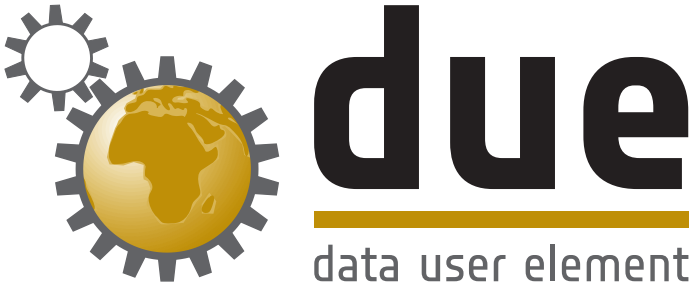
ESA Studies: Agriculture, Forest, Wetland, Costal Water

Preparing for Sentinel-2



Fostering the development and validation of EO applications with and for user communities

Olivier Arino, Benjamin Koetz, Marc Paganini, Simon Pinnock, Frank-Martin Seifert, Bianca Hoersch, Mark Doherty, Fabrizio Ramoino, Carsten Brockmann, Sophie Bontemps, Sven Giliam, Christopher Sannier, Suhyb Salam, Kathrin Weise

The DUE programme, working with user communities

"The DUE - like its forerunner DUP - is an instrument to support the development of operational EO applications. It is in particular working to support the users of such applications along with the EO service industry, and is instrumental also to encourage the cooperation between parties in the various participating states."

Dr. Nico Bunnik - Former National Delegate to the Earth Observation (EO) Programme Board

User Groups: National & sub-national public authorities, European institutions, International organizations, NGOs

User requirements consolidation

Ground truthing In-situ data access

Products validation

Service assestment

EO data

Service Development

Products

Service Demonstration

Sentinel-2 User requirements

S2 preparatory symposia – 2012 & 2014, ESRIN

- Objective: requirements for S2 R&D preparatory activities
- Global scientific community (ca. 400 participants)
- Wide range of EO applications
- recommendations for hyper-temporal S2 capabilities (2012)
  - [5] Time series of simulated Sentinel 2 L1C products
  - [8] Time Series Analysis Methods (tools for different applications)

Extension to running projects

FOREST

GSE Forest Monitoring

Addressing the policy related demands for securing the ecological functions in the forestry sector.

Prime: **GAF** (DE)

http://www.gmes-forest.info

COASTAL ZONES

coastcolour

Improving the uptake of MERIS for coastal water monitoring

Prime: BROCKMANN CONSULT(DE)

http://www.coastcolour.org

WETLANDS

GLOBWETLAND

Regional pilot project of the Ramsar Convention on Wetlands for wetlands inventory, assessment and monitoring.

Prime: **Jena Optronik** (DE)

http://www.globwetland.org

AGRICULTURE

GMFS Global Monitoring for Food Security

Providing crop monitoring services for food security.

Prime: **VITO** (BE)

http://www.gmfs.info

sentinel-2 agriculture

Prime: UCL

www.esa-sen2agri.org

Preparing for S-2 exploitation in agricultural monitoring

Objective of S2 preparatory studies

- **Study** the adequacy of S2 time series to efficiently capture the temporal variability in different domains of application,
- **Exploring** the usefulness and develop methods adapted to 5 days time series

- **Outputs**:
  1. an Algorithm Theoretical Basis Document (ATBD), with a description of the algorithms tested, an analysis of uncertainty estimates and some considerations on the calibration and validation of the subject algorithms.
  2. Demonstrated products

Simulated Sentinel-2 Time Series
(part of Take5 initiative of CESBIO/CNES)

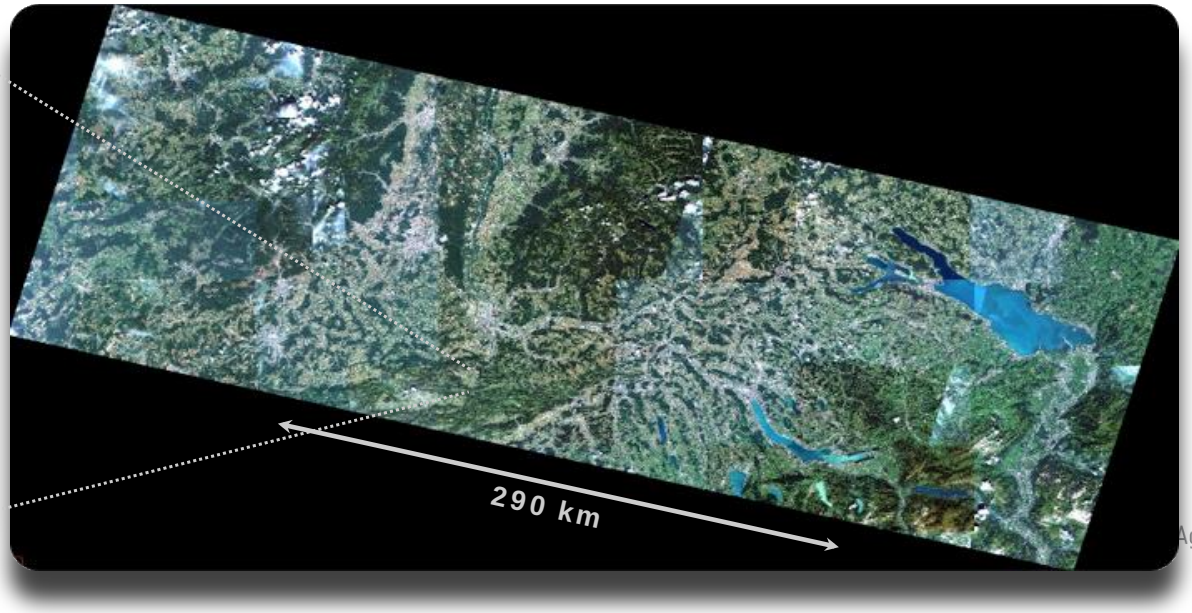
- 14 test sites, globally distributed
- Four major EO applications: Forest, Marine, Agriculture, Wetlands
- **Multi-sensor & multi-temporal data set** (February-June 2013)
  - SPOT4: 5 days repeat, 20 m, 60x60 km2, L1c & L2a
  - RapidEye: 5 days repeat, 5 m, 25x25 km2, L3a
  - Landsat-8: 16 days repeat*, 30 m, 180x180 km2, L1T

*since 15th of April (preferential acquisition)

http://due.esrin.esa.int/s2t5.php

Agriculture: Multi-temporal crop monitoring Morocco, Ethiopia & GEOGLAM

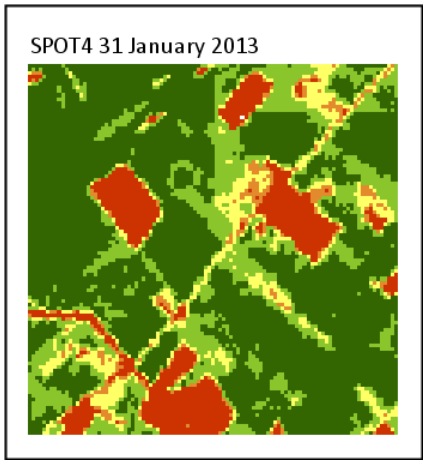
- Multi-temporal algorithm development focused on:
  - Monitoring of **crop dynamics** for crop health/growth and vegetation anomalies
  - Individual **field separation** in complex landscapes
  - Improved **crop type** mapping based on crop phenology
  - Improved **crop masks** by crop vs natural vegetation

