Belgian Science Policy

The **World Wide Watch** project experience :

lessons learnt from operational products development, implementation and exploitation

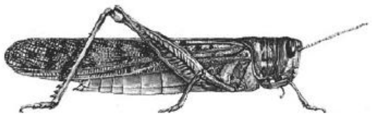
P. Defourny, C. Lamarche, T. Jacobs, B. Smets, and K. Cressman

UCL Université catholique de Louvain
Earth and Life Institute - *Geomatics*

vito vision on technology

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

FAO FIAT PANIS



WCMC UNEP

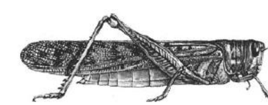
Objectives

After 40 years of Earth Observation from space and many research projects, not so many operational land applications !

WWW Research objectives:

- **To design a overall strategy to develop EO services**
- **To experiment the strategy by developping 3 very targeted products**
  - **Desert Locust habitat monitoring (Year I)**
  - **Phenologycal metrics (Year I & II)**
  - **Pan Tropical Forest Change (Year II)**

FAO FIAT PANIS



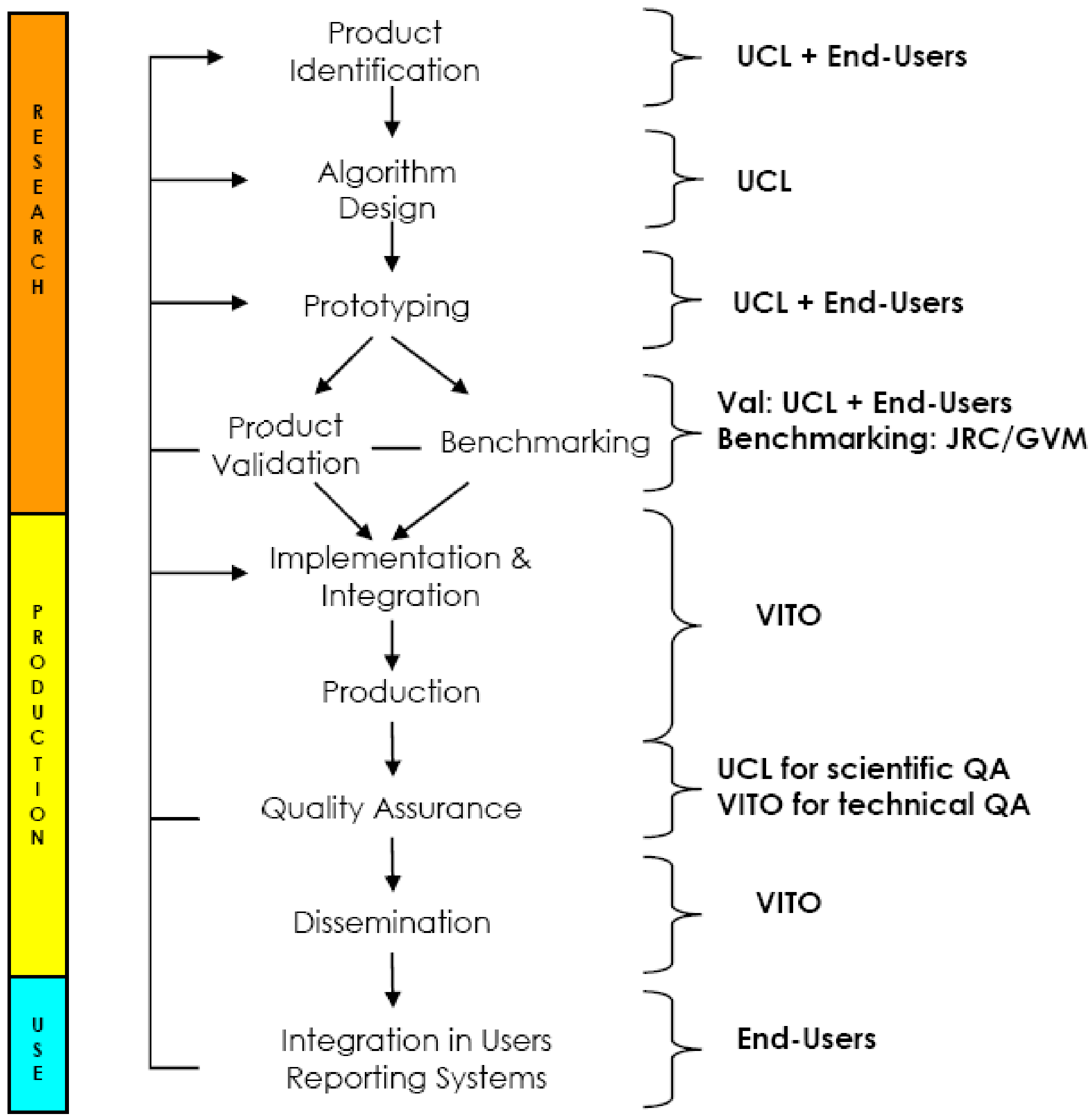
GLOBAL WATCH GIEWS

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

WCMC UNEP

Only two ideas for the overall strategy

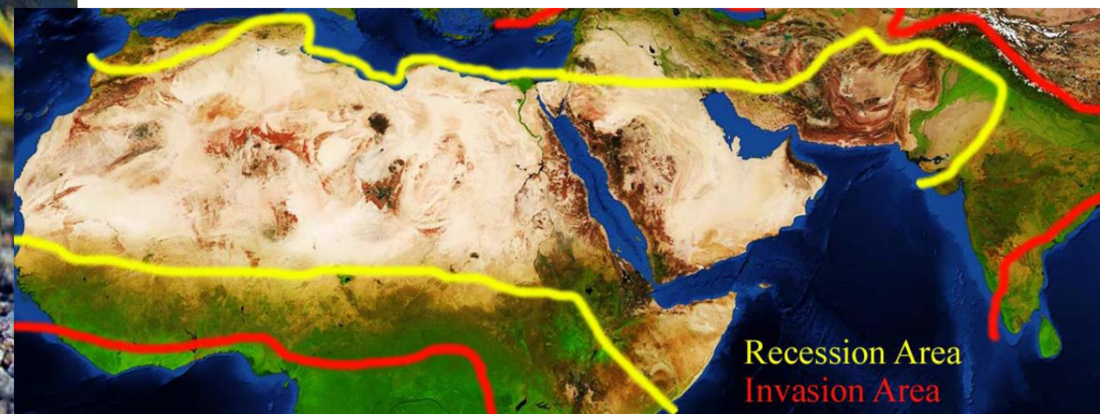
Several loops

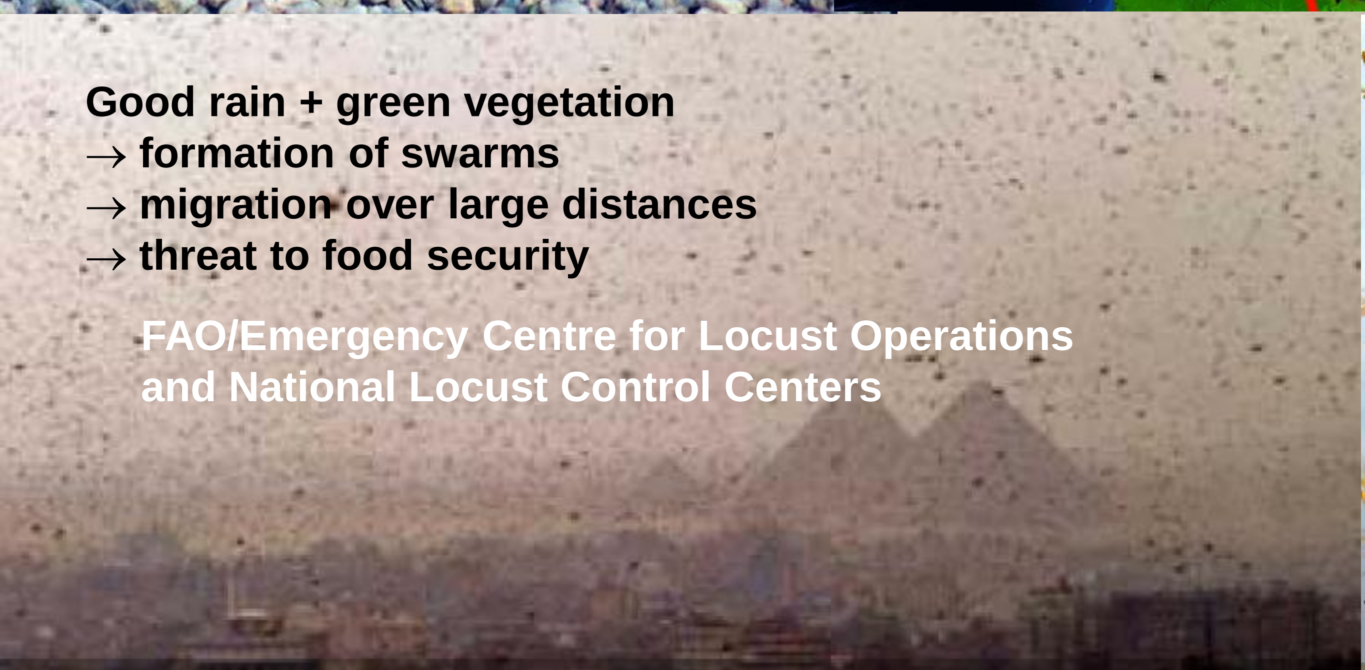


S–U–P partnership

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

FAO/Emergency Centre for Locust Operations and National Locust Control Centers

Food and Agriculture Organization of the United Nations   *Helping to build a world without hunger*

Locust watch
Desert Locust

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français

Information | Mapper | Activities | Publications | Archives

Information
- Latest additions
- News/Events
- Links
- Contacts
- Locust FAQs
- Other locusts
- eLERT

EMPRES

Emergency operations

Libyan outbreak

Sahel threat

Desert Locust situation update   3 September 2012

A second generation of breeding expected to commence shortly in Niger and Mali

The Desert Locust situation continues to remain serious as widespread breeding is in progress in **Niger** within a large portion of the northern desert, the central pasture areas and in parts of the south. Vegetation is much greener and is present up to 150 km further north than usual. Consequently, ecological conditions are favourable for a second generation of breeding that is expected to occur in **Niger** and **Mali** during September and October. This will cause locust numbers to increase further. As vegetation dries out, small groups, bands and swarms are expected to form in both countries from October onwards. Survey operations should be maintained in all affected countries and control operations carried out when possible in order to reduce locust numbers, the potential threat to crops and pastures and eventual migration to Northwest Africa.

The situation is less clear in northern **Mali** but is likely to be similar. There was an unconfirmed report of hopper bands in the north near Kidal last week.

Elsewhere, breeding on a smaller scale is in progress in **Mauritania** and **Chad**. Only low numbers of adults were reported in **Sudan** and along the **Indo-Pakistan** border.

Latest Desert Locust Bulletin (No. 407, August 2012)

English   Français

Previous Desert Locust Bulletin (No. 406, July 2012)

Arabic   English   Français

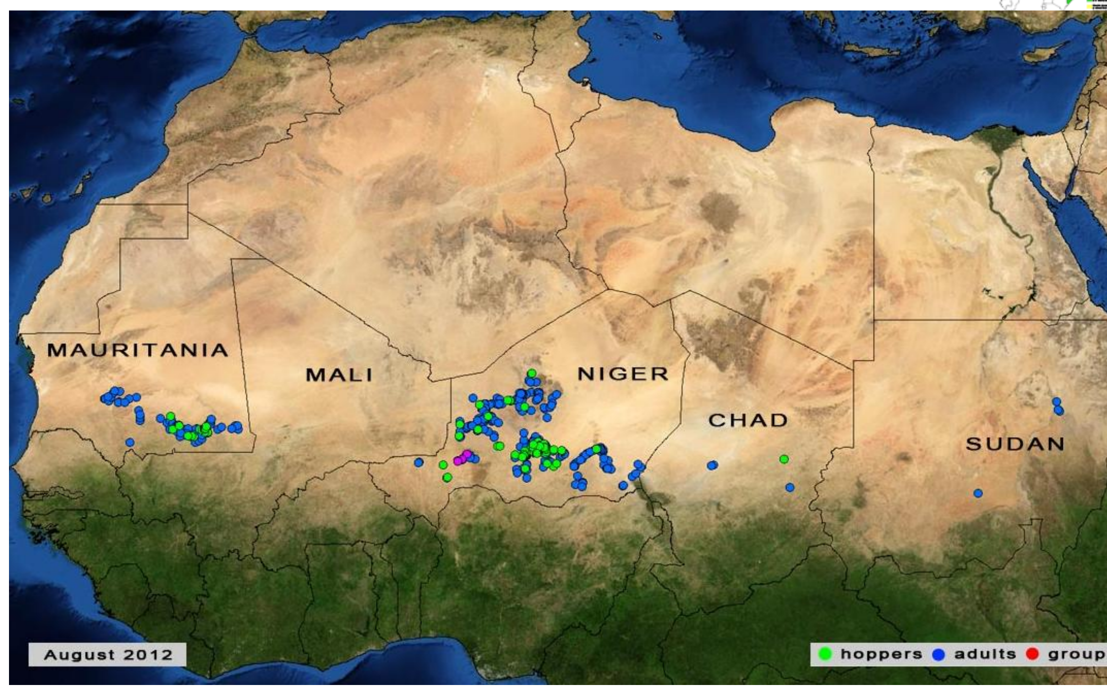
situation THREAT

Locust breeding in Niger (click for larger view)

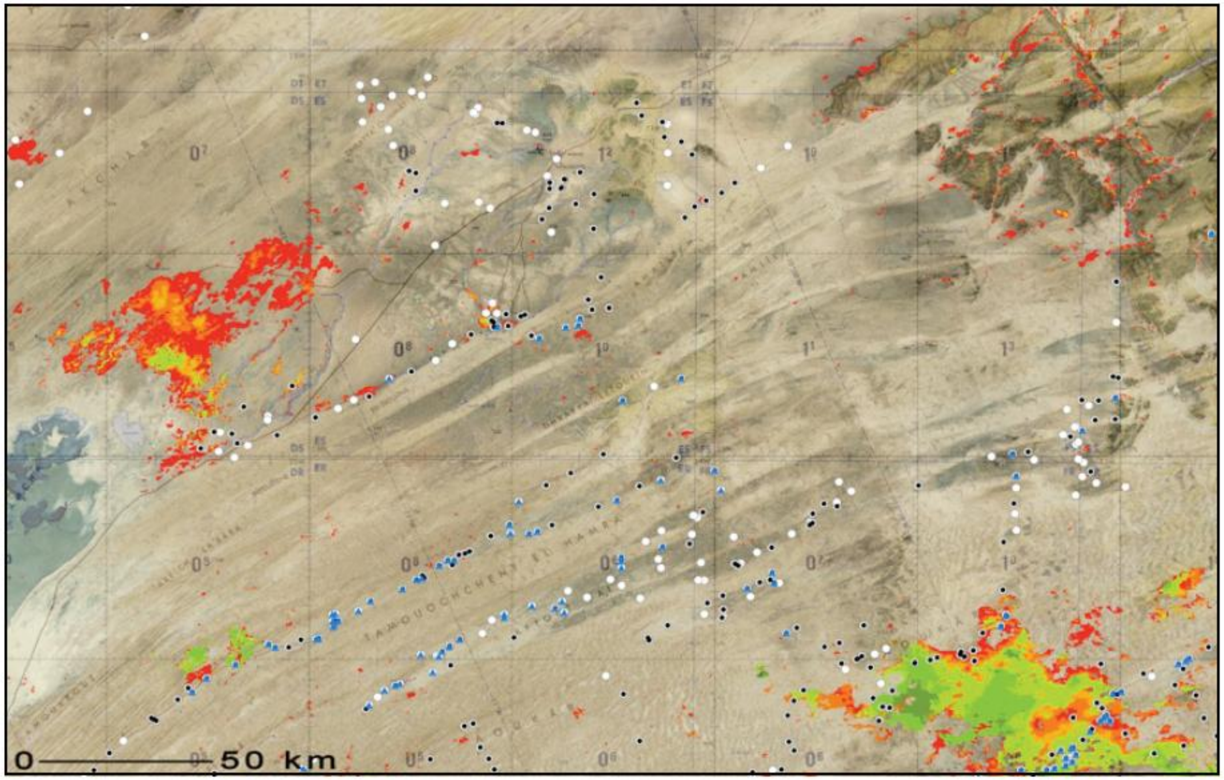
4 years later :

operational EO service included in DLIS every 10-day

…with end-users screeming when the product is not delivered !



