Belgian Science Policy

World Wide Watch

Earth observation products for FAO operational locust habitat monitoring and for GIEWS agriculture monitoring

Vlaamse instelling voor technologisch onderzoek

VITO

UCL

Research Unit in Environmetrics and Geomatics

FAO

GLOBAL WATCH GIEWS

Global Information and Early Warning System on food and agriculture [GIEWS]

GEM

Global Environment Monitoring Unit /JRC

Background

- Availability of frequent and relevant Earth's surface information from medium spatial resolution sensors (SPOT-VGT, AATSR, MODIS, MERIS)

- Growing need for global Earth observation products
  - on a frequent basis
  - for environmental monitoring

Objectives

- To ***develop*** new or more efficient global products by interactions with end-user communities
- To operationally ***deliver*** the products to these end-user communities.
- 3 products:
  - Desert Locust habitat monitoring for FAO/ECLO (Emergency Centre for Locust Operations)
  - Phenology monitoring for FAO/GIEWS (Global Information and Early Warning System)
  - Pan-tropical forest change product for UNEP/WCMC (World Conservation Monitoring Center)

Global Information and Early Warning System - on food and agriculture [GIEWS]

WCMC UNEP

Objectives

- Product cycle: development + production

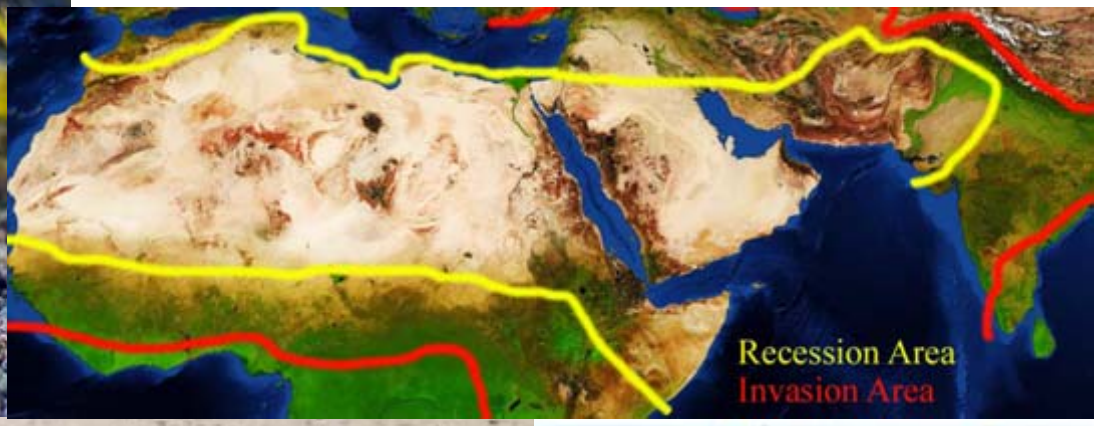
design and prototype specific products in interaction with end-users (UCL)

operational delivery in near-real time (VITO)

- Product development:
  - multi-sources approach to ensure services based on the best available information
  - iterative approach to ensure services that are tailored to specific applications and end-users

Desert Locust habitat monitoring

Take the Desert Locust under control → Preventive strategy
→ Early Warning System



Good rain + green vegetation
→ formation of swarms
→ migration over large distances
→ threat to food security

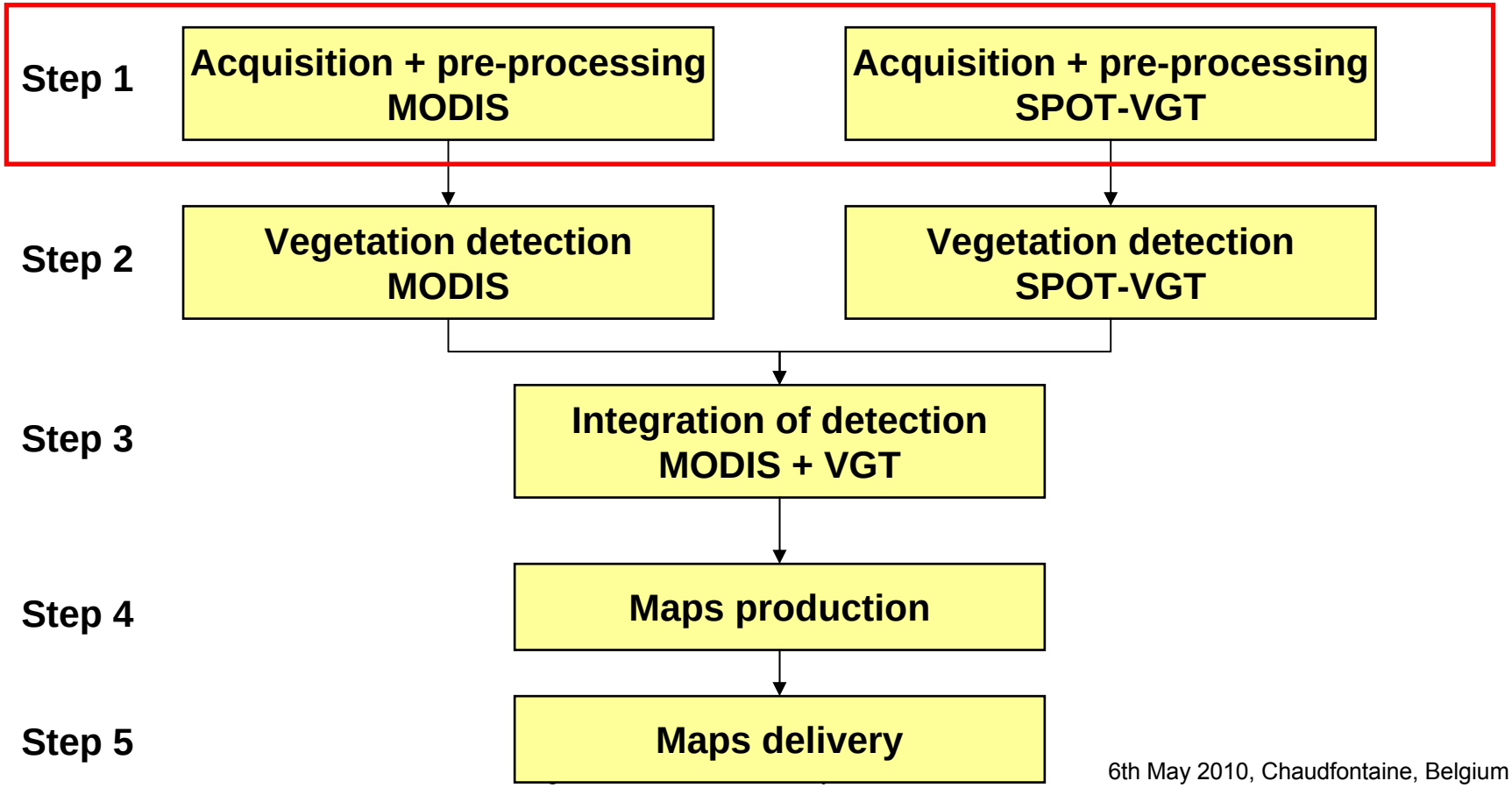
Desert Locust habitat monitoring

- Early warning system =
  - ***continuous*** vegetation monitoring
  - at the ***continental scale***
  - in ***near real time***

- Challenges
  - Vegetation detection close to the onset → avoid confusion with bare soil
  - Near real time analysis and delivery
  - Automatic processing

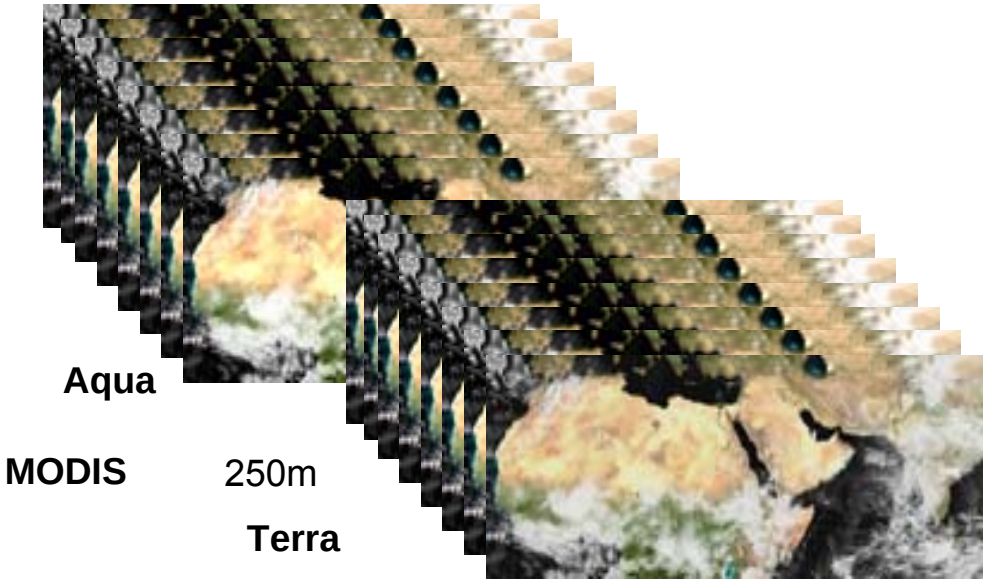
Desert Locust habitat monitoring

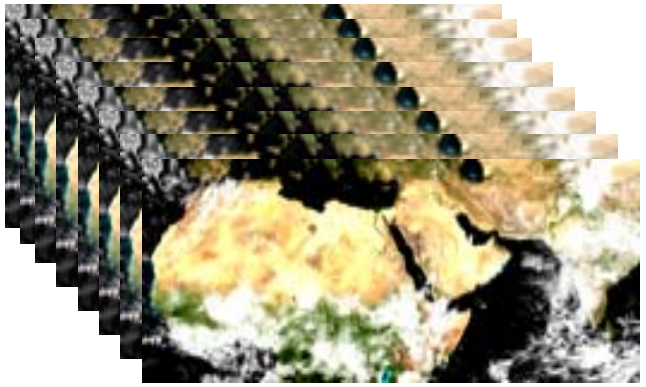
- Processing chain:
  - Product at 250m
  - Based on 2 sensors (SPOT-VGT + MODIS)