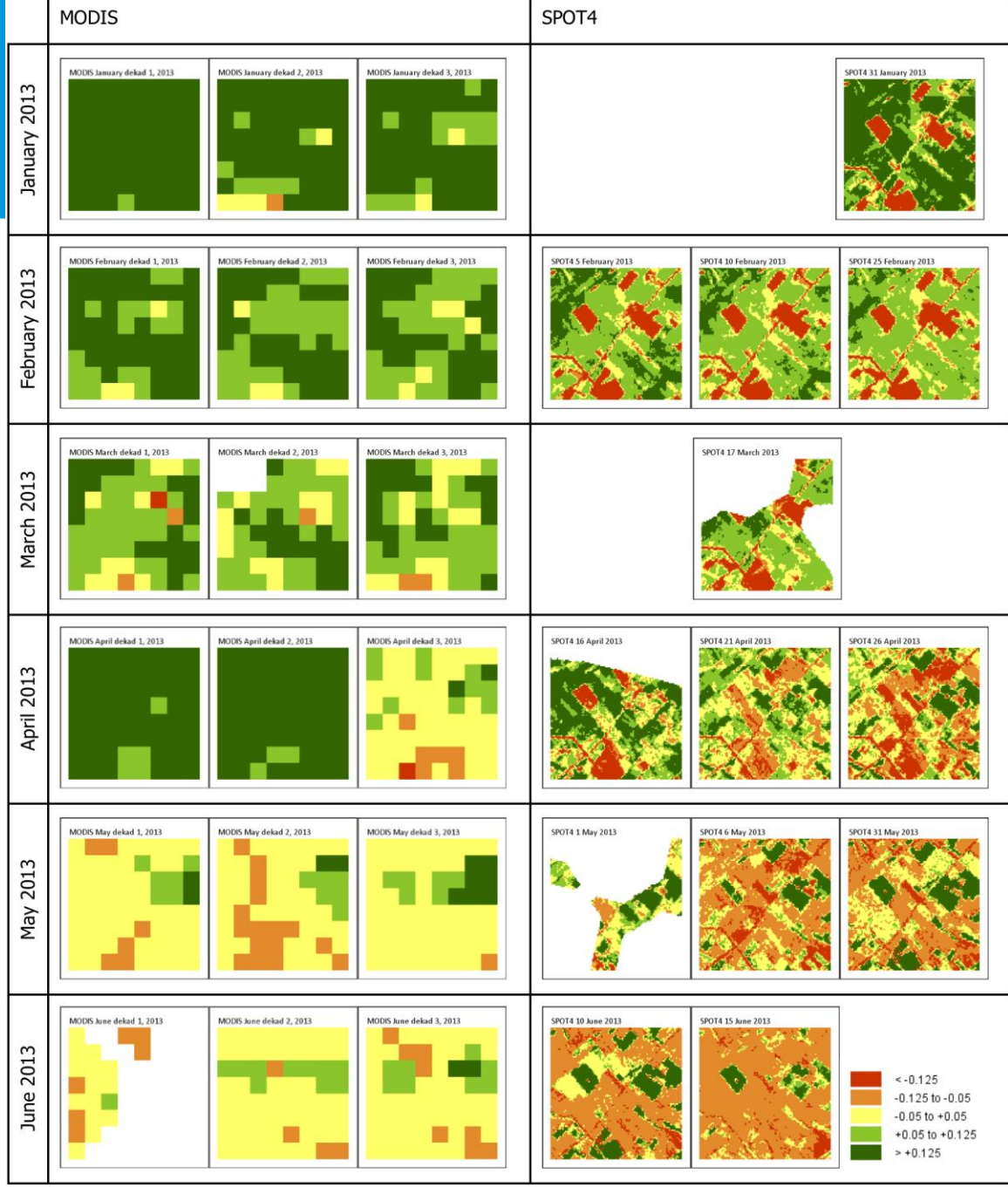


Detecting Vegetation Anomalies at High Resolution

GMFS
Global Monitoring for Food Security

- Anomaly measure = Absolute Difference Vegetation Index (ADVI)
- Calibration of SPOT-4 to long-term MODIS NDVI average
- **Benefit**: Anomaly monitoring at field scale (SPOT-4 and RapidEye resolution) at high frequency.





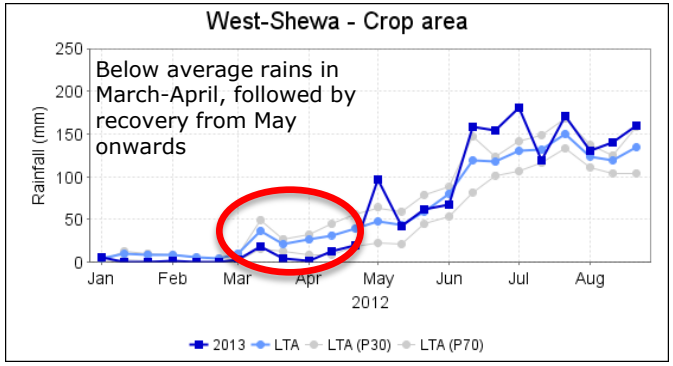
Comparison of SPOT-4 & MODIS vegetation anomalies (ADVI) (2x2 km^2 area, Morocco)

Vegetation Anomalies – Crop Growth stages

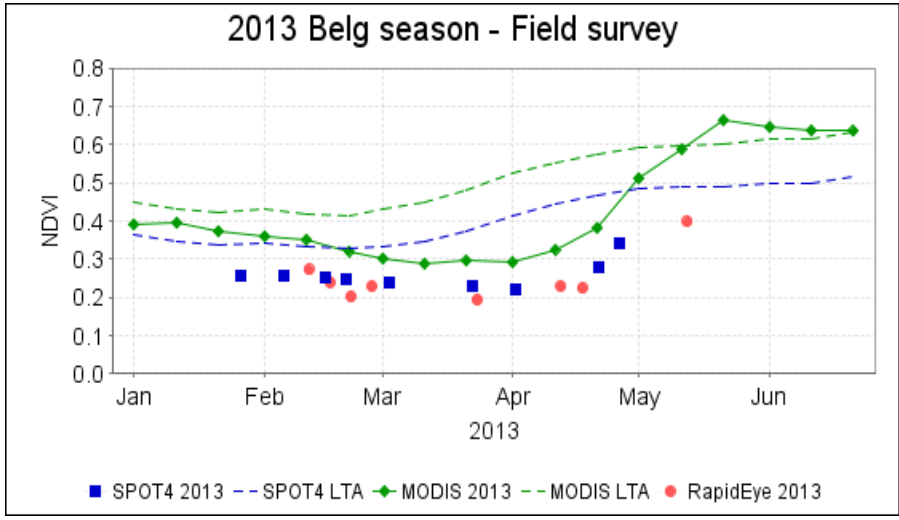
GMFS
Global Monitoring for Food Security

Validation in Ethiopia

- **timing of crop growth stages**: Field surveys along roads and interviews with farmers



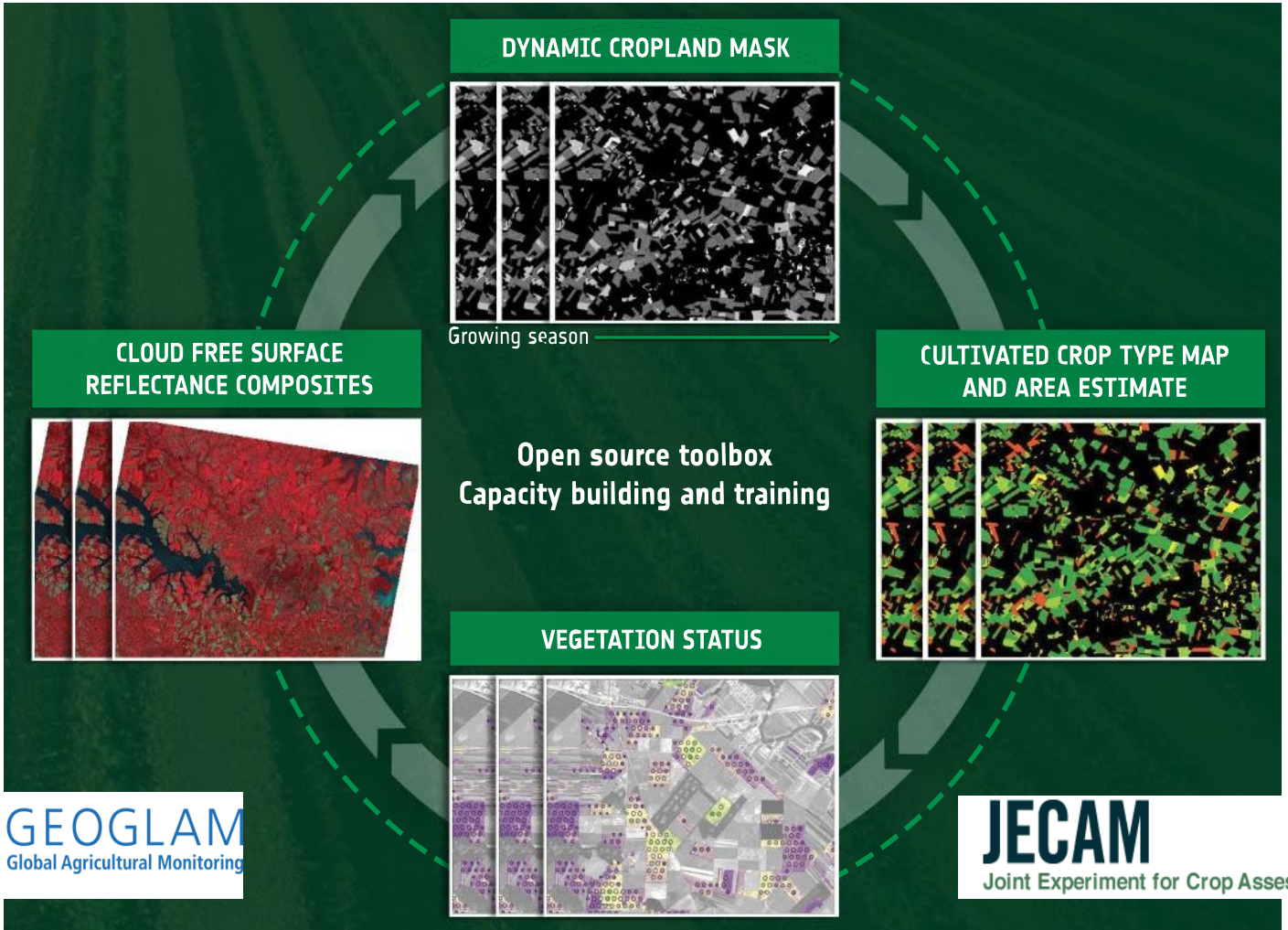
- Surveys indicated a **late season onset** followed by recovery of vegetative growth towards the end of the season – consistent with analysis of ECMWF rainfall.
- Late start to crop season is visible in both SPOT-4 and RapidEye NDVI time series.
- **Overall good consistency** with MODIS NDVI, field work and rainfall
- **Higher resolution allows better separation** of individual fields, crops and natural vegetation.



