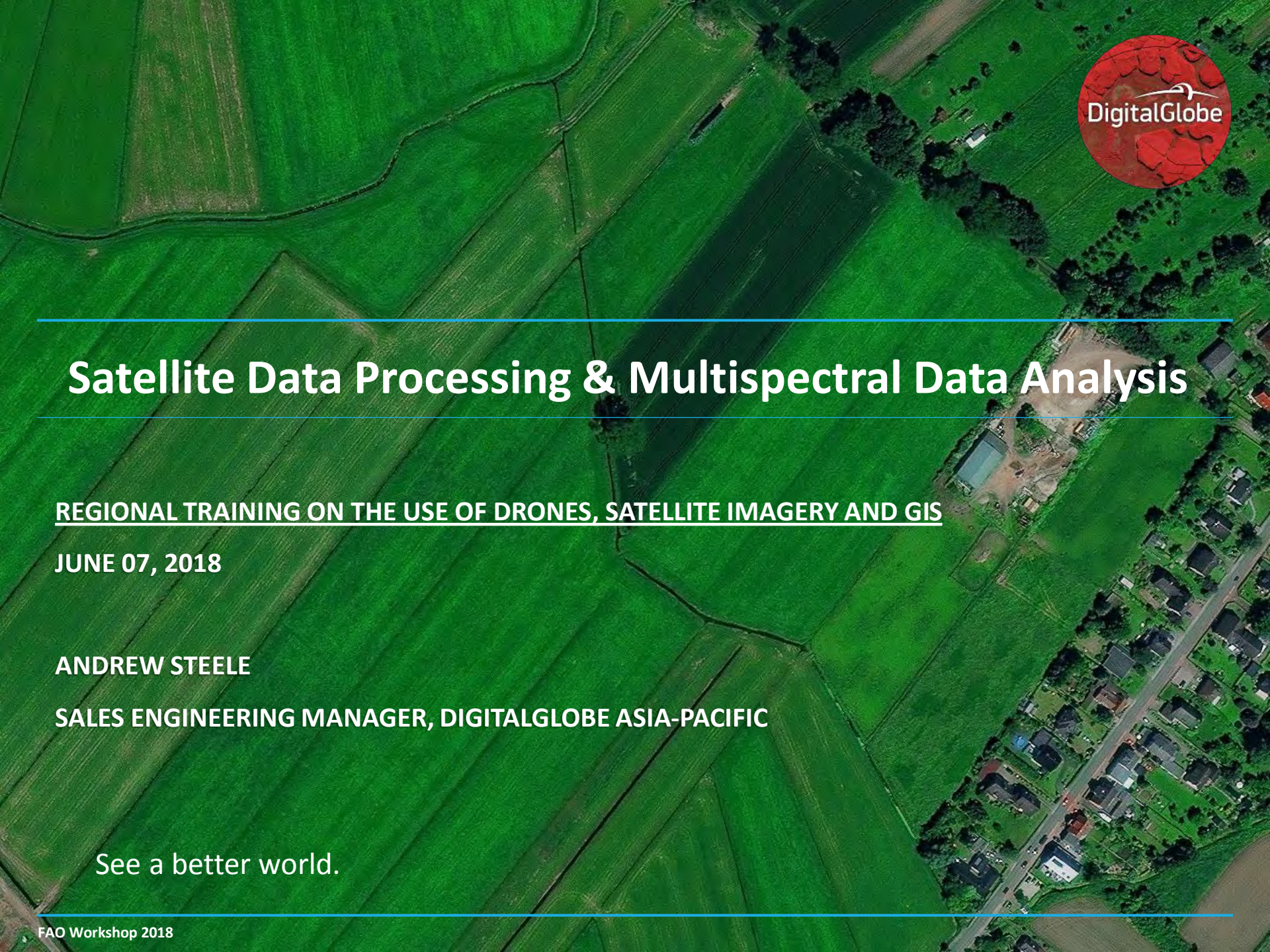


Satellite Data Processing & Multispectral Data Analysis

REGIONAL TRAINING ON THE USE OF DRONES, SATELLITE IMAGERY AND GIS

JUNE 07, 2018

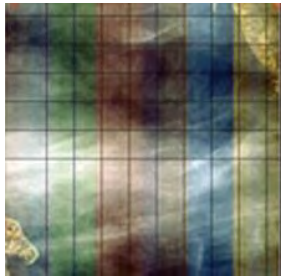
ANDREW STEELE

SALES ENGINEERING MANAGER, DIGITALGLOBE ASIA-PACIFIC

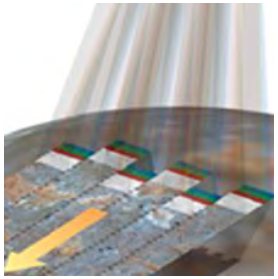
See a better world.

What does Processing mean?

PROCESSING	DESCRIPTION
Radiometric Correction	Relative radiometric response between detectors, Non-responsive detector fill, conversion to absolute radiometry
Sensor Correction	Internal Detector geometry, Optical distortion, scan distortion, any line-rate variations
Geo-Rectification	Projected to a plane using a map projection and datum, projection to constant base elevation (Calculated on the average terrain elevation based on order area of interest for View-Ready Products)
OrthoRectification	Orthorectified Imagery products offer the highest degree of cartographic accuracy. They are radiometrically-corrected, sensor-corrected, orthorectified, and mapped to a cartographic projection and datum.

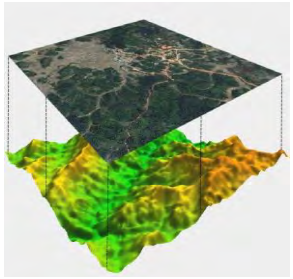


Radiometric



Sensor

Georectification



Orthorectification

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System Ready (Basic Imagery)

Basic Imagery (Level 1B)

Radiometric corrections (Yes)

- Sensor corrections (Yes)
- Camera frame of reference (Yes)
- North remains in sensor scan direction (Yes)
- Geometric corrections (No)
- Topographic distortion corrections (No)

Accuracy

Horizontal pointing accuracy of 5 m CE90 (QB:23m CE90), excluding terrain and off-nadir effects, can be achieved at less than 30° off-nadir.

Spatial Resolution

Varies with off-nadir angle

- As collected, pixels will not be uniform
- Requested production GSD sets a "not-to-exceed"
  GSD for the product

columns
27,552 (pan)
6,888 (MS)

rows
27,424 (pan)
6,856 (MS)

Use-Case

- Basic imagery products are commonly used by imagery experts who want control all aspects of image processing, manipulation and/or photogrammetric analysis.
- Requires advanced remote sensing experience and image processing tools.

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View Ready (Standard Imagery)

Standard Imagery (Level 2A)

Radiometric corrections (Yes)

- Sensor corrections (Yes)
- Geometric corrections (Yes)
- Processed using a course elevation model (Yes)
- Atmospheric Compensation (Yes)
- Topographic distortion corrections (No)

Accuracy

Horizontal pointing accuracy of 5 m CE90 (QB:23m CE90), excluding terrain and off-nadir effects, can be achieved at less than 30° off-nadir. The shortwave infrared (SWIR) Standard Imagery product has an accuracy of 7.5 m CE90.

Spatial Resolution

Uniform GSD

- Standard imagery (Level 2A) products are processed using a coarse elevation model. The coarse elevation model is not sufficient to remove all topographic distortions.

Use-Case

- Standard imagery products are Ready-to-use imagery.
- The coarse elevation model used to process the level 2A product doesn't make an idea product for value-added production.
- If a customer wants to perform additional value-added production, we suggest using the level OR2A.
- The level 2A product is typically used for preliminary logistic studies for route planning or site assessment.

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View Ready (Standard Imagery)

Standard Imagery (Level OR2A)

Radiometric corrections (Yes)

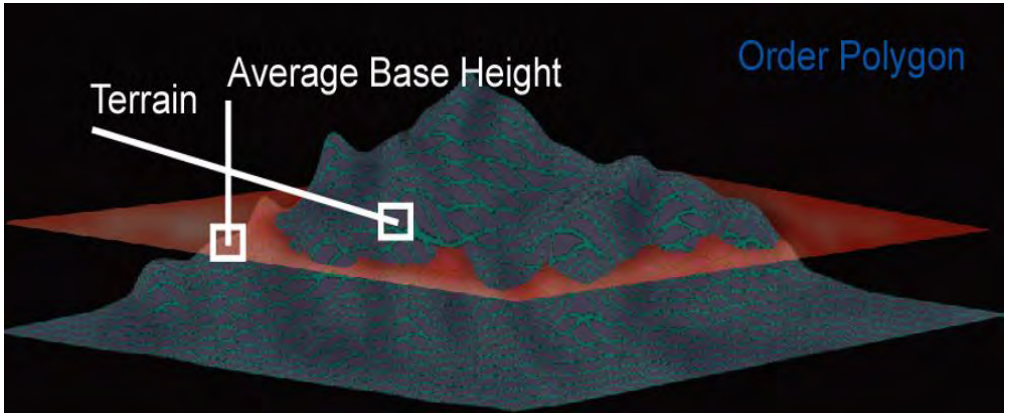
- Sensor corrections (Yes)
- Geometric corrections (Yes)
- Projected to a constant base elevation (Yes)
- Atmospheric Compensation (Yes)
- Topographic distortion corrections (No)

Accuracy

Horizontal pointing accuracy of 5 m CE90, excluding terrain and off-nadir effects, can be achieved at less than 30° off-nadir. The shortwave infrared (SWIR) Standard Imagery product has an accuracy of 7.5 m CE90.

Spatial Resolution

Uniform GSD



- Base Elevation is calculated on the average terrain elevation per order polygon or can be supplied by the customer.

Use-Case

- Standard imagery products are Ready-to-use imagery.
- The coarse elevation model used to process the level 2A product doesn't make an idea product for value-added production.
- If a customer wants to perform additional value-added production, we suggest using the level OR2A.
- The level 2A product is typically used for preliminary logistic studies for route planning or site assessment.

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Map Ready (Ortho Imagery)

Standard Imagery (Level OR2A)

Radiometric corrections (Yes)

- Sensor corrections (Yes)
- Geometric corrections (Yes)
- Topographic distortion corrections (Yes)
- Geolocation (Map) Accuracy (Yes)
- Atmospheric Compensation (Yes)

Accuracy

The accuracy is determined by the difference in the location of a feature representing the control point in the image and actual location of the control point.

- Ortho product accuracy represents the absolution geolocation accuracy of the satellite. The map ready product provides an accuracy that you can perform accuracy studies and define distances.

Spatial Resolution

Uniform GSD

Use-Case

For immediate use in GIS operations or location-based applications when you need the highest quality of visual aesthetics, consistency, and accuracy

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Atmospheric Compensation – What is AComp and who needs AComp?

What?

Proprietary Algorithm* / unique in market

Removes haze, water vapor and particulates

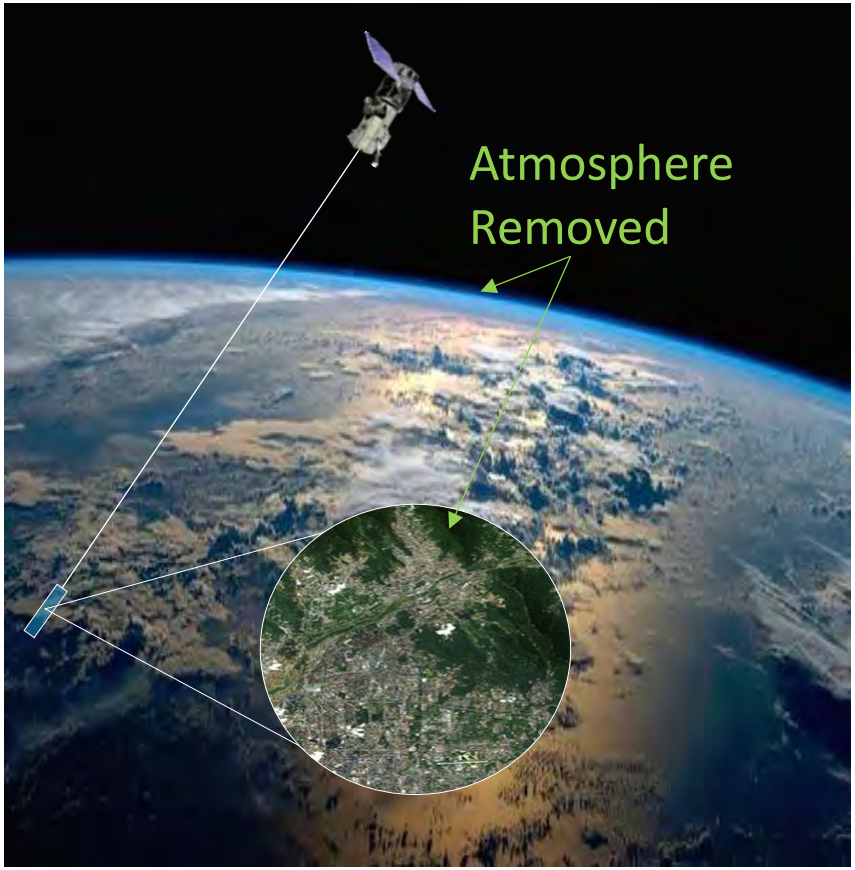
Normalize pixel values to a true surface reflectance

Who?

Consumer
Foundational tool for solving problems

Scientist

True reflectance improves automated analysis



DigitalGlobe's proprietary algorithm removes the effects of haze and ensure a crispness and clarity of the images akin to the view at ground level.

* F. Pacifici, N. Longbotham and W. J. Emery, "The Importance of Physical Quantities for the Analysis of Multitemporal and Multiangular Optical Very High Spatial Resolution Images," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 52, no. 10, pp. 6241-6256, Oct. 2014.

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Wuhan, China | WorldView-3| **Standard Processing**

Position for customers that want to control all aspects of image processing

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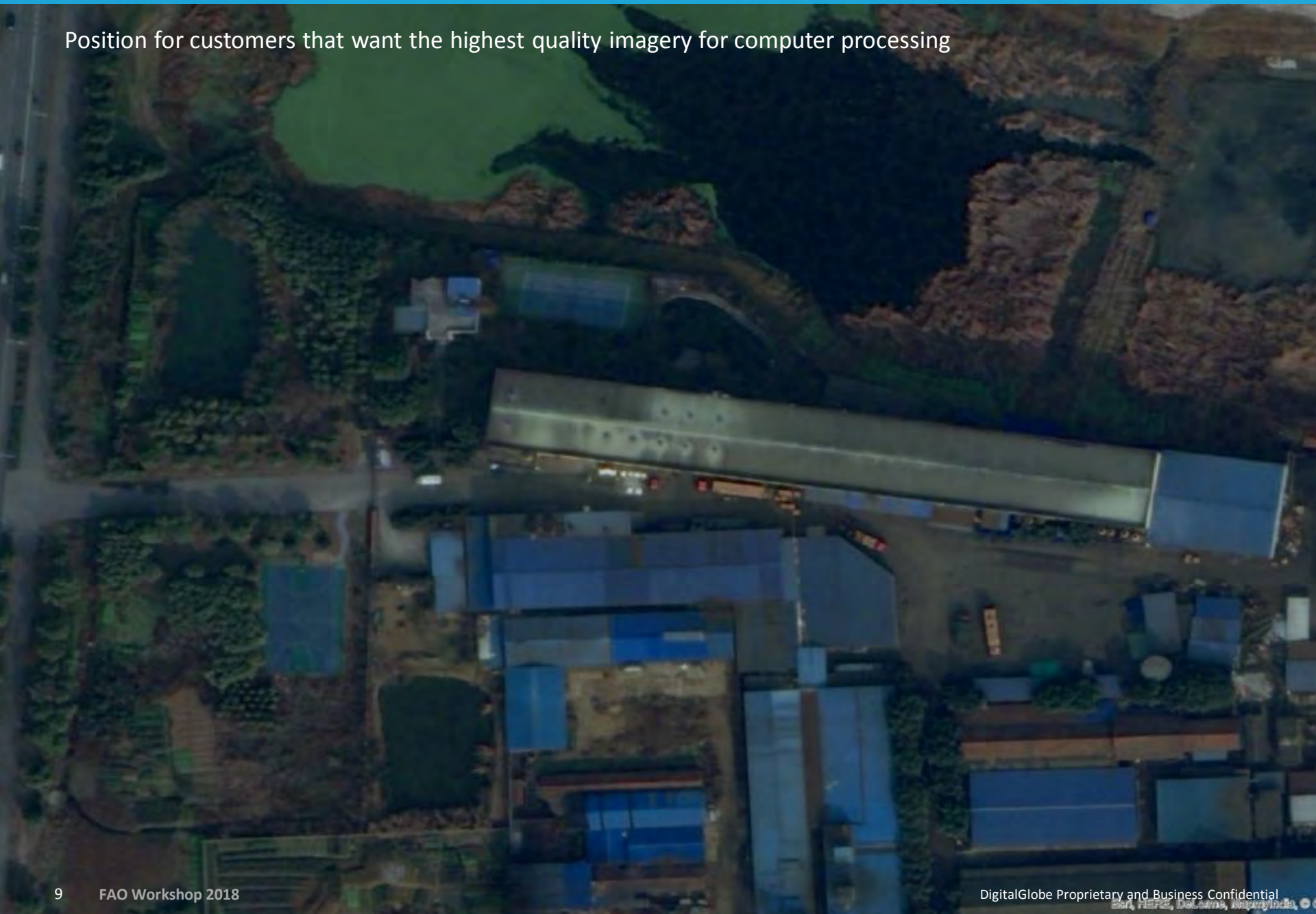
Wuhan, China | WorldView-3| **Atmospheric Compensation| No Stretch**