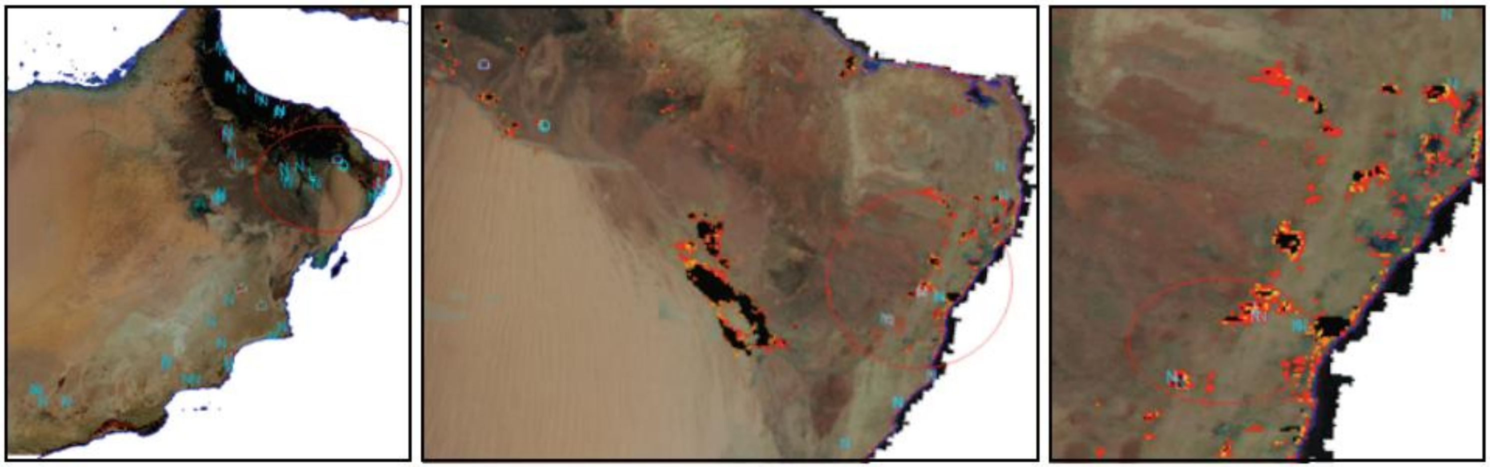
Dynamic Greenness Maps
in the FAO Desert Locust Information Service

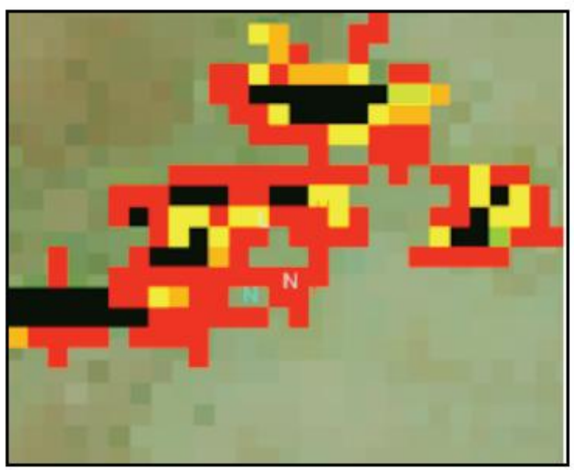


Mauritania (October 2010) : field observations from national survey teams of hoppers (black), adults (blue) and no locusts (white) with MODIS imagery including the dynamic greenness maps (the warmer the colour, the more recent the green vegetation) (source : K. Cressman, 2012)

Dynamic Greeness Maps for NLCC

Omam, March 2012 **:** *teams found that Desert Locust hoppers and adults were present in a remote area detected by the product that otherwise would not have been surveyed.*



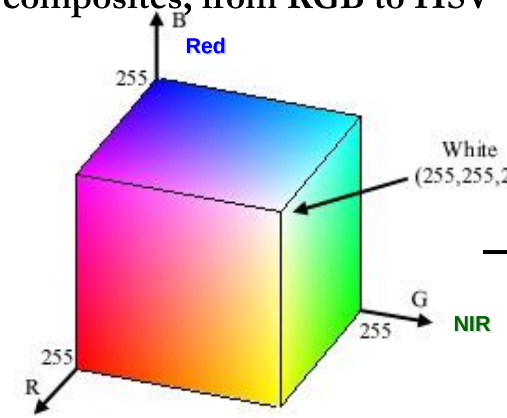


(source : K. Cressman, 2012)

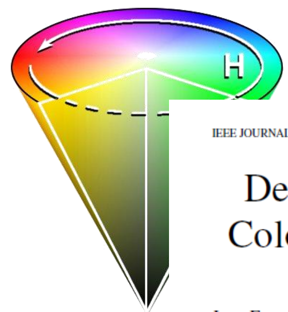
New research development
to address the users requirements

- **Original research for arid vegetation detection in near real time :**
  => color space transformation (Pekel et al., 2010 IEEE)

The automatic algorithm proceeds in near real time to the color space transformation of each composites, from RGB to HSV



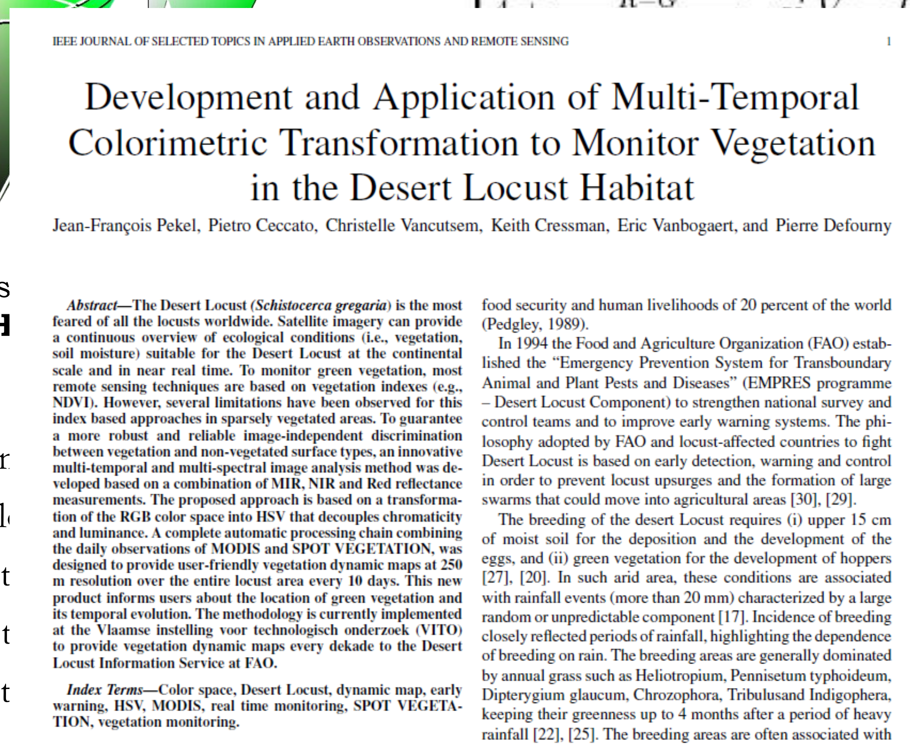
Representation of
the **RGB** space



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

Repres
the **H**

- The **HSV** color space is described geor
- The **H**ue value represents the basic col
- The **S**aturation component represents t
- The **V**alue or Intensity is the height in t
- The range of the saturation and the Int



Development and Application of Multi-Temporal Colorimetric Transformation to Monitor Vegetation in the Desert Locust Habitat

Jean-François Pekel, Pietro Ceccato, Christelle Vancutsem, Keith Cressman, Eric Vanbogaert, and Pierre Defourny

***Abstract*—The Desert Locust *(Schistocerca gregaria)* is the most feared of all the locusts worldwide. Satellite imagery can provide a continuous overview of ecological conditions (i.e., vegetation, soil moisture) suitable for the Desert Locust at the continental scale and in near real time. To monitor green vegetation, most remote sensing techniques are based on vegetation indexes (e.g., NDVI). However, several limitations have been observed for this index based approaches in sparsely vegetated areas. To guarantee a more robust and reliable image-independent discrimination between vegetation and non-vegetated surface types, an innovative multi-temporal and multi-spectral image analysis method was developed based on a combination of MIR, NIR and Red reflectance measurements. The proposed approach is based on a transformation of the RGB color space into HSV that decouples chromaticity and luminance. A complete automatic processing chain combining the daily observations of MODIS and SPOT VEGETATION, was designed to provide user-friendly vegetation dynamic maps at 250 m resolution over the entire locust area every 10 days. This new product informs users about the location of green vegetation and its temporal evolution. The methodology is currently implemented at the Vlaamse instelling voor technologisch onderzoek (VITO) to provide vegetation dynamic maps every dekade to the Desert Locust Information Service at FAO.**

***Index Terms*—Color space, Desert Locust, dynamic map, early warning, HSV, MODIS, real time monitoring, SPOT VEGETATION, vegetation monitoring.**

food security and human livelihoods of 20 percent of the world (Pedgley, 1989).

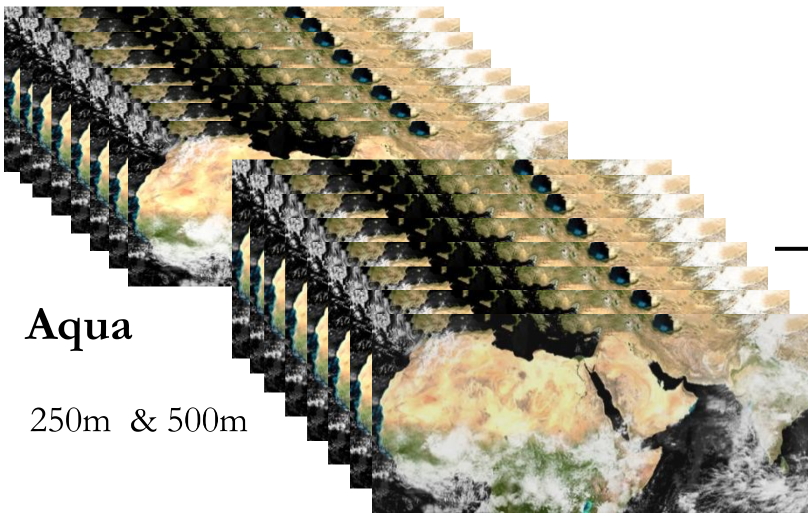
In 1994 the Food and Agriculture Organization (FAO) established the "Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases" (EMPRES programme – Desert Locust Component) to strengthen national survey and control teams and to improve early warning systems. The philosophy adopted by FAO and locust-affected countries to fight Desert Locust is based on early detection, warning and control in order to prevent locust upsurges and the formation of large swarms that could move into agricultural areas [30], [29].

The breeding of the desert Locust requires (i) upper 15 cm of moist soil for the deposition and the development of the eggs, and (ii) green vegetation for the development of hoppers [27], [20]. In such arid area, these conditions are associated with rainfall events (more than 20 mm) characterized by a large random or unpredictable component [17]. Incidence of breeding closely reflected periods of rainfall, highlighting the dependence of breeding on rain. The breeding areas are generally dominated by annual grass such as Heliotropium, Pennisetum typhoideum, Dipterygium glaucum, Chrozophora, Tribulusand Indigophera, keeping their greenness up to 4 months after a period of heavy rainfall [22], [25]. The breeding areas are often associated with

Prototyping to assess the product with the users

From two daily MODIS surface reflectance to the Dynamic Greenness Map

Automated data collection and enhanced preprocessing

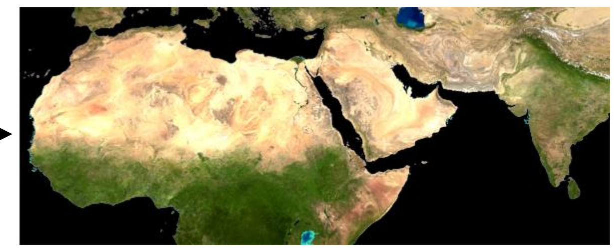


Aqua

250m & 500m

Terra

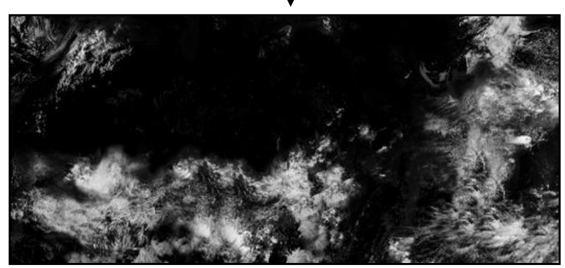
Quality control stage

I → 

Mean Composite (SWIR, NIR, RED)

(Vancutsem et al., IJRS 2008)

0 ↓

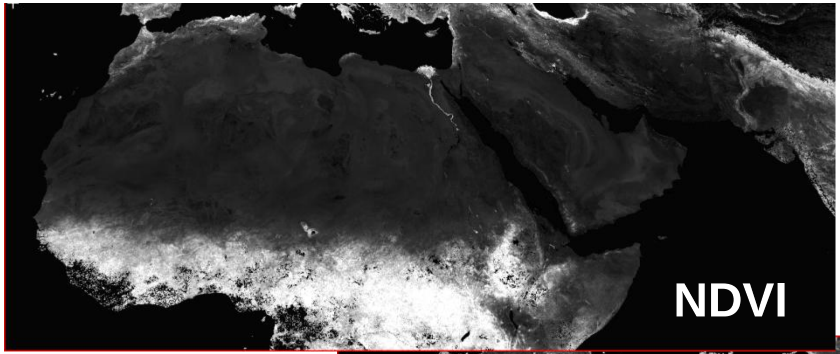


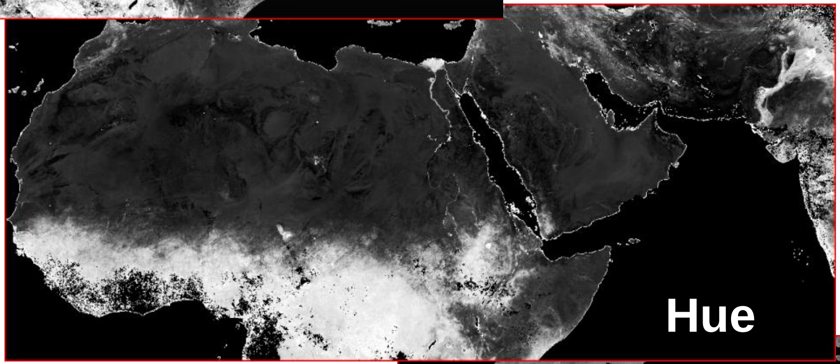
Clouds, hazes and pixel anomalies

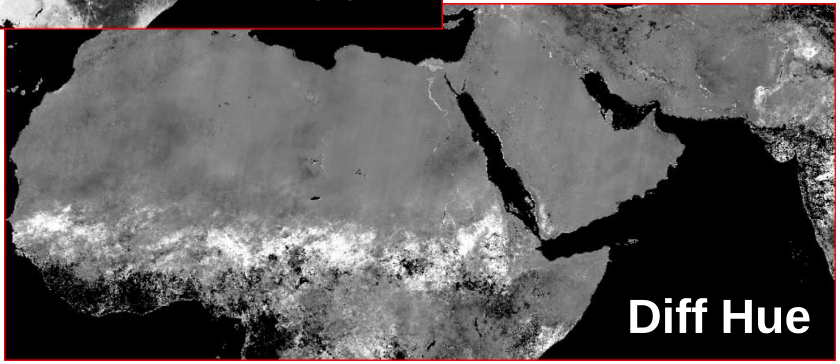
Prototyping to assess the product with the users

From two daily MODIS surface reflectance to the Dynamic Greenness Map

Green vegetation detectiony every 10 days







Methodology based on the use of 3 variables

Prototyping to assess the product with the users

Integration between the detections of different sensors

For each decade

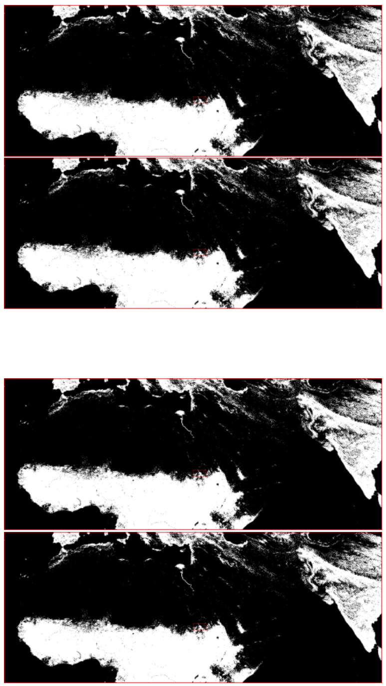
MODIS detection

Terra 250m

Aqua 250m

Terra 500m

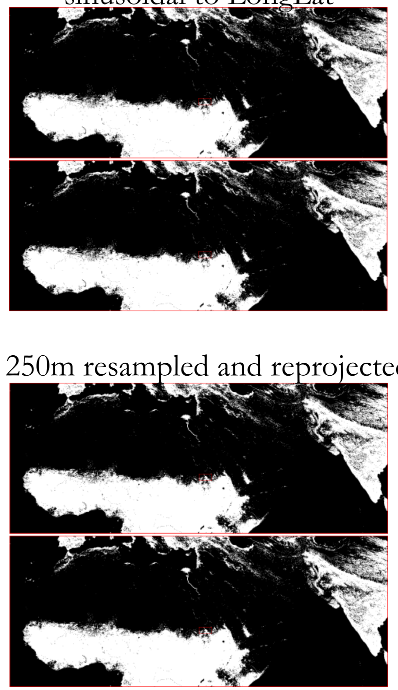
Aqua 500m



→

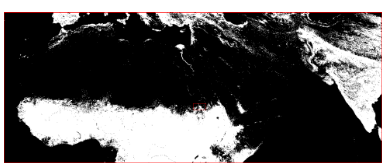
Reprojected from sinusoidal to LongLat

250m resampled and reprojected



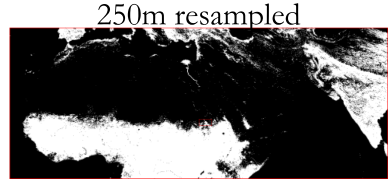
VEGETATION detection

1km



→

250m resampled



1

2

3

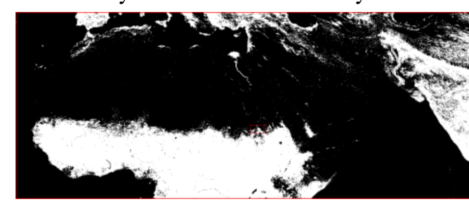
4

5

DECISION RULE

Integrated Detection at 250m

This integrated product is a mask VGT°/No VGT°
It provides the best information available everywhere and every time

