# Wildfire monitoring via the integration of remote sensing with innovative information technologies

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## Existing fire detection capacities in NOA

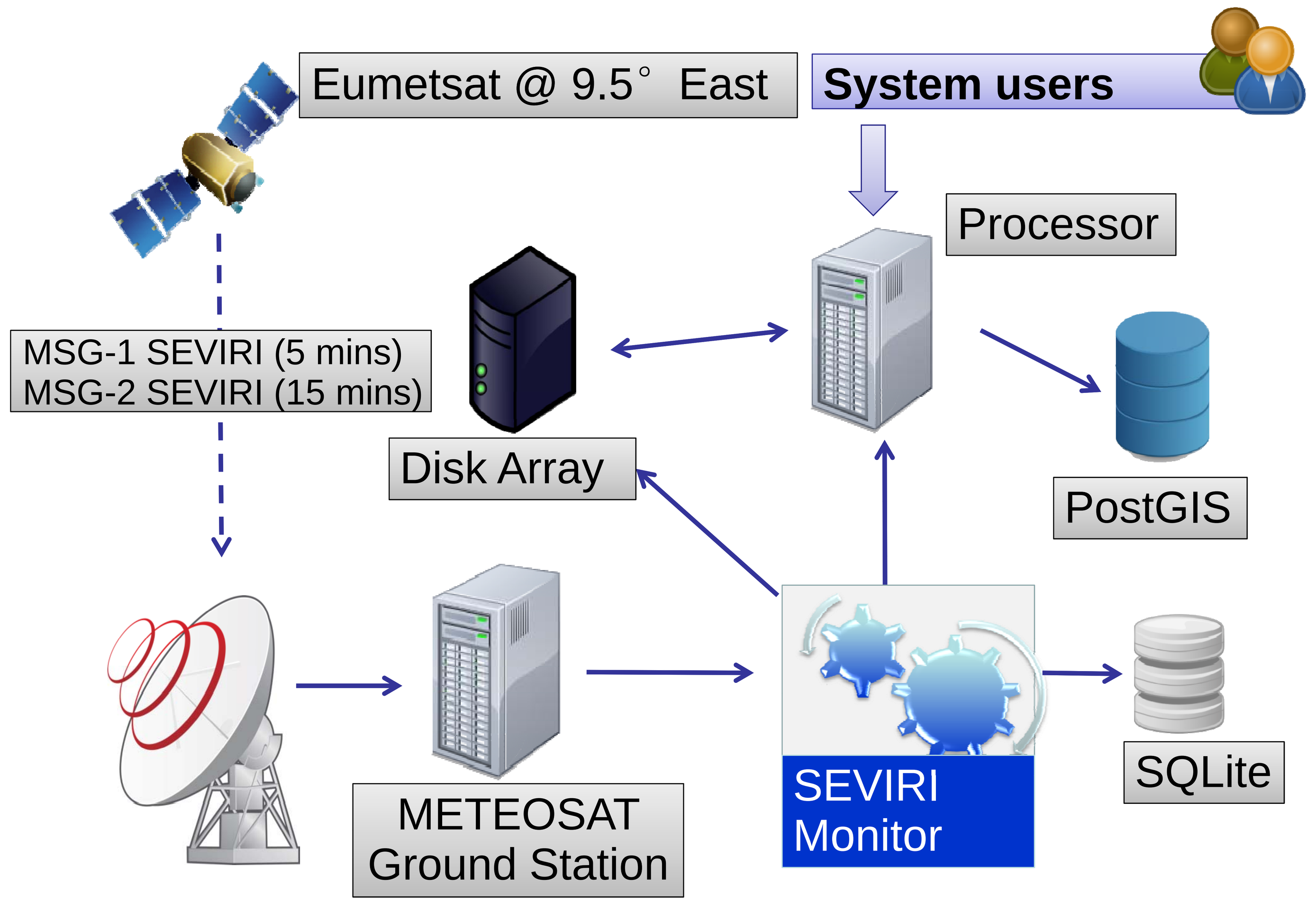
**Framework**

Fire monitoring and management in Europe, and in the wider Mediterranean region in particular, is of paramount importance. Almost every summer massive forest wildfires break out in several areas across the Mediterranean, leaving behind severe destruction in forested and agricultural land, infrastructure and private property, and losses of human lives.

European initiatives in the area of EO like GMES have therefore undertaken an active role in the area of fire monitoring and management in Europe, and supported the development of relevant European operational infrastructures through projects such as linkER and SAFER.

In the framework of SAFER, the National Observatory of Athens (NOA) has been archiving and processing on a routine basis, large volumes of satellite images of different spectral and spatial resolutions (low, middle, and high spatial resolution) in combination with auxiliary geo-information layers (land use/land cover data, administrative boundaries, and roads and infrastructure networks data) to generate, validate and deliver fire-related products and services to the entire Southern Europe (Spain, France, Italy, Portugal, and Greece).