Position for customers that want the highest quality imagery for computer processing



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Wuhan, China | WorldView-3| **Atmospheric Compensation| Percent Clip Stretch**

Position for customers that want the highest quality imagery for viewing

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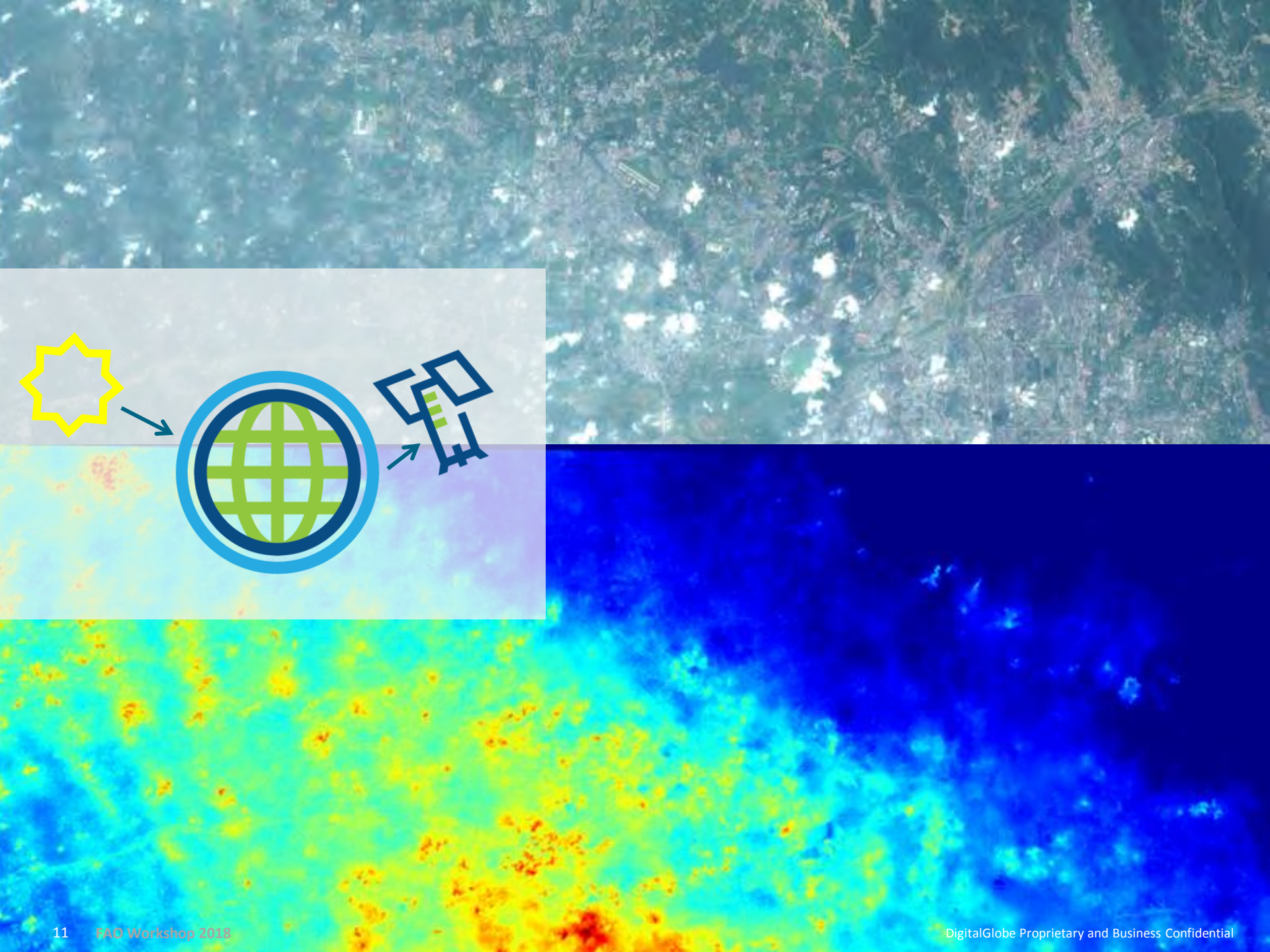

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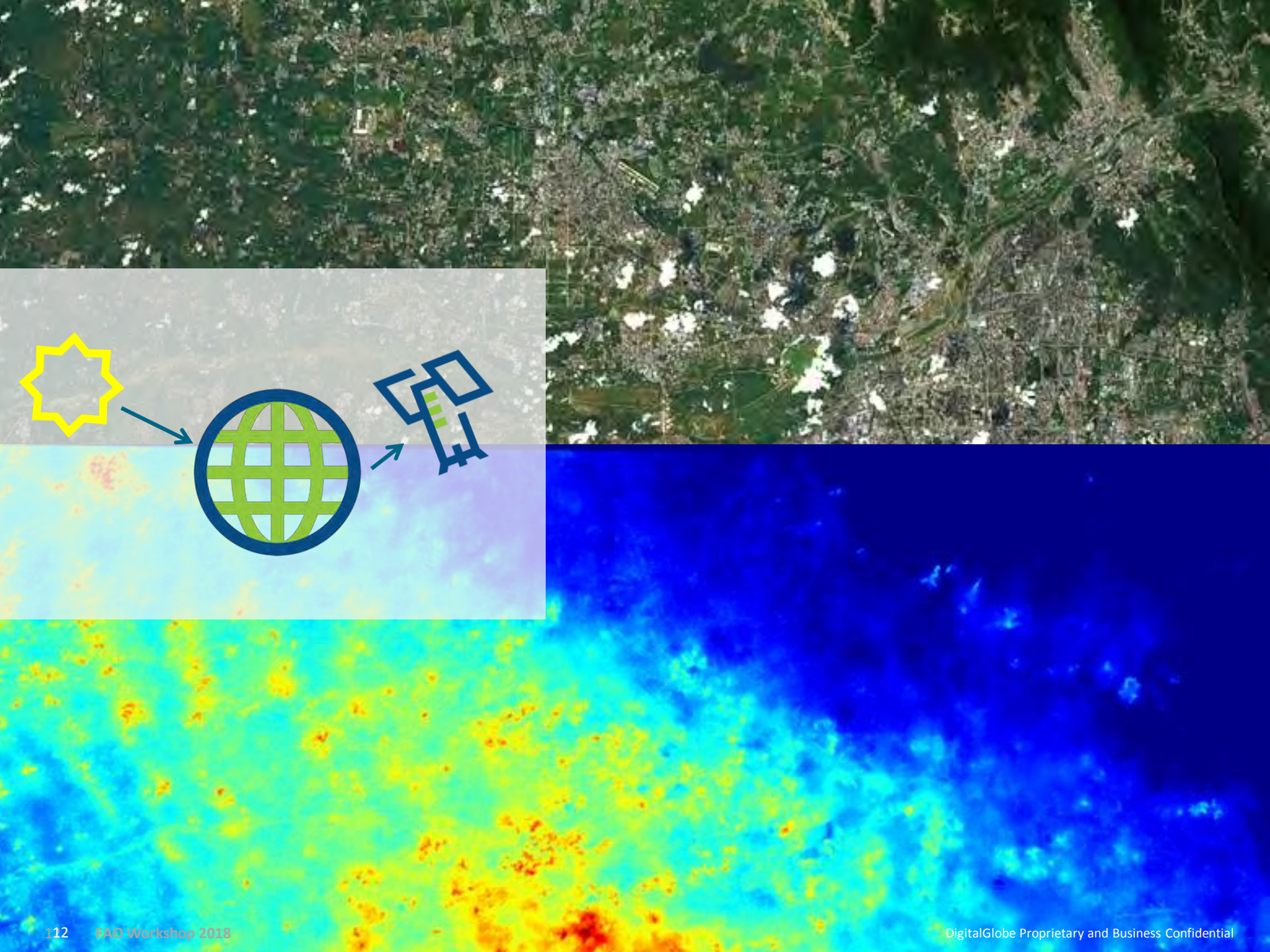

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Multispectral Analysis

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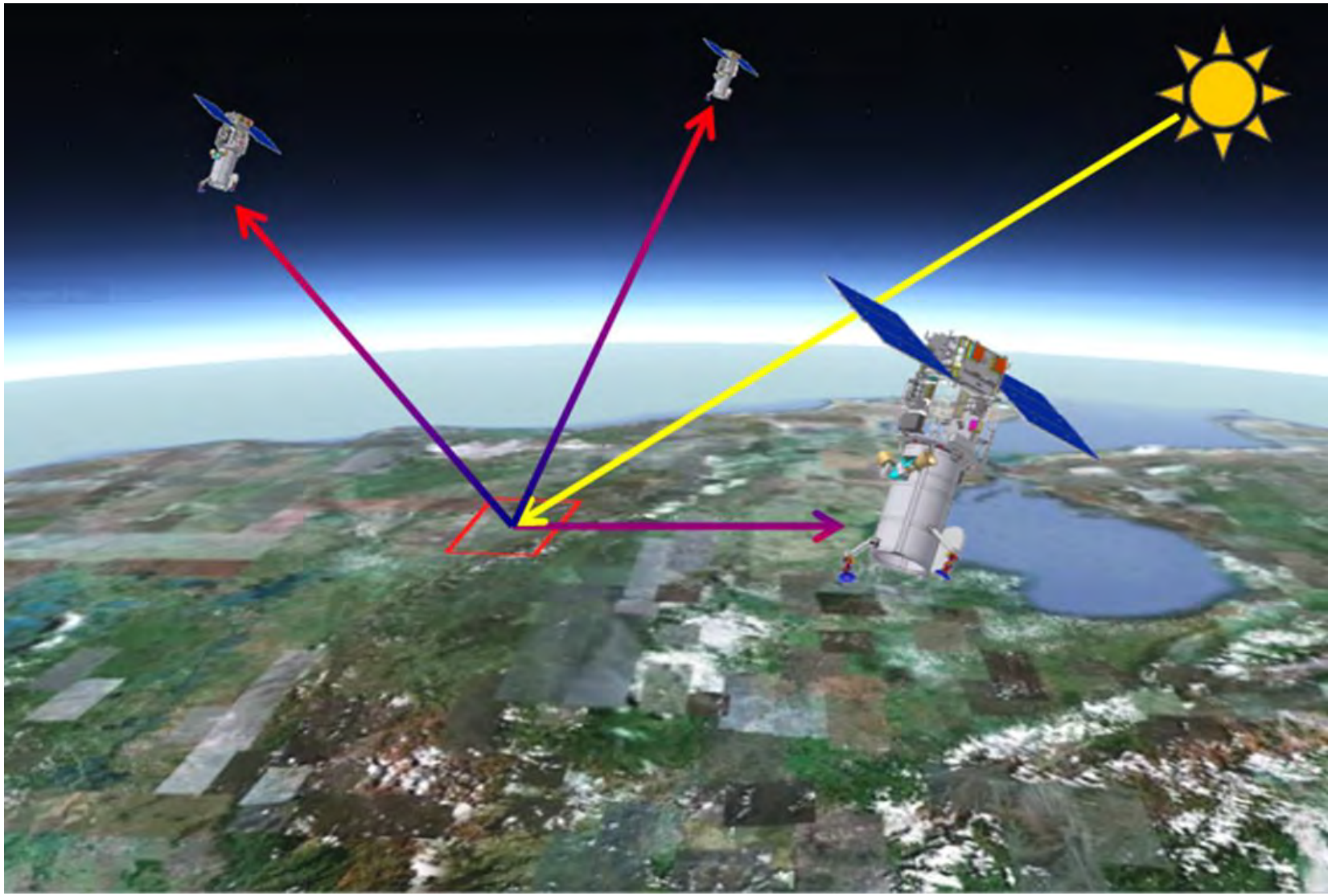
Our satellites capture light reflected or emitted from the surface of the earth



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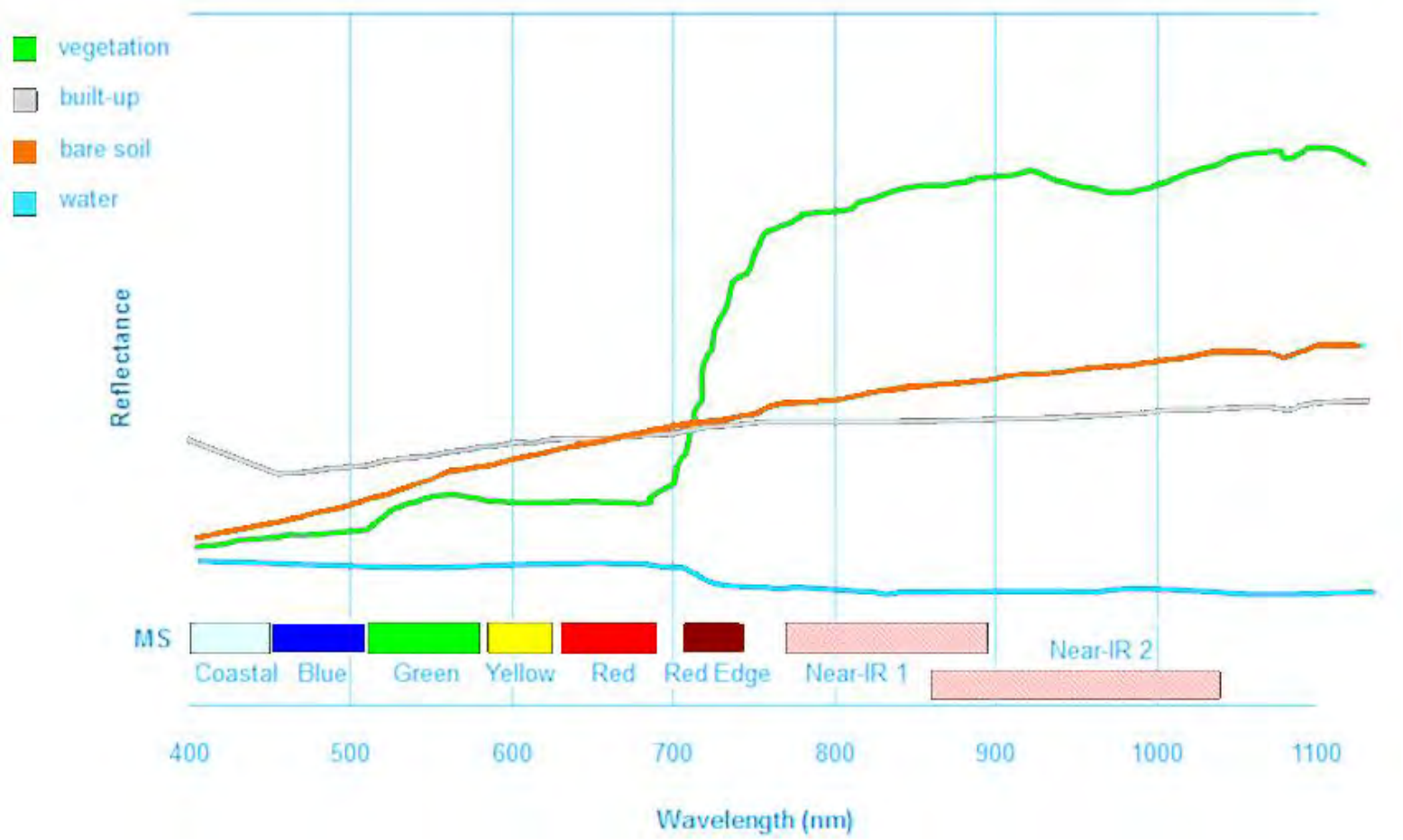
Our 8-band systems are designed to identify key land-covers: vegetation, built-up, bare soil, and water



The rate that light is reflected or absorbed at each wavelength reveals the key characteristics of a material

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Band ratios

Useful for a purer visualization and identification of materials

- **Band ratios are equations** that have been found to be useful for a more confident identification of certain materials than a standard band combination.