Desert Locust habitat monitoring

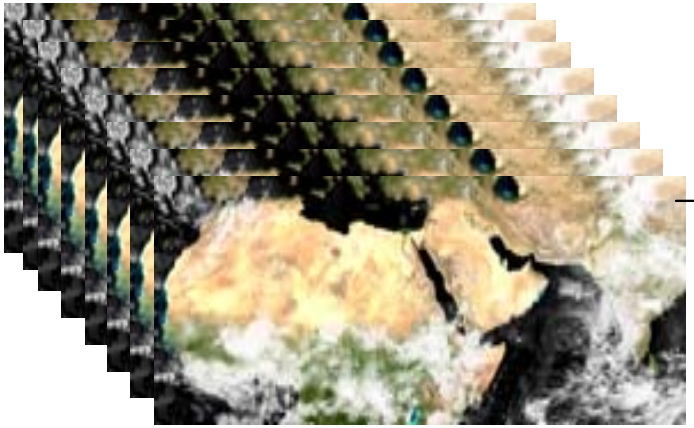
- Step 1: data acquisition and pre-processing
  - 1.1: Automatic and continuous daily data acquisition





Desert Locust habitat monitoring

- Step 1: data acquisition and pre-processing
  - 1.1: Automatic daily data acquisition
  - 1.2: 10-day compositing and NDVI computing



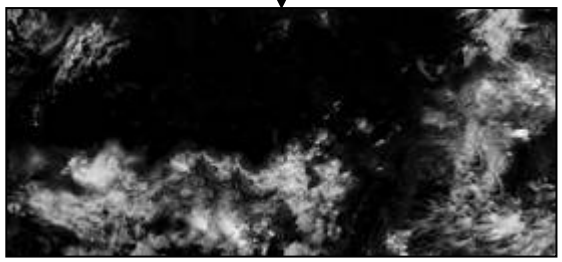
Daily data

Quality control stage

1

Mean Composite (SWIR, NIR, RED)

0



Clouds, hazes and pixel anomalies

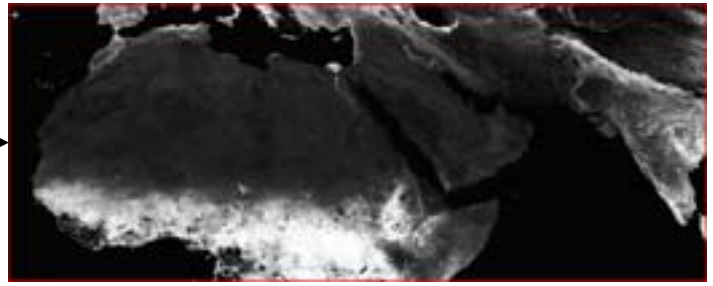
For each sensor

Desert Locust habitat monitoring

- Step 1: data acquisition and pre-processing
  - 1.1: Automatic daily data acquisition
  - 1.2: 10-day compositing and NDVI computing

Multispectral Composite

(SWIR, NIR, RED)



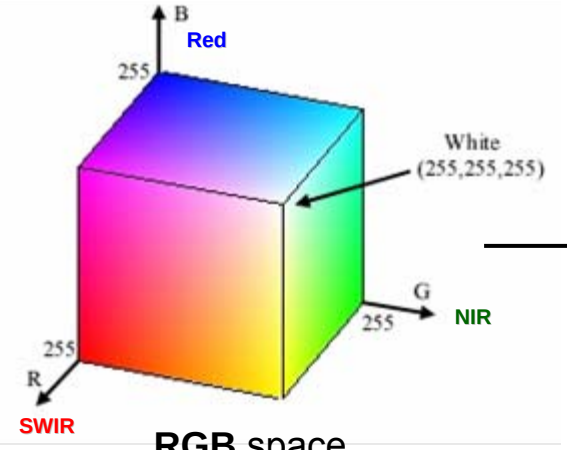
NDVI

For each sensor,

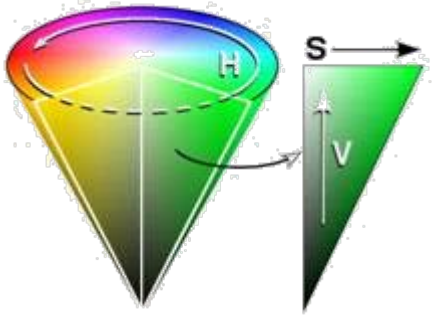
every 10 days

Desert Locust habitat monitoring

- Step 1: data acquisition and pre-processing
  - 1.1: Automatic daily data acquisition
  - 1.2: 10-day compositing and NDVI computing
  - 1.3: Color space transformation from RGB to HSV



RGB space



HSV space

$$H = \begin{cases} \frac{G-B}{V-min(R,G,B)} & si\ V = R, \\ 2 + \frac{B-R}{V-min(R,G,B)} & si\ V = G, \\ 4 + \frac{R-G}{V-min(R,G,B)} & si\ V = B. \end{cases}$$

$$S = \frac{V - min(R,G,B)}{V},$$

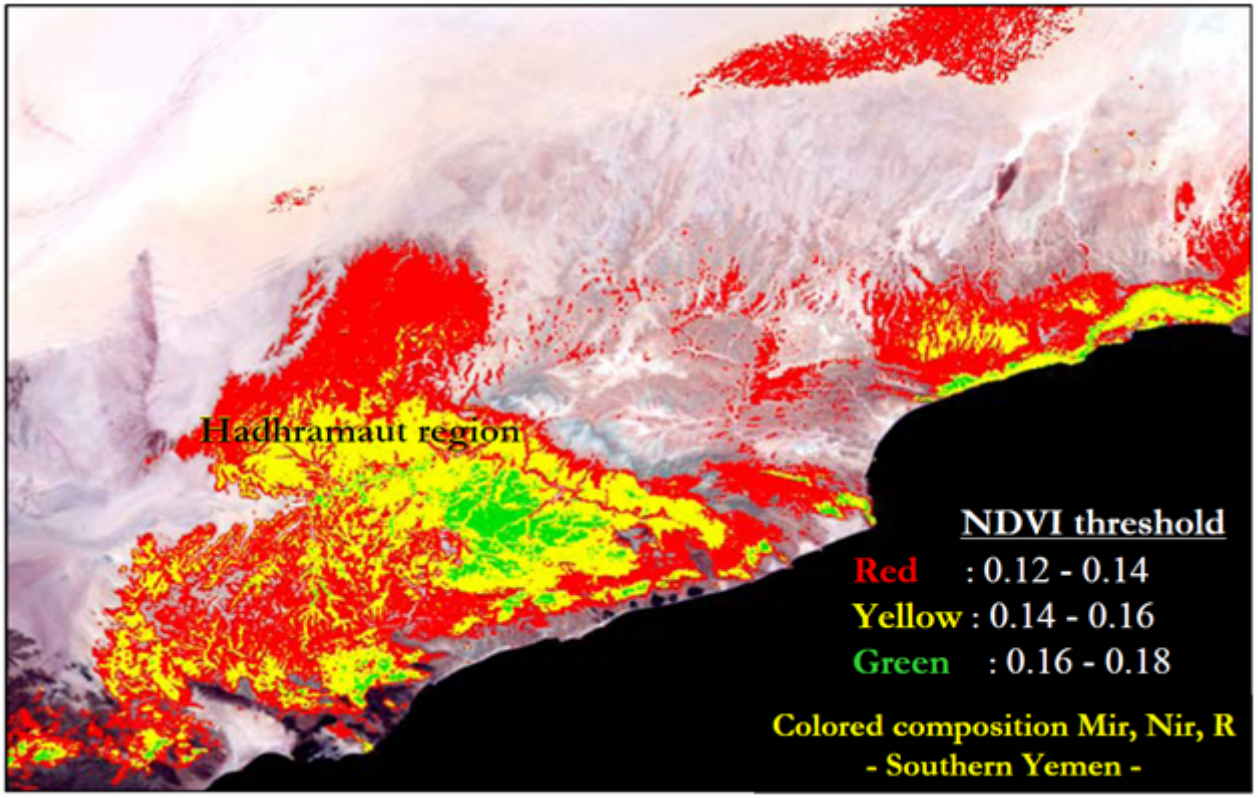
$$V = max(R,G,B),$$

- Hue = basic color
- Saturation = radial distance from the cone center
- Value (or Intensity) = height in the axis direction