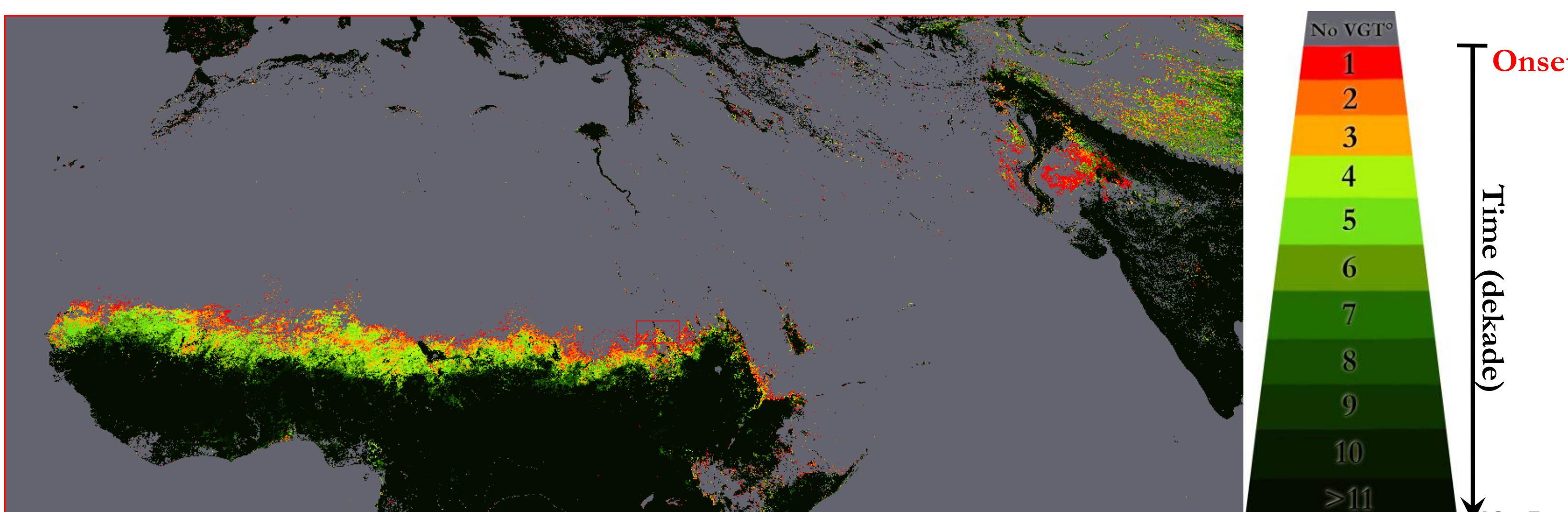


Product design

Dynamic Greennness Maps including a time meter

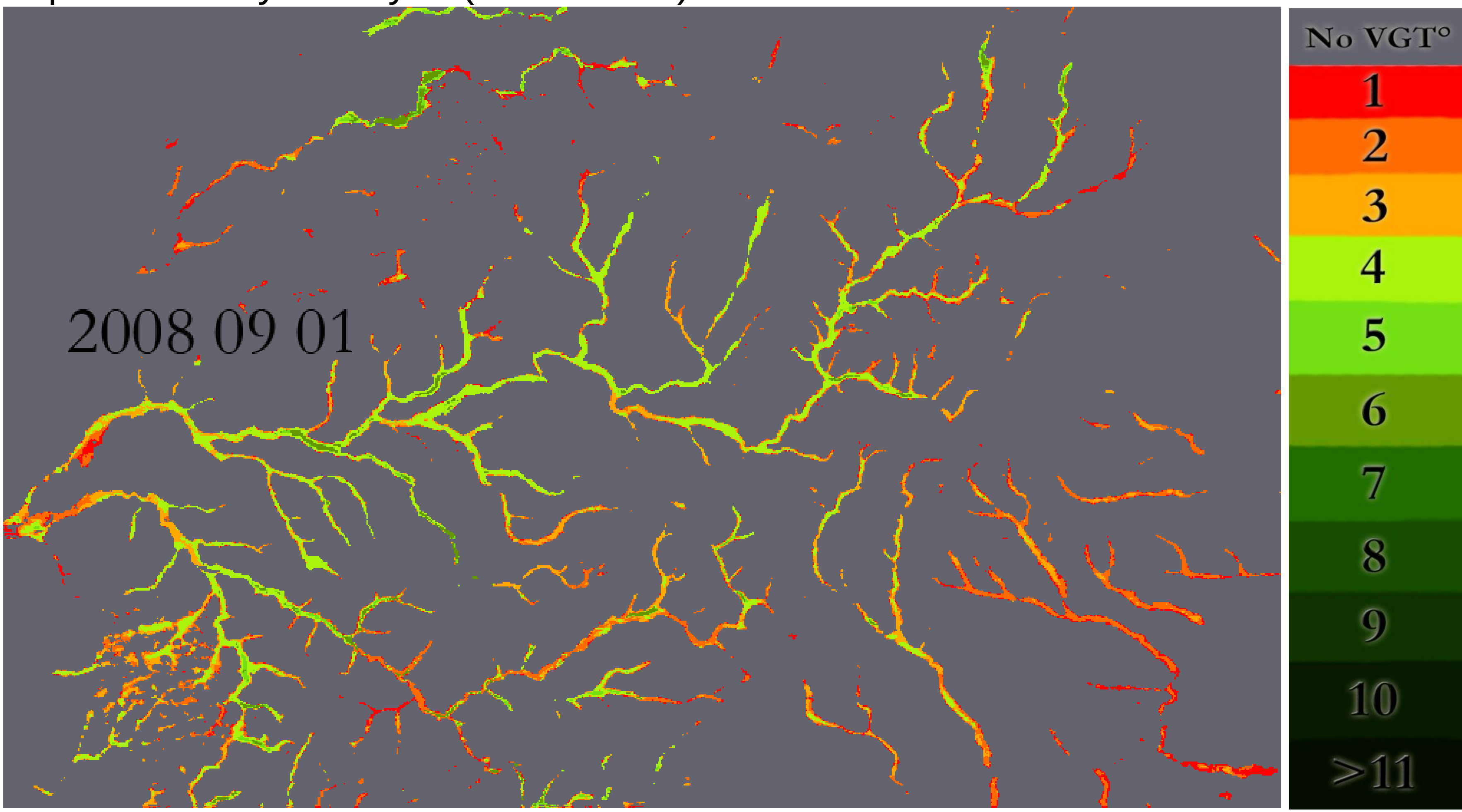
- Through a single file updated every 10 days, the Desert Locust Analyst knows:
  - the vegetation areas at the onset (red) or close to the onset (orange)
  - the false onset areas (not enough rain for a sustainable vegetation)
  - the areas of seasonal vegetation
  - the areas of evergreen vegetation
  - indirectly the rain distribution scheme through the vegetation development dynamic

- The comparison of the current situation with a past situation is easy (historical detections)
- All this information is available at 250m of resolution over all the locust area



Dynamic Greennness Maps in near real time (10 days)

Updated every 10 days (East of Mali)



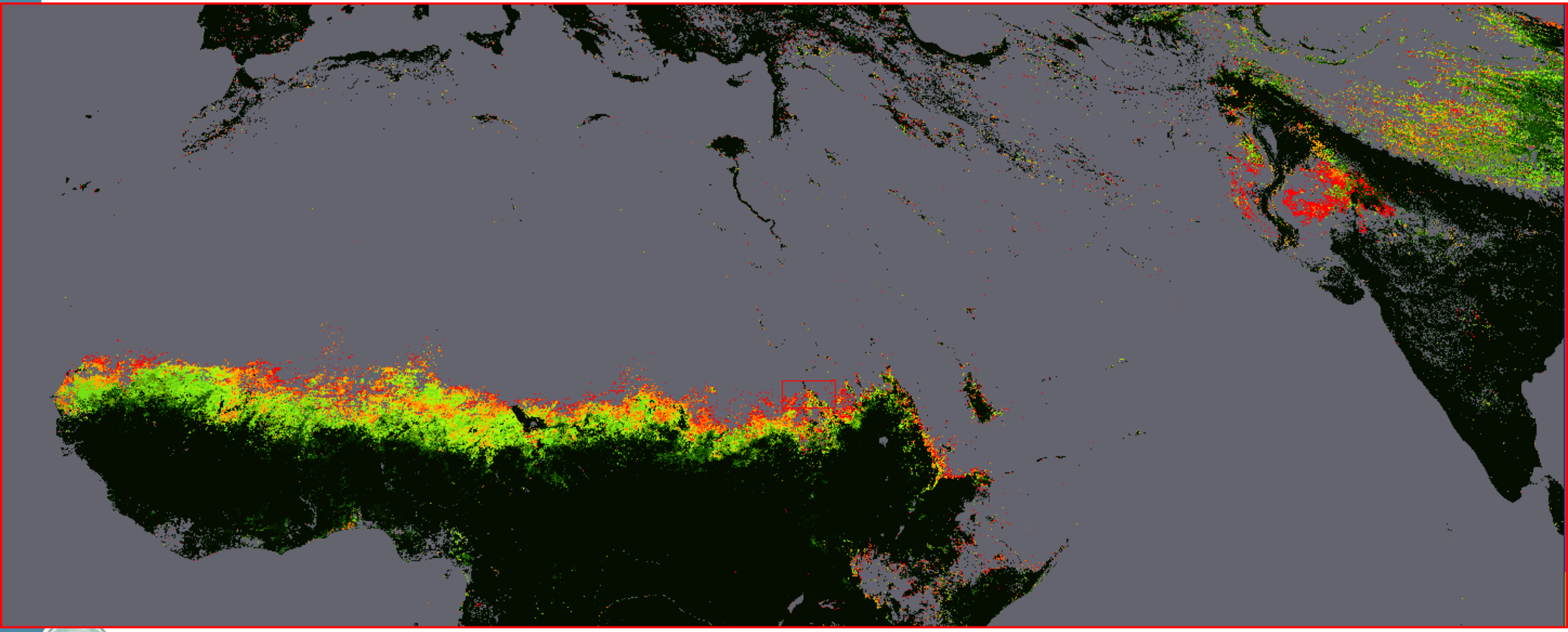
Prototyping to assess the product with the users

Full scale prototype products fined tune after 1 year operations

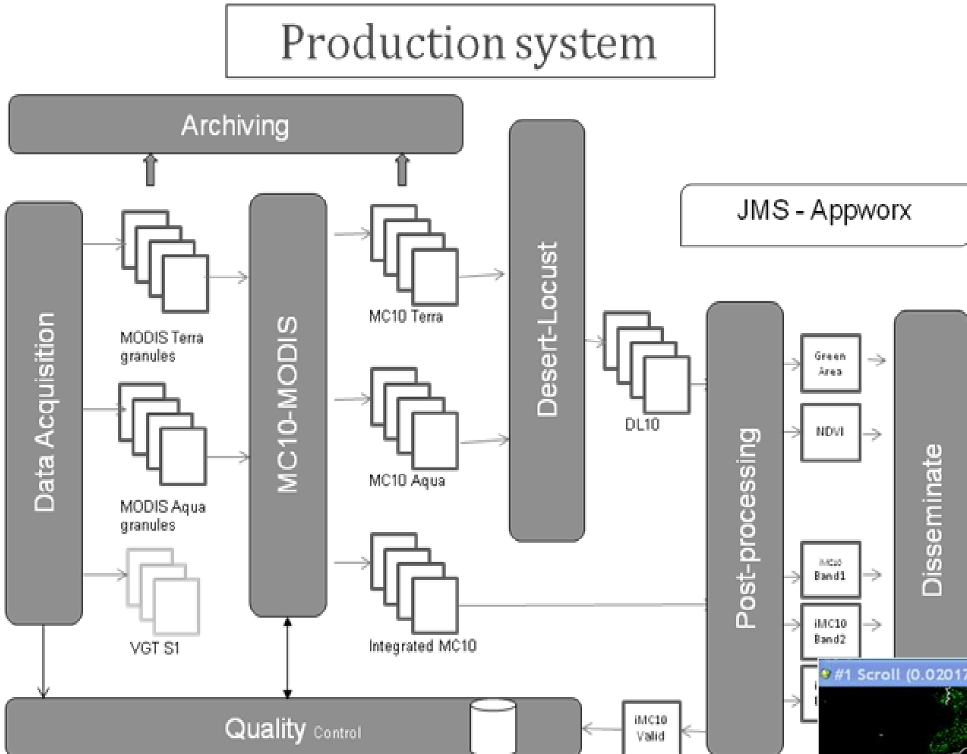
Three products are provided:

1. The Green Vegetation Dynamic Map
2. The composite (SWIR, NIR, Red)
3. The NDVI

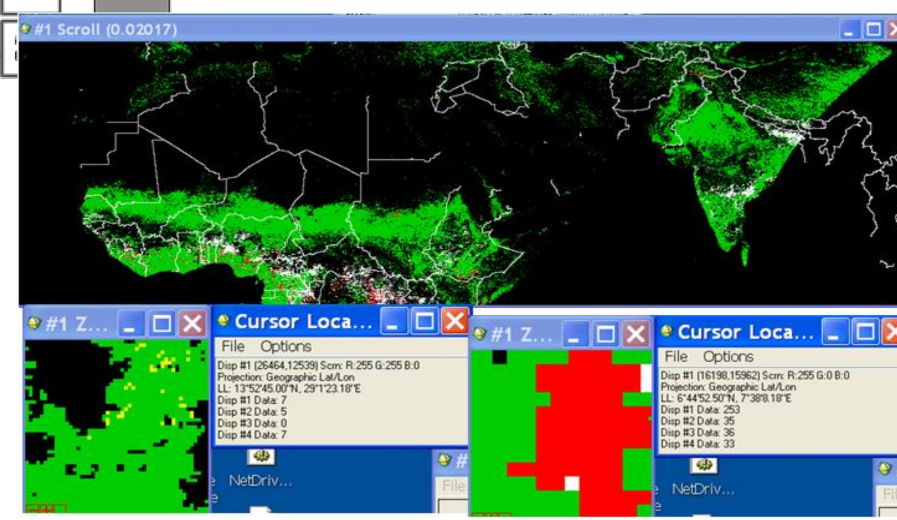
With a frequency of 10 days and a resolution of 250m



Development of the operational production chain



Verification and Quality Control jointly VITO and UCL, then users



Dissemination


GEONETCast for and by Developing Countries

DevCoCast

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...and need adec
derived environmental

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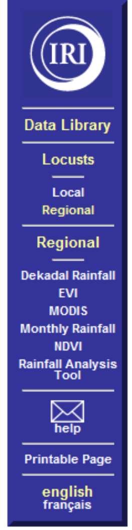
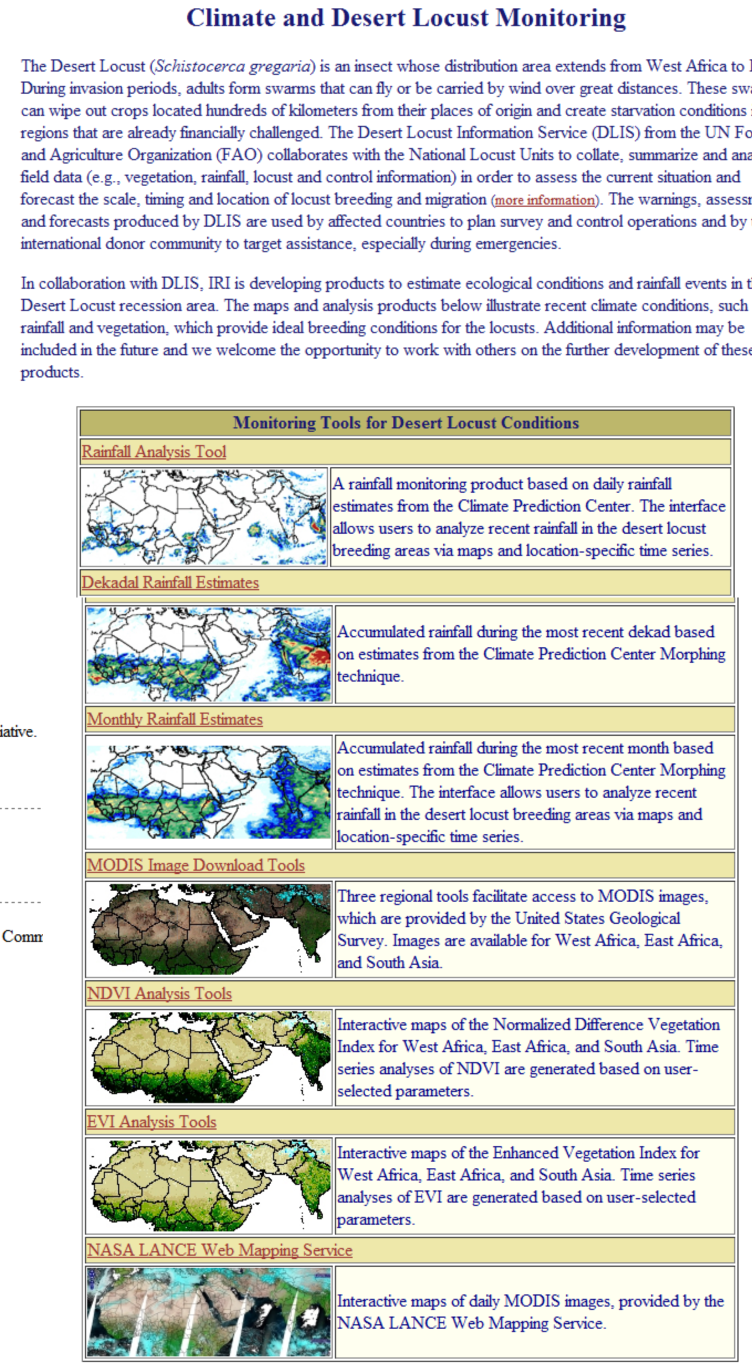
The **GEONETCast for and by Developing Countries** (DevCoCast) project involves Developing Countries more closely in the GEONETCast initiative.