Sentinel-2 for local to global agricultural monitoring – contribution to GEOGLAM

sentinel-2

→ AGRICULTURE



Project

UCL Université catholique de Louvain

CESBIO

CS

CS ROMÂNIA

Key Users

FAO

WFP

IFAD
Enabling poor rural people to overcome poverty

JRC EUROPEAN COMMISSION

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

RCMRD

GEOGLAM
Global Agricultural Monitoring

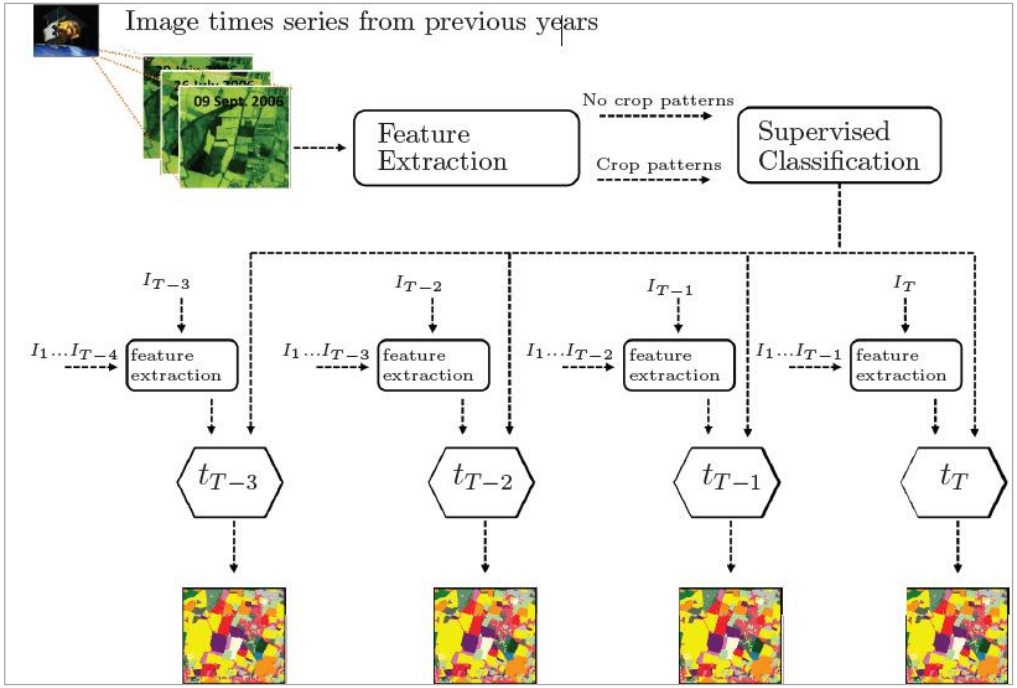
JECAM
Joint Experiment for Crop Assessment and Monitoring

Benchmarking of algorithms
making full use of multi-temporal dimension

sentinel-2

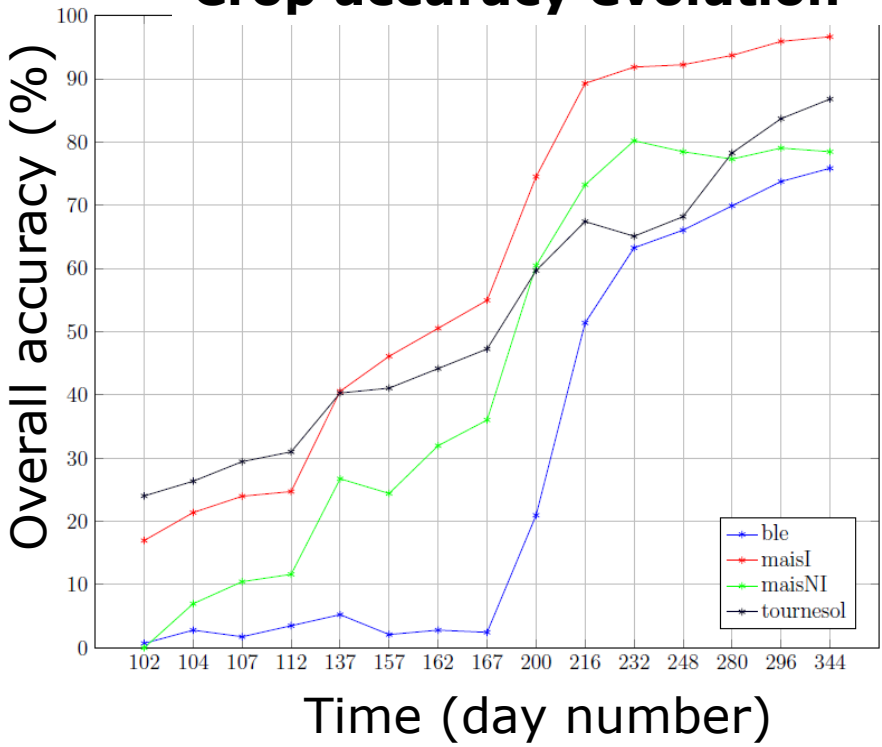
→ AGRICULTURE

- Mapping crop types along the season, based on S4-T5 time series (+ Landsat-8, RapidEye)



Running the algorithm each time a new image is available, parameters optimization at each step

Crop accuracy evolution



Results of Sen2Agri projects presented during this workshop

sentinel-2

→ AGRICULTURE

1. **Crop type & area:**
   J. Inglada, Automatic **land-cover map** production of agricultural areas using supervised classification of SPOT4 (Take5) and Landsat8 image time series.
2. **Cropland Mask:**
   S. Valero, Real time production of a **crop mask** using high spatial and temporal resolution time series
3. **Vegetation Status:**
   D. Morin, Cartography of irrigated crops and **estimation of biophysical variables** with high temporal and spatial resolution images

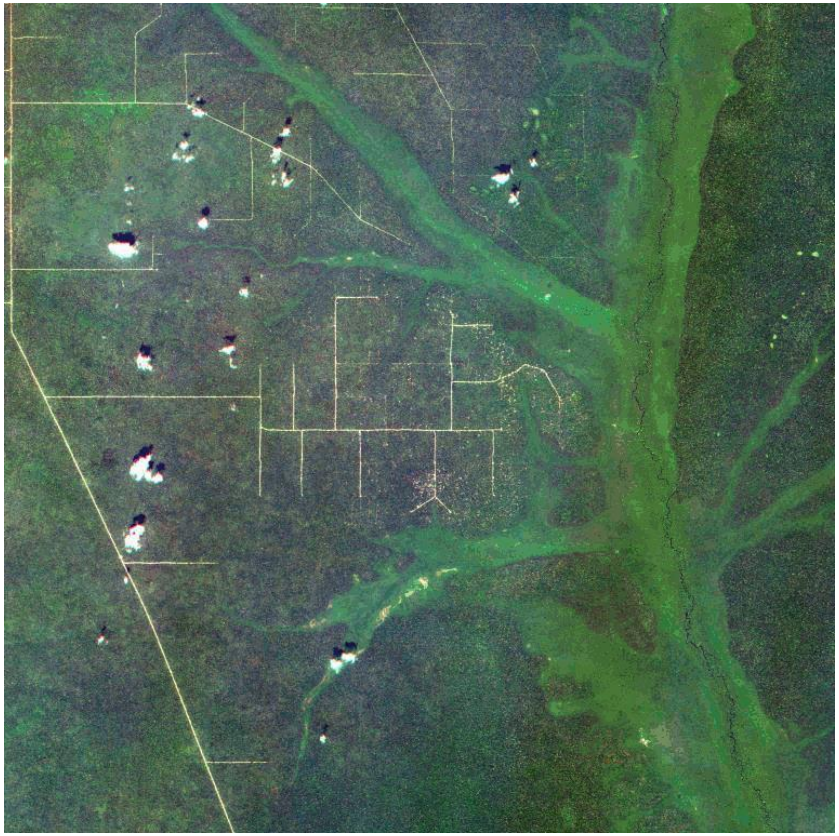
Forestry: Multi-temporal Forest Monitoring in the Congo Basin & Gabon