For each composite

Desert Locust habitat monitoring

- Step 1: data acquisition and pre-processing
  - 1.1: Automatic daily data acquisition
  - 1.2: 10-day compositing and NDVI computing
  - 1.3: Color space transformation from RGB to HSV



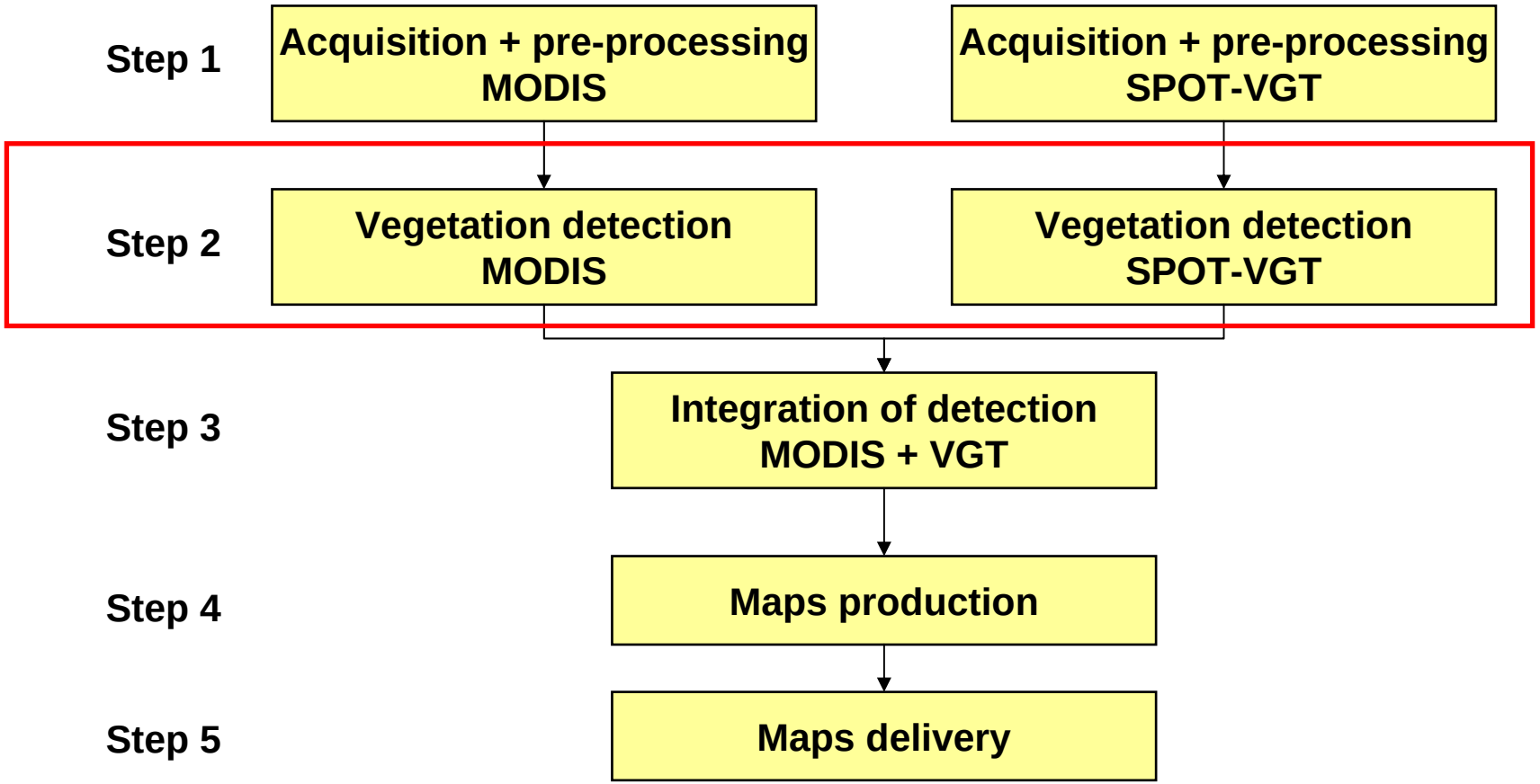
NDVI-based methods:

confusion with bare soil

→ false alarms

(Despland, 2004; Ceccato, 2005)

Desert Locust habitat monitoring

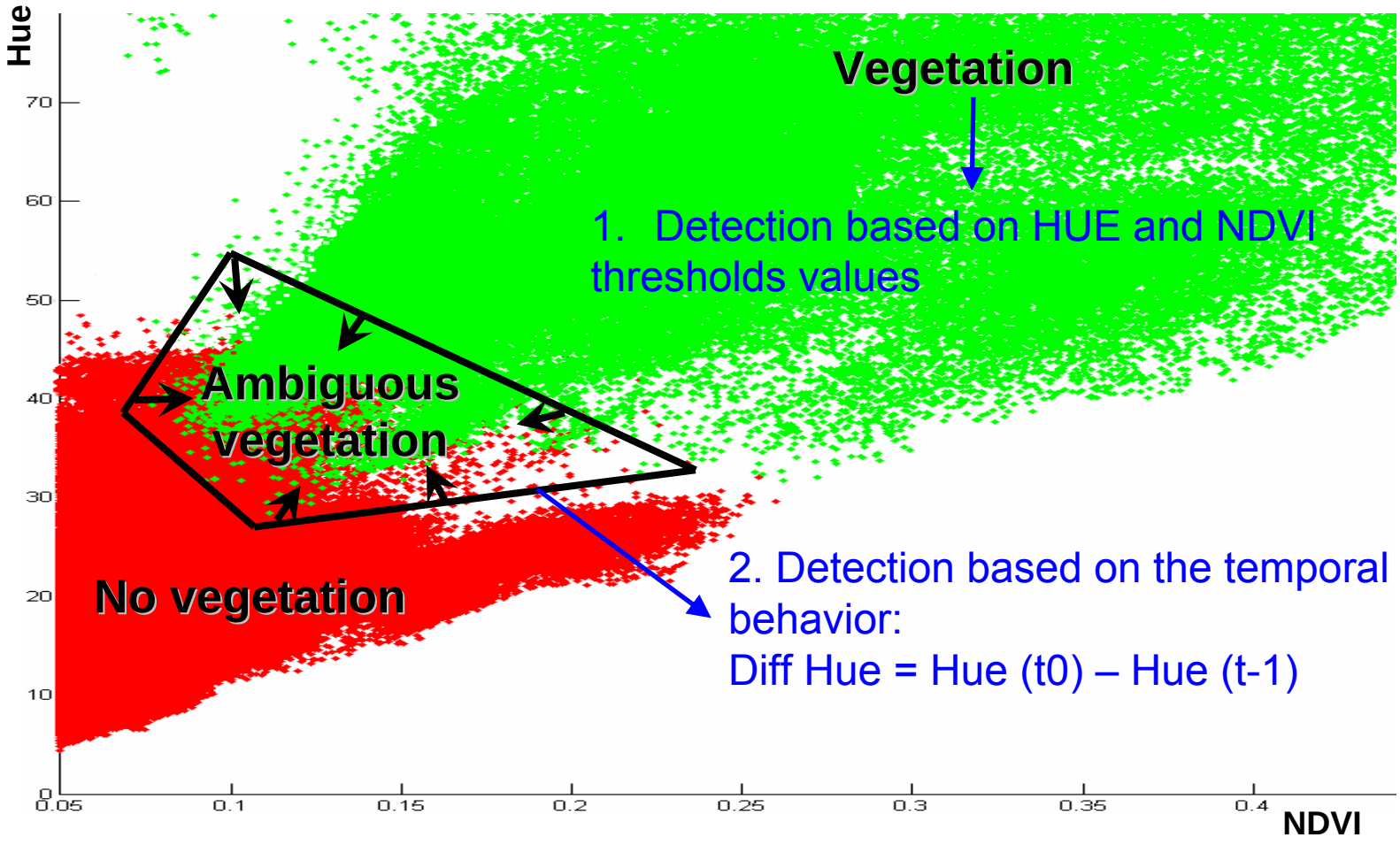


Desert Locust habitat monitoring

- Step 2: vegetation detection for each sensor
  - Threshold-based detection
  - Based on 3 parameters: NDVI, Hue, Diff Hue
  - Thresholds identification based on an exhaustive sampling of pixels in space and over time