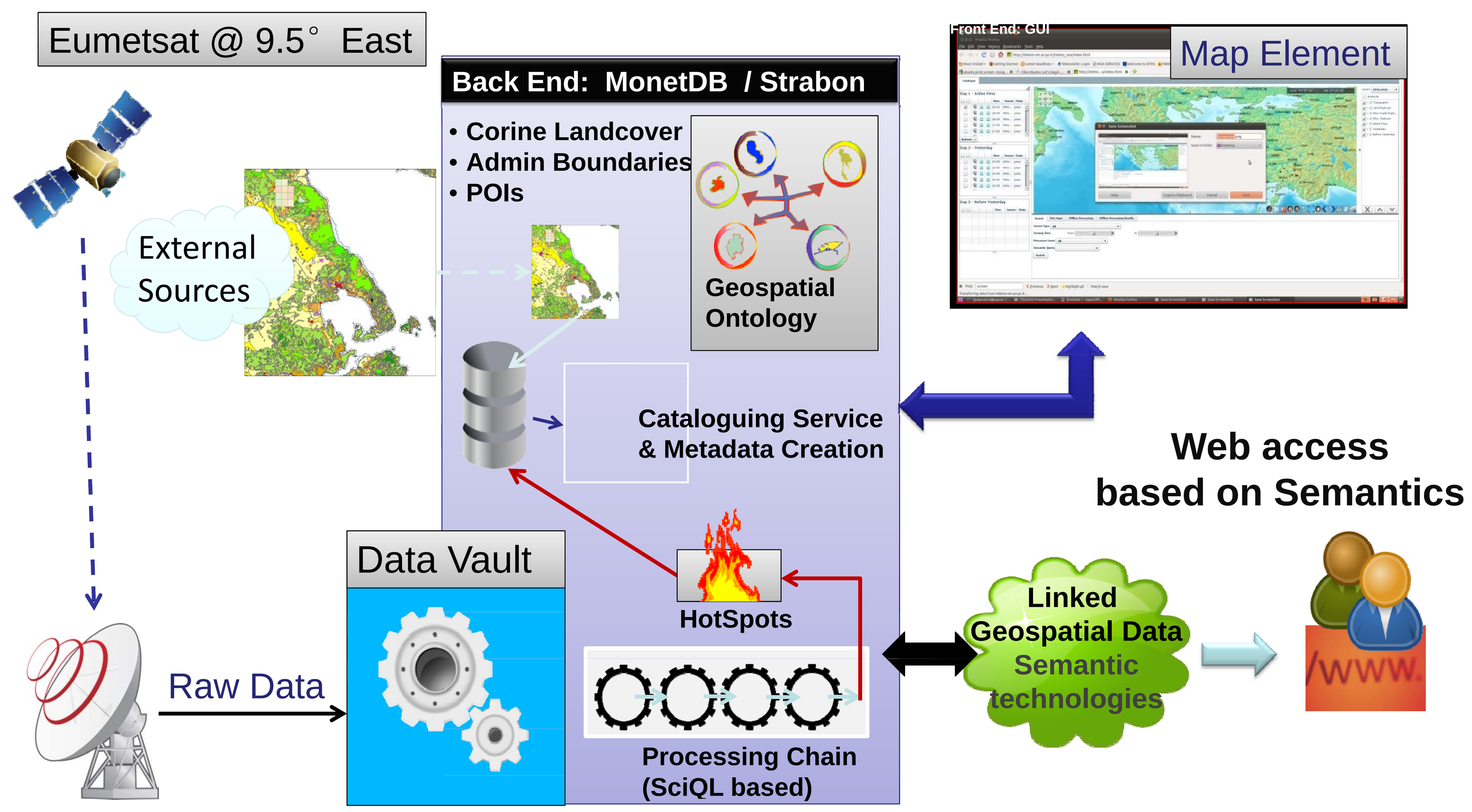
In this context NOA has been developing a real-time fire hotspot detection service for effectively monitoring a fire-front. The technique is based on the use of acquisitions originating from the SEVIRI (Spinning Enhanced Visible and Infrared Imager) sensor, on top of MSG-1 (Meteosat Second Generation satellite, renamed to Meteosat-8) and MSG-2 (renamed to Meteosat-9) satellite platforms. Since 2007, NOA operates an MSG/SEVIRI acquisition station, and has been systematically archiving raw satellite images on a 5 and 15 minutes basis, the respective temporal resolutions of MSG-1 and MSG-2.




