Use Case II
Real-time fire monitoring

Part A: Introduction to the Use Case

2nd User workshop
Darmstadt, 10-11 May 2012

Presenters: Haris Kontoes & Ioannis Papoutsis (NOA)
Background - GMES

The objective is to provide Earth Observation = satellite information services to policy and decision-makers.

EARTH OBSERVATION SYSTEMS
(satellite images, aerial photographs, in-situ data)

Space Agencies
In-situ Observing systems
Scientific Community
EO Value Adding Industry

Satellite Images Information

Needs (user driven)

PUBLIC POLICIES
(Environment & Security)

National Governments and Agencies
European Union Institutions
Inter-Governmental Organisations (IGOs)
Non Governmental Organisations (NGOs)

5/10/2012
Background - GMES

Space Systems
Mission Operations
Observational Networks
Data Centers

GMES Core Services

Urban Atlas

Powered and supported by

Safer

Climate Change

Atmosphere

Downstream Services

Land

5/10/2012
SAFER - LinkER ERS projects rationale

The projects SAFER - LinkER aims to implement and validate a preoperational version of the GMES Emergency Response Service, reinforcing the European capacity to respond to such challenges.

- **First priority:** Validate an information service focusing on rapid mapping during the response phase.
- **Second priority:** Enrich this service with a wider set of thematic products.

In the long term, ERCS provide tangible benefits for all citizens, in Europe and worldwide, in terms of better quality of life, better health, and increased safety.

5/10/2012
Fire monitoring application

Available datasets

- NOA hotspot service
  - Raw data
  - Intermediate products
  - Hotspots
  - MSG2 (15 minutes) & MSG1_RSS (5 minutes)

- Ready products
  - FMM-1 hotspot shapefiles & kml
    - Derived from MSG/SEVIRI, on a 15 minutes basis
    - Derived from MODIS, 2-3 times per day
  - FMM-2 burnt area shapefiles & kml
    - Derived from MODIS, on a daily basis
  - Burn Scar Mapping shapefiles
    - Derived from HR and VHR sensors, on a seasonal basis
  - Available in the framework of SAFER

- Auxiliary datasets
  - GIS layers: administrative boundaries, road network, places of interest & toponyms
  - Digital Elevation Model (DEM)
  - CORINE Land Cover raster and vector layers
  - Background mosaic, derived from LANDSAT 5 TM images
Dataset examples

FMM-1, MODIS derived hotspots

- Shapefile & kml
- Delivered 2-3 times per day
- Summer seasons of 2009, 2010 & 2011
- Spatial resolution 1x1km

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Dataset examples
FMM-2, MODIS derived burnt areas

- Shapefile & kml
- Accumulated burnt areas
- Daily burnt areas
- Summer seasons of 2009, 2010 & 2011
- Spatial resolution 250×250m
Dataset examples
BSM example in Greece

Rapid Fire Mapping – Greece 2007

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Dataset examples
BSM, derived from HR and VHR satellite images

- Shapefile
- Delivered seasonally
- High and Very High resolution satellite imagery (2m – 30m)
Dataset examples

BSM example in Ioannina
Dataset examples

BSM example in Corsica
Dataset examples
Auxiliary information

- Background images and mosaics from various sensors
- GIS layers (administrative, places of interest, toponyms, etc.)
- Contour lines derived from DEM
- Corine Land Cover, in raster and vector format, in 3 layers of detail
Fire monitoring
The 2007 wildfires

Services in support of emergencies & humanitarian aid

forum Gmes 2008
Use Case II
Objective

- Design, implement, and validate a **fully automatic fire monitoring processing chain**, for **real time fire monitoring and rapid mapping**, that combines in real-time:
  
  i) Volumes of EO image acquisitions.
  
  ii) Volumes of GMES fire monitoring products.
  
  iii) Models/Algorithms for data exchange and processing
  
  iv) Auxiliary geo-information.
  
  v) Human evidence, in order to draw reliable decisions and generate **highly accurate fire products**.
Use Case II
Real-time fire monitoring

Part B: An insight at the various components

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Real-time Fire Monitoring

- Refinement of hotspot service
  - Automation of the processing and storage
    - Processing chain triggering
    - Systematic archiving of raw data and storage of hotspot products
  - Geo-referencing with increased geometric accuracy
  - Increased thematic accuracy using a dynamic threshold approach
- Product refinement using semantics
- Generation of thematic maps using Linked data
- Easy integration of new processing modules using SciQL
- TELEIOS system infrastructure - DEMO
Fire monitoring application
Advancements – integration of the TELEIOS technologies

Eumetsat @ 9.5° East

Front End: GUI
Map Element

Back End: MonetDB / Strabon

- Corine Landcover
- Admin Boundaries
- POIs

Geospatial Ontology

Cataloguing Service & Metadata Creation

Data Vault

HotSpots

Processing Chain (SciQL based)