A few tips on how to use this website:

For faster navigation, please disable the display of images via the [Images Off] link at the top right.

The DevCoCast project received funding from the 7th Framework Programme for Research and Technological Development (FP7) of the European Comm




Climate and Desert Locust Monitoring

The Desert Locust (*Schistocerca gregaria*) is an insect whose distribution area extends from West Africa to I During invasion periods, adults form swarms that can fly or be carried by wind over great distances. These swa can wipe out crops located hundreds of kilometers from their places of origin and create starvation conditions regions that are already financially challenged. The Desert Locust Information Service (DLIS) from the UN Fo and Agriculture Organization (FAO) collaborates with the National Locust Units to collate, summarize and ana field data (e.g., vegetation, rainfall, locust and control information) in order to assess the current situation and forecast the scale, timing and location of locust breeding and migration (more information). The warnings, assessn and forecasts produced by DLIS are used by affected countries to plan survey and control operations and by international donor community to target assistance, especially during emergencies.

In collaboration with DLIS, IRI is developing products to estimate ecological conditions and rainfall events in t Desert Locust recession area. The maps and analysis products below illustrate recent climate conditions, such rainfall and vegetation, which provide ideal breeding conditions for the locusts. Additional information may be included in the future and we welcome the opportunity to work with others on the further development of these products.

Monitoring Tools for Desert Locust Conditions	
Rainfall Analysis Tool	
	A rainfall monitoring product based on daily rainfall estimates from the Climate Prediction Center. The interface allows users to analyze recent rainfall in the desert locust breeding areas via maps and location-specific time series.
Dekadal Rainfall Estimates	
	Accumulated rainfall during the most recent dekad based on estimates from the Climate Prediction Center Morphing technique.
Monthly Rainfall Estimates	
	Accumulated rainfall during the most recent month based on estimates from the Climate Prediction Center Morphing technique. The interface allows users to analyze recent rainfall in the desert locust breeding areas via maps and location-specific time series.
MODIS Image Download Tools	
	Three regional tools facilitate access to MODIS images, which are provided by the United States Geological Survey. Images are available for West Africa, East Africa, and South Asia.
NDVI Analysis Tools	
	Interactive maps of the Normalized Difference Vegetation Index for West Africa, East Africa, and South Asia. Time series analyses of NDVI are generated based on user-selected parameters.
EVI Analysis Tools	
	Interactive maps of the Enhanced Vegetation Index for West Africa, East Africa, and South Asia. Time series analyses of EVI are generated based on user-selected parameters.
NASA LANCE Web Mapping Service	
	Interactive maps of daily MODIS images, provided by the NASA LANCE Web Mapping Service.

Test : web portal versus satellite transmission

2 GIS softwares for Desert Locust Information Service but

- **The incompatibility of the Green Maps with ArcView**
- **The incompatibility of MODIS 250m color composition (SWIR, Nir, Red) with ArcGIS.**

Quantitative product validation

- good accuracy for dense temporary vegetation (cc>40 %)

but variable according to soils type and season (Marocco, Mauritania)

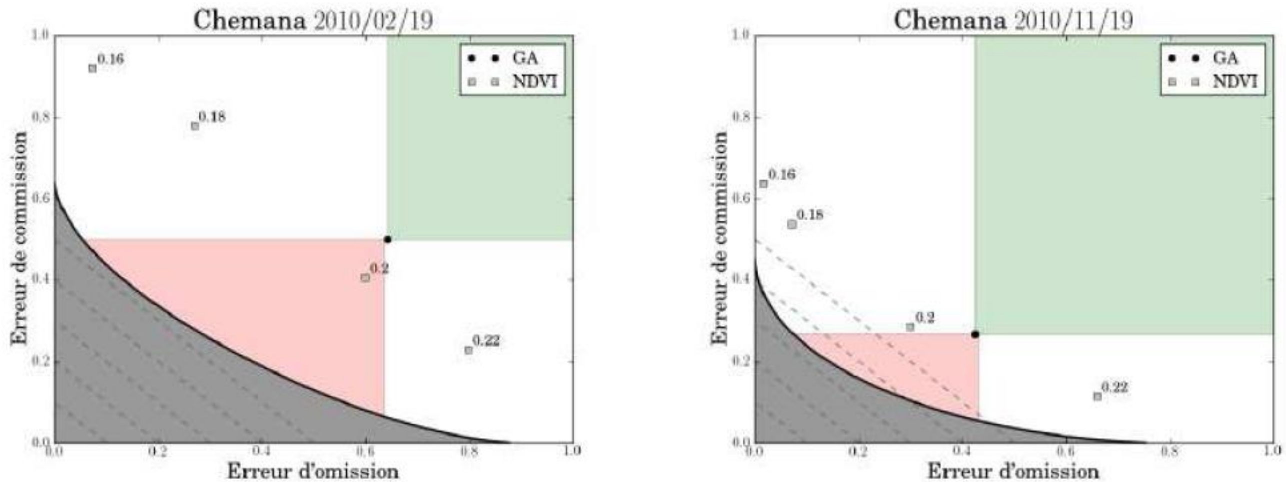
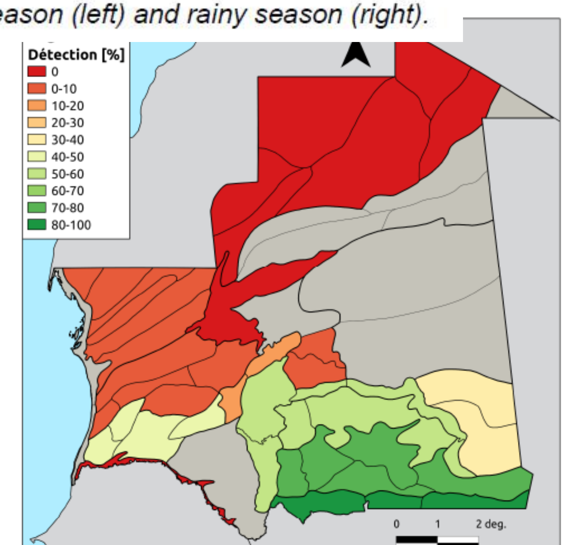


Figure 3: Comparison of the commission and omission errors during dry season (left) and rainy season (right).



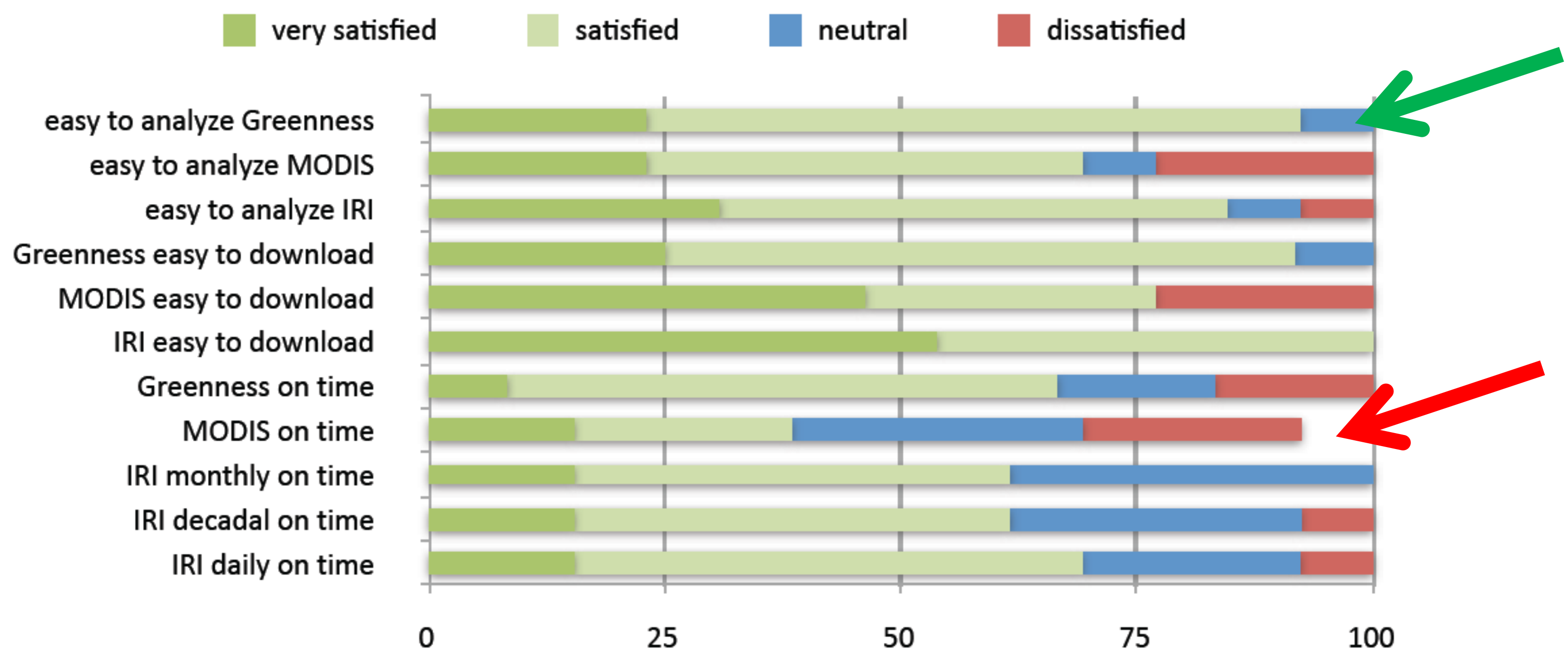
(Waldner, 2012)

Figure 4: Percentage of correct detection during the July to September period of 2011 (based on the RAMSES database)

Report on EO usage from users survey

(K. Cressman, May 2012)

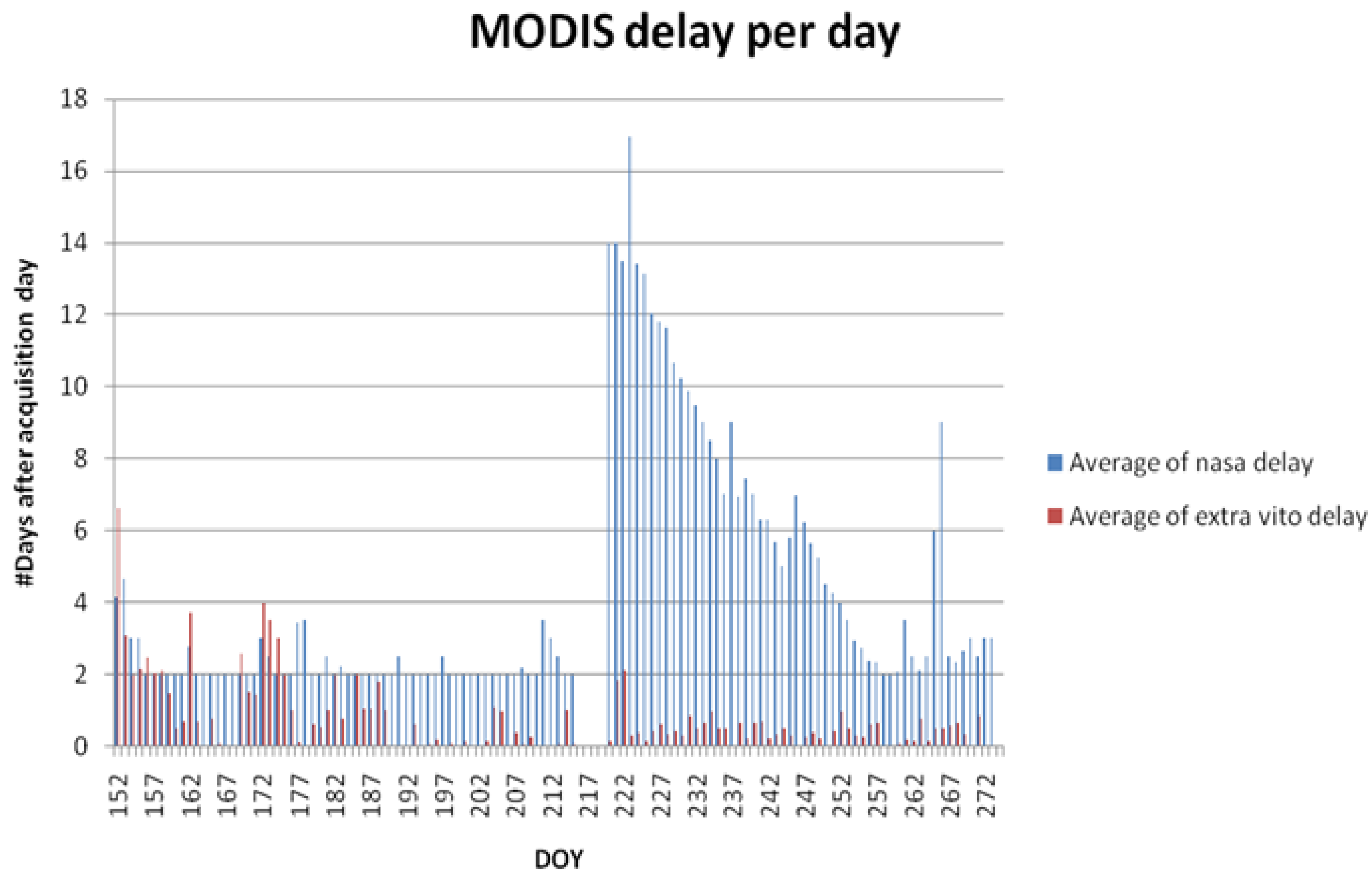
Dynamic Greenness Maps : most useful of all remote sensing products



National locust information officers are generally satisfied (indicated as percent) about the operational provision and use of remote sensing products in Desert Locust monitoring and early warning in their countries (online questionnaire, April 2012).