NAME	DESCRIPTION	EQUATION
WorldView – Water Index (WV-WI)	Useful for detecting standing, flowing water, or shadow	((B1-B8)/(B1+B8))
WorldView – Vegetation Index (WV-VI)	Useful for detecting vegetation and assessing vegetation health	((B5-B8)/(B5+B8))
WorldView – Soil Index (WV-SI)	Useful for detecting and differentiating exposed soil	((B3-B4)/(B3+B4))
WorldView – Built-up Index (WV-BI)	Useful for detecting man made objects especially buildings and roads	((B6-B1)//(B6+B1))
WorldView – Iron Index (WV-II)	Useful for detecting exposed iron	((B3*B4)/(B2*1000))

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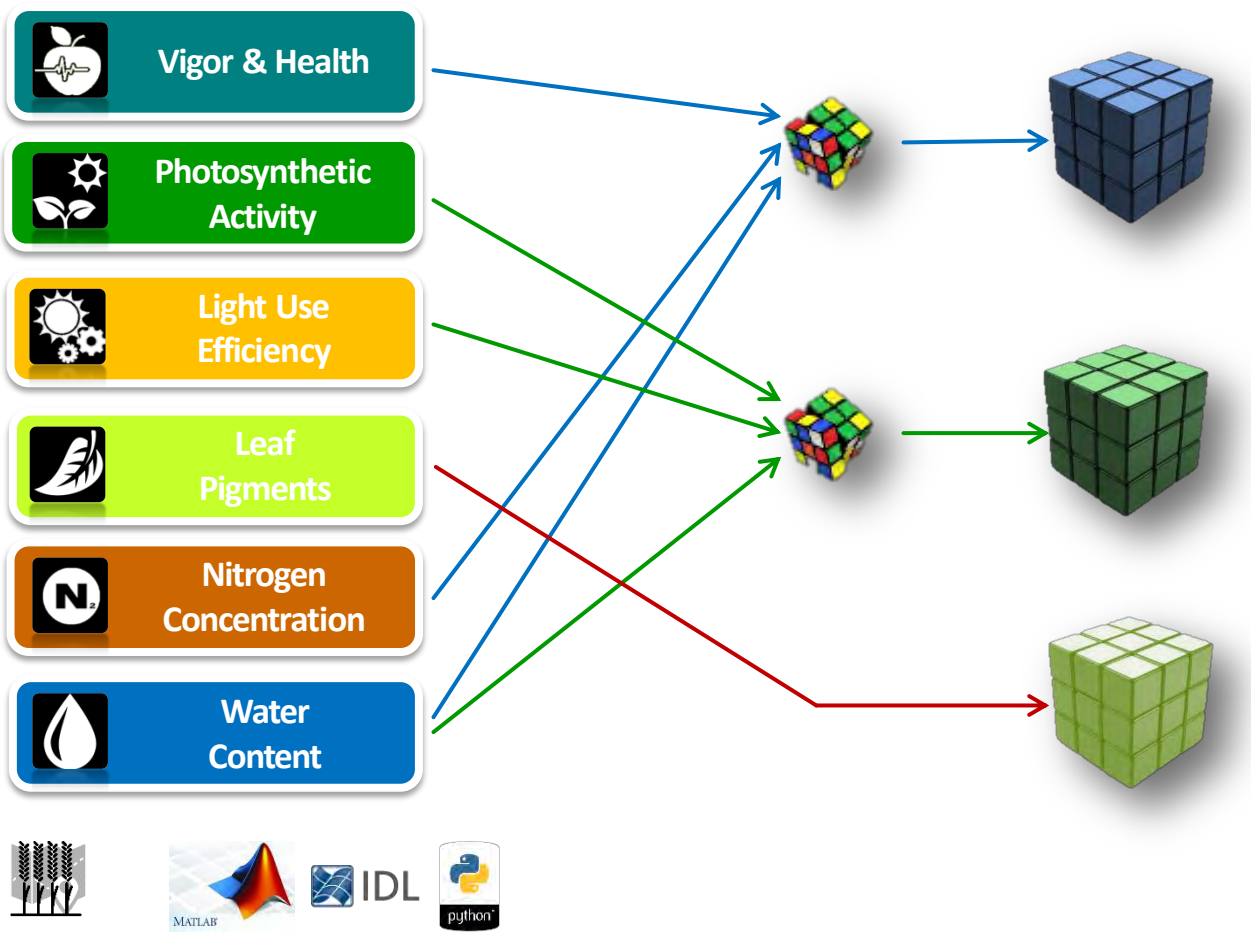
Agriculture Specific Vegetation Indices



WHAT FOR?

- Crop variability mapping
- Site Specific Management
- Crop phenology monitoring
- Paddock and farm zoning
- Variable harvest
- Production quality estimation
- Early disease detection
- Adjust rated treatments
- Variable Rate Fertilization
- Irrigation scheduling

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SATELLITE BASED PRESCRIPTION MAPS

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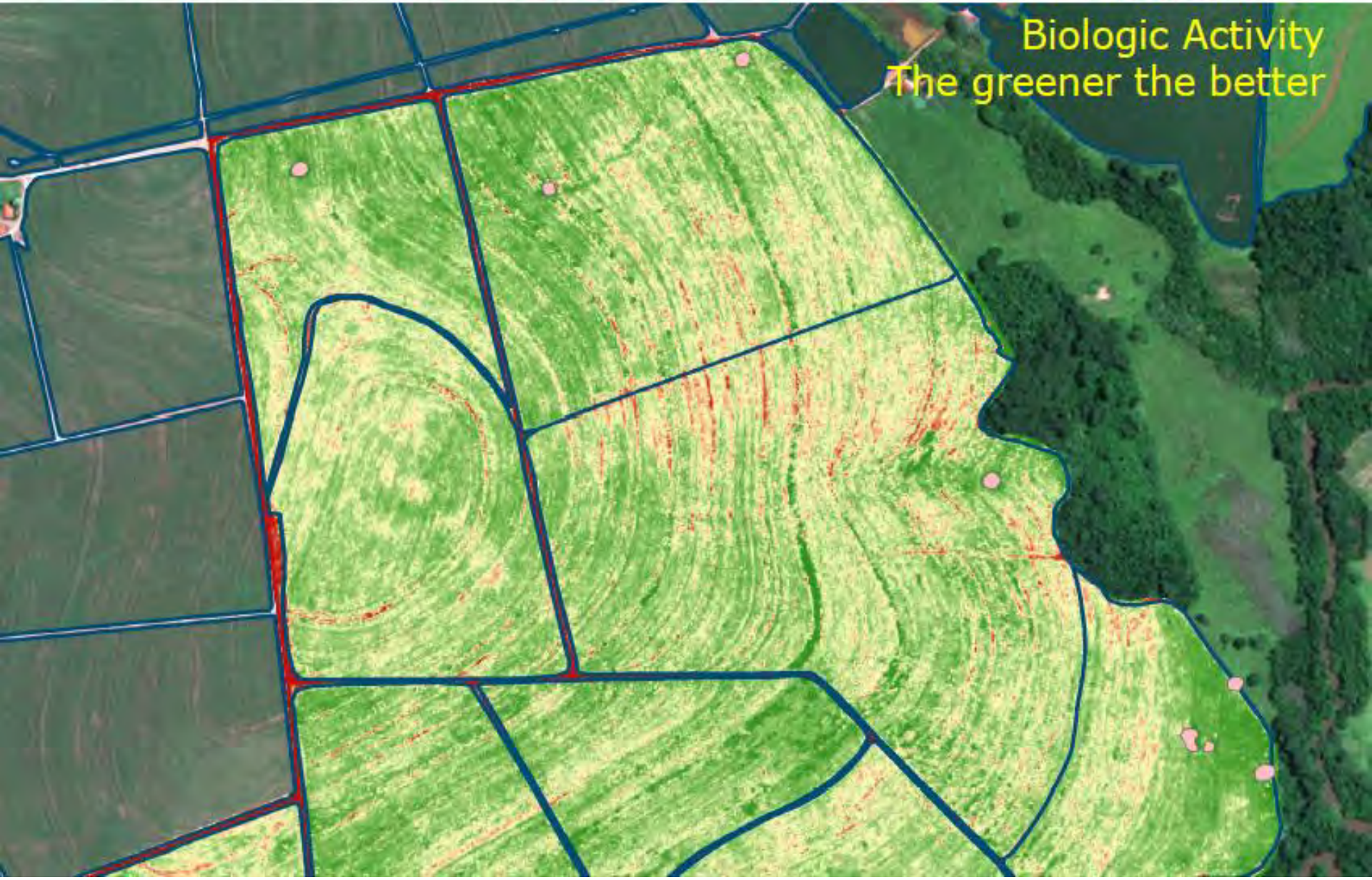
SATELLITE BASED PRESCRIPTION MAPS



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SATELLITE BASED PRESCRIPTION MAPS

DigitalGlobe Proprietary and Business Confidential

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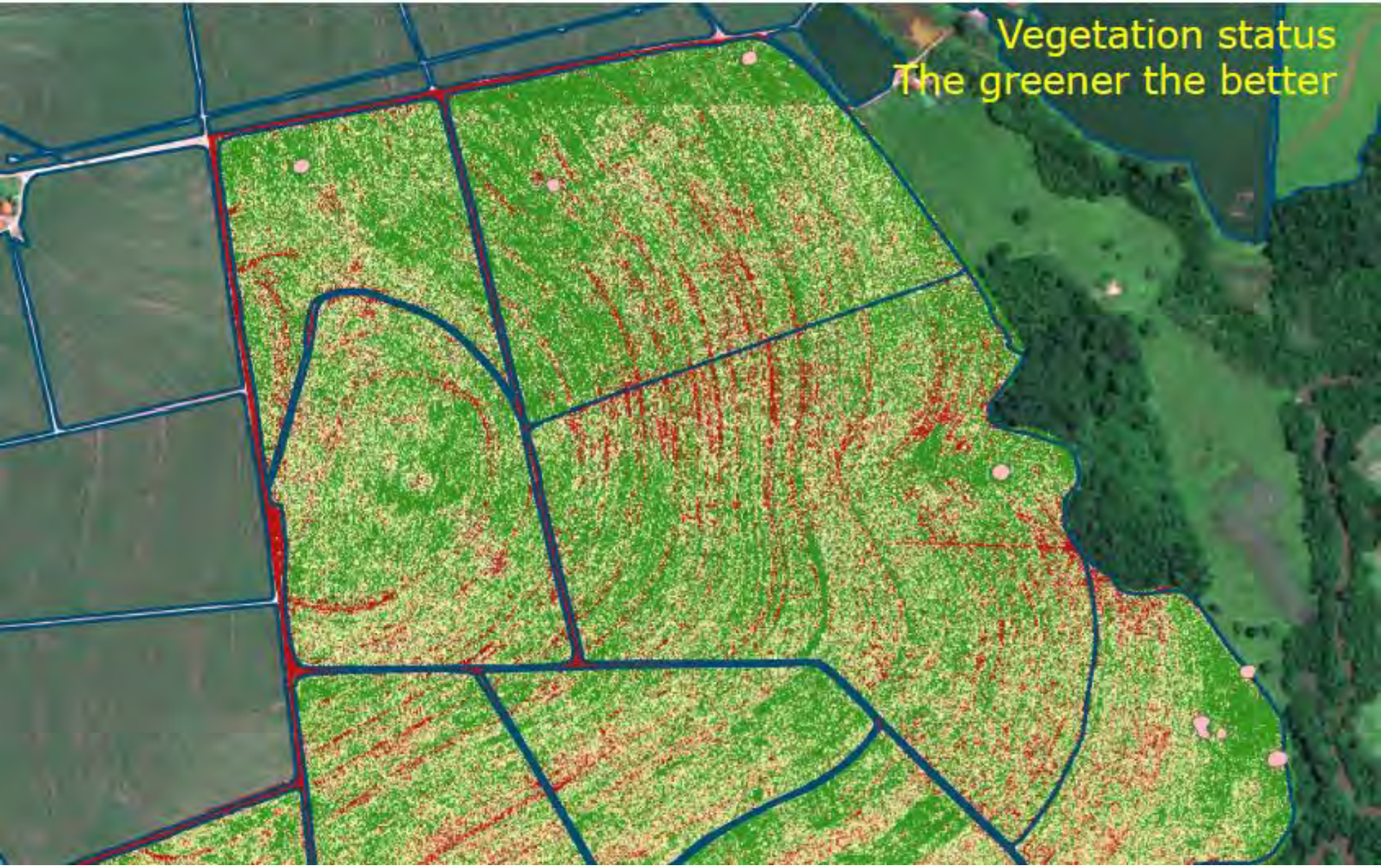

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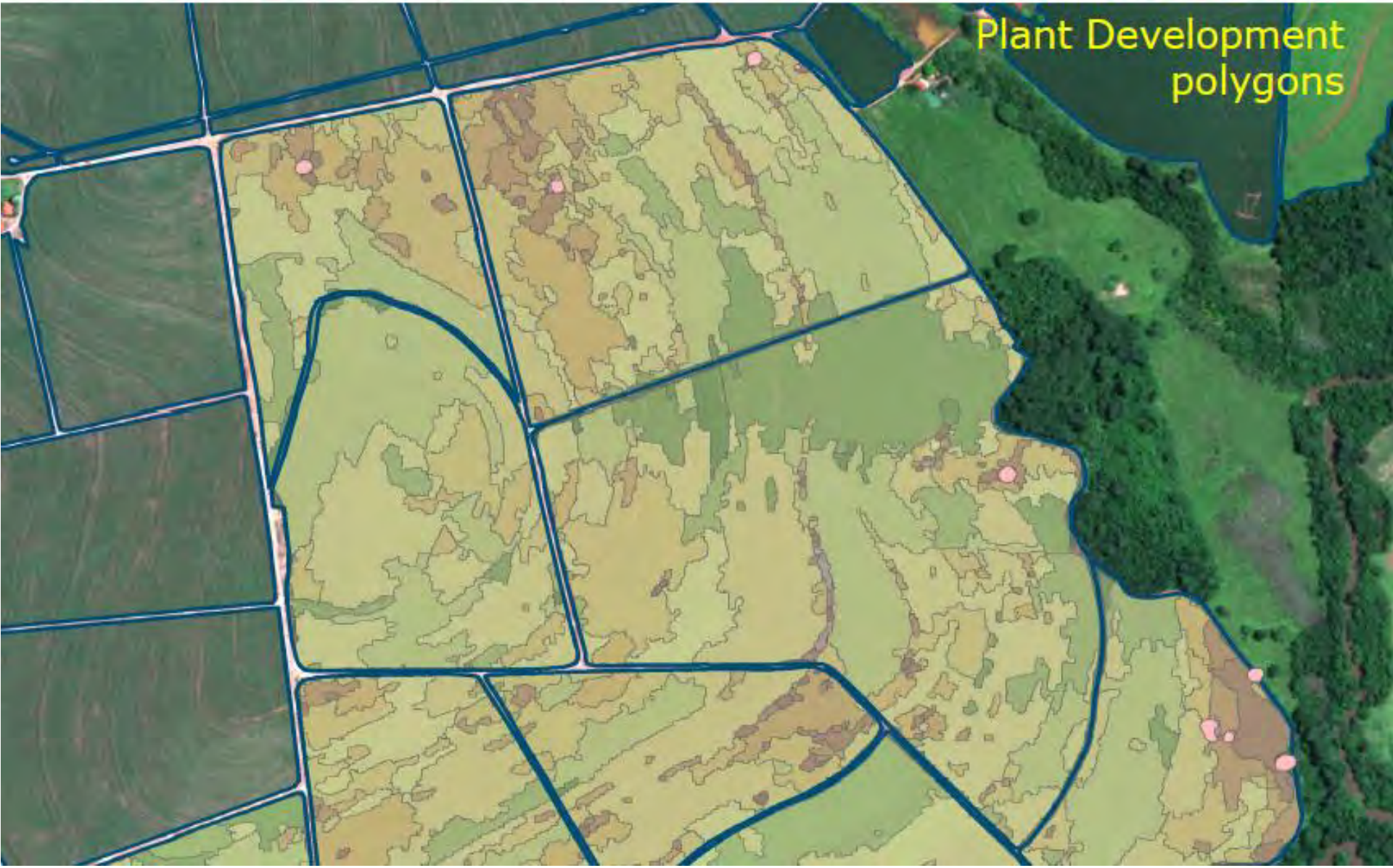
SATELLITE BASED PRESCRIPTION MAPS