Multi-temporal experiment will look specifically on methods to:

- **Reduce effects of clouds and cloud shadows** by multi-temporal pixel mosaicking in cloud persistent areas
- Provide **early warning of deforestation** and **detection of forest degradation** based on frequent change detection

Main outcomes:

- Monthly automatic detection of forest disturbance



RapidEye over Congo

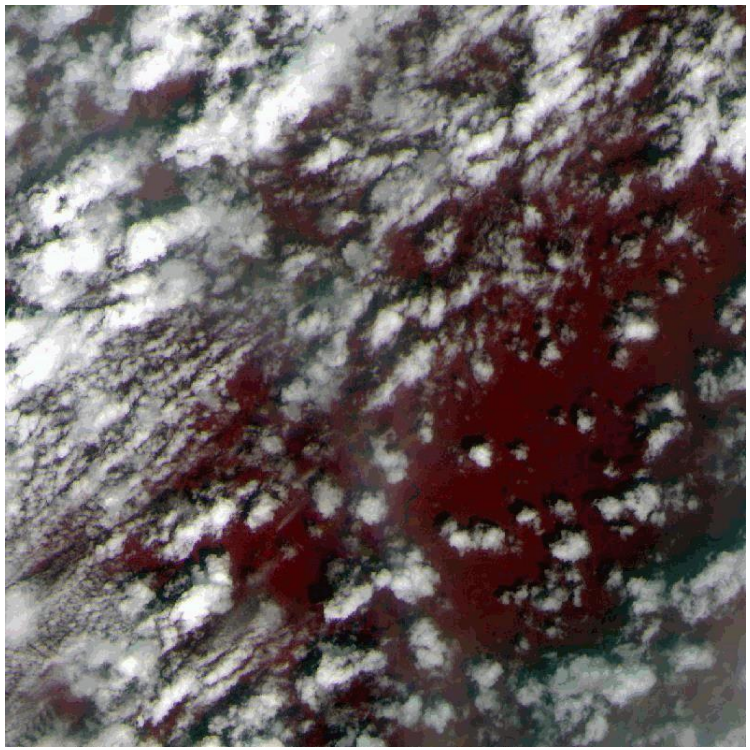
GSE Forest Monitoring

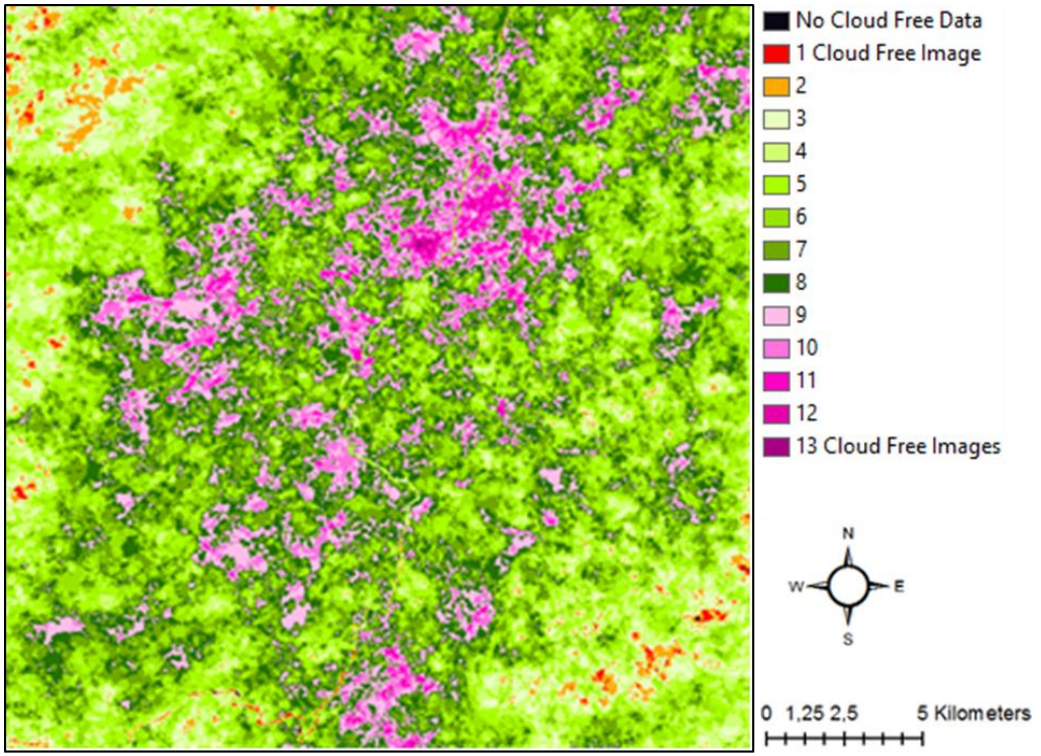
SIRS

European Space Agency GAFAG

Combined SPOT 4 & RE Coverage over Gabon - seasonal coverage in the tropics

Spot 4: 15 images from Jan to May 2013, 5 useable
RapidEye: 24 Images from Feb to June 2013, 9 useable





98% of the area covered by 3 images or more
(Spot alone only 50%, RapidEye alone 85% of area covered)