External Sources

External Sources

Linked Geospatial Data Semantic technologies

Web access based on Semantics

Linked Data

- Search & Display
- Search for raw & Processing
- Real-time Fire Monitoring
- Refinement (Post-Processing)

Raw Data
Fire monitoring service
Processing chain

Data Import
- Band Separation
- Transformation of raw imagery to appropriate internal format for processing

Cropping
- Crops image to the area of interest

Georeferencing
- Georeference input image bands
- Each pixel can be geographically identified

Product generation
- Exports final products to raster and vector formats

Classification
- Derive physical indexes through band operations
- Assign each pixel a fire non-fire flag with an associated level of confidence, via index thresholding
Fire monitoring service
Processing chain – intermediate products

Data Import

Cropping

Georeferencing

Classification
Fire monitoring service

Products

Raster

Vector
Classification approach #1: Fire detection is based on fixed thresholding, applied on two spectral bands using simple band algebra.

Classification approach #2: The thresholds are dynamically calculated for each new image and for every pixel of the raw imagery.

- Step 1: Calculation of latitude and longitude for each pixel using bilinear interpolation.
- Step 2: Estimation of Solar Zenith Angle per image, per pixel.
- Step 3: Definition of new thresholds depending on this angle, with a linear interpolation.
Fire monitoring service
Algorithmic improvements – an example

2007-08-24 14:00:00 UTC
Discussion on TELEIOS technologies

Benefits from using MonetDB

- Hide completely the details/complexity of the raw data format, using the Data Vault
- Use higher-level languages, stop worrying about how to store and manage data, just focus on the actual processing
- Express common earth observation operations easily using the purpose-build SciQL instead of using a lengthy C program
- Easily handle massive loads due to advanced processing capabilities of column-store MonetDB
- Allow algorithm execution to be optimized by the DBMS’s query optimizer.
Discussion on TELEIOS technologies

Benefits from using Semantic technologies

- Refine products by using spatio-temporal queries expressed in stSPARQL:
  - Identify and eliminate hotspots occurring in the sea
  - Decide for hotspots that are partly located in non-consistent underlying land use
  - Attribute a variable confidence level according the spatio-temporal persistence of a hotspot

- Express semantic queries
  - “Find hotspots within 2 km from a major archeological site”

- Use other Linked Data together with fire products to further enhance our products’ value:
  - Greek government data (geodata.gov.gr), Administrative Geography of Greece, Open Street Map, Wikipedia, Gazeteers (e.g. Geonames)

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Discussion on TELEIOS technologies

Benefits from using Semantic technologies
**Burn Scar Mapping service**

**Processing chain**

### Pre-processing

- **Input data**
  - High & Very high spatial resolution

- **Geo-referencing**
  - Identification of reference control points

- **Cloud masking**

### Core processing

- **Raster to vector conversion**
- **Noise removal**
  - Application of two spatial filters
- **Classification**
  - NBR, ALBEDO, Near-Infrared and NDVI difference indexes are used

### Post-processing

- **Visual refinement**
  - Use of auxiliary GIS layers

- **Attributes enrichment**
  - Involves spatial operations with geo-information layers

- **Map production**
  - and delivery to end users
The Automated Precise Orthorectification Package (AROP) provides geometric image correction and additionally computes water and cloud products. The LEDAPS preprocessing software contains the following options:

1. Calibration & atmospheric correction
2. Computes water-land and cloud mask products

Procedure 1 (AROP) provides general image georegistration and orthorectification for Landsat-like data sources. Procedure 2 provides images georegistration and orthorectification for Landsat-like data sources.

For each LANDSAT Image:

- 7 TIF BANDS: Base = BAND 5
- Metadata File

400+ LANDSAT-4 & LANDSAT-5 Satellite Image Archive


1. Orthorectified Landsat Image (*.IMG)
2. Water-Land-Cloud (0-1-2) Mask (*.TIF)
Burn Scar Mapping service
Core processing

- Classification based on trained thresholds
  - NBR, ALBEDO, Near-Infrared, NDVI difference indexes

- Filtering of the classified pixels
  - Spatial filtering for gap filling through a 3x3 (variable) window
  - Grouping to pixel clusters
  - Elimination of clusters where area < 1ha (variable)
  - Connect neighboring clusters with distance shorter than 2 pixels (variable)

- Raster to vector conversion
Application of refinement queries:
  - False alarms near the coastline
  - Burnt crops during the summer

Attribute enrichment with the use of Linked data

Ability to produce rapid mapping products in rush mode

Process large archives enabling a time-series analysis

Pose queries on historical products for long-term analysis