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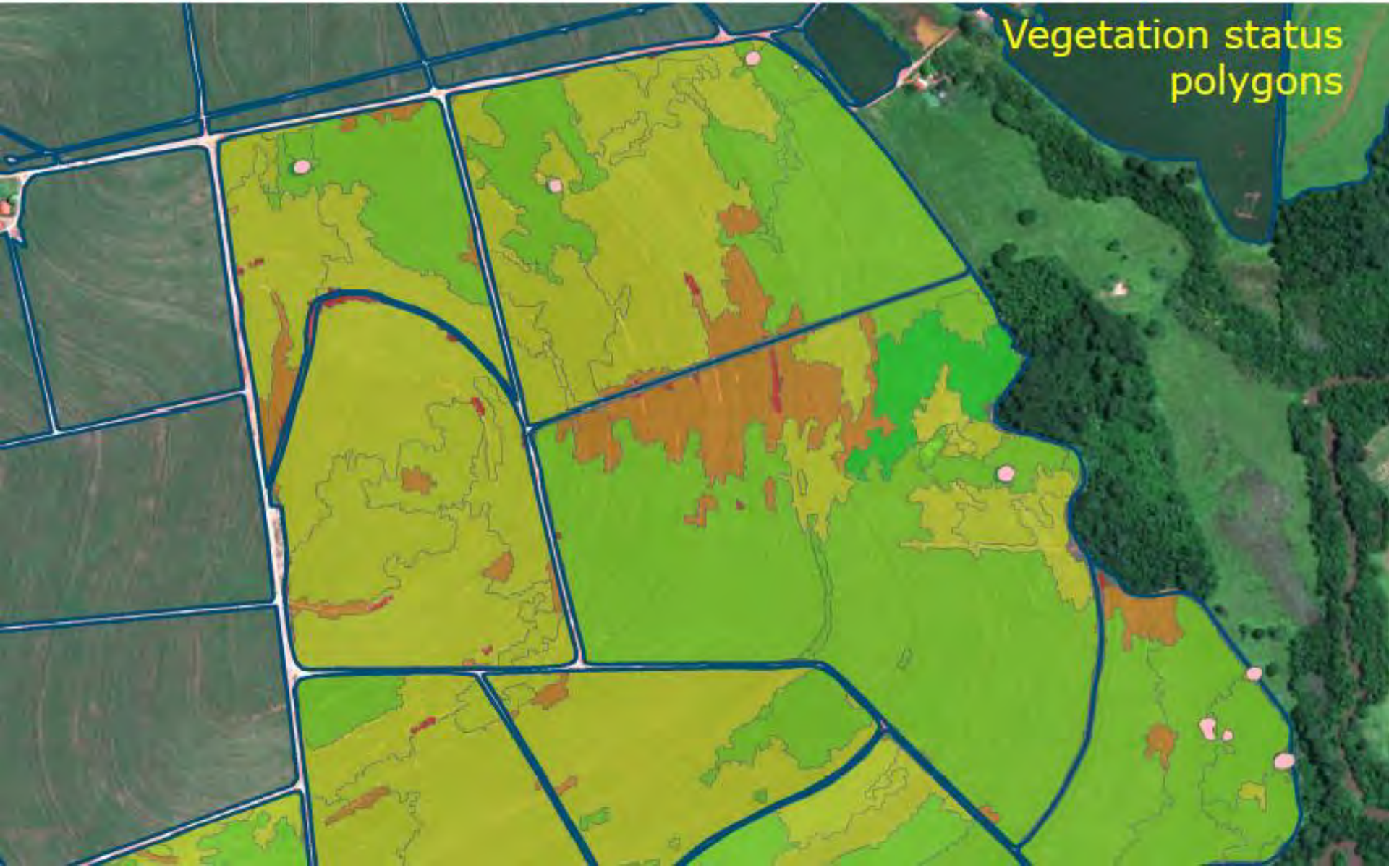
SATELLITE BASED PRESCRIPTION MAPS



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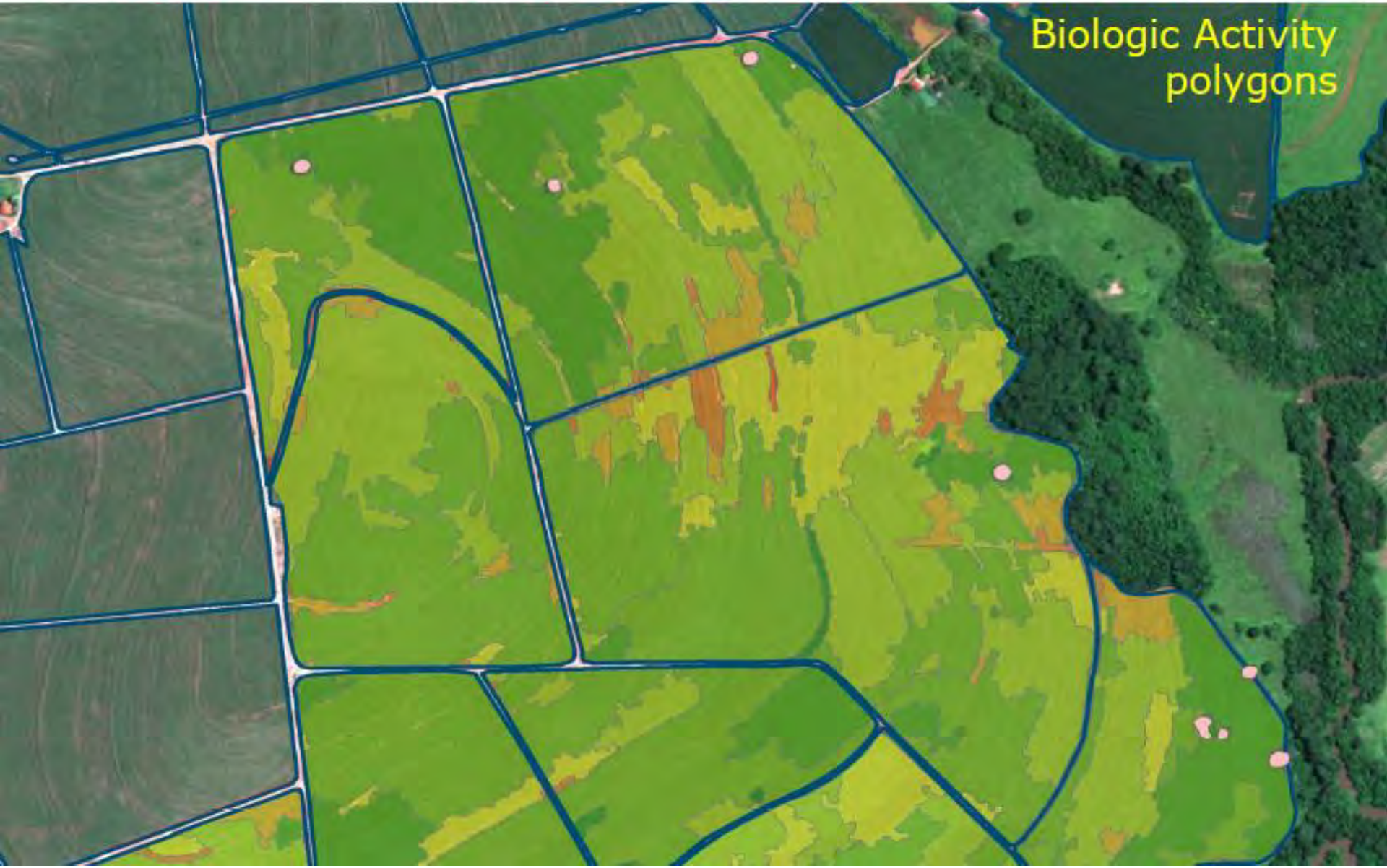
SATELLITE BASED PRESCRIPTION MAPS



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VNIR commercial use cases

Useful Band combinations and band ratios for quick identification of objects

USE CASE	BAND COMBINATION	BAND RATIO(S)*
General land cover	8,4,1	WV-WI, WV-VI, WV-BU, WV-SI
Water	8,7,6	WV-WI
Exposed Soil	5,8,4	WV-SI
Vegetation	8,7,6	WV-VI
Roofing and Roads	5,7,8	WV-BI
Artificial materials in desert	4,1,7	
Artificial materials in dense vegetation	6,7,4	
Underwater Obstruction	1,2,3	
Direction of travel	6, 5, 4	
Dirt roads/trails between canopy	N/A	5, WV-VI, WV-WI
Fire through light smoke	8,7,6	
Subsurface materials	8, 7, 6	WV-SI, 7, 1

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Example: general land cover

Natural Color (R, G, B)

False Color [NIR2, NIR1, RE]

- Clear delineation of water, soil, built up and vegetated areas

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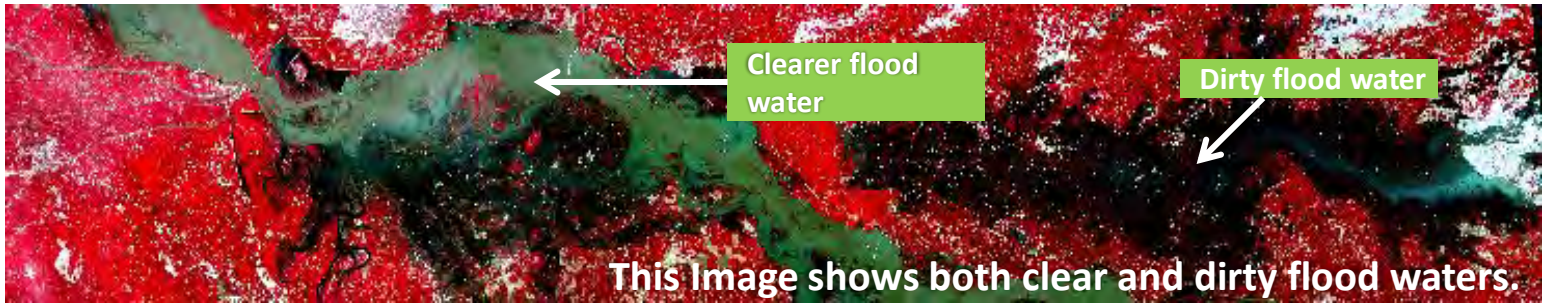
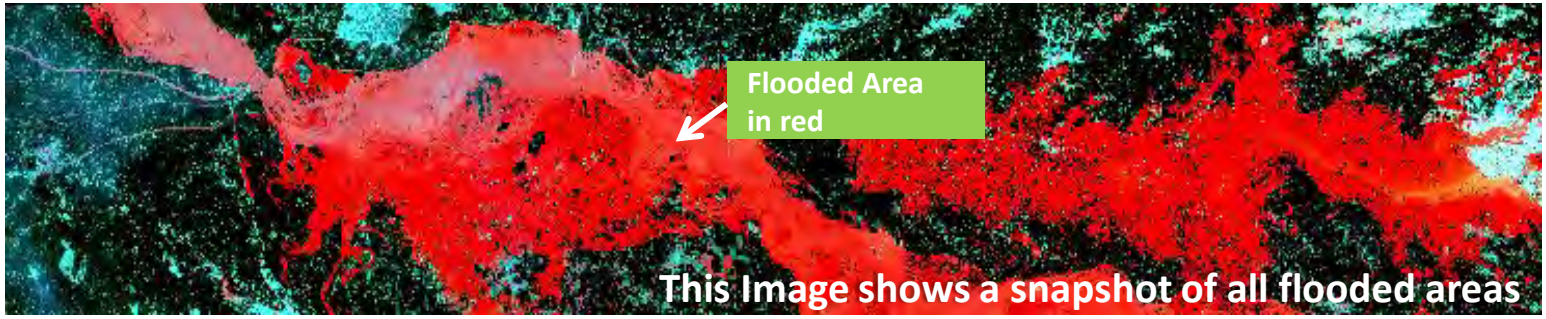
Example: identifying flowing and inundating water

Flooded River in WorldView-2 Visible Colors

Flooded River in WorldView-2 Infrared Colors



Flooded River in WorldView-2 Manipulated Colors*



** Manipulated Bands means that a little fancy math was applied to unlock more information from the picture!*

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Example: exposed soil

Natural Color (R, G, B)

- Low contrast between fallow fields

False Color [RE, NIR1, Y]

- High contrast between fallow fields and changes in soil pattern
- Clear identification of breaks in soil pattern

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Short Wave Infrared (SWIR) Imagery Use Cases

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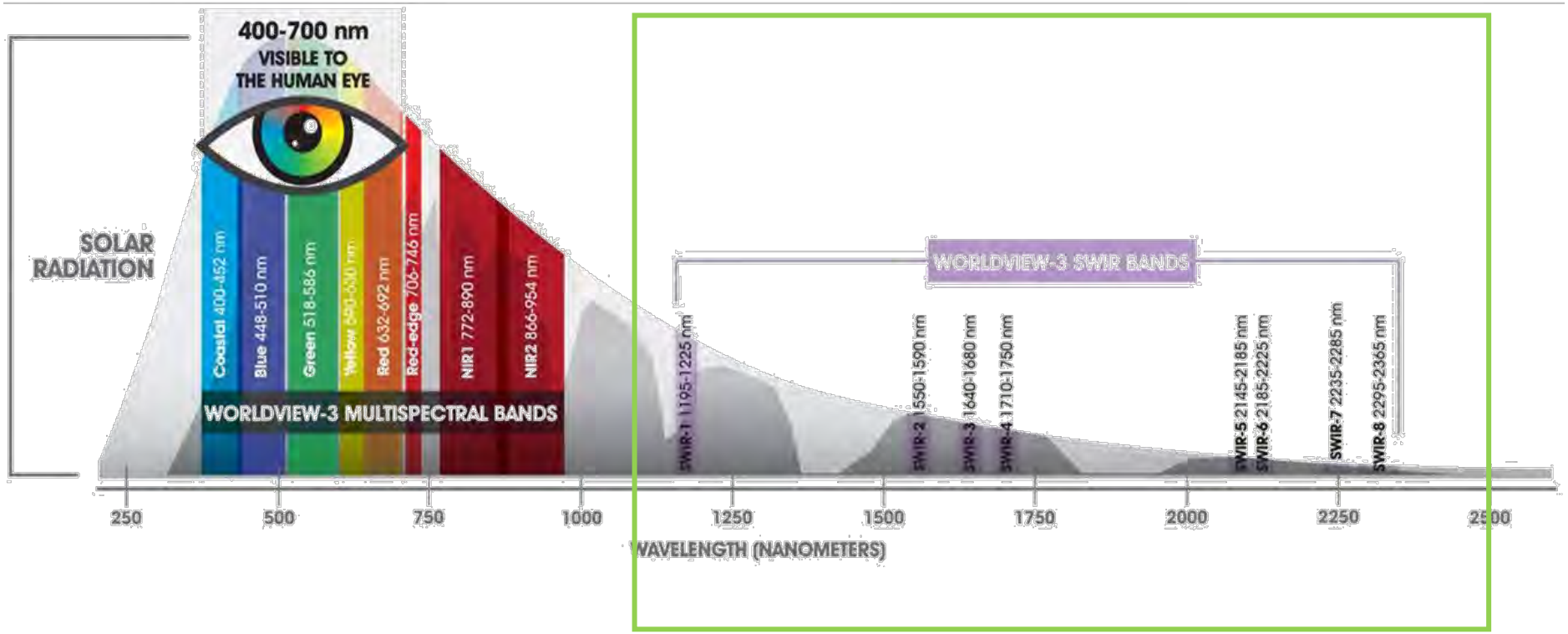
SWIR band location in the electromagnetic spectrum with respect to VNIR bands



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SWIR use cases

Signature	Use Case Descriptions
Thermal – High Heat	• Detection of fire, burning structures, current or impending gas flares, current ordinance explosion
Smoke Penetration	• Ability to penetrate smoke from fires, burning oil , or explosions
Material identification: Plastics and Polymers	• Distinguish camouflage from natural surroundings, • Distinguish the use of tarps to hide vehicles or activity
Material identification: Steel and Iron	• Distinguish materials composed of steel and iron such as the armor surrounding military vehicles
Marine Vessel Movement	• Detect marine vessel's extended wake and use it to determine direction of travel
Soil and Mineral Mapping	• Distinguish ground disturbances that are evidence of activity such as tunneling or mass grave sites
Soil Moisture	• Improves accuracy of mobility mapping, detect soil moisture used to produce illicit crops