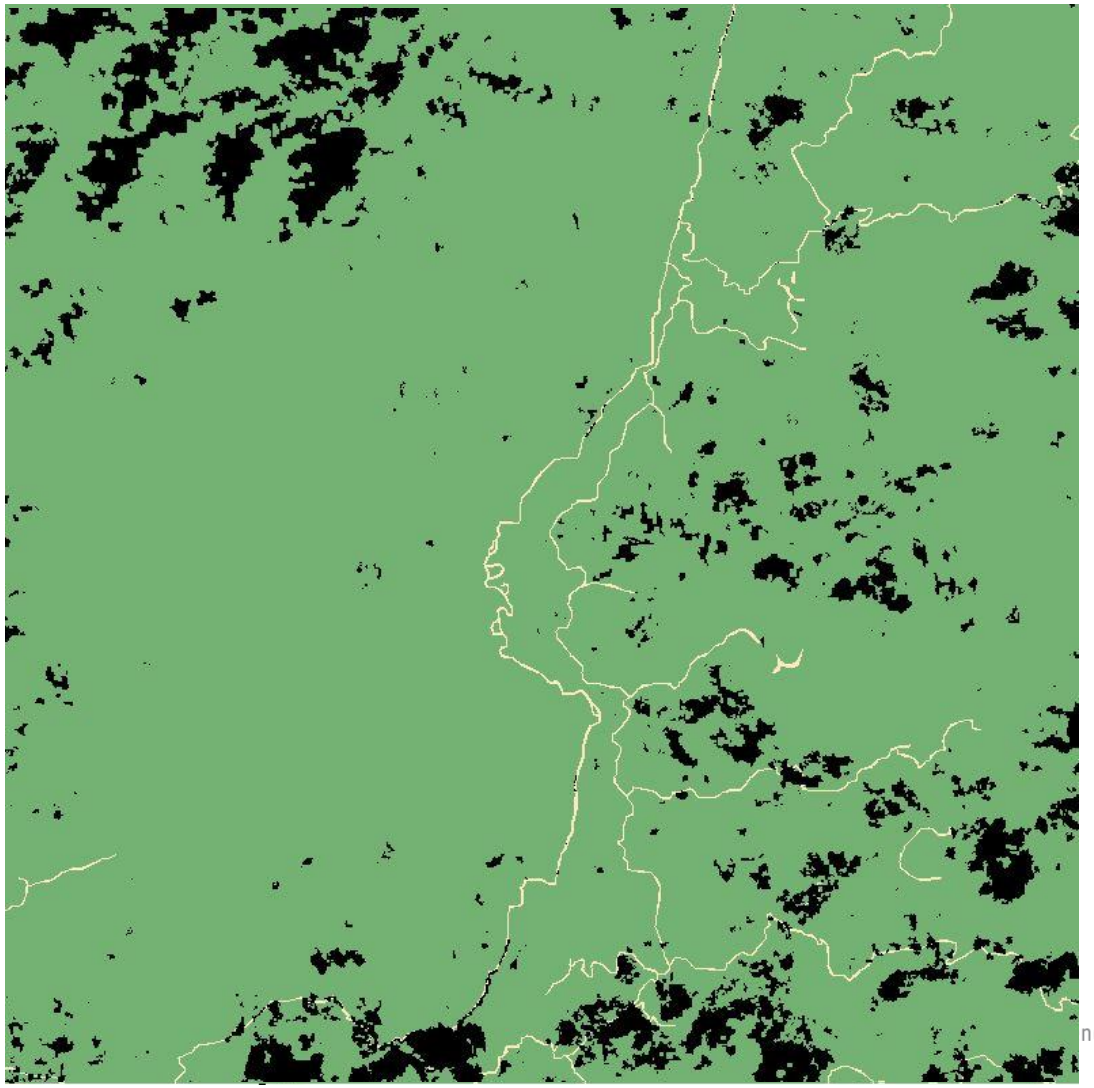
GSE Forest Monitoring

European Space Agency
SIRS

Example of F/NF Output in Gabon per period

From April to May

91.2% of the area is covered

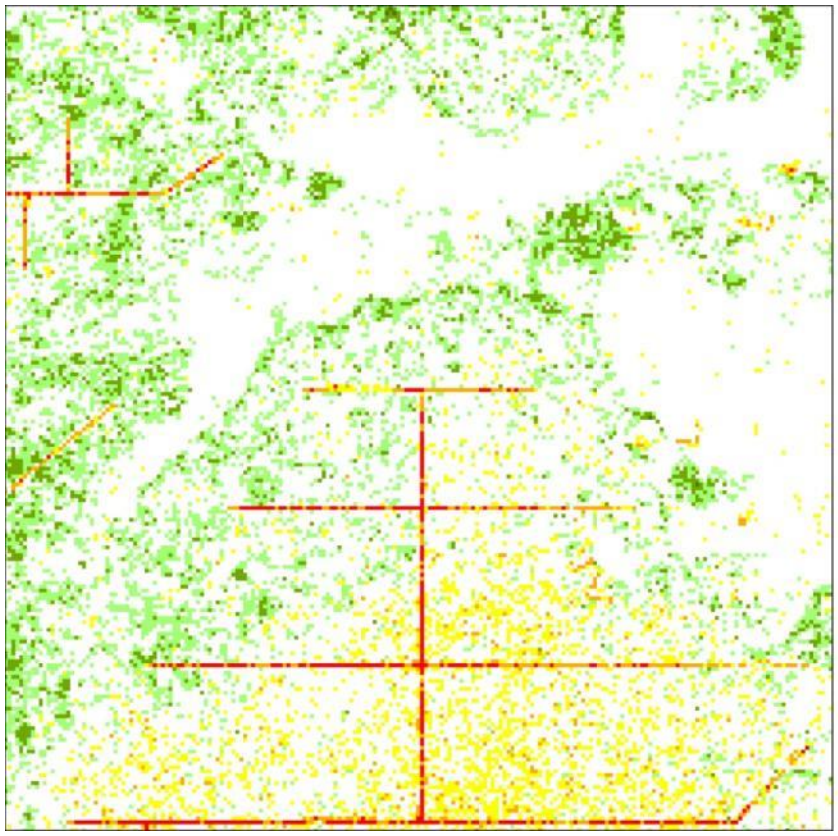


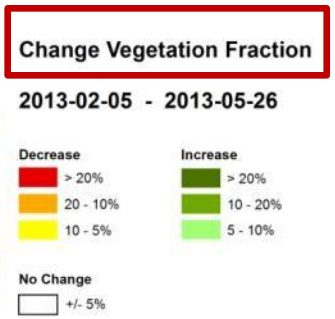
Forest

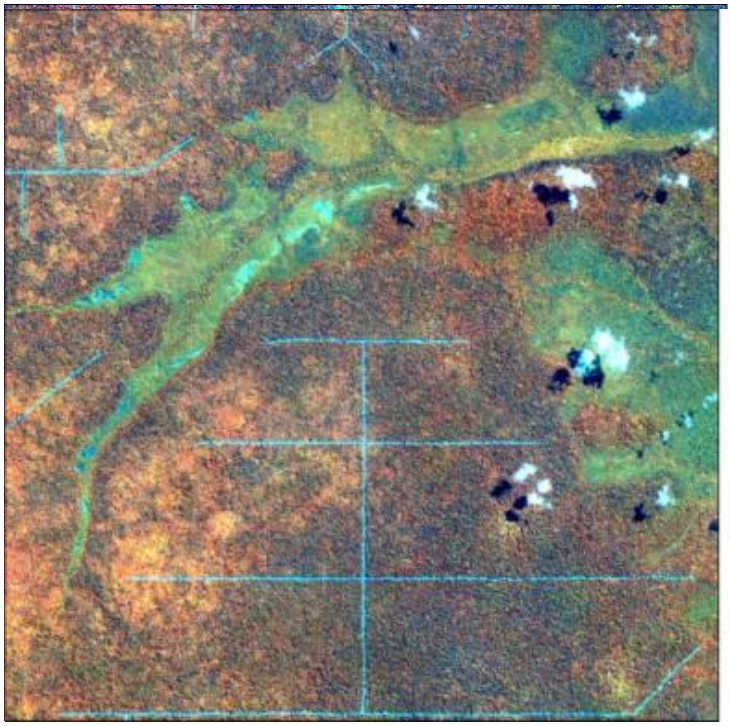
Non Forest

ncy

Forest Degradation (Rep. of Congo)







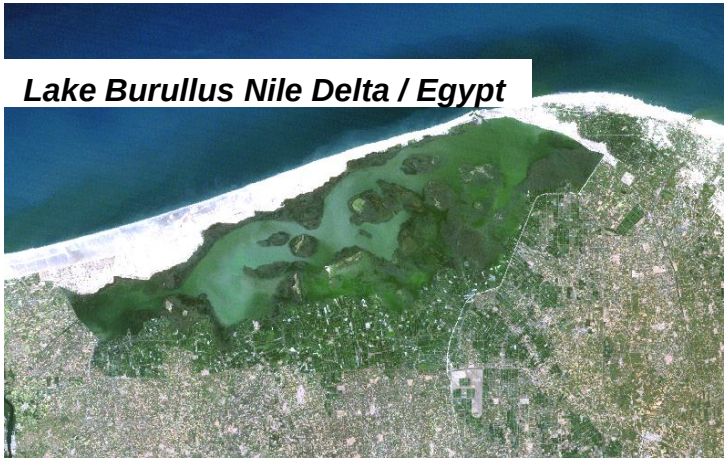
RoC: 2 out of 14 Spot 4 images usable

3 out of 27 RapidEye images usable

Wetlands: Multi-temporal water bodies & wetland mapping

Outlook – Sentinel 2 for Wetland mapping

- Multi-temporal algorithm development focused on:
  - Monitoring the high water dynamics of wetlands
  - Resolving small wetlands in highly fragmented landscapes