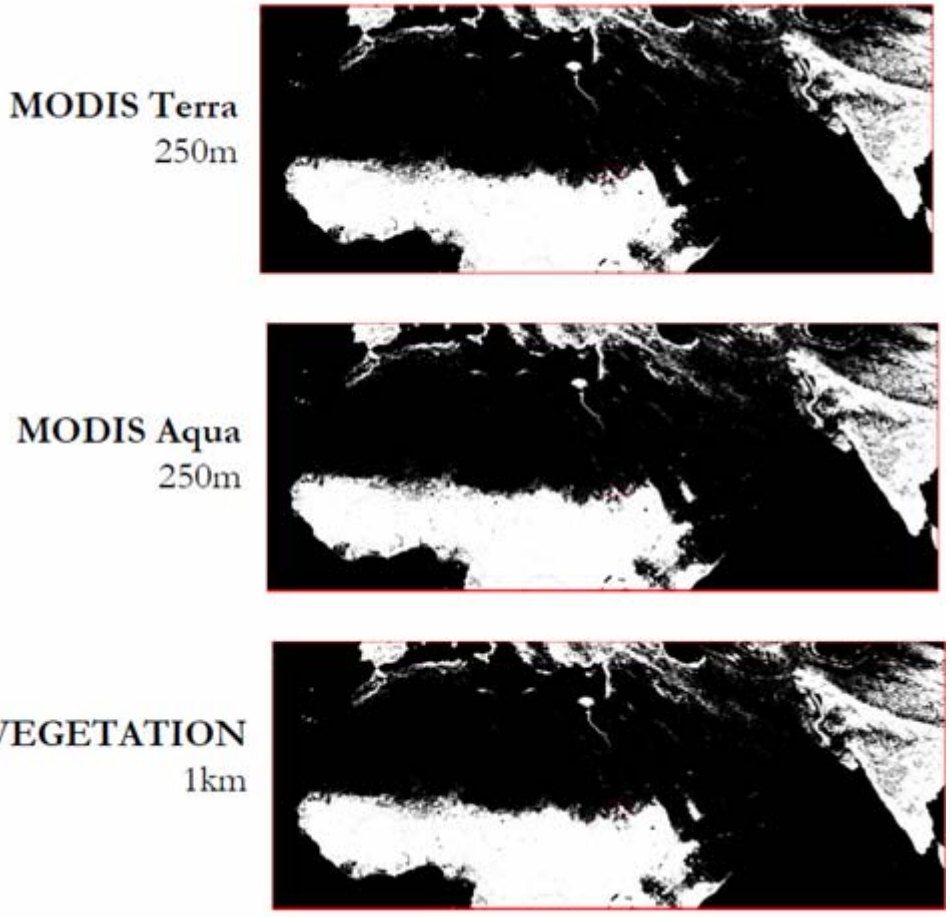
Desert Locust habitat monitoring

- Step 2: vegetation detection for each sensor

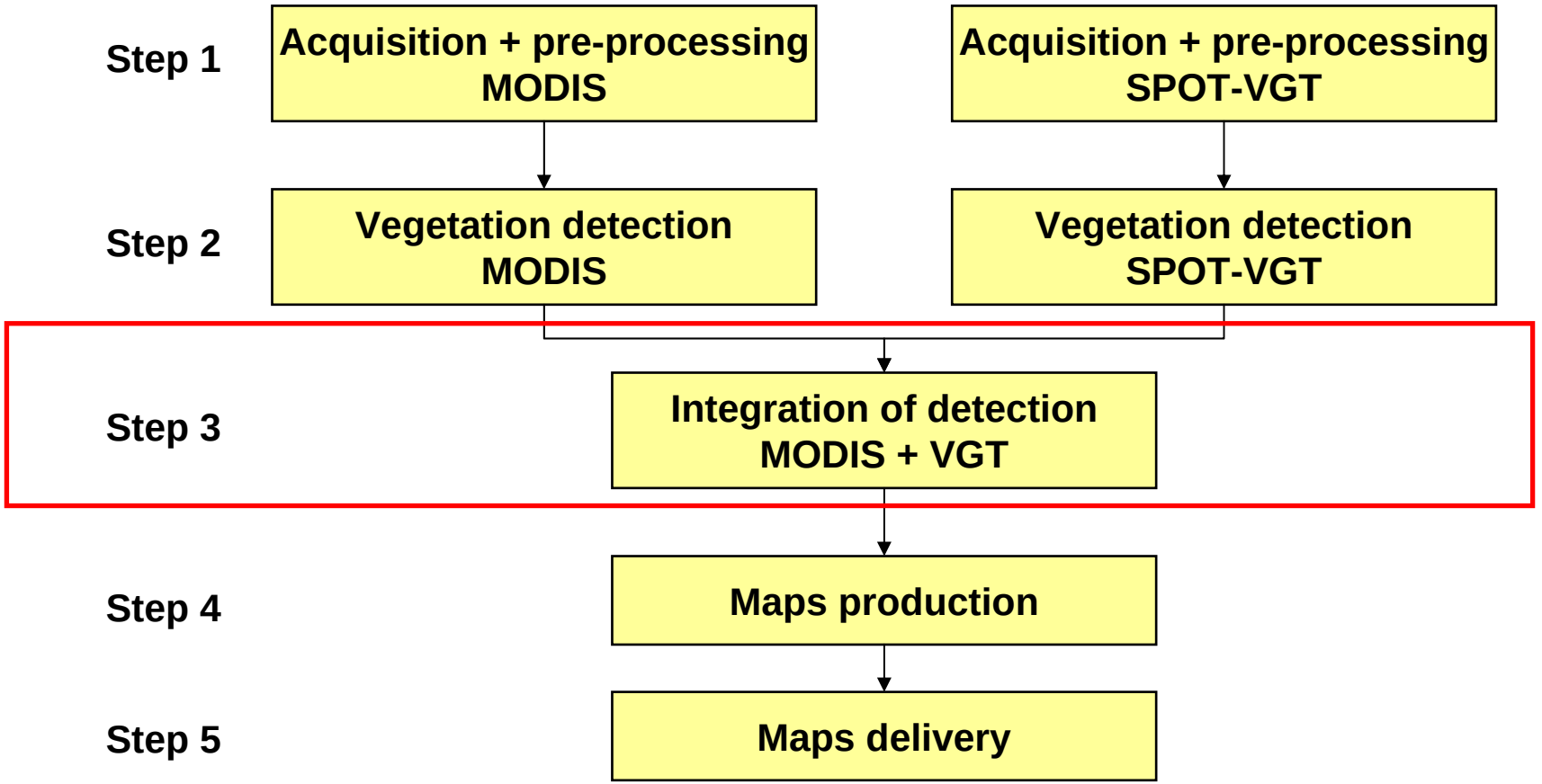


Desert Locust habitat monitoring

- Step 2: vegetation detection for each sensor
  - Based on thresholds, creation of a decadal vegetation mask for each sensor