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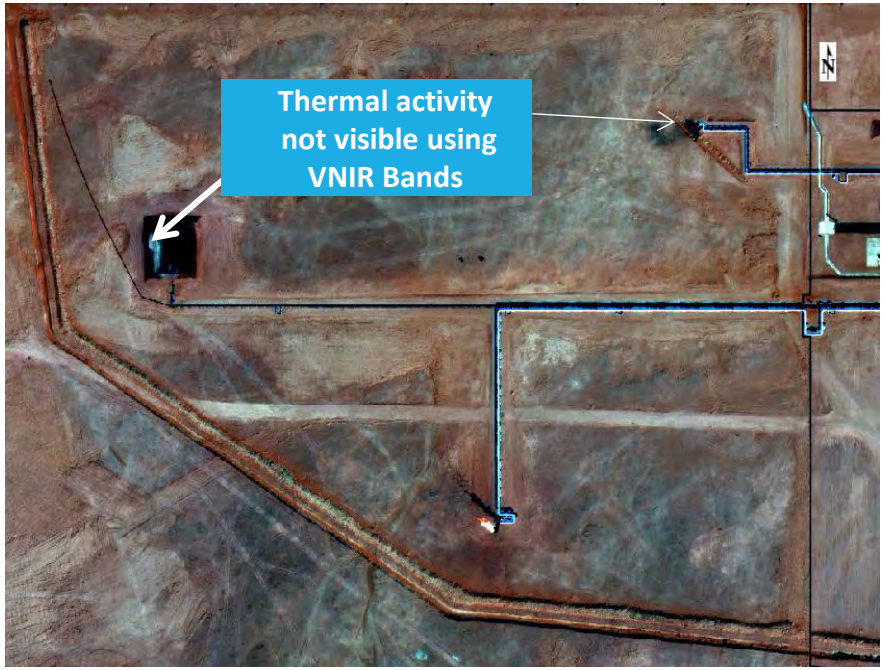
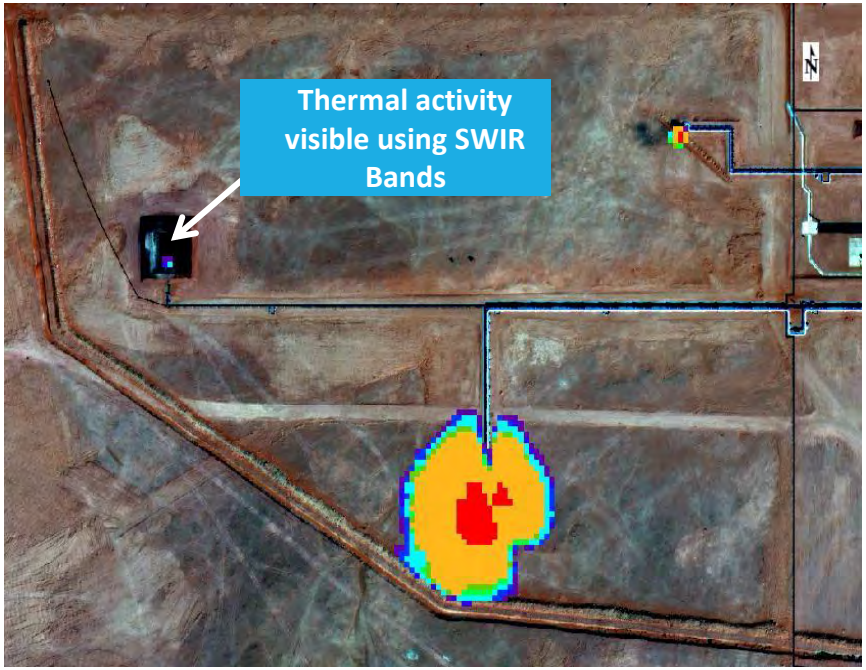
Thermal – High Heat:

thermal response for industrial flaring

Natural Color (R, G, B)



SWIR Based Thermal Overlay



- Significant thermal signature from flare
- Two smaller sources are emitting heat but no visual signature

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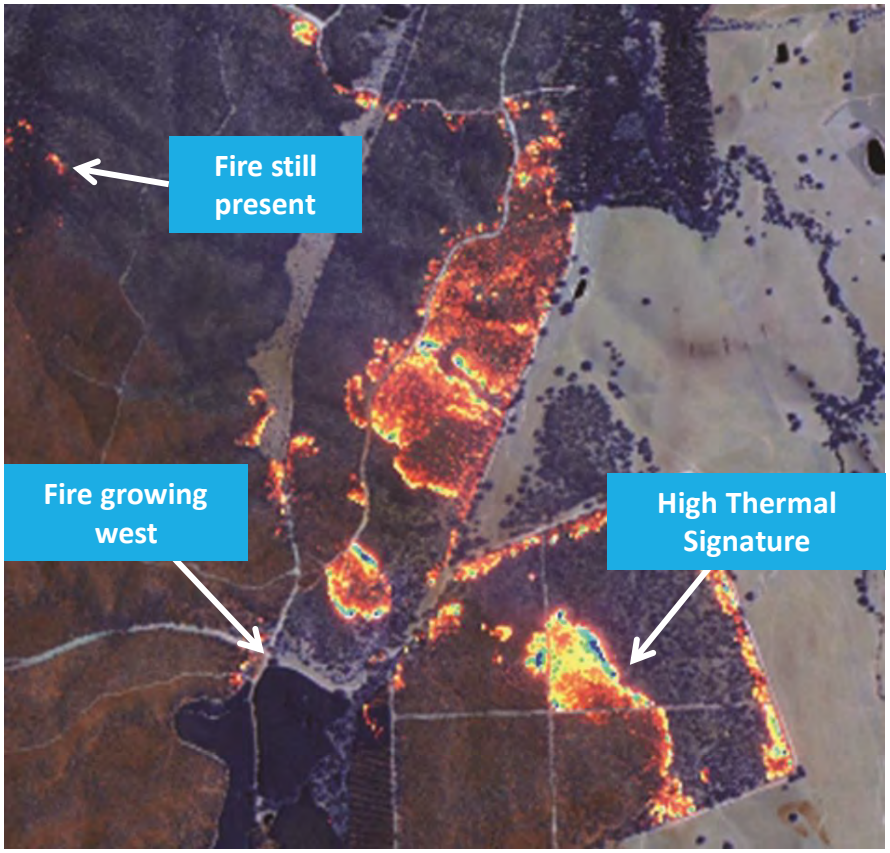
Thermal – High Heat/Smoke Penetration:

penetrate smoke to detect areas of high heat from fires

Natural Color

SWIR



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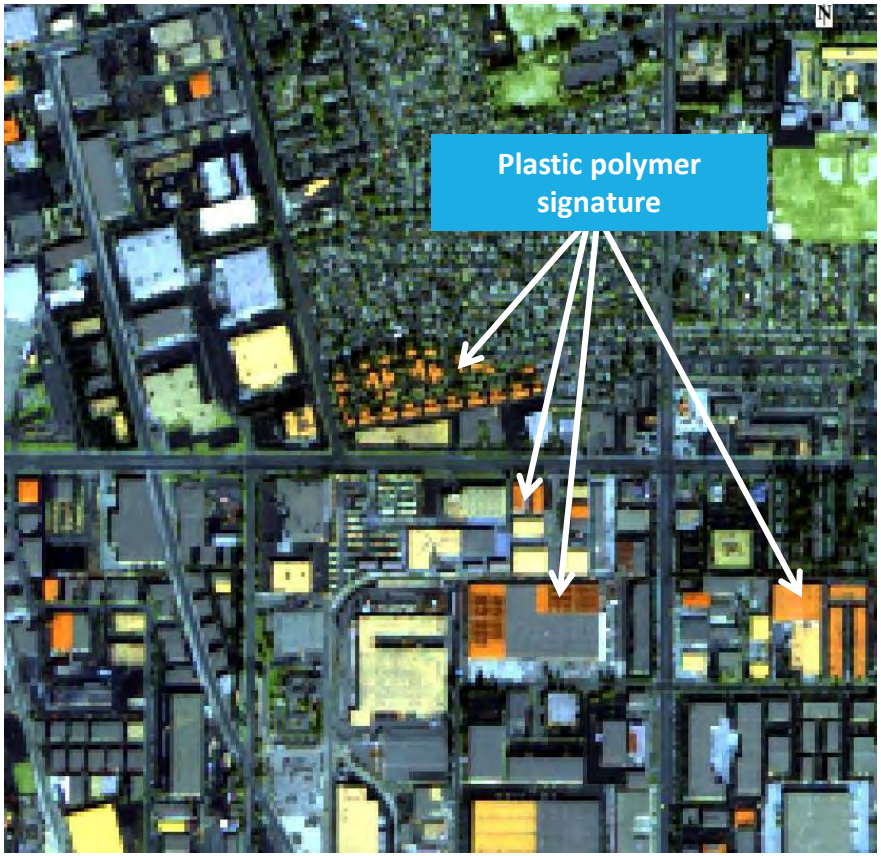
Material Identification:

distinguish plastics and polymers

Natural Color

SWIR



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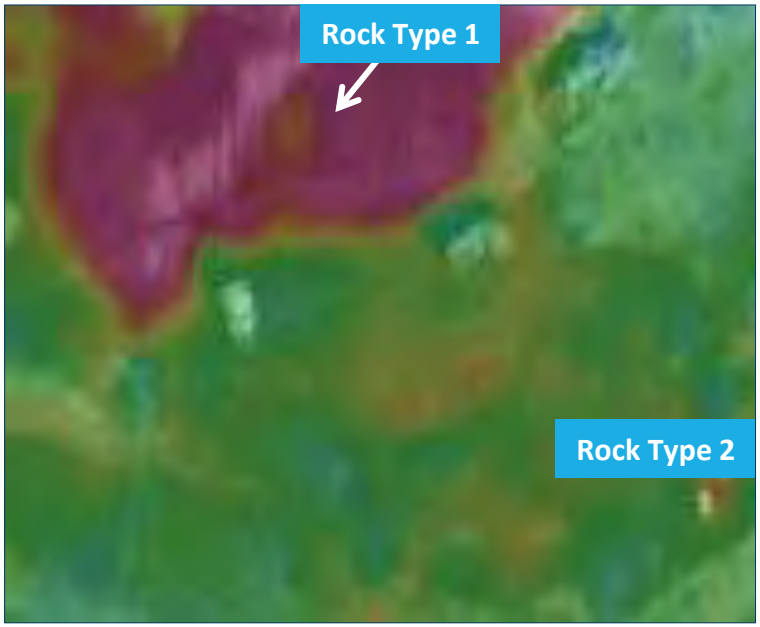
Soil and Mineral Mapping:

Natural Color

SWIR



- SWIR of New surface sediment reveals indication of originating rock type

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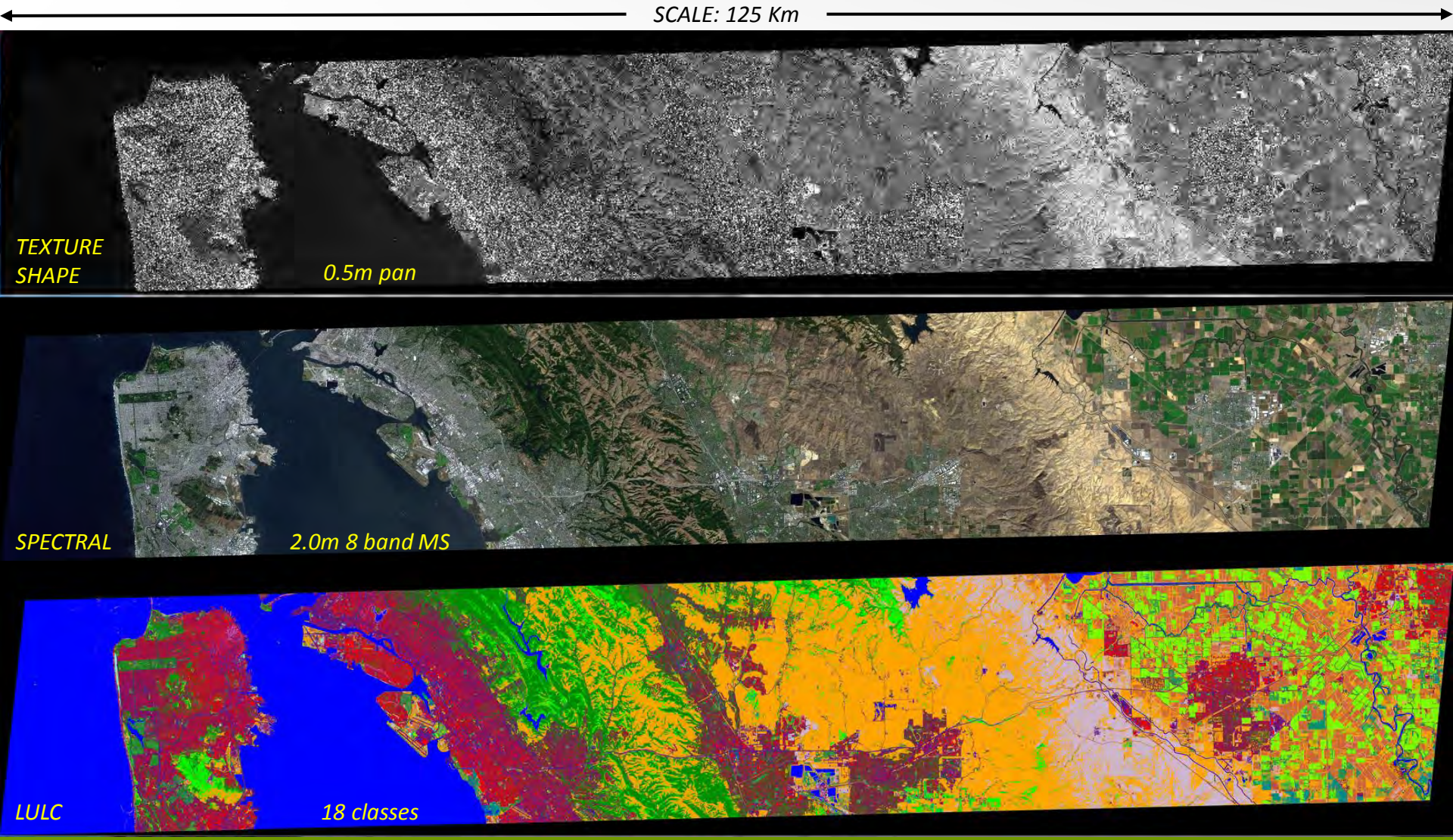
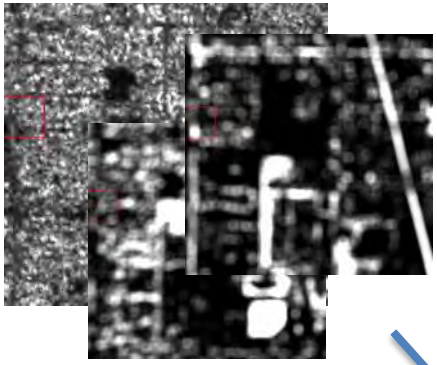
Land Use Land Cover Classification (LULC)



What is LU/LC classification

Machine learning based approach to derive “types” of land cover and land use from remotely sensed imagery.

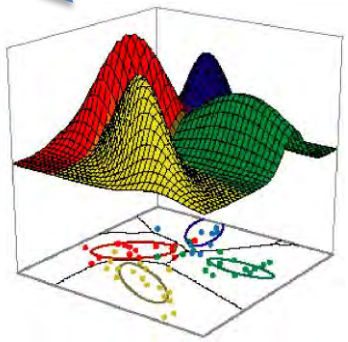
Pixel Data



Feature Extraction

Classification

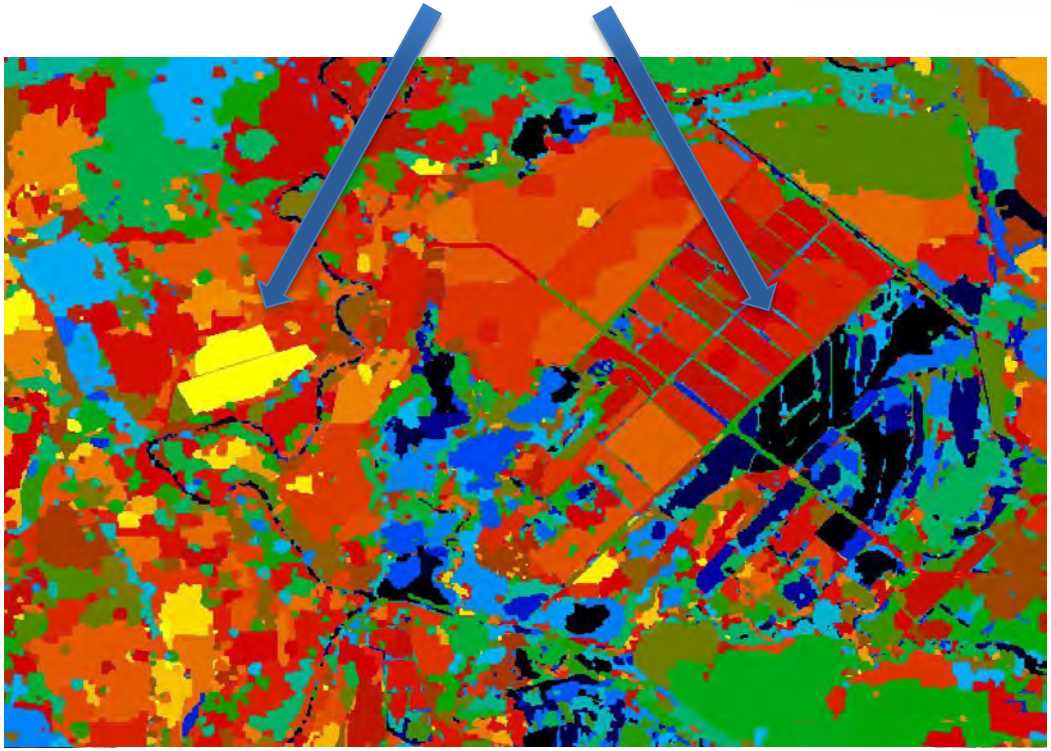
Supervised Examples



Model Building

We can see things nobody else can

Are these two crops the same?