**NOA fire monitoring service architecture**

- The ground-based receiving antenna collects all spectral bands from MSG-1 and MSG-2.
- The raw datasets are decoded and temporarily stored in the METEOSAT Ground Station.
- The application SEVIRI Monitor manages the data stream in real-time by offering the following functionality:
  - o Extract and store the raw file metadata in an SQLite database.
  - o Filter the raw data files and dispatch them to a dedicated disk array for permanent storage.
  - o Remotely trigger the processing chain to derive hotspots.
  - o Dispatch the derived products to the disk array and additionally store them to a PostGIS database.
- Dissemination to the end user community (civil protection agencies, regional authorities through a web application.

## Upscaling through state-of-the-art IT




**Envisaged fire monitoring service architecture:**

- The data vault, responsible for the ingestion policy, enabling the efficient access to large archives of image data and metadata in a fully transparent way, without worrying for their format, size and location.
- The backend of the system that consists of MonetDB and Strabon for:
  - o the implementation of the hotspot detection processing chain based on SciQL.
  - o the evaluation of semantic queries for improving the accuracy of the products and generating thematic maps, based on stSPARQL.
- A geospatial ontology which links the generated hotspot products with stationary GIS data (Corine Land Cover, Coastline, Greek Administrative Geography), and with linked geospatial data available on the web (LinkedGeoData, GeoNames), expressed in OWL.
- The front-end interface, for controlling the back-end functionality with user-friendly tools, and disseminating the products to the end-user community. A visual query builder is also currently being developed.

## Array DataBase technologies

SciQL, is a new SQL-based query language for scientific applications with arrays as first-class citizens. SciQL uses multi-dimensional arrays to represent EO data of various processing levels. This allows us to store EO data(e.g. satellite images) in the database, and query and manipulate their content transparently within the high-level declarative database query language. This has three important advantages. First, it allows us to express low level image processing (e.g., cropping, resampling, geo-referencing, etc.) as well as image content analysis (e.g. feature extraction, pixel classification) in a user-friendly high-level declarative language that provides efficient array manipulation primitives. Second, it opens up these algorithms to be optimized by the DBMS's (extended) query optimizer. Third, using the seamless integration and symbiosis of relational tables and multi-dimensional arrays, query processing and knowledge discovery can exploit both image metadata (tables) and image data (arrays) at the same time.

## Semantic technologies

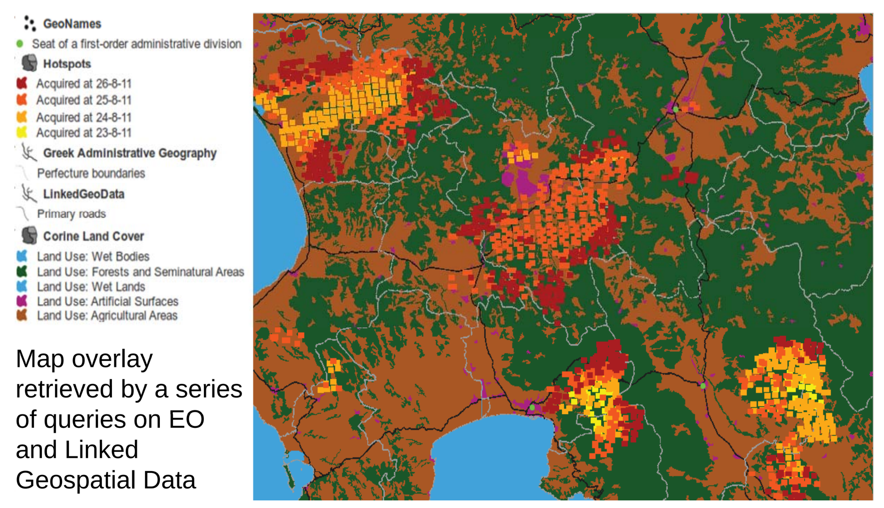
We are utilizing the model stRDF, an extension of the W3Cstandard RDF that allows the representation of geospatial data that change over time. stRDF is accompanied by stSPARQL for querying and updating stRDF data, based on OGC standards.

**Product refinement using semantics**

Use spatio-temporal reasoning for a) identifying and eliminating hotspots occurring inside the sea, b) deciding for hotspots that are partly located in non-consistent underlying land use (e.g. urban or agricultural areas), and c) attributing a variable confidence level to each hotspot according to its spatio-temporal persistence.

**Generation of thematic maps using Linked Data**

Pose stSparQL queries which connect distributed datasets with NOA's fire products, as more and more organizations expose their data as Linked Data.