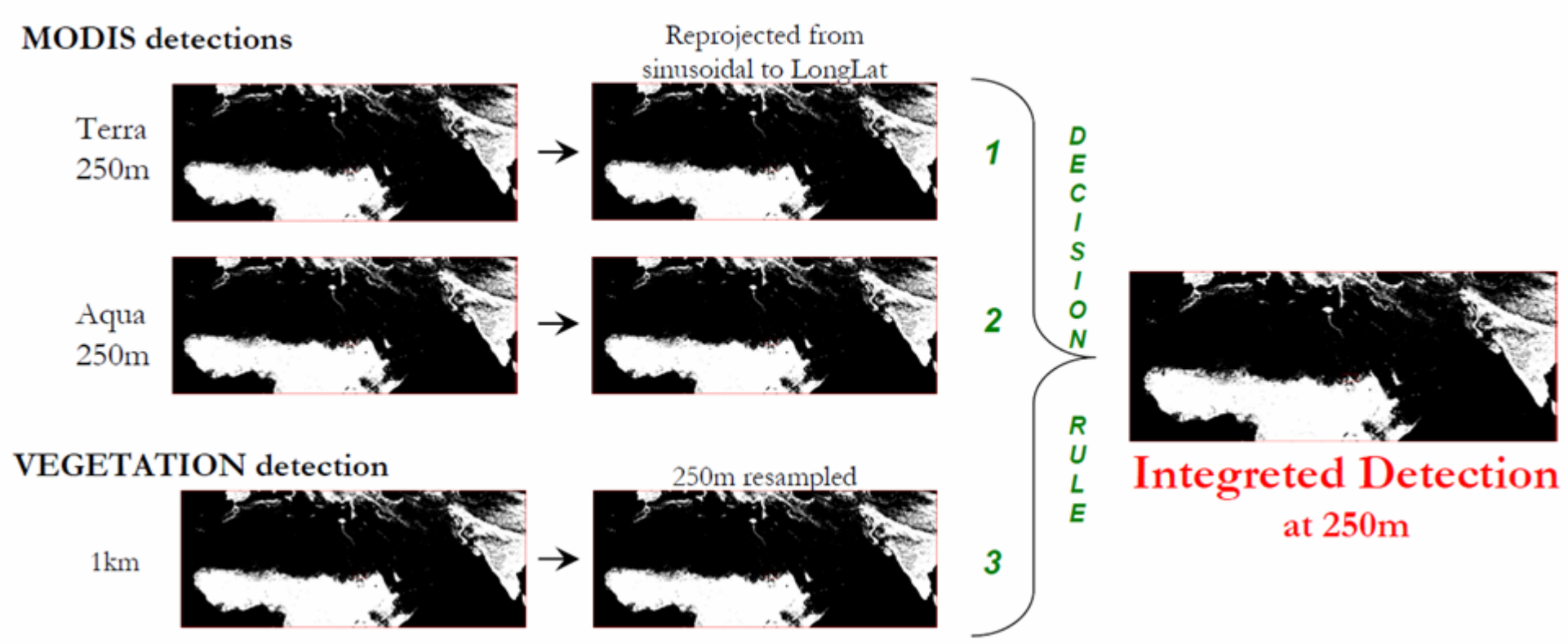


Desert Locust habitat monitoring

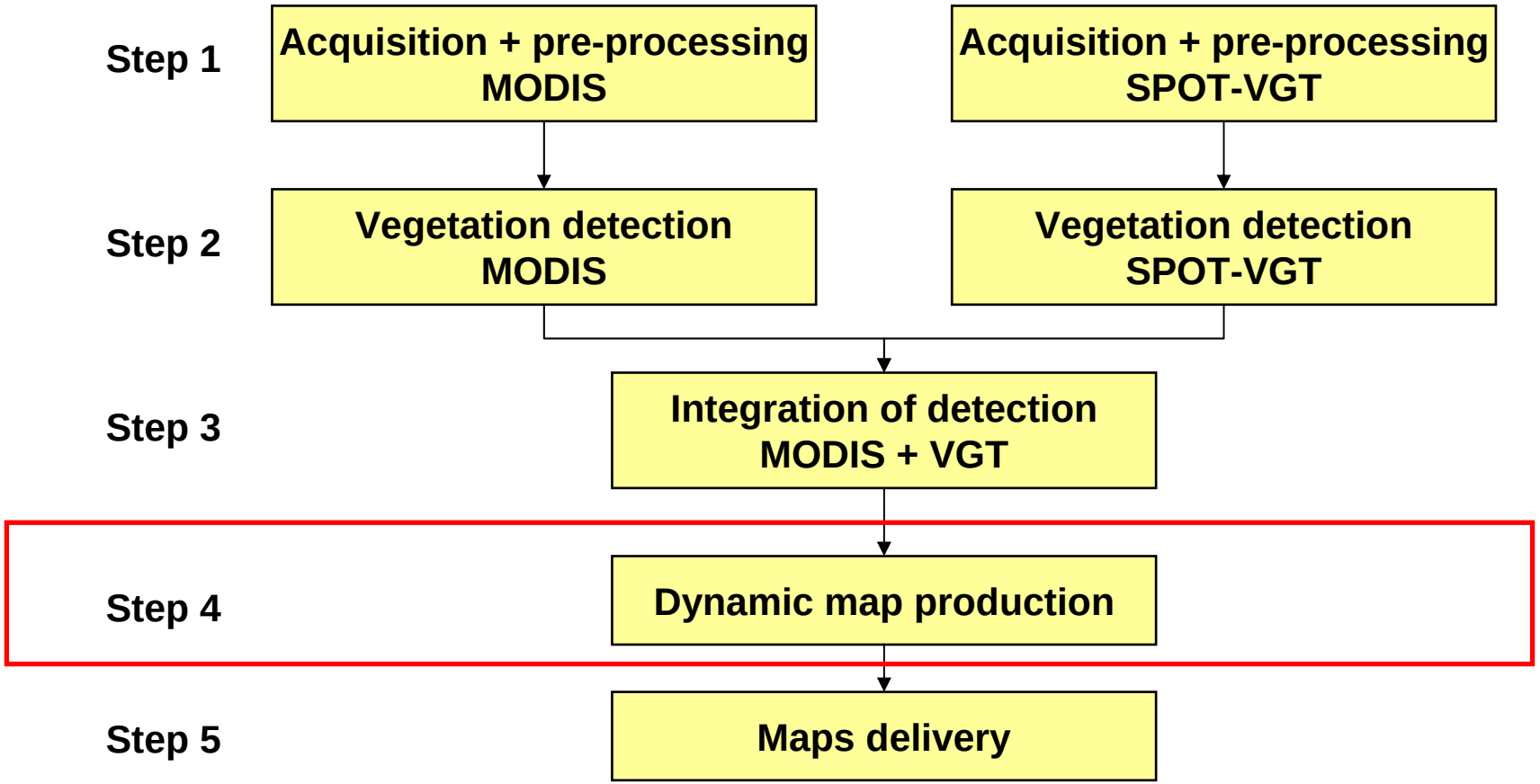


Desert Locust habitat monitoring

- Step 3: integration detection product
  - Decadal product computed using the best information available everywhere and every time from both Terra and Aqua MODIS and SPOT-VGT



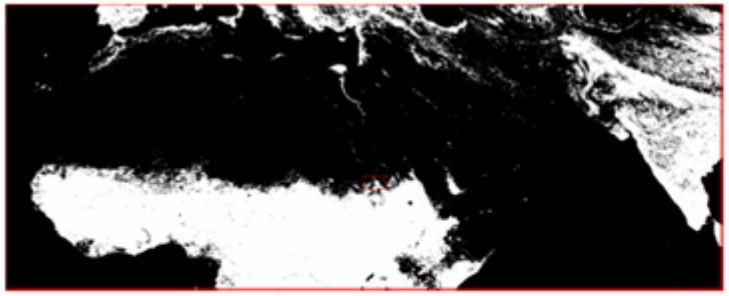
Desert Locust habitat monitoring



Desert Locust habitat monitoring

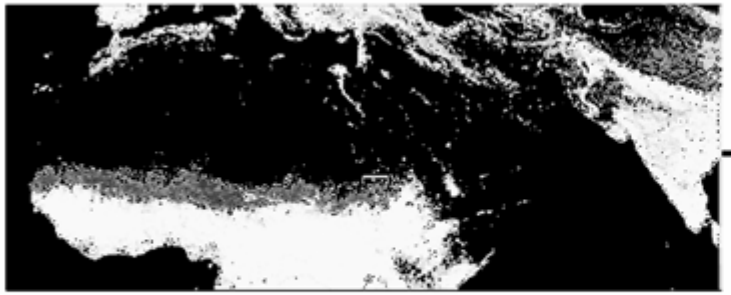
- Step 4: production of green vegetation dynamic maps

- Spatial and temporal distribution of the vgt
- A time meter computes the number of decades during which a pixel is detected as green vegetation from its onset to the current decade