WV2 Red Edge

KEY FEATURES/BENEFITS

- Supports massive agricultural monitoring campaigns:
  - ✓ Extraction of field boundaries
  - ✓ Crop identification
  - ✓ Predicting crop yield
  - ✓ Monitoring of crop stress/health
- Scalable to a country (1-2M Km^2), consistent with our big data strategy

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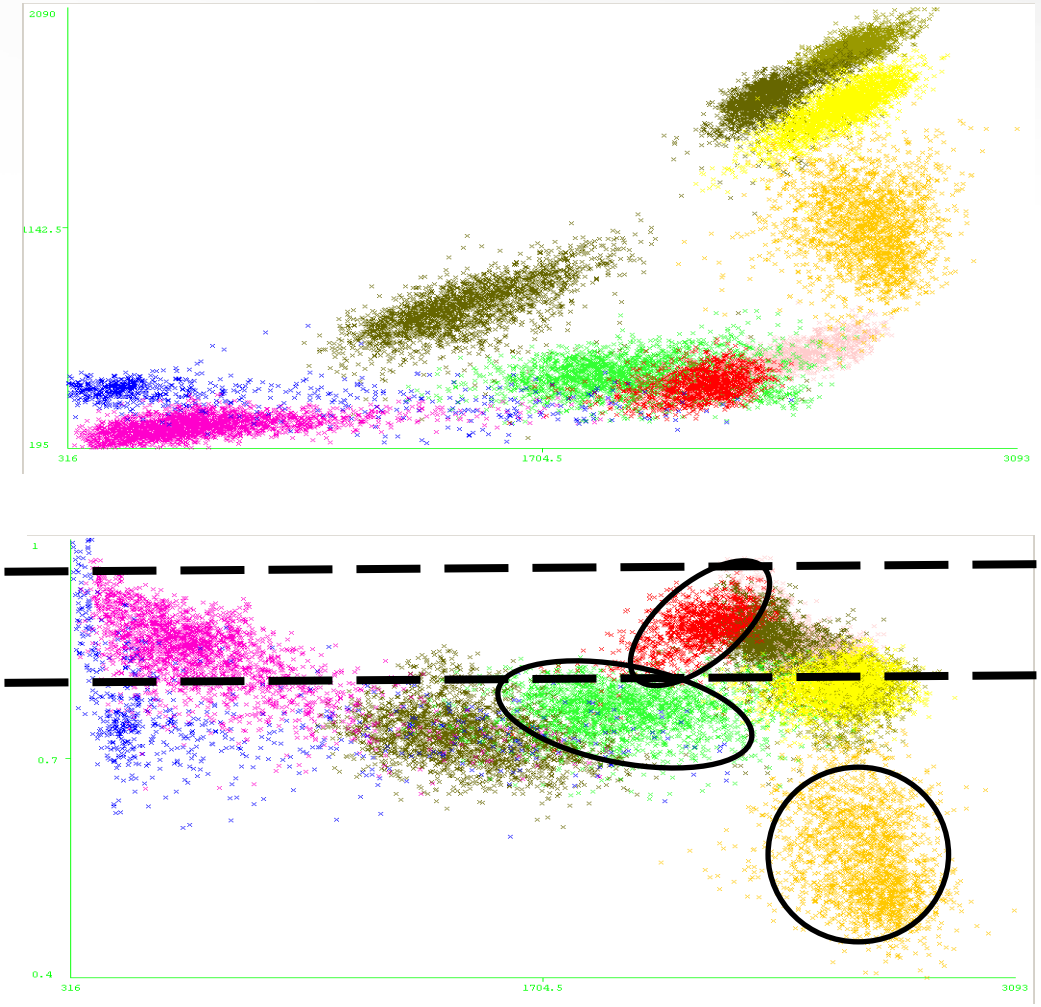
Crop Separability



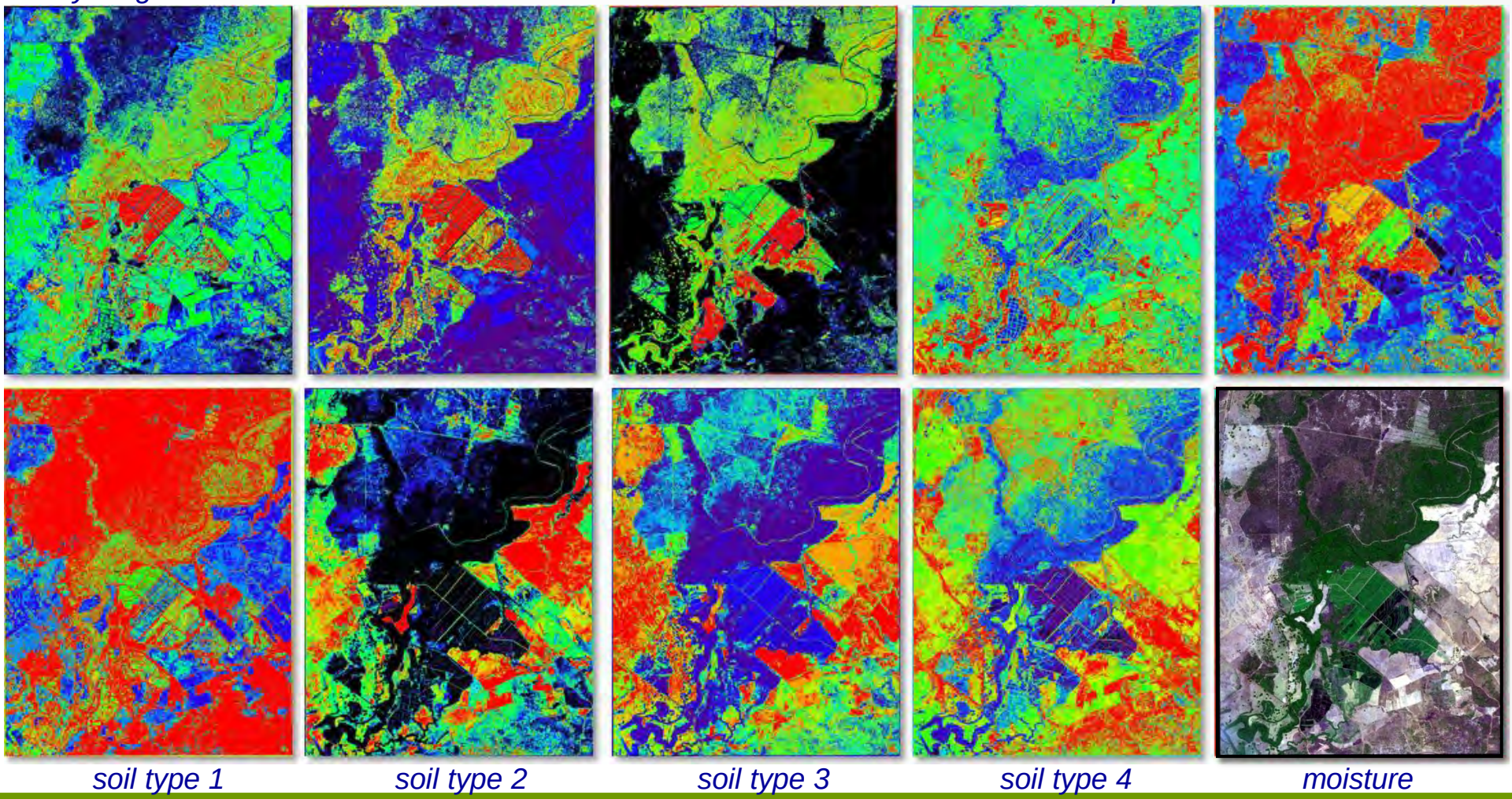
young sugarcane
mature sugarcane
dead sugarcane
other vegetation
other crop

Y

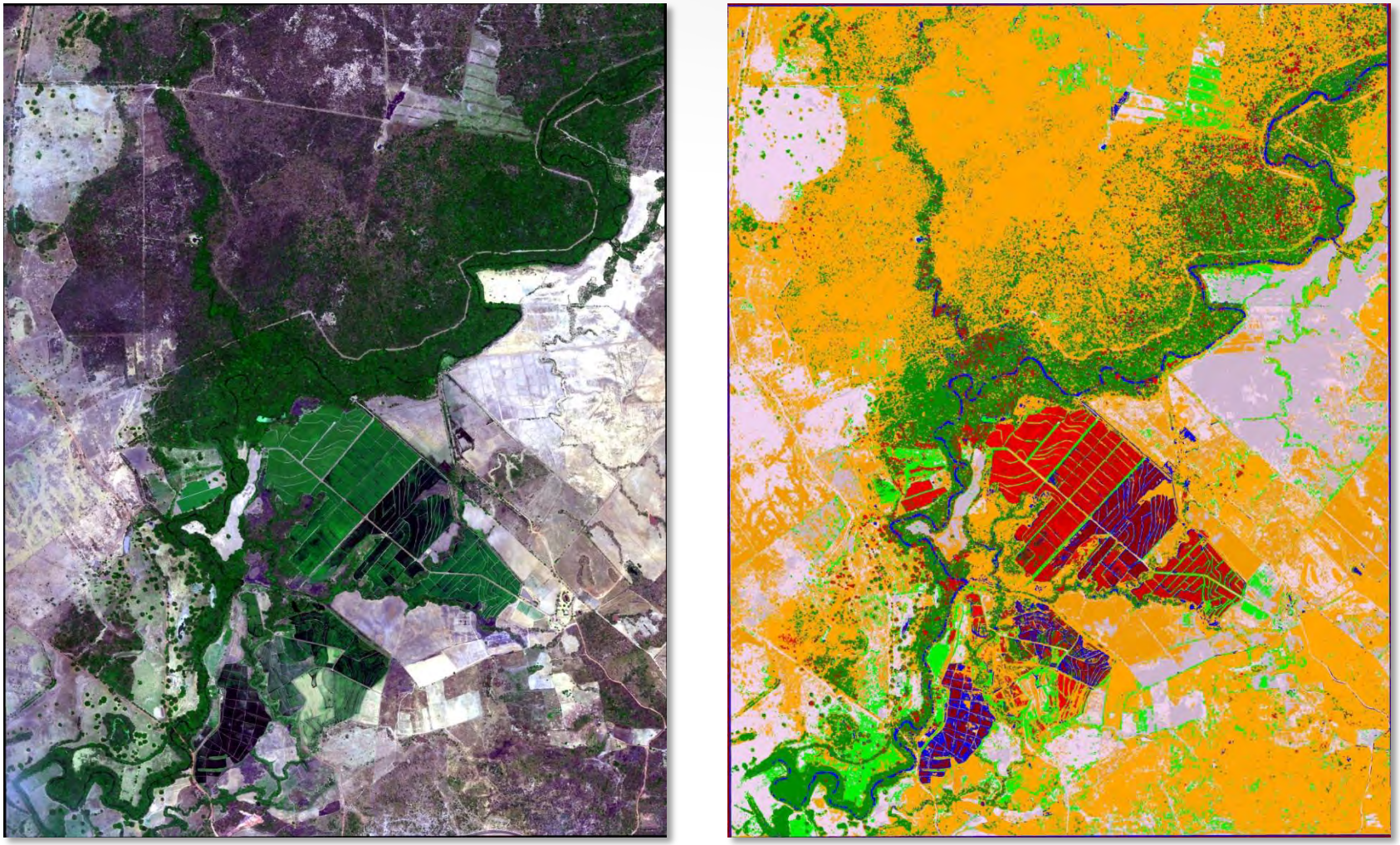
correlation texture from 0.50m pan

RE

Probability Maps for Selected Land Covers



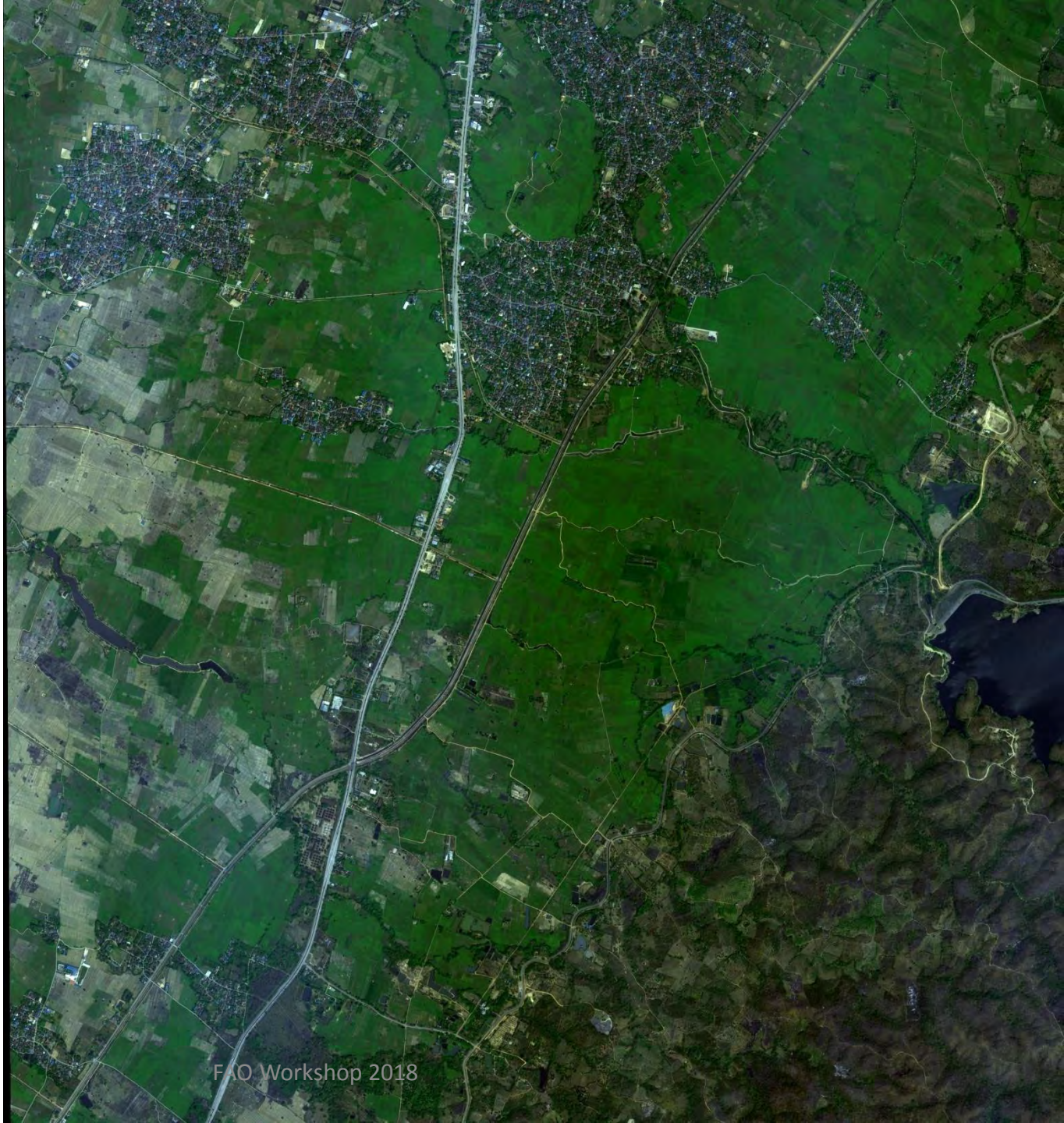
Classification Map (sugarcane vs. other crops)



young sugarcane | mature sugarcane | dead sugarcane | other vegetation | other crop