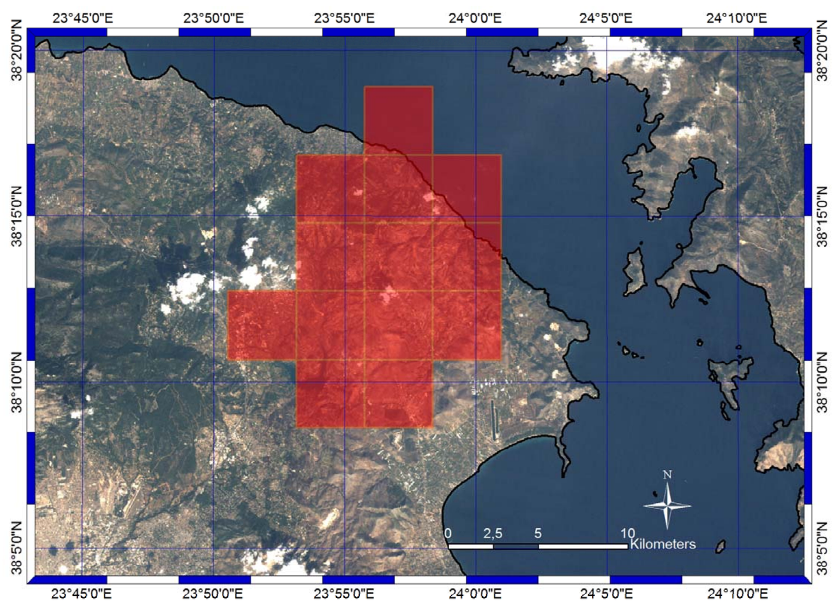
Map overlay retrieved by a series of queries on EO and Linked Geospatial Data

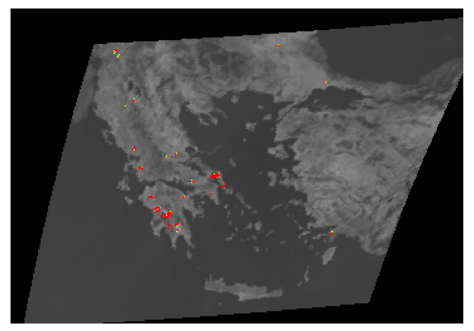
**Semantic queries**

"Find an image taken by a MSG satellite on August 25, 2007 which covers the area of Peloponnese and contains hotspots corresponding to forest fires located within 2 km from a major archaeological site"

## Typical fire monitoring products

Final products are both in raster and vector format cropped to the area of interest – Greece in this scenario, georeferenced to the Hellenic geodetic reference system (HRGS 87) and classified to fire and potential-fire pixels according to EUMETSAT recommendation.





(left) Vector hotspot layer depicting fires that occurred in 2009 at northeastern Attica, and (top) raster overview of the 2007 Peloponnesus forest wildfires.

## Motivation

The development of fully automatic processing chains reliant on

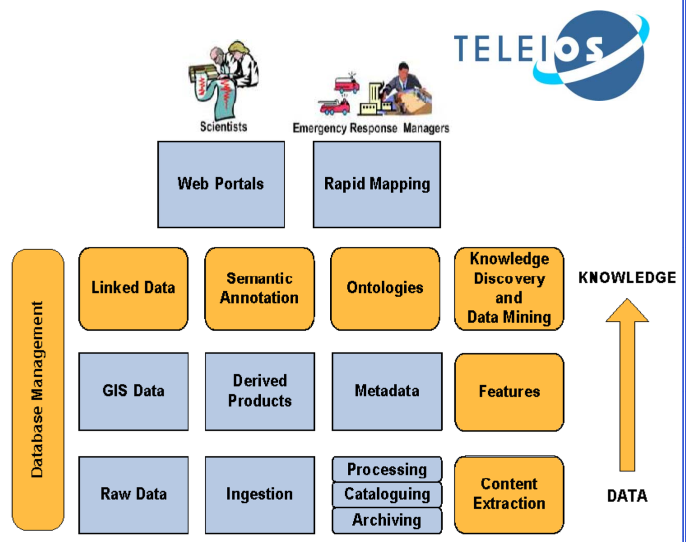
a) effective storing, processing and management of the large amount of EO and GIS data, with a robust and user-friendly system that will allow the integration and customization of the available capacities.
b) post-processing refinement of the fire products using semantics, in order to increase the thematic accuracy of the delivered fire-products.
c) creation of thematic maps and added-value services, via the combination of diverse information sources.

NOA, as a service provide aims at delivering to the end-user community reliable and comprehensive information for fire related emergency situations.

## The TELEIOS project

TELEIOS (http://www.earthobservatory.eu) is an EC funded project which started in September 2010 with 36 moths duration. Its main innovation is the development of a Virtual Observatory infrastructure that goes beyond the current state of the art in Earth Observation portals and Image Information Mining systems. This will be achieved by combining advanced image mining, database, geospatial and semantic web technologies. The partners in TELEIOS are the National and Kapodistrian University of Athens (Coordinator), Fraunhofer IGD, German Aerospace Center, Centrum Wiskunde & Informatica, National Observatory of Athens, Advanced Computer Systems.

Concept view of the TELEIOS Earth Observatory

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