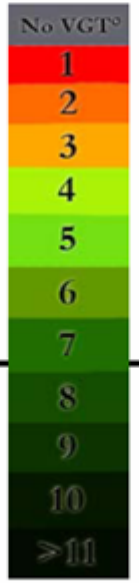


Integreted Detection mask

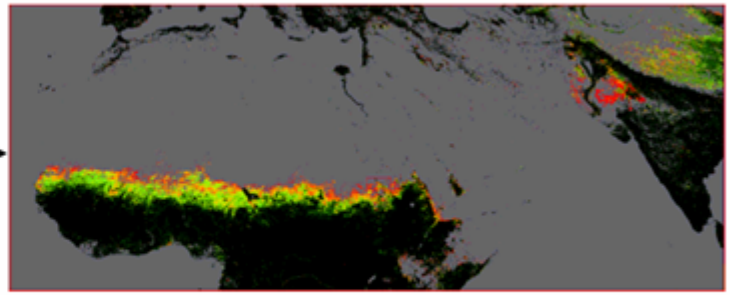
Incrementation



Detections time meter

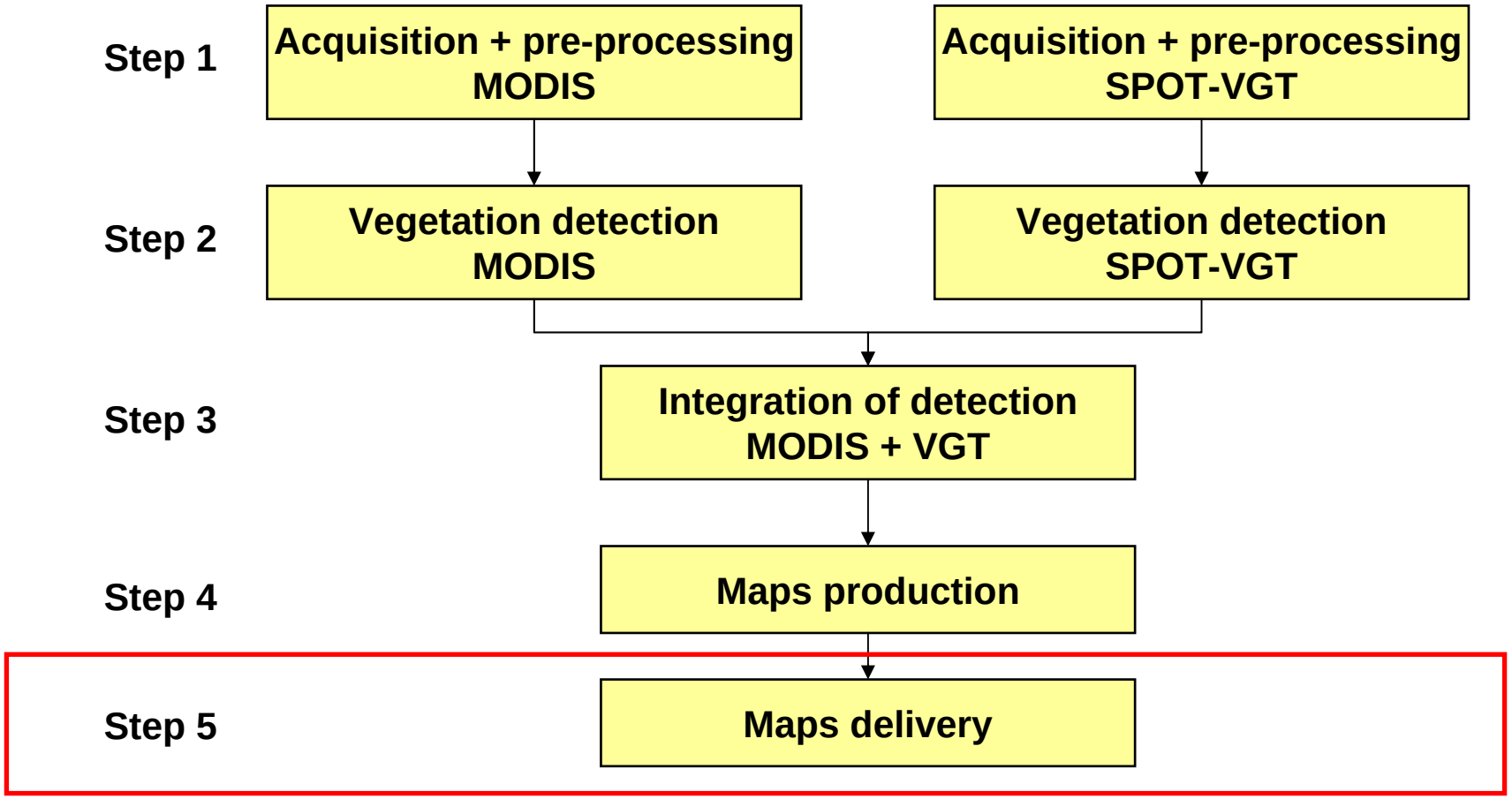


Color table



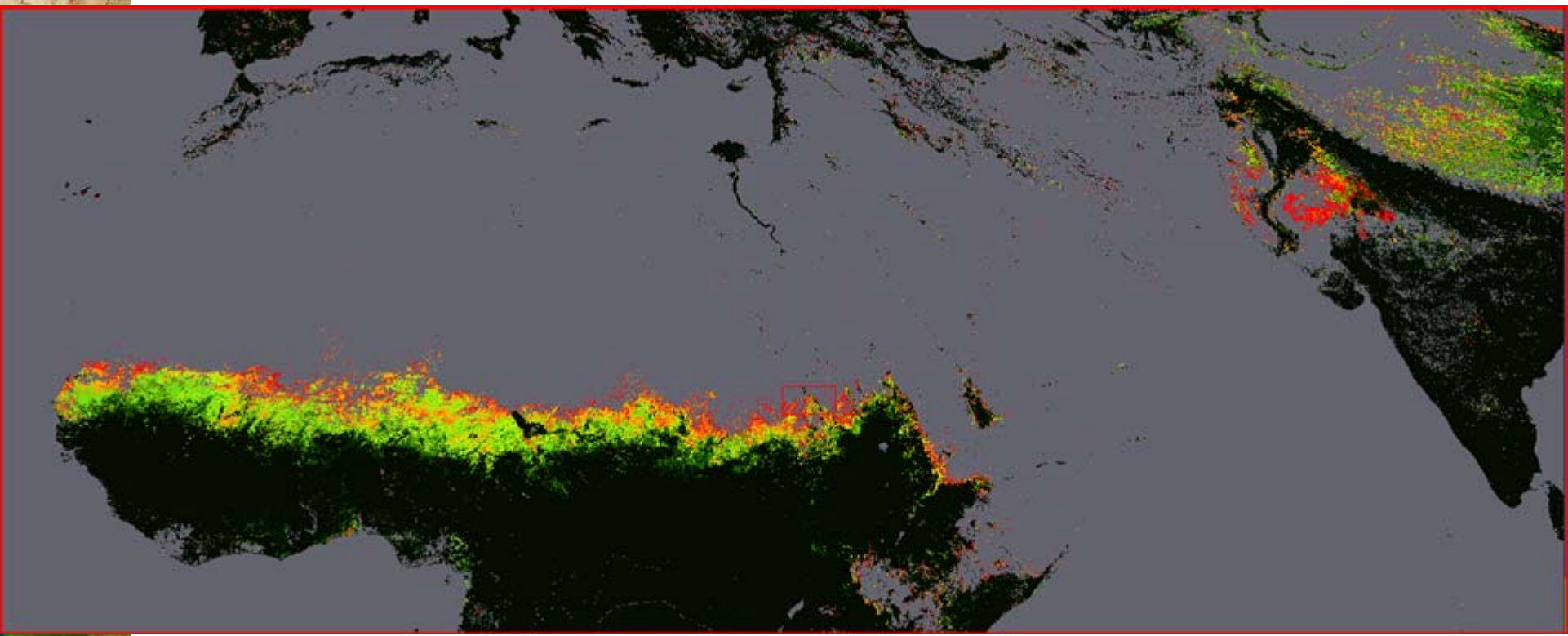
Green Vegetation Dynamic Map

Desert Locust habitat monitoring



Desert Locust habitat monitoring

- Step 5: products delivery (every 10 days)
  - 10-day multispectral composite (SWIR, NIR, Red)
  - 10-day NDVI composite
  - Green vegetation dynamic map



Desert Locust habitat monitoring

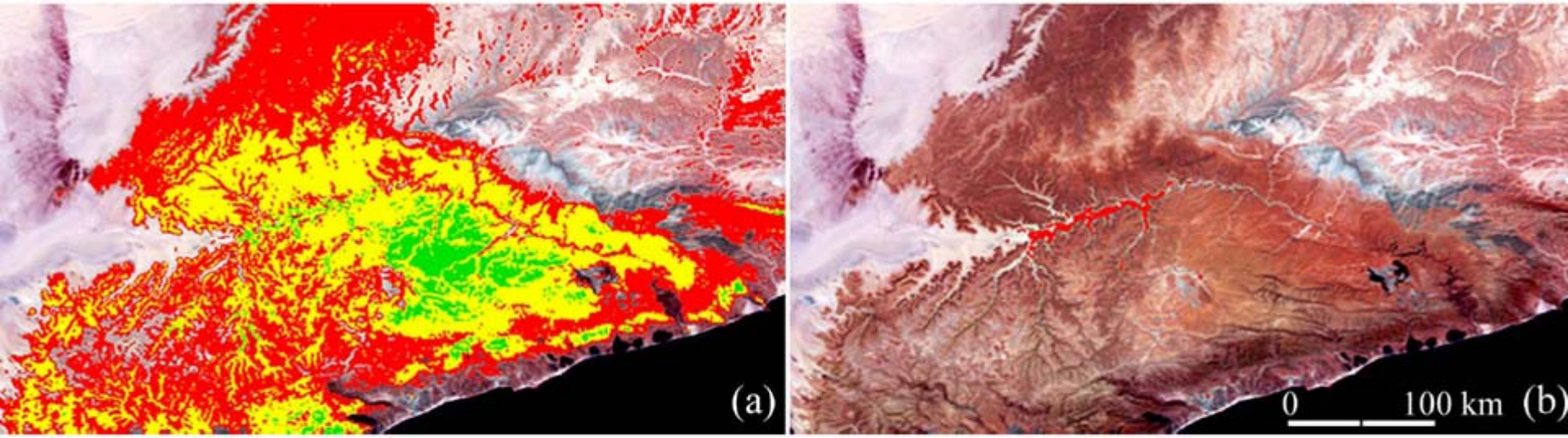
- Results (Air Mountain Niger)

Desert Locust habitat monitoring

- Used in a operational context by the FAO/ECLO (Emergency Centre for Locust Operations)
- Master thesis in progress (UCL-FAO) to go on improving the product

Desert Locust habitat monitoring

- Successful assessment in a operational context by the FAO/ECLO (Emergency Centre for Locust Operations)and by some national teams
- Master thesis in progress (UCL-FAO)
- Issue of false alarms considerably reduced



NDVI-based detections *Hue-based detections*

Desert Locust habitat monitoring

- Successful assessment in a operational context by the FAO/ECLO (Emergency Centre for Locust Operations)and by some national teams
- Master thesis in progress (UCL-FAO)
- Issue of false alarms considerably reduced
- Validation in progress:
  - Estimation of omission errors with a dataset of 32000 ground truth observations over all the recession area in 2004 (provided by FAO)
  - Estimation of commission errors by photo-interpretation of 300 random points over 3 areas (Yemen, Niger, Algeria) known to be problematic