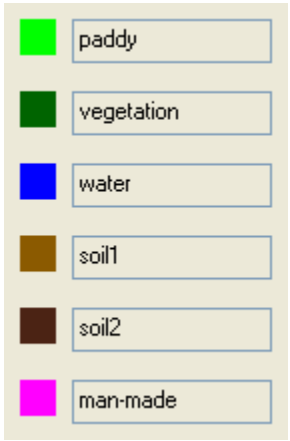
Inventorying Rice Paddies in Thailand

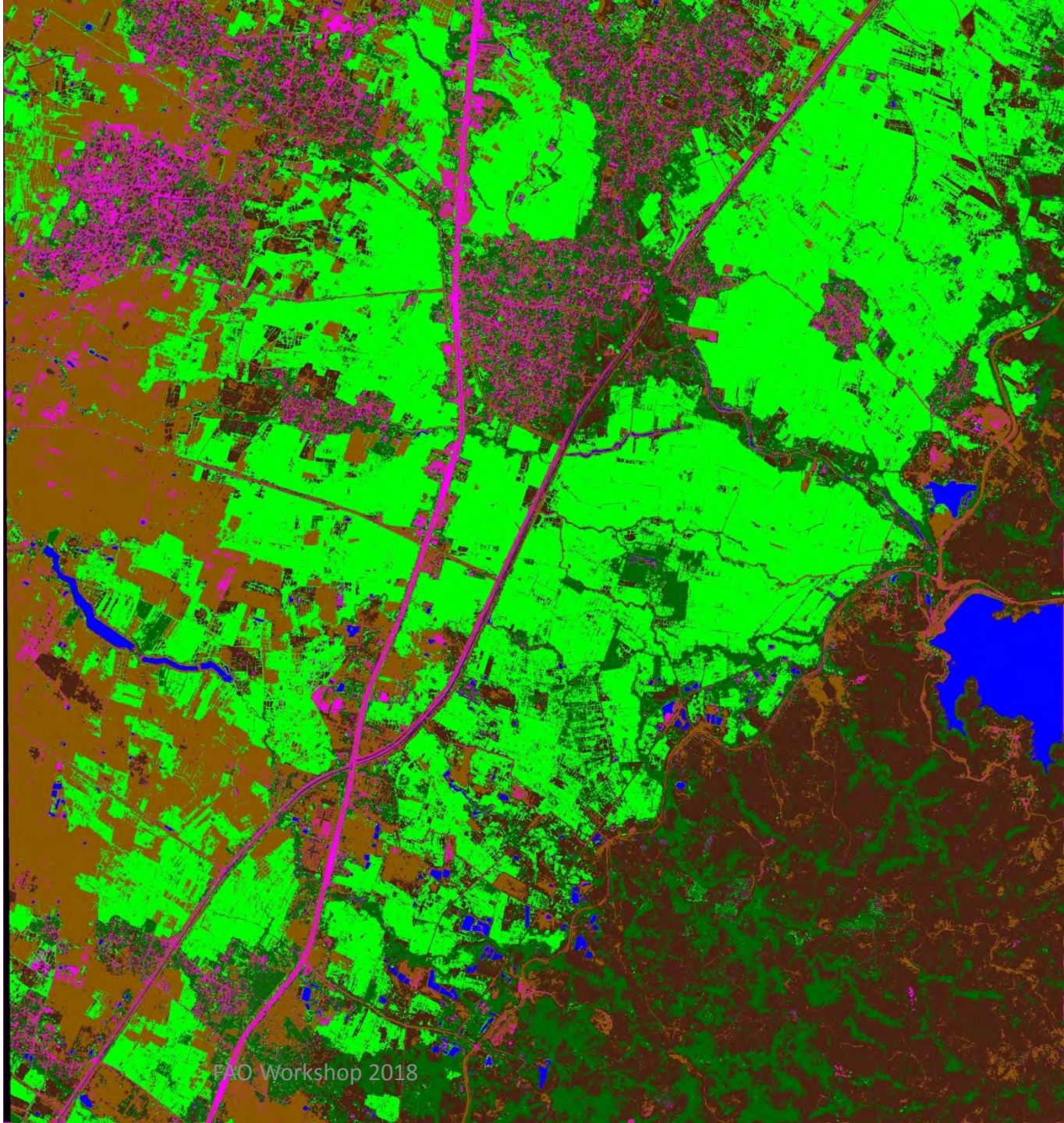
WorldView-2
natural color
2m image
March 13, 2010



Inventorying Rice Paddies in Thailand

WorldView-2
classification
March 13, 2010



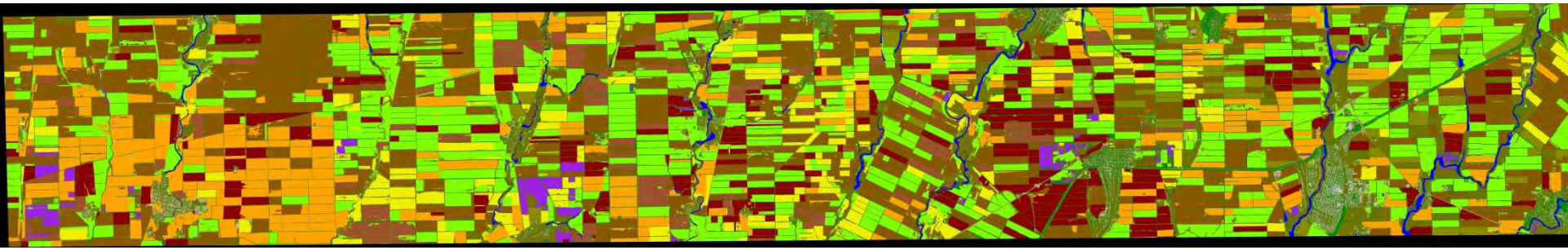


Precision Agriculture in Russia
(Extracted Field Boundaries)

input WV2 image – Krasnodar region

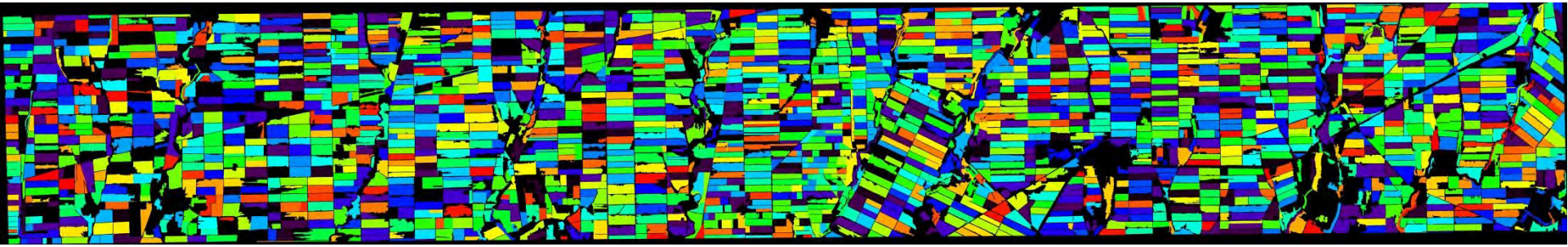
crop types from spectral and textural properties

speed: ~2days/1,000,000Km^2 on a single 128 CPU rack



field boundaries from morphological properties

speed: ~10 minutes/1,000,000Km^2 on a single 128 CPU rack



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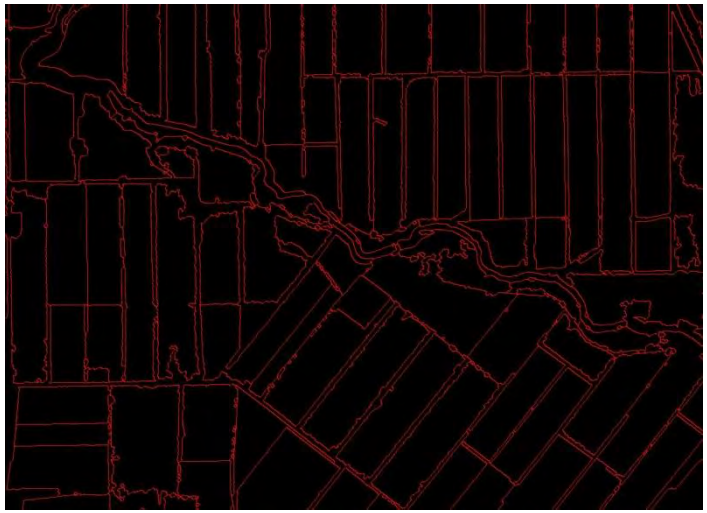
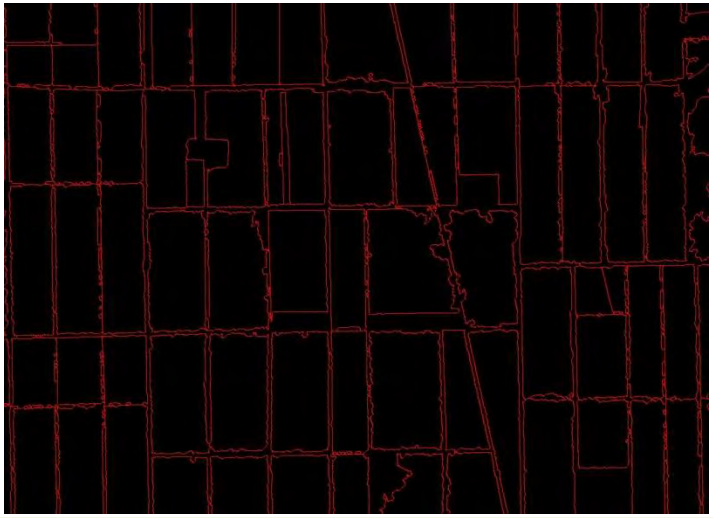
Precision Agriculture in Russia

(Extracted Field Boundaries)