Report on EO usage from users survey

time delivery : maximum 5 days but NASA…

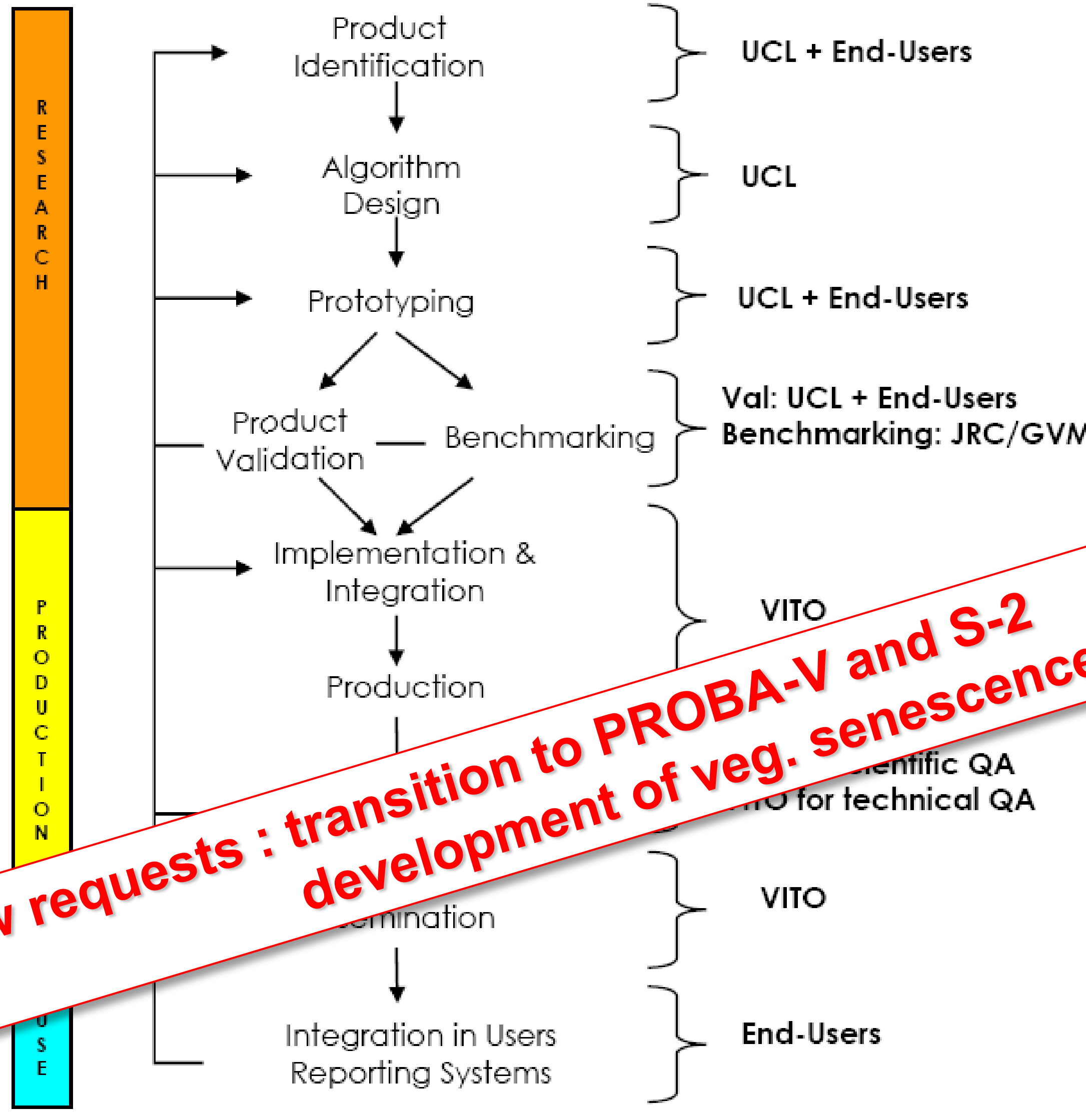


MODIS granule availability with NASA downtime in August 2010

+ long term commitment for the NRT service !

Only two ideas for the overall strategy

Several loops

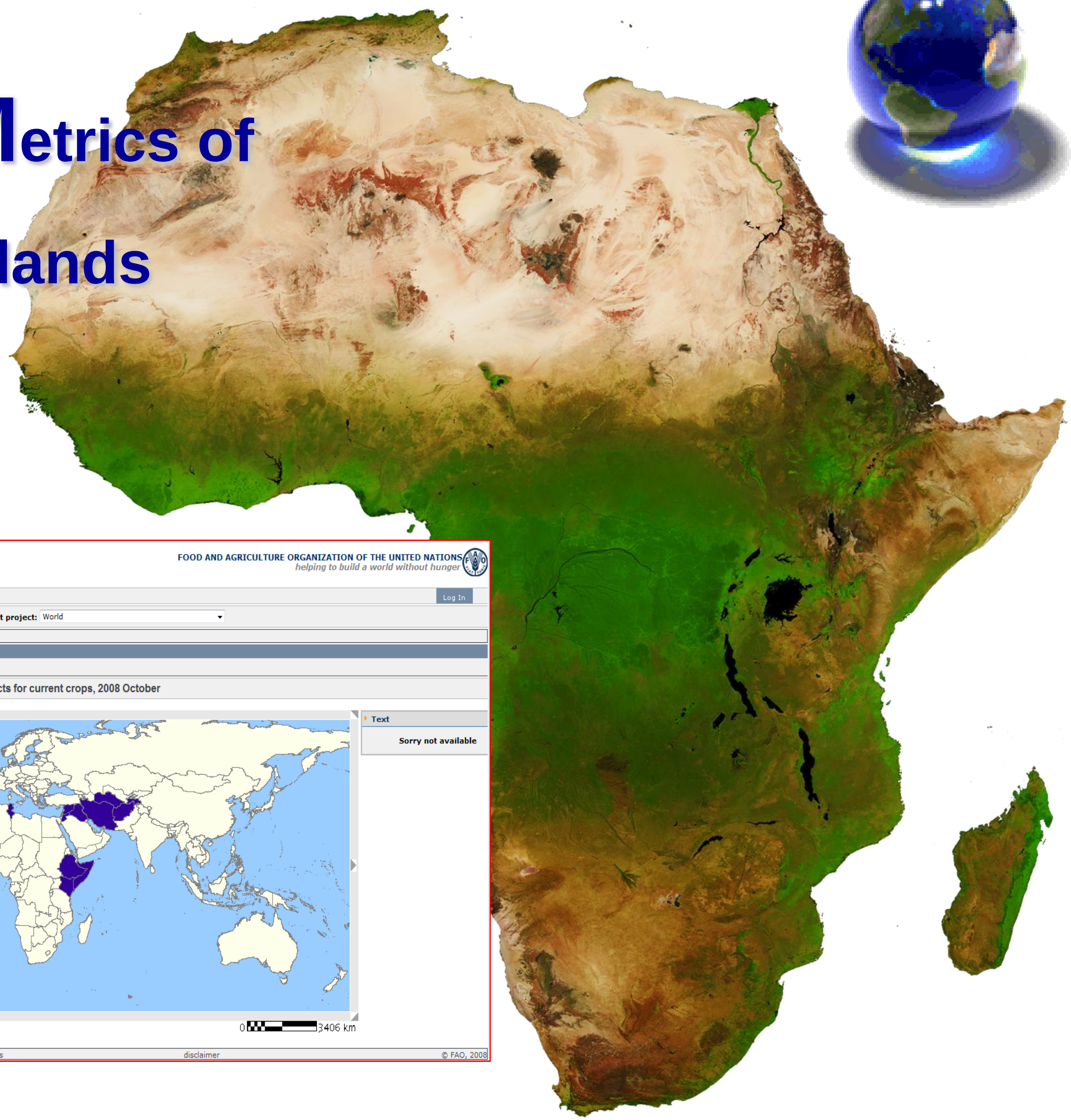


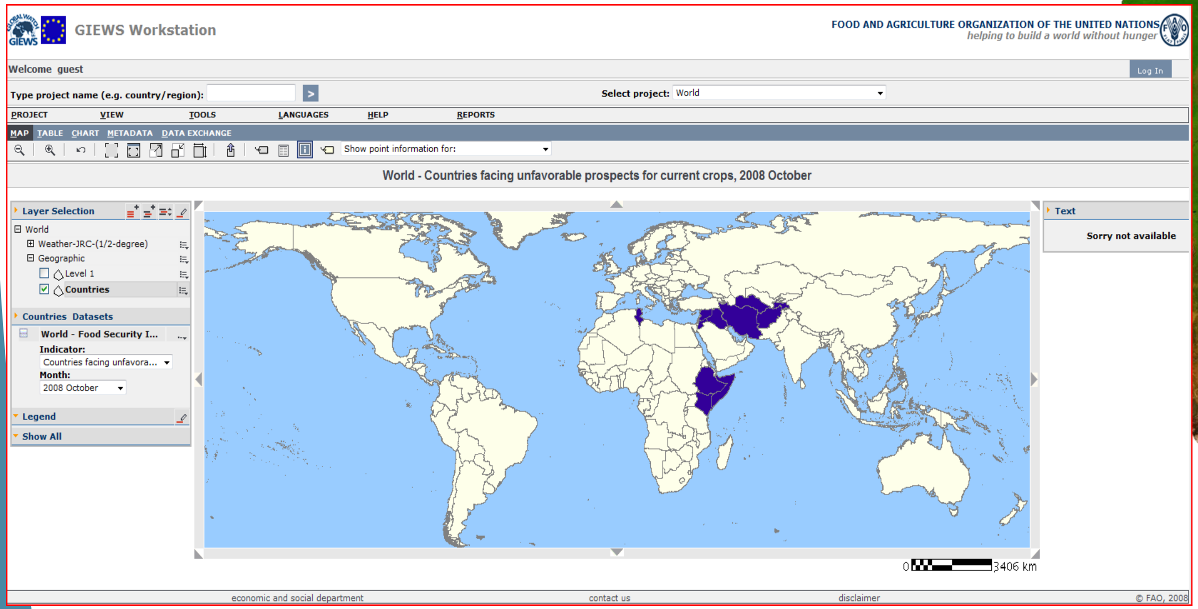
S–U–P–E-R partnership

Two new requests : transition to PROBA-V and S-2 development of veg. senescence product

…a consequence : a joint adventure which it takes much longer than a 2-y joint project !

Phenological Metrics of Agricultural lands





Phenology metrics for ag. monitoring

Users requirements and product specification

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

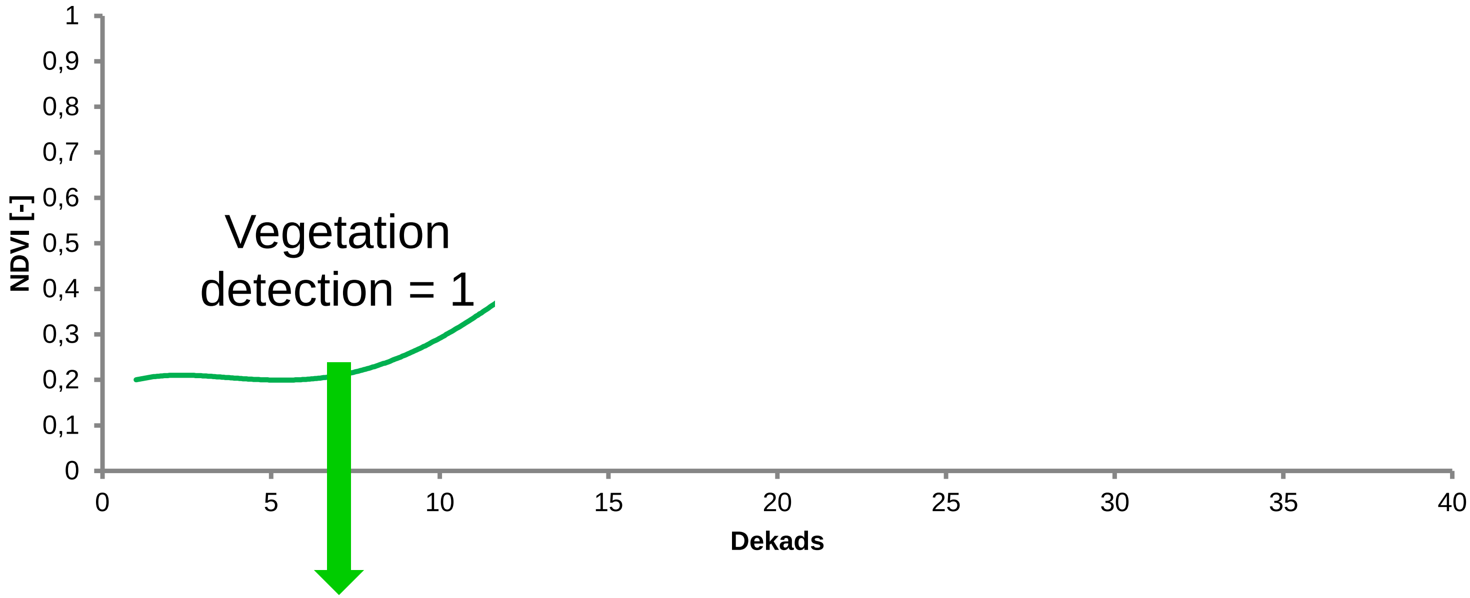
Decade of the first vegetation detection

Decade of the last vegetation detection

Phenology metrics for ag. monitoring

Users requirements and product specification

- ONSET



Onset Date
NDVI at Onset

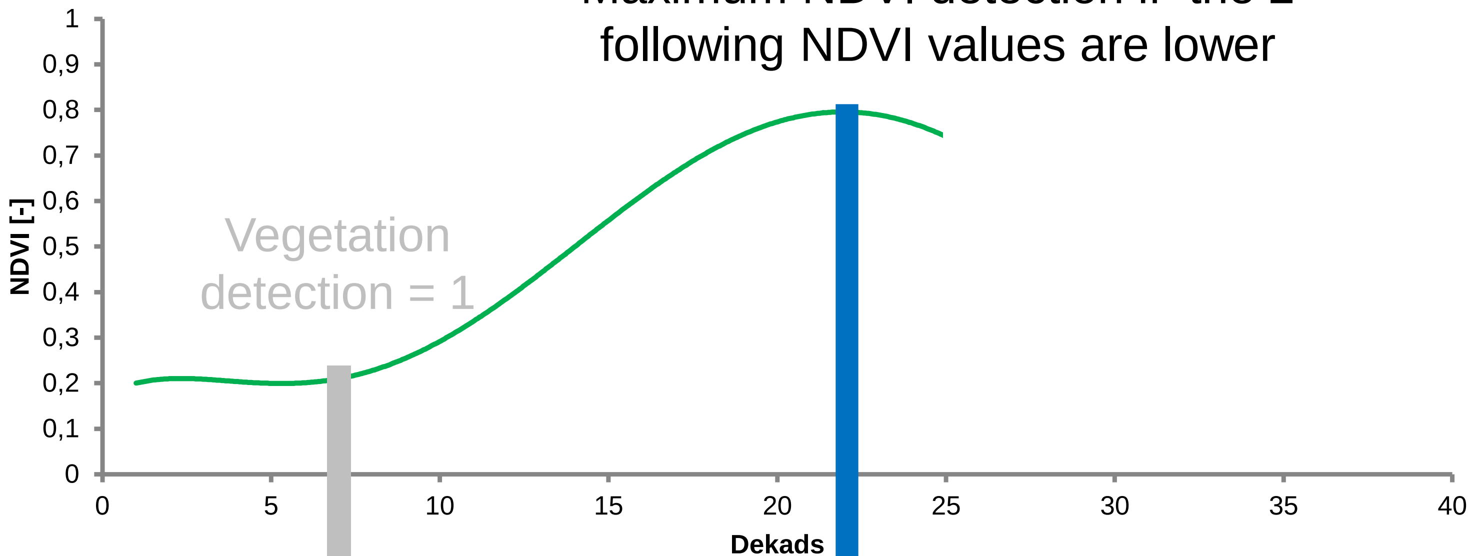
Delivered in near real-time
Once a season