Desert Locust habitat monitoring

- Conclusion
  - Innovative vegetation detection methodology based on a color space transformation from RGB to HSV
  - Robust detection of the green vegetation in arid and semi-arid areas
  - Full automatic and multi-sensor processing chain designed and used by VITO for the operational production
  - Green Vegetation Dynamic Map produced at 250m and updated every 10 days
  - Spatial and temporal distribution of vegetation in a single image file thanks to a time meter associated to a color table

Phenology monitoring

- International response to food insecurity → relevant and timely information on all aspects of food supply and demand
- FAO/GIEWS (Global Information and Early Warning System) Workstation
  - web-based integrated GIS linked to a database on food security at global, regional, national and sub-national levels
  - assessment of rainfall and vegetation conditions in important agricultural areas new workstation to come
  - working on a new workstation

Phenology monitoring

- Objectives:

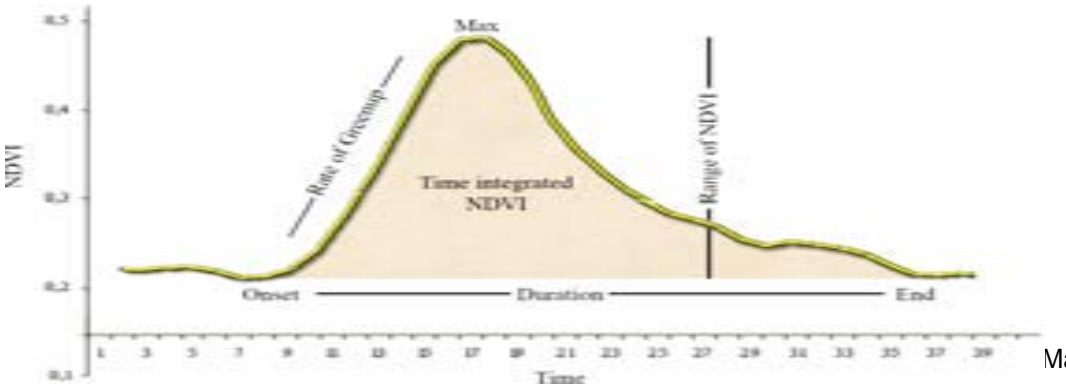
  providing an accurate and continuous monitoring of agricultural areas
  - At the continental scale
  - In near-real time
  - Through the estimation of phenological metrics

  designing this product for a direct integration in the new GIEWS Workstation

Phenology monitoring

- Products selection by GIEWS:

	Temporal Metrics:	**Phenological interpretation:**
✓	Date of onset of greenness	Beginning of photosynthetic activity
✓	Date of end of greenness	End of photosynthetic activity
✓	Duration of greenness	Length of photosynthetic activity
✓	Date of maximum greenness	Time when photosynthesis is at maximum
	NDVI-value Metrics:	
✓	NDVI value of onset of greenness	Level of photosynthesis at start
✓	NDVI value of end of greenness	Level of photosynthesis at end
✓	NDVI value of maximum	Level of photosynthesis at maximum
✓	Range of NDVI	Range of measurable photosynthesis
	Derived Metrics:	
✓	Accumulated NDVI	Net primary production

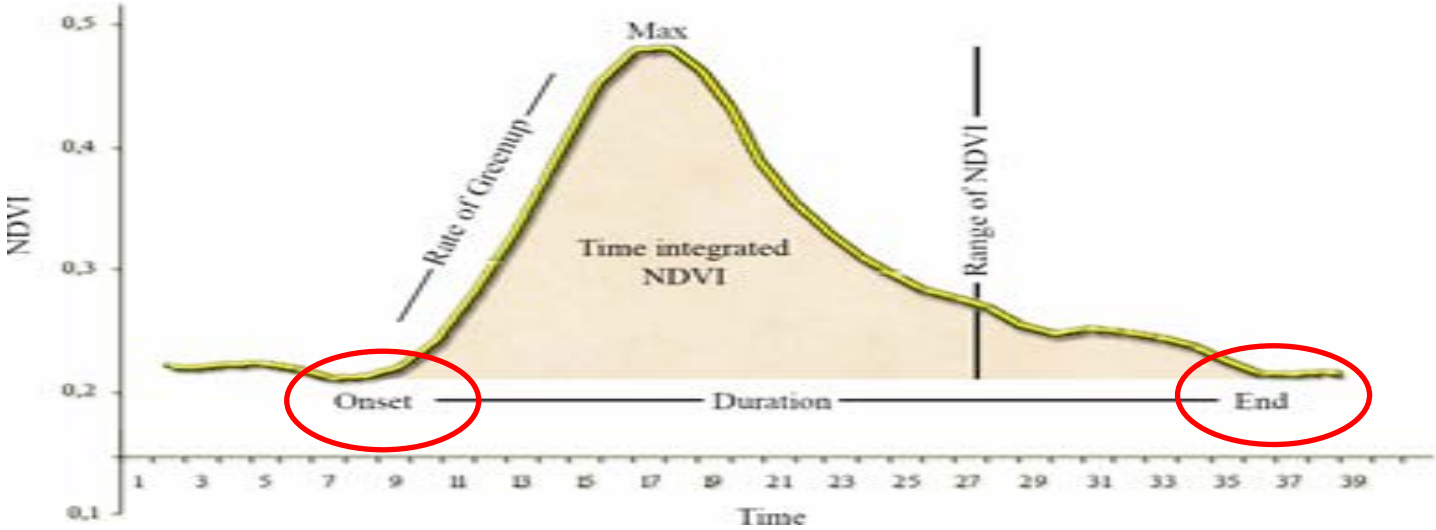


Phenology monitoring

- Products selection by GIEWS:
  - Phenological metrics
  - In agricultural areas:
    - NDVI profiles over 5 years
    - Rainfall estimation
    - Agricultural calendar

Phenology monitoring

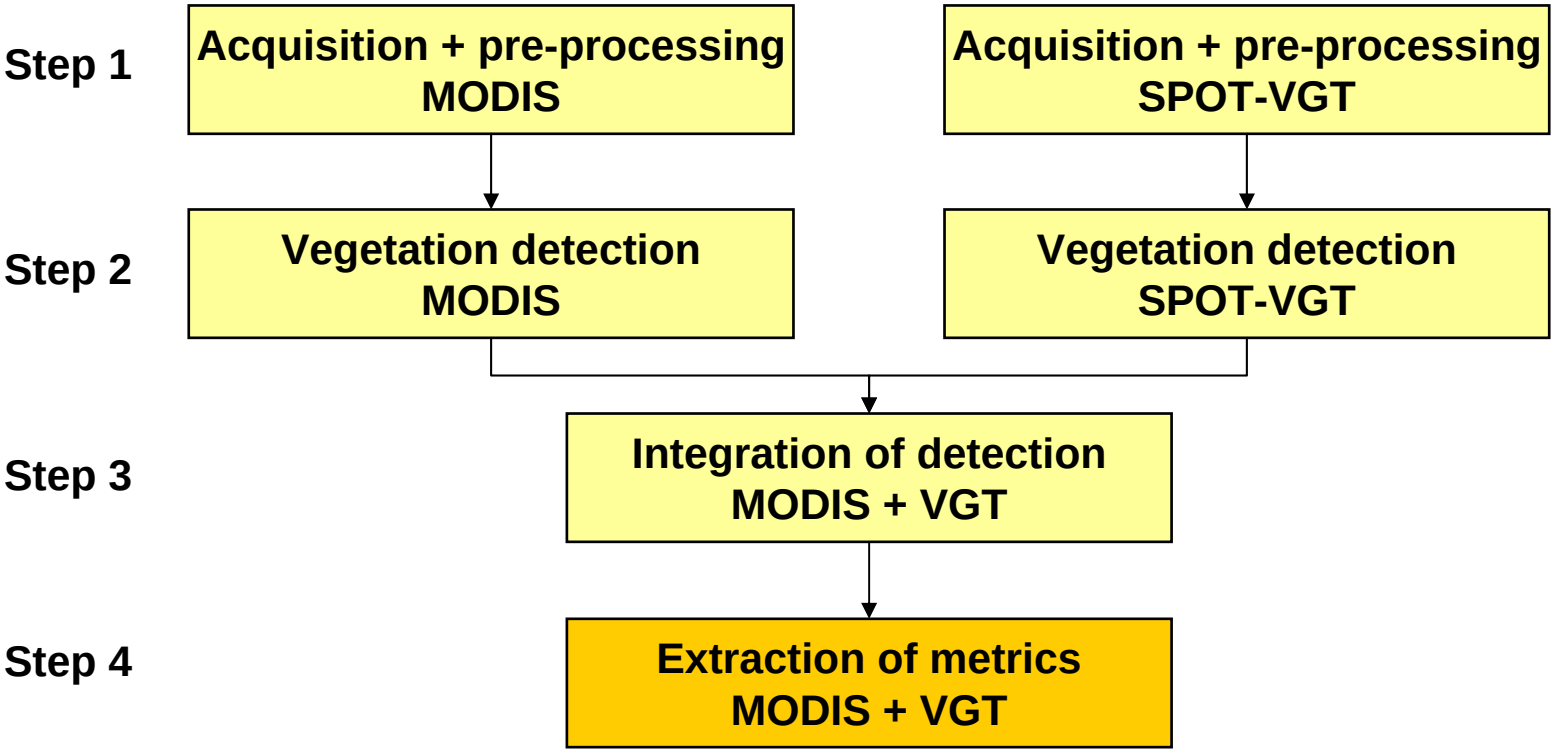
- Products selection by GIEWS:



  - 2 key metrics: onset and end of greenness
  - Detection of small amount of vegetation → same challenge than for the desert locust habitat monitoring (i.e. detection of vegetation in desert areas)

Phenology monitoring

- Processing chain:
  - like an “add-on” of the Desert Locust chain



Phenology monitoring

Temporal Metrics:

Date of onset of greenness

Date of end of greenness

Duration of greenness

Date of maximum greenness

NDVI-value Metrics:

NDVI value of onset of greenness

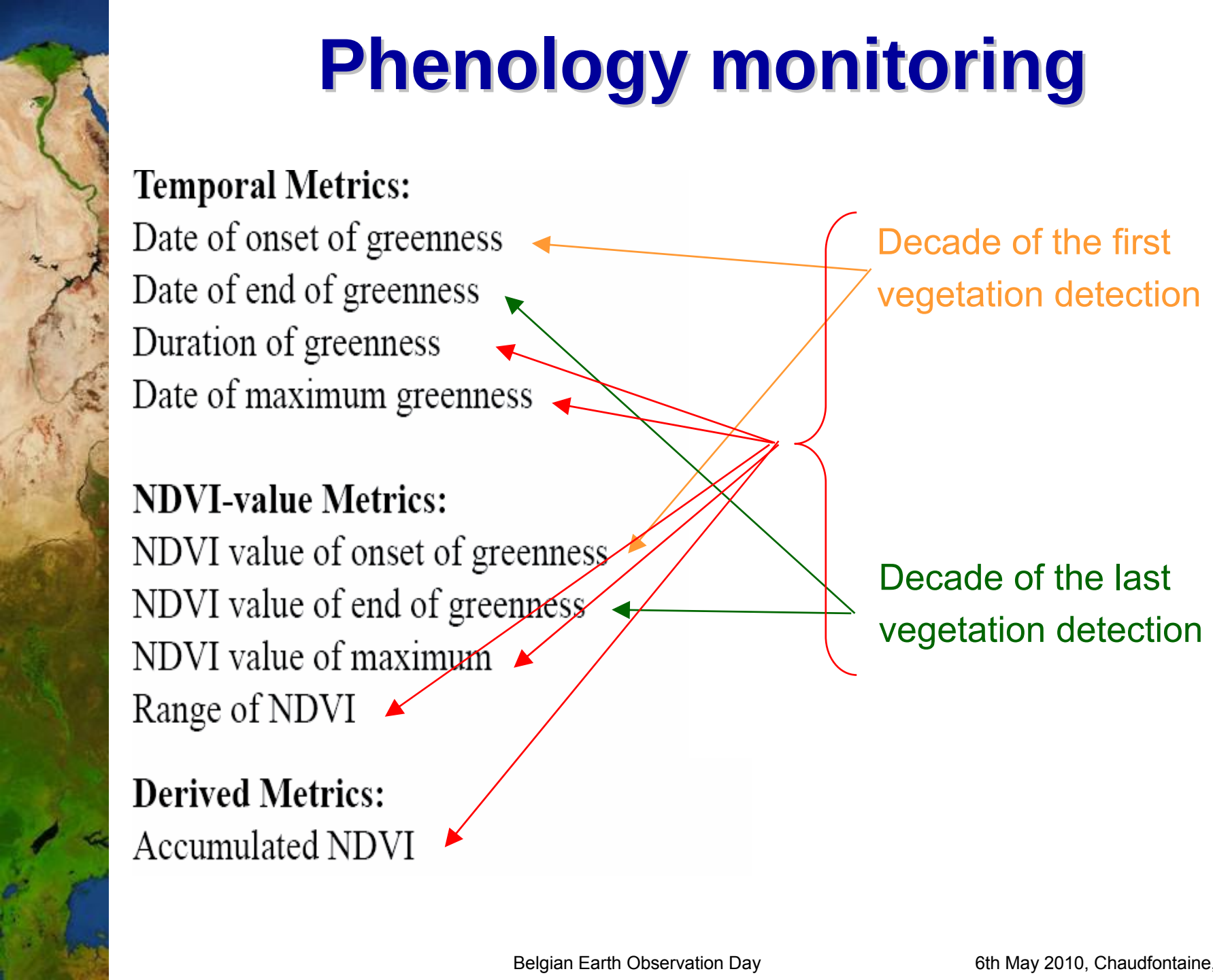
NDVI value of end of greenness

NDVI value of maximum

Range of NDVI

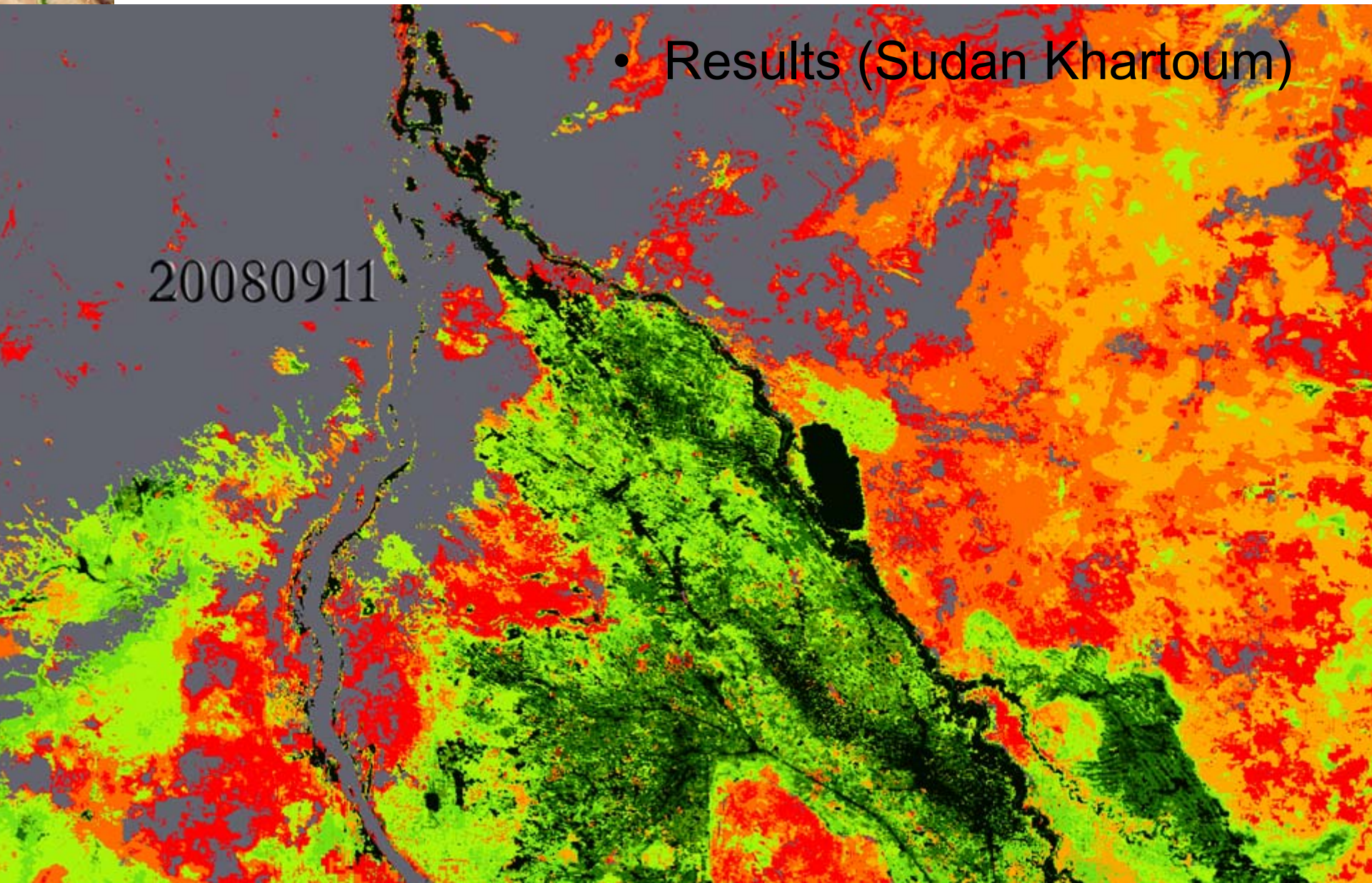
Derived Metrics:

Accumulated NDVI



Phenology monitoring

- Results (Sudan Khartoum)



Phenology monitoring

- Conclusion:
  - Mostly based on the desert locust processing chain
  - Desert locust methodology relevant for
    - detection of small amount of vegetation

      $\Rightarrow$ of the onset and end of greenness
    - automatic processing chain

      $\Rightarrow$ near-real time analysis
  - First results delivered to GIEWS


Thank You