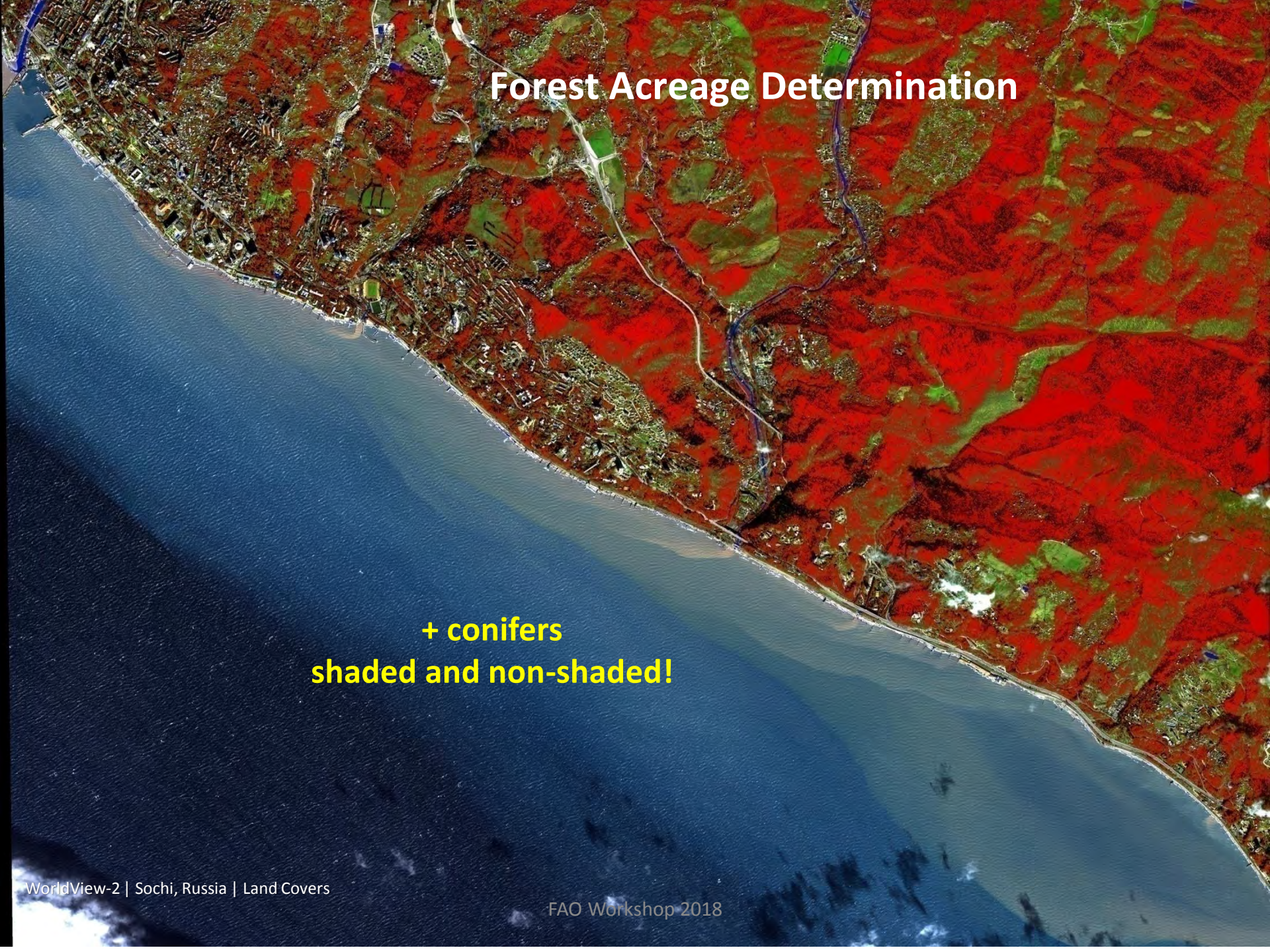


Level of Detail Allows Tree Discrimination

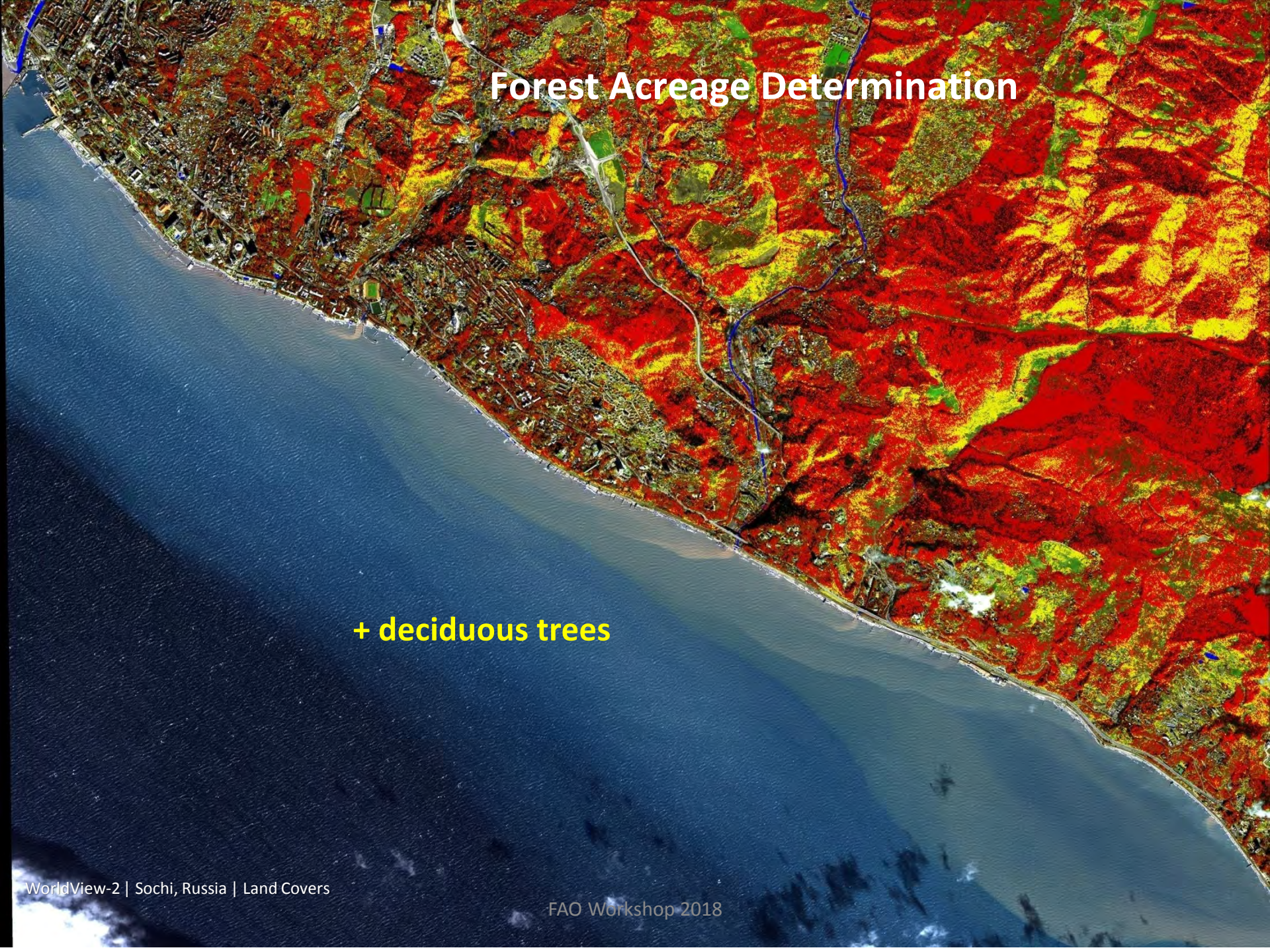
DigitalGlobe

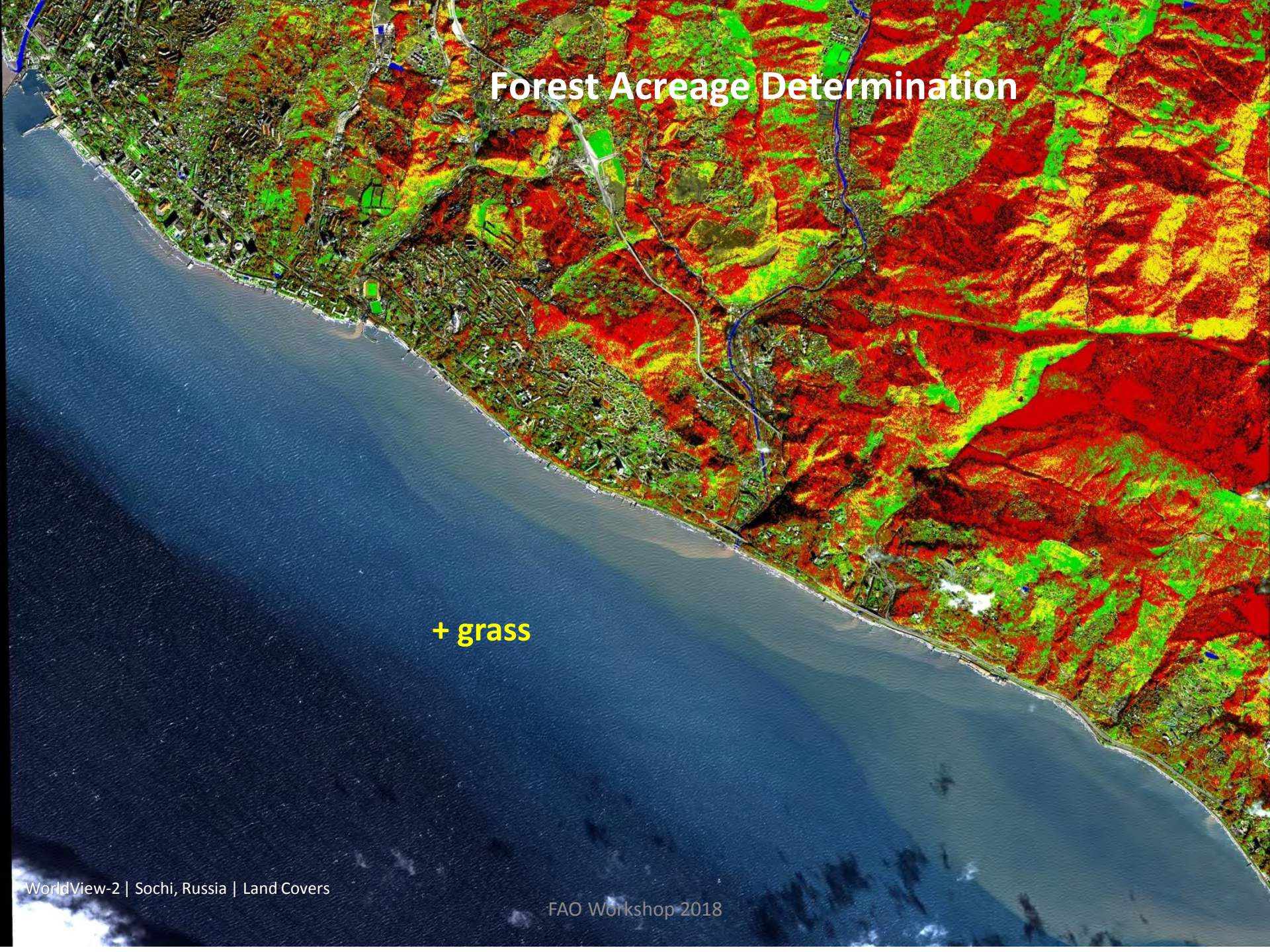
from Type to Species

WorldView-2 | Sochi, Russia



WorldView-2 | Sochi, Russia | Land Covers

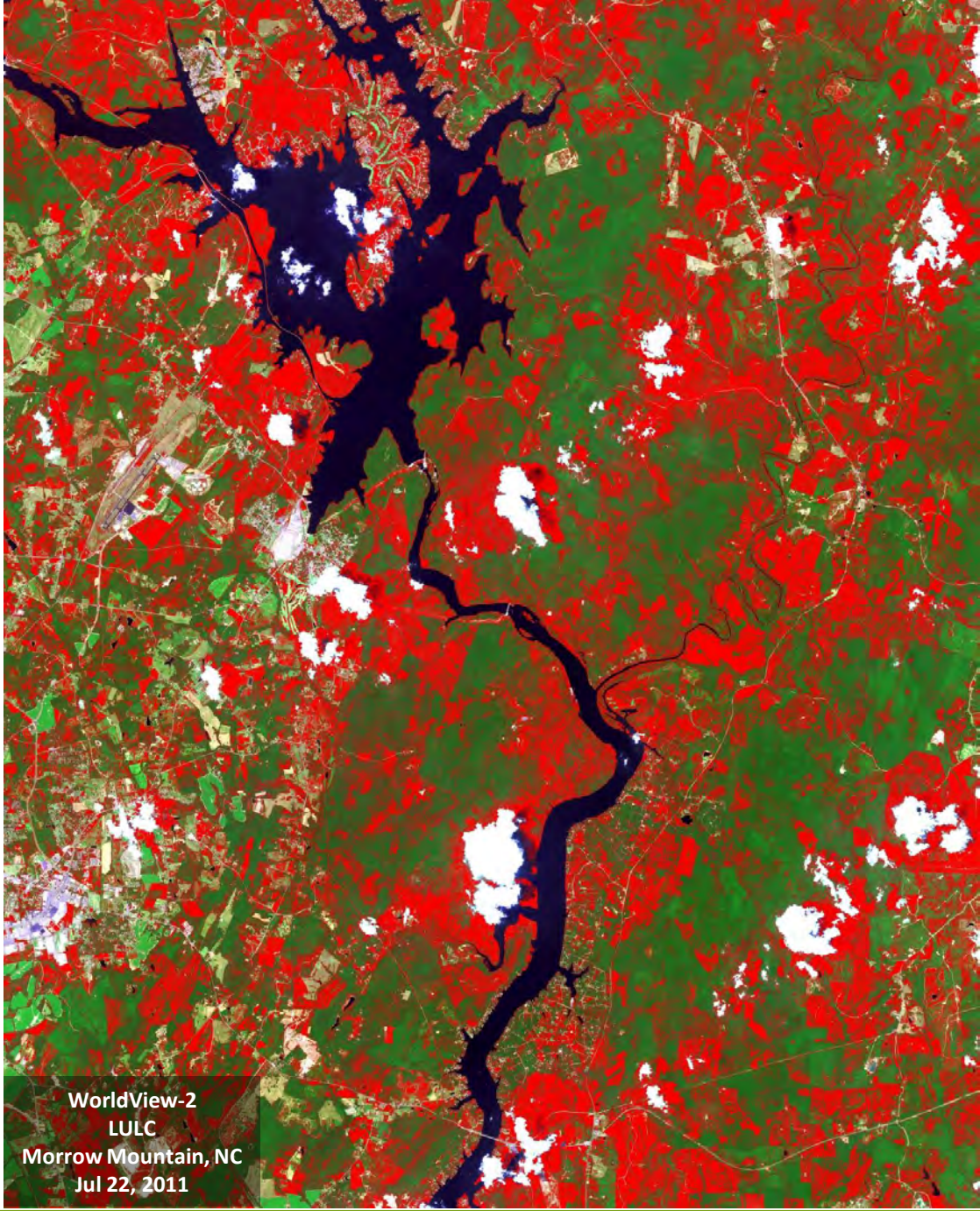

Forest Acreage Determination
+ deciduous trees
WorldView-2 | Sochi, Russia | Land Covers


Forest Acreage Determination
+ grass
WorldView-2 | Sochi, Russia | Land Covers

Forest Acreage Determination

Forest Acreage Determination

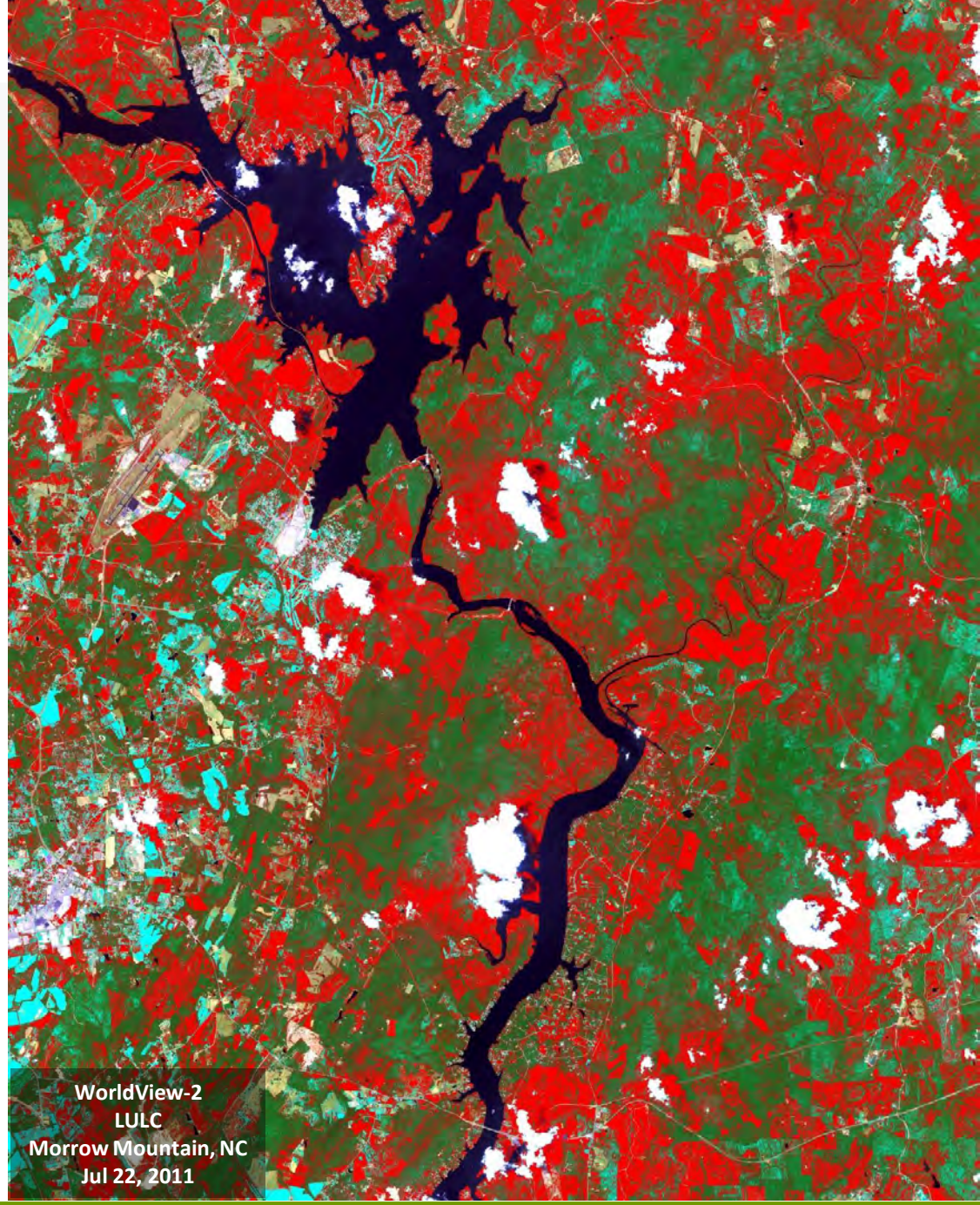
+ conifers



Forest Acreage Determination

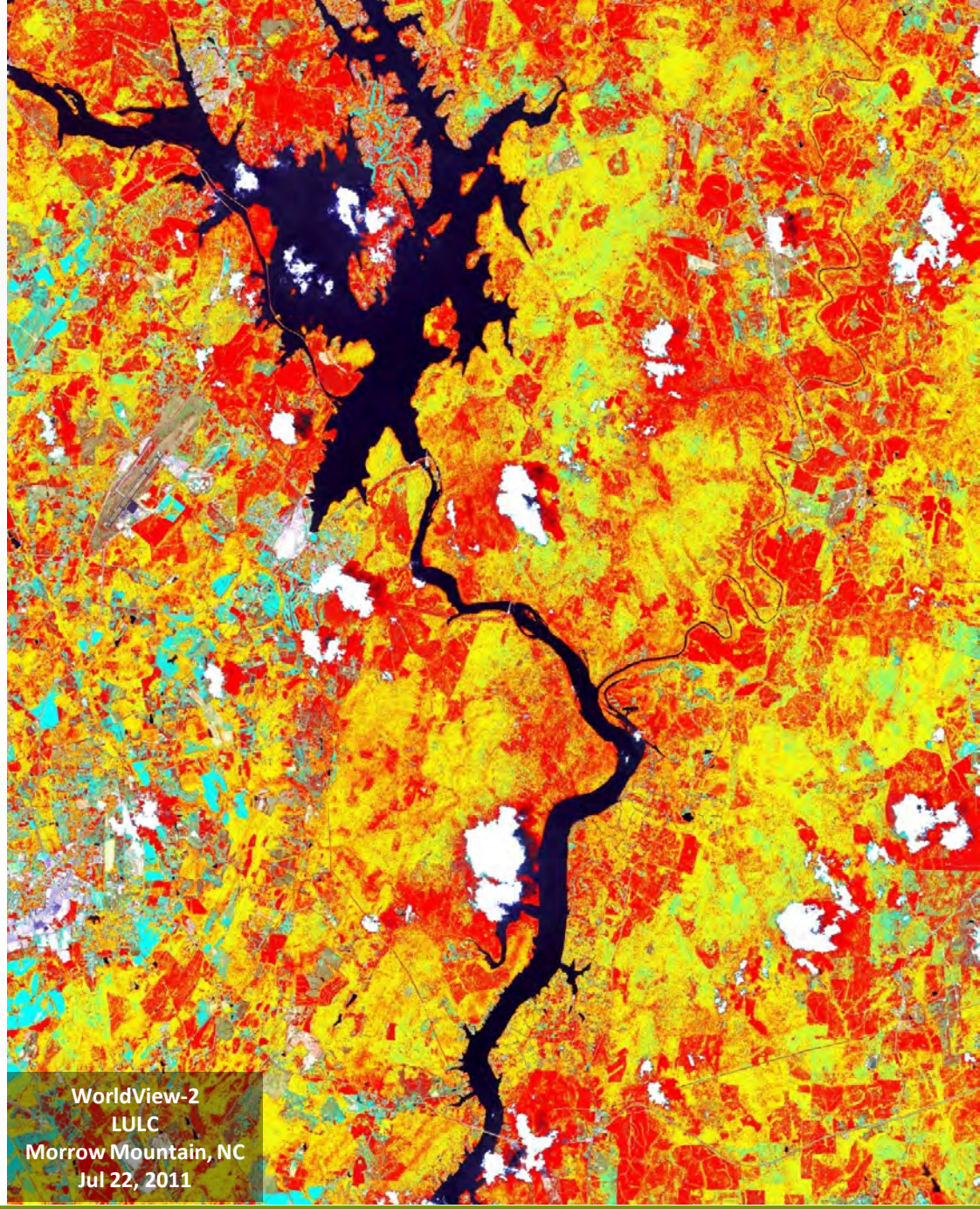
+ conifers

+ grass



Forest Acreage Determination

+ conifers

+ grass

+ deciduous