Phenology metrics for ag. monitoring

Users requirements and product specification

- MAXIMUM

Maximum NDVI detection if the 2 following NDVI values are lower



Onset Date
NDVI at Onset

Delivered in near real-time
Once a season

Max Date
Max NDVI
Range NDVI

Once a season

Accumulated NDVI

In continuous until the end

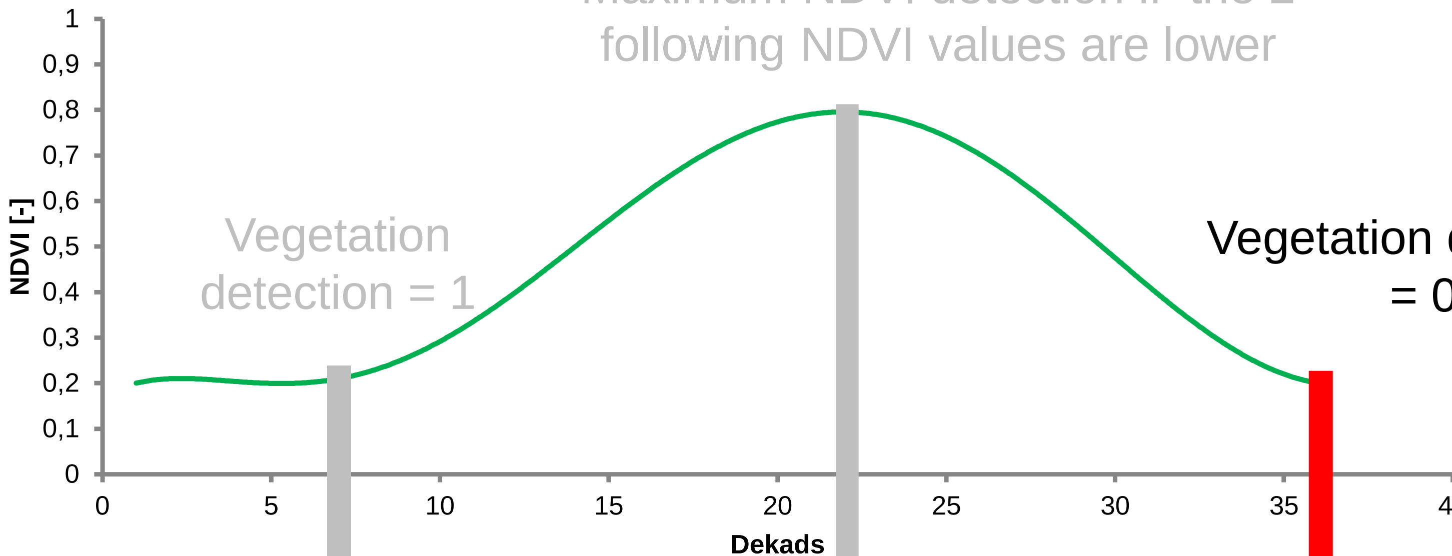
Delivered at Max + 2 dekads

Phenology metrics for ag. monitoring

Users requirements and product specification

- END

Maximum NDVI detection if the 2 following NDVI values are lower



Vegetation detection = 0

Onset Date
NDVI at Onset

Max Date
Max NDVI
Range NDVI

Accumulated NDVI

End Date
End NDVI
Duration NDVI

Final Acc. NDVI

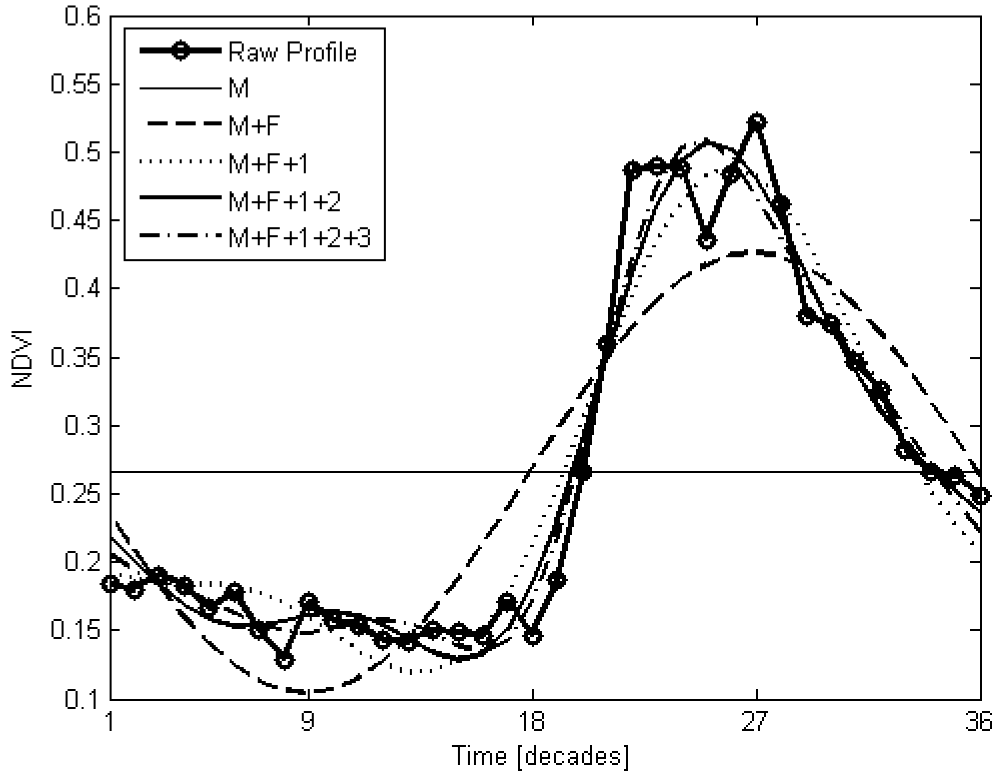
Delivered in near real-time
Once a season

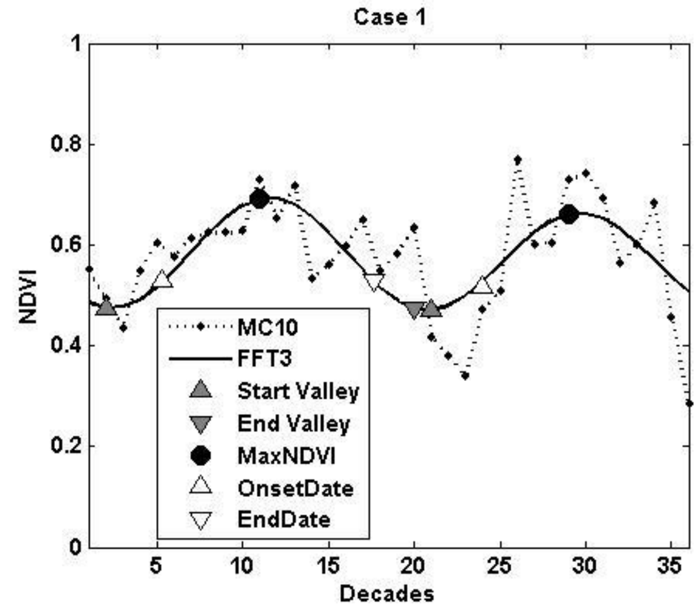
Delivered at Max + 2 dekads

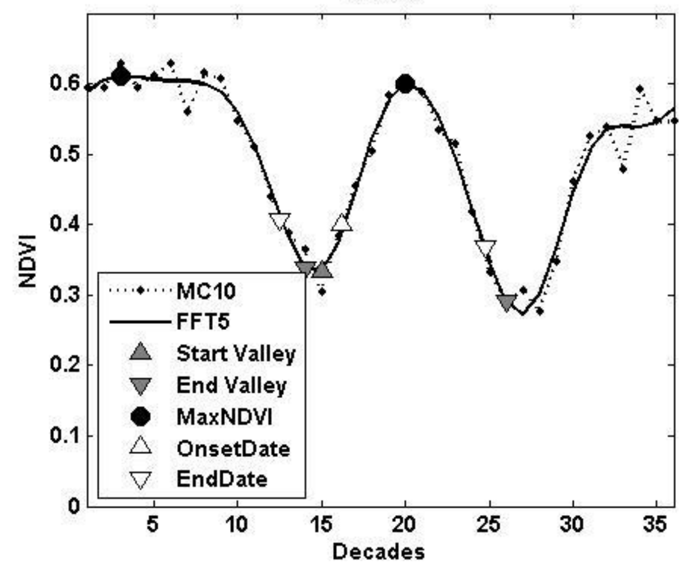
Near real-time
Once a season

Phenology metrics for ag. monitoring

R&D on time series smoothing and metrics

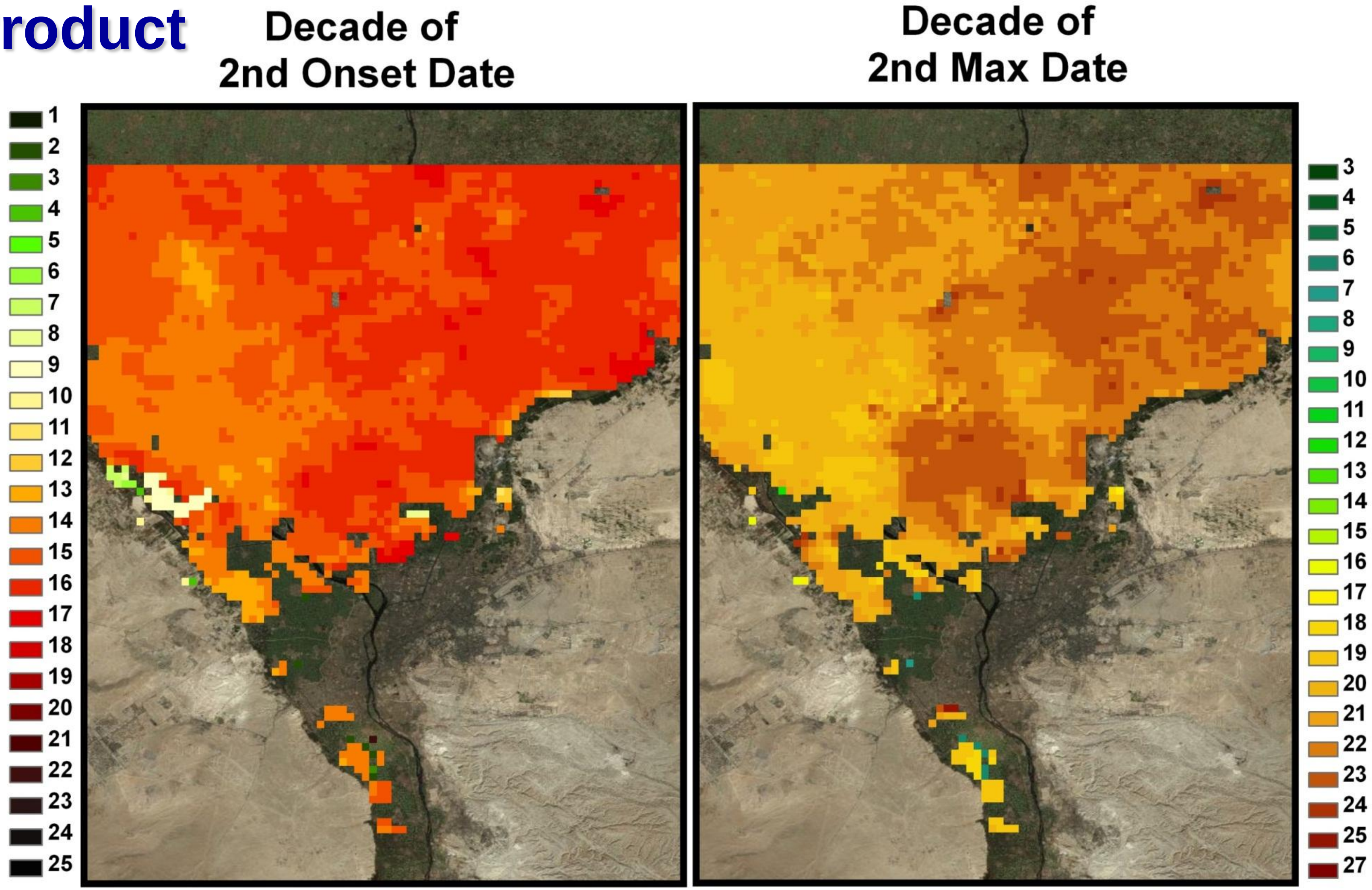






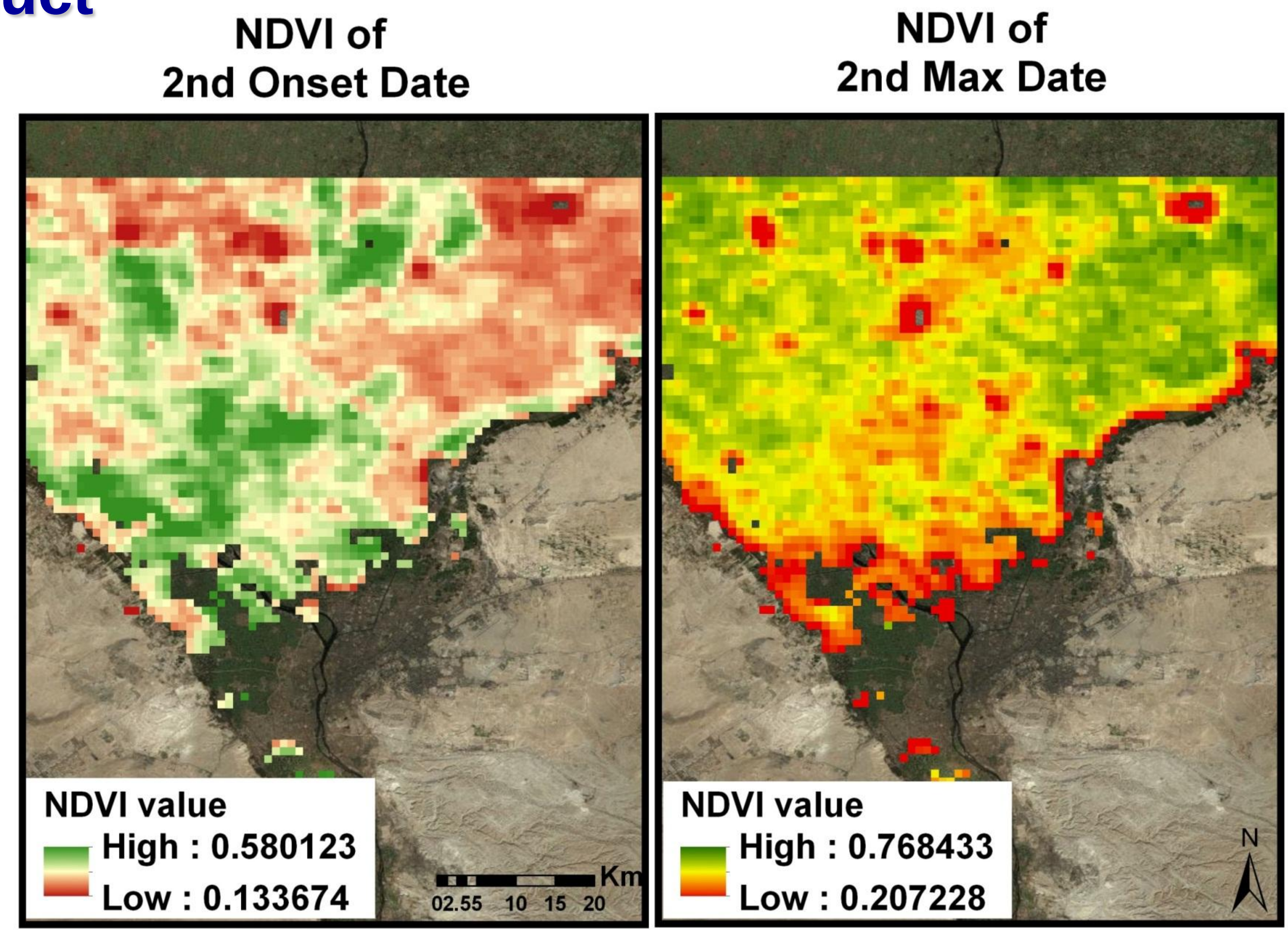
Phenology metrics for ag. monitoring

Product



Phenology metrics for ag. monitoring

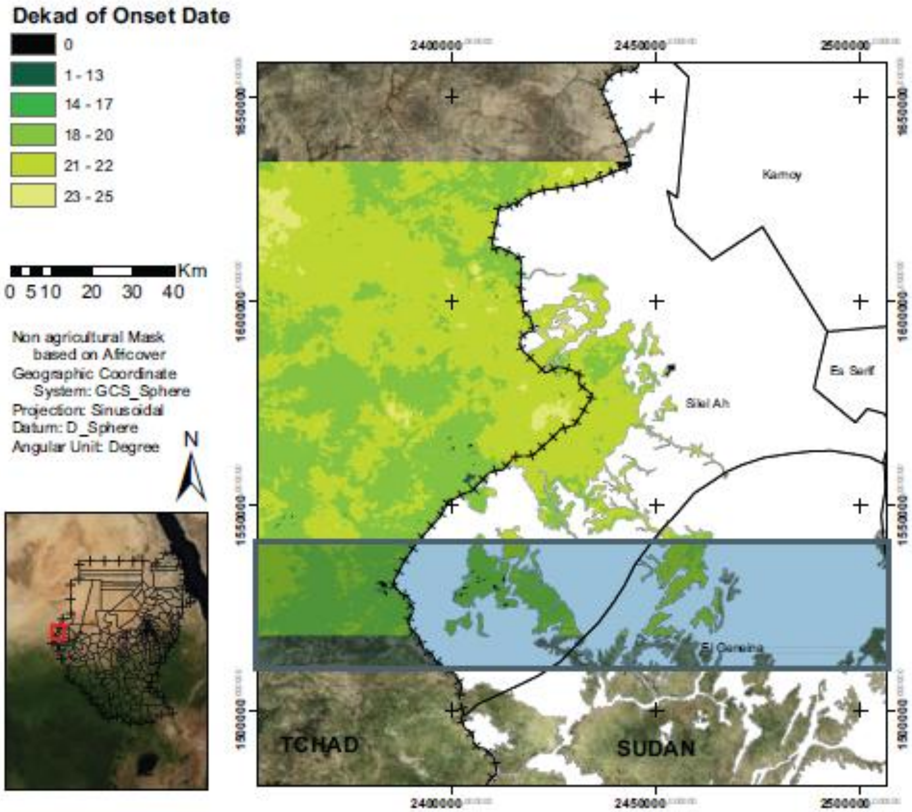
Product

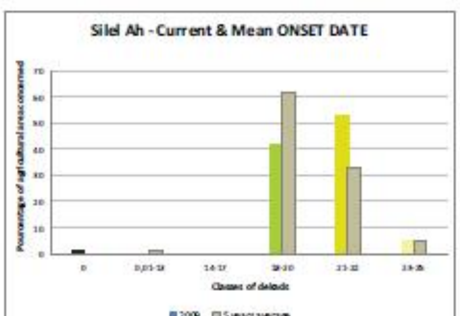


Global Information and Early Warning System

Prototype Product
West Sudan - Onset Date - December 2009 (Dek36)

