferrari, Ph.D — Sr. **Climate Scientist**, Rutgers U
- Lori Wiles, Ph.D — **Crop Science**, North Carolina State U
- Stewart Collis — CTO, **Modeling**, U of New South Wales
- Jim Pollock — VP, **Product Strategy**, MIT
- Dave Lundberg — EVP, **Agricultural Business**, Iowa State U
- John L'Heureux — **Meteorologist**, North Carolina State U
- Michael Cullen, Ph.D — **Agricultural Economics**, Oxford U

- Plus more than 30 other professionals and growing…

Product Lines

Dev aWhere

- SaaS Data Mgmt
- Large Scale Ag Projects
- Surveys, Science, Adoption

Grow aWhere

- Multi-field Monitoring
- Yield Curve Management
- Harvest Date

Weather aWhere

- **WeatherTerrain™**
  - Forecast, Observed, Historical
- **WeatherAgronomics™**
  - Derived Models, Crop/Pest/Disease
- **WeatherKit™**
  - API's, Widgets for App Development

Intel aWhere

- Food Security
  - Regional / National
- Commodity Tracking
  - By Crop
  - By Geography