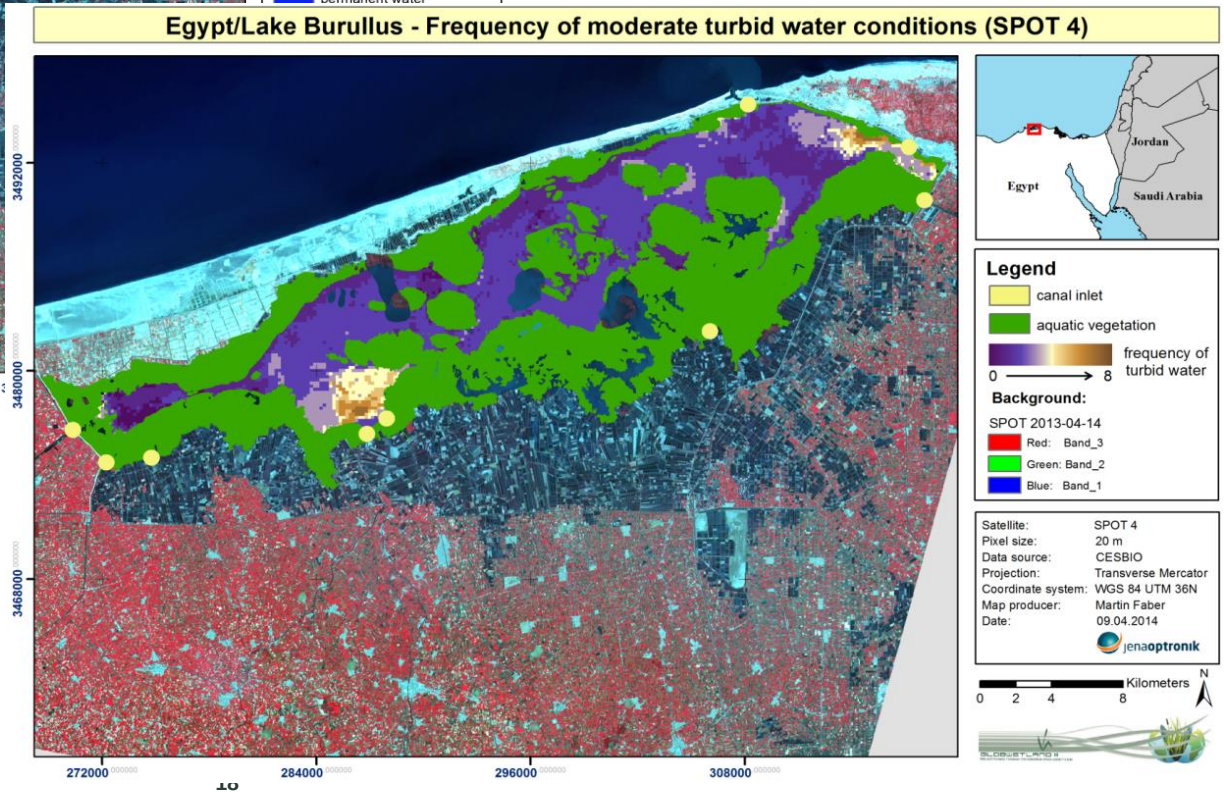
Lake Burullus Nile Delta / Egypt

Azraq Oasis in Jordan

GLOBWETLAND

Water Dynamics: Aquatic vegetation & Turbidity

Time series to delineate precisely the water extent and detect aquatic vegetation changes



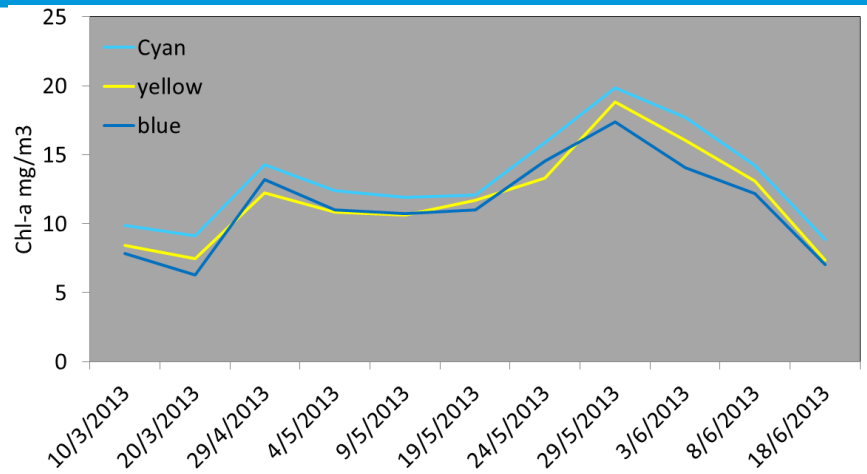
Turbidity hot spots (local and temporal), frequency and extend of turbidity

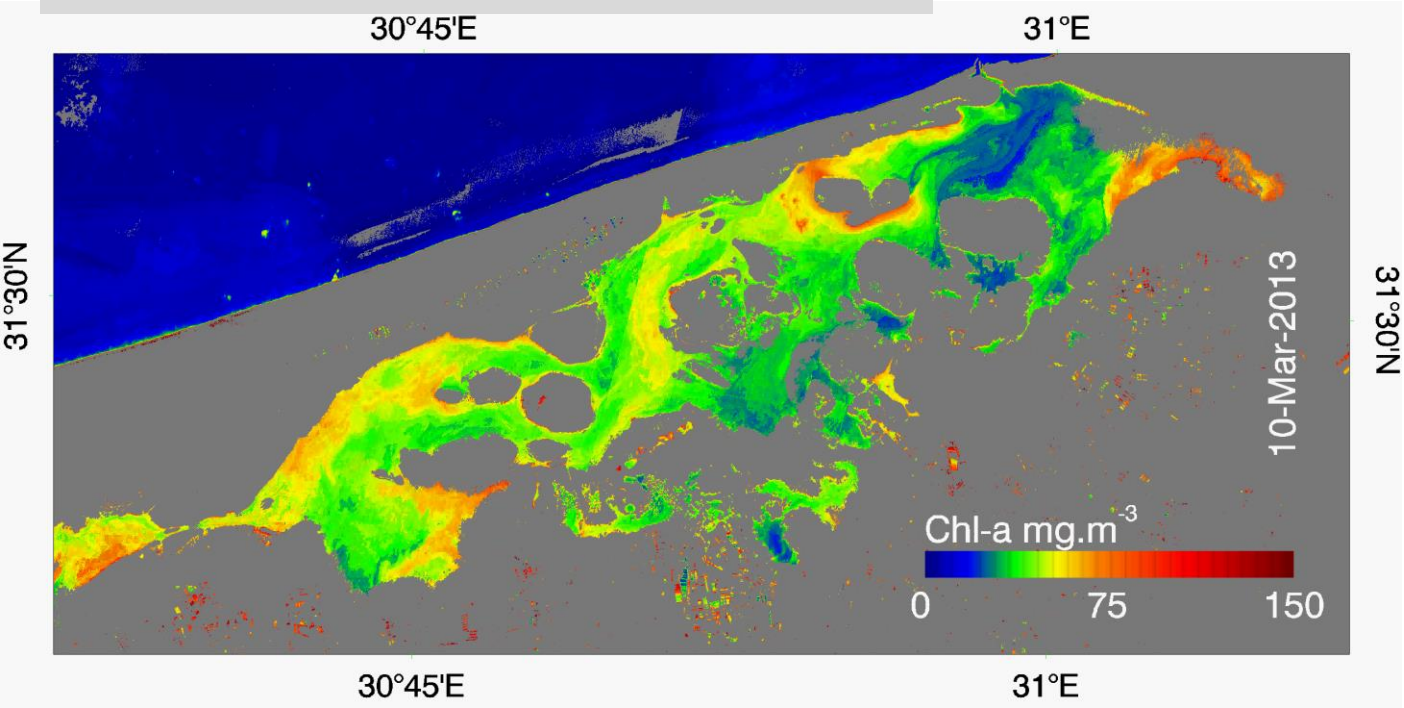
GLOBWETLAND

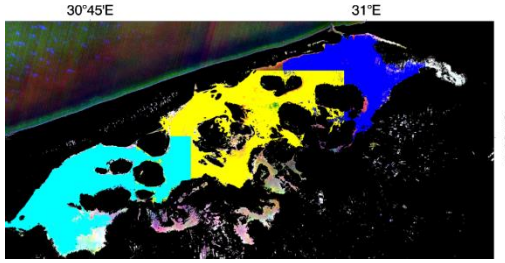
Inland Water Dynamics: Spot-4 products of Chl-a

Spring and summer blooms are shown for three spatially averaged regions

The regions seem to have the same temporal behavior
The start of the summer bloom is delayed in the middle region