World Wide Watch Project
Phenology Product
Development Phase



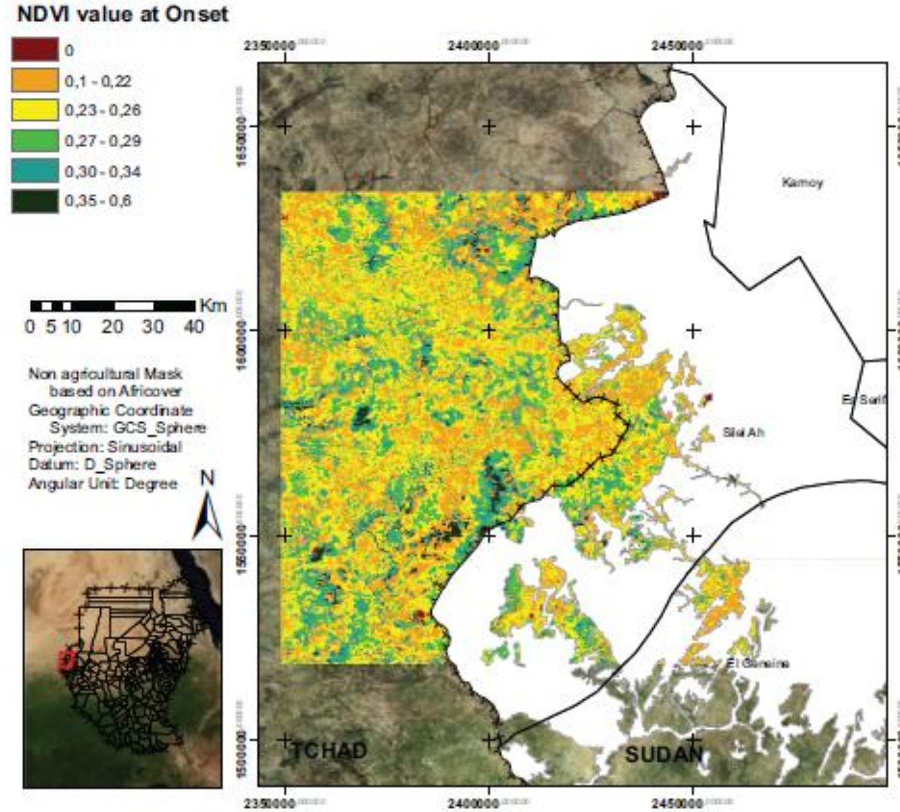


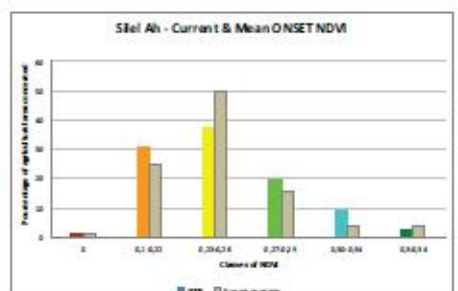
ONSET DATE		ONSETDATE AVERAGE	
Classe	Importance of agricultural zone [%]	Classe	Importance of agricultural zone [%]
0	1,1	0	0,1
0,01-13	0,1	0,01-13	1,1
14-17	0,0	14-17	0,0
18-20	41,4	18-20	61,6
21-22	52,7	21-22	32,7
23-25	4,7	23-25	4,7

Global Information and Early Warning System

Prototype Product
West Sudan - Onset NDVI - December 2009 (Dek36)

World Wide Watch Project
Phenology Product
Development Phase





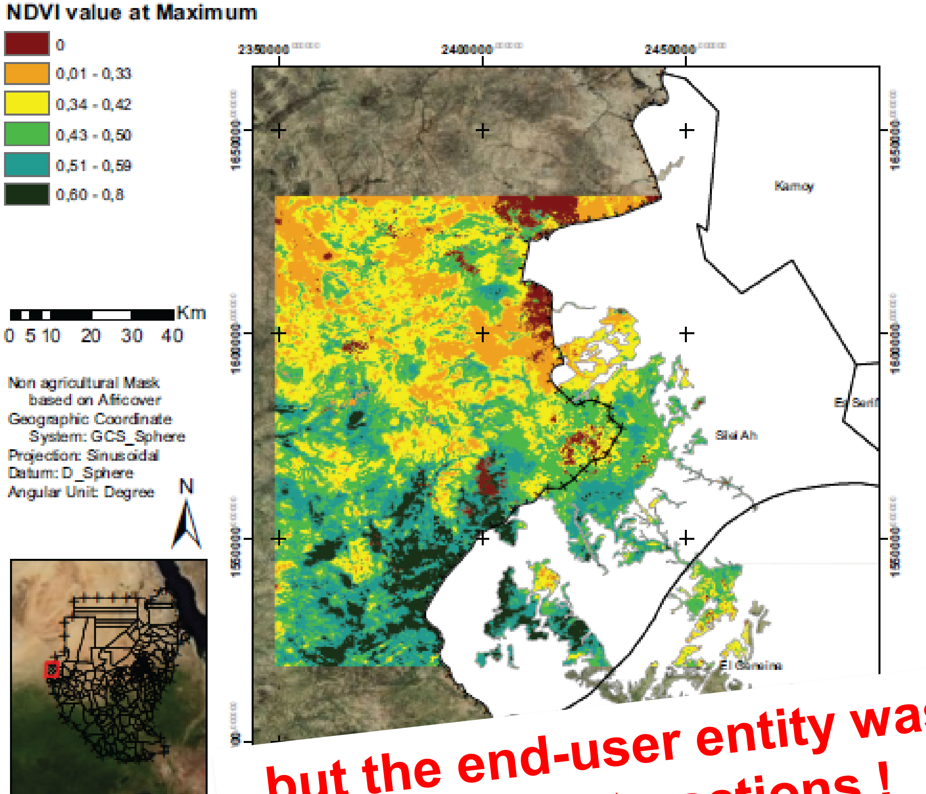
ONSET NDVI		ONSET NDVI AVERAGE	
Classe	Importance of agricultural zone [%]	Classe	Importance of agricultural zone [%]
0	1,1	0	1,0
0,1-0,22	30,8	0,1-0,22	25,0
0,23-0,26	37,1	0,23-0,26	50,1
0,27-0,29	19,7	0,27-0,29	15,7
0,30-0,34	8,9	0,30-0,34	4,0
0,3-0,34	2,4	0,3-0,34	4,2

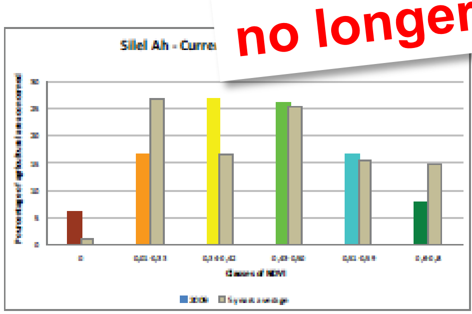
GIEWS Global Information and Early Warning System

Prototype Product

West Sudan - NDVI Max - December 2009 (Dek36)

World Wide Watch Project
Phenology Product
Development Phase





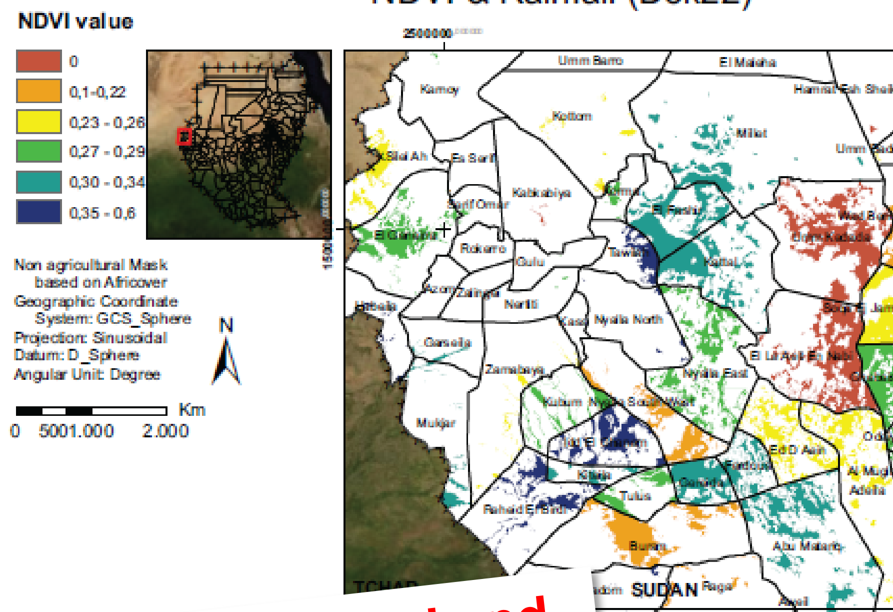
MAX NDVI		MAX NDVI AVERAGE	
Classe	Importance of agricultural zone [%]	Classe	Importance of agricultural zone [%]
0	6,1	0	1,1
0,01-0,33	16,6	0,01-0,33	26,6
0,34-0,42	26,6	0,34-0,42	16,6
0,43-0,50	26,2	0,43-0,50	25,2
0,51-0,59	16,6	0,51-0,59	15,6
0,6-0,8	7,8	0,6-0,8	14,8

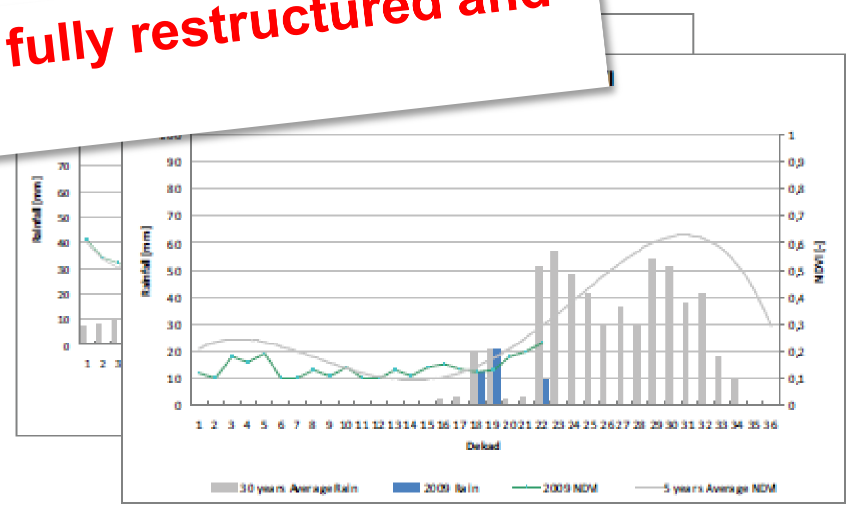
GIEWS Global Information and Early Warning System

Prototype Product

West Sudan - Spatially averaged metrics NDVI & Rainfall (Dek22)

World Wide Watch Project
Phenology Product
Development Phase

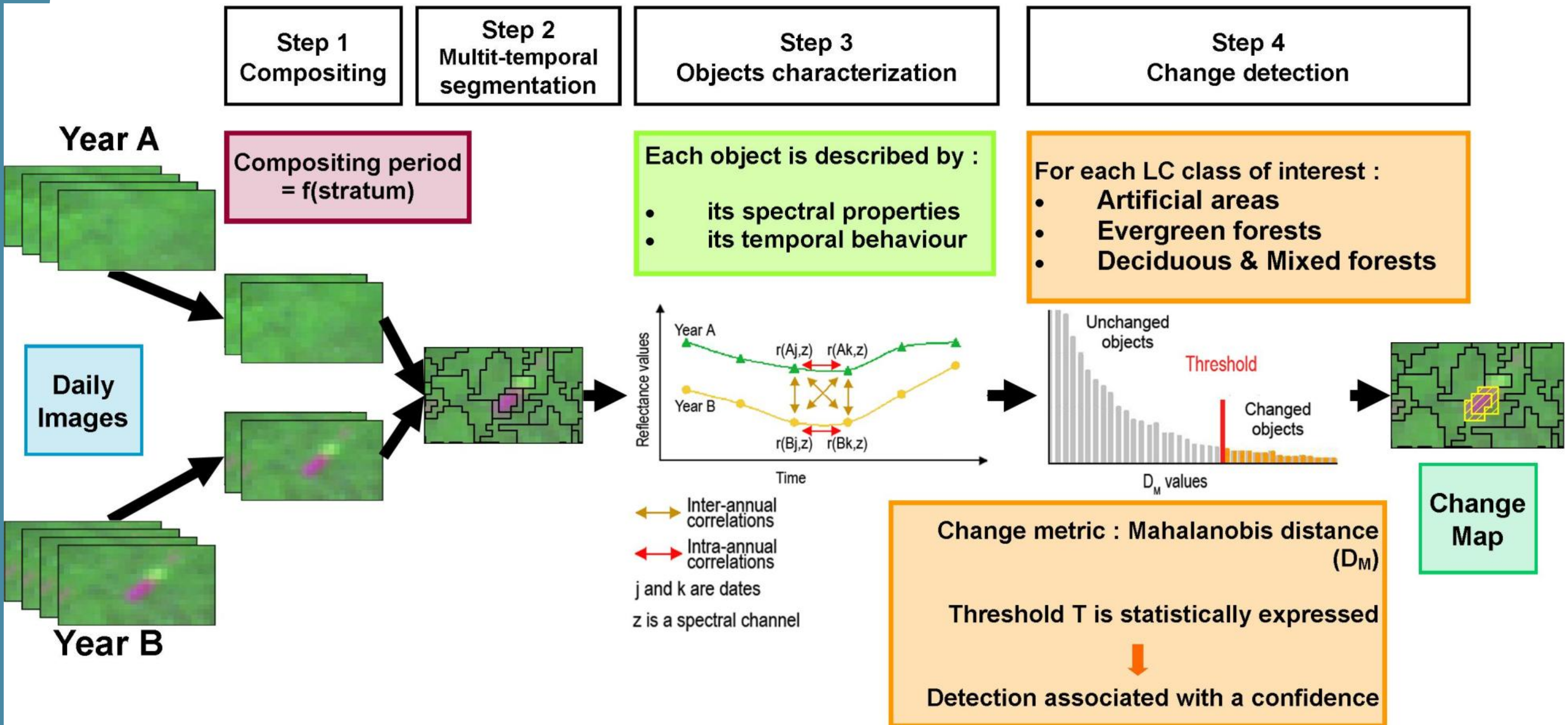




..but the end-user entity was fully restructured and no longer in interactions !

Pan Tropical Forest Change Product

Product definition and research development in WWW project

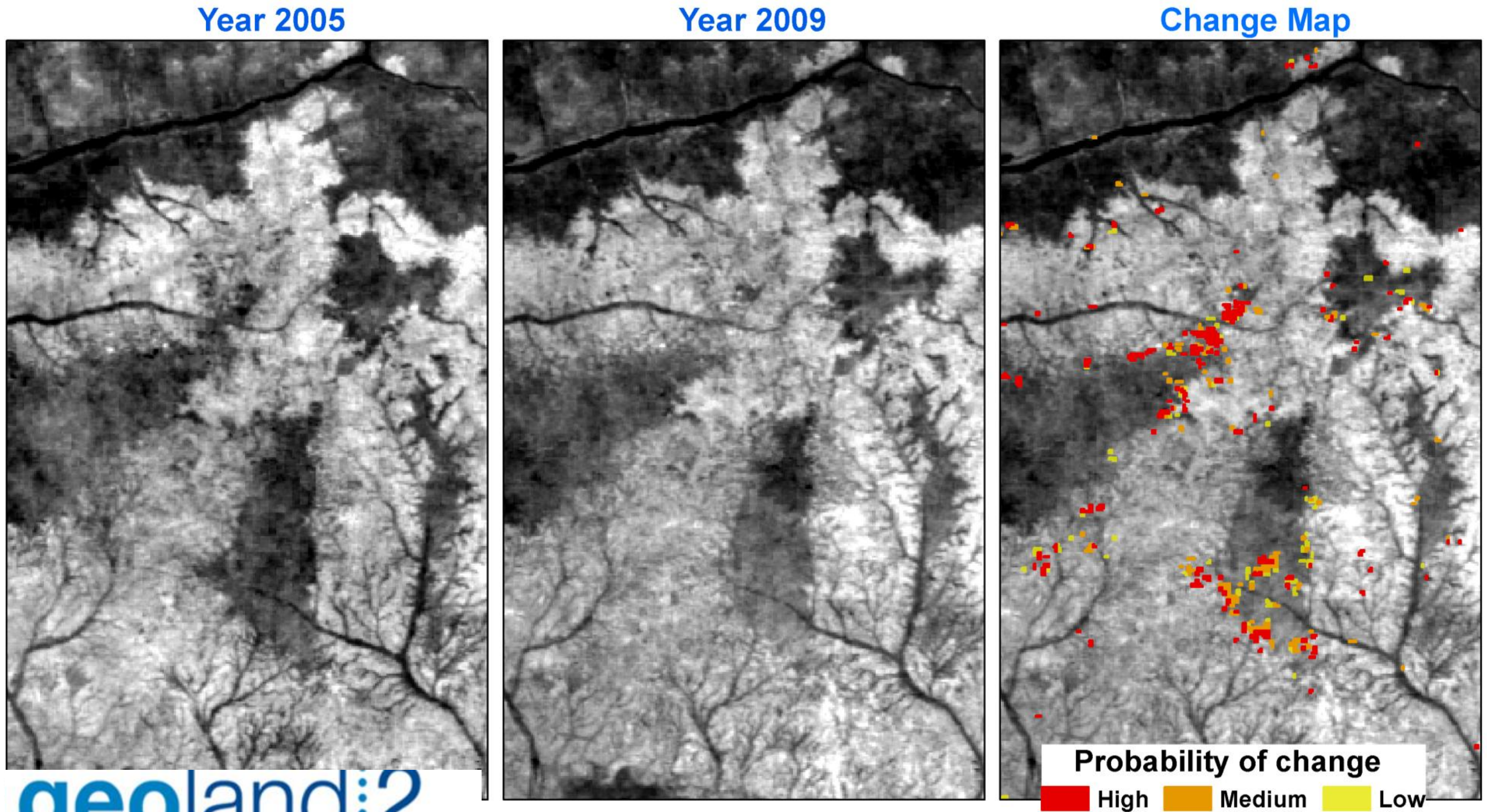


(modified from Bontemps, 2010)