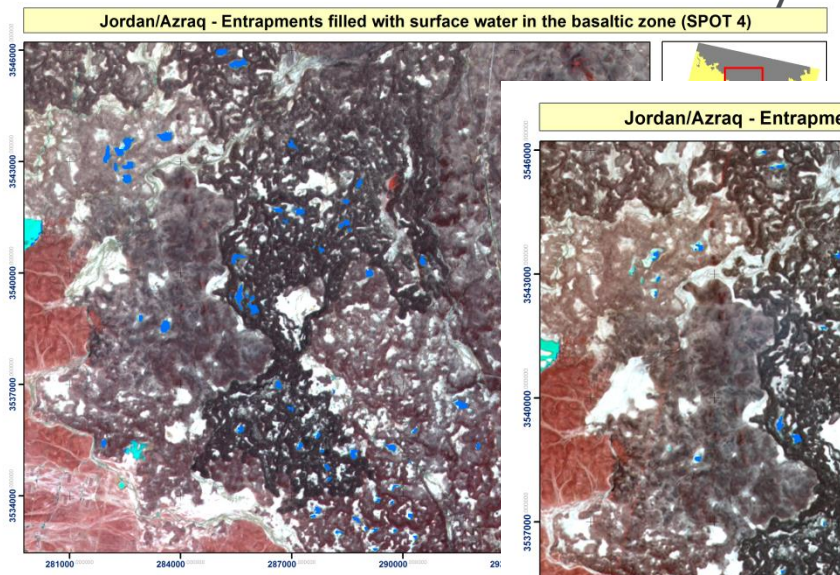


M. S. Salama, H. Farag and V. Vekerdy
University of Twente, The Netherlands

TIGER AFRICA

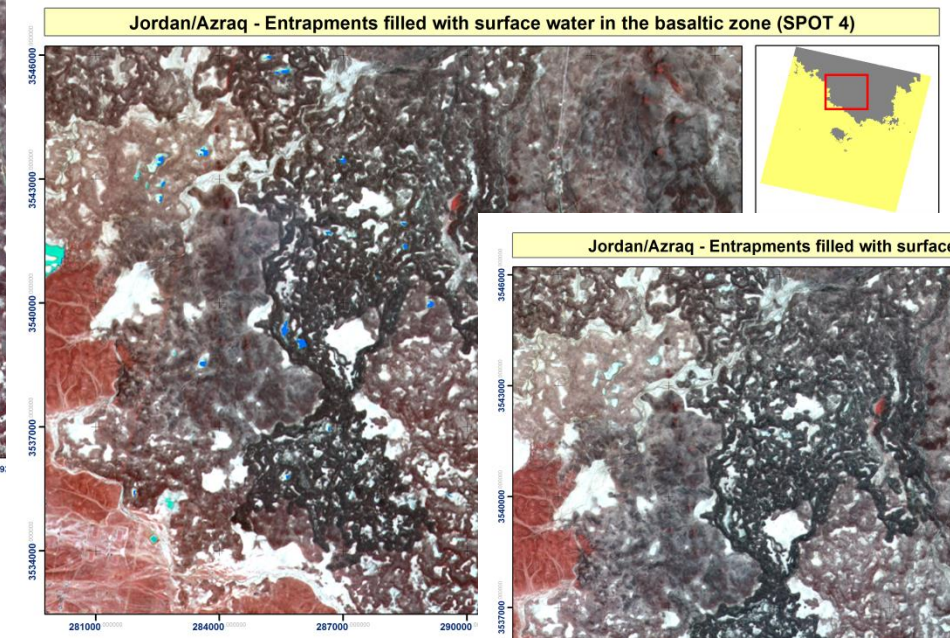
Water Extent Dynamics

February

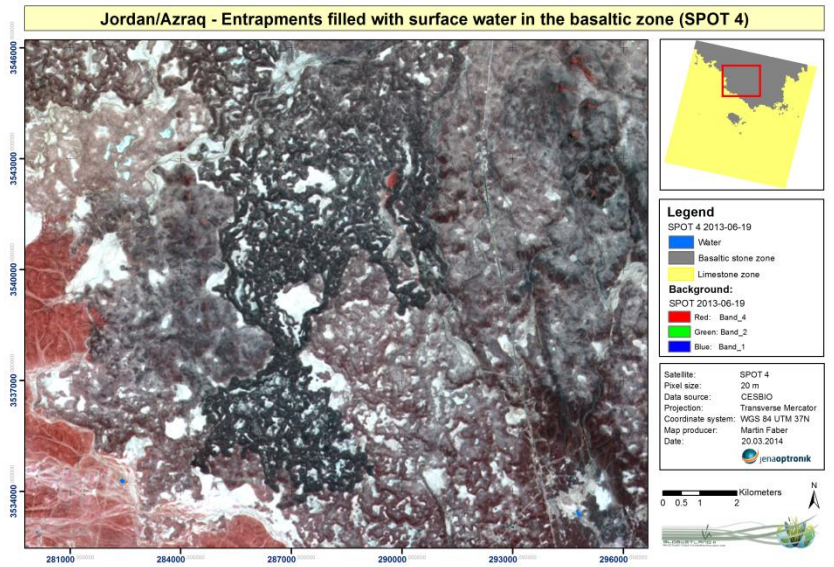


Time series for maximum and minimum water extent

March



June



Short term available water entrapments in the desert, detected and delineated with time series – holes could be drilled into the basaltic stone to harvest the water to refill the aquifer

GLOBWETLAND

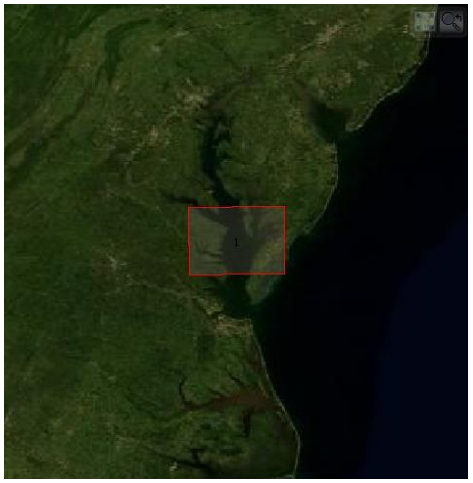
Mapping Water Bodies from Space - 2015
ESRIN (Frascati – Italy), 18-19 March 2015
http://due.esrin.esa.int/mwbs2015/

Coastal Zone: Multi-temporal monitoring of coastal waters

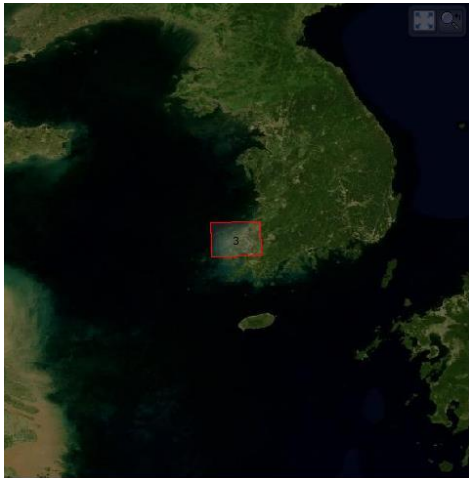
Multi-temporal algorithm development focus:

- "easy" sediment dominated turbid case 2 waters without much chlorophyll or CDOM
- Estimation total suspended matter or turbidity
- Empirical algorithms based on low resolution EO water quality products
- Study areas:
  - Chesapeake Bay (USA): NASA/NOAA validation site
  - South Korean coast: highly turbid
- High resolution & frequency needed for monitoring of dynamic & heterogeneous coastal waters

Chesapeake Bay, USA

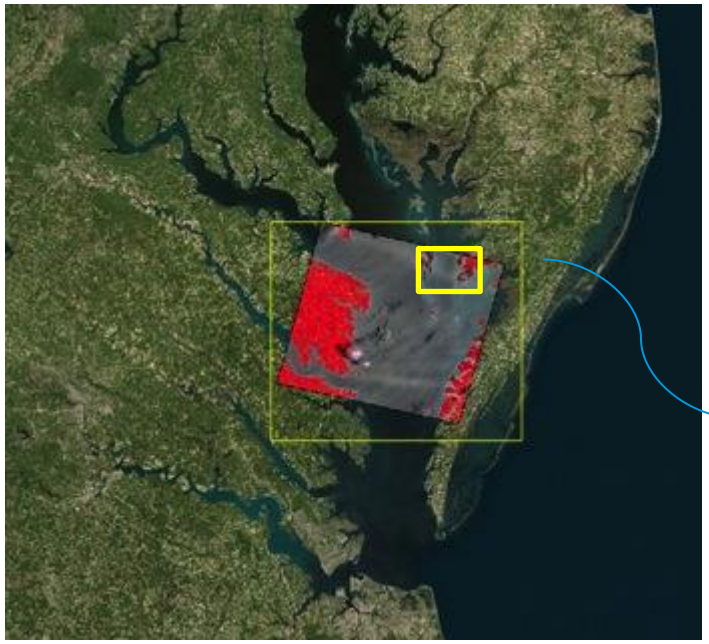


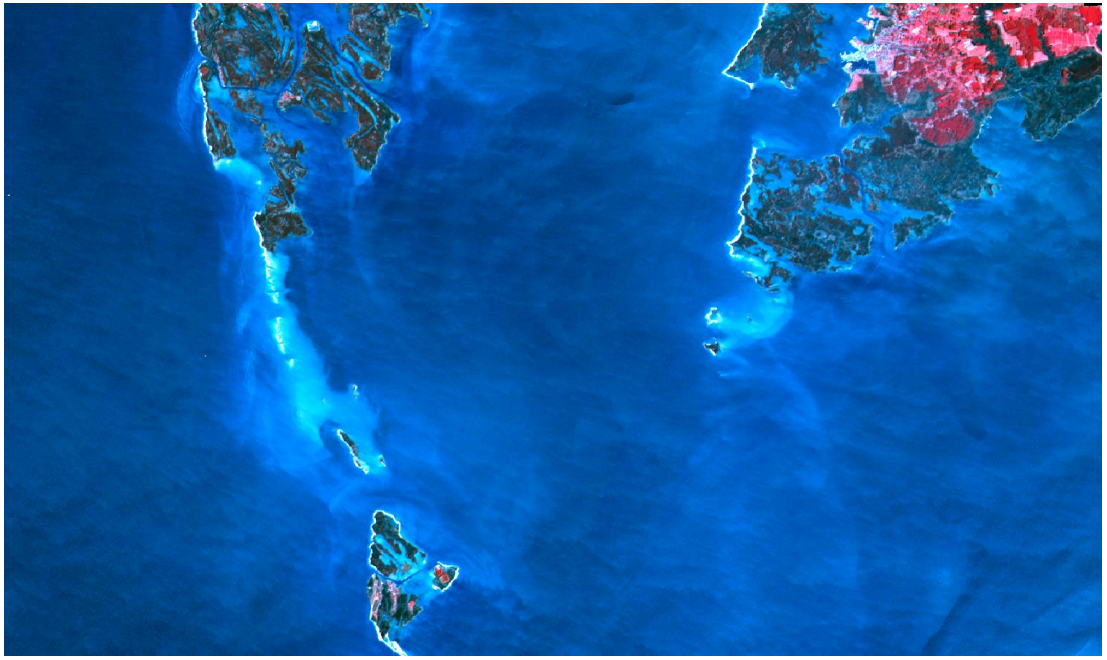
South Korea



coastcolour

Costal Zones: High diversity of water types and applications





Chesapeak Bay

- Optically complex waters
- 3 different regimes within the bay
  - Eutrophic, mesotrophic, oceanic
  - 150 rivers
- Cooperation with NASA
  - US standard coastal site
  - Long time series

Korean Coast

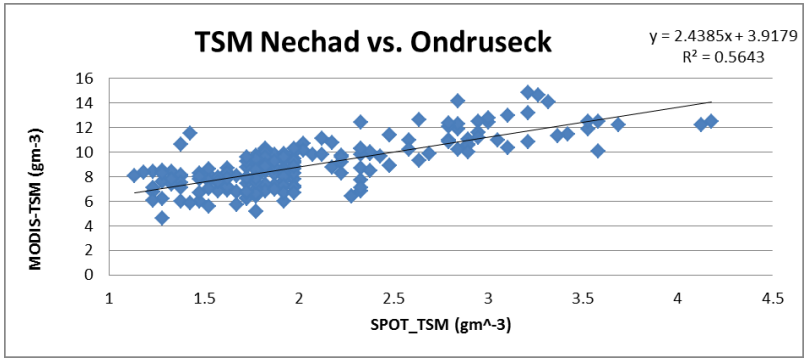
- Highly turbid water
- Dry fallen intertidal flats
- Important coastal areas
  - Fishing vs Environmental protection
- Cooperation with KORDI
  - GOCI Geostationaly Ocean Colour Imager

coastcolour

Estimation of (multi-temporal) Turbidity

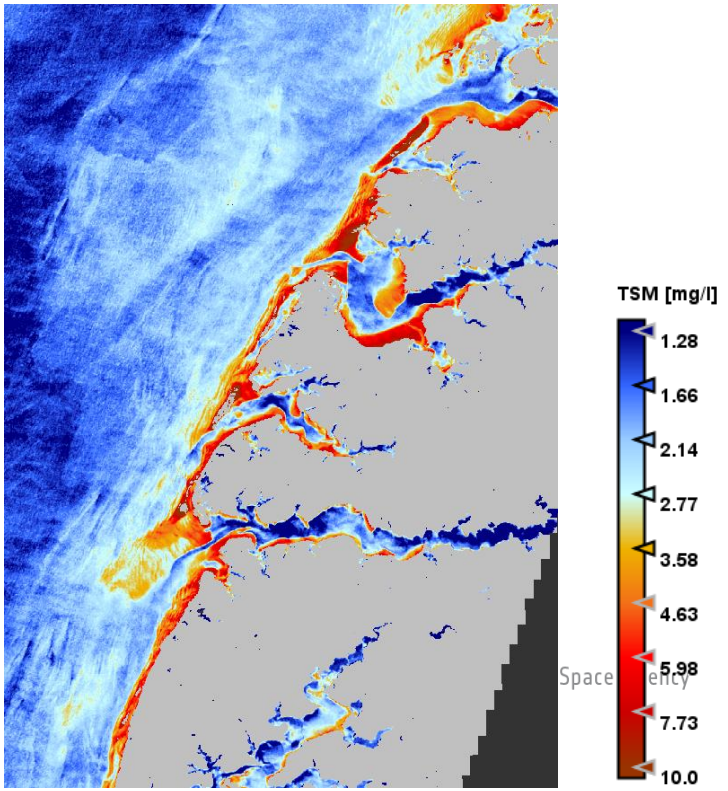
Results:

- Successful retrieval of High Resolution TSM from SPOT-4 Take-5 time series.
- Resolving the **fine spatial pattern of TSM in the river estuaries**
- A single-band retrieval (Nechad, 2012) for total suspended matter (TSM)



Limitations:

- Unforeseen lack of in-situ was a major drawback to the study.
- Poor cloud-screening of the HR data
- Bottom reflection, adjacency effects, glint, haze and mixed-pixels also caused complications
  => New Methods need to be developed



Conclusions

- Building on DUE heritage addressing a wide diversity of applications & user communities for the **preparation of Sentinel-2 exploitation**
  - **Agriculture, Biodiversity/Wetland, Forestry, Costal Zones**
- Time Series Analysis allow for **new information products:**
  - High resolution vegetation anomalies
  - Forest degradation and latest logging activities (roads)
  - Seasonal water bodies dynamics
  - High resolution turbidity of costal and inland waters
- Next steps
  - Dedicated algorithm development needed
  - Demonstration and preparation of user communities

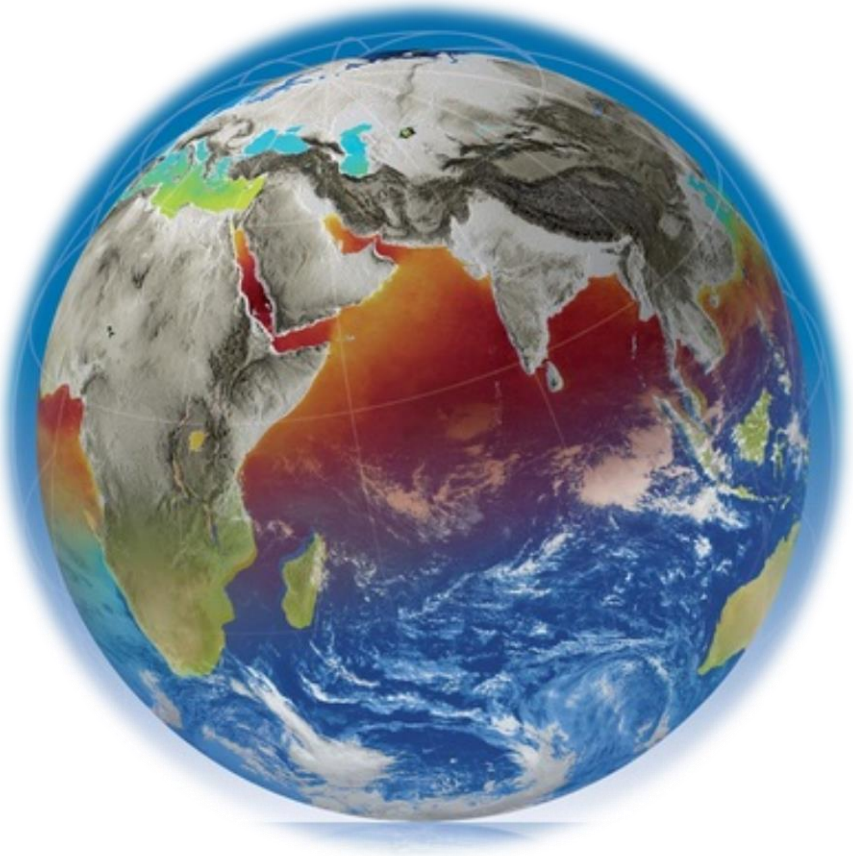
Special Sentinel-2 Session at IGARSS

Sentinel-2 mission status and preparation for mission exploitation

Chairs: Bianca Hoersch, Olivier Arino

- This session will give a presentation on the mission status (including initial mission check-out during Commissioning Phase under the assumption of a launch during spring 2015), preparatory projects in the main operational and scientific application domains will be presented.

Thank you
for your attention



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