Pan Tropical Forest Change Product

Prototype implementation in Geoland 2

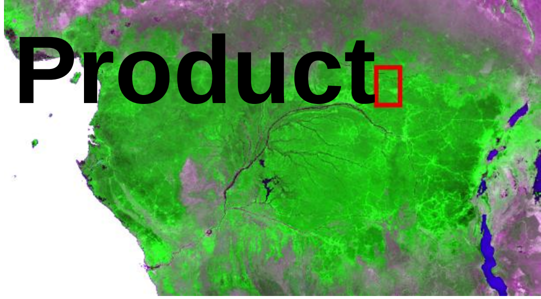
- Africa – example 1

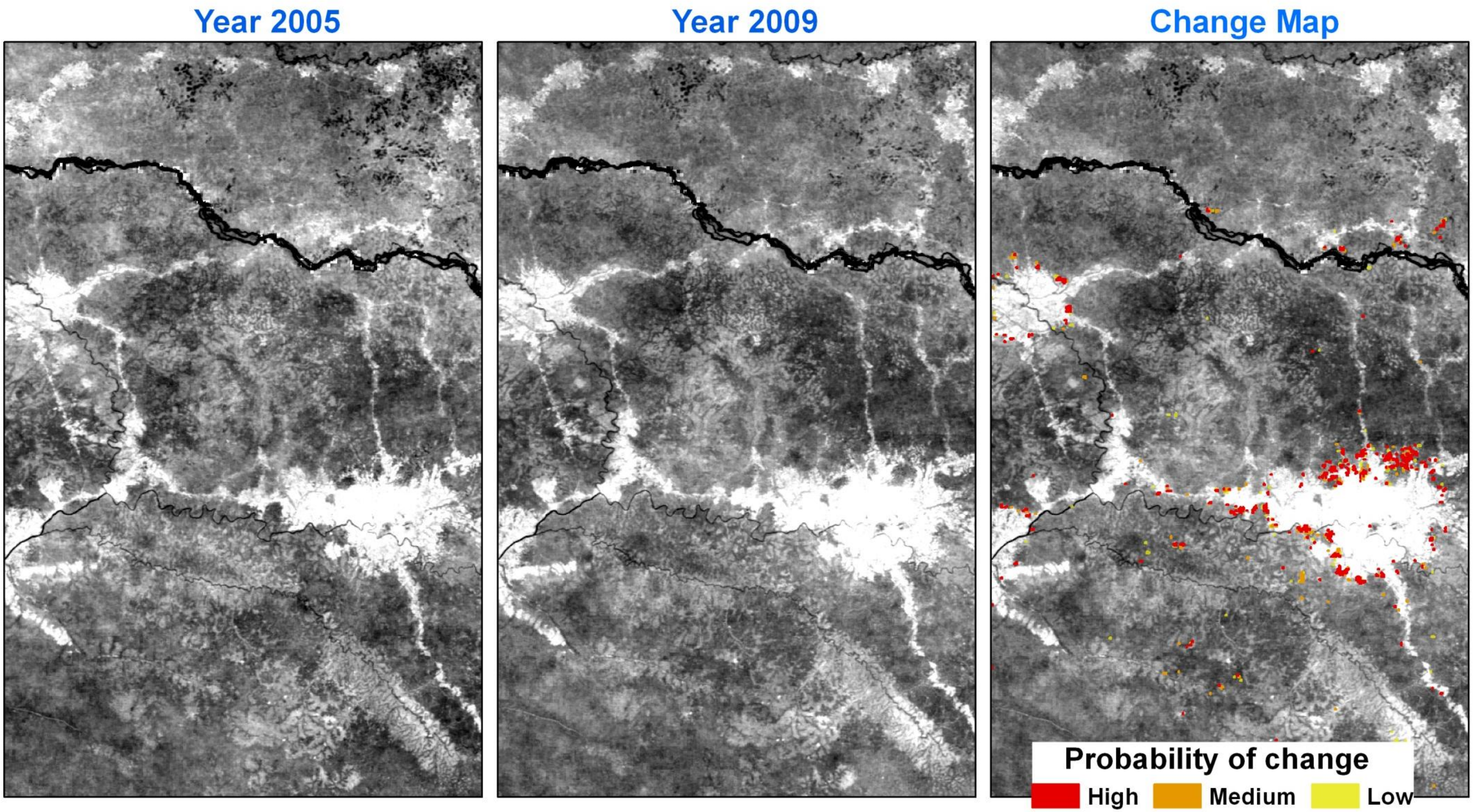


Pan Tropical Forest Change Product

Protototype implementation in Geoland 2

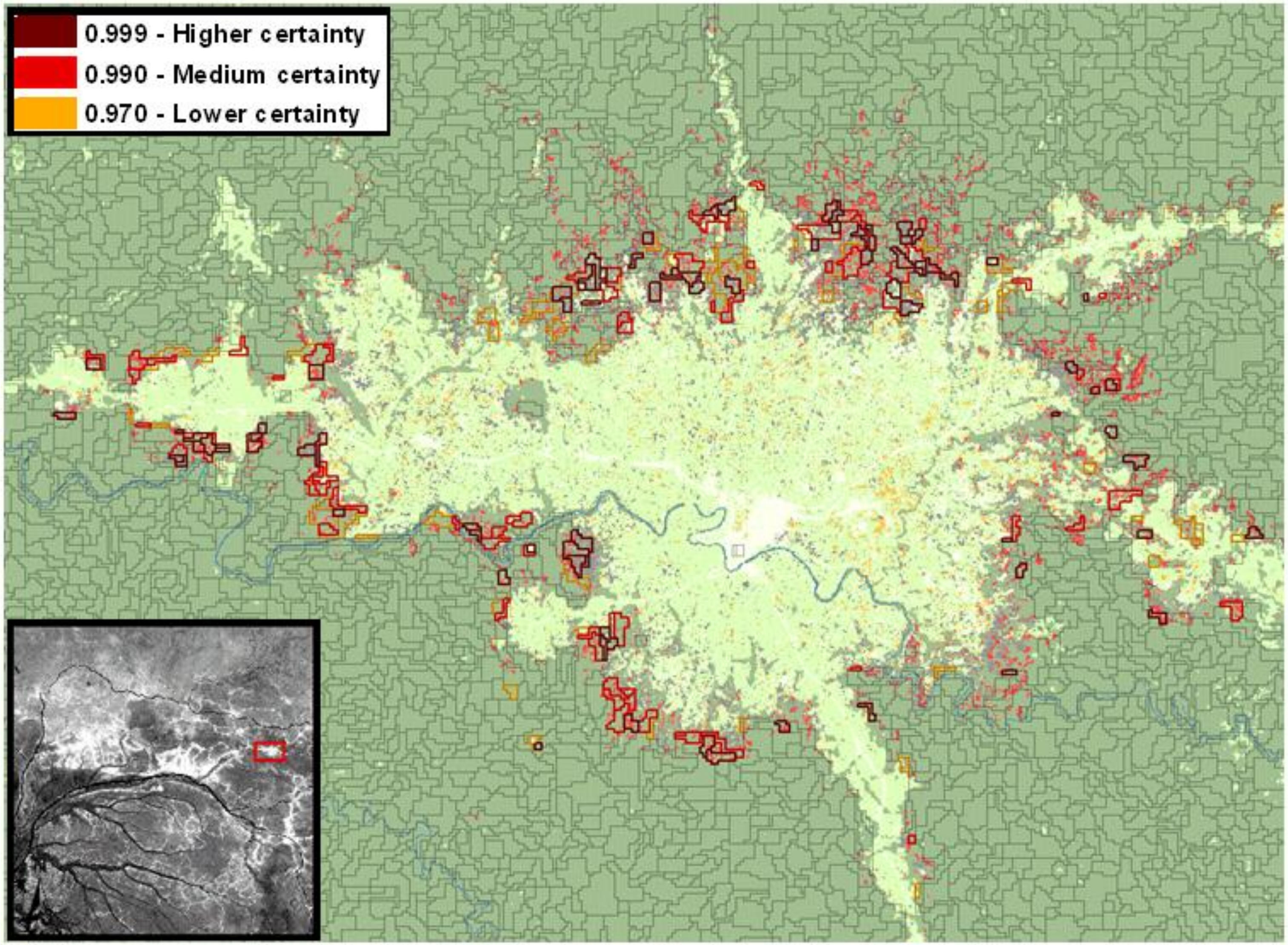
- Africa – example 2





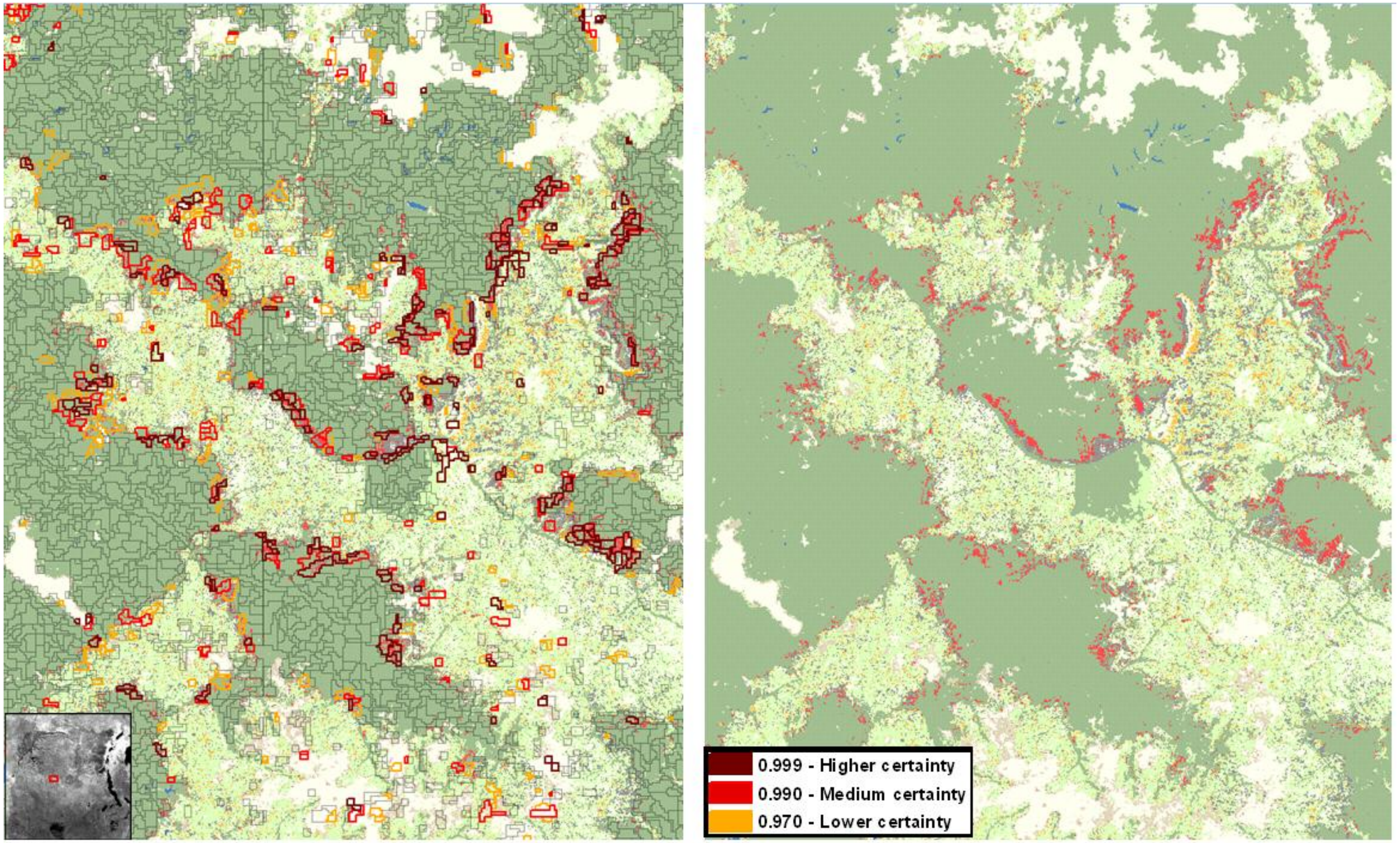
Pan Tropical Forest Change Product

Protototype product format



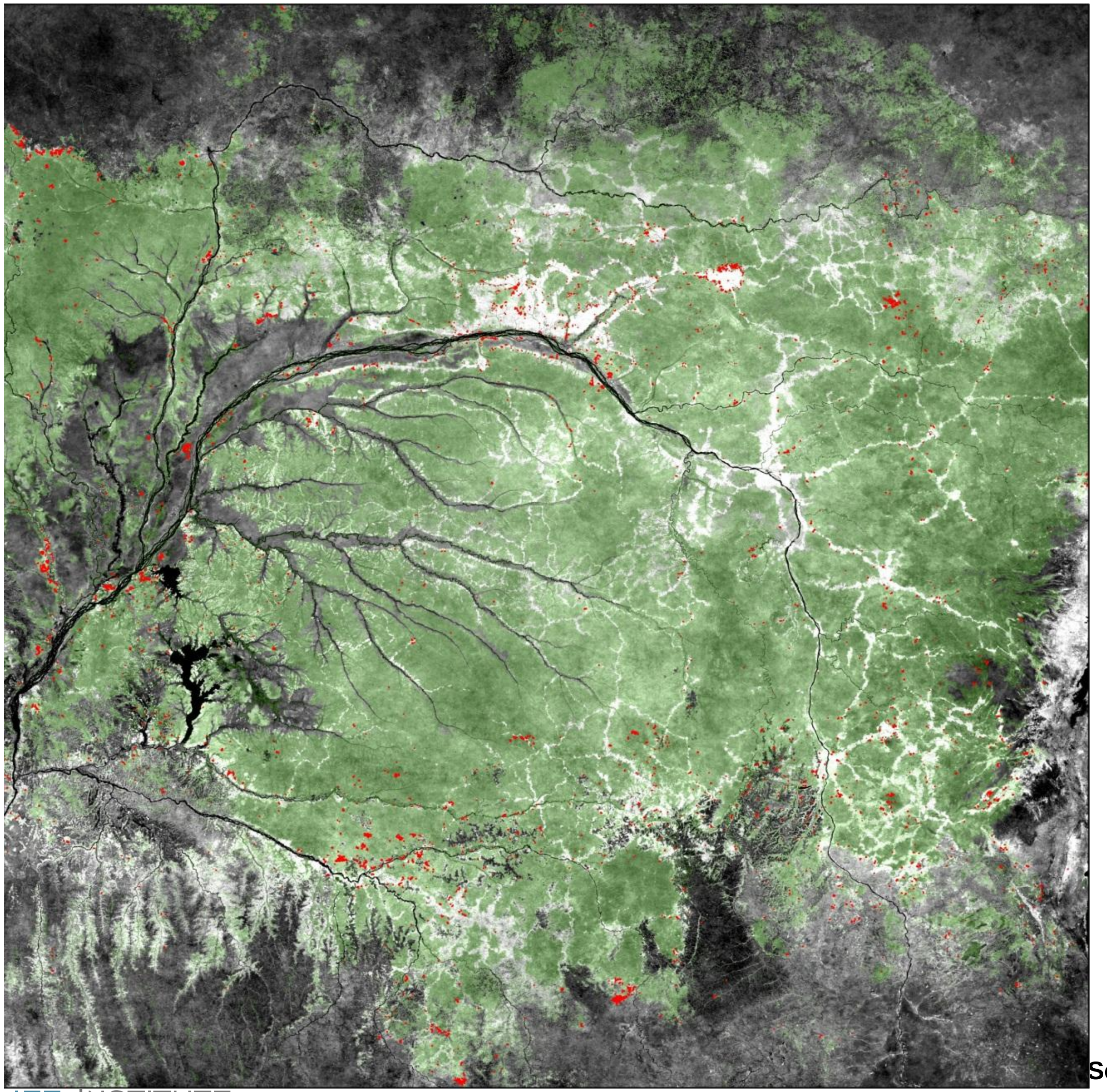
Pan Tropical Forest Change Product

Prototype product validation



Pan Tropical Forest Change Product

Demonstration product



Lessons learnt from WWW

- the **iterative approach** between the end-users product definition and the product development was found very critical
- **full scale prototyping** for final product assessment as early as at the development stage
- **delivering a product prototype in operational context** to really test from a users perspective => major fine tuning and specific formatting
- **production chain** development and test not only from an algorithm definition document but also **in close interaction** with the research team
- last but not least, **in situ assessment of the actual use** of the product by operational users leading to new requirements for complementary product developments.
- …the most challenging aspect remaining **the long term commitment from a technology and financial